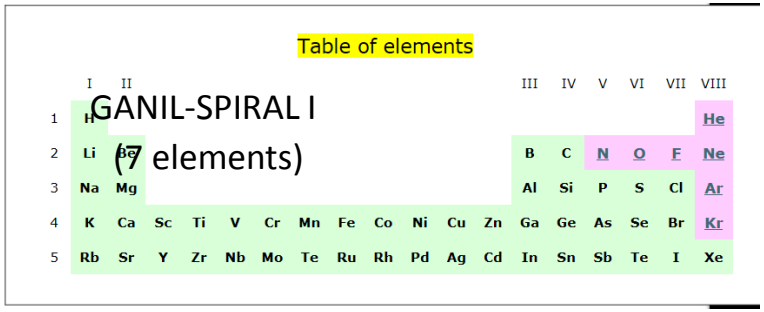
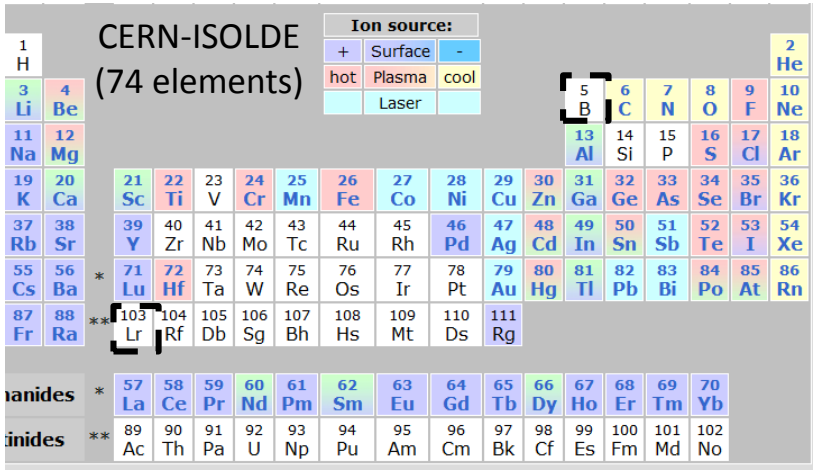
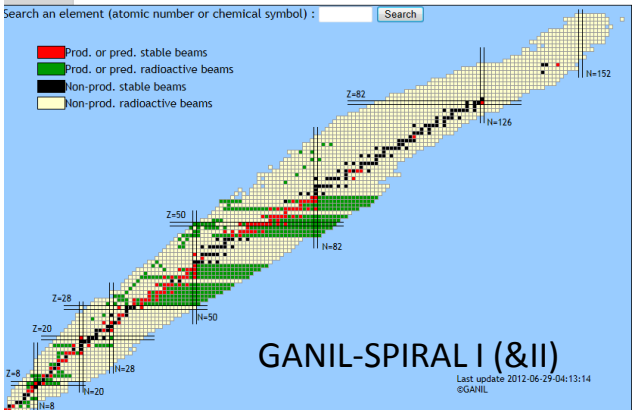
Target and Ion Source Development

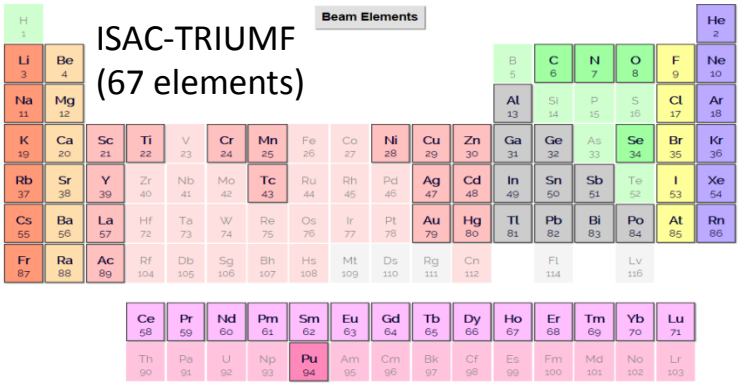
Thierry Stora

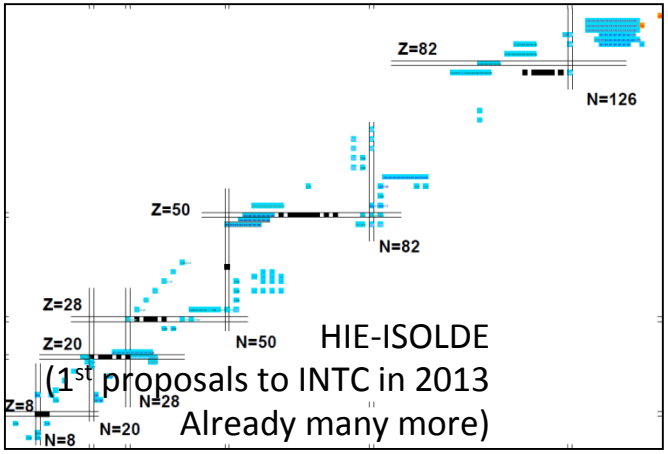
Beams at ISOL facilities*











* 1 development is ~ 2-5 man.year effort if the technology is within scope

ISOL Beam intensity and availability

RIB intensity: $I = \Phi \sigma N \varepsilon_{release} \varepsilon_{ion}$

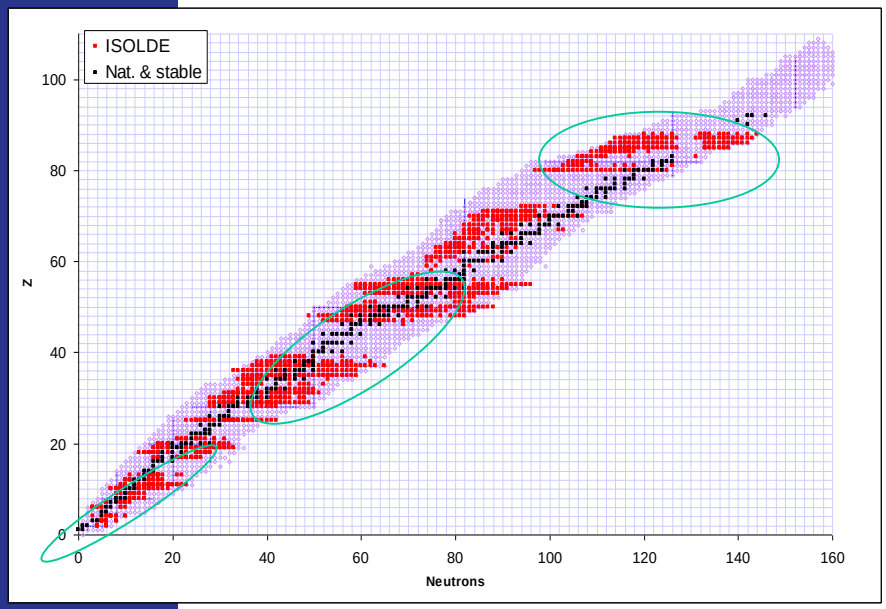
Proton beam Intensity

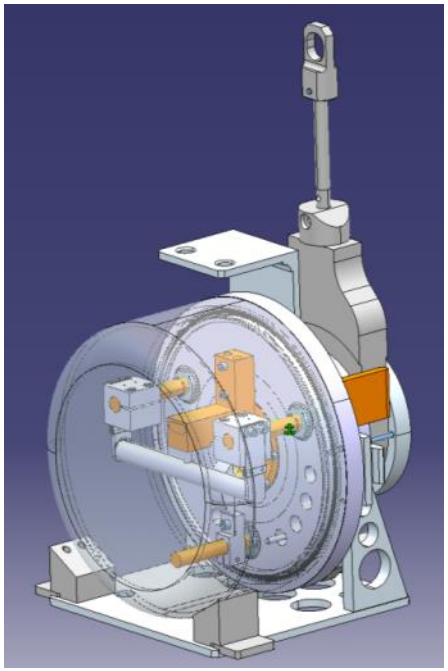
Target thickness

Cross section

Release Efficiency

Ionization Efficiency





Material science (nanostructured targets, molten salts,…)

Chemistry (adsorption enthalpy, molecule formation,…)

Ion sources (cathode, plasma,…)

Targetry (secondary reactions molten metal shower,…)

Beam developments in the past 8 years

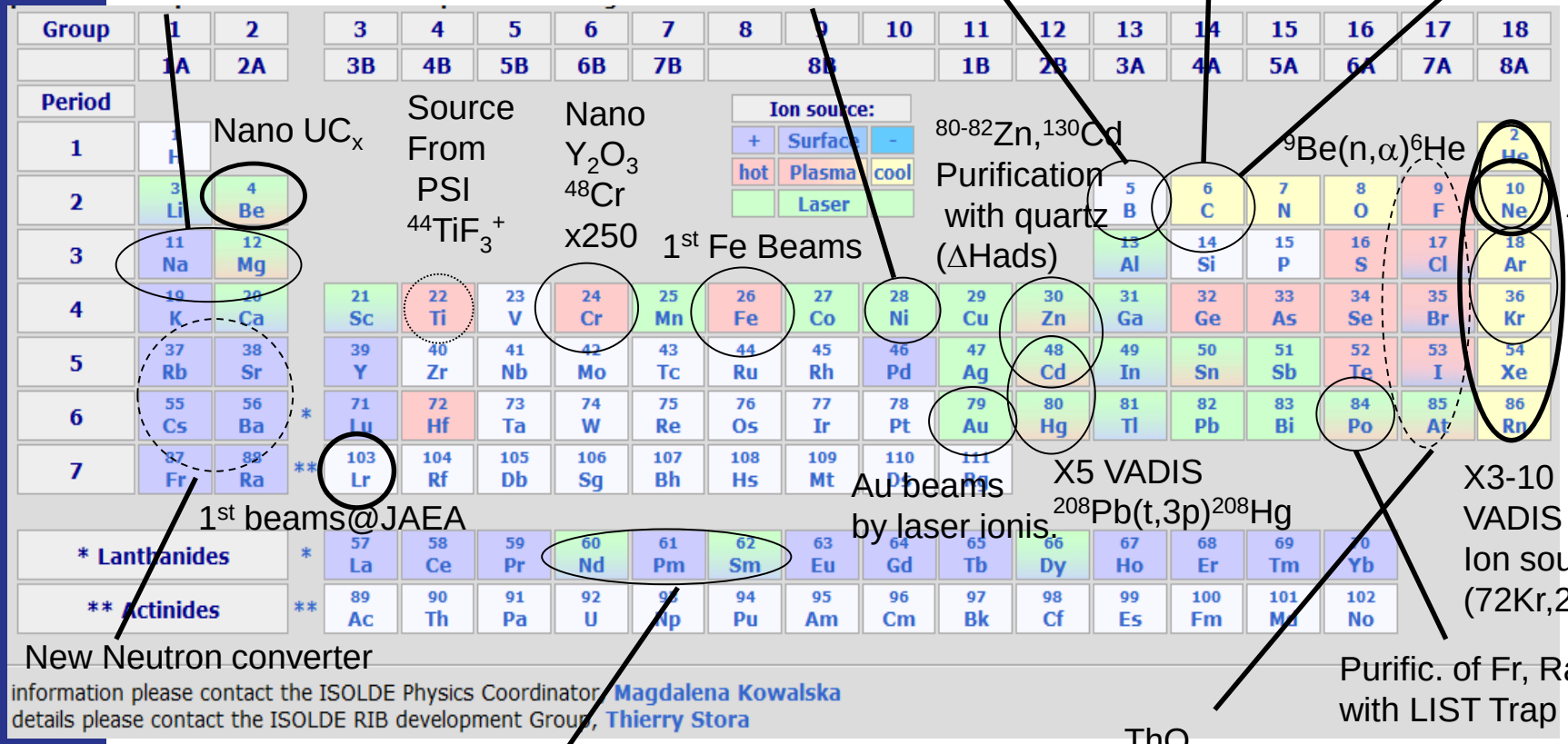
X5 ^{30}Na Re ion source
X10 ^{20,21}Mg
sub-μm SiC

1st ^{8}B ISOL beams
BF_2^+ from nanotubes

$^{70+}$Ni beams

^{9,17}C as CO^+
Helicon Ion source

Molten salt
Target
^{11}C as CO^+



Nano UC$_x$

Source
From
PSI
$^{44}TiF_3^+$

Nano
Y_2O_3
^{48}Cr
x250

1st Fe Beams

80-82Zn,^{130}Cd
Purification
with quartz
(ΔHads)

^{9}Be(n,α)^{6}He

Nano
CaO
Target
(Ar)

1st beams@JAEA

Au beams
by laser ionis.

X5 VADIS
^{208}Pb(t,3p)^{208}Hg

X3-10
VADIS
Ion source
(72Kr,229Rn)

New Neutron converter

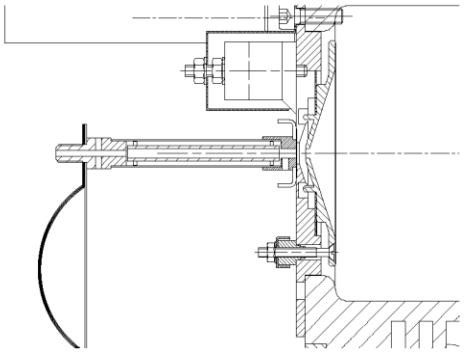
Purific. of Fr, Ra
with LIST Trap

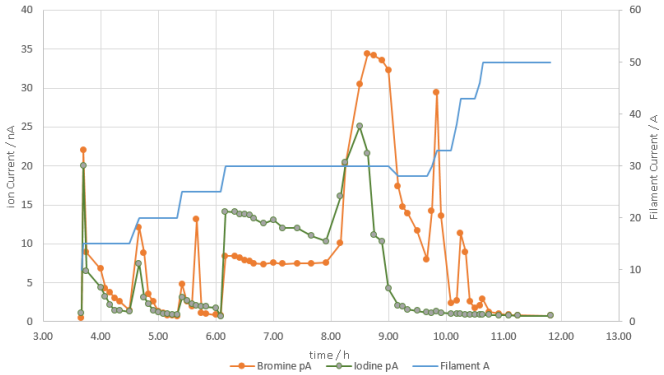
Purification of lanthanide beams ^{140}Nd, $^{140-142}$Sm:
GdB_6 ion source cavity + RILIS

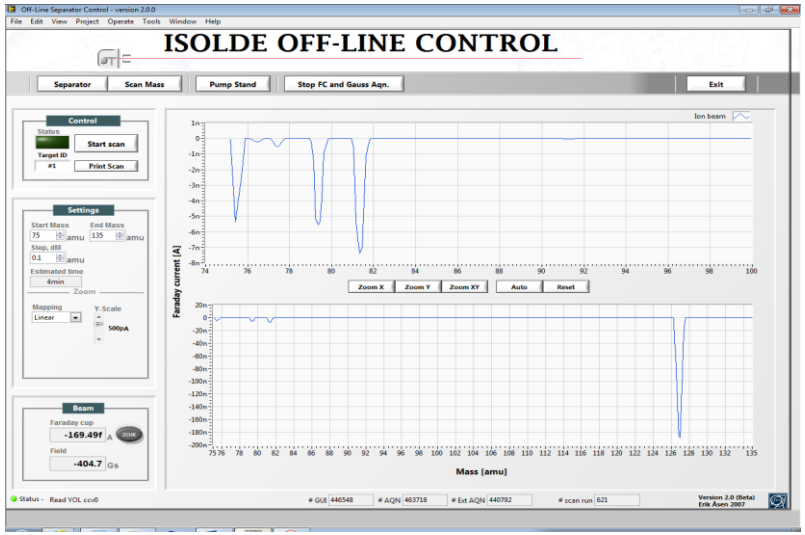
ThO,
Negative
ion sources

Recent results

- Negative beams :
  - Negative ion source prototype (GdB6 tub ion, Menna et al. NIMB, 266(2008) 4391)







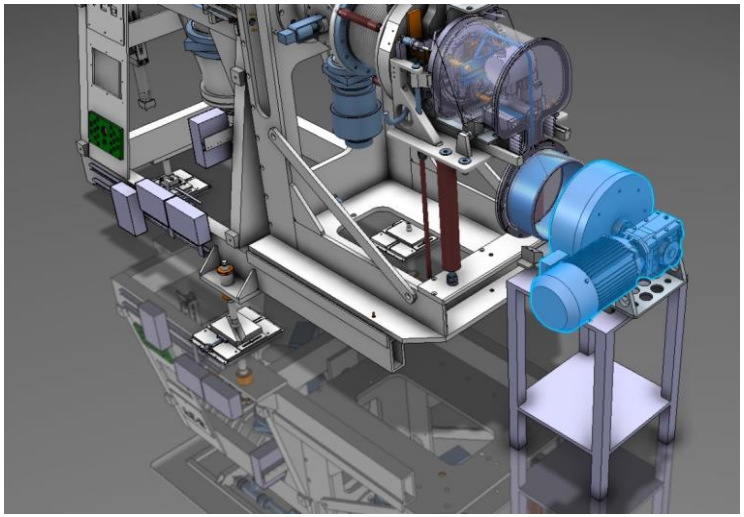
Offline efficiencies 2015:
ε (Br-,I^-) = 17% @1700C
with some questions remaining

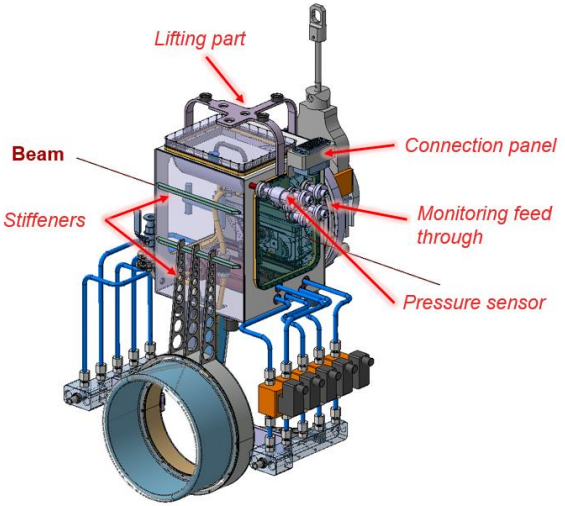
Online TISD with Nb535
and ThO540 targets, starting this week

Y. Martinez, J. Ballof, T. Mendonca

Recent results

- LIEBE (Liquid Lead Bismuth target loop for EURISOL)





Prototype construction starting (detailled drawings)
Offline tests foreseen end 2015
Online tests foreseen in 2016

M. Delonca, T. Mendonca, & many more !
CERN, CEA, SCK, PSI, SINP, IPUL + GANIL

Recent results

8B beams

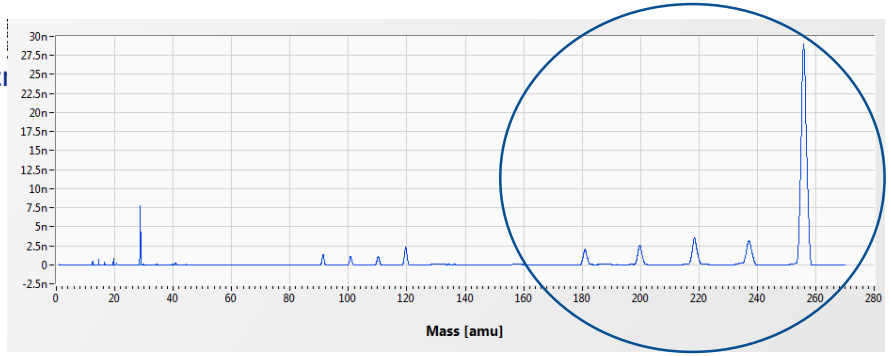
Target unit #499:

- Target material: Carbon nanotubes (MWNCT), ρ=0,43 g/cı
- Standard Ta container, cold transfer line, VADIS ion source
- SF_6 in container,(0,37*10^{-4} mbar*l/s, p(SF_6)~1-2 bar)

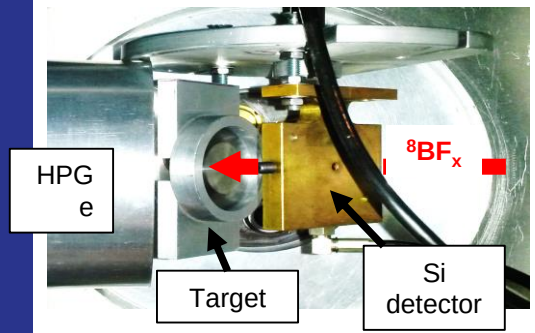
Release of ^{8}B & ISOLTRAP's MR-ToF:

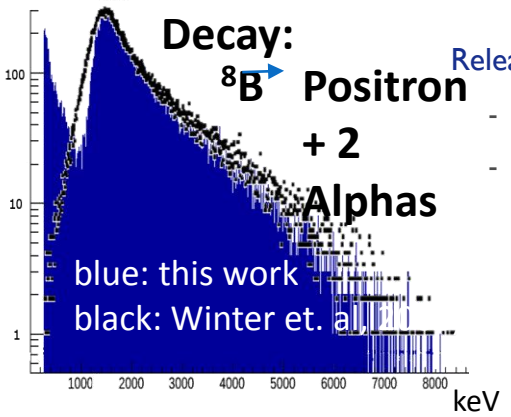
- No $^8BF_n^+$ (n=1,2,3) or Oxyflourines detected
- Positron activity on A=8 corresponds to **3*10^2 1/uC**
- Proof that activity originates from ^{8}B still pending

TaFx$^+$ ion beams



Target unit #513 : (Same characterisics as #499, higher SF_6 injection: 1 10^{-4} mbar*l/s,)





Release of ^{8}B & LA1 (Tengblad et al.):

- $^8BFn^+$ (n=1,2,3) detected this time !
- Positron activity on A=46 corresponds to **3$10^4$-10^5/uC (~1nA stable contaminant also detected)**

Ch. Seiffert, J. Ballof, M. Delonca, B. C. Gonsalves, W. Hwang, R. Lica, M. Madurga Flores, T.M. Mendonca, J. P. Ramos, T. Stora, O. Tengblad, D. Torresi, K. Riisager, M. Borge, M. Owen,et al

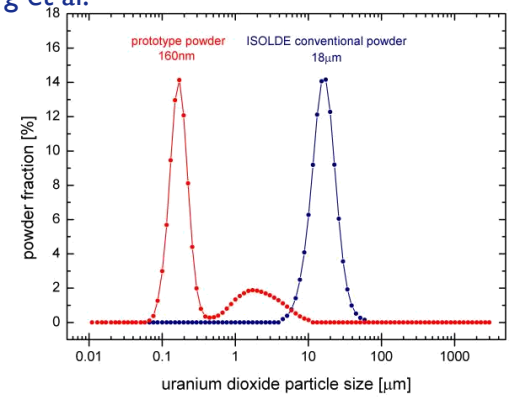
Recent results

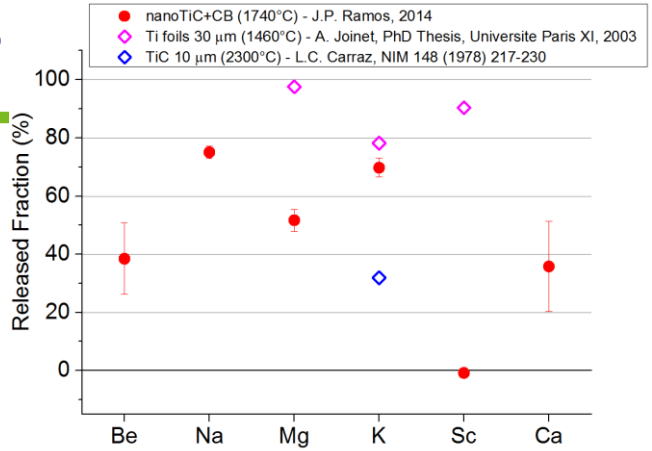
- Nanomaterials

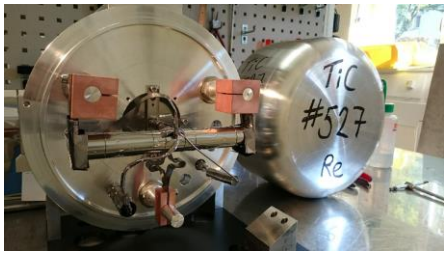
NanoUCx+MWCNT (ActlLab, ENSAR) has been operated at **IPNO-ALTO in Jun 2015**

Good and stable yields of n-rich Rb and Cs (99,100Rb, 148Cs)

A. Gottberg et al.

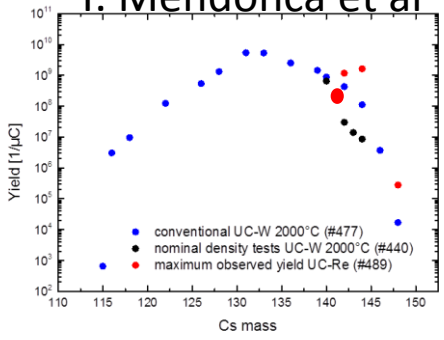


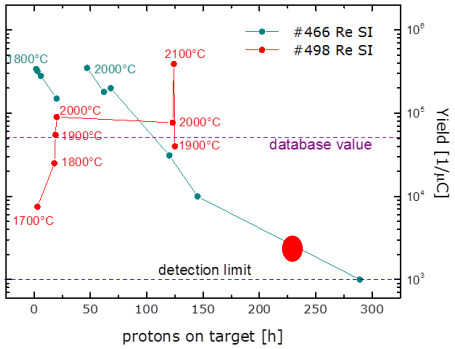


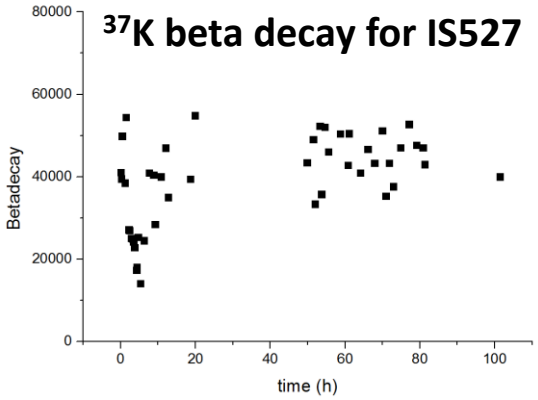


- New UO_2 powder batch : 1st unit UC539

T. Mendonca et al







Delivered stable 1e6pps 37K (>8e6 was expected)

J.P. Ramos et al.

T. Stora EN-STI

Organization

- Developments discussed 1x/year at GUI meetings (New website under construction): http://isolde.web.cern.ch/group-upgrade-isolde-gui

- Priorities (old):
- priority I : approved INTC proposals asking techn. dvlpt + missed scheduled beams
- Priority II : LoIS
- Priority III : R&D

- New Priorities:
- Priority I : aproved INTC LoI`s asking for techn dvlpt + missed scheduled beams
- Priority II : R&D

Past developments and …

ZrO_2 – HP	SeCO	^{70}Se	**IS405 (IS394)**	**DONE 2005**
C (graphite) - W	Offline/ PSI C target	^{7}Be	**IS391 IS366**	**DONE 2004**
UC_x – MK5	n-rich Sn	Many	**IS413**	**DONE 2005/2006**
REX dev.	—	Many	**REX**	**DONE 2006**
UC_x	n-rich Zn	^{76}Zn -^{78}Zn -^{80}Zn	**IS412 IS413**	**DONE 2005**
U/Th – LIS	Au	^{201}Au ^{203,205}Au	**I60 IS447**	**DONE 2006**
UC_x – LIS	n-def. Po	RILIS Po	**I57**	**DONE 2006**
RILIS	Hg	RILIS Hg	**TISD**	**DONE 2006**
SiC – W	F / AlF - LaF	^{17}F	**IS424**	**DONE 2007**
Ti foil Si "foil" SiC	n-def. Mg	^{22}Mg ^{23}Mg ^{21}Mg	**IS427 IS413**	**DONE 2007**
Pb	^{182,184}Hg	^{182,184}Hg	**IS452**	**DONE 2007**
ZrO_2 TiO free	^{62}Ga	^{62}Ga	**IS406**	**DONE 2008**
UC_x	n-rich Cd		**IS393 IS411**	**DONE 2008**
Y2O3 - VADIS ion source		^{72}Kr	**P228**	**DONE 2009**
CaO - VADIS	Ar	^{35}Ar	**IS433**	**DONE 2009&2011**
Several			**TISD**	**DONE 2007**
Light (MgO) Bi-valve			**TISD**	**DONE 2008**
Various standard	Various	Various	**TISD**	**DONE 2009**
Various			**TISD**	**DONE 2010**
UC_x	n-rich Cd	^{128}Cd	**P226**	**DONE 2009**
Y2O3 VD7	several	^{72}Kr		**DONE 2011**
UC_x	Na	^{30}Na		**DONE 2011**
Ta-GdB6	Lanthanides	^{140}Nd, $^{140-142}$Sm	**IS496**	**DONE 2010&2011**
Ti-LIST ZrO-LIST	RILIS TiO2 impur.	n-def Mg	**TISD IS462**	**DONE 2011**
source+VD5+CF4 TiF3+	Ti	^{44}Ti	**I70 IS543**	**DONE 2012**
neutron converter	fissions (Cd, Zn, Cu, etc)	n-rich	several	**PHASE I DONE 2012**
UCx-LIST	RILIS		**TISD**	**DONE 2012**
UC_x	various	various	**TISD**	**DONE 2012**
nanoTi, RILIS	n-def K, Ca	37K	**IS527**	**DONE 2014**
MgF, CaF, CNTs + CF4	B	^{8}B	**I126, I127, I128,I129, I130**	**DONE 2015**
Negative ion sources	F, Br, Cl, I, At, Au, Po,S	many	**I157, IS575**	**UNDERWAY 2015**

And pipeline

ThO2, nanoUC, LIST, New n-conv	Cu	^{75}Cu $^{76-79}$Cu	**IS535**	Done this year ?
Pb, UCx	n-rich Hg, Tl	$^{207-210}$Hg $^{208-214}$Tl	**IS463**	^{207,208}Hg done this year
ThO,UC_x – HP(molecule) ThO,UCx – LIS (elementary) LIST, n-conv	n-rich Te	$^{132, 134, 136}$Te	**IS411, IS596**	
UC_x – W + CF_4	n-rich Ba, n-rich Sr	^{144}Ba	**IS411, IS523**	
Y_2O_3 VD5	several	^{48}Cr, ^{56,57}Co ^{75}Se, ^{77}Br	**IS450 IS453 IS487 IS492 IS501**	
Neutron converter	fissions (Cd, Zn, Cu, etc)	n-rich	several	
UCx, ThCx,		150-152Cs	**IS579**	
Pb/Bi loop	Hg, (Cd if molt Sn, Ne/C if molt NaF)	n-def	**IS490 IS521**	Done, addendum
LaCx/molten La-surf +CF4	Ba as BaF+	113-118Ba	**IS545**	
UCx, LIST, NIS	n-rich Po	211m,212mPo	**IS456**	
nanoY2O3, ZrO2, RILIS	n-def Te	^{118}Te	**IS516**	
nanoUCx-VD7	n-rich Ar	46-48Ar	**IS490**	already scheduled 2015
No Ucx : ThO2, molecular?	n-rich Sc		**IS532**	
UCx + VADIS + CF4	Hf		**IS537**	
UCx+VADIS + S34+n-conv	132Sn	132Sn 121-136Sn	**IS595 IS573**	
ZrO+VADIS+CO as SeCO		68Se 70 Se 72Se	**IS597 IS569 IS570**	
Ucx, ThO, GeS	Ge	64-66Ge	**IS570**	

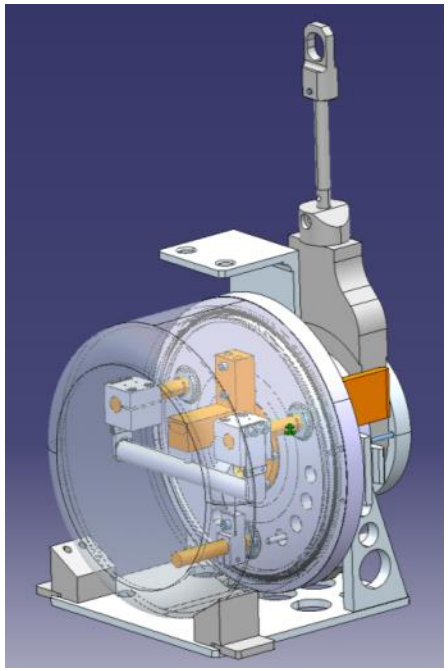
To be scheduled: ? 55Ca, IS532 ADD1, ISOLTRAP
Failed: 30Na, IS532, Miniball – delivered, but not yet to Miniball

To be scheduled: N-rich Tl and Pb: UC+LIST(+quartz)?

Target evolutions

In the past ten years,

the developments have been such that the Target and Ion Source units constructed in 2016 have at least one improvement with respect to 2006.



Team & Collaborations

- E. Barbero, B. Crepieux, M. Owen, S. Marzari: (STI-RBS) Target Production, infrastructures

- TISD team:
- Dr. T. Mendonca : Senior fellow, High power targetry (salt target, LIEBE project) : →Jul 16 (4 months maternity leave)
- (Dr.) M. Delonca : LIEBE project : → Feb 17
- J. Ballof : molecular beams (8B, carbonyl of refractory elements) : → Dec 17
- J. P. Ramos : Target nanomaterials (EPFL) : → Oct 15 +6months
- Y. Martinez (KULeuven) : 50% → 2018
- WJ Whang (RISP) : → Jul 15

GANIL, IPNO, INFN, (ENSAR2 ?), + TRIUMF, JAEA, Mainz
ITN (neutronics, UCx)
EPFL, Aveiro, (materials)
ESS, CEA, SCK●CEN-Myrrha, SINP, PSI (LIEBE project)
R. Augusto (Fluka team)