FRIEDRICH-SCHILLER-UNIVERSITÄT JENA

IOQ JENA
Friedrich-Schiller-Universität

GSI HI JENA
Helmholtz Institute Jena

Optimization of the stripper foil material and thickness for the GF

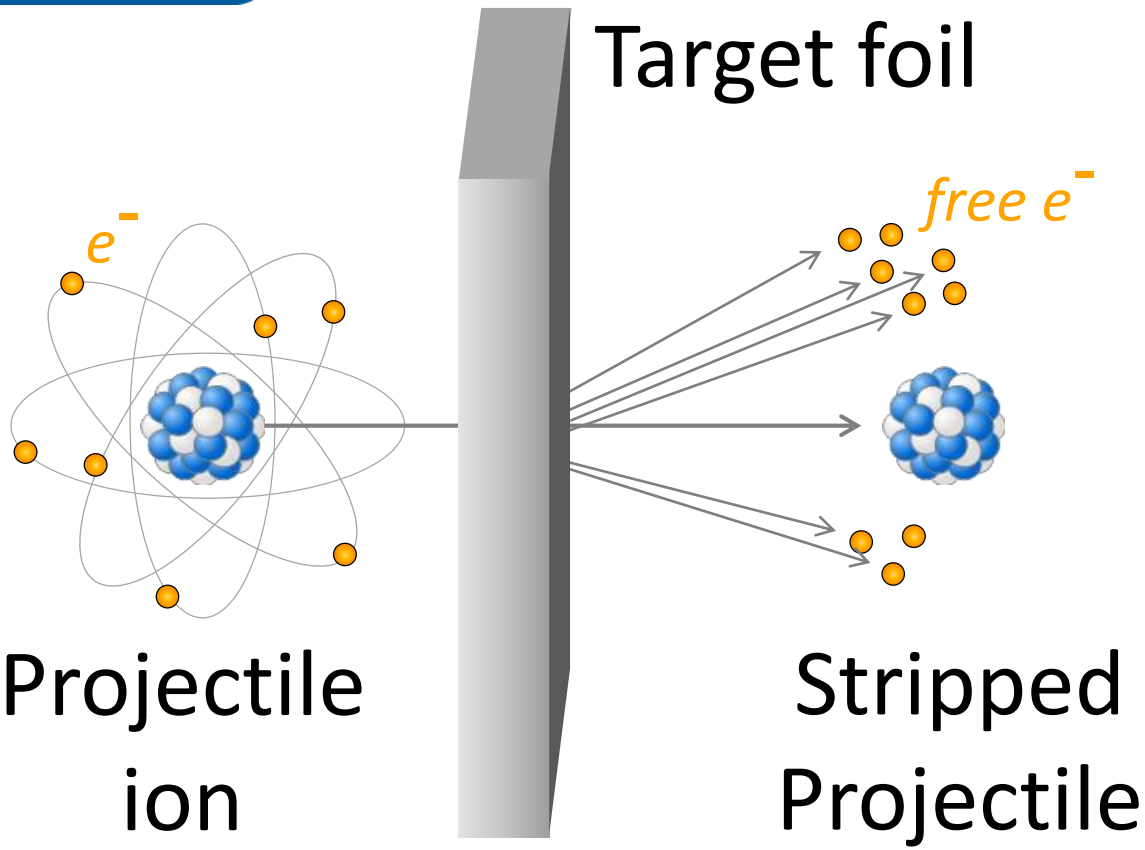
Felix Kröger, Günter Weber, Thomas Stöhlker

Gamma Factory Meeting - CERN

Overview

- Stripping process
  - Charge exchange processes
  - Cross sections
- Calculation programs
- Stripping scenarios for Pb^{80+} and Pb^{81+}
- Stripper foil material & thickness
- Results for Pb^{79+}, Pb^{80+} and Pb^{81+}

Stripper Foils

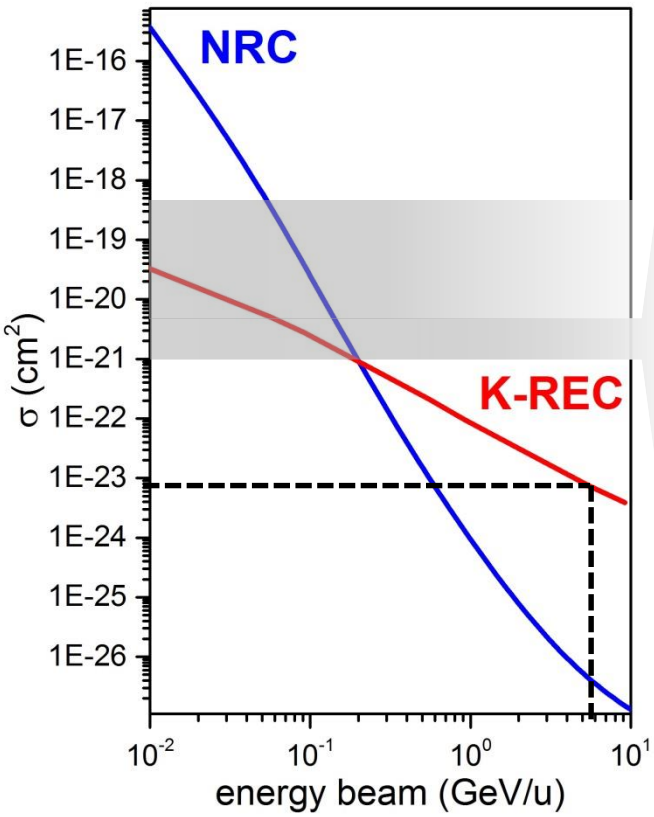


$\sigma_{ionisation} >> \sigma_{capture}$

HI JENA
Helmholtz Institute Jena

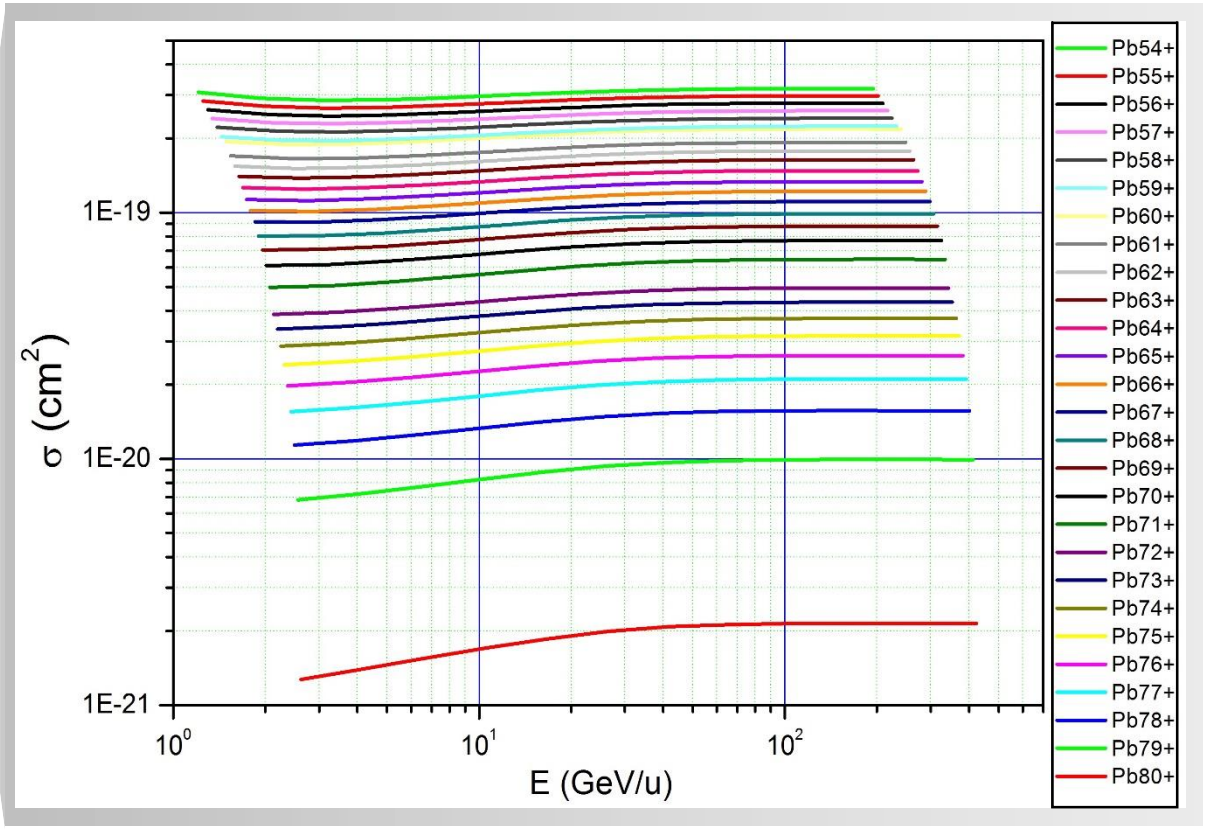
Cross sections

Electron Capture



Pb^{82+} on $_{13}Al$ at 5.9 (GeV/u)

Ionization



HI JENA
Helmholtz Institute Jena

Challenge: foil thickness

Cross sections

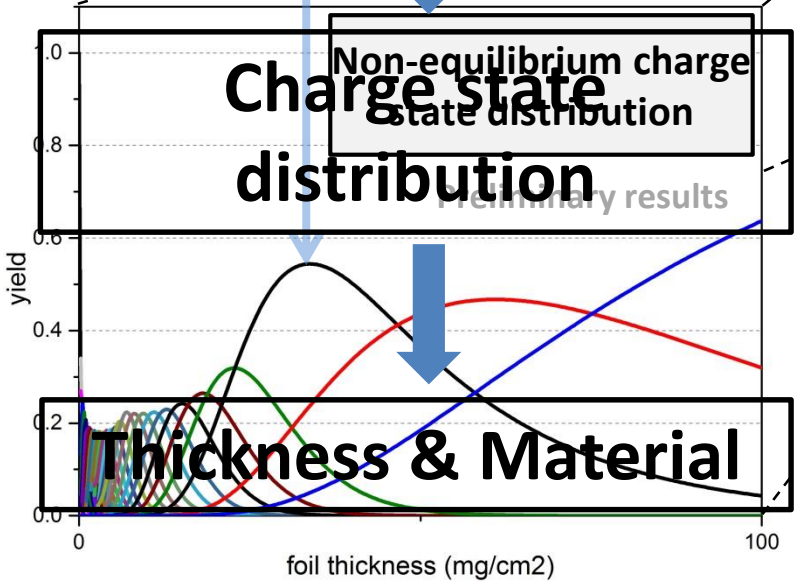
Exact foil thickness

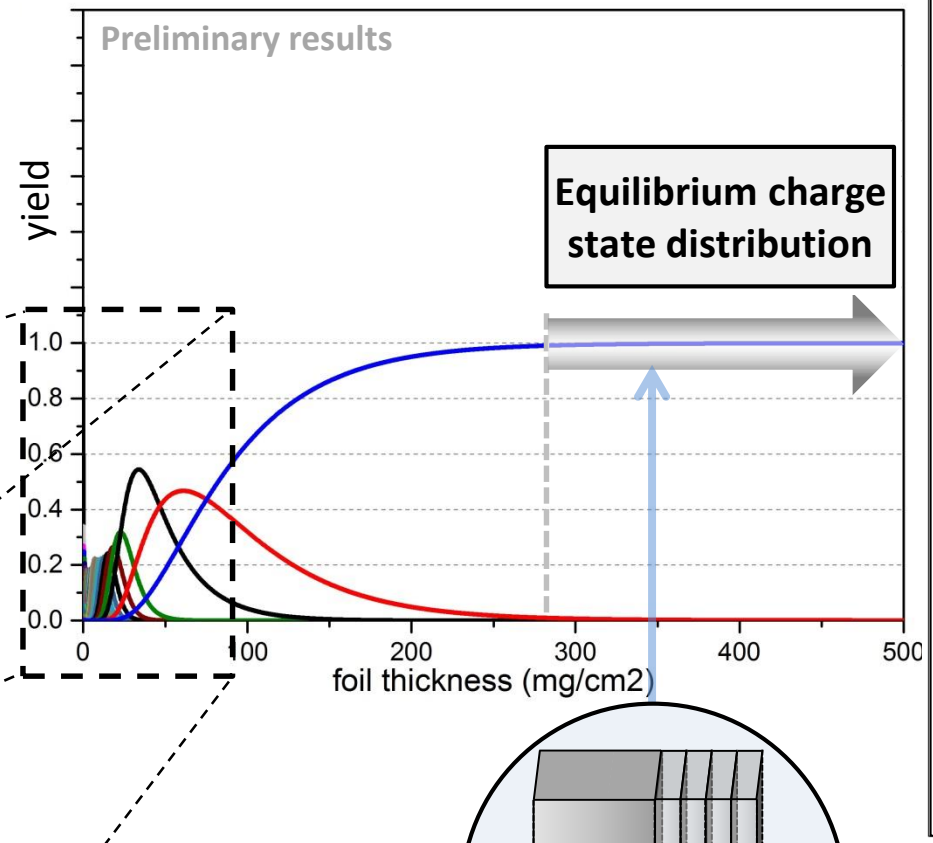
Balance rate equations

Charge state distribution

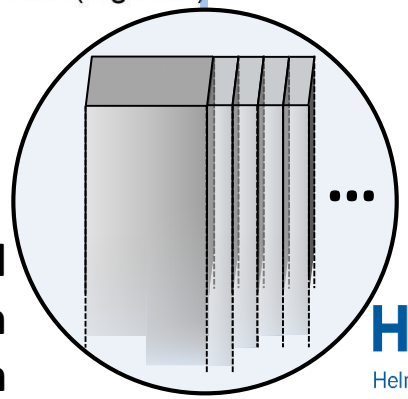
Non-equilibrium charge state distribution

Thickness & Material





Equilibrium charge state distribution



Beyond the required thickness to reach equilibrium

HI JENA
Helmholtz Institute Jena

Calculation programs

- **GLOBAL code, CHARGE code, …**

Limitations : the number of accounted charge states, ion energy range, and others

- **BREIT code**

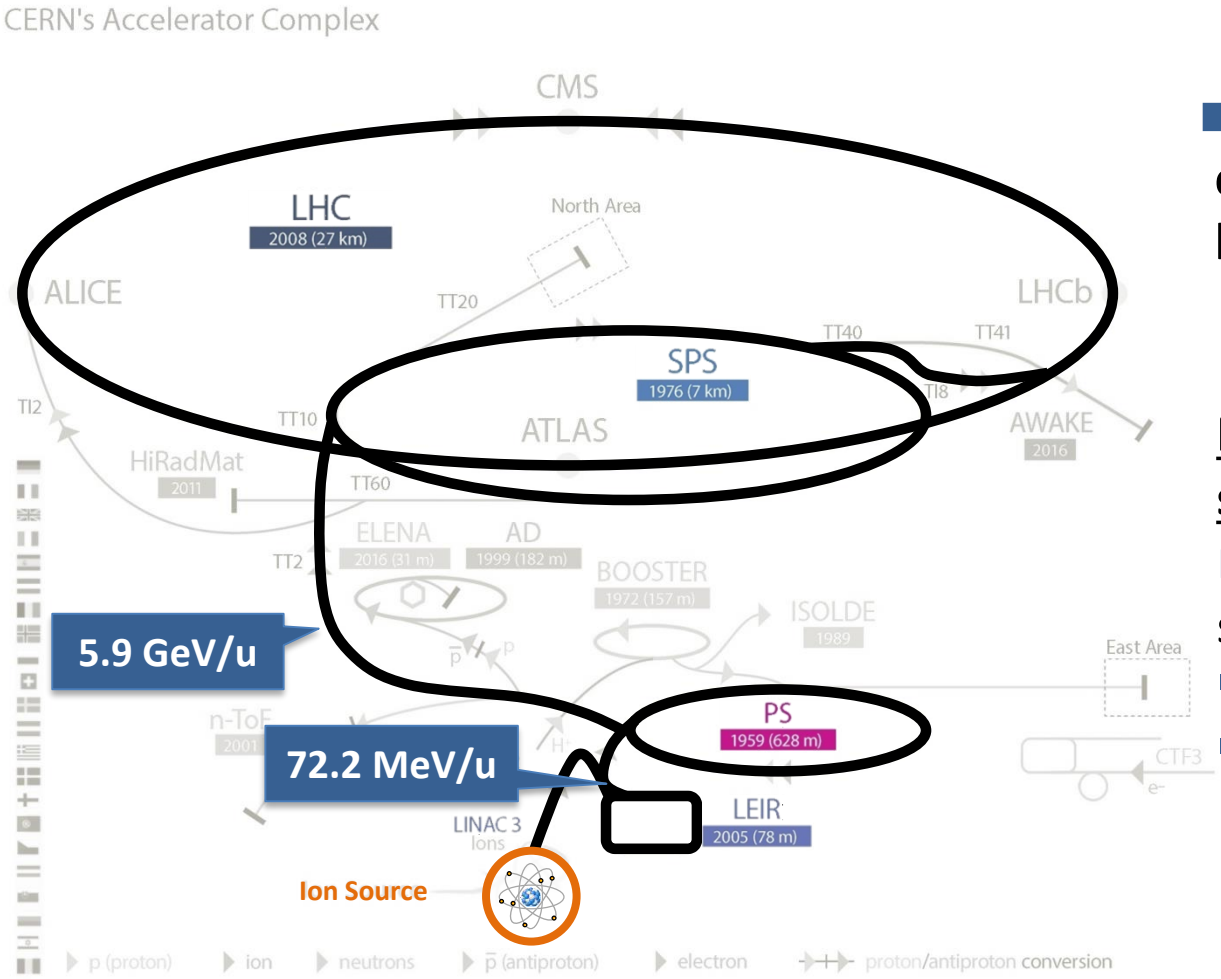
BREIT = Balance **R**ate **E**quations of **I**on **T**ransportation

➡ **Allows to overcome these limitations**

But: charge-exchange cross-sections have to be supplied by user

HI JENA
Helmholtz Institute Jena

Stripping Scenarios



http://te-epc-lpc.web.cern.ch/te-epc-lpc/machines/lhc/general.stm, 2017.

➡ Up to now, usually completelty stripped ions have been stored at LHC

Production of partially stripped ions

➡ 2 different stripping scenarios possible :

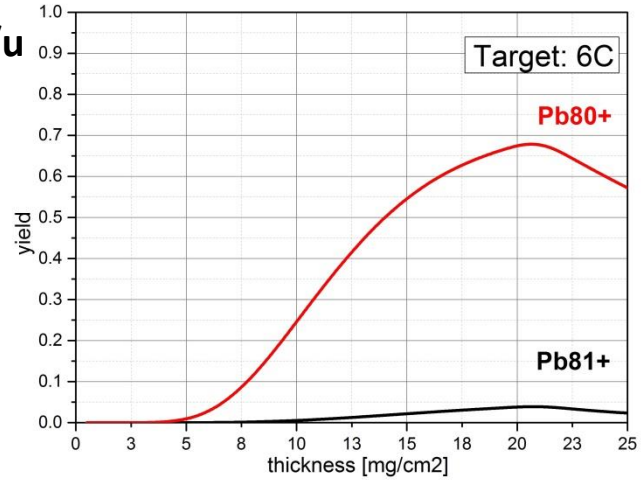
- Low energy : **GLOBAL**
- High energy : **BREIT**

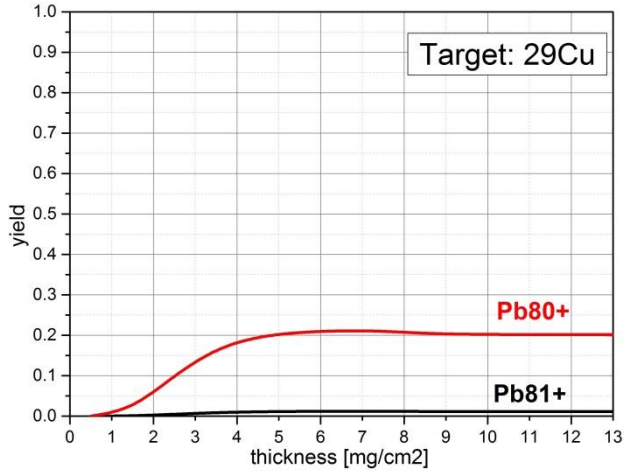
HI JENA
Helmholtz Institute Jena

Stripping Scenarios

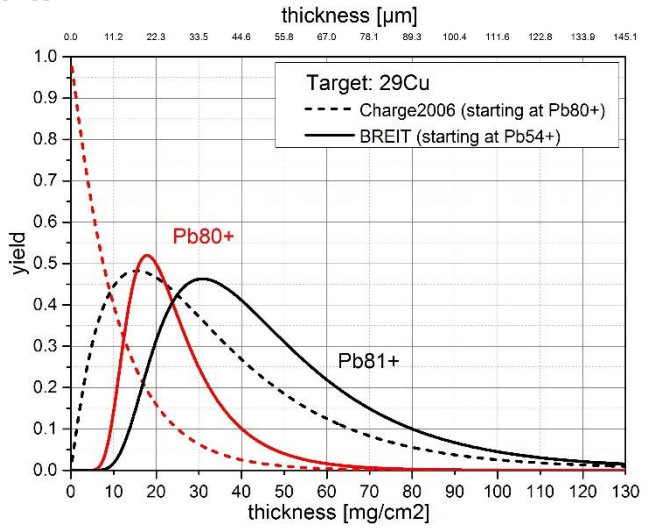
Preliminary results

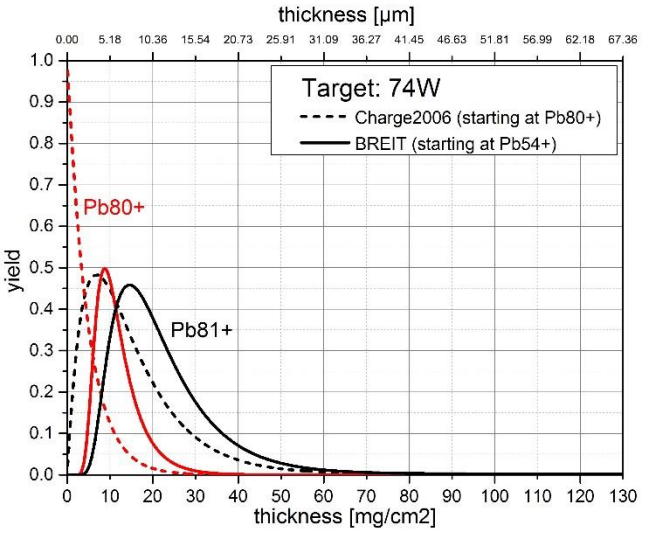
72.2 MeV/u
GLOBAL





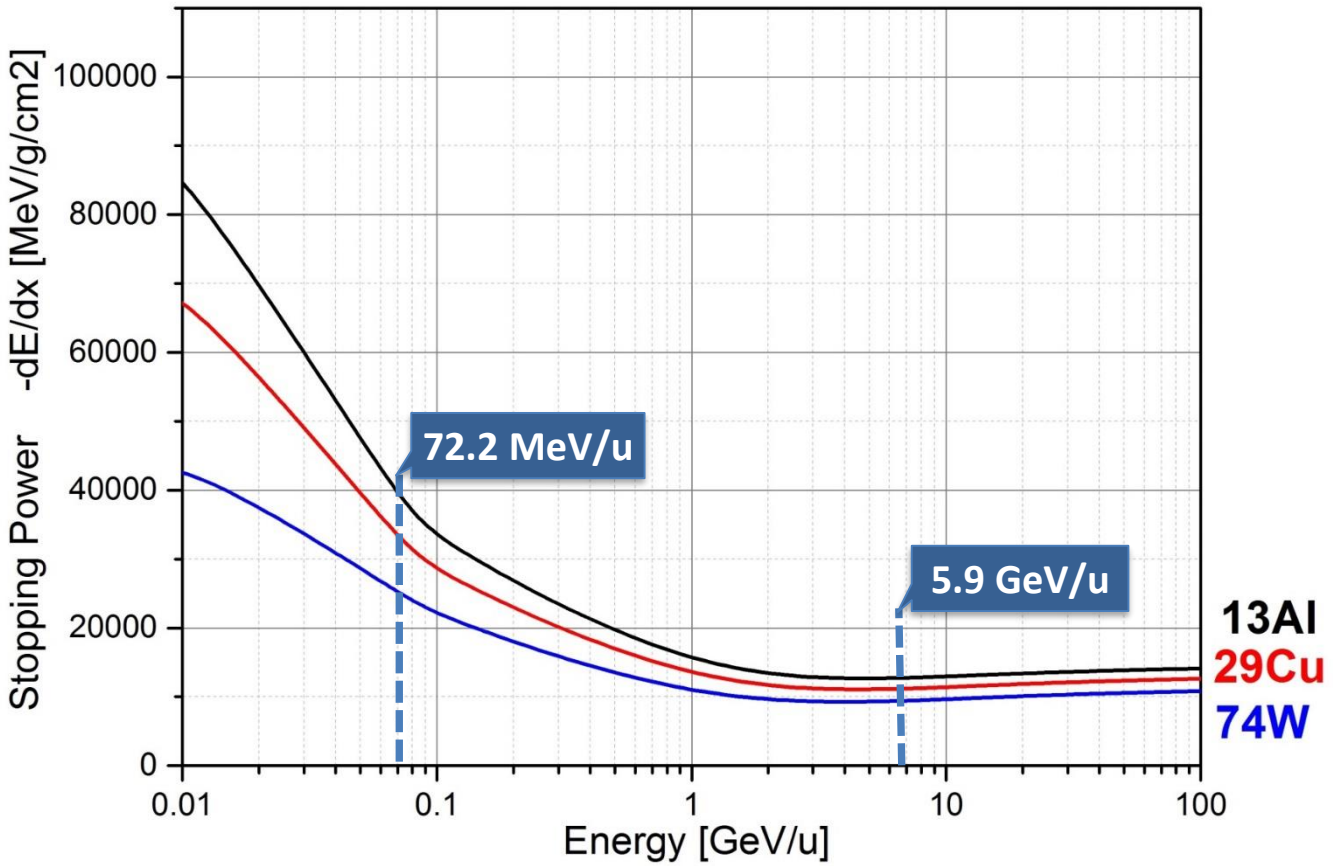
CHARGE/
BREIT





JENA
Helmholtz Institute Jena

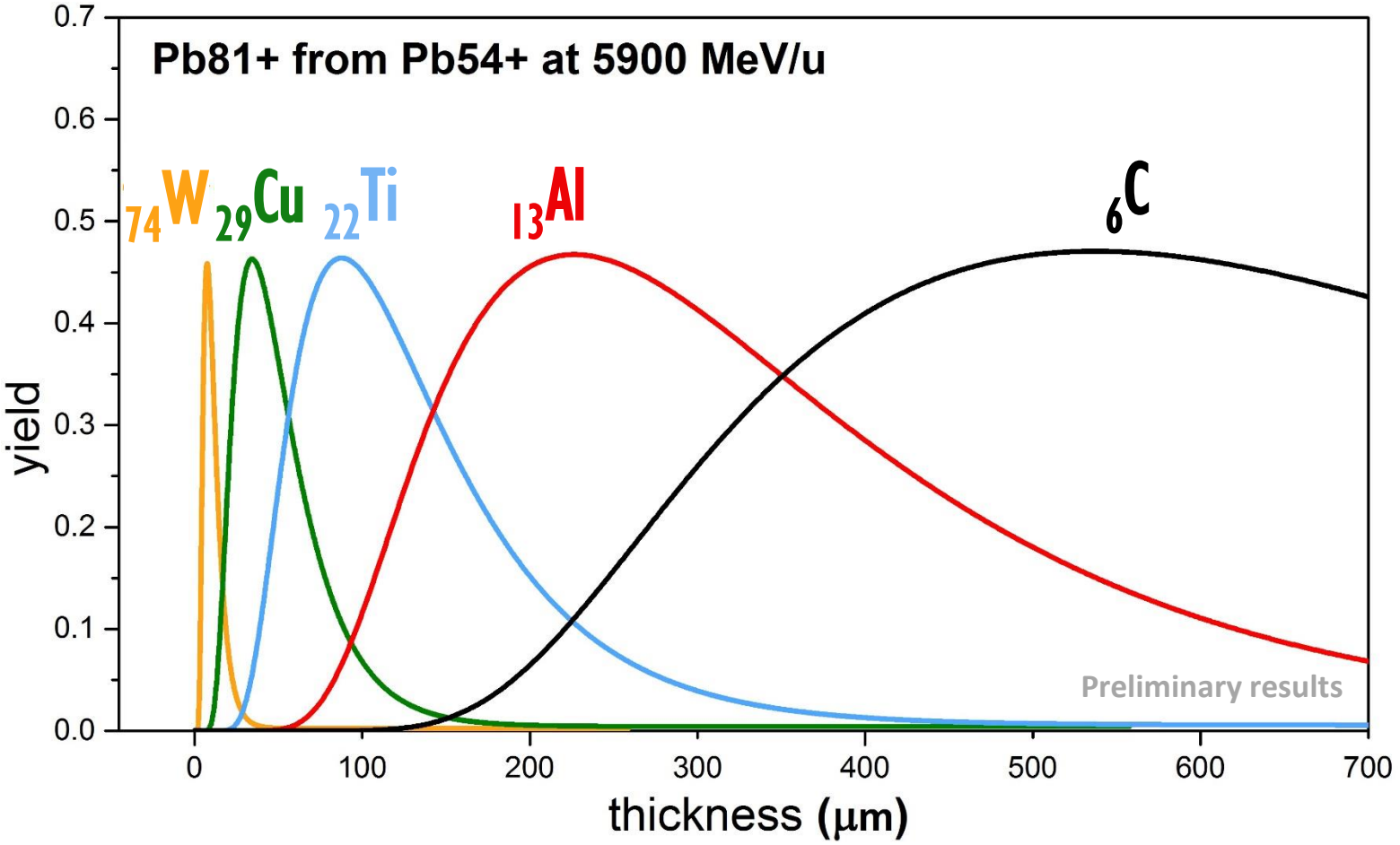
Energy loss



- **At higher energy E-loss and energy straggling are minimal**

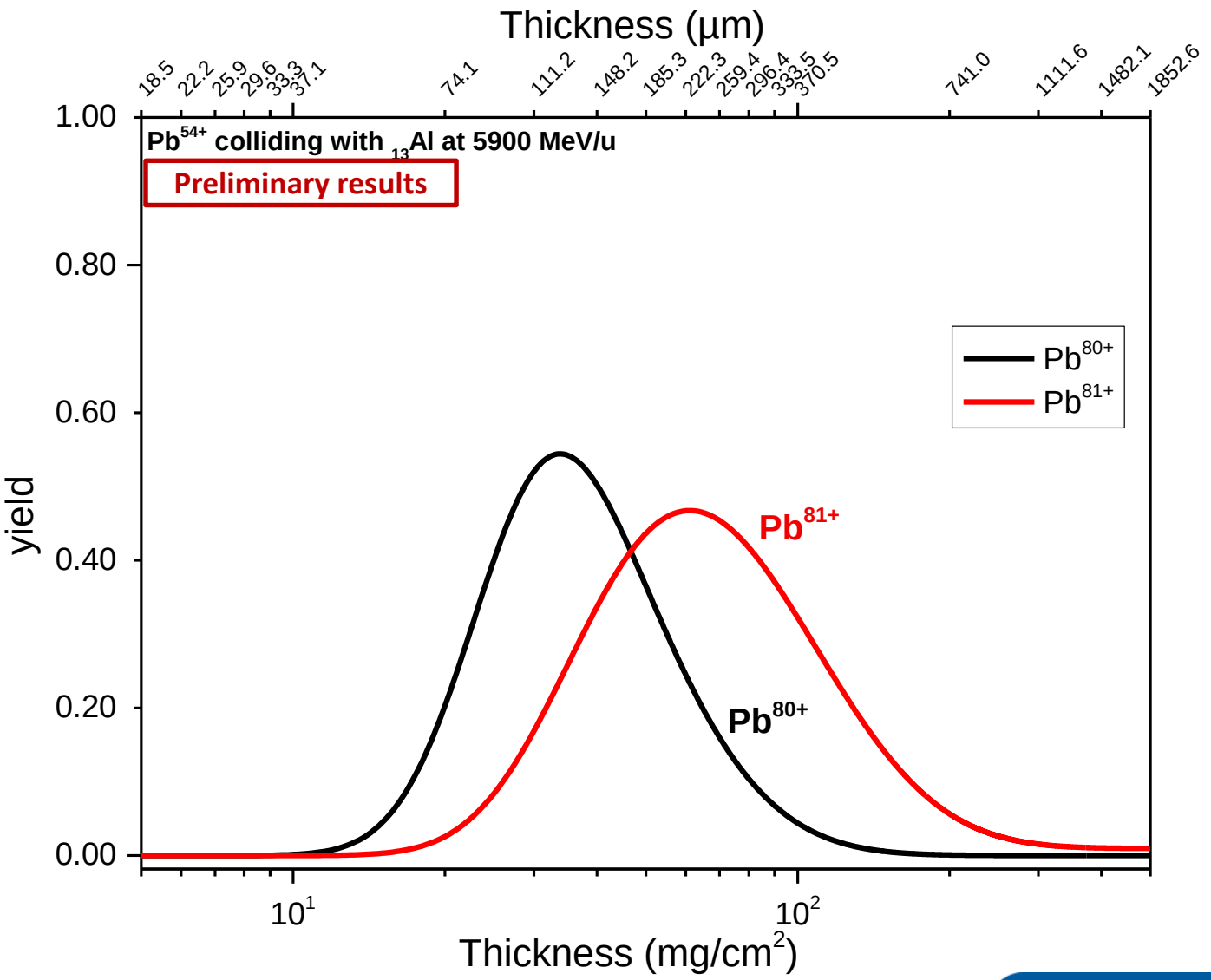
HI JENA
Helmholtz Institute Jena

Stripper foil material



HI JENA
Helmholtz Institute Jena

Stripper foil thickness



HI JENA
Helmholtz Institute Jena

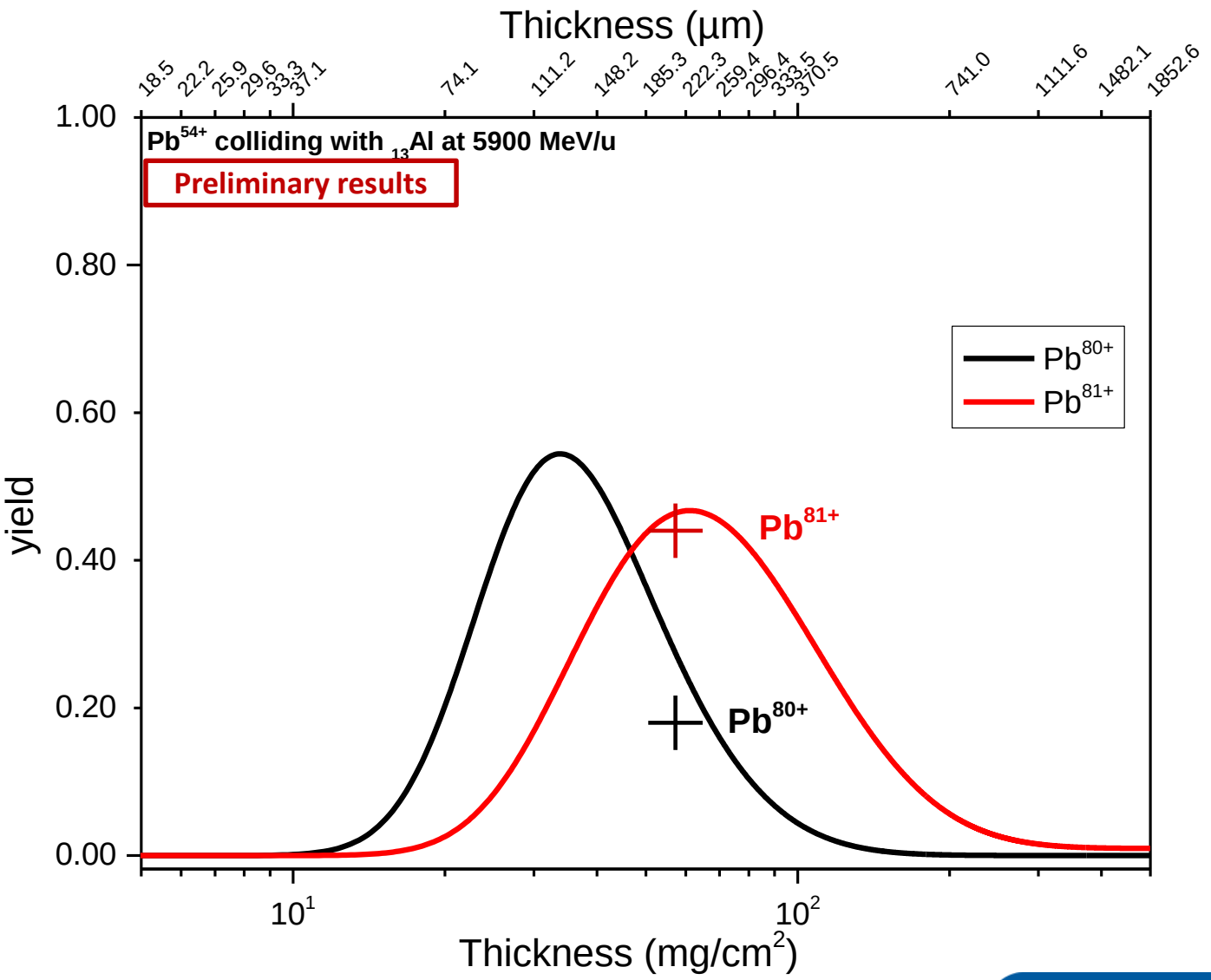
Proof-of-principle experiment

- **Testing $_{13}$Al at beam time in 2018**

Illustrations from: Picture from Witek Krasny and the Gamma Factory study group.

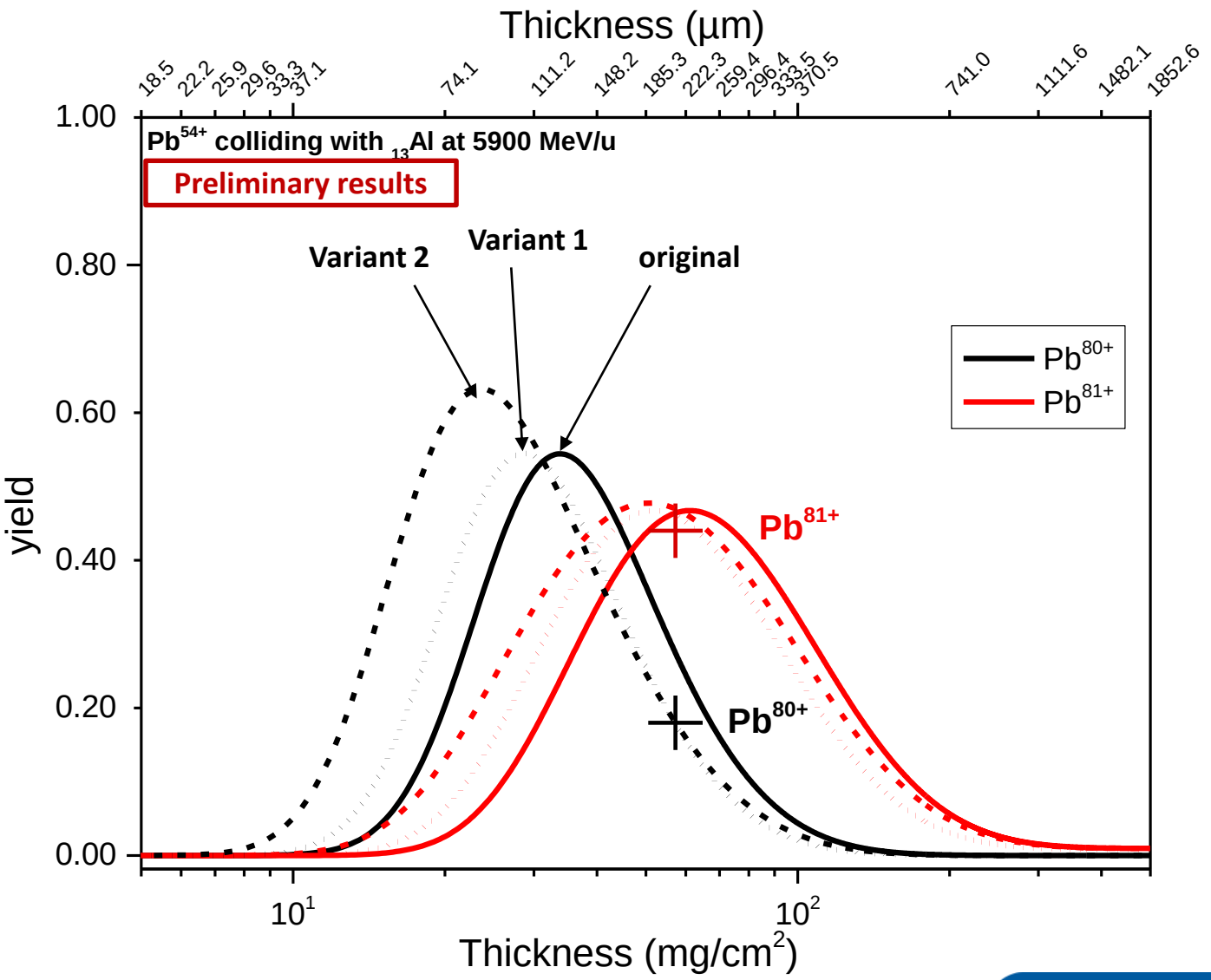
HI JENA
Helmholtz Institute Jena

Stripper foil thickness



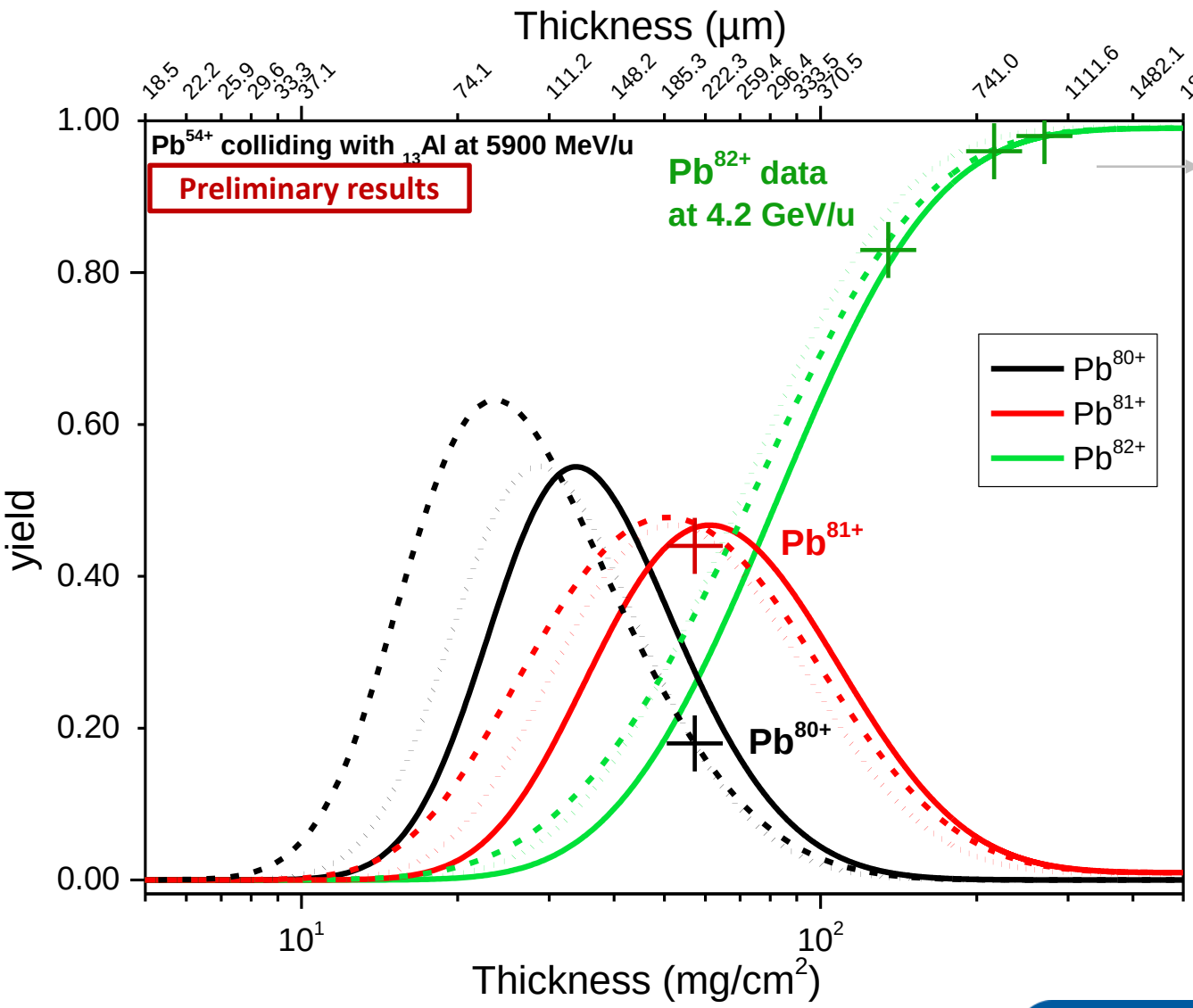
HI JENA
Helmholtz Institute Jena

Benchmarking



HI JENA
Helmholtz Institute Jena

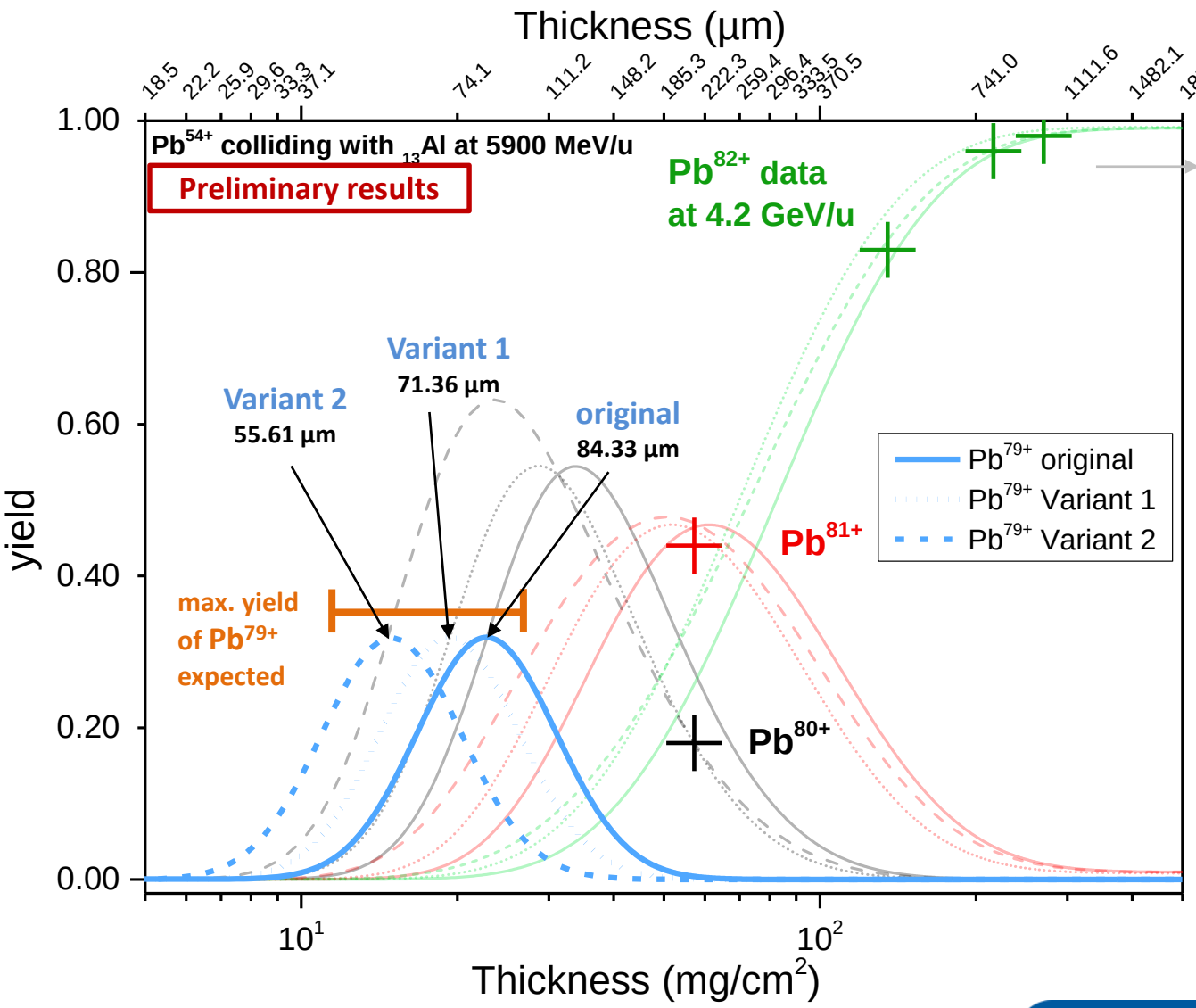
Benchmarking



G. Arduini et al., Proceedings of the 5th European Particle Accelerator Conference, 1996.

HI JENA
Helmholtz Institute Jena

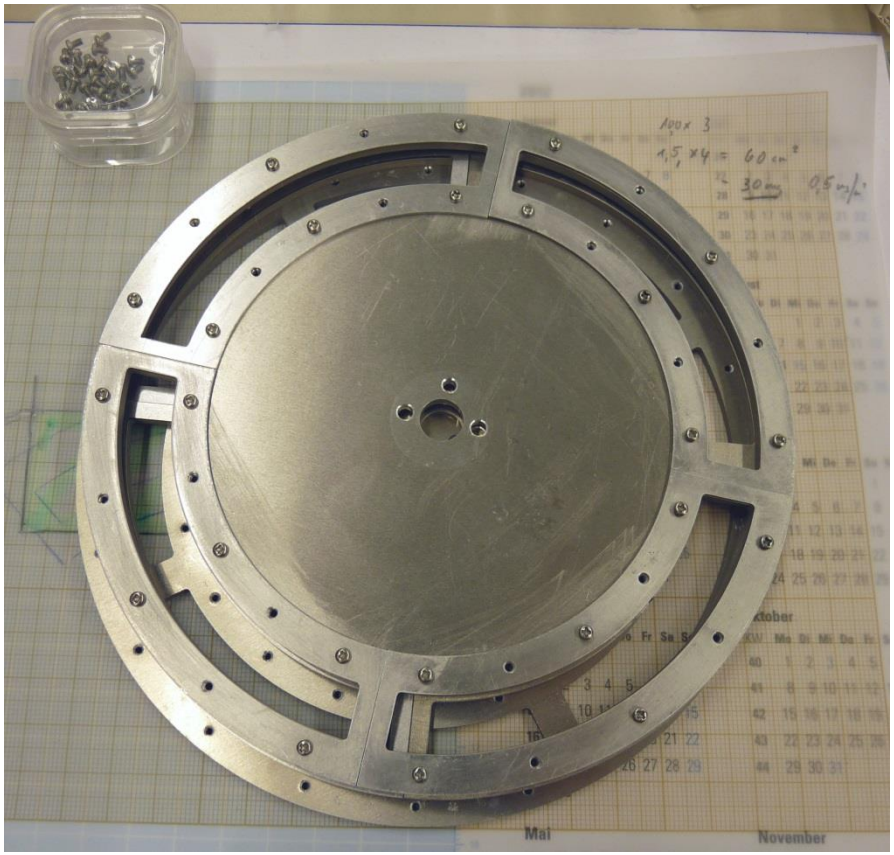
Predictions for Pb^{79+}



HI JENA
Helmholtz Institute Jena

Thickness probing

- Usually used : movable frame for multiple foils & rc manipulator



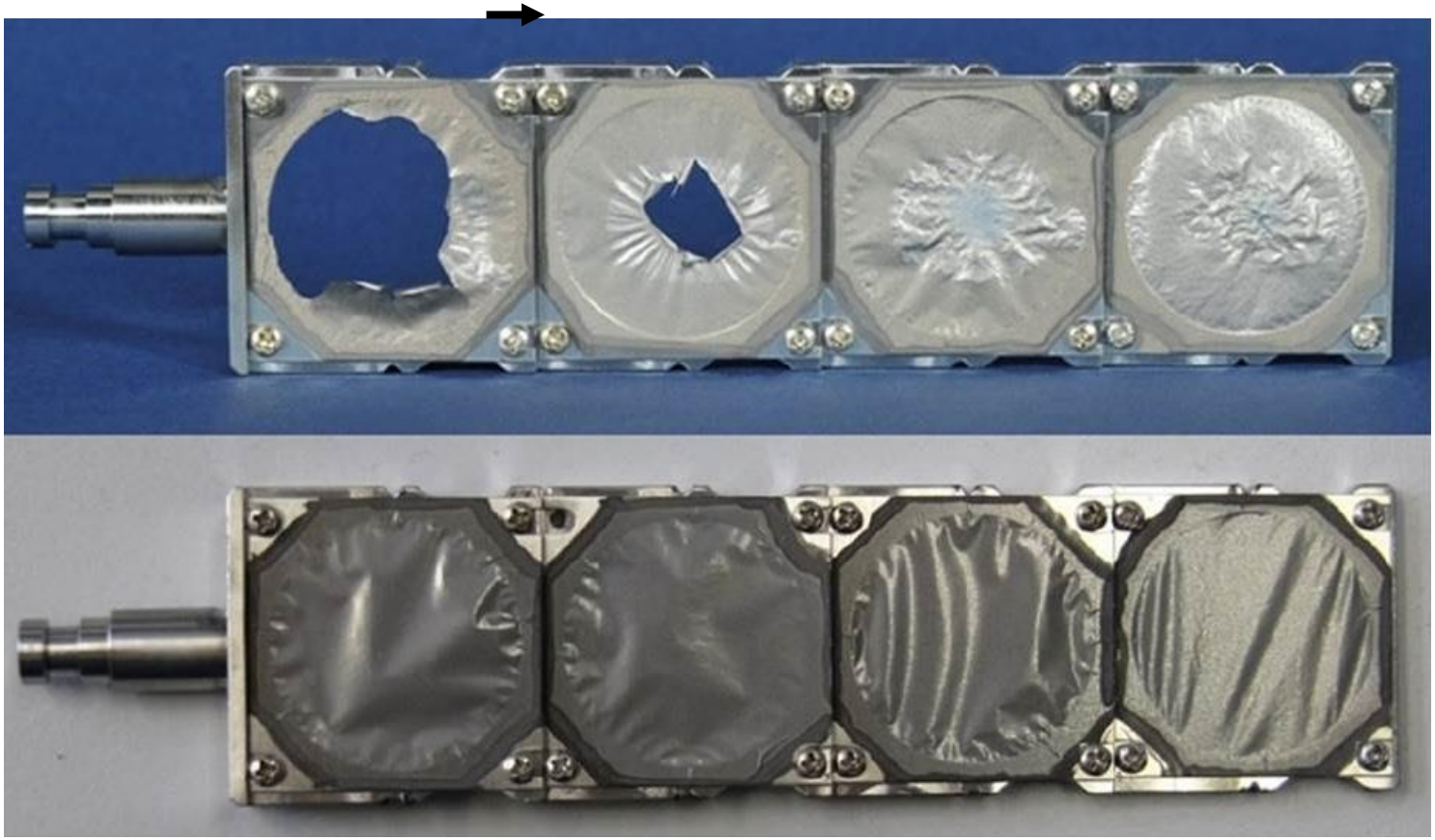
Empty target-wheel for 4 target foils.

Target-wheel for 3 target foils after stripping.

(illustrations: GSI/G. Otto)

HI JENA
Helmholtz Institute Jena

Thickness probing



Target-ladder with 4 different carbon stripper foils before and after use.

(Illustration: Barth, W., et al., "High Current U40+ Operation in the GSI UNILAC." LINAC2010, MOP044 (2010): 154.))

HI JENA
Helmholtz Institute Jena

Thank you for your attention!

HI JENA
Helmholtz Institute Jena