CHAPTER II

PROJECT STRUCTURE, SCHEDULE AND COSTS

2.1 Project Description

SPES is an integrated national facility of INFN, sited at LNL (Laboratori Nazionali di Legnaro, Legnaro, Italy), aimed at the production and acceleration of nuclear species of limited lifetime (exotic nuclei), for the scopes of fundamental research in the structure and dynamics of nuclei, research and production of radioisotopes of medical interest, neutron irradiation for material research.

SPES integrates the existing superconducting linear accelerator ALPI, operational at LNL since 1994 and used – in the SPES framework, for acceleration of exotic nuclei, with a proton cyclotron, a target-ion-source assembly and a system for the selection and pre-acceleration of the desired exotic ion into ALPI.

The facility, developed mainly by accelerator and nuclear physics experts of LNL, is to be considered the national facility for exotic beams, to the design and construction of which concur, in primis, LNS (Laboratori Nazionali del Sud, Catania, Italy) and a number of INFN units at various Italian universities.

The facility is being funded with INFN ordinary budget, plus extraordinary budget which might be supplied to the INFN by the Italian Ministry for Education, University and Research.

The main goal of the SPES project is the realization of a second generation ISOL (Isotope Separation On Line) system able to deliver neutron rich beams for the study of nuclei far from stability. The research on these nuclei, both from the point of view of structure and of reaction mechanisms, represents a current frontier of the nuclear physics and astrophysics.

The second aim of the SPES project is the construction of a facility for interdisciplinary research; of particular significance is the possible use of the second beam line of the cyclotron for the production of new radioisotopes used in medicine.

2.2 Scope

As stated above, the scope of the SPES facility is three-fold: fundamental research in the structure and dynamics of nuclei, research and production of radioisotopes of medical interest, neutron irradiation for material research.

SPES concurs to a world-wide effort of the nuclear physics research to push the knowledge of nuclei and their interactions far from the so called “Valley of stability”.

It is part of an integrated European framework, aiming at realizing a network of complementary facilities and related nuclear instruments, in various European countries.

ELI (Extreme Light Infrastructure) will be developed in the Eastern Europe. It is based on four new scientific infrastructures devoted to the investigation and applications of laser-matter interaction at the highest intensity level. Atomic and nuclear physics, relativistic physics and high power laser applications are the main topics.

FAIR (Facility for Antiproton and Ion Research), in Germany, will provide antiproton and ion beams with unprecedented intensity and quality. It is an extension of the GSI facility and it consists of eight ring colliders and two linear accelerators. It is part of the facility, the production of Radioactive Ion beams by in-flight separation at energies of 100-1000 MeV/u

EURISOL is aimed at the design – and subsequent construction – of the "next-generation" European ISOL radioactive ion beam facility. The ISOL technique is complementary to the in-flight separation. The expected ion yields at EURISOL will exceed a factor 10-100 the beams delivered by the current ISOL facilities or those under construction (HIE-ISOLDE, SPES, SPIRAL2). The main structure of EURISOL will consists of: (i) a driver accelerator; (ii) a neutron converter to generate high-energy neutrons for exotic isotope production; (iii) a high power (Multi Mega Watt - MMW) target-ion-source unit for two-step isotope production (neutron induced), and several direct target stations (100 kW) in which exotic isotopes are directly produced by the driver beam impinging on the target material. The construction of the EURISOL facility is expected after the development of "second generation" facilities as HIE-ISOLDE, SPES, SPIRAL2 addressing some of the main technological challenges.

2.3 Main technical characteristics

The second generation ISOL facilities distinguish themselves from the current ones by three main features:

- Increase in the intensity of the delivered radioactive beams,
- Increase in the energy of the reaccelerated species,
- Improvement of the degree of purity of the beams.

A large interest for nuclear physics research is focused on neutron-rich exotic nuclei that are produced by U or Th fission. The fission production in the ISOL target and the release efficiency is a main topic for an up-to-date ISOL facility (the EURISOL goal is 10^{15} fissions per second in the target).

SPES aims at reaching 10^{13} fissions per second in the direct target and is conceived to deliver 1-to-2 orders of magnitude more intense beams than current facilities. The use of the superconducting ALPI Linac enables to achieve reacceleration energies above 10 A MeV, thus giving the possibility to perform experiments for multi-nucleon transfer reactions not achievable with the present facilities, like REX ISOLDE.

The realization of a mass separator (R ~ 1/20000 - 1/40000) will moreover allow to reach a degree of purity of the beam nowadays not available. Data-taking is expected to achieve 10^7–10^9 particles per second in a wide range of nuclear masses, namely $60 < A < 160$.

In conclusion, the expected beam features are not currently available in the international context.

2.4 European contest

The SPES Project is well connected to the European background of the second generation ISOL facilities, where the other two projects SPIRAL2 and HIE-ISOLDE, are in progress (see Table 2.1).

These three facilities are all included in the NuPECC Road Map, which recommends them as an intermediate important and necessary stage towards the realization of the future next generation facility (EURISOL).

Table 2.1 *– Performance comparison among the expected characteristics of the SPES, Spiral2 and HIE-Isolde Projects*

	Primary beam	Power on target	UCx target	Fission s-1	Reacceler ator	Nominal energy AMeV A=130
HIE ISOLDE upgrade	p 1-1.4 GeV - 2 μA	0.8 kW	Direct (150g)	**$4 \cdot 10^{12}$**	SC Linac	5-10
SPIRAL2	d 40 MeV 5mA	200 kW	Converter (4000g)	**10^{13}** 10^{14}	CIME Cyclotron	5
SPES	p 40 MeV 200 μA	8 kW	Direct (30g)	**10^{13}**	ALPI SC Linac	10

SPES proves competitive for beam intensity and energy. It must be underlined moreover that the completion of SPES, foreseen in 2017, makes it competitive with respect to the other projects. In particular, the SPIRAL2 Project, aiming especially at high intensity stable beams, plans to start only in 2015 the construction of the part regarding radioactive beams (including the production target, the beam lines junction and the related infrastructures). As regards the HIE-ISOLDE project, the upgrade to 10 A MeV requires the construction of the new superconducting LINAC for re-acceleration, which is not expected to be completed before 2016.

Owing to the peculiar timing of the facility duty cycle and taking into account the necessary time needed for the development and optimization of the beam for a specific radioactive species, which can require up to one year, the above mentioned facilities have to be considered to be complementary in order to fulfill the requirements of the international end users.

To this purpose, a strict collaboration among the different laboratories is desirable and has been prompted on several occasions by the international committees supervising the aforementioned projects. In addition, the development of new radioactive beams has been and still is a technological challenge which must be faced with a common approach among laboratories.

2.5 National and international collaborations

The SPES project has developed a wide network of national and international collaborations (see Fig. 1) on several issues, such as: the scientific programme, the experimental techniques, the source and the ISOL target, the selection and manipulation of beams, the superconducting LINACs and safety.

Among the most important actions, one has to mention the MoU with GANIL (LEA) and ISOLDE and the participation in the European Projects ENSAR, NUPNET, as well as the "preparatory phase" of SPIRAL2. In the framework of the cooperation with other European Laboratories the formation of an ERIC is under study.

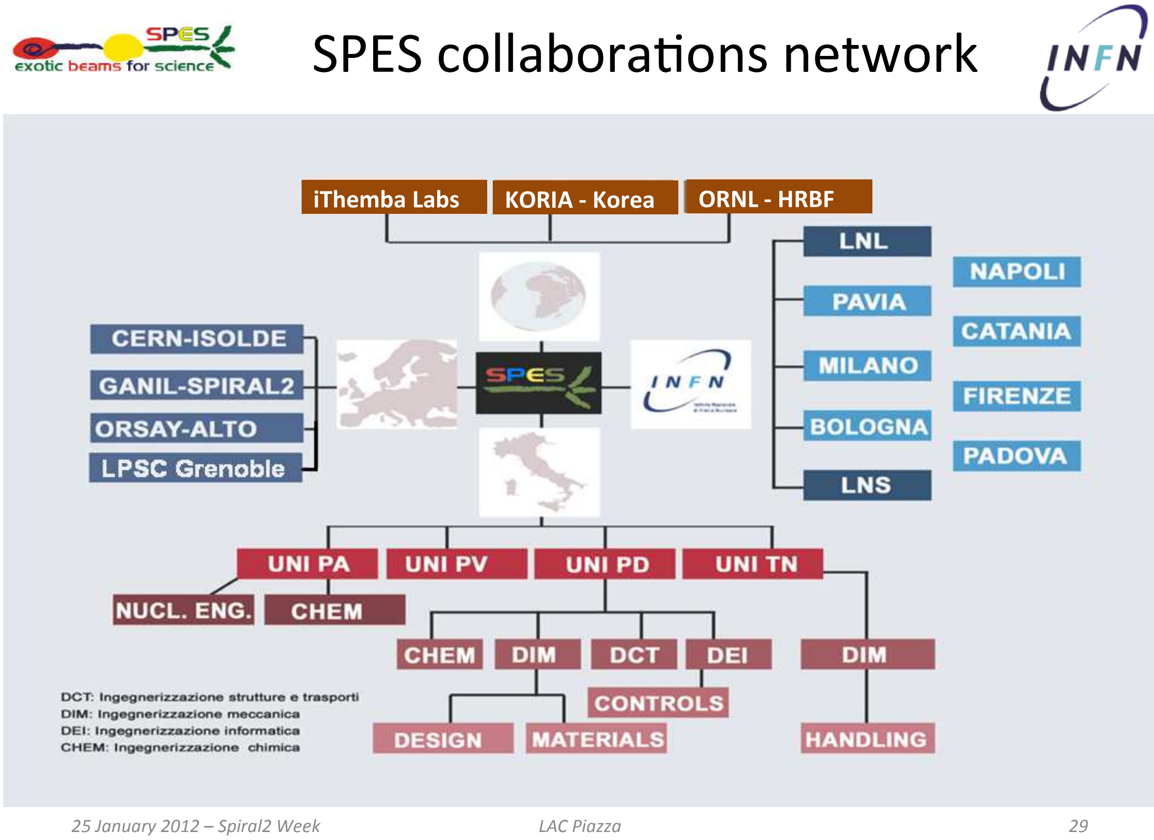


***Figure 2.1** – Outline of the collaboration network for the realization of SPES.*

2.6 Applied research projects at SPES

The capability of the proton cyclotron to supply two beams at the same time offers the possibility to operate a second target, besides the ISOL one.

The layout of SPES was designed in such a way to operate two targets at the same time distributing the beam according to a schedule that minimize the radiation problems. It should be considered that the activation of materials at a beam power of 20-30 kW do not allow to operate the same target for long time. A detail of the SPES layout is shown in Fig. 2.2; the proton beam can be sent to two ISOL target caves, two irradiation areas (mainly dedicated to neutron production) and to the radioisotopes production area. Considering a shift of two weeks with 2 days for beam preparation and 12 days of beam on target and 7 shifts for maintenance, we can offer at least 5000 hours per year of beam dedicated to the ISOL targets and 5000 for applications.

2.6.1 Research and production of radioisotopes of medical interest

The cyclotron proton beam is well suited for the production of new radioisotopes of interest for medical application exploiting the high energy and current. In France a cyclotron with similar characteristics is operated at the ARRONAX center for the same topic.

It is part of SPES the creation of a center for innovative radionuclides production for radiopharmaceuticals. Such a dedicated project, named LARAMED (Laboratory of

RAdionuclides for MEDcine) will take advantage of the high performance of the SPES proton cyclotron (70 MeV, 750 microamps).

The main focus of LARAMED is the study and development of efficient methods for the production of medical radionuclides using the new, high-beam-current, high-energy cyclotron. It was designed according to the following research lines:

- development of a target technology suitable for operating with high-current, high-energy proton beams,
- development of alternative, more efficient procedures for obtaining important medical radionuclides, including Tc-99m, Cu-64, Cu-67, I-124, Sr-82, Ge-68 and Zr-89 using a 70-MeV, 750-μA cyclotron,
- high-precision determination and re-evaluation of cross-sections of relevant nuclear reactions employed for the production of medical radionuclides,
- development of fully automatized radiochemical procedures for target processing, separation and purification of medical radionuclides,
- Design and development of novel radiopharmaceuticals for targeted guided imaging and therapy in oncology.

Radionuclides are fundamental components of nuclear medicine (NM) technology, which in turn constitutes one of the most important imaging modality and therapeutic approach for the treatment of many critical diseases. Correct functioning of NM is crucially dependent on the availability of essential radionuclides in sufficient amount to ensure widespread distribution to hospitals. Similarly, progress in NM is always tightly linked to the continuous development of effective production processes of novel radionuclides having peculiar nuclear properties that might help finding unprecedented solutions to unsolved clinical issues. The present project aims at exploiting the improved technical characteristics of the new, high-current, 70-MeV cyclotron, under installation at LNL, both to develop more efficient methods for the production of well-established radionuclides already playing a key role in NM, and to investigate yet unexplored production routes for novel radionuclides having potentially interesting nuclear properties for medical applications, but still not available in NM. Ultimately, the major objective of this project is to establish a Science and Technology Centre with the aim to study, develop and produce innovative relevant medical radionuclides to be distributed to hospitals and clinical departments for both routine use in patients’ treatment and clinical research purposes, leading to new health care improvements.

2.6.2 Neutron irradiation for material research

The cyclotron proton beam is suitable for the production of fast neutrons at a rate exceeding 10^{14} n/s. A project for a neutron and proton irradiation facility (NEPIR) was submitted to INFN as an application part of the SPES project.

NEPIR will use the protons of the SPES variable energy high current cyclotron to produce:

- an intense quasi mono-energetic neutron (QMN) beam with a controllable energy peak in the 35-70 MeV energy range;
- an intense beam of fast neutrons with a continuous energy (white) distribution similar to that of neutrons found at flight-altitudes and at sea-level (Atmospheric Neutron Emulator).
- Independent variable energy, low intensity beam of direct protons is also foreseen; it would be designed once the QMN and white neutron beam lines are financed.
- To complete the facility a high intensity slow neutron beam line will be developed in a second step.

The primary purpose of NEPIR is to study radiation damage effects in electronic devices and systems induced by atmospheric neutrons and solar protons. The high intensity slow neutron beam line could be used to perform neutron imaging or prompt gamma activation analysis of materials and industrial and cultural/archaeological artefacts.

The QMN will be produced by an assortment of thin lithium and beryllium targets (1-4 mm thick). The proton energy and thickness of the thin targets are changed to produce nearly mono-energetic neutrons at several discrete energies. The protons that pass through the thin targets without causing nuclear reactions are deflected by a bending magnet and guided to a heavily shielded beam dump. A multi-angle collimator will be used to correct data taken in the forward (0°) direction, by subtracting data obtained at larger angles (typically in the 15°-30° range). While many proton irradiation facilities exist, QMN facilities for Single Event Effects studies are limited and difficult to access.

The atmospheric neutron emulator system is based on a rotating composite target made of beryllium and a heavy element such lead or tantalum. It will produce atmospheric-like neutrons in the 1-70 MeV energy range: the incident proton beam impinges alternatively on the two materials and the neutron energy spectrum is directly shaped to resemble the seal-level atmospheric one without the use of moderators. The proton beam is not stopped by the target (to avoid damage of the Be): the spent low energy protons that emerge are magnetically deflected towards a beam dump; a simpler option under investigation is to stop them in a thin copper plate.

After the development of the QMN and the atmospheric neutron emulator the NEPIR program is to develop a proton beam line for direct irradiation and a very high flux slow neutron line. It will be based on a thick (proton stopping) tungsten high power target. A tailored system of moderators and reflectors would then shift the energy of the produced neutrons to deliver neutrons with the energy spectrum similar to the Generation IV reactors.

TIME MANAGEMENT PLAN

2.8 Project Status as of December 2013.

The SPES project is in progress since 2007: the proposal consists in the construction of a second generation ISOL facility based on a direct UCx target irradiated by protons delivered by a compact cyclotron (70 MeV of energy, 750 μA of current divided into two extraction lines. The facility layout is shown in Fig. 2.2.

After a two-year study of the target, the construction stage has begun with the development of the target-source system and of the first part of the exotic beam transport line. The system has been recently completed with the Wien filter for the beam selection and is working for laboratory tests on the ionization sources. This experimental activity is included in the European programmes for the development of ISOL systems (ENSAR-ActiLab) and has produced over 40 degree theses, 3 PhD theses and 30 publications.

The purchase order for the cyclotron has been issued in 2010. The tender has been awarded to the Canadian firm BEST Theratronics Ltd. The construction of the cyclotron is under way with frequent and positive contacts between the firm and the INFN working group.

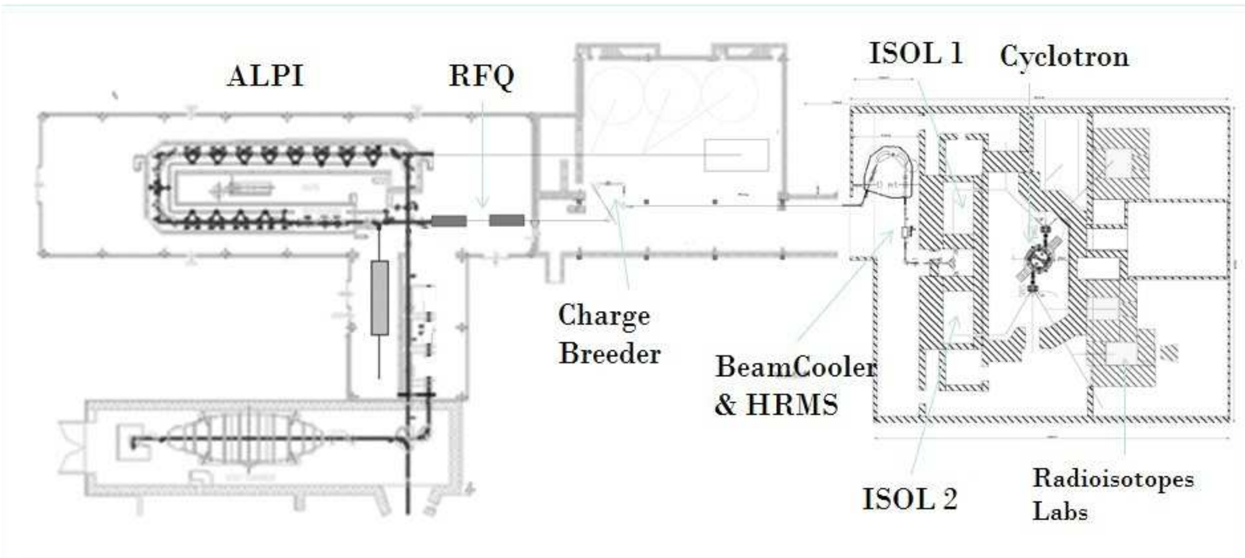


Figure 2.2 *- SPES layout.*

The building layout has been defined. It includes the building that will lodge the cyclotron, the target areas and the beam selection system, as well as an area for applied research and the support laboratories for the cyclotron and the target. The executive project has been completed in 2012 and the tender has been awarded to the firm nBI (Bologna) belonging to Astaldi Group. Construction works will begin on January 2013.

The re-acceleration through ALPI represents a topic of excellence for radioactive beams, since it will enable the delivery of heavy beams (A=130) at energies of 10 MeV/n, giving rise to multi-nucleon transfer reactions: a new research topic for radioactive beams. To this purpose, a technological progress has begun. In particular, the low beta section has been improved in order to allow a more effective acceleration of the heavy beams that will be produced by SPES.

The operating license has been granted by the competent authorities. It deals with the operation on UCx targets with currents up to 5 microA and on other targets up to the maximum current obtainable by the single line (500 microA). This enables the production of exotic beams rich in protons (targets made of SiC, B_4C, LaC, TaC, ...) and the performance of production tests with UCx targets. In order to perform experiments with UCx targets at high energy (200 microA) the obtained licence will have to be amended.

In order to improve the safety measures during SPES operation, the definition of a quality and safety system including risk analysis, operation procedures and document editing is in progress (Chapter 4 of this document).

2.9 Construction Planning

The work that has to be done yet for the completion of SPES **(FULL_SPES)** can be divided into 9 areas:

- ISOL Target with Laser Source
- UCx Laboratory Building
- Radioactive Ion Beam Transport
- High resolution mass selection (HRMS and Beam Cooler)
- Charge Breeder
- RFQ for pre-acceleration
- Superconducting ALPI accelerator upgrade
- Safety and control systems

A few comments on these areas are necessary :

i) The core of the facility is represented by the ISOL target, i.e. the system including the target- beam source with charge 1+, to which most of the R&D activity carried out up to now has been devoted. Among the different available sources, the high selectivity laser source is deemed to be the most promising in terms of performance and therefore it has been given a priority development line.

ii) Downstream the ISOL target a transport and analysis system (even at low resolution $R=M/\Delta M\approx 300$) will carry the beam to the charge breeder. This will increase the charge state of the exotic particles, making the energy rise in ALPI more effective. ALPI will be used as re-accelerator, namely as re-accelerator of the exotic species.

iii) The charge breeder is followed by a mass separator at medium resolution ($R=M/\Delta M\approx 2000$) and from the RFQ pre-accelerator, that will be designed and realized in synergy with the IFMIF project.

iv) After the RFQ, the beam is transported to ALPI for re-acceleration. In order to fit SPES requirements and to work properly for a fair number of years, ALPI needs to be improved and refurbished, especially in the cryogenic, vacuum and beam detection systems.

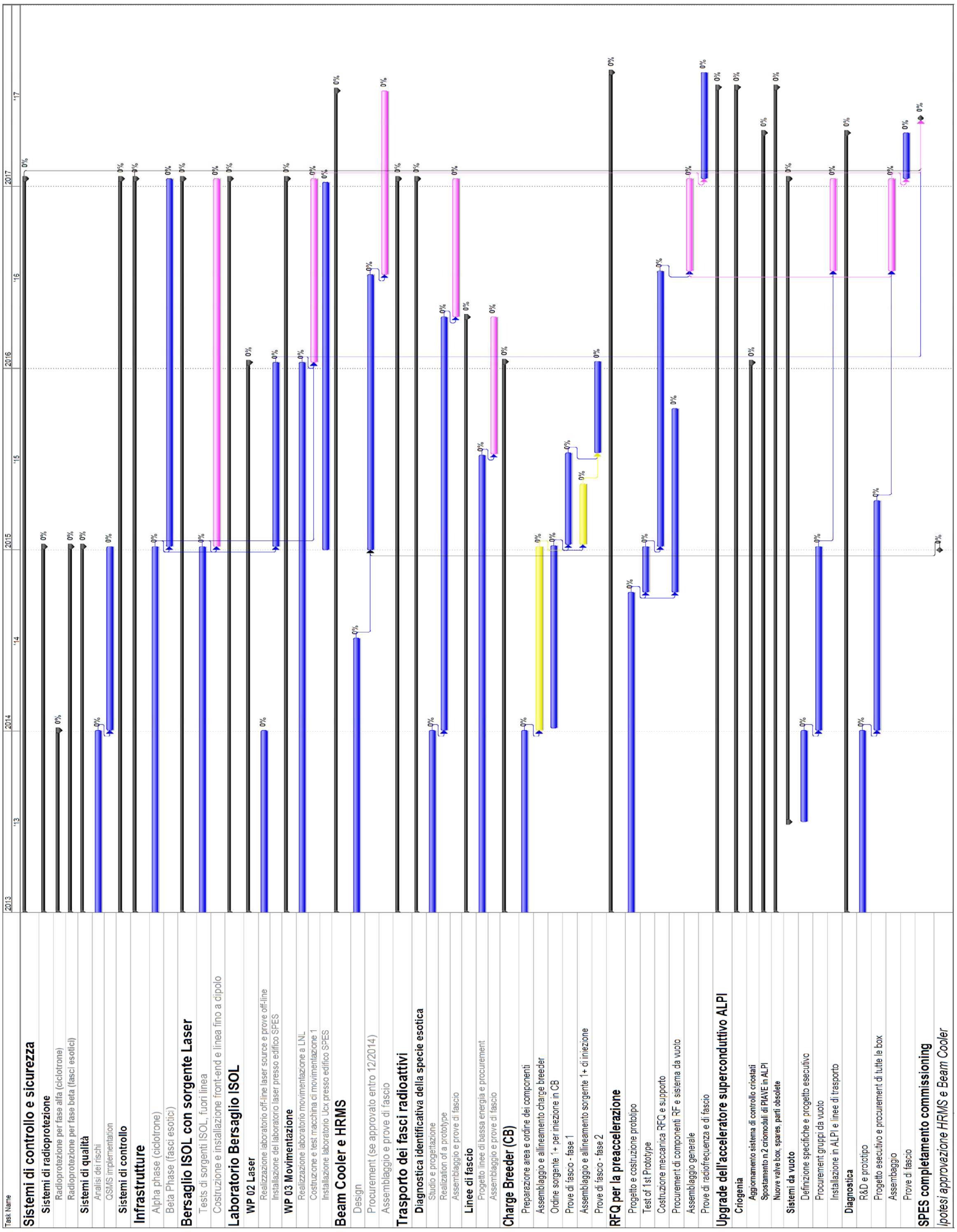
The above described tasks regard the realization of the so-called **FULL_SPES**. However, in order to operate the system within competitive time limits with respect to the other facilities under construction, the first experiments are expected to be performed without the high resolution selection system (HRMS and Beam Cooler). This reduced version of the SPES project will be hereafter referred to as **CORE_SPES**.

The construction planning for the accomplishment of CORE_SPES has been conceived in the space of 5 years, in order to be realistic on the basis of the available resources of the laboratory, adequate from the point of view of the international competition and achievable with regard to the yearly financial effort requested.

The construction planning is analyzed in Table III below (and more in detail in table A4 in the Annex). One can infer that:

1) The construction of CORE_SPES can be finished by 2016.
2) 2017 will be devoted to commissioning.
3) The construction of HRMS requires 3 years. If the resources will be granted in 2015, FULL_SPES will be available in 2018.

Table 2.2 *– Outline of the time-plan of the SPES project over 5 years, the fourth year for the general assembly and the fifth for the commissioning.*



RESOURCE MANAGEMENT PLAN

2.10 Finance

In connection with the activity carried out up to now, 20.5 Meuro have been spent or invested as described in Table 2.3.

Table 2.3 *–Sums already invested for the SPES project.*

Item	**Status**	**Investment (Meuro)**
Building and Plants	Tender finished. Contract to be signed. Expected date for work beginning: January 2013.	6,5
Cyclotron	Under construction at BEST	10,5
ISOL System	Prototype completely developed and in operation with ionizing sources.	1
Charge breeder	Within the LEA framework, 500 Keuro have been invested in order to construct the plasma camera of the charge breeder.	0.5
ALPI	Low beta section upgrade	1
Other	Supply material and travels since 2007	1
TOTAL		**20.5**

2.11 Personnel

Finally as regards the personnel, during 2012, 25 FTE corresponding to 50 full-time people have been involved in SPES (see Table A1 in the Annex). With regard to the contract type, we obatin the following distribution:

1) 11 FTE corresponding to 32 employees from permanent staff
2) 4FTE corresponding to 5 people from temporary staff, almost completely devoted to SPES.
3) The remaining 10 FTE are training staff (Ph.D. students, grant holders, etc.), completely devoted to SPES.

With reference to the permanent staff, Table 1.4 shows the involvement and the distribution of the workload, distinguishing between SPES activities and non-SPES ones (the last two columns show the increase of SPES activities expected in the next years, see paragraph 7).

With regard to the Accelerator Division, the involvement is analyzed in the Annex, Table A7. The table shows the FTE assigned to SPES and to the other non-SPES activities, among which of particular importance are the activities connected to the operation of the accelerators and to the IFMIF project.

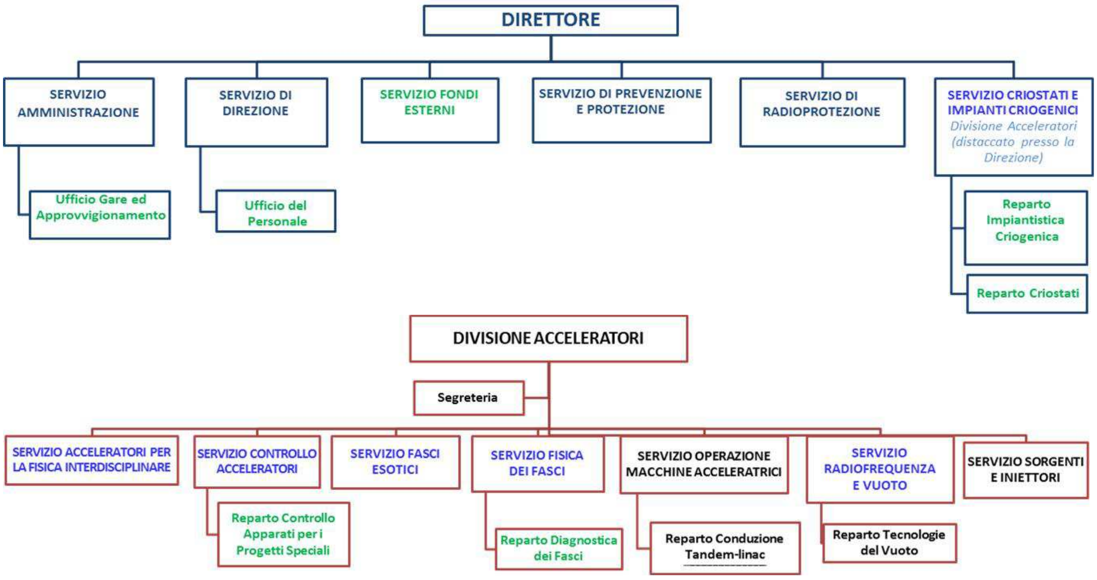
As one can deduce from table 2.4, with operating machines the laboratory can devote to SPES about the 10% of the available FTE.

Table 2.4: *Allocation of LNL permanent staff (administrative, technical, technological and research staff), workload for SPES activities and other activities (laboratory running, other projects, etc.). The last columns show the increase in SPES activities expected during the construction and commissioning of the facility (2013-2017).*

Subunit	**Current status**			**Estimate for the period 2013-2017**	
	Permanent Staff units	**non-SPES activity (FTE)**	**SPES activity (FTE)**	**Increase**	**SPES activity (FTE)**
Research Division	**37**	34.7	2.3	1	**3.3**
Accelerator Division	**38**	33.8	4.2	3	**7.2**
Technical Division	**17**	15	2	0	**2**
Other Services (Radioprotection, Administration, etc.)	**16**	13.5	2.5	1	**3.5**
TOTAL	**108**	**97**	**11**	**5**	**16**

2.12 Organizational structure

The functional organizational chart of INFN-LNL is structured in three divisions (Research, Accelerator and Technical), their services (units) and sub-units and is reported in the following fig. 1.4. Each division depends hierarchically from the laboratory director. It is to be noted that a number of units depend hierarchically from the LNL director directly (e.g. Radioprotection Unit, …).



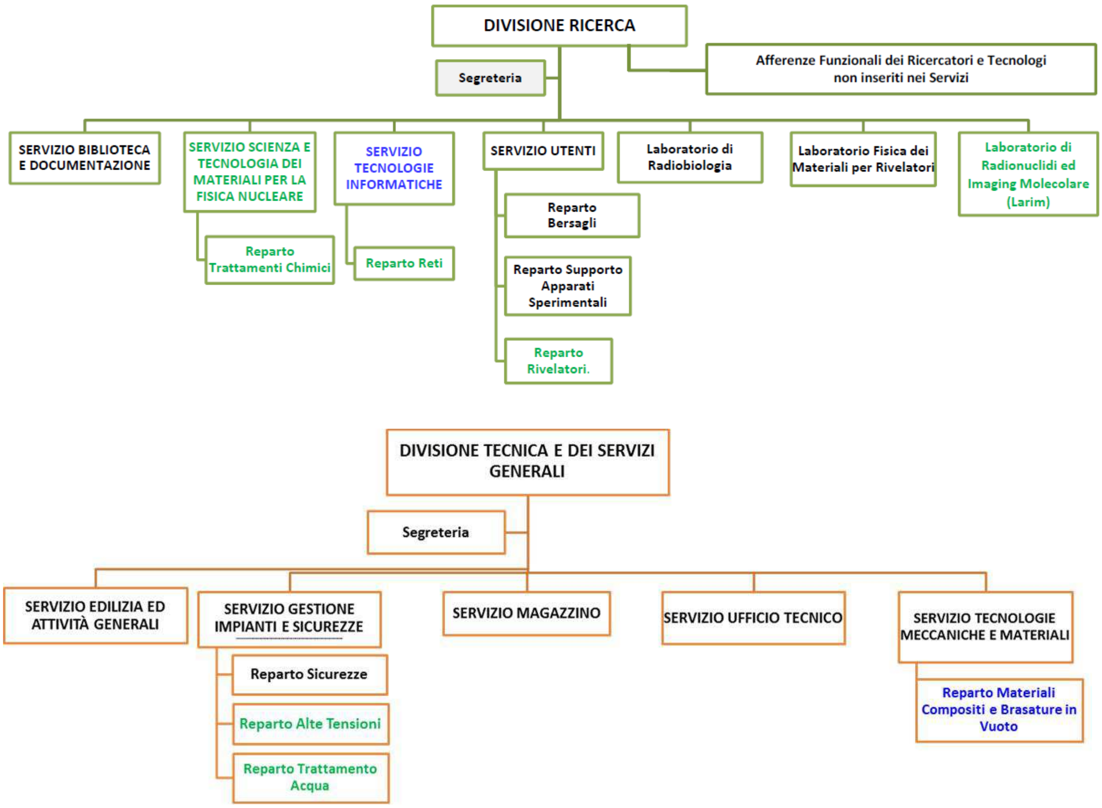


Figure 2.4: *Functional organizational chart of INFN-LNL*

The project organizational chart (fig.2.5), due to the limited total number of working units involved (limited in itself, though large on the LNL scale) matches the functional organizational chart in a sort of matrix in which the leader of the row often coincides with the leader of the column. The reason of this choice is to limit the main drawback of the matrix organization, which is the lack of unicity in command and decision. A serious problem when a small overall number of people is involved.
It is recalled here that, as stated in the Time Management Plan above, the project schedule has to coexist with managing the accelerators and, in general, the laboratory facilities for their users in a sort of "business-as-usual" fashion, albeit with a reduced duty cycle (50% of the year). This also calls for the kind of organizational chart which is explained above.

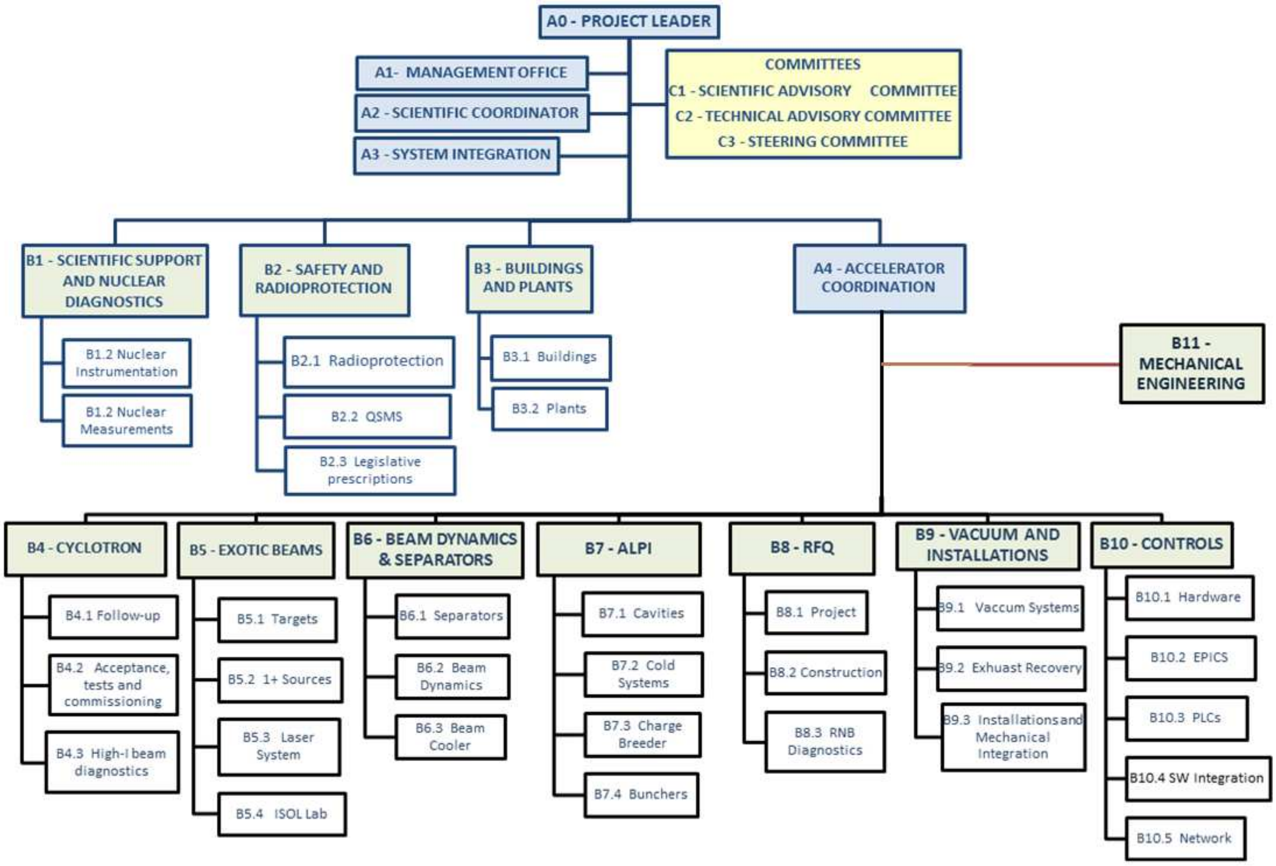


Figure 2.5: *SPES Project Organizational Chart*

Those marked with the letter A are the management units, those marked with letter B are the project realization work units, each of them split in sub-units.
To each unit and sub-unit a deliverable is attached, as listed in the table below:

2.13 Responsibility Matrix

The SPES Project conforms to the RACI matrix scheme, as far as decisions are concerned. The scheme of the RACI matrix principle is shown in fig.2.6. For each sub-project unit, the roles of those who are responsible (assigned to do the work), accountable (taking the final decision), consulted (must be consulted before a decision is taken) and informed (that a decision has been taken) are identified.

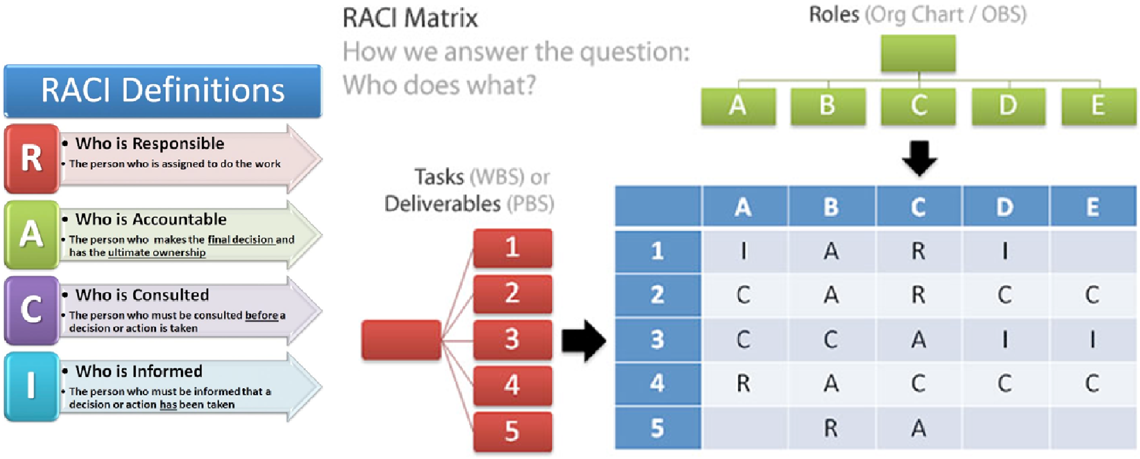


***Figure 2.6** – Principle of the RACI matrix*

The RACI matrix of SPES, as applied to the individual sub-projects, is the following (refer to fig.2.5, the Project Organizational Chart)

B3 - Buildings and Plants	Head B3.1	Head B3.2	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B3.1 - Buildings																
B3.2 - Plants																

B4 - Cyclotron	Head B4.1	Head B4.2	Head B4.3	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B4.1 - Follow-up																	
B4.2 - Acceptance tests and commissioning																	
B4.3 - High-I Diagnostics																	

B5- Exotic Beams	Head B5.1	Head B5.2	Head B5.3	Head B5.4	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B5.1 - Targets																		
B5.2 - 1+ Sources																		
B5.3 - Laser System																		
B5.4 - ISOL Lab																		

B6 - Beam Dynamics and Separator	Head B6.1	Head B6.2	Head B6.3	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B6.1 - Separators																	
B6.2 - Beam Dynamics																	
B6.3 - Beam Cooler																	

B7 - ALPI	Head B7.1	Head B7.2	Head B7.3	Head B7.4	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B7.1 - Cavities	R	C	I	I	A	C	I	A	I	I	I	I	I	I	A	I	I	I
B7.2 - Cold Systems	C	R	I	I	A	C	I	A	I	I	I	I	I	I	A	I	I	I
B7.3 - Charge Breeder	C	I	R	I	A	C	I	A	I	I	I	I	I	I	A	I	I	I
B7.4 - Bunchers	I	I	I	R	A	C	I	A	I	I	I	I	I	I	A	I	I	I

B8 - RFQ	Head B8.1	Head B8.2	Head B8.3	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B8.1 - Project																	
B8.2 - Construction																	
B8.3 - RNB Diagnostics																	

B9 - Vacuum and Installations	Head B9.1	Head B9.2	Head B9.3	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B9.1 - Vacuum Systems																	
B9.2 - Exhaust Recovery																	
B9.3 - Installation and Mechanical Integration																	

B10 - Controls	Head B10.1	Head B10.2	Head B10.3	Head B10.4	Head B10.5	A4	A3	A2	A1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B10.1 - Hardware																			
B10.2 - EPICS																			
B10.3 - PLCs																			
B10.4 - SW Integration																			
B10.5 - Network																			

Figure 2.7 *– RACI Matrix applied to SPES organizational chart*

To each of the work units and sub-units identified above, a deliverable has been identified and attached. The deliverable list is reported in the following table.

Unit (sub-unit)	**Deliverable**
B1 - Scientific Support and Nuclear Diagnostics	Provide nuclear data and exotiv beam identification tools for the SPES project requirements
B1.1 - Nuclear Instrumentation	Provide fully equipped diagnostics tools for RN-beam Identification
B1.2 - Nuclear Measurements	Provide validated measurements in support of diverse operation and radioprotection scenarios
B2 - Safety and Radioprotection	Provide assessment and decisions concerning integral safety of the facility and its components (involving LNL Director and RSPP in addition to the SPES RACI Matrix)
B2.1 - Radioprotection	Provide calculations of RP interest, define shieldings, give prescriptions, define access rules
B2.2 - QSMS	Define risks of non-radioprotection nature concerning construction and future operations of the facility and its components (responsibility of the fulfillment of the SPES QSMS system)
B2.3 - Legislative Prescriptions	Identify prescriptions of interest for the various construction and operational scenarios of the project.
B3 - Buildings and Plants	Provide the necessary building and plant installations for the newly built facilities and the adaptaion of the existing ones.
B3.1 - Buildings	Follow the construction of SPES new buildings and modification to the existing ones, in accordance with contract, legislative prescriptions, radioprotection requirements, needs of the facility
B3.2 - Plants	Project and construction of integrated facility plants, concerning electricity and cooling for machine components and HVAC systems
B4 - Cyclotron	Chair of the cyclotron accelerator during construction, tests and preliminary operation
B4.1 - Follow-up	Active monitoring of the cyclotron construction activities, till FAT
B4.2 - Acceptance tests and commissioning	Active monitoring of the cyclotron construction activities during SAT, provide knowledge dissemination and education of personnel operating the cyclotron on the SPES site
B4.3 - High-I Diagnostics	Develop and build fully equipped diagnostics tools for the high-I proton beam, from the cyclotron exit to the target-ion-source system
B5- Exotic Beams	Chair the construction and prelimnary operation of the SPES target-ion-source system
B5.1 - Targets	Develop a fully operational target system for the SPES-beta project needs
B5.2 - 1+ Sources	Develop fully operational ion sources for the SPES-beta project needs
B5.3 - Laser System	Develop a fully operational laser system for the LIS
B5.4 - ISOL Lab	Exploit all activities of the TIS kind, finalized to the best possible exploitation of such system in the SPES-beta facility
B6 - Beam Dynamics and Separator	Chair of all the beam lines of SPES, including transport lines and spectrometer, excluding those elements along the beam line which are covered by specific units (charge breeder, RFQ, cryostats), but including the beam dynamics of those too.
B6.1 - Separators	For any M-spectrometer in SPES beamline: provide physical and engineering design, follow up the construction, assembly and test the system, execute acceptance tests and preliminary operation
B6.2 - Beam Dynamics	Provied the beam dynamics caluclation for the whole SPES beam line, from the TIS system to the final experimental station after ALPI, to the degree of precision required by the construction specs of the variou components.
B6.3 - Beam Cooler	Provide the required R&D, project and build the SPES beam cooler, up to the acceptance tests and commissioning with first beams.

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B7 - ALPI	Chair all modifications and upgrades of ALPI, realized in the SPES framework.
B7.1 - Cavities	Provide the sputtered resonators and the RF systems in the cryostats, required by SPES project in addition to the existing ones, or differently placed along ALPI beam line.
B7.2 - Cold Systems	Upgrade the cryogenic system and their controls, funded under the SPES budget; design and build (or adapt) cryostats, either new or differently placed along ALPI beam line (including all cryogenic equipment and control)
B7.3 - Charge Breeder	Design build and test the SPES charge breeder, in collaboration with LPSC Grenoble, following up the construction and the "FAT" phase, chairing the SAT phase at LNL. Design and construct alla components required to match the CB to the beam line (1+ source aside the CB, mechanical support, ...). All above includes the necessary equipment
B7.4 - Bunchers	Design build and tests the new bunching system required by SPES, including those in PIAVE which are made necessary by the displacement of PIAVE cryostats onto the ALPI beam line.
B8 - RFQ	Chair the construction of the SPES RFQ and the RIB diagnostics instruments
B8.1 - Project	Design the new CW SPES RFQ (beam dynamics, RF structure and system, mechanical and cooling aspects, …);
B8.2 - Construction	Follow up construction and acceptance tests and commissioning
B8.3 - RNB Diagnostics	Design and build new diagnostics boxes, equipped for both stable and rare ions, perform acceptance tests and chir their commissioning (including interface to electronics and control)
B9 - Vacuum and Installations	
B9.1 - Vacuum Systems	Calculate, design and prepare order of the vacuum system required on the beam lines of SPES. Be in charge of armonization of the vacuum system provided by other work units (Target-ion-source, beam cooler, charge breeder, RFQ, …), both in terms of fundamental equipment and control HW
B9.2 - Exhaust Recovery	Design, build and test one or more vacuum exhaust recovery systems for the various components along the SPES beam line
B9.3 - Installation and Mechanical Integration	[cancelled, included in B10]
B10 - Controls	
B10.1 - Hardware	
B10.2 - EPICS	
B10.3 - PLCs	
B10.4 - SW Integration	
B10.5 - Network	
B11 - Mechanical Engineering	
B10.1 - Mechanical design	Provide support and standardization requirements for mechanical design of components of SPES, either directly or through the support of external personnel
B10.2 - Mechanical drawings	Provide support and standardization requirements for mechanical drawings of components of SPES, either directly or through the support of external personnel
B10.3 - Mechanical realization	Follow up the realization of mechanical components which are not to be followed up directly by the various SPES units; both internally (LNL mechanical workshop) and externally (specialized factories).

Figure 2. 8 *– Deliverable list associated to the various units and sub-units of the SPES project*

2.13.1 Approval procedure.

In particular, before applying for decision, the Responsible shall have consulted with all Consulted (C in the RACI matrix). Each order proposal, to be proposed by the Responsible, shall have to be preliminarily ratified and approved – for each sub-project – by those who are Accountable for that sub-project.