SPES Project

SPES status

Gianfranco Prete
SPES Project leader

One-Day Workshop

Physics at SPES with non reaccelerated beams

Milano, April 20th 2015

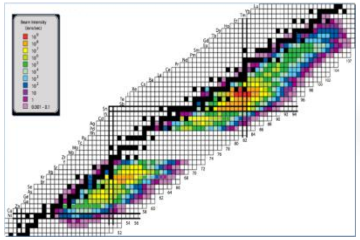
SPES Strategy

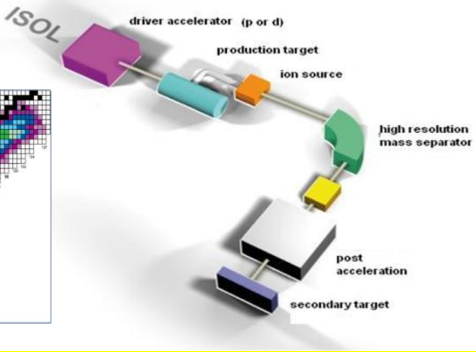
BEST Cyclotron installation & commissioning:

- 70 MeV proton beam
- 750 μA

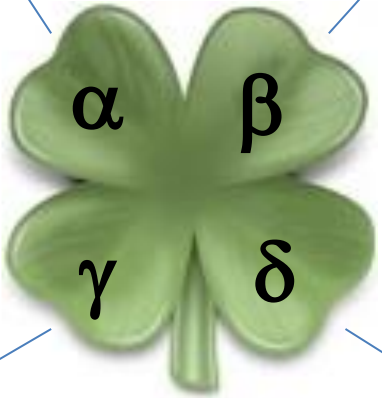
Second generation ISOL facility

Toward EURISOL

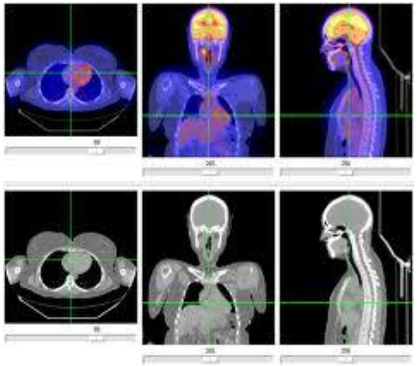




Production & re-acceleration of **exotic beams. Neutron–rich** from **p-induced Fission** on **UCx (10^{13} f/s)**

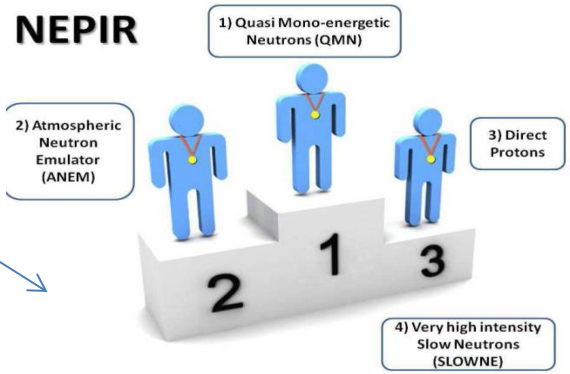


LARAMED



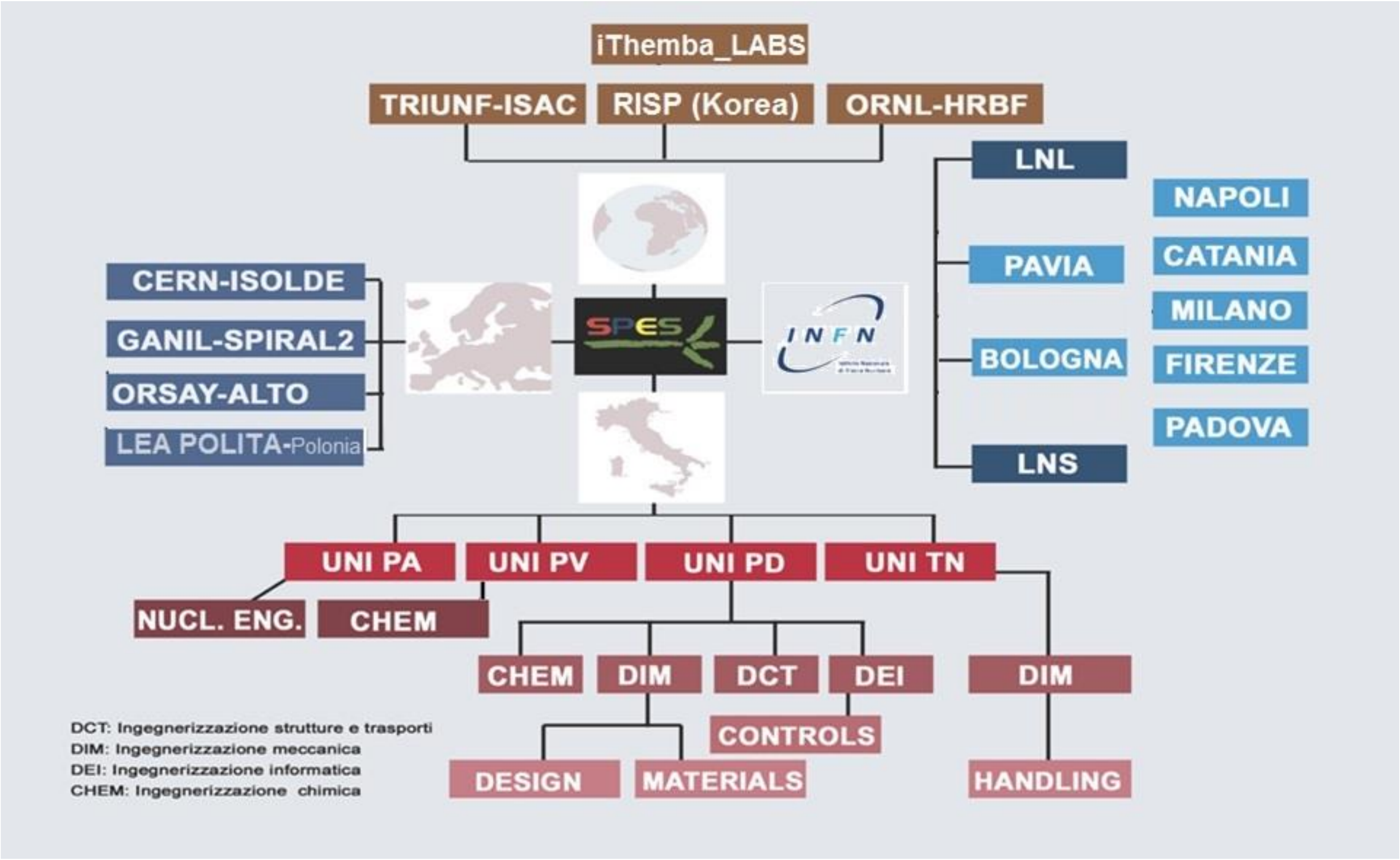
Research and Production of **Radio-Isotopes for Nuclear Medicine**

NEPIR

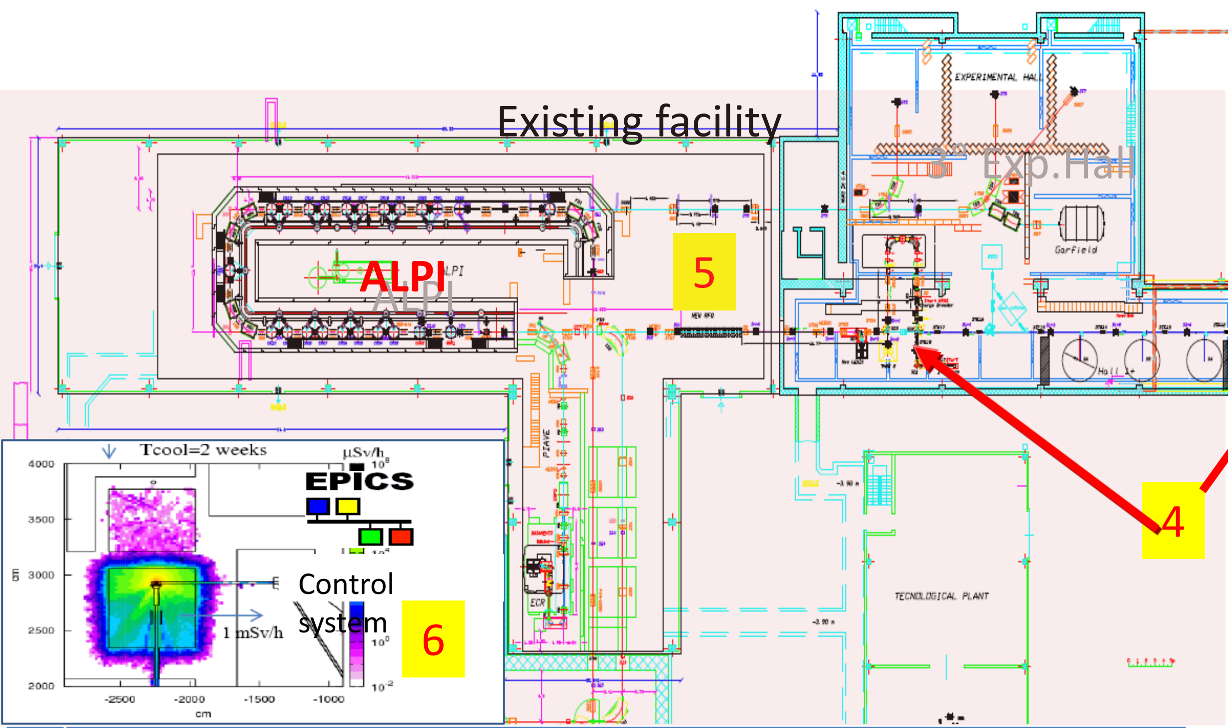


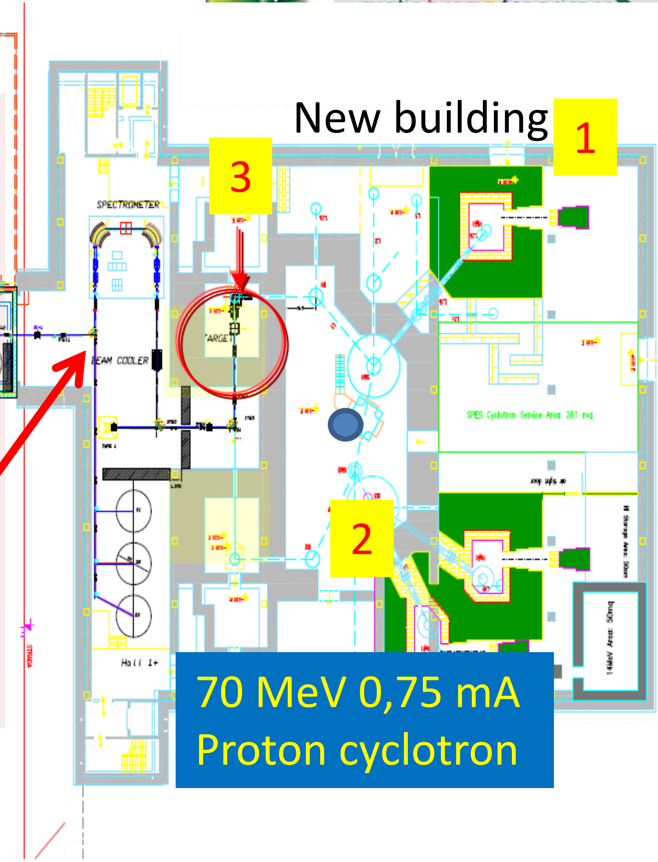
Accelerator based neutron source (**Proton and Neutron Facility for Applied Physics**)

SPES collaboration network



SPES Facility Layout



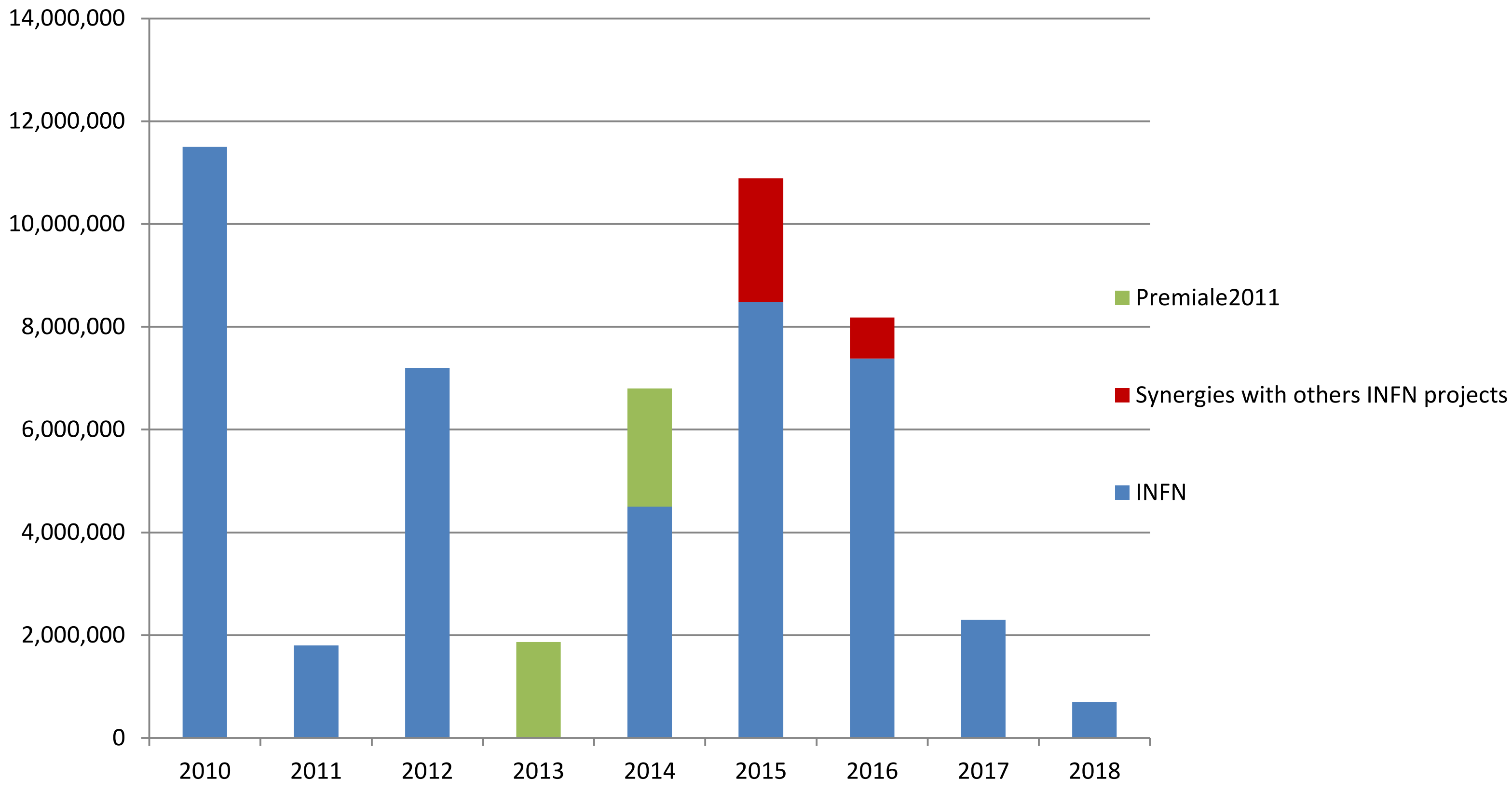


	SPES sub-systems
1	Building and infrastructures **with 2 ISOL bunkers for radioactive beam** and application area for radioisotopes and neutrons
2	Cyclotron 70 MeV protons with 2 independent exits
3	ISOL UCx target designed for 10^{13} f/s -**direct production with p**
4	Beam transport with **High Resolution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

Total cost for SPES construction:
51 Meuro.

Invested up to now:
27 Meuro

Piano SPES 2010-2018



SPES funding plan

SPES subsystems and construction cost for each subsystem

Values in Meuro	2002 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	6.5	0.3	0.5	2.1	0.1			**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**
	20.5	**1.9**	**6.7**	**10.9**	**8.2**	**2.3**	**0.7**	**51.2**

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

Presentazione GIUNTA INFN Ott. 2104

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								

Main Milestones

2014/semestre 2	**Cyclotron Factory Acceptance Test (FAT) completed**
2014/semestre 2	**Request of authorization for UCx target irradiation**
2015/semestre 1	**Building and plants completed**
2015/semestre 2	**Commissioning of Radioprotection surveillance**
2015/semestre 2	**Cyclotron Acceptance Test (SAT) completed**
2015/semestre 2	**RFQ engineering design completed**

Main bids 2015

	12.209.000
Radiologic system	1.159.000
1ST Tender Dipoles and lenses (CB-to-RFQ and ALPI) 1.3M€, PS 0.7M€	2.000.000
Infrastructurs hot-cell Ucx_lab	2.900.000
Full Safety system (progetto e controlli 0.65, impianti 0.8)	1.500.000
RFQ (1.8), Bunchers (0.8), BeamCooler (0.2)	2.800.000
Beam line and MRMS platform	1.300.000
Diagnostics and controls (0.55)	550.000

1. SPES: the Construction Site

2. Cyclotron test at BEST Company site (Ottawa)

November 2014 Factory Acceptance Test

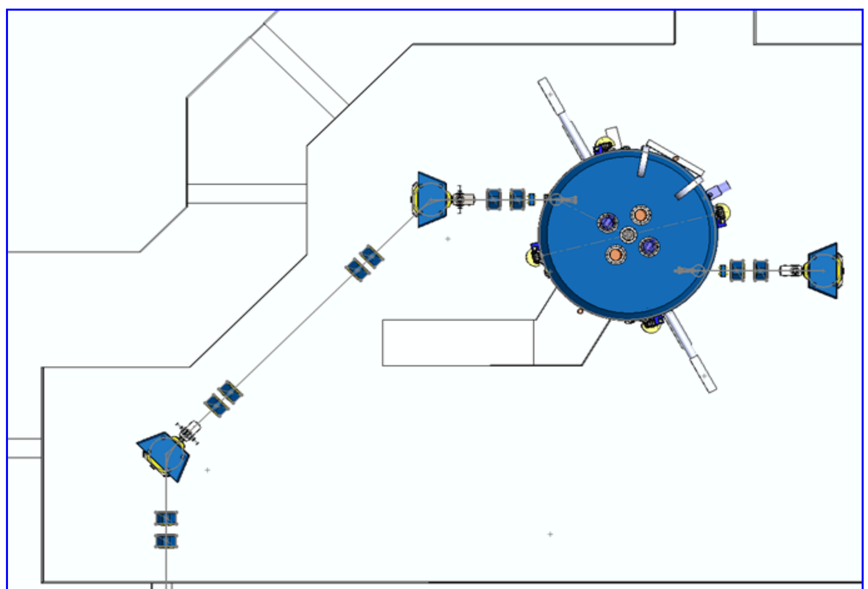
Main Parameters	
Accelerator Type	Cyclotron AVF 4 sectors
Particle	**Protons (H^- accelerated)**
Energy	**Variable within 30-70 MeV**
Max Current Accelerated	**750 μA** (52 kW max beam power)
Available Beams	**2 beams at the same energy** (upgrade to different energies)
Max Magnetic Field	1.6 Tesla
RF 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

Cyclotron assembled and operated with 700 μA at 1MeV

Get going to LNL

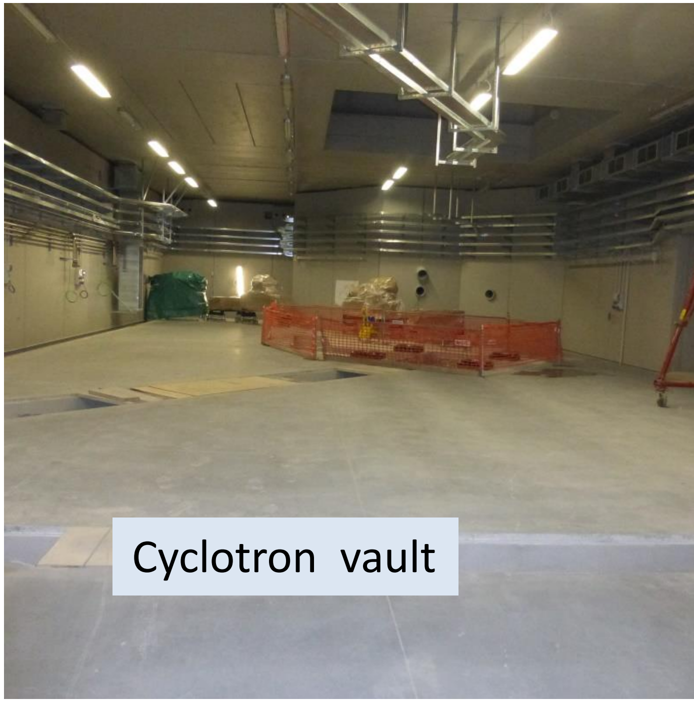
SPES: Cyclotron Schedule (2013-2015)

	2013		2014			2015		
	II	III	I	II	III	I	II	III
Final Assembly and Testing								
Factory Commissioning								
Disassembly and Shipping								
Installation at LNL								
Commissioning at LNL								



Courtesy A. Lombardi

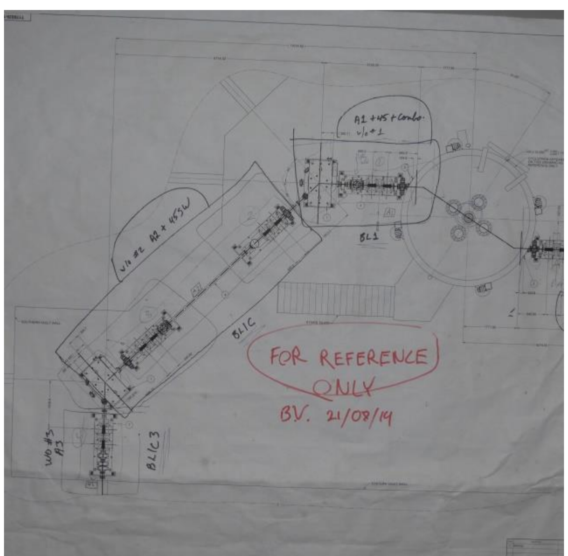
Cyclotron installation   20-April-2015



Cyclotron vault

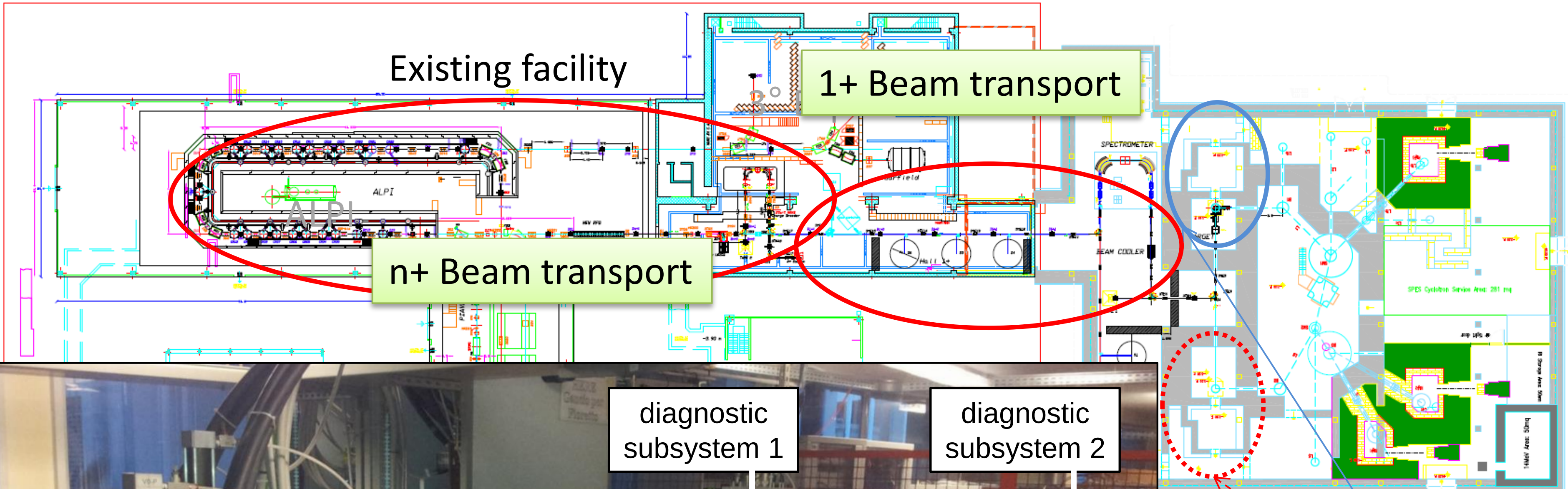
Cyclotron beam line

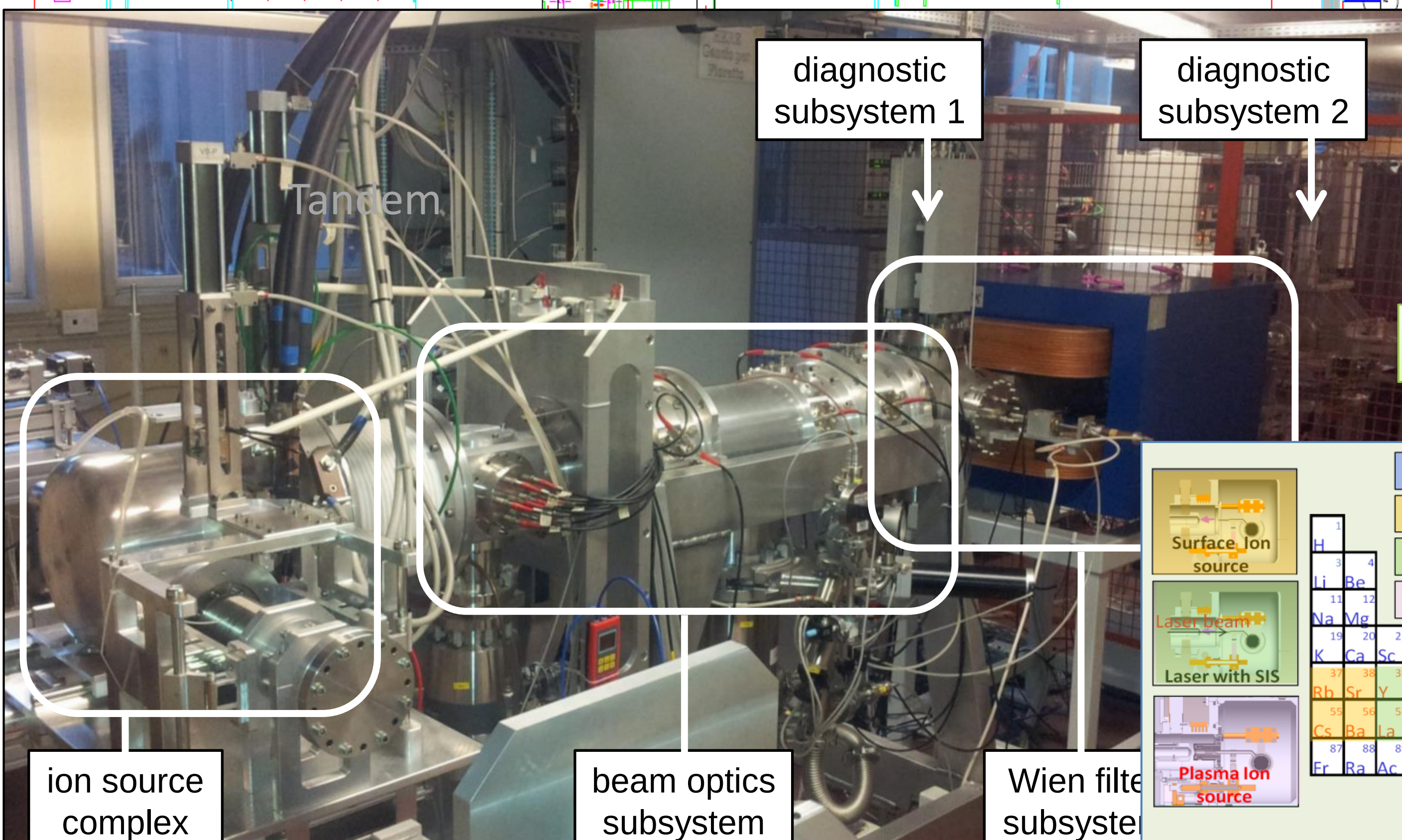
Cyclotron location

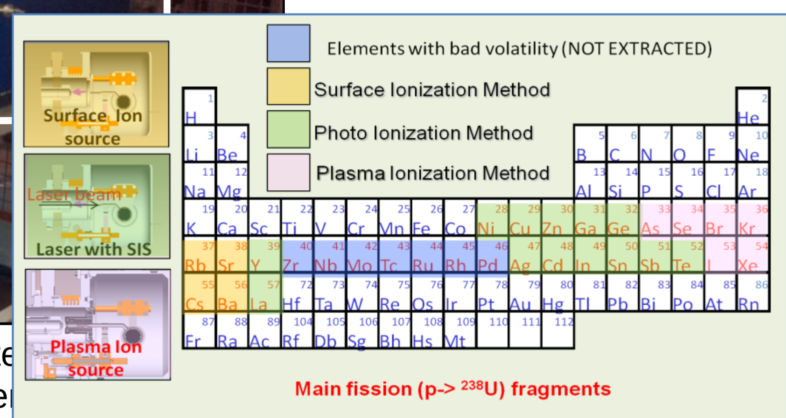


Cyclotron Power supply room

3. ISOL target and front-end



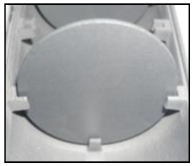


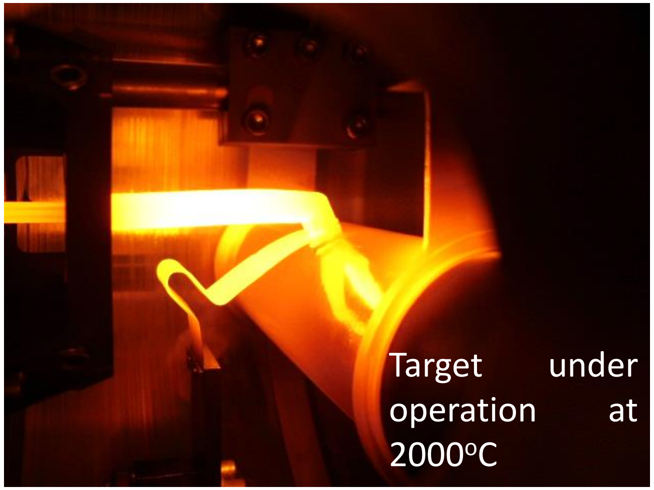


Technical highlights: the production target

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

- 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;





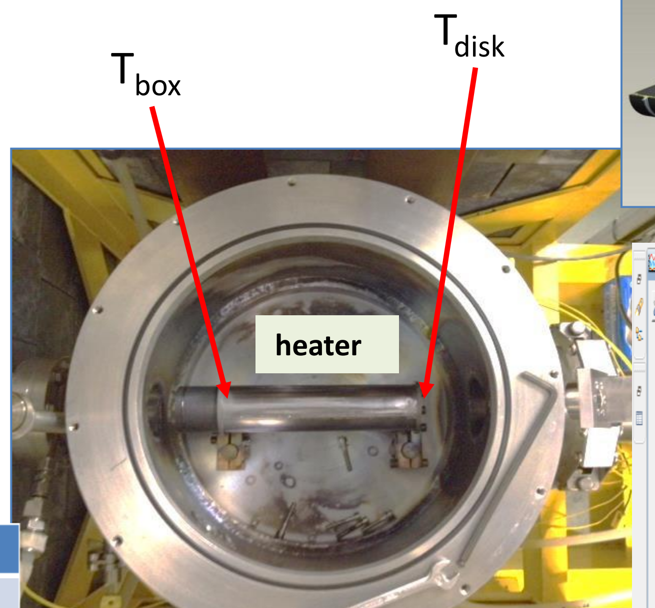
SPES: Target Power test @ iThemba Lab

May 15, 2014

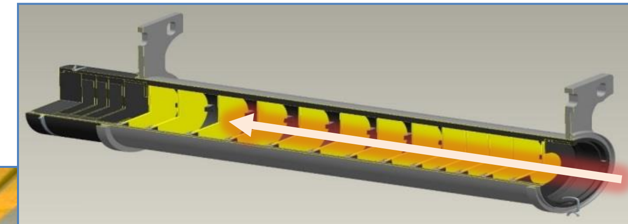
SPES target **in-beam power test** (SiC target)

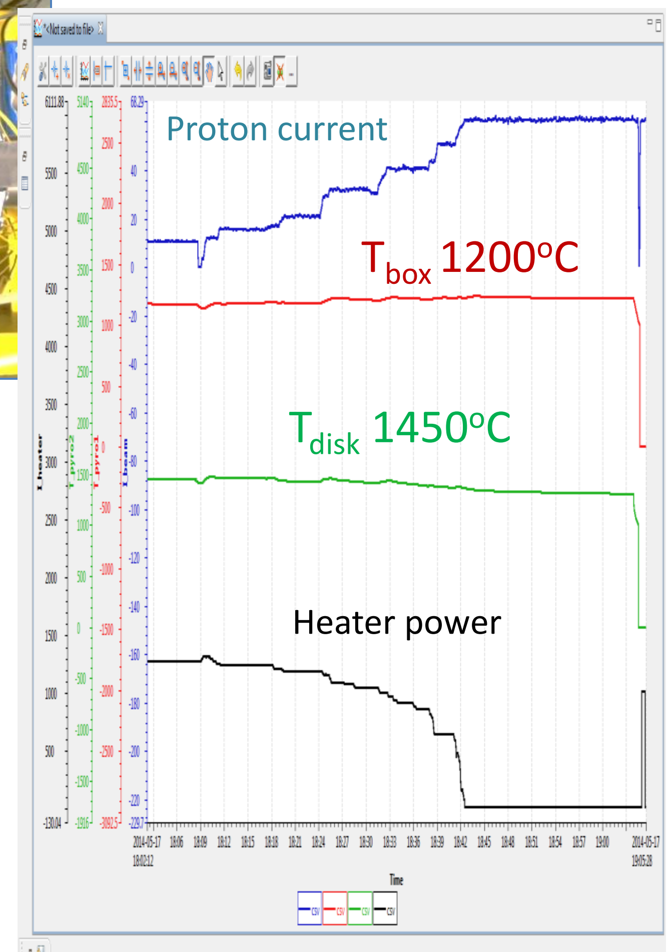
Heater power compensated by proton beam.

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



Proton beam 66MeV 60 μA





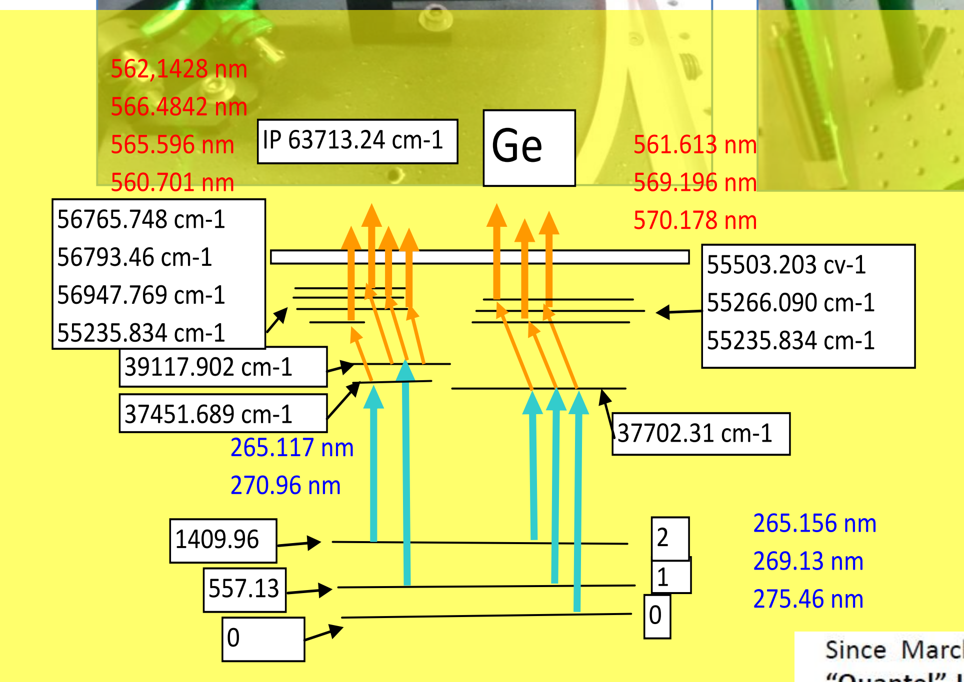
Measure [°C]	Estimated by FEM model [°C]
1° disk: 1365 ± 30°C	1390
Box: 1230 ± 25°C	1267
Dump on chamber: 728°C ± 10°C	750

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

SPES new LASER Laboratory @ LNL

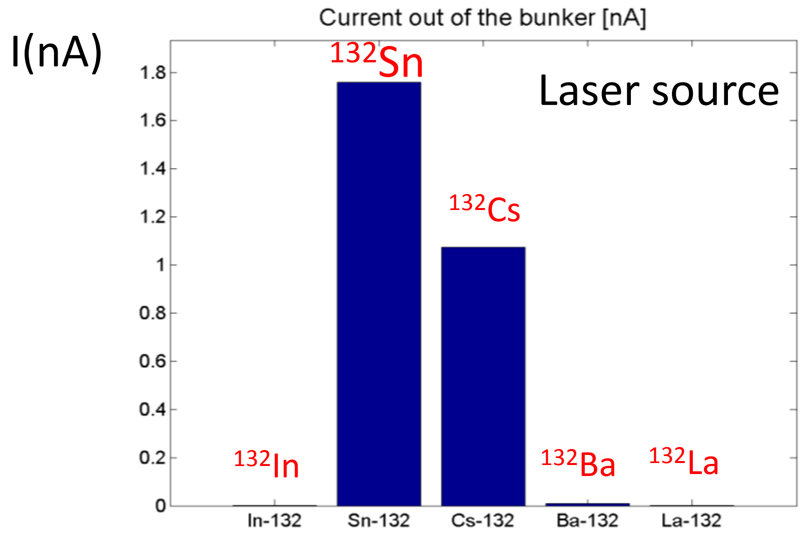
D. Scarpa

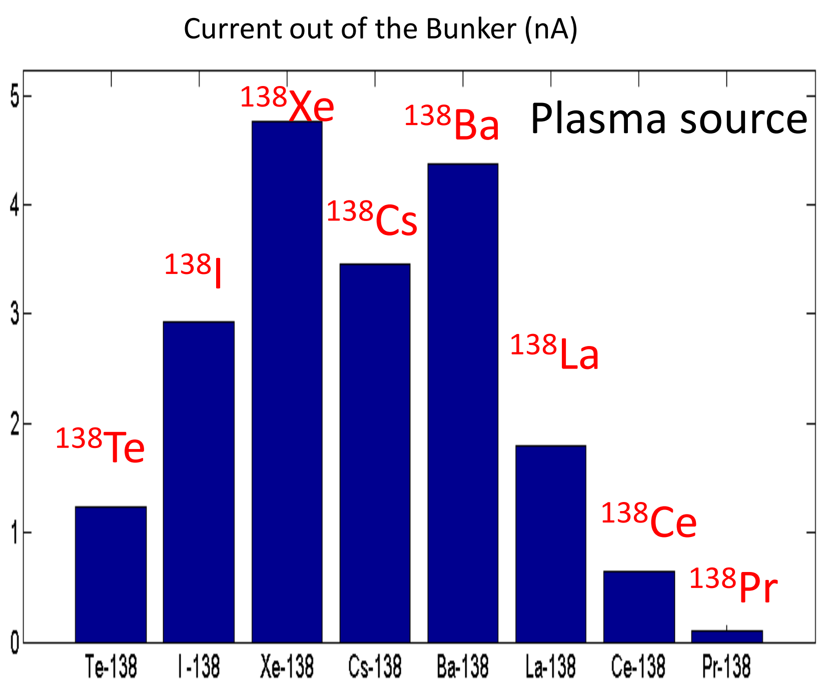
A tunable dye laser system ready for atomic spectroscopy study

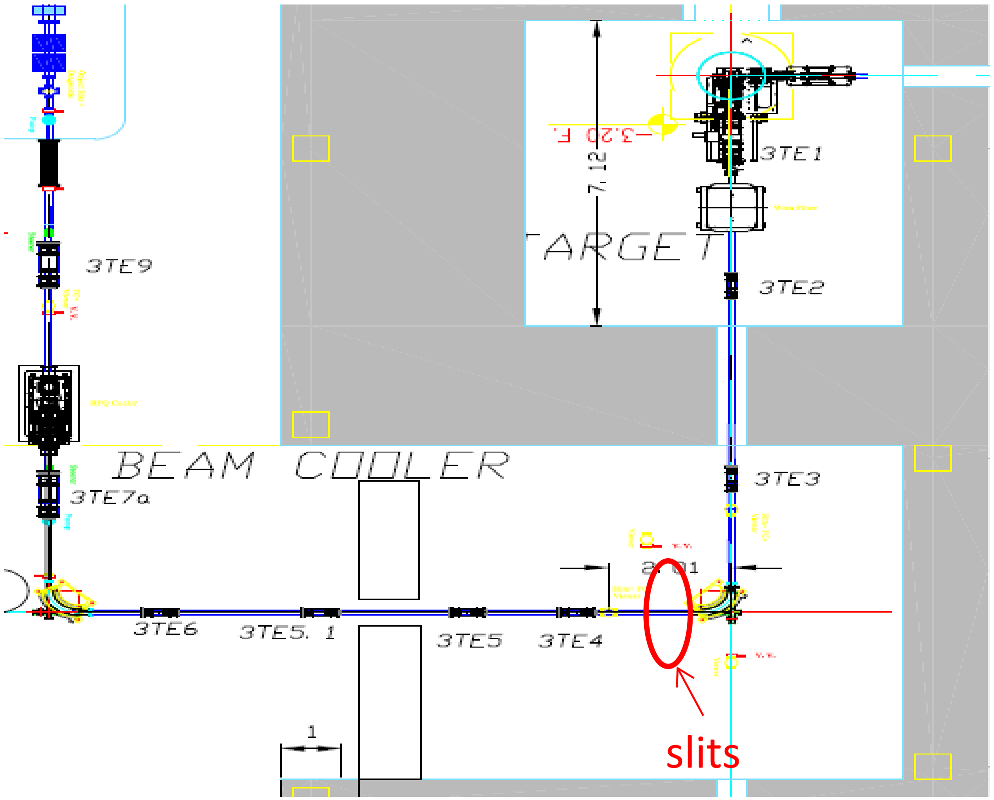


Since March 2013 a new laser laboratory is operational at LNL. At present a **Nd:YAG "Quantel" Laser** is used for ablation studies; the **new all solid state tunable laser** system for the SPES project will be tested .

Ion source Beam Selection







Beam at production bunker exit ($\delta M/M=1/200$)

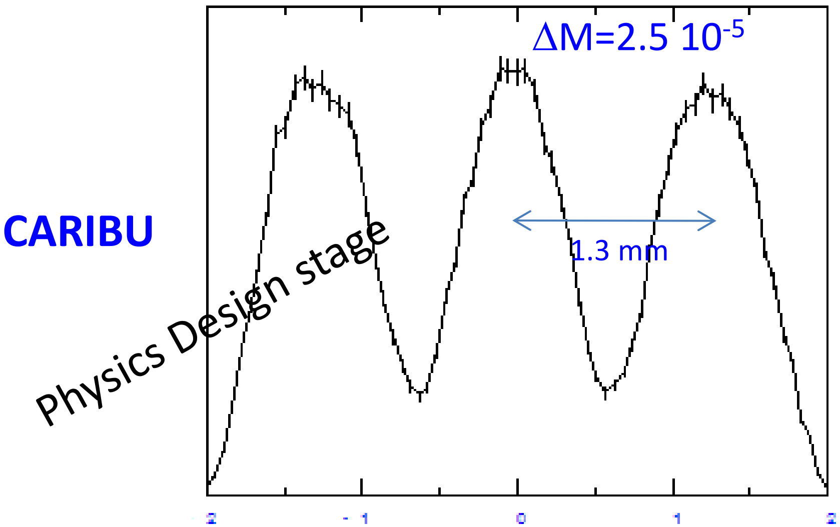
High Resolution Mass Separator & Beam Cooler

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

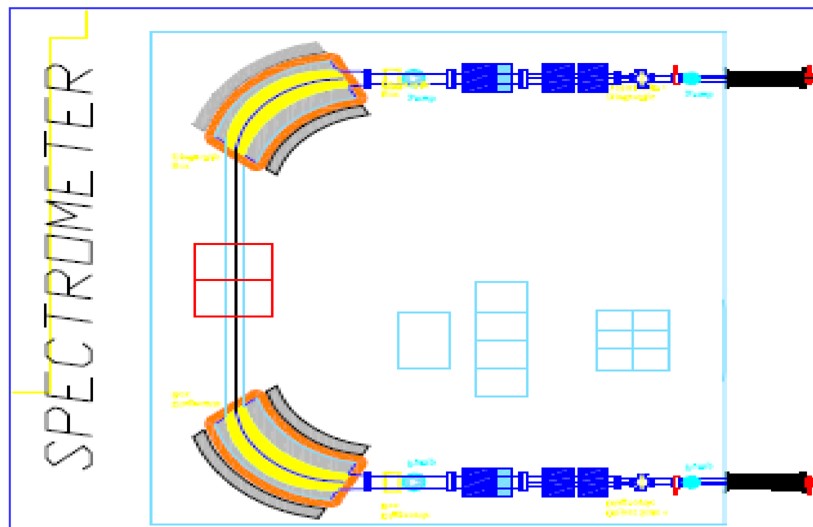
Approaching Mass resolution: 1/40000 !

Synergies with LNS
Collaboration SPES – CENBG Bordeaux

Scaled-up version of the separator designed for CARIBU
Mass resolution: 1/40000



High Resolution Mass Separator



New study with EXCYT dipoles

Beam Cooler to match the HRMS input requirements

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

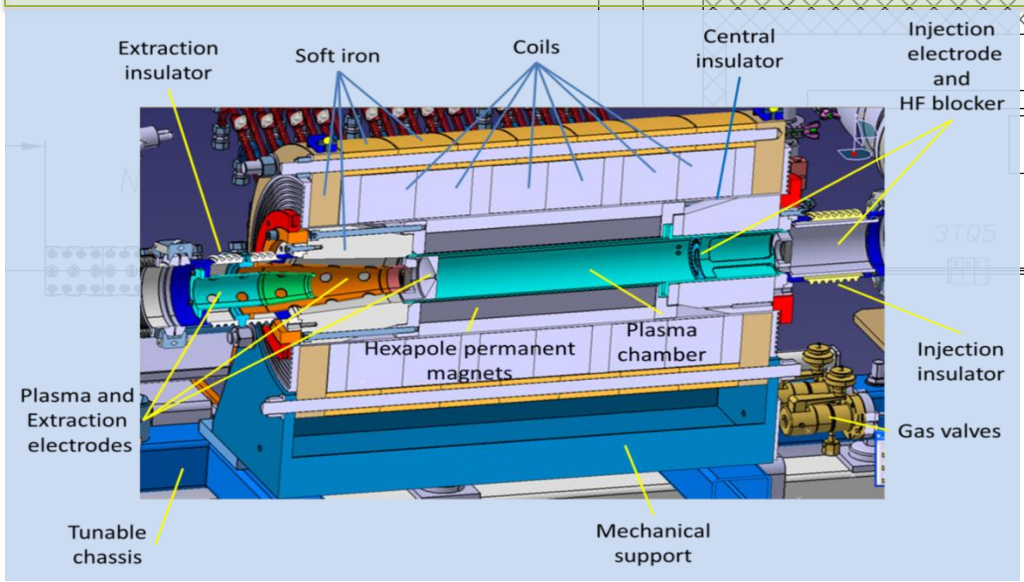
M.Maggiore

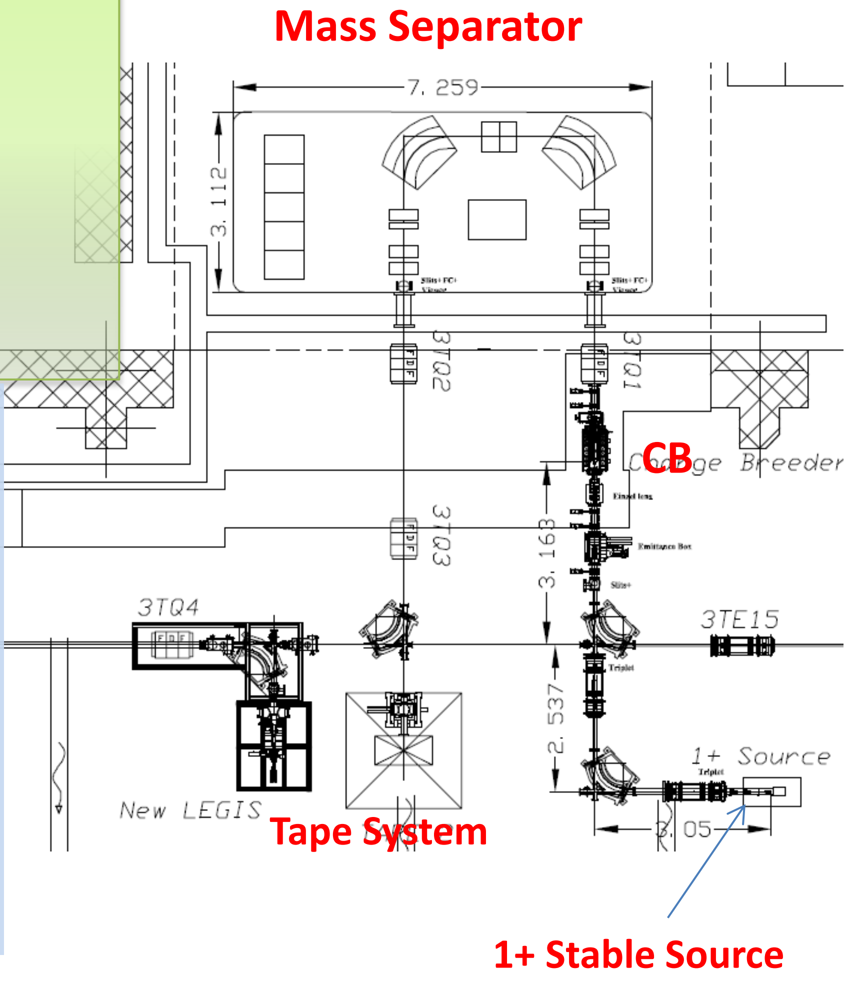
Exotic Beam reacceleration

Collaboration 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





Validation of the SPES-CB

LPSC April 4th, 2015

Charge Breeder Beams:

✓Global capture up to 90% !

✓Beam stability within ±

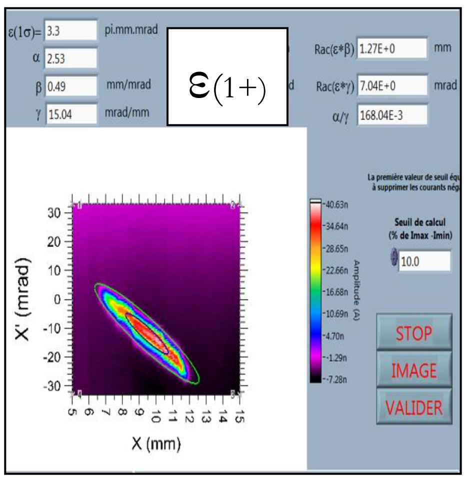
Injected beams:

✓Ar^{1+}, Xe^{1+}, Rb^{1+}, Cs^{1+}

✓Max current: 1 μA

✓Max emit: 3*π*mm*mrad

✓Max energy: 20 keV

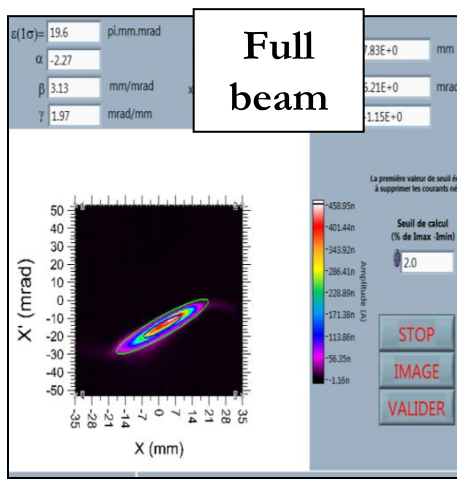


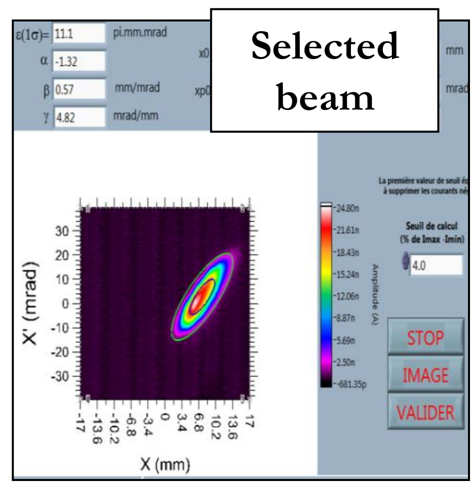
1+ Beam

1+÷N+ Beams

		EFFICIENCY* [%]		
ION	Q	SPES req	Best LPSC	SPES-CB
Cs	26	≥ 5	8,6	11,7
Xe	20	≥ 10	10,9	11,2
Rb	19	≥ 5	6,5	7,8
Ar	8	≥ 10	16,2	15,2

**results obtained for the same 1+ injected current*

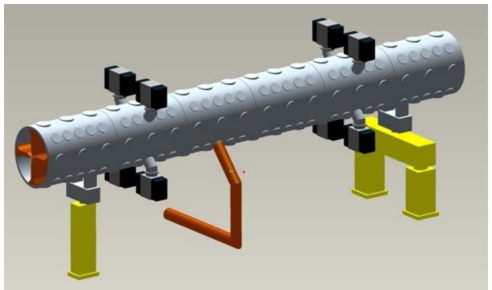




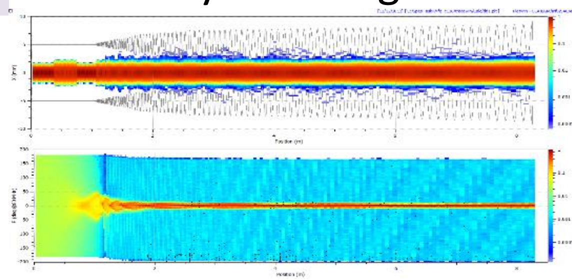
- **Ar^{8+}:**
  - ✓$\varepsilon_{norm,rms}$ ~ 0,03*π*mm*mrad (96%)
  - ✓Efficiency ~ 15%
  - ✓τ_{CB} ~ 80 ms

Exotic Beam reacceleration: room temperature RFQ

Mechanical layout of the **RFQ**

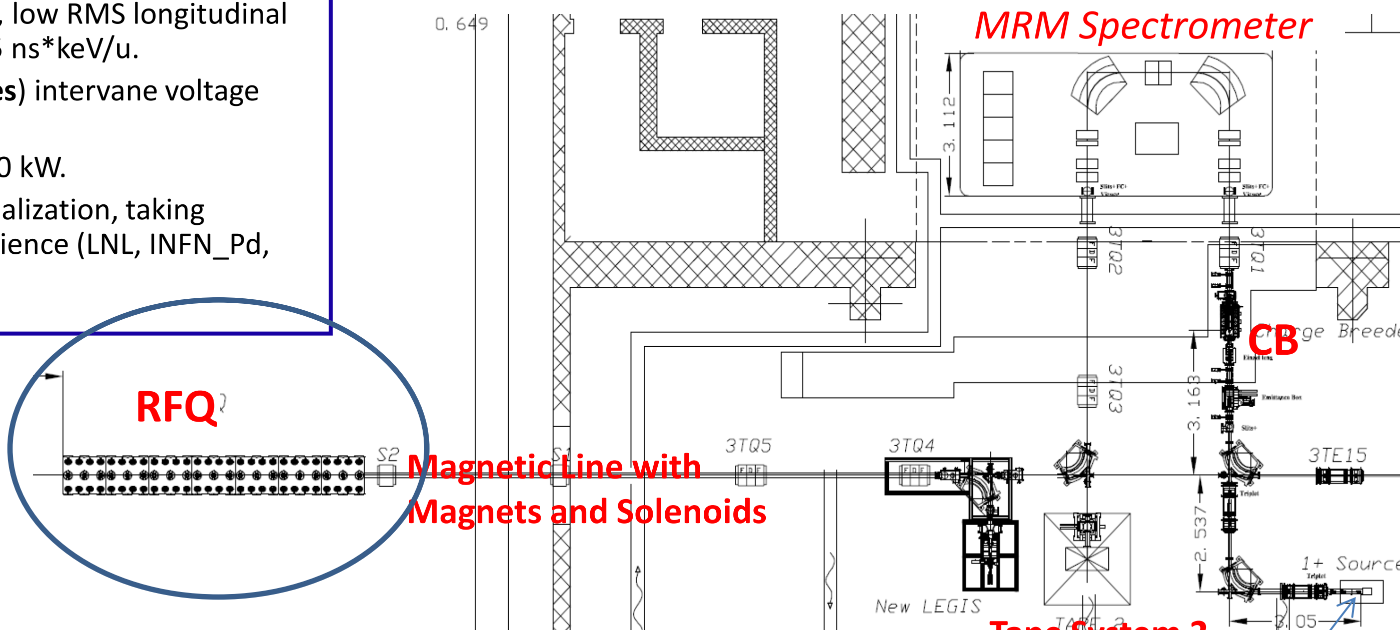


Physics design



High power RF Coupler 200kW
100% duty cycle

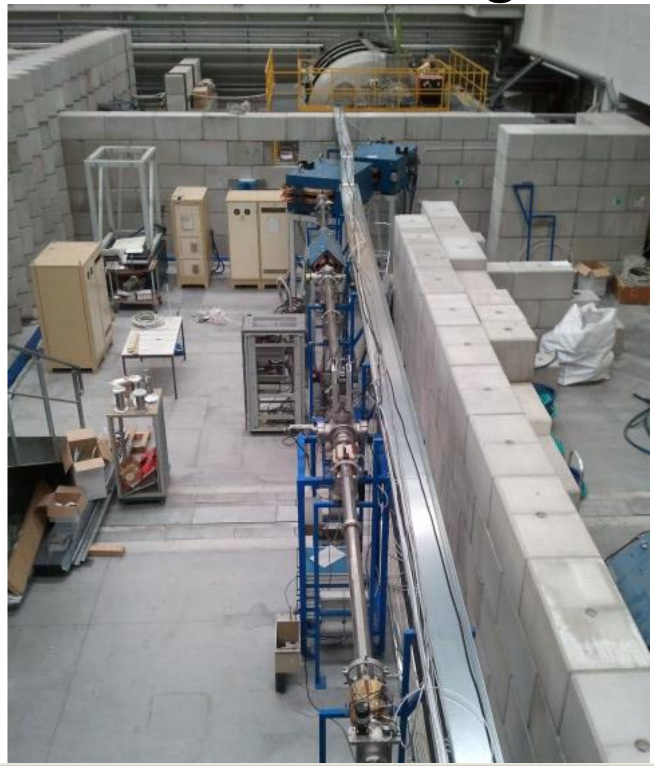
- Energy 5.7 → 727.3 [β=0.0395] KeV/A (A/q=7)
- Frequency 80 MHz
- Beam transmission >95%, low RMS longitudinal emittance at output: 0.15 ns*keV/u.
- Length 695 cm (**7 modules**) intervane voltage 63.8 – 85.8 kV
- RF power (four vanes) 100 kW.
- Mechanical design and realization, taking advantage of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



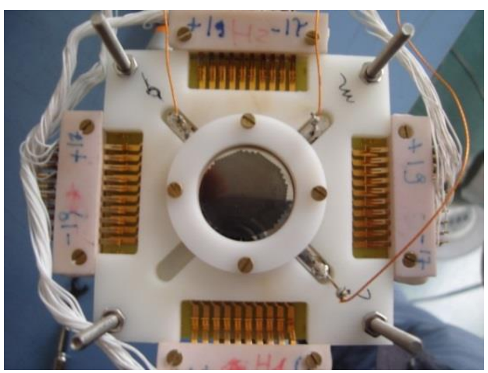
E. Fagotti, A. Pisent

Exotic Beam reacceleration and diagnostics

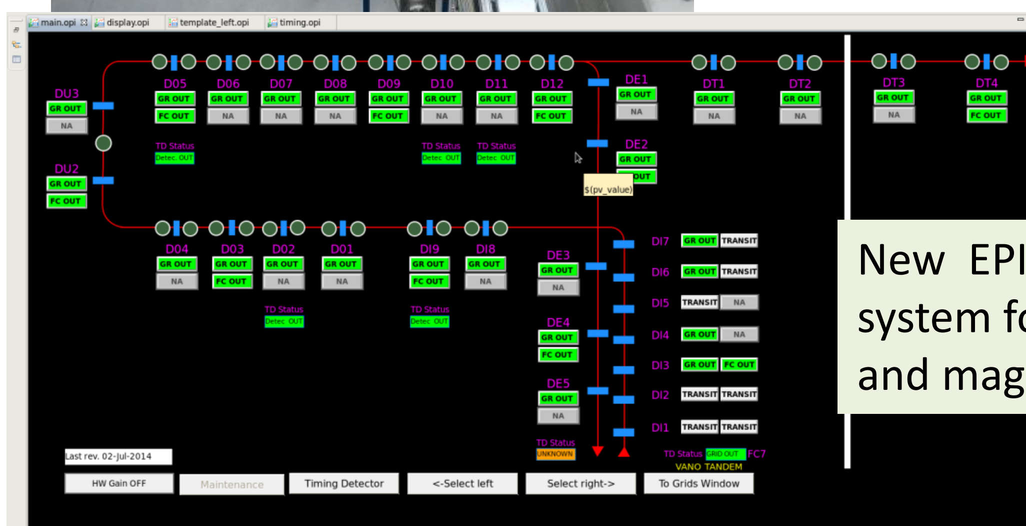
Tape system



Installation of new High Energy beam line.
(Commissioning completed)



MCP based Low intensity beam monitor

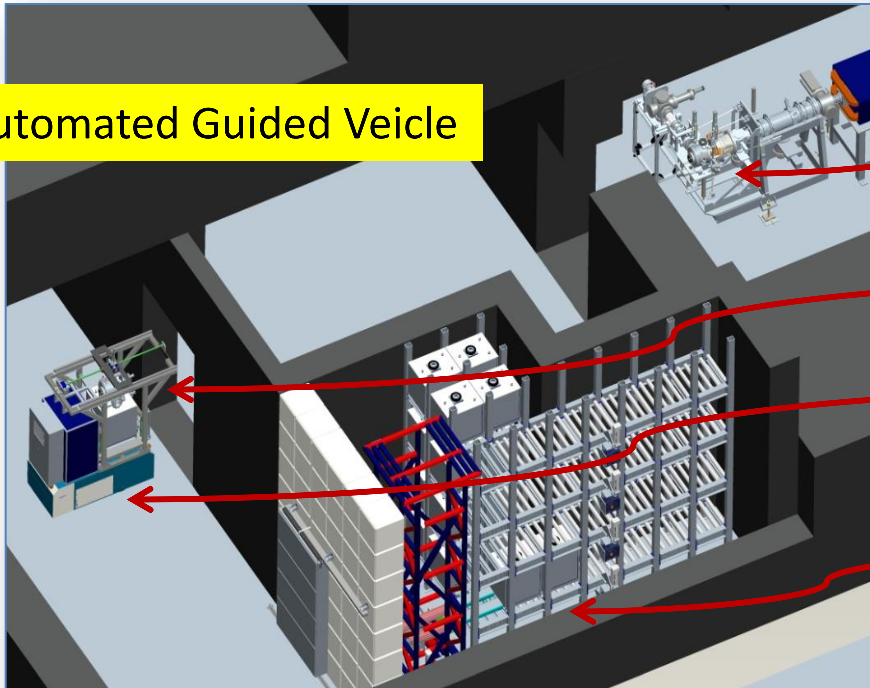


New EPICS control system for diagnostic and magnets

A. Pisent, M.Poggi, T.Marchi

SPES Technical highlights: The Horizontal target handling system

Automated Guided Veicle

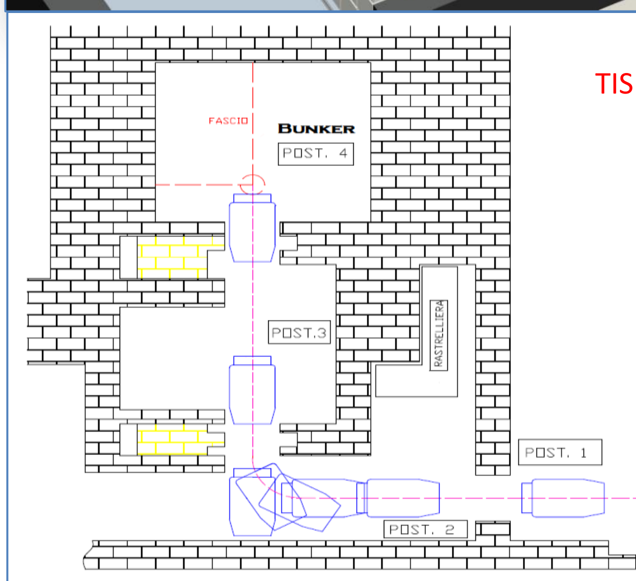


1) Coupling table handling

2) Cartesian handling

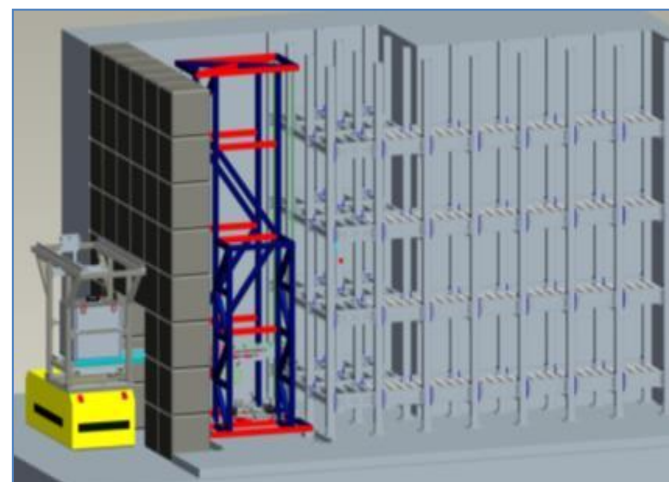
3) AGV trip

4) Storage handling



Temporary test lab
(from Sept ‘14)

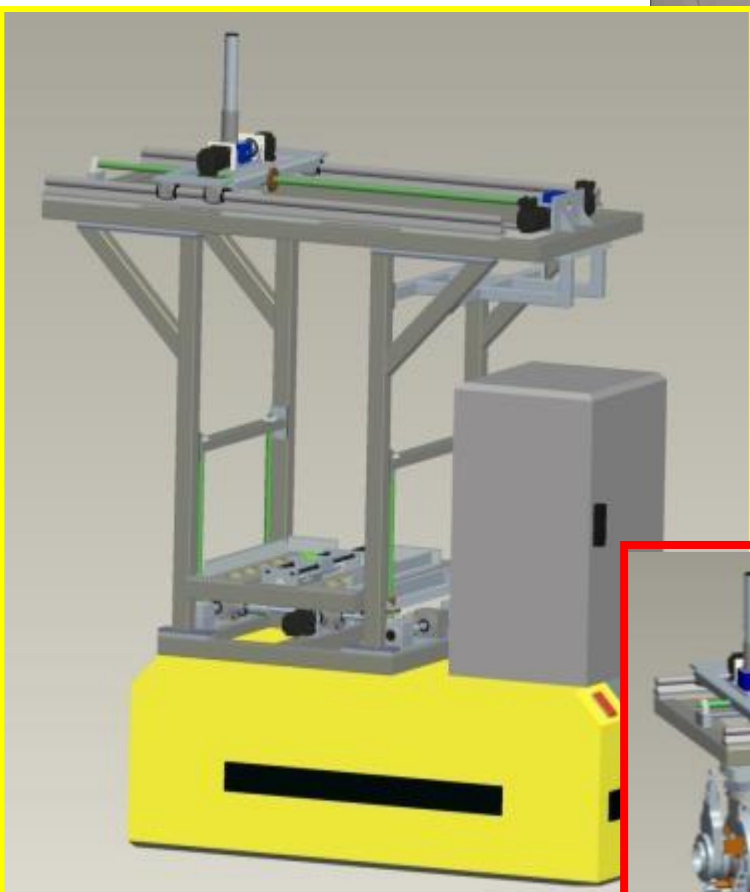
storage



WG-04

Horizontal device (AGV based)

Devices under construction at the LNL mechanical workshop



AGV with cartesian device

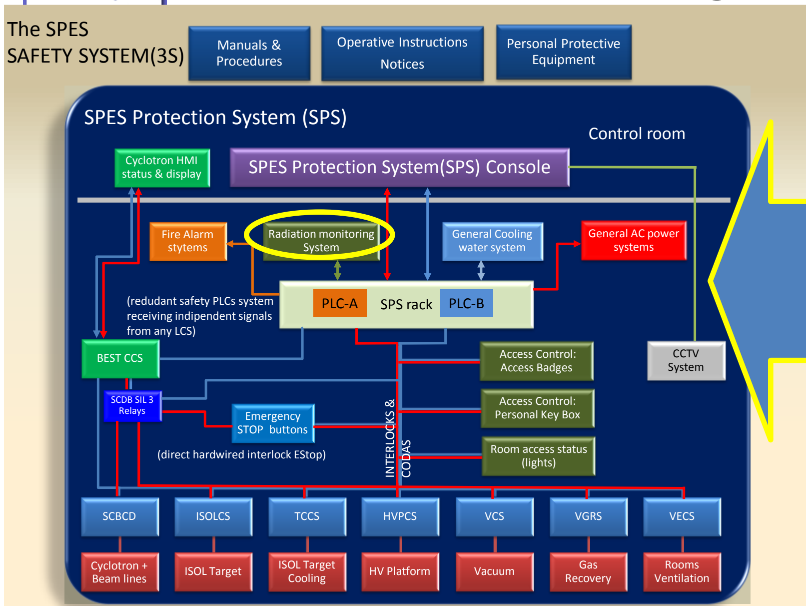
Target inside the shielding box

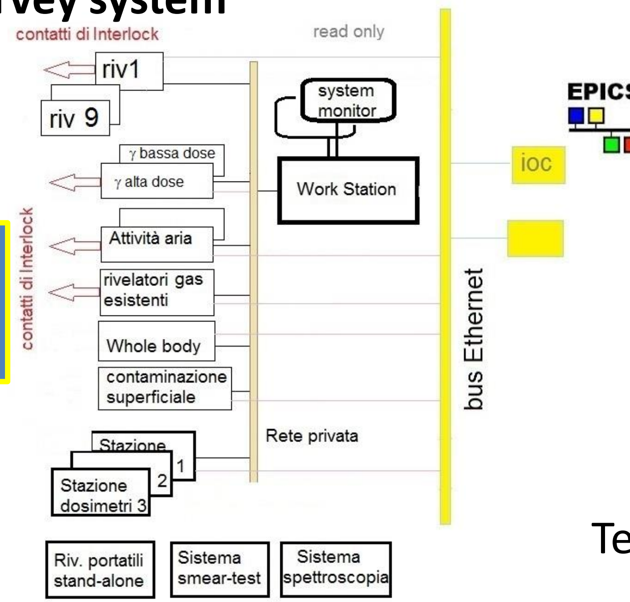
IEEE International Conference on Mecha

Vicenza (ITALY) - February 27-28 , March 1 2013

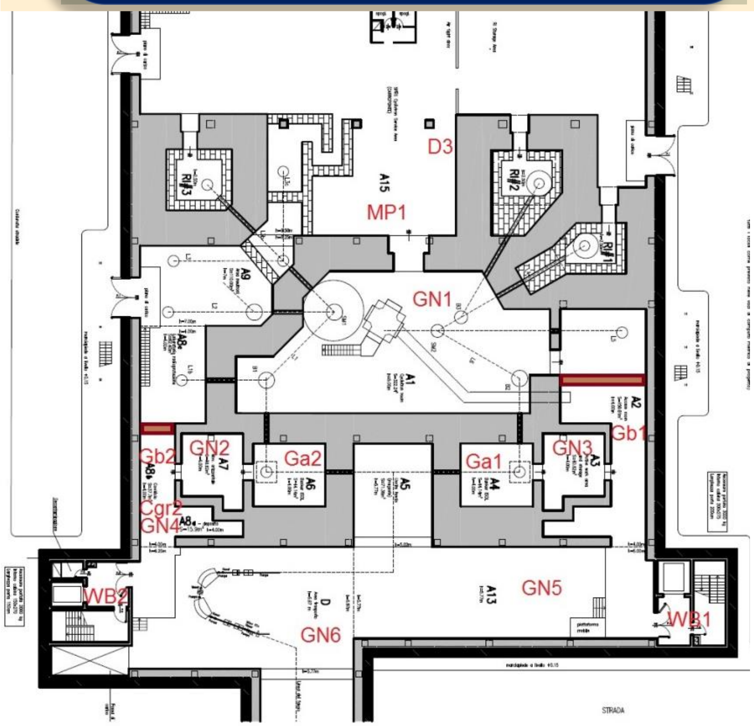
WG-04

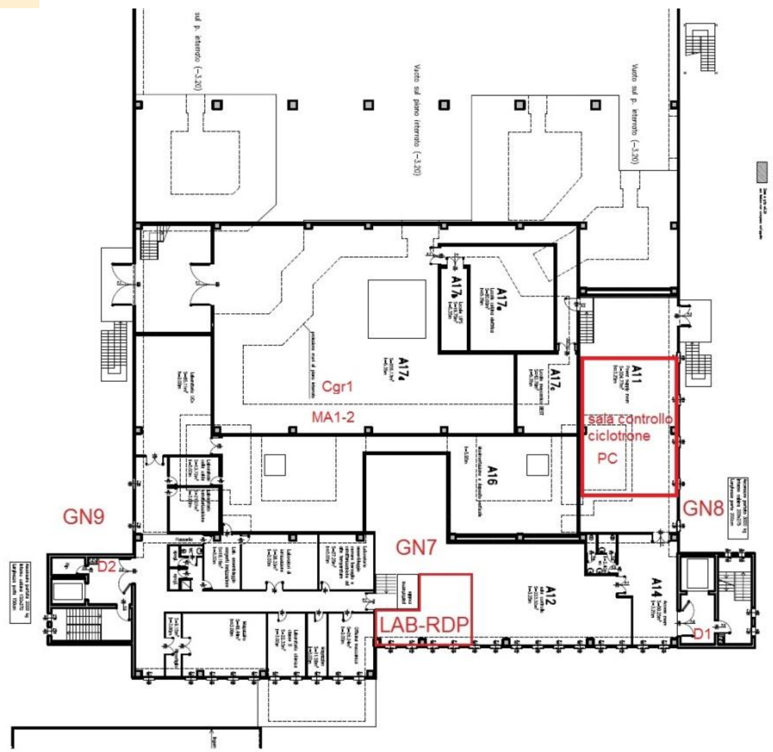
Radiologic survey system





Tender for 1.2 Meuro





CONCLUSIONS

- The SPES project is financed by INFN up to the completion
- The cyclotron will be in Leganro at the beginning of May
- The building is ready to accept the cyclotron
- The proton beam is expected to be extracted in September

  2015 for the Site Acceptance Test
- The ISOL sistem will be intstalle in 2016
- First radioactive beam in 2018 (no reacceleration)