Beam developments in the Hg and ^{100}Sn vicinity

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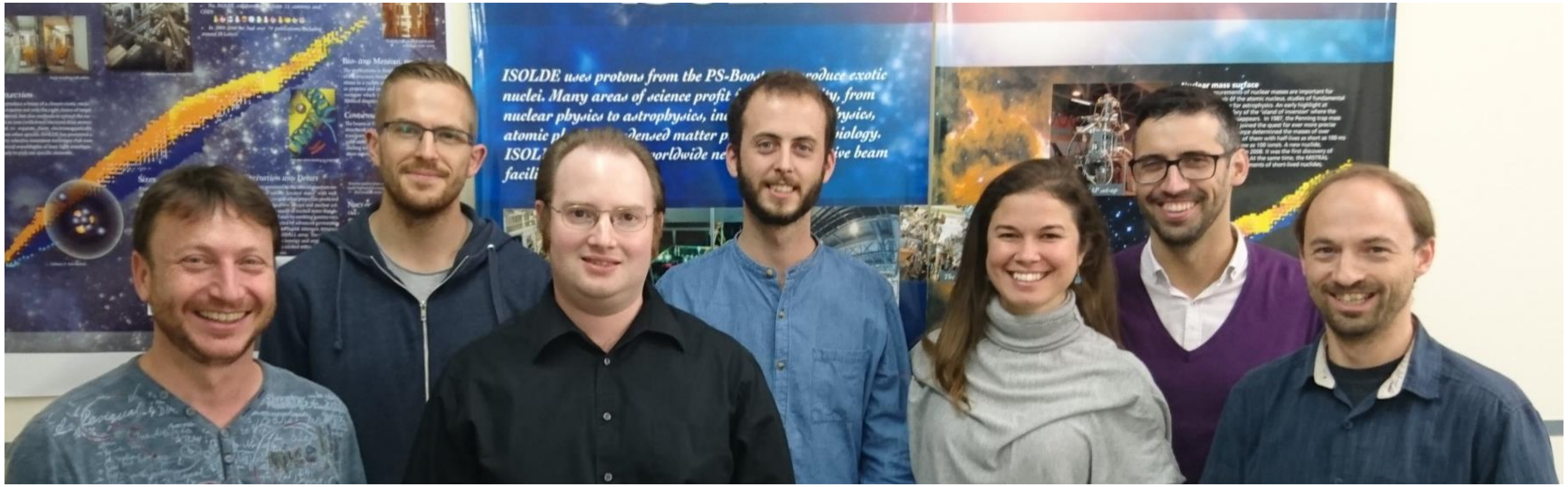
ENGINEERING
DEPARTMENT

ISOLDE Target and Ion Source Development team

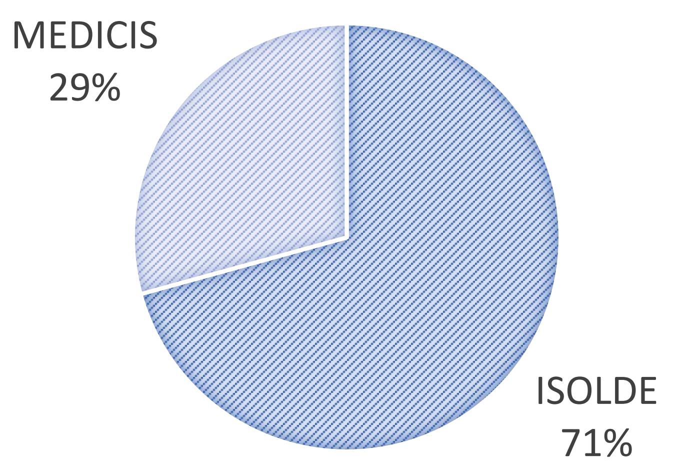


David Leimbach Ferran Boix Pamies Joao Pedro Ramos

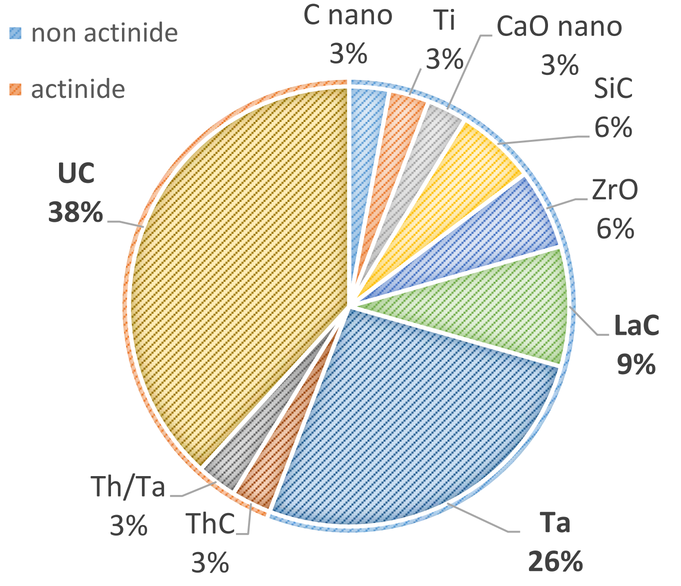
Thierry Stora Jochen Ballof Yisel Martinez Sebastian Rothe

ISOLDE Target Production 2018

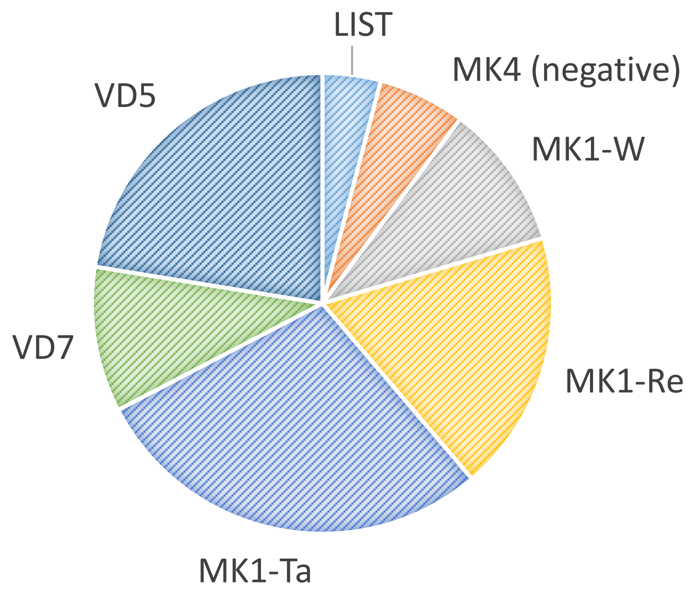
TARGET DESTINATION



TARGET MATERIALS



ION SOURCES



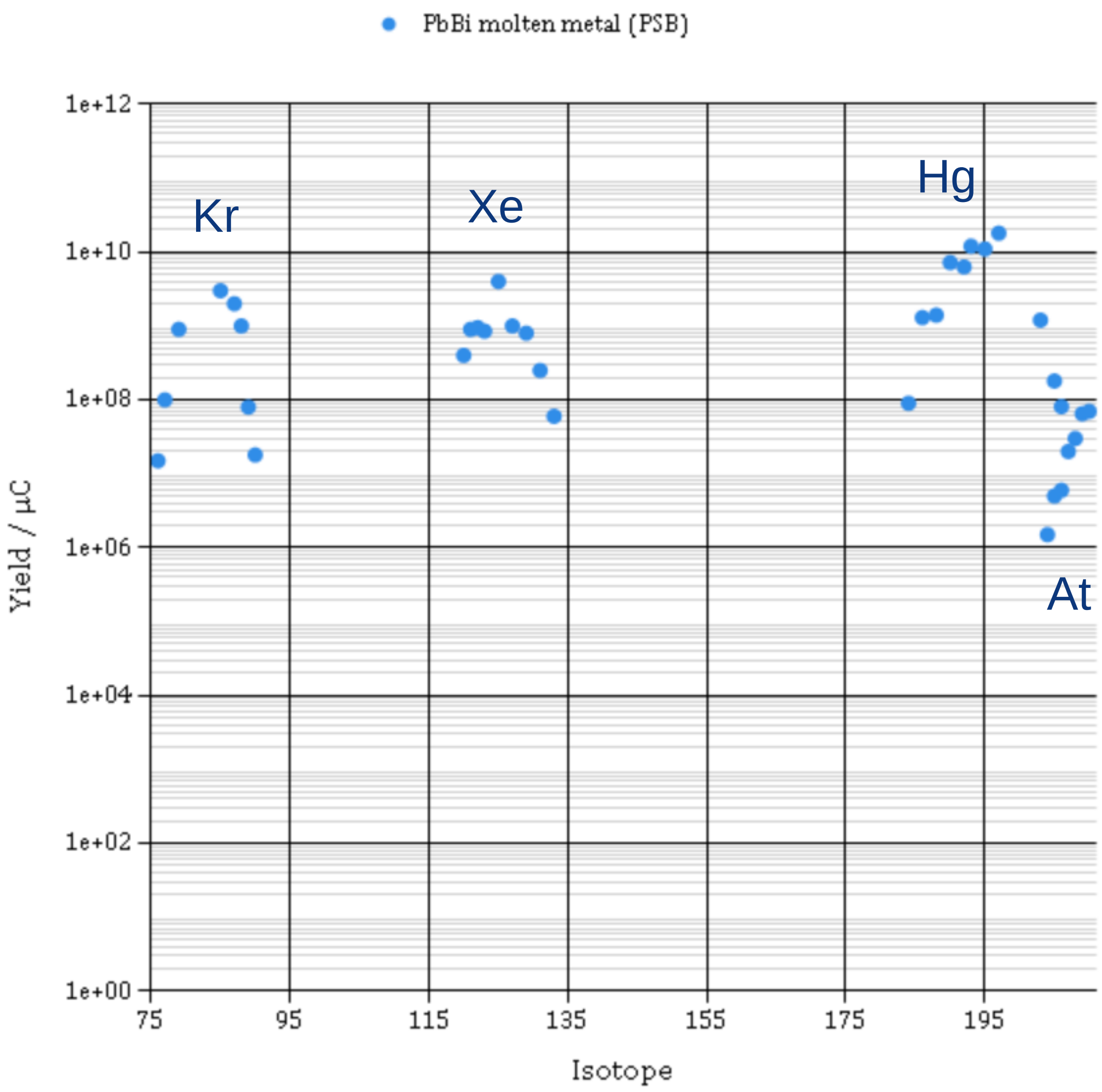
Total targets assembled end of 2018 : **49**

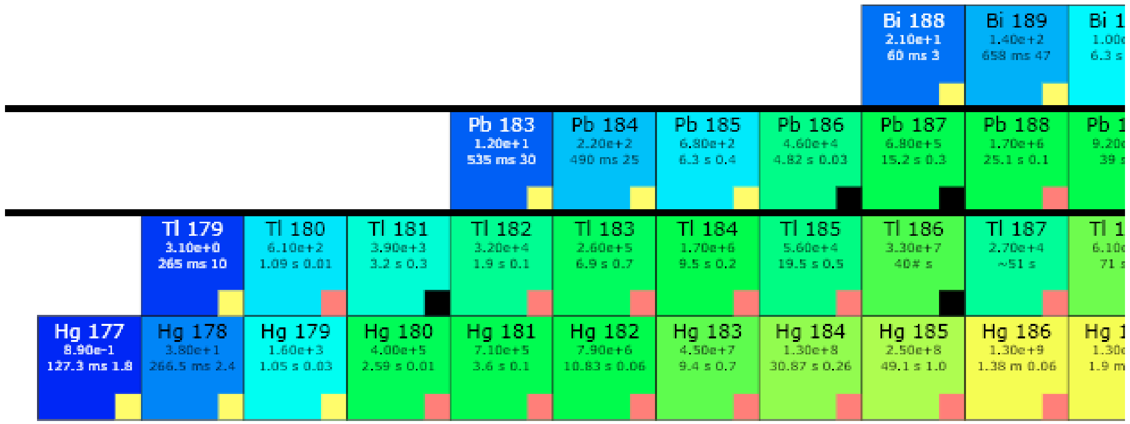
- Delivered to ISOLDE: **29**
- Delivered to MEDICIS: **10** + 2 in December
- Used for development: **8** (16%)

- **10 different materials**
- Mostly carbides and metal foils
- Most popular: **uranium carbide**

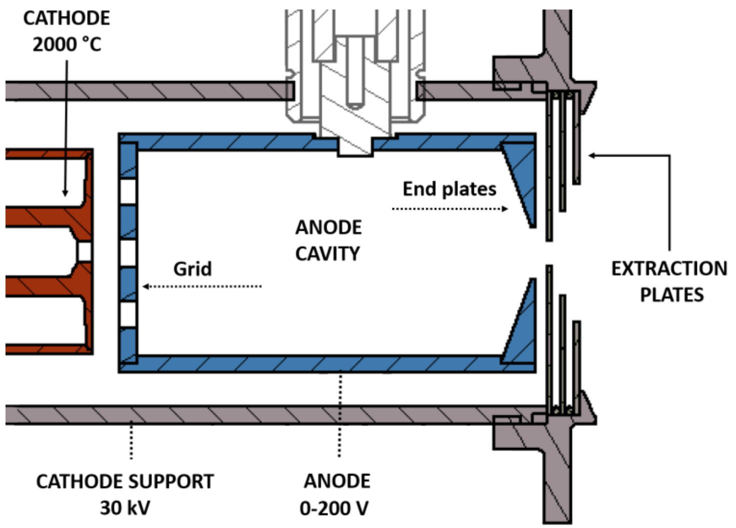
- **7 different ion sources**
- LIST and negative ion source back in action

Yields from static Pb(Bi) targets



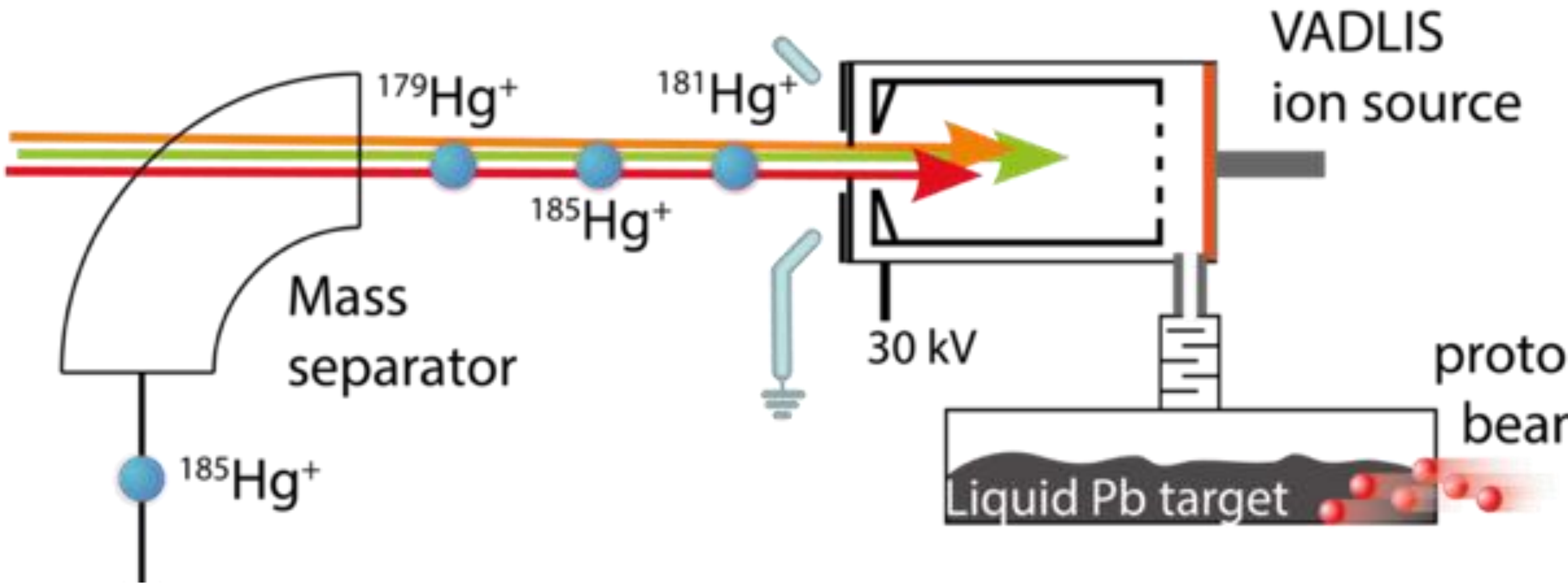


The ISOLDE Yield Database, Version 0.1, https://cern.ch/isolde-yields, 2019, [Online; accessed 20.03.2019].



FEBIAD (VADIS)
Forced electron beam induced arc discharge ion source

Clean ^{206}Hg beams with VADLIS



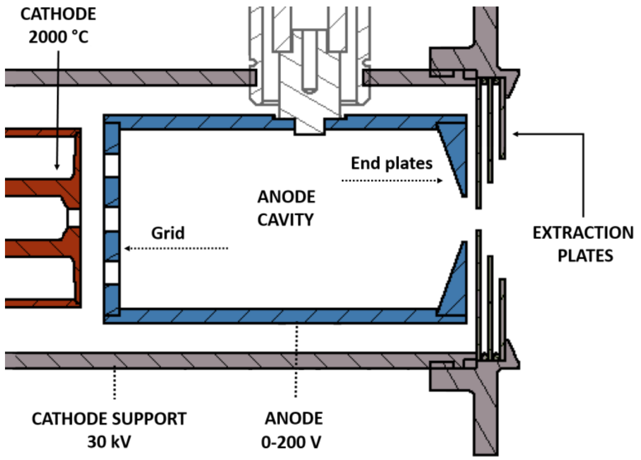
- 3^{rd} on-line application of VADLIS ion source for an experiment
  - (full **Hg chain** for in source laser spectroscopy; Mg + Ne for ISOLTRAP, **206Hg** for Miniball)
- RILIS–mode achieves similar efficiency to VADIS-mode

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

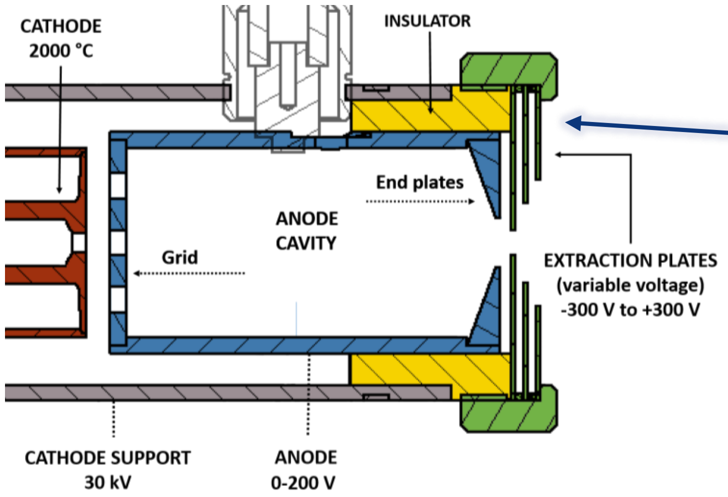
B.Marsh

VADIS / VADLIS developments

Standard VADIS



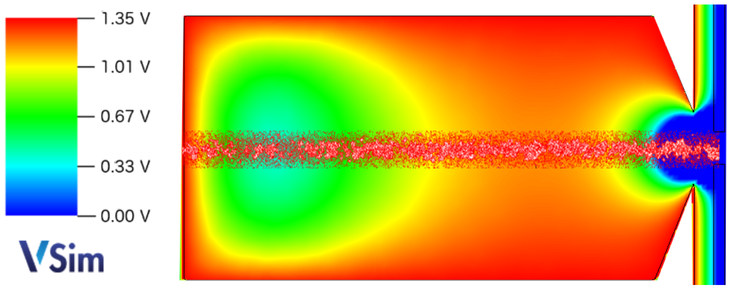
VADIS Dev. [1]



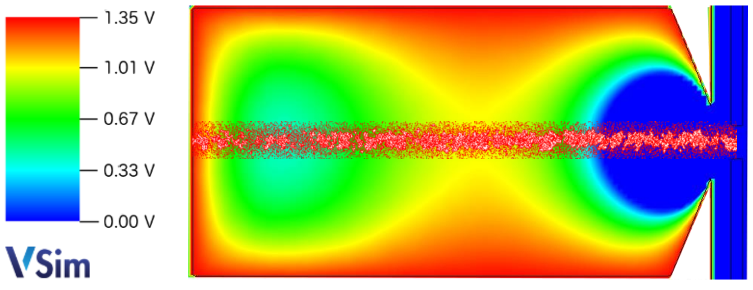
Biased extraction plates enable efficient extraction in RILIS mode

Factors 2.5 … 7 reported

Extraction plates 0 V



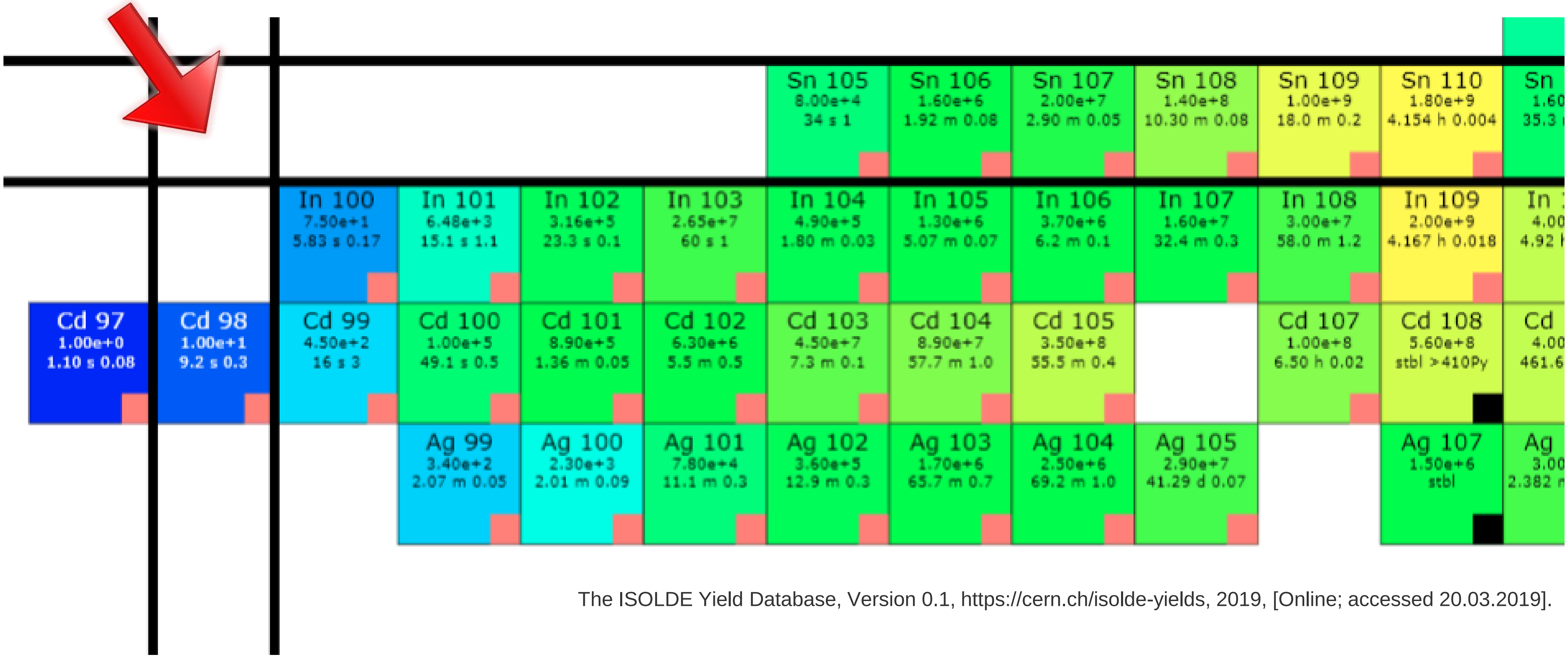
Extraction plates -100 V



B.Marsh

[1] Y Martinez, B Marsh et al, NIMB, 431, 2018, 59-66

Towards ^{100}Sn



The ISOLDE Yield Database, Version 0.1, https://cern.ch/isolde-yields, 2019, [Online; accessed 20.03.2019].

Neutron deficient Sn from LaC

Target #620 LaC Ta + RILIS. (2017)

Betas => Ions/µC							β Counts	v2(2016)
by J.P. Ramos							9179	
Isotope	104Sn			2.08E+01 s			9159	8.9E+03
Half-life	0.0	0.0	0.0	0.0	20.8	0	8718	
	y	d	h	m	s	ms	8490	
3.30E+13 ppp	ppp or uA?		uA				Background	8418 counts
0.39 uA								
							atoms on tape	1.41E+03
							transport corr.	2.90E+02
Delay	10 ms							
Collection	5000 ms							
Measurement	10000 ms						Yield	
Transport	900 ms						1.0E+03 ions/uC	±3.8%
Transmission	73%							

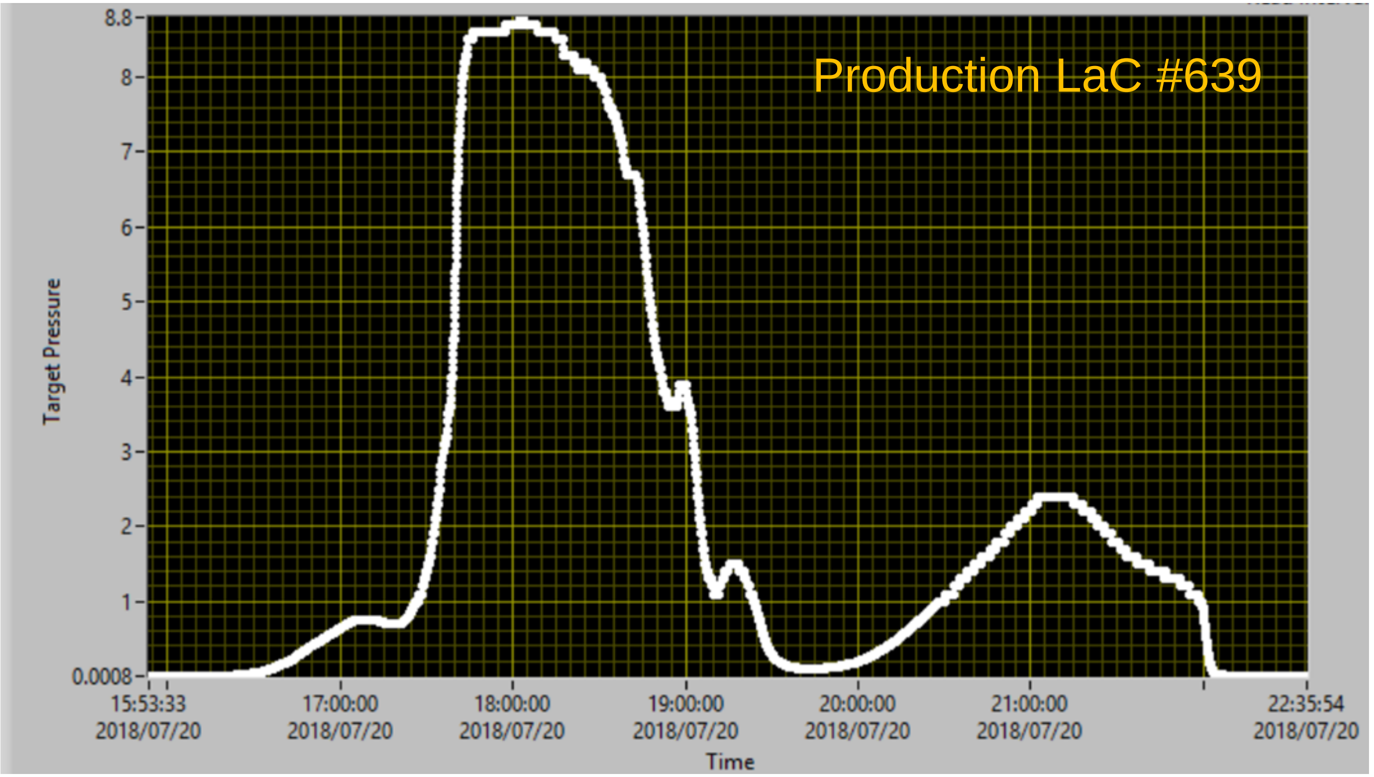
^{104}**Sn: 1000** ions per second (betas)

Target #639 LaC Ta + RILIS. (2018)

^{104}**Sn: 1500** ions per second (CRIS experiment)

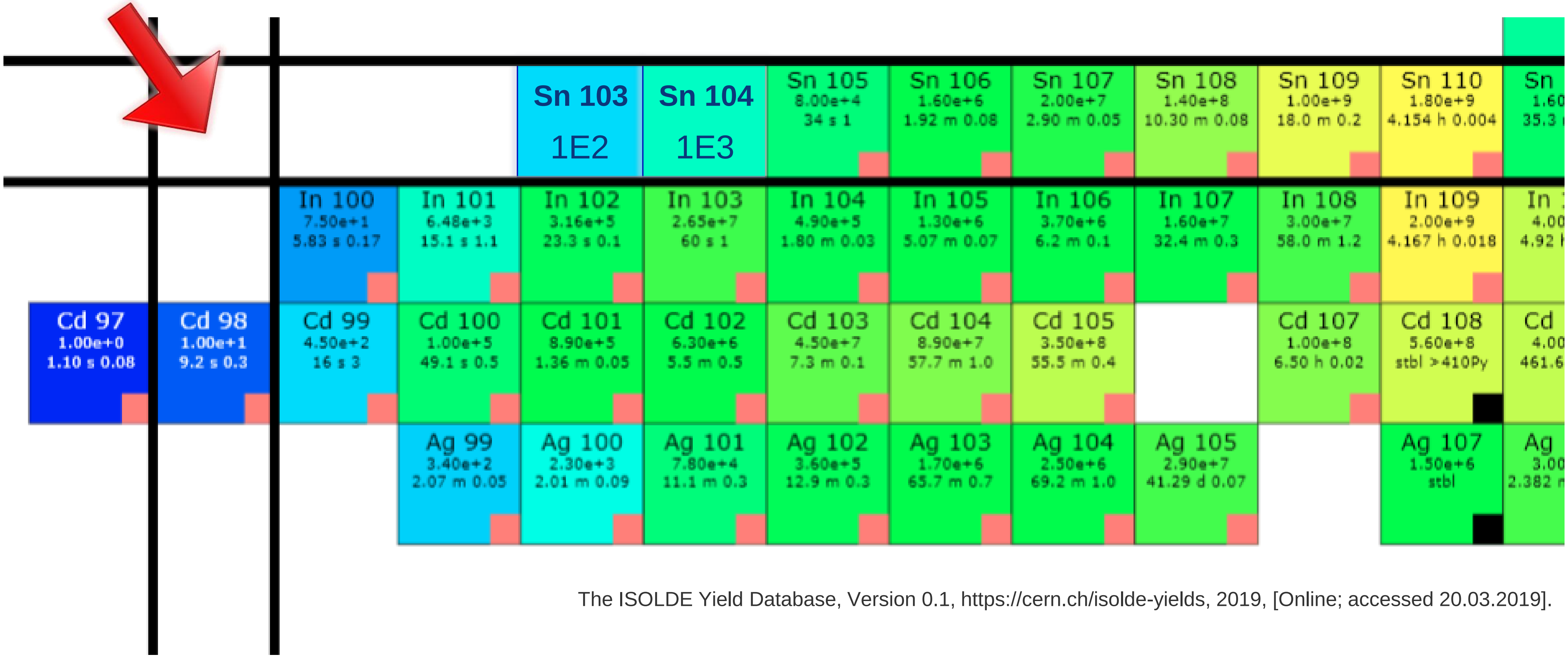
^{103}**Sn: 100-1000** ions per second (CRIS experiment)

Both used improved 1 day carburization process of LaC



5 h production time (increased by factor 24)

Towards ^{100}Sn



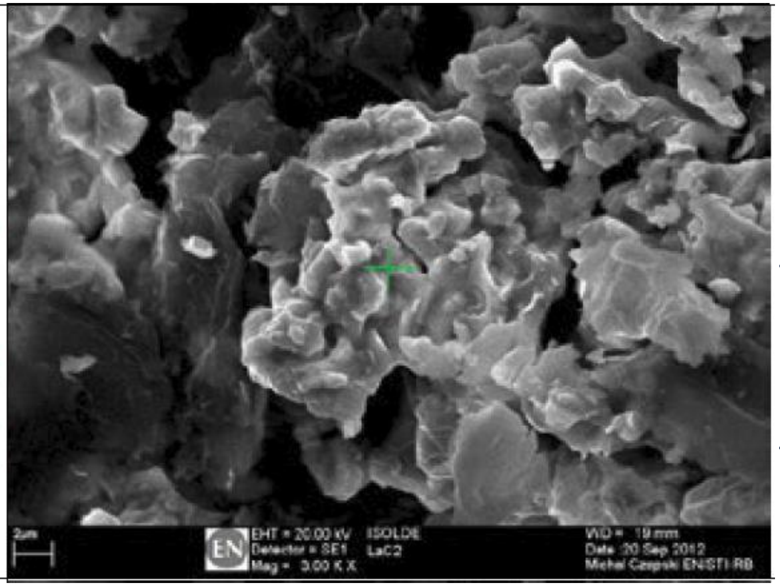
The ISOLDE Yield Database, Version 0.1, https://cern.ch/isolde-yields, 2019, [Online; accessed 20.03.2019].

LaC – Next steps

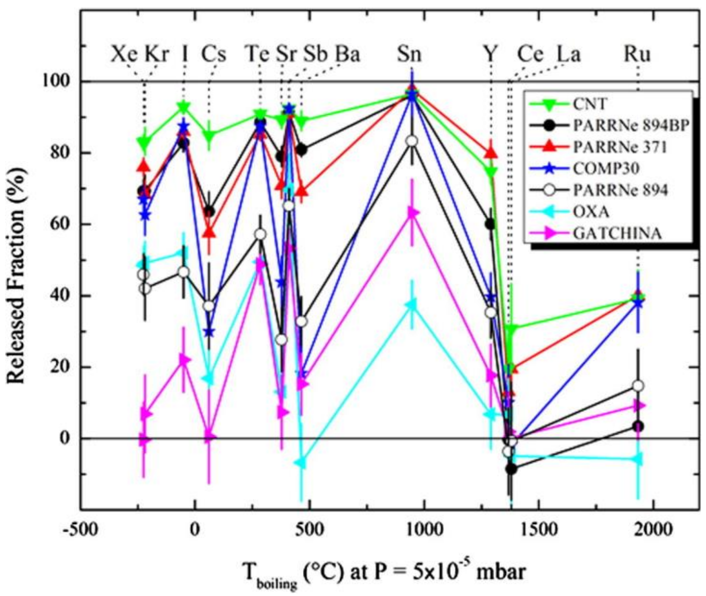
- Investigate the effect of the production process on the material properties (grain size, porosity)
  - Similar studies ongoing for UCx
  - Release studies could be performed at ALTO or TRIUMF

- **Going nano :** Prototype Target #489 – LaC operated on-line
  - High release efficiency for Ba and Cs observed, **Molecular beams extracted using SF6 reactive gas**

s4b LaC_3 – BLACK – x3k



Joao Pedro Ramos et al, EDMS: 1245228



Nenez et al. NIMB, 370, 1 March 2016, Pages 19-31

Requires dedicated nano lab

-> Generally: release Efficiency better for nano structured materials

La (liquid metal)

Dens. 5.94 g/cm3, MP=920°C, BP=3464°C

The ISOLDE Yield Database, Version 0.1, https://cern.ch/isolde-yields, 2019, [Online; accessed 20.03.2019].

^{100}Sn from liquid La loop:

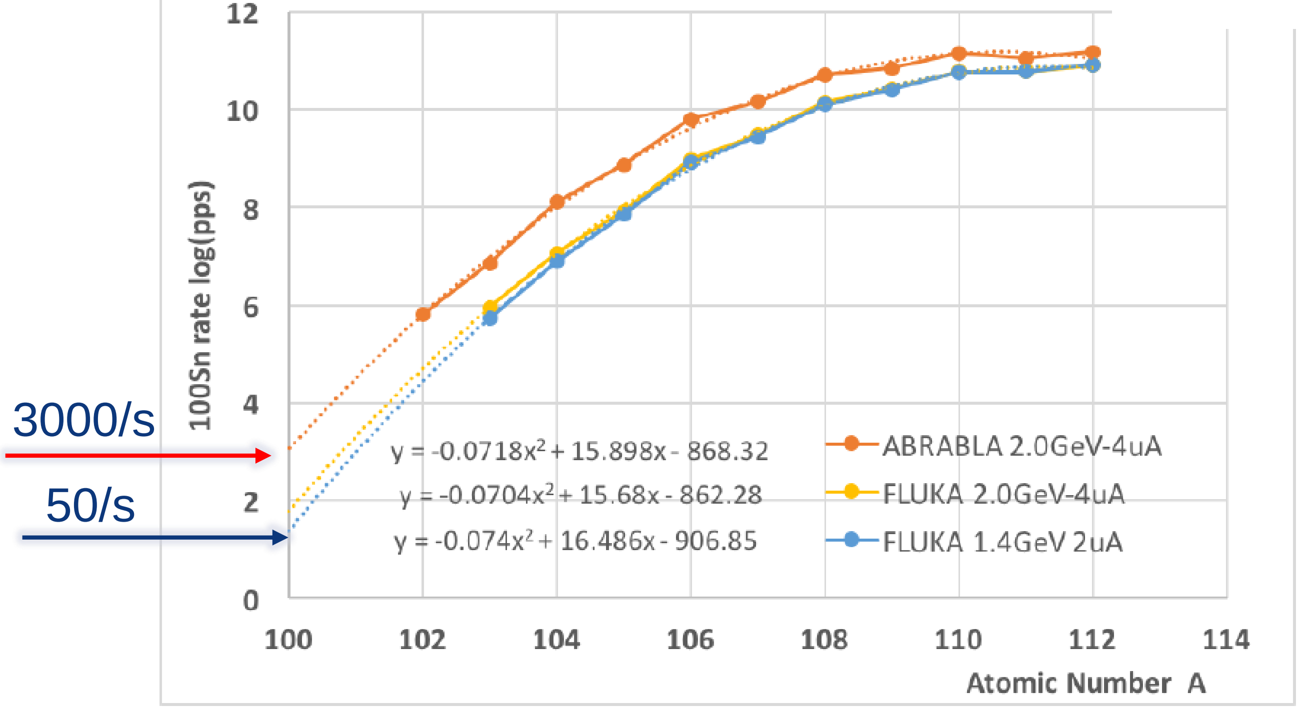
The LIEBE high-power target: Offline commissioning results and prospects for the production of ^{100}Sn ISOL beams at HIE-ISOLDE

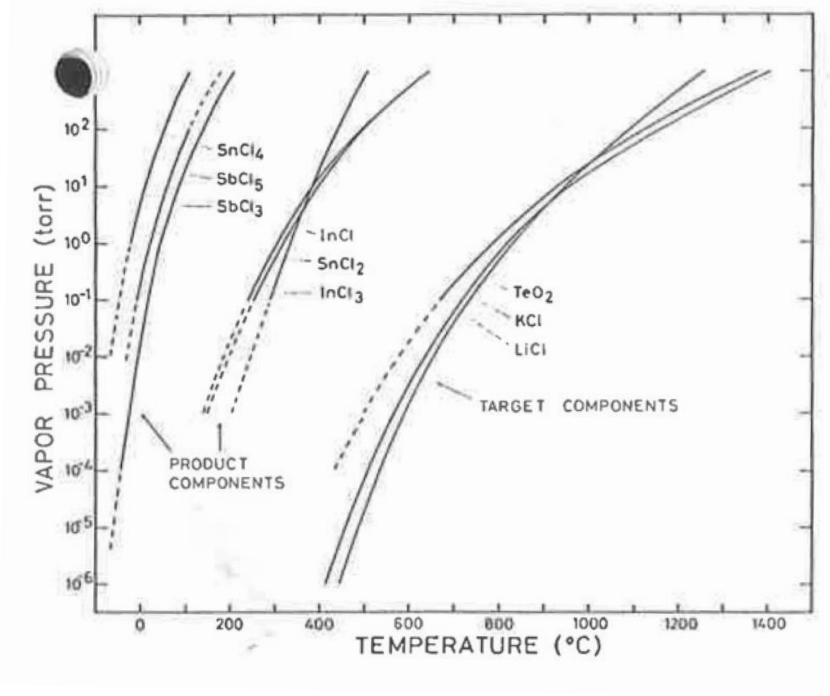
F.Boix Pamies[a], T.Stora[a], E.Barbero[a], V.Barozier[a], A.P. Bernardes[a], R. Catherall[a], B.Conde Fernandez[a], B.Crepieux[a], L.Goldsteins[b], J.L. Grenard[a], E. Grenier-Boley[a], D.Houngbo[c], K.Kravalis[b], G.Lili[a], S. Malbrunot[a], G. Neyens[a], L.Prever-Loiri[a], J.P. Ramos[a], J.M. Riegert[a], S. Rothe[a], C. Veiga Almagro[a], A. Vieitez[a]

[a] *European Organization for Nuclear Research, CERN*
[b] *Institute of Physics University of Latvia, IPUL*
[c] *Belgian Nuclear Research Center, SCK-CEN*

Submitted NIMB, EMIS2018

Sn in-target production from liquid La (assuming 100% La metal)





CDS: 0.5170/CERN-1981-009

- **Careful:** log extrapolation over 2 masses
- Sn, Sb and In form volatile **chlorides**

- Sn, Sb and In form volatile chloride molecules

Prediction for extracted 100Sn: 0.5 …. 30 /s

Studying molecular beam formation

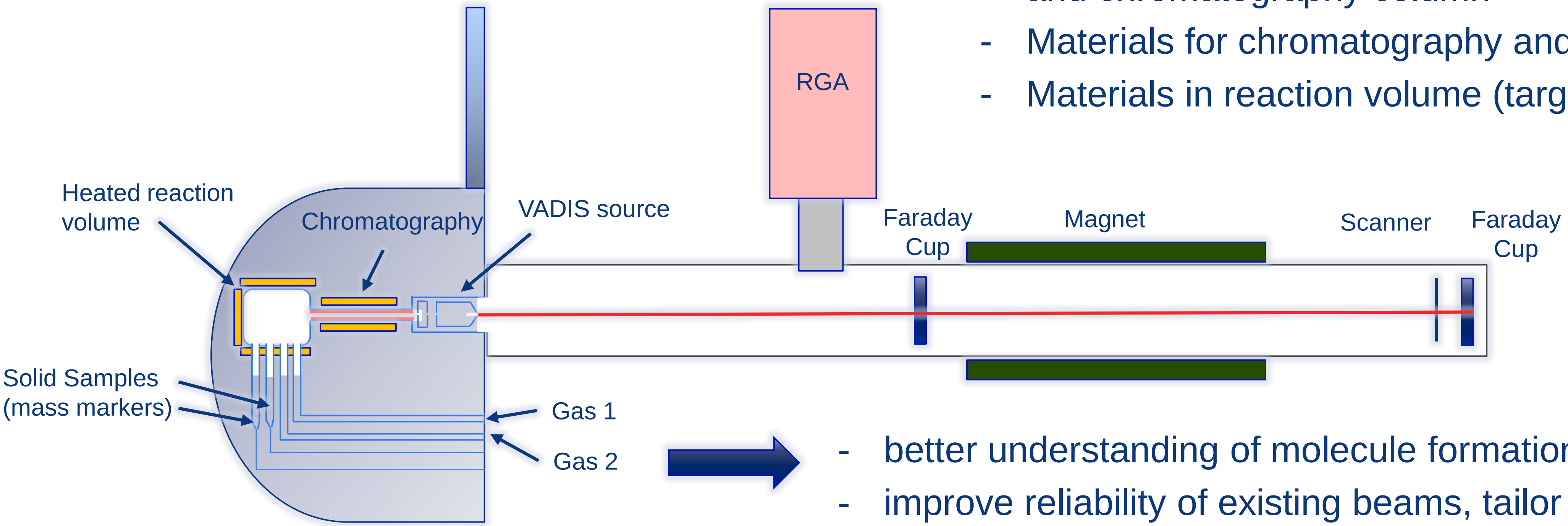
Concept for a dedicated development unit for molecular beams

Study chemical reactions

- Injection of gases and vapor of solid samples into reaction volume
- Suppression by quartz and other materials

Parameters

- 2 gases, controllable flow rates
- 2 mass markers
- Controllable temperatures in reaction volume and chromatography column
- Materials for chromatography and
- Materials in reaction volume (target matrix)

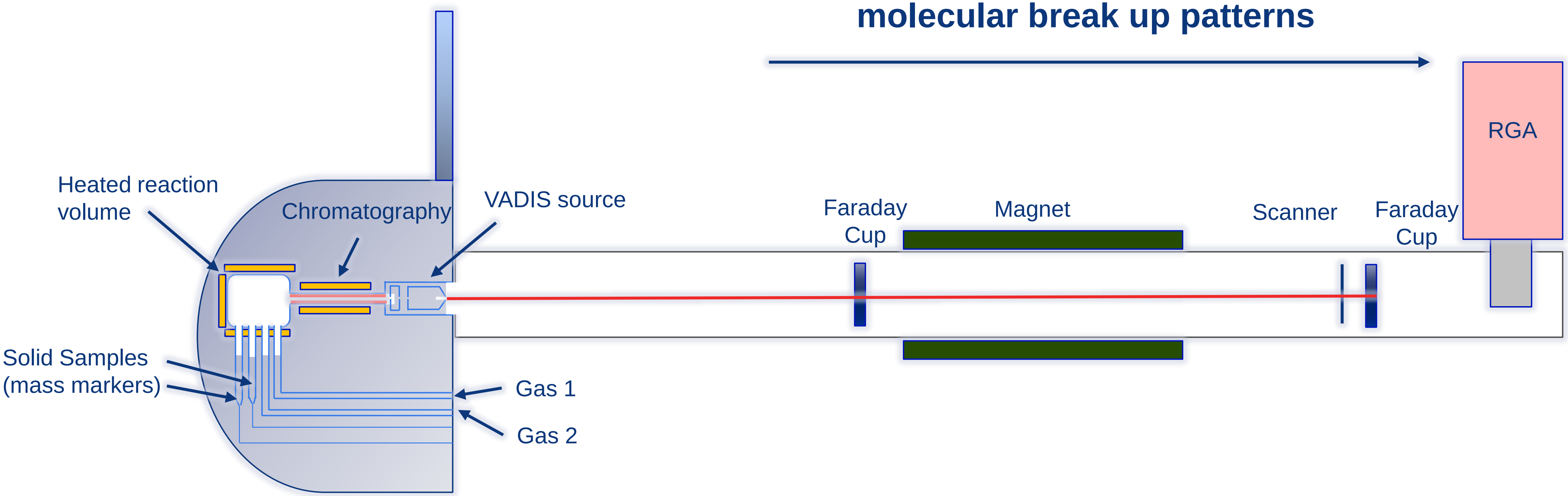


- better understanding of molecule formation
- improve reliability of existing beams, tailor new beams

Studying molecular beam formation

Concept for a dedicated development unit for molecular beams

- Move residual gas analyzer to identify separated beam composition through **molecular break up patterns**

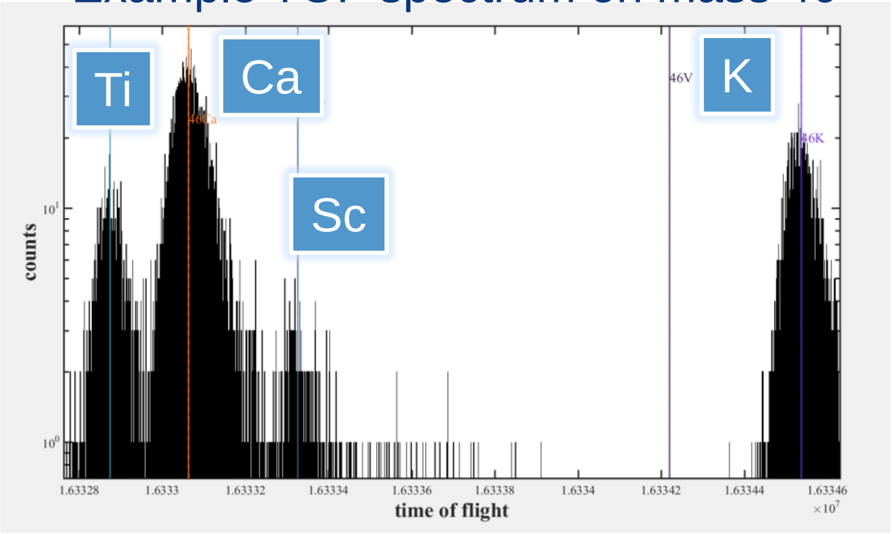


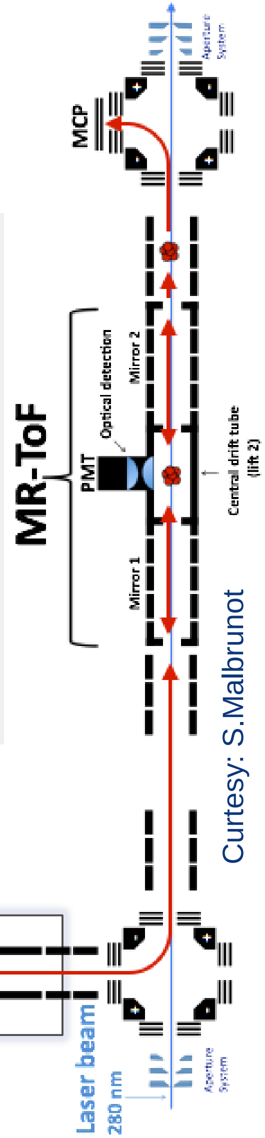
Studying molecular beam formation

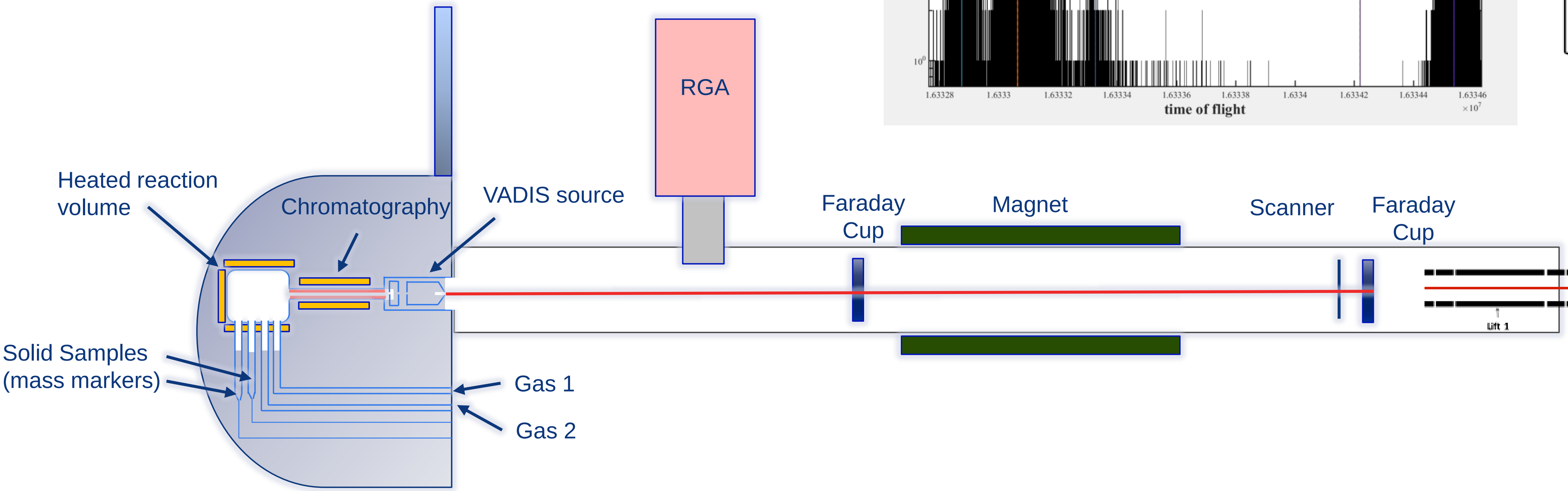
Concept for a dedicated development unit for molecular beams

- Add **Multi Reflection Time of Flight (MR-ToF)** mass spectrometer: allows ISOBAR separation.
- Collaboration with MIRACLS experiment launched

Example TOF spectrum on mass 46



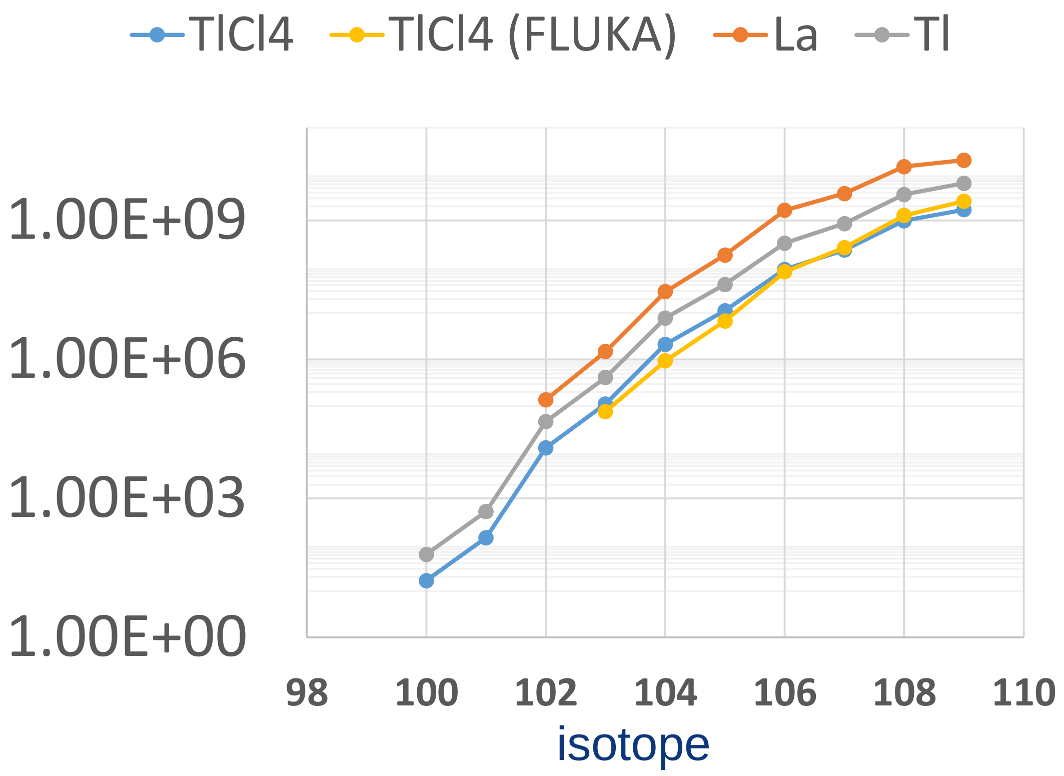




^{100}Sn from Tellurium

- **$TeCl_4$** – used at ISOLDE in the past for Sn Extraction (SC)
  - 3.26 g/cm^3 (MP=224°C, BP=380°C)
- **TeO_2** – used at ISOLDE for Sb production
  - 5.67 g/cm^3 (MP=732°C, BP=1245°C)
- **Te** – never used
  - 5.7 g/cm^3 (MP=449.5°C, BP=988°C)

1.4 GeV – Sn yield /μC ABRABLA / (FLUKA)

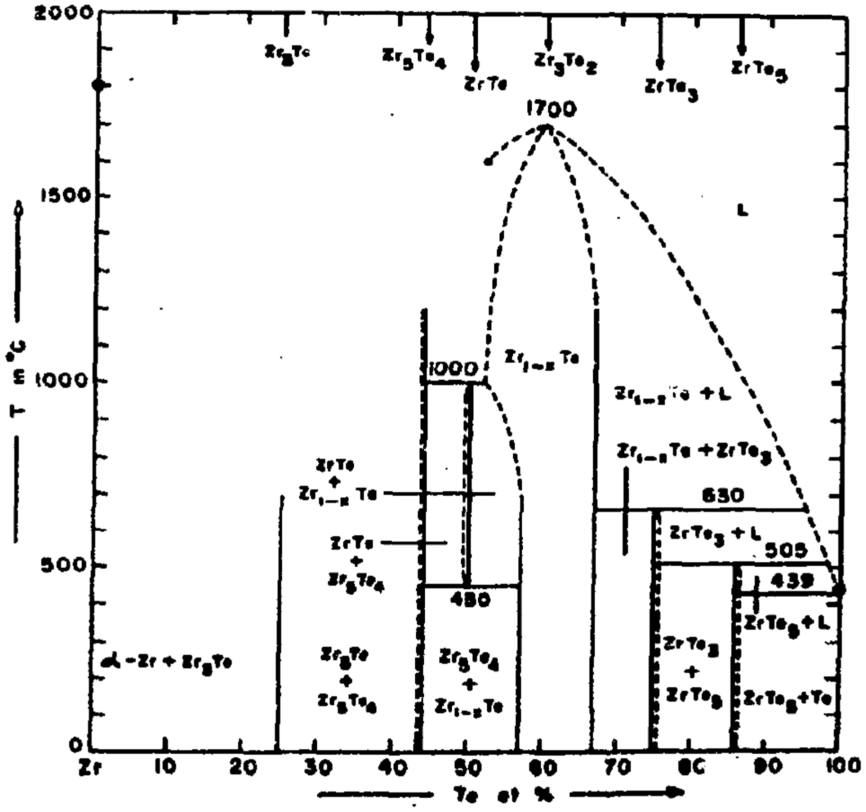


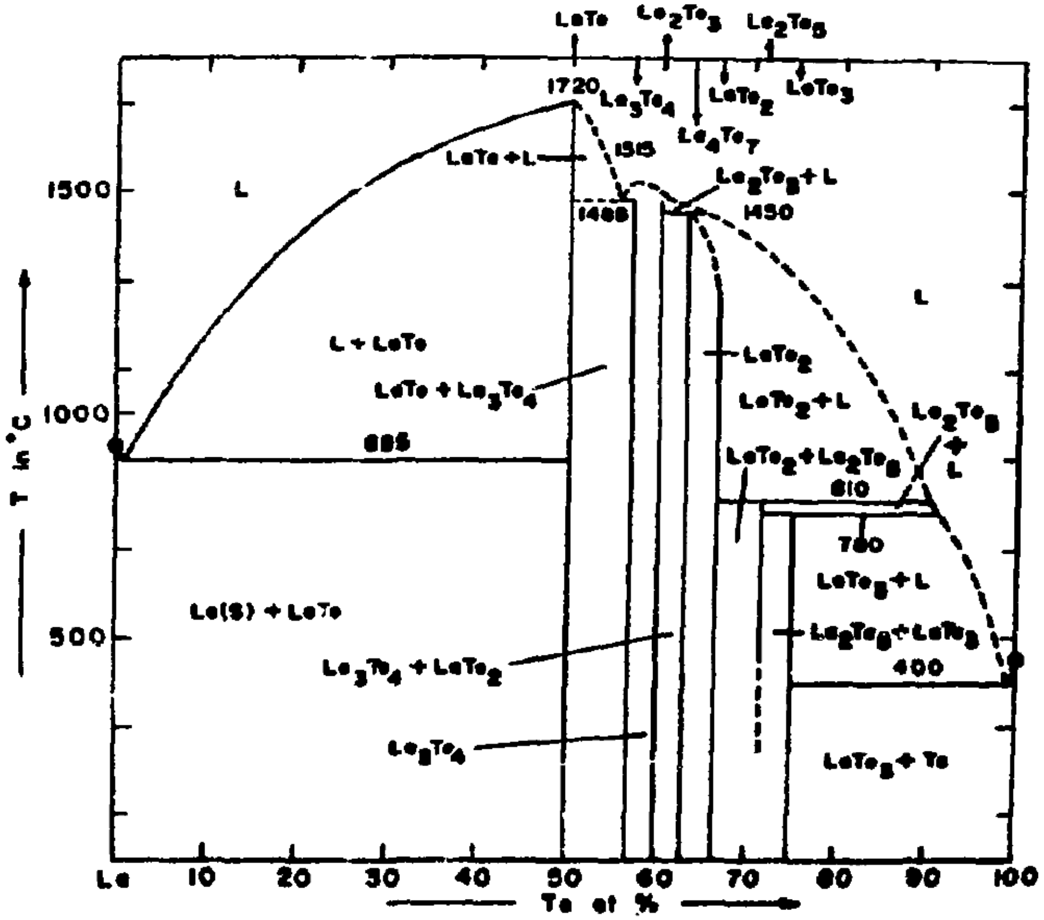
- Codes actually predict 100Sn from Te

^{100}Sn from solid tellurides

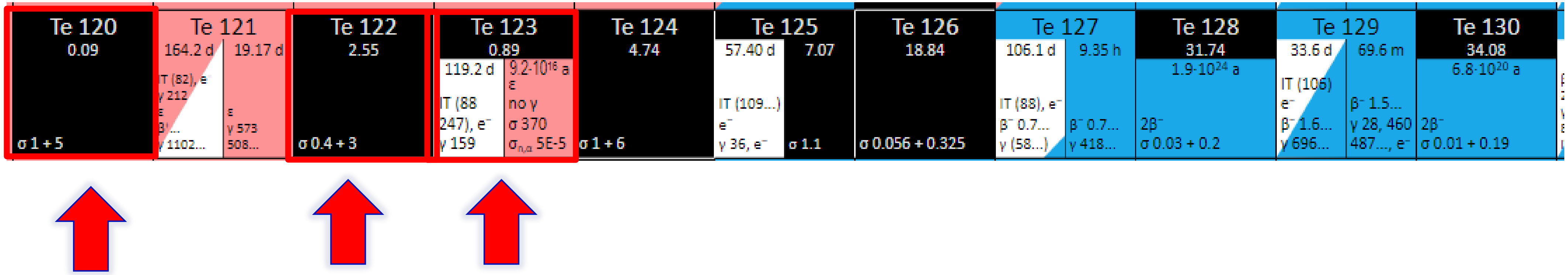
- **Cr_2Te_3,** MP= MP=1300°C
- **Zr_3Te_2**, MP = 1700°C
- **LaTe** ,MP=1720°C

https://inis.iaea.org/search/search.aspx?orig_q=RN:20083495





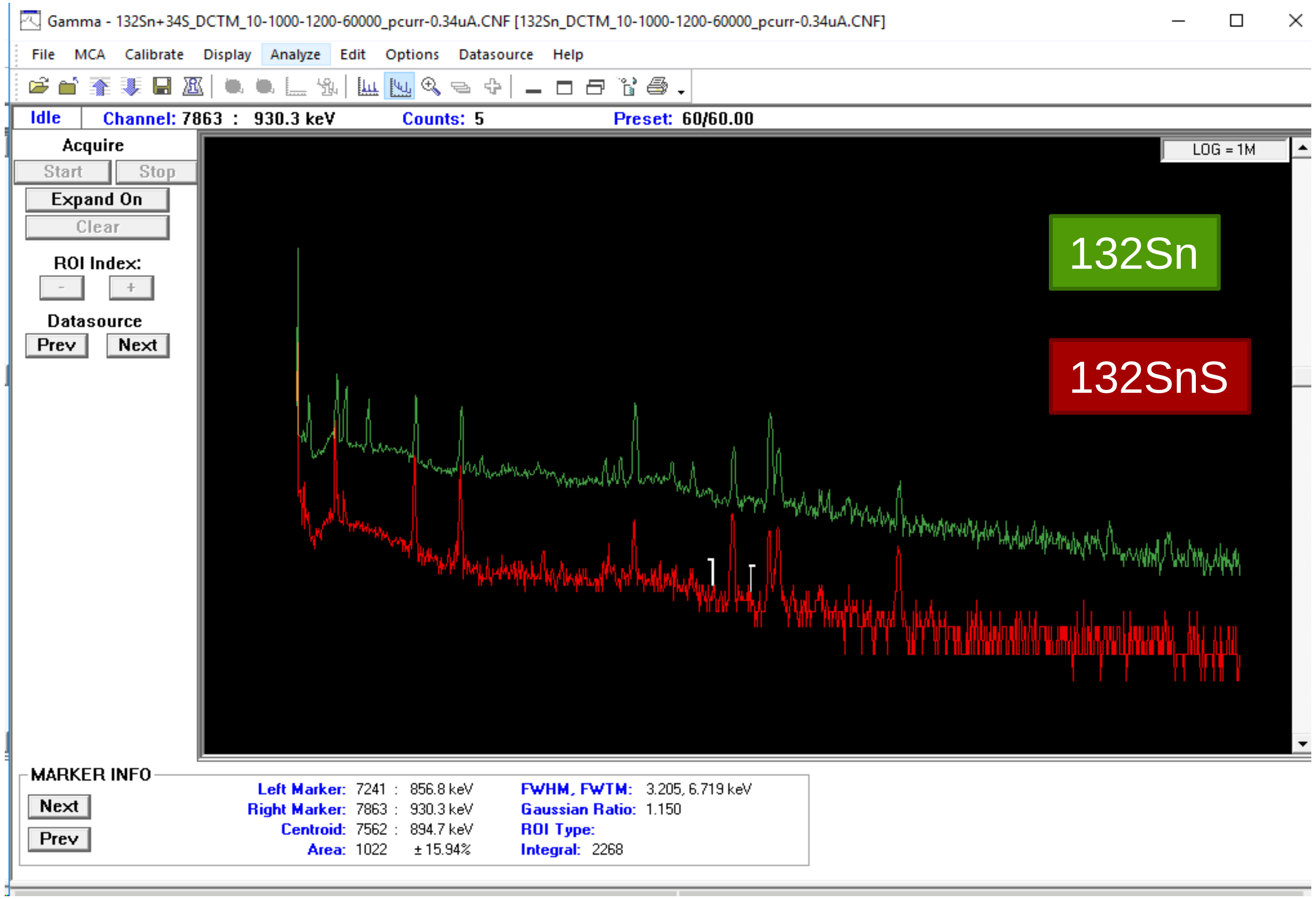
^{100}Sn from enriched Te ?



- Only 3 isotopes contribute to 100Sn
- Enriched target could give factor 30 in ^{100}Sn yield for any Te target
- Rather not due to extreme costs (> 1000 CHF / mg for 56% enriched 120Te) [1]

[1] Private communication: U.Köster

Molecular tin beams : $^{132}Sn^{34}S$



- Comparing gamma spectra of ^{132}Sn and $^{132}Sn^{34}S$

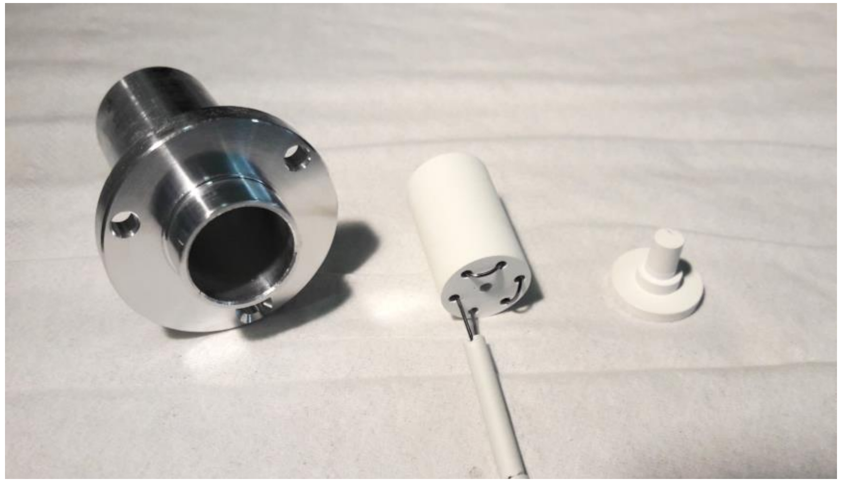
Mass marker design for 34-Sulphur as reactant

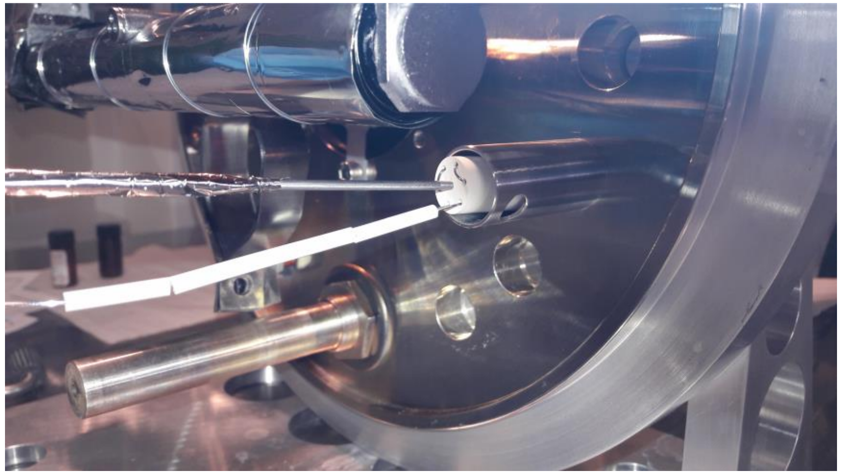
Observed problem:

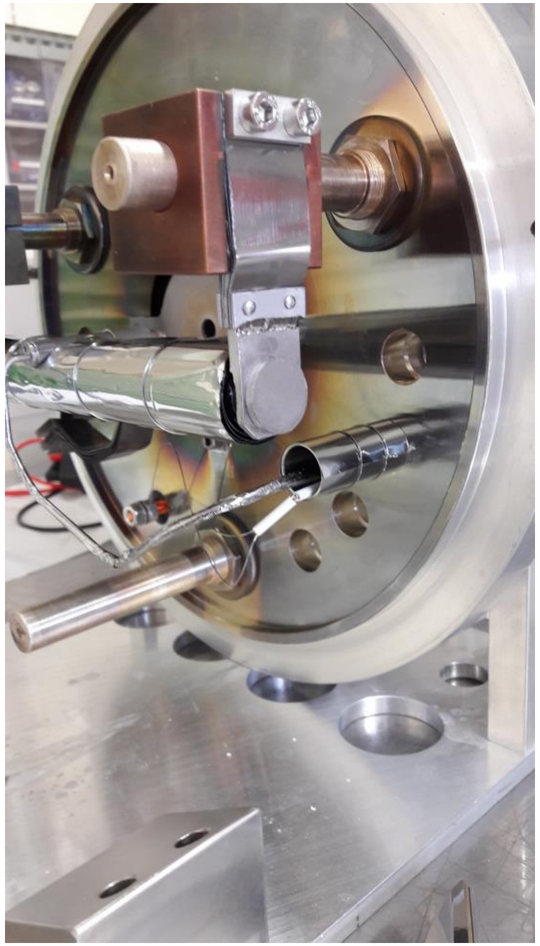
- Yield drops over time as S continues to evaporate from conventional oven
- -> Uncontrolled release.

New design:

- Sulphur reservoir placed in water cooled base plate.
- No line of sight with hot surfaces.
- Ohmic heating through Ta wire heats BN chamber
- -> Controlled release.







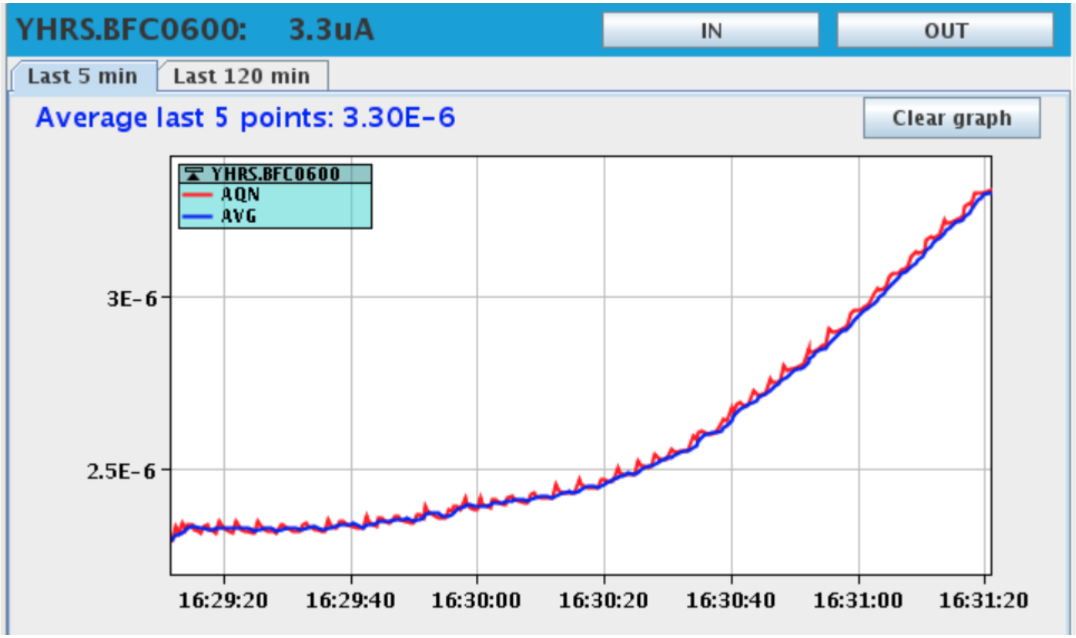
Sulphur mass marker on-line

08/09/2018 16:30

DAY ISO HRS

Significant increase in total current after heating up Oven2 from 5 to 6.5 A.

/JAR/Miniball



- Reacts at relatively low currents
- Heater can be optimized to allow finer steps