Status of the mass analysis of the s455 / ^{238}U(γ,f) experiment.

R3B week

November 2023

Mainz, Germany

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SOFIA : Studies On Fission with GLAD (~~ALADIN~~) - I

General purpose of the experiment

- Measurement of fission yields and total prompt-neutron multiplicity

  → for a large number of radioactive (or stable) fissioning systems

- Inverse kinematics at relativisitic energy

  → Fission induced by Coulomb excitation: relativistic beam on a heavy target

  → Example for the coulex induced fission of ^{238}U:

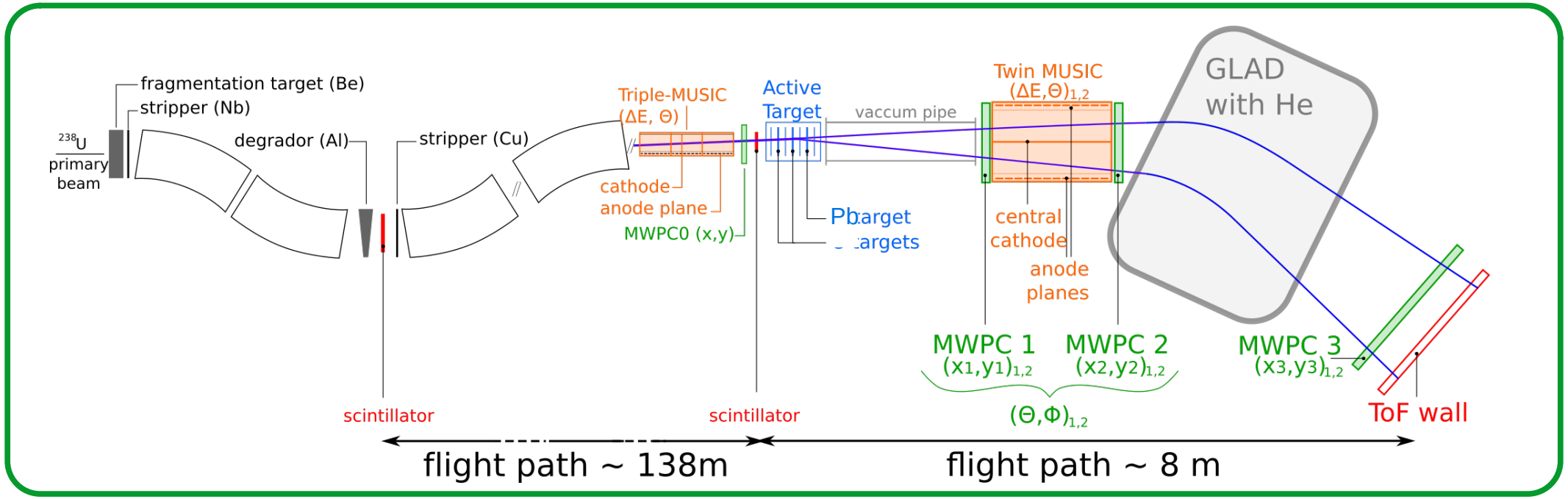
  - $\langle E^* \rangle \sim 14.7$ MeV: low energy fission
  - $\sigma \sim 2$ barns: **high statistics data**

WE NEED TO IDENTIFY IN MASS AND CHARGE SECONDARY BEAM AND BOTH FISSION FRAGMENTS

SOFIA : Studies On Fission with GLAD - II

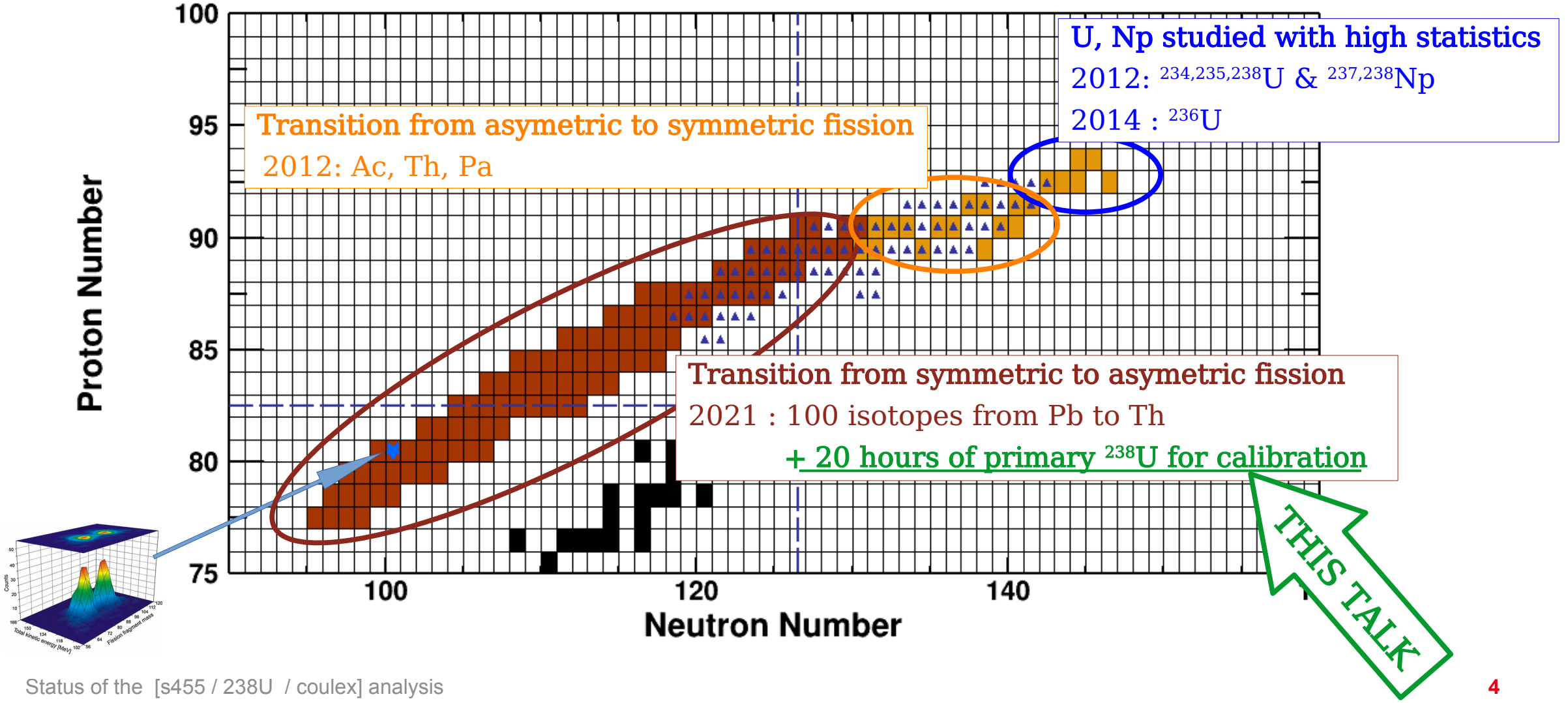
Experimental set-up: Identification in nuclear charge and mass

- Based on the well-known triptych Bρ - Tof - ΔE from position, Tof, energy loss measurement
- For secondary beam at FRS, from S2 to Cave C with a flight length ~ 140m
- For both fission fragments in coincidence: at Cave C with a flight length ~ 8m



SOFIA : **S**tudies **O**n **Fi**ssion with GL**A**D - III

Physics cases of the three experiments in 2012, 2014, 2021

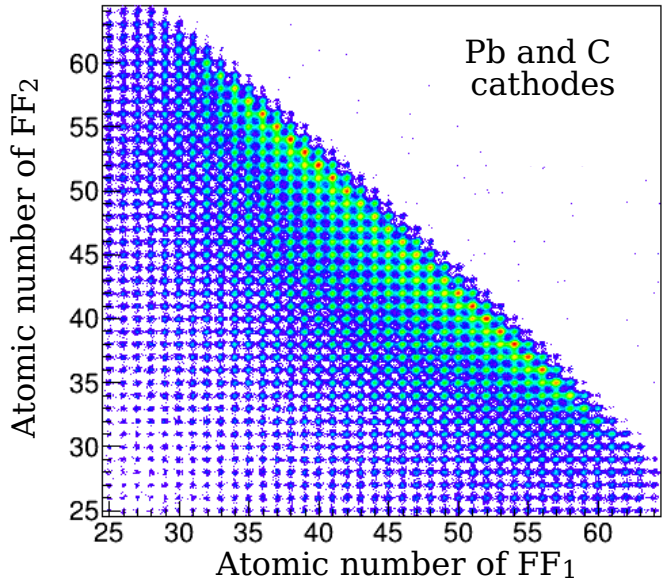


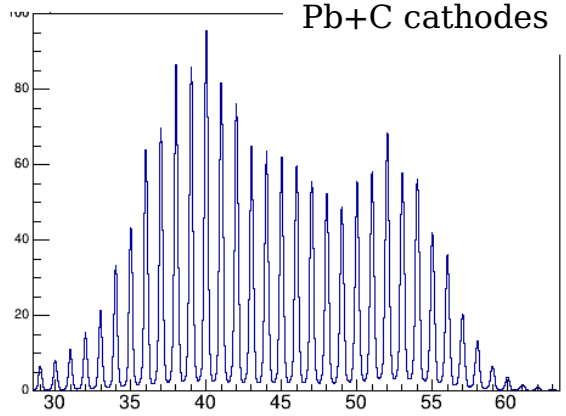
Nuclear charge distribution

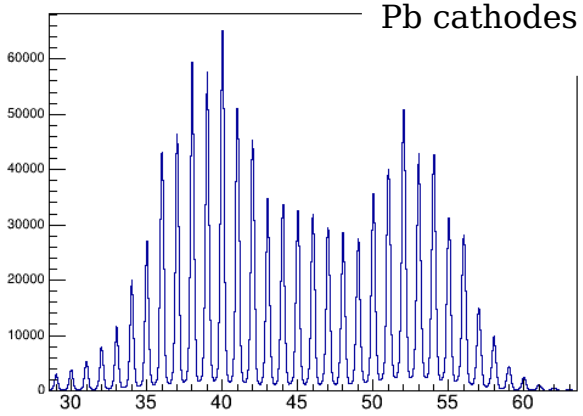
- **Atomic number is easy to obtain from ΔE (MUSIC)**

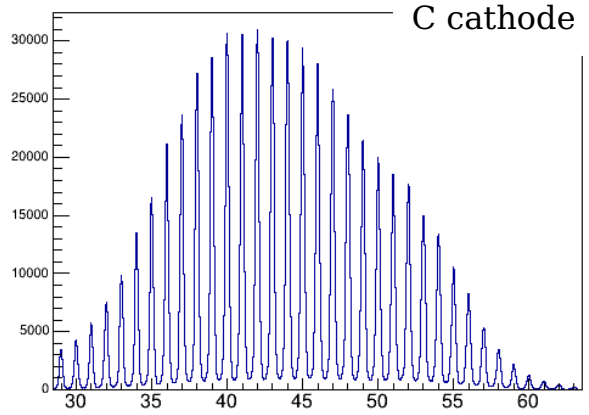
  → corrected from β and x position due to attachment

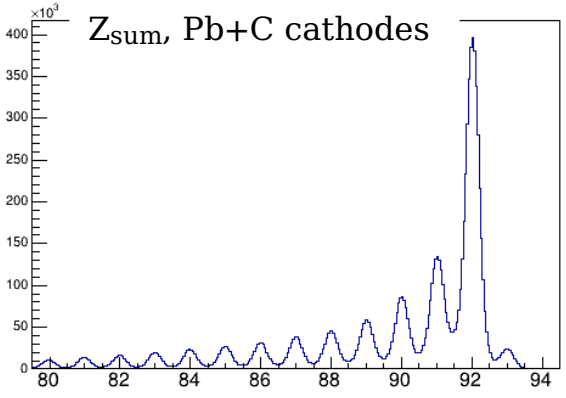
  → Preliminary results for s455 : ^{238}U(γ,f)

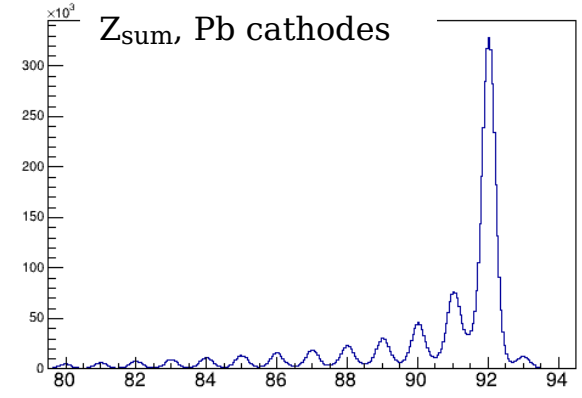


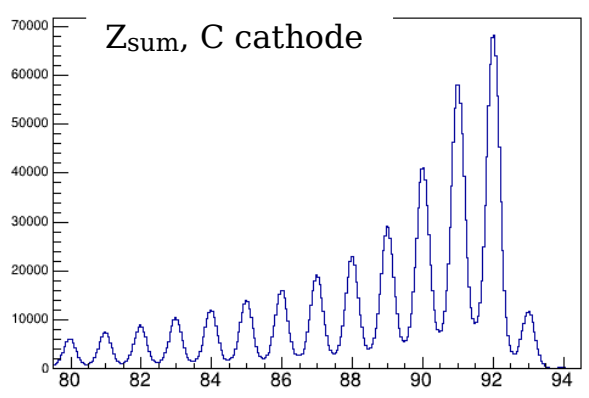


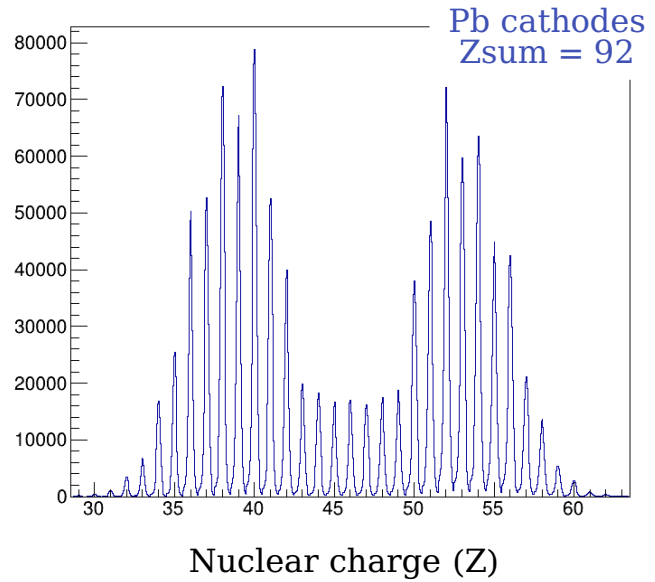












OK

1. Standard mass analysis

GLAD considered as a DIPOLE with an homogeneous magnetic field

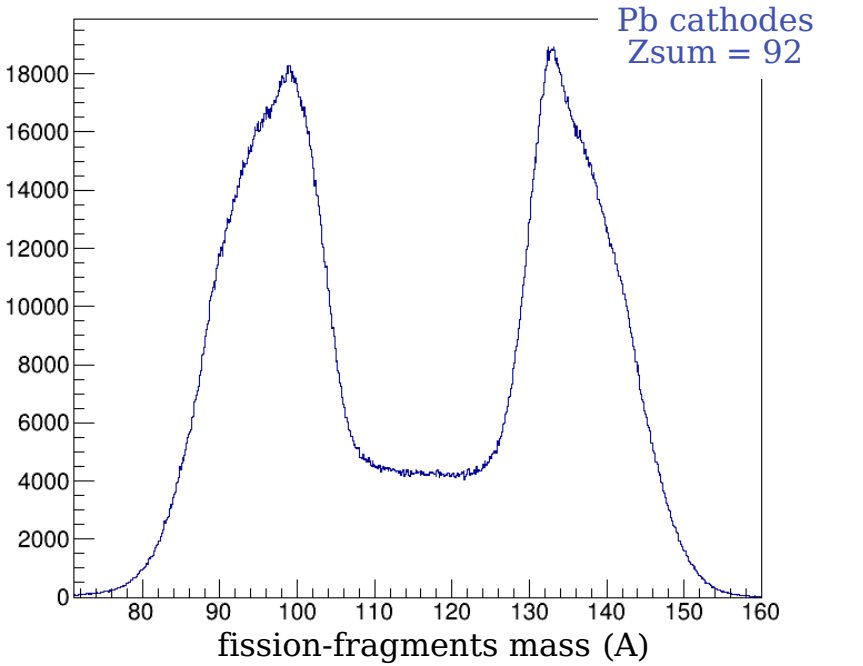
With a basic tracking

GLAD field as a DIPOLE with an homogeneous field on a fix effective length

- From the map field: ⟨By⟩ = 2.225T and ⟨Leff⟩ = 2211.8 mm

SOFIA-2021

before calibrations and nuclear subtraction



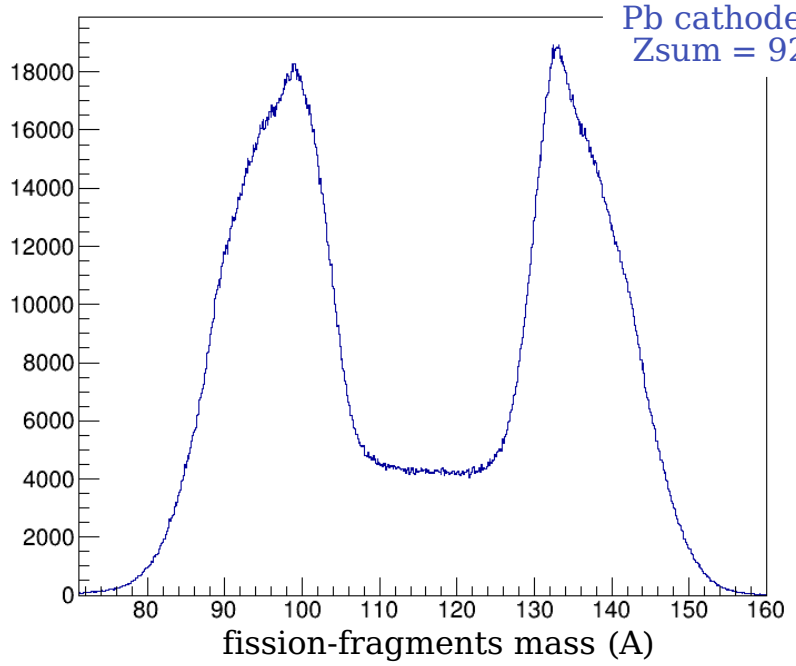
Importance of ^{238}U(,f) data for mass calibration

High statistics in few hours of ^{238}U(γ,f) (A_{FF} << A_{beam})

- Calibration per plastic and variation of the parameters as a function of Z
- Need to cut on a single element per plastic : we need high statistics

SOFIA-2021

before calibrations and nuclear subtraction

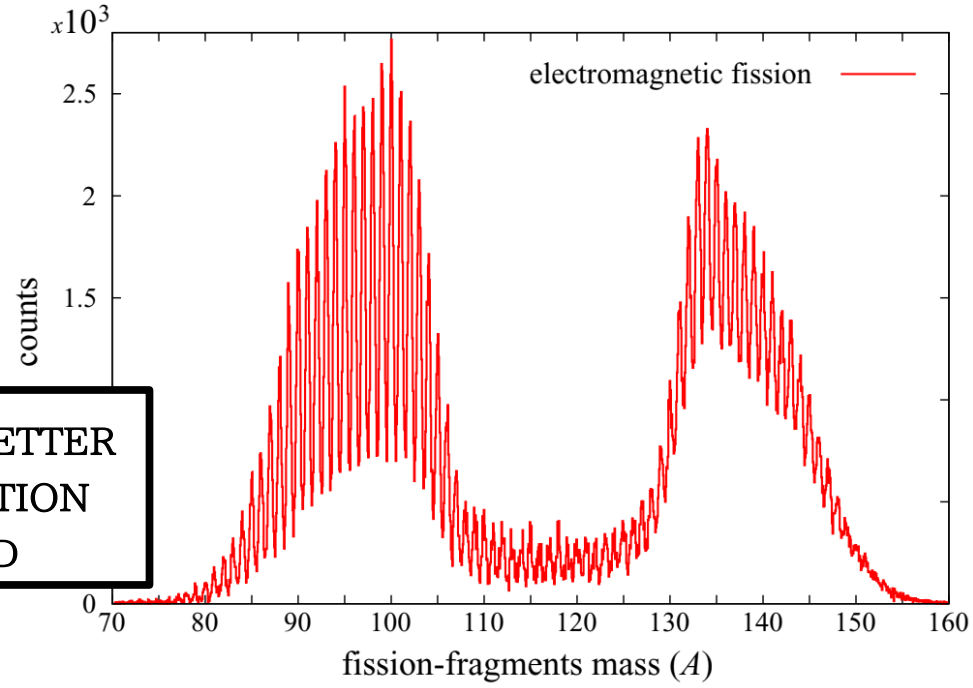


CALIBRATION

WE EXPECT A BETTER MASS RESOLUTION WITH GLAD

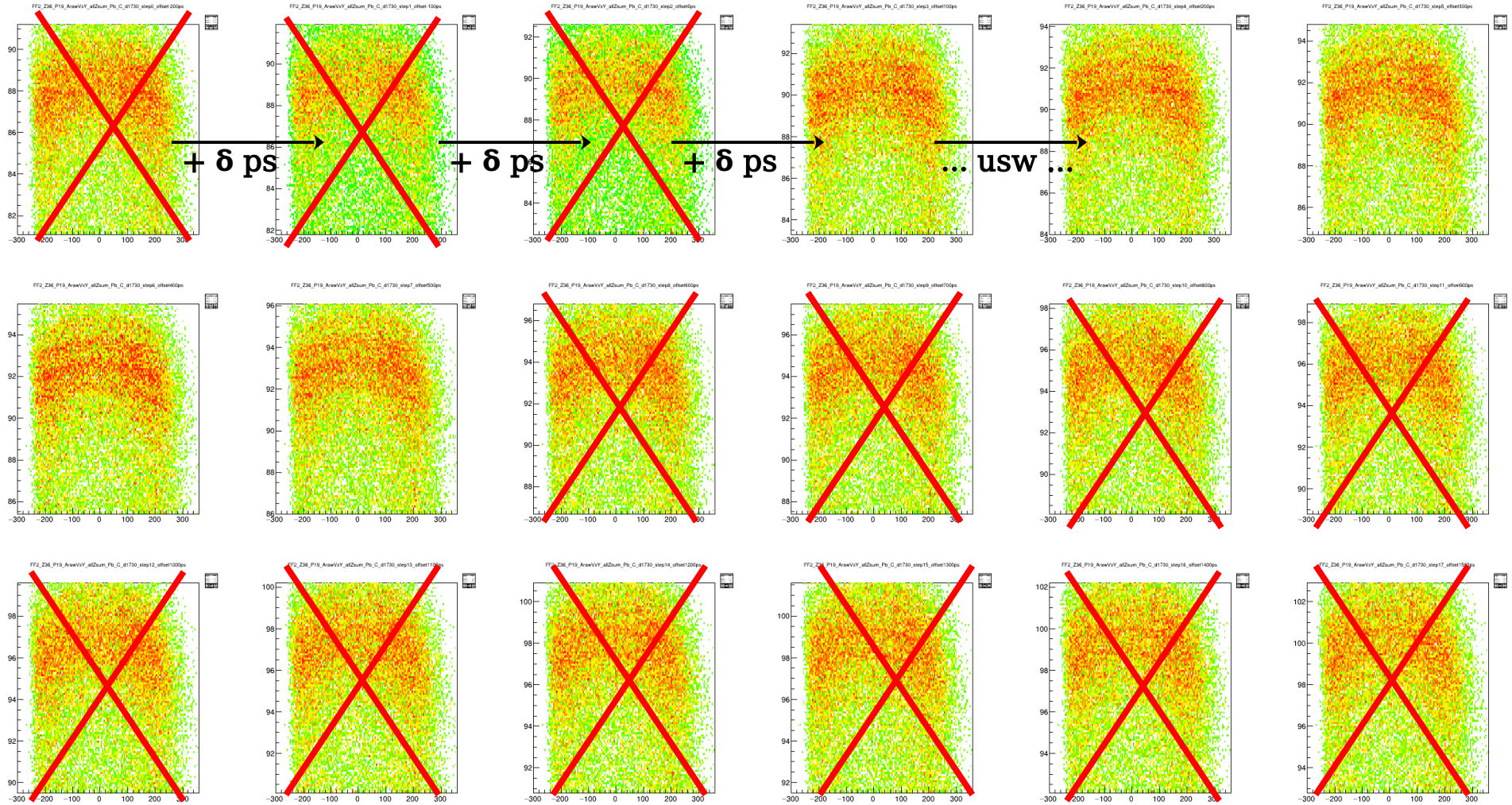
SOFIA-2012 with ALADIN

after calibrations and nuclear subtraction



CALIBRATION STEP 1 : Araw vs Y per Z and P

Ex: case for Z=36, P=19

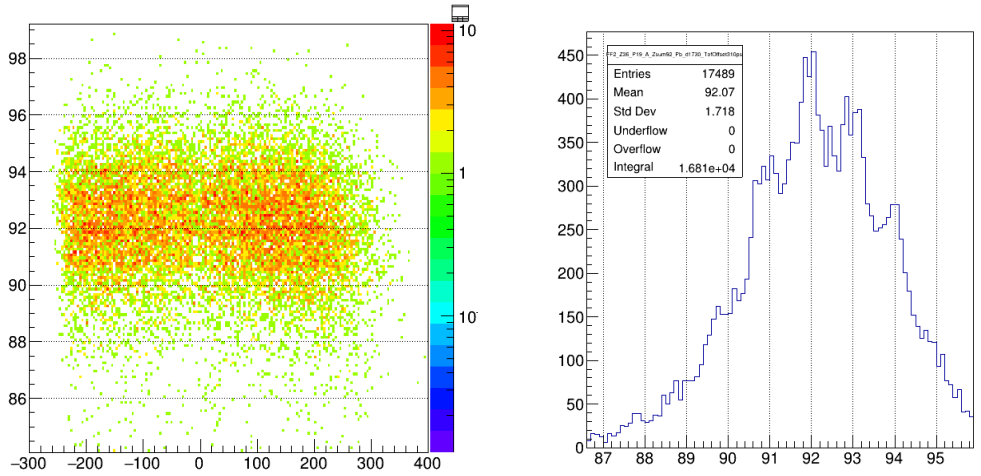


CALIBRATION STEP 1 : A corrected from Y dependency

With the correction of A vs Y obtained with the best δ

- PROBLEM !!!! After Y corrections, no other dependencies observed

  → cannot continue with the standard analysis



- Not promising: mass resolution seems poor even for light FF

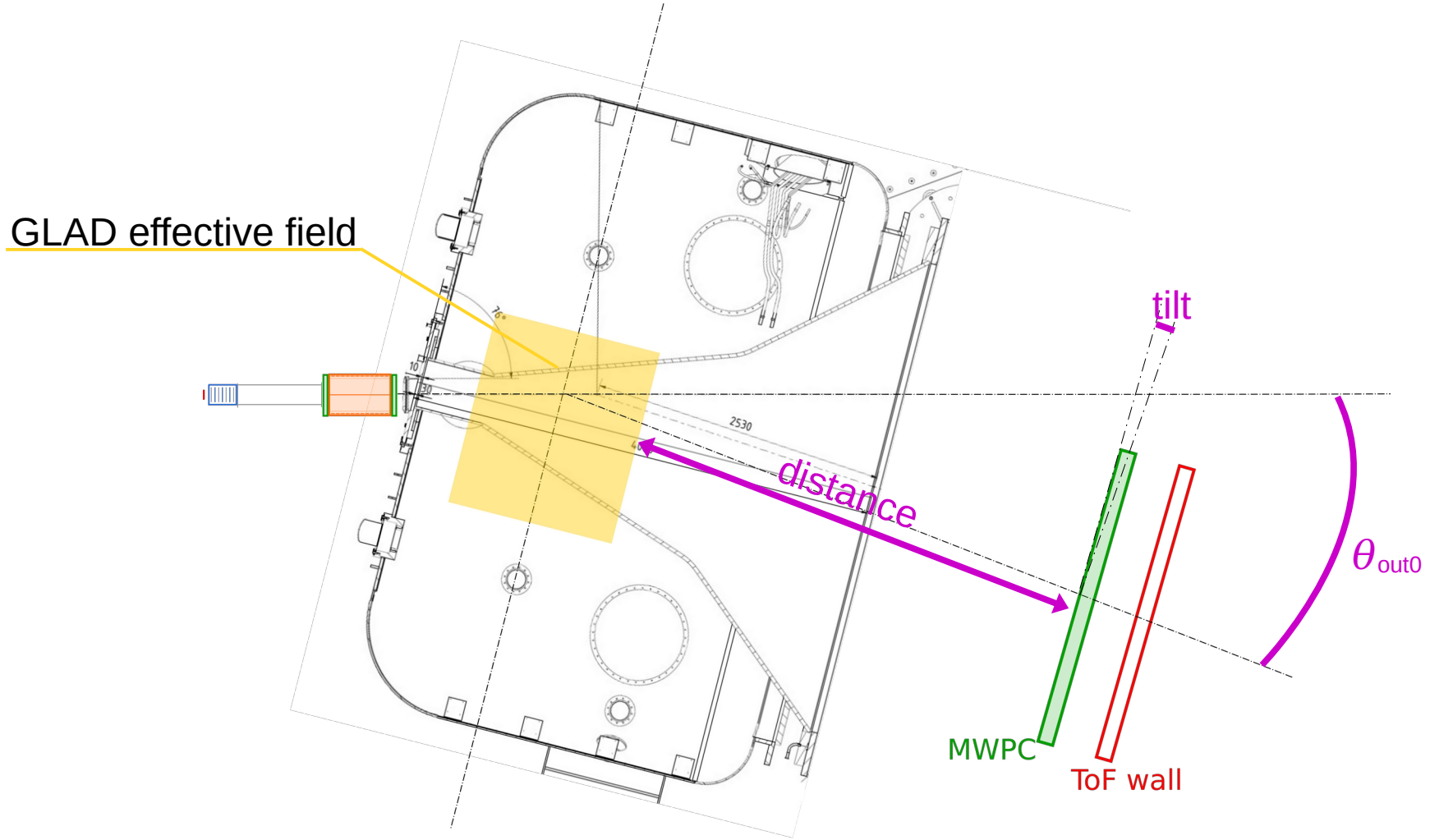
  → problem of resolution in Tof or position ?

  → problem of detectors position : difficult to measure the position and angle of Mw3 and TofW

2. Move Mw3+TofW

3 parameters to « move » Mw3+TofW

Tilt, θ_{out0} and the distance from the effective field

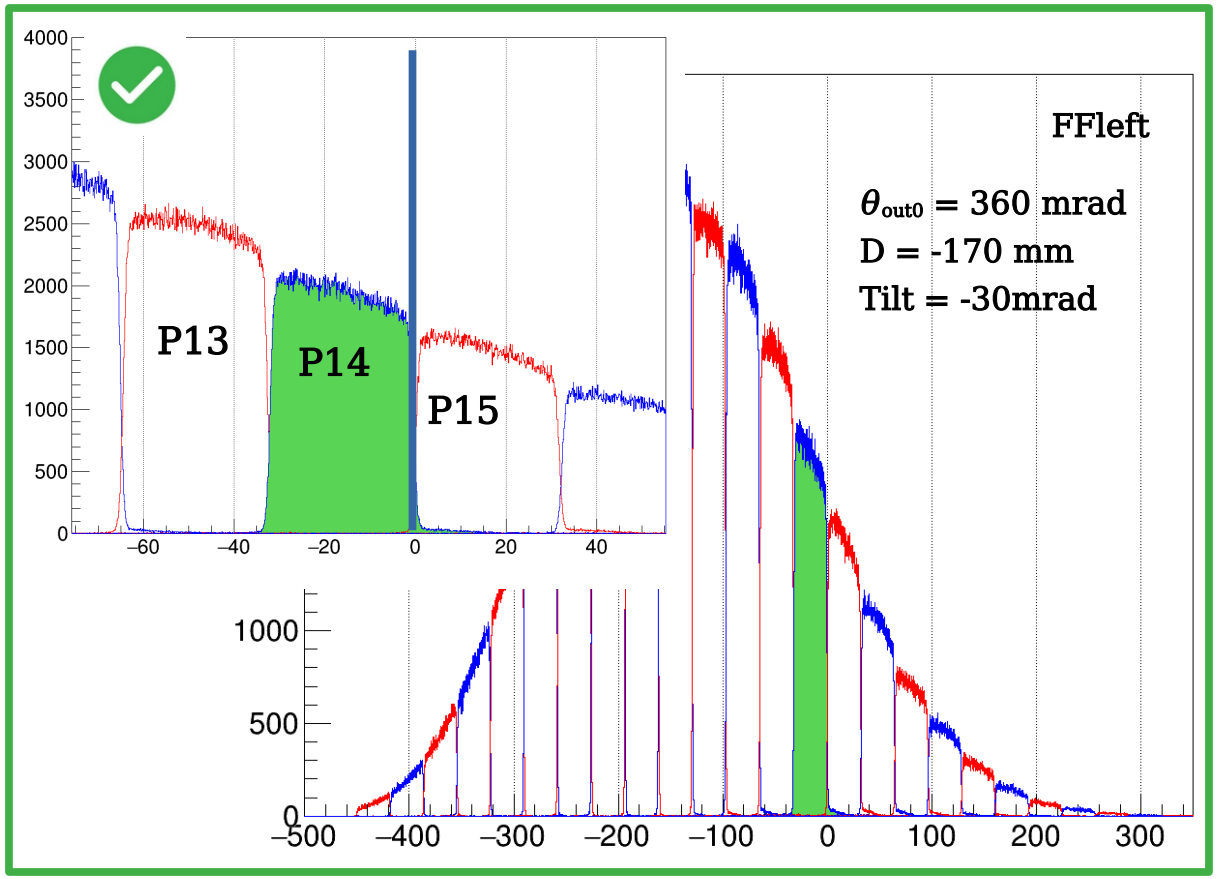


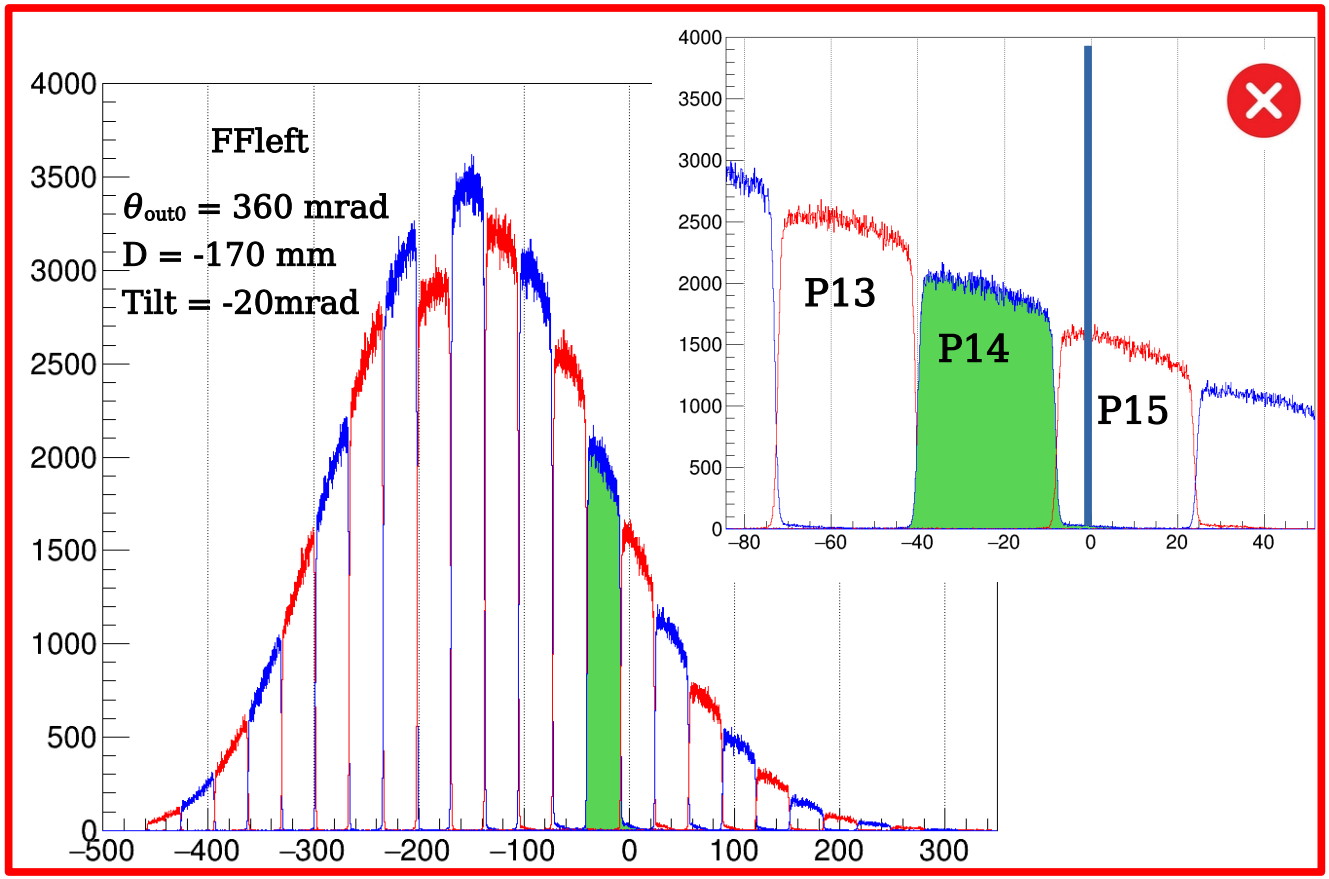
3 parameters to « move » Mw3+TofW

Tilt, θ_{out0} and the distance from the effective field : which criteria ?

- X position reconstructed in the TofW frame

[data: all cathodes, all plastics]

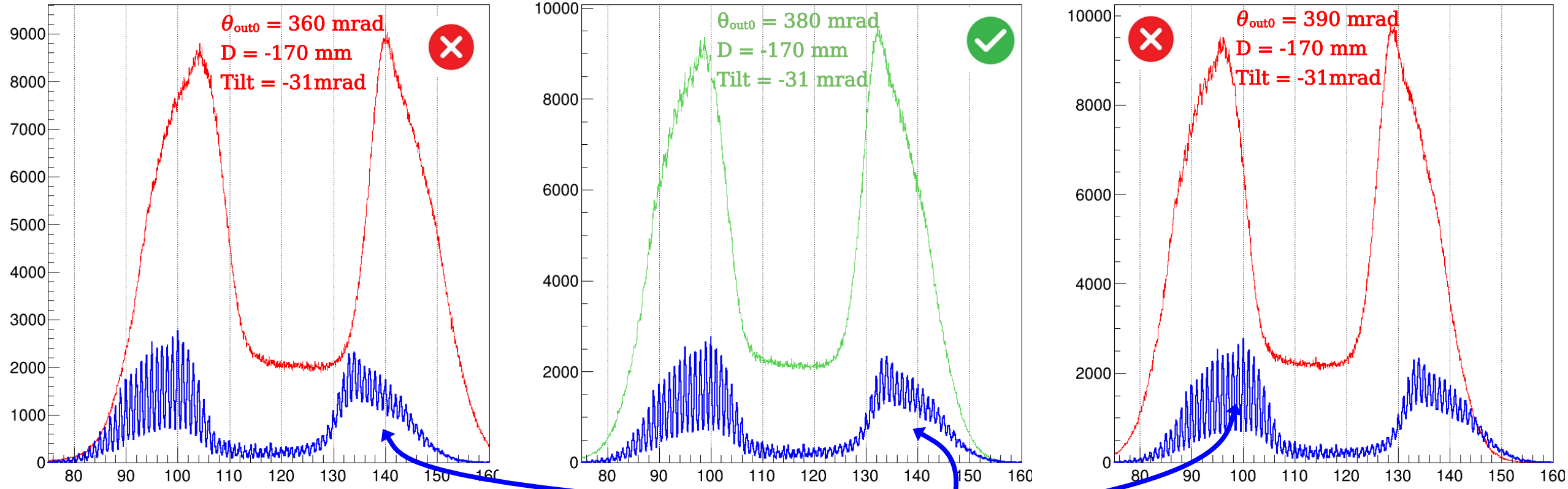




3 parameters to « move » Mw3+TofW

Tilt, θ_{out0} and the distance from the effective field : which criteria ?

- Position reconstructed in the TofW frame `[data: all cathodes, all plastics]`
- Shape of the mass distribution `[data: Pb cathodes, all plastics, Zsum=92]`



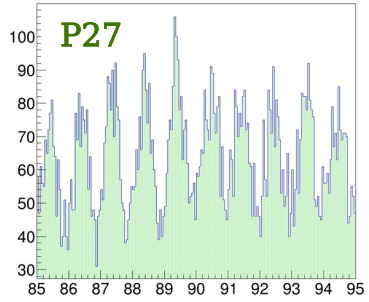
SOFIA 2012 – after calibration
U238 coulex only

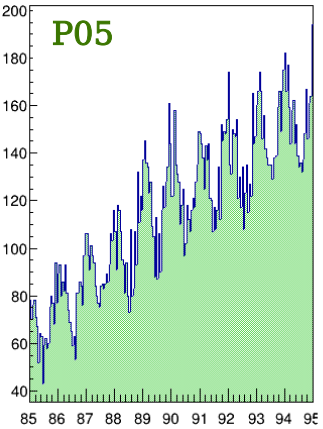
3 parameters to « move » Mw3+TofW

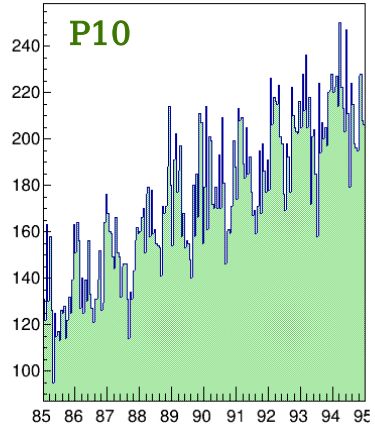
Tilt, θ_{out0} and the distance from the effective field : which criteria ?

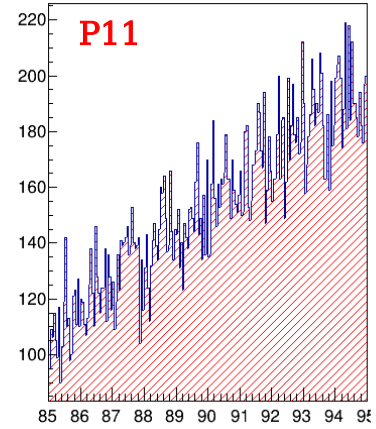
- Position reconstructed in the TofW frame `[data: all cathodes, all plastics]`
- Shape of the mass distribution `[data: Pb cathodes, all plastics, Zsum=92]`
- Mass resolution for light masses `[data: all cathodes, per P, all Z, Y +/- 5cm]`

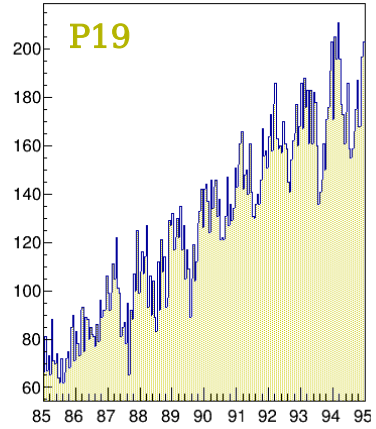
  → Best compromise with the best A resolution for most plastics
- Masses are observed for most plastics **without correction (only with Y cut)**.
- Very encouraging mass spectrum per plastic before any calibration

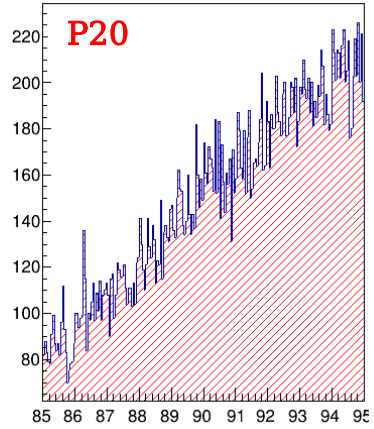


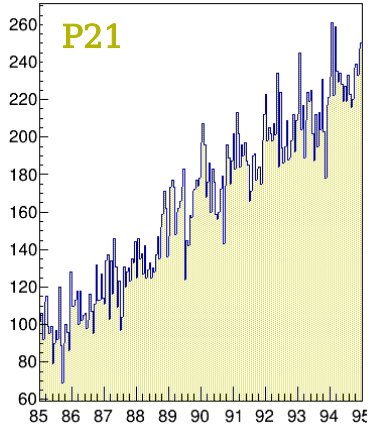


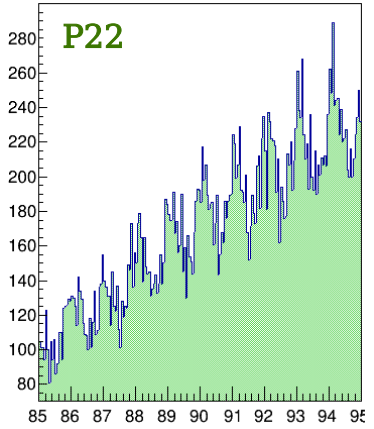








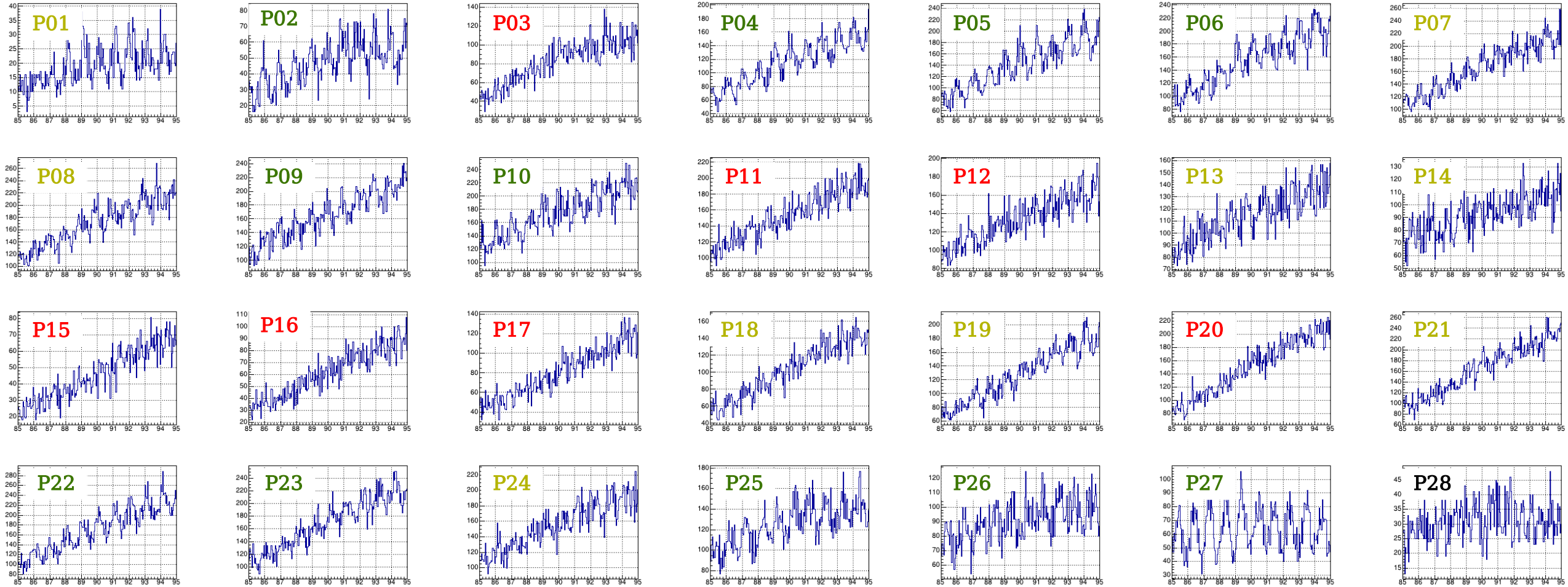




« Move » Mw3+TofW

Tilt=-31mrad, θ_{out0} = 372 mrad, d=-175mm from nominal position, CutY = +/-50mm

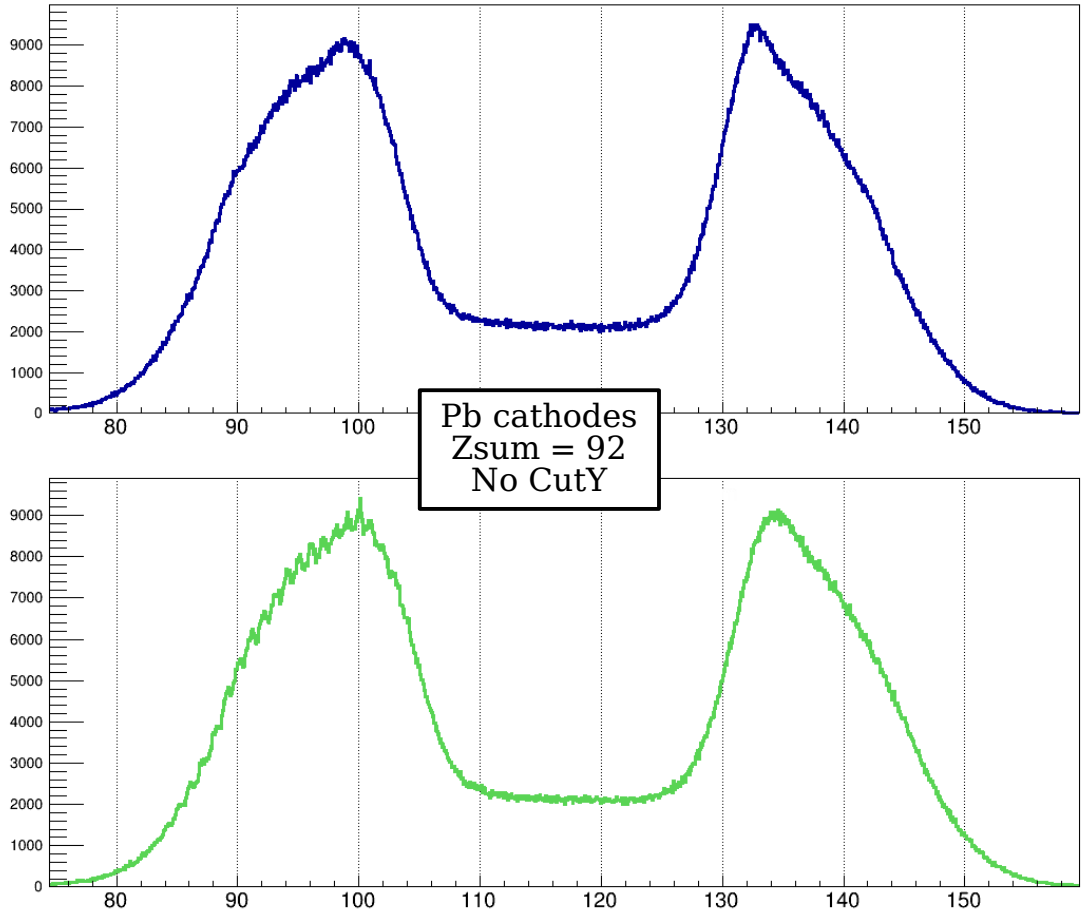
- In general, it seems better on the left and right than in the center



With the new geometry of Mw3+TofW

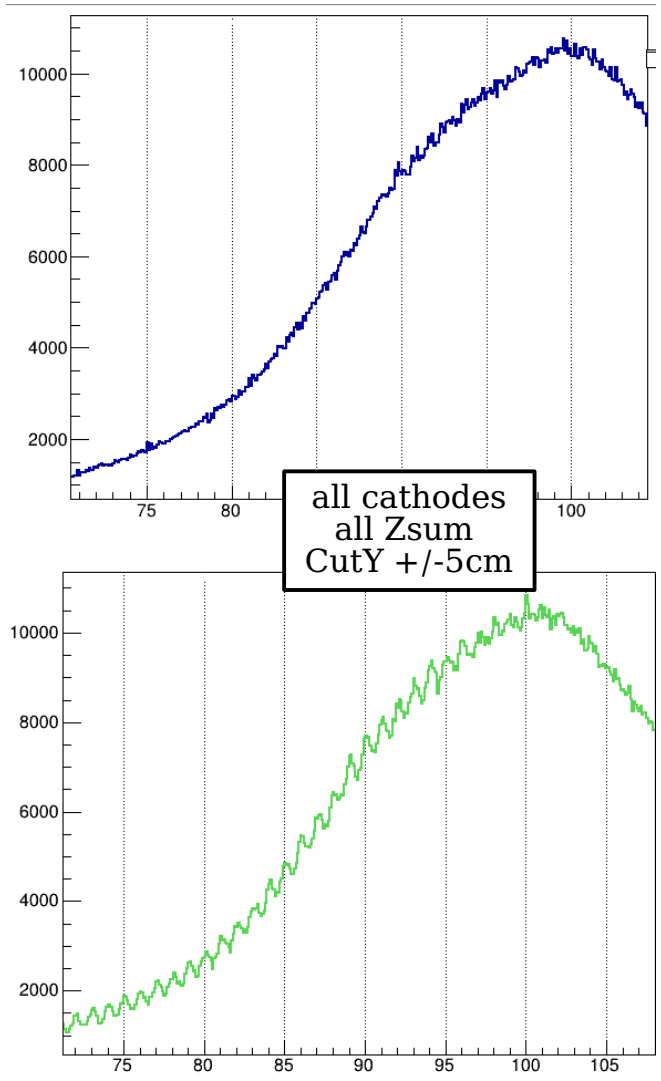
Tilt=-31mrad, θ_{out0} = 372 mrad, d=-175 from nominal position

- Very encouraging mass spectrum before any calibration



with the
"old" geometry

with the
new geometry



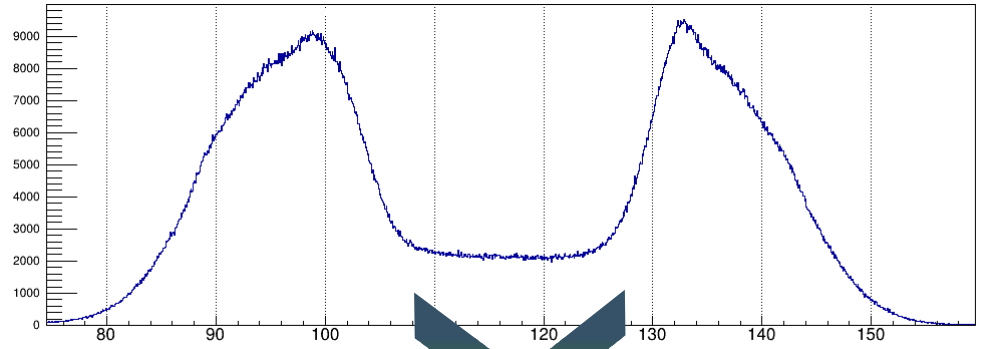
3. Tof offsets (δ) per P & Walk correction

Back to the STEP 1 calibration :)

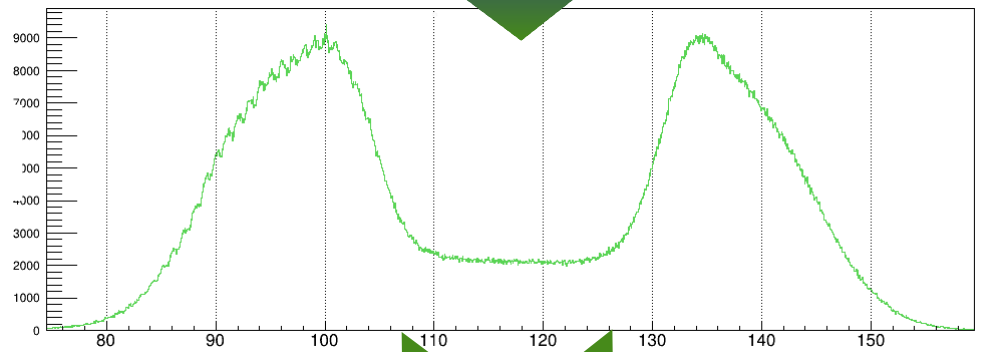
in order to get the full Y range

Pb cathodes only, Z_{sum}=92, all plastics

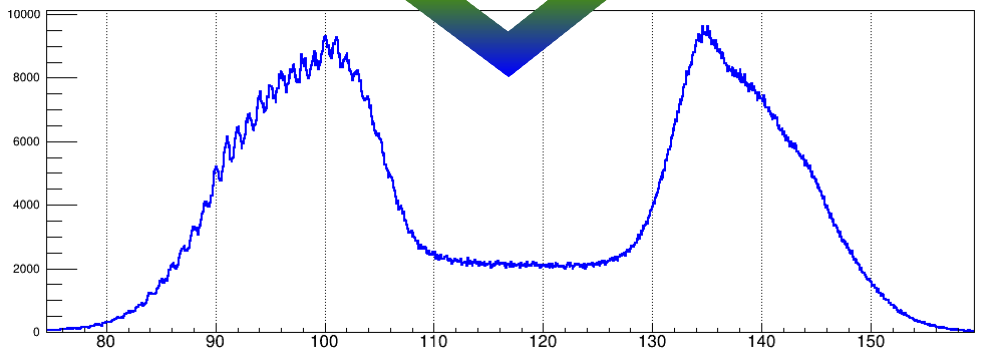
with the "old" geometry



with the new geometry

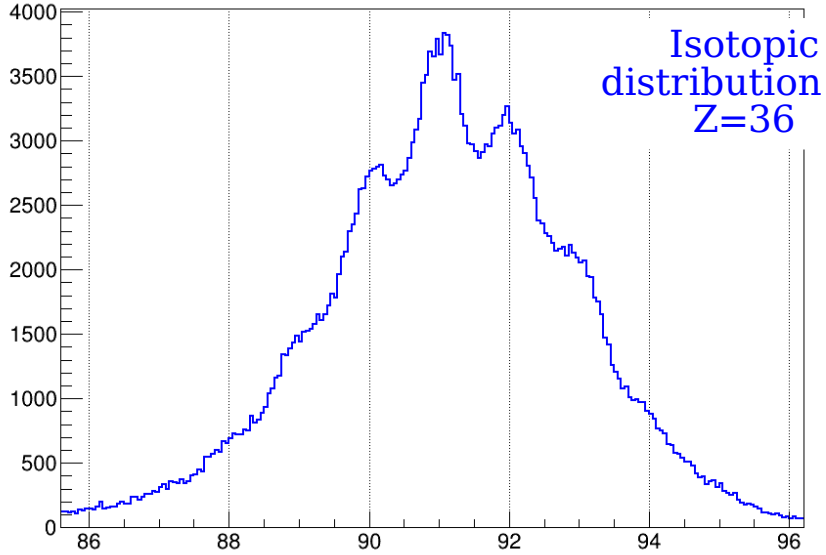


with the correction of Y dependency + best δ



Encouraging,

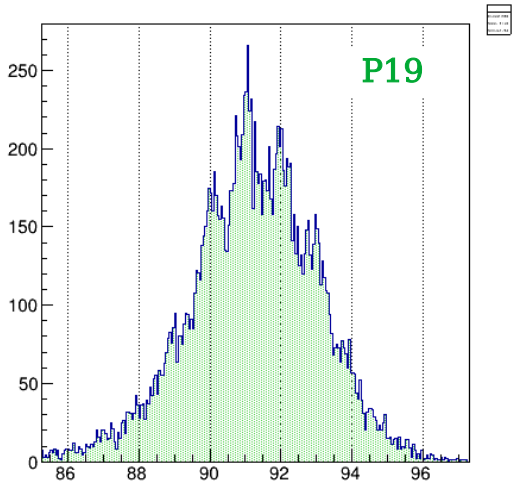
But before to continue the corrections…

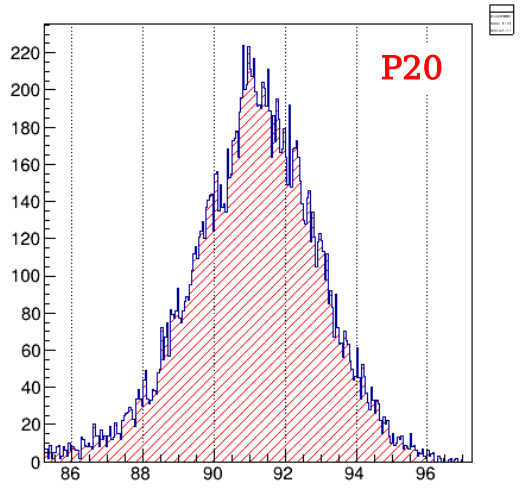


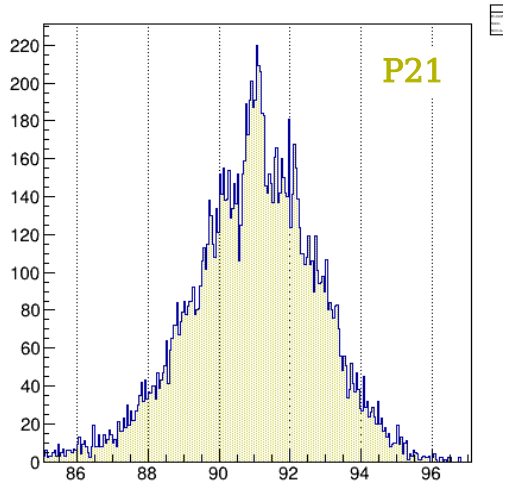
Isotopic distribution for Z=36

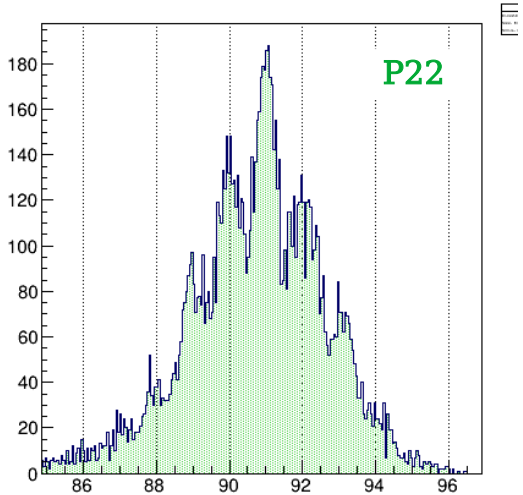
Answer to plenty of open questions ... I

- **Why some plastics have a degraded mass resolution compare to others ?**









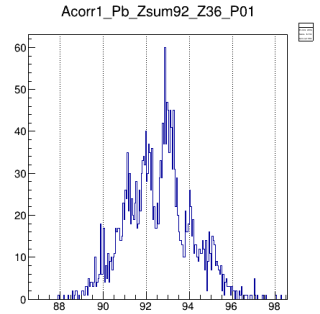
→ detection problem (optical glue) ?

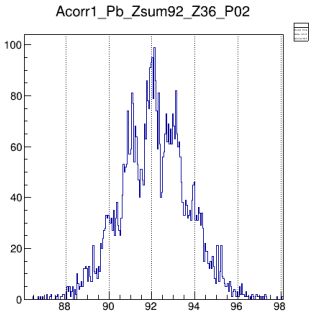
→ some PMTs suffered from the field (despite the double mu-metal shielding) ?

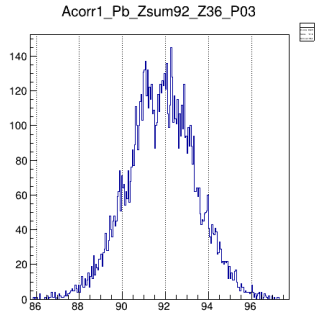
→ calibration of the θin (from Twin-MUSIC) imperfect ?

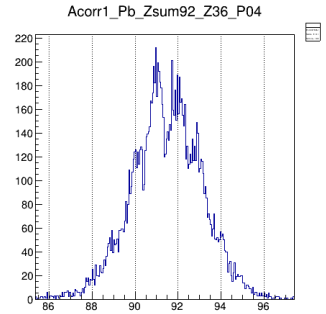
Answer to plenty of open questions ... II

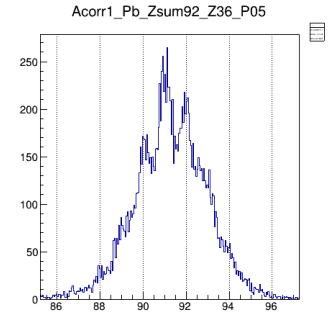
- **Why the mass resolution on the left side of the SofTofW decrease and increase again ?**

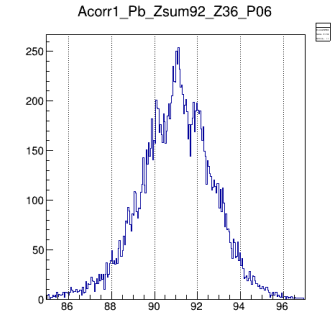


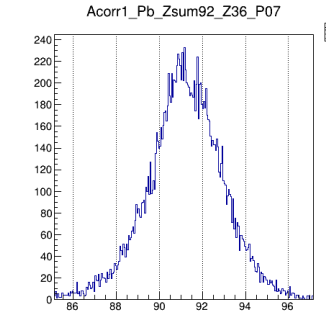


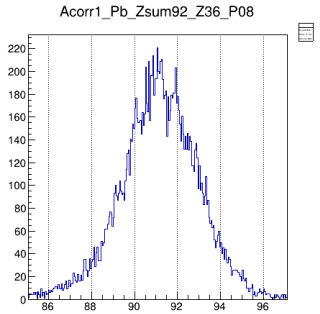


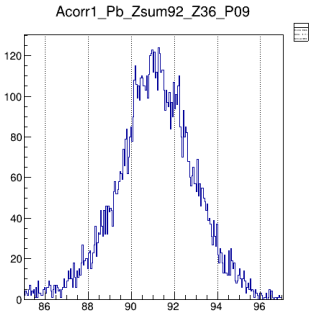


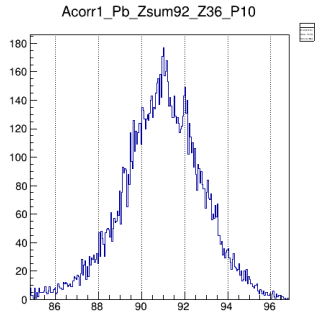


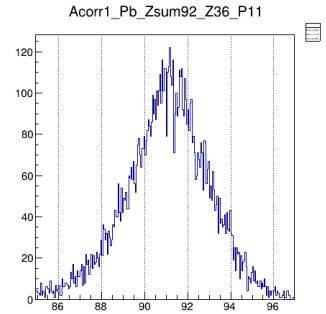


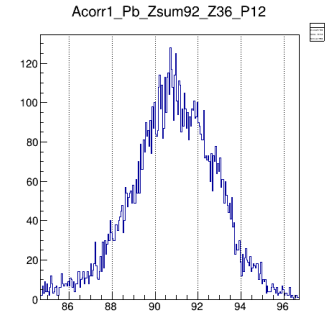


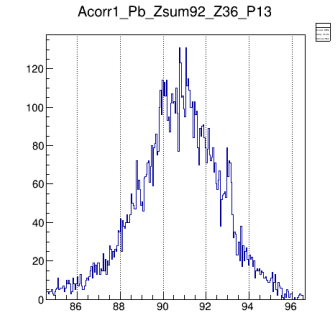


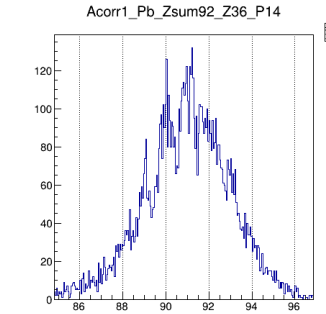












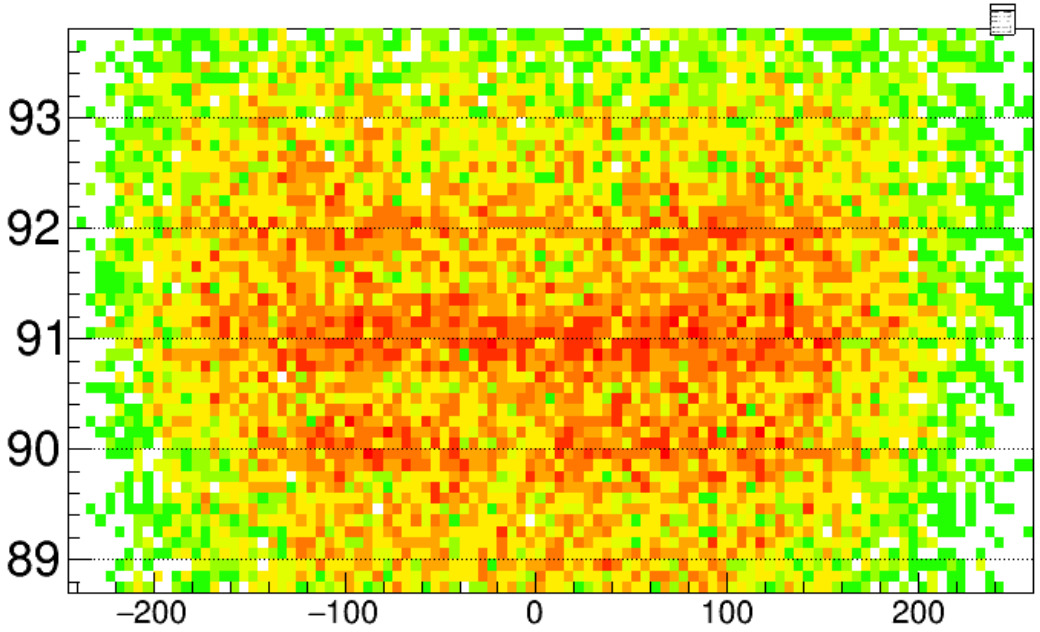
→ field inhomogeneity (already proven by Aleksandra, Michael and Valerii)

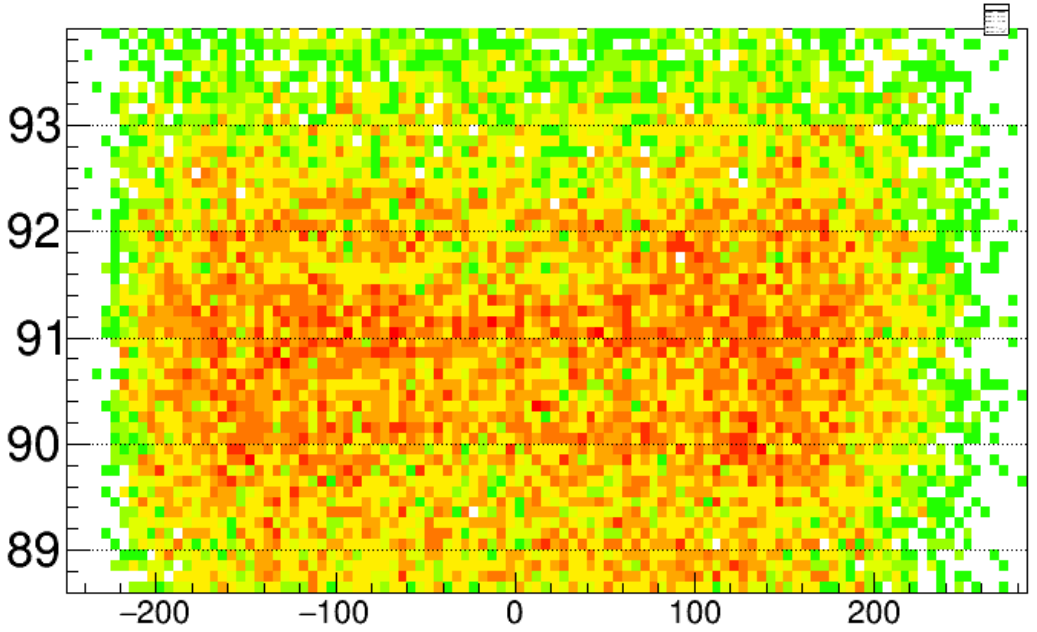
→ calibration of the θin (from Twin-MUSIC) imperfect ?

Answer to plenty of open questions ... III

- **Mass resolution can fluctuate depending on Y position (see A vs Y)**

P05





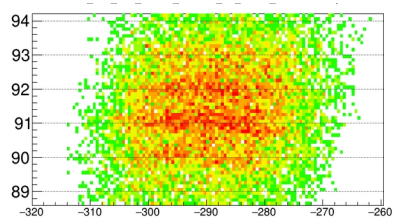
P06

→ field inhomogeneity (already proven by Aleksandra, Michael and Valerii)

Conclusion

- This is only a starting point

- For most plastics, masses are observed but with different mass resolution
  → when peaks are observered, other dependencies are also observered
  → resolution should improve



- If GLAD cannot be considered as a dipole, and field inhomogeneity is the main issue:
  → tracking based on the theoretical field map should help
  → 238U data are perfect to test such a tracking (high statistics & large angle)

- Thanks to the U238 data, it will anyhow be possible to calibrate <A> per Z
  → **Encouraging to complete the neutron-deficient pre-actinides fission study**

Thank you for your attention