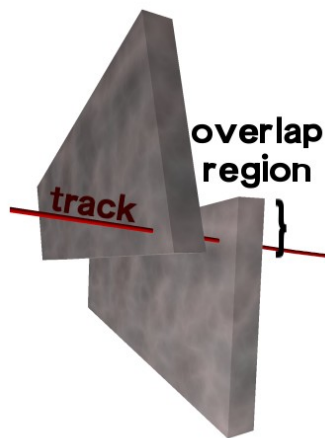
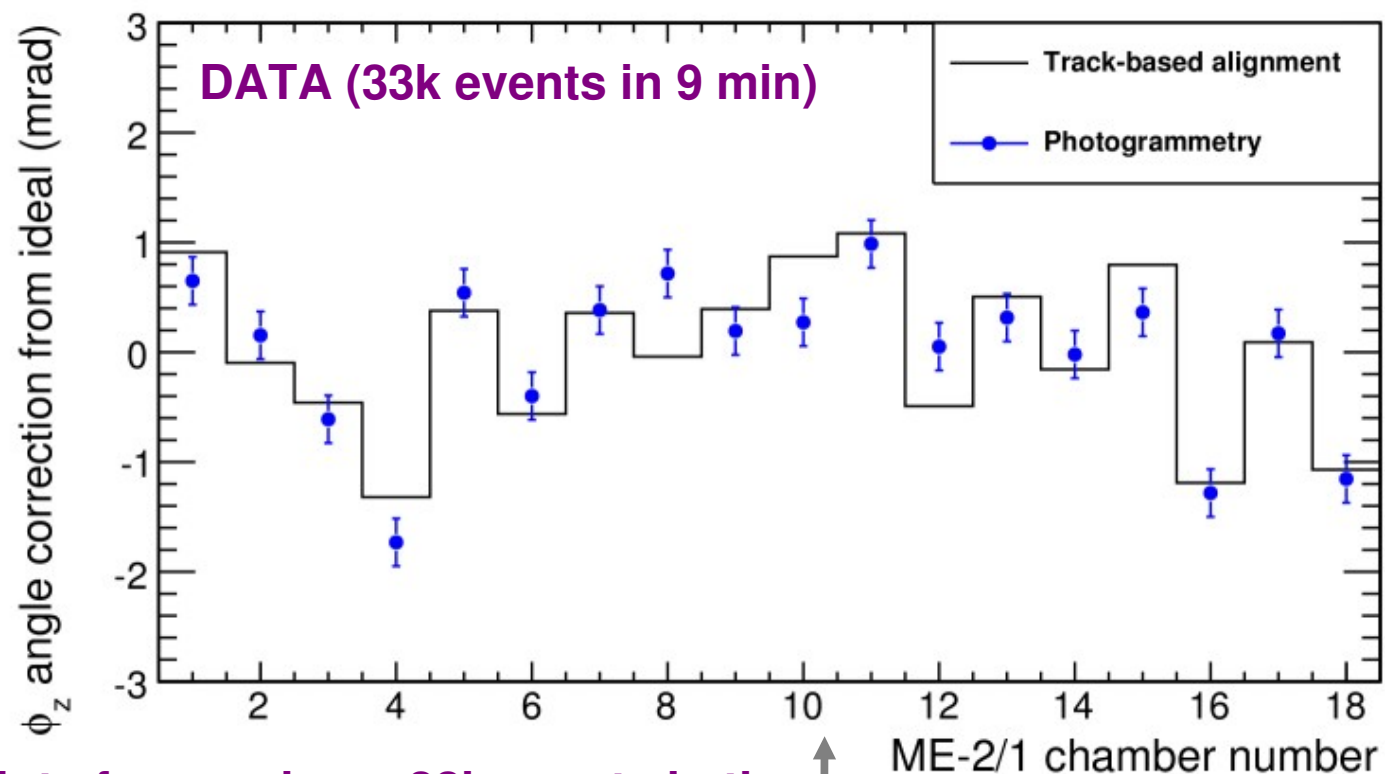


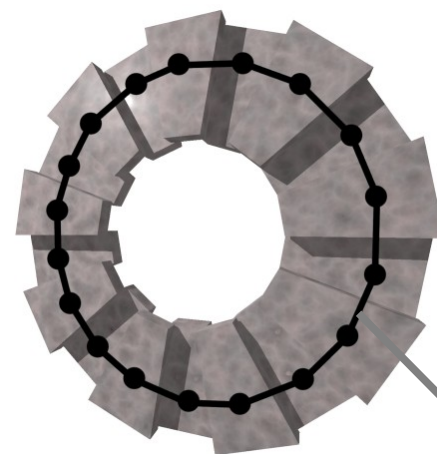
# CSC Alignment with beam-halo muons



- Select tracks that pass through overlap of two chambers
- Determine relative position by requiring consistency between the two track segments:
  - $r\phi$  position (most important for momentum resolution)
  - $\phi_z$ : rotation in layer's plane (second most important)
  - $\phi_y$ : rotation around alignment pin axis



- Align by solving system of 18 or 36 equations

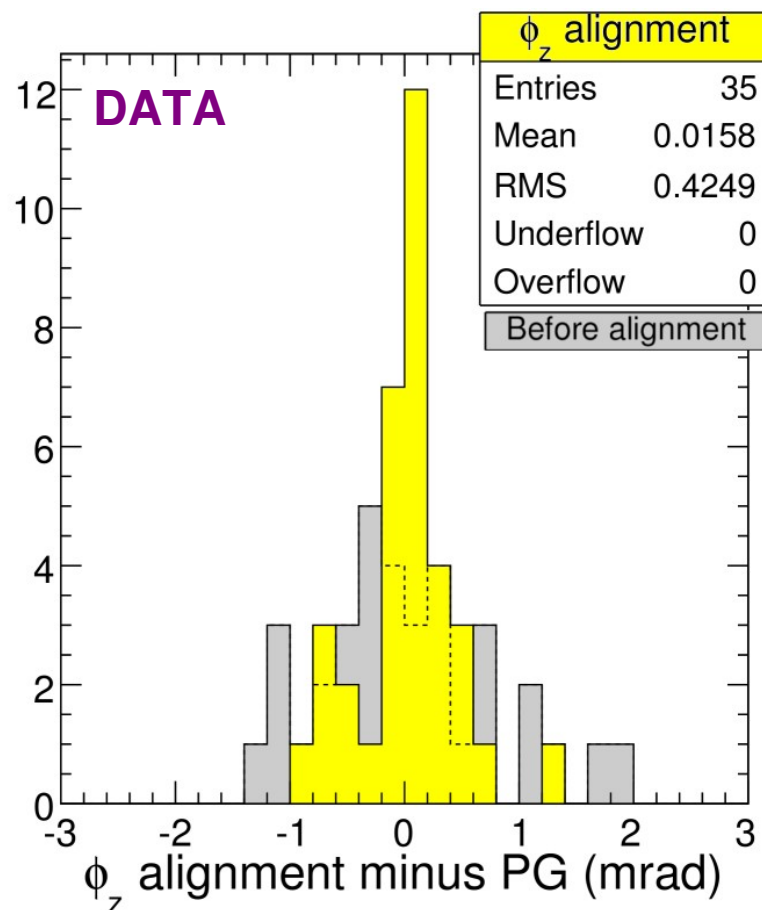
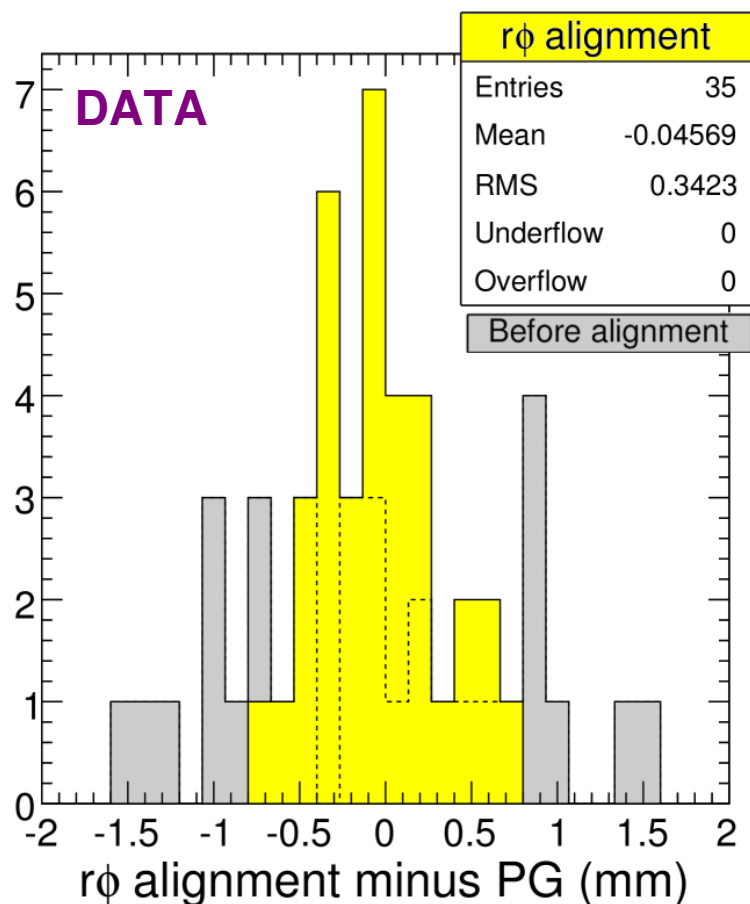


- Cross-check against photogrammetry

Note for speakers: 33k events in the overlap regions of minus endcap, not total

# Accuracy determined from photogrammetry (PG)

- Photogrammetry is alignment from a literal photograph of the detector: completely independent from tracks, 210  $\mu\text{m}$   $r\phi$  and 0.23 mrad  $\phi_z$  resolution
- Chamber-by-chamber difference with respect to PG before (gray) and after (yellow) alignment with tracks shows improvement (35 chambers below)
- Track-based alignment accuracy: 270  $\mu\text{m}$   $r\phi$  and 0.35 mrad  $\phi_z$   
(from RMS of difference minus PG resolution in quadrature; no PG data for  $\phi_y$ )

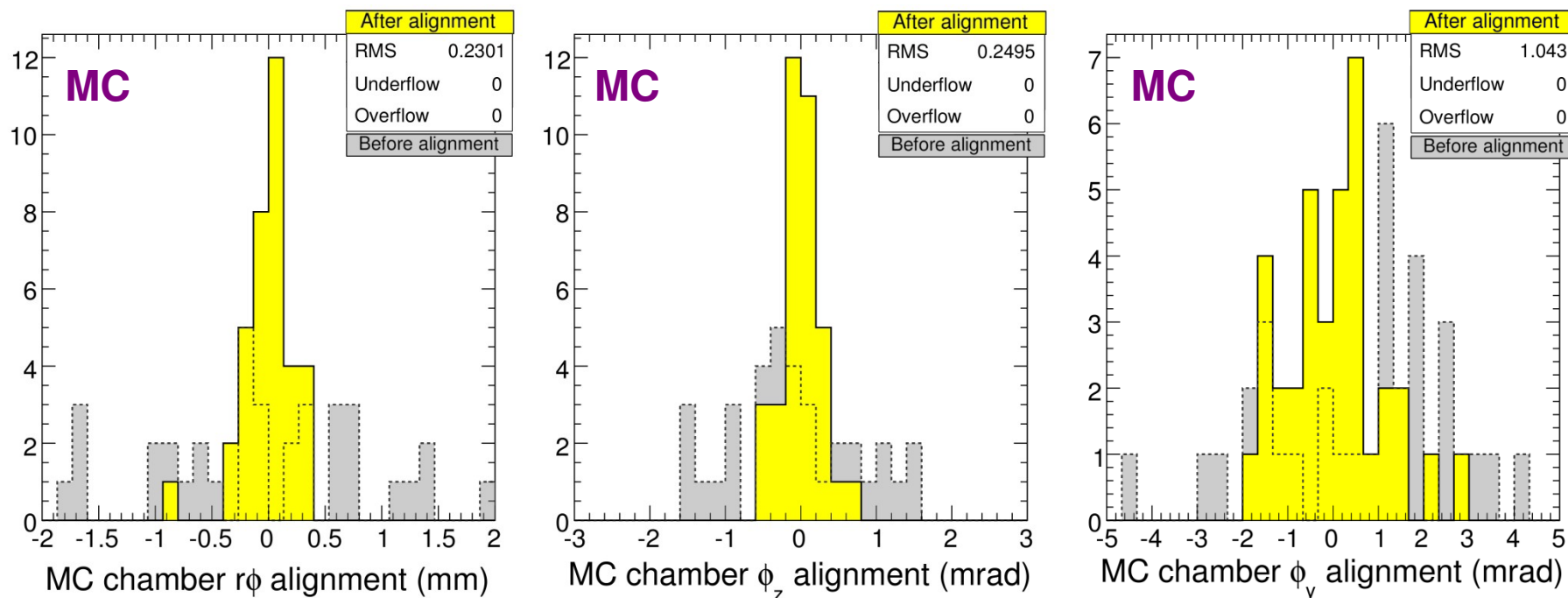


Alignment goal:

- 200-300 microns
- achieved with 9 min of LHC beam!

# Simulation of procedure in beam-halo Monte Carlo

- Roughly the same statistics, observe roughly the same resolutions



## Consistency of residuals

- Sum of residuals around ring must be zero (must form a consistent circle)
  - always zero in MC (for  $r\phi$ ,  $\phi_z$ , and  $\phi_y$ )
- offset of  $r\phi$  residuals in data led to discovery of CSC description error (0.09% error in strip pitch angle)

Note to speakers: the fact that we had an error and later fixed it is not public, only the initial and final results

