Global SVT alignment with Mollers

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SVT alignment

- Local alignment (Millepede): move sensors around to minimize track χ^2
- Local alignment is blind to "weak modes" that uniformly shift track parameters without changing χ^2
  - Each track parameter corresponds to a weak mode
- Strategy: run local alignment, use tweaks to fix the global alignment, rerun local alignment for second-order corrections
- I'm assuming local alignment is perfect
- Global alignment: use external references to get things right
- SVT top and bottom each need to be aligned

Past work

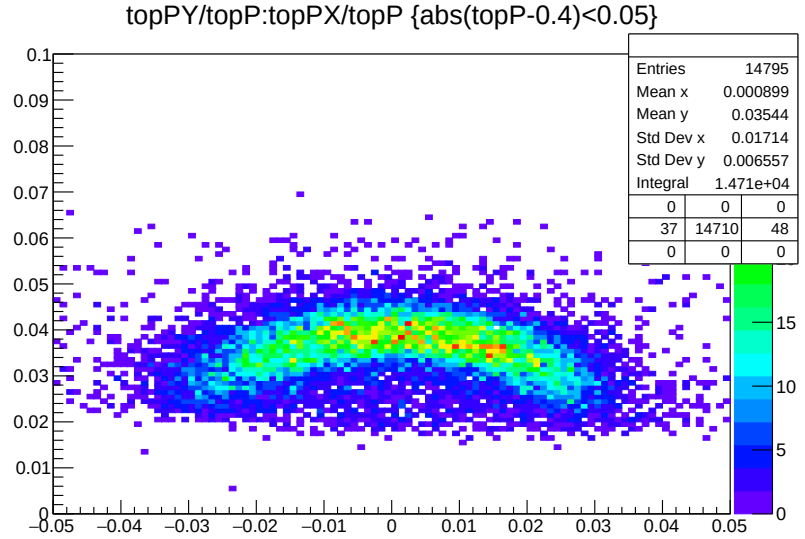
- Initial Millepede alignment gave very bad FEE momentum (O(10%) shifts), inconsistent beamspots in top and bottom
- We developed formulas to "tweak" the alignment constants along each weak mode without disrupting local alignment
  - Used SVT survey as a prior (if we can't constrain a weak mode, use the value that minimizes deviation from survey)
  - Shove curvature to roughly the right place, make top and bottom beamspots agree at $z = 0$
- What we didn't do:
  - Think about how to assess global alignment (curvature is easy, everything else is hard)
  - Get things exactly right
- Current recon alignment has beamspot near $(0, 0)$ and momentum within 2%, nothing else was even checked
  - Apparent beam tilt: real, or alignment?
  - Vertex Z dependence on mass: clear sign of bad global alignment

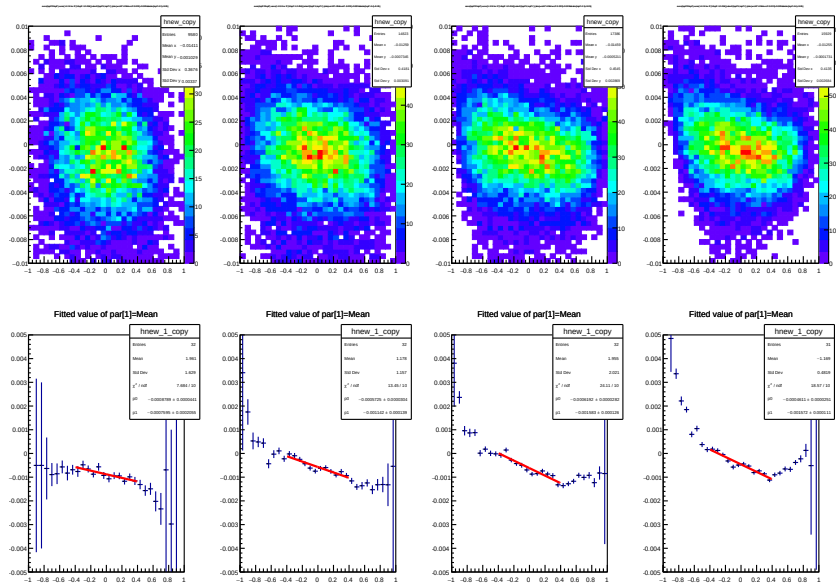
Doing global alignment right

- External references: FEE momentum, beam axis, beam spot
  - Set everything to nominal values for now, we can decide later if we need to tilt the beam or shift the beam spot
- Get curvature right: correct the known FEE momentum shifts (Omar: 1.040 in top, 1.069 in bottom)
  - Straight-throughs ought be a better way to constrain this
- Use Moller two-body kinematics to do top and bottom separately

Mollers: θ vs. E

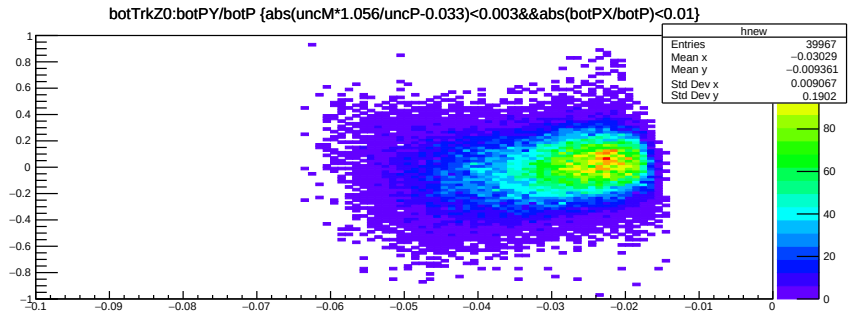
- Energy-angle relation:
  $\cos\theta = 1 - m_e(1/E - 1/E_{beam})$
- Cut on energy, get a ring centered around the beam axis
- We only have a bit of the ring: plot the θ residual against ϕ, fit
  - Constant term: vertical tilt (or energy, but we calibrated that already)
  - Linear term: horizontal tilt
- Repeat at different energies to make sure we're not getting biased by acceptance

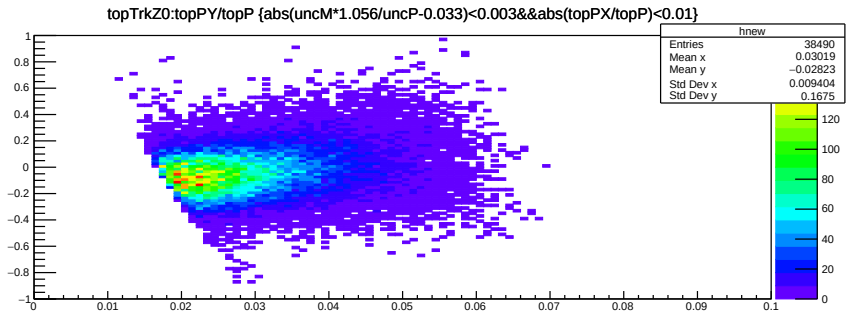


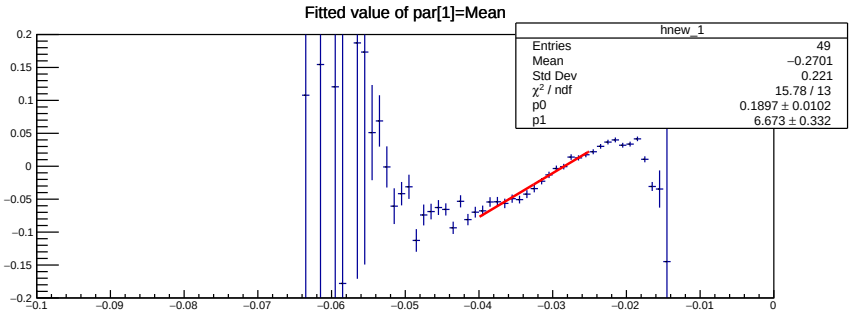


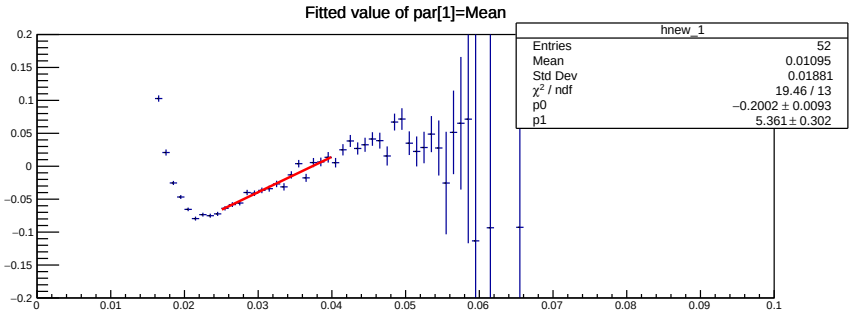
Mollers: θ_y vs. z_0

- Plot $y(z = 0)$ against θ_y, fit
  - Constant term: vertical offset
  - Linear term: Z offset
- Looks like target is at negative Z and our earlier attempt at global alignment "corrected" by applying spurious shifts and tilts



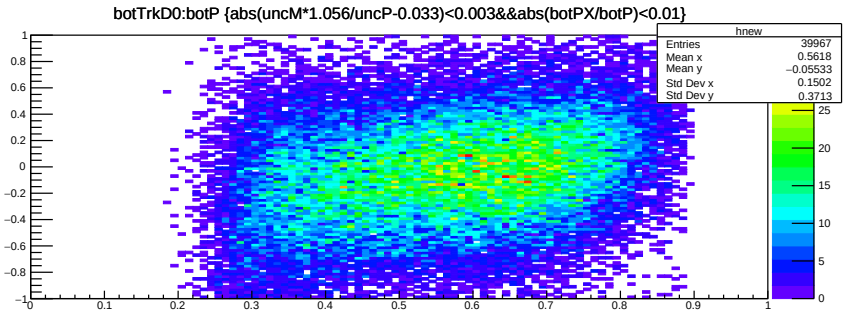


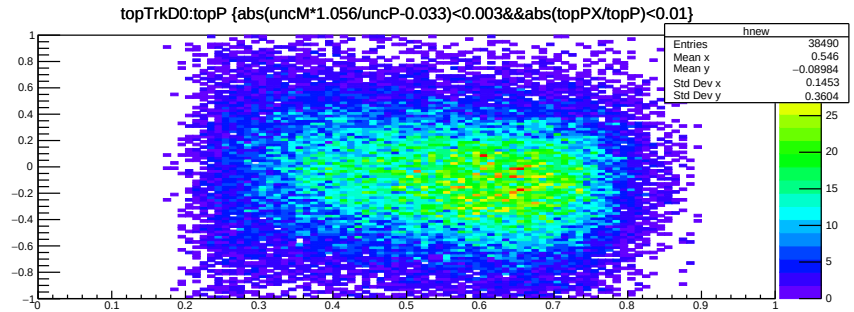


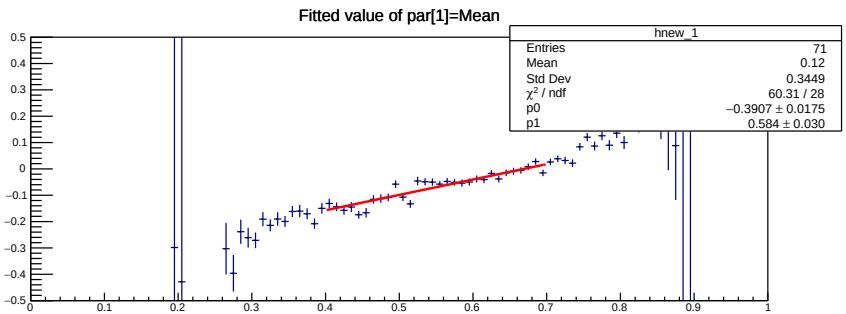


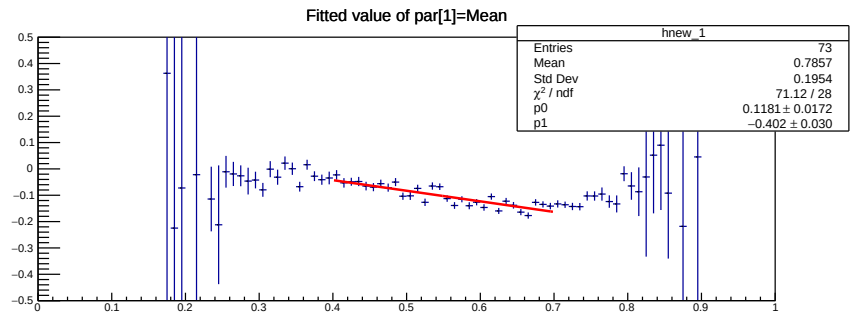
Mollers: θ_x vs. d_0

- Plot $x(z = 0)$ against θ_x, fit? Too much momentum dependence
- Plot $x(z = 0)$ against p
- Fringe field? Why is the sign of the effect different in top and bottom?









Work in progress

- Need to compare with MC
- Need to improve sensitivity: would be nice to get $\sim$0.1 mrad for tilts and $\sim$1 mm for target Z, not quite there yet
- Cross-check against tridents and FEE
- Corrections can be applied to track parameters post-recon (I do this in my tuple maker); can be pushed into the alignment later