Status of the SPES facility at INFN-Legnaro

Alberto Andrighetto
SPES Technical Coordinator

CERN-Isolde 25-1-2018

Talk Overview

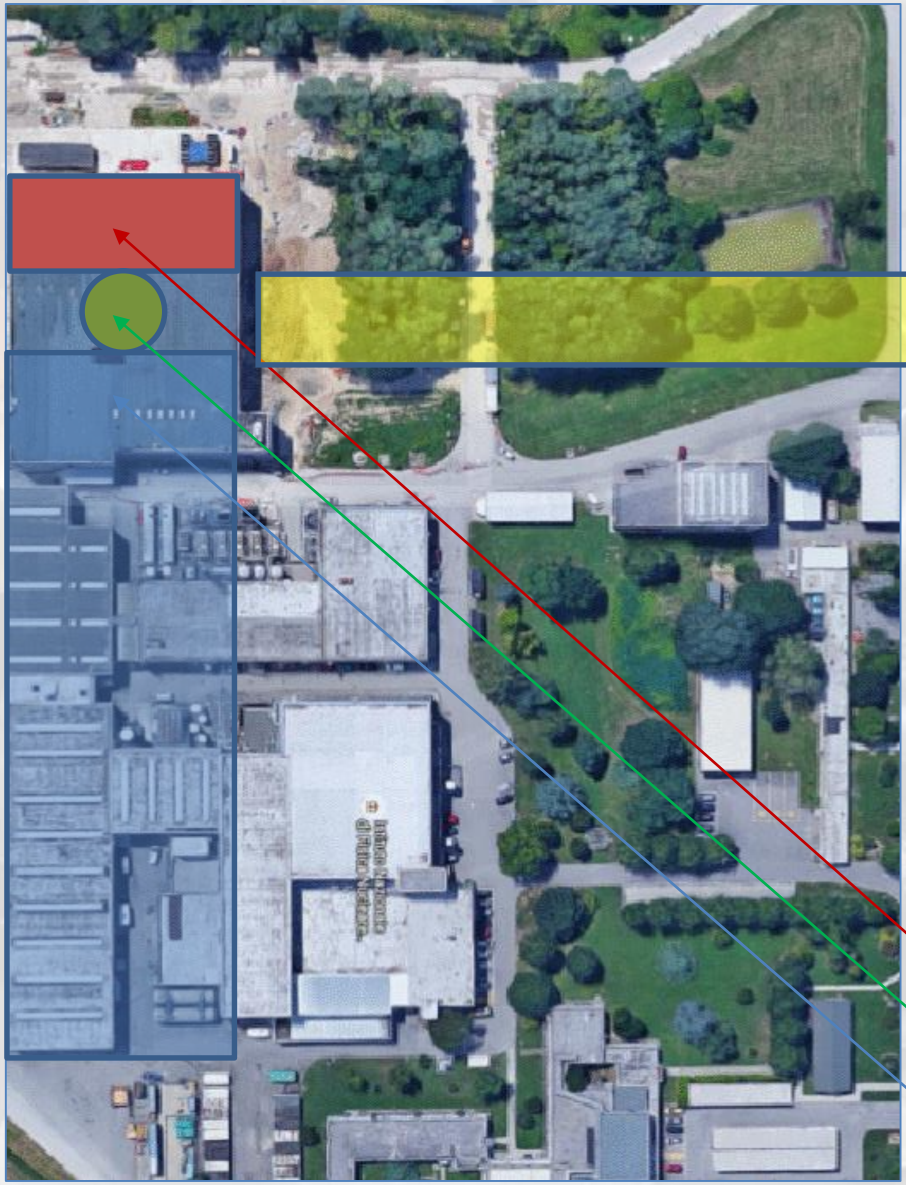
- The SPES Project goals
- The RIB +1 line.
- Possible first RIB's @ SPES
- Conclusions

Direct UC_x Target for the SPES Project

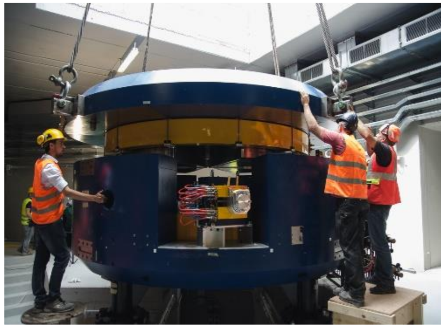
Alberto Andrighetto
INFN - Laboratori Nazionali di Legnaro

CERN - 01/03/2005

The SPES at LNL: Facility Layout



New Building:



Project financed by INFN

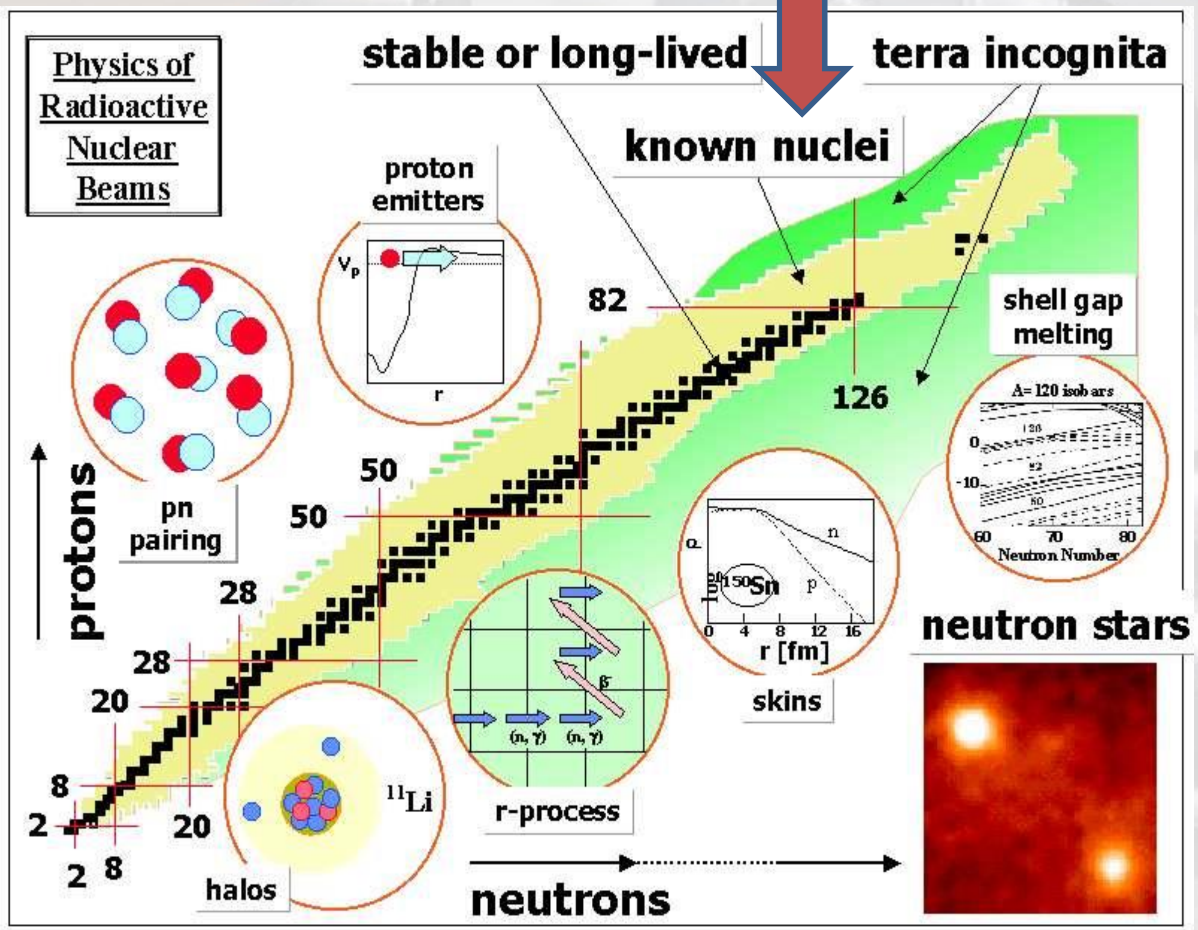
New infrastructure for:

- Application Facility
- Cyclotron
- RIB facility (2th generation ISOL)

Physics with RIB's

Definition of RIB (Radioactive Ion Beam) -> Ions with 'exotic' protons-to-neutron ratio.

The RIB is a important probe in order to investigate the nuclide chart, for nuclei far from the stability valley -> different behavior!



Nuclear Physics with RIB

- High angular momentum
- Deformed nuclei
- Correlation (pairing)
- Shell evolution

Nuclear Astrophysics with RIB

- Heavy elements origin (r,p,s process)
- Stellar explosion
- Neutron stars
- X-ray burst and supernovae

Nuclear Medicine with RIB

Radiopharmaceutical prodution for:

- Therapy
- Diagnostic

SPES: Is the future of LNL

SPES is: 1) A second generation ISOL facility (for neutron-rich ion beams)

2) An interdisciplinary research center (for p,n applications)

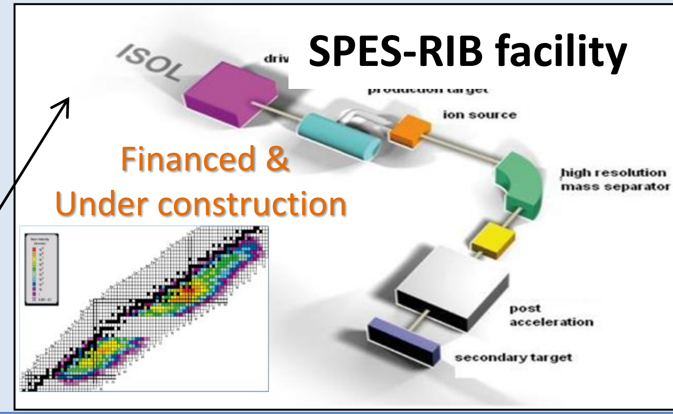
SPES-DRIVER

Cyclotron installation & commissioning:

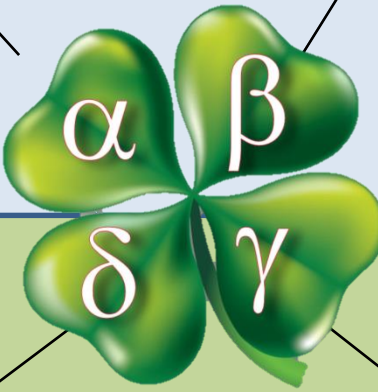
- E=70 MeV proton beam, I= 750 μA

RIB Facility

SPES-RIB facility



Production & re-acceleration of **exotic beams,** from **p-induced Fission** on **UCx**



LINUS Neutron facility

Accelerator based neutron source

(Proton and Neutron Facility for Applied Physics)

Application Facility

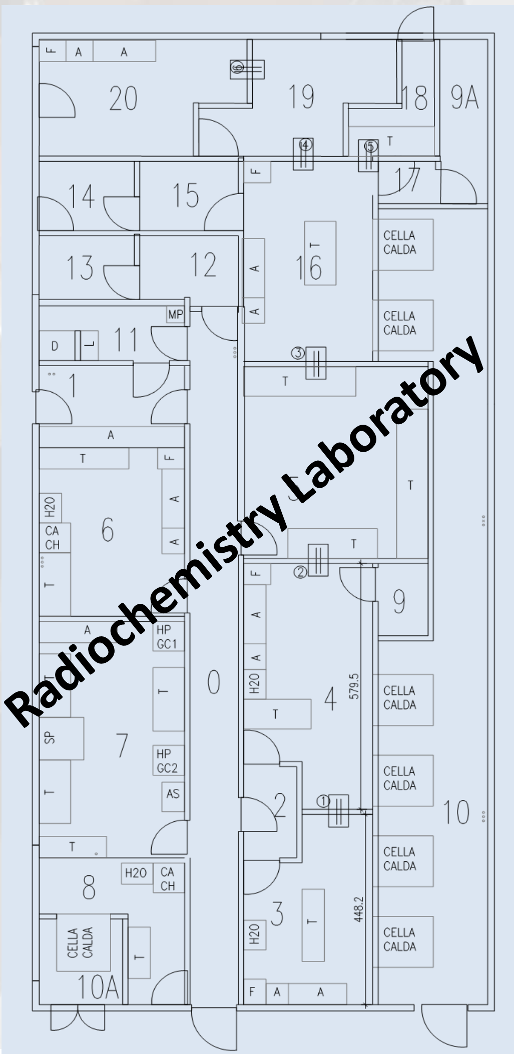
SPES for medicine

LARAMED & ISOLPHARM projects

Radioisotopes for medical applications

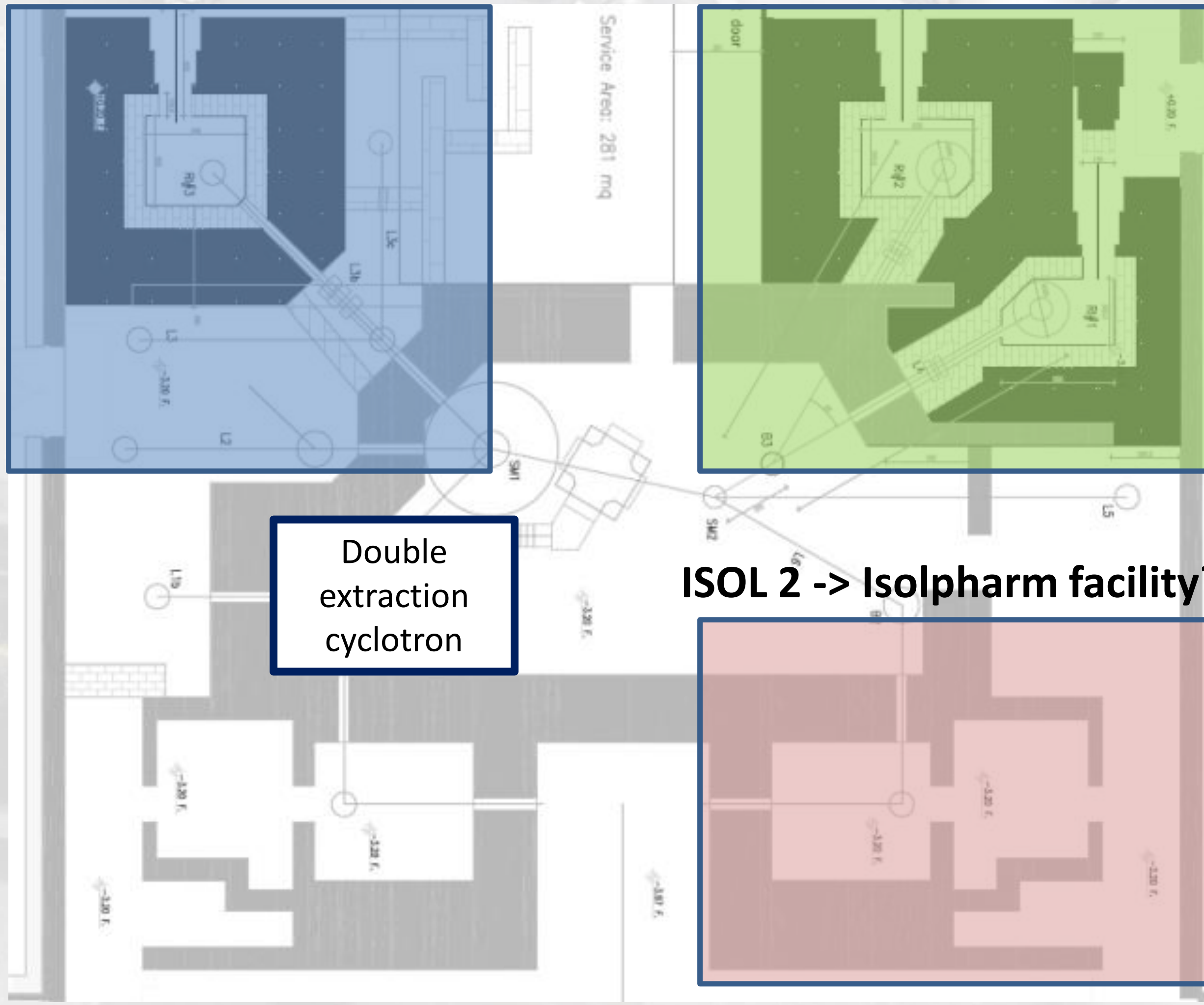
Medical applications @ SPES :

important investment and great opportunity for the INFN



Radioisotope Laboratory

Radioisotope Factory



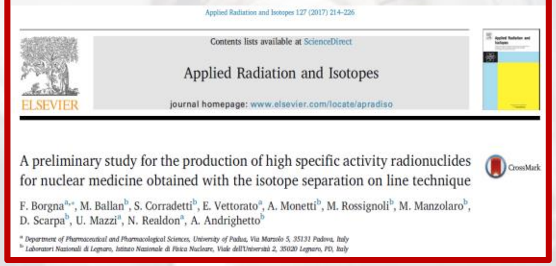
ISOLPHARM Method overview

The ISOLPHARM method is capable of selecting and isolating on-line a SINGLE RADIO-ISOTOPE

→ *extremely high specific activity*

→ *higher efficacy in therapy and diagnosis*

PUBLISHEDPAPER


Applied Radiation and Isotopes 127 (2017) 214–226

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

A preliminary study for the production of high specific activity radionuclides for nuclear medicine obtained with the isotope separation on line technique

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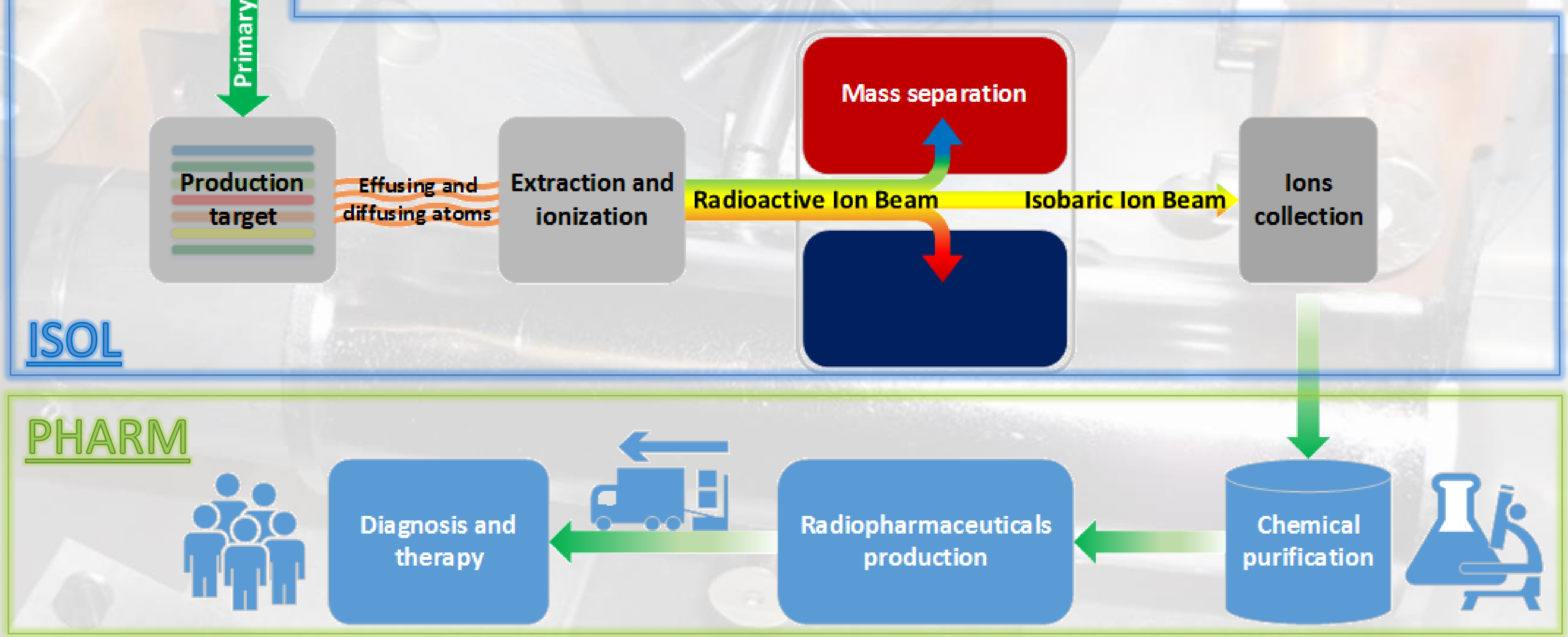
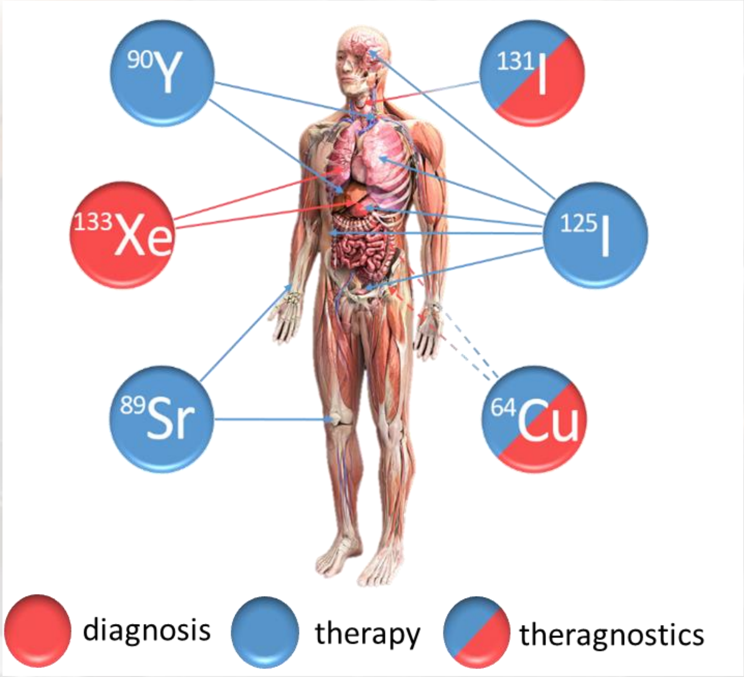


ISOLPHARM 1 & 2

ISOLPHARM 1

- **First set** of isotopes studied in the framework of ISOLPHARM collaboration:

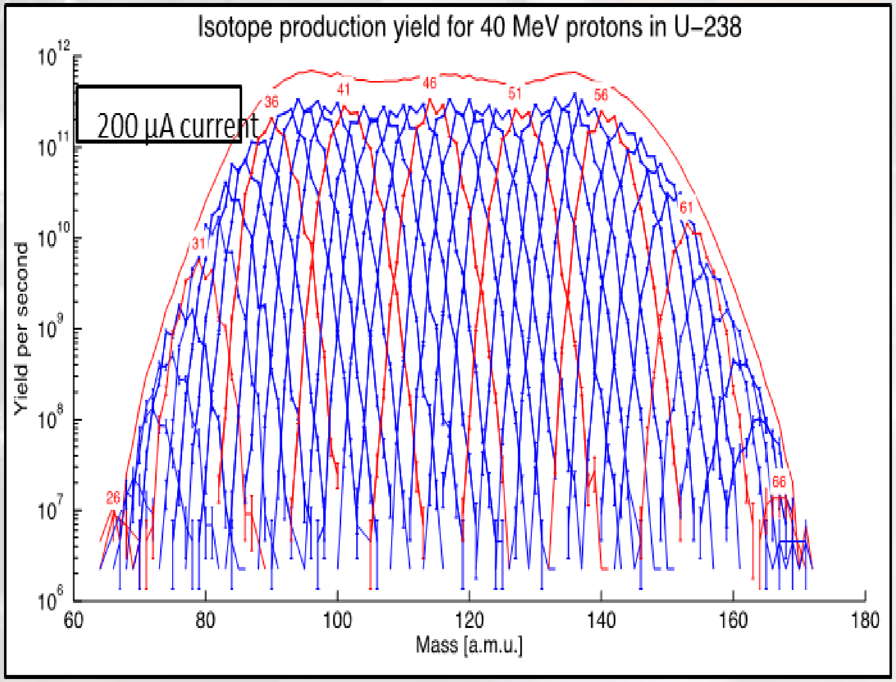
radiopharmaceuticals available in the market



ISOLPHARM 2

- **Innovative** radio-isotopes produced with different types of target

radiopharmaceuticals absent in the market



Innovative Target concepts: overview

The ISOL method requires specific targets.

Targets have to be:

- Solid
- Refractory (more refractory than the element for which they were designed)

Three target concepts are currently under investigation:

UC_x new targets (Operation temperature: 2200°C)

- Target R&D and state of: Nuclear reactions studied | Designed | Tested
- Innovative isotopes production: ^{111}Ag

ZrGe target (Operation temperature: 1800°C)

- Target R&D and state of: Nuclear reactions studied | Designed | Tested
- Innovative isotopes production: As & Ga isotopes
- $^{64/67}$Cu unexpected production!

TiC/TiB_2 target (Operation temperature: 2000°C)

- Target R&D and state of: Nuclear reactions studied | Designed | Tested
- Innovative isotopes production: Sc isotopes

ISOLPHARM: possible beams

^{90}Y

^{89}Sr

^{125}I

UC_x target

^{131}I

^{111}Ag

^{64}Cu

ZrGe target (?)

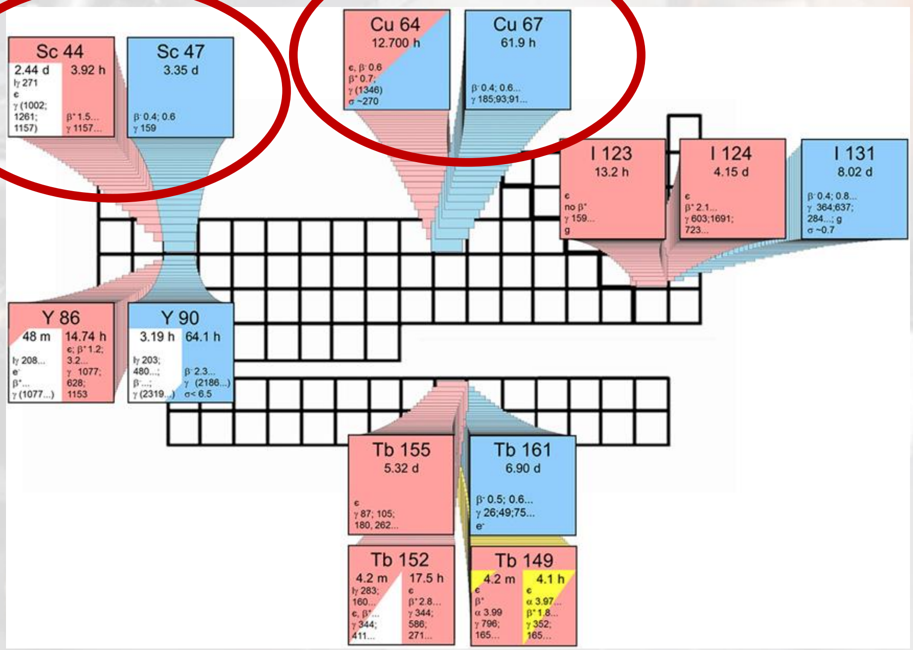
^{67}Cu

^{43}Sc

^{44}Sc

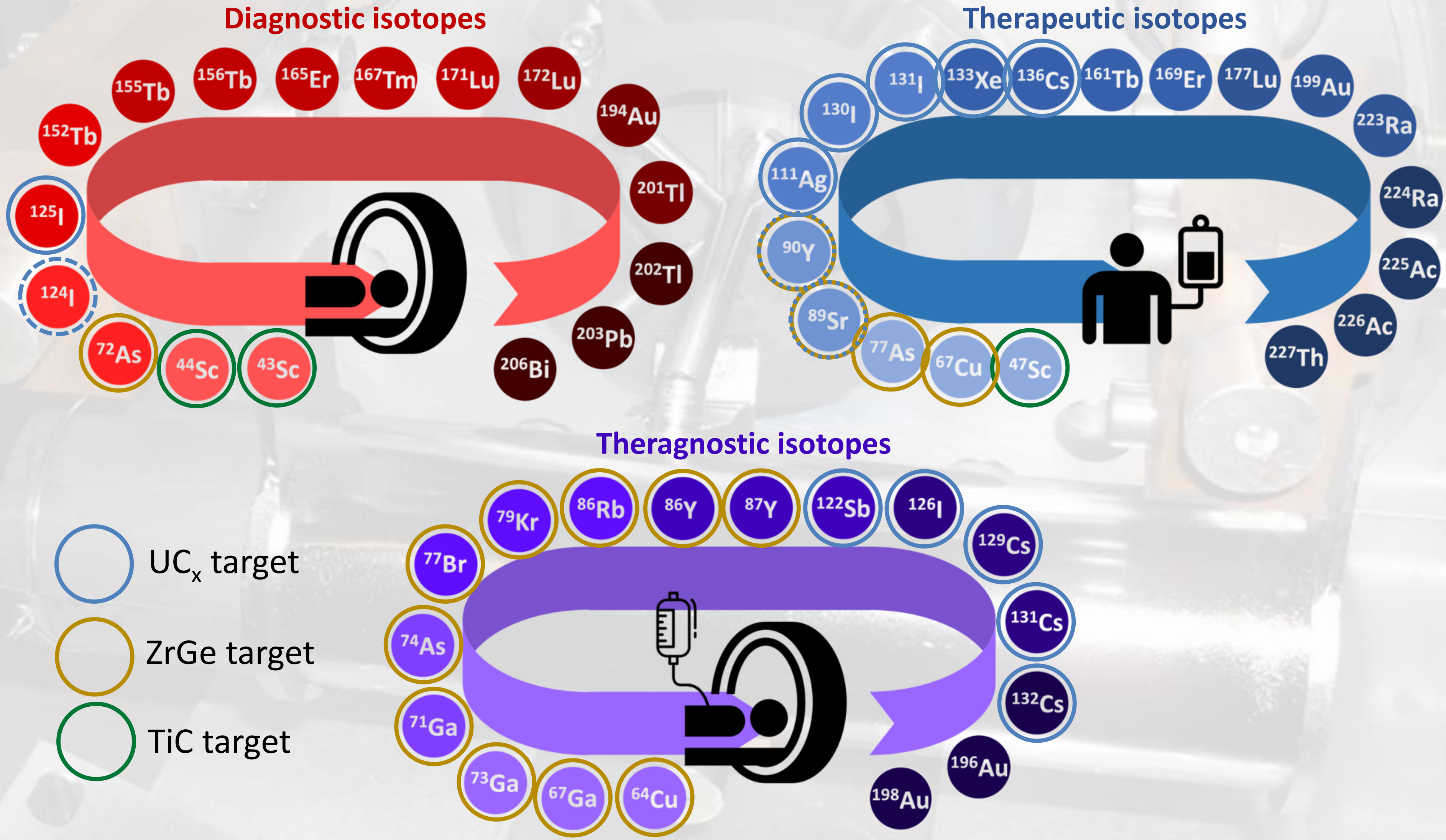
TiC target

^{47}Sc

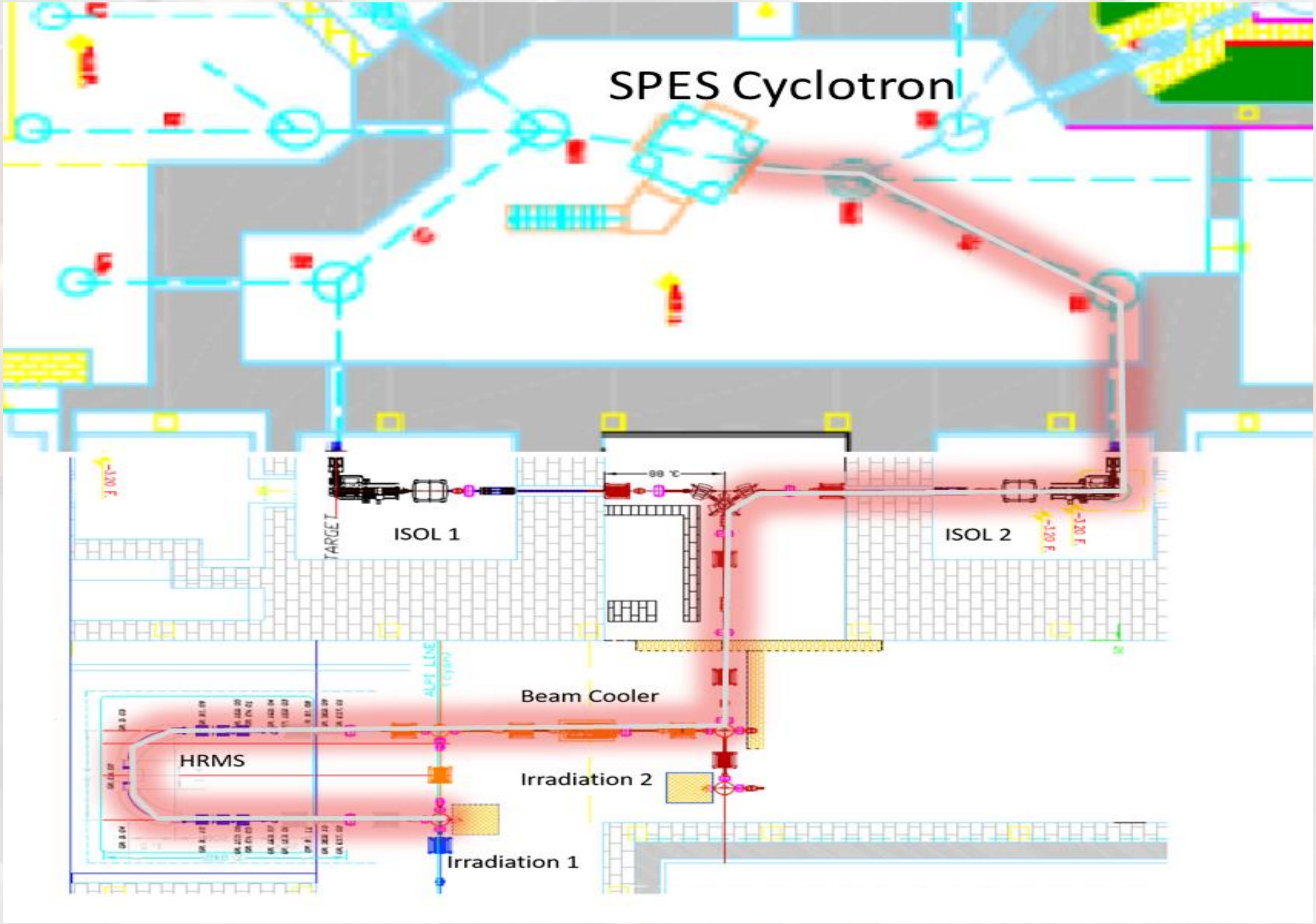


ISOL Isotopes of medical interest

Almost 60 isotopes (up to now!) are producible with the ISOL technique

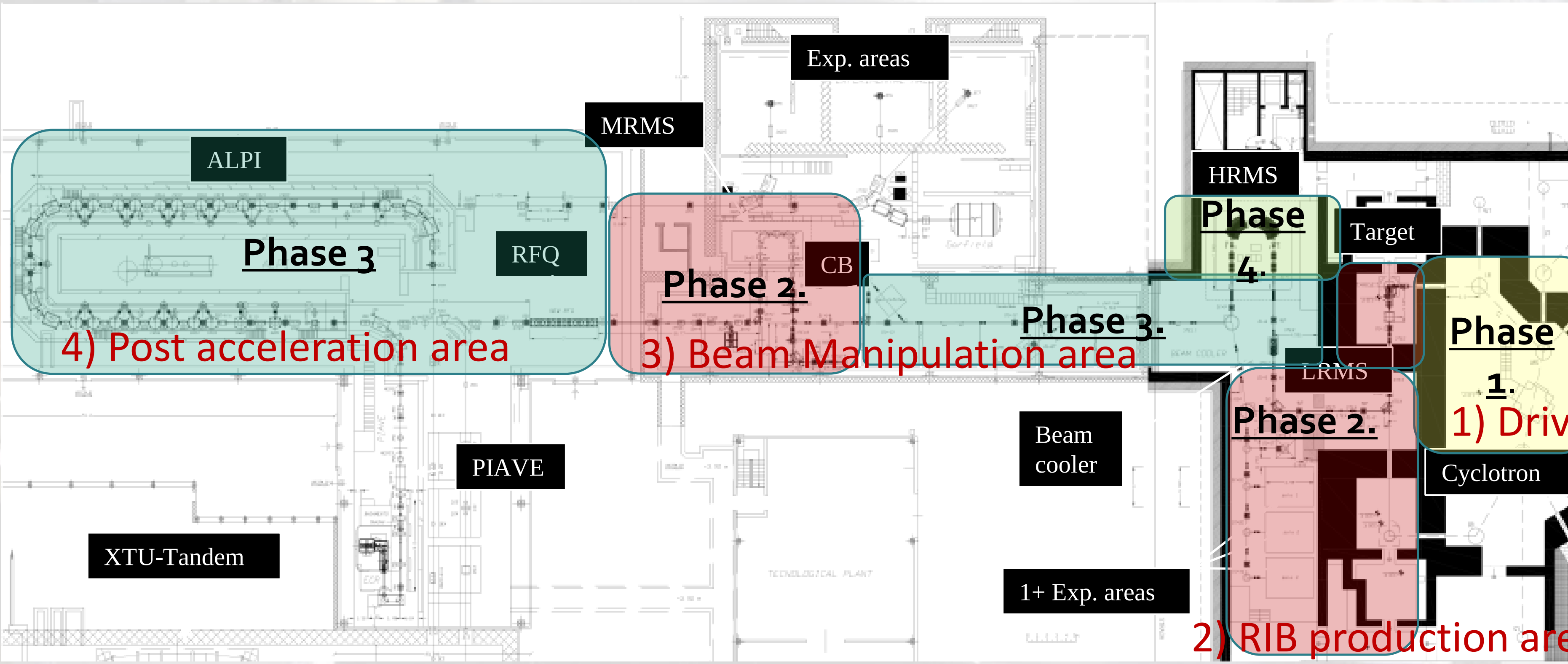


ISOLPHARM as future facility…



Status of the ISOL facility

SPES-RIB construction phases

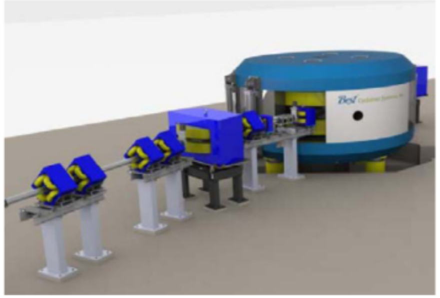


- **Phase 1.** - Building + First operation with the cyclotron
- **Phase 2.** - From C.B. to RFQ + SPES target, LRMS, 1+ Beam Lines
- **Phase 3.** - From the LRMS to the CB + from RFQ to ALPI
- **Phase 4.** - HRMS + Beam Cooler

- The driver
- The RIB manipulation
- The post accelerator
- The RIB production & L.E. line

Cyclotron installation

Dual port Cyclotron
Proton beam 35-70 MeV
Total current 750μA

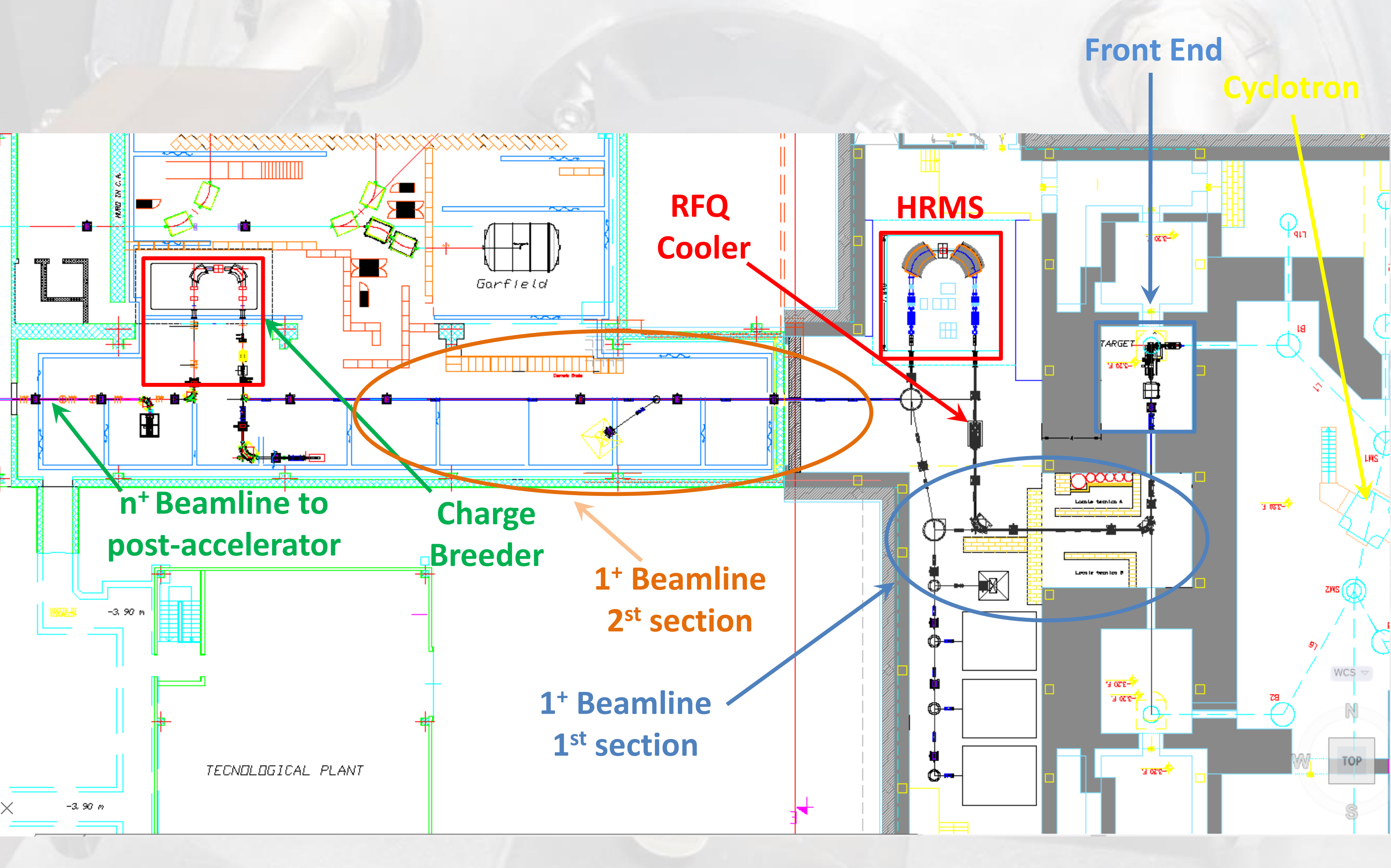


Main Dimensions
Diameter = 4.5 m
Height= 1.7 m
Weight = 210 tons

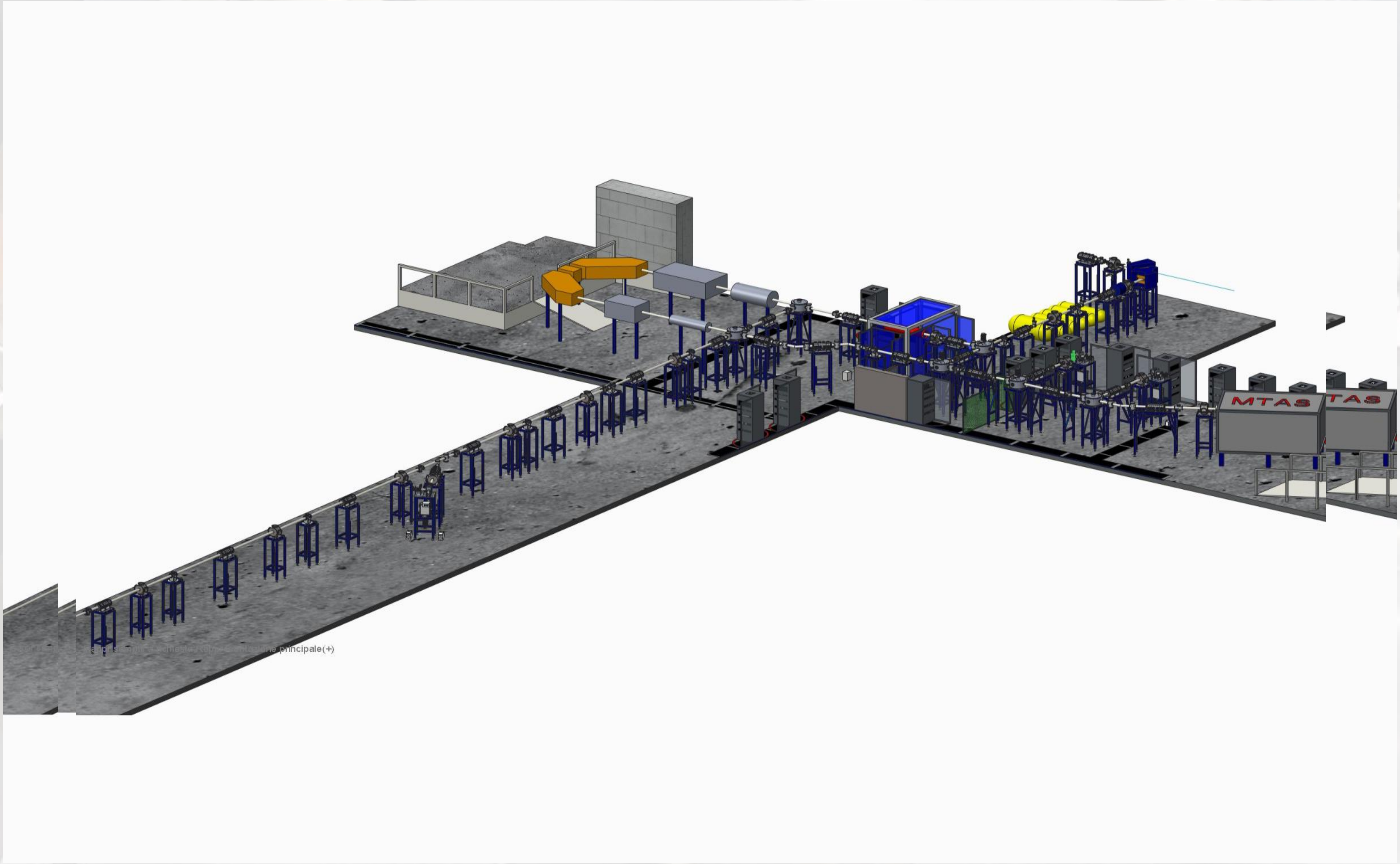
Accelerated Particle	H-
Extracted Particle	Protons
Energy	35-70 MeV (variable)
Current	> 700 uA (variable)
Extraction System	By stripping → simultaneous dual beam extraction
Injection System	Axial Injection → External Multicusp Ion Source 15-20mA DC
Main Magnet	B_{max} = 1,6 T Coil current = 127 kAt Power supply = 30 kW 4 sectors, deep valley
RF System	2 resonators Frequency= 58 MHz Harmonic mode=4 Dissipated Power=15 kW per cavity DEE voltage=60-80 kV
Operational Vacuum	2 e -7 mbar

- The driver
- The RIB manipulation
- The post accelerator
- The RIB production & L.E. line

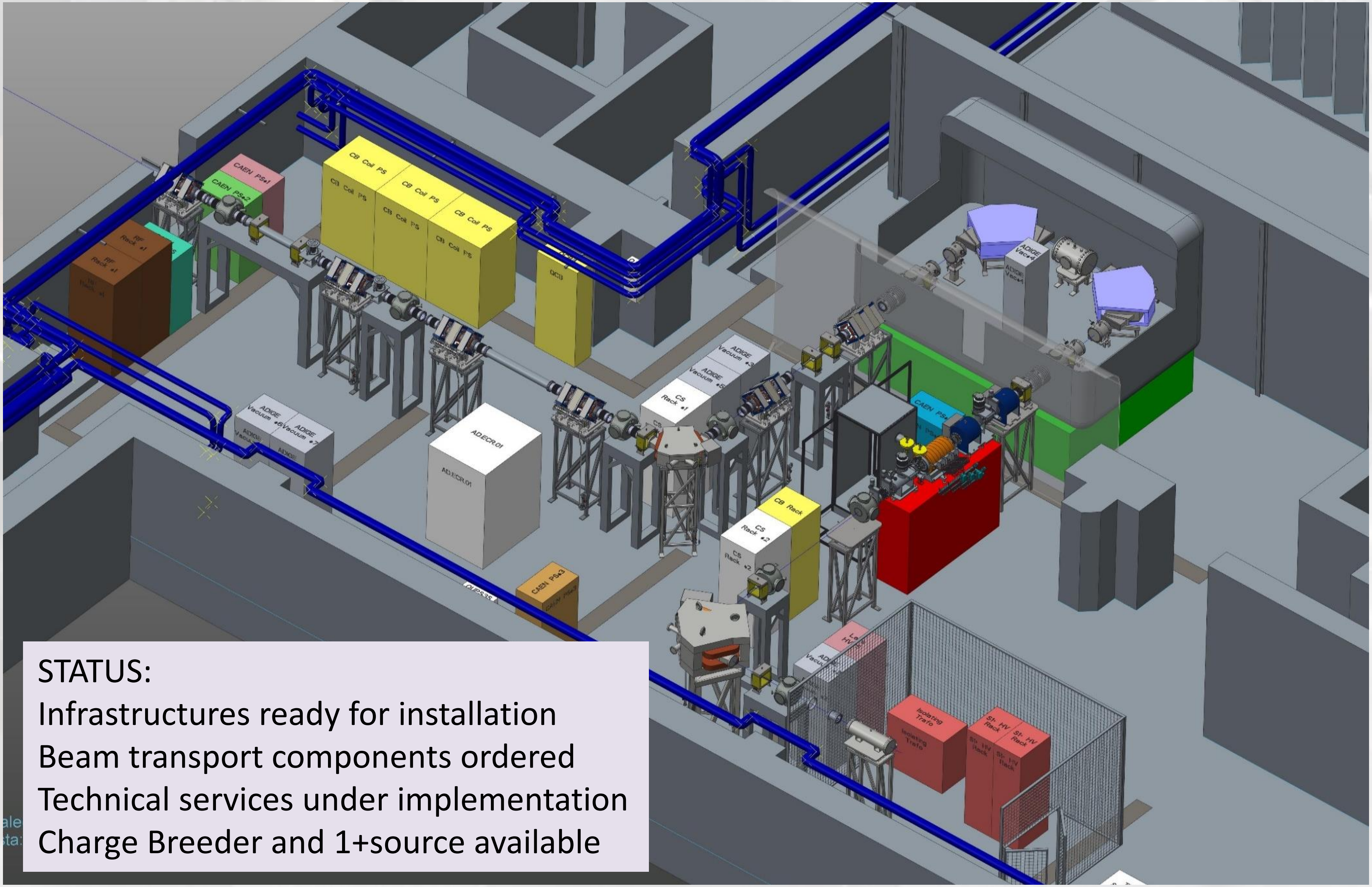
The beam transport line



The 1+ beam line: the construction phases



n+ Beam line



STATUS:
Infrastructures ready for installation
Beam transport components ordered
Technical services under implementation
Charge Breeder and 1+source available

- The driver
- The RIB manipulation
- The post accelerator
- The RIB production & L.E. line

Optimization of ALPI post-accelerator

Goal: To achieve E=10 MeV/A for A/q up to 7

a) Cavity upgrades

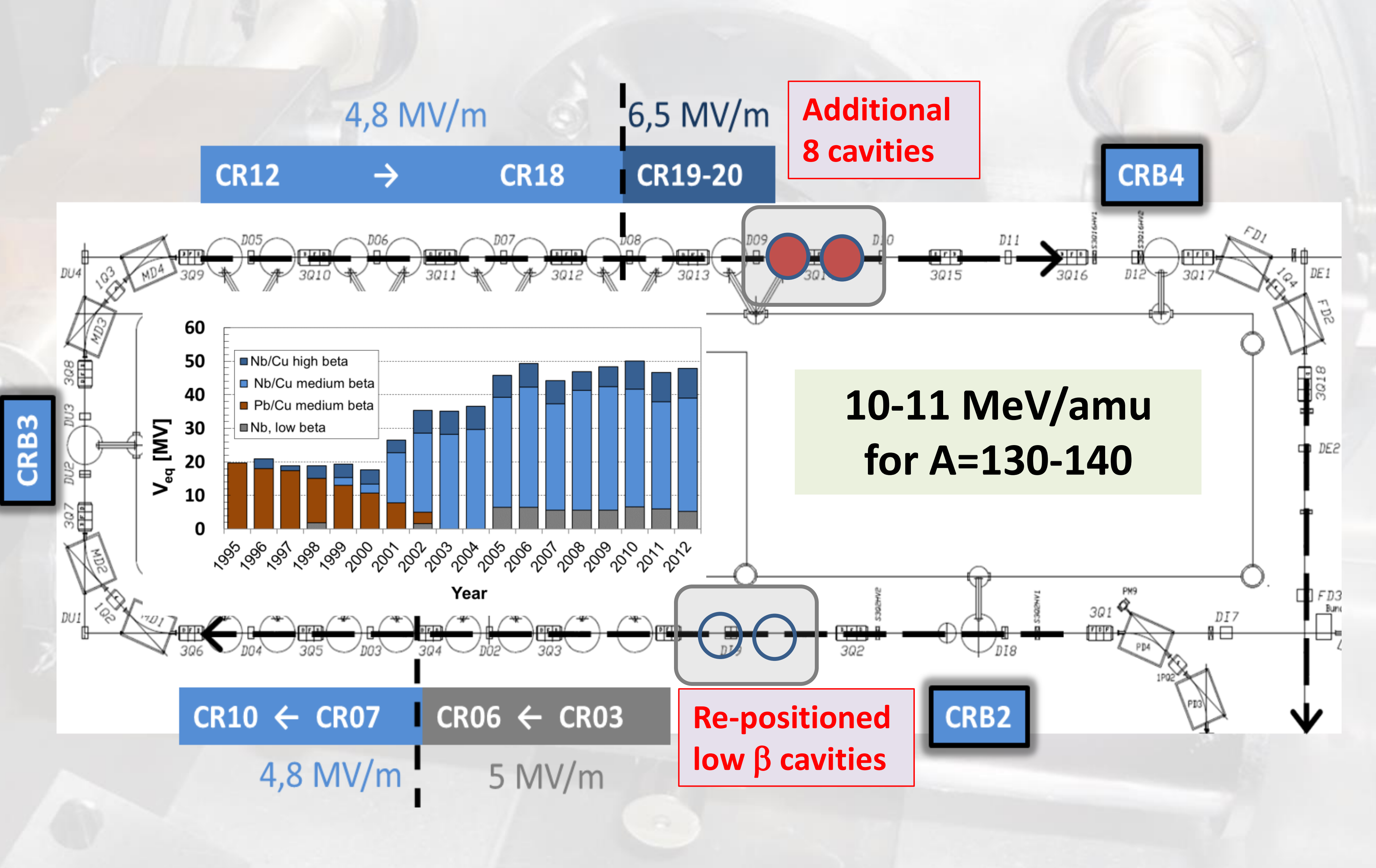
1. Lower-b_{opt}- resonators added
2. Field increase in medium-b_{opt}-cavities
3. Two additional higher-b_{opt}-CMs (8 resonators)

b) Cryogenic power increase

c) New magnetic triplet of quadrupoles

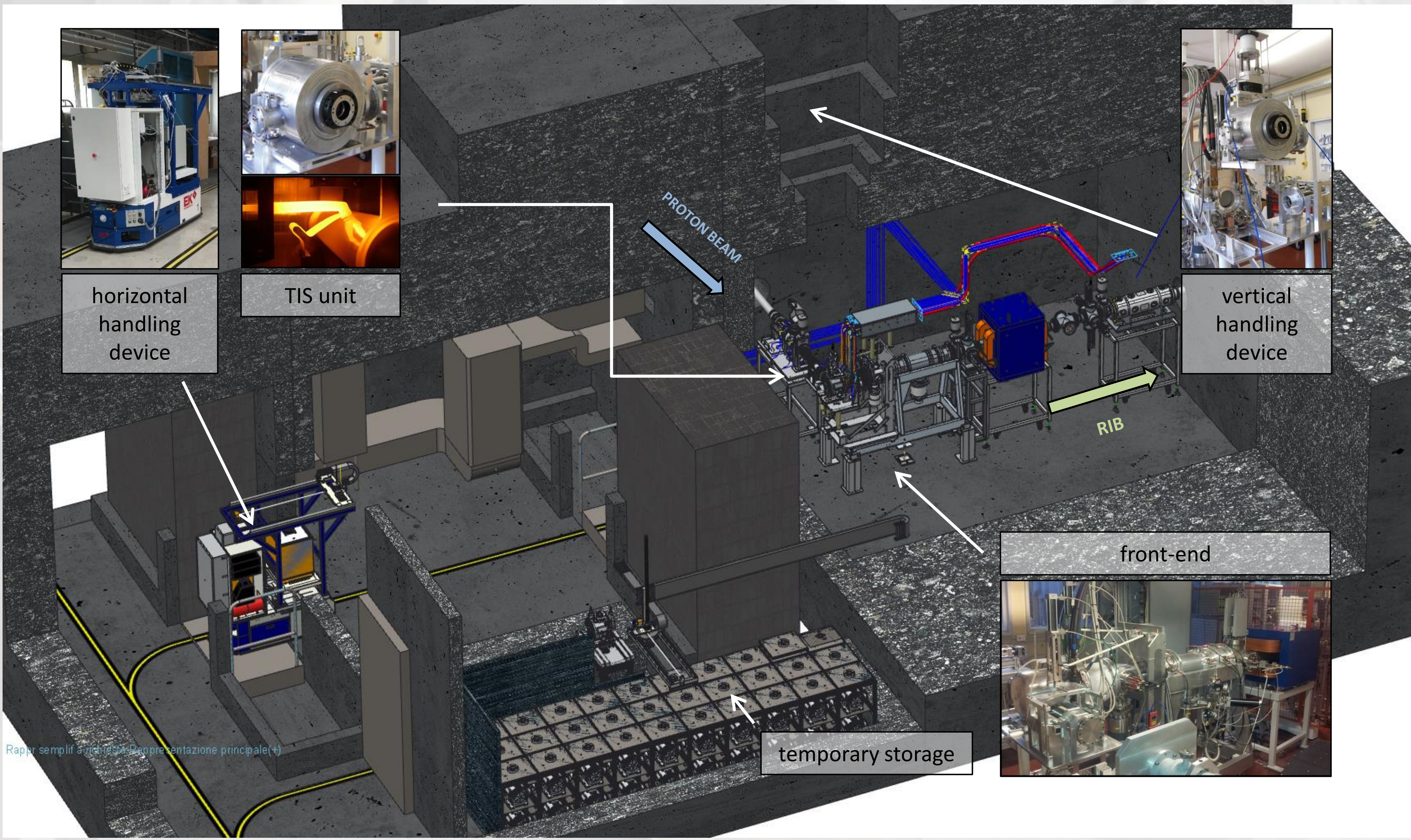
exotic beams for science

Cavity Upgrades

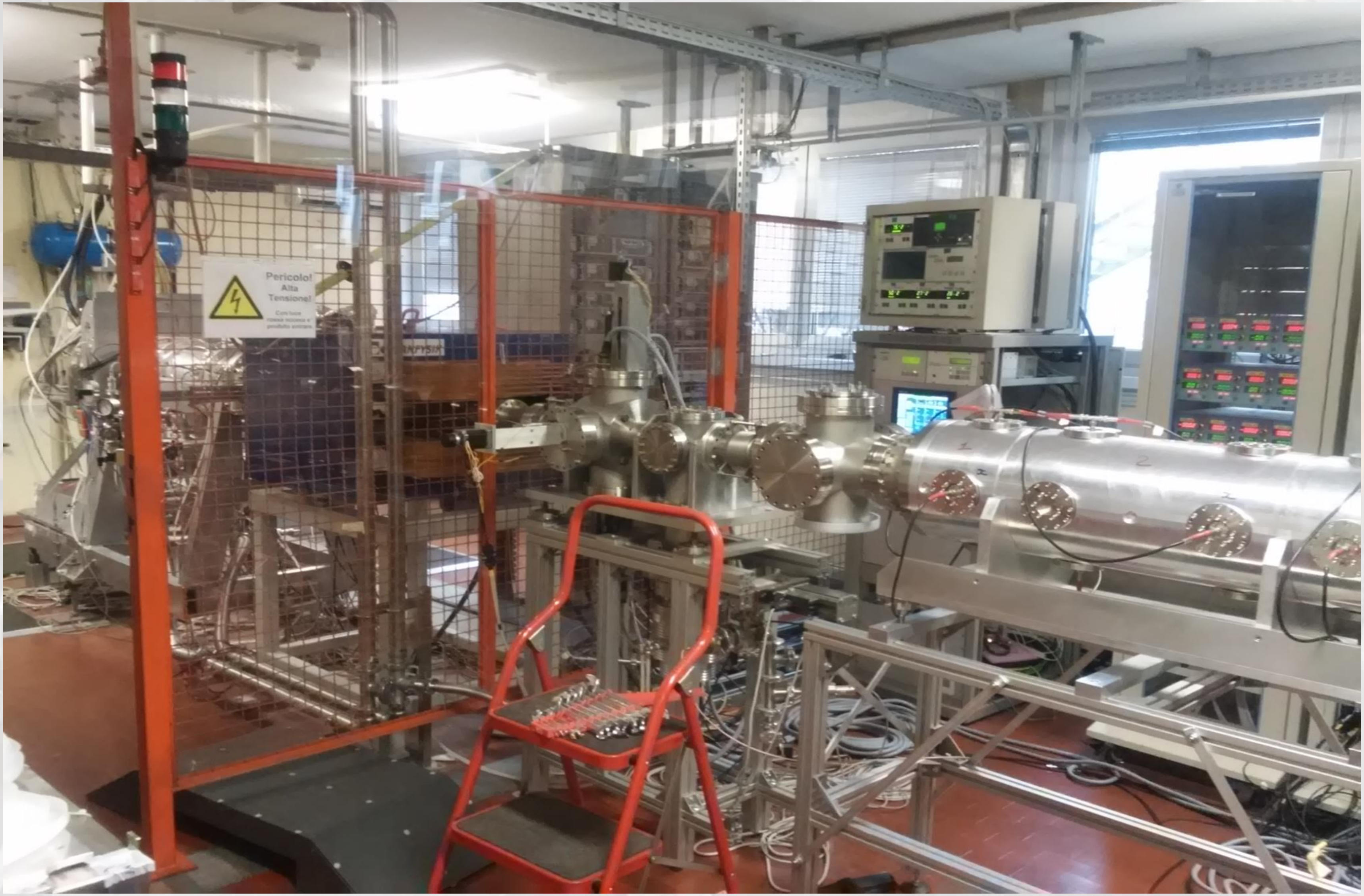


- The driver
- The RIB manipulation
- The post accelerator
- The RIB production & L.E. line

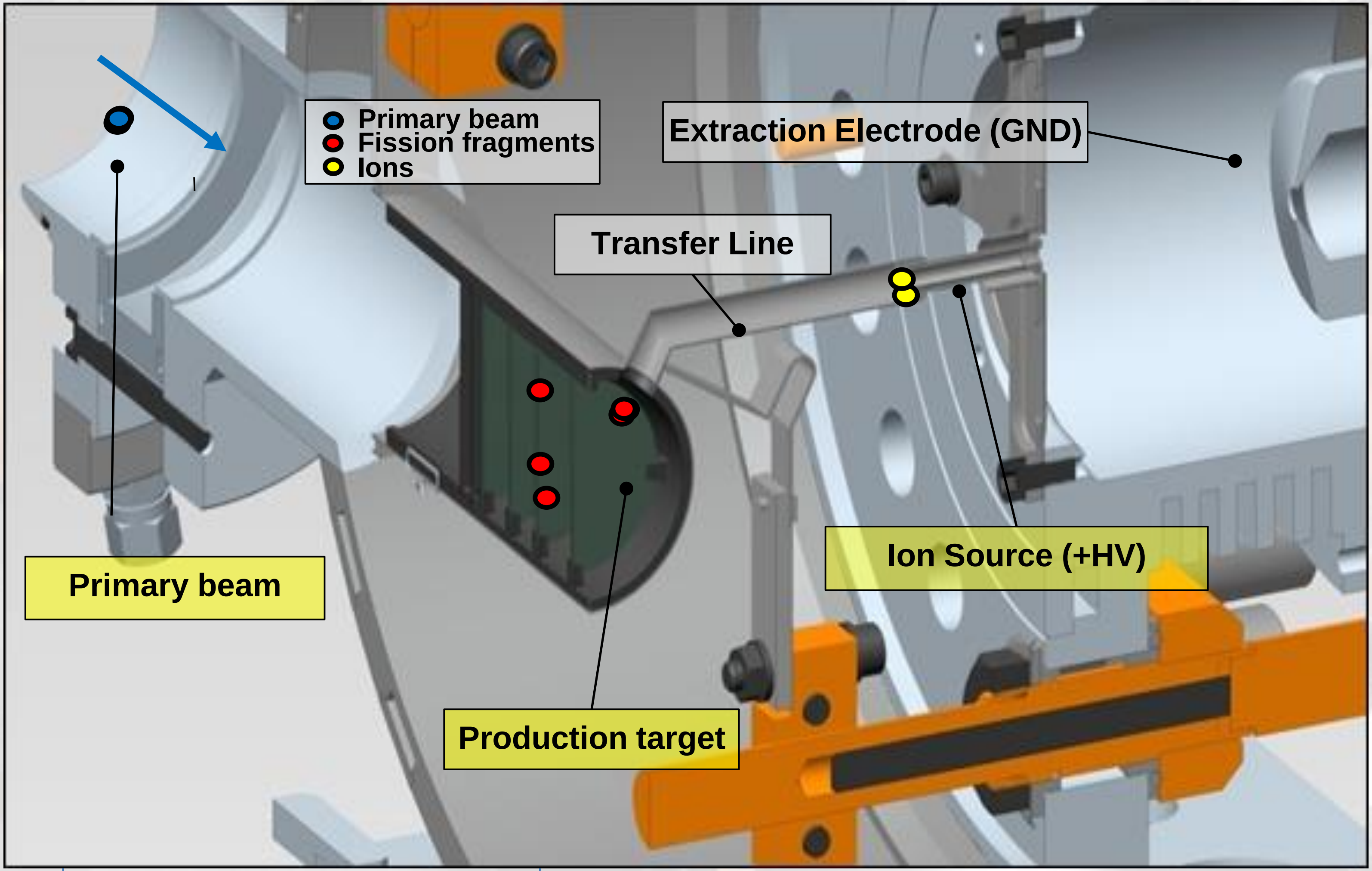
The SPES ISOL - RIB source



RIB Bunker set-up



The SPES TIS UNIT

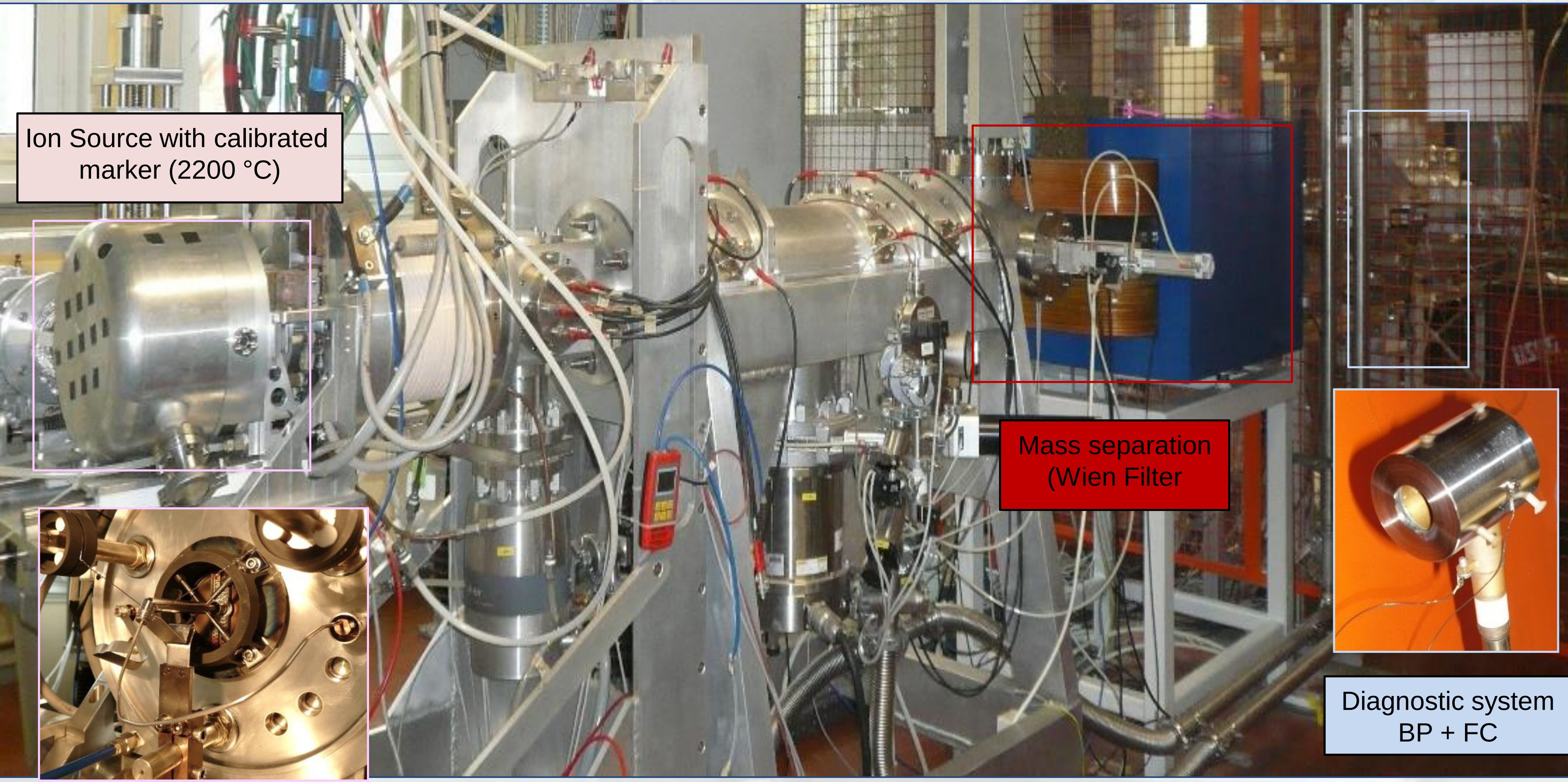


Driver vs. Target

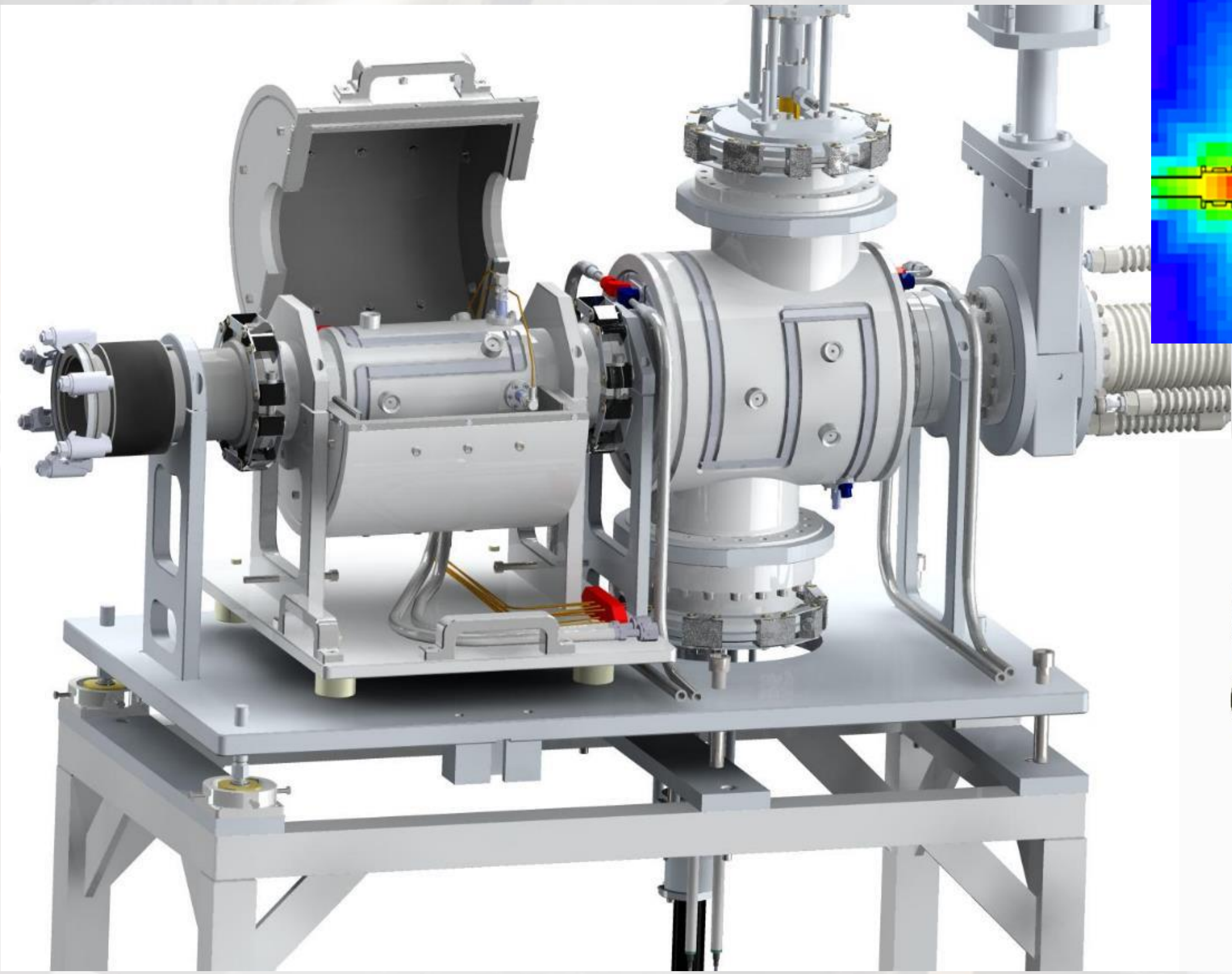
Target vs. Ion Source

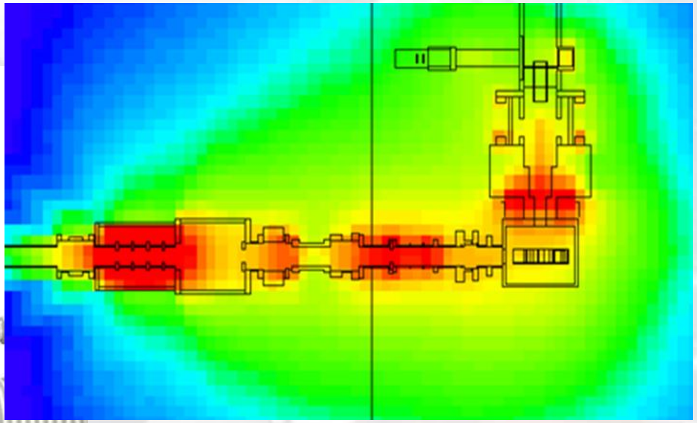
I.S. study: The experimental set-up

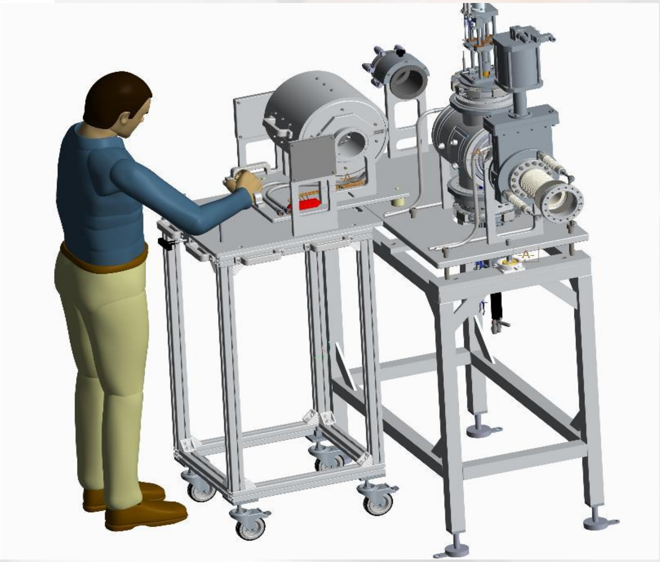
Off-line TIS Front-end : operative at LNL since 2011



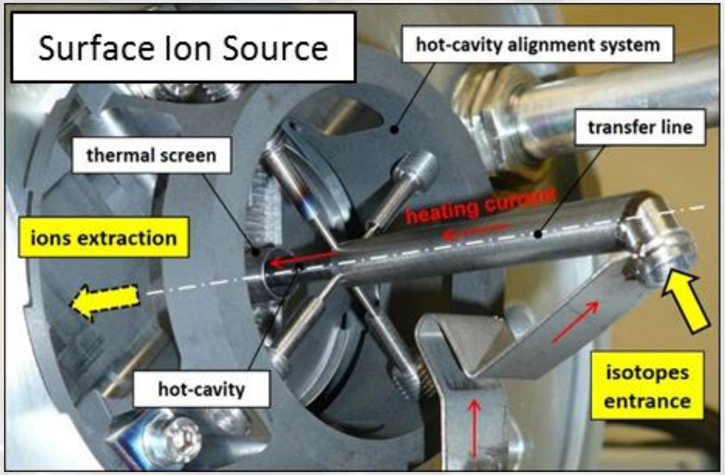
front-end (protonic beam line)

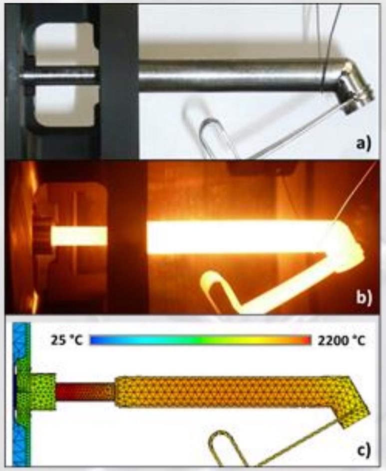




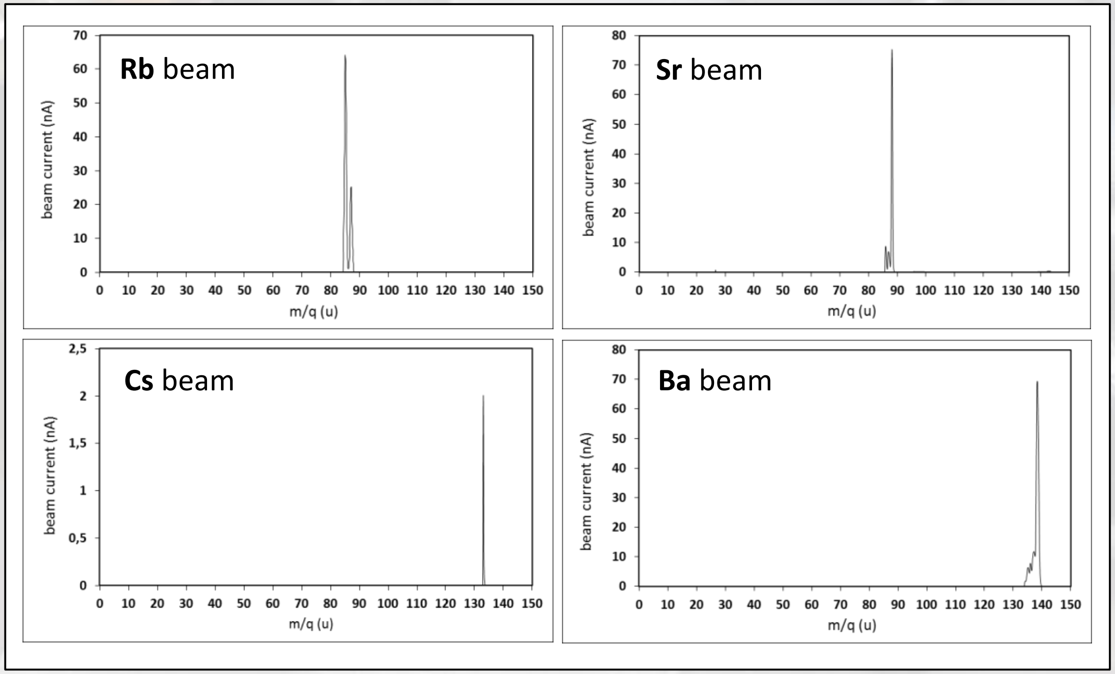


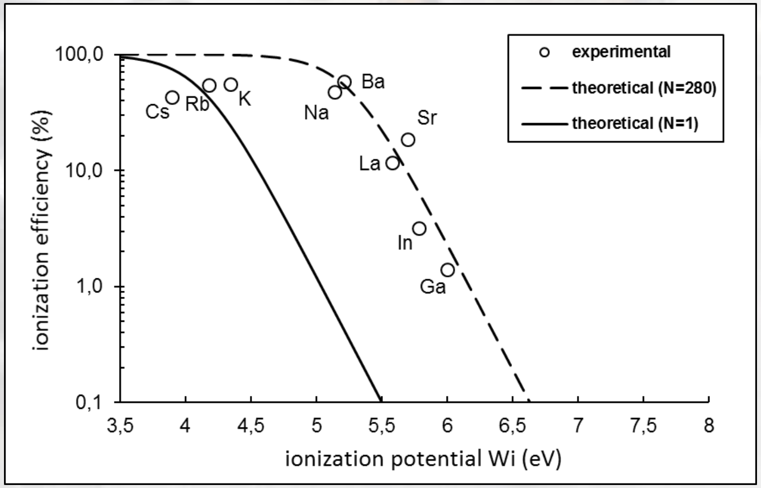
Characterization of the SPES Surface Ion Source



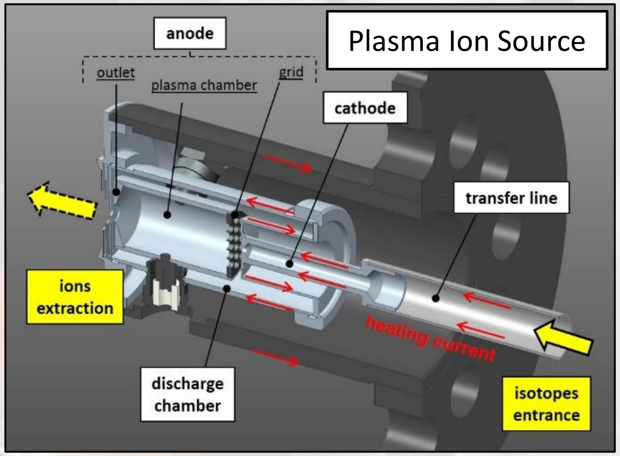


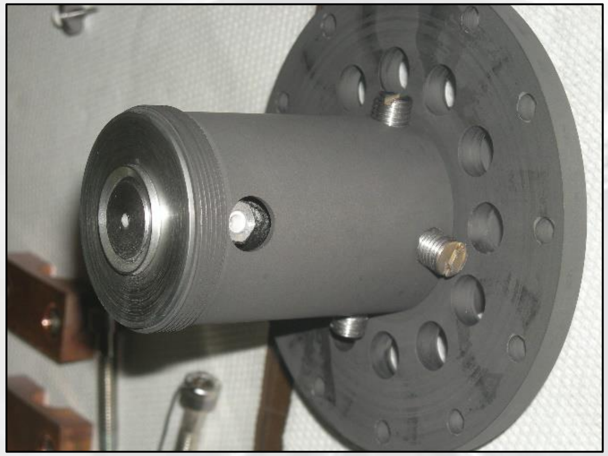
beam	ion. eff. (%)	hot-cavity temp. (°C)	hot-cavity material
Na	47,6	2200	Ta
K	55,4	2200	Ta
Ga	1,4	2200	Ta
Rb	**54,5**	**2200**	**Ta**
Sr	**18,5**	**2200**	**Ta**
In	3,2	2200	Ta
Cs	**43,2**	**2200**	**Ta**
Ba	**58,8**	**2200**	**Ta**
La	20,1	2200	Ta

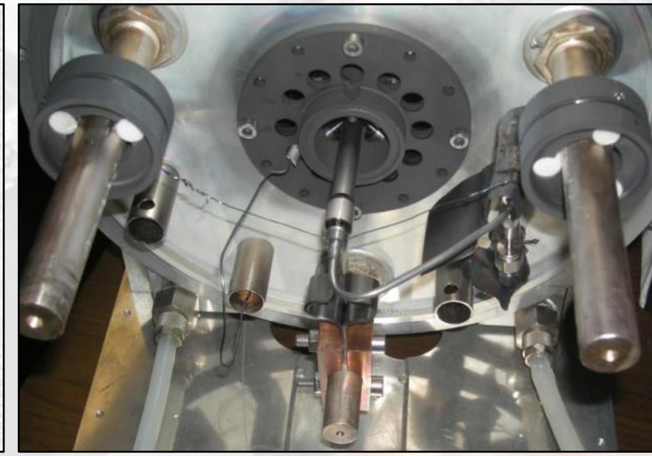


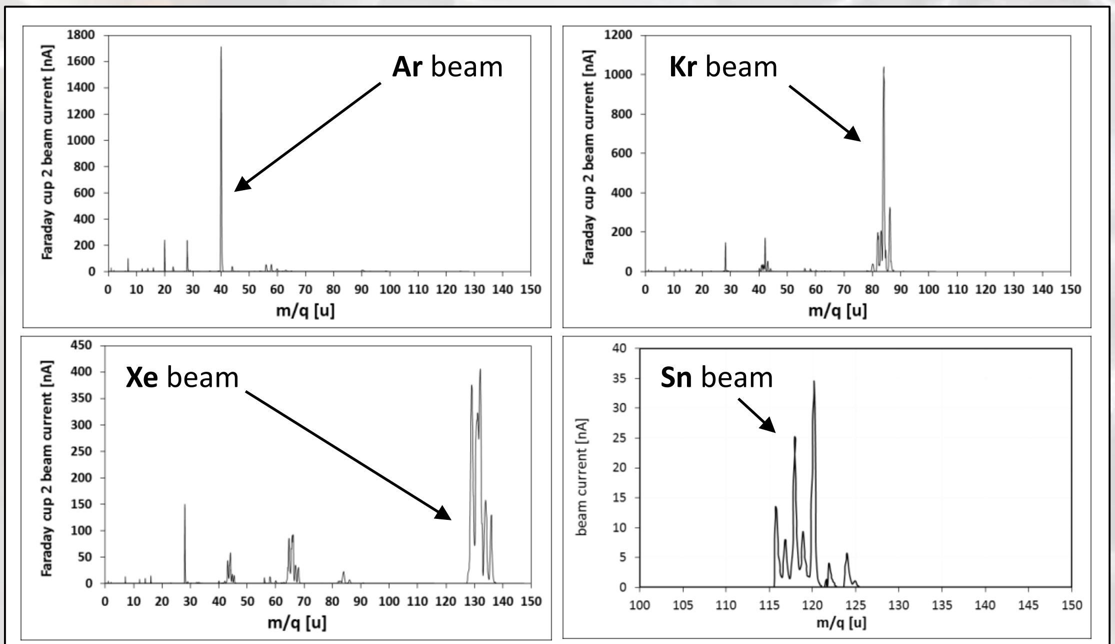


Characterization of the SPES Plasma Ion Source









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

Off-line Laser Laboratory

Equipment's ready

1 Nd:YAG Ablation laser

1 TOF

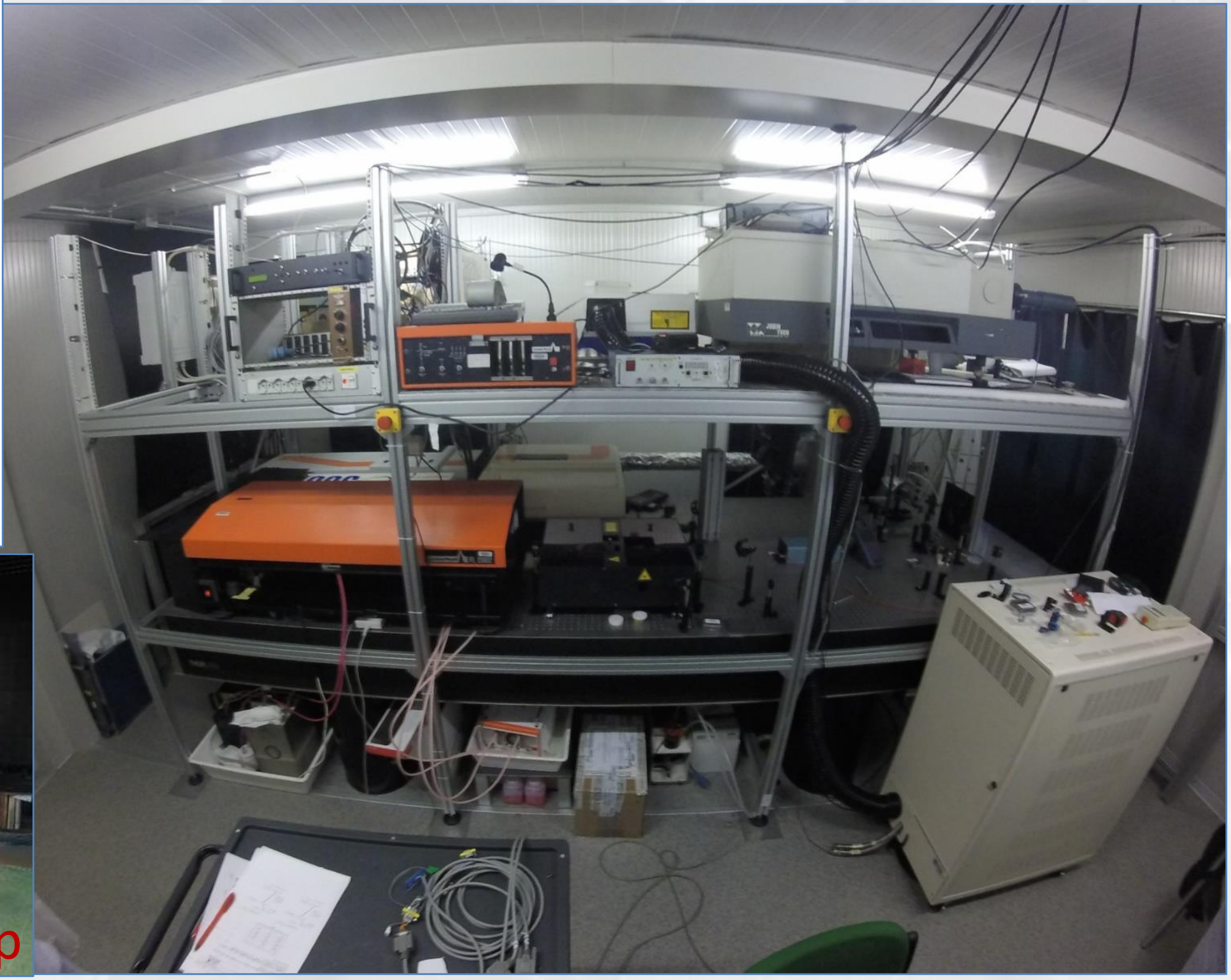
2 Nd:YAG Pump lasers:

3 Tunable DYE Lasers

1 Monochromator

8 HCL

Ready for test since 2014...

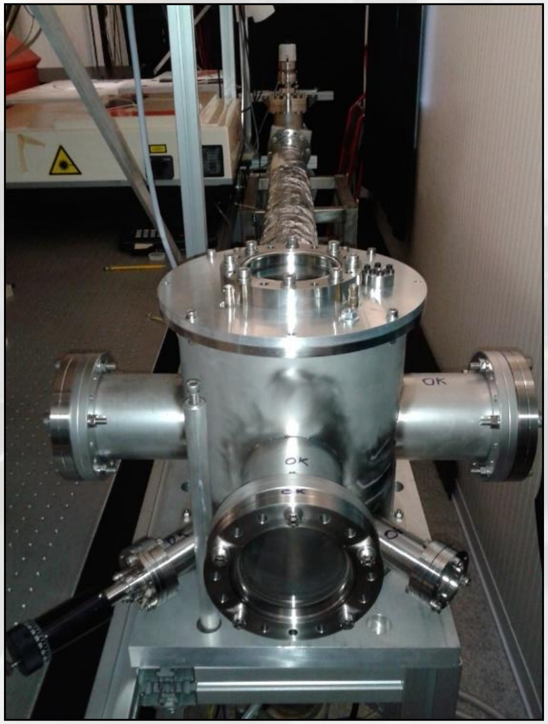


exotic beams for science

STATUS of resonant laser ionization

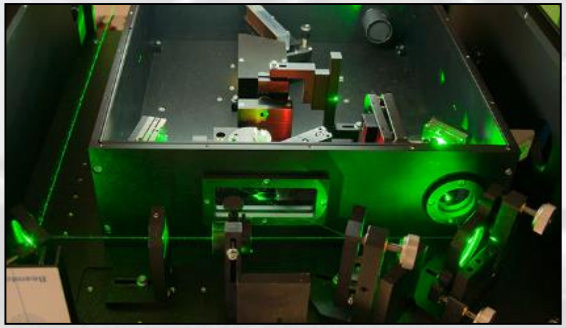
Spectroscopy:

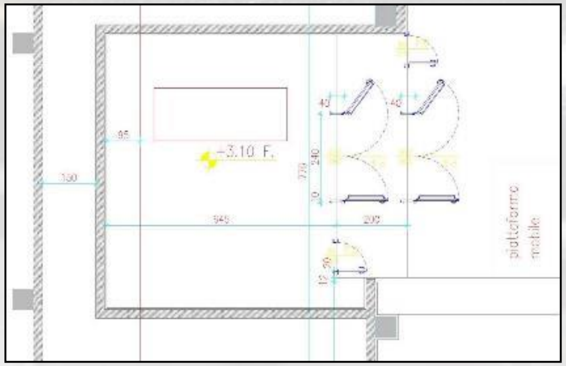
- Study of different elements of interest
- Offline-lab with 10Hz dye laser system
- HCL & ToF-MS



New SS laser:

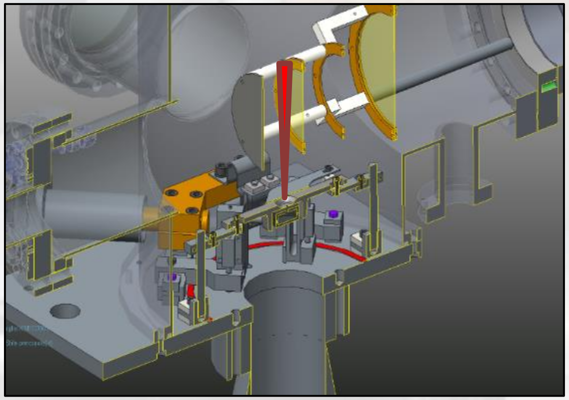
- Defining RIB production laser requirements
- 10 kHz TiSa laser
- New laser lab requirements

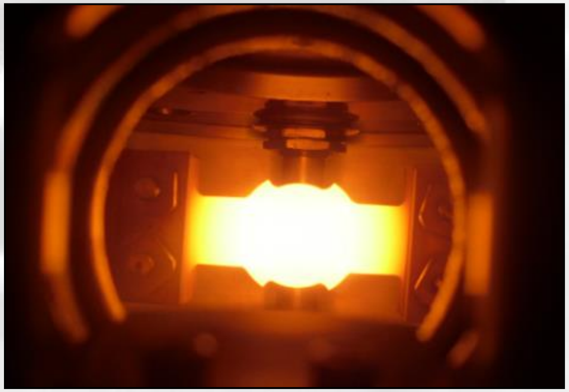




Laser FE:

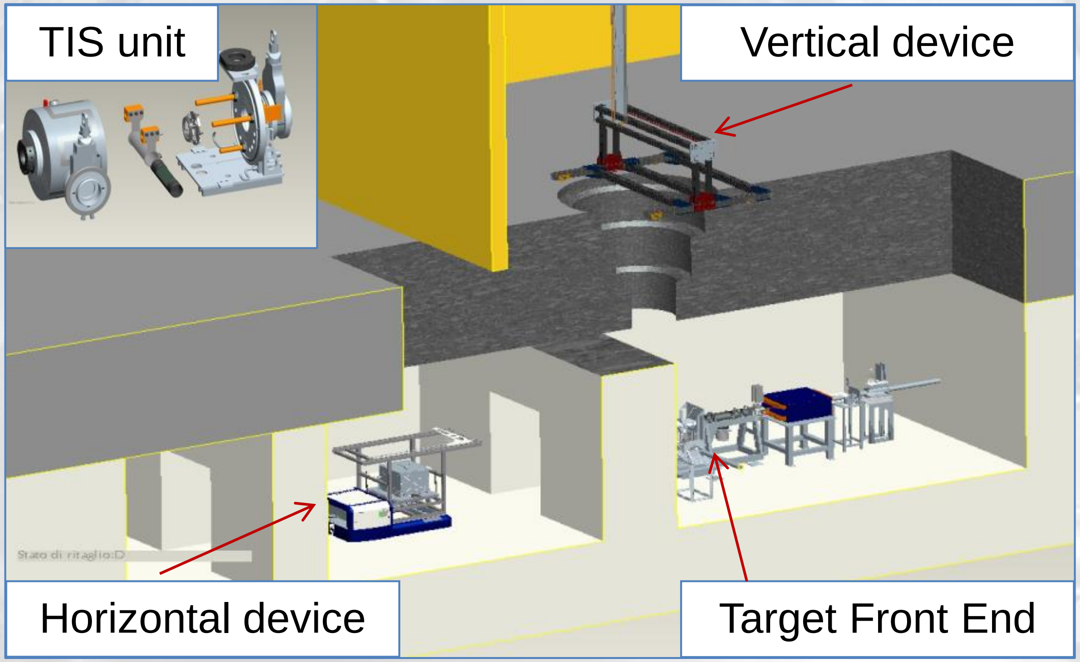
- ToF system
- Hot cavity
- Efficiency measurements





The target chamber handling

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



Environmental conditions and consequences:

-Very high radioactive emission due to the Exotic Beam

-Replacement of TIS unit every 28 days

-Impossibility to operate by humans

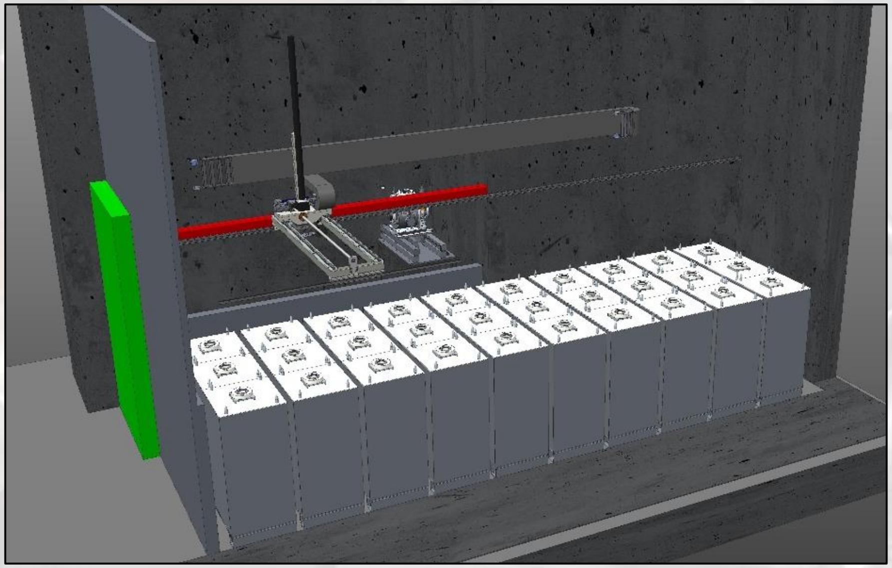
-Remote handling system

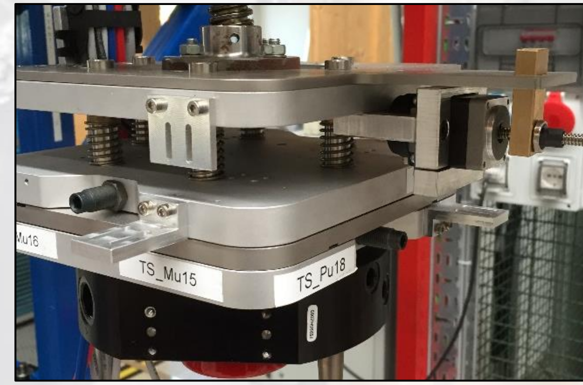
The Horizontal machine

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

The new Chamber Unit Storage

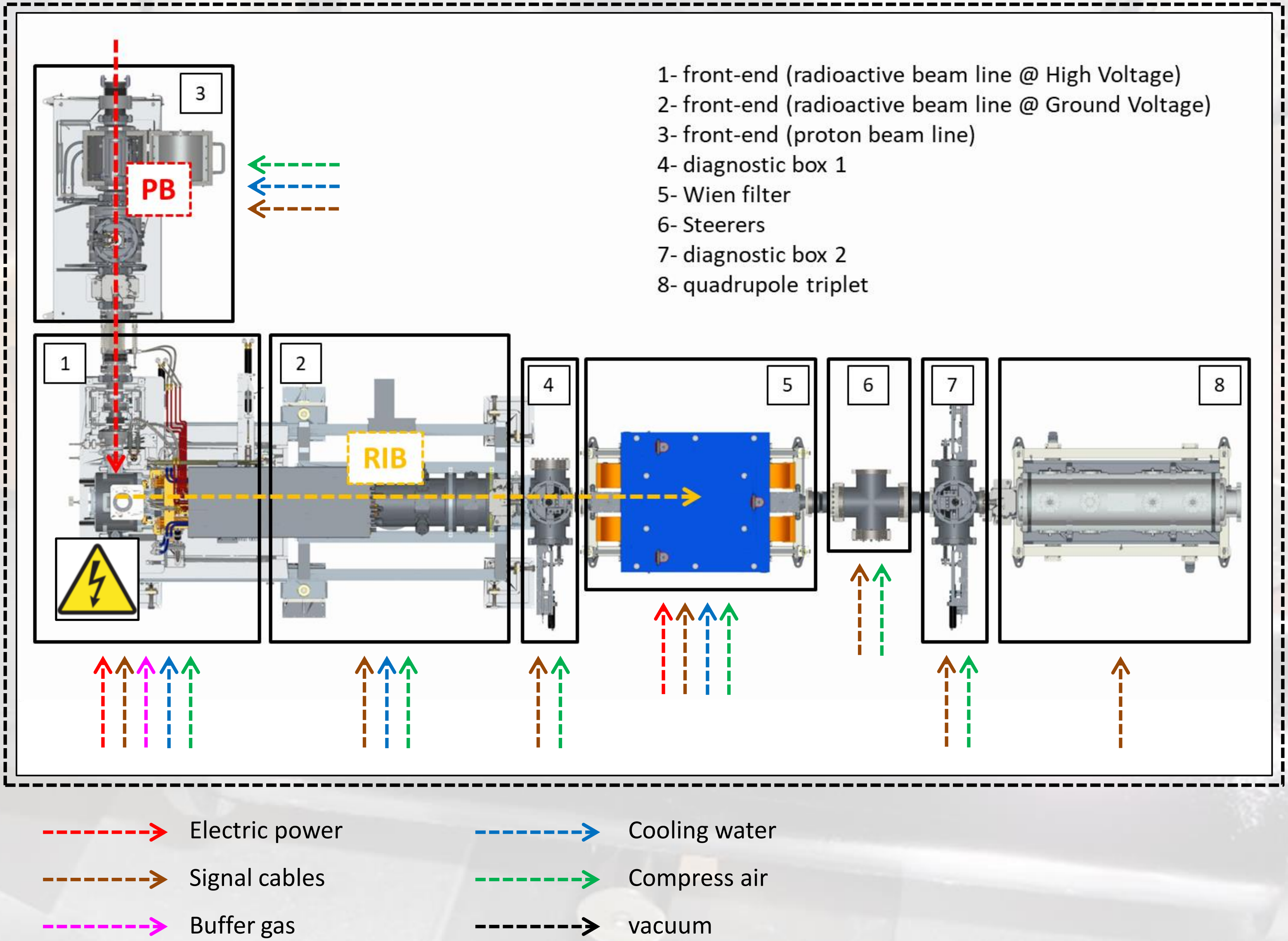
The layout:



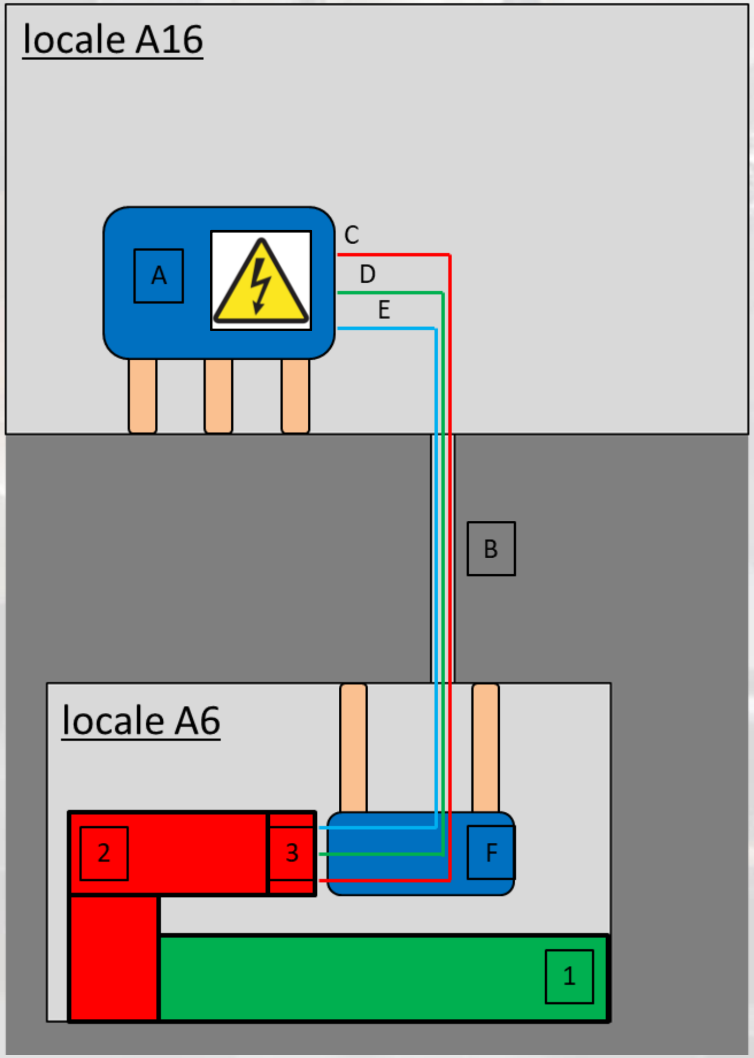


Storage cartesian system prototype

Bunker subsystems

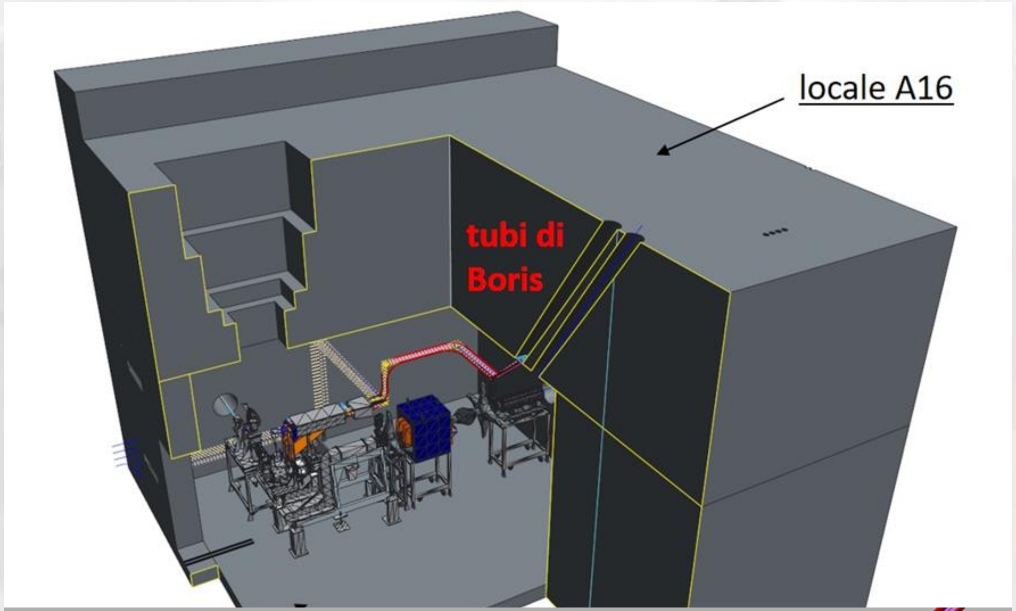


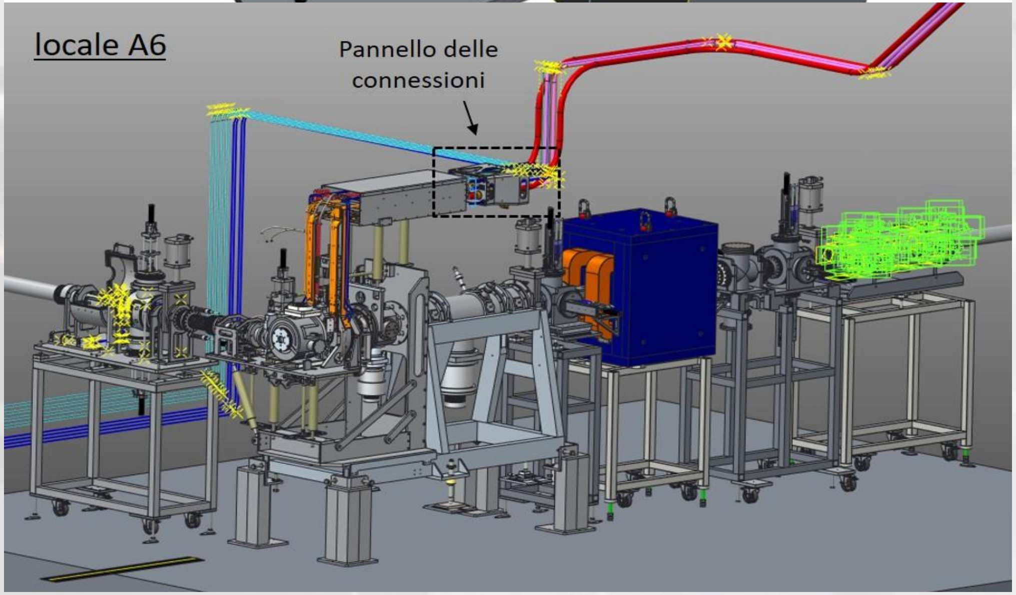
HV subsystem



Preliminary Technical report

ready

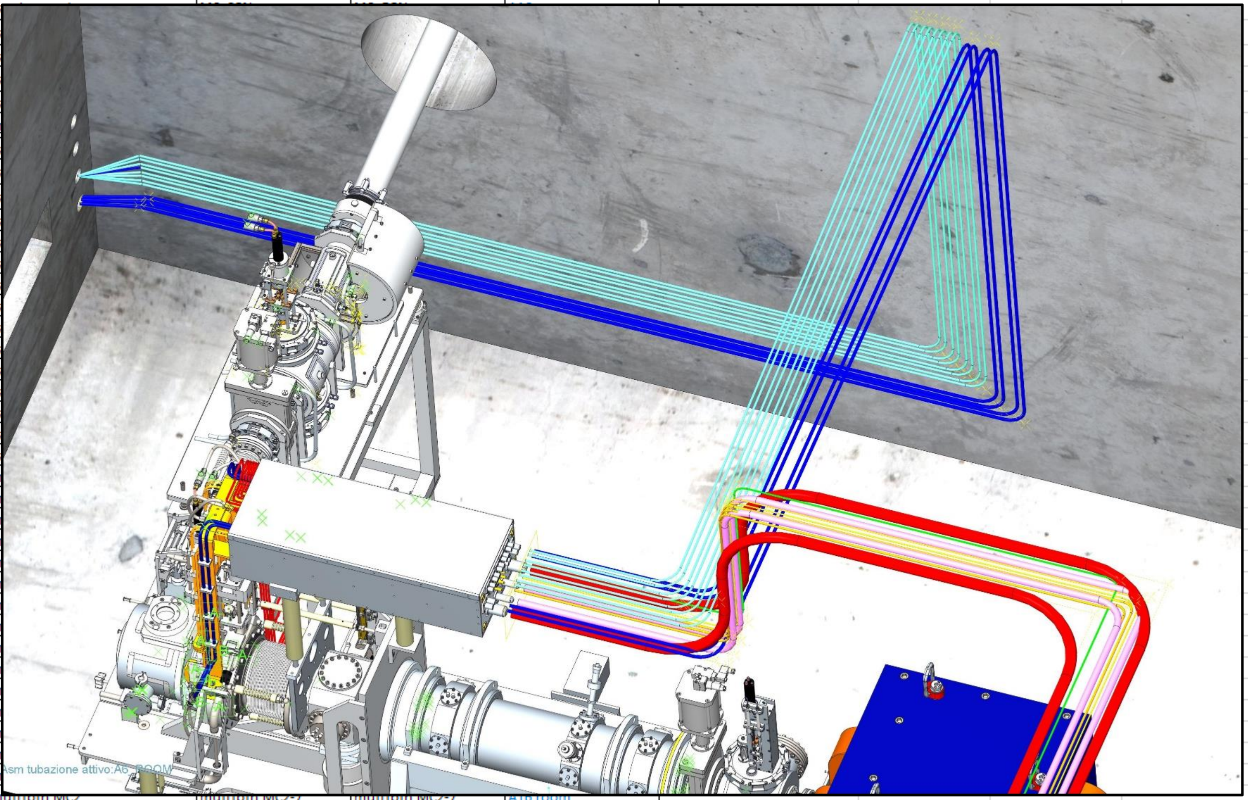




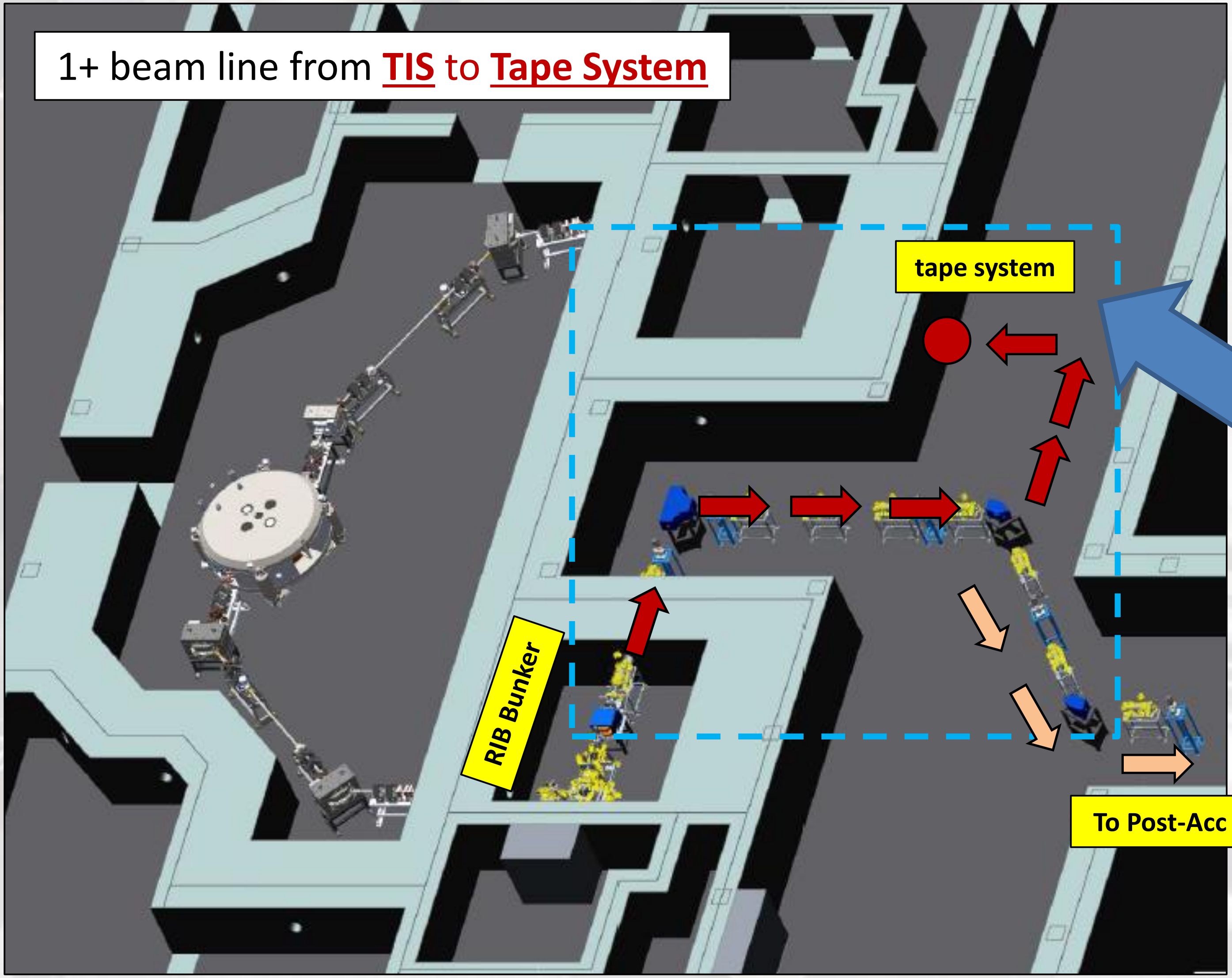
front-end (radioactive beam line piping)

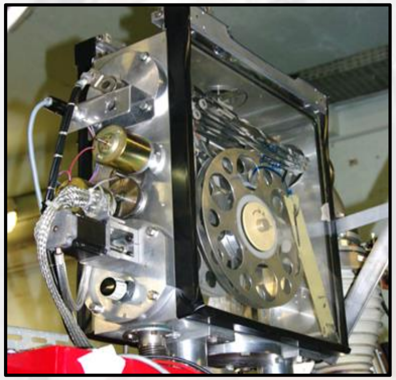
1- CABLING_PIPING_BUNKER_A6_rev02.xlsx

	A	B	C	D	E	F	G	H	I	J	K
1	label	equipment description	load specifications / notes	front-end interface	front-end connector	cable/pipe connector	destination	destination specification	cable/pipe type	cable/pipe name	cable/pipe colour
2											
3	1	heater (+)	I_{max} = 1400 A, DV_{max} = 0.8 V	patch panel	MC_S40N	MC_B40N	A16 room				
4	2	heater (-)	I_{max} = 1400 A, DV_{max} = 0.8 V	patch panel	MC_S40N	MC_B40N	A16 room				
5	3	line (+)	I_{max} = 500 A, DV_{max} = 1 V	patch panel	MC_S25N	MC_B25N	A16 room				
6	4	line (-)	I_{max} = 500 A, DV_{max} = 1 V	patch panel	MC_S25N	MC_B25N	A16 room				
7	5	oven 1 (+)	I_{max} = 110 A, DV_{max} = 30 V	patch panel	MC_S8N	MC_B8N	A16 room				
8	6	oven 2 (+)	I_{max} = 110 A, DV_{max} = 30 V	patch panel	MC_S8N	MC_B8N	A16 room				
9	7	oven (-)	I_{max} = 110 A, DV_{max} = 30 V	p							
10	8	magnet (+)	I_{max} = 50 A, DV_{max} = 30 V	p							
11	9	magnet (-)	see line (-)	p							
12	10	anode 1 (+)	I_{max} = 5 A, DV_{max} = 300 V	p							
13	11	anode 1 (-)	see line (-)	p							
14	12	anode 2 (+)	I_{max} = 5 A, DV_{max} = 300 V	m							
15	13	anode 2 (-)	see line (-)	p							
16	14	high voltage	I_{max} = 2 mA, DV_{max} = 65000 V	p							
17	15	gas inlet	P_{max} = 3 bar	p							
18	16	compressed air inlet - prot. gate		p							
19	17	compressed air outlet - prot. gate		p							
20	18	compressed air inlet - rad. gate		p							
21	19	compressed air outlet - rad. gate		p							
22	20	compressed air inlet - prot. coupling		p							
23	21	compressed air outlet - prot. coupling		p							
24	22	compressed air inlet - rad. coupling		p							
25	23	compressed air outlet - rad. coupling		p							
26	24	cooling water inlet 1_cover		p							
27	25	cooling water outlet 1_cover		p							
28	26	cooling water inlet 2_plate		p							
29	27	cooling water outlet 2_plate		p							
30	28	target termocouple TC1 (+)		m							
31	29	target termocouple TC1 (-)		m							
32	30	target termocouple TC2 (+)		m							
33	31	target termocouple TC2 (-)		m							
34	32	dump termocouple TC3 (+)		m							
35	33	dump termocouple TC3 (-)		m							
36	34	cover thermo-resustance PT100 (+)		m							
37	35	cover thermo-resustance PT100 (-)		m							
38	36	dump current		m							
39	37	spare termocouple TC4 (+)		m							
40	38	spare termocouple TC4 (-)		m							
41	39	spare termocouple TC5 (+)		m							
42	40	spare termocouple TC5 (-)		m							
43	41	collimator current		m							
44	42	spare signal 1		m							
45	43	spare signal 2		multipin MC2	multipin MC2-7	multipin MC2-7	A16 room				
46	44	spare signal 3		multipin MC2	multipin MC2-8	multipin MC2-8	A16 room				



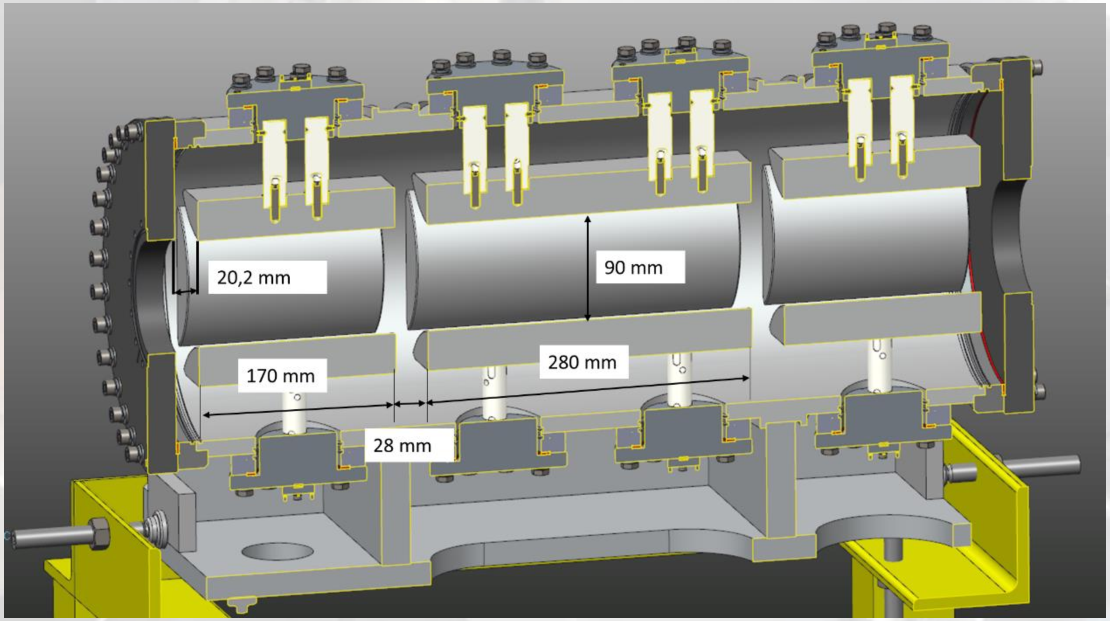
First Goal -> First Beam to 1+ Experimental area

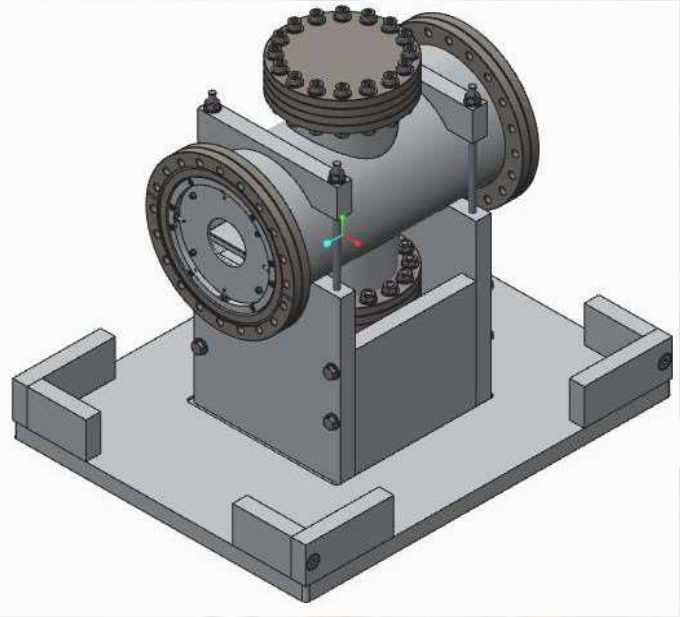


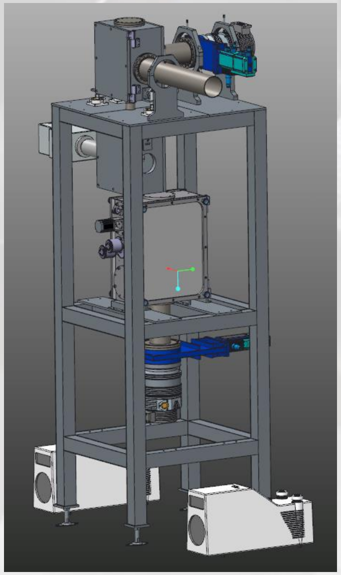


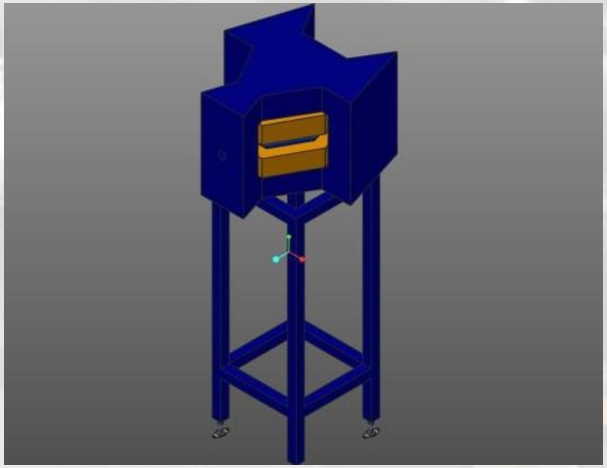
First Goal

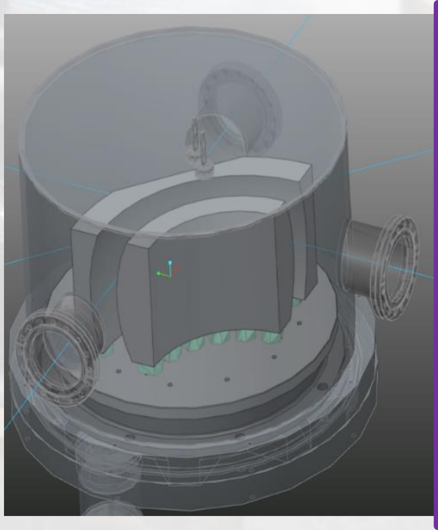
1+ beam line operation: Devices

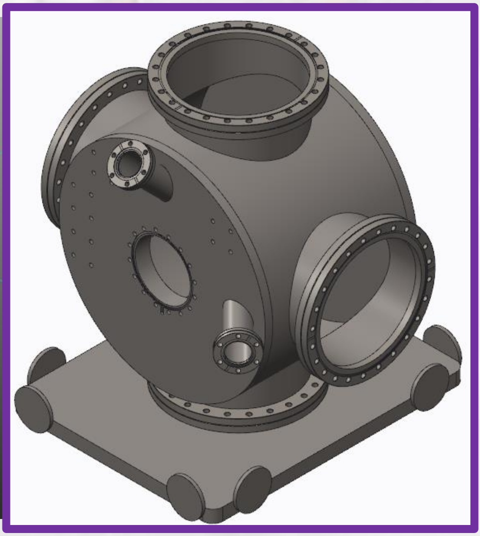








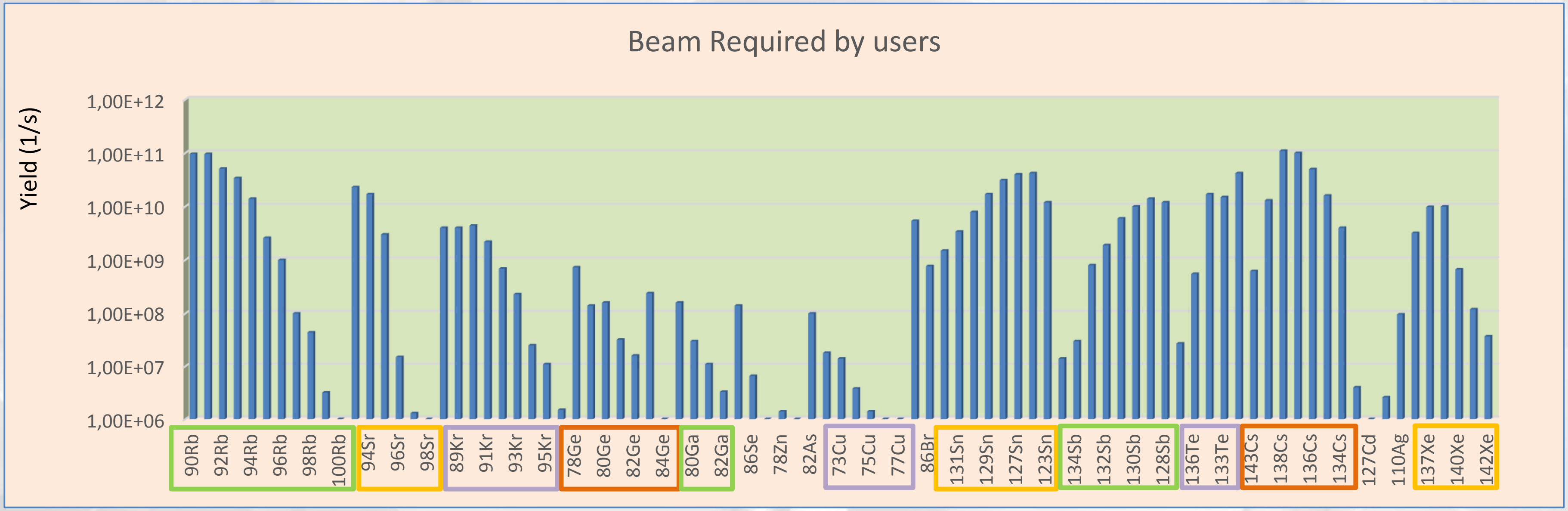




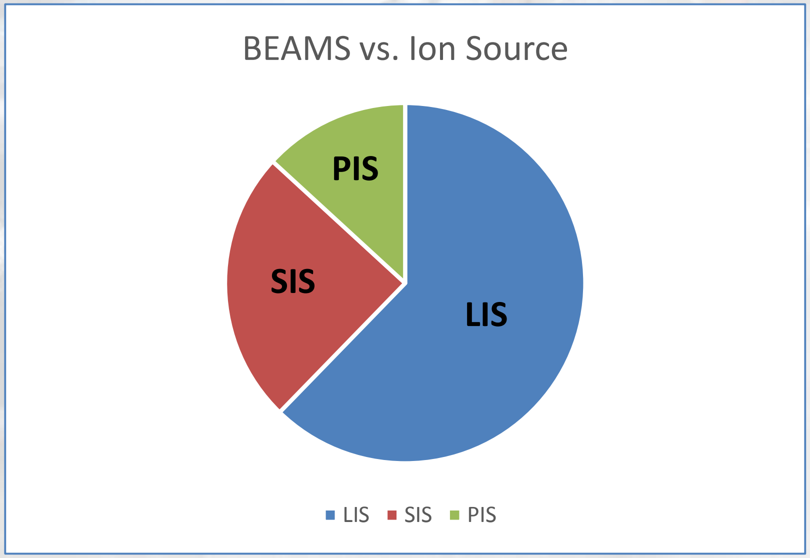
Possible SPES RIBs

(for first physics experimental campaign)

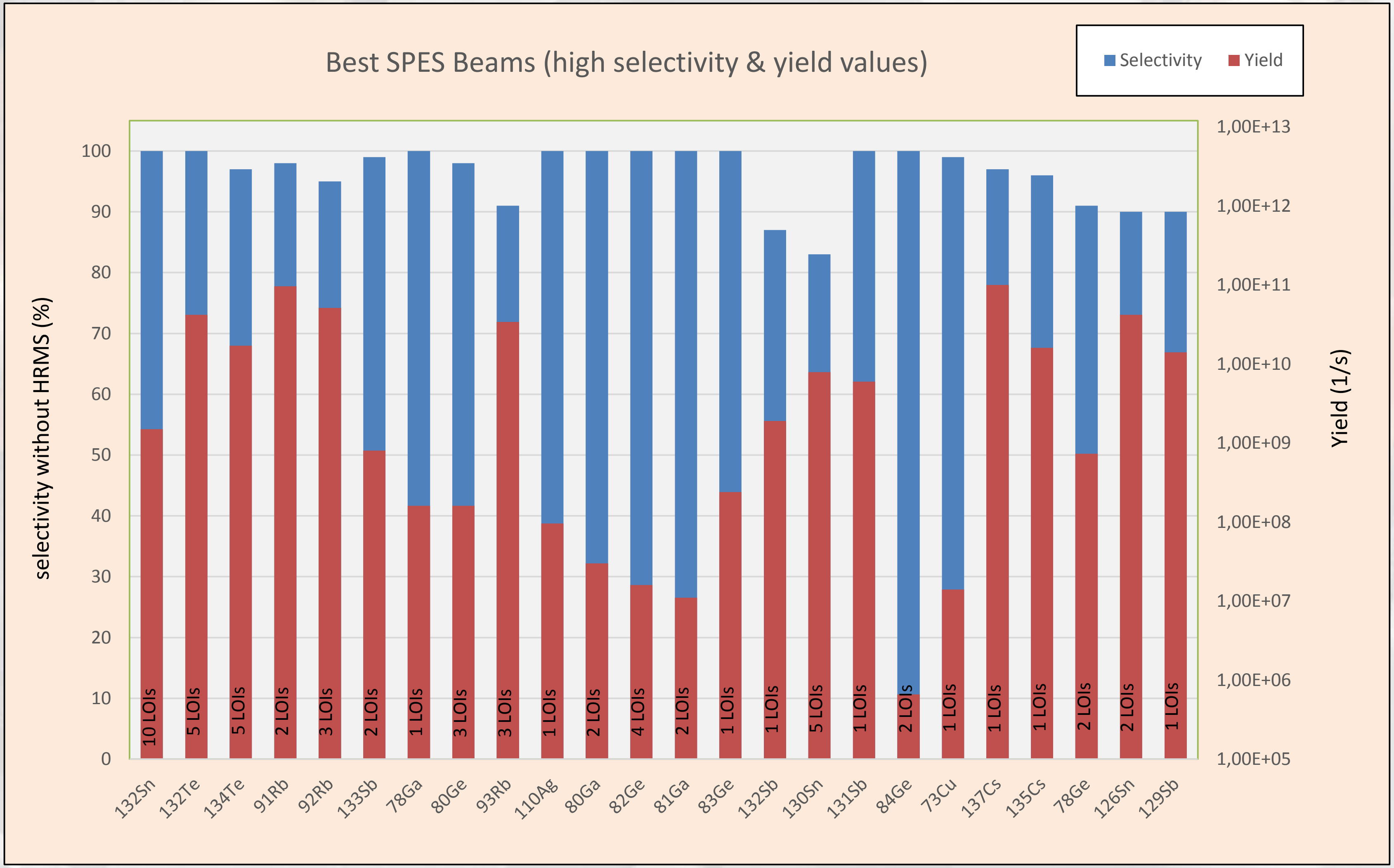
a) First goal: RIB for users



Total Beams:	89		19 Elements	
Beam with LMR:	47	(95 LOI)		53% (56%)
Benefit with 5000 HMR :	3	(3 LOI)	-> 50 beams (98 LOI)	56% (58%)
Benefit with 10000 HMR :	17	(31 LOI)	-> 67 beams (129 LOI)	75% (77%)
Benefit with 15000 HMR :	15	(25 LOI)	-> 82 beams (154 LOI)	92% (92%)
Benefit with 20000 HMR :	7	(10 LOI)		



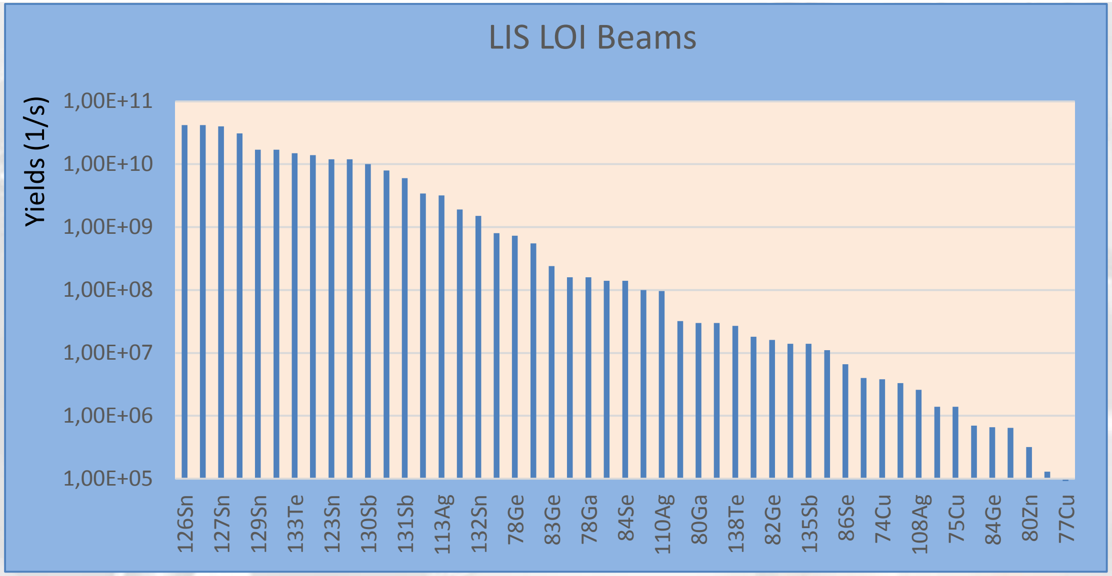
Best LOI Beams



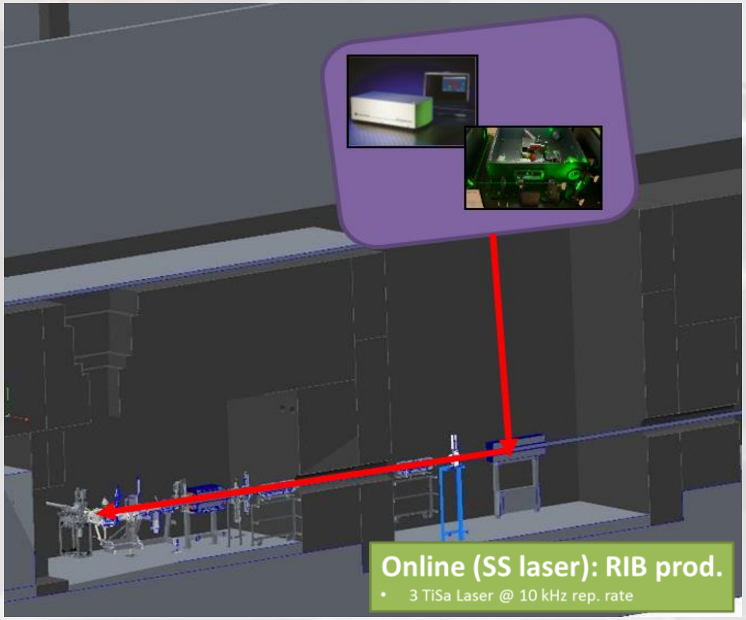
exotic beams for science

LIS Beams

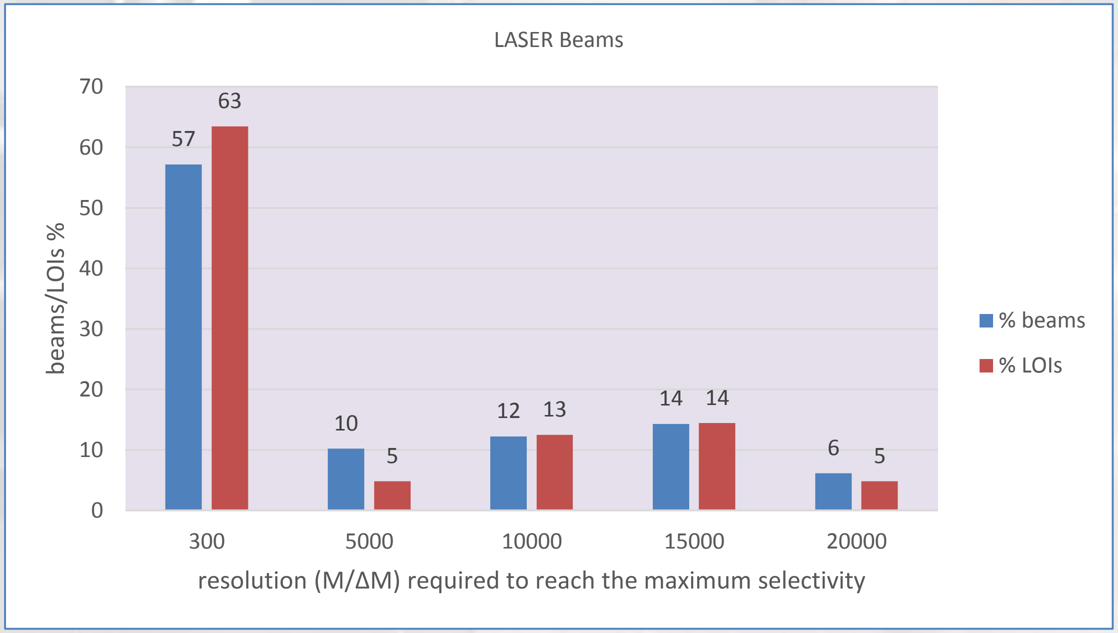
Offline: Spectroscopy
• 3 Dye Laser @ 10 Hz rep. rate



LIS LOI Beams
Yields (1/s)
1,00E+11
1,00E+10
1,00E+09
1,00E+08
1,00E+07
1,00E+06
1,00E+05
126Sn
127Sn
129Sn
133Te
123Sn
130Sb
131Sb
113Ag
132Sn
78Ge
83Ge
78Ga
84Se
110Ag
80Ga
138Te
82Ge
135Sb
86Se
74Cu
108Ag
75Cu
84Ge
80Zn
77Cu

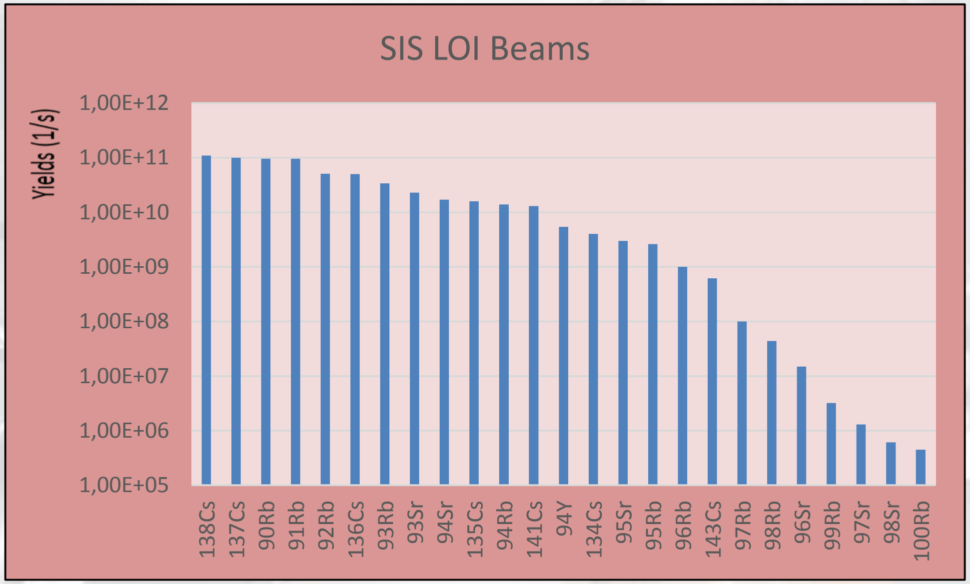


Online (SS laser): RIB prod.
• 3 TiSa Laser @ 10 kHz rep. rate

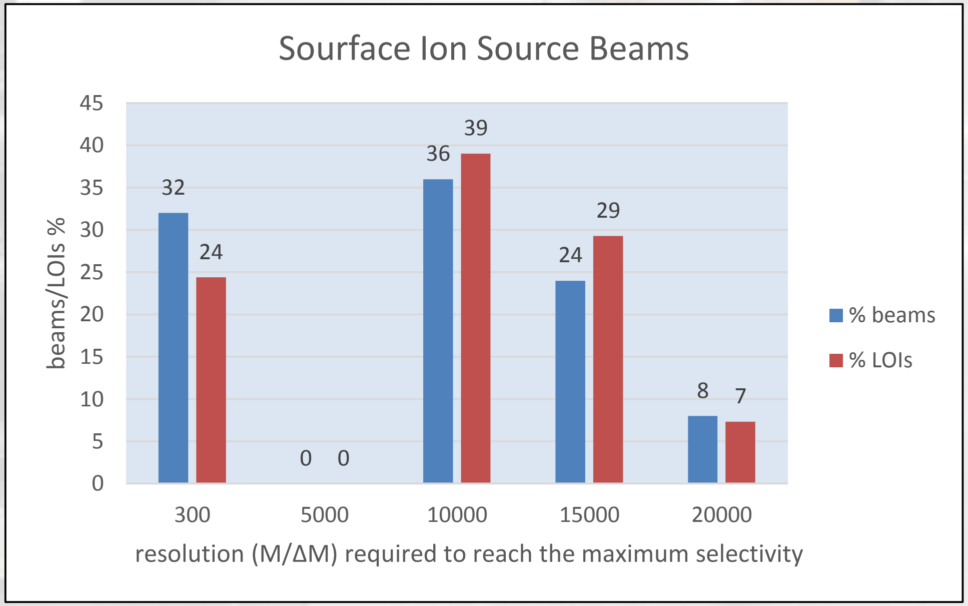


LASER Beams
beams/LOIs %
70
60
50
40
30
20
10
0
57
63
10
5
12
13
14
14
6
5
300
5000
10000
15000
20000
resolution (M/ΔM) required to reach the maximum selectivity
% beams
% LOIs

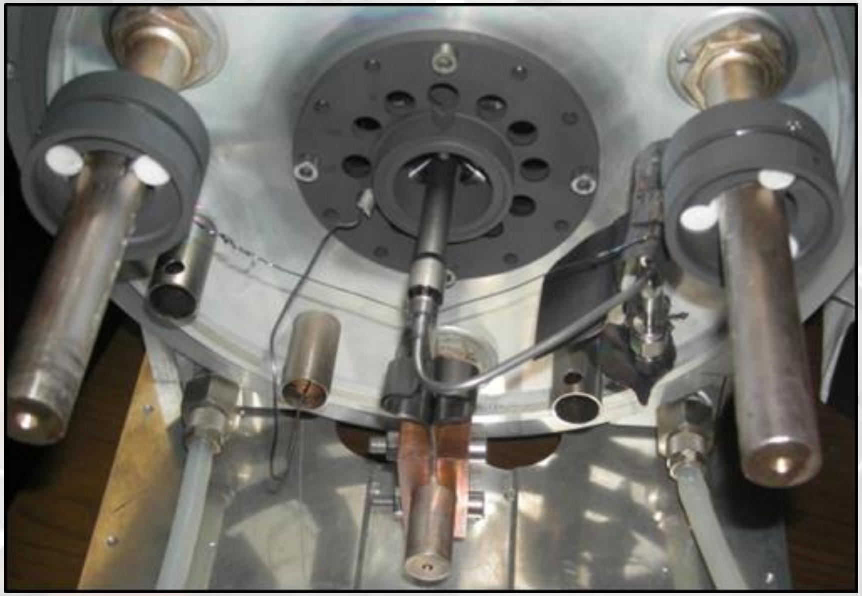
SIS Beams

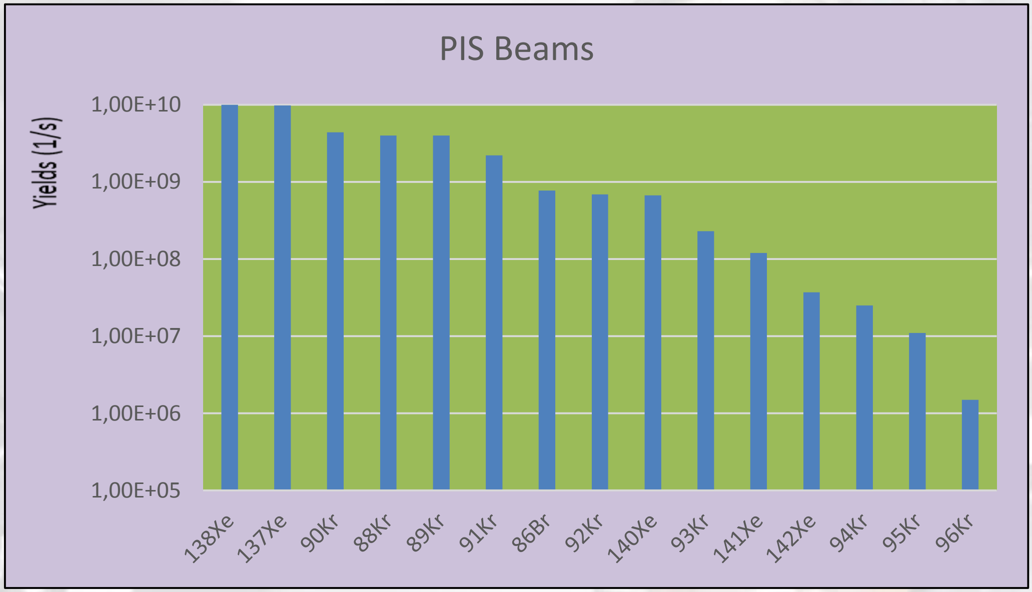


beam	ion. eff. (%)	hot-cavity temp. (°C)	hot-cavity material
Na	47,6	2200	Ta
K	55,4	2200	Ta
Ga	1,4	2200	Ta
Rb	54,5	2200	Ta
Sr	18,5	2200	Ta
In	3,2	2200	Ta
Cs	43,2	2200	Ta
Ba	58,8	2200	Ta
La	20,1	2200	Ta

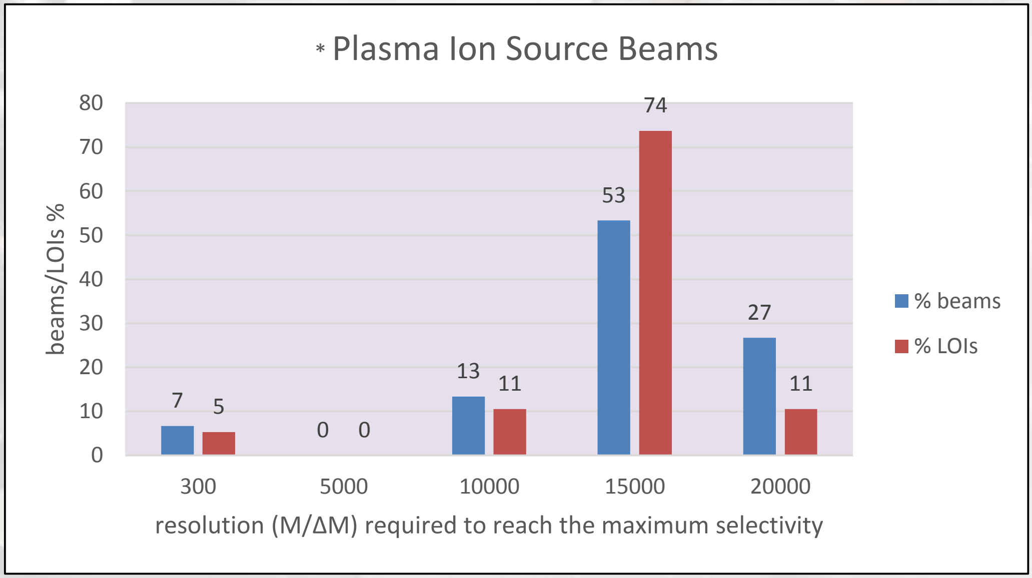


PIS Beams

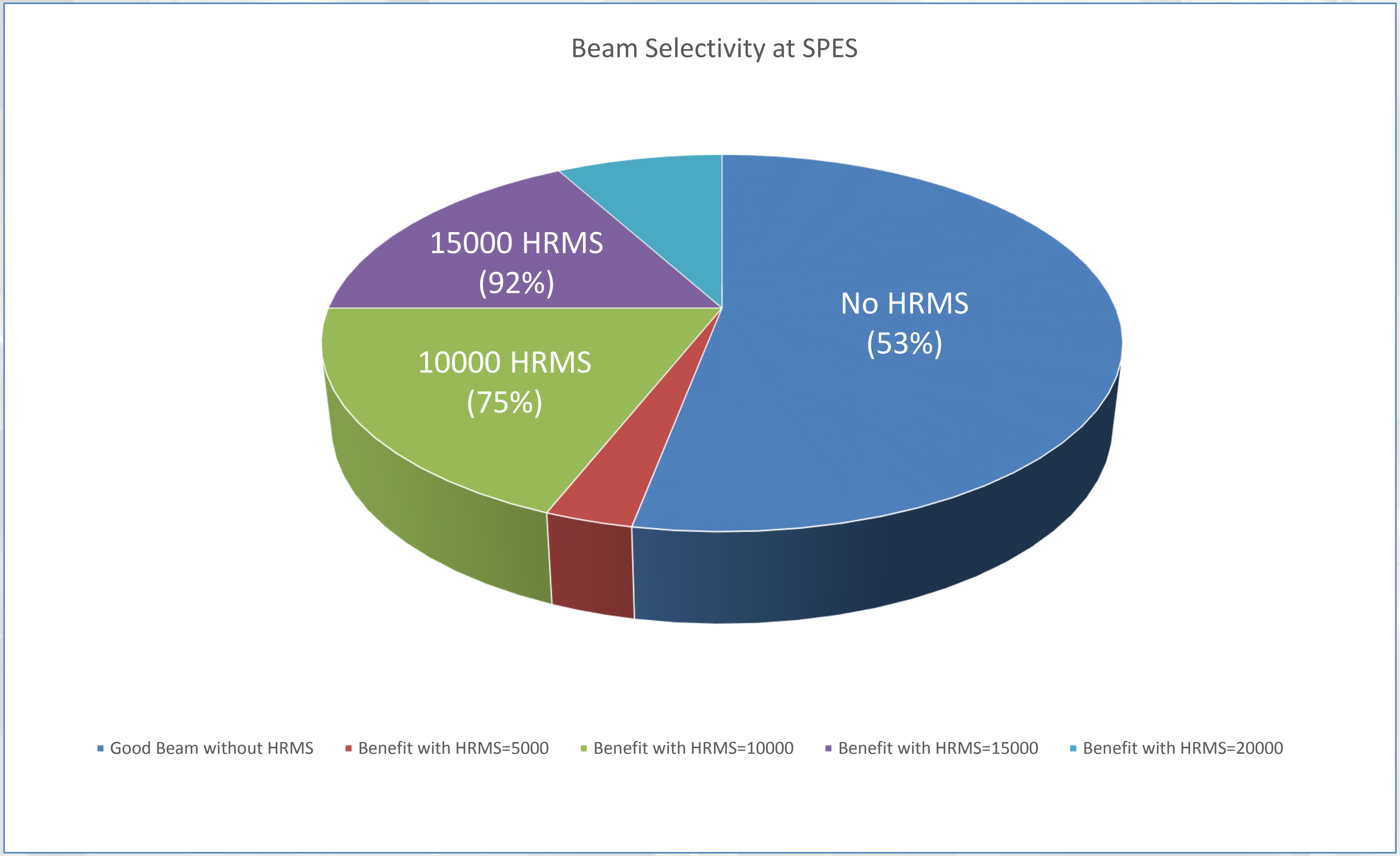




beam	ion. eff. (%)	injection mode	cathode temp. (°C)
Ar	6	gas tube	2200
Br	WIP	oven	2200
Kr	8,5	gas tube	2200
Y	very low	oven	2300
Sn	10	oven	2200
I	19	oven	2200
Xe	11	gas tube	2200

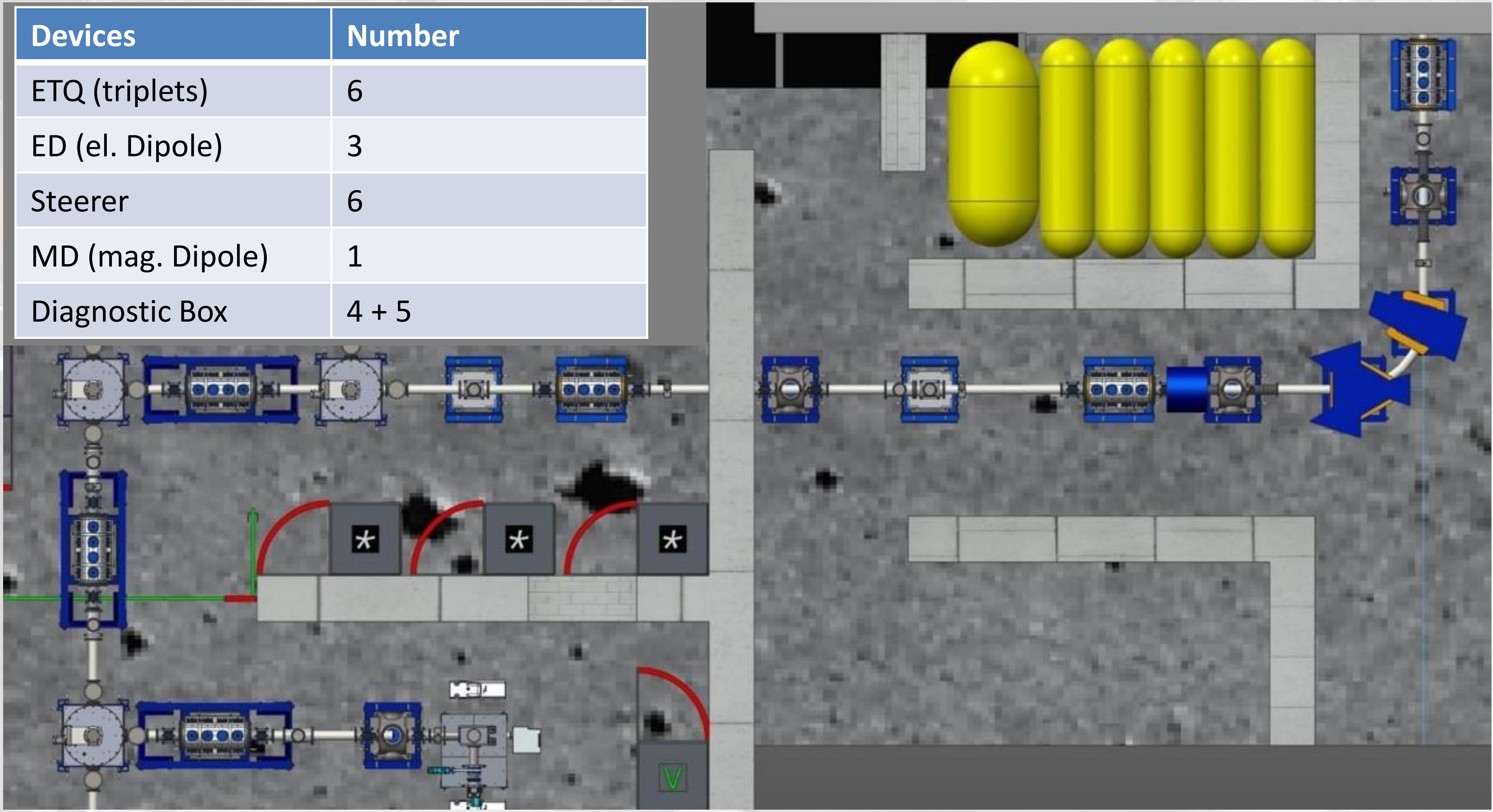


Selectivity: Summary



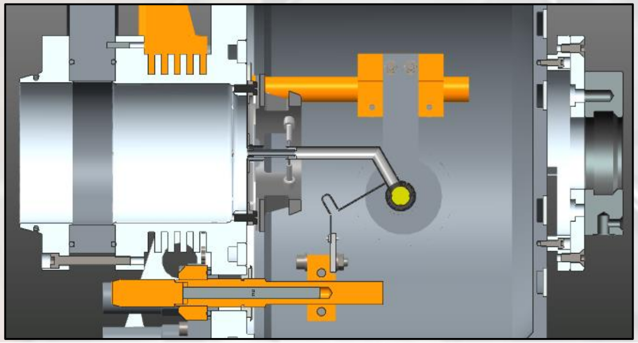
First Experiment in the LE area

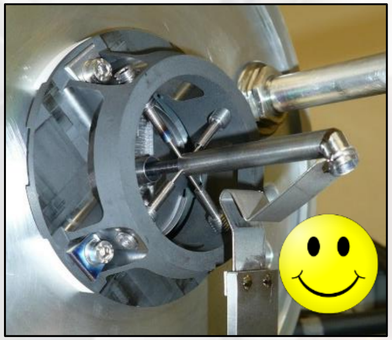
Devices	Number
ETQ (triplets)	6
ED (el. Dipole)	3
Steerer	6
MD (mag. Dipole)	1
Diagnostic Box	4 + 5



Possible Low Energy RIBs (1)

Option 1: UCx Target + Surface Ion Source (-> Easy Configuration)





beam	yield (pps) @ 20 μA	selectivity (%)	ion source type	main contaminants (if sel. < 60%)	notes	LOI reference
96 Rb	9.89E+07	31	SIS	Sr	easy beam	37
147 Cs	4.91E+04	1.7	SIS	Ba	easy beam	10
100 Rb	4.49E+04	1.2	SIS	Sr	easy beam	10

LOI n.10) K.P. Rykaczewski (ORNL Oak Ridge, USA)
Nuclear structure of neutron-rich nuclei determined through beta decay spectroscopy of fission fragments

LOI n.37) A.Nannini (INFN_Fi, Italy)
Electron conversion measurements at SPES 1+ beam line: measurement of E0 transitions in 96Sr

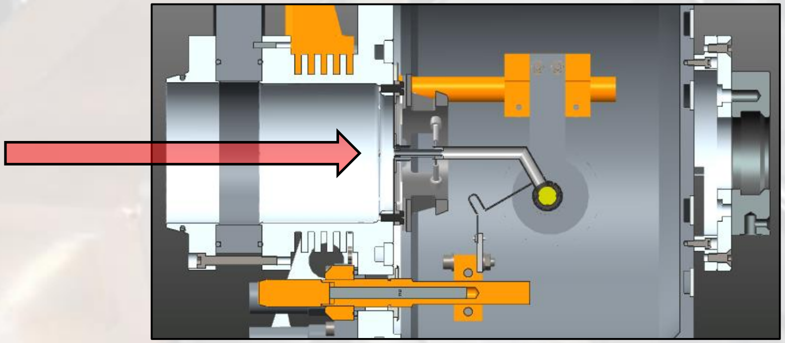
With this configuration other RIBs cab be produced, characterized by higher selectivity values

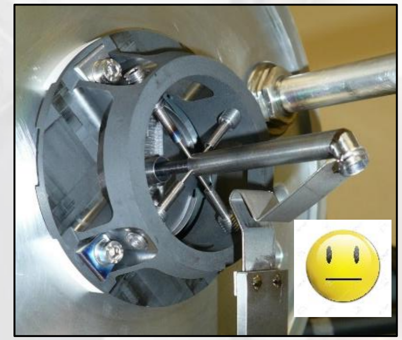
beam	yield (pps) @ 20 μA	selectivity (%)	ion source type
138Cs	1.10E+10	76	SIS
137Cs	1.00E+10	100	SIS
91Rb	9.60E+09	100	SIS
92Rb	5.10E+09	100	SIS
136Cs	5.00E+09	89	SIS
93Rb	3.40E+09	91	SIS

beam	yield (pps) @ 20 μA	selectivity (%)	ion source type
135Cs	1.60E+09	100	SIS
94Rb	1.40E+09	75	SIS
141Cs	1.30E+09	60	SIS
134Cs	4.00E+08	87	SIS
95Rb	2.60E+08	65	SIS

LOIs & UCx target: RIBs Low Energy (2)

Option 2: UCx Target + Surface Ion Source + Laser (-> Laser Lab in operation)





beam	yield (pps) @ 20 µA	selectivity (%)	ion source type	main contaminants (if sel. < 60%)	notes	LOI reference
123 Sn	1.28E+09	12	LIS	In	low selectivity beam	38
121 Sn	2.02E+08	6.6	LIS	In	low selectivity beam	38
83 Ge	2.47E+07	100	LIS	-	selective beam	27
82 As	1.07E+07	71	LIS	-	selective beam	27
110 Ag	9.60E+06	100	LIS	-	selective beam	38
80 Ga	3.05E+06	100	LIS	-	selective beam	27
134 Sn	2.49E+06	3	LIS	In, Cs, Ba	low selectivity beam	10
84 As	1.86E+06	69	LIS	-	selective beam	27
82 Ga	3.29E+05	100	LIS	-	selective beam	10; 27
108 Ag	2.58E+05	38	LIS	Rb, Sr, In	low selectivity beam	38
84 Ge	6.61E+04	100	LIS	-	selective beam	10; 27
83 Ga	6.06E+04	100	LIS	-	selective beam	10; 27

With this configuration other RIBs cab be produced, characterized by higher selectivity values

beam	yield (pps) @ 20 µA	selectivity (%)	ion source type
132 Sn	1.50E+08	100	LIS
132 Te	4.00E+09	100	LIS
132 Sb	1.90E+07	100	LIS

LOI n.10) K.P. Rykaczewski (ORNL Oak Ridge, USA)
Nuclear structure of neutron-rich nuclei determined through beta decay spectr. of fission frag.

LOI n.27) A.Gottardo (IPNO, France)
Shell structure and collective excitations and res. at and beyond N=50 with decay spectroscopy

LOI n.38) S.Cristallo (INAF, Italy)
Letter of Intents for measure. at SPES on beta-decay prop. of nuclei belonging to the s-process path

LOIs & UCx target: RIBs Low Energy (overview)

Global list of the first SPES RIBs available for low-energy experiments

nucl. sy.	yield (pps) @ 20 μA	selectivity (%)	ion source type	main contaminants (if sel. < 60%)	notes	LOI reference
123 Sn	1.28E+09	12	LIS	In	low selectivity beam	38
121 Sn	2.02E+08	6.6	LIS	In	low selectivity beam	38
83 Ge	2.47E+07	100	LIS	-	selective beam	27
82 As	1.07E+07	71	LIS	-	selective beam	27
110 Ag	9.60E+06	100	LIS	-	selective beam	38
80 Ga	3.05E+06	100	LIS	-	selective beam	27
134 Sn	2.49E+06	3	LIS	In, Cs, Ba	low selectivity beam	10
84 As	1.86E+06	69	LIS	-	selective beam	27
82 Ga	3.29E+05	100	LIS	-	selective beam	10; 27
108 Ag	2.58E+05	38	LIS	Rb, Sr, In	low selectivity beam	38
84 Ge	6.61E+04	100	LIS	-	selective beam	10; 27
83 Ga	6.06E+04	100	LIS	-	selective beam	10; 27
96 Rb	9.89E+07	31	SIS	Sr	easy beam	37
147 Cs	4.91E+04	1.7	SIS	Ba	easy beam	10
100 Rb	4.49E+04	1.2	SIS	Sr	easy beam	10
86 Br	7.73E+07	42	PIS	As, Se, Kr	low selectivity beam	44
139 I	5.94E+06	1.5	PIS	Xe, Cs, Ba	low selectivity beam	10
140 I	9.17E+05	0.1	PIS	Xe, Cs, Ba	low selectivity beam	10
141 I	1.40E+05	0.1	PIS	Xe, Cs, Ba	low selectivity beam	10

^{83,84}Ge; ^{80,83}Ga; ^{110}Ag -> LOI selective beams !

Nuclear structure of neutron-rich nuclei determined through beta decay spectroscopy of fission fragments 10

K.P. Rykaczewski, D.W. Stracener, N.T. Brewer, B.C. Rasco, J.M. Allmond, Y. Liu (ORNL Oak Ridge), R.K. Grzywacz, S.V. Paulauskas, S. Go, K. Smith, K. Schmitt (Uni. Tennessee Knoxville), C. Mazzocchi, A. Fijałkowska, A. Korgul, M. Karny, K. Miernik, M. Wolińska-Cichocka (Uni. Warsaw) W. Królas (INP-PAN, Kraków), G. Benzoni, S. Bottoni, A. Bracco, F. Camera, S. Ceruti, F. Crespi, A. Giaz, S. Leoni, O. Wieland (INFN and University degli Studi di Milano), T. Marchi (KU, Leuven), J.J. Valiente Dobon, G. de Angelis (INFN-Legnaro) and A. Gottardo (IPN Orsay)

Shape coexistence and N=50 gap: transfer reactions on ground and isomeric states 27

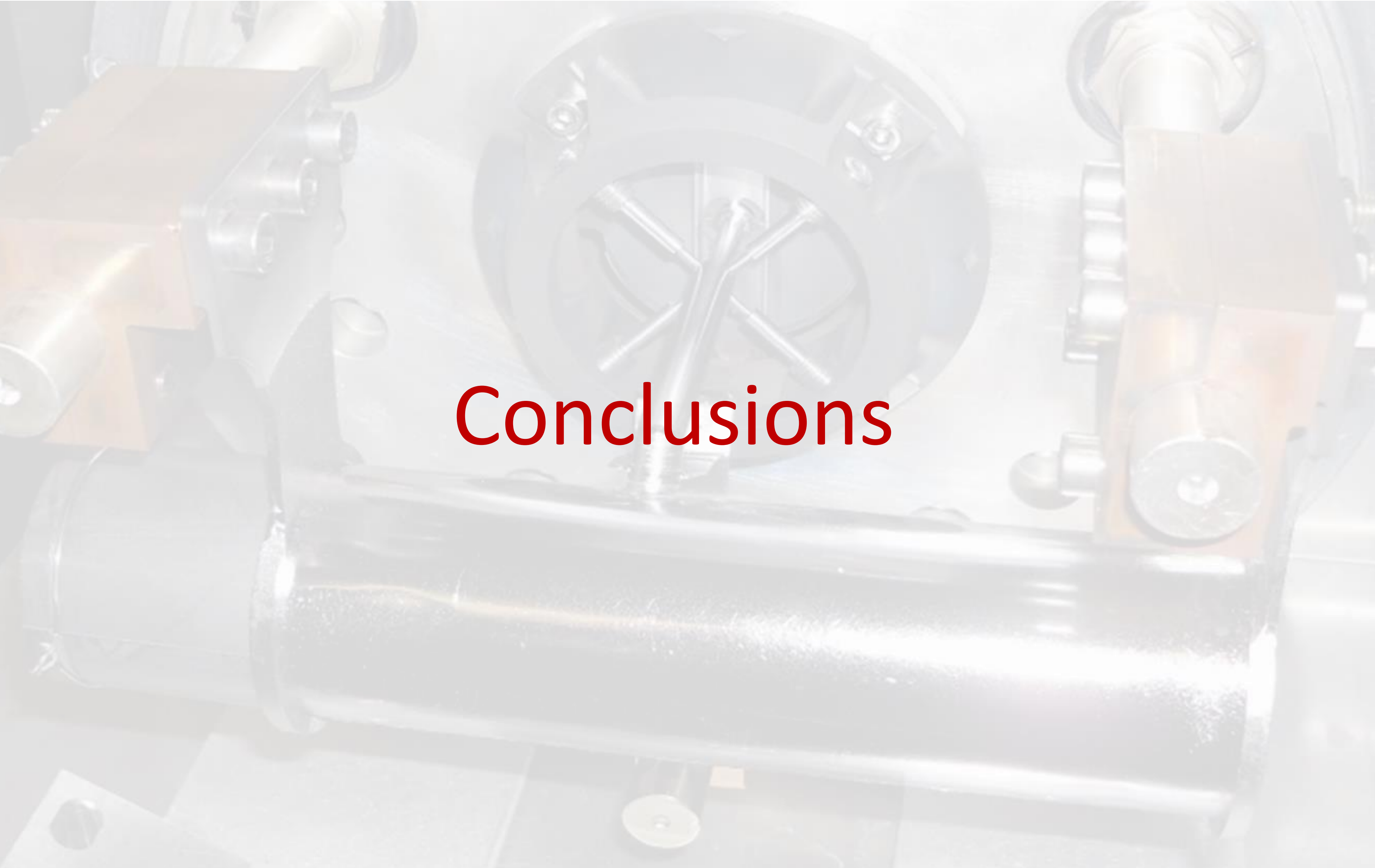
A. Gottardo[1], D. Verney[1], G. de Angelis[2], D. Bazzacco[3], G. Benzoni[4], A. Boso[3], A. Bracco[4], F. Camera[4], F. Crespi[4], C. Delafosse[1], M.C. Delattre[1], I. Deloncle[5], D. T. Yordanov[1], F. Flavigny[1], S. Franchoo[1], C. Gaulard[5], G. Georgiev[5], A. Giaz[4], A. Goasduff[2], Gramegna[2], J. Jaworski[2], P.R. John[3], F. Ibrahim[1], S. Lenzi[3], S. Leoni[4], J. Ljungvall[5], S. Lunardi[3], I. Matea[1], T. Marchi[6], D.Mengoni[3], D. Napoli[2], L. Olivier[1], R. Orlandi[7], B. Roussière[1], F. Recchia[3], S. Roccia[5], I. Stefan[1], D. Testov[2], J.J. Valiente-Dobón[2], O. Wieland[4], S. Bottoni[8] and S. Ceruti[6], S. Peru-Desenfants[9]

Letter of Intents for measurements at SPES on beta-decay properties of nuclei belonging to the *s*-process path. 38

M.M. Busso, S. Palmerini, O.Trippella
Department of Physics and Geology - University of Perugia, Perugia, Italy
INFN - Section of Perugia, Perugia, Italy

S. Cristallo, L. Piersanti
INAF - Osservatorio Astronomico di Collurania, Teramo, Italy
INFN - Section of Perugia, Perugia, Italy

Conclusions



Goals: beam delivery & RIB Source Commissioning

User requirements vs . Project Construction Phases

selettività	23 - Valiente
1 - Bednarczyk	24 - LaCognata
2 - Morelli	25 - Mengoni
3 - Chipps	26 - Gottardo
4 - Marchi	27 - Gottardo
5 - Kozulin	28 - Pain
6 - Kurtukian	29 - Trippella
7 - Corradi	30 - Iskra
8 - Pirrone	31 - Leoni
9 - Stahl	32 - Leoni
10 - Rykaczewski	33 - Leoni
11 - Fioretto	34 - Hadynska
12 - Stefanini	35 - Testov
13 - Zhang	36 - Pierroutsakou
14 - Szilner	37 - Nannini
15 - Modamio	38 - Cristallo
16 - Casini	39 - Verney
17 - Nannini	40 - Benzoni
18 - Valiente	41 - Benzoni
19 - Piantelli	42 - Vardaci
20 - Melon	43 - Assie
21 - Goasduff	44 - Crespi
22 - Crespi	45 - Raabe

within the end of 2019
40 MeV, 20 μA

SiC target

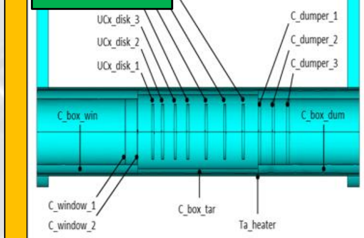
SAINT-GOBAIN

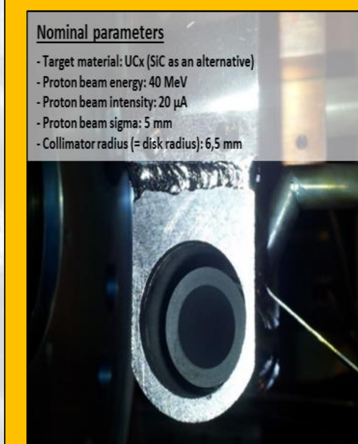
First SPES RIB (^{26}Al)

40 MeV, 20 μA, 10^{12} f/s

UCx target

the scaled SPES target for low intensity RIBs



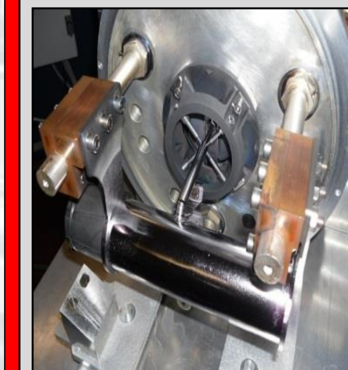


first n-rich fission isotopes

40 MeV, 200 μA, 10^{13} f/s

UCx target

the full-scale SPES target for high intensity RIBs



Nominal parameters

- Target material: UCx (SiC as an alternative)
- Proton beam energy: 40 MeV
- Proton beam intensity: 200 μA
- Proton beam sigma: 7 mm
Wobbling radius : 11 mm

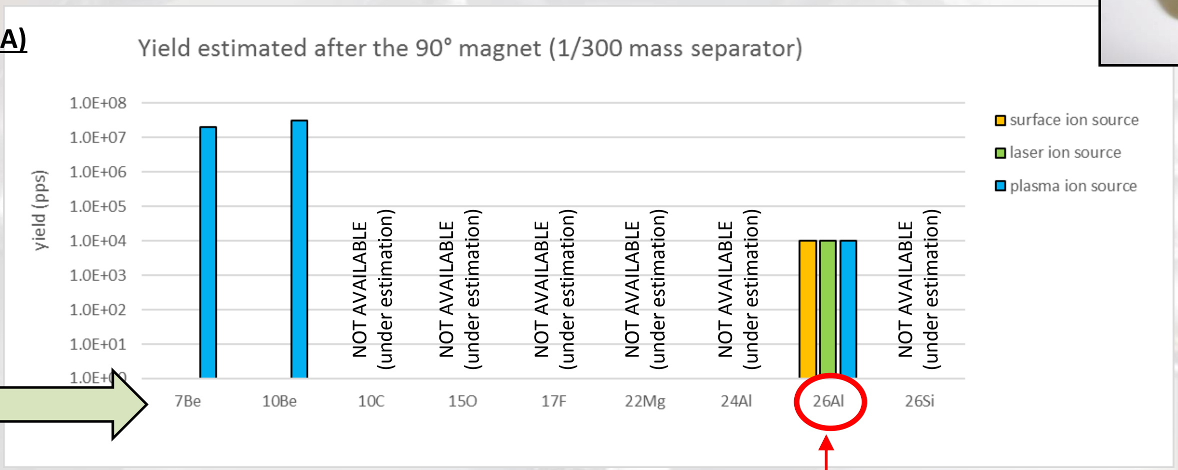
SPES exotic beams for science

The 'demonstrative' (first) beam:

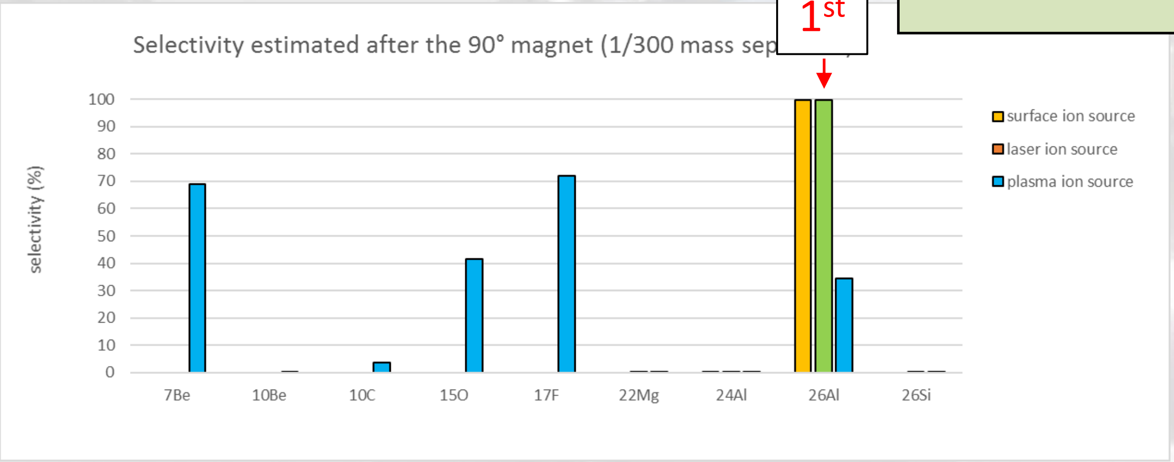
1st SPES RIB (26Al) at the end of 2019

A scaled SiC target
(40 MeV protons up to 20 μA)
will be used for the first SPES RIBs

SiC target beams requested by LOIs



1st



LOI	beams
L. Morelli	7Be, 10Be
J.J. Valiente	10C, 17F, 20Na, 22Mg, 24Al, 26Si
M. La Cognata	26Al
M. Assié	7Be, 26Si, 15O

High energy LOI beams with dedicated targets (no UCx)

> High yields

> High selectivity
(even without HRMS)

- **Low energy**
- **Different IS**

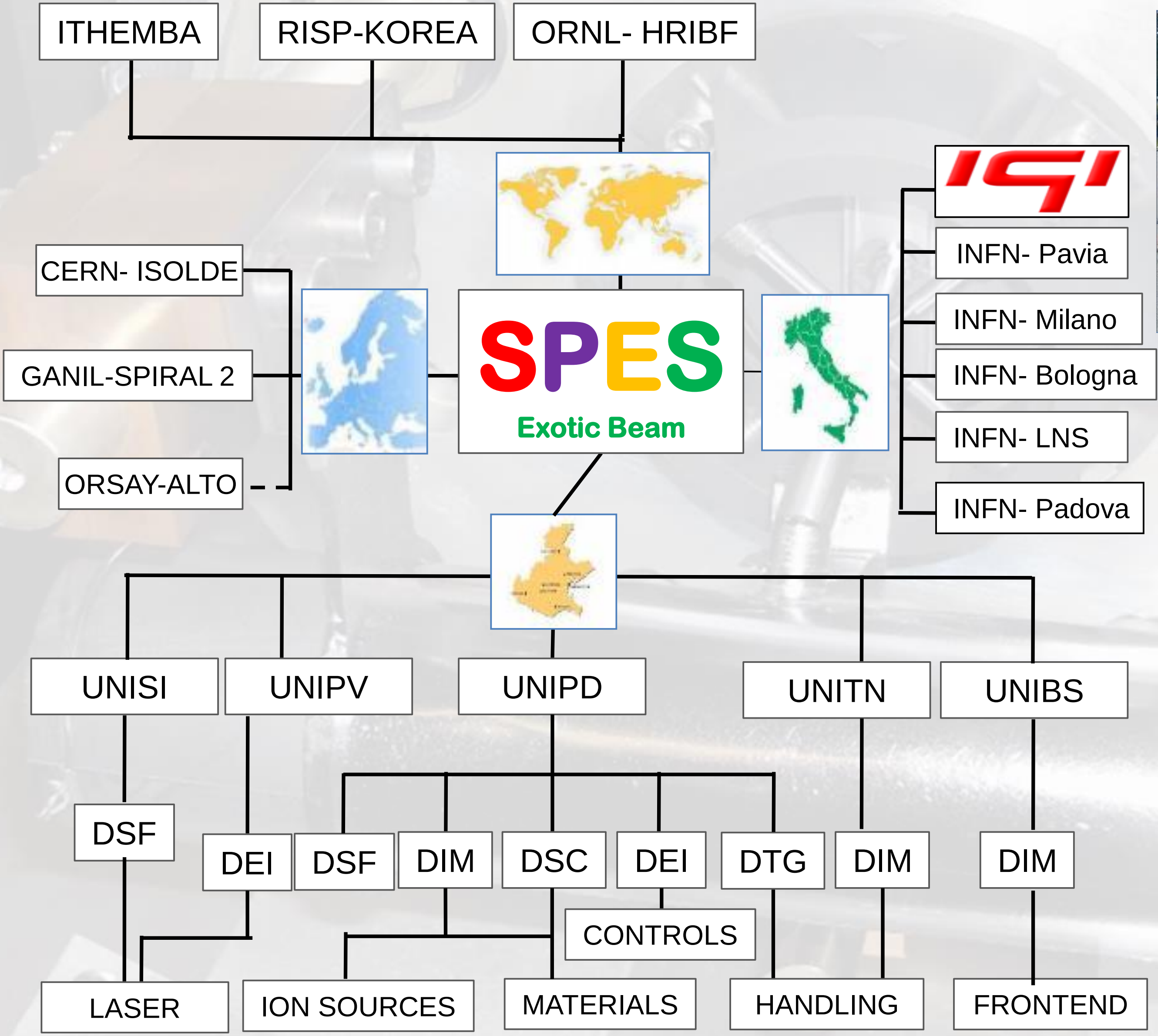
^{26}Al

1st SPES RIB

preparatory beam for the post-acc. phase
(requested by LOIs)

exotic beams for science

The collaboration network for SPES



- > 45 Tesi Magistrali
- > 25 Tesi Triennali
- 4 Tesi di PhD
- 15 Ospiti Stranieri (FAI)

Conclusion