Global Alignment

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With beam and No Field

The Process

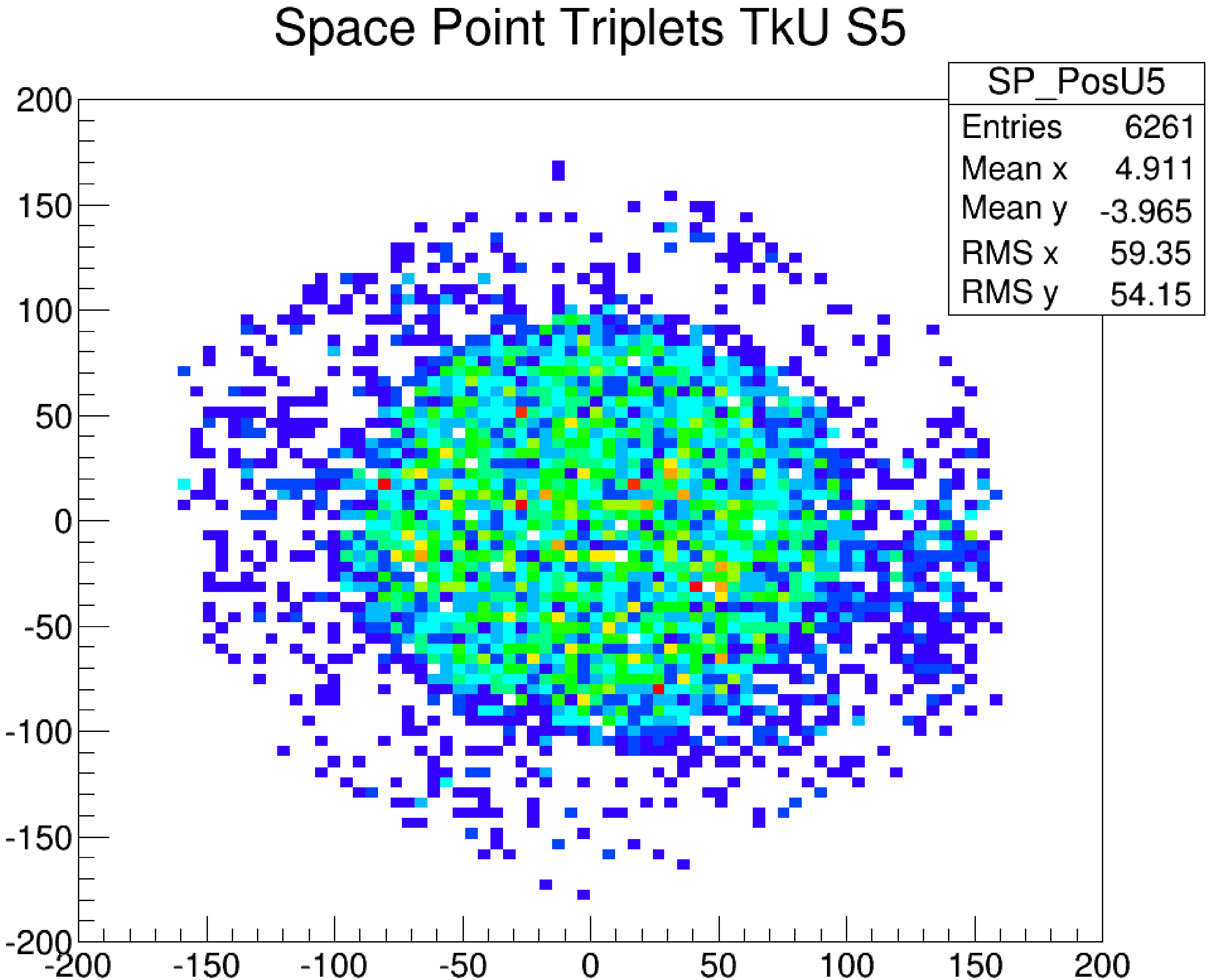
- Begin with each Tracker in turn.
  - Calculate efficiency
  - Compare track reconstruction to best fit straight track
  - Calculate residuals
  - Minimise residuals
  - Input offsets into SW.
- As above comparing straight tracks in US to DS Tracker
- The same method again, now for the fitted and corrected US to DS Tracker positions vs other detectors.

Efficiencies

- For station x of Tracker y:
  - Select tracks that should have made it through every station of Tracker y.
  - Identify tracks that have triplet spacepoints reconstructed for every other station in the detector.
  - Extrapolate track to station x and determine expected location of triplet spacepoint.
  - $\varepsilon_{\text{station x}}$ = % fitted = reconstructed triplet spacepoints
- If efficiency is lower than expected <99.5% then this can be repeated for plane x.

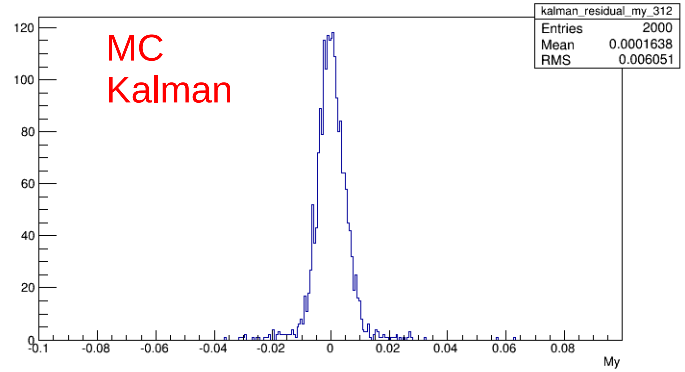
Efficiencies Considerations

- Any known dead channels can be accounted for by requiring doublet spacepoints etc.
- Consider the effect of including doublet spacepoints rather than requiring triplets. This should not be necessary if efficiency is high but will give answers as to possible causes of low efficiency.
- Kalman can be used to do this.
  - Also simple and easy to write a ROOT macro for the purpose that can run outside of MAUS and would be a good double check. - Done!



For more beautiful plots see the Tracker commissioning talk at 4.30 today - C Heidt

Residuals



- Fit a straight line to tracks.
- For a given station:
  - Residuals = reconstructed spacepoint position – fitted position.
- Plot offsets in position.
- Iterate accounting for offsets (linear least squares) to improve residuals. Redoing step 1 and replotting residuals.
- Potential issues:
  - Undefined degrees of freedom (eg. shift in z and pitch angle offset).
  - Overall stretch (all stations larger than they should be, account for by plotting vs position).
  - Too many iterations required.

Residual Minimisation

- Begin using a simple ROOT macro (written and about to be MC tested).
  - This should be good enough as no major offsets are expected … but...
- If too many iterations are required/ internal alignment is worse than expected, there are several high power well understood tools for the job.
- Milipede II, (used by Atlas and others)
  - can account for < 100000 parameters
  - Uses survey data and beam data simultaneously
  - Can weight outliers.
  - Fast to run (for what it is).
  - CAN ALSO USE FOR HELICALS AND INCLUDE HALL PROBE DATA
- Don't want to use a sledgehammer to crack a nut. We will start with the simple solution and move to the higher order one as necessary.

US to DS Tracker Alignment

- Calculate efficiencies for each tracker
  - using the same method as earlier but now treating the detector as a whole incorporating the earlier position adjustments.
- Calculate residuals
  - Measured Track spacepoints - Fitted track spacepoints
- Plot offsets and iterate again to minimise residuals.
- If too many iterations are required (eg both Trackers equally offset in z) use a higher power tool eg Milipede II.

Residual and Efficiency Plots

- Tracker Internal:
  - Efficiency per station/plane.
  - Residuals (after each iteration in offset) per station/plane.
  - Residual vs Spacepoint location in station.
  - Residual vs Channel Number.

Gives info on hidden effects eg. Stretch/ skew

- Tracker efficiency US and DS
- Tracker residuals and minimisation
- Other suggestions welcome!

Global Detector Alignment

- The globals team have developed a handy straight track matching tool for this purpose!! (See globals talks at this CM).
- Calculate efficiencies for each tracker
  - using the same method as earlier but now treating the detector as a whole incorporating the earlier position adjustments.
- Calculate residuals
  - Measured Track spacepoints - Fitted track spacepoints
- Plot offsets and iterate again to minimise residuals.
- If multiple iterations are required (eg both Trackers equally offset in z) use a higher power tool eg Milipede II.

Beam requirements

- (For commissioning require >200k particles as 200 channels per view. Alignment does not require this as:)
- 30 free parameters (15 planes per Tracker)
- Require 1000 muons/parameter prefer 5000.
- 5000 → 150,000 muons at DS Tracker
- Muon beams of 200MeV/c and 300MeV/c requested.
  - Can constrain residual fields systematic: Diff momenta = same alignment we believe the residuals are negligable.
- Data taking began this weekend:
  - Pion ref run (~260 MeV, TBC from TOF TOF0 to TOF1.) 100k triggers at TOF2
  - (3, 200) muon beam. p_z~220 MeV. 70k triggers at TOF2.
  - More work to do on commissioning before data can be used but we have it in the bag!

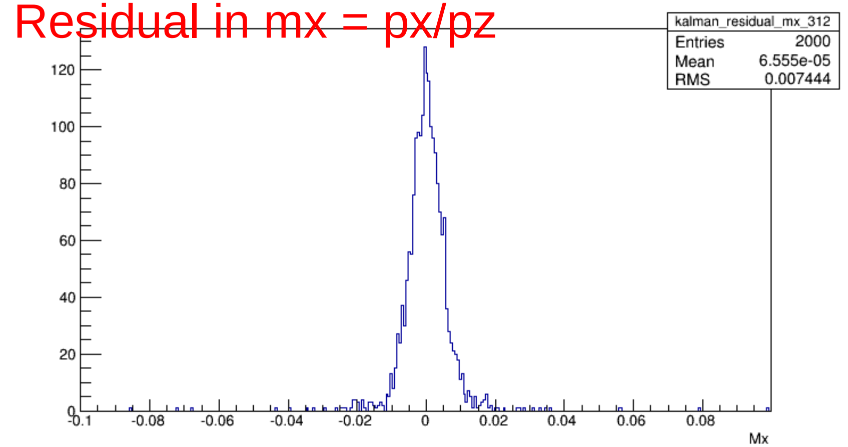
Earths Magnetic Field

- 5×10^{-5} Tesla
- 200MeV/c μ beam = Radius of curvature 13.3 km
- 300MeV/c μ beam = Radius of curvature 20 km
- Deflection due to B_E negligible (less than position resolution of tracker) but can be considered.
- Deviation from straight path:
  - Over 1 tracker: ~25 μm (300 MeV/c)
~30 μm (200 MeV/c)
  - US through DS Trackers: ~250 μm (300 MeV/c)
~300 μm (200 MeV/c)

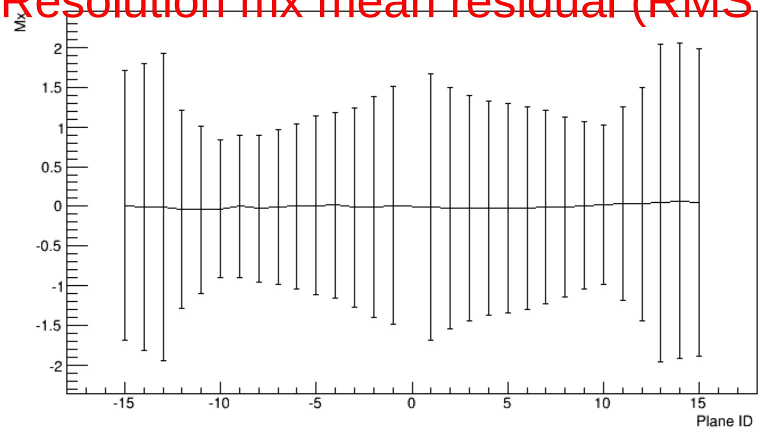
MC from Klaman
Chris Hunt

Tracker Efficiency

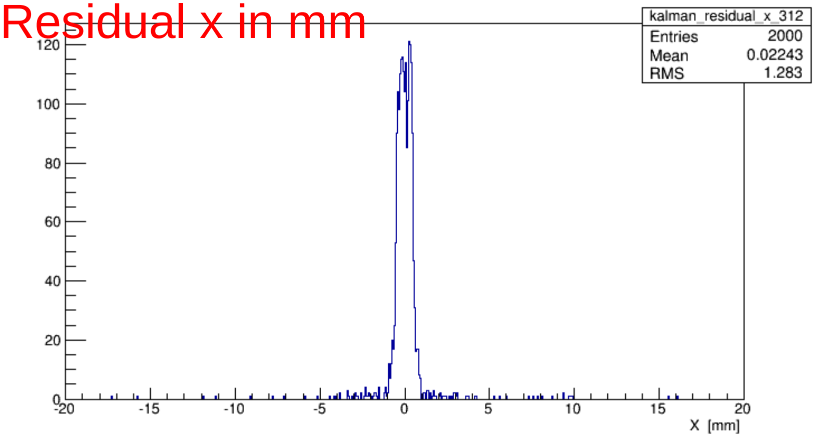
Residual in mx = px/pz



Resolution mx mean residual (RMS width)



Residual x in mm



- Position resolution 470 µm per doublet layer.
- A huge amount of work in improving the kalman fitter has been done by Chris Hunt.
- Efficiency currently:
  - ~99.9% for straight tracks.
  - ~99% for helicals (work ongoing).
- Enough to measure normalised emittance to 0.1%.
- Global reconstruction can compare tracker and other detectors to aid overall efficiency.
- Discussions as for all detectors have begun.

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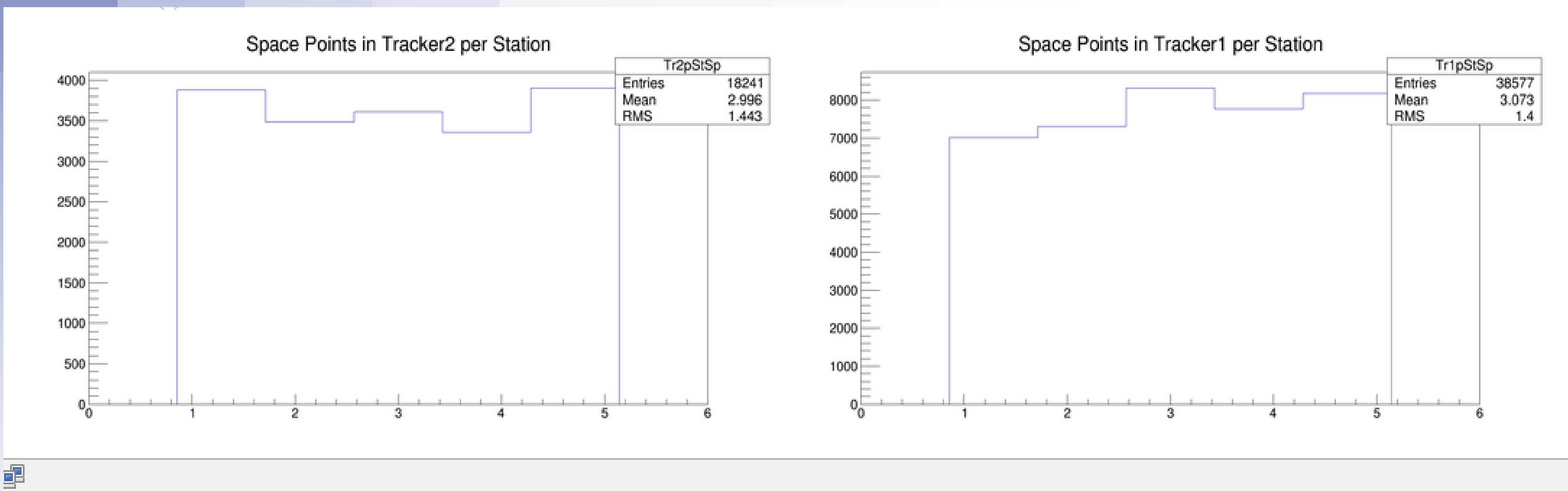
Other Detector Efficiencies

- See the talks at this afternoons meeting – one for each detector.
- Will also be considered in Globals.
- Global Efficiency is calculated including and excluding the effect of detector inefficiencies (See globals talks at this CM).

Exciting 1st Beam in Trackers

- Alignment data taking has begun!
- Data taken this weekend
- More to do to understand it before it can be



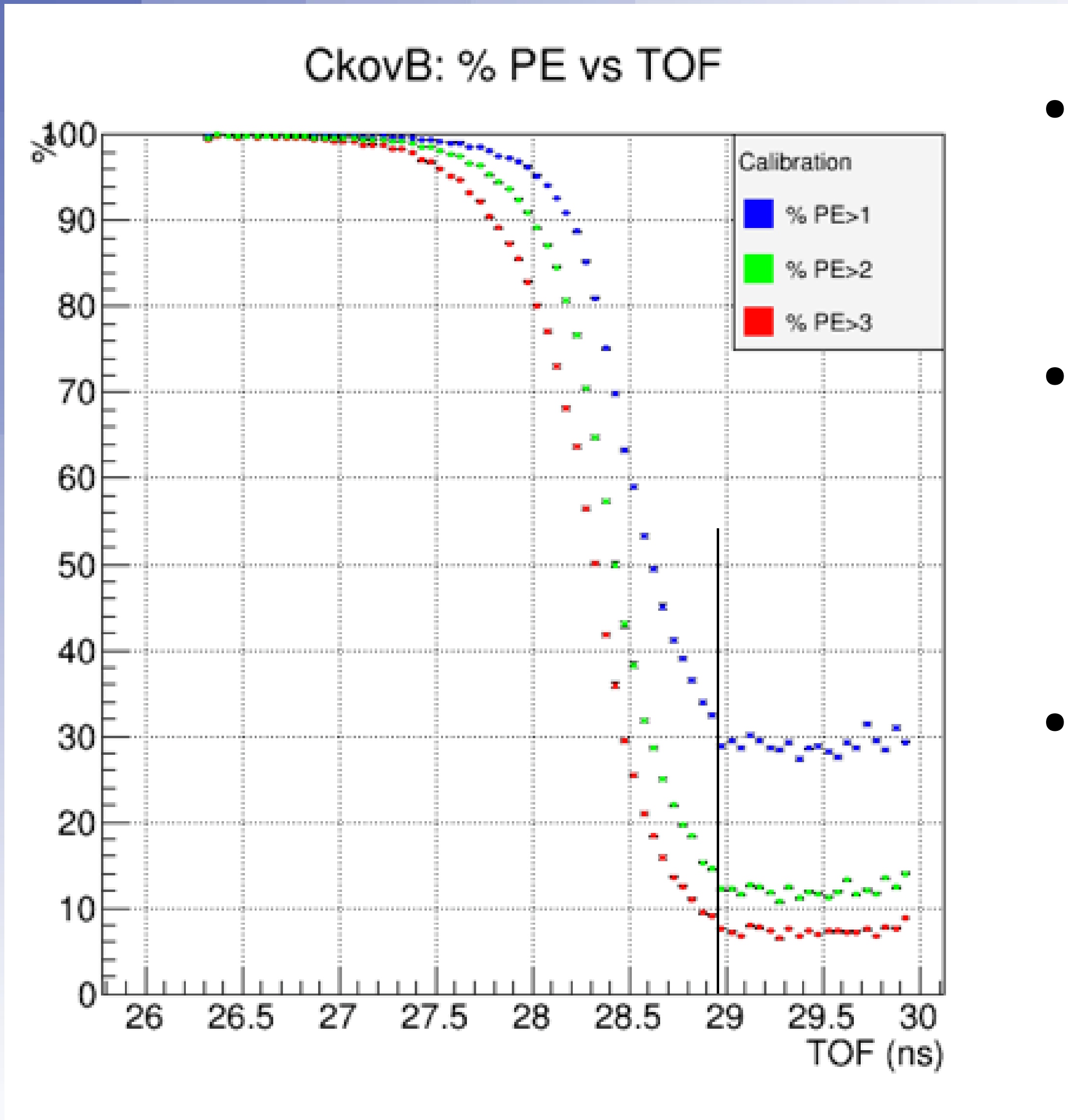
Plenty more where this came from, see the Tracker commissioning talk this afternoon!

Conclusions

- Alignment plan is in place.
- Simple script is written.
- MC is in place to test script and capabilities of recon SW to handle offsets.
- First data requested and is being taken.
  - 5000 particles per free parameter
  - Multiple momenta for residual systematic reduction.
- Efficiency and residuals defined.
- B_E negligable
- If necessary a more robust tool Milipede will be used for alignment study.
- Can also be used on helicals inc hall probe data.

Lucien Cremaldi

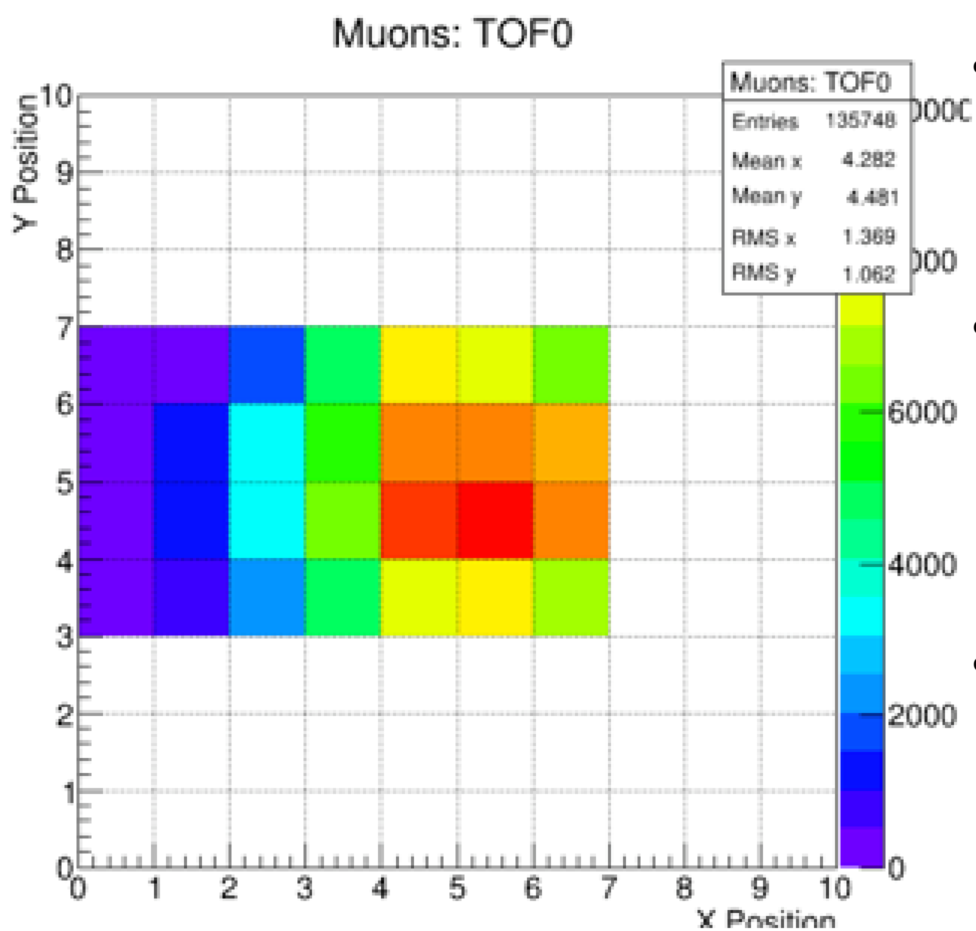
CkoV Efficiency



- Plot shows fast particles with TOF<27.5 ns from an accumulation of runs.
- For muons above Cherenkov threshold the efficiency is very high ~98-99%.
- With a few runs one can approach the same conclusion. Again these are normal calibration or muon runs where particles have momenta p>210 MeV/c.

Lucien Cremaldi

CkoV Alignment and Globals



Plot shows muon run at TOF0, which may be used to fit the beam centre. Ckov is not sensitive to this position, but a beam offset is seen!

- Global track reconstruction requires the positions of the hits in the detectors which cannot be obtained from the Ckovs, but globals can still be useful to them.
- The ckov responses are not very sensitive to alignment at the +/- 2cm level, the CKov response is rather flat as a function of x or y of the particle impact.
- But once TOF0 is aligned, the CKov can be referred to that position. (CKov targets can be resurveyed if neccessary.)
- Can use TOF0 and TOF1 to get the course profiles with in x and y.
- Discussions are ongoing with globals team to ensure optimum functionality