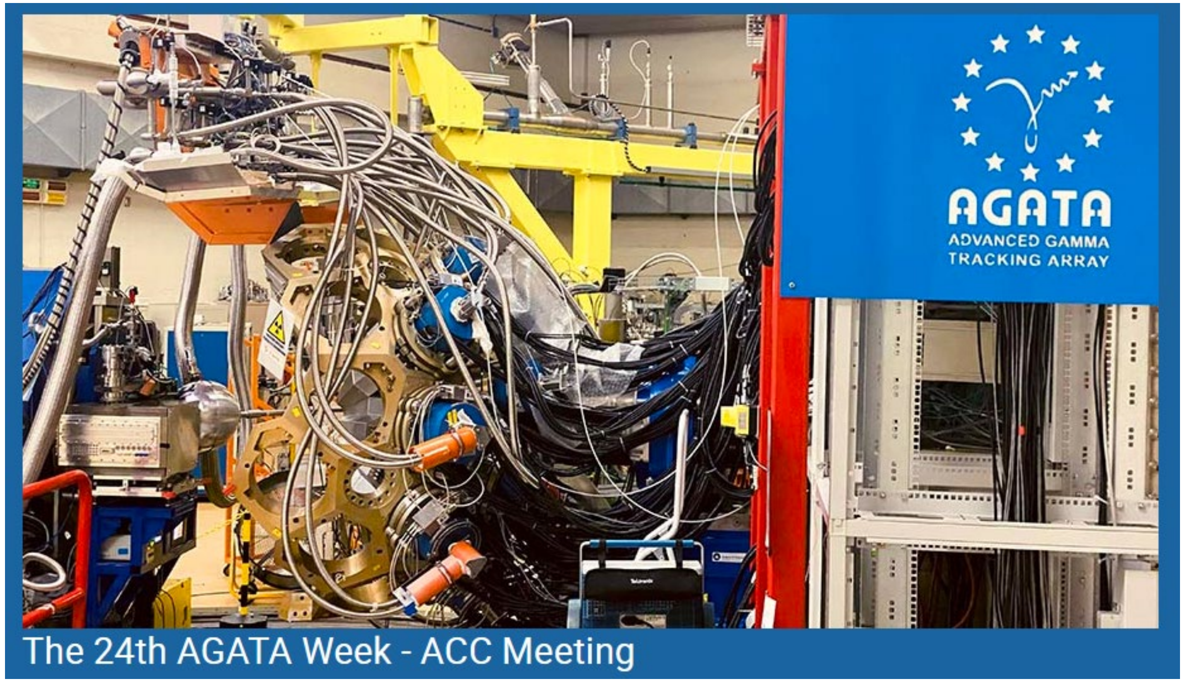
Status of the SPES project at LNL

T. Marchi



Milano – September, 9th 2024

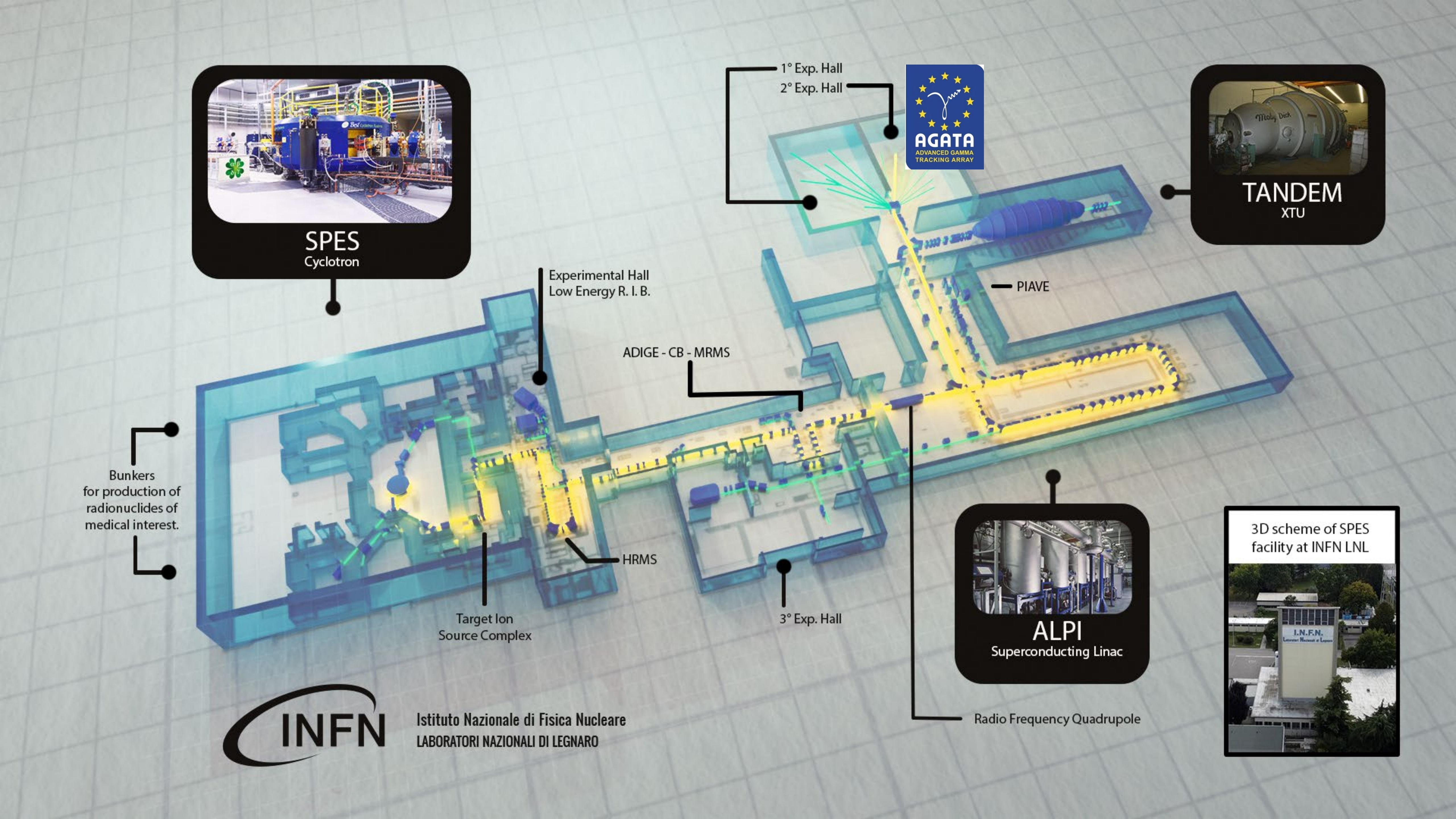
Summary – an update with respect to May 2023 (23rd AGATA week)

1. A phased approach for the SPES project implementation

2. Report on *phase 1* completion

3. Status of *phase 2*

4. Outlook


SPES
Cyclotron
1° Exp. Hall
2° Exp. Hall
AGATA
ADVANCED GAMMA TRACKING ARRAY
TANDEM
XTU
Experimental Hall
Low Energy R. I. B.
PIAVE
ADIGE - CB - MRMS
Bunkers
for production of
radionuclides of
medical interest.
HRMS
Target Ion
Source Complex
3° Exp. Hall
ALPI
Superconducting Linac
3D scheme of SPES
facility at INFN LNL
I.N.F.N.
Radio Frequency Quadrupole
INFN
Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

Infrastructure completion

STATUS of the main deliverables for the SPES infrastructure as presented to this community in May 2023

(SPES-α)

Hot topics – BUILDING :

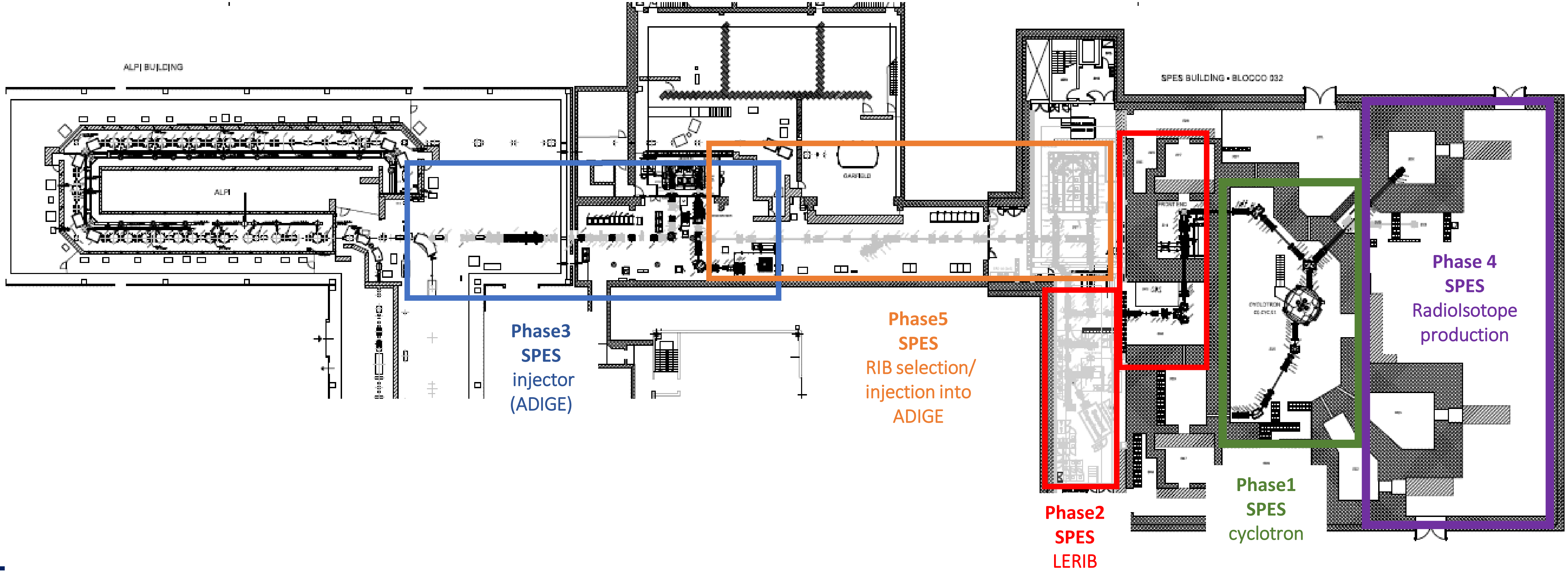
1. Water sealing ✓
2. Fire prevention authorization compliance *IN PROGRESS*
3. Basic plants completion (LOTTO2) ✓
4. Shielding doors upgrade ✓
5. Finishing of the surfaces
6. Completion of the civil construction works *IN PROGRESS*

Hot topics – cyclotron :

1. Upgrade of the cooling system ✓
2. Integration of the control system *Testing phase*
3. Delivery and installation of the BL2 ✓

SPES new phased approach

- Phase1: operation of the SPES cyclotron
- Phase2: Commissioning of the ISOL low-energy radioactive beams
- Phase3:Complete the ADIGE new injector and RFQ for ALPI (SPES post-accelerator)
- Phase4: Radioisotope production facility
- Phase 5:Commissioning of post-accelerated radioactive beams (SiC target)



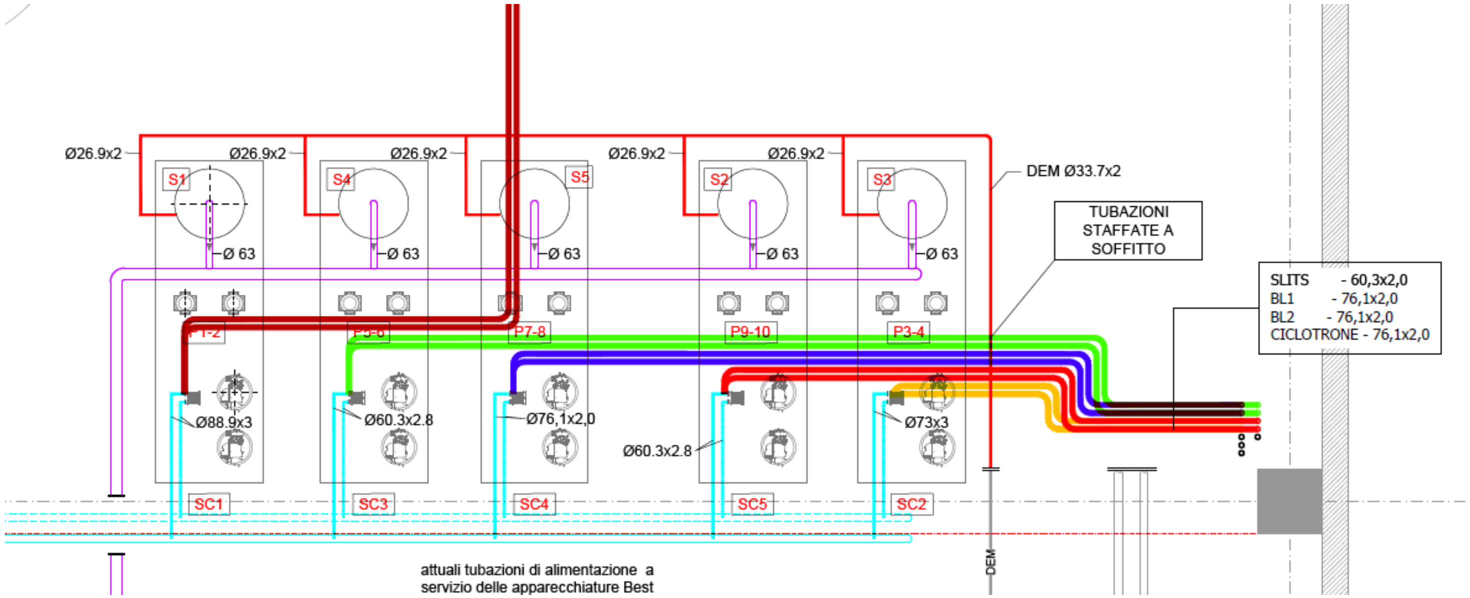
Phase 1

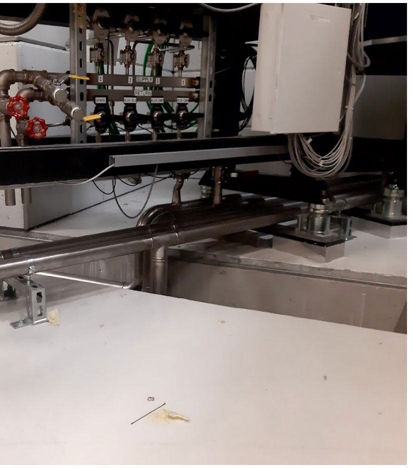
n and related plants – main upgrades completed

- Finishing of the surfaces
- Fire prevention integration in the ventilation system
- Installation of the BL2 beamline
- Upgrade of the cooling skids and water circuits
- Complete revamping of the cyclotron's control system

- Irradiation bunker and pre-bunker shielding doors replacement

of the cyclotron’s Cooling plants





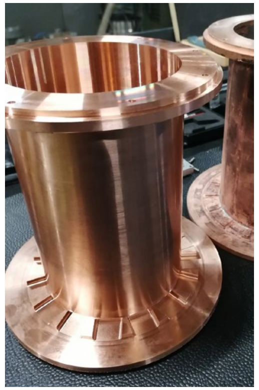
Installation of five different circuits to better manage the heat-load and to minimize the amount and path of activated water.

the issues we had to go through: the cyclotron’s ion source and RF amplifier refurbishment

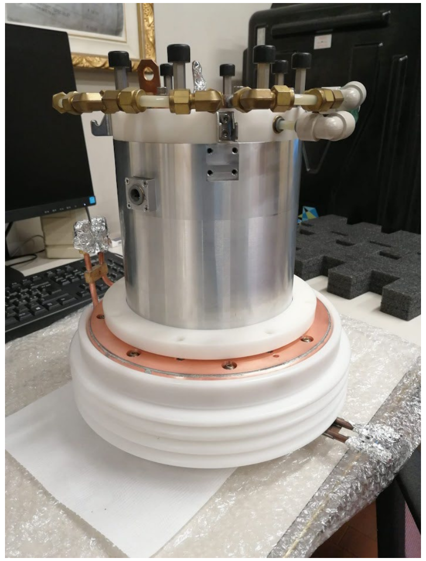
Intrinsic weakness due to unsafe brazing -> **a backup solution is needed**

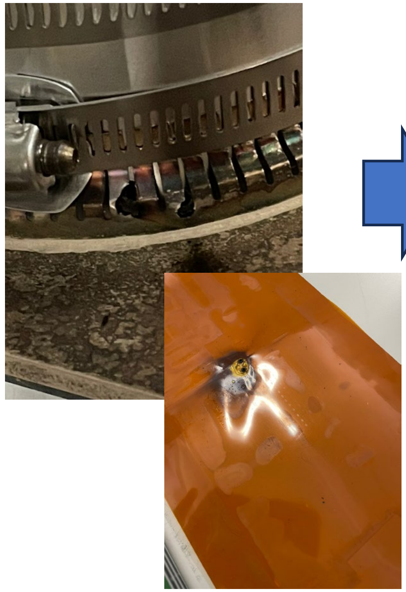
Plasma chamber machined from a single piece of material

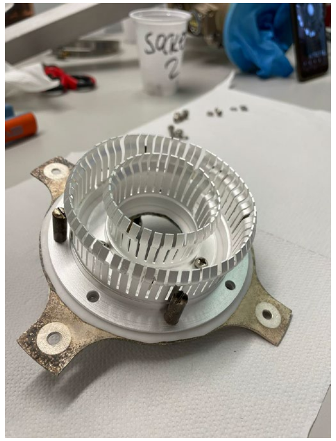
Al dummy



Cu final production







v ’23 | Dec ’23 | Jan ‘24 | Feb ‘24 | Mar ‘24 | May ‘24 | Beam delivered

of a
k in
ma
er.

Dismounting and assessment of the problem.

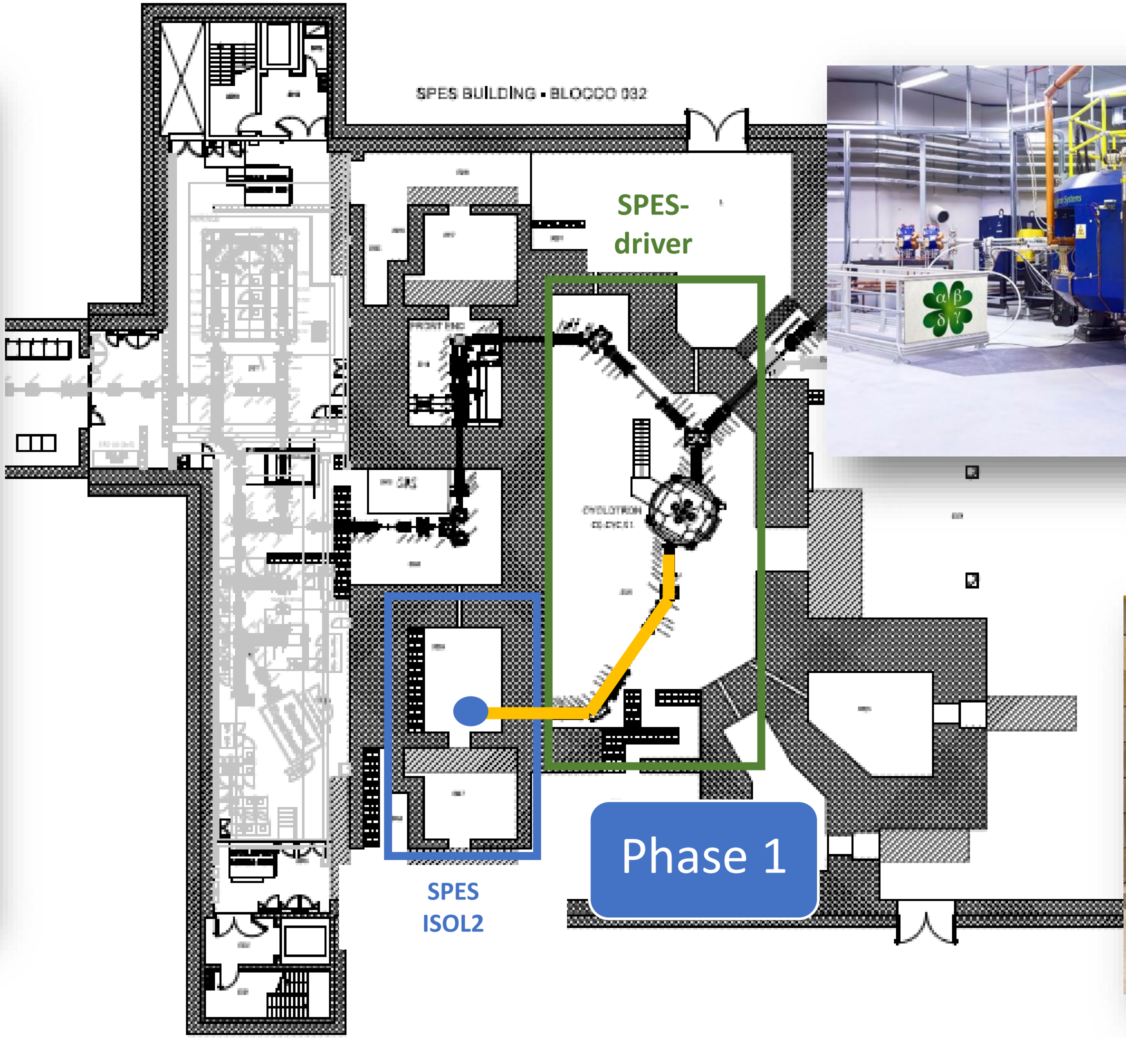
Reverse engineering and machining of an Al dummy chamber.

Assembly of the source using the new chamber. Magnets and o-rings are also replaced.

Offline and online tests of the repaired source.

RF amplifier issues identified. Possibile cause: humidity in the rack. Restoring of the finger, new Ag coating, humidity control.

t completion: beam delivered May 2024



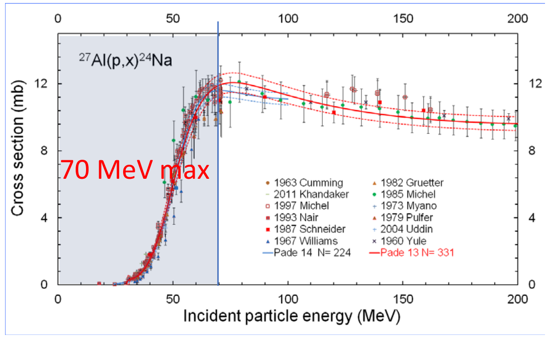
adiation runs with 35, 50 and 70 MeV protons

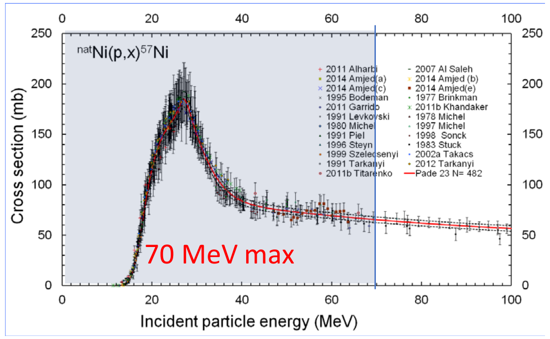
acterization process using IAEA
ons
.iaea.org/medical/monitor_reactions.html

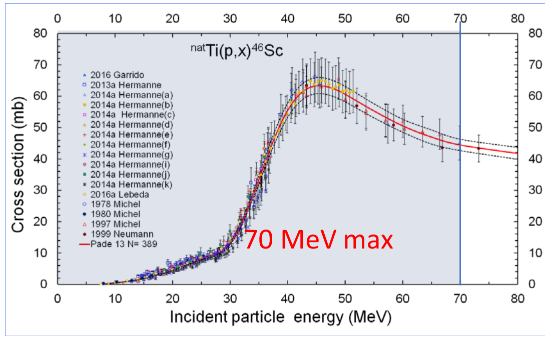
$^{nat}Al(p,x)^{22/24}Na$

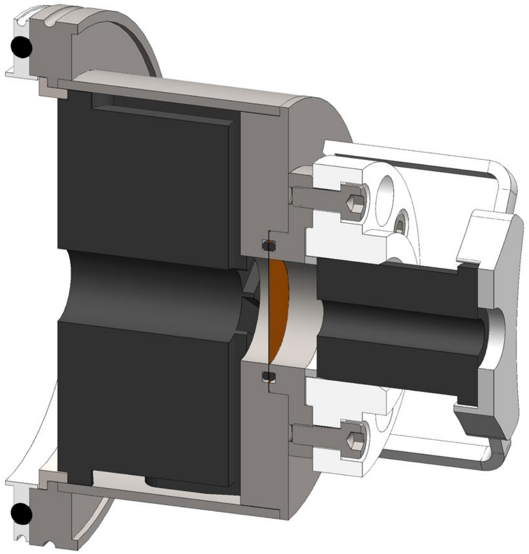
$^{nat}Ni(p,x)^{57}Ni$

$^{nat}Ti(p,x)^{46}Sc$

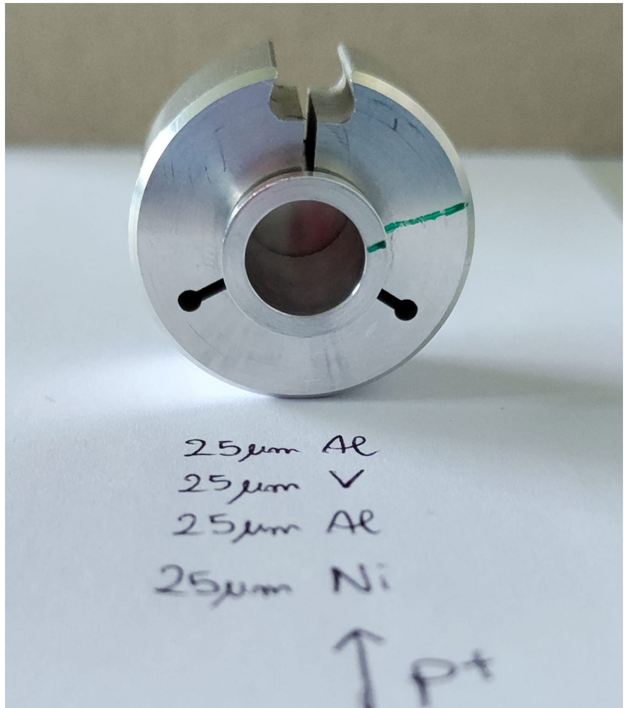








Scheme of the graphite collimators and kapton window



Target holder and scheme of the stacked-foils

t completion

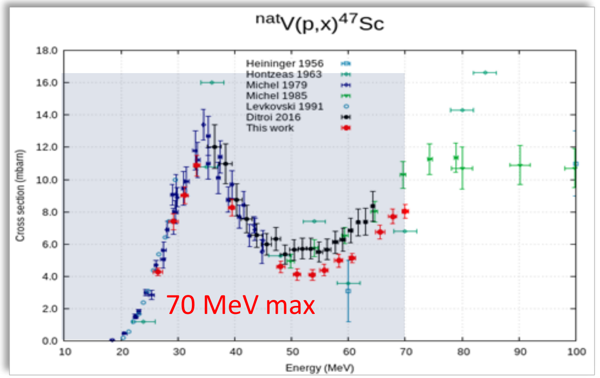
acked-foils target composed by: 25 μm Al, 25 μm V, 25 μm Al, 25 μm Ni

30.05.24: EP = 34.67 MeV; Calculated IP = 73 nA

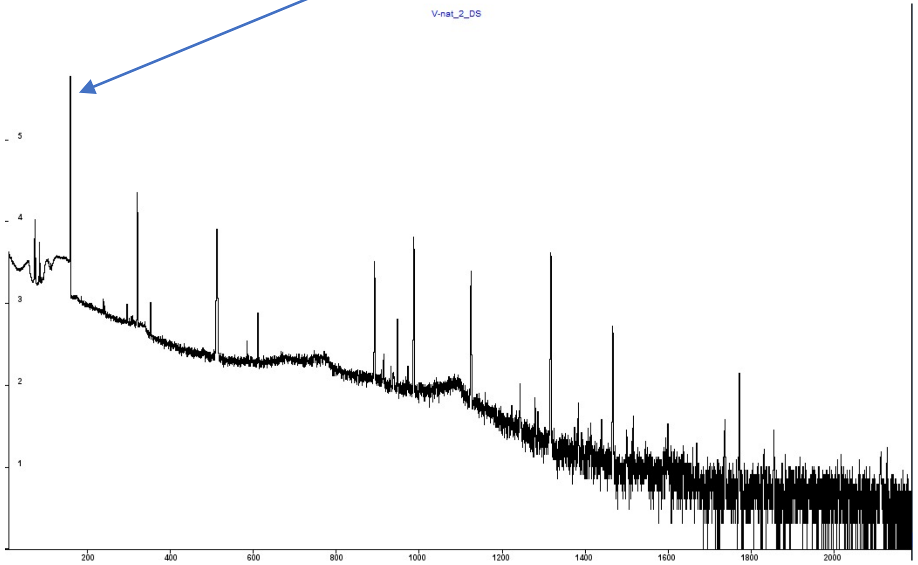
run 03.06.24: EP = 70.00 MeV; Calculated IP = 50 nA

Remeasuring xs for ^{47}Sc production route

$^{nat}V(p,x)^{47}Sc$

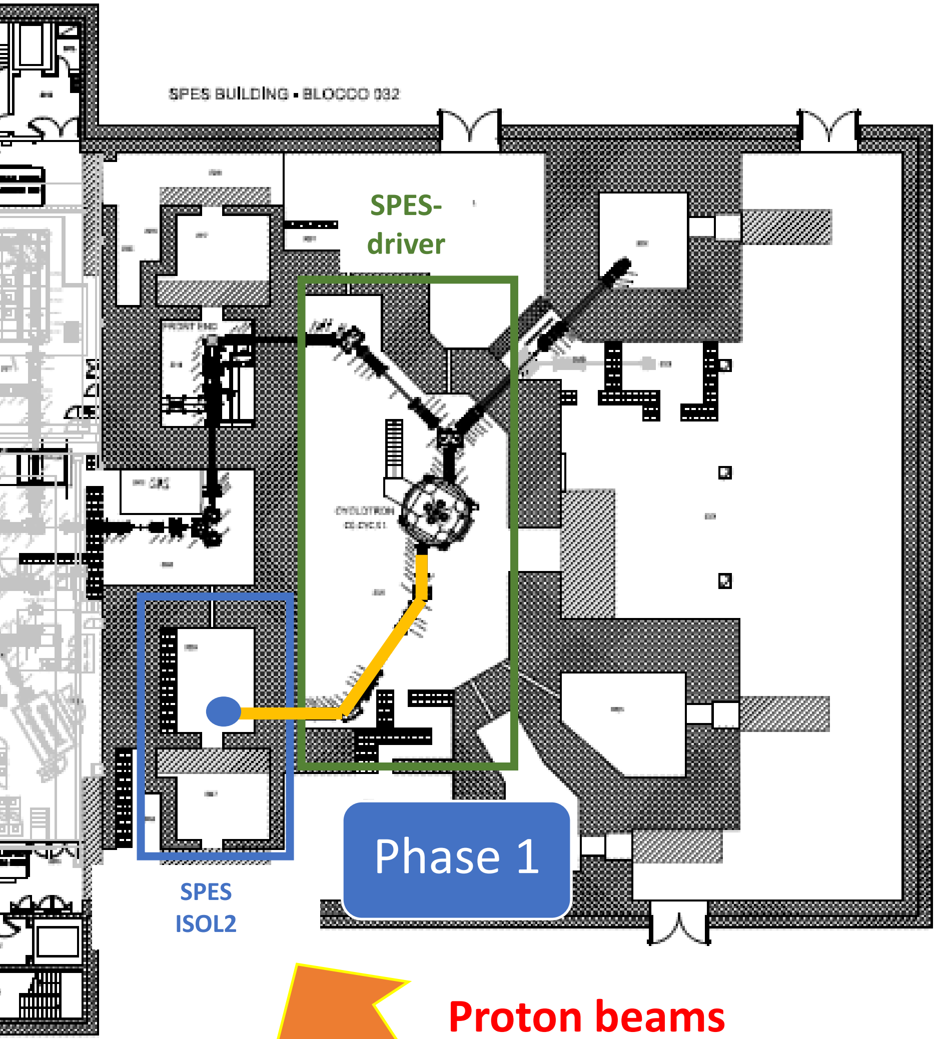


159 keV γ-line from ^{47}Sc



Gamma-spectrometry of the ^{nat}V sample irradiated with 35 MeV (semilog scale)

pportunities 1: proton beams

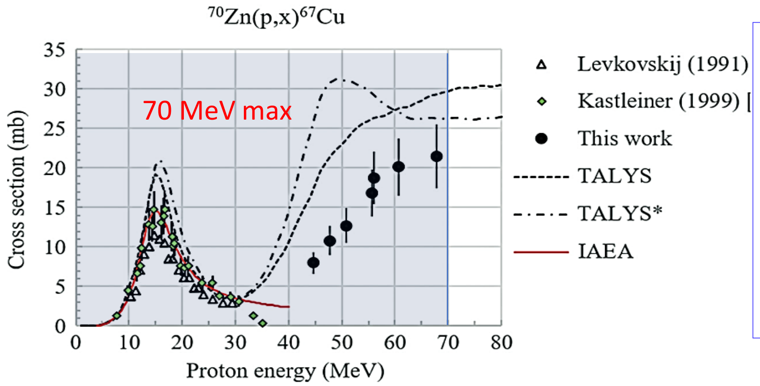


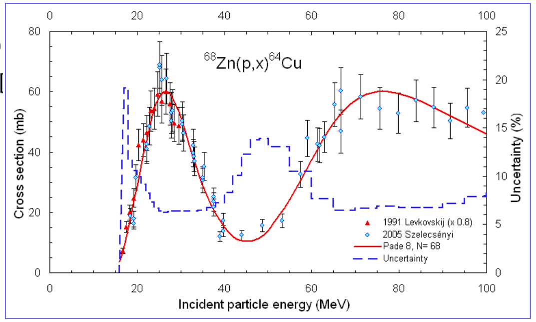
Proton beams
E: 35-70 MeV, I > 50-100 nA

Remeasuring xs for ^{67}Cu production route

$^{68}Zn(p,x)^{67/64}Cu$

$^{70}Zn(p,x)^{67/6}4Cu$



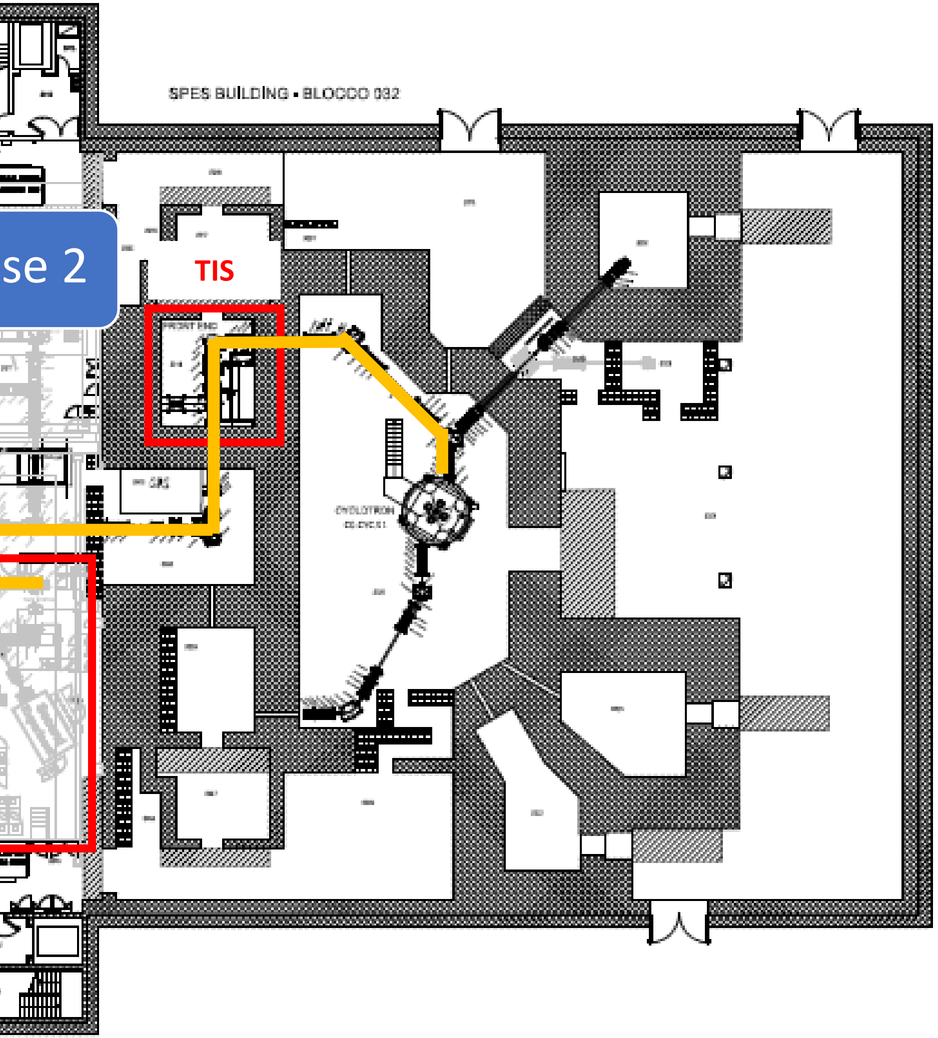


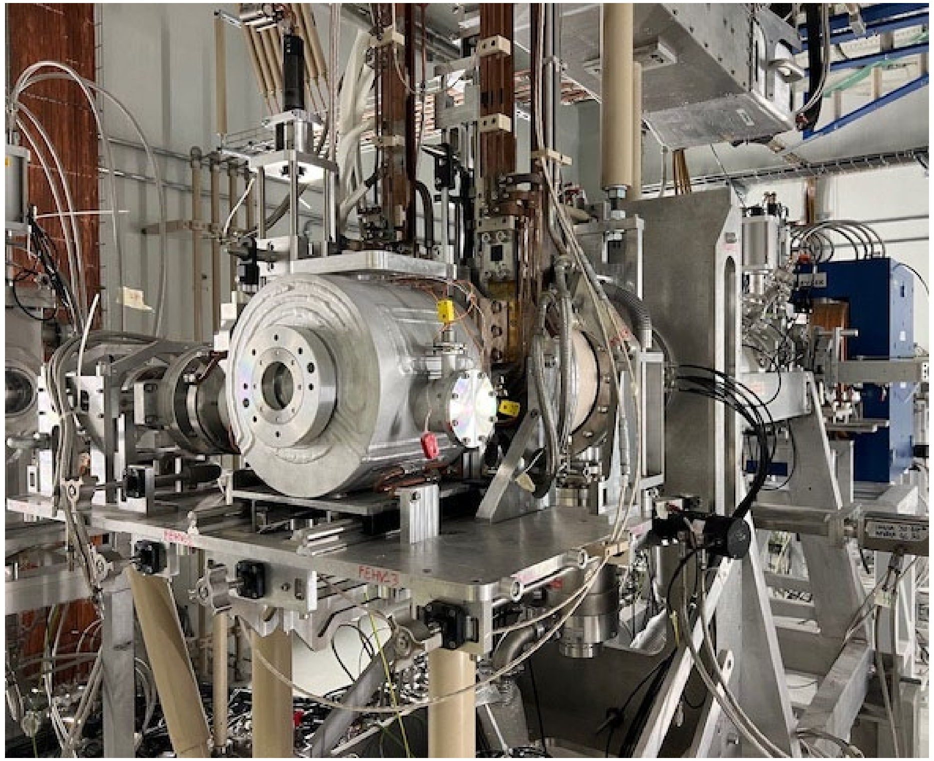
And: 159Te(p,5n)155Dy->155Te

Phase 2

rm physics opportunities 2: 40 keV RIBs

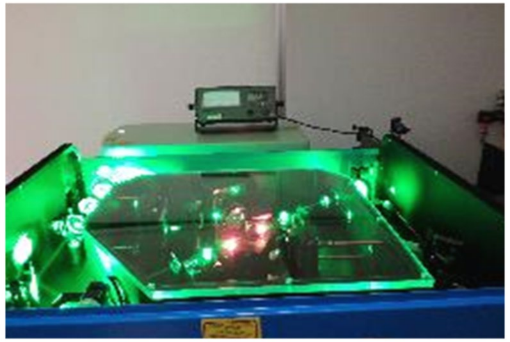
se 2





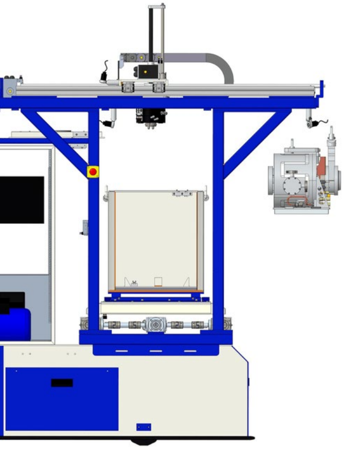
S Target Ion Source

Aux plants:
-HV plants
-Ground plants
-TSS machine



l, all systems are being tested.

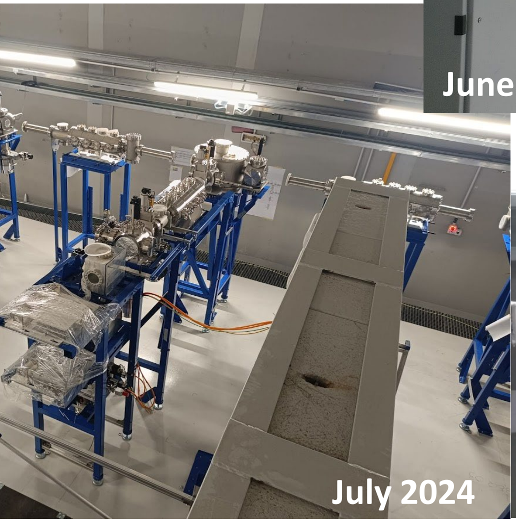
Handling of Target-Ion-Sources ready and tested



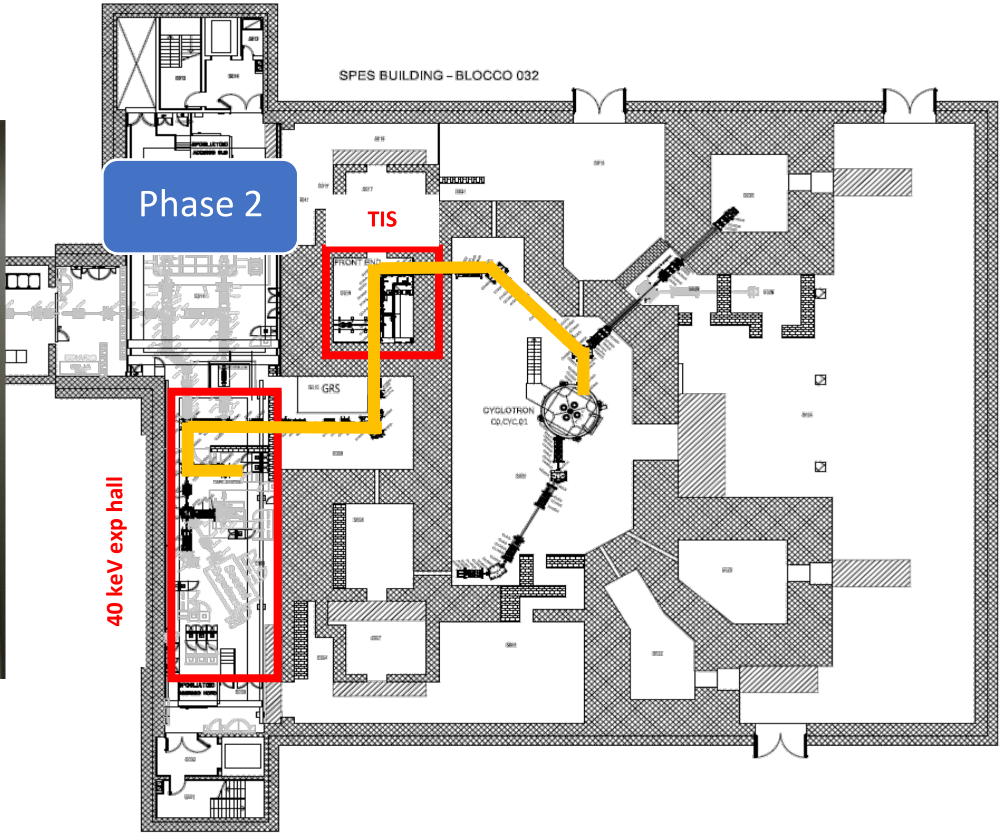
Irradiated Target-Ion-source Storage System : ready and oprational

4) – The Low Energy Radioactive beam-line installed

June 2024



July 2024

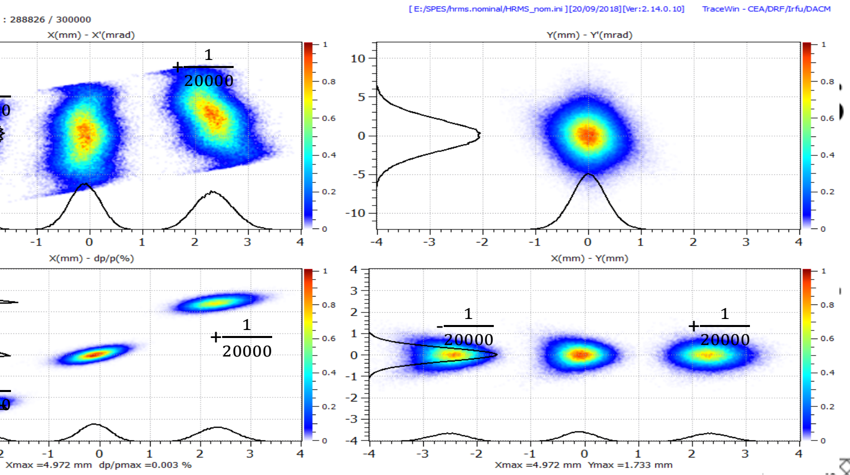


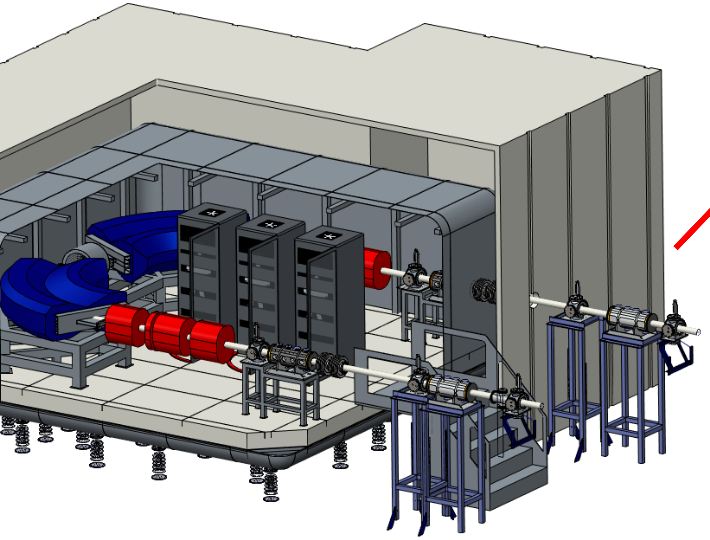
Phases 3 – 5

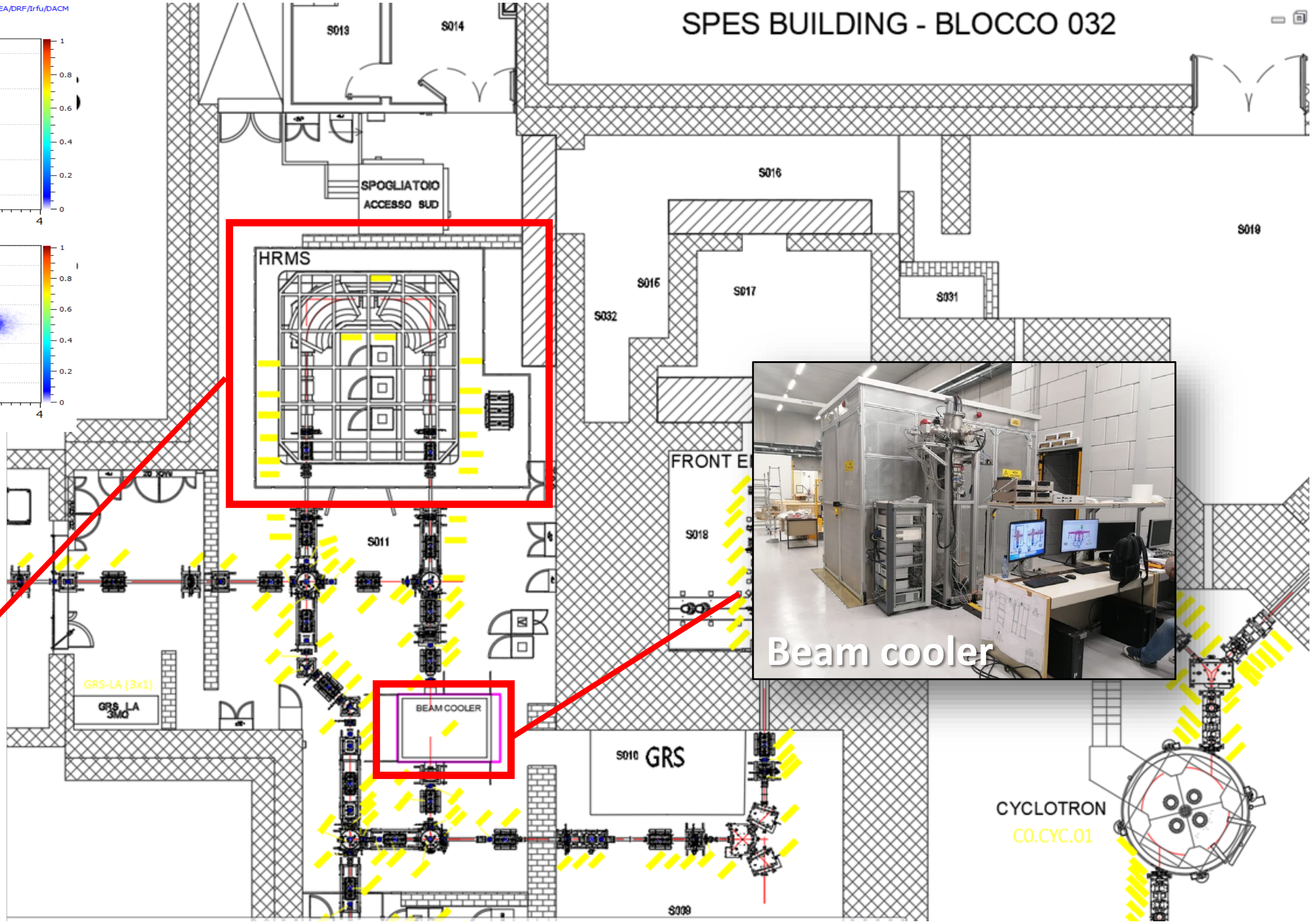
Activities noninterfering with phase 2 are carried on

solution Mass Separator and Beam Cooler

formance: beam separation of 1/20000



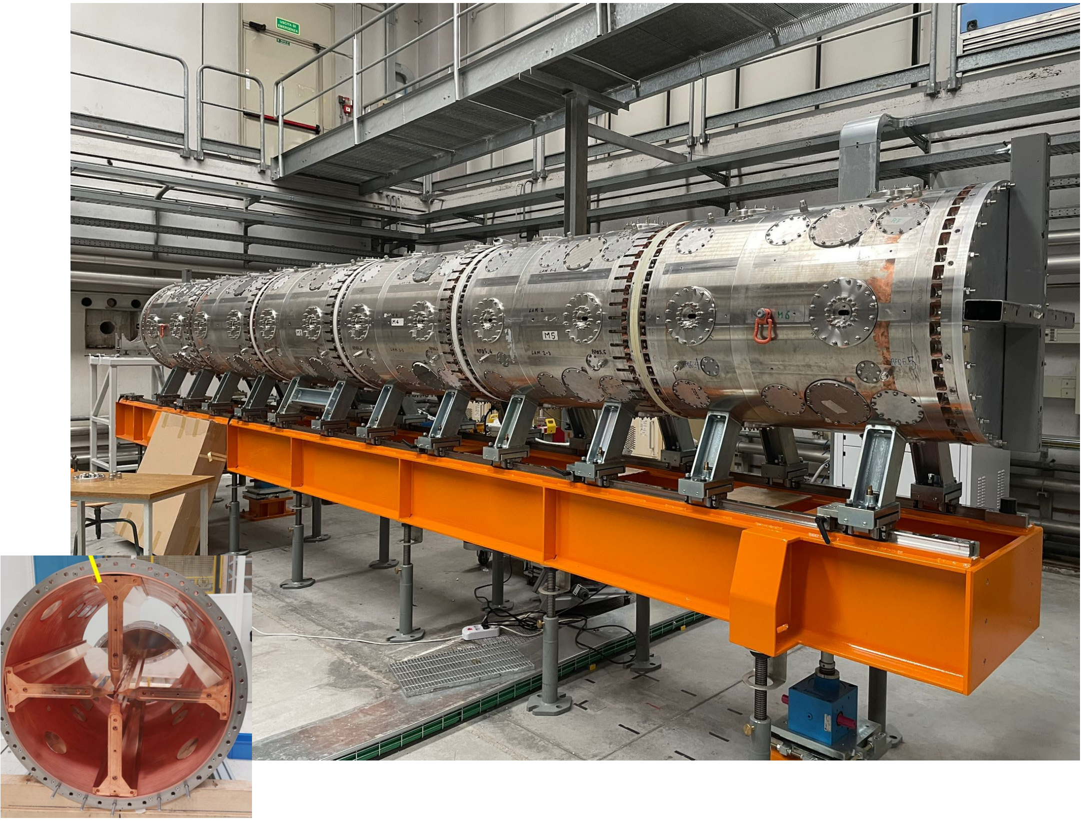


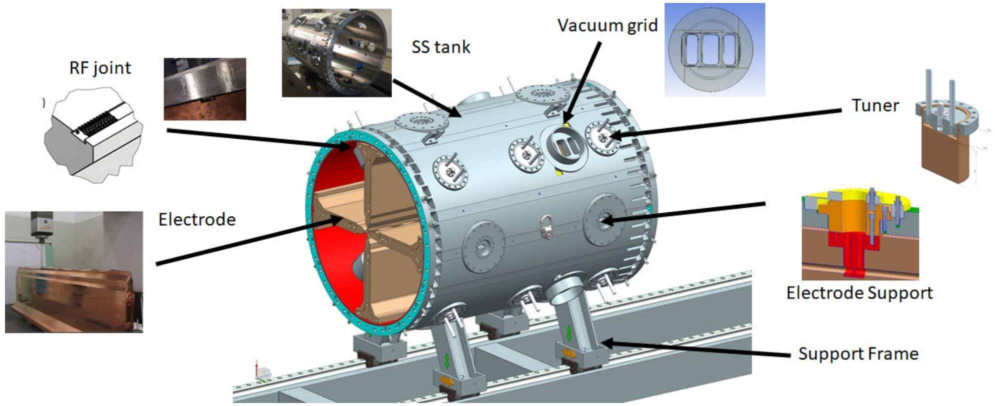


Q

is designed to accelerate beams in CW with A/q ratios from 3 to 7.
mposed of 6 modules about 1.2 m long each.

Paramater [units]	Design value
Frequency [MHz]	80
Duty Cycle [%]	100 (CW)
In/out. Energy [keV/u]	5.7-727 (β=0.0035-0.0359)
Intravane voltage [kV]	63.76-85.85 (A/q=7)
Beam current [mA]	0.1
Vane Length [m]	6.95
R_0[mm]	5.29-7.58
ρ/R_0	0.76
Synchronous phase (deg.)	-90 ÷ -20
Focusing Strength B	4.7 ÷ 4
Transmission [%]	94
Output Long RMS Emit [keV deg /u]	4.35
Q0 value	14000
Dissipated Power in the cavity [kW]	100
RF power [kW]	120
Tank Radius R [mm]	377





3 phased approach

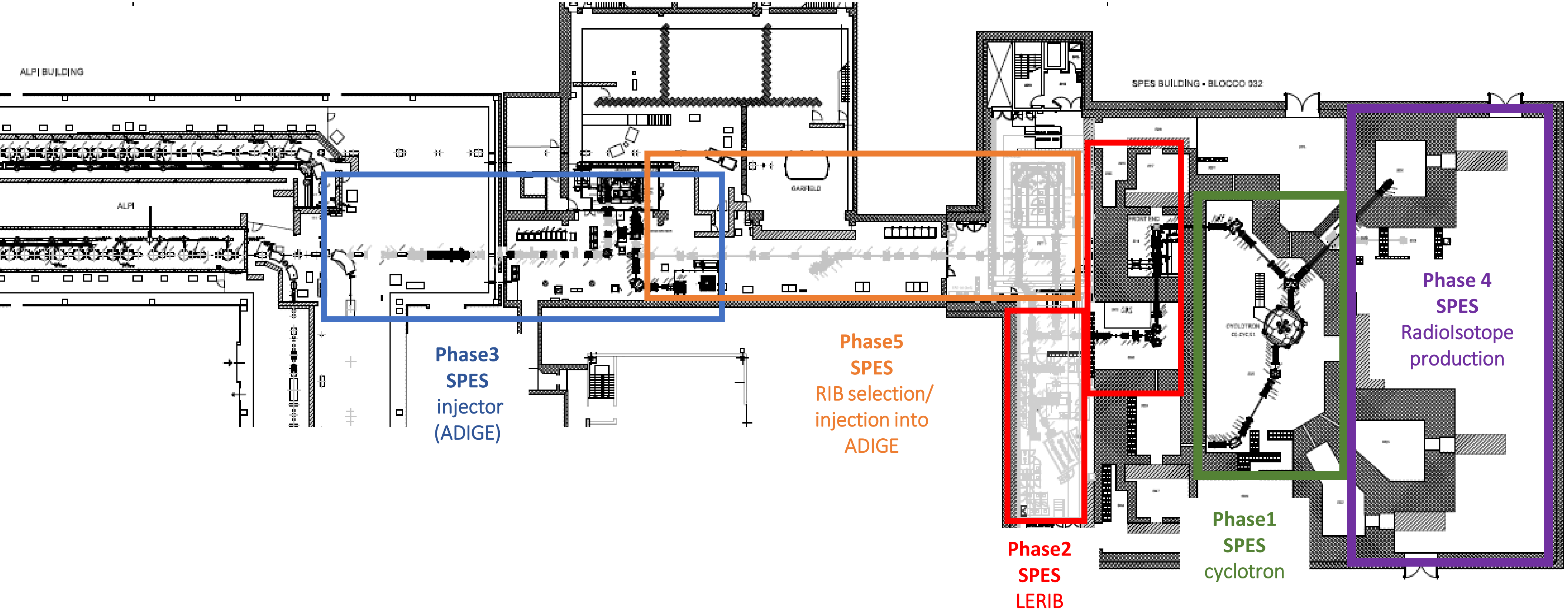
operation of the SPES cyclotron April 2024 and first experiment May 2024

Commissioning of the ISOL low-energy radioactive beams: early 2025

omplete the ADIGE new injector and RFQ for ALPI (SPES post-accelerator): early 2026

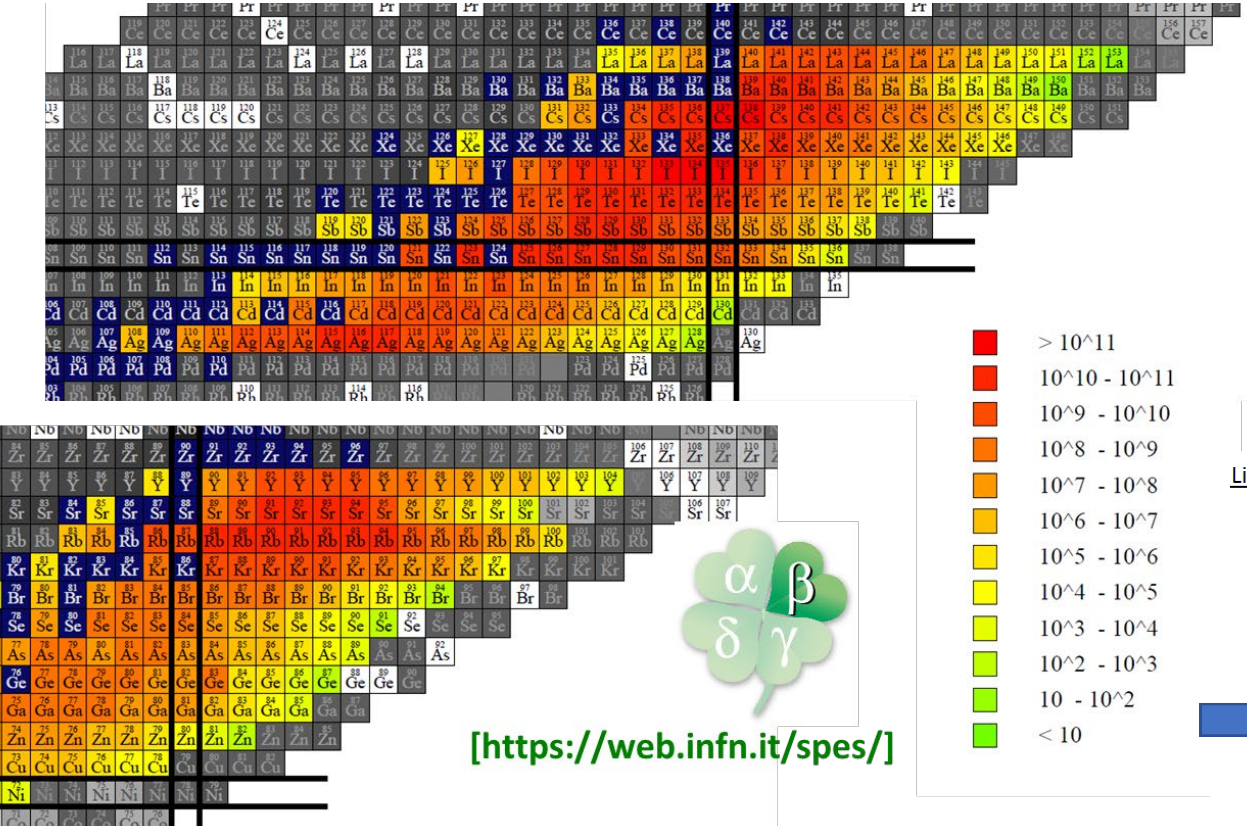
Radioisotope production facility : end 2027

Commissioning of post-accelerated radioactive beams (SiC target): mid 2027

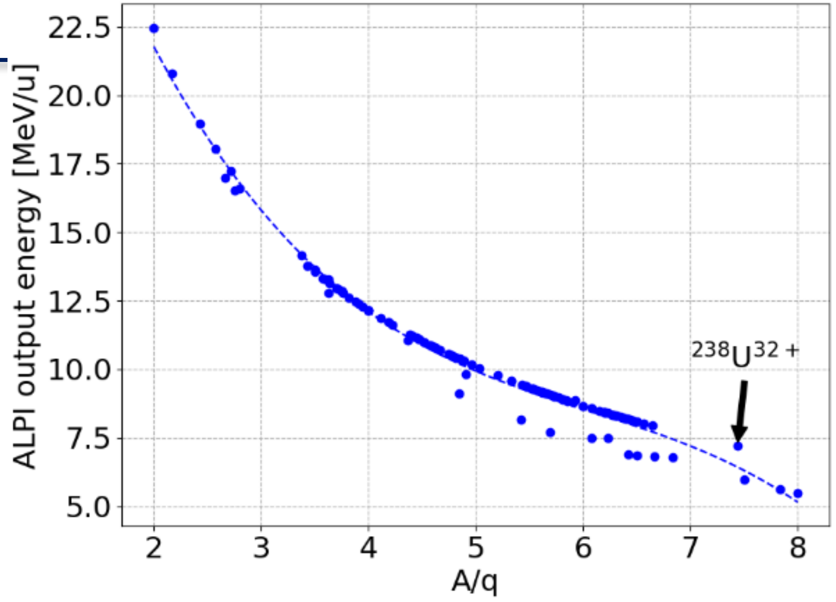


INFN

l goal for SPES RIBs @ LNL



[https://web.infn.it/spes/]



List of possible first SPES beams:

Primary target	Beam	Intensity (pps)	Max energy (MeV/A)
TiC	43Sc	2,40E+07	10
TiC	44Sc	2,25E+08	10
TiC	42K	3,70E+07	10
UCx	130Sn	3,95E+06	10
UCx	132Sn	7,70E+05	10
UCx	132Te	2,11E+07	10
UCx	132Sb	9,50E+05	10
UCx	134Te	1,50E+04	10
UCx	94Rb	6,80E+06	10
UCx	75Ga	1,10E+05	10

The intensities are to be considered at the target position.