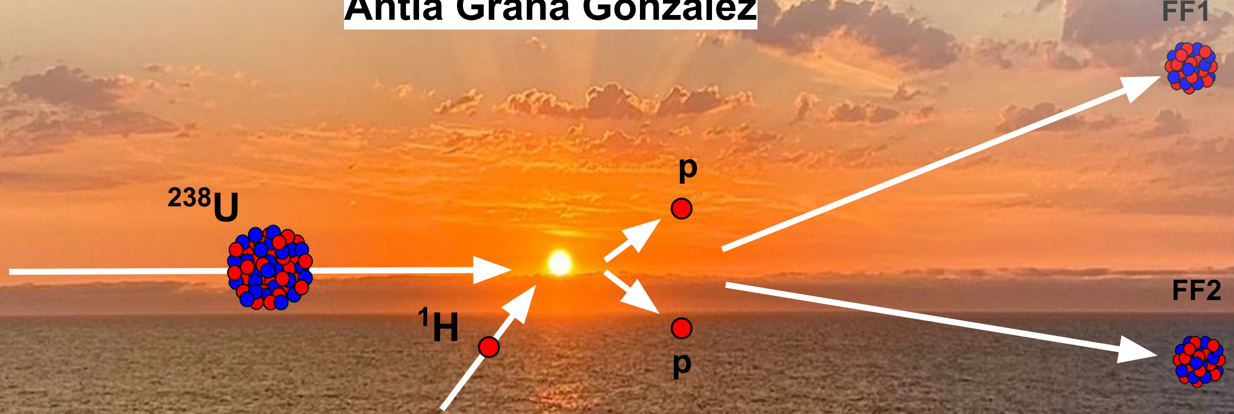
R^3B Collaboration meeting 2023

Analysis report of the quasi-free (p, 2p) fission experiment S455

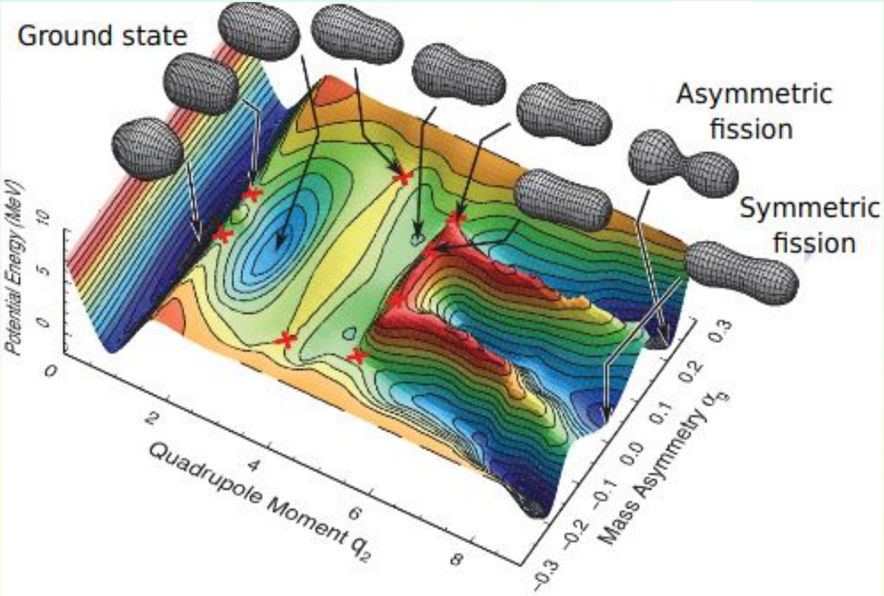
Antía Graña González

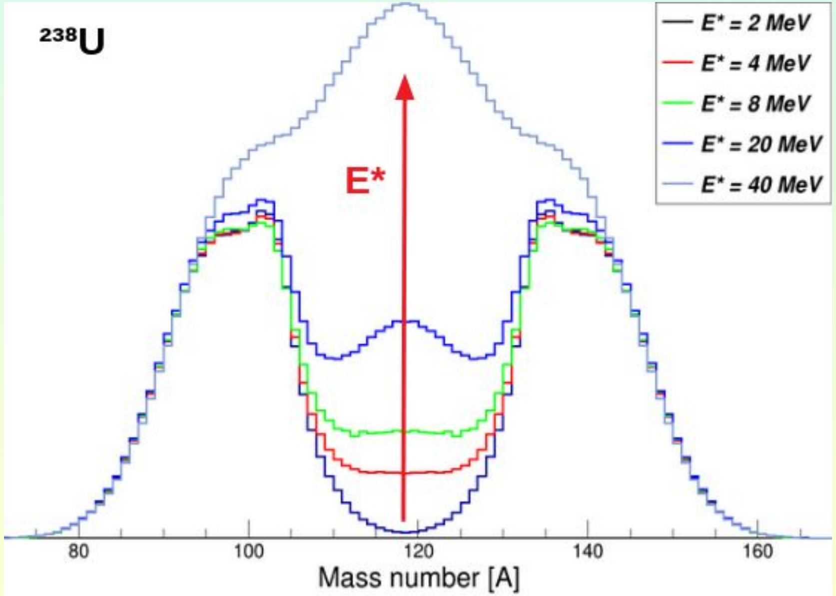


Introduction

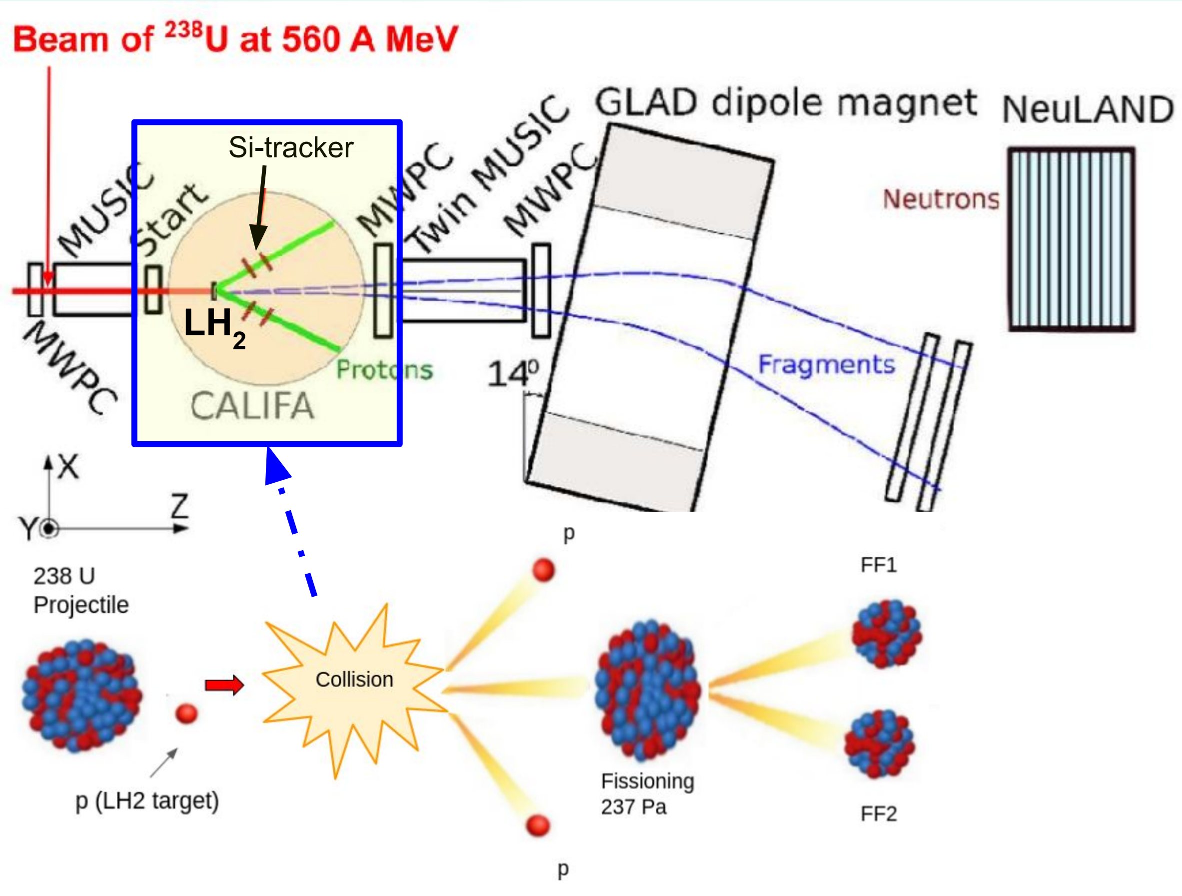
Experiment S455: **(p,2p) - fission experiment.** Scientific goals:

- **Fission yields and cross sections**
- **Correlate the fission yields with the excitation energy.** The excitation energy can populate different regions of the potential energy landscape, leading to different fission paths which will be evidenced in the fission yields distributions: transition from asymmetric to symmetric fission with ↑E*

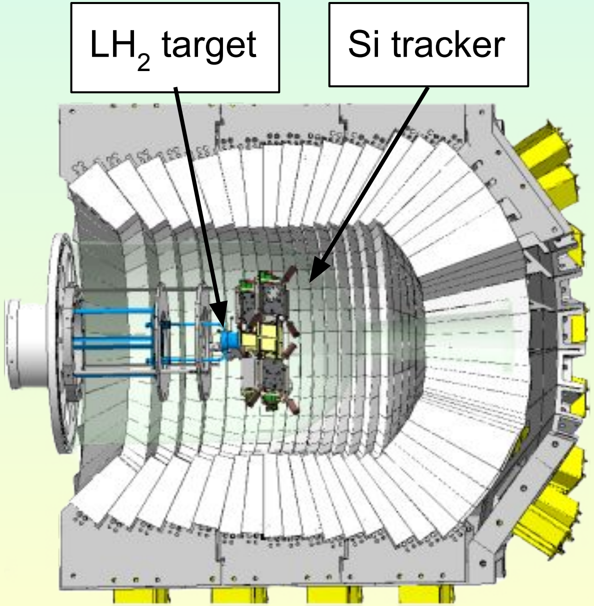




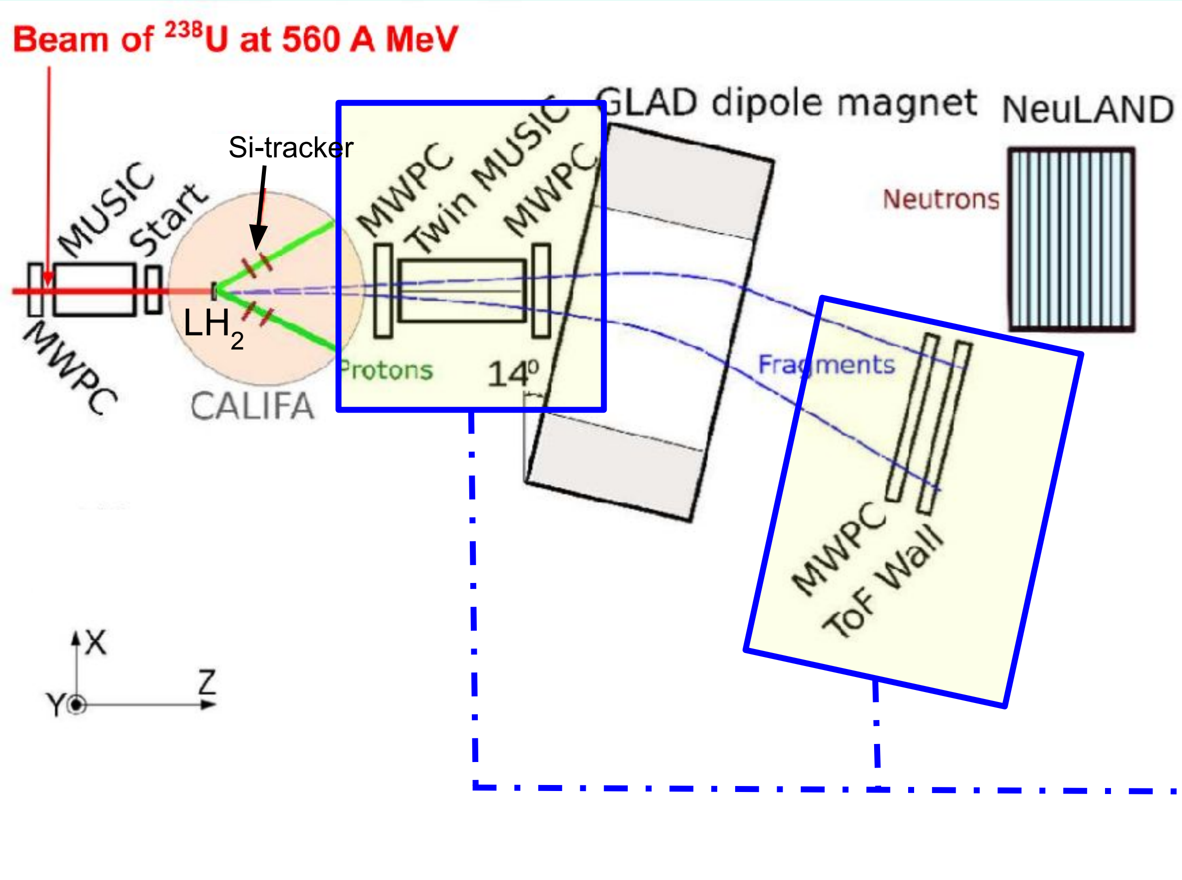
Methodology and set-up



Missing energy method: The measurement of the momenta of the outgoing protons allows to reconstruct the excitation energy.



Methodology and set-up



Inverse kinematics with R3B Set-up allows **full isotopic identification of both fission fragments simultaneously**.

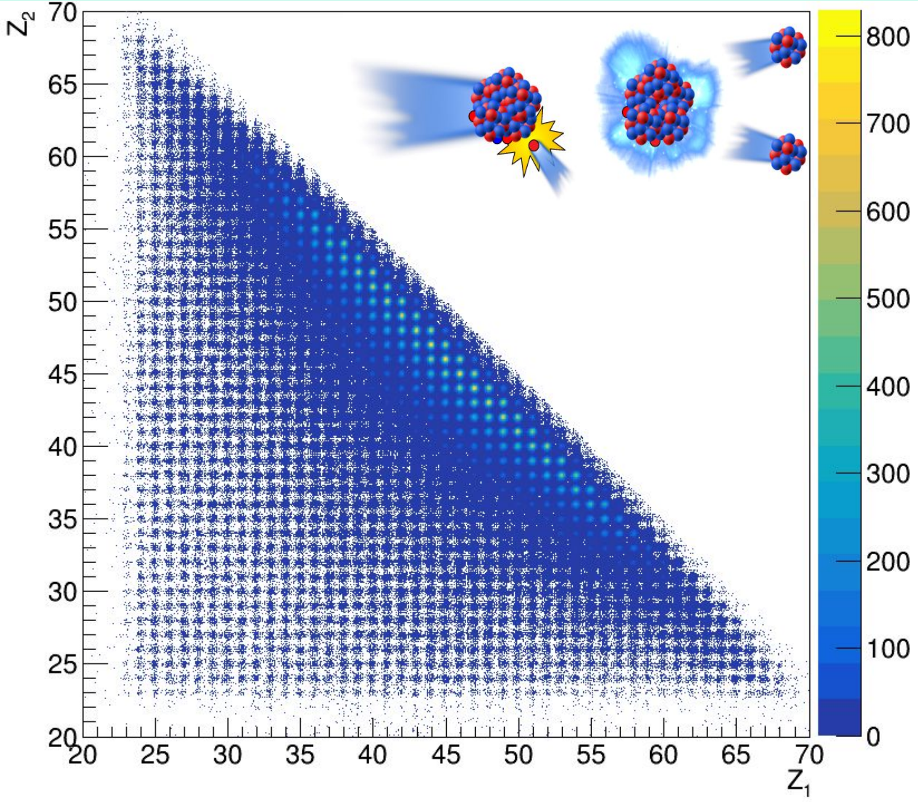
- Tracking detectors: MWPCS
- Tof detectors: Tof Wall and start scintillator
- Ionizations chambers to measure charge: Twin
- Dipole to deflect the ions according to their magnetic rigidity: Glad

Mass reconstruction:

$$B\rho = \frac{A}{q\,e} u\,\beta\,\gamma\,c$$

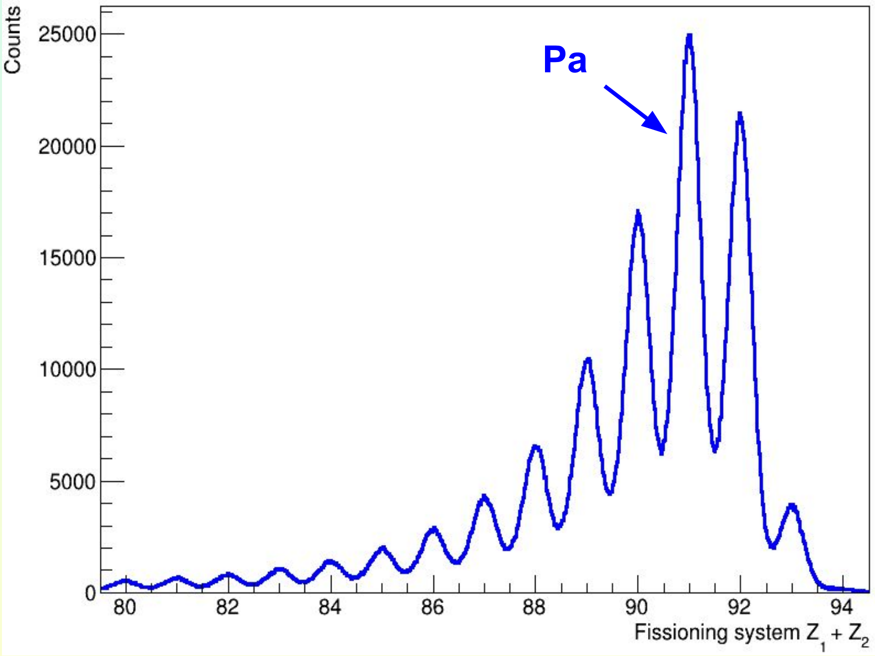
Charge identification

Fission fragments charges correlation

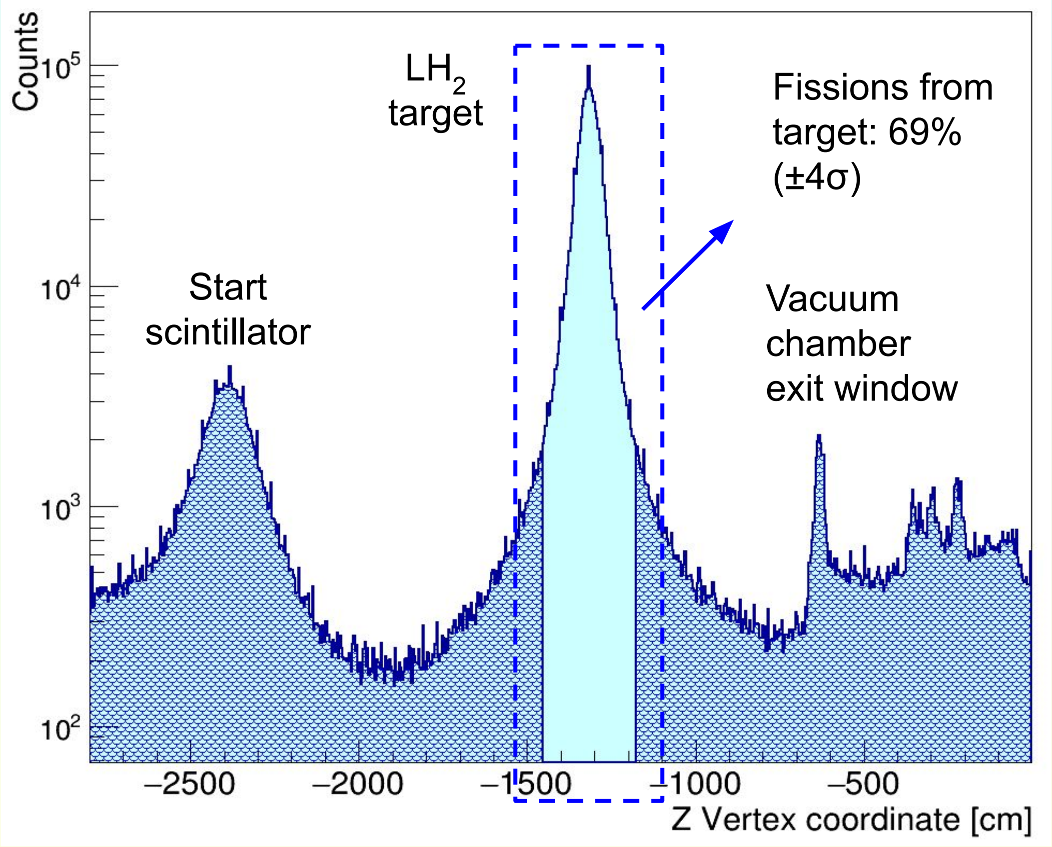


ΔZ = 0.38 FWHM (central charges)

Fissioning systems distribution

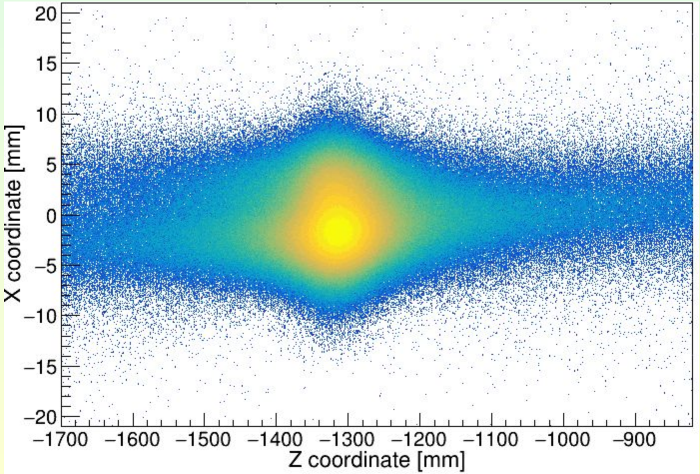


Vertex reconstruction



Average Vertex Z position = –1314 mm
Vertex position measured in the lab "by rule" 1340 mm (centre of the target)

Reconstructed estimated target width=28cm
Real target width=1.5cm
➡Poor vertex reconstruction resolution in Z
X position compatible with the expected beam profile size in the target

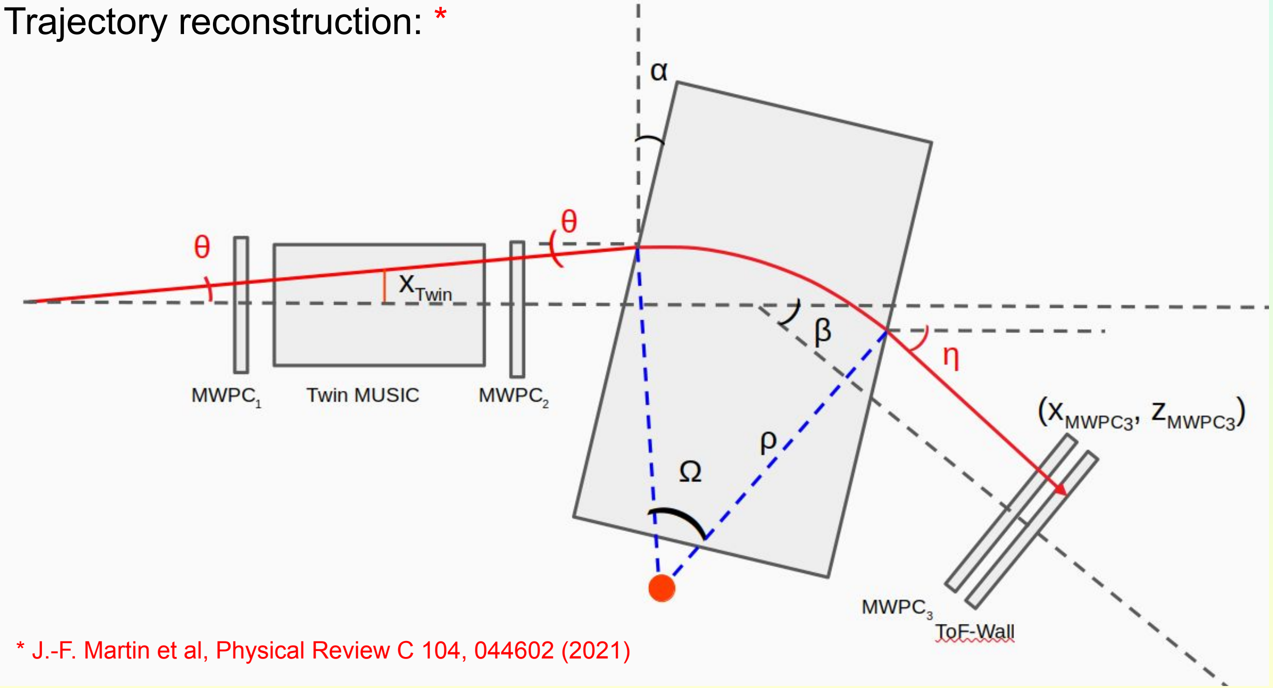


Masses reconstruction

$$B\rho = \frac{A}{q\,e} u\,\beta\,\gamma\,c$$

qe →Twin music charge identification
β = L/ToF/c → L= trajectory length
ρ = curvature ratio inside GLAD

Trajectory reconstruction: *



* J.-F. Martin et al, Physical Review C 104, 044602 (2021)

XTwin
XMwpc3
θ
} η

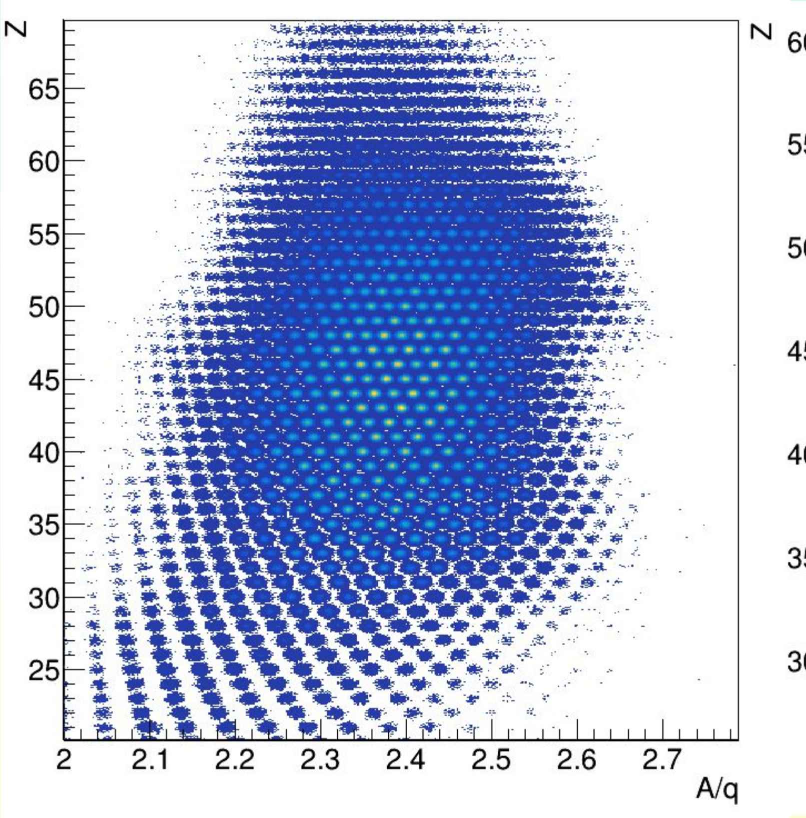
η,θ → ρ

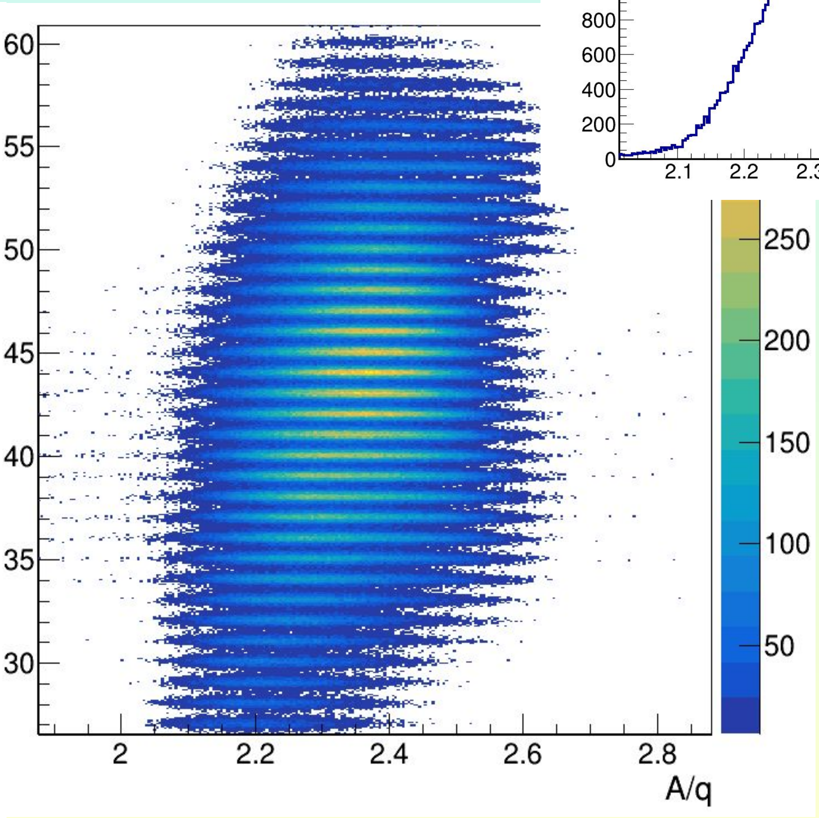
Comparing with simulation:

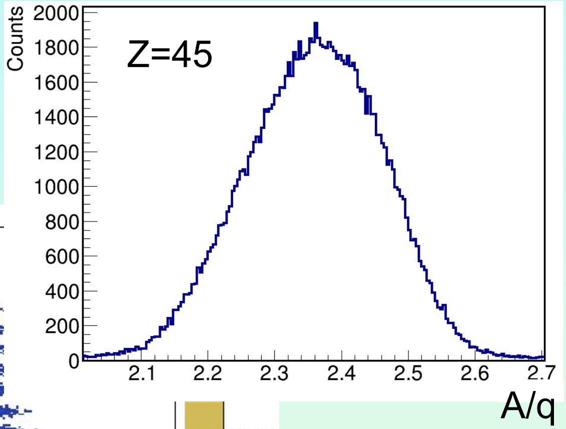
ΔL = 5.5 mm
ΔBρ = 0.04 Tm

Masses reconstruction

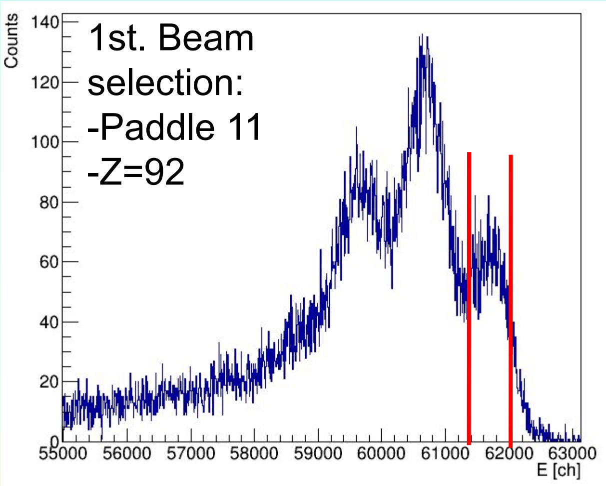
Mass calibration by comparison with simulated data

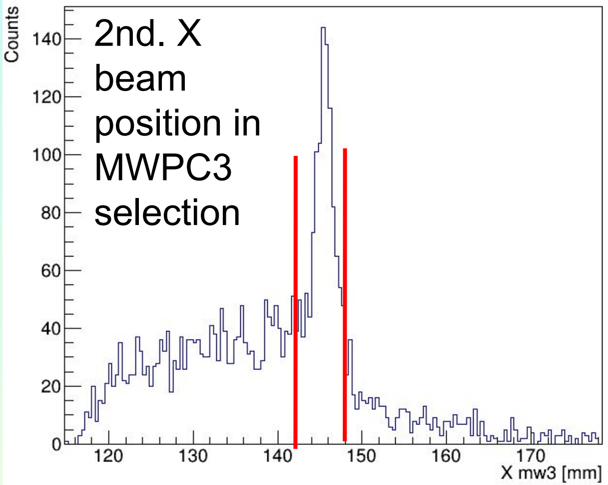


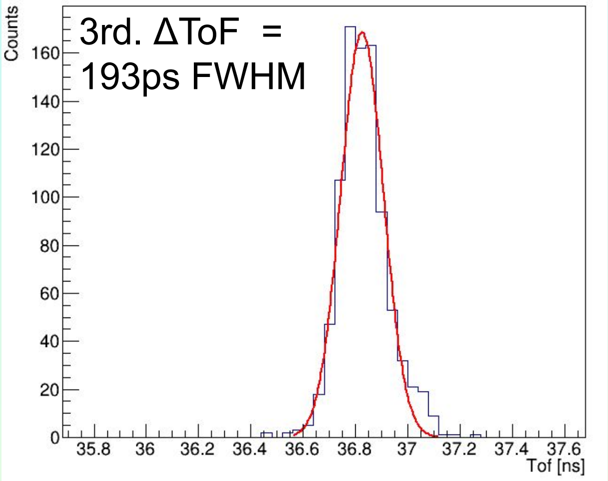




ToF Resolution





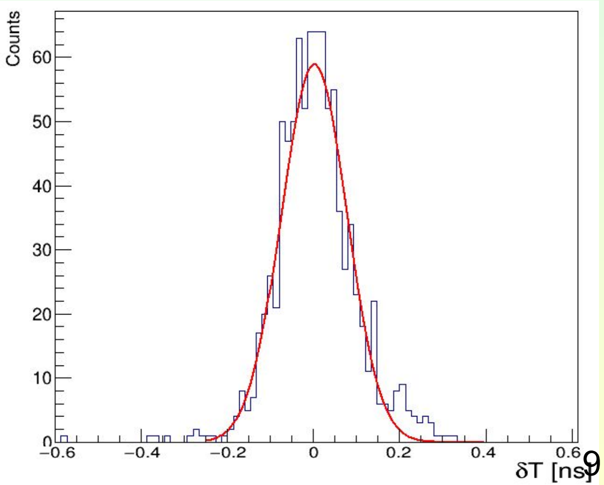


4th. Length correction

t(L)= L/V

L from the reconstructed trajectory and V given by Atima (0.78c) .

δT = (t-t(L))



High intensity beam:

ΔtoF = 179ps FWHM

Low intensity beam:

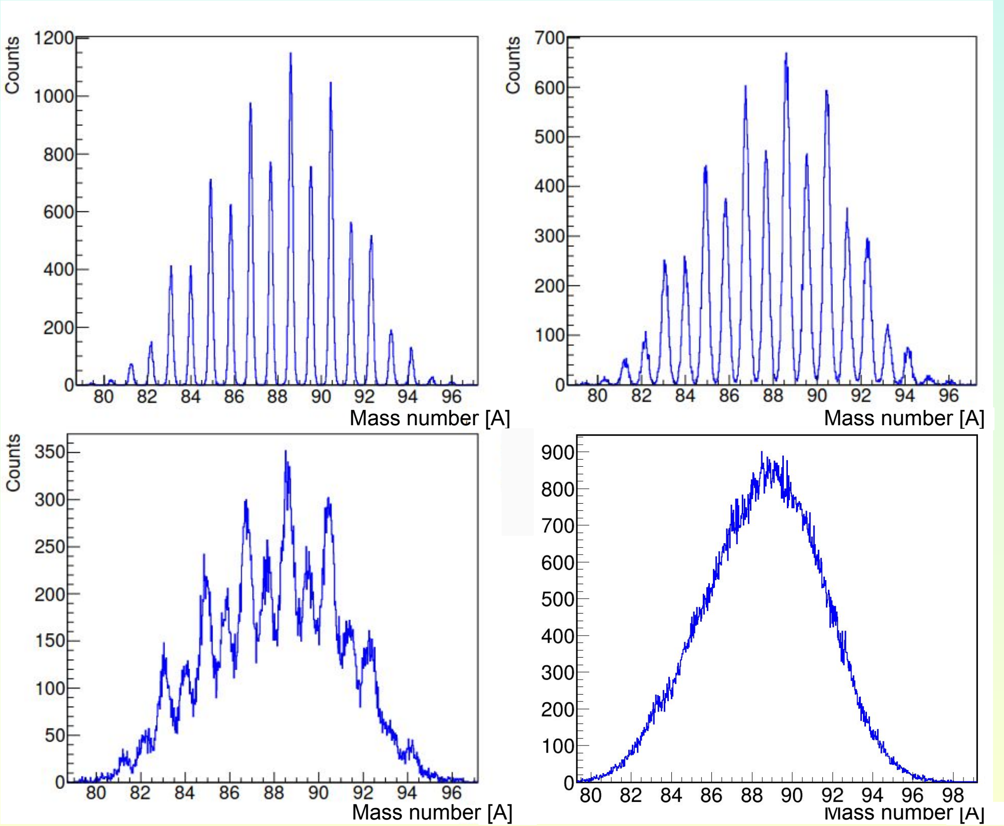
ΔtoF = 96ps FWHM

Masses reconstruction from SIMULATION for different tof resolutions

Resolutions:
ΔToF = 0 ps FWHM
ΔA = 0.20 FWHM

Resolutions:
ΔToF = 96 ps FWHM
ΔA = 0.66 FWHM

*Masses resolutions obtained for central masses



Resolutions:
ΔToF = 40.03 ps FWHM
ΔA = 0.35 FWHM
ΔA(Aladin) = 0.59 FWHM*

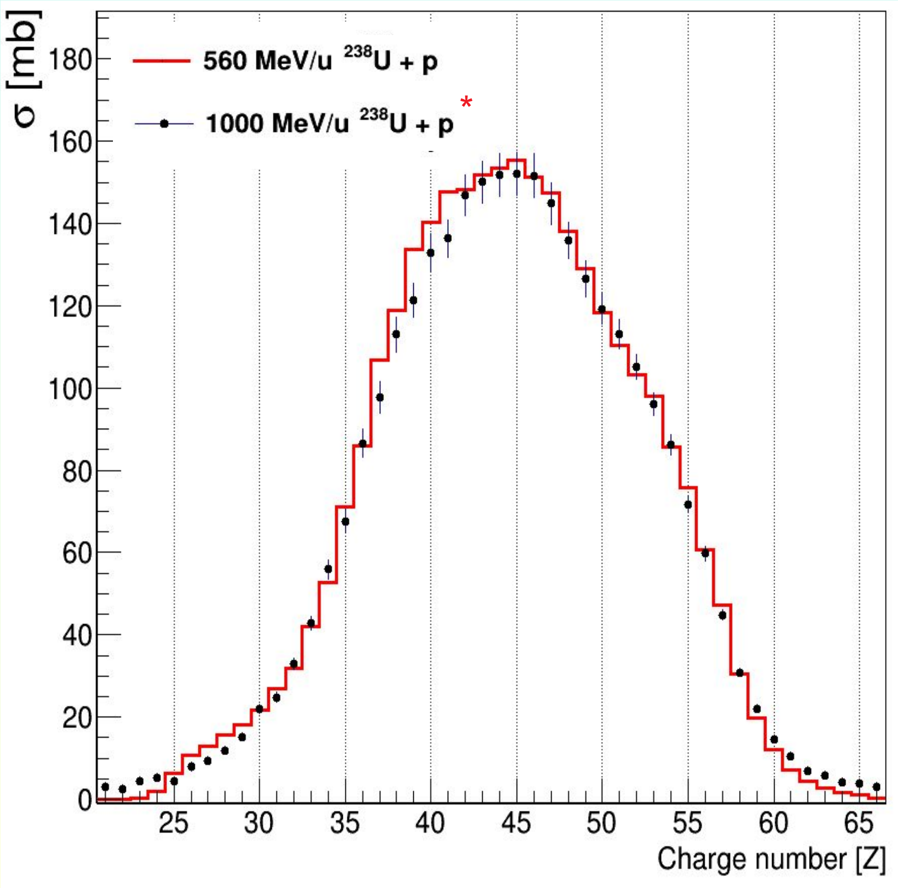
* J.-F. Martin et al, PRC 104, 044602 (2021)

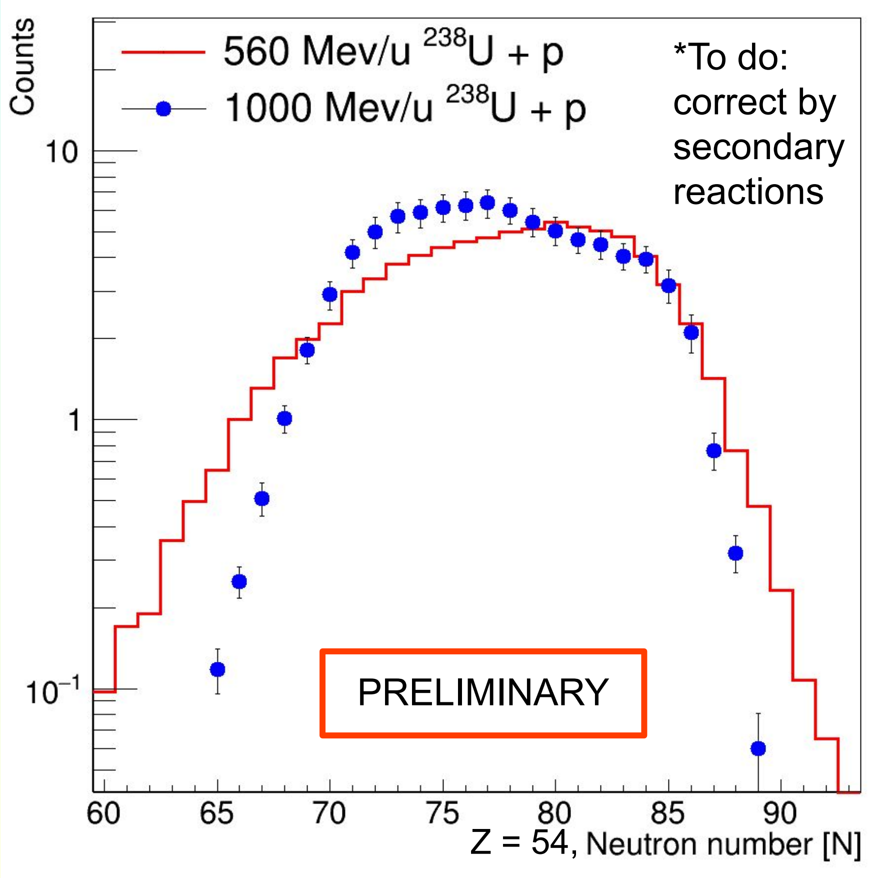
Resolutions:
ΔToF = 179 ps FWHM
ΔA = 1.2 FWHM

Current ToF resolution obtained from primary beam selection

Charge and isotopic distributions comparison

*Data from M.Bernas et al, Nuclear Physics A 725 (2003) 213–253

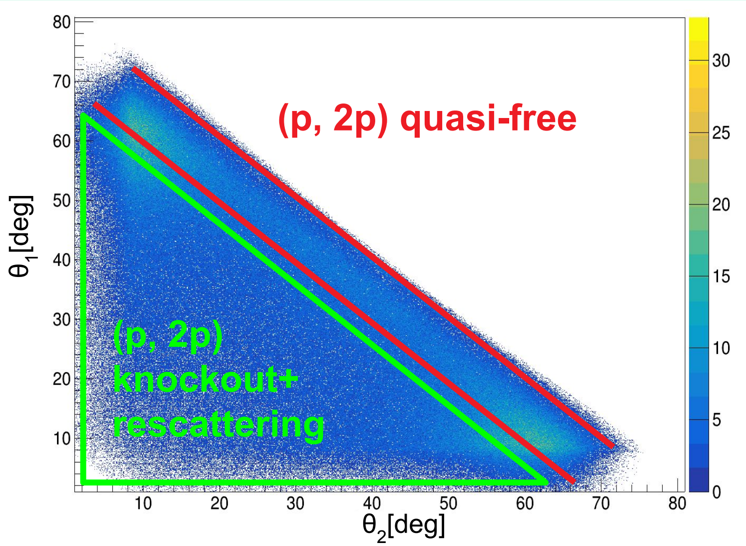




Charge and mass distributions dependence on excitation energy

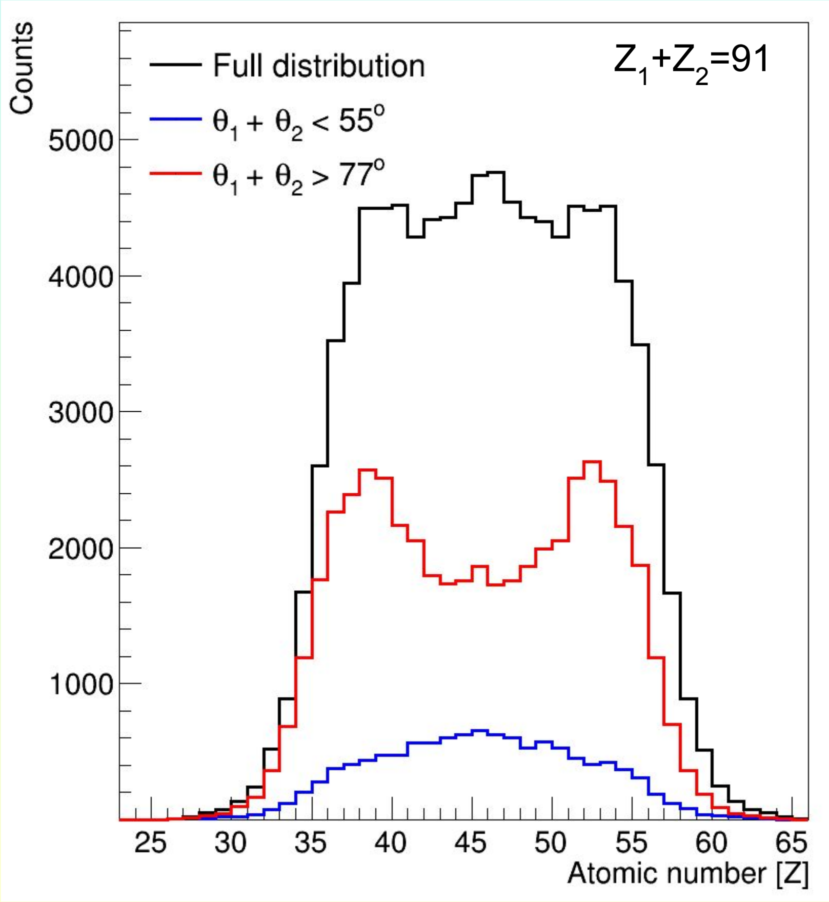
Observables sensitive to the excitation energy:

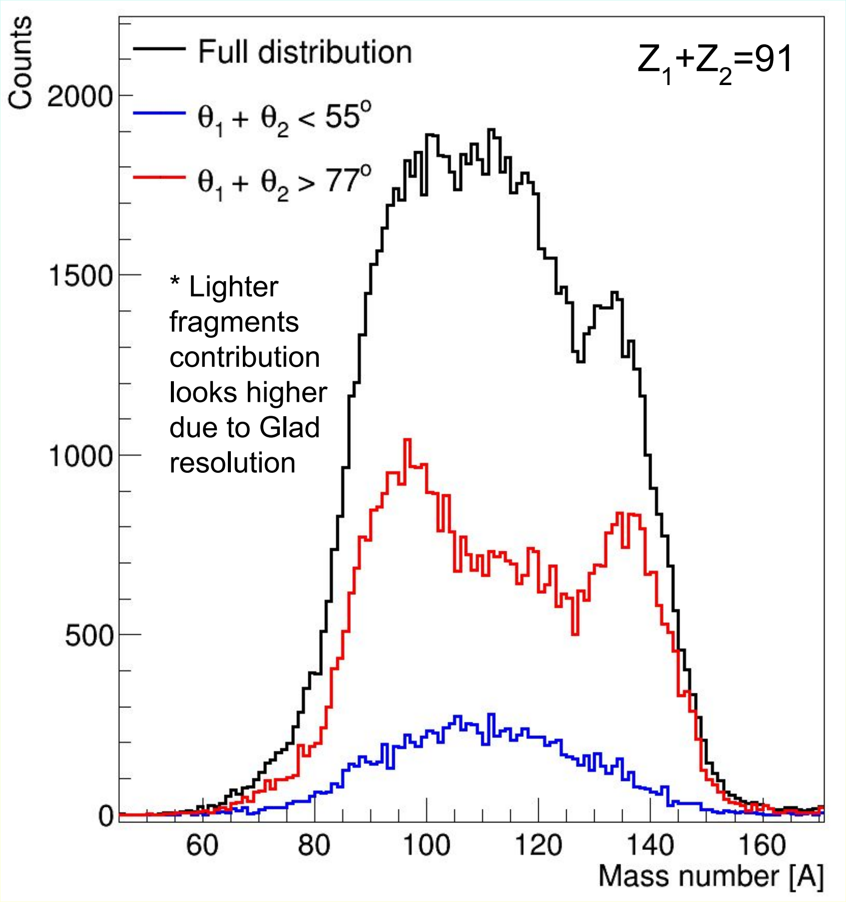
- **The (p, 2p) reaction opening angle**:
  - $\theta_1+\theta_2 \gtrsim 77$: quasi-free (p, 2p), meaning that the excitation energy can range from few to tens of MeV
  - $\theta_1+\theta_2 \lesssim 70$: (p, 2p) knockout reactions + rescattering which can go up to hundreds of MeV



- **Fissioning system mass**:
  - Reactions where $231 < A_1+A_2 < 238$: low neutron emission meaning the reaction happened at lower excitation energies
  - Reactions where $A < 224$: high neutron emission, high excitation energy

Charge and mass distributions dependence on (p, 2p) opening angle ($\theta_1+\theta_2$)

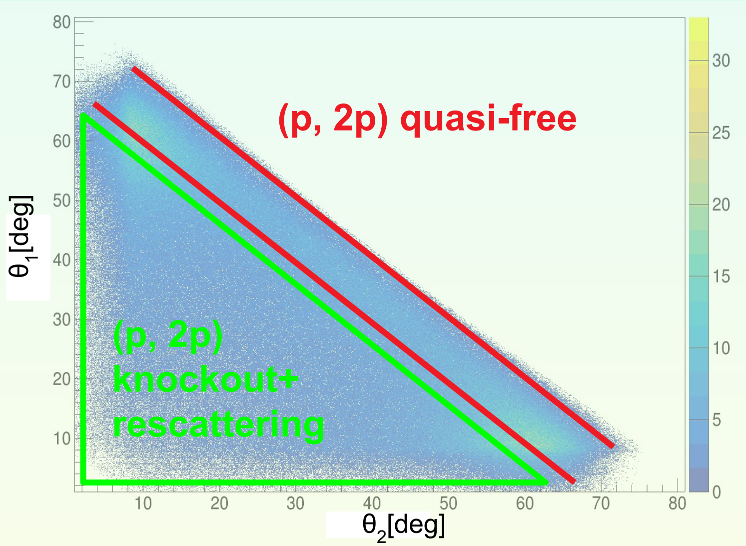




Charge and mass distributions dependence on excitation energy

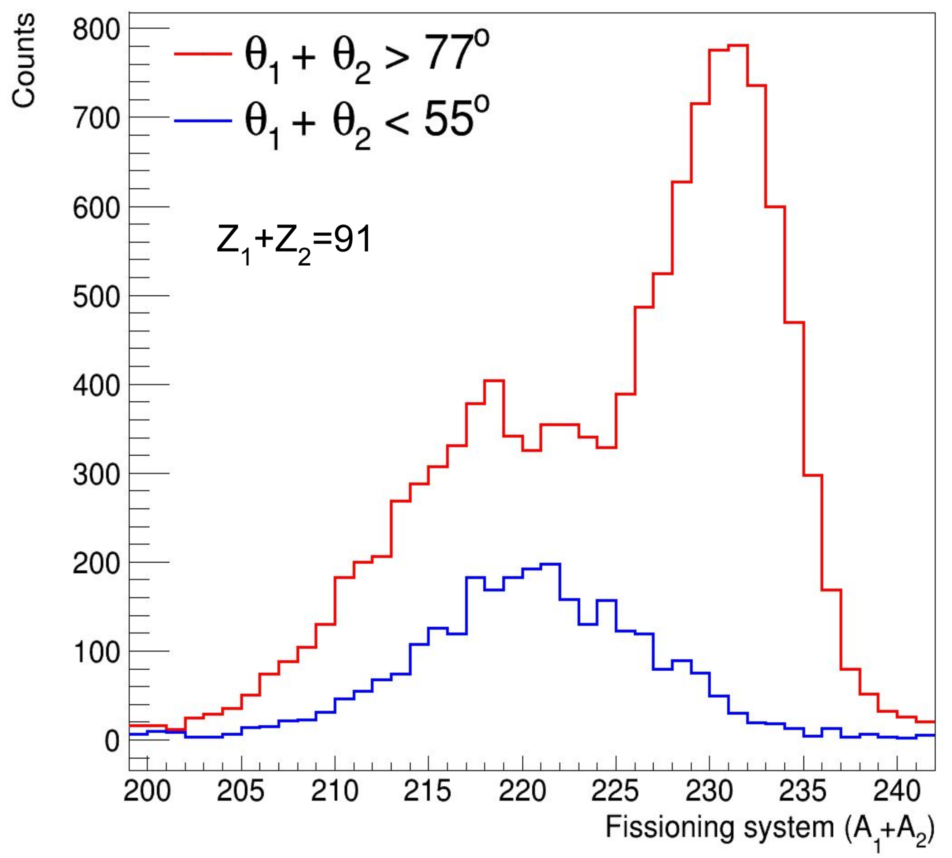
Observables sensitive to the excitation energy:

- **The (p, 2p) reaction opening angle**:
  - $\theta_1+\theta_2 \gtrsim 77$: quasi-free (p, 2p), meaning that the excitation energy can range from few to tens of MeV
  - $\theta_1+\theta_2 \lesssim 70$: (p, 2p) knockout reactions + rescattering which can go up to hundreds of MeV

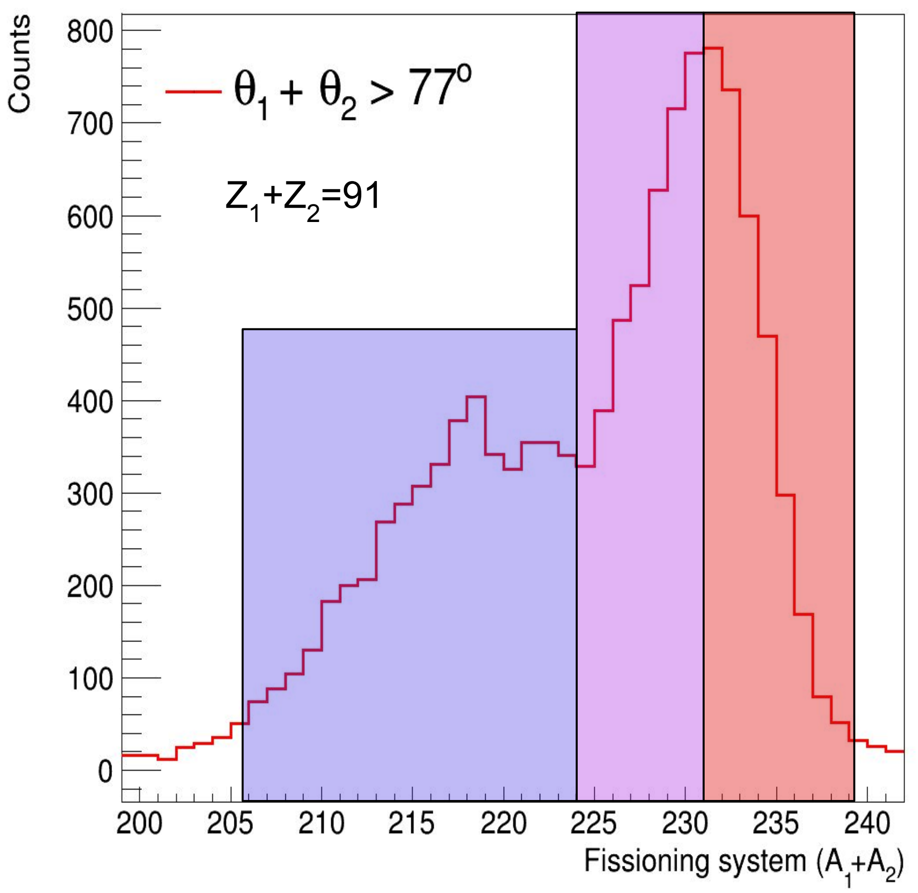


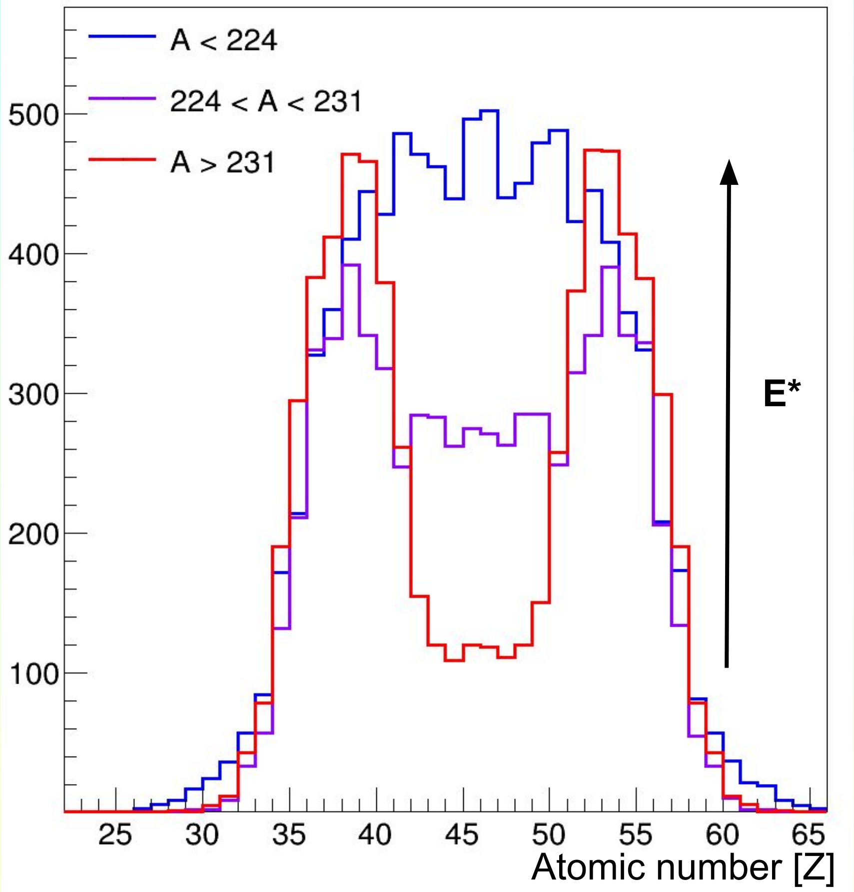
- **Fissioning system mass**:
  - Reactions where $231 < A_1+A_2 < 238$: low neutron emission meaning the reaction happened at lower excitation energies
  - Reactions where $A_1+A_2 < 224$: high neutron emission, high excitation energy

Charge distributions dependence on fissioning system mass



Charge distributions dependence on fissioning system mass



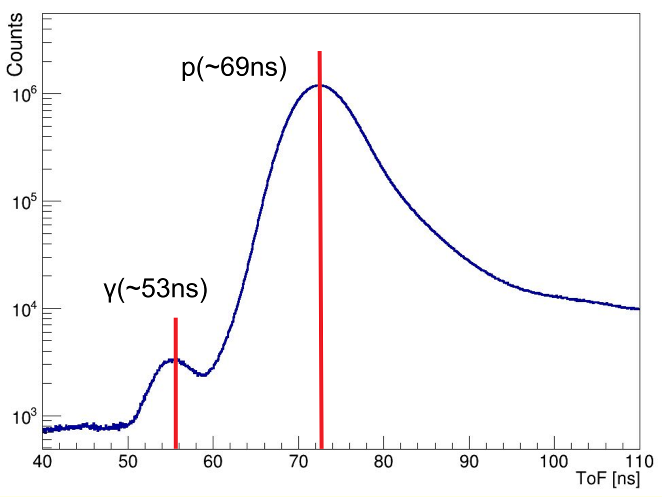


Future work and conclusions

Conclusions:

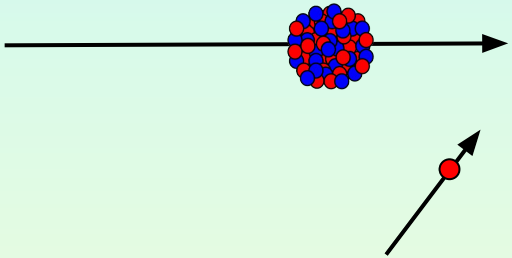
- ToF resolution and consequently mass resolution are not the expected ones
- Charge and mass distributions in good agreement with previous studies
- The fission yields asymmetry increases with the opening angle and the mass number of the fissioning system, showing the role of the excitation energy.

Ongoing work: Neuland calibration

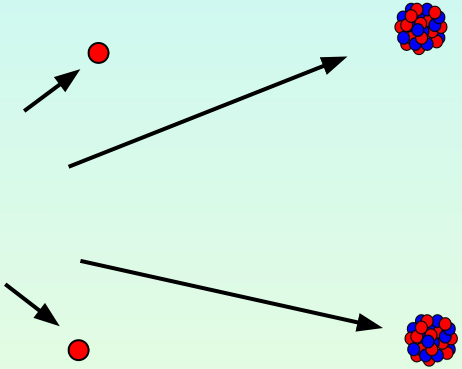


Future work:

- Neuland analysis to extract the neutron multiplicities and neutron kinetic energies in order to have a more restrictive selection of the excitation energy



The end



Thank you for your attention !

Knockout reconstruction: Excitation energies

Courtesy by Gabriel García Jiménez