Simulations of transfer reactions at HIE-ISOLDE

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SAFE
Senter for Akseleratorbasert Forskning og Energifysikk

ISOLDE CERN

INTRODUCTION

Higher energy – new opportunities

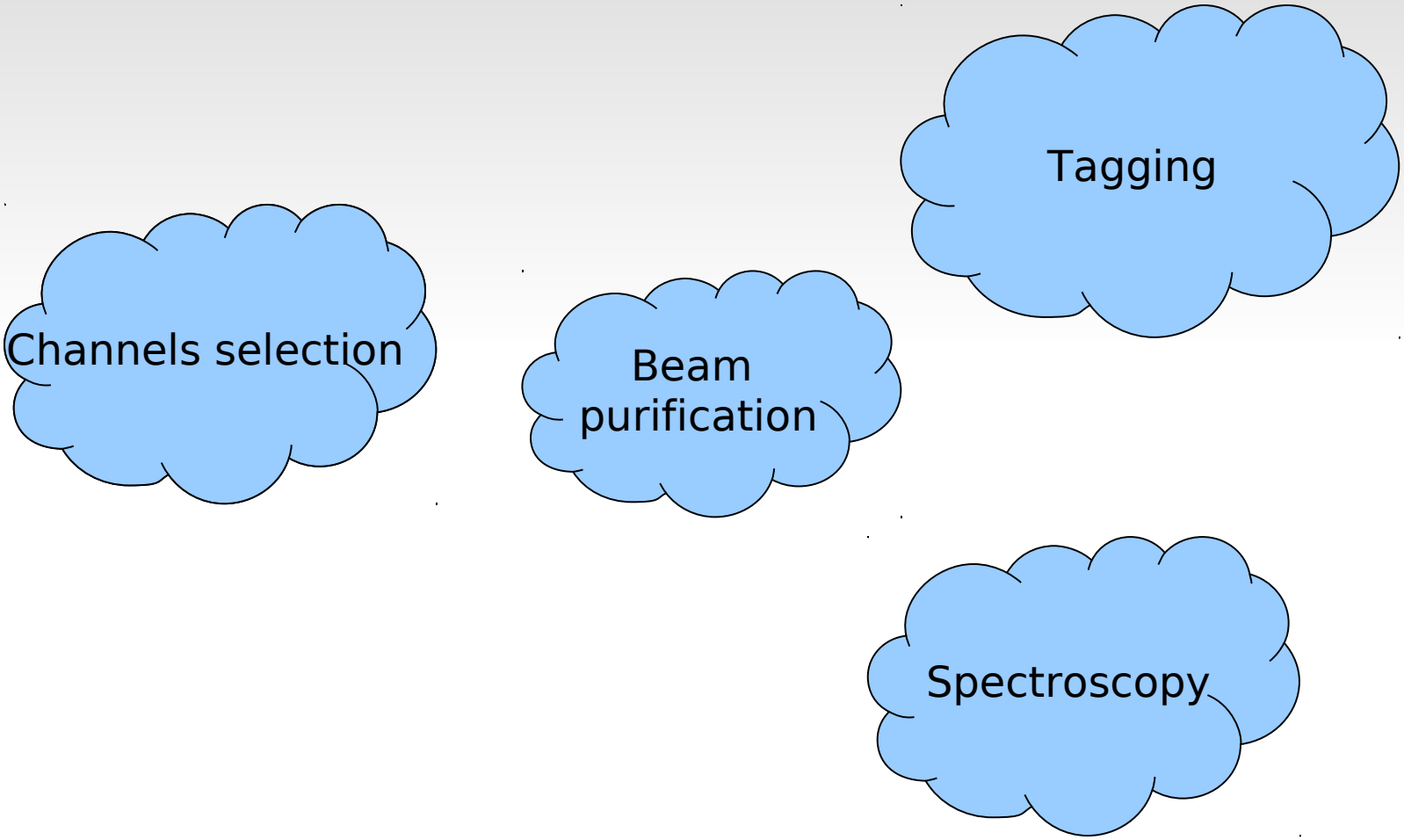
- A wide variety of direct reactions such as (d,n) and (d,p)
- Deep inelastic scattering and multinucleon transfer reactions
- Fusion-evaporation

Higher energy – new opportunities

- Direct reactions (inverse kinematics): Small scattering angles for the heavy product.

- Deep inelastic:
  Large distribution in both angle and momentum. Maximum cross section at the grazing angle (typically 50-70 degrees).

Higher energy – new instrumentation?



What can we learn?

From one-nucleon transfer reactions such as (d,p) and (d,n):

- Low excited states / single particle character
- Spin of states
- Indirect method for (n,g) and (p,g) reactions

In-depth studies of existing technology

SPECTROMETER TYPES

Existing technologies

Raytracing spectrometer

- Ions are tracked in order to identify the ions
- Aberrations are corrected for in software during data analysis
- Large solid ange, up to 80 msr
- Flexible devices

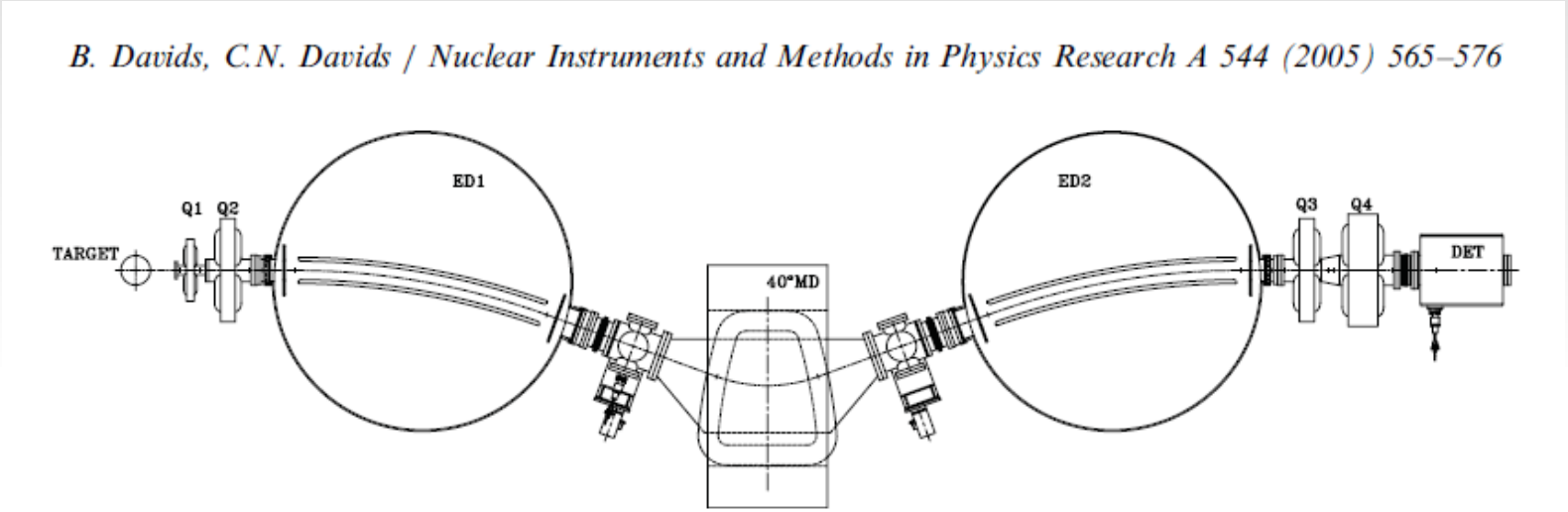
Mass separator

- Ion identification depends on position at the focal plane
- Aberrations are corrected for using hardware
- Can achieve high precision (at the cost of solid angle)
- Simple data analysis

Some examples of spectrometers

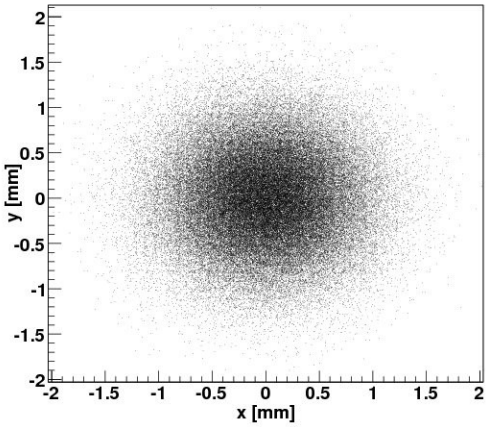
- FMA@Argonne NL: mass separator
- RITU@JYFL: gass filled mass separator
- VAMOS@Ganil: Multi-mode raytracing spectromerer
- PRISMA@LNL: Magnetic raytracing spectrometer

EMMA
under construction@TRIUMF

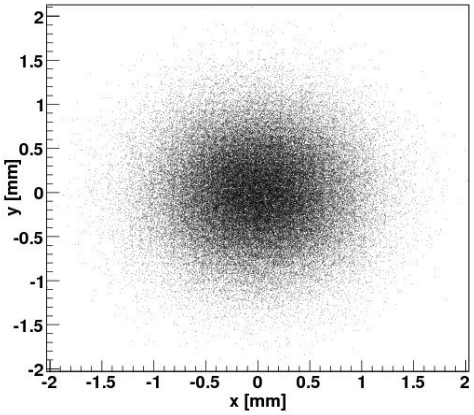


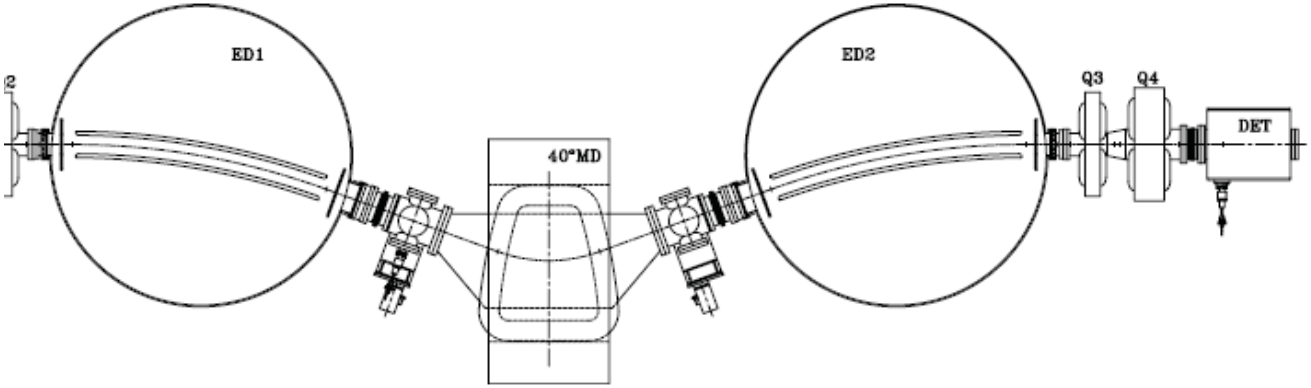
Similar design to FMA@Argonne
Covers 16 msr
Length to focal plane: 9.0 m

EMMA@TRIUM



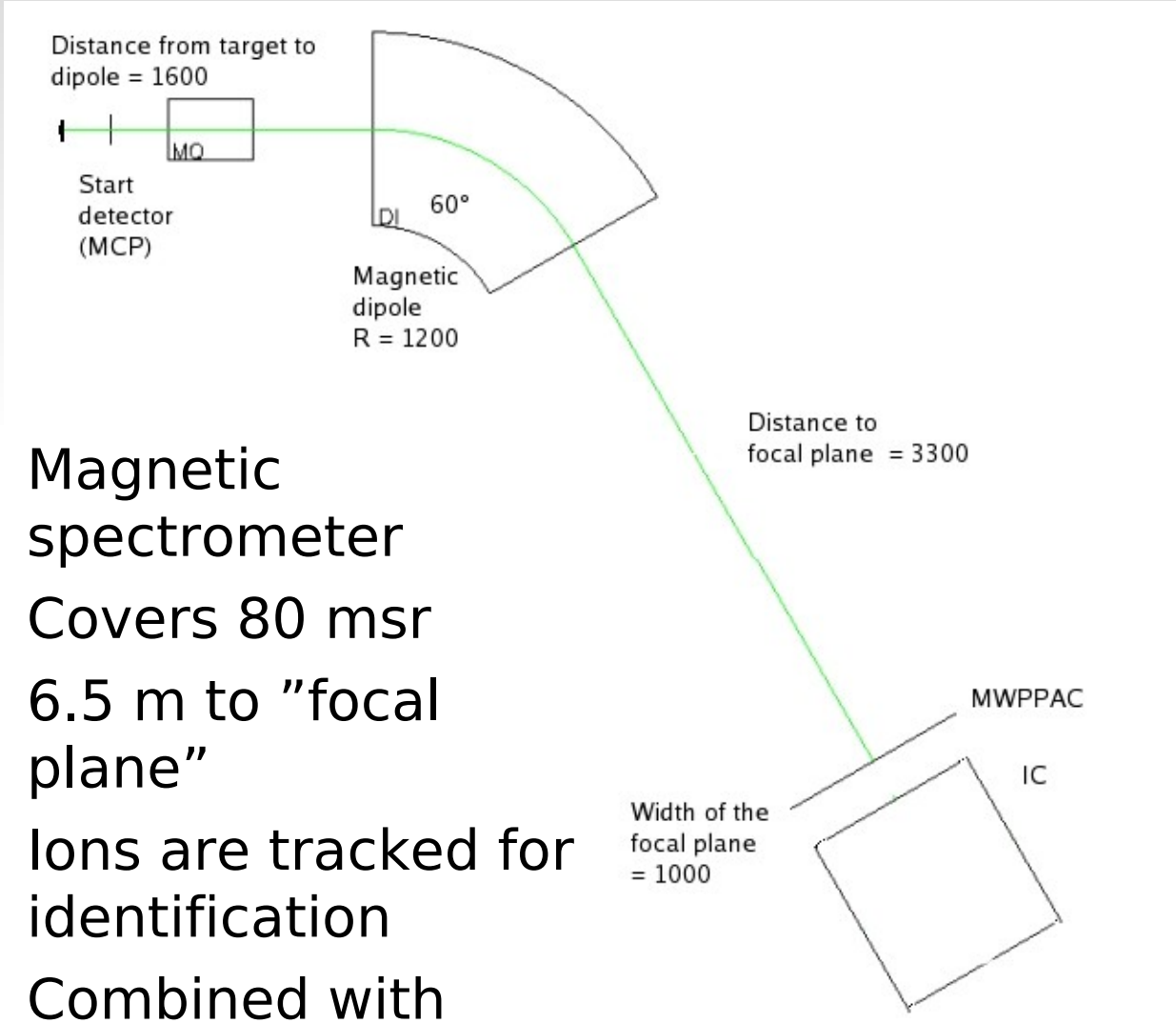
B. Davids, C.N. Davids / Nuclear Instruments and Methods in Physics





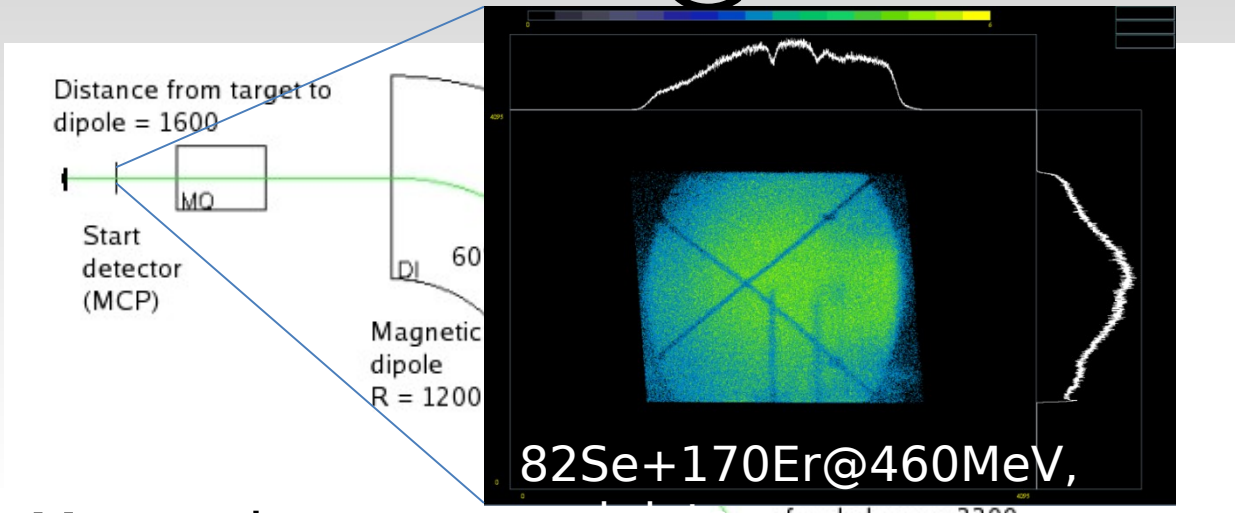
Dispersion at the focal plane ~ A/q
Focusing effect for angle and energy

PRISMA@LNL



- Magnetic spectrometer
- Covers 80 msr
- 6.5 m to ”focal plane”
- Ions are tracked for identification
- Combined with gamma-detectors

PRISMA@LNL



x, y, t

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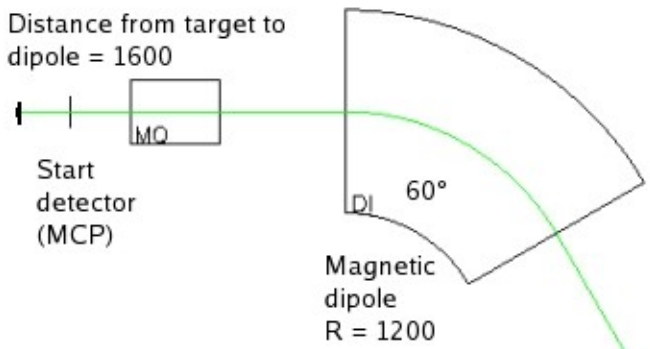
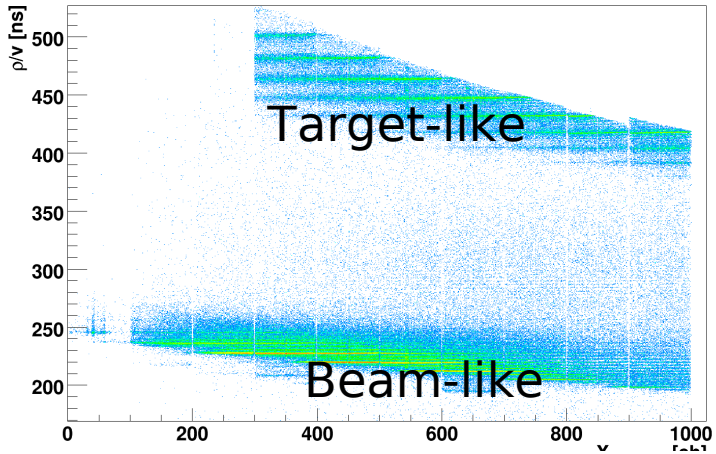
PRISMA@LNL





x-position

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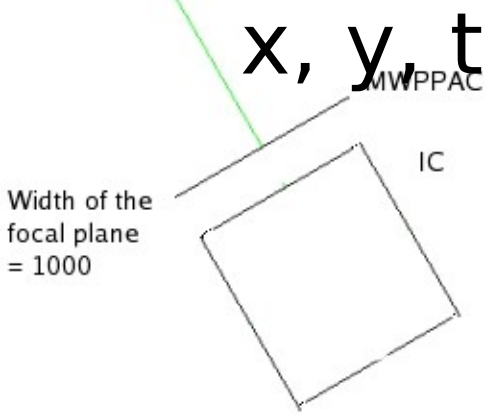
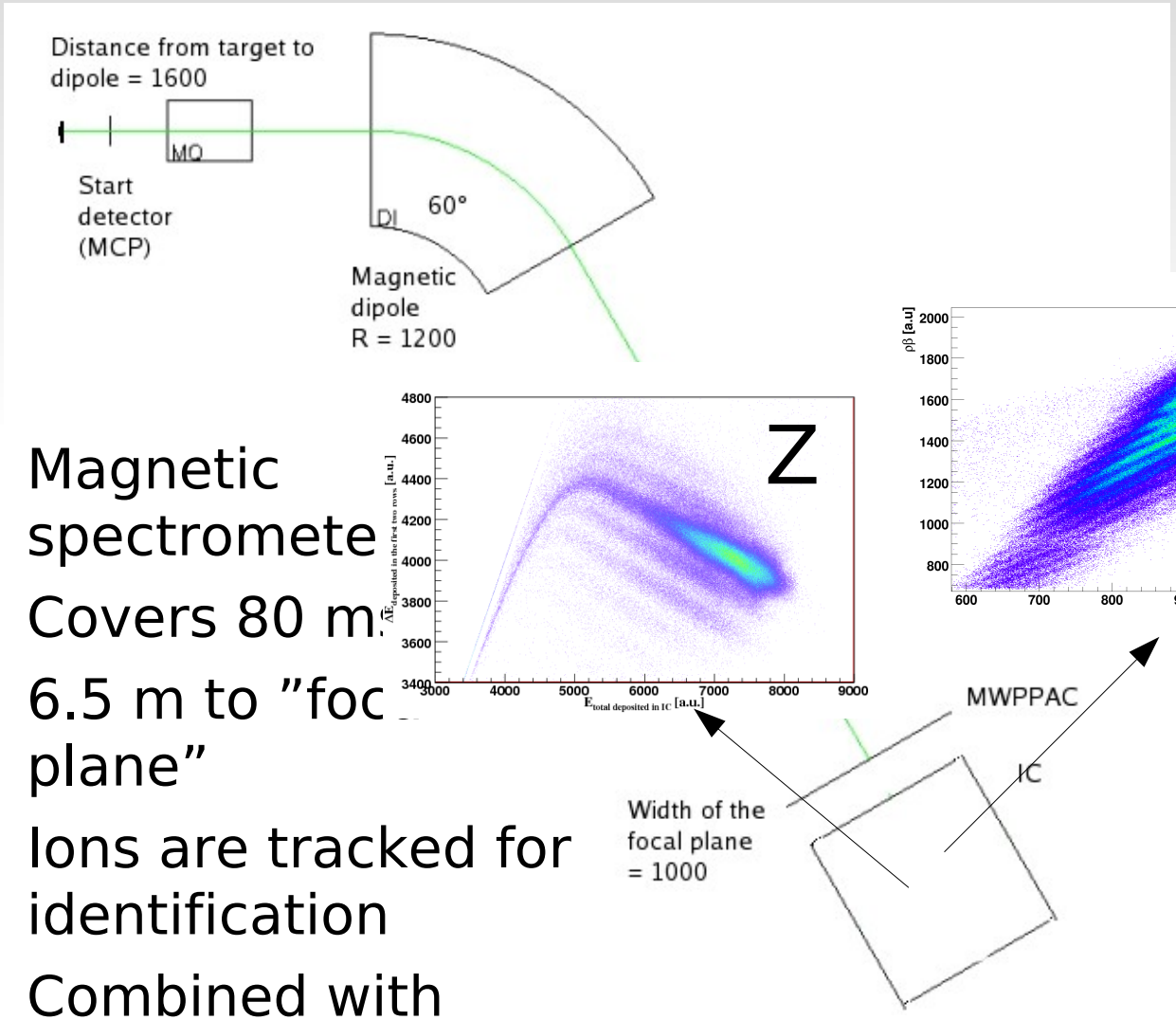


PRISMA@LNL



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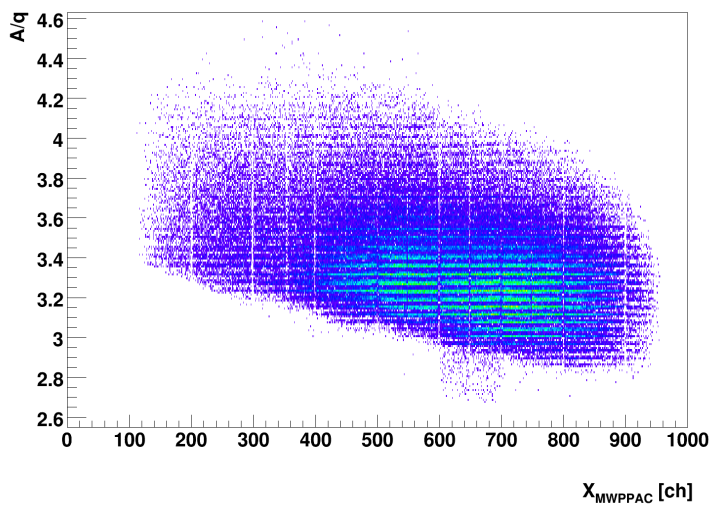
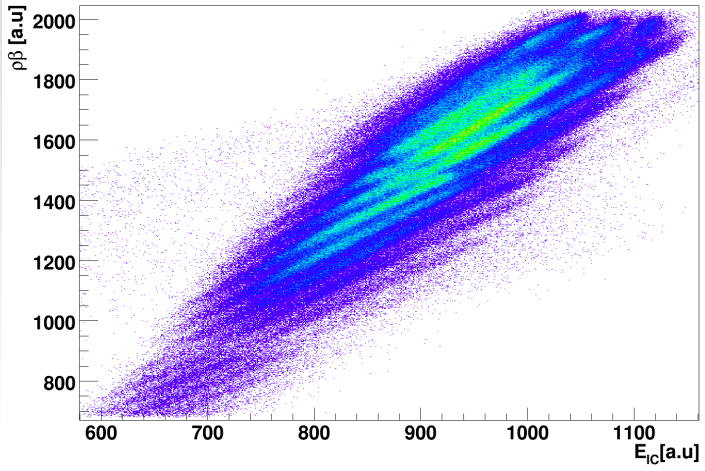
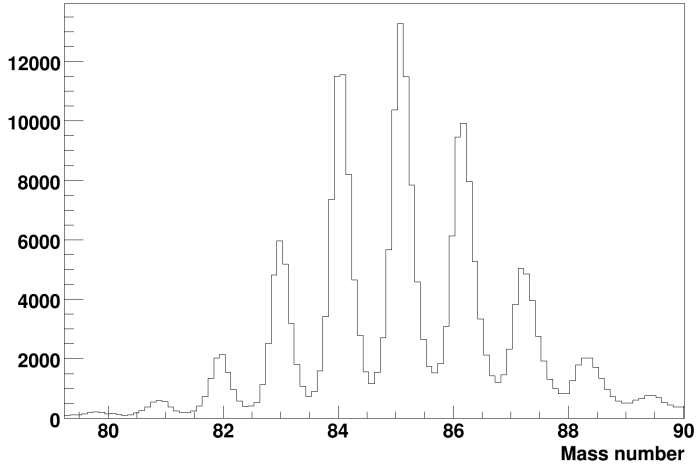




- Combine A/q and q information for the ion to obtain a mass spectrum



Simulations for EMMA- and PRISMA-like ion-optical layouts

SIMULATIONS

Simulation tools

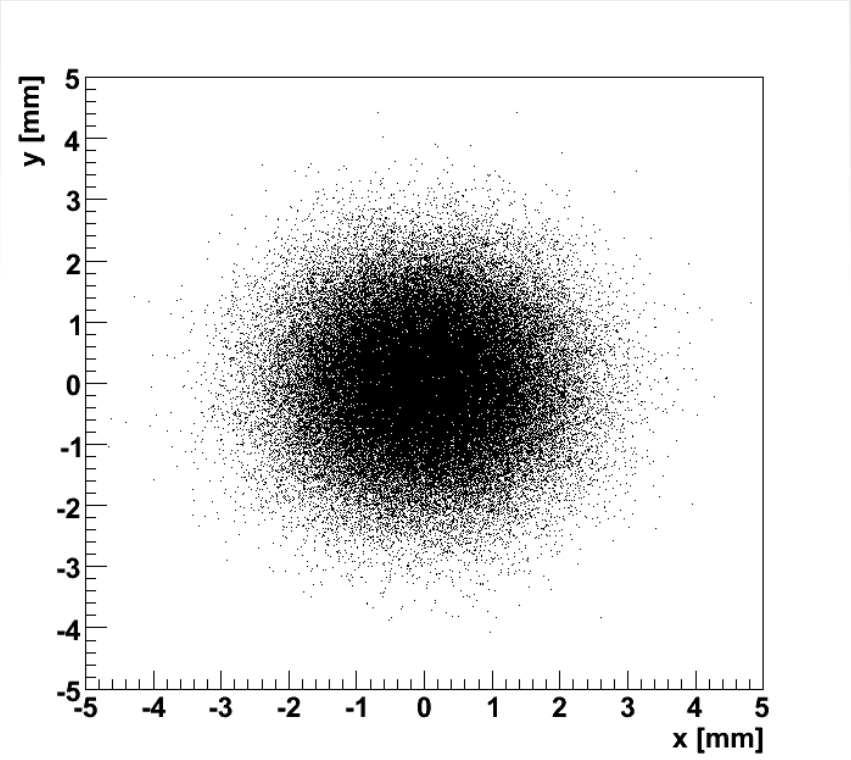
- COSY infinity 9.0 (ion optics)
- SRIM (interaction with matter)
- GEANT4
- LISE++ (q-state distribution by Schwietz)
- ROOT

Test cases

- 9Li(d,n)10Be
- 22Mg(d,n)23Al
- 68Cu(d,p)69Ni
- 132Sn(d,p)133Sn

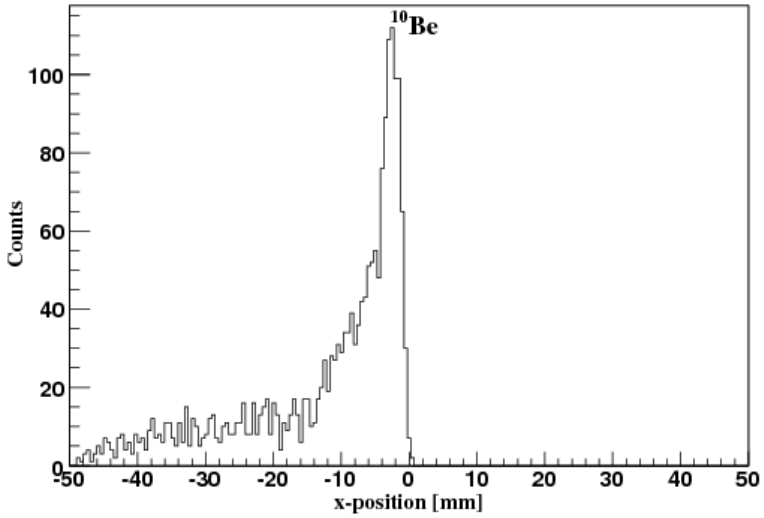
Input to the simulations

- 90% of particles within a radius of 2 mm
- 6 mmπmrad
- 0.5% energy spread of beam
- Additional energy straggling simulated using SRIM or GEANT4

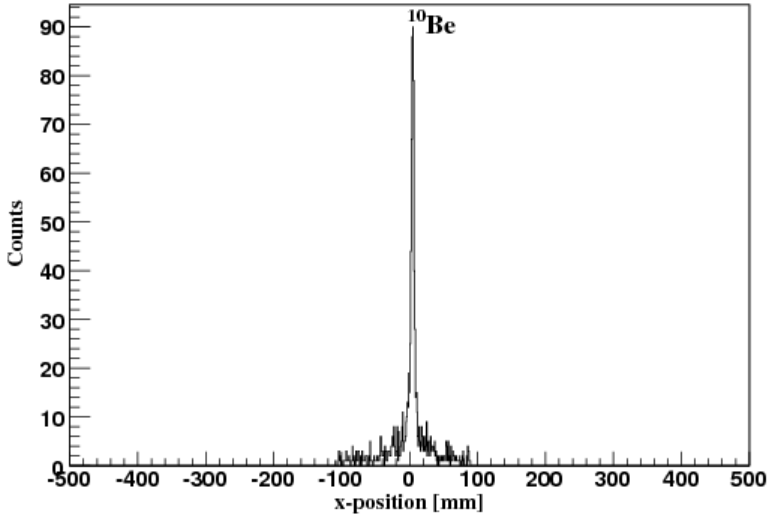


9Li(d,n)10Be

With EMMA-like layout



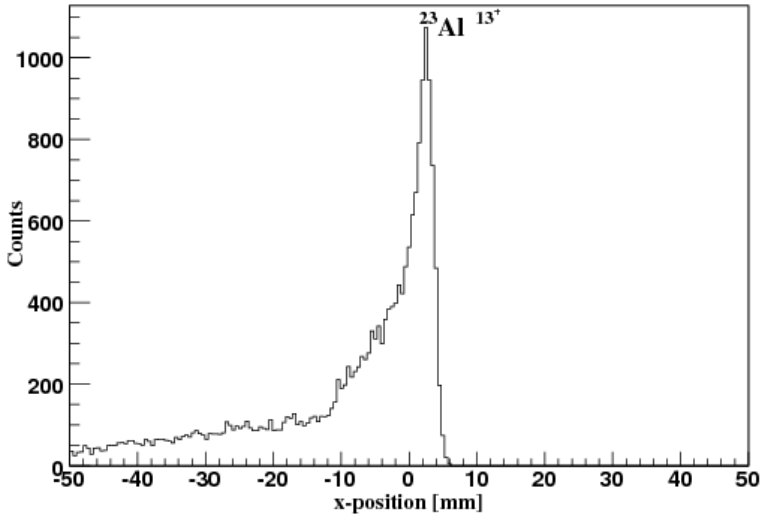
With PRISMA-like layout



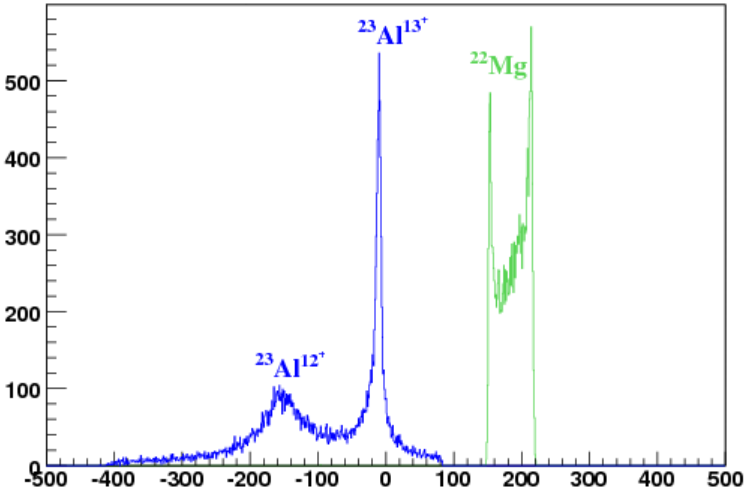
Fully stripped reaction product even at 5 MeV/u

22Mg(d,n)23Al

EMMA-like layout



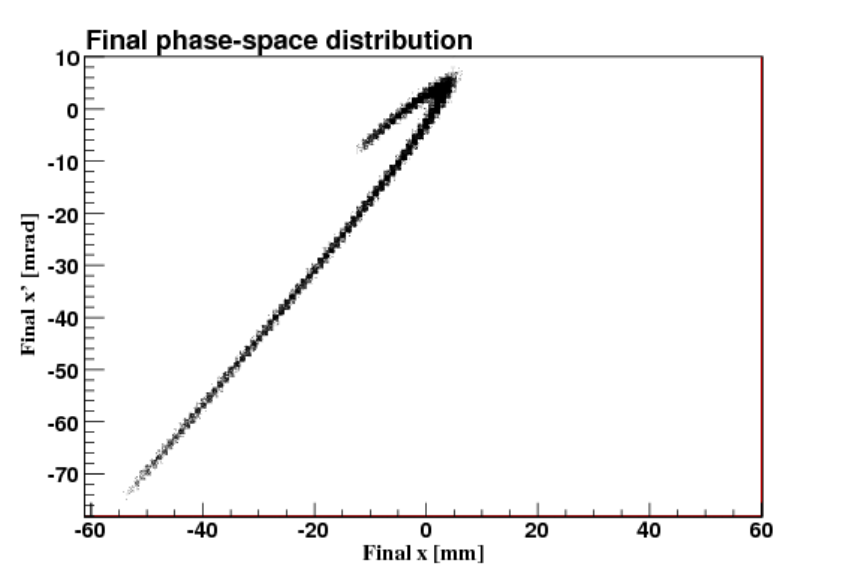
PRISMA-like layout



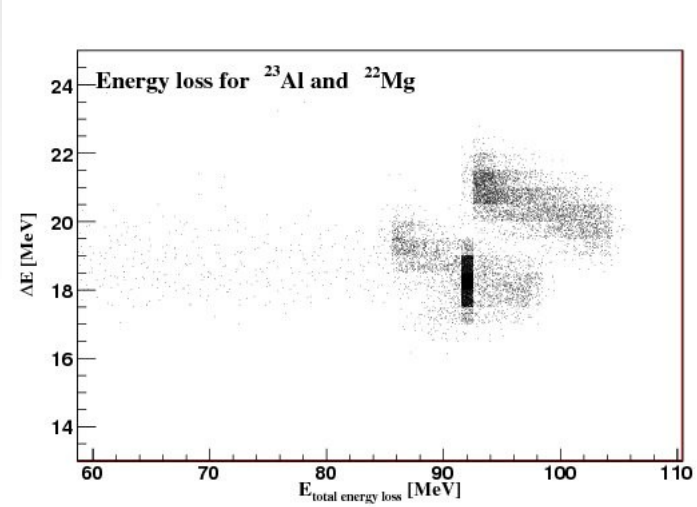
Typically two charge states in this mass region

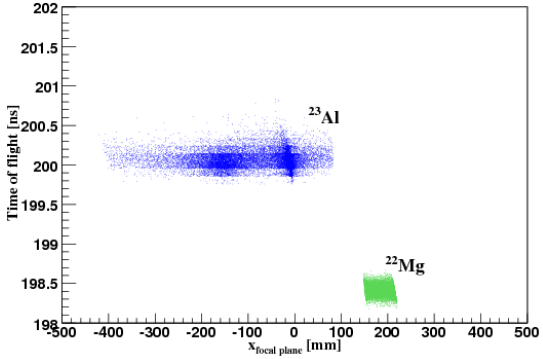
22Mg(d,n)23Al

EMMA-like layout



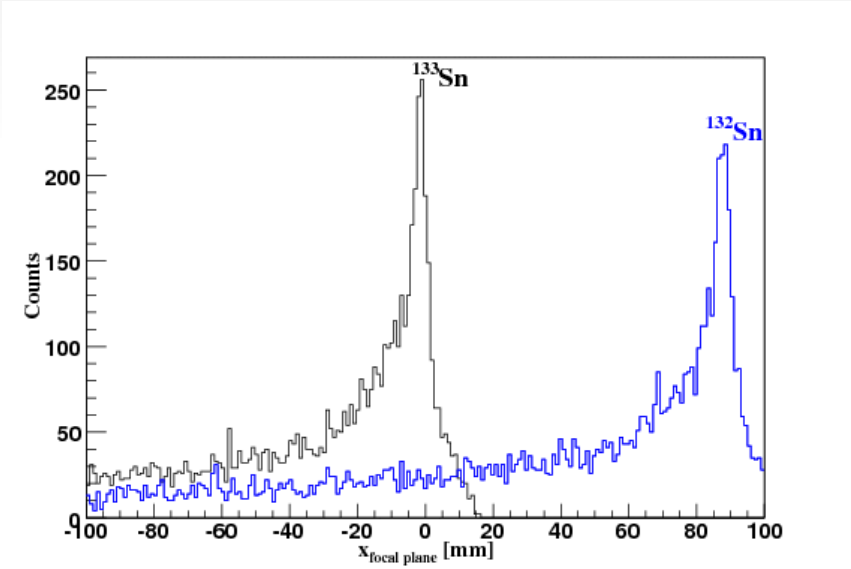
PRISMA-like layout





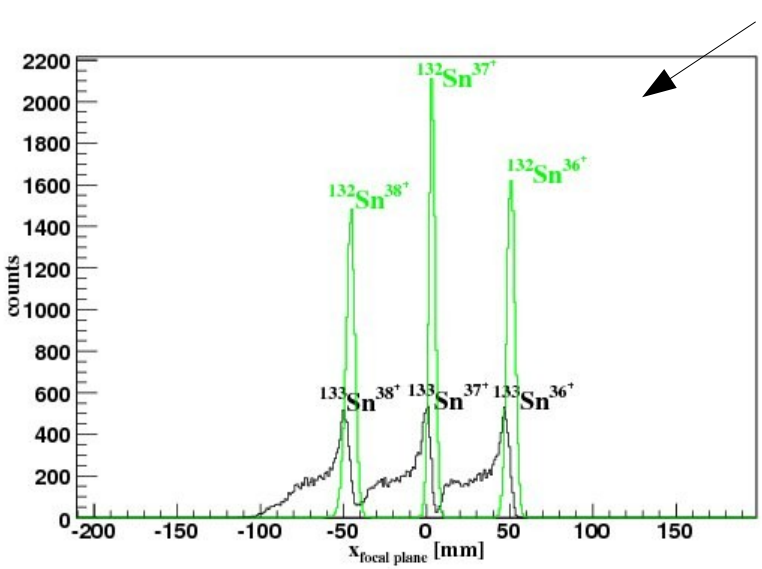
132Sn(d,p)133Sn

EMMA-like layout



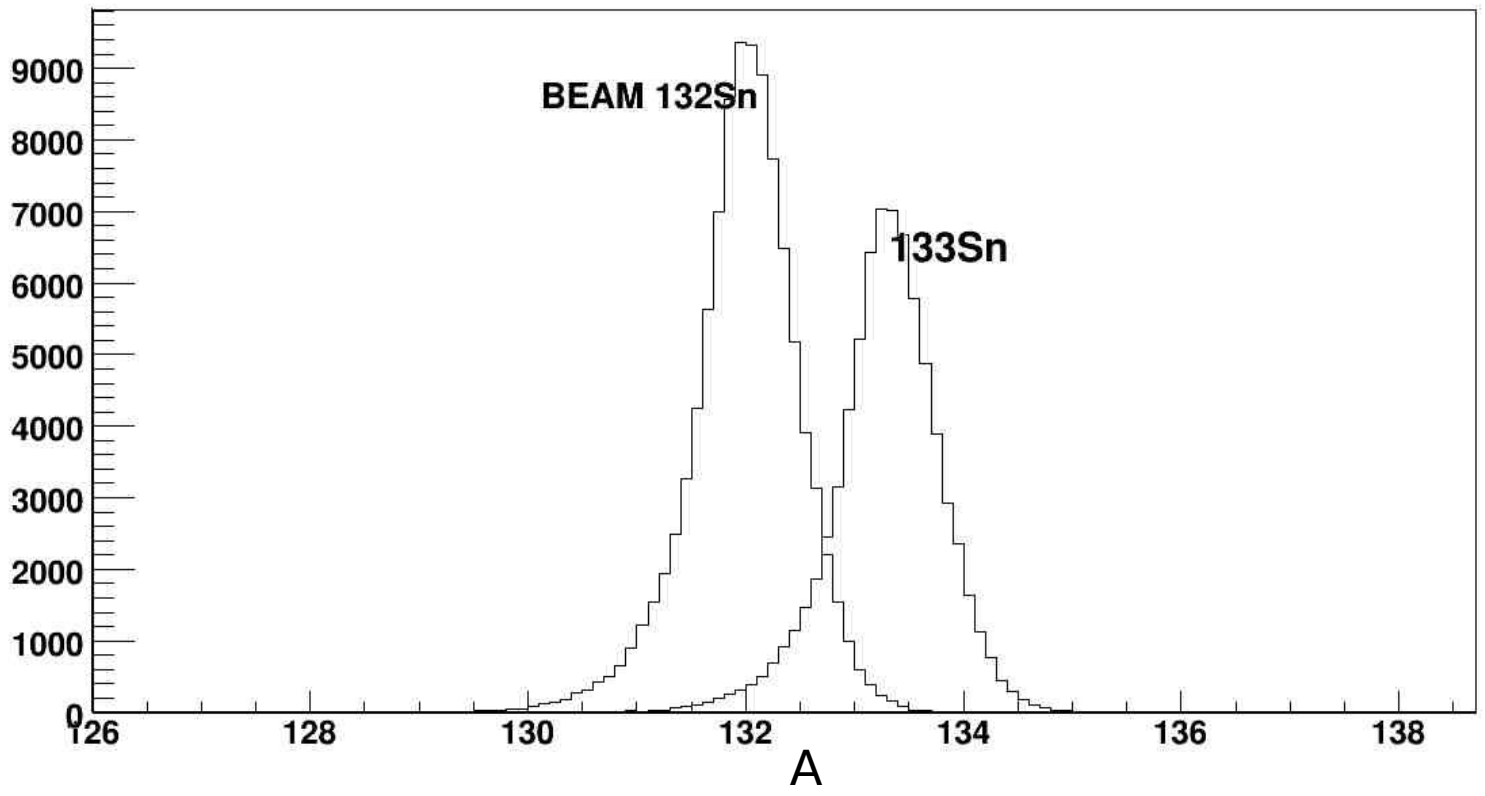
PRISMA-like layout

Before tracking!



About 5-6 charge states in this mass region

132Sn(d,p)133Sn, PRISMA-like



After tracking procedure

Transmission of reaction product

	EMMA-like layout	PRISMA-like layout
9Li(d,n)10Be	4%	58%
22Mg(d,n)23Al	8%	88%
68Cu(d,p)69Ni	33%	92%
132Sn(d,p)133Sn	38%	96%

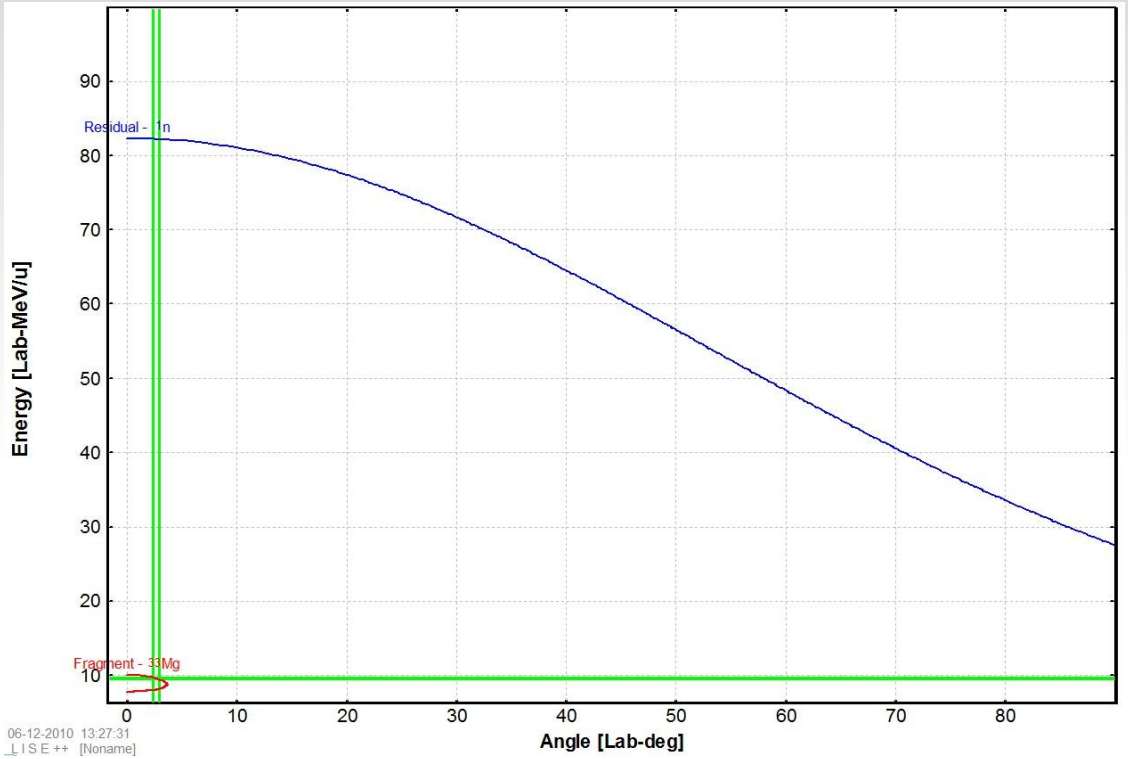
Outlook

- Simulate a greater number of reactions and estimate yields
- Simulate deep inelastic reactions with neutron-rich beams
- Finish writing report that summarizes my simulation work
- Workshop in Lund for everyone interested in a HIE-ISOLDE spectrometer
  (HIE-ISOLDE LOI: INTC-I-113)

Thank you for your attention

- Questions?

Inverse kinematics



Small exit angels!