

Alignment of the ATLAS Muon Spectrometer

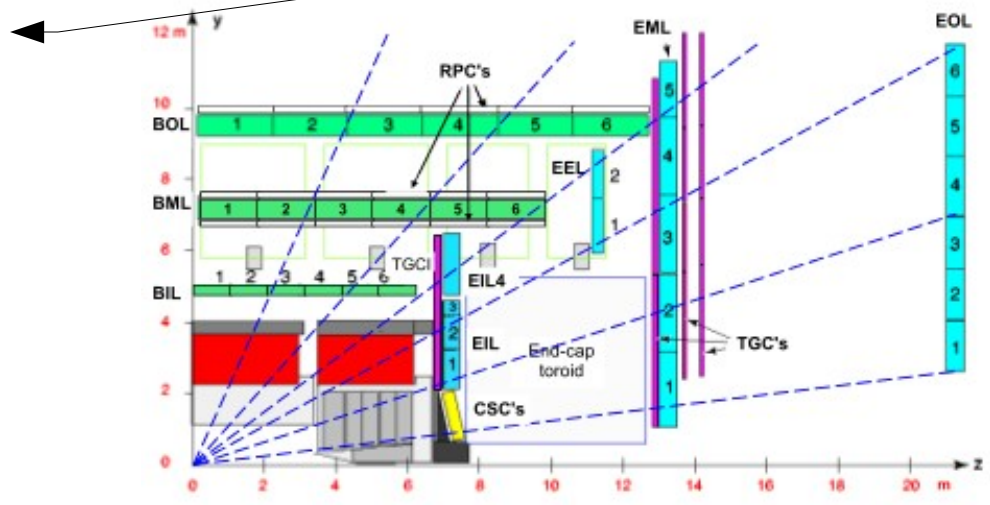
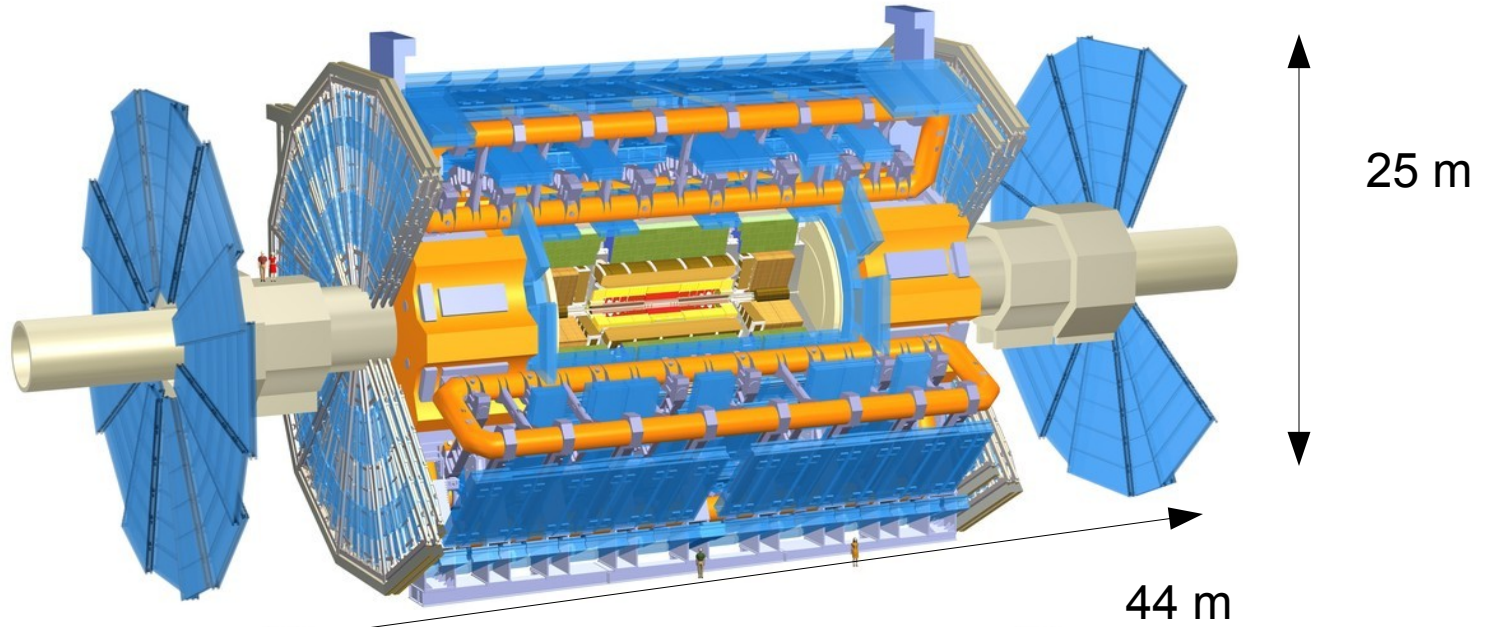
Scott Aefsky

Brandeis University

On behalf of the ATLAS Collaboration

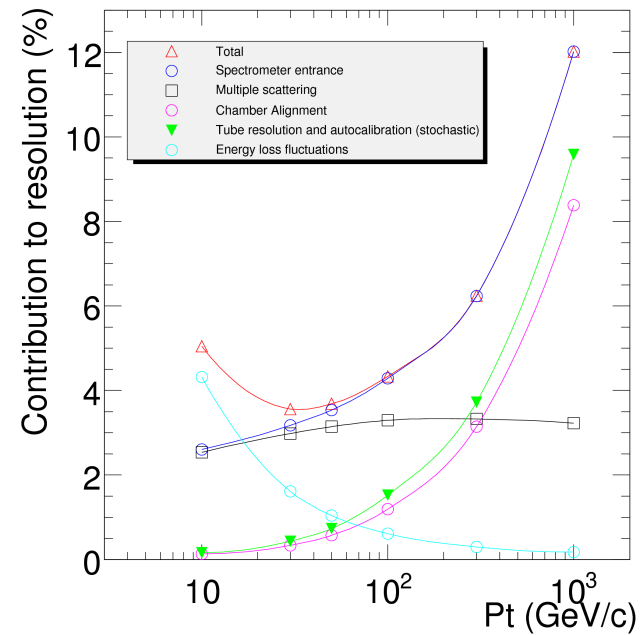
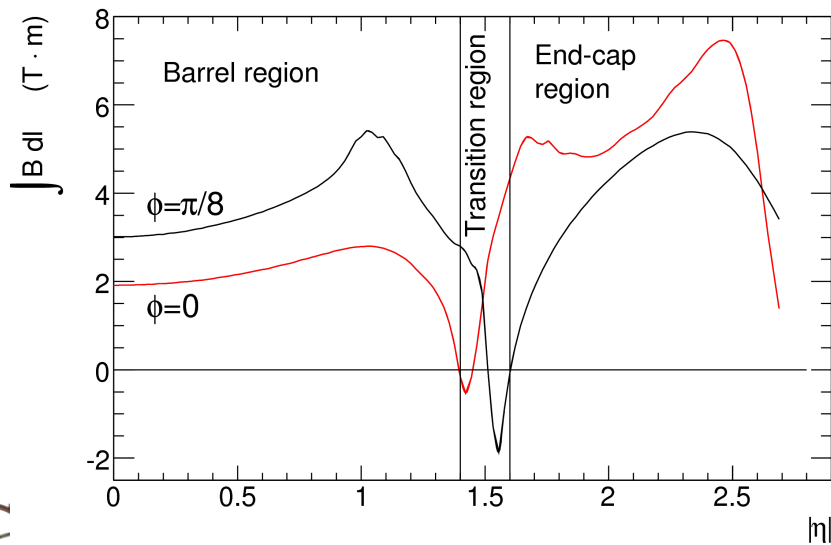
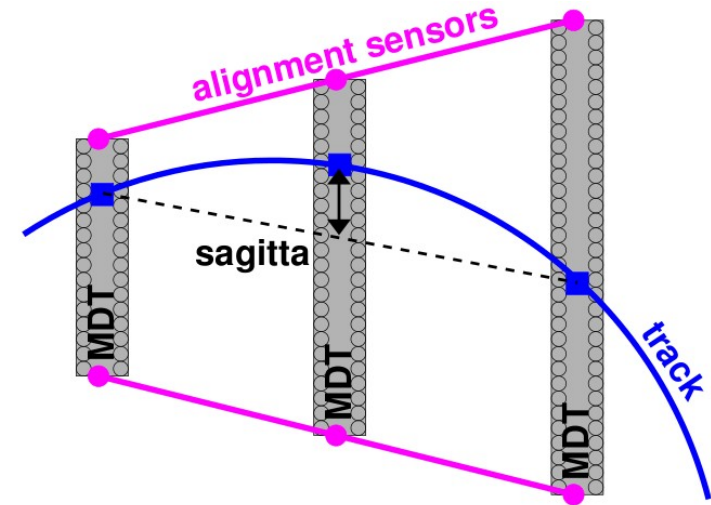


Muon Spectrometer



Alignment Goals

- ATLAS is a “discovery machine”
 - New physics at high-pT
 - Small sagitta
 - $\sim 500 \mu\text{m}$ at 1 TeV
 - Alignment is major contributor to resolution
 - For 10% resolution, need better than $50 \mu\text{m}$ alignment



Alignment Strategy

- Barrel and Endcap built differently, have different challenges
 - Different strategies for alignment
- Barrel
 - Alignment with tracks used to determine initial position
 - Optical sensors track changes
 - “Relative” alignment
- Endcap
 - Optical sensors used exclusively to determine position of chambers
 - “Absolute” alignment
- Barrel-to-Endcap
 - Use tracks in transition region, very difficult
- Muon Spectrometer to rest of ATLAS
 - Use tracks, also difficult



Alignment Strategy

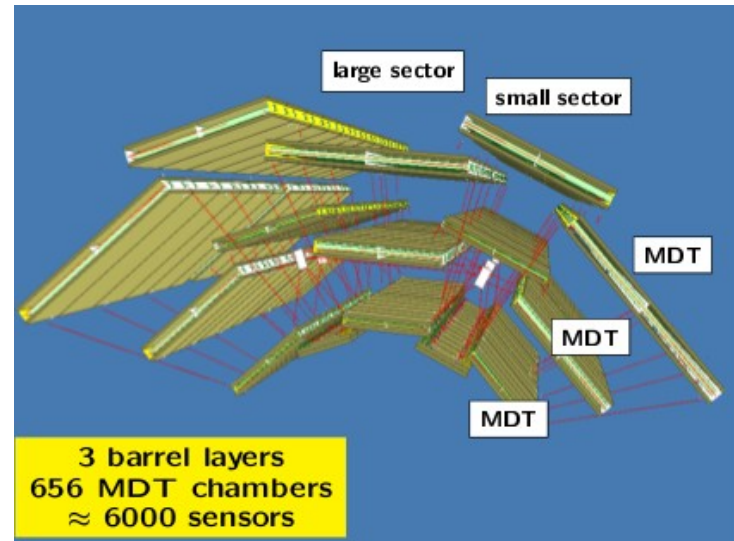
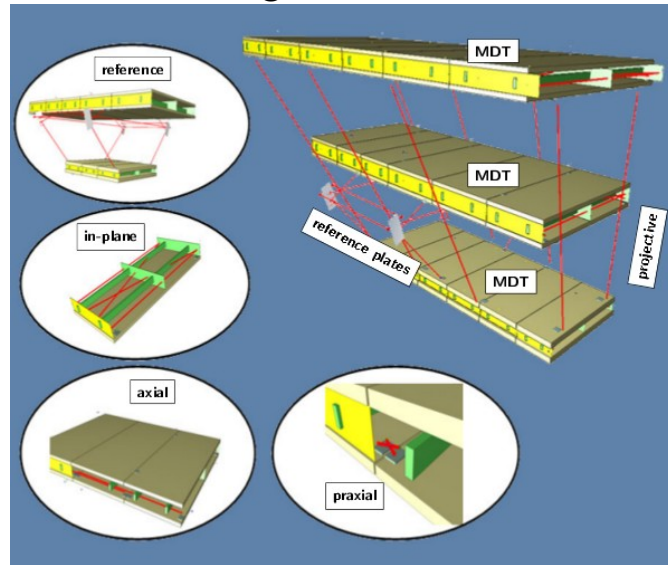
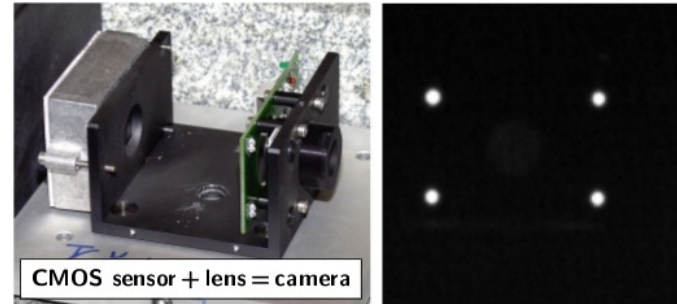
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Ignored here



Optical System - Barrel

- Sensor types
 - SaCAM
 - 4 LEDs in an image, can measure distance, position and rotation
 - Rasnik
 - Modified chessboard, can measure distance, position, and rotation
- Sensor Arrangement



Barrel Alignment With Tracks

- Used one magnet-off cosmic run in April 2009

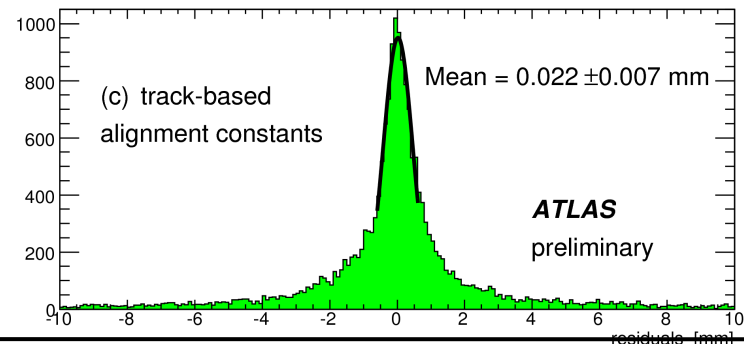
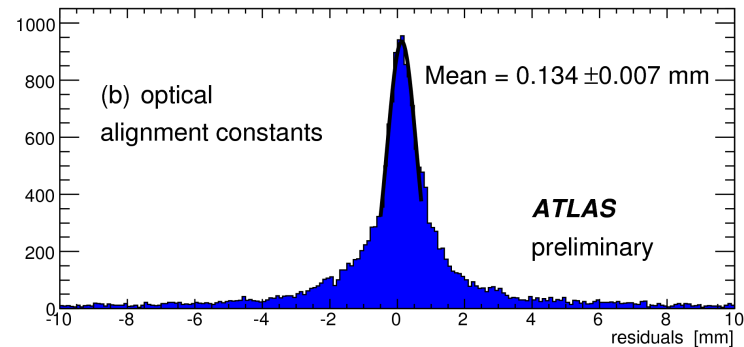
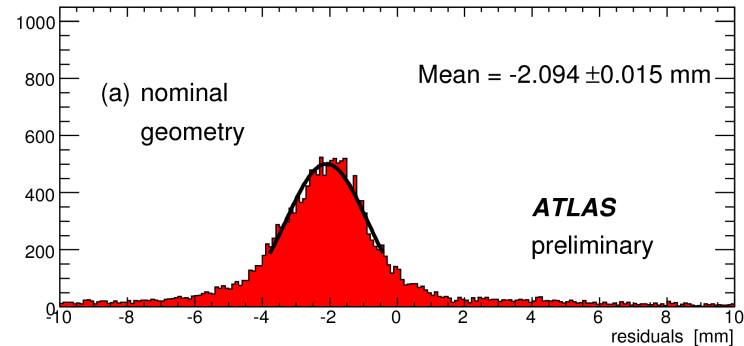
- Several 100k tracks in most sectors

- Use both optical sensors and tracks

- Find positions that minimize

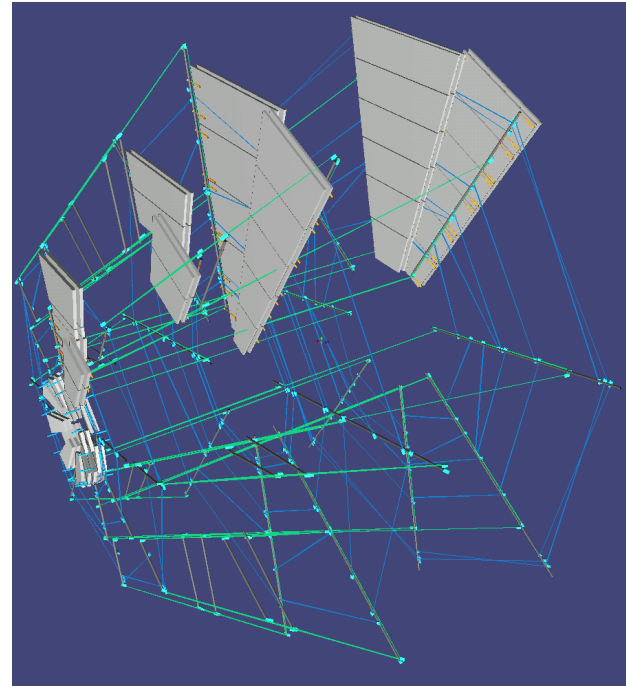
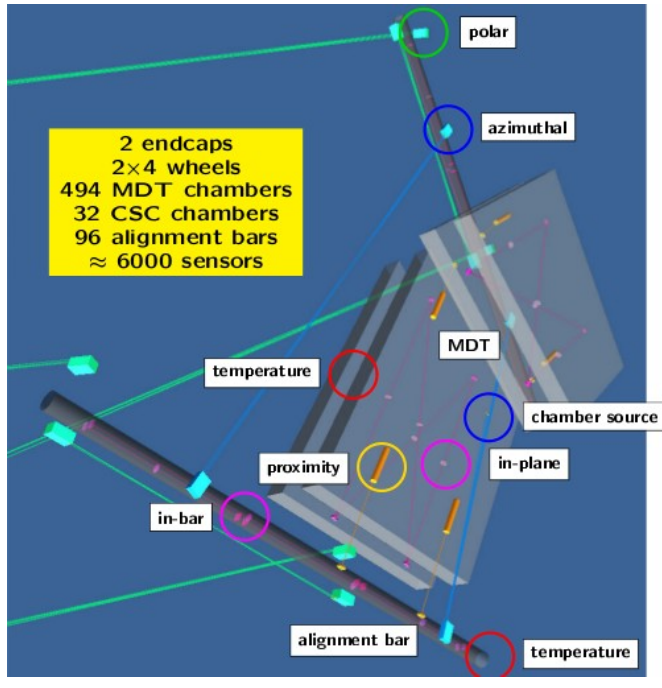
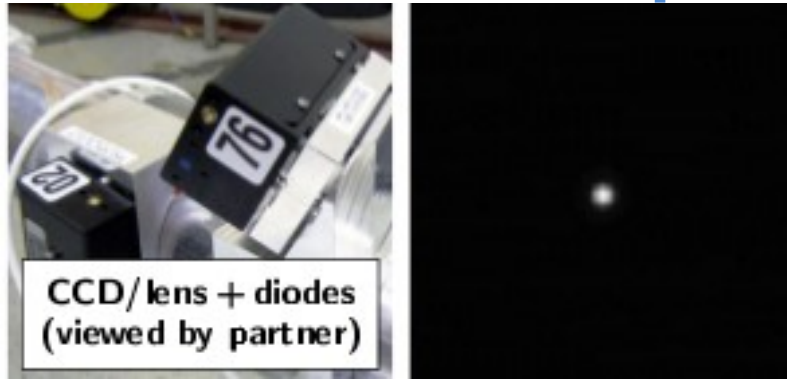
$$\chi_{total}^2 = \chi_{optical}^2 + \chi_{tracks}^2$$

- The alignment constants from this run have been used as a baseline ever since



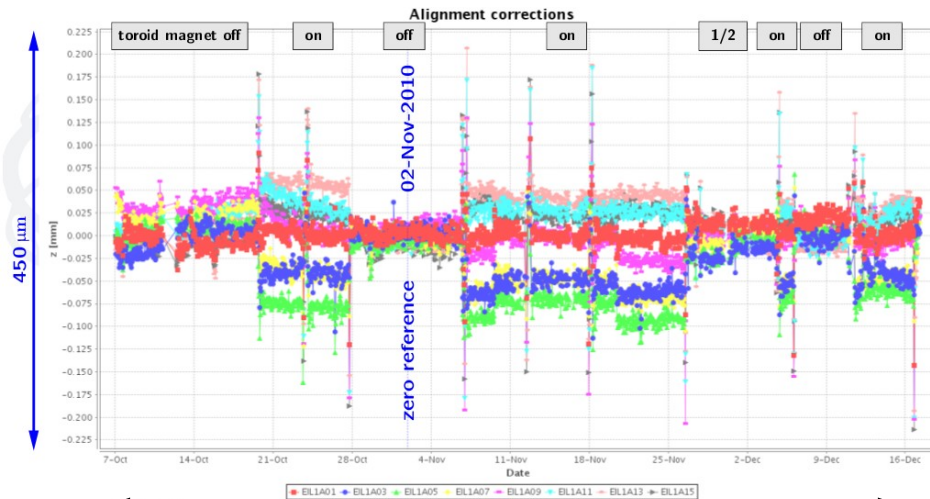
Optical System - Endcap

- Sensor types
 - BCAM
 - 2 LEDs, images taken separately
 - Combining images gives distance, rotation, position
 - Rasnik
- Sensor Arrangement



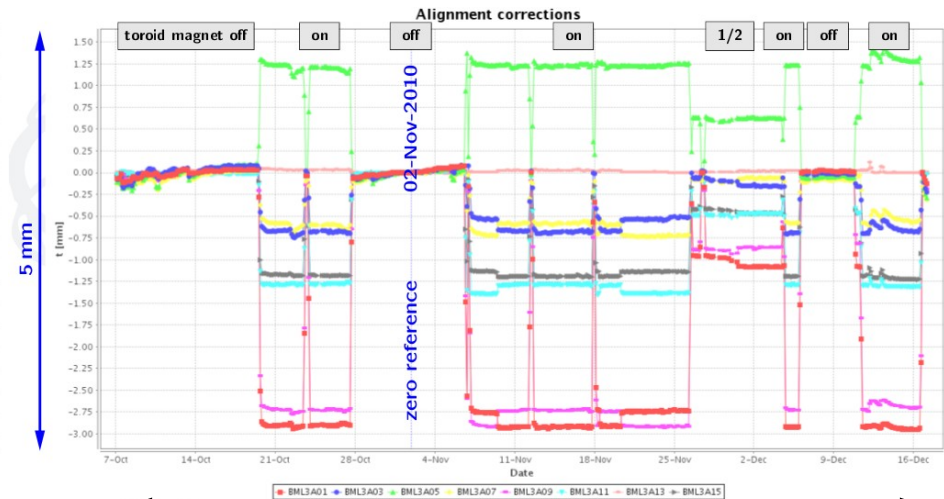
Monitoring

Endcap



~2 months

Barrel



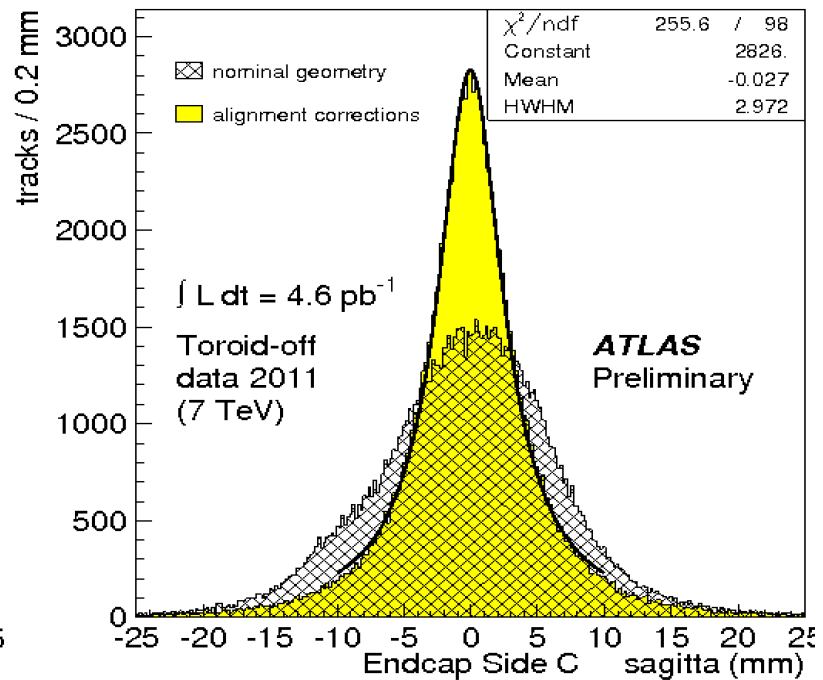
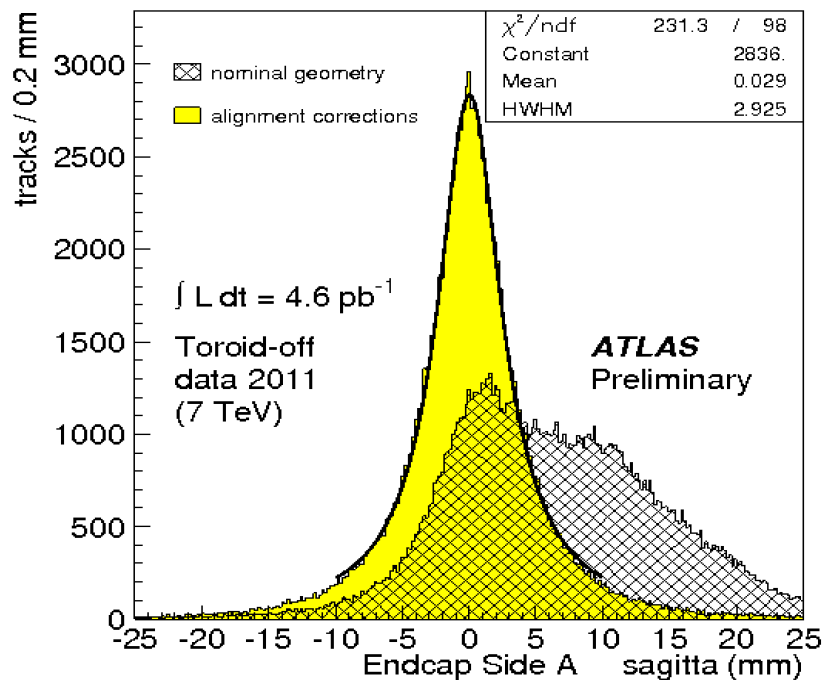
~2 months

- Major hardware failures can be seen in ATLAS Control Room
- Chamber positions entered into ATLAS databases automatically
- Experts can monitor movement
 - Periodically (daily) check to make sure no problems
 - Errors in fit
 - Sensor failures
 - On average, chambers stable to ~100 μm over several weeks
 - Chambers move significantly when magnets turn on
 - Takes $O(\text{days})$ to stabilize
 - Magnet completes turn on in hours

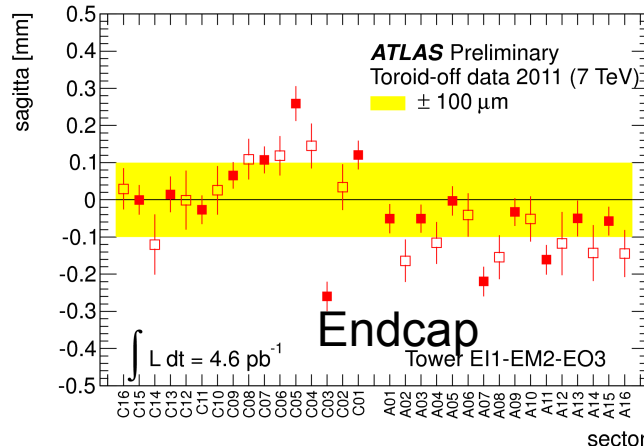
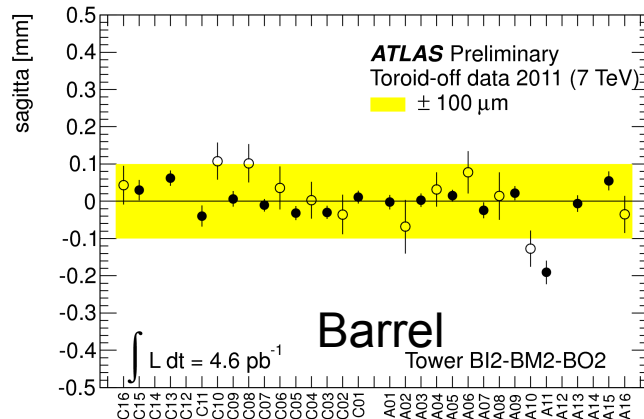
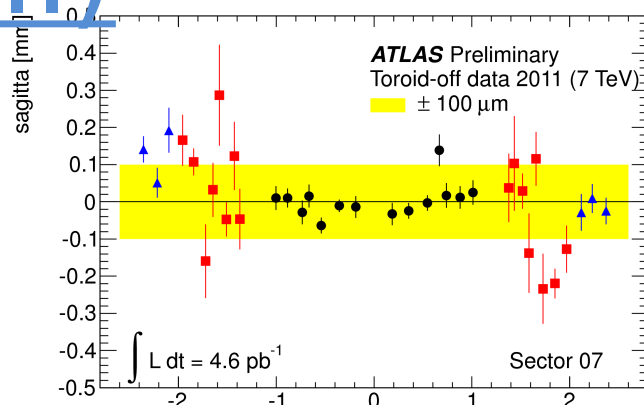
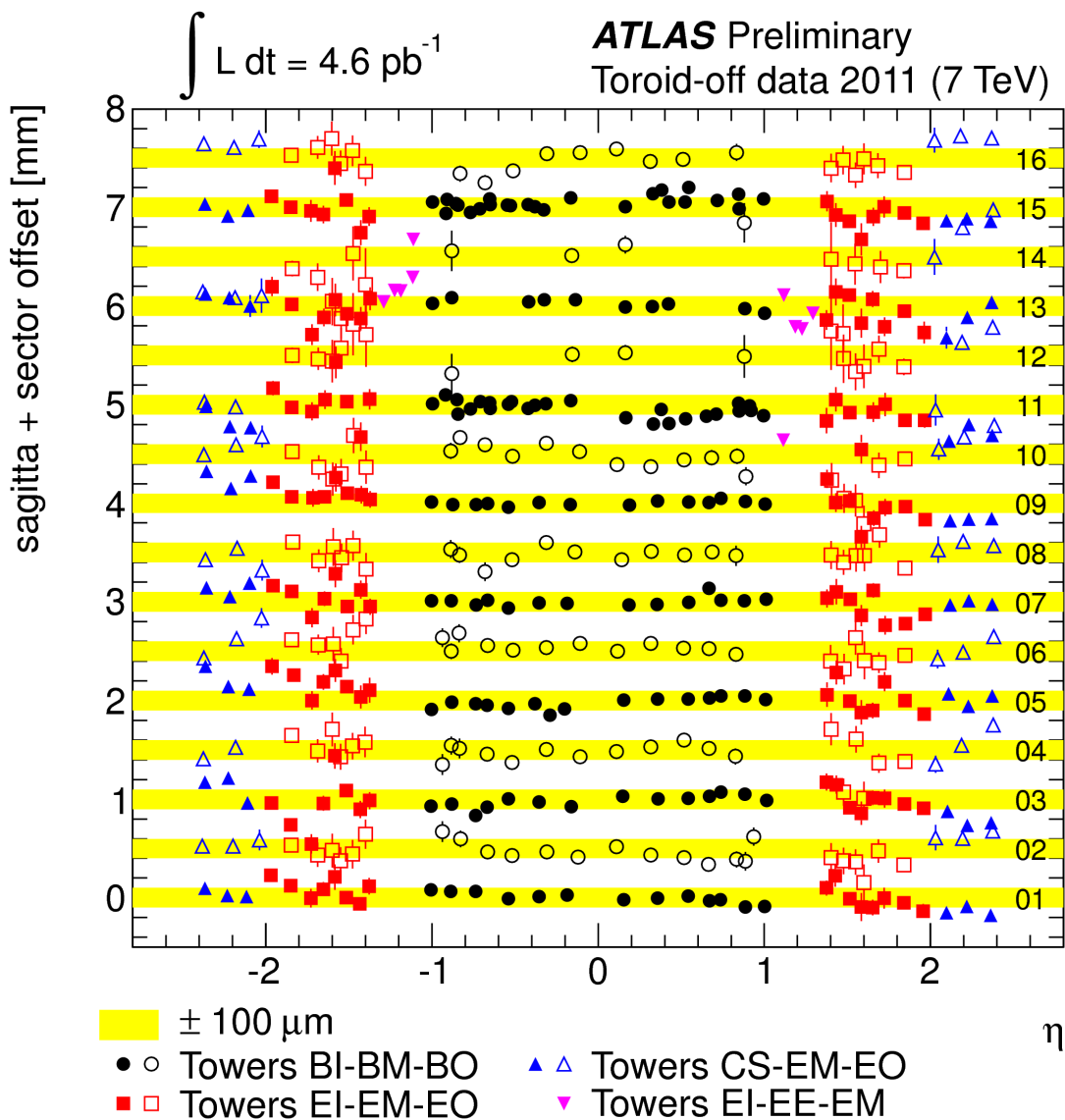


Validation

- Straight tracks provide alignment check
 - Should have sagitta=0, width dominated by multiple scattering
- Magnet-Off runs early 2011 ($\sim 5 \text{ pb}^{-1}$) provide millions of $p > 25 \text{ GeV}$ straight tracks
 - Plotted sagitta distribution with and without alignment corrections
 - Gives us a picture of how good the alignment is
 - Looking only at averages can hide small-scale problems



Validation (II)



June 2011

Scott Aefsky - TIPP11



Summary

- ATLAS Muon Alignment system working very well
 - Hardware installed and working at ~99%
 - Multiple methods to monitor and validate the alignment are in place
- MDT Barrel alignment at $O(50)$ microns)
- MDT Endcap alignment at $O(100)$ microns)
- Several outstanding issues
 - CSC alignment at $O(150-200)$ microns)
 - MS-ID alignment $O(\text{few mm})$ and Barrel-Endcap $O(2 \text{ mm})$ alignment works in progress
 - Very small effect on momentum measurement, but can be improved

Acknowledgements: Muon Alignment Group, Christoph Amelung (Brandeis), Florian Bauer (IRFU-SACLAY), Pierre-Francois Giraud (IRFU-SACLAY), Igor Potrap (MPI)

