Beam developments during the LS1

Thierry Stora, EN-STI-RBS

Priorities

GROUP for the UPGRADE of ISOLDE
GUI

Chairman: Maria J. Borge

Scientific secretary: Thierry Stora

http://isolde-upgrade.web.cern.ch/isolde-upgrade/

The GUI collects information and discusses necessary actions for the upgrade of the ISOLDE facility. The committee meets twice a year. The priorities for Target and ion source R&D are discussed in the September meeting.

GUI mandate

GUI members

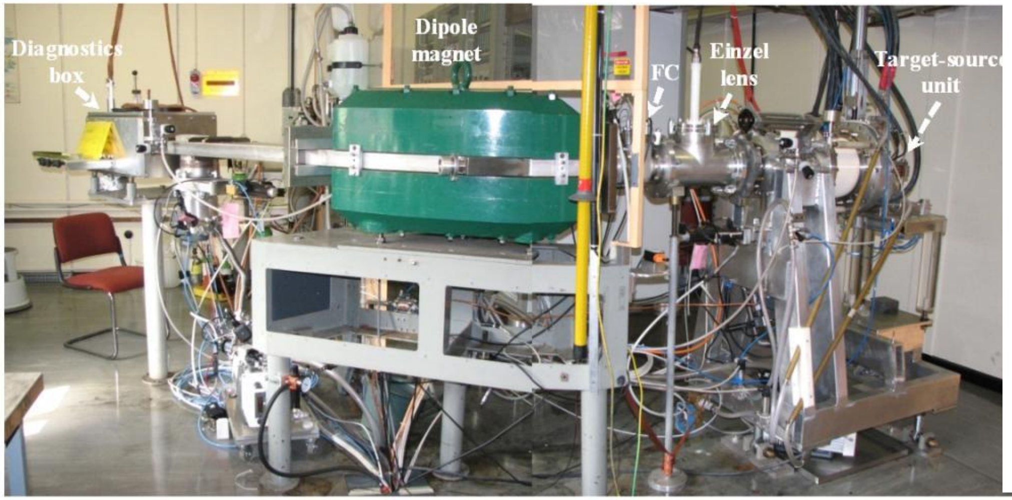
GUI Minutes

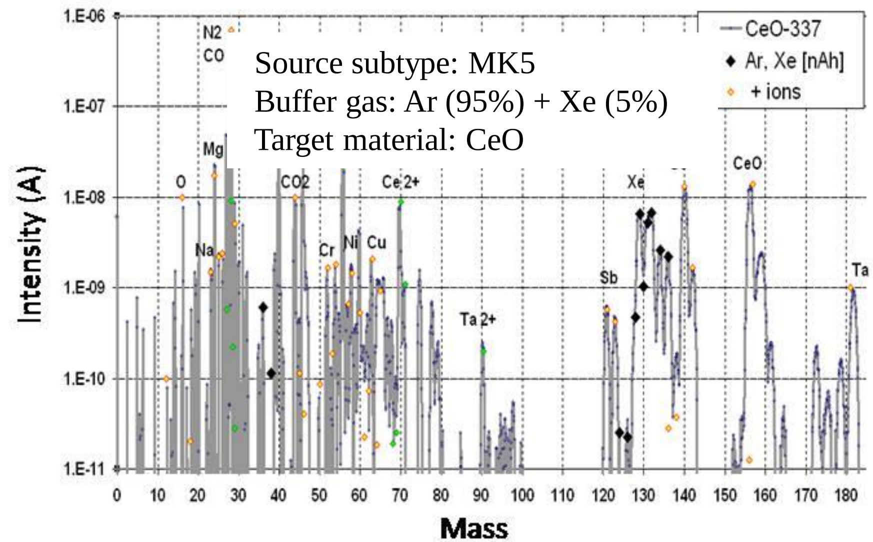
GUI next agenda - Next meeting 22nd Oct. 2013

GUI priority list for Target and ion source R&D

neutron converter	fissions (Cd, Zn, Cu, etc)	n-rich	several			Beam purity/intensity	X	X	R. Luis		PHASE II UNDERWAY
Pb/Bi loop	Hg, (Cd if molt Sn, Ne/C if molt NaF)	n-def	IS477 IS490 IS521			diffusion chamber/time cst	X	X	T. Stora	EURISOL P.O.	UNDERWAY
Ta(&W&Ir)-W UC-W	Lanthanides, At	^{140}Pr(int) $^{178-180}$Yb Dy, Er $^{221-223}$At(pur)	IS517 IS498	COLLAPS ISOLTRAP		Beam purity/intensity			T. Stora	S. Kreim, D. Yordanov	Stand-by
YO-molten ZrF4 - VD5	Kr	70,71Kr	IS490	ISOLTRAP		Beam intensity			T. Mendonca/JP Ramos	S. Kreim	Stand-by

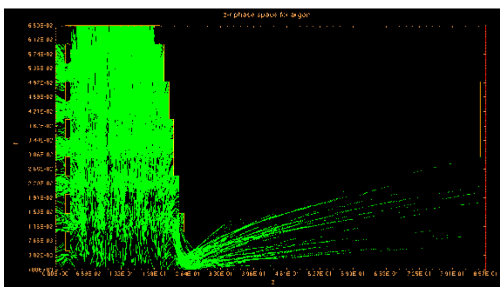
What is in the toolbox ?





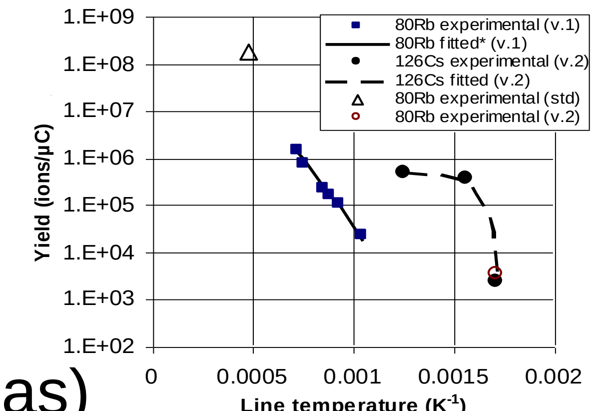
(plasma)-**physics**

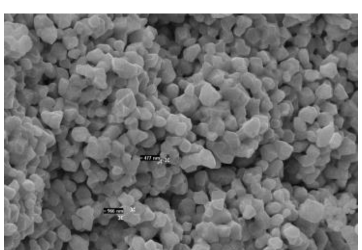
(Modeling, experimental)



chemistry

(ad/desorption, phases, gas)



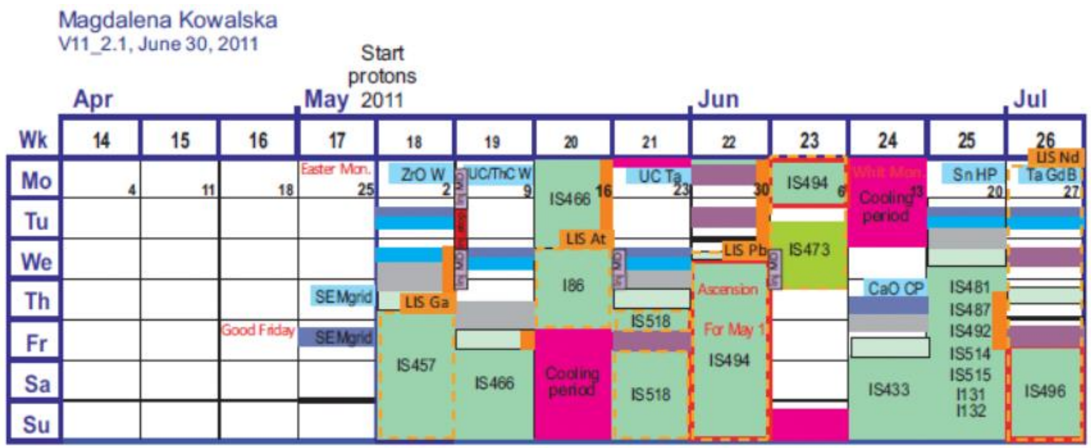


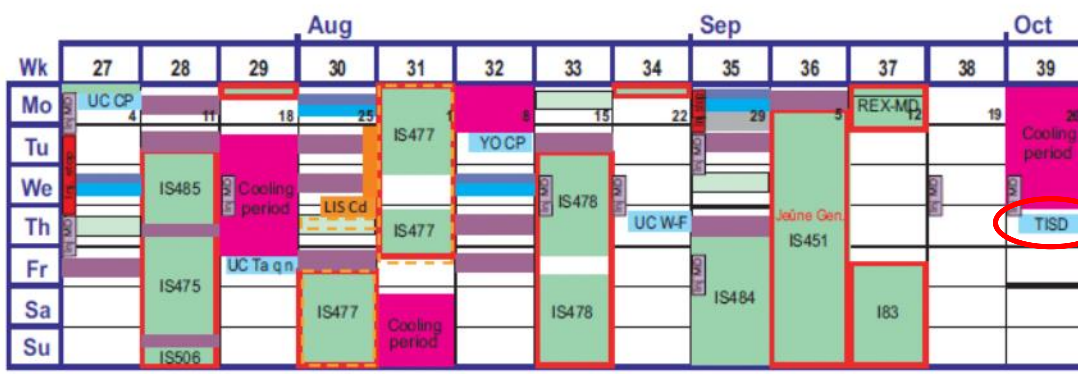
(nano)-**materials**

(Synthesis, ageing, diffusion)

$$f_{th}(\lambda,T)=e^{\lambda\cdot t_0\cdot\int\frac{dn_{coll}}{dl}e^{(-\Delta H_{ad}/kT(l))}dl}$$

A normal year of operation … But not during LS1 !





Online Tests!

ID		Target No.	Target type	Source	MM (A,B:same MM A/B:different MM)				
1		#459	empty	-	-				
2		#442	Ti	W-LIST	Mg/Mg1000nAh/Rb				
3		#443	Ta	W	Sm,Dy/1000nAh Sm/Cs				
4		#444	ZrO	W	Ga/Rb/Zn				
5		#445	ThCx	W	Tl/Au				
6		#446	YO	VD5	leak<= 1e-6mbarL/s				
7		#447	UC	Ta	Tl/Pb				
8		#448	Ta	W	Dy/1000nAh Dy/Cs				
9		#432	CaO	VD7	leak<= 1e-6mbarL/s				
10		#449	Sn	VD5	leak<= 1e-6mbarL/s				
11		#450	Ta	GdB6	*Nd/Cs/Sm+Pr*				
12		#451	UC	Ta	Ag/Cs/Na				
13		#460	pellets	W	1MM+return				
14						+ 1 VADIS on plexi support for demo	Control room	Fri 7/1/11	Fri 7/1/11
15		#452	UC	VD7	leak<= 1e-6mbarL/s	full TANTALUM VADIS proto in place of Mo !!	HRS	Mon 6/20/11	Fri 7/1/11
16		#453	UC	Re	Tl/Cs/Na	***Re foil in W cavity - container vertic. elect. Connections***	GPS	Wed 6/29/11	Tue 7/12/11
17		#454	UC	*W n qartz*	Cd/Cs	cold quartz. Same temp profile (& 128Cd/In yields) as UC362	HRS	Fri 7/8/11	***Thu 7/21/11***
18		#455	UC	W	Cd/Cs/Tl?	***back up 447? -full Re cavity ion source if possible***	GPS	Fri 7/15/11	Thu 7/28/11
19		#456	YO	VD7	leak<= 1e-6mbarL/s	for 72Kr Impurities Ge, As, etc/ 35% Kr eff.	HRS	Tue 7/26/11	Mon 8/8/11
20		#457	UC	Re	Na/Mn/Rb	tbd	GPS	Mon 8/1/11	Fri 8/12/11
21		#458	UC	W	leak 1e-4mbarL/s	for possible CF4, but no injection before confirmation !!	HRS	Thu 8/11/11	Wed 8/24/11

From the last GUI

8B

9C

37K

Pb/Bi target for EURISOL (LIEBE project)

nano-UCx (ActILab-ENSAR)

refractory molecular beams combined with RILIS

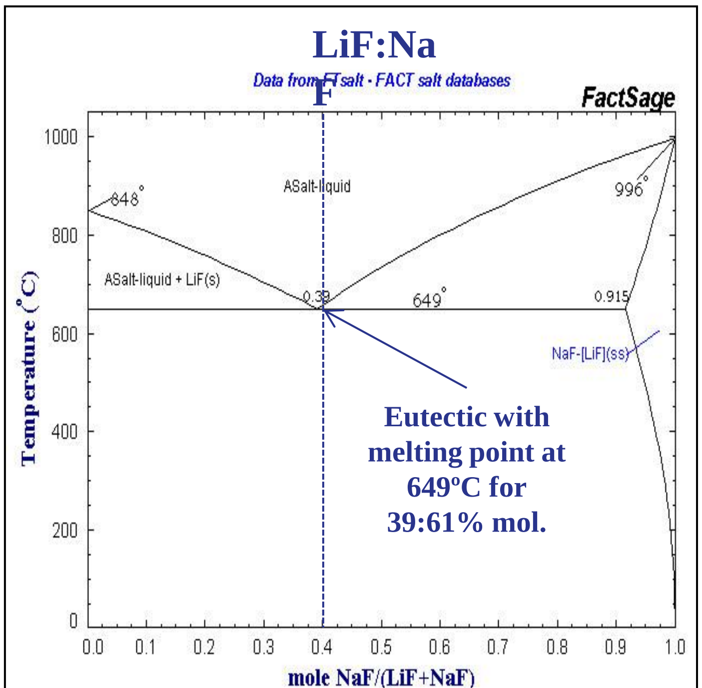
New neutron converter (with TRIUMF)

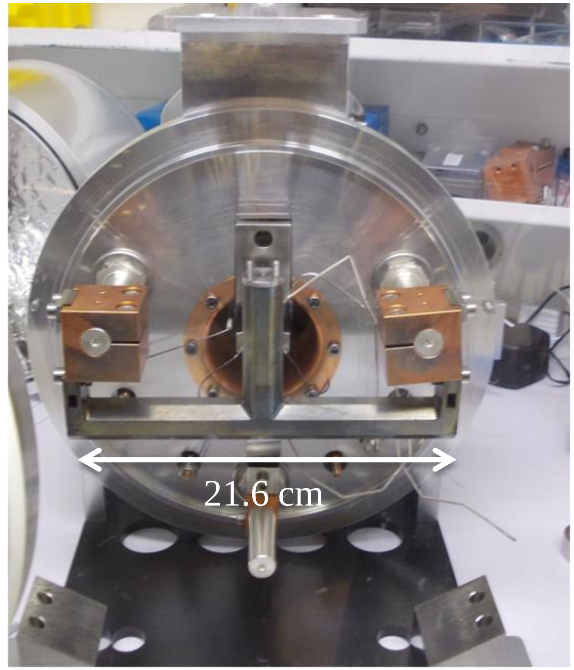
Ba beams

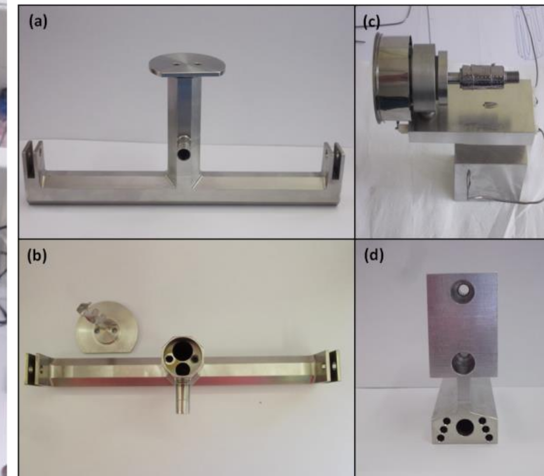
Molten salt unit

Table 2. Selected phase transition properties of salt compounds and key mixtures

Salt constituent(s)	Freezing point (°C)	Normal boiling point (°C)	900°C vapor pressure (mm Hg)
LiF	845	1681	0.1
NaF	995	1704	0.07
KF	856	1502	1.2
RbF	775	1408	0.75
ZrF_4	912	905 (sublimes)	722
BF_3	−126	−100	NA







Static unit

- Material: Haynes 242
  (corrosion resistant alloy)
- VADIS ion source
  ε_{Ne}~1.8%
  (via cold transfer line)
- Three thermocouples
  (container, chimney, cold line)

T. Mendonca et al., NIMB (answer to referees)

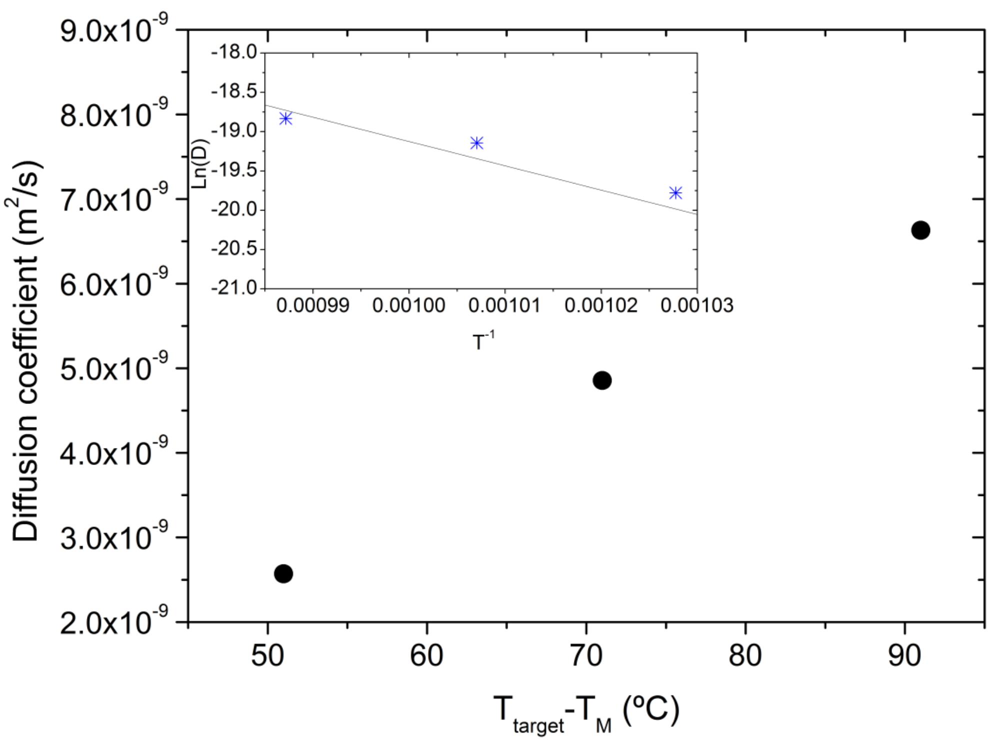
Analysis

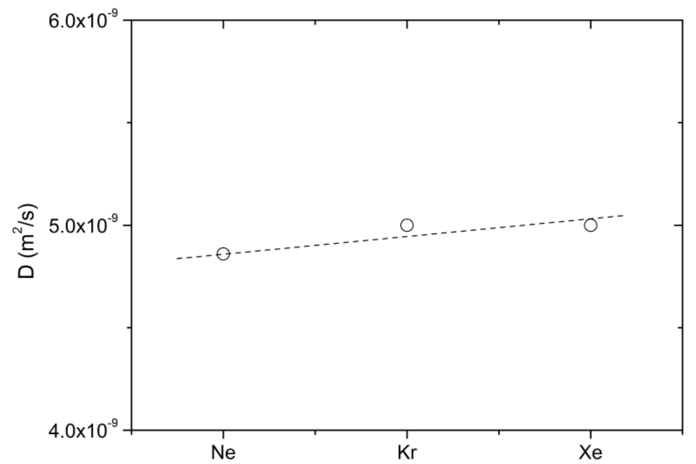
Diffusion and release efficiency

$$\varepsilon_{rel} = \frac{3(\sqrt{\lambda\pi^2/\mu} \times \tanh\sqrt{\lambda\pi^2/\mu} - 1)}{\lambda\pi^2/\mu}$$

$$\mu = \frac{\pi^2 D}{d^2}$$

Thin film approach
μ=delay parameter
D= diffusion coefficient
d=thickness





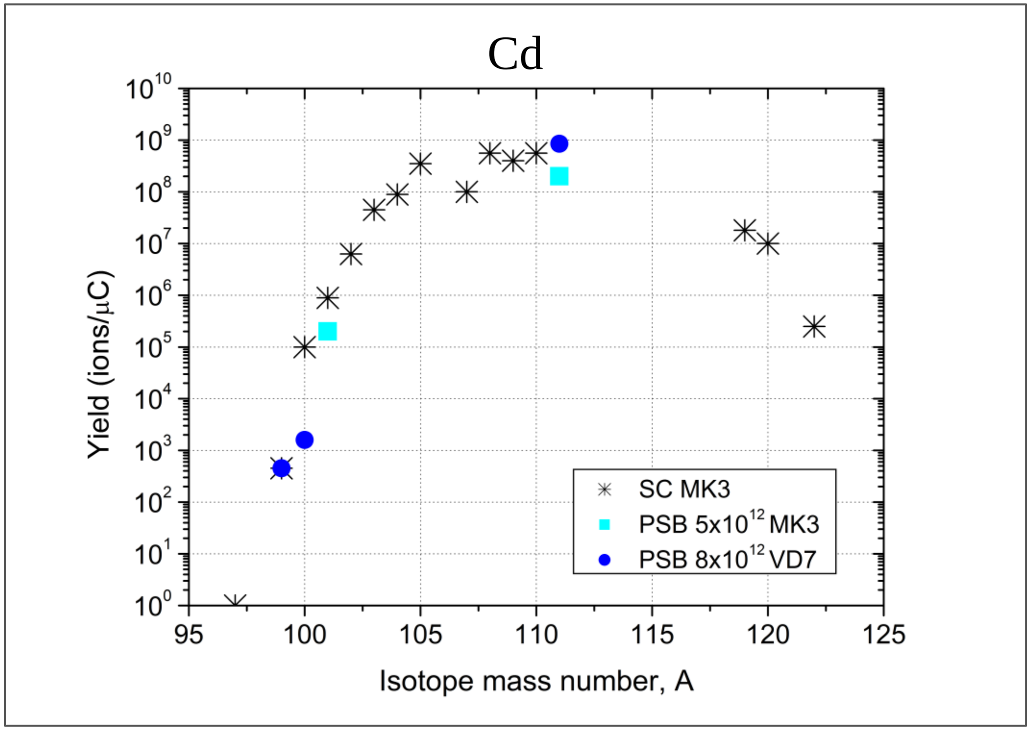
D(Ne) in NaF:LiF is 8 orders of magnitude higher than oxide targets (CaO, Al_2O_3 with $D \sim 10^{-17}$ m^2/s)

T. Mendonca et al. Letter in preparation

Molten Sn and Pb targets with VADIS

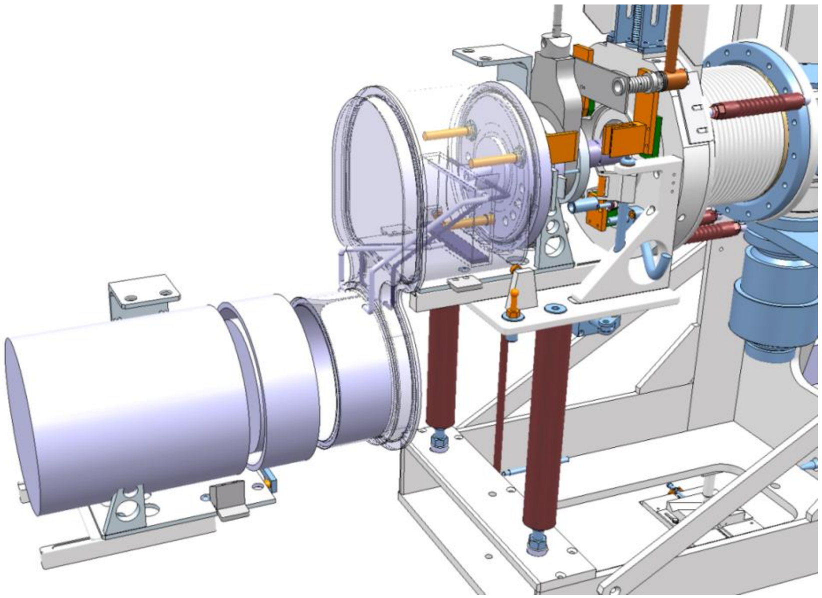
Improvement of ~x2-4 with VADIS on ^{111}Cd yield

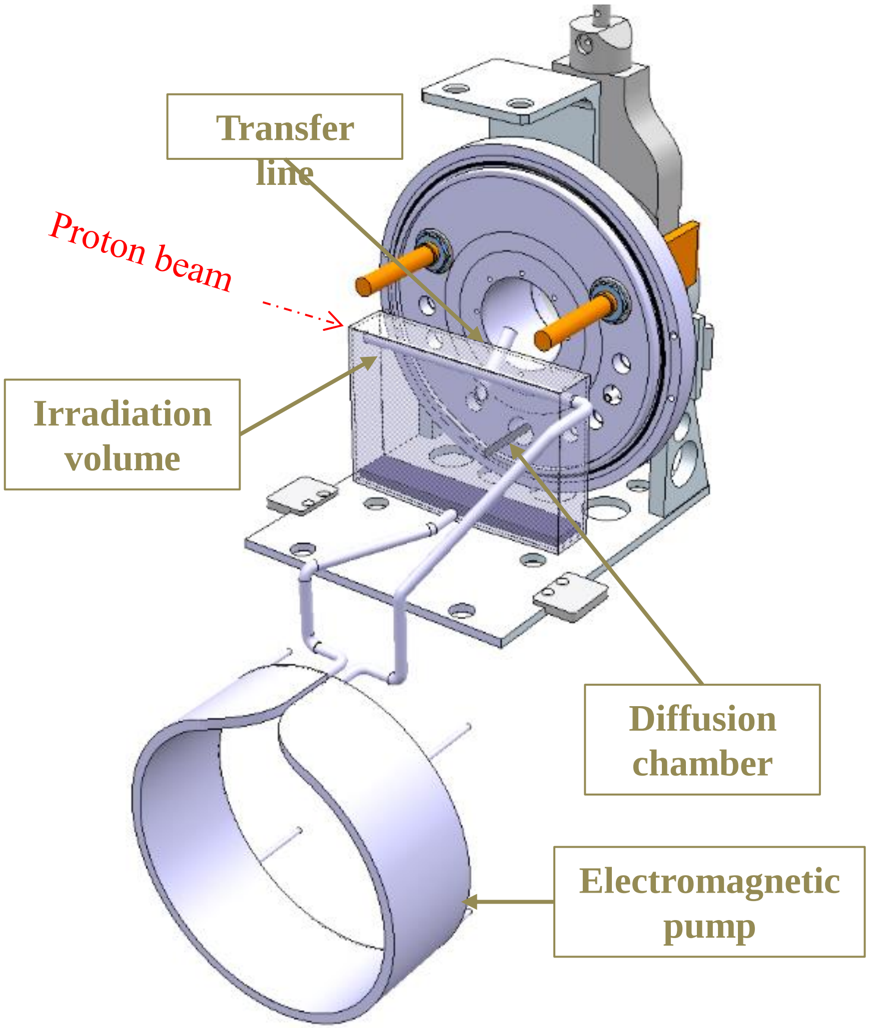
X3 on Hg yields



T. Mendonca et al.

LIEBE project





Reference isotope ^{177}Hg ($T_{1/2}$=130 ms)

Diameter/thickness shape: 100 μm

Sphere: 0.57

Cylinder:0.44

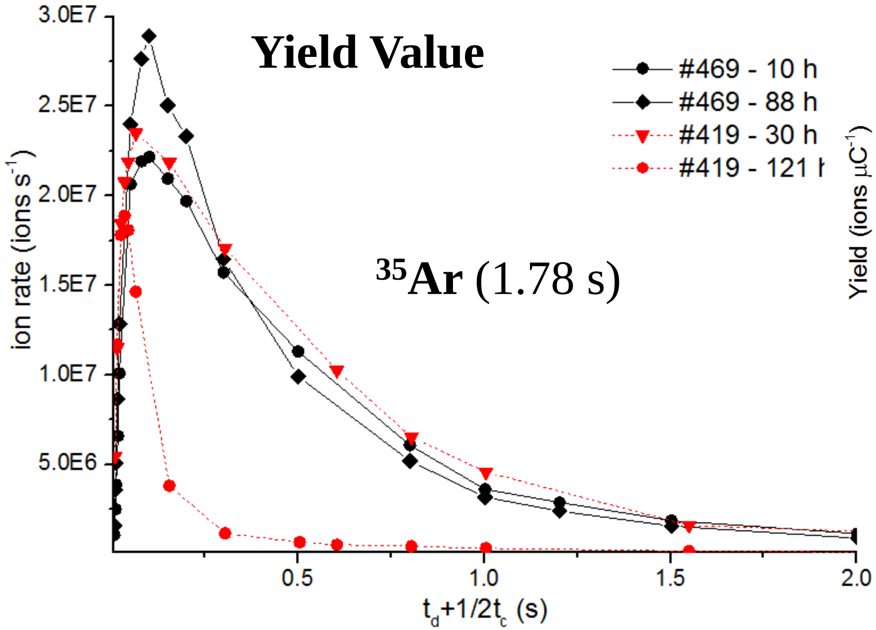
Foil:0.26

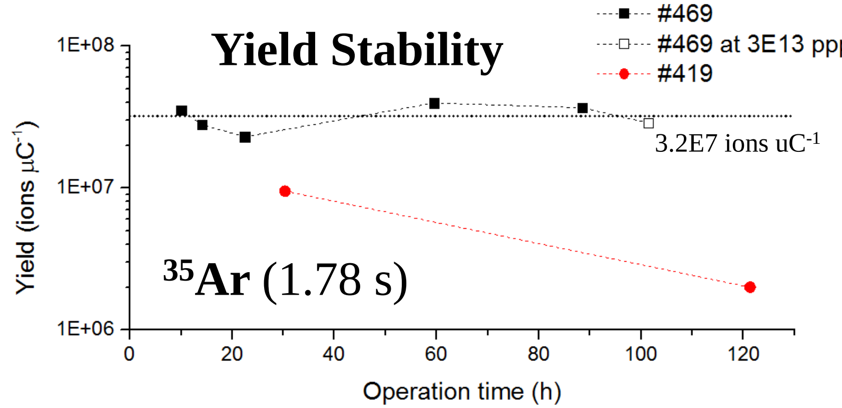
Effusion efficiency for ^{177}Hg: 0.87

Containment in stainless steel

Courtesy of V. Barozier and M. Delonca

Nano CaO





#469 nano CaO

#419 conventional

^{31}Ar (15.1 ms)	
Nano CaO	Conventional
34 µC^{-1}	5 µC^{-1}
Value at 80 h of operation	1 uC^{-1} after few hours

Factor ~4 of difference on scaling isotope (^{33}Ar) between tapestation and IS476

Ramos J. P., and et. al, 2013, "Intense 31-35Ar beams produced with nanostructured CaO target at ISOLDE.", submited to Nucl. Instr. Meth. B

Nano TiC

Beams of interest

Ta foils

^{37}K – 1.22 s

(Produced at ISOLDE)

ISOLDE (SC)

7.1E6 uC^{-1} with titanium foils

Estimated total release efficiency from nano TiC target

<u>1E-3 to 5E-3</u>

Production 1E9 (50g TiC)

Target yield goal of

2E8 to 8E6 uC^{-1}

^{35}Ca – 25 ms

(Never produced at ISOLDE)

^{37}Ca – 181 ms - ISOLDE (SC)

5.5 uC^{-1} with titanium foils

Estimated total release efficiency from nano TiC target

<u>1E-5 to 5E-5</u>

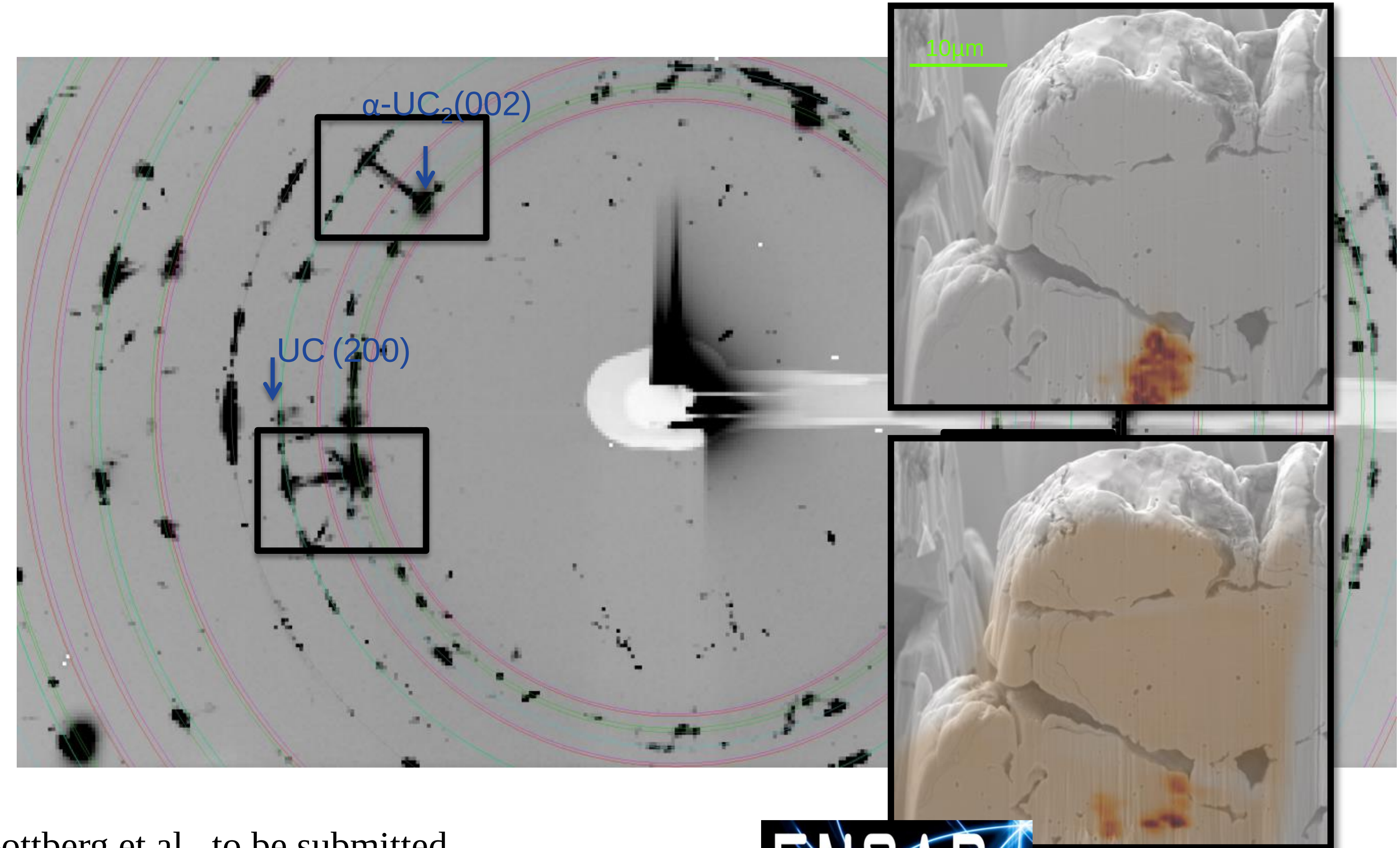
Production 5E3 to 1E4 (50g TiC)

Target yield goal of **0.2 uC^{-1}**

TiC used as a target material in TRIUMF

Turrion M., and Urszula H.-I., "ISOLDE yield database" [Online]. Available: https://oraweb.cern.ch/pls/isolde/query_tgt.
TRIUMF, "ISAC Yield Database" [Online]. Available: https://mis.triumf.ca/science/planning/yield/beam

ISOLDE UCx at PSI-SLS



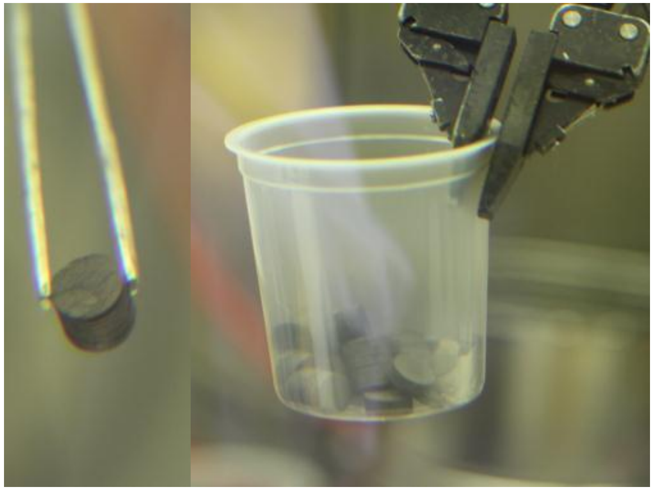
A. Gottberg et al., to be submitted

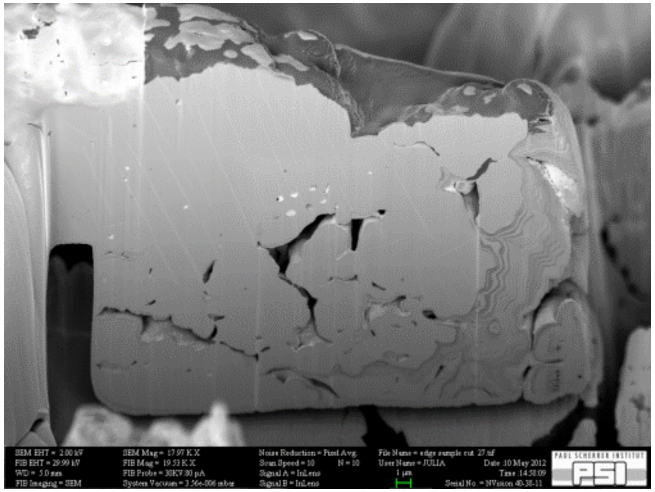
ActILab

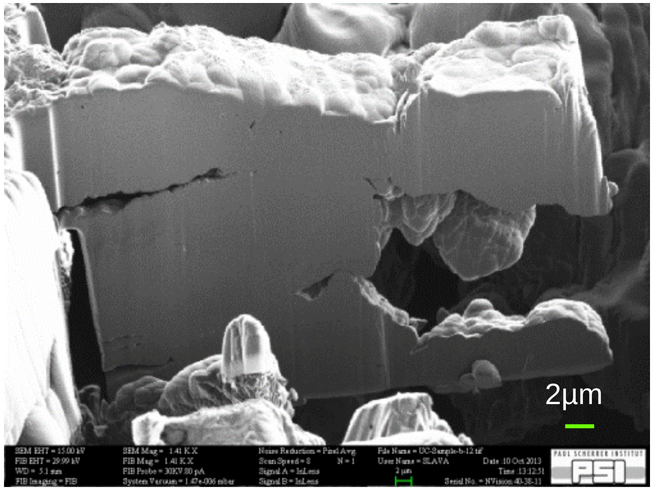
Ucx after irradiation

Before irradiation

After operation







From Last week

Data on crystalline phase evolution and fission product chemistry curr

ActILab

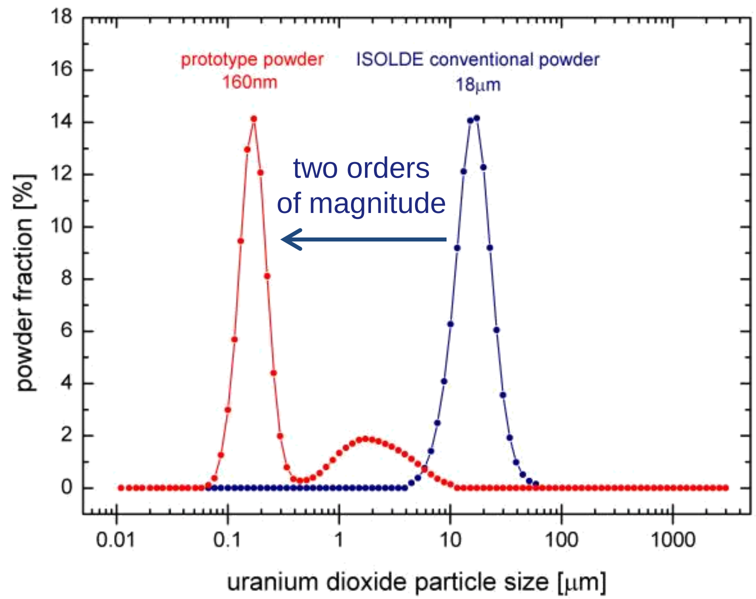
A. Gottberg et al.,

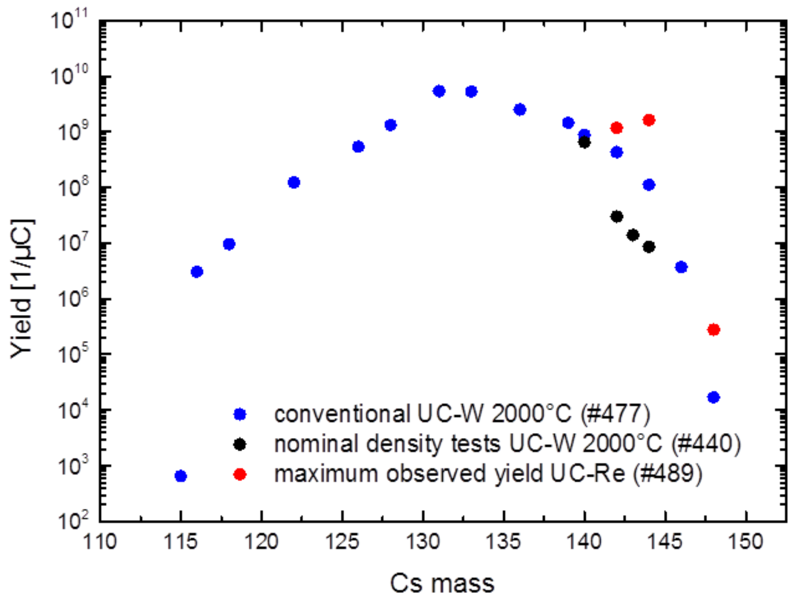
Carbon naotubes + $NanoUO_2$

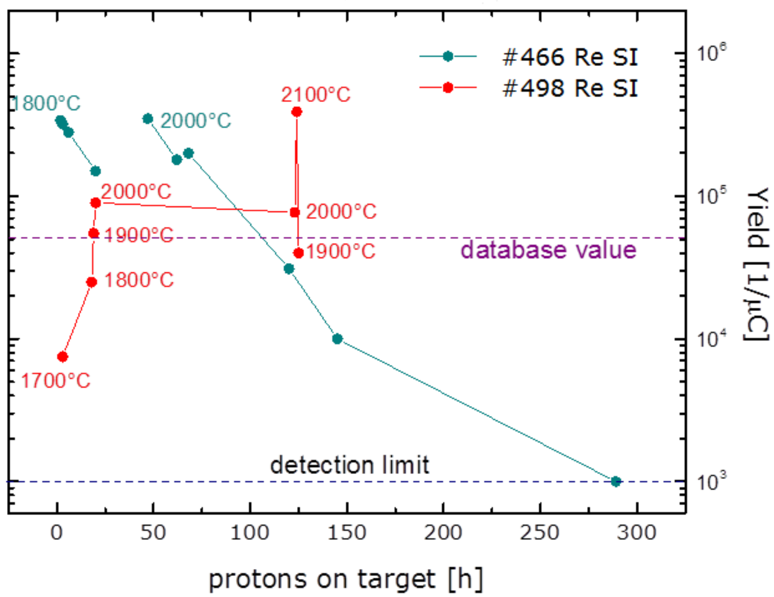
- Design of synthesis procedure for smaller UO2 particle size

Despites major technical difficulties:

- ^{11}Be: $6.0 \cdot 10^7$ 1/µC, database: $7 \cdot 10^6$ 1/µC (confirmed)
- Record yields for all measured Cs isotopes
- Structure appears to be widely conserved over time and temperature

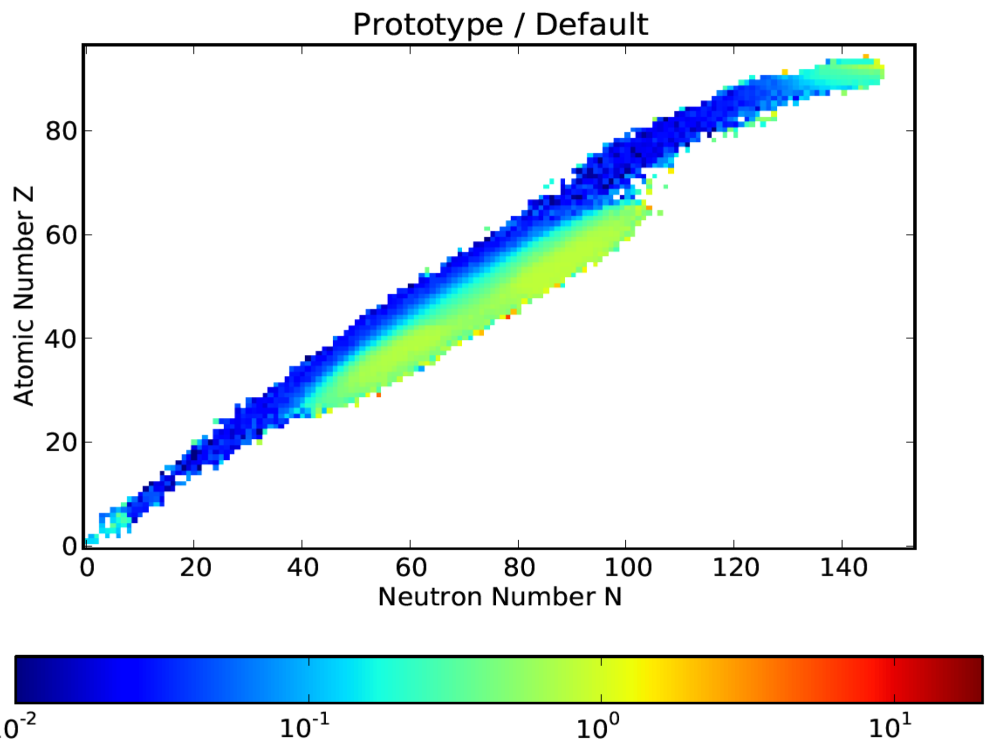


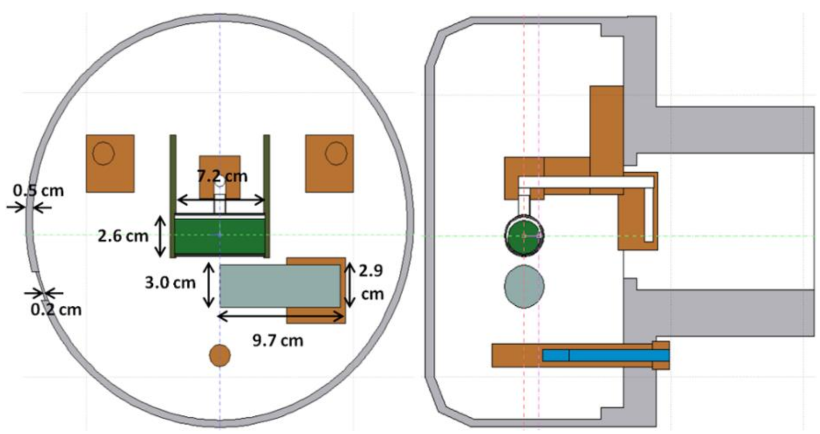




A. Gottberg et al.,

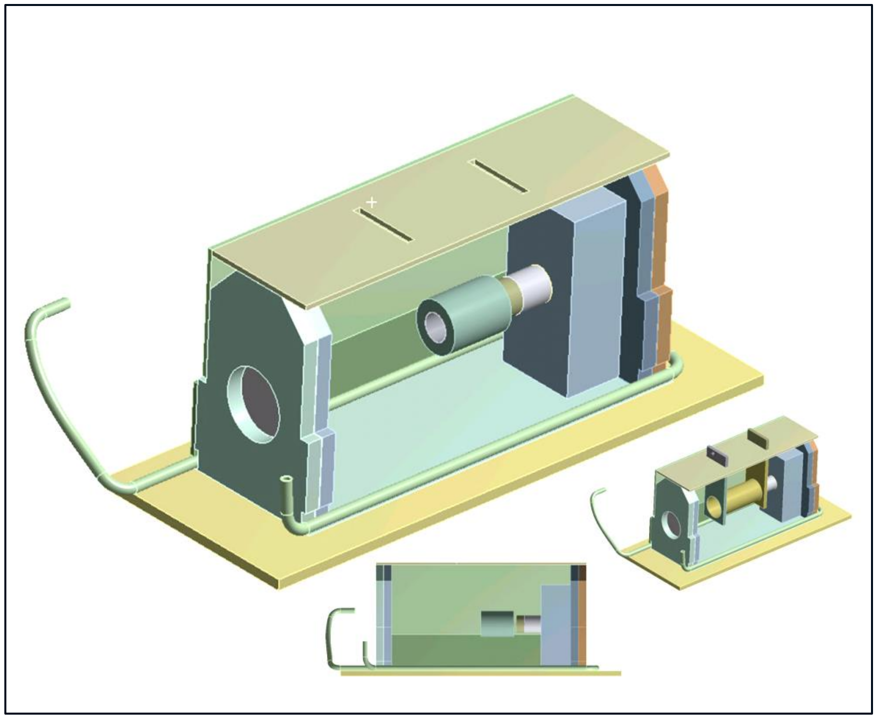
Neutron converter

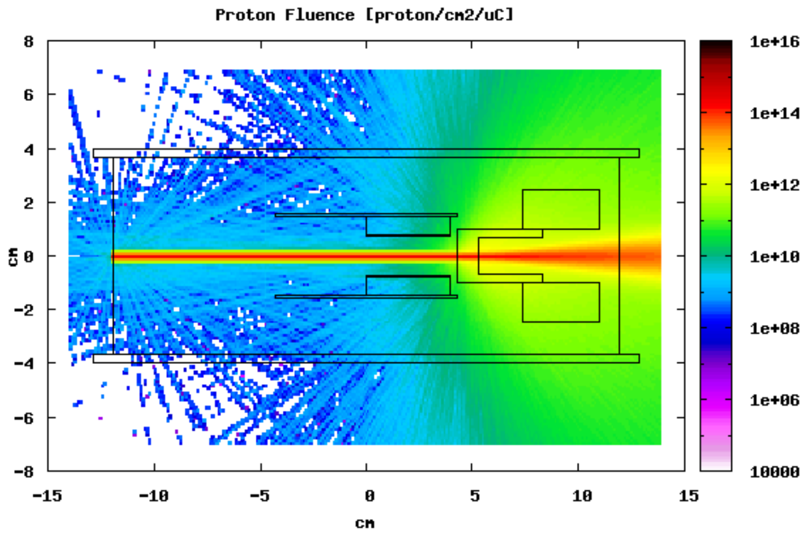


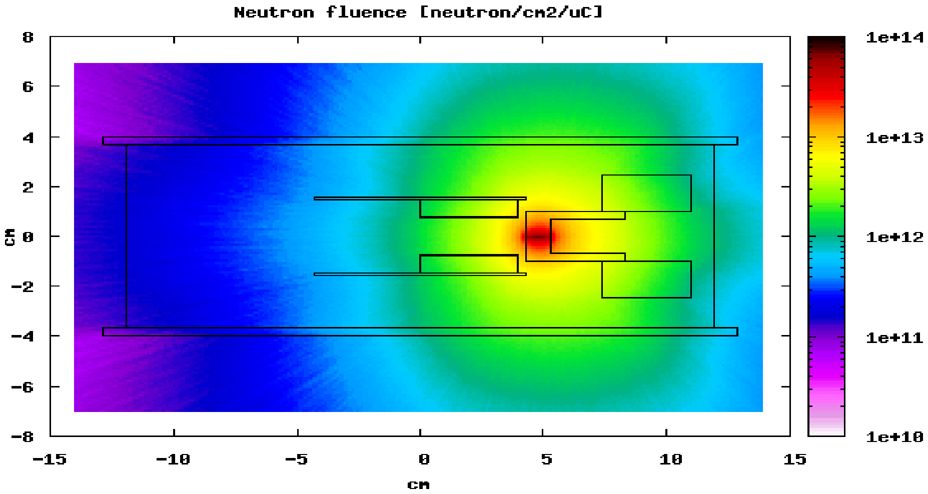


(1st version at ISOLDE:
A. Gottberg, T. Mendonca, R. Luis et al.
Experimental tests of an advanced neutron-to-neutron converter at ISOLDE-CERN, ready for Subm. To NIMB)

Neutron converter v2.0





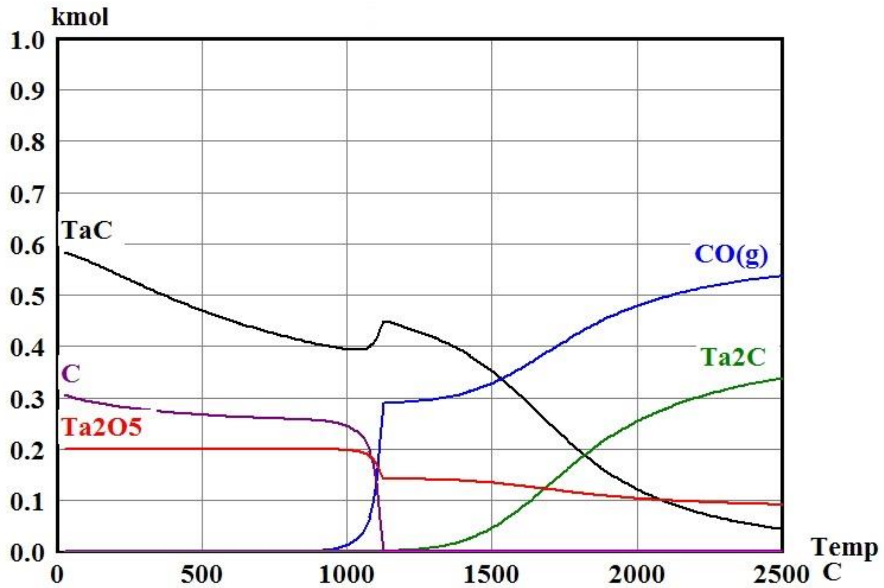


S. Cimmino et al.
In collaboration with TRIUMF

9-C as CO+

- Systematic studies of former online runs with Carbon release:
  - Data available from 7 online runs
  - 9-C extracted only once for short period (~24h) from Y2O3 target
  - Main reason seems to be slow extraction

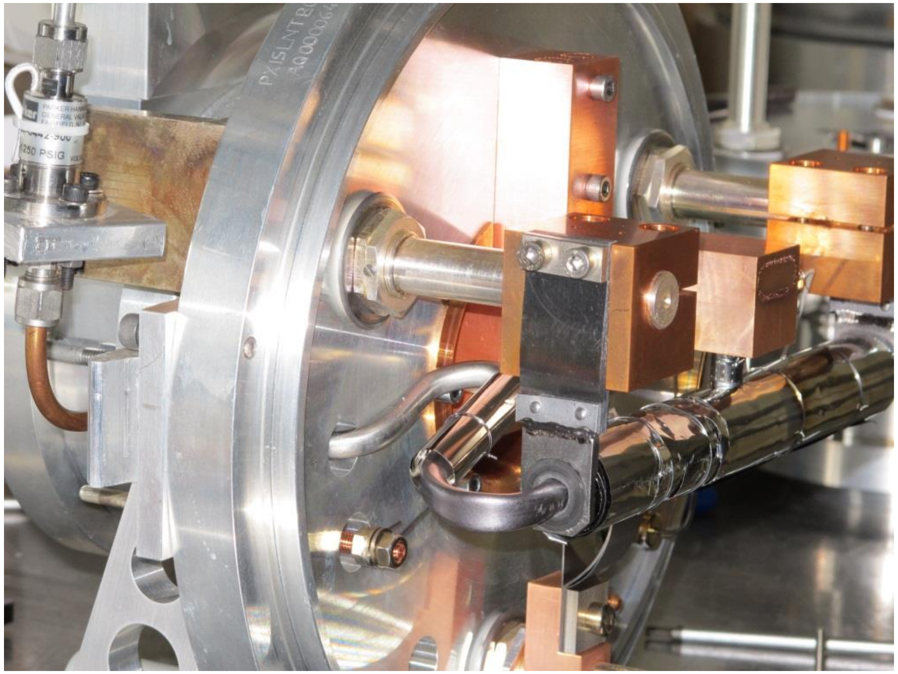
    -> Choice of materials crucial factor

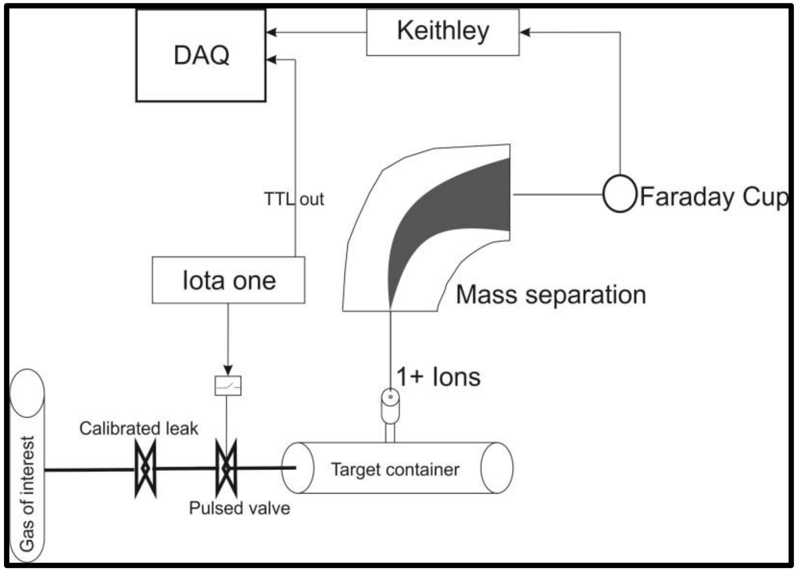


C. Seiffert et al.

Release Studies on CO+

- Release studies at Off-line mass separator
  - Injection of bursts of gas of interest (13-CO2, 13-CO, noble gases)
  - Release gives information about release efficiency and time structure
  - Investigation of different ion sources and materials

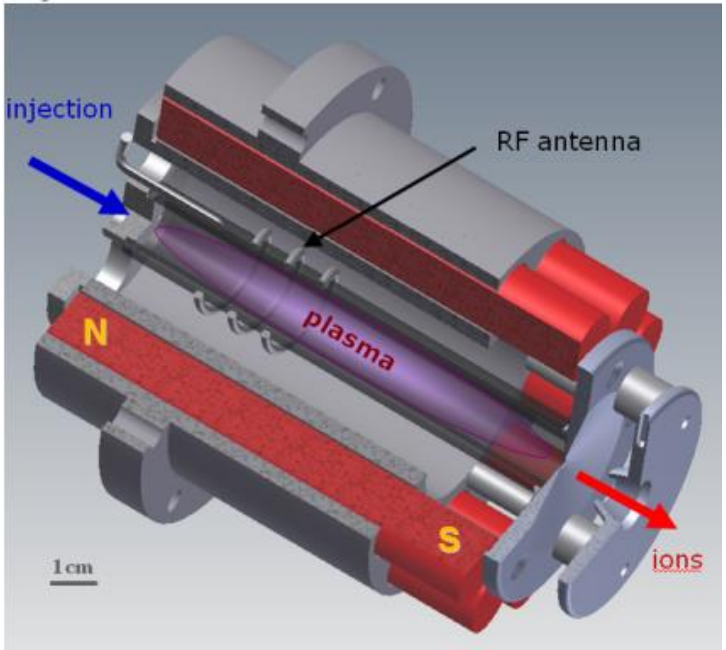




C. Seiffert et al.

HELICON Source

- An ion source for molecular beams
  - High efficiencies seen with the MINIMONO ion source (Electron Cyclotron Resonance)
  - No hot tantalum surface
  - Helicon developed by Pekka Suominen & Matthias Kronberger
  - Two online runs on GPS : 2011 HfO2 fibers, 2012 CaO nano structured powder

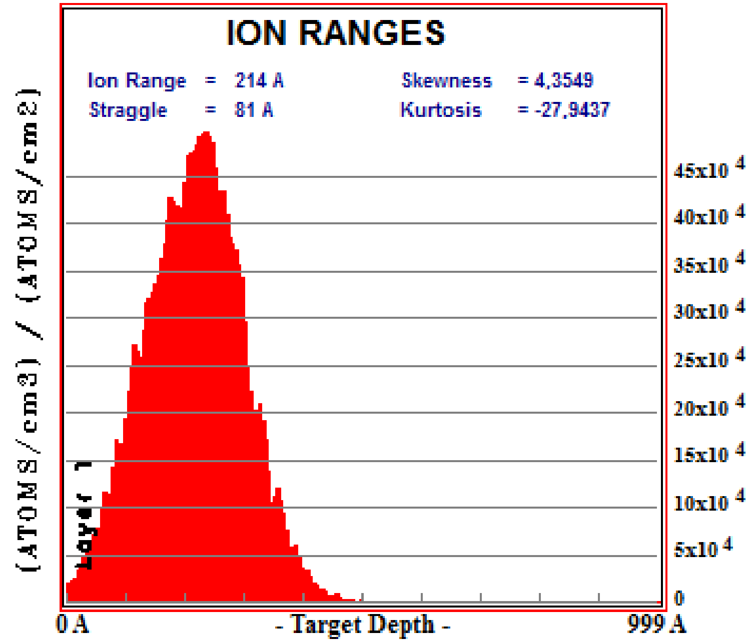


Isotope ($t_{1/2}$)	Target Material	Yield [1/uC]
17-C (173ms)	HfO2	8
10-C (19.3s)	CaO (nano)	1.7*10^4
11-C (1222.2s)	CaO (nano)	2.7*10^6

M. Kronberger et al., NIMB, online (2013)

8-B from Boron fluoride

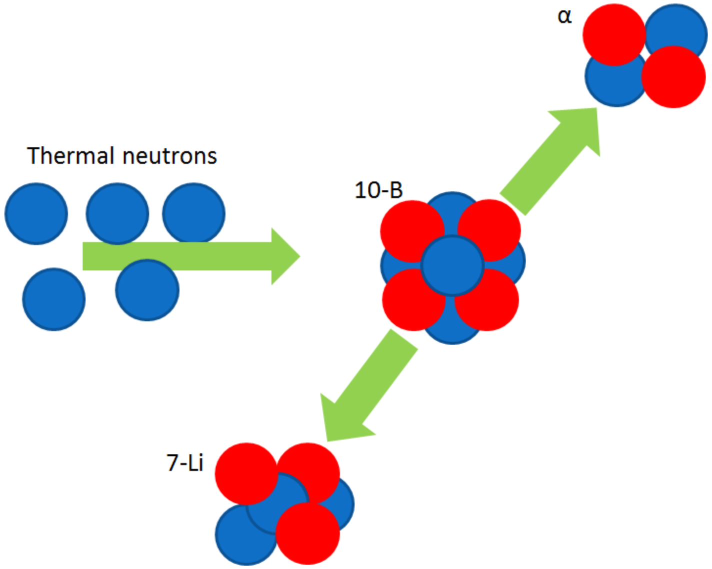
- Study on chemical behaviour and diffusion properties
- Boron has to be extracted as a fluoride
- Diffusion studies with alpha energy loss method [10-B(n,α)7-Li]
  - Step 1: Implantation of 10-B as 10-BF2 into target materials at offline separator
  - Step 2: Measurement of initial distribution with 10-B(n, α)7-Li method
    - Capture cross section of 10-B for thermal neutrons: σ=3840 mbarn
    - Use of strong Pu-Be source: 1.1*10^8 neutrons/second @4Pi
  - Step3: Heating of Sample
  - Step4: Measurement of new distribution
  - Eventually choice of best target material
- Collaboration with Saraf/Israel, n-TOF, PSI, Ya

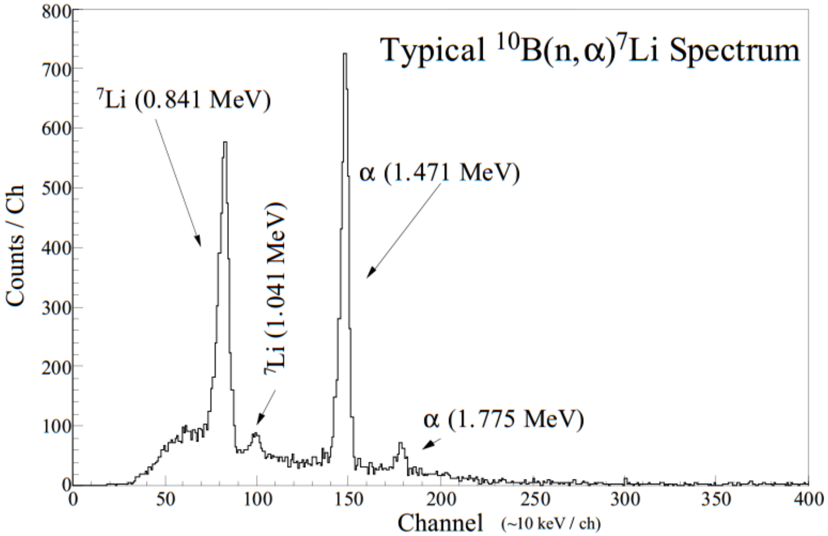


C. Seiffert et al.

8-B from Boron fluoride

Set-up for 10B neutron depth profiling with Ci neutron source at CERN ($1^{e}8$n/s), 1st spectrum yesterday !
C. Seiffert et al.





M. Gai et al.

Team & Collaborations

- E. Barbero, B. Crepieux, M. Owen, S. Marzari: Production, infrastructures

- C. Seiffert : molecule evaporation

- R. Luis : neutronics (ITN, Lisboa)

- Dr. A. Gottberg : target materials, incl. Uranium (ENSAR-FP7, ActILab).
- J. P. Ramos : Target nanomaterials (Univ. Aveiro)
- M. Czapski : material analysis support (CATHI ITN Marie-Curie program)

- Dr. T. Mendonca : High power targetry
- S. Cimmino : Thermal management

GANIL, IPNO, INFN, PSI (Uranium, ENSAR "ActiLab"), TRIUMF, JAEA
ITN (neutronics, UCx)
EPFL, Aveiro, ITN (materials)
ESS, CEA, SCK●CEN-Myrrha, SINP, PSI (high power targetry)

Outlook

- As much offline studies as possible.
- Many publications done, submitted or in preparation
- Some online tests foreseen in other facilities, eg ALTO for ActILab, SARAF for 10B implanted target or TRIUMF for new n-converter
- Already some developments ready for tests/confirmation at start-up
- Input from GUI this morning…