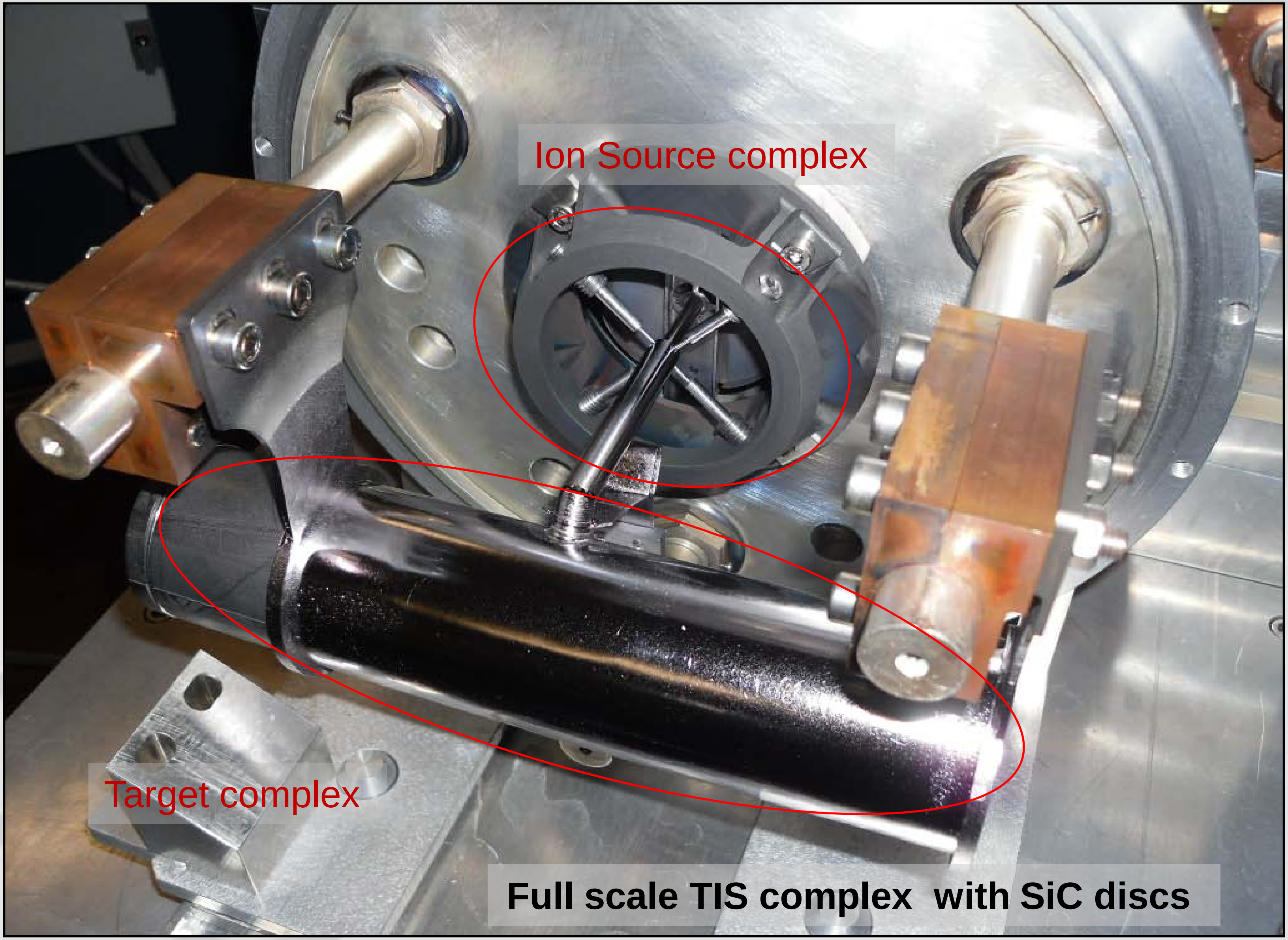
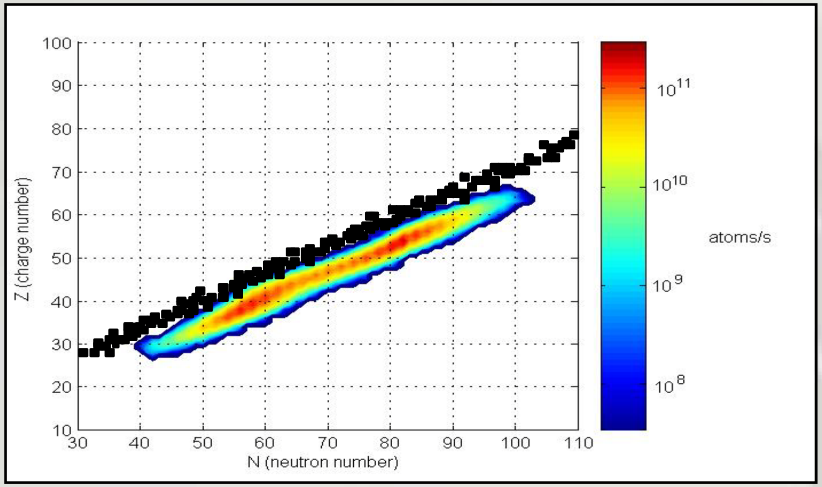
Target & Ion Source activities

Alberto Andrighetto
INFN – Laboratori di Legnaro

The target ion source complex



10^{13} f/s -> a challenging goal



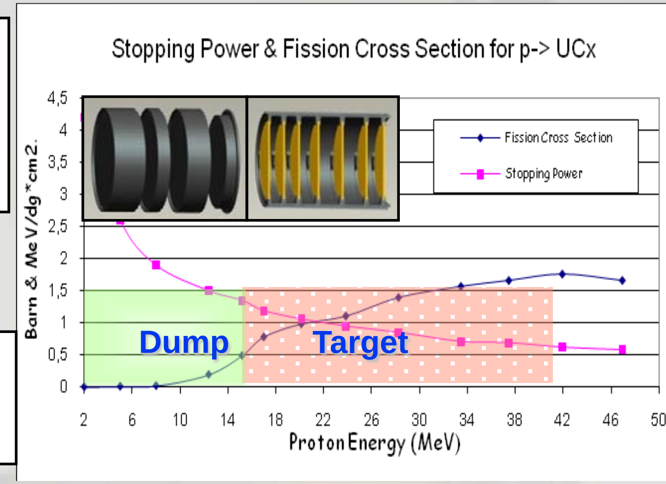
10^{13} fission per second

Goal for the 2nd generation ISOL facilities

↕

for a direct target ->

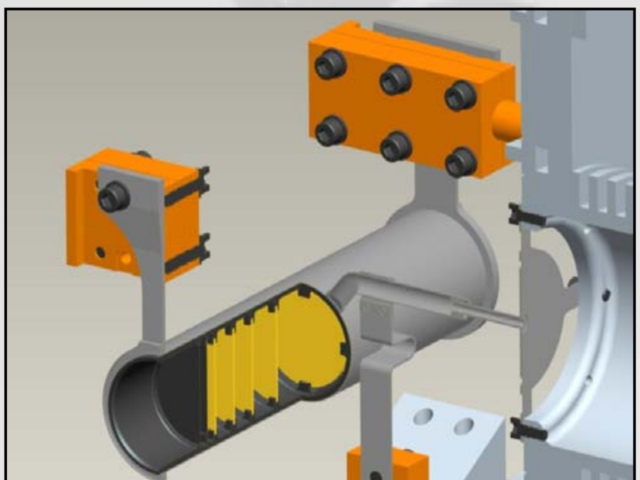
8 kW heat the target !



To dissipate the EM Power is necessary to study a new target set-up:

1) MULTIPLE SLICES : increase the radiation surface area ($P = \varepsilon \cdot \sigma \cdot S \cdot T^4$ Stefan-Boltzmann law)

2) DUMP : send the proton with low fission rate & high stopping power value

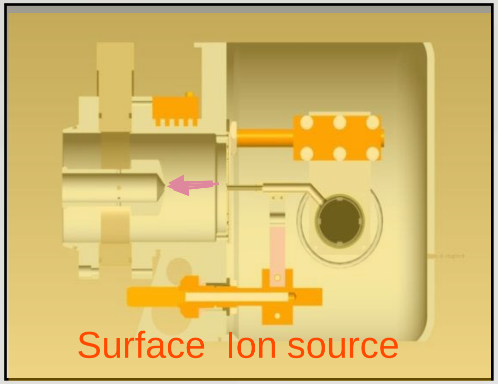


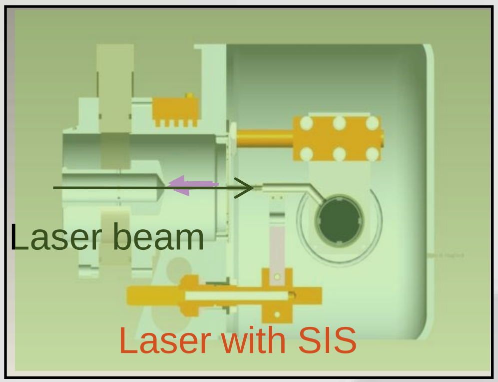
SPES 2010 Workshop

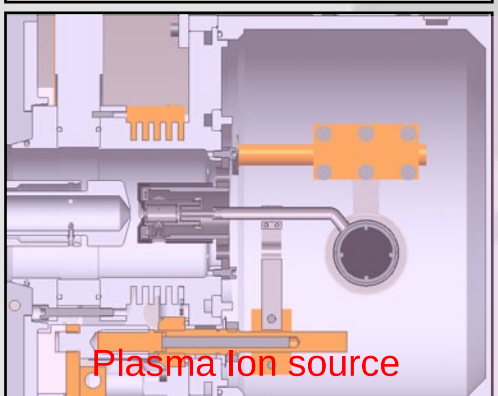
Alberto Andrighetto

IONIZATION methods for SPES n-rich RIB's

(3 methods, 2 Ion sources)







- Elements with bad volatility (NOT EXTRACTED)
- Surface Ionization Method
- Photo Ionization Method
- Plasma Ionization Method

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112						

Main fission (p-> ^{238}U) fragments

The SPES target is a optimization of:

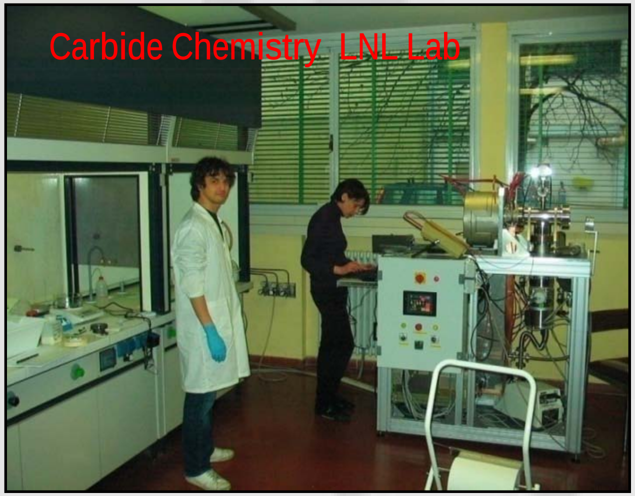
Power dissipation – Short release – Easy handling…

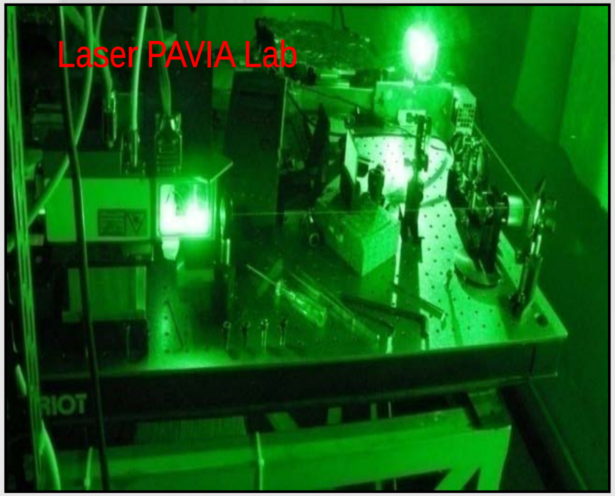
CHANGELLING JOB!

A dedicated (& well organized!) R&D on:

Material science, Mechanical engineering, Laser technology, Handling is required!

The TIS SPES Laboratories





SPES TIS Work Packages

Mission: feasibility study of the target complex

WP01: Mechanical Developments (M. Manzolaro - LNL)

WP02: Material Developments (L. Biasetto - LNL)

WP03: Photoionization (P. Benetti PV; D. Scarpa - LNL)

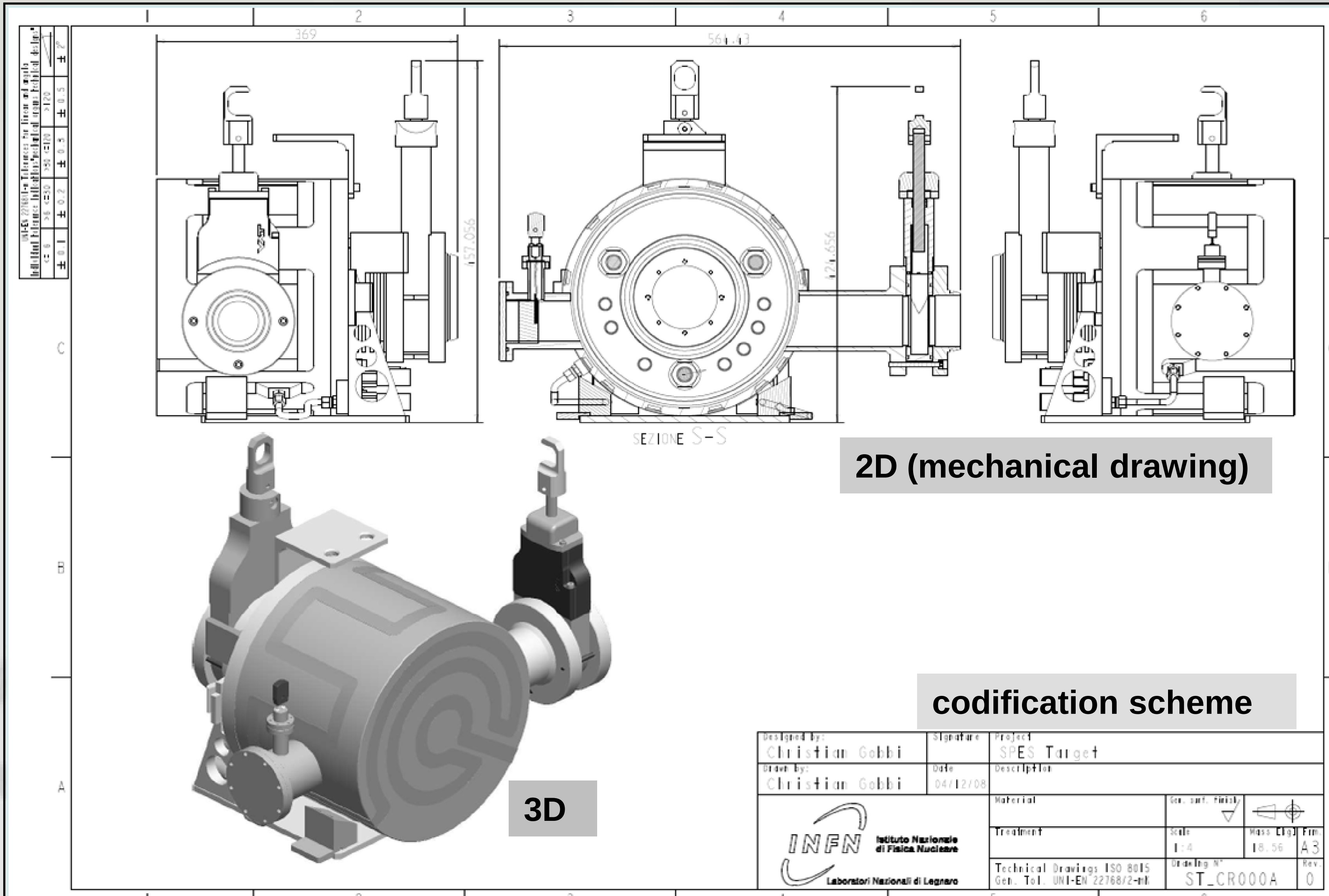
WP04: Target Handling (M. Guerzoni - BO)

WP05: Controls (J. Vasquez - LNL)

Overview on the WP activities

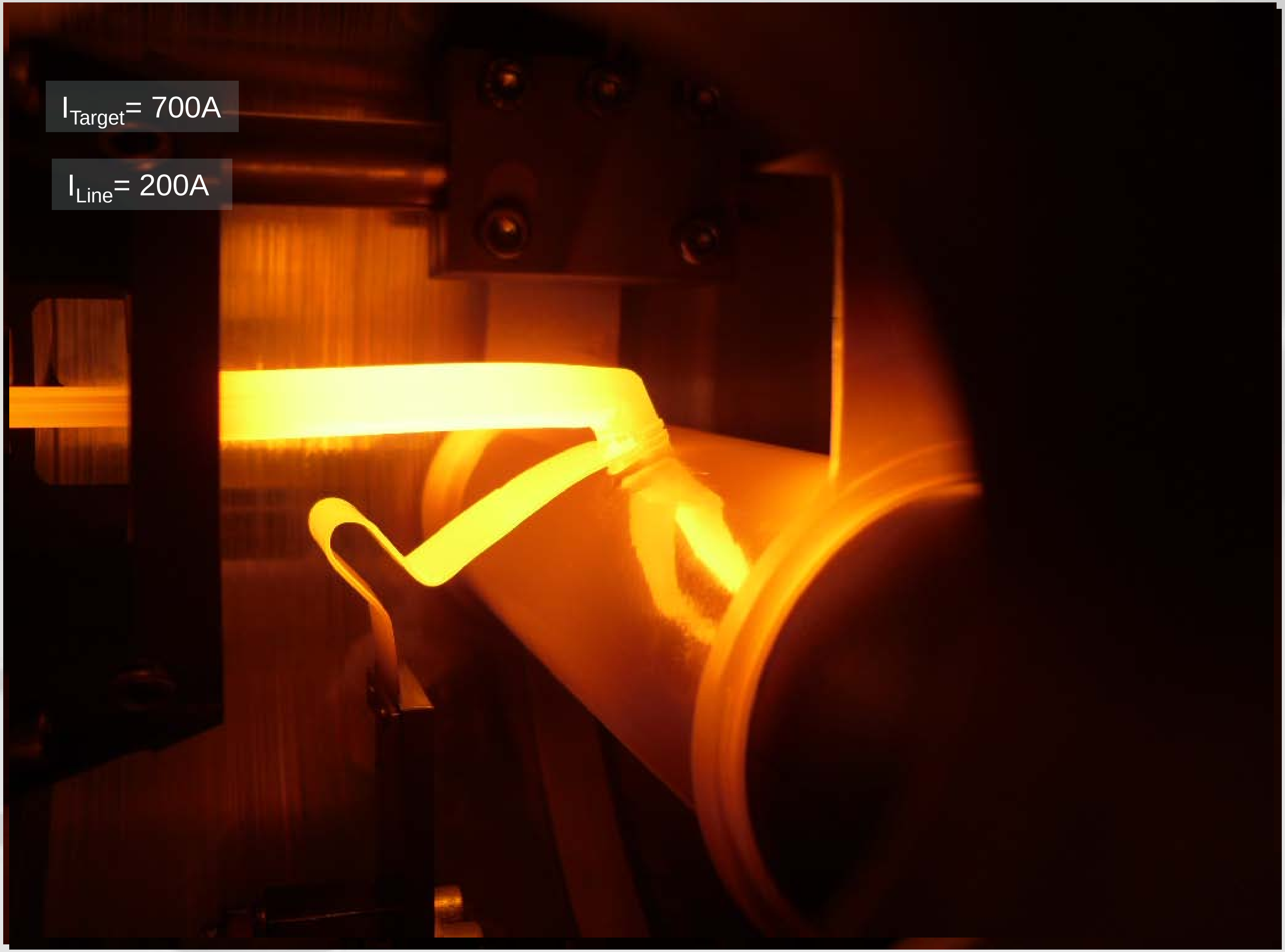
WP01: The Mechanical R&D

Modeling and codification for all devices



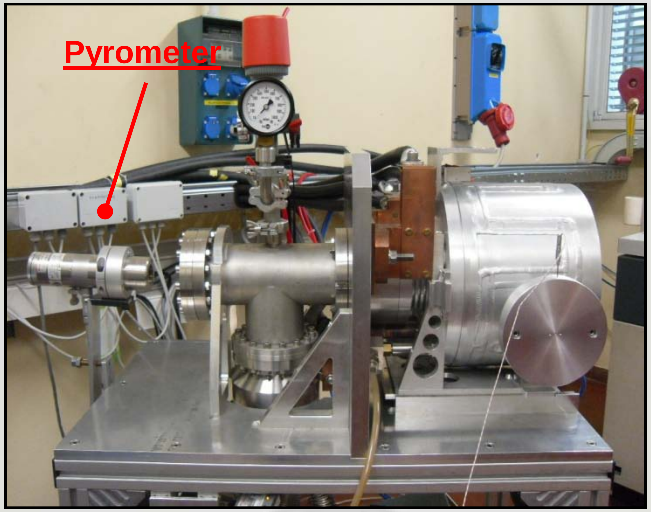
TIS heating process

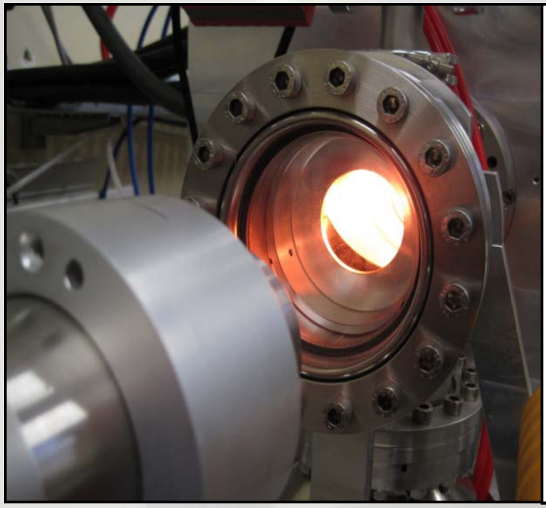
With two independent current circuits

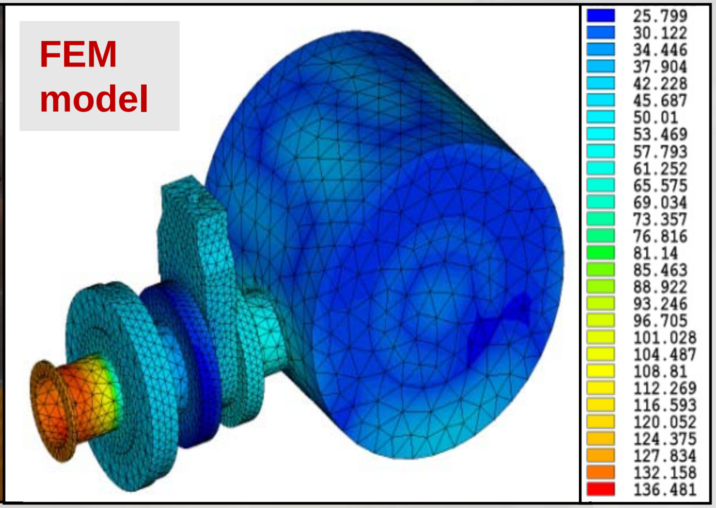


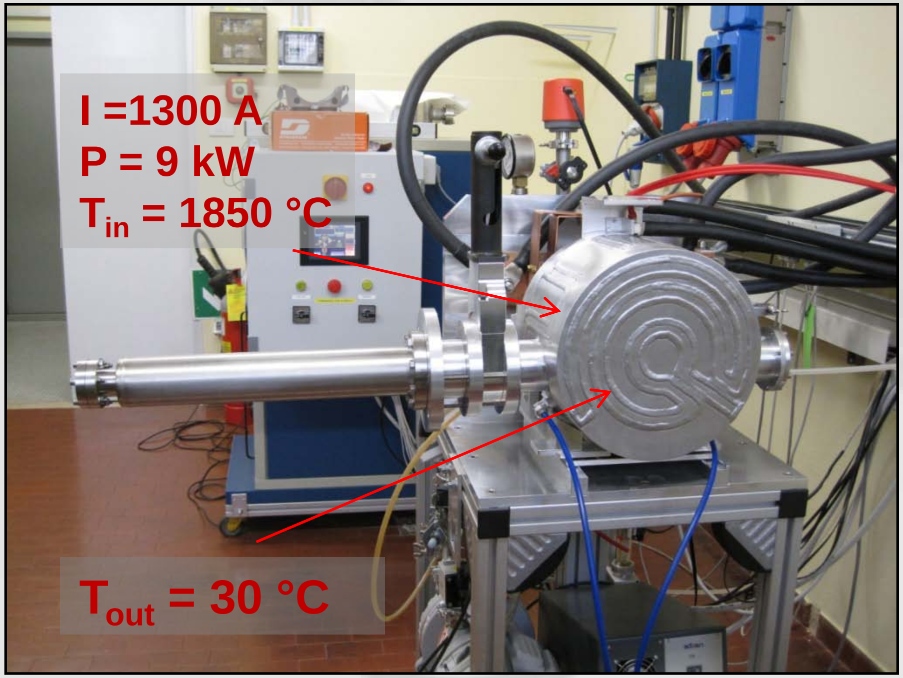
The SPES target chamber complex

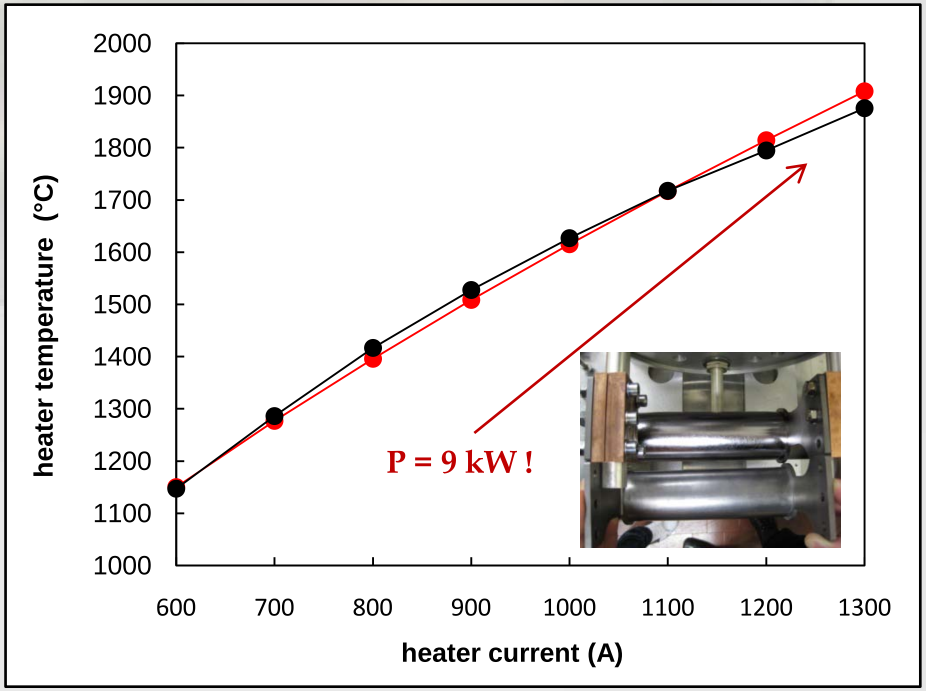
On line test with 9kW imposed into the target -> successfully tested !





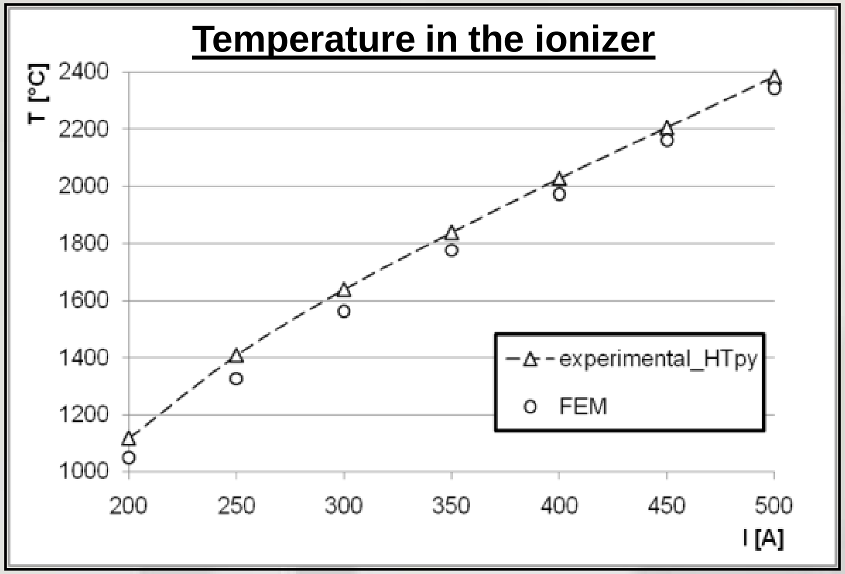


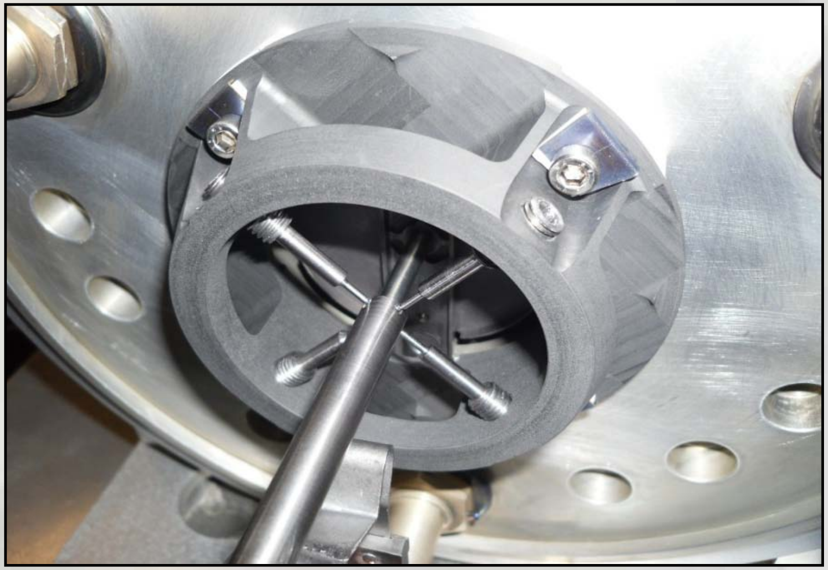


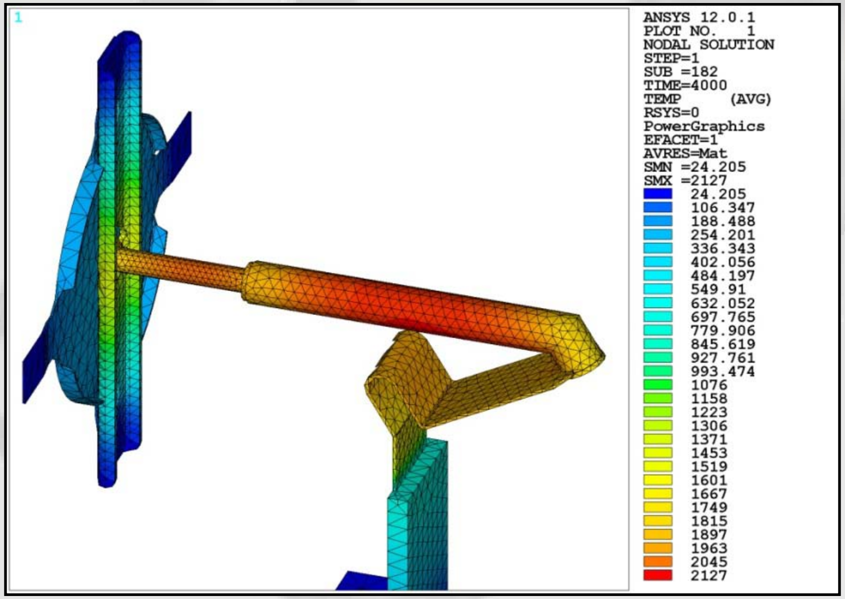


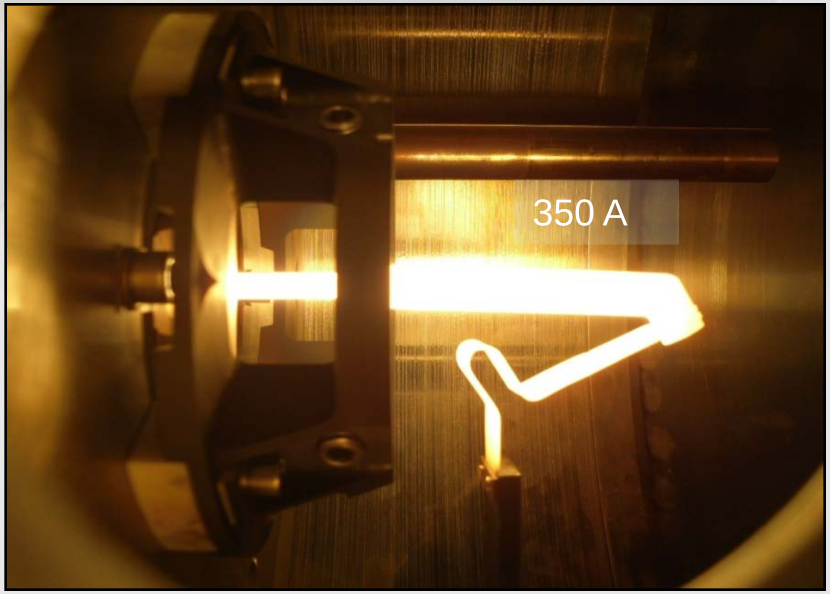
The final SPES SIS

FE model validated experimentally





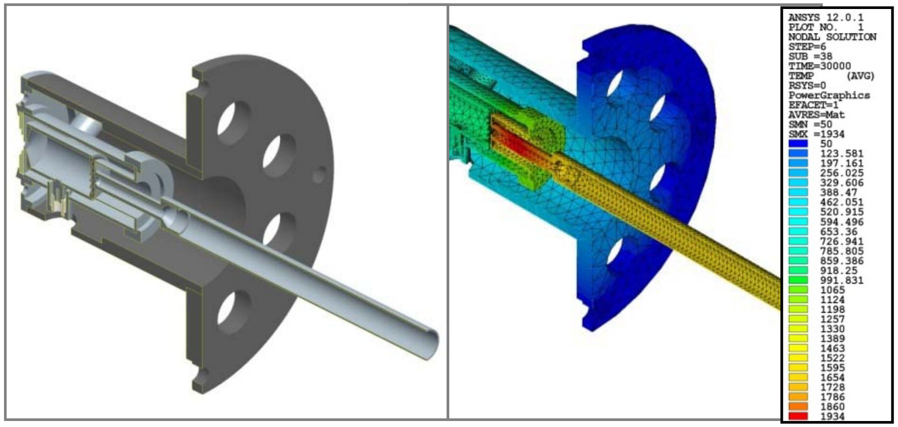




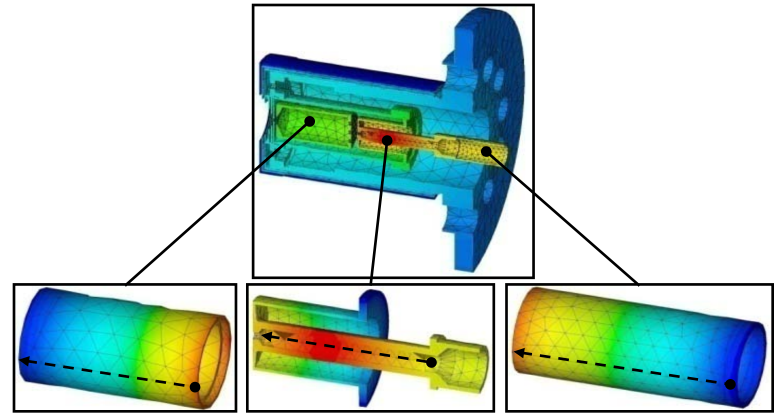
Developments on Plasma Ion Sorce

Mechanical behavior test of the Febiad performed at LNL

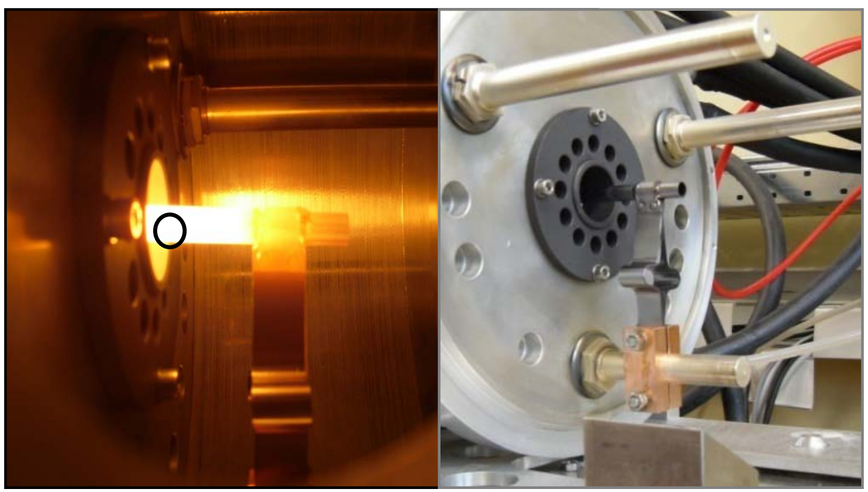
1) Elettro-termo-struttural of the (Isolde) and (Hribf) FEBIAD



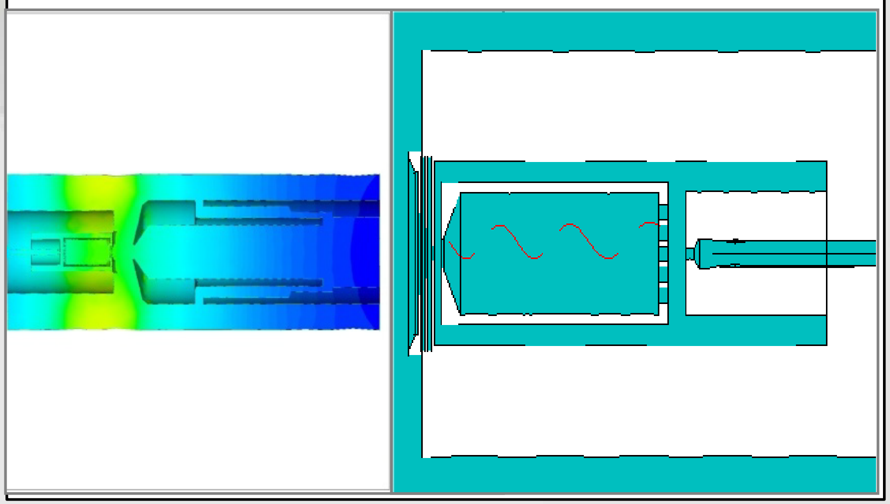
2) Comparison focused toward the new SPES FEBIAD



3) Validation of the FEM model



4) Study of the magnetic field using FEM



WP02: Proton-rich beams for SPES-α

Alkaline - Alkaline earth metals

Post-transition elements

Halogens

Noble gases

Transition metals

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra																

Lanthanides

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Te	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Boron carbide (B_4C) production

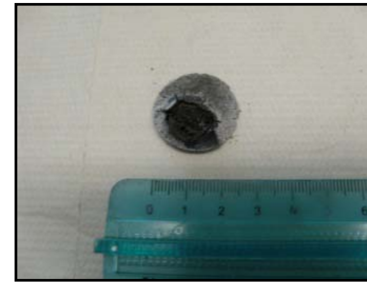
New Technique: Sol-gel synthesis -> boric acid $B(OH)_3$ + citric acid $C_6H_8O_7$

Solution of the acid

Gel formation

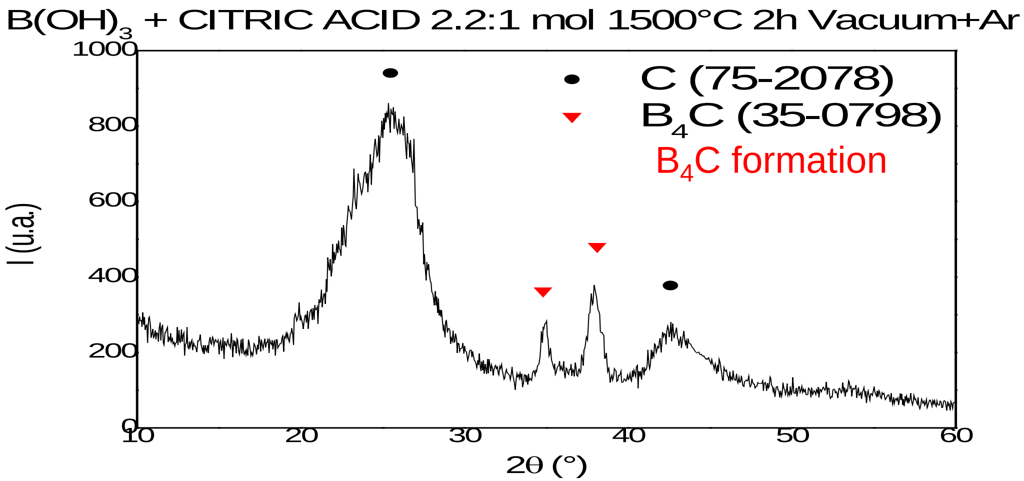
Dried gel

Grounding and cold pressing



Thermal treated sample

Thermal treatment :
- up to 800°C in low vacuum ($5*10^{-2}$mbar), 0.5 °C/min
- up to 1500°C in vacuum with Ar flow ($5*10^{-1}$ mbar), 3°C/min
- 2 hours at 1500°C



Further treatments:

Different boric acid/citric acid ratios

Different time/temperatures

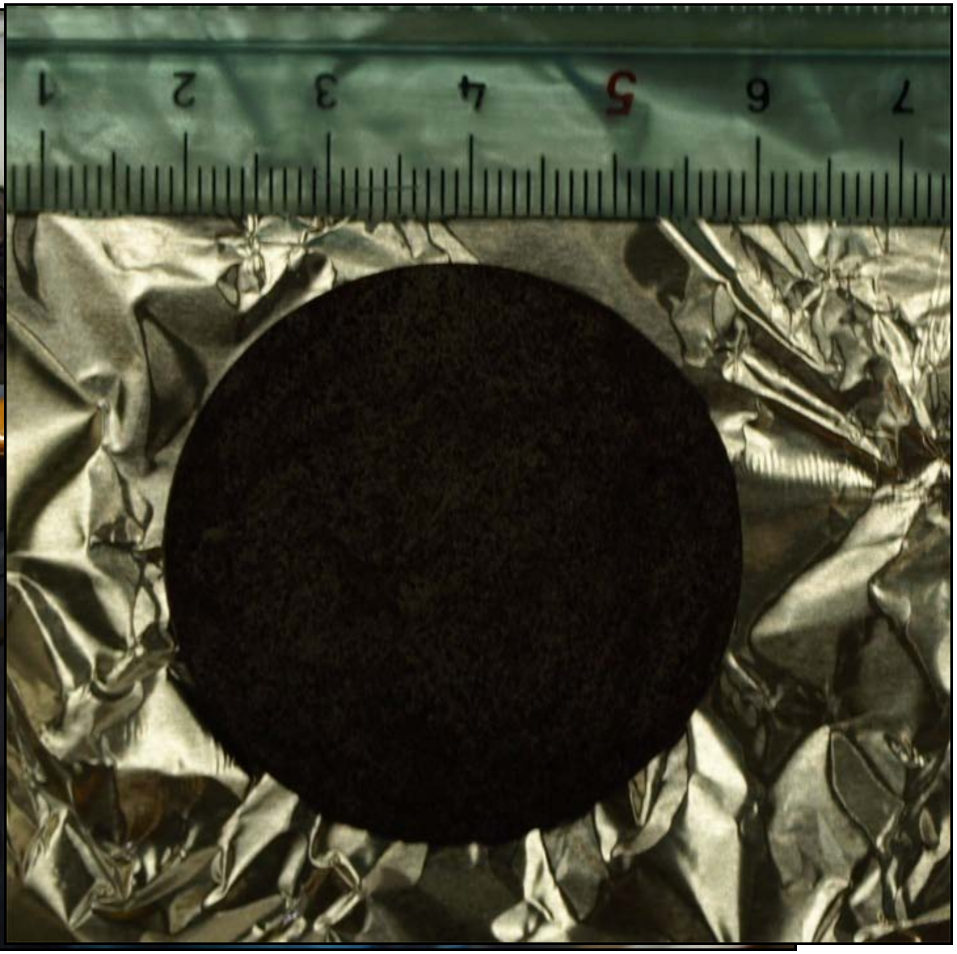
Different pressures during treatment

- Use of binders

UCx 40mm. diameter pellet
(full scale SPES disc!)

Before thermal treatment

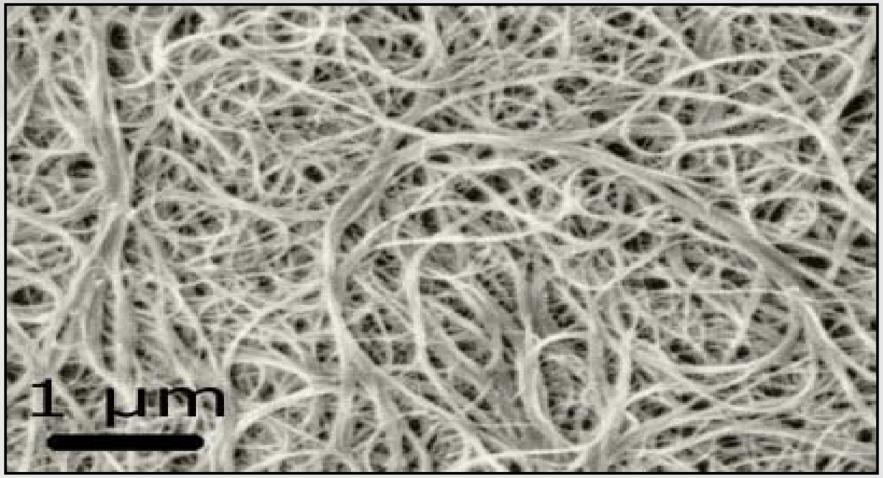
After thermal treatment



UCx using Carbon Nanotubes

Production in progress at Padova UCx Laboratory

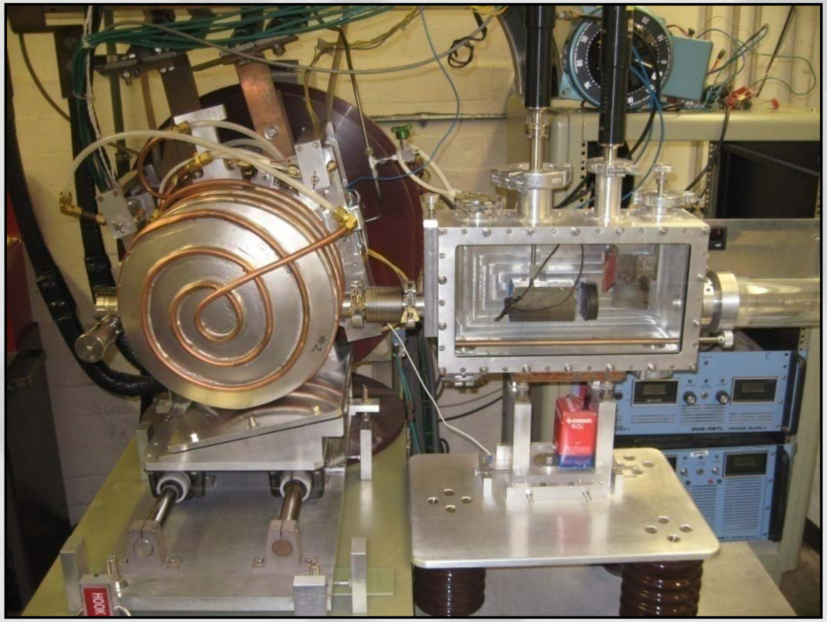
Shipment to ORNL before Christmas

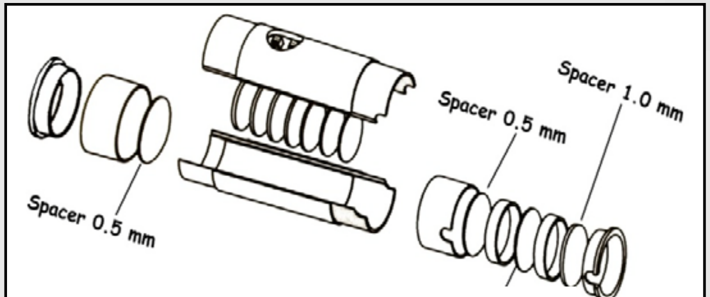


On line UCx test at HRIBF

Test performed on March ’10 (thanks to D. Stracener)

- Seven UC_2 samples SPES Target Group (in collaboration with HRIBF)
- Densities in the range of 4.2 g/cm^3
- Yield measurements were made at the HRIBF using low intensity proton beams from the Tandem (40 MeV, 50 nA)
- Heated to 2000° C for about two weeks without any out-gassing or obvious change in structure (samples observed after the on-line test)



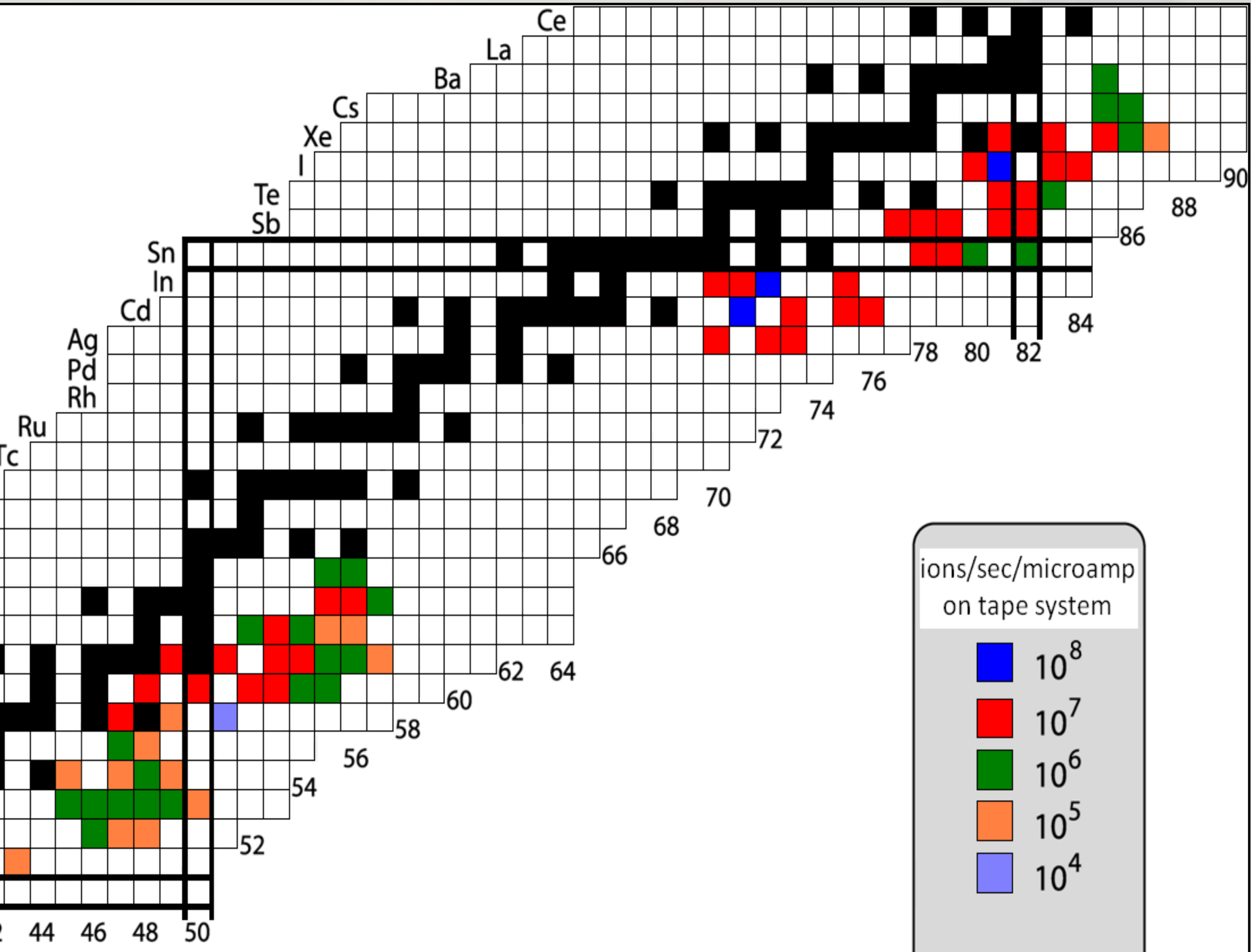


7 UCx pellets of 13 mm. diameter

On line UCx test at HRIBF

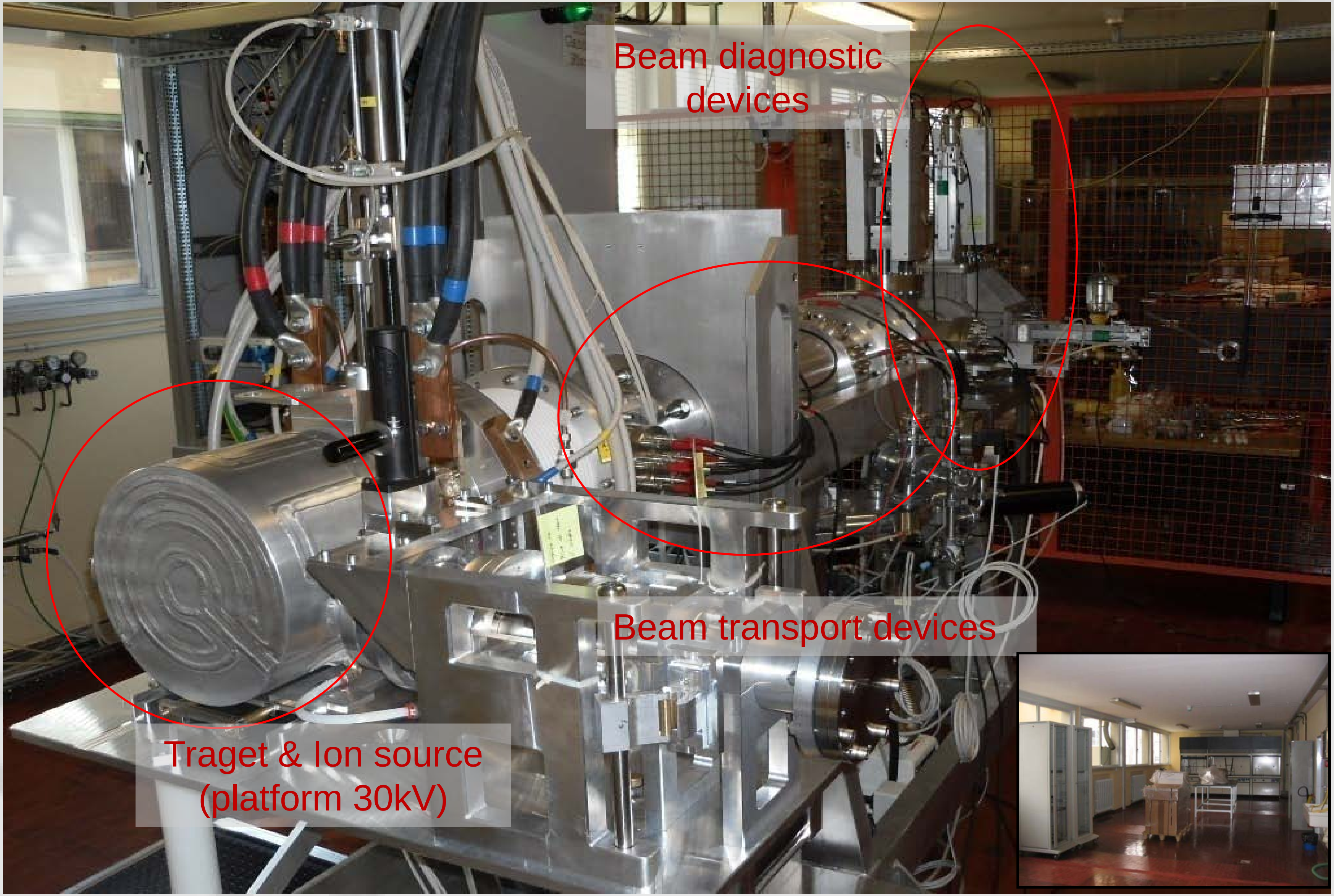
N-Rich Isotopes yields

Target discs status
after (6 days) 40 MeV irradiation

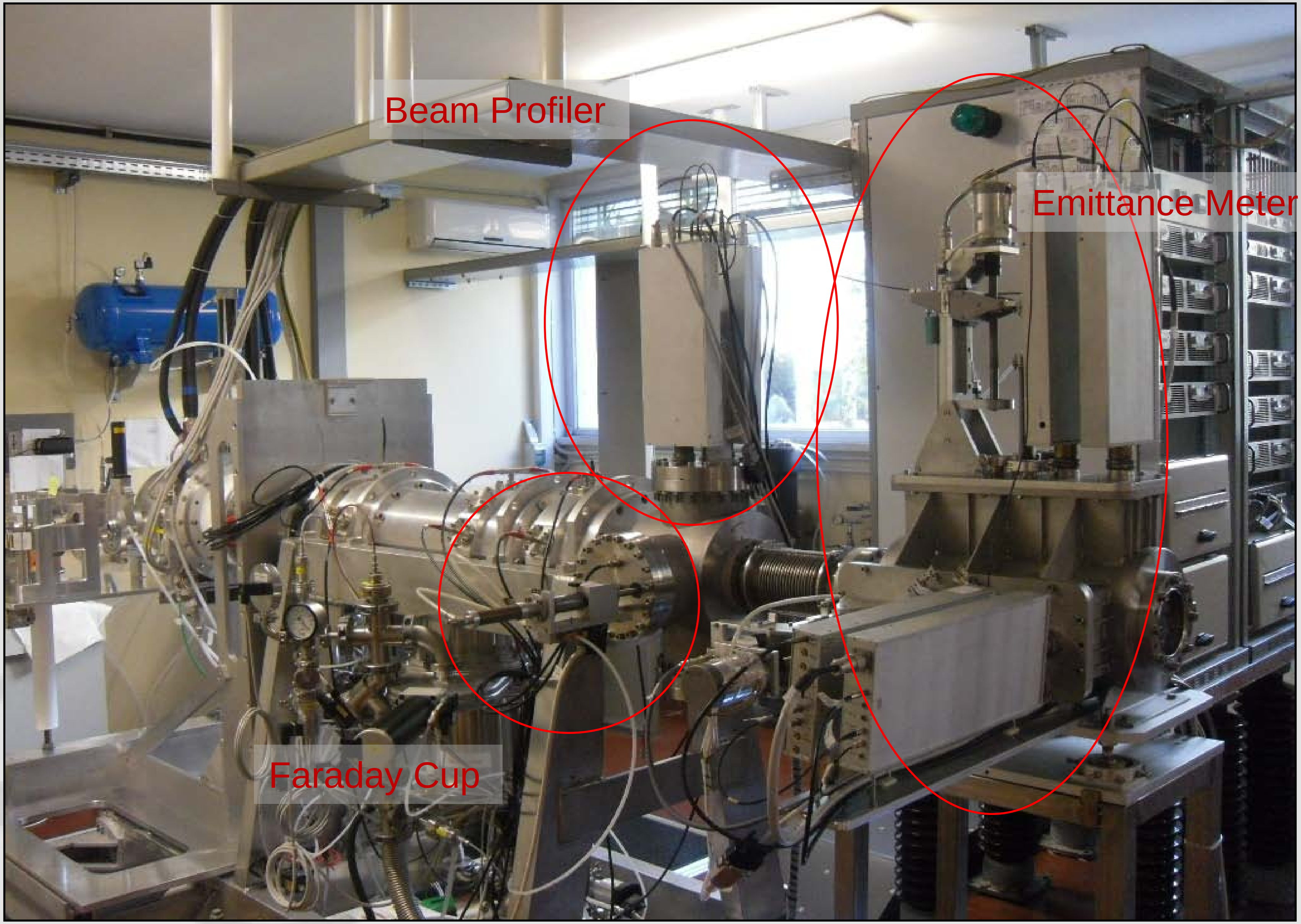


WP03: Ionization measurements

Front end running since June '10



Beam diagnostic set-up



Ionization test with Rb

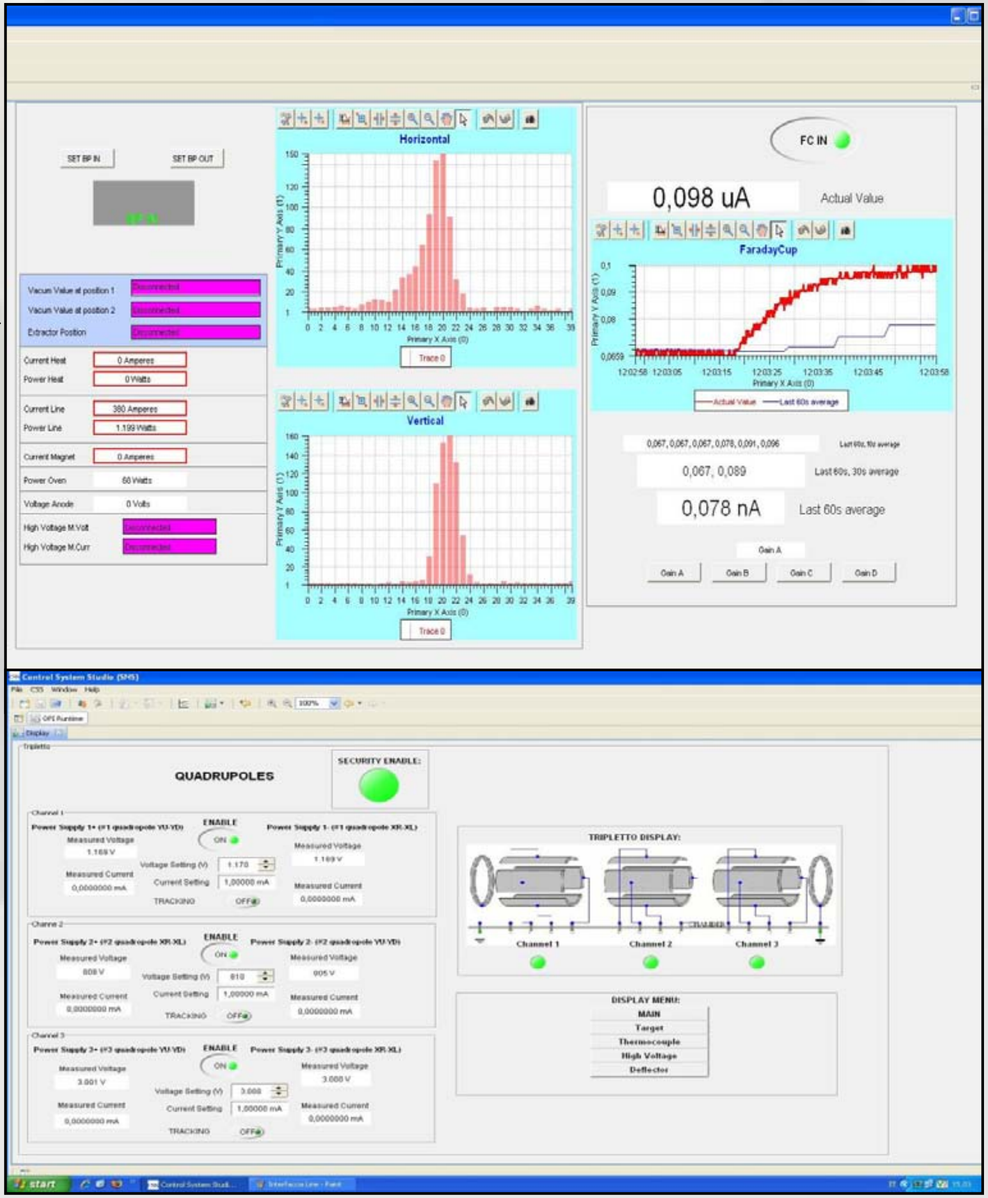
FARADAY CUP BEAM INTENSITY MEASUREMENT

ionization Rubidium

Up to 1,7 μ A in F.C

($T_{ionizer}$~ 1900 °C)

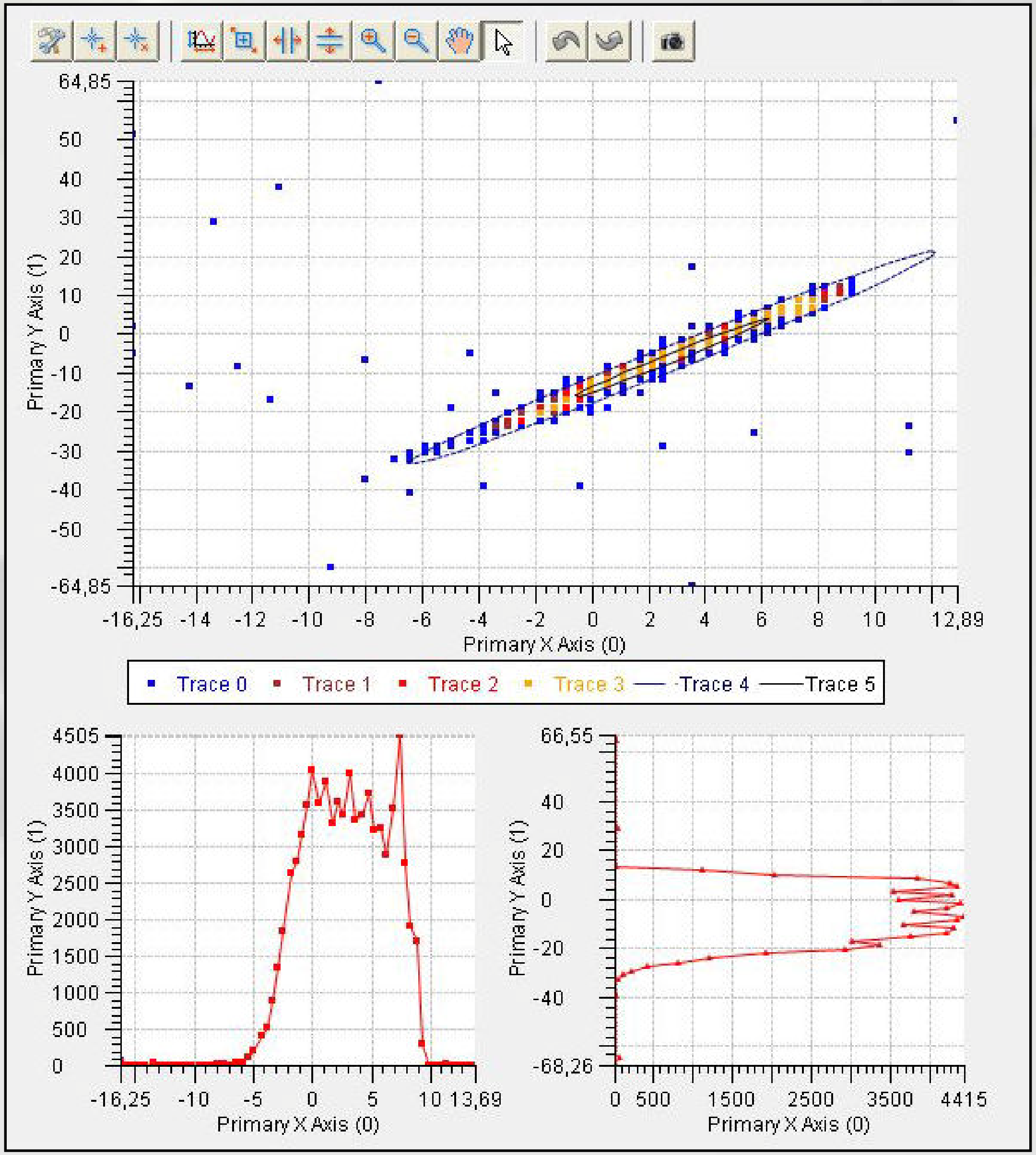
Rb $\varepsilon_{ionization}$= 50 % (preliminary)



Tantalum oven tube with rubidium

(Mass Marker Capillarity Method)

SIS emittance of Rb



E $_{rms}$ = 2 π ·mm · mrad

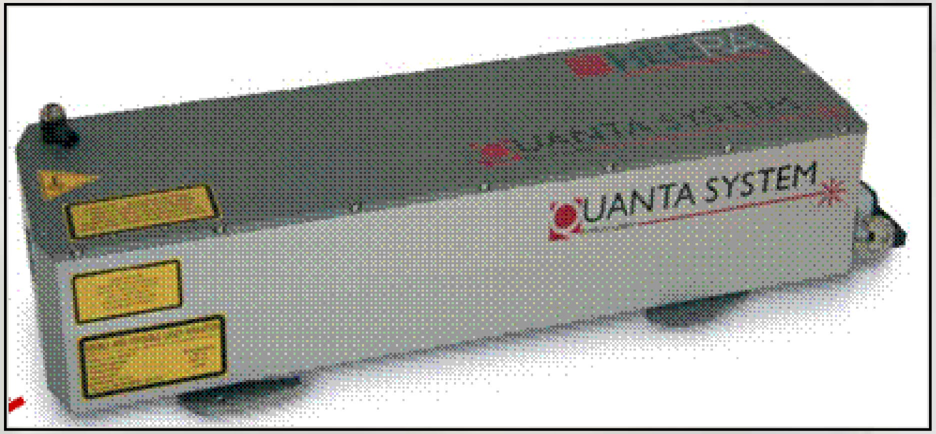
@ 30 kV (preliminary)

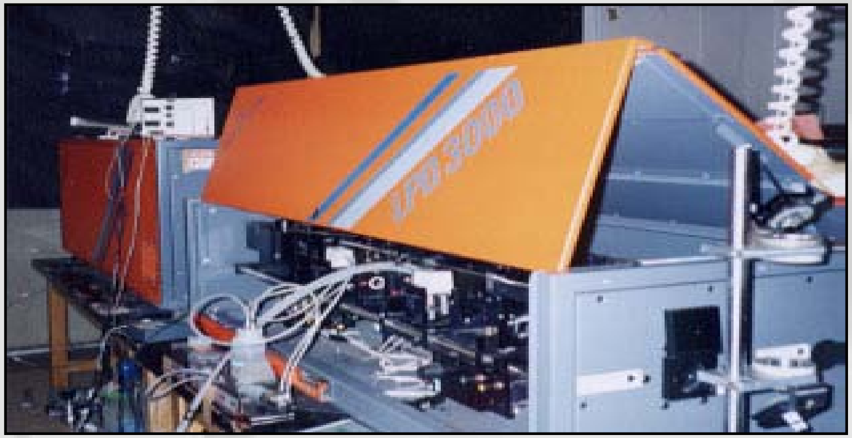
PAVIA Laboratory setup

Since April 2010, 3 tuneable lasers are working properly

1 Pump Laser:

- Quanta System G.Y.L 101/102
  - Nd:YAG laser
  - Impulse Energy up to 300mJ
  - Repetition rate max 10Hz





3 Tuneable Dye Laser :

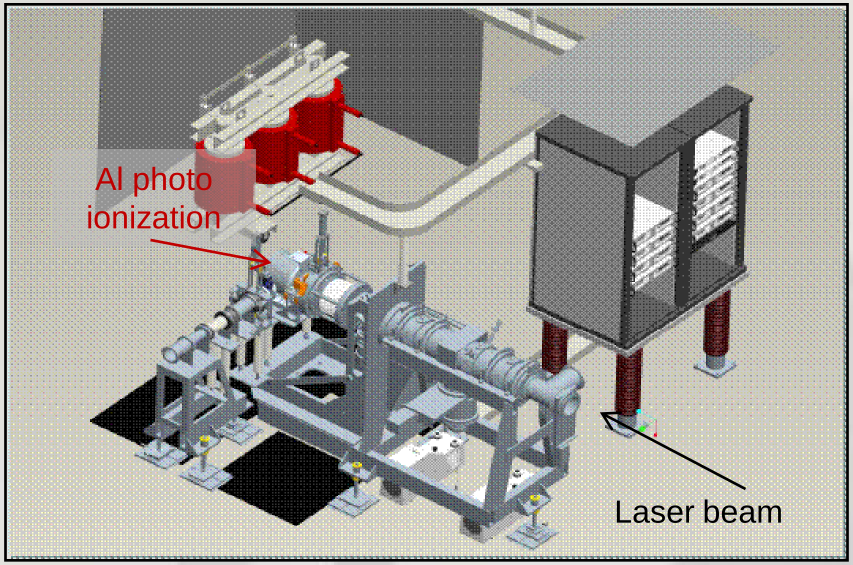
- Lambda Physik FL3002E and Lambda Physik LPD3002E
  - Bandwidth 0,2 cm^{-1}
  - Repetition rate according to pump

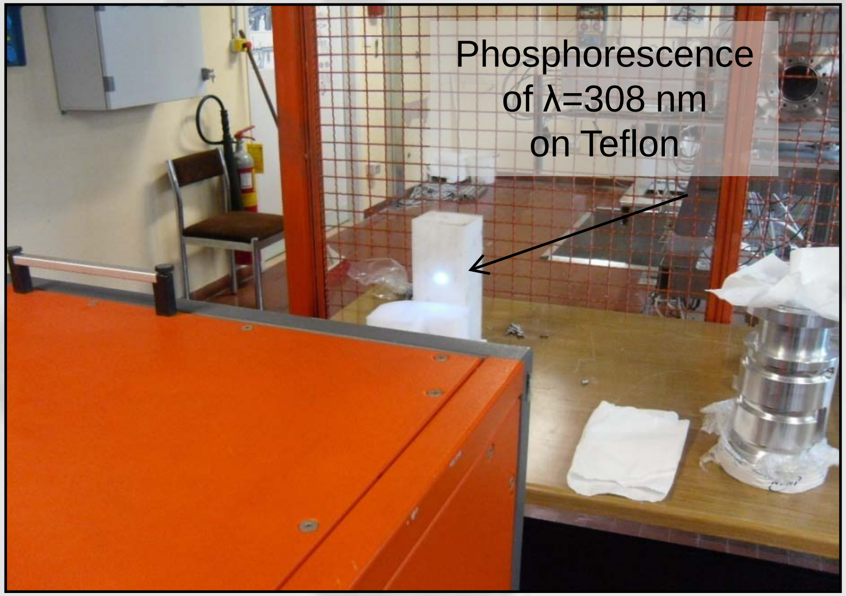
Goal:

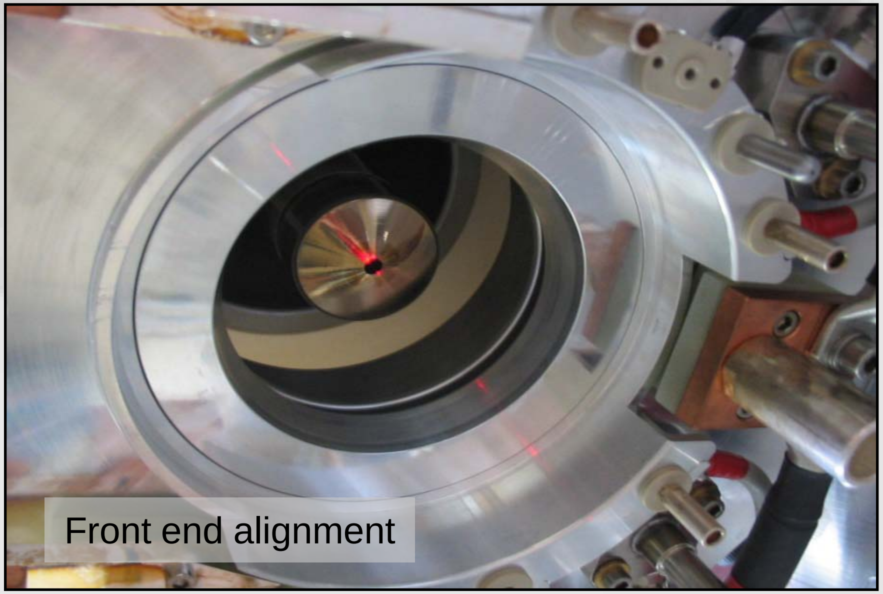
Build up a complete 3λ ionization scheme for metals

Laser test at LNL with excimer

Aluminum photoionization with a single wavelength

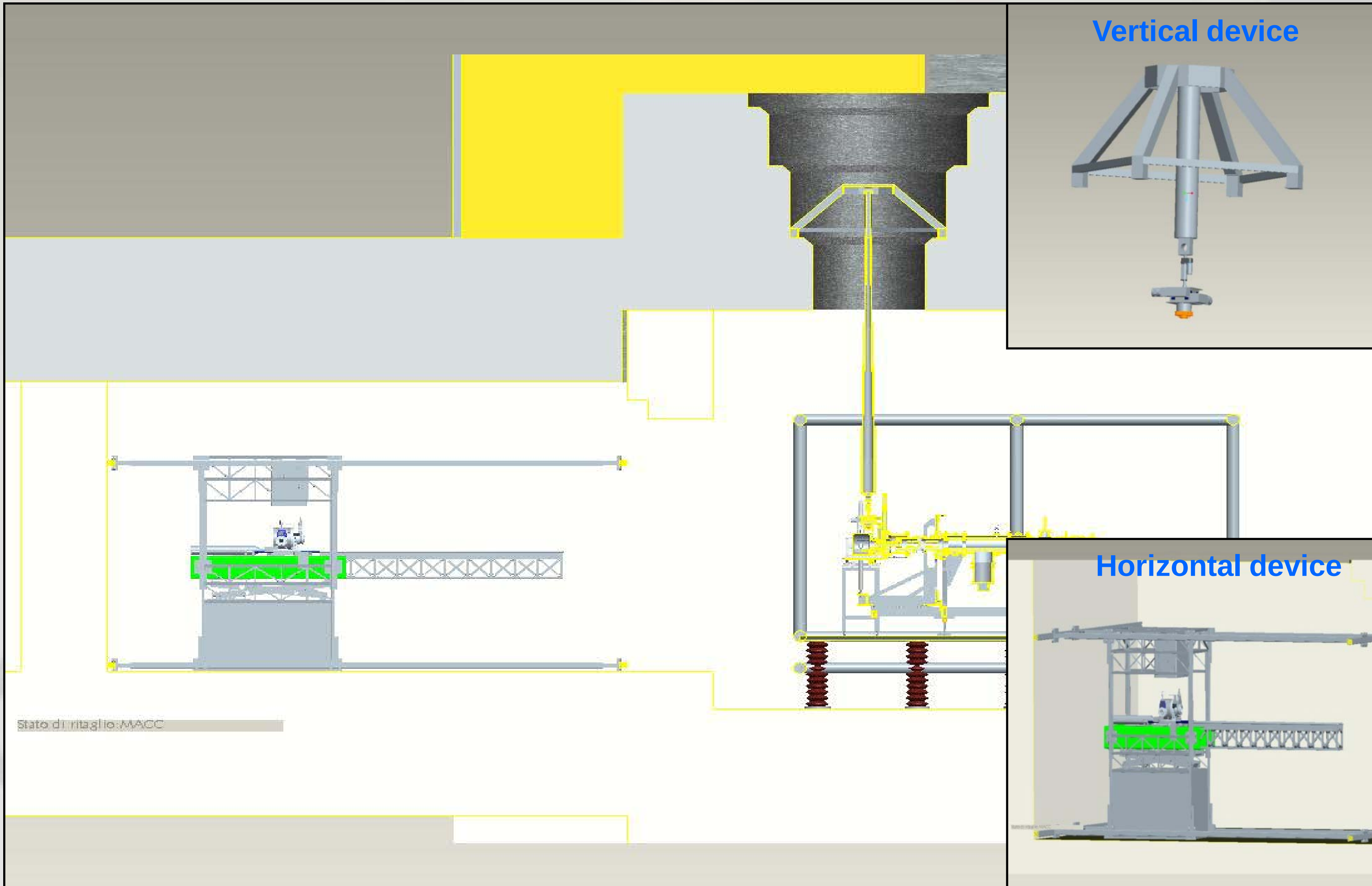




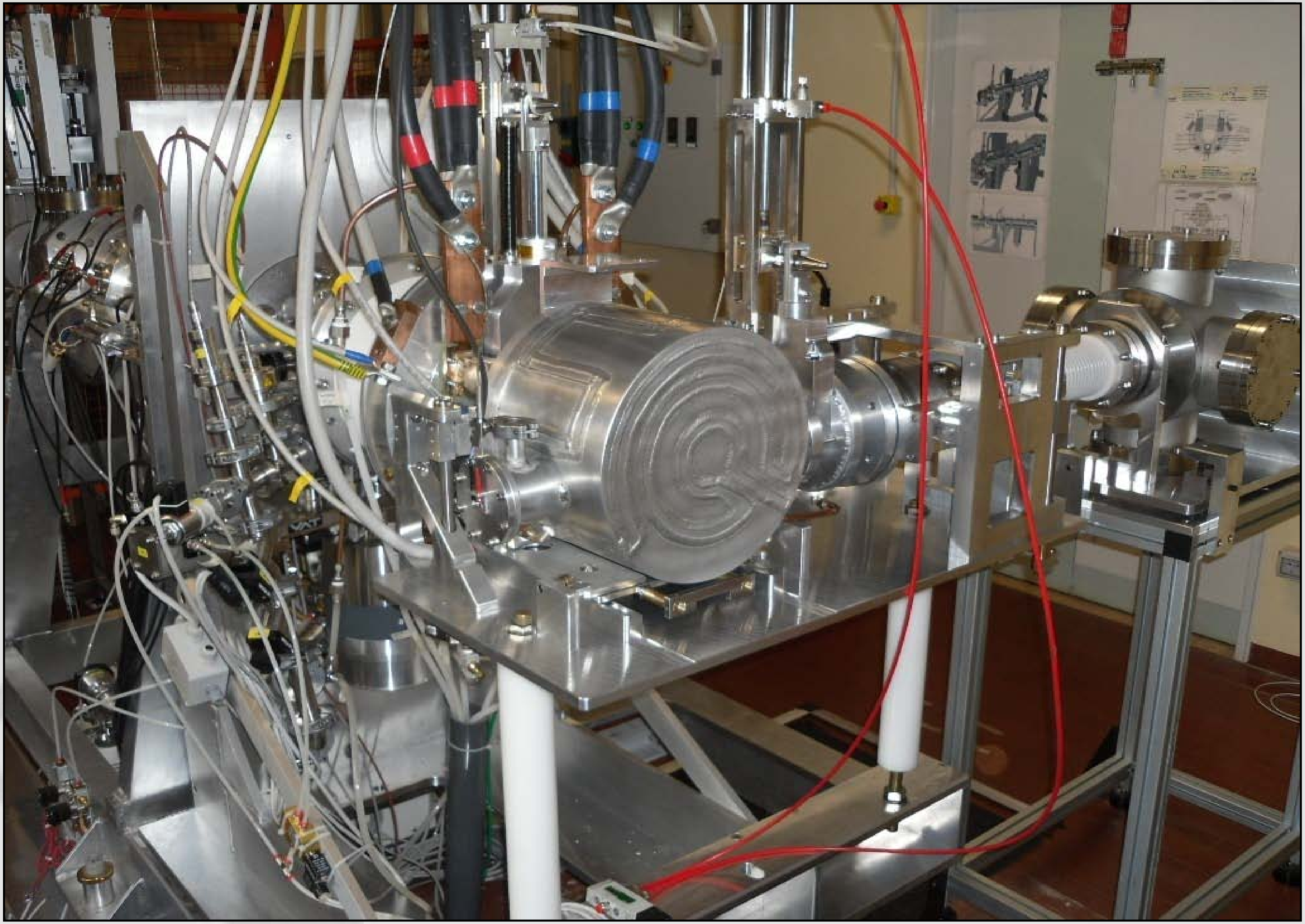


WP04: The target handling

Two systems: in order to increase the handling security level

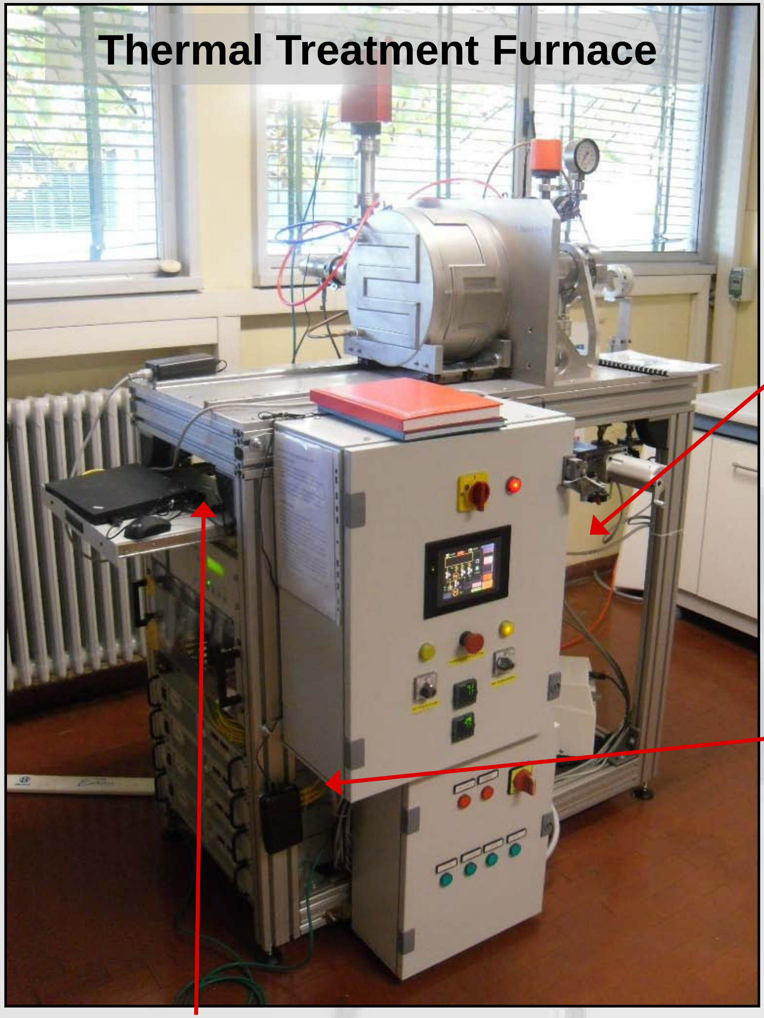


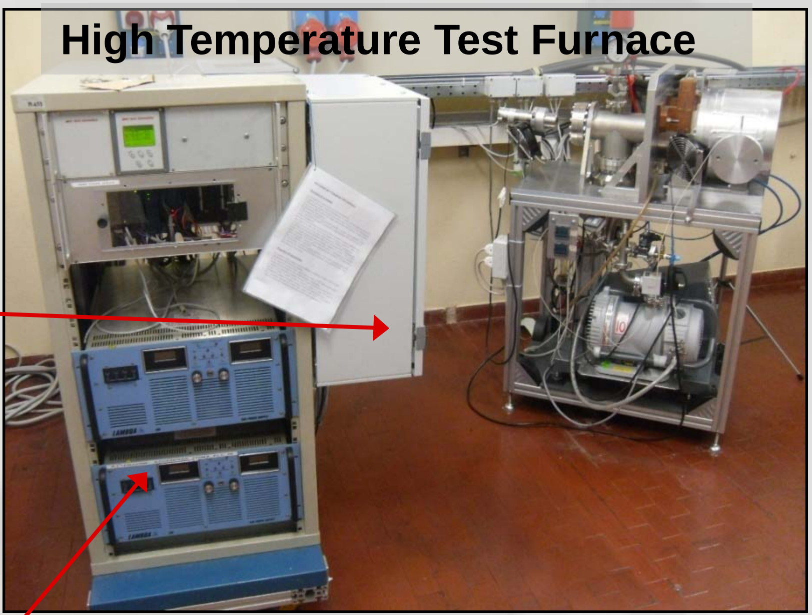
Front End Handling System

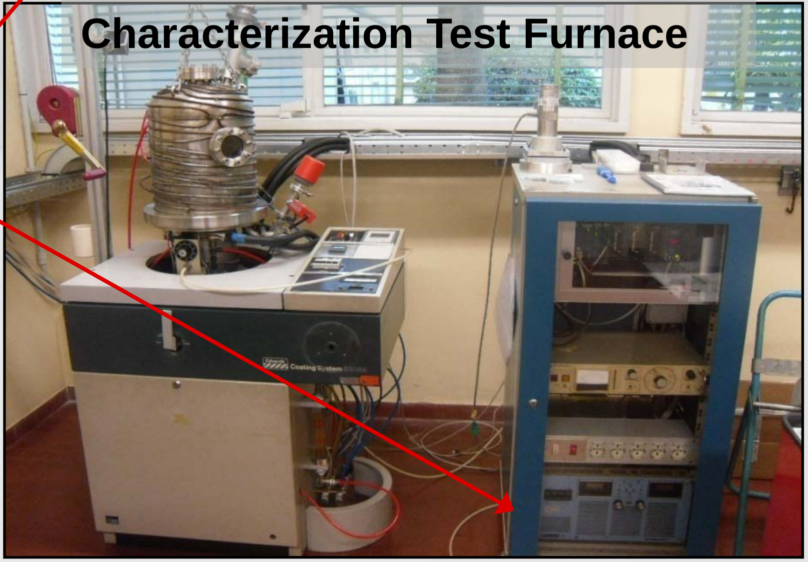


WP5: LNL Furnace Control System

(Lab View based)





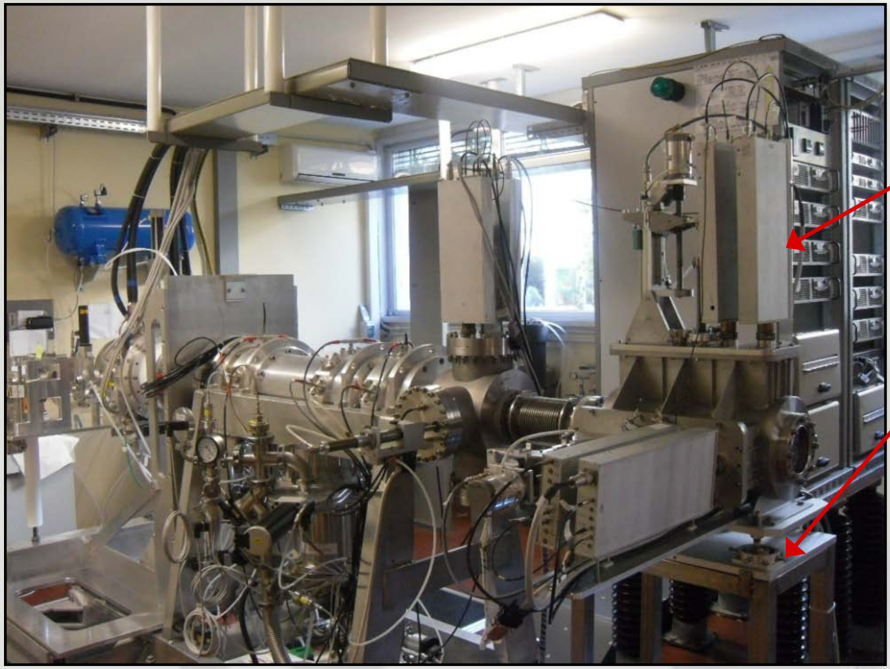


Vacuum System Control (PLC)

Power Supplies

Power Supply Control (PC+LabView)

Front End Control System



Power Supplies

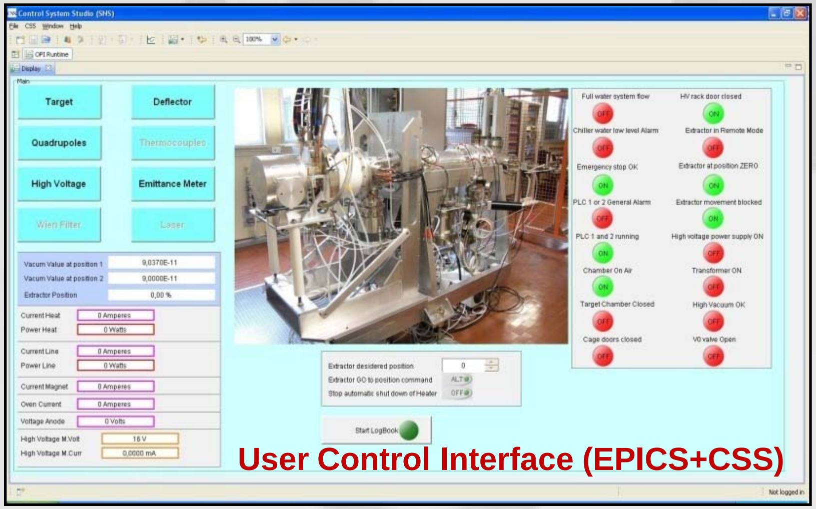
(Target System)

High Voltage Platform

Power Supplies

(High Voltage System)

Data Acquisition Systems



Conclusions

What next…

-Test at ORNL using UCx SPES target with CNT

- Ionization of noble gases with FEBIAD at LNL

- Photoionization campaign of metals, with 3λ, at PV

- Photoionization of Al with excimer at LNL

- Target handling test at LNL

- New UCx laboratory at LNL …

SPES Target papers

(About 20 contributions since 2005)

Eur. Phys. J. A (2005)
DOI 10.1140/epja/i2005-10064-8
THE EUROPEAN PHYSICAL JOURNAL A

Fission fragment production from uranium carbide disc targets

A. Andrighetto[1,a], S. Cevolani[2], and C. Petrovich[2]

Eur. Phys. J. A 30, 591–601 (2006)
DOI 10.1140/epja/i2006-10144-3
THE EUROPEAN PHYSICAL JOURNAL A

Multifoil UC_x target for the SPES project —An update

A. Andrighetto[1], C.M. Antonucci[2], S. Cevolani[2], C. Petrovich[2,a], and M. Santana Leitner[3]
[1] INFN Laboratori Nazionali di Legnaro, Viale dell'Università 2, 35020 Legnaro (PD), Italy
[2] ENEA, Via M.M. Sole 4, 40129 Bologna, Italy
[3] AB-Department, CERN, 1211 Geneve 23, Switzerland

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 583 (2007) 256–263
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Synthesis and characterization of lanthanum dicarbide-carbon targets for radioactive ion beams generation via the carbothermal reaction

S. Carturan[a,*], M. Tonezzer[a], L. Piga[b], P. Zanonato[b], P. Colombo[c], A. Andrighetto[a], L. Biasetto[a], P. Di Bernardo[b], G. Maggioni[a], F. Gramegna[a], G. Prete[a]

Eur. Phys. J. Special Topics 150, 273–274 (2007)
© EDP Sciences, Springer-Verlag 2007
DOI 10.1140/epjst/e2007-00321-6
THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

The SPES direct UCx target

A. Andrighetto[1], C. Antonucci[2], M. Barbui[1], S. Carturan[1], F. Cervellera[1], S. Cevolani[2], M. Cinausero[1], P. Colombo[3], A. Dainelli[1], P. Di Bernardo[4], F. Gramegna[1], G. Maggioni[1], G. Meneghetti[4], C. Petrovich[2], L. Piga[1], G. Prete[1], V. Rizzi[1], M. Tonezzer[1], D. Zafiropoulos[1], and P. Zanonato[4]

Eur. Phys. J. Special Topics 150, 275–276 (2007)
© EDP Sciences, Springer-Verlag 2007
DOI 10.1140/epjst/e2007-00322-5
THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

Release time calculations for the SPES direct UCx target

M. Barbui[1,a], A. Andrighetto[1], C. Antonucci[2], S. Carturan[1], F. Cervellera[1], S. Cevolani[2], M. Cinausero[1], P. Colombo[3], A. Dainelli[1], P. Di Bernardo[4], F. Gramegna[1], G. Maggioni[1], G. Meneghetti[3], C. Petrovich[2], L. Piga[1], G. Prete[1], V. Rizzi[1], M. Santana-Leitner[5], M. Tonezzer[1], P. Zanonato[4], and D. Zafiropoulos[1]

Eur. Phys. J. Special Topics 150, 281–282 (2007)
© EDP Sciences, Springer-Verlag 2007
DOI 10.1140/epjst/e2007-00324-3
THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

Thermal treatments and characterizations of pellets for SPES direct target

M. Tonezzer[1], S. Carturan[1], L. Piga[1], P. Colombo[2], P. Di Bernardo[3], P. Zanonato[3], A. Andrighetto[1], C. Antonucci[4], M. Barbui[1], F. Cervellera[1], S. Cevolani[4], M. Cinausero[1], A. Dainelli[1], F. Gramegna[1], G. Maggioni[1], G. Meneghetti[5], C. Petrovich[4], G. Prete[1], V. Rizzi[1], and D. Zafiropoulos[1]

Journal of Nuclear Materials 378 (2008) 180–187
Contents lists available at ScienceDirect
Journal of Nuclear Materials
journal homepage: www.elsevier.com/locate/jnucmat
ELSEVIER

Lanthanum carbide-based porous materials from carburization of lanthanum oxide and lanthanum oxalate mixtures

L. Biasetto[a,b,*], P. Zanonato[c], S. Carturan[b], P. Di Bernardo[c], P. Colombo[a,d], A. Andrighetto[b], G. Prete[b]

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Instruments and Methods in Physics Research B 266 (2008) 4257–4260
NIM B Beam Interactions with Materials & Atoms
www.elsevier.com/locate/nimb

The SPES multi-foil direct target

A. Andrighetto[a,*], L. Biasetto[b], M. Manzolaro[c], M. Barbui[a], G. Bisoffi[a], S. Carturan[a], M. Cinausero[a], F. Gramegna[b], G. Prete[a], V. Rizzi[a], C. Antonucci[d], S. Cevolani[d], C. Petrovich[d], P. Colombo[b], G. Meneghetti[c], P. Di Bernardo[e], P. Zanonato[e], I. Cristofolini[f], V. Fontanari[f], B. Monelli[f], R. Oboe[f]

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Instruments and Methods in Physics Research B 266 (2008) 4289–4293
NIM B Beam Interactions with Materials & Atoms
www.elsevier.com/locate/nimb

Calculations and first results obtained with a SiC prototype of the SPES direct target

M. Barbui[a,*], A. Andrighetto[a], C. Antonucci[b], L. Biasetto[a,d], S. Carturan[a], F. Cervellera[a], S. Cevolani[b], M. Cinausero[a], P. Colombo[d], A. Dainelli[a], P. Di Bernardo[c], M. Giacchini[a], F. Gramegna[a], M. Lollo[a], G. Maggioni[a], M. Manzolaro[a,d], G. Meneghetti[d], C. Petrovich[b], L. Piga[a,c], G. Prete[a], M. Re[a], V. Rizzi[a], D.W. Stracener[f], M. Tonezzer[a], D. Zafiropoulos[a], P. Zanonato[c]

Eur. Phys. J. A 38, 167–171 (2008)
DOI 10.1140/epja/i2008-10665-6
THE EUROPEAN PHYSICAL JOURNAL A
Regular Article – Experimental Physics

Emissivity measurements of opaque gray bodies up to 2000 °C by a dual-frequency pyrometer

L. Biasetto[1,2,a], M. Manzolaro[1,2], and A. Andrighetto[1]

Journal of Nuclear Materials 385 (2009) 582–590
Contents lists available at ScienceDirect
Journal of Nuclear Materials
journal homepage: www.elsevier.com/locate/jnucmat
ELSEVIER

Fabrication of mesoporous and high specific surface area lanthanum carbide–carbon nanotube composites

L. Biasetto[a,b,*], S. Carturan[a], G. Maggioni[a], P. Zanonato[c], P. Di Bernardo[c], P. Colombo[b,d], A. Andrighetto[a], G. Prete[a]

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Physics A 834 (2010) 754c–757c
NUCLEAR PHYSICS A
www.elsevier.com/locate/nuclphysa

Production of high-intensity RIB at SPES

A. Andrighetto[a], L. Biasetto[a], M. Manzolaro[a], D. Scarpa[a], J. Montano[a], J. Stanescu[a], P. Benetti[b], I. Cristofolini[c], M.S. Carturan[a], P. Colombo[d], P. di Bernardo[e], M. Guerzoni[f], G. Meneghetti[d], B. Monelli[c], G. Prete[a], G. Puglierin[a], A. Tomaselli[b], P. Zanonato[e].

Eur. Phys. J. A 42, 517–521 (2009)
DOI 10.1140/epja/i2009-10776-1
THE EUROPEAN PHYSICAL JOURNAL A
Regular Article – Experimental Physics

Research and development for the SPES target

L. Biasetto[1,2,a], M. Manzolaro[1,2], A. Andrighetto[1], G. Meneghetti[2], S. Carturan[1], P. Zanonato[3], P. Colombo[2], and G. Prete[1]

Journal of Nuclear Materials xxx (2010) xxx–xxx
Contents lists available at ScienceDirect
Journal of Nuclear Materials
journal homepage: www.elsevier.com/locate/jnucmat
ELSEVIER

Developing uranium dicarbide-graphite porous materials for the SPES project

L. Biasetto[a,b,*], P. Zanonato[c], S. Carturan[b], P. Di Bernardo[c], P. Colombo[a,d], A. Andrighetto[b], G. Prete[b]

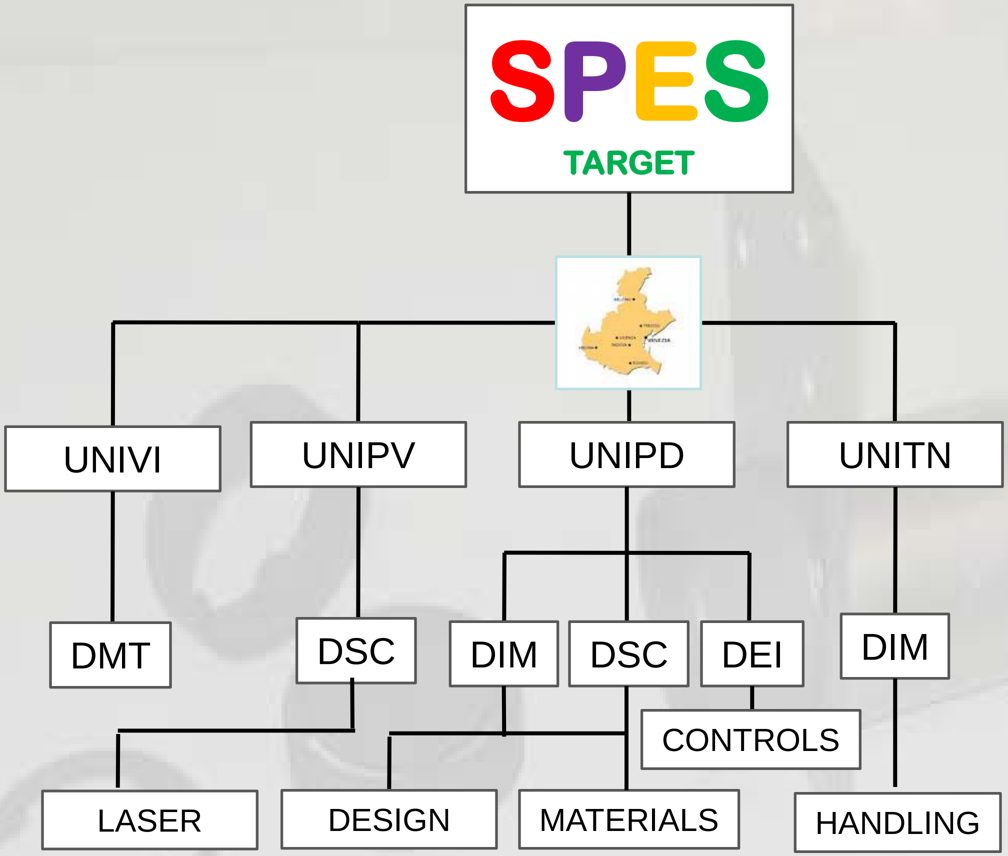
Nuclear Instruments and Methods in Physics Research A 623 (2010) 1061–1069
Contents lists available at ScienceDirect
Nuclear Instruments and Methods in Physics Research A
journal homepage: www.elsevier.com/locate/nima
ELSEVIER

Thermal-electric numerical simulation of a surface ion source for the production of radioactive ion beams

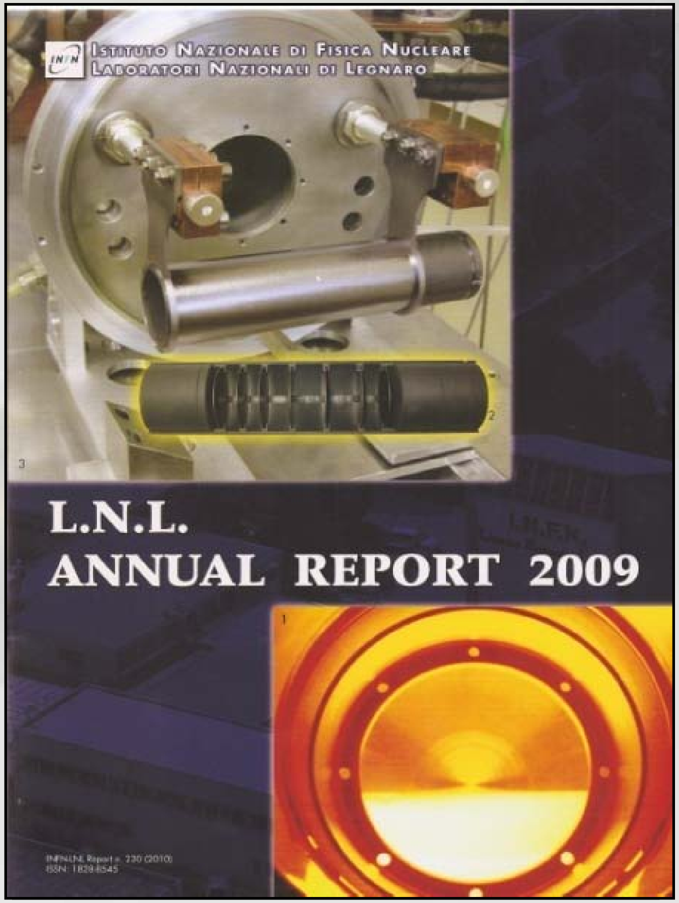
Mattia Manzolaro[a,b], Giovanni Meneghetti[a,*], Alberto Andrighetto[b]

Good news…

Collaboration with Universities



Some recent choices from LNL…



Since 2004:
32(!) thesis performed in the frame of target SPES activities

The SPES TIS group

The target-ion source group (February '10)