CERN

Target group: J.P. Ramos, S. Rothe, D. Leimbach, J. Ballof, F. B. Pamies, T. Stora, E. Barbero, B. Crepieux
Beam manipulation: T. Giles, S. Warren
RILIS: B. Marsh, K. Chrysalidis, S. Wilkins, C. Granados
ISOLTRAP: M. Mongeot, J. Karthein
SCK-CEN: D. Houngbo, L. Popescu, M. Dierckx
TRIUMF: L. Egoriti, A. Gottberg

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84th ISOLDE Collaboration Committee meeting
19th of March 2019

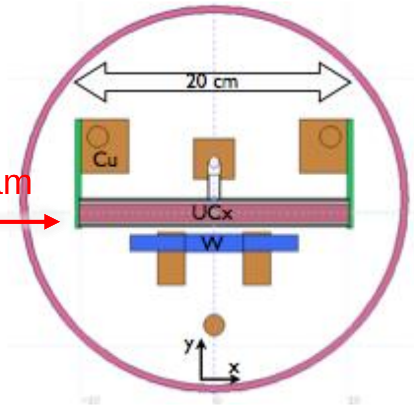
Results from tests with the new p2n converter

Simulations and concepts

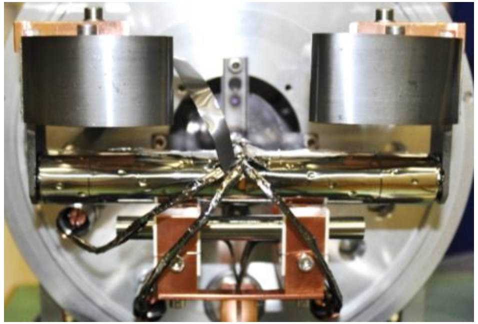
Offline developments

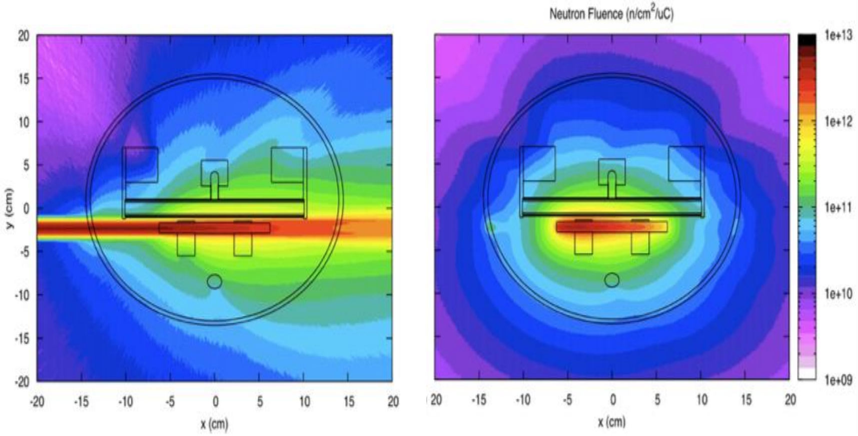
Online run

p2n-converter



p beam



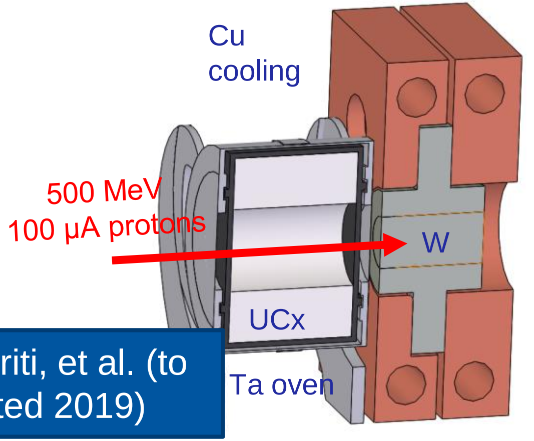


Brings relatively high purity neutron-induced fission fragments

TRIUMF	ISOLDE	
500 MeV	1.4 GeV	2.0 GeV
100 μA	2 μA	(4 μA)
cw	pulsed	pulsed
50 kW	**2.8 kW**	**(8 kW)**
	1.2 GW	**(3.5 GW)**

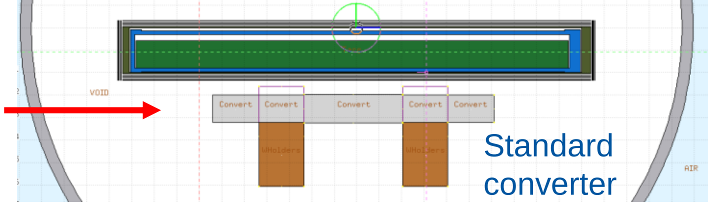
Collaboration started to design two p2n-converters:

- Improve the one of ISOLDE
- Design one for TRIUMF ISAC



L. Egoriti, et al. (to be tested 2019)

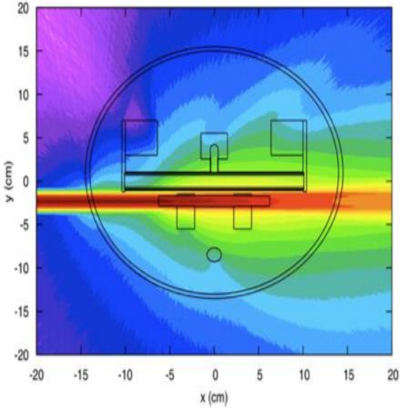
Concept history

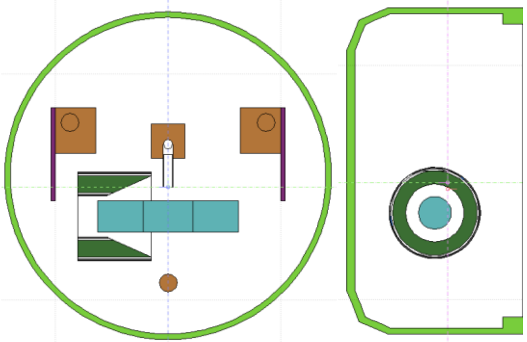


Problem: scattered protons

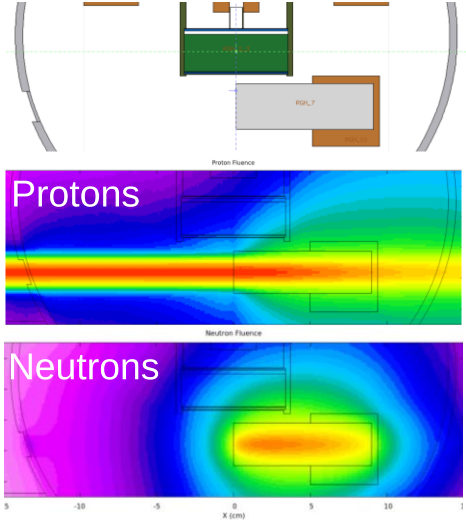
isotope intensity loss (70-80%)

Simple prototype was designed and tested





R. Luis, et al., , et al., EPJA 48 (2012) 90

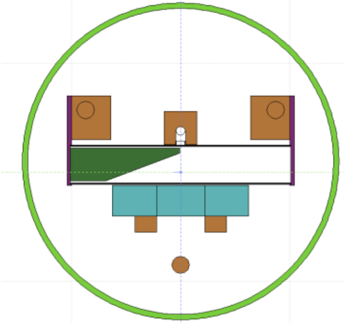


Low yields but very high purity
Target oven could not reach 2000 °C

A. Gottberg, et al., NIMB 336 (2014) 143–148.

Main ideas:

- **Thick converter** – reduce "proton cone"
- **Short target and shifted (annular)** – avoid the proton scattering zone



Converter optimization has two directions:

- Avoid as much as possible the scattered protons for **low proton flux**
- Have the converter as close as possible to the 2000 °C target for **high neutron flux**

Project management

This project used:

openSE

cern.ch/opense

Scientific project management framework

TRIUMF + SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

For development

Converter is very relevant:

- 53 INTC documents where p2n-converter is mentioned (up to March 2018)
- 10/83 INTC documents for 2016/2017 where p2n-converter is requested

3 boards (project steering and reporting):

- 20th March 2018
- 12th June 2018
- 25th October 2018
- Last board (soon)

Project board:

Person	Affiliation	Role
R. Catherall	CERN (EN/STI)	Chairperson/funding/expertise
G. Neyens	CERN (EP/SME)	Users representative
K. Johnston	CERN (EP/SME)	Users representative
T. Stora	CERN (EN/STI)	Technical expert
A.P. Bernardes	CERN (EN/STI)	Safety expert
A. Dorsival	CERN (HSE/RP)	Radioprotection expert
J.P. Ramos	CERN (EN/STI)	Project responsible/secretary

Funding (resources)	EN/STI-RBS
Users	EP/SME (representing EP/UIS)
Regulators	HSE/RP and ISOLDE safety
Expertise (feasibility)	EN/STI-RBS
Project manager	Appointed project responsible

Strategic decisions

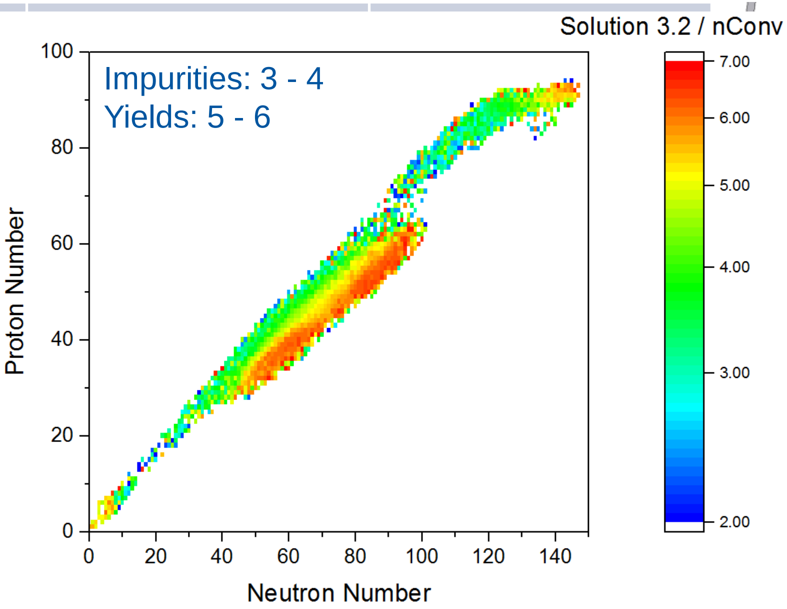
Analysis – preferred solution

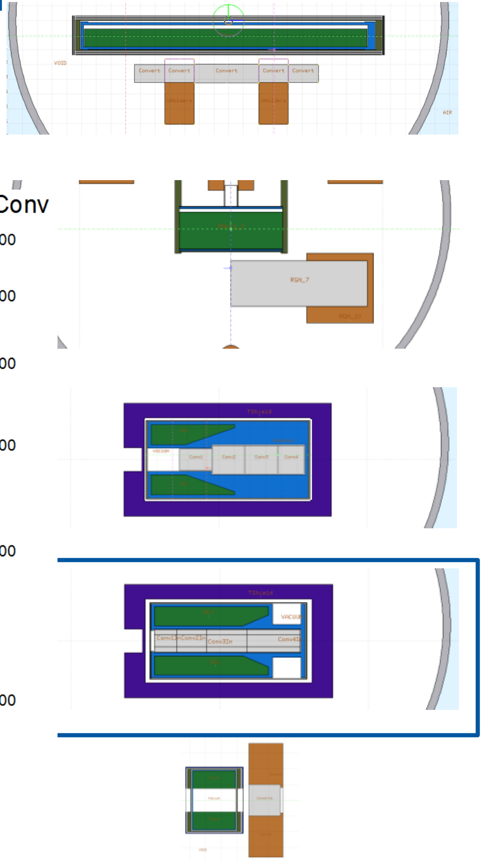
FLUKA Data – In-target fissions

	n-ind fissions (/s)	p-ind fissions (/s)	% p-ind fissions (from T)
Standard converter	7.05E10		
Raul	5.01E10 (0.71)		
Compromise*	1.57E11 (2.23)		
High Intensity*	4.19E11 (5.94)		
(TRIUMF concept)	3.85E11 (5.46)		

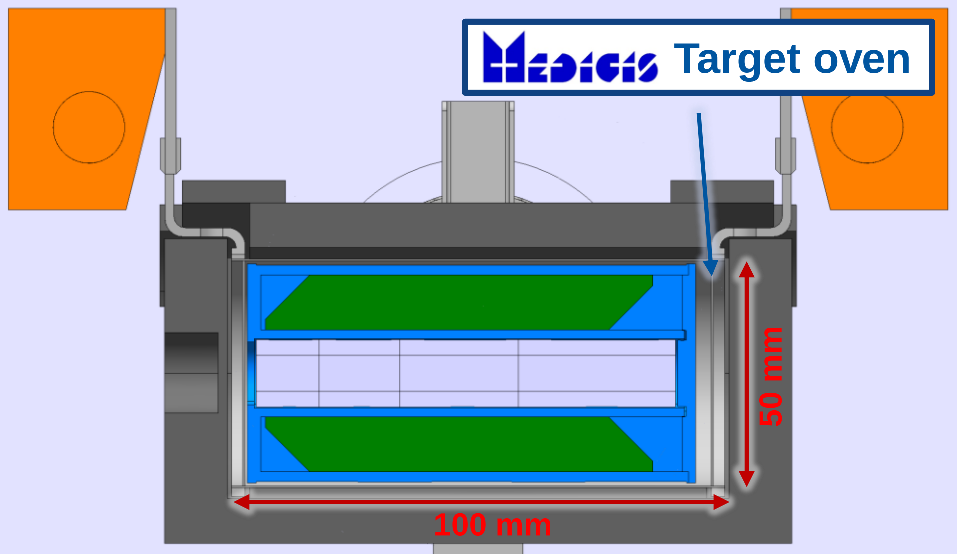
*for new prototypes assumed smaller density (mater
pressed but powder manually compacted

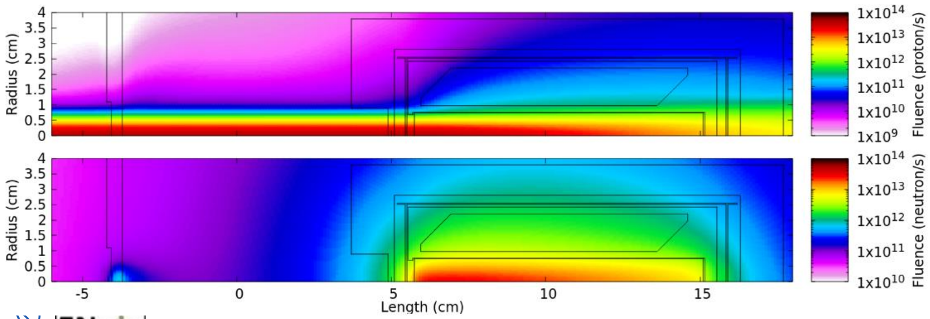
Brings roughly 2 – 4x more yield in all isotop

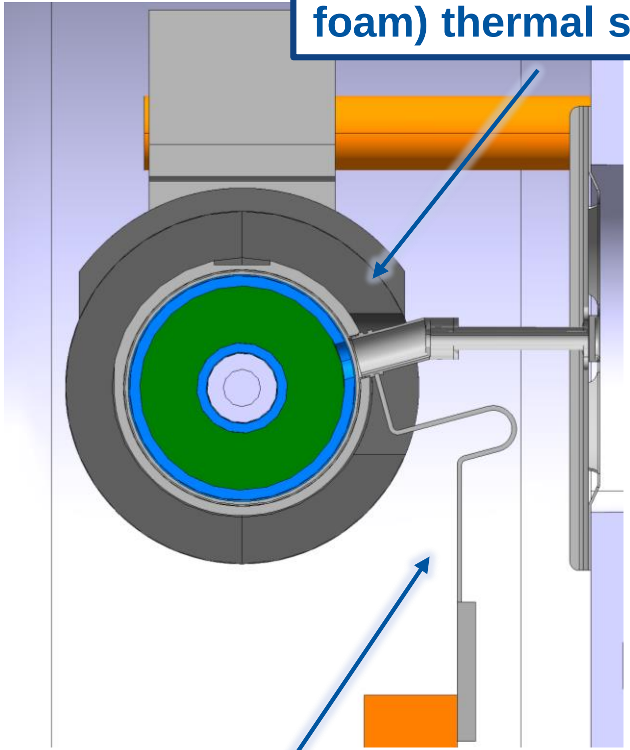




The final concept







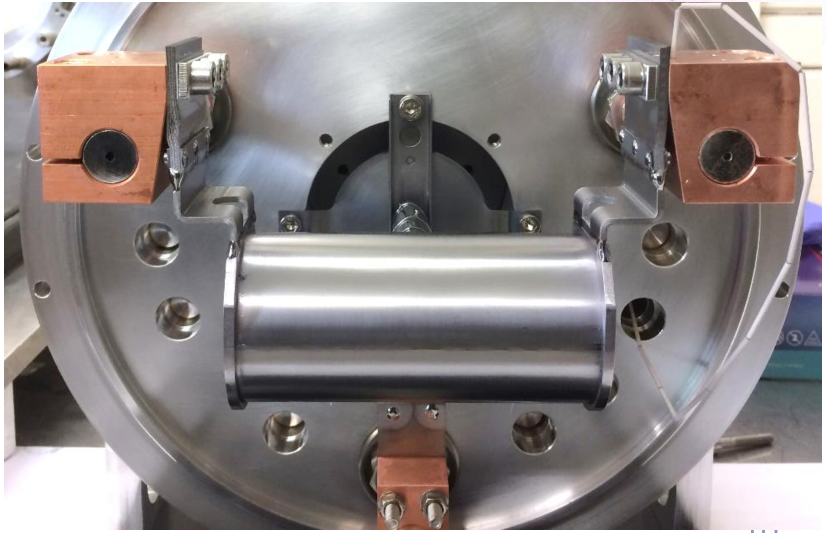
J.P. Ramos, et al., EMIS 2019 Proceedings, to be published

Simulations and concept

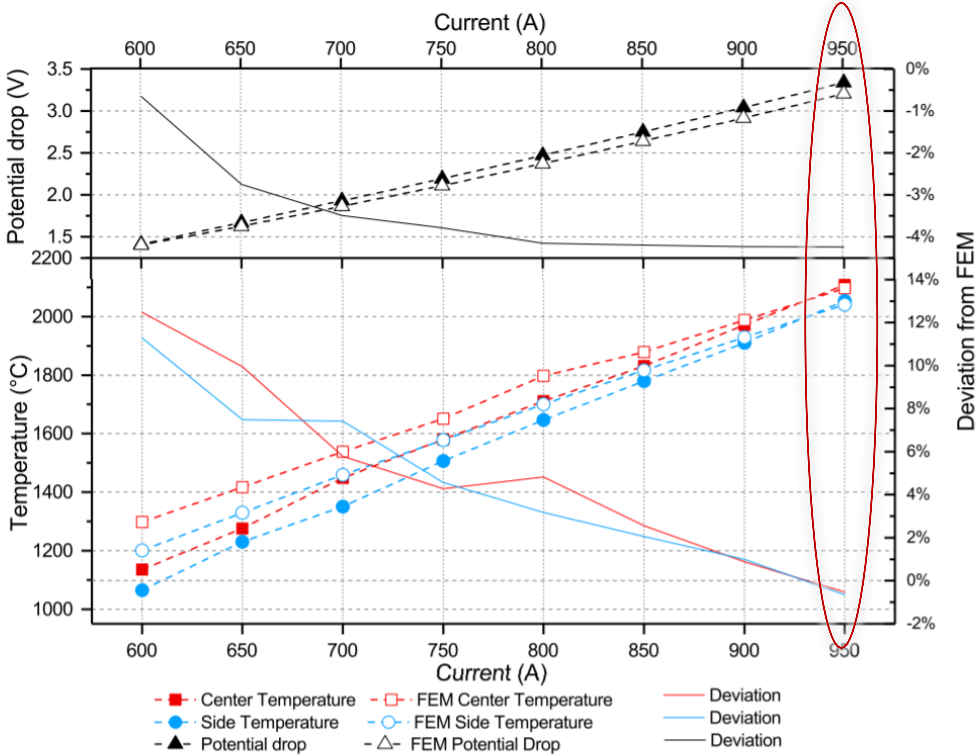
Offline developments

Online run

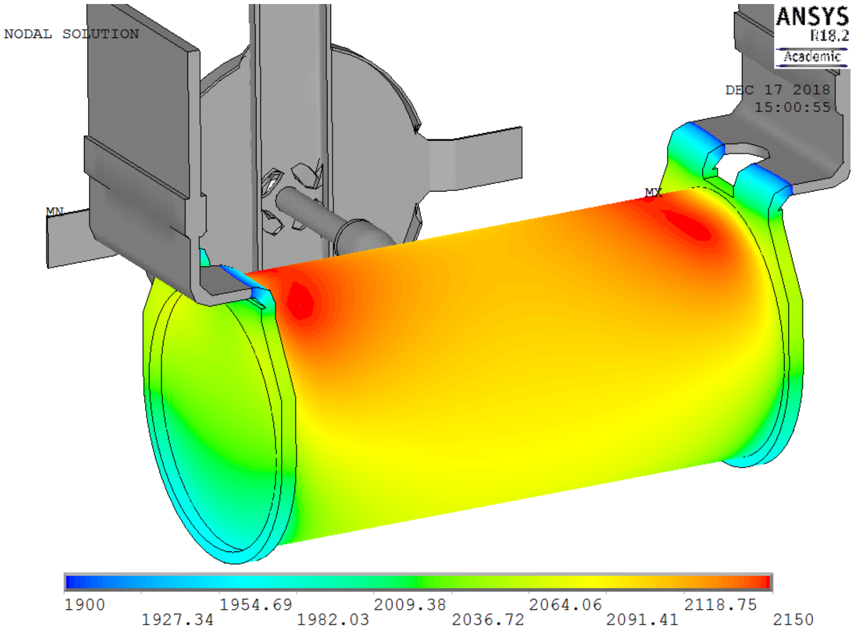
Material acquirement



Oven tests

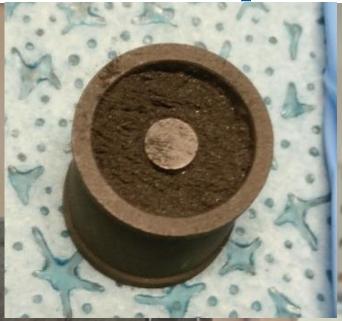


Current (A)
600
650
700
750
800
850
900
950
Potential drop (V)
3.5
3.0
2.5
2.0
1.5
0%
-1%
-2%
-3%
-4%
2200
2000
1800
1600
1400
1200
1000
Temperature (°C)
14%
12%
10%
8%
6%
4%
2%
0%
-2%
Deviation from FEM
Current (A)
Center Temperature
Side Temperature
Potential drop
FEM Center Temperature
FEM Side Temperature
FEM Potential Drop
Deviation
Deviation
Deviation



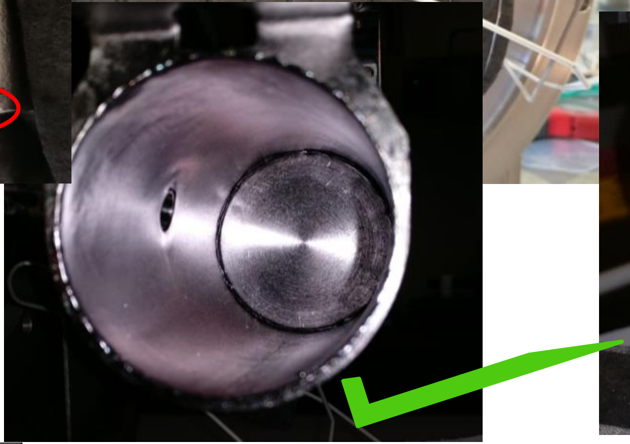
NODAL SOLUTION
ANSYS
R18.2
Academic
DEC 17 2018
15:00:55
MN
MX
1900
1927.34
1954.69
1982.03
2009.38
2036.72
2064.06
2091.41
2118.75
2150

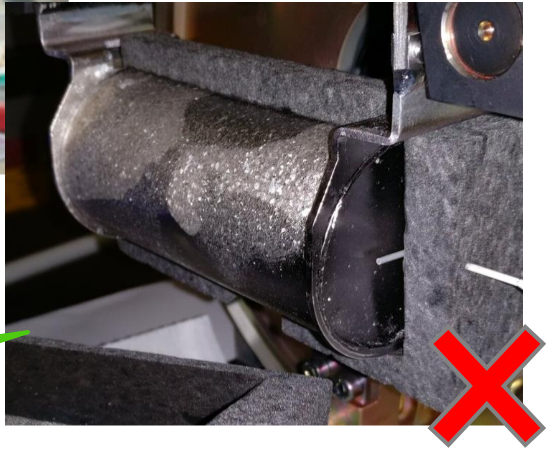
Material compatibility



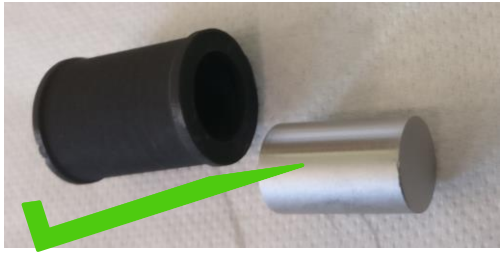
Before – UO_2 + 4C

After – UC_2+2C





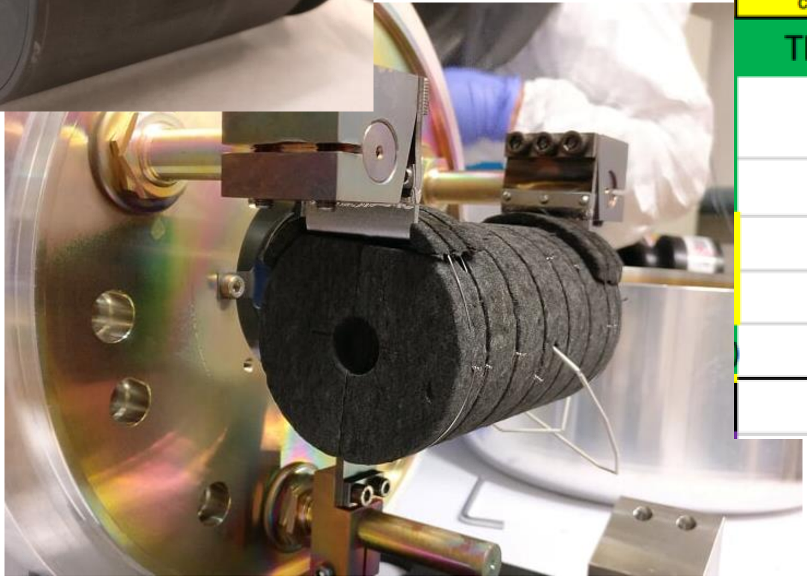
W not water cooled, but at >2000 °C)



After (2200 °C – 16 h) – no change

Use standard (tilted) UCx pellets

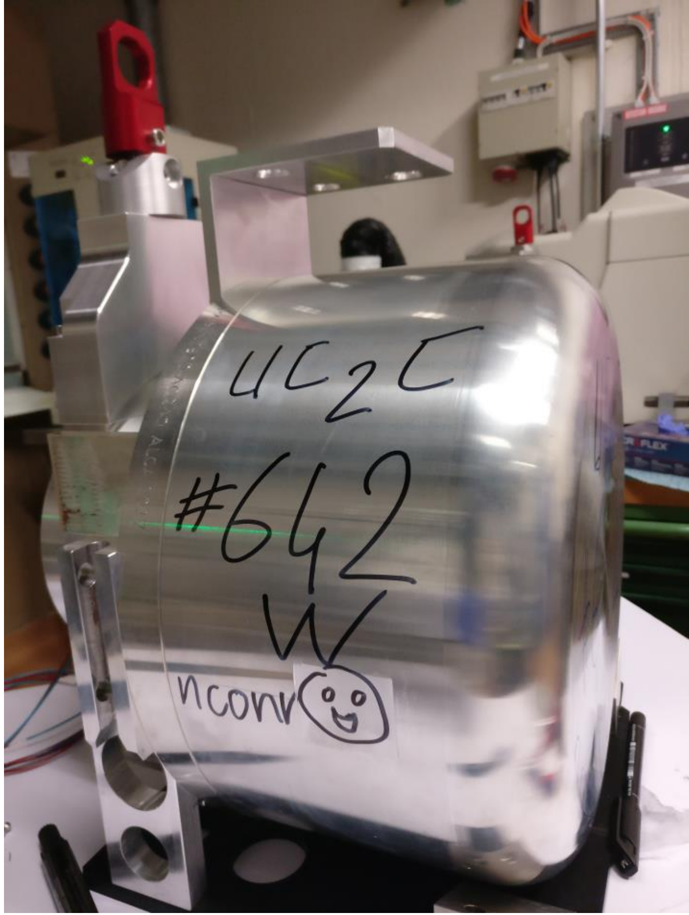
Online target ready



Offline tests successful

HRS

44	45
#642 UC n(ew)-conv	TISD 5
TISD	TISD
	#672 CaO VD7
	WISArD LOI172
	RILIS: for TISD



W ion source installed

Online run

Simulations and concept

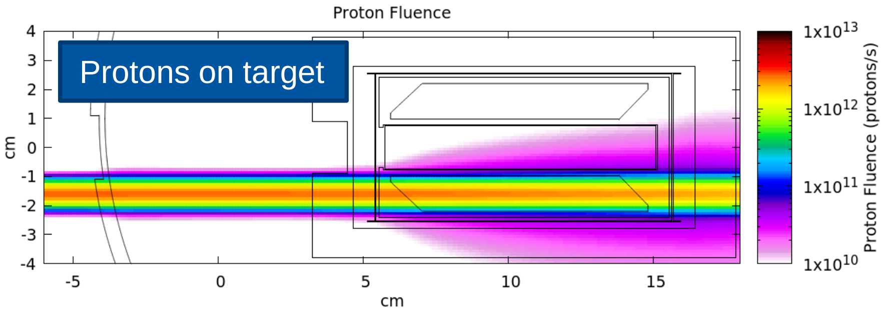
Online run

Online run

Run split in two

First part:
- Proton scan
- Cs yields
- Rb yields

Second part (laser ionized)
- Zinc
- Gallium
- Indium
- High proton intensity tests



Measure full isotope chains

Protons on target and on converter

<u>Gamma detector was broken – only beta detector was available</u>

FCup and ISOLTRAP

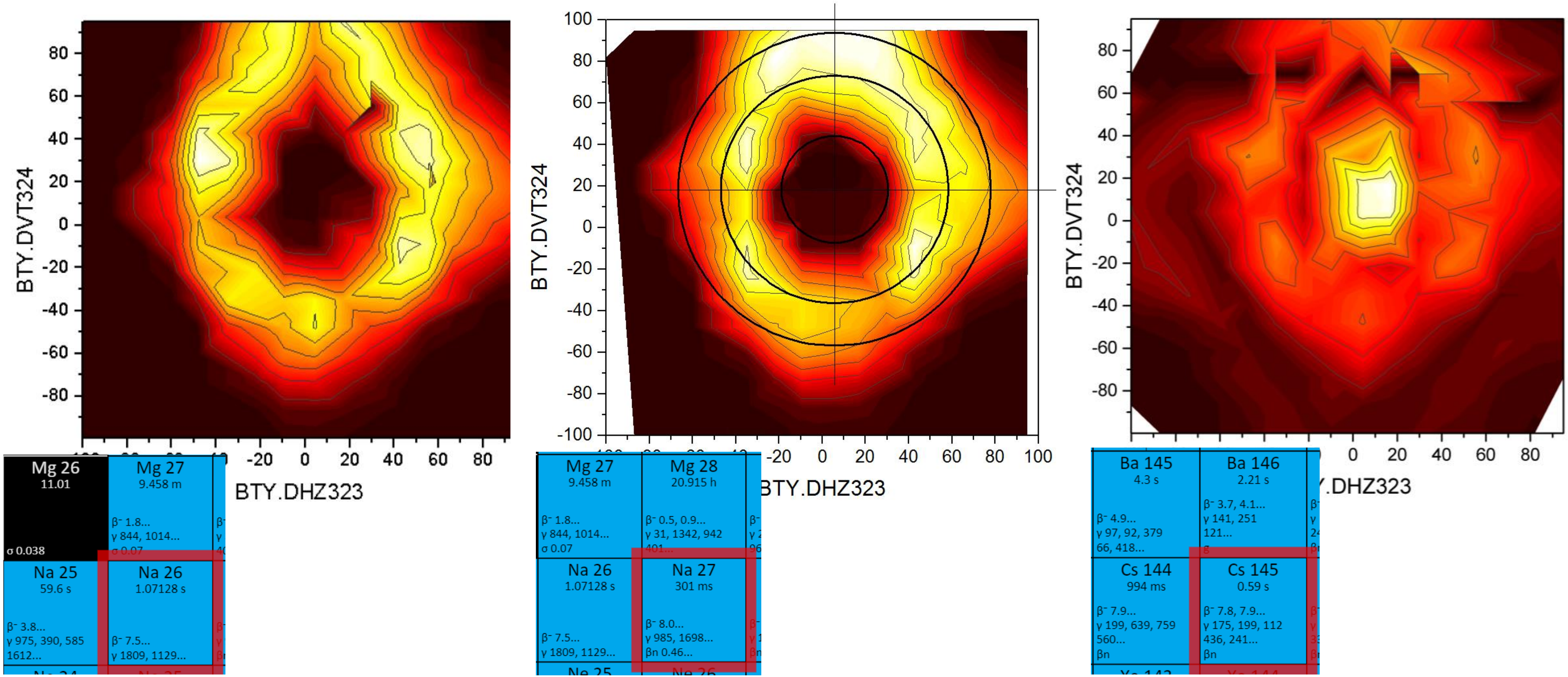
Laser on/off

> 100 yields

Proton scan

Converter
H: 20, V: 0

Target
H: 60, V: 0

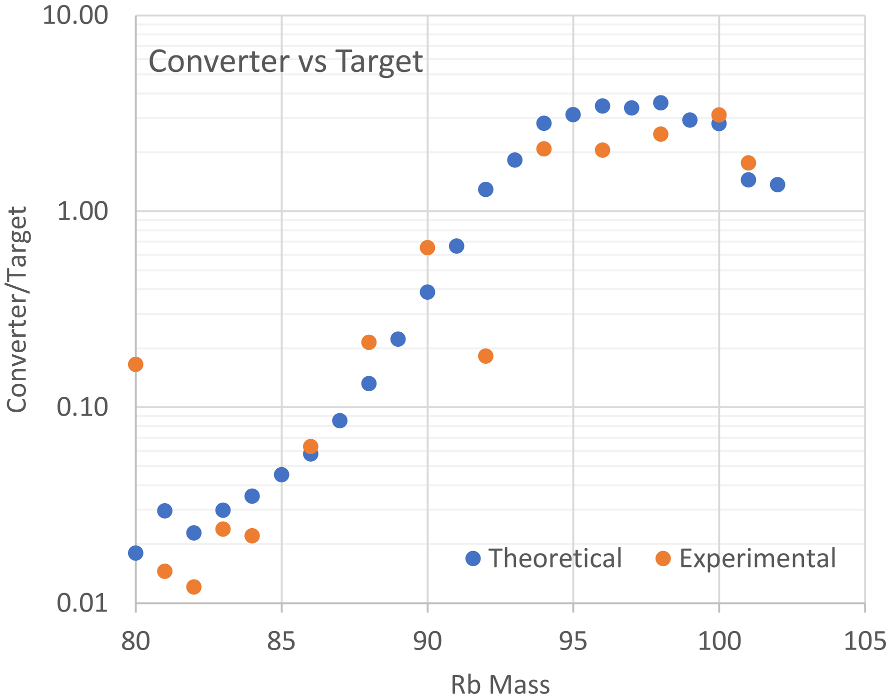


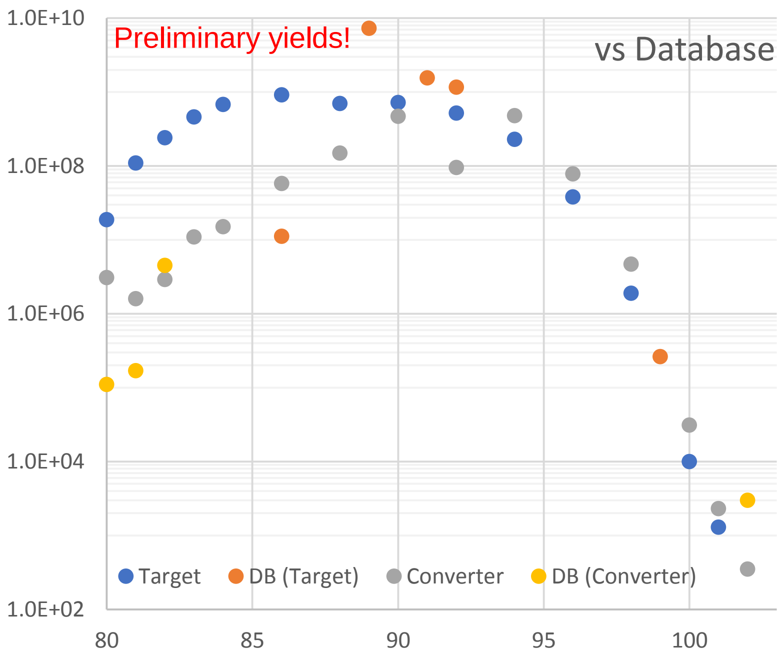
J.P. Ramos, et al., to be published.

Rb yields

Target
2000 °C (850A)

W ion source
~2150 °C (255A)





ISOLTRAP – Rb/Sr > 10

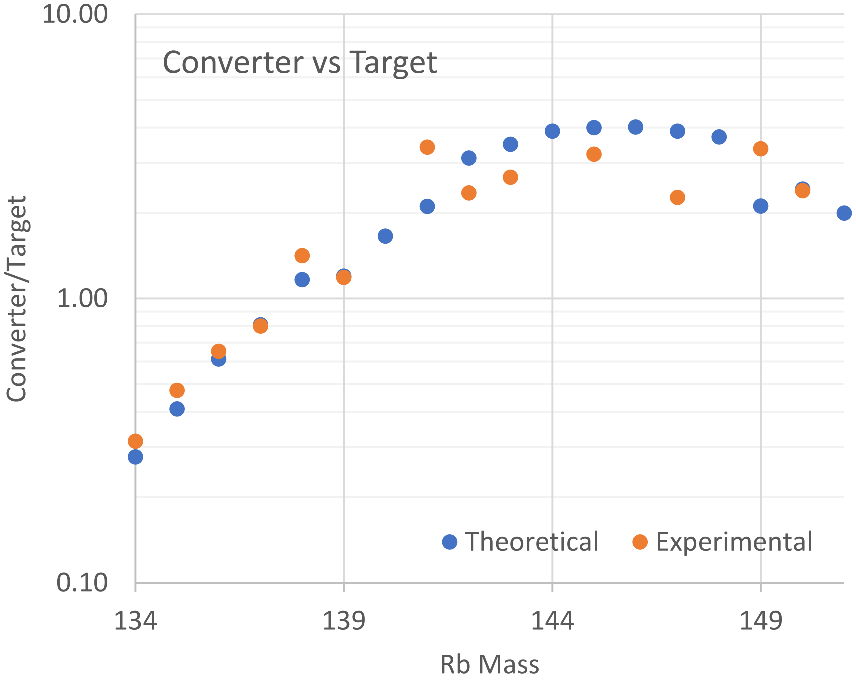
T_b = 688 °C
$T_{P=1Pa}$ = 161 °C

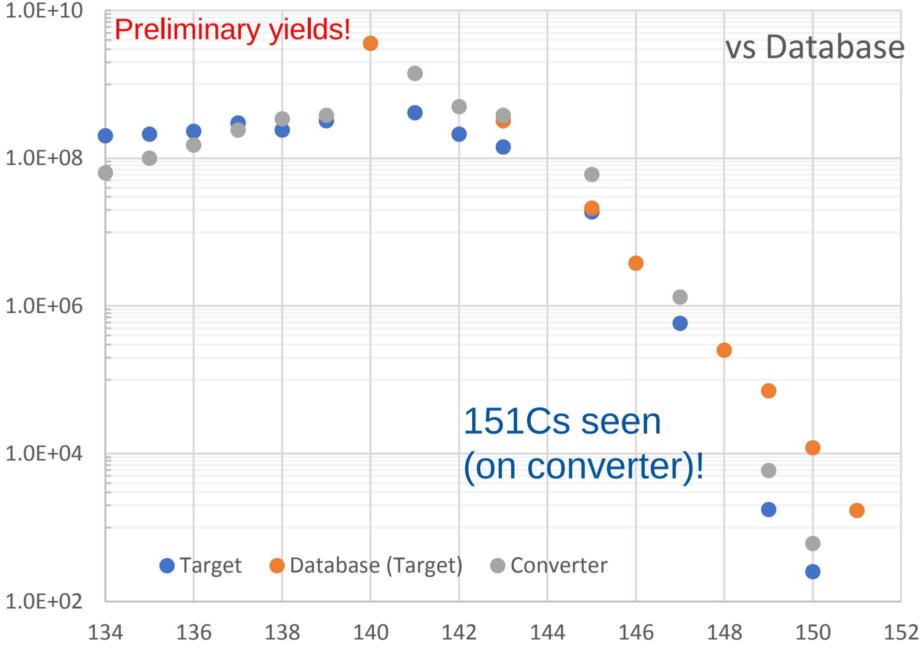
J.P. Ramos, et al., to be published.

Cs yields

Target
2000 °C (850A)

W ion source
~2150 °C (255A)



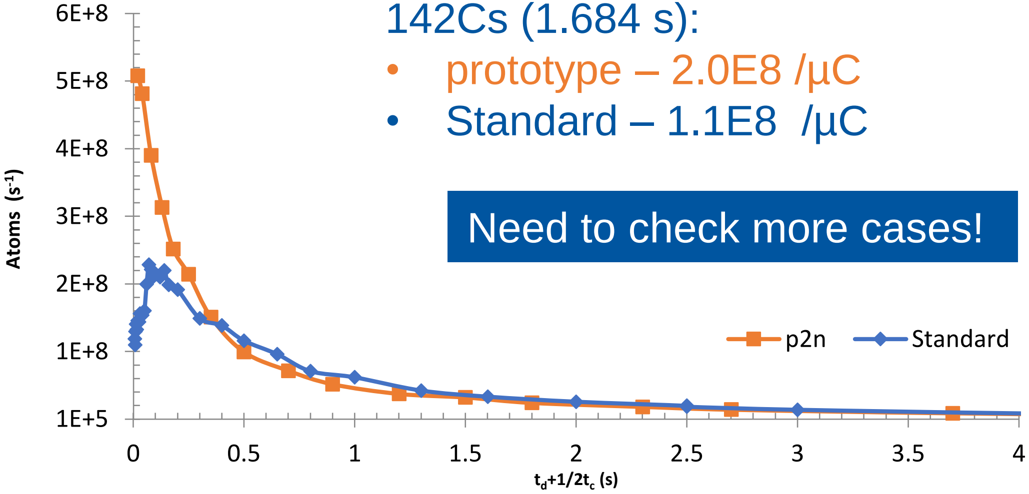


ISOLTRAP – Cs/Ba ~ 10, Cs/La > 100

T_b = 671 °C
$T_{P=1Pa}$ = 145 °C

J.P. Ramos, et al., to be published.

Release properties



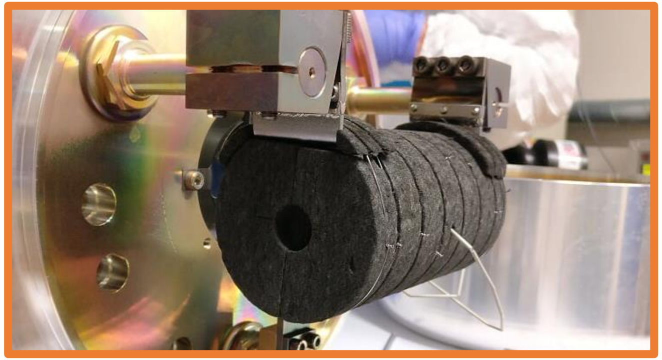
142Cs (1.684 s):

- prototype – 2.0E8 /µC
- Standard – 1.1E8 /µC

Need to check more cases!

- Diffusion should not be affected (same material, same pellets)
- Effusion is affected (larger volume, annular shape)

- Temperature inhomogeneities of 200 to 300 °C
- Target volume is 60 cm^3

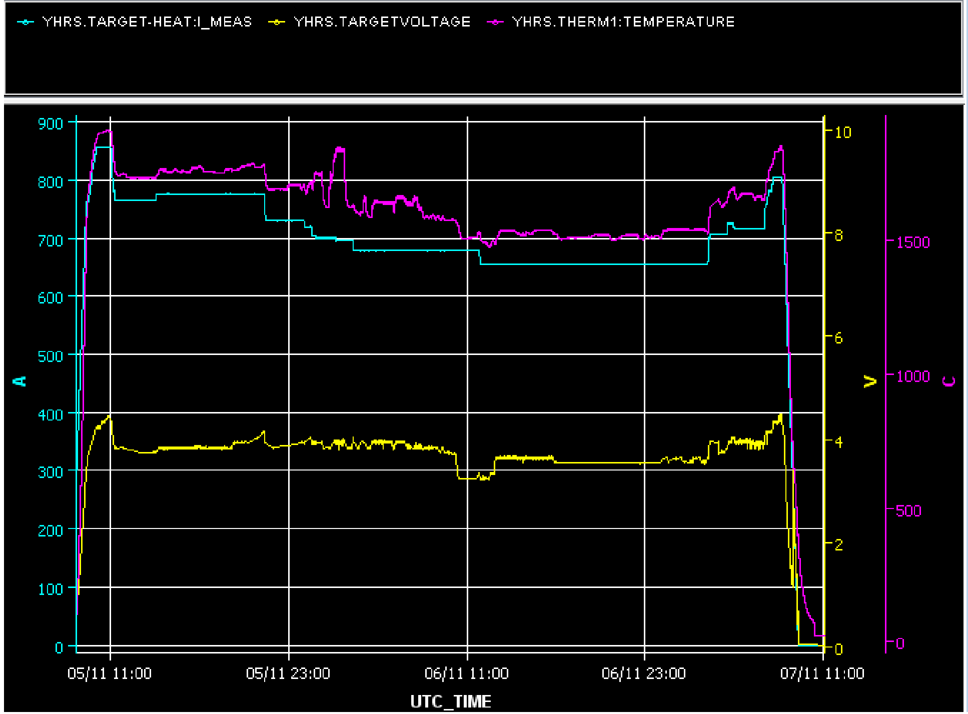


- No cold spots
- Large target volume (200 cm^3)
- Anular target

2nd part of the run

Target heating issues:

- Voltage increased continuously (container failure sign)
- Decreased target current to keep voltage stable (same power)
- Target temperature was heavily influenced



Another large target was irradiated and tested at MEDICIS

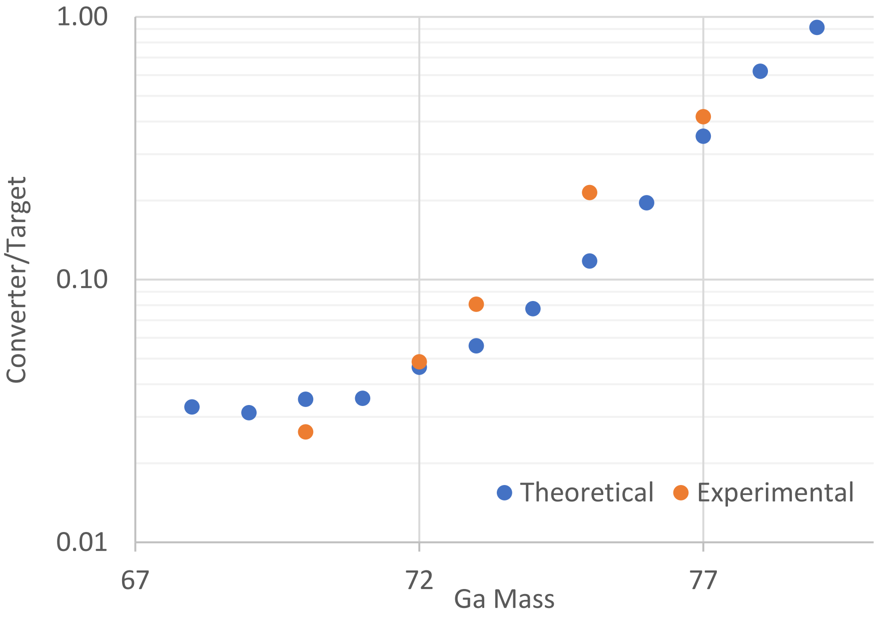
- Failure of the target oven (brough to >2300 °C)

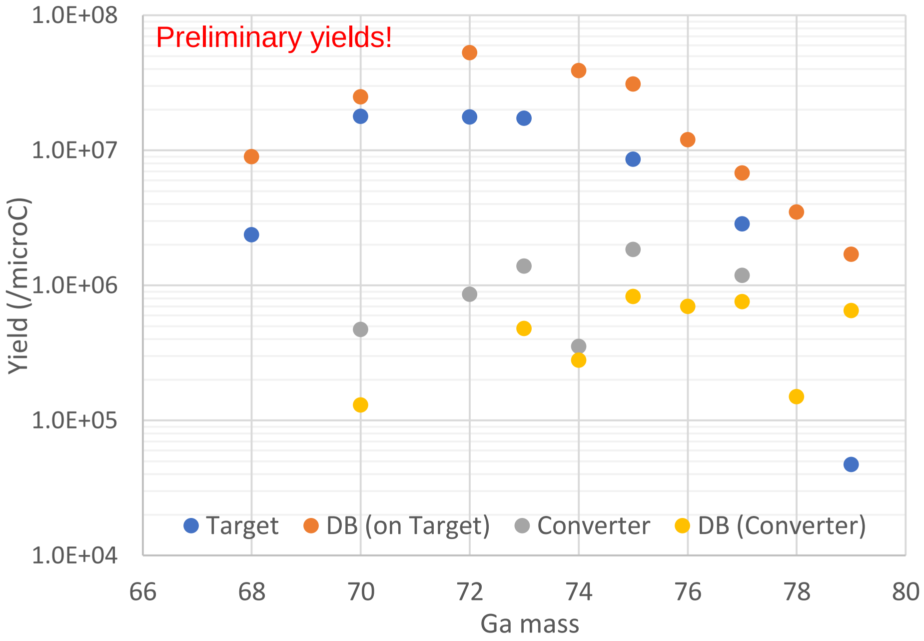
Can affect the reliability of the yields taken after (laser ionized Ga, In, Zn)

Ga yields

Target
1444 to 1764 °C (665 to 775A)

W ion source
~2150 °C (255A)





Laser enhancement was only x4.3 (expected 40-50)!
Optimization done on radioactive (peak)!

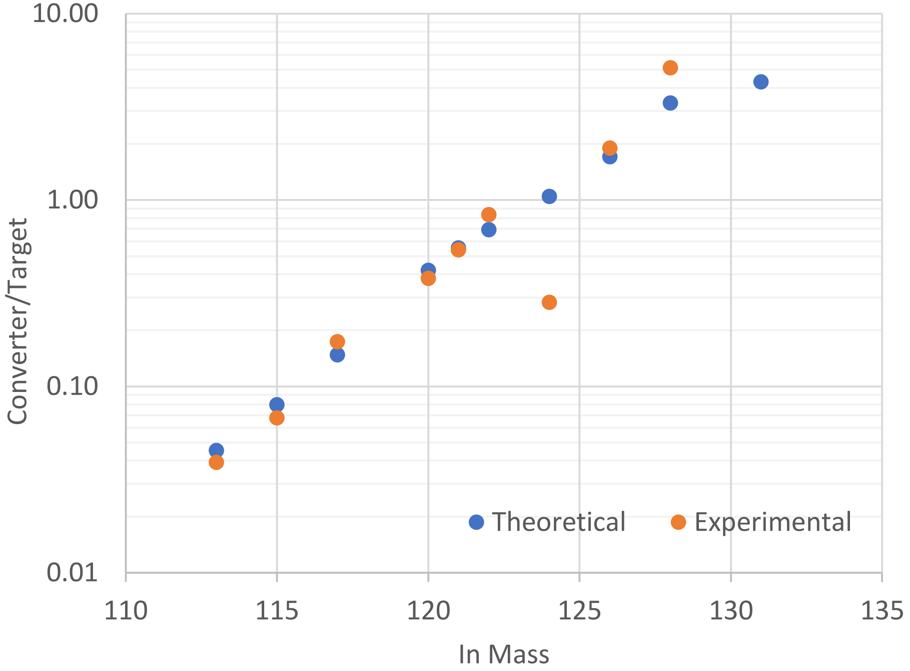
T_b = 2400 °C
$T_{P=1Pa}$ = 1037 °C

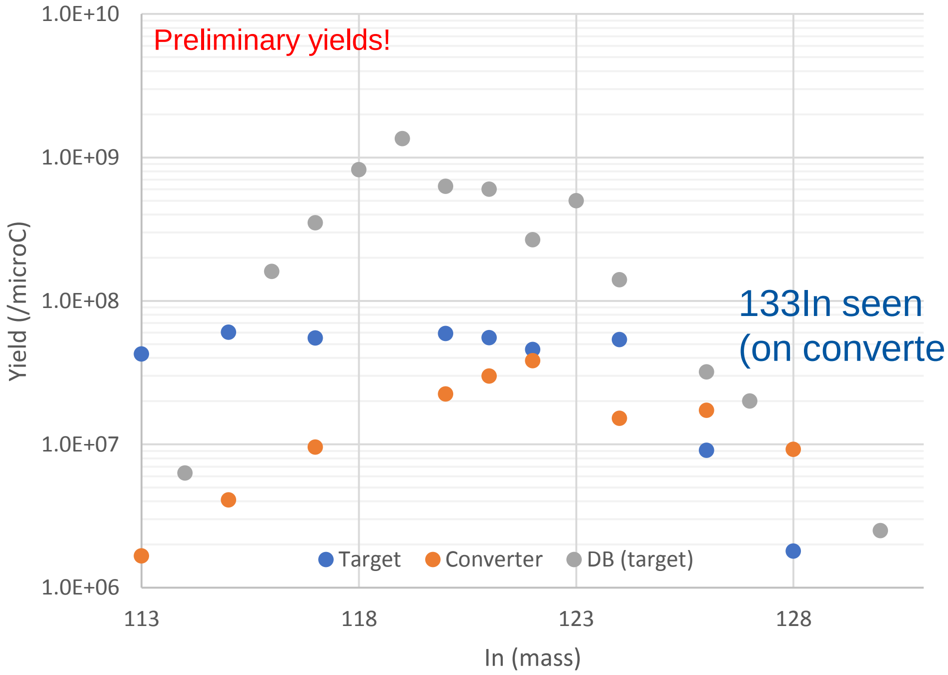
J.P. Ramos, et al., to be published.

In yields

Target
1406 -1476 °C (655 - 680A)

W ion source
~2150 °C (255A)





133In seen (on converter)!

Laser enhancement was x4.9 from 113 In!
Optimization done on radioactive (peak)!

T_b = 2072 °C
$T_{P=1Pa}$ = 923 °C

J.P. Ramos, et al., to be published.

Zn yields

Target
1432 °C (655A)

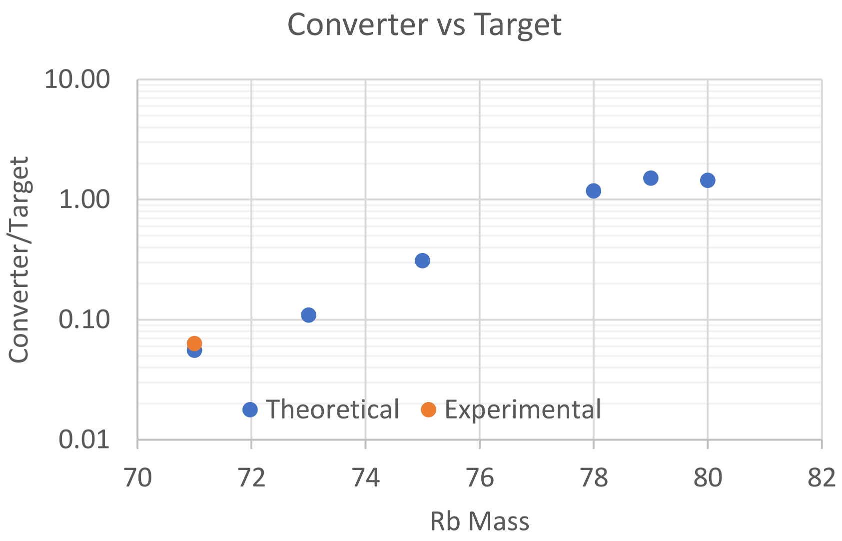
W ion source
~2150 °C (255A)

Data still in analysis…

Only 4 data points taken
Target was much degraded by then…

Example 75Zn (ISOLTRAP)
3.6E5 /µC
(DB 5.6E7 /µC)

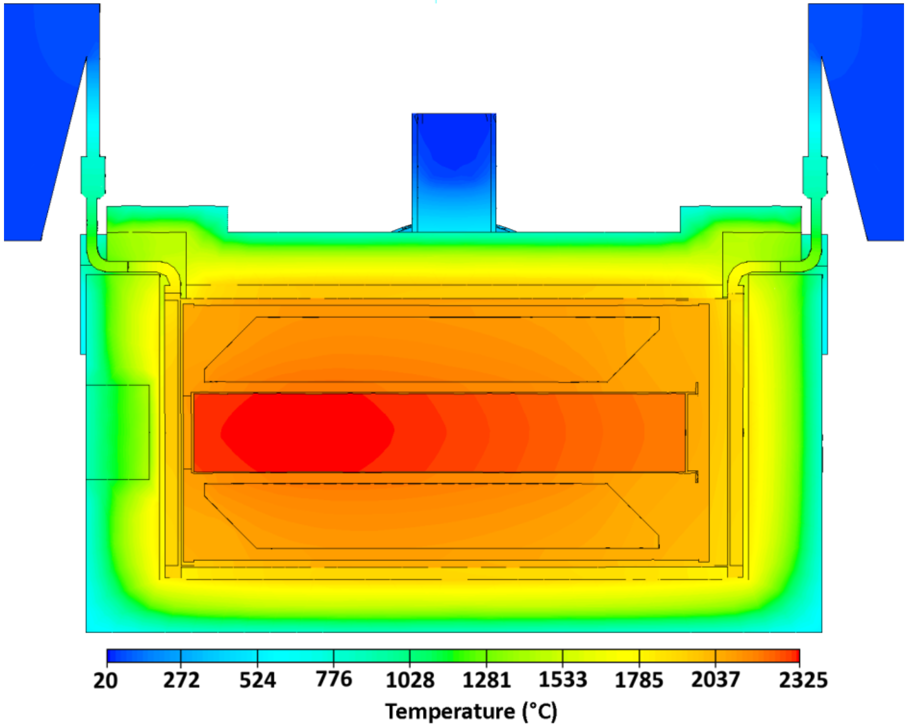
Low yields on Zn

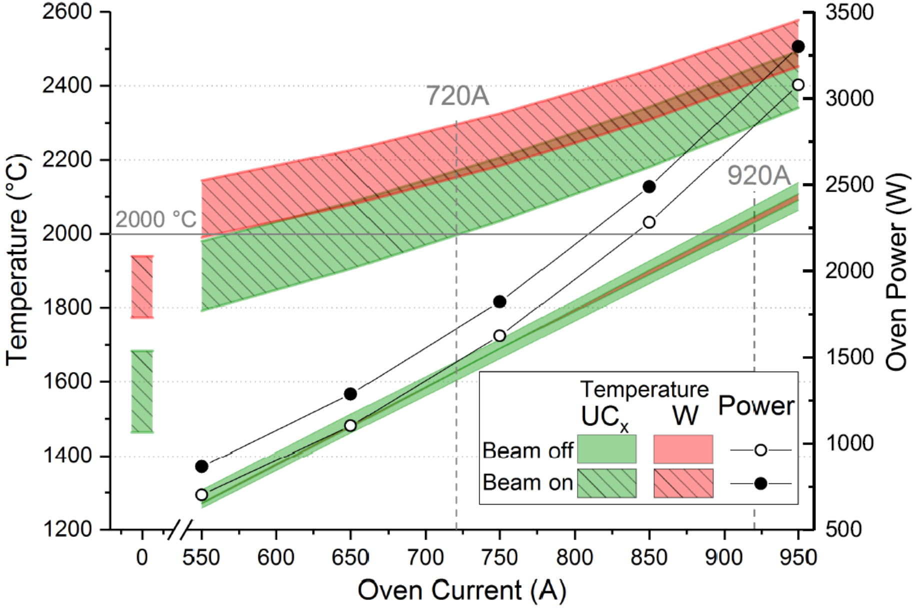


T_b = 907 °C
$T_{P=1Pa}$ = 337 °C

J.P. Ramos, et al., to be published.

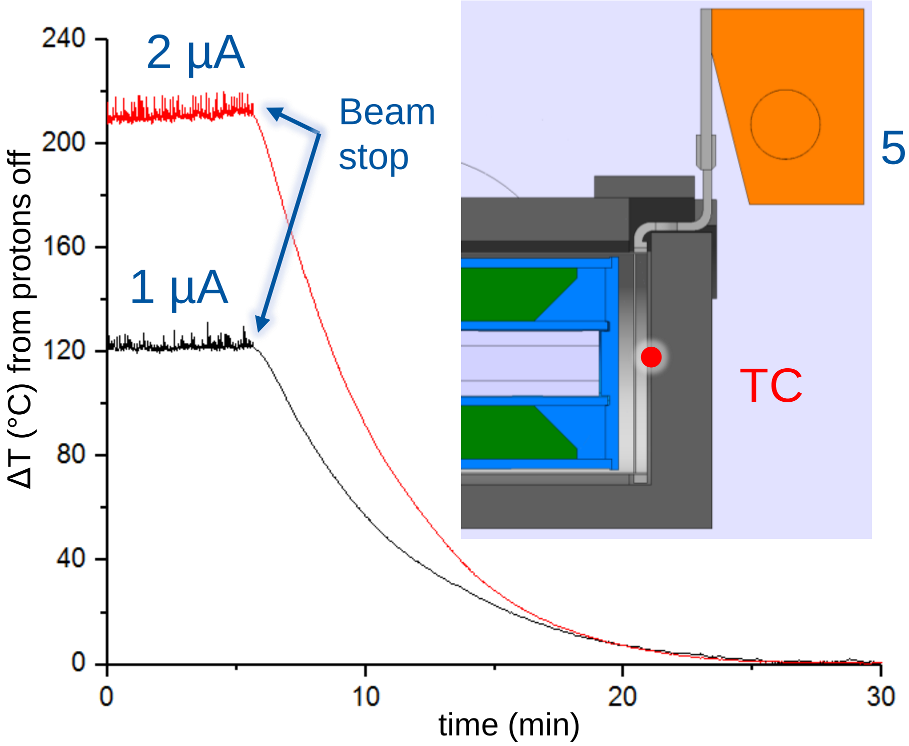
First high power target - simulations

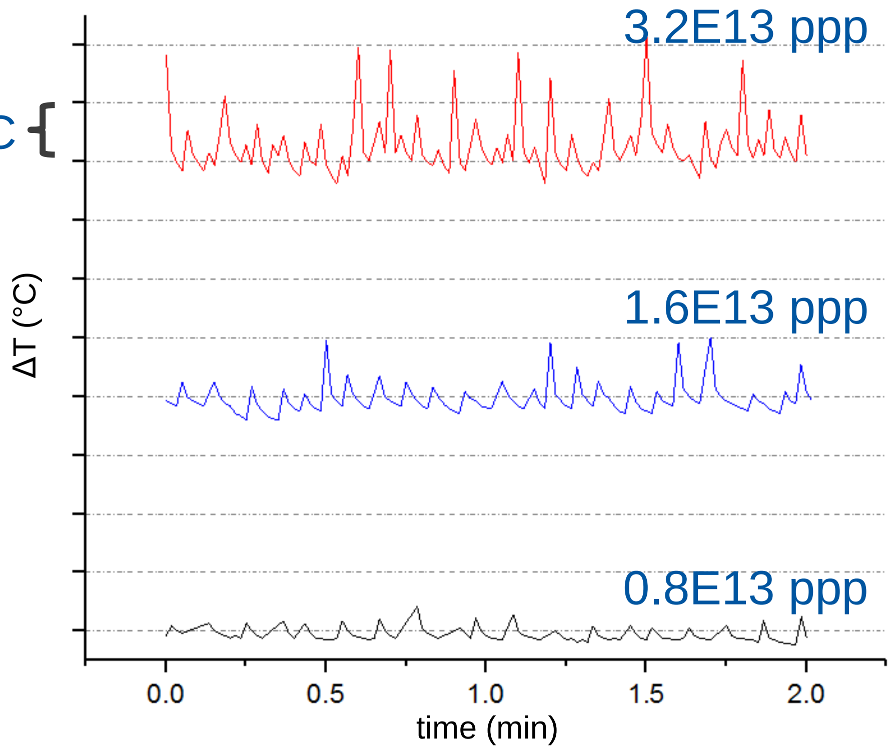




J.P. Ramos, et al., EMIS 2019 Proceedings, to be published

First high power target - data



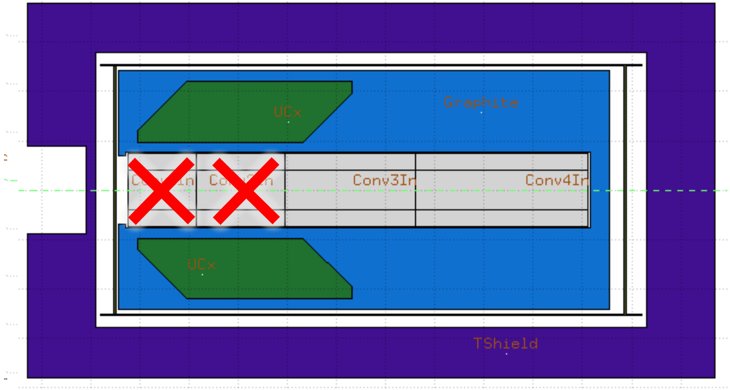


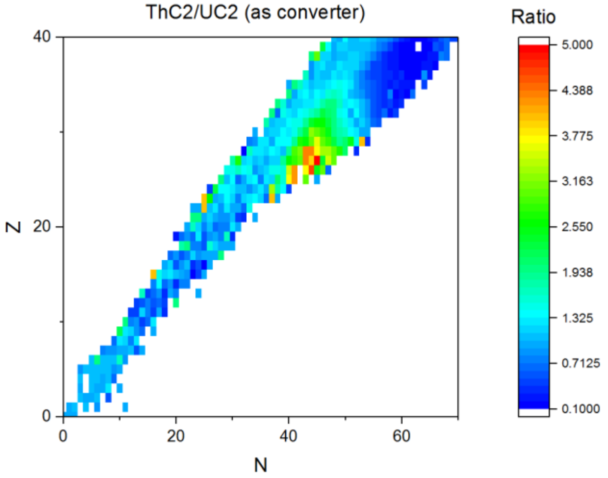
J.P. Ramos, et al., to be published.

Conclusions (Outlook)

- Cs and Rb yields are high and match predictions
- In, Ga and Zn were taken at low temperatures (and less optimized RILIS conditions)
- The target oven needs additional development
  - Post-mortem analysis will be done (at PSI)
  - Already on-going by V. Samothrakis)
- First high power target of ISOLDE
  - Temperature needs to be adjusted if beam intensity changes
- Outlook:
  - Modular target personalized for user – can maintain target yield but get a factor 4-10 in purity
  - Usage of ThC2 with converter material (for Cu, Ni, Fe, Co)

Modular converter – personalized for user.
Example of purity driven converter:





Thank you!

This project used:

openSE

cern.ch/opense

Scientific project management framework

Target group: J.P. Ramos, S. Rothe, D. Leimbach, J. Ballof, F. B. Pamies, T. Stora, E. Barbero, B. Crepieux, V. Samothrakis
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SCK-CEN: D. Houngbo, L. Popescu, M. Dierckx
TRIUMF: L. Egoriti, A. Gottberg
MEDICIS-Promed (SPES): M. Ballan, S. Marzari

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