CVT Updates Overview

Advanced restructuring of reconstruction code:

–Most distortions observed with old code understood and resolved, few remaining anomalies being debugged (detailed MC studies)

–Algorithm improvements impacting efficiency and resolution

* KF residuals calculation
* Swimming to surfaces (BMT cylinder parallax effect resolution)
* Signed doca instead of doca

–New geometry package and layer removal functionality to support alignment

--BMT geometry with functionality for alignment

–Functionality to reconstruct zero field beam data and cosmic data

—Systematic validations with MC, data, BG merging

Recent Development (BMT):

--Lorentz angle validation

--Use of timing information

- to be used for out-of-time rejection
- Used in new clustering algorithm

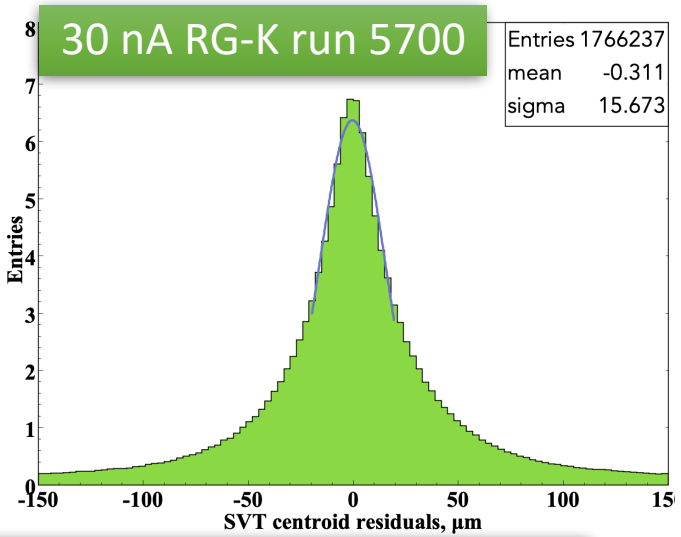
--Additional banks for alignment

Layer Exclusion algorithm Validated

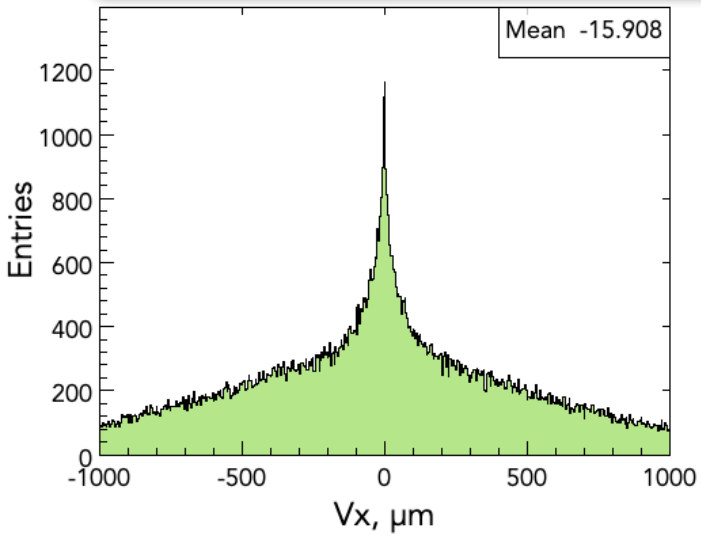
1. Find seed using all hits → e.g. SVT L1,…6, BMT L1,…6.
2. Refit seed, resetting the hits (tracking corrections, associated tracking ids, etc…) and using only the hits not specified as belonging to the list of excluded layers (specified in YAML)
3. Compute spatial residuals for all layers

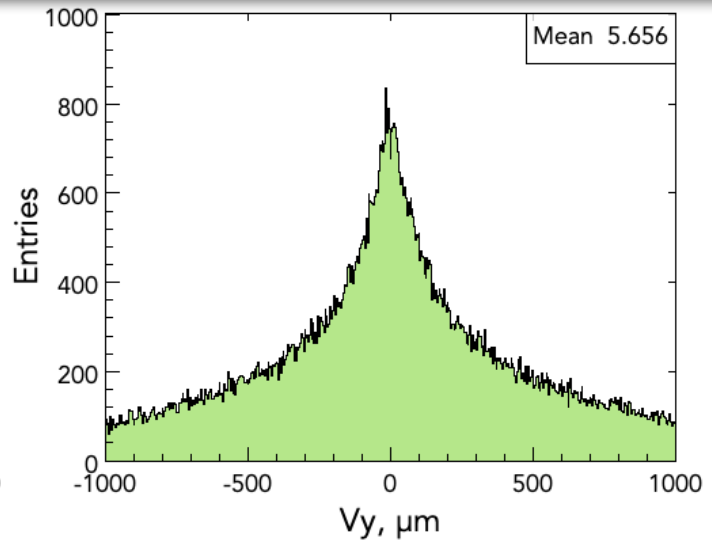
- **Used to extract alignment parameters (successfully employed for SVT)**

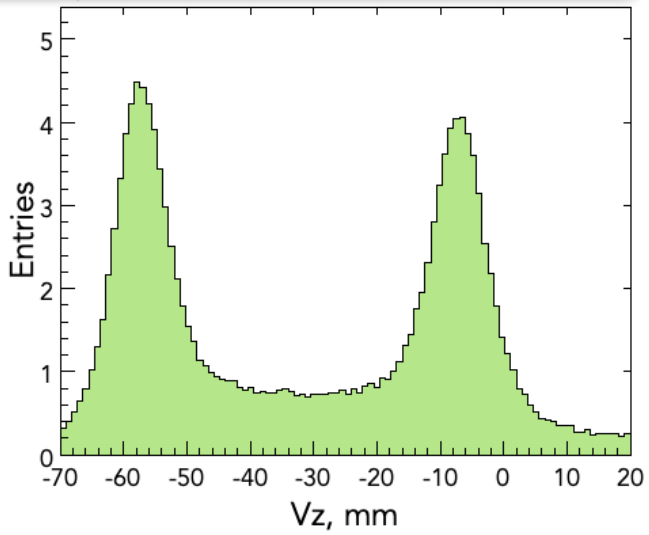
30 nA RG-K run 5700



0 T CVT alignment run 6342







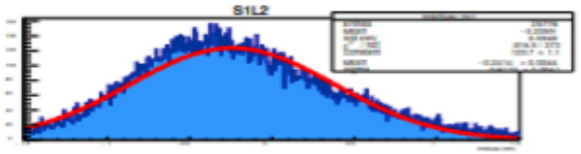
Resolution Improvements: New Clustering Algorithm Being Tested

- Alternative BMT Clustering and Lorentz-Angle Correction (Maxime)
- Promising results implementing an **alternative clustering algorithm** to reduce sensitivity to Lorentz effect in Micromegas
  - CCDB entries for Lorentz angles and HV values tested
  - Tests performed using SACLAY suite → new clustering has been merged into new tracking
  - Validation in progress

Maxime

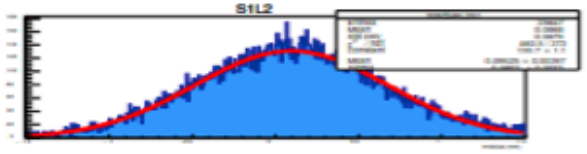
e.g. Run 5990
Representative tile

No alignment,
Old clustering:



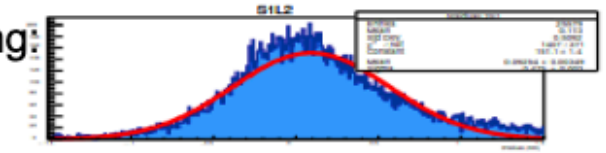
Mu = -0,2 mm
sig = 0,62 mm

Alignment :



Mu = 0,1 mm
sig = 0,55 mm

Alignment + new clustering:



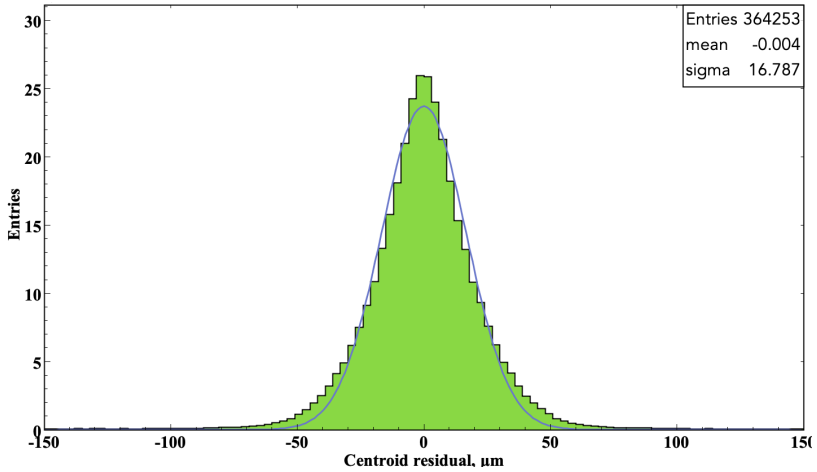
Mu = +0,1 mm
sig = 0,47 mm

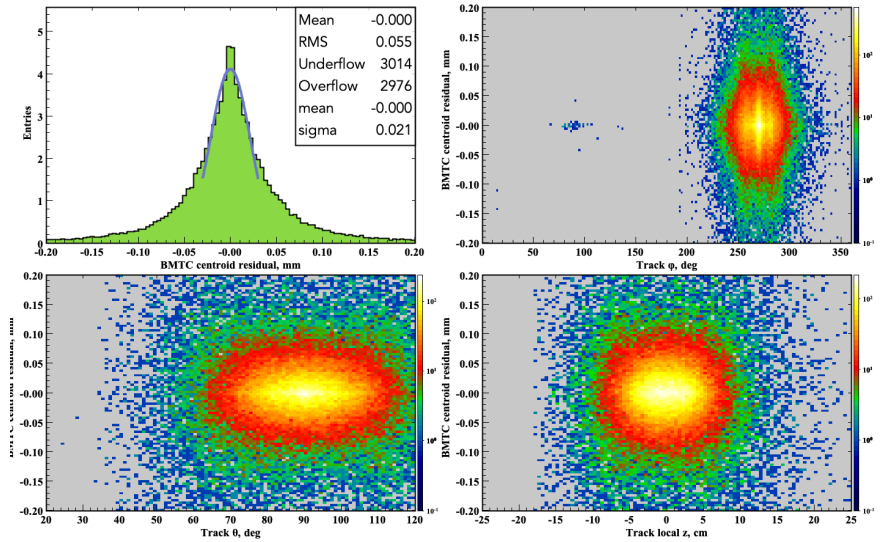
Alignment Functionality: Ability to Run on Straight Tracks from the Target and on Cosmics

SVT spatial resolution

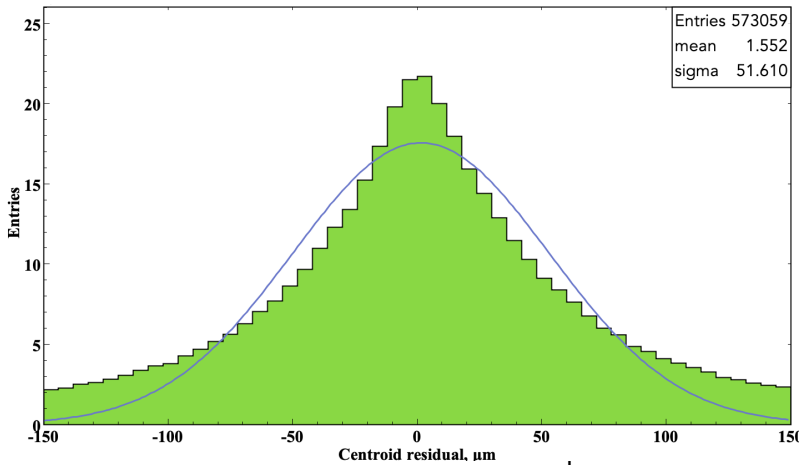
BMT spatial resolution

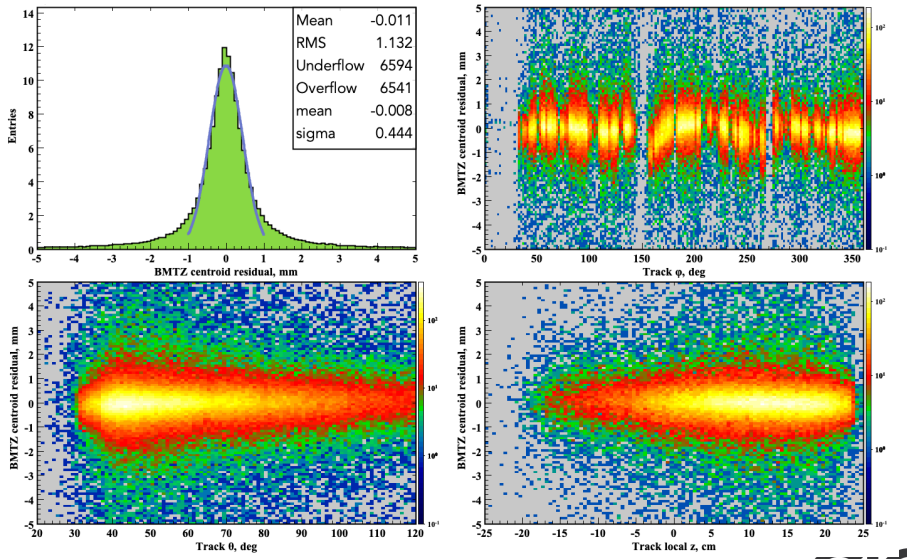
MC Cosmics



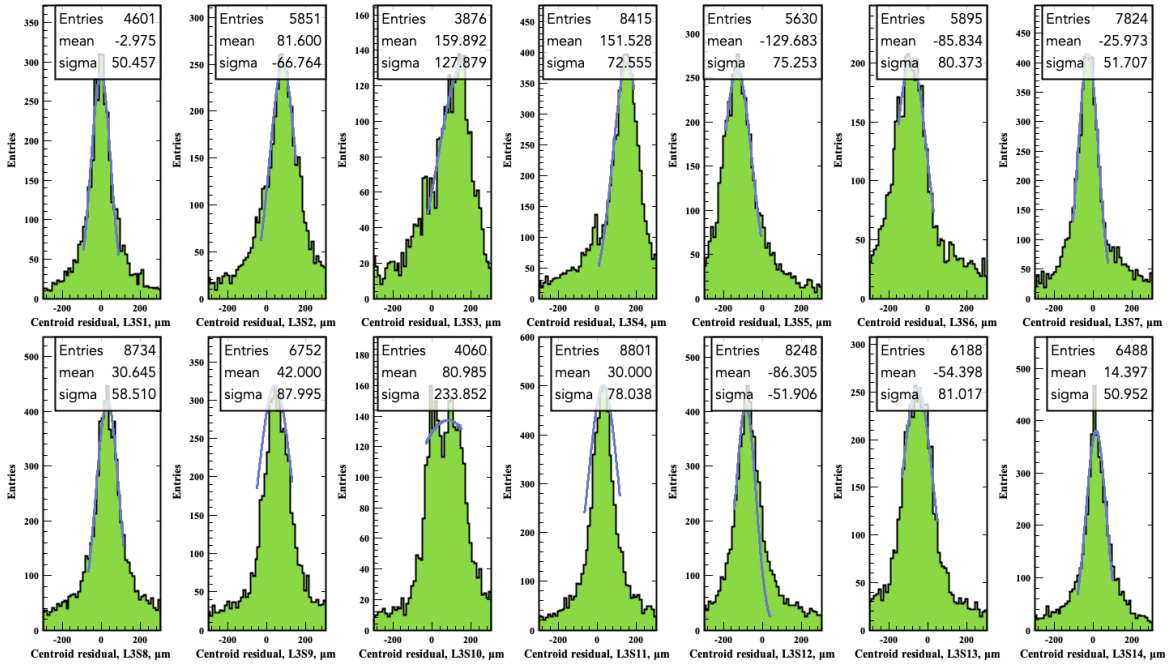


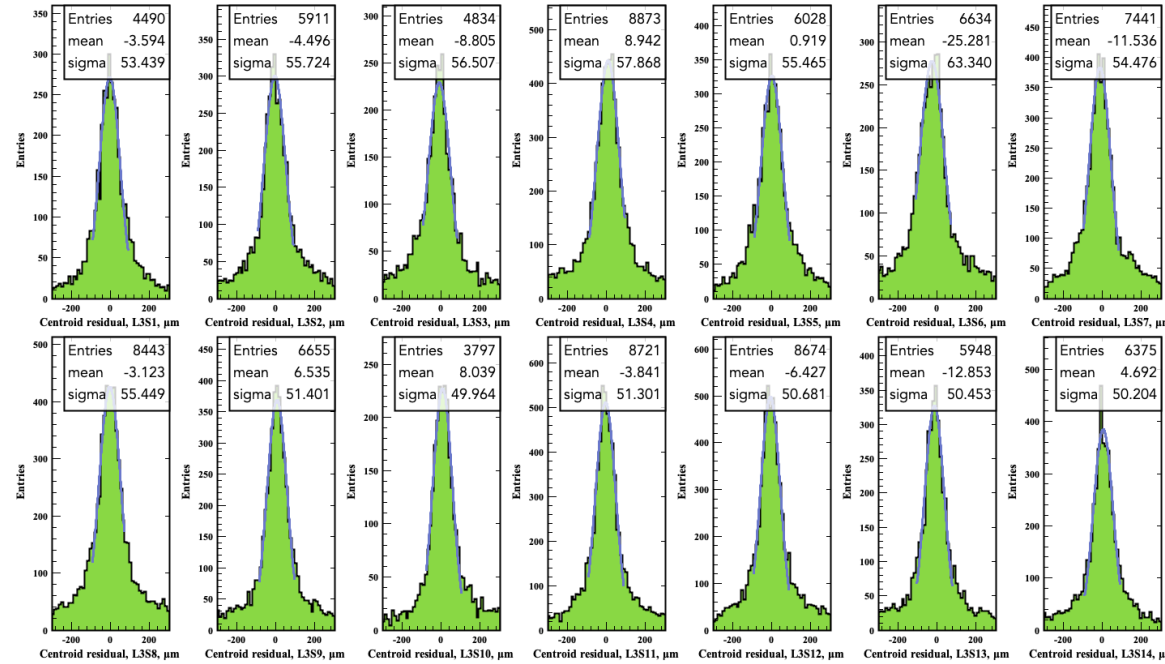
0 T CVT run 6342

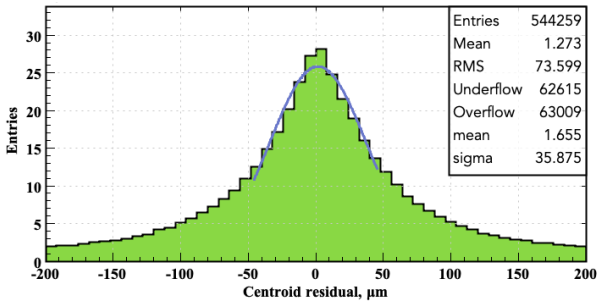


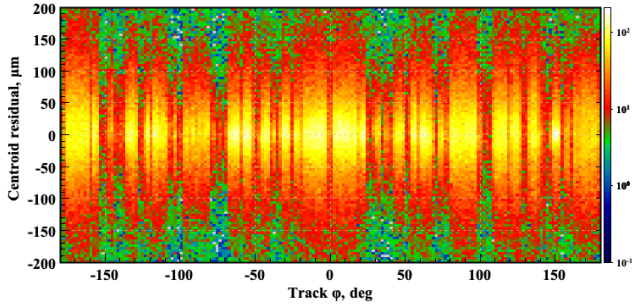


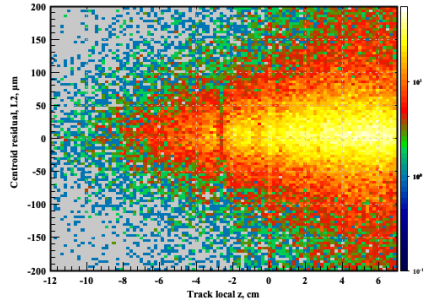
CVT alignment run 6342, SVT residuals (CVT reco, TracTools-ExLayr) [Yuri]

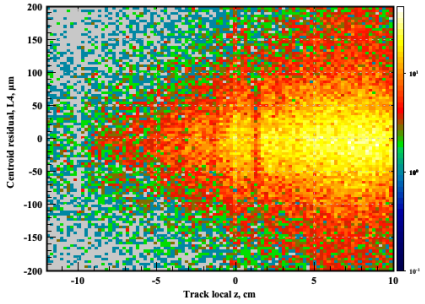


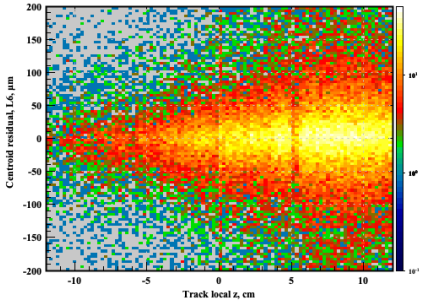


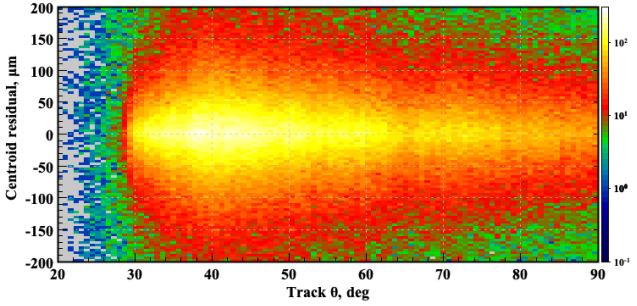


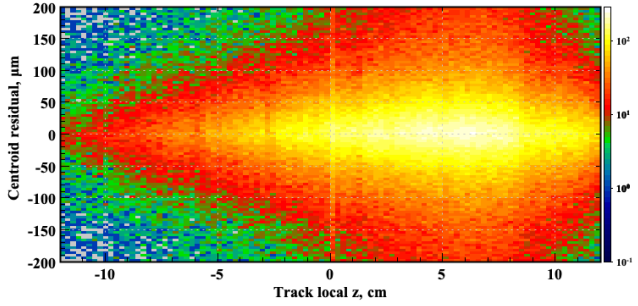


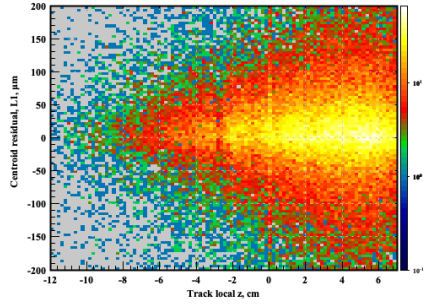


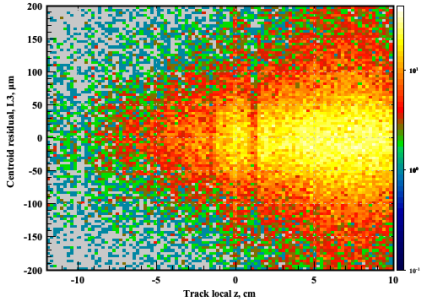


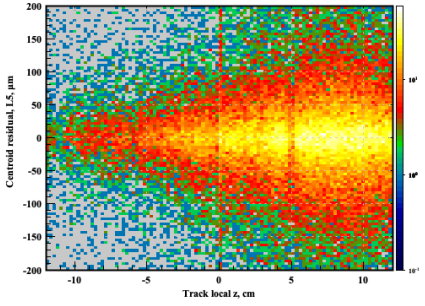












Energy Loss in CVT Tracking Development

- Implemented Eloss class in Common KF package to compute Eloss thru material
  - Using Bethe Bloch
- Updated Surface class with fields and methods for material budget and thicknesses
- Modified KF to compute Eloss in state vector propagation (assumes chosen hypothesis based on MC for testing/debugging)

- Checking the implementation and studying effect on low momentum tracks.

- Validation in progress

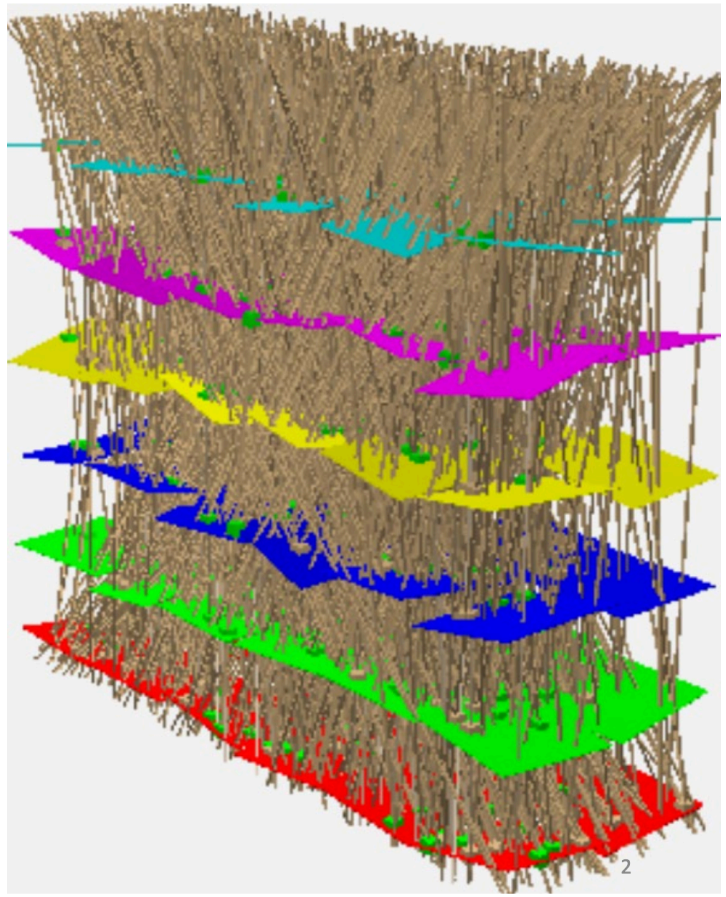
Reconstruction Remaining Tasks

- CVT Efficiency improvements
  - Study timing cuts (Yuri)
  - Further studies of seeding under high background conditions
- Complete E-loss package
  → In progress
- Check chi2 and covariance matrix
  → In progress
- Improve reconstruction speed
  - 5x5 matrix; remove Jama dependency and switch to jnp matrix
  - Code cleanup
- Implementation of new BMT clustering and Lorentz angle algorithm developed by Maxime
  → done, validation in progress
- Investigate remaining biases
  - Vz mean,
  - Top/bottom SVT modules shift offset (order of few microns) → investigation of swimming
  - Lorentz angle correction → fix implemented, validation in progress
  - Cluster residuals (BMT)
  - Cosmic track reconstruction (residuals)

Alignment via Kalman Filter

Kalman-Filter Alignment (KFA) Algorithm:

- General alignment package developed at CERN
- Input:
  - For each measured cluster in a track:
    - measured value
    - extrapolated value
    - derivatives of extrapolated value with respect to alignment
    - derivatives fitted track variables
- Output:
  - Evolution of every alignment parameter
  - Validation plots, including χ^2/d.o.f. before and after alignment



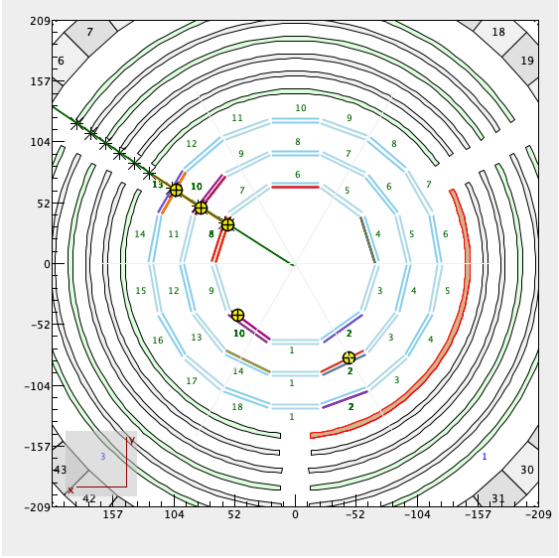
Rendering of KFA for example detector in built-in test suite

Kalman-Filter Alignment for CLAS12 CVT

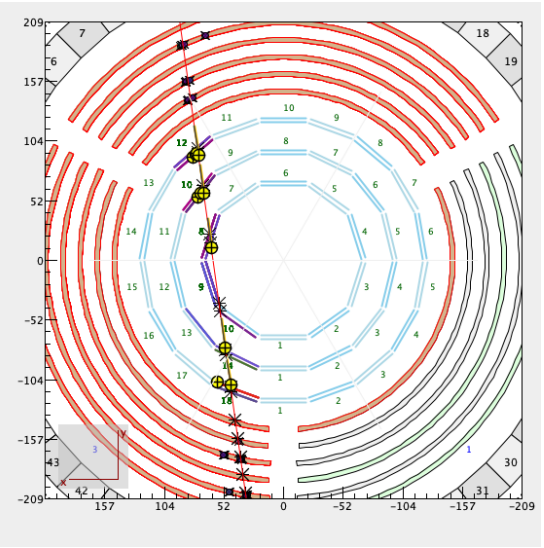
Using KFA with CLAS12 CVT:

– Procedure:
  – Recon on raw data using current alignment values (CCDB)
  – Run “prealignment” service, which takes the output of the recon and calculates the values to give to the input for the KFA
  – Run KFA
  – Adjust the alignment values in the CCDB according to the last iteration in the KFA.
  – Repeat
– Datasets:
  – Cosmic data
  – Beam-on, field-off data

Straight tracks from target



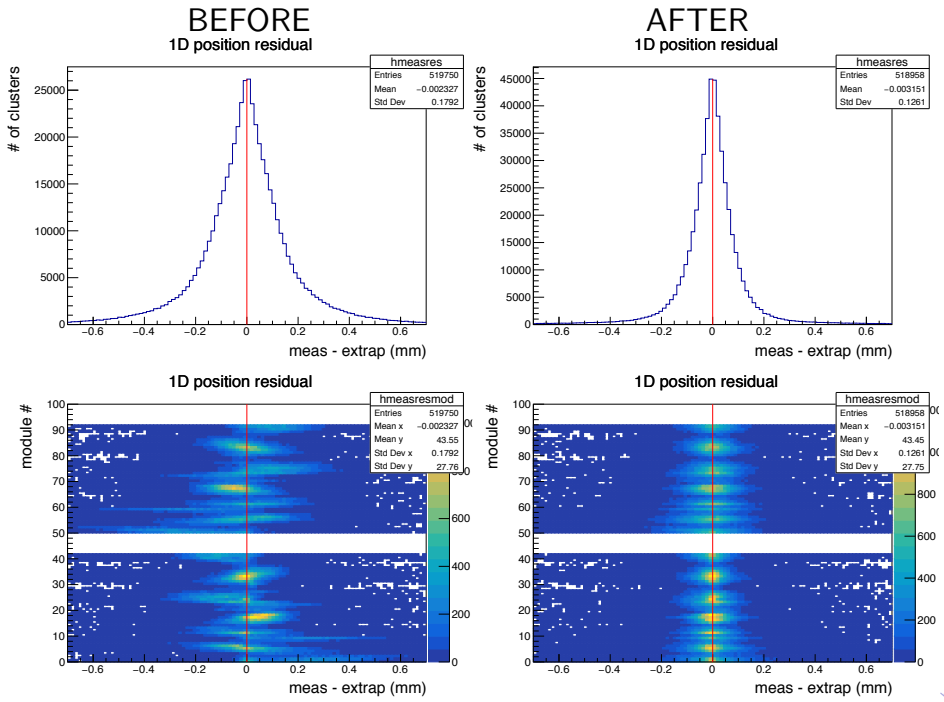
Cosmic tracks



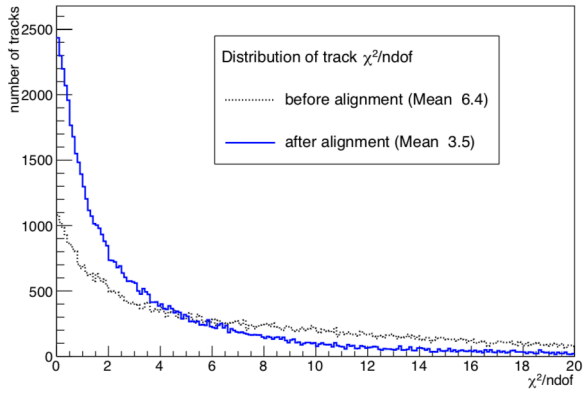
Status of KFA for CLAS12 CVT: SVT

- Successfully alignment of SVT, reducing residuals using cosmic tracks.
- RMS residual went from 179 μm to 126 μm
- χ^2/dof went from 6.4 to 2.4

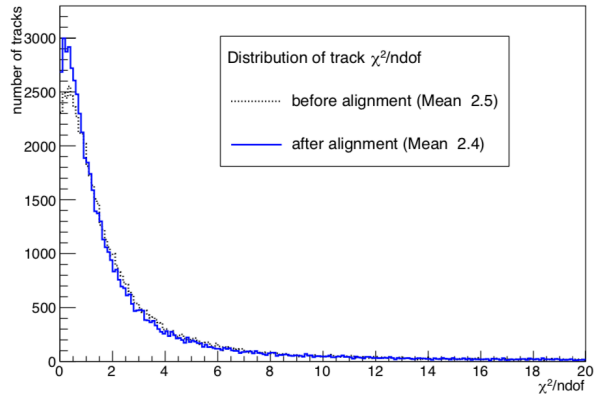
Results: Residuals



Results: χ^2/n_{dof} (first iteration)

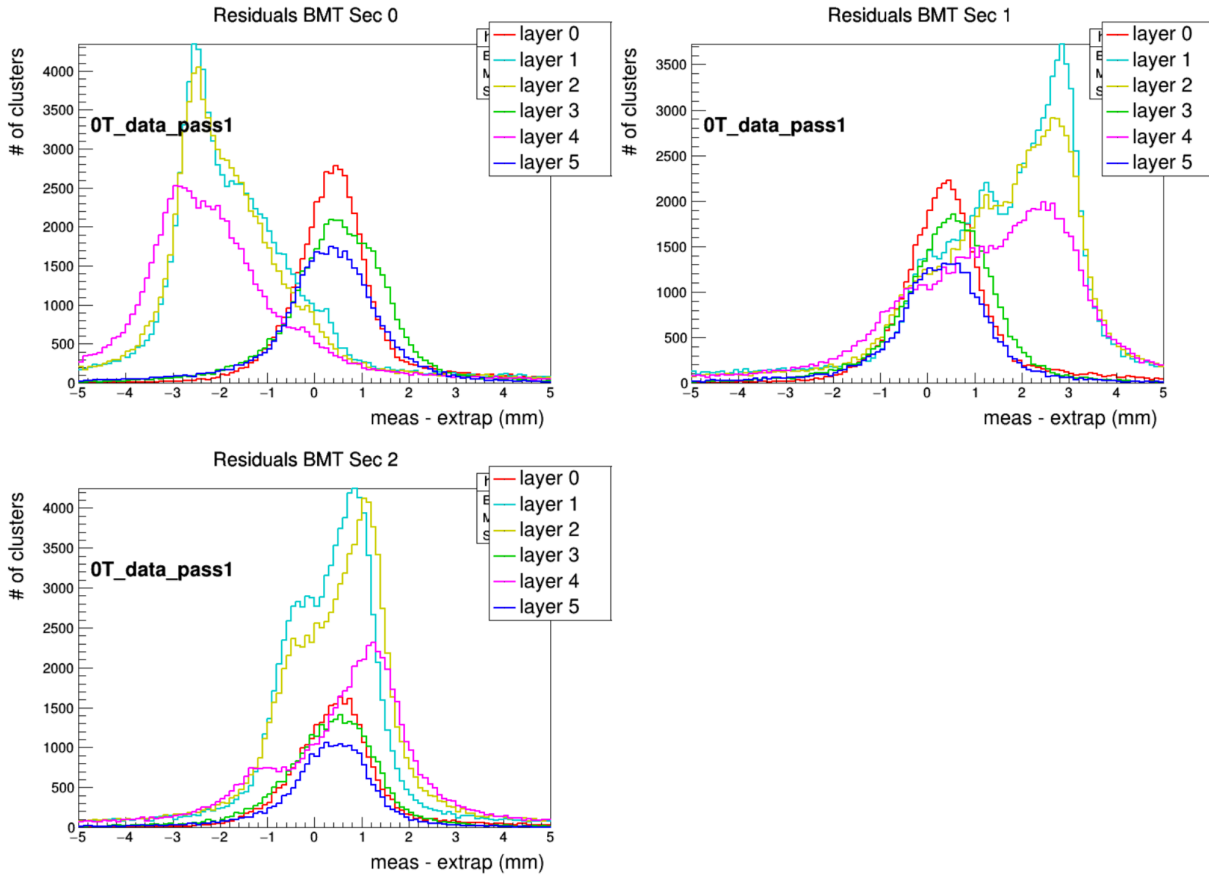


Results: χ^2/n_{dof} (after several iterations)



Status of KFA for CLAS12 CVT: BMT

- We are still debugging the pre-alignment service for the BMT.
  - Pre-alignment service indicates much larger residuals than in the recon, indicating that the pre-alignment might be accessing geometry differently than the recon.
  - Rather than recalculate everything in the pre-alignment, we are refactoring so that most of the geometric calculations needed for pre-align are done in the recon
    - New banks are being output in the recon for this purpose (validation in progress)
      - unit vectors longitudinal, normal, and transverse to the strips
      - endpoints of the Z layer strips
      - center point, origin, angular coverage and cylinder axis of the C layer strips.



Summary of the status of the KFA for CLAS12 CVT

- Successfully implemented for the SVT.
  - Residuals and χ^2/dof are greatly reduced
- Due to problems with the input for the KFA for the BMT, we are refactoring the way that some of these values are calculated
  - New banks added to recon in order to address this issue.
  - Validation and debugging in progress