TISD activities in 2017/18

Sebastian ROTHE
EN-STI-RBS

ENGINEERING
DEPARTMENT

The Target and ion Source Development (TISD) team

T. Stora D. Leimbach J. Ballof F. Boix Pamies Y.Martinez J.P.Ramos S.Rothe

Providing a large choice of **intense** and **pure** radioactive beams

Constant development is required to keep ISOLDE at the forefront of RIB facilities

RILIS Team

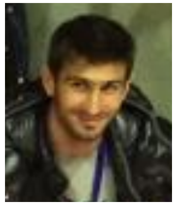
Valentin Fedosseev
Section Leader
EN-STI-LP

Bruce Marsh
Staff Member
EN-STI-LP

Fellow #2
CERN Fellow
Shane Wilkins
October onwards

Camilo Buitrago
CERN Fellow
April 2017 onwards

Katerina Chrysalidis
Doctoral student
Univ. Mainz



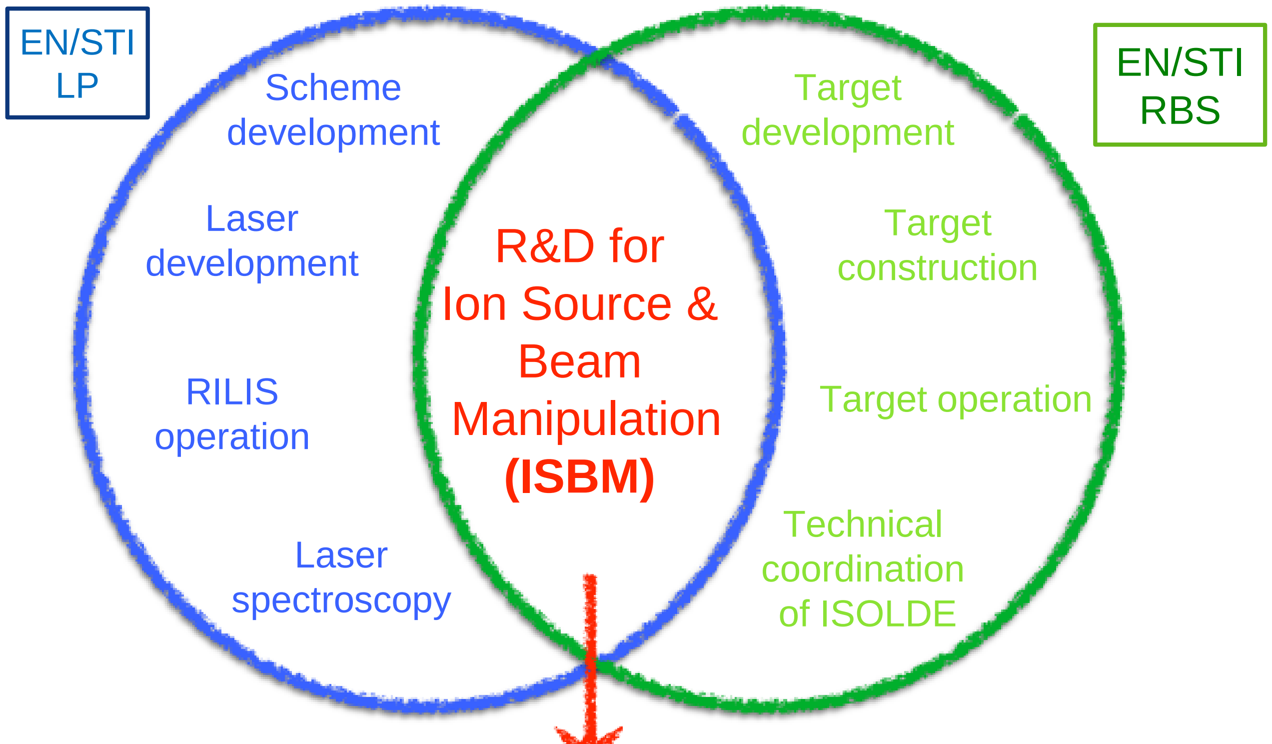
Pierre Larmonier
CERN VIA trainee

RILIS

Support from PNPI: Dima Fedorov, Pavel Molkanov, Maxim Seliverstov

LARISSA group: Dominik Struder, Reinhard Heinke

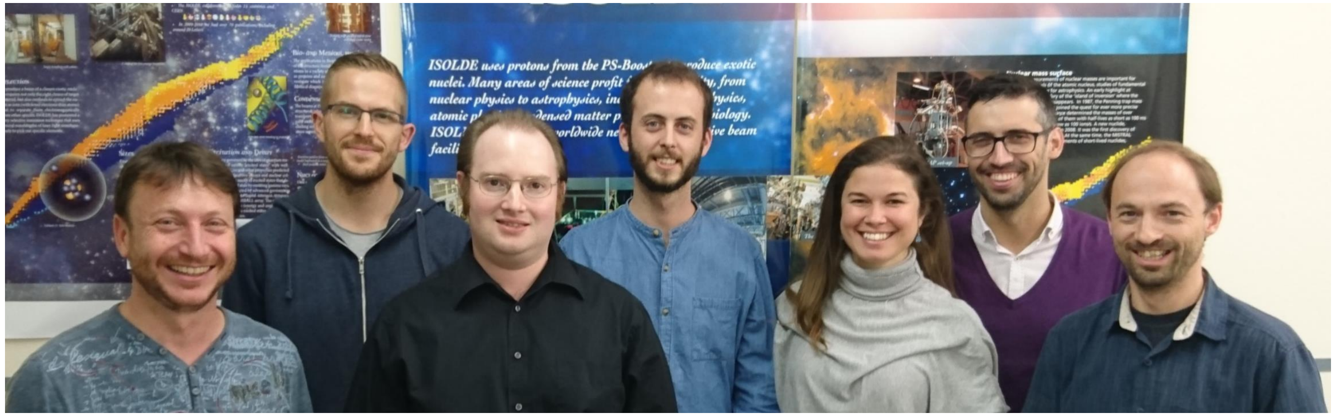
ISBM working group



Ongoing development projects

- LIST
- Development of refractory metal beams
- Ion source selectivity
- FEBIAD optimization
- VADLIS
- Optical pumping in ISCOOL
- ISCOOL upgrades
- ToFLIS
- Negative ion beams
- Fast beam gating
- Ion beam multiplexing
- HRS upgrade

Target and ion Source Development (TISD) mandate



Providing a large choice of **intense** and **pure** radioactive beams

Constant development is required to keep ISOLDE at the forefront of RIB facilities

- target and ion source units
- target materials
- beam interactions (p2n converter)
- ion source design / mode of operation shared with ISBM group

- yield & release study
- ion source efficiency measurements
- prototype tests

Sharing same resources as the ISOLDE physics program
- WORKSHOP: target unit production
- OFFLINE: target quality control
- ISOLDE: beamtime

Expected TISD @ ISOLDE (presented to GUI February 2017)

- Sc: Ti foils (CF4, RILIS)
- Te: yields with RILIS
- M(CO)x formation @ MEDICIS irradiation point
- ThO felt + Negative ion source
- LIEBE @ GPS-online
- STAGISO beam test
- Si from UCx
- TiC-CNT (pending safety clearance)

Expected TISD @ ISOLDE (presented February 2017)

• Sc: Ti foils (CF4, RILIS)	**DONE**
• Te: yields with RILIS	**DONE**
• M(CO)x formation @ MEDICIS irradiation point	**ongoing**
• ThO felt + Negative ion source	**ongoing**
• LIEBE @ GPS-online	**ongoing**
• STAGISO beam test	**DONE**
• Si from UCx	**ongoing**
• TiC-CNT (pending safety clearance)	**pending**

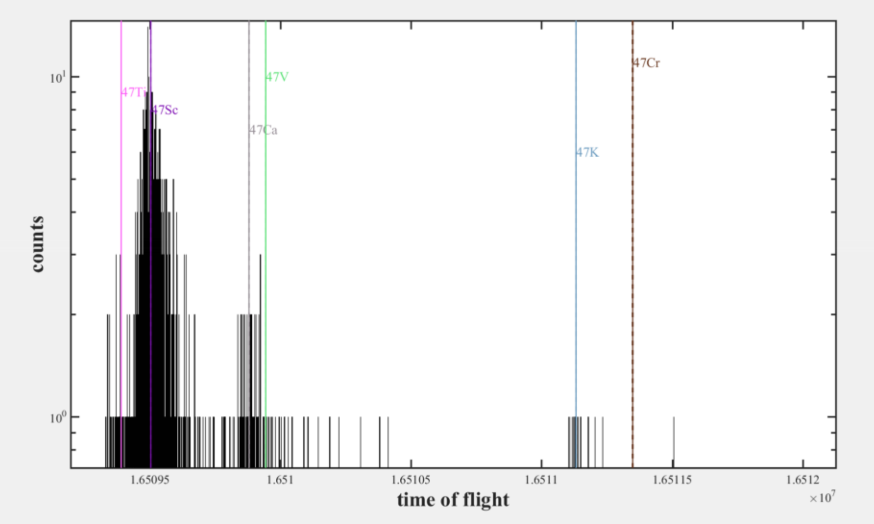
Scandium beams

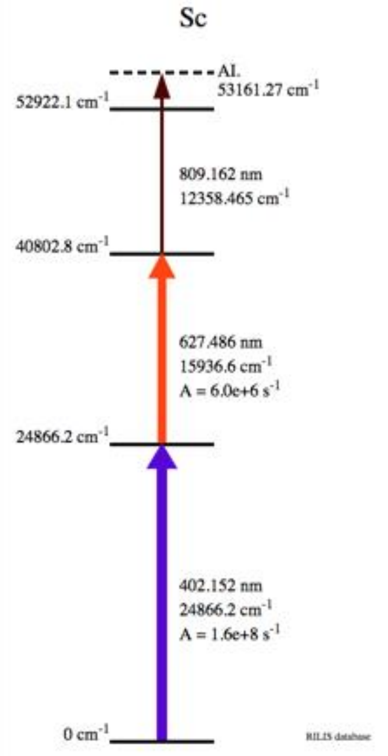
Target: **#565** Ta Ta

	^{43}Sc β^+=100%	^{44}Sc β^+=100%	^{45}Sc Abundance=100 %	^{46}Sc β^-=100%	^{47}Sc β^-=100%	^{48}Sc β^-=100%	^{49}Sc β^-=100%	^{50}Sc β^-=100%	^{51}Sc β^-=100%
FC				1.5E+07	1.2E+07	8.1E+06	7.3E+05		
betas							7.6E+05	1.8E+04	
MR-TOF				2.3E+06	1.6E+06	1.2E+06	7.4E+05	1.3E+04	
Extrap.	3.6E+05	1.2E+06							1E+02

RILIS

ISOLTRAP
MT-ToF spectrum



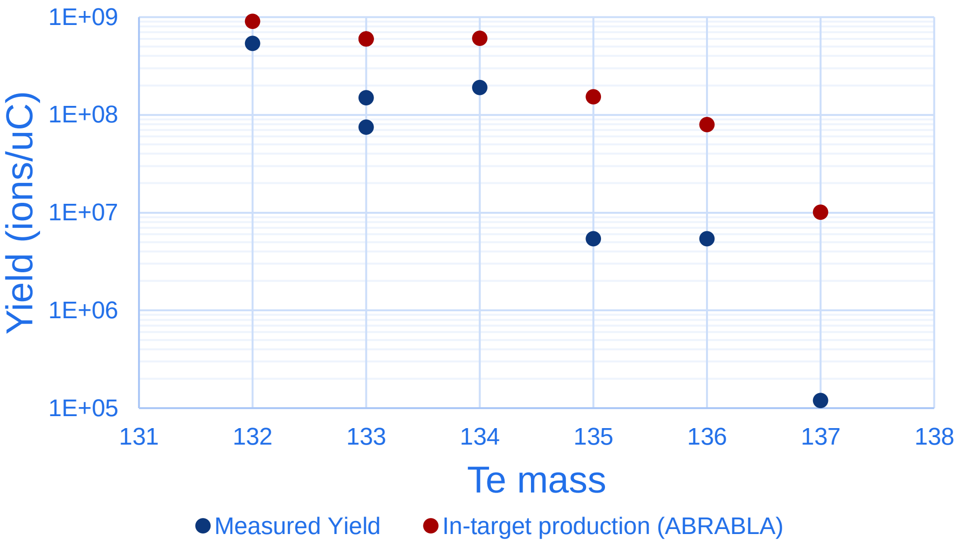


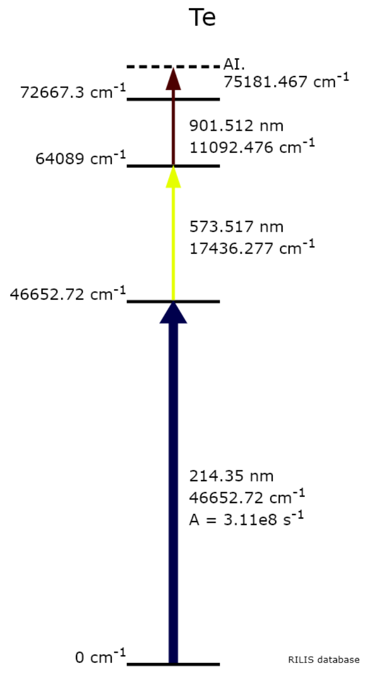
Mass scan (FC.558)

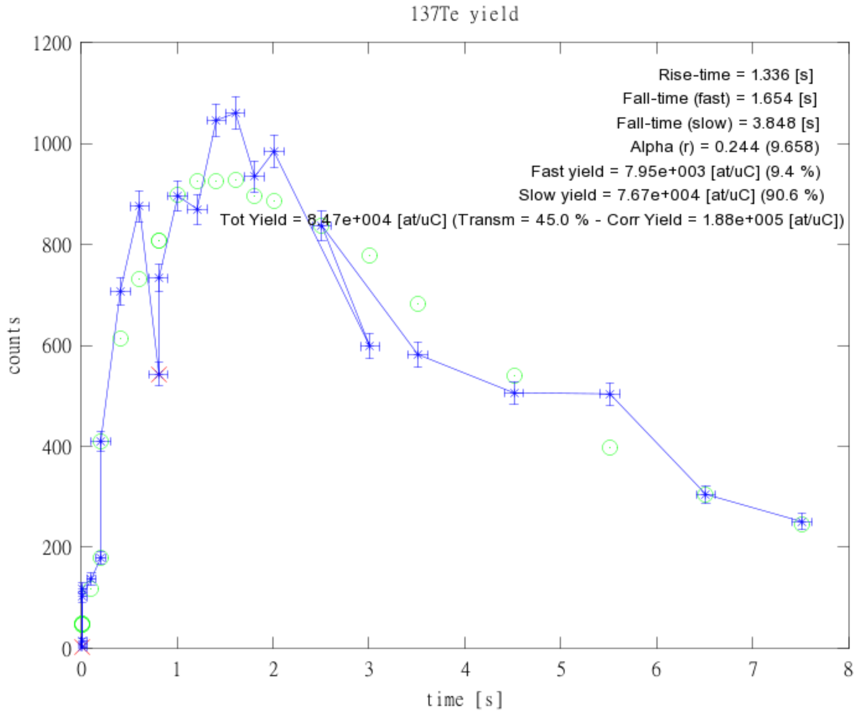
Tellurium beams

Target #601 UC n

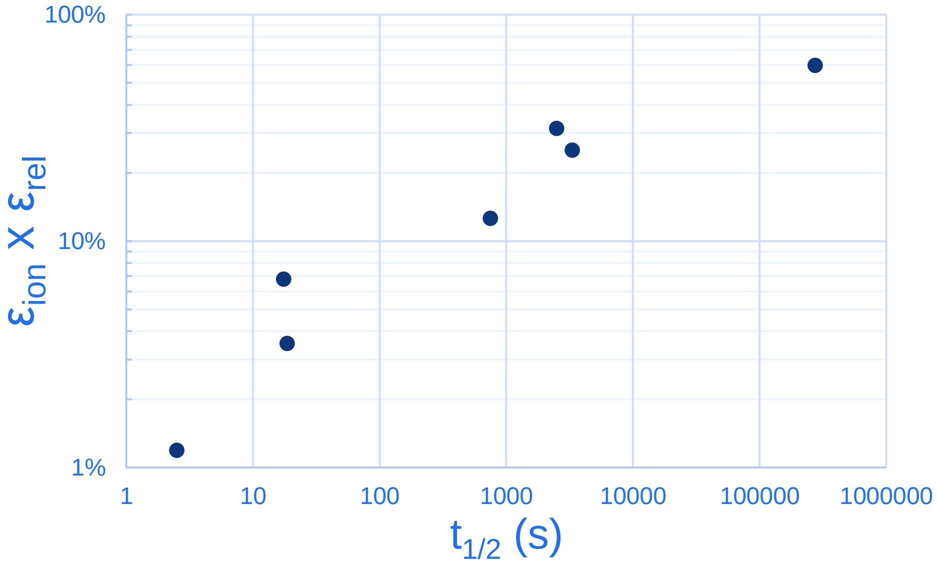
A (Te)	t1/2	Te Yield	Cs yield	t1/2	A (Cs)
132	76.3	5.40E+08		6.47 d	132
133	12.5 m	7.50E+07		stable	133
133m	55.4 m	1.50E+08		stable	133
134	41.8 m	1.90E+08	1.10E+09	2.90 h	134m
135	18.6 s	5.40E+06	5.50E+08	53 m	135m
136	17.5 s	5.40E+06	5.30E+08	19 s	136m
137	2.5 s	1.20E+05		30.17 y	137







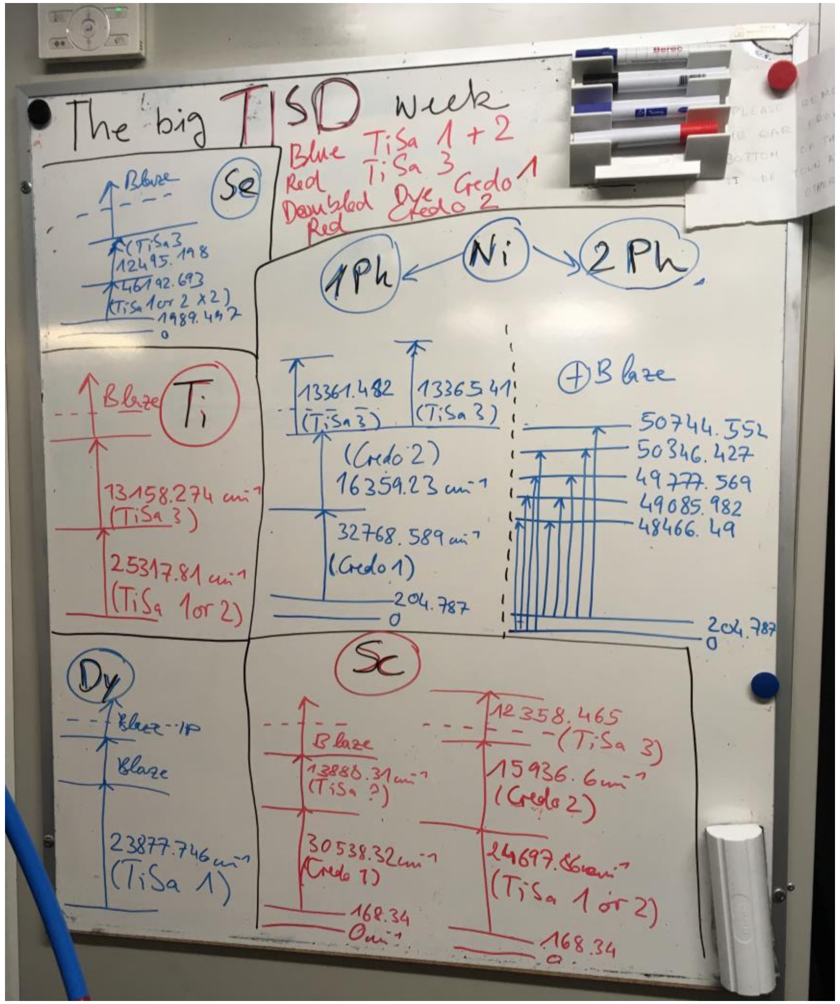
Total efficiency = Ionization efficiency x release efficiency

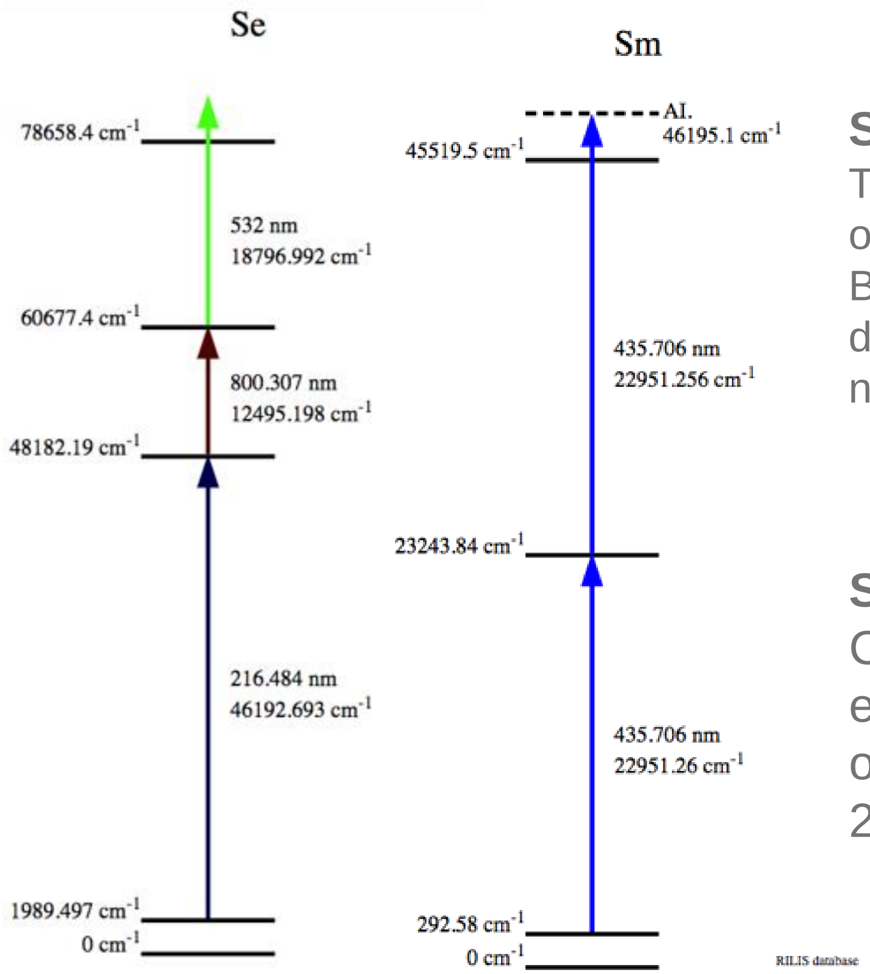


J.P. Ramos, S. Rothe, et al.

5 RILIS elements in one week: new record!

Titanium
↓
Scandium
↓
Dysprosium
↓
Scandium
↓
Selenium
↓
Dysprosium
↓
Nickel



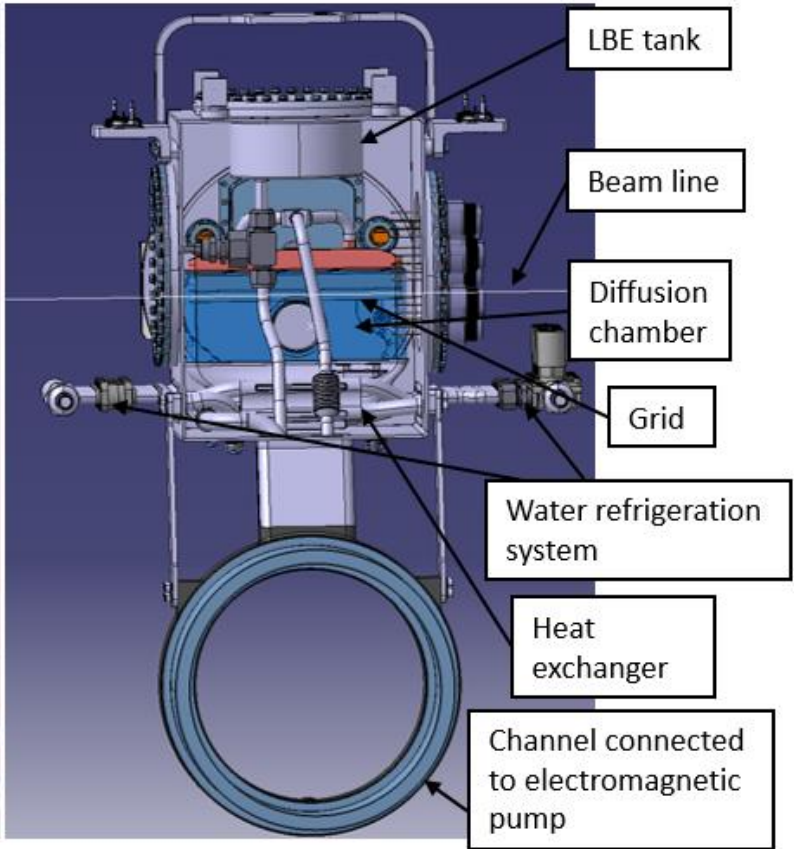


Selenium
Tested
on-line
But further beam development needed

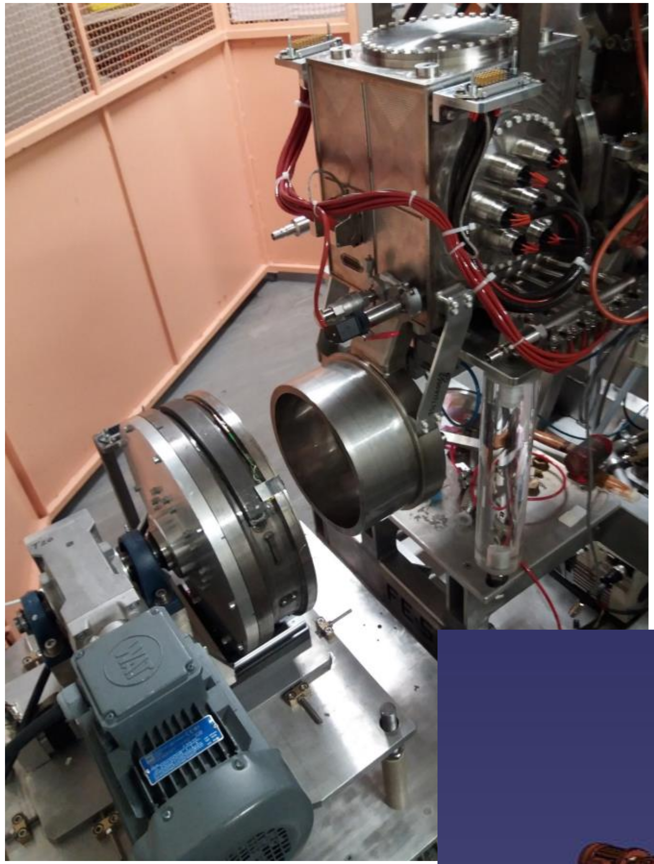
Samarium
Convenient
efficient
one-laser
2-step scheme

B.Marsh

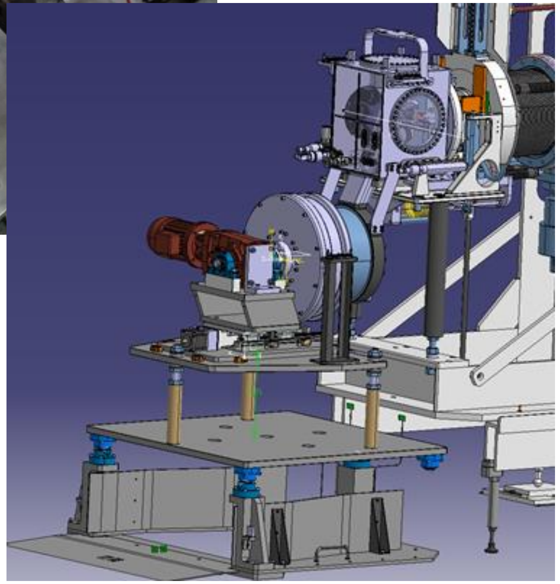
The LIEBE target – Assembled



LIEBE loop before enclosement.



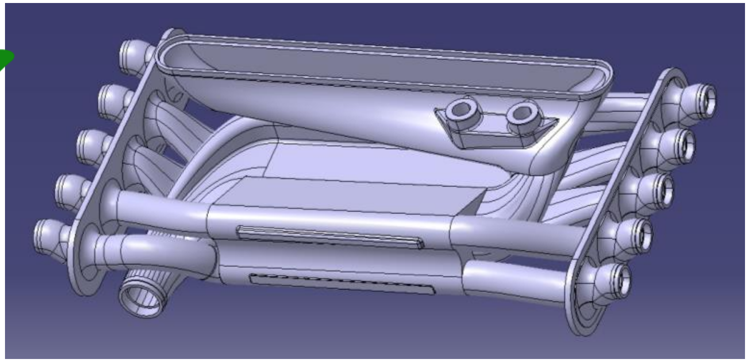
LIEBE fully assembled and coupled to offline 1

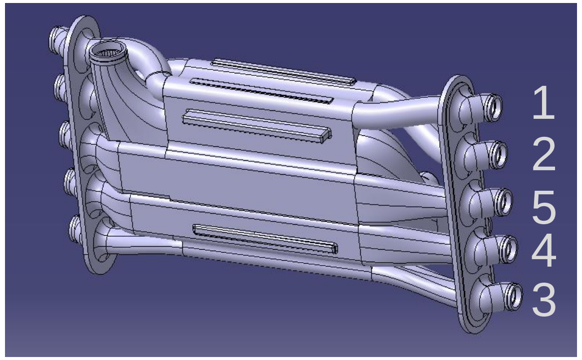


F. Boix Pamies

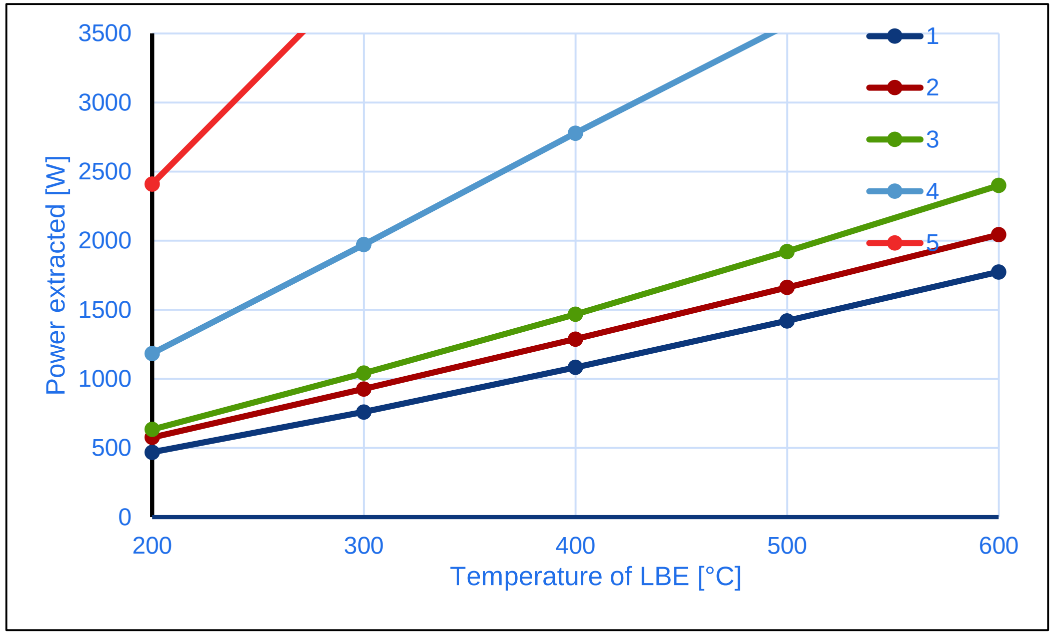
The LIEBE target – Offline tests

- Offline tests:
  - Leak tests
  - Vibration tests
  - **Heat exchanger calibration**
  - Ion source test





3D model of the heat exchanger, 5 water channels to cope with 5 different temperatures.

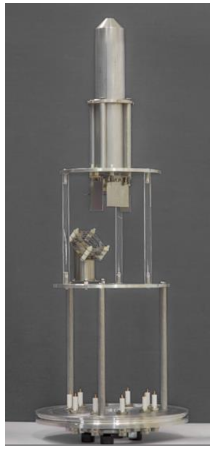
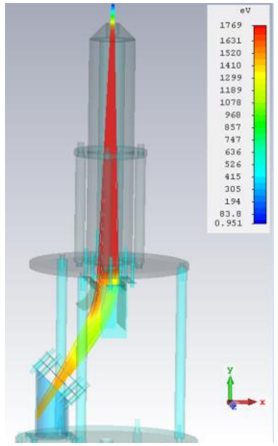


Ansys CFX simulations of heat exchanged for every water channel.

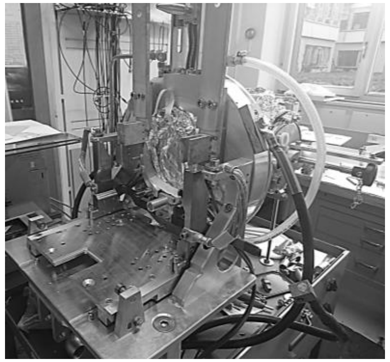
- Offline tests 6th-10th November
- Operational review 3rd week of November
- Target to be installed at GPS end of November

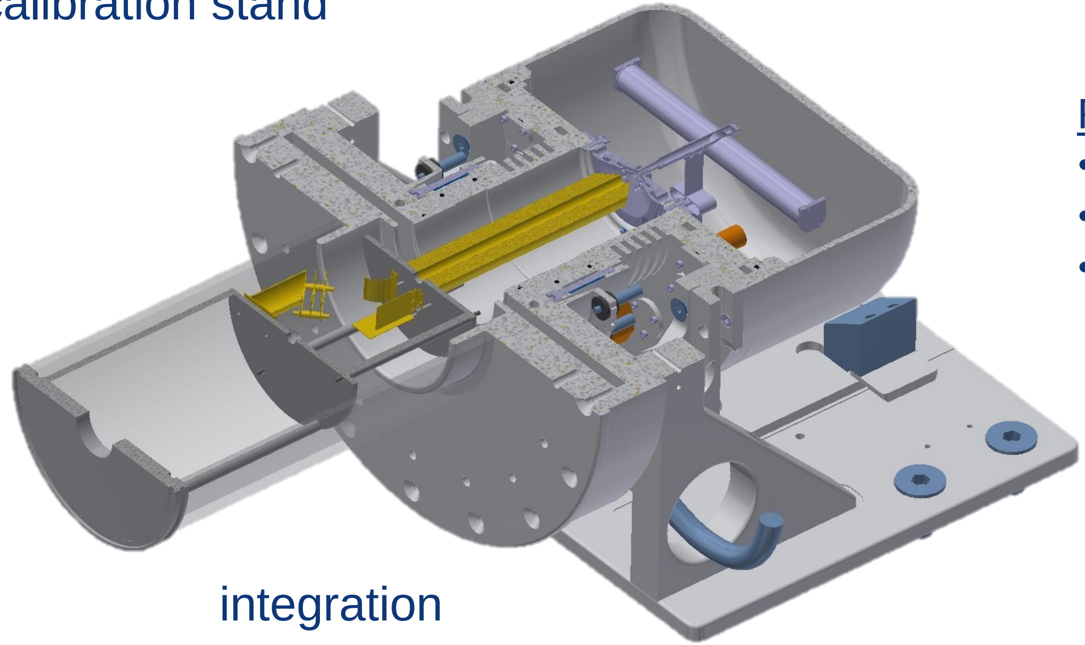
F. Boix Pamies

Dedicated test stand for ion source development

ISOLDE calibration stand





integration

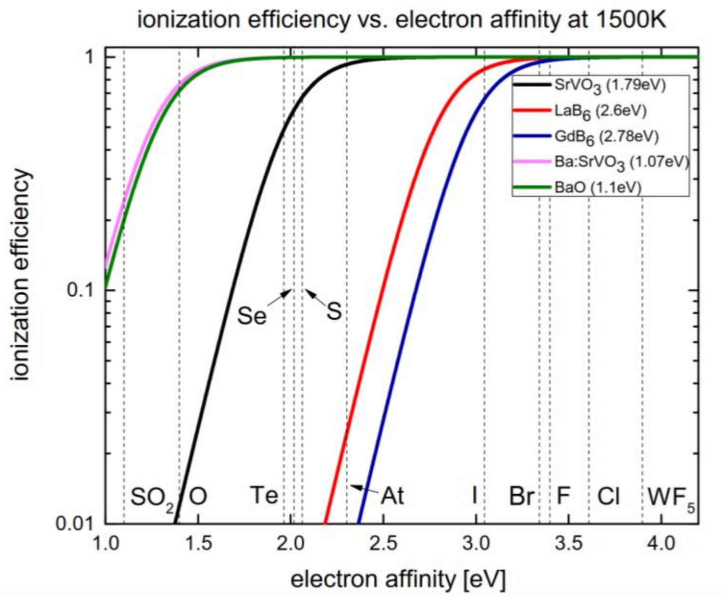
<u>Main features</u>:
- ion **beam extraction** and detection
- residual gas analyzer (RGA)
- **automated control and data recording (LabVIEW)**

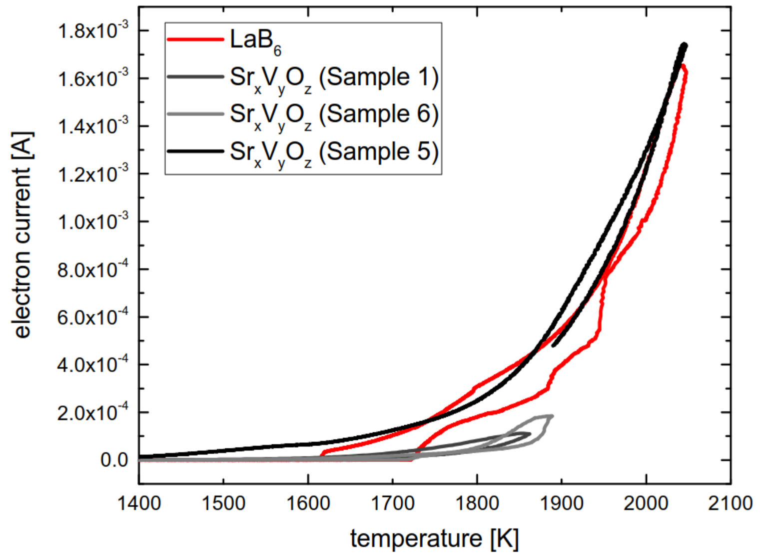
<u>First application:</u>
- **negative ion source** development
- investigation of source poisoning and regeneration

<u>Future plans:</u>
- long-term performance studies
- thermal stress tests
- destructive tests
    - **operational limits**
    - **failure mode analysis**

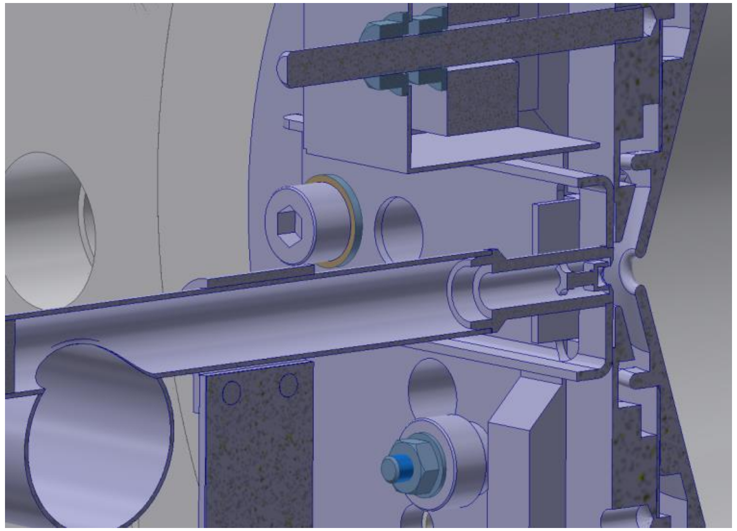
D.Leimbach

Low work function materials for negative ion production

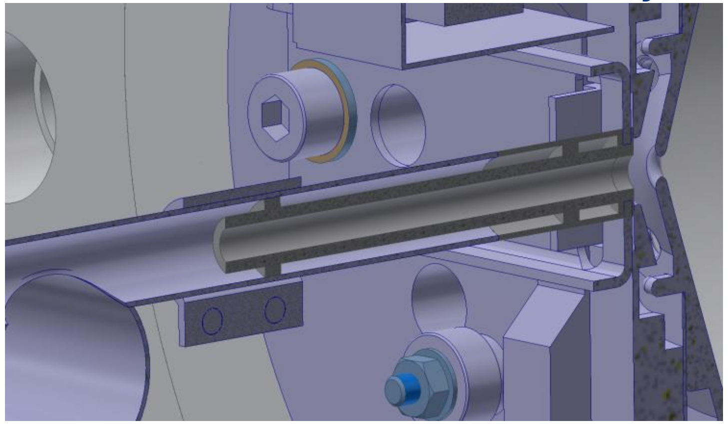




MK4 – Pellet source



Tubular low workfunction cavity



Improvement of ionization efficiency:

- Elements with low affinities are not efficiently ionized by LaB_6
- New compounds needed:
  - $SrVO_3$ with expected work function <2eV

First steps:

- Production of suitable candidates
- Electron emission tests with LaB_6 as benchmark
- Performance studies

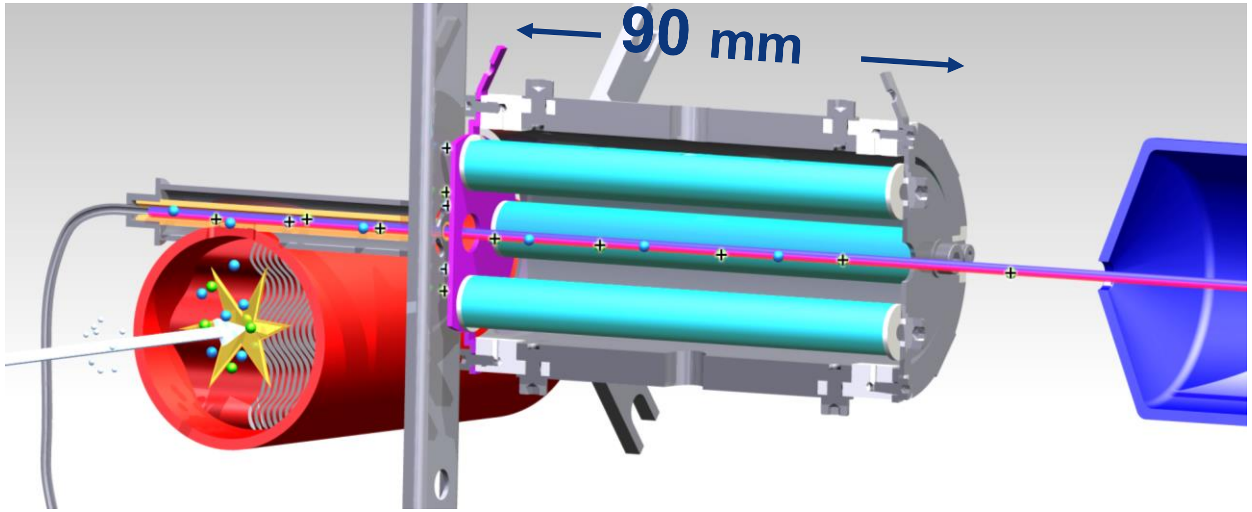
Next steps:

- Compare geometries offline

D.Leimbach

LIST

HFS studies of polonium / supression of francium (IS456, September 2012)



JOHANNES GUTENBERG UNIVERSITÄT MAINZ

JG|U

RILIS

Bundesministerium für Bildung und Forschung

R.Heinke

Isobaric suppression > 1000, efficiency loss ≈ 50

On-line implementation and first operation of the Laser Ion Source and Trap at ISOLDE/CERN, D. Fink et al**.**, **NIMB 344**, 83-95 (2015)

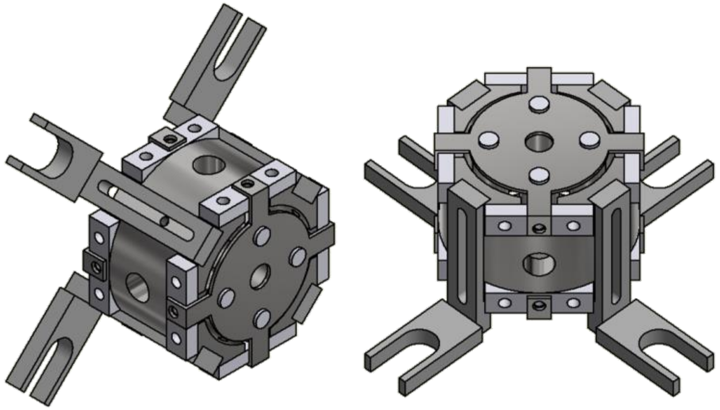
In-Source Laser Spectroscopy with the Laser Ion Source and Trap: First Direct Study of the Ground-State Properties ^{217,219}*Po*, D. Fink et al., **PRX 5**, 011018 (2015)

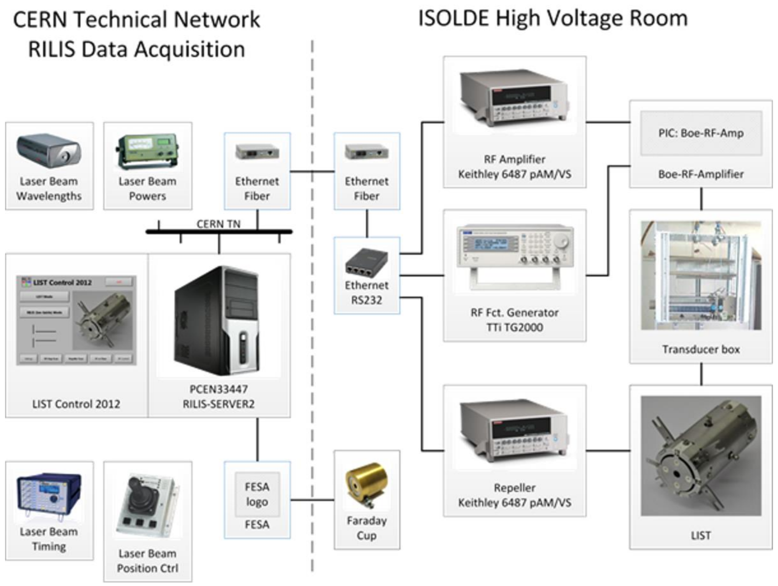
LIST 2018

- Obtained technical drawings from Larissa Group Mainz

  https://edms.cern.ch/document/1400724/1

- LIST 2.0 assembly will be provided from Mainz
- To be verified: status of RF cable at GPS
- LIST control system: replicate 2012 setup

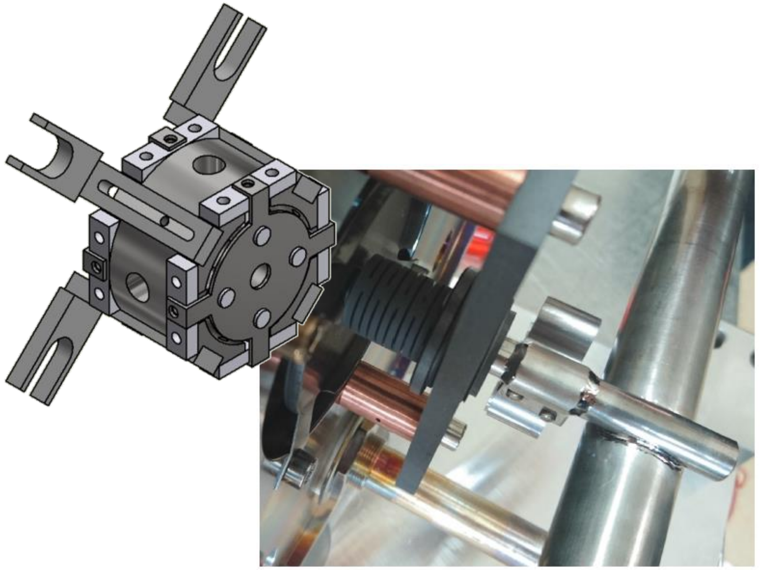


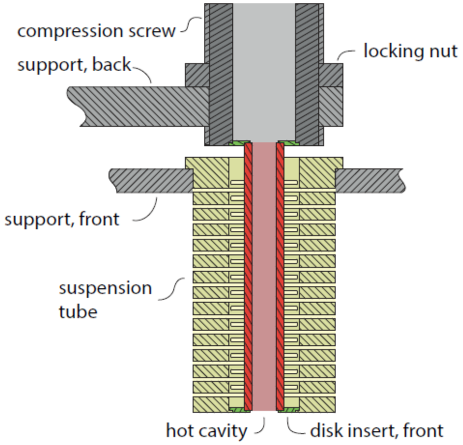


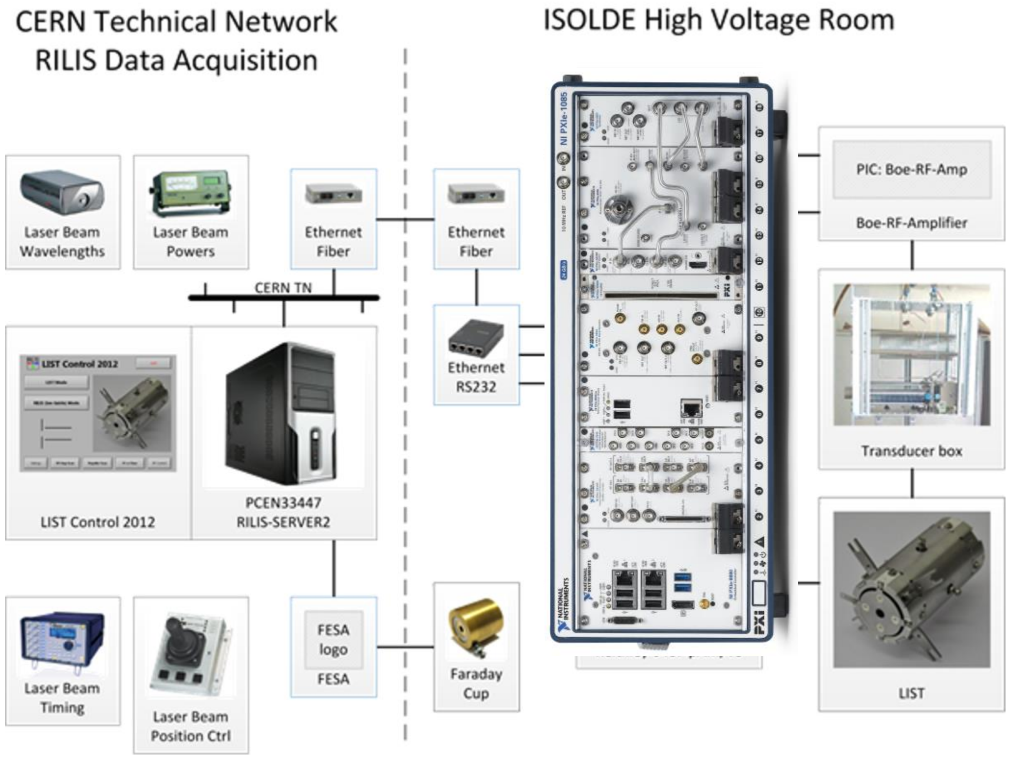
R.Heinke

LIST Development (LS2)

- Full integration to ISOLDE infrastructure
- Fast line heating inversion
- Connection to quartz transfer line
- Connection to ToFLIS project



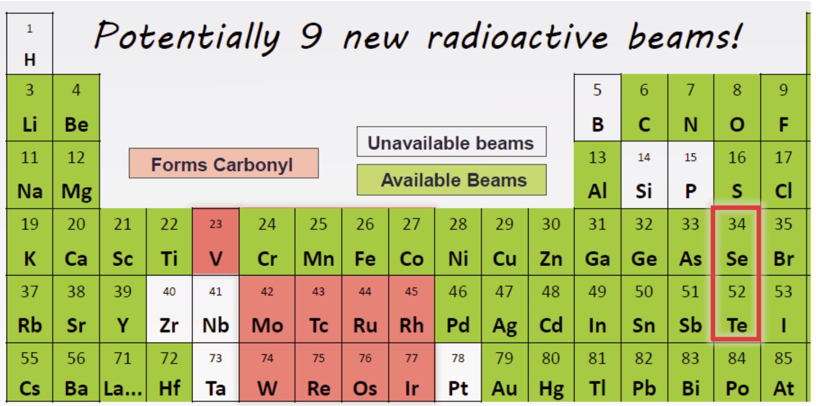




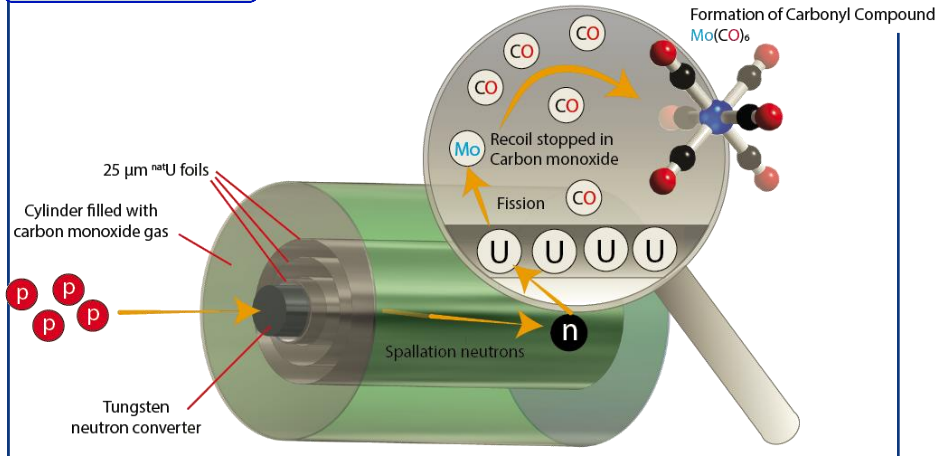
Volatile Carbonyl Compounds for New Refractory Beams at ISOLDE

J. Ballof[1,2], C. Seiffert[1], Ch. E. Düllmann[2,3,4], J. P. Ramos[1], S. Rothe[1], T. Stora[1], A. Yakushev[3,4]

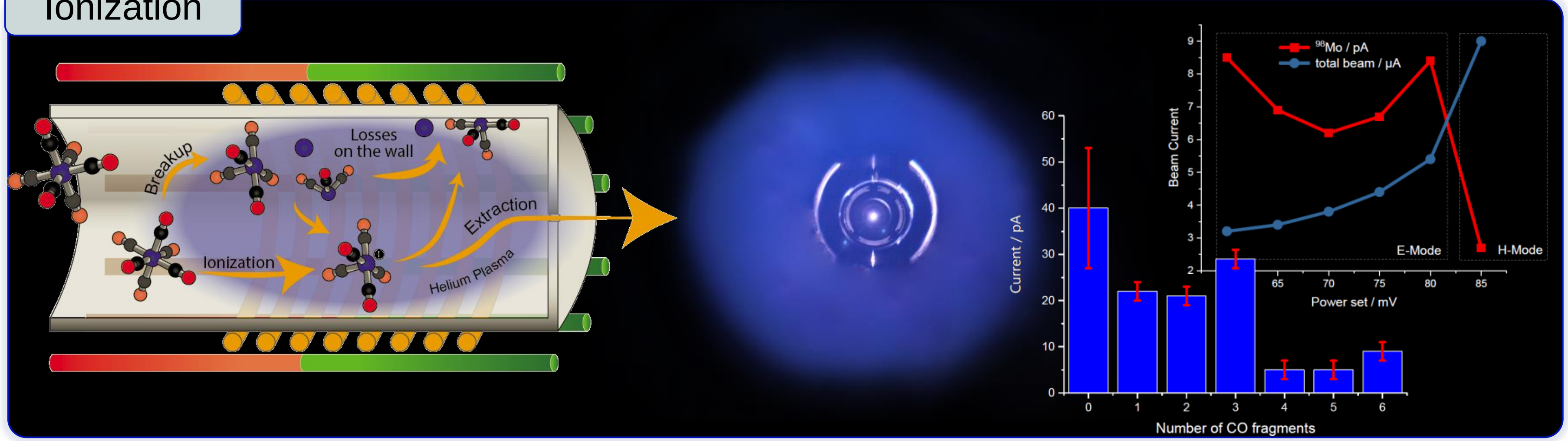
Motivation



Production



Ionization

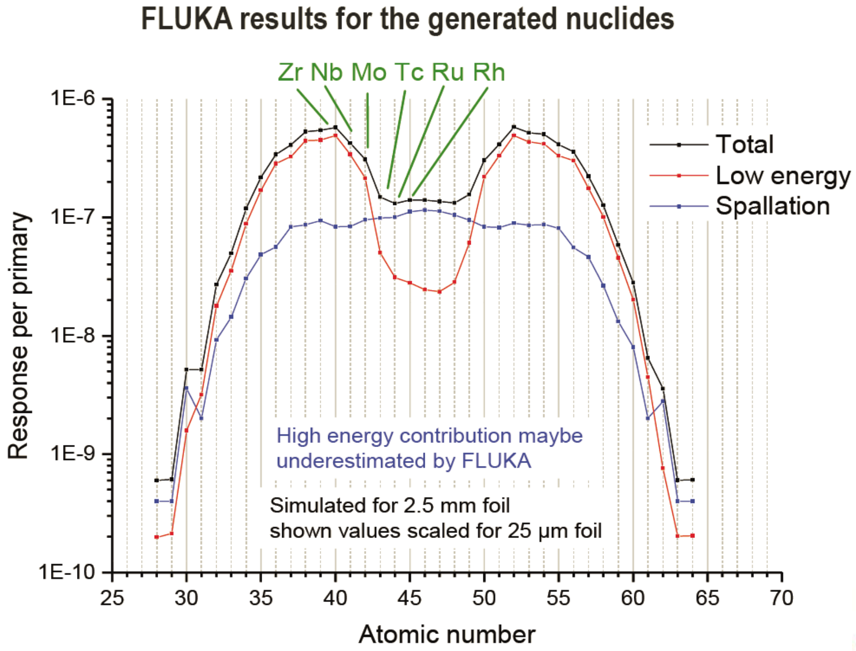


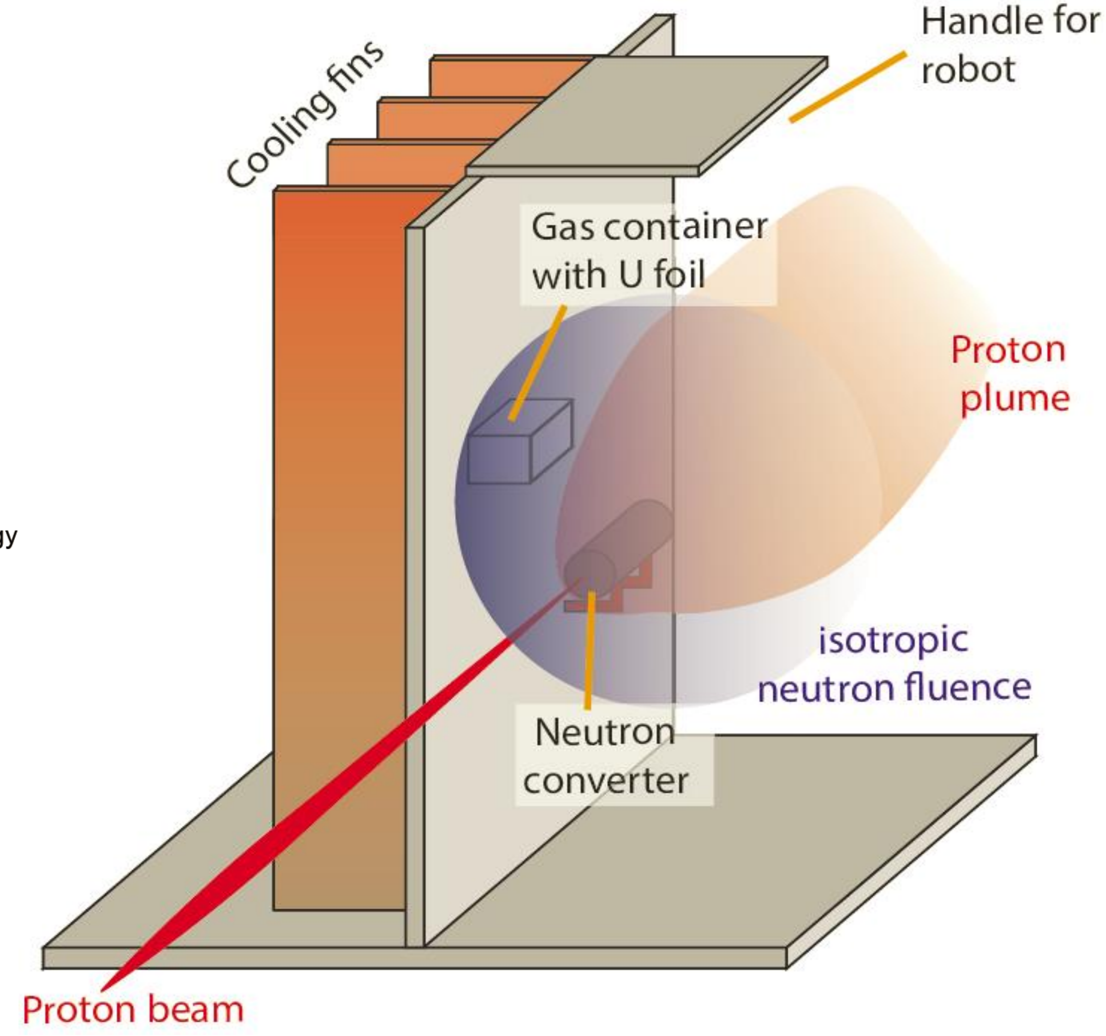
J.Ballof

Up next

Irradiations at MEDICIS

→ carbonyl formation and Stability at ISOLDE





J.Ballof

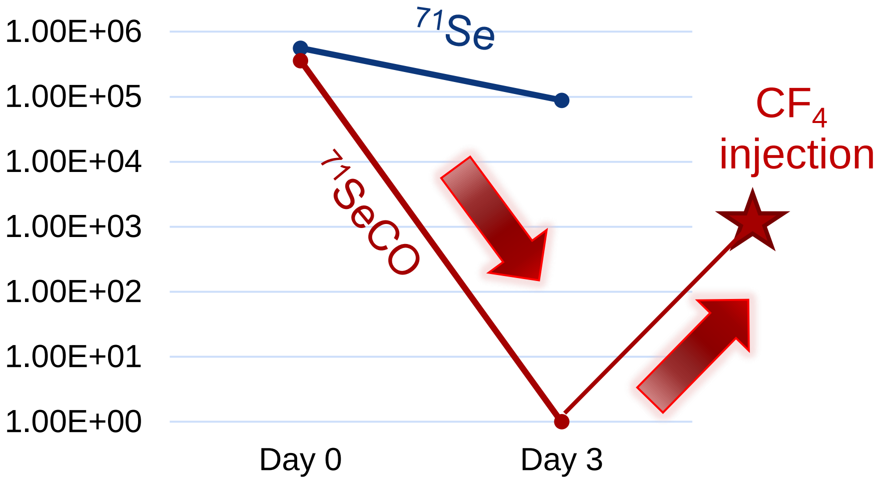
Neutron deficient SeCO beams

Principle: $Se + CO \rightarrow SeCO$

Shifting the mass to get pure beams

Beam available since many years.

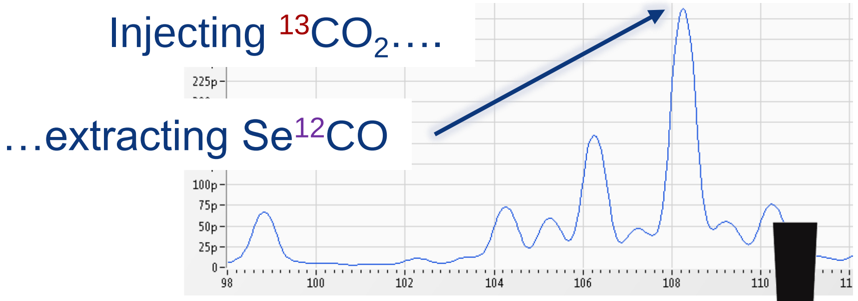
but….



- SeCO gone after a few days
- Atomic Se still released after days

Target #605 and #612
Zirconia fibers, stabilized with ca. 10% Yttria

Why does SeCO disappear, even if we inject CO_2?



Injected CO_2 gas does not promote SeCO formation!

What's the source of carbon?

Carbon from the ion source?
-> Placed graphite grid, but still depleting

Carbon from the target material?
-> EDS (preliminary) shows no carbon in ZrO fibers

Indications, that CF_4 gas might serve as carbon source. Work in progress.

J.Ballof

Boron fluoride beams

Principle: $B + 3\,F \rightarrow BF_3$ *Volatilization of refractory boron by injection of SF_6 gas*

First prototype #499

- Small gas leak (3.7e-5 mbar L / s)
- Absence of TaF_x and SF_x in mass spectra

→ Unit did not produce BFx beams
no fluorine saturation

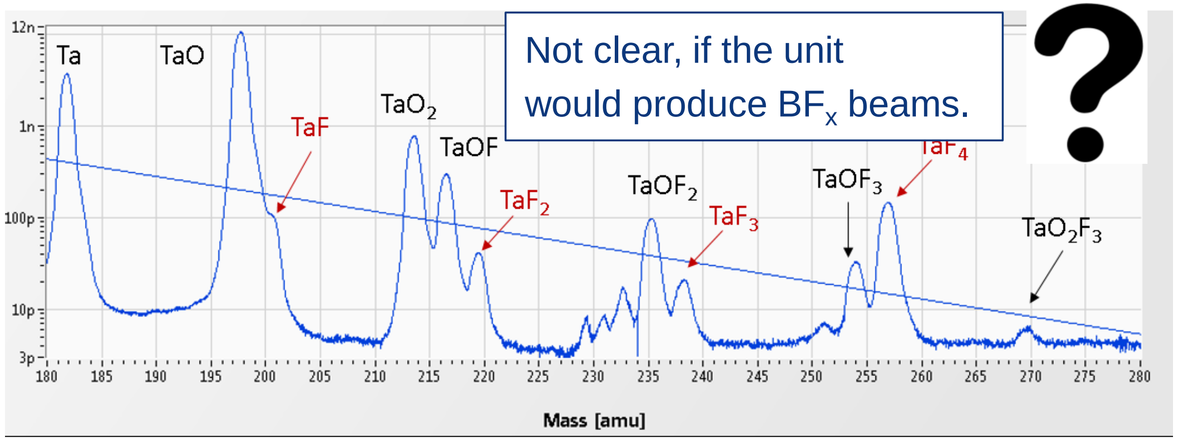
Second prototype #513

- Increased leak (1.84e-4 mbar L/s)
- Strong TaF_x and SF_x peaks
- No TaO peaks

→ Stable and intense 8BFx beams

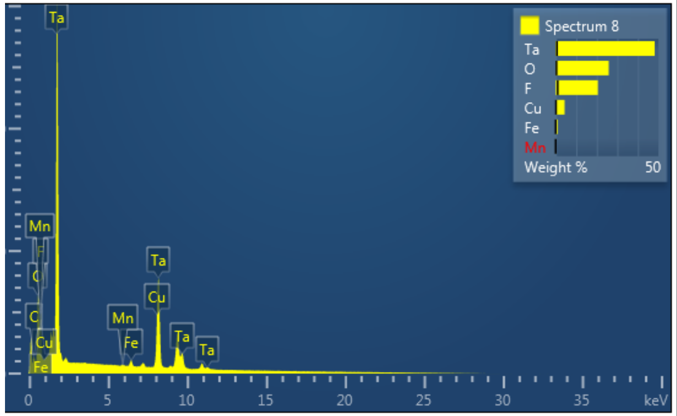
First production unit #606

Despite high injection,
low fluorination, and presence of oxygen. H_2O or air leak?



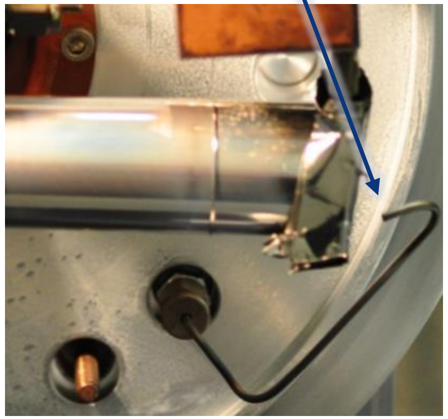
Not clear, if the unit would produce BF_x beams.

?



TaO_xF_y deposits in target

Gas line rupture



Ion source simulations: VSim

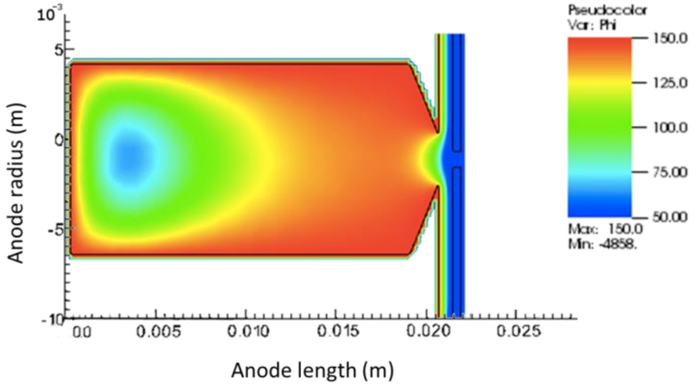
RILIS

VSim
TECH-X
SIMULATIONS EMPOWERING YOUR INNOVATIONS

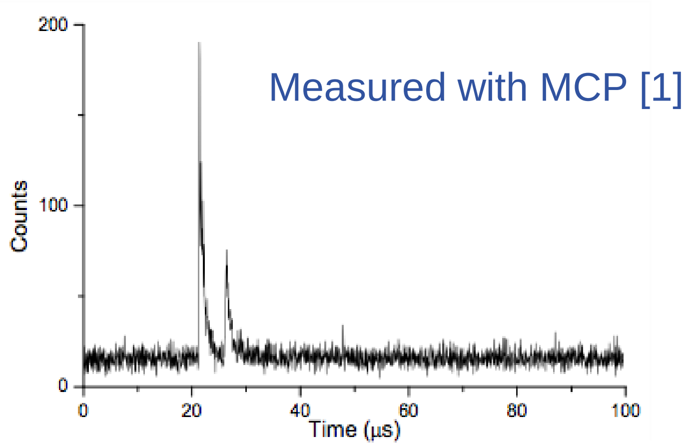
Is a flexible, multiplatform, multiphysics software tool for running computationally intensive electromagnetic, electrostatic, magnetostatic, and plasma simulations in the presence of complex dielectric, magnetic, and metallic shapes.
(https://www.txcorp.com/vsim)

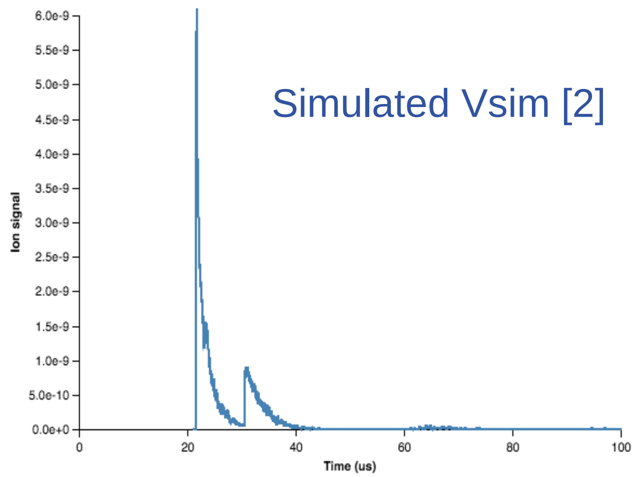
1 kCHF per core / year
License purchased for 2016/17

Goal: Full Simulation **VADIS ion source**



- 1st reproduction of electrostatic field distribution inside the VADIS using PIC code



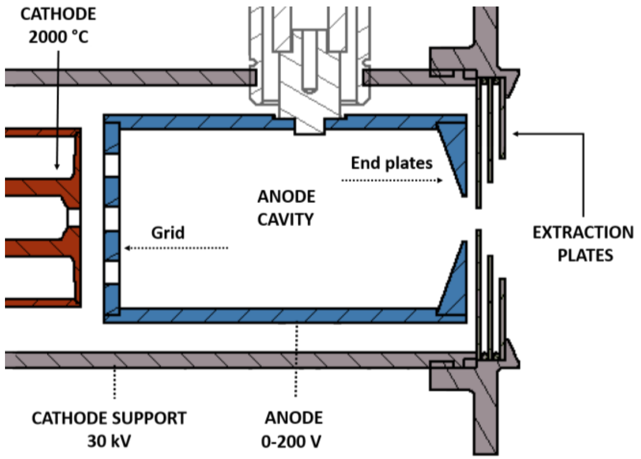


[1] T. Day Goodacre et al., NIM B 376, 39 (2016). [2] *Y. Martinez et al. In preparation.*

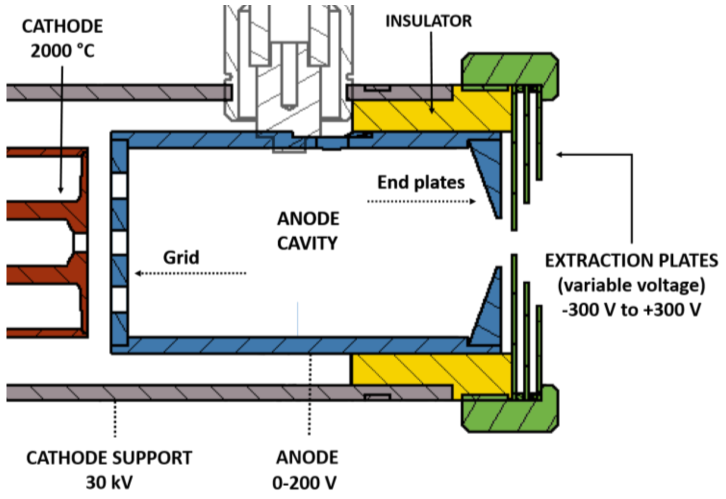
Y.Martinez

VADIS / VADLIS developments

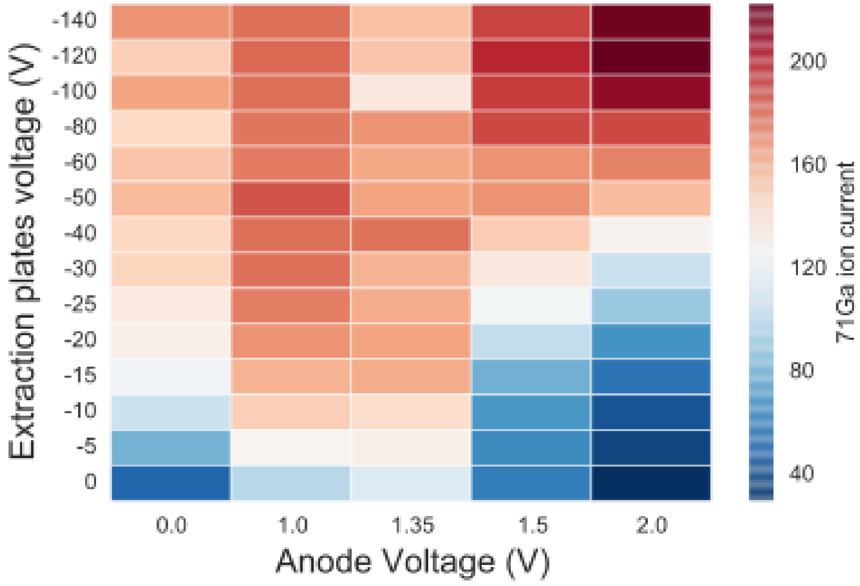
Standard VADIS



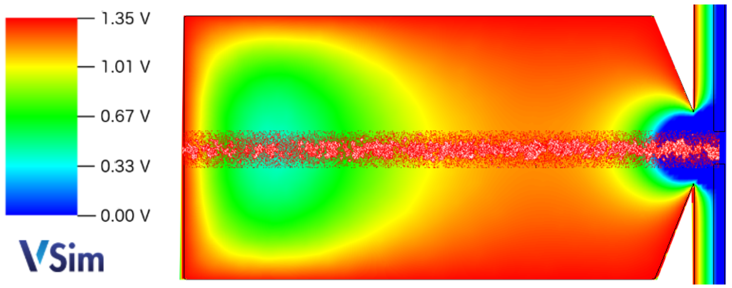
VADIS Dev. [2]



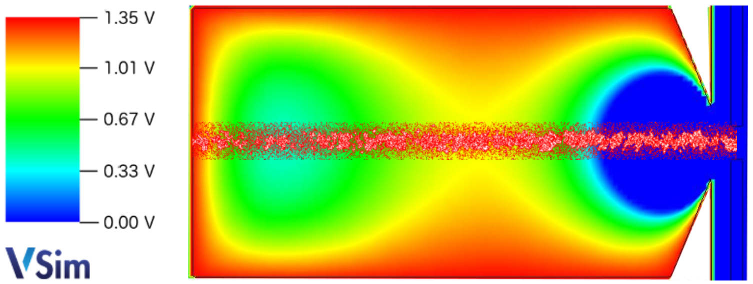
2D voltage scan (RILIS mode)



Extraction plates 0 V



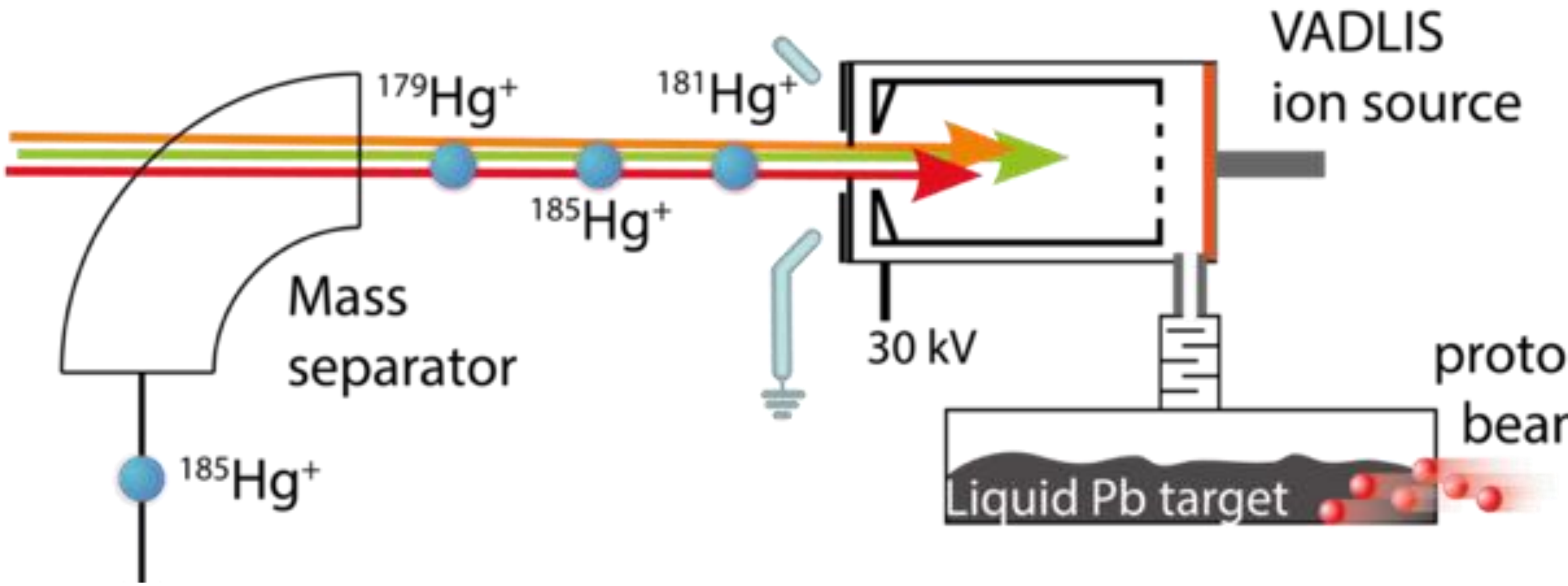
Extraction plates -100 V



Y.Martinez

[2] *Y. Martinez et al. In preparation*

Clean ^{206}Hg beams with VADLIS



- 3^{rd} on-line application of VADLIS ion source for an experiment
  - (full Hg chain for in source laser spectroscopy; Mg + Ne for ISOLTRAP, 206Hg for Miniball)
- RILIS–mode achieves similar efficiency to VADIS-mode

- Note: RILIS-mode efficiency is expected to improve by at least **2 x** if the adjustable-extractor VADIS is used.

B.Marsh

VSim - Future

Suggestion:

- **Continue licensing** of the software. Different models available.
- **Extend simulations** to negative ion source and plasma source (David, Jochen)
- Purchase **dedicated server** hosted by EN-STI-RBS
- Endorse **collaboration** with SCK.CEN and VSim users at CERN.
- Organize ISOL related User meeting

VAD(L)IS - Future

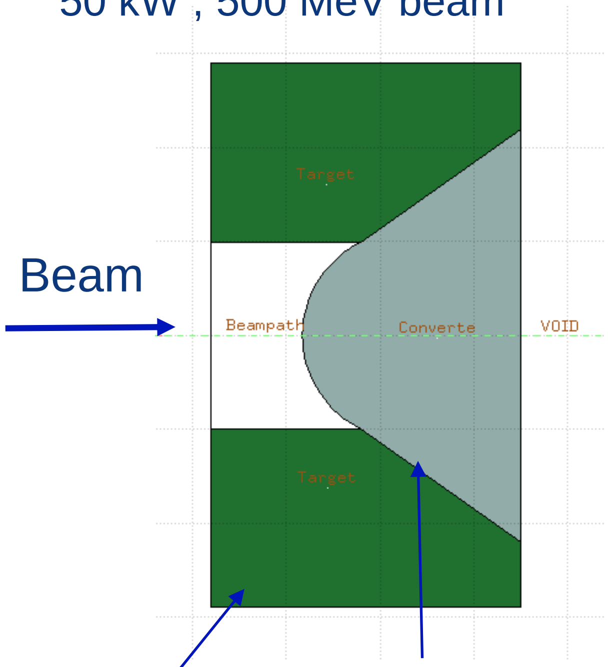
- Continue development & simulations (separate grid electrode, geometries, assembly)
- Validate development steps both offl-ine and on-line
- Extract Negative ions (speculative)

p2n-converter development (as Presented in previous GUI)

Within CERN-TRIUMF MoU + SCK-CEN

50 kW , 500 MeV beam

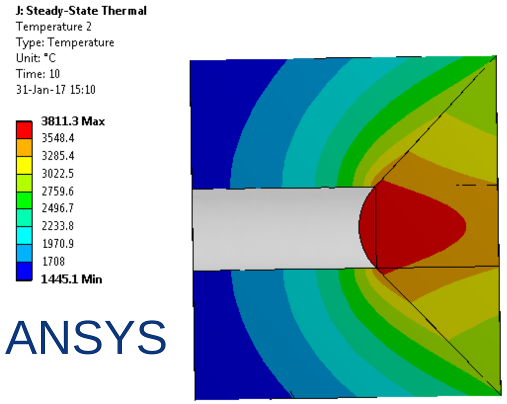
Beam



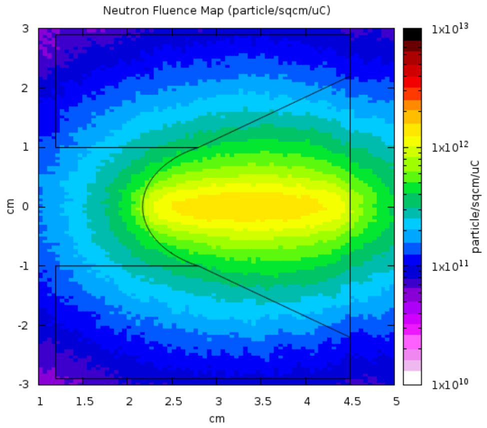
UCx

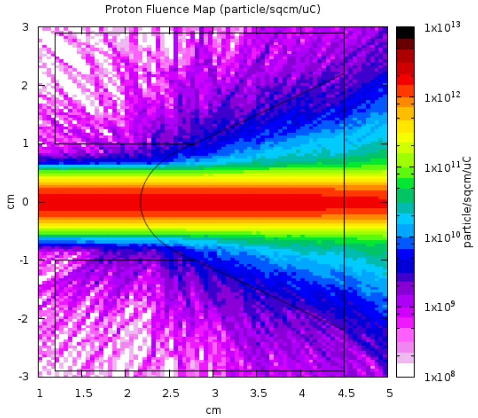
Converter

ANSYS



FLUKA





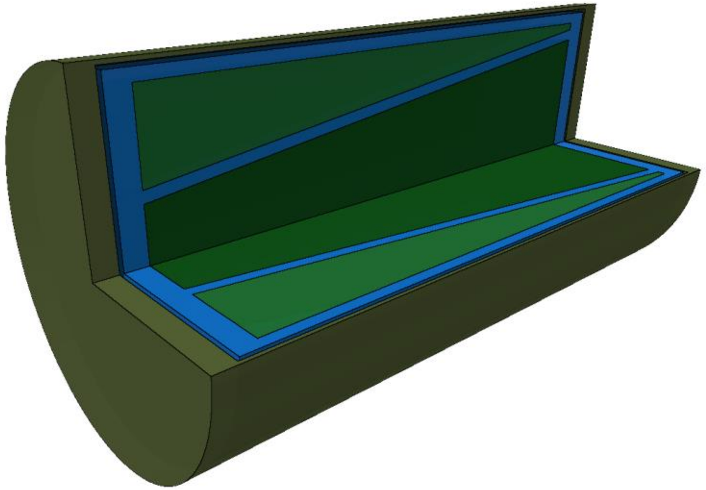
- Project Started in December
- Weekly meetings with CERN/TRIUMF/SCK

Preliminary time line:

Apr-2017	Sep-2017	Jan->May-2018	?-2018	Aug->Dec-2018
Concept	Design + Offline Tests	Prototype ready	**ISOLDE test**	TRIUMF tests

J.P.Ramos

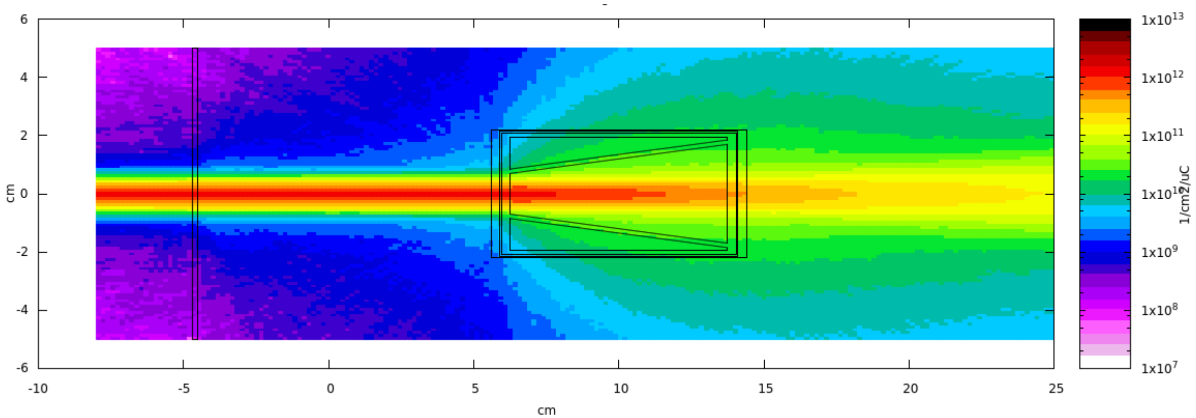
ISOLDE neutron converter design



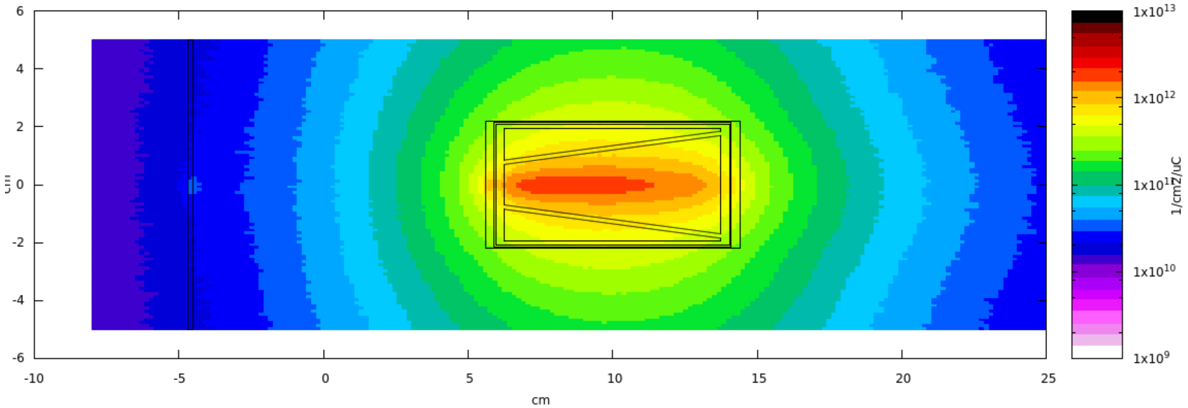
Done:
- Systematic FLUKA simulations for geometry optimizations

At the moment:
- Thermomechanical simulations of the larger oven
- Procurement of materials
- mechanical design of prototype

	New	Old
n-ind fissions (/s)	2.79E**11**	4.55E**10**
p-ind fission ratio	10.8%	16.1%
Deposited Power	690 W	553 W
UCx Volume	60 cc	30 cc



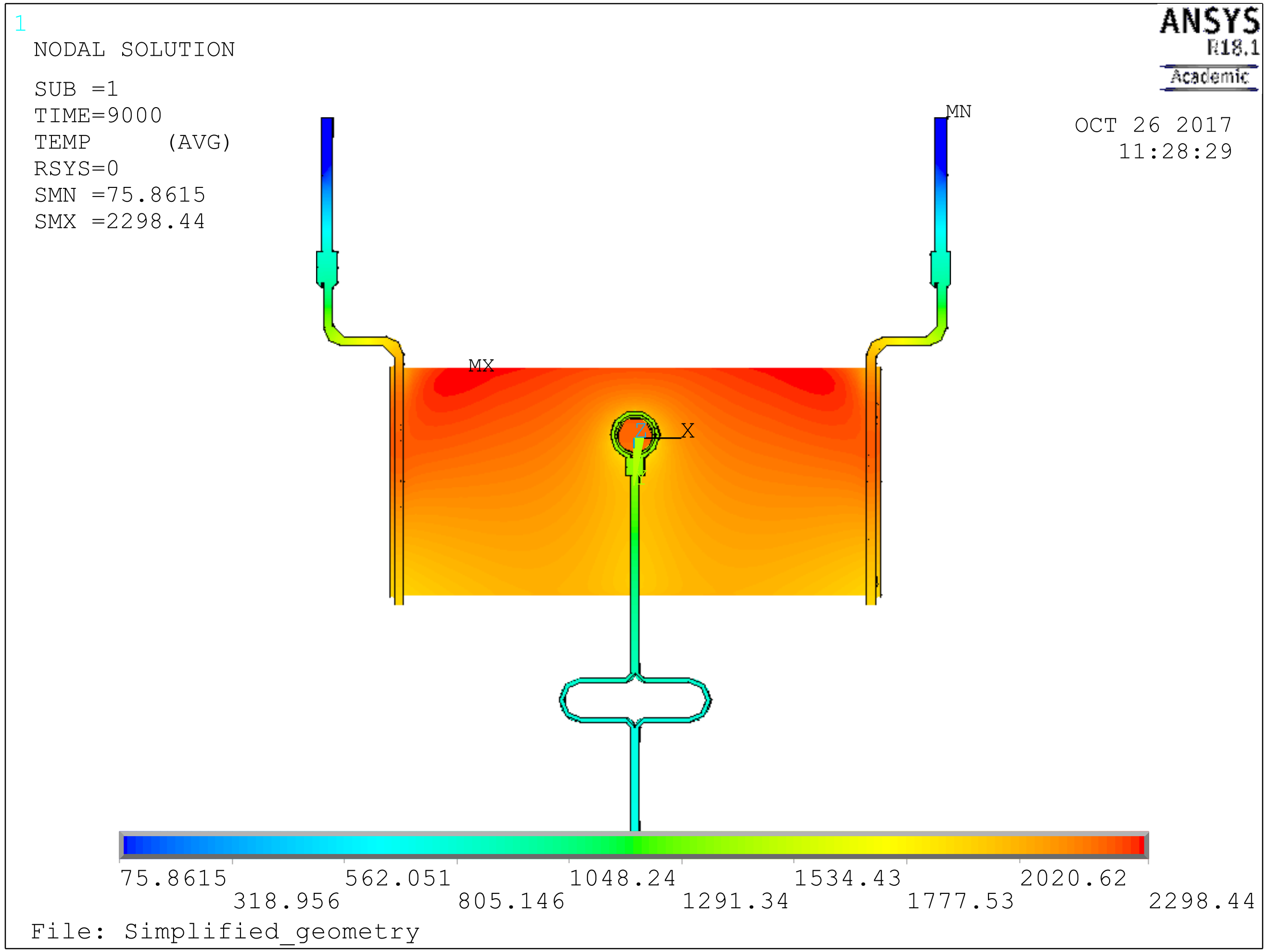
Proton fluences

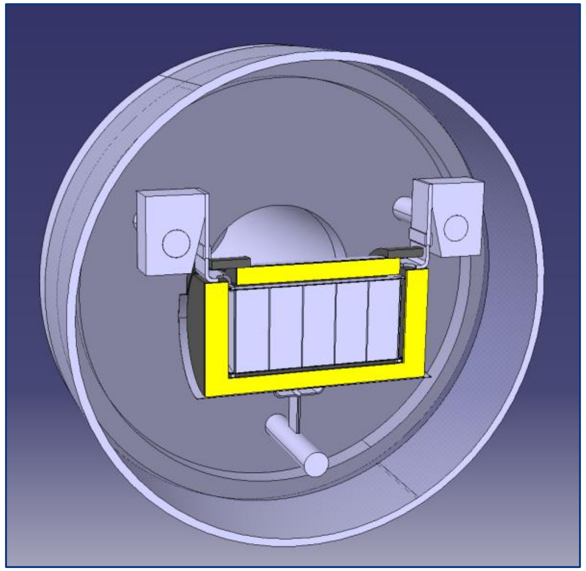


Neutron Fluences

Main challenges: **Large oven to heat up** and electrical **insulate tungsten from oven current**

FEM model p2n Target: container temperature (1000 A)





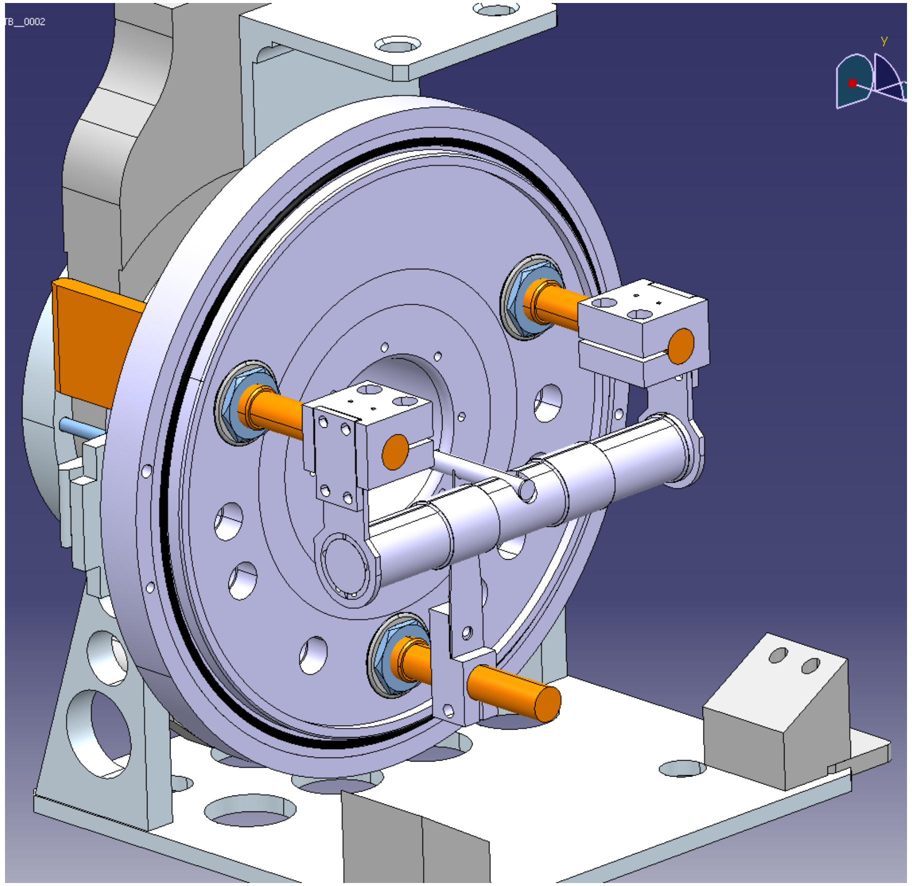
- Container outer diameter: 51 mm
- Container thickness: 0.25 mm
- SGL® **SIGRATHERM thermal screen**: 10 mm
  - https://edms.cern.ch/document/1128002/1
- Mo thermal screen: 0.2 mm

To be used for **MEDICIS target** and potentially for p2n target at TRIUMF

M. Ballan, INFN

S. Marzari

Optimize Target heat screens

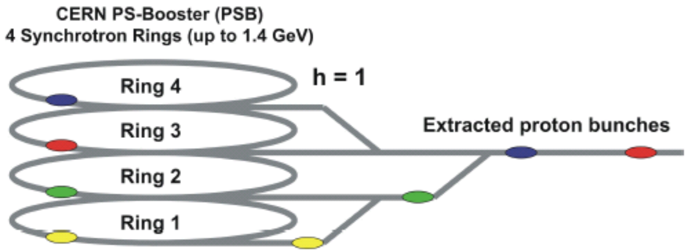


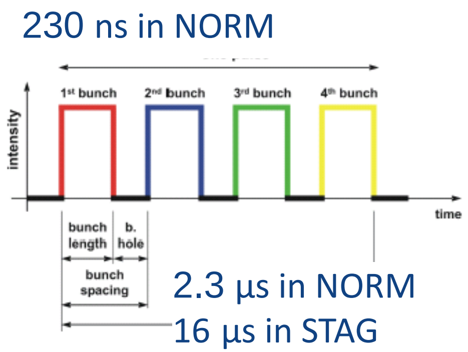
- Sigratherm study: EDMS:1128002
- Obtain reproducible temperature calibration
- Design thermal profile for uniform heating

S. Marzari

STAGISO vs NORMISO Study

J.P. Ramos

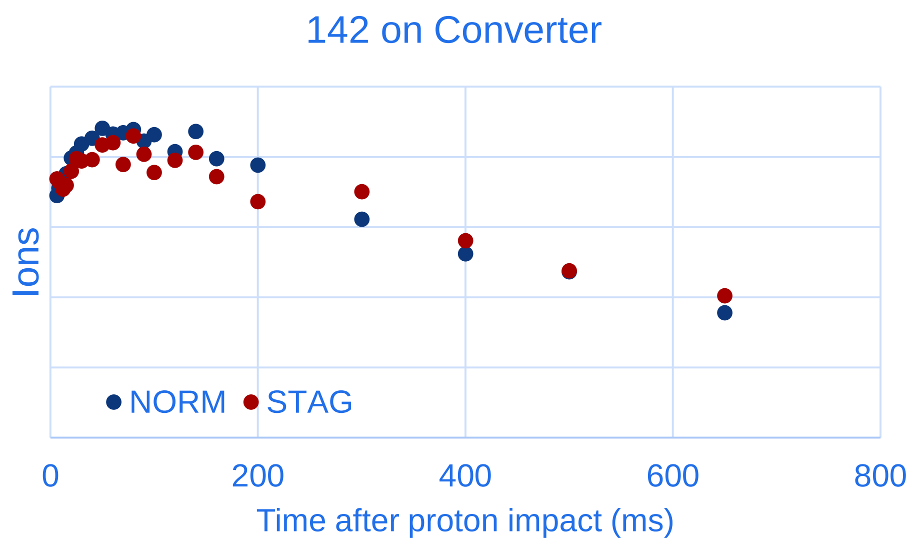


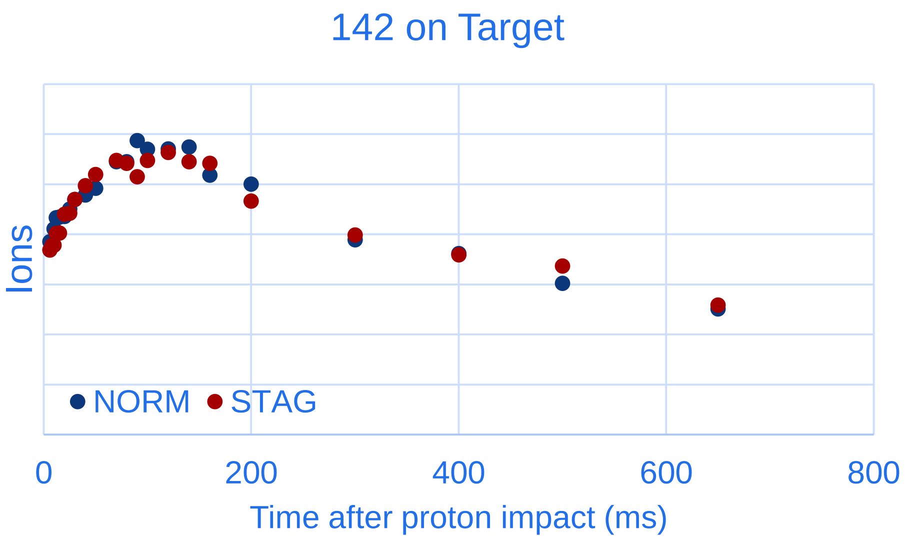


Booster pulse pictures from PhD Thesis, R. Wilfinger

Release measured on:

- GPS and HRS
- Target and Converter
- 26Na and 142Cs



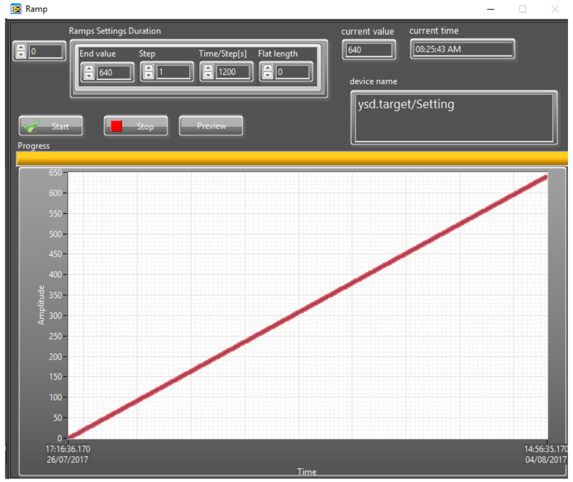


No difference between STAGISO vs NORM

Results to be published soon.

Ucx production: Previous process

2UO (s) + 3 C (s)-> 2 UC (s) + CO2 (g)



Setting ramp

Monitor pressure via webcam

Write down values manually

Detect end of carburization
by pressure drop

CARBURATION UO2+C

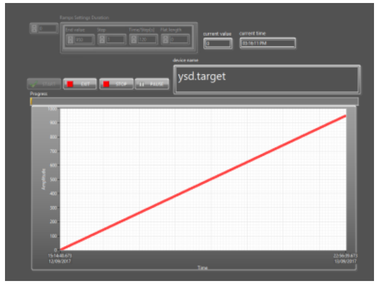
Pds container 30,9g	Pds cont.+UO2-C 127,6g	Pds UO2-C => 96,7g

Titre

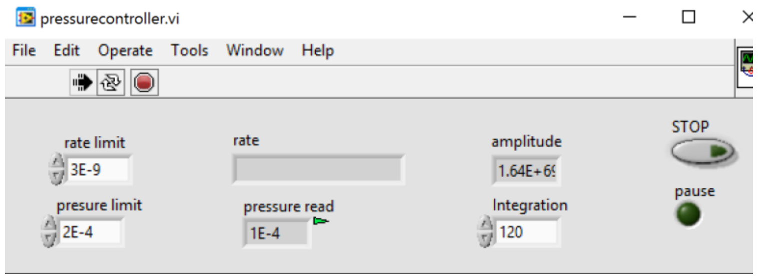
Dates	Heure	Pression	I(A)	U(V)	OT	TT	Observations
14.08	15h00	1,0E-5	0	0			↗ 50A (1A/60sec)
	16h48	1,2E-5	50	0,07			↗ 80A "
15.08	9h05	2,0E-6	80	0,10			↗ 150A (1A/60sec)
	9h54	5,7E-5	130	0,17			" "
	10h08	1,5E-5	144	0,21			"
	10h35	1,1E-4	150	0,21			→ 150A
	11h01	8,8E-5	150	0,21			↗ 160A (1A/60sec)
	11h52	6,0E-5	160	0,24			↗ 180A "
	13h10	1,9E-5	180	0,28			↗ 210A "
	13h35	1,5E-5	202	0,31			↗ 250A (1A/30sec)
	14h19	1,4E-6	0	0			coupure ↗ 210A (1A/30sec)
		6,3E-6	210	0,35			↗ 230A (1A/30sec)
	16h50	6,7E-6	230	0,38			↗ 440A (1A/600sec)
18.08	10h00	8,5E-5	450	1,46			↗ 460A (1A/120sec)
19.08	13h20	8,9E-5	460	1,49			↗ 470A "
21.08	9h47	5,8E-5	470	1,56			↗ 490A "
	10h58	1,2E-4	490	1,63			↗ 495A "
	13h40	1,2E-4	495	1,67			↗ 500A "
	15h15	1,3E-4	500	1,70			↗ 505A "
	17h35	1,4E-4	505				↗ 520A (1A/20mn)
22.08	9h10	1,1E-4	520	1,81			↗ 530A (1A/60sec)
	11h50	1,1E-4	530	1,91			↗ 570A (1A/60sec)
	15h10	1,6E-4	570	2,08			↗ 650A (1A/30sec)
25.08	10h15	4.2E-7	600				↗ 650A (manually)
	10h20	2.3E-6	650	2.36			
	10h53	1.5·10⁻⁶	650	2.43			↗ 675A (manually)
	11h10	2.1·10⁻⁶	675	2.54			↗ 700A "
	11h20	3.8·10⁻⁶	700	2.66			↗ 725A "
	11h30	1.4·10⁻⁵	725	2.86			↗ 775A "
	11h40	3.8·10⁻⁵	775	3.14			↗ 850A "
	11h50	5.6·10⁻⁵	850	3.75			↗ 900 A "
	12h10	6.1·10⁻⁵	900	3.92			
	13h03	6.1·10⁻⁶	900	3.90			↘ 0A

May result in inconsistent carburization.
Time consuming (~10 days).

Automatic UCx Production



- Setting a ramp
- Set thresholds
- Start carburization



- Heating is regulated automatically

Successfully used for **UC611** and **UC618**
Finished in **4 days** without human intervention

Proposed solution for production

- Integrate pressure readout using **CERN standards**
  - LabVIEW support / Vacuum support (requires new pumps/readouts) [BUDGET]
- Integrate pressure veto to pumpstand control software
  - LabVIEW support
- Add residual gas analyzer: gives additional information to the production process. Production speed could be optimized. Also contaminants could be identified during production.
  - Requires ~10k CHF + integration through LabVIEW support.

MWCNT Target production for #606

CERN has forbidden any handling of nanomaterial

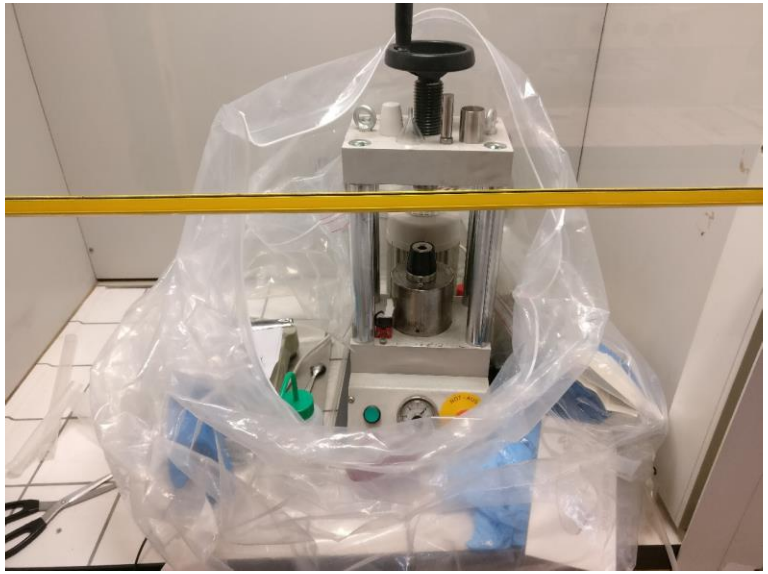
- Nanomaterials are requested at ISOLDE for physics (in this case MWCNT)

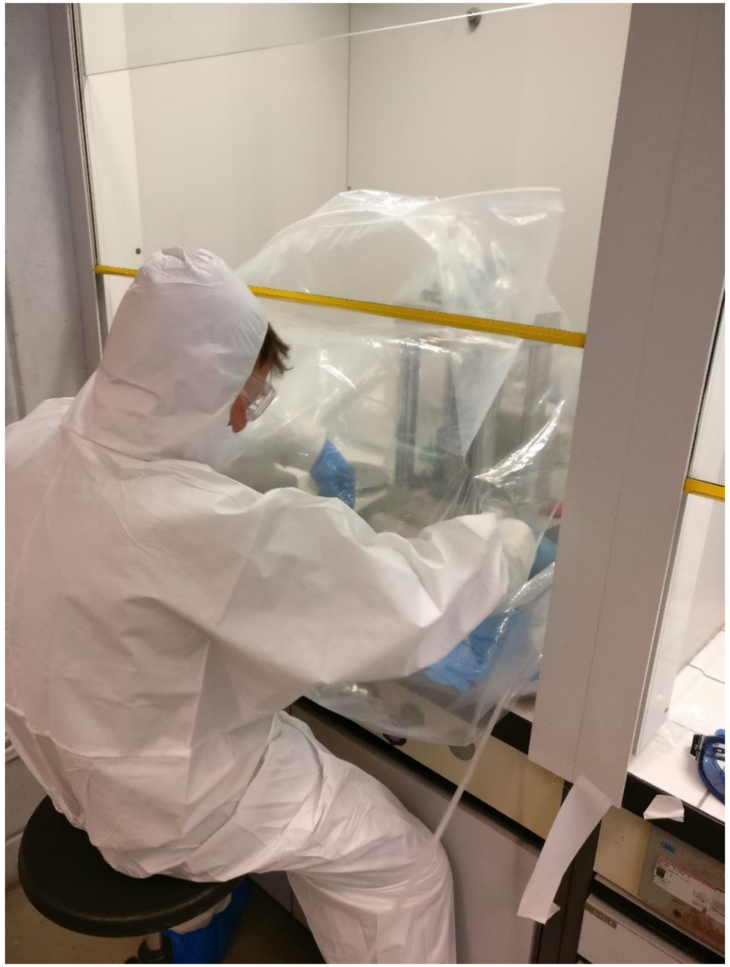
Powder technology laboratory in **EPFL**, has a class “nano 2”

- Accordingly to EPFL specifications “nano 3” is needed to handle MWCNT (need to have the nanomaterial sealed in glovebox)

Glove’s bag was bought from Sigma Aldrich and used instead of Glove’s box.

- Possible solution to lift the prohibition of handling nanomaterials





Successful press of full batch of MWCNT for ISOLDE target #606

J.P. Ramos, B. Crepieux, T. Stora, et al.

Nanolab

Option 1

Actinide pill production Nano +non-nano

oxidation

Non-actinide nano

Ventilation units

1. Carburisation
2. Calibration
3. Hotte
4. Presse
5. Malaxeur
6. Boite a gants
7. Plan de travail

Option 2

Actinide pill production Nano +non-nano

oxidation

Non-actinide nano

Ventilation units

1. carburisation
2. Calibration
3. Hotte
4. Presse
5. Malaxeur
6. Boite a gants
7. Plan de travail

- Funding secured
- Construction to be finished 2018
- Connection of ventilation foreseen in 2019

Dedicated oven for CaO production

Target unit building → Glove's box for material transfer into unit (very sensitive to CO2 and H2O)

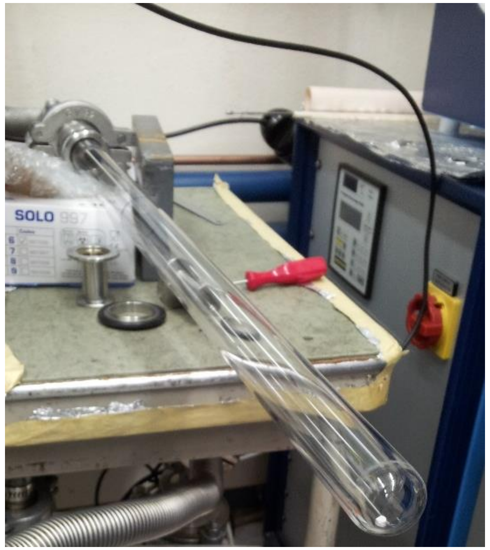
Material production → Glove's box for material transfer into unit (very sensitive to CO2 and H2O)

→ Calibration Target + Ion Source → Offline tests → ISOLDE

$CaCO_3 \rightarrow CaO + CO_2$ About a week to produce material in pump stand

<u>Current issues:</u>

- Thermocouple positioning difficult (can't trust readout)
  - Use pyrometer but readout is difficult in the 700 – 800 °C range
- Thermal gradient in the container makes process much longer than should
- CaO production unit difficult to handle in gloves box



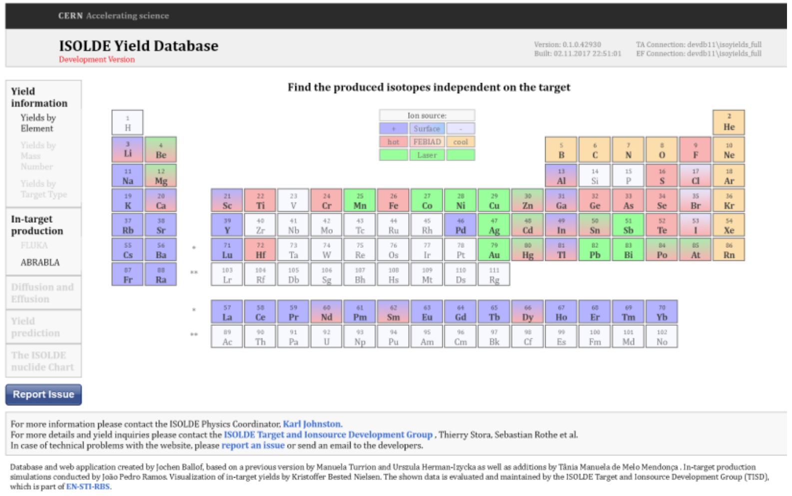
- Precise control of temperature
- Temperature uniformity

Higher quality CaO

- Quartz tube easy to handle in glovesbox
- Production will be reduced to half-day.

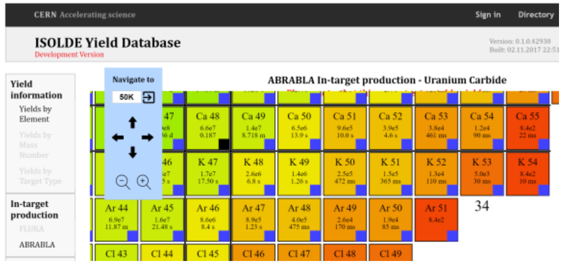
J.P. Ramos, et al.

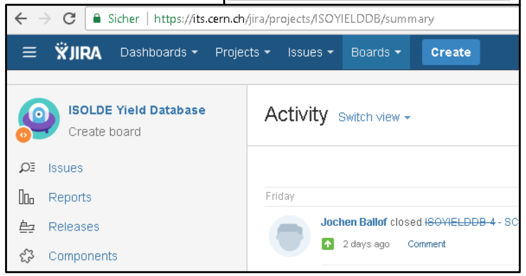
ISOLDE Yield Database YYDB(https://isoyields2.web.cern.ch)

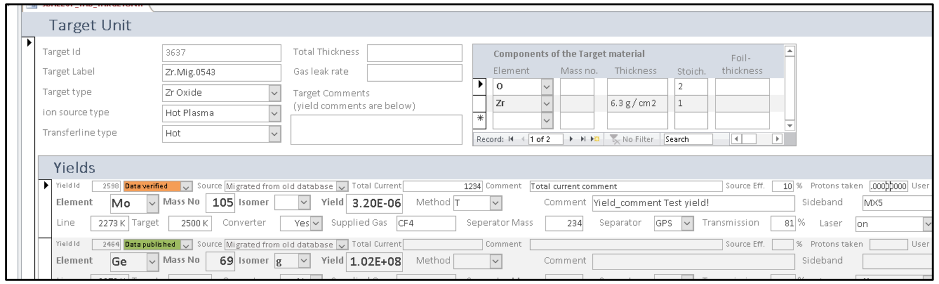


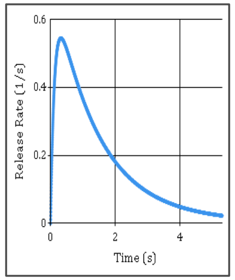
Target Unit	
Target Number	UC365
Material	U Carbide
Ion source	VADIS Cold Plasma VD7
Transferline	Water cooled
Total thickness	50.00 g/cm2
Source efficiency	22%
Target condition comments	F contam.
Target temperature	2273 K
Source temperature	2073 K
n-conv. used	No
Laser status	Laser off

Secondary beam	
Yield Id	63
Isotope	204 g Rn (1.24 m 3)
Yield	9.00e+6 uC
Method	B









Features

- CERN SSO
- New Database design
- In target production (ABRABLA)
- Release curves available
- More target details visible
- Issue tracking

Philosophy

- All measurements (TISD, USERS) get entered into YYDB
- Manually change attribute (measured -> validated -> published)
- Attribute determines visibility (after login, no login required)

Future

- Web based interface allows entering of yields to registered users
- Add FLUKA results for in-target production
- Add yield prediction
- Establish link to CRIBE database

J.Ballof

Potential TISD @ ISOLDE, 2018

- LIEBE @ GPS-online (2017)
- LIST 2.0
- M(CO)x formation @ MEDICIS irradiation point
- P2n converter prototype test

- Negative ion source
- Si beam development
- VADLIS prototype online

Thanks to the TISD and RILIS teams