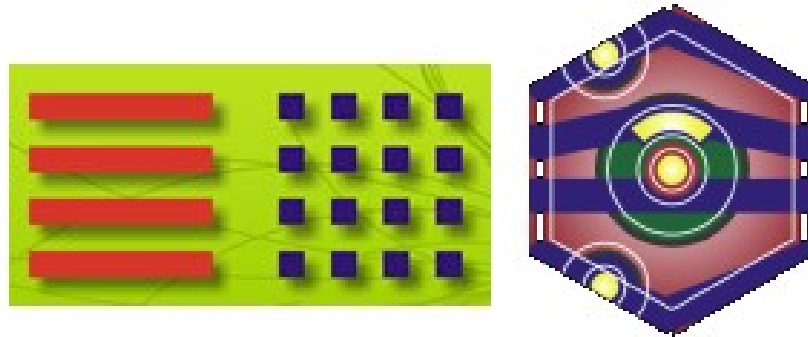# VXD Alignment



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**9-11 September 2015**
**Trieste, Italy**

# Overview

- The basf2 Calibration Framework
  - Status
  - Issues
  - Plans

- Alignment package
  - General Broken Lines Fit
  - Millepede Calibration Module
  - Global Status Overview

- VXD Alignment Test

- Questions/Requests
- Plans
- Conslusions

# The basf2 Calibration Framework

- Status
  - Initial implementation of main features:
    - Dependencies, Iterations, Splitting of data collection and calibration/monitoring
    - Histogram/Tree management with standard basf2 (RootMergeable)
    - Not safe for e.g. „per run" calibrations:
- Issues
  - Histogram management (especially in parallel processing) with data from multiple runs

# The basf2 Calibration Framework

- Plans
  - Possible solution to histogram/tree management tested
  - Calibration framework should adopt this soon
  - MillepedeCalibration module will adopt this first

  - Prepare a small tutorial „How to write and use calibration modules" for B2GM with evaluation of the interfaces (calibration developers have chance to make requests and present their use-cases)

# Alignment Package

- ## General Broken Lines Fit

  - Special treatment of multiple scattering (kink in tracks)

  - Experiment independent implementation in GENFIT

  - In basf2: GBLfit Module

  - Supported sub-detectors in the fit: VXD, CDC, BKLM
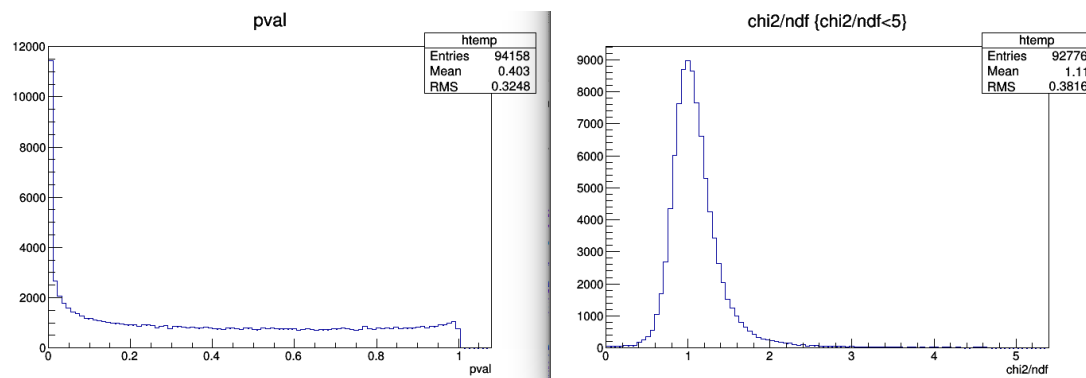


- ## Millepede Calibration Module

  - Collects binary data from GBL fitted tracks and uses standalone Millepede II to find alignment/calibration parameters' corretions

  - Millepede: Global Chi2-minimization: all track and alignment parameters free and fitted simultaneously – correlations kept

  - The more data and parameters (detectors) included, the more powerfull is the procedure

    - Full scale alignment/calibration not just with VXD (full control over cross-detector correlations)

5

# Alignment Package

- Global Status Overview
  - Detector with Genfit/General Broken Lines interface
    - VXD, CDC – in full operation, working fine
    - BKLM – Currently small reconstruction bias being solved
  - Detectors with Millepede interface
    - VXD – in full operation. 6 parameters per sensor, working fine
    - CDC – tested axial layer alignment, simple drift velocity calibration, but not in svn
    - BKLM – in test operation, 6 parameters per module, in svn
      - Reconstruction issues to be solved first
  - Fully included in calibration framework

# VXD Alignment Test

- Full example in alignment/examples
  - generate_samples.sh (takes some hours) … GenDST.py
  - calibrationFramework.py
- Sample
  - 100k particle gun events + 300k cosmic rays
    - Only about 100k cosmic muons pass selection:
      - 4 < # hits < 24
      - Fit success & p-value > 0.001 (ideal geometry)
- Fixed 6th SVD layer and all slanted SVD sensors
  - Not misaligned. Used as reference.
  - Slanted - low statistics for cosmics & selection criteria

# VXD Alignment Test

- Generated misalignment: random per each (non-fixed) sensor and param
  - u, v, w … 100 micrometers
  - alpha, beta, gamma … 1 mrad

- On following plots:
  - **Black**    ideal geometry
  - **Blue**      misaligned reconstruction geometry
  - **Red**       reconstruction geometry after Millepede alignment (2nd iteration with complete refit)

    misalignment – alignment = residual misalignment
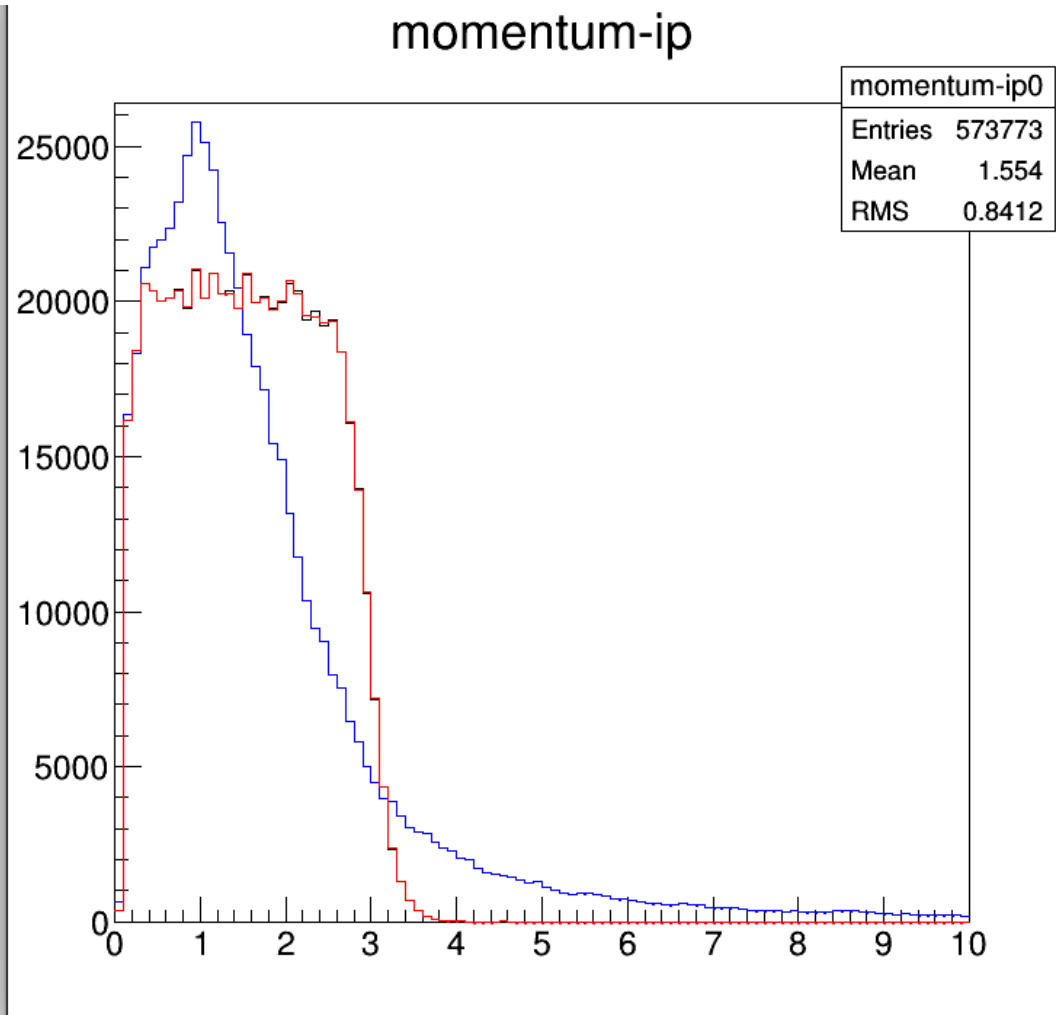
# Chi squared
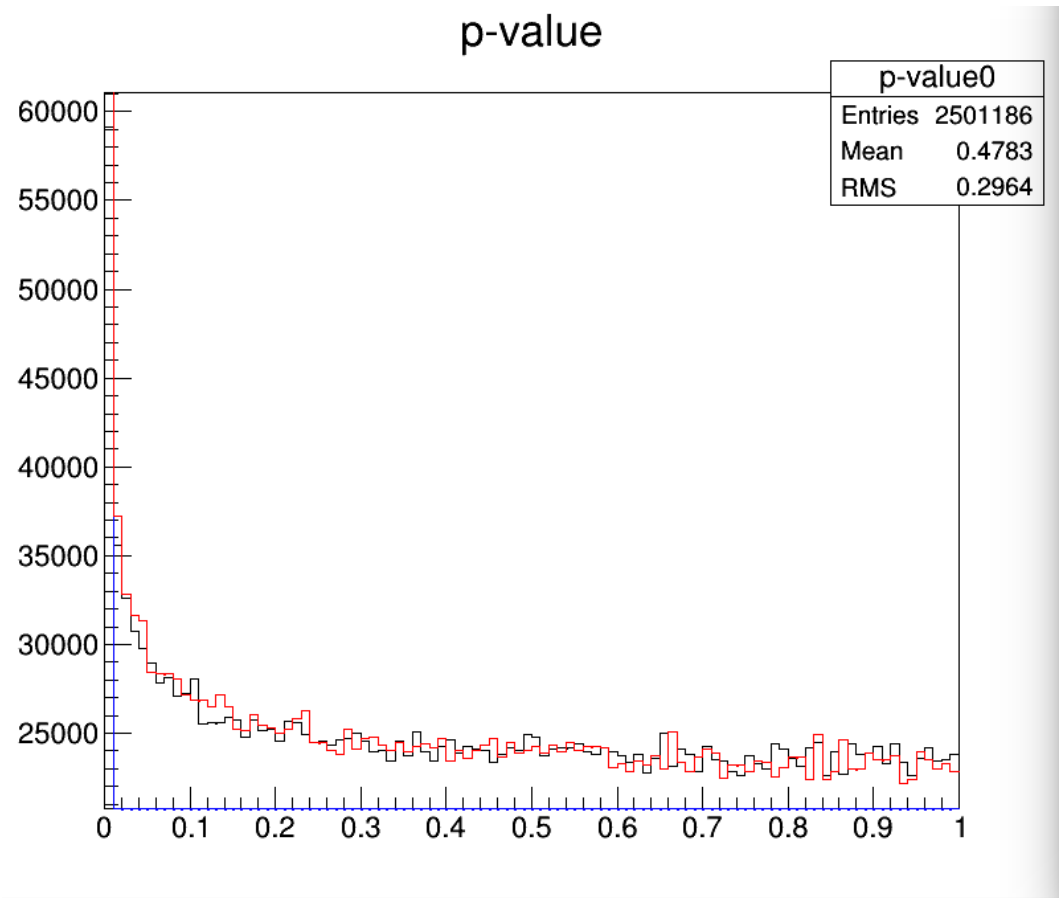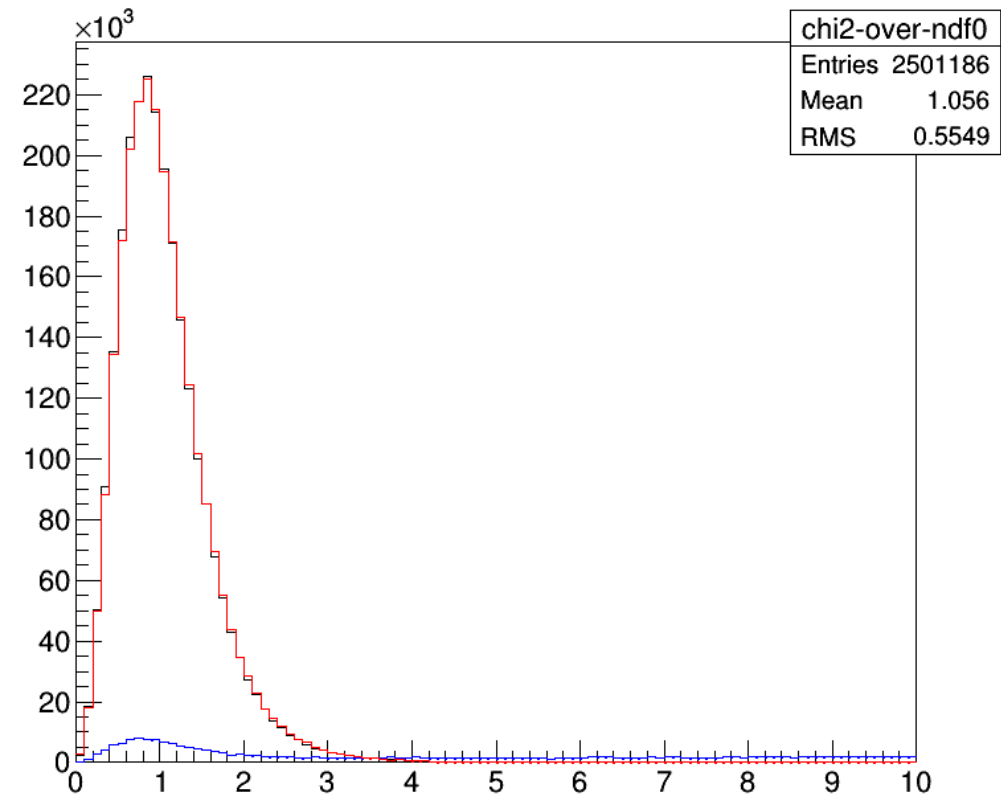
# U (R-Phi) Residuals [cm]
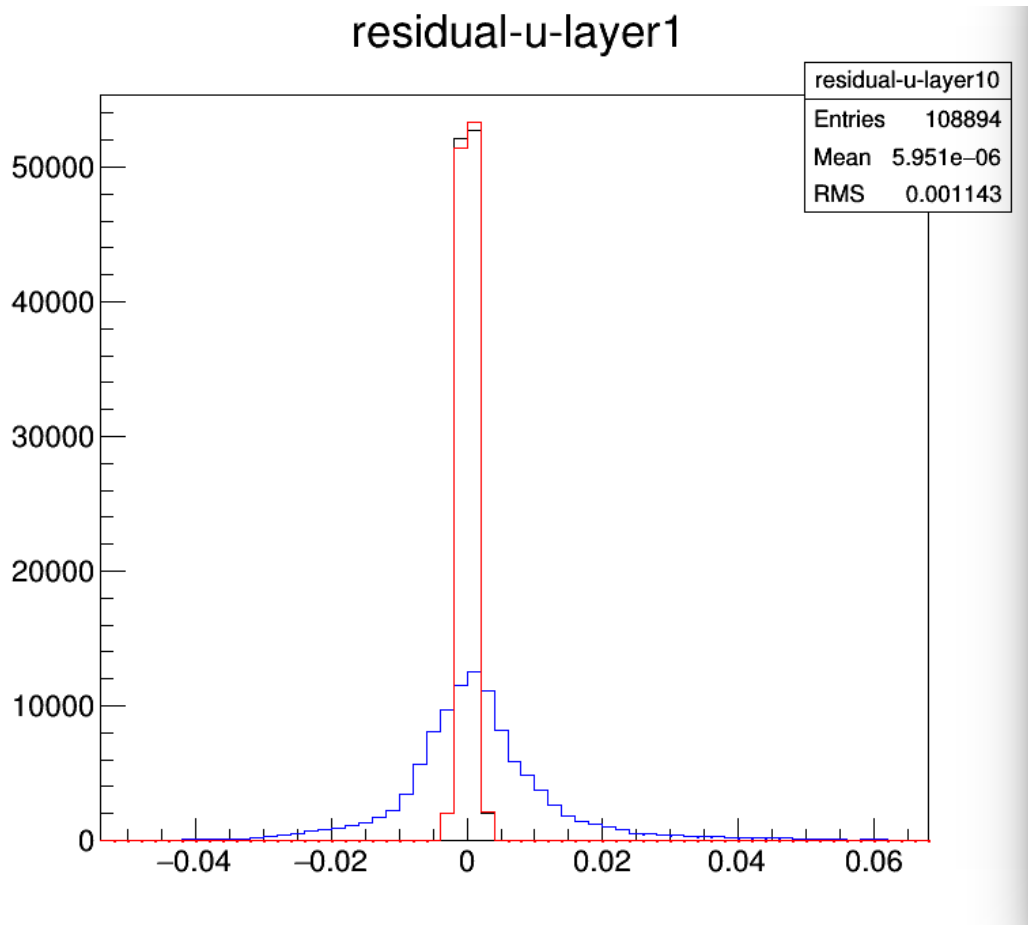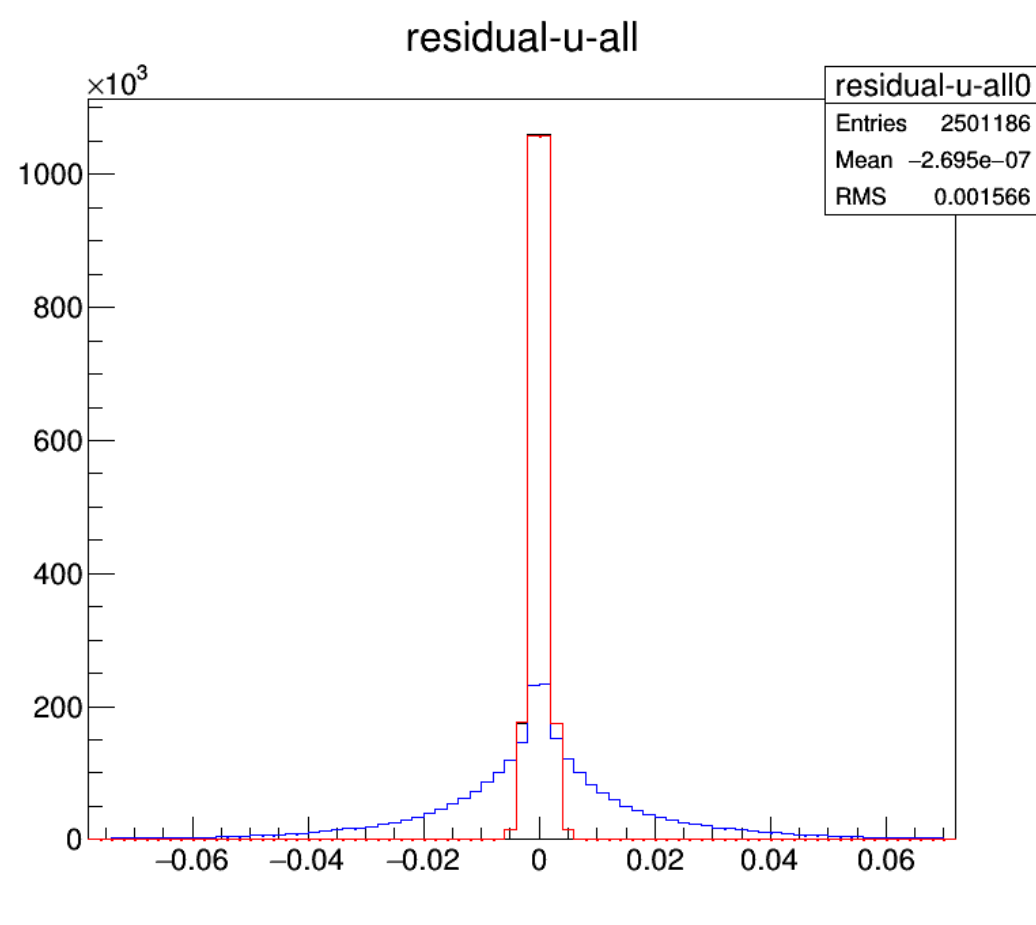
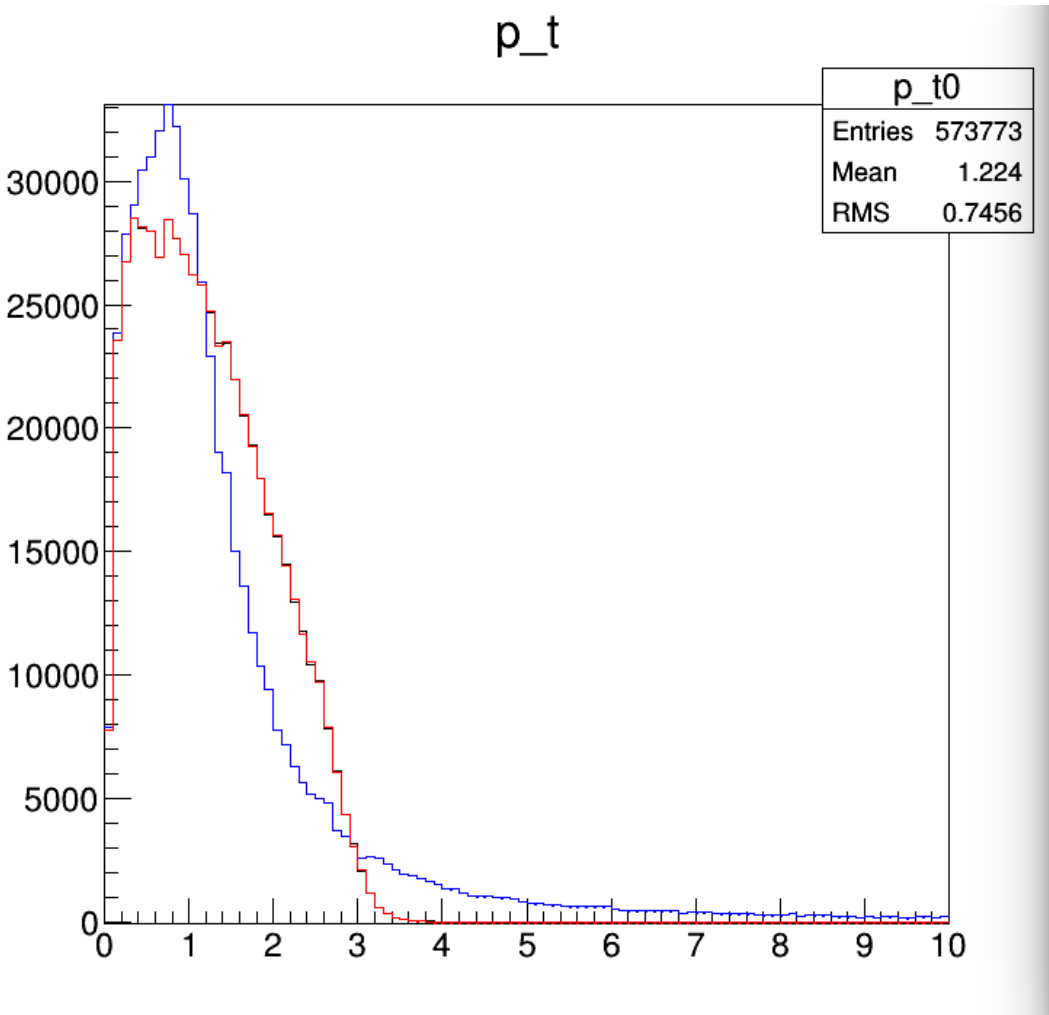# V (Z) Residuals [cm]
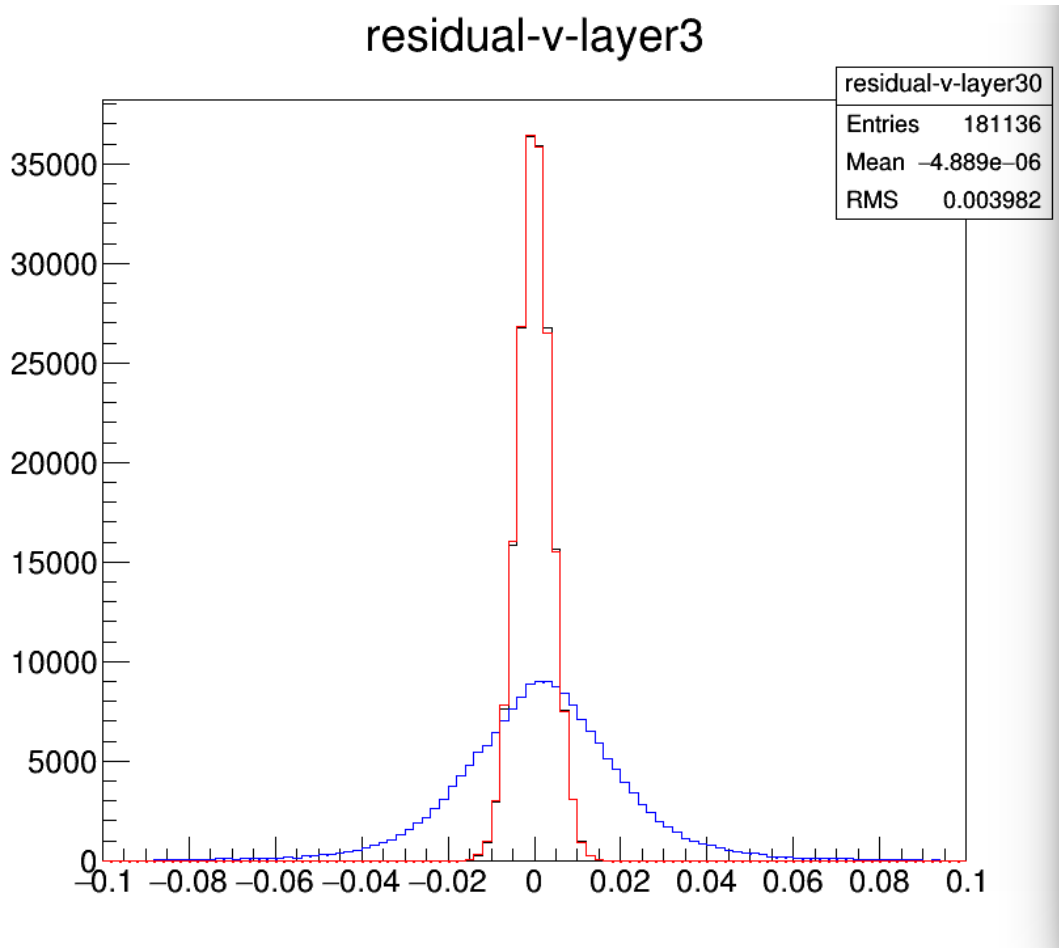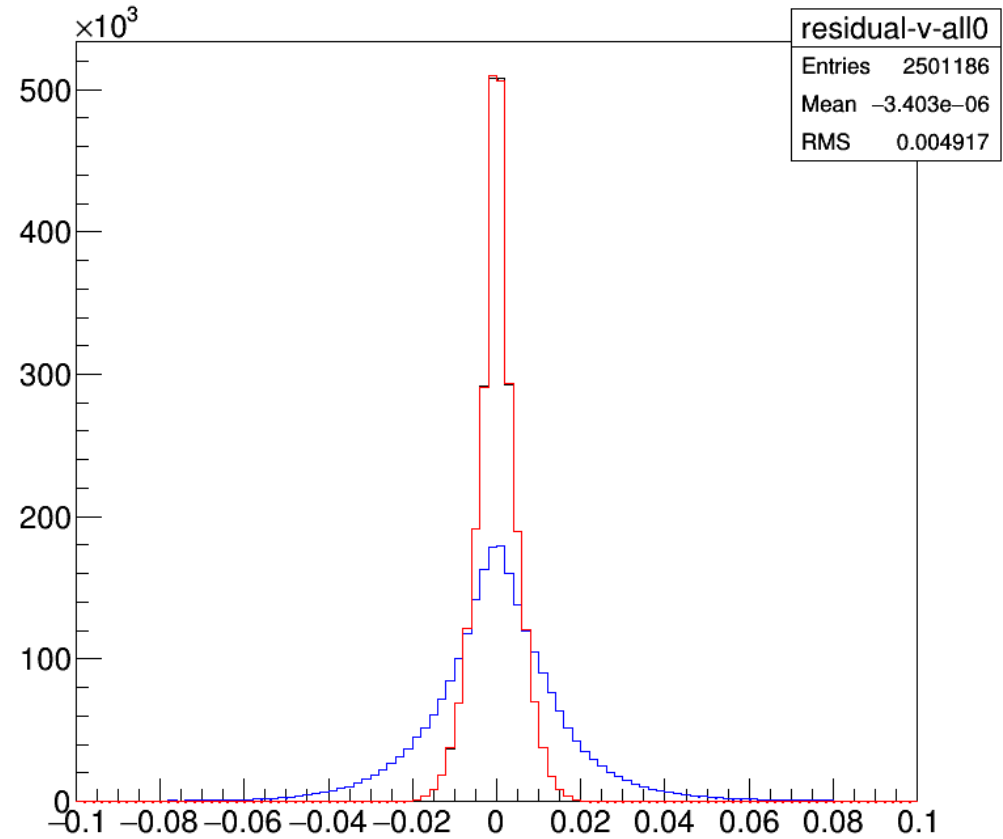
# Vertex estimation in VXD [cm]
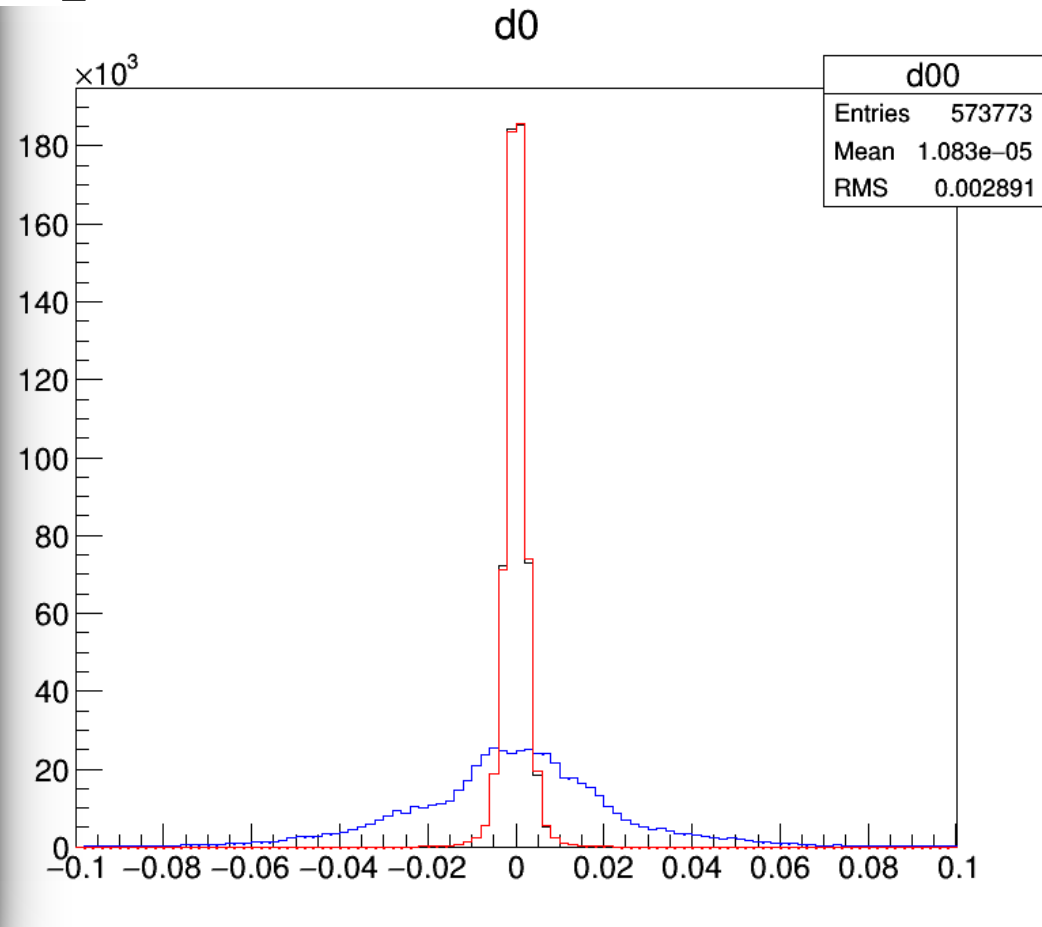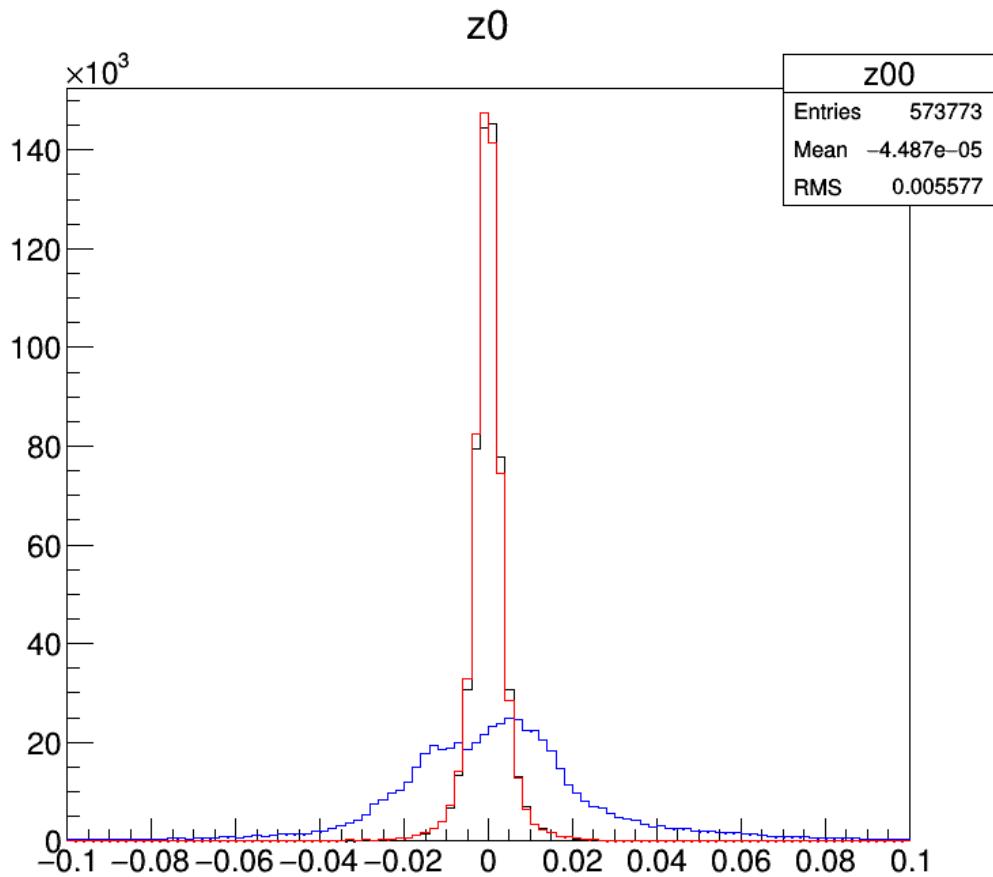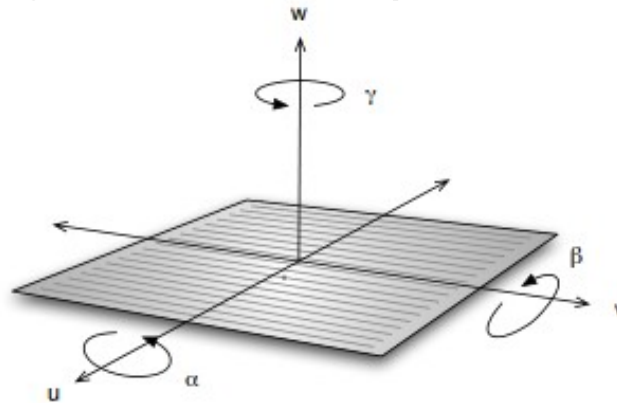
# Momentum estimation in VXD [GeV/c2]

# Residual Misalignment Shifts [um]
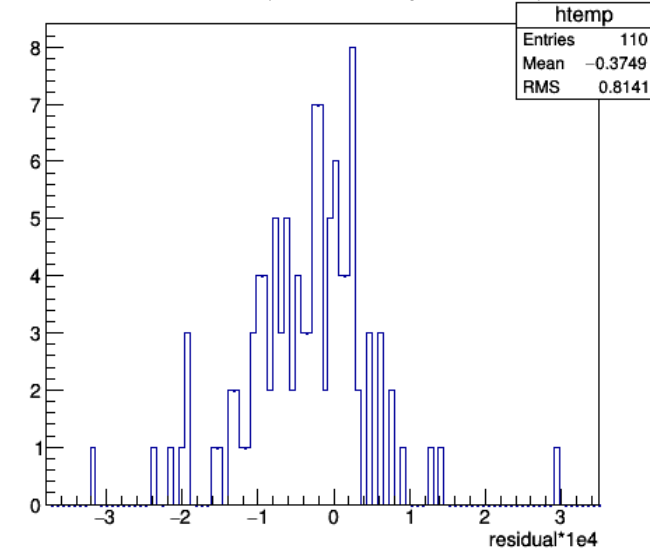
residual = input misalignment – computed alignment



u RMS=0.4um
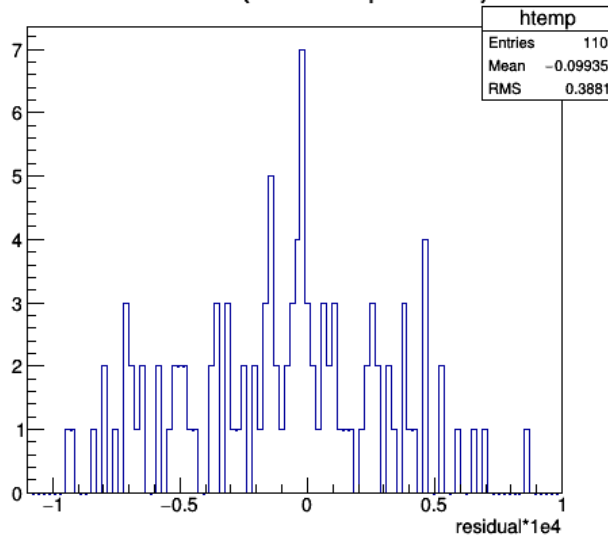
w RMS=0.8um
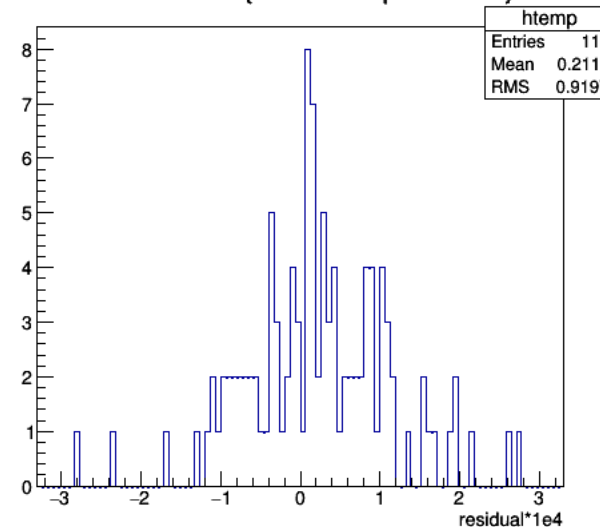
v RMS=0.9um

# Residual Misalignment Angles [mrad]
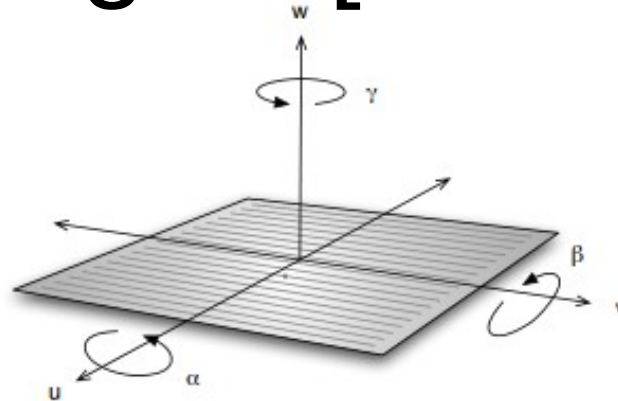




Alpha
RMS=0.02 mrad

Beta
RMS=0.08 mrad

Gamma
RMS=0.02 mrad
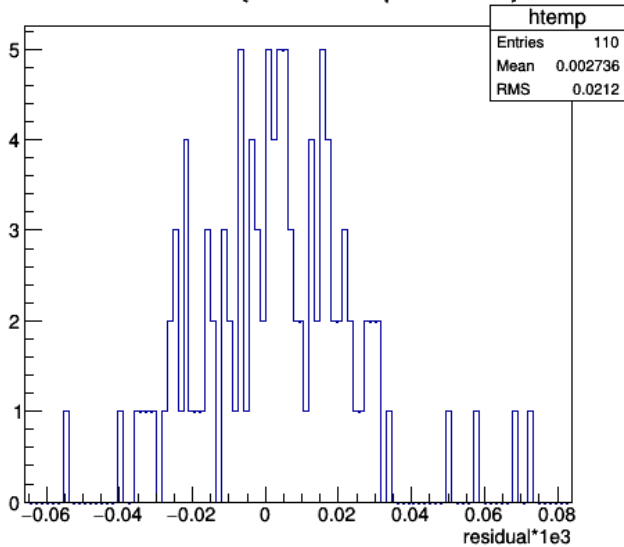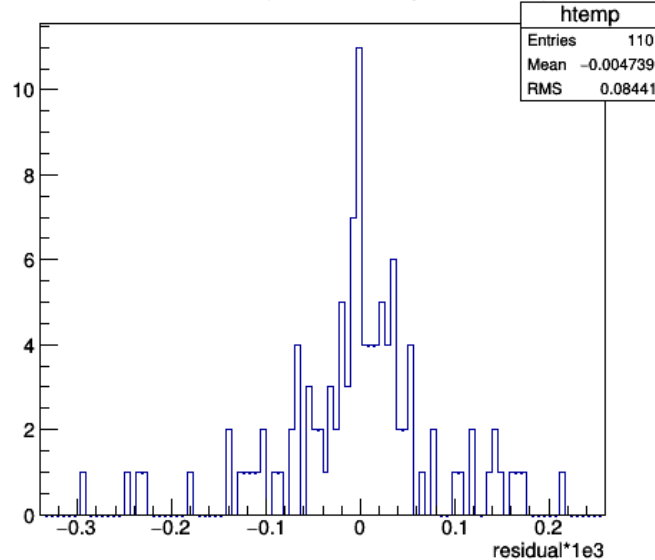
# Residual Misalignment
# Pulls of all parameters



residual/error {error>0.}

| htemp | |
|---|---|
| Entries | 660 |
| Mean | −0.06318 |
| RMS | 1.152 |

RMS = 1.152

Millepede is quite good in error estimation
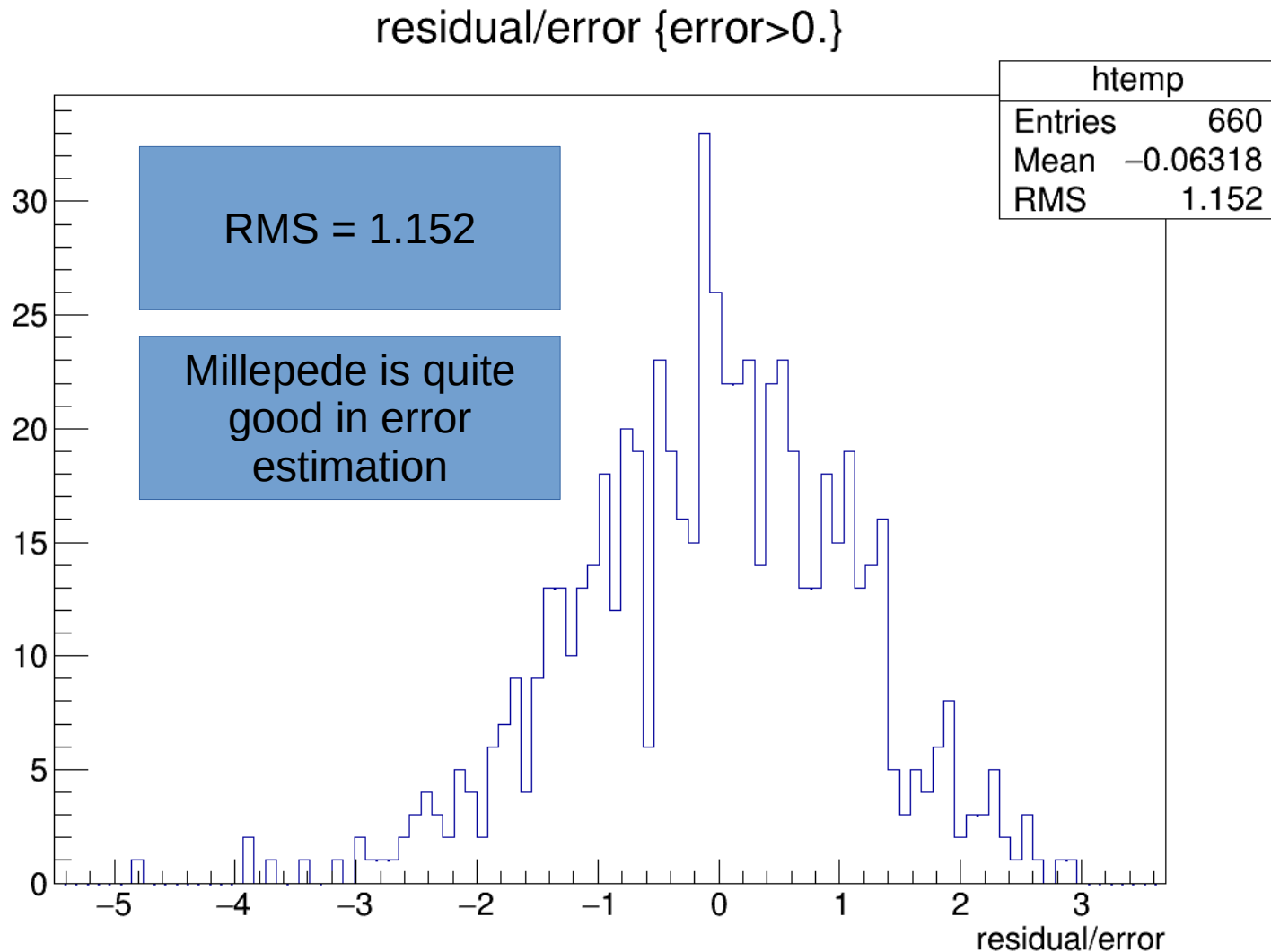
# Questions / Requests

- What is the possible initial misalignment?

    - How precisely are sensors mounted to ladders, ladders to layers, layers to support?
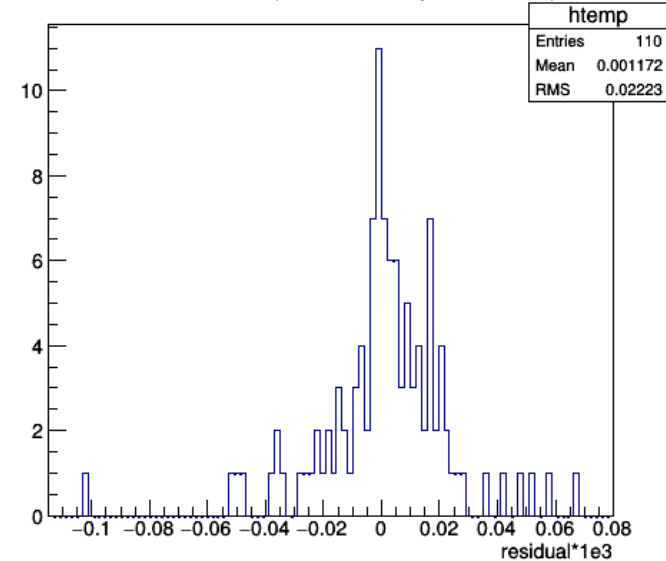
- What sub-structures should be considered

    - Are half-shelves mechanically independent?

- Survey measurements

    - Vital to alignment as (precise) external reference

    - What is planned?

    - Discussion how to interface e.g. laser measurements in-place (online) to Millepede alignment

# Plans

- Calibration Framework
- Alignment/Calibration
  - Run(even intra) dependence in Millepede (initial implementation ready → testbeam!!!)
  - Lorentz shift calibration in VXD (testbeam!!!)
  - Sensor deformations for VXD (2nd order) (testbeam?)
  - Hierarchy (for all detectors?) + constraints
  - CDC alignment & calibration
  - BKLM: add EKLM, solve reconstruction issues
  - J/Psi→mumu in alignment

# Conclusions

- We can already do quite good VXD alignment
  - (Still) ready for beam test


- We have four(!) different subdetectors interfacing Millepede alignment/calibration
  - PXD + SVD + CDC + BKLM


- We need (a lot of) contributions from sub-detectors
  - Parameters, misalignment/alignment, hierarchy, precisions and possible misalignment, database …

# Thank you for attention!