ISTITUTO NAZIONALE DI FISICA NUCLEARE

CVI REPORT 2014

INFN SCIENTIFIC PRODUCTIVITY AND ITS SOCIO-ECONOMIC AND INTER-DISCIPLINARY IMPACT

Contents

1 Introduction

More than ten years after the launch of the Lisbon Strategy, the European Union has to face a global economic downturn lasting since 2008. In recent years Europe has been the real focus of economic crisis requiring extraordinary measures. In order to increase competitiveness, European Research Institutions and Universities are under pressure to both keep up with their research programmes, and to deliver more to the Society at large despite often declining budgets.
The only way to perform better is to attempt to measure the outcome and to (sometime) redirect resources to the best players.

INFN has always been focussed in tracking its research programmes, thanks to several bodies which perform *ex-ante, in-itinere* and *ex-post* evaluation of experiments and initiatives. In addition to the Executive Board, the Board of Directors (CD) and the Scientific Committees there is now a Technical-Scientific Council. Its role is to provide suggestions to the Board of Directors concerning new large-scale projects proposed by the Scientific Committees.
In the subsection 1.1 a short report of the activities of the CTS since its start.

Research Line	GLV	CSN Chair
Subnuclear Physics (CSN1)	Clara Troncon, Marco Costa, Monica Pepe	F. Bedeschi
Astroparticle Physics (CSN2)	Laura Patrizii, Rossella Caruso, Giuseppe Ruoso	R. Battiston
Nuclear Physics (CSN3)	Paolo Pedroni, Vito Lenti, Adriana Nannini	M. Taiuti
Theoretical Physics (CSN4)	Luciano Canton, Vittorio Lubicz, Dario Zappalà	A. Lerda
Technological & Interdisciplinary (CSN5)	Luca Tomassetti, Giuseppina Bisogni, Alessandro Montanari	M. Carpinelli

INFN Research Lines, corresponding Evaluation Groups and chairs of the Scientific National Committee (2013)

The overall situation is then presented every year to this Committee (CVI), which has specific mandate to review the quality of INFN activity as a whole.
CVI is a reference for the Ministry of Education, University and Research (MIUR). Year 2012 marked the first evaluation of Italian research in many years. The Valutazione della Qualità della Ricerca (VQR) for 2004-2010 took most of the efforts of the INFN GLV (Gruppi di Lavoro per la Valutazione) during the first six months of 2012. The final outcome of the VQR 2004-2010 was issued in July 2013 and its results for INFN were discussed in an appropriate section of last year report.
In this Report, first an overview of recent INFN scientific and technological highlights, selected by the Chairs of the National Scientific Committees (CSNs) is presented. The special focus for this year is TIFPA (Trento Institute for Fundamental and Applied Physics). It is a new National Centre generated by a novel interaction of local INFN groups with University of Trento, Local Government and Bruno Kessler Foundation. The scientific productivity and some comparison are then addressed in Section 4 which also provides some parameters for an international comparison. An update on special activities discussed in previous reports (GSSI, LABEC and CNAO) is also given in the same Section. Gender and equal opportunity issues are then discussed in Section 5. Section 6 deals with the role played by INFN in Higher Education and in Section 7 we report in a quantitative way the first destinations of INFN master and PhD graduates.
INFN activities in the Third Mission are addressed in Section 8. We separately discuss, for sake of clarity, the Technology Transfer activities and our efforts to monitor and measure their effectiveness. Other Third mission activities, and our attempt to measure and record them, are also reported. Section 9 provides an update on INFN participation to European initiatives and bodies and the situation in terms of fund-raising in competitive calls.
This Report is prepared by the Working Groups on Research Evaluation (GLVs, Conveners underlined in the inset) coordinated by Giorgio Chiarelli, with the advice of the Chairpersons of the

INFN CNSs and in close connection with the INFN Executive Board.
After the successful VQR 2004-2010 (discussed in last year report), INFN Giunta Esecutiva instructed the GLV to devise the best strategy, and to develop the technical tools, for the next VQR.
In order to fulfil this new charge, GLV is adding more information to the ensemble of data it collects and analyses. At the same time it is preparing comparisons with the past VQR exploiting new instruments. For example, thanks to a more standardized and open way of collecting data within the Italian Public Administration (since June 2014 the SIOPE portal reporting income and expenditures of Italian PA by single entity is open to everybody), we can easily compare and monitor present trends with previous results related to income from different sources. The underlying idea is to track relevant aspects of INFN activities and to use this picture to pre-evaluate the effect of the next evaluation exercise.
Also, the GLV is keeping up to date with the international debate on evaluation and on the (national) discussion on the next VQR with the aim to provide INFN management with the appropriate information in order to be ready for the future evaluation exercise. Currently the Science Europe Working Group on *Impact Evaluation* is preparing a set of recommendations to the body.

1.1 The CTS (Comitato Tecnico Scientifico)

CTS, much alike the CSNs, is a consulting board, established by the new INFN Statuto. Its mission is defined by art. 4 subsection 2 where it reads "*During planning of major (with respect to economic impact) initiatives, the Institute profits of the fairness opinion of the Comitato Tecnico Scientifico.*"
And in subsection 3, that says "*Opinions on the developments of the scientific lines provided by the CSNs and that one of fairness on the initiatives with a relevant economic impact provided by the CTS are acquired by the Board of Directors in order to evaluate the Triennial Plan of Activity and the Ten-Year Document of Strategic Vision*".

Composition and functions of the CTS are defined by art. 18 that establishes:

1. *The CTS is composed by national and international experts in the fields of interest for the Institute.*
2. *CTS is nominated by the CD, after a proposal of the INFN President and after consultation, through the member of the CVI, of the scientific, economic and productive communities: CTS is composed by no more than seven members, duration of the mandate is four years, renewable only once.*
3. *Besides what foreseen by art.4, subsection 3, upon specific request by the CD, CTS is called to timely evaluate the congruity of the human and economic resources and the adequacy of the INFN infrastructures of single project; by also keeping into account the availability of the local resources during the time span foreseen to perform such projects.*

It is clearly stated that the Board of Directors is the body asking the CTS to evaluate the adequacy of the economic and human resources required by a given project as well as to evaluate their pertinence with respect to the scientific aims. It is also obvious that the CTS is a consultant for the CD that is the final recipient of its report.
Current members (six) of the CTS were nominated in November 2011. They are: Prof. Claudio Campagnari (UCSB), Prof. Marco Durante (GSI), Prof. Frank Linde (Nikhef), Dr. Marzio Nessi (CERN), Prof. Guenther Rosner (FAIR) and Prof. Enrico Iacopini (Florence) who is also the Chair.
There was a decision that CTS meets formally twice a year.
As a first step, in order to obtain homogeneous information, an Application Form was set. Similar to forms used in EU project, it requires: the INFN Scientific Commission, the duration of the

project, total cost, scientific motivations, how it sets in the research field, competitor initiatives (ongoing or foreseen), structure of the Collaboration, role of INFN components in terms of responsibility and costs, a comprehensive description of the project, a detailed breakup of the project and of Work Packages (WP) (costs, time span, personnel, milestones and risk assessment), possible requests of existing (or to be built) INFN infrastructures, economic and human resources vs time profile, possible need of temporary personnel, technical innovation of the project and its final impact once it has been realized. Also, a CV of the Spokesperson(s) is required.
In fall 2013, the CTS considered the project concerning the INFN contribution to the *LHCb* upgrade, already presented to the board by Dr. Giovanni Passaleva in the 2013 July meeting.
The CTS was well impressed by the results already obtained by the *LHCb* and positively considered the arguments put forward by the Collaboration for an upgrade of the detector. However, before coming to a decision, the CTS asked the Collaboration to provide additional information and several clarifications, which were timely provided, and found completely satisfactory. The CTS conclusions were presented by its chairperson at the 29th January meeting of the Board of the INFN Directors, where the project was recommended for the approval with a core financial envelope of 5560 k€ (including 15% contingency) and no additional temporary manpower. The only warning was that the other major Funding Agencies involved in the upgrade, should also agree to fund it.
The CTS met also in June 2014, when an informal presentation concerning the *SoX* project was given to the Council by prof. Marco Pallavicini. The project aims to study short distance neutrino oscillations at LNGS, using radioactive sources in *Borexino*. Some important issue are still to be clarified and the project will be formally submitted to the CTS soon, in order to be considered at the next November meeting.

1.2 What Next

The impressive confirmation of the validity of the two Standard Models of particle physics and cosmology, together with the absence of clear hints of some new physics beyond them reachable through our established observational roads, pose research agencies and institutions worldwide a challenging question: what to do next, namely in parallel with the paths which are already part of their envisaged research programs, are there other avenues to be first envisaged and then possibly explored?

Just to be explicit, take two main roads to explore beyond SM physics: colliders (high-energy road) and dark matter searches. In both cases, a "canonical" path is already drawn: the 14TeV and then high-luminosity phases of LHC physics and the 1-ton and then multi-ton noble liquids or bolometric WIMP searches, respectively. The issue is what to do if no signals of new physics show up at LHC or in WIMP searches?

INFN decided to avoid a top-down approach promoting an unprecedented "consultation" with all its components, a wide-range exploration of alternative, new roads different or at least diverting from the above mentioned "ballistic" physics research programs.
The goal of this major effort, named "What Next" program, is not to produce the roadmap of INFN activities in the next, say, ten years, a kind of 10-yrs extensions of the usual INFN 3-yrs plan. Here, the objective is at the same time more limited (in scope), but also more ambitious: not a survey of the future developments of the already envisaged roads (LHC and WIMP searches, in the above example), but the individuation of new research projects with a possible high risk/high gain profile.

Concretely, the work of What Next is structured along 9 research lines: SM Precision Physics, Flavor Physics, Beyond SM, DM, Neutrino Physics (DBD, Oscillations), Cosmic radiation, Gravitational Waves, Fundamental Physics, New Directions; in addition, these 9 WGs find the support for the technological innovative content required in their respective fields from a team on new technologies which is not going to operate abstractly, but in strict contact with the demands and technological challenges faced by the WGs.

As it can be gathered from the above WG list, on one hand What Next intends to address the nuclear, subnuclear and astroparticle research fields where INFN is already engaged to individuate "non-ballistic" paths in such a more "traditional" INFN research context and, on the other side, in particular in the two last WGs of the above list, it wants to address topics new to INFN, at least in its experimental activities, like the study of the CMB polarization or the dark energy or ultra-cold atoms etc.

These 9+1 WGs were constituted right at the beginning of this year and in 3 months prepared some preliminary material for the What Next kick-off meeting which took place in Rome on April 7-8 with the participation of more than 700 INFN physicists (plus a small, but relevant, foreign participation – not scared by the use of the Italian language throughout the entire meeting).

We have already some output on the intense work carried out in the WG in these last 8-9 months: all the three (nuclear, subnuclear and astroparticle) INFN research areas produced ideas for new projects with an impressive variety of themes (from a new technique for axion searches to the study of the CMB polarization with a balloon experiment, LSPE, from the search of heavy neutral leptons in a new beam dump experiment to be carried out at CERN to an innovative approach to get complementary information on the nuclear matrix elements in neutrinoless double beta decay, just to make a few examples). At the same time, a large amount of "collateral" work has been and is being produced with the clear intent to create a suitable background for further innovative projects to be proposed.

We emphasize that the INFN management has launched the What Next program not only with the goal of stimulating a formidable think tank involving the entire INFN researchers' community on new ideas, but also – even more important – with the precise objective to transform at least a selection of them from ideas to concrete new experiments. That's why INFN is starting allocating seed money to its CSNs for moving forward with the most promising, challenging, but not impossible projects.

As for the next steps of the What Next program: in this last period of the year, the various WGs are organizing individual (or with the participation of 2-3 WGs) meetings in preparation of a kind of mid-term meeting with all the WG conveners together (but open also to others interested in the program) to be held at LNF between January and February of next year. Then, in the fall of next year we'll have the closing meeting of What Next with the subsequent release of the INFN What Next "white book" early 2016.

After some initial perplexity (amply justifiable given the somewhat unprecedented nature of the initiative), we have witnessed a great response (in some cases, even some enthusiasm) from the INFN community to the What Next call. This makes us confident that our challenge to skip the attempt to go for the n-th roadmap on the physics prospects etc. and, instead, face the much harder question of What Next declined in its What Else content may represent a great opportunity for our lively community that, as it occurs worldwide, also feels the difficulty to know which directions to take after the astonishing confirmation of the SM.

2 Highlights from the Scientific Committees

CSN1 Sector	FTE	Budget
Hadronic Physics (LHC, Tevatron)	57.3	61.3
Flavor Physics (including LHCb)	24.0	26.9
Charged Lepton Physics	4.8	7.6
Proton Structure	3.2	3.4
R&D for Future Applications	1.0	0.8

Table 2.1 - CSN1 Sectors, FTE and budget (%)

INFN mission is to study the basic constituents of matter, and to conduct theoretical and experimental research in the fields of subnuclear, nuclear, and astroparticle physics, in close collaboration with the academic world.
All the activities carried forward by the scientific committees are developed in close connection with the academic world and other scientific institutions both in Italy and abroad. For all of them, the variety and quality of the research carried out are proven by the number of papers, citations and talks at international conferences. Web pages of the Scientific Committees can be accessed directly by the main INFN web page (www.infn.it).
While 2012 was certainly marked by the discovery of the scalar boson responsible of the EW Symmetry Breaking and 2013 by the Nobel Prize to the theoreticians who predicted its existence half a century ago, we had important developments in all fields of research.

2.1 Particle Physics at Accelerators

In 2013 and the first part of 2014 the experiments engaged on particle physics performed at accelerator facilities have explored several fundamental fields of the sector, all of them at the forefront of High Energy Physics research, and/or are completing or improving their detectors for new upcoming data taking campaigns. There are several active lines of research, whose composition and budget is summarized in Table 2.1. The total number of FTE is 739.

By far, the central role, human and resource-wise, is played by the running of the LHC experiments. After a very successful operation until early 2013 the LHC has been turned off for extensive improvement and consolidation work, which is expected to be completed on schedule by the end of 2014. During this year and the previous one the LHC experiments have undergone extensive maintenance and consolidation, while extracting additional results from the analysis of the substantial data set collected until the end of 2012.

More than 500 INFN supported physicists participate with large and visible roles in ATLAS, CMS, LHCb, LHCf and TOTEM, participating in the construction, maintenance and operation of the experiments, as well as in the associated analysis work.

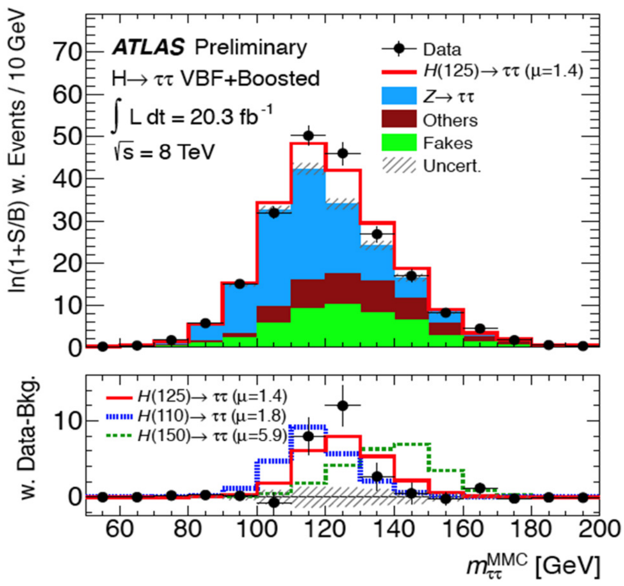


Figure 2.1– ATLAS experiment: invariant mass distribution of opposite sign τ pairs. The $H\rightarrow\tau\tau$ excess shown in the plot has a statistical significance of 4.1 σ.

After the recent outstanding success of the Higgs discovery, we are now entering a new era where the Higgs boson is used as a tool for new discoveries. All its properties have to be studied with the best possible

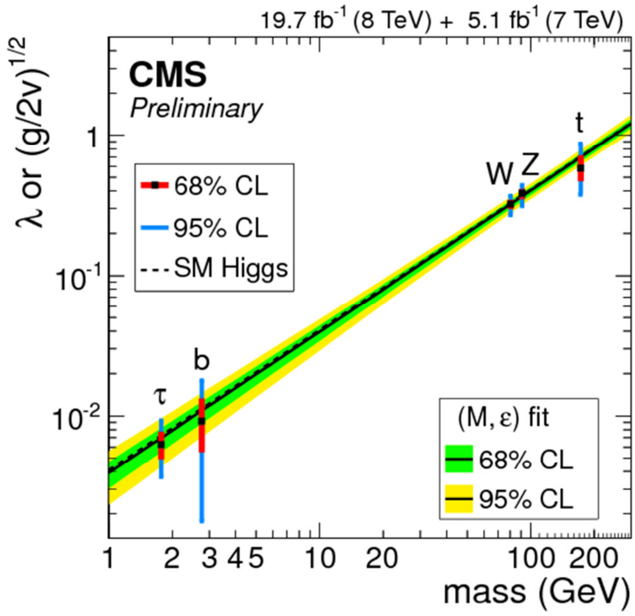


Figure 2.2 – CMS experiment: Higgs couplings vs. mass compared to SM expectations.

precision to achieve this goal and new ideas are needed to do more and better than was previously expected. During the last year significant work has gone into strengthening the fermion signal with important improvements in the measurement of the decay of the Higgs boson to b-quarks and especially to τ leptons. In fig. 2.1 we show the ATLAS result for the process H→ττ and in fig. 2.2 a summary, recently compiled by the CMS experiment, of the Higgs boson couplings to various particles as a function of their mass, indicating a strong consistency with the Standard Model (SM) expectations. The mass of the Higgs boson has also been measured with better accuracy and consistency after careful recalibration of the detectors. New ideas are emerging that could lead to measurements at LHC previously assumed to be only possible at future electron-positron accelerators; for instance the measurement of the Higgs self-coupling or the measurement of its width from the four lepton invariant mass spectrum in the ZZ* channel. In fig. 3 we show the current upper limits on the Higgs boson width obtained by the ATLAS and CMS experiment. In 2013 measurements of the top-quark mass by ATLAS and CMS experiments almost reached the accuracy of Tevatron experiments. As of fall 2013 LHC combined top mass is 173.29±0.23±0.92 GeV/c^2 versus a Tevatron combination of 173.2±0.51±0.71 GeV/c^2, accuracy better than 1 GeV. CMS observed for the first time the single-top production in association with a W boson.

Extensive searches for new physics have been made by the experiments at the LHC. This has resulted in the highest limits ever set on the scale of many potential new physics scenarios. In particular supersymmetric squarks and gluinos are now excluded up to about 1.5 TeV.

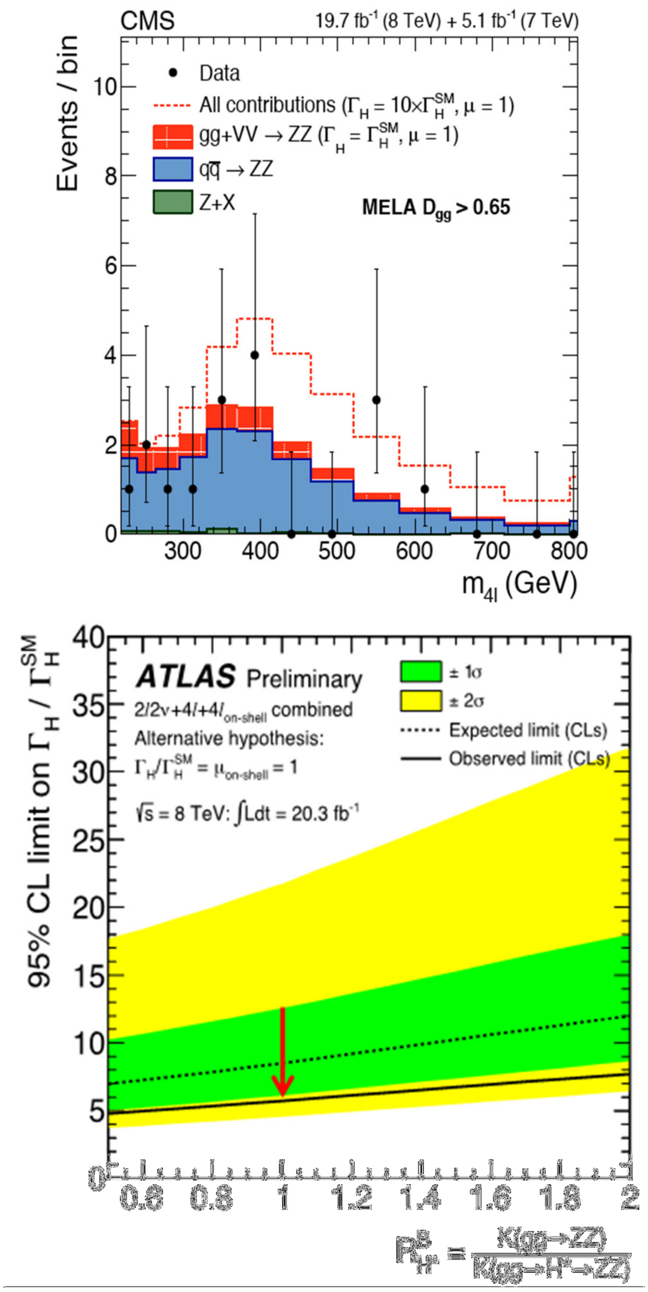


Figure 2.3 – LHC upper limits on the Higgs boson width: CMS experiment (top): 4 lepton invariant mass distribution yielding $\Gamma_H<5.4x\Gamma_H(SM)$ at 95% CL;
ATLAS experiment (bottom): 95% CL on the ratio between the measured and expected Γ_H as a function of the background K factor, K(gg→ZZ).

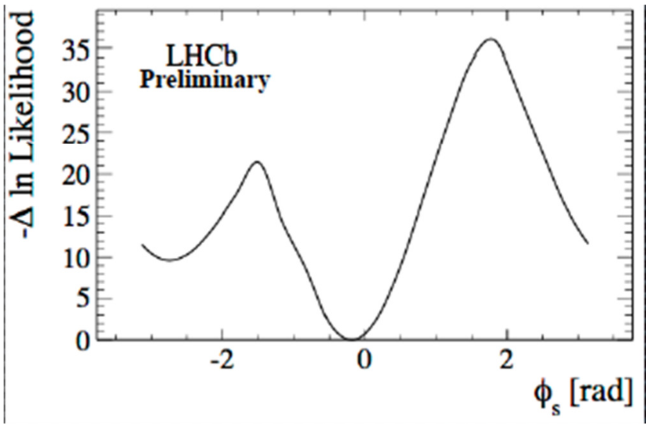


Figure 2.4 – LHCb experiment: log-likelihood variation vs. mixing phase ϕ_s from fit to Bs→φφ time evolution.

The TOTEM experiment consolidated its integration with CMS and presented combined multiplicity distributions. A detailed study of Coulomb interference is also expected soon.

The analysis of the data collected by the LHCf experiment are already discriminating among several air shower models and have extended their results adding ATLAS information and ion collisions data taken at the beginning of 2013.

The line of the study of flavor physics is now showing a clear leadership of the LHCb experiment at LHC. ATLAS and CMS experiments achieved important results in the sector of flavor and top physics. B_s mesons have been extensively studied, and precise measurement of CP violation and difference of B_s mesons lifetime have been achieved. Detailed properties of B meson decays have been studied, like for $B^0 \rightarrow K^{0*}\mu\mu$ angular analysis. These measurements cross-check the higher resolution LHCb results with different systematics. BaBar is still producing results and CDF is completing its most important measurements including all the data available; given the symmetry of the proton-antiproton initial state, these measurements are important benchmarks for LHCb. The latter experiment is proving the full power of a dedicated B physics experiment at a hadron collider surpassing all other experiments in key measurements such as rare decays, the mixing frequency Δm_s and its phase ϕ_s for Bs mesons, measurements of CP violation, and several other high precision measurements sensitive to new physics. We note in particular recent results on the measurement of the phase of the CKM element V_{ub}, also known as the γ angle of the unitarity triangle, where LHCb has reached a resolution better than the previous results of BaBar and Belle, and the measurement of the mixing phase in the pure penguin process Bs→φφ (fig. 2.4).

	Male (%)	Female (%)
National Coordinators of CSN1 Experiments	75	25
Local Coordinators of CSN1 Experiments	77	23
CSN1 Coordinators in INFN Sections	59	41
FTE of CSN1 INFN Staff	79	21
FTE of CSN1 University Staff	80	20
Talks at Conferences of CSN1 Researchers	75	25
INFN Ph.D. Thesis in CSN1	88	12

Table 2.2 – Gender Statistics in CSN1 –

The collaboration of INFN with the BES-III experiment at BEPC-II in Beijing, China, is growing rapidly and producing many results in the area of charm quark and tau lepton physics. We note the discovery and study of several unconventional mesons in the X, Y and Z_c series.

As for the kaon part the new CERN experiment NA62, aiming at the measurement of ultra-rare K decays, is completing the construction and preparing to start taking data in the fall of 2014.

KLOE has successfully completed the installation of all of its detector upgrades and the DAΦNE accelerator has undergone a massive refurbishing and optimization program to improve its luminosity and reliability. The expectation is to collect between 5 and 10 fb^{-1} over the next three years. Its program will span over rare kaon decays, radiative φ decays, total cross section determinations, γγ physics (for which a tagger has been developed), CPT and Lorentz invariance tests, that are considered a probe for physics at the Planck scale. In year 2014 KLOE obtained the best sensitivity ever reached in the quark sector on CPT and Lorentz invariance using $\phi \rightarrow K_S K_L \rightarrow \pi^+\pi^- \pi^+\pi^-$ final states and data corresponding to 1.7 fb^{-1} of integrated luminosity collected in the old data taking campaigns.

The recently started collaboration with the Belle II experiment at KEK in Japan is functioning well. INFN has major responsibilities in the areas of vertex detector, particle identification and crystal calorimetry.

Studies of the proton structure, in particular the parton distribution functions in polarized hadrons, are performed by the COMPASS at CERN, which is currently completing its detector upgrade. The analysis of previous data has led to high-statistics measurements of transverse spin effects in di-hadron production. Precision high statistics spectroscopy led to the observation of a new iso-vector resonance a_1 (1420). The experiment is expected to restart data taking toward the end of 2014.

The MEG experiment at PSI in Switzerland is updating its limit on BR ($\mu \rightarrow e\gamma$) with all the data collected until 2013. The result is expected by fall 2014 and will improve the world best limit obtained last year by the same experiment. The MEG collaboration is currently engaged in a major detector upgrade aiming to improve the sensitivity by another order of magnitude by the end of this decade.

We would also point to a significant participation to the R&D project UA9 that aims to give a solution to the problem of the collimation of the LHC beams by exploiting the channeling in bent silicon crystals.

The main results achieved in the period considered can be summarized as follows:

- the ATLAS and CMS experiments improve the Higgs boson property measurements;
- the ATLAS and CMS experiments begin new studies on the Higgs boson such setting limits on its width and self-coupling;
- the LHCb experiment measures ϕ_s in the pure penguin decay $Bs \rightarrow \phi\phi$;
- The BES-III experiment observes and studies several new unconventional mesons in the X, Y and Z series.

2.2 Astroparticle Physics

The area of Astroparticle and Neutrino Physics is coordinated by the Second National Scientific Committee (CSN2).

The Mission

The study of astro-particle physics is one of the institutional research areas of INFN. This type of research addresses issues related to the fundamental properties of particle and fields in a complementary way to the studies carried out at particle accelerators. The understanding of the properties of neutrinos, the direct detection of gravitational waves, the identification of the constituents of dark matter, the explanation for the absence of antimatter in the Universe, the study of the composition and spectrum of cosmic radiation, the very high precision measurement of fundamental constants, the search of new physics at atomic or nuclear scale, and the study of subtle effects predicted by General Relativity are some of the questions in fundamental physics that can be answered with non-accelerator techniques and infrastructures, with neutrino beams or man-made neutrino sources, by looking at astrophysical sources or using table-top and small-lab-scale experiments. The CSN2 researches often take place in particular environments, both natural (e.g. space, deep sea) or artificial (e.g. underground laboratories), to optimize the ratio of signal and background for the study of phenomena based on extremely rare effects present in the details of cosmic radiation or provided by neutrino beams. A significant (and growing) fraction of the activity of CSN2 is made in space.

CSN2 Sector 2	FTE	Budget
Neutrino Physics	14.8	27.5
Search for Rare Processes	10.3	24.5
Cosmic Rays (ground &u/water)	27.9	17.5
Cosmic Rays (space)	23.4	14.6
Gravitational Waves	17.7	12.2
General Physics	5.5	3.7

Table 2.3. CSN2 budget and personnel by research line (in %)

The CSN2 is organized in six sectors (called Linee Scientifiche) covering the most important fields of research in astro-particle and neutrino physics. They are:

- Neutrino Physics: mostly performed at the Gran Sasso National Laboratory (LNGS). This sector includes experiments with natural neutrino sources, solar (e.g. BOREX) or galactic supernovae (LVD) and with artificial neutrino beams (OPERA, ICARUS-T600, T2K in Japan, JUNO in China, NESSiE R&D);
- Search for Rare Processes: mostly performed at LNGS. This sector includes experiments for dark matter (DAMA, XENON, CRESST, and DarkSide); neutrinoless double beta decay (CUORE, GERDA) searches.
- Study of Cosmic Rays (ground & underground/water): This sector includes experiments on gamma rays: ARGO (Tibet), MAGIC (Canary Islands) and the future CTA, on cosmic rays in the very high energy sector: AUGER (Argentina), ARGO and, on neutrino astronomy: ANTARES, KM3 (Mediterranean Sea).
- Study of Cosmic Rays (space): This sector includes gamma ray astronomy (AGILE, Fermi), searches for antimatter and dark matter (WIZARD-PAMELA, AMS-02) and activities for future missions; a new activity for the study of Cosmic Microwave Background Radiation (CMBR) is under development.
- Gravitational Waves: This sector includes experiments with resonant bars (AURIGA, ROG), ground interferometer detectors (VIRGO, Advanced Virgo) and the space interferometer LISA-PF;
- General Physics: General Physics: this sector includes experiments on gravity (MAGIA, MICRA), on quantum gravity (HUMOR) and quantum vacuum effects (PVLAS, MIR). A collaboration with ASI is also in progress for the study of the correlation of earthquake induced electromagnetic field emission with anomalous charged particle precipitation in the ionosphere and in the magnetosphere (LIMADOU).

The groups involved in all these research activities have a worldwide visibility and recognized leadership roles.

In the reference period, the CSN2 activity involved about 530 FTE's, distributed as follows: INFN staff (28%), University staff (60%), Postdocs (8%), Graduate Students (10%). The research activity of the CSN2 is presently organized in 35 experimental initiatives distributed over the six sectors previously mentioned, with the budget sharing for the years 2013 provided in the following Table 2.3, while gender distribution within CSN2 is reported in Table 2.4.

	Male	Female
National Coordinators of CSN2 Experiments	78	22
Local Coordinators of CSN2 Experiments	70	30
CSN2 coordinators in INFN Units	83	17
FTE of CSN2 INFN staff	83	17
FTE of CSN2 University staff	77	23
Talks at conferences of CSN2 researchers	68	32
INFN Ph.D. Thesis in CSN2	71	29

Table 2.4. Gender statistics in CSN2 (%)

Highlights from 2013-2014

In the period under consideration, researchers of the CSN2 obtained several interesting scientific results that are partially listed in the following.

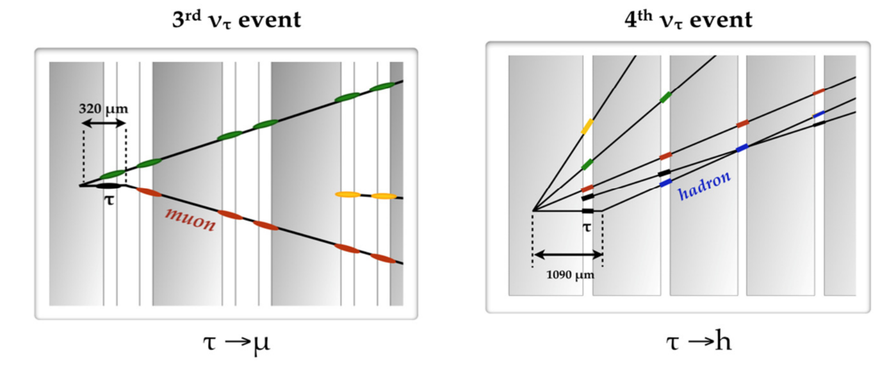


Fig. 2.5 – The 3rd and 4th ν_τ candidate observed by the Opera experiment.

- **MAGIC** at Roque de Los Muchachos (La Palma, Canary Islands) has published the observation of two magnetars and the detection of high energy gamma events in correspondence to peculiar transient event Swift J1644+57 in collaboration with another CSN2 project, AGILE.
- **OPERA** at the Gran Sasso Laboratories, presented the observation of a third event candidate tau neutrino from the oscillation $\nu_\mu \rightarrow \nu_\tau$ in 2013 and a fourth very recently (Fig. 2.5). Evidence of neutrino oscillations in ν_τ appearance is obtained at 4.2 σ level.
- **BOREXINO** at the Gran Sasso Laboratories, published on Nature in summer 2014 the first evidence for direct detection of pp Solar Neutrinos, the neutrinos emitted by the primary nuclear reaction in the Sun (see Fig. 2.6).
- **ICARUS** at the Gran Sasso Laboratories presented a new limit on $\nu_\mu \rightarrow \nu_e$ oscillations constraining the LNSD evidence for a sterile neutrino to a region around 0.5 eV^2 of mass.
- **MAGIA** in Firenze has provided a very high precision measurement of the *G* Newton's constant by means of atom interferometry (*Nature* **510**, 518–521 (2014)). With the same technique it also provided a stringent test of the equivalence principle with Sr atoms with and without spin (Phys. Rev. Lett. **113**, 023005 (2014)).
- **GERDA** at Gran Sasso successfully completed the Phase I, publishing a limit on the ^{76}Ge neutrinoless double beta decay half-life of 2.1x10^{25}yr at 90% C.L.; the operation for the preparation of the Phase 2 is in progress.
- **VIRGO** in Cascina performed an analysis putting very stringent limits to the maximum height of "mountains" on the Vela and Crab pulsars (of the order of 1 m!). The work for the upgrade of the detector to Advanced Virgo is proceeding and the new physics run is foreseen for the beginning of 2016.

Moreover significant steps forward were done by several experiments. Below a selection.

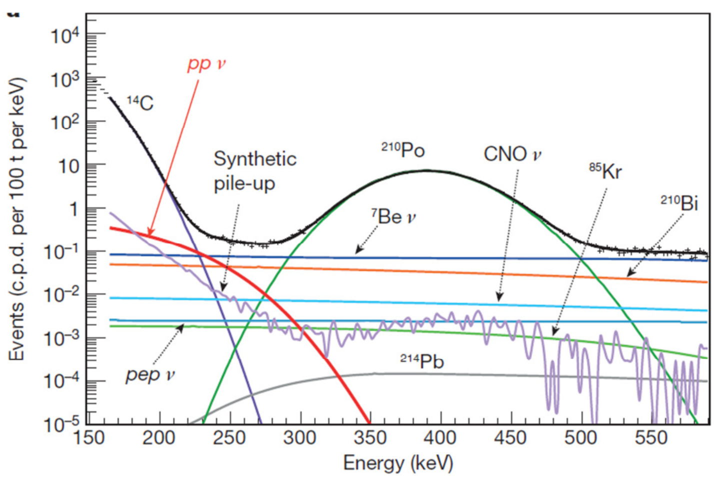


Fig. 2.6 – The observation of pp neutrinos made by the Borexino collaboration at Gran Sasso

- The **KM3** project at Capo Passero has successfully deployed the first string in water. The deployment of two other strings is foreseen by the end of 2014, with the remaining ones expected to be installed by 2015. Interesting results were also obtained by ANTARES which has been continually running since 2008.
- The **AMS-02** experiment on the ISS successfully completed the first year on the ISS in May 2012: it collected more than 20 B Cosmic Ray events by the end of 2013 and

recently published a very interesting result on the excess of positrons over electrons at high energy (PRL 113.121102).

2.3 Nuclear Physics

The area of experimental research in Nuclear Physics is coordinated by the Third National Scientific Committee (CSN3). A detailed description of the Committee activities and of its organization is provided on http://www.infn.it/csn3/.

The year 2013 has been important for the nuclear physics research programs because several upgrades to old facilities were completed and new ones are under construction. JLab has completed the 6 GeV program in 2012 and in 2013 first beam at 12 GeV was delivered. MAMI has resumed the experimental activity with the new installed detectors at Mainz and Bonn with the new installed detectors, and LHC started the long shut-down after an important p-Pb run. SPES at LNL consolidated its budget and started the construction phase; LUNA-MV at LNGS also consolidated its budget. The first neutron beam was delivered at the second experimental area of the n_TOF facility at CERN. The AGATA detector was moved to GSI where it is foreseen to remain till 2014. The quality and the number of scientific papers and presentation at conferences are comparable to the previous years. Research activities in CSN3 are grouped in 4 different lines: Quarks and Hadron Dynamics, Phase Transition in Hydronic Matter, Nuclear Structure and Nuclear Dynamics, Nuclear Astrophysics and Interdisciplinary Research. The resources allotted to each line are given in table 2.5, while table 2.6 shows the gender distribution of the CNS3 personnel (a total of 490 FTE).

CSN3 Sector	**FTE**	**Budget**
Quarks and Hadron Dynamics	21.9	21.1
Phase Transition in Hadronic Matter	30.9	36.3
Nuclear Structure and Reaction Dynamics	30.0	30.0
Nuclear Astrophysics and IR	17.2	12.6

Table 2.5 - CSN3 Sectors, FTE and budget (%)

Highlights from CSN3 experiment

The year 2013 has been important for the nuclear physics research programs because several upgrades to old facilities were completed and new ones started operation. JLab completed the 6 GeV program in 2012 and in 2013 already circulated the first beam of the 12 GeV era. MAMI at Mainz and Bonn just resumed the experimental activity with the new installed detectors, and LHC started the long shut-down after an important p-Pb run. The facility SPES at LNL consolidated its budget and started the construction phase; also LUNA-MV at LNGS consolidated its budget. The second experimental area of the n_TOF facility at CERN received its first neutron beam and finally the AGATA detector was moved to GSI where it is foreseen to stay till 2014.
In parallel all experiments with already collected data keep publishing new results.

	Male	Fem.
National Coordinators	52	48
Local Coordinators	76	24
coordinators in INFN	64	36
FTE INFN staff	70	30
FTE University	71	29
Talks at conferences	67	33
INFN Ph.D. Thesis	53	47

Table 2.6. Gender statistics in CSN3

In particular The ALICE data analysis produced several important measurements. In the heavy flavor sector, the production of J/psi, Upsilon and D (R_{AA}, flow, particle ratio…) now casts new light on the interaction of hard probes with the medium and provides first evidence of a mass dependence of the energy loss in the QGP. In the light flavor sector, the spectra and correlations of identified particles were published both for Pb-Pb and p-Pb data. The Pb-Pb data analysis confirmed that a hot, low viscosity matter, is produced in these interactions. Data collected in p-Pb collisions allowed to estimate the cold nuclear effect on the particle spectra confirming that it cannot reproduce the various

Pb-Pb results. P-Pb data also provided indications of collective effects in the long rapidity range correlations (ridge effect) and are now being compared with different theoretical calculations that include shadowing, saturation and hydrodynamical expansion, in order to explore and understand the origin of such effects. Results from J/psi production in ultra-peripheral collisions were obtained for the first time at the LHC, allowing comparison with data from HERA and providing discrimination with respect to QCD models and new input on the nuclear PDFs.

At LNL the properties of the pygmy states[1] were investigates in ^{208}Pb and ^{124}Sn nuclei, in particular, by inelastic scattering of ^{17}O at 20 MeV per nucleon, measuring with the first phase of the AGATA spectrometer the gamma decay with good resolution. Advanced theoretical nuclear models describe the pygmy states either as a mixing between an isoscalar compressional mode and an isovector proton-neutron oscillation, or as a reminiscence of particle-hole excitations. Results are compared with previous experimental investigations that used different probes, such as photons, protons and alphas. The AGATA experiments confirmed the splitting of the pygmy strength in two parts of different nature and allowed to quantitatively extract, for the first time, the isoscalar compressional mode E1 component.

At LNS the MAGNEX spectrometer was used by the DREAMS collaboration to study Double Charge Exchange processes. In particular an exploratory measurement of the reaction $^{11}B(^{18}O,^{18}Ne)^{11}Li$ demonstrated the capability of MAGNEX to measure nuclear processes connected to the nuclear matrix element of the double beta decay. The proposal for a dedicated experimental campaign to investigate those nuclei of interest for the double beta decay is in preparation.

ASACUSA analyzing the data acquired in 2012 showed a clear detection of an antihydrogen beam 2.7 m downstream of the mixing region. The first-time production of a cold antihydrogen beam represents a milestone towards the microwave spectroscopy of the hyperfine splitting of the antihydrogen ground state.

2.4 Theoretical Physics

INFN research activities in theoretical physics are coordinated by CSN4. These activities are developed in close connection with the academic world and other scientific institutions both in Italy and abroad. The variety and quality of the research carried on by the CSN4 are proven by the number of papers, citations and talks at international conferences. A large portion of the theoretical investigations is deeply entangled with the experimental research of INFN in particle, nuclear and astroparticle physics. Due to the broad spectrum of topics, the CSN4 activities are organized in six areas covering the most important fields in theoretical physics. These areas, also dubbed “Linee Scientifiche” (LS), are the following:

- LS1: String and Field Theory.
- LS2: Particle Phenomenology.
- LS3: Hadronic and Nuclear Physics.
- LS4: Mathematical Methods.
- LS5: Astroparticle Physics and Cosmology.
- LS6: Statistical and Applied Field Theory.

[1] In neutron rich nuclei the properties of collective mode of excitation are strongly affected by the neutron excess. In the case of the Giant Dipole Vibration, with an energy larger than the particle separation energy, a concentration of strength, denoted as pygmy states, is observed around and below the particle separation energy. It reflects the properties of the oscillation of the neutron skin and has implication on relevant astrophysics problems, such as the neutron stars and the r-process nucleosynthesis.

	Male	Fem.
National Coordinators	96	4
Local Coordinators	87	13
coordinators in INFN Units	88	12
INFN FTEs	89	11
FTE from University	85	15
Talks at conferences	84	16
INFN Ph.D. Thesis	82	18

Table 2.6: gender distribution in CSN4 (%)

In the reference period, slightly more than 1050 physicists - corresponding to about 950 FTE's - were involved in the CSN4 research. They were organized in 39 groups called "Iniziative Specifiche" (IS). As compared to previous years, there has been a significant decrease in the number of IS (which were 50 or even more in the recent past) as a consequence of a major reorganization that took place during 2013. The composition in terms of human (FTE) and budget resources for 2013 are shown in Table 2.5. The distribution of roles and activities by gender are summarized in Table 2.6

In 2013 CSN4 physicists published 1300 papers, corresponding to 1.34 paper per FTE with an average Impact Factor of about 3.6 per paper. International collaborations are strongly supported (the internationalization index is 0.74); indeed the largest portion of the full CSN4 budget goes to support exchanges with foreign institutions. We now briefly comment on the most significant scientific results obtained in the last year within CSN4.

CSN4 Sector	FTE	Bdgt
LS1: String and Field Theory	31	27
LS2: Particle Phenomenology	16	18
LS3: Nuclear and Hadronic Physics	12	13
LS4: Mathematical Methods	12	13
LS5: Astroparticle and Cosmology	17	19
LS6: Statistical and Applied Field Theory	12	10

Table 2.5: FTE composition and budget distribution in (%)

The experimental discovery at the LHC of a scalar particle with a mass of about 125 GeV and properties compatible with the Higgs boson triggered a significant activity also on the theoretical side. Among one of the most interesting issues that have been investigated we can mention the study of the Higgs width. Indeed knowing how tightly around 125 GeV is the Higgs mass, is important to check how many different ways the Higgs can decay in and to study their properties. Furthermore the Higgs width is a key-indicator for new physics beyond the Standard Model. In this respect it has been demonstrated, under very few assumptions and using events with pairs of Z particles, that the high off-shell mass tail can be exploited to severely constrain the Higgs width. This theoretical result has been systematically used by the experimental collaborations in their data analyses.

In 2013, the first ever Parton Distribution Function set including LHC data was published with a significant contribution from CSN4 physicists. Calculations and PDF were computed both at LO and at NNLO. Also, a first PDF set including QED evolution and a photon PDF determined from data (and not from a model) was released. On the computational side, an implementation of the production of three jets at NLO plus parton-shower effects in the POWHEG BOX has been presented and an implementation of electroweak corrections into the POWHEG framework for single W production (charged current Drell-Yan) has been generalized to cover the neutral current Drell-Yan process. Interesting work on the scale choice in NLO calculations was also developed, allowing the first construction of a NNLO accurate generator for Higgs production matched with shower generators. This generator is the first one of this kind appearing in literature. Another interesting topic that was actively investigated in the last year is the stability of the Standard Model vacuum up to very high energies. The Higgs boson mass of about 125 GeV makes the vacuum unstable. While the standard treatment assumed that new physics interactions have no influence on its lifetime, last year it was shown that new physics actually can influence the vacuum lifetime in a way that strongly depends on the UV completion of the SM. This fact could therefore be essential in order to constrain the models for the physics beyond the SM. We should also mention that work on the infrared structure of multi-particle QCD amplitudes to all orders was carried on and a thorough study, including all available experimental results, of the D-Dbar mixing in the presence of CP-violation has been completed.

In flavor physics CSN4 researchers continued their investigations within the UTfit Collaboration whose aim is to determine the Cabibbo-Kobayashi-Maskawa matrix and the unitary triangle by combining experimental and theoretical information. In this framework several analyses were performed both in the SM and in beyond the SM frameworks. Furthermore, the B-Bbar mixing was analyzed within the framework of an effective theory in order to constrain the scale where new physics effects could appear. This analysis employs, for the first time, the results for the B-parameters obtained by the European Twisted Mass Collaboration (ETMC) in the unquenched lattice QCD limit.

In astroparticle, the 2013 theoretical activity on dark matter tackled many different aspects of the problem. Concerning detection signals, the most relevant advancement has been a novel and quite promising proposal: namely, the idea to study the cross-correlation of the cosmological gamma-rays emission with weak-lensing observables and more specifically the cosmic shear (a direct gravitational probe of the distribution of dark matter in the Universe). The signal consists in the cross-correlation angular power spectrum obtained by linking Fermi/LAT studies with the future Dark Energy Survey and Euclid gravitational-lensing surveys. The cross-correlation idea was then extended to include other wavelengths (specifically radio waves and X-rays, as well as CMB). In the last year a complete analysis of all indirect detection signals was performed by CSN4 groups; in particular gamma-rays intensity was studied in view of an innovative analysis of the extragalactic astrophysical components, and new bounds on dark matter properties were derived. Furthermore, a complete updated analysis of the antiproton and antideuteron signals was performed, and the electron/positron channel has been thoroughly investigated after the release of the new AMS-02 data. Concerning dark matter particle candidates, the activities concentrated on Wino dark matter and axion dark matter, and various connections of dark matter with neutrino physics were investigated. Advanced studies on the impact of electroweak correction on the dark matter relic abundance were performed, and finally the quest for dark matter was linked to LHC physics through the study of LHC observables for specific DM benchmarks models.

After the 2012 measurement of the Θ_{13} mixing angle, in CSN4 there has been an intense activity towards the determination of the complete neutrino mixing through measurements of the mass hierarchy and CP violation. Various phenomenological applications of neutrinoless double β decay experiments have been thoroughly investigated by CSN4 groups. Also the possibility of oscillations of active neutrinos into sterile neutrinos has been analysed during the last year, together with the cosmological implications of massive neutrinos which became relevant after the PLANCK and BICEP2 results.

On the formal side, we mention that various perturbative and non-perturbative aspects of string theory were analyzed and used to shed light on the structure of the low-energy effective actions in brane-world models. Many non-perturbative features of supersymmetric gauge theories have been investigated using and extending the so-called localization method and remarkable progress has been achieved in the (perturbative) analysis of integrability for 3- and 4-dimensional conformal field theories involved in the AdS/CFT correspondence, and in the calculation of scattering amplitudes, light-like Wilson loops and form factors beyond the planar limit in Chern-Simons matter theories using the AdS4/CFT3 correspondence. A traditional research field for several CSN4 groups is supergravity. In the last year the structure and various applications of (extended) supergravity theories in diverse dimensions were investigated. Here we mention in particular the construction of a new N=1 no-scale supergravity model with both F and D-term breaking which extends the class of models admitting no-scale vacua and has therefore some potential phenomenological applications. Several cosmological models and their phenomenological implications have been investigated; in particular the possible consequences of "brane supersymmetry breaking" for the CMB have been analyzed. Finally, various issues related to entanglement in quantum systems were studied.

In hadronic physics, the exploration of the 3-dimensional structure, in the partonic momentum space, of the nucleons has continued through the study of the Transverse Momentum Dependent partonic distribution functions (TMD-PDFs), and a global re-analysis of the most recent experimental data on azimuthal asymmetries in Semi Inclusive Deep Inelastic Scattering from the HERMES, COMPASS and BELL collaborations was done. In nuclear physics particular attention was devoted to the study of the structure and of the collective excitations of exotic nuclei, both in few-body systems and in light-medium nuclei, for which improved shell model calculations were performed. Also shell model studies of nuclear structure and realistic effective interactions were continued along with the analysis of the structural evolution of nuclei away from the stability line in a shell model approach. In addition, for the first time a full microscopic calculation for proton emission from deformed odd-odd nuclei where nuclear structure and decay aspects are exactly taken into account was completed.

COMPUTING:

In 2013 the CSN4 completed the upgrade of its computer cluster in Pisa, an INFN infrastructure dedicated to users requiring medium-size computing resources (Tier-1 users). This new system has approximately 1600 computing cores corresponding to about 16 TFlops in total; a further upgrade has been planned for 2014 leading to about 2000 cores and about 20 TFlops in total. This CSN4 cluster, called Zefiro, is available to all CSN4 users through a queing system with local user interface. This cluster represents a really important resource for the CSN4 activity and has been already used to its full capacity by many groups belonging to about a dozen of IS.

GGI:

The Galileo Galilei Institute for Theoretical Physics in Arcetri (GGI), an initiative of CSN4 since 2005, has achieved an impressive record of high-level activities and by now is counted among the leading international institutes for the organization of long-term workshops. The activities carried on during 2013 and first part of 2014 include:

- five long-term workshops:
  - Higher Spins, Strings and Duality;
  - Beyond the Standard Model after the first run of LHC;
  - Geometry of Strings and Fields;
  - The Structure and Signals of Neutron Stars: from birth to death;
  - Advances in Non-Equilibrium Statistical Mechanics;
- four schools (see the next paragraph on training)
- several satellite meetings and focus or training weeks related to the long-term workshops and a few of conferences.

The details about these activities can be found at http://www.ggi.fi.infn.it/.

TRAINING:

A traditional activity of the CSN4 physicists is the training of young researchers and students. This is reflected in the large number of publications involving Post-Docs and Graduate Students. Since 2005, the CSN4 awards the Sergio Fubini Prize (which in 2007 became an official INFN award) to the best three doctoral theses in theoretical physics of the year. In 2013 the Fubini Prize was awarded to three Ph.D. theses on the following topics:

- Single vector boson production at QCD and EW NLO with POWHEG;
- Thermal Brane Probes;
- Higher-Spin Interactions: Three-point functions and beyond.

The three winners were all male.

In 2013/14 the CSN4 has sponsored a series of four schools for Ph.D. students at the Galileo Galilei Institute in Florence with the aim of gathering together students from different Italian and foreign universities and offering them high-level training and pedagogical courses in various areas of theoretical physics. Here is the full list:

- LACES 2013 (Advanced Lectures on String and Field Theory), 3 weeks, 72 hours of lectures, with 24 students (of which 11 Italians) ;
- GGI Lectures on the Theory of Fundamental Interactions, 3 weeks, 60 hours of lectures, with 50 students (of which 30 Italians);
- Statistical Field Theories, 2 weeks, 46 hours of lectures, with 43 students (of which 26 Italians);
- Frontiers in Nuclear and Hadronic Physics, 2 weeks, 48 hours of lectures, with 23 students (all Italians).

We plan to continue this successful initiative also in the next years.

2.5 Technological and inter-disciplinary research

CSN5 coordinates technological research and promotion of the use of fundamental physics instruments, methods and technologies in other sectors. INFN is a firm point of reference in Italy and worldwide for the development of next-generation prototypes and the production of today's particle accelerators. These are used not only in fundamental physics research projects, but also in other areas of research and economic and social life.
Another branch of activity involves the development of radiation detectors, electronic and computer systems in close collaboration with other research centers in Italy and abroad, and as part of inter-disciplinary research projects. All these technologies have significant socio-economic impacts, for instance in the fields of medical imaging, in cancer therapy and in the protection of the cultural and environmental heritage. A significant impact brought to the development of radiotherapy treatment plans with protons and ions (hadron therapy).

Sector	FTE	Budget
Detectors, Electronics and Computing	25.0	22.6
Accelerators and Related Technologies	23.4	44.1
Interdisciplinary Physics	51.6	33.3

Table 2.7. CSN5 budget and personnel distribution (%)

The activity coordinated by the CSN5 is organized in three sectors covering the most important fields of research in experimental physics. They are:

- Detectors, Electronics and Computing;
- Accelerators and Related Technologies;
- Interdisciplinary Physics

In the reference period, the CSN5 activity involved more than 600 FTEs (550 in 2012) whose activities are summarized in Table 2.9. In 2013 the CSN5 physicists published more than 318/375 (ISI/total) (280/350 in 2012) papers, corresponding to about 0.66/0.77 (0.52/0.63 in 2012) paper per FTE and an average Impact Factor of 2.14 per paper, the intellectual property of INFN is about 0.5 (0.59 in 2012). In the same period about 310 (350 in 2012) papers have been presented at International Conferences. Some activities and leadership roles by gender are summarized in Table 2.10. In the period under consideration, researchers of the CSN5 obtained several interesting scientific results that will be discussed in the following in this report.

	Male	Fem.
National Coordinators	85	15
Local Coordinators	80	20
INFN FTEs	81	19
FTE from University	71	29
INFN Ph.D. Thesis	76	24

Table 2.8 Gender statistics in CSN5

- **ELIMED (MEDical application at ELI beamlines)**

ELIMED is a multidisciplinary project funded by the Fifth Scientific Committee of INFN, dedicated to the application of charged-particle beams accelerated by then interaction of high-intense lasers with the matter. This project is carried on in strict connection and collaboration with the ELI-Beamlines facility that is being built in Prague (CZ).

The ELI-Beamlines facility

This facility will be a high-energy, repetition-rate laser pillar of the ELI (Extreme Light Infrastructure) project. It will be an international facility for both academic and applied research, stated to provide user capability by the beginning of 2018. The main objective of the ELI-Beamlines Project is the delivery of ultra-short high-energy pulses for the generation and applications of high-brightness X-ray sources and accelerated particles. These secondary sources beamlines are part of different Research Programs (RP2-RP6). The RP3 (Particle Acceleration by Lasers) Program aims at designing, implementing and commissioning two different beamlines based on the acceleration of ion and proton beams, which will be offered to the user community. In particular, the ion beamline will be focused on multidisciplinary application of laser-accelerated beams, which can be used in different fields (material science, medicine, nuclear physics, pump-probe of plasmas, etc.).

A special care will be devoted to the demonstration of a future applicability of laser-driven proton beams in hadrontherapy. Two different PW-class laser systems will be available to such beamline (30J/30fs and 150J/150fs) in order to offer the possibility to investigate different acceleration regimes providing ion beams with different characteristics.

The ELIMED project and its main results

The coexistence of well-established research areas present inside has allowed to launch in the past months the European ELIMED initiative. ELIMED, acronym of ELI-beamlines MEDical applications, is an international task force born from the collaboration between INFN-LNS and ELI Experimental Program Department (ELI_BEamlines, Prague) researchers. The project aims to realize, within 2018, a facility completely dedicated to physics and radiobiology studies of high energy protons (60-250 MeV) accelerated by high-power laser-target interaction. As discussed in several theoretical studies and shown in some experimental campaigns with low-power laser systems, the emitted particles have specific peculiarities that make their eventual medical application really a challenge. Indeed, the interaction of laser with the matter generates extremely intense pulsed beams (10^9–10^{12} protons per pulse with 0.1-1 ns pulse duration) characterized also by very large energy spreads (typically exponential energy distribution). Therefore, the ELIMED laser facility will be specifically designed and optimized to demonstrate the clinical applicability of the laser-driven beams. The collaboration composing the ELIMED INFN project is now growing up and groups from several INFN Units are joining the project, which is at the moment one of the biggest projects approved by CSN5.

The ELIMED project is organized in three Work Packages (WP), each one grouping specific activities: target optimization, PIC (Particle in Cell) simulations and beam handling (WP1); beam diagnostics (WP2); hadrontherapy transport, dosimetry and radiobiology (WP3). The planned activities concern the design of innovative transport devices and the development and test of new detectors for beam diagnostics and dosimetry. Moreover a huge Monte Carlo simulation activity has been envisaged especially in the preliminary phase. Prediction of fluences and particle distributions is, indeed, of great importance in order to better develop and configure the experimental setup to be used at the laser facilities available for preliminary tests: PALS (Czech Republic), TARANIS (Belfast, UK), Gist (Korea), LULI (France), LOA (France) and Flame (Italy).

The second year of activity is coming to an end and most of the milestones have been already fulfilled. In particular, the following activities have been carried on in these first months, involving theoretical studies, realization of apparatus and experimental measurements.

- An upgrade of the Thomson Parabola spectrometer (TP) for charged particle beam diagnostics has been carried out.
- In order to perform a precise characterization of the TP electric and magnetic deflections, in October 2013 the spectrometer has been calibrated using the proton beam delivered by the

TANDEM accelerator at LNS-INFN in Catania in the energy range between 6 and 12.5 MeV. The Q/A resolutions and the energy limits have been also evaluated proposing a mathematical model that can be used for data analysis, for the experimental set up and for the device scalability for higher energy.

- A successful experimental campaign has been performed at PALS laser facility in Prague, where the TP has been used as diagnostic device during an experiment for target optimization, showing good results.
- During the experiment a slotted CR39 has been used in series with micro channel plate detector to perform a calibration of the imaging system. During the same experiment other detectors have been tested in order to understand their response, such as radiochromic films and SiC detectors. In particular, tests have shown that for SiC detector a fast and properly dedicated electronic needs to be developed.
- An energy Selector System (ESS) has been designed and realized with the aim of filtering the energy of the laser-driven proton beams and transporting proton beams with a reduced energy spread (of the order of tens of %). The ESS consists of four permanent magnetic dipoles and one moveable collimation slit placed after the second magnet for the energy selection and it represents the key element of the beam transport system. It has been preliminary tested in April 2013 with conventional proton beams accelerated by the Superconducting Cyclotron (SC) at LNS-INFN in Catania.
- In order to precisely determine the correspondence between the slit position and the energy selected, the ESS has been accurately calibrated in the energy range between 4.5 and 12 MeV at LNS-INFN (September 2013) using the proton beam delivered by the TANDEM accelerator and in the energy interval between 2 and 5 MeV at LNL-INFN facility in Legnaro (May 2014) using the proton beam delivered by the CN accelerator. The energy resolution curves have been also extracted from the experimental results. According to the preliminary results, the ESS prototype can operate in the energy range between 2 and 60 MeV allowing selecting a proton beam with an energy spread ranging from few % up to 30%.
- Moreover during the LNL-INFN test, a complete beam optics study of the ESS has been performed at 4.5 MeV.
- A first characterization of the ESS performances has been successfully carried out with the laser-driven proton beam available at the TARANIS laser facility, Queen’s University of Belfast (UK) in November 2013. The energy and angular distributions of the proton beam generated for the laser-target interaction have been extracted using Radiochromic film stacks placed upstream the ESS. The laser-driven proton beam filtered by the ESS has been characterized in terms of fluences, divergence and energy spreads using CR39, Imaging Plate detectors and an additional magnet placed downstream the ESS. Preliminary results show that the device allows selecting the 4.5 and 7 MeV components of the TARANIS proton energy distribution with energy spreads, respectively, of ±6% and ±8%. The preliminary results are in quite good agreement with the Geant4 Monte Carlo predictions carried out so far.
- A detailed Monte Carlo simulation of the ESS has been developed with the Geant4 code. In particular, the transmission efficiency of the ESS and the energy distributions of selected particles have been investigated, studying the fluence and dose distributions expected at the laser facilities where tests will be performed.
- An integrated system for dosimetric measurements and cell sample irradiation has been studied in details and has been already designed. It includes the housings for the relative dosimetry (Radiochromic films, CR39, transmission ionization chambers and scintillators for proton spectrometer) and a dedicated Faraday Cup (FC) for dose rate independent measurements of the absolute dose. Moreover a first prototype of an in-beam monitor device

based on proton elastic scattering on a thin Au target (named ELIMON) has been realized and tested with alpha sources and conventional proton beams at the LNS-INFN.

- A first prototype of a FC, specifically designed to perform accurate absolute dose measurements, has been already realized at LNS-INFN.
- A complete Geant4 Monte Carlo simulation of the FC prototype has been carried out in order to determine shape, sizes and electric fields involved with the aim to optimize the charge collection.
- A first test with the FC has been performed in June 2014 at PALS facility in Prague with the aim to characterize the electromagnetic pulse (EMP) effect on the device response in a laser facility environment. The FC prototype will be calibrated in charge and dose with monoenergetic proton beams at LNS-INFN and then it will be tested as dosimetry device for laser-driven ion beam at Apri-GIST facility in Korea.
- During the same experiment performed at PALS in June 2014, the EMP effect characterization has been carried out also on the ELIMON diagnostic device.
- Moreover, in the same experiment SiC and CVD diamond detectors have been used for ToF measurements in order to discriminate the different ions produced in the studied reaction.
- During the last year, a focusing system prototype based on four permanent magnetic quadrupoles (PMQs) has been designed. The PMQs prototype will be delivered at the LNS-INFN by the end of the year. The purpose of such element will be to reduce the initial angular divergence of the particle beam accelerated from the target improving the transmission and selection efficiency of the entire transport system. The PMQ prototype consists of two 80 mm and two 40 mm length PMQs with a 20 mm bore and a magnetic gradient exceeding 100 T/m. It will be provided with a mechanical stage, which will allow modifying the relative distance of the PMQs along the longitudinal axis and, thus, the focal point position as function of the beam energy. The designed PMQs prototype will allow focusing and transporting up to 30 MeV proton beam. The PMQs will be characterized with conventional proton beams at LNS-INFN and LNL-INFN. The prototype will be tested, coupled together with the ESS, with laser-driven proton beams in two experimental campaign already scheduled for the next year at the TARANIS and LOA laser facilities.

- **NORCIA**

The NORCIA project in the framework of and a large collaboration among INFN, SLAC, KEK and UCLA is dedicated to design studies, manufacture and high power operations of novel X-band accelerating structures. We manufactured two X-band structures coated with a 3 μm thick Au galvanic layer and 4 mm of Ni with a roughness of 10 nm and 70 nm, respectively. The mandrel made of an Al alloy was easily dissolved by a chemical etching of sodium hydroxide on completion of the electroforming process. At this stage, the main objective of the project was to evaluate the possibility to improve this well-established fabrication process with “built in” cooling channels in the irises of these devices. As a matter of facts, it was desirable to use the natural tendency of the electroforming process to leave an open channel in high aspect ratio components. This process can be optimized both during design and production phases. As an example, by design areas of high current density and, therefore, inducing a faster growth at the entrance of the high aspect ratio grooves in the mandrel while forming the irises, and at the same time during the process, closing the groove with the electro deposited material. Connection among cooling channels can be achieved using conventional stainless steel tubes drilled into the cavity and fixed by brazing or adhesives. Cooling size depends by the dimension of the iris channels and the required water flow rate. The hollow for the cooling design has to be still optimized and, at present, we may only report the feasibility of the cooling procedure for a 2 mm thick iris. However, the results of the low level RF tests of this structure are in perfect agreement with numerical simulations. The structure has been also tested at SLAC the first four months of 2014 at high power as function of the RF pulse length and the data analysis is in progress.

11.424 GHz hybrid gun

An hybrid photo-injector operating at 11.424 GHz has been manufactured in the Frascati's Laboratory. This device is an integrated structure consisting of initial standing wave gun cells connected from the input coupler to a traveling wave section. The device eliminates RF reflections from the SW section. In addition, a 90° phase shift in the accelerating field at the coupling cell gives a strong velocity bunching. The current initiative in the X-band follows an S-band hybrid, already made in the LNF and successfully tested at high power at Los Angeles (UCLA). While a design scaling from S-band to X-band is conceptually simple, practical limits require changes in both RF and magnetostatic designs. As the field is limited by the RF breakdown to 200 MV/m peak-fields, to reach 3.5 MeV the SW section must be expanded to 2.5 cells. This design permits also a flexibility in the solenoid design. Here we summarize the technological requirements to fabricate an 11.424 GHz hybrid SW/TW photoinjector and some preliminary RF cold measurements. The device has been made in OFHC copper and the machining has been realized using numerical controlled lathe and milling machines. Each cell of the gun was carefully checked. A quality control test of the geometrical dimensions (internal diameter, cell length, iris diameter and iris length) and of the machining precision was performed. The surface finishing was obtained directly by machining with custom diamond mono-crystal cutting tools. Machining was performed at constant temperature in order to maximize at the best the uniformity of the mechanical dimension of the cells. In each of them there are two bidirectional tuners except in the first one of the SW part that due to the limited space available has no tuners. The couplers have been machined in two separate parts and joined with a thermal treatment. The 11.424 GHz hybrid gun prototype we fabricated is shown in Figure 2.7. Before the final brazing, the structure has been joined applying an axial torque with four threaded bolts. Low power RF measurements have been also performed. The working π mode of the SW part is ~7 MHz off, an acceptable result considering that the measurement has been made in air without a tuning of the structure. The loaded quality factor of the working mode has been measured and its value (4750) is in agreement with HFSS simulations. Using the bead pull technique we also measured the longitudinal electric field. Further measurements are planned after the final brazing with the input and output couplers.

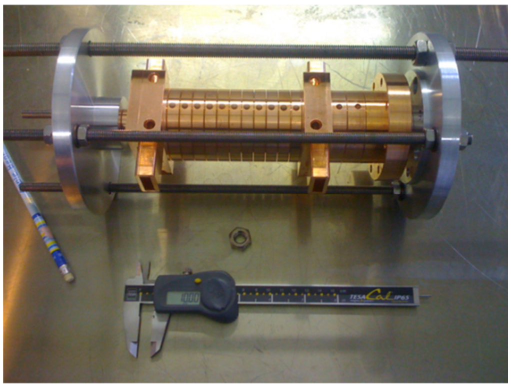


Figure 2.7 3D model of a X band hybrid photoinjector

Mo coatings

Within the NORCIA framework we characterized metallic coatings grown by RF magnetron sputtering technique at room temperature in order to control and minimize the electrical resistivity. With the main goal to improve and optimize performances of metallic Mo films and coatings we made morphological, structural and electronic characterizations of Mo coatings growth by RF magnetron sputtering and later annealed up to 600 ºC. Geometrical information have been obtained by FIB images while transport properties, crystallinity, local structures and electronic properties were measured with different techniques. In particular, synchrotron radiation X-ray Absorption experiments have been performed at the Mo K edge to identify the chemical status of Mo atoms, probe the presence of different oxides contribution and together with XRD data to control the disorder nature of these films. The thick films (from 300 to ~1000 nm) we investigated are multiphase metallic coatings with negligible contributions of disordered oxide phases where however large changes of the resistivity may occur. These coatings exhibit a resistivity less than one order of magnitude higher than the Mo bulk. Results point out that the combination of magnetron sputtering and post-deposition annealing is a powerful method to grow homogenous coatings suitable for accelerator applications. However, although the conductivity values appear promising and dedicated RF devices with Mo coatings have been already manufactured, a lot of work is still necessary to achieve the performance required by operations of real devices coated by Mo and working at high power. The available analytical methods and results are promising and further enhancements of the conductivity of Mo coatings are probably achievable tuning growth parameters and post treatment processes, specifically optimized to improve these particular multiphase systems characterized by percolative phenomena. The analysis has been submitted for publication to Surf. Coat. & Tech. (2014).

New Materials

As far as new materials are concerned thin films deposition combined to precision electroforming offer new possibilities and new classes of innovative materials. In particular nano-structured materials may be produced nowadays by physical vapor deposition up to thickness of ten micromenters or higher. This is the thickness range (comparable to the skin depth of e.m. radiation) interested by the beakdown and remelting processes in X-band technology, as shown by SEM-FIB analyses performed in 2013 on cavities exposed to high power radiation fields (Fig. 2.8). The advantage of PVD deposited coatings consist in the possibility to finely control their composition, internal stress, mechanical thoughness and micro-structure. All these physical properties influence the thermo-mechanical stability of the surface and may be tailored to the specific application in a range of values not attainable for bulk materials. This is a completetely un-explored field. In this context a feasibility study has been launched at the Legnaro laboratory to produce new coatings for the accelerating structures using the expertise in multilayer deposition and surface characterization using, among the others, the low energy MeV ion accelerators.

The production scheme consists in depositing over the aluminum mandrel a nano-textured metallic layer of several micrometer thickness prior to electroforming. After mandrel chemical dissolution the atomically deposited material will constitute the internal wall of the X-band cavity. As an example, to reduce the surface breakup by thermal cycle fatigue and electrical breakdown, new metallic layers made of thousands high quality Cu/Mo, Cu/Ta or Cu/W alternate thin films are under development. These materials are believed to be capable to strengthen the cavity internal surface due to expected reduced roughness, intergrain diffusion, reduced crack formation and propagation, limited mobility of dislocations and high compressive stress, while preserving the highest electrical conductivity. The complexity of the coating process in high aspect-ratio structures is partially overcome by adopting a special ionized sputtering technology that allows to deposit fully dense coatings into deep grooves by high density plasma pulses of peak power up to 1MW.

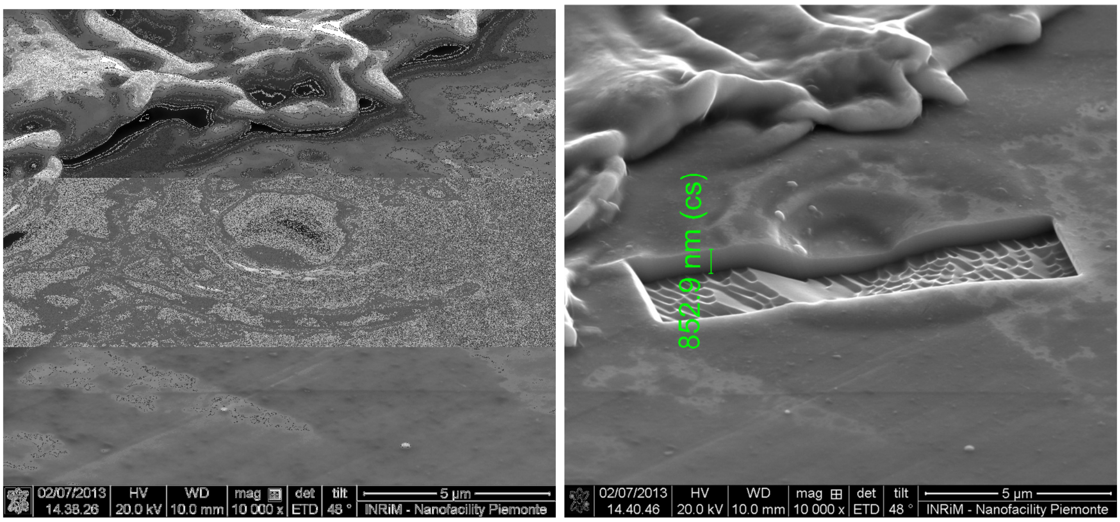


Figure 2.8 FIB and SEM investigation of damaged Copper at the boundary of fully melted regions near the iris where destructive events are isolated. (Cavity exposed at SLAC - courtesy of V.Dolgachev)

This novel approach is compatible with the industrial production of high performance accelerating structures and first results will be presented in 2014.

- **COMB**

The SPARC photoinjector is a 1.6 cell S-band RF gun, followed by 3 S-band accelerating sections, which boost the beam energy up to 150–200 MeV. With this machine configuration a new technique called Laser Comb, aiming to produce a train of short electron bunches, has been succesfully tested in the past. In this operating mode the photocathode is illuminated by a comb-like laser pulse to extract a train of electron bunches which are injected into the same RF bucket of the gun. The SPARC laser system, based on a Ti:Sa oscillator has been upgraded for this specific application.

Up to four electron beam pulses shorter than 300 fs each and separated by less than 1 ps have been characterized and a narrowing THz radiation spectrum produced by such a bunch train has been measured. Coherent excitation of plasma waves in plasma accelerators will be also performed with this technique.

Electro-Optical Sampling (EOS), a specific diagnostics able to make precise measurements of the temporal profile of extremely short electron bunches, has been recently implemented for a detailed understanding of the bunch train structure, showing a resolution of 100 fs. An upgraded version in foreseen in the near future.

With this injector configuration a very succesfull new experiment has been recently performed: two electron beam pulses with a relative energy difference of about 1 MeV and overlapped in time, have been injected in the undulator and a characteristic two colors spectrum produced by the SASE FEL interaction in this exotic configuration has been observed, confirming that both pulses have been correctly matched to the undulator and were both lasing

This technique has been also adopted at LCLS FEL in the X-ray domain with a significant impact on the users interested to fast pump and probe applications.

To improve the stability of the two colors FEL radiation produce at SPARC_LAB a low energy external signal, produced by a conventional Ti:Sa laser, has been recently injected and synchronized (in time and space) with the electron beam. In this new configuration (Two Colors Seeded FEL) the energy and the stability of the output signal have been improved by an order of magnitude.

Tests to optimize the COMB configuration for the Plasma Acceleration experiment are underway with the phoinjector. During next year the Plasma interaction chamber will be installed in the SPARC_LAB beam line and we will start with the acceleration experiments.

- **SEAMLESS**

Great progress has been achieved in the field of superconducting cavities both for low Quarter wave low beta resonators and for high beta accelerators.

Referring to QWR Resonators, we have succeeded in back-extruding a seamless resonator just from a short pill of Copper. A whole resonator can be back-extruded in a process that takes a few seconds and presents no swarf. The status of the internal surface is extremely smooth. The cost reduction obtainable by this method is much smaller than the one obtainable with any other forming technique, since there is no weld, and the quantity of copper at the start is just the needed amount of material constituting the cavity, because there is almost no machining.

A new magnetron for sputtering Niobium onto those resonators has been conceived and built. The RRR of the Niobium film is up to 60. A Copper cavity of the ISOLDE shape has been sputtered in only 20 minutes, rather than in 36 hours as it happens for the traditional DC Biased Diode sputtering. A cryostat has been built and the cavity is currently waiting to be measured.

Referring to Electron cavities, there has been a breakthrough in the field, opening a new horizon of research. It has been discovered a jump in the Surface resistance versus temperature at the superfluid Lambda transition, when measuring at constant RF power. This jump, that happens when helium becomes superfluid, just proofs that thermal exchange is more important than what previously foreseen. Starting from this consideration, it has been seen that:

- the external anodization of Niobium 6 GHz cavities is beneficial in terms of Q and accelerating field;
- the removal of such oxided layer is detrimental;
- a cavity electropolished outside has poorer performances;
- the superheating of liquid Helium is a not less importance of superheating of the Niobium material;
- an externally wet cavity immediately cooled in liquid He will result in better performances.

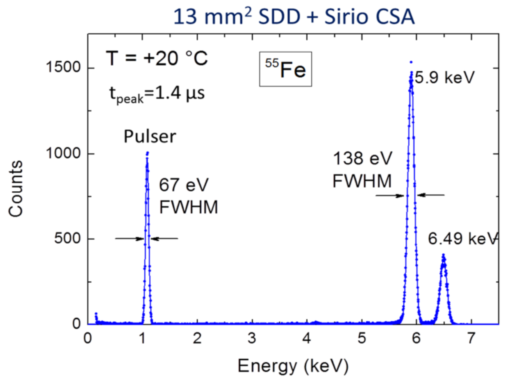


Figure 2.9: High energy resolution at room temperature, 20 ℃, without detector cooling. Result obtained with detectors and ASICs developed within project REDSOX.

In summary, while the whole scientific community is concentrated on the optimization of the cavity interior, it has been seen that also the control of the external surface immersed in Liquid Helium affects the thermal boundary resistance, and at the end affects the cavity performances.

- **REDSOX**

REDSOX (http://andromeda.iaps.inaf.it/redsox/) is a collaboration including researchers from Sincrotrone Trieste, IASF-INAF, FBK-CMM-Trento, Politecnico di Milano and Università di Pavia. It aims at the development of innovative devices for X- and gamma-ray sensing, based on large area silicon drift detectors (SDD). The focus of the REDSOX project in 2014 is the development of sensors for the Advanced Light Sources (synchrotron and Free Electron Laser facilities) with very good energy resolution even at room temperature. The detector production process has been optimized to realize devices having very low leakage currents (as low as 25 pA/cm^2) that set the new state of the art, and the ASIC preamplifier has been designed to minimize the noise of the first transistor, and make negligible all other noise sources. The first test results, presented at the iWoRID 2014 workshop (138 eV FWHM at 5.9 keV and 20 ℃), show that high precision X-ray spectroscopy is now possible with low power and very compact instrumentation with no need to cool down the detector (see Figure 2.9). Both the sensor and the ASIC are the fundamental building blocks that will be used to realize the X-ray fluorescence detectors of the TwinMic and XAFS beam lines at the Electra synchrotron. The aim is to improve by an order of magnitude the measurements throughput, and to provide new capabilities to the experimental laboratories by means of the advancements on the detector/electronics technology.

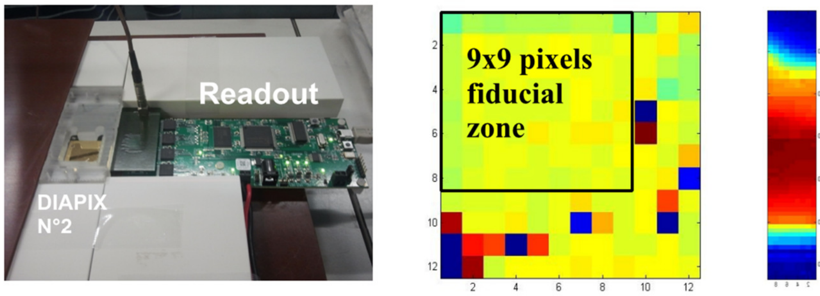
At the same time, REDSOX is improving the performance of the very-large area, multi-anode, linear SDD with a redesign of the detector collection zone to reduce the anode capacitance, and by introducing shallow implants (typically used as the entrance window of spectroscopy SDDs) on the drift cathodes to boost the quantum efficiency below one keV. These new developments will allow widening the scientific objectives of astrophysics satellite missions the like of LOFT (the Large Observatory for X-ray Timing, http://www.isdc.unige.ch/loft/index.php/outreach). The REDSOX project is also starting the development of pixel drift detectors with element size in the millimeter range to improve the spectroscopy and imaging capabilities over the CCD technology for the image plane of X-ray telescopes (e.g. the LFA detector of the Chinese X-ray Timing and Polarization mission XTP). X-ray imaging detectors of this kind could be optimized also for other areas of application, including medical imaging, material studies and other industrial applications.

- **DIAPIX**

The goals of the DIAPIX experiment are to realize large area diamond detector for precise tracking and fast timing in high energy physics and 2D dosimetry for Intensity Modulated Radiotherapy Technique (IMRT). In such development several critical aspects of the diamond detector technology were also investigated such as: novel and in-house methods to fabricate electric contacts, qualification of new diamond sensor suppliers and use of state-of-the-art low noise electronics.

Three large size poly-crystal diamond sample (25x25x0.3mm^3), after a careful material analysis, were metallized with Cr/Au-pixel contacts (12 x 12 pixels) at XUV lab - INFN Firenze to fabricate Schottky contacts to be employed at null-bias mode for two-dimensional dosimetry in advanced radiotherapy application such as IMRT. The typical I-V characteristics at low-voltage of a double Schottky structure was observed both in dark and under irradiation with photon beams. The pixel arrays were glued on kapton circuit and equipped with 144 readout channels interconnected by wire bonding and fully characterized by X-ray.

The realization of the 2D dosimetry was very successful and 9x9 pixel area with very uniform response were identified. Anyway, some optimization of the electric contacts are still needed to avoid some bad area with low gain pixels. The response of the 2D dosimeter in the fiducial 9x9 pixel area were tested under uniform and IMRT photon beams and compared to the response of more traditional silicon detector, giving very similar dosimetric results but better spatial resolution (Fig. 2.10). The performances obtained are very promising for the targeting application and could lead to industrial spin-off.



a) b) c)

Figure 2.10 DIAPIX with readout (a), fiducial zone and color coding.

Three diamond hybrid pixel detector prototypes with pixel size of 50μmx50μm were instrumented by the superPIX0 CMOS readout chip provided by the superB collaboration. The sensor metallization to realize ohmic contacts on both sides (TiW/Cu spattering and lithography) and the interconnection with the readout chip (SnAg bump-bonding) were made by the IZM company. The pixel detectors were characterized on the bench by electrical tests and one of them under 120 GeV pion beam at CERN. Radiation damage of the hybrid pixel diamond detectors are planned at INFN LNS when accelerator operation will recover from the source failure.

The existence and qualification of different reliable diamond suppliers is crucial to diamond detector applications to reduce the cost and the project risks. The main diamond sensor supplier was Element VI Ltd (Bristol), which produces wafer-size high quality poly-crystal diamond sensor by Chemical Vapor Deposition (CVD) and makes them commercially availability. In the same time several samples of high quality diamond sensors were request to the Russian Academy of Science (Moscow). Mobility measurements and response to ^{90}Sr and Co-60 source of limited sized sensors from the Russian Academy of Science were done showing good performance. Large size CVD diamond sample from Infrared-II-VI were acquired and tested with beta sources, showing performance even better than the ones supplied by Element VI Ldt. Furthermore, large size sample of very thin diamond sensor (50μm) from Applied Diamond (USA) are under delivery and test of sandwich structures for timing application and active target studies are planned.

Several test-beam were made to measure timing properties of mono-crystal and poly-crystal pad and strip detectors with 62 MeV protons at INFN LNS, 120 GeV protons at FNAL, 120 GeV pions at CERN and 5 GeV electrons at DESY. Two kind of electronics front-end were used: a fast charge sensitive amplifier with 100 MHz bandwidth and a RF voltage amplifier with 3 GHz bandwidth and the corresponding time resolution was measured applying different techniques and as a function of particle track angle. The timing resolution of a MIP was also boost by placing the diamond detector parallel (grazing incidence) to the electron beam at DESY and about 100 ps time resolution was achieved for 6.5 mm long polycrystalline diamond detector.

Laser writing techniques were pioneered successfully to fabricate ohmic electrodes on diamond surface such as pad (3.5x3.5mm^2), strips (40 strips 4 mm long and with a pitch of 100 µm) and pixels (16x16 pixels of 1 mm^2 each). Measurements with β sources and several tests with particle beams showed that such graphitized contacts are capable to detect ionizing radiation in counting mode without trapping charge in the diamond-graphite interface (about 100% efficiency) and with a fast response (which was dominated by the electronic front-end rise-time of about 2 ns).

Irradiation tests at INFN LNS with 62 MeV protons up to an integrated fluence of about 2x10^{15} p/cm^2 were done with polycrystalline diamond pad detector having commercial made and in-house made graphite electric contacts. The detector response was measured before and after the irradiation campaign, confirming the radiation resilience of the diamond material and also of in-house laser made graphitic contacts.

RDH

INFN has decided to gather the most important activities concerning hadrontherapy into a single project, organized in different working packages, with the aim of establishing a better scientific coordination. Such a coordination also provides an improved communication among the researchers working in this field. Last but not least it gives the possibility of representing in an effective way INFN in front of external partners, both at industrial and scientific level. It must be stressed that the Italian Ministry of University and Research has approved a dedicated project, prepared after the experience gained in RDH, assigning a dedicated fund of about 6 MEuro. This will allow financing of the next years of activities and also to start some infrastructural investments of INFN at CNAO further improving research opportunities.

The most relevant scientific achievements in the second year of activity of the activity are the following:

- progress in the technological transfer activity concerning the development of a new Treatment Planning System for particle therapy, which has brought to the preparation of a patent claim (INFN and IBA); also we started discussions with Raysearch (customer of CNAO) for the insertion of the INFN-IBA TPS kernel in their user interface system for research purposes. At the same time, still for application into research studies, the same kernel is being inserted in a new software platform developed by IBA.
- Start of dedicated research activities, in collaboration with CNAO, in the field of radiobiology applied to particle therapy, for the investigation of possible combined treatments (hadrontherapy plus chemotherapy) in order to improve the effects for some kinds of tumors, in view of both an increased effectiveness and a reduction of time in hadrontherapy treatments.
- Close to radiobiological activity, there is the successful start of investigation of the new way to use gold nanoparticle as enhancing agent for particle therapy, as already noticed in conventional radiotherapy. The new idea is to attach nanoparticles to chemical substances already in use for PET diagnostic imaging, so to concentrate the intake in tumor regions.
- Important test beam activities started at CNAO and Heidelberg aiming to finalize the design of new techniques for the monitoring in-vivo of hadrontherapy (Figure 2.11) exploiting the residual nuclei and the secondary particles produced by the interaction of therapeutic beams. Fundamental progresses were made to demonstrate the feasibility of our projects aiming to in-beam PET monitoring. At the same time, developments of Monte Carlo models necessary to reach these goals have been produced, also in connection with similar activities carried on

in the framework of FP7 European Projects (ENVISION, ENTERVISION).

- In the last year the design for the experimental area of CNAO was completed thanks to the contribution of INFN researchers and technical personnel. The operative phase of this project is starting under the joint responsibility of INFN and CNAO .
- Contacts are now being established to start common research activity in hadrontherapy together with the new proton-therapy facility in Trento.

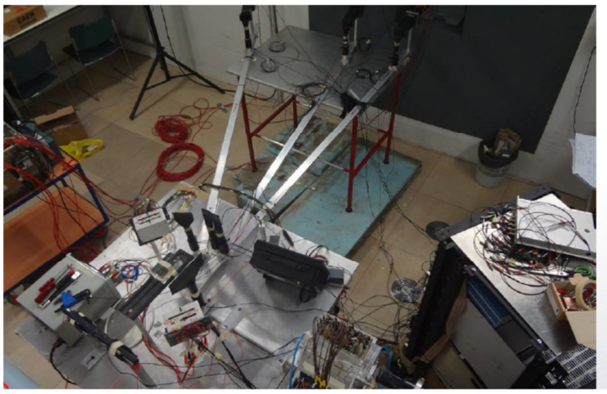


Figure.2.11 Picture of a test beam setup for the development of in-beam monitoring techniques applied to hadrontherapy.

3. Focus on

Every year this report focuses on a specific initiative/activity. This year we present TIFPA, the new INFN center for excellence and innovation. We also report on GSSI (focus last year) , CNAO (special topic of the Report for 2011), and LABEC in Florence (visited by the CVI in 2011) as updates on those activities.

3.1 TIFPA: the last born INFN Scientific and Technological Center

On January 2013, INFN established a new scientific-technological Center in Trento, named **T**rento **I**nstitute for **F**undamental **P**hysics and **A**pplications (TIFPA). The foundation of TIFPA represents the achievement of a long journey of collaboration between INFN and Scientific Institutions sited in Trento Area, among them, Trento University (UNITN) through the Physics Department (TPD), the Foundation Bruno Kessler (FBK, former Istituto Trentino di Cultura), The European Center for Theoretical Studies in Nuclear Physics and Related Areas (ECT*). It is worthwhile mentioning the important role of facilitator played by the local Government (Provincia Autonoma di Trento, PAT) which has provided substantial financial and logistical support to most of the successful research programs carried out jointly by INFN, UNITN, FBK. While the governance of TIFPA is under responsibility of INFN, the Center activities are supported, at the moment, by three partners: UNITN, FBK, and APSS (formerly ATreP). The Center is open to other future partners. According to the new Statute of INFN and to the recommendations of PAT, the mission of TIFPA should comply with :

- international contest of the research activities;
- research activities embedded in the territory;
- excellence of the expected results;
- innovation triggered by the research activities;
- transfer of knowledge to the society.

TIFPA is an environment structured to intimately combine basic Science (Particle, Astroparticle and Nuclear Physics) activities with R&D programs. Challenges of basic Science trigger innovation, innovation in turn makes possible to address new frontiers of knowledge. This vital circle is realized in TIFPA combining the virtues of the INFN Sections (research activities organized according to the five CSNs) with a modern organization devoted to innovation and knowledge transfer (FBK). Day by day operations and mid-long terms programs are regulated by a Convention which also defines the governance of the Center. Implementation Agreements define the specific role of each partner. Three important bodies are in charge to advise the Director of TIFPA :

- Committee supervising the coherence of the partner initiatives with the general planning of the Center. It is chaired by the Director of TIFPA and composed by one representative per partner;
- Council of the Center in support of the Director managing actions. It is composed by the traditional research group coordinators and by the Supervisors of the new born Technological Sectors (TS). TSs are virtual laboratories which include all the infrastructures, tools and professional skills needed to address R&D strategic projects optimizing resources and timing;
- Technical-scientific Committee monitoring the implementation of the research programs and their position in the international contest;

TIFPA is a high priority initiative of the 2014-2016 Strategic Plan of Trento University, Department of Physics, and comes as a follow-up of the development strategy 2012-2014 approved by PAT and directed to strengthen the joint initiatives between University and Research National Institutions in Trento area. In particular , the presence of INFN in Trento will contribute to the birth of a Center of excellence for space and ground Research in Astroparticle Physics and associated technologies.

Trento Department of Physics

TDP was founded in the present configuration in the year 2012 when a new Statute was adopted for the Trento University. Among the important missions of the TDP, particular attention was dedicated to research programs of international relevance. The contribution of the TDP to the establishment of ECT*, BEC and TIFPA Centers was crucial and decisive. The Research themes carried out in the TDP span over fundamental interaction, studies in gravitation and cosmology, nuclear and sub-nuclear Physics, many body quantum systems, ultra-cold gases, and B-E condensation, atomic and molecular physics, bio-physics and chemistry, material science, photonics and nanoscience. The very large number of links with national and international Universities and Research Institutions, ensure additional (external) funds to the TDP mainly to the benefit of young generations, otherwise eliminated from research activities because of lack of funds. The relationships and the interactions with industry are very strong and generate innovation and patents of great impact. The academic Staff consists of 27 Full and Associated Professors, 17 Researchers (including temporary staff). Technician and Administrative staff consists of 38 units and PhD and Post-Doc count for 47 and 26 position respectively.

TIFPA is hosted in an area of TDP of about 500m^2 which includes Direction Offices, a clean room laboratory and a data acquisition area dedicated to AMS2 and LISA-Pathfinder missions. Other laboratories dedicated to gravitational waves act as infrastructures for the TIFPA experimental groups involved in the long standing program Advanced Virgo and LISA-PATHFINDER.

The program MEMS, the gate-way of INFN- FBK collaboration

The Program MEMS represents the joint effort of INFN and FBK to realize devices of interest to the INFN experimental research program based on Silicon-micro-technology. In this context, there was a substantial funding contribution by PAT, FBK, and INFN to improve the infrastructures in operation with the installation of a micro-nano facility. The success of the collaboration lies in the specific expertise of FBK researchers which, starting from the challenges of INFN Research Activity, could develop innovative devices that are crucial parts of complex detector systems. Another important follow up of the MEMS initiative was the possibility for many young researchers to continue their work in the Trento area, with a positive impact of the interaction of research institutions with the local communities.

The micro-nano facility is a complex infrastructure, consisting of laboratories organized according to industrial concepts, but flexible enough to be adopted in a research environment. The facility is conceived to design, fabricate and test the devices of interest to the parties. A successful case is the industrial development of of Silicon Photomultiplier (SipM). Conceived and developed for fundamental research detector systems, SipMs have been employed in industrial applications and commercialized through a Spin-off Company, born in FBK. The MEMS program in seven years of collaboration between INFN and FBK substantially improved the technological offer in terms of tools and devices. Eleven INFN Units participated to the program investigating four hundred masks used to make devices, as part of a set of 90 work-packages.

Theoretical Physics

There is a long standing tradition in Trento of theoretical studies related to INFN activities. TIFPA incorporated all these research groups, providing a new development perspective. The nuclear theory group at the Physics Department of the University (previously part of the Padova INFN Unit) has a consistent record of top-level scientific production. One of its most interesting aspects is an intrinsic vocation to interdisciplinary connections and constant innovation. Nowadays the main research branches include few-body and many-body physics and hadron physics. In the last ten years there has been an increasing focus on methods that require substantial computational resources, and a very interesting ensemble of expertise was developed. Both few-body and many-body calculations, for instance, require the use of massive parallel computers. The experience gathered in Italy and abroad by the members of the group was transferred to Trento, that became one of the leading institutions in ab-initio theories in low-energy nuclear. As computational approaches in few- and many-body physics share important technical aspects with several branches of condensed-matter physics (materials science, soft-matter and biophysics, strongly interacting systems) made it possible to establish a very fruitful cooperation and scientific exchange with colleagues operating at FBK in these research fields. This cooperation gave rise to a novel institution crossing the University-FBK border named LISC (acronym for "Laboratorio Interdisciplinare di Scienza Computazionale", Interdisciplinary Laboratory for Computational Science). This was meant both as an interdisciplinary think-tank in computational science, aiming to exploit as much as possible the cross-fertilization made possible by the coexistence in the Trento area of such diverse expertise, and as a competence center for the entire scientific community of Trentino area whose research involves or might involve massive computing. LISC was also hosting the AURORA project, based on an innovative concept of efficient and scalable communication and extreme compactness of the hardware. The AURORA project involved most of the local research institutions (FBK, University, FEM), and several INFN Units spread all over Italy.

One of the examples of the fruitfulness of LISC is the development of a research line in biophysics, involving people with backgrounds both in nuclear physics and condensed matter. This new line of research is based on the application of theoretical quantum-field and quantum many-body ideas to the study of the classical diffusion problem, and in particular to the problem of describing phenomena occurring on very long time scales. This research line produced world-class results in the study of protein dynamics as well as in the study of the quantum diffusion problem.

Along with the activity in nuclear physics there is a strong group working on gravitation and cosmology, that has a long tradition of cooperation with many institutions in Italy and abroad. Over the years this group provided basic competences that cover the areas of mathematical physics and field theory.

A very important role in creating a productive scientific environment for theoretical physics is played by ECT*, the European Centre for Theoretical Nuclear Studies and related areas, managed by FBK, but supervised by the Nuclear Physics European Collaboration Committee, and funded by many European countries. The presence of ECT* guarantees first of all the possibility of cooperating with local scientists (residents and post-docs), but also a great opportunity of meeting and to exchange ideas with fellow scientists coming from all over the world to attend the very rich and diverse workshop program that characterizes the ECT* main activity. TIFPA is developing stronger ties with ECT*, in order to favor the scientific interaction and foster further collaborations.

Besides the interactions with the local environment, the TIFPA theoretical group enjoys a wide network of international collaborations, in particular with European and US institutions.

Medical applications

The TIFPA partner APSS (Trento Agency for Welfare) which runs in Trento a new Cyclotron Center for cancer treatment, offers the possibility to use the proton beams for a variety of experiments covering the study of the interaction of ion-beam both with matter and living matter in the energy range up to 220MeV. This experimental activity can be done thanks to the availability of an experimental hall that, since the beginning, was meant to host instrumentation aimed to:

- design, development and tests of detector systems, specifically dedicated to Imaging (proton tomography);
- on-line monitoring of cancer treatment detecting the secondary radiation emitted during the treatment itself; tests of new treatment planning;

- study of radiation effects on biology material (radiobiology) to the benefit of oncological therapy;
- collaborative efforts to consolidate a program of international relevance aimed to study the radioprotection issues for space mission.

This collaboration could allow INFN to promote a national network of universities and research institutions (CNAO first) to strengthen the national participation to European call of medical applications of hadrontherapy.

Near Future

The main scope to start TIPFA was to consolidate the traditional scientific research lines of INFN in the Trento area, where there is a great potential of development for new strategic activities aimed to applications of industrial interest. For this reason, besides the close traditional collaboration with the TDP, other partners like FBK and APSS were included in the founding Convention. It is expected that the creation of TIFPA will contribute to attract new external resources and to expand, at international level, collaborations with prestigious Universities and Research Institutions.

It is assumed that the Center will be in full operation in year 2015. The budget made available by the partners in the Three Year plan 2013-2015 is of about 2.7M€ (1.7M€ by INFN, and the remaining covered by TDP and FBK). The budget will cover personnel costs (mostly short term contracts) and investments finalized to equip already mentioned 500m^2 made available by TDP.
As far as the budget is concerned, it should be mentioned that an additional amount of about 500 k€ per year is assigned by INFN to the institutional research activities of TIFPA through the CSNs.
In the years 2013-2015, the resources will be concentrated on two main lines:

- consolidate the institutional research of INFN: experimental physics in astroparticle domain, physics of fundamental interactions , interferometers to detect gravitational waves, high precision experiments with quantum –opto-mechanics devices;
- development of technologic platforms. Trento is considered a center of growing attraction for space research. The basic activities concentrate on the preparation of space missions in the field of gravitation and gravitational waves (LISA-PATHFINDER), the development of advanced detector for astroparticle physics on the ground and in space, and finally the development of space missions for Earth and planets observation.

For what concerns the development of advanced detector, it should be stressed that the collaboration with FBK is strategic for the future. The creation of the center will secure and strengthen the support of ASI and ESA to TIPFA activities.
To create synergies among the different experimental space activities, there is a proposal to set up a laboratory for space related technologies dedicated to the exploration of Earth and the Universe.

Nuclear Physics research applied to Biology

With the construction of a proton-therapy Center at Trento, based on the already mentioned Cyclotron, capable of accelerating the proton beam of energy up 220 MeV, there are the optimal conditions to conduct experiments in the field of radio-biology, dosimetry, radiation damage. A program like this could profit of INFN resources as well of the international links which INFN fostered over the last decade. TIFPA could benefit of being part of a national network created with the goal to participate to European calls from a position of greater competitiveness. In the present year, INFN has provided additional funds to properly equip the experimental hall served by the Trento Cyclotron. Much in the same ways as for space related activities, synergies among the various research lines can be developed, setting-up a "Laboratory for the study of radiation effects on man-kind by ionized radiation, including experiments and models development".

Radiation detectors and micro-electronics

The traditional collaboration between INFN and FBK now managed in the TIFPA context, includes the development, of sensors, micro-electronics and micro-systems. In addition to the projects triggered by INFN experiments, new applications are going to be developed in order to compete in national and international scenarios . TIFPA participates to the R&D of new sensors for future detectors based on Cerenkov light. INFN-TIFPA was granted funds by the Ministry of University and Research to participate to the Cherenkov Telescope Array (CTA) and to the Gamma-400 international projects. Gamma-400 foresees the construction of a large number of detectors based on micro-strips sensors to build a satellite dedicated to gamma astronomy.

3.2 CNAO

CNAO is progressively entering a full operational autonomy from the point of view of clinical treatments. As far as research activities are concerned, the collaboration with INFN remains fundamental. A new three year agreement was established last April in order to cover all aspects of mutual interest, including, beyond research, common actions on technology transfer.

A new important item included in the new agreement is the start of the construction of the extraction line for the research area of CNAO. The final design has been completed by a joint INFN-CNAO research group and the work for the construction is now starting, again under a joint direction of the two institutes. The access to this new facility (a dedicated test beam) will be based on research proposals that will be judged by a joint (INFN-CNAO) committee.

In the meanwhile, INFN groups continue to use CNAO beam, whenever possible, for a number of purposes mostly related to research and development in charged particle therapy, namely radiobiology, testing of new treatment, development of control and imaging techniques to monitor hadrontherapy treatments. These research programs are carried out by INFN groups thanks to the funding coming both from the Institute and from Italian Ministry of University and Research. Often these activities are carried on in synergy with dedicated European projects. The number of scientific projects in which both INFN researchers and CNAO medical physicists are collaborating together is indeed increasing. There is a significant number of Ph. D. students whose thesis are also connected to these projects.

INFN and CNAO also cooperate in the realization of workshops, schools and other public events .

3.3 GSSI- Gran Sasso Science Institute

The INFN center for advanced study and international PhD school *Gran Sasso Science Institute* (GSSI) started its educational and scientific activities in October 2013, and is now entering his second year of life.

The recruitment of PhD students for the first academic year 2013/14 involved a total of 36 three-year doctoral scholarships, divided into four courses: Astroparticle Physics; Mathematics in Natural, Social and Life Science; Computer Science; Urban Studies. Recently GSSI has also launched a two-year program of 16 Post-doc research grants for talented young people. The calls received a considerable number of applications: 552 for the PhD scholarship and 411 for the PostDoc positions. In Figure 3.1 we show the distribution of applications divided by subject areas. Applications were received from 63 different nations. In Figure 3.2 we report their geographical distribution.

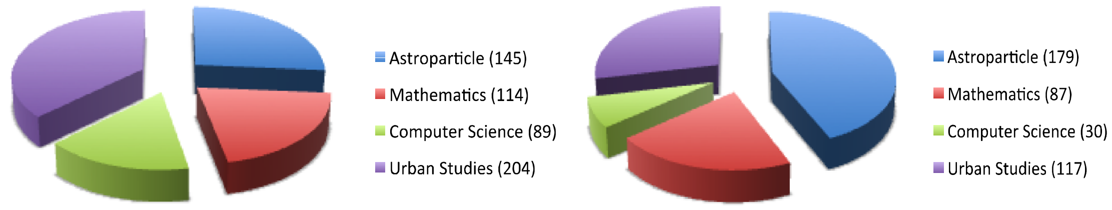


Figure 3.1: Applications received for the PhD (left) and PostDoc (right) fellowships.

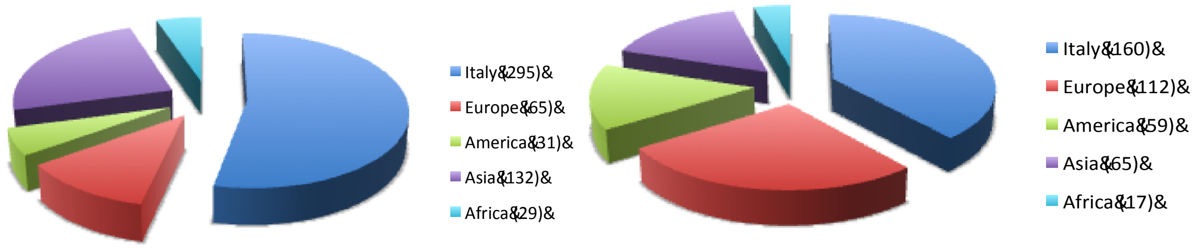


Figure 3.2: Geographical distribution by continent of the PhD and PostDoc applicants, with Italy shown separately.

The high degree of foreign applicants, more than 46% for PhDs and about 61% for the PostDocs, shows the attractiveness of the educational and research activity of the GSSI at international level.
Among the 36 selected PhD students the level of internationalization has remained very high, with a percentage of more than 36% foreign students. In the case of PostDocs, those coming from abroad are equal to 50% of the total.
Let's point out that these people come from universities among the best in Italy and the world.

Italian Universities

University 'La Sapienza' Rome	6
University of L'Aquila	5
University of Bologna	3
University of Roma-3	2
University of Milano-Bicocca	2
University of Genova	1
University of Pisa	1
University of Ferrara	1
Polytechnic University Milan	1
Total	**22**

Foreigner Universities

University of Saint Petersburg - Russia	1
Technical University Dresden - Germany	1
Comsats Institute of Information Technology Islamabad - Pakistan	1
University of São Paulo - Brazil	1
Fon University Prilep - Macedonia	1
University Nice Sophia Antiplis - France	1
University of Isfahn - Iran	1
Amrita University - India	1
King's College London - United Kingdom	1
Vrije University Bruxelles - Belgium	1
Tbilisi State University - Georgia	1
Yditepe University - Turkey	1
University of Strasbourg - France	1
University of Cardiff - United Kingdom	1
Total	**14**

Table 3.1: Home universities of the selected 36 PhD students (2013).

Italian Research Institutions and Universities

University of L'Aquila	2
Gran Sasso National Laboratory	2
University of Florence	1
Polytechnic University of Turin	1
University of Rome "La Sapienza"	1
University of Pisa	1
Total	**8**

Foreigner Research Institutions and Universities

Ludwig Maximilians University, Munich - Germany	1
University Paris Diderot, Paris - France	1
University of Houston, Huston - USA	1
University of Oxford, Oxford - UK	1
University Pierre et Marie Curie, Paris - France	1
Barcelona Autonomous University, Barcelona - Spain	1
Uppsala University, Uppsala - Sweden	1
Adam Mickiewicz University, Poznan - Poland	1
Total	**8**

Table 3.2: Home universities of the selected 16 Post-Docs.

The faculty of the GSSI is made of staff from the best Italian and foreign universities. Among these, in addition to SISSA, IMT and Scuola Superiore S. Anna, with whom the GSSI is in close collaboration, we can mention the Scuola Normale Superiore of Pisa, the US Universities of Princeton, Yale and Columbia; the Max Planck Institute of Heidelberg, the University "Science Po" in Paris. Teaching activities consist of lectures for a total of about 300 hours for each PhD course.

During this first year of activity, the GSSI has hosted approximately 60 events, including series of seminars, conferences and workshops. Among these initiatives, it is worth mentioning the conference "Italian High Energy Physics Meeting", which saw the participation of more than 200 elementary particle physicists, the workshop "The Changing Italian Cities: Emerging Conflicts and imbalances", which was attended by the best experts in Italian and European economic planning of urban areas, the conference "From Atomistic to Continuum Models in Materials Science", a conference attended by more than 50 mathematicians from all over the world.

Among the awards, the GSSI has successfully participated in the program of the European Union "Marie Curie" with the proposal GRAWITON of "Early Stage Researchers", thanks to which three young foreign researchers will have a fellowship at GSSI. Moreover, the GSSI PostDoc researcher Catia Trubiani won the Microsoft Research Award, $ 40.000, for the development of innovative software.

GSSI is one of the promoter of the new Inter-University Centre on Urban Policy, together with the Polytechnic of Milan, the Polytechnic of Turin and the University of Bologna, IAUV Venice, Naples and Rome TRE.

3.4 LABEC and the Network for Cultural Heritage

LABEC, the INFN-Firenze laboratory for cultural heritage and environment protection, is now part of a wider INFN network CHNet (www.infnbeniculturali.net) that, in turn, participates with CNR and INSTM (Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali) to the making of the Italian infrastructure IPERION_CH (www.iperionchit.net). The aim is to create IPERIONCH-ERIC to be included in the ESFRI map of "mature" infrastructure to be quickly evolved into an ERIC. CNR received in July 2013 a financial support by MIUR to create the Italian hub. Still in 2013 CNR, MIBACT (Italian Ministry for Culture) and Tuscany Regional Government signed an agreement to propose Florence as the hub location. Since March 2014 the situation progressed and now INFN and INSTM sits at a table together with CNR and MIBACT to set the Roadmap for this project.

The first joint INFN-CNR-MIBACT-INSTM initiatives were to participate to Educational activities (training camps), and pilot calls for "Sovrintendenze" and individual researchers to give them access to the available infrastructures. For INFN, besides the LABEC accelerator there are facilities and technical support in Units of Bari, Bologna, Catania, Ferrara, Firenze, LNF, LNS, Milano Bicocca, Napoli, Torino). The first international training camp took place in 2014 in San Sepolcro (Arezzo), with *in situ* use of advanced tools on paintings and other ancient artifacts. Besides, several stages already took place at LABEC where the collaboration with Opificio delle Pietre Dure of Florence is also ongoing.

As for the pilot calls, the first one by IPERION_CH.it is dedicated to *in situ* non-destructive measurements (to be eventually complemented if needed with micro-destructive measurements). A peer-review panel will judge the proposals on scientific and feasibility basis. The ones selected will have free access to all the available technical tools and expertise.

Overall the network is now capable to perform different measurements in an integrated and optimized way. The portal is also the *point of access* to the INFN expertise for private users.

In 2013 work for others was performed with the help of TECNART srl (a spin-off in the Turin area) which provides the interface between the Institute network and private users. Among the other activities, 20 measurements using AMS (accelerator mass spectrometry) radiocarbon dating and 5 days for 8 hours of beam for Pixe, Pige etc. analysis were performed at the LABEC tandem. The plan is that, starting 2015, besides collaborating with dedicated spin-offs, the portal will also be used by individuals/private companies to directly obtain services.

4. Scientific productivity

Within the goals of fundamental research in INFN activities there is definitely the increase of scientific knowledge, by improving our understanding of the basic constituents and fundamental laws of Nature and by developing the required technological instruments. The accountability of this process puts a natural emphasis on scientific publications on international journals as one of the main results. The source for bibliometric information is ISI, the Institute for Scientific Information owned by Thomson, http://isiknowledge.com (accessible upon subscription) and data we use refer to papers published by INFN scientists. Other sources for bibliometric analysis are now gaining more momentum on the scene, e.g. SCOPUS by Elsevier B.V. http://www.scopus.com. INFN units can now access the Scopus DB as well. However, at the moment our results are mainly based on ISI, unless otherwise indicated.

As for non-journals, more informal ways of disseminating information, we are aware that those ways are also used. However the Italian VQR, as well other exercises worldwide used to measure research, makes this territory still *terra incognita* to be carefully explored. This goes hand to hand with the pressure of allowing *Open Access* to research results.

4.1 Overall scientific production

In Table 4.1 the update on the overall production is presented, for the INFN Scientific Lines, compared to past values. The *Common* row refers to publications which are not strictly identifiable in the research of a specific CSN, but are either contributed by mixed authors (e.g. one theorist and one experimentalist) or refer to very particular subjects. From the table it is clear that strong efforts were made to assign every paper to a given CSN. *Multiple* refers to papers that can be assigned to

	2013	2012	2011	2010	2009	2008	2007
CSN1	575	502	340	301	262	306	309
CSN2	291	292	293	274	242	233	202
CSN3	342	353	289	267	235	209	269
CSN4	1300	1376	1262	1291	1192	1133	1129
CSN5	353	342	329	315	321	337	408
Common	793	651	722	628	600	821	829
Multiple	97	146	159	123	95	84	83
Total	***3646***	***3380***	***3076***	***2953***	***2757***	***2955***	***3063***

Table 4.1 Distribution of INFN pubblications per year, by CSN. Snapshot as of September 15, 2013.

more than one CSN (for example joint papers by experimentalists and phenomenologists).
First of all, we note that the total number of papers is constant or even increasing, a sign of the very healthy status of publication activity by INFN researchers. The large increase in the CSN1 line is due to the production of physics papers by LHC experiments. The large increase of production in CNS3 is, again, due to LHC experiment ALICE. The effect of the LHC contribution is also sizeable in terms of fraction of INFN authors (down to 20% for CSN1) as the large Collaborations tend to dilute the Italian contribution. Overall in 2012 and 2013 ATLAS, CMS and LHCb were the first three contributors in terms of papers to the CSN1 productivity, still closely followed by CDF2. This effect is also visible in Table 4.2 where the fraction of papers per FTE in CSN1 jumps to 0.7 from 0.38 in just two years.

The number of publications is just one of the elements useful in the evaluation of scientific productivity. Indicators like Impact Factor, or the related citation analysis, are often used to measure the quality of the work done, and this is the case of VQR 2004-2010 where, moreover,

		Fraction of INFN Authors (%)							Average Impact Factor					
	2013	2012	2011	2010	2009	2008	<04-06>	2013	2012	2011	2010	2009	2008	<04-07>
CSN1	28	20	22	38	30	42	36	4.4	4.6	4.77	3.80	3.90	3.10	3.75
CSN2	50	50	51	51	53	64	75	3.5	3.6	3.8	4.08	4.40	2.80	2.33
CSN3	45	43	43	50	44	51	47	3.1	2.8	3.21	2.85	2.60	2.80	2.60
CSN4	46	59	61	55	56	63	59	3.6	3.59	3.71	3.73	3.73	3.47	3.48
CSN5	47	59	61	66	61	67	66	2.14	2.13	1.72	1.97	1.96	1.70	1.48
		Personnel (FTE)							Publications / FTE					
	2013	2012	2011	2010	2009	2008	<04-07>	2013	2012	2011	2010	2009	2008	<04-07>
CSN1	739	767	796	783	791	813	804	0.75	0.66	0.38	0.35	0.25	0.31	0.36
CSN2	527	550	607	650	644	674	653	0.45	0.57	0.33	0.40	0.37	0.33	0.31
CSN3	490	505	521	520	527	521	474	0.7	0.6	0.5	0.49	0.42	0.40	0.54
CSN4	973	940	973	949	920	977	875	1.34	1.37	1.14	1.25	1.19	1.22	1.32
CSN5	623	553	607	598	600	608	524	0.66	0.52	0.59	0.53	0.55	0.55	0.53

Table 4.2 - Indicators of INFN Scientific Productivity. Since 2012 CSN5 figures refer only to ISI publications.

papers are divided into homogenous subsets. For example the relatively low IF of papers in CSN5 is typical of the publication in the *Instrumentation* sector. It must be recalled that the Impact Factor qualifies a journal in its entireness, and it is not *per se* a measurement of the quality of a single paper. Therefore the indicators we present are only an indicative, we do not attempt to evaluate every single paper. However, to deal with VQR 2004-2010, the INFN GLV built a software infrastructure that allows a bibliometric evaluation of every ISI paper, based on IF and (ISI) citations received by papers. The package was used to optimize the papers sent to ANVUR for the VQR. At present we are keeping the whole infrastructure operational. Although using it for internal evaluation requires a non-trivial amount of human resources, it can be useful to check how we would score if a VQR would be done tomorrow based on the same ingredients.

Table 4.2 updates the usual indicators for 2013. The fraction of INFN Authors mirrors the degree of internationalization of the corresponding Collaborations: this is evident for the sub-nuclear and nuclear lines. The number of scientists authoring INFN papers follows the trend of previous years: the number of publications per Full Time Equivalent (FTE) is particularly good for CSN4, which is still the most prolific of INFN scientific lines. It is also fairly constant also for the other lines, with

	2013	2012	2011	2010	2009	<04-08>	2013	2012	2011	2010	2009	<04-08>
CSN1	91	93	85	89	73	79	30	30	27	23	30	26
CSN2	88	88	78	63	56	75	56	39	56	55	57	47
CSN3	84	88	83	84	86	81	47(32)	46	47	50	45	38

Table 4.3 Milestones achieved (left) and leadership roles (right). In parenthesis the % of women out of the total Italian roles

an increase for CSN1 and CSN3 due to the publications by LHC experiments (ALICE experiment is one of the CSN3 activities).

As it is customary for INFN, the objectives to be achieved during the incoming year are yearly formulated by each experiment along with the funding requests. To help researchers and executives to trace the status, and apply corrective actions when needed, a set of milestones is then agreed between the experiment and its referees. In Table 4.3 the corresponding performance figures are given for the large experimental CSNs: a very good share of the milestones is met every year. The increase in the CSN1 value reflects the readiness of the LHC experiments for the data-taking period. An additional comment refers to CSN5, which, even with a much larger number of initiatives compared to the other CSNs, scores in 2013 a level of success of more than 80%, in line with previous years.

Given the high international level of the activities described above, another indicator of the relevance of INFN work inside the Collaborations is the share of Leadership roles attained by INFN scientists. As can be seen in Table 4.4 this value is rather high, always exceeding the corresponding INFN funding fraction to the experiments, which is a fair demonstration of the high scientific role played by the Institute in International Collaborations and an acknowledgment to the researchers' management capacity.

While there are a few studies about scientific collaborations, in order to really understand the different structures and the real leadership roles of such complex entities, a full network analysis would be needed. In 2014 the GLV, with the help of the Collaborations, studied the different layout of the management structures, and decided the appropriate sets of management roles to be counted (depending upon the specific scientific area, the size of the group etc.).

4.2 International framework

	2013	2012	2011	2010	2009	2008	<04-07>
CSN1	100	100	99	96	96	96	95
CSN2	71	71	69	73	64	68	70
CSN3	95	96	94	93	85	91	94
CSN4	74	70	68	64	64	62	58
CSN5	35	25	25	21	24	21	21

Table 4.4 - % of publications in International Collaborations

As it was shown in previous reports, in the comparison of INFN with respect to several representative European Countries, the Italian production in nuclear, sub-nuclear and astro-particle physics (experimental and theoretical) is at the same level, in both quantitative and qualitative terms. This also stems naturally from the fact that INFN research is mostly operating in an international framework, achieving, as we have seen, also a good position in the corresponding leadership roles. Table 4.4 provides a snapshot of the situation. The different values across the CSNs reflect the different sociological (and financial) fabric of each research line. CSN1 and CSN3 are striking examples, for almost all of the publications are done in collaboration with colleagues from foreign institutions. Let's remind that one of the measurement of internationalization of research in the MIUR VQR 2004-2010 is linked to the fraction of (excellent) papers written in collaboration with non-Italian physicists. One may also notice that, even in the field of theoretical physics, there is a shift towards more international collaborative work across national borders, which is probably reflecting the increased need for co-operation with experts of other countries.

Differentiation with respect to other countries may be found by looking at some specific structural organization of INFN. For example, one of the INFN highlights is the existence of four major National Laboratories, offering a wide spectrum of experimental facilities and hence of research opportunities. Such facilities are of course available to non-Italian researchers: indeed many experiments performed in INFN Laboratories are done within an international framework and

	2013			2012		2011		2010		2009	
	A	B	B/A	A	B	A	B	A	B	A	B
LNF	742(165)	184(43)	0.25	501(100)	216(44)	495	244	460	215	439	190
LNL	719(166)	201(53)	0.28	851(198)	274(66)	744	282	1022	336	904	270
LNGS	650(116)	365(35)	0.56	384(65)	175(*)	876	592	862	550	883	544
LNS	553(163)	163(32)	0.30	688(152)	264(32)	558	192	504	172	365	117

Table 4.5. Statistics on users of National Labs. A is the total number of users, B is the number of foreign users. In parenthesis the number of female users in each group.
(*) Since 2012 the foreign users accounting for LNGS has been homogenized to the way it is computed for the other labs.

many foreign researchers spend extensive periods of their time there. Table 4.5 shows the number of users in the different Laboratories: the fraction of foreign colleagues is rather high for all the four sites. This of course does not reflect only local running of experiments together with INFN scientists, but also the time for discussion and data analysis.

Moving from papers to people, researchers, especially in large Collaborations and especially if young, gain a major visibility through presentations at Conferences. In large experiments the policy is indeed to allow them to be on the forefront in many scientific events, hence the total number of presentations to Conferences is both a measure of the vitality of the whole community and in particular of its younger component. In Table 4.6 the situation is summarised for all CSNs and compared to previous years: once again one can note a very good pattern, showing that INFN researchers are very active in communicating to peers their scientific achievements.

However, competition in large international collaborations is very hard and may not be easy to have a fair share of presentations at the most important Conferences and Workshop in the INFN research fields. An analysis has been performed for the three experimental lines by choosing a representative set of conferences for each CSN and the percentage of talks given by INFN researchers has been compared to the ones of some European countries (and to USA and Japan as external references): the outcome is presented in Table 4.7 where we show the result for 2013 and (in parenthesis) the average 2007-2012.

However, these figures depend also on the size of the corresponding research communities in the different countries. As in previous years, an attempt has been made to normalize Table to these sizes. For CSN1 an obvious reference are the MoUs of its International Collaborations, which

	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
CSN1	601(25)	511	494	393	396	332	255	281	259	209
CSN2	311(32)	275(26)	263	210	255	244	248	168	207	173
CSN3	445	397	366	378	390	278	271	258	189	242
CSN4	629	754	582	575	661	846	940	694	606	431
CSN5	311(30)	349	361	326	329	353	307	282	275	371

Table 4.6 - Number of INFN talks given at International Conferences. In parenthesis the % of female speakers

define also the financial contributions for the different countries, based on the size of their participation to the initiatives. In this approach, Italy is almost perfectly aligned to the number of active researchers, and Germany scores particularly well. In CSN2 an approach based on the head-count from paper author lists and Web sites has been used to estimate the number of contributors to the field in the various countries. In this case, Italy essentially at the expected value, while

	Italy	Germany	France	UK	USA	Japan
CSN1	14(9)	13(15)	9(6)	8(9)	23(27)	4(3)
CSN2	11(10)	12(11)	6(7)	5(5)	30(33)	10(8)
CSN3	14(10)	18(15)	8(8)	3(5)	23(26)	6(6)

Table 4.7- Comparison of the percentage of talks at a set of International Conferences in 2013, in parenthesis the average for 2007-2012.

Germany and Japan scores about 30% higher. For CSN3 the fraction of personnel committed in the four research lines in the main countries has been deduced from the *NuPECC Survey 2006 on Resources in Nuclear Physics Research in NuPECC Member Countries* (including some support staff). Within this set of countries, they all get the fair share of talks to international conferences, with Germany and UK performing slightly better than the other European partners. The statistical base is rather sound, thousands of talks are considered for this exercise: e.g. for CSN3 more than 3500. Table 4.7 shows result for 2013, in parenthesis result for period 2004-2012.

On the whole, INFN activity of educating, training and merging the young researchers with the high scientific environment of its experiments allows the Institute to create a robust generation of scientists who will be the main characters at play for tomorrow's developments and discoveries.

Another way to evaluate INFN performance in an international framework is to use bibliometric data. Thomson Reuters (WoS) provides a wealth of information, in Table 4.8 we divided the main INFN activities according to WoS division of Science Categories. Then we can count the fraction of papers with INFN authors in each category, and compare to the fraction of Italian papers in the same category. Finally we look at the fraction of INFN papers appearing in the top cited 5% and 1% articles. The first figure is an estimate of the overall INFN contribution to a given area, from which we can infer that Particle and Fields and Nuclear Physics in Italy are mostly related (as expected) to INFN researches. Simply looking at the outcome in terms of highly cited papers, in essentially all SC, INFN scores at least a factor two better than the simple statistics cont. With ten percent of the papers in particle and fields, INFN collects one fourth of the top cited articles. In Nuclear Physics, six percent of the papers collect 14% of the top citation ones.

Science Category	**INFN/ World**	**Italy/ World**	**INFN top 5%**	**INFN top 1%**
Physics, Particle and Fields	10.2	12.1	14.3	26.3
Physics, Nuclear	5.6	8	9.7	13.7
Nuclear Science and Tecnology	3.2	6.3	7.3	7.1
Astronomy and Astrophysics	3.5	10.3	5.3	5.9
Instruments & Instrumentation	2.3	6.7	2.5	3.2
Physics, Multidisciplinary	1.1	3.6	3.3	4.7
Physics, Applied	0.2	3.0	0.16	0.13
Physics, Mathematical	1.7	6.0	2.6	4.0

Table 4.8- Fraction of INFN papers by Science Category. Most cited papers (top 5% and top 1%) in the leftmost columns. All figures are in %

5 Equal opportunities, gender parity and gender balance

The analysis performed in this paragraph starts from two issues:

- Italian context: INFN has a leading role not only in the Italian research context, but also in many international collaborations due to its high level of excellence in research and technological development. Furthermore, in recent years knowledge and technological exchanges between the Institute and Society, the Institute and Industries as well as Education were improved (Third Mission).
- European context: the core of the EU strategy for economic and social development is innovation in research and in bringing ideas to society. A better integration of the gender perspective in research alongside a better inclusion of women in the research and innovation (R&I) workforce will improve the quality, objectivity and relevance of knowledge, technology and innovation for the benefit of all members of society. EU Horizon 2020 Strategy has a strong gender dimension, which, if ignored, can result in missed opportunities for innovation in research and in development of markets. Furthermore the European Research Area (ERA) also seeks to capitalize on the "diversity of views and approaches" that fosters excellence in research.

It is clear that the inclusion of gender dimension in research is crucial for INFN in order to maintain a position among leading research organizations in Europe. Indeed Third Mission and the Horizon2020 "long term perspective" require a "diversity of views and approaches". This inclusion must be able to overcome gender biases, which could be defined as systematic error in the gender approach to the research process. The EU recommendations require a conscious transformation of organizational processes without which the outcomes will be unchanged: fewer women, less diversity of experience and outlook, and failure to grasp the benefits expected from the enhancement of the potential pool of researchers and innovators, etc. In order to overcome the barriers, there must be willingness at the top to open up discussion and to support the process of self-study.

Although substantial progress is visible in the INFN context, there is still significant discrimination, even indirect, based on gender or age: women are 22% of the researchers below 49 years old, down from 26% in the range 50-54 years old. In the context of administrative and technical areas, a woman is head of an office in 25% of cases, but we have only one (out of 45) woman head of department. Some progresses were done in the direction of 'knowing the Institute' from a gender perspective. Unfortunately even if disaggregated data are now available for Human Research analyses only the *Central Guarantee Committee* (*Comitato Unico di Garanzia, CUG*) uses them always for official documents. However it is increasing the number of reports that exploits this information; see this same report or the INFN "Three Years' Plan".

From the point of view of the INFN CUG the inclusion of gender in research must be seen through an integrate perspective between scientific excellence, people capacity enhancement, work-life balance, and transparency. Recently the CUG proposed an affirmative action plans (PTAP in Italian) that, starting from the critical issues related to equal opportunities between men and women, aims to exploit people and the reality in which they work. More information can be found at: https://web2.infn.it/CUG/index.php/it/piani-triennali-di-azioni-positive

The V PTAP transposes the Ombudsperson report on "Organizational wellbeing", the gender audit results from Genislab EU-project, the EU recommendations present in the report "Structural change in research institutions: Enhancing excellence, gender equality and efficiency in research and innovation". In order to remove critical issues, this last report underlines some targets, which are the main objects of CUG actions:

a. to increase the transparency in decision-making process and to increase the information circulation;

b. removing unconscious bias from institutional practices;
c. promoting excellence through diversity;
d. improving research by integrating a gender perspective;
e. modernising human resources management and the working environment

The affirmative actions ought to be integrated inside a global structural change strategy, where three elements are important:

1. to know the institute and its employees, by means of statistical analysis and equality indicators in order to take a snapshot of the institute and to identify the problem;
2. the management has to fully support the structural change;
3. to support and to diffuse opportunities for learning and developing management expertise on critical issues of human resource management, mainly on gender issue

Work done and to be done

Transparency is, or should be, a principle that any kind of organisation and project is asked to comply with. This is even more important in the case of programmes aimed to protecting rights, as the gender equality programmes actually are. With respect to transparency, CUG draws the attention of INFN management to the need of concretely adopt the EU "Minerva" code for each recruitment procedure of researchers[2]. CUG asked, for each recruitment procedure, to collect in a database the curricula of the selection committee and of the applicants. It was also asked to publish within an internal web page the scientific curricula of the INFN employees.

In the direction of transparency CUG proposed a new procedure for the election of the new CUG board. Instead of a top-bottom, it should start from an "open consultancy procedure" to acquire personnel availability to become part of the board. This proposal was adopted (see link below) in July by the Boards of Directors, and it is now enforced. It is the first time that such procedure is adopted by INFN.
http://web2.infn.it/presidenza/images/presidenza/Documenti/Delibere_CD/2014/luglio2014/13320_cdd.pdf

The "*Human Resource Budget*". As mentioned many times, an effective way to integrate the gender perspective inside the INFN certainly requires a *gender-disaggregated breakdown of information* for all the institute reports. After CUG proposal, INFN decided to implement a Human Resource Budget that will monitor the respect of the diversity in the age distribution and gender balance in the state of the employees, the evolution of the research activity, the careers, as well as in the different research sectors, geographical areas, and professional categories. The Human Resource Budget will also monitor the professional training, social tools, and medical prevention. Several statistical plots were produced but, due to changes in all the databases management, the remaining work is still to be done. On the positive side, most of the information collected can be broken up on a gender basis, see: https://web2.infn.it/CUG/index.php/it/statistiche-infn

Enhancement of human resource in the working environment

Greater diversity and equality of opportunity are crucial points in a process of enhancement of human resources in a sustainable and "people" centred working environment. The final and complete report on the research program proposed by the Ombudsperson -"Consigliera di Fiducia"- in collaboration with CUG - on the "Organizational wellbeing" perceived by the INFN employees has been presented. The analysis showed that "organizational equity" and "people capacity enhancement" are critical factors. These factors are especially true for women. In order to face these problems in all the INFN structures a training program for "circles of well-being" was proposed to

[2] Minerva code as approved by the EC-led Helsinki Group on Women and Science to give full effect to the European Charter for Researchers and the Code of Conduct for their recruitment (2005).

take place in 2014/2015.

A gender perspective that encourages gender diversity can be the starting point to overcome the employee requirements in order to improve the INFN organizational wellbeing.

- A "Competency Format" was implemented on INFN internal WEB area in order to underline and recognize the competencies of all the employees. The compilation is done on voluntary basis: www.infn.it/cvonline.
- Starting from a "Best Practice" discussed in the PRAGES report[3], the CUG proposed a newsletter for the INFN web site publishing interviews to employees, only women for the first year. The goal is to promote the knowledge of the different contributions, of the daily work that make possible the scientific activity and also of the importance of balancing private and working life. Three newsletters with interviews have been published showing an interesting and different world. web2.infn.it/CUG/.

5.1 A European gender project: GENIS-LAB

INFN participate to the GENISLAB project (funded by the European Commission under FP7) together with other six scientific European organizations: CSIC (Spanish Higher Council for Scientific Research) Institute for Polymer Science and Technology; IPF-Leibniz Institute of Polymer Research Dresden; FTM UB-Faculty of Technology and Metallurgy, University of Belgrade; NIC, National Institute of Chemistry, Slovenia; BTH, Blekinge Institute of Technology, Sweden, and three technical partners: Fondazione Giacomo Brodolini (project coordinator), Associazione Donna e Scienza, and the International Training Centre of the ILO. More info and documents can be found at www.genislab-fp7.eu. INFN activity has its own web page at http://web2.infn.it/genislab/).

The project started in 2011 lasting for 48 months. It aims to implement structural changes in the six research organizations to overcome factors that limit the participation of women in research. GENIS-LAB aims to improve changes at three levels: organizational, social/environmental and transnational (European). The first phase of the project took place over 2011 and engaged all the six organizations by mean of a "participatory gender audit" (PGA), a well-tested ILO methodology based on qualitative self-assessment.

The PGA output is an ensemble of recommendations which offer to INFN management, and all the staff involved, ideas on how to capitalize on the richness of already existing resources and experiences, and contribute to the practical implementation of its existing gender equality policies and strategies. The recommendations can be summarized as follows:

> *Policy dialogue and reinforcing accountability frameworks; Reinforce the monitoring systems; Align human resource strategies and management tools to EU policies; Promote a gender transformative culture in internal information and external communication; Staff development: targeted action and promoting collaborative behaviors; Work-life balance.*

The Audit recommendations evolved in an Action Plan, which is being implemented with the help of CUG and which require clarifying responsibilities among a much larger set of internal actors (e.g. Human Resources Services, the Directors, members of Selection Panels etc.).

2013 Activities

The Tailored Action Plans (TAPs) for the 6 scientific organizations involved in the project represent a crucial milestone in Genis-Lab implementation.

[3] http://www.retepariopportunita.it/prages/

During 2013 the Genis-Lab activities where mainly devoted to the implementation of the self-tailored action plans. INFN TAP can be found at http://web2.infn.it/genislab/. TAPs are a key output of the work implemented in the framework of the collaboration between technical partners and scientific partners during the first 2 years of project activity. TAPs are crucial in order to achieve the Genis-Lab objective of structural change in scientific organizations, combining the three dimensions (HRM, GB and Stereotypes) and the three levels (organizational, social /environmental, transnational and European) identified in Genis-Lab.

The INFN Tailored Action Plan

The INFN TAP was officially approved by the Executive Committee on January 2013 and

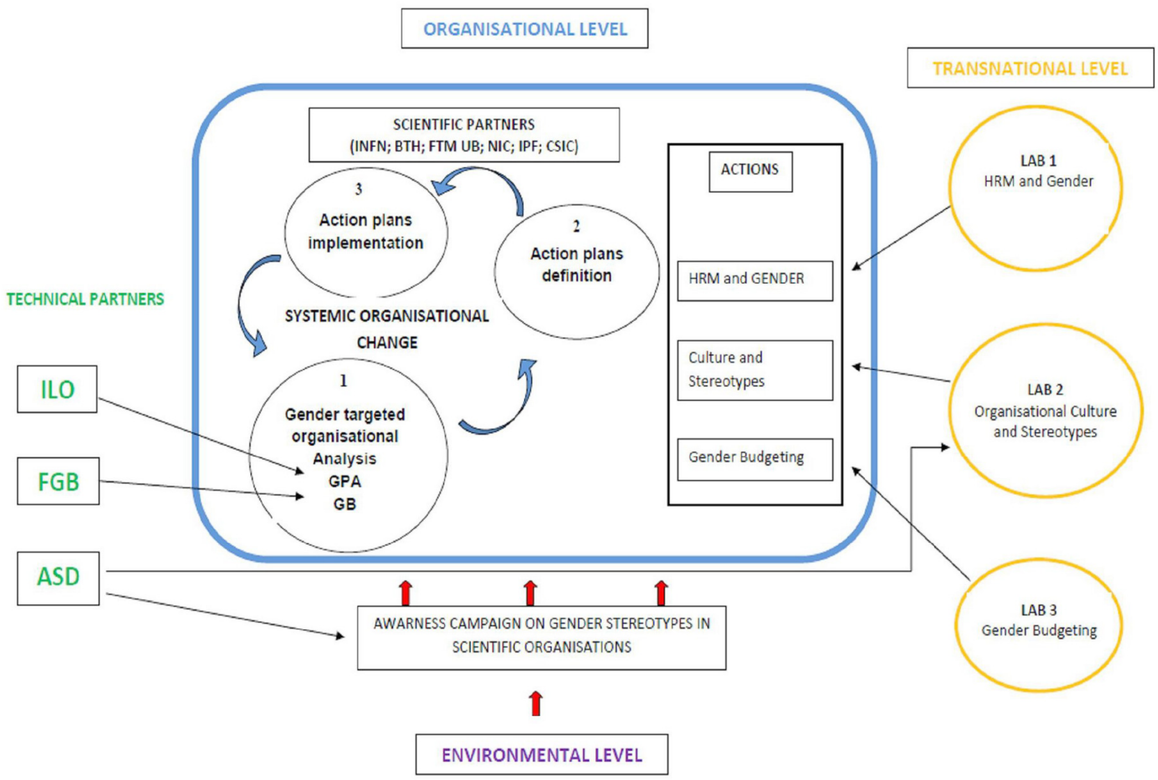


Figure 5.1 The picture represents the Genis-Lab's implementation strategy. The three levels are integrated adopting a systemic approach in order to face internal and external resistance to change. Promoting change in the scientific transnational and European communities helps organizational change in each partners' organization.

will last up to December 2014.

Objectives and actions defined in the TAP are based on the analysis of the results and recommendations of the participatory gender audit that was run in March 2011, and on other meetings with the technical partners during the ensuing months. Theoretical background as well as objectives, actions and methods were discussed within INFN Genis-Lab team with the support of the technical partners of the project, shared with INFN CUG Chairperson and members as well as with a number of other INFN Structures in meetings and seminars.

The long-term objective of this TAP is to initiate structural change in INFN, so as to improve its working environment for all and improve the quality of its scientific production. Genis-Lab is aware that the achievement of these objectives in a sustainable and efficient way requires that the TAP of Genis-Lab takes advantage of, and is integrated in, the broader framework of the initiatives that already exist towards gender equality in the Institute, and that are undertaken by different institutional actors. This is of particular importance especially in view of the size and complexity of the Institute and its governance structure.

All actions are and will be concerted and implemented in collaboration or in consultation with CUG. CUG is seen as the privileged instrument to disseminate the results of pilot actions, ensure coherence and impact among the different initiatives and monitor the correct institutionalization of products and processes.

TAP Implementation (WP4):

The TAP, as part of Genis-Lab project, is coordinated by the Training Department of INFN which is part of the Central Administration, but Genis-Lab team members come from different decentralized sections, as the TAP includes objectives and actions which are meant to benefit the whole organization.

Gender Budgeting

Action 1: Fund allocation to research groups: Gender analyses of beneficiaries

The Genis Lab team has finalized analysis of gender composition of research groups, and group leaders and the fund allocation to research groups taking in consideration various inputs from technical partners (FGB and the ITC/ILO) of the project.

Action 2: Gender provisional budget and research composition for each of the 5 national scientific committees

On the base of the results of the action 1 the Genis Lab team chooses the items sensitive to the gender dimension to introduce gender data concerning research teams and funded projects in the provisional budget (2015). The team is planning to introduce the breakdown of costs split by gender to the annual financial statement sent to MIUR.

Action 3: Gender pay gap

The Genis Lab team completed the action 3 providing a preliminary system of collecting and processing gender remuneration data, a simpler 'remuneration gap analysis' which gave an insight to differences in salaries among different professional profiles and education levels of employees. In particular it found a typical example of a horizontal segregation referring to the existence of, usually lower-paid, 'women's jobs'.

Action 4: Observatory for monitoring and evaluating women participation in research.

The objective is to establish a permanent observatory for monitoring and evaluation, appointed by the board, formed by: CUG working group specifically involved in Equal Opportunity, team of Genis Lab project, HR department, components of internal and external evaluation committees (CIV, CVI), coordinated by S. Falciano (member of the Executive Committee and past Vice President of the INFN).

Dimension HRM and Gender

Action 1: Align of HR strategies and management tools to EU policies (ECR and Minerva Code)

The objective is to comply with existing EU policies and tools to promote excellence and gender equality in research. Discussion is in progress with CUG and INFN Executive Committee.

Action 2: Develop and adopt HR procedures to promote transparency in recruitment, performance, promotion criteria

After preliminary analysis of competency model, meetings and seminars about awareness and promotion of INFN competency model inspired by the CERN competency model (CCM), the team working on implementation of INFN competency model. This time the work involved a second pilot unit: Frascati National Laboratories. During 2014 the main focus of Genislab activities will be on HRM dimension, particularly on the objective to develop an INFN competency-based HRM Model to improve fairness, objectivity and transparency of HR procedures.

Action 3: Development and dissemination of Guidelines on non-discriminatory recruitment and management

The objective is to ensure that all competitions and promotions processes are checked against discriminatory stereotypes and carried out in discriminatory-free ways.

The work is in progress. A first draft (focus on the evaluation assessment process: criteria, evaluation, procedures; an overview on the peer review) was shared and discussed with technical partners *Donne e Scienza* and *ITC-ILO*. Drafting of core guidelines will be provided together with competency-based HRM Model to which they will be attached. We will propose that in the recruitment phase a competency based interview be included.

Action 4: Organize training/awareness activities for managers and members of selection committees on Competency-based model

The objective is to ensure that the Model is understood and tested appropriately and that managers in charge of recruitment and performance evaluation are aware of bias free selection and performance management practices. The Genis Lab team proposed a training course titled: "Change Management - The Competency Model and Organizational Change Management", approved by CNF, held in Frascati (RM) on February 2014. Participants: top managers, administrative executives, personnel representatives, CUG, evaluation committees and Genis Lab facilitators.

Organizational Culture and Stereotypes

Action 1: Soft-skills training for managers

The objective is to upgrade managerial competences and ensure HRM practices which are free from gender bias.

In September 2013 the soft-skills training for managers was proposed to the National Training Committee for the National training program 2014 titled: "Gender balance: the development and management of human resources through the promotion of gender equity".

INFN National Training Plan was approved by National Training Committee (CNF) in November 2013 and the training will be held in November 2014. Target participants are: top managers, administrative executives, personnel representatives, CUG, evaluation committees and Genis Lab facilitators.

Action 2: knowledge and awareness raising activities on stereotypes and non-discrimination at all levels.

One seminar was organized on October 7th 2013 at Sapienza University (Rome INFN Section) with *Donne e Scienza* titled "Why to promote women in science" (by Flavia Zucco). On December 10 2013 the Genis Lab team organized a Re-ACT play at Frascati, proposed by Donne e Scienza, which involved employees together with actors in a collective research to investigate and deconstruct gender stereotypes in the scientific community. The play was based on the INFN most representative stereotypes identified during an experiential workshop held on December 3 2013. The play was attended also by INFN HR director and Frascati National Laboratories director.

6 Students and Graduates training

One of the institutional goals of INFN is the training of graduate students, young researchers. The strong synergism between INFN and the Italian Universities manifests itself also in higher-education initiatives and in training of highly qualified personnel. A large number of INFN researchers supervise higher-level training activities, with the involvement of both INFN staff and University staff associated to INFN research projects.

A first indicator is represented by the volume of training of students during their thesis work. These theses have been completed in connection with INFN scientific activities, experiments and theory projects, associated with the different Scientific Commissions. Table 6.1 illustrates the number of theses, all the 1st- and 2nd-level University theses, denoted “Laurea” and “Magistralis”, respectively, and Doctorate theses, completed in 2013 in the Italian Universities and related to INFN research projects. The theses are subdivided into the different Scientific Commissions. The 2nd- level degree is most important for the training of Highly Qualified personnel in the specific fields related to the INFN activities, before the students eventually enroll further into doctorate (Ph.D.) programs. The figures in parenthesis refer to the previous year (2012). There is an indication that the number of theses has decreased in 2013 with respect to the previous years. The substantial reduction of the 1st-level “Laurea” could be due to change in the methodology of registration of the entries in the INFN database. The new rules are stiffer and some theses are not registered properly in the database, with significant loss of records. This is more likely to happen in the Theory Sector, where the theses are not strongly associated to an organized experiment, but mainly to an independent supervisor. In addition, in few departments it is becoming more and more customary to assign the 1st-level degree without the need of discussing a thesis work.

	CSN1	CSN2	CSN3	CSN4	CSN5	TOTAL
Laurea	36	26	20	106	34	222(317)
Magistralis	60+4	33+1	26+2	119+2	47+4	298(372)
Doctorate	36	17	27	47	26	153(173)
Total	136	77	75	274	111	673(862)

Table 6.1 Number of students that completed their University Theses in INFN research programs in 2013. The TOTAL in the right column exceeds the sum by row as there are some theses which were done in Special Projects outside CSNs. In parenthesis 2012 figures. In the row “Magistralis” the figures added to the right represent the theses referring to courses (Vecchio Ordinamento) organized according to rules set up before the 2004 university reform.

The amount of effort that INFN is putting into training and education of young researchers is better understood if we compare (see Table 6.2) the number of students trained at INFN in research-related activities, to the total number of theses in physics nation-wide, obtained by the information provided in the database of the Ministry of University and Research (MIUR). The comparison shows that about 40% of all the theses in Physics are done in connection with INFN Labs or structures, or within research projects cofounded by INFN. The most recent data given by MIUR refer to 2012 for all the II-level theses (Magistralis etc.), and for the Ph.D. theses.

The Institute provides also fellowships to students at various levels of their careers, and we focus here in particular to the higher-level positions, the doctoral and post-doctoral fellowships (see

		Masters						Doctorate				
Year	2013	2012	2011	2010	2009	2008	2013	2012	2011	2010	2009	2008
INFN	298	372	386	288	302	368	153	173	174	141	139	163
MIUR	N/A	821	848	808	868	907	N/A	438	398	371	381	374

Table 6.2 Comparisons of theses carried out within INFN activities, with respect to previous years and with respect to the data extracted from the Official Ministry of University and Research database.

Table 6.3). Typically, the Ph.D. fellowships are for three years, and the post-doctoral fellowships for foreigners are issued to attract highly qualified young researchers from all over the world, to do experimental and theoretical research in INFN structures for two years. The remaining post-doctoral fellowships (Assegni di Ricerca) are about 150 and are issued directly by the Institute. INFN also subsidizes indirectly University Fellowships with funding from the Institute. It is worth to comment that the 46 PhD Fellowships are issued by INFN to the University Doctorate Schools, without putting any restriction on the research subjects selected of the candidates. This policy allows the Universities to enroll in their Doctorate programs the best applicants without any additional conditions (i.e. conditional to subjects of interest to INFN) that could introduce distortions in the selection criteria. Given the large number of INFN fellowships, the impact of INFN is quite significant.

INFN FELLOWSHIPS	#
Ph.D Fellowships	46
Post-Doc for foreigners	29
INFN Post-Doc also for Italians	155
University Post-Docs supported by INFN	46

Table 6.3 Number of fellowships and Post-Doc positions offered by INFN in 2013.

INFN fosters excellency also by awarding annual prizes to the best PhD theses. The selections of the two best PhD theses are done within each national scientific commission, CSN. The awards are named after eminent Italian physicists of the past (Conversi for experimental physics at accelerators, Rossi for astro-particle physics, Villi for nuclear physics, Fubini for theoretical physics and Resmini for instrumentation development).

INFN actively participates in the organization of schools at various levels for training students, young researchers and highly-qualified personnel. Many INFN scientists and technologists are involved in the organization of schools, in teaching university courses (doctorate, masters etc.) and in a variety of training activities. The most important recent endeavor in the training of highly-qualified personnel is the start of the courses at the Gran-Sasso Science Institute (GSSI) and the organization of the related didactic activities. For the first time, INFN plays a major role in the organization of a PhD school, while in the past this used to be an exclusive prerogative of the Italian Universities.

Another doctorate school where the INFN involvement is important is the School in Physics of Particle Accelerators, organized in collaboration with the University of Rome “La Sapienza”. There are 8 positions per year, covered by fellowships, and the teacher's board of the doctorate is made of 15 members from Italian Universities and INFN labs. INFN represents the main Institute that possesses the appropriate know-how to build accelerators in Italy.

Amongst the master schools organized by Universities in close collaboration with INFN we mention the one held in Bari, “Development and management of data centers for high performance scientific computing”, and the one held in Legnaro/LNL/Padova, “Surface treatments for industrial applications”. Both are II-level Masters, the one in Bari for the formation of highly qualified personnel that can contribute to the developments of tools, services and innovative products for industrial and scientific applications that require use of massive supercomputing architectures and high-performance computing. The one in Legnaro-Padova aims to combine the metallurgic and surface treatments knowledge with the ability to use new technologies and diagnostics, essentially for the innovation of industrial processes. In both cases the aim is the formation of highly specialized super-technologists that can also transfer in innovative industrial environments the know-how fostered in complex nuclear and particle-physics experiments.

In addition, a number of schools are held every year for training young researchers on a variety of topics and subjects. These activities are organized directly by INFN or in collaboration with other institutions. To mention a few: the International School on: "Architectures, tools and methodologies for developing efficient large scale scientific computing applications", (Bertinoro, FC) in 2013 was at the V edition. The Erice International School on Subnuclear Physics (at the 51st edition) was focused on *REFLECTIONS ON THE NEXT STEP FOR LHC.* The special topic of the Erice International School on Nuclear Physics, at the 35th edition, was on Neutrino Physics. The

International School on AstroParticle Physics European Doctorate School (ISAPP) is organized by a network of European Doctorate Schools. In 2013, the schools were held outside Italy, but ten Italian institutions (including LNGS) are involved in this network devoted to provide students with a European curriculum on astroparticle physics. Also CSN4 has a flourishing activity of training, in particular connected with the activities at the GGI institute, which were already presented in Section 2.4.

A non-exhaustive list of schools co-organized by INFN is given in Table 6.4. The estimated total number of participants to all the 2013 schools is greater than 700.

Recently, the GLV created an internal database where INFN personnel as well as associate, can upload various information about their activities strictly on voluntary basis. One of the information recorded is the number of *institutional* teaching duties held. We counted the courses given at all level for Academic Year 2012-2013 and found 24 courses held for the Bachelor (also dubbed First Level or *Triennale*), 45 held at Master level, 18 in doctorate and master schools. Even with the caveat that we are estimating this effort on a conservative side, it is a sizeable contribution by INFN researchers and technological staff to the higher education process.

6.1 Formazione Interna

Training and long-life learning is not limited to students, but it addresses INFN personnel as a whole. Indeed, from the '90s, INFN started a program of professional Training courses for its employees and appointed a National Committee for professional Training (Commissione Nazionale Formazione – CNF). The Committee promotes and coordinates training initiatives following the recommendations and under the supervision of the INFN Management. The Coordinator of CNF is a member of the Executive Board. Members of CNF appointed by INFN President are: the director of the Personnel Department, the responsible for the Training Office, two Representatives of the Directors of INFN Sections and National Laboratories, one Representative of the persons in charge for Administrative Services, the two Representatives of Researchers and of Technologists, Technical and Administrative staff sitting in the Board of Directors.

The National Collective Labour Agreement (NCLA) for public administration personnel establishes an amount (ranging from 1 to 2% of the salaries budget) to be devoted to training and professional skills development of the scientific, technical and administrative employees. The annual budget for staff training was of 2200 K€ in the year 2009. Starting year 2010, due to financial restrictions by the government, the budget is reduced to 1100 K€.

Training activities cover 3 main areas: basic technical and managerial training, scientific and technological training and health and safety training. The Personnel training office activity relies on National, multi-Units and Local Training Plans. For 2013 there were 605 proposals, 260 of which were approved. In the end about 200 courses took place. The total is split as follows (in parenthesis the number of approved proposals in each category): 20(22) National courses, 2(4) Multi-Units courses, 43(57) individual participations approved by CSN or CCR, 10(13) CSN & CCR courses. The remaining are local courses (many on safety issues and safety training in general or specific areas). According to NCLA, training plans are devoted to personnel with a contract (either temporary or permanent positions). However, provided that expenses are covered by different sources, exceptions are made to give to people associates to INFN activities the opportunity to take part to some particularly interesting initiatives.

Participants were 282 (44) females and 570 (123) males, in parenthesis we report the number of researchers. More details are available on the web page http://www.ac.infn.it/personale/formazione/ and on a widespread data base containing all information on participants, initiatives, budget, etc.

Training initiatives can be proposed by each employee and accepted as eligible at local level (Director of the Section or National Laboratory) are finally discussed with unions and approved by the CNF.

Two aspects of INFN staff training system are worthwhile noting. The first is the tendency to develop “self-tailored” initiatives based on internal expertise, if available, which are particularly effective in enhancing the personnel’s skills. The second aspect is the building of the training database, which records the training history of each INFN employee and is available for consultation.

7 A Study of the first destination of master and PhD INFN students

MASTER	PhD
PhD Italy	Post-doc Italy
PhD abroad	Post-doc abroad
Industry :IT	Industry :IT
Industry: Finance	Industry: Finance
Industry : other	Industry : other
School Teacher	School Teacher
Other	Other
Unknown	Unknown

Table 7.1. First destination of graduates, as classified by the survey.

Following comments by the CVI on the need of a quantitative assessment (possibly with international comparison) of the destination of former INFN students (Master and PhD students); this issue was addressed on a general basis.

A survey was conducted on the initial occupations of Physics Master[4] and PhD students achieving their degree in in the years 2009-2013 with a thesis focused on INFN programs. The survey program was started early in 2013: information concerning people graduating in 2009-2011 was collected by contacting students who had signed either a Master or a PhD thesis on INFN projects, and/or experiment group leaders. From 2012 on, the national contacts of INFN activities are requested to include in the annual summary of each initiative/experiment the first destination of exiting graduates students. Possible destinations are listed in Table 7.1. The data coverage is 80% and 100% for graduate classes 2009-2011 and 2012-2013, respectively, amounting overall to ~ 1600 Physics Master and ~ 800 PhD graduates. In the category “Industry: other”, an examination case by case, shown that most of the times, the industry is in the manufacture sector.

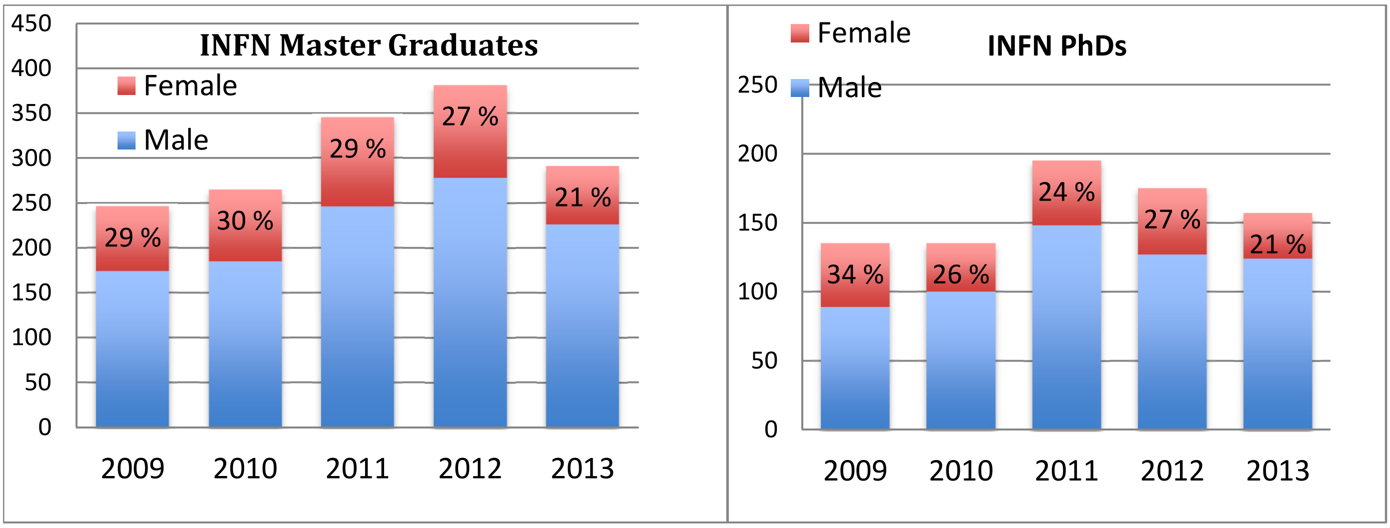


Figure 7.1 Yearly distribution of INFN graduates. Left Master, Right PhDs.

[4] By Master degree we indicate the second level Italian University degree (so-called Laurea Specialistica o Magistrale). This degree is relevant for the high-level training and educational activities at INFN, before the students eventually enroll into a doctorate program.

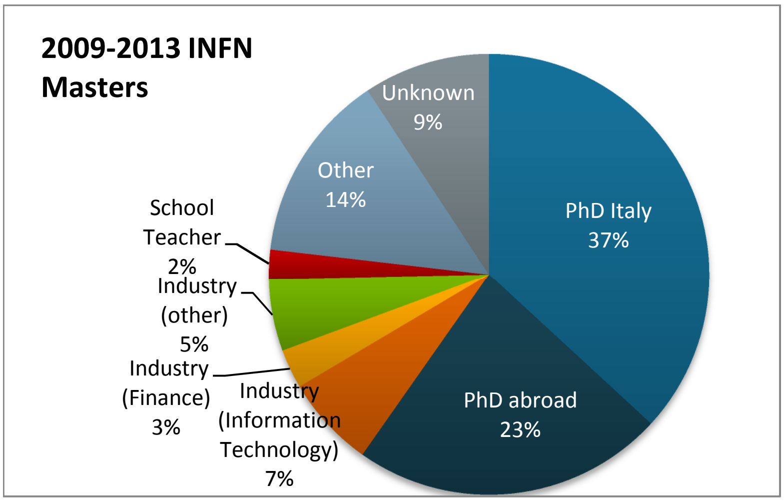


Figure 7.2 First occupations of master degree recipients, years 2009-2013

7.1 First Occupation of Master's Graduates

The number of tracked graduates versus year is shown in Figure 7.1. A marked decrease is observed in the fraction of female graduates (red bars) for 2013. The first destination breakdown by category is shown in 7.2.A fraction of 60% of Master graduates continues with a PhD program, of which 37% abroad. In the private sector, the Industry employs about 15% of graduates, with the largest proportion (7%) in the Information Technology sector. High school provides initial temporary occupation to a very low percentage (2%) of Master degree recipients; other activities account for about 11% of graduates, including post-Laurea Schools and Masters (e.g. Health Physics School). Masters' first destination by year is shown in Figure 7.3; an increase in "Other" and "Unknown" categories is observed for 2012 and 2013 with respect to former years, which can be partially ascribed to a change in our survey method, but likely, also to the short time people have had, after graduating, to find an occupation. The comparison by gender of first

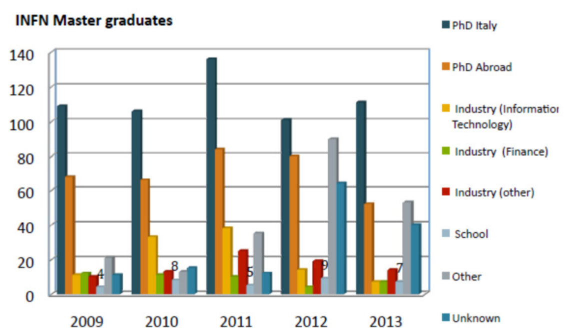


Figure 7.3 Masters' first destination, by year

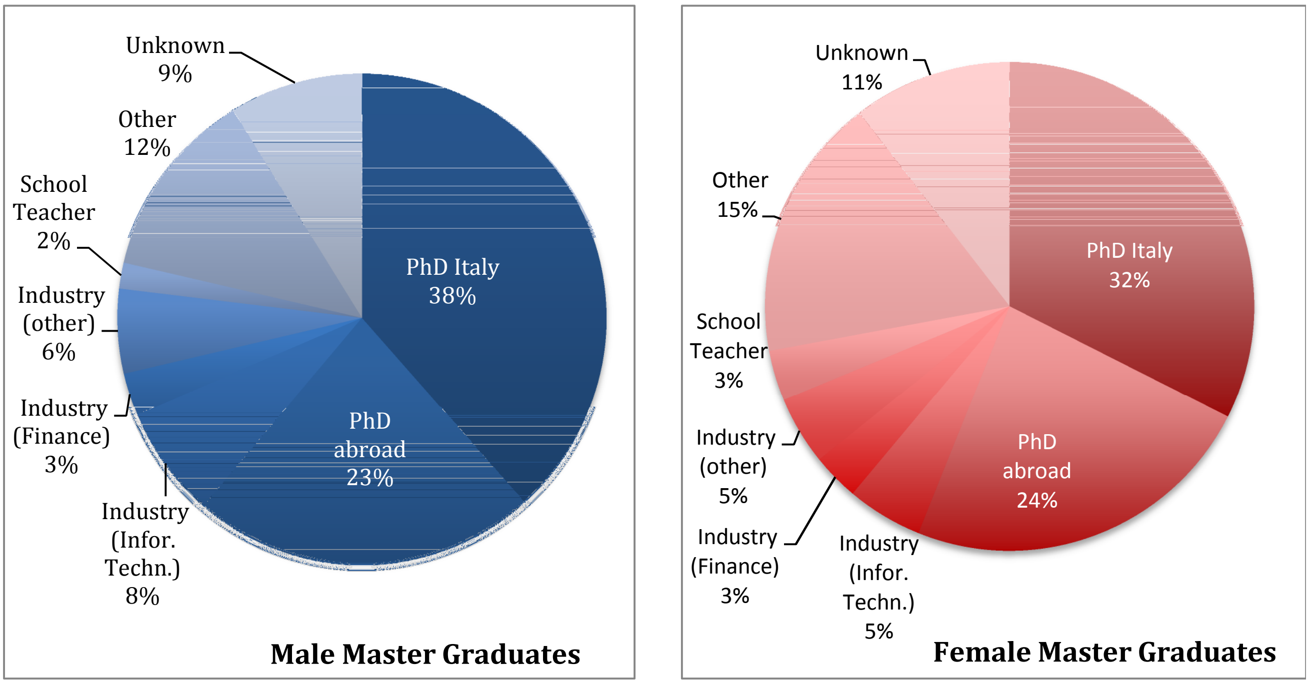


Figure 7.4 First occupations of male (left side) and female (right) Master graduates in 2009-2013

destination is shown in Figure 7.4. The average fraction of female graduates amounts to 27%, with a marked decrease in 2013 (21%). A fraction of 61% of male graduates continues with a doctorate program, a proportion slightly larger than their female peer (56%), which is entirely accounted for by the larger fraction of male graduates enrolling in a PhD program in Italy. These figures may indicate a persisting gender biased selection of PhD candidates.

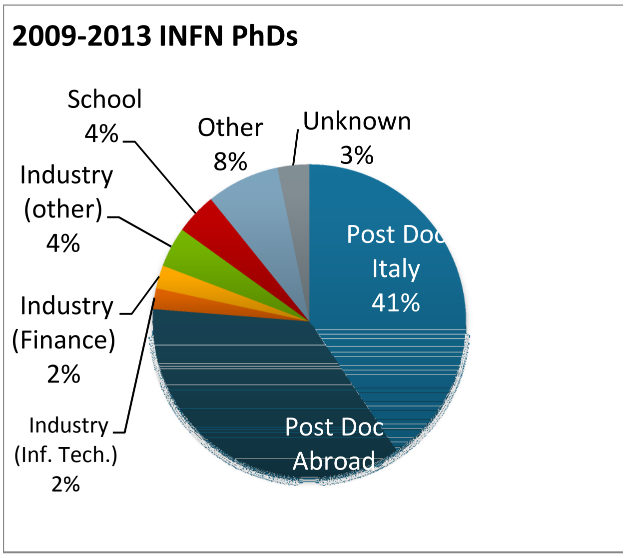


Figure 7.5 First occupations of 796 PhD degree recipients, years 2009-2013

7.2 First Occupation of PhD's Graduates

The number of tracked PhD's graduates versus year is plotted in Figure 7.5. Red bars indicate the female fraction in each year. Decrease in 2013, as observed also for female Master graduates. The initial employment of 796 PhDs is broken down in Figure 7.5. Fractions, as large as 77%, of new doctorates continue with a post-doc fellowship program, of which more than 40% abroad. The Industry employs only 8% of exiting PhDs; new Physics teachers at High Schools are 3%, mostly in temporary positions. "Other" sector includes medical facilities and hospitals, and others not elsewhere specified.

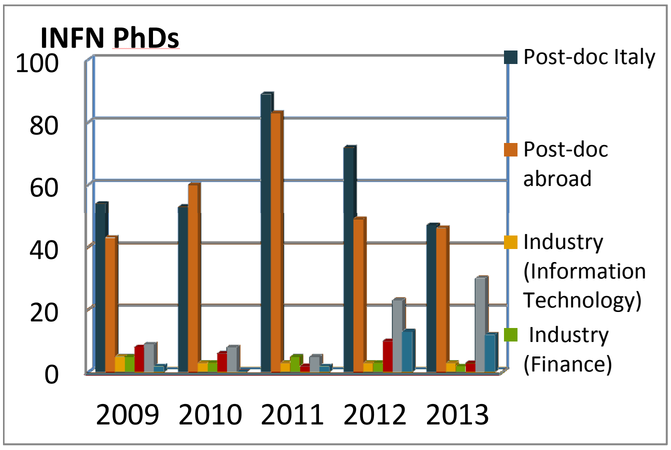


Figure 7.6 Distribution of PhD first destination, by year

The distributions by year and by category of PhD's initial destinations are shown in Figure 7.6. An increased proportion of "Other" and "Unknown" categories are observed for the years 2012 and 2013, likely due to a shorter time to find an occupation after graduating, with respect to previous years. By gender comparison of PhD's destinations is shown in Figure 7.7

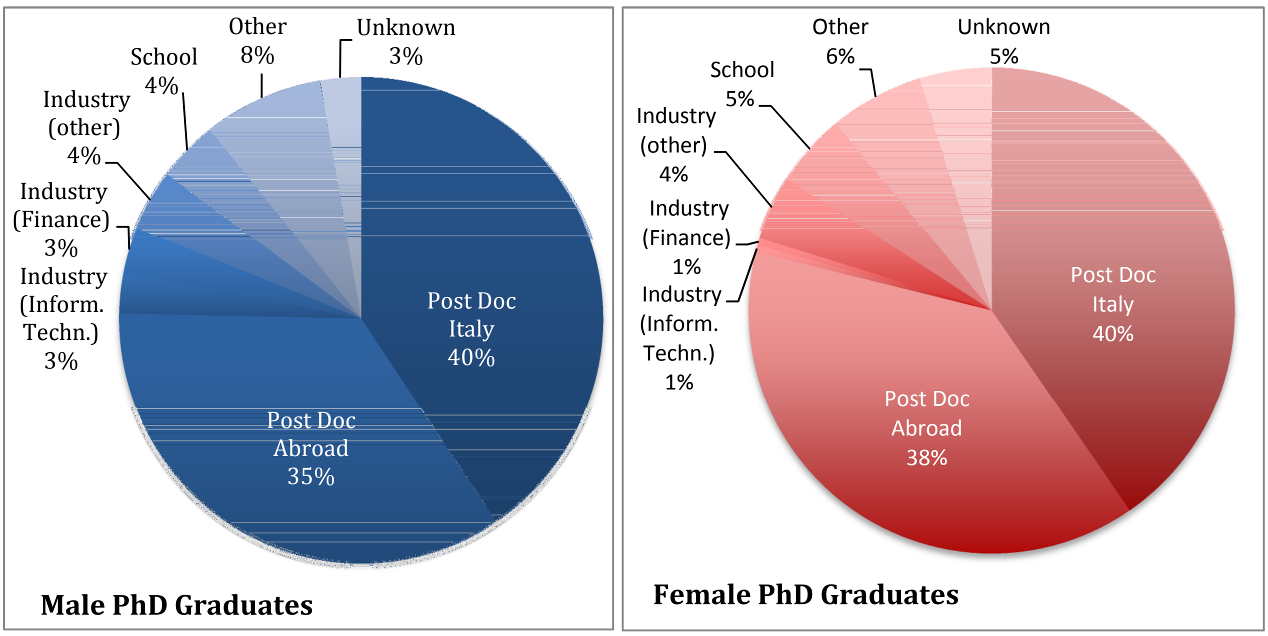


Figure 7.7 First occupations of male (left side) and female (right) PhDs in 2009-2013

Female doctorates are more willing to accept a post-doc fellowship abroad (the average fraction is 38%, with a peak of 63%) than their male peers (35% average fraction, 42% peak value). The pattern may indicate a more marked go-ahead attitude for women and/or, as noted above, the persistence of gender biased recruitment system.

8 Third Mission and INFN

INFN has been focused for more than sixty years on research. Thanks to its strong links with University, INFN personnel have always been involved with higher education aspects. From teaching to mentoring students, education has been one of the focuses of INFN researchers. Despite the fact that this facet of our activity is sometimes formally neglected (for example in VQR we were banned from listing PhD students performing their activities inside INFN as "personnel being formed"), teaching –in its wider meaning- is embedded in INFN culture.

Third Mission (3M) is a different story. In the following we will use this term to indicate all activities that do not belong to either research or education[5]. For practical reasons we sometimes separately discuss 3M activities linked to Technology Transfer (patents, Work for Others-WFO, spin off etc.), activities linked to Social Engagement and finally activities linked to continuous education (lifelong learning). However, as will see, we are trying to introduce this concept in INFN activities as a "whole". Reason is twofold. From a practical point of view it is difficult to classify an event (say a Science Fair) where we introduce both general public and potential industrial partners to our technological research under "Social Engagement" rather than "Technology Transfer-informal contacts with Industrial partners". In current literature for 3M evaluation this problem is understood and we acknowledge the difficulty, and the arbitrariness of some choices we make when we perform any listing.

Despite a formal absence of a policy for 3M, INFN personnel do engage in such activities. In the past the recording of these wide (and varied) activities was non-uniform over time and location. Due to the recent requirements of evaluation of social impact, recording has been more accurate. The breadth of the activities (from lifelong learning through stages and summer schools to activities with schools) suggests that a sizeable fraction of personnel is involved in 3M (non TT) events. One of the goals of the current management is to encourage people to get more involved in 3M (TT and non TT) activities. First and foremost because we believe that a modern Research Organization must live inside Society at large and the best way to be known and understood is to work with the "outside world". This will help in breaking an "ivory tower" attitude that can still be present within the Organization. Second, Governments (and Society at large) ask scientists to help industries (above all small and medium businesses -SMBs) to improve their capability in this period of crisis and recession. In this period of economic crisis, the existence of a World-class research organization can be an asset in much respect, from lifelong learning to know-how transfer. It is difficult to imagine that a researcher closed in an ivory tower, can transform himself/herself quickly into a person capable to talk to a SMB. It is much easier that a researcher used to be engaged in a two-way relationship with the outside world, can become a driving force towards TT.

From the point of view of evaluation, we are still refining and improving our tools. For the TT part a thorough discussion of the ongoing activities will follow in a separate section. However, as you will see, for the moment we are still a little better than at "counting activities". INFN started projects to better assess TT but, due to limited manpower, there was no improvement over the last year. For the non-TT part the data base used to record initiatives (so called "Event Data Base", EDB in the following) established in 2005-2006 was improved. First, the recording was more accurate thanks to the effort of the management. Second, with the help of the SSI and the Communication Office, a better classification scheme was adopted. Moreover, as now the EDB is linked to the main INFN page providing a national advertisement, people engaged in these activities are keener to use it in order to add visibility to the events.

After several years of experience and after cross-analysis of the EDB and of other sources we realized that individuals do perform a number of Third Mission activities that get unreported due

[5] For 3M activities and their evaluation, there is a large literature. See for example: Green Paper. Fostering and Measuring "Third Mission" in Higher Education Institution by E3M with support from the EC, in the Lifelong Learning Programme of the EC., Available at http://www.e3mproject.eu/results.html; also the final report of the ESF Forum on *Science in Society*, available at http://www.esf.org/coordinating-research/mo-fora.html.

to a variety of reasons. Therefore in May 2013 we launched a new initiative. A self-filled DB in which every person associated with INFN (staff or not) can file her/his own activities. There is a wide variety of options: from mentoring to outreach; from teaching in University to high school students seminars; from tutoring to masters. We allow people to fill a number of entries. This initiative is still in its infancy, but we hope to get a better (i.e. more complete) picture of 3M (and also teaching) activities performed by INFN researchers and technologists.
In spring 2013 the Italian ANVUR organized a Workshop on "Measuring 3M activities". During the Workshop one of the Working groups was devoted to "Measuring Science in Society Activities". Based on the VQR experience, as well as on a number of experiences in Italy and abroad, one of the key points was that, due to their own nature, this kind of activities needs to be reported by individuals rather than by Academic/Research Organization. Our internal DB is a first attempt in this direction. After a few months we already have more than 200 individual 3M activities listed. While still in its infancy, this DB collects a number of interesting data.

8.1 Technology Transfer

Part of the INFN mission has always been devoted to the transfer of know-how to industrial firms and to nurture technological developments. Over the years the increasing number of contacts with industries has created a kind of "diffused technological district" that, although not geographically determined, constitutes *de facto* a pool of high tech realities.

The need for Italian firms to play on the global market has increased the request to research institutes to transfer more research and innovation to our industrial sectors. In order to meet this new challenge, INFN management took several actions. First the (already existing) Comitato Nazionale per il Trasferimento Tecnologico (CNTT) was strengthened in its role of coordination of the Technology Transfer (TT) activities as well as scouting for internal know-how. In order to match this increased attention to the needs of external users, a dedicated Office was set in the Central Administration (TTO). This Office is an important support for the CNTT and all TT activities as it covers the administrative part as well as the management of the Intellectual Property (IP). For the scouting activity a network of dedicated people (TT Referents), one per INFN Unit, was created and supported by continuous meetings and training sessions. TT Referents shall become the backbone of the TT action in all what regards local scouting and valorization actions, acting as a link between the central TT organization and the different units. In the last year several general meetings of TT Referents took place in order to exchange ideas, good practices and set the base for a change of attitude. The TT activities are also coordinated with the CERN Technology Transfer Network.

We believe that, given the present INFN expertise, we can contribute to several areas :

- Biomedicine. From medical imaging to radiation treatment, real time dosimetry and cellular evolution, radiopharmaceuticals.
- Cultural Heritage studies and protection using non-invasive nuclear techniques. There are areas where we already have great expertise.
- Environment studies through nuclear techniques (with and without beams). There are already ongoing programs to study radionuclides in collaboration with IAEA; LABEC is participating in European Programs in this area.
- Information Technology for the citizen. We are participating to Smart Cities programs where we bring our expertise in the field of cloud and distributed computing.
- Acceleration technology for medical and industrial applications.
- Product innovation involving advanced electronic solutions and sensors.
- Applications in the frames of Active and Healthy Ageing.
- Laser retroreflectors for precise positioning (geo-referencing) in space with application to satellite navigation (European Space Flagship "Galileo") and to Earth Observation

(European Space Flagship "Copernicus", formerly in FP7 called GMES, Global Monitoring for Environment and Security). Same technology for precise ground geo-referencing networks (Copernicus ground segment). Same laser positioning technologies are of interest for solar system exploration in the framework of the NASA-INFN Partnership.

CNTT also organized several topical seminars in INFN units. The goal was both to scout for new technological opportunities to be valued and to raise awareness of the opportunities of TT.

The development of a portal (http://www.pg.infn.it/cntt7/) for both internal and external use has enormously increased the exchange of information among people participating in the TT activities as well as an entry point for external partners. One of the important achievements in 2013 was the streamlining of several activities for IP and TT, also thanks to new manpower available in the dedicated office.

A very important, quantitative result was obtained by the shortening of time between internal request of patenting to the INFN office and actual licensing. The aim is to further shorten this time lag to less than 60 days (see Figure 8.1).

INFN activities in the last year can be summarized as follows:

- Intellectual Property: improve the rules to protect and value what is created within the Institute. Also set the mechanisms to award personnel participating in these activities (including spin-offs, Work For Others-WFO etc.).
- Scouting and training of people in INFN Units.
- Support of participation to collaborative calls (at any level).
- Analysis of the impact of our activities within society.
- Synergy with international partners (i.e. Technology Transfer Office of CERN).
- Stronger link of the TTO with other INFN services: legal service, external funds service, press office.
- Collaborative agreements with some important Italian firms.

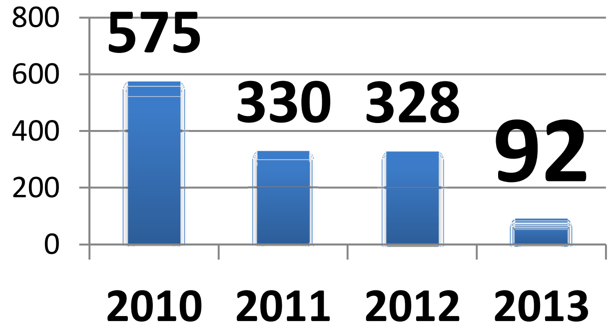


Figure 8.1 Days between proposal for patent and actual request

A huge effort has been carried out, starting in 2013, to revisit the TT rules of the Institute. A new set of rules will be submitted in October to the Board of Directors together with a set of guidelines for the administrations. These new rules will bring assignment of TT tasks to the INFN Units rather than to the central TTO with the constant help of the CNTT. This new scheme of assignments will speed up any TT administrative process. Results and impact of this new strategy can be evaluated only in one year from now.

The collaboration with the national industry has been highlighted by means of research agreements with some important firms having a long standing tradition of collaboration with INFN. These agreements address research topics of common interest, include exchange of personnel and financial support for young people with technological skills. A cooperation agreement between INFN and Confindustria will be signed soon, several specific regional agreements will follow on definite topics under this general framework agreement.

From the point of view of unique capabilities, the INFN expertise in building and running accelerators is widely recognized. In this perspective the construction of the ELI-NP facility (separately discussed later in this section) is another case of TT activity that, although brokered directly by the Giunta Esecutiva, is a case in point.

Impact	**Humanitarian and economics benefit** Leverage Technology for humanitarian and economic benefits Impact on the national economy **Financial management** Spend taxpayer funds responsibly
Strategic benefit	**Technology Leveraging** Organize technology to increase return on R&D investments **Minimize cost of innovation** Find cost effective solutions to face complex problems; improve the make-vs -buy decision process; reduce financial burden of innovation **Enhance Recognition and prestige** Improve rankings, leading to more funds for research
Innovation Management	**Innovation spirit** Foster the innovation spirit to maximize innovation **IP Protection** Capture and protect IP innovations

Table 8.1. Targets of TT

8.2 Measuring Technology Transfer activities inside INFN

The measurement of TT activities is a difficult task as there are many factors (internal and external to the performing organization), that are difficult to measure. Besides, sometime, even defining a metrics can be a distortion. At this stage we would rather consider *indicators* for which we set metrics but without any suggestion to take them face value to *measure* TT.

The purpose of a performance metrics is to measure how well a given program meets its goals. Without a clear mapping of the metrics to the goals, the metrics activities lose their principal meaning. Therefore, before establishing performance metrics, it is important to state the TT program's goals then define the metrics as support to achieve those goals. A public research organization like INFN places an emphasis on the public benefits to be gained from its research. In this respect, technology transfer is understood as a mean to serve the society and the program goals reflects this attitude. A listing of TT goals is given in Table 8.1

Being INFN a public research organization devoted to fundamental research on particle physics, the research activity has aspects and starting point that allow the transfer of know-how and technology towards different disciplines and towards the industrial world (in a wide sense). Trying to list a few of them we can indicate:

- The level of complexity of most experimental activities is such that most detectors and technologies are developed by researchers. In this way we directly tackle the existing limits and –if needed- they are overcome. This does not only apply to sensors and radiation detectors but also to microelectronics, accelerator techniques, engineering of complex system, to software (to name a few). In more general terms we can assert that, to fulfil their goals, within our context of international competitions, our scientists push technologies to their limits and develop innovative methods.
- Experiments are international endeavours developed by large collaborations. As such our researchers and technological support staff develop an attitude to work in a collaborative way on a competitive basis. Also they learn how individuality is appreciated in such competitive environments.
- Experiments require large international commitments, both in terms of human and financial

Licensing			
Metric	2011	2012	2013
# licenses/options active at 31.12.YY	3	3	6
# licenses granted to Italian enterprises	1	1	3
# licenses granted to EU enterprises	2	2	3
# licenses generating revenues in the year	0	2	3
# licenses linked to a patent	3	3	3
Revenues from licenses active at 31.12.YY (K€)	***0***	***20***	***20***

Table 8.2 Licensing, years 2011-2013

resources. Several times the large quantities involved need a tight connection with industrial firms. This implies that businesses involved in our sector interact often with researchers that are –in turn- confronted with the needs of the various firms.

Starting from these premises, INFN is developing a strategy to transfer technologies and know-how following a model in which the Institute, together with other Research Organizations and firms, runs collaborative researchers aimed to innovation. This is obtained in Consortia, Joint Laboratories working on behalf of third parties and *spin-off* companies.

This frame is also coherent with the development of the physicist as a professional able to integrate in the production world and in society at large thanks to his/her scientific training, specific capabilities and to his/her capacity to deal with different problems in various sectors (biology, medicine, cultural heritage, energy, ambient protection).

Based on the previous consideration, the traditional metrics generally adopted to quantitatively assess the performance of a TT Office are not strictly applicable to the INFN model. These metrics are essentially based on the Intellectual Property management that deals with new inventions protection, patents, licensing and other financial aspects of the technology transfer process.

To better understand and evaluate the outcomes of the new technologies and processes developed to run the INFN experiments and their impact on the industrial sector and on society at large, a new metric is needed that takes into account both direct outputs and indirect outcomes of the Technology Transfer process matured within the INFN. Another important aspect to consider is the so called "human capital" of INFN researchers and technologists with their high specialized skills in advanced technologies applied to electronics, mechanics, computing and data analysis. These competencies are very appealing for the corresponding industrial sectors and INFN personnel is often asked for collaborative research with companies, consulting and training activities. Last aspect (but not less important than the others) of TT to measure is the outreach. The number of press releases related to tech transfer as also the public outreach event supported and a dedicated website contribute to communicate the INFN value to society and to make the general public aware of the benefits deriving from fundamental research.

Intellectual property management			
Metric	2011	2012	2013
# Invention Disclosures	5	7	20
# Confidentiality Agreement	Na	Na	Na
# priority applications filed (in Italy)	1	7	10
# patent applications filed	1	7	15
# patents (both applications and patents issued) active at 31.12.YY	5	10	20
Expenditure on legal support for patenting process K €	20	19	47

Table 8.3. Intellectual property management. YY=2011-2013

As indicated in last year report, we divided the structure of the TT measurement system in five areas:

a. *New Technology*
b. *Collaborative-Public/private Partnerships for Research and development*
c. *Scientific Work Products*
d. *Professional Valorisation*
e. *Outreach*

a. *New technology*

This area comprehends the *Intellectual Property (IP) management, licensing and spin-off support*. The development, patenting and licensing of new inventions remains an important part of Technology Transfer. Table 8.2 and 8.3 report the situation for Patents and other IP initiatives. Besides the traditional metrics (number of invention disclosures, patents, licences, royalties in the fiscal year), the number of spin-offs created or active in the year, their incomes and the number of jobs created are considered as performance indicator of the TT process.

b. *Collaborative-Public/private Partnerships for Research and development*

An effective way to transfer knowledge and technology to the industrial world is through collaborative research contract (CRC). CRCs remain an important tool for collaboration between public research organizations and other organizations and an important way to gauge cooperation. Some figures that can be collected (and used) are:

- Total number of CRCs
- New CRCs in Fiscal year
- Resources generated from CRC (also in-kind) in the fiscal year
- Other collaborative agreements active in fiscal year (NDA, research contracts, Third-party contracts)
- Revenues from Other collaborative agreements active in fiscal year
- Number of Partnership in competitive calls (i.e. EU project calls, national and regional project calls)

c. *Scientific Work Products*

Although intellectual property has traditionally been tracked as a measure of TT, most of INFN research results are transferred through publications of scientific articles. Patent protections for all research innovation is expensive and it is not the only way to transfer know how. Therefore, by monitoring the volume of peer-reviewed publications, the amount of knowledge transfer to society can be measured, even when technologies cannot be patented. Furthermore, the impact that the INFN publications has on industry can be indirectly measured through the proxy of patent citations of INFN articles and full text download statistics. We have devised a plan to tracks this part of our impact but we lack human resources to pursue it directly. Therefore we started collaboration with LIUC University (Università Carlo Cattaneo in Castellanza, VA) to this aim.

d. *Professional Valorisation*

Concerning the transfer of know-how from INFN researchers and technologists to industry, we propose a set of parameters:

- Professional training courses held by INFN personnel;
- Secondment periods;
- Number of Equipment and facility services requested by third parties.

e. *Outreach*

The metric proposed for the dissemination of the TT achievement to the general public is composed of the following parameters:

- Number of press releases related to TT;
- Number of public outreach events supported by INFN;
- Number of presentations given;
- Number of website hits.

The largest effort in 2012-2013 was to set-up the appropriate metrics to start monitoring the performance of the TT program's goals in a consistent and homogenous way through the years. The next step will consist of developing and implementing a process to consistently capture the data needed to drive the metrics as well automatic reporting capabilities. Such a process will be truly efficient when integrated with other databases for tracking progress through the technology transfer

Spin-off support			
Metric	2011	2012	2013
# spin-offs created in the year	1	2	0
# spin-offs active at 31.12.YY	2	3	3
# active spin offs with external funds participation	0	1	1
# active spin-offs with industrial participation	0	1	1

Table 8.4 Situation for spin-offs in 2011-2013

pipeline. At present, the procedure is not yet optimised and in particular the information retrieval is the bottle-neck. As a matter of fact, data reside in different databases and are managed by different administrative offices, thus making data collection a complex and time-consuming task. For this reason, in this report we are able to present only a sub-set of the proposed indicators. In this respect this report is not changed with respect to last year.

In particular, tables 8.4-8.5 list the values of a set of parameters targeting the TT area of Spin-Offs and collaborative research activities. Data have been collected and organized by the Technology Transfer Office (TTO) of the INFN and refer to fiscal years 2011, 2012 and 2013. As for the spin-offs, they are described in the following paragraph.

Spin off

INFN understands the need to nurture technology transfer. Depending upon the economic contest, spin offs are a way to obtain this goal. In the following we will describe the three companies that started in 2012 as soon as the new INFN regulation about spin-offs was set in place.

DIXIT srl (Turin)

DIXIT srl was born thanks to the INFN research in the field of distributed medical image analysis, carried on through the MAGIC-5 project between 2004 and 2011. The initial stimulus came from a group of clinicians that was implementing a multi-center clinical trial that required the time-constrained exchange of PET/CT scans between the recruiting centers and the panel of reviewers.

WIDEN (Web-based Image and Diagnosis Exchange Network), was developed starting in 2007 and has been on the market since 2011: it offers a customizable implementation of the workflow in imaging-based clinical trials, together with a high-level real-time quality control on the compliance of scanners and scans to the clinical trial protocol. Among its customers you can find the Fondazione Italiana Linfomi (FIL), the Swiss collaborative group IELSG, the Centre Antoine Lacassagne in Nice. WIDEN is being used by about 200 health facilities in the world in more than 10 clinical trials. The service is continuously evolving with new functionality, with the goal of making a PET quantitative assessment reliable.

Currently, one person is working full time on DIXIT, with contributions from the co-founders in the R&D phase. Administration and financial activities are outsourced.

R&D is particularly important: 3 patents were filed in the EU, 1 in the US. Other products, presently not disclosable, are being developed. The 2012 and 2013 budgets show a positive result, although the

PiXiRad Imaging Counters srl (Pisa)

PIXIRAD Imaging Counters srl was born as INFN spin-off company in March 2012. Its main goal is to bring to the market innovative, high-tech detectors for X-Ray imaging applications in the medical, industrial and scientific fields. The technological foundations of the company rely on the long experience and know-how of INFN and of the INFN Pisa team in the development of advanced radiation detectors based on the highest possible integration of solid state sensors and their read-out electronics. In its initial phase PIXIRAD was a partnership between INFN physicists and engineers and external experts with a long successful experience in creating and managing X-ray imaging companies and in VLSI technology.

Metric (K€)	2011	2012	2013
Revenues from research contracts in the year	190	214	60(*)
Revenues from research contracts and consulting activities signed in the year	15	152	82

Table 8.5. Revenues from collaborative research activities.
(*) Data to be checked

In September 2012 the distribution of the company shares was reshaped to give room to the participation of a Venture Capital (VC) initiative. This brought to the company the financial resources to address further technology advancement. PIXIRAD has currently 2 direct employees (engineers) and 5 contractors. The main product is based on Chromatic Photon Counting technology. It represents a radical leap forward compared to the standard methods currently available on the market. PIXIRAD detectors are able to count individually the incident X-ray photons and to separate them in real time according to their energy (high speed spectroscopic X-ray imaging). The individual PIXIRAD detection block is a two or four side buttable semiconductor radiation detector made of a thin pixellated solid state crystal (Si, Ge, GaAs) coupled to a large area VLSI CMOS pixel ASIC (512×476 pixels). Among the initial targets, PIXIRAD has shown up to now the greatest impact in the industrial and scientific markets (X-ray diffraction, Non Destructive Testing, Synchrotron labs) with a steadily growing rate of sales.

I-See srl (Turin)

I-See (Internet-Simulation Evaluation Envision) is a high tech start-up operating in the field of Monte Carlo simulations and wed-based software. I-See is an academic spin off of the University of Torino and the local unit of INFN. Created in May 2010, I-See expertise is the result of 15 years of experience in the field of simulations, radiation effects and their application in oncologic field within the department of experimental physics and the national institute of nuclear physics in Torino. I-See comes up with a solution: the web applications (web apps) for fully customized MC simulations according to the requirements of the final users. The I-See computing service, thanks to its original modality makes a difference mainly thanks to its high level know how in advanced radiation therapy technique, a customized set of products aimed to solve the specific requirements of its clients, a scalable solution, and a fast answer thanks to the use of parallel computing.

Service is based on annual subscription and its first customer is CNAO center in Pavia. While the portfolio of ready-to-use apps is widening, this company is also hiring new professionals (a physicist and a computing scientist). In its fifth year of operation, and with a larger set of customers, it plans to consolidate its financial position by including a venture capital in its board.

This spin-off won the third prize for the best start-up in the Turin-Piedmont area.

The European Collaboration EuroGammaS and ELI-NP

In the context of the ELI-NP Research Infrastructure[6], which is in construction at Magurele (Bucharest, Romania), as one of the three ELI (Extreme Light Infrastructure) Pillars - the one devoted to Nuclear Physics and Photonics - an advanced Source of Gamma-ray photons is under development, capable to produce beams of mono-chromatic and high spectral density gamma photons, up to two orders of magnitude better than present state of the art. The aim is to open the era of nuclear photonics and pursue advanced applications, not addressable nowadays, in the field of national security and nuclear non-proliferation, nuclear waste treatment, nuclear medicine, as well as fundamental studies in nuclear physics, dealing with the nucleus structure and the role of giant dipole resonances in star nucleo-synthesis.

The Gamma Beam System is based on a Compton back-scattering source. Its main specifications are: photon energy tunable in the range 1-20 MeV, rms bandwidth smaller than 0.5% and spectral density lager than 10^4 photons/sec·eV, with source spot sizes smaller than 50 microns, brilliances larger than 10^{23} (ph/s·mm^2·mrad^2·0.1%bdw) and polarization of the gamma-ray beams larger than 99%.

In order to design and build a machine capable to meet these challenging requirements, a

[6] http://www.eli-np.ro/

European collaboration has been formed among the following Institutions: Istituto Nazionale di Fisica Nucleare, Università di Roma La Sapienza, Université Paris Sud, CNRS/IN2P3, and STFC. Several Industrial Partners joined this Collaboration (EuroGammaS) from several European countries (Italy, Denmark, France, Germany, Slovenia, Sweden), together with many sub-contractors[7].

In May 2014, after three consecutive open European Tenders had been issued by IFIN-HH[8], EuroGammaS was appointed with the contract for the construction and commissioning of the ELI-NP-GBS in Magurele. EuroGammaS has a financial support of 67 MEuro, and 4 years to accomplish the project, which is due by the end of 2018 (delivery of the gamma ray beams to the users). By contract, EuroGammaS has been recognized as the sole and best provider world-wide for this kind of advanced and completely new machine. Within EuroGammaS, INFN has been leading the Collaboration since its very initial phase, thanks to its profound expertise on high brightness electron beams and advanced radiation sources, mainly developed at LNF (Laboratori Nazionali di Frascati) in the context of SPARCLAB. Therefore the Institute took responsibility of the scientific coordination during the preparation of the machine TDR[9].

INFN has taken also the leader role of coordinating most of the industrial partners for the construction of several machine components, the photo-injector, and the integration of all machine components in Magurele at the ELI-NP site, and the services and utilities design and construction, involving the relevant expertise in these fields of the Acceleration Division of LNF. Not to mention that INFN is leading the EuroGammaS members also regarding the legal commitments and liabilities against the customer requests linked to the contract clauses on penalties due to late or incomplete/unsuccessful deliverables of the gamma ray beam performances.

The machine is based on a C-band RF Linac equipped with an S-band photo-injector similar to SPARC, delivering a high phase space density electron beam in the 250-720 MeV energy range, colliding with a high power laser to produce via Compton back-scattering the gamma-ray photon beam, as described in the machine TDR. The RF Linac will work in the multi-bunch mode, in such a way that the amplified laser pulse colliding at the interaction points will be recirculated: the laser recirculator is a new optical system that has been conceived, studied and designed by the EuroGammaS collaboration, and will represent a significant advancement in the technology of Compton Sources[10].

The formation and characterization of the mono-chromatic highly collimated gamma ray beam is achieved thanks to an innovative collimator system and by a complex detection apparatus, able to measure the spectral behavior and intensity characteristics of such a challenging gamma ray beam.

8.3 Dissemination of Scientific Culture and Service to Community

INFN is well aware of the increasing importance of dissemination of scientific culture and outreach activities and, since 2011, has put renewed enthusiasm in organizing (or participating to) events devoted to public at large. Thanks to the actions of the Communication Office, active at the INFN Headquarters for several years, and of many people contributing from several INFN Units as well, a large number of initiatives have been realized. The positive outcome during VQR 2004-2010 is an additional stimulus to improve and refine our efforts.

2012 was a very peculiar year, marked by the Higgs discovery and the worldwide media coverage acted as a lens for Italian media to focus on INFN work at CERN as well as on INFN work in general. Last year (2013) we still saw the aftermath of the big excitation following this discovery

[7] http://www.e-gammas.com
[8] IFIN-HH is Rumanian institution beneficiary of the ELI-NP funding.
[9] ELI-NP-GBS Technical Design Report, http://arxiv.org/abs/1407.3669
[10] K. Dupraz et al., Phys. Rev. STAB **17,** 033501 (2014).

and the recognition with the Nobel Prize to the people who first developed this idea.
In the following we provide some statistics and some classification of the events we organized and/or co-organized, and we will also show that we did not forget to take this chance to present the overall picture of our activities.

The Communication Office (also UC in the following) is the central actor of INFN relationship with media at large. Its excellent coordination Office spans all the communication aspects, from media relations to institutional communication and outreach activities. This allowed the presentation of the nuclear and particle physics researches and their more relevant results to a very large number of people. The Office is strategically based in the center of Rome, nearby the main media headquarters. INFN is the major particle physics communication source in Italy and the only big research institute which focus on particle physics as its main research theme. The core of INFN communication work is to empower Italian media and public's interest on particle physics research and its possible applications, and acts as a reliable source of information for the media system.

The Communication Office produces press releases, visual and audio material for the media system. The communication flow usually starts with a press release written with the direct contribution of the researchers involved and released after the approval by the President. In order to raise the interest of Italian media on particle physics, INFN is following a strategy based on a wide offer of information and multimedia tools such as infographics, images and video. These products are designed to be suitable in different contests and to appear on various media, such as the page of a newspaper, a web site or an exhibition. INFN has also a Facebook and a Twitter profile.
In 2013 we scored more than 100 news and press releases with 1792 citations on the press and on the web, 74 on TV media. Starting from 2007, the presence of INFN on the media has increased significantly, spreading the idea of INFN as a focal point for the communication issues not only on LHC but also on physics in general.

The communication office manages and almost daily updates four website: www.infn.it, the official and institutional website of INFN, www.infn.it/comunicazione, the communication office website focused on media and disseminations initiatives, www.asimmetrie.it, the website of the institutional INFN magazine and www.infn.it/lhcitalia, completely dedicated to LHC and to the Italian research community working at LHC experiments.

The Communications Office conceives and sets up exhibitions for both museums and scientific or cultural festivals. In the first category we find:

- *L'energia del vuoto*, January 19th – February 10th, Bologna (about 35.000 visitors);
- *Il Dono della Massa*, September 27th in occasion of the European Researchers' Night, CERN, Geneve (about 5000 visitors);
- *L'Italia del Futuro* (promoted by the Italian Ministry for Foreign Affairs and in collaboration with other scientific Institutions), Tokio, Los Angeles, San Francisco, Budapest;
- Memoria/Futuro, ONU, Ginevra (in collaboration with other Institutions).

INFN UC also invented and developed a new kind of show format for science dissemination. The show *Quello che non so* opened the 2013 edition of the Genova Science Festival. This format told the public (400 people) about all the things we have yet to discover about our universe and nature and about the latest and most fascinating scientific challengers. The show was performed in Genoa on October 23rd, 2013 with the participation of Guido Tonelli (former spokesperson CMS experiment at LHC, CERN), Caterina Biscari (Director of Cells Alba laboratory in Barcelona, Spain) and Antonio Zoccoli (INFN Executive Board and ATLAS experiment at LHC, CERN).
The UC also organized a public event as part of the cultural manifestation "Libri Come" at the Auditorium of Rome, on March 14th, 2013. The event was mainly oriented to high school students and more than 700 people attended it. Fabiola Gianotti (former spokesperson ATLAS experiment at LHC, CERN), Guido Tonelli (former spokesperson CMS experiment at LHC, CERN) took part to

LNF	2013	2012	2011	2010	2009	2008	<04-07>
Masterclasses/winter stages	280	82	83	77	174	67	62
Guided tours / Week of Science/Open day	1900	2500	2810	2855	3162	3650	3700
Physics Meetings for High School Teachers	200	230	200	149	250	152	1950
Summer Stages	214	125	104	89	157	94	97
Conferences and Lectures	130	820	945	1110	320	371	657
Quasar programme for primary school	750			290	241	520	N/A
Science Festival and Scientific Coffee	--					238	530
Researchers Night and related events	--	1450	300	220	700	600	900
Training Courses for High School Students	221	950	465				
LNGS							
Visits to the Laboratory	2340		6263	7300	10000	9800	4000
Open day	1100	2000	1600	1600		1200	1420
Training courses for teachers	100			50			140
Summer School	25	20	45	25	20		
LNL	130						
Guided tours/Open day	768	800	662	1050	1080	950	1110
Stages for students	5	50	185		10	57	33
Scientific Exhibition “Sperimentando” (in Padova)	9000	10100	9560	12000	8243	7753	3890
LNS							
Guided tours	750	780	615	700	350		
Week of scientific culture/Special Events/Researchers Night	2700	1500	2665	2500	2050	2000	1940
Physics Olympic Games	120	150	110	120	120	200	100
Summer stages/Masterclasses	N/A	50	424				

Table 8.6 Some events of dissemination of Scientific Culture at INFN National Laboratories. Last column is the avg for 2004-2007. *La Notte dei Ricercatori* started in 2006.

the event, together with Luciano Maiani (former CERN Director General) who presented his book *A caccia del Bosone di Higgs*.

The UC oversaw the participation of the INFN President in the events “Higgs in campo” where also the interactive exhibit “Il Dono della Massa” was set up at the edge of a basketball court in occasion of an important match of the Italian championship.

The Communications Office realized in collaboration with CERN, ESA, ESO and UNESCO *Origins* an international event in Bologna, Geneve and Paris in occasion of the European Researchers’ Night.

The UC oversaw the INFN participation in the Festival di Scienza e Filosofia in Foligno and in the Festival della Filosofia of Modena, Carpi, and Sassuolo with the talk *Il sentimento del Bosone* held by the INFN President and the APPEC Director (more than 400 people as public).

The Office also shares the responsibility for ***Asimmetrie***, the institutional magazine edited by INFN. Each issue is a monograph on frontier physics researches currently developed by INFN. Target of *Asimmetrie* are both the institute researchers and the high school students who are reached through their physics teachers. Authors are INFN researchers and the editing process is guided by the Communication Office. *Asimmetrie* is also an online review entirely available on the website www.asimmetre.it. Everyone can receive it by compiling the online form.

The Communication Office represents Italy in 3 international networks. **EPPCN** (European Particle Physics Communication Network), established with the aim to strengthen the communication on particle physics, and, in particular on LHC, in European CERN member states, is mainly composed by communicators. **IPPOG**, the International Particle Physics Outreach Group, promotes the outreach activities of particle physics institutes and laboratories in the CERN Member States. **Interactions**, a communication resource from the world’s particle physics laboratories, which

provides press release, news, images and documentation material about experiments, infrastructure, laboratories.
Scientific dissemination and outreach take also place in many local INFN Units, always in close contact with the Communication Office. Some of initiatives in the INFN National Labs in 2013 are shown in Table 8.6; previous years are also reported for reference. Many of these events, as usual in INFN, intertwine outreach, education and training. It is also important to note that often the dissemination activities at INFN National Laboratories are performed in close collaboration with researchers of other INFN units, in particular the nearest ones.

To assess this overall dissemination score in an international framework, Table 8.7 compares the total number of visitors at INFN laboratories to the number of visitors at some major national laboratories abroad. This year several laboratories have not (yet) answered our request for information.

Always large is the number of initiatives targeted to schools. They are normally addressed to high school students but there are also examples of different targets. For example *Incontri di Fisica*, addressed to teachers, at LNF saw the participation of about 200 teachers in 2013. LNGS organizes also a competition, "*Anch'io scienziato*", which is now at the 11th edition. In this initiative all Abruzzo pupils of all ages (K-12), are encouraged to present their original works and projects, as true scientists; the total number of participants grew to 730 in 2011 to more than 1700 (most of the

Laboratory	2013	2012	2011	2010	2009	2008	2007	2006	2005
CERN (CH)	97000	163000	76996	55929	37632	23693	25491	26110	24380
TRIUMF (CND)	N/A	3260	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FERMILAB (USA)	N/A	22300	33624	34029	31633	29250	12200	14726	17600
JLAB(USA)	N/A	20500	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SLAC(USA)	900(*)	10300	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DESY (D)	N/A	7600	21070	17000	20350	6575	7725	7682	8348
IHEP (CHINA)	N/A	5000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
KEK (JP)	20200	21500	12185	13603	13842	11793	12038	8859	6666
INFN (IT)	22500	22000	28937	30345	27057	28252	28095	19095	22637

Table 8.7 – Number of visitors in foreign and INFN laboratories in years 2004 to 2013. SLAC suspended its tour program in 2013.

increase is due to grade K-5). Like in the past, in 2013 several INFN sites hosted the selections of the *Physics Olympic Games*, often offering students the opportunity of visiting a scientific laboratory. Participation of INFN sites to the European Master classes is increasing (in 2013 almost all INFN units took part) http://www.physicsmasterclasses.org), with more than 1000 students from Italian high schools. It is worth noticing that the Italian edition of Master classes is coordinated by the Communication Office that obtained, for 2013, a financial support by MIUR.

Since May 2013 ANVUR provided INFN with a scheme to classify our Third Mission activities aimed to the dissemination of scientific culture, therefore we decided to make an exercise and reclassify our activities accordingly. The taxonomy itself is made of 13 sets each one with its own subset. A good fraction of our initiatives can be classified as *Service to Community*. In this category we have projects with schools, local events and/or projects organized within the community where our Units/labs are located. There is also a strong dedication to *Science in Society* (Open days, scientific fair, exhibitions, web sites, institutional involvement in dissemination of scientific culture). However, interesting enough, our initiatives aimed to re-train professionals (Master) or provide secondary school teachers with formal refresher courses (for example in Frascati the *Incontri di Frascati*) are classified as *Alignment of curricula to the economic and social needs* (essentially lifelong education programs). Also, in this taxonomy, there is room to classify niche initiatives like participation in local programming of economic development, institutional

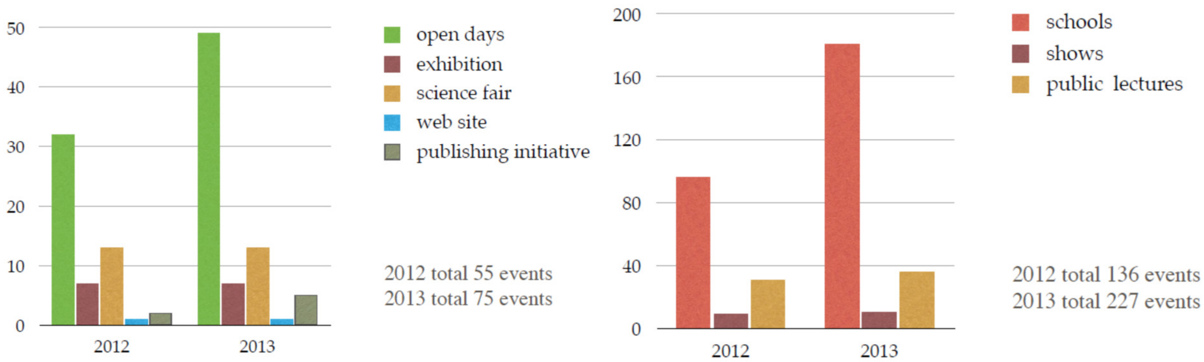


Figure 8.2 Distribution of events in 2012 and 2013 according to ANVUR classification. Left “Science in Society”, right “Service to community”.

support to stages for high-school and undergraduate students etc. Figure 8.2 shows the distribution of events in the different categories.

8.4 Science in Society

Overall the total number of events recorded for 2013 is 337, up from 222 in 2012. We believe that the increase is also partly due to better bookkeeping.196 events took place in the large National labs, with the remaining in the local units. It is interesting that –set aside the 18 events to be classified as higher education- the remaining are almost evenly split between events for schools and for the public at large. In figure 8.3 we show the distribution of events for the different INFN units (normalized by FTE). We believe that this is an estimate (on the conservative side) of this class of activity.

The events, however, have not the same impact, nor –of course- see the same number of participant or share the same communication aim. For example in 2013 the large exhibition “L’energia del vuoto” that took place in Bologna, was visited by more the 40000 people, and the exhibition, in Pisa, on Bruno Pontecorvo’s life collected more than 5000 visitors. Of course the impact is wide in terms of raising awareness of INFN activities within the country, while the aims are different. Overall exhibitions in 2013 were visited by more than 70000 people (including the exhibit “Sperimentando” organized in Padova with the participation of Legnaro National Laboratory and the already mentioned exhibitions in Bologna and Pisa. Scientific fairs (for example “Notte dei ricercatori”) are becoming a stable and widespread activity in Italy. Thanks to its links to local community and to universities, INFN participates in most, if not all, of the events.

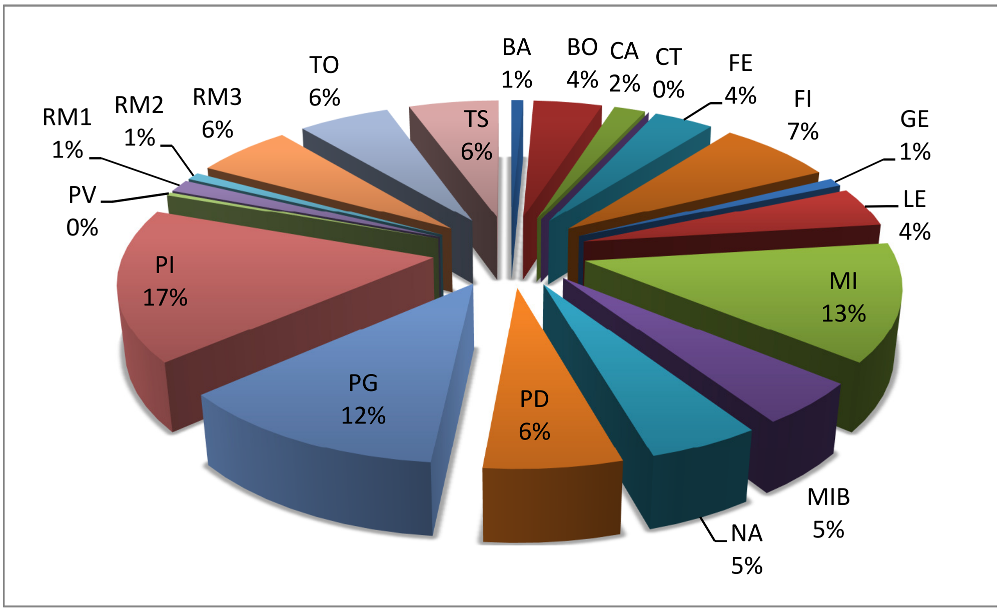


Figure 8.3 Distribution of events normalized by FTE for each INFN unit.

The large visibility of particle physics in the public at large, thanks to the discovery of the Higgs boson has been an instrument to increase the awareness of the public interest in basic research. Open days at National Labs attracted several thousand people.

Last but not least, INFN is becoming a permanent actor at the “Fiera della Filosofia” that takes place in Modena every year. It is important, from the point of view of the Institute, to be present in such a high-level, high-visibility forum which is obviously not immediately connected, for the large public, to the scientific research.

8.5 Lifelong learning/continuous Education

This is one of the goals at European level. Address the problem of re-training and updating curricula to the needs of society at large, with the help of Academic and Research Organization. While Universities are more naturally outfitted to this scope, we believe that –based on our experience- INFN can do its own share.

Since many years the already mentioned Frascati School of Physics (*Incontri di Fisica di Frascati)* provides –free of charge- about 200 teachers/year with the chance to update their curricula. The School is, since the beginning, formally recognized by the Italian Ministry of Education (MIUR). It is also open to participation of media professionals. In a similar way, LNGS organized, in collaboration with AIF (Associazione Insegnanti di Fisica) five courses for high school teachers for a total of 100 participants. Padova unit organized an introductory course to the open source program *Scratch* addressed to elementary and middle school teachers. At a different level, LABEC in Florence organized a Workshop of one day on the use of advanced techniques in the Cultural Heritage Conservation (in collaboration with OPD- Opificio delle Pietre Dure, 200 participants).

We are confident that similar initiatives are, and can be, organized in many realities and in a number or areas. Also, there is a strong need in the Italian School System to address the problem of drop-outs and to provide students with appropriate skills useful in the current economy. MIUR is addressing this issue by proposing more stages aimed to gaining specific technical skills for students. Our laboratories, where already a number of students participate also in technical stages, are in an excellent position to become the leaders of experimental initiatives. A test was done in early 2014 at LNF, where a proposal to obtain regional funds is now being prepared.

We need, however, a coordination of the initiatives in order to optimize our efforts. The INFN Management is closely following this issue, and there is a growing involvement of the Communication Office in the organization of local events and in training researchers.

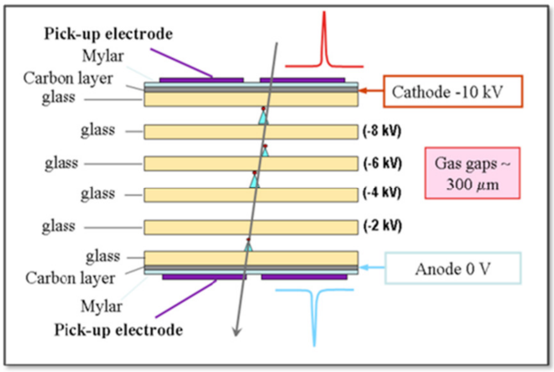


Figure 8.4 – Layout of an MRPC used for the EEE experiment

Before closing we would like to provide an update on EEE (Extremely Energetic Events). EEE is an activity project started by Centro Fermi, with INFN collaboration. In 2013 it was financed as a special project by MIUR (*Fondi Premiali*, see Section 9). The “EEE project” started around 2005 with the purpose of making an Astroparticle Physics experiment in collaboration with secondary schools, spread out all over Italy in order both to have a very large area cosmic rays (muons) detection array and to disseminate scientific culture among students of secondary schools. Nowadays there are 43 telescopes built, tested and operative: 38 are located inside schools, 3 in the INFN Units of Bologna, Catania and Pisa, and 2 at CERN; the EEE array includes 25 towns (24 in Italy, 1 in Switzerland). Another 20 schools have already expressed their interest to join the project.

The EEE telescopes are based on the Multigap Resistive Plate Chambers (MRPC) technology. A telescope consists of three large chambers, each with (0.82x1.58) m^2 active area, spaced by a vertical distance that can be varied from 0.4 m to 1.0 m. The students and teachers involved carried out the construction and tests of the MRPCs (see Figure 8.4) at CERN, under the supervision of researchers from "Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi" (*Centro Fermi*), INFN and CERN. Data taking and analysis is going on almost continuously. A centre to collect data taken all over Italy was first developed in Erice at the EMFCSC ("Ettore Majorana" Foundation and Centre for Scientific Culture) in order to allow coincidence events analysis easier and more efficient. A key point is the strict collaboration between INFN researchers, University researchers and professors, and secondary school students and teachers. Thanks to the MIUR extra funding obtained by the EEE project as joint INFN-*Centro Fermi* "Progetto Premiale 2012", the number of EEE telescopes is being currently increased up to a total of 50 (within 2015). At the same time the EEE computer centre is being upgraded (to allow for automatic data transfer from the schools) and moved to INFN centre CNAF in Bologna.

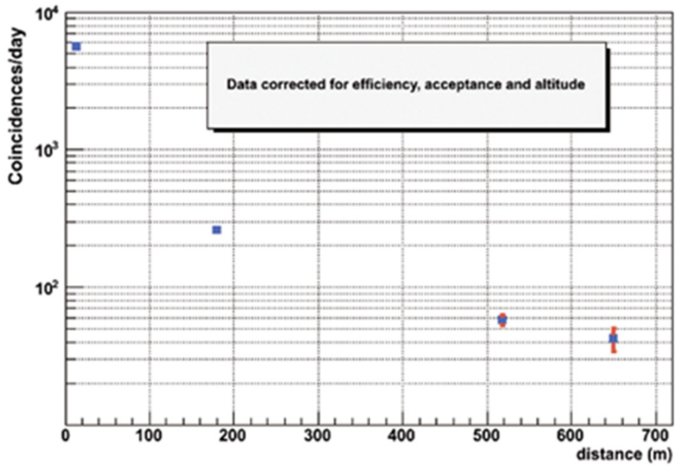


Figure 8.5 – Corrected number of coincidences per day, as measured by different telescope pairs of the EEE network, as a function of the relative distance between the two telescopes. Data from the following sites are included in the plot: CERN (15 m), L'Aquila (180 m), Cagliari (520 m) and Frascati (650 m).

The search for muon coincidences among nearby telescopes is going on, being the main goal of the EEE (Extreme Energy Events) experiment. A first evidence of the identification of extensive air showers was first obtained from the correlation analysis of muon events detected in two telescopes placed 180 m apart in L'Aquila[11]. A larger data sample was analyzed in order to evaluate the dependence of the number of correlated muon events between two telescopes by their relative distance. Data from four different telescope pairs of the EEE array, at different distances, was considered. The analysis of the time correlation clearly demonstrates[12] the possibility to identify two-telescopes correlations, hence extensive air showers signatures, up to relative distances between telescopes for which accidental two-fold coincidences become non negligible with respect to true coincidences, of the order of 700 m, as shown in Figure 8.5. Results, properly normalized for detector acceptance, efficiency and location altitude, were extracted and compared with calculations based on CORSIKA and COSMOS air shower simulations[13].

As a further demonstration of the excellent EEE performance, in February 2011, a class X2 solar flare, followed by an important Coronal Mass Emission (CME) gave origin to a Forbush decrease recorded by some of the stations of the Neutron Monitor Network (NMN). Two stations of the EEE array saw a similar decrease in the muon rate, with an intensity profile clearly comparable to the ones observed by the NMN stations[14]. Another Forbush decrease in March 2012 was again

[11] M. Abbrescia et al., First detection of extensive air showers with the EEE experiment, Il Nuovo Cimento 125 B (2010) 243.
[12] M. Abbrescia et al., Time correlation measurements from extensive air showers detected by the EEE telescopes, The European Physical Journal Plus 128 (2013) 148.
[13] M. Abbrescia et al., Cosmic rays Monte Carlo simulations for the Extreme Energy Events project, The European Physical Journal Plus 129 (2014) 166.
[14] M. Abbrescia et al., Observation of the February 2011 Forbush decrease by EEE telescopes, The European Physical Journal Plus 126 (2011) 61.

simultaneously observed by 5 stations of the EEE array, in 3 different sites[15]. This decrease was associated to one of the largest flares (categorized as X5.4) of solar cycle 24, making it the second largest flare since the solar activity segued into a period of relatively low activity, called solar minimum, in early 2007. Figure 8.6 shows the secondary cosmic rays flux as a function of time, for the neutron monitors of Oulu (65.05°N, 25.47°E) and Rome (41.90°N, 12.52°E), and for the EEE telescopes of Altamura (40.8°N, 16.6°E), Catania (37.5°N, 15.1°E) and Bologna (44.5°N, 11.3°E).

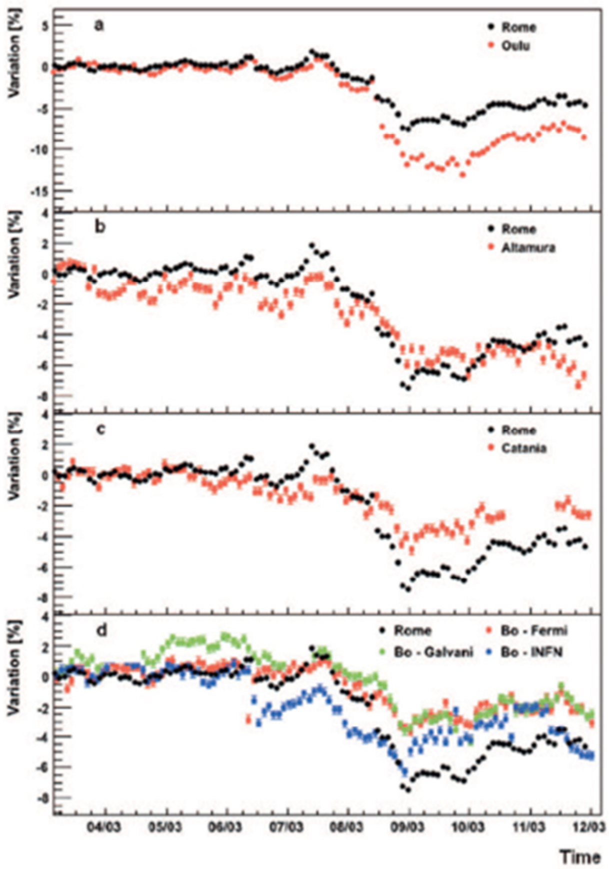


Figure 8.6 – The March 2012 Forbush decrease, as observed by (a) the Oulu and Rome detectors of the Neutron Monitor Network (NMN) and by (b) the Altamura, (c) Catania, and (d) Bologna EEE telescopes.

[15] M. Abbrescia et al., The EEE experiment project: status and first physics results, The European Physical Journal Plus 128 (2013) 62.

9. External Collaborations and Fund Raising

This year marks the start of the new Framework Programme for Research and Innovation of the European Commission, *Horizon 2020* (*H2020*). *Horizon 2020* is part of *Europe 2020*, the European Union comprehensive long-term strategy, which recognizes and aims to address the crucial challenges Europe is facing: low growth, insufficient innovation, and a diverse set of environmental and social challenges. Science and innovation are key factors that will help Europe to move forward, but the goal of *Horizon 2020* is to eliminate the separation present in the former Framework Programmes (like *FP7*) between "research" and "innovation".

Horizon 2020 sets out three strategic policy objectives: raising and spreading the levels of excellence in the research base; tackling major societal challenges; and maximizing competitiveness impacts in the productive system. *Horizon 2020* is structured around three priorities which link directly to these aims.

Given the mission of our Institute, it is clear that the first pillar ("Excellent Science") is the one that can more easily attract the efforts of INFN researchers, when compared to the other two pillars ("Industrial Leadership" and "Societal Challenges"). However, the history of INFN is constellated also by success stories related to the industrial cooperation (e.g. in the construction of LHC detectors) or the societal fall-outs (health sector, in the cultural heritage conservation etc.). It is clear that, given the activities of the Institute, there is room for impacting on Industrial Leadership and societal challenges, if the personnel are motivated and lead to look at the research programmes with an appropriate perspective.

Horizon 2020 is different from the former Framework Programmes also in terms of the evaluation procedures and, most importantly, criteria. The Institute has put in place since last year a Unit ("External Funds") whose aim is to coordinate the efforts of the researchers in approaching competitive calls for fund raising. One of the major objectives of the Unit has been to drive a cultural change and to create a greater awareness in the community about the (sometime hidden) potentiality of our activities and the capability to transform fundamental, basic, mission-driven research, into a set of suggestions aimed to identify the right topics for project submission.

Founding element for this translation is a proper educational programme, which the Unit realised through a set of courses (several organized using the "Formazione Interna" funds), aiming to inform about the different funding instruments of *Horizon 2020* and to help proponents in laying out their projects in order to maximise the matching to the new evaluation criteria.

The supporting element is, of course, a careful tracking of the proponents in the preparation/writing process of the proposal, avoiding "mistakes" of different nature. The most common one is related to explain plainly, and clearly, the idea behind the project. An obvious limitation for this kind of support activity is the number of suitable people currently available in the Unit, five as we write.

This effort, which might look natural, is not trivial in Italy. The Country, for several reasons is lagging behind in bringing research closer to innovation and hence to seed the transformation of its own productive texture. From this point of view INFN is not an exception. Even in case of more science-oriented proposals, related to the European Research Council (ERC) grants, and that are still present in *Horizon 2020*, the meaning of *excellence* is intertwined with the innovation aspects; hence proponents must be educated in writing a project rather than a paper for a scientific journal. Moreover in H2020 the Commission has tightened the restrictions for a proponent who does not pass the first evaluation step in the ERC schemes: up to two years without resubmission of any project.

9.1 Europe and first Horizon 2020 Calls

A few months are not certainly enough to understand whether the initiatives brought forward by the Institute to pave a different way will be successful: however the participation and the outcome of the first calls of *Horizon 2020* give some indication for possible patterns.

European Researcher's Night (http://ec.europa.eu/research/researchersnight/index_en.htm), the call of the Commission for dissemination of scientific culture to the large public within the Marie Skłodowska-Curie Actions (MSCA), has seen INFN co-winner of four projects, involving the majority of INFN Structures. This success is particularly relevant because it entitles the Institute to run the *Night* also for the year 2015.

In the same MSCA environment, the new RISE (Research and Innovation Staff Exchange) instrument offers a combination of opportunities that were formerly in the IRSES and other Marie-Curie actions. INFN participated to the first call and two projects lead by INFN, one centred on BES-III activities in China, the other on Japanese experiments (T2K, BELLE-II), were selected, for a total of about 4 M€ out of which 1.5 M€ directly to the Institute. This clearly is related by the intrinsic international nature of INFN activities and its capacity of contributing to large world-wide collaborations.

A slightly different story is told by the submission of individual proposals, as for the ERC Calls. INFN researchers applied for the Starting (StG) and Consolidator (CoG) Grants, and are in this moment preparing for the Advanced (AdG) Grant. As mentioned before, the Institute is active in promoting the participation to these calls, with an eye on the differences with respect to the former FP7 Programme. This time no preliminary selection of the proposal is applied. Presently only the results of the first pass for the evaluation of the StG are available, and none of the INFN proposals has been selected. One should bear in mind, however, that the EU-averaged success rate for this type of calls is low (about 9%) and a single run cannot tell the whole story. In FP7, INFN earned three StG (and one CoG, previously linked to the StG), with a success rate of about 6%, for a total funding of 4.7 M€. As a comparison, the EU-averaged success rate for the AdG is 11.8%, and INFN earned four grants (12.1% success rate, 9.5 M€ funding).

Preliminary indications, extracted from the Evaluation Summary Reports of the projects, point to the *curriculum* as one weak point of the StG proponents, as the scientific activities of the individual proponents are not sufficiently varied. This is partly stemming from the structure of the Italian academic system, as well as a drawback of large, big-science, collaborations. The Institute (and especially the External Funds Unit) is now trying to find corrective actions to improve the situation in the next calls.

INFN as a whole is also participating to the first calls of the Innovative Training Networks, the individual MSCA Fellowships (to attract researchers from abroad), the infrastructural programmes (e-INFRA, INFRADEV, INFRAIA) and to the Future and Emerging Technologies (FET). The latter is particularly relevant to the transformation process described above, because it bridges the Excellent Science pillar into the other two, leveraging on the researcher's capacity to move her/his daily work on detectors, electronics, computing into a visionary and radically new idea to drive future developments.

In closing it is worthwhile mentioning that, in the tail of the Seventh Framework Programme, INFN enriched its success portfolio in the Programmes EURATOM (*CHANDA*, challenges from nuclear data, *MU-BLAST*, muon scattering tomography); COOPERATION (*SR2S*, Space radiation superconductive shielding, *TRIMAGE*, trimodal – PET/MR/EEG – imaging tool for schizophrenia); CAPACITIES (*EUCARD-2*, building an European network for accelerator science); PEOPLE (*INFIERI*, frontier exploitation in research and industry, *GRAWITON*, Gravitational Wave Initial Training Network). Moreover, in the Flagship FET Project *GRAPHENE*, INFN has achieved a major result, succeeding in one competitive call (Graphene-Based Revolutions in ICT) and becoming then a Partner of the Consortium.

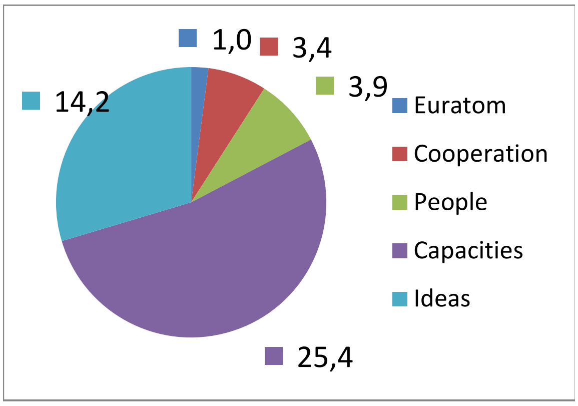


Figure 9.1 – Budget (M€) for the FP7 schemes

The final score over seven years of FP7, brings to

INFN 85 winning projects, with a total EU contribution of about 48 M€ (see Figure 9.1 for details of the sharing among the different schemes). In 2013 only, INFN received more than 5M€ from UE.

9.2 Cooperation with other national Institutions

The Institute continues to maintain excellent relationships with all the leading national public research institutions and agencies (CNR, INAF, ENEA, ASI, INGV), whose collaborations are regulated by appropriate Framework Agreements in order to facilitate the activation of common projects, with dedicated operating tools.

Historically, there are several examples, from SPARX (CNR, ENEA), to LANDIS (CNR) to the joint realizations with ASI for the experiments AMS, PAMELA, FERMI, to the seismic monitoring together with INGV, and to common initiatives for research and training in the field of high performance computing.

In the health sector, the Institute has brought an essential contribution to the realization and maintenance of the CNAO (National Centre for Oncological Hadron-therapy) synchrotron in Pavia for the treatment of oncological diseases with particle beams. The Centre has started in 2014 to be fully operational for clinical operations, after more than 200 patients have been treated in trials with protons and Carbon ions. This fruitful, and socially relevant, cooperation continues with the construction, led by INFN, of a dedicated beam line for research in radio-biology and irradiation damages. At LNS in Catania continues, in collaboration with the local University and the Hospital Agency, the project CATANA for the treatment with protons of ocular tumours.

Other collaborations are ongoing in the energy sector (Ansaldo Nucleare, ENEL), in the field of decommissioning of nuclear facilities and treatment of nuclear waste (SOGIN), and in the field of Cultural Heritage, where the LABEC Laboratory is active, in collaboration with the University of Florence, a landmark in the application of our technologies to the field of analysis, preservation and restoration of cultural heritage.

The structure of the financial scheme for Research Organisations in Italy (until 2013) foresaw the creation of a money pot, built out of 7% of the standard allocation to each Institution (about 16 M€ for INFN), to be then redistributed on the basis of competitive calls (*Fondi Premiali*). This scheme is now being revised to take also into account the results of the research evaluation by the National Agency ANVUR. However in 2013 an important set of achievements was accomplished by the Institute. Several projects were presented either individually by INFN or in collaboration with one or more of the above mentioned public research institutions. This kind of collaboration had been underlined by the Minister as a crucial aspect to foster the creation of a more solid research tissue in Italy, possibly built at the same time by sharing and enlarging the different expertise from different institutions.

Eleven INFN projects were declared eligible for funding, in various scientific fields, ranging from nuclear and particle physics (LHC detector upgrades, underground nuclear astrophysics), to accelerator science (sources for plasma accelerators and Compton radiation sources with lasers and beams), to the health sector (radionuclides production, innovative radio and particle therapy). An outreach program (EEE), in collaboration with Centro Fermi was approved. The total funding in favour of INFN has been of about 40 M€. Compared to the size of the money pot mentioned earlier, this shows that the Institute was able to establish an impressive price/performance ratio.

The Ministry and the Regional Authorities also run programmes to respond to the challenges of the EU cohesion policy, based, fully or partially, on EU funding (European Social Fund, European Regional Development Fund, and others). INFN, through its structures (Units and National Laboratories) has put forward proposals and received funding on all (national, regional and local) schemes. National strategies for research and innovation as well as regional smart specialisations find a natural reference point in the scientific and technological activities in which the Institute is engaged. Thanks to its widespread presence throughout the national territory and to the technological centres of excellence, the Institute can provide a qualified contribution to the enhancement of the strengths and potential of excellence of each Region, with the construction of new infrastructure or by improving and integrating existing ones. INFN is naturally embedded in a network of international relations, which draw from both the scientific and productive world, since its scientific enterprises have been possible thanks to the synergy of public and private investments.

Proposals at the national level often take inspiration from strategic actions that the Institute pursues for its institutional mission. In the field of the National Operative Programme (Programma Operativo Nazionale, PON) one should mention KM3_Net, for the construction of a large multi-disciplinary underwater laboratory, RECAS and PRISMA for computing infrastructures, NAFASSY for testing items built with superconducting technology. These projects received a total contribution of about 31 M€ in the past three years, and have to be completed, following EU rules, by the end of 2015.

In the regional and local contexts (Regional Operative Programme, Programma Operativo Regionale – POR – and similar) the action of the Institute is to ensure the positioning of a defined territory in international value chains, which is a fundamental asset of the Institute. Shining examples in this case are the three major projects related to LNGS in the Abruzzo Region, worth about 4 M€ for INFN, and AISHa (Advanced Ion Source for Hadron-therapy) at the LNS, with a funding of 1.3 M€.

Finally, it is worth noticing that, in particular in PON Smart Cities (a bridge between FP7 and H2020) and in some regional POR, funded partly by the ESF and the ERDF, the Institute achieved significant results both for projects supporting better management of local governments and in connection with business, including numerous training activities directly related to the needs of the productive world. Two recent accomplishments are: *Open City Platform* (2.3 M€), to provide cloud solutions and tools that enable the PA to share and reuse applications and services and citizens to easily access services; *Active eAgeing for Smart Cities* (0.6 M€), based on wearable sensors and cloud computing to improve the quality of life and cure of the elder population.

A specific aspect of the collaboration with other National Research Institutions is the participation to the programs in the ESFRI roadmap. This identifies a set of Research Infrastructures (RI), new or substantially enhanced, defined as "analytical facilities", one of the pillars of European investment in favor of scientific and technological competitiveness of the European Union. There are common features of these ESFRI-RIs. Either to be based on electron accelerators which feed sources of X-rays, from synchrotron or free-electron-laser (ESRF-Upgrade, EUROFEL, X-FEL) or sources of ultra-short pulses (attosecond), ultra-intense (exawatt), and γ-rays from e- γ collisions (ELI). Either to be using sources from ions (protons) accelerators that feed spallation neutron sources (ESS-Spallation Source).

Three major institutions, INFN, CNR and Elettra, contribute to the Italian participation in the analytical-RI and give rise to the scientific return that follows from their construction and use, making a big plus for the Italian scientific community which is widely distributed in the Universities, including membership to Inter-University Consortia, and for the Italian industry.
Starting from this approach, the institutions have jointly proposed to MIUR, each one with requests related to the part of direct responsibility, the financing of the individual analytical ESFRI infrastructures in a coordinated proposal.

It is indeed the INFN close connection with the Universities, in terms of facilities, personnel and training, which resulted in the synergy that allowed the research in nuclear and sub-nuclear physics of our country to achieve and maintain a high standard, and an international dimension unanimously recognized. There are thirty-one Universities which host INFN structures. With each University an agreement is signed, governing the use of space, staff and equipment to achieve the scientific goals of common interest. Overall, INFN pays annually to the contracted Universities about 1.8 million Euros as a contribution to libraries and operating costs. During 2012 and 2013, respectively, INFN financed 2.5 million Euros for 46.5 and 46 PhD Fellowships and in 2013 about 438.000 Euro for three temporary research positions.

INFN is also present in Masters Courses and participates to the CASAP educational projects co-financed by MIUR. These courses are an important bridge between fundamental research and the professional needs of companies, a technology transfer process extremely helpful that the Institute is determined to pursue and actively expand over the next three years.

In the Cultural Heritage field, worthwhile mentioning is CoIRICH, with initiatives towards the European Commission (Synergy Grants), regional and national (PON) funds and Confindustria (PICH).

9.3 European strategy

Thanks to its mission, INFN has always promoted and supported initiatives to strengthen ties with scientific institutions and researchers from abroad, either through special hospitality programs of foreigners in Italy as the Fund for International Affairs (FAI), and through the exchange of researchers on the basis of specific agreements and conventions, such as those in place with MIT, CERN, CIAE, DOE, NSF, ISSNAF. Participation in Consortia as EGO (Italy-France), infrastructures as ESRF (Grenoble), the ECFA and ICFA Committees for Future Accelerators and Organizations such as the European Science Foundation and Science Europe, all these initiatives testify the strong European and international vocation of INFN.

INFN is a Member Organization (MO) of the European Science Foundation (ESF) since its establishment: it is represented in the Physics and Engineering sciences Standing Committee (PESC) and in the NuPECC Expert Committee. ESF has several instruments and activities to accomplish its mission of bringing European researchers together to network and share their knowledge for the benefit of the European Research Area (ERA). Among them, the Member Organization Fora is the one where INFN is mostly active. MO Fora are output-oriented, issue-related venues for Member Organizations, involving others as appropriate, to exchange information and experiences and to develop joint actions.

ESF is now slowly evolving in a new science policy actor, Science Europe (SE), an association of European FAs and RPOs based in Brussels. Science Europe is aimed at achieving the objective of funding and performing excellence in research through cross-border collaboration. It provides its members with a platform to speak with a common voice to the European institutions, national governments and other stakeholders, and seeks to develop common positions on a wide-range of science policy issues: a third voice in the ERA, together with national government and the European Commission.

The policy-related work of Science Europe is guided by the *"Vision on a Globally Competitive ERA and their Road Map for Actions"*, jointly developed in 2009 by the members of the European Heads of Research Councils (EUROHORCs) and the ESF. The roadmap currently lists ten areas of action, which constitute the principal focus of SE policy work. Science Europe is putting in place dedicated expert Working Groups to make concrete progress on issues related to these policy areas, drawing on the extensive experience of the Member Organizations.

INFN is participating to five of the already started Working Groups, covering the issues of Open Access to Publication, Open Access to Data, Research Infrastructures, Gender and Diversity, Research Careers. A full revision of the Road Map is currently under way, to be completed by the end of 2014.