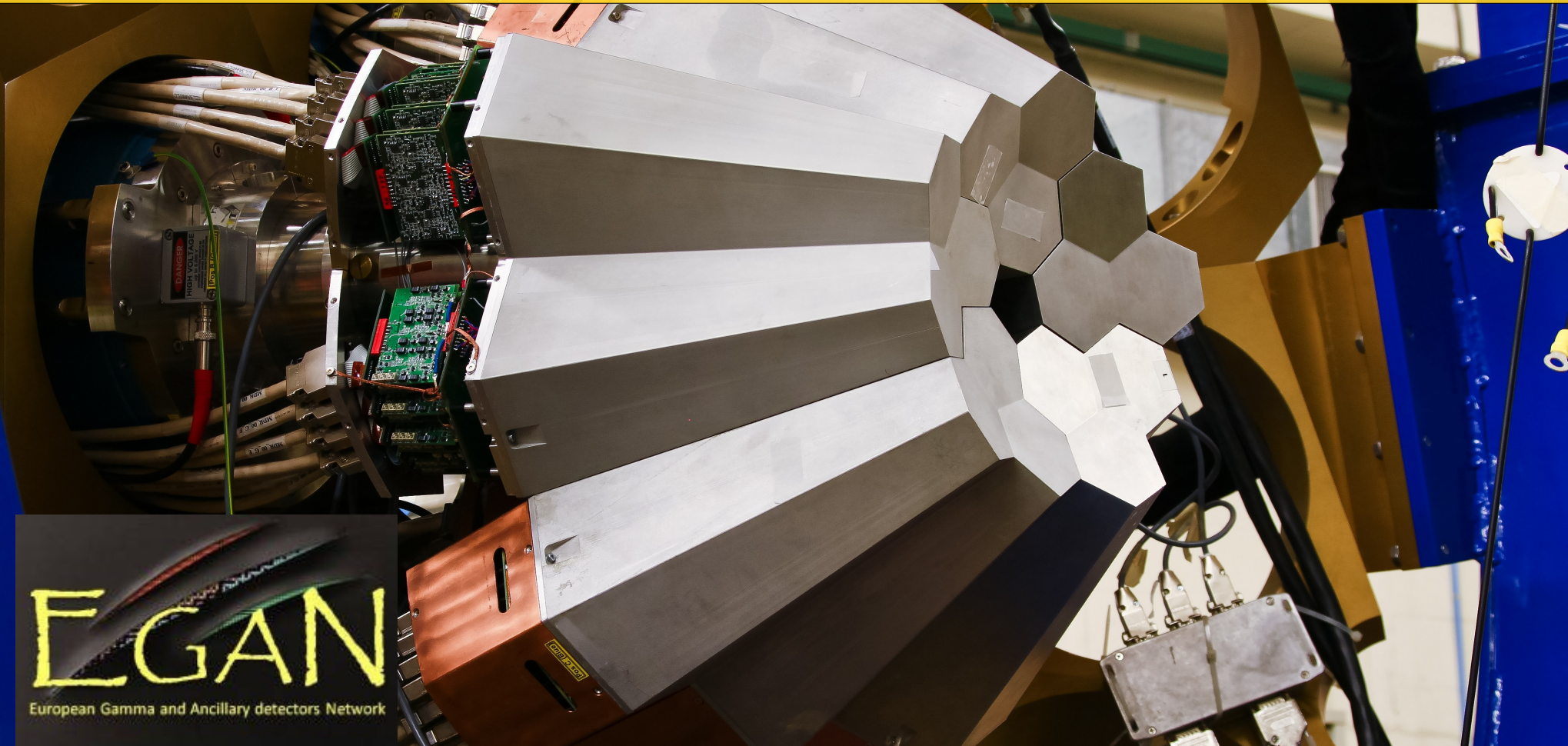


Spectroscopy of neutron rich Th and U nuclei after multi-nucleon reactions



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Physics motivation: spectroscopy of neutron rich $Z=90-92$ actinides

- Recent theoretical investigation of the neutron rich actinide nuclei
 - Shell Correction Energy
A.SOBICZEWSKI, I. MUNTIAN, Z. PATYK, PHYS. REV. C, 63 (2001) 034306
 - Alternative Parity States
SHNEIDMAN, ET AL. PHYS. REV. C 74, 034316 (2006)
 - Mean field and beyond mean field calculations, Gogny force
J.-P. DELAROCHE ET AL. NUCLEAR PHYSICS A 771 (2006) 103–168
 - Relativistic nuclear energy density functionals
D. VRETENAR, ET AL., INT. JOURNAL OF MODERN PHYSICS E (2010)
- Experimental proof of theories needed for extrapolation to SHE
- Explore hardly accessible actinide region with multi nucleon transfer
 - Feasibility of recoil coincidence method (Prisma / Dante)
 - Prisma clara experiment showed good results

Experimental setup

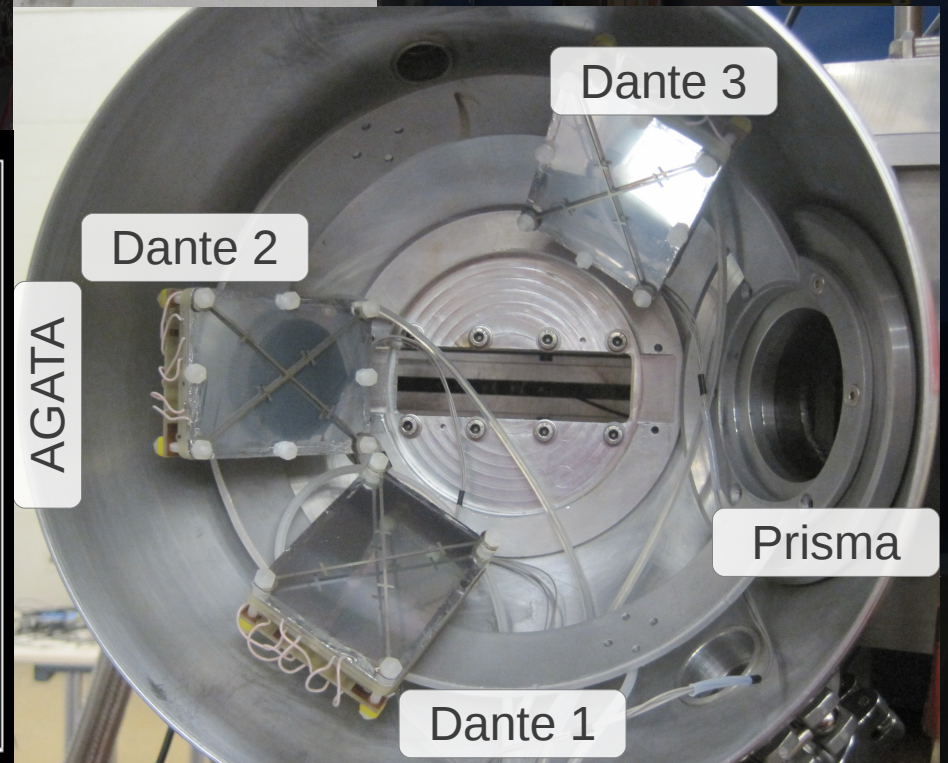
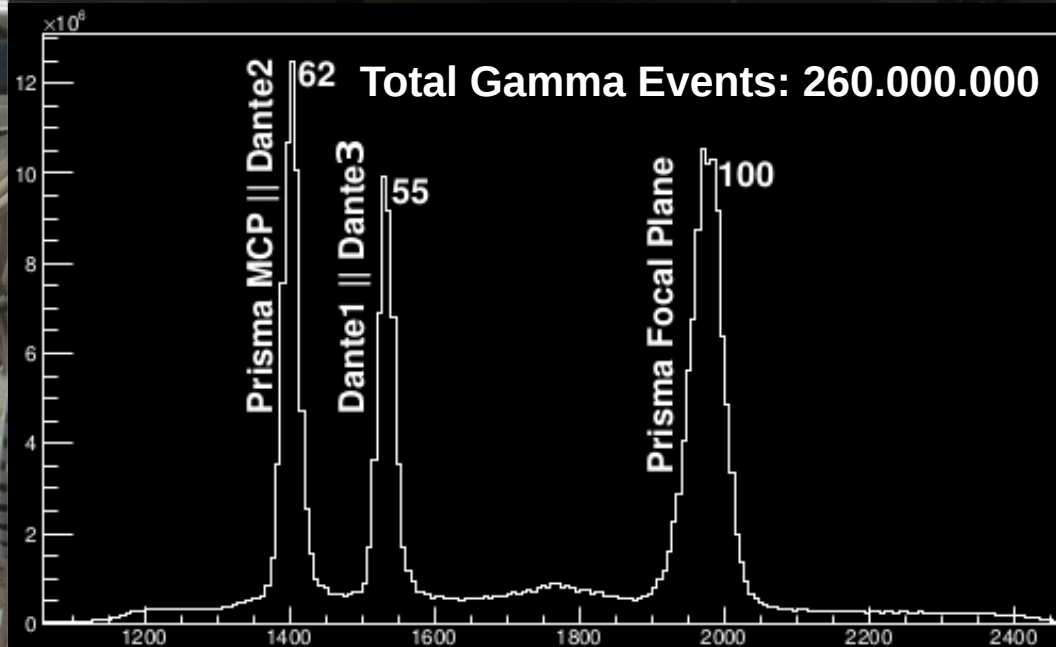
Experiment 11.22 – October 2011
97 h of beam time

Beam: ^{136}Xe
1 GeV – 2 PnA
Target: ^{238}U (1 or 2 mg / cm²)
Nb Backing (~ 0.7 mg / cm²)
Vertical to beam axis
Prisma: Rotated by 50°
AGATA: 5 ATC in Operation
Dante: 3 Dante MCP
58° Ring

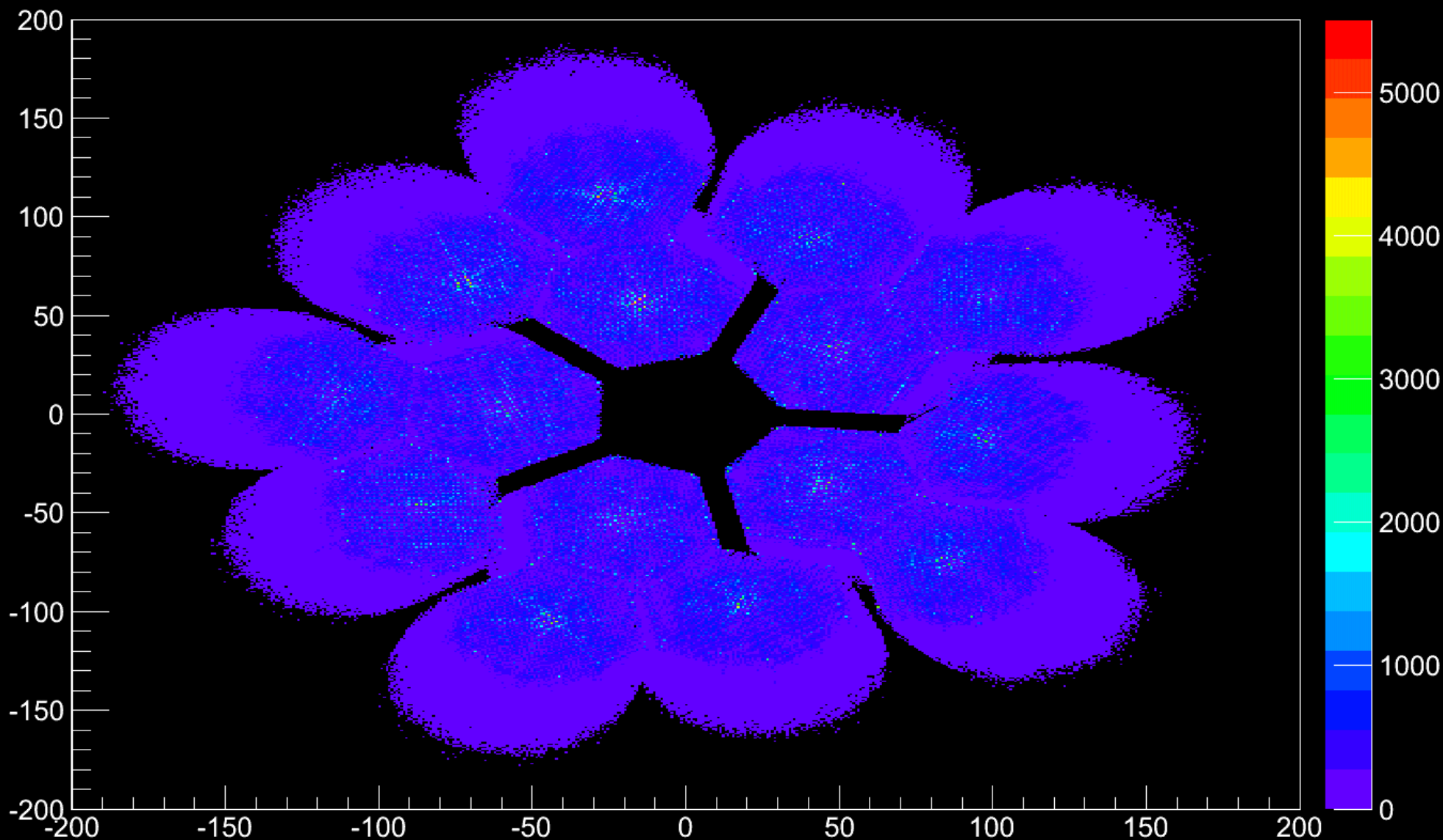


Trigger Conditions

PRISMA Focal Plane
||
Dante 2 && Prisma MCP
||
Dante 1 && Dante 3



AGATA – Advanced Gamma Tracking Array



Position resolution $\sim 5\text{mm}$
Energy resolution $\sim 2.5\text{ keV @ } 1.3\text{ MeV}$
Full Reconstruction of Gamma Events

More Information:
AGATA—Advanced GammaTrackingArray, NIM A, 668(2012)26–58

Prisma Calibration

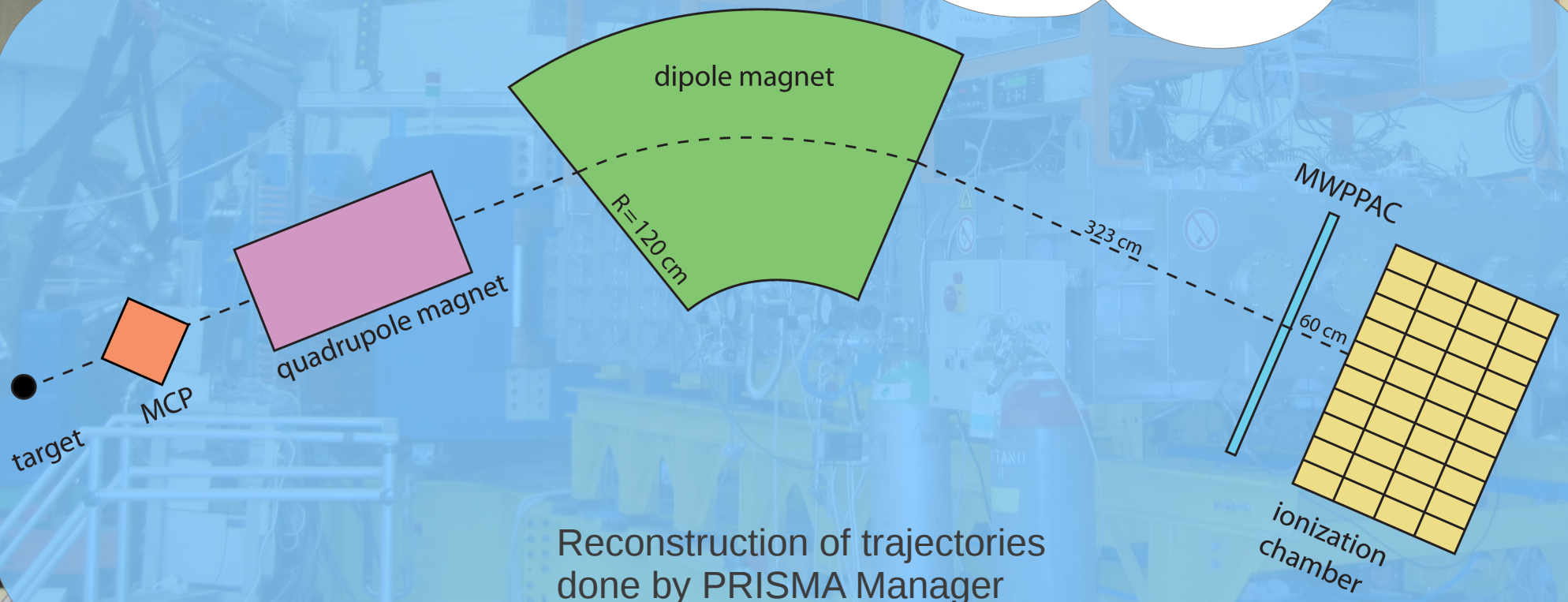
- + Calibration of MCP entrance Detector
- + Calibration of MWPPAC Focal Plane
- + Calibration of Ionisation Chamber
- + Alignment of TOF

Prisma Analysis

- Z Identification (dE/E from IC)
- Charge State Identification
- A Identification

Details can be found in
Bachelor thesis of Andreas Vogt

<http://www.ikp.uni-koeln.de/groups/reiter/publikationen.html>



Reconstruction of trajectories
done by PRISMA Manager

Analysis Scheme

Femul - Replay of Data
+ Full Data
+ Merging of Ancillaries
+ Recalibration

7 TByte

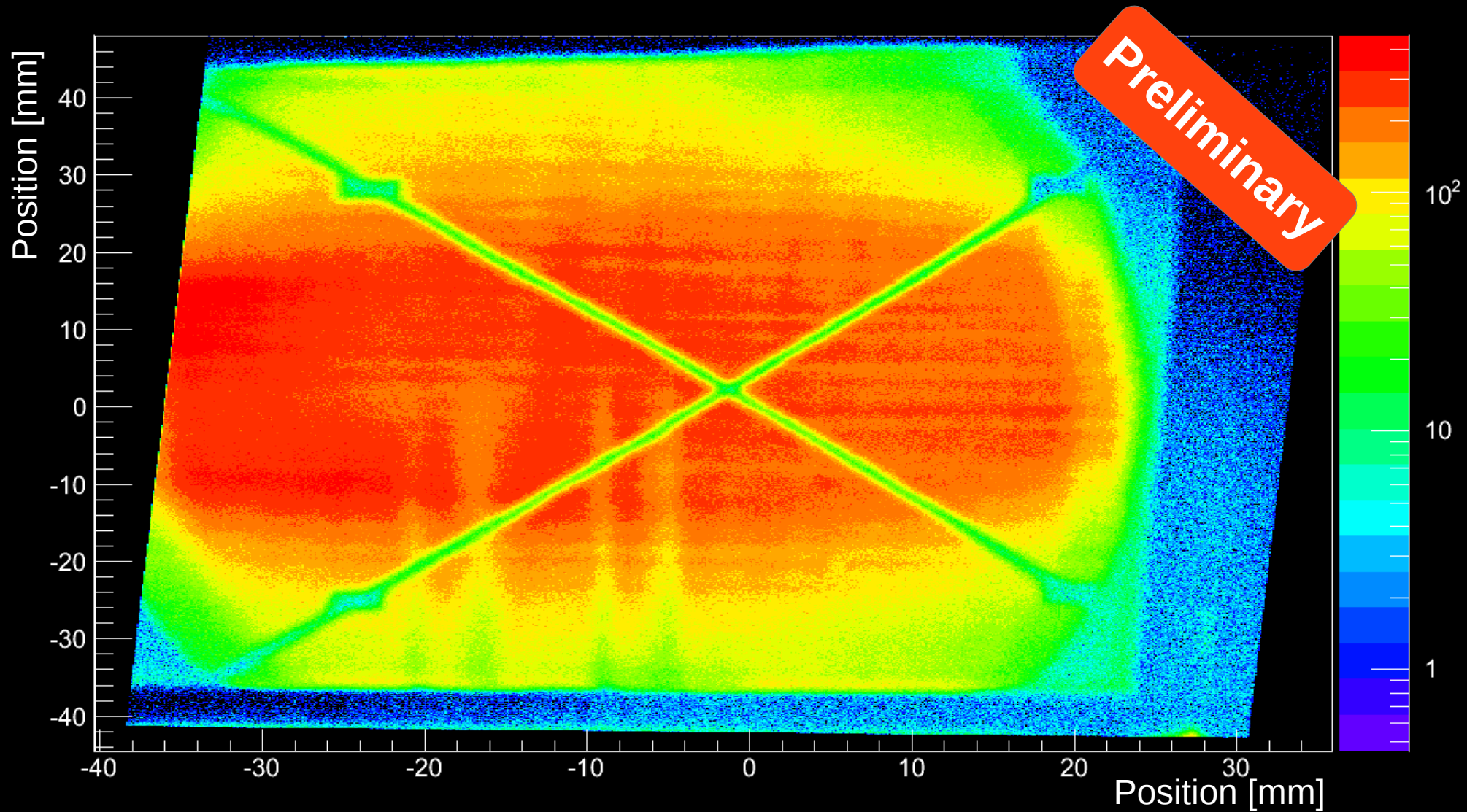
GammaWare / Watcher / PRISMA
Generate Calibrated Root-Tree
+ Spacial Calibrations
+ Complete Prisma Analysis
+ ROOT Tree

200 GByte

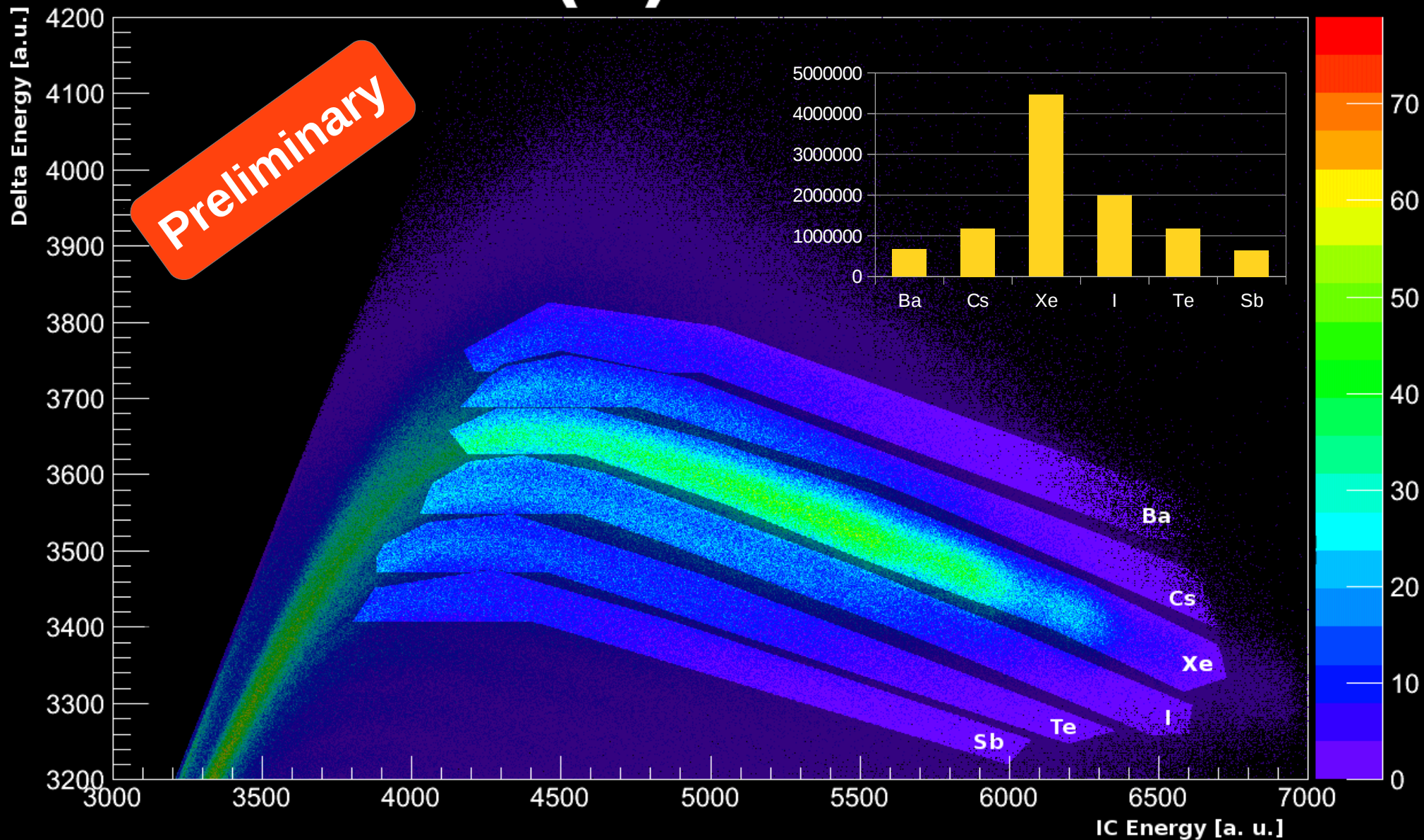
ROOT / hdtv
+ Doppler Correction
+ Tests
+ Cuts
+ Spectra

PRISMA MCP Calibration

MCP calibrated



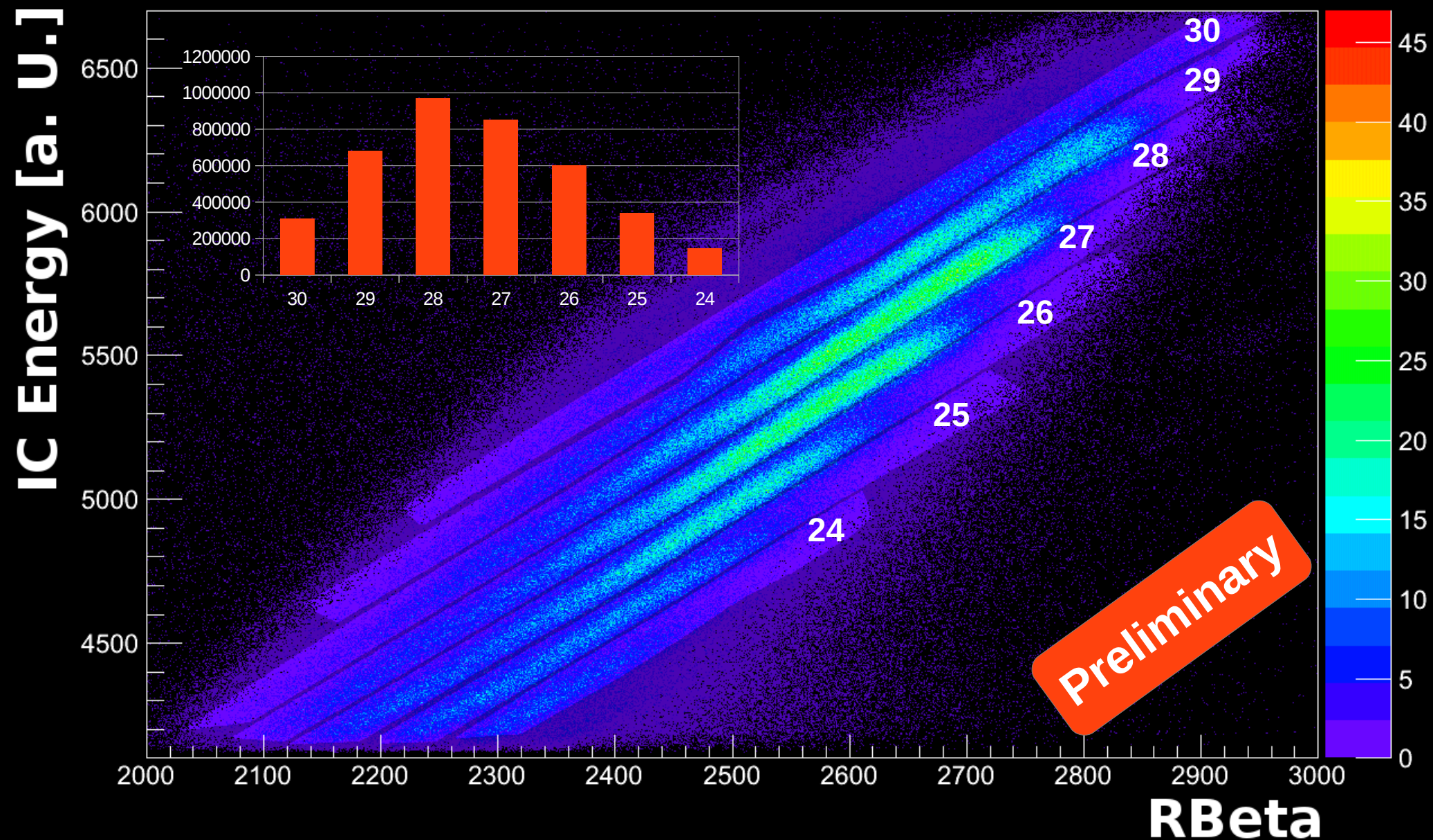
Element (Z) Identification



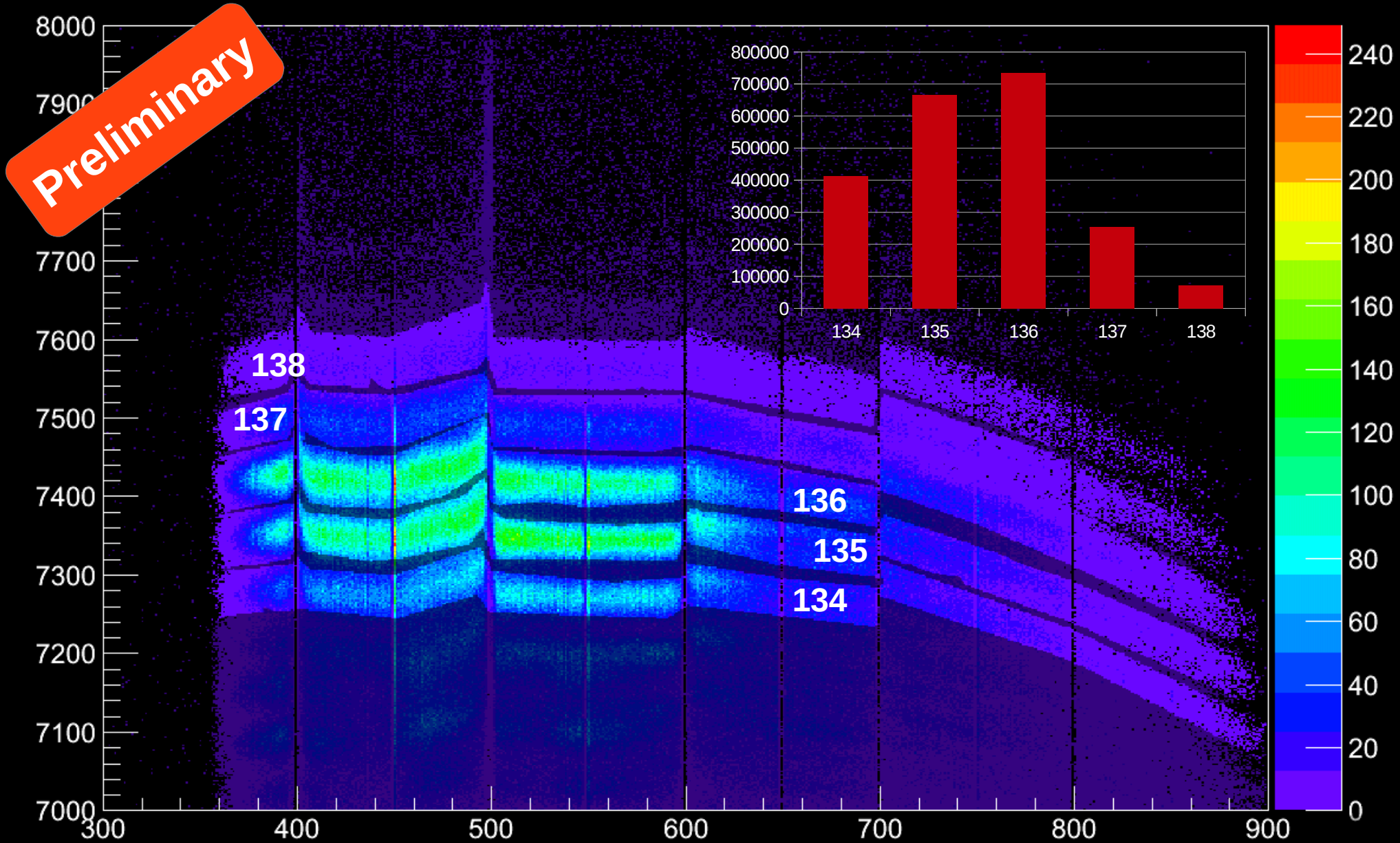
Preliminary

Only straight trajectories were used !

Charge State Identification for Z=54 (Xe)

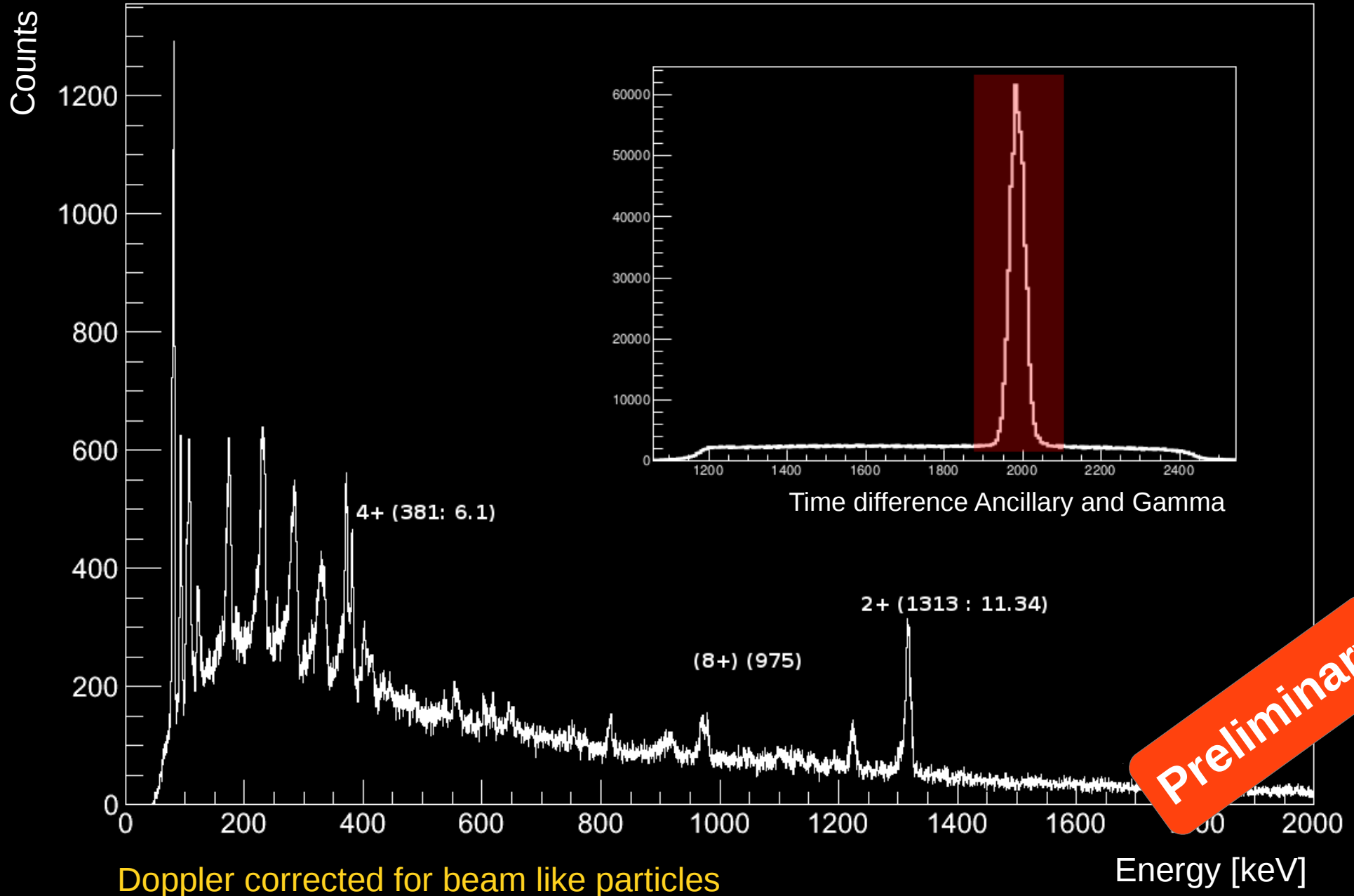


Mass (A) Identification for Z=54 (Xe)

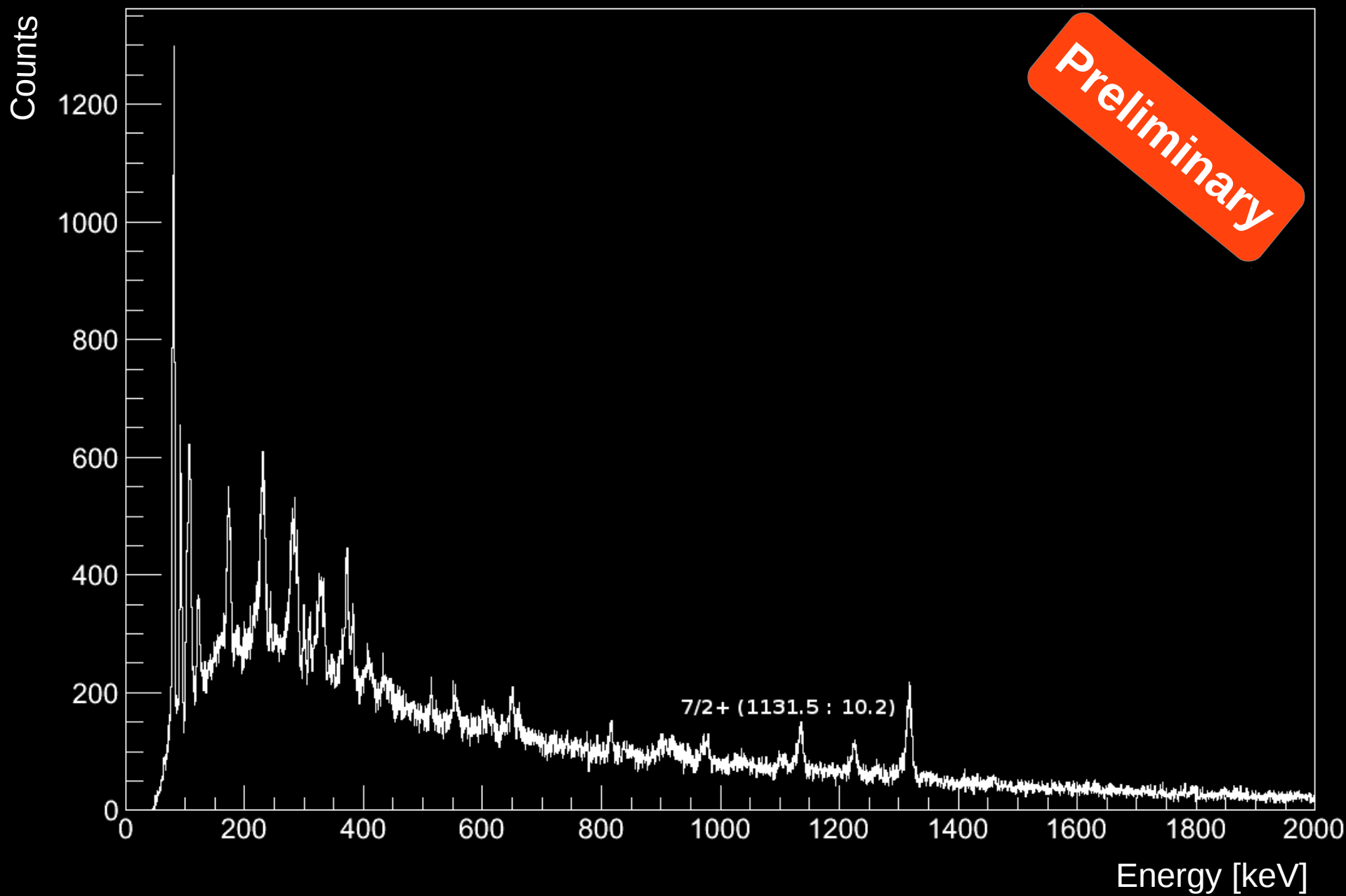


Aberration correction done!

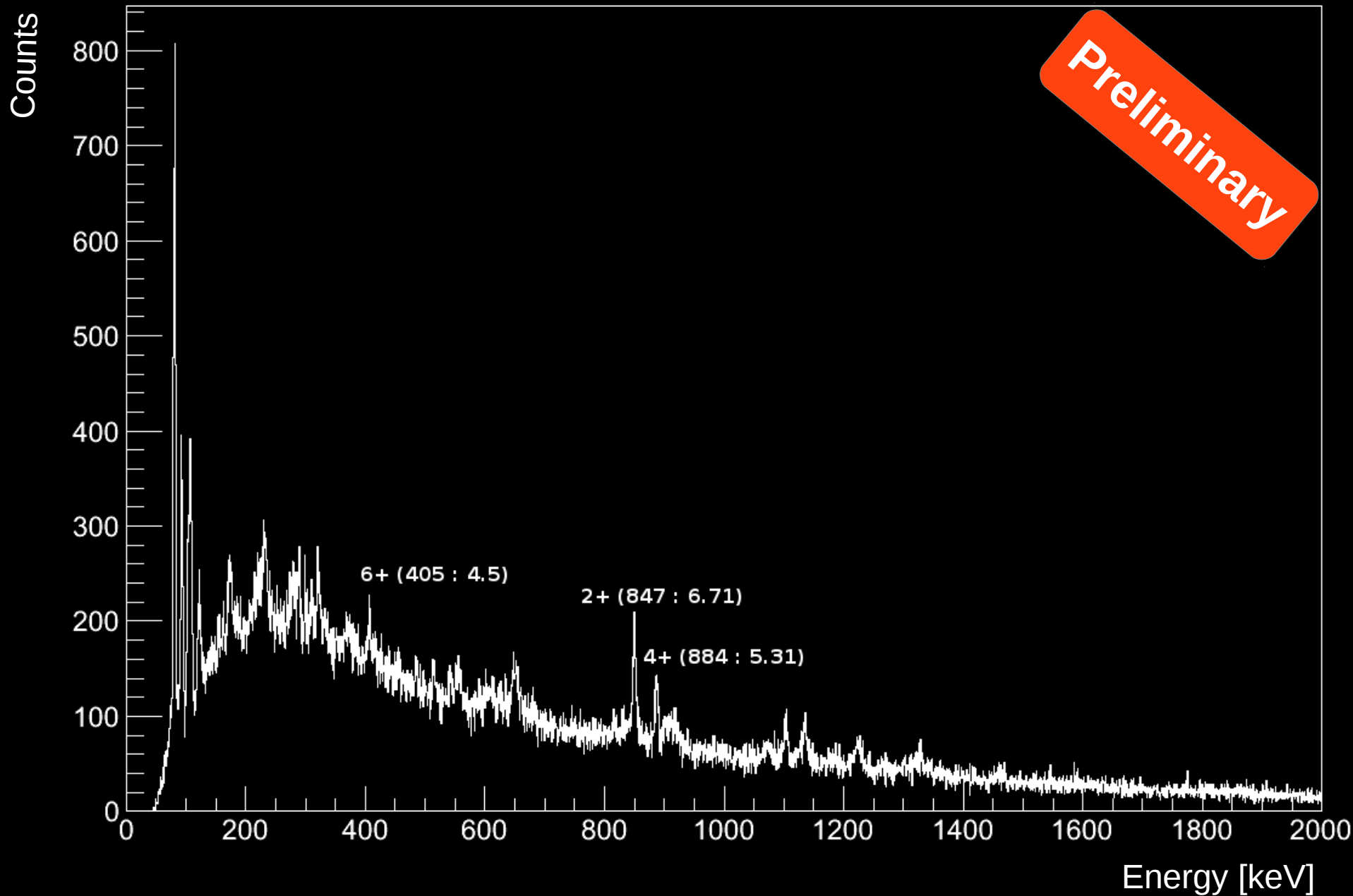
Gamma Spectrum Xe 136



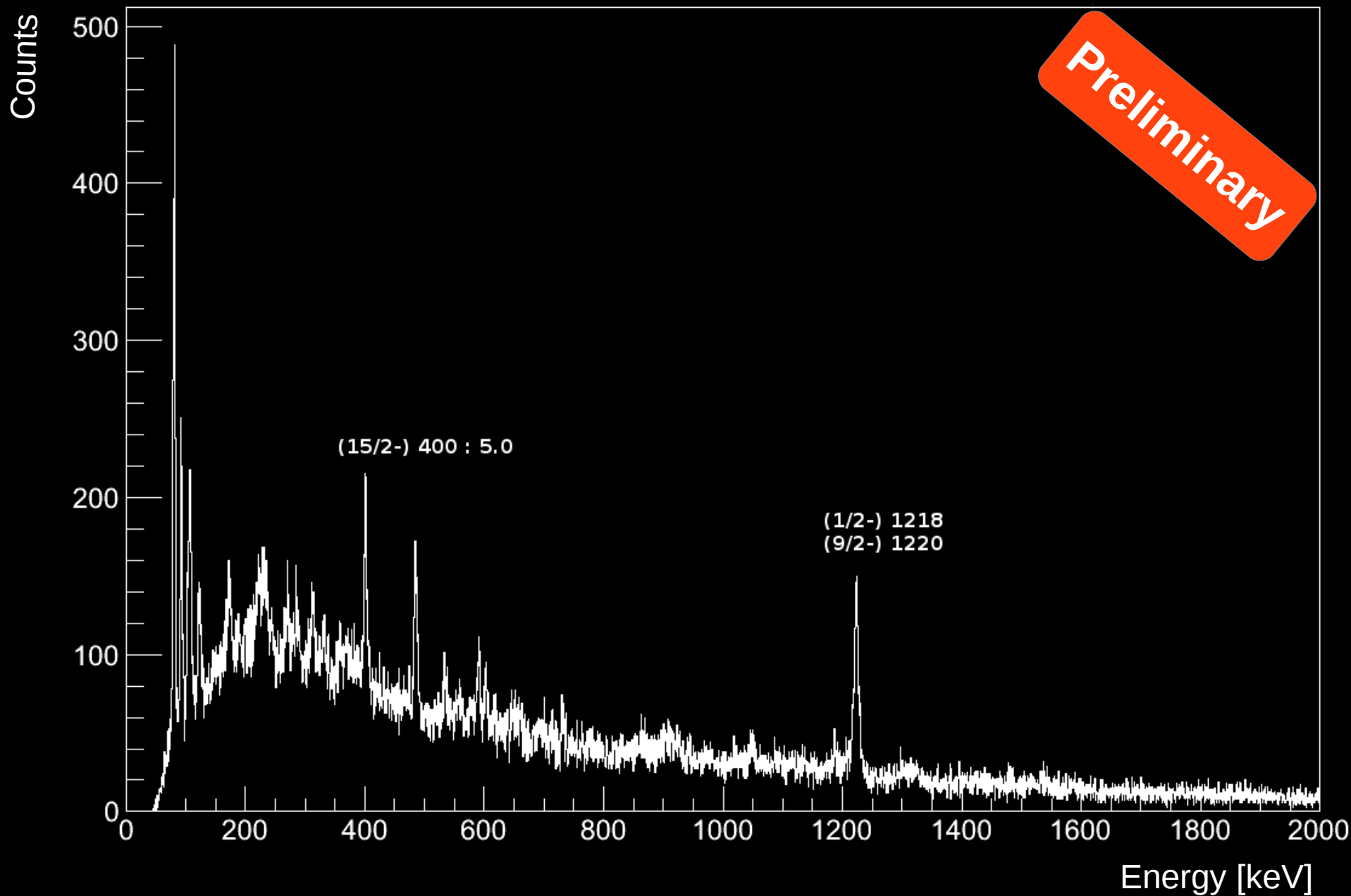
Gamma Spectrum Xe 135



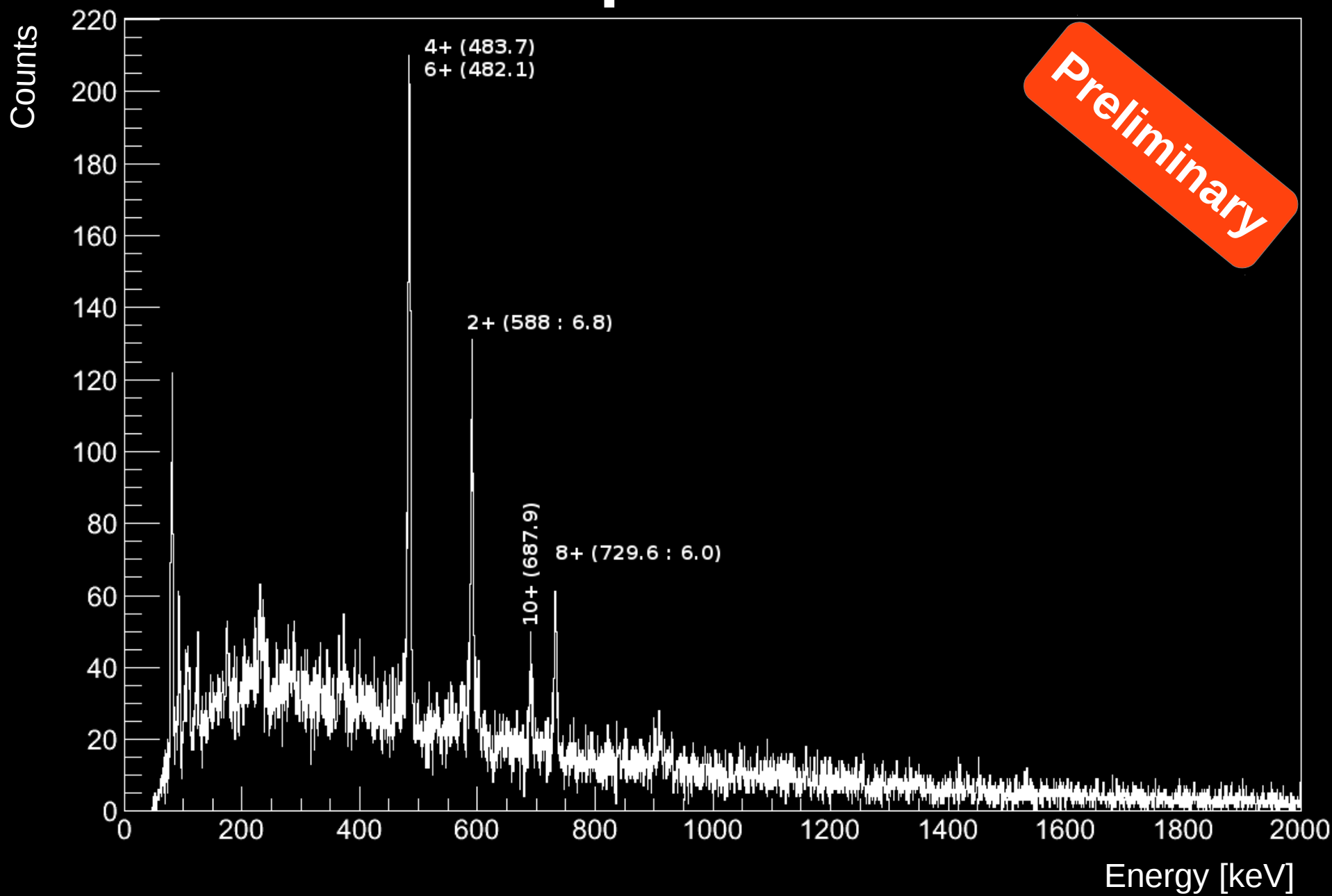
Gamma Spectrum Xe 134



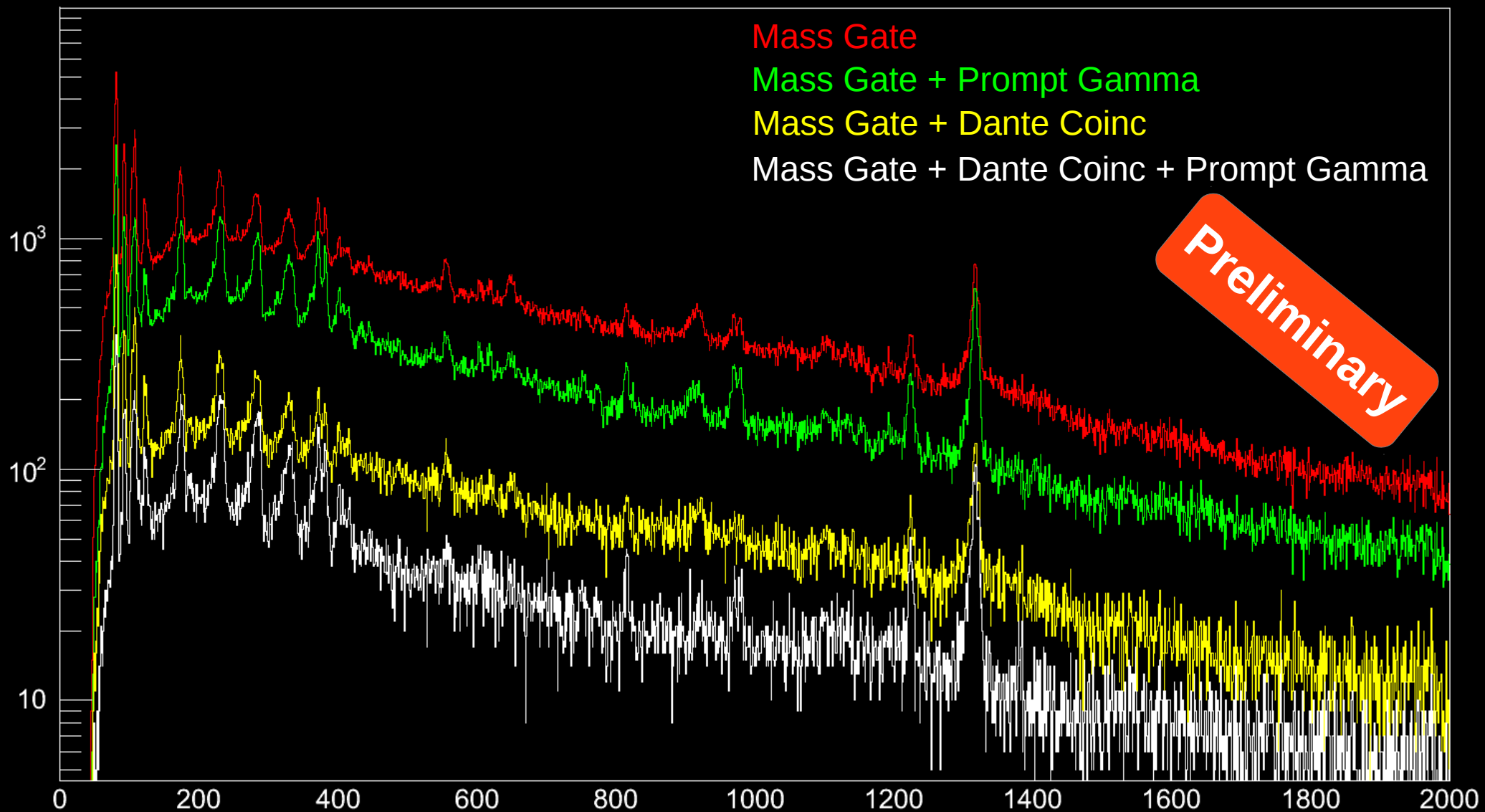
Gamma Spectrum Xe 137



Gamma Spectrum Xe 138



Gamma Spectrum Xe 136



Done

- ✓ successful Experiment with AGATA / Prisma /Dante and the ALPI
- ✓ AGATA data replayed using femul
- ✓ AGATA and Prisma Analysis using GammaWare / Watcher / Prisma Manager
- ✓ Isotope identification by gated gamma spectra
- ✓ Coincidence between Dante and Prisma
- ✓ Ejectile Doppler correction

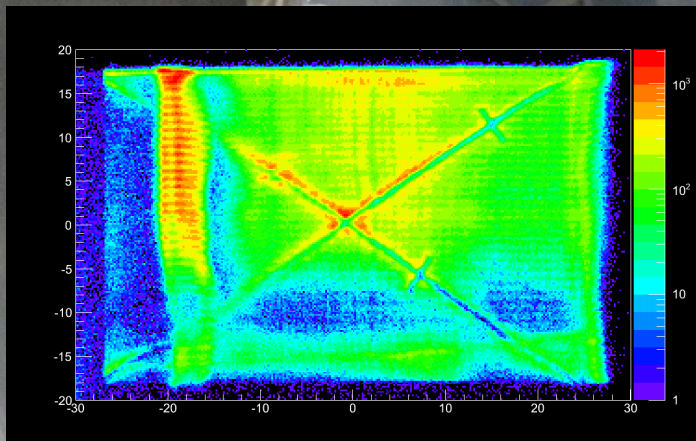
ToDo

- ✗ Rework calibrations of MCP / TOF / AoverQ / AGATA
- ✗ Improve Recoil and Ejectile Doppler correction
- ✗ Check Dante for recoil direction information
- ✗ Analyze Dante Dante Coincidence

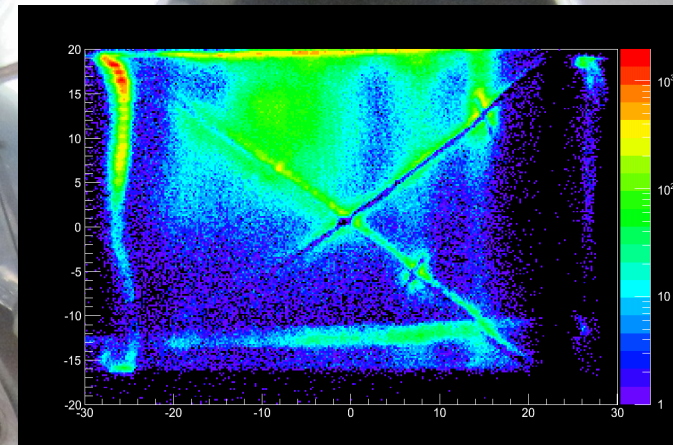
Trigger Conditions

PRISMA Focal Plane
||
Dante 2 && Prisma MCP
||
Dante 1 && Dante 3

Dante 2

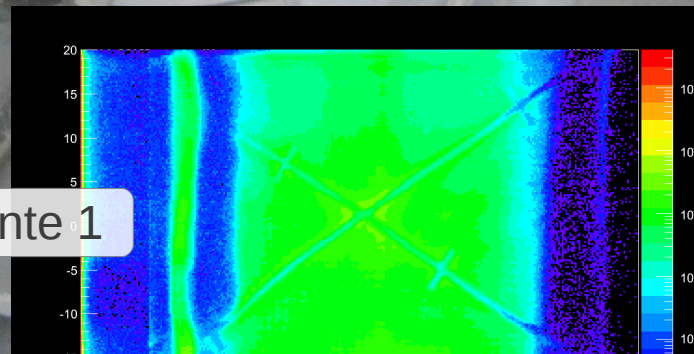


Dante 3

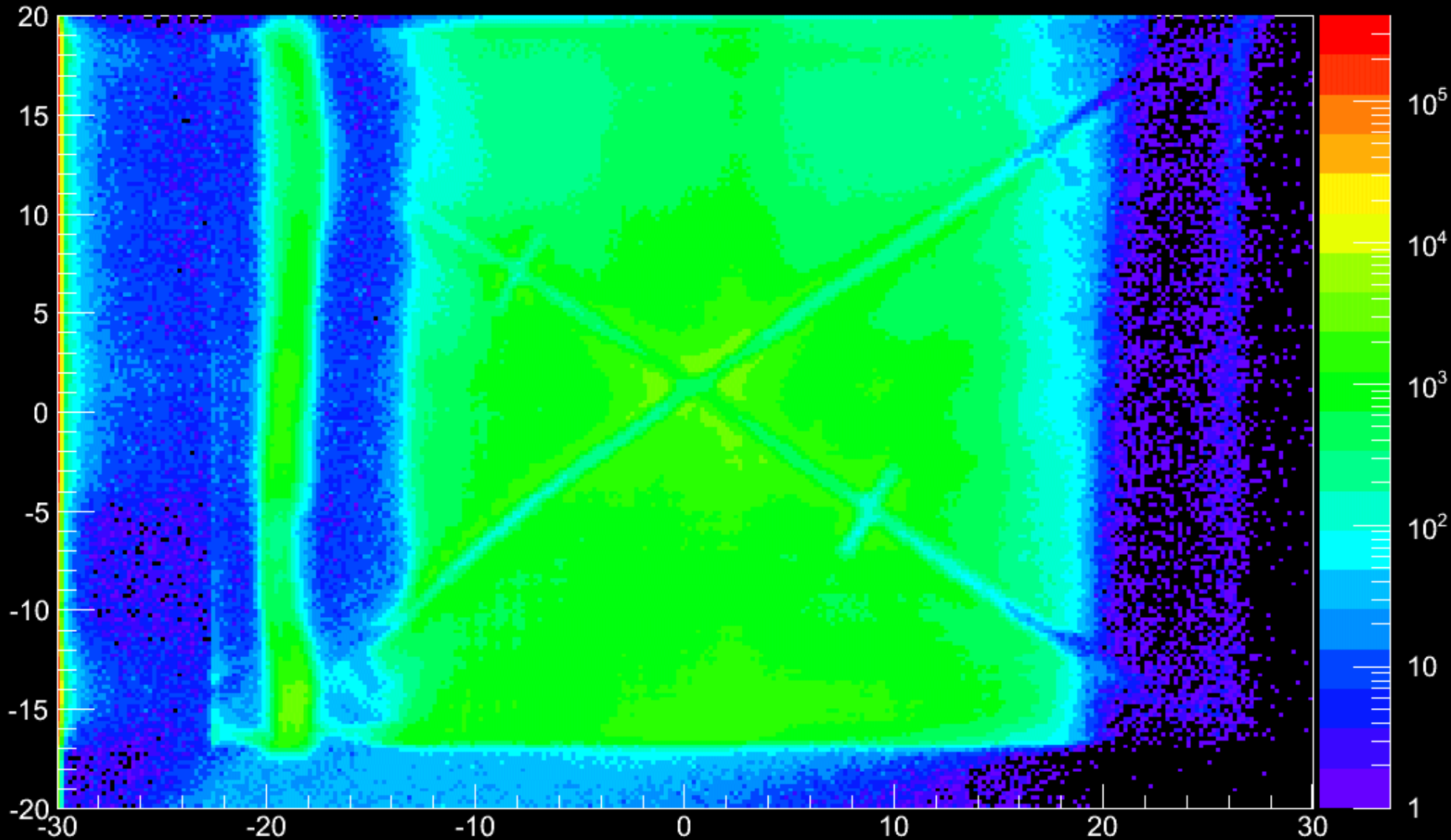


Prisma

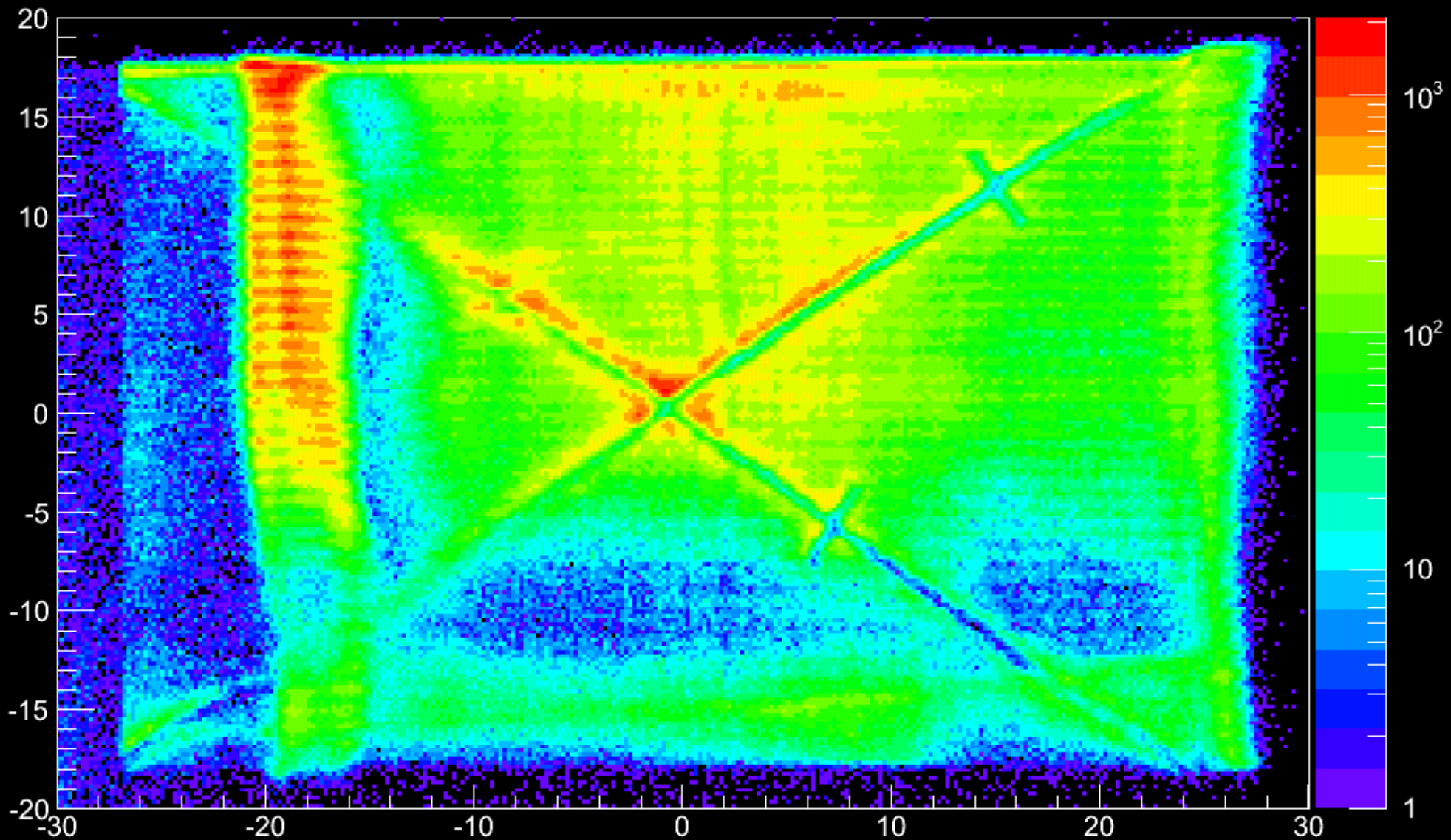
Dante 1



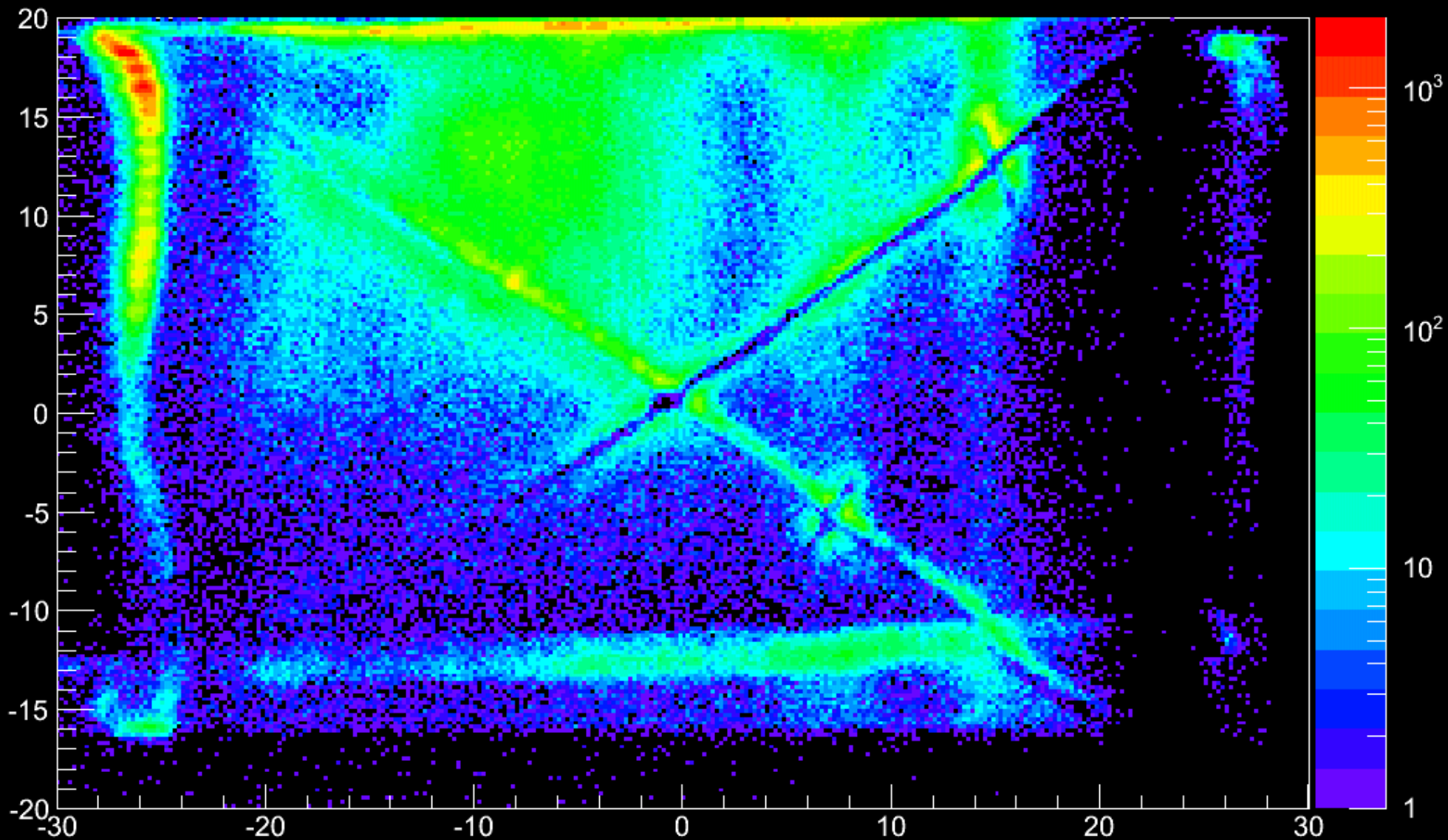
Dante 1 Detektor (bottom left)



Dante 2 Detektor (left)



Dante 3 Detektor (top right)



Peak broadening

$$E_Y^{\text{CM}} = E_Y \frac{1 - \beta \cos(\theta)}{\sqrt{1 - \beta^2}} \quad (\beta, \theta \text{ and } E_Y \text{ in Lab frame})$$

$$(\Delta E_Y^{\text{CM}})^2 = \left(\frac{\partial E_Y^{\text{CM}}}{\partial \theta} \right)^2 (\Delta \theta)^2 + \left(\frac{\partial E_Y^{\text{CM}}}{\partial \beta} \right)^2 (\Delta \beta)^2 + \left(\frac{\partial E_Y^{\text{CM}}}{\partial E_Y} \right)^2 (\Delta E_Y)^2$$

$$(\Delta E_Y^{\text{CM}})^2 = \left(E_Y \frac{\beta \sin \theta}{\sqrt{1 - \beta^2}} \right)^2 (\Delta \theta)^2 + \left(E_Y \frac{(\beta - \cos \theta)^2}{(1 - \beta^2)^{3/2}} \right)^2 (\Delta \beta)^2 + \left(\frac{1 - \beta \cos \theta}{\sqrt{1 - \beta^2}} \right)^2 (\Delta E_Y)^2$$

Current Resolution
1313 keV Xe 2+

9.64 (with left tail free)
11.23

Energy broadening for different angle and beta errors

