



Muon Alignment Status Report

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Main Theme

The muon alignment *process* is basically working (most stations) and performs better than expected.

Now we need to

- (a) continue looking for sources of systematic error
- (b) correct a bug in ME1/1
- (c) improve our layer-alignment strategy
- (d) develop cosmic-ray and beam-halo procedures
- (e) create additional monitoring tools
- (f) *actually* align the detector: MTCC as soon as possible, beam-halo and $Z \rightarrow \mu\mu$ when available

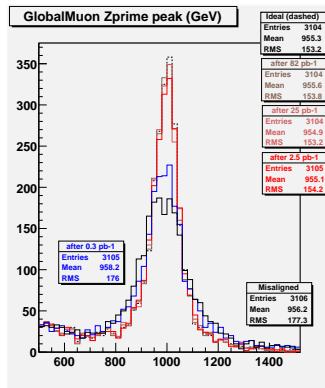
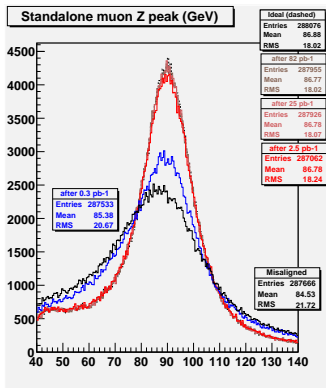
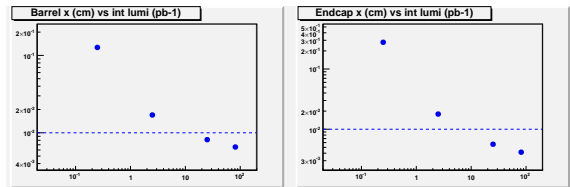


PART I: WHAT WORKS



Working procedure

Reaches alignment goals
with 5 pb^{-1} of Z, W
(20,000 high- $|\vec{p}|$ muons),
assuming no surprises





Anticipating surprises: systematics studies

Done

- ▶ Dependence on miscalibration: negligible
- ▶ Dependence on tracker misalignment: only significant at 1–2 times the “tracker short-term scenario”

Partial

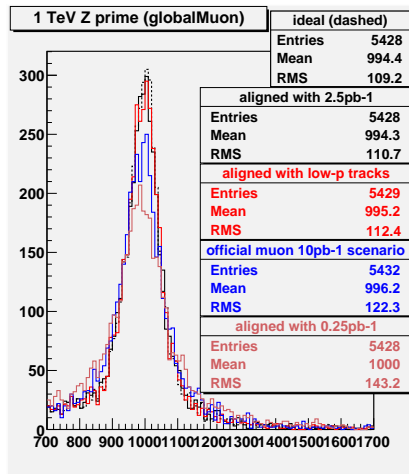
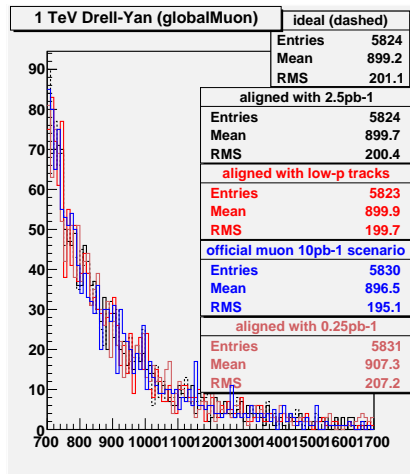
- ▶ Dependence on momentum: aligned high- $|\vec{p}|$ $Z \rightarrow \mu\mu$ (60+ GeV) and low- $|\vec{p}|$ $Z \rightarrow \mu\mu$ (~ 20 to 60 GeV), but not realistic physics distributions

low- $|\vec{p}|$: 10% of chambers placed at too large radius (2–8 mm)

To-do

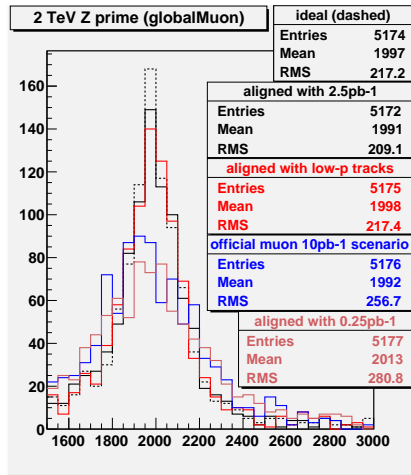
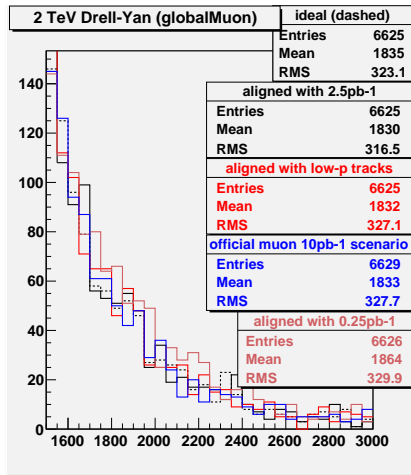
- ▶ Mismeasured magnetic field
- ▶ Incorrect material budget/distribution
- ▶ Backgrounds (contamination with non-muons)

All systematics studies applied to TeV Drell-Yan and Z'



“low-p” means 20-60 GeV $Z \rightarrow \mu\mu$
 official 10 pb⁻¹ scenario is pessimistic

(private 1_5_4 Z' samples)

All systematics studies applied to 2 TeV Drell-Yan and Z' 

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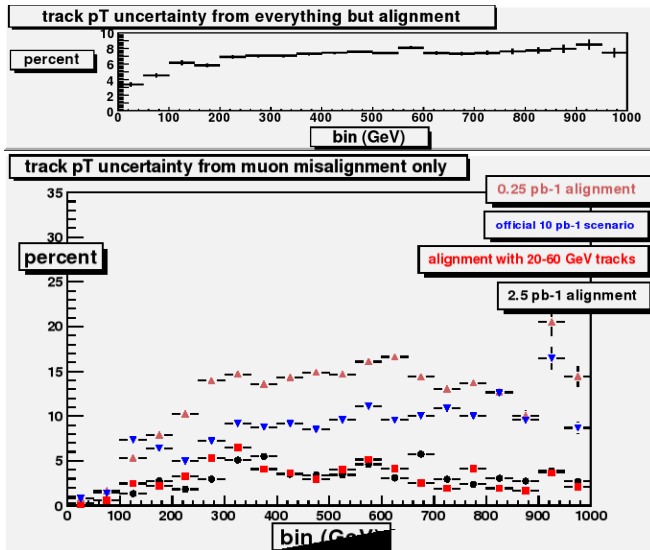
Using effect on TeV muons as “alignment quality”

$$\text{RMS of event-by-event} \frac{\text{misaligned di-muon mass}}{\text{ideal di-muon mass}} - 1$$

Source of alignment	$Z'(1000)$	$Z'(2000)$	DY(>500)	DY(>1000)
1k μ (0.25 pb^{-1})	6.0%	5.5%	4.8%	6.6%
10k μ (2.5 pb^{-1})	1.8%	1.7%	1.6%	2.1%
100k μ (25 pb^{-1})	1.2%	1.1%	1.0%	1.3%
325k μ (82 pb^{-1})	1.0%	1.0%	0.7%	1.2%
$ \vec{p} > 60 \text{ GeV}$	1.0%	1.0%	0.8%	1.2%
$20 < \vec{p} < 60 \text{ GeV}$	1.7%	1.7%	1.5%	2.1%

With this as a bottom line, we can make statements like “switching to $|\vec{p}| > 60 \text{ GeV}$ is as good as getting a factor of ten more tracks.”

Uncertainty in track p_T , binned in p_T and factorized



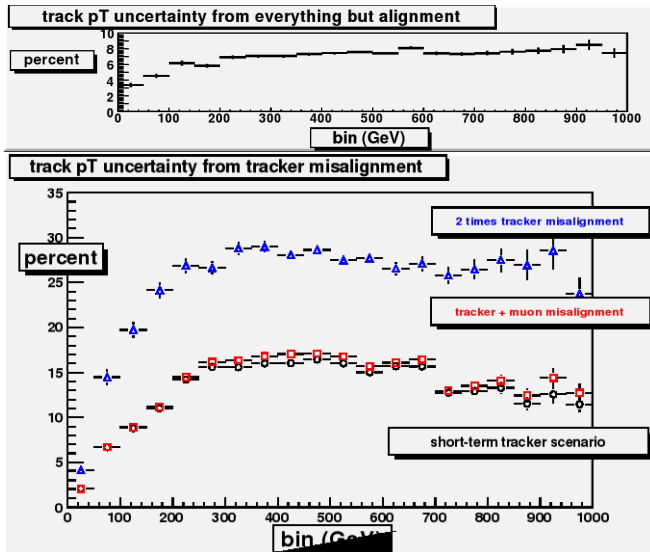
everything but
alignment

effect of alignment

$$\left(\frac{\sigma_{p_T}}{p_T} \right) = \left(\frac{\sigma_{\kappa}}{\kappa} \right)$$

= sum in quadrature
of both uncertainties

Uncertainty in track p_T , binned in p_T and factorized



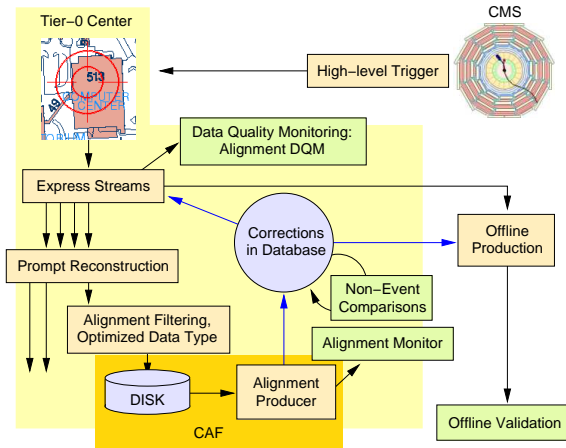
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$$\left(\frac{\sigma_{p_T}}{p_T} \right) = \left(\frac{\sigma_{\kappa}}{\kappa} \right)$$

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Software infrastructure will be tested next Wednesday
That's when we start our CSA07 jobs

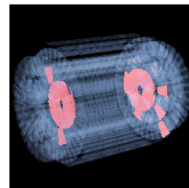
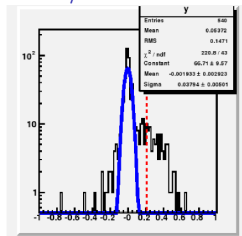




PART II: WHAT NEEDS WORK

ME1/1: bug in alignment and/or reconstruction

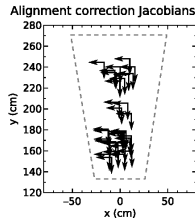
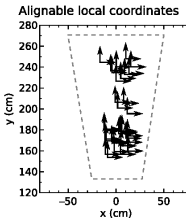
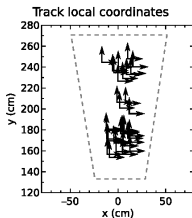
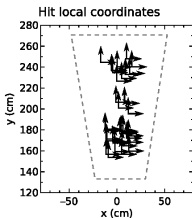
Asymmetric non-Gaussian tail in aligned y positions due to ME1/1



Chambers with $y > 0.2$

Problem with coordinate systems? ME1/1's unique geometry?

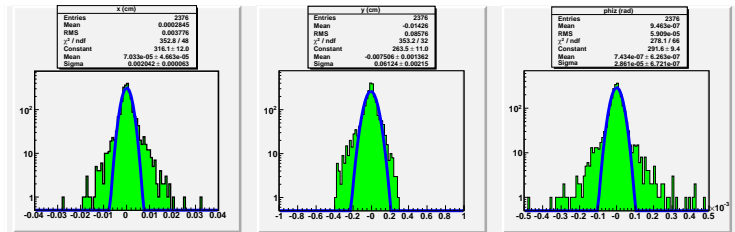
Alexey Kamenev (Dubna) and I are beginning investigation...



Need a more effective procedure for CSC layers

- CSC layer misalignment is known (Karoly, Andrey, Oleg...)

	current (RMS)	after 82 pb^{-1} alignment (RMS)
x	$190 \text{ } \mu\text{m}$	$38 \text{ } \mu\text{m}$
y	$340 \text{ } \mu\text{m}$	$860 \text{ } \mu\text{m}$
ϕ_z	0.04 mrad	0.06 mrad



Note: “alignment quality” studies use *current* layer misalignment



PART III: COSMIC RAYS AND BEAM-HALO



Cosmic rays (Alexey Kamenev)

- ▶ Very recently freed from other obligations, Alexey is ready to work on alignment
- ▶ We're starting with the ME1/1 bug
- ▶ We'll use Adam Roe's re-processed MTCC until official sample becomes available

Beam-halo (Karoly Banicz)

- ▶ Generating reliable beam-halo samples
- ▶ Successfully ran an alignment
- ▶ We have yet to optimize the procedure, but the initial results are promising (I peeked at the output)



PART IV: TOOLS FOR MONITORING

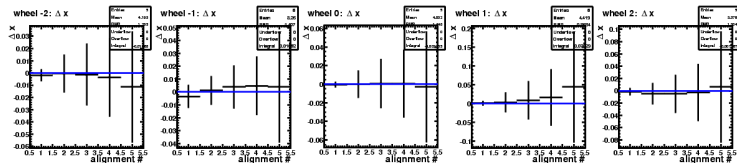
Done

- “Sanity checks” generated in the alignment job (used, for example, to diagnose ME1/1)

Started

- Geometry comparison tool: compare alignments at the database level, without events

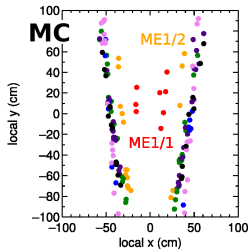
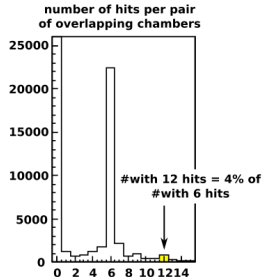
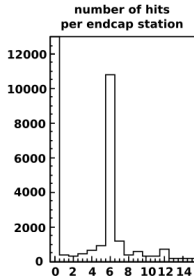
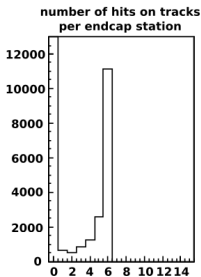
Example time-series plot: barrel alignments with increasingly misaligned tracker



Brand New

- Overlap plots: to identify misaligned chambers *in data*...

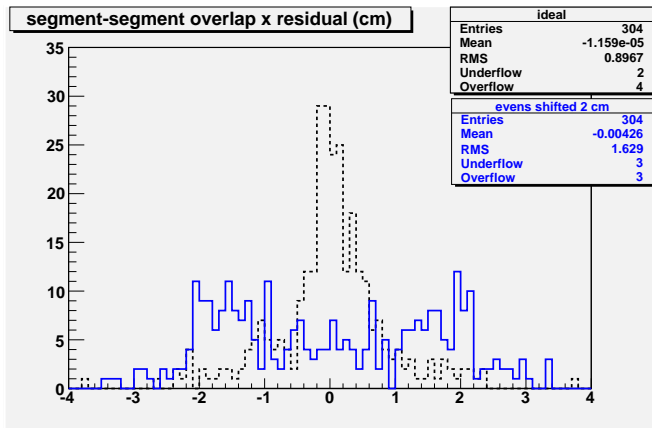
Prerequisites for overlap plots



- ▶ No tracks overlap neighboring pairs of chambers in the same station
- ▶ Very few muons do ($\sim 4\%$)
- ▶ But 12-hit events usually have segments with good χ^2 , in the right regions

Overlap plot (MC)

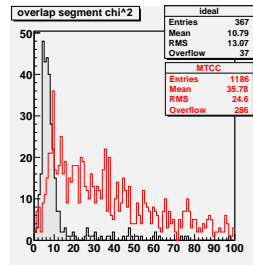
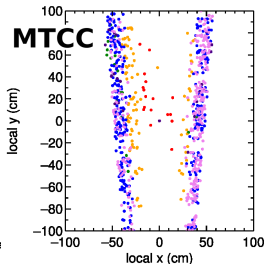
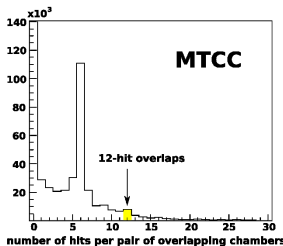
- ▶ Linear extrapolation over $\Delta z \approx 25$ cm
- ▶ Poor resolution, even with all chamber-pairs combined
- ▶ Still have sign ambiguities to resolve





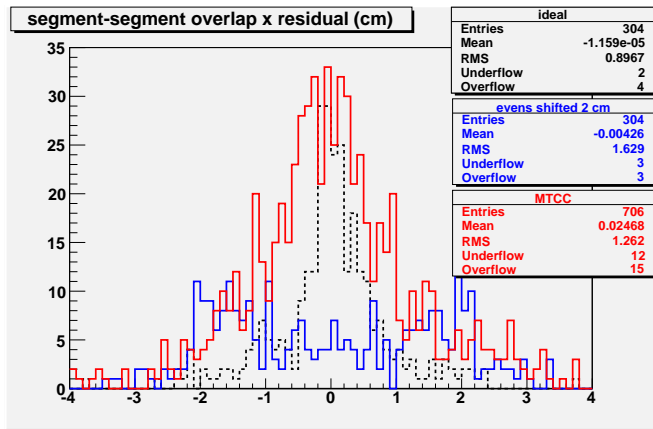
PART V: TOWARD *REAL* ALIGNMENTS (not just realistic)

Making overlap plots with MTCC



- ▶ Adam Roe's privately re-processed sample
- ▶ Somewhat more background and larger segment χ^2 values
- ▶ Not a fair comparison because:
 - ▶ $Z \rightarrow \mu\mu$ MC versus cosmic ray MTCC
 - ▶ MTCC layers are misaligned, ideal MC are not
 - ▶ MTCC could be miscalibrated, ideal MC is not

MTCC overlap plot superimposed on MC



- ▶ Chamber misalignments are probably smaller than $\mathcal{O}(1 \text{ cm})$
- ▶ How would we see them with 1 cm resolution?



Conclusions!

- ▶ $Z \rightarrow \mu\mu$ alignment procedure is not in danger of being late
- ▶ We cautiously anticipate needing only 5 pb^{-1} , even with preferring high- $|\vec{p}|$ tracks to high statistics
- ▶ Still checking systematic effects for potential spoilers
- ▶ Still building monitoring tools to catch the problems we don't think of
- ▶ Using TeV muons as a test-bed for alignment quality (in MC)
- ▶ Developing ways to test alignment quality in data
- ▶ MTCC and beam-halo alignment efforts are ramping up