Pixel resolution studies

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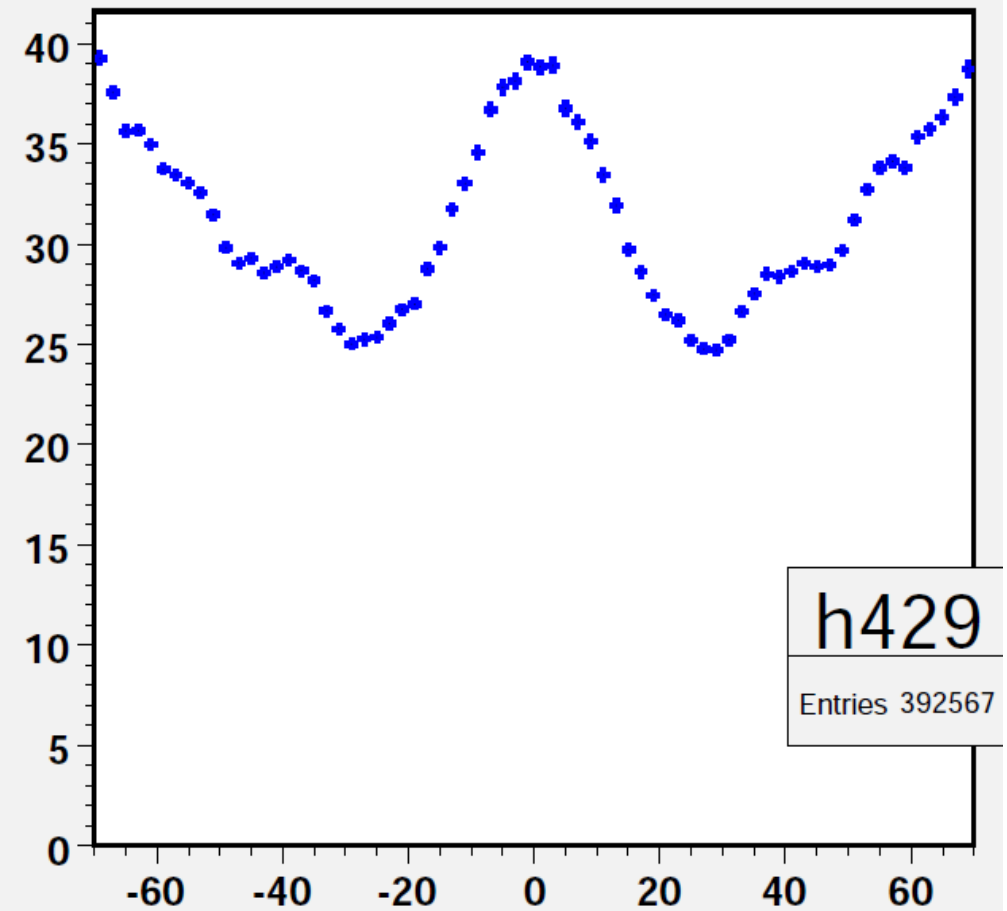
CMS Tracker Upgrade 23.2.2011



- Triplet method
- Hit resolutions
- some dependencies

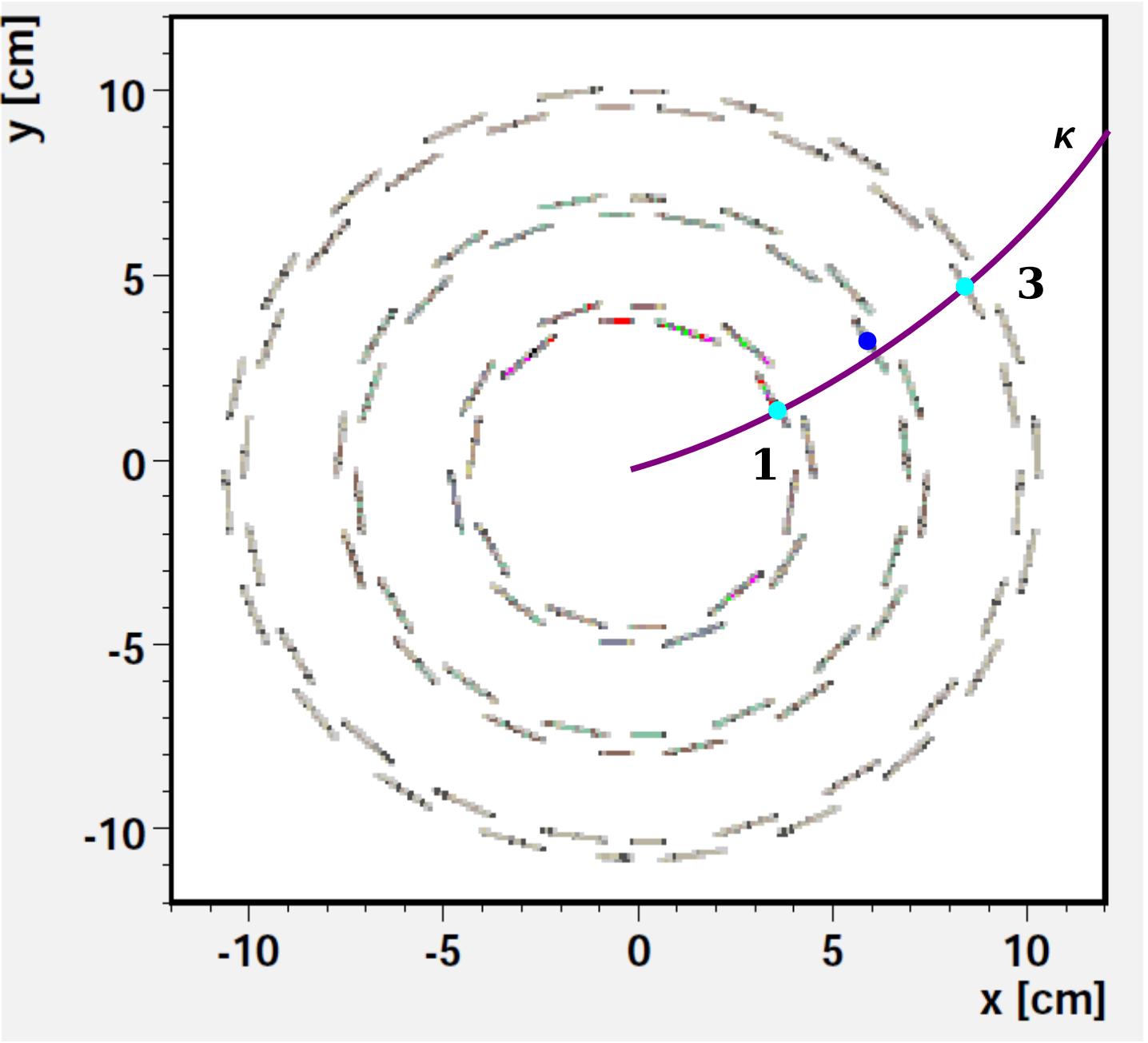
Questions

- What is the intrinsic position resolution of the barrel pixel detector?
  - In rφ and in z, data and MC.
  - Test of alignment, hit reconstruction, and track reconstruction.
- Future monitoring:
  - rφ resolution is expected to degrade with radiation damage (mobility degradation, Lorentz angle reduction, and trapping all reduce the charge sharing between pixels in a cluster).

Tools

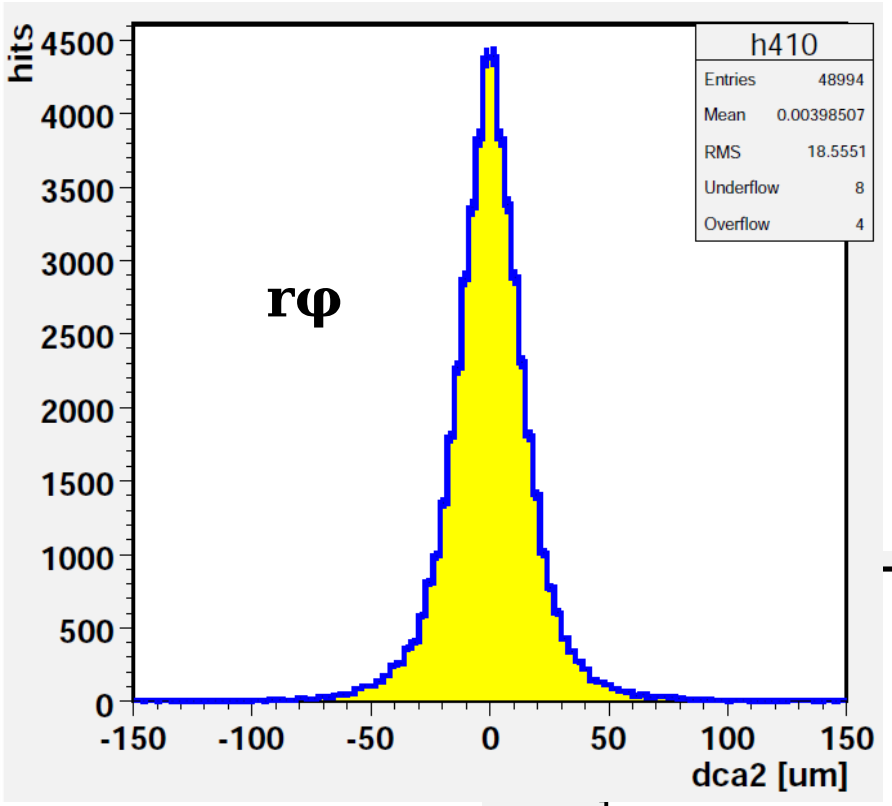
- Overlap regions (2 hits in one layer):
  - used extensively during CMS commissioning,
  - less sensitive to misalignment.
  - low statistics, only explores sensor edge, not used here.
- Triplets (hits in 3 layers).

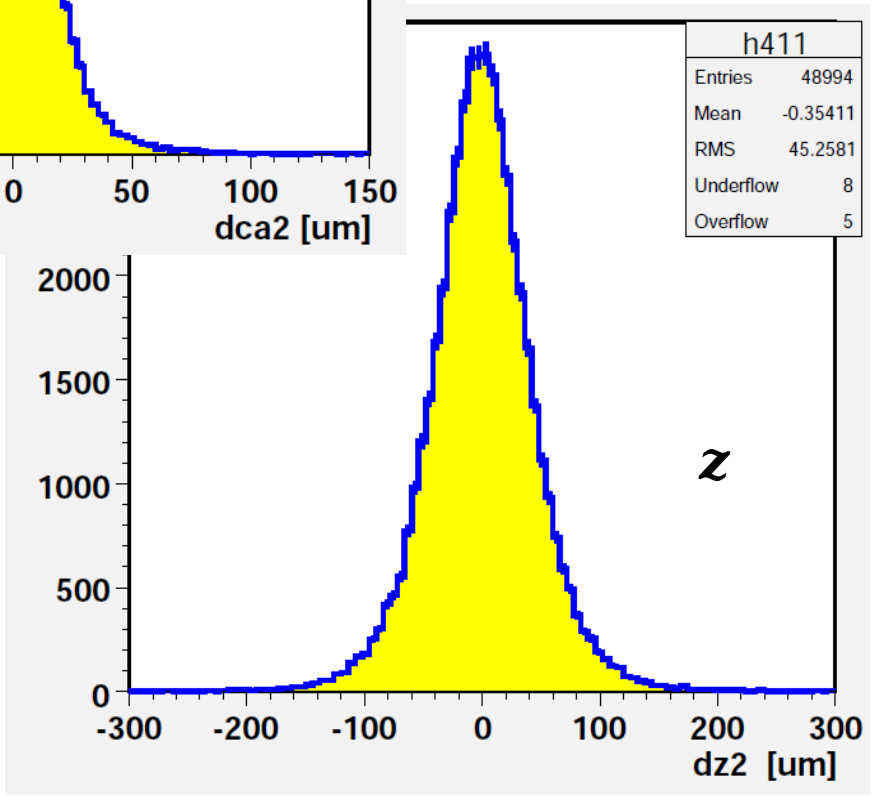
Pixel triplets



- Select tracks with hits in 3 pixel layers.
- Redefine track:
  - curvature from full tracker,
  - position and angles from hits 1 and 3.
  - analytic code from J. Gassner 1996.
- Interpolate to middle layer:
  - residual between track and hit.

Triplet residuals

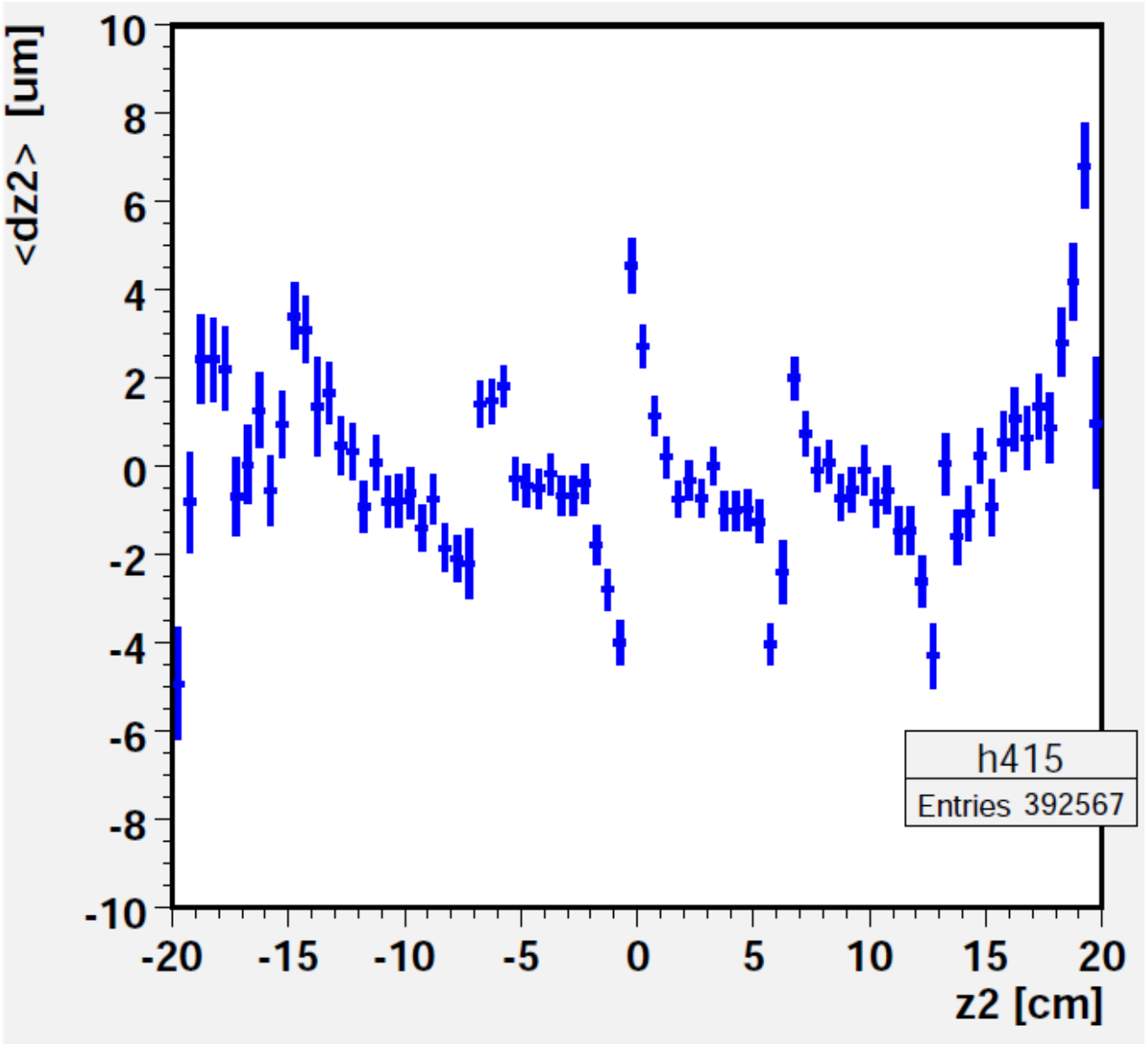




$p_t > 4$ GeV

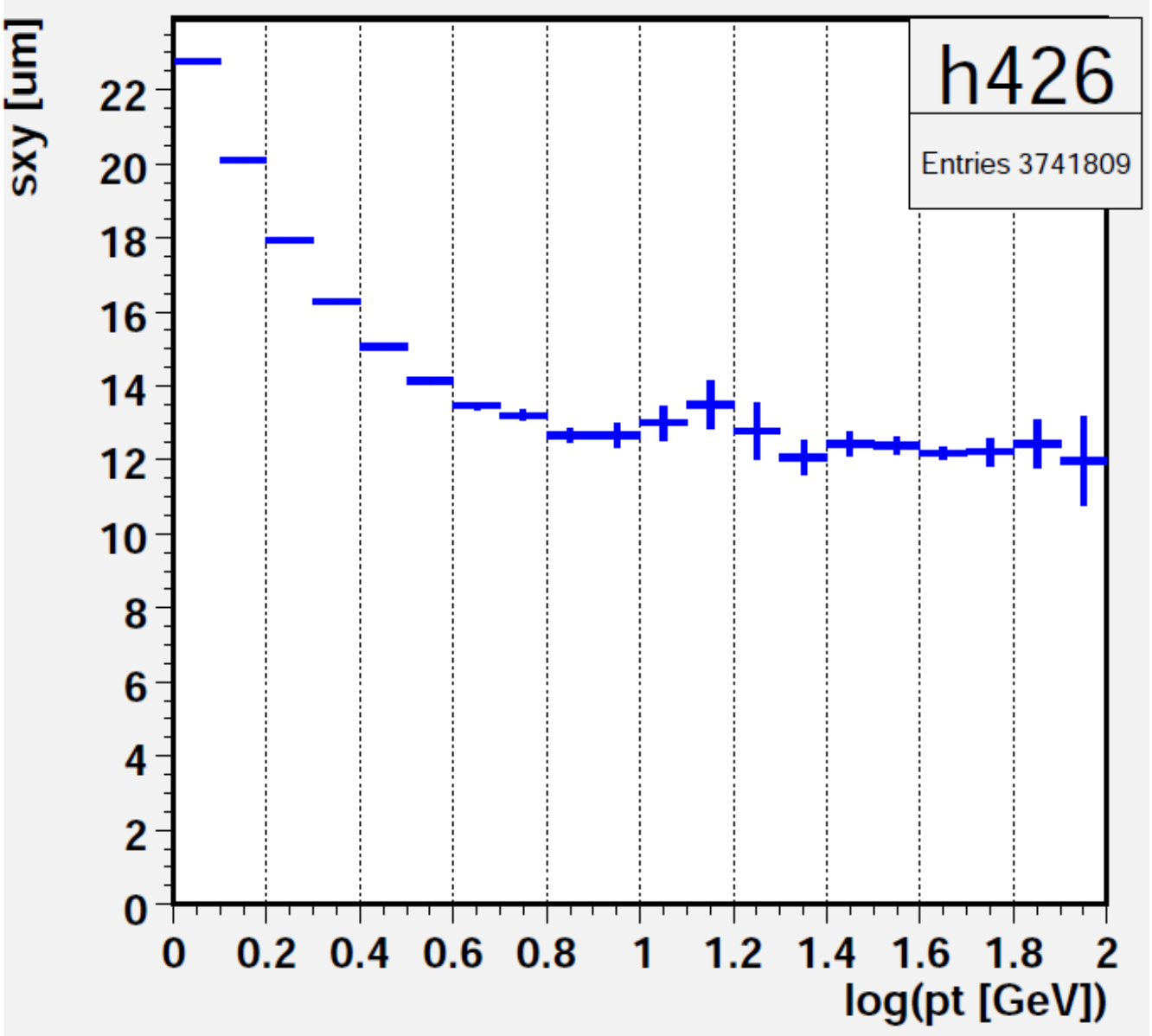
- RECO data taken Oct 2010, Dec22 reRepro, minBias and Zmumu.
- Using generalTracks.
- Using TransientRecHits:
  - alignment applied.
- Mean residual is zero:
  - Method works,
  - alignment is good.
- Hits on tracks:
  - no outliers, no background.

z dependence of mean z residual



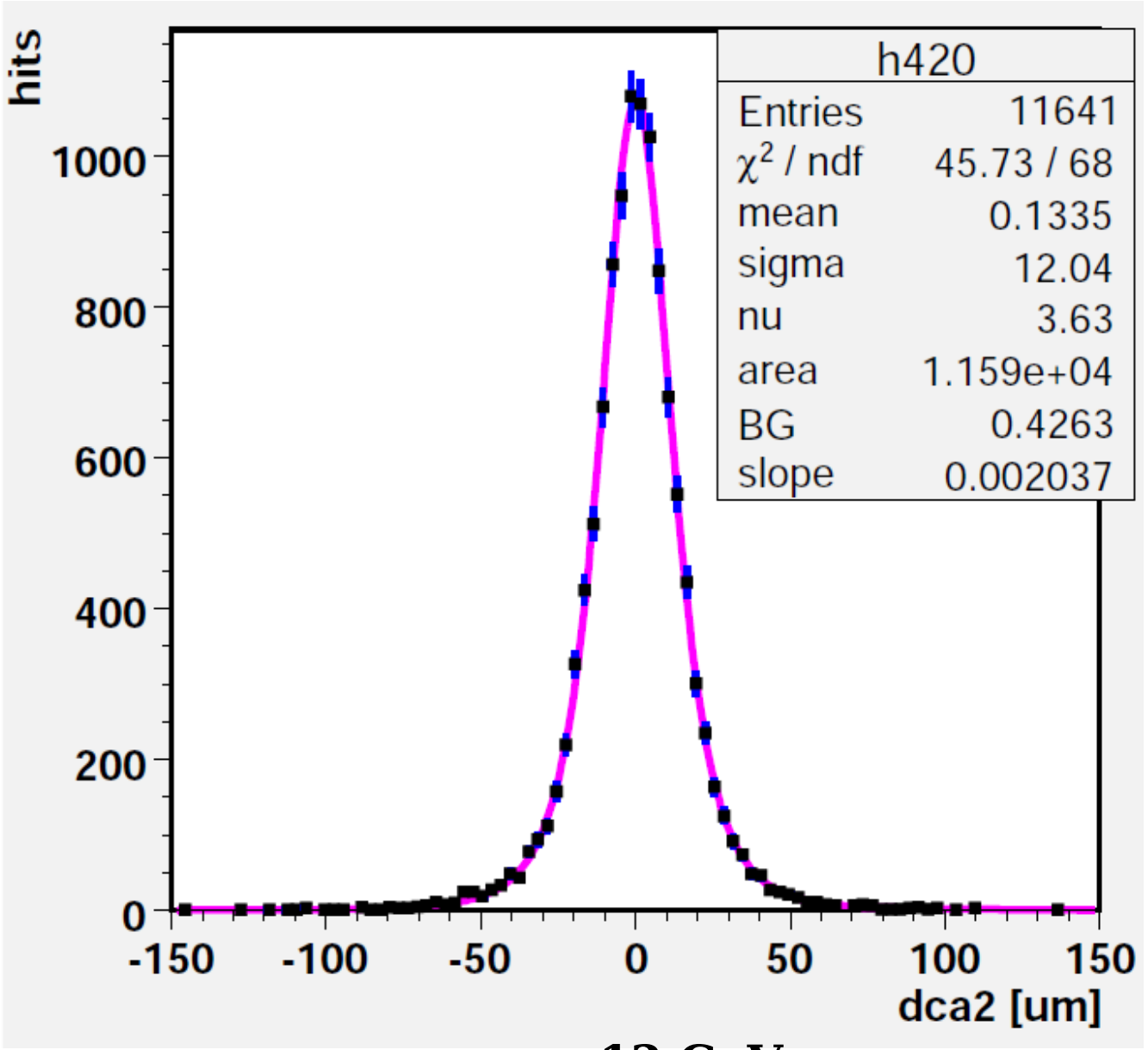
- ±4 µm trend repeats every 6.4 cm:
  - bowed modules?
  - fodder for the alignment group…

p_t dependence of rφ resolution



- Width of the residual distribution is affected by multiple scattering in layers 1 and 2:
  - Need p_t > 4 GeV to observe intrinsic pixel resolution.

triplet rφ residuals at high p_t



p_t > 12 GeV

- Width of the residual distribution at high p_t:

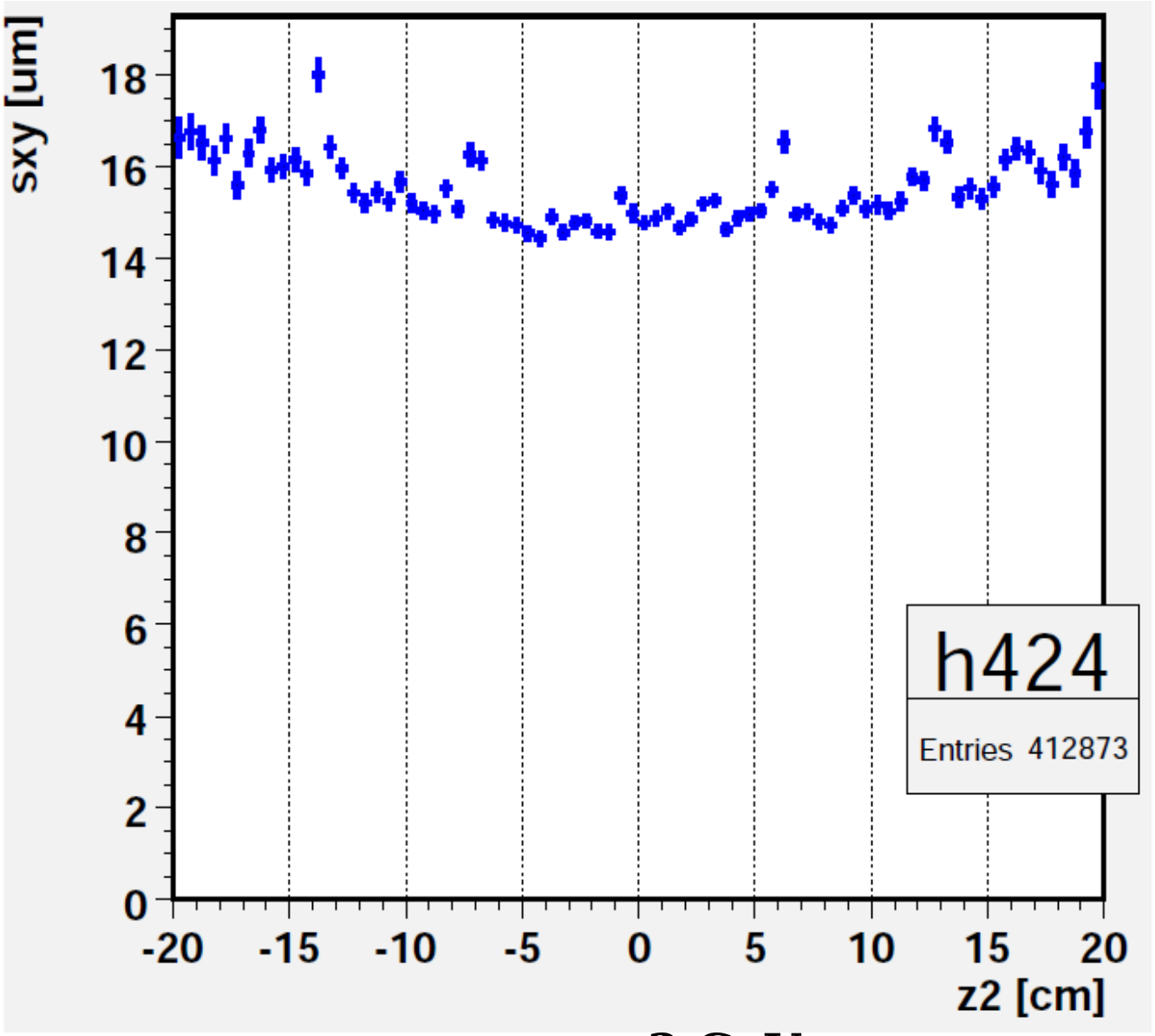
$$\sigma_r^2 = \sigma_2^2 + (\sigma_1/2)^2 + (\sigma_3/2)^2$$

- All σ equal:

$$\sigma_r = \sqrt{3/2}\,\sigma_i$$

- Result:
  - σ_i = 10 µm,
  - with 100 µm pitch.
  - in 3.8 T.

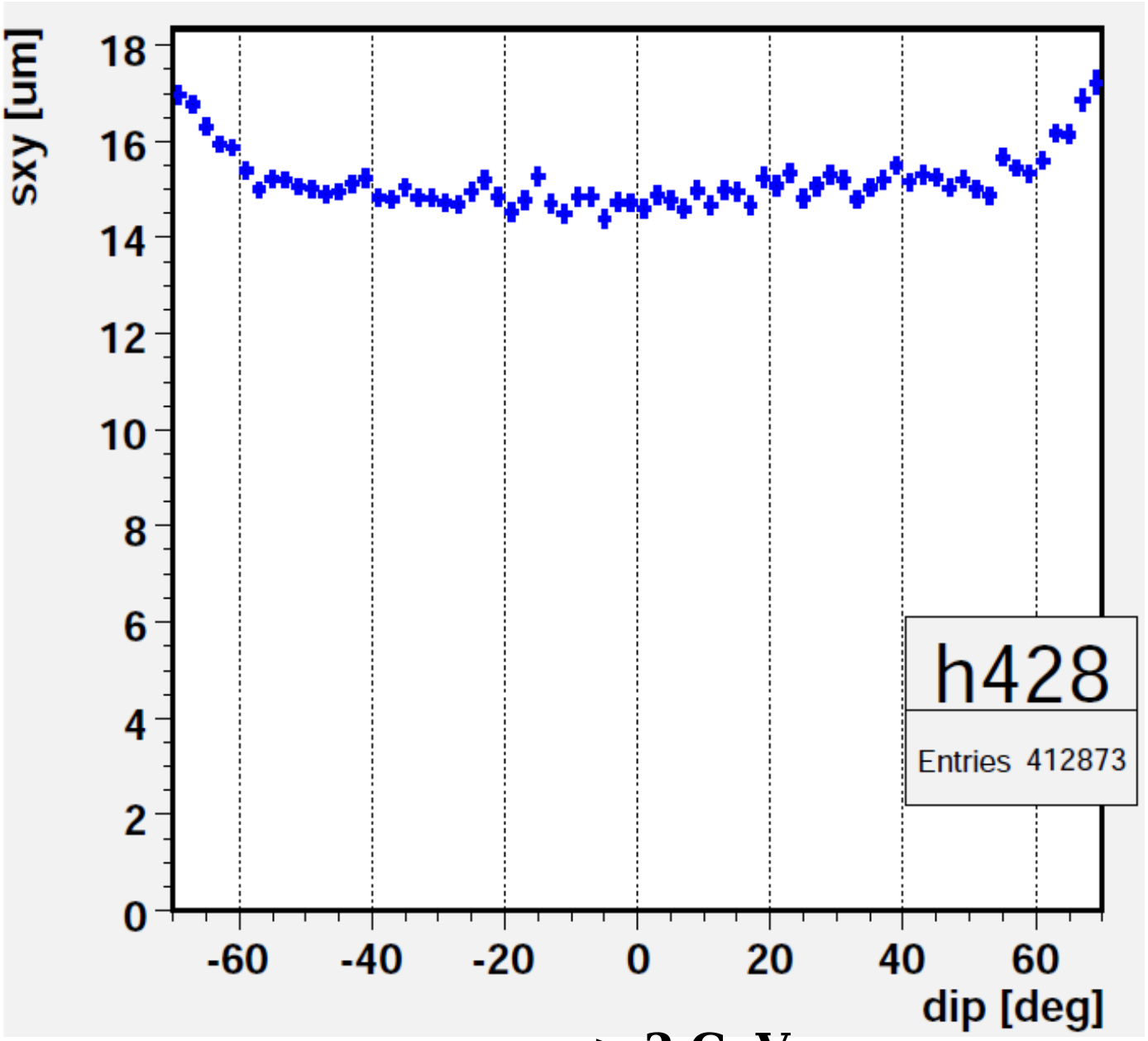
z dependence of rφ resolution



p_t > 2 GeV

- rφ resolution deteriorates at z-gaps between modules.

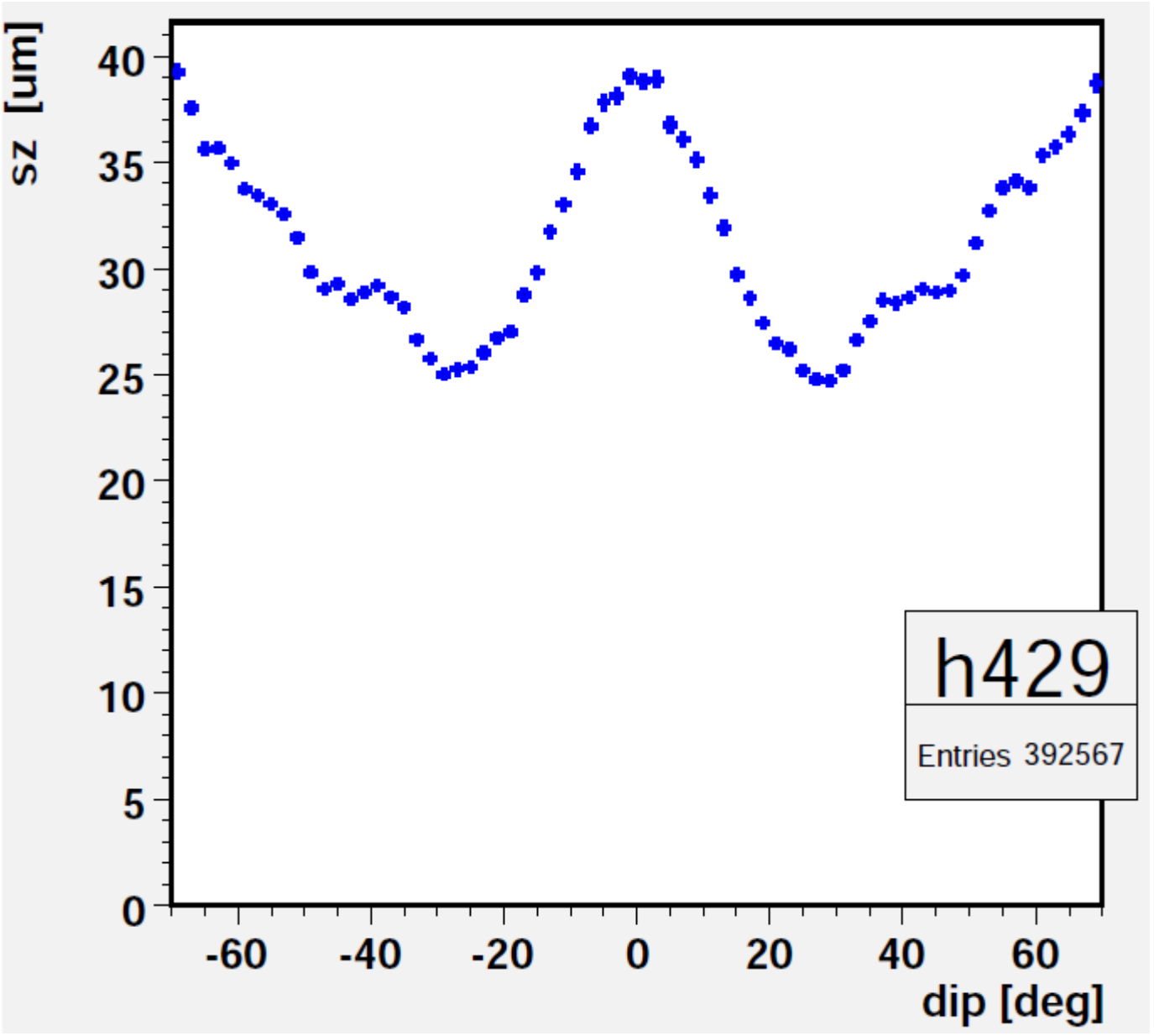
dip angle dependence of rφ resolution



p_t > 2 GeV

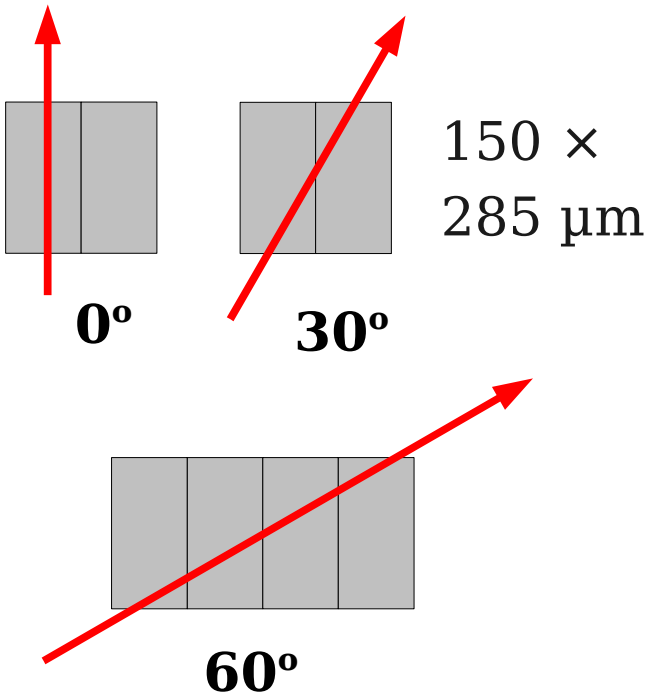
- dip angle:
  - $\lambda = \pi/2 - \theta$.
- rφ resolution deteriorates at large dip angles:
  - poor curvature measurement in the tracker?

dip angle dependence of *z* resolution



p_t > 2 GeV

- dip angle:
  - $\lambda = \pi/2 - \theta$.
- optimal resolution at $\lambda = \pm 30^o$:
  - sharing between neighboring pixels



Summary

- Tracks with 3 pixel hits:
  - one degree of freedom in z, e.g. the middle hit.
  - use of an external curvature measurement gives one degree of freedom in rφ as well: triplet method.
  - (remove any bias: repeat track fit without 2nd pixel layer...).
- Mean residuals are zero within a few microns:
  - Alignment is good
  - small systematic trend along z with module structure.
- Pixel rφ resolution is 10 µm, measured at high p_t.
- Pixel z resolution:
  - varies with angle of incidence (or rapidity).
  - reaches 25 µm, with 150 µm pitch.
- Next:
  - look at MC.