Imperial College London

Tracking & Ecal Positional/Angular Resolution

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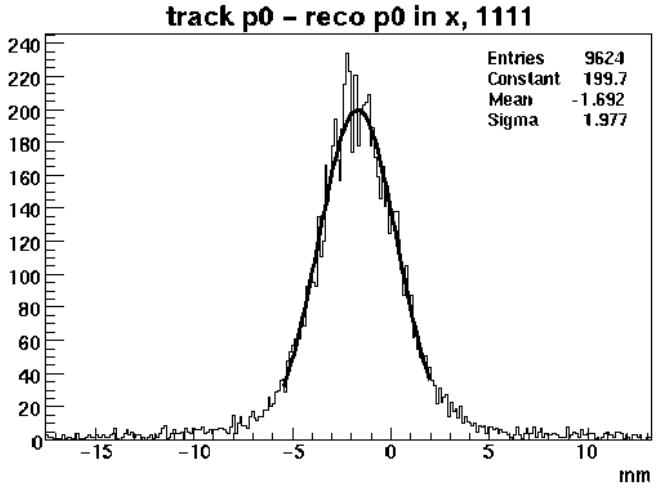
Outline

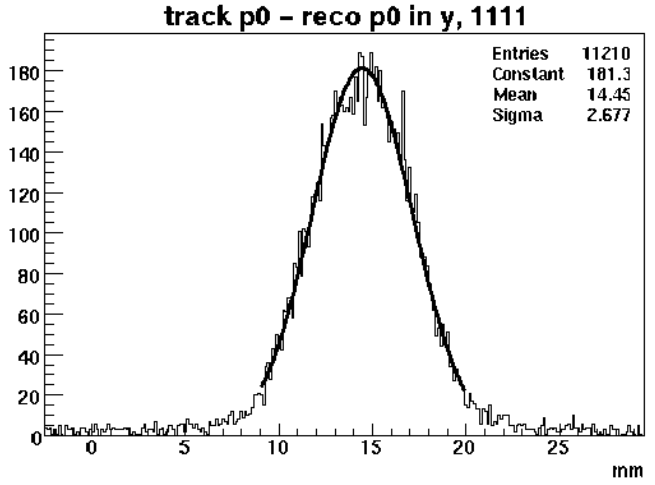
- Motivation:
  - Tracking system is used to determine ECAL resolution, so need to understand and quantify contributions to track resolution
- This talk will look at a number of systematic effects in tracking and take these into account in giving best estimate yet of ECAL resolutions, both in data and MC
- Also a first look at ECAL cross-checks and systematics
- All based on the DESY setup

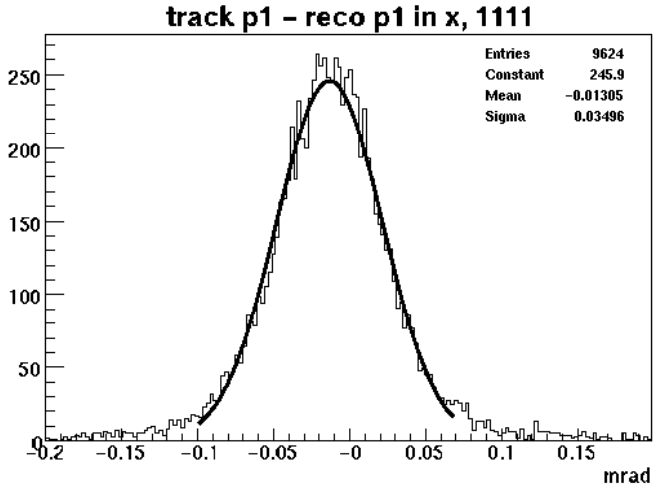
MC/data used

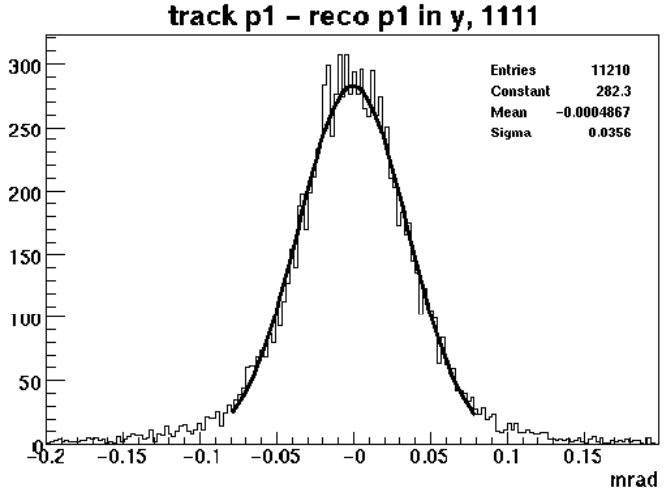
- Home-produced MC runs used from Mokka 06-03-p01
  - Made to replicate the geometry from DESY data runs 230097-230104 (~100,000 events apiece)
  - EcalTranslateX/Y still guessed at; centre of wafer aimed at
- Used reco runs 0403-pre4, with tracking
  - No 1.5GeV run reconstructed with centre of wafer aimed at, so used an edge run for main studies
  - Rec_0304-pre4 runs without tracks: 230134, 140-143, 248, 252
  - Used other runs to compare beam position at wafer centre/edge/corner
  - Used David Ward's energy cut
  - Also, layers 3 and 14 cut due to bad wafers

Method









- Ecal resolution calculated by subtracting track resolution from reconstructed linear fit resolution
- We need to know and understand the track resolution

Tracking systematics on track resolution

- Calculated from simulation
- Statistical (in MC):
  - A result of the 100k events per run
  - Very small contribution to tracking systematics
- Other contributions:
  - Residual misalignment of tracking system
  - Imperfect modelling of scattering material
  - Uncertainty in intrinsic DC resolution
  - Imperfect modelling of tracking chamber backgrounds

Systematics

- Misalignment:-
  - Estimated by reconstructing simulated events with tracking chamber drift velocity increased by 5%
    - Reconstructed with different drift velocity to that used in digitisation
  - Looked at how track resolution at ECAL front face changed (as with all systematic effects)
- Scattering Material:-
  - Imperfect modelling of the beam line material will result in track fit error matrix being incorrect
  - Scattering material matrix was varied by ±10%

Systematics

- Intrinsic DC resolution:-
  - The measured DC resolution of 400 microns was varied by ±50 microns
- Background:-
  - Chamber backgrounds were modelled by adding random hits at roughly the rate observed in data in run 230101
  - Estimate of systematic error was evaluated by scaling the simulated background by ±50%
  - Non-zero background increases resolution beyond that given by ‘perfect’ track fit error propagation

Summary of tracking systematics

	Beam Energy (GeV)						
Source	1.0	1.5	2.0	3.0	4.0	5.0	6.0
Position resolution (mm)							
Simulation statistics	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Residual misalignment	0.16	0.14	0.09	0.06	0.04	0.02	0.02
Material modelling	0.13	0.09	0.07	0.04	0.03	0.03	0.02
Intrinsic resolution	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Background rate	0.05	0.04	0.02	0.02	0.02	0.01	0.01
Total systematic error	0.22	0.18	0.12	0.09	0.07	0.06	0.06
Angle resolution (mrad)							
Simulation statistics	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Residual misalignment	0.02	0.02	0.02	0.01	0.00	0.00	0.00
Material modelling	0.23	0.15	0.12	0.08	0.06	0.05	0.04
Intrinsic resolution	0.03	0.02	0.02	0.02	0.02	0.02	0.02
Background rate	0.14	0.06	0.04	0.02	0.02	0.01	0.01
Total systematic error	0.27	0.16	0.13	0.09	0.07	0.06	0.05

- Differences in systematics between x and y negligible

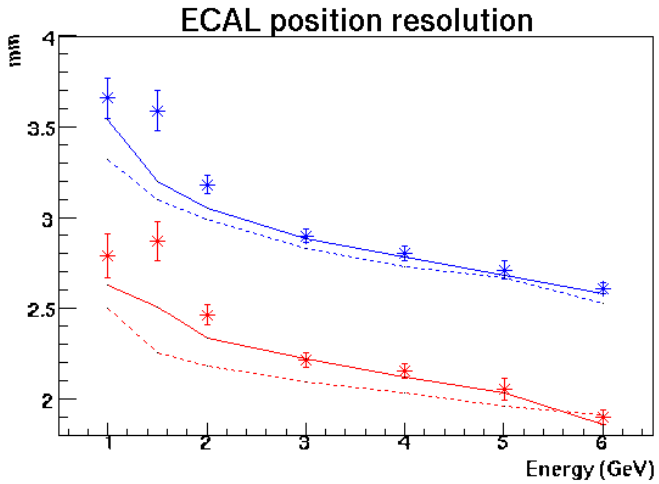
Deduced tracking resolutions

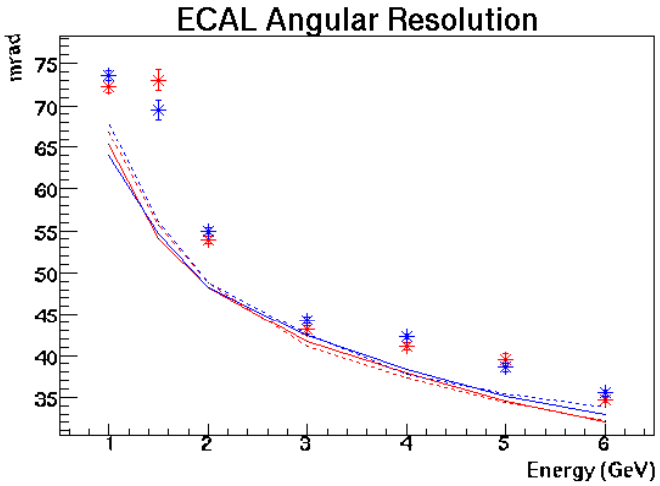
	x		y	
Beam Energy (GeV)	Position (mm)	Angle (mrad)	Position (mm)	Angle (mrad)
1.0	1.68 ± 0.22	2.48 ± 0.27	1.57 ± 0.22	2.41 ± 0.27
1.5	1.19 ± 0.18	1.65 ± 0.16	1.19 ± 0.18	1.67 ± 0.16
2.0	1.00 ± 0.12	1.34 ± 0.13	0.98 ± 0.12	1.30 ± 0.13
3.0	0.81 ± 0.09	0.92 ± 0.09	0.79 ± 0.09	0.90 ± 0.09
4.0	0.72 ± 0.07	0.73 ± 0.07	0.69 ± 0.07	0.72 ± 0.07
5.0	0.66 ± 0.06	0.62 ± 0.06	0.65 ± 0.06	0.61 ± 0.06
6.0	0.60 ± 0.06	0.53 ± 0.05	0.59 ± 0.06	0.52 ± 0.05

- These are what are subtracted from real data to give the ECAL resolutions

Corresponding ECAL resolutions

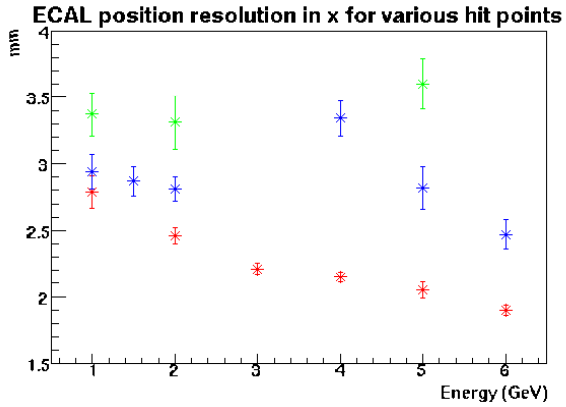
- Calculated by subtracting track fit from reconstructed fit
- x is red, y blue
- Data points are starred; MC from track is solid; MC from truth ('fake' layer minus linear fit) is dotted
- Three main points:
  - Data values > MC for low E—modelling of material?
  - y > x due to staggering—y may also lose energy due to gaps
  - MC truth and track position values differ. Bias in method? Needs investigation

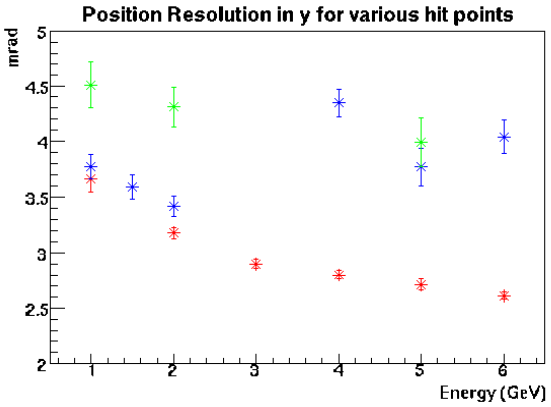


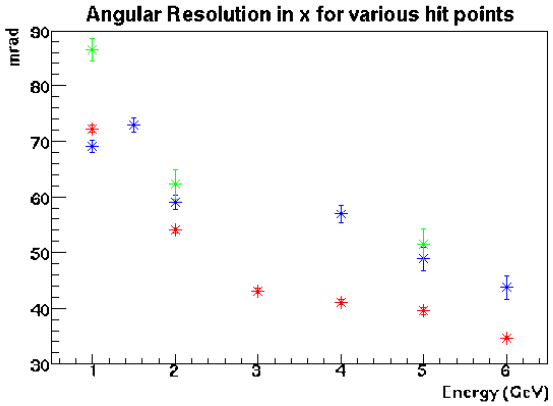


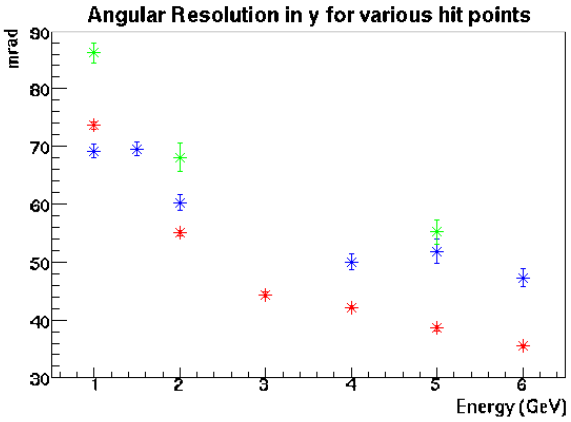
Wafer centre/edge/corner resolutions

- 1.5GeV run (wafer edge) has worse resolution than expected
- Below is a look at ECAL resolutions for all available data runs
- Red = centre; blue = edge; green = corner





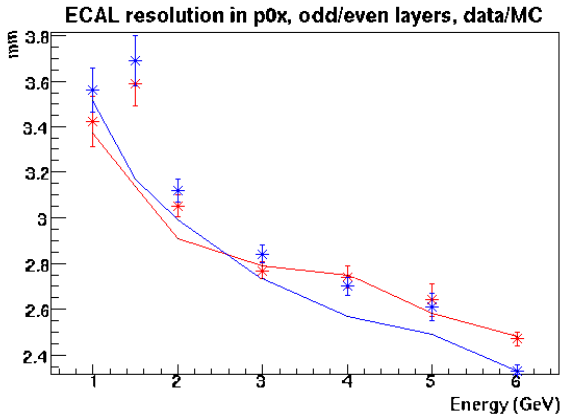


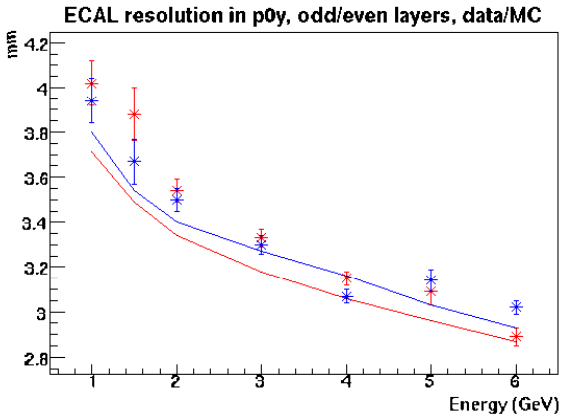


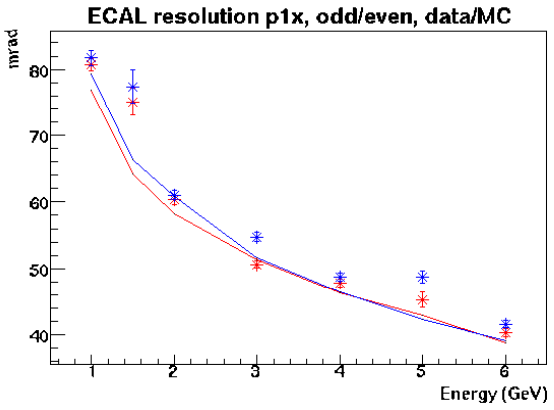
•Clear worsening of resolution when beam is aimed at edge/corner

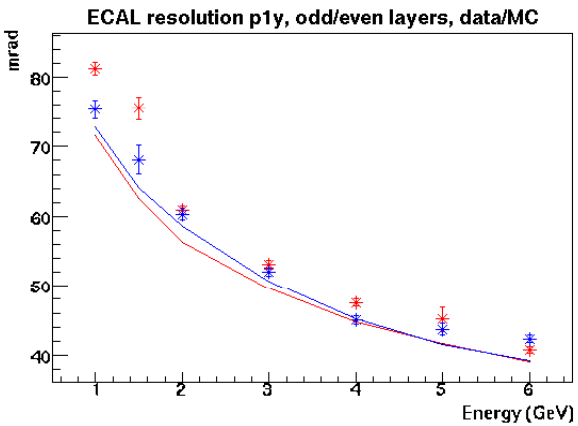
•Plan is to quantify effect by doing the same thing for MC

Odd/even layers





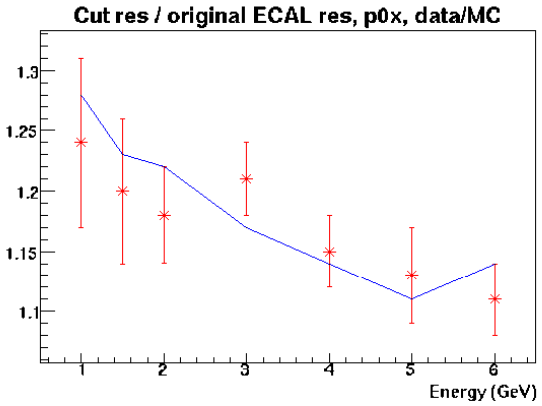


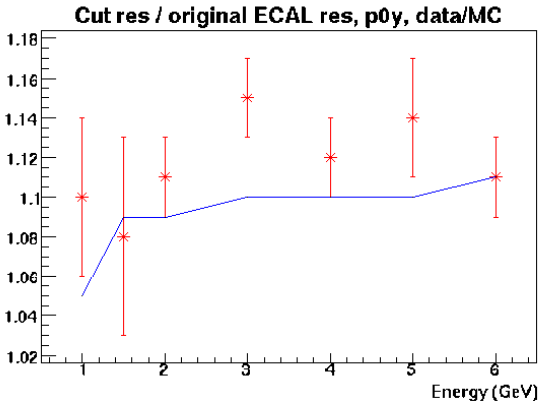


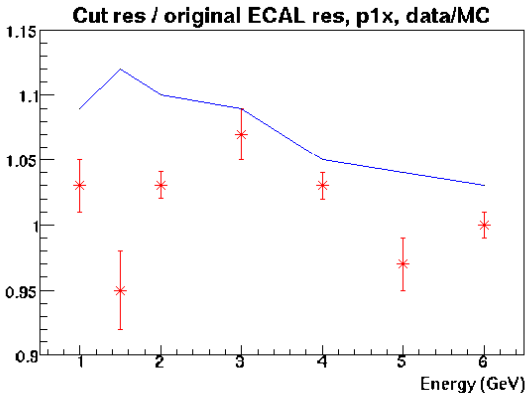
- Consistency check performed by cutting on odd/even layers and comparing deduced ECAL resolutions
- Red = odd; blue = even; points = data; lines = MC
- Odd and even seem in reasonable agreement—possible discrepancy for y angles at low energy in data
- Similar discrepancies seen between data and MC as on slide 10

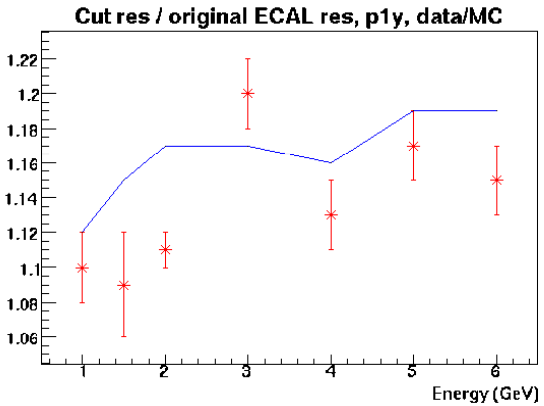
Effect of bad channels

- Layers 1 and 10 cut as these have dead cells near shower centre
- New ECAL resolutions calculated and divided by 22-layer ones
- Red = data; blue = MC (top plots = position; bottom = angle)
- If bad channels have a noticeable effect, MC will worsen more than data
- No evidence in position; possibly in angle
- Will cut good layers and compare









Summary

- Tracking systematics calculated from MC
- Values give updated track resolutions which are subtracted from linear fit-calculated ECAL front-face distributions to give ECAL resolutions
- Some discrepancy between data and MC
  - Is consistent with a lack of scattering material in MC (~20%?)
- Some discrepancy between MC-track and MC-truth
  - MC self-consistency indicates possible bias in method
- Different ECAL resolutions are obtained when beam is aimed at wafer centre/edge/corner—need to extend this study to MC in order to quantify
- Odd/even layer study shows reasonable consistency
- Effect of bad channels is probably small in ECAL systematics; a closer look is necessary