SPES beams at LNL

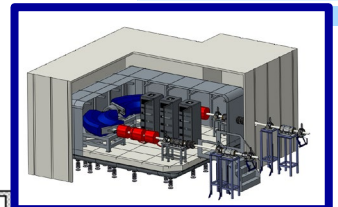
Danilo Rifuggiato

INFN LNS, Catania, Italy

- Authorization to operate: infrastructures and safety
- ISOL installations
- SPES beams

The SPES complex

ALPI

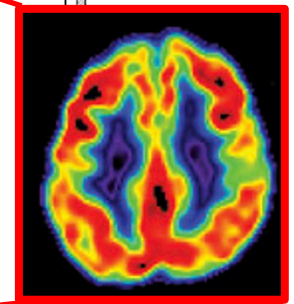


HRMS

Cyclotron

Multi-disciplinary neutron source

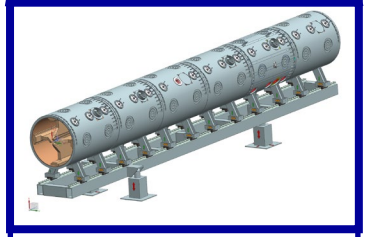
RILAB



RIFAC

LARAMED Radionuclides of medical interest

ADIGE-CB- MRMS



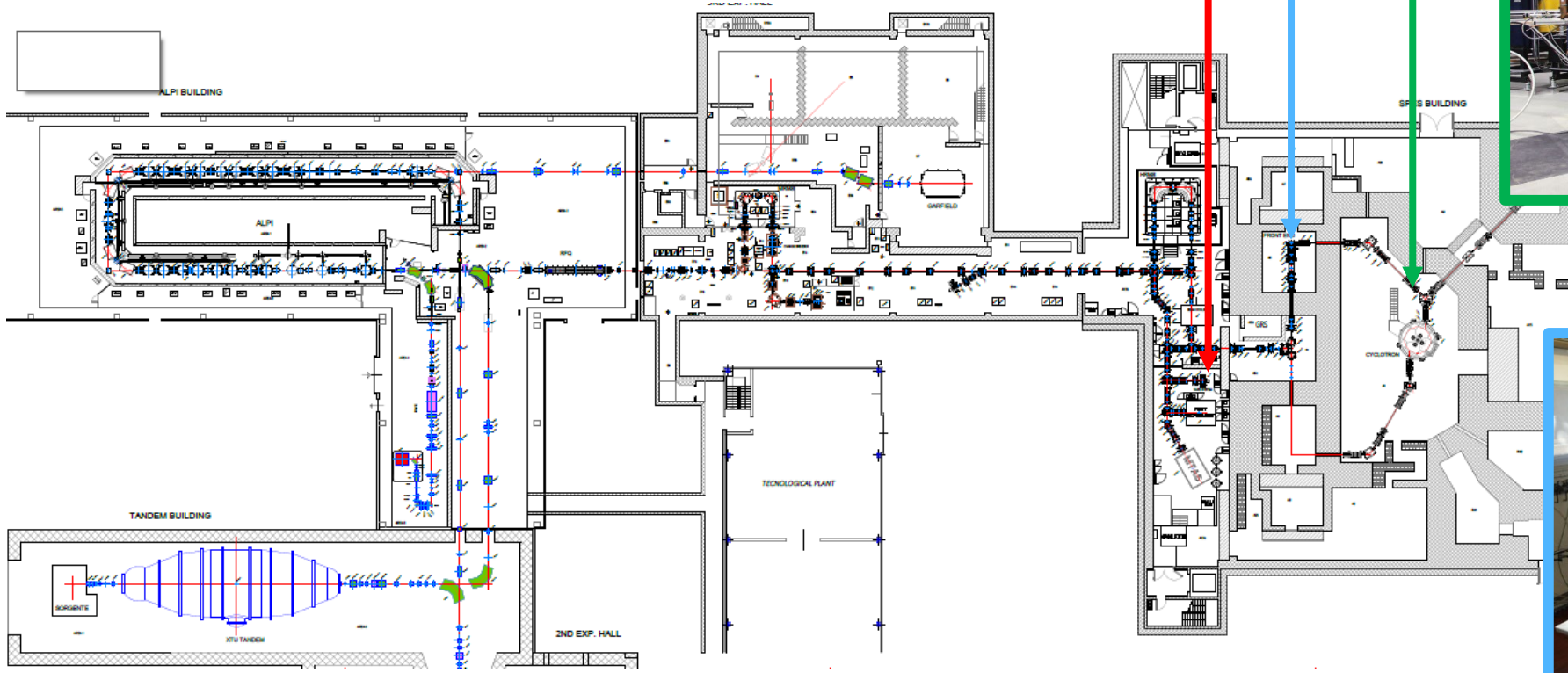
Radio Frequency Quadrupole

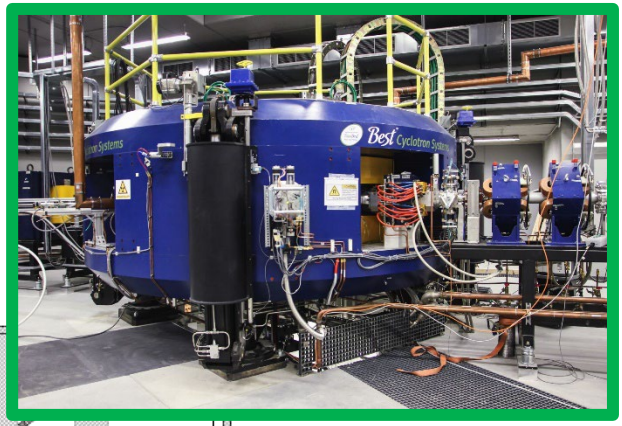
Experimental hall Low Energy R.I.B.

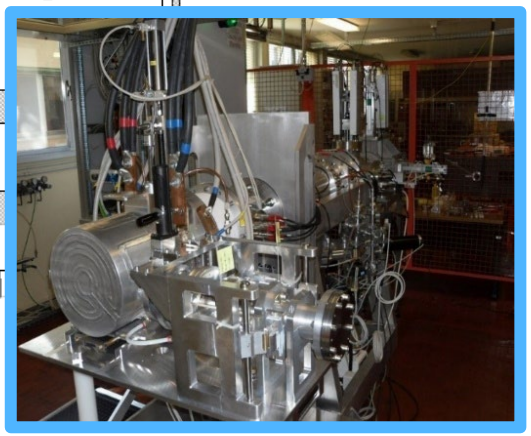
Target Ion Source Complex

Short term objectives

- Cyclotron high intensity operation
- Cyclotron beam delivery on Target Ion Source complex and production of radioactive ion beams
- Experimental activity with L.E. radioactive beams







Authorization to operate

D.I. (Permission Decrees) issued by ISIN, National Inspectorate for Nuclear Safety and Radioprotection

Phase alfa – Permission Decree D.I. 11/09/2012

- Production of 70 MeV, 750 µA proton beams with the Cyclotron
- Production of radioactive beams with conventional targets (SiC, C, LaC2, …) and re-acceleration with ALPI, production of radioactive beams with UCx targets and 40 MeV, 5 µA proton beam for commissioning

Phase beta – Permission Decree D.I. 05/06/2019

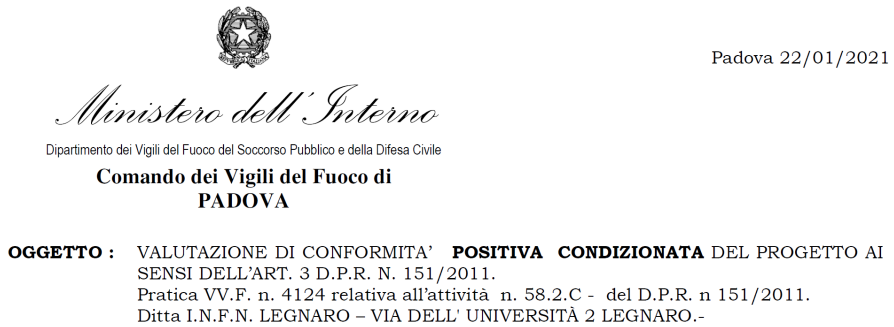
Production of radioactive beams with UCx targets and 40 MeV, 200 µA proton beam and re-acceleration with ALPI

Phase gamma – Permission Decree D.I. 05/06/2019

Production of innovative radioisotopes, both for medical purposes and for applied research

Fire Prevention Certificate is needed too, to be released by the Fire Brigade

January 2021: fire prevention design for phase alfa presented to the Fire Brigade



Ministero dell'Interno

Dipartimento dei Vigili del Fuoco del Soccorso Pubblico e della Difesa Civile

Comando dei Vigili del Fuoco di PADOVA

Padova 22/01/2021

OGGETTO : VALUTAZIONE DI CONFORMITA' **POSITIVA CONDIZIONATA** DEL PROGETTO AI SENSI DELL'ART. 3 D.P.R. N. 151/2011.
Pratica VV.F. n. 4124 relativa all'attività n. 58.2.C - del D.P.R. n 151/2011.
Ditta I.N.F.N. LEGNARO – VIA DELL' UNIVERSITÀ 2 LEGNARO.-

January 22, 2021: a document of positive evaluation of compliance issued, conditioned to the realization of what has been declared

Before starting the facility operation, a communication (S.C.I.A.) has to be presented to the Fire Brigade in order to get the C.P.I. (Fire Prevention Certificate)

Fire prevention infrastructures

Fire prevention design phase alfa: Risk assessment and protection actions

1. General safety objectives (normal operation and emergency)
2. Nuclear safety objectives
3. Confinement objectives: Reaction to fire of materials, Fire resistance of structures, Fire compartmentalization

Fire compartmentalization and fire sealing implementation

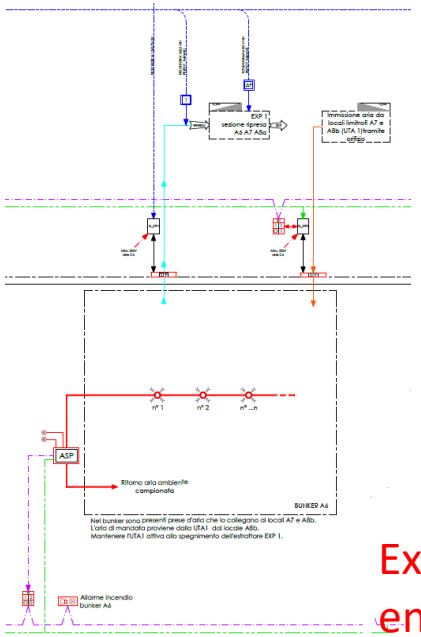
Executive design ready April 2022

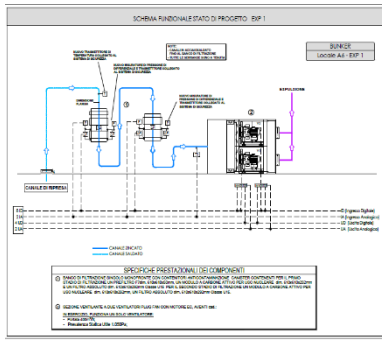
Infrastructural Actions for fire prevention

Tender: Apr-Jul 2022

Works: Sep-Nov 2022

Upgrade of the ventilation system according to ISO 17873 - Criteria for the design and operation of ventilation systems for nuclear installations different from nuclear reactors



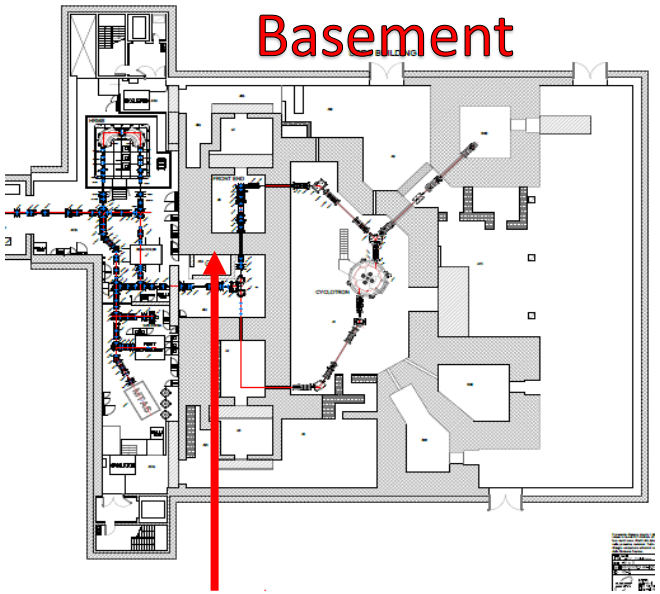


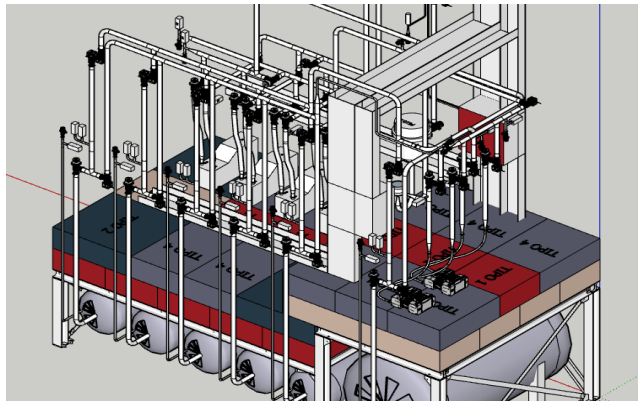
STEAM

Executive design ready end 2021

Safety activities: Gas Recovery System completed

Basement

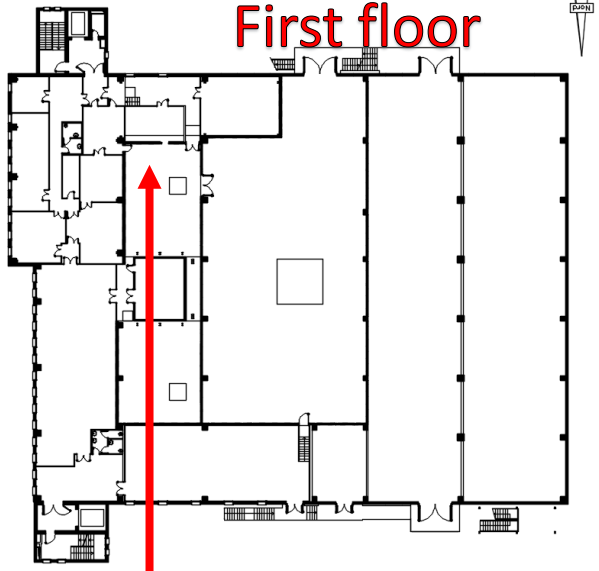




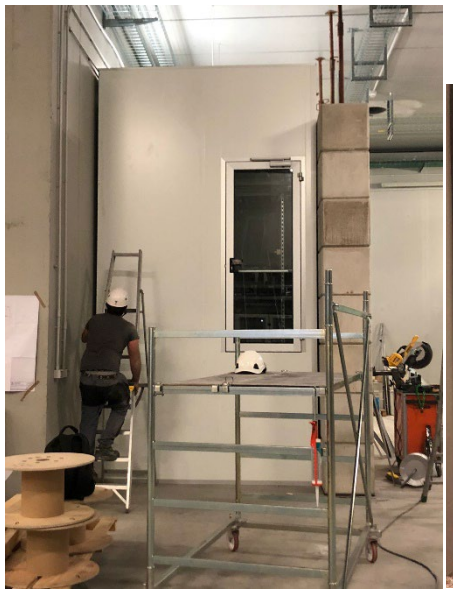
Jun 2021

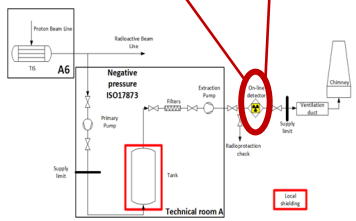
TECNO DELTA S.r.l.

First floor



Jan 2022





TNE TECHNOLOGY NUCLEAR ELECTRONICS SPA

Detector for **iodine** (NaI Scintillator) and detector for **noble gases** (Dual PIPS type)

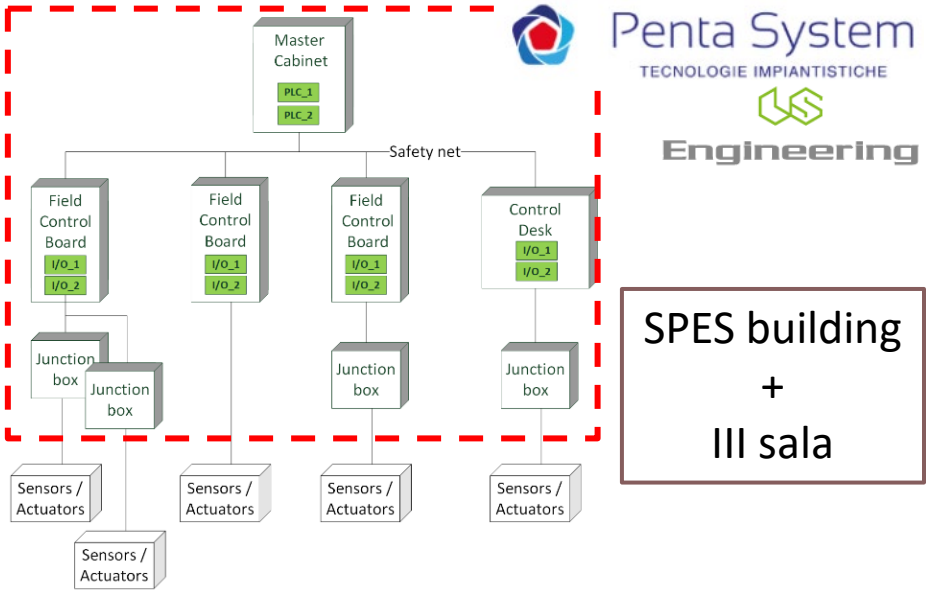
Safety activities: Final tests of the safety system

The SPES safety system was designed by the LNL safety group in collaboration with PILZ according to the safety guidelines and rules for nuclear installations

Safety network installed

PLCs, safety I/O modules, local nodes, racks and junction boxes

Mar 2021 – Jan 2022



SPES building
+
III sala

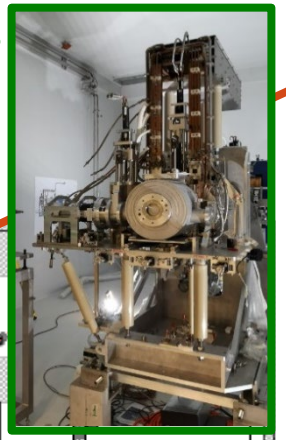
Bench tests and final tests (the last 2 milestones of the PILZ contract) will not be accomplished with PILZ

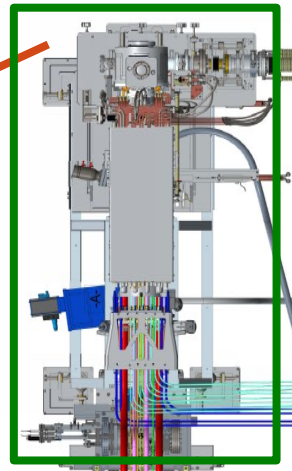
A new company with proper competences will replace PILZ

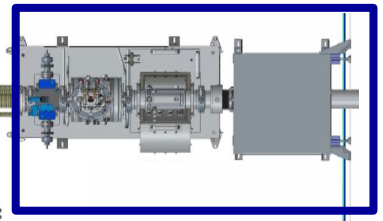
Tender: Jun-Sep 2022 **Tests: Oct-Nov 2022**

ISOL installation: TIS complex installed in the ISOL bunker

July 2021
Front-end

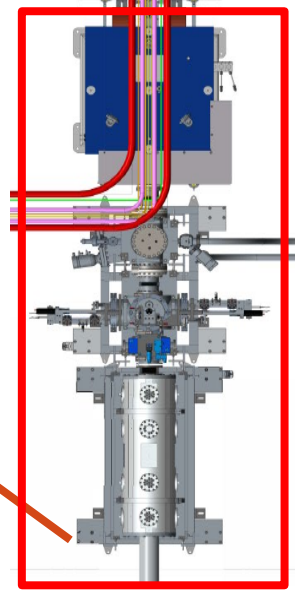






October 2021
Proton beam line

Basement floor

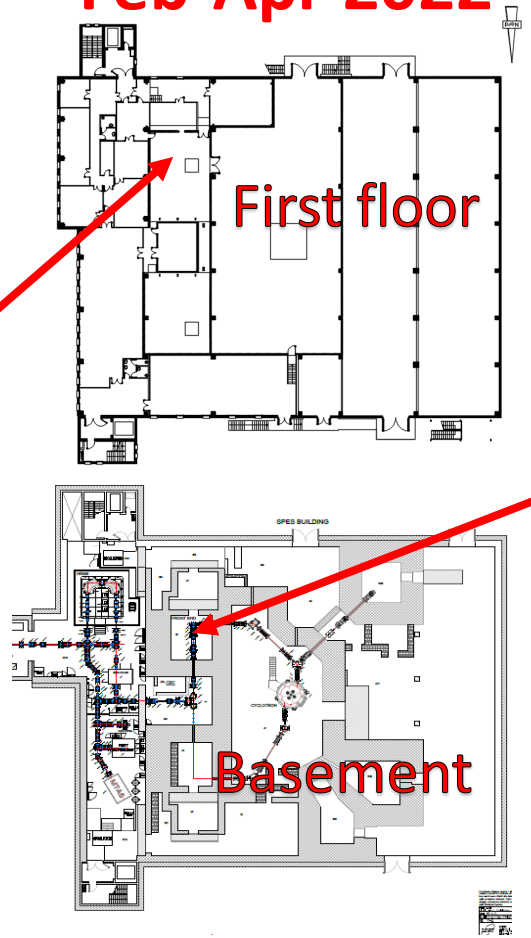


March 2021
Wien filter & Electrostatic triplet

ISOL installation: TIS complex installed in the ISOL bunker

ISOL installation activities: TIS HV platform

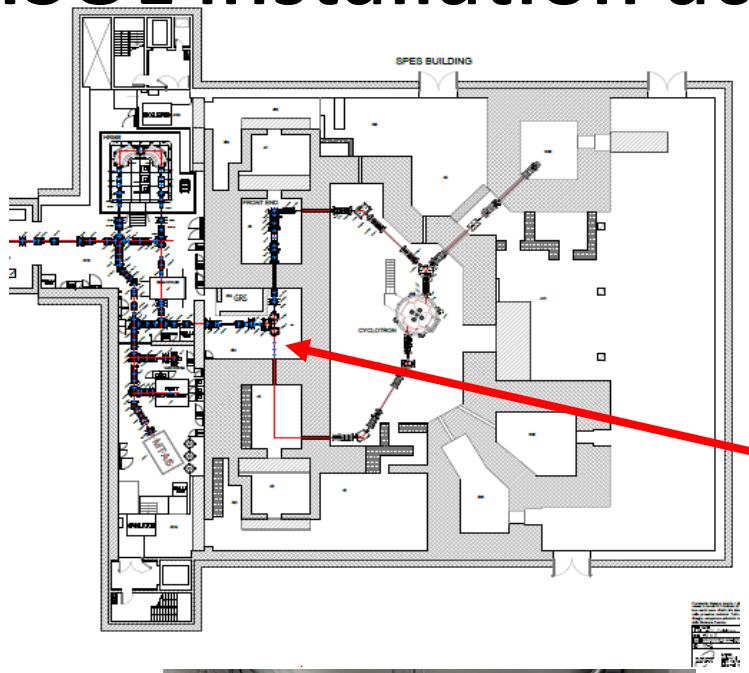
Feb-Apr 2022

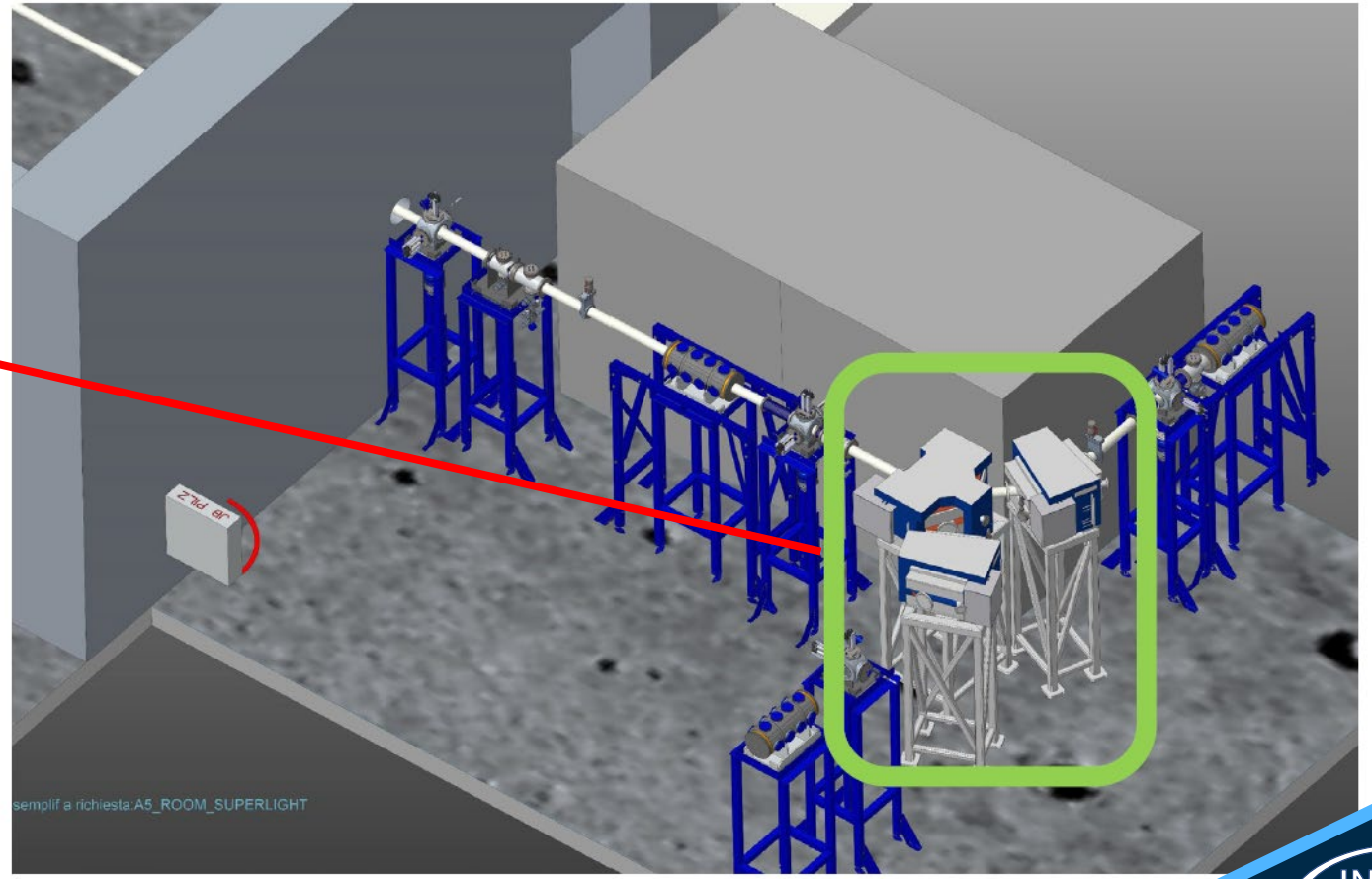


Installation of electrical, hydraulic, pneumatic plants: **May-July 2022**

Tests of the Target Ion Source complex with stable beams: **Sep-Dec 2022**

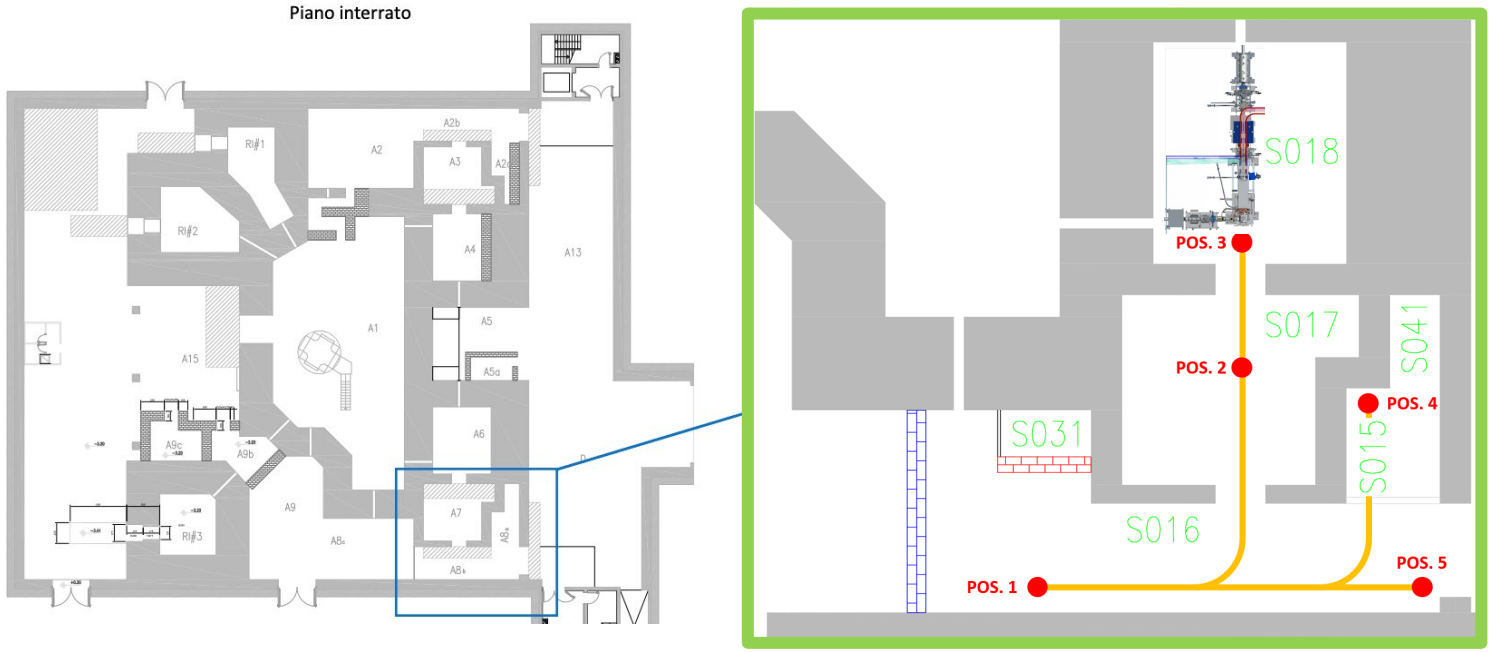
ISOL installation activities: Low Resolution Mass Separator

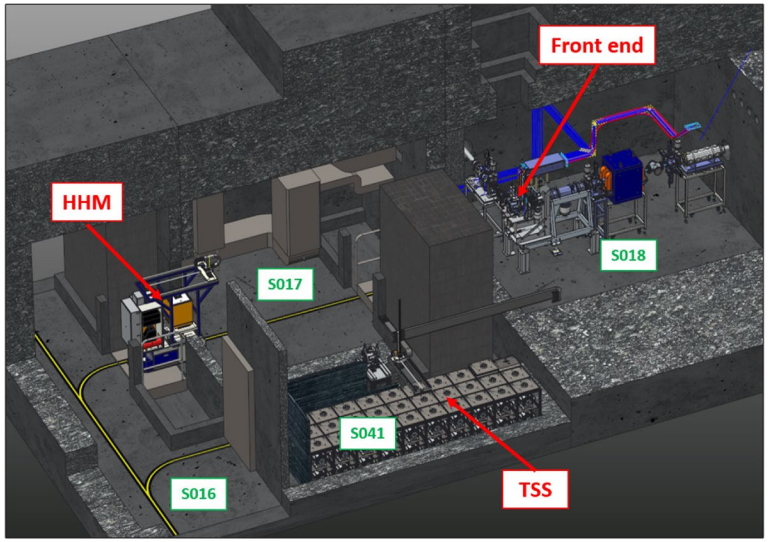


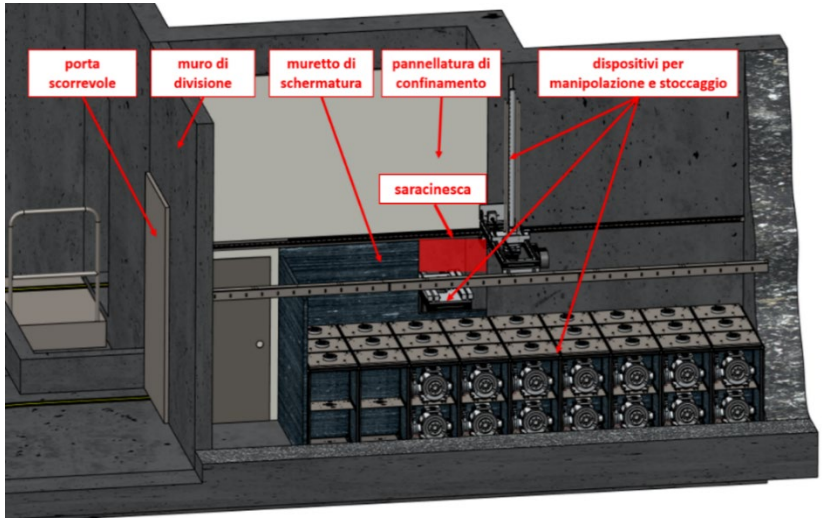


Apr-Jun 2022

ISOL installation activities: Temporary Storage System







Infrastructures:

Tender: **May-Jul 2022**

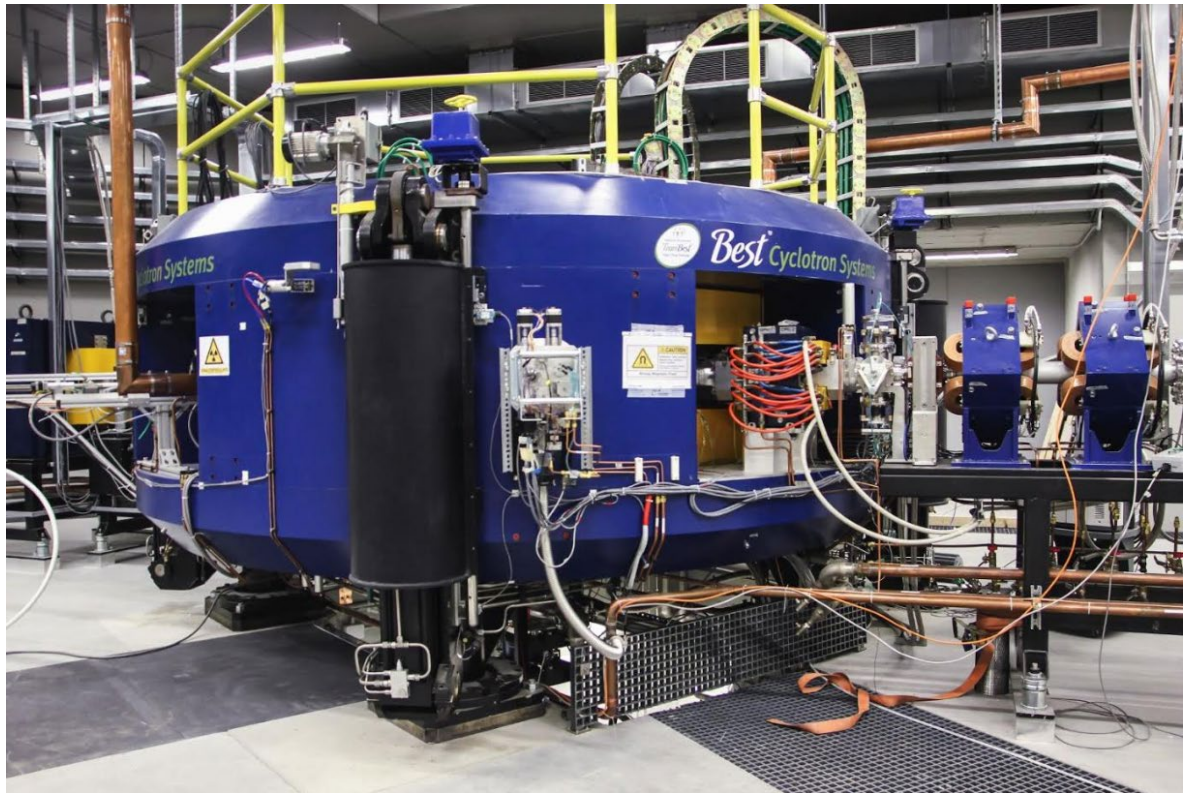
Works: **Sep-Oct 2022**

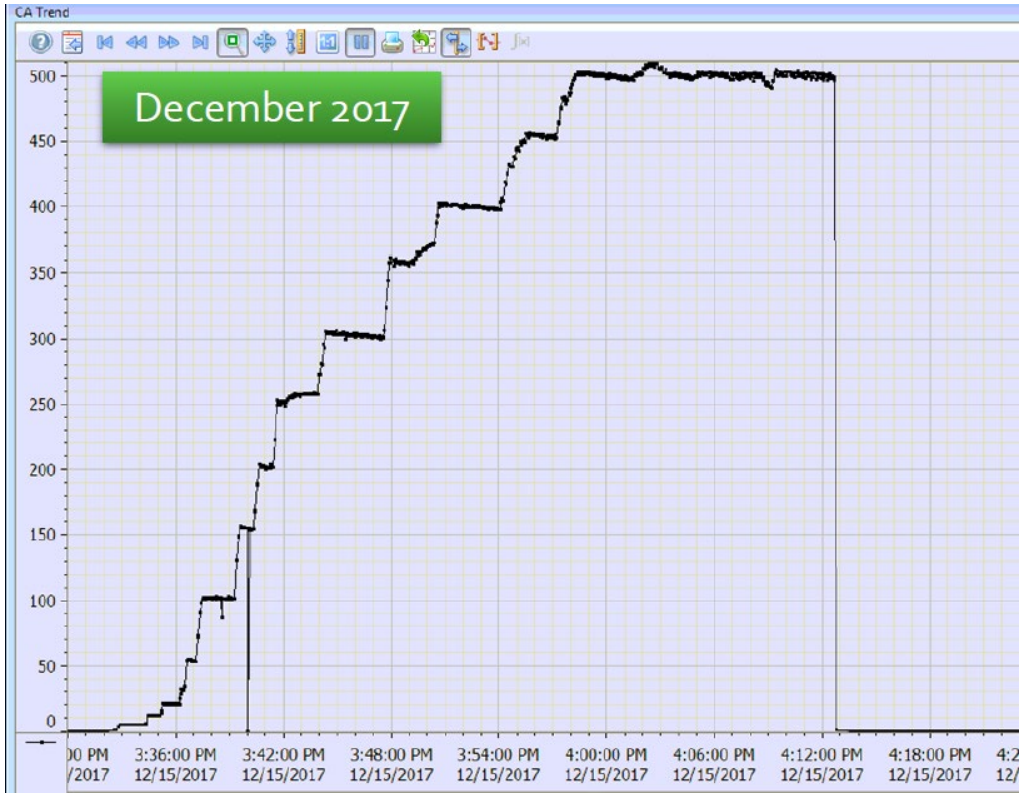
Mechanics:

Tender **awarded**

Works: **Nov 22-Mar 23**

Cyclotron





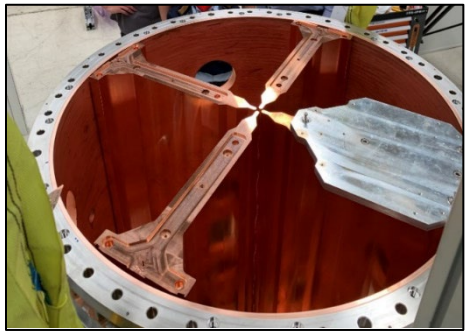
2011-2014
Study, construction, FAT

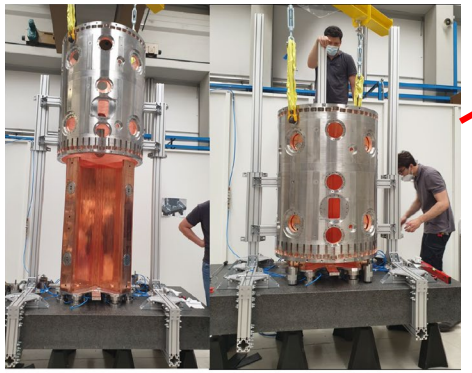
2015
Installation

2016
First beam

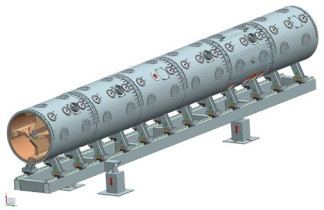
2017
SAT
protons 500 μA 70 MeV

Re-acceleration activities: RFQ, ADIGE, HRMS

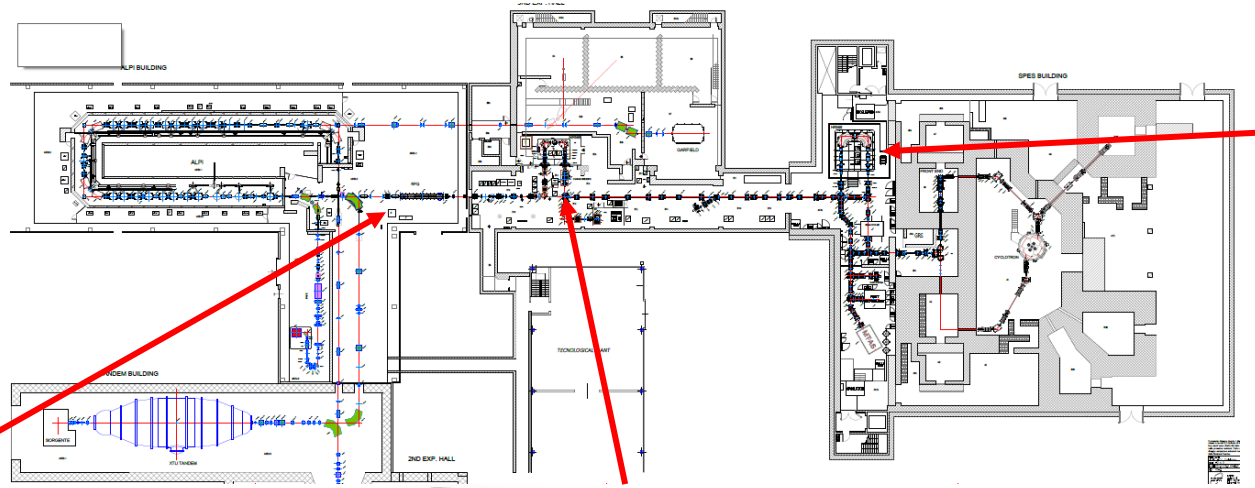


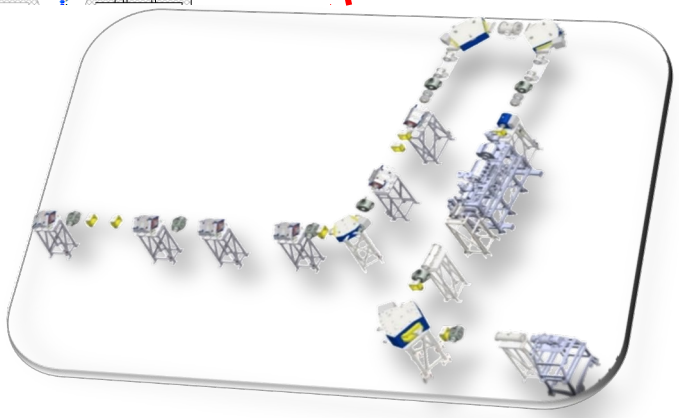


Electrodes and tank assembly



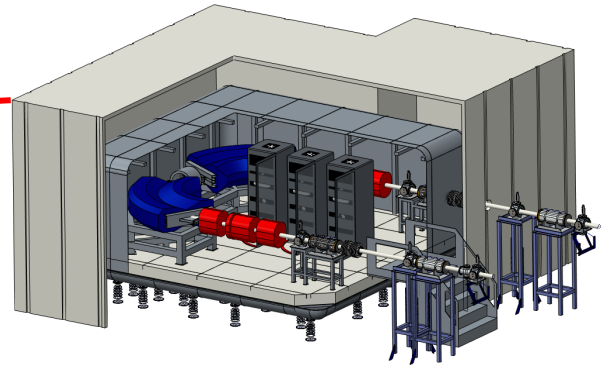
- First module assembled in 2021
- 5 modules to be assembled in 2022
- RF tests and tuning mid 2023
- Expected to be operative end 2023



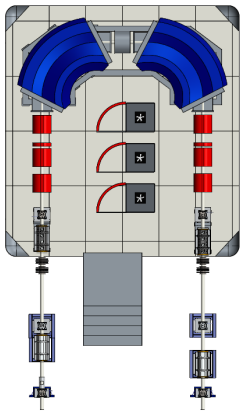


- Source characterization operations
- Beam pipe installations
- Beam line operations
- Charge breeder tests

Expected to be operative end 2023 -> mid 2024

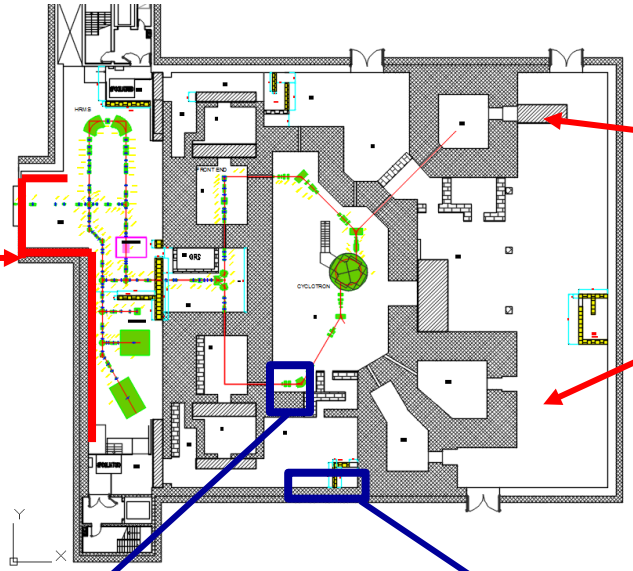


- Tender started: Dec 2021
- Tender completed: Jan 2023
- Delivery: mid of 2024
- Installation: mid 2025



Water infiltration

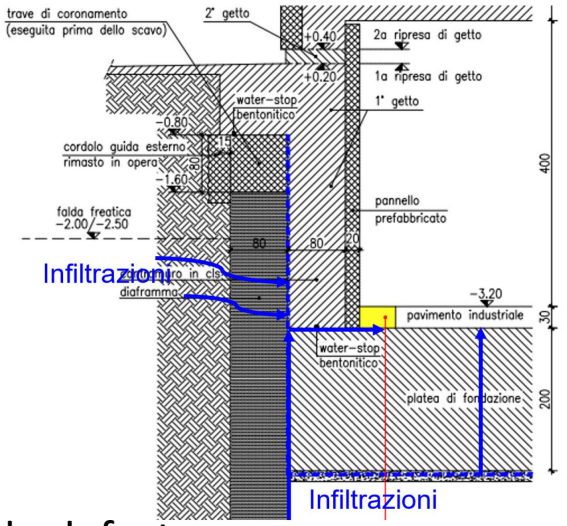
- Evidence at the time of the building delivery (2015). Problem mitigated in 2017 through sealing interventions
- In February 2021 the previous condition came back independently from rain -> ground water
- Water located around the whole perimeter of the building, especially in the experimental area and in the Cyclotron vault, and close to the Laramed bunkers



27 infiltration locations
all around the perimeter
+ internal areas close to
Laramed bunkers

Analysis of water infiltration

The Department of Civil and Environmental Engineering of the University of Padova has been consulted to investigate on the infiltration origins and find a feasible solution



Possible defects:

- Diaphragm walls with no effective water stops
- Bentonite layer probably not acting as a sealing layer
- Concrete not correcly poured over the slab…

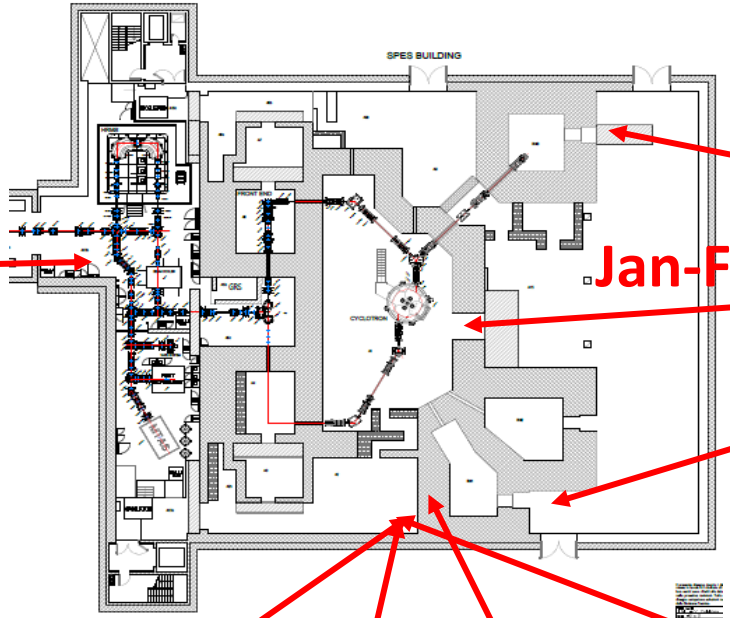
Courtesy of P. Simonini, Dept. ICEA University of Padova

Solutions (not simple)

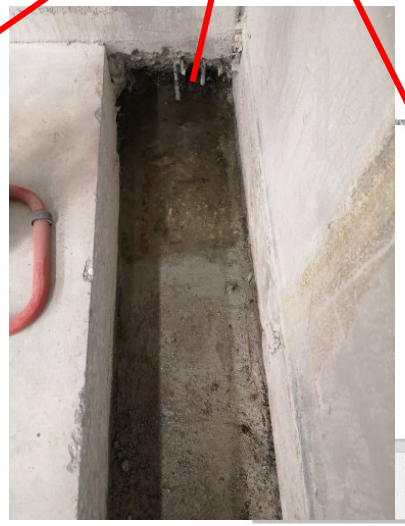
1. Inner sealing using resin of vertical joints between precast panels and horizontal joints between panels and slab and in the slab
2. External drainage (more complicated to be realized): excavating a pherimetral trench down to 6.0-6.5 m below ground surface down to the permeable sandy layer, install pipes to collect continuously (by pumping) the water seepage flow from the surrounding soil (high cost of maintainance).

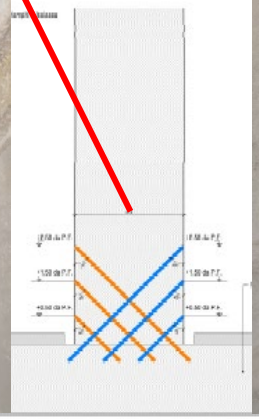
October 2021 – Order to a professional study to develop the executive design solution 1.

Water infiltration: preliminary tests in view of sealing works



Jan-Feb 2022





Executive design for sealing works ready **April 2022**

Expected time short term objectives

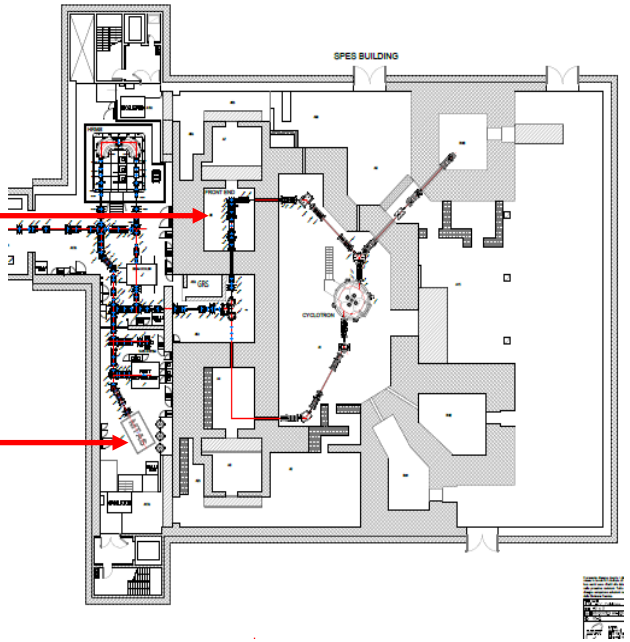
Authorization to operate SPES phase alfa: end 2022

Cyclotron beam on TIS@ISOL bunker: beg 2023

Production of L.E. (40 keV) radioactive ion beams: mid 2023

Equipment of A13 exp. hall: mid - end 2023

Experiments with L.E. radioactive ion beams: mid - end 2023



Expected time re-acceleration

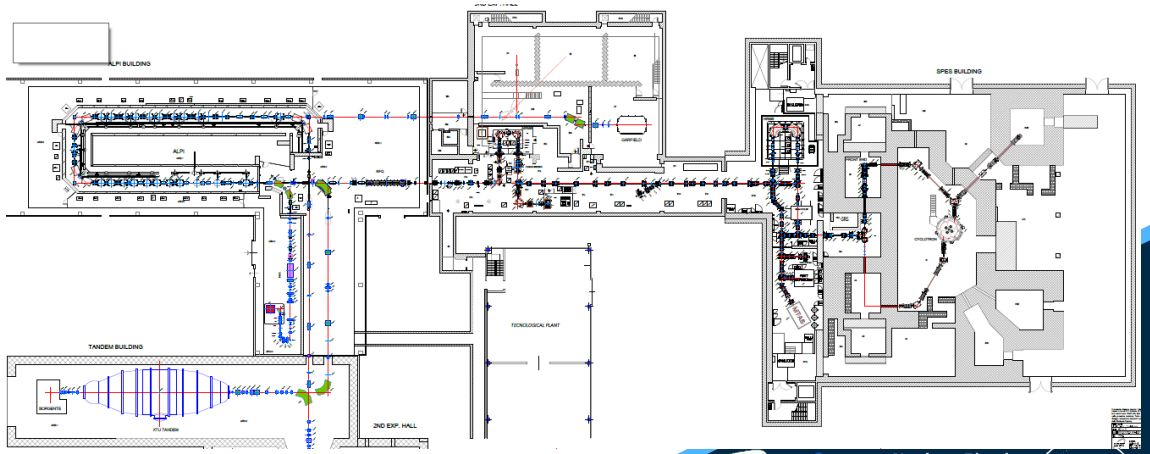
Authorization to operate SPES phase beta: end 2023

ADIGE and RFQ operative: end 2023 – mid 2024

Post acceleration operation no HRMS: mid 2024

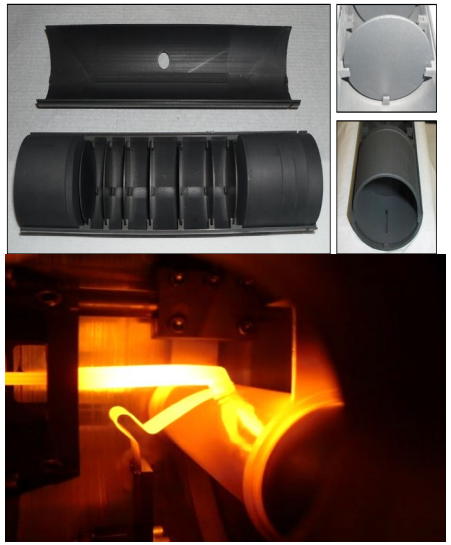
Installation of HRMS: mid 2025

Post acceleration operation with HRMS: end 2025

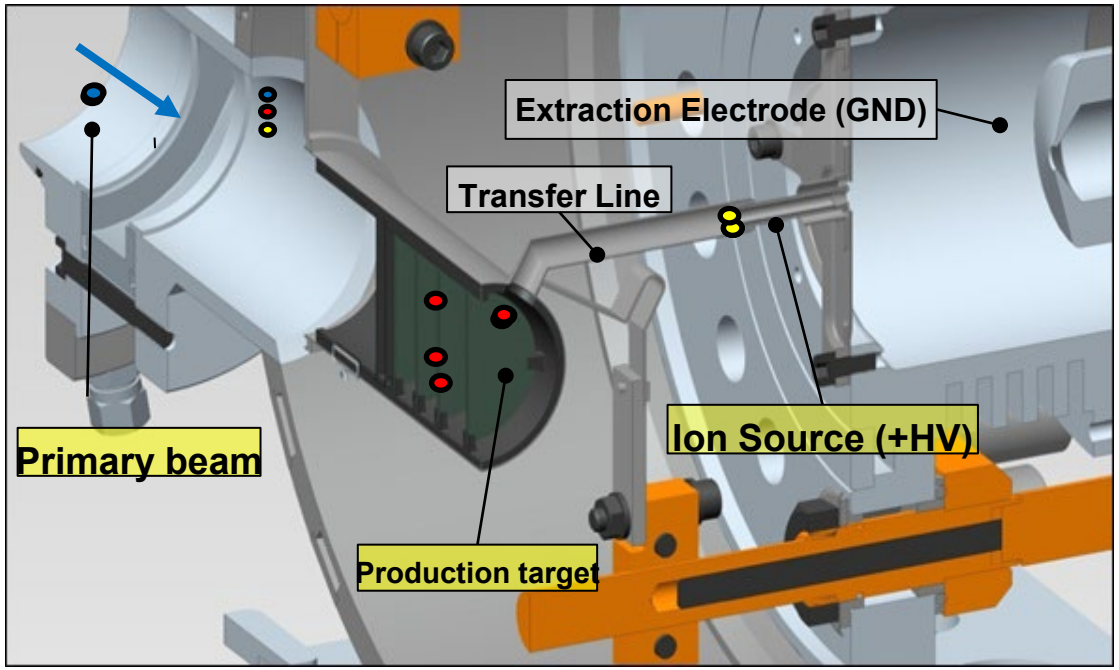


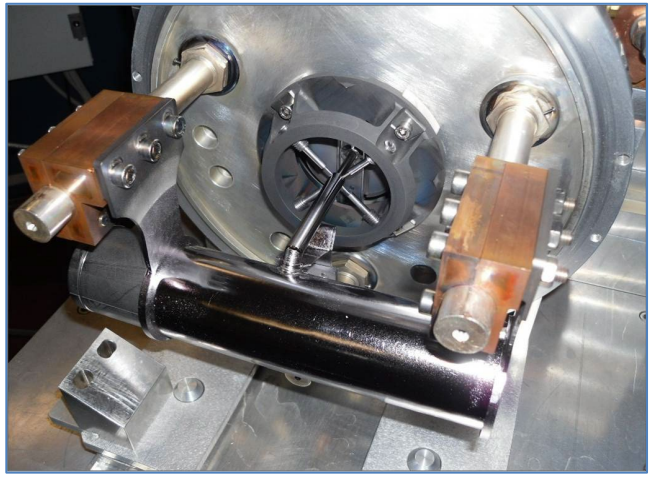
SPES beams

Target



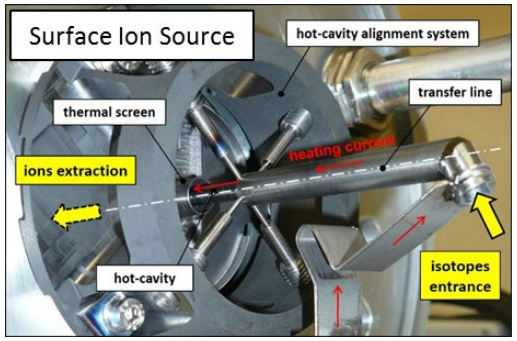
- UCx
- SiC
- ZrGe
- TiC



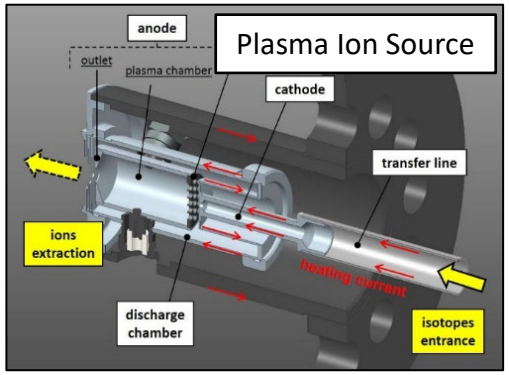


TIS UNIT

Sources



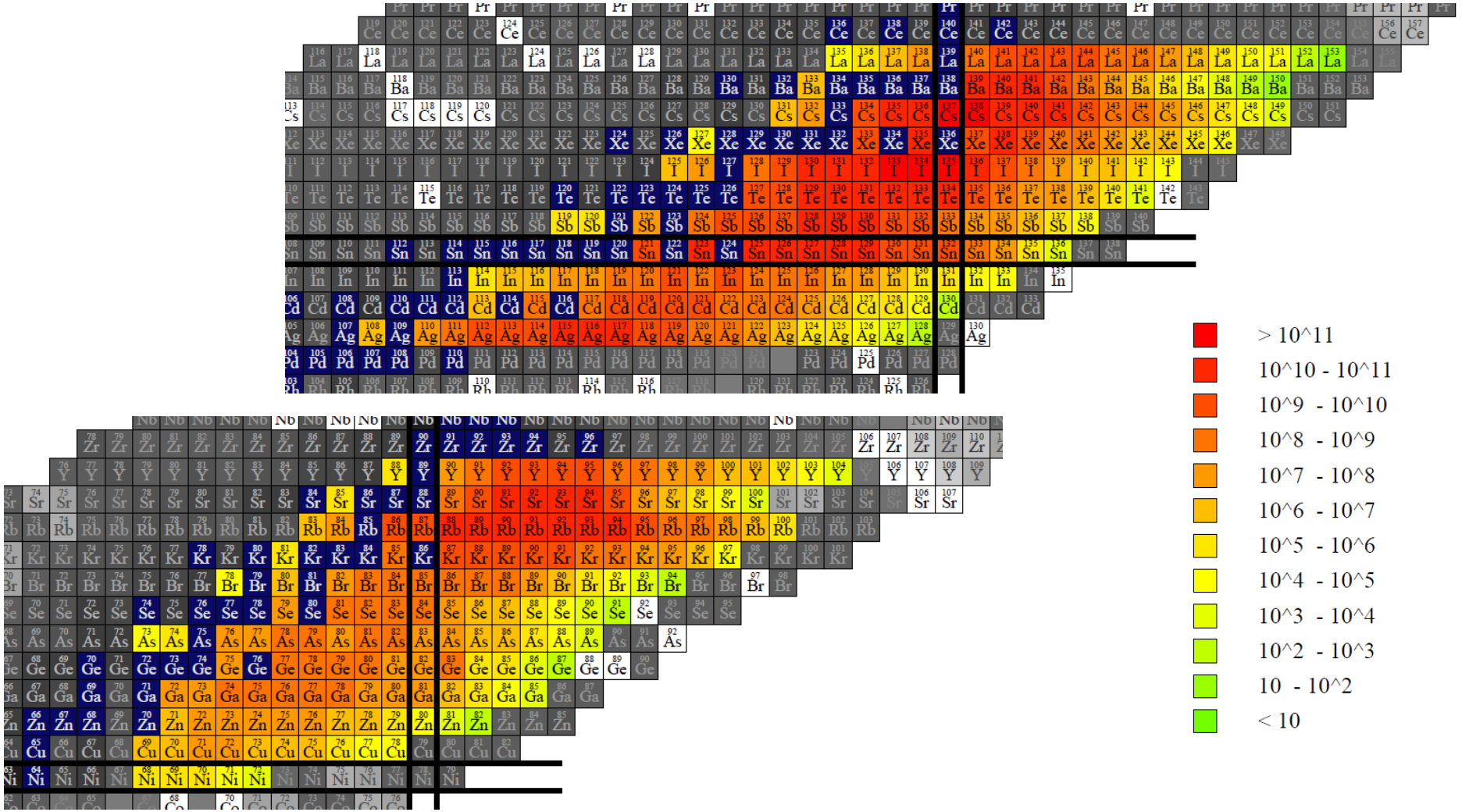
SIS: Rb, Cs, Sr, Ba



PIS: Kr, Xe, Br, I, Se

LIS (Laser -> SIS)

SPES beams

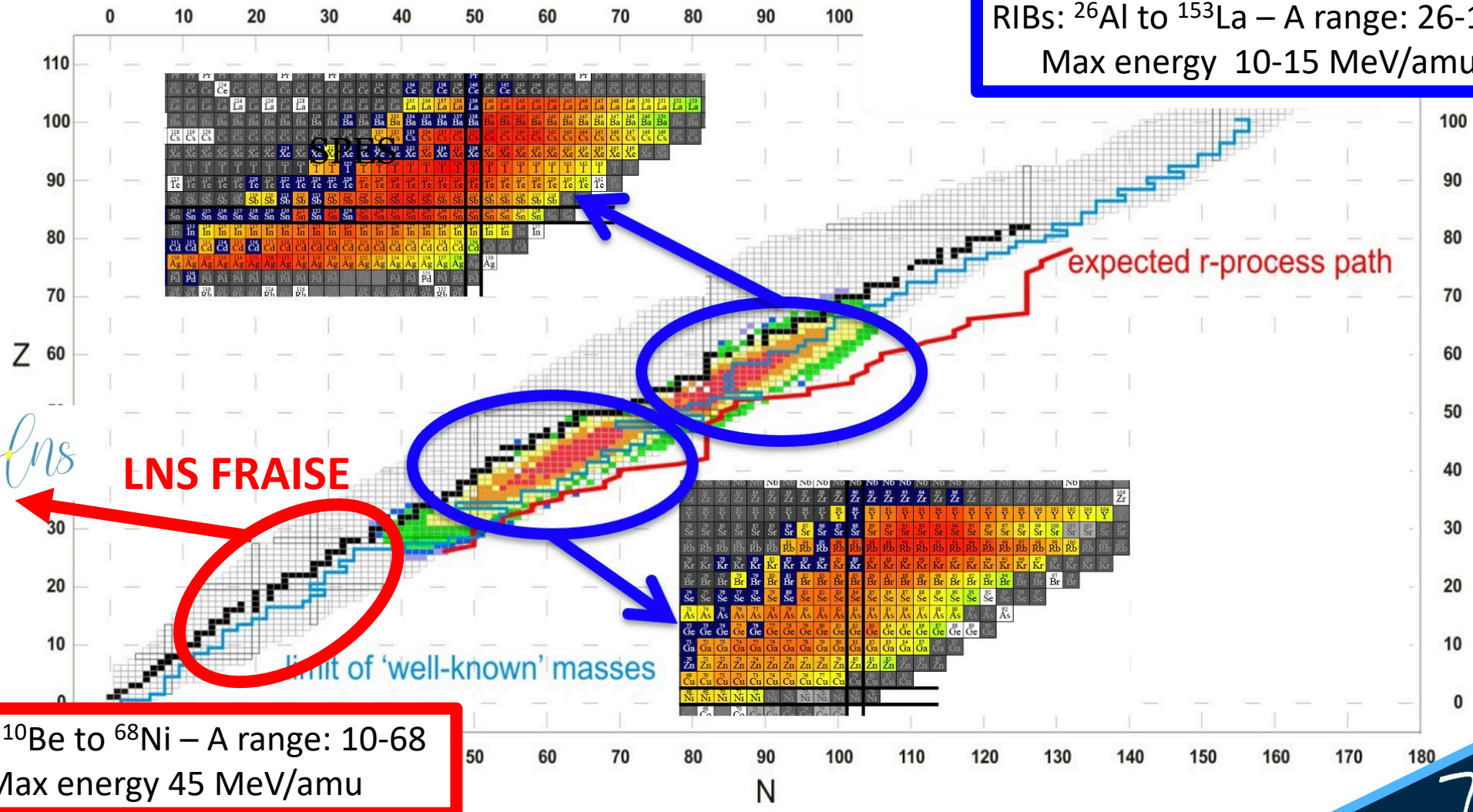


https://web.infn.it/spes/index.php/characteristics/spes-beams-7037/spesbeamstable

LNL-LNS complementarity

LNL SPES

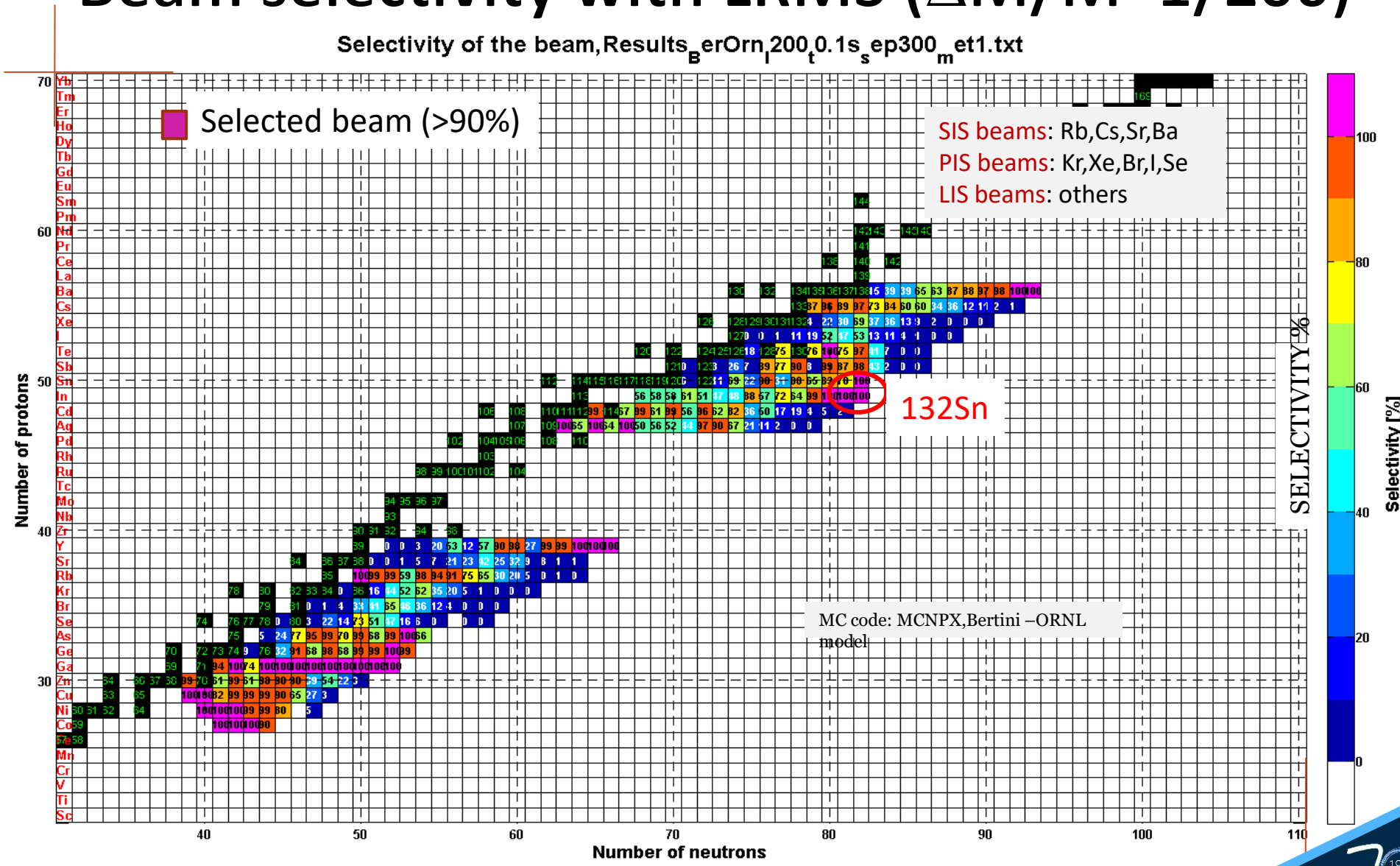
RIBs: ^{26}Al to ^{153}La – A range: 26-153
Max energy 10-15 MeV/amu



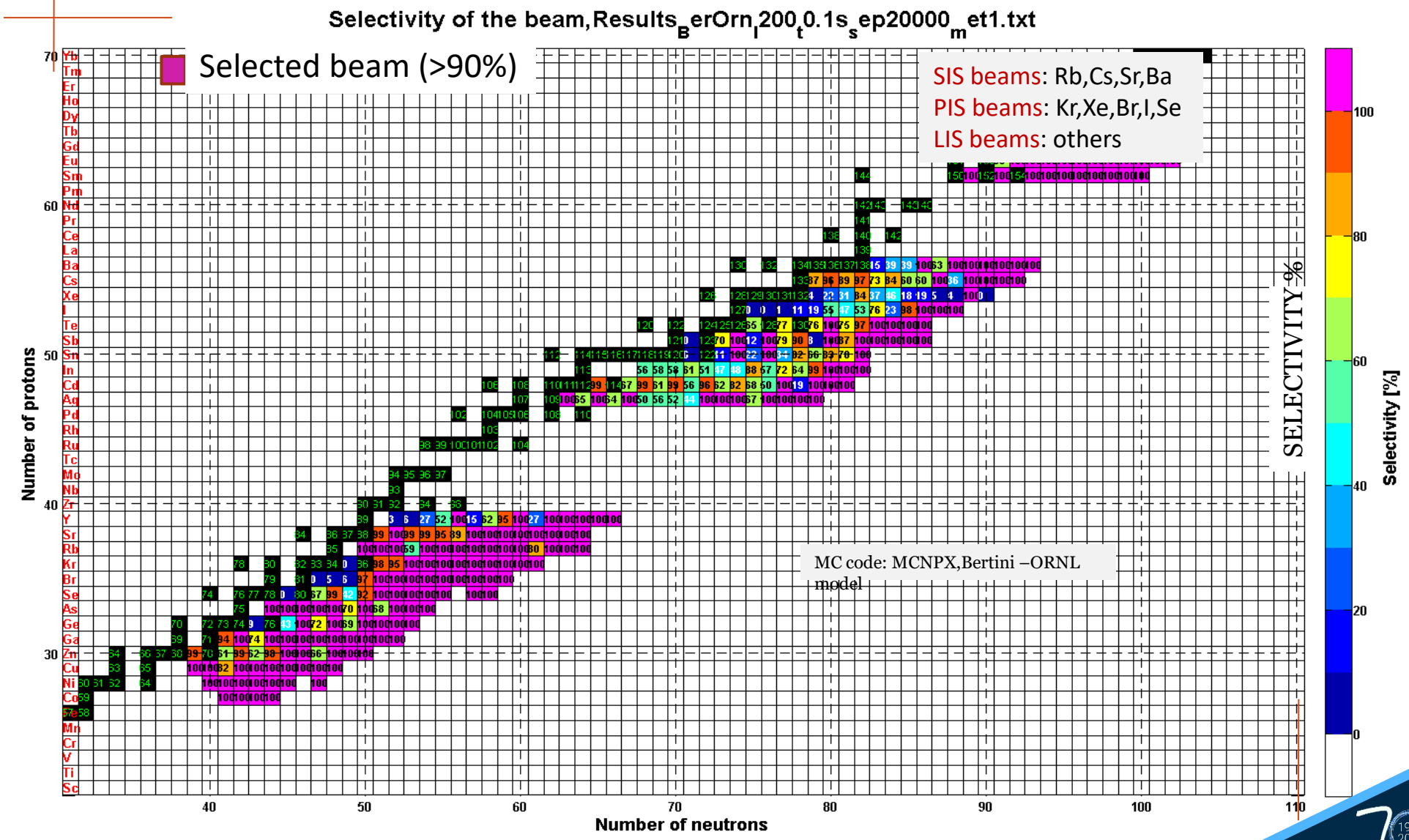
LNS FRAISE

RIBs: ^{10}Be to ^{68}Ni – A range: 10-68
Max energy 45 MeV/amu

Beam selectivity with LRMS (ΔM/M=1/200)



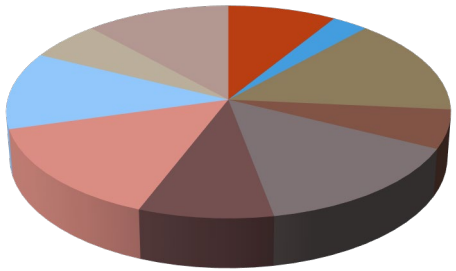
Beam selectivity with HRMS (ΔM/M=1/20000)



Third International SPES Workshop

10-12 October 2016 *INFN Laboratori Nazionali di Legnaro*
Europe/Rome timezone

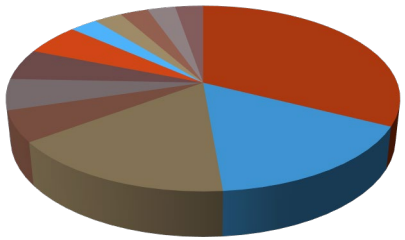
SPES LOIs Topics



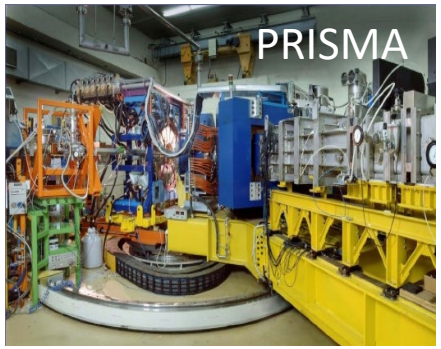
- GS properties
- moments
- Coulex
- DirReac with ActiveTarget
- DirReac with Si
- Mn transfer

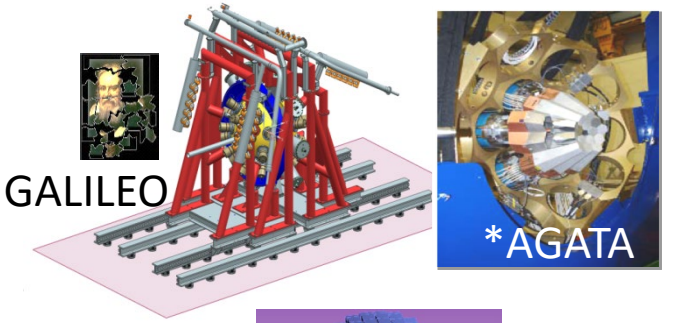
Presented 47 Letters of Intent

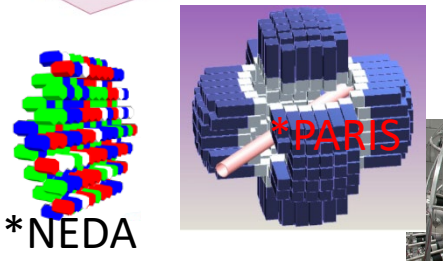
SPES LOIs Spokespersons

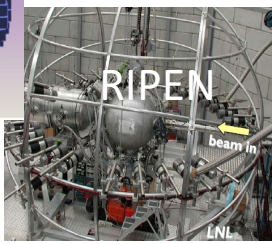


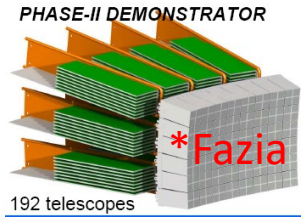
- Italy
- France
- Poland
- Russia
- USA
- Belgium
- Croatia
- Norway
- Bulgaria
- Spain
- Russia
- China

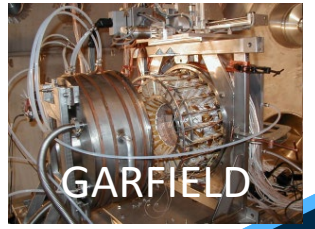


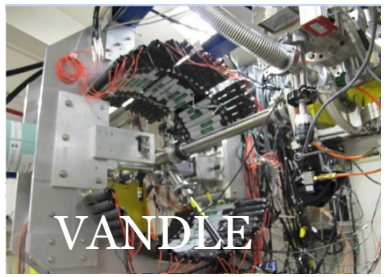






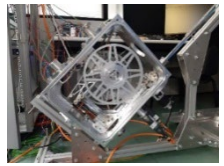




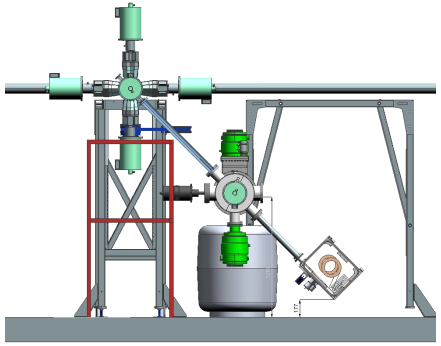


SPES beams to the Low Energy experimental area

Beam diagnostics - Tape station

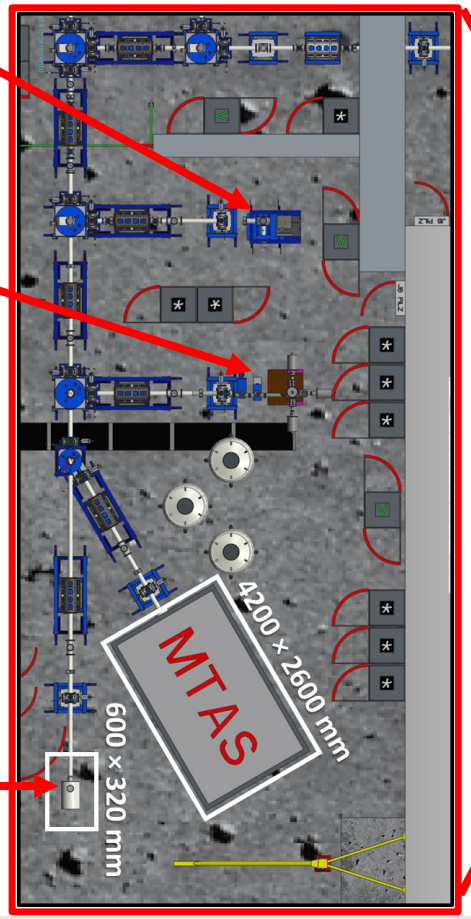


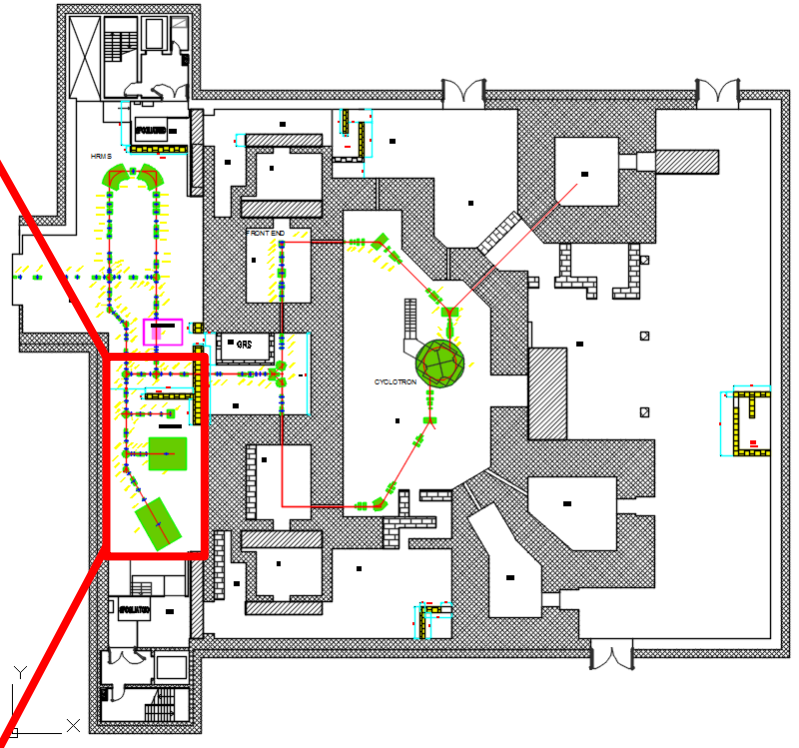
Beta decay station - SLICES



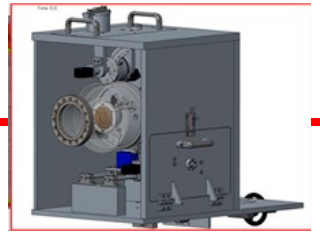
β-DS: decay spectroscopy following b decay (mylar tape + beta detectors + HPGe)

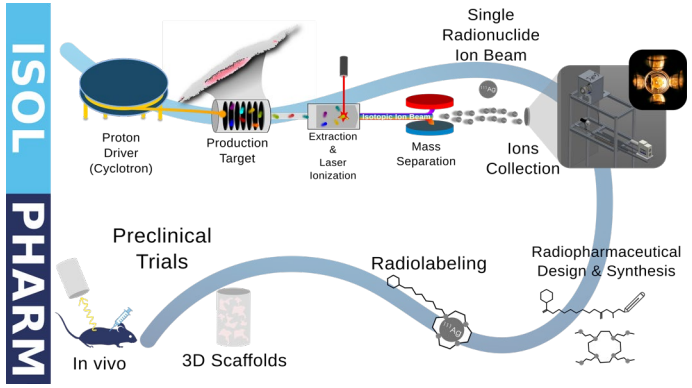
SLICES: conversion electrons and E0 transitions following β decay (mylar tape + Si(Li) + HPGe)





ISOLPHARM





- **^{111}Ag** can be produced with **high purity**, but also with **high production rate:** up to 2 Ci in target after 5 days (8kW UC_x target)
- All **Ag isotopic contaminants will be removed** using the **on-line mass separation.**
- In the market **No radiopharmaceutical** Silver-based yet!

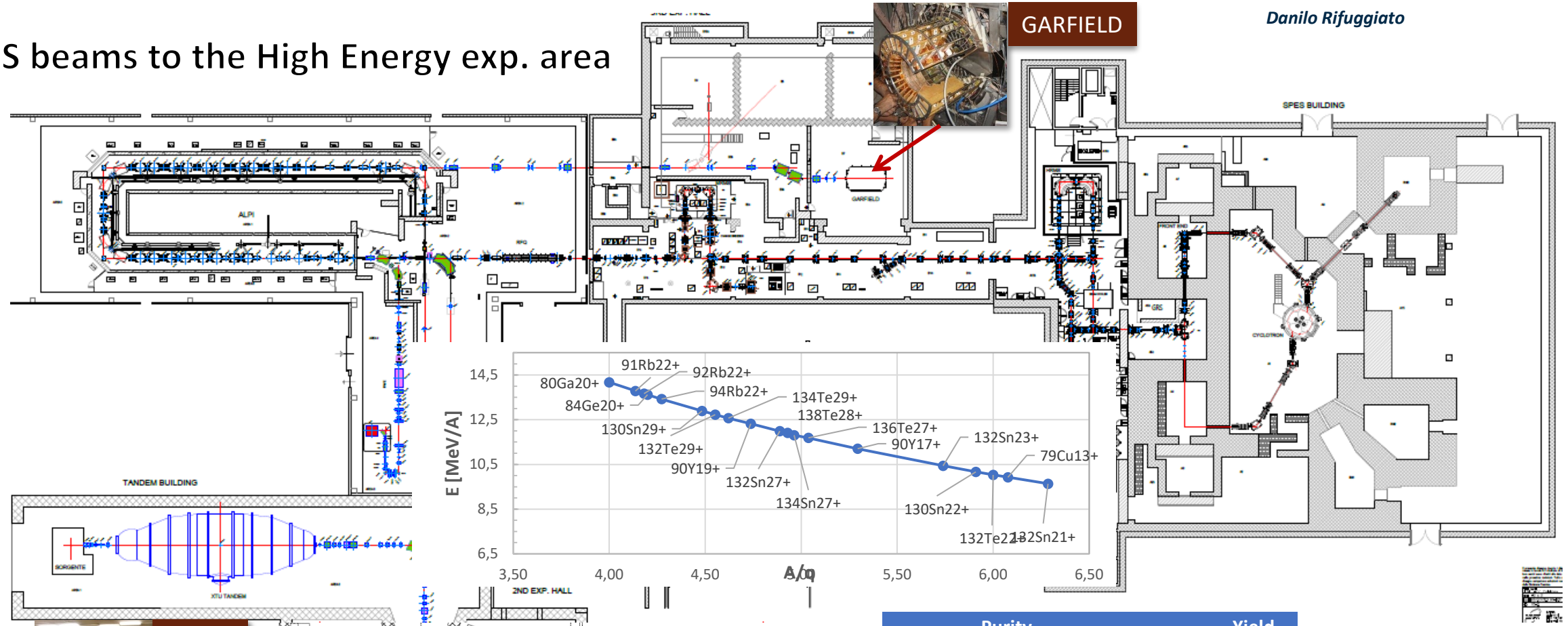
Beam	Purity (%)	Target	Source	Yield (pps)
^{83}Ge	100	UCx	LIS	$2.5 \cdot 10^{8}$
^{84}Ge	100	"	LIS	$6.6 \cdot 10^{5}$
^{80}Ga	100	"	LIS	$3 \cdot 10^{7}$
^{82}Ga	100	"	LIS	$3.3 \cdot 10^{6}$
^{110}Ag	100	"	LIS	$9.6 \cdot 10^{7}$

From the LOIs

3° Int. SPES Workshop

SPES beams to the High Energy exp. area

Danilo Rifuggiato



Beam	Purity (%)	Target	Source	Yield (pps)
^{84}Ge	100	UCx	LIS	$1.3 \cdot 10^4$
^{80}Ga	100	"	LIS	$6.1 \cdot 10^5$
^{132}Sb	100	"	LIS	$3.8 \cdot 10^7$
^{132}Sn	100	"	LIS	$3.1 \cdot 10^7$
^{132}Te	100	"	LIS	$8.4 \cdot 10^8$
^{130}Sn	83	"	LIS	$1.6 \cdot 10^8$
^{134}Te	97	"	LIS	$2.3 \cdot 10^8$
^{94}Rb	75	"	SIS	$2.7 \cdot 10^8$
^{91}Rb	100	"	SIS	$1.9 \cdot 10^9$
^{92}Rb	100	"	SIS	10^9
^{138}Cs	76	"	SIS	$2.4 \cdot 10^9$

From the LOIs
3° Int. SPES Workshop

Cappella degli Scrovegni
Giotto

Thank you