Review panel for LIEBE

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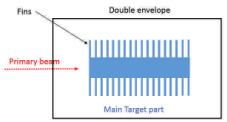
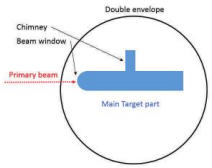
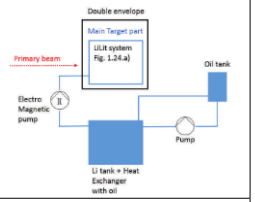
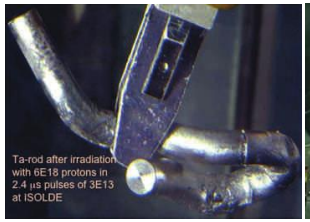
CERN | EN ENGINEERING DEPARTMENT

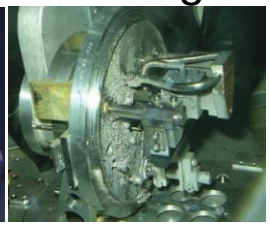
Larger framework of high power targets: ISOL specificity : release of isotopes, “high T”

Melanie Delonca’s PhD

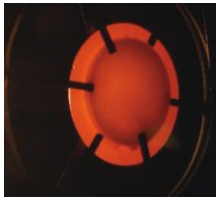
Target name	Facility	Beam characteristics	Cooling system	Isotope release	Innovation	Safety measures	Schematic
ISAC Targets [21]	Triumf	proton beam - up to 25 kW constant power - continuous beam	Radiation from fins	Separated disks Material choice	Use of fins	Double enclosure	
Liquid Lead/Salt Targets [20]	Isolde	Proton beam - 3 kW average power - $11.7.10^6$ kW peak power - 0.8 Hz frequency	Radiation	Material choice (liquid) Splashing from shock waves induces droplets	Beam windows developed / chimney / liquid material	Double enclosure	
LiLit Target [22]	SARAF	proton beam - 2.3 kW average power - 20 kW peak power - 1 Hz frequency	Heat Exchanger	-	Heat Exchanger / Pump for liquid circulation / Li (metallic) window-less	Double enclosure	
MEGAPIE Target [11]	PSI	neutron beam - up to 66.10^3 kW constant power - continuous beam	Heat Exchanger	-	Heat Exchanger / Pump for liquid circulation	Double enclosure	

And also some hard learning cases

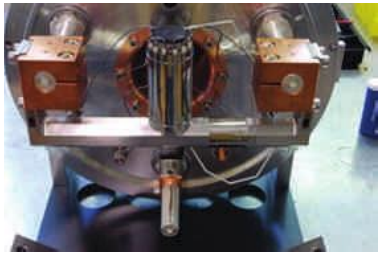




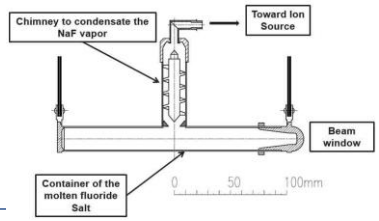
1st high power oxide direct ISOL Target @ TRIUMF



1st salt target at ISOLDE-PSB

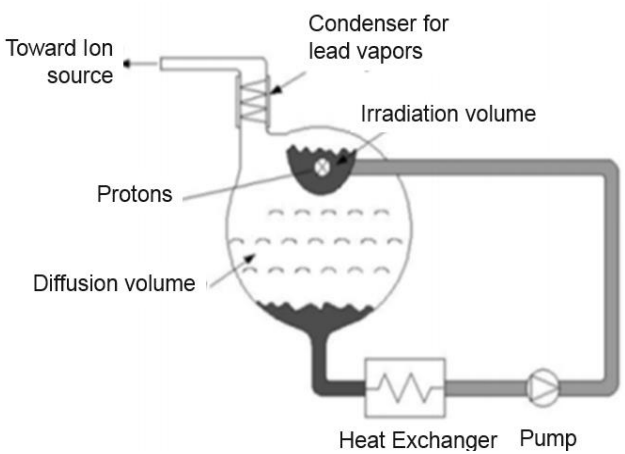


(a) Molten Fluoride Salt target [47]

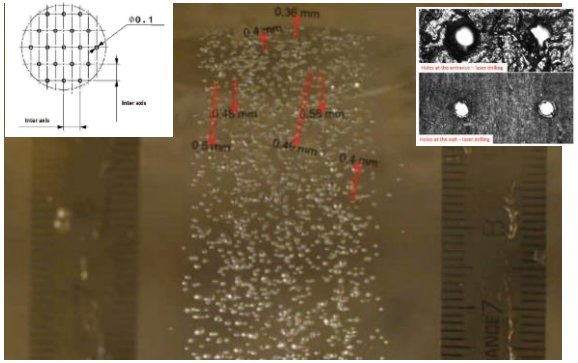


Initial concept & LIEBE prototype

Conceptual design + prelimin. tests, E. Noah et all, EURISOL-DS (2005-2009)



Critical Weber number for small droplet formation from LBE → possibly solves the main Liquid target drawback of slow release



Double enclosure, etc

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

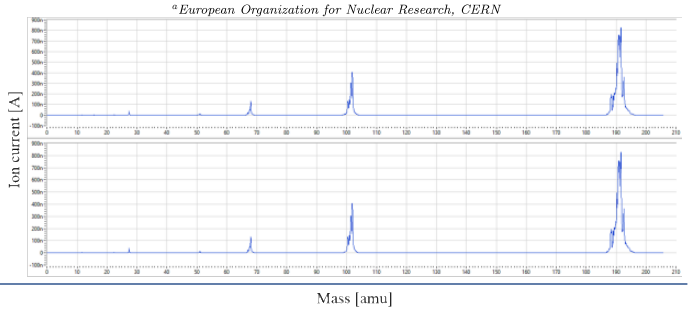
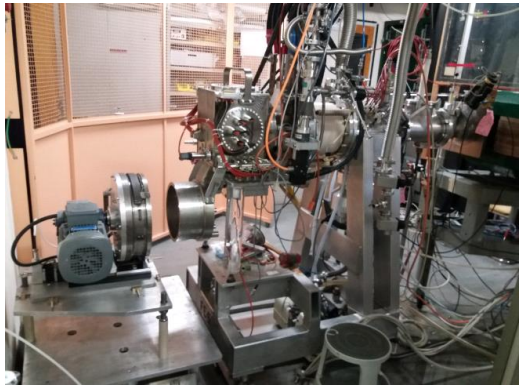


Figure 7: Mass scan with LBE at 200° C except HEX at 150° C and EM pump rotor at $Fr = 25Hz$.



Test and beam at the offline separator

Review

Committee members: Marc Dierckx (SCK-CEN), Ramon Folch (CERN, EN Safety Office), Simone Gilardoni (CERN, EN/STI), Michael Paul (Hebrew university Jerusalem), Heinz Vincke (CERN, HSE/RP) Marco Calviani (CERN, EN/STI, chair)

Presentations available there : https://indico.cern.ch/event/805955/

2. **Design of the LIEBE target and operational feedback**

The basic design of the LIEBE target is judged to be capable to comply with the main objective of the project to improve the release efficiency of short-lived isotopes from liquid metal targets by enhanced effusion by droplet formation. However, the offline tests have shown that the current design has some technical flaws. First of all, it appears that liquid

Review Conclusions

7. **Recommendations**

The following recommendation are provided to the Project team:

1) **The process of design and the results of test with the prototype revealed a number of important critical points that have been solved but also some weaknesses that are still to be addressed; review the lessons learned from the operation of the LIEBE target and prepare a summary document with these aspects as well as with the plans to solve them in the current or modified LIEBE hardware;**
2) **Profit from the lessons learnt and the expertise gained to carry out a FMEA (Failure Mode and Effect Analysis) involving experts in the field;**
3) **Document the functional specification and engineering specification of the current LEIBE target in a concise and complete document in order to provide the state-of-the-art status of the assembly following the offline results;**
4) **It is recommended to explore the physics case for the current LIEBE target and eventual La-based liquid target with the Standing group for the Upgrade of the ISOLDE facility (SGUI) (to be endorsed by the ISOLDE Collaboration), including the timescale required for the physics case to be still interested at the ISOLDE facility;**
5) **Based on the recommendation of the SGUI, prepare an update Project management document to detail the resources and manpower requirements in order to prepare an eventual La-based liquid target to be presented to the EN-STI management;**

The promises with a fast released molten metal loop

Molten targets operated online		
Material	Operation temperature	Beams
Ge	1100	Zn
Sn	1100	Cd
Pb	700	Hg
Bi		
Pb-Bi	600	Kr/Xe/I/Cd/Hg/At
NaF-LiF	700	CO/Ne
$TeCl_4$	420	SbCl/SnCl
Sc-La	1300	Ca/K/Ar
Y-La	1300	Sr/Rb/Kr
La	1400	Ba/Cs/Xe
Th-La	1400	Ra/Fr/Rn
Gd-La	1400	Eu/Sm
Lu-La	1400	Yb/Tm
Prospective eutectics for beams in the ^{100}Sn region		
Ag-La	518 ↙	Cd/MCl_x (M=In,Sn,Sb)
Au-La	561 ↙	Cd/MCl_x (M=In,Sn,Sb)
Ni-La	532 ↙	Cd/MCl_x (M=In,Sn,Sb)

Where do we stand today

- ^{100}Sn physics potential for HIE-ISOLDE
- Options to complete the lessons learned action : failure analysis at IPUL (LBE spill in ion source/F End)
- Offline operation of (modified) LIEBE with LBE at CERN

- Define the optional LIEBE-next project: La-base option, safety file requirements, RP and waste management to be evaluated by EN-STI

Initial pists to complete this phase

- French ANR : REPARE (lead by GANIL (G d France), with Arronax, Subatech, CERN : passed 1st evaluation phase wih rather positive evaluation.

- SCK.CEN contribution in the framework of the CERN-SCK MoU under discussion