Optimizing the corrected alignment procedure

Jim Pivarski

Texas A&M University

20 November, 2007

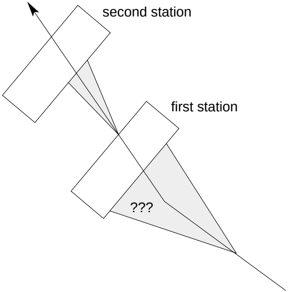
In this talk

1. New three-pass procedure
2. Optimizing Alignment Parameter Errors (APEs) in a 1-dimensional setting
3. Optimizing degrees of freedom in a 6-dof setting, with application to TeV muons

This is a work-in-progress talk: how things are going, rather than final results

Why not align everything at once?

Problem: tracks emerge from calorimeter/solenoid with more uncertainty than they do when passing through the iron between stations, so we get a poor alignment if we let everything float at once



Solution: align the outer stations only after the inner stations are well-placed: at least two passes

The current procedure

1. Align muon barrel station 1 (MB1) and endcap stations ME1/1 and ME1/2 with 2 cm APEs (loose), all other muon stations have 5 cm (very loose).

   At this point, the inner stations are aligned to 400–500 μm.)

2. *Align all other stations (MB1, ME1/1, and ME1/2 are now fixed) with 5 mm APEs.*

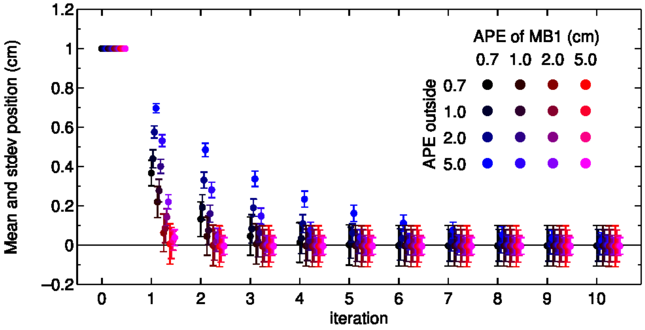
   At this point, the outer stations are aligned to 400–800 μm, with MB4 and ME4/1 having the worst resolution: 1.5 cm. Chambers probably have better relative alignments than global alignments.

3. Try to align groups of internally-aligned chambers to the tracker by re-aligning everything with 500 μm APEs.

How APEs were optimized

Start with artificial misalignments: all chambers in a station (MB1 here) are moved 1 cm, chambers in other stations are Gaussian-distributed.

Each chamber is realigned independently: plot mean and stdev



Alignment results: general 1-dimensional

Now we do more a realistic alignment with all chambers randomly distributed ± 5 mm, but still 1-dimensional (local x).

Alignment resolution of x in microns (stages 1&2 only):

MB1	430	MB2	400	MB3	700	MB4	1174
ME1/2	380	ME1/3	340	ME2/2	510	ME3/2	730
ME1/1	520	ME2/1	620	ME3/1	850	ME4/1	1030

Alignment resolution *if inner chambers were perfectly aligned*

MB1	430	MB2	70	MB3	120	MB4	160
ME1/2	380	ME1/3	190	ME2/2	200	ME3/2	230
ME1/1	520	ME2/1	270	ME3/1	120	ME4/1	130

(There's still a significant problem with propagating errors through the system, mostly at the third step: maybe I should revisit the idea of one pass for each station...)

More general misalignments:

- Misalign chambers uniformly ± 5 mm, ± 5 mrad in all directions (very messy starting point!)
- No wheel/disk misalignments yet (I expect that to be easy)
- Assume that the optimal 1-dof APEs optimize the 6-dof problem
- Allow various parameters to float
  - MB1–3 (good y measurement): drop all combinations of z and ϕ_x
  - MB4 (no y measurement): certainly drop y and ϕ_x, maybe drop z
  - ME (poor y measurement): probably drop z, ϕ_x, and maybe even ϕ_y
- Determine alignment quality from TeV p_T resolution

What was allowed to float

2 TeV track resolutions through η ranges (in % of p_T)

MB1–3	MB4	ME	barrel	ME1/3	ME1/2	ME1/1
ideal	ideal	ideal	5.3	4.9	5.0	5.9
$xy..\phi_y\phi_z$	$x...\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.4	6.1	6.1	6.7
$xy..\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.4	6.1	6.1	6.6
$xy.\phi_x\phi_y\phi_z$	$x...\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.3	6.2	6.0	6.5
$xyz.\phi_y\phi_z$	$x...\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.2	5.8	6.2	6.4
$xyz.\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.2	5.8	6.2	6.2
$xyz\phi_x\phi_y\phi_z$	$x...\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.2	5.8	6.0	6.2
$xyz\phi_x\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.1	5.8	6.0	6.2
$xyz\phi_x\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xyz\phi_x\phi_y\phi_z$	6.1	5.8	6.0	6.2
$xyz\phi_x\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xy...\phi_z$	6.1	5.7	6.0	6.6
$xyz\phi_x\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xy..\phi_y\phi_z$	6.1	5.7	5.9	6.5
$xyz\phi_x\phi_y\phi_z$	$x.z.\phi_y\phi_z$	$xy.\phi_x\phi_y\phi_z$	6.1	5.8	5.9	6.6

Conclusion: it doesn't make much difference, but allowing more to float is slightly better.

Results for best scenario (MB1-3 $xyz\phi_x\phi_y\phi_z$ MB4 $x.z.\phi_y\phi_z$ ME $xyz\phi_x\phi_y\phi_z$)

Stages 1&2 only (mm and mrad):

	x	y	z	ϕ_x	ϕ_y	ϕ_z
barrel	0.94	2.1	2.6	2.0	0.87	0.78
endcap	0.91	3.5	4.0	flat 5 mm	1.5	1.2

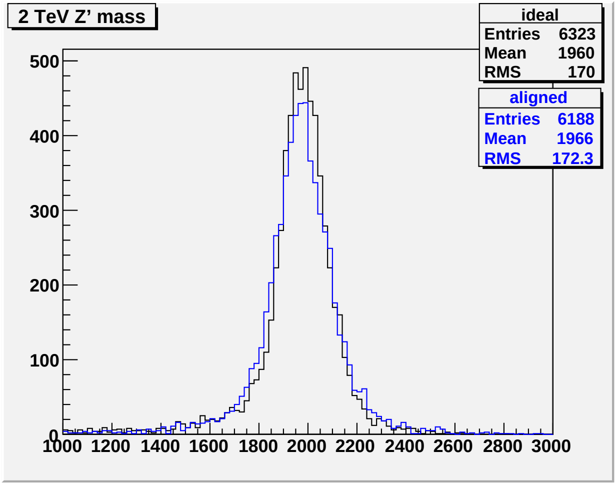
Stage 3 (small APE align everything):

	x	y	z	ϕ_x	ϕ_y	ϕ_z
barrel	0.81	2.0	2.4	2.0	0.70	0.63
endcap	0.85	3.5	4.0	flat 5 mm	1.1	1.1

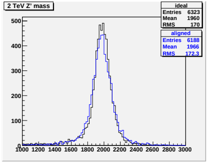
- Stage 3 does help in x and ϕ_z (the most important parameters)
- Let's not align endcap z or ϕ_x; they're not really converging in 10 pb^{-1}

The Bottom Line!

Reconstructed 2 TeV Z' from scratch using the new alignments: this is our latest 10 pb^{-1} scenario



Comments on the bottom line



- Still much better than standard muon alignment scenario (which has about $\frac{1}{2}$ the resolution of ideal)
- Standard scenario has 500 μm chamber errors and 2–5 mm wheel/disk errors; our simulation had no wheel/disk misalignments
- Time to try wheel/disk alignments in the new procedure!
- The track-finding efficiency is 2% lower with misalignment
- Baseline track-finding efficiency is 94% (Dubna group)