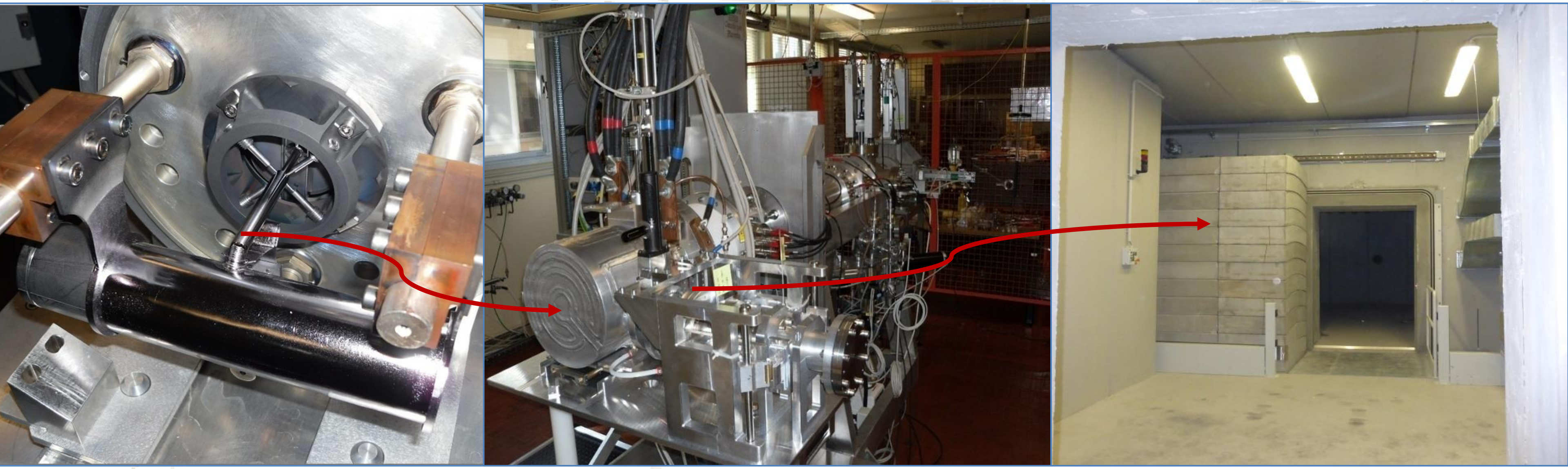
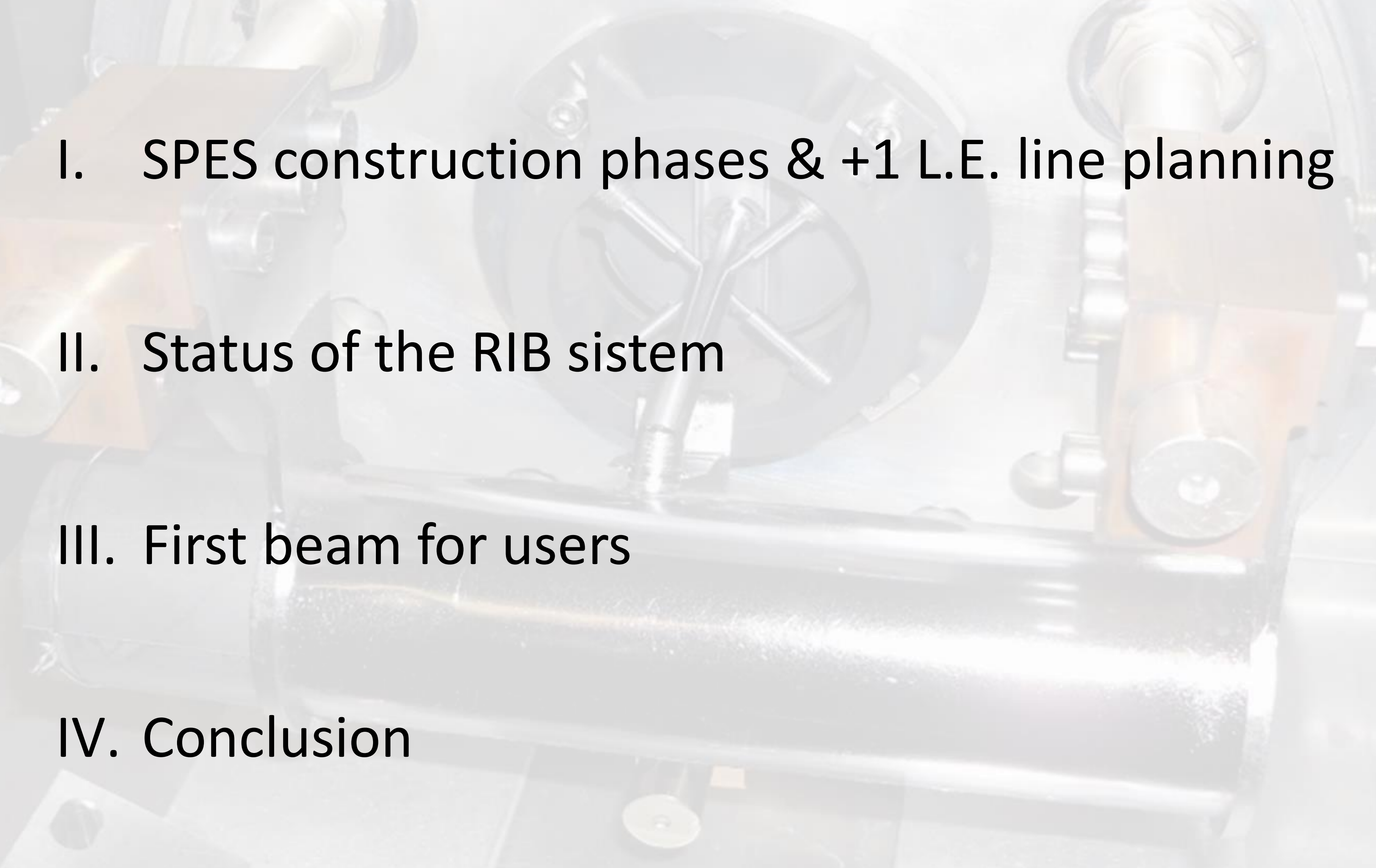
SPES secondary beam planning



A. Andrighetto
INFN – Laboratori di Legnaro

SPES Workshop
LNL, October 10th, 2016

Talk Overview



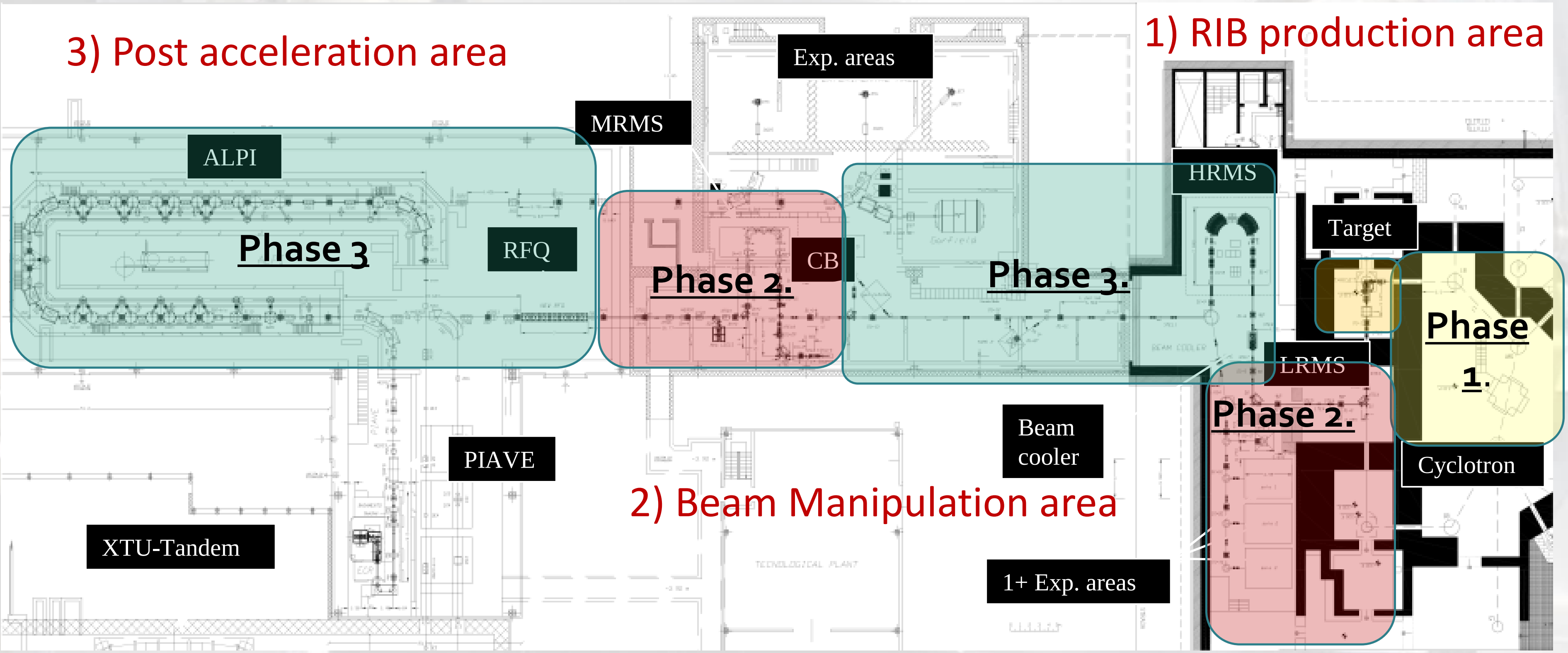
I. SPES construction phases & +1 L.E. line planning

II. Status of the RIB sistem

III. First beam for users

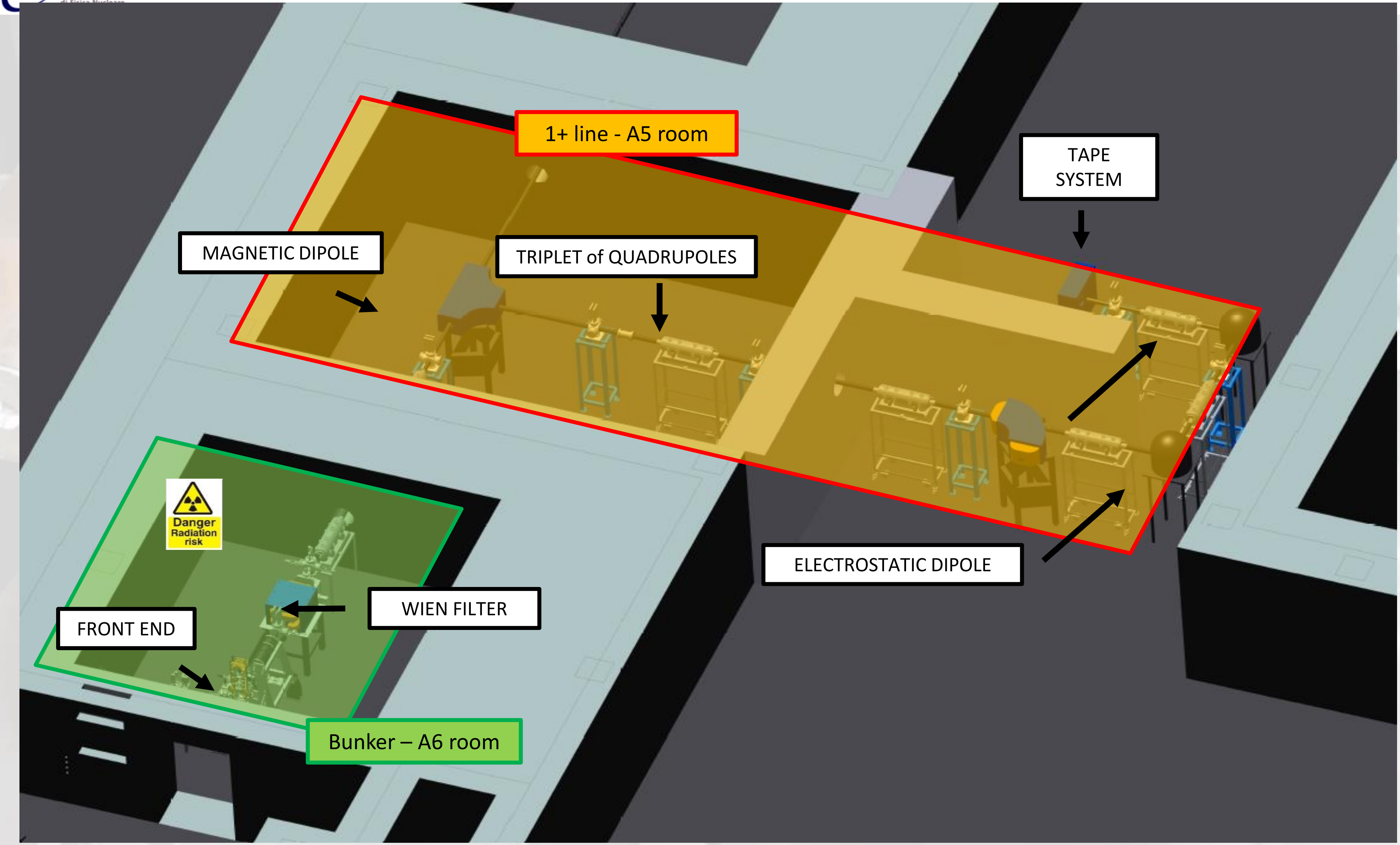
IV. Conclusion

Project construction phases



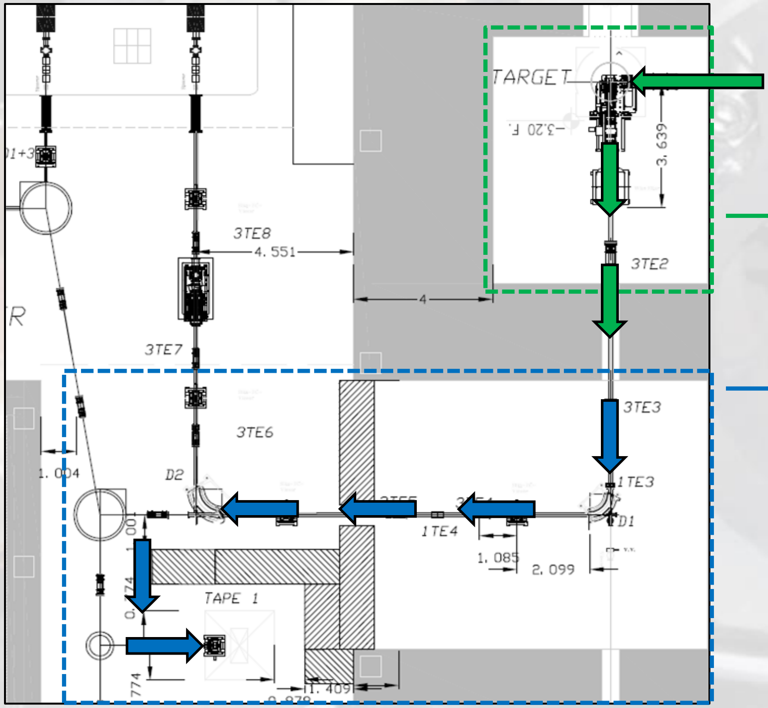
- **Phase 1. 2016** - Building + First operation with the cyclotron ← NOW!
- **Phase 2. 2017-19** - From C.B. to RFQ + SPES target, LRMS, 1+ Beam Lines
- **Phase 3. 2019-20** - From the LRMS to the CB + rom RFQ to ALPI

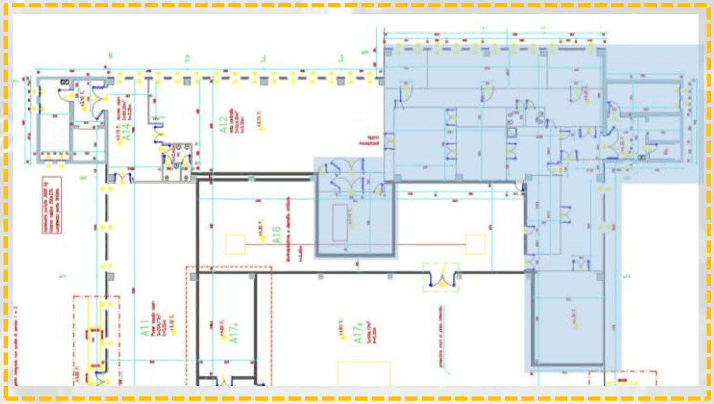
The Low Energy 1+ beam line (“TIS – Tape System”)



Goal: To Have first no-accelerated RIB before end 2019

Working plan for the 1+ (TIS – tape system)





Working plan and follow-up for the three main issues listed below:

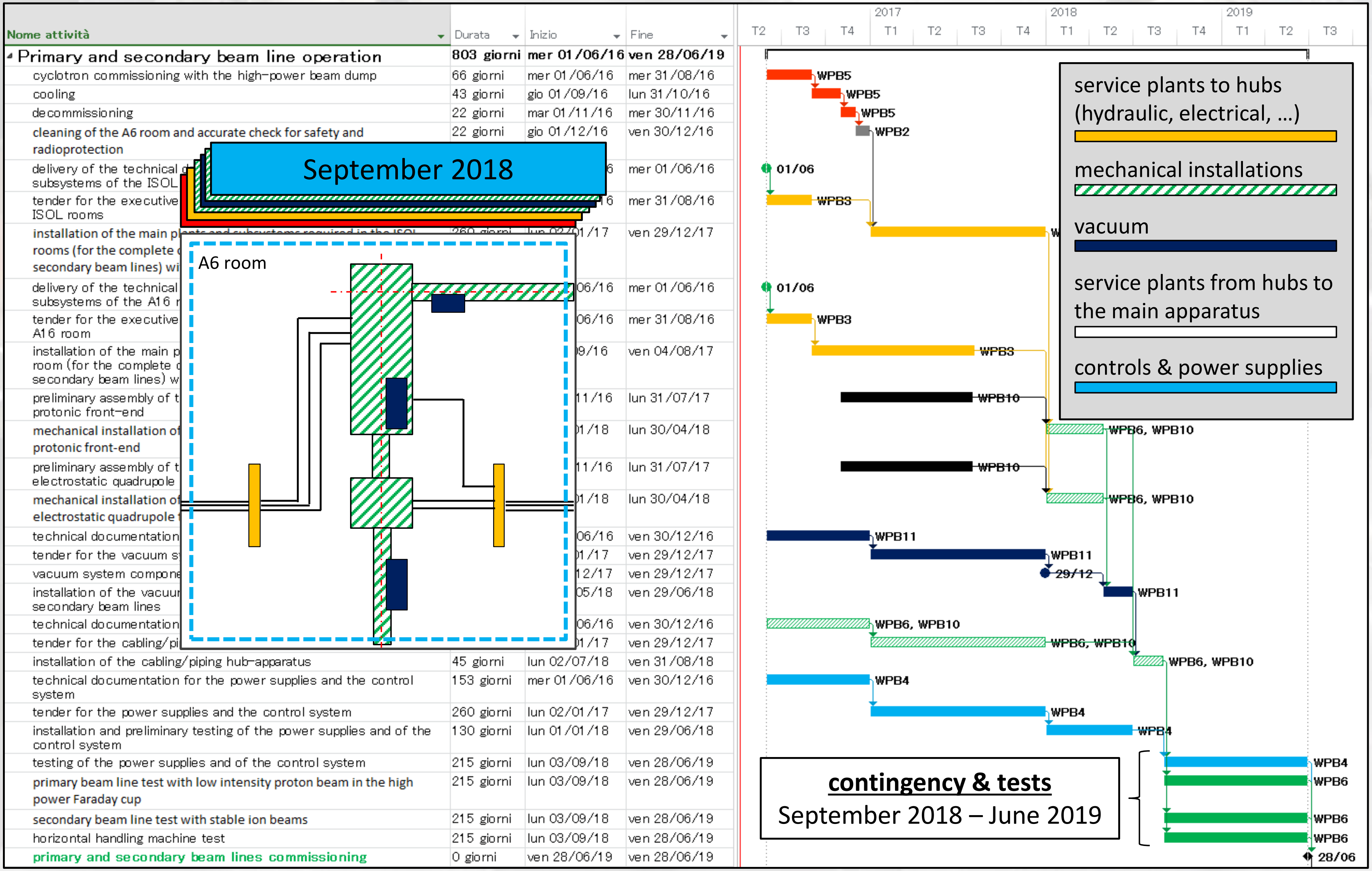
1) Bunker beam line (proton & RIB)

2) 1+ beam line

3) SPES ISOL laboratories operation

Milestone 2019: first low intensity RIB @ SPES

Planning of Bunker beam line



Nome attività	Durata	Inizio	Fine
Primary and secondary beam line operation	**803 giorni**	**mer 01/06/16**	**ven 28/06/19**
cyclotron commissioning with the high-power beam dump	66 giorni	mer 01/06/16	mer 31/08/16
cooling	43 giorni	gio 01/09/16	lun 31/10/16
decommissioning	22 giorni	mar 01/11/16	mer 30/11/16
cleaning of the A6 room and accurate check for safety and radioprotection	22 giorni	gio 01/12/16	ven 30/12/16
delivery of the technical d subsystems of the ISOL		6	mer 01/06/16
tender for the executive ISOL rooms		6	mer 31/08/16
installation of the main pl rooms (for the complete secondary beam lines) wi	260 giorni	lun 02/01/17	ven 29/12/17
delivery of the technical subsystems of the A16 r		06/16	mer 01/06/16
tender for the executive A16 room		06/16	mer 31/08/16
installation of the main p room (for the complete secondary beam lines) w		9/16	ven 04/08/17
preliminary assembly of t protonic front-end		11/16	lun 31/07/17
mechanical installation of protonic front-end		1/18	lun 30/04/18
preliminary assembly of t electrostatic quadrupole		11/16	lun 31/07/17
mechanical installation of electrostatic quadrupole f		1/18	lun 30/04/18
technical documentation		06/16	ven 30/12/16
tender for the vacuum s		1/17	ven 29/12/17
vacuum system compone		12/17	ven 29/12/17
installation of the vacuu secondary beam lines		05/18	ven 29/06/18
technical documentation		06/16	ven 30/12/16
tender for the cabling/pi		1/17	ven 29/12/17
installation of the cabling/piping hub-apparatus	45 giorni	lun 02/07/18	ven 31/08/18
technical documentation for the power supplies and the control system	153 giorni	mer 01/06/16	ven 30/12/16
tender for the power supplies and the control system	260 giorni	lun 02/01/17	ven 29/12/17
installation and preliminary testing of the power supplies and of the control system	130 giorni	lun 01/01/18	ven 29/06/18
testing of the power supplies and of the control system	215 giorni	lun 03/09/18	ven 28/06/19
primary beam line test with low intensity proton beam in the high power Faraday cup	215 giorni	lun 03/09/18	ven 28/06/19
secondary beam line test with stable ion beams	215 giorni	lun 03/09/18	ven 28/06/19
horizontal handling machine test	215 giorni	lun 03/09/18	ven 28/06/19
primary and secondary beam lines commissioning	0 giorni	ven 28/06/19	ven 28/06/19

September 2018

service plants to hubs (hydraulic, electrical, …)

mechanical installations

vacuum

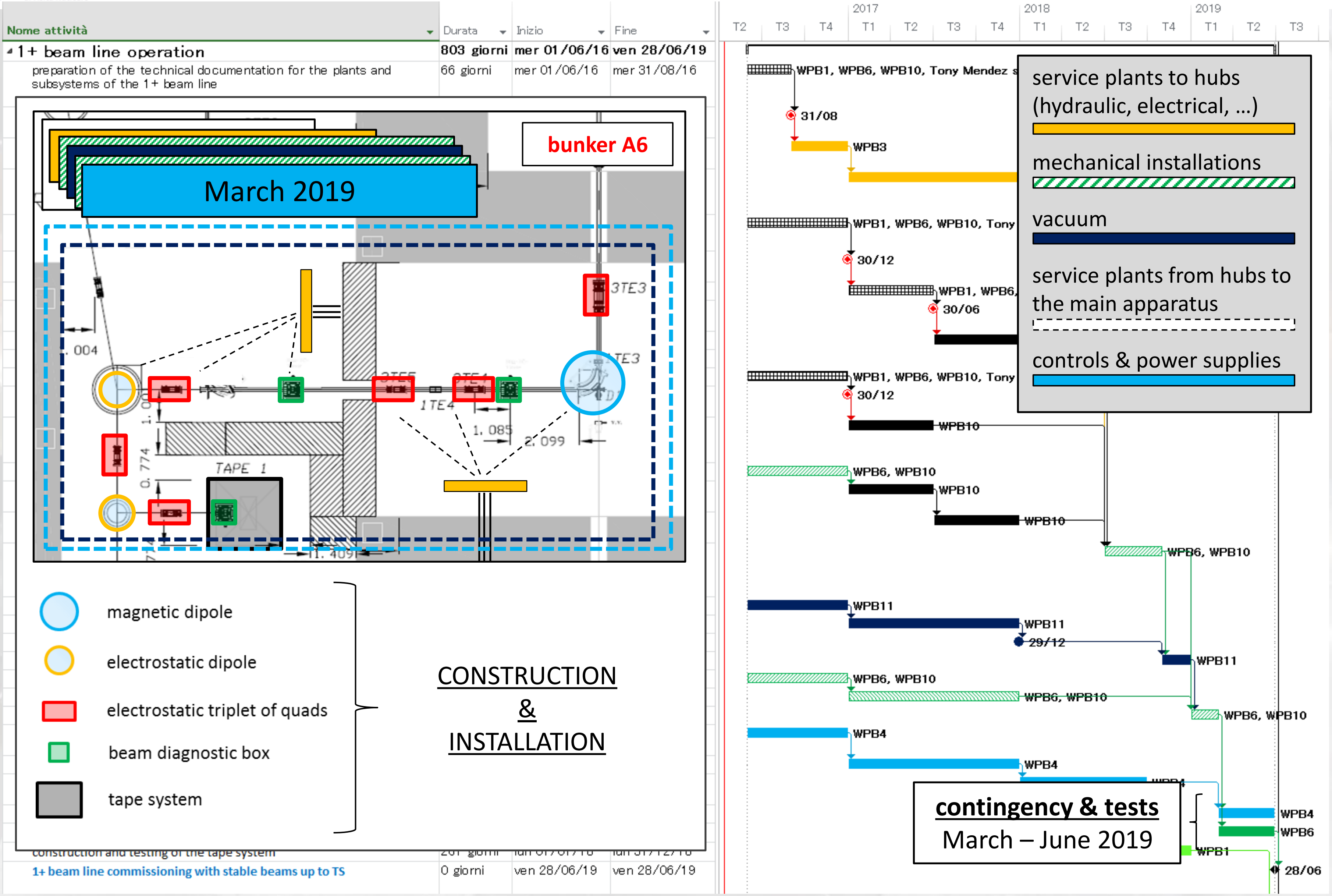
service plants from hubs to the main apparatus

controls & power supplies

contingency & tests

September 2018 – June 2019

Planning of 1+ beam line



Nome attività	Durata	Inizio	Fine
1+ beam line operation	803 giorni	mer 01/06/16	ven 28/06/19
preparation of the technical documentation for the plants and subsystems of the 1+ beam line	66 giorni	mer 01/06/16	mer 31/08/16
construction and testing of the tape system	201 giorni	lun 01/01/18	lun 31/12/18
1+ beam line commissioning with stable beams up to TS	0 giorni	ven 28/06/19	ven 28/06/19

service plants to hubs (hydraulic, electrical, …) 🟧

mechanical installations ▨

vacuum 🟦

service plants from hubs to the main apparatus ⬚

controls & power supplies 🟦

○ magnetic dipole

○ electrostatic dipole

🟥 electrostatic triplet of quads

🟩 beam diagnostic box

⬛ tape system

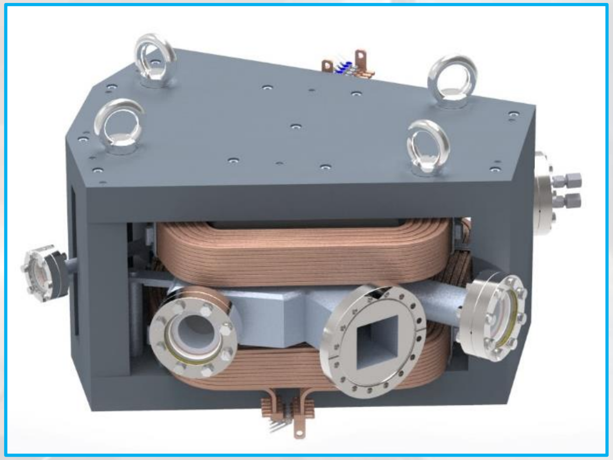
CONSTRUCTION & INSTALLATION

contingency & tests
March – June 2019

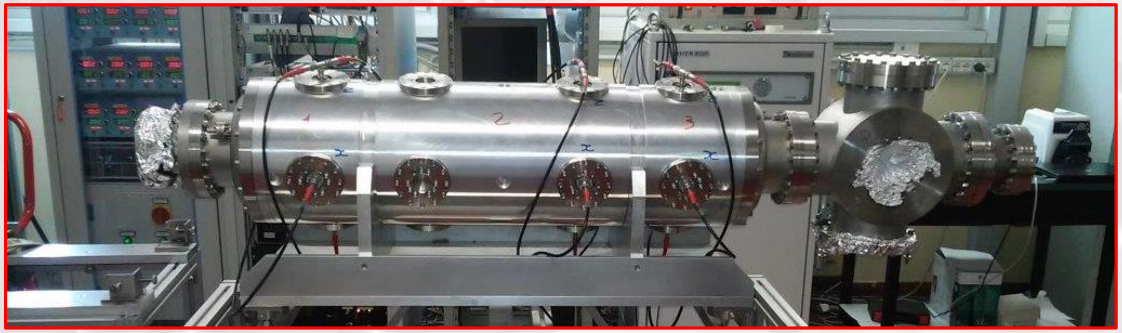
1+ beam line operation (from TIS to tape system)

WIP for the specific 1+ beam line components

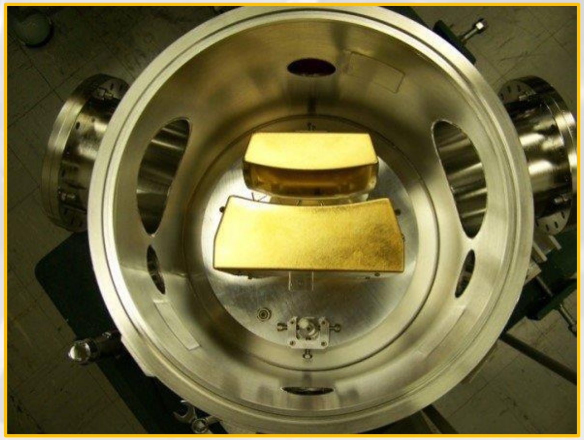
magnetic dipole



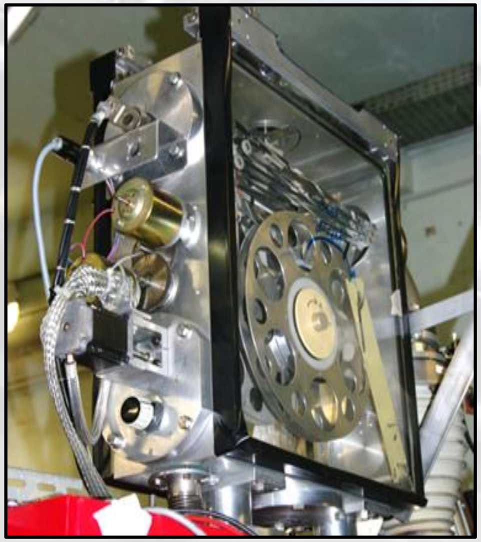
electrostatic triplet of quads



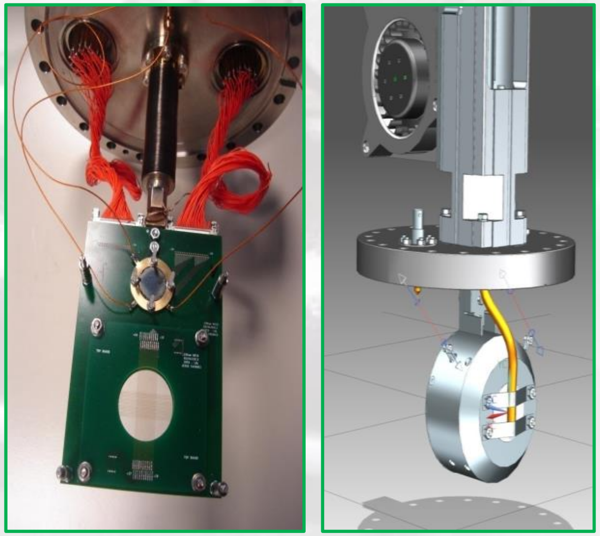
electrostatic dipole



tape system

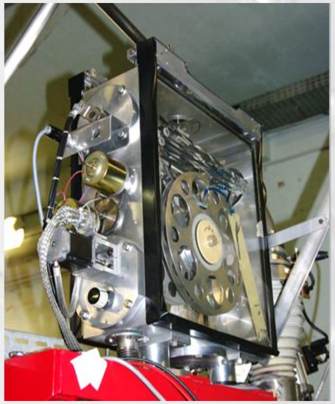


beam diagnostic box



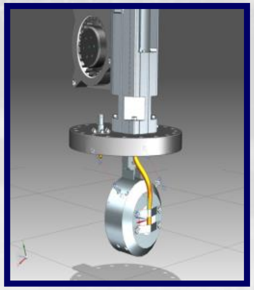
Future Implementations

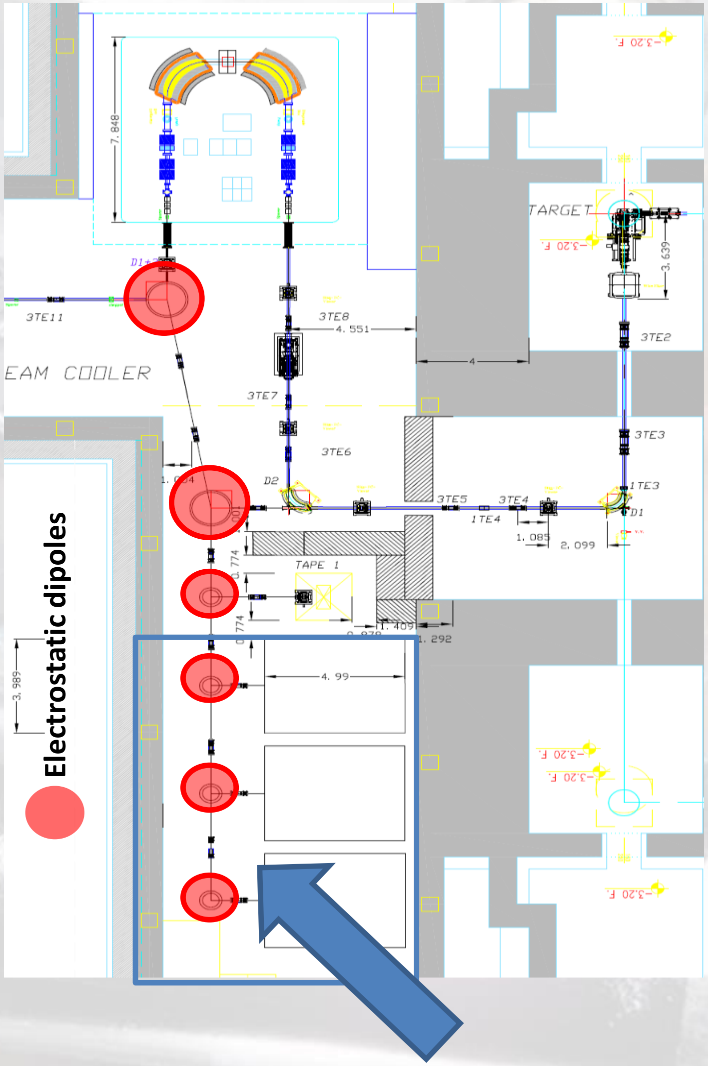
Tape station for beam characterization



Low intensity beam monitors

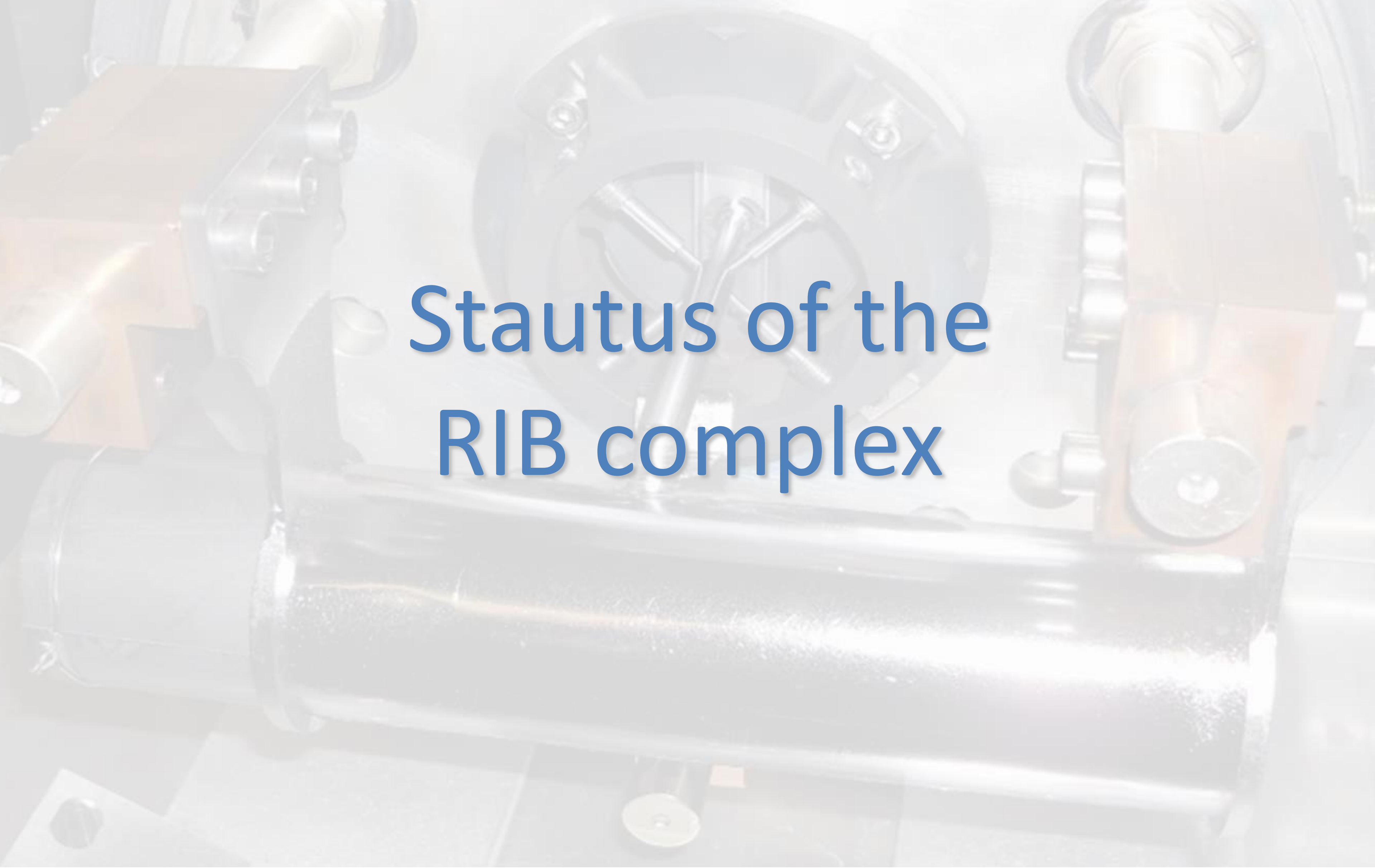
MCP & grid beam monitor





Low Energy Experimental Room (not financed yet)

Alberto Andrighetto

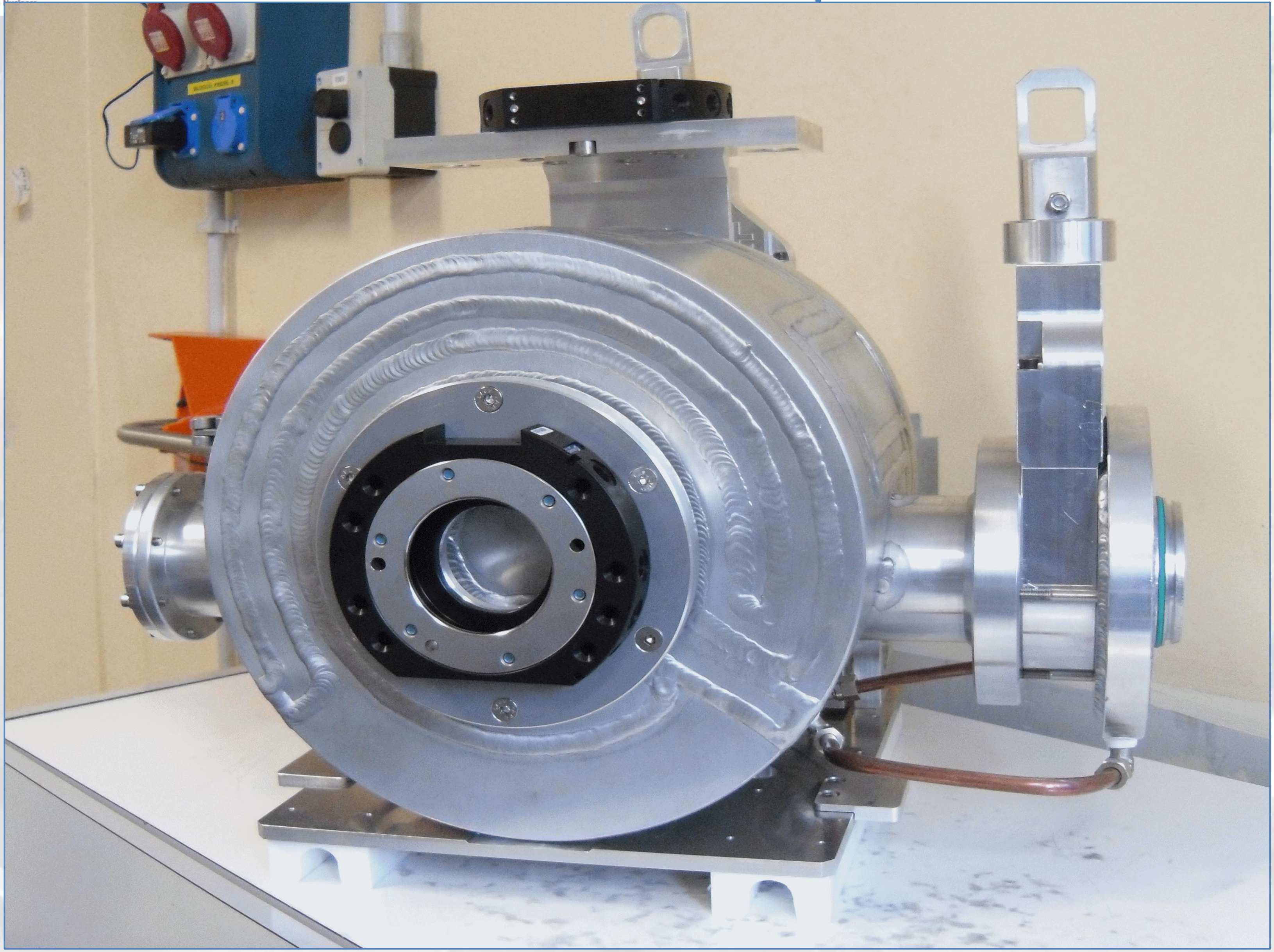


Stautus of the RIB complex

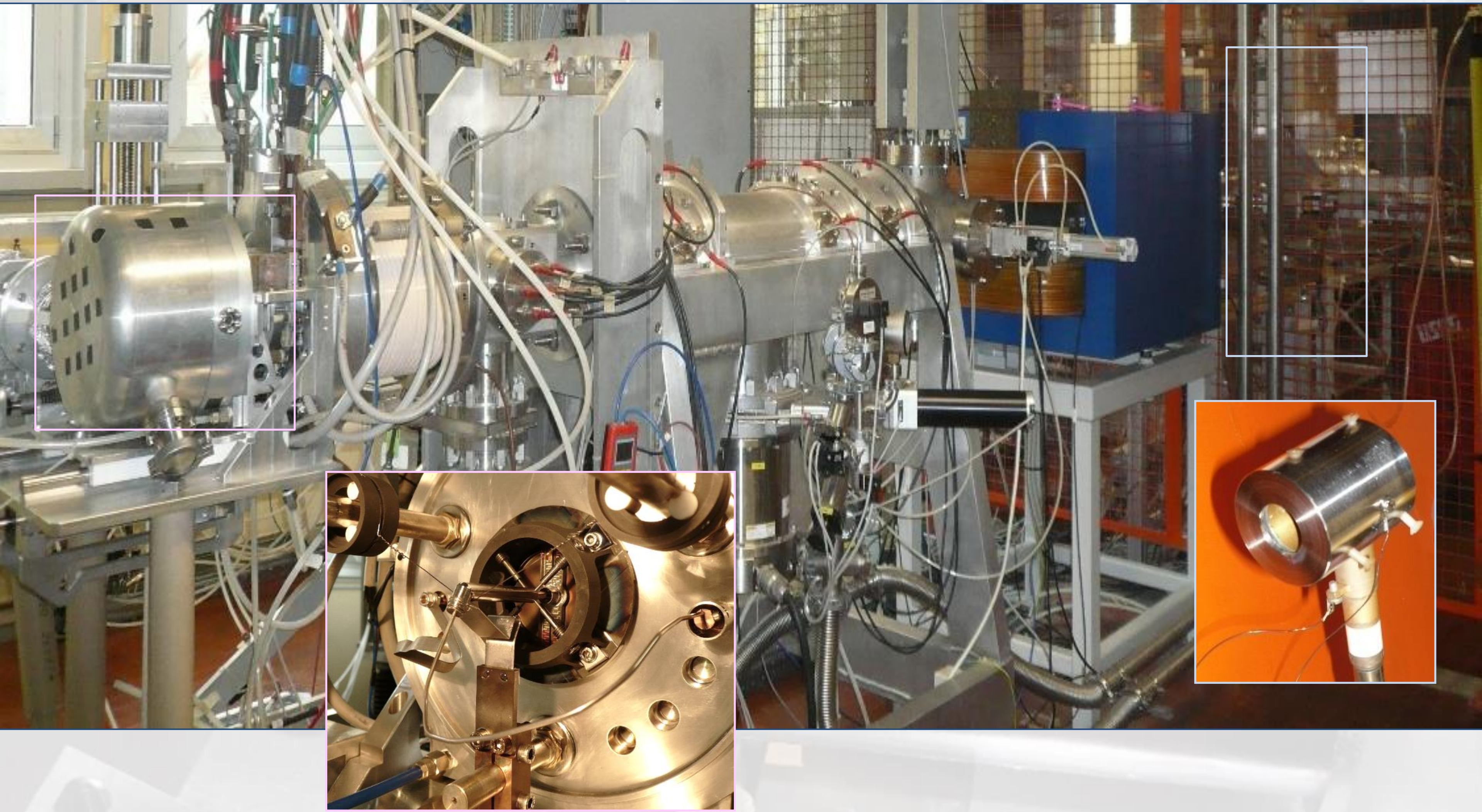
Alberto Andrighetto

III SPES workshop: 10th October 2016

The SPES TIS complex



The OFF-LINE fron-end



Laboratories & Organization

WG1:
TIS

WG2:
Materials

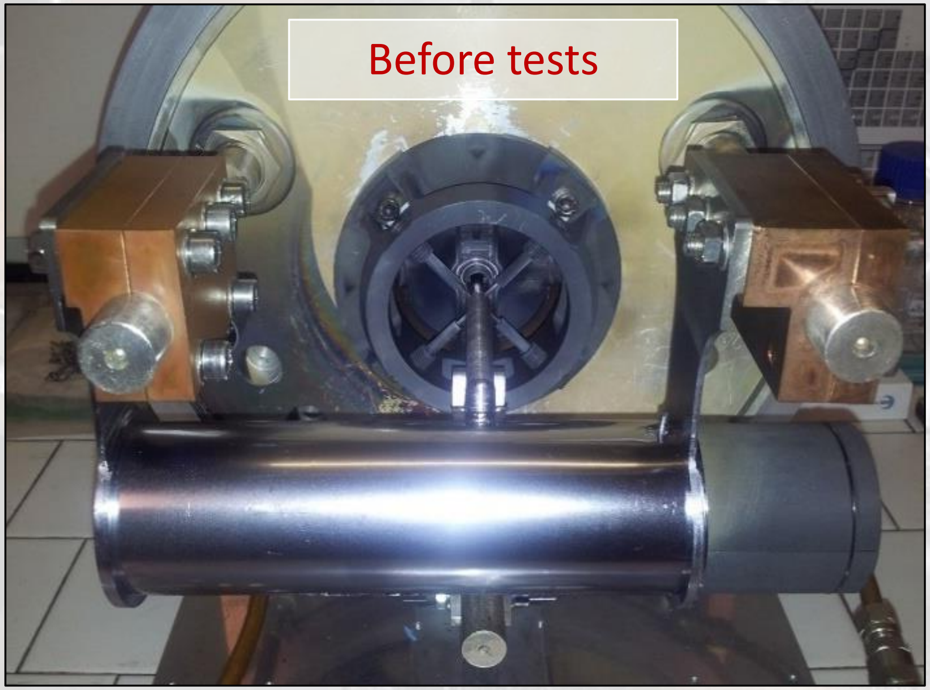
WG3:
Laser

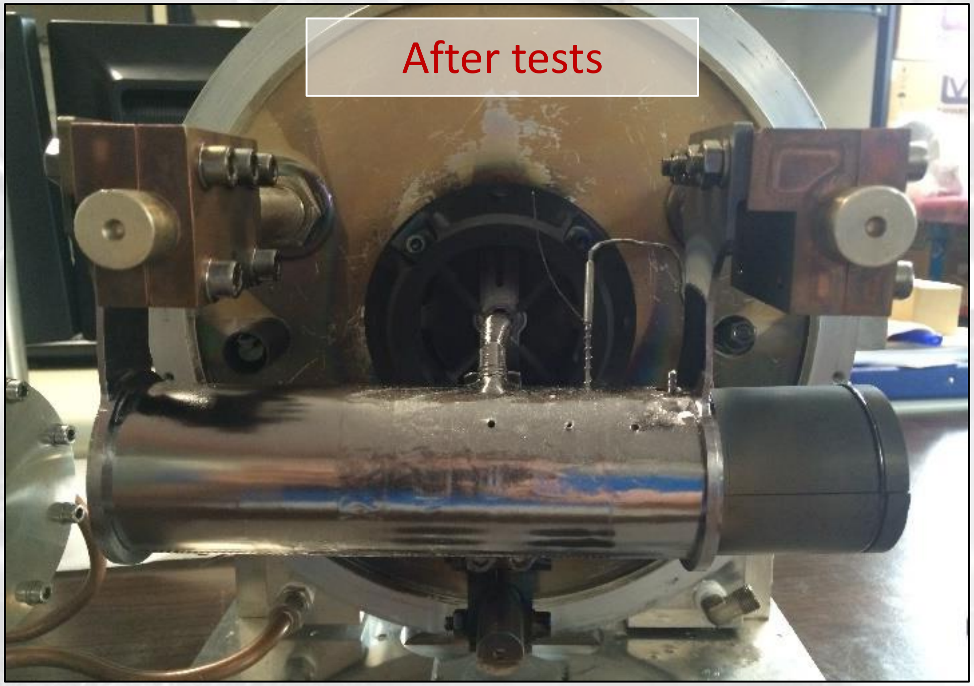
WG4:
Handling

WG5:
Front End

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)

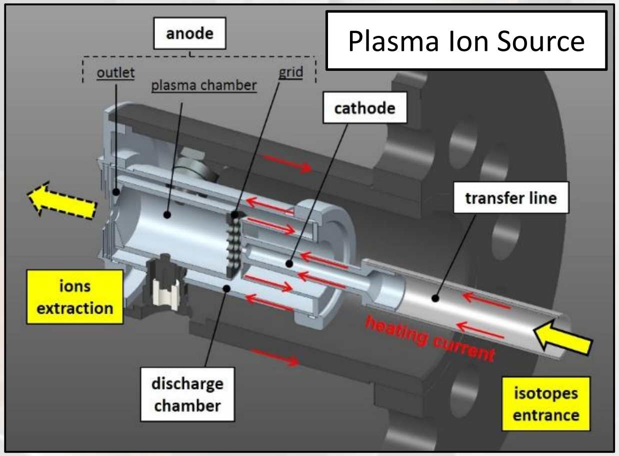

Before tests

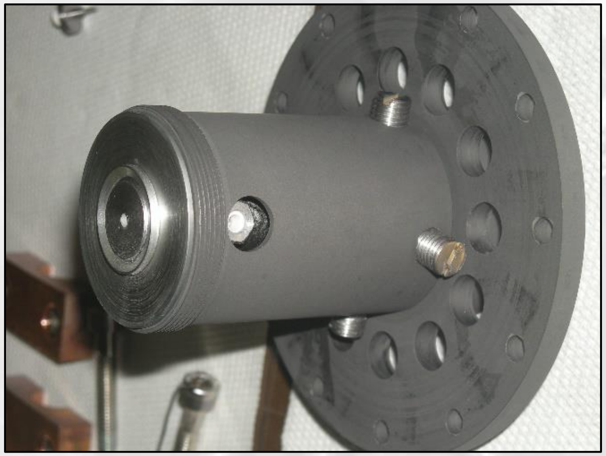

After tests

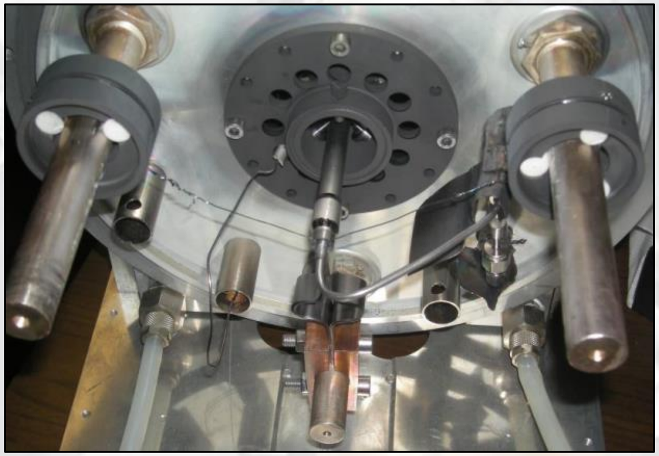
- ≈ 415 testing hours at high temperature -> ≈ 220 hours at maximum power (12kW)
- 79 heating cycles sustained -> **9 with current ramps of 1 s from 0 A to 1300A (!)**
  to 350A (!)

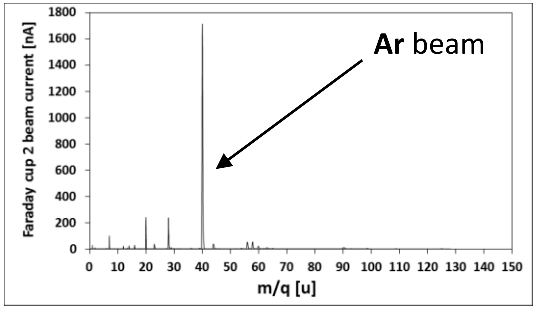
TIS UNIT STILL OPERATIVE !!

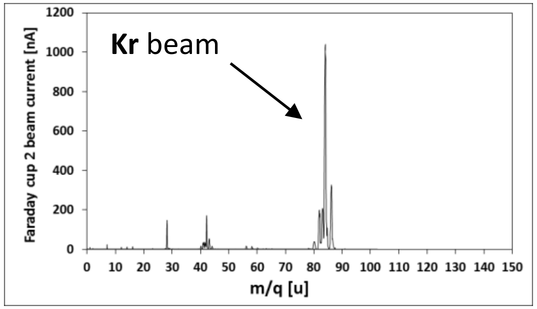
Plasma ion sources: off-line beam production

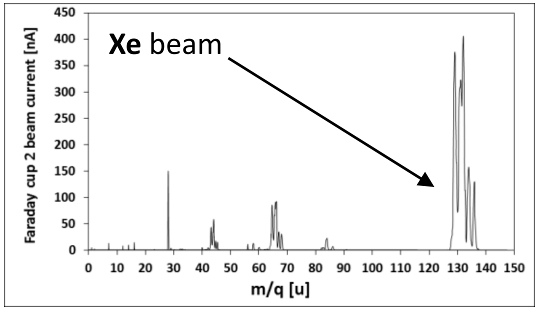


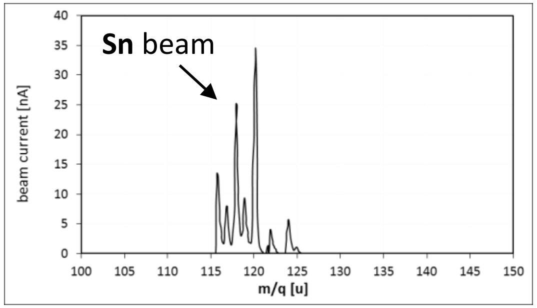






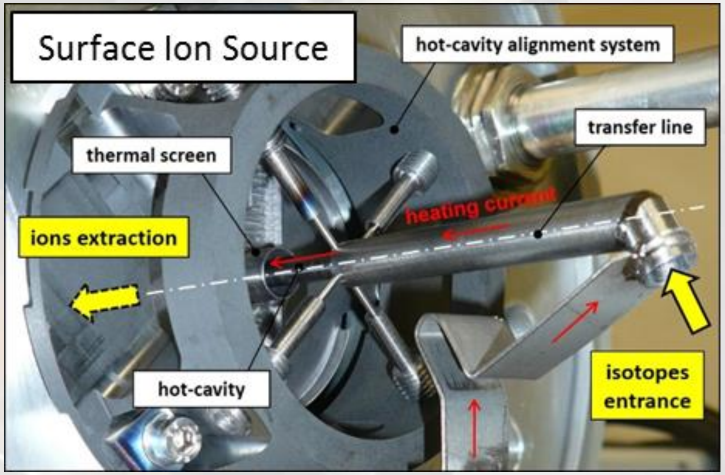


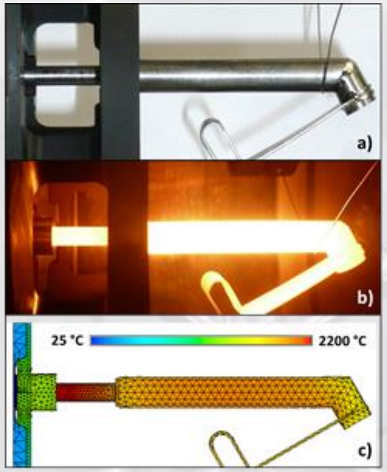




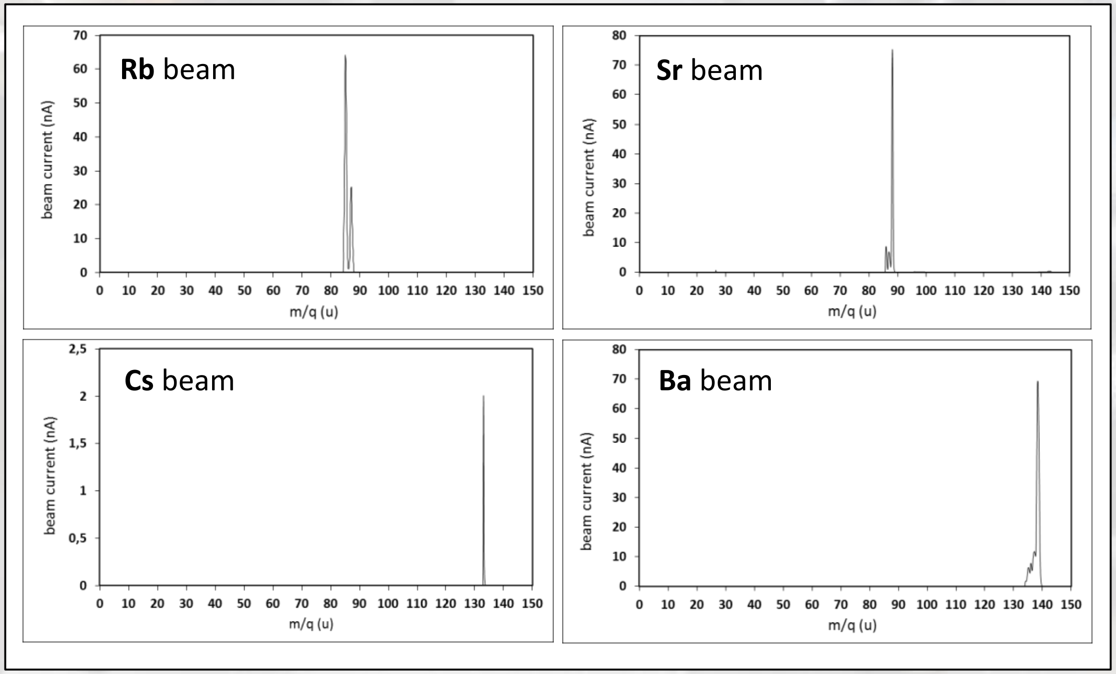
beam	ion. eff. (%)	injection mode	cathode temp. (°C)
Ar	6	gas tube	2200
Br	**WIP**	**oven**	2200
Kr	8,5	gas tube	2200
Y	very low	oven	2300
Sn	10	oven	2200
I	19	oven	2200
Xe	11	gas tube	2200

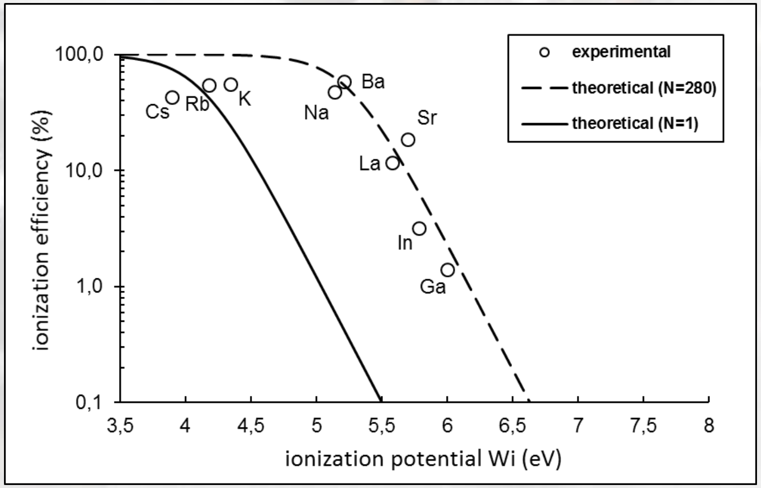
Sourface ion sources: off-line beam production





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





Alberto Andrighetto

Target materials production and tests

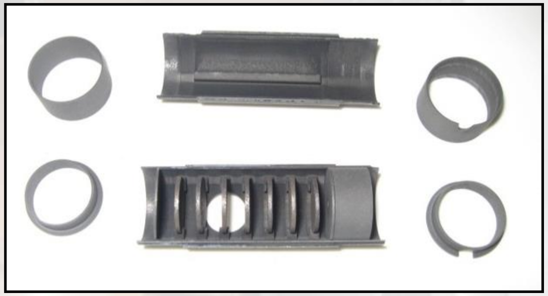
New laboratory for the production of UC_x at Legnaro

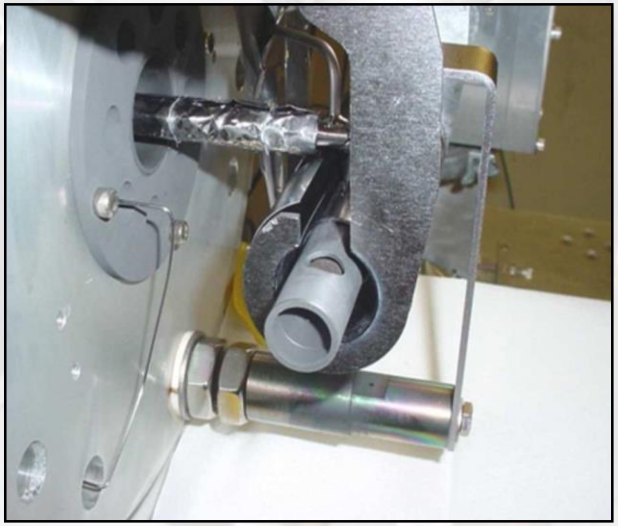
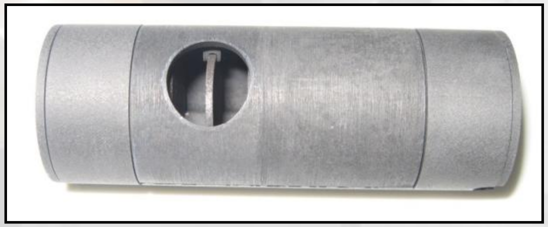
Ready for UCx production

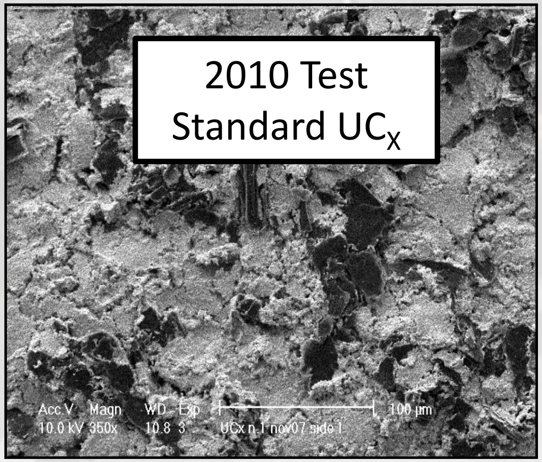
Ventilation and fire extinguishing systems are ready, instruments are placed and ready to be used

Target material and UCx production

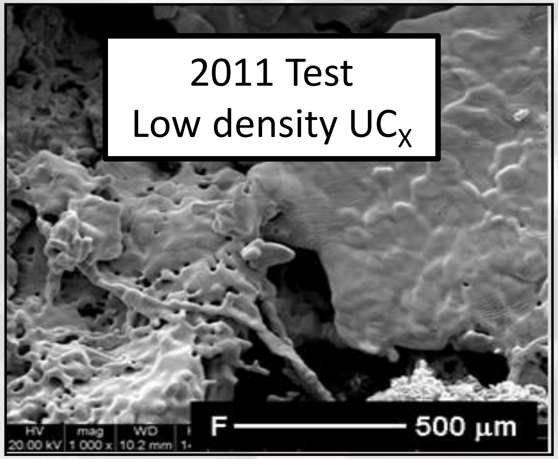
- On-line testing of the SPES target material and architecture @ ORNL (2010-2012)
- 40 MeV, 50 nA proton beam on a UCx target





2010 Test
Standard UC_X



2011 Test
Low density UC_X

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

Target materials production and tests

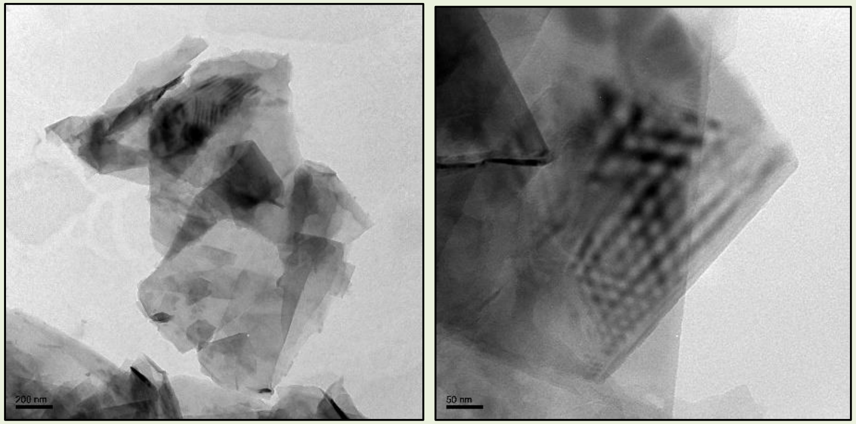
Synthesis of a novel type of UC_x using graphene

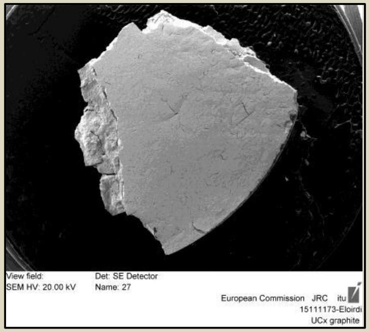
Experiment submitted & accepted at Karlsruhe: n. AUL-176 "Study of the use of Reduced Graphene Oxide as source of carbon for UCx-Graphene nanocomposites production"

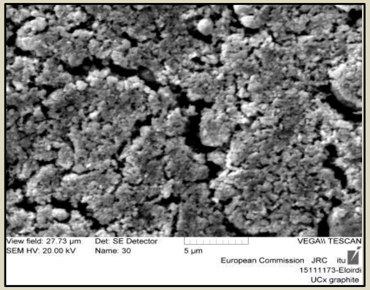
Final phase (Nov-Dec 2015, JRC-ITU Karlsruhe, ActusLab)

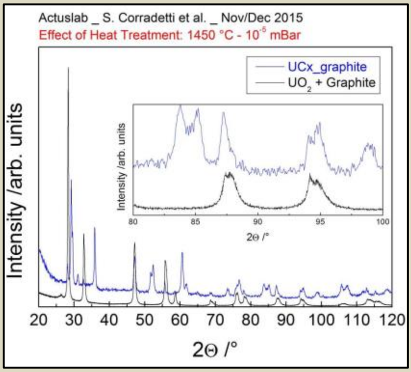
Production of uranium carbide using graphite or graphene as carbon sources

$$\underline{UO_2+6C\rightarrow UC_2+2C+2CO}$$









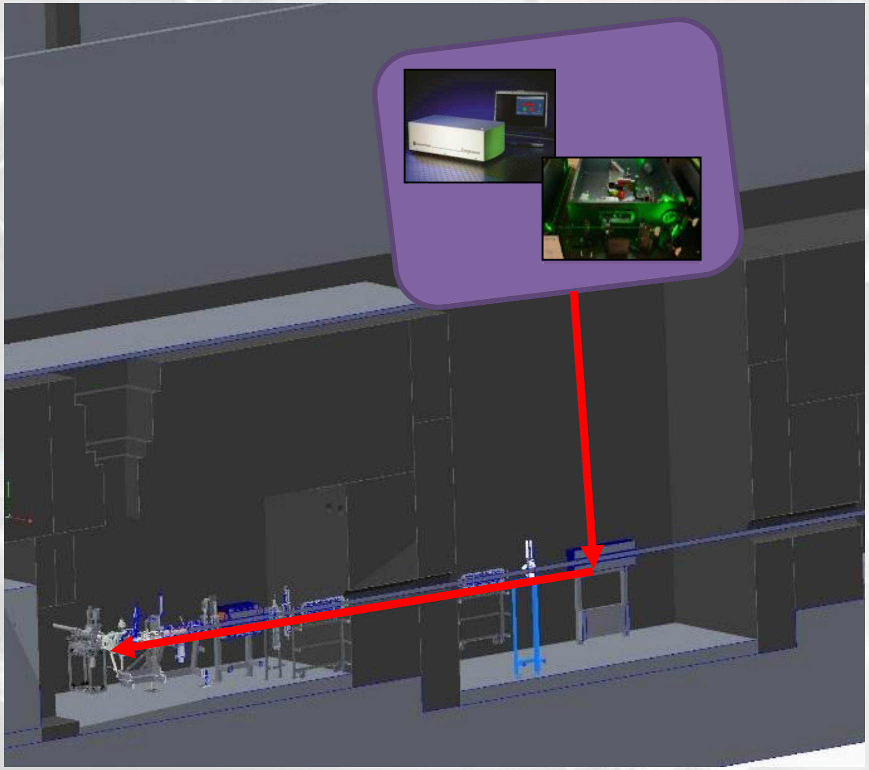
Laser Laboratories..

Offline: Spectroscopy

- 3 Dye Laser @ 10 Hz rep. rate

Online (SS laser): RIB prod.

- 3 TiSa Laser @ 10 kHz rep. rate



Diagnostic tools:

- Monochromator
- HCL
- ToF Mass Spectrometer

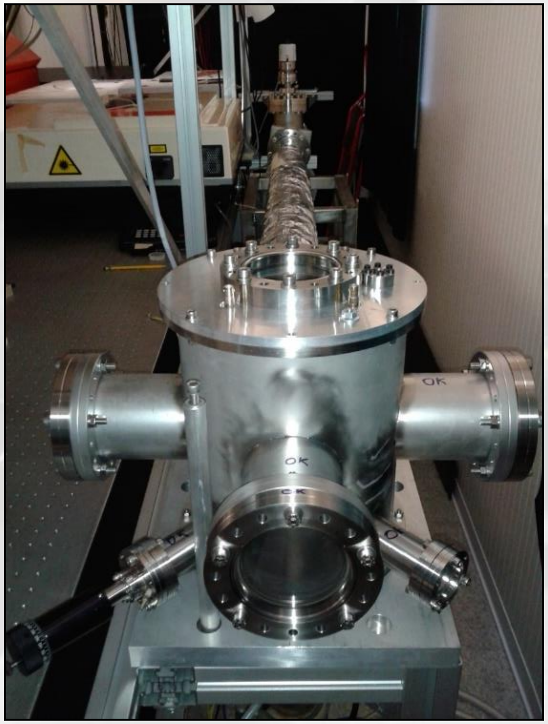
Diagnostic tools:

- Λ-meter
- Alignments System
- Ion-Beam

Development of the RIB apparatus: resonant laser ionization

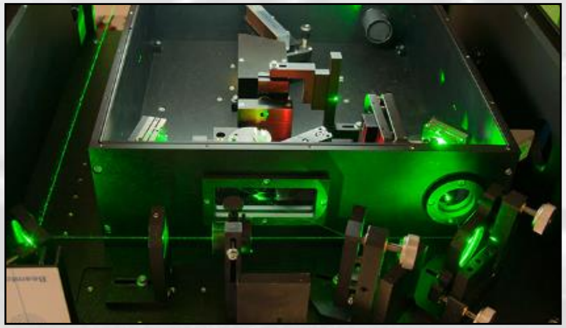
Spectroscopy:

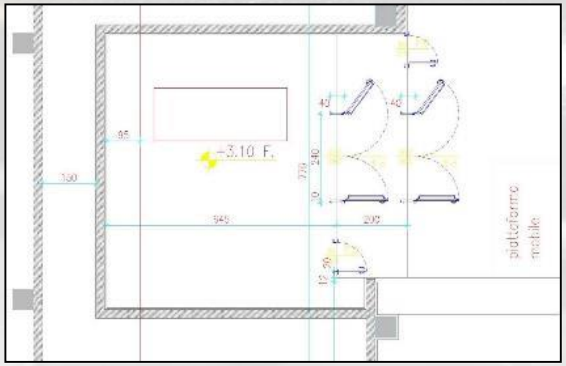
- Study of different elements of interest
- Offline-lab with 10Hz dye laser system
- HCL & ToF-MS



New SS laser:

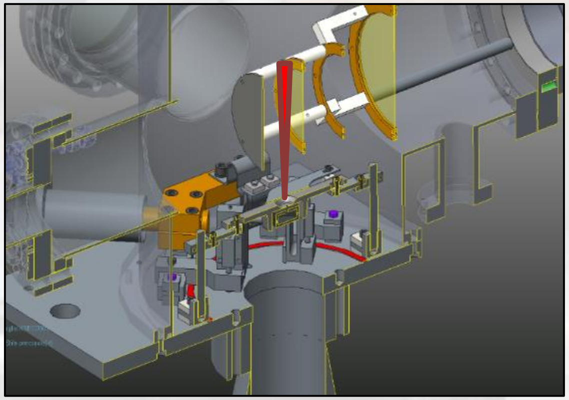
- Defining RIB production laser requirements
- 10 kHz TiSa laser
- New laser lab requirements

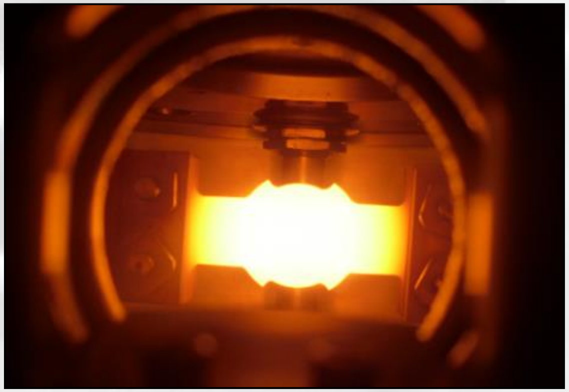




Laser FE:

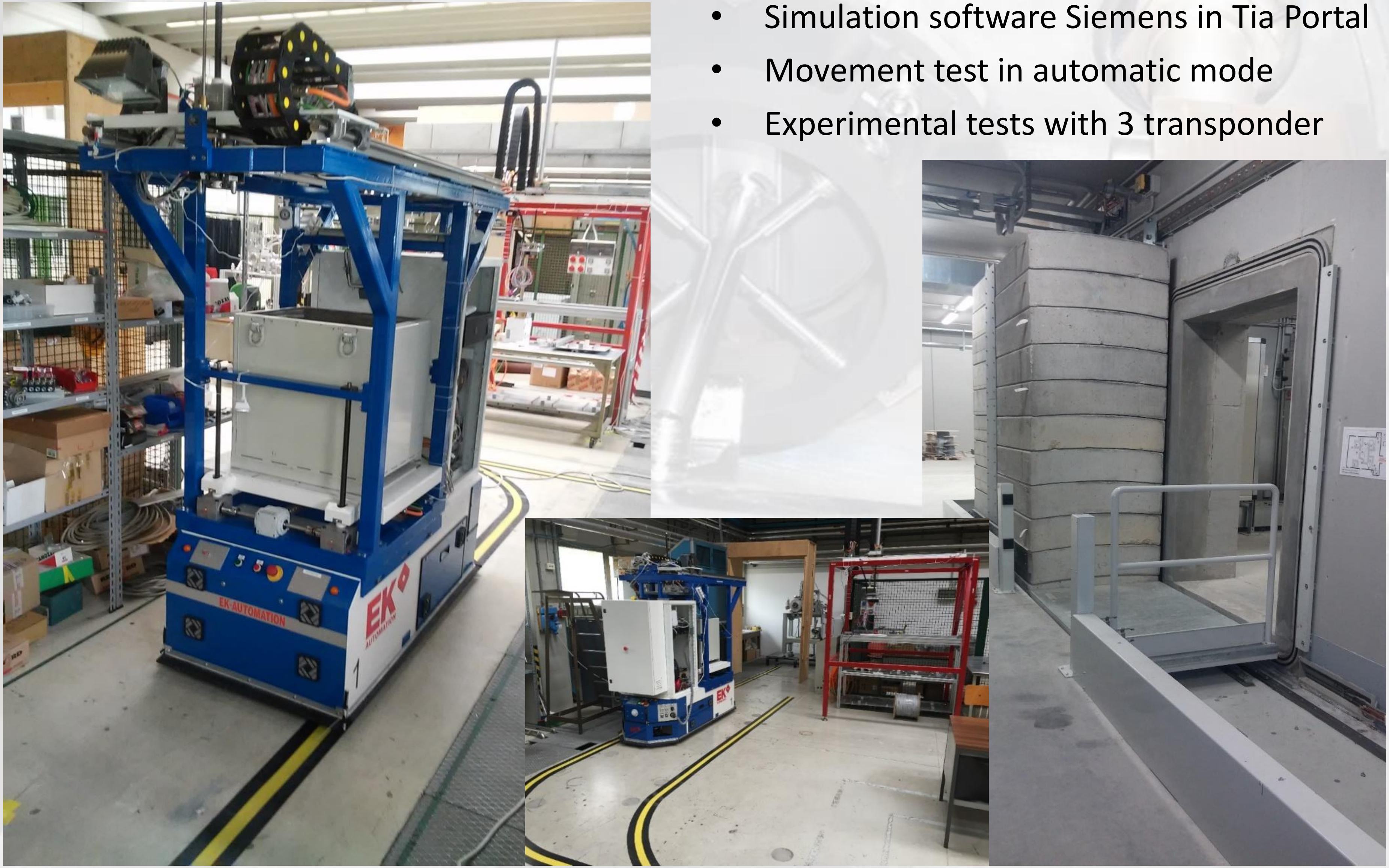
- ToF system
- Hot cavity
- Efficiency measurements





The SMO test at LNL

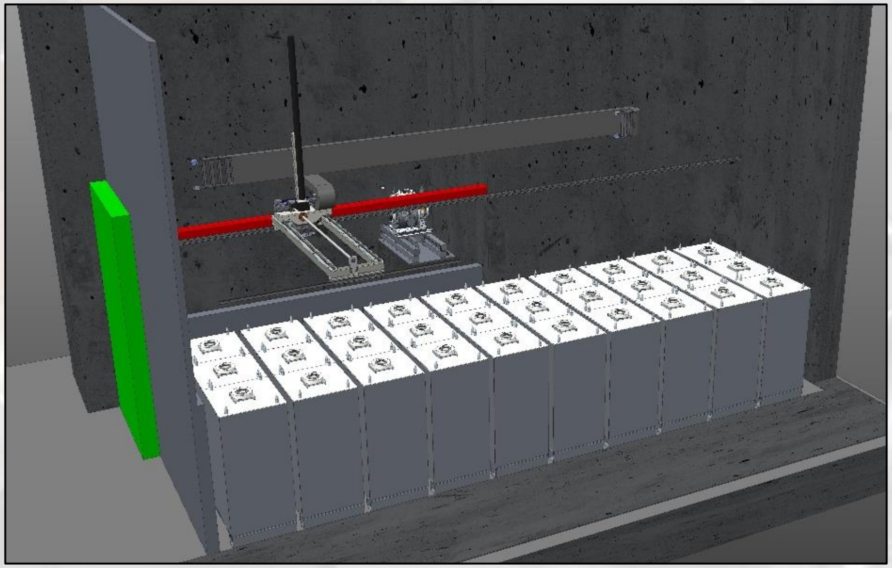
- Simulation software Siemens in Tia Portal
- Movement test in automatic mode
- Experimental tests with 3 transponder

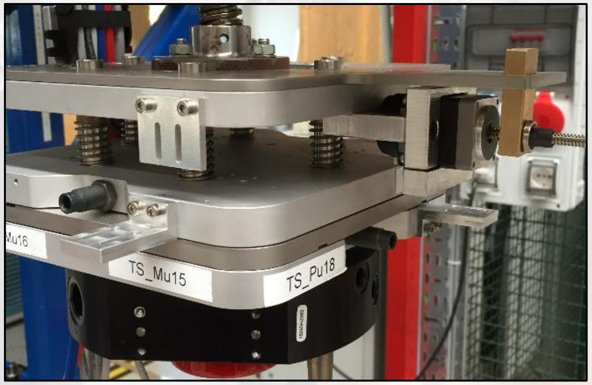


The agv trip

The new Chamber Unit Storage

The layout:





Storage cartesian system prototype

ISOL front end: mechanical design upgrades

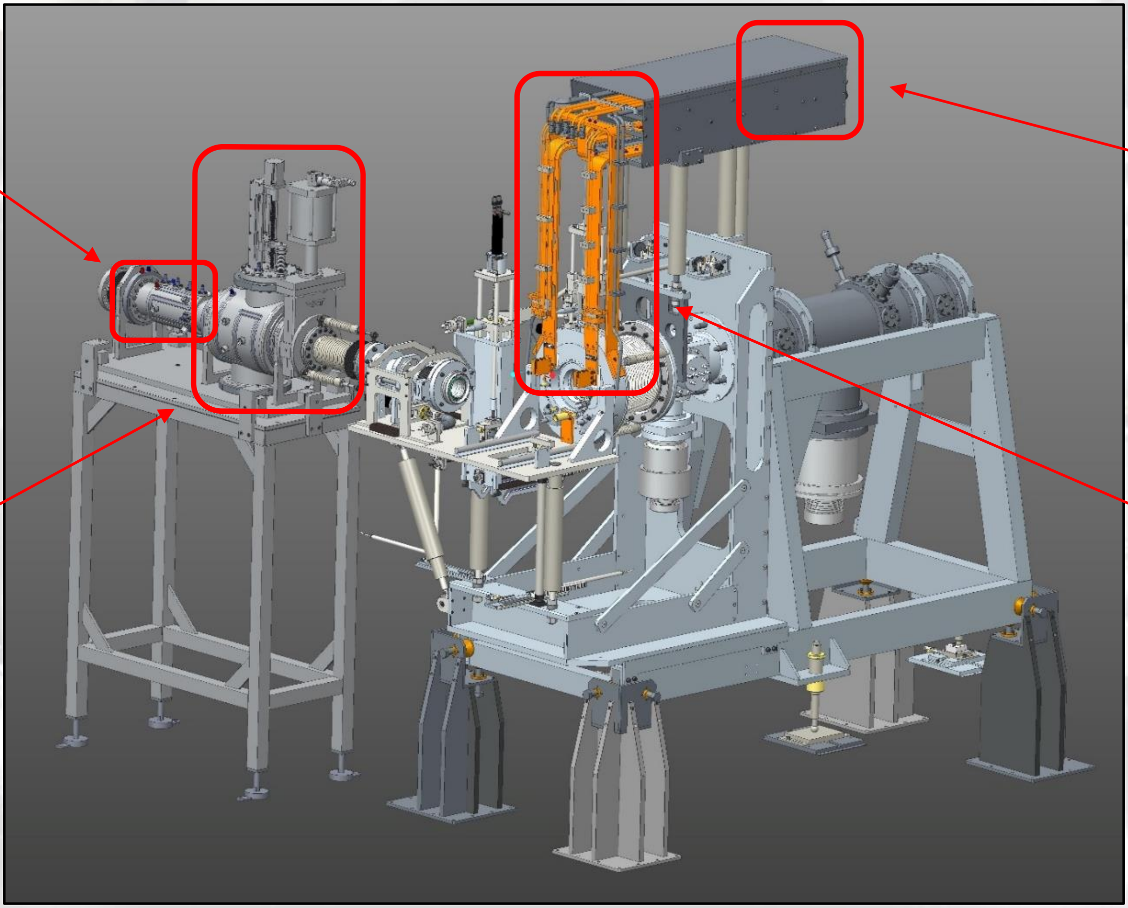
Proton Beam collimator box

end 2016

Proton Beam diagnostic cross

end 2016

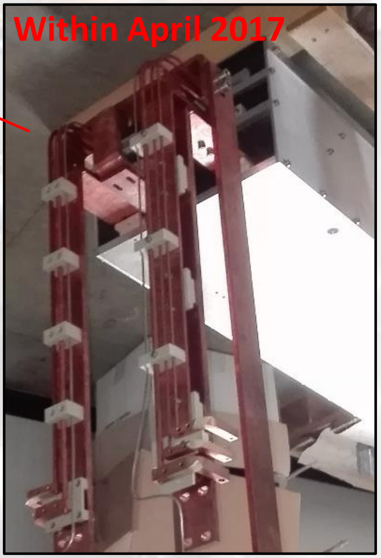
for:
- High Power Faraday Cup
- High Power Beam Profiler



Pneumatic, hydraulic and power fast connections

Within April 2017

Power cables without insulation



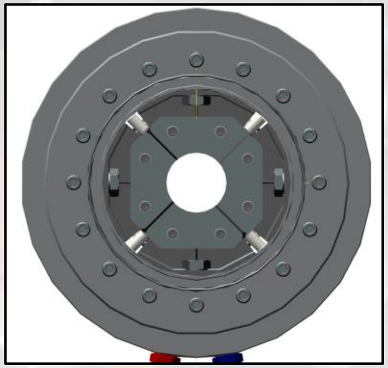
Within April 2017

General remarks for the Front-End design
- Elastomer seals are foreseen only in the fast connection for both the pneumatic and hydraulic loops (maybe VAT valves).
- Hydraulic loops have compatible interfaces for demineralized water (AISI304L/316L - copper or AISI304L/316L - aluminum) in order to prevent corrosion phenomena.

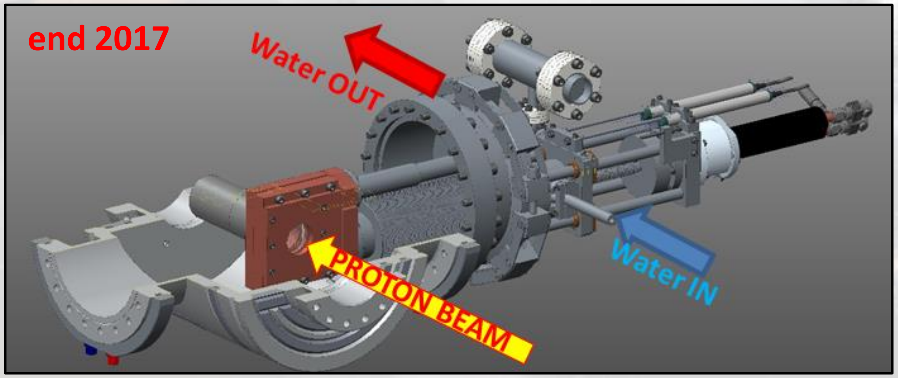
ISOL front end: general design upgrades

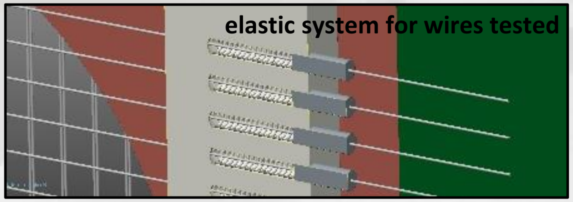
Proton beam line

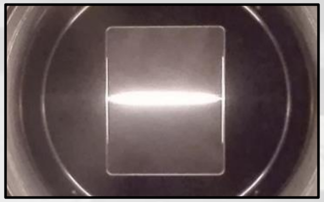
Collimators



High Power Beam Profiler and Faraday Cup

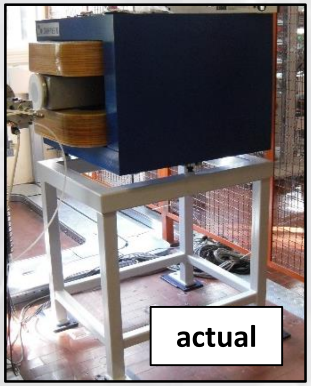


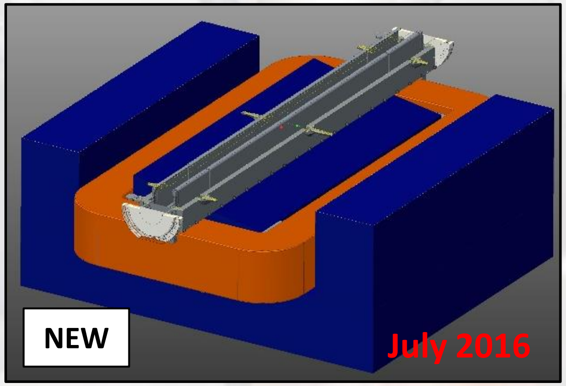


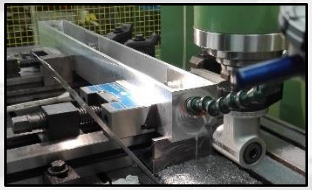


RIB line

Electrostatic module upgrade for the Wien Filter

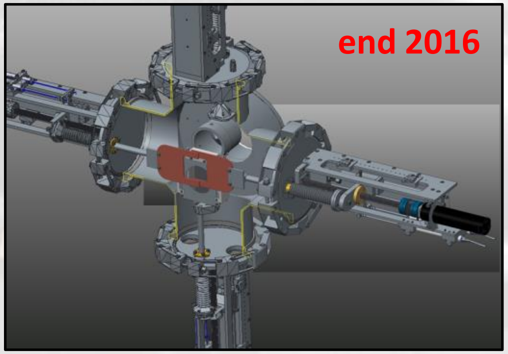


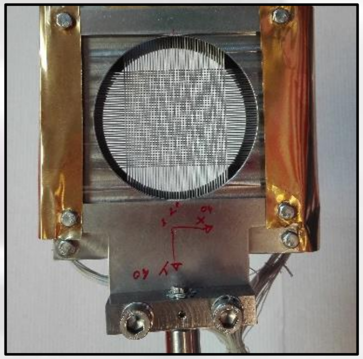




Mass resolution improvement from 80 to 140

Upgraded diagnostic boxes

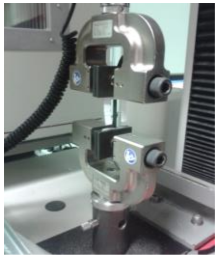


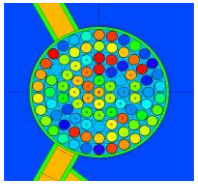


ISOL front end: study of radiation damage on materials

RESULTS of the study on elastomeric vacuum O-rings for the target chamber

1. Dosimetry calculations with MCNPX: **LNL – UniPv – UniBs**
2. Irradiation in a mixed n+γ field at **TRIGA reactor: UniPv (LENA)**
3. Mechanical and physical tests at **MaST Laboratory: UniBs**





FOUR TESTED PRODUCTS:

5Pascal

U.T.S. FORNITURE INDUSTRIALI

DICHTOMATIK

James Walker

EPDM 2

✓ Best price/performance ratio

✓ Recommended up to 15 days life cycle and beyond

DICHTOMATIK

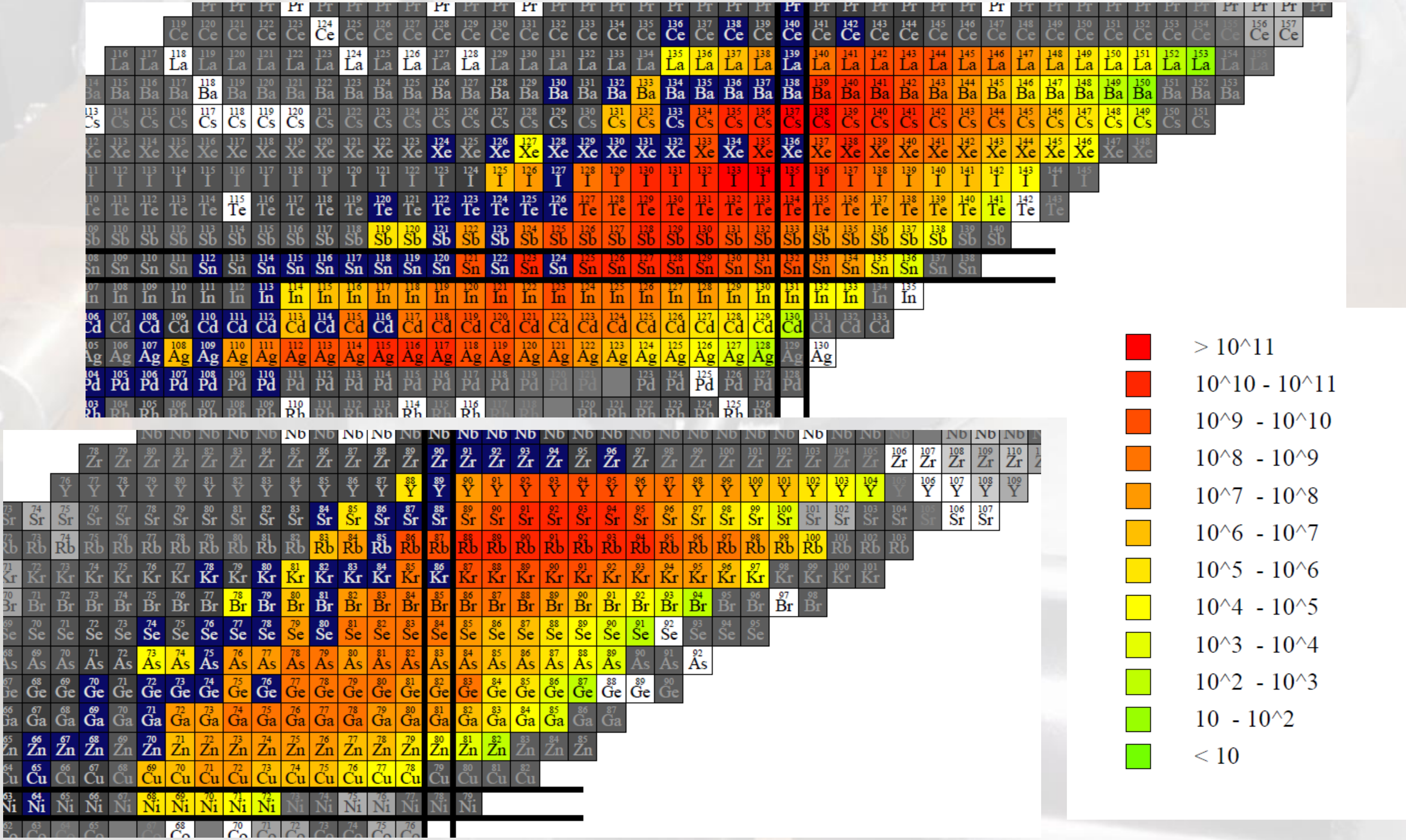
PROSPECTS FOR RDS_SPES ACTIVITIES:

- Experimental study of other components:
  lubricants and greases, optical fibers, cable insulators, etc.
- Possible collaboration with ESS
  for rad-hard test of materials in reactor n+γ mixed fields

ess EUROPEAN SPALLATION SOURCE

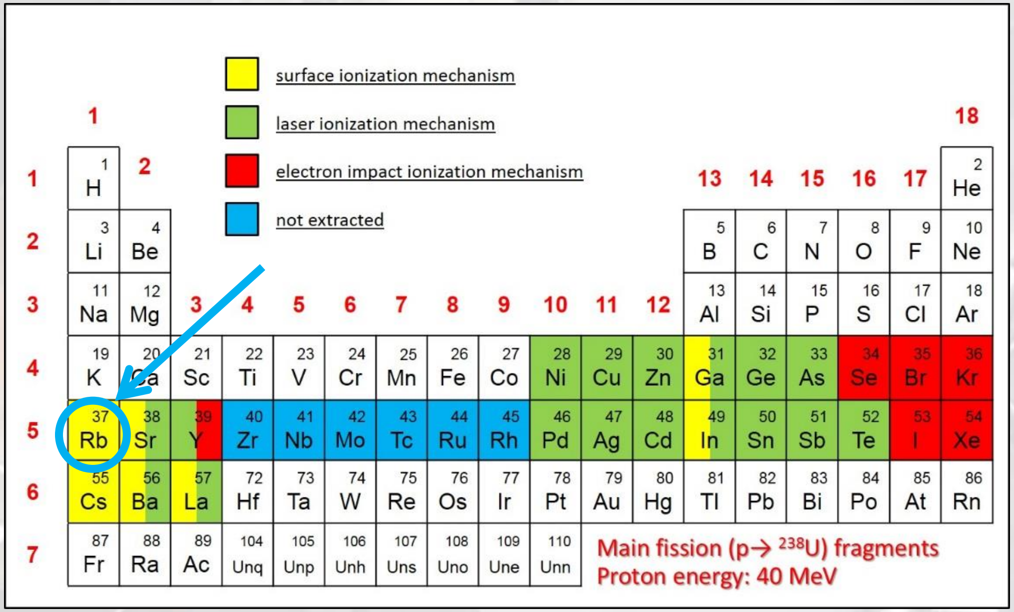
First Beam for users

List Beam for users (SPES web-page)



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

Rb beams (Surface Ion Source)



- 🟨 surface ionization mechanism
- 🟩 laser ionization mechanism
- 🟥 electron impact ionization mechanism
- 🟦 not extracted

Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Possible First Beam

Rubidium (Rb)

alkali metal

atomic number Z = 37

standard atomic weight = 85,468

first ionization potential = 4,18 eV

ionization efficiency = 54,5 %

working temperature (hot-cavity) = 2200 °C

injection technique = folded Ta ribbon inside a tubular Ta oven

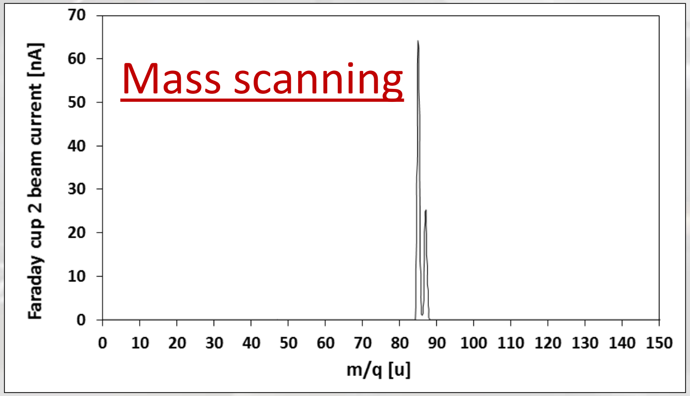
calibrated solution = 10 µl ($RbNO_3$ in $HNO_{3(aq)}$)

total beam intensity ≈ 300 nA

beam RMS emittance = 1,5 π mm mrad

extraction voltage = 25 kV

Selectivity: Very Good (also without HRMS)



stable Isotopes:

- ^{85}Rb (72,17 %)
- ^{87}Rb (27,83 %)

isotopes produced @ SPES
(p→^{238}U, 40 MeV 200 µA)

Production Yield: Very Good

- 🟥 > 10^11
- 🟥 10^10 - 10^11
- 🟧 10^9 - 10^10
- 🟧 10^8 - 10^9
- 🟧 10^7 - 10^8
- 🟨 10^6 - 10^7
- 🟨 10^5 - 10^6
- 🟨 10^4 - 10^5
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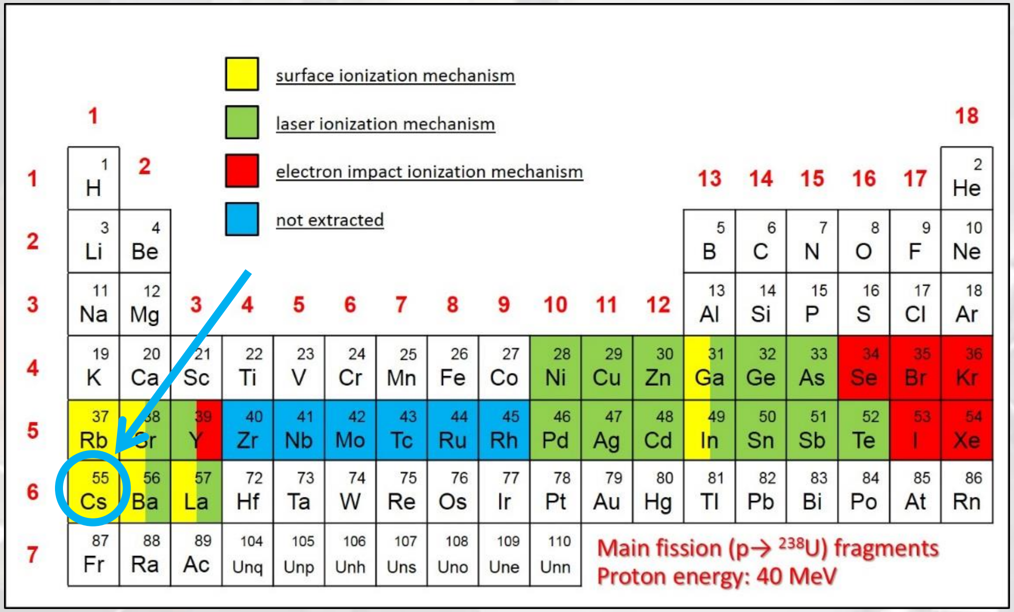
- 🟩 10 - 10^2
- 🟩 < 10

(pps)

Cs beams (Surface Ion Source)

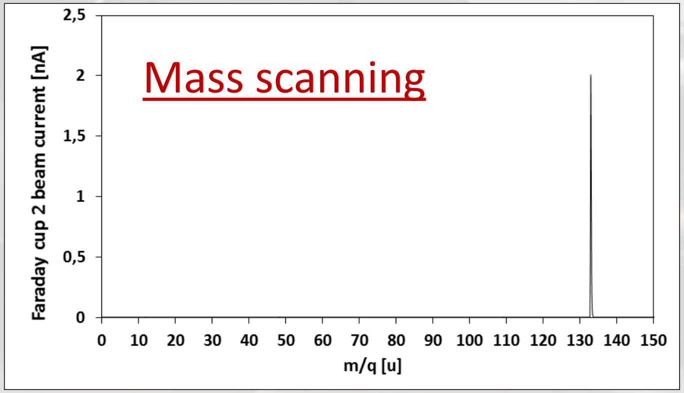


Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Caesium (Cs)

alkali metal
atomic number Z = 55
standard atomic weight = 132,905
first ionization potential = 3,89 eV
ionization efficiency = 43,2 %
working temperature (hot-cavity) = 2200 °C
injection technique = folded Ta ribbon inside a tubular Ta oven
calibrated solution = 20 µl ($CsNO_3$ in $HNO_{3(aq)}$)
total beam intensity ≈ 300 nA
beam RMS emittance = 1,5 π mm mrad
extraction voltage = 25 kV
Selectivity: Good (also without HRMS)

Possible Second Beam

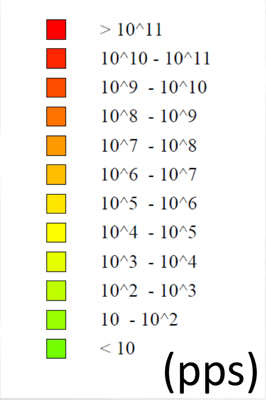


stable Isotopes:

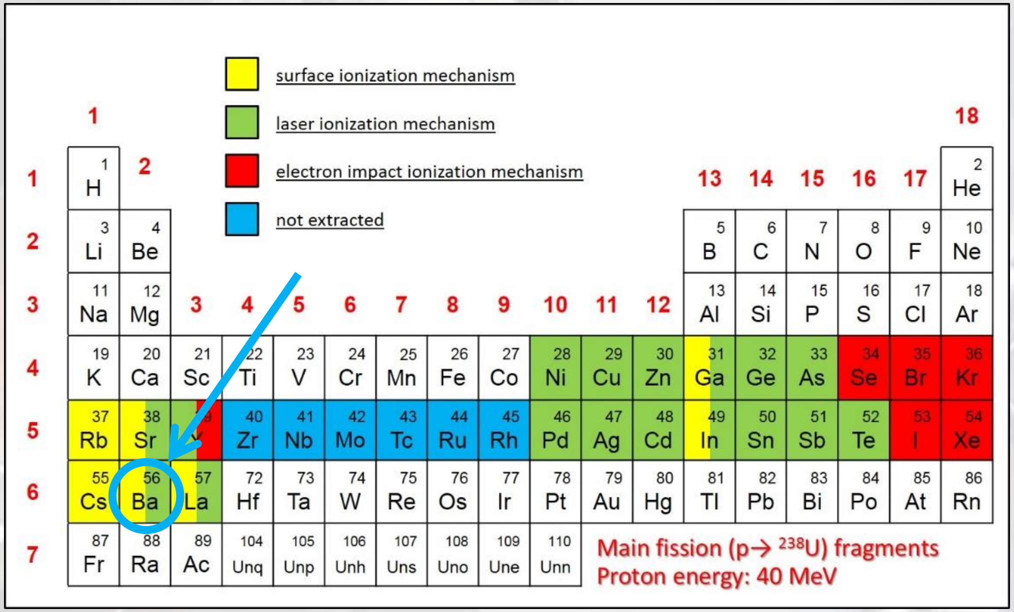
- ^{133}Cs (100 %)

isotopes produced @ SPES
(p→^{238}U, 40 MeV 200 µA)

Production Yield: Very Good



Ba beams (Surface Ion Source)



Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Barium (Ba)

alkaline earth metal

atomic number Z = 56

standard atomic weight = 137,327

first ionization potential = 5,21 eV

ionization efficiency = 58,8 %

working temperature (hot-cavity) = 2200 °C

injection technique = folded Ta ribbon inside a tubular Ta oven

calibrated solution = 20 µl ($BaCO_3$ in $HNO_{3(aq)}$)

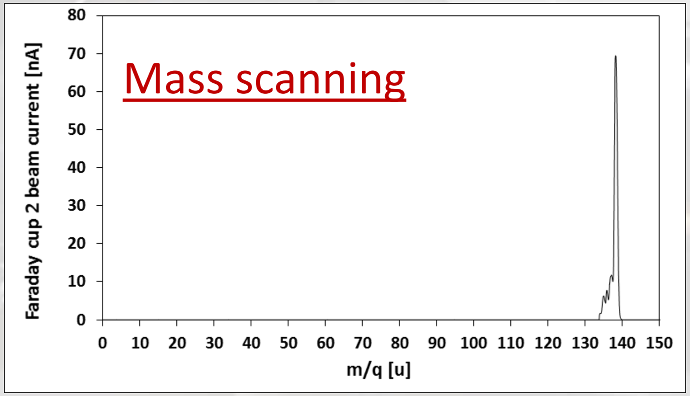
total beam intensity ≈ 300 nA

beam RMS emittance = 1,5 π mm mrad

extraction voltage = 25 kV

Selectivity: Good (also without HRMS)

Possible good Beam



Mass scanning

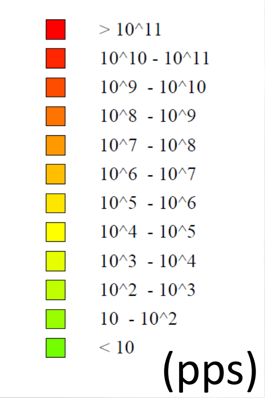
stable Isotopes:

- ^{134}Ba (2,42 %)
- ^{135}Ba (6,60 %)
- ^{136}Ba (7,85 %)
- ^{137}Ba (11,23 %)
- ^{138}Ba (71,7 %)

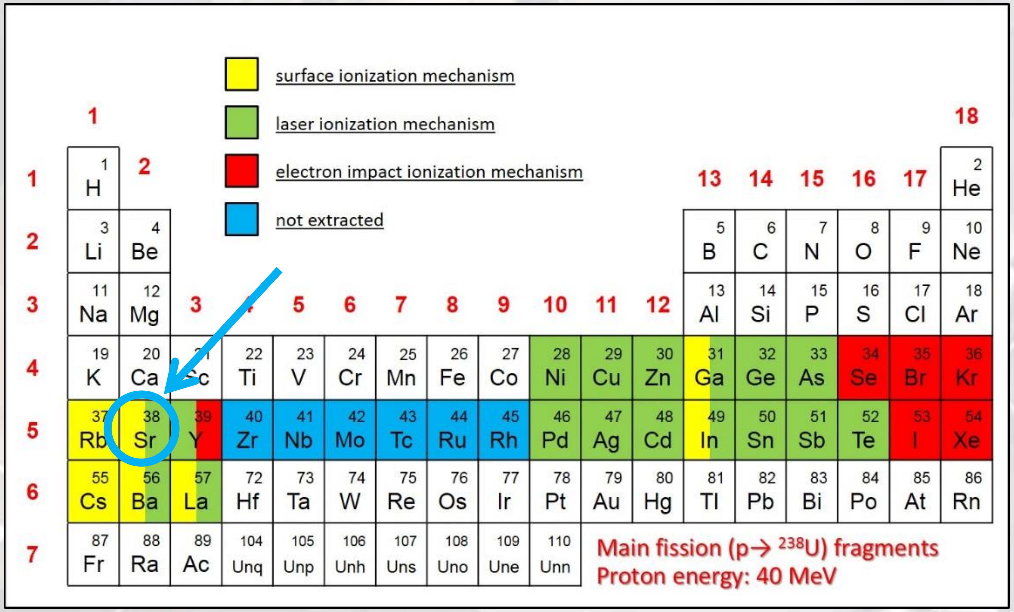
isotopes produced @ SPES

(p→^{238}U, 40 MeV 200 µA)

Production Yield: Good




Sr beams (Surface Ion Source)



Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Possible good Beam

Strontium (Sr)

alkaline earth metal

atomic number Z = 56

standard atomic weight = 87,62

first ionization potential = 5,70 eV

ionization efficiency = 18,5 %

working temperature (hot-cavity) = 2200 °C

injection technique = folded Ta ribbon inside a tubular Ta oven

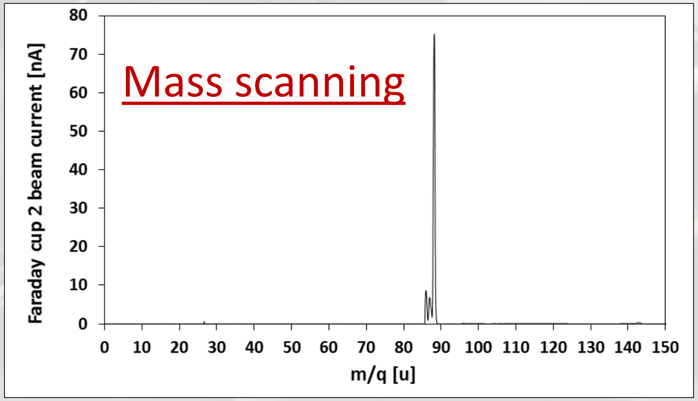
calibrated solution = 40 µl ($Sr(NO_3)_2$ in $HNO_{3(aq)}$)

total beam intensity ≈ 300 nA

beam RMS emittance = 1,5 π mm mrad

extraction voltage = 25 kV

Selectivity: Good (also without HRMS)



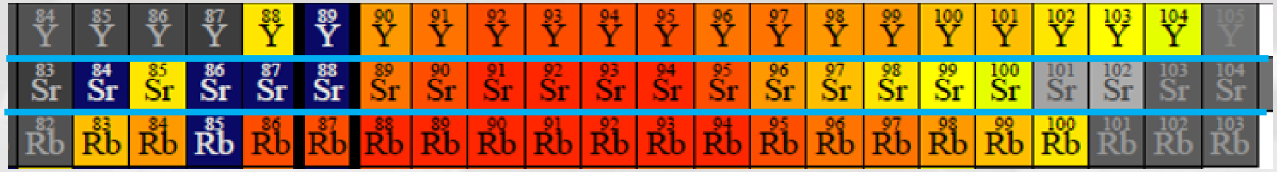
Mass scanning

stable Isotopes:

- ^{84}Sr (0,56 %)
- ^{86}Sr (9,86 %)
- ^{87}Sr (7,00 %)
- ^{88}Sr (82,58 %)

isotopes produced @ SPES
(p→^{238}U, 40 MeV 200 µA)

Production Yield: Good



🟥 > 10^11
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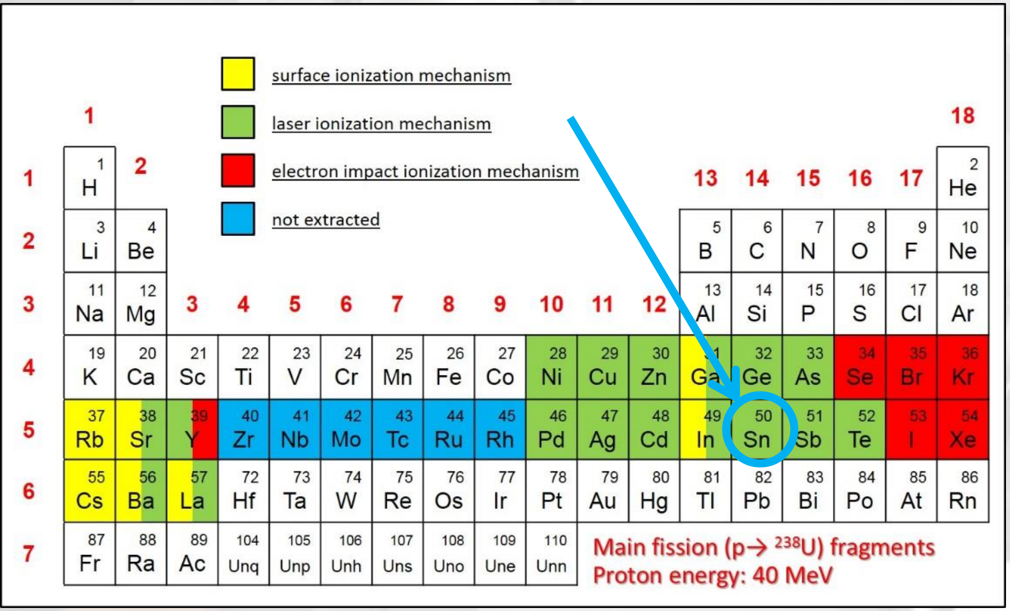
🟨 10^4 - 10^5
🟨 10^3 - 10^4
🟩 10^2 - 10^3
🟩 10 - 10^2
🟩 < 10

(pps)

Sn beams (Plasma Ion Source)

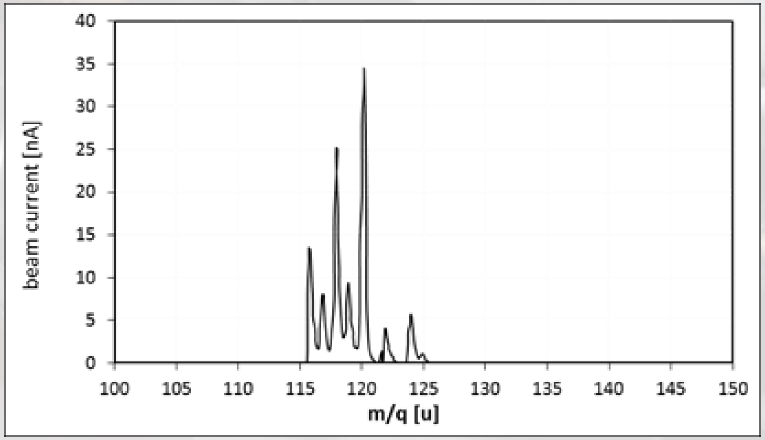


Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

WORK IN PROGRESS
important Beam

Tin (Sn)

post-transition metal
atomic number Z = 50
standard atomic weight = 118,710
first ionization potential = 7,334 eV
ionization efficiency = 9,5 %
working temperature = 2200 °C
injection technique = folded Ta ribbon inside a tubular Ta oven (Sn metal)
Sn beam intensity observed during the tests ≈ 300 nA
beam RMS emittance = 5 π mm mrad
anode voltage = 150 V
extraction voltage = 25 kV



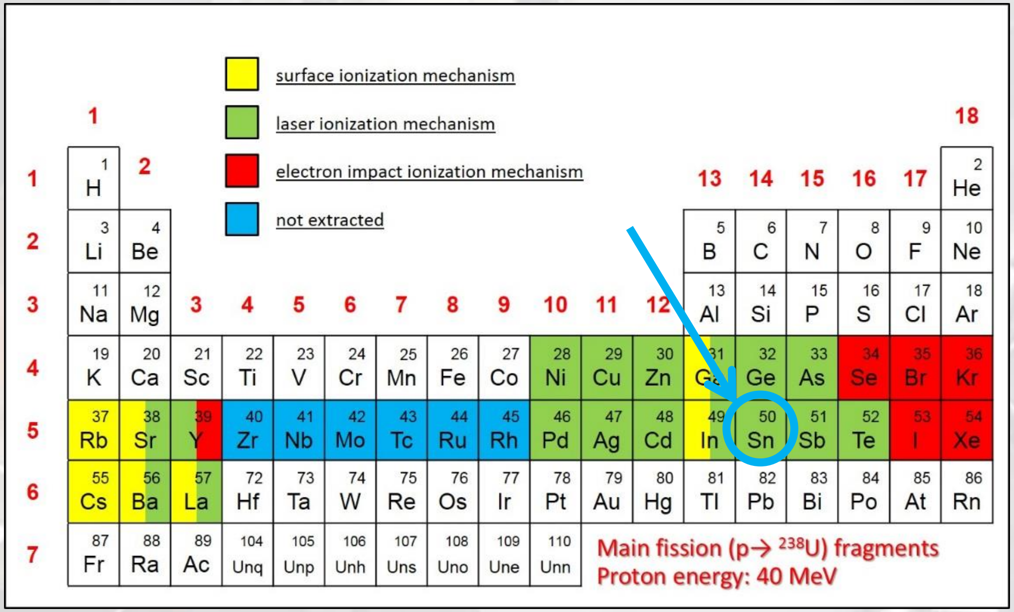
stable Isotopes:

- ^{112}Sn (0,97 %)
- ^{114}Sn (0,66 %)
- ^{115}Sn (0,34 %)
- ^{116}Sn (14,54 %)
- ^{117}Sn (7,68 %)
- ^{118}Sn (24,22 %)
- ^{119}Sn (8,59 %)
- ^{120}Sn (32,58 %)
- ^{122}Sn (4,63 %)
- ^{124}Sn (5,79%)

isotopes produced @ SPES
(p→^{238}U, 40 MeV 200 μA)

- 🟥 > 10^11
- 🟥 10^10 - 10^11
- 🟧 10^9 - 10^10
- 🟧 10^8 - 10^9
- 🟧 10^7 - 10^8
- 🟨 10^6 - 10^7
- 🟨 10^5 - 10^6
- 🟨 10^4 - 10^5
- 🟩 10^3 - 10^4
- 🟩 10^2 - 10^3
- 🟩 10 - 10^2
- 🟩 < 10

Sn in Laser Laboratory (Future LIS)



🟨 surface ionization mechanism

🟩 laser ionization mechanism

🟥 electron impact ionization mechanism

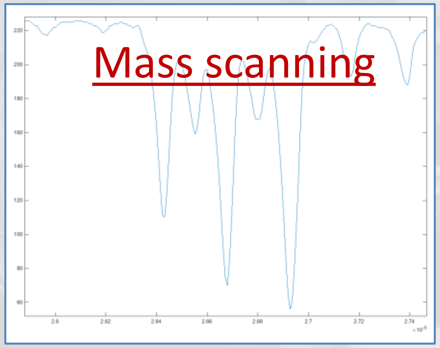
🟦 not extracted

Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Tin (Sn)
post-transition metal
atomic number Z = 50
standard atomic weight = 118,710
first ionization potential = 7,34 eV
ionization efficiency = NA
working temperature (hot-cavity) = NA
injection technique = yes
calibrated solution = yes
total beam intensity ≈ NA

Ionization wavelength path = yes

important Beam

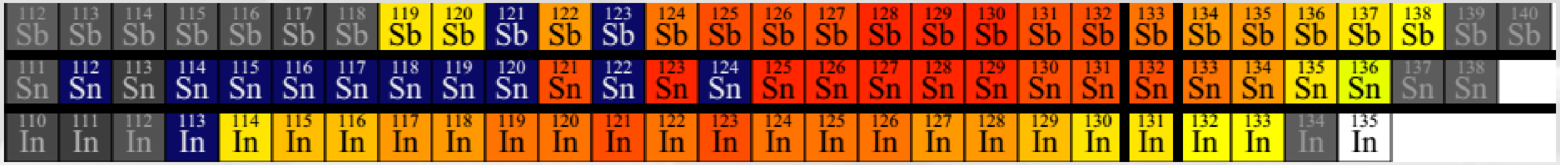


stable Isotopes:

- ^{114}Sn (0,96 %)
- ^{115}Sn (0,66 %)
- ^{116}Sn (14,3 %)
- ^{117}Sn (7,61 %)
- ^{118}Sn (24,03 %)
- ^{119}Sn (8,58 %)
- ^{120}Sn (32,85 %)
- ^{122}Sn (4,72 %)
- ^{124}Sn (5,94 %)

isotopes produced @ SPES
(p→^{238}U, 40 MeV 200 µA)

Production Yield: Good



112 Sb	113 Sb	114 Sb	115 Sb	116 Sb	117 Sb	118 Sb	119 Sb	120 Sb	121 Sb	122 Sb	123 Sb	124 Sb	125 Sb	126 Sb	127 Sb	128 Sb	129 Sb	130 Sb	131 Sb	132 Sb	133 Sb	134 Sb	135 Sb	136 Sb	137 Sb	138 Sb	139 Sb	140 Sb
111 Sn	112 Sn	113 Sn	114 Sn	115 Sn	116 Sn	117 Sn	118 Sn	119 Sn	120 Sn	121 Sn	122 Sn	123 Sn	124 Sn	125 Sn	126 Sn	127 Sn	128 Sn	129 Sn	130 Sn	131 Sn	132 Sn	133 Sn	134 Sn	135 Sn	136 Sn	137 Sn	138 Sn	
110 In	111 In	112 In	113 In	114 In	115 In	116 In	117 In	118 In	119 In	120 In	121 In	122 In	123 In	124 In	125 In	126 In	127 In	128 In	129 In	130 In	131 In	132 In	133 In	134 In	135 In			

- 🟥 > 10^11
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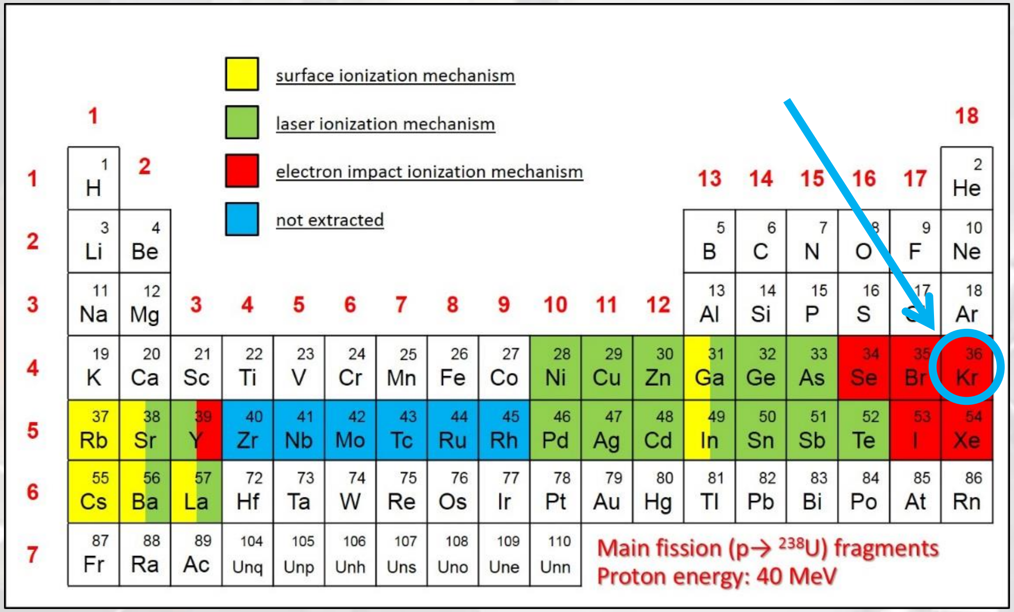
- 🟨 10^4 - 10^5
- 🟨 10^3 - 10^4
- 🟩 10^2 - 10^3
- 🟩 10 - 10^2
- 🟩 < 10

(pps)

Alberto Andrighetto

III SPES workshop: 10th October 2016

Kr beams (Plasma Ion Source)



Krypton (Kr)

noble gas

atomic number Z = 36

standard atomic weight = 83,798

first ionization potential = 13,99 eV

ionization efficiency = 4,6 %

working temperature = 2200 °C

gas injection rate (leak) = $5,0\cdot10^{-6}$ mbar l/s

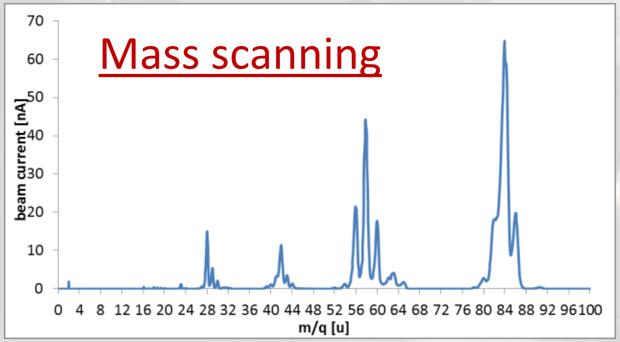
total beam intensity ≈ 3000 nA

beam RMS emittance = 5 π mm mrad

anode voltage = 150 V

extraction voltage = 25 kV

Selectivity: Bad (without HRMS)

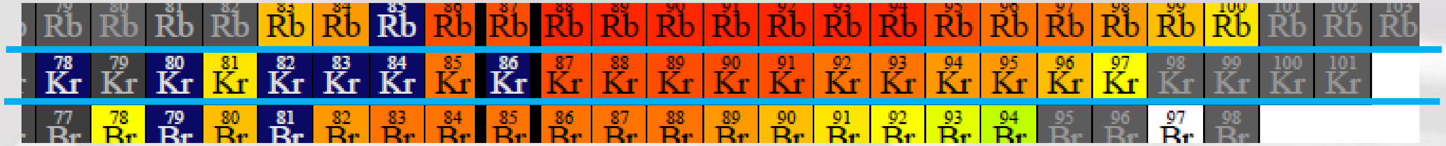


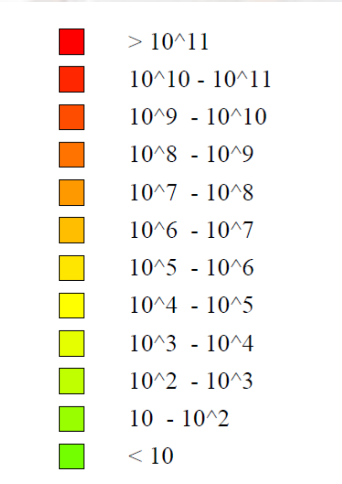
stable isotopes:

- ^{78}Kr (0,35 %)
- ^{80}Kr (2,25 %)
- ^{82}Kr (11,6 %)
- ^{83}Kr (11,5 %)
- ^{84}Kr (57 %)
- ^{86}Kr (17,3 %)

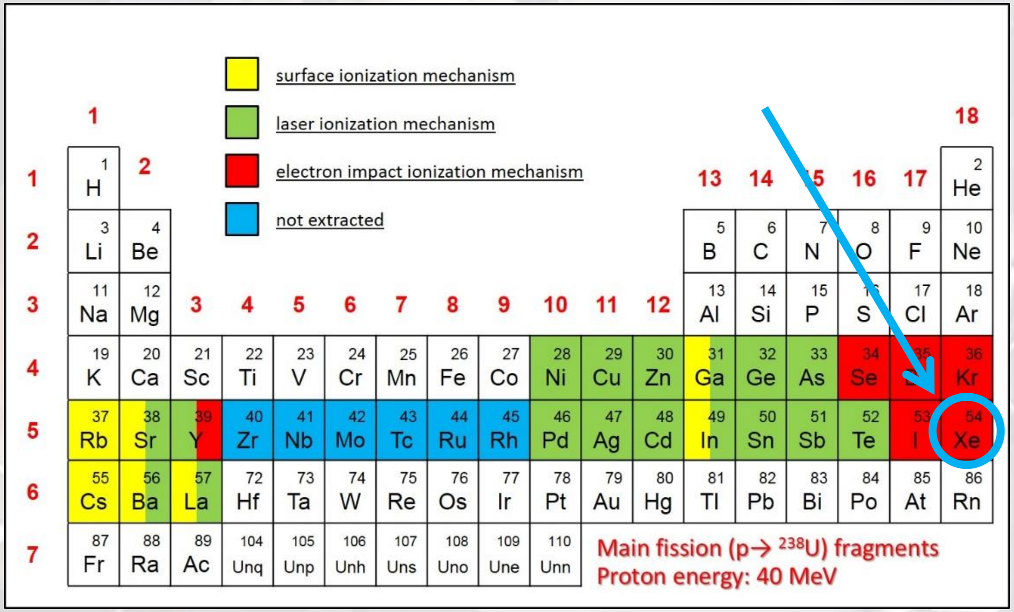
isotopes produced @ SPES

(p→^{238}U, 40 MeV 200 µA)





Xe beams (Plasma Ion Source)



🟨 surface ionization mechanism

🟩 laser ionization mechanism

🟥 electron impact ionization mechanism

🟦 not extracted

Main fission (p→ ^{238}U) fragments
Proton energy: 40 MeV

Xenon (Xe)

noble gas

atomic number Z = 54

standard atomic weight = 131,293

first ionization potential = 12,13 eV

ionization efficiency = 5,3 %

working temperature = 2200 °C

gas injection rate (leak) = $5{,}0 \cdot 10^{-6}$ mbar l/s

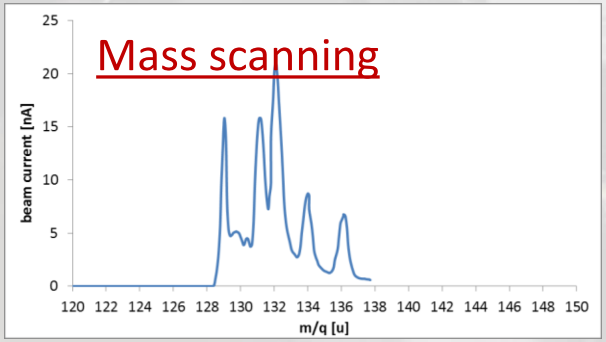
total beam intensity ≈ 3000 nA

beam RMS emittance = 5 π mm mrad

anode voltage = 150 V

extraction voltage = 25 kV

Selectivity: Bad (without HRMS)

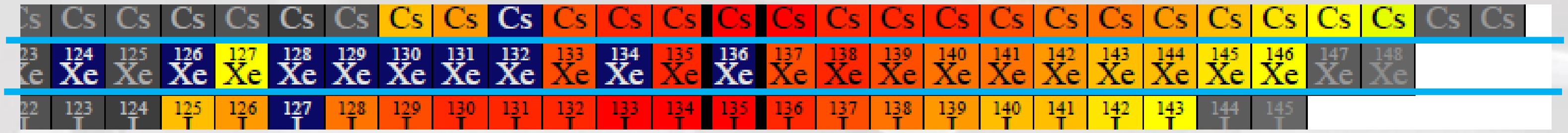


Mass scanning

stable Isotopes:

- ^{124}Xe (0,1 %)
- ^{126}Xe (0,09 %)
- ^{128}Xe (1,91 %)
- ^{129}Xe (26,4 %)
- ^{130}Xe (4,1 %)
- ^{131}Xe (21,2 %)
- ^{132}Xe (26,9 %)
- ^{134}Xe (10,4 %)
- ^{136}Xe (8,9 %)

isotopes produced @ SPES
(p→ ^{238}U, 40 MeV 200 μA)



🟥 > 10^11
🟥 10^10 - 10^11
🟧 10^9 - 10^10
🟧 10^8 - 10^9
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🟨 10^5 - 10^6
🟨 10^4 - 10^5
🟨 10^3 - 10^4
🟩 10^2 - 10^3
🟩 10 - 10^2
🟩 < 10

Beam Selectivity Calculation (using ORNL model)

Copper (Cu) Z=29

Laser I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
69	1,71E+02	9,87E+06	100
70	4,50E+00	7,89E+06	100
71	1,95E+01	1,69E+07	100
72	6,60E+00	1,39E+07	100
73	3,90E+00	9,17E+06	89
74	1,50E+00	3,81E+06	81

Kripton (Kr) Z=36

Plasma I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
88	1,02E+04	4,04E+09	44
89	1,89E+02	3,99E+09	46
90	3,23E+01	4,37E+09	53

Proton beam: E= 40 MeV , I=200 µA

No HRMS

Rubidium (Rb) Z=37

Surface I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
86	1,61E+06	1,90E+09	100
87	1,50E+18	7,99E+09	100
88	1,07E+03	2,21E+10	99
89	9,09E+02	4,75E+10	99
90	1,58E+02	9,62E+10	98
91	5,84E+01	9,62E+10	97
92	4,49E+00	5,09E+10	91
93	5,84E+00	3,38E+10	90
94	2,70E+00	1,37E+10	76

Strontium (Sr) Z=38

Surface I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
94	7,53E+01	1,27E+10	79
95	2,39E+01	3,00E+09	100
96	1,07E+00	1,57E+07	100
97	4,26E-01	1,31E+06	100
98	6,53E-01	6,16E+05	100
99	2,69E-01	2,80E+04	100
100	2,02E-01	2,30E+03	100

Beam Selectivity Calculation (using ORNL model)

Tin (Sn) Z=50

Laser I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
123	1,12E+07	1,28E+10	62
125	8,33E+05	3,50E+10	96
126	3,16E+12	4,21E+10	100
127	7,56E+03	4,08E+10	100
128	3,54E+03	3,18E+10	100
129	1,34E+02	1,75E+10	100
130	2,23E+02	7,89E+09	99
131	5,60E+01	3,42E+09	76
132	3,97E+01	1,56E+09	100

Xenon (Xe) Z=54

Plasma I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
135	3,29+04	1,96E+10	44
137	2,29E+02	9,86E+09	28
138	8,45E+02	1,01E+10	29

Proton beam: E= 40 MeV , I=200 µA

No HRMS

Cesium (Cs) Z=55

Surface I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
131	8,37E+05	8,21E+06	98
132	5,60E+05	8,94E+07	100
134	6,52E+07	4,08E+09	99
135	7,26E+13	1,68E+10	99
136	1,14E+06	4,96E+10	95
137	9,49E+08	1,07E+11	93
138	2,00E+03	1,18E+11	76
139	5,56E+02	9,77E+10	76
140	6,37E+01	3,41E+10	54
141	2,49E+01	1,30E+10	55

Barium (Ba) Z=56

Surface I. S.

Isotopes	Half-life (seconds)	Intensity (pps)	Purity (%)
141	1,10E+03	1,61E+10	43
142	6,38E+02	9,33E+09	79
143	1,43E+01	1,48E+08	25

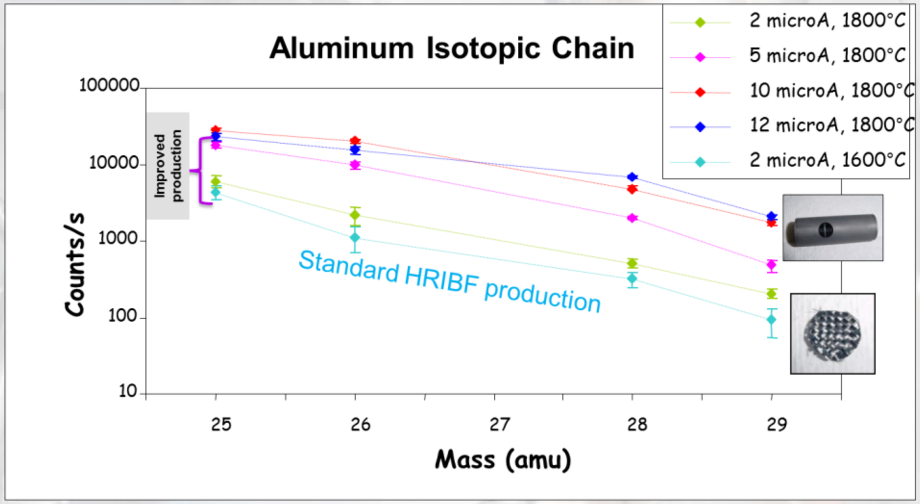
SPES devoted as ^{132}Sn factory?

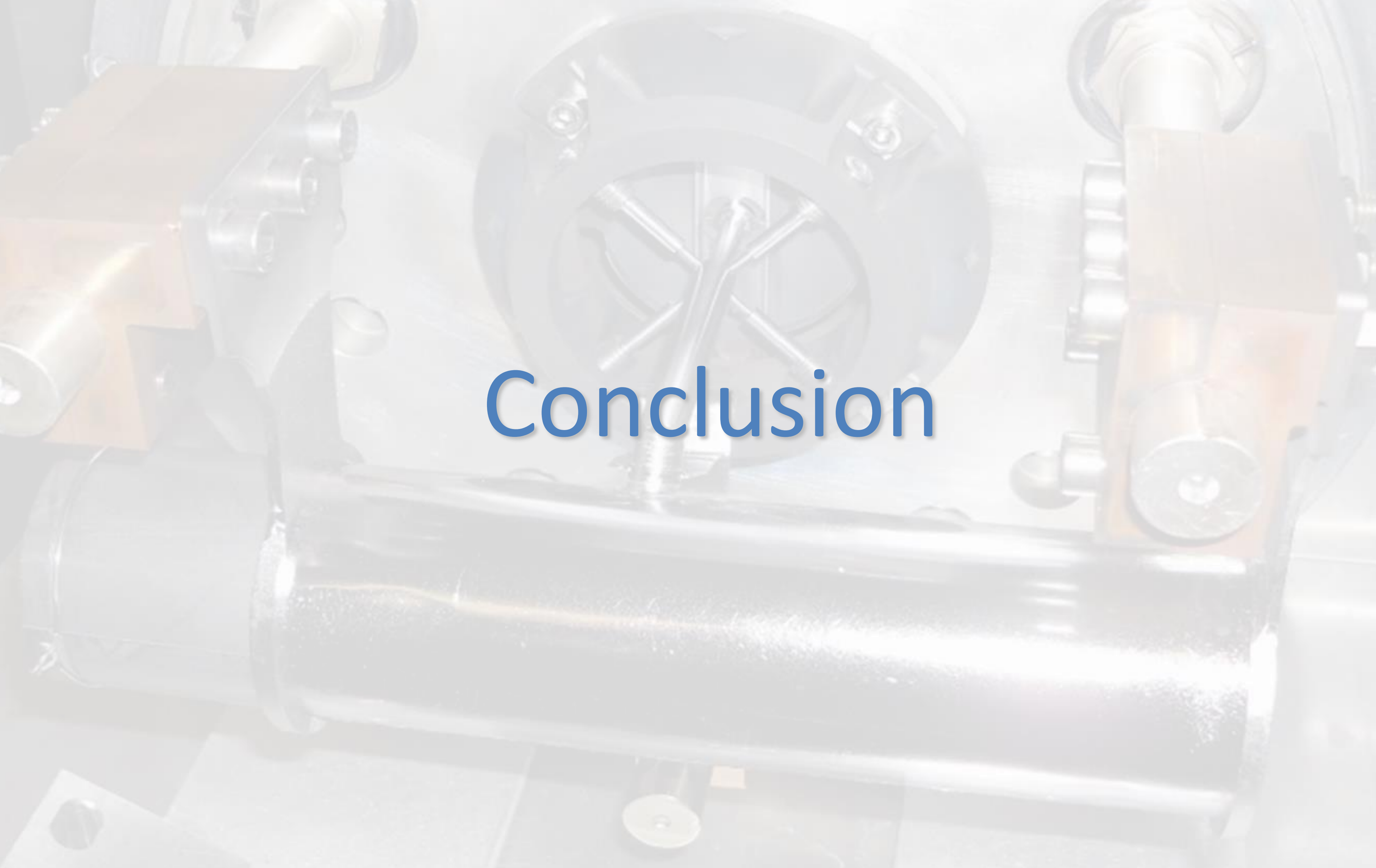
Yield for possible n-poor beams

Graphite Target

Isotope	Half-life	Total Yield (FLUKA)
P-> 12C	t1/2	[nuclei/s]
^{7}Be	53 d	4,37E+12
^{8}B	770 ms	6,64E+11
^{11}C	20 m	2,45E+13
^{12}B	20 s	3,50E+08
^{12}N	11 ms	5,72E+11
^{13}N	9,9 m	3,33E+10
^{15}O	122 s	6,99E+08

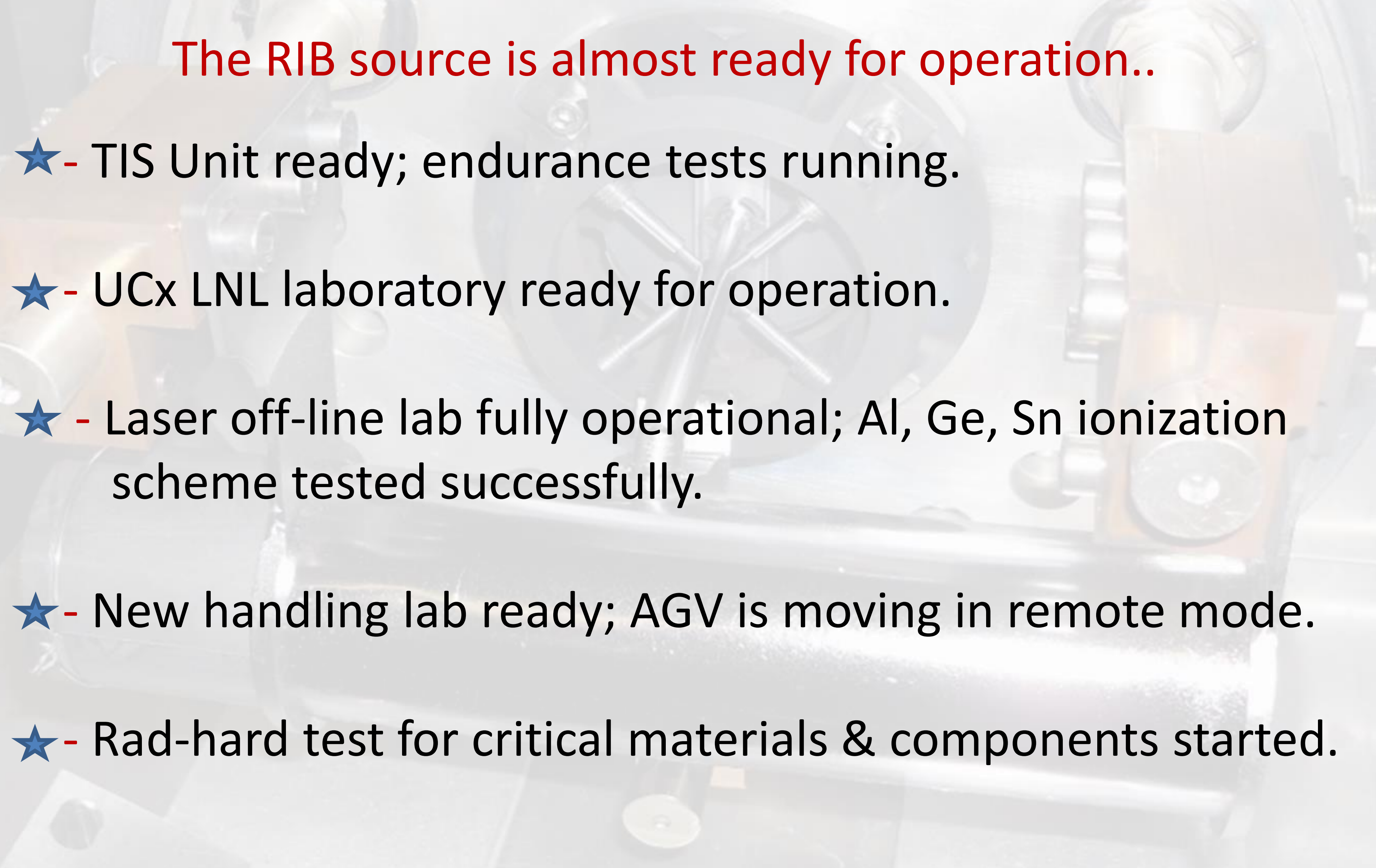
Silicon Carbide Target (test 2006)





Conclusion

Concerning the RIB complex…



The RIB source is almost ready for operation..

★- TIS Unit ready; endurance tests running.

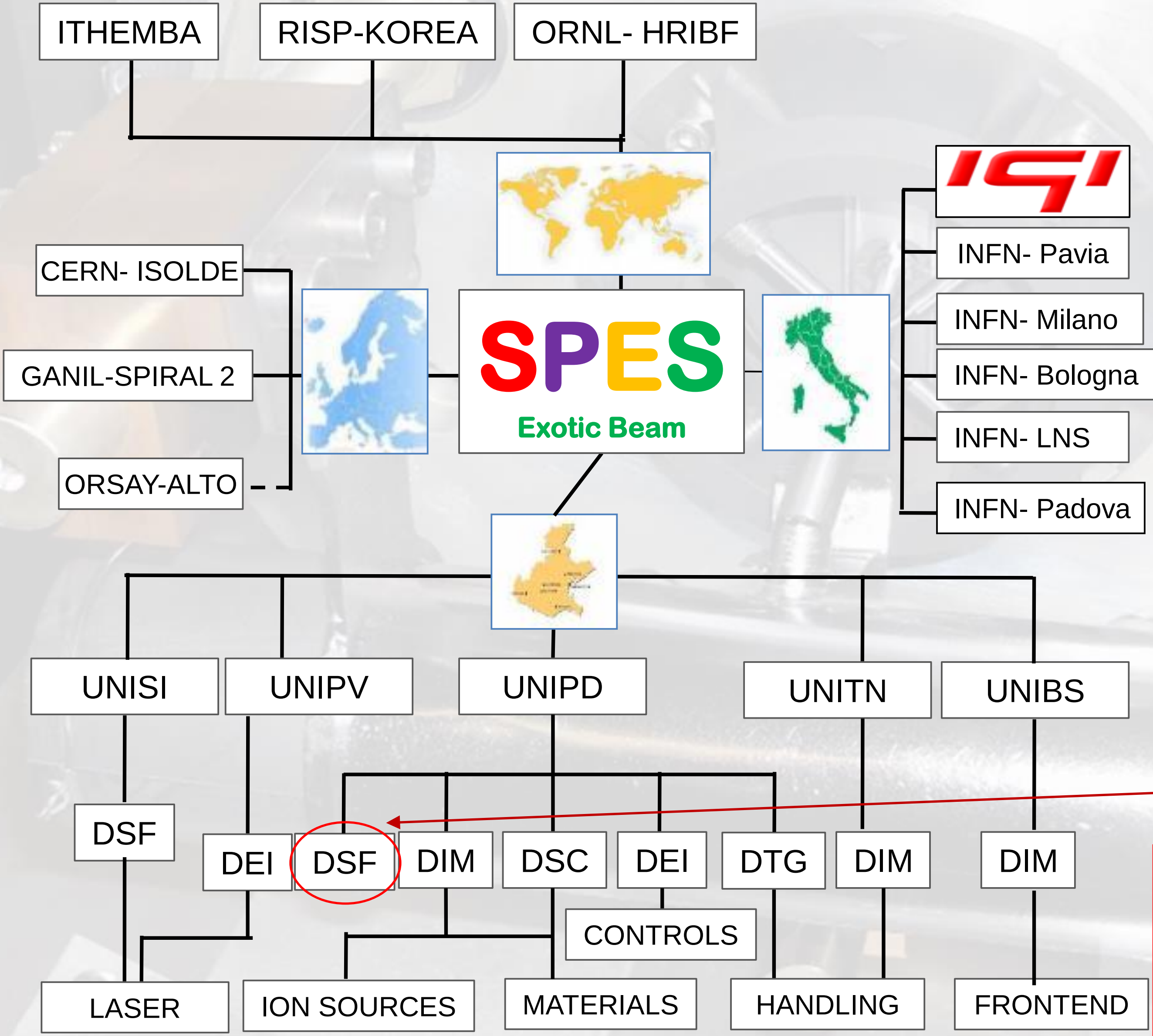
★- UCx LNL laboratory ready for operation.

★ - Laser off-line lab fully operational; Al, Ge, Sn ionization scheme tested successfully.

★- New handling lab ready; AGV is moving in remote mode.

★- Rad-hard test for critical materials & components started.

Collaboration network with partners



ITHEMBA
RISP-KOREA
ORNL- HRIBF

CERN- ISOLDE
GANIL-SPIRAL 2
ORSAY-ALTO

SPES
Exotic Beam

IGI
INFN- Pavia
INFN- Milano
INFN- Bologna
INFN- LNS
INFN- Padova

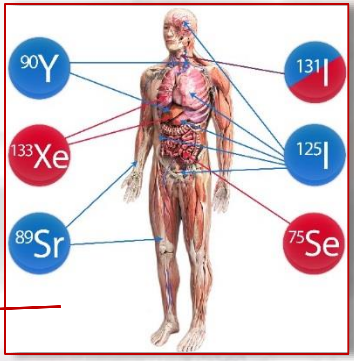
UNISI
UNIPV
UNIPD
UNITN
UNIBS

DSF
DEI
DSF
DIM
DSC
DEI
DTG
DIM
DIM

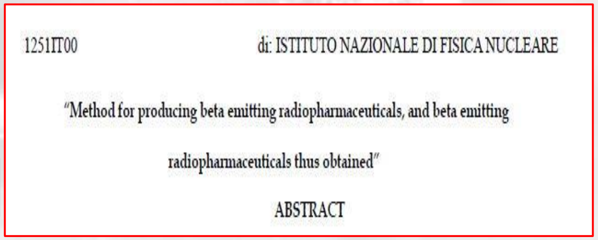
CONTROLS

LASER
ION SOURCES
MATERIALS
HANDLING
FRONTEND

33	Tesi Magistrali
20	Tesi Triennali
3	Tesi di PhD
15	Ospiti Stranieri (FAI)



ISOLPHARM
SPES exotic beams for medicine



1251IT00 di: ISTITUTO NAZIONALE DI FISICA NUCLEARE

"Method for producing beta emitting radiopharmaceuticals, and beta emitting radiopharmaceuticals thus obtained"

ABSTRACT

Second conclusion: thanks to the team!