



SPES status & perspectives

Fabiana GRAMEGNA

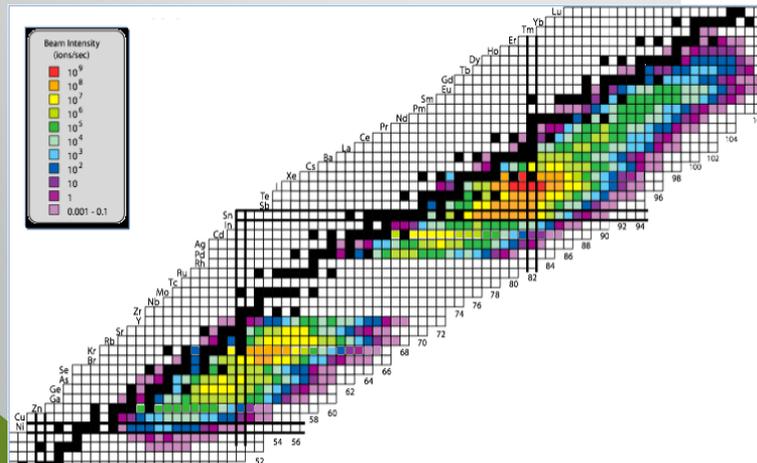
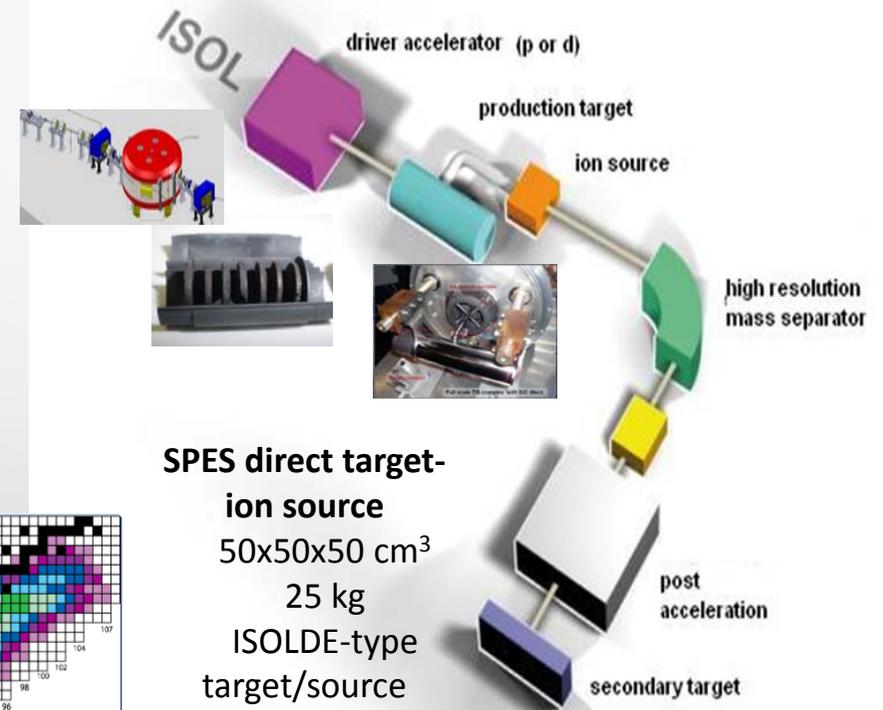
Research Division Coordinator
SPES -WP B1- Scientific Support Coordinator

Laboratori Nazionali di Legnaro
GHT Meetings – March 2015

SPES: Selective Production of Exotic Species

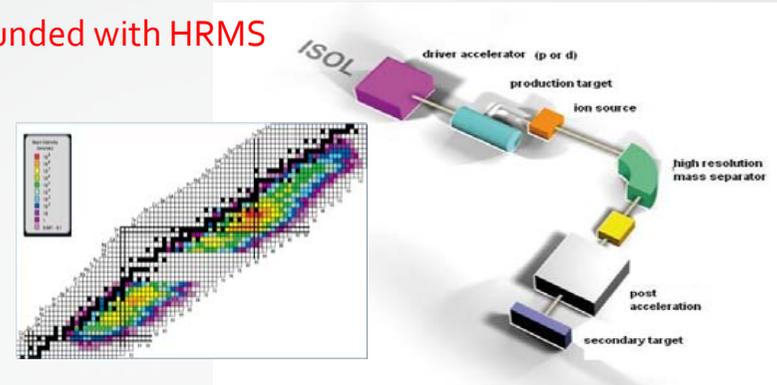
- SPES *Phases & aims*
- SPES in the *European framework*
- Status: *details & improvements*
- Preparing the *Physics Program @ SPES*
- Instrumentation
- Updated Schedule

'Commercial' Cyclotron → Proton Driver:
70MeV 0.75 mA 2 exit ports





Funded with HRMS

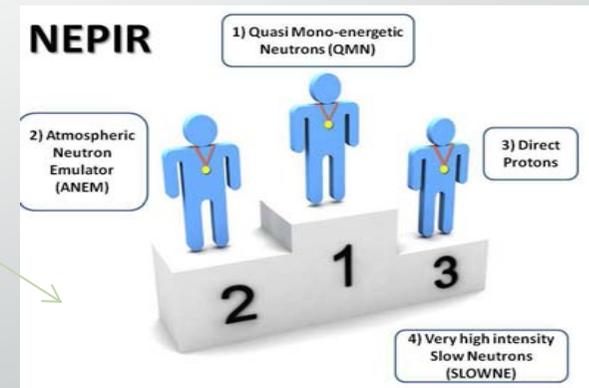


Funded

New SPES Building
BEST Cyclotron installation & commissioning:

- 70 MeV proton beam
- 750 μ A

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

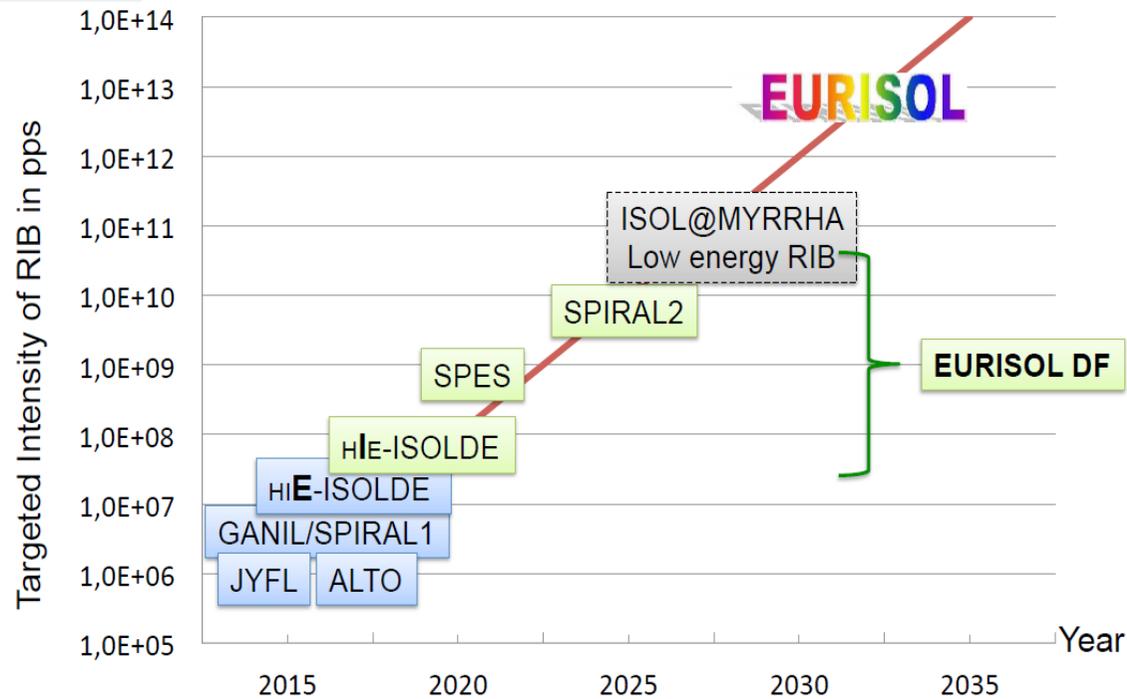


Research and Production of **Radio-Isotopes** for Nuclear Medicine (Funded with 6.8ME)

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



EURISOL DF: Intermediate step towards single site project



Complementarities: Instrumentation eg. AGATA, FAZIA, GASPARD, PARIS

Challenges: High-power targets & sources, purification of RIB

EURISOL DF

- LEA POLITA → Poland-Italy

(Collaboration on Nuclear Physics & Astrophysics, Detector and Accelerator Technology) → **signed on May 2014**

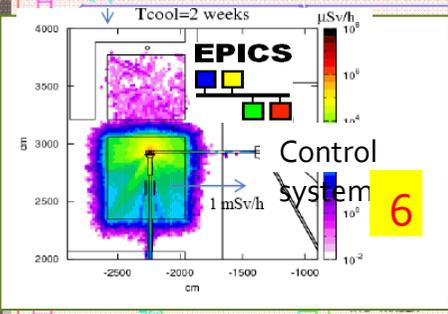
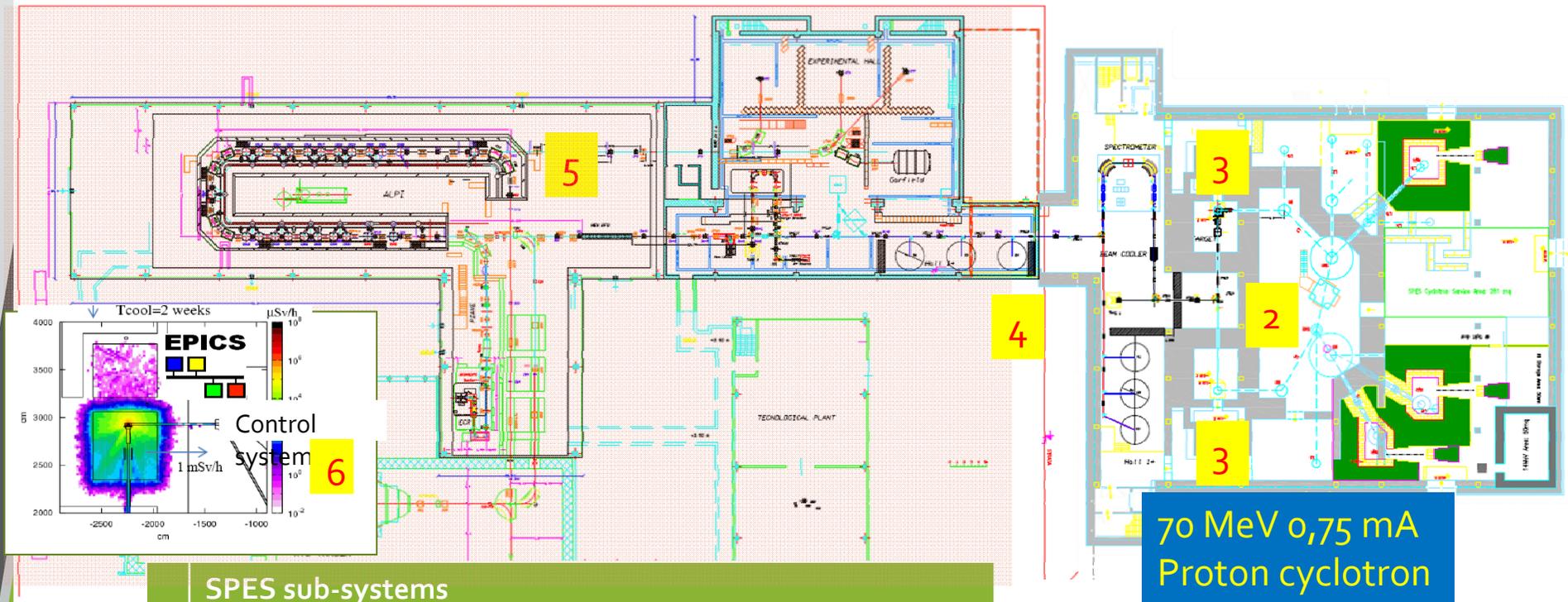
- LEA Colliga → France-Italy (SPES, SPIRAL₂, ALTO, EXCYT, FRIB, Collaboration on Nuclear Physics & Astrophysics, Detector and Accelerator Technology)

- ISOLDE (CERN) → SPES (Italy)

International collaboration on Innovative Itinerant Detectors & on experimental proposals to keep a qualified & competitive level AGATA, FAZIA, PARIS, NEDA, GASPARD, ACTAR ...

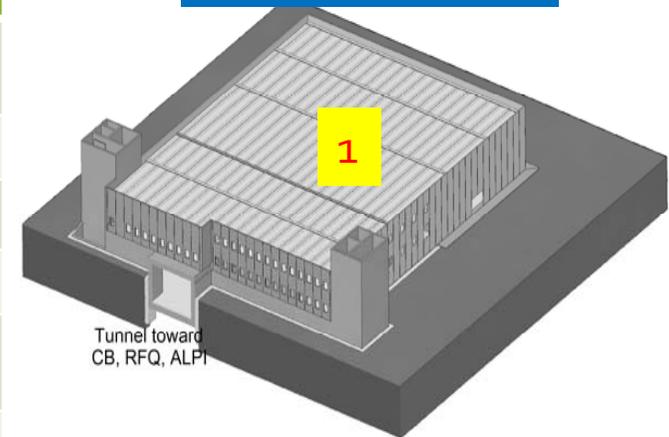
Italy → France, England, Spain, Poland, Romania, Bulgaria, Turkey, Germany, Croatia, Sweden, Finland, Denmark, Belgium





SPES sub-systems

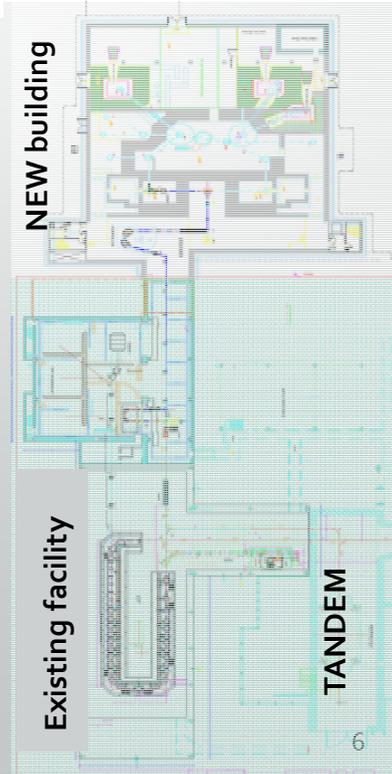
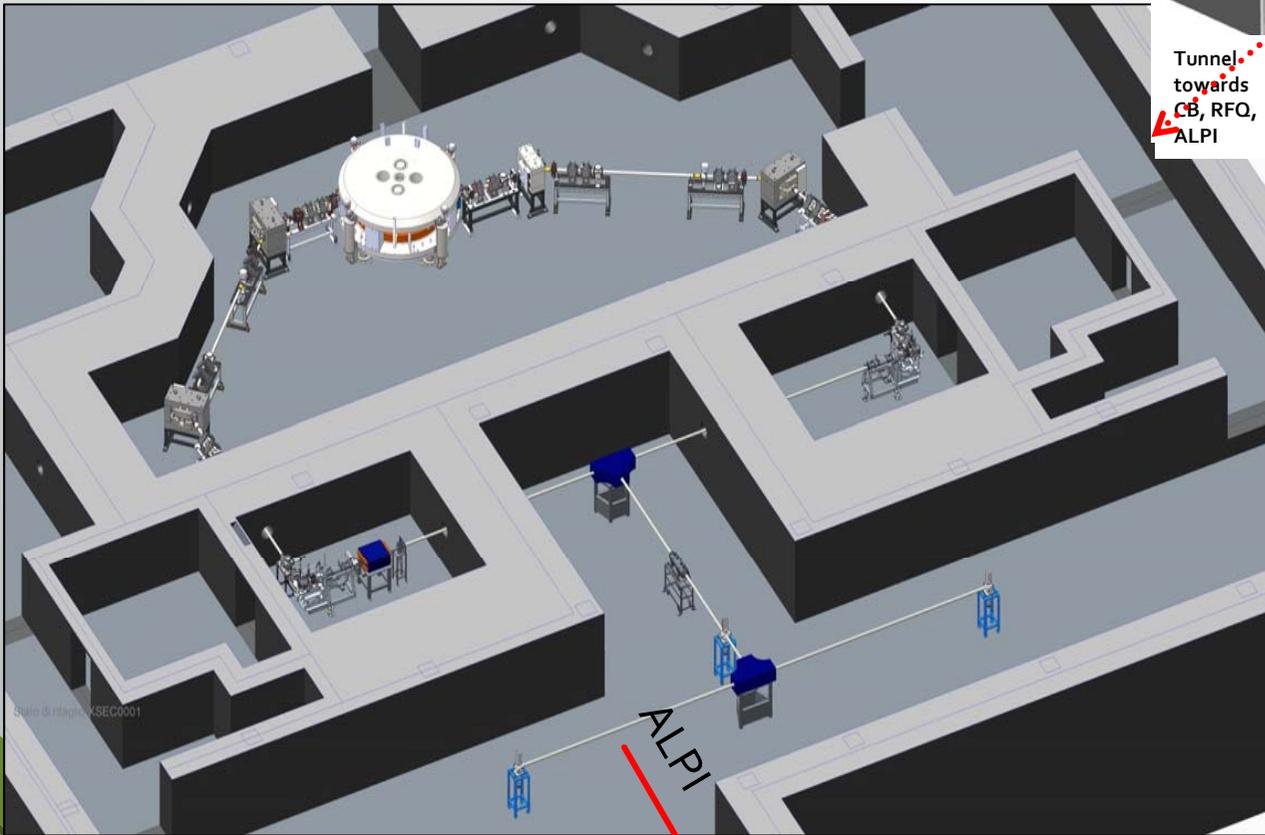
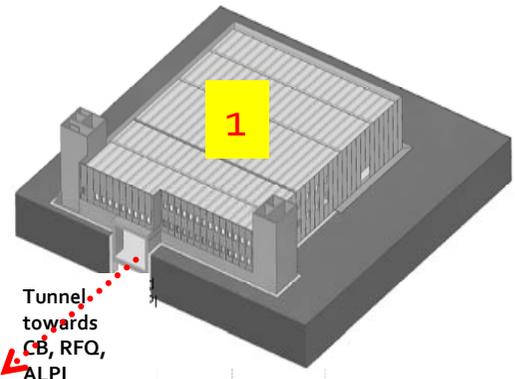
- 1 Building and infrastructures with 2 ISOL bunkers for radioactive beam and application area for radioisotopes and neutrons
- 2 Cyclotron 70 MeV protons with 2 independent exits
- 3 ISOL UCx target designed for 10^{13} f/s
- 4 Beam transport with High Resolution Mass Separation
- 5 Reacceleration with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

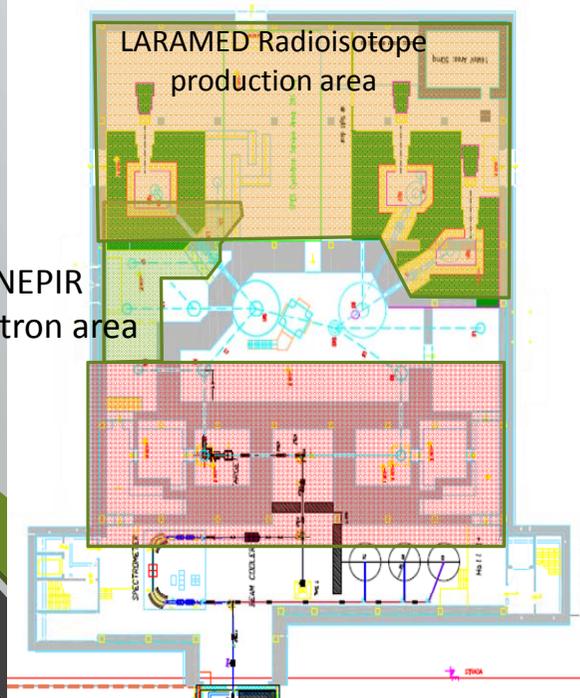


SPES 3D LAYOUT: the NEW building

Cyclotron area + two Production Target areas
.... the CAD 3D....

- Accelerator system at **underground level** to match existing ALPI beam line
- **2 ISOL bunkers** for redundance and optimal operation





At present



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	$\Phi=4.5$ 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**).

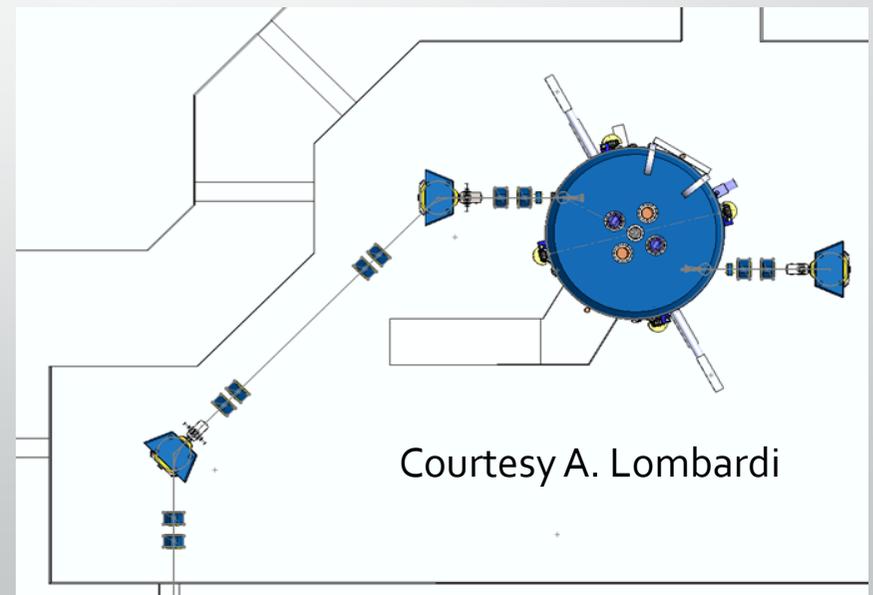
Factory Acceptance Test approved on November 29

Cyclotron assembled and operated with **700 μA at 1MeV**

	2014	2015																
Factory Assembly & Tests	■	■	■															
Disassembly & Shipping			■	■	■	■	■											
Installation @LNL							■	■	■									
Test & Commissioning @LNL								■	■	■	■	■	■	■	■			

The **Contract** with **BEST Theratronics** provides for:

- Cyclotron
- Two exit channels
- High power beam transport line (up to SPES target)



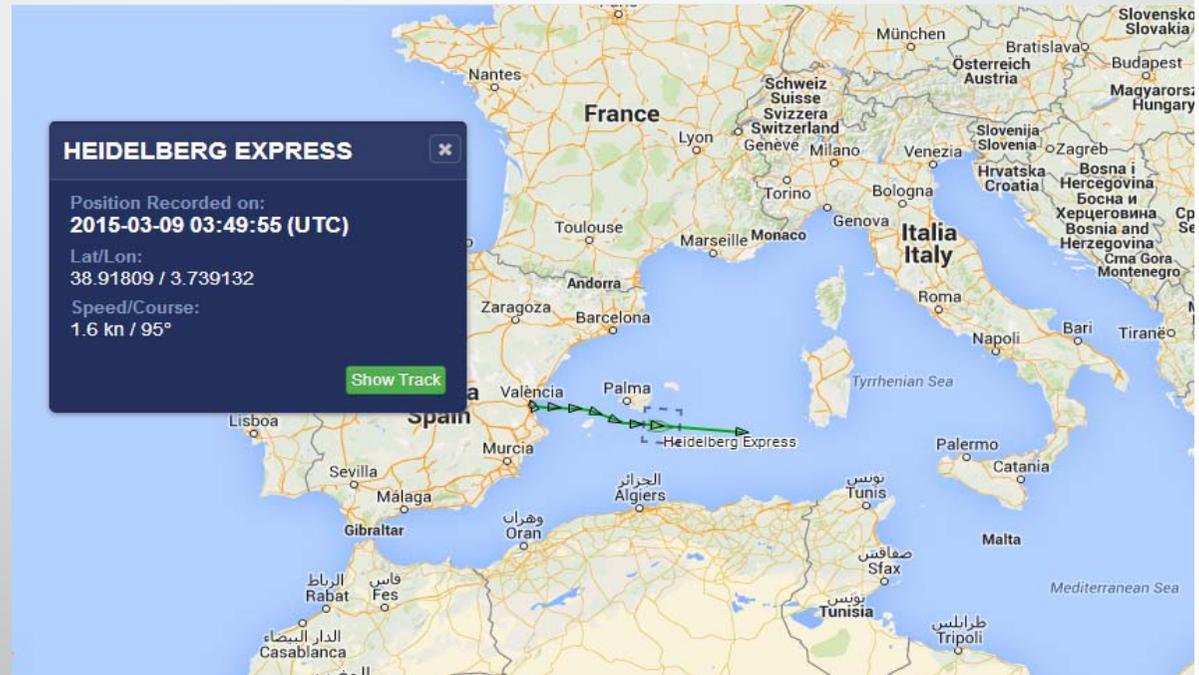
Courtesy A. Lombardi

4 Shipments:



Shipping plan provided to INFN (as per Feb 9th equipment)

- 1st shipment arrival in Genoa ~10-Mar-15
- 2nd shipment arrival in Genoa ~15-Apr-15
- 3rd shipment arrival in Genoa – MM ~13-Apr-15**
- 4th shipment arrival in Genoa ion source ~Jun-15



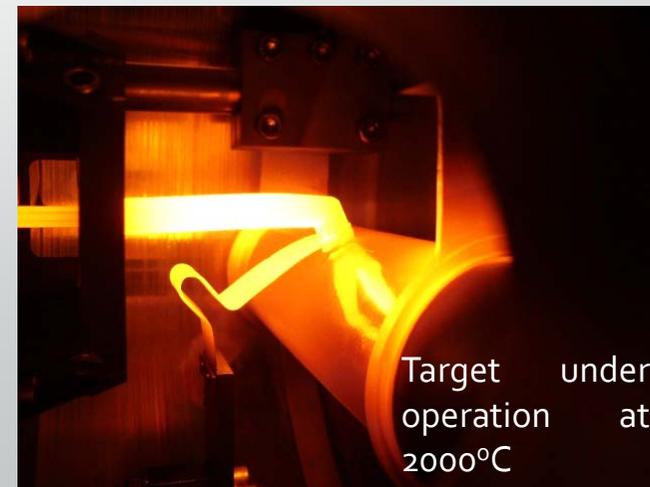
Heidelberg Express

A. Lombardi

SPES DIRECT TARGET CONCEPT to operate with 8 kW proton beam

(A. Andrichetto 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;
- Developments on Ion Sources

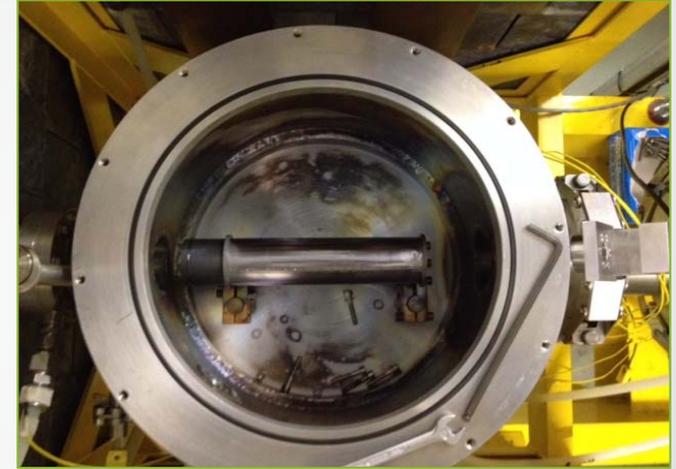


Proton beam 66MeV 60 μA

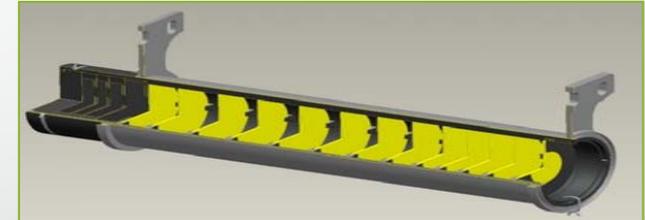
SPES target in-beam power test (SiC target)

Heater power compensated by proton beam.

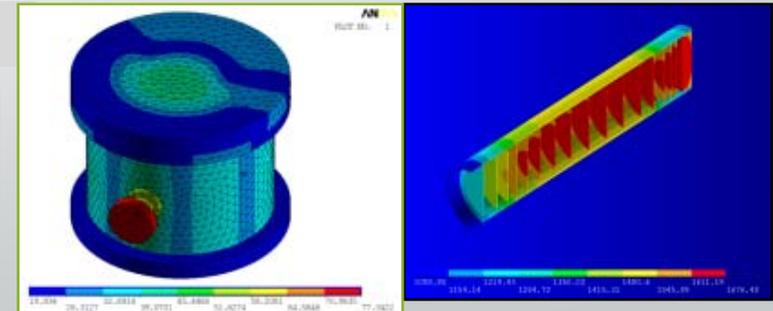
- Up to **4 kW proton beam** in target.
- **Stable temperatures**
- **Stable vacuum** ($3 \cdot 10^{-5}$ mbar)



Measure [°C]	Estimated by FEM model [°C]
1° disk: $1365 \pm 30^\circ\text{C}$	1390
Box: $1230 \pm 25^\circ\text{C}$	1267
Dump on chamber: $728^\circ\text{C} \pm 10^\circ\text{C}$	750

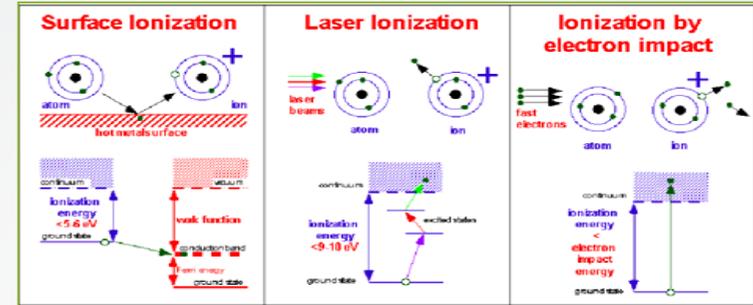
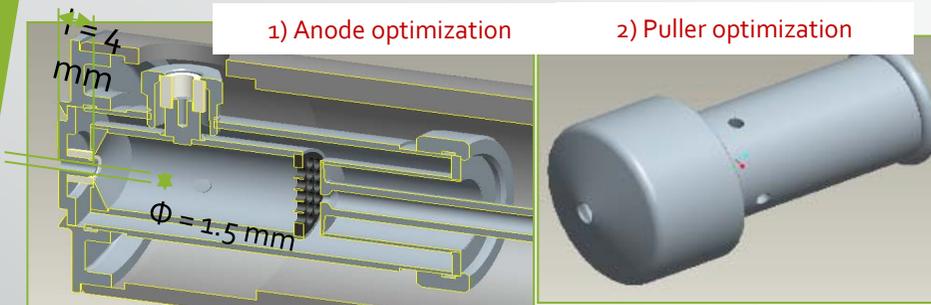


Thanks to Rob, Lowry and all the iThemba_Labs Cyclotron staff

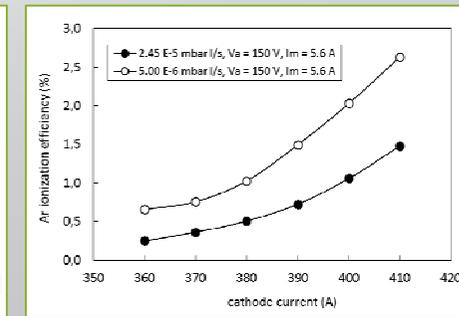
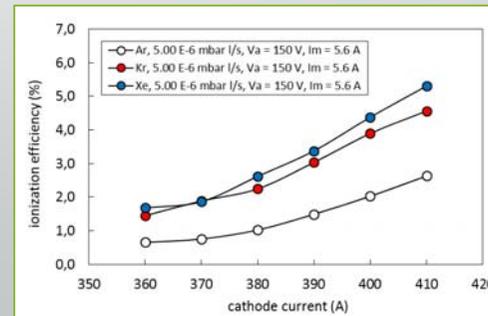
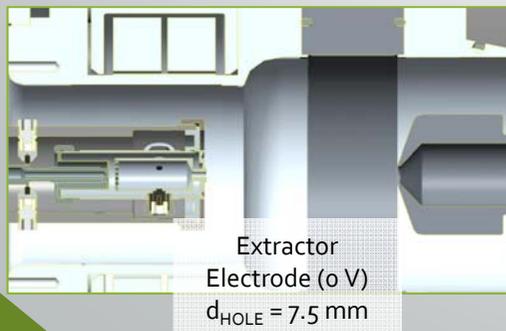
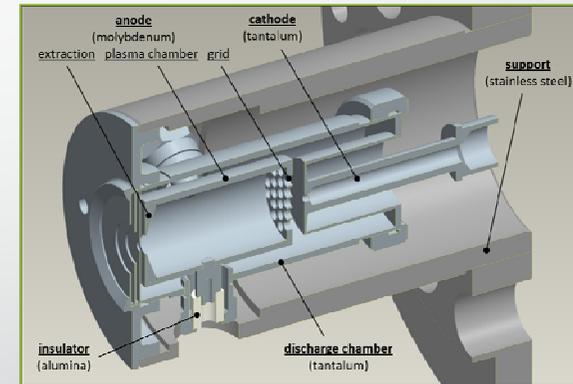
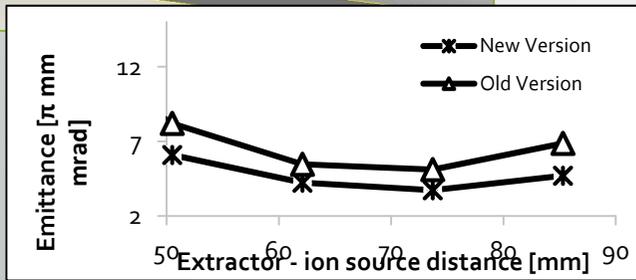


New developments to improve the Source Efficiencies:
→ new cathodes, new materials etc.

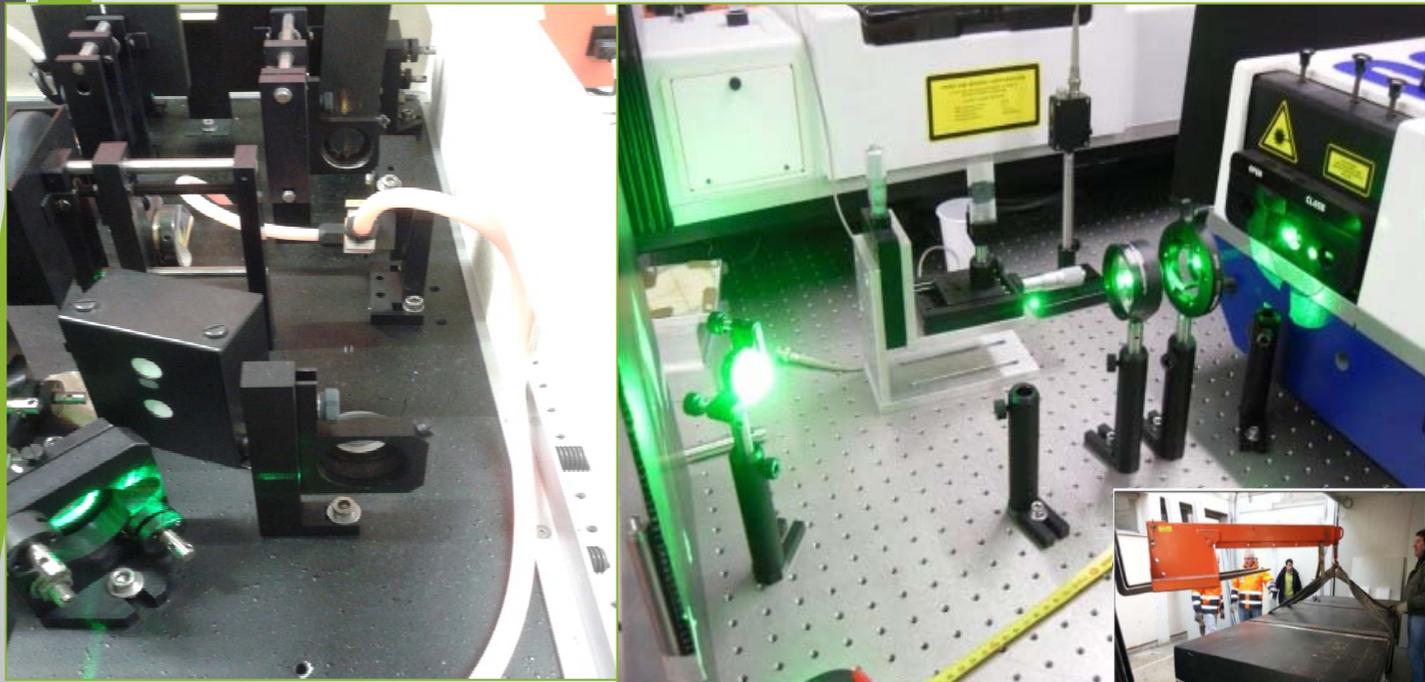
Optimization of Plasma Ion Source optics in order to increase the RIB transport



PIS efficiency of noble gases



A new SPES laser laboratory was built @LNL in 2013



A tunable dye laser system ready for atomic spectroscopy study



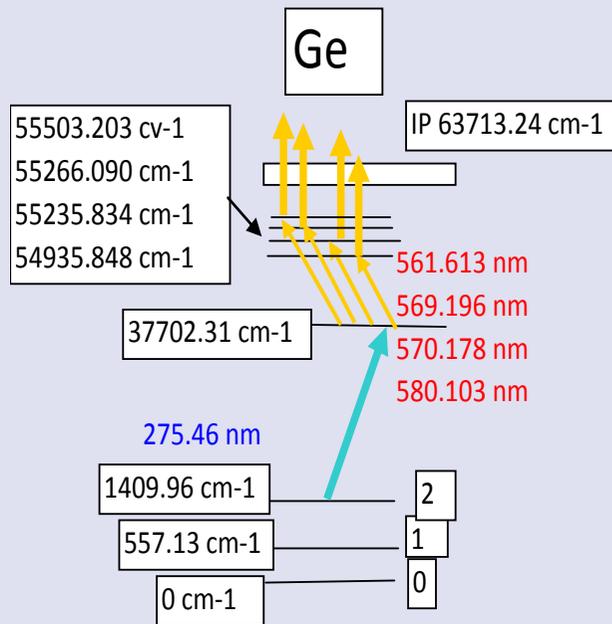
A. Andrichetto, D. Scarpa et al.

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 .

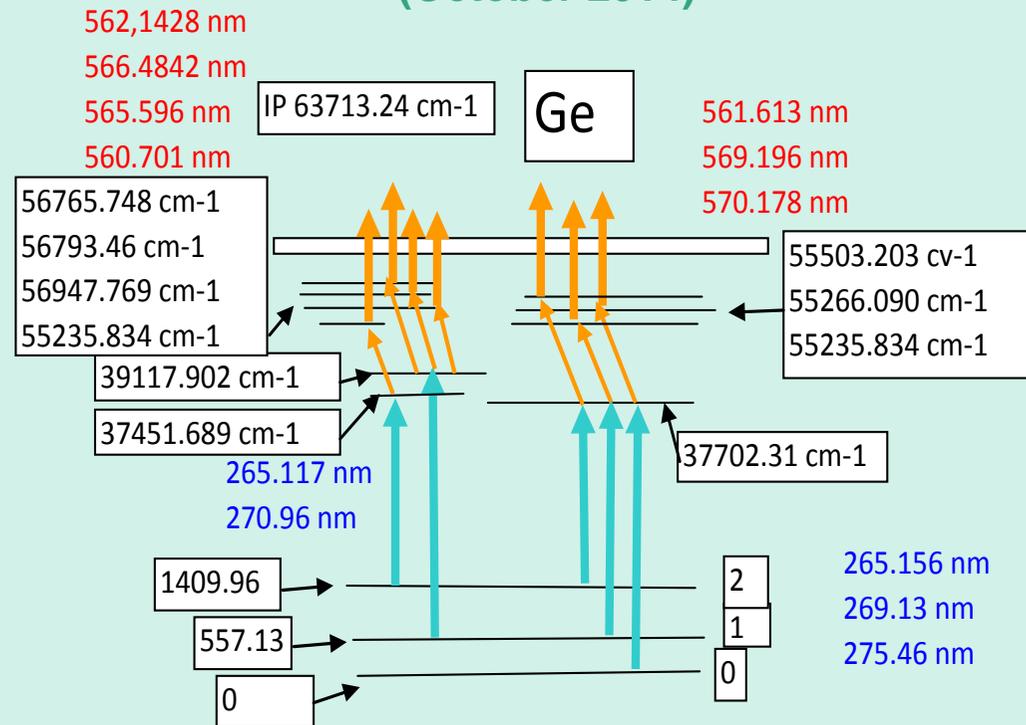
Germanium spectroscopy study

A range of three-step two-colors ionization schemes arranged with dye laser system has been checked at LNL:

Tested at ISOLDE (July 2014)



Tested at LNL (October 2014)



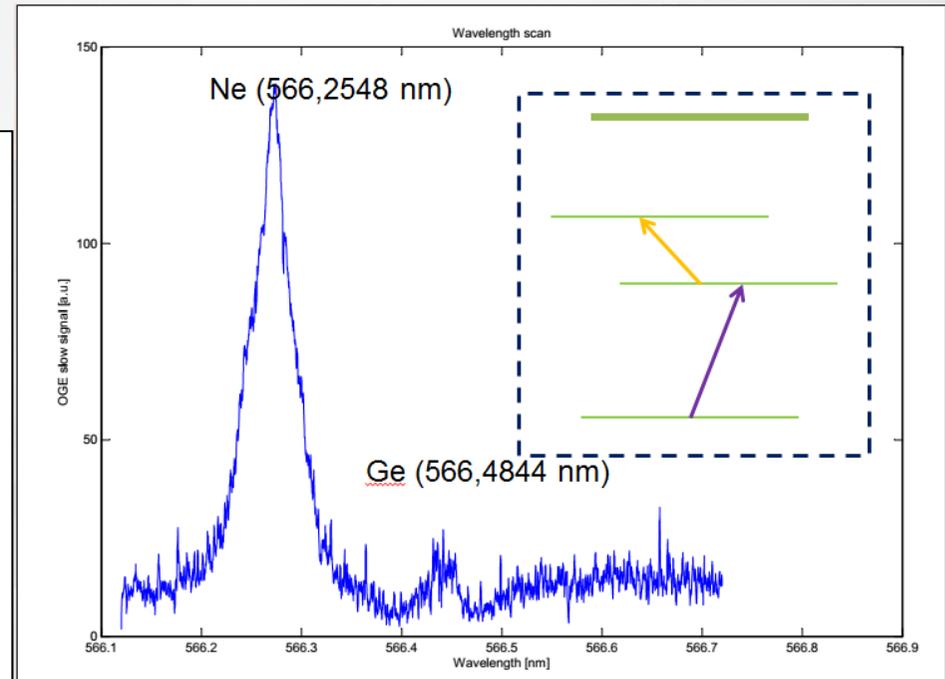
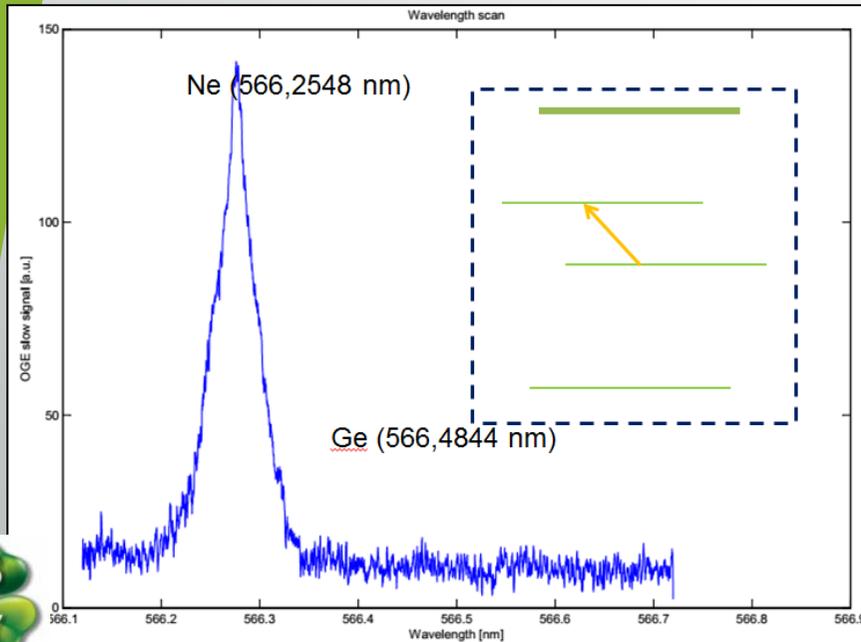
5 first step transitions and 7 second transitions were tested successfully

WG-03

“Slow signal” of ionization scan with the fixed at 303 nm first step

Scan across 566 nm resonance was performed with TDL 50

No first step; Only second step



First step + Second step

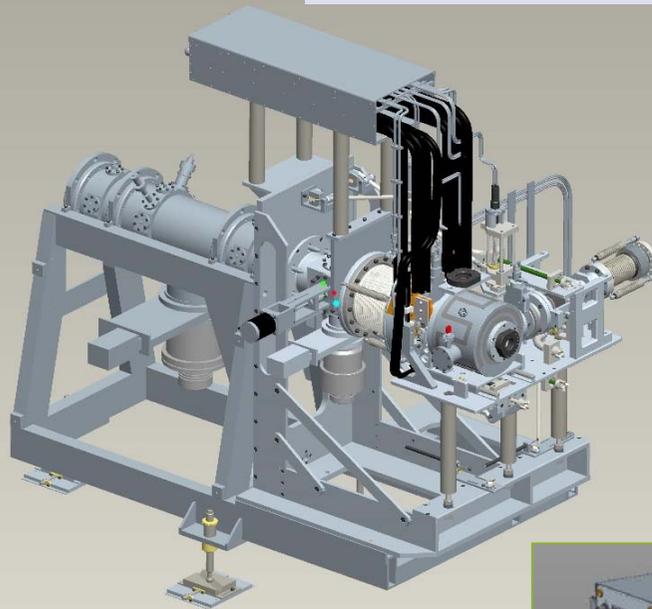


RAD-HARD version

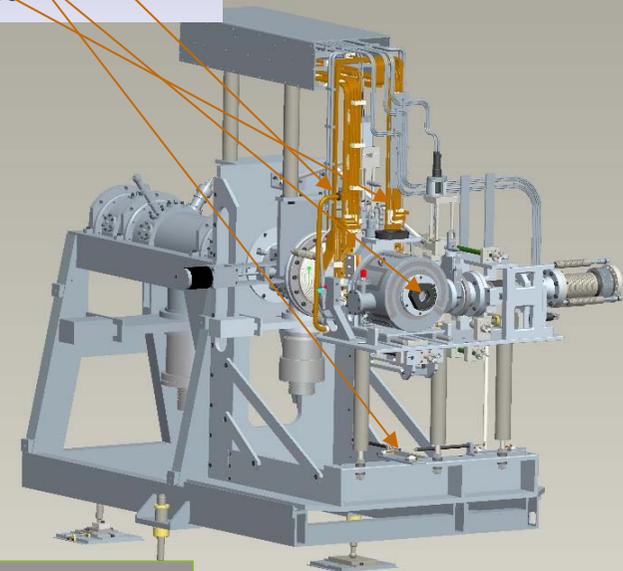
A. Andrichetto et al.

Critical material List

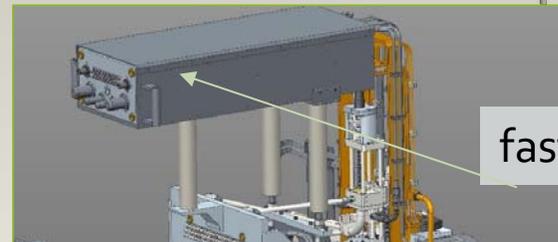
Teflon with glass fibres	-> alumina
Polyethylene	-> peek
Viton O-rings	-> EPDM
Plastic cable insulator	-> air (close the target)
Normal motors	-> RAD HARD motors



before

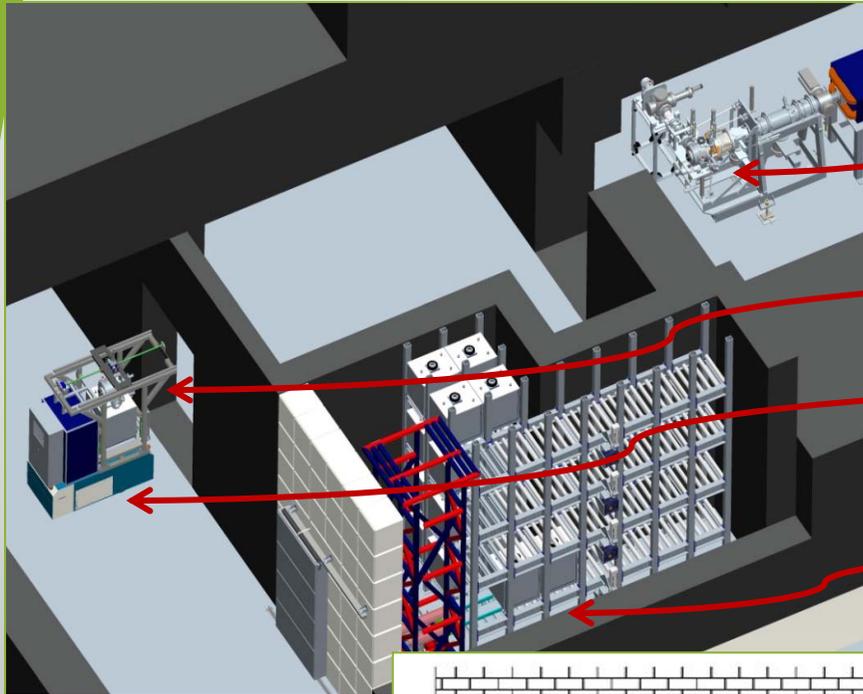


after



fast connectors





1) Coupling table handling

2) Cartesian handling

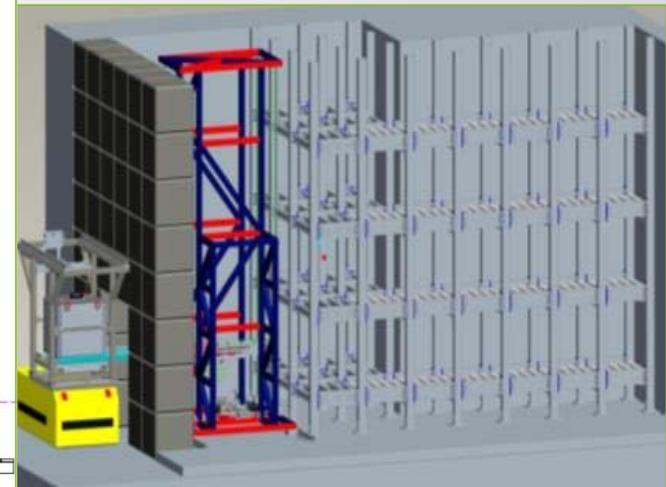
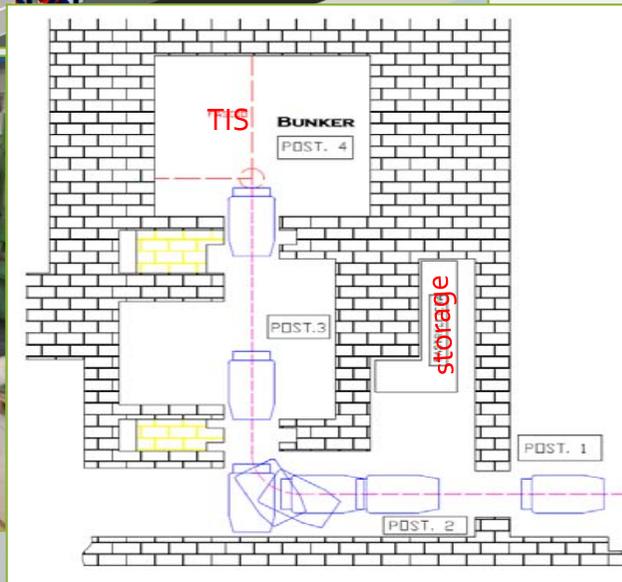
3) AGV trip

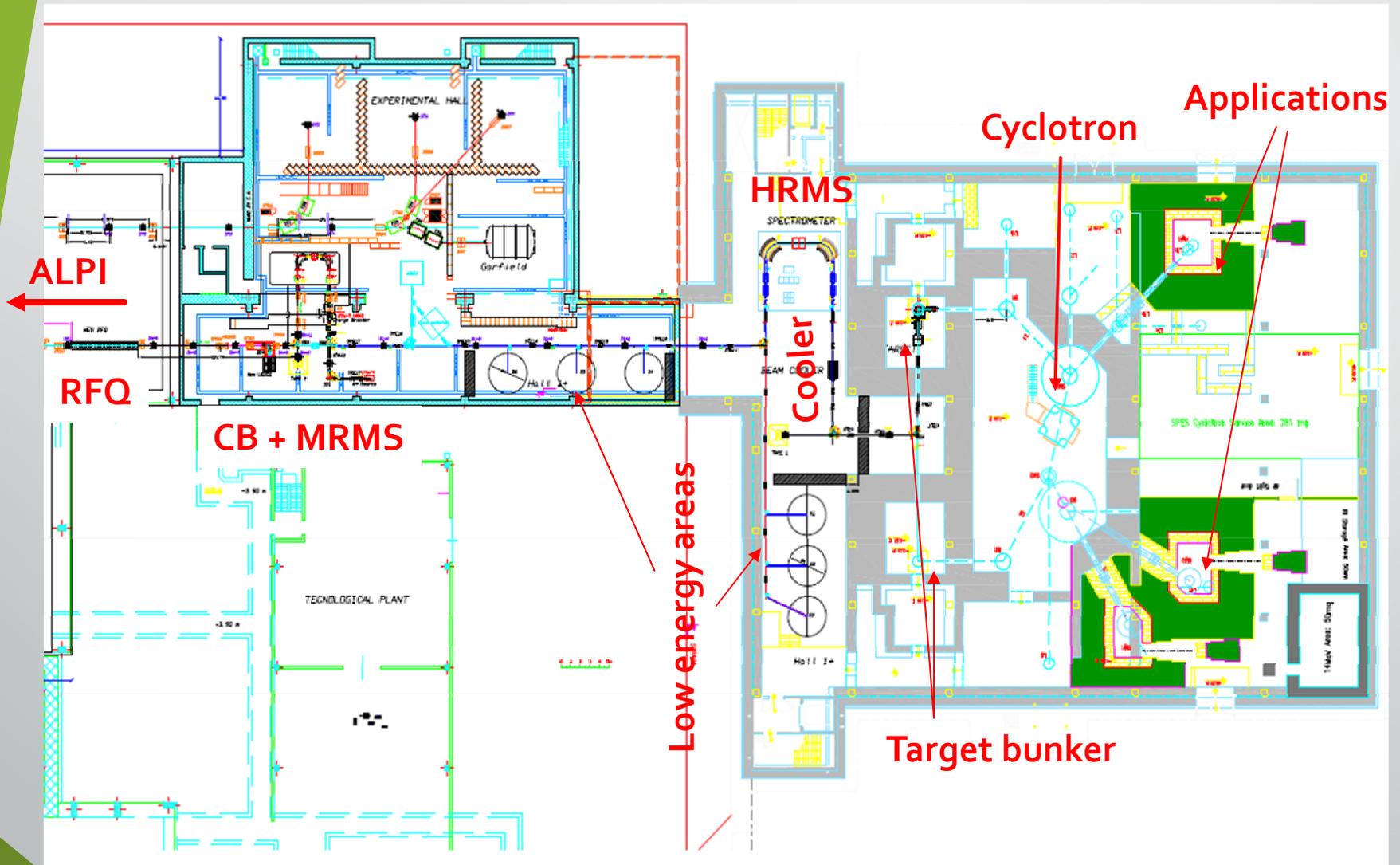
4) Storage handling

Temporary test lab
(from Sept '14)

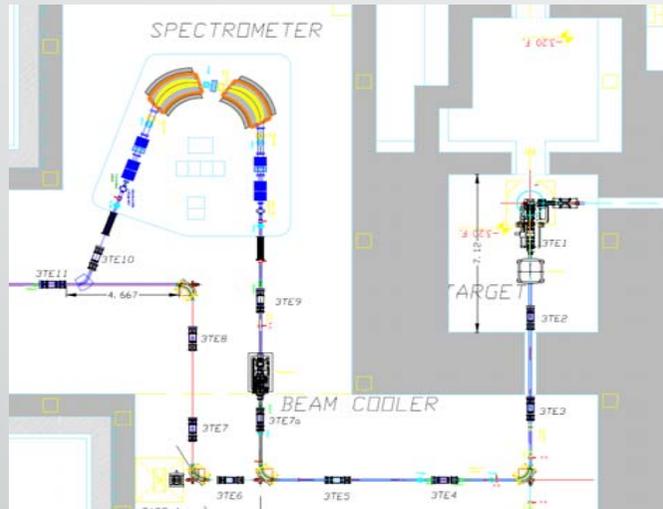


AGV

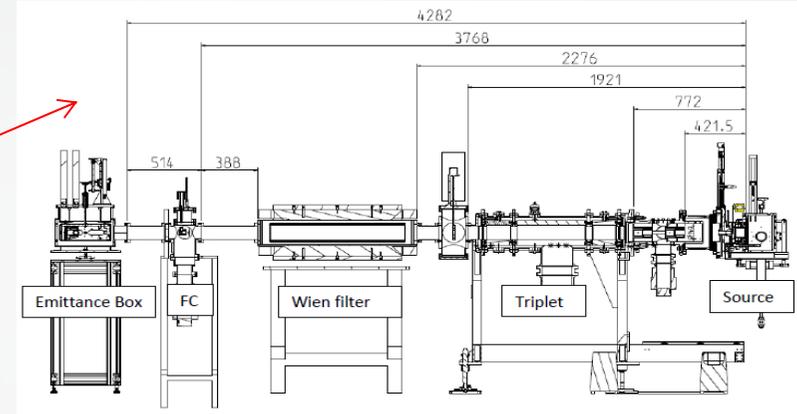




M. Comunian, L. Calabretta, S. Russo



Target room



E : electric field [V/m]

S_t : target position [mm]

U : beam potential [kV] (=20 kV)

L_w : eff. length [mm] (=782 mm)

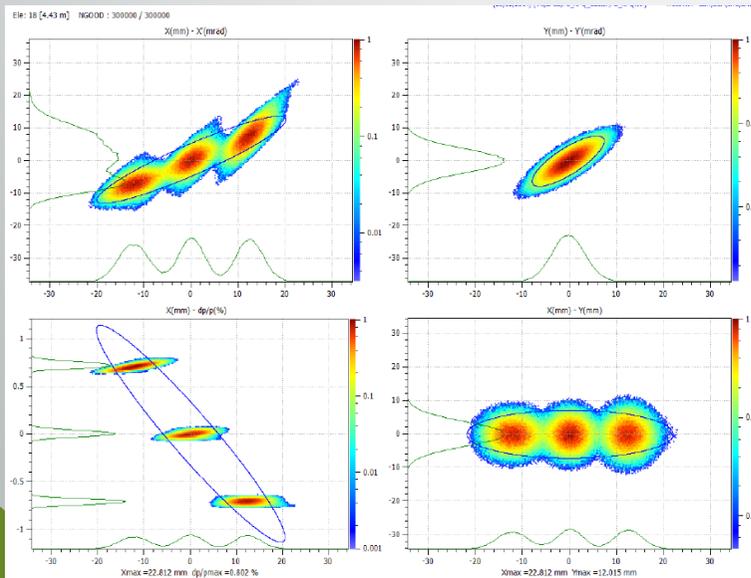
δS : required deflection [mm] (=15 mm)

$$B = \frac{E}{\beta c}$$

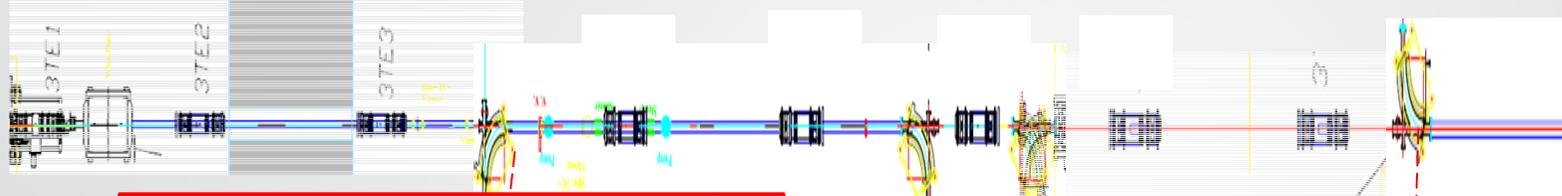
Expected mass resolution from first order formulas:

$$\frac{4U}{L_w S_t E} \delta S = 0.013 = \frac{\Delta M}{M} = 1/77$$

Nucl. Instr. Meth. I22 (1974) pp 511-515



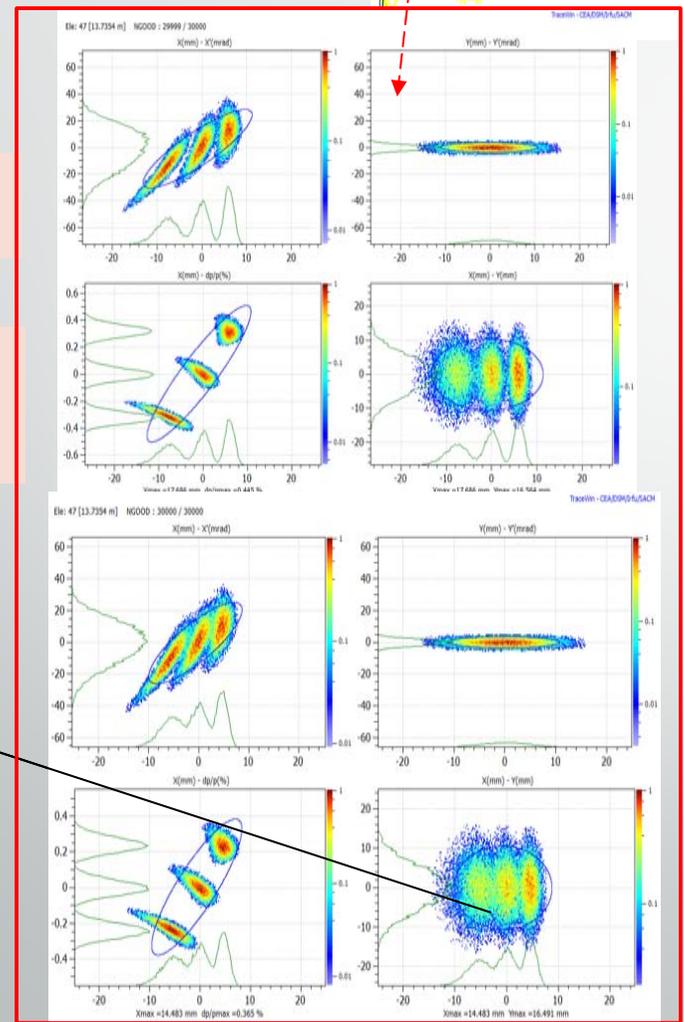
M. Comunian, L. Calabretta, S. Russo



$$\frac{\Delta M}{M} = \frac{1}{150}$$

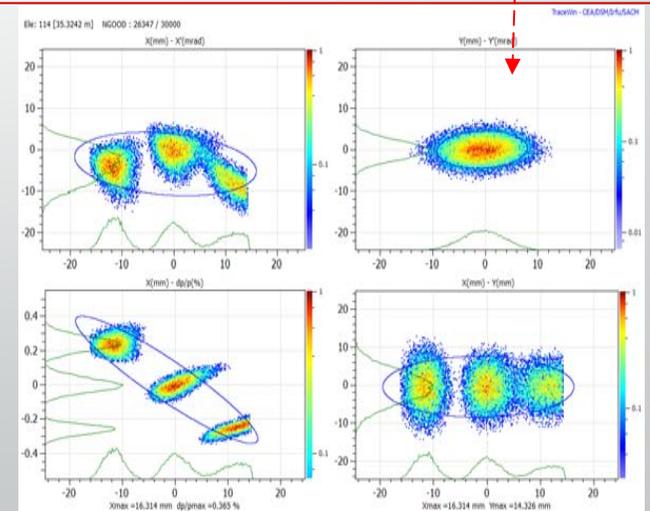
Final goal: it needs to be improved

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



NEWS OF 1+ LINES

- Usage of short electrostatic triplets (for little areas)
- 1/200 via D1 dipole. Isotopes from isobars separation
- HRMS to CB
- Wien Filter as a pre-mass separator.
- Usage of dipoles for bending magnets in order to control the dispersion.



3 gaussian beams with the same rms normalize emittance of 0.007 mm mrad, separated in mass

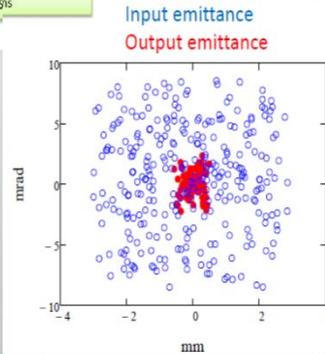
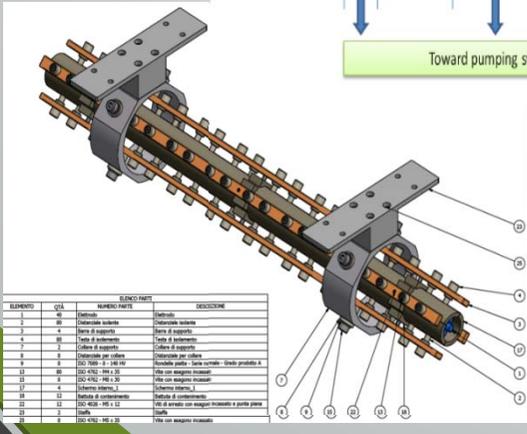
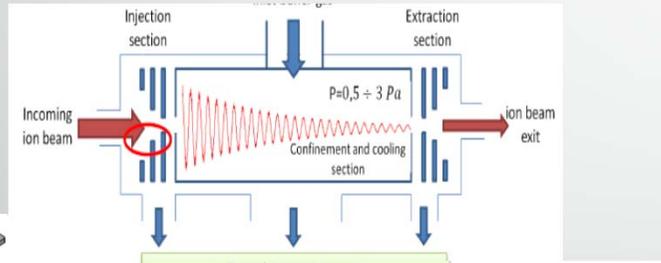
Collaboration SPES – CENBG Bordeaux (SPIRAL2)

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

Beam Cooler to match the HRMS input requirements

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

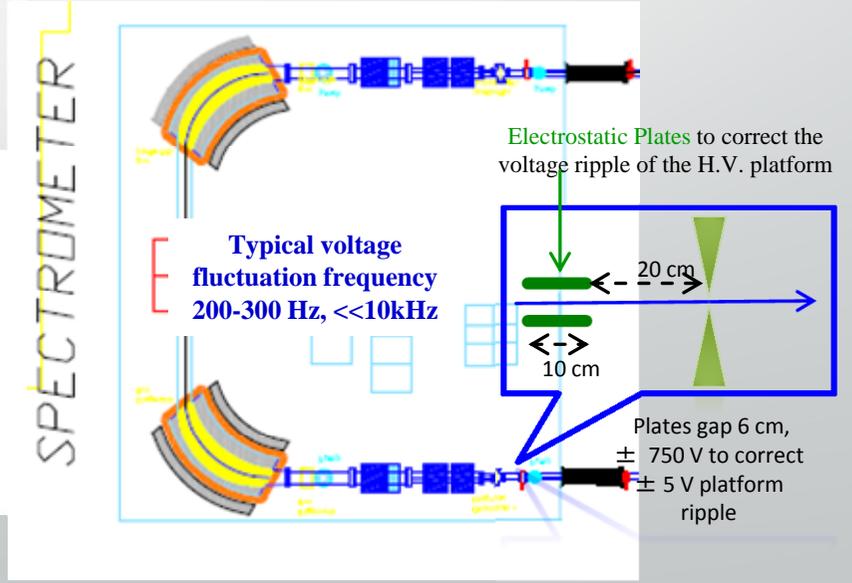
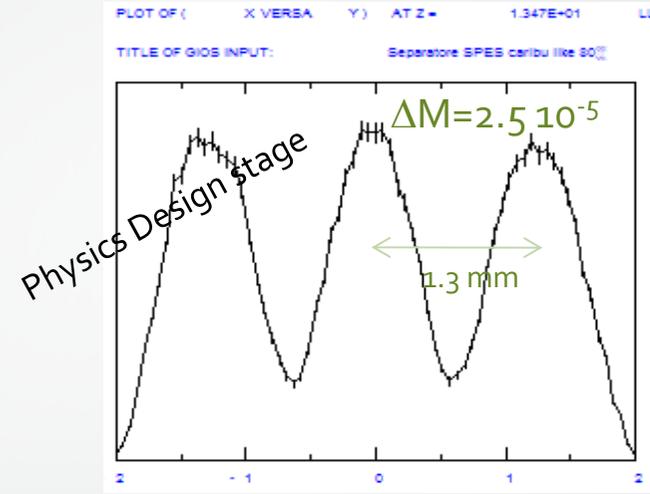
M. Maggiore



ELEMENTO	CELLA	NUMERO PARTI	DESCRIZIONE
1	40	1	Struttura
2	80	1	Chiamatale sinistra
3	4	1	Struttura
4	80	1	Chiamatale destra
5	4	1	Struttura
6	80	1	Chiamatale per collima
7	4	1	Struttura
8	80	1	Chiamatale per collima
9	4	1	Struttura
10	80	1	Chiamatale per collima
11	4	1	Struttura
12	80	1	Chiamatale per collima
13	4	1	Struttura
14	80	1	Chiamatale per collima
15	4	1	Struttura
16	80	1	Chiamatale per collima
17	4	1	Struttura
18	80	1	Chiamatale per collima
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24	80	1	Chiamatale per collima
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26	80	1	Chiamatale per collima
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32	80	1	Chiamatale per collima
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35	4	1	Struttura
36	80	1	Chiamatale per collima
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72	80	1	Chiamatale per collima
73	4	1	Struttura
74	80	1	Chiamatale per collima
75	4	1	Struttura
76	80	1	Chiamatale per collima
77	4	1	Struttura
78	80	1	Chiamatale per collima
79	4	1	Struttura
80	80	1	Chiamatale per collima

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

High Resolution Mass Separator



Possible use of EXCYT components to improve SPES

(items to be discussed)

dipoles for mass selection

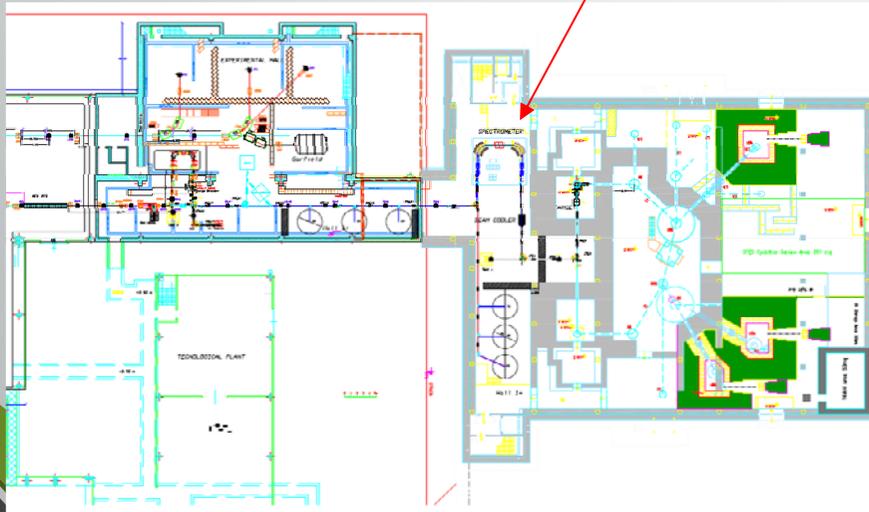
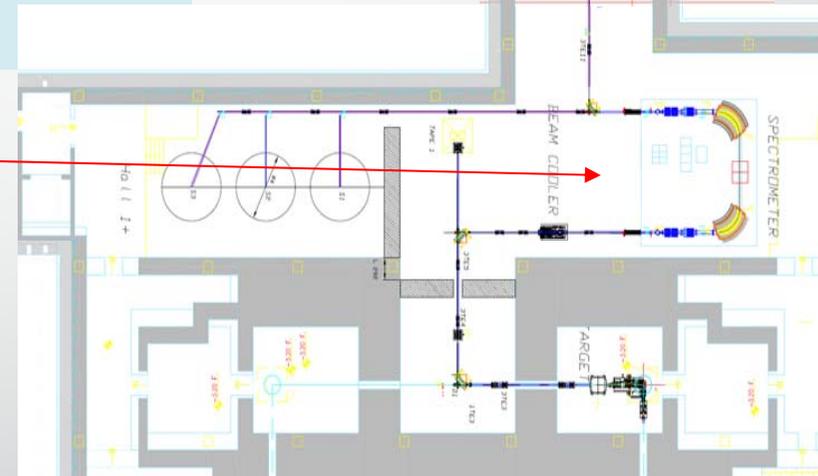
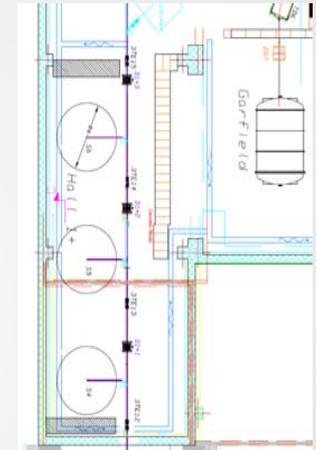
High Voltage platform parts

HV power supply

development of gas recovery system



Collaboration SPES – CENBG Bordeaux (SPIRAL2) for the High Resolution Mass Separator design.



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

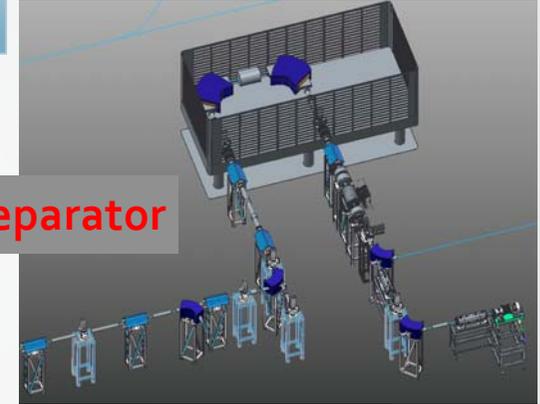
The development of an Upgraded PHOENIX booster is Part of a MoU in the frame of the European Associated Laboratories (LEA-Colliga) with GANIL. (In exchange: development of SPIRAL2 n-converter by INFN) Project and construction by LPSC_Grenoble

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



UNIVERSITÉ DE GRENOBLE

Mass Separator

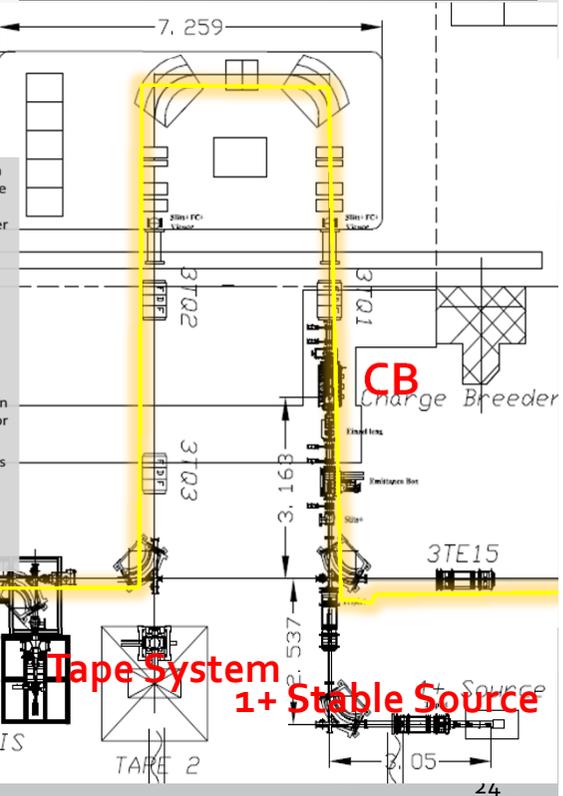
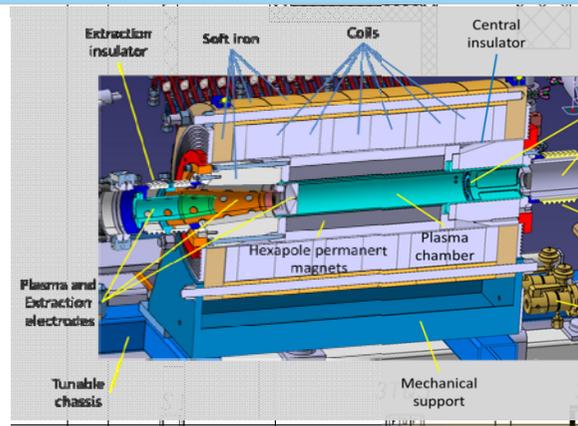


BREAKING NEWS:

Very good news for the CB:

→ A. Galatà, T. Lamy and Angot are performing the **Acceptance Tests @ LPSC.**

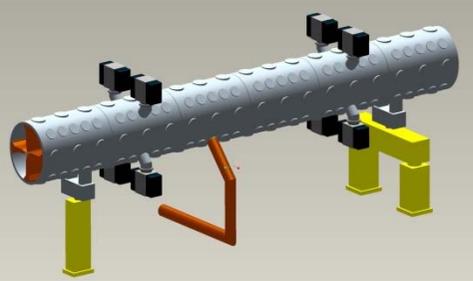
Test with Ar & Xe: a factor 3 better in **Emittance** than expected and **Efficiencies** close to "best ever" values for Phoenix @ LPSC.



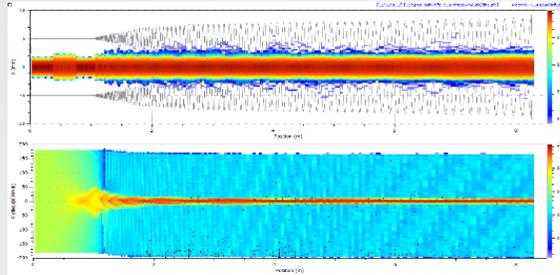
Tape System
1+ Stable Source



Mechanical layout of the RFQ



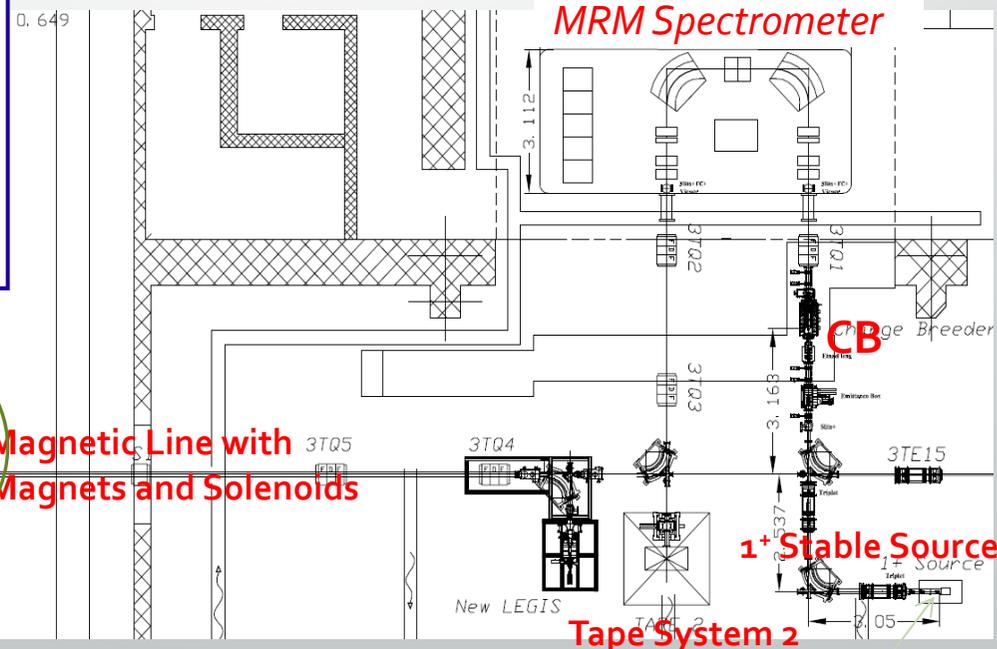
Physics design



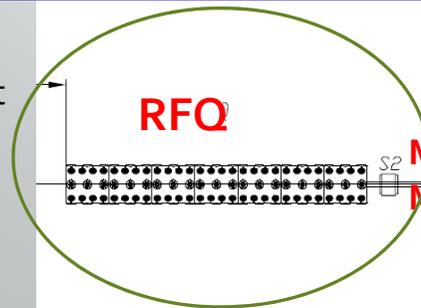
High power RF Coupler 200kW
100% duty cycle



- Energy 5.7 → 727.3 [$\beta=0.0395$] 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

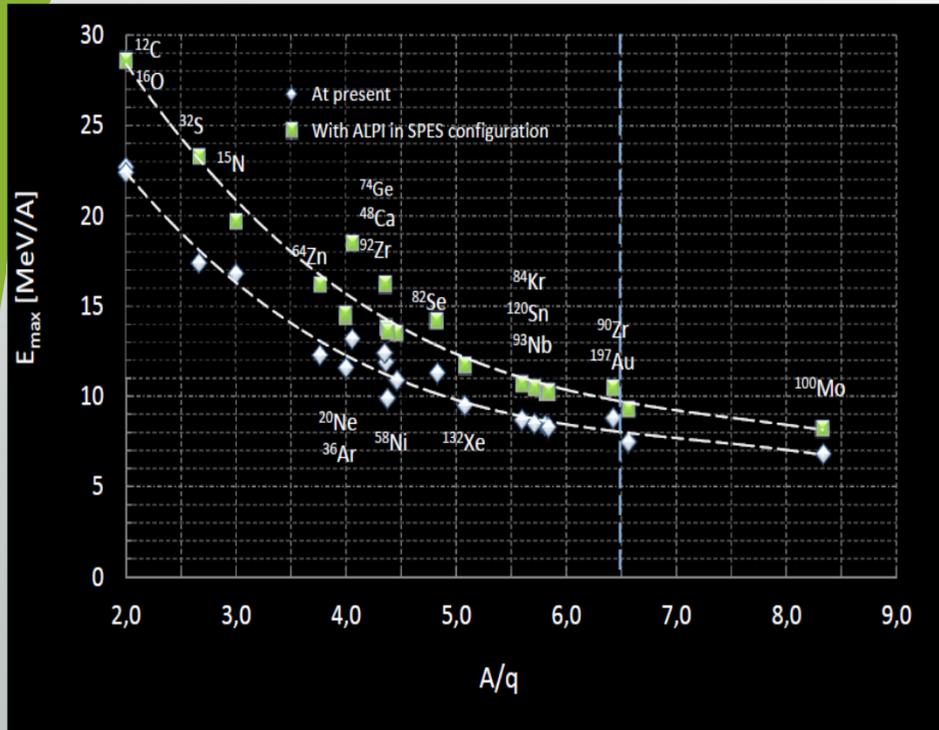


Magnetic Line with
Magnets and Solenoids

Tape System 2

1+ Stable Source

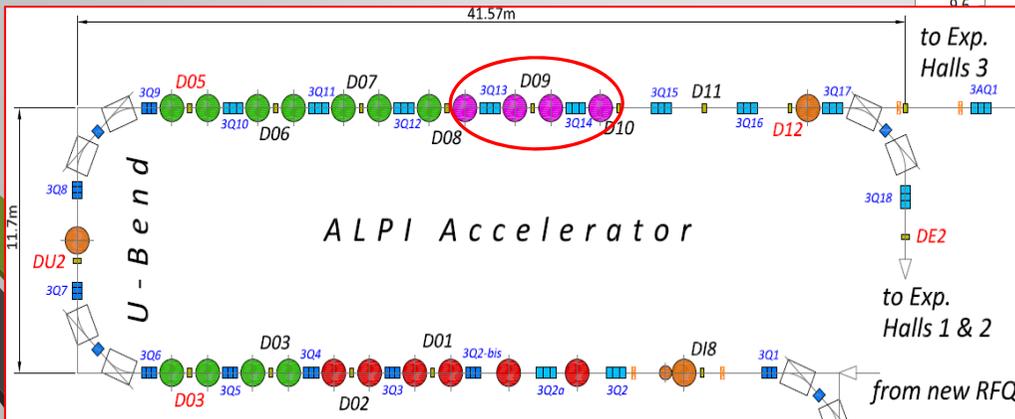
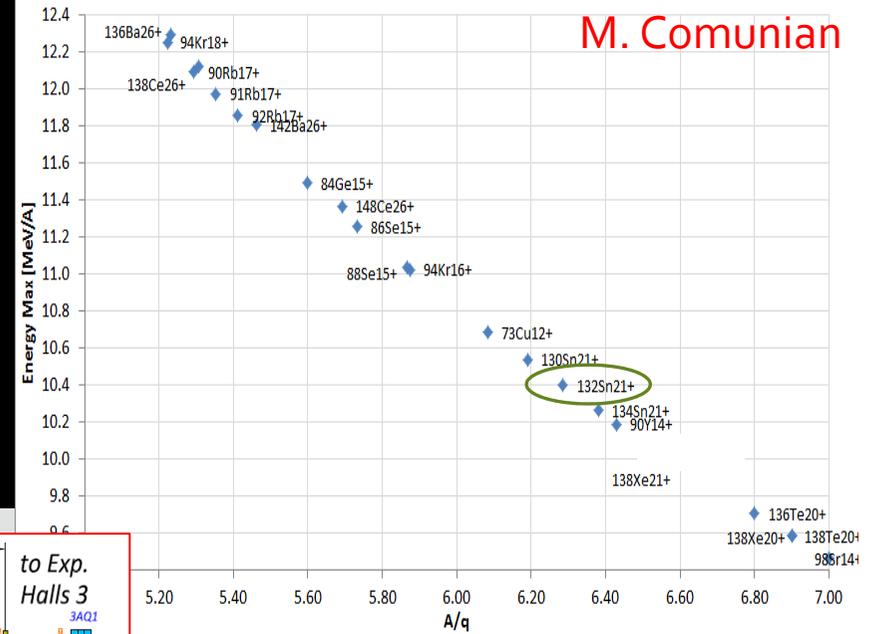
For stable beams



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



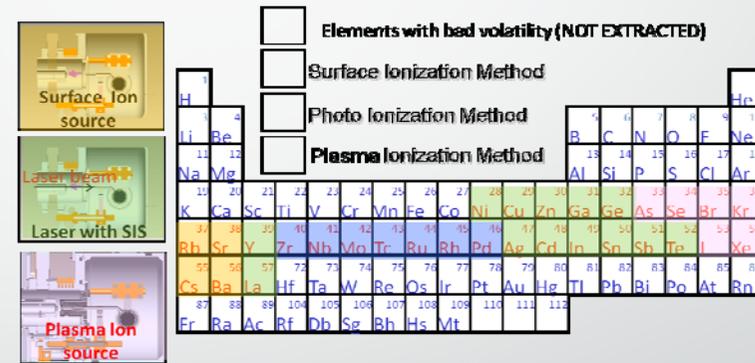
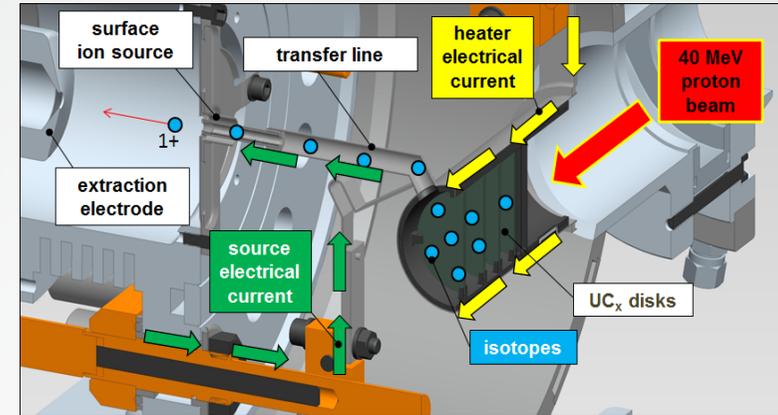
Re-shaping and improvement of low beta cavities.
Added high beta cryostats to improve the final energy.

Production Target

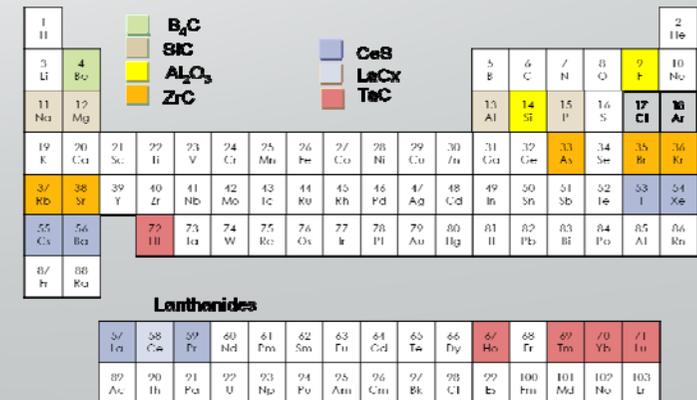
- Characterized by:
- Material of the target (production yield)
- Release time ($\approx 1s$ for **Fast Targets**)
- Element Vapour pressure

Ion source target

- ▶ Characterized by:
 - Ionization efficiency
 - Emittance
- ▶ The **SELECTIVITY** of the source depends on the ionization efficiency of each element.



Main fission ($p \rightarrow {}^{235}\text{U}$) fragments



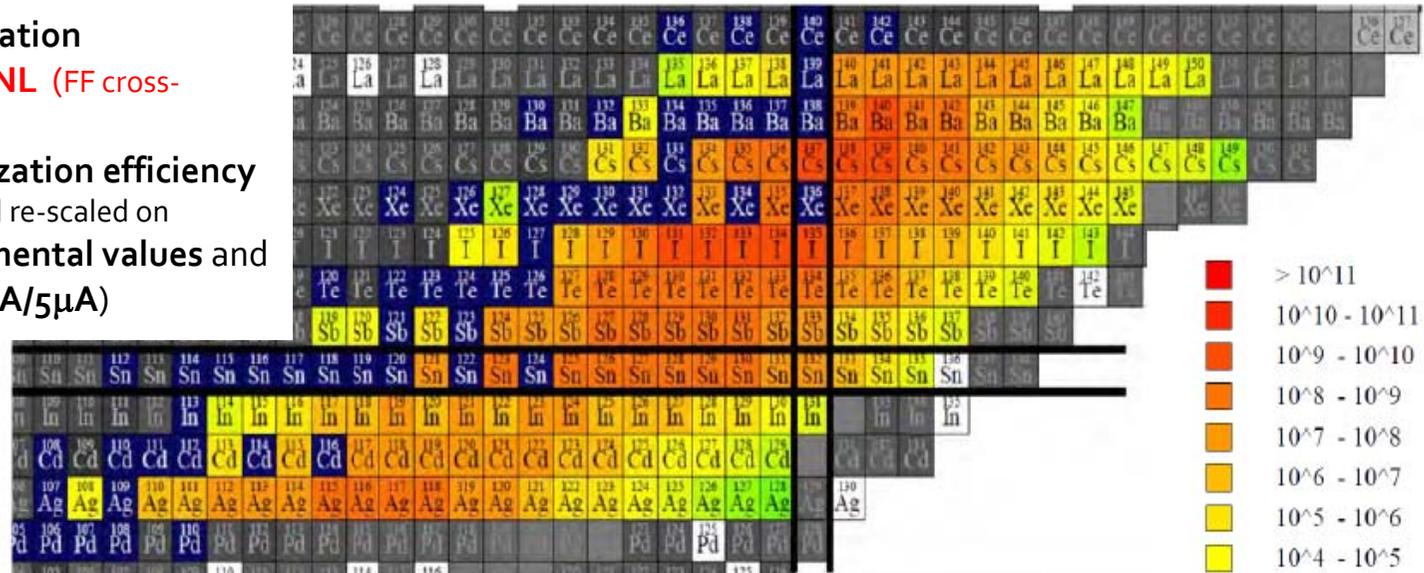
Yield of a nuclear species

$$Y = \sigma \cdot \Phi_p \cdot N \cdot \epsilon_d \cdot \epsilon_e \cdot \epsilon_i \cdot \epsilon_t$$

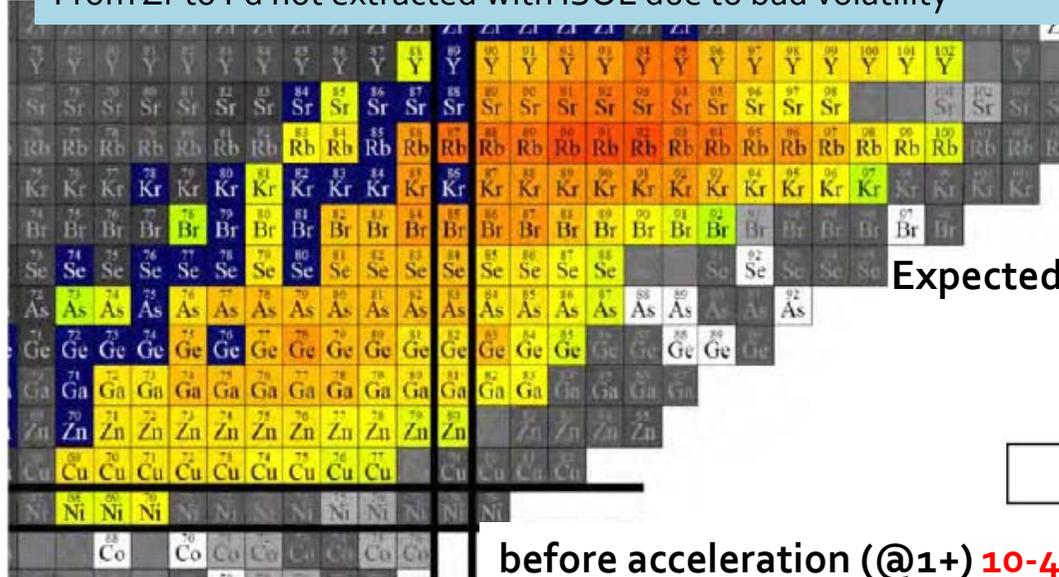
It depends on \rightarrow half-life, cross-section, proton flux, diffusion and effusion time, ionization and transport efficiencies

<https://web.infn.it/spes/index.php/news/spes-beam-tables>

- MCNPX Calculation
- **BERTINI – ORNL** (FF cross-sections)
- **Release & ionization efficiency** in agreement and re-scaled on **HRIBF experimental values and currents (200µA/5µA)**



From Zr to Pd not extracted with ISOL due to bad volatility



Expected SPES re-accelerated beam intensities (q+)
(fission UCx)

Courtesy of T. Marchi

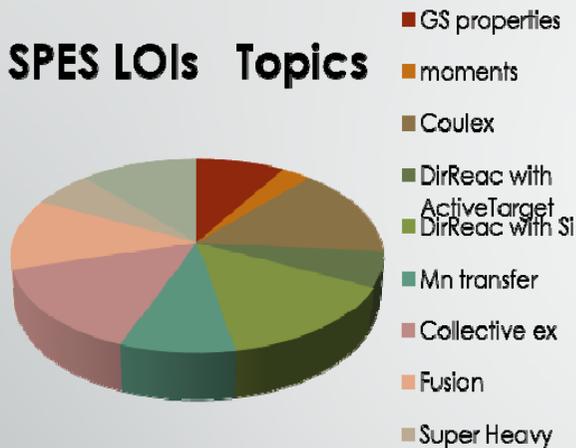
before acceleration (@+1) **10-40 times** more intense



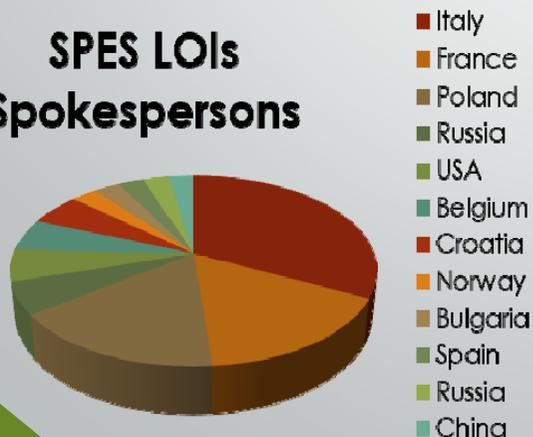


Presented 37 Letters of Intents

SPES LOIs Topics



SPES LOIs Spokespersons

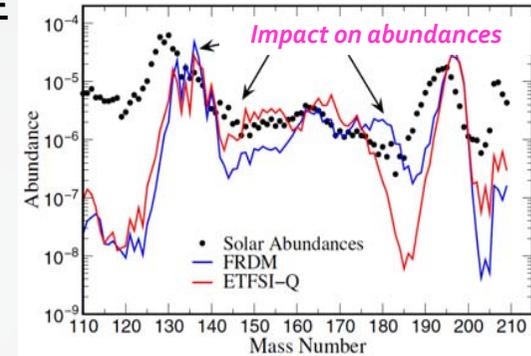


The **SAC was impressed** with the **number of LOI's** and the **broad scientific spectrum** proposed to be studied with the SPES Radioactive Ion Beams (RIB). The SAC **appreciates the progress of the SPES project**; on the civil construction, the target ion source developments and the ALPI upgrade. From the information supplied in the LOI's and exchanged through the different presentations that were given during the "SPES Second International Workshop" (Legnaro, May 26-28, 2014), it can be concluded that **the preparation of the experimental program, including the necessary instrumentation, is to a large extent focused and well advanced**. The involvement of a **large international community in several of the LOI's** and the **plans to bring new instrumentation from abroad was highly appreciated**.

In view of the scientific program **envisaged attention** to guarantee **not only the high RIB intensities** but also the **necessary degree of purity of the final RIB**. The latter is a **crucial issue** for many RIB experiments and can only be reached by **combining different purification stages** including the **high-resolution separator** and a **laser ion source**. **Developments in these directions should be strongly supported**. As partially discussed during the LOI presentations, it is beneficial to consider extending these activities to the use of molecular beams, negative ions and, for the low-energy branch, a **Multi-Reflection Time of Flight (MR-TOF) system**.

**MOVING AWAY FROM THE STABILITY VALLEY:
EXOTIC NUCLEI & LIMIT of NUCLEAR EXISTENCE**

- ❑ Limit of Nuclear Existence ?
- ❑ Robustness of Magic Numbers ?
- ❑ Validity of Quantum Numbers (Isospin, K, ...)?
- ❑ Change in Structure due to n-excess ?
- ❑ β -decay and r-process path location ?



The open questions:

1. Shell Evolution & interactions
2. Symmetries (isospin mixing $T=0, T \neq 0$ in $N=Z$ nuclei)
3. Order & Chaos Transition
4. Collective States: Part-Vib-Coupling, Pygmy & Giant Resonances
5. β -decay & r-process
6. Isospin effects on structure & reaction dynamics

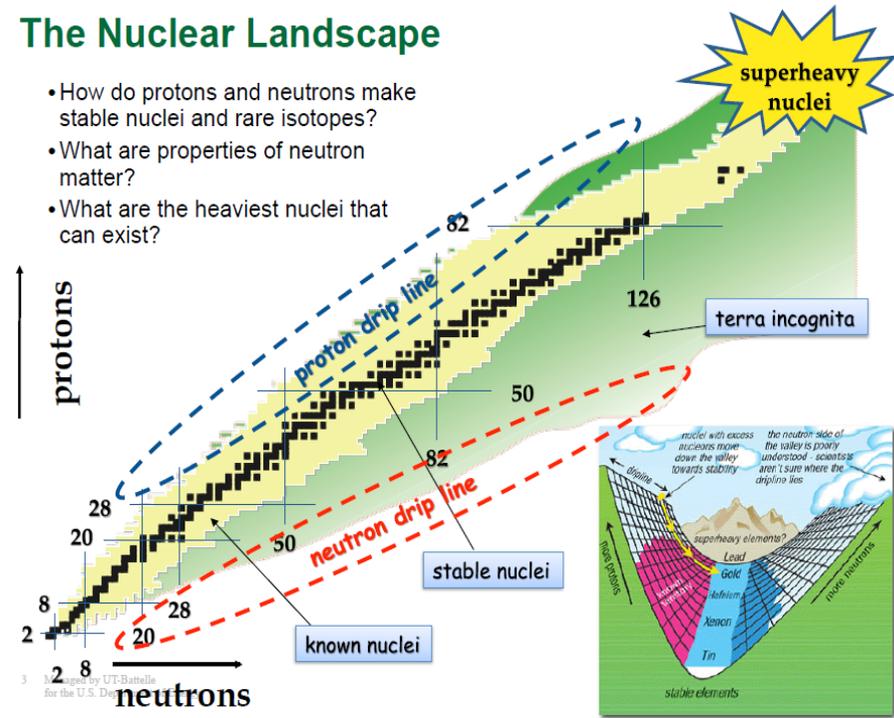
The Experimental techniques:

- Coulomb Excitation
- Transfer Reactions
- Decay Spectroscopy
- Reaction Studies



The Nuclear Landscape

- How do protons and neutrons make stable nuclei and rare isotopes?
- What are properties of neutron matter?
- What are the heaviest nuclei that can exist?



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

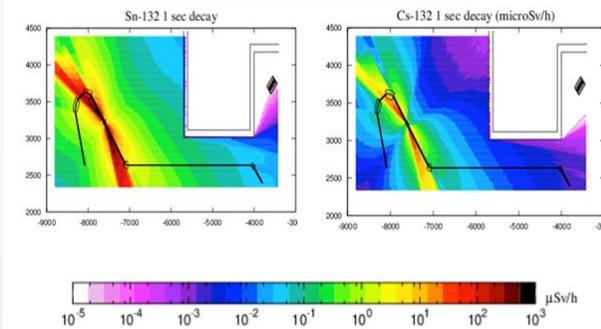


Figure 6 Gamma dose rate ($\mu\text{Sv/h}$) 1 second after the end of the extraction of a beam of Sn-132 and Cs-132 impacting on the charge breeder plasma chamber.

Z\A	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
42	0.00E+00																						
43	0.00E+00																						
44	0.00E+00																						
45	0.00E+00																						
46	0.00E+00																						
47	0.00E+00																						
48	0.00E+00																						
49	3.60E+09	2.52E+09	4.20E+09	3.85E+09	4.19E+09	2.94E+09	2.52E+09	1.72E+09	1.26E+09	3.03E+08	1.79E+08	9.94E+07	2.31E+07	1.93E+06	1.96E+05	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																						
52	0.00E+00																						
53	0.00E+00																						
54	0.00E+00																						
55	0.00E+00	3.13E+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	1.10E+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	1.31E+06	1.66E+07	6.34E+07	1.01E+08	2.93E+08	3.98E+08	5.74E+08	1.02E+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	3.77E+06	1.13E+07	3.62E+07	1.13E+08	2.09E+08	4.46E+08	5.68E+08	1.03E+09	1.49E+09	2.23E+09	1.66E+09	2.41E+09	1.96E+09	2.32E+09								
58	0.00E+00																						
59	0.00E+00																						
60	0.00E+00																						
61	0.00E+00																						

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

Selective capability of the SPES mass separators

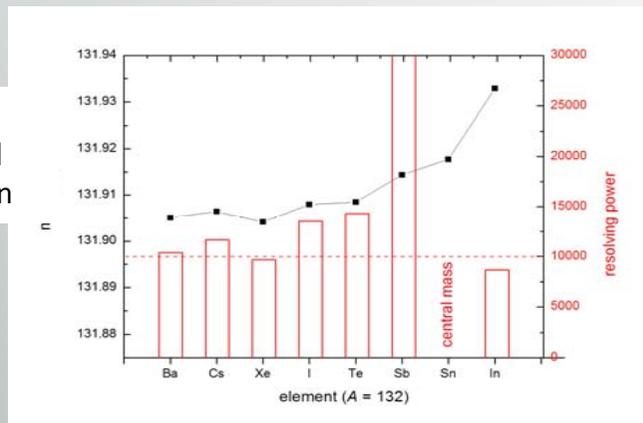
most requested beams

Prod.Intensities: $3.84 \cdot 10^{10}$ p/s
After $T_{\text{release}}=1\text{s} \rightarrow 4.52 \cdot 10^{10}$ p/s

Expected @ $1^+ \rightarrow 1.56 \cdot 10^9$ p/s
Expected @ User $\rightarrow 3.11 \cdot 10^7$ p/s

$^{132}\text{Sn} T_{1/2} = 39.7 \text{ s}$

HRMS
Expected
resolution



Prod.Intensities: $1.45 \cdot 10^{10}$ p/s
After $T_{\text{release}}=1\text{s} \rightarrow 7.47 \cdot 10^9$ p/s

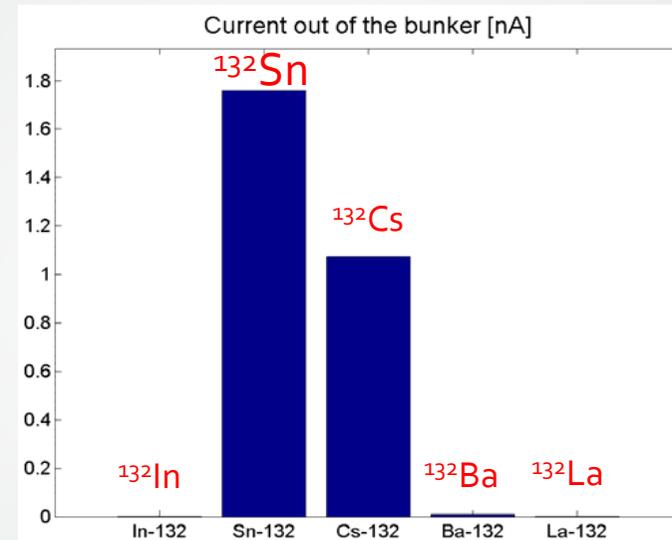
Expected @ $1^+ \rightarrow 2.49 \cdot 10^7$ p/s
Expected @ User $\rightarrow 4.99 \cdot 10^5$ p/s

F. Gramegna GHT Meetings - March 2015

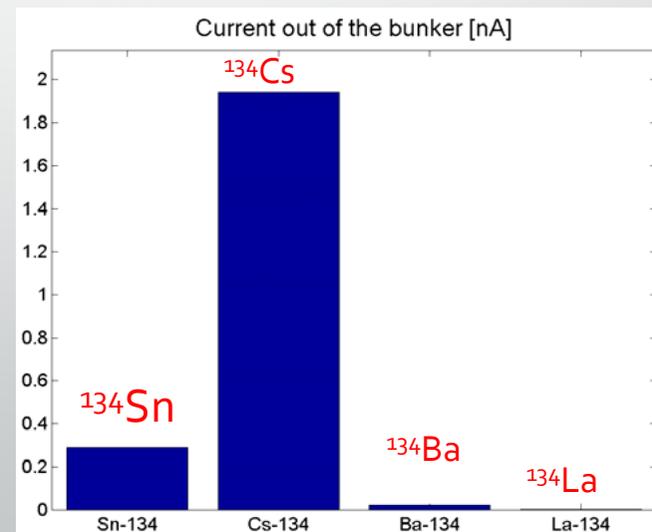
$^{134}\text{Sn} T_{1/2} = 1.12 \text{ s}$

LIS source $T=1500 \text{ }^\circ\text{C}$

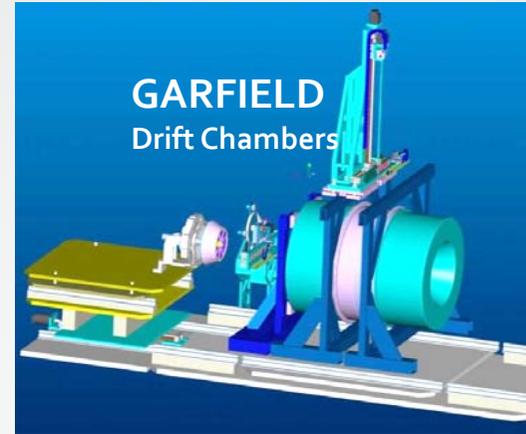
I(nA)



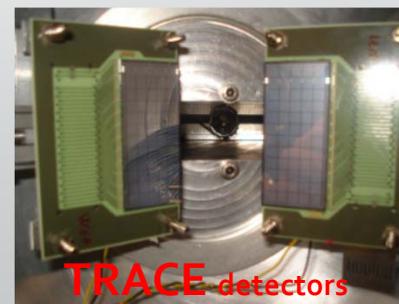
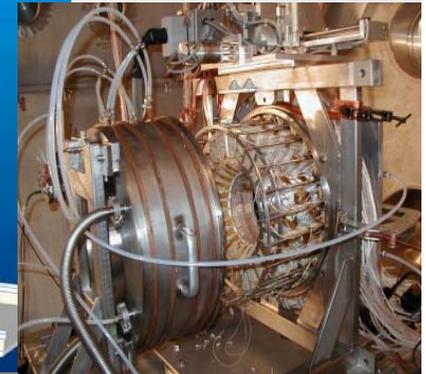
I(nA)



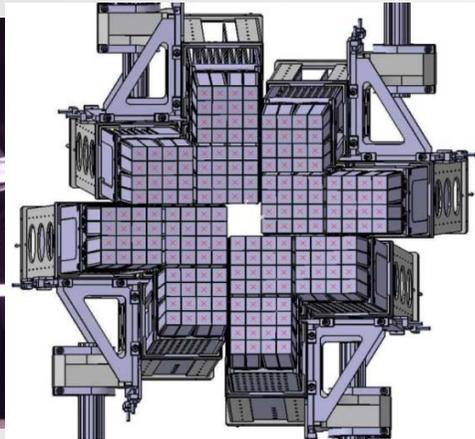
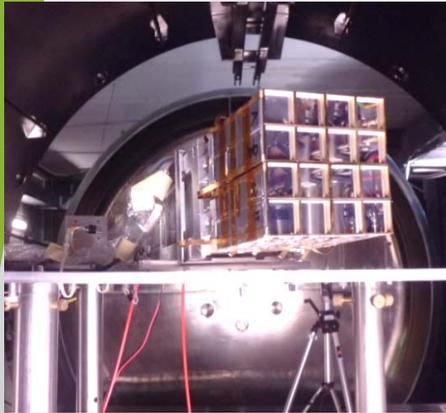
PRISMA: a large acceptance
magnetic spectrometer
 $\Omega \approx 80$ msr; $B\rho_{\max} = 1.2$ Tm
 $\Delta A/A \sim 1/200$
 Energy acceptance $\sim \pm 20\%$
 Uograting \rightarrow 2nd arm for Kinematical coincidences



4 π -LCP & Fragments

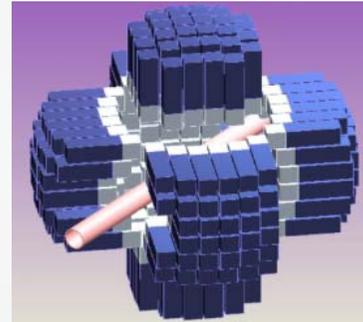


FAZIA: LCP & fragments detection

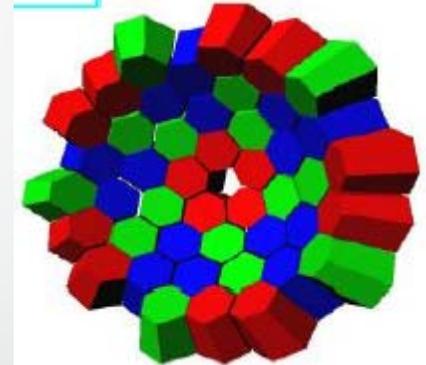


International Collaborations:
itinerant detectors

PARIS (High Energy
 γ -ray Detector Array)



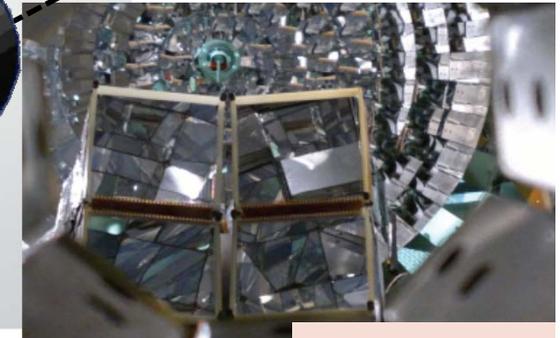
NEDA (NEutron
Detector Array)



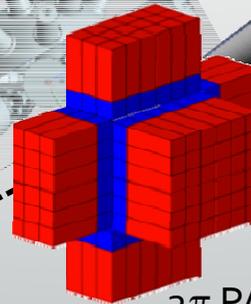
AGATA : innovative γ -
rays tracking array)



RFD
(Kracow)



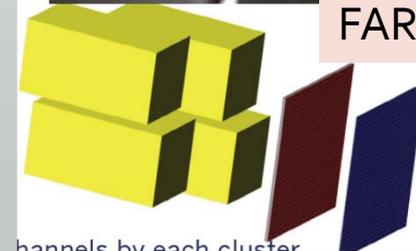
GALILEO



2π PARIS



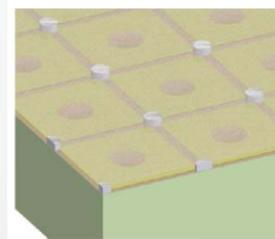
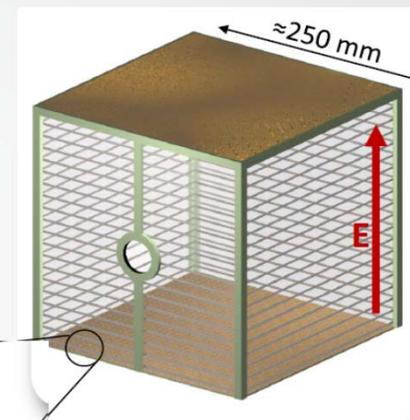
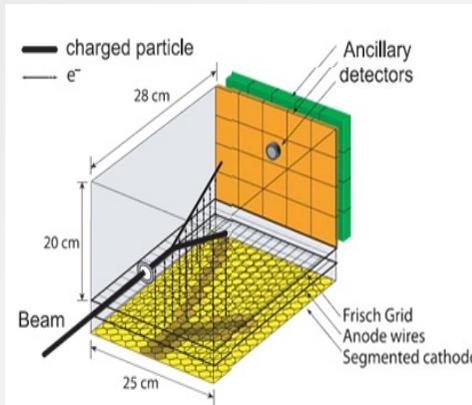
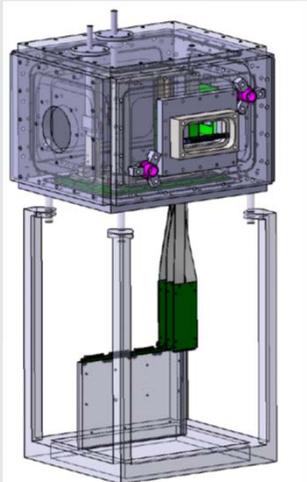
FARCOS



DSSSD 32X32



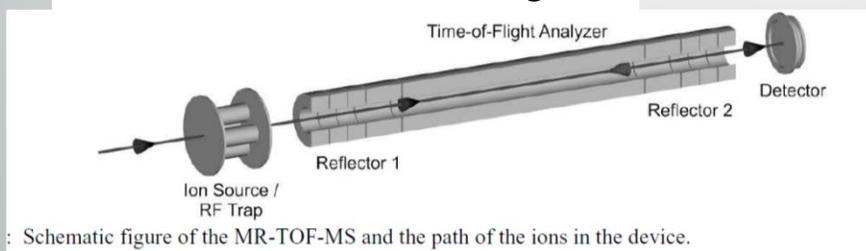
ACTAR (Active Target Detector)



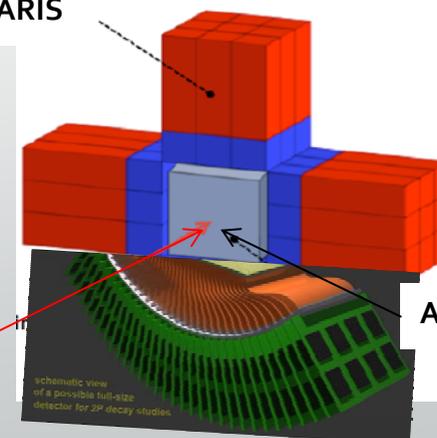
Courtesy of R. Raabe
G. Grinyer

Starting activity with ACTAR collaboration

Multi-reflection TOF system → possible collaboration with GSI
Contact with Scheidenberg



PARIS



BEAM

ATS_TPC

GET Electronics

COMPLEMENTARY Activity (LNL-LNS)

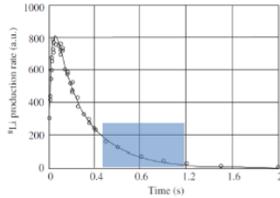
- Tagging & Tracking
- New Ancillary detectors developments
- Training & experiment preparation



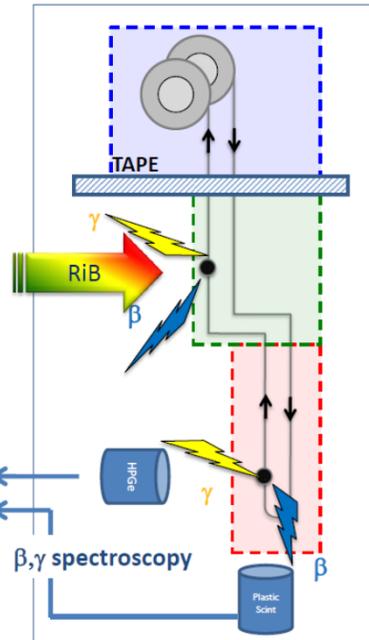
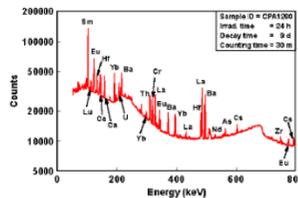
1. The tape station(s) for SPES

Beam characterization:

- Release Curve



- Beam Composition and Isotopic Yields



The tape station is the "eyes and ears" of an ISOL facility.
Tim Giles, seminar on ISOLDE diagnostic tools, LNL May 2014

- Requirements:
- 1-Reliability
 - 2-Lasting operability
 - 3-Ease of use

Moving the tape, the residual activity due to the long lived isotopes is minimized.

T. Marchi

2nd SPES TAC meeting

LNL, Dec 4 – 5 2014



Diagnostics for SPES:
2 tape stations
to characterize the RiB

BEDO @ALTO



A further station is foreseen to be implemented for β -decay studies with non accelerated beams (G. Benzoni –Mi) → low energy area

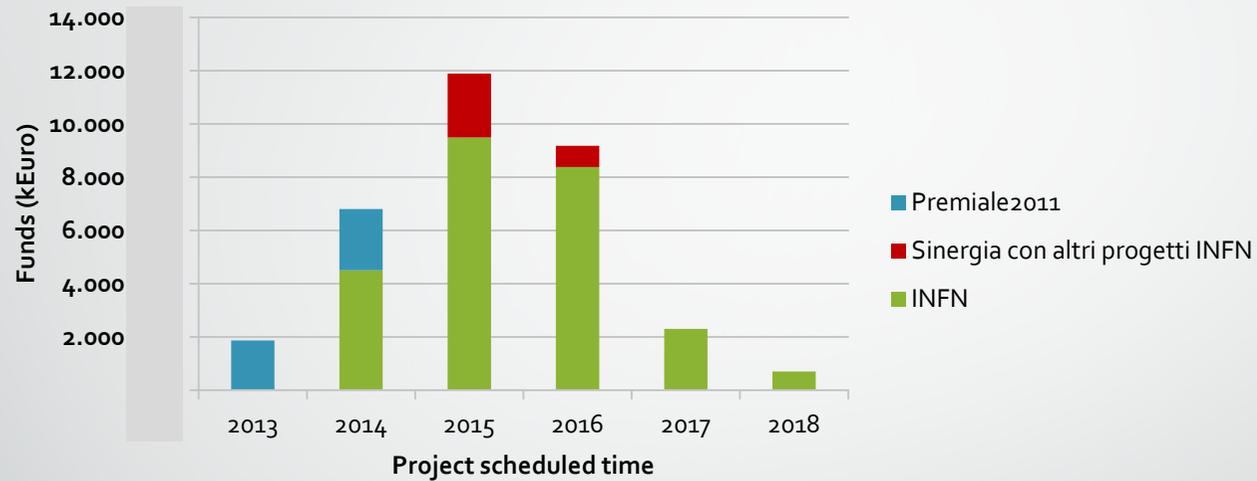
(meeting in Milan – low energy physics @ SPES April 20-21 2015)

Strong collaboration with ALTO (D. Verney, A. Gottardo) → to be formalized with a MOU within a larger agreement between ALTO & SPES

	2012	2013	2014	2015	2016	2017	2018	2019
Authorization to operate and safety	UCx 5microA							
ISOL Target-Ion Sources development & improvement								
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)				HRMS				
Construction and Installation of RIBs transfer lines , CB and spectrometers								
Stepwise commissioning and first exotic beam (2018), HRMS in 2019								

Revised planning including of the HRMS development





(kEuro)	2013	2014	2015	2016	2017	2018
Total SPES 2013-2018	1.900	6.800	11.900	9.100	2.300	700
32.700 kEuro						

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

