

Fragmentation Cross-section Measurements at FRS Using the Uranium Beam

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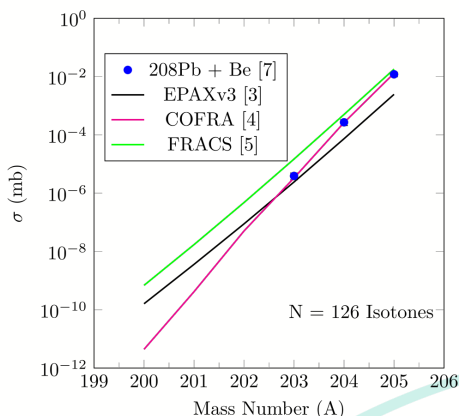
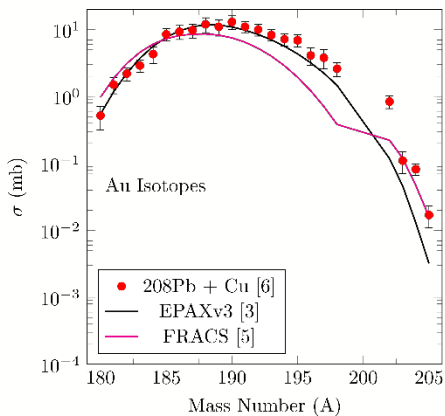
Based on the work done by J. Ahokas

Nordic Meeting on Nuclear Physics 2026, Visby
8 May 2026

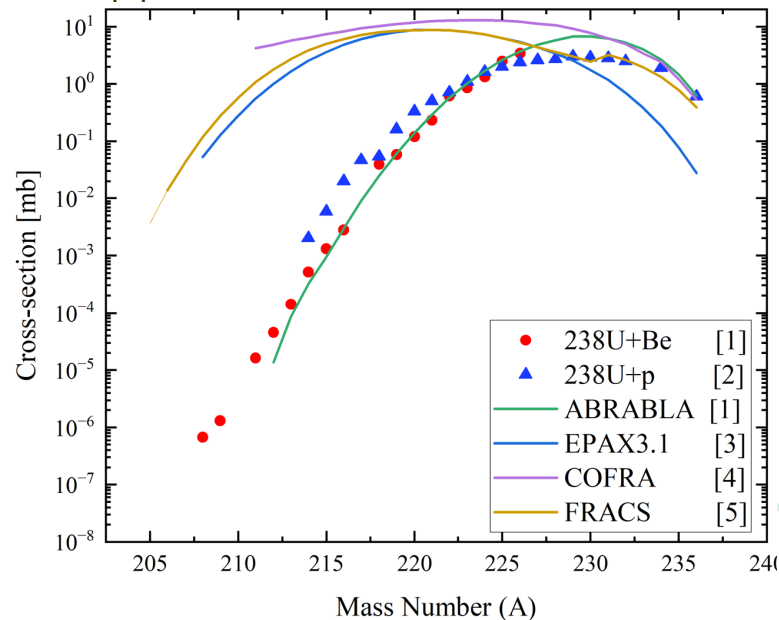


Motivation

- Lack of production cross-section data of new beams
- Different models give different cross-section predictions and are not all generally applicable
- Development and improvement of fragmentation models
- If data for production cross-section exist, it is only for a limited variety of beam and target combinations



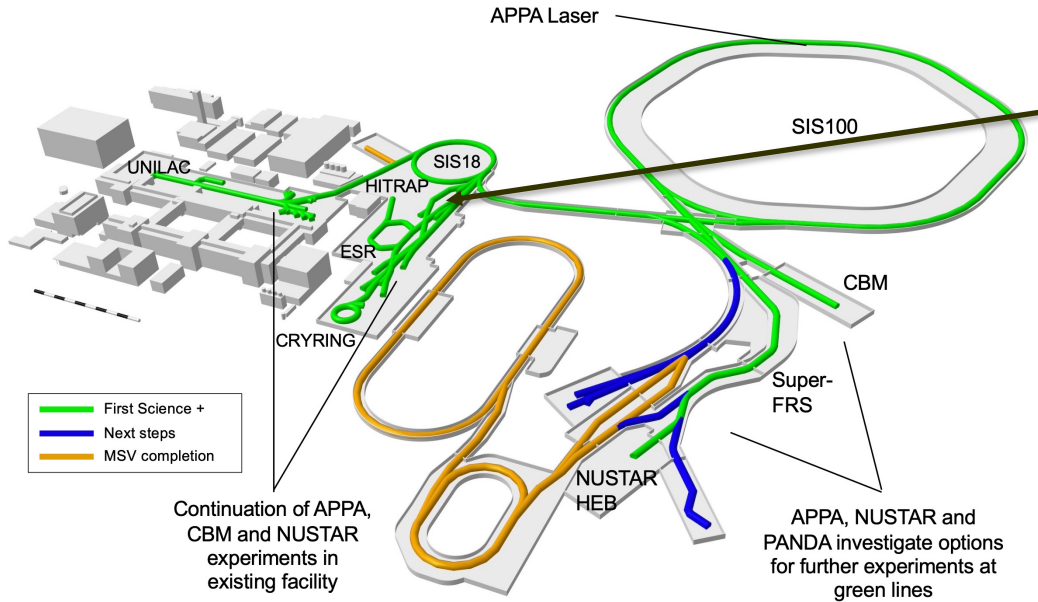
Cross-sections for production of the neutron deficient Th isotopes in the U+Be [1] and U+p [2] reactions at 1000 MeV/u



- [1] T. Kurcewicz *et al.*, Nucl. Phys. A 767 (2006) 1
- [2] J. Taïeb *et al.*, Nucl. Phys. A 724 (2003) 413
- [3] K. Sümmerer, Phys. Rev. C 86, (2012) 014601
- [4] J. Benlliure *et al.*, Nucl. Phys. A 660 (1999) 87
- [5] B. Mei, Phys. Rev. C 95, (2017) 034608
- [6] M. de Jong *et al.* Nucl. Phys. A 628 (1998) 479-492
- [7] T. Kurcewicz *et al.* Phys. Rev. C 89 (2014) 024616

Courtesy of S. K. Singh

GSI and FAIR

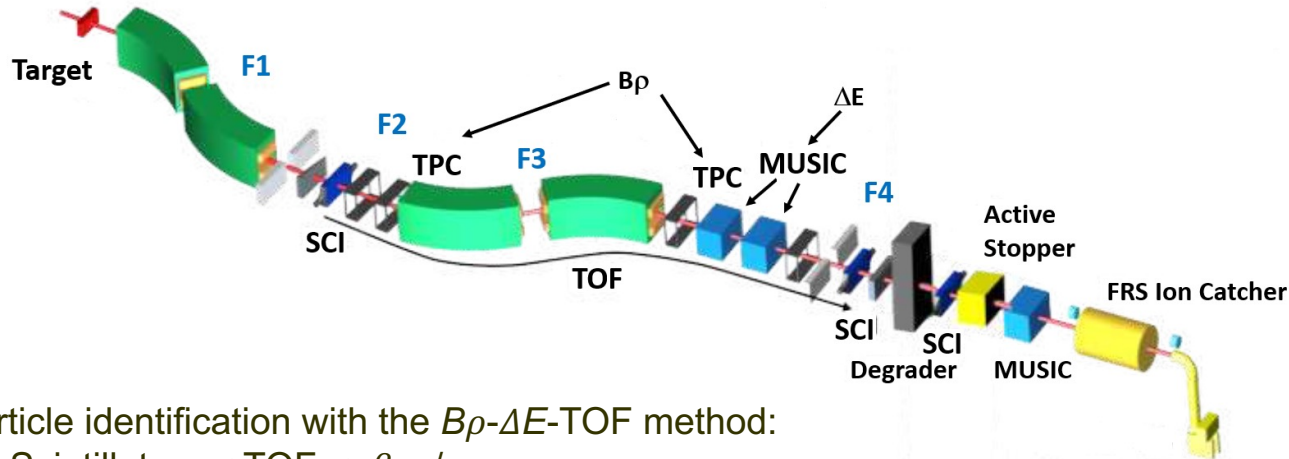


GSI Fragment Separator (FRS)

Beam delivered to FRS by the UNILAC linear accelerator and the SIS18 synchrotron.

Figure from FAIR RRBs

GSI and FAIR



Particle identification with the $B\rho$ - ΔE -TOF method:

- Scintillators \Rightarrow TOF $\Rightarrow \beta = v/c, \gamma$
- TPC + $\beta \Rightarrow A/Q$
- MUSIC $\Rightarrow \Delta E \Rightarrow Z$

\Leftrightarrow Talks by S. Pietri and A. Heinz

Experiment

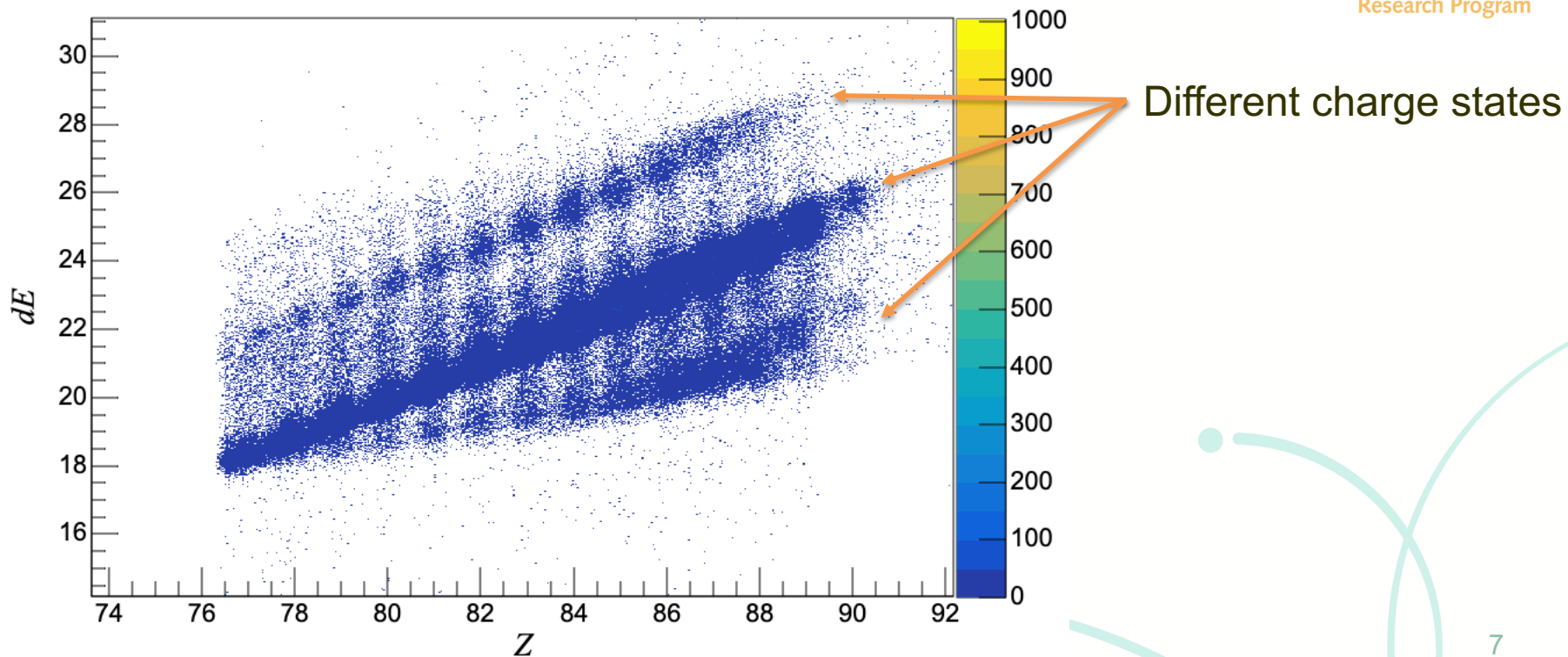
- 1.0 AGeV ^{238}U primary beam at $8.5 \cdot 10^8$ particles per spill
- 1032 mg/cm 2 ^9Be + 220 mg/cm 2 ^{93}Nb target
- Standard FRS detectors



- Datasets for ^{227}Ac , ^{225}Ac , ^{222}Ac , ^{219}Ac , ^{216}Ac , ^{213}Ac , ^{210}Ac , ^{207}Ac , ^{204}Ac , ^{201}Ac , and ^{198}Ac (11 FRS settings).
- **Six** shifts of beam time granted and ran in May 2024. A couple of accelerator failures \Rightarrow beam time (partially) compensated in June 2024

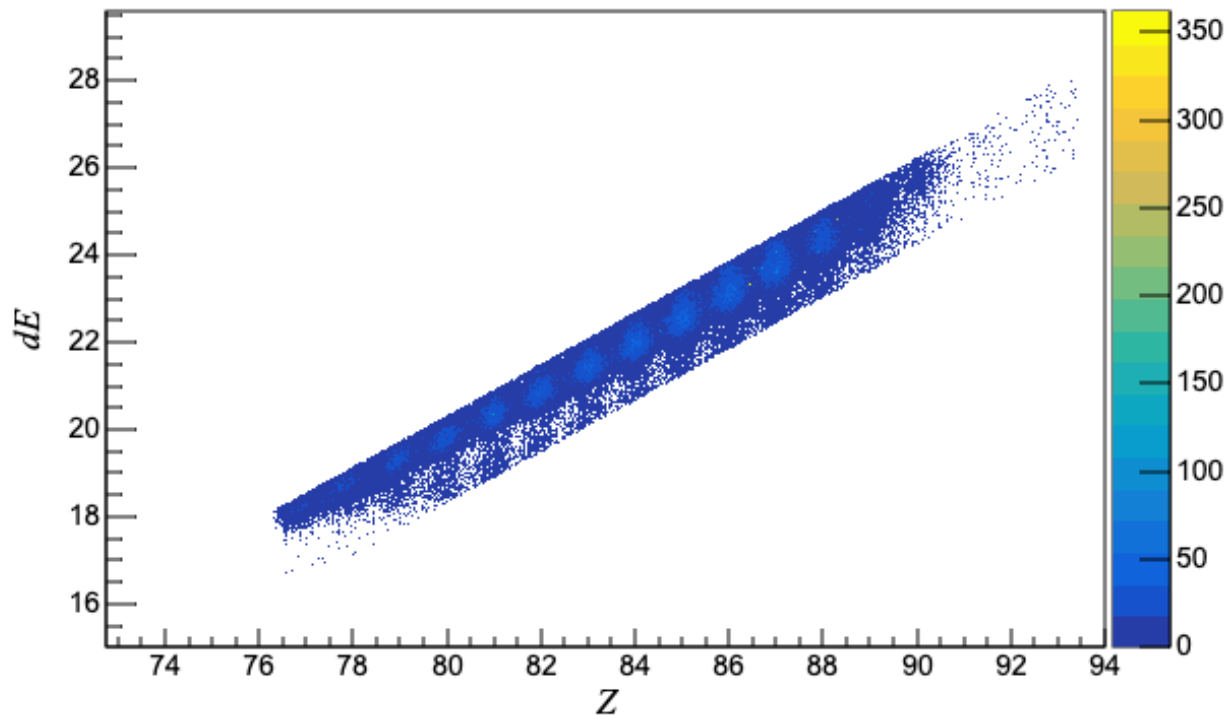
Charge states at final focal plane

FRS centered at ^{216}Ac , preliminary



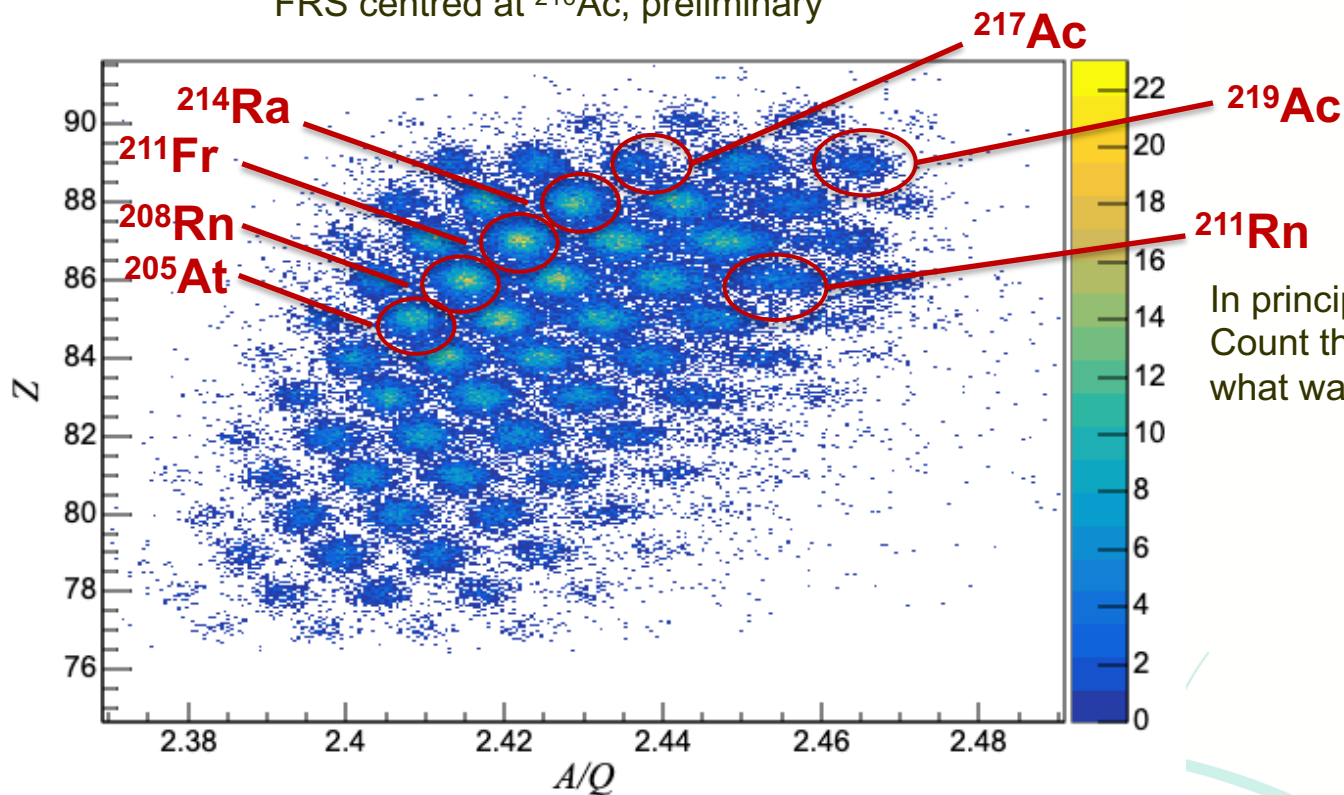
Charge states at final focal plane

FRS centered at ^{216}Ac , preliminary



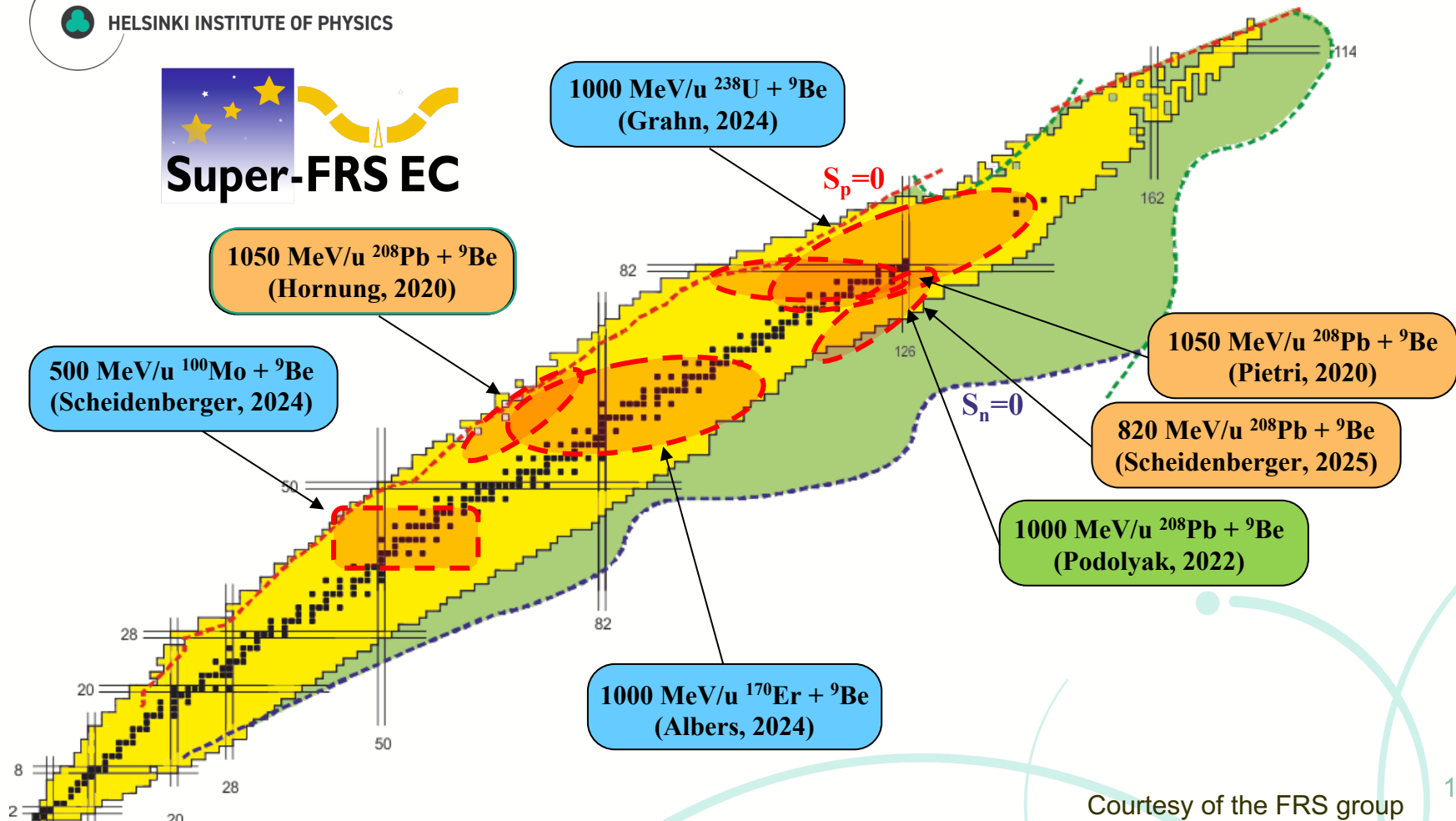
Particle identification (preliminary)

FRS centred at ^{216}Ac , preliminary



In principle, a simple procedure:
Count the event and compare
what was delivered on the target.

Cross-section Measurements at the FRS in FAIR Phase-0



Outlook

- Primary beam intensity → at SIS100 and Super-FRS this will be higher
- Lack of pre-separation → especially in heavy fragments the background is high → prevents to measure the low cross sections
→ Super-FRS should fix this issue
- One proposal (W primary beam) accepted at FRS, but after that Super-FRS should start
- These data often come `as a bonus` with other experiments



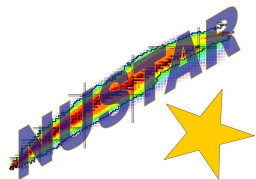
Super-FRS pre-target area, copyright: J. Hosan, GSI/FAIR

In collaboration:

- ✓ University of Warsaw
- ✓ University of Groningen
- ✓ Michigan State University
- ✓ IJCLAB CNRS
- ✓ ELI-NP
- ✓ Silesian University
- ✓ Chinese Academy of Sciences
- ✓ University of Jyväskylä
- ✓ Helsinki Institute of Physics
- ✓ GSI/FAIR
- ✓ JLU Giessen
- ✓ Super-FRS Experiment Collaboration



Thank you for your attention!



Obs! NUSTAR Week in Jyväskylä 29 Nov – 1 Oct 2026. Save the date!