Spectroscopy and fission studies in inverse kinematics: ^{208}Pb + ^{9}Be with AGATA and PRISMA

Filippo Angelini

Università degli Studi di Padova

INFN - LNL

Young GAMMAs Workshop

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Overview

+ Physics cases
+ Performed experiment
+ Functioning of PRISMA
+ Status of PRISMA analysis
+ Outlooks and conclusions

Physics case : Evolution of N = 50 shell gap

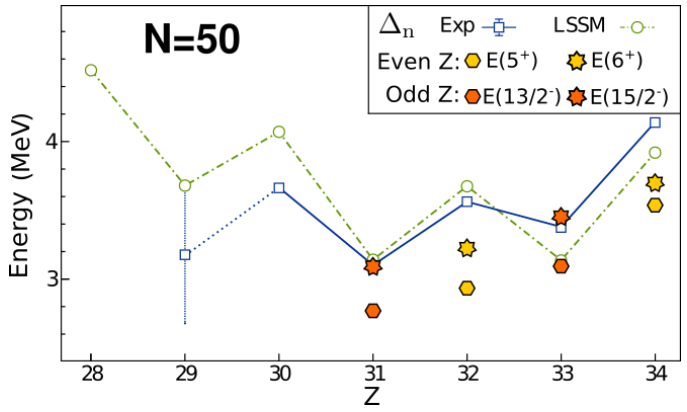
Decrease in the N=50 energy gap towards ^{78}Ni: compatible behaviour with **two different methods**

1. Mass measurements: decrease of gap up to ^{81}Ga
   Re-increase measured for ^{80}Zn

S. Baruah et al., Phys. Rev. Lett. 101, 262501 (2008)
J. Hakala et al., Phys. Rev. Lett. 101, 052502 (2008)

$$\Delta n = BE(Z,N=51)+BE(Z,N=49)-2\cdot BE(Z,N=50)$$ **Mass gap**

2. "Spectroscopic" gap estimated from energy of lowest core-breaking neutron excitations in N=50 isotones



J. Dudouet et al, Phys. Rev. C 100, 011301(R) (2019)
T. Rzaca-Urban et al., Phys. Rev. C76, 027302 (2007)

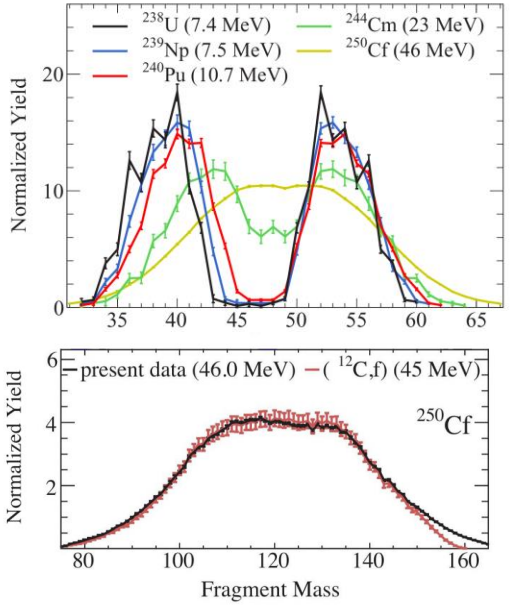
$5^+,6^+,7^+$ states in even Z, $13/2^-$, $15/2^-$ in odd Z

In ^{80}Zn J≥5 cannot be reached only by valence protons

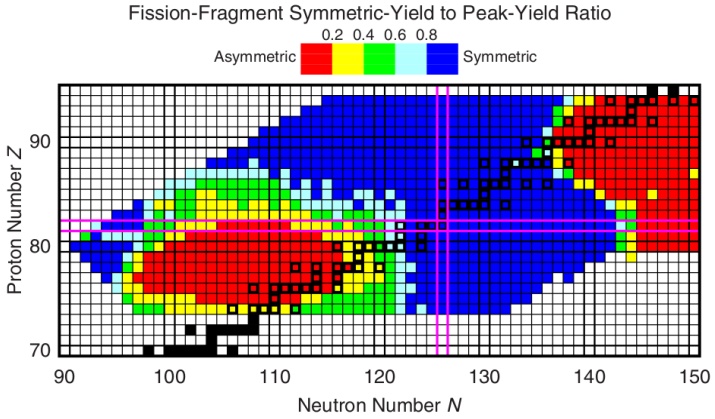
→ 1p-1h neutron excitations

Spectroscopy of ^{80}Zn
Fission populates medium-high spins

Physics case: Fission studies



D. Ramos et al., Phys. Rev. C 97, 054612 (2018)



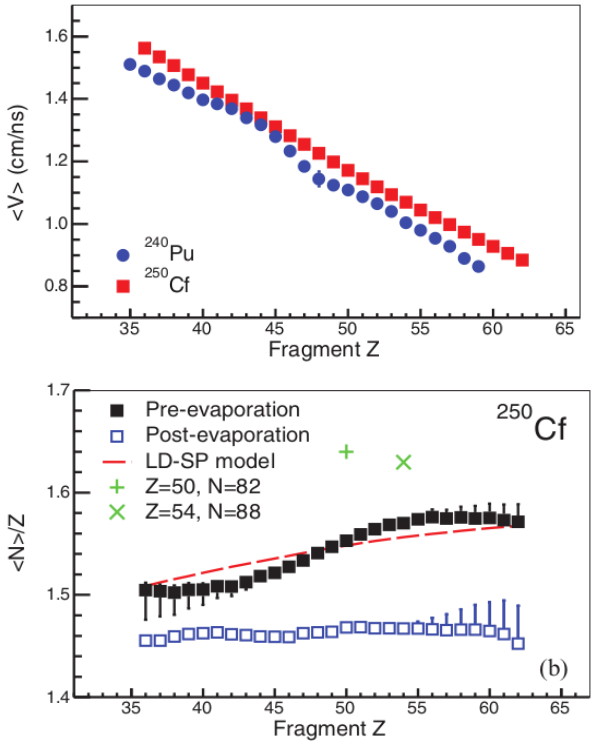
P. Möller and J. Randrup, Phys. Rev. C 91, 044316 (2015)

Inverse kinematics allows the study of kinematic fission observables: yields, velocity distributions, N/Z

Fission fragment structure affects the scission and formation of the final system

^{217}Rn: **symmetric** fission is expected

Shell effects should be smaller, but no study was done on the influence of shell effects in this area

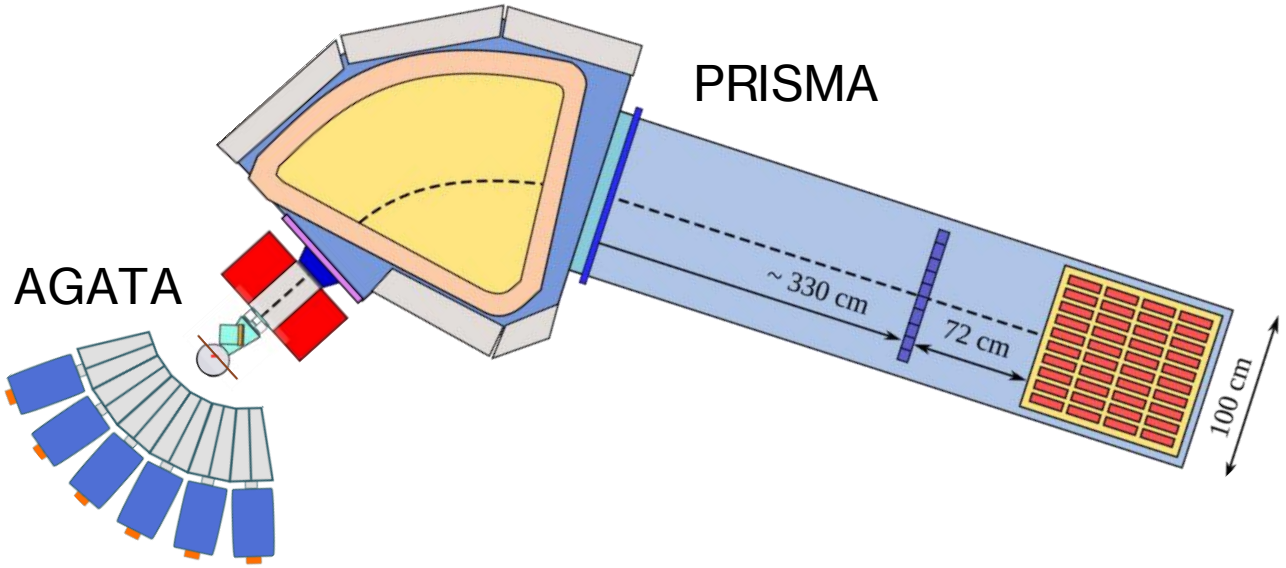


M. Caamaño et al., Phys. Rev. C 92, 034606 (2015)

Study of fission mechanism

AGATA + PRISMA experiment at LNL

Exp. 22.23, december 2022



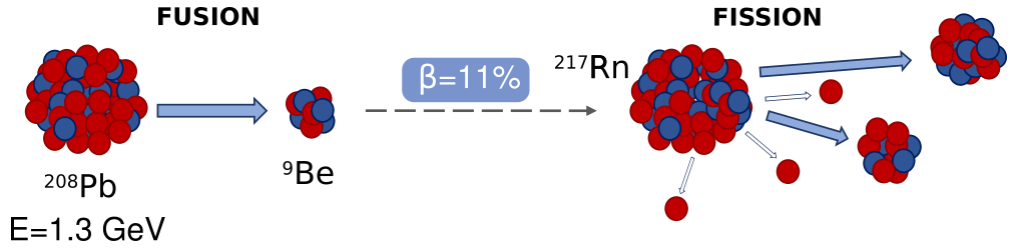
^{208}Pb+^{9}Be fusion-fission in inverse kinematics

Kinematic focusing of fission fragments
(A,Z) identification with PRISMA

Measurement of de-excitation ɣ rays with AGATA

Issues with TP during acquisition: **most exotic gamma channels do not have much statistics**

Further inspection on gamma spectroscopy on nuclei in the region N~40-50, Z~28-32

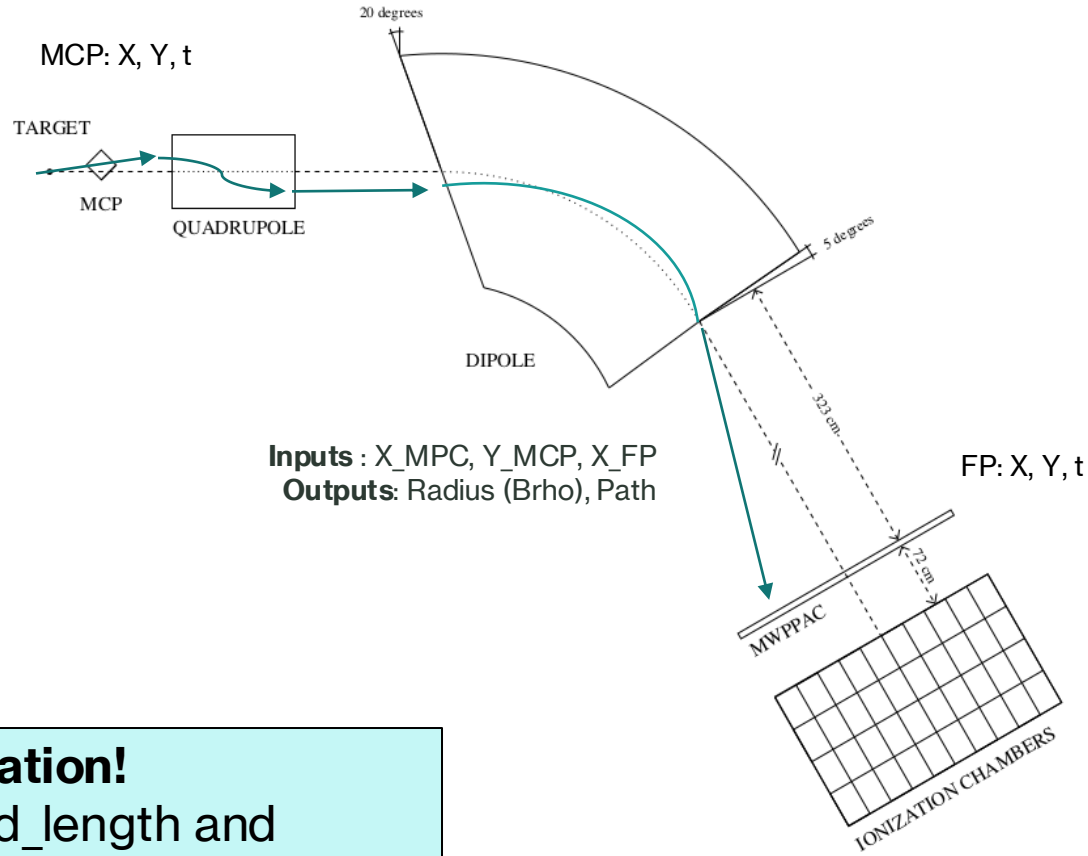


CN: ^{217}Rn with E_{ex} = 39.9 MeV, J = 17.5 ħ

PRISMA trajectory reconstruction

Analytic solution to the trajectory

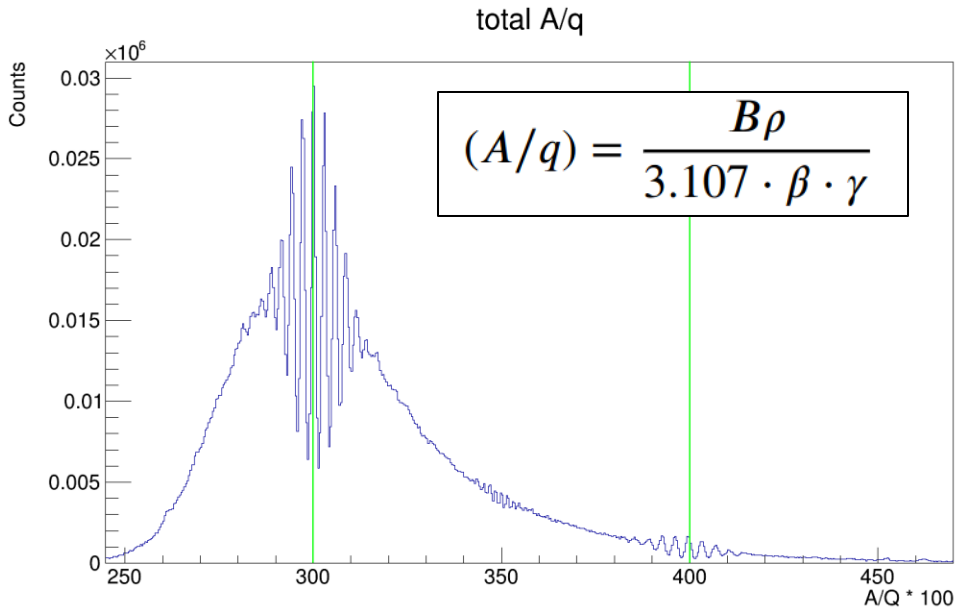
- MCP position gives flight direction
- First order treatment of quadrupole and dipole (**no fringe fields**) - **Very simplified**
- Propagation until focal plane
- Iteration over Radius until **calculated X_FP matches the measurement**



Inputs : X_MPC, Y_MCP, X_FP
Outputs: Radius (Brho), Path

Good convergence and separation!
But tuning of optical parameters (quad_length and target_dipole_dist) is necessary

PRISMA analysis of fission fragments

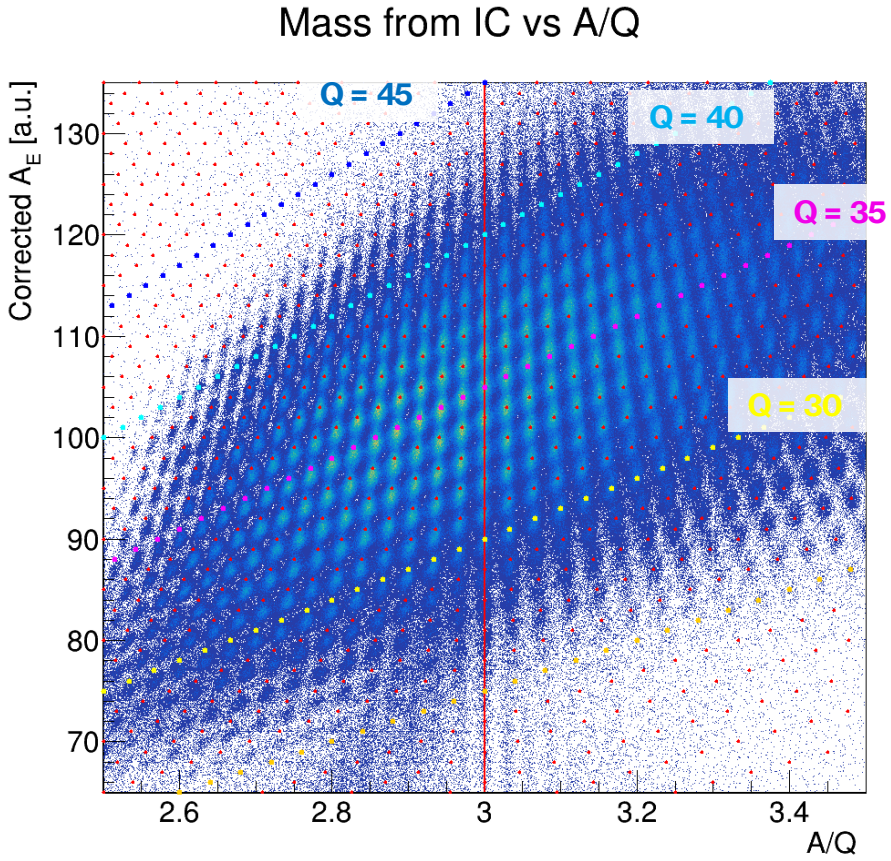


$$(A/q) = \frac{B\rho}{3.107 \cdot \beta \cdot \gamma}$$

A/Q from trajectory reconstruction (Brho)

A/Q must be a ratio of integer numbers

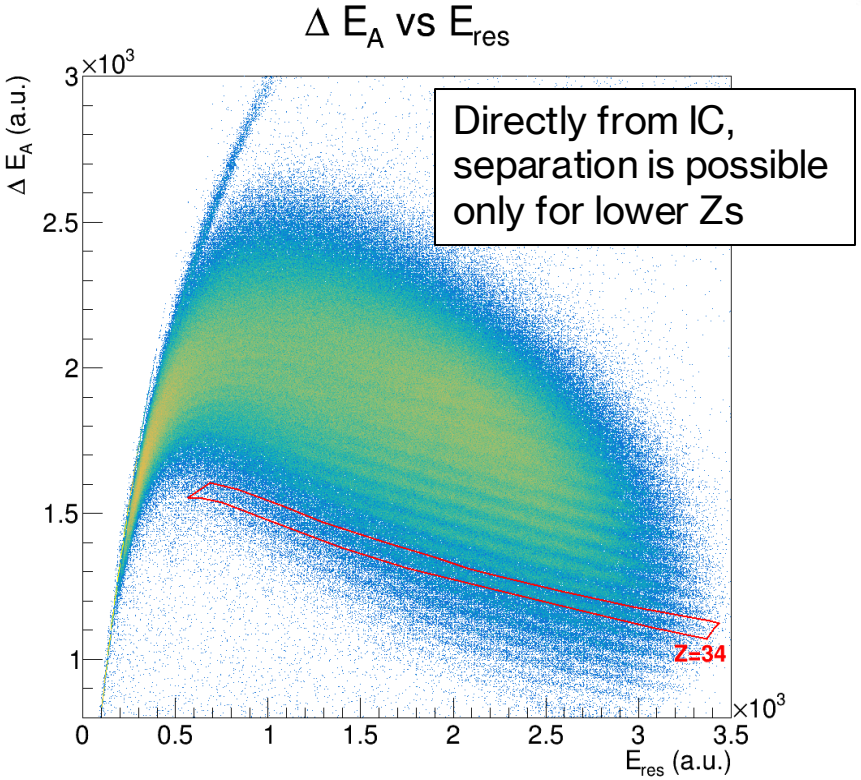
Theoretical values can be used to calibrate the variables (e.g. A/Q = 3)



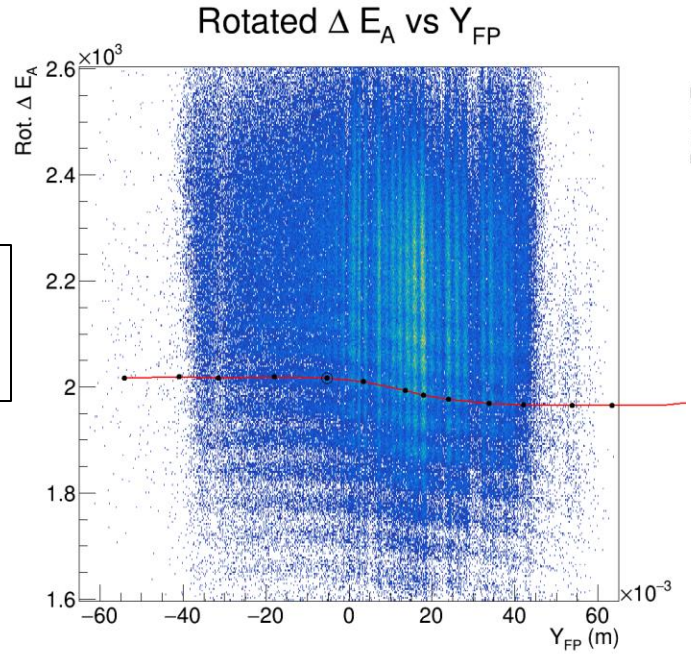
$$A_E = \frac{E}{u(\gamma - 1)}$$

Mass estimate from IC energy
Poor resolution, but useful to double check

Atomic number Z selection

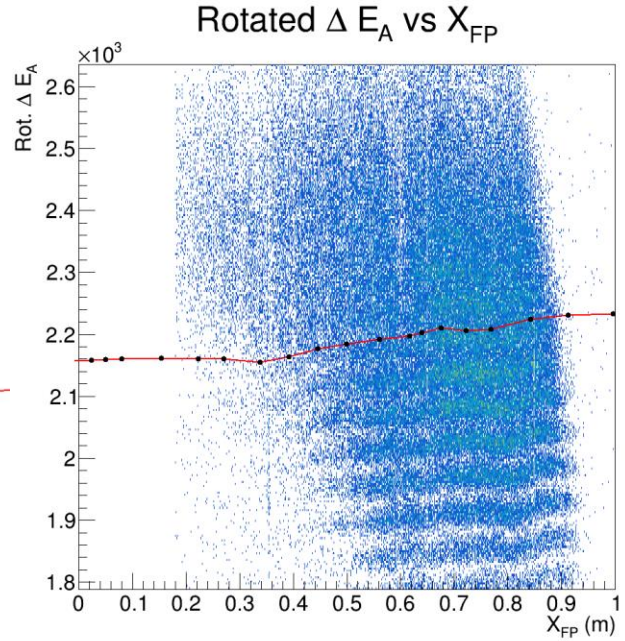


Directly from IC, separation is possible only for lower Zs



Dependence of Z bands on Y:

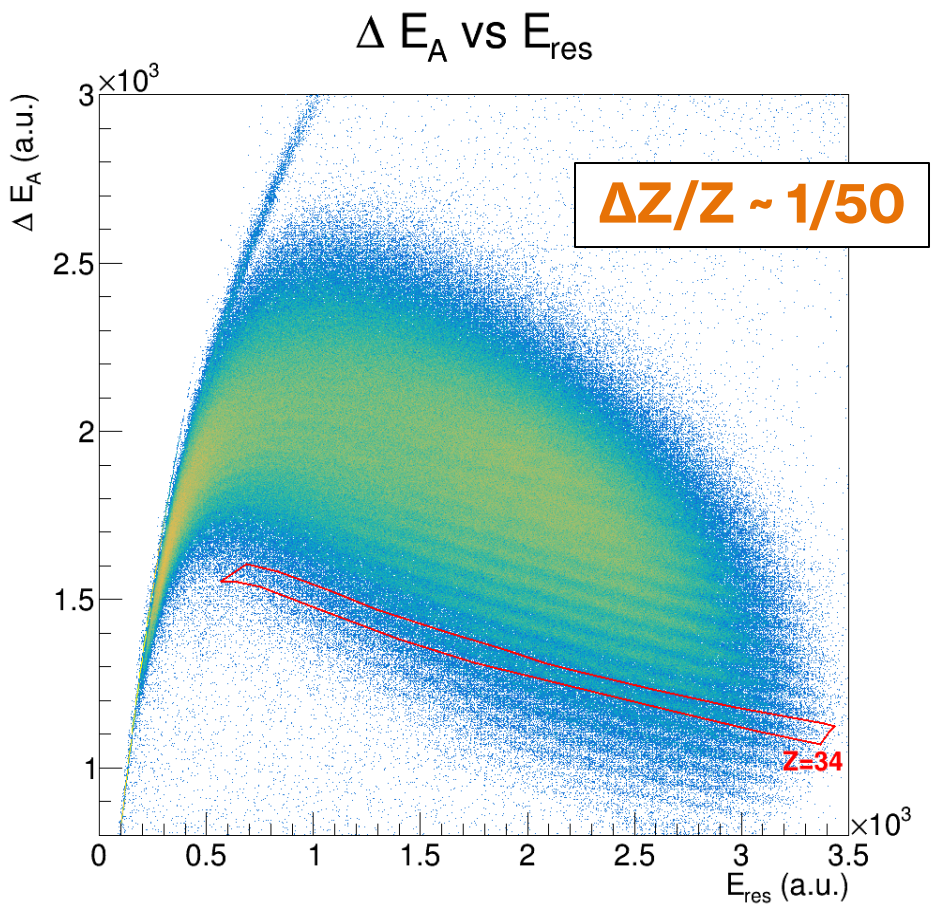
The longer drifts of charges in IC, the lower the collection efficiency

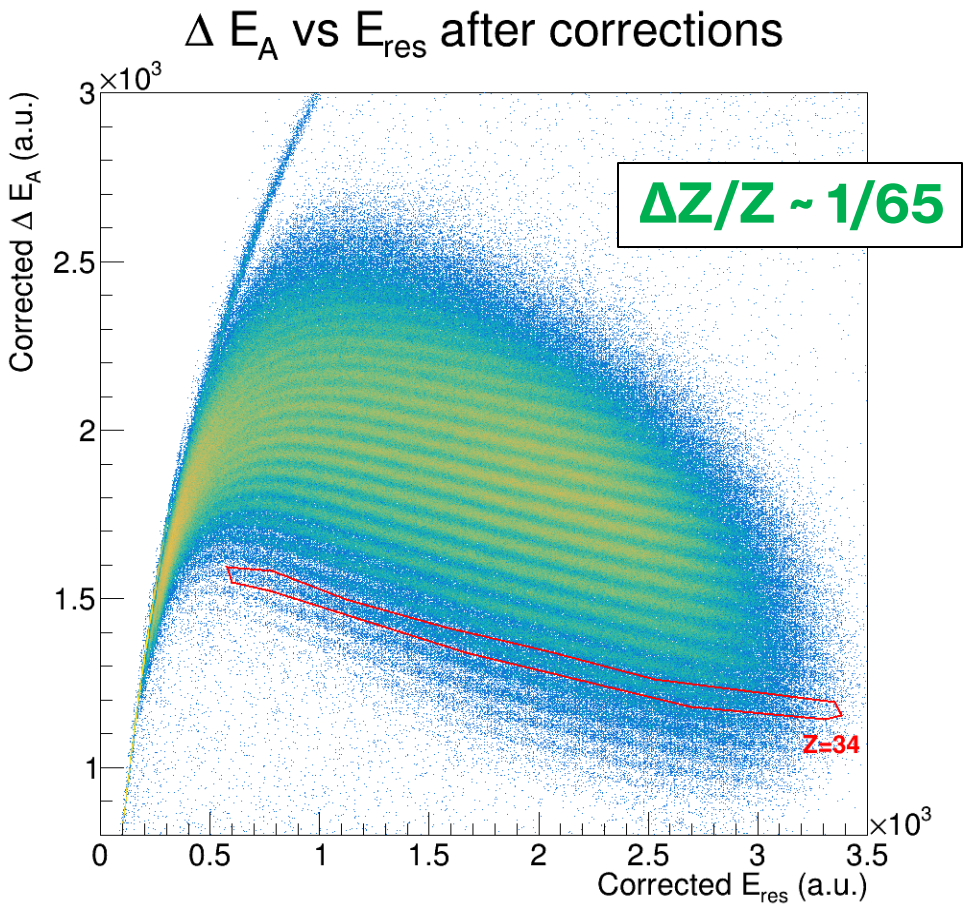


Dependence of Z bands on X:

Not understood, but large effect

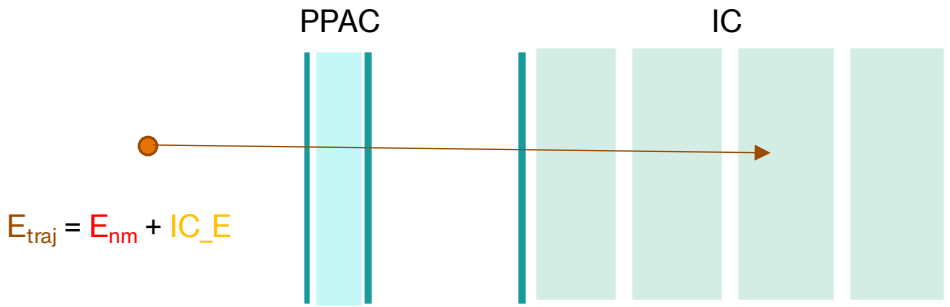
Atomic number Z selection



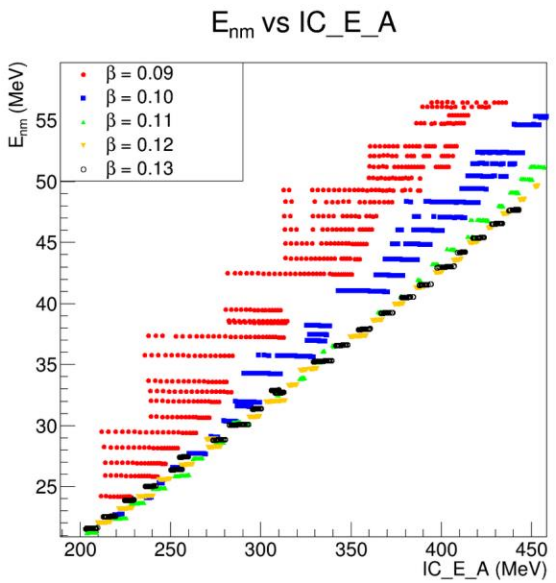


Charge state Q selection

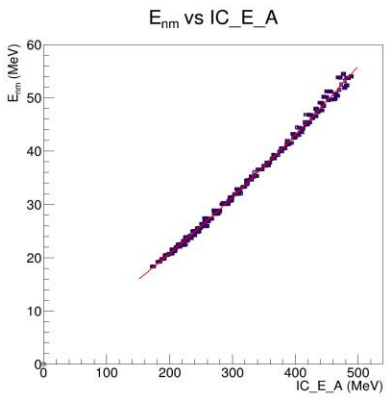
Energy measured in IC < Trajectory energy



Non measured E (E_{nm})

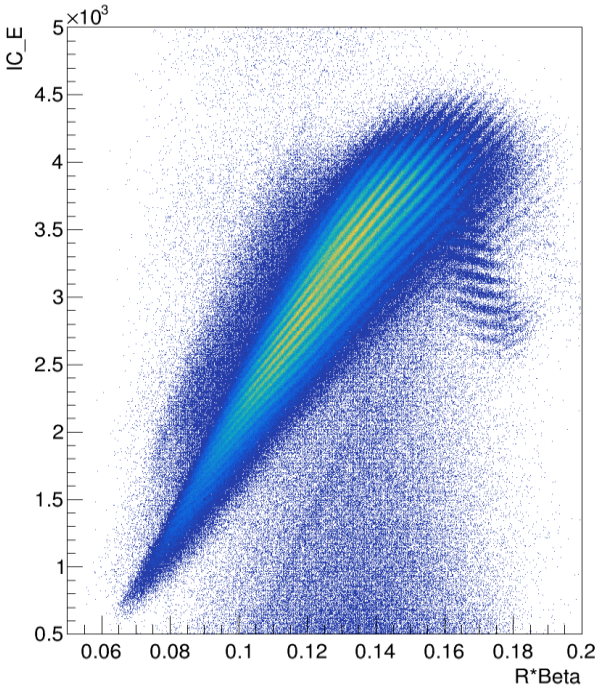


Measured E (IC_E)

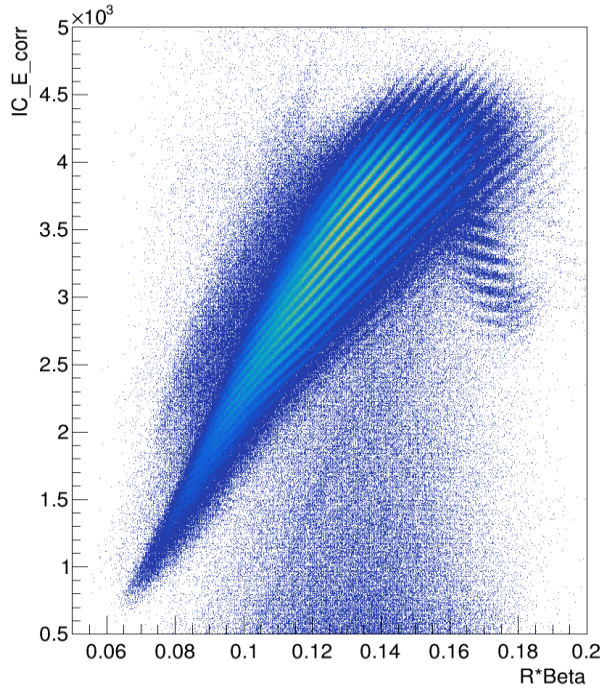


E_{nm} estimated with **SRIM** for a range of ions and fitted to IC_DE_A

Charge states

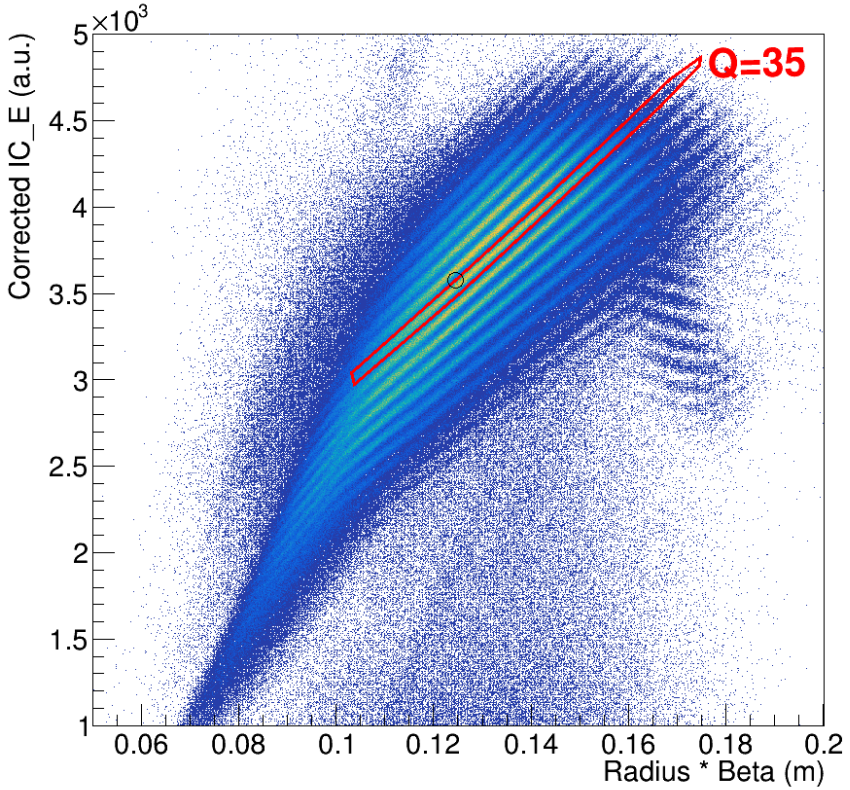


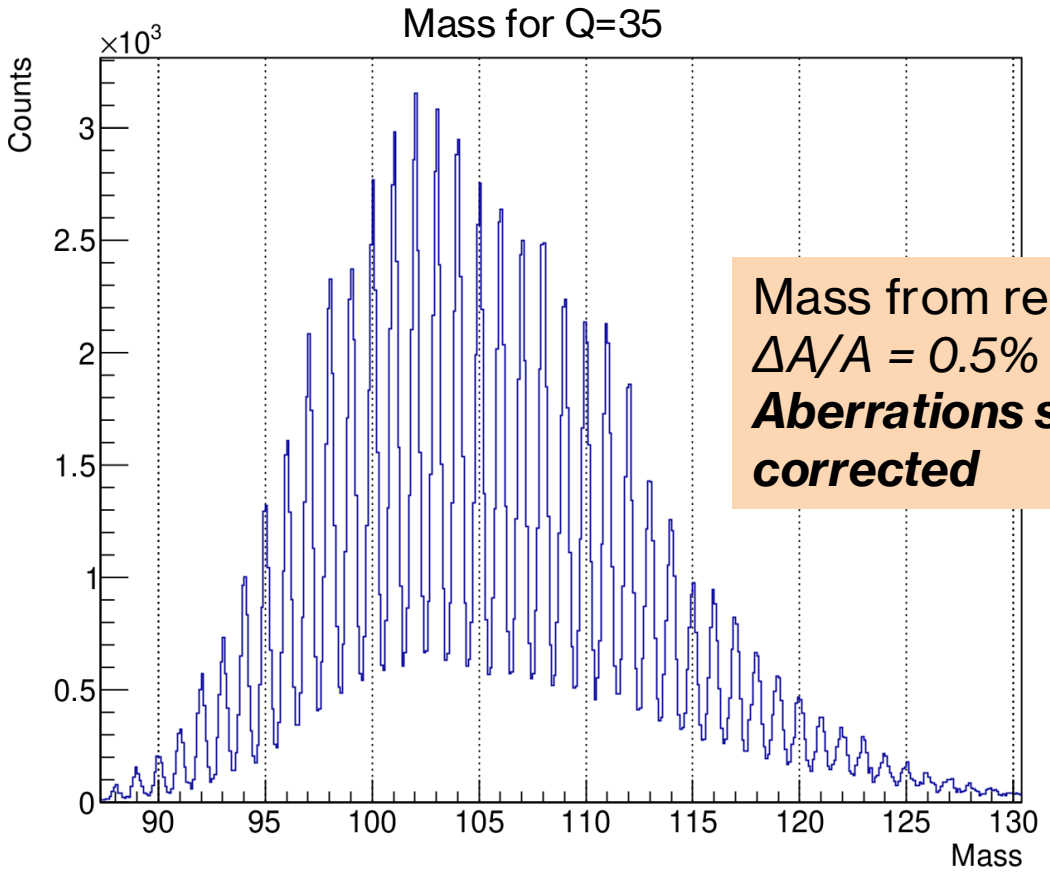
Charge states with E_{nm} correction



Correction proportional to IC_DE_A

Mass calibration



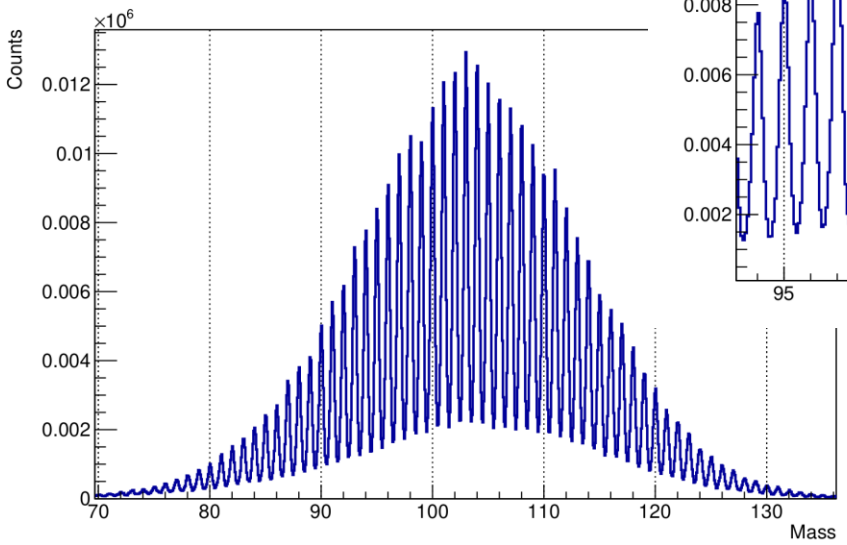


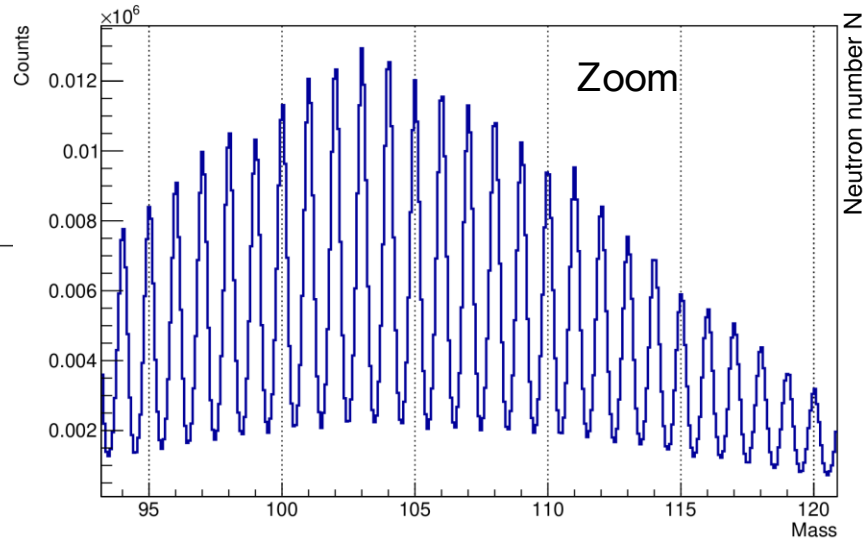
Mass from reconstruction:
ΔA/A = 0.5% = 1/200
Aberrations still not corrected

A/Q calibrated with TOF offsets of the PPAC sections
No extra calibration

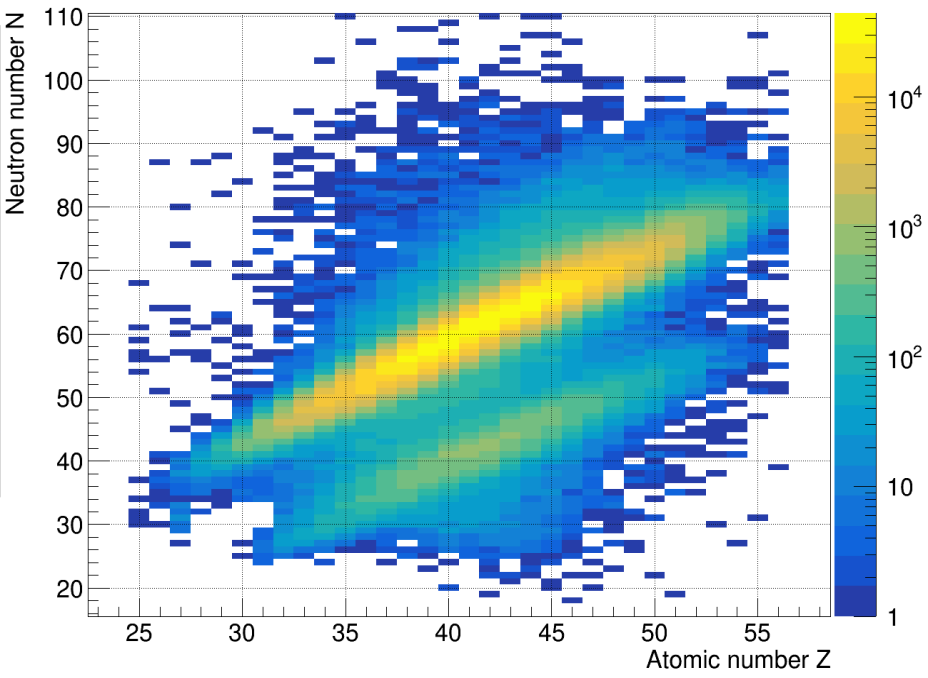
FF yields and distributions

Total Mass Spectrum





N vs Z



Symmetric mass distribution

Outlook and conclusions

Global identification of fragments -> Easier look at coincident gammas

Further adjustments to calculation of **yields, velocity and N/Z distributions**

Comparison with calculations to check for features in the distrubutions

QUESTIONS?