


Track-based Muon Alignment: Updated Procedures, Tools, and Systematics Studies

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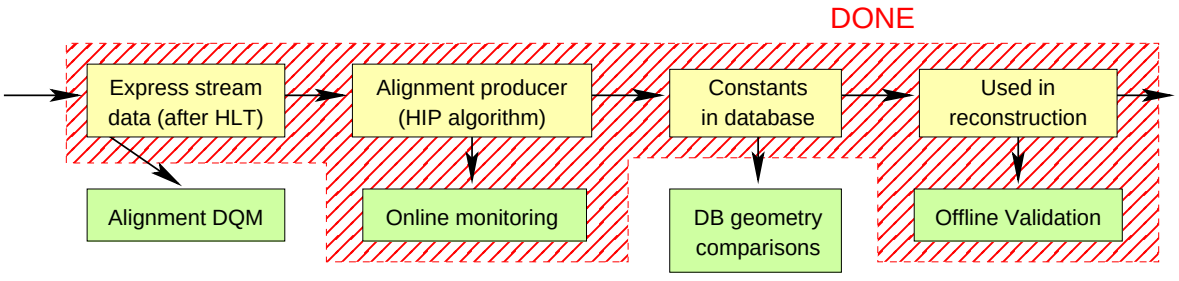
Overview

	Status
Infrastructure for online alignment 	Central path is done; work on DB monitor has resumed
Systematics studies	Some completed
Background studies; finalize cuts	CSA07 exercise
Beam-halo alignment (Karoly Banicz)	Checking feasibility
Cosmic ray and MTCC alignment (Alexey Kamenev)	Near future

What we're focusing on and why

Present

- Monitoring: to catch and fix mistakes quickly
- Systematics studies: quantify complicating effects and make sure they're not show-stoppers
- Beam-halo alignment: potential opportunity to align all CSC layers with tracks before first collisions

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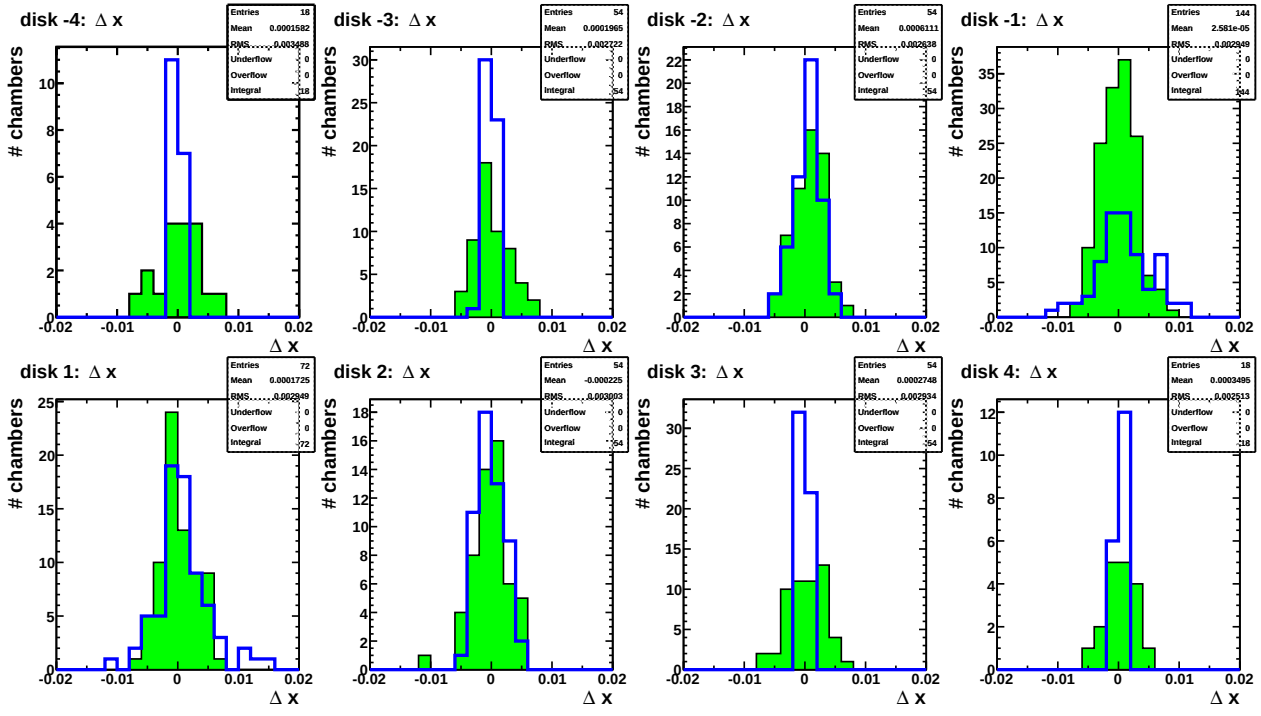
Near future

- Background studies: loosen event selection from $Z \to \mu\mu$ to an inclusive p_T cut. Requires a realistic event sample with all backgrounds, which we can get from CSA07.
- MTCC: real data, includes $\vec{B}(t)$ and an opportunity to connect track-based alignment with photogrammetry and laser system. Data must be re-processed in a 1_5_X+ release.

Monitoring alignment changes in the database

Example from DB geometry comparison tool

- Comparison of real alignment output (blue line) with a misalignment scenario (filled green)



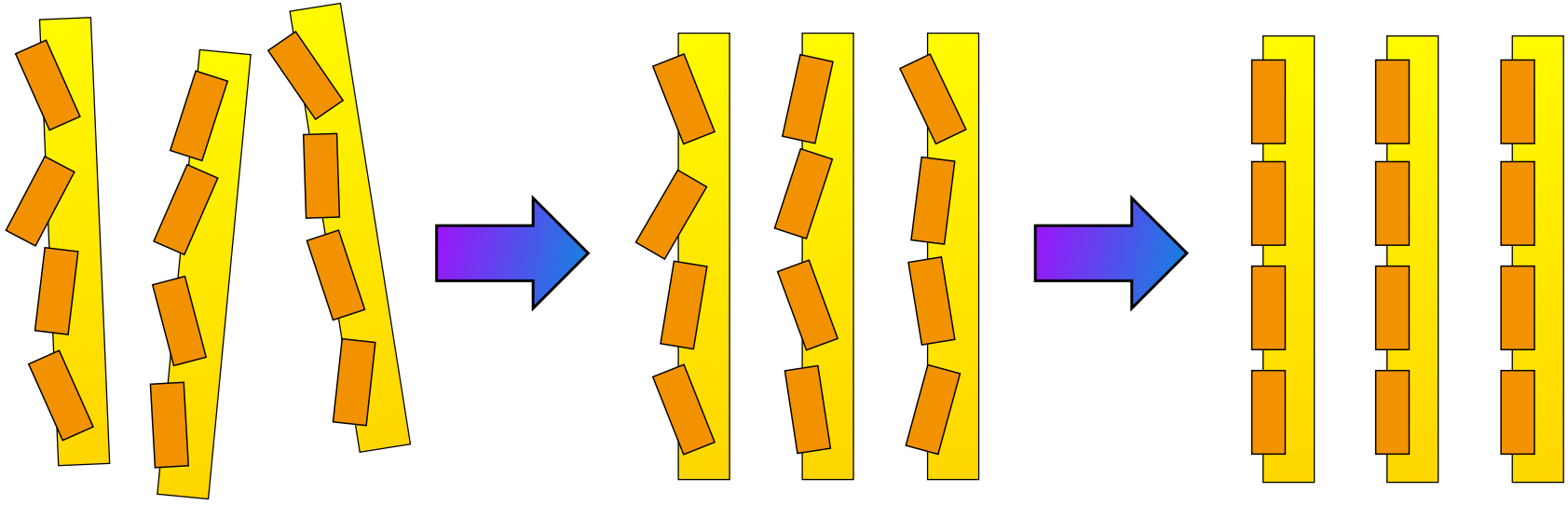
Aligned − ideal local x in endcap

- New student: Vadim Khotilovich

Optimized alignment procedure

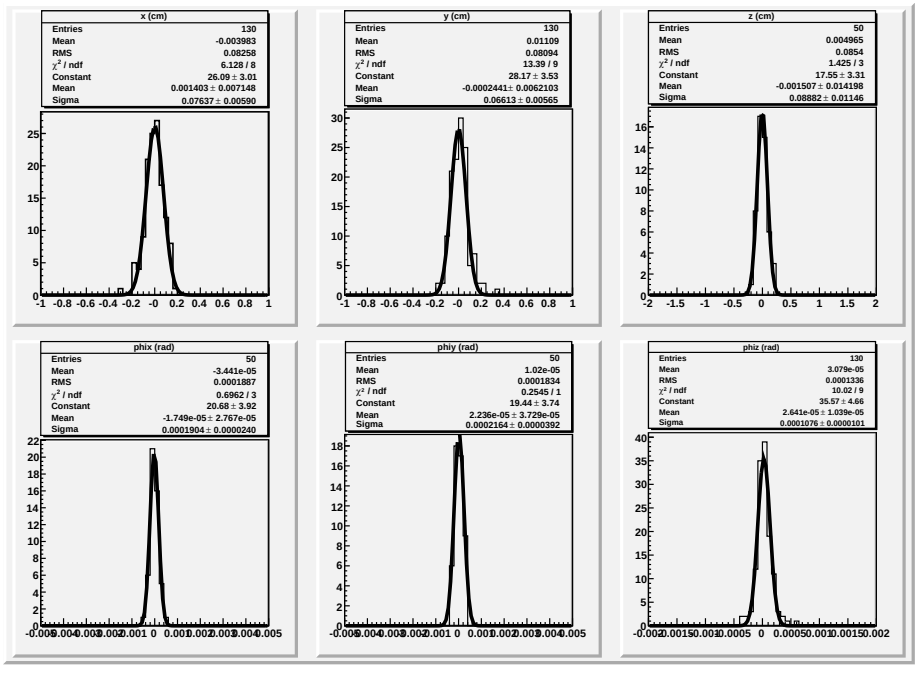
Hierarchical 2–3 step process

1. Determine wheel/disk positions to 0.7 mm accuracy with a few hundred muons
2. Determine chamber positions to 100 μm with 10 pb^{-1}
3. Determine CSC layer positions, if necessary



Wheel/disk alignment results × 10 trials

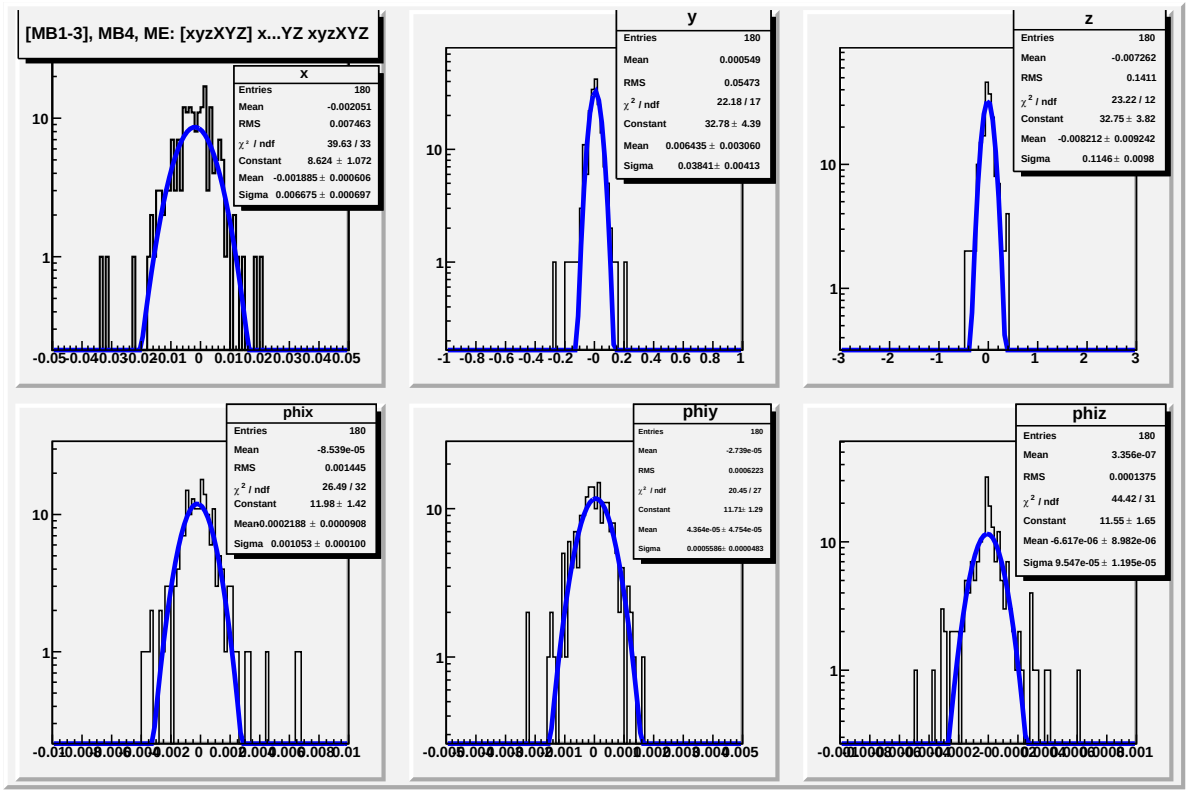
x, y positions	0.71 mm
z positions (barrel only)	0.89 mm
ϕ_x, ϕ_y angles (barrel only)	0.20 mrad
ϕ_z angle	0.11 mrad



6 d.o.f. float in barrel
only x, y, ϕ_z in endcap

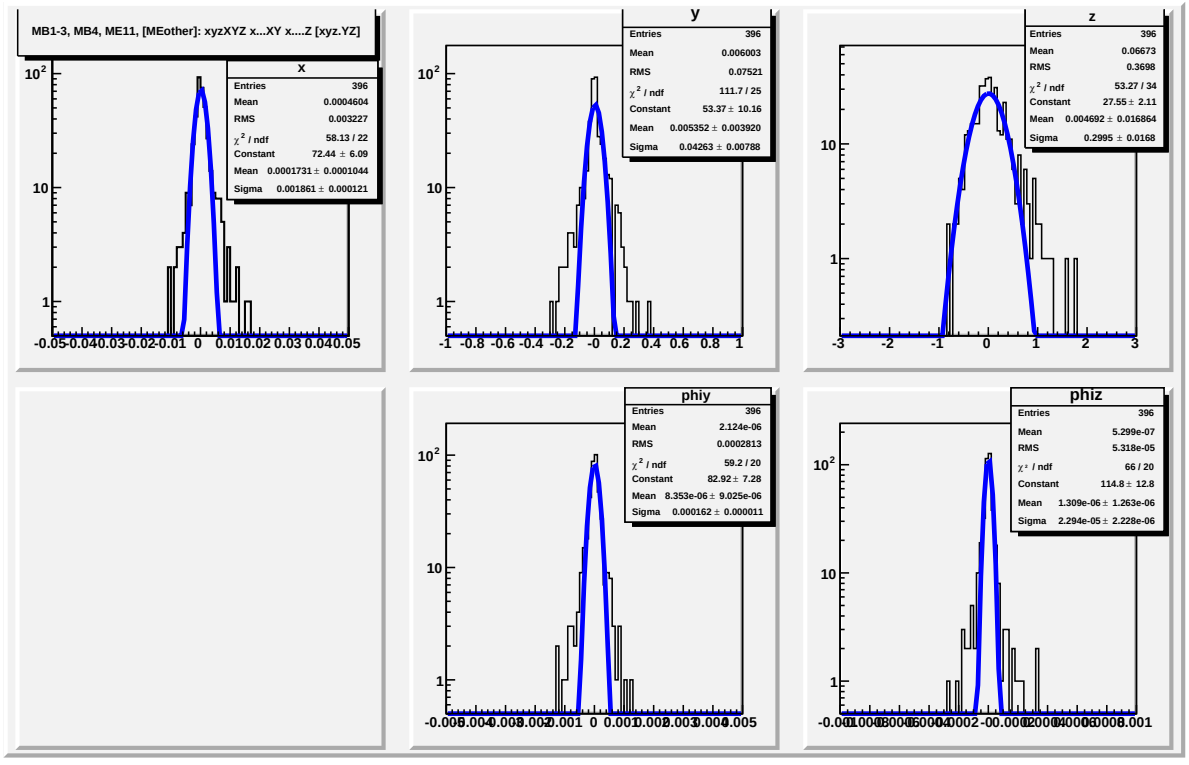
Independent of the number of muons ("brick wall" is ∼20 tracks)

Barrel chamber results (MB4 not shown)



MB 1–3				MB 4			
x	67 μm	1.05 mrad	ϕ_x	x	28 μm		
y	384 μm	0.56 mrad	ϕ_y			0.57 mrad	ϕ_y
z	1.15 mm	0.095 mrad	ϕ_z			0.004 mrad	ϕ_z

Endcap chamber results (ME1/1 not shown)



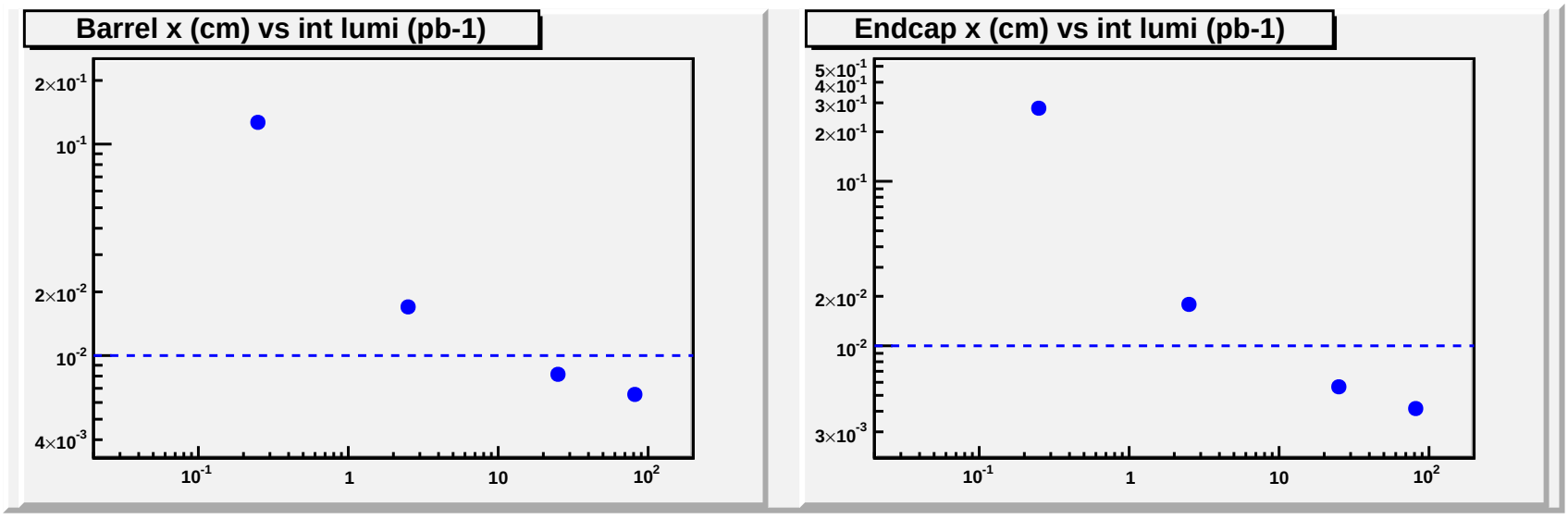
All but ME1/1

x	19 μm		
y	430 μm	0.16 mrad	ϕ_y
z	3.0 mm	0.03 mrad	ϕ_z

ME 1/1: possible software bug

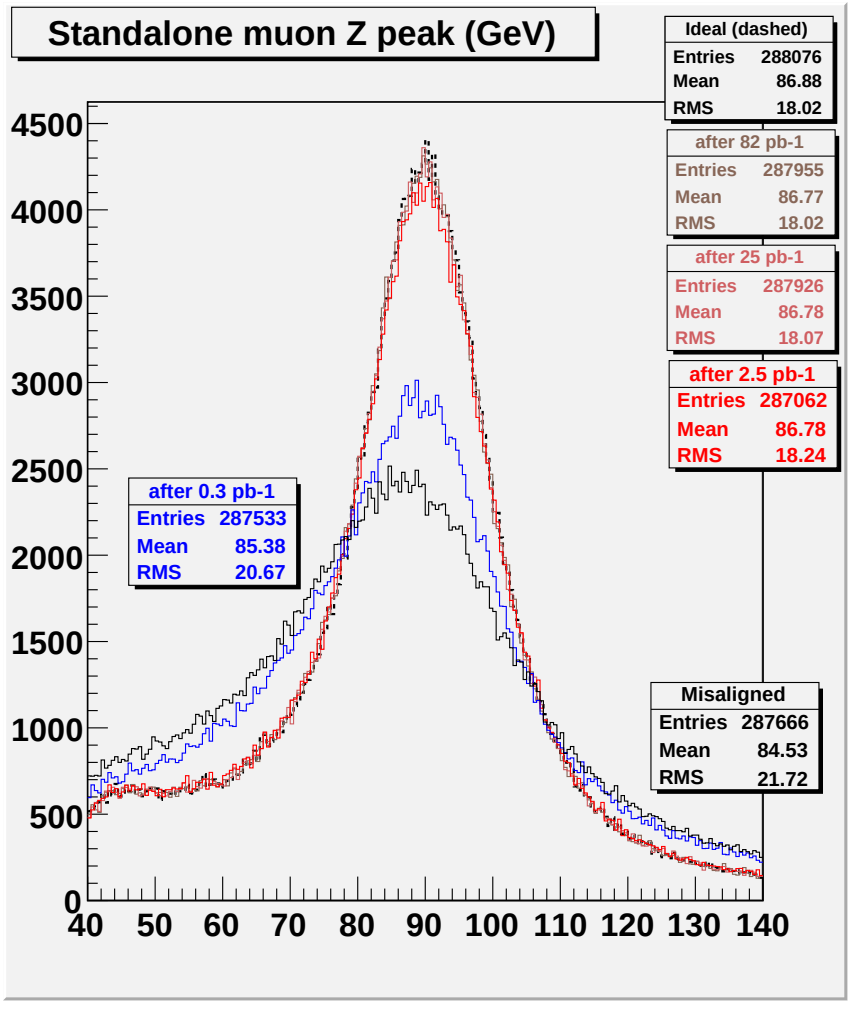
x	300 μm
y	2–6 mm asymmetry
angles	1 mrad or more

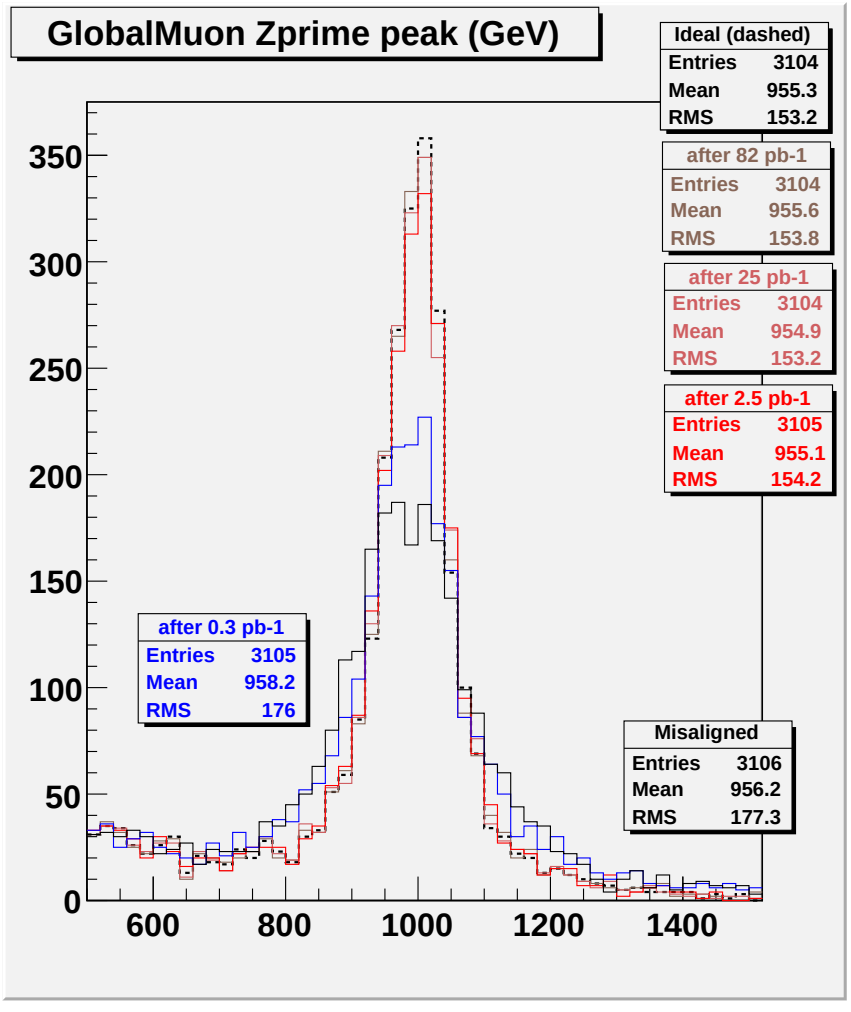
Dependence on integrated luminosity: accuracy



- Points: RMS of distribution, Line: 100 μm
- x accuracy reaches 100 μm with 10 pb^{-1}

Dependence on integrated luminosity: Z, Z' resolution



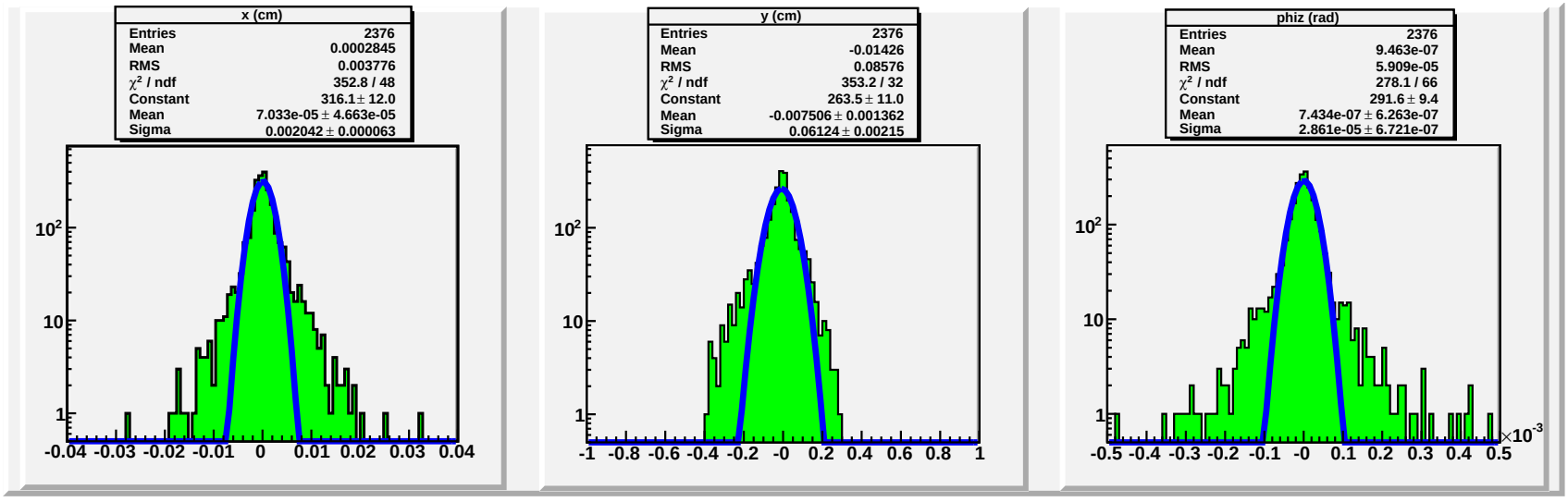


- To do: higher moments of distribution— Drell-Yan smearing

CSC layer-by-layer alignment

- CSC layers known to be misaligned (Karoly, Andrey, Oleg. . .)

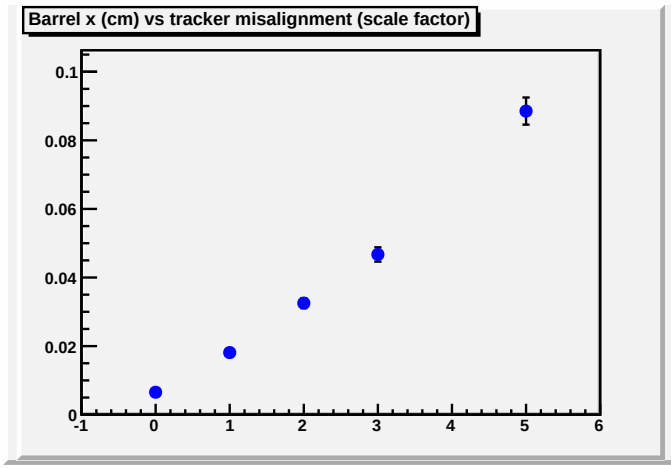
	current (RMS)	after 82 pb^{-1} alignment (RMS)
x	190 μm	38 μm
y	340 μm	860 μm
ϕ_z	0.04 mrad	0.06 mrad

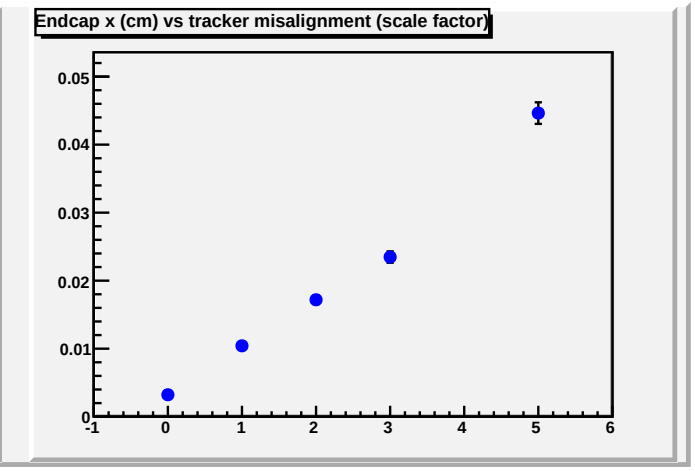


Systematics studies

Effect of tracker misalignment

- Most sensitive parameters: x and ϕ_z
- Accuracy versus $N \times$ tracker "short-term" scenario (ST)



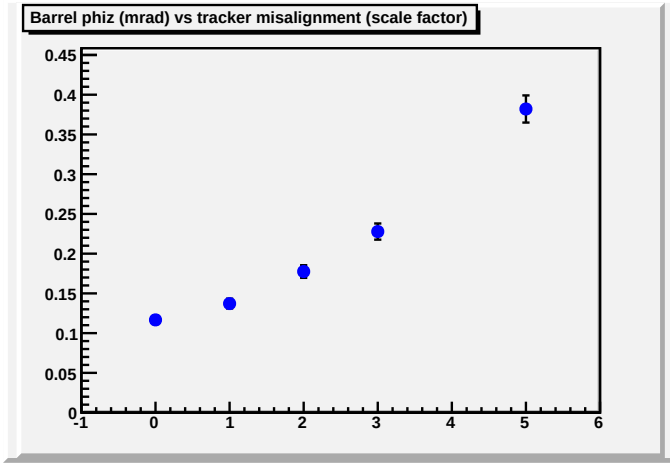


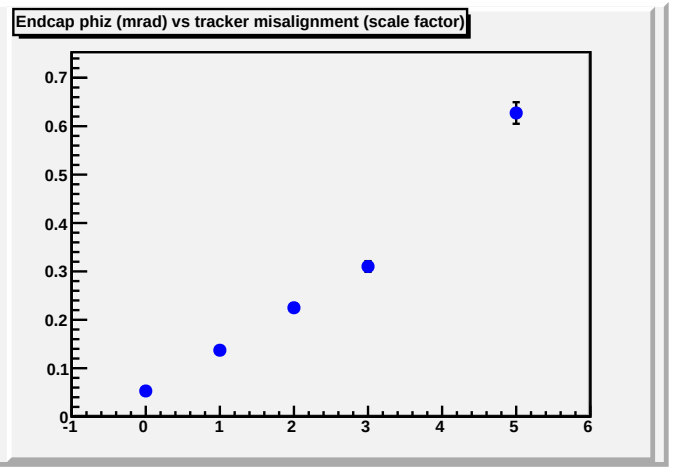
Barrel x:
200 μm/ST

Endcap x:
100 μm/ST

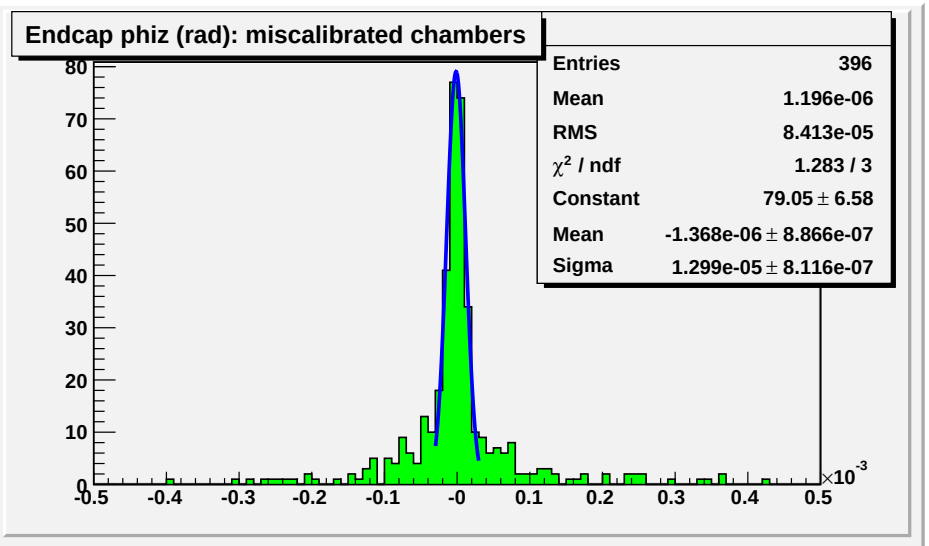
Barrel ϕ_z:
0.5 mrad/ST

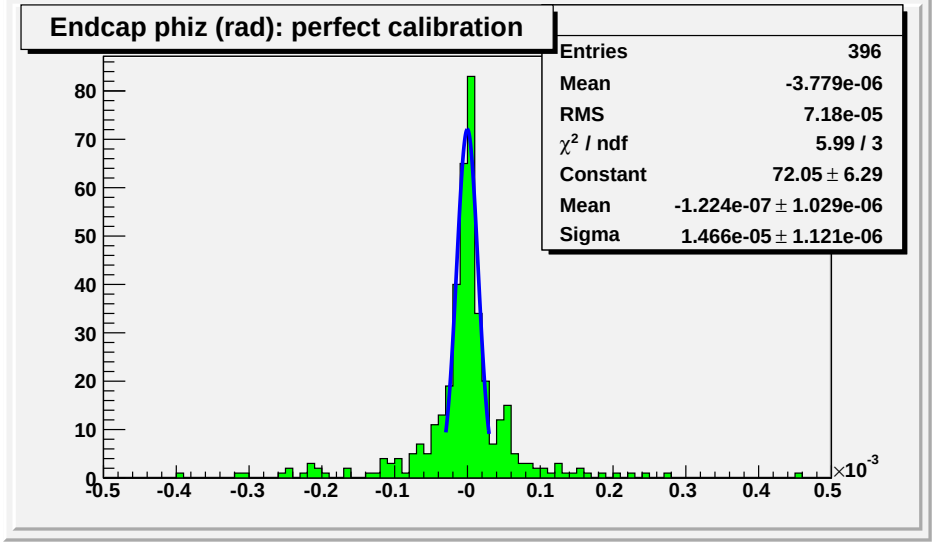
Endcap ϕ_z:
1 mrad/ST





Effect of miscalibration





- 10 pb^{-1} miscalibration scenario
- Small influence on tails

Barrel (Δ RMS)

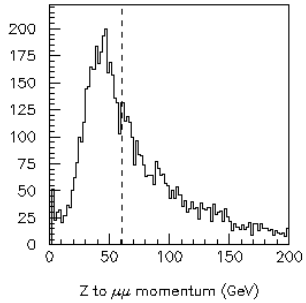
x	6%	0%	ϕ_x
y	1%	3%	ϕ_y
z	0%	10%	ϕ_z

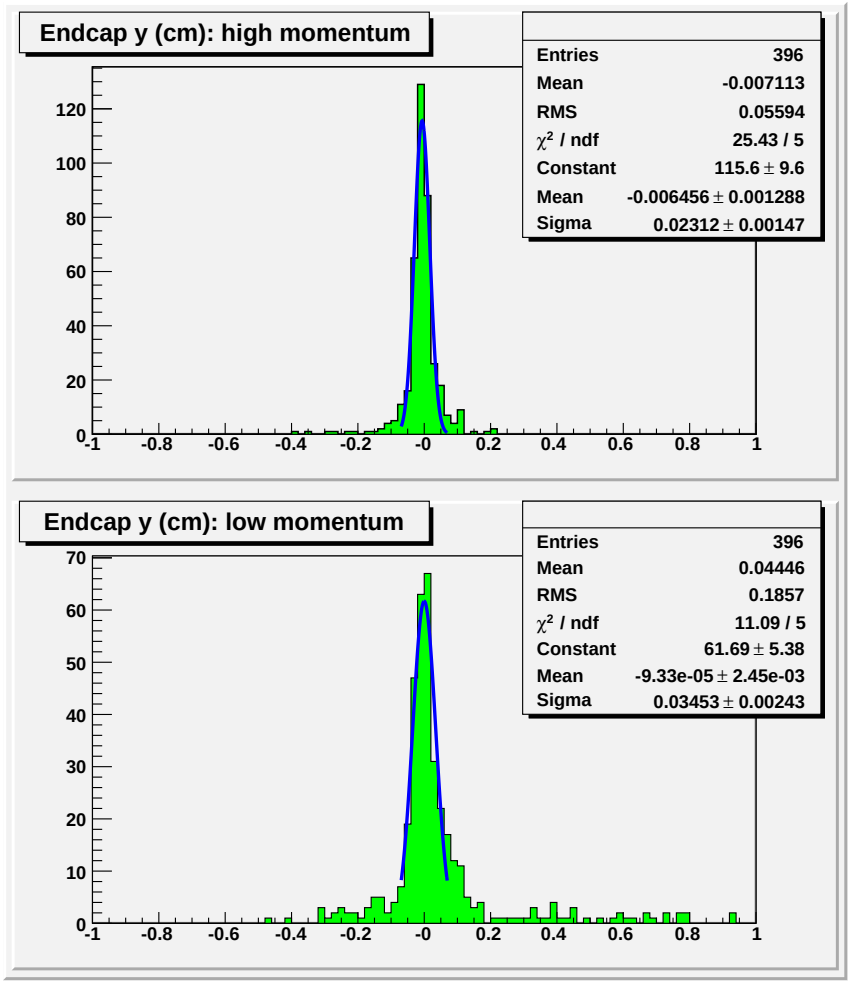
Endcap (Δ RMS)

x	15%		
y	9%	3%	ϕ_y
z	2%	17%	ϕ_z

Dependence on muon momentum

- Divide $Z \rightarrow \mu\mu$ sample along 60 GeV median



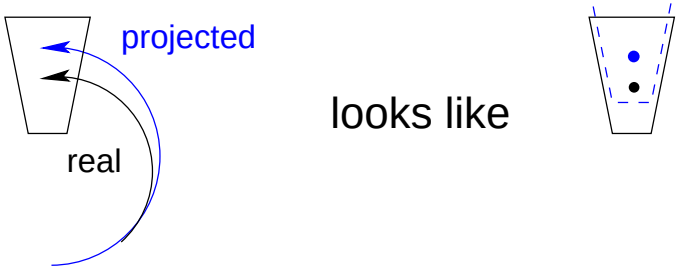


Δ Resolution

Barrel: $< 5\%$ in each parameter

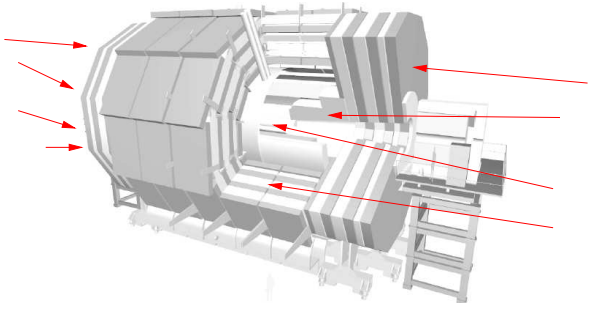
		core	RMS
Endcap:	x	$\times 1.5$	$\times 3$
	y	$\times 1.5$	$\times 3$
	z	$\times 3$	$\times 3$
	ϕ_y	$\times 1.6$	$\times 3.5$
	ϕ_z	$\times 1.2$	$\times 2$

Note asymmetric tail in y!



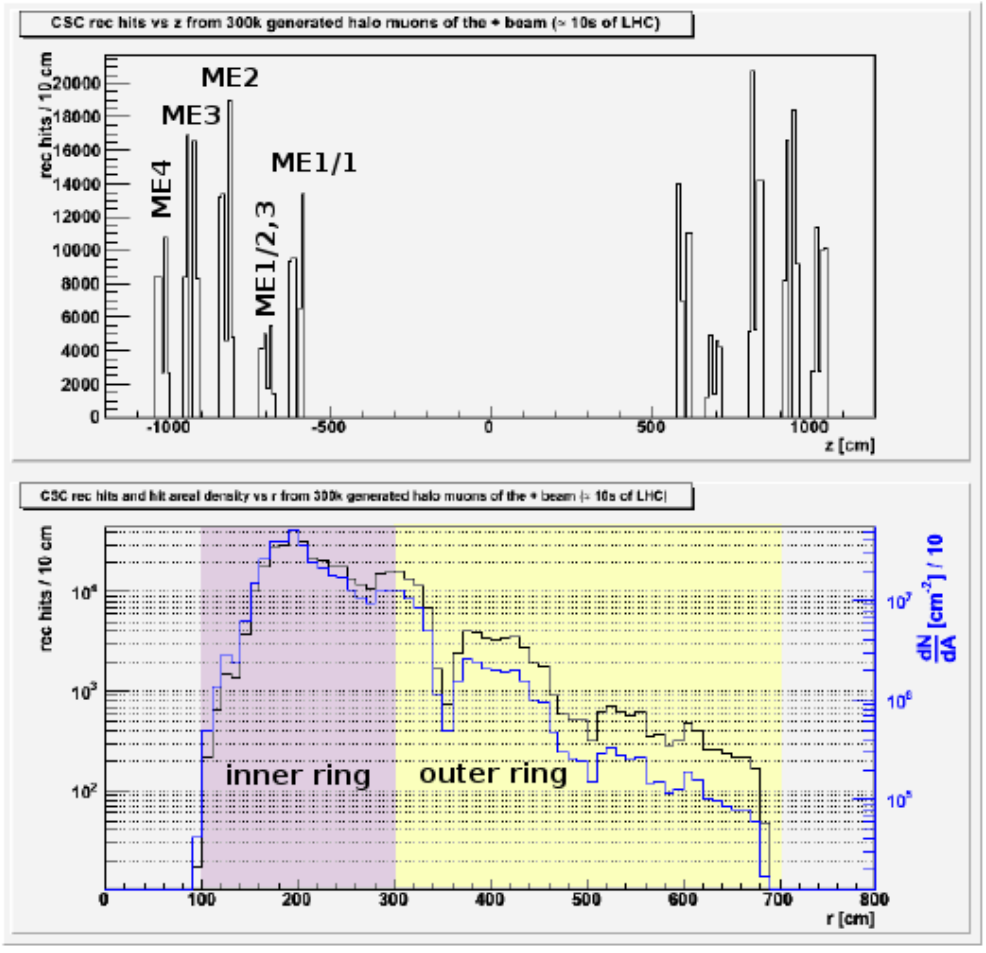
Beam-halo studies (Karoly)

Alignment plans with beam-halo



- Before first collisions
  - Accumulate beam-halo muons from accelerator studies with constant conditions (constant $\vec{B}(t)$, detector positions)
  - Align CSC layers; remains valid even after chambers/disks move
  - Will the rate be high enough? To be determined...
- With collisions
  - Combine muons from the vertex with beam-halo muons: requires a new trigger (under discussion)
  - Alignment will be improved by more orthogonal tracks

Beam-halo illumination

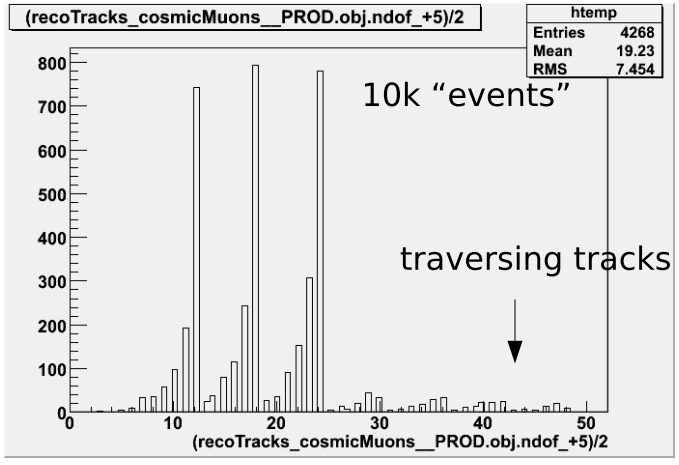


Top: z (cm) Bottom: r (cm)

All four stations covered

Chambers in outer rings will get uneven statistics

A few tracks connect both sides



Number of hits

Conclusions

- Basic infrastructure is in place for CSA07 and beyond; we are developing monitors
- Continuing to improve the baseline procedure
- Problem with ME1/1, possible software bug
- Learning quantitative relevance of systematic effects, some of which are responsible for outliers
  - Tracker misalignment — important if worse than "short-term"
  - Chamber miscalibration — only small effects
  - Muon momentum — degradation in endcap with 20–60 GeV
- Karoly is making great progress with beam-halo alignment feasibility studies
- MTCC/alignment with cosmic rays is a high priority