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Preliminary Studies of the Tracking Resolution at DESY

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Outline

- Why good tracker resolution?
- Contributions to resolution
- MC generation
- Mathematical technique (scattering / initial beam spread)
- Results
  - Error matrices
  - Resolutions at Ecal front face & collimator
- Run-by run effects
- Multiple electron events
- Summary

Why good tracker resolution?

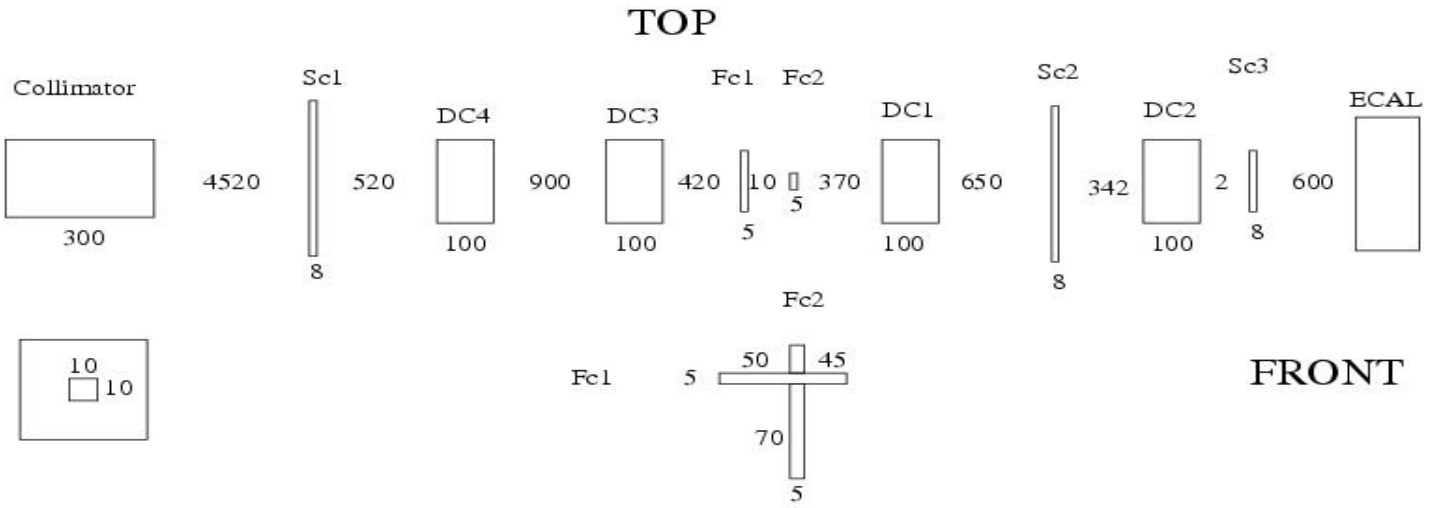
- Want to compare reconstructed Ecal entry point with true entry point from reconstructed track
- Previous MC studies show Ecal position resolution to be ~3-4mm
- Require reconstructed track resolution at Ecal front face to be at least as good as Ecal position resolution in order to accurately measure the Ecal resolution in data

Resolution Contributions

- Intrinsic DC Resolution
  - CALICE analysis & software phone meeting (20/12/06); P. Dauncey gave a value of ≈0.5mm
- Small-angle scattering through ≈10m of air/scintillator
- Angular/positional spread of beam at collimator
- Factors relevant to data analysis:
  - Run-by-run shifts in beam position
  - Drift velocity; ≈30 microns/ns calculated
  - Misalignment of DCs

MC Generation

- Mokka 06-02 (old co-ordinate system) with TBDesy0506 model
- ~100,000 electrons of 1, 3 and 6GeV produced at normal incidence at z=-10,000mm (no position or momentum spread)

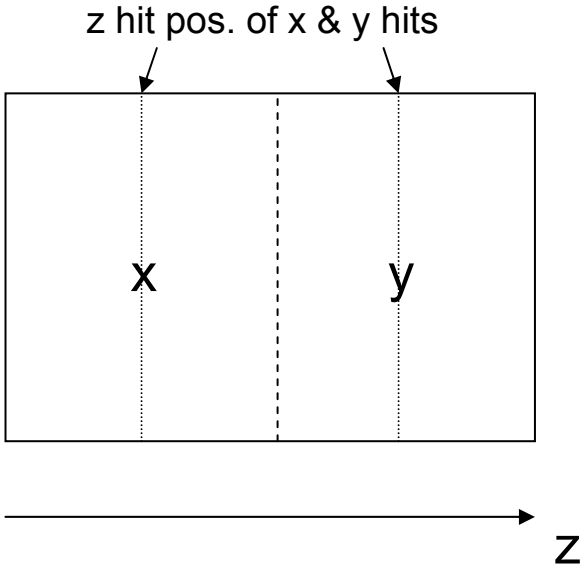


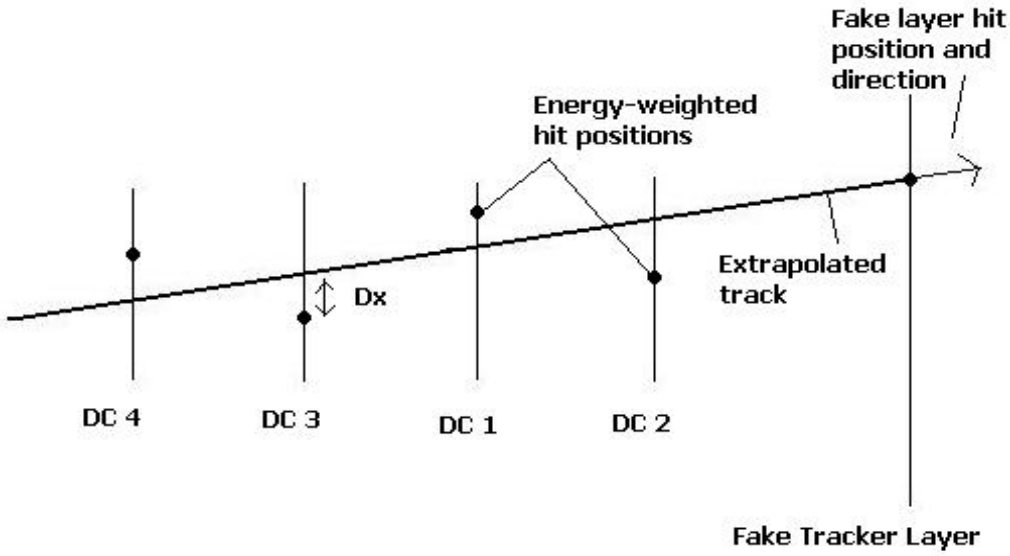
Sc1 and Sc2 are 200x200
Sc3 is 120x120

All distances are in mm

Mathematical Technique (Scattering)

- Extrapolated a truth track from the fake tracker layer (MC layer at front of Ecal), per event, using position and momentum components of highest energy particle registering a hit
  - There are often multiple hits due to bremsstrahlung occurring upstream
- Took upstream half of hits in a given DC as hits in x, with the z hit position at the centre of the upstream half; opposite for y (???)





Mathematical Technique (Scattering)

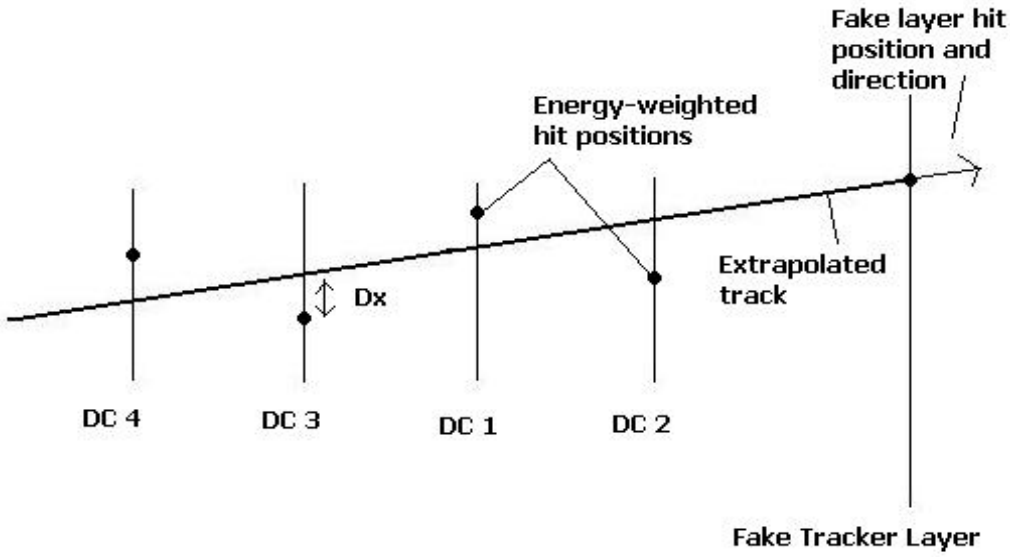
- Defined hit position per DC as deposited energy-weighted in x and y:
- Calculated distance between track and hit position per DC, and calculated error matrix elements (in DxDx, DyDy and DxDy):

$$\frac{\sum_i E_i x_i}{\sum_i E_i}$$

(Summed over hits)

$$\overline{Dx_i Dx_j}$$

(Indexes represent DC no.)



Results (Scattering)

- Error matrix example for DxDx at 1GeV:
- Similar results in DyDy; DxDy negligible—can treat x and y independently
- Higher energies show smaller diagonal elements due to less scattering (DxDx @ 6GeV):
- DC2 looks odd

1xx	DC 2	DC1	DC 3	DC 4
DC 2	0.95mm^2	0.77	1.14	1.56
DC 1	0.77	8.94	16.96	26.02
DC 3	1.14	16.96	34.87	54.42
DC 4	1.56	26.02	54.42	87.31

6xx	DC 2	DC1	DC 3	DC 4
DC 2	1.53mm^2	0.58	0.33	0.14
DC 1	0.58	1.07	0.75	0.86
DC 3	0.33	0.75	1.45	1.80
DC 4	0.14	0.86	1.79	3.18

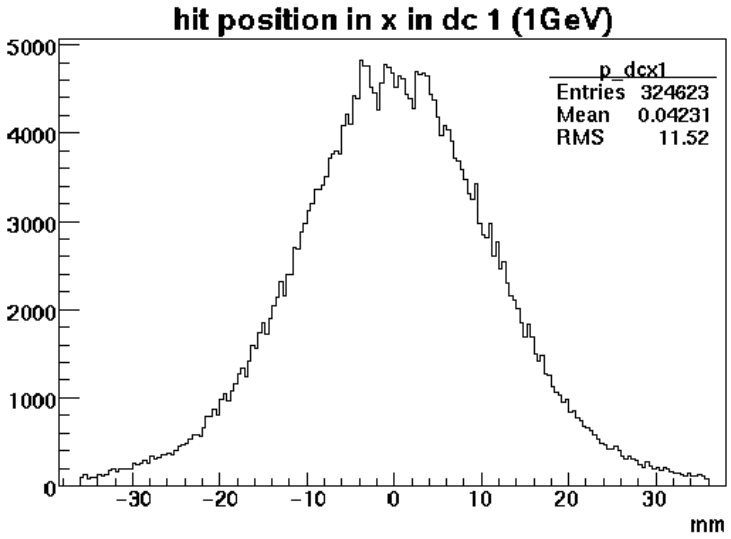
Results (Scattering)

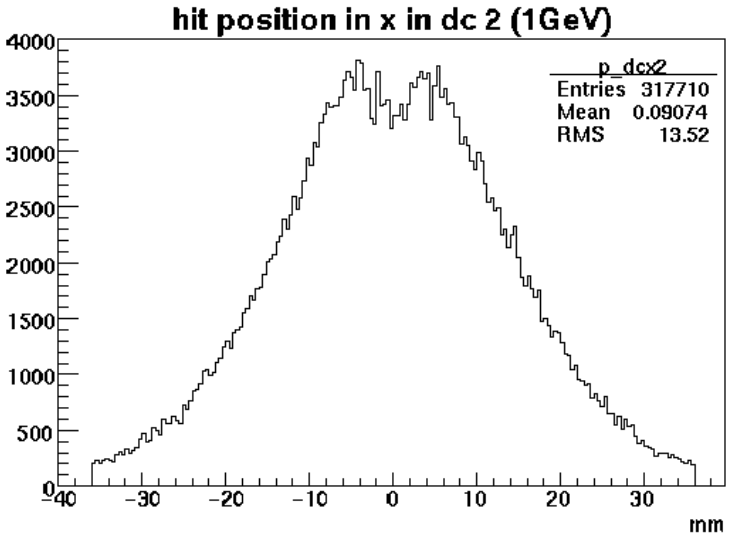
- Normalise error matrices by their diagonals to compare off-diagonal elements
- The extrapolated tracks of lower energy electrons, more subject to scattering, should have high correlations visible in these elements
- Therefore, fitting a track without taking these correlations into account gives the wrong answer

1xxN	DC 2	DC1	DC 3	DC 4
DC 2	1	0.26	0.20	0.17
DC 1	0.26	1	0.96	0.93
DC 3	0.20	0.96	1	0.99
DC 4	0.17	0.93	0.99	1

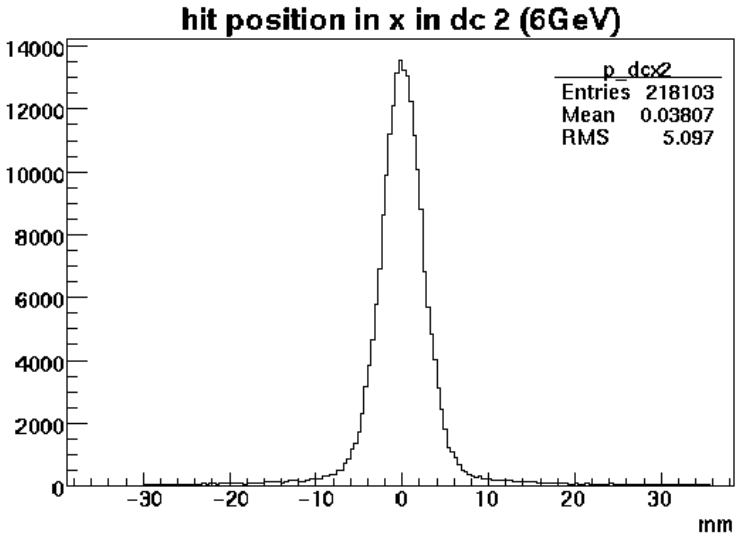
6xxN	DC 2	DC1	DC 3	DC 4
DC 2	1	0.45	0.22	0.07
DC 1	0.45	1	0.61	0.47
DC 3	0.22	0.61	1	0.84
DC 4	0.07	0.47	0.84	1

Results (Scattering)





- Plots are of truth hit positions in x in DCs 1 & 2 for 1GeV, DC 2 for 6GeV. Similar is seen in y
- Possible explanation for 1GeV results, but not for 6
- Needs more study



Results (Scattering)

- From error matrices calculated resolutions at Ecal entrance
- Added $(0.5\text{mm})^2$ to the diagonal terms of the error matrices when doing this to include intrinsic DC resolution
- Eventually want to use error matrices to reconstruct track; these are the resolutions for the track fit

	p0 (mm)		p1 (mrad)	
E	x	y	x	y
1	2.4	2.4	3.0	3.0
3	1.6	1.7	1.2	1.2
6	1.5	1.6	0.8	0.9

Initial Beam Spread

- Same as with scattering except extrapolated using initial MC particle properties (in this case along positive z-axis from z=-10,000mm)
- Used this to create error matrices and calculate resolution at collimator

	p0 (mm)		p1 (mrad)	
E	x	y	x	y
1	14.2	14.5	2.8	2.8
3	6.7	7.1	1.2	1.3
6	4.7	5.1	0.8	0.8

Initial Beam Spread

- In the future, plan is to use DESY physics runs with these error matrices to see how reconstructed beam spread compares with expected spread due to scattering and DC resolution
- Can be subtracted in quadrature to obtain real beam angle and spread
- However, given the large resolutions of 5mm or more, it may be hard to be very accurate

Run-By-Run Effects (Data Analysis)

- Looking at (Gaussian-fitted) mean beam position run-by-run for particular DC channels
- Assume drift velocity is 30 microns/ns
- Mean time for a given channel, *a*, can be written as:

$$\overline{t_a} = k_a \pm \overline{x_a} / v - \overline{t_0}$$

k = constant term (cable length, alignment, etc.)

Second term is beam position (over v); ± depends on wire placement

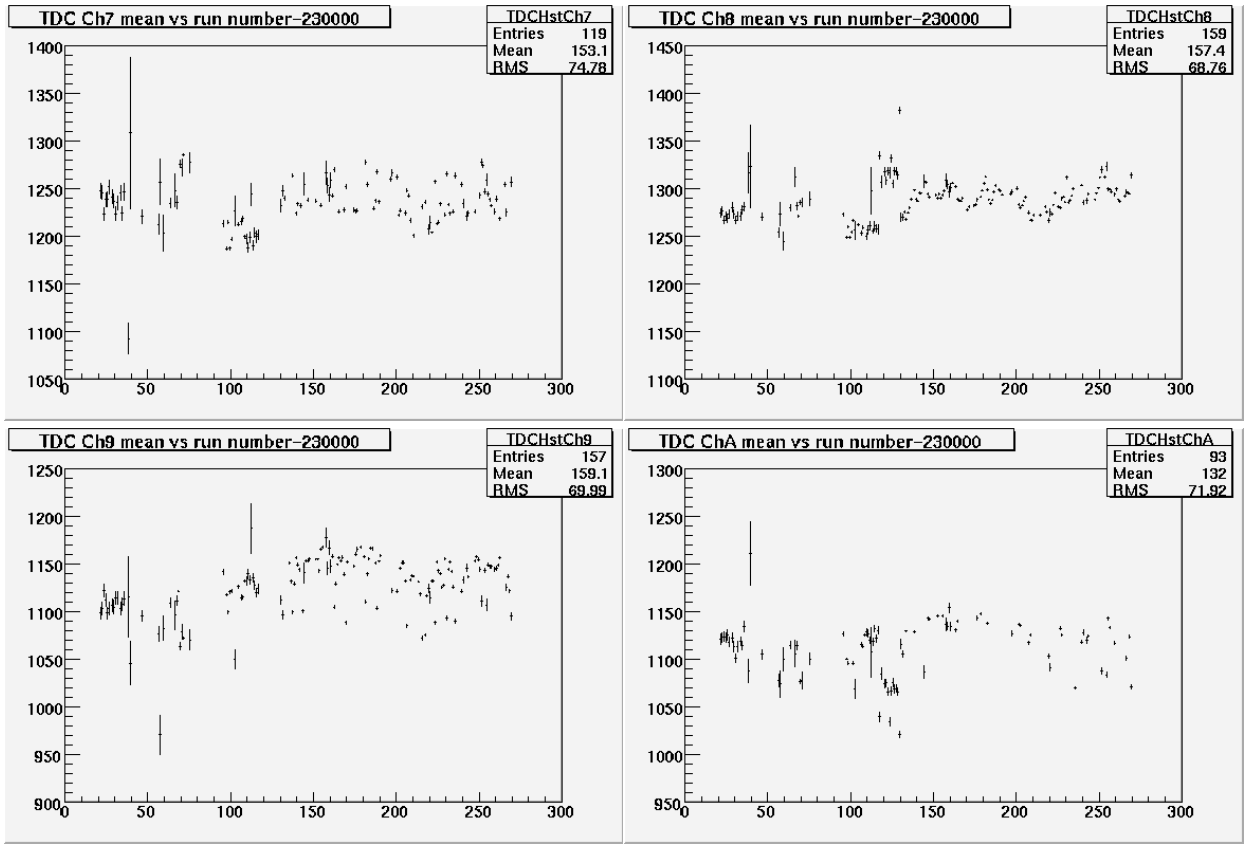
t_0 = DC start time (should be constant for all runs)

- Can add/subtract this quantity between different channels in a given run to eliminate terms

Run-By-Run Effects

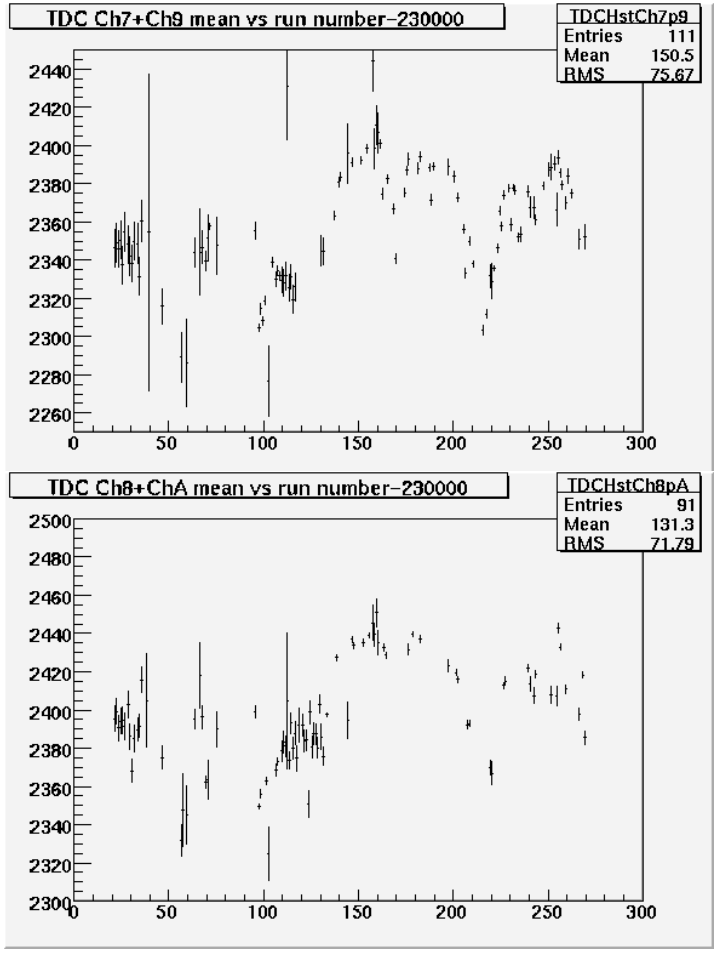
Top left: DC 3, x wire
Top right: DC 3, y wire

- Plots show mean hit time for certain DC channels over all DESY runs
- y-axis range is 350ns, equates to ~10mm
- Overall movement of ~3mm between non-anomalous runs is seen—large compared to resolution we need
- Possibly beam movement



Bottom left: DC 4, x wire
Bottom right: DC 4, y wire

Run-By-Run Effects



Top: DC3x + DC4x

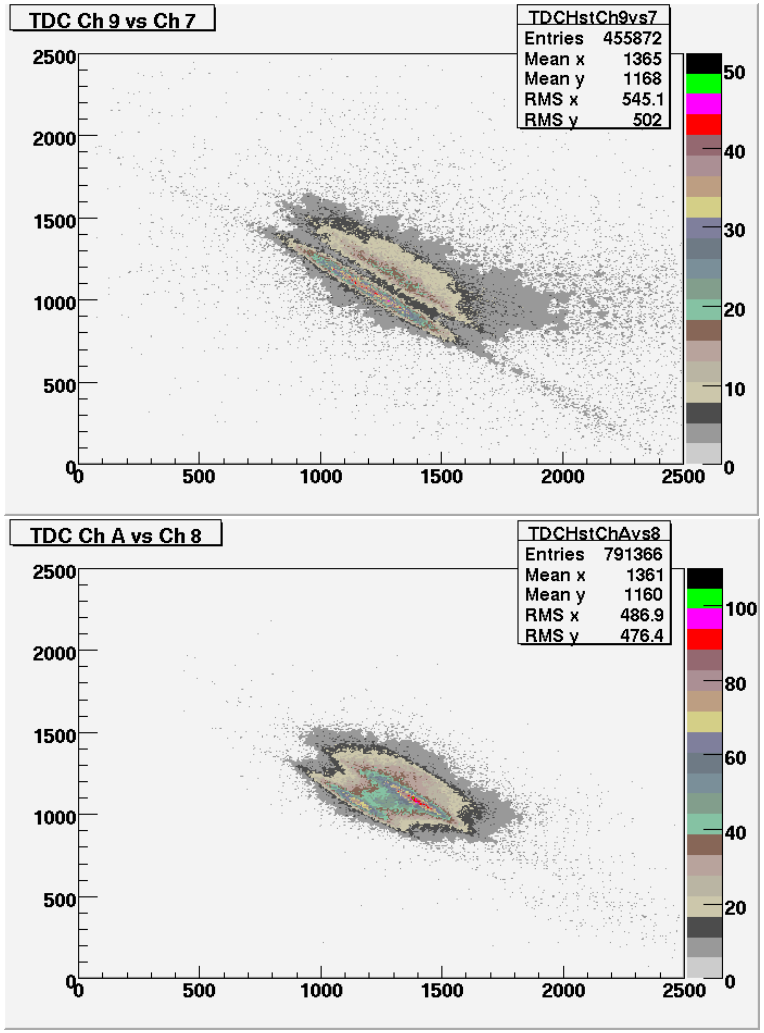
Bottom: DC3y + DC4y

- Plots show means of the sums of the shown DC channel hit times
- Beam movement term eliminated (assuming constant v)
- y-axis range ~6mm
- Run-by-run motion shows changes in alignment/drift velocity/cabling
- Many effects at mm level need to be understood

Single Run Effect

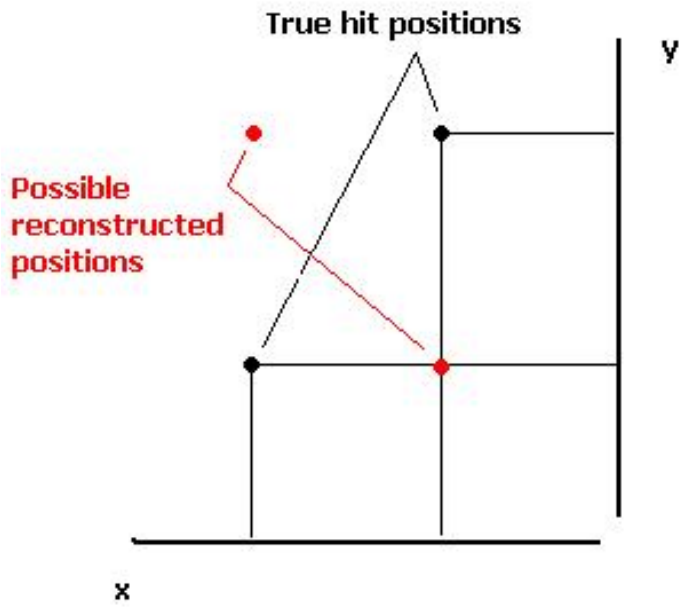
- 2-D scatter plots of DC channel hit times for run 230137
- A constant sum is a 45 degree slope, but x and y intercepts are not equal
- Indicates that drift velocities differ between channels by ~15%
- Requires measuring for each run
- Lots of background noise, so measurement of slope is not trivial

Top: DC4x vs. DC3x
Bottom: DC4y vs. DC3y



Double Electron Events

- No correlation between x and y leads to 2-fold ambiguity in calculating position of double hits (6-fold with triple hits)
- How to deal with this in track reconstruction?
- Reconstruct all 4 tracks? Reconstruct x and y separately?
- What if 1 x and 2 y hits?



Summary

- Scattering and beam spread error matrices created, although possible issue with MC?
- Need to know DC layout!
- Beam movement looked at, although many small effects need close scrutiny run-by-run. Particularly, drift velocity does not appear to be constant between channels.
- Any ideas for double events?