


Effect of Muon Alignment on TeV tracks

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Context

- We have been developing a muon alignment procedure in the CSC DPG and the Alignment & Calibration groups
- Baseline procedure has stabilized, ready to be applied to physics

Outline for this talk

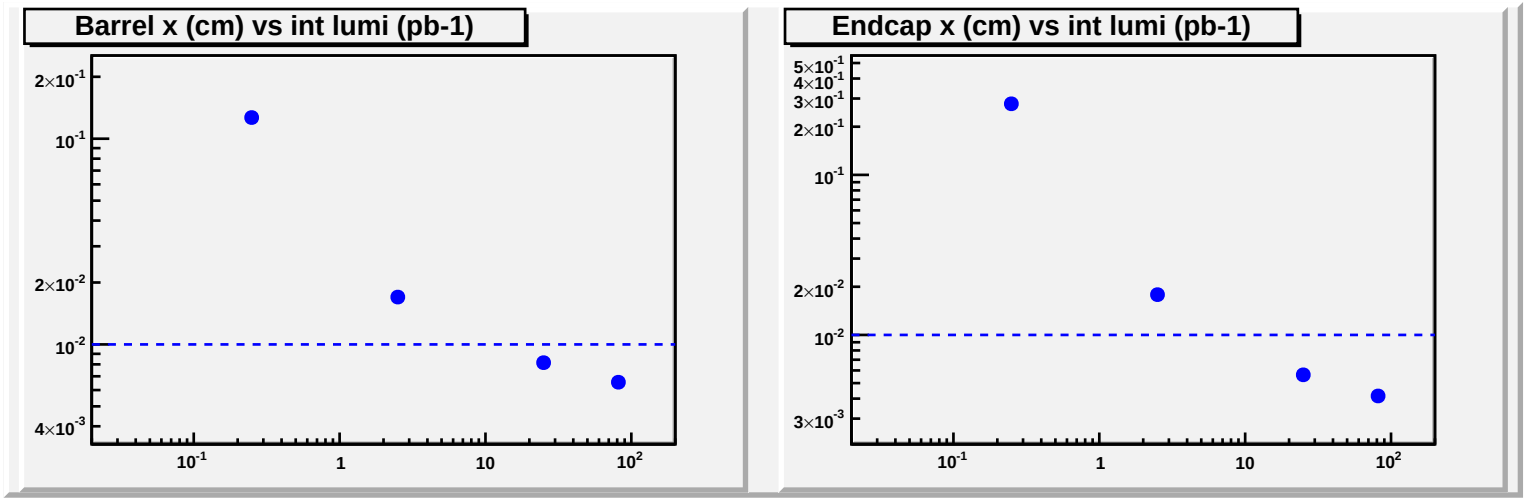
- Overview of the procedure
- New set of scenarios, comparable to Muon10InversePb and Muon100InversePb
- Consequences for physics

Baseline procedure

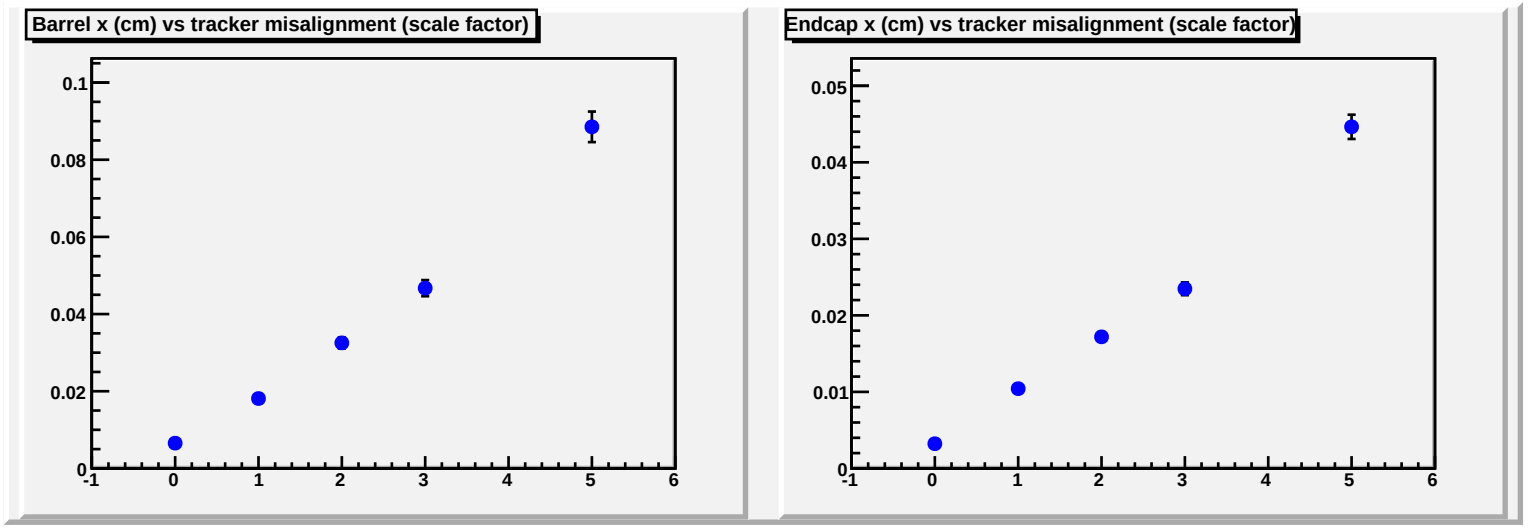
- Based on HIP algorithm in the CommonAlignment framework
- Applies equally to barrel and endcap
- Breaks circular dependence between track-fitting and alignment by using tracker as an external reference
- Reaches 100 μm accuracy with 5 pb^{-1} of high-momentum muons from Z, W decays (apart from systematics)
- Studying systematic effects one by one

Dependence on miscalibration	negligible
. . . on tracker misalignment	$\mathcal{O}(200\ \mu\text{m})$ (next slide)
on momentum of tracks	radial outliers (backup)
inclusive sample, backgrounds	*to do. . .*
mismeasured $\vec{B}(\vec{x})$	*to do. . .*
incorrect material budget/distribution	*to do. . .*

Dependence on number of muons (local x is global $r\phi$)



Dependence on tracker misalignment (1 = short-term scenario)



New set of scenarios

Alignment simulation output:

1. Misalign detector
2. Run alignment procedure under controlled conditions
3. Save output geometry for re-reconstruction

Standard scenarios

- Conservative estimate
  - 2–5 mm wheels/disks, 500 μm chambers for 10 pb^{-1}
  - 1 mm wheels/disks, 200 μm chambers for 100 pb^{-1}
- isotropic misalignments
- approximate correlations through superstructure hierarchy
- Gaussian misalignments

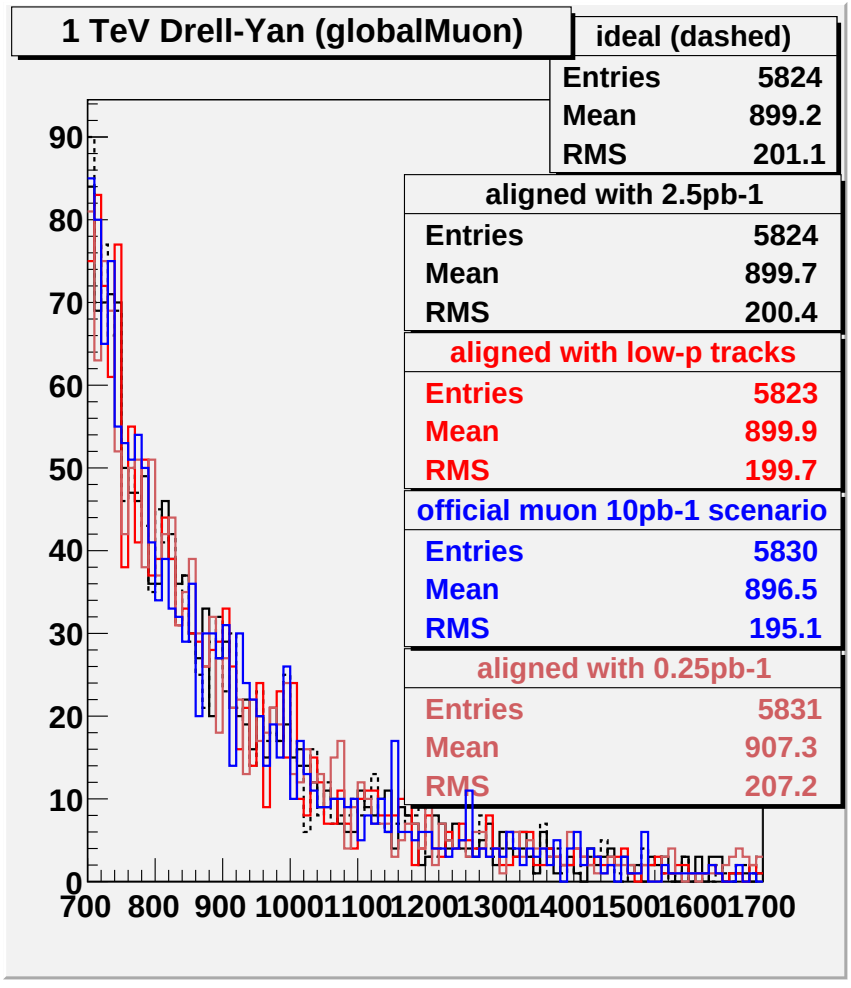
Alignment simulation output

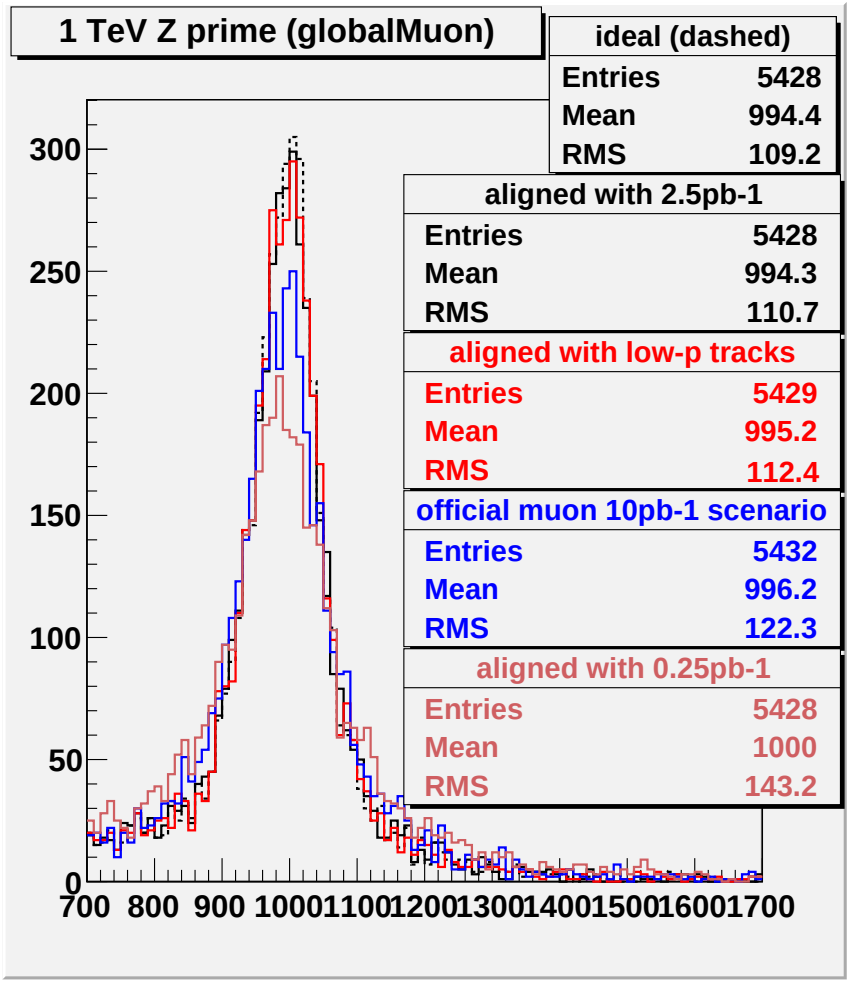
- Realistic simulation (as realistic as MC)
  - 0.8 mm wheels/disks, 100–200 μm chambers for 5 pb^{-1} of $Z\&W$
- elliptical misalignments (e.g. CSC x is measured 20 times better than y)
- correlations from tracks
- not necessarily Gaussian (especially for systematic effects)

https://twiki.cern.ch/twiki/bin/view/CMS/SomeSamplesSUSYBSM2007MuonGeometries

Consequences for physics

Application of new scenarios to TeV Drell-Yan and Z'

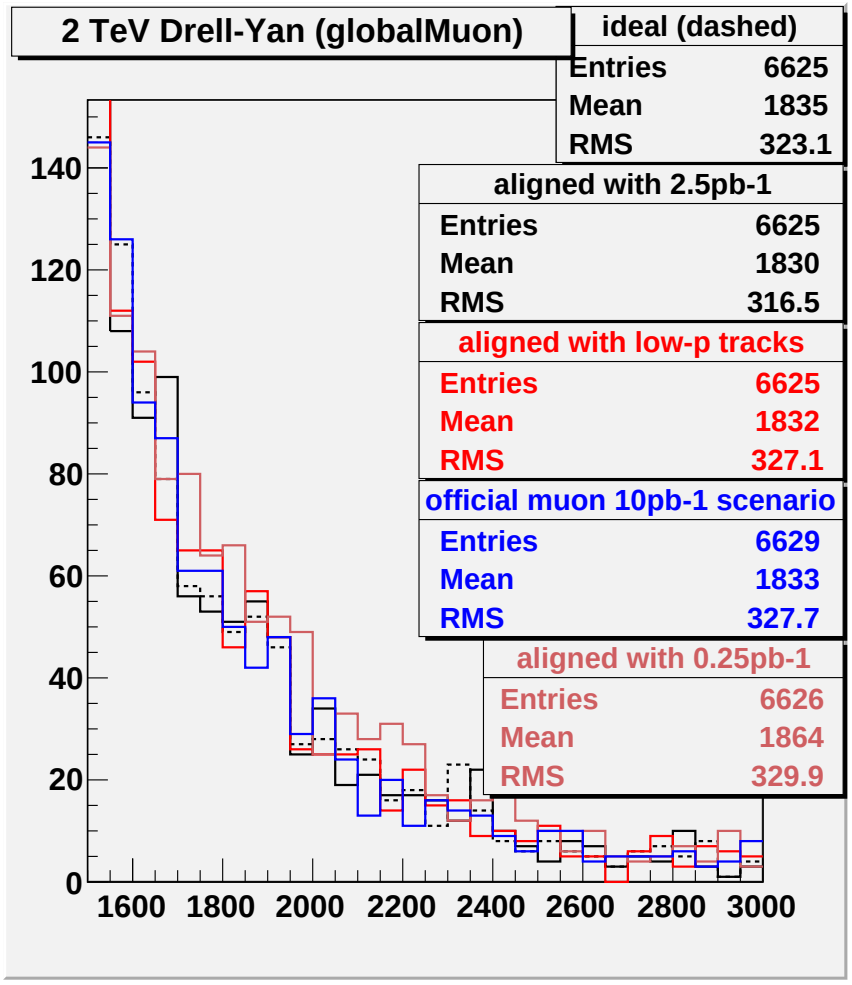


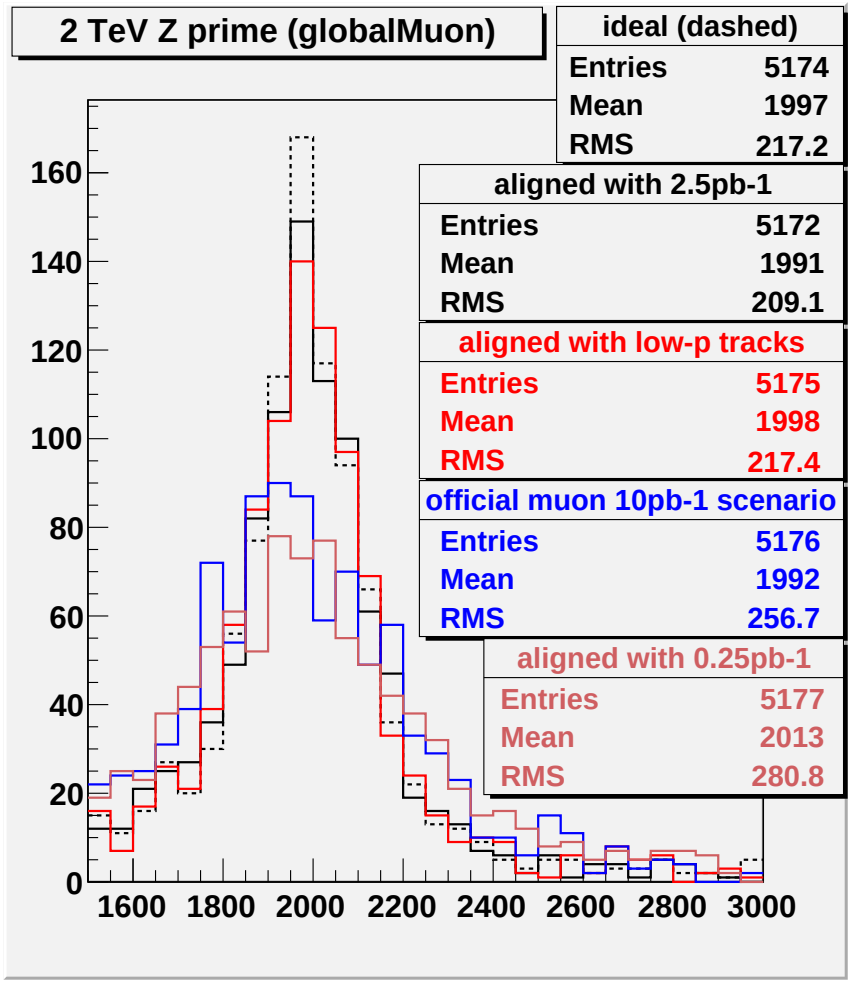


"low-p" means 20-60 GeV $Z \to \mu\mu$ (private 1_5_4 Z' samples)

official 10 pb^{-1} scenario is pessimistic

Application of new scenarios to 2 TeV Drell-Yan and Z'





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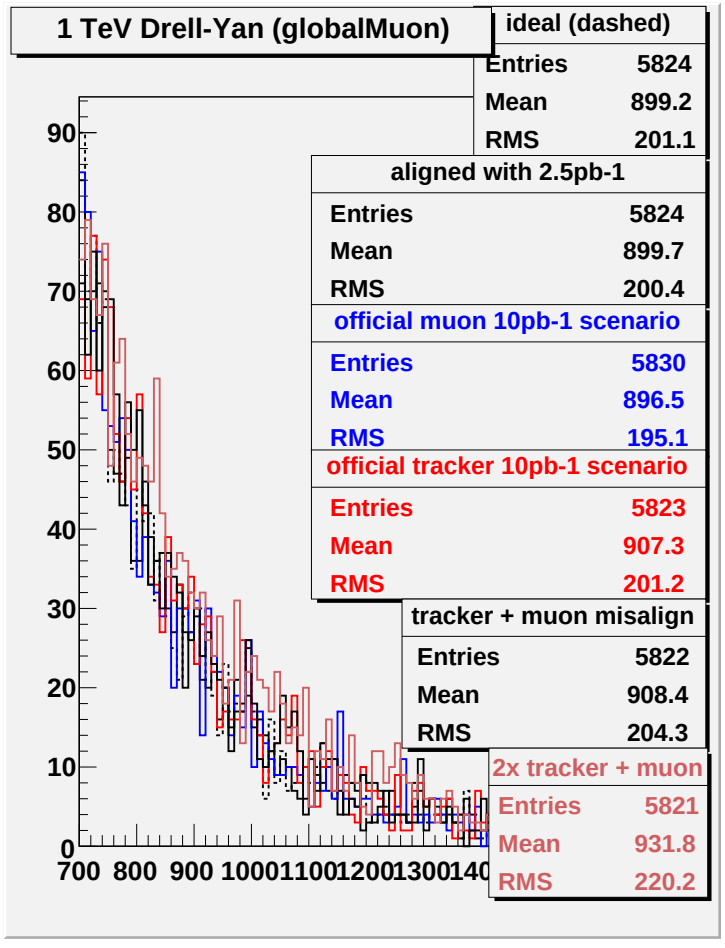
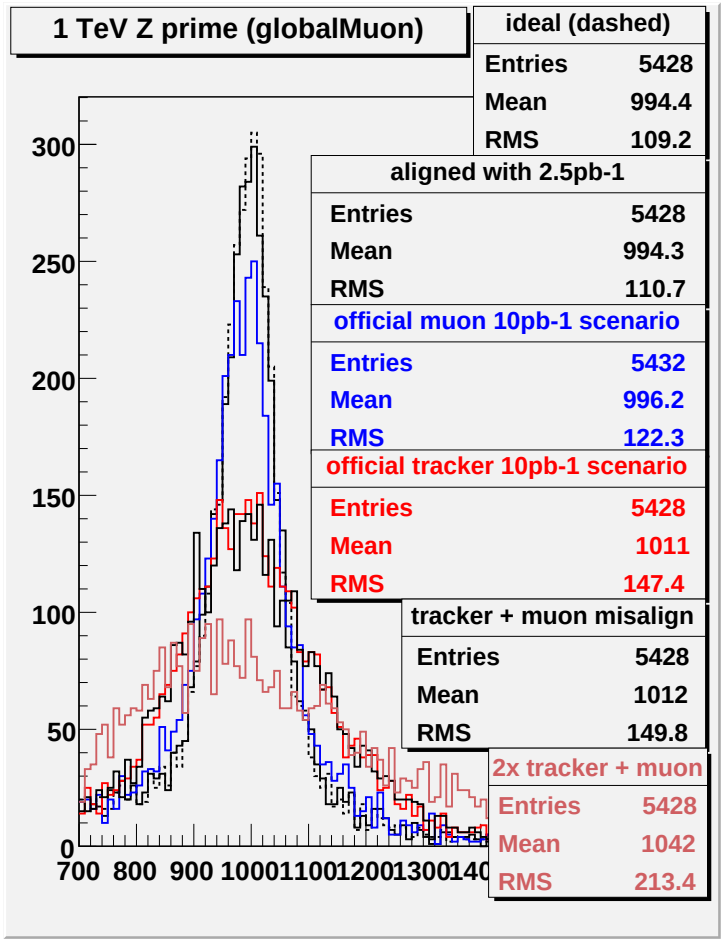
Comparison of tracker and muon misalignments (1 TeV)

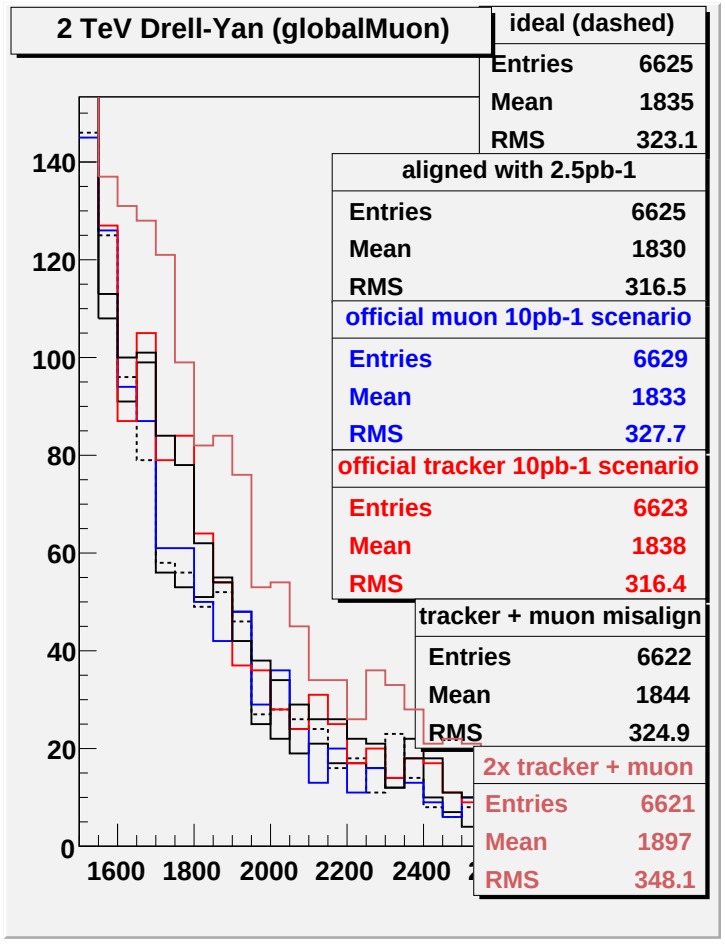


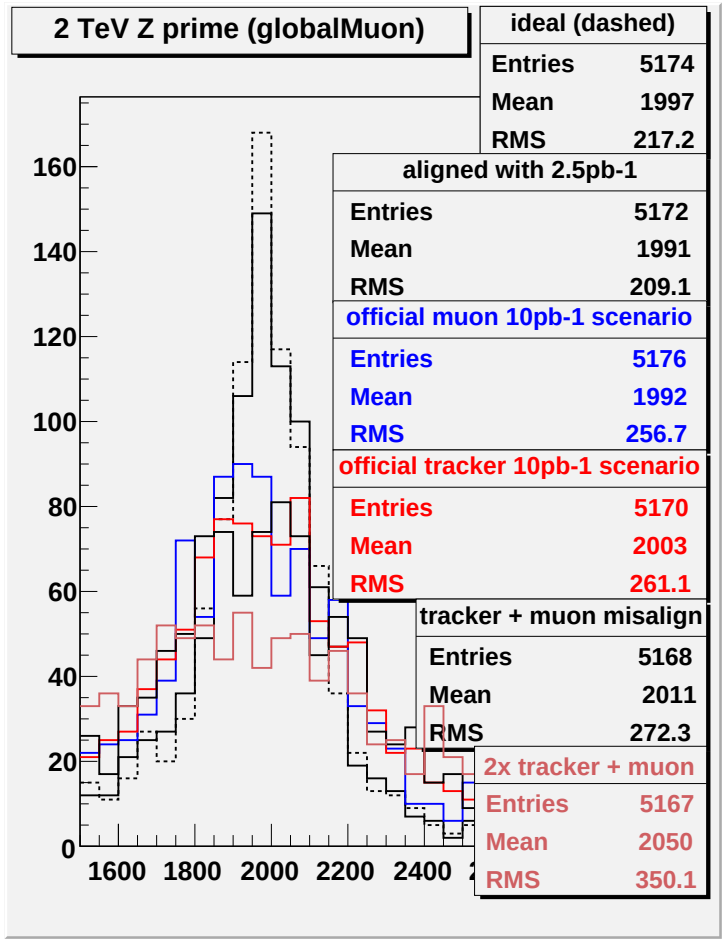


How realistic is the tracker 10 pb^{-1} scenario?

CSA07 (scaled by $\sqrt{N}$) is 0.1–15$\times$ better, depending on parameter

Comparison of tracker and muon misalignments (2 TeV)





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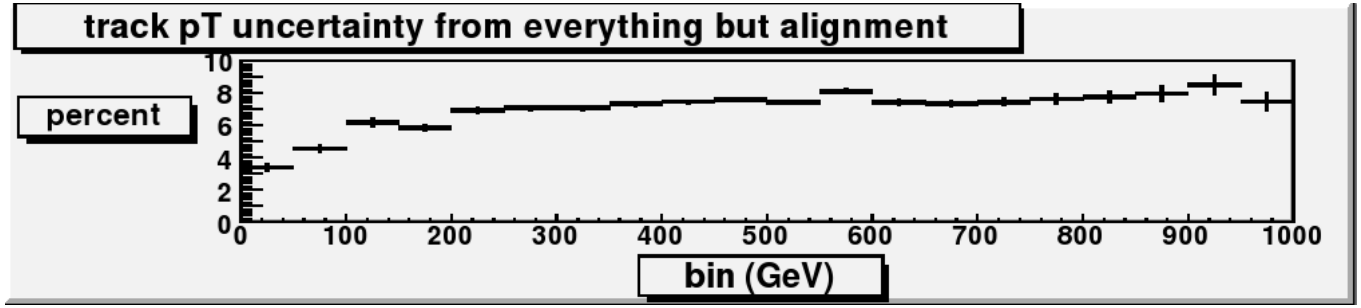
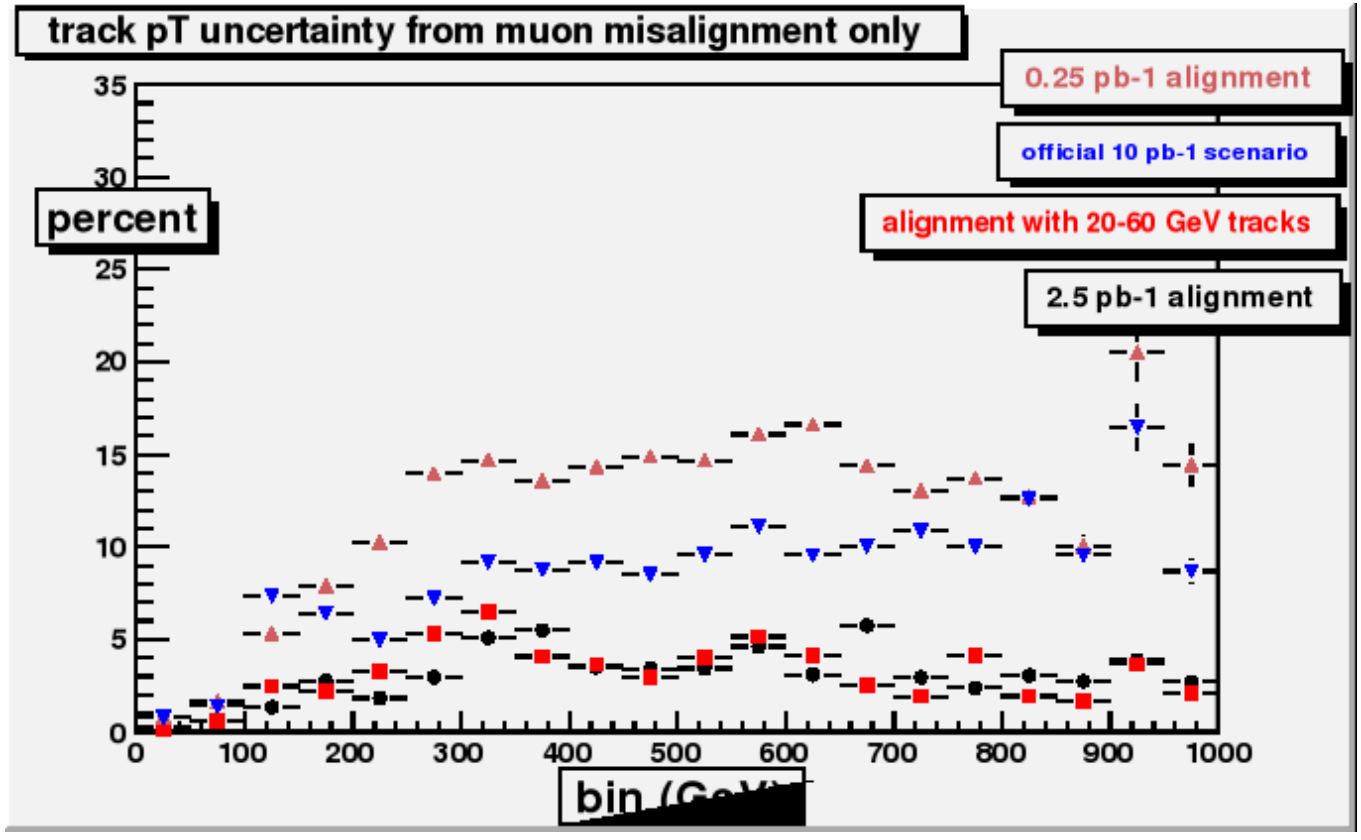
Effect of muon misalignment on single-track momenta



everything but alignment

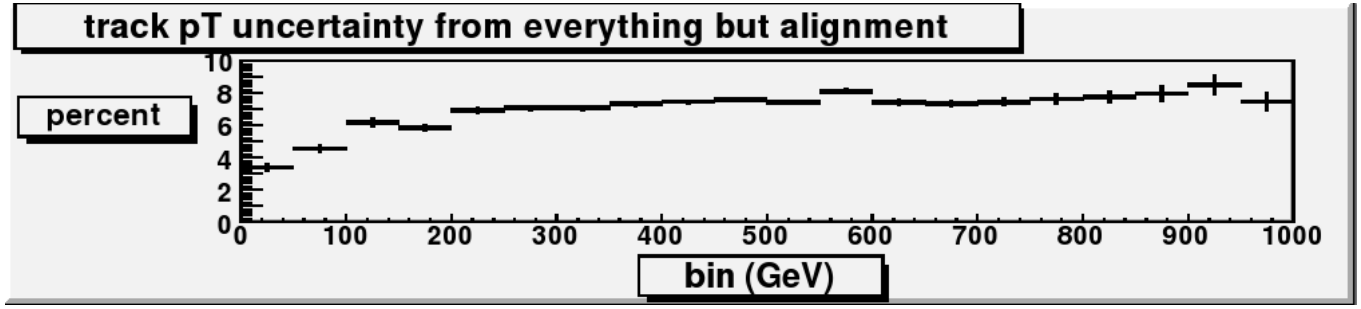


effect of alignment only

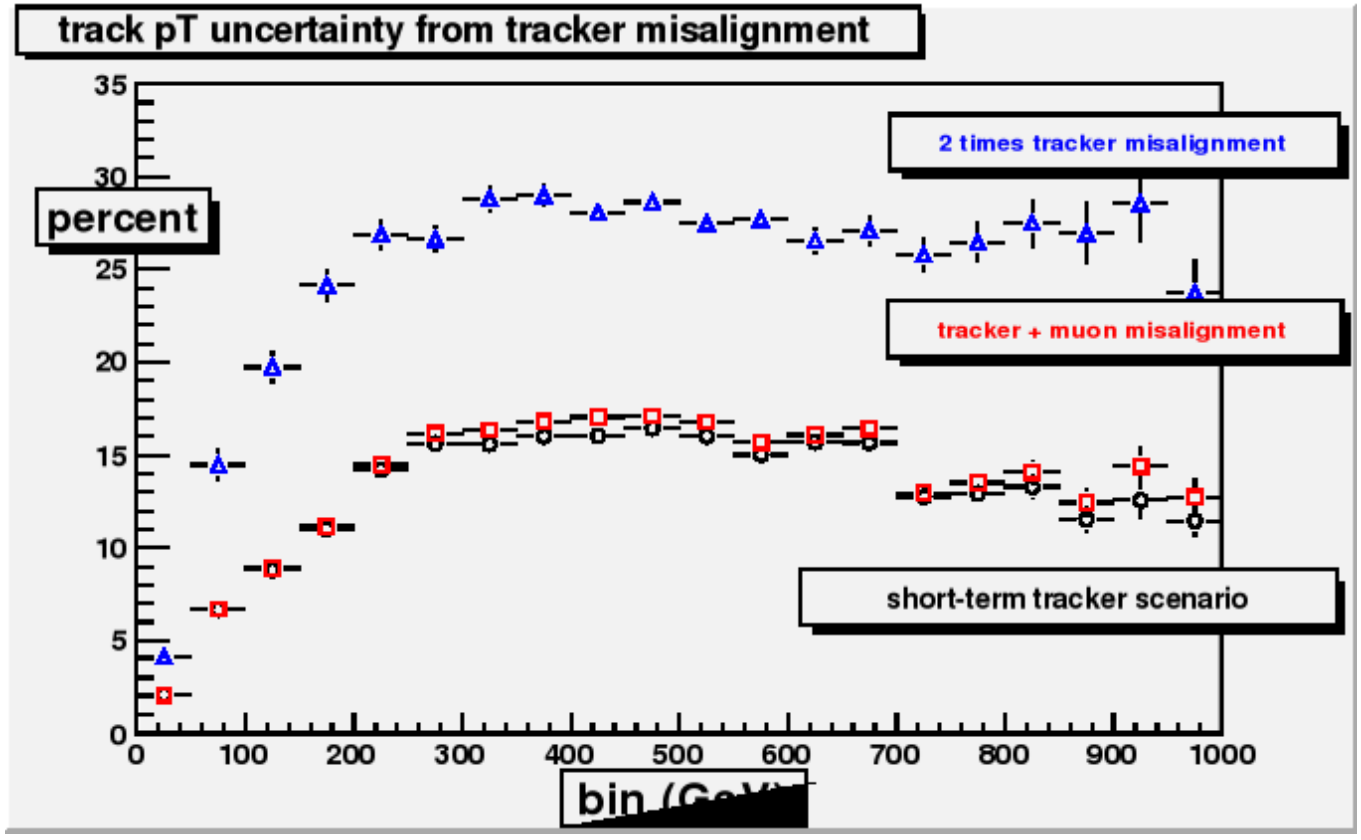
$$\left(\frac{\sigma_{p_T}}{p_T}\right) = \left(\frac{\sigma_\kappa}{\kappa}\right)$$

= sum in quadrature of both uncertainties

Effect of tracker misalignment on single-track momenta



everything but alignment



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

= sum in quadrature of both uncertainties


Conclusions

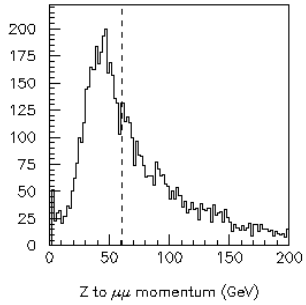
- Stable baseline muon alignment procedure, ready to apply to physics
- Realistic simulations yield significantly higher-quality alignments than the standard scenario
- Drell-Yan backgrounds are not strongly affected

Ongoing work

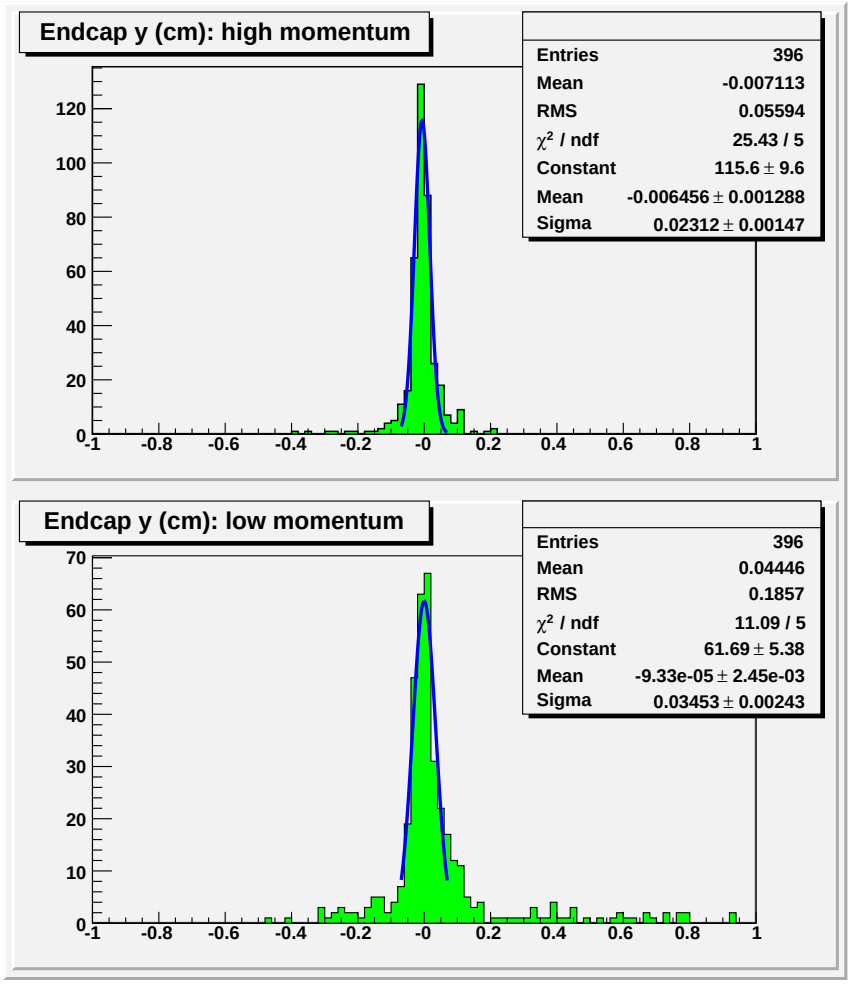
- Use tracker CSA07 output as a starting point for muon alignment
- Apply to Dmitry Bourilkov's 1_6 Z'/Drell-Yan samples
- Fully reconstruct with new geometry, rather than refitting existing tracks
- Contribute to TeV muon analysis note by validating toy MC alignment


Backup slides

Dependence on muon momentum



Radial (local y) residual misalignments



- Divide $Z \rightarrow \mu\mu$ sample along 60 GeV median
- Effect on barrel: $< 5\%$ in each parameter
- Effect on endcap: low-momentum sample has 1.5–3 times worse alignment

Note asymmetric tail!