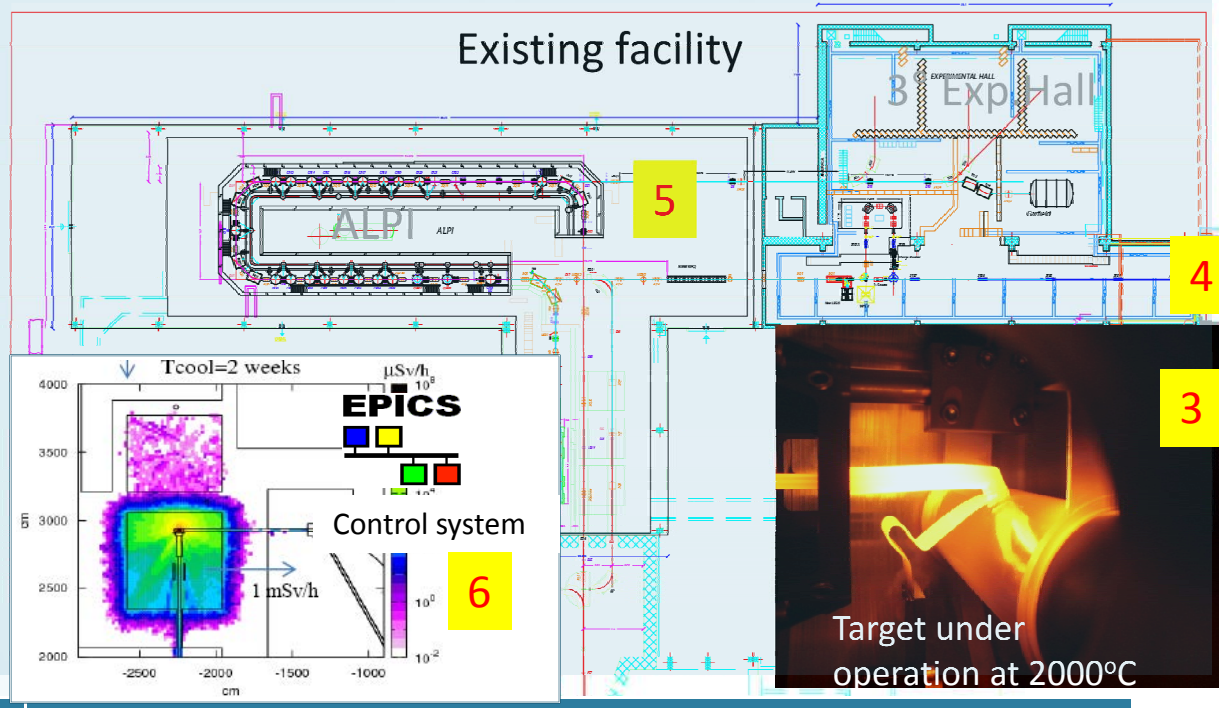
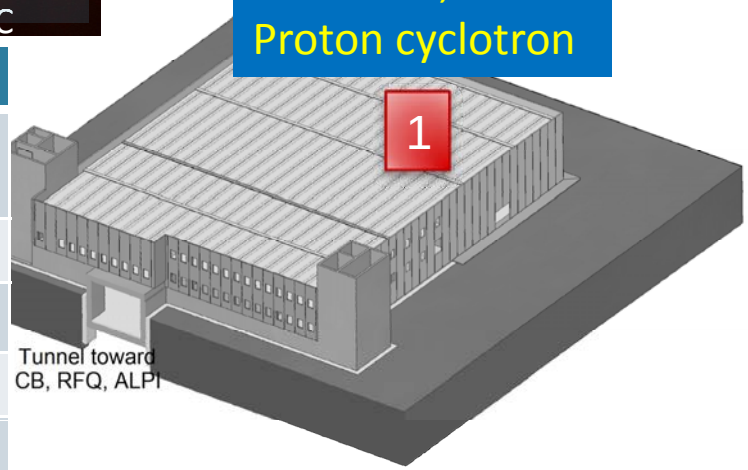
SPES Facility Layout

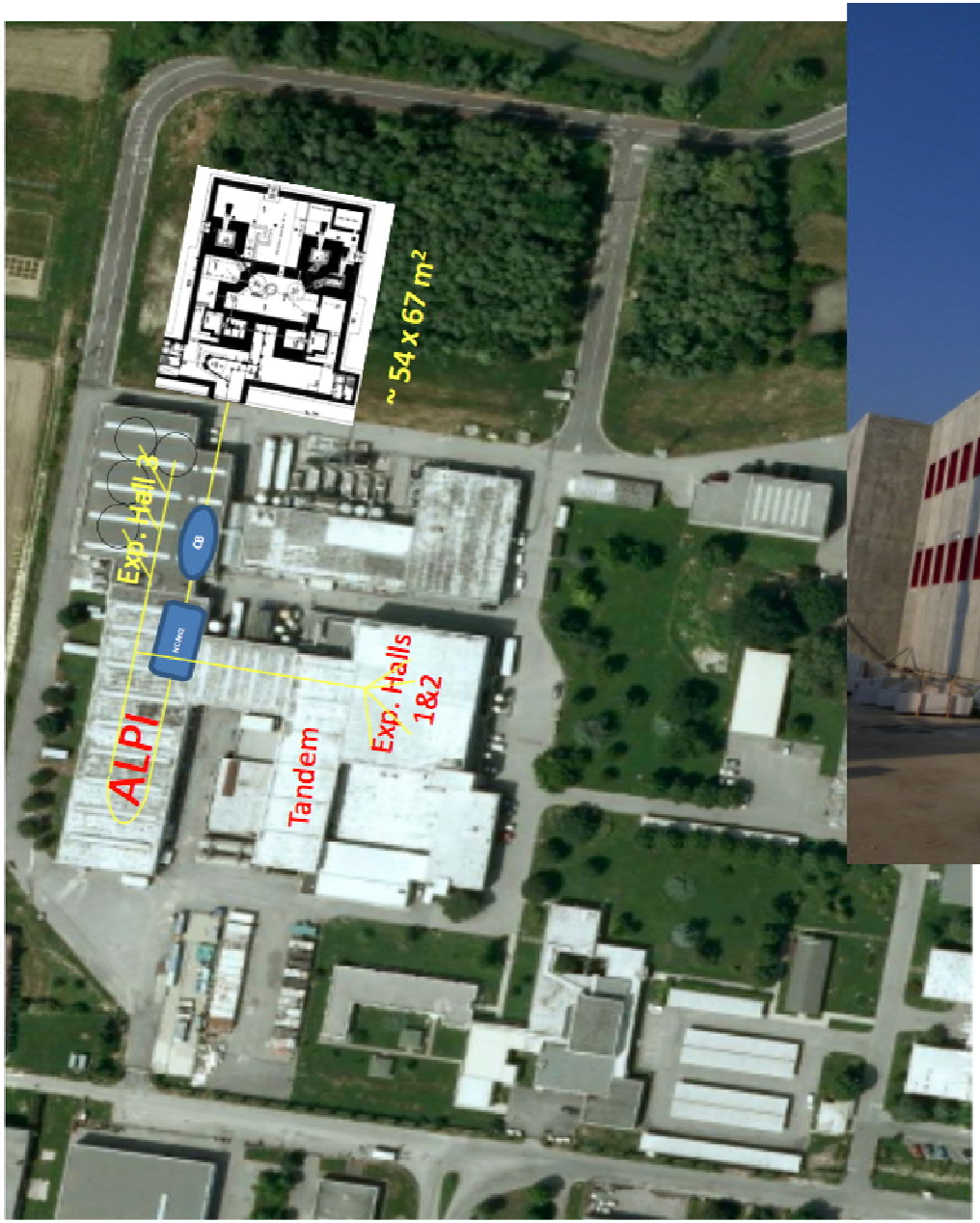


70 MeV 0,75 mA
Proton cyclotron



	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 Facility Layout



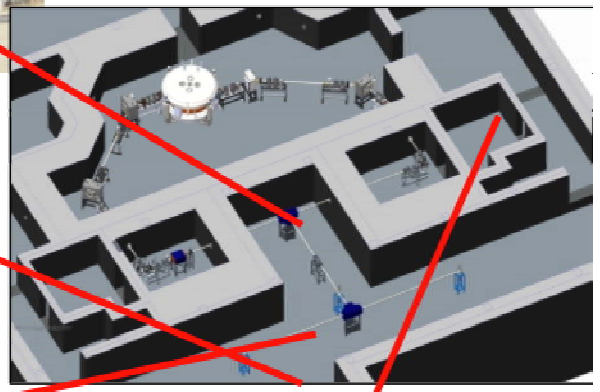
New infrastructure for:

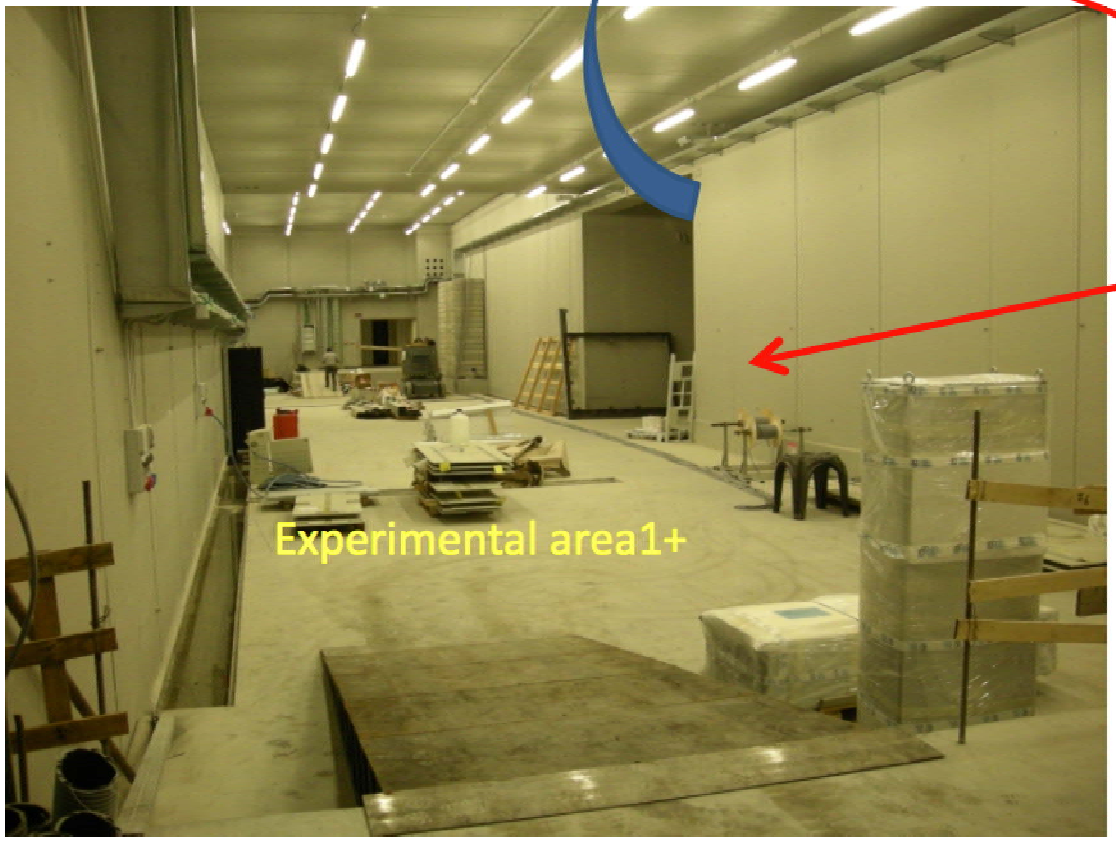
- cyclotron
- RIB (Radioactive Ion Beam)
- application facility

https://www.youtube.com/watch?v=gOcJFW4I6_Q


Toward Sala3

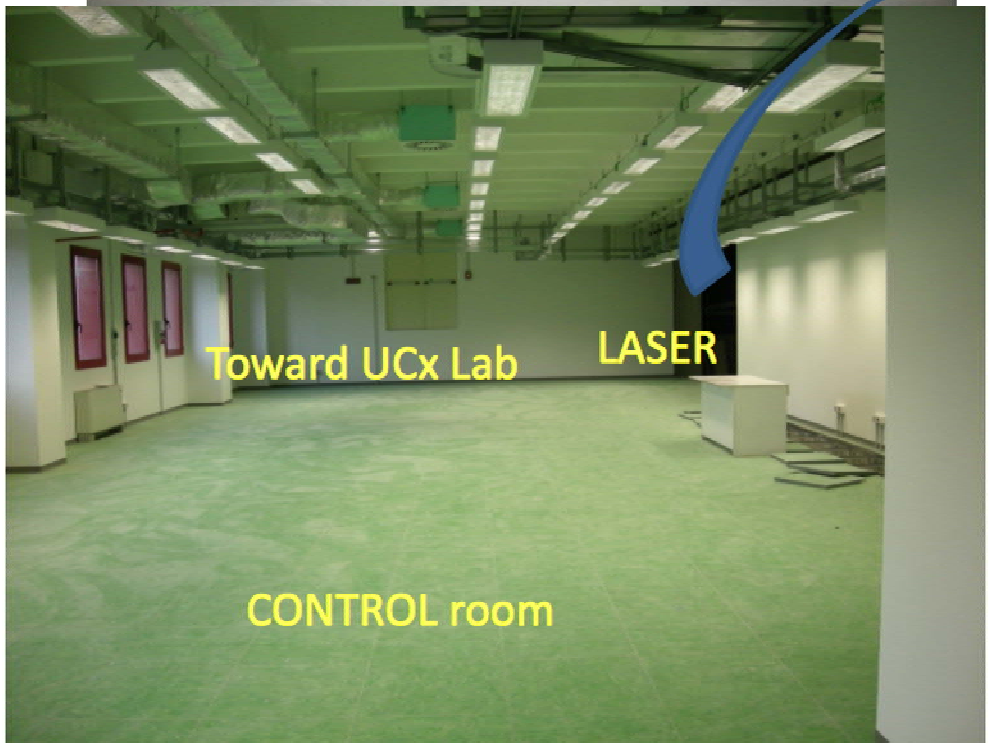

LRMS area



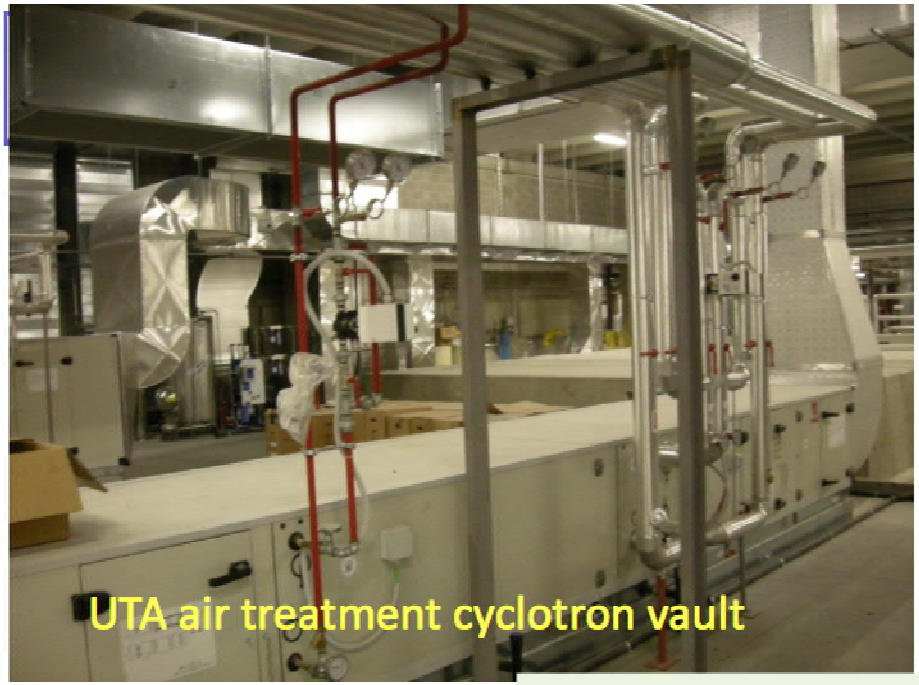

Experimental area1+


Pre-bunker and bunker

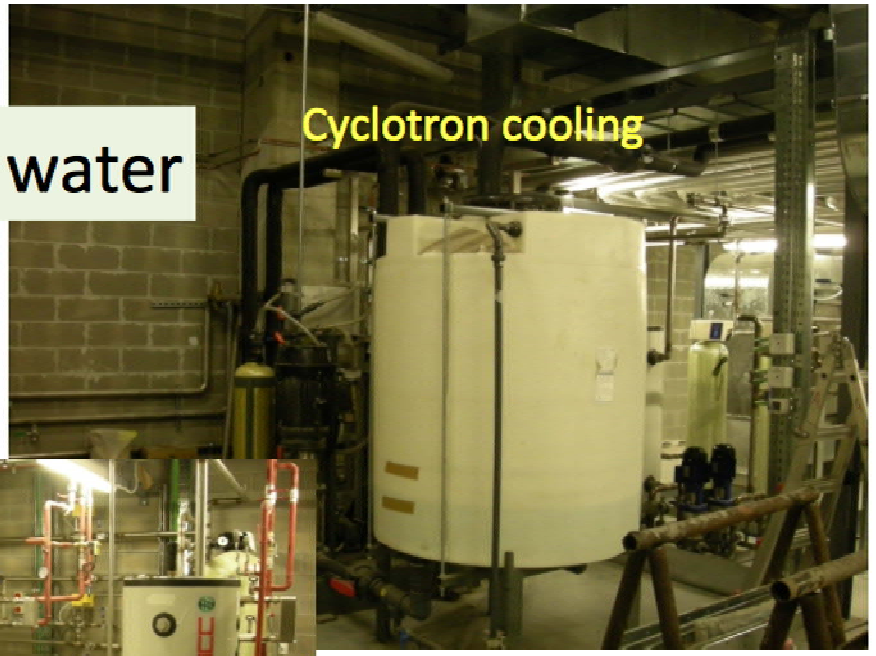
SPES building: LEVEL +1



PLANTS: air and water



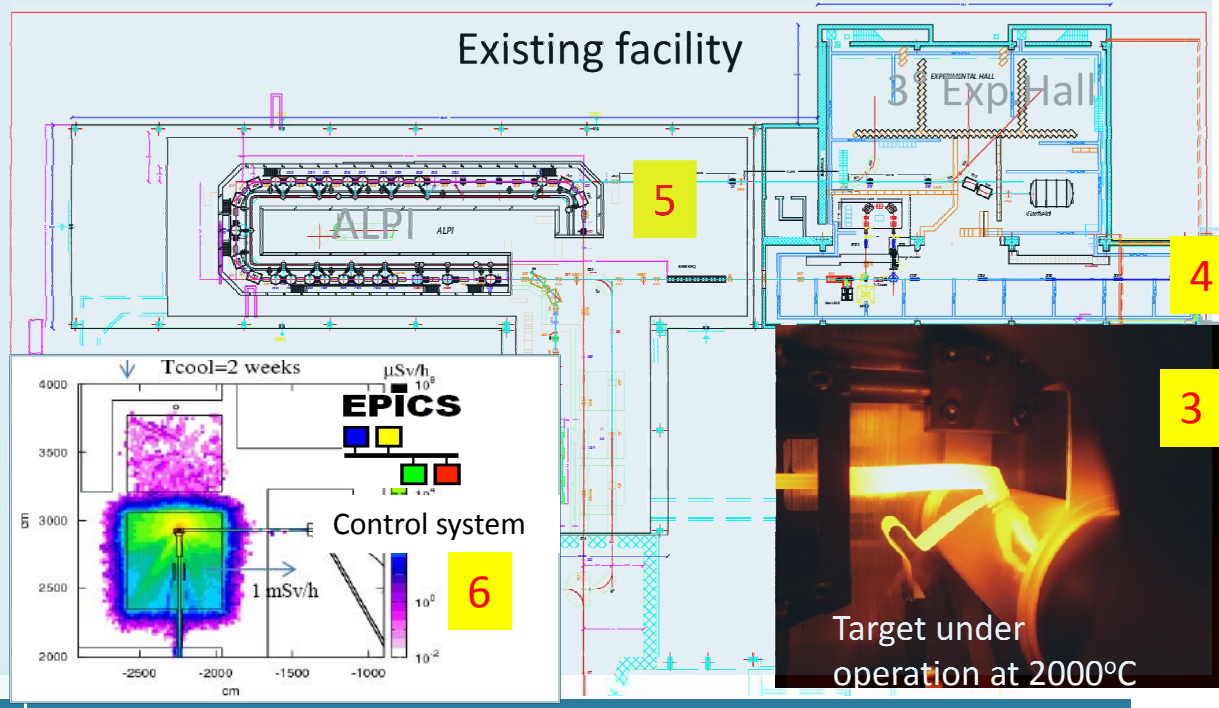
UTA air treatment cyclotron vault



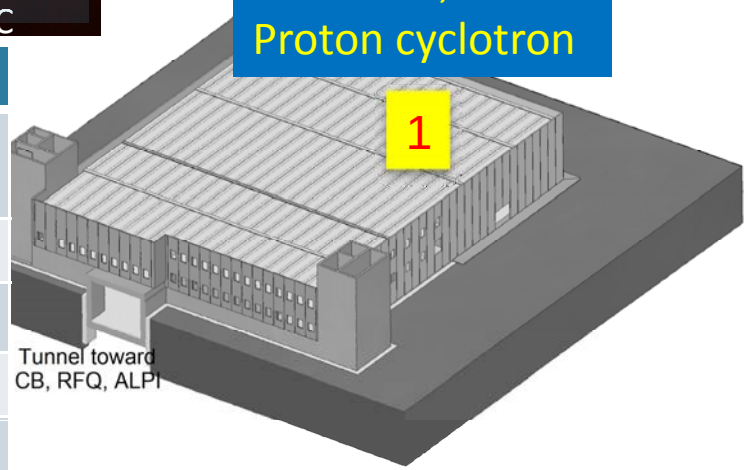
Cyclotron cooling

Moduls for cooling water

SPES Facility Layout

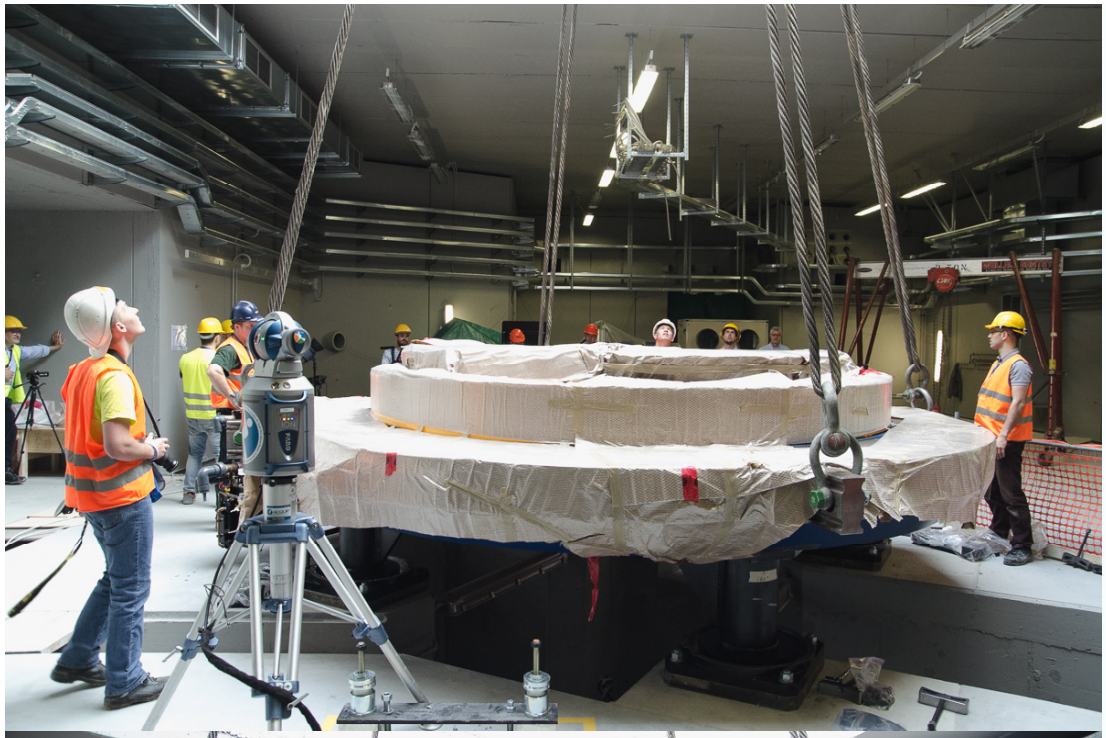


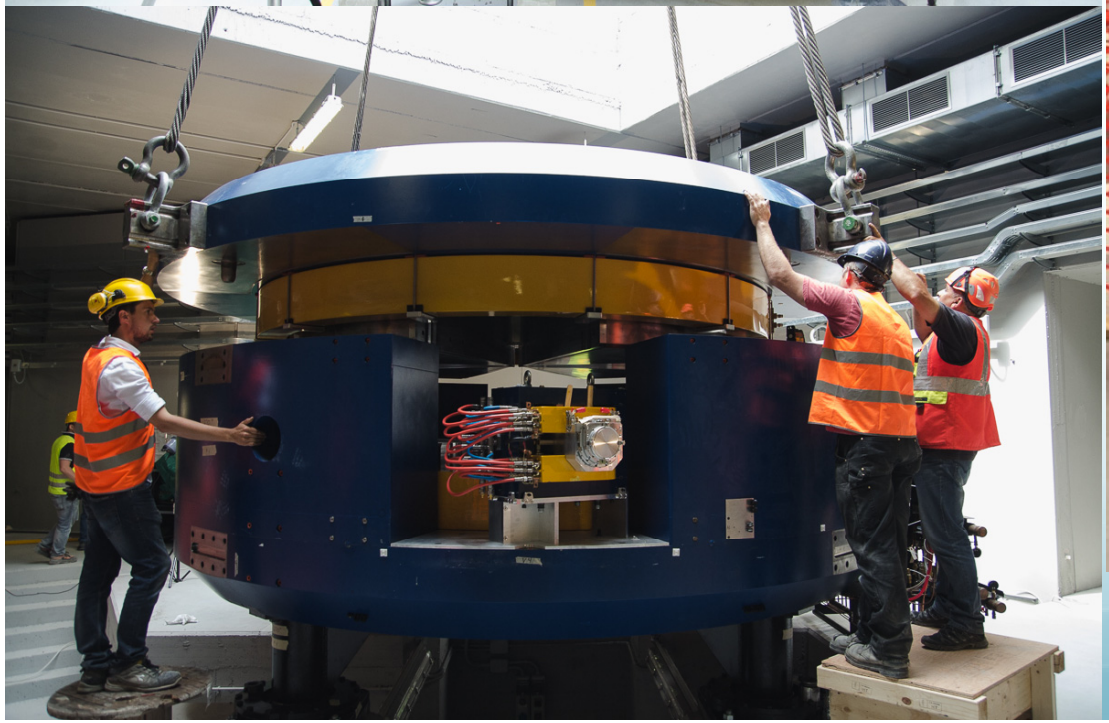
70 MeV 0,75 mA
Proton cyclotron



	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

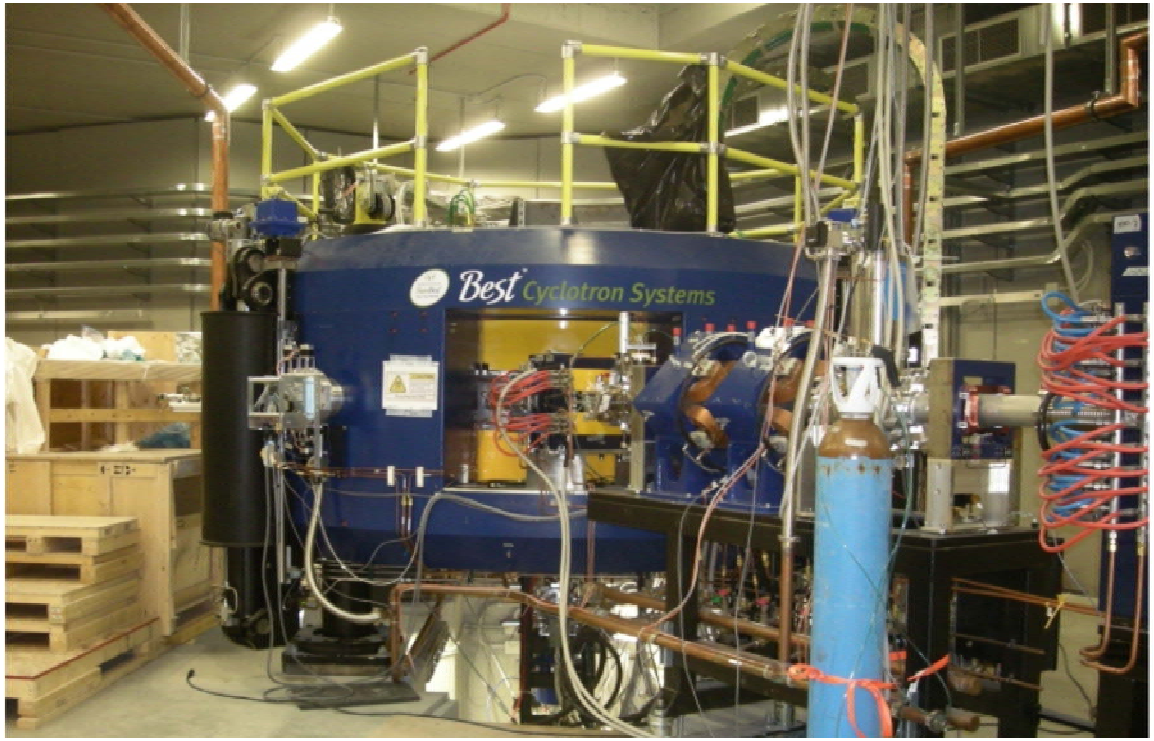
SPES
exotic beams for science



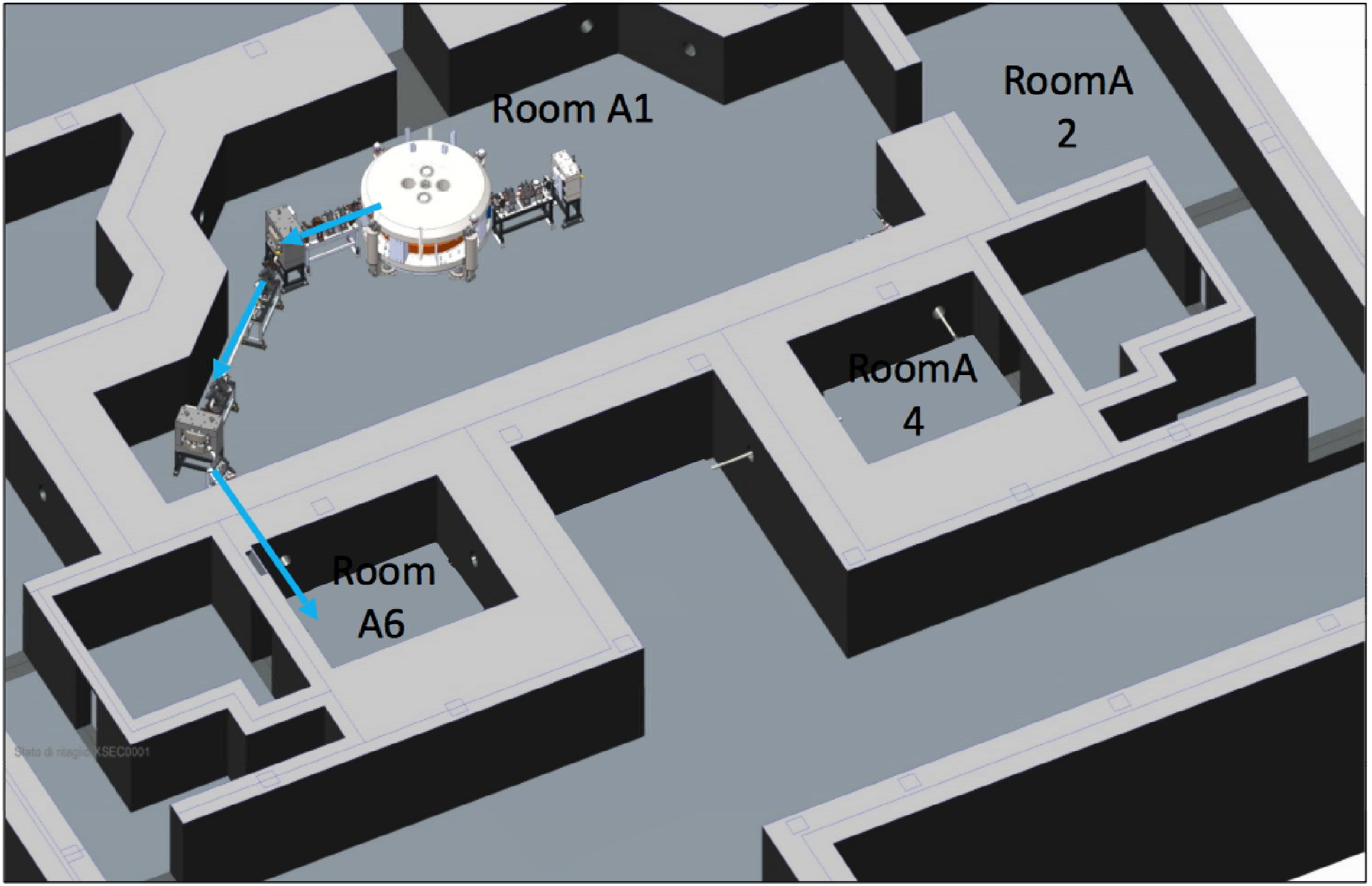


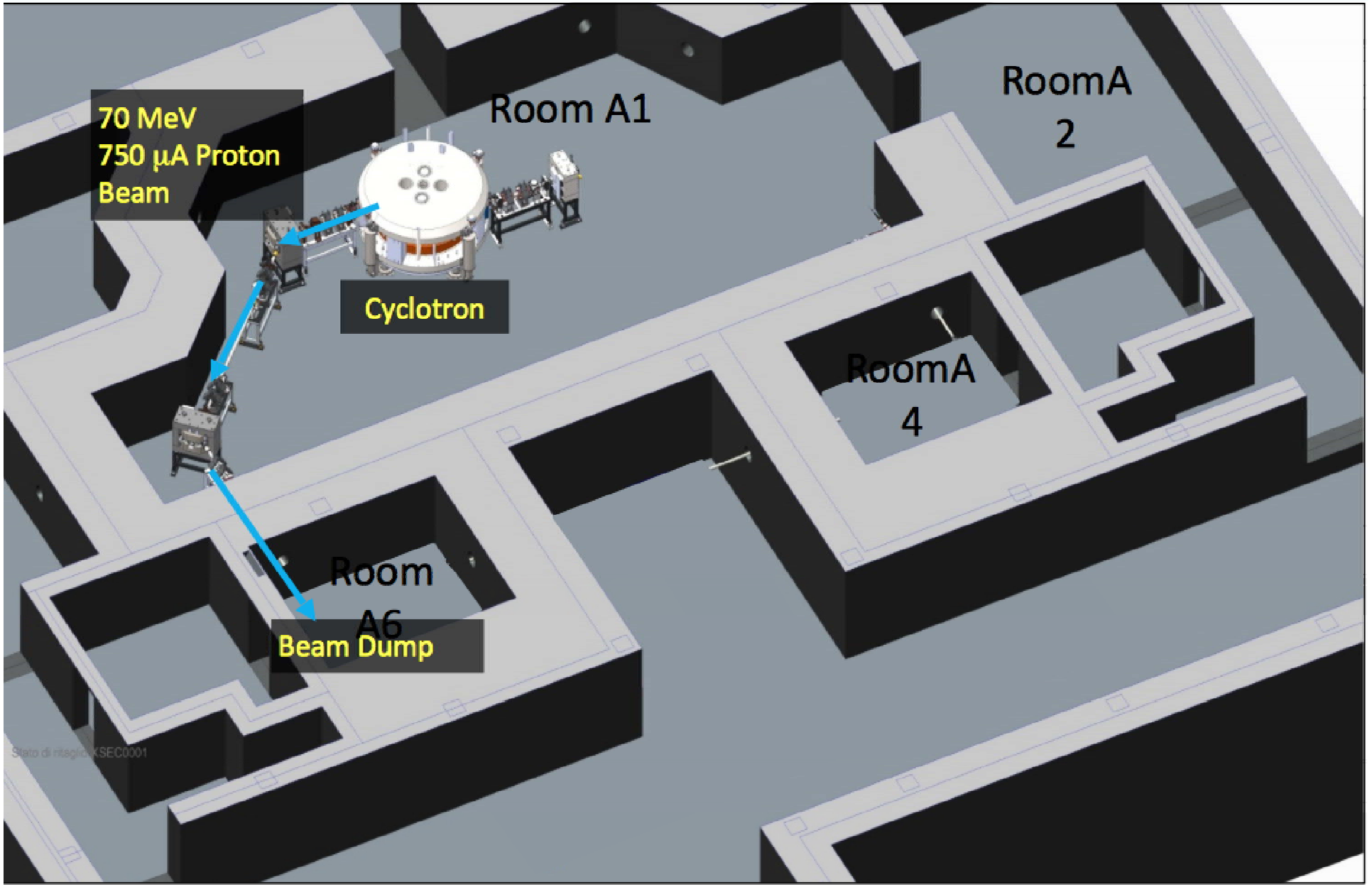
SPES
exotic beams for science

Phase 1: cyclotron installation and SAT

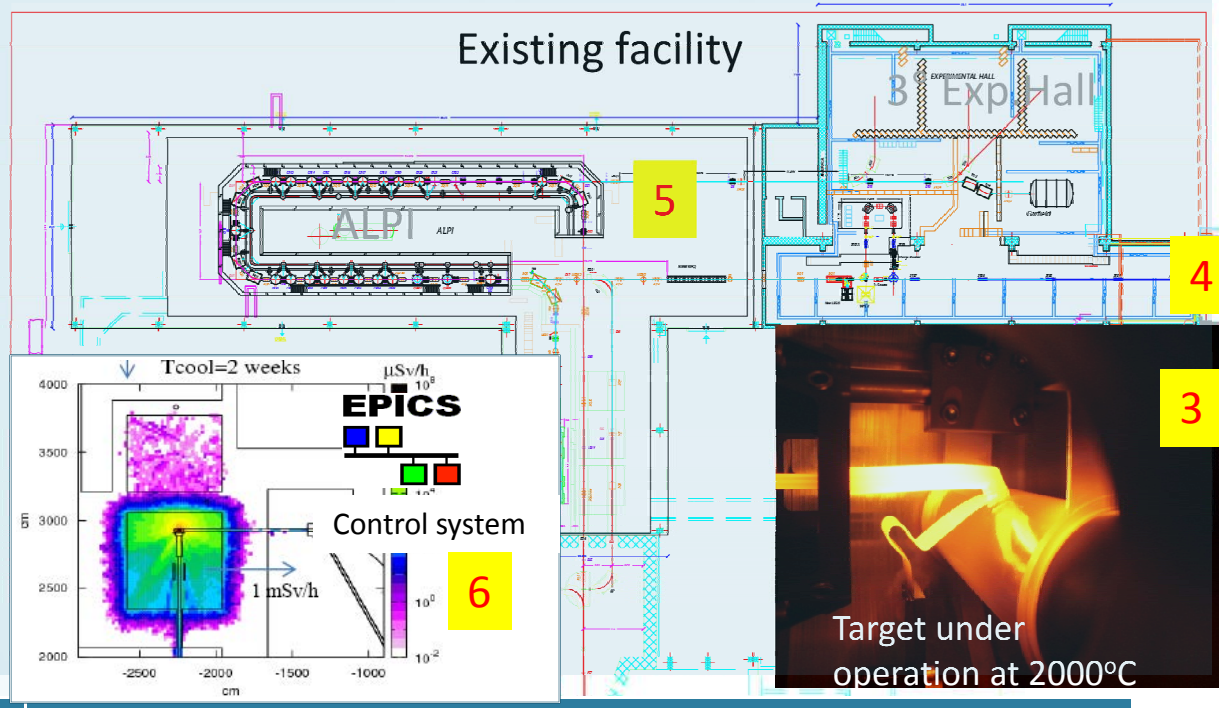


Main Parameters	
Accelerator Type	Cyclotron AVF 4 sectors
Particle	Protons (H^- accelerated)
Energy	Variable within 30-70 MeV
Max Current Accelerated	750 μA (52 kW max beam power)
Available Beams	2 beams at the same energy (upgrade to different energies)
Max Magnetic Field	1.6 Tesla
RF frequency	56 MHz, 4th harmonic mode
Ion Source	Multicusp H^- I=15 mA, Axial Injection
Dimensions	Φ=4.5 m, h=1.5 m
Weight	150 tons

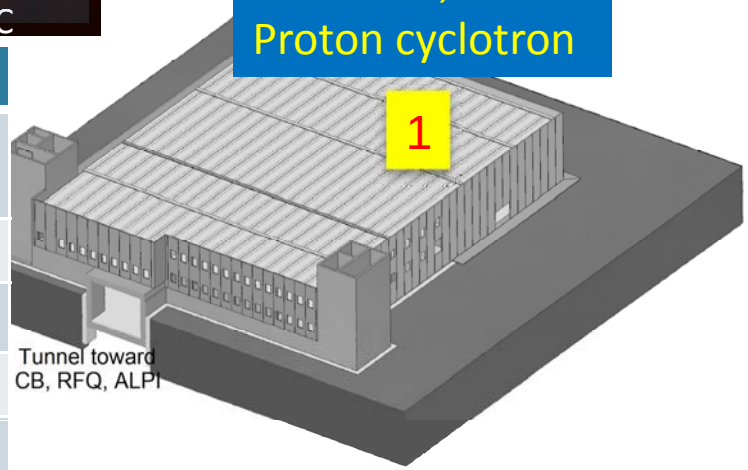

Room A1
RoomA
2
RoomA
4
Room
A6


70 MeV
750 µA Proton
Beam
Room A1
RoomA
2
Cyclotron
RoomA
4
Room
A6
Beam Dump

SPES Facility Layout



70 MeV 0,75 mA
Proton cyclotron



	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

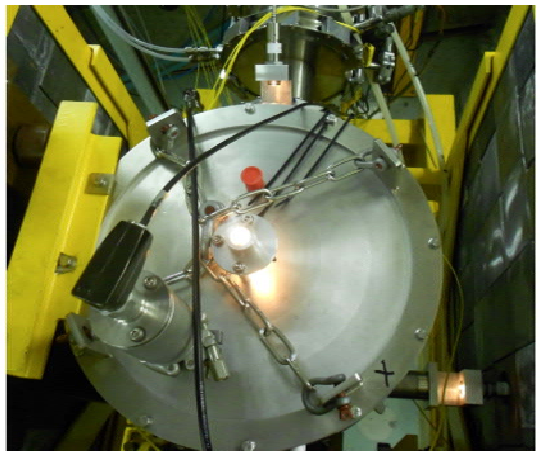
SPES: Target Power test @ iThemba LABS

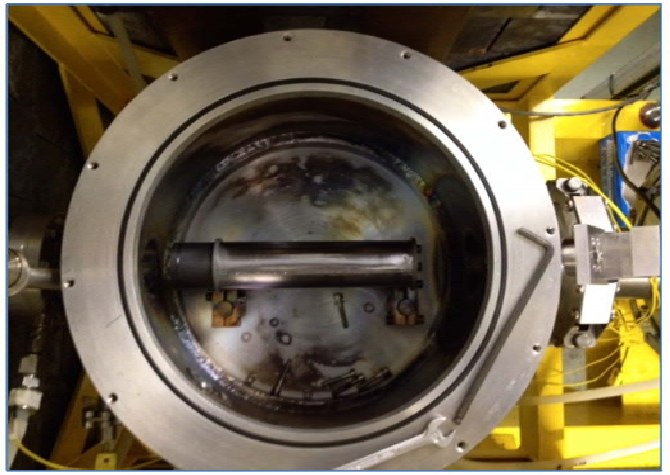
SPES target in-beam power test (SiC target) May 2014

Heater power compensated by proton beam.

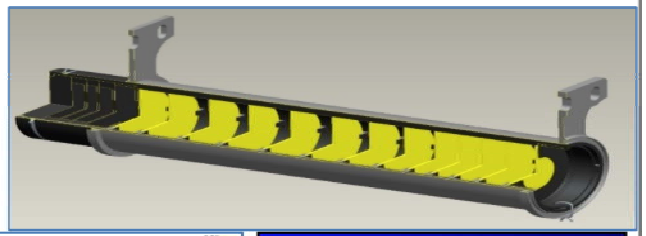
- Up to 4 kW proton beam in target.
- Stable temperatures
- Stable vacuum (3 10^{-5} mbar)

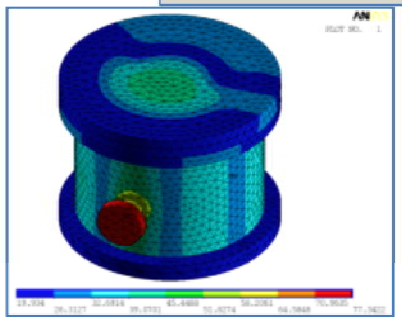
Proton beam 66MeV 60 μA

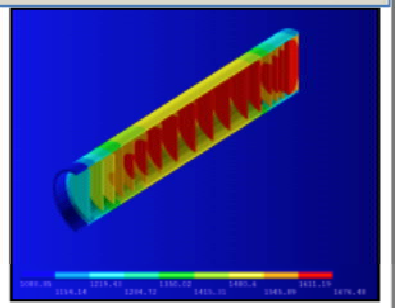




Measure [°C]	Estimated by FEM model [°C]
1° disk: 1365 ± 30°C	1390
Box: 1230 ± 25°C	1267
Dump on chamber: 728°C ± 10°C	750





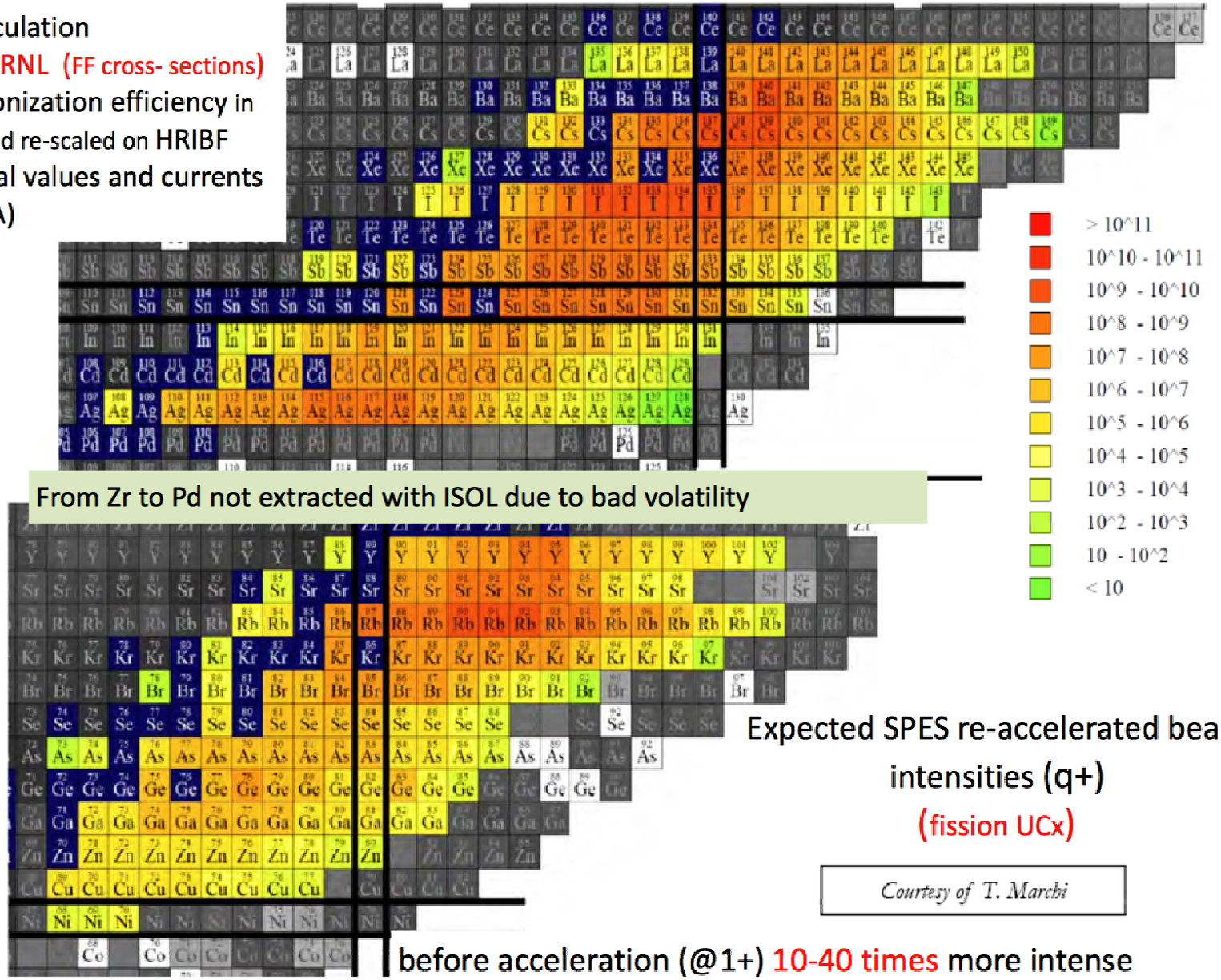


Thanks to Rob, Lowry and all the iThemba_Labs Cyclotron staff

SPES PHYSICS: Expected beams

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

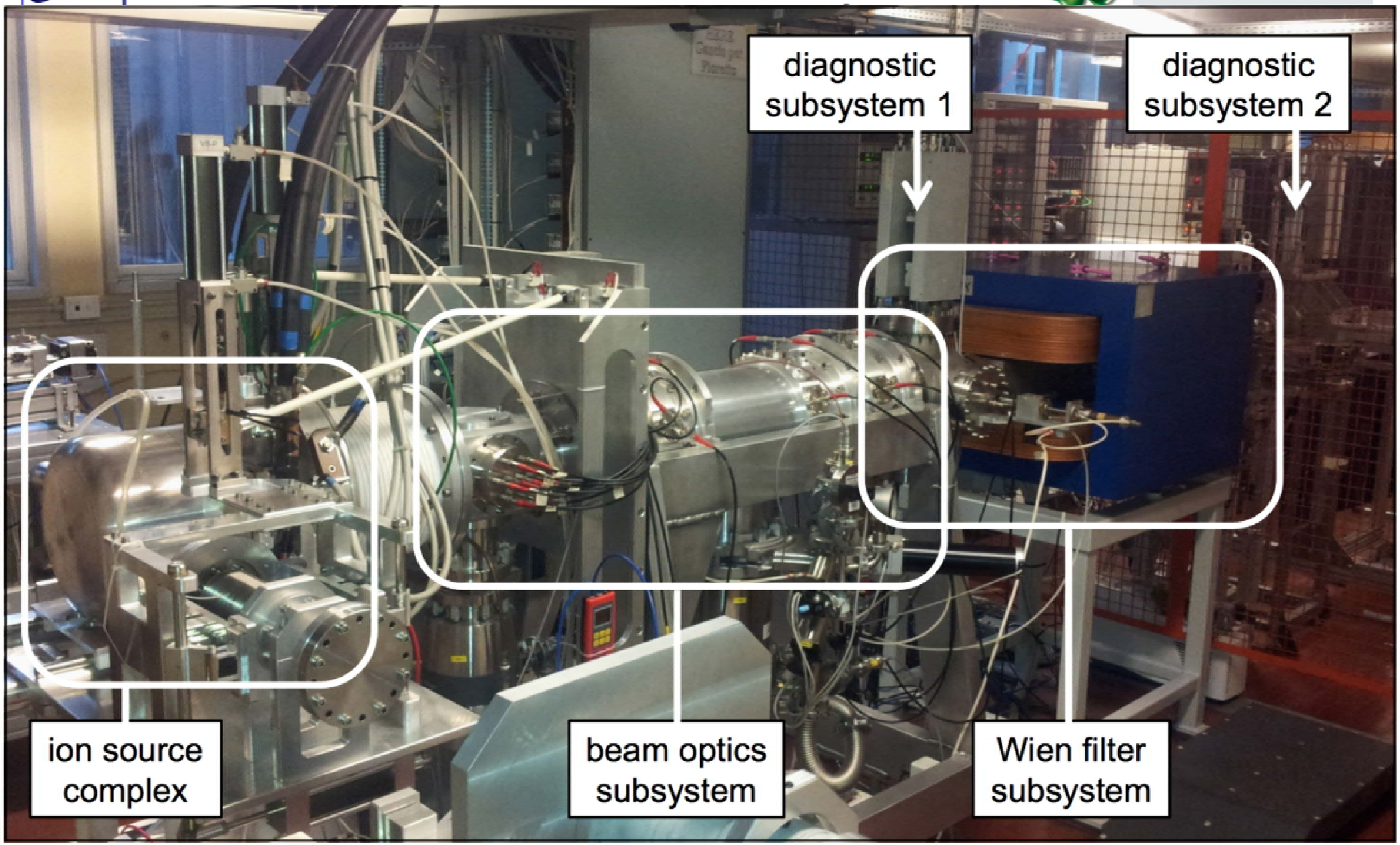
Expected SPES re-accelerated beam intensities (q+)

(fission UCx)

Courtesy of T. Marchi

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

SPES ISOL system

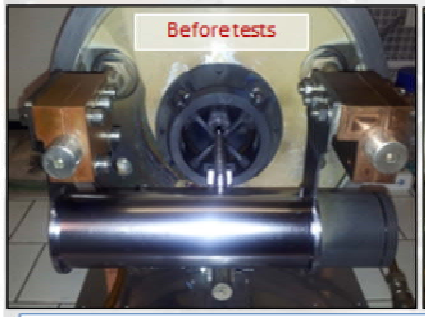


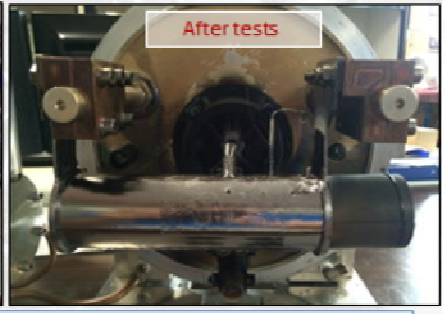
System under operation for source commissioning.
Updated version (radiation hardness improved) under construction.

ISOL system

TIS unit endurance test:

Tests at high temperature with Joule heating thermal load (1300A target heater, 350A line):
heating power ≈ 12 kW > primary proton beam thermal load (≈10 kW)





- ≈ 415 testing hours at high temperature -> ≈ 220 hours at maximum power (12kW)
- 79 heating cycles sustained -> 9 with current ramps of 1 s from 0 A to 1300A (!) to 350A (!)

TIS UNIT STILL OPERATIVE !!

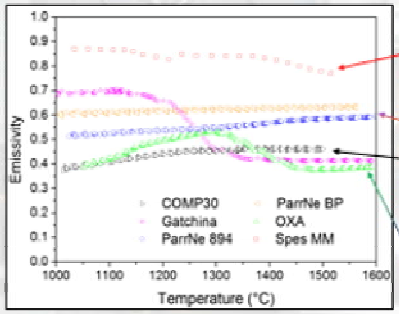
Target materials production and tests 2/5

Emissivity measurements on different uranium carbides

Direct emissivity measurements on heated UC_x discs using a dual frequency pyrometer

Old UNIPD UC_x lab

Uranium carbide samples of different composition and synthesis routes produced in different laboratories participating to ActiLab



SPES UC_x (Φ 30 mm) with <20 µm UO_2

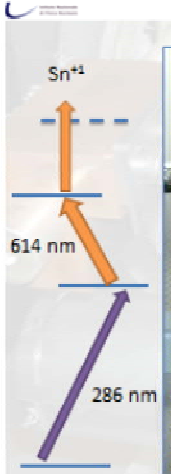
IPNO UC_x by U_3O_8 + C

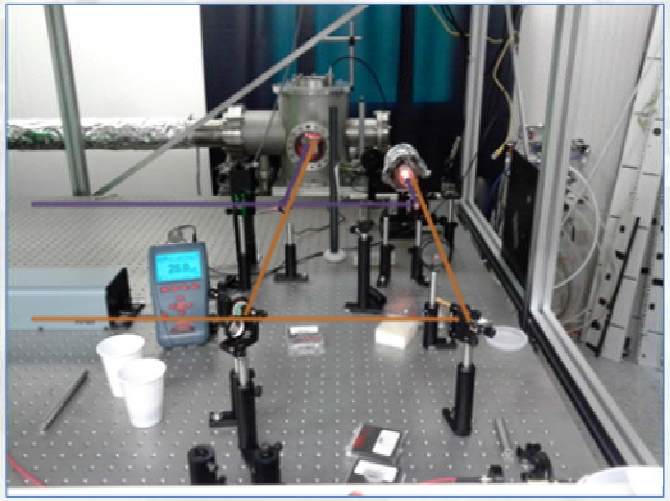
Designed to obtain UC_x but result is UC_2 + minor am. C

HD UC

HCL + ToF on Tin laser ionization

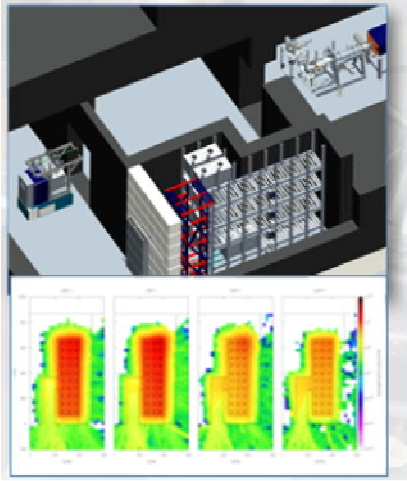
Double system to check laser resonant ionization:

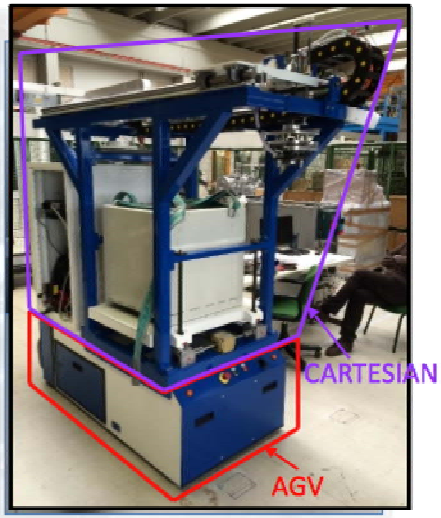




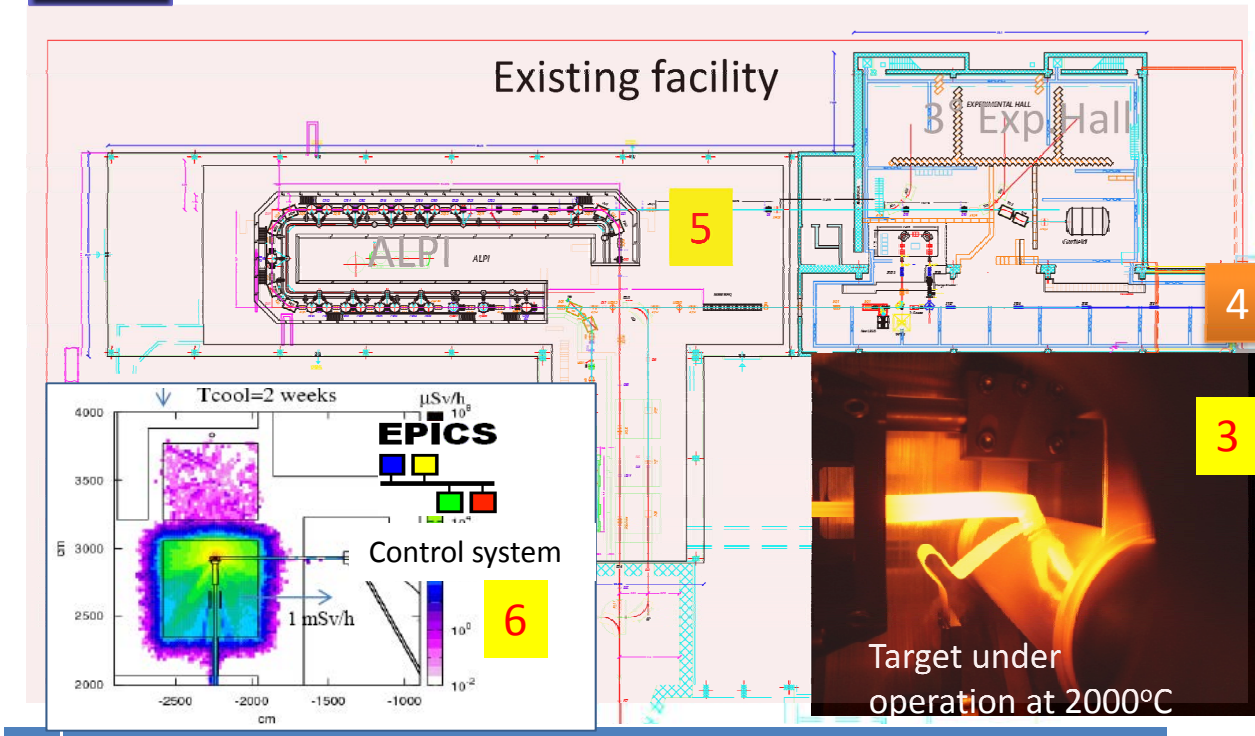
The (new) Chamber Unit Storage

OLD: Storage of several 700 kg of lead box

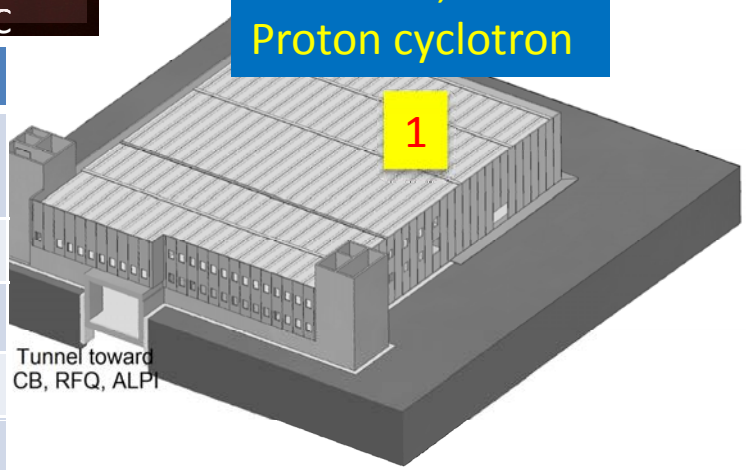




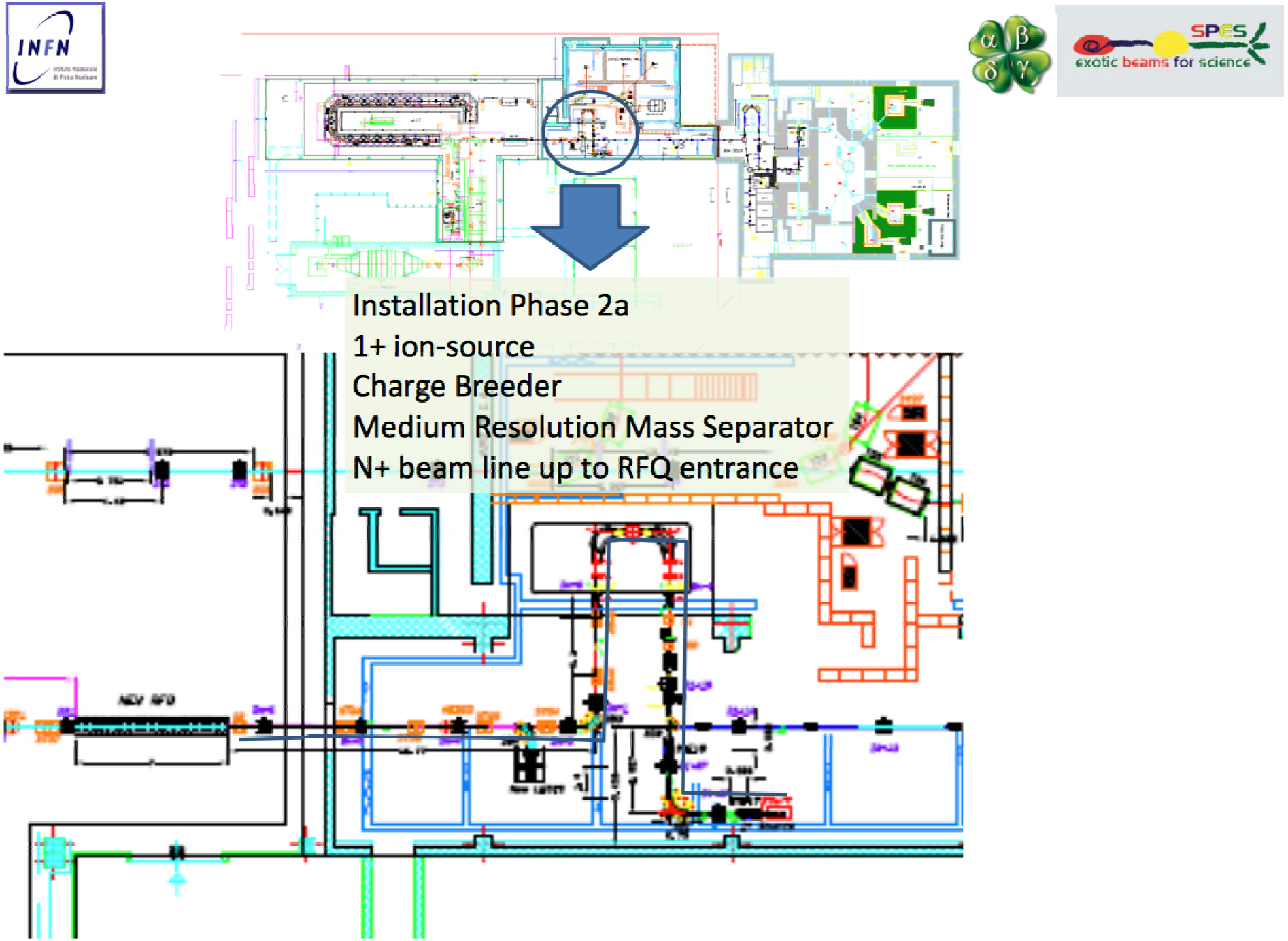
SPES Facility Layout



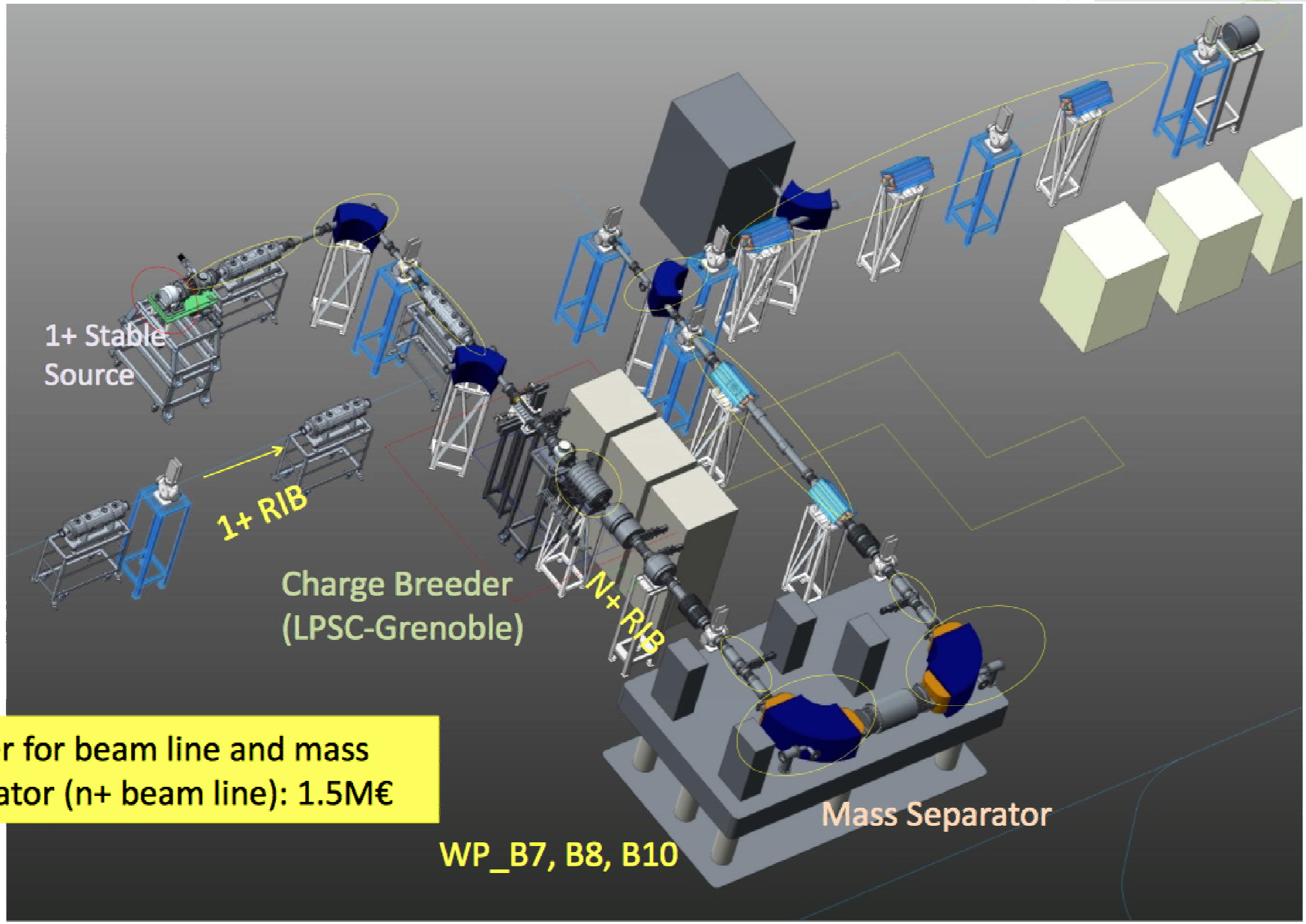
70 MeV 0,75 mA
Proton cyclotron



	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


Installation Phase 2a
1+ ion-source
Charge Breeder
Medium Resolution Mass Separator
N+ beam line up to RFQ entrance

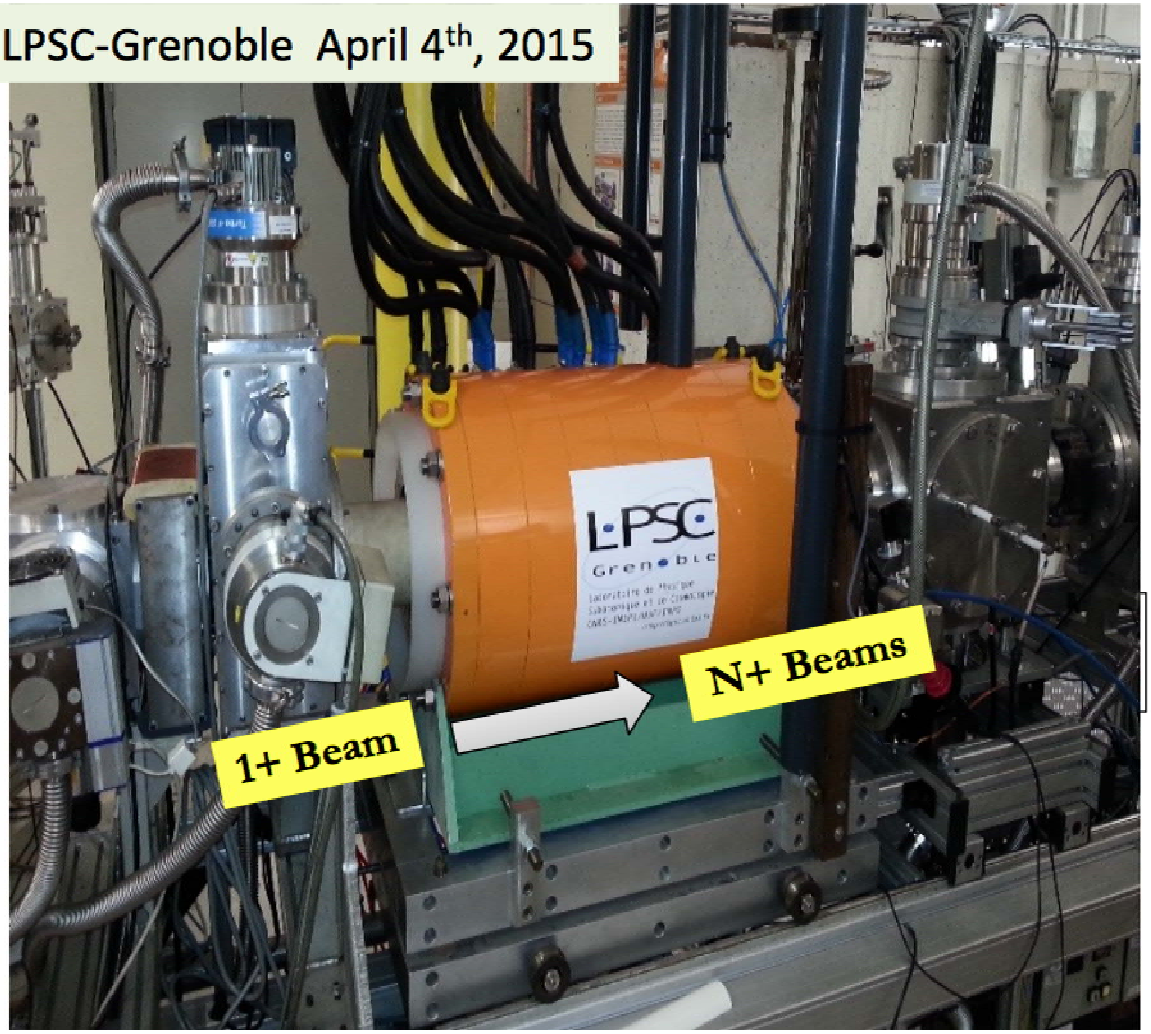
Exotic Beam reacceleration: Charge breeder and MRMS up to RFQ



Tender for beam line and mass separator (n+ beam line): 1.5M€

Validation of the SPES-CB

LPSC-Grenoble April 4th, 2015



Development at LPSC (Grenoble) of an Upgraded PHOENIX booster as Part of a MoU in the frame of the European Associated Laboratories (LEA-Colliga)

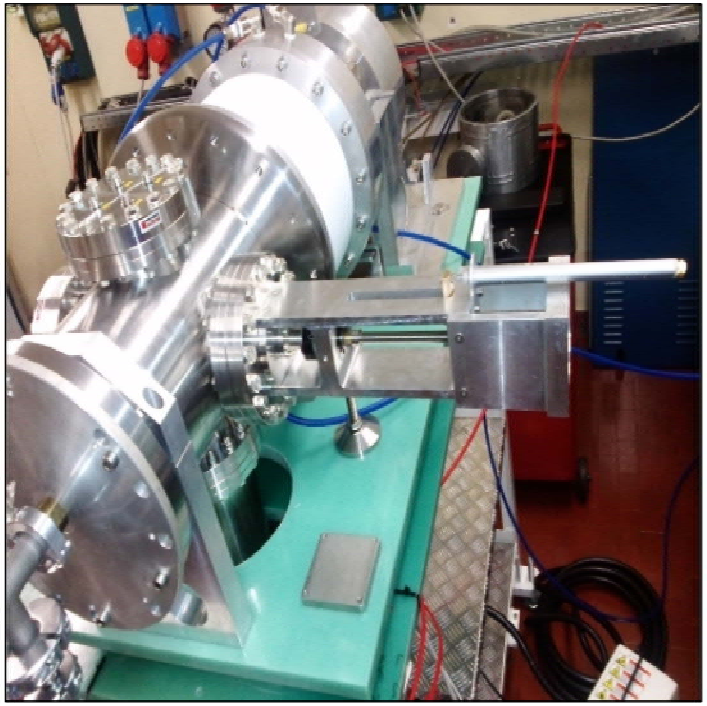
- 2010 Preliminary measurements
- 2011 Conceptual design
- 2012 Design
- 2013 Agreement definition
- 2014 Construction
- 2015 Commissioning at LPSC
- 2015 Delivery to LNL
- 2016 Installation and test

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

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

1+ Source for Charge Breeder

Ready for installation



- Assembly of 1+Source Front-End

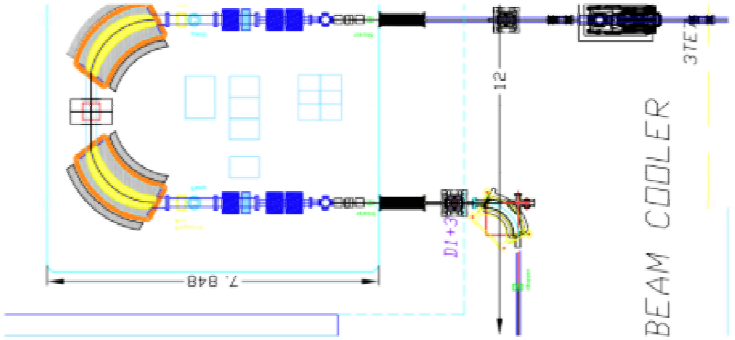
- Target box Cooling system tested - no leackage
- Vacuum of full system testes - final vacuum = 1.2E-6 mbar

M.Manzolaro

High Resolution Mass Separation

Collaboration: LNS, LNL, CENBG Bordeaux

Physics design: 1/40000

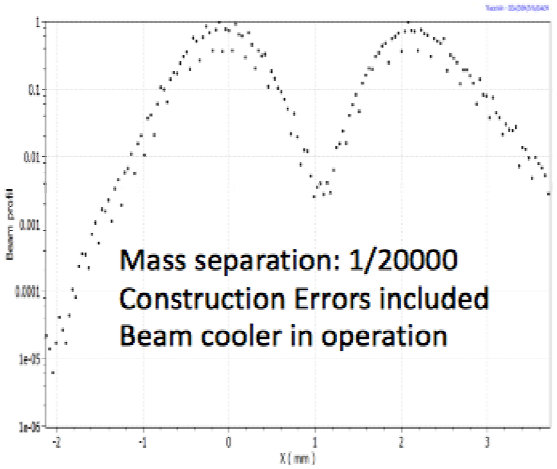


$\Delta E = \pm 1$ eV

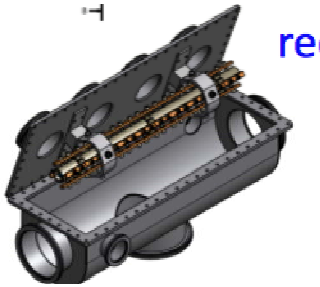
Emittance rms = 0.68 πmm mrad

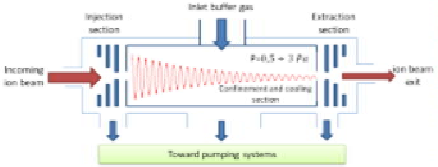
Type	Max range
Misalignment (x,y) (no effect on R)	0.5 mm
Tilt (xy,yz,xz)	0.1°
Field error	0.05%
All errors	0.25 mm, 0.05°, 0.025%

^{132}Sn beam in simulations



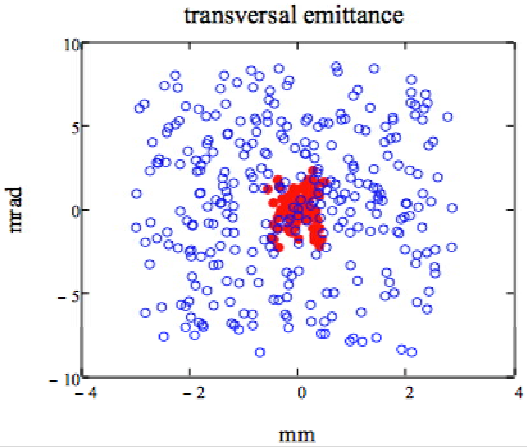
Beam Cooler to match the HRMS input requirements





COOLBEAM experiment financed by INFN-CSN5, 2012→2015

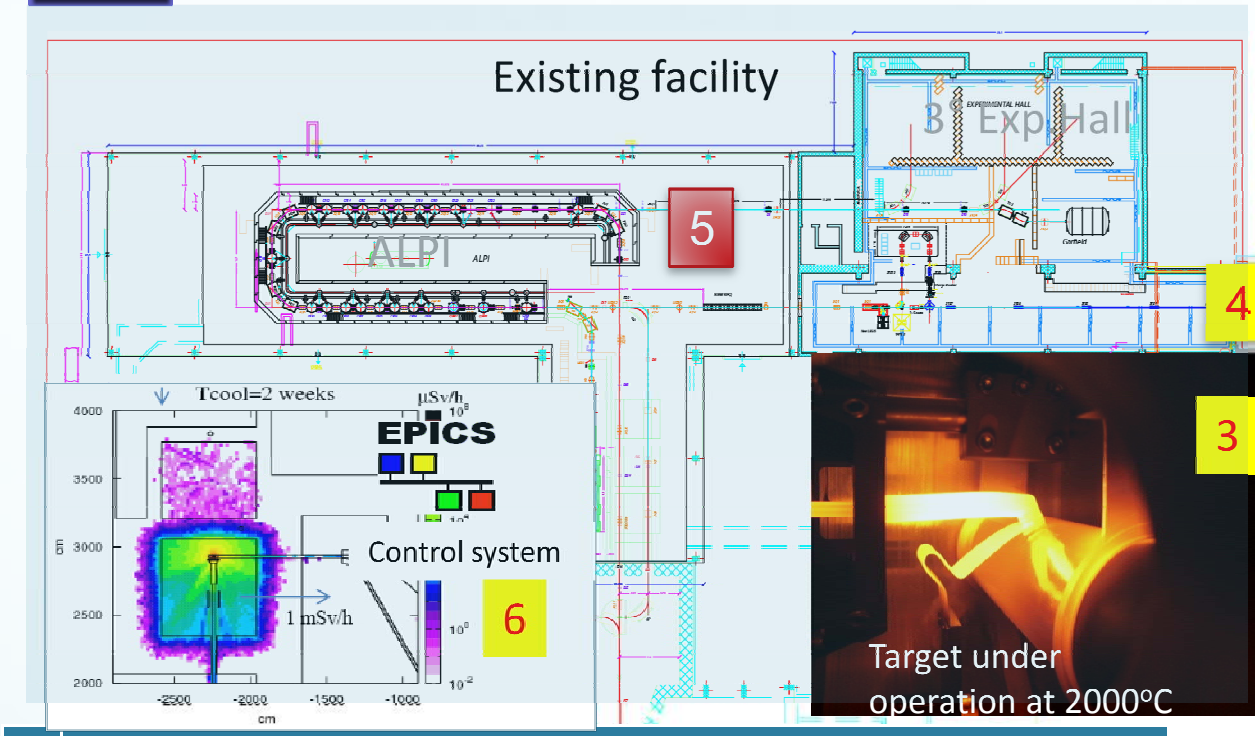
Collaboration: LNL-LNS - Milan



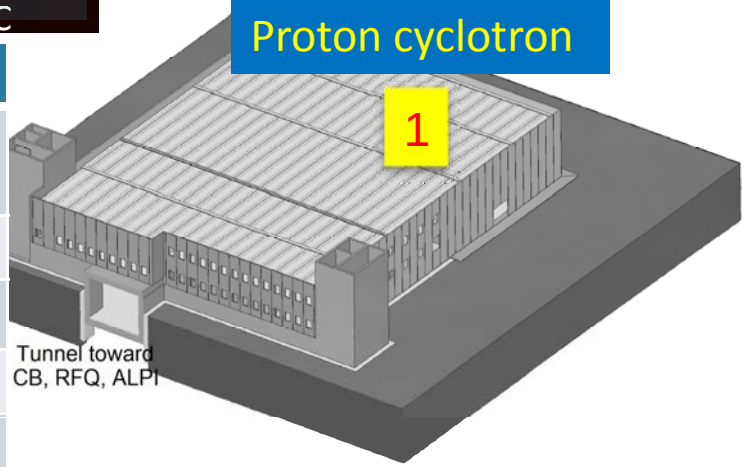
Input T emittance

Output T emittance

SPES Facility Layout



70 MeV 0,75 mA
Proton cyclotron



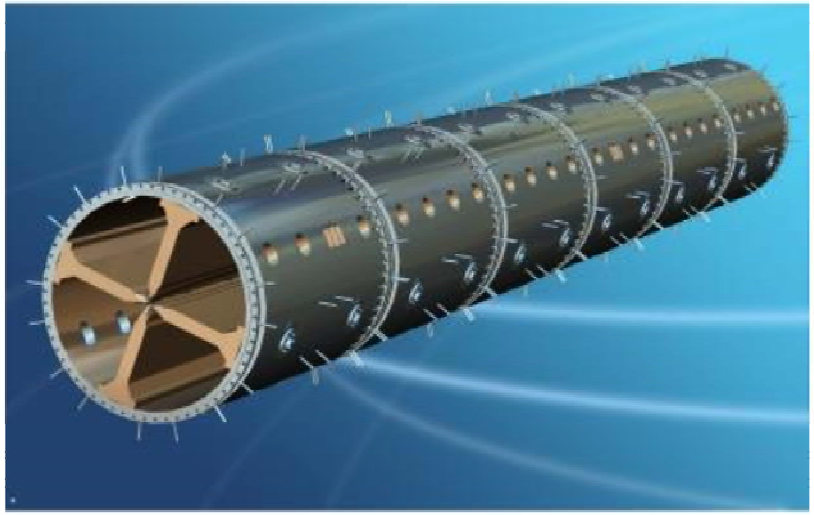
	SPES sub-systems
1	Building and infrastructures with 2 ISOL bunkers for radioactive beam and application area for radioisotopes and neutrons
2	Cyclotron 70 MeV protons with 2 independent exits
3	ISOL UCx target designed for 10^{13} f/s
4	Beam transport with High Resolution Mass Separation
5	Reacceleration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

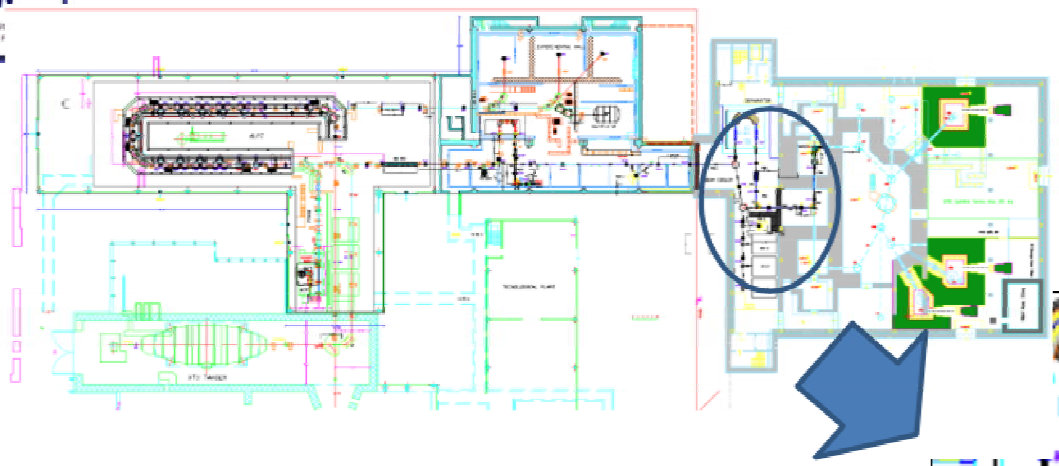
SPES-RFQ

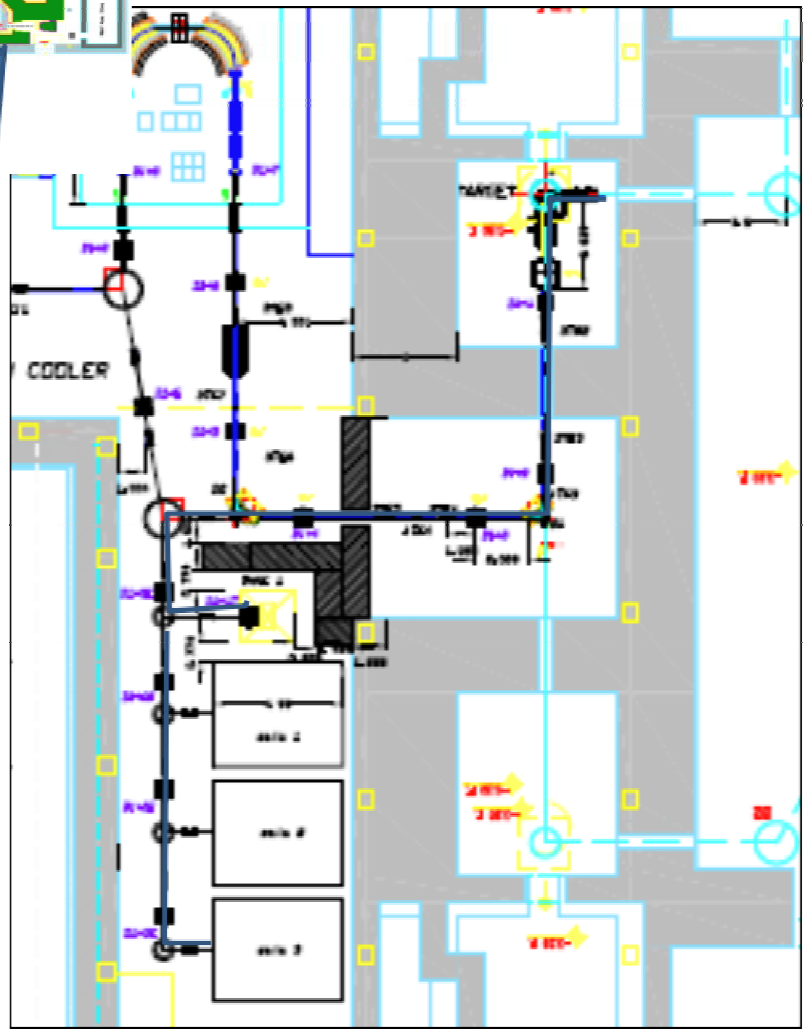
Design almost completed .
Additional study to finalize RF and Tank.
Construction started (electrodes).

Parameter (units)	Design Value
Operational mode	CW
Frequency (MHz)	80.00
Injection Energy (keV/u)	5.7 (β=0.0035)
Output Energy (keV/u)	727 (β=0.0395)
Accelerated beam current (μA)	100
Charge states of accelerated ions (Q/A)	7 – 3
Inter-vane voltage V (kV, A/q=7)	63.8 – 85.84
Vane length L (m)	6.95
Average radius R_0 (mm)	5.33 – 6.788
Synchronous phase (deg.)	-90 – -20
Focusing strength B	4.7 – 4
Peak field (Kilpatrick units)	1.74
Transmission (%)	95
Output Long. RMS emittance (mmmrad) / (keVns/u)/(keVdeg/u)	0.055 / 0.15 / 4.35

- Andrea Pisent (WP coordinator, LNL)
- Antonio Palmieri (deputy coordinator, LNL)
- Luigi Ferrari (Mechanics design)
- Michele Comunian, Luca Bellan (Beam dynamics, LNL)
- Carlo Roncolato (Vacuum system and brazing, LNL)
- Next future
  - Enrico Fagotti (Acc. Physics and cooling system, LNL)
  - Damiano Bortolato and Francesco Grespan, Mauro Giacchini (RF system, controls)
- Synergies with Torino and Padova INFN sections for the mechanics development (P. Mereu and A. Pepato respectively), common aspects with ESS DTL and IFMIF RFQ design







Installation Phase 2b
ISOL system
Wien Filter, Low Resolution Mass Separator
Tape Station1 ,
possibly 1+ beam lines for experiments