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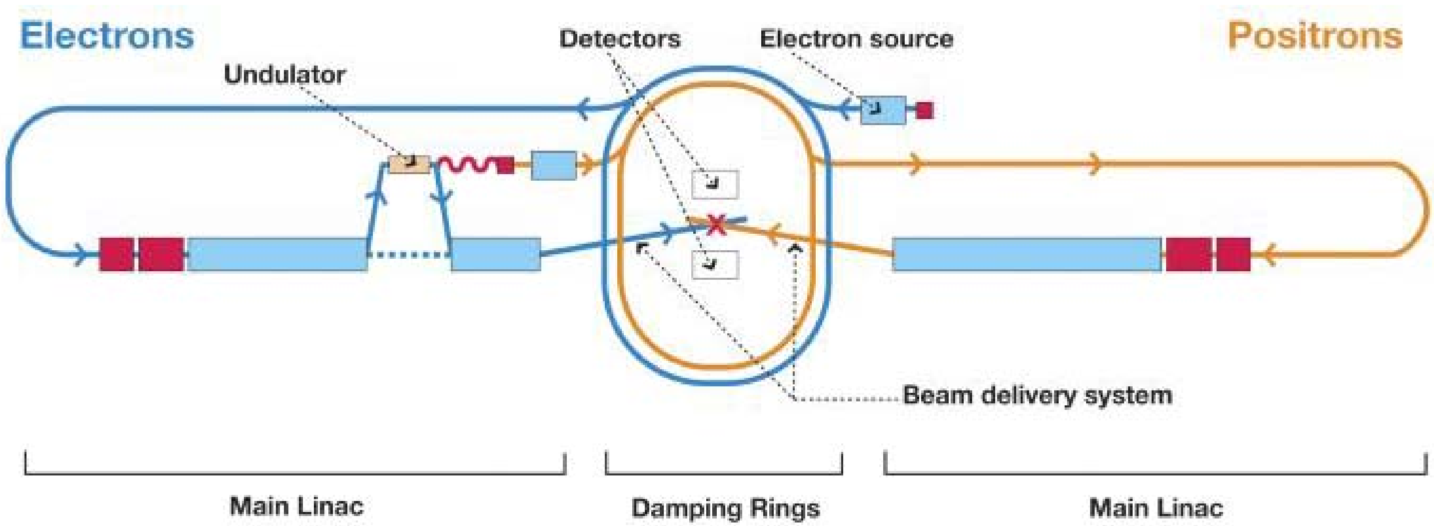
Positional and Angular Resolution of the CALICE Pre-Prototype ECAL

Hakan Yilmaz

Imperial College London

Introduction

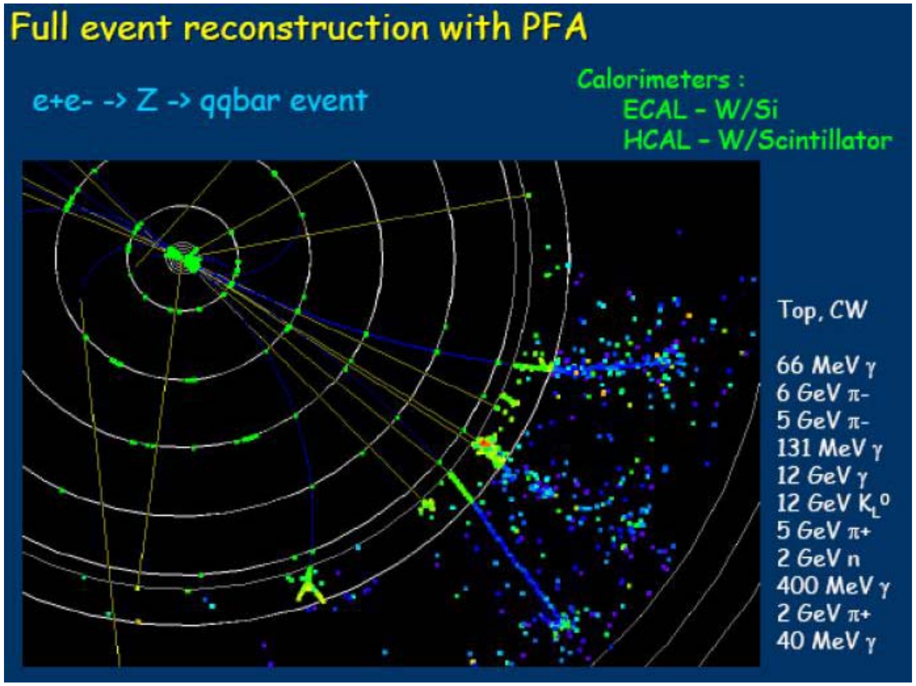
- CALICE is an international collaboration looking at CAlorimetry for the LInear Collider Experiment
- The ILC is planned to be a 0.5-0.8 TeV $\sqrt{S}$ e^+e^- linear collider, with the aim of making precision measurements after the predicted discoveries at the LHC
- E.g., an important physics aim is to separate $e^+e^- \rightarrow$ Z jets from $e^+e^- \rightarrow$ W jets.
- Therefore it is important to have an excellent hadronic jet energy resolution of $\sigma_E/E=0.3/\sqrt{E(GeV)}$



PFLOW

- A particle flow algorithm together with high granularity calorimetry gives best results
- This is done by using tracker to measure momentum of charged particles and subtracting their deposits in the HCAL and ECAL so as not to double count
- Association confusion term is dominant using this method, so good track-shower matching is required
- Good spatial granularity for showers and jets is therefore required, rather than good energy resolution per particle—hence the use of high granularity calorimetry

- The full detector event below shows how energy deposits can be tracked accurately through the calorimetry and associated with the correct tracks



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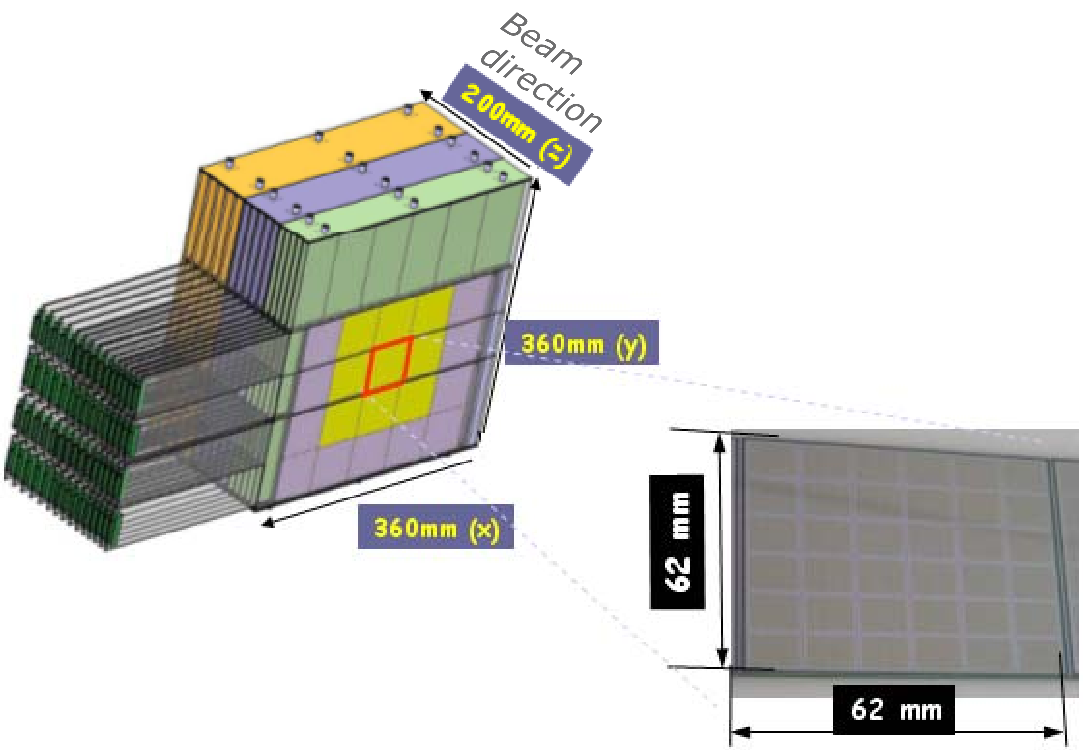
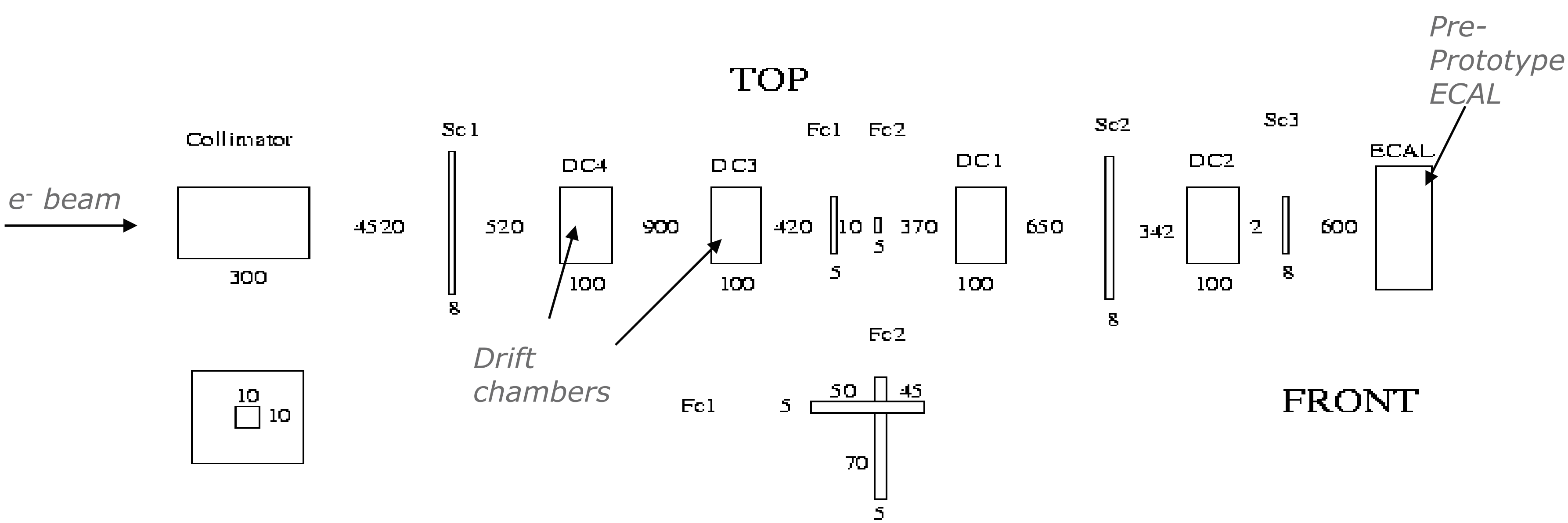
Prototype ECAL

- CALICE has been developing calorimetry which utilises these principles
- Shown below is a schematic of the pre-prototype 30 layer SiW sampling ECAL
- The prototype ECAL is made in 3 sections of increasing tungsten thickness, and uses 18x18 1cm^2 silicon pads per layer



Test Beam Programme

- CALICE is currently pursuing an extensive test beam programme, testing both the pre-prototype ECAL and the AHCAL
- Will focus on DESY '06 test beam as well as associated MC production.



Sc1 and Sc2 are 200x200
Sc3 is 120x120

All distances are in mm

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Resolution Studies

•Accurate track-shower matching requires a good ECAL positional and angular resolution, and my work is to calculate and optimise this for the CALICE ECAL (in response to electrons)

•Basic idea is to use detected EM shower energy deposits to reconstruct the shower back to the ECAL front face

•An energy-weighted method is one way of defining a measured hit position per layer:

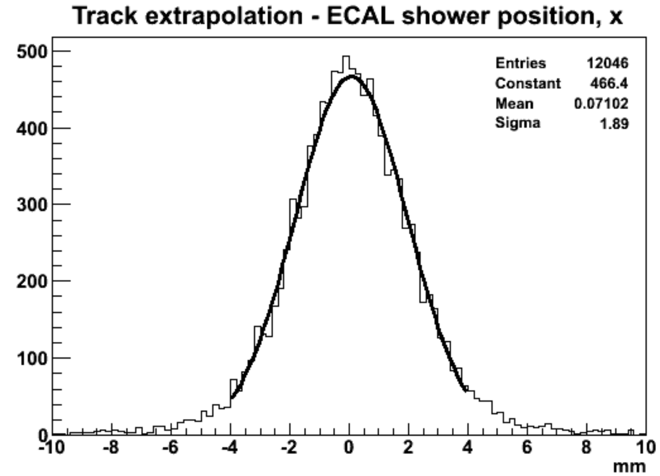
$$x_m = \frac{\sum_{i=1}^{N} E_i x_i}{\sum_{i=1}^{N} E_i}$$

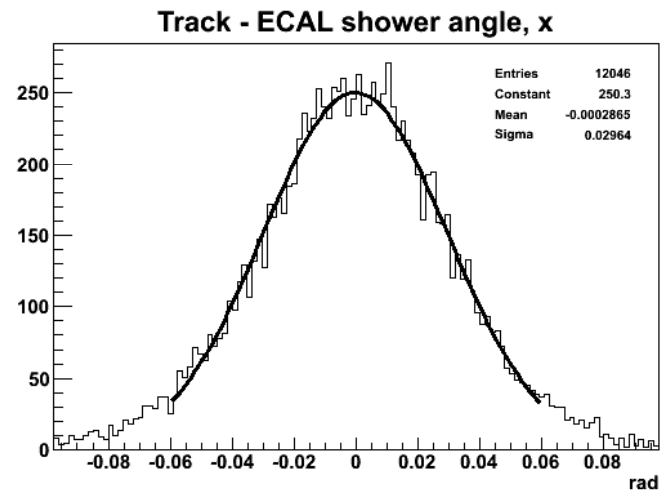
•In MC, truth information can be used to project a truth particle from the ECAL front face, thus allowing the production of a full error matrix, including correlations

•The error matrix can then be used on data to reconstruct showers and compare with tracking information

Tracking

- In order to calculate ECAL resolutions in reality, tracking available at the DESY, and the other test beams can be used to project an estimated track at the ECAL, to compare with reconstructed showers
- However, the track itself has an intrinsic resolution which needs to be subtracted from the observed distributions in order to obtain the ECAL resolution—the histograms opposite show a combination of tracking and ECAL resolutions
- This tracking resolution must be small compared with the ECAL resolution, so the resolution isn't dominated by tracking error





Tracking Systematics

- For the intrinsic tracking resolutions there are a number of systematic effects which have been calculated
- These include drift chamber (DC) misalignment, modelling of scattering material, intrinsic DC resolutions and DC background modelling
- To do this, the values were altered by ±5-10% in MC.
- Differences between x and y are negligible

	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

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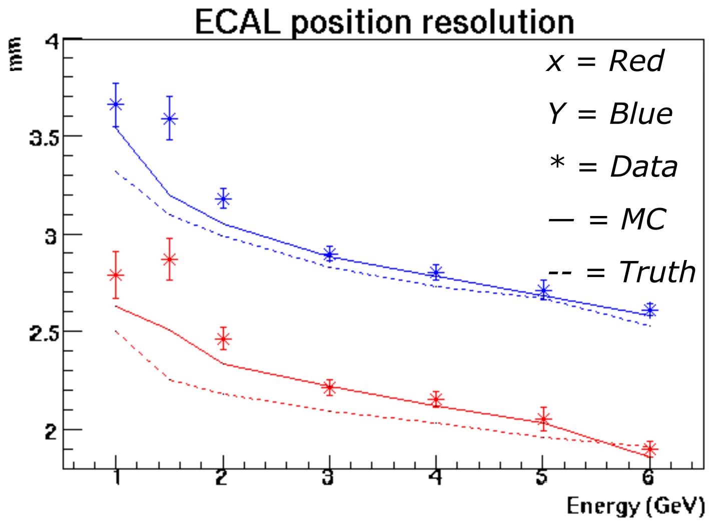
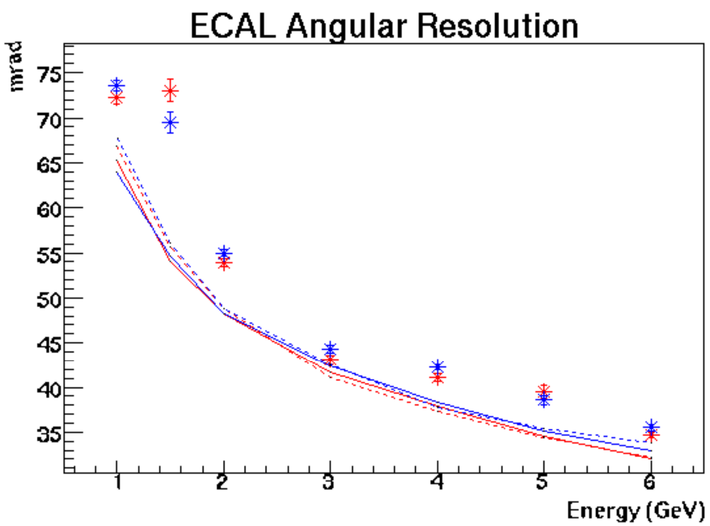
Tracking Resolutions

- The table shows the deduced tracking resolutions and errors
- These are what are subtracted from real data to give ECAL resolutions, and turn out to be small in comparison…

	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

ECAL Resolutions





- The plots show the ECAL resolution calculated from data and MC, and the MC truth
- Low energy discrepancy is likely due to material modelling
- The difference between the MC and truth curves is possibly due to an internal bias in the procedure. However, the same procedure gives consistent results in data.
- Difference between x and y is due to staggering of SiW layers in x

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Summary

- In order to achieve the physics goals of the ILC, the CALICE group believe that high granularity calorimetry employing a particle flow algorithm is the way forward
- I look at the track-shower matching capabilities of the CALICE pre-prototype ECAL with the aim of employing these techniques in a full detector simulation
- Tracking and ECAL resolutions have been calculated for the DESY test beam
- Future work will be to extend the work to further test beam data, as well as angled incidence beams