Hit residuals from track fitting

ePIC Track Reconstruction meeting
22 February 2024

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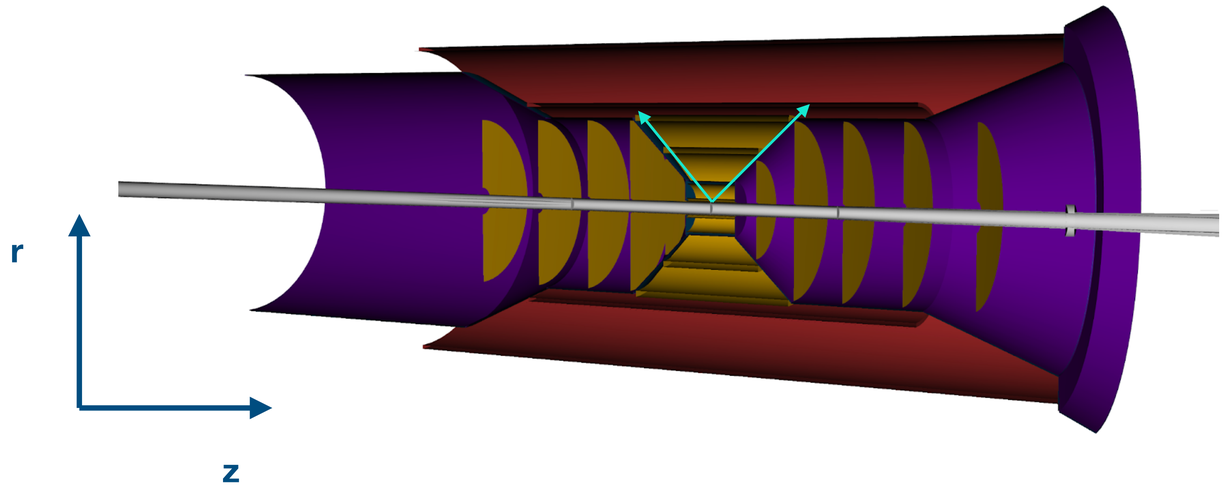
Motivation

- Study the track reconstruction performance at each layer of the central tracker geometry
- The χ^2 depends on tracking parameters and is not as straightforward as a residual
- There is also an arbitrary χ^2 cut of 15 that separates hits from becoming measurements or outliers

Process

Events used:

- Single muon events, 10,000 events
- 0.5 < p < 20 GeV
- Only looking at the central tracker

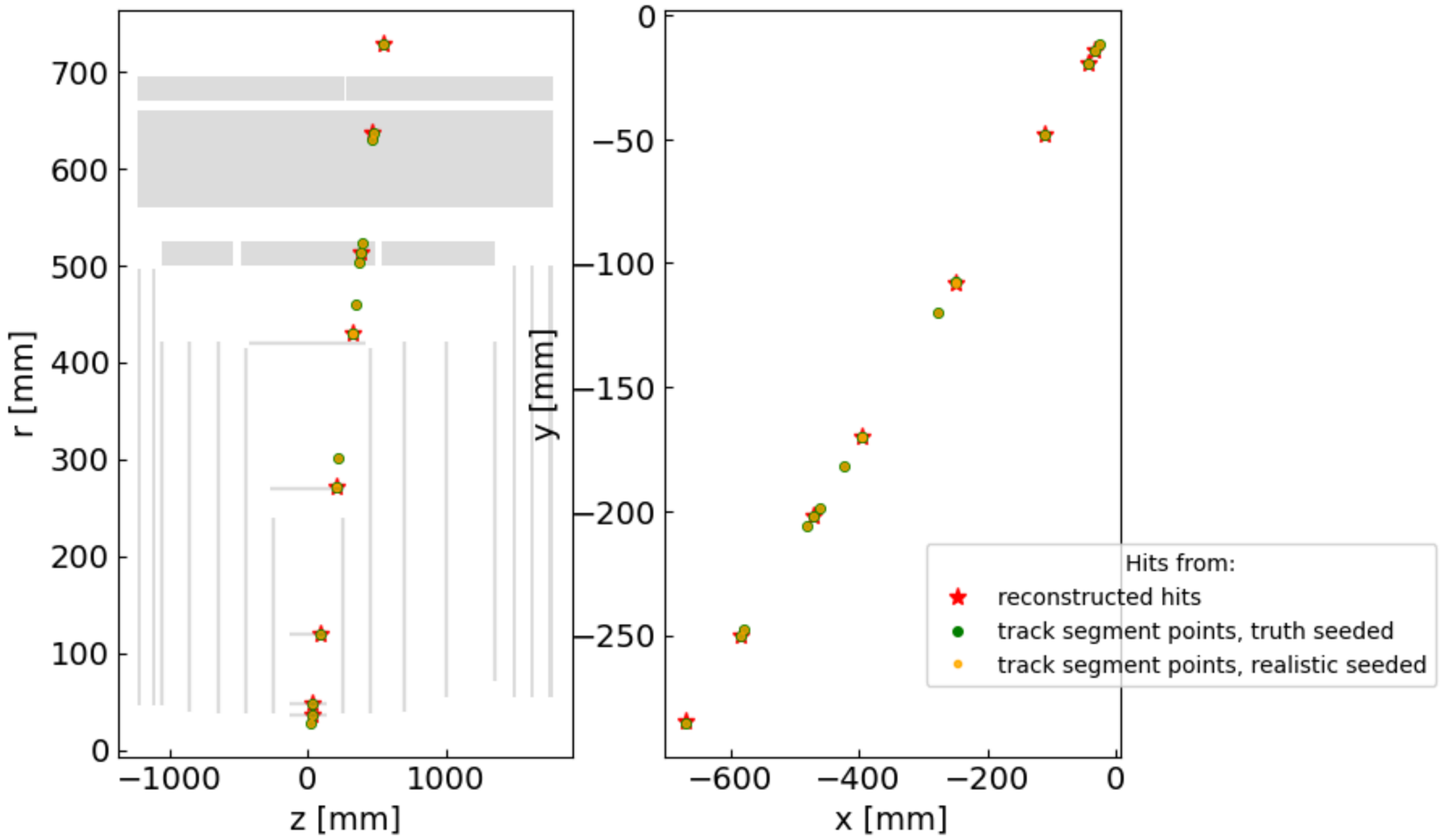


Calculating residuals:

- Compare the “CentralTrackSegment.points” with the “RecHits” to see how the hits compare to the reconstructed track
- Find the track point with the closest distance to the reconstructed hit in Δr(Δz) for the barrel(endcap)
- Barrel layer residual = Δz = $z_{\text{hit}} - z_{\text{trackpoint}}$
- Endcap layer residual = Δr = $r_{\text{hit}} - r_{\text{trackpoint}}$

Example of a track

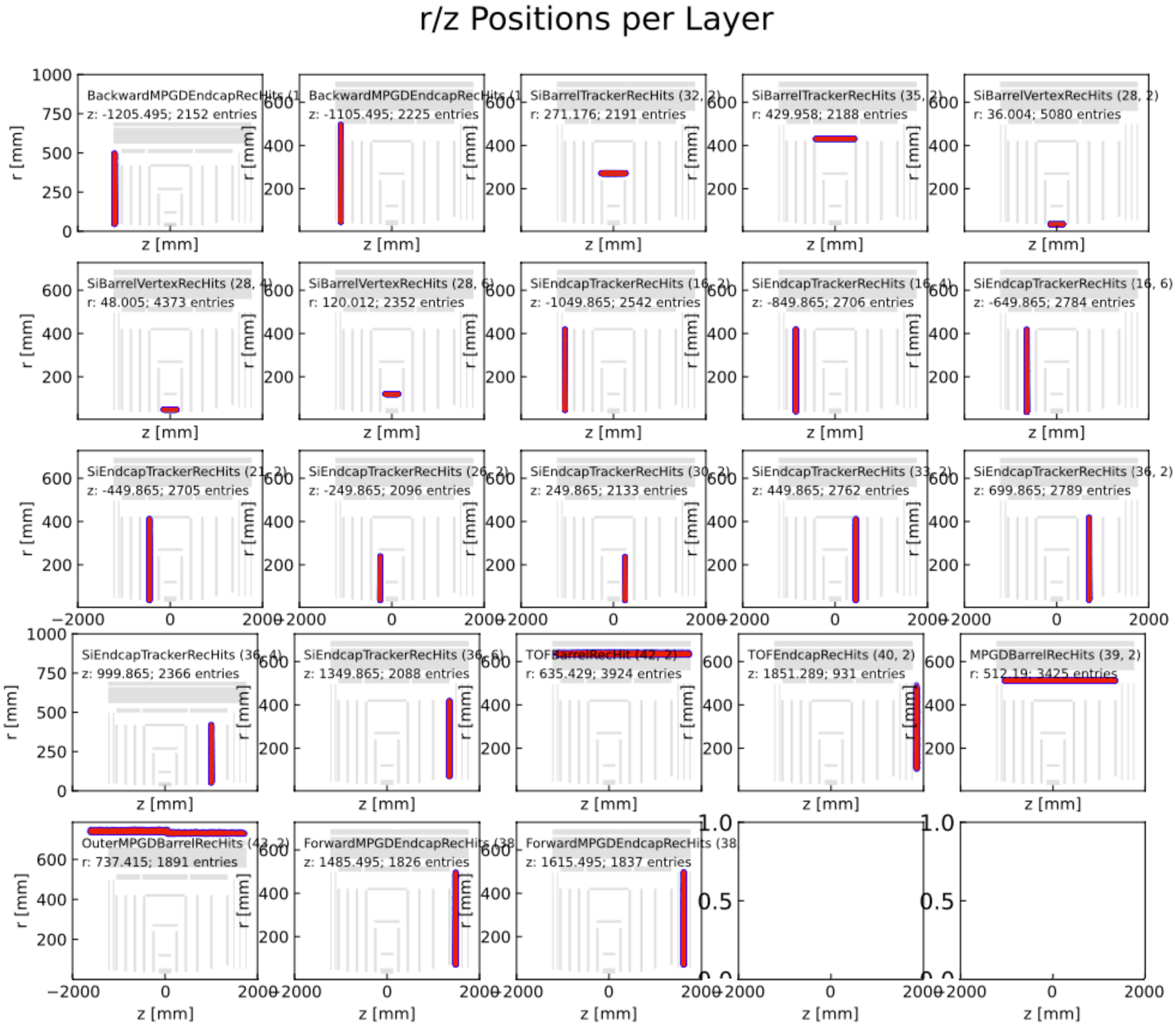
- Reconstructed hits
  - Plotted are both “measurementHits” and “outlierHits”
- Track segment points = the points on a track at each surface
  - Includes calibrated+uncalibrated states



r/z positions per layer

Central Track Measurements
Track segment points matched to Central Track Measurements
Detector configuration

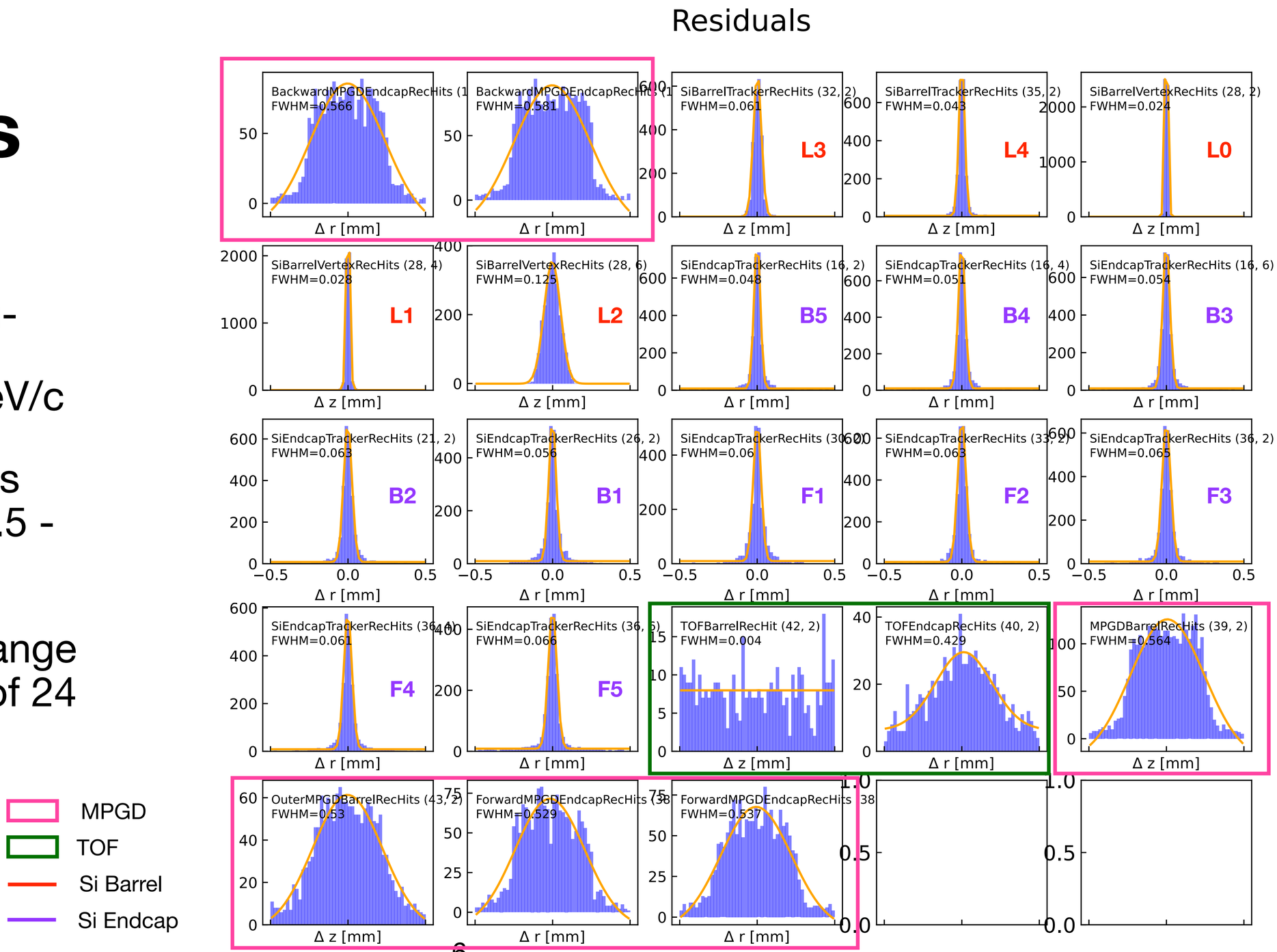
- Visually, it looks like the measurements line up nicely with the track points



Residuals

per layer

- Truth seeded, μ-
- 0.5 < p < 20 GeV/c
- All x-axis ranges are between -0.5 - 0.5 mm
- Silicon peaks range from a FWHM of 24 - 125 μm



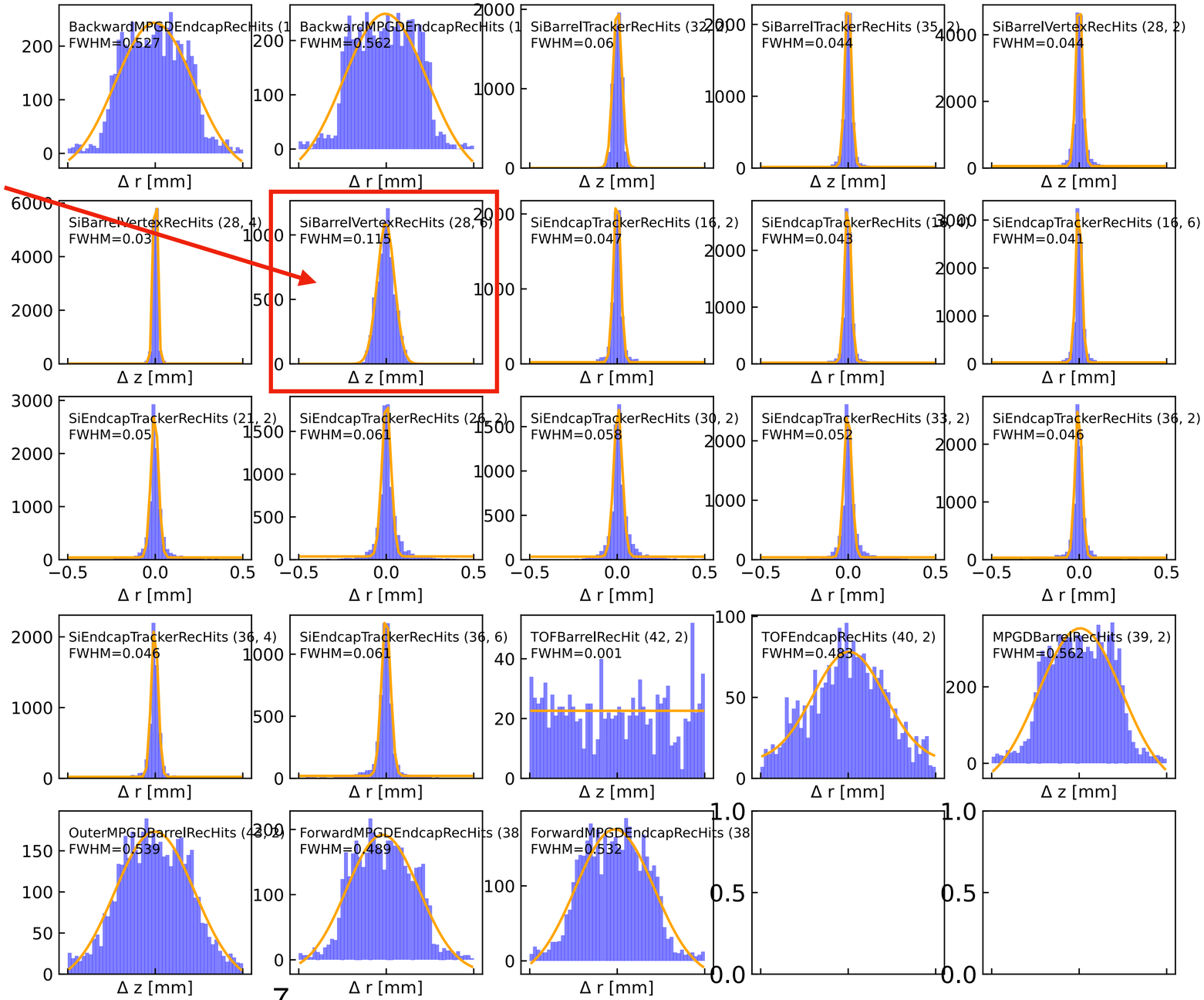
MPGD
TOF
Si Barrel
Si Endcap

Residuals

per layer

- Realistic seeded, μ-
- 0.5 < p < 20 GeV/c
- Silicon peaks range from a FWHM of 30 - 115μm
  - (compared to truth seeded: FWHM ranges from 24 - 125 μm)

Silicon L2



FWHM at different layers

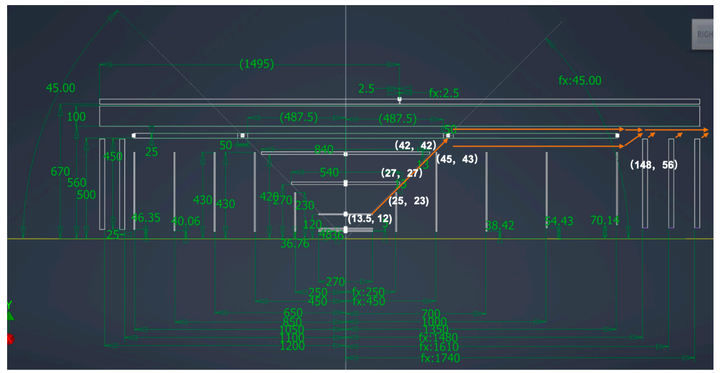
*See different TOF endcap coordinates at: https://eic.jlab.org/Geometry/Detector/Detector-20231031150001.html

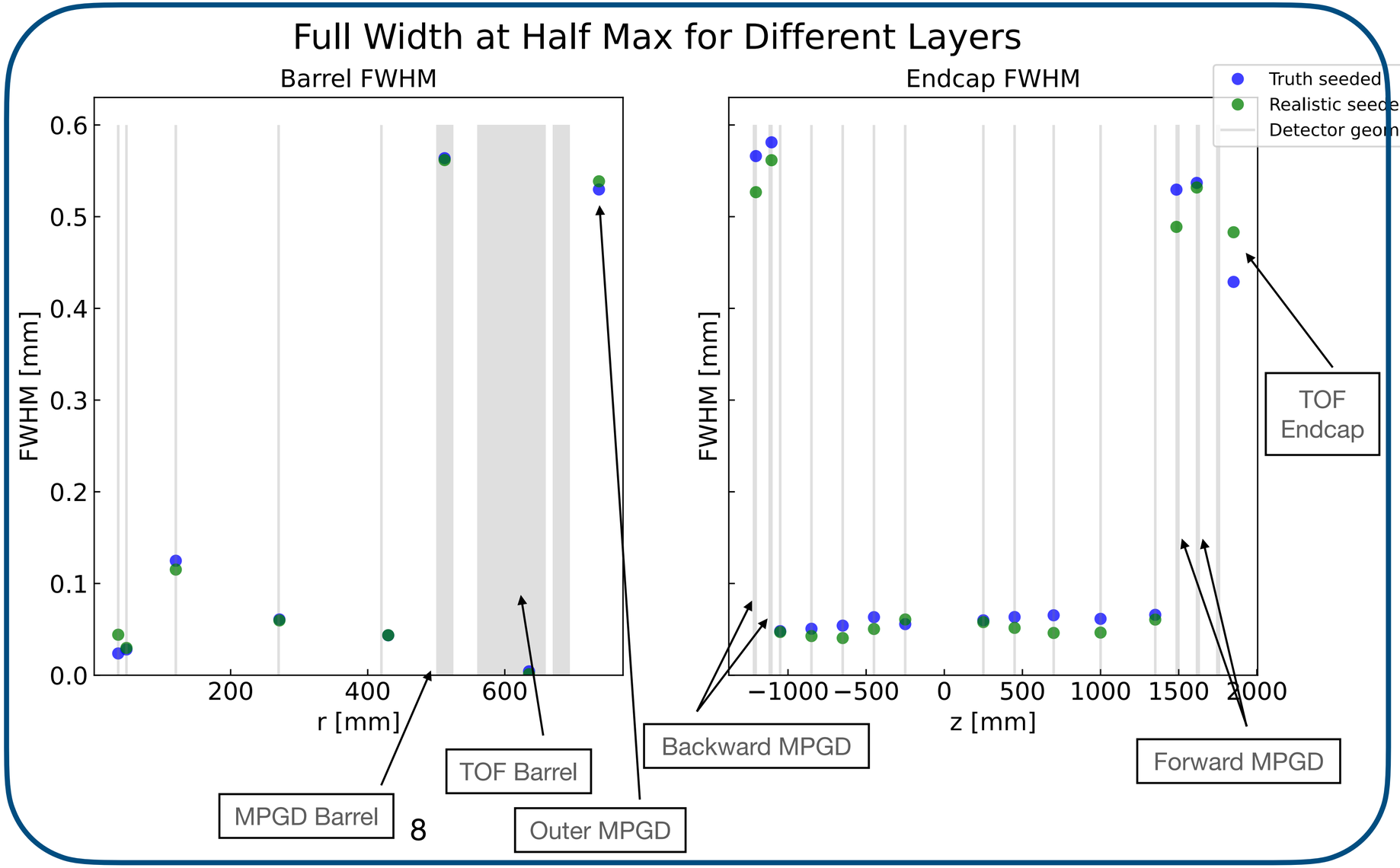
Region	Layer	radius [mm]	length [mm]	X/X0
IB	L0	36	270	0.05 %
	L1	48	270	0.05 %
	L2	120	270	0.05 %
OB	L3	270	540	0.25 %
	L4	420	840	0.55 %

Region	Disk	z [mm]	inner radius* [mm]	outer radius [mm]	X/X0
EE	ED0	-250	36.76	240	0.24 %
	ED1	-450	36.76	415	0.24 %
	ED2	-650	36.76	421.4	0.24 %
	ED3	-850	40	421.4	0.24 %
	ED4	-1050	46.35	421.4	0.24 %

Region	Disk	z [mm]	inner radius* [mm]	outer radius [mm]	X/X0
HE	HD0	250	36.76	240	0.24 %
	HD1	450	36.76	415	0.24 %
	HD2	700	38.46	421.4	0.24 %
	HD3	1000	53.43	421.4	0.24 %
	HD4	1350	70.14	421.4	0.24 %

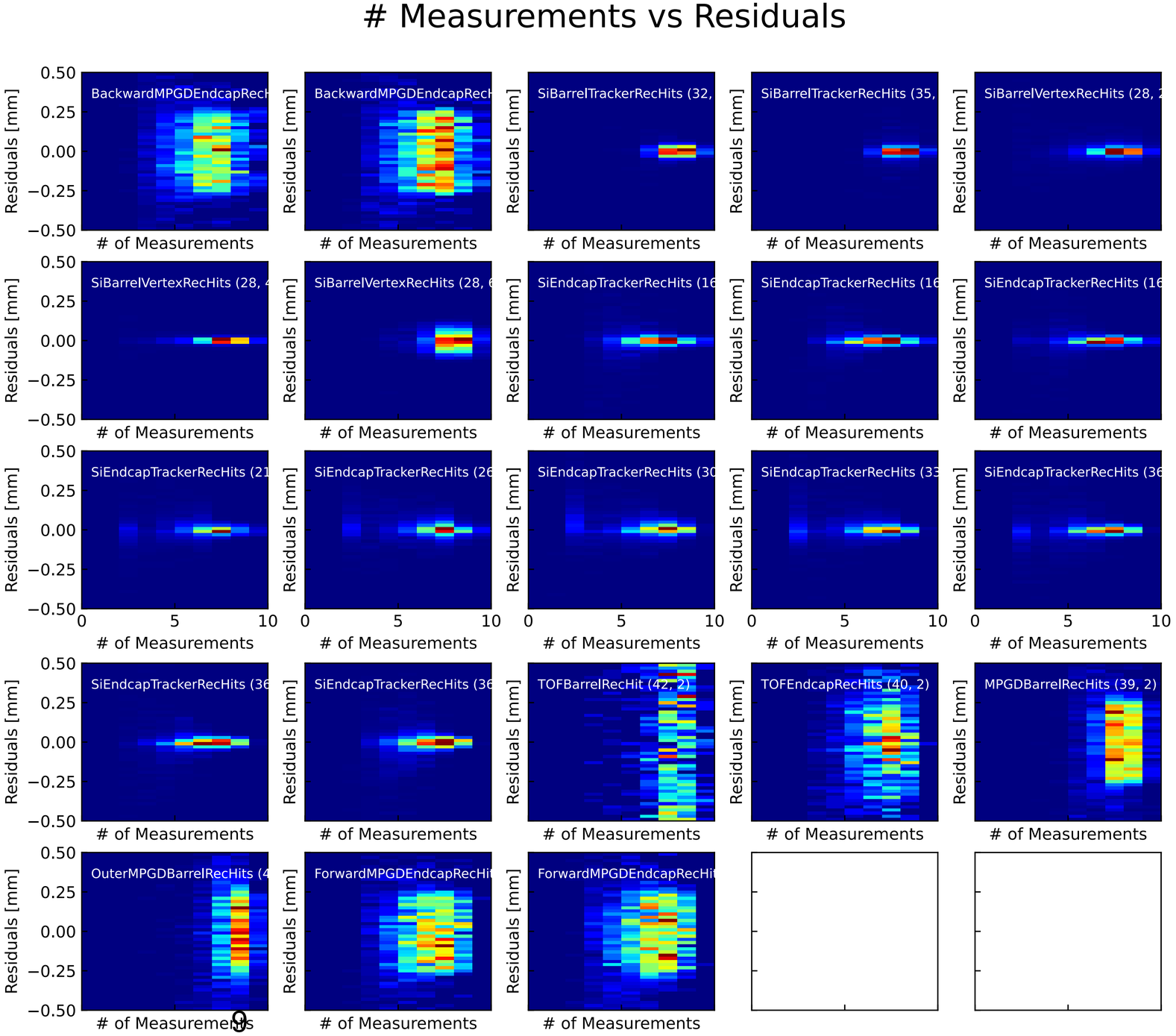
https://wiki.bnl.gov/EPIC/index.php?title=Si_Vertex_Tracker





Looking at the # of measurements

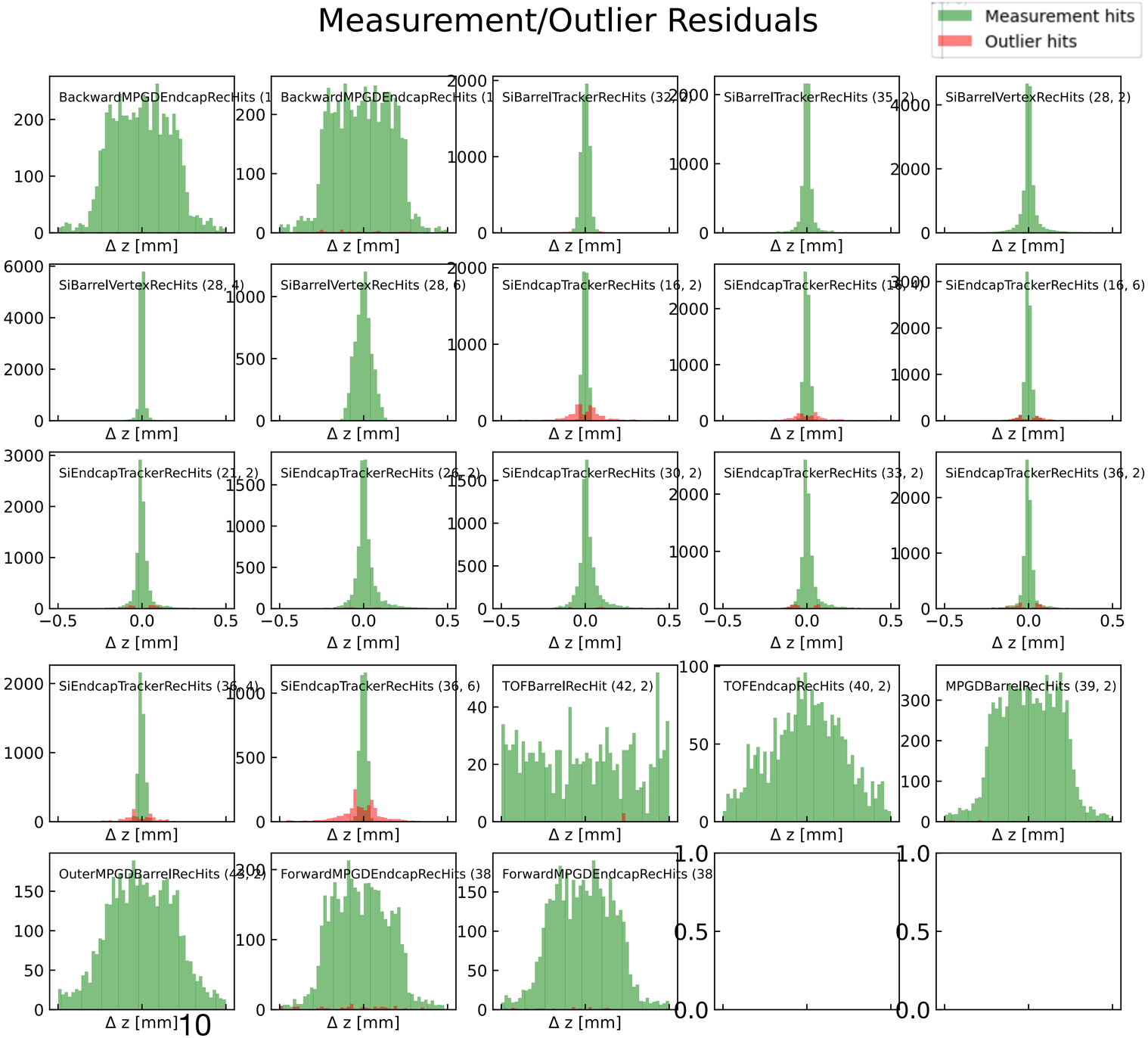
- # of measurements vs residuals
- residuals is a hit quantity, # of meas is a track quantity
- mostly 6-8 hits per track



jet

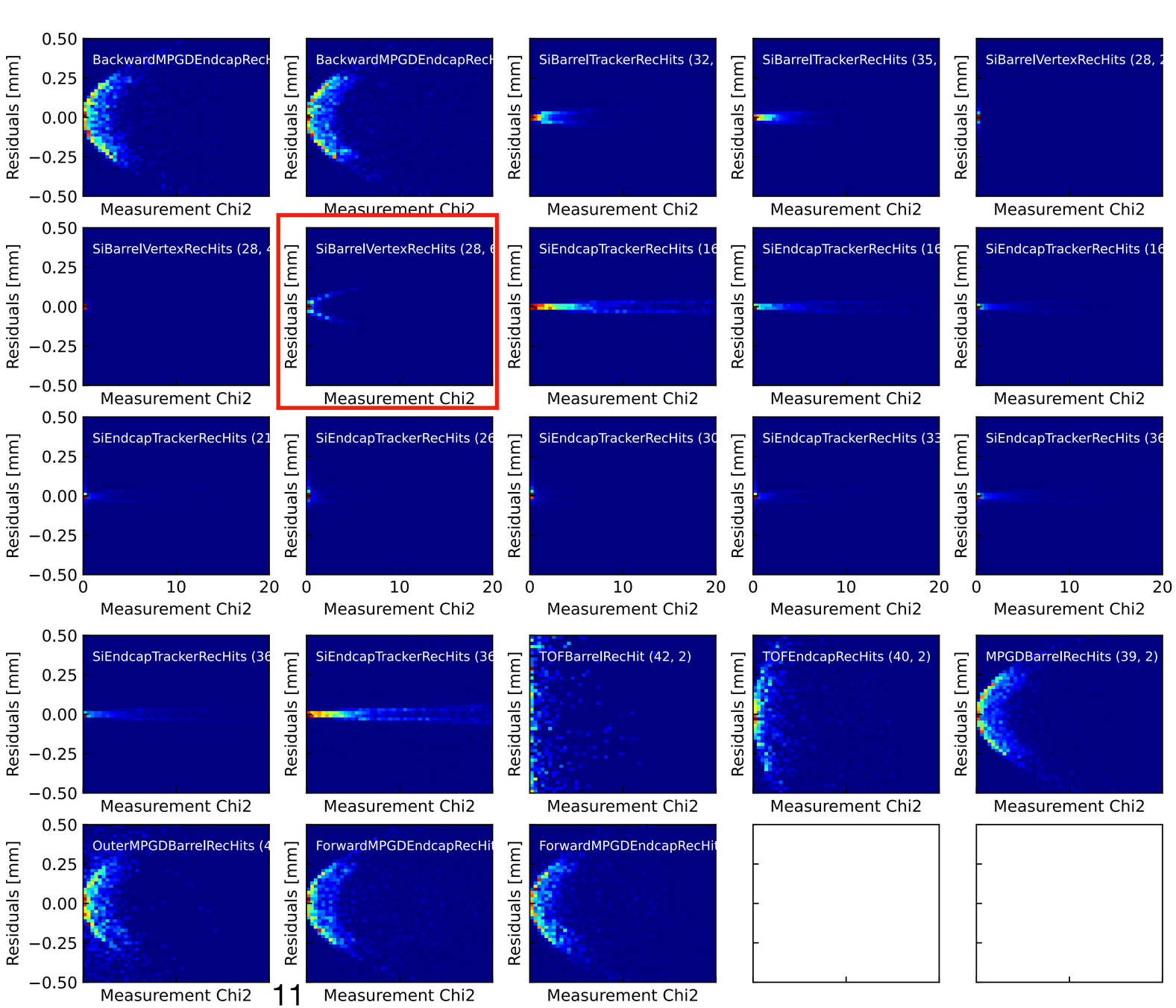
Measurement vs outlier hits

- Wanted to see which hits were used in the final track fit



Measurement Chi^2

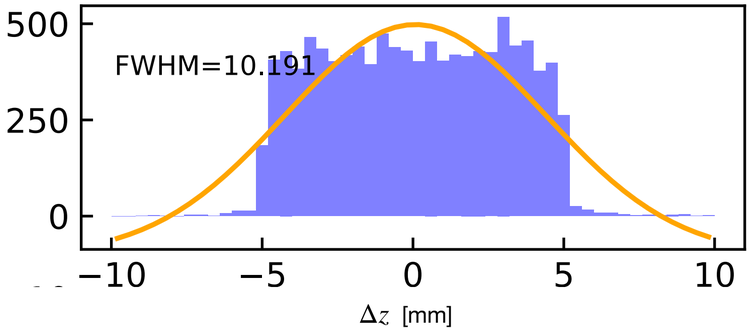
- See more prominent correlation between measurement chi^2 and the residual in silicon L2



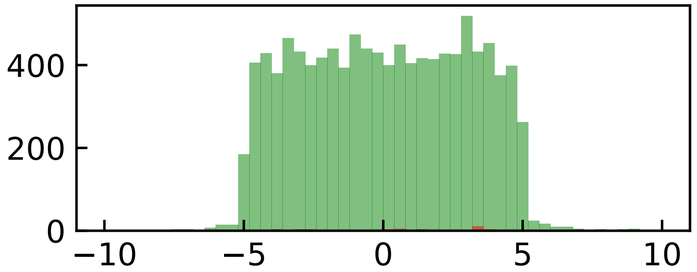
jet

TOF Barrel layer

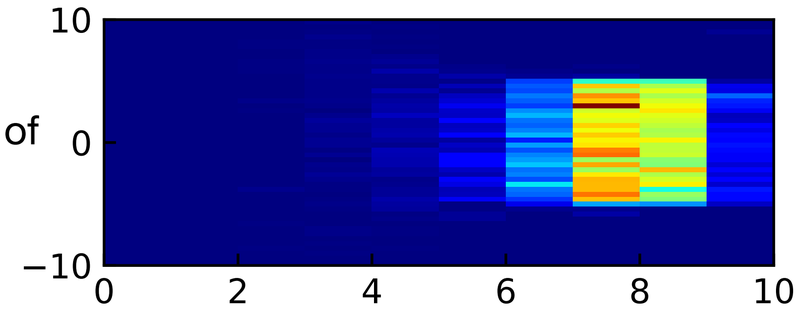
Residuals [mm]:



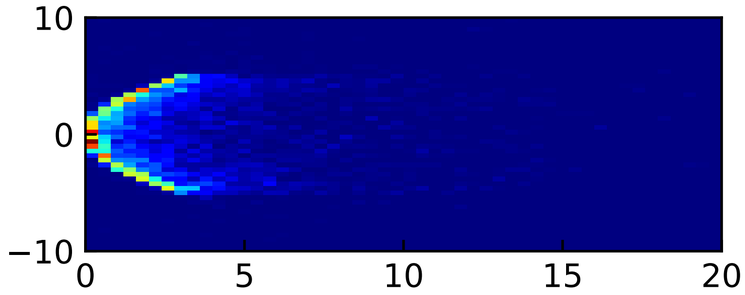
Residuals [mm] for measurements vs outliers:



Residuals [mm] vs # of measurements:



Residuals [mm] vs measurements chi2:



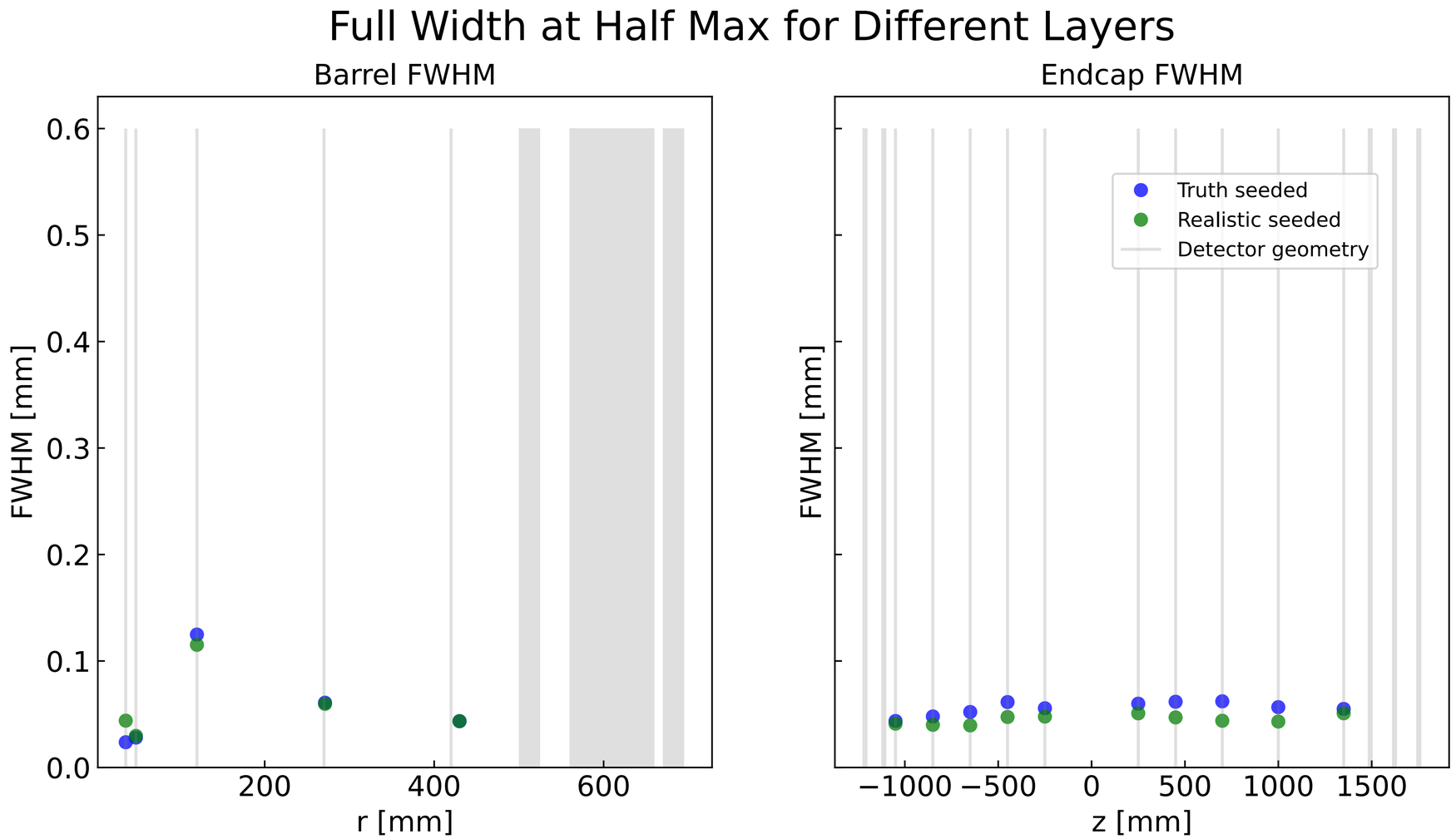
*azimuthal residuals in progress

Summary and Next Steps

- Truth & realistic seeded residuals are now easily calculated
- Studied some of the correlations between the measurements and the residuals
- Silicon L2 residual is currently being investigated in further detail

- To do:
  - Make unbiased residuals
    - Some functionality already in ACTS to do this

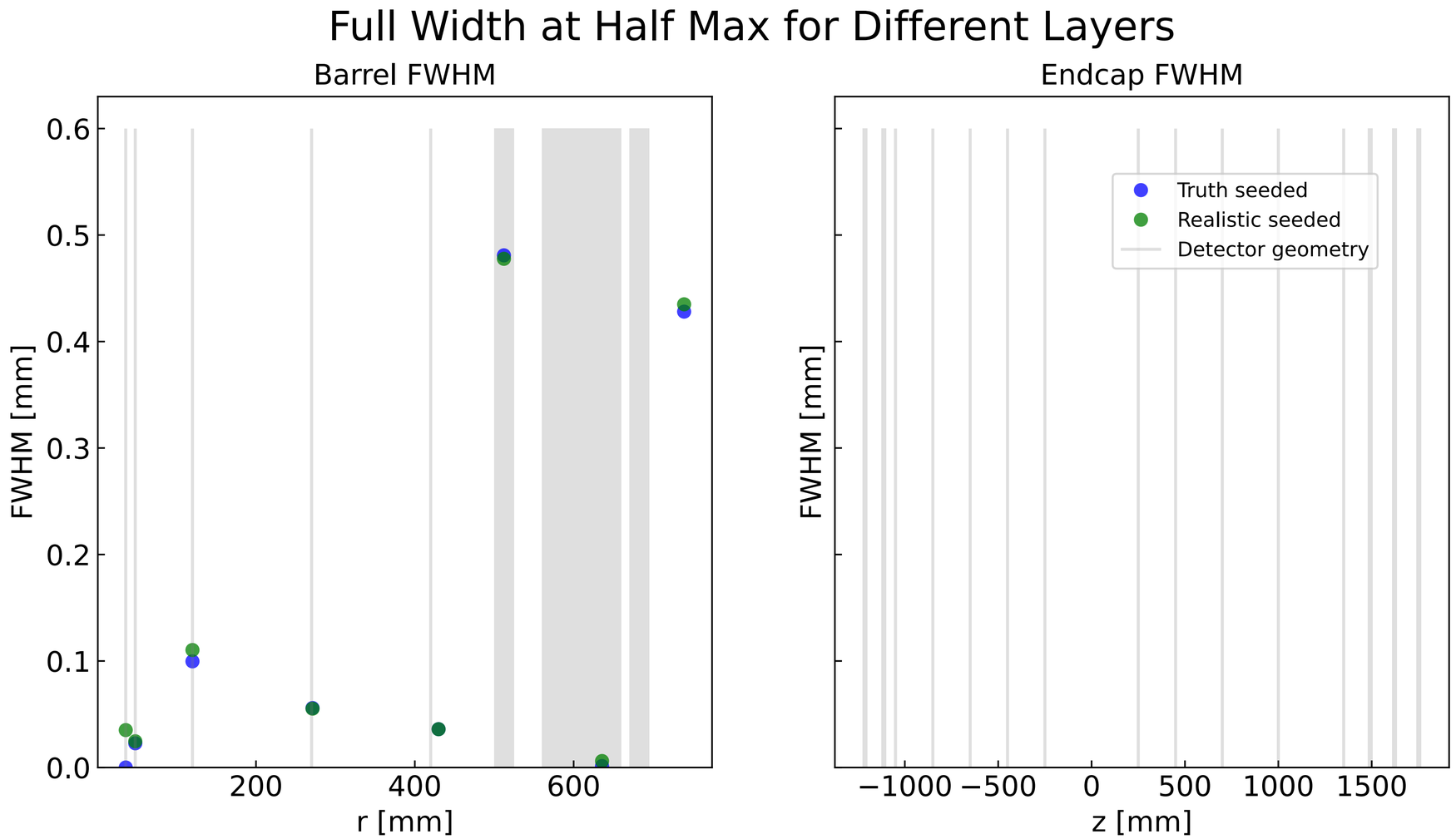
FWHM at different layers



- Not much changed

Single μ-, silicon only reconstruction

FWHM at different layers

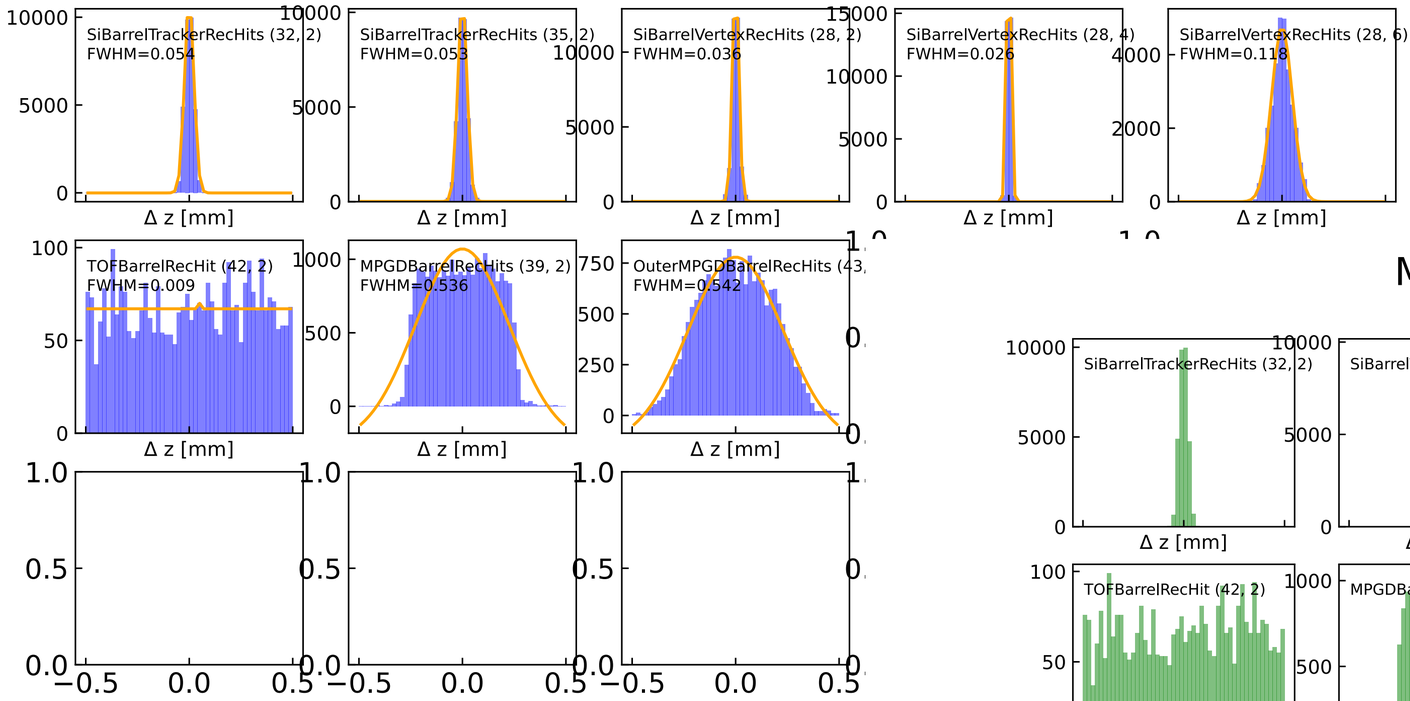


- Only looked at muons that were in the range of 85°<θ<95°

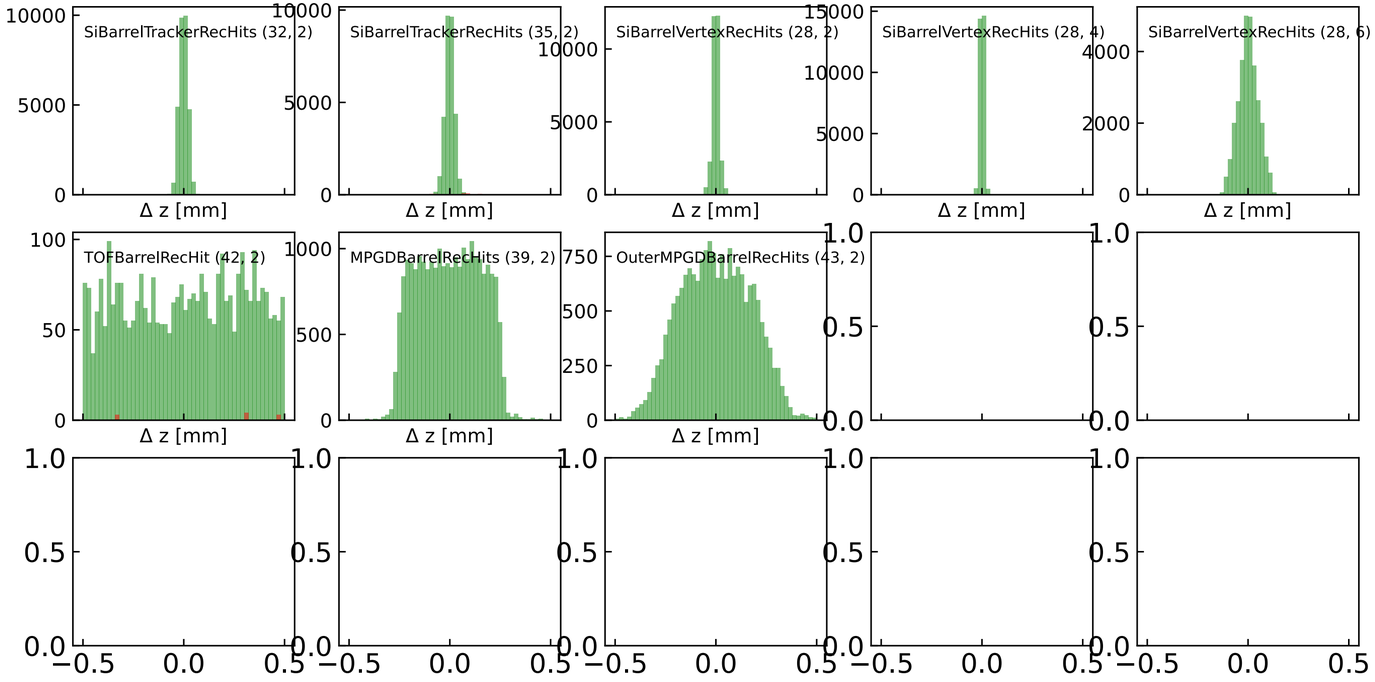
Single μ-, full reconstruction

90 degree muons

Residuals



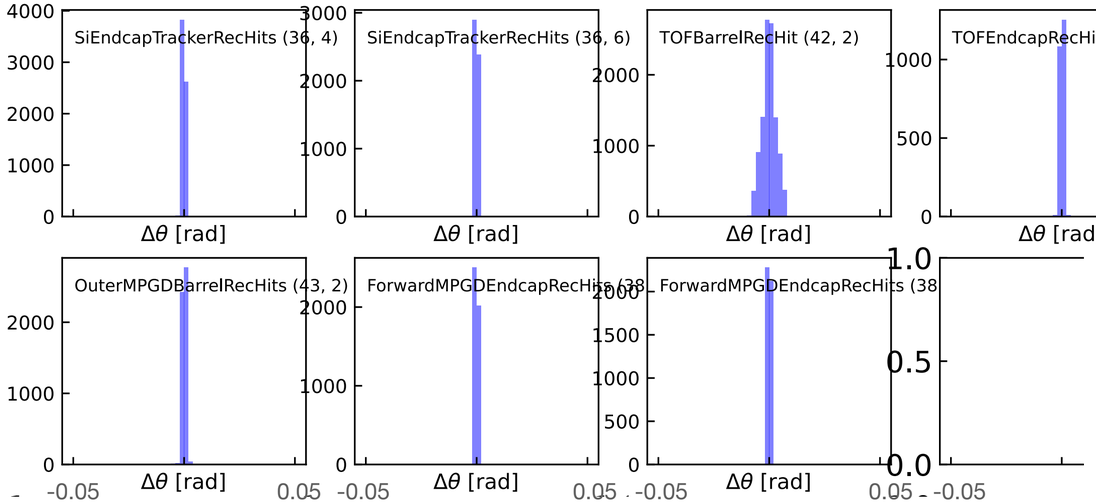
Measurement/Outlier Residuals

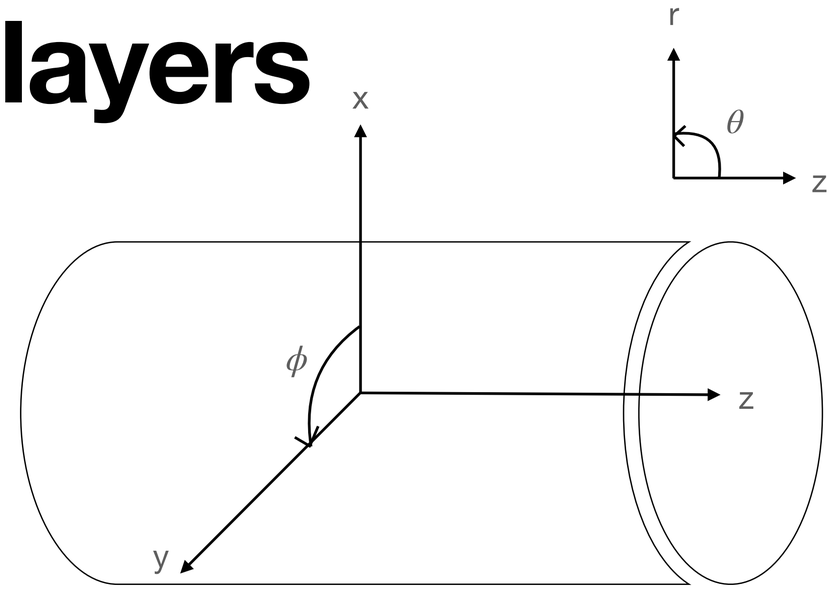


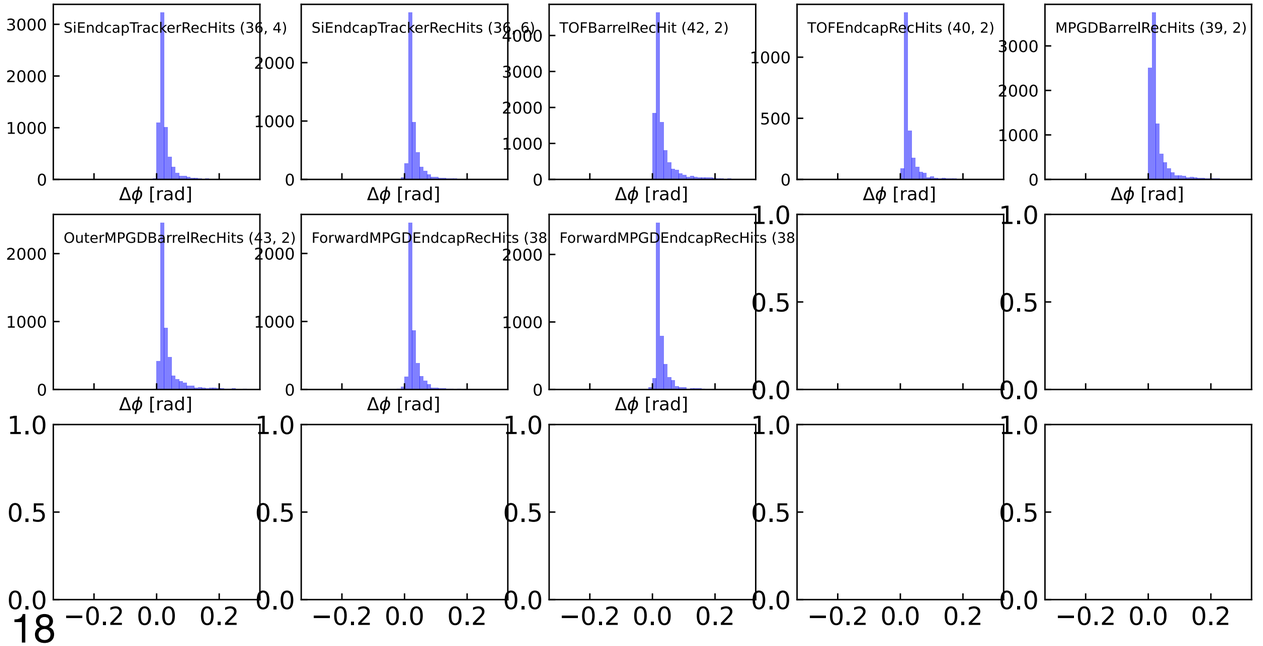
5 GeV muons

Angular residuals, remaining layers

per layer



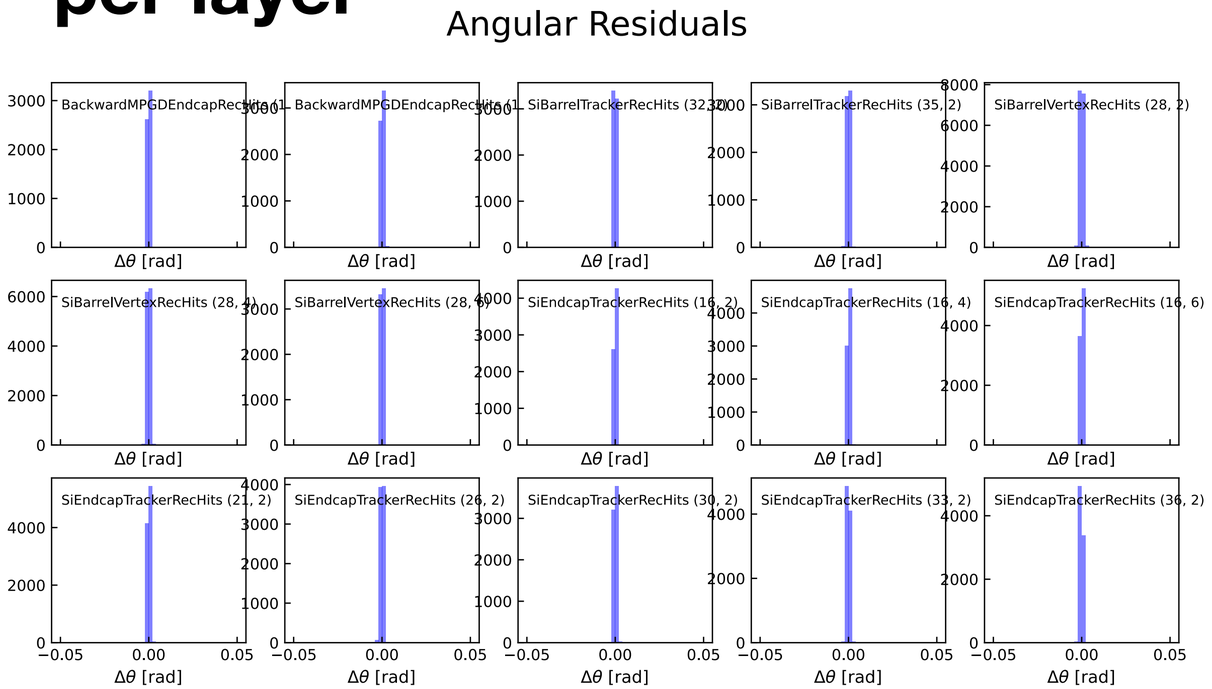


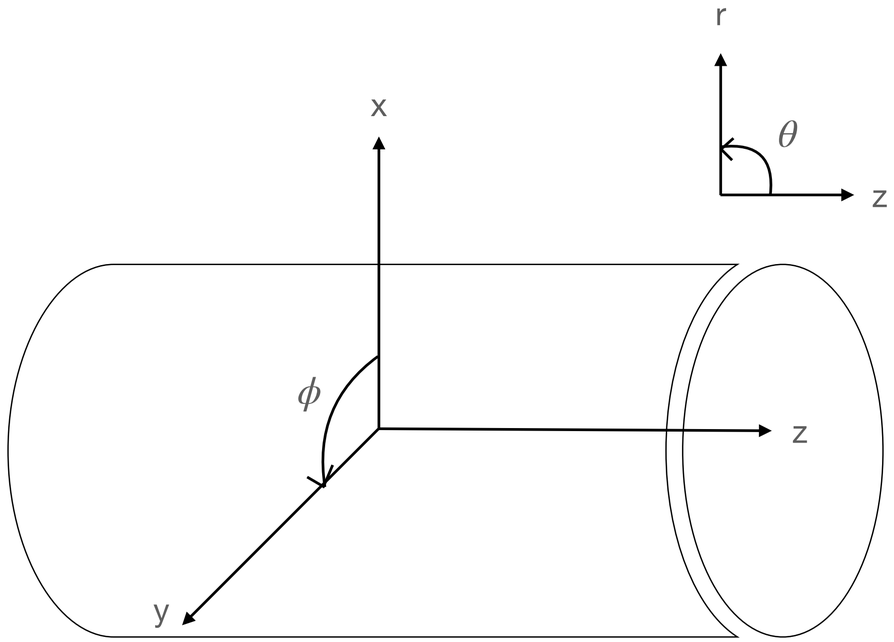


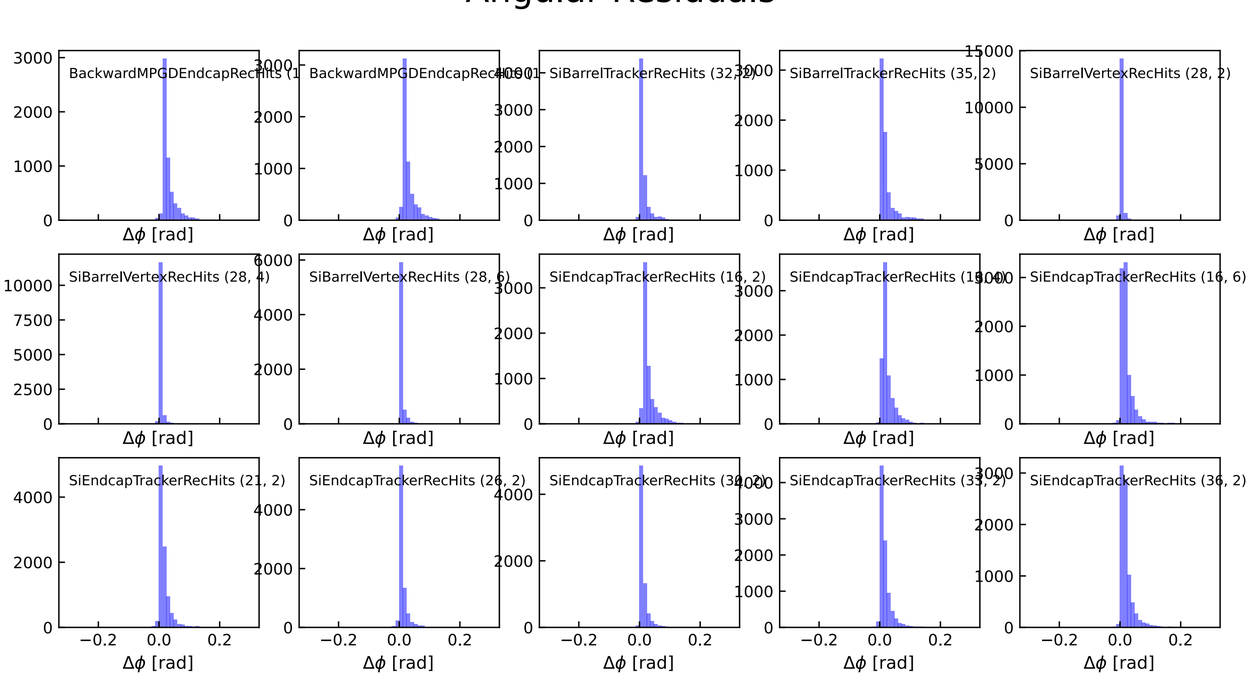
- Quick look at finding the difference in θ and ϕ

Angular residuals

per layer





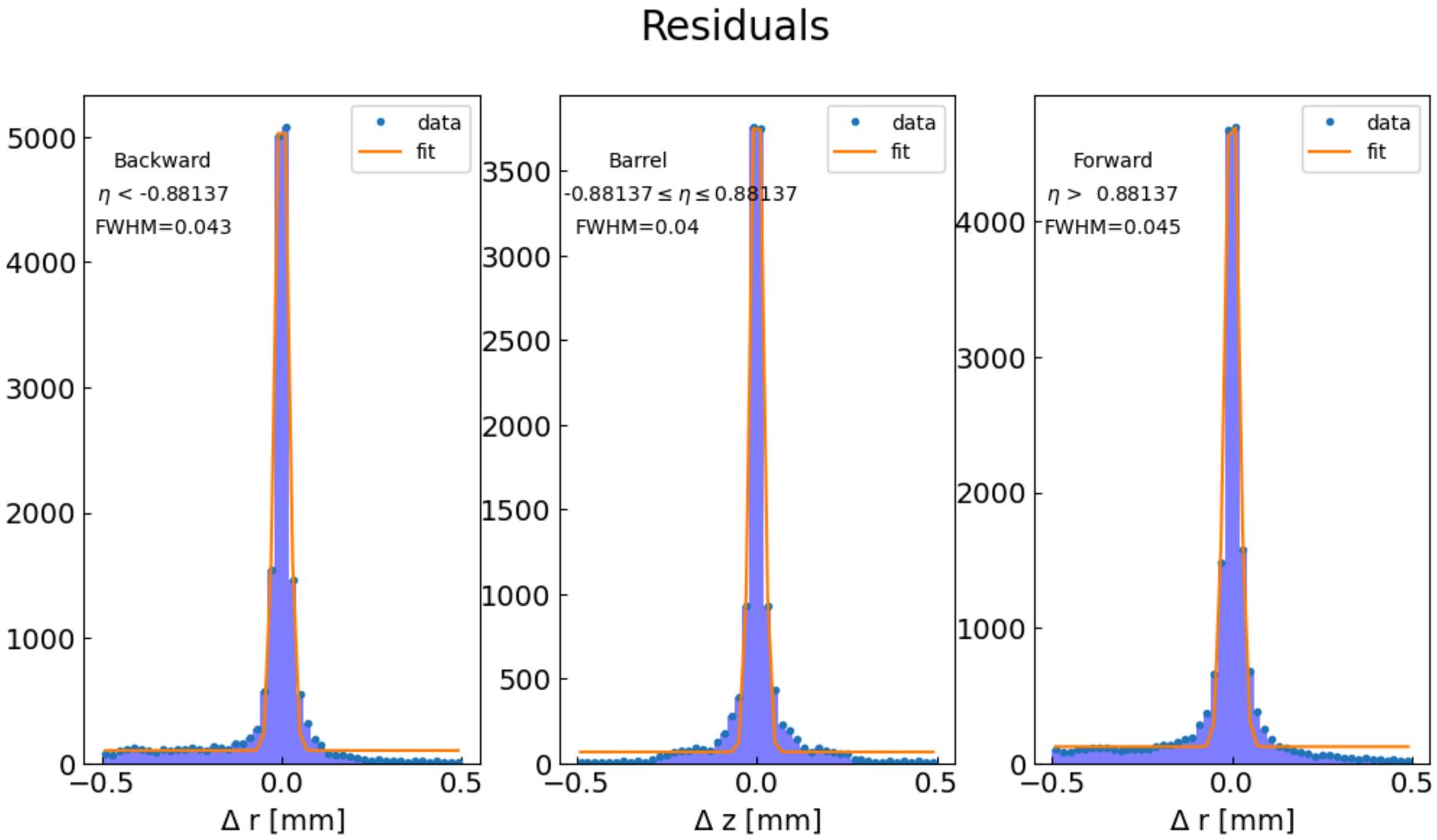


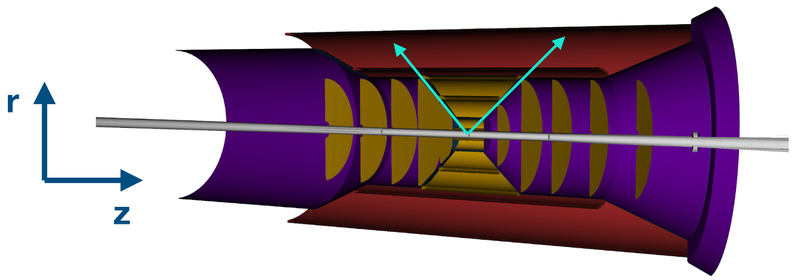
- Quick look at finding the difference in θ and ϕ

Residuals

per eta region

- Residuals shown for different eta regions





The different collections

- Barrel:
  - SiBarrelTrackerRecHits
  - SiBarrelVertexRecHits
  - TOFBarrelRecHit
  - MPGDBarrelRecHits
  - MPGDDIRCRecHits
  - OuterMPGDBarrelRecHits
- Endcap:
  - BackwardMPGDEndcapRecHits
  - SiEndcapTrackerRecHits
  - TOFEndcapRecHits
  - ForwardMPGDEndcapRecHits

- Other collections ignored for now
- Multiple layers included in a given collection