



Recent developments on the RILIS hot cavity design with GISELE at GANIL

Nathalie Lecesne
GANIL

PhD Thesis – Jose Luis Henares González



Laser Ion Sources @ SPIRAL2

Phase 1: High intensity stable beams + Experimental rooms (S³ + NFS)

→ In flight RIBs & RILIS in Gas cell in S³ (REGLIS)

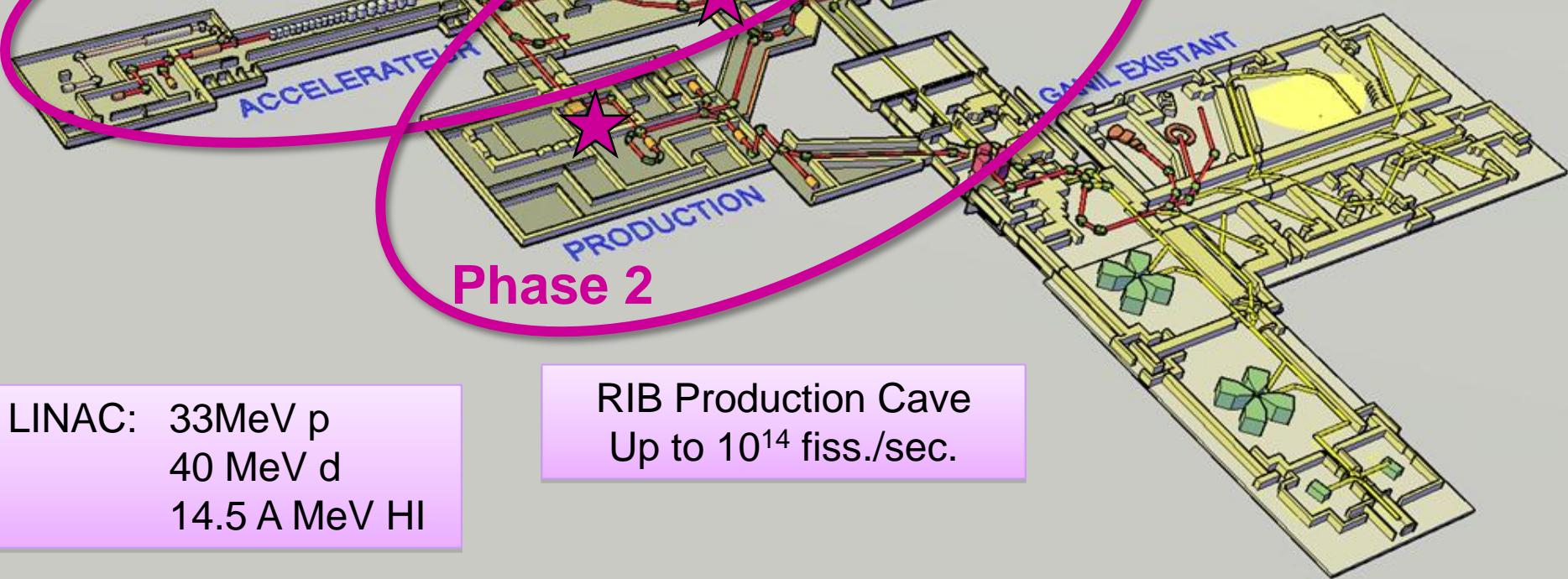
Phase 2: High intensity Radioactive Ion Beams (Production Building)

→ ISOL RIBs & RILIS in Hot Cavity

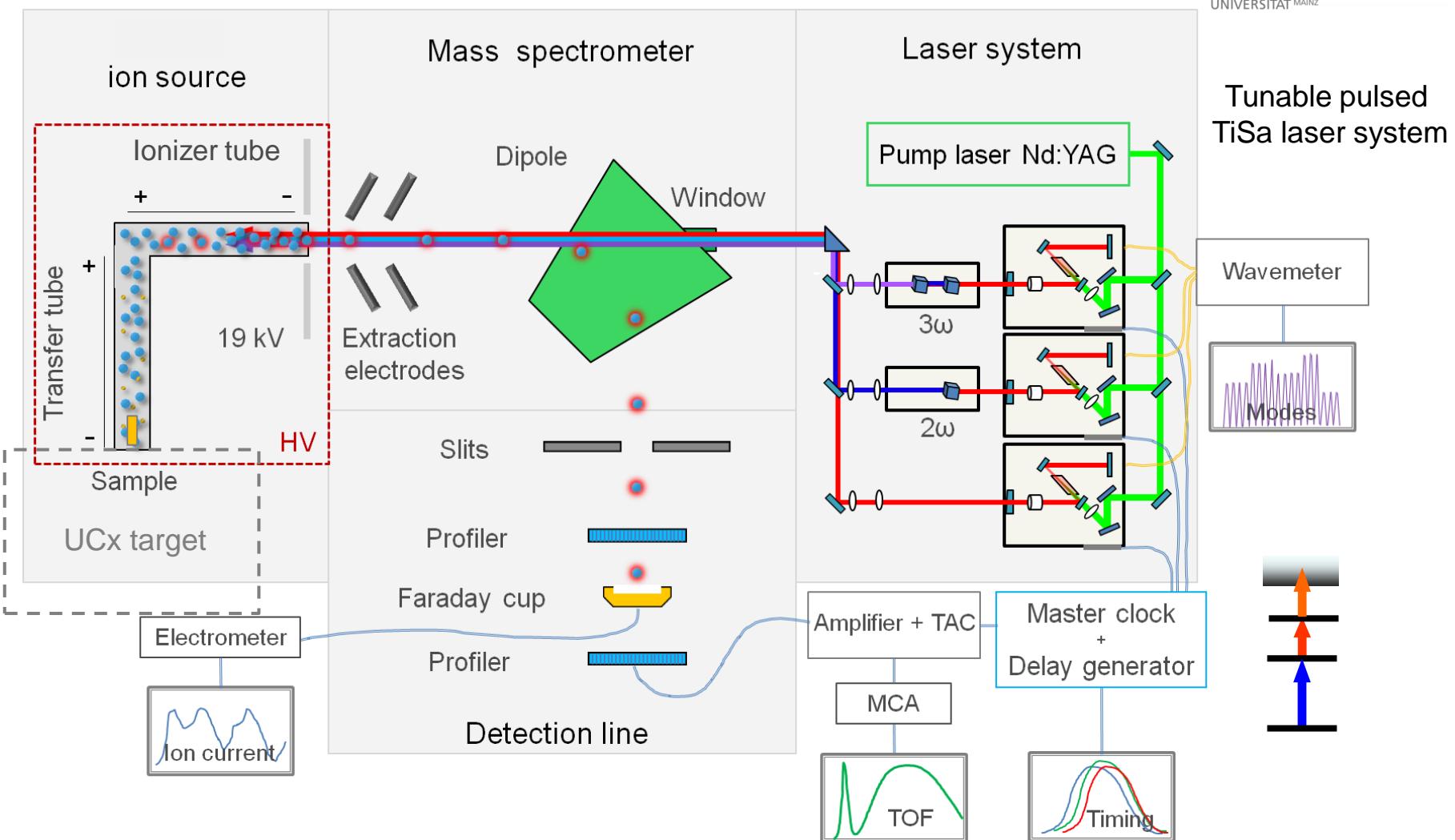
Phase 1

Phase 2

CIME cyclotron RIB
at 1-20 AMeV (up to
9 AMeV for FF)



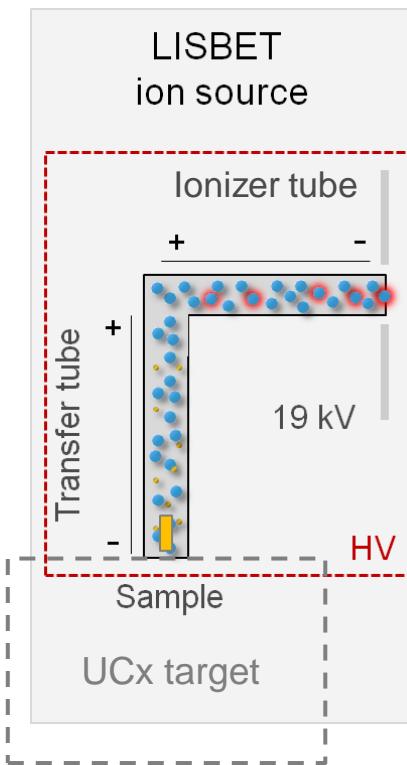
Test bench setup



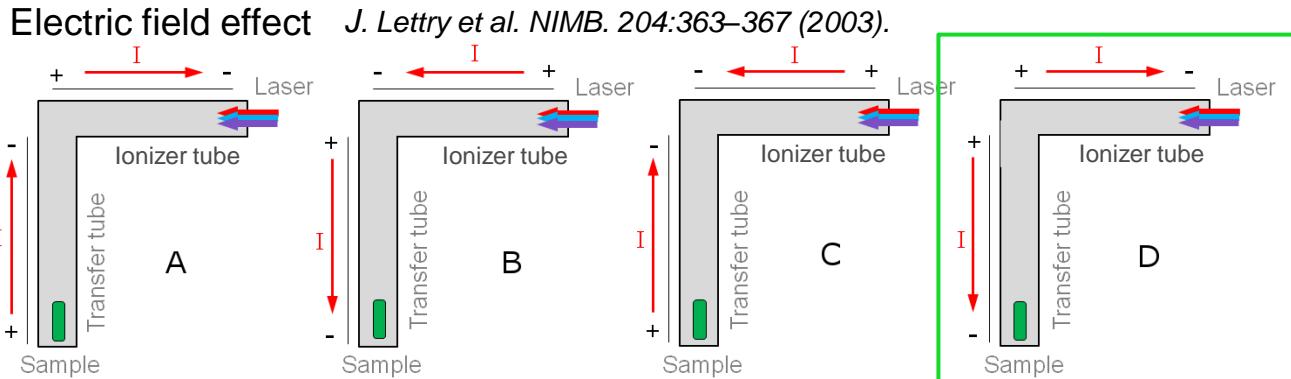
PhD Thesis – Jose Luis Henares González

Ion Source Geometry Configurations

Ion source configurations

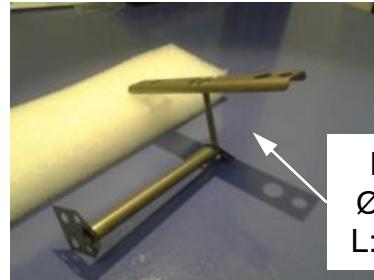


Electric field effect



Ion source geometry configurations

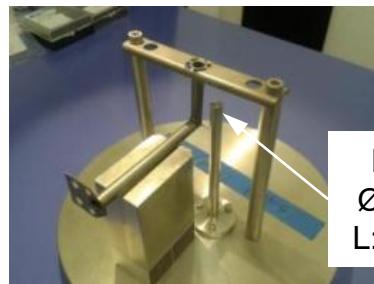
LISBET-D3L35



LISBET-D3L60



LISBET-D7L35



LISBET-D7L60



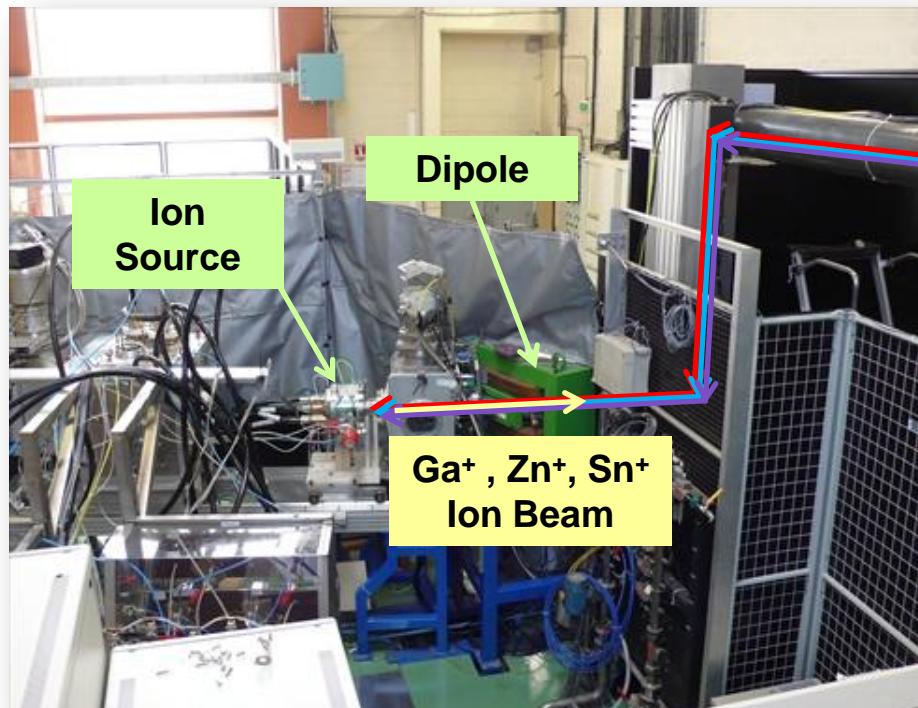
LISBET : Ta tubes, 0.2mm thick
 \Rightarrow Electric potential : 3 - 5V

LISBET : Laser Ion Source Body using Efficient Techniques

PhD Thesis – Jose Luis Henares González

GISELE

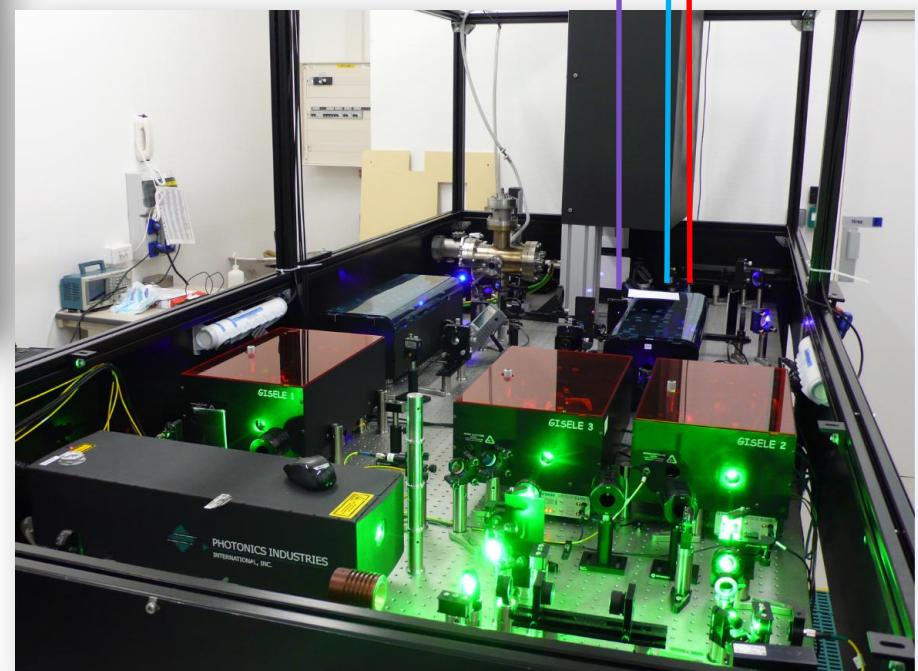
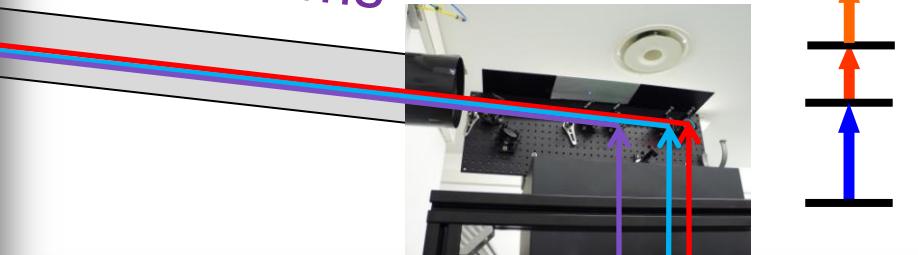
GANIL Ion Source using Electron Laser Excitation



Laser beam transport, Separator & Ion Source



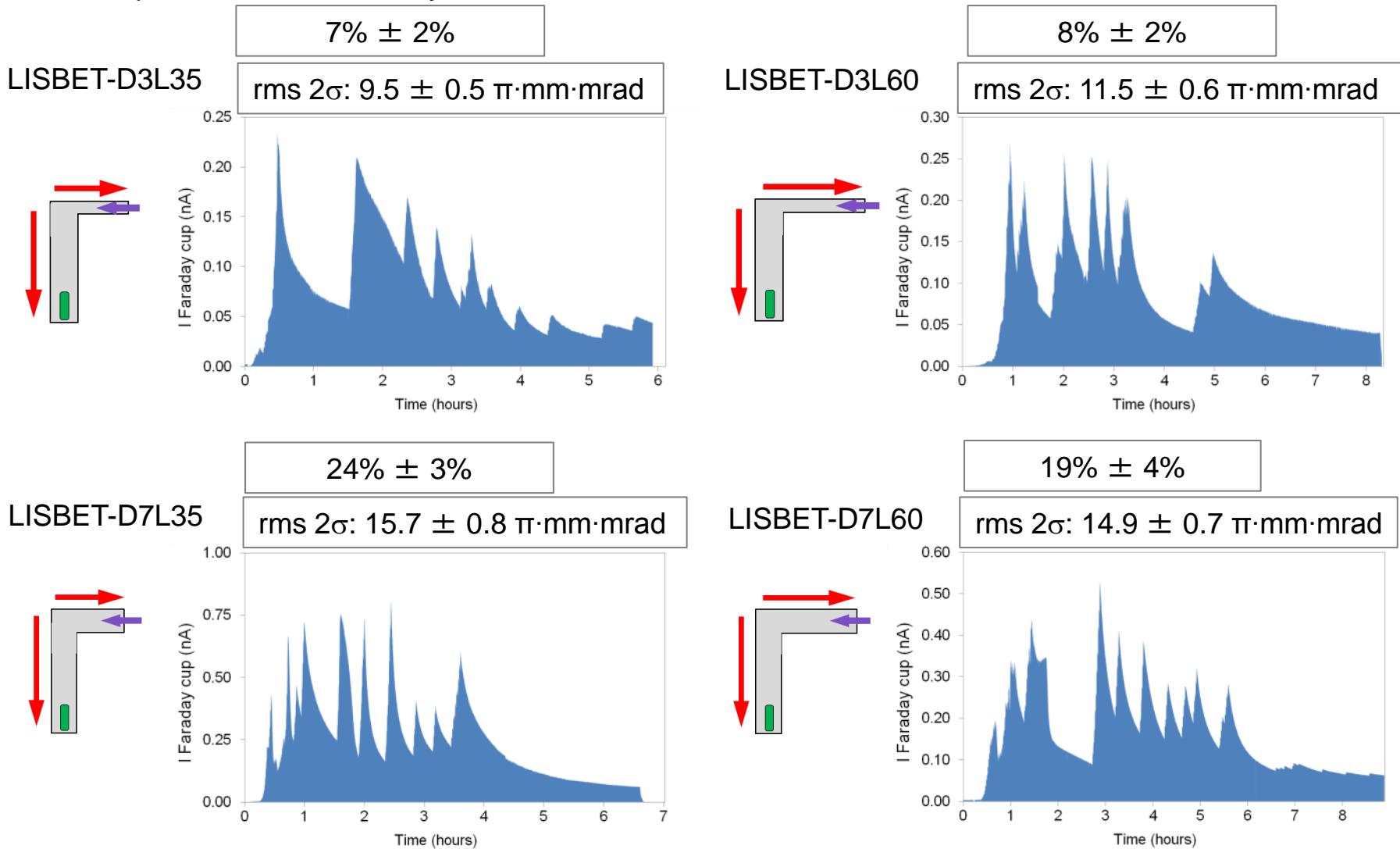
Laser beams



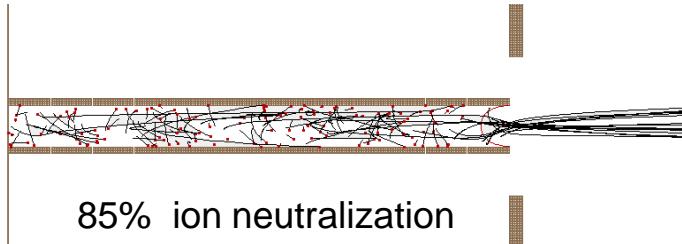
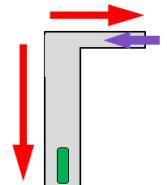
GISELE laser System

Efficiency measurements

^{124}Sn production for efficiency measurements



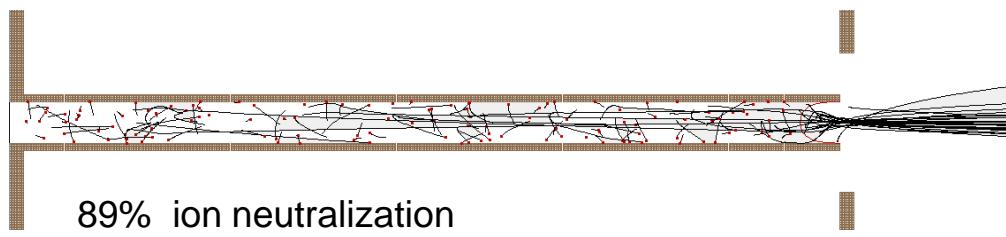
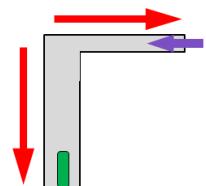
LISBET-D3L35



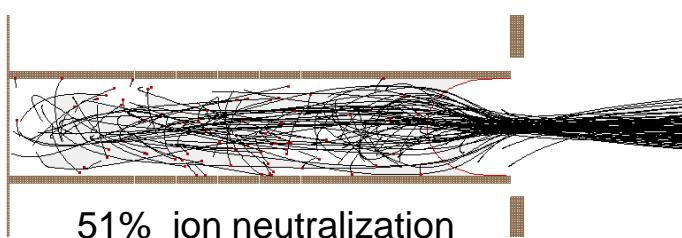
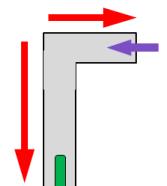
Parameters:

- Isotope: ^{124}Sn
- Charge state: +1
- Ion distribution: Cylindrical (homogeneous)
- Initial speed: Maxwell-Boltzmann distribution
- Initial velocity direction: 2π cone

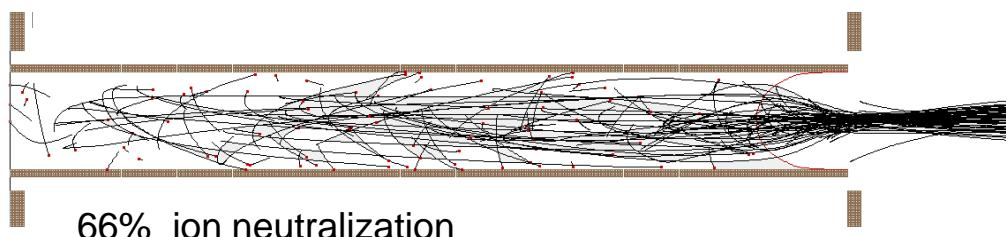
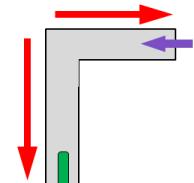
LISBET-D3L60



LISBET-D7L35



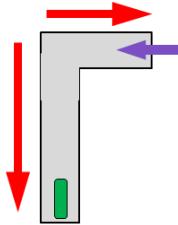
LISBET-D7L60



^{124}Sn production for efficiency measurements

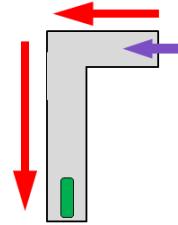
LISBET-D7L35

$24\% \pm 3\%$



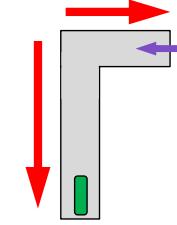
Reversed polarity

$5\% \pm 1\%$

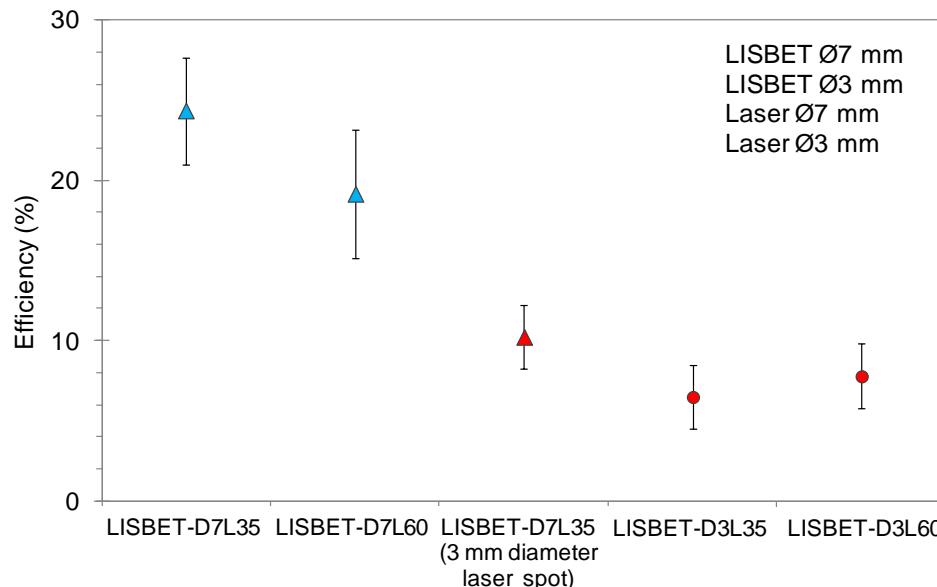


Laser beams focused to 3 mm

$9\% \pm 1\%$



Summary of the efficiency measurements

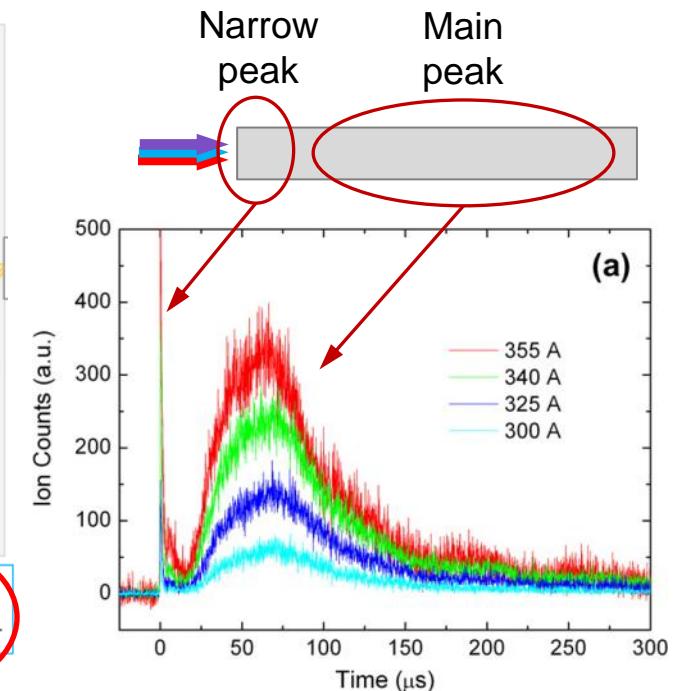
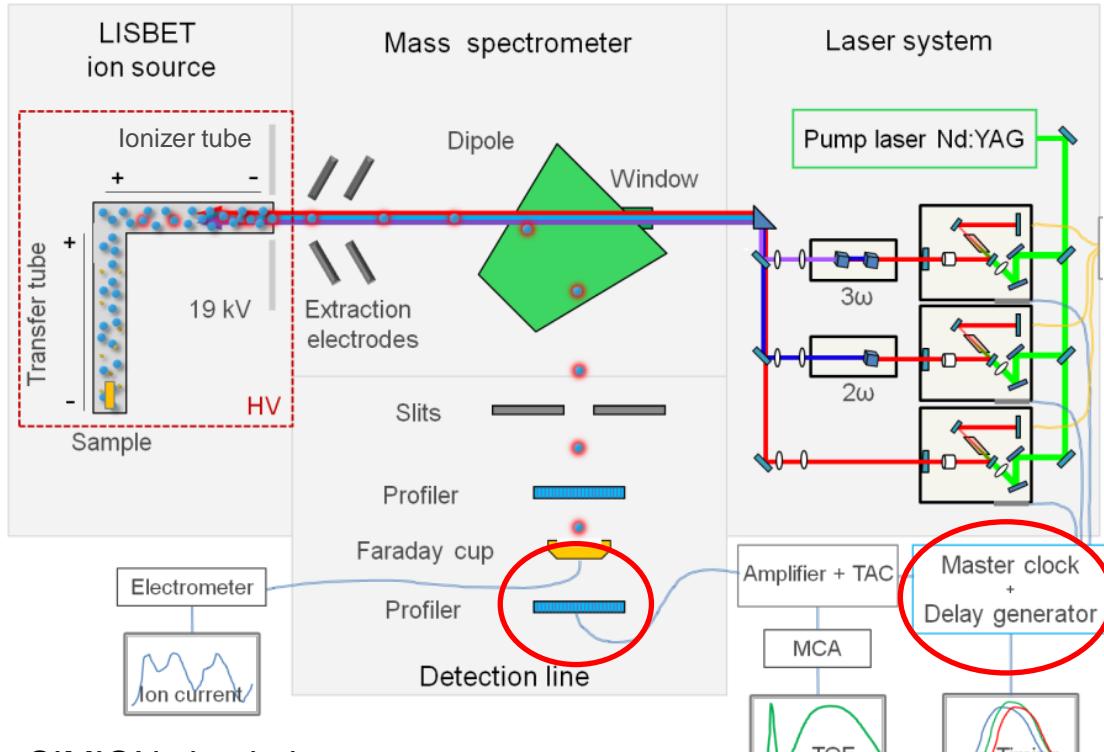


Conclusion:

- Increase of ionizer diameter
 - ↓
 - Decrease neutralization
 - ↓
 - Increase of ion production
- Increase of length: No effect
- Laser interaction

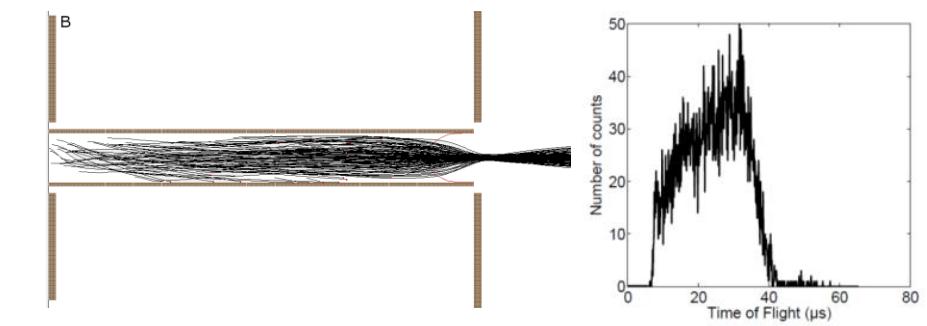
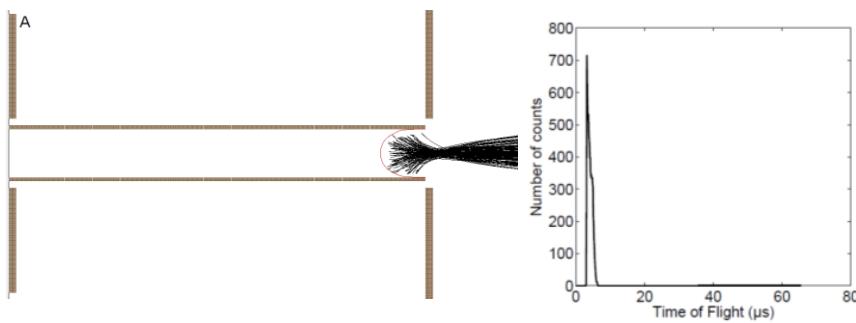
Time profile structures

Time-of-flight acquisition system



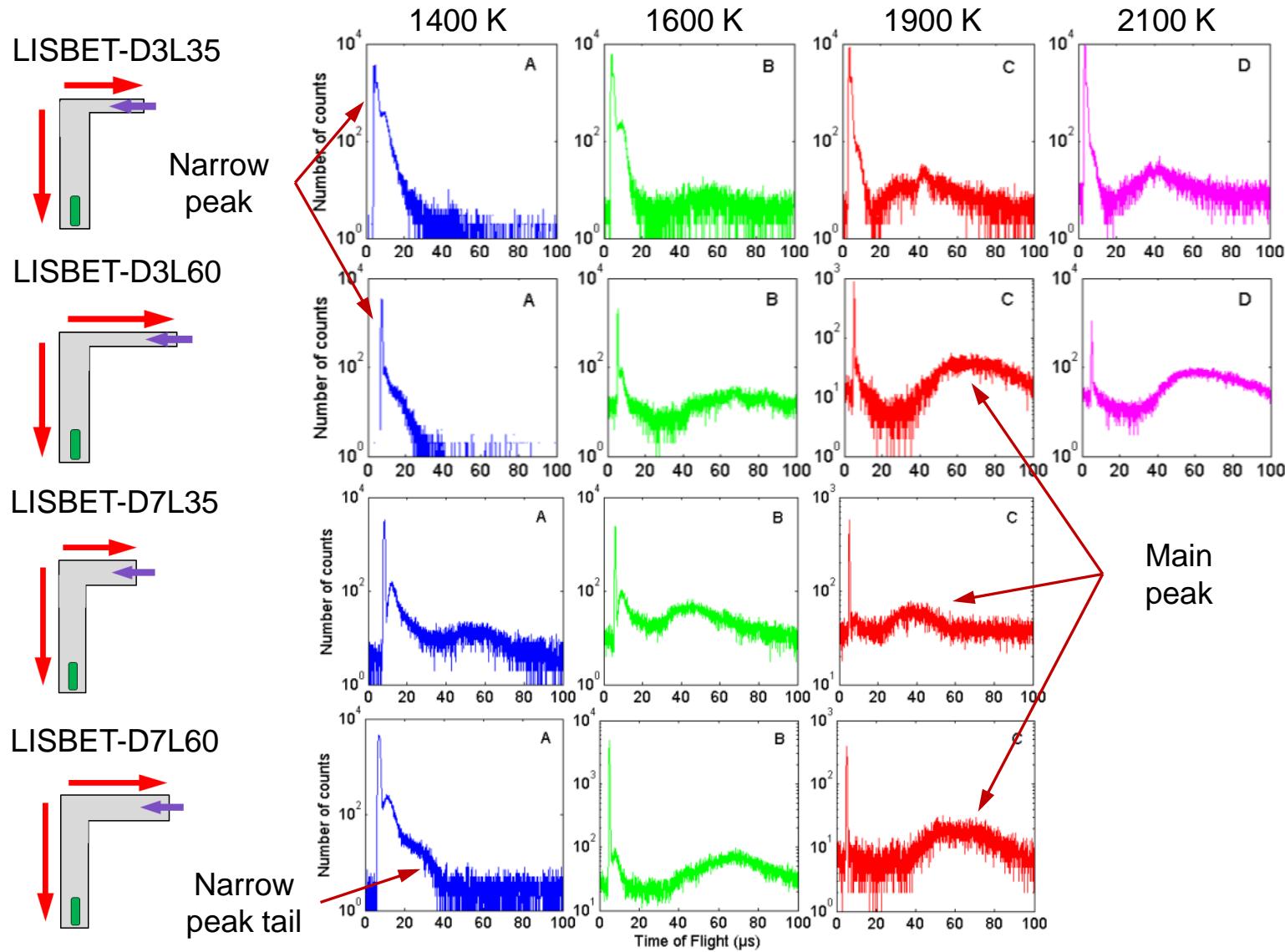
J. Lettry et al. NIMB. 204: 363–367 (2003)
 Y. Liu et al. NIMB. 269: 2771–2780 (2011)

SIMION simulation



PhD Thesis – Jose Luis Henares González

Time profile structures vs Temperature



Calculation of $N_{\text{MainPeak}}/N_{\text{total}}$ ratios

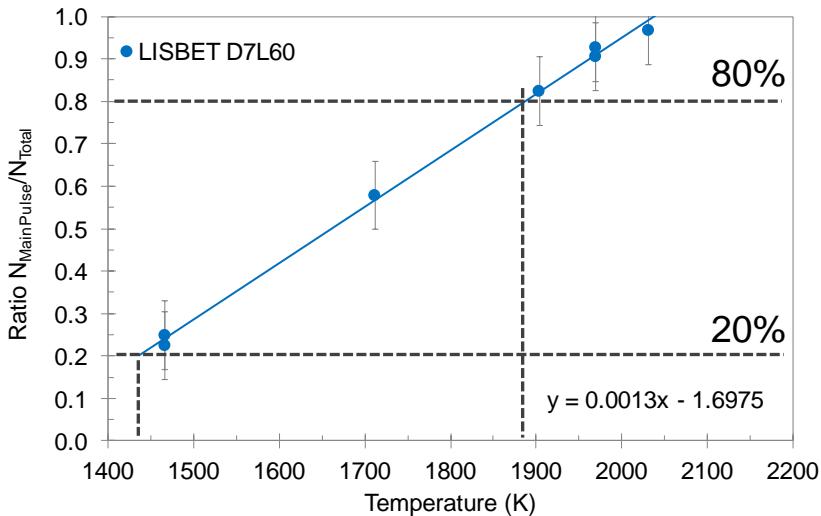
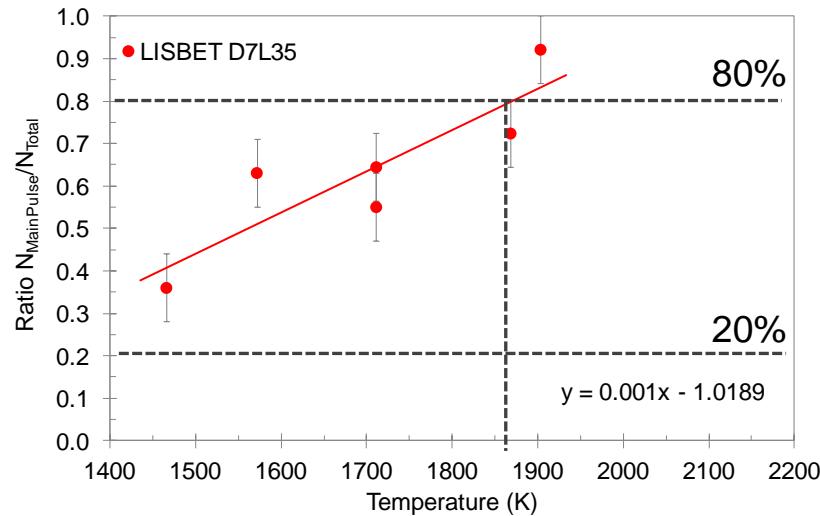
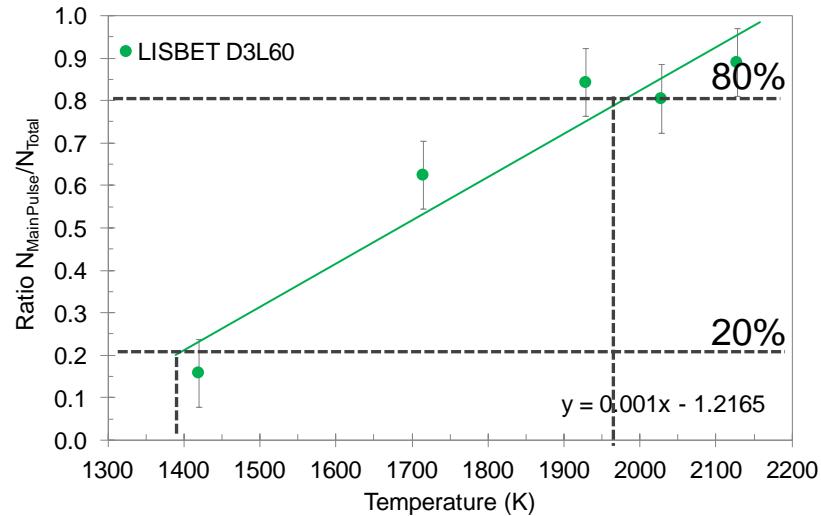
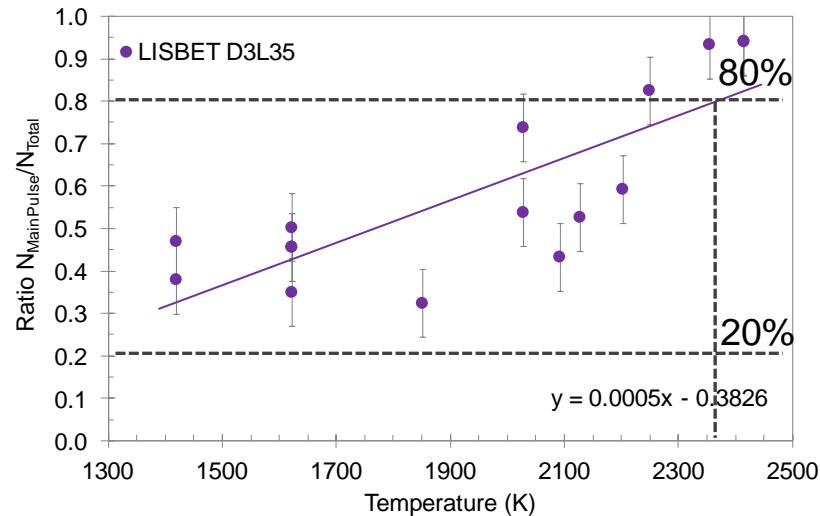
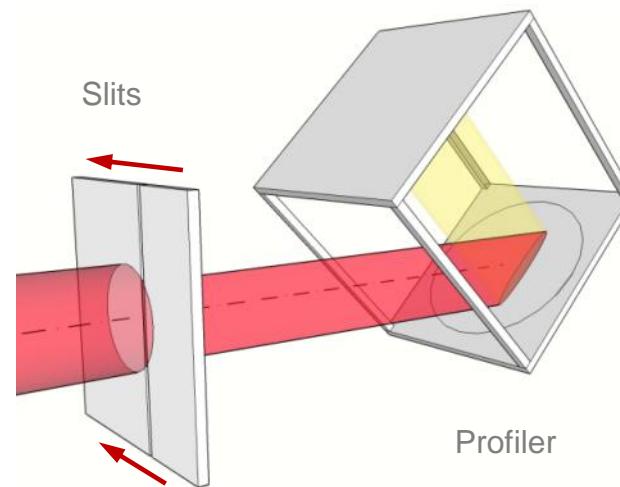
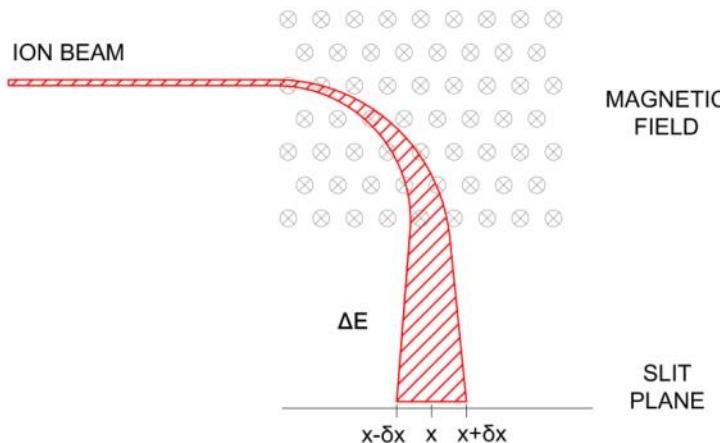
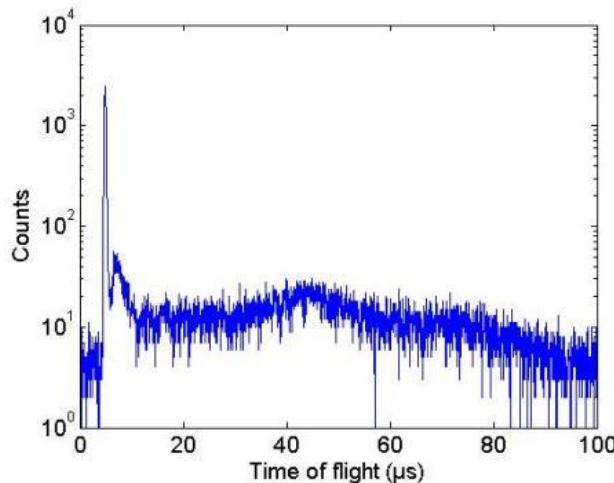


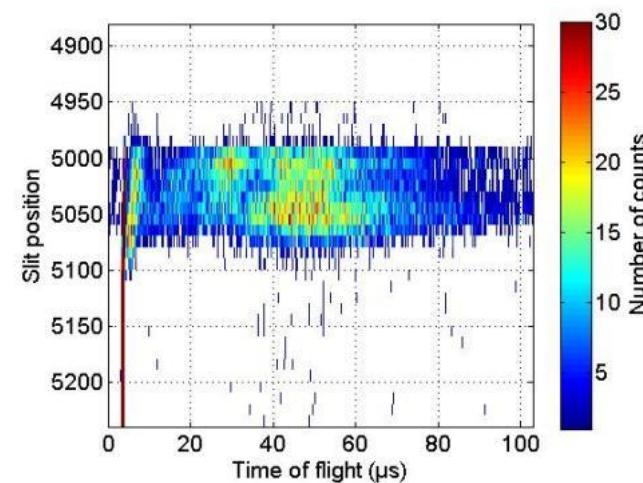
Diagram of the time profile energy scan measurement



Time profile structure

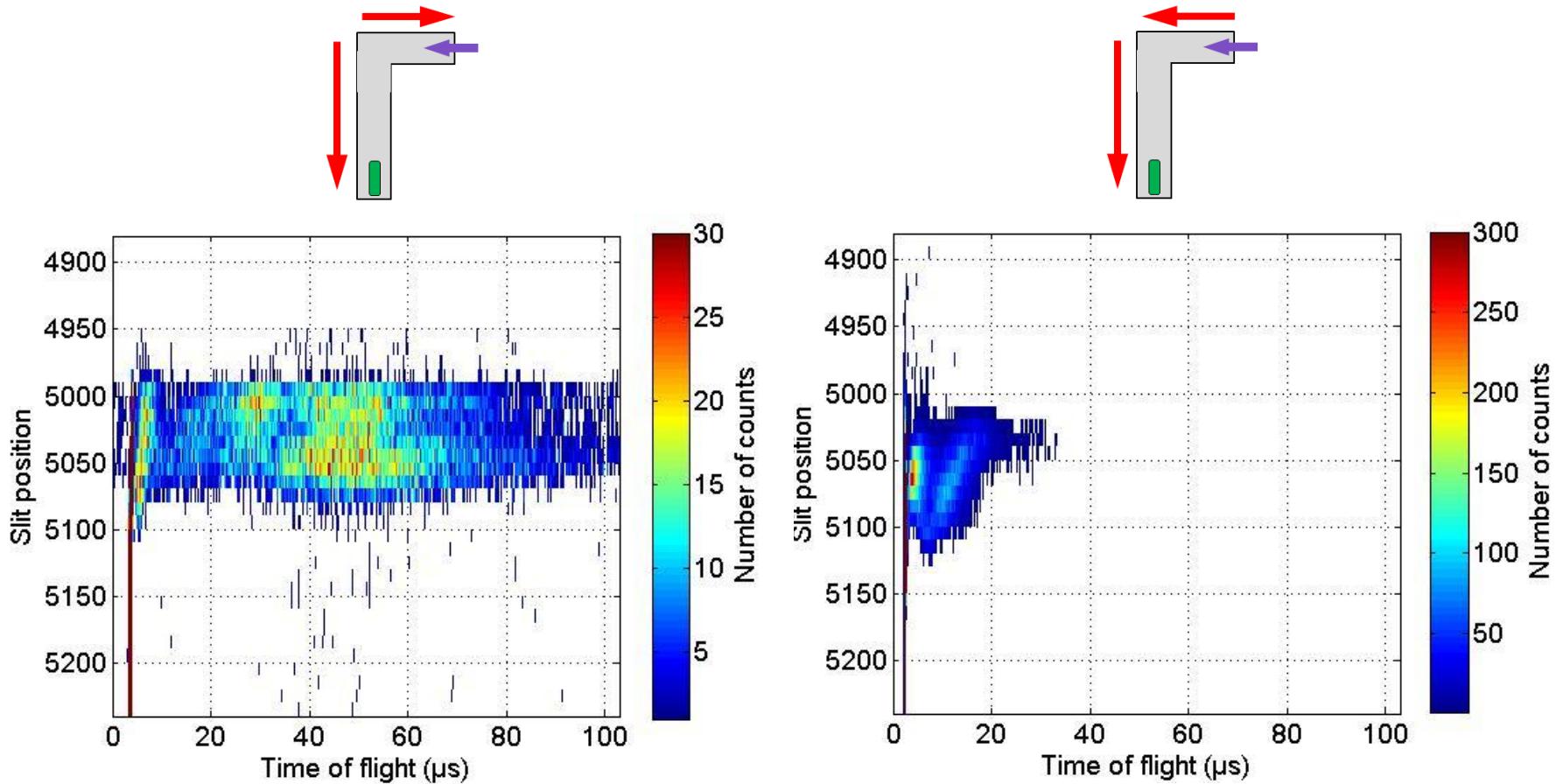


Time profile energy scan



PhD Thesis – Jose Luis Henares González

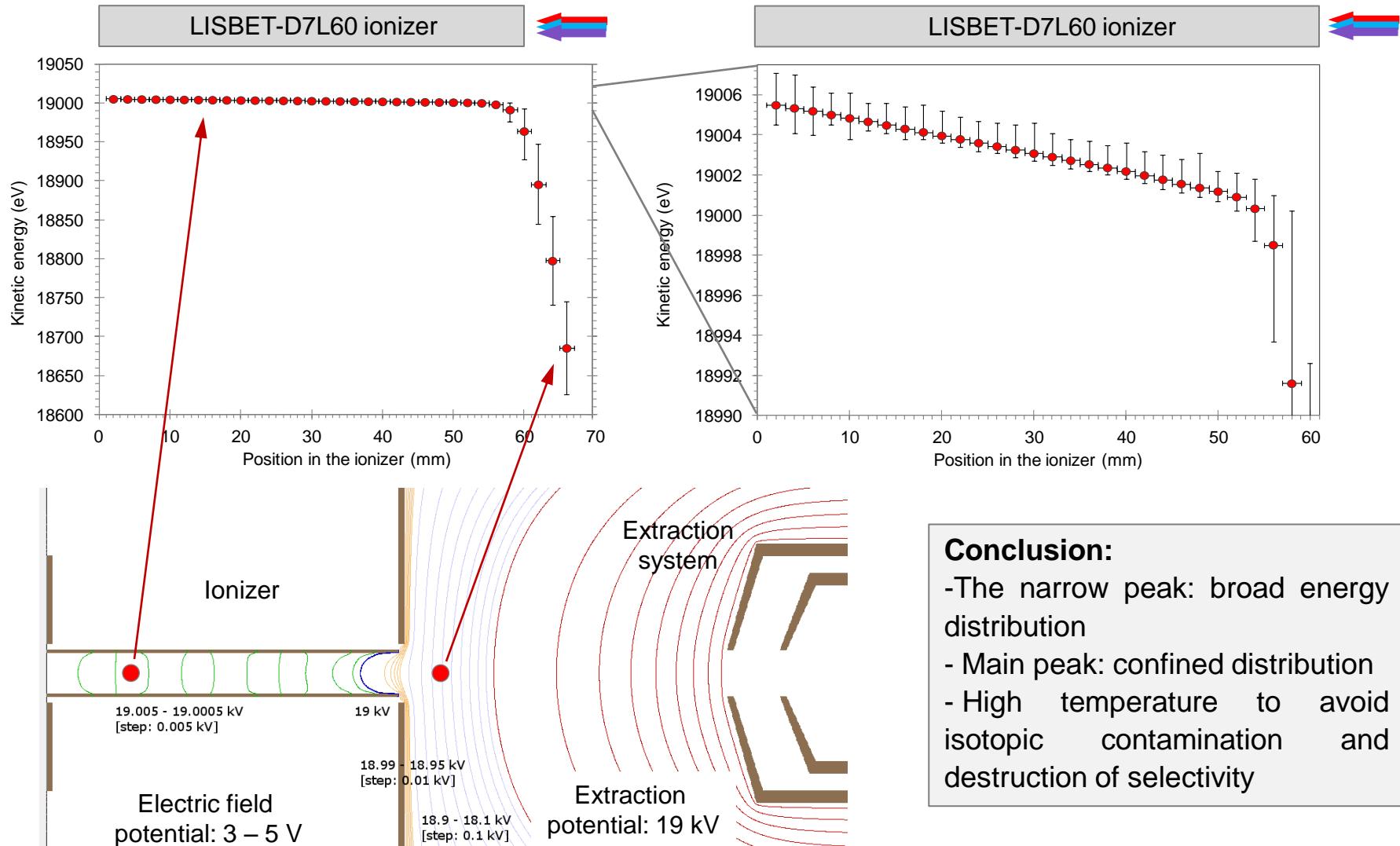
Time profile energy scan measurement: LISBET-D7L35



J.L. Henares, et al., NIM A, 01689002 (2015).

PhD Thesis – Jose Luis Henares González

SIMION simulation

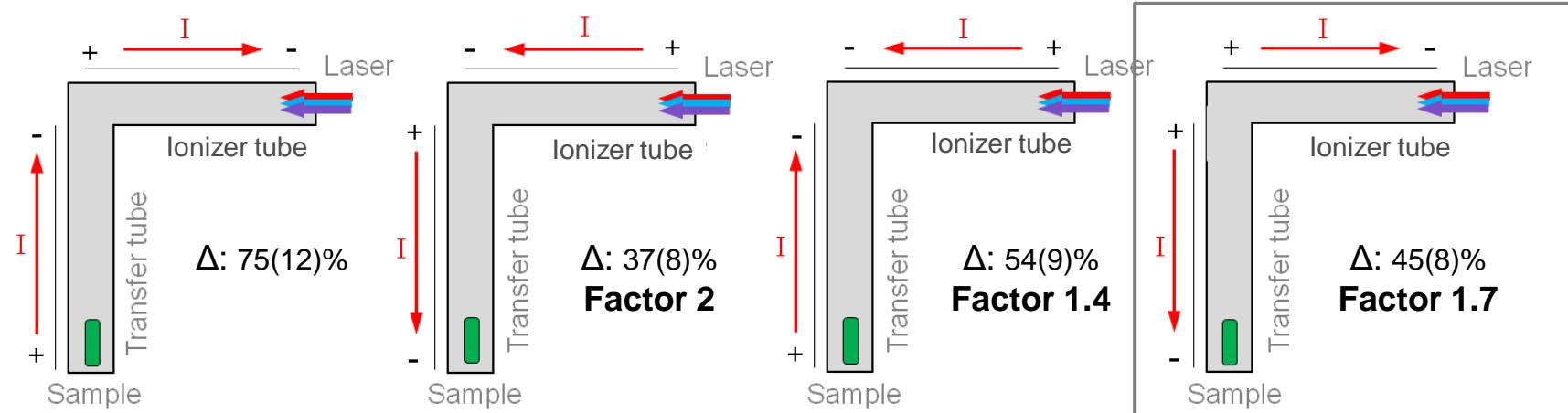


Conclusion:

- The narrow peak: broad energy distribution
- Main peak: confined distribution
- High temperature to avoid isotopic contamination and destruction of selectivity

^{85}Rb surface ion comparison: LISBET-D7L35

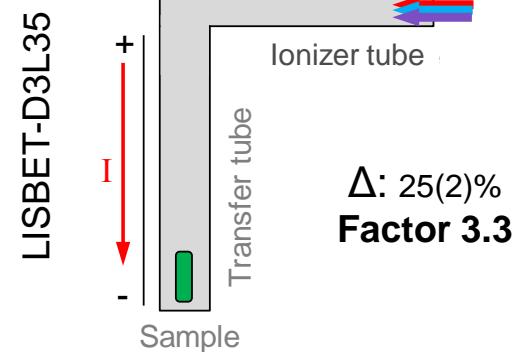
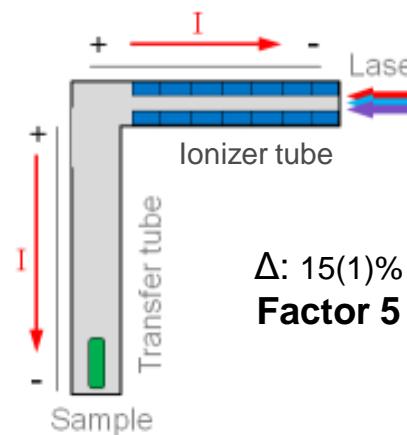
Reduction factor



Low work function materials



$$\begin{aligned}\phi_{\text{Ta}} &= 4.2 \text{ eV} \\ \phi_{\text{ZrC}} &= 3.3 - 3.7 \text{ eV}\end{aligned}$$



- Ionizer geometry comparison:
 - Diameter increase:
 - Sn^+ RILIS Efficiency: **Increases 7% → 24%**
 - Emittance: $10 - 15 \pi \cdot \text{mm} \cdot \text{mrad}$
 - Increase of alkali contamination production
 - Length: No effect
- Time structures and energy scans:
 - Structures: Narrow peak - Main peak
 - High temperature relation
 - Main peak: Confined energy
 - Narrow peak: Isotopic contamination
 - **Decrease of selectivity**
- Contamination reduction:
 - Electric field: Factor 2 reduction
 - ZrC material: Factor 5 reduction (diameter effect)

Jose Luis Henares PhD manuscript: <http://hal.in2p3.fr/tel-01314260>

PhD Thesis – Jose Luis Henares González

Collaboration



GANIL:

B. Bastin, S. Damoy, L. Hijazi, J.L. Henares, N. Lecesne, R. Leroy



University of Mainz:

T. Kron, P. Naubereit, S. Raeder, F. Schneider, D. Studer, K. Wendt



TRIUMF:

J. Lassen, A. Teigelhöfer



RILIS-ISOLDE:

S. Rothe

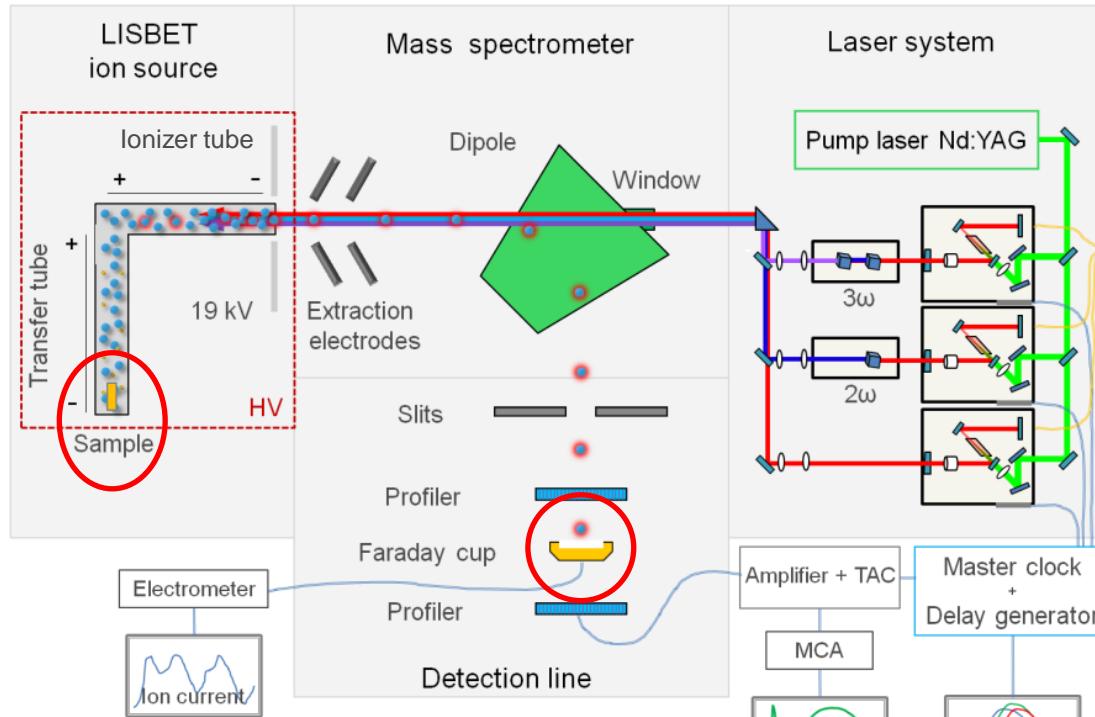


AND THANK YOU ALL FOR YOUR ATTENTION

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289191.

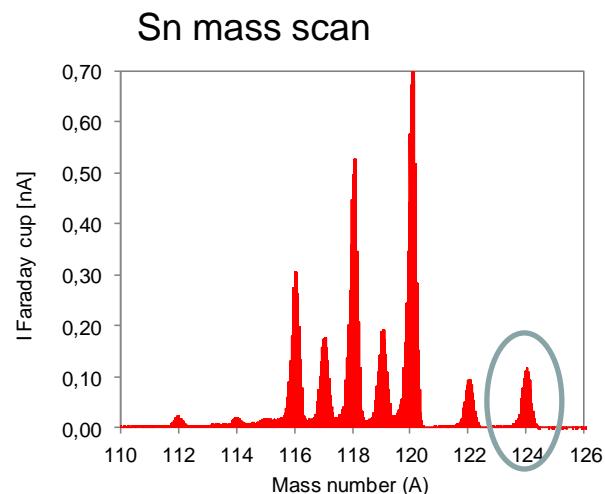
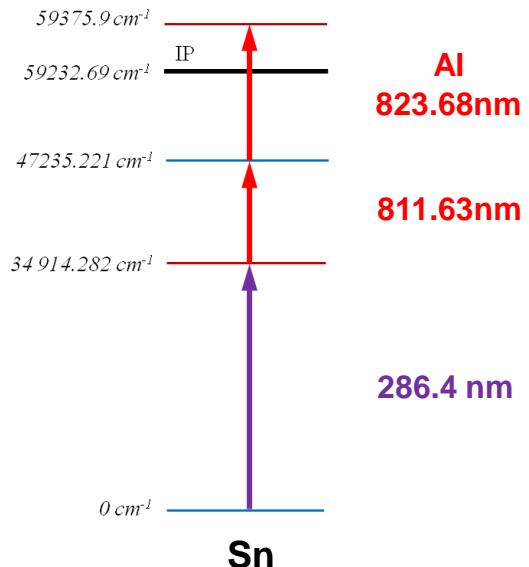
Efficiency measurements on Sn

^{124}Sn production for efficiency measurements



$$\varepsilon_{eff} = \frac{K_{Total}}{N_{iso}}$$

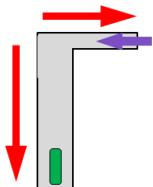
K_{total} : Ions after the magnet mass spectrometer
 N_{iso} : Atoms placed in the atomizer



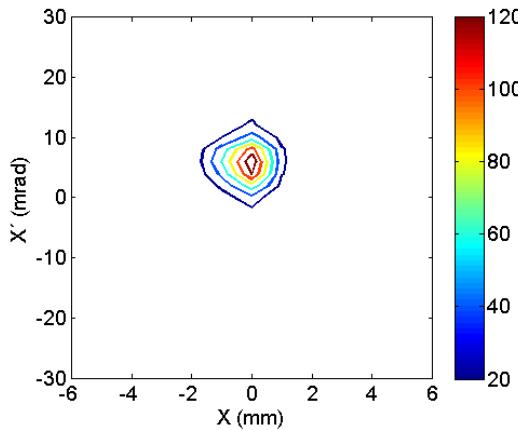
PhD Thesis – Jose Luis Henares González

^{124}Sn production for rms 2σ emittance measurements

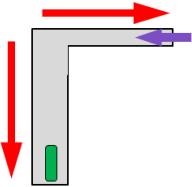
LISBET-D3L35



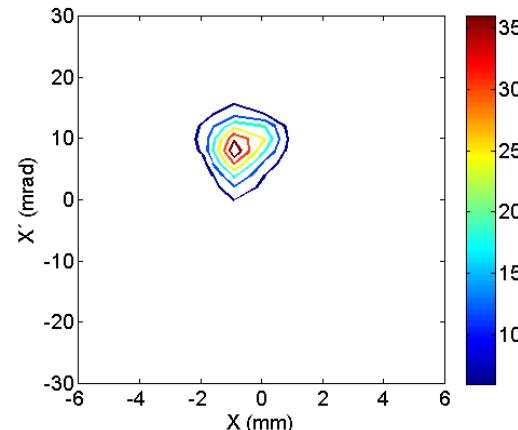
$9.5 \pm 0.5 \pi \cdot \text{mm} \cdot \text{mrad}$



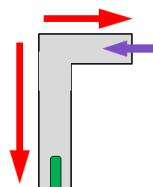
LISBET-D3L60



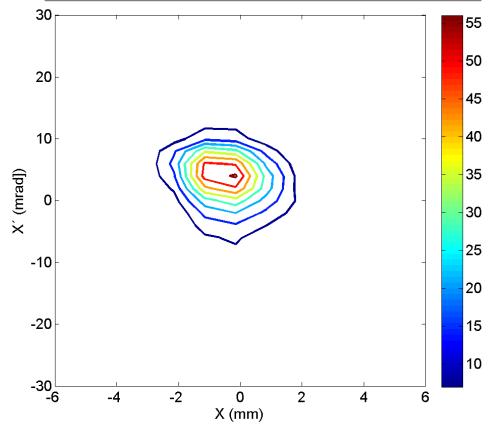
$11.5 \pm 0.6 \pi \cdot \text{mm} \cdot \text{mrad}$



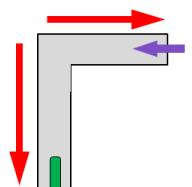
LISBET-D7L35



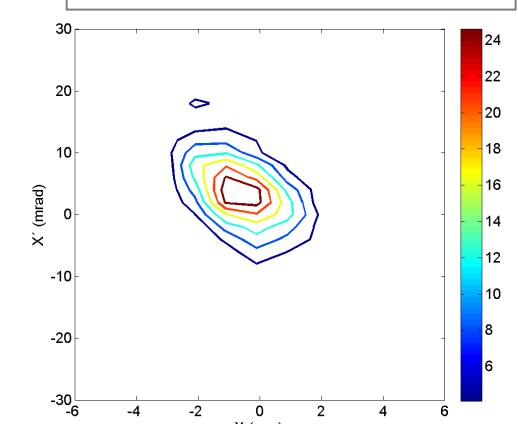
$15.7 \pm 0.8 \pi \cdot \text{mm} \cdot \text{mrad}$



LISBET-D7L60



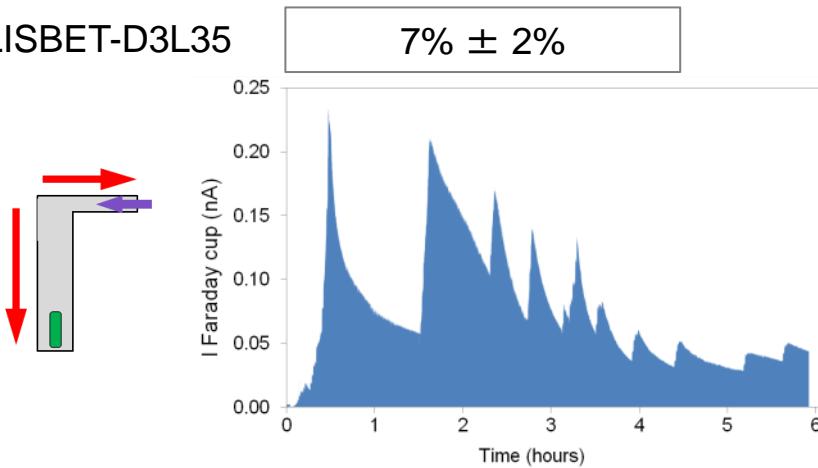
$14.9 \pm 0.7 \pi \cdot \text{mm} \cdot \text{mrad}$



^{124}Sn production for efficiency measurements

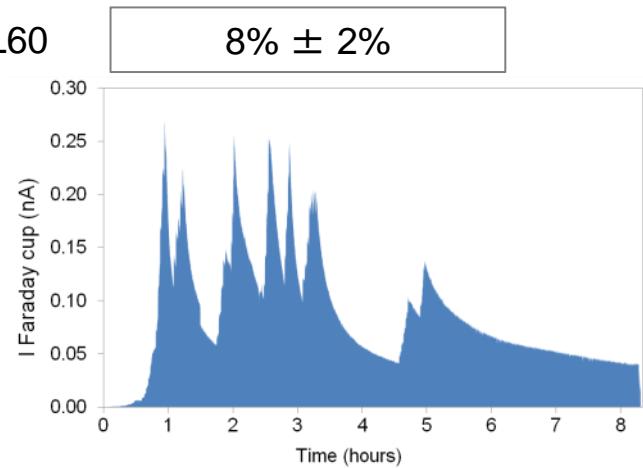
LISBET-D3L35

$7\% \pm 2\%$



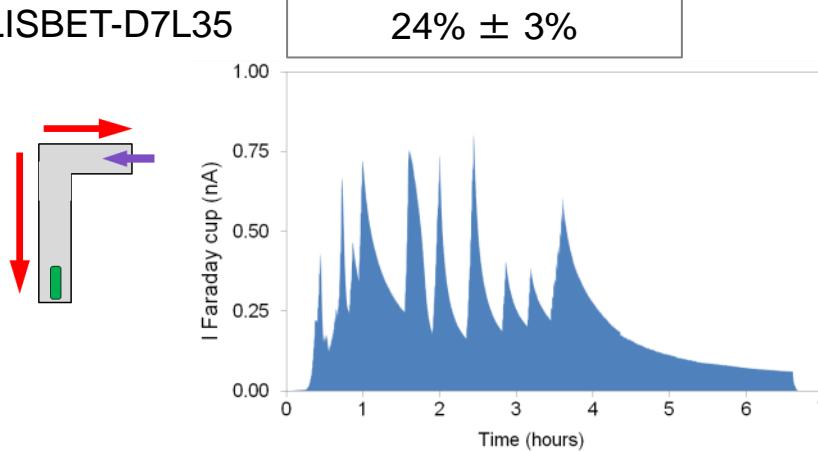
LISBET-D3L60

$8\% \pm 2\%$



LISBET-D7L35

$24\% \pm 3\%$



LISBET-D7L60

$19\% \pm 4\%$

