SPES Project

BOZZA

SPES status

2° Meeting of the SPES Technical Advisory Committee

Gianfranco Prete
Project leader

LNL, December 4th 2014

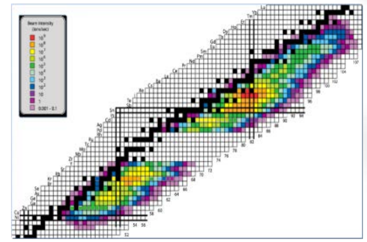
SPES Strategy

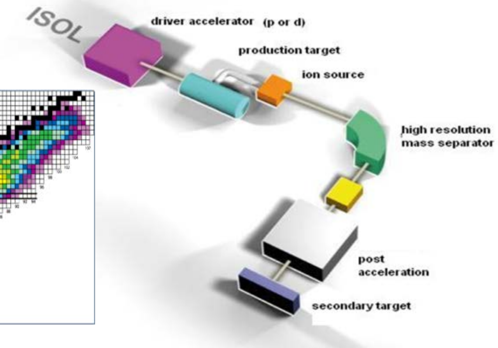
BEST Cyclotron installation & commissioning:

- 70 MeV proton beam
- 750 μA

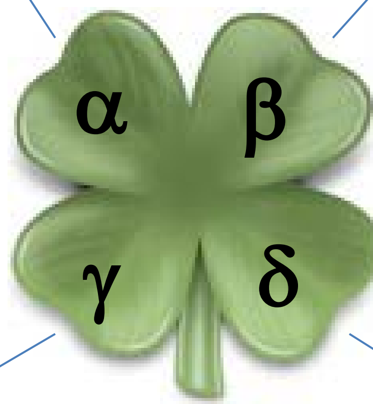
Second generation ISOL facility

Toward EURISOL

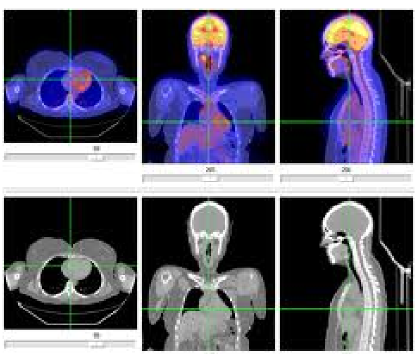




Production & re-acceleration of **exotic beams**, especially **neutron–rich** from **p-induced Fission** on **UCx**

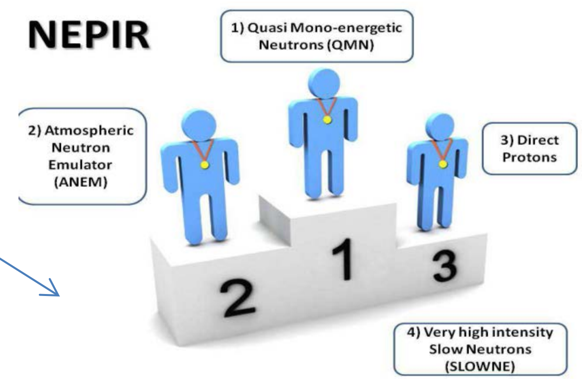


LARAMED



Research and Production of **Radio-Isotopes for Nuclear Medicine**

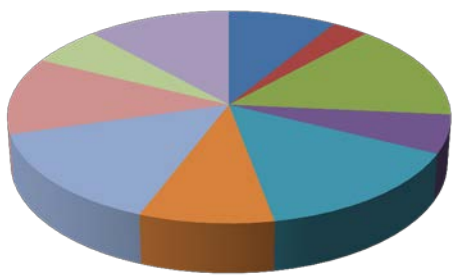
NEPIR

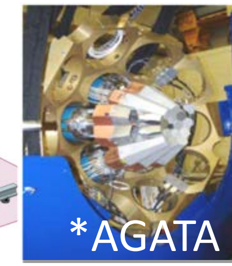


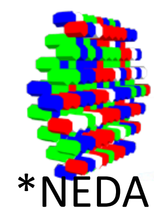
Accelerator based neutron source (**Proton and Neutron Facility for Applied Physics**)

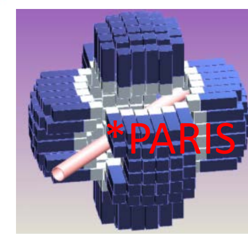
Presented 37 Letters of Intents

SPES LOIs Topics

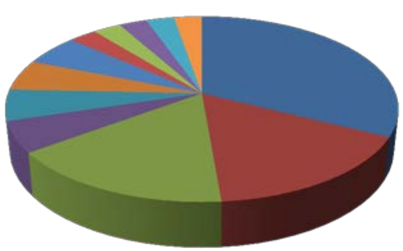


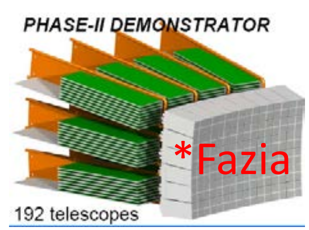


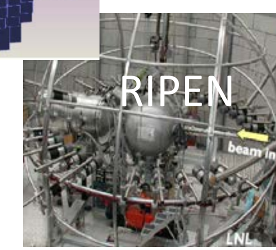


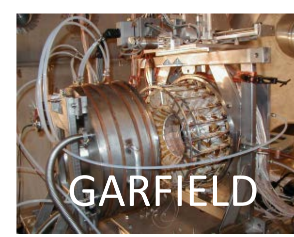


SPES LOIs Spokespersons









SPES up-grade:

High level «European» instrumentation

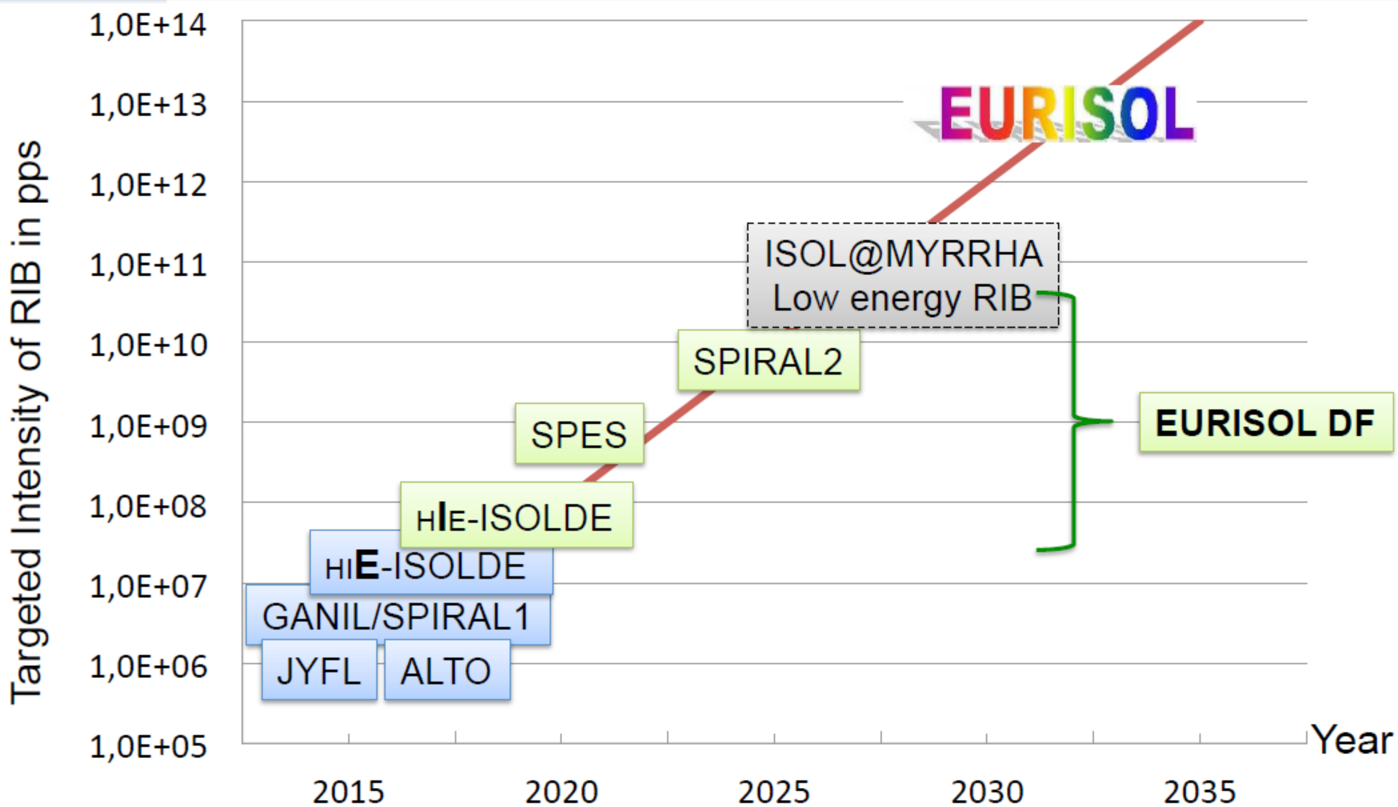
Second ISOL bunker and High intensity

High resolution mass separation at 1/40000

Reaccelerated beam energy upgrade

New cavities for ALPI
New EBIS Charge Breeder with up to date performances

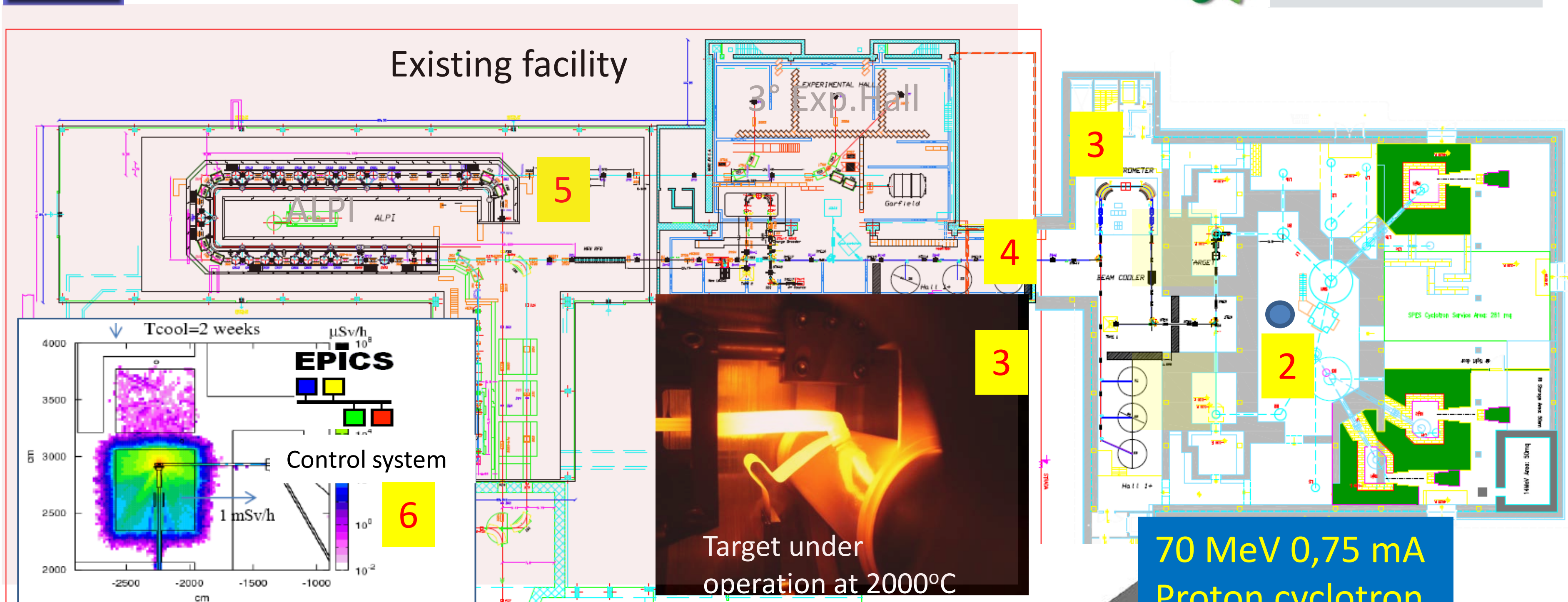
EURISOL DF: Intermediate step towards single site project

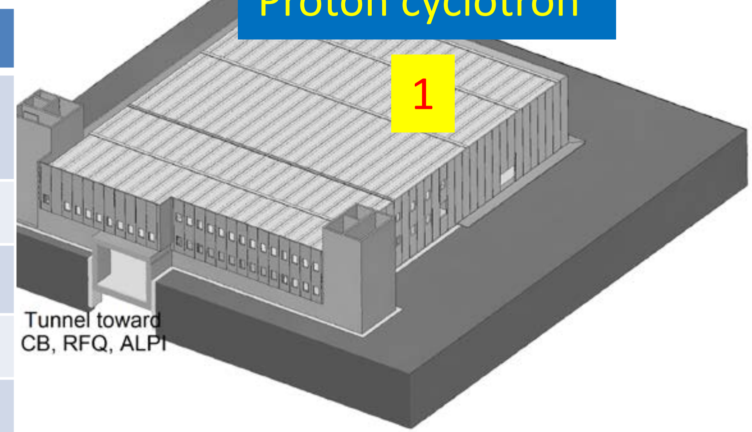


Complementarities: Instrumentation eg. AGATA, FAZIA, GASPARD, PARIS
Challenges: High-power targets & sources, purification of RIB

Curtesy M.Lewitowicz EURISOL DF

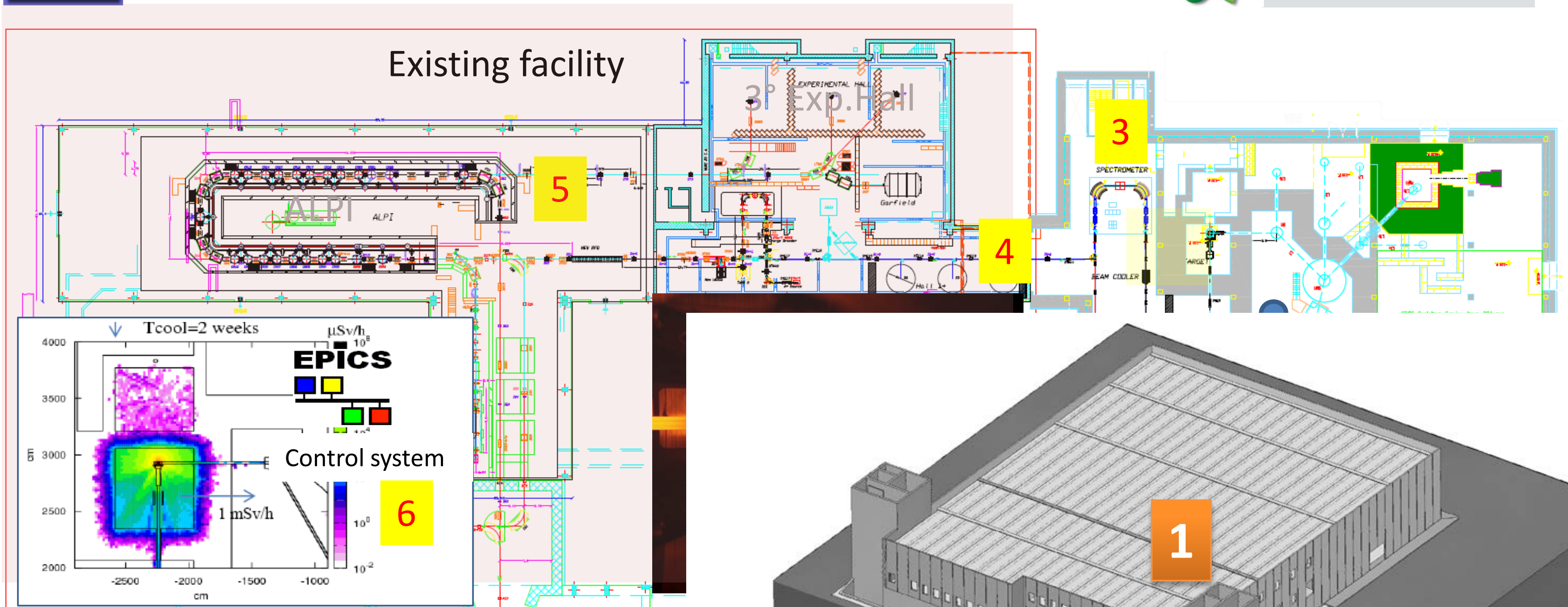
SPES Facility Layout

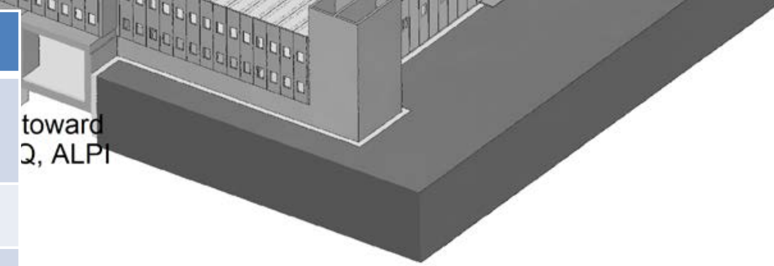




	SPES sub-systems
1	Building and infrastructures with 2 ISOL bunkers for radioactive beam and application area for radioisotopes and neutrons
2	Cyclotron 70 MeV protons with 2 independent exits
3	ISOL UCx target designed for 10^{13} f/s
4	Beam transport with High Resolution Mass Separation
5	Reacceleration with ALPI superconducting linac (10A MeV A=130)
6	Radioprotection, safety & controls

Infrastructures





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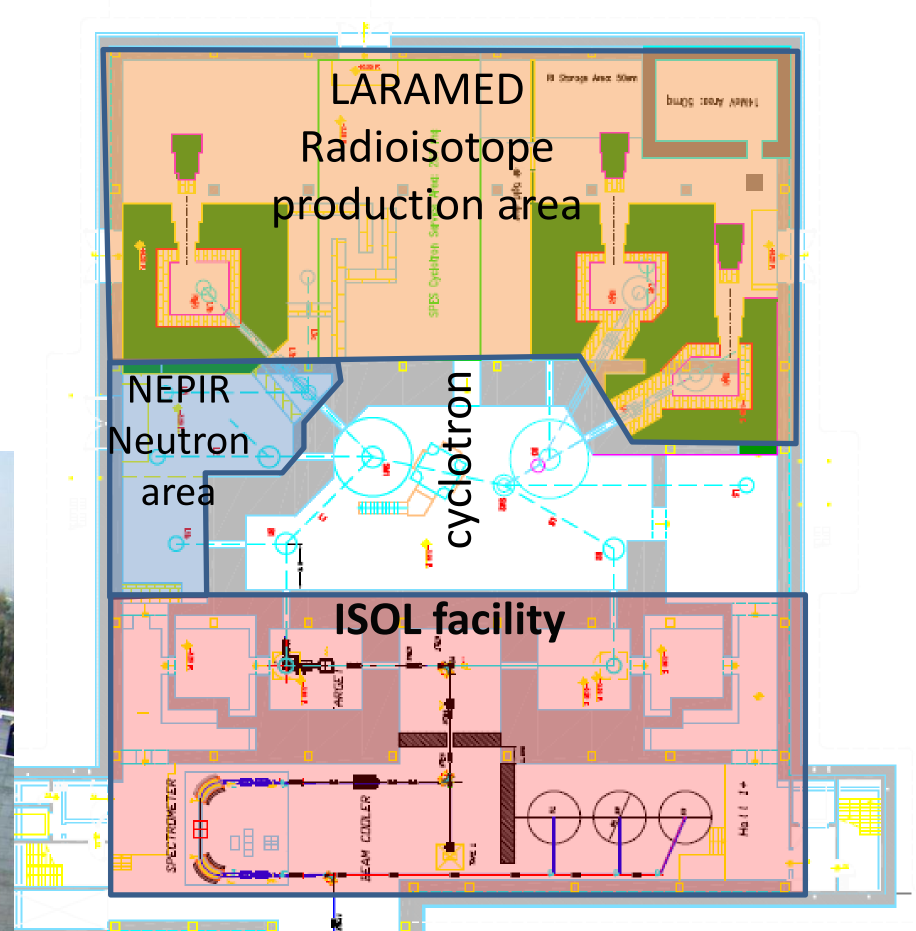
WORK in progress

SPES building construction



Milestones to accept cyclotron :

1. Delivery of building **Feb 28, 2015**
2. Delivery of infrastructures **Apr 30, 2015**

LARAMED Project

Funded with 6.8 Meuro

Joint Research lab of INFN, CNR, Universities and external companies:

- Measurement of cross section through targets activation
- High power targets tests
- Radioisotopes/radiopharmaceuticals Production test facility (^{99m}Tc, ^{64}Cu, ^{67}Cu, ^{82}Sr, ...)

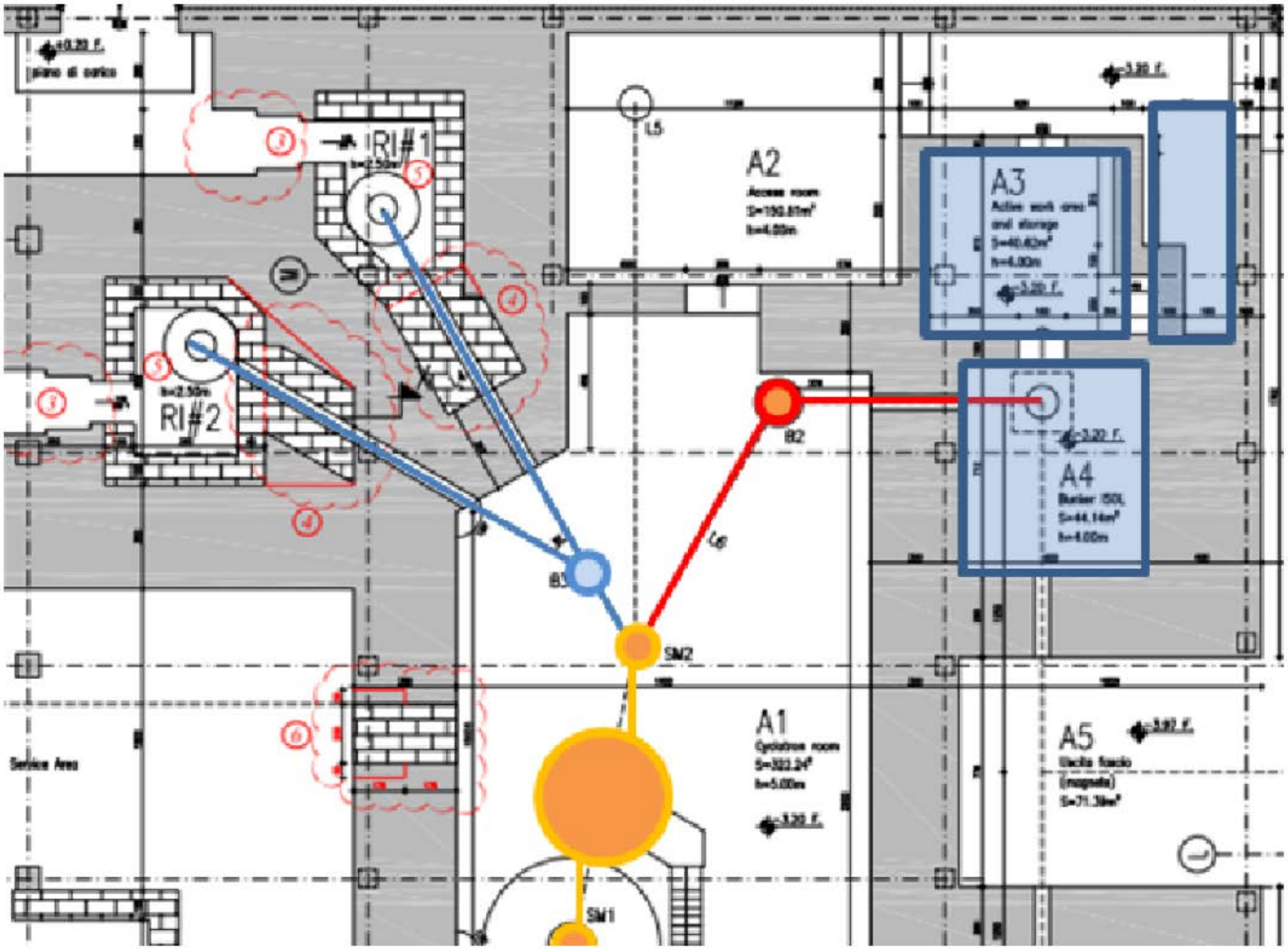
Production laboratory in conjunction with external companies:

Selected isotopes of medical interest

STATUS:

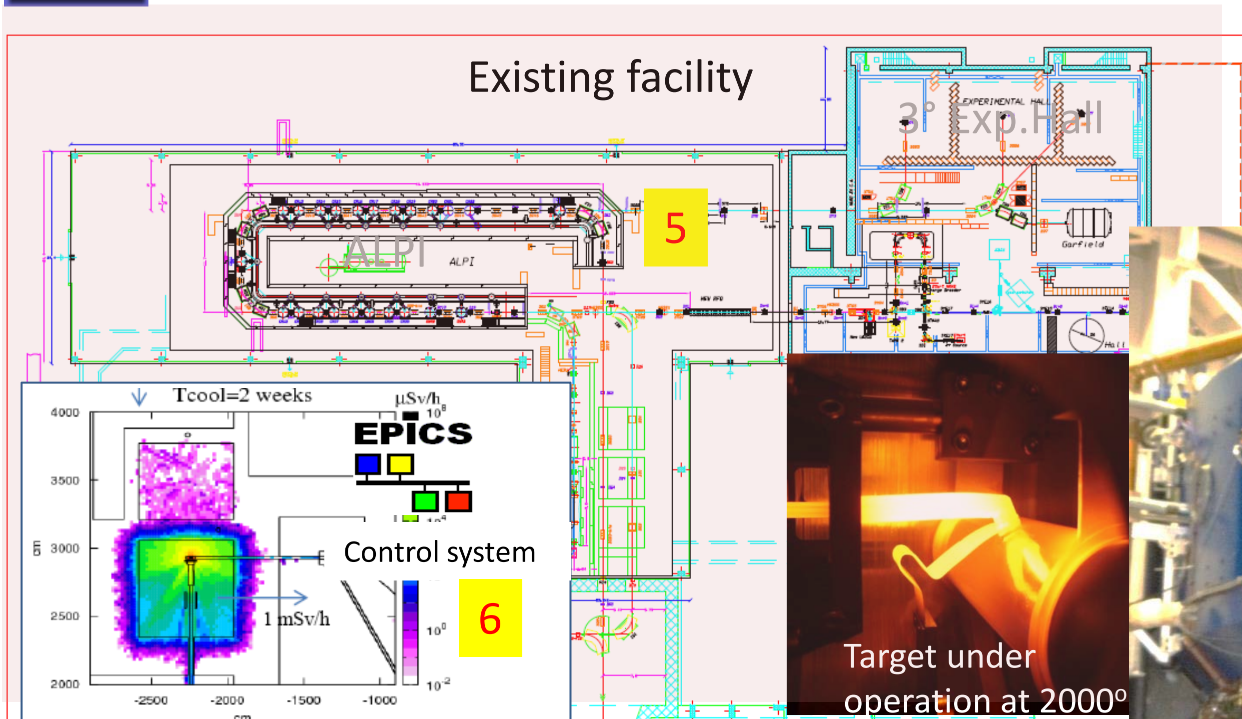
- Building and infrastructures development
- Design of radiochemistry labs
- Design of beam line and target management
- Contract with company for radioisotopes production to be finalized

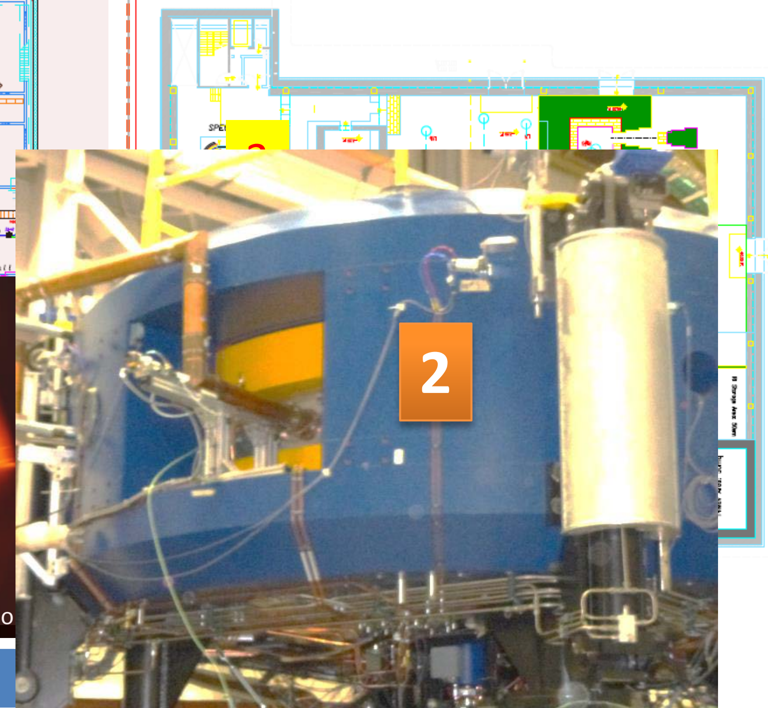
Temporary A3-A4 installation

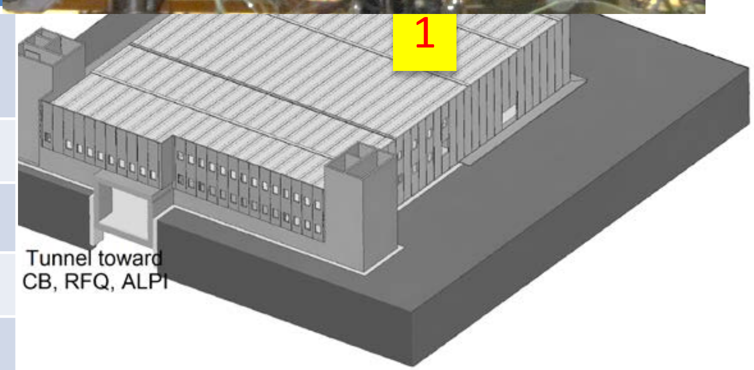


Operation allowed by SPES alpha authorization (500μA, 70MeV in the limit of rad.prot. rules)

Cyclotron







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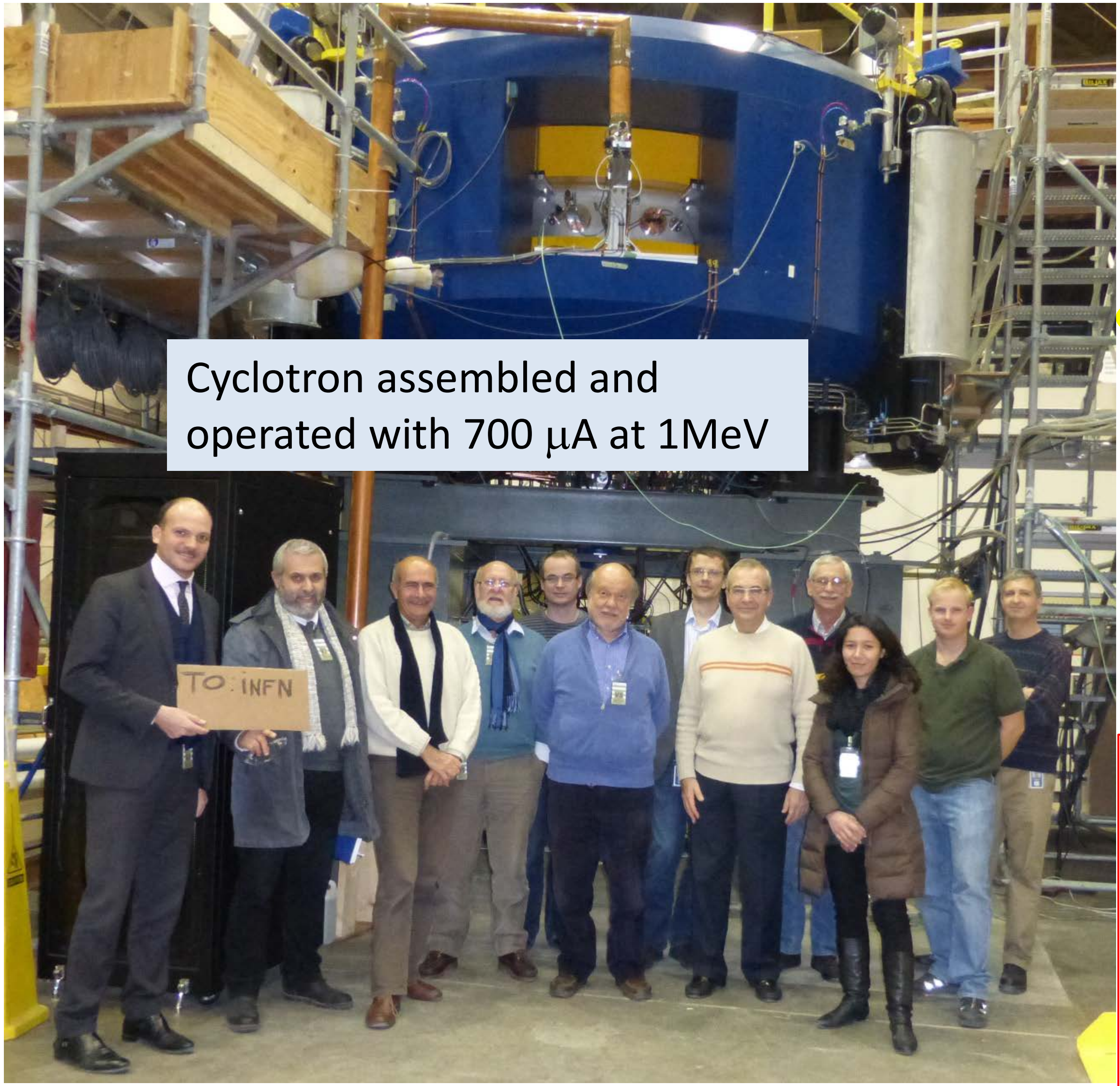
Cyclotron test at BEST Company site (Ottawa)



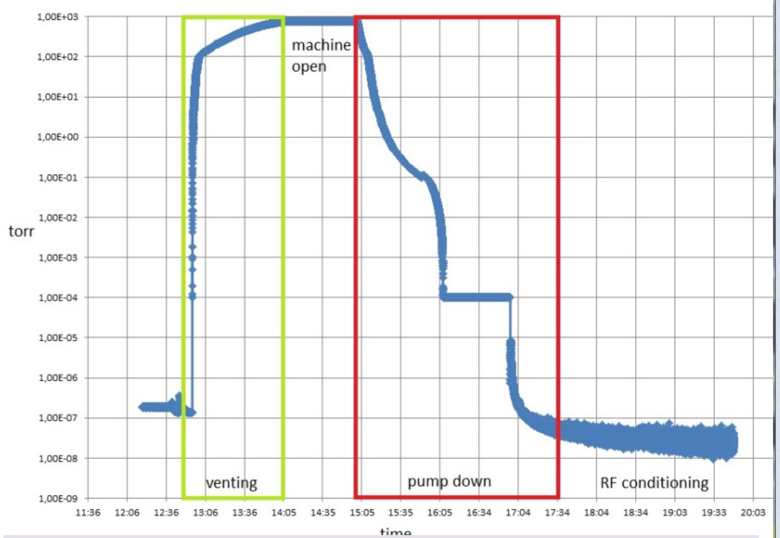
Cyclotron assembled and operated with 700 μA at 1MeV

Main Parameters	
Accelerator Type	Cyclotron AVF 4 sectors
Particle	**Protons (H^- accelerated)**
Energy	**Variable within 30-70 MeV**
Max Current Accelerated	**750 μA** (52 kW max beam power)
Available Beams	**2 beams at the same energy** (upgrade to different energies)
Max Magnetic Field	1.6 Tesla
RF frequency	56 MHz, 4^{th} harmonic mode
Ion Source	Multicusp H^- I=15 mA, Axial Injection
Dimensions	Φ=4.5 m, h=1.5 m
Weight	150 tons

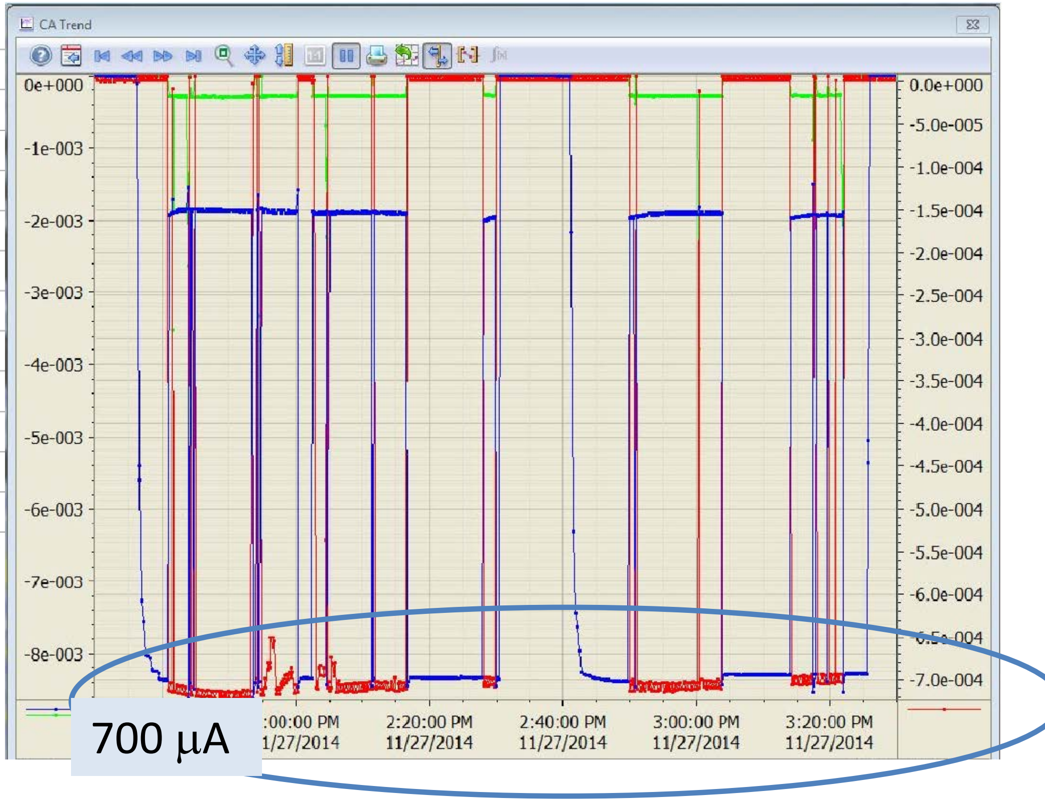
In the factory at Ottawa, the construction and the assembly of the Cyclotron is completed. The assembly of the **RF resonators is over** and the **injection and acceleration phase started** according to the schedule (**1 MeV at full current**).

FAT partially approved on November 29^{th}

Final Fatory Acceptance Test in Ottawa next week



Succesful vacuum test: below 10^{-7} Torr after 2hours pumping

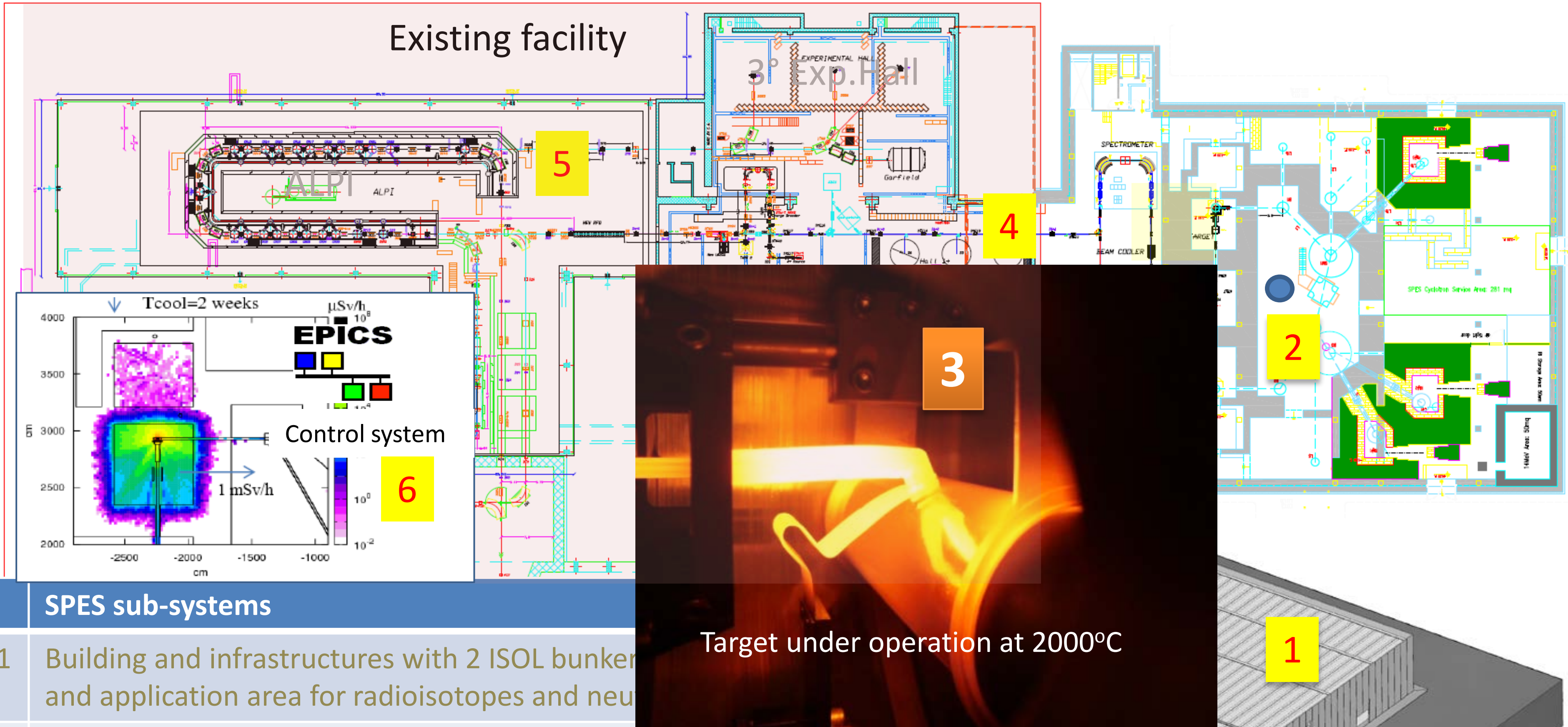


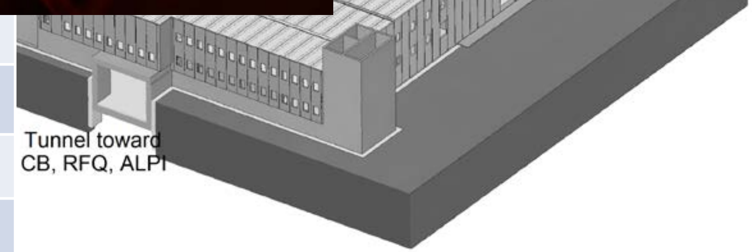
See Augusto presentation

current measured at inflector collimator (green), beam stop (blue) and 1MeV probe (red).

Test was not completely succesfull, under discussion the following steps (more exaustive test in Ottawa or cyclotron dismounting and transfer to Italy)

ISOL production





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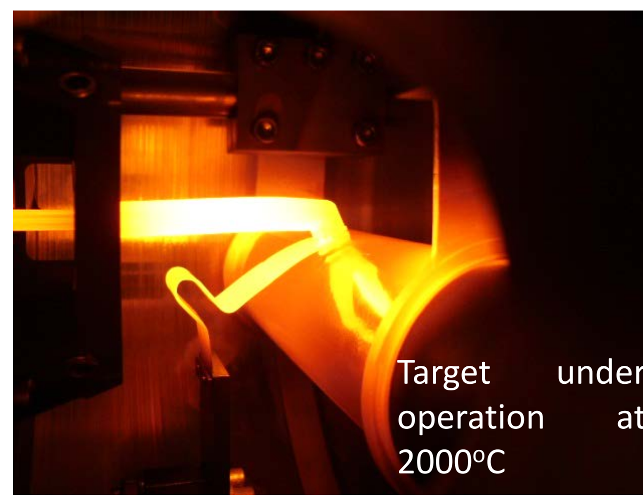
Technical highlights: the production target

SPES DIRECT TARGET CONCEPT to operate with **8 kW** proton beam

(A. Andrighetto et al.)

- Direct Target carefully designed to reach **10^{13} fissions/s** with **8 kW** proton beam (thermo-mechanical considerations);
- **In beam test** performed at **iThemba lab (South Africa)** on May 2014;
- Prototype under operation.
- Fully developed **front-end** following ISOLDE design;

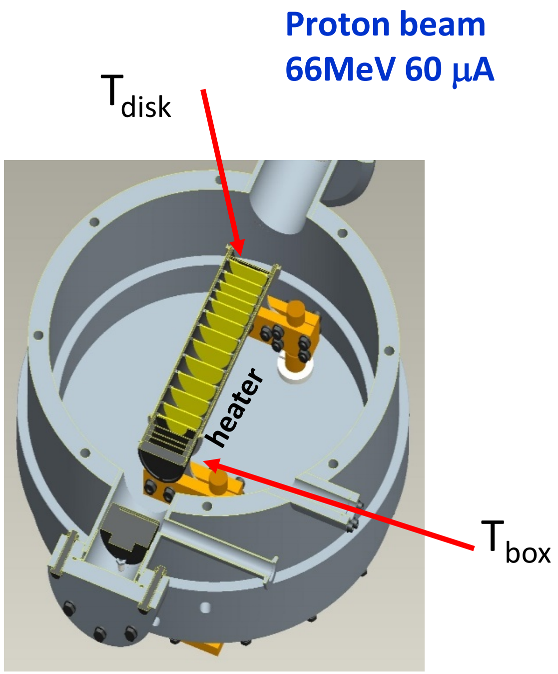


Target Power test @ iThemba Labs

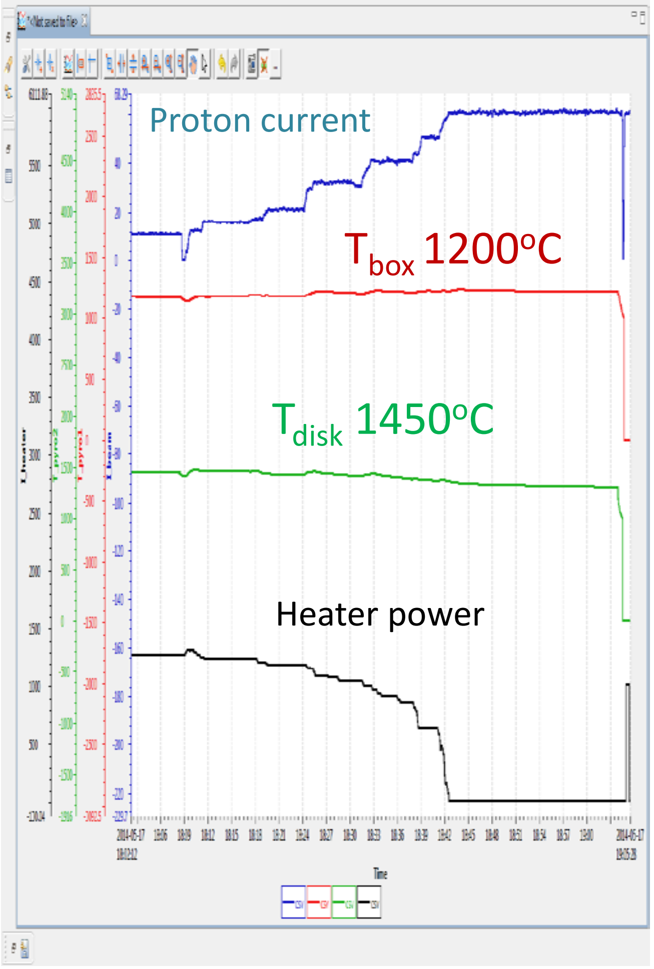
SPES target **in-beam power test** (SiC target, operating temperature 1450°C)

Heater power compensated by proton beam.

- Up to **4 kW proton** beam in target.
- **Stable temperatures**
- **Stable vacuum** (3 10^{-5} mbar)



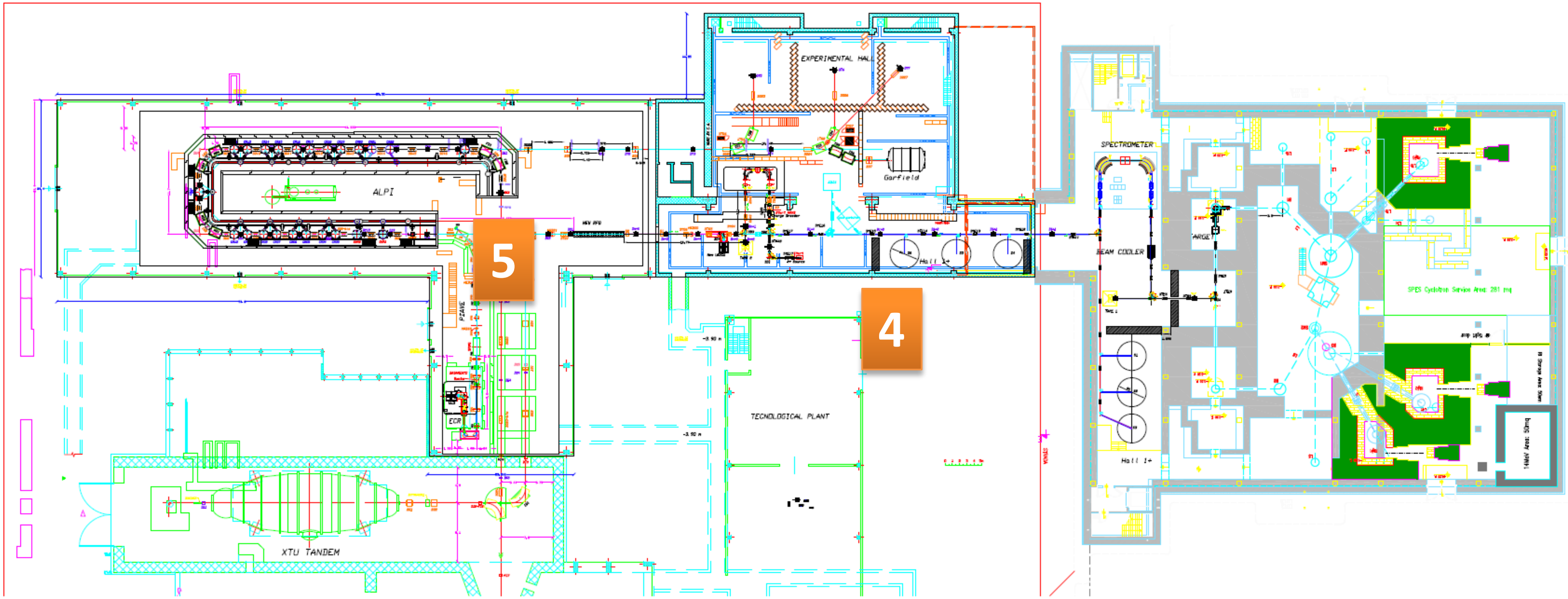
Thanks to Rob, Lowry and all the **iThemba_Labs Cyclotron** staff



iThemba_Labs, May 17th, 2014

A.Monetti, J.Vasquez

Beam transport and reacceleration



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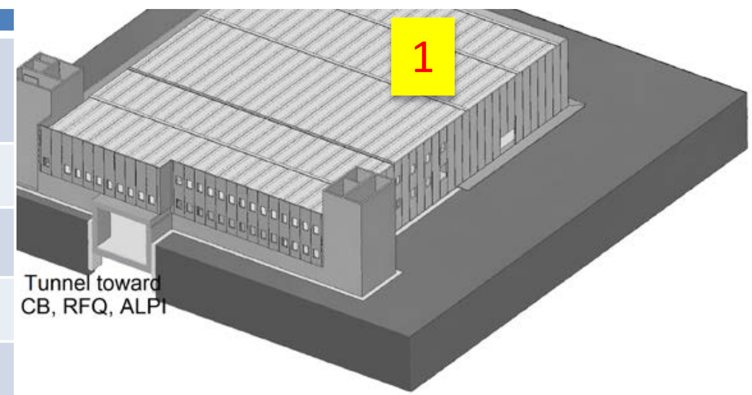
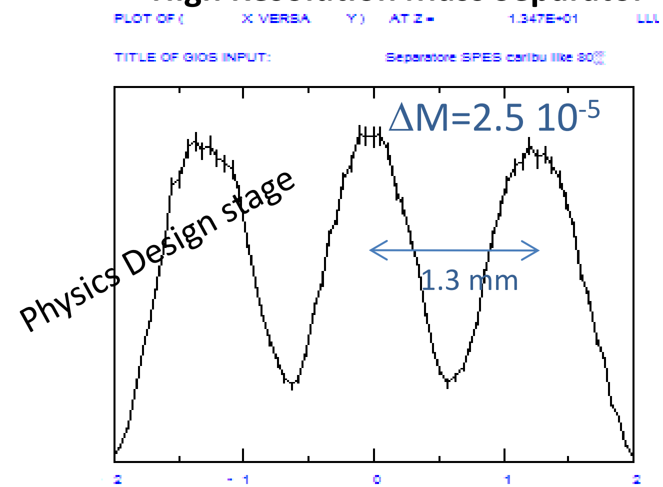


High Resolution Mass Separator & Beam Cooler

Collaboration SPES – CENBG Bordeaux (SPIRAL2)

- Scaled-up version of the separator designed by Cary Davids for CARIBU, Argonne
- Mass resolution: 1/40000 (eng. design: 1/25000)

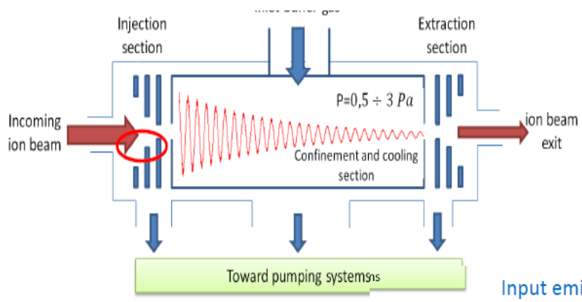
High Resolution Mass Separator

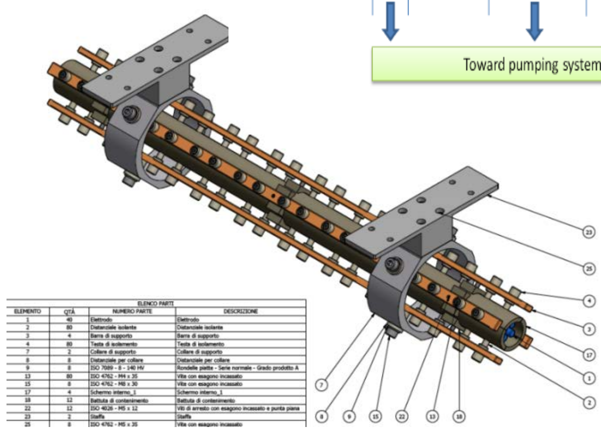


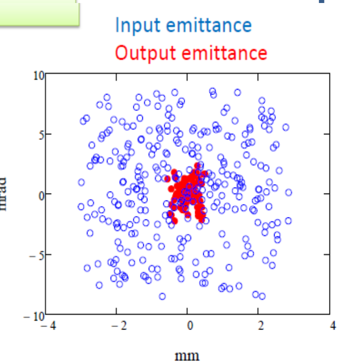
Beam Cooler to match the HRMS input requirements

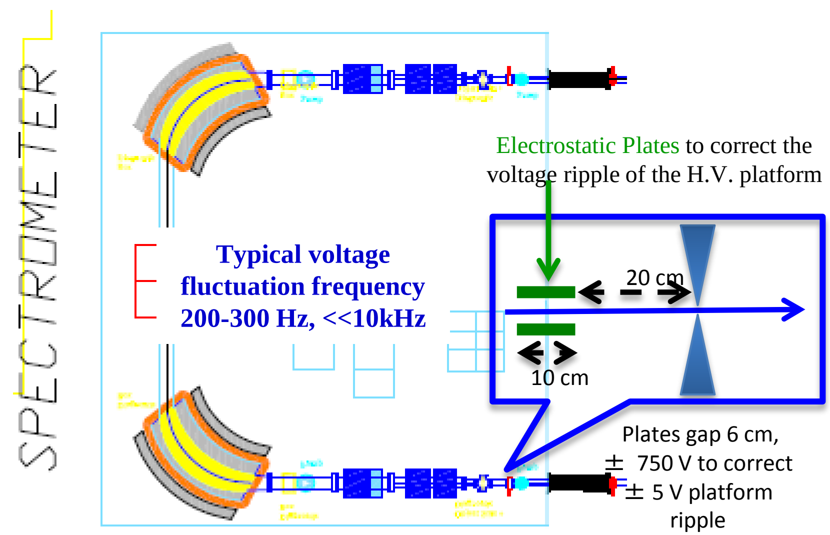
COOLBEAM experiment financed by INFN-CSN5, 2012→2015
Collaboration: LNL-LNS, Mi bicocca

M.Maggiore









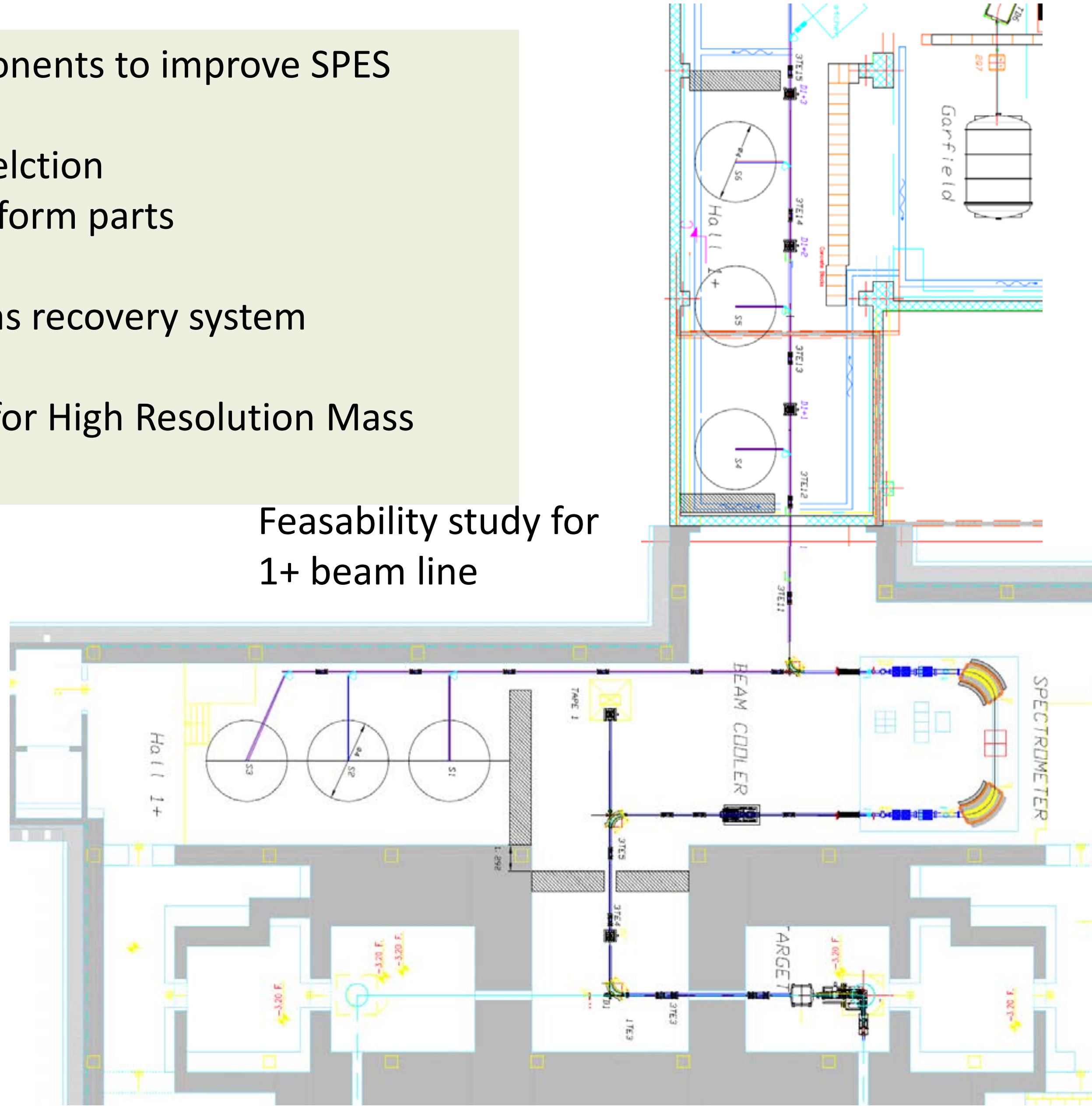
L.Calabretta, M.Comunian, A.Russo, L.Bellan

HRMS 1+beam line and sinergies with LNS

Possible use of EXCYT components to improve SPES (items to be discussed)

- dipoles for mass selction
- High Voltage plateform parts
- HV power supply
- development of gas recovery system

Collaboration with SPIRAL2 for High Resolution Mass Separator design.



Feasability study for 1+ beam line

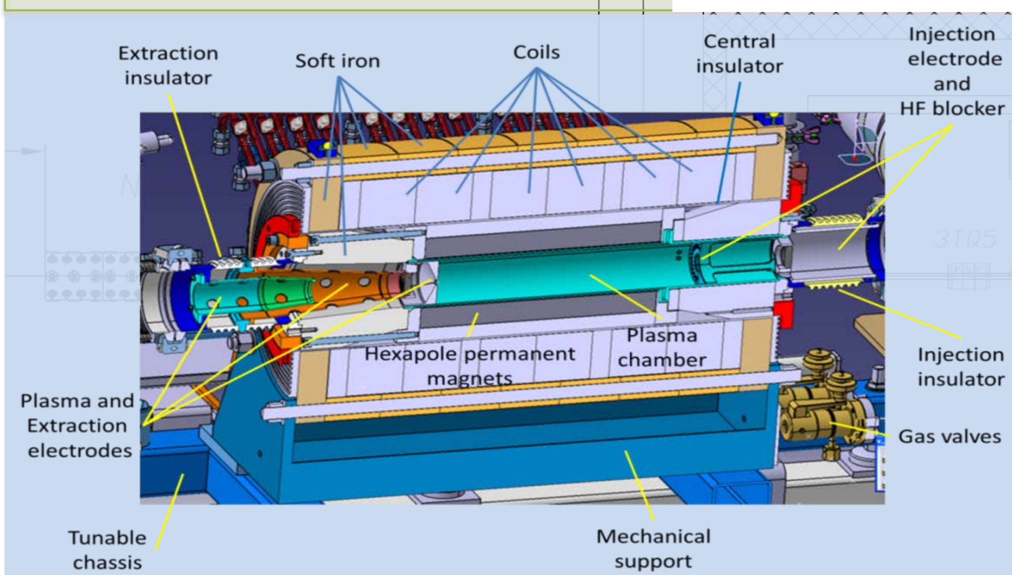
Charge Breeder development and medium resolution mass separator

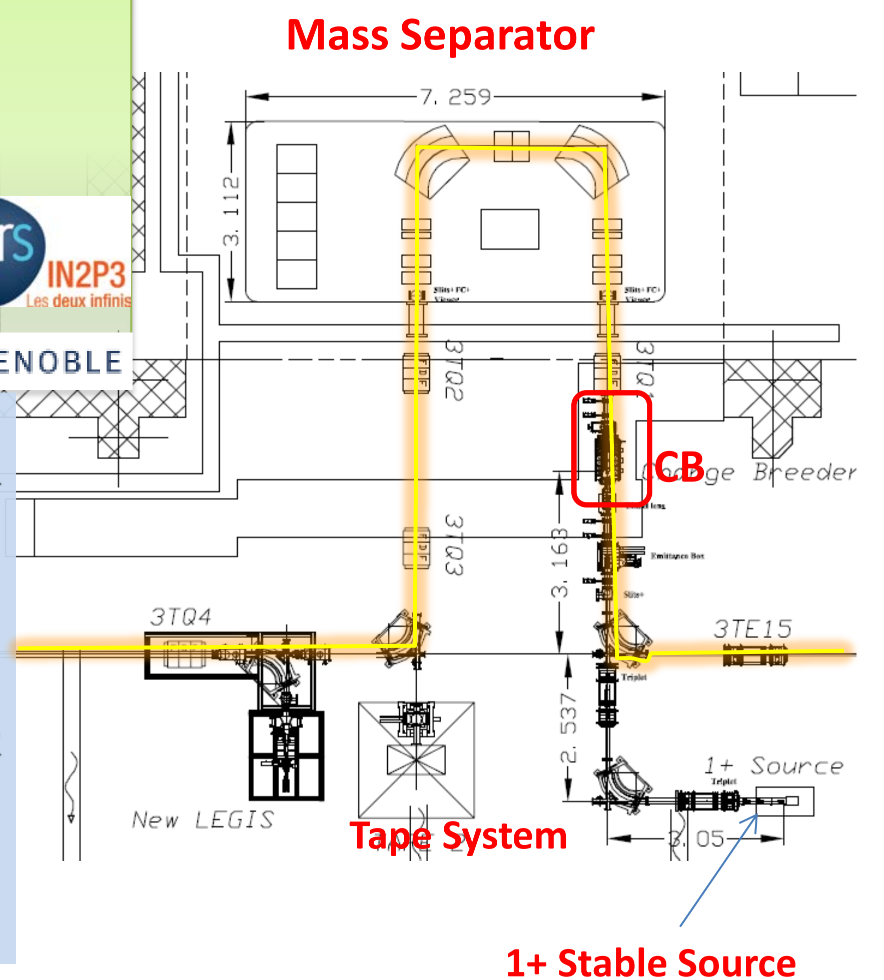
Collaboration agreement with LPSC (Grenoble) for the SPES Charge Breeder

The development of an Upgraded PHOENIX booster is Part of a MoU in the frame of the European Associated Laboratories (LEA-Colliga) with GANIL.
(In exchange: development of SPIRAL2 n-converter by INFN)
Project and construction by LPSC_Grenoble

- 2010 Preliminary measurements
- 2011 Conceptual design and schedule definition
- 2012 Design
- 2013 Agreement definition
- 2014 Construction
- 2015 Commissioning

LPSC Grenoble — CNRS IN2P3 Les deux infinis — UNIVERSITÉ DE GRENOBLE



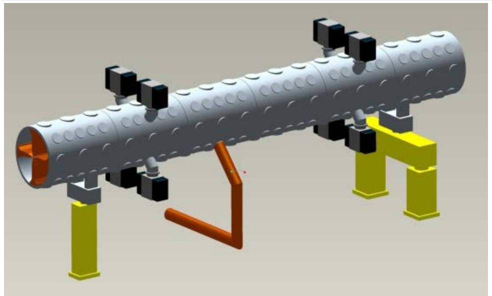


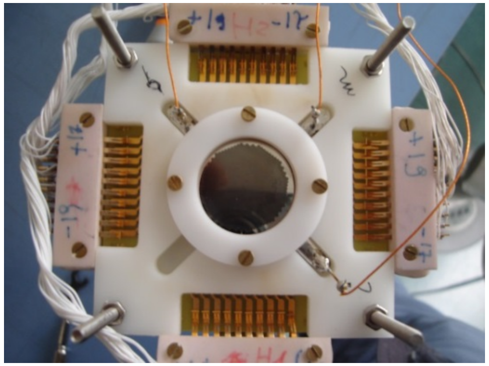
T. Lamy (LPSC), A. Galatà (INFN), et al.

Exotic Beam reacceleration and diagnostics

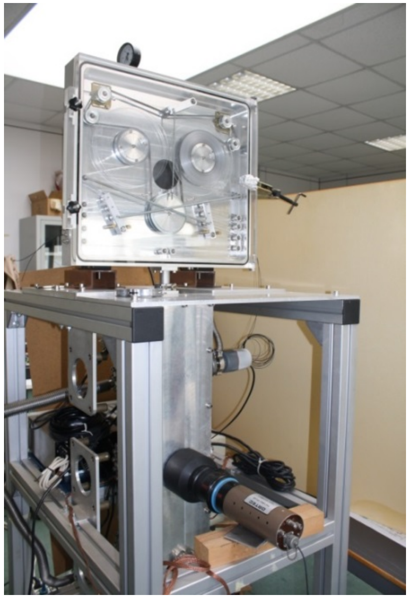
Room temperature RFQ

Mechanical layout of the **RFQ**



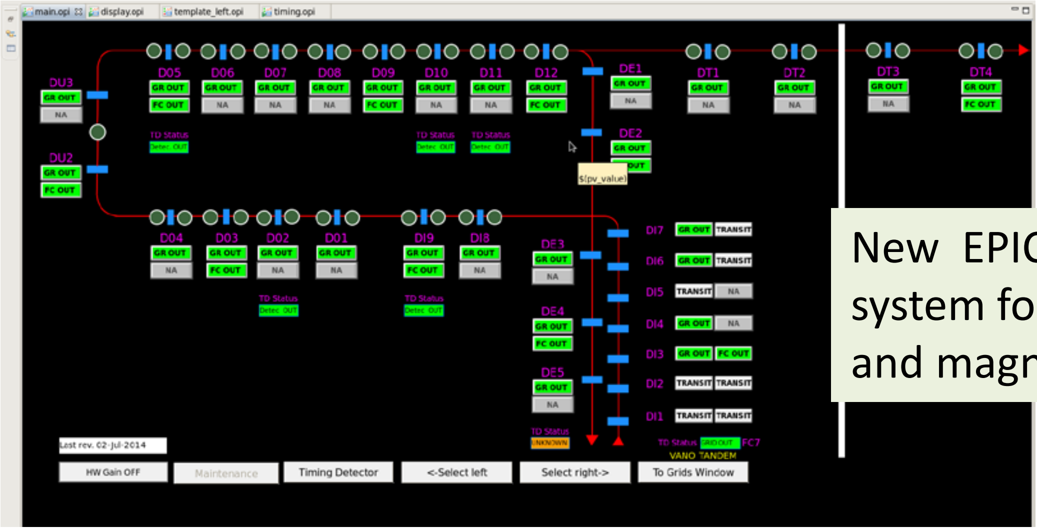


MCP based Low intensity beam monitor



Tape system

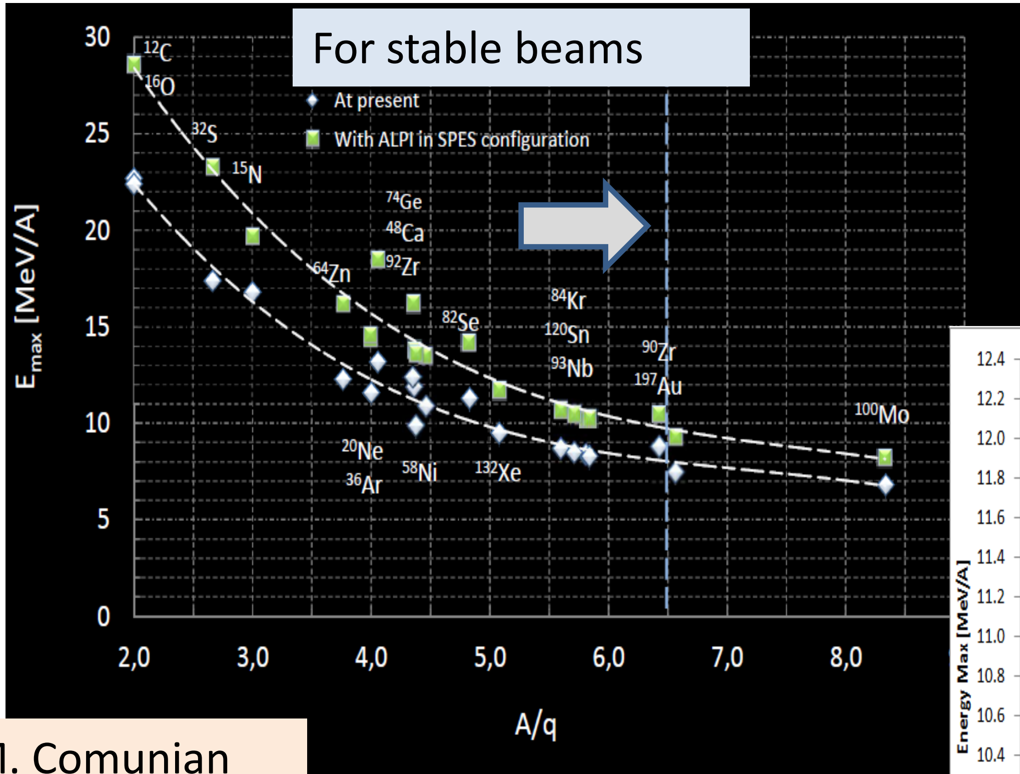
Installation of new High Energy beam line. (Today under commissioning)



New EPICS control system for diagnostic and magnets

A. Pisent, M.Poggi, T.Marchi

The Upgraded Alpi post-accelerator

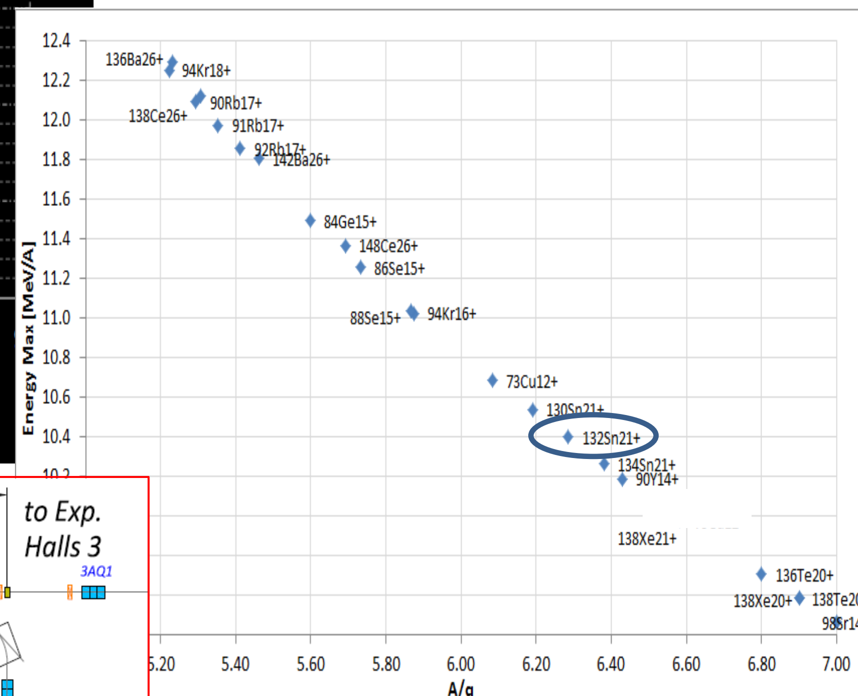


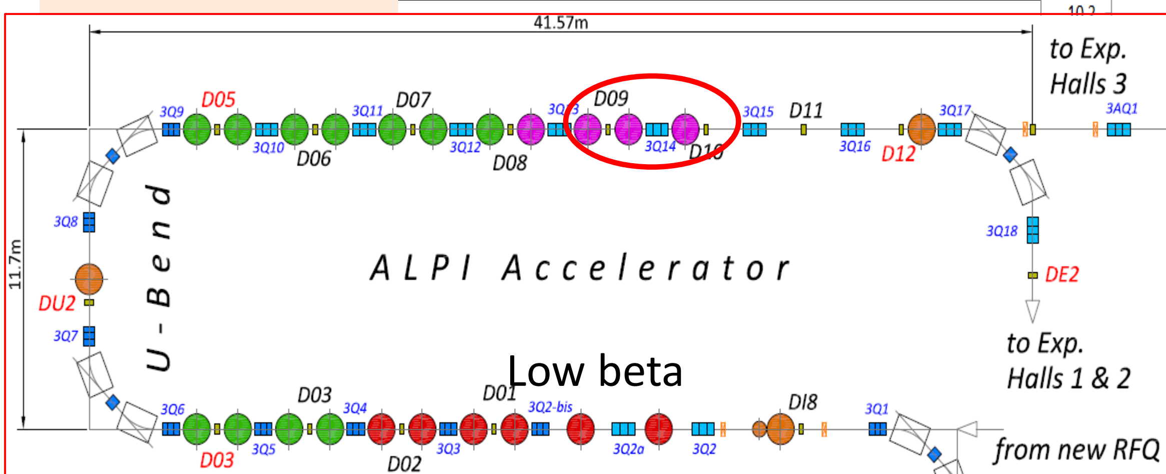
M. Comunian

For exotic beams

Low Beta=5 MV/m, Medium Beta=4.3 MV/m, High Beta=5.5 MV/m

Conservative value: 2 cavities off in the calculation.

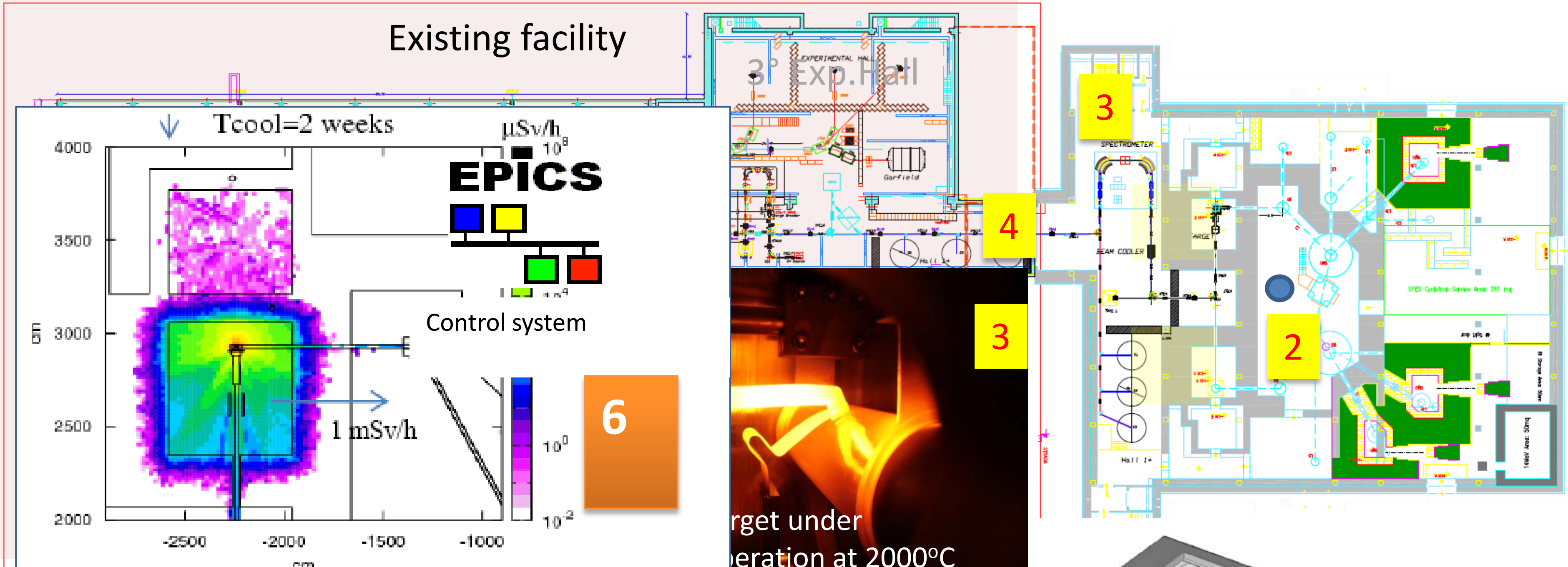


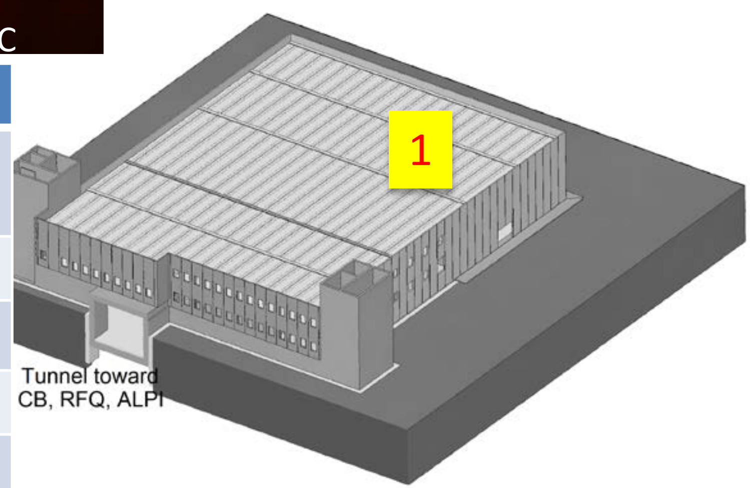


Reshape and improvement of low beta cavities.

Added high beta cryostats to improve the final energy.

Rad.Prot, safety & controls





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6	**Radiation protection, safety & controls**

Radioactivity distribution inside SPES beam lines

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

SPES exotic beams for science

SISTEMA DI GESTIONE PER LA QUALITA' E SICUREZZA DI SPES				
Codice doc.	DOC_00000020	Distribuzione della radioattività lungo la linea di fascio di SPES	Rev.	00
			Pag.	1 di 44

Contenuto Documento
Documento che descrive la distribuzione della radioattività lungo la linea di fascio di SPES.

The input data for the calculation are resumed in the table, showing the beam of interest ^{132}Sn extracted with a current of 1.759 nA and the contaminant beam ^{132}Cs with a current of 1.073 nA.

Element	Z	N	nA	$T_{1/2}$
Sn	50	82	1.759	39.7 sec
Cs	55	77	1.073	6.48 days

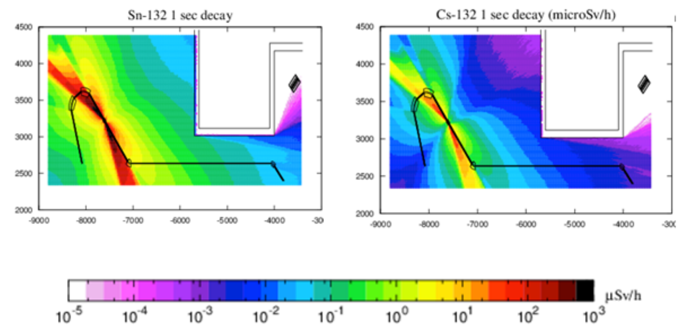


Figure 6 Gamma dose rate (μSv/h) 1 second after the end of the extraction of a beam of Sn-132 and Cs-132 impacting on the charge breeder plasma chamber.

Z\A	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141		
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.	
43	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.	
44	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.	
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	3.60E+09	2.52E+09	4.20E+09	3.85E+09	4.19E+09	2.98E+09	2.52E+09	1.72E+09	1.26E+09	3.03E+08	1.73E+08	9.94E+07	2.31E+07	1.93E+06	1.96E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	9.96E+09	1.84E+10	1.29E+10	2.10E+10	1.57E+10	2.36E+10	1.85E+10	2.42E+10	2.03E+10	2.43E+10	1.63E+10	1.30E+10	2.60E+09	2.52E+09	1.25E+09	2.09E+08	2.79E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
52	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	0.00E+00	3.15E+06	1.95E+07	2.23E+07	1.24E+08	1.88E+08	5.05E+08	7.47E+08	1.40E+09	2.06E+09	3.75E+09	3.15E+09	7.56E+09	8.11E+09	1.29E+10	1.31E+10	1.87E+10	1.16E+10	1.44E+10	1.10E+10	1.33E+10	7.76E+09	1.13E+10
56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+06	1.51E+06	1.66E+07	6.34E+07	1.01E+08	2.93E+08	3.98E+08	5.74E+08	1.05E+09	2.01E+09	2.14E+09	4.07E+09	4.33E+09	6.79E+09	4.82E+09	6.24E+09	4.48E+09	6.78E+09	3.08E+09
57	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.77E+06	1.13E+07	3.62E+07	4.22E+07	1.33E+08	2.09E+08	4.46E+08	5.68E+08	1.03E+09	1.40E+09	2.23E+09	1.66E+09	2.41E+09	1.96E+09	2.32E+09
58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Selective capability of the SPES mass separators

Figure 14: Z\A plane with the particle currents and the separation places, (brown) WF, (green) 90 deg dipole, (light blue) HRMS (beam cooler losses have been considered). Purple indicates the nominal species.

Access control description

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

SPES exotic beams for science

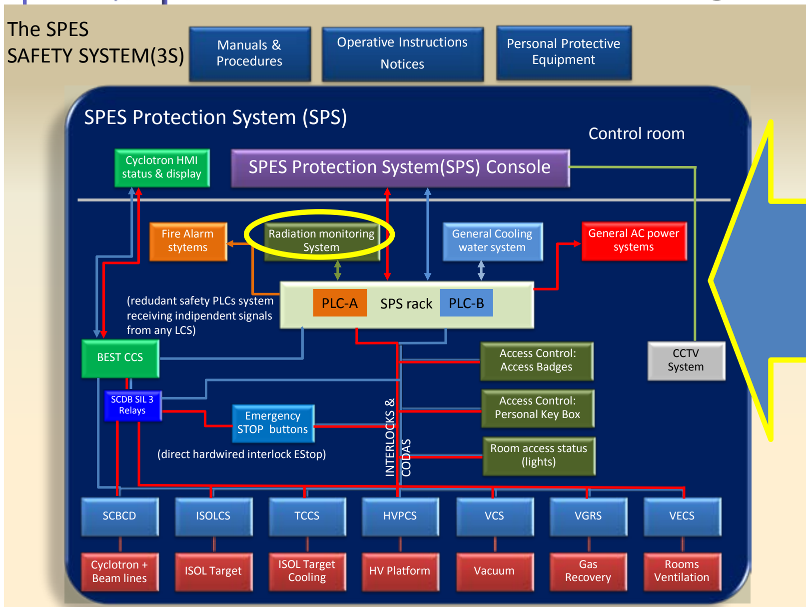
SISTEMA DI GESTIONE PER LA QUALITA' E SICUREZZA DI SPES

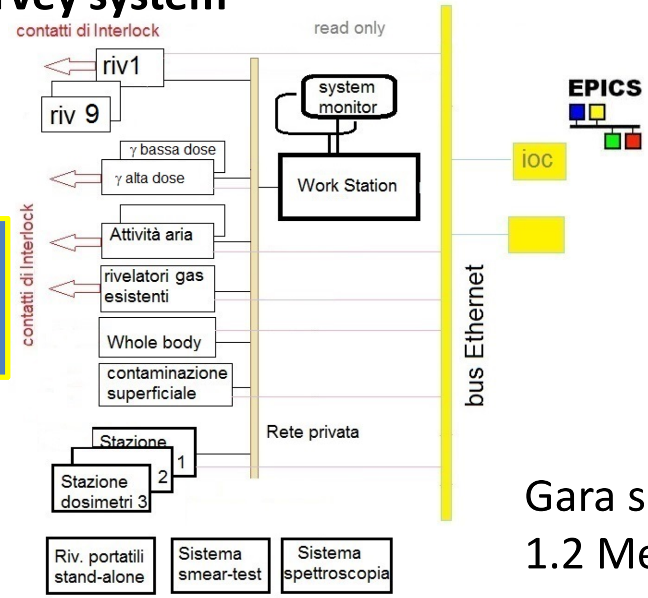
Codice doc.	DOC_00000024	Sistema Controllo Accessi di SPES Fase Alfa	Rev.	00
			Pag.	1 di 19

Contenuto Documento

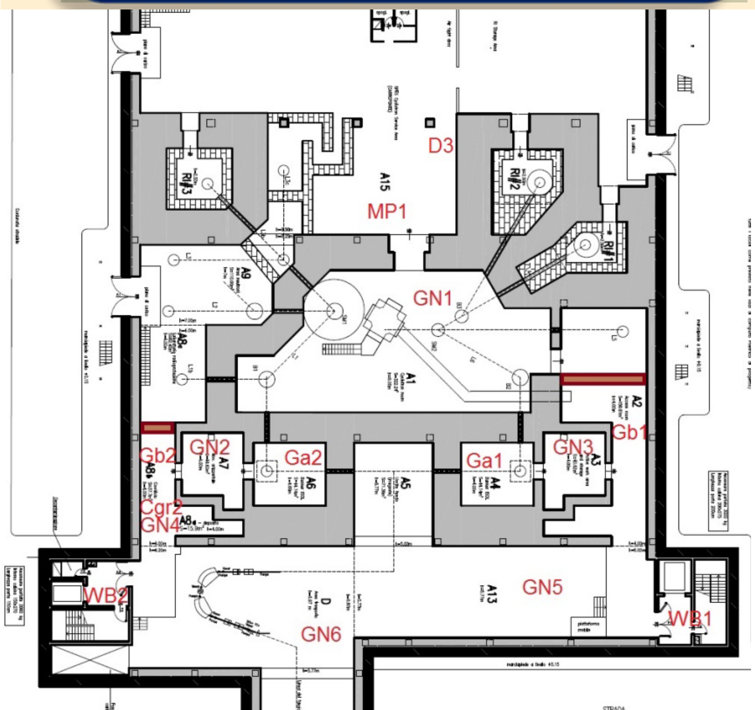
Documento che descrive il Sistema di Controllo Accessi per il progetto SPES – Fase Alfa.

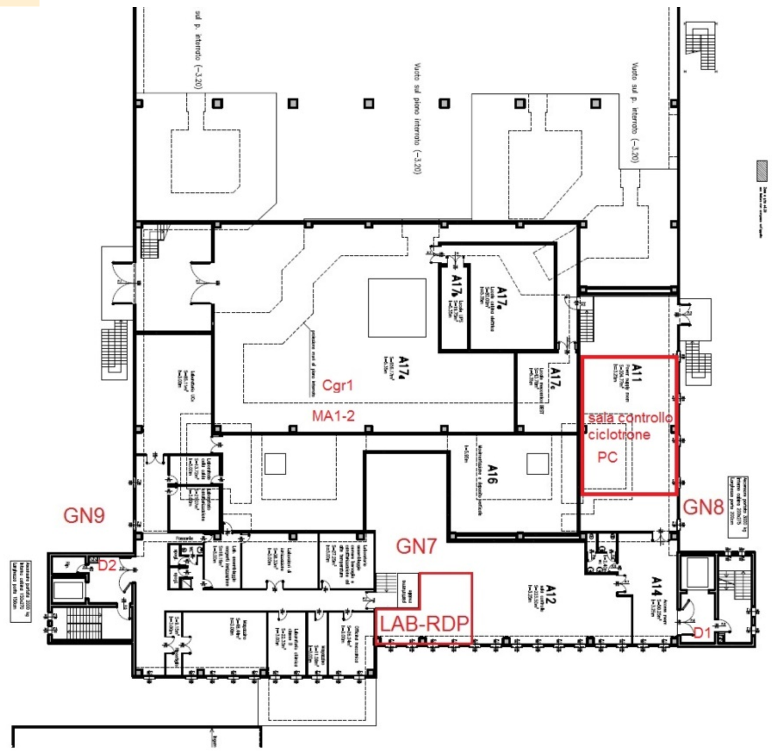
Radiologic survey system





Gara sottomessa all'INFN
1.2 Meuro





SPES Safety TAC Nov 19-20, 2014

SPES Safety
Technical Advisory Committee

November 19-20, 2014

Laboratori Nazionali di Legnaro (Padova), Italy

November 19, 2014

ITRODUCTORY TALKS

9.00-9.30 G. Prete – "The SPES Project" (**15 min** +15)

9.30-9.45 F. Gramegna – "Radioactivity Inventory along the SPES Beam Line" (**20 min** +10)

ENERAL SAFETY

9.45-10.15 A.-P. Bernardes (CERN) – "Overview of the activities inside the primary area and safety impact" (**20 min** +10)

10.15-10.45 J. Esposito / D. Phan "Main Safety issues of SPES" / "Safety Issues of the Front-End and the target handling system" (**20 min** +10)

10.45 – 11.15 Coffee break

ARGETS AND HANDLING

11.15-11.45 R. Catherall (CERN) – "The ISOLDE Target Life Cycle" (**20 min** +10)

11.45-12.15 Andrighetto/Silingardi – "Target-Ion-Source Handling Issues" (**20 min** +10)

12.15-12.45 Discussion

12.45-14.00 Lunch

ADIATION PROTECTION

14.30-15.00 J. Vollaire (CERN) – "Radiation Protection experience with the operation of the ISOLDE facility at CERN and considerations for future projects" (**20 min** +10)

15.00-15.30 L. Sarchiapone "RA Material Inventory and doses in SPES areas and surroundings" (**20 min** +10)

15.00-15.30 D. Zafiropoulos "Radiation Monitoring Plan, RA waste storage and conditioning" (**20 min** +10)

- R. Catherall (chair) will report tomorrow about findings, comments and recommendations

  (debriefing on-going…)

- Prioritization of actions on safety and plants for:

1. Execution of cyclotron SAT tests (from and 2015, see Lombardi)
2. Exploitation of the cyclotron for Nulear Physics tests and radioisotope production (from 2016)
3. Explotation of SPES-beta (from 2018)

Planning for final SPES Safety System development

- **Risk analysis** on the way, following the ISOLDE safety roadmap (*based also on information on safety systems for similar projects /facilities (e.g. ISOLDE (CERN), ALBA (Spain), ELETTRA (Italy)*)
- **Full design of Safety System** with support of external companies
- Preliminary contacts with some companies in the field (**Siemens, Pilz, Schneider.....**)

The goal is to have:

- **Bid for executive project** of Safety System : **January 2015**
- **Bid for implemetation** of Safety System : **June 2015**

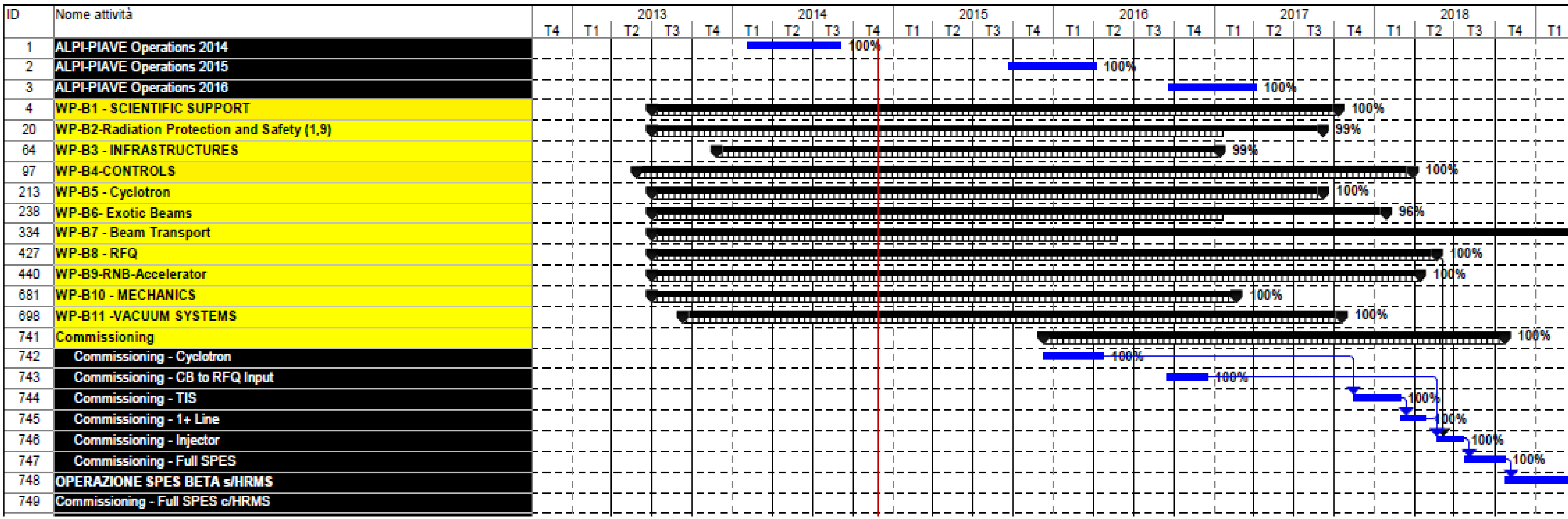
SPES general planning

	2012	2013	2014	2015	2016	2017	2018	2019
Authorization to operate and safety	UCx 5microA							
ISOL Target-Ion Sources development								
ISOL Targets construction and installation								
ISOL on-line commissioning								
Building Construction	Executive project	raw building construction						
Cyclotron Construction & commissioning				Cyclotron at LNL				
RFQ development and Alpi up-grade								
Design of RIB transport & selection (HRMS, Charge Breeder, Beam Cooler)								
Construction and Installation of RIBs transfer lines , CB and spectrometers								
Stepwise commissioning and first exotic beam (2018), HRMS in 2019								

Versus TAC1, stretched by 10 months for better planning (see next slide), and by 10 months due to the addition of the BC+HRMS construction and commissioning

Schedule updated in «Project»

(750 tasks)



Main commissioning milestones:

- End 2015: Cyclotron
- End 2016: Charge Breeder to RFQ injection (and training on breeding and mass separation)
- End 2017 – end 2018: first commissioning of SPES w/o BC and HRMS
- End 2019: completion of commissioning w/BC and HRMS (and of the project).

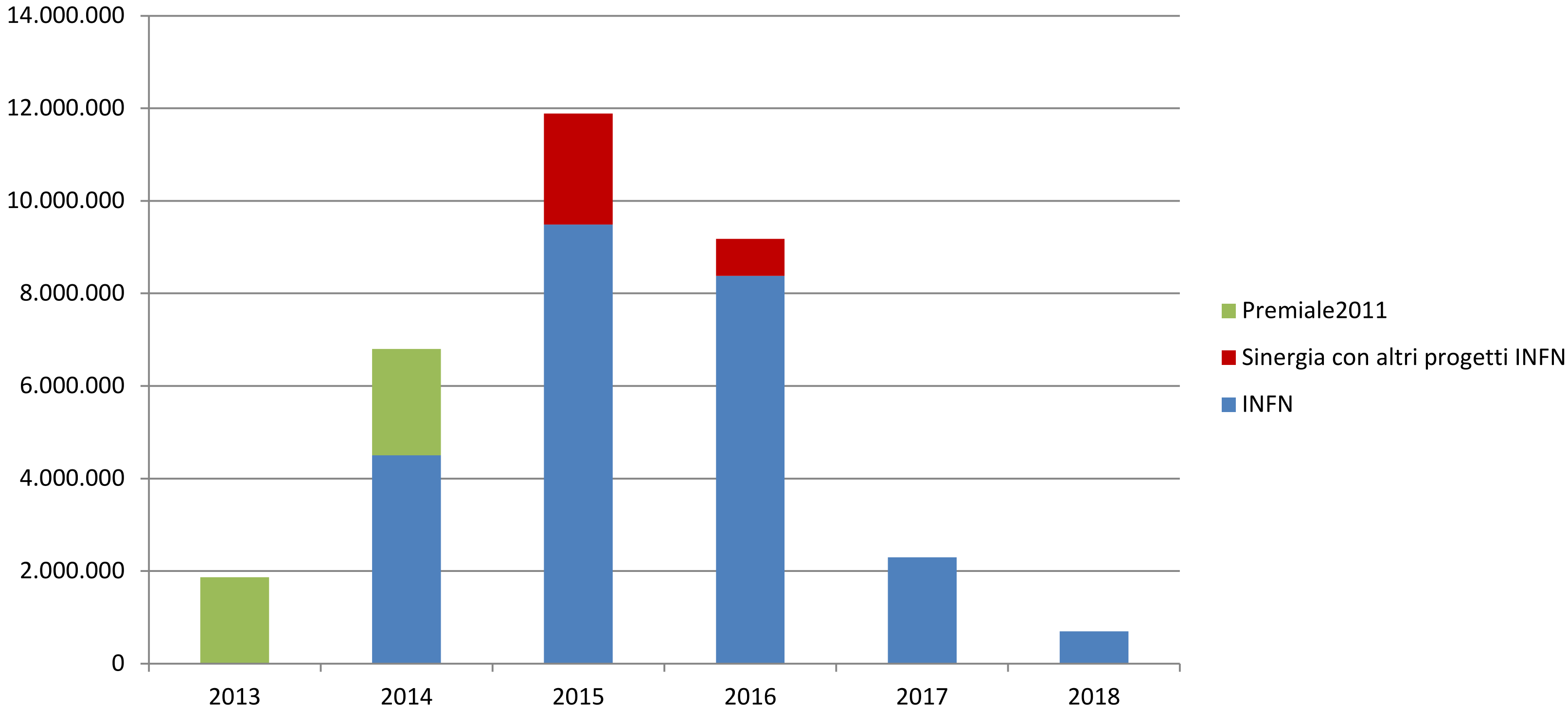
SPES funding plan

SPES subsystems and construction cost for each subsystem

Values in Meuro	2012	2013	2014	2015	2016	2017	2018	Grand Total
Radiation prot, Safety &Controls		0.1	1.6	3.3	0.8	0.3		**6.1**
INFRASTRUCTURES	4.5	0.3	0.5	3.1	1.1			**9.5**
CYCLOTRON	10.7			0.2				**10.9**
EXOTIC BEAMS	0.9	0.8	0.5	0.9	0.8	0.1		**4.0**
BEAM TRANSPORT	0.5	0.2	3.3	1.5	5.8	1.8	0.7	**13.7**
Re-ACCELERATOR	1.9	0.4	0.9	3.0	0.7	0.2		**7.2**
	18.5	**1.9**	**6.7**	**11.9**	**9.2**	**2.3**	**0.7**	**51.2**

*HRMS (2,7M€) included, residue of bid for building (2M€) included

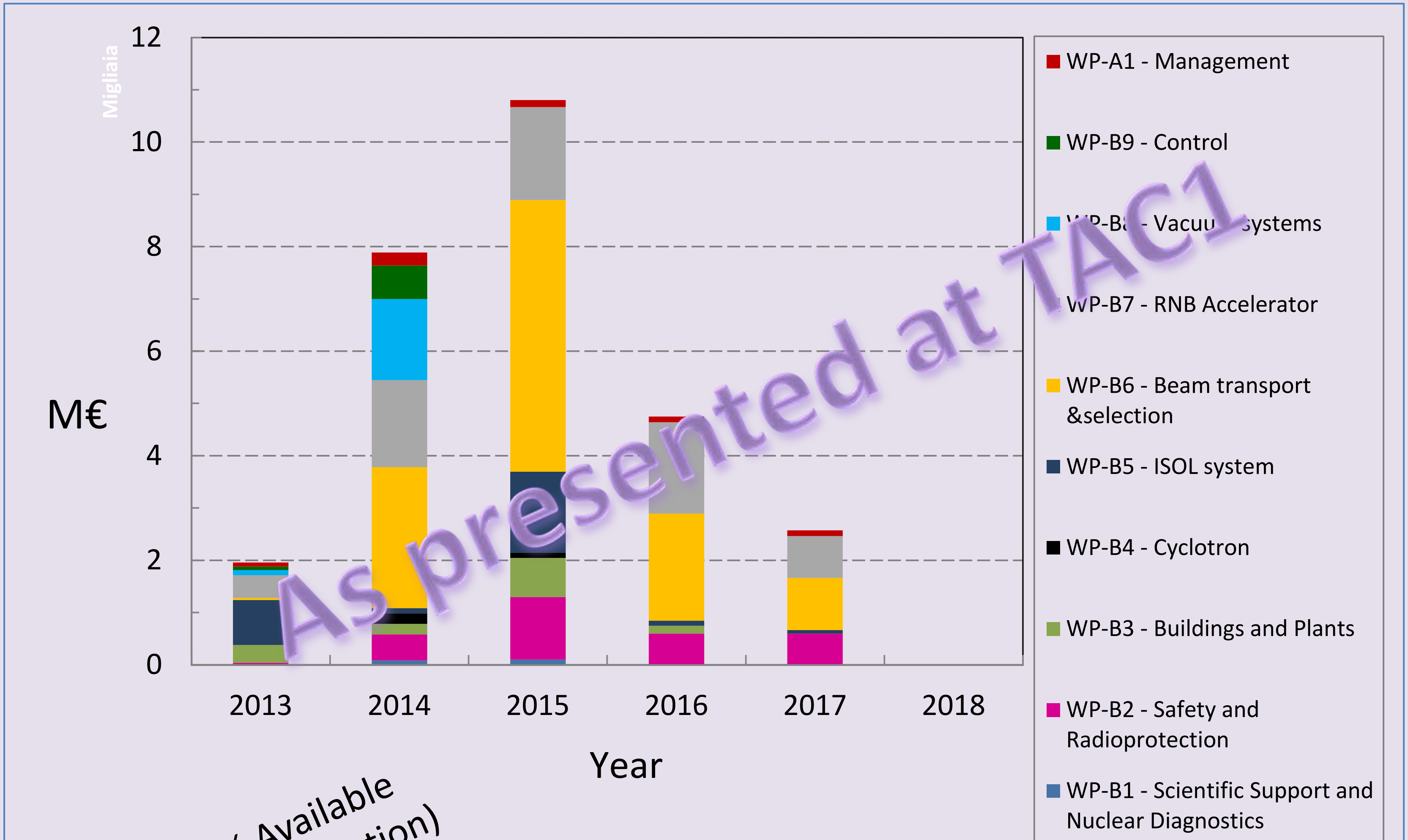
Economic planning for SPES construction 2013-2018



(kEuro)	2013	2014	2015	2016	2017	2018
Total SPES 2013-2018 32.660 kEuro	1.860	6.800	11.900	9.100	2.300	700

*HRMS (2,7M€) included, residue building (2M€) included

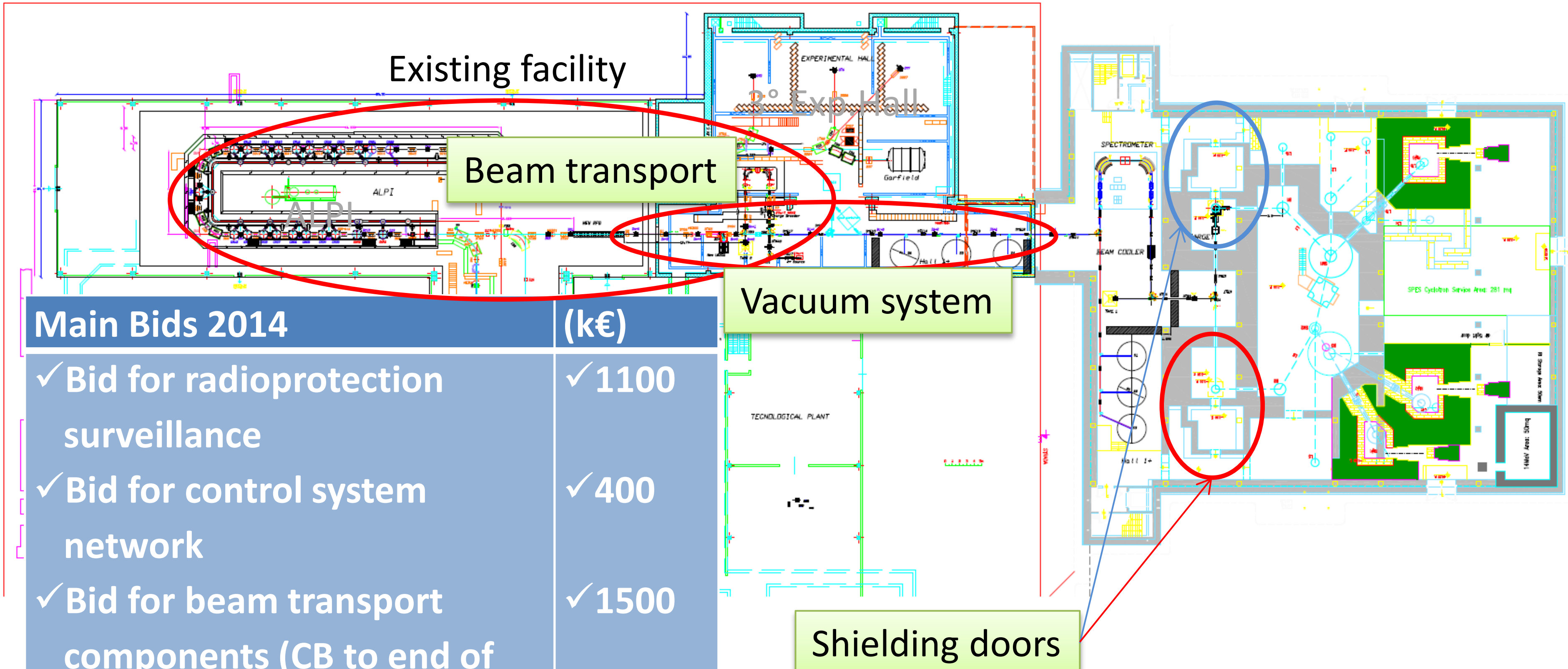
CORE SPES funding plan



2014 Budget: 50% Available
(also subject to TAC evaluation)

Main differences: beyond the 4,5 M€ (?) of Prize Project

Main bids 2014



Main Bids 2014	(k€)
✓Bid for radioprotection surveillance	✓1100
✓Bid for control system network	✓400
✓Bid for beam transport components (CB to end of ALPI)	✓1500
✓Bid for cryogenics upgrade	✓800
✓Bid for vacuum system (CB-Alpi injection)	✓1200
✓Bid for additional bunkers doors	✓700
✓Bid for Laser source	✓500

Available funds 2014: 6.8 Meuro
(4.5 of them assigned at end of October)

Tentative schedule for the subsequent phases of cyclotron acceptance tests and operation

First phase of cyclotron installation and operation (beginning of SAT tests).

April 2015 expected Cyclotron at LNL

- ❑ Building and infrastructures required for the cyclotron operation should be in place.
- ❑ January-April 2015:
  - Validation of the safety aspects of the technical specifications regarding the cooling and ventilation system that will be delivered in April 2015 (e.g. redundancy, interlocks, emergency procedure).
  - Design of the high-power beam dump (35 kW) and preliminary risk analysis for tests execution at low and high power beam.
  - Definition and set-up of the storage location for the beam dumps (low and high power) after acceptance test.
- ❑ April-September 2015:
  - Cyclotron installation.
  - Delivery of radiation protection surveillance system (consistent with ongoing order procedure).
  - Construction of high power beam dump.
  - Evaluation of ventilation system with doors installed.

Tentative schedule for the subsequent phases of cyclotron acceptance tests and operation

Expected situation in October 2015 for starting Cyclotron operation

- ISOL bunker completed with shielding and air tight doors and ready to host the beam dump.
- Absence of access control system will be managed by locked doors when the beam is on.
- Production of contaminated air will be controlled by radiation density monitor on the outer chimney, with a feedback on the cyclotron on/off state if the threshold is reached (1Bq/gr).

- **All the above allows us to carry out first tests with the proton beam from the cyclotron in very preliminary and temporary conditions.**

2015 Milestones and bids

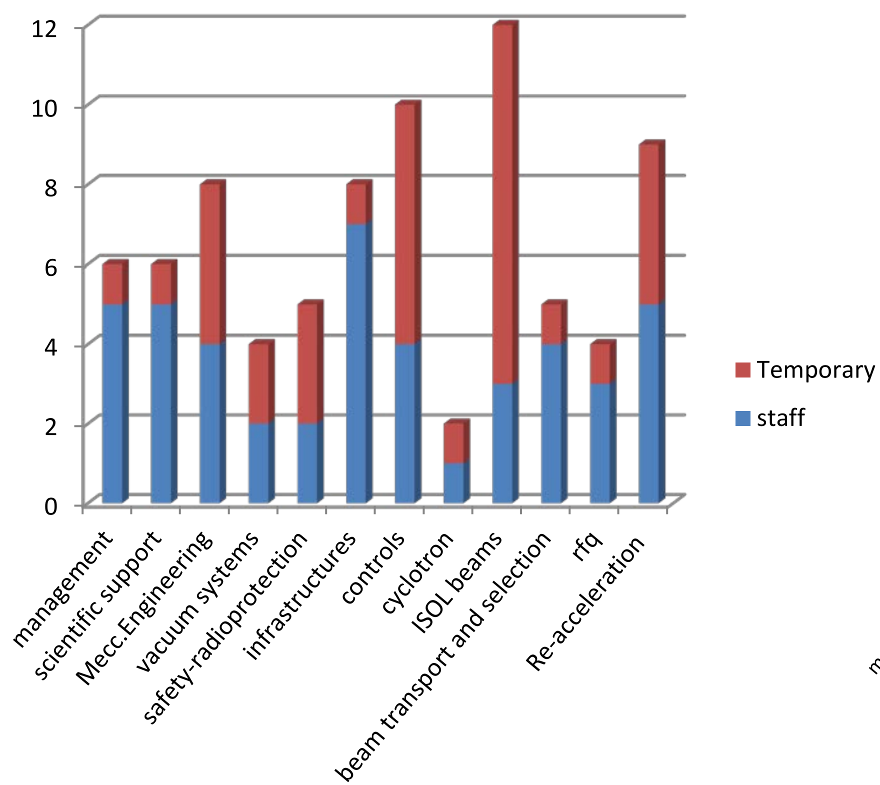
Funds 11.900 kEuro

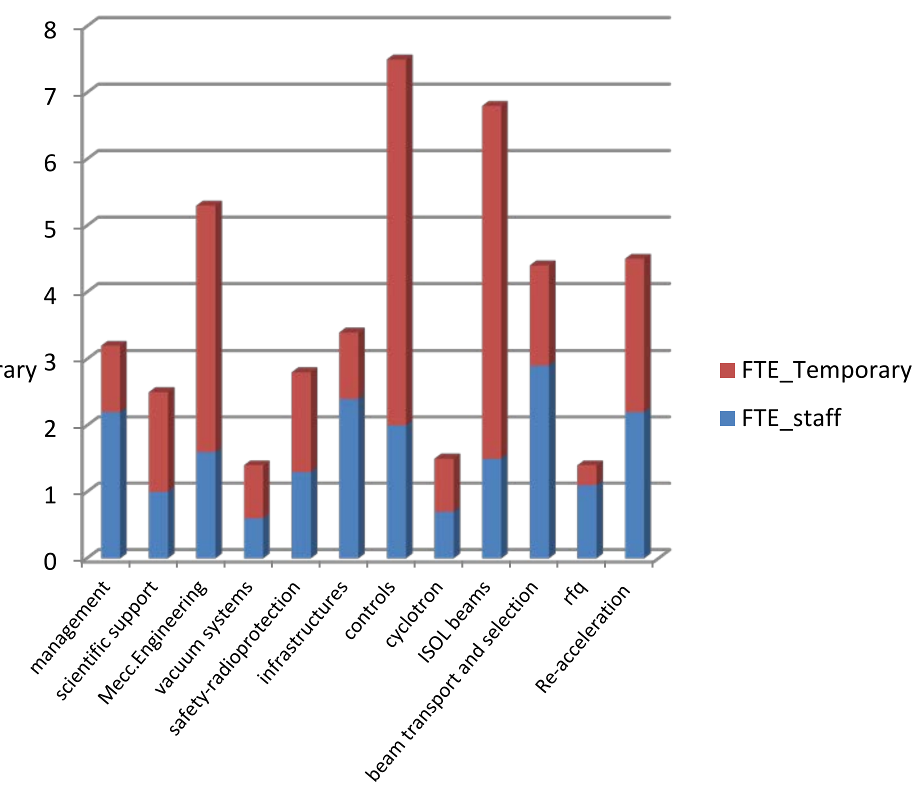
Milestones	Main Bids	(k€)
1- Building and plants completed	Bid for ISOL laboratory and hot cell	2900
2- Cyclotron: delivery, installation and SAT	Bid for transport system (BC, 1+line, MRMS-platform, diagnostic)	1500
3- Commissioning of target remote handling system	Bid for RFQ materials and RF System	1900
4- Commissioning of diagnostic box prototype	Bid for access control system	600
5- Charge Breeder installed	Bid for Safety System	1200
5- RFQ engineering design completed	Bid for control of RF, diag, transp	1500
6- Installation of access control system	Partial payment of building	1000
6- Commissioning of Radioprotection surveillance		

(index refers to SPES components)

SPES personnel plan

SPES personnel in 2014





Personnel involved: about 70 persons

46 FTE

It was 68 persons, 44 FTE in TAC1

45 (18 FTE) staff

8 (7 FTE) temporary contracts

21 (21 FTE) training

Personnel for cyclotron operation and management

- Responsible (Tecnologo/Ricercatore II liv)
- RF engineer (Tecnologo III liv)
- Accelerator Physics (Ricercatore/Tecnologo III liv)
- RF technician
- Diagnostic and control technician
- Vacuum/mechanics technician
- N.6 Machine Operators

6 units in 2015 and 6 in 2016

Management Challenges and Weaknesses

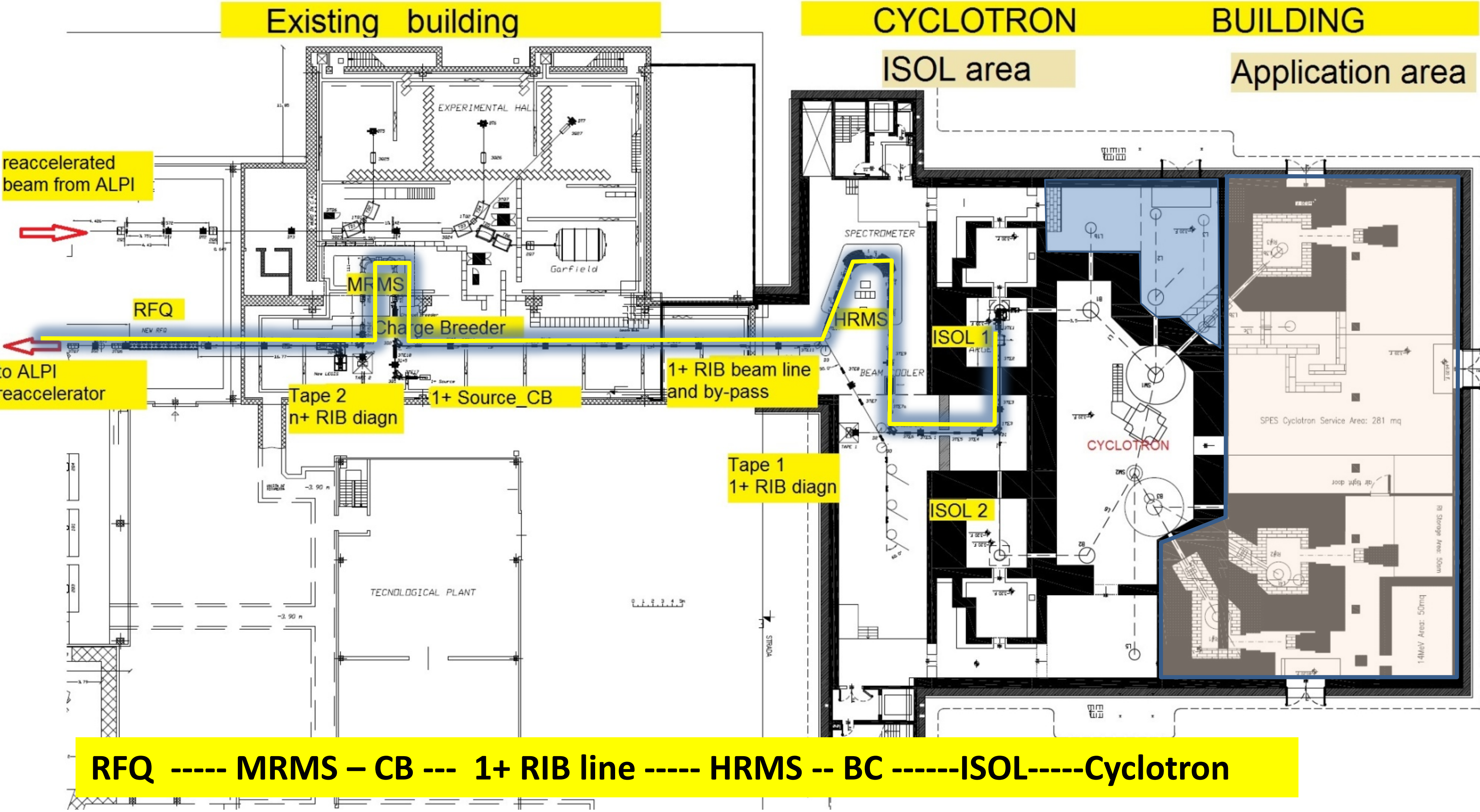
- **Decreasing lab personnel for government restrictions;**
- **Overlap with projects with equivalent priority (IFMIF, then ESS, …) with critical people in critical positions in both;**

- **Lacking people/competences:**
  - Effort to maintain strategic competences using turn over
  - Lack on Management and administration (quality management, project management, project secretariat, project administation)

  - Steep increase in everyone’s committments leaves too little room for: meetings (MB, project team, …); appropriate preparation of documents;
  - (system integrator started, but at the moment with strong committment on IFMIF…) – TO BE FIXED ASAP

Additional slides

SPES layout



RFQ ----- MRMS – CB --- 1+ RIB line ----- HRMS -- BC ------ISOL-----Cyclotron

$\frac{\Delta M}{M}$=1/1000

$\frac{\Delta M}{M}$=1/20000

$\frac{\Delta M}{M}$=1/200

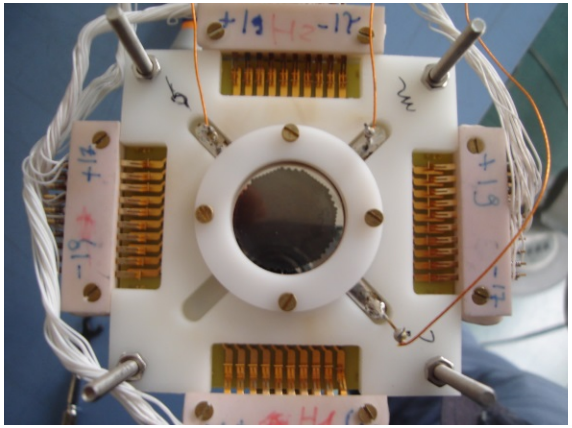
Cyclotron criticalities

Factory Acceptant Test: Ottawa 24-28 Nov 2014
Delivery a LNL started : 5 Feb 2015
Delivery to LNL completed: 28 Feb 2015
Installation : 2 months
Site Acceptance Test: within Sep 2015

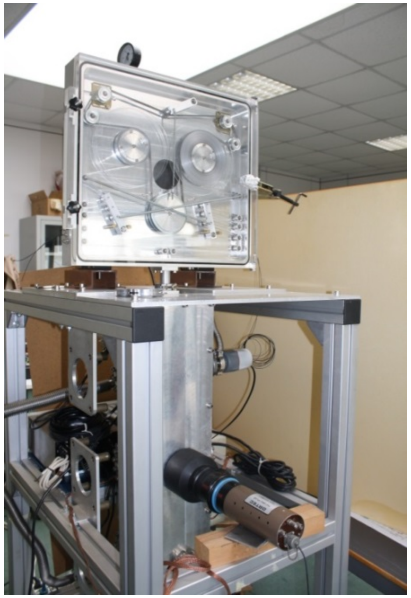
Critical points:

1. Synchronize delivery, installation and tests of cyclotron and beamline with building and plants for SPES-alpha phase
2. Personnel
3. Logistic support from LNL to BEST for installation
4. Technical support from LNL to BEST for hardware tests and commissioning (SAT)
5. Detailed agreement on SAT (updated agreed upon version), with particular concern for critical components as beam diagnostics and high-P beam dumps

Beam Diagnostics



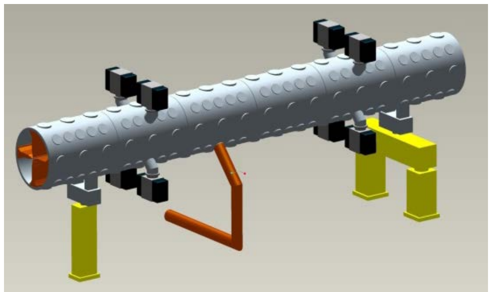
<u>Beam position and profile monitors,</u> based essentially on microchannel plates (MCP) as beam intensifiers. MCP is put directly on the beam line. Electrons produced on it and collected, after multiplication, on a position sensitive anode give the beam impact position. Measured 0.75 mm position resolution was mesured for a 100 fA ^{12}C beam. **<u>FC, E, ϕ detectors</u>** are developed too.



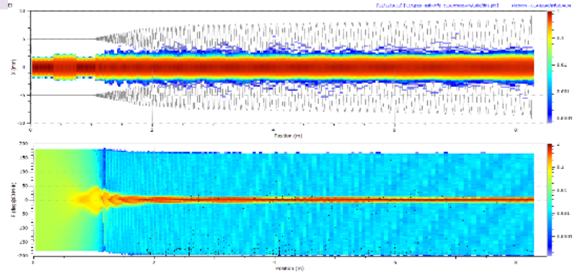
<u>Tape station system</u>: under development for SPES<u>; moving tape system (1 cm wide mylar tape) and γ-ray counting chamber</u>. Ge detectors, well shielded from potential background in the beam pipe, will be located at the counting chamber in a different position, a few cm far from the tape. The counting chamber will also accommodate plastic detectors for detecting positron decays.

Exotic Beam reacceleration: room temperature RFQ

Mechanical layout of the **RFQ**

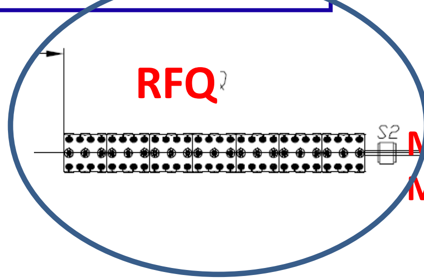


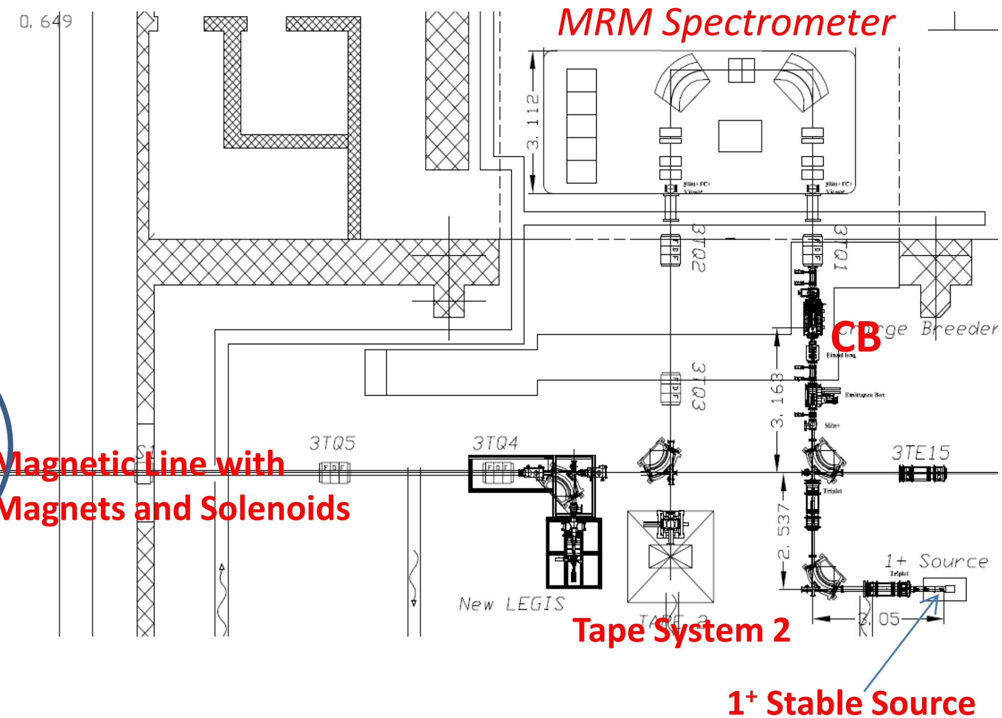
Physics design



High power RF Coupler 200kW 100% duty cycle

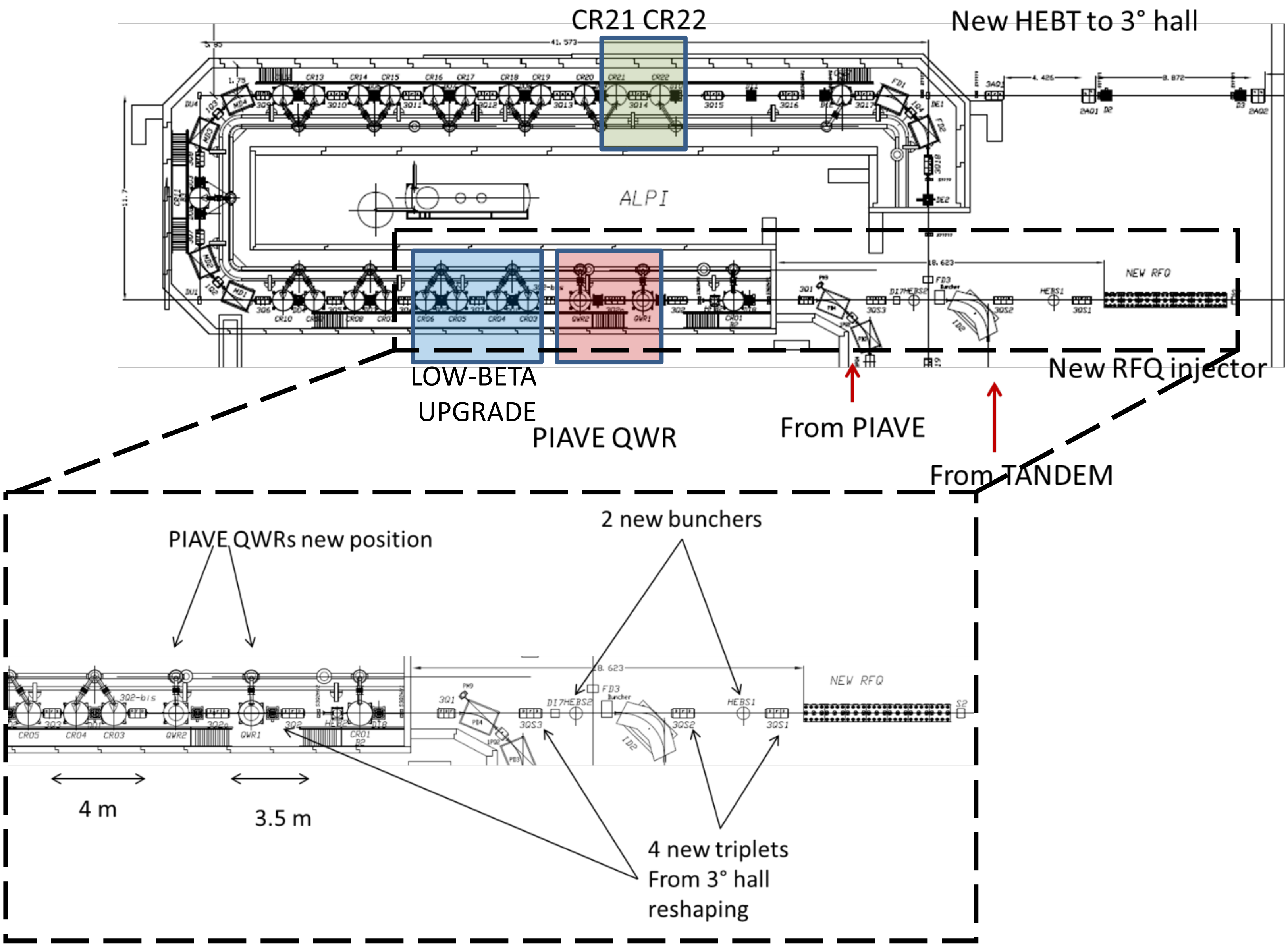
- Energy 5.7 → 727.3 [β=0.0395] KeV/A (A/q=7)
- Frequency 80 MHz
- Beam transmission >95%, low RMS longitudinal emittance at output: 0.15 ns*keV/u.
- Length 695 cm (**7 modules**) intervane voltage 63.8 – 85.8 kV
- RF power (four vanes) 100 kW.
- Mechanical design and realization, taking advantage of IFMIF experience (LNL, INFN_Pd, Bo, To).

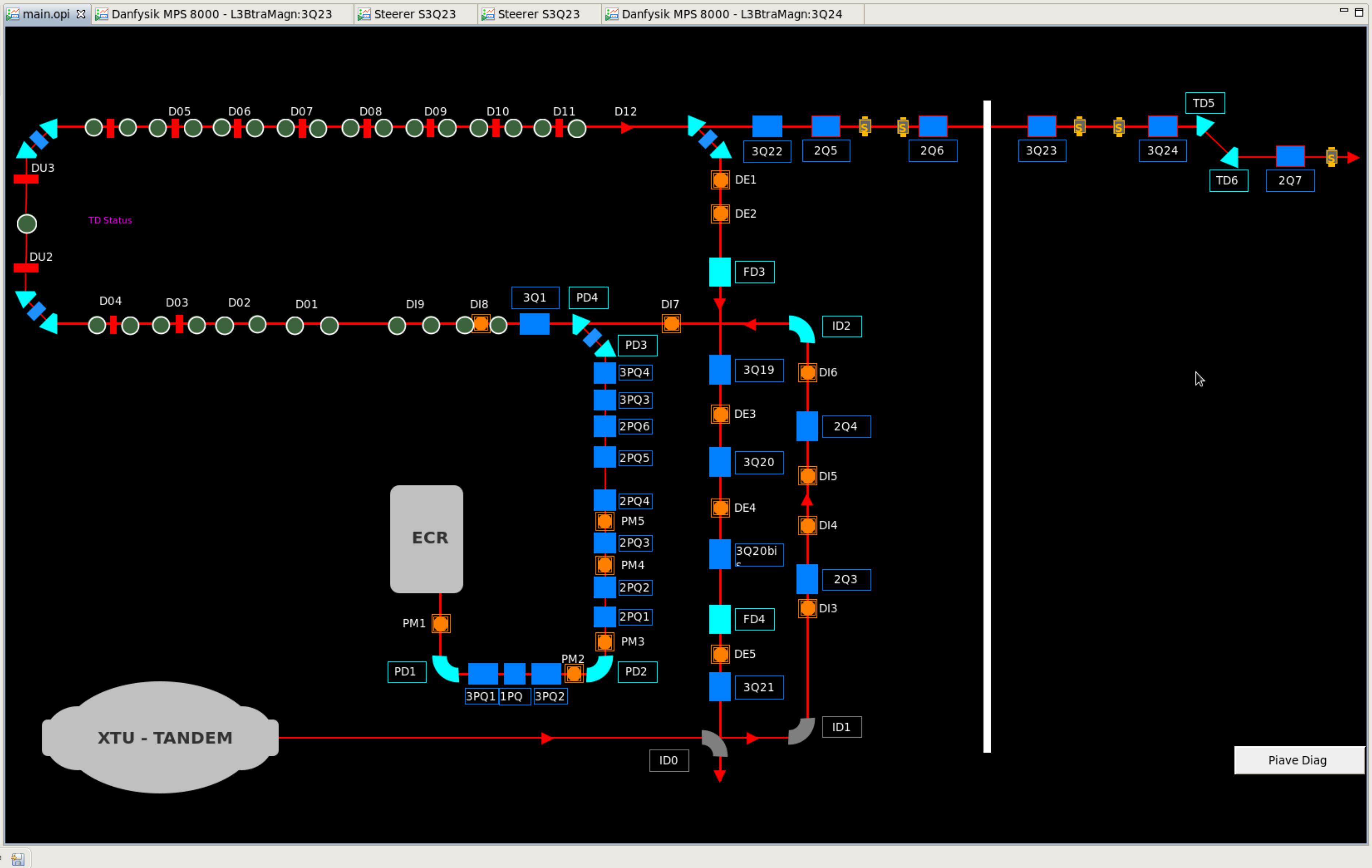




E. Fagotti, A. Pisent

SC Resonator Improvements on ALPI

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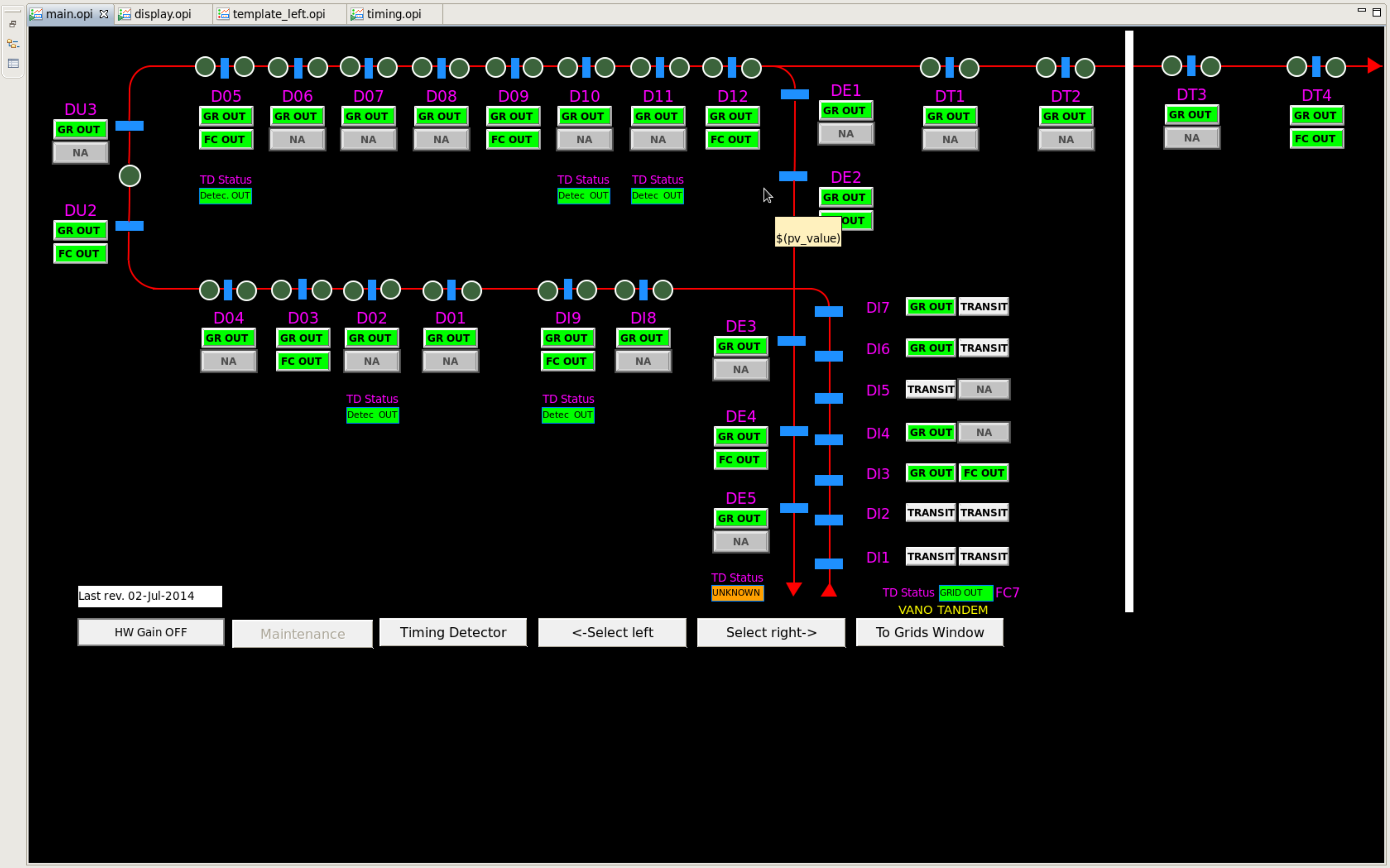
Danfysik MPS 8000 - L3BtraMagn:3Q23
Steerer S3Q23
Steerer S3Q23
Danfysik MPS 8000 - L3BtraMagn:3Q24
D05
D06
D07
D08
D09
D10
D11
D12
3Q22
2Q5
2Q6
3Q23
3Q24
TD5
TD6
2Q7
DU3
TD Status
DU2
DE1
DE2
FD3
D04
D03
D02
D01
DI9
DI8
3Q1
PD4
DI7
ID2
PD3
3PQ4
3PQ3
2PQ6
2PQ5
2PQ4
PM5
2PQ3
PM4
2PQ2
2PQ1
PM3
PM2
PD2
3PQ1
1PQ
3PQ2
PD1
PM1
ECR
3Q19
DE3
3Q20
DE4
3Q20bis
FD4
DE5
3Q21
DI6
2Q4
DI5
DI4
2Q3
DI3
ID1
ID0
XTU - TANDEM
Piave Diag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timing.opi
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NA
DU2
GR OUT
FC OUT
D05
GR OUT
FC OUT
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GR OUT
NA
D08
GR OUT
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D09
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FC OUT
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TD Status
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DE1
GR OUT
NA
DE2
GR OUT
OUT
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NA
DT2
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GR OUT
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DT4
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D04
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D03
GR OUT
FC OUT
D02
GR OUT
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GR OUT
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DI9
GR OUT
FC OUT
DI8
GR OUT
NA
TD Status
Detec OUT
TD Status
Detec OUT
DE3
GR OUT
NA
DE4
GR OUT
FC OUT
DE5
GR OUT
NA
TD Status
UNKNOWN
DI7 GR OUT TRANSIT
DI6 GR OUT TRANSIT
DI5 TRANSIT NA
DI4 GR OUT NA
DI3 GR OUT FC OUT
DI2 TRANSIT TRANSIT
DI1 TRANSIT TRANSIT
TD Status GRID OUT FC7
VANO TANDEM
Last rev. 02-Jul-2014
HW Gain OFF
Maintenance
Timing Detector
<-Select left
Select right->
To Grids Window

SPES Economic planning

Work Pakage	2012	2013	2014	2015	2016	2017	2018	Grand Total
WP-B1 – Scientific support	0.0	0.0	0.0	0.3	0.2	0.0	0.0	**0.5**
WP-B2-Radiation Protection and Safety (1,9)	0.0	0.0	1.3	1.3	0.0	0.0	0.0	**2.6**
WP-B3 - Infrastructures	4.5	0.3	0.5	3.1	1.1	0.0	0.0	**9.5**
WP-B4-Controls	0.0	0.1	0.3	2.0	0.8	0.3	0.0	**3.5**
WP-B5 - Cyclotron	10.7	0.0	0.0	0.2	0.0	0.0	0.0	**10.9**
WP-B6- Exotic Beams	0.9	0.8	0.5	0.9	0.8	0.1	0.0	**4.0**
WP-B7 - Beam Transport	0.5	0.1	2.0	1.1	3.2	1.5	0.7	**9.0**
WP-B8 - RFQ	0.0	0.0	0.0	1.9	0.3	0.1	0.0	**2.3**
WP-B9 - Re-Accelerator	1.9	0.4	0.9	1.1	0.4	0.1	0.0	**4.8**
WP-B10 - Mechanics	0.0	0.0	0.0	0.0	0.0	0.1	0.0	**0.2**
WP-B11 –Vacuum systems	0.0	0.1	1.3	0.1	2.4	0.2	0.0	**4.0**
	18.5	**1.9**	**6.7**	**11.9**	**9.2**	**2.3**	**0.7**	**51.2**

Milestones and bids up to the end of the project

Year	INFN provision (k€)	Milestones (index referred to SPES components)	Main Bids (k€)
2016	8.300	2- Cyclotron in operation 3- Installation ISOL target and ion source system 3- Design of target storage system 4- Commissioning of Charge Breeder and MRMS 4- HRMS engineering design completed 6- Safety system for cyclotron operation available	Bid for tape station (500) Bid for second part of vacuum system and gas recovery system (2500) Bid for transport components (ISOL to CB) (1600) Bid for Diagnostic boxes (1+ beam line ISOL to CB) (700) Bid for low frequency bunchers (385) Bid for Beam Cooler (700) Partial payment building (1000)
2017	2.300	3- ISOL laboratory and hot cell completed 3- Commissioning of ISOL system and 1+ beam 5- Low frequency bunchers available 6- Machine Protection system completed 6- Authorization process for UCx operation completed	Bid for HRMS
2018	700	3- Commissioning of Laser laboratory 4- Commissioning of Beam Cooler 5- Commissioning of RFQ	Bid for HRMS platform
2019		4- Commissioning of HRMS SPES full operation with reacceleration of purified neutron rich beams	

SPES main milestones

2014/2	**Cyclotron Factory Acceptance Test (FAT) completed**
2014/2	**Start authorization request for UCx target irradiation**
2015/1	**Building and plants completed**
2015/2	**Commissioning of Radioprotection surveillance**
2015/2	**Cyclotron Acceptance Test (SAT) completed**
2015/2	**RFQ engineering design completed**
2016/1	**Safety system for cyclotron operation available**
2016/1	**Installation ISOL front end and ion source system**
2016/1	**Commissioning of Charge Breeder and MRMS**
2017/1	**HRMS engineering design completed**
2017/2	**Commissioning of ISOL system and 1+ beam**
2018/1	**Commissioning of RFQ**
2018/1	**Commissioning of 1+ beam line**
2018/1	**Authorization process for UCx operation completed**
2018/2	**Commissioning of ALPI reacceleration for radioactive beams**
2019/1	**Commissioning of HRMS**

2014 Milestones and bids

Funds: 6.800 kEuro

Milestones	Main Bids	(k€)
1- Row building construction completed 2- Cyclotron Factory Acceptance Test (FAT) completed 3- Construction of target remote handling system 3- Online high power test of ISOL target (iThembaLabs) 4- Beam transport study with error analysis (CB to expTarget) 5- Upgrade cryogenic system (new controls) 6- Design of Cyclotron Control Access 6- Design of control system and EPICS implementation 6- Authorization request for UCx – Laramed operation (pending)	✓Bid for radioprotection surveillance ✓Bid for control system network ✓Bid for transport components (CB to end of ALPI) ✓Bid for cryogenics upgrade ✓Bid for vacuum system (CB-Alpi injection) ✓Bid for additional bunkers doors ✓Bid for Laser source	✓1100 ✓400 ✓1500 ✓800 ✓1200 ✓700 ✓500

(index refers to SPES components)

2015 Milestones and bids

Funds 11.900 kEuro

Milestones	Main Bids	(k€)
1- Building and plants completed	Bid for ISOL laboratory and hot cell	2900
2- Cyclotron: delivery, installation and SAT	Bid for transport system (BC, 1+line, MRMS-platform, diagnostic)	1500
3- Commissioning of target remote handling system	Bid for RFQ materials and RF System	1900
4- Commissioning of diagnostic box prototype	Bid for access control system	600
5- Charge Breeder installed	Bid for Safety System	1200
5- RFQ engineering design completed	Bid for control of RF, diag, transp	1500
6- Installation of access control system	Partial payment of building	1000
6- Commissioning of Radioprotection surveillance		

(index refers to SPES components)

SPES organization

INFN

SAC

INFN MAC

TAC

INFN nuclear physics community

Steering Committee

SPES Project Leader

Scientific coordinator

Management Board (WP Leaders and Deputies)

Scientific working group

Project Work Packages and Work Units

Scientific Advisory Committee

Gilles de France (GANIL),
B.Fornal (Kracow),
P.Van Duppen (Leuven-Rex-Isolde),
T. Motobayashi (RIKEN),
K.Gelbke, (FRIB)
T.Aumann (Darmstadt),
A.Vittuti, A.Olmi
ex-officio:
G. deAngelis, G.Cuttone,
G.Fiorentini, G.Prete

Steering Committee:

Giovanni LaRana, (Sez. Napoli)
Mauro Bruno (Sez. Bologna)
Sara Pirrone (Sez. Catania)
Adriana Nannini (Sez. Firenze)
Franco Camera (Sez. Milano)
Dino Bazzacco (Sez. Padova)
Lorenzo Corradi (LNL)
Titti Agodi (LNS)
Luigi Cosentino (LNS)

Technical Advisory Committee

Y. Blumenfeld (IPN-Orsay),
L.Miralles (CERN),
R. Ferdinand (GANIL),
D. Rifuggiato (LNS),
R. Catherall (ISOLDE),
M. Pellicccioni (INFN)
P. Fabbricatore (INFN-Ge)

~ as in TAC1: MB better defined; 1 replacement in TAC

SPES Project Organization

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

SPES exotic beams for science

SISTEMA DI GESTIONE PER LA QUALITA' E SICUREZZA DI SPES				
Codice doc.	**DOC_000000xx**	**Quadro organizzativo delle responsabilità per il progetto SPES**	Rev.	**00**
			Pag.	1 di 21

Contenuto Documento
Documento volto ad esplicitare i compiti e le responsabilità necessarie per il progetto SPES.
ıaro, l'attuale le specifiche o e il quadro

SISTEMA DI GESTIONE PER LA QUALITA' E SICUREZZA DI SPES				
Codice doc.	**DOC_000000xx**	**Quadro organizzativo delle responsabilità per il progetto SPES**	Rev.	**00**
			Pag.	2 di 21

SOMMARIO

Project Structure

Project leader (A0): G.Prete

Accelerator Coordinator (A1): G.Bisoffi
Infrastructure Coordinator (A2): P.Favaron
Safety Coordinator (A3): D.Zafiropoulos
Scientific Coordinator (A4): G.deAngelis

Management office Coordinator (A5): G.Bisoffi
Quality & safety Management System (A6): D.Benini
System integration (A7): E.Fagotti

Work Packages
Head (Deputy)

Scientific support (B1):
F.Gramegna (J.Valiente)

Radiation Protection and Safety (B2):
D.Zafiropoulos (J.Esposito)

Infrastructures (B3):
P.Favaron (M.Calderolla)

Controls (B4):
M.Bellato (M.Gulmini)

Cyclotron (B5):
A.Lombardi (M.Maggiore)

Exotic Beams (B6):
A.Andrighetto (M.Manzolaro)

Beam Transport and Selection (B7):
A.Pisent (M.Comunian)

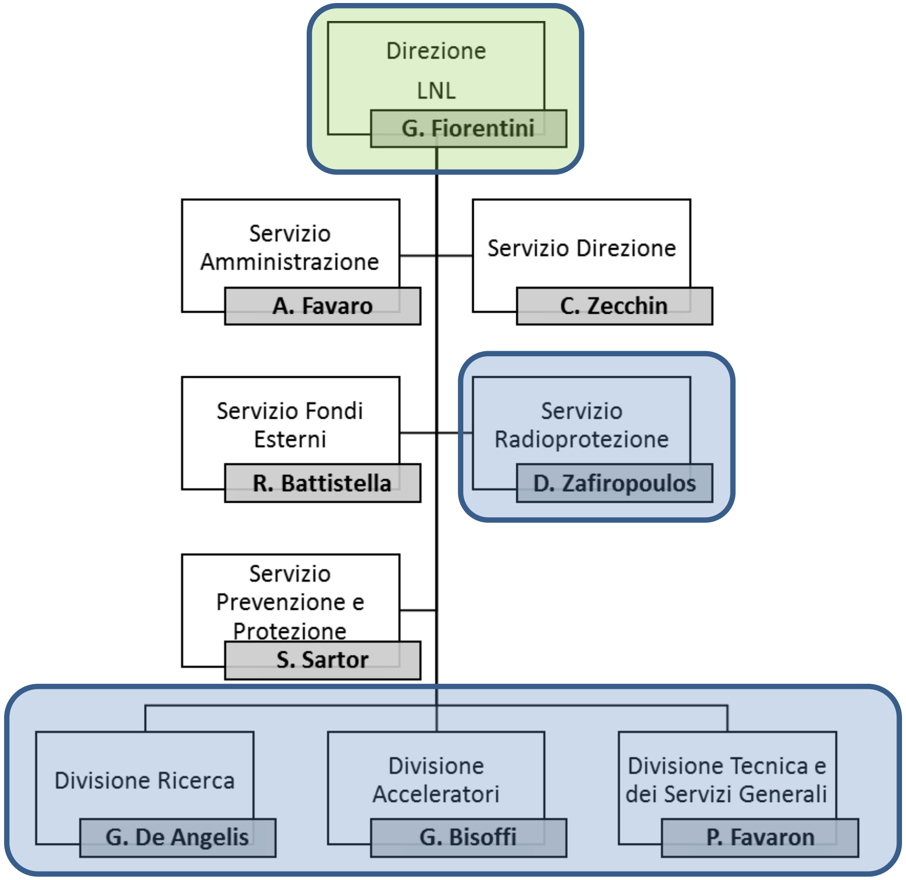
RFQ (B8):
A.Pisent (R.Dima)

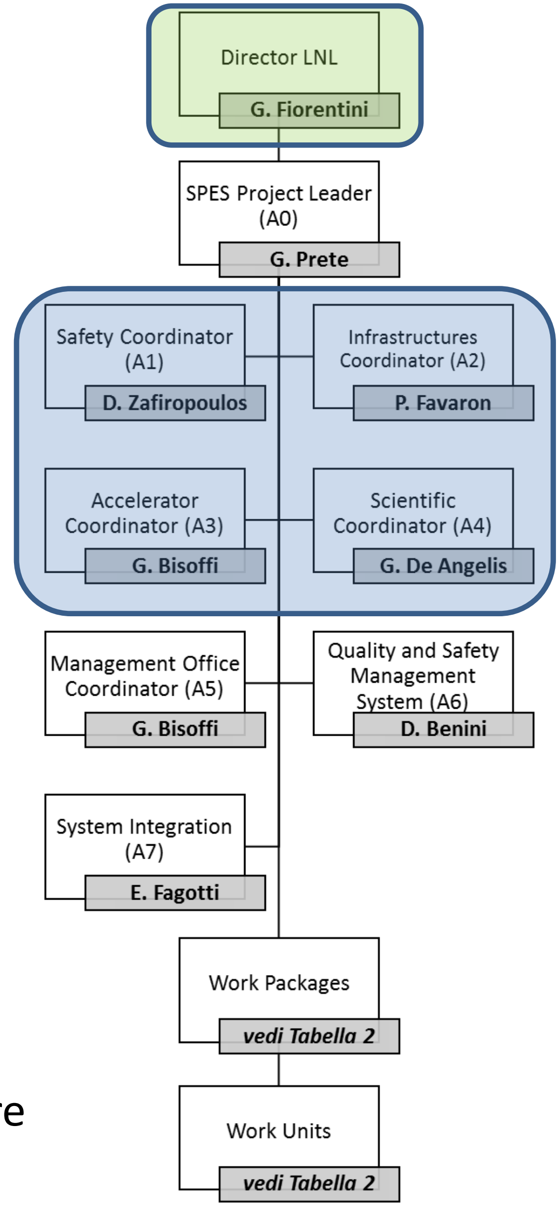
RNB-Accelerator (B9):
G.Bisoffi (A.Porcellato)

Mechanics and Engineering (B10):
A.Andrighetto (M.Rossignoli)

Vacuum systems (B11):
AM.Porcellato (C.Roncolato)

Alignment between LNL structure and Project structure





The high level structure of the project and the WP structure bears some alignment
with the LNL structure, which is deemed to be more efficient than a pure matrix,
given the rather limited number of units involved.

Personale in formazione e a Tempo Determinato per la realizzazione del progetto

Personale in formazione (Borse e Assegni)
Fondi Direttore LNL
COSTI personale formazione (k€):

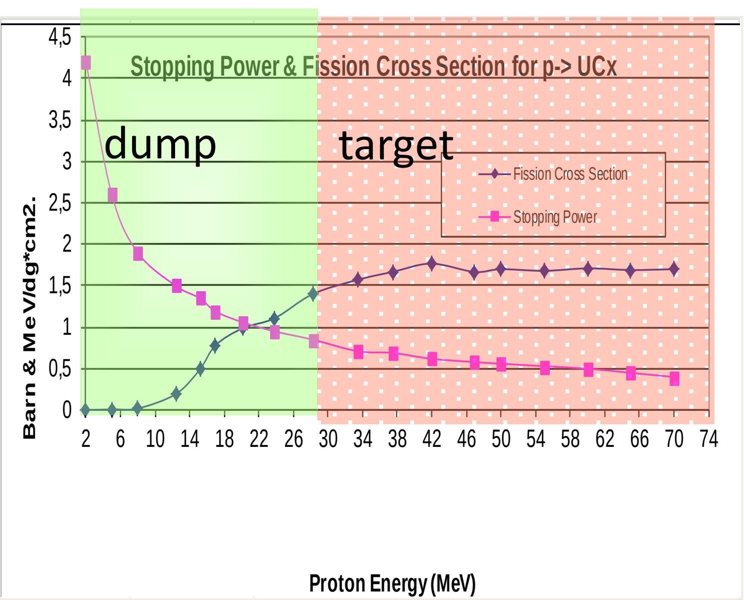
anno	keuro
2015	430
2016	252
2017	117
2018	138

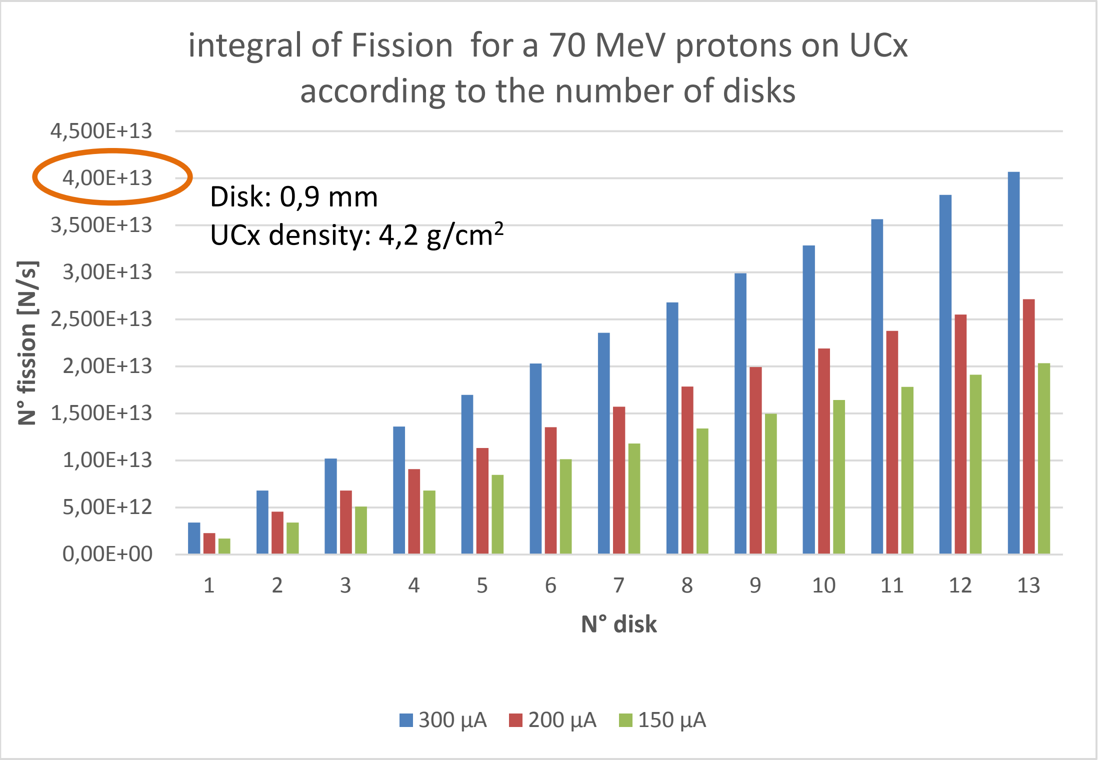
	compertenze	Formazione	TD
1	Sicurezze e radioprotezione	1	2
2	Controlli EPICS e di sicurezza	5	1
3	Sviluppo bersagli UCx	1	
4	Sorgente ISOL	1	1
5	LASER per ionizzazione		1
6	Charge Breeder e ECR	1	1
7	Beam Cooler e separazione in massa	2	
8	Impianti vuoto e recupero gas		1
9	Handling bersaglio	2	
10	Ciclotrone	1	1
11	Infrastrutture	1	
12	Progettazione Meccanica	3	
13	Meccanica	2	
	Altri (TapeSystem)	1	
		21	8

Piano del direttore per il personale a Tempo Determinato da mantenere su fondi esterni fino al 2018

High Power SPES Target (70 MeV)

	Proton Energy	Proton current	UCx target	Target power	In-target Fission/s
SPES	40 MeV	0.2 mA	30 gr	8 kW	10E13 f/s
Up-grade under study	70 MeV	0.15 mA	60 gr	10 kW	2x10E13 f/s
Up-grade to be evaluated	70 MeV	0.3 mA	60 gr	20 kW	4x10E13 f/s



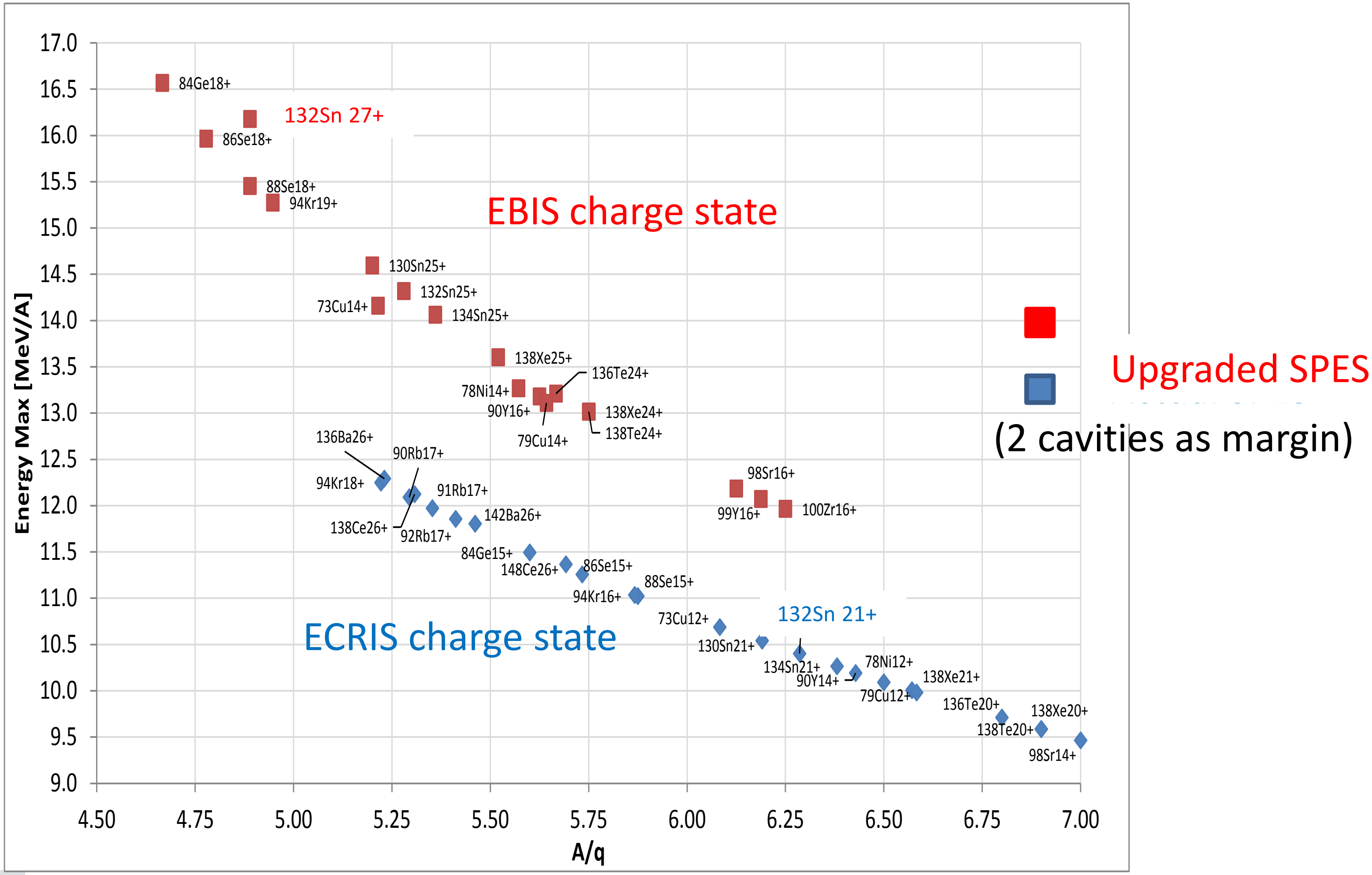


Energy of SPES Post-Accelerator as function of A/q

Preliminary results for ALPI upgraded performances

Low Beta=5 MV/m, Medium Beta=5.5 MV/m, High Beta=5.5 MV/m

Low Beta=5 MV/m, Medium Beta=4.3 MV/m, High Beta=5.5 MV/m



LARAMED Products

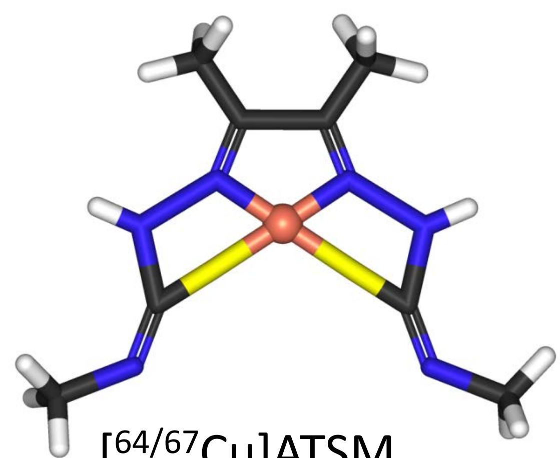
Radioisotope	Half-life
Fe-52	8.3 h
Cu-64	12.7 h
Cu-67	2.58 d
Sr-82	25.4 d
Ge-68	270.8 d
I-124	4.18 d
Ac-225	10 d

Some radionuclides of interest for nuclear medicine. They can be produced by means of the cyclotron of the SPES-α phase

^{64}Cu and ^{67}Cu

- In the last few years a new radiopharmaceutical has been developed, labelled with Cu-64 e Cu-67, that selectively concentrates in hypoxic cells
- The new molecule ([64/67Cu]ATSM) has proved to be particularly useful in **diagnosys and therapy** of prostatic neoplasies, where the tracer [^{18}F]FDG cannot be used.
- A cyclotron of medium-high energy is an effective tool to increase the production yields of Cu-64 and, consequently, enhance the availability of [^{64}Cu]ATSM

Isotope	Cu-64	Cu-67
$\tau_{1/2}$	12.7h	2.5d
EC	41%	-
β+	19%	-
β-	39%	100%



[$^{64/67}$Cu]ATSM

$^{68}Ge/^{68}Ga$

Isotope	Ge-68 →	Ga-68
$\tau_{1/2}$	271d	68m
EC	-	-
β+	-	100%
β-	100% in Ga-68	-

- Together with F-18 e C-11, recently, the request of the β^+ emitter radionuclide ^{68}Ga has grown exponentially.
- This interest is based on the fact that Ga-68 proved to be very useful being stably labeled to small peptidic biomolecules , used in the diagnosys of many pathologies of peptide receptor tissues.
- The production, by means of medium-high energy cyclotrons, will provide an effective solution to the problem of availability of the generator nuclide ^{68}Ge, whose production, with the methods used nowadays, is insufficient.

$^{82}Sr/^{82}Rb$

- The ion Rb^+ is a biologic analog of K^+, fundamental in the heart cell operation.
- Once administered by intravenous injection, Rb+ is assembled in the myocardium and, when sustituted with a γ emitter radioisotope, it can be use as tracer to study the cardiac operation.

Isotope	Sr-82 →	Rb-82
$\tau_{1/2}$	25d	1.27m
EC	100% in Rb82	-
β+	-	100%
β-	-	-

- This radioisotope is actually produced in low energy cyclotrons, that do not allow high yields due to low energy and intensities .