The Target-Ion-Source System

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LNL-INFN

SPES TAC meeting - LNL January 22, 2014

Talk Overview

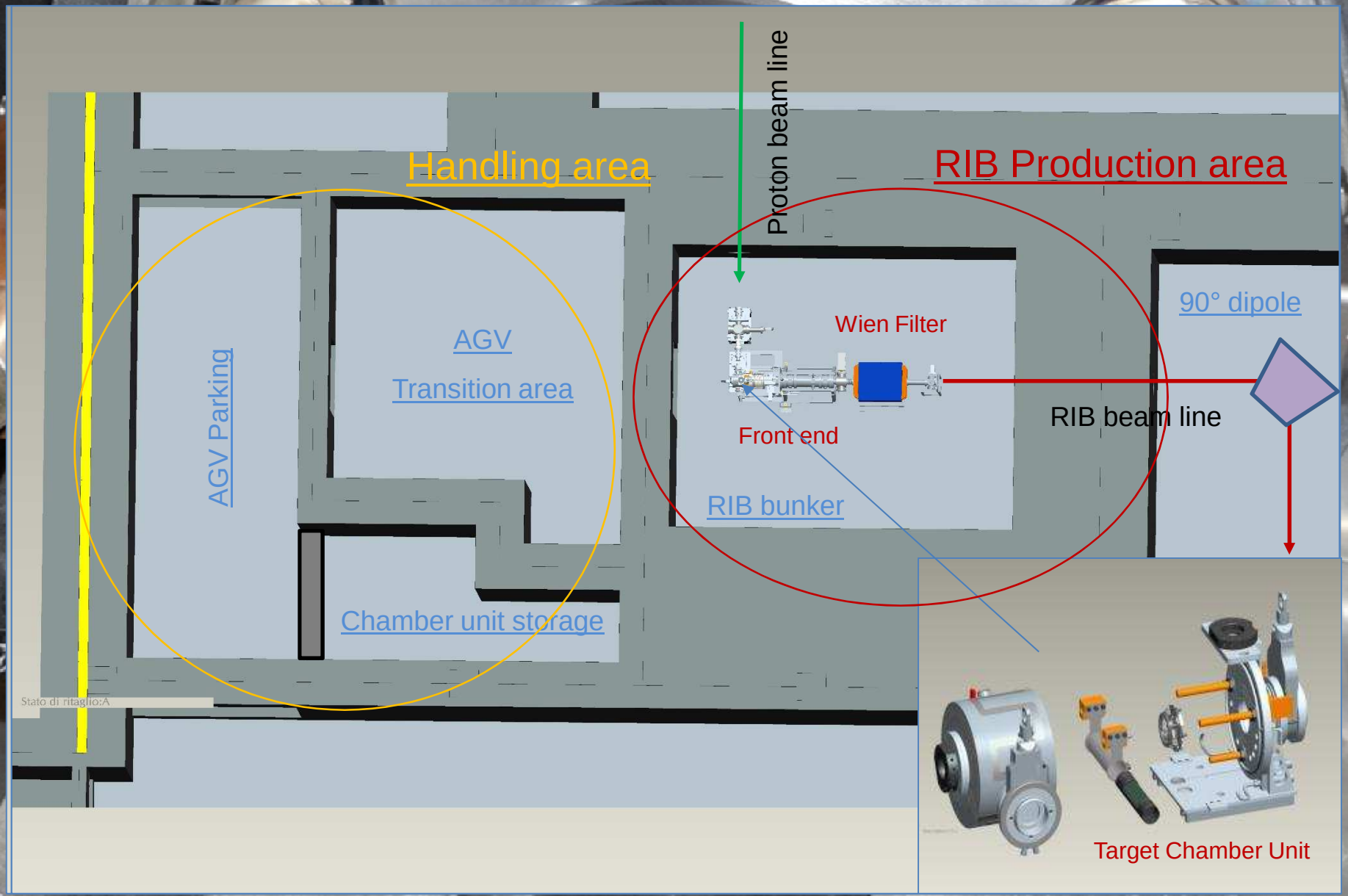
-The production target system.

- The TIS organization.

- The TIS activities.

- Final remarks.

The target-ion source area



The TIS device

SPES Target :

Optimized for 8 kW power dissipation

(E= 40 MeV, I= 200 μA)

7 UCx coaxial disks:

thickness: 1.3 mm

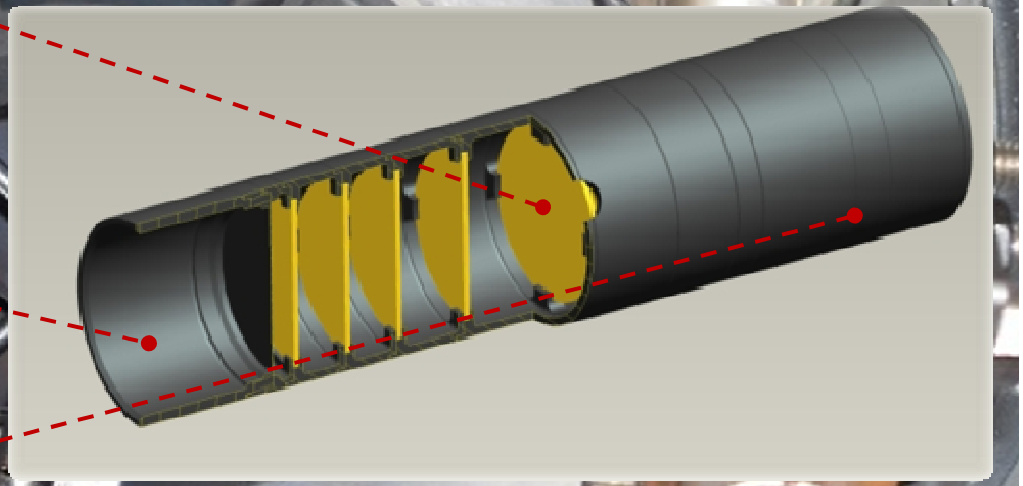
diameter: 40 mm

Graphite box:

external diameter: 49 mm

average length: 200 mm

3 graphite dump disks



SPES Heater, Ionizer & Chamber

Tantalum tube:

external diameter: 50 mm

thickness: 0.35 mm

length: 200 mm

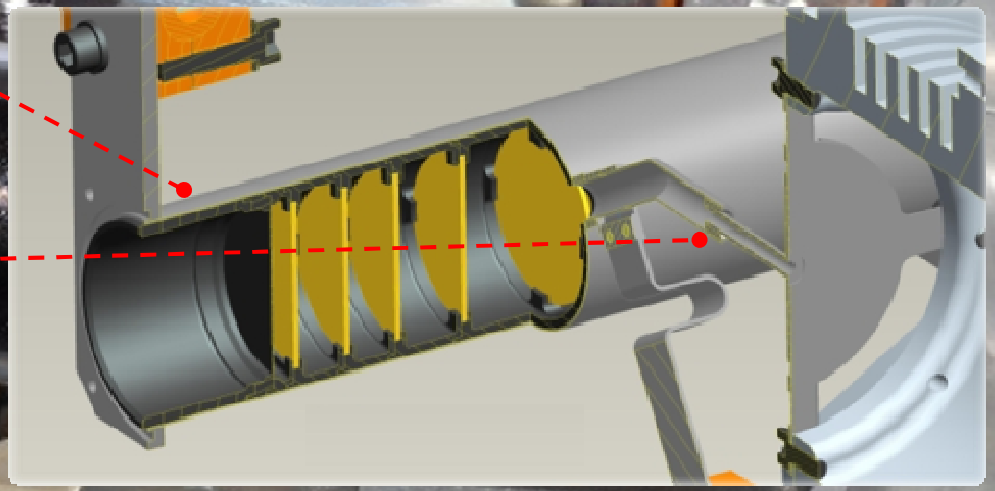
Ionizer & Transfer tube:

thickness: 1 mm

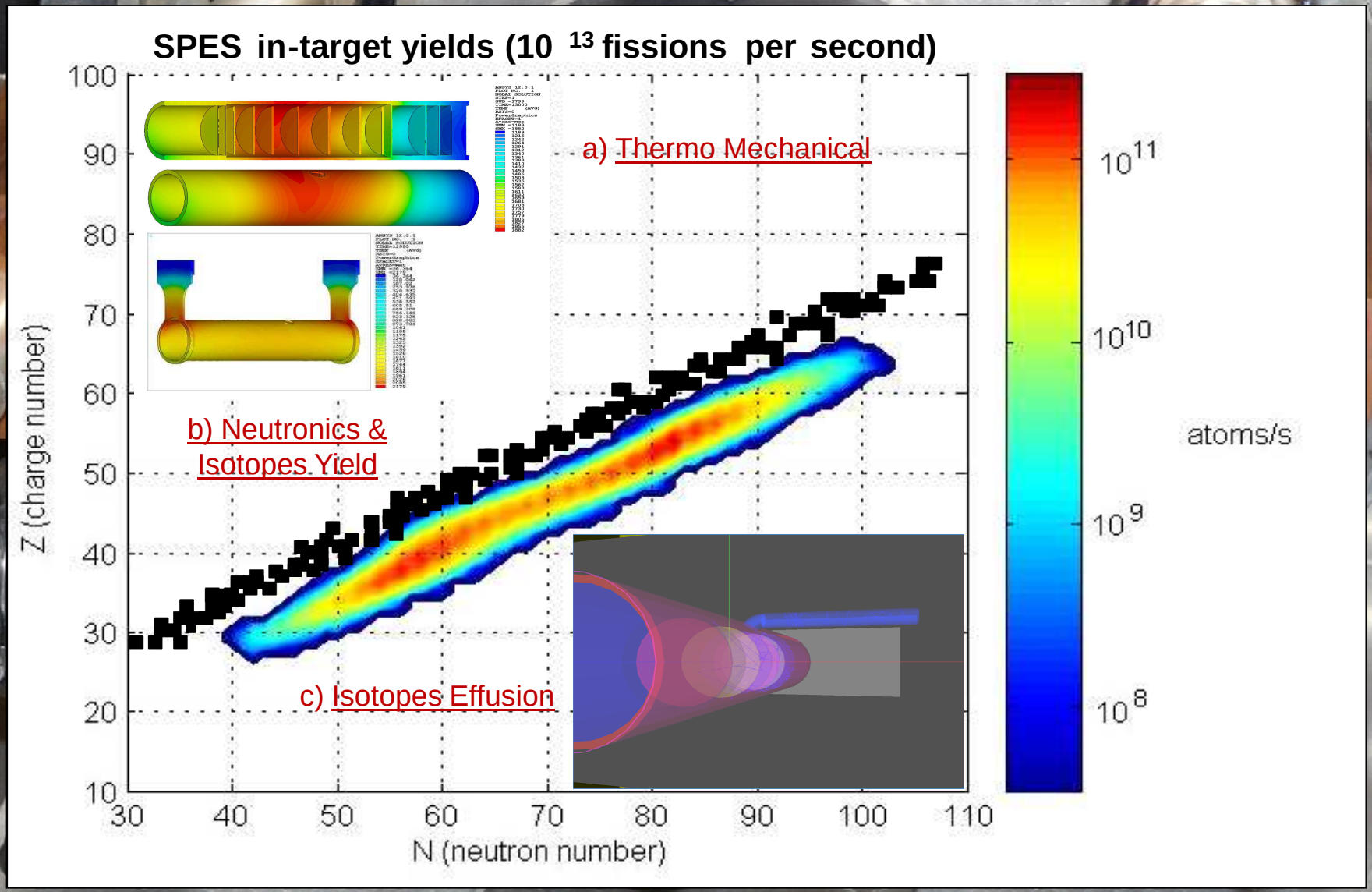
height: 34 mm

Inner diameter: 3 mm

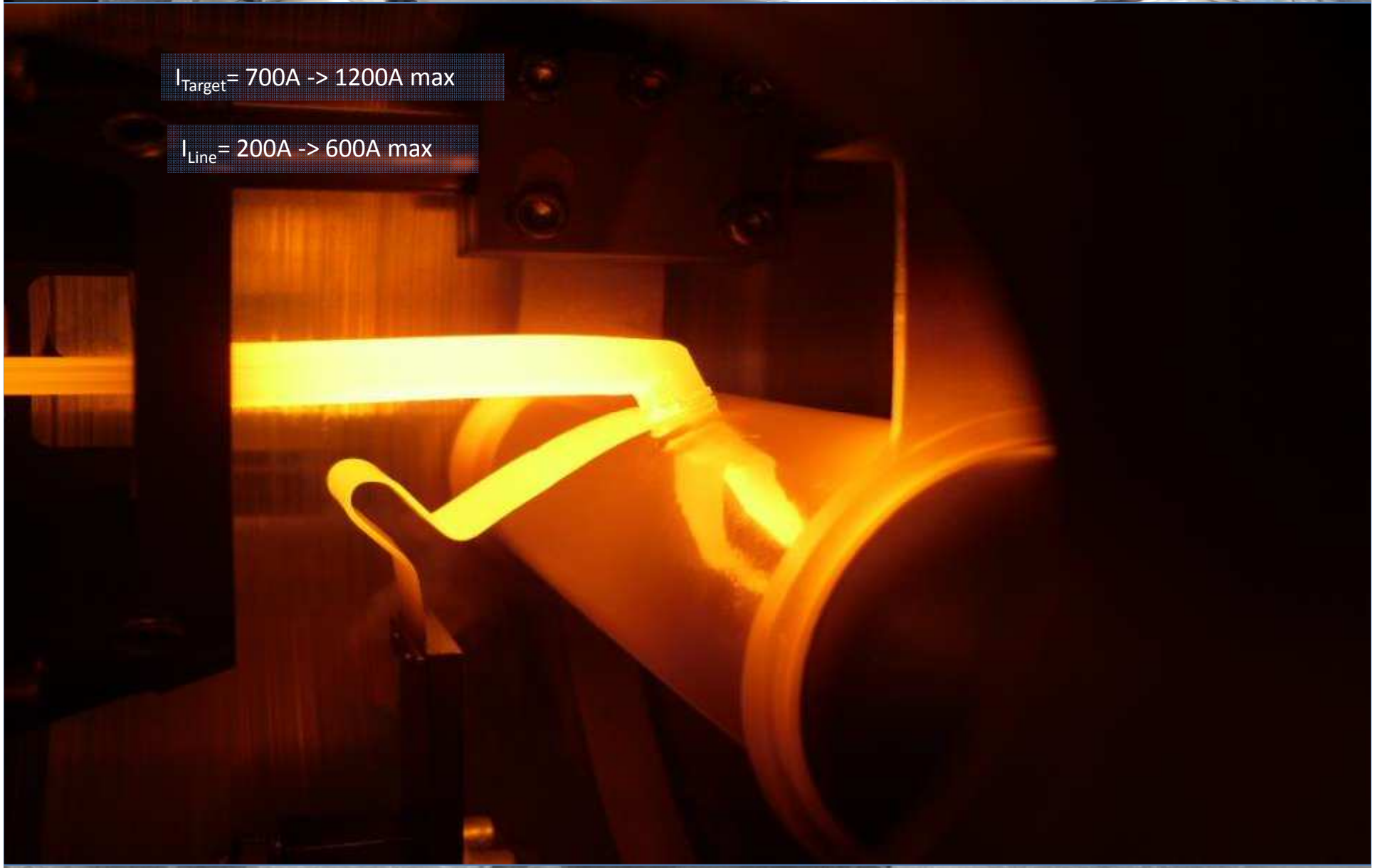
Aluminum Target Unit



The target calculations:



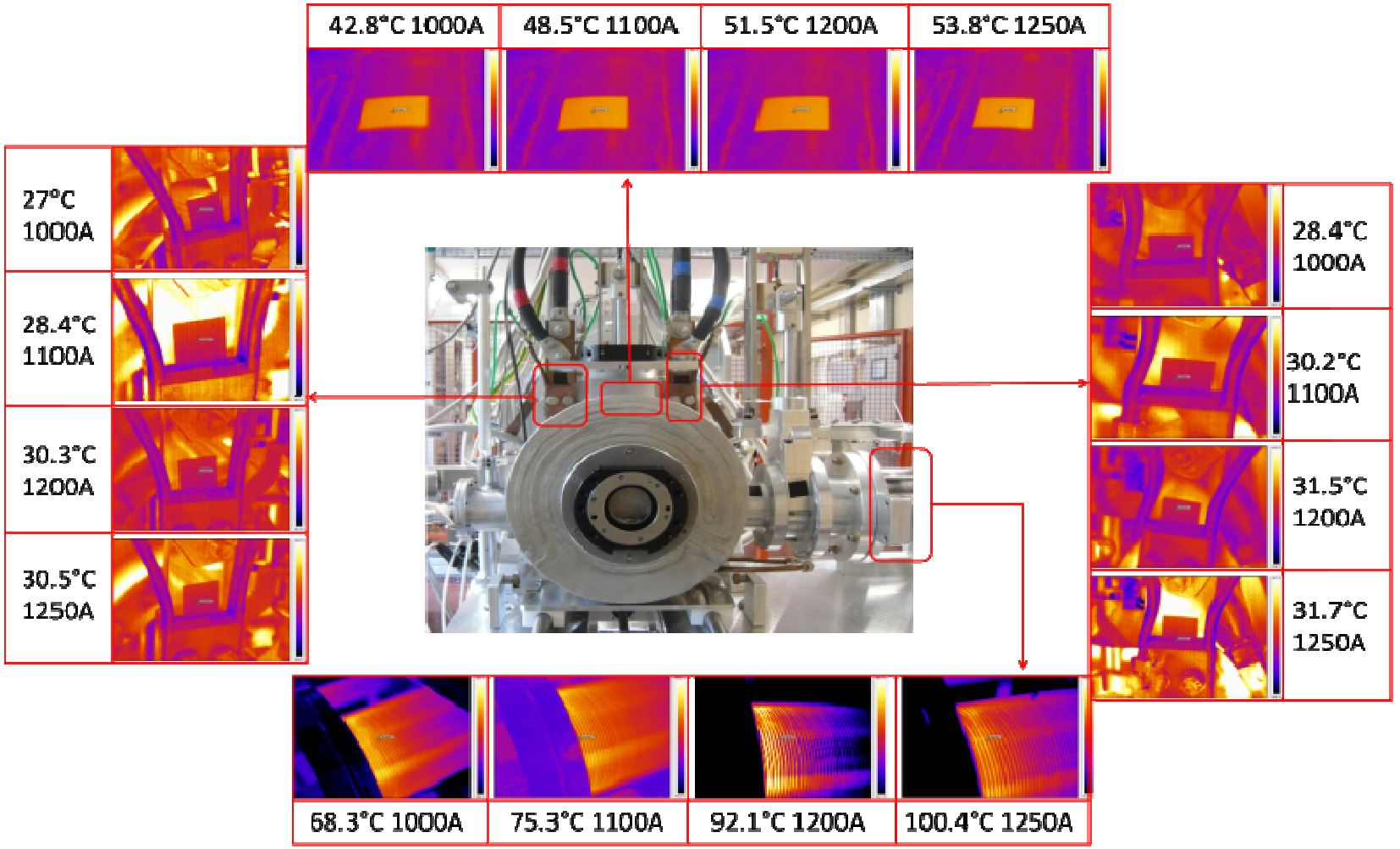
The target & ion source complex



The Target Chamber

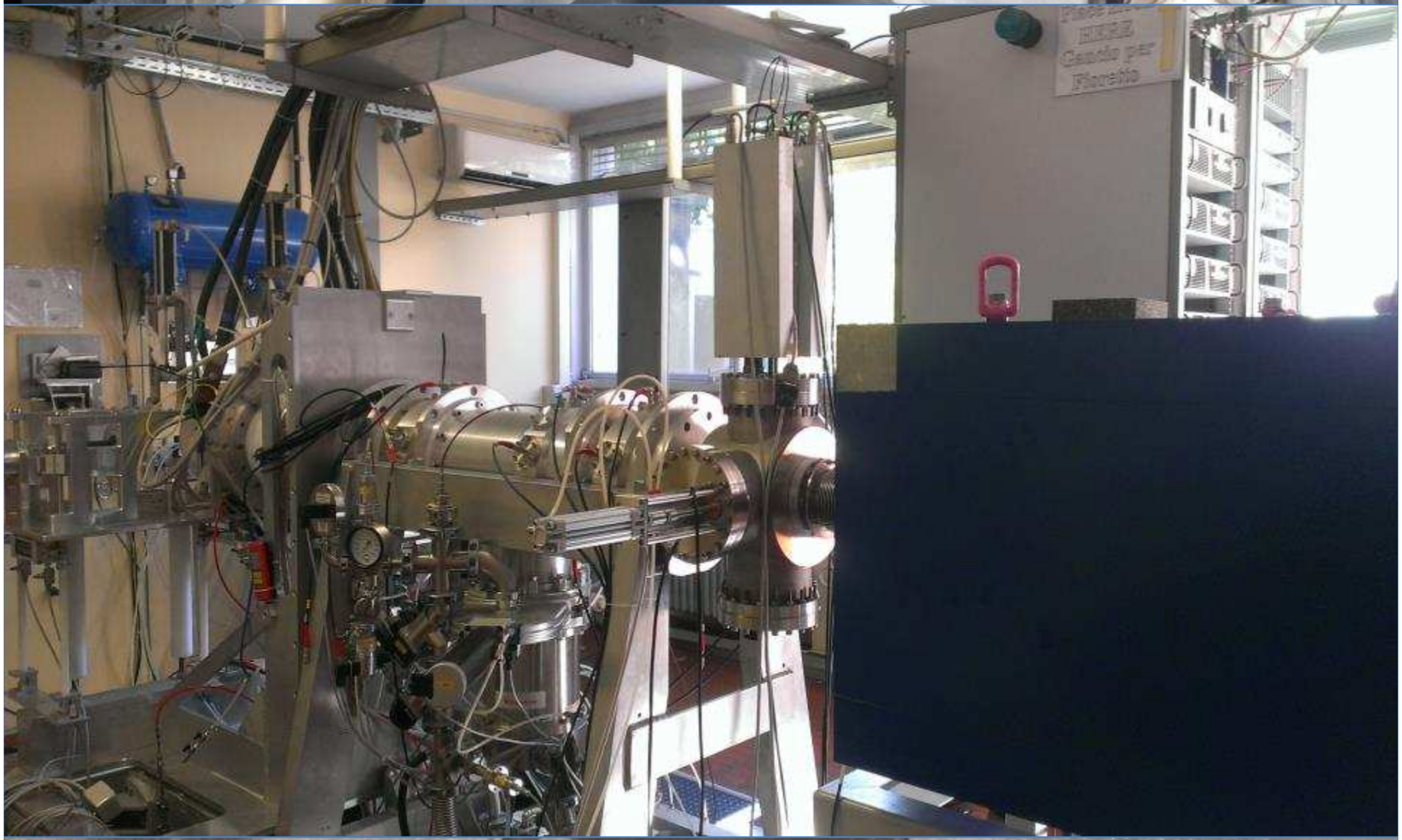
high power testing (≈ 10 kW) of the water-cooled target chamber

accurate temperature monitoring of critical components with IR thermography



The SPES off-line Front end

(working since 2010 - evolution of ISOLDE FE6)



The TIS Working Package Organization

The TIS Working Groups

WG-1: Target and Ion Sources

-> M. Manzolaro

WG-2: Target Materials

-> S. Corradetti

WG-3: Laser

-> D. Scarpa

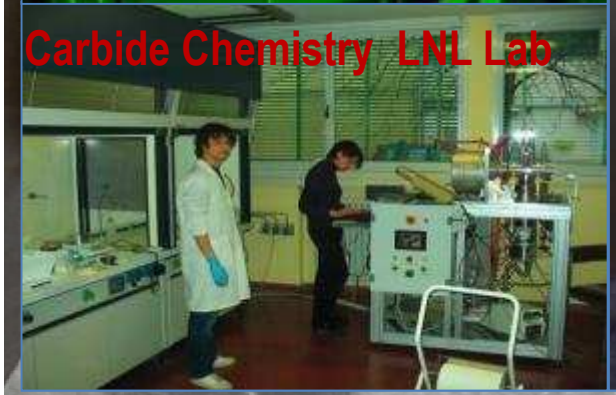
WG-4: Handling

-> M. Calderolla

WG-5: Front End

-> A. Monetti

The TIS SPES Laboratories



The SPES-TIS : collaboration network

ITHEMBA

RISP-KOREA

ORNL- HRIBF

CERN- ISOLDE

GANIL-SPIRAL 2

ORSAY-ALTO

SPES

TIS

INFN- Pavia

INFN- Milano

INFN- Bologna

INFN- LNS

INFN- Padova

UNIPV

UNIPD

UNITN

DSC

DIM

DSC

DEI

DIM

CONTROLS

LASER

ION SOURCES

MATERIALS

HANDLING

Since 2004: 50 thesis performed in the frame of target SPES activities

European Project:

ENSAR (2010-2014):
JRA Actilab (target material)

ENSAR2 (next call):
JRA Resist (laser technology)
JRA Beamlab (TIS technology)

(About 36 contributions since 2004)

SPES TIS Papers

The TIS activities

SPES TIS W.P.

RIB ionization methods:

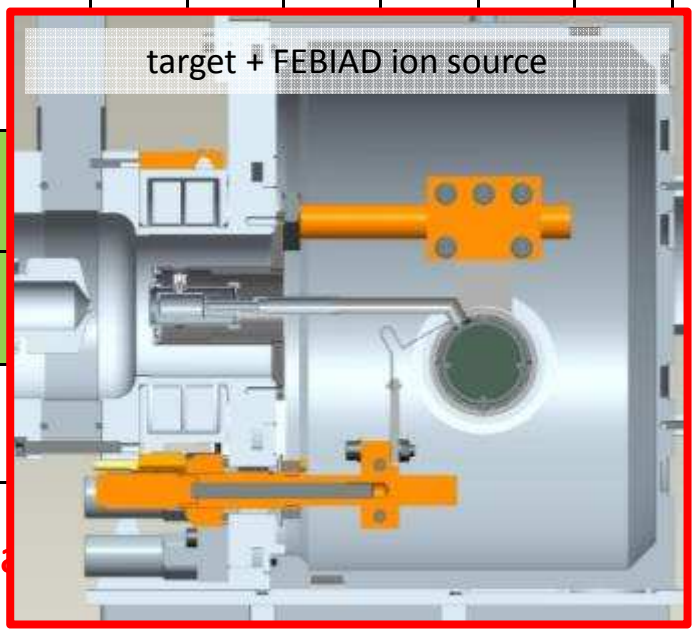
surface ionization mechanism

laser ionization mechanism

electron impact ionization mechanism

not extracted

1																	18
1	1 H	2										13	14	15	16	17	2 He
2	3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne



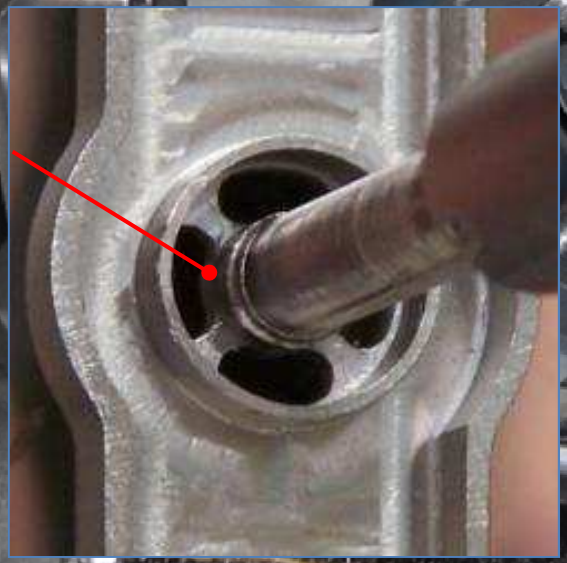
Ion Source Developments

> The Ion Source adopted for the SPES facility

The SIS Ion source

Efficiency measurements at different temperatures (1600°C, 1800°C, 2000°C, 2200°C) for Cs, Rb, Sr, Ba

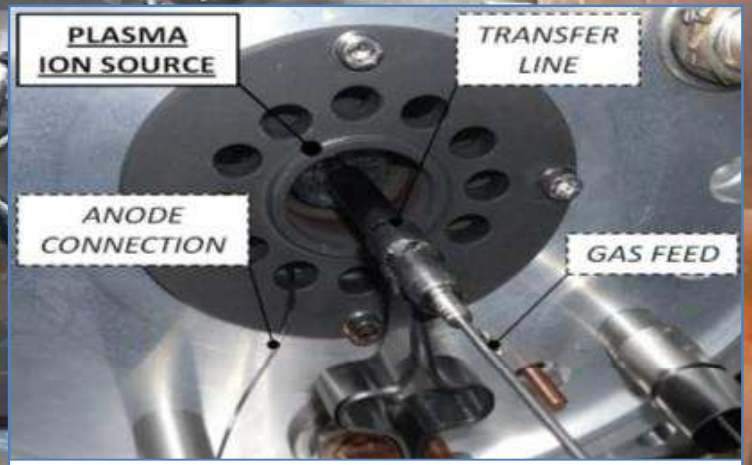
screen support

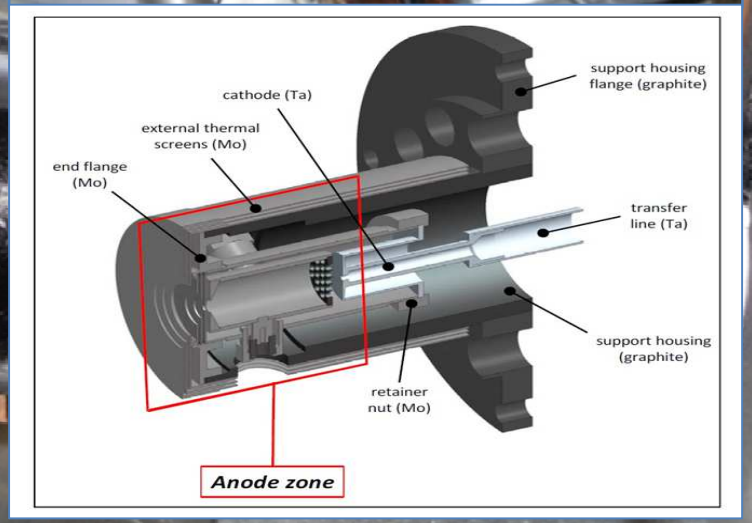


screen

The PIS Ion source

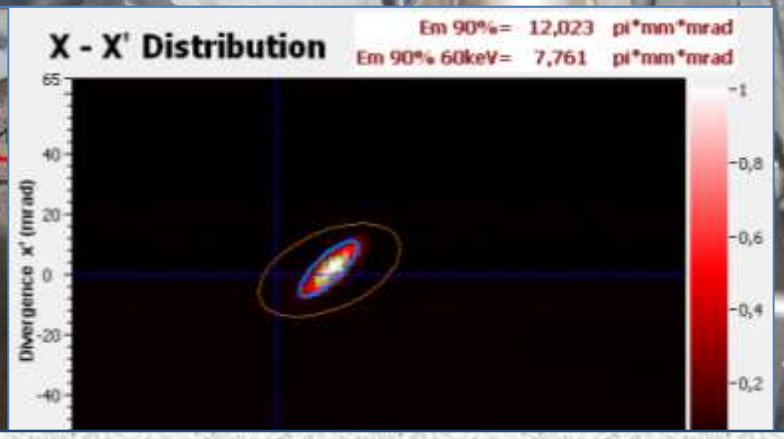
Ionization efficiency measured for Ar; Kr and Xe beams has been produced

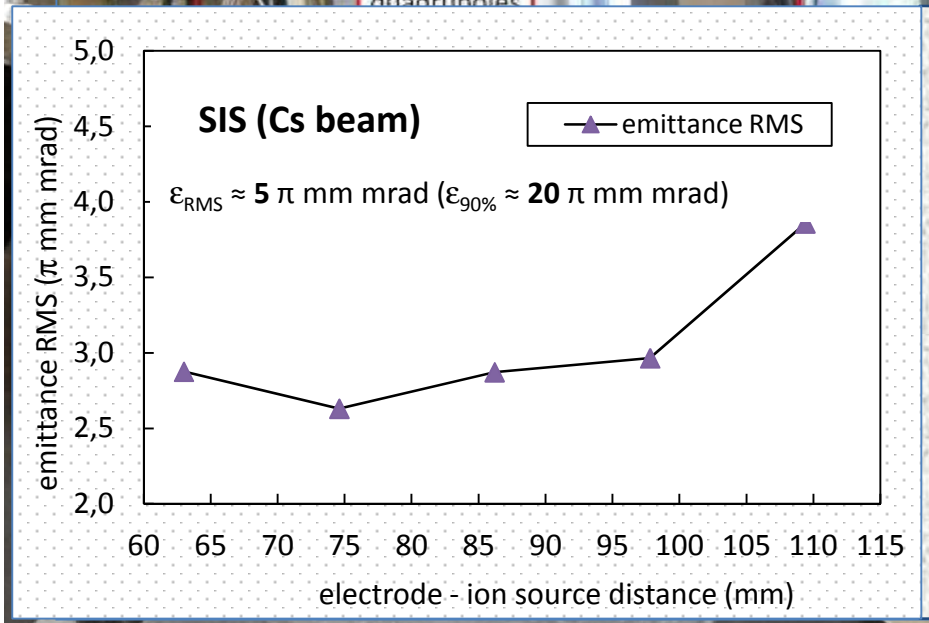


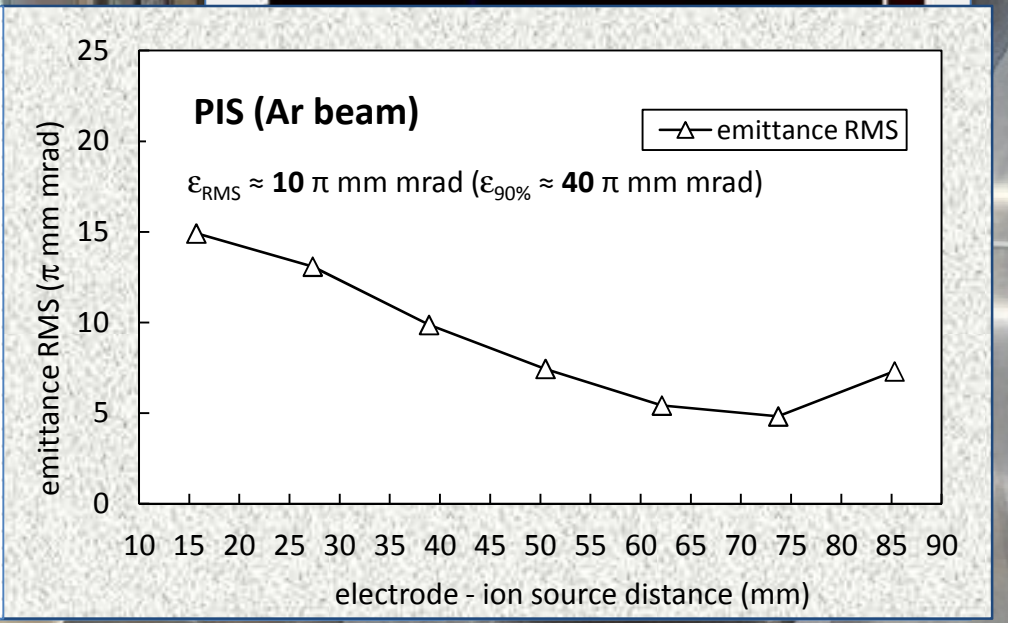


Ion Source Developments

> Emittance measurements for SIS and PIS (@ 25kV extraction voltage)







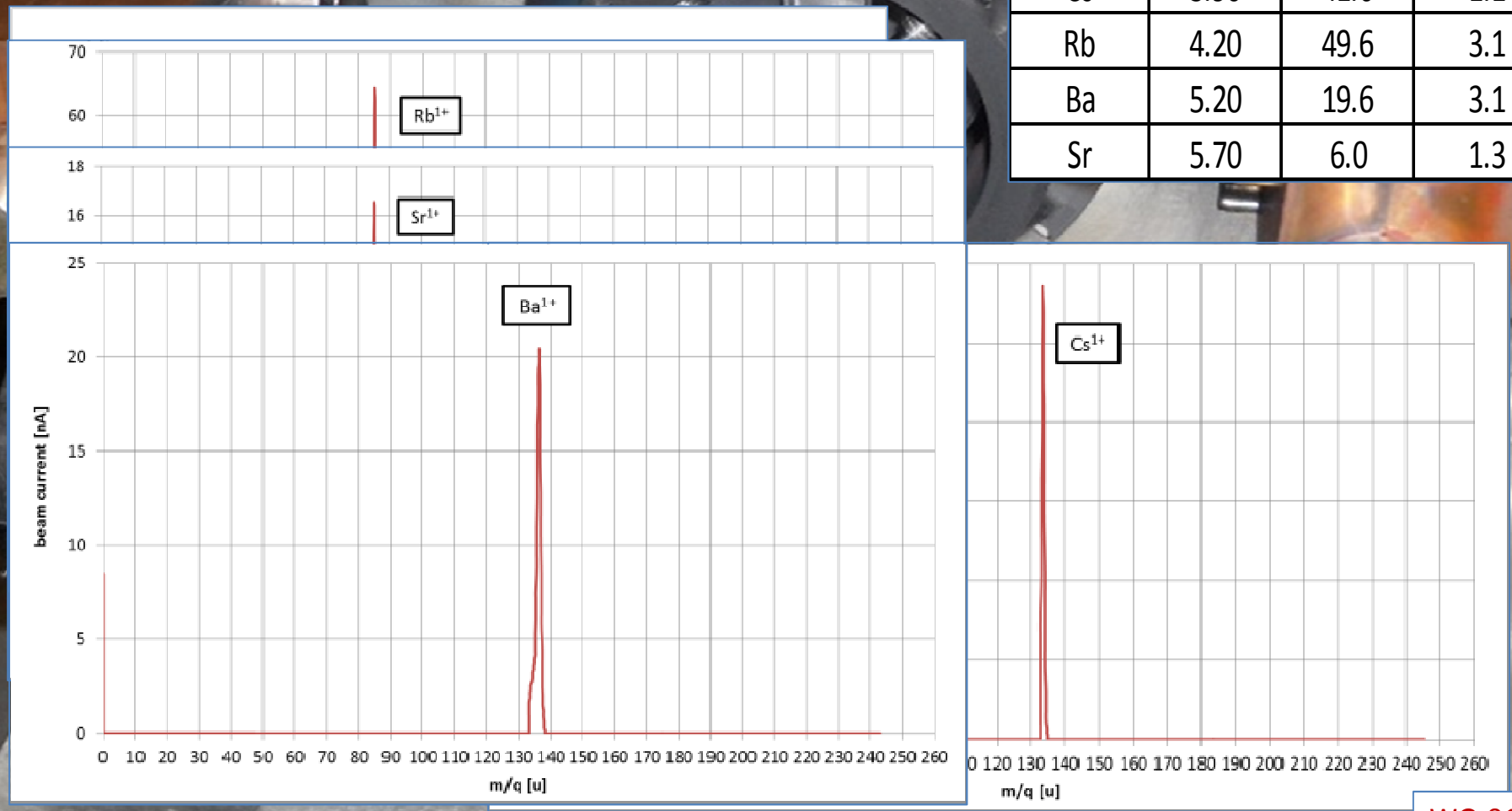
> See the M. Comunian talk for further details concerning the beam transport…

Ion Source Developments (SIS)

> Efficiency measurements for SIS

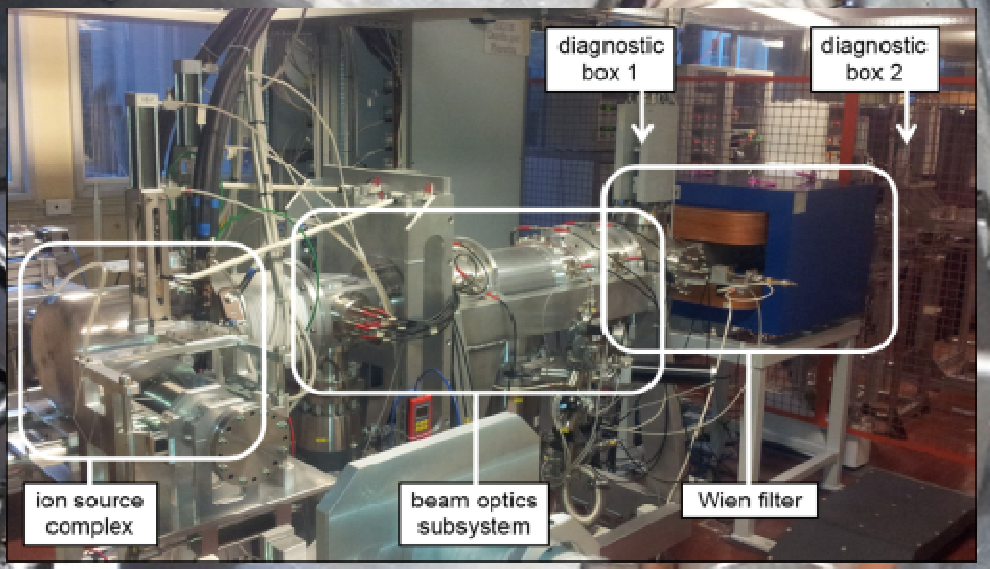
Ta - SIS efficiency data (off-line measurements)

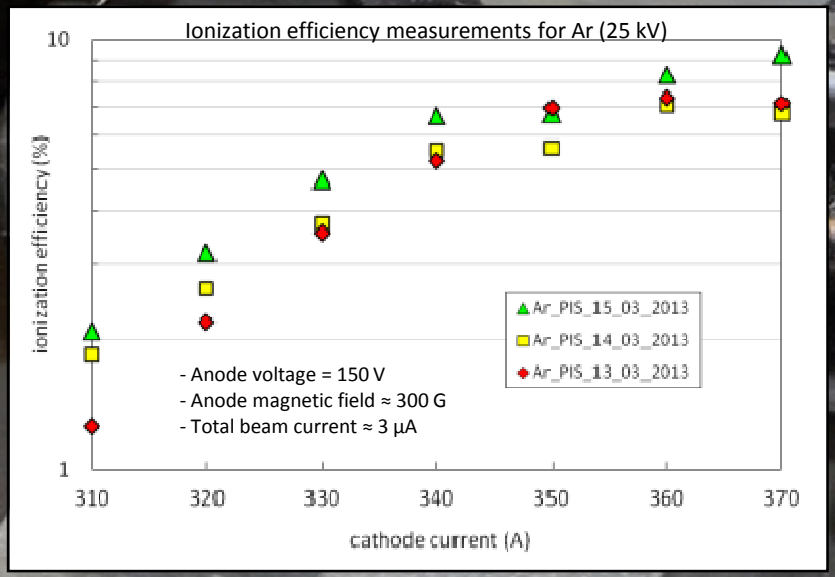
Element	Ta	T = 2200 °C	
(/)	(eV)	ε_{CLEAN} [%]	Dev. St. [%]
Cs	3.90	41.6	1.1
Rb	4.20	49.6	3.1
Ba	5.20	19.6	3.1
Sr	5.70	6.0	1.3

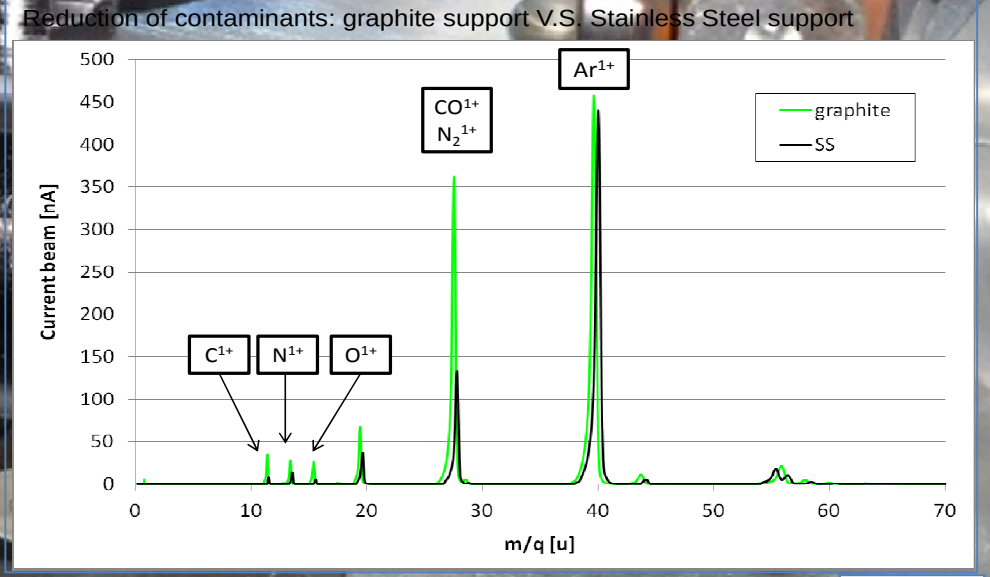


Ion Source Developments (PIS)

> Efficiency measurements for PIS



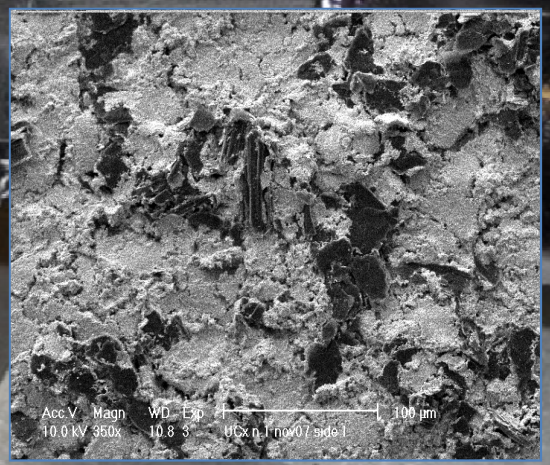




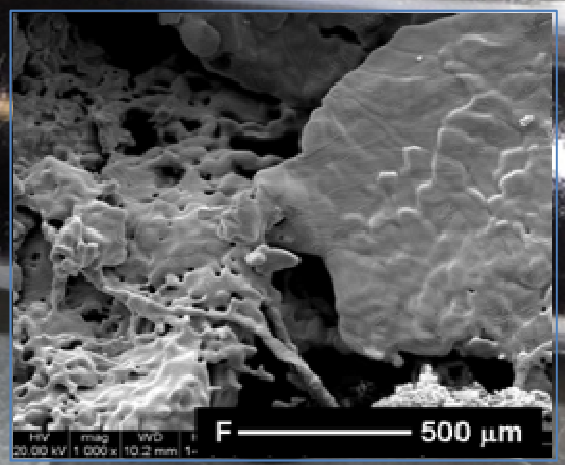
Target production

Study of the target porosimetry on the isotopes production yield

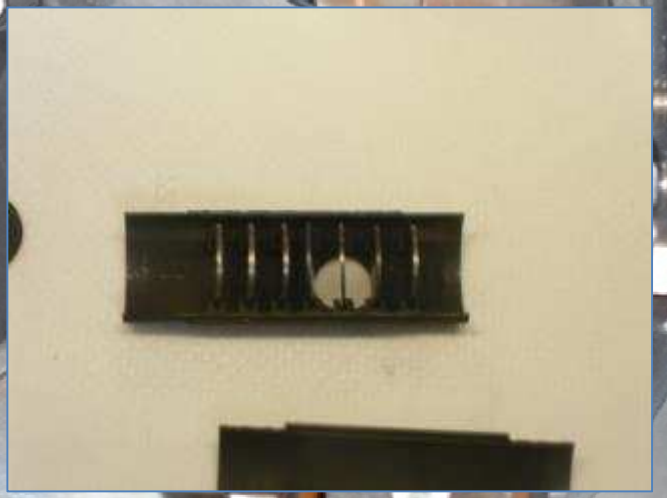
2010 Test
Standard UC_x



2011 Test
Low density UC_x



2012 Test
Medium density UC_x

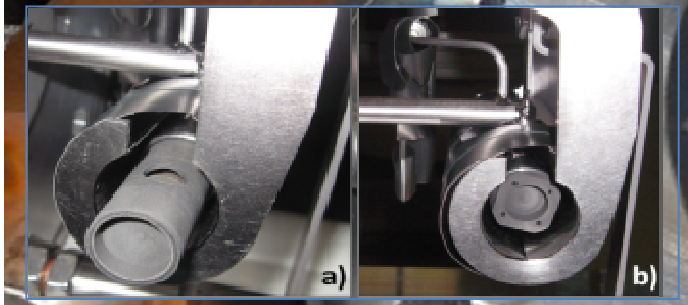


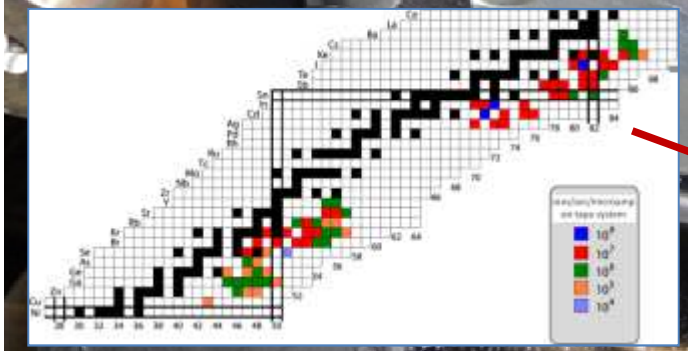
	2010	2011	2012
Density (g/cm^3)	4.25	2.59	6.38
Diameter (mm)	12.50	13.07	12.91
Thickness (g/cm^2)	0.41	0.41	0.41
Calculated porosity (%)	58	75	37

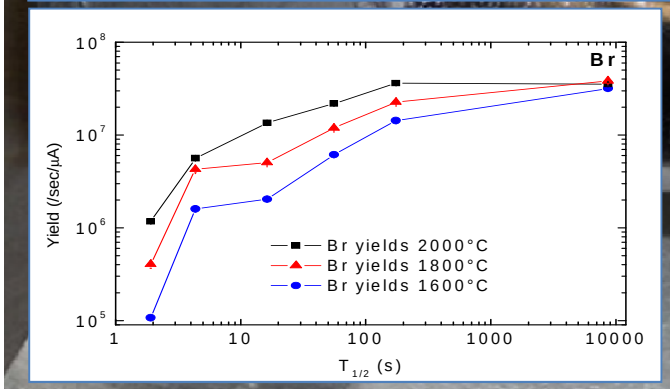
Experimental tests at HRIBF

Irradiation by 40 MeV, 50 nA proton beam, ionization with plasma ion source

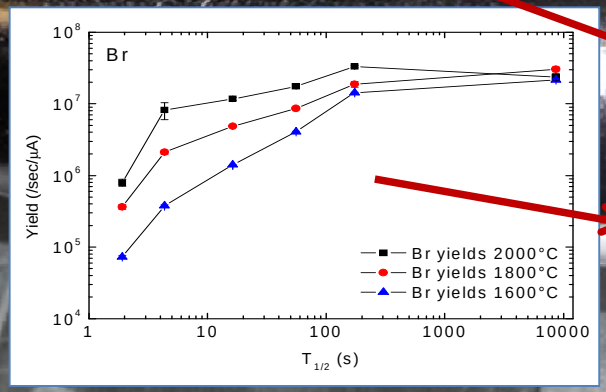
2010 Test
Standard UC_x







2011 Test
Low density UC_x



2012 Test
Medium density UC_x

shipped to ORNL for test (end of 2012?)

- Targets tested at 3 different T: 2000°C, 1800°C and 1600°C
- 20 elements, about 80 isotopes collected
- Yield vs. half-life characterization

UO_2 particle size selection

Main goal → selection of precursor (UO_2) grain size

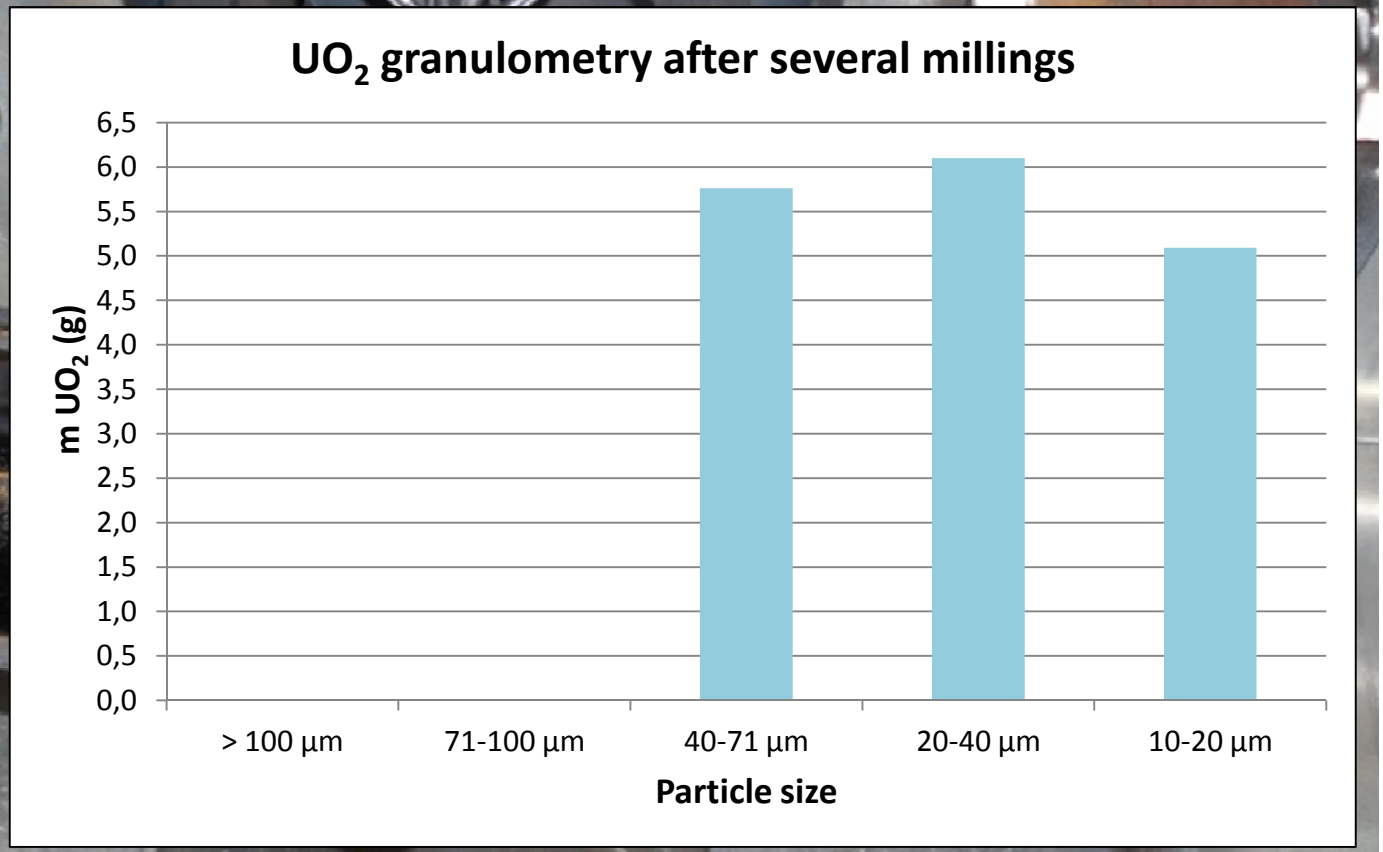
Starting point: UO_2 of unknown granulometry

Goal: UO_2 of controlled (low) granulometry to perform the reaction $UO_2 + 6C \rightarrow UC_2 + 2C + 2CO$

New equipment

Vibratory micro-mill

Sieves



UC_X pellets production

Main goal → use of a selected precursor (UO_2) particle size to produce UC_X discs

$$UO_2 (< 20\ \mu m) + 6C \rightarrow UC_2 + 2C + 2CO$$

Starting point: UO_2 of selected particle size (<20 μm)

Goal: production of 10 UC_X discs to be tested at IPNOrsay in 2014 (ENSAR ActiLab) → on-line irradiation tests and off-line characterization

10 samples successfully produced and ready to be tested

Discs properties

- 13 mm diameter, about 0.85 mm thickness
- Density of about 4.3 g/cm^3, similar to SPES standard target

UC_X for measurements of thermal conductivity

Main goal → production of 30 mm diameter pellets of various types of UC_X to perform thermal conductivity tests

30 mm diameter precursor pellet (UO2+ graphite)

30 mm diameter UC_X pellet

Successfully produced five ϕ 30 mm samples

UC_X from UO_2 of different particle sizes:

- p.s. < 20 µm
- 20 µm < p.s. < 40 µm
- 40 µm < p.s. < 71 µm

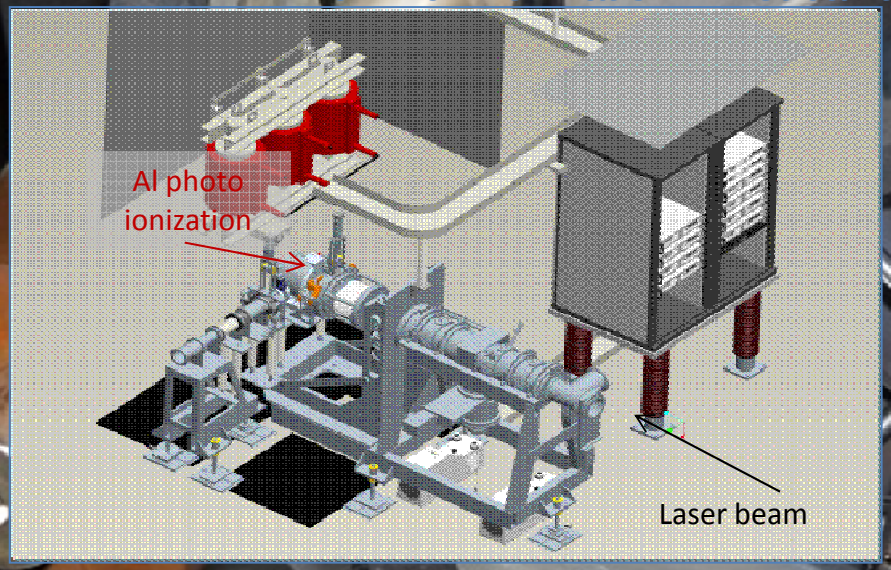
UC_X from different precursors:

- Non-milled UO_2
- Non-milled U_3O_8

Thermal conductivity measurements (2014) Rev. Sci. Instr. 84 (2013) 054902.

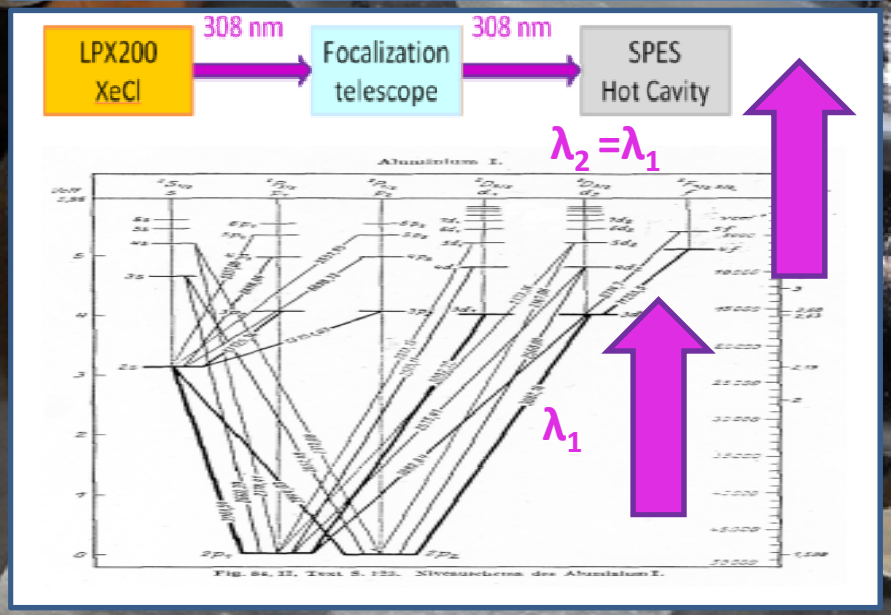
Laser test at LNL with excimer

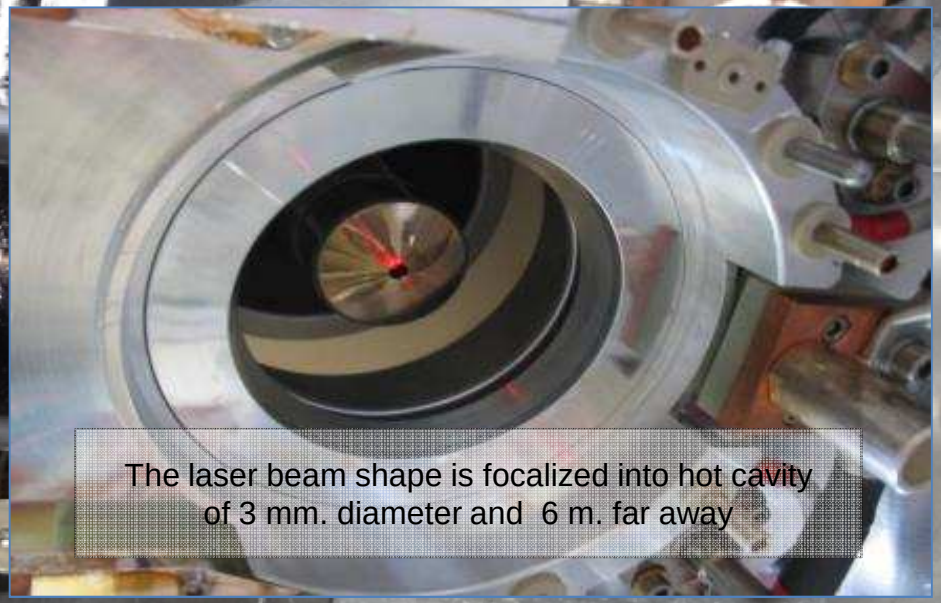
Aluminum ionization in hot cavity with a single wavelength



LPX200 XeCl excimer *laser*

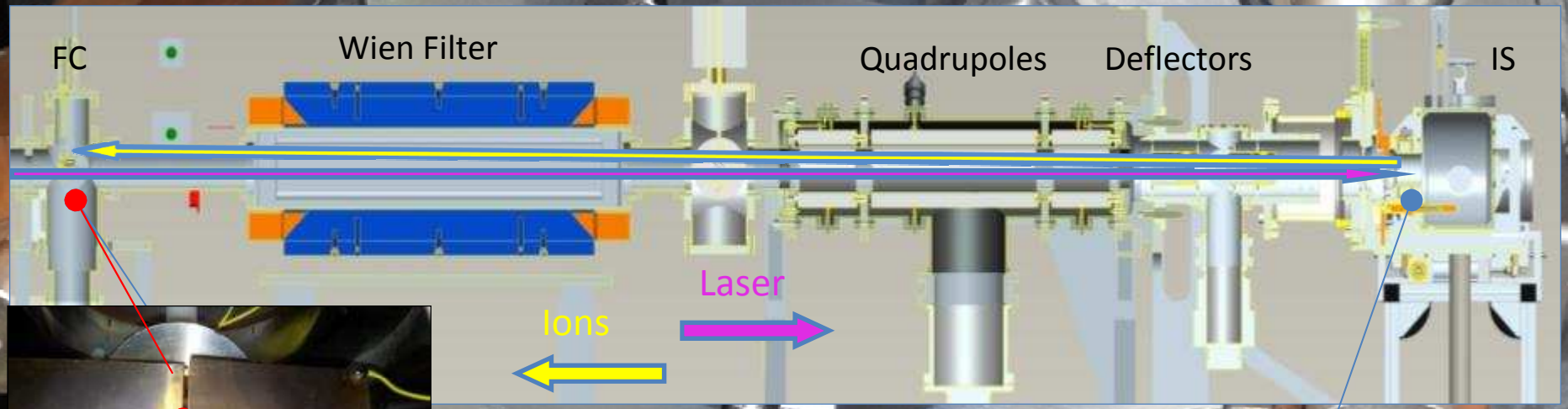
Pulse. 15 ns
λ=308 nm

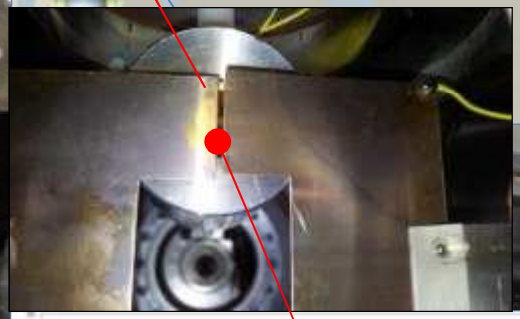


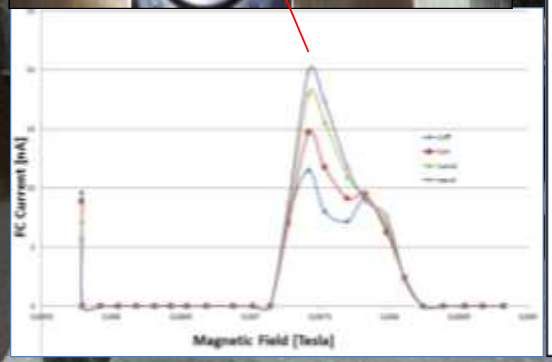


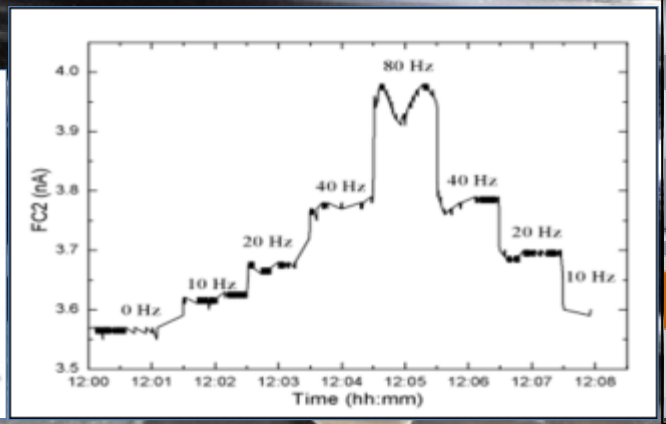
The laser beam shape is focalized into hot cavity of 3 mm. diameter and 6 m. far away

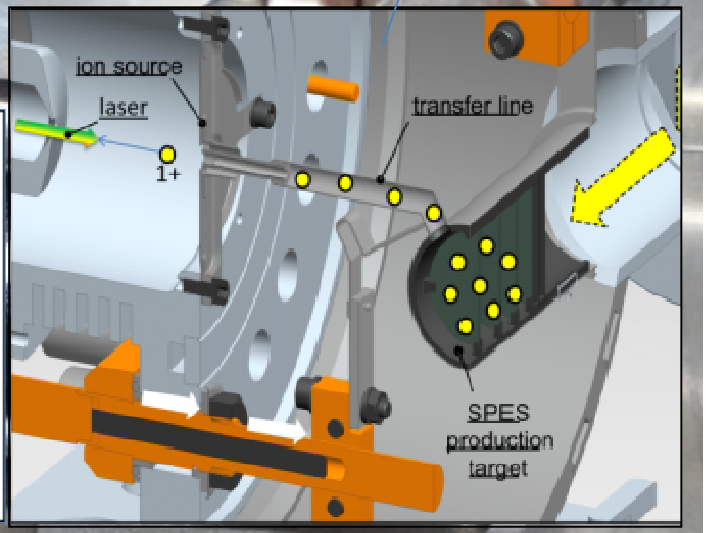
Aluminum Laser Resonant Ionization in the SPES Hot Cavity





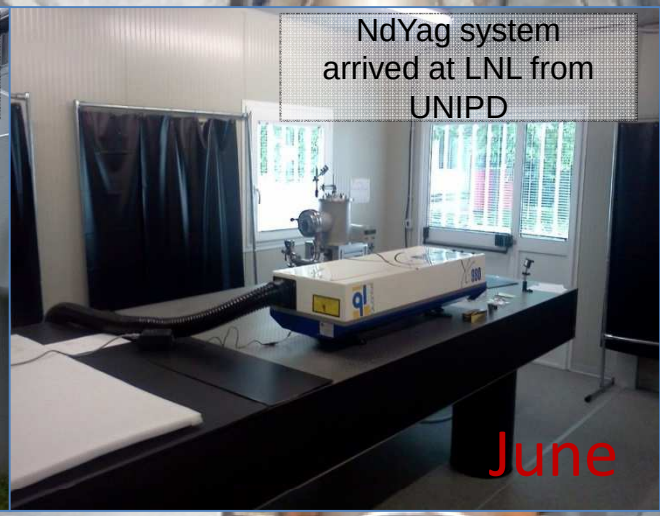






LNL Laser Laboratory

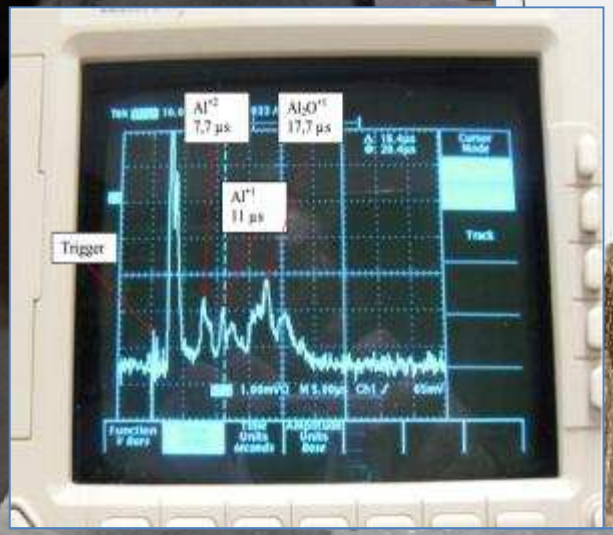
In 2013 a new SPES laser laboratory was build

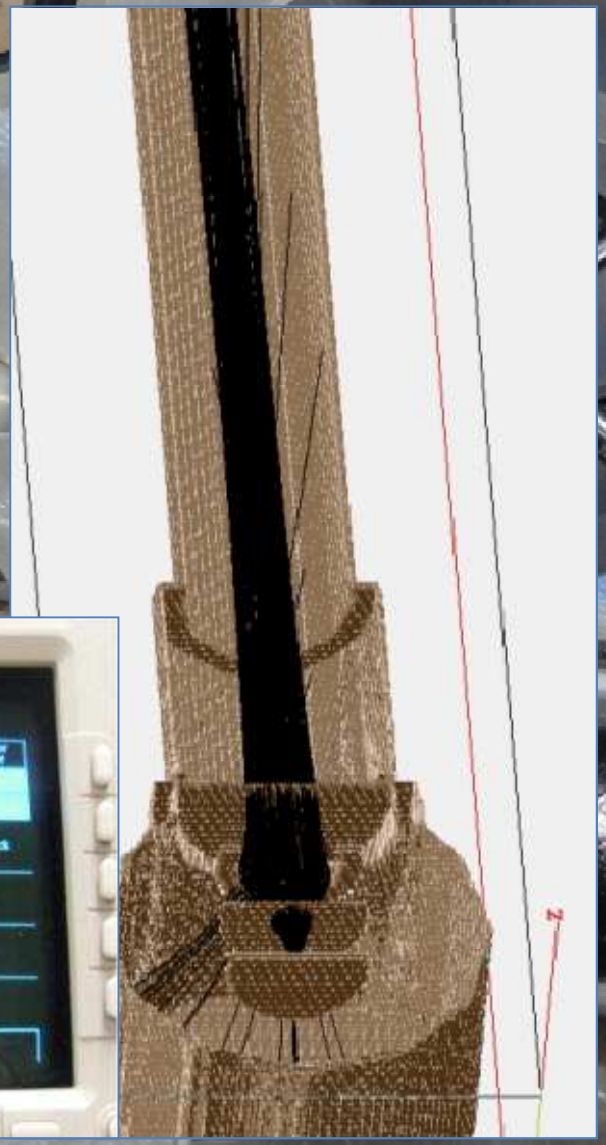


Home made ToF Mass Spectrometer

Design/construction of new Time of Flight Spectrometer

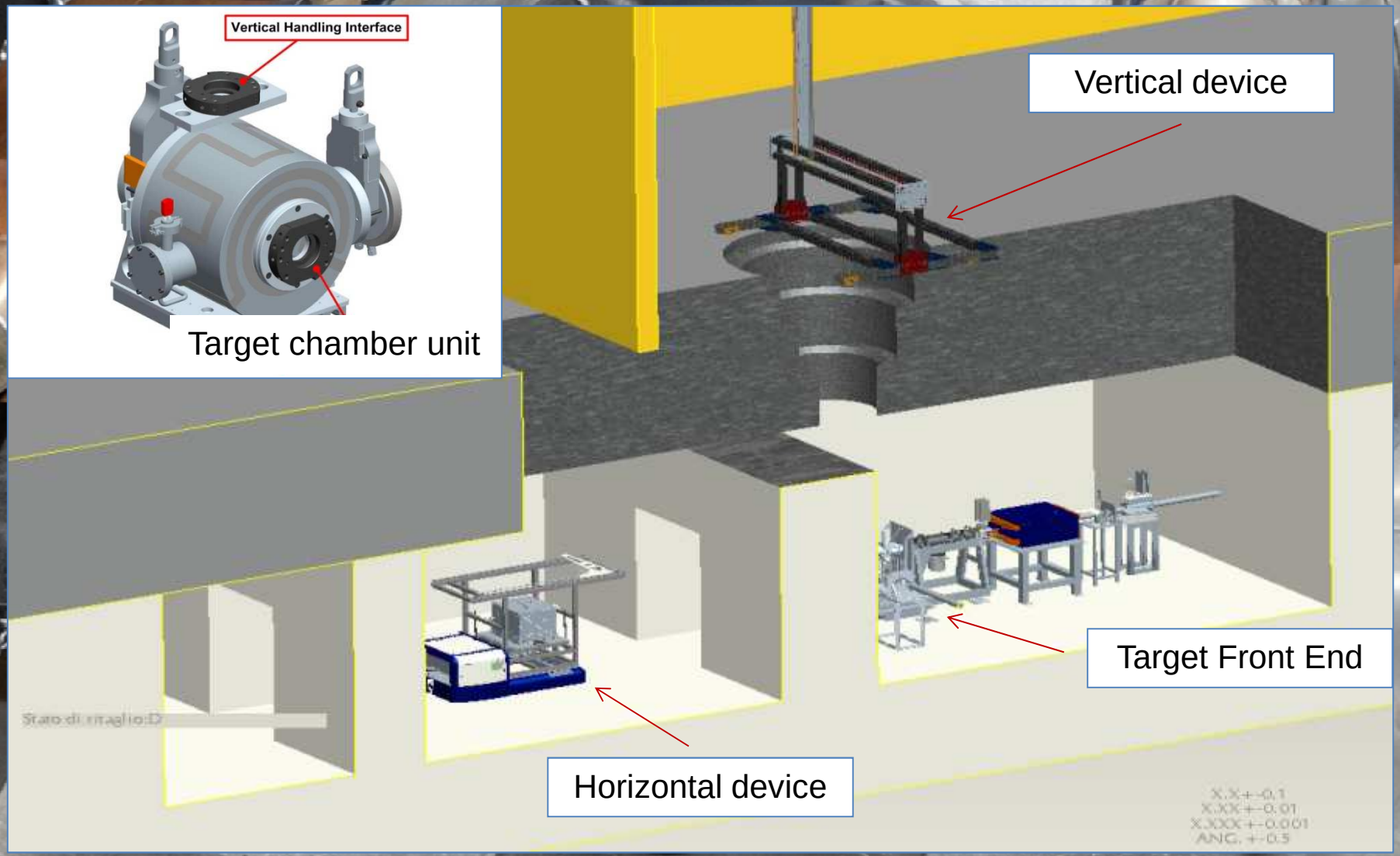
Simion® was used to design the layout and electrical field setup for the new ToF-MS in SPES laser laboratory.
Tests are under development to valuate the instrument capability



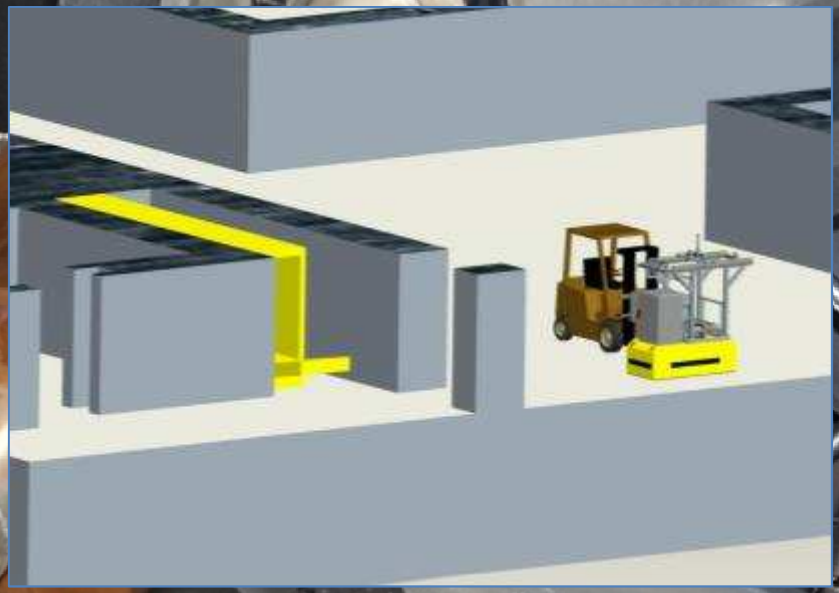


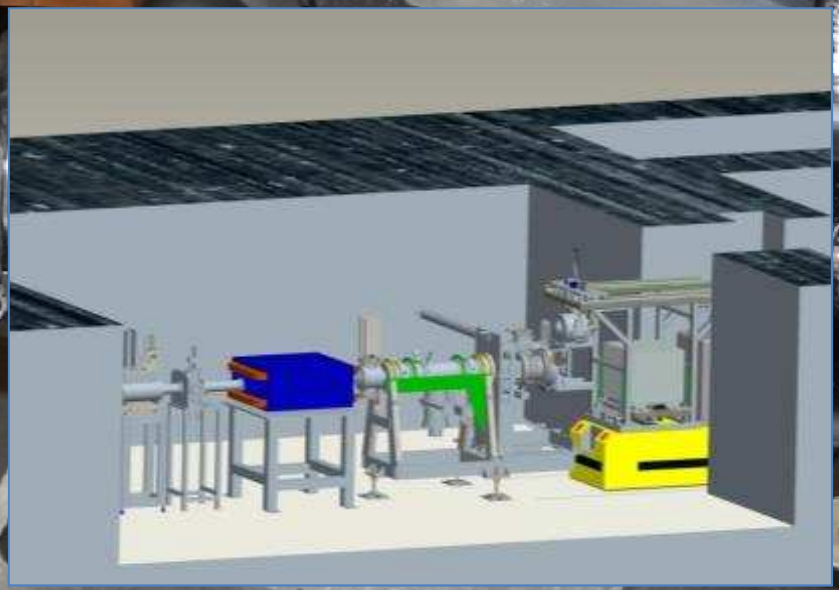
The target chamber handling

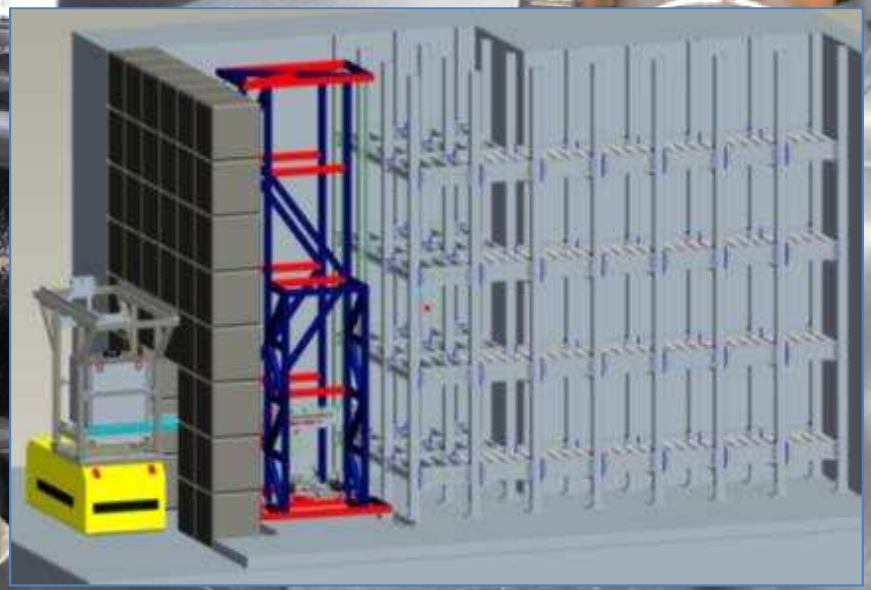
Two systems are foreseen in order to increase the handling security level



SPES Horizontal Handling system

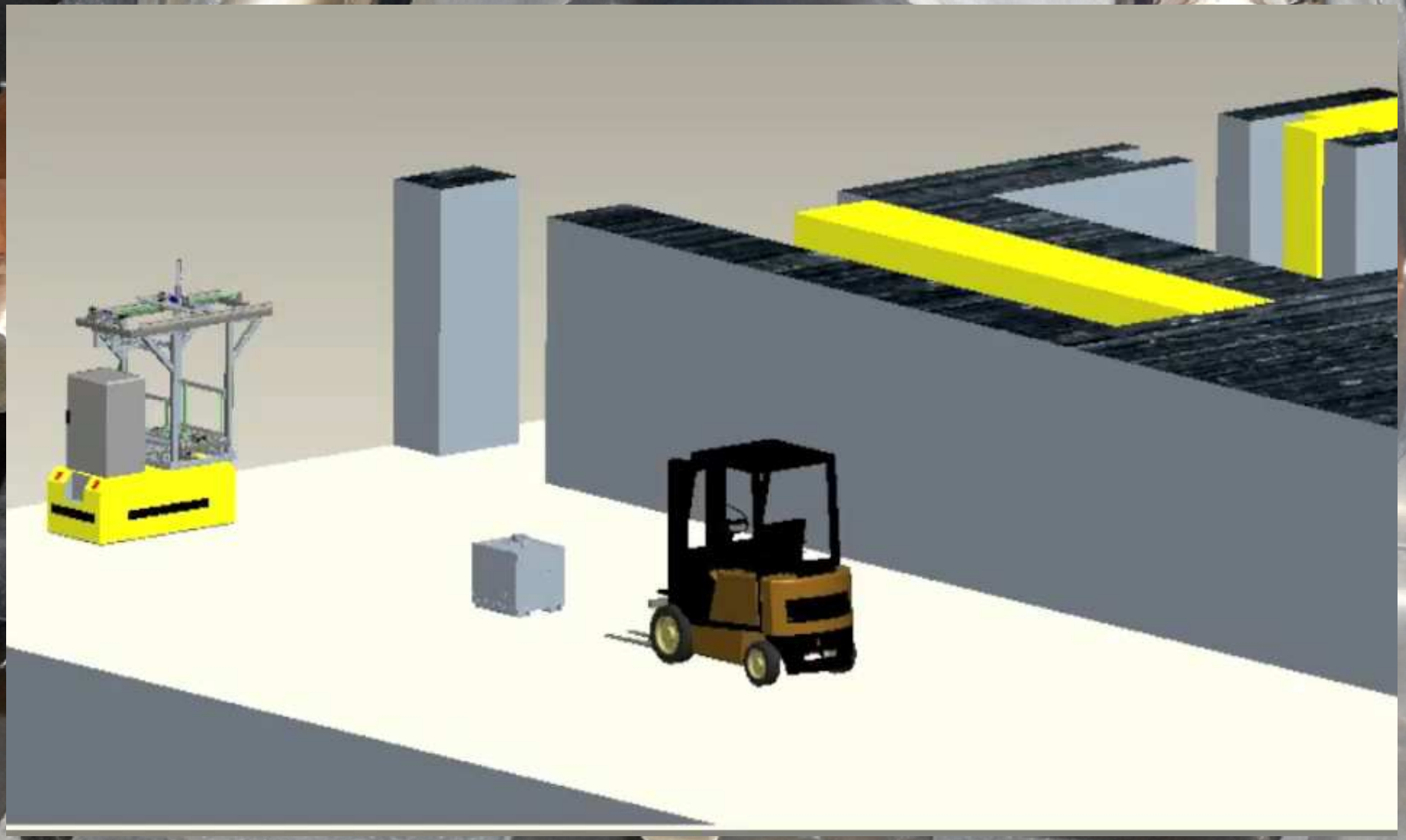






SPES Horizontal Handling system

All system has been developed according the safety & radioprotection rules



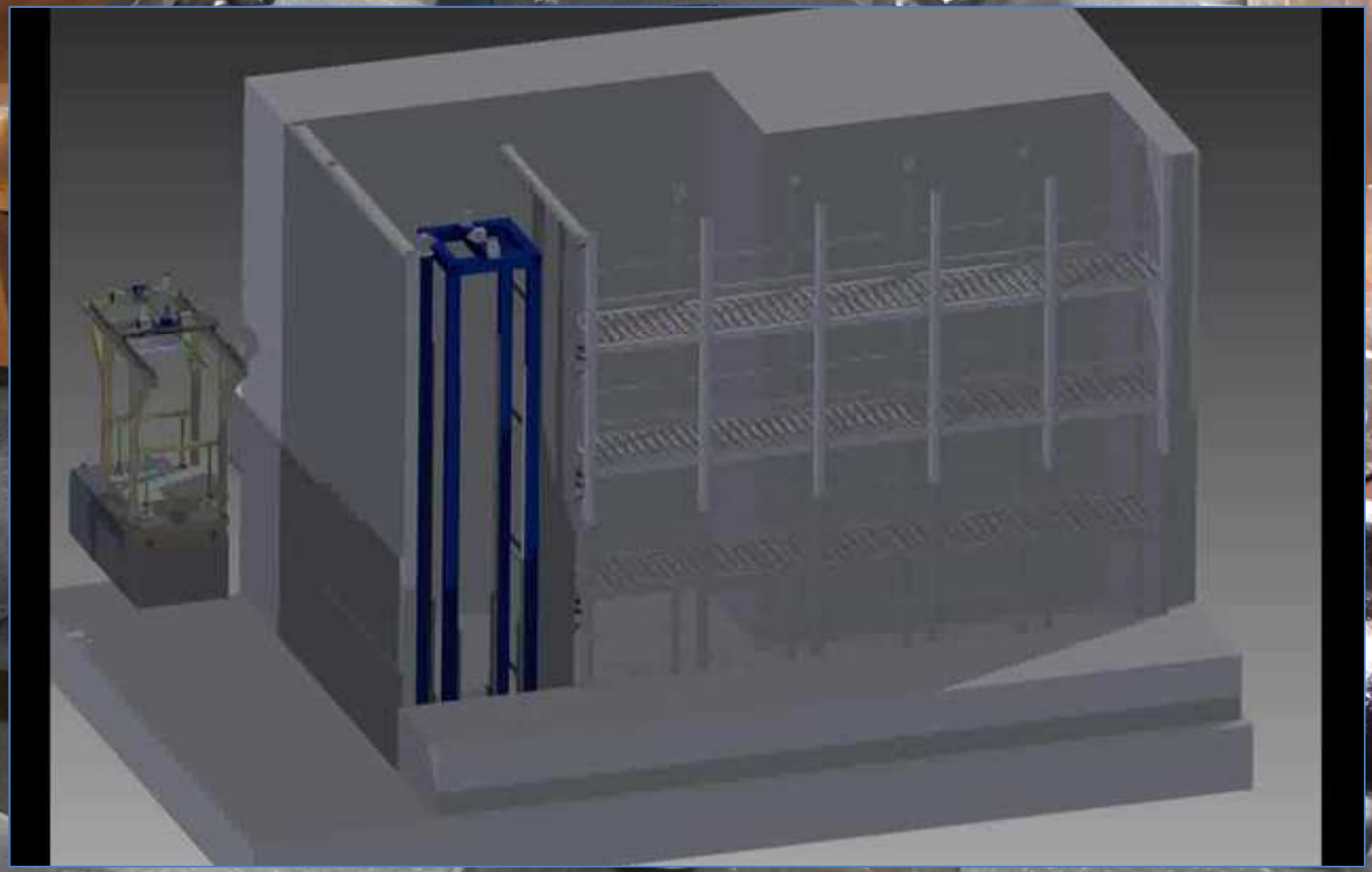
Horizontal device (AGV based)

Devices under construction at the LNL mechanical workshop

Target chamber rack-storage system

The storage system is able to accommodate up to 44 boxes, with the possibility of expelling the box with lower radioactivity (FIFO logic)

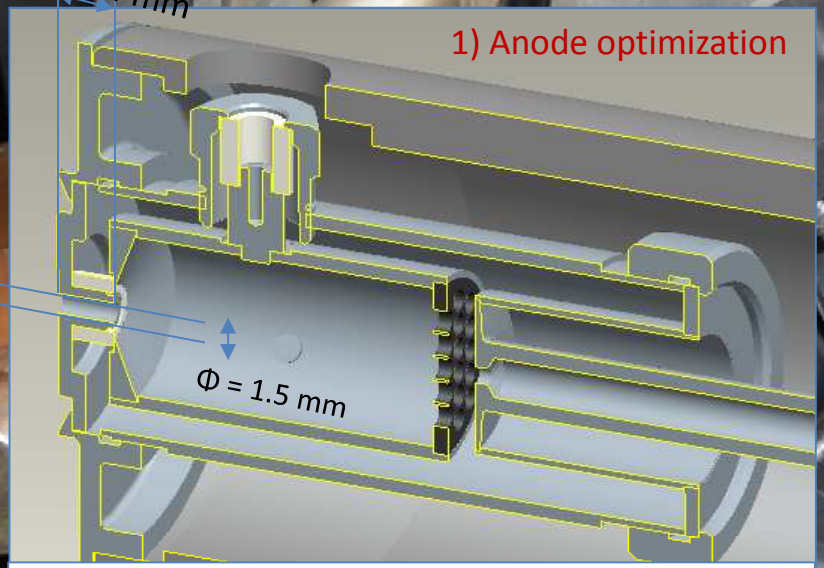
The system automatically picks up the Pb box from the AGV and placed in the rack.



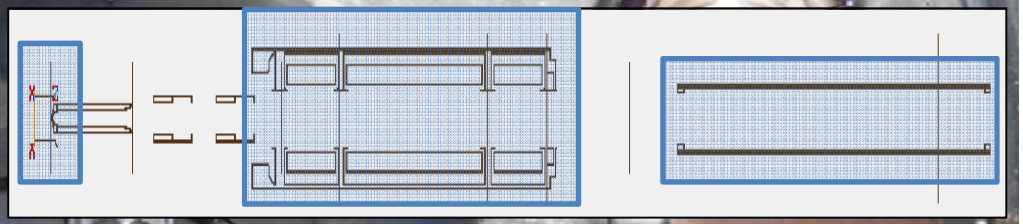
Design of the new extraction system

Optimization of FE optics in order increase the RIB transport

1) Anode optimization



Tested with a reduction of 25% of emittance
(ε = 11 π mm mrad @ 25 kV)

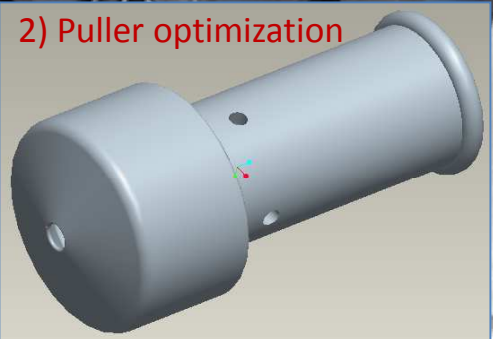


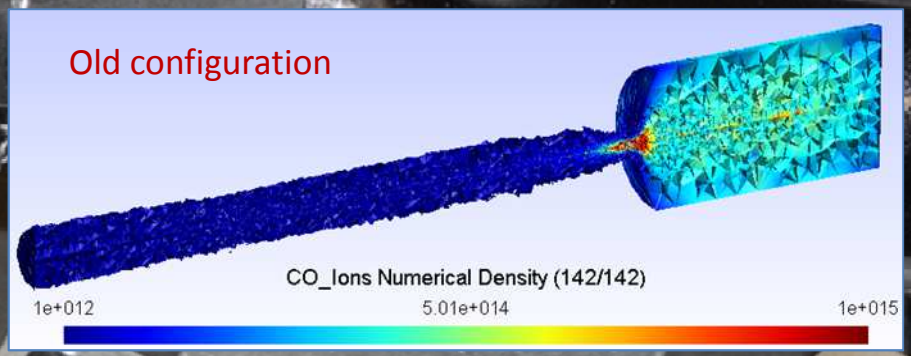
Source:
PIS
SIS (and LIS)

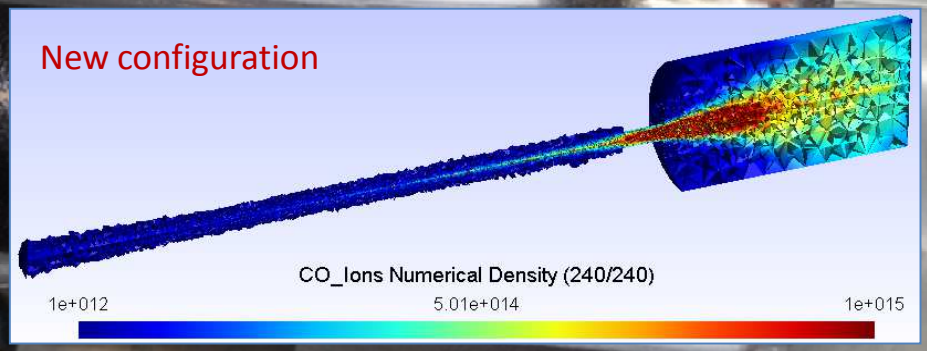
Quadrupoles:
SIS (and LIS)
PIS (presence of non-linear effects)

Wien Filter:
Mass resolution Transport efficiency

2) Puller optimization





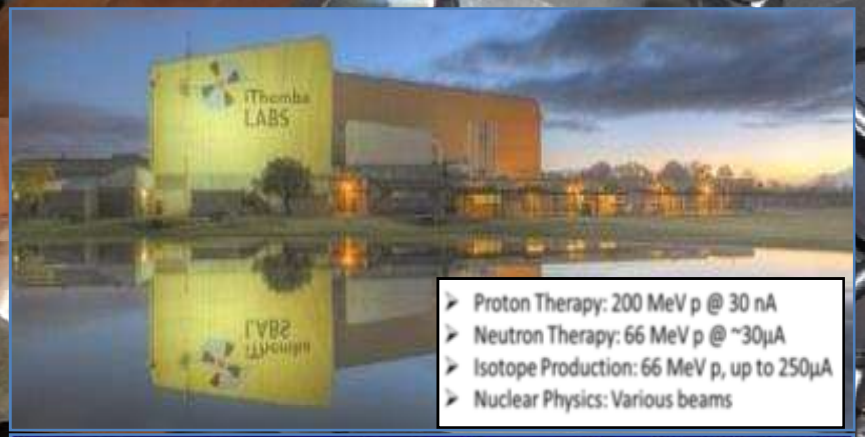


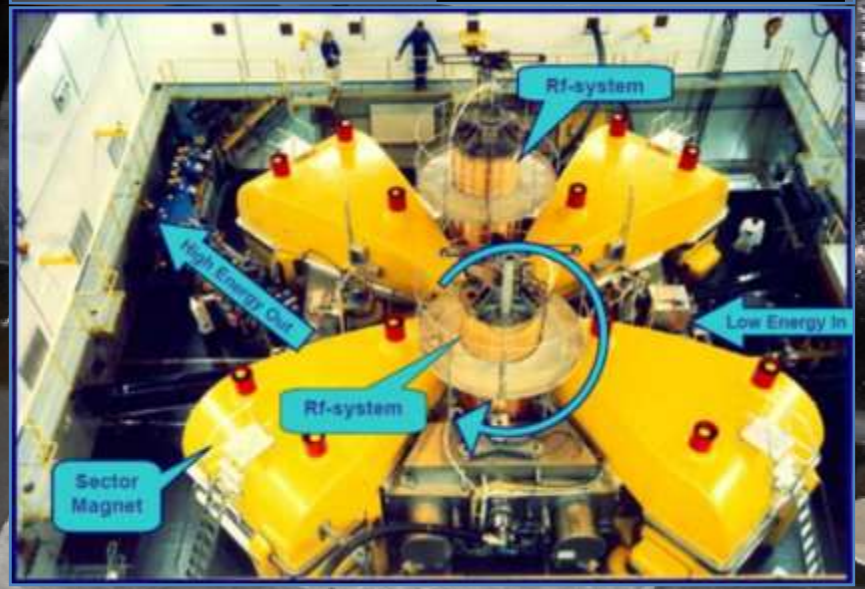
Main goal: PIS emittance comparable with SIS without losing in efficiency

Final remarks

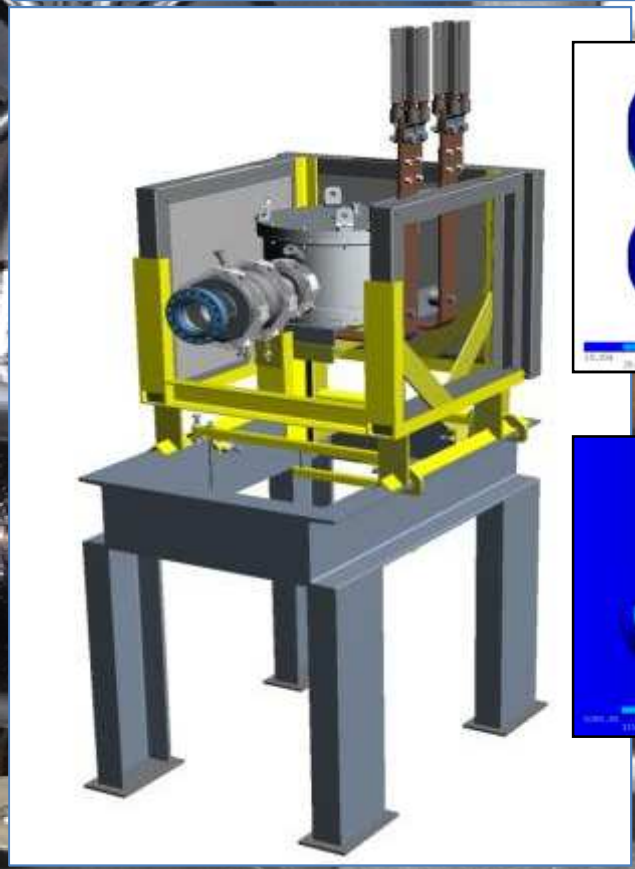
On-line test at IThemba

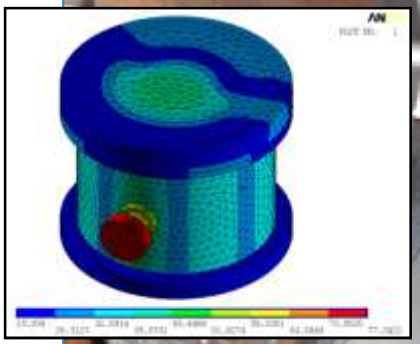
- On-line testing of the SPES target architecture @ iThemba (2013-2014)
- 66 MeV, up to 150 µA - proton beam on a SiC target

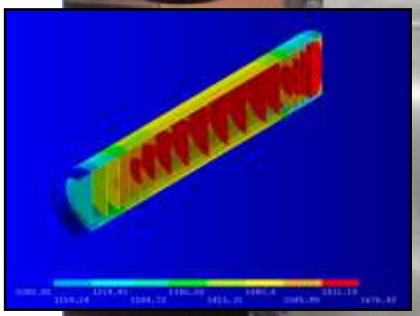




iThemba LABS
Target Ion-Source funding approved

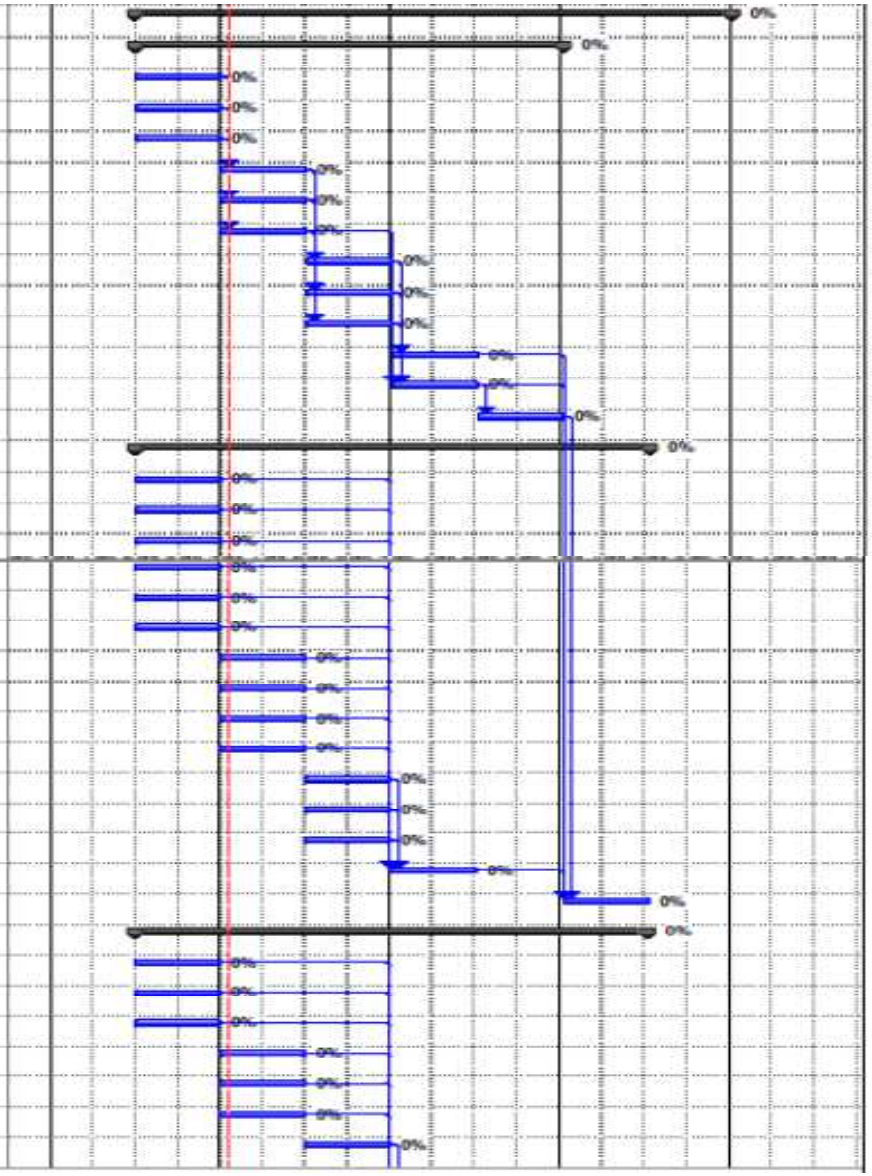




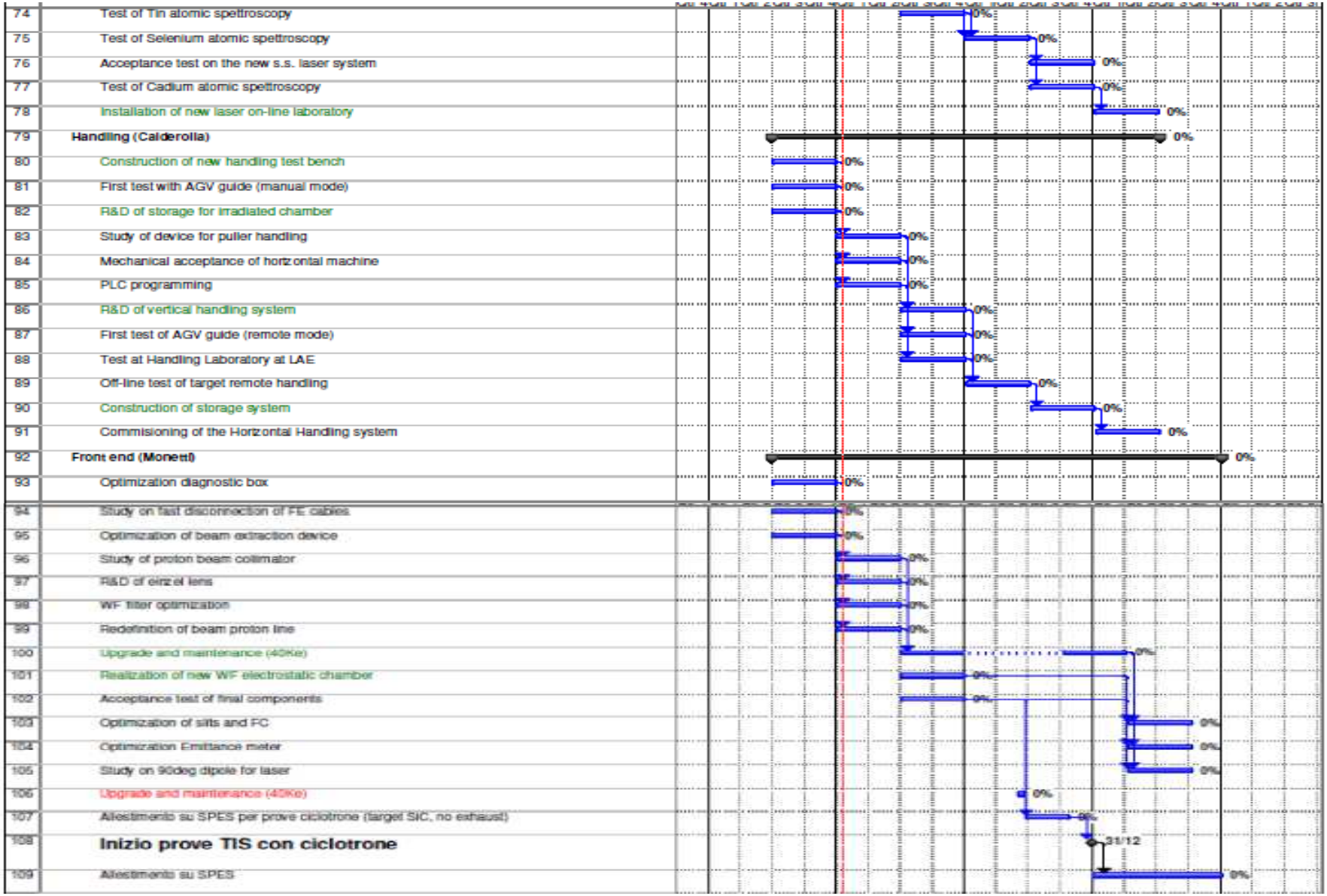


SPES Target planning (1/2)

36	**BS- Exotic Beams (Andrighetto, Manzolaro)**
37	**Target Maeerial (Corradetti)**
38	On line test at ALTO with new UCx
39	Set-up for UCx Therm. Conduc. Meas.
40	Production of new high pourous material
41	First meaasurements of Ucx T.C.
42	Emissivity meas. Of Ucx samples
43	Off line Characterization of Ucx
44	Equipments transfer form PD to LNL
45	42
46	Commissioning of LNL UCx laboratory
47	UCx vapour pression measurem.
48	First UCx production a LNL
49	Production of 40 mm UCX discs
50	**Target Ion Source (Manzolaro)**
51	Upgrading high power circuit
52	Study of external Graphite window
53	New PIS anode
54	PIS characterization - efficiency
55	PIS characterization - emittance
56	R&D on low power target system
57	On Line test at Ithemba
58	High power testing of the low power target system
59	New PIS cathode & transfer line
60	PIS characterization - emittance
61	R&D of new target dump system
62	Argon circuit for fire safety
63	SIS/LIS acceptance and reliability test
64	PIS acceptance and reliability test
65	TIS system (target + SIS) off line commissioning
66	**Laser (Scarpa)**
67	Installation of Dye system at LNL
68	TOF construction and assembly
69	Test with NdYag laser
70	Test with first Dye sistem
71	Study of OPG laser sistem
72	Test of Germanium atomic spettroscopy
73	Test with optical fiber



SPES Target planning (2/2)



74	Test of Tin atomic spettroscopy	0%
75	Test of Selenium atomic spettroscopy	0%
76	Acceptance test on the new s.s. laser system	0%
77	Test of Cadium atomic spettroscopy	0%
78	Installation of new laser on-line laboratory	0%
79	**Handling (Calderolla)**	0%
80	Construction of new handling test bench	0%
81	First test with AGV guide (manual mode)	0%
82	R&D of storage for irradiated chamber	0%
83	Study of device for puller handling	0%
84	Mechanical acceptance of hortzontal machine	0%
85	PLC programming	0%
86	R&D of vertical handling system	0%
87	First test of AGV guide (remote mode)	0%
88	Test at Handling Laboratory at LAE	0%
89	Off-line test of target remote handling	0%
90	Construction of storage system	0%
91	Commisioning of the Hortzontal Handling system	0%
92	**Front end (Monetti)**	0%
93	Optimization diagnostic box	0%
94	Study on fast disconnection of FE cables	0%
95	Optimization of beam extraction device	0%
96	Study of proton beam collimator	0%
97	R&D of einzel lens	0%
98	WF filter optimization	0%
99	Redefinition of beam proton line	0%
100	Upgrade and maintenance (40Ke)	0%
101	Realization of new WF electrostatic chamber	0%
102	Acceptance test of final components	0%
103	Optimization of slits and FC	0%
104	Optimization Emittance meter	0%
105	Study on 90deg dipole for laser	0%
106	Upgrade and maintenance (40Ke)	0%
107	Allestimento su SPES per prove ciclotrone (target SIC, no exhaust)	0%
108	**Inizio prove TIS con ciclotrone**	31/12
109	Allestimento su SPES	0%

The SPES-TIS group