Status of the SPES project

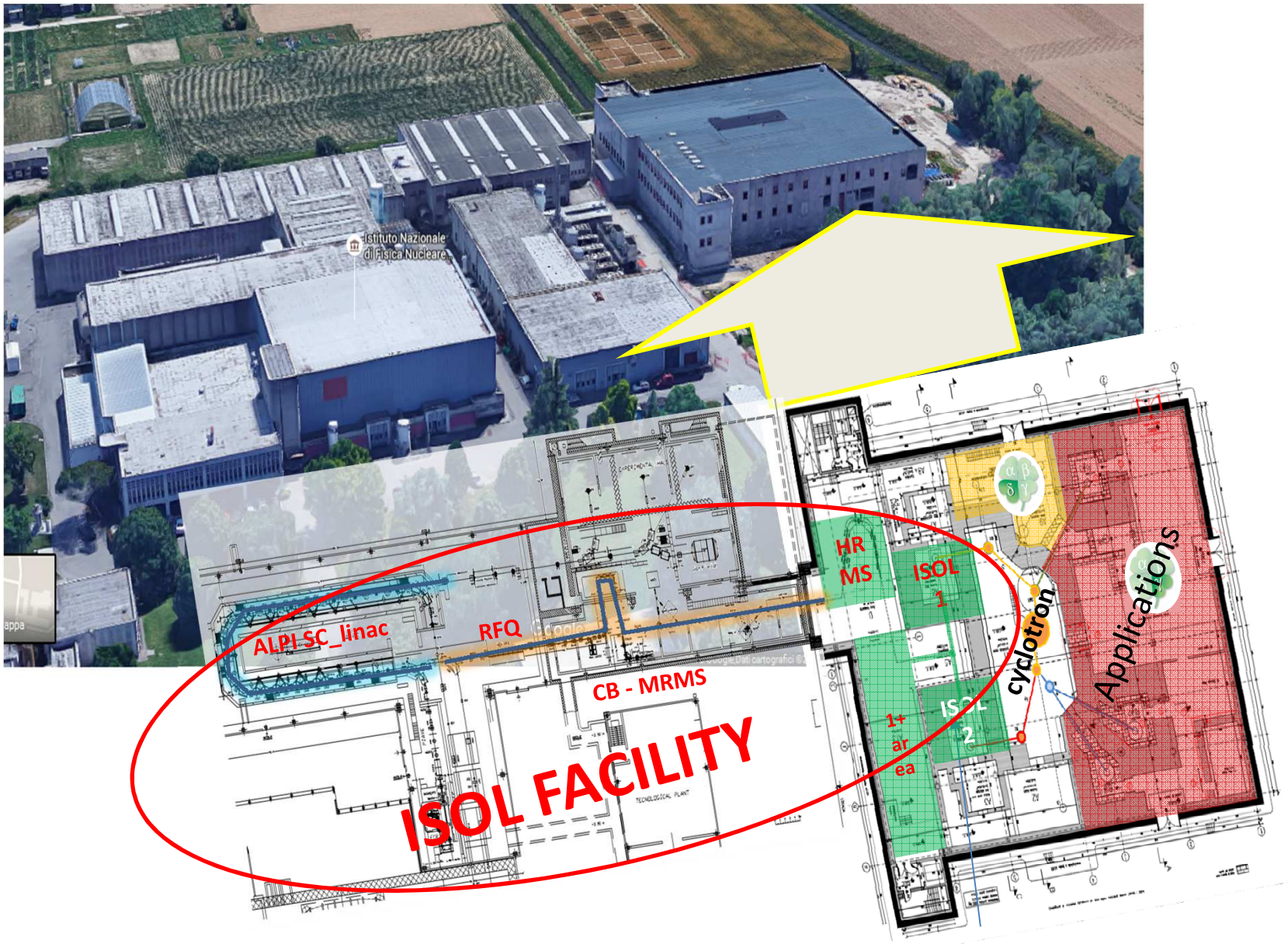
Selective Production of Exotic Species

Gianfranco Prete LNL-INFN
On behalf of the SPES Collaboration

NuPECC Nuclear Physics European Collaboration Committee

NuPECC Long Range Plan 2017, Town Meeting
11-13 January 2017, Darmstadt

SPES infrastructure - layout



SPES layout: ISOL facility installation phases

- **Phase 1. 2016** - Building + First operation with the cyclotron NOW!
- **Phase 2. 2017-18** - From C.B. to RFQ + SPES target, LRMS, 1+ Beam Lines
- **Phase 3. 2019 – 20 -** HRMS-BeamCooler + RFQ to ALPI

2019: phase2b
no-reaccelerated
radioactive beams

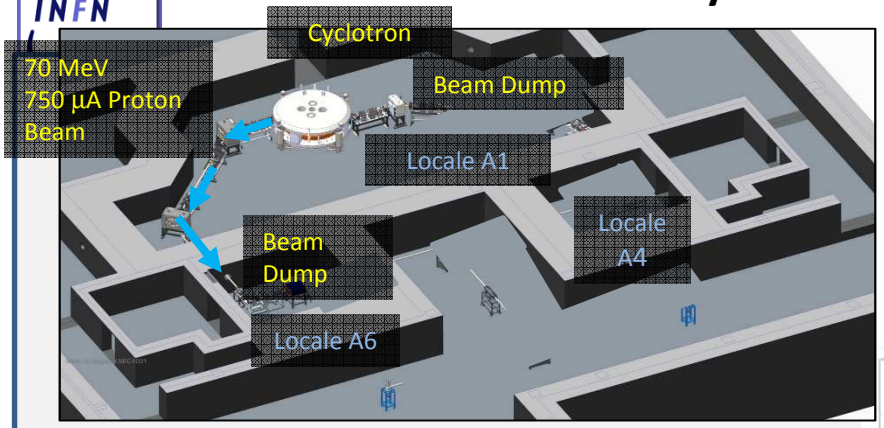
The SPES cyclotron

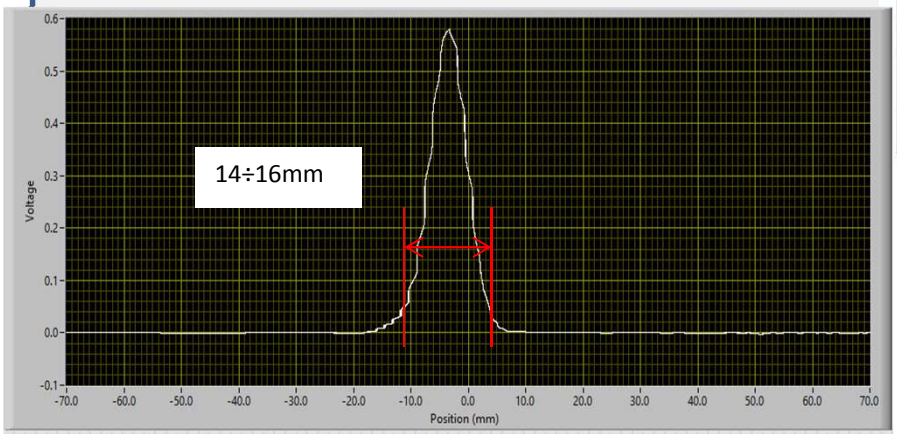
Built by BEST Cyclotron Systems

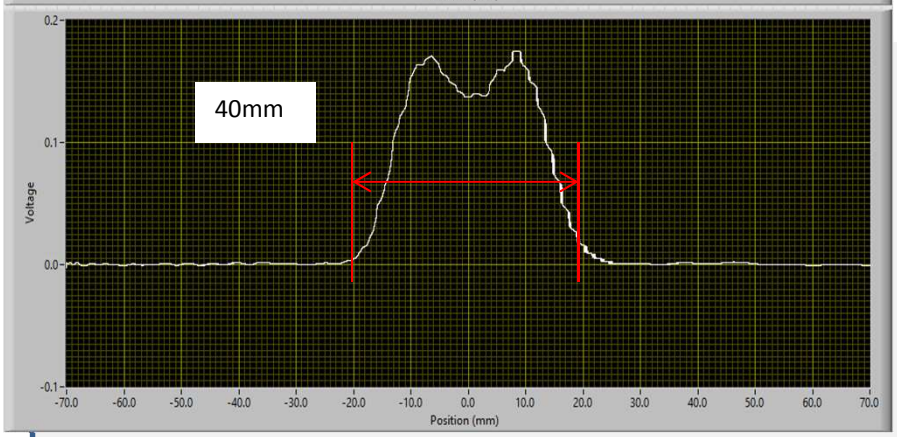
- Negative Hydrogen ion (H-)
- Simultaneous **double beam** extraction
- 35 to 70 MeV variable energy
- 700 μA combined beam current (to be upgraded to 1 mA)

-Factory Acceptance Tests (FAT) passed
-Cyclotron arrived at LNL in May 2015
-Dual beam operation demonstrated
-Cyclotron commissioning at final step
(endurance test to be performed)

Cyclotron beam operation:

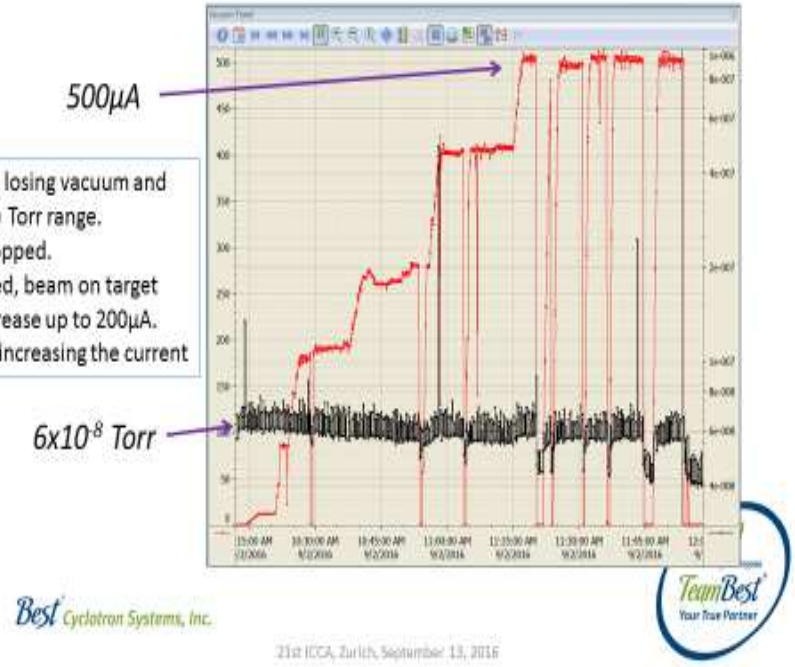




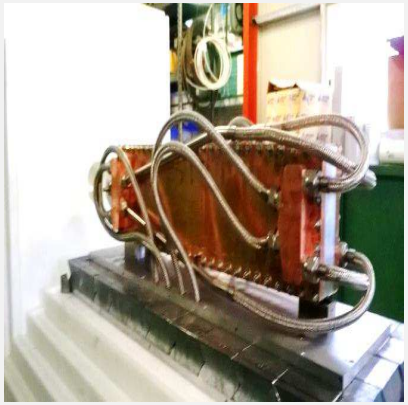


Beam profile with wobbler ON

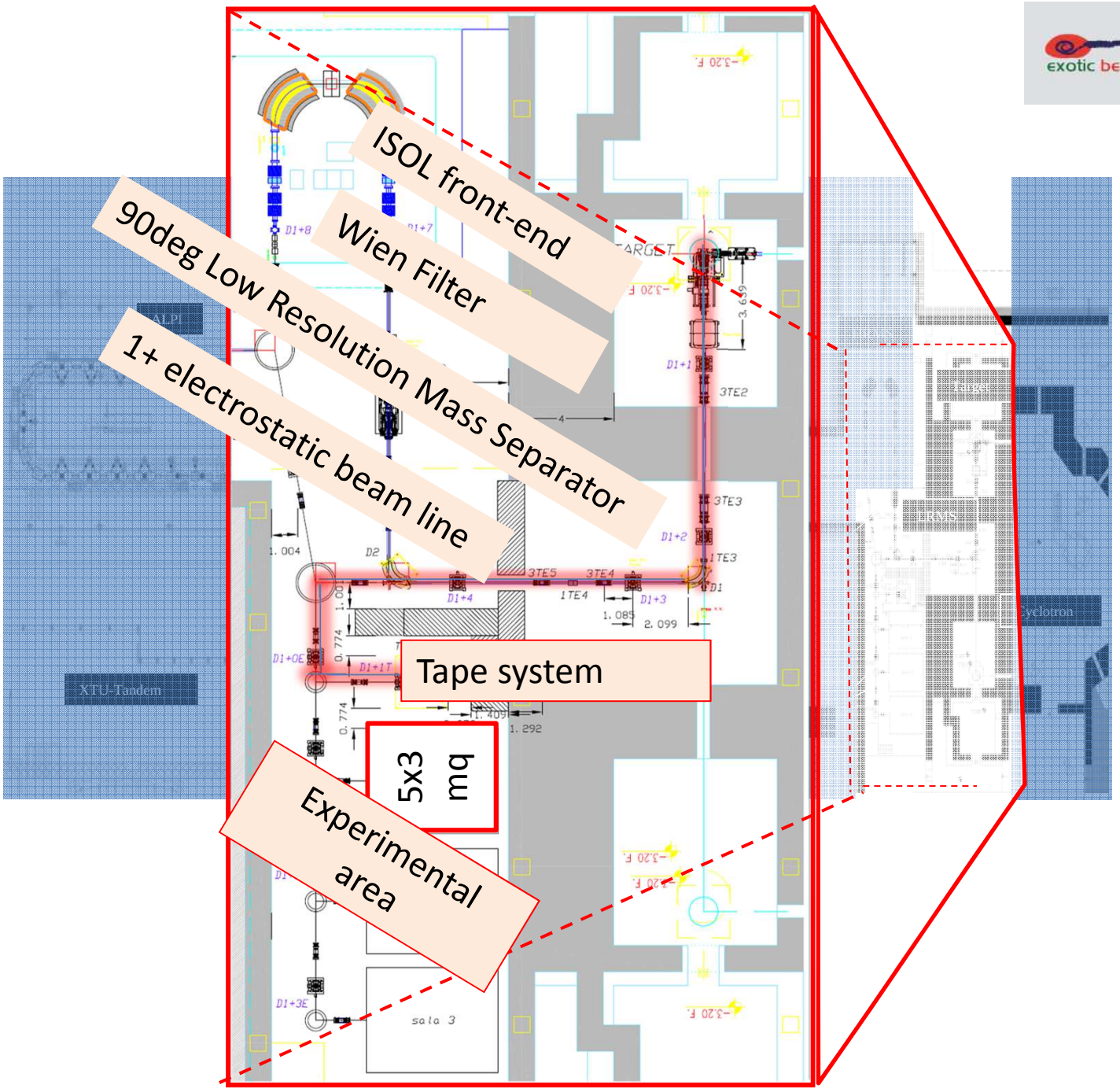
Beam test on 50kW INFN target



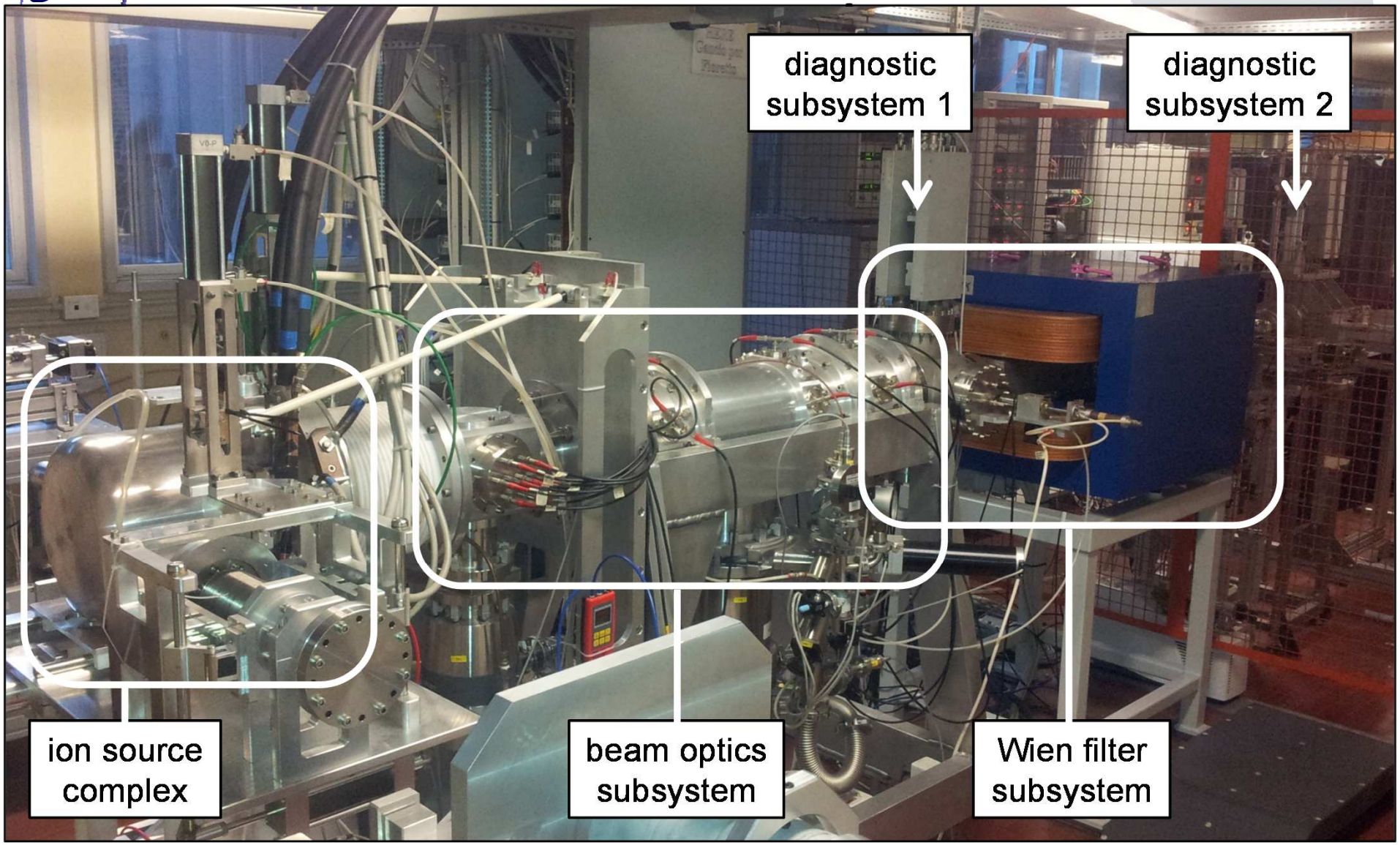
Beam dump start losing vacuum and went to the 10(-4) Torr range.
The beam was stopped.
Operation resumed, beam on target incrementally increase up to 200µA.
Vacuum recovers increasing the current



Beam Dump 50kW


ISOL front-end
Wien Filter
90deg Low Resolution Mass Separator
1+ electrostatic beam line
Tape system
5x3 mq
Experimental area
ALPI
XTU-Tandem
Cyclotron
sala 3

SPES ISOL system

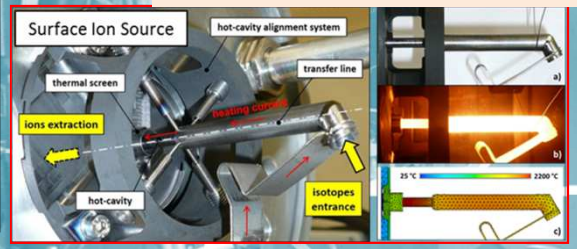


System under operation for source commissioning.
Updated version (radiation hardness improved) under construction.

SPES ISOL system

Multi disk target

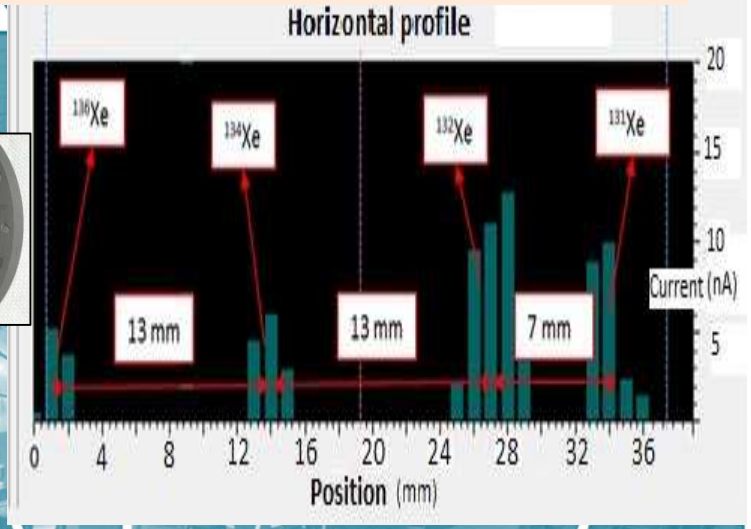
Source characterizzation and beam production



Plasma source

Wien filter upgrade (1/70→1/130)

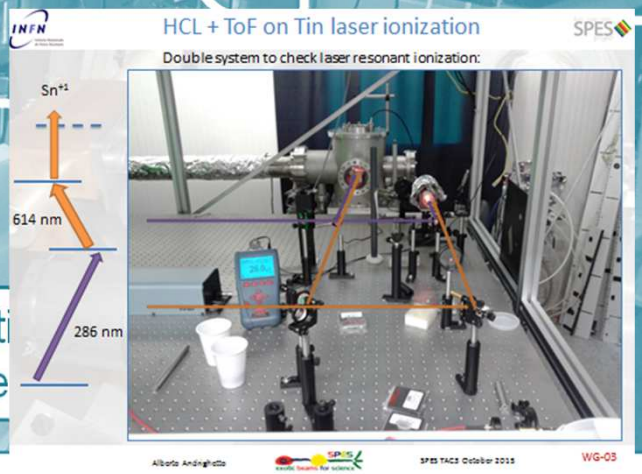
Reduced radioactivity out of the bunker



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

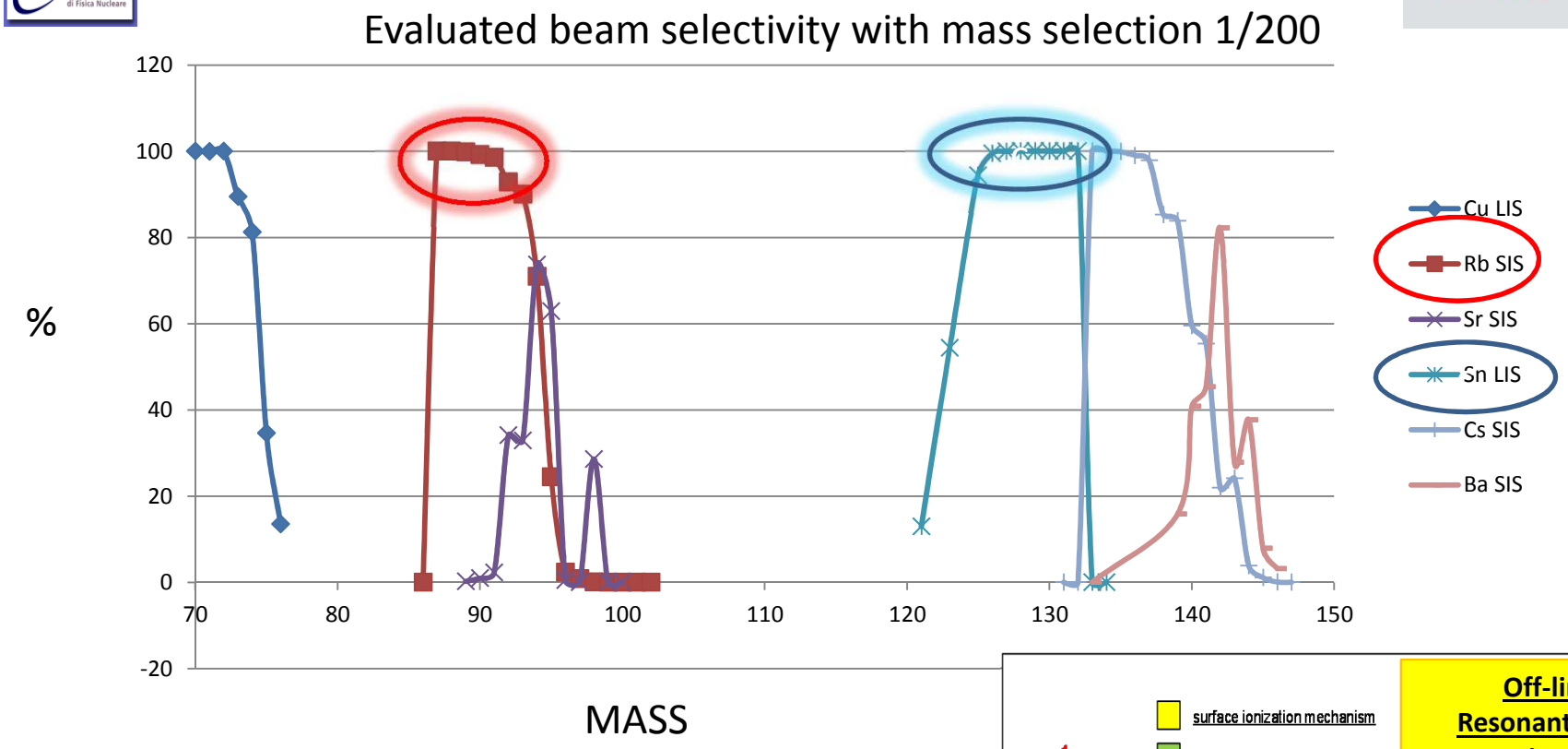
iThemba_LABS 2014.
(SiC target)

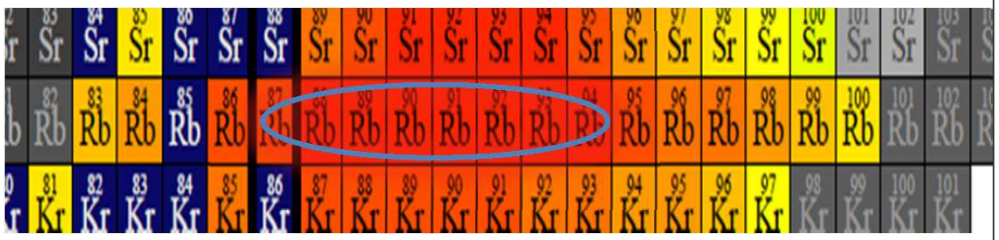
beam	ion. eff. (%)	hot-cavity temp. (°C)	hot-cavity material
Na	47,6	2200	Ta
K	55,4	2200	Ta
Ga	1,4	2200	Ta
Rb	54,5	2200	Ta
Sr	18,5	2200	Ta
In	3,2	2200	Ta
Cs	43,2	2200	Ta
Ba	58,8	2200	Ta
La	20,1	2200	Ta

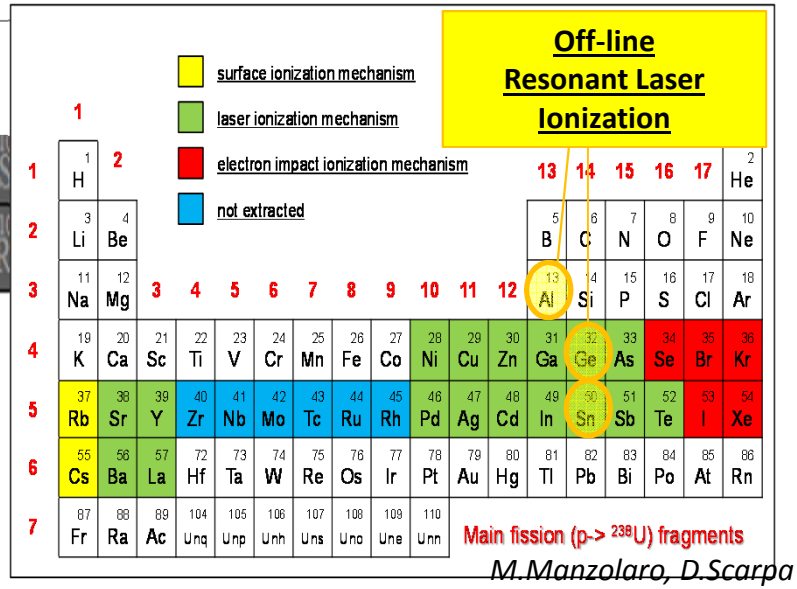


ion source complex

Ion source selectivity







Rb → Possible first n-rich beam

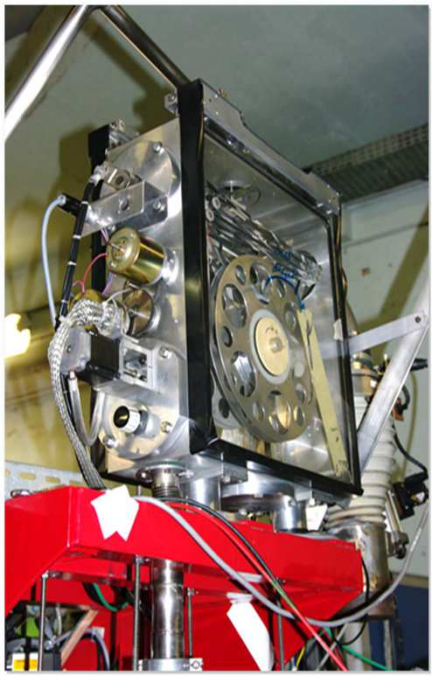
Good selectivity expected for 132Sn with LIS

M.Manzolaro, D.Scarpa

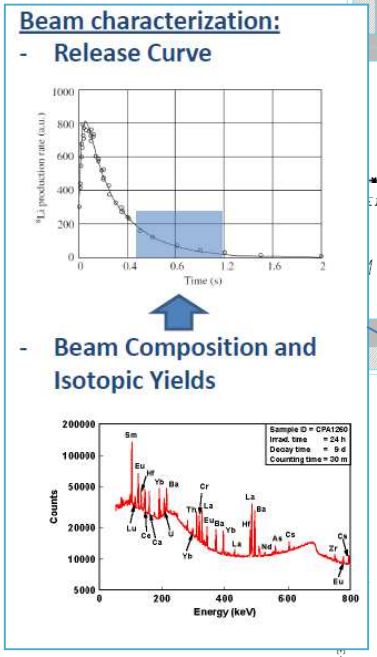
Instrumentation@SPES: Tape system

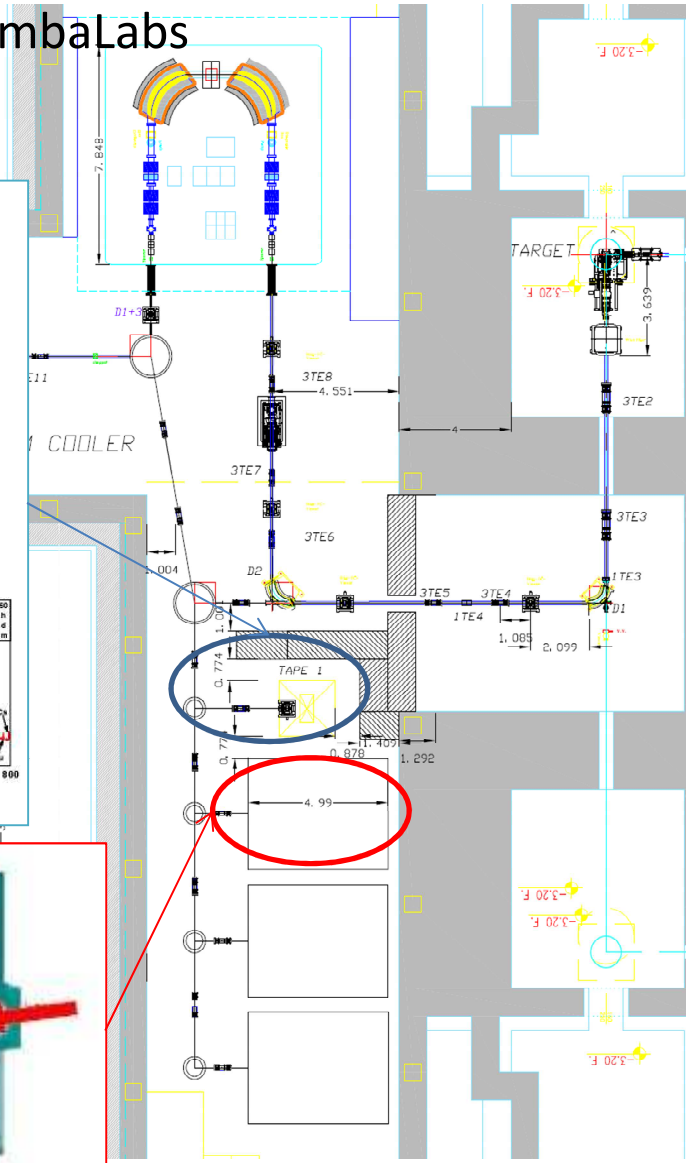
Tape station based on Orsay design (BEDO)

Collaboration ALTO-INFN-iThembaLabs



Diagnostics for SPES:
tape stations
to characterize RIBs

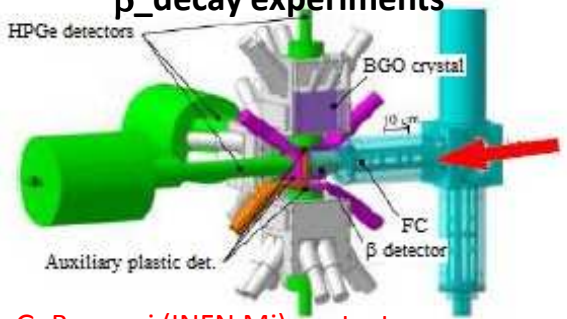




Beta decay station as a permanent and flexible setup

- Tape station + β detector
- Coupling to HPGe, LaBr3, neutron detectors etc…

β_decay experiments

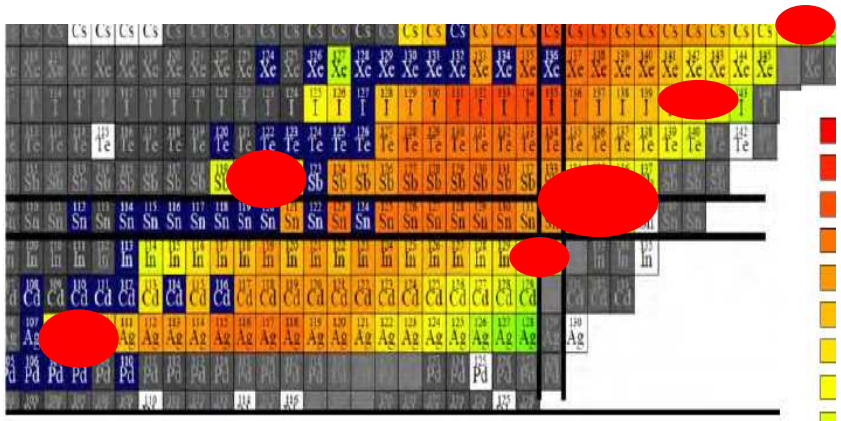


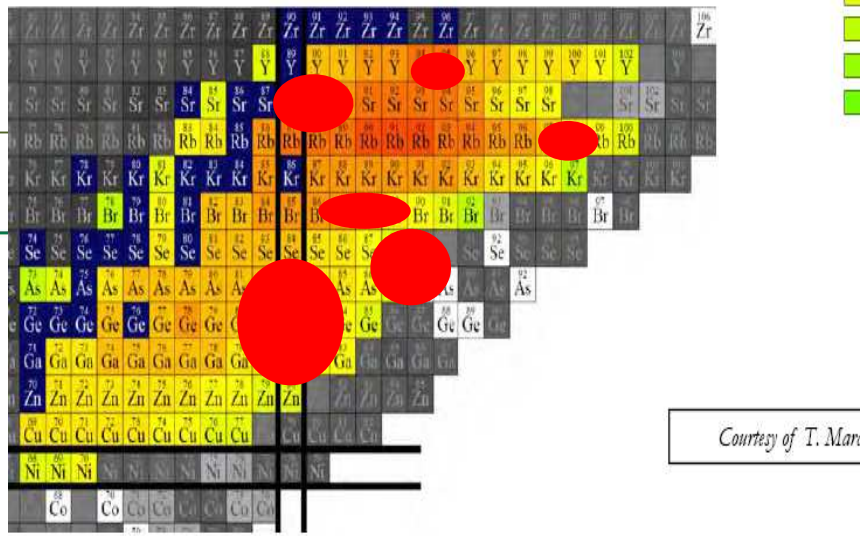
G. Benzoni (INFN Mi) contact person

SPES LoI's for beta decay station

Astrophysics: input for r and s process
Nuclear structure: Shell evolution and nuclear shape
Exotic decay : Pygmy resonance by β_decay

Additional instrumentation and collaborations



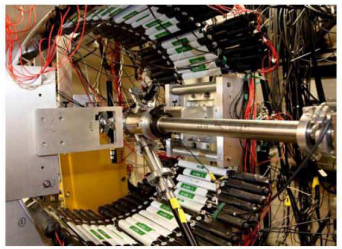


Courtesy of T. Mar

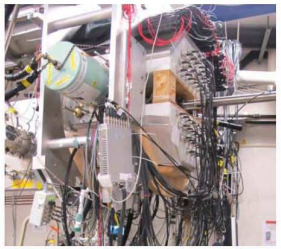
Decay spectroscopy techniques to study neutron-rich fission fragments at SPES

Krzysztof P. Rykaczewski, Robert Grzywacz, Carl J. Gross, Daniel W. Stracener, Yuan Liu
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6371, USA
in collaboration with
C. Mazzocchi, A. Korgul, M. Karny, K. Miernik, U. of Warsaw, Warsaw, Poland
W. Krolas, Institute of Nuclear Physics PAN, Krakow, Poland

MTAS = Modular Total Absorption Spectrometer



VANDLE = Versatile Array of Neutron Detectors for Low Energy

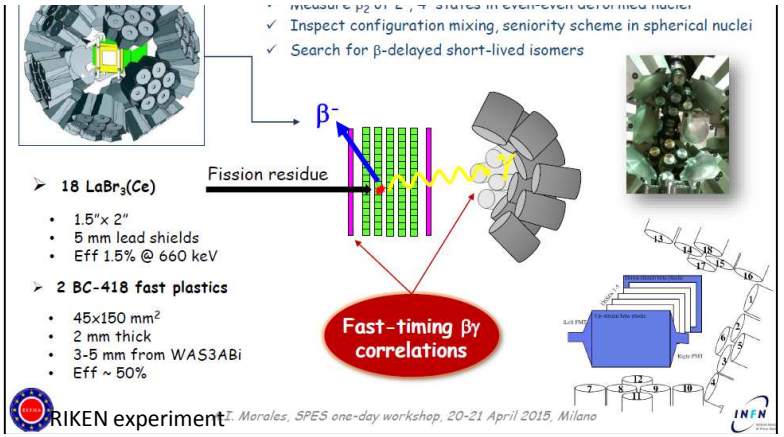


3Hen = Helium-3 Neutron Detectors
Hybrid-3Hen = 3Hen + Clover Ge

The physics of neutron-rich fission fragments
- nuclear structure evolution as N >> Z
- spectroscopy near and above the neutron separation energy
- rapid-neutron capture half-lives and beta-delayed neutron branchings
- societal impact in better data for modeling neutron-rich environments such as nuclear reactors
- more detailed understanding of the anti-neutrino spectra from reactors

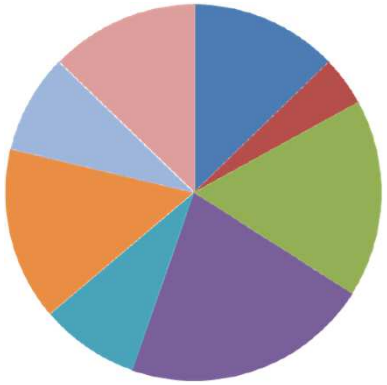
U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY



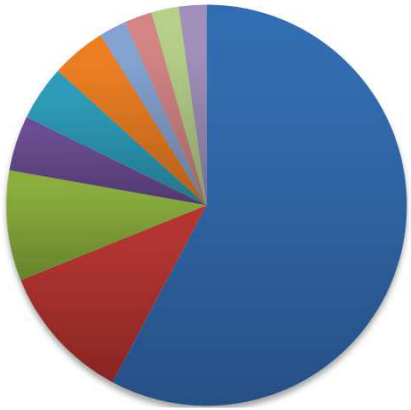
Presented 47 Letters of Intents

LOIs 2016 TOPICS

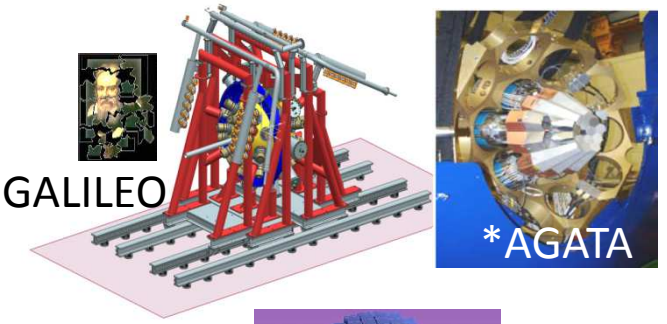


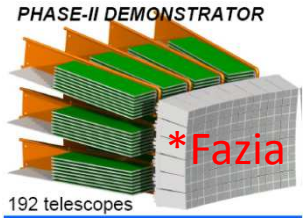
- Decay Studies
- Elastic /Inelastic
- COULEX
- Transfer
- Deep Inelastic/MNTR
- Fusion/Fission
- New instrumentation
- Astrophysics

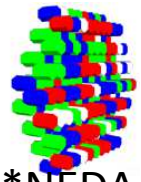
LOIs 2016

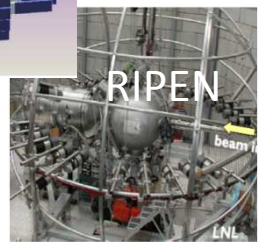


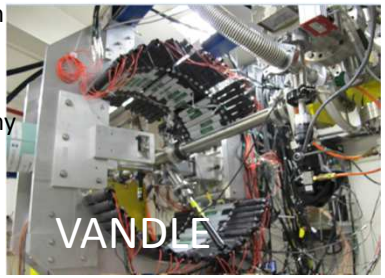
- Italy
- France
- USA
- Poland
- Belgium
- Russia
- Germany
- Cina
- Croatia
- Norvey

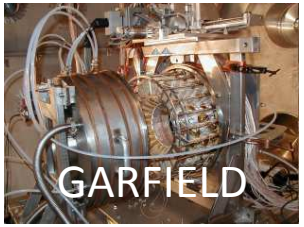




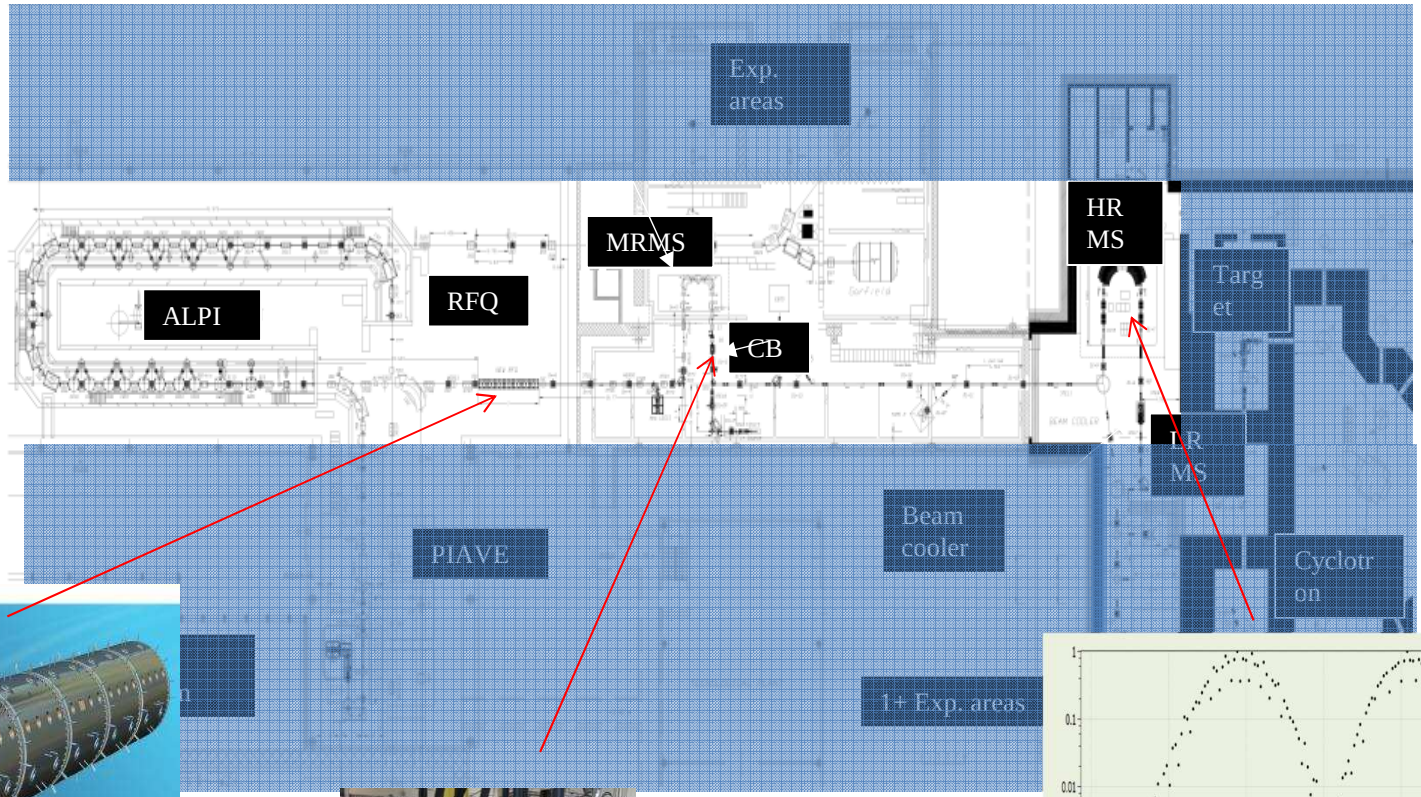


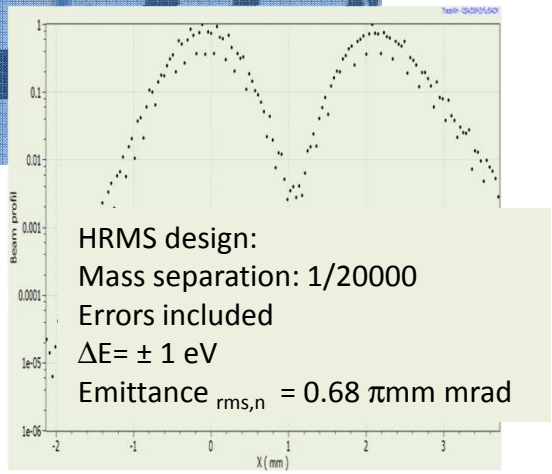






Beam transport and reacceleration





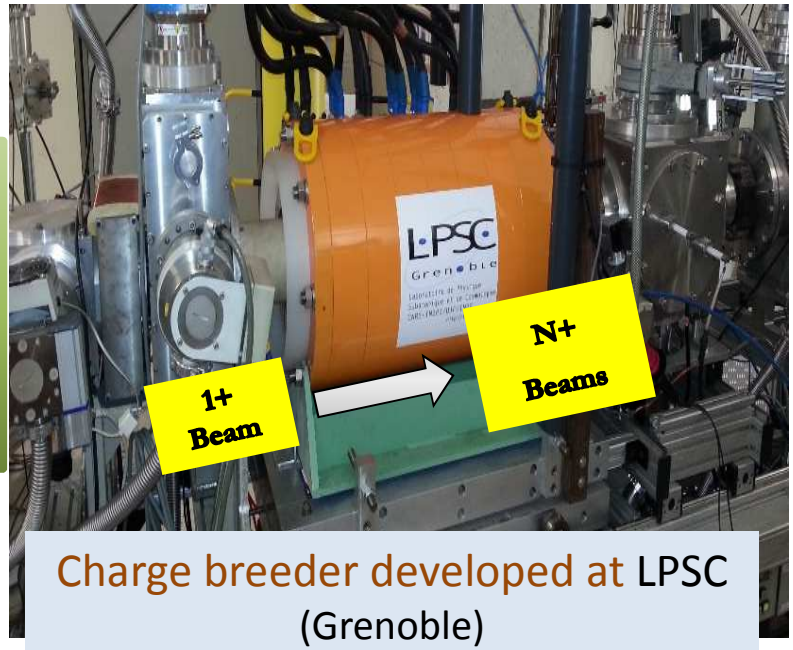
HRMS design:
Mass separation: 1/20000
Errors included
ΔE= ± 1 eV
Emittance $_{rms,n}$ = 0.68 πmm mrad

Phase 2A: Installation of Charge Breeder and n+ beam line

Assembly of 1+Source Front-End

SPES production, similar to ISOL source

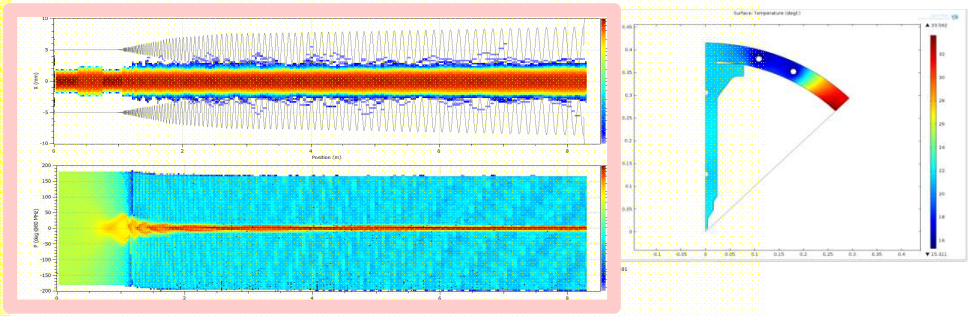
- Hall prepared
- Assembly and connection of 1+ source and CB in 2017



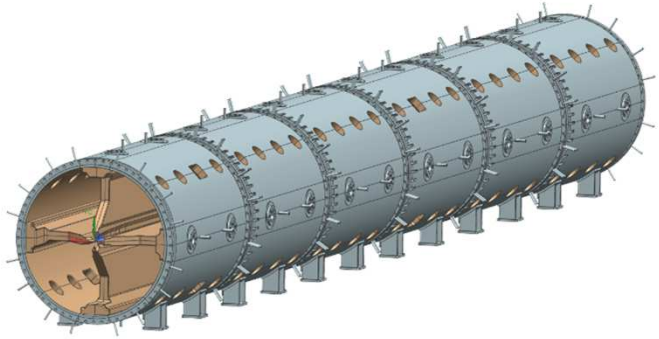
Charge breeder developed at LPSC (Grenoble)

Exotic Beam RFQ Injector for ALPI (7 m, 6 modules)

- **Energy 5.7 –> 727.3 keV/A** [β=0.0395] (A/q=7)
- **Beam transmission** >93% for **A/q=3÷7**
- **RF power** (four vanes) **100 kW** (f=80 MHz) **for up to 1 mA beam (…future higher I stable beams)**
- **Mechanical design** and realization, similar to the Spiral2 one, takes advantage of IFMIF technological experience



Beam dynamics, EM design, Mechanical design and Thermal Analysis COMPLETED

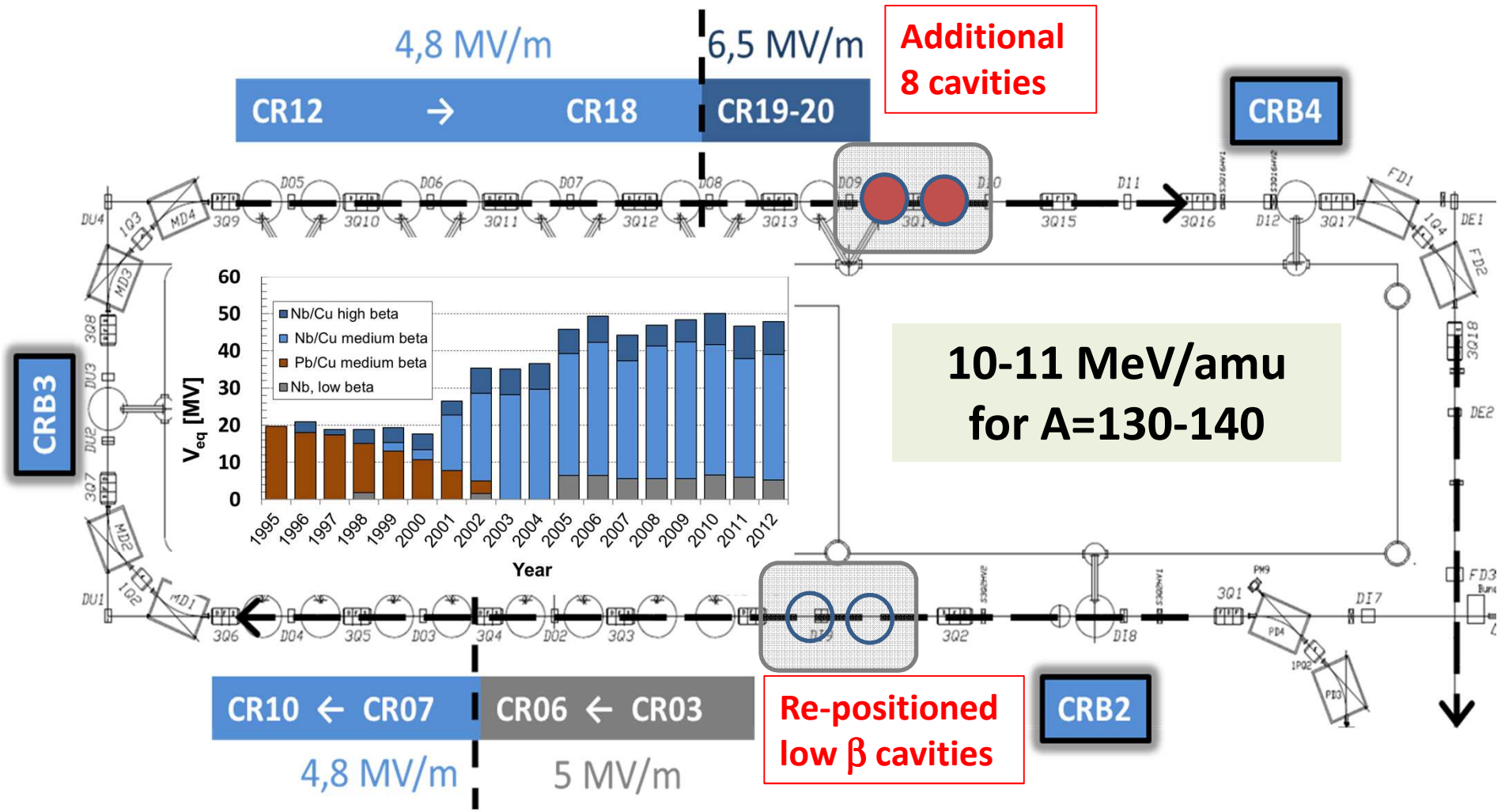


200 kW **RF amplifier** (175 MHz→ 80 MHz tuning required); 200 kW **Power Coupler** developed

Status

- **Materials ordered**
- **Construction of vanes: tender completed (July 2016)**
- **Prototype in preparation**

Matching into ALPI SC linac



CONCLUSIONS

- **SPES is in the construction phase**
- **Infrastructures and Cyclotron are completed**
- **In the next two years the ISOL system and the Charge Breeder will be installed**
- **In 2019 radioactive beams with no-reacceleration will be available**
- **Reacceleration will be completed in 2021 using ALPI to reach 10-11 MeV/n**
- **SPES is partner of EURISOL_DF**
  - **An European distributed facility for radioactive beams** will offer a wide alternatives of exotic beams to the international nuclear physics community