Heavy nuclei in the $^{136}Xe + ^{208}Pb$ deep-inelastic reaction using the AGATA tracking array

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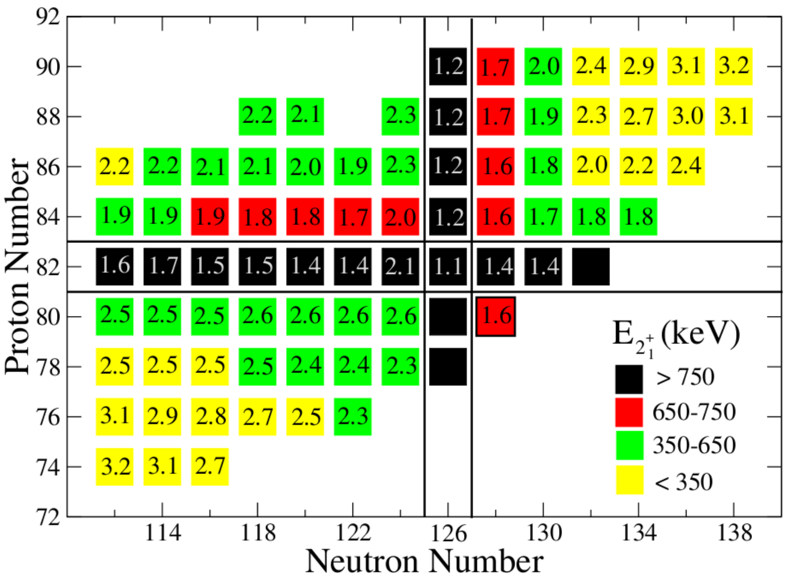
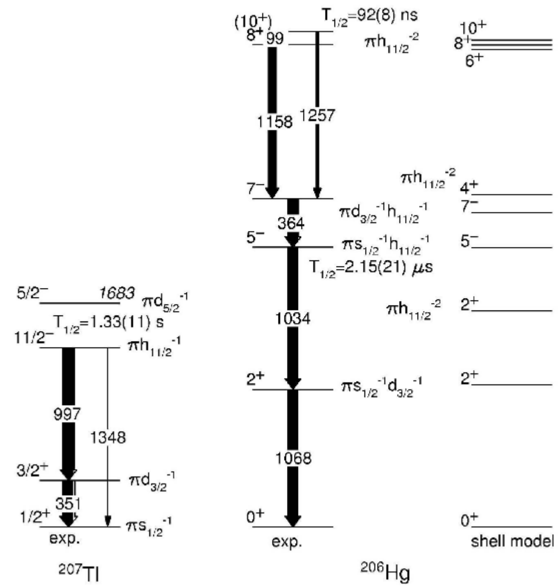
Motivation

- N~126 neutron-rich nuclei: info on two-body interactions and single-particle energies
- Deep-inelastic experiment, so PRISMA needed to decipher the many reaction products created
- Main aims: ^{208}Tl & ^{206}Hg, cross-coincidence
- South and south-east of ^{208}Pb is lacking in information, especially details of the excited states
- Obtain information on shell model states of nuclei along the N=126 line, and also where N>126 & Z<82
- The results will help produce more accurate predictions of systems of greater complexity





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Motivation

Region of interest

- Deep-inelastic transfer reaction with kinematic reconstruction
- Target like nuclei not detected, only the beam like
- ^{136}Xe+^{208}Pb->^{137}Cs+^{207}Tl etc we detect ^{137}Cs, and kinematic reconstruction ^{207}Tl
- Neutron transfer and evaporation, many isotopes, $^{135-140}$Cs for example
- The heavy and slow target like nuclei cannot be identified unambiguously in PRISMA
- Identify the binary reaction partner, investigate the target, cross-coincidence
- PRISMA needed to distinguish many reaction products

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Experimental Setup

- Legnaro National Laboratory (INFN) PIAVE+ALPI accelerator system
- $^{136}Xe + ^{208}Pb$ (1mg/cm^2) at 940MeV, max intensity 1.8 pnA (→1 pna)
- Deep-Inelastic reaction, cross-coincidence
- AGATA (Gamma ID)+PRISMA (Mass ID)+DANTE (Reconstruction)
- 3 ATC's @ 3khz per crystal
- PRISMA at 42˚ with respect to beam-line
- Target at 45˚ with respect to the beam-line
- AGATA ATC's at 90˚ to the beam line (horizontal) and distance of 18.8 cm
- On-line pulse shape analysis (PSA) and gamma-tracking
- No on-line analysis (blind), no analysis code, approx 8 TB of data
- DANTE (x4) ring at 58˚
- PRISMA dipole: 0.087 T Quadrupole: 0.076 T (Ratio 0.94), IC: 78 mb

AGATA ADVANCED GAMMA TRACKING ARRAY

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AGATA
ADVANCED GAMMA TRACKING ARRAY

Equipment Overview

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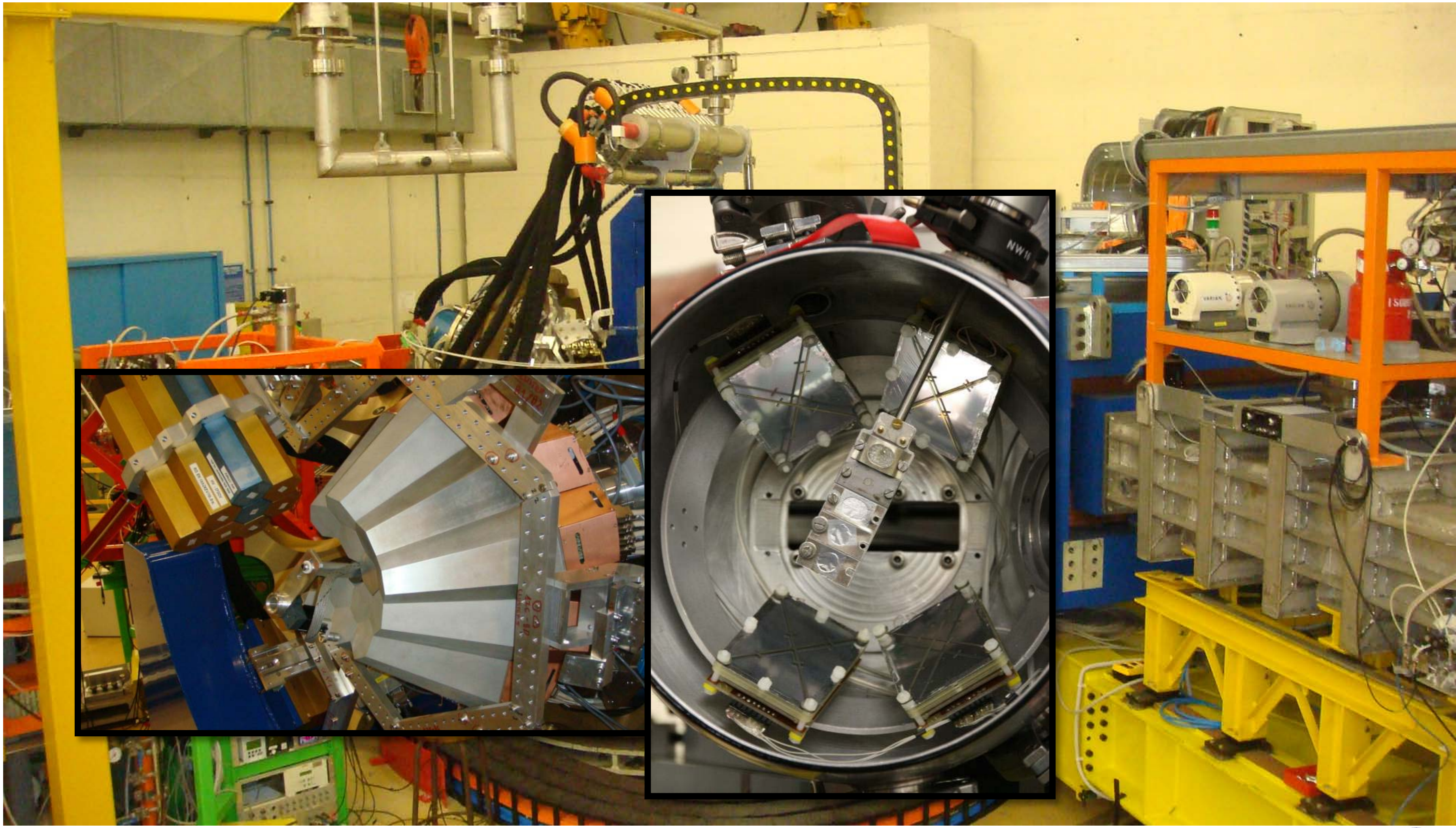

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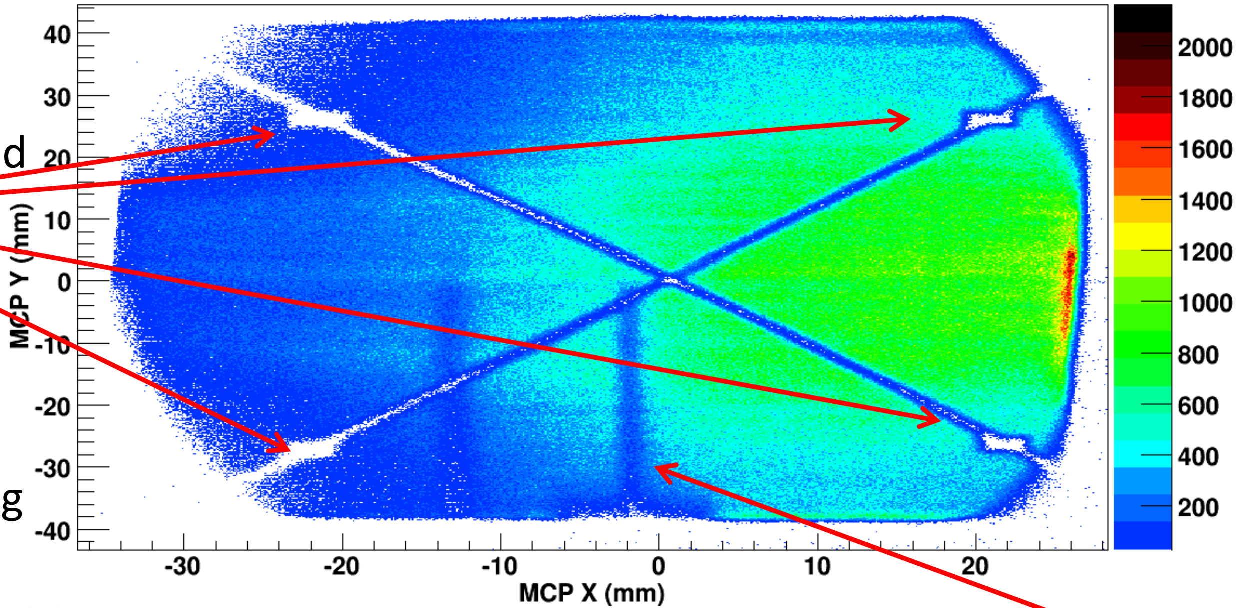
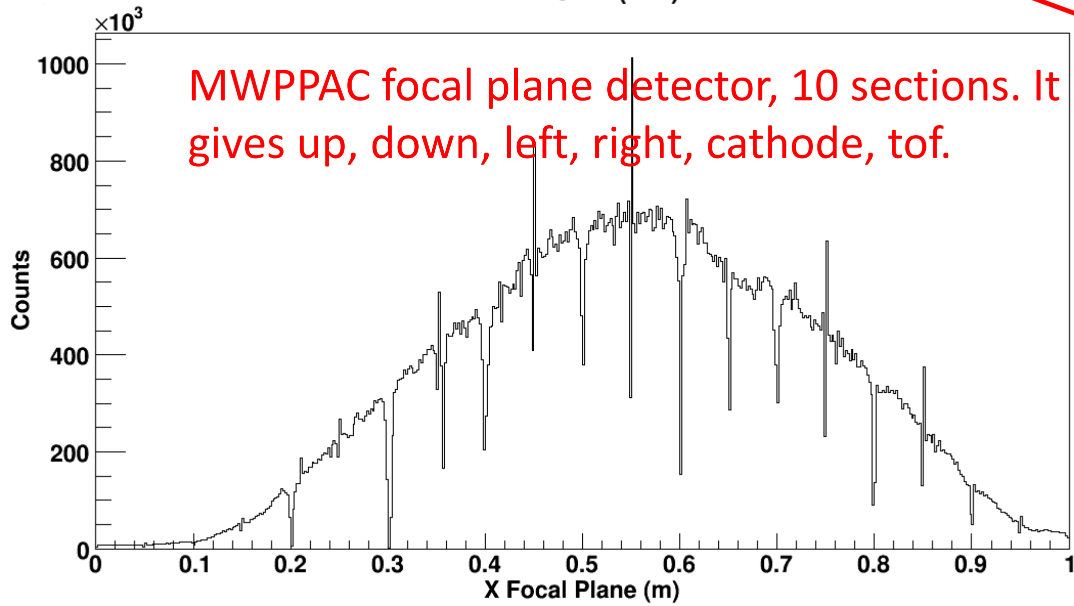
MCP & Focal Plane

MCP after alignment and calibration. Markers on the physical unit to aid this process.



Focal plane detector at the entrance to PRISMA, gives position information of incoming nuclei. Also acts as a check for valid events along with the MCP

Pins to show correct orientation.

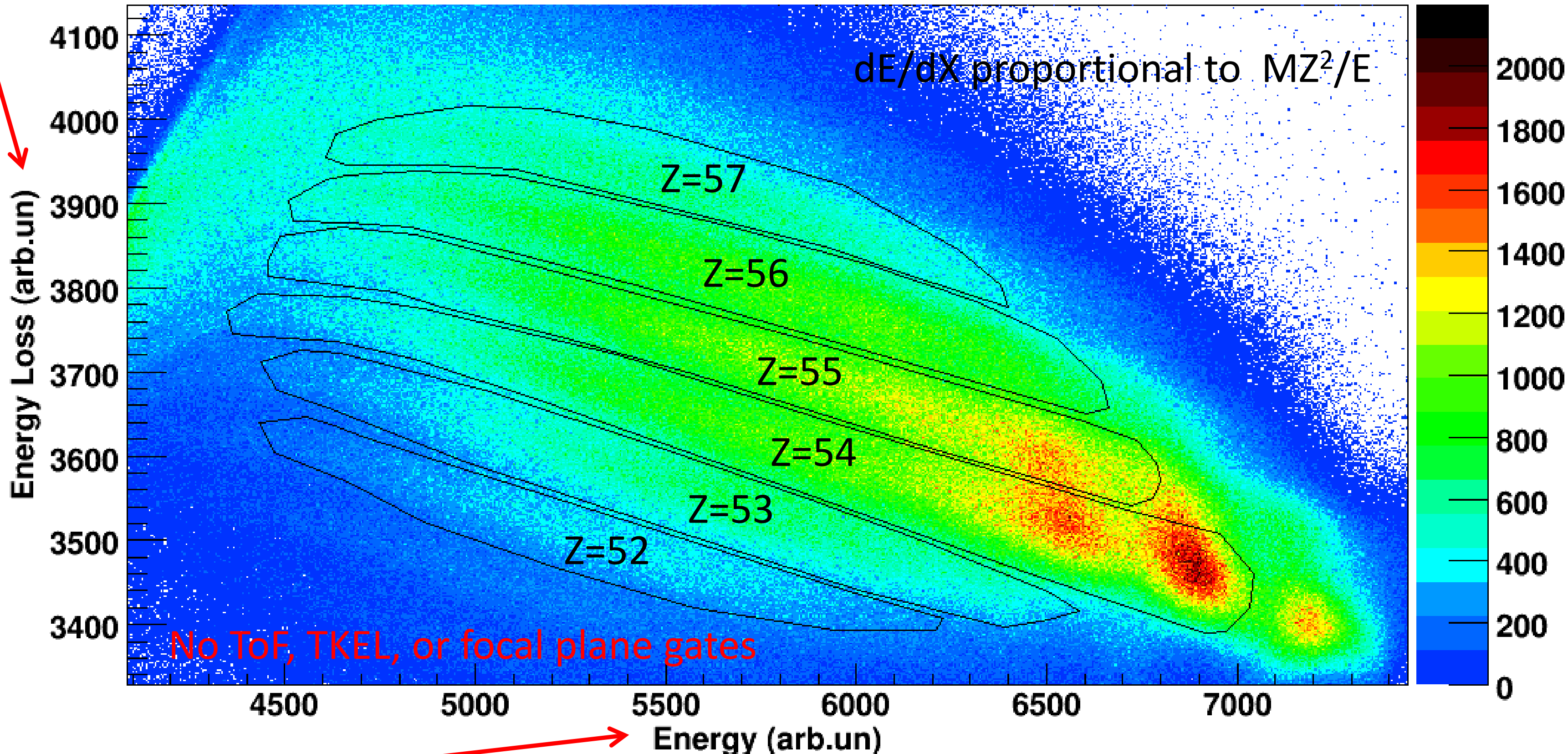


TOF fine and

coarse matching

Ionisation Chamber

Energy deposited in first two rows of the ionisation chamber



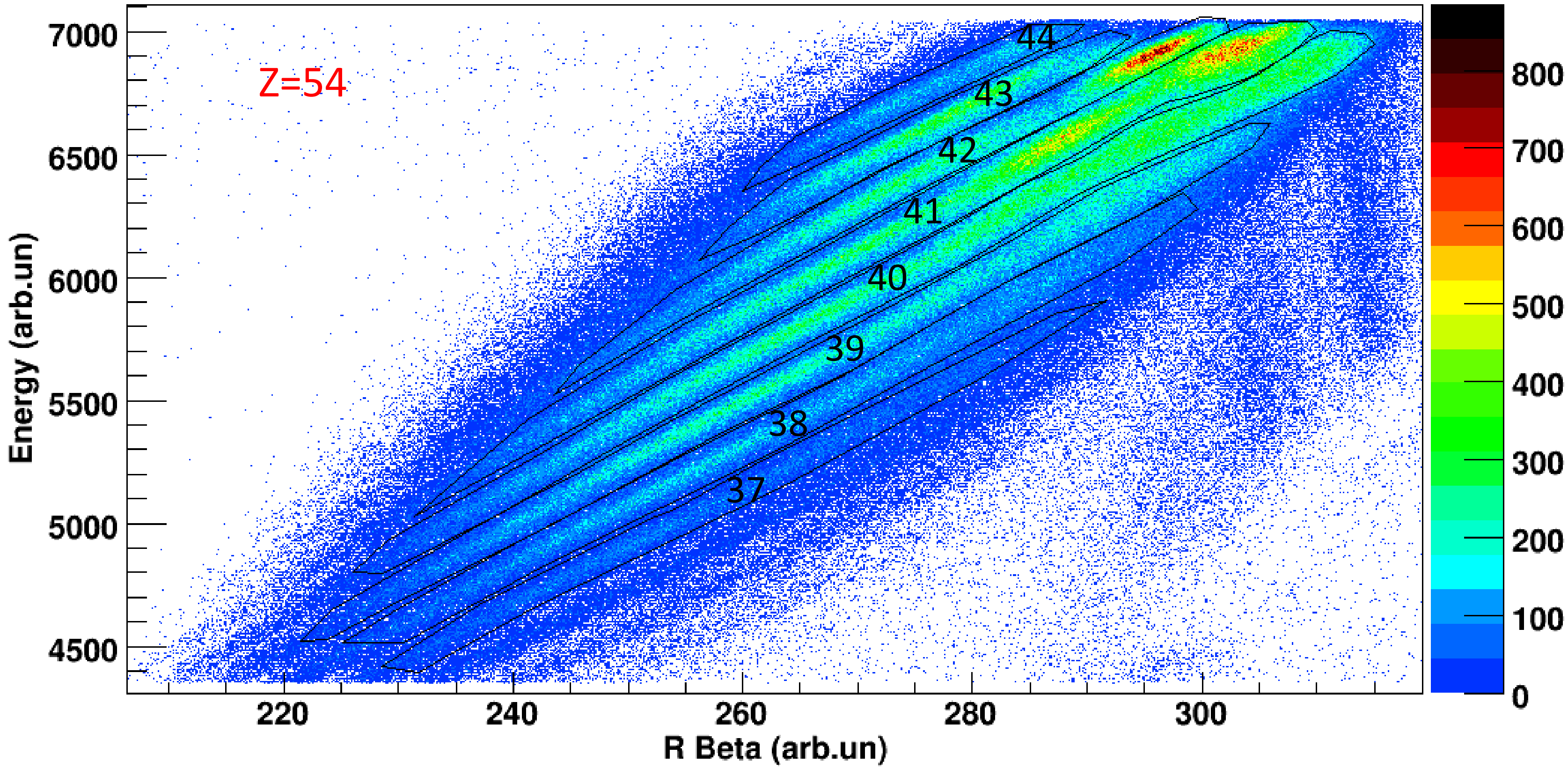
Energy deposited in all rows of the ionisation chamber

Re-construct PRISMA trajectories (TOF, Path, length, radius) ToF = MCP - MWPPAC

Charge State Distribution

R Beta = C (m/s) x B Dipole (Tesla) x Radius (m) x Beta Gamma

Each charge state comprise of several masses



Use "Reaction" to calculate the most probable charge states, and assign them to regions of this histogram. This is for one Z, can assume a increase of one in the charge State for the next Z. Once identified and calibrated multiply by A/Q to get A

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(Based on PRISMA trajectory reconstruction)

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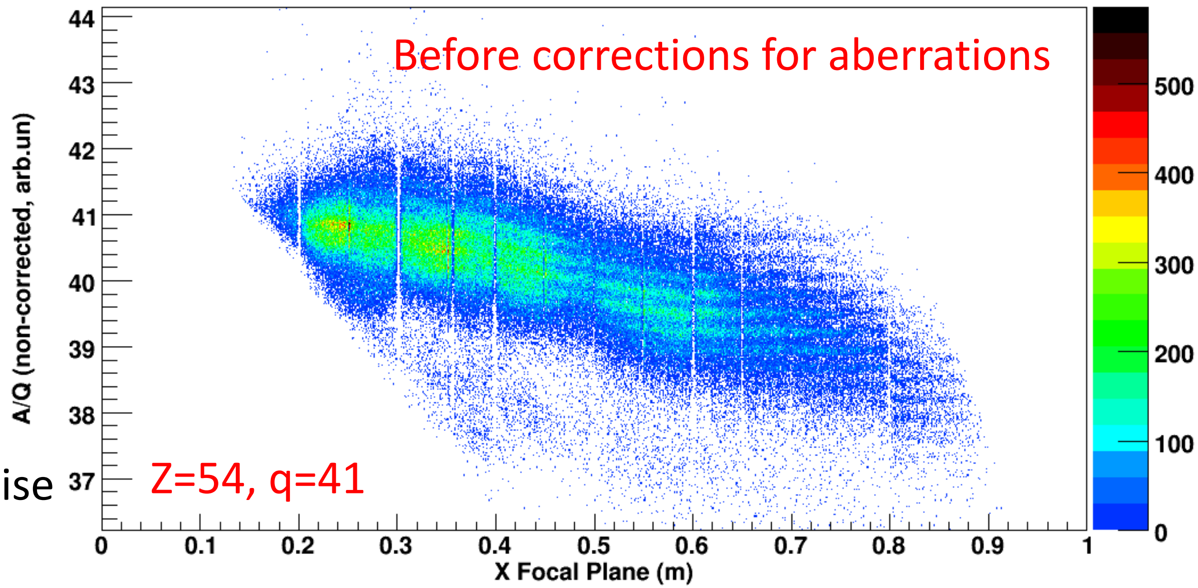
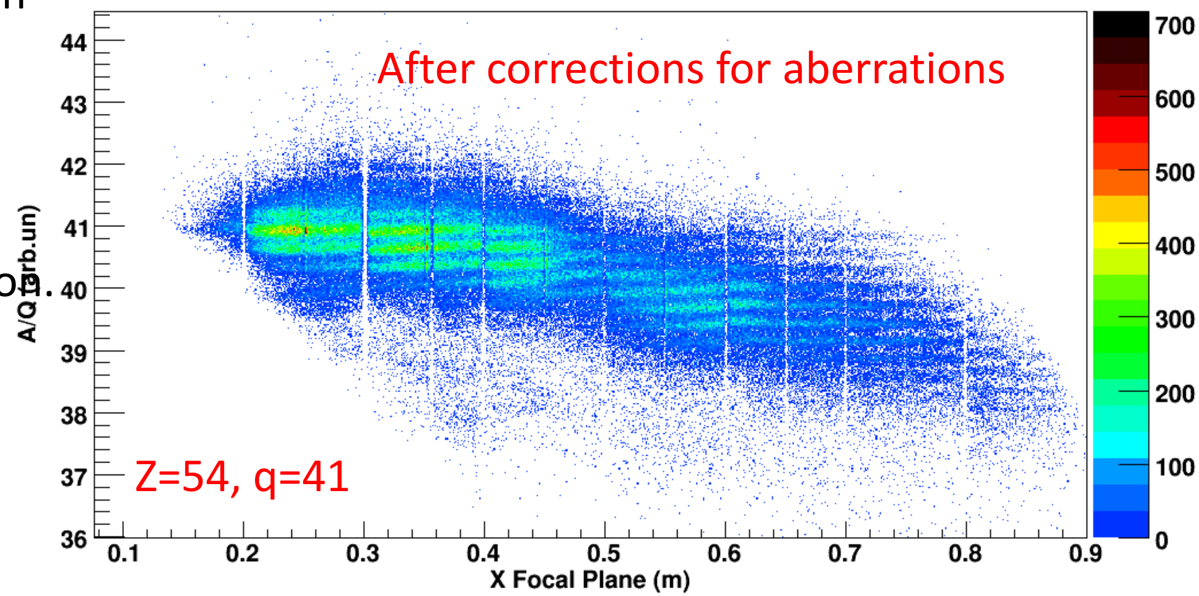
Aberration Corrections

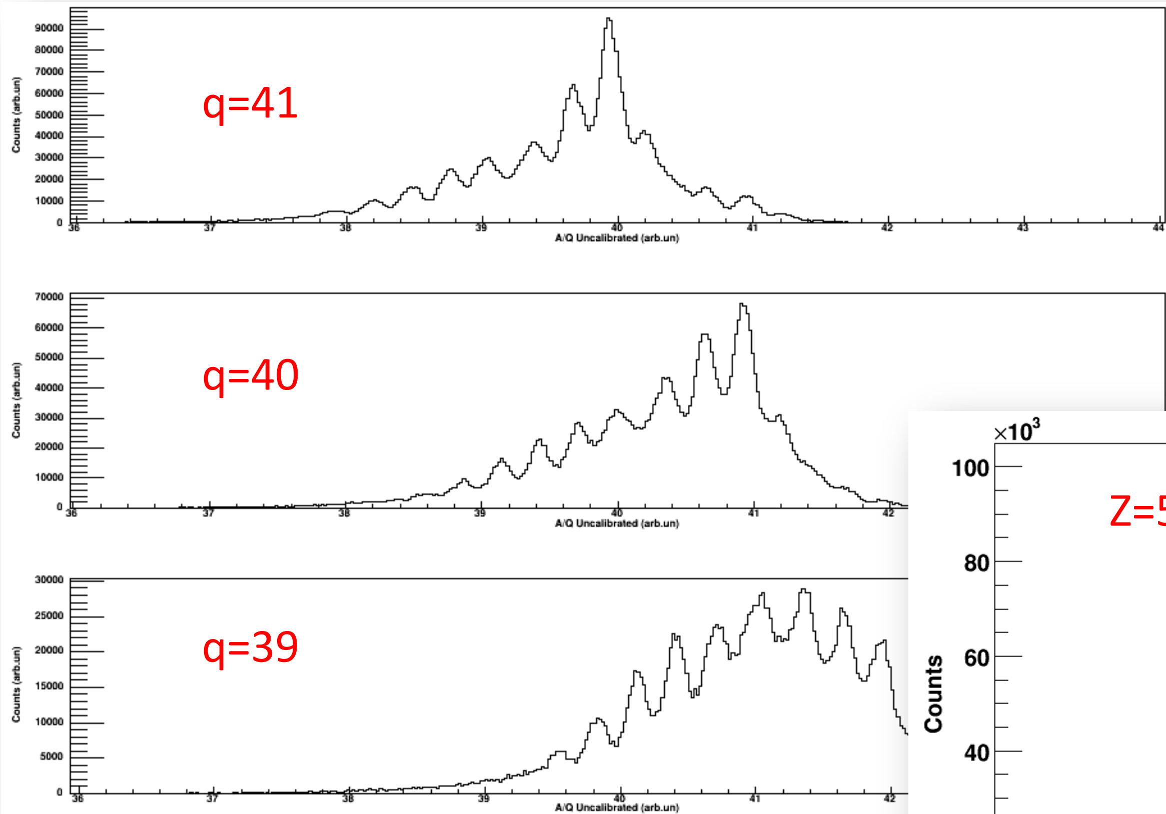
Routines developed to correct for these aberrations. Otherwise the mass resolution would have been non-existent.

Essentially remove event by even a line equal to the distortion.

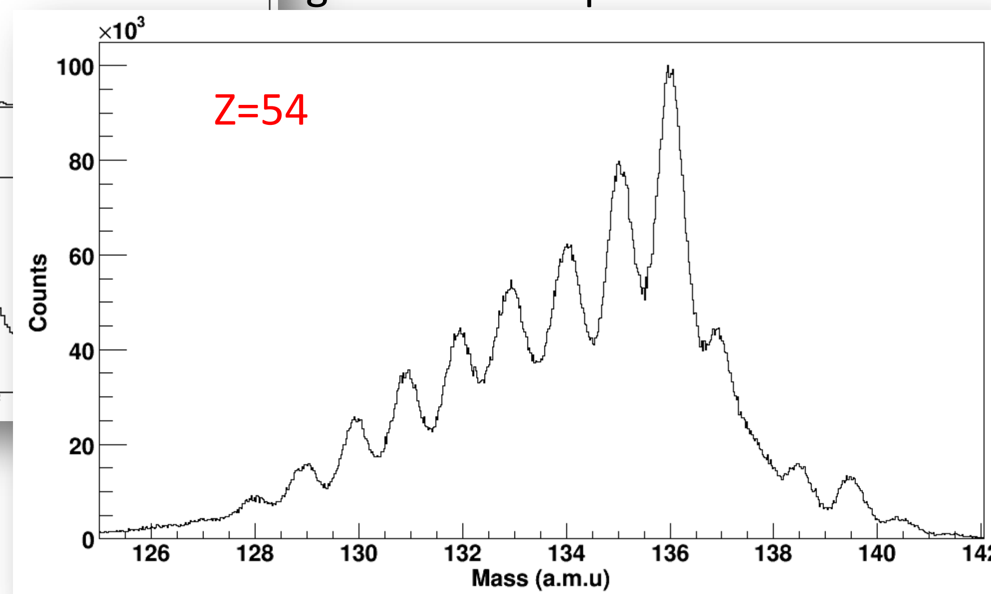




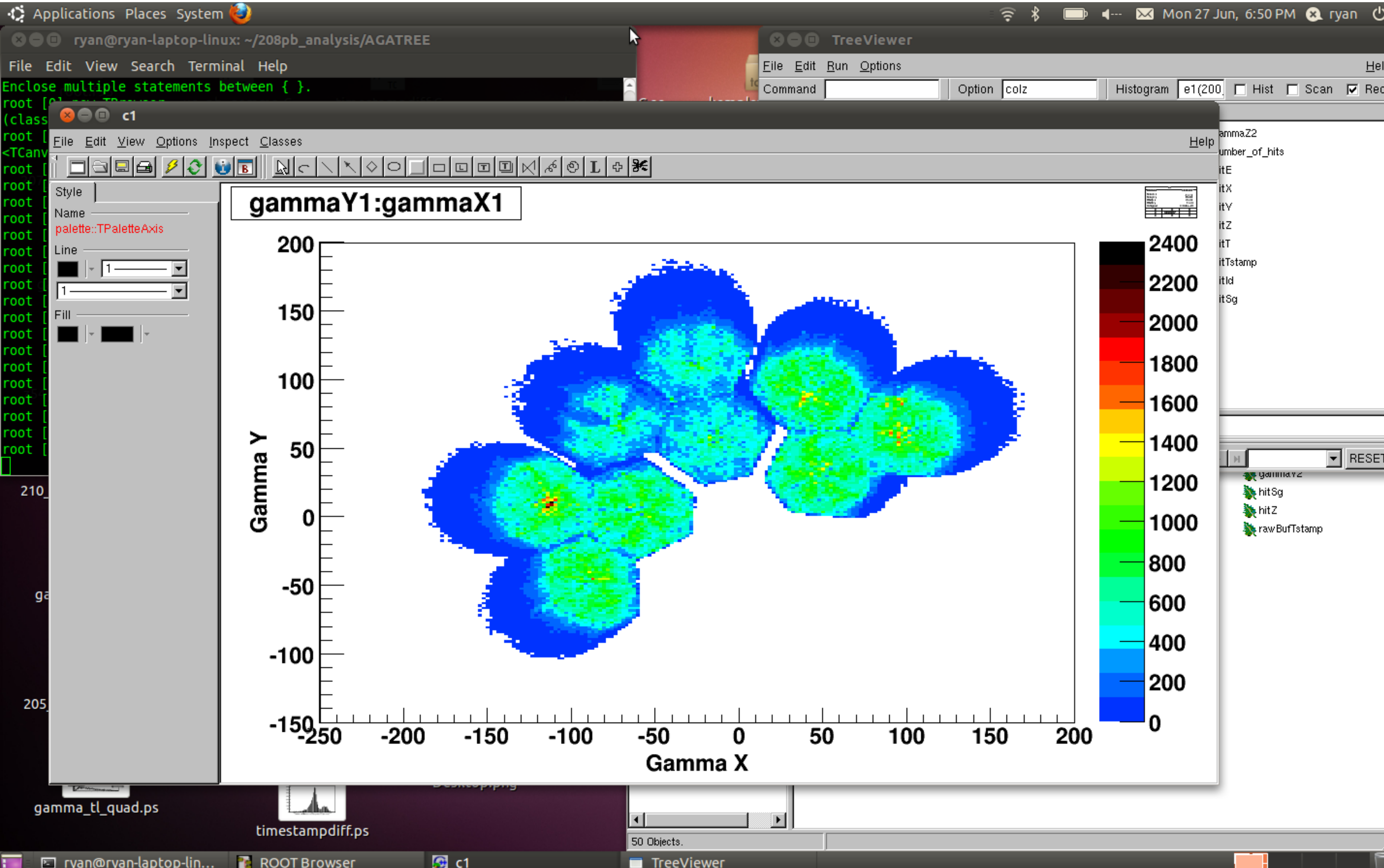
Mass Calibration



Individual A/q spectra, gated for each q. Linear fit applied assuming most intense peak is M=136 (This is easy when dealing with the beam) Once the fit is applied we have a calibration factor, so when added together and multiplied by A/q, we get the mass spectra below.



AGATA



Applications Places System
Mon 27 Jun, 6:50 PM ryan
ryan@ryan-laptop-linux: ~/208pb_analysis/AGATREE
TreeViewer
c1
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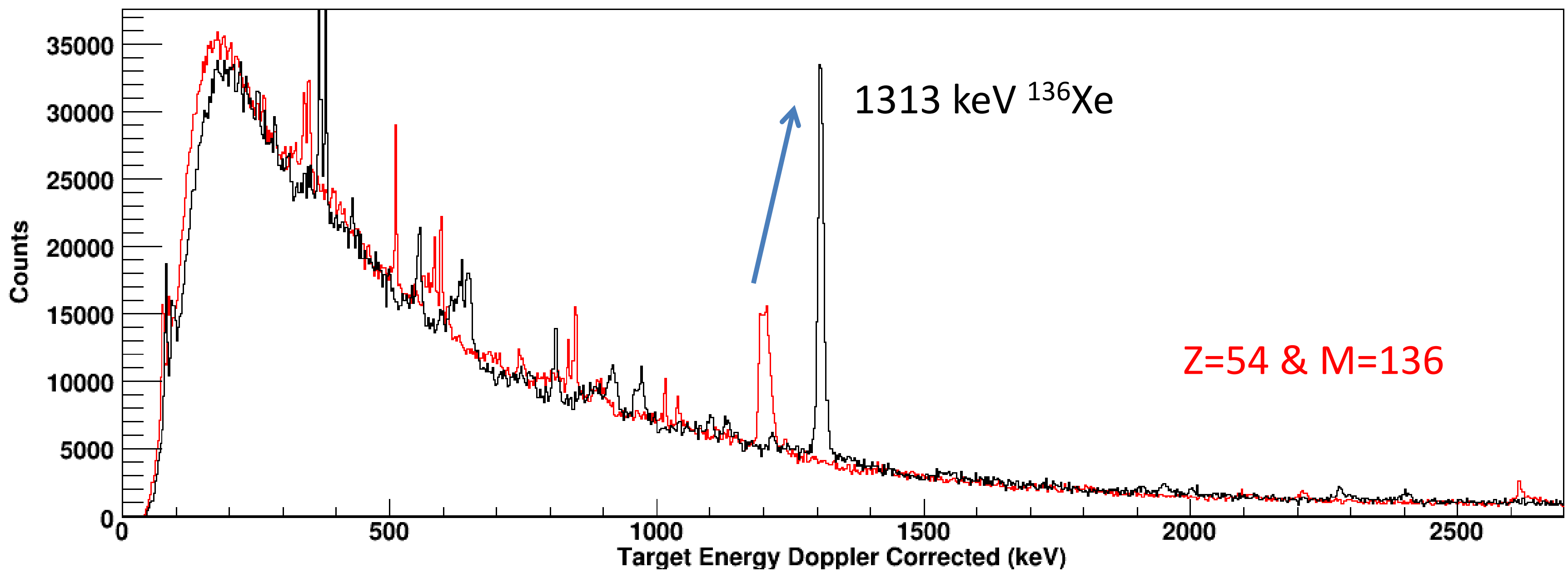
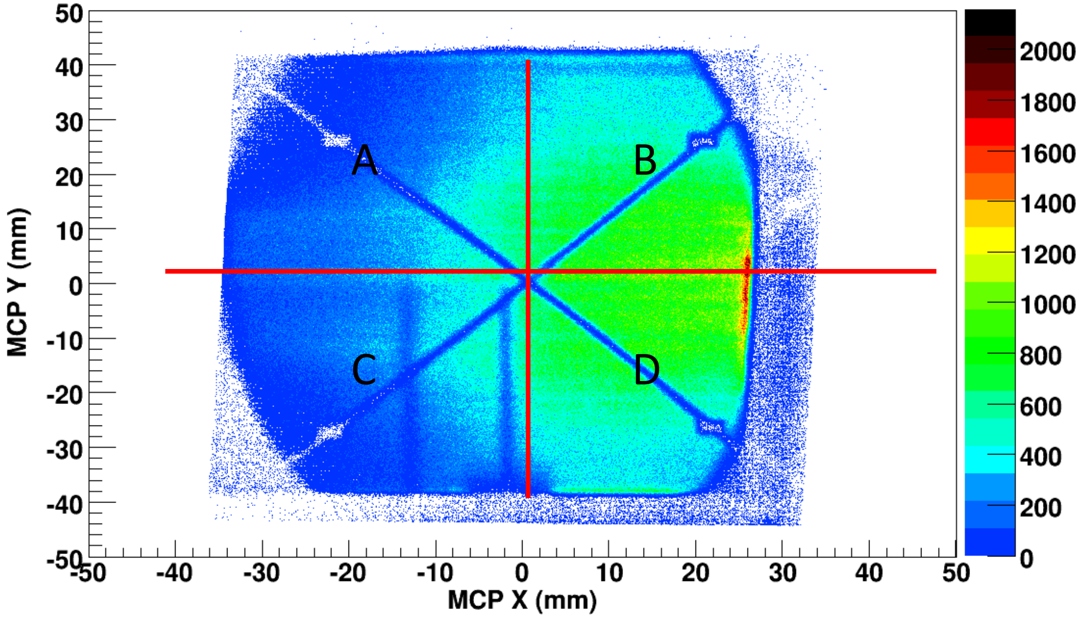
RESET
hitSg
hitZ
rawBufTstamp
gamma_tl_quad.ps
timestampdiff.ps
50 Objects.
ryan@ryan-laptop-lin...
ROOT Browser
c1
TreeViewer

Doppler Correction

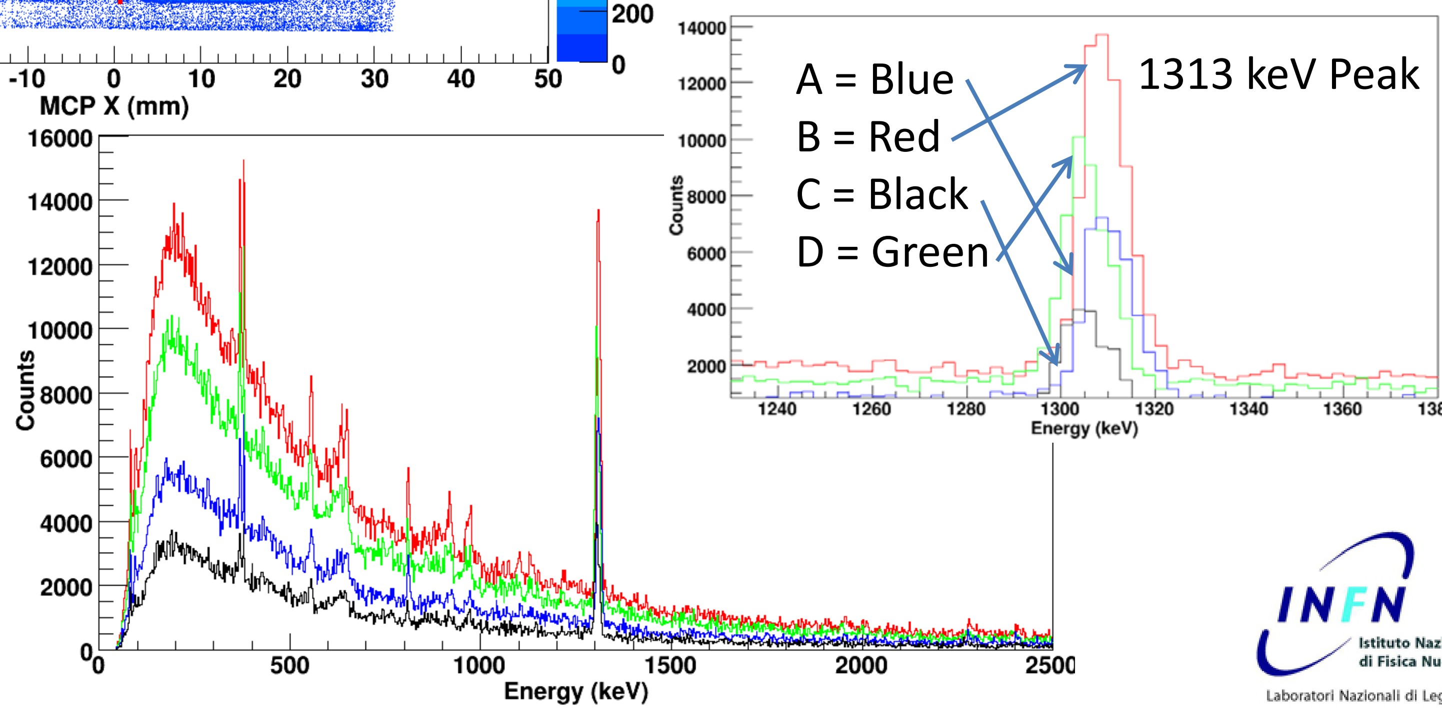


Example of current Doppler correction in action. FWHM (~10-15 keV at 1.3 MeV)still not with in acceptable region. Currently working on resolving this via code.

MCP Effect on Energy



- MCP set to quarters via gates.
- Noticeable shift on peak energy.
- Shift past 1313 keV for A & B.
- Shift below 1313 keV for C & D.



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Gated Gamma Spectra

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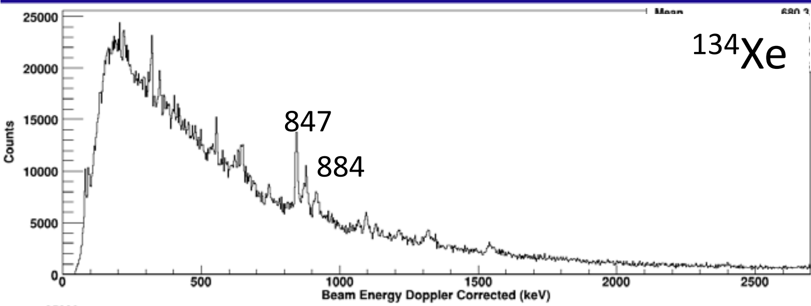

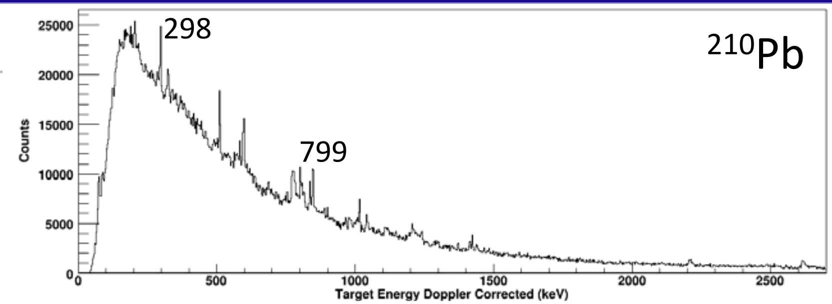

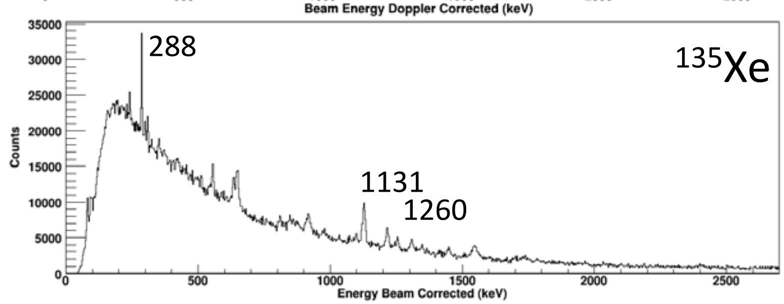

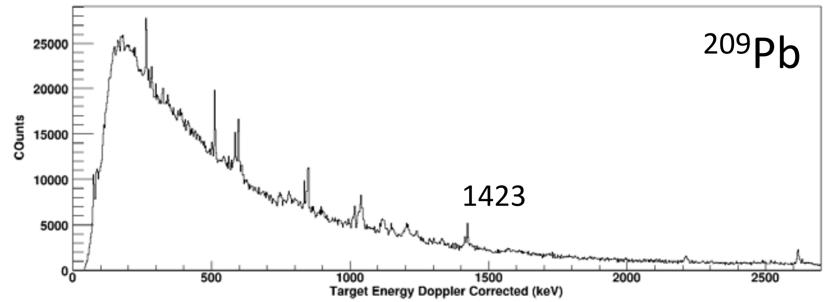

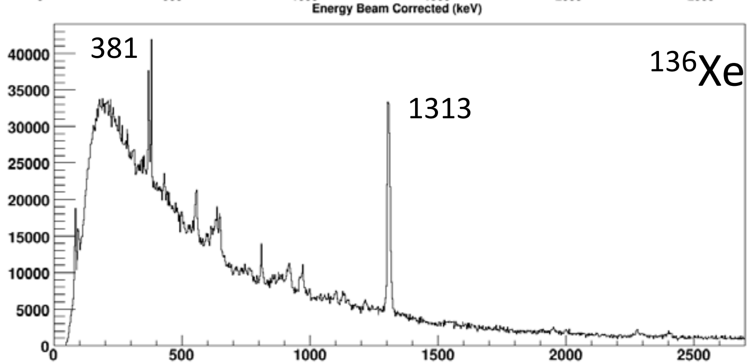

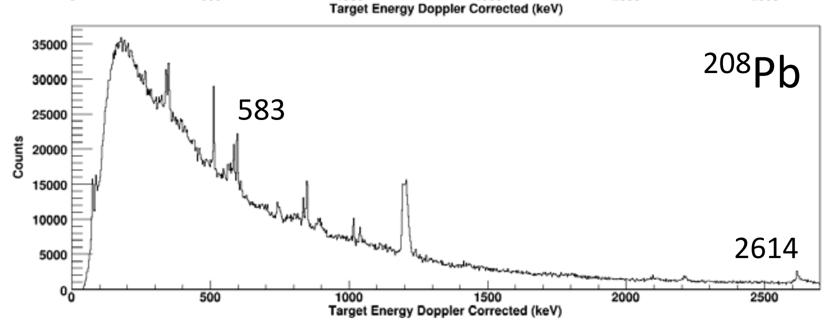

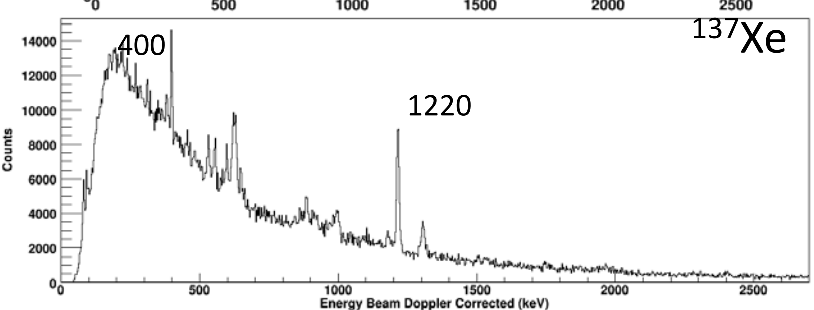

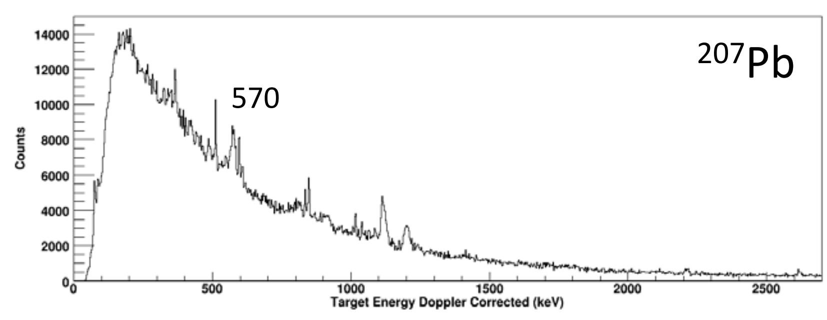

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Summary

- AGATA/PRISMA/DANTE worked well and as expected
- One reaction channel taken to the end of the analysis chain
- Developed code working well, Doppler correction of target
- Gamma/Mass spectra reached
- Need to apply to all reaction channels (Z=53,55,56 etc)
- Re-run of experiment to apply gate information to the root tree
- Removal of the background/random coincidences
- Coincidence measurements to build level schemes
- Analysis into ^{206}Hg and ^{207}Tl

Two fully-funded PhD Research Studentships in Nuclear Physics at the University of Padova

*The **Nuclear Physics Research Group** at the **University of Padova** has two fully-funded PhD studentships available. PhD projects are available in experimental nuclear physics, within all of the themes in our research programme.*

The University of Padova has a long and well established history in Nuclear Physics research, which goes back in 1960 with the foundation of the "Nuclear Research Centre" at Legnaro where the Van de Graaff CN accelerator was built, at the time being the most powerful research instrument for the Italian Nuclear Physics community. The national role of the the Legnaro Laboratory was recognized in 1968 when it became a National Laboratory of the Istituto Nazionale di Fisica Nucleare (INFN).

Presently, the Experimental Nuclear Physics Research Group in Padova and Legnaro has a variety of research interests, such as: nuclear structure at the limits of spin and isospin, isospin conservation, nuclear magic numbers evolution by using gamma-ray spectroscopy. Major projects with which the Padova-Legnaro group is involved are the Advanced Gamma-ray Tracking Array (AGATA), TRACE, NEDA, GALILEO.

One of the available studentship is connected with the development of state-of-the-art instrumentation for the study of exotic nuclear matter, in particular with the design of a dedicated Front End Electronics (FEE) for a highly-segmented silicon detector. Although much of the development work for equipment will be done at Padova or Legnaro, where excellent facilities for the construction and commissioning are available, the successful candidate will be required to spend a consistent part of the PhD at the University of Milano.

The second offered studentship will be dedicated to the study of exotic nuclear matter at the extremes of isospin. The experimental nuclear physics group is actively involved in nuclear spectroscopy experiments at Laboratori Nazionali di Legnaro as well as in other international laboratories such as GSI (Germany), GANIL (France), ISOLDE-CERN (Geneve), RIKEN (Japan) and MSU (usa). These facilities provide complementary experiments that allow us to understand the behavior of the nuclear force for very exotic nuclear systems.

PhD Students are expected to give contributed talks at conference, as well as presenting their work at Group and wider collaboration meetings. The skills acquired on the three-year course include experience of the latest detector systems, electronics, computing and high vacuum technology. A powerful suite of computers is available for data analysis within the department, running Linux and Microsoft Windows operating systems.

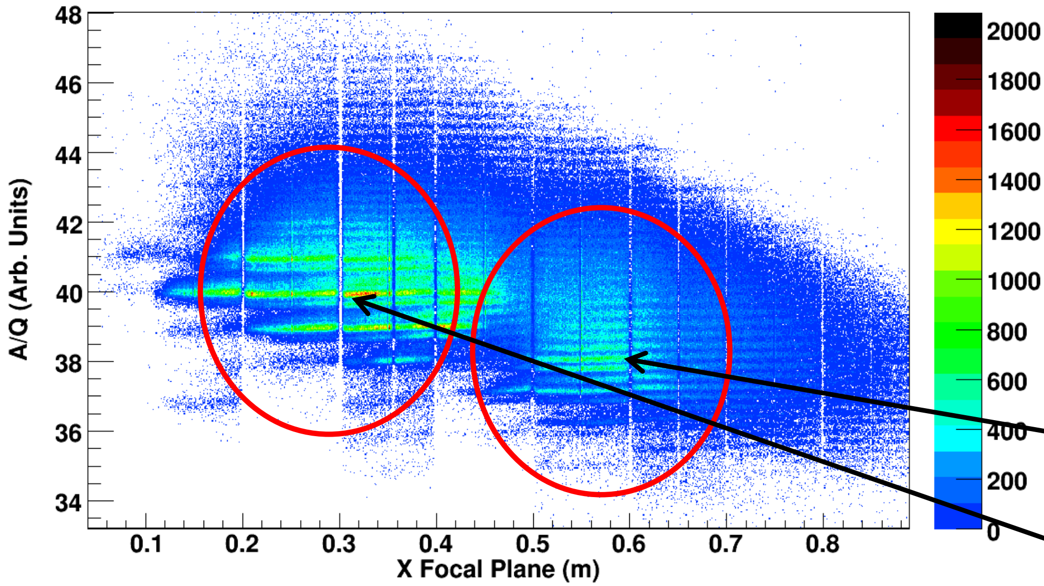
The studentships are intended for the next academic year, starting in early 2012. The studentships will cover fees and provide a net stipend of approximately 13k euro per year. Applicants should attend a public exam and, if positively assessed, expected to be appointed for a three-years-long PhD at the Padova University.

Applicants will have to contact Dr. Mengoni and Dr. Valiente-Dobon before the end of September.

For further information, please contact : daniele.mengoni@pd.infn.it or javier.valiente@lnl.infn.it

Two fully funded PhD fellowships at the University of Padova to work with ancillary detectors for AGATA and experimental physics with AGATA.

A/Q & ToF/Focal Plane

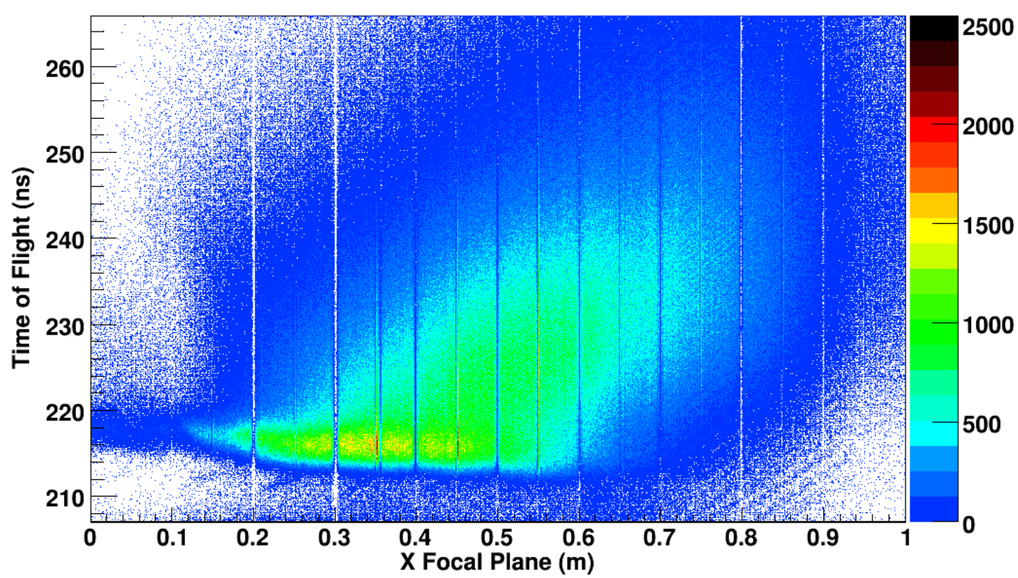


- Final A/Q (un-calibrated) with aberrations removed
- Still some Dispersion from right to left
- Two distinct regions (beam/target?).

Produces good mass spectra

Partial non-linear mass distribution

Fine and coarse matched ToF spectra vs X Focal plane



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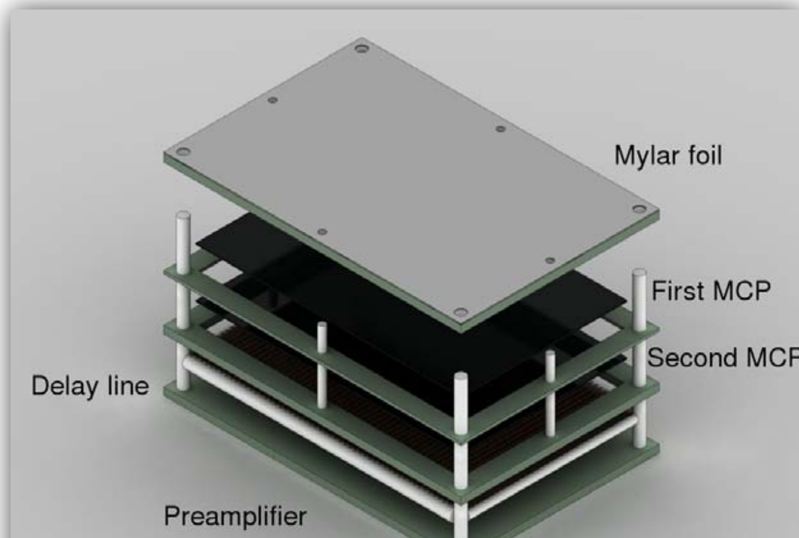
DANTE

DANTE: Detector Array for multi-Nucleon Transfer Ejectiles

A heavy-ion position-sensitive ancillary array

Efficient detection of gamma-gamma coincidences

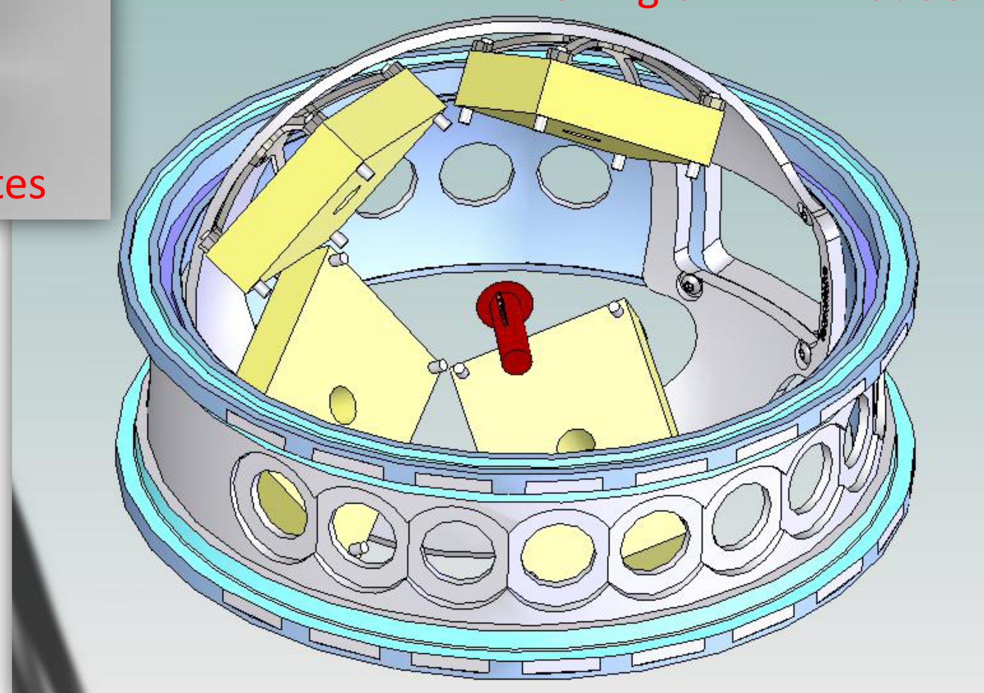


Sandwich of micro-channel plates

Even by event kinematic reconstruction

Used to increase overall statistics due to its large solid angle coverage

No particle identification


The ring of DANTE at 58°

Mylar foil to facilitate electron production

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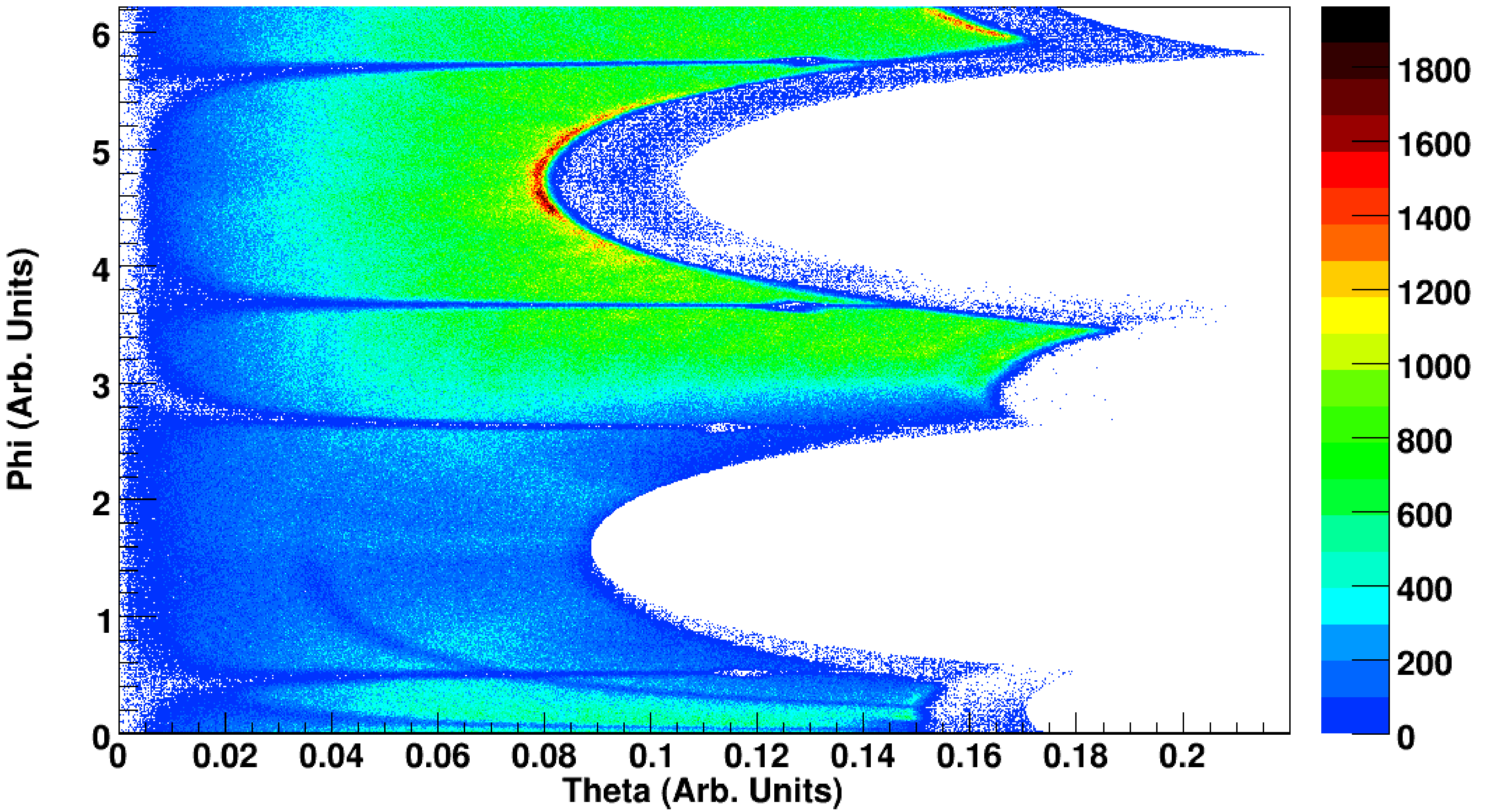
MCP as Theta & Phi



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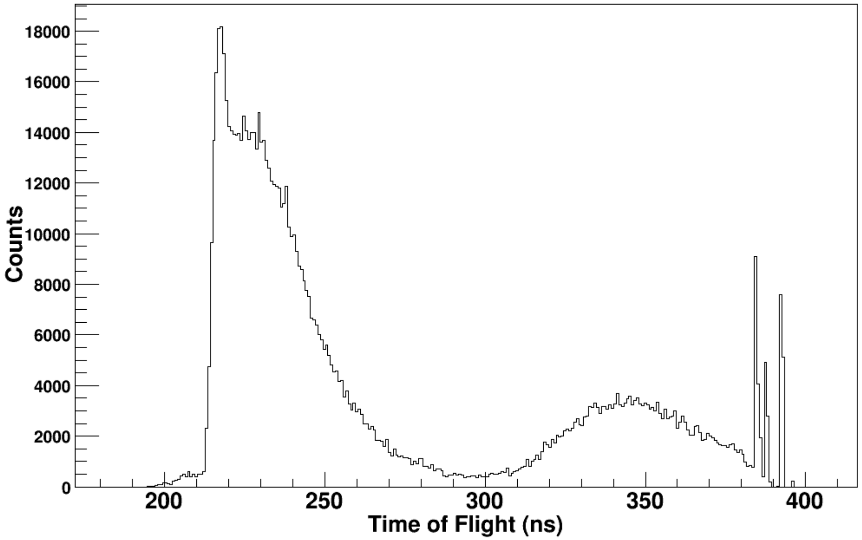
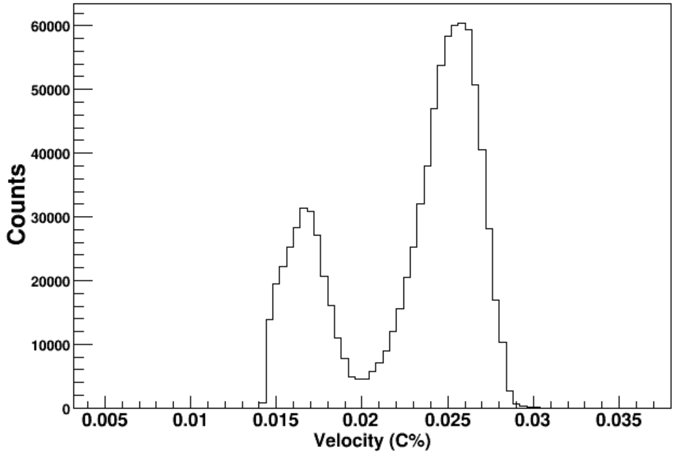
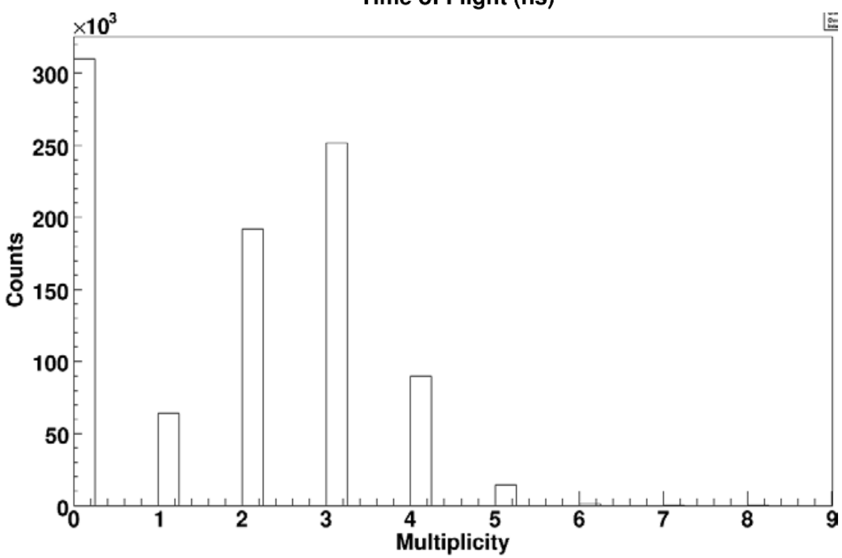
Various Distributions







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