


Effect of Alignment Systematics on High Di-Muon Mass (This analysis is still rather rough)

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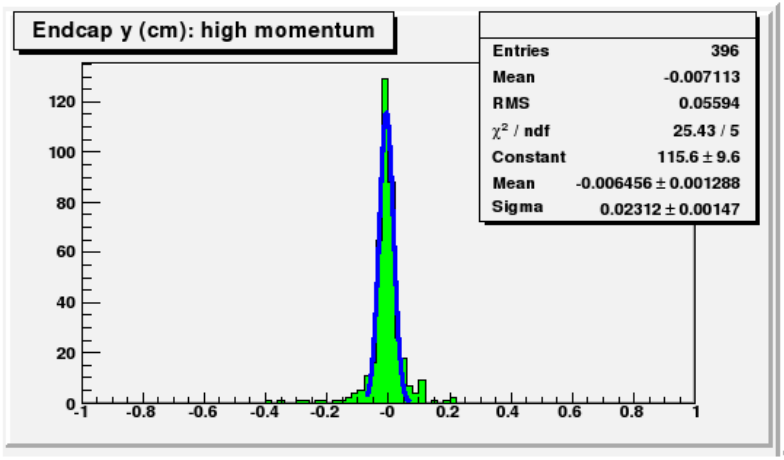
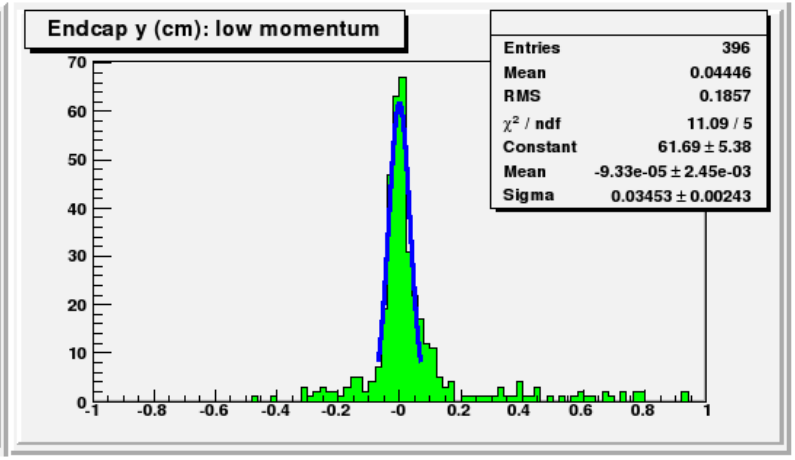
Figure of merit for a good alignment

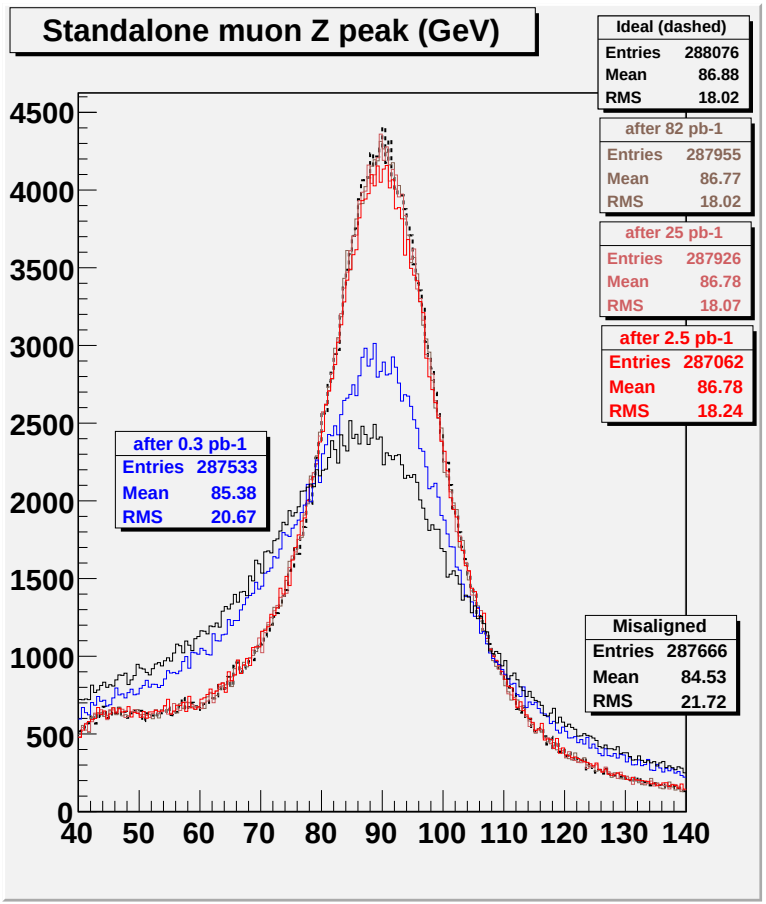
- I have been using accuracy as a figure of merit: RMS and core fit of residual misalignment after an alignment process
- But there is a different accuracy for each degree of freedom
- and distributions can sometimes be non-Gaussian

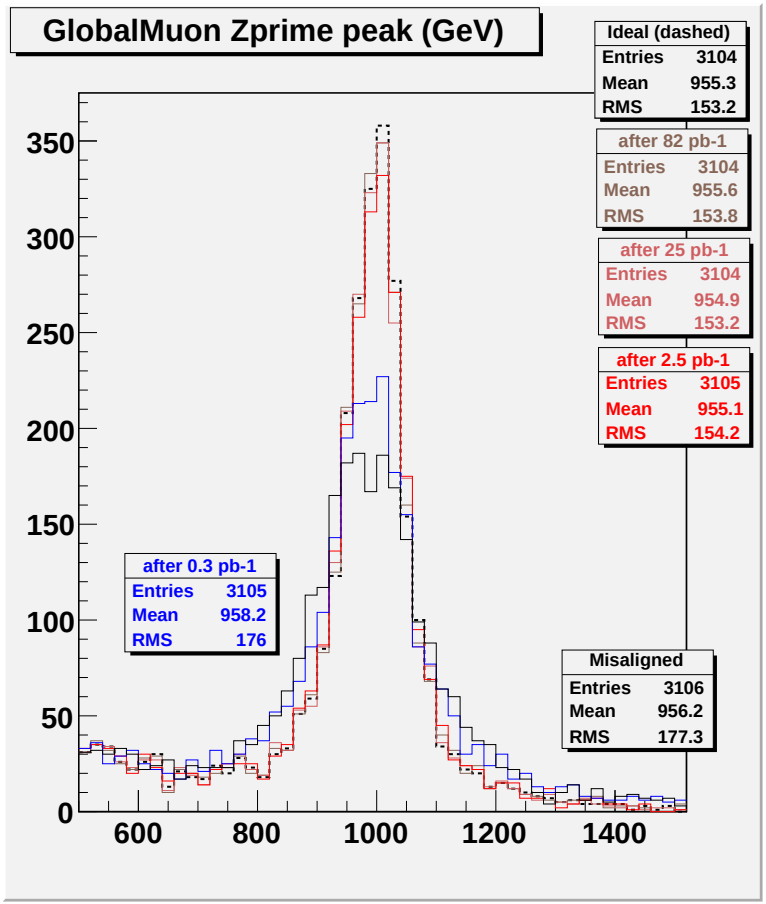




- How important are e.g. ϕ_x and y relative to x?
- How important are tail contributions relative to core width?
- $\Rightarrow$ look at consequences for physics

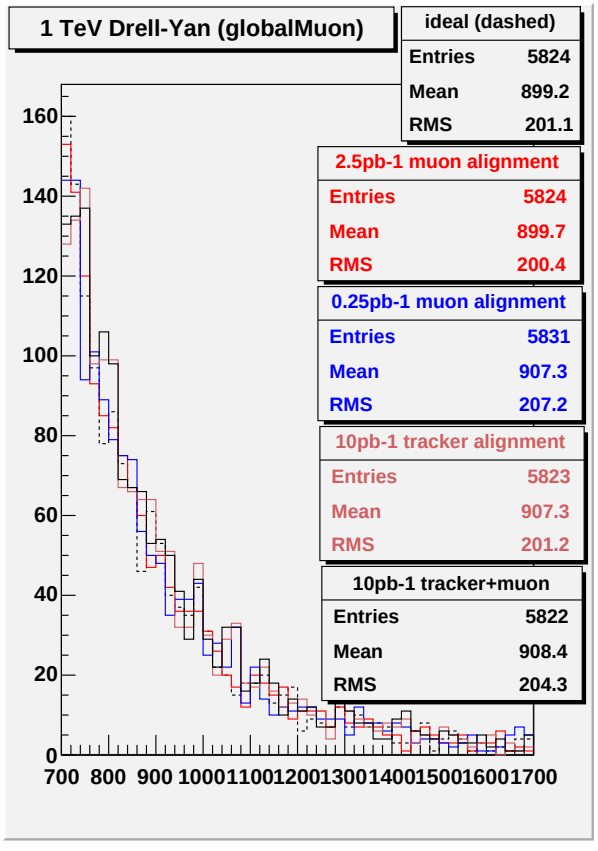
Dependence on integrated luminosity: Z, Z' resolution

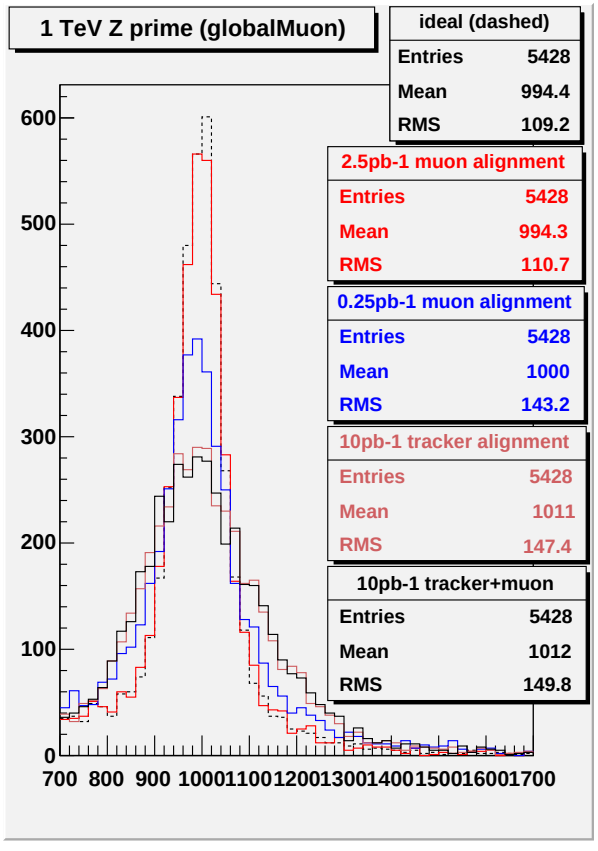




- Muon alignment only influences ∼100 GeV muons in standalone mode; I'll focus on ∼1000 GeV

Drell-Yan and Z' at 1 TeV



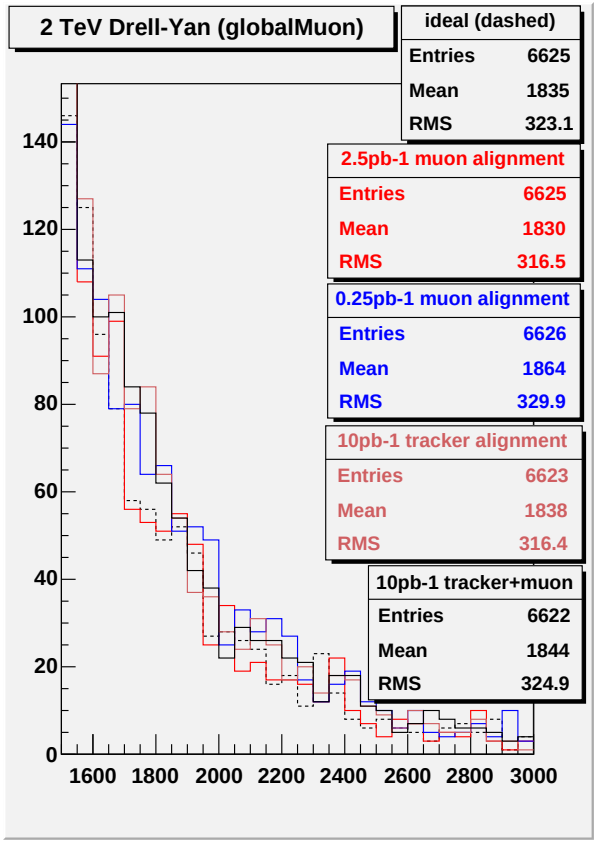


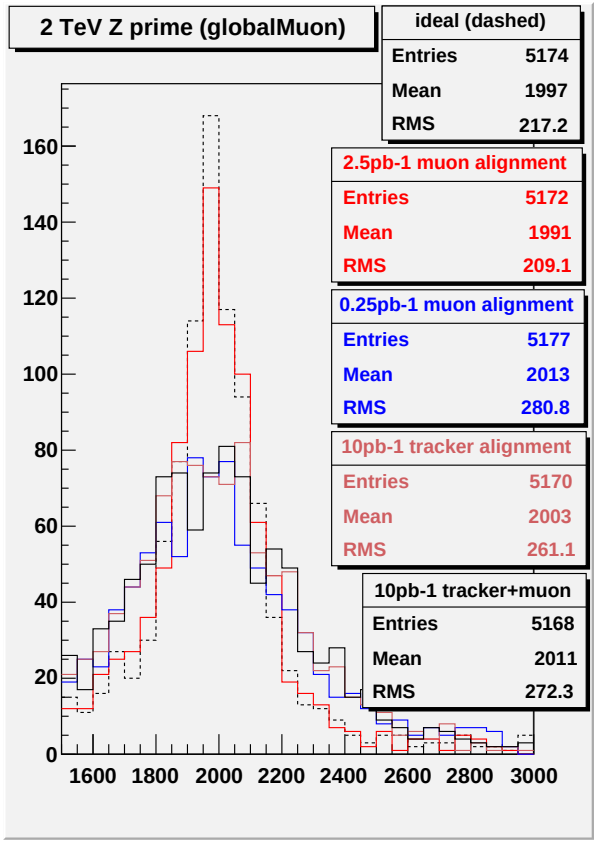
2.5 pb^{-1} and 25 pb^{-1} muon alignments have ideal tracker

10 pb^{-1} tracker alignment is the standard scenario with ideal muon alignment

tracker + muon has both misaligned: muon alignment has small systematic errors from tracker $\longrightarrow$ muon track extrapolation

Drell-Yan and Z' at 2 TeV





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What's surprising to me: not much Drell-Yan smearing

- Drell-Yan is exponentially distributed: $f(x) = e^{-kx}$
- Convoluted: $f(y) = \int f(x) \frac{1}{\sqrt{2\pi}\sigma} \exp\left(\frac{-(x-y)^2}{2\sigma^2}\right) dx$
- $f(y) = e^{-ky} \exp(\sigma^2 k^2/2)$
- Convolution kernel is a series: $A_1 e^{x^2/2/{\sigma_1}^2} + A_2 e^{x^2/2/{\sigma_2}^2} + \ldots$ ("tails" are wide Gaussians with small contribution)
- $f(y) = e^{-ky}(A_1 \exp({\sigma_1}^2 k^2/2) + A_2 \exp({\sigma_2}^2 k^2/2) + \ldots)$
- Depends linearly on A_i and as $e^{{\sigma_i}^2}$ on width: could be big!

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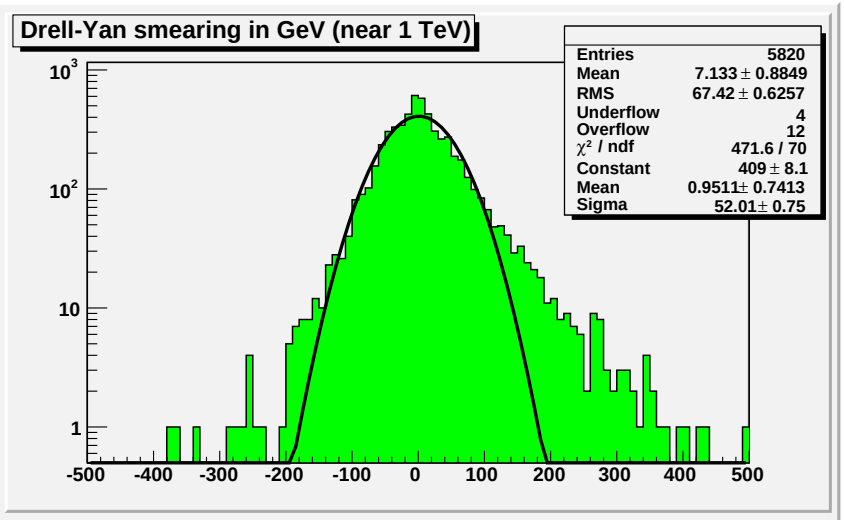
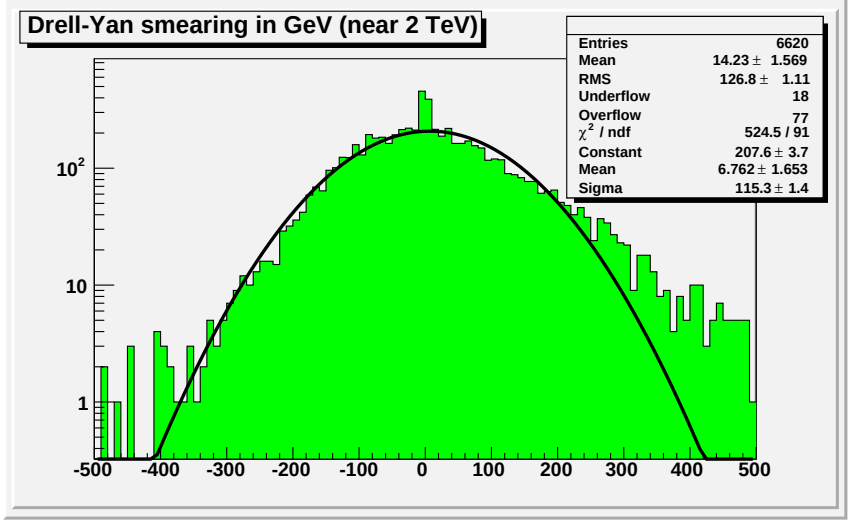
- Fit Drell-Yan distributions: $k = 6{\times}10^{-3}$/GeV (near 1 TeV)
  and $3.4{\times}10^{-3}$/GeV (near 2 TeV)
- What's σ?

Worst case: tracker + muon misalignment





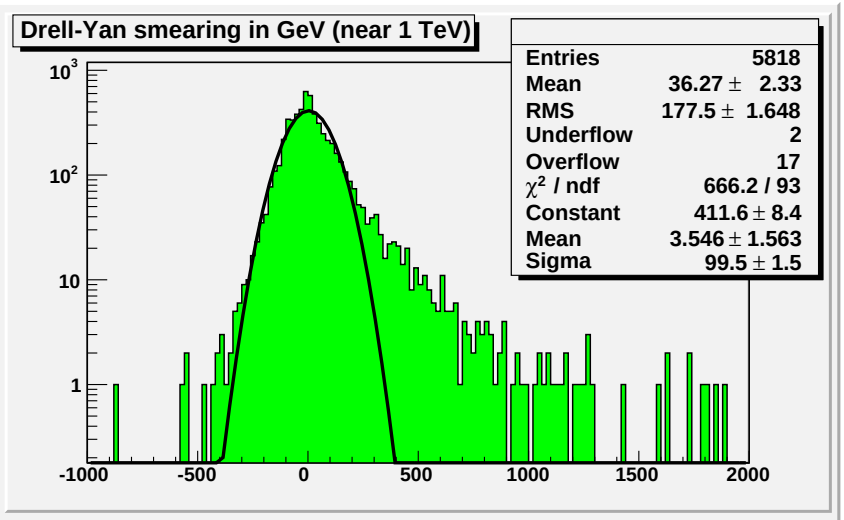
Sample	Central σ	$e^{\sigma^2 k^2/2}$
Near 1 TeV	52 GeV	1.05
Near 2 TeV	115 GeV	1.08

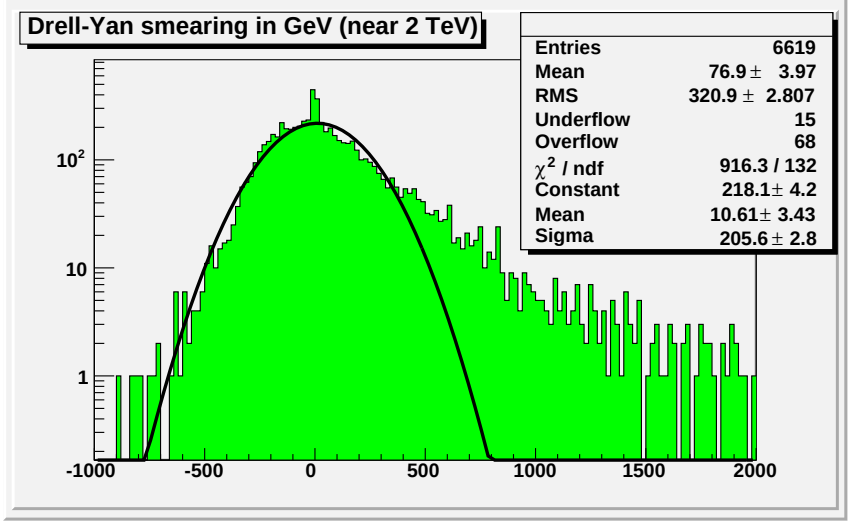
A Gaussian twice as wide would be down by a factor of $\sim$10:

Sample	Tail σ	$e^{\sigma^2 k^2/2}$
Near 1 TeV	100 GeV	1.21
Near 2 TeV	230 GeV	1.36

$$0.9 \times 1.08 + 0.1 \times 1.36 = 1.11$$

Worse than worst case: 2× tracker + muon misalignment





Estimates of Gaussian series

A_i	Width	$A_i\, e^{{\sigma_i}^2 k^2/2}$
0.9	100 GeV	1.08
0.1	200 GeV	0.21
0.01	300 GeV	0.05
		1.34

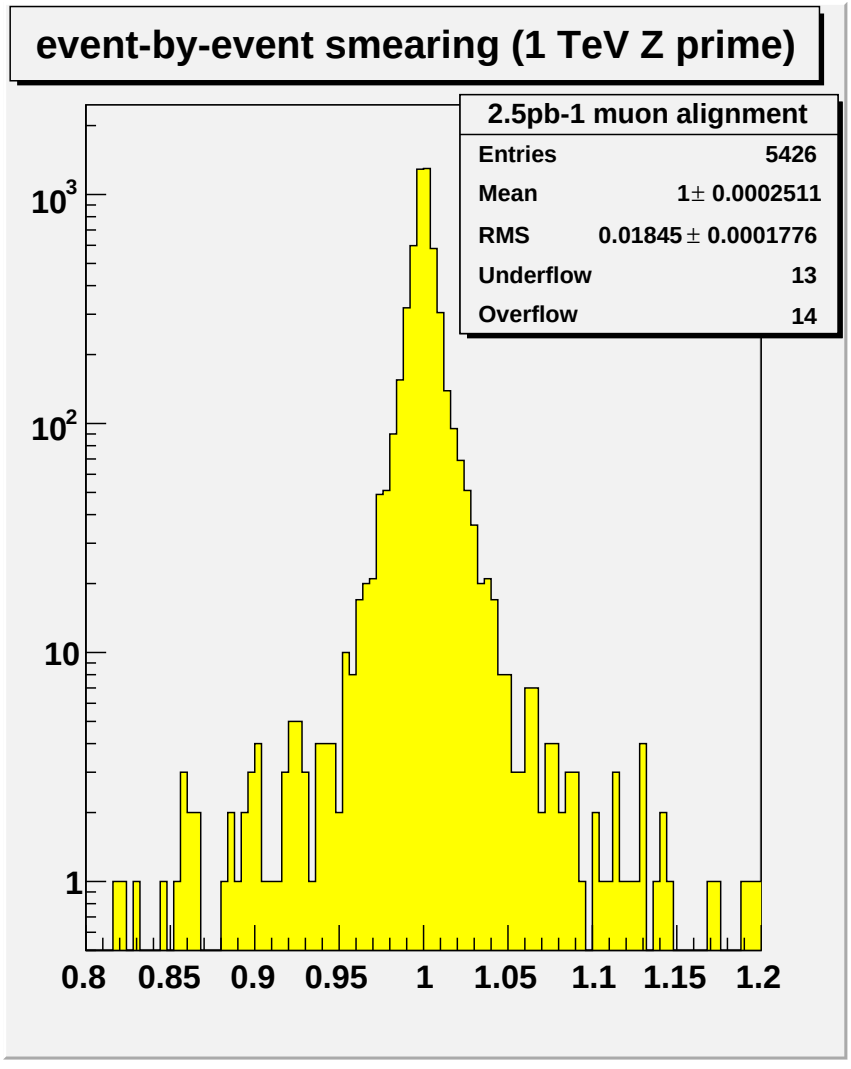
Estimates of Gaussian series

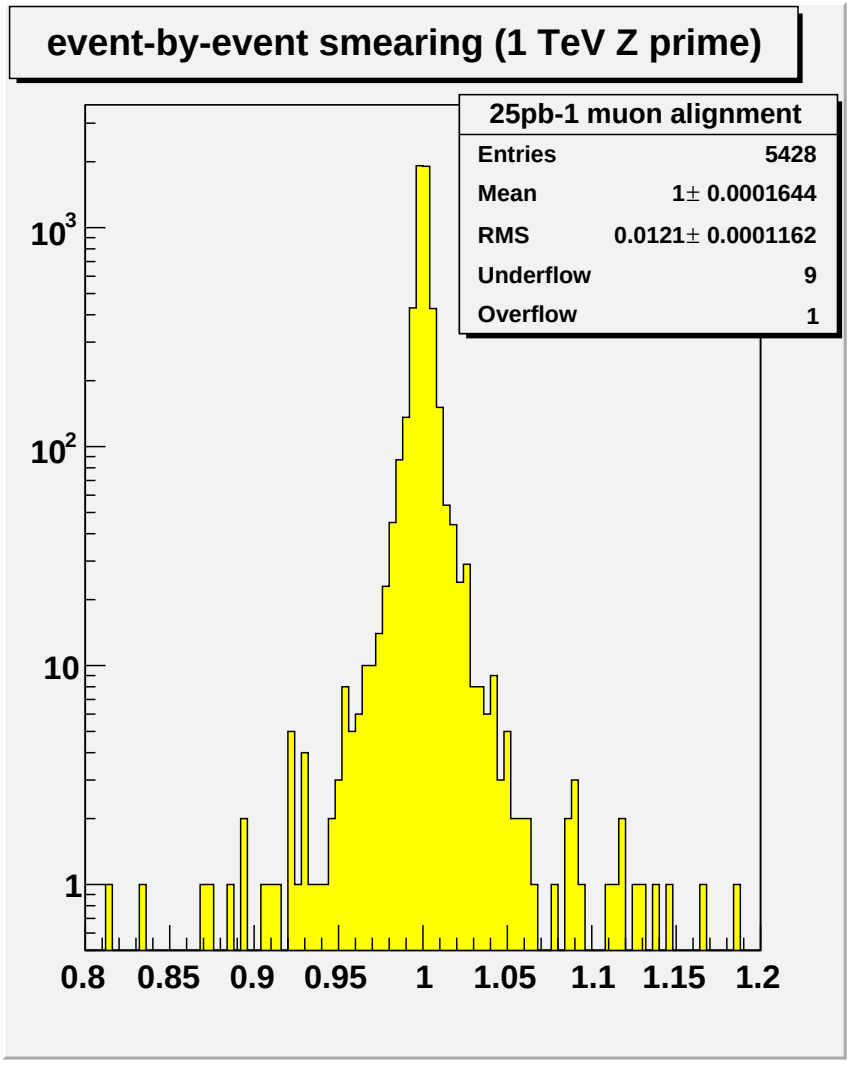
A_i	Width	$A_i\, e^{{\sigma_i}^2 k^2/2}$
0.9	205 GeV	1.15
0.1	300 GeV	0.07
0.01	400 GeV	0.03
		1.25

Conclusions for Drell-Yan smearing

- Not as bad as I imagined: smallness of k wins over σ
- I need a better way to fit double-, triple-, or Nle-Gaussians
- or maybe an expansion series, like Taylor or Fourier (I couldn't find one)
- There must be a threshold where $A_i\, e^{{\sigma_i}^2 k^2/2}$ explodes: how close are we to that threshold?

Event-by-event effect of alignment





Helps to express effect more quantitatively

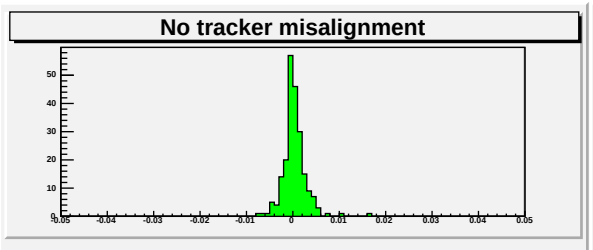
RMS of event-by-event $\dfrac{\text{misaligned di-muon mass}}{\text{ideal di-muon mass}}$

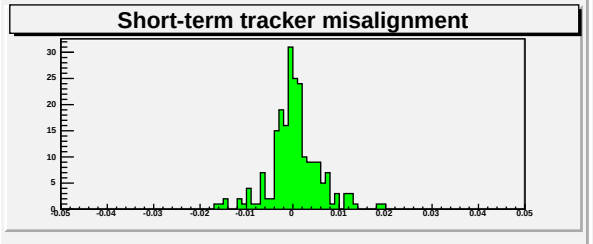
Source of alignment	$Z'(1000)$	$Z'(2000)$	DY(1000)	DY(2000)
1k μ (0.25 pb^{-1})	6.0%	5.5%	4.8%	6.6%
10k μ (2.5 pb^{-1})	1.8%	1.7%	1.6%	2.1%
100k μ (25 pb^{-1})	1.2%	1.1%	1.0%	1.3%
325k μ (82 pb^{-1})	1.0%	1.0%	0.7%	1.2%
high $\lvert\vec{p}\rvert$ ($>$ 60 GeV)	1.0%	1.0%	0.8%	1.2%
low $\lvert\vec{p}\rvert$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

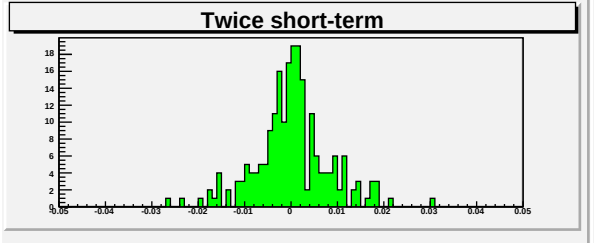
"Restricting to high $\lvert\vec{p}\rvert$ is like getting a factor of ten more tracks"

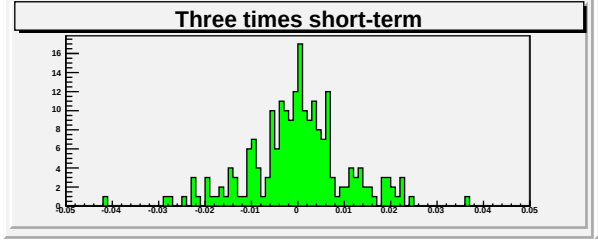
Not shown at EMU: effect of tracker misalign at high η

Outer endcap

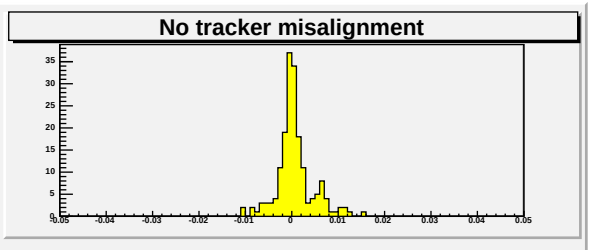


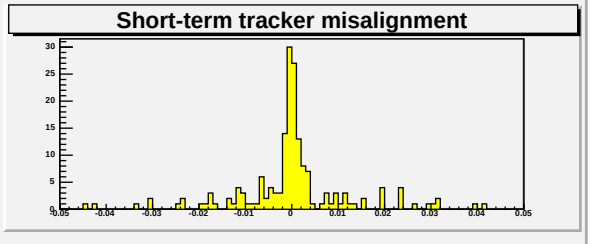


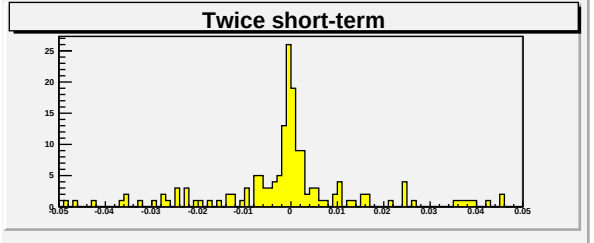


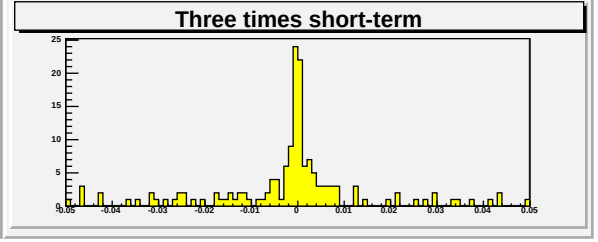


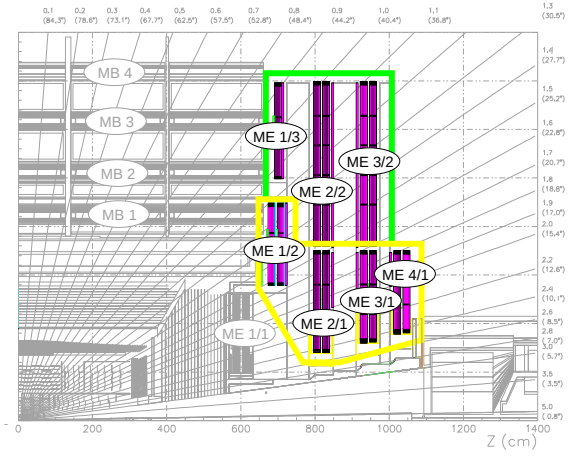
Inner endcap









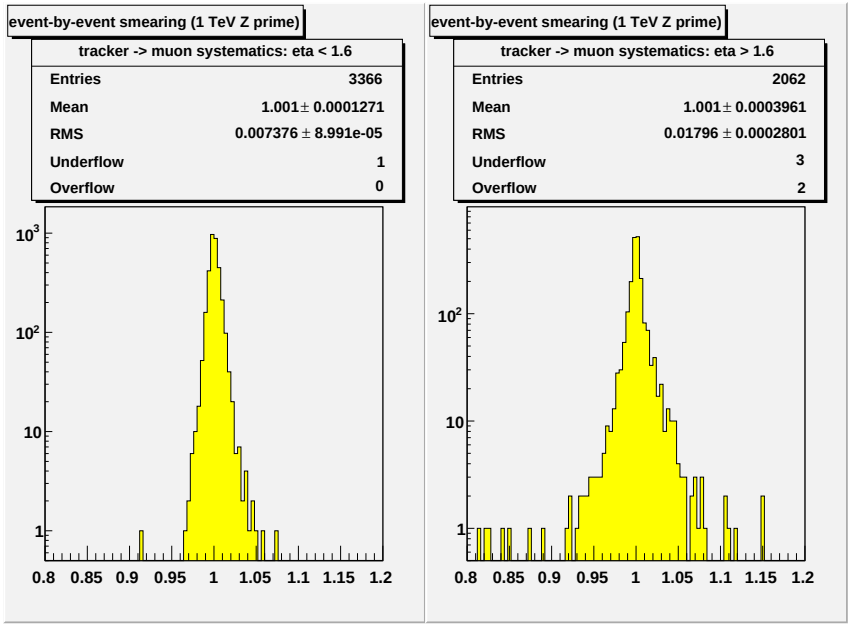


Outer endcap (1/3, 2/2, 3/2) only widens

But inner endcap (1/2, N/1) gets more outliers

May need to apply standalone procedure to these, if tracker is bad

Tracker systematic



$$\text{RMS of } \frac{\text{tracker and muon misaligned di-muon mass}}{\text{tracker misaligned di-muon mass}}$$

	$Z'(1000)$	$Z'(2000)$	DY(1000)	DY(2000)
Both μ's in $\lvert\eta\rvert < 1.6$	0.7%	0.9%	0.5%	1.0%
One in $\lvert\eta\rvert > 1.6$	1.8%	1.5%	1.3%	2.0%

Conclusions

- In even the worst sample alignments, the tails in the accuracy distribution (outlier chambers) are not large enough to significantly smear the Drell-Yan distribution. (As a background to high-mass resonances, they are only increased by tens of percent by alignment.)
- The second moment of the distribution (RMS) matters most: Z' peaks are deflated by about a factor of 2.
- Careful! I'm comparing muon alignment output (realistic) with tracker alignment scenario (possibly pessimistic).
- Standalone muon analysis would be cleaner, but less relevant to physics goals
- Perhaps I should look at a less digested distribution: event-by-event smearing of individual tracks as a function of momentum. I'd still have to detangle tracker misalignment effects from muon misalignment effects.