TPAC Response & DESY Beam Test Analysis

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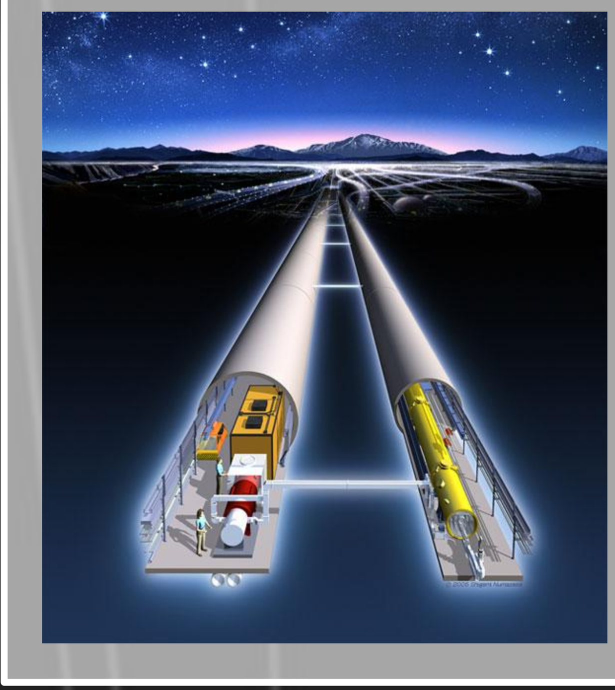
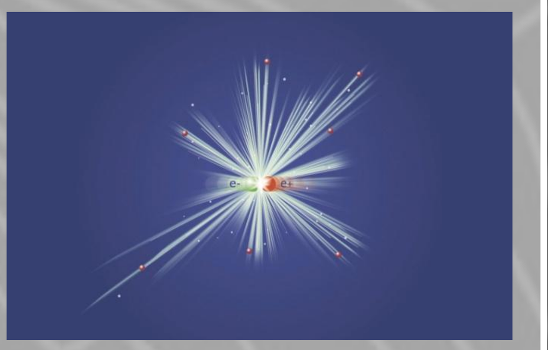
SPiDeR

http://spider.ac.uk/

The International Linear Collider



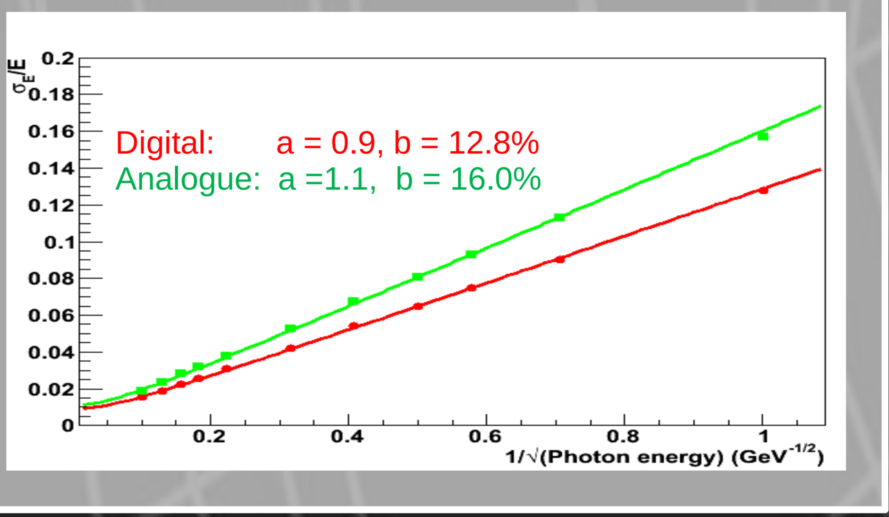
The ILC is an e^+e^- linear collider with an initial $\sqrt{s} \leq 500$ GeV rising to 1 TeV after the first phase. The ILC will be largely complementary to the LHC. Despite an eventual $\sqrt{s} = 14$ TeV, PDFs at the LHC lead to an effective centre of mass of the order 1 TeV and the initial state is largely unknown. The ILC with $\sqrt{s} \leq 1$ TeV is thus the same order of magnitude for discoveries and a cleaner initial state makes precision measurements possible.



The energy range of the ILC will allow precision studies of electroweak symmetry breaking, Higg's boson, supersymmetry; and dark matter. The proposed luminosity of 5×10^{34} $cm^{-2}s^{-1}$ will lead to 500 fb^{-1}/year. If the ILC runs at the WW production resonance will allow W-mass to be measured with a precision of 6 MeV, and a 10 point scan of the ttbar threshold will allow $\Delta m_t \approx 34$ MeV.

Digital Electromagnetic Calorimetry

To fully utilise the ILC, the detectors need unprecedented resolutions, especially the calorimeter systems. Conventional calorimeters sample the shower and the analogue readout is then summed and multiplied by a sampling fraction. The use of digital MAPS technology gives increased performance at reduced cost by using CMOS sensors to count the number of particles in a shower reducing the resolution contributions from Landau fluctuations.

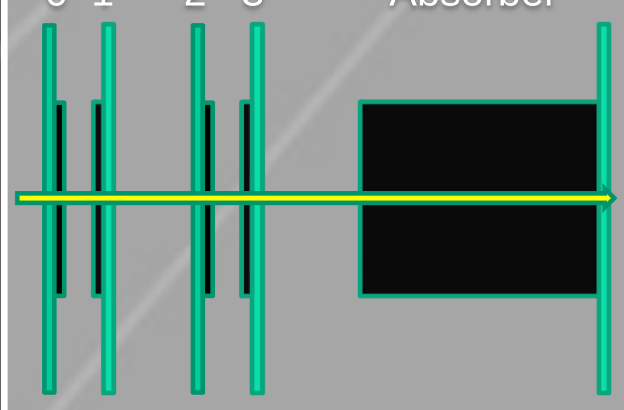


TPAC 1.2 Sensor

- 50 µm pitch CMOS sensor
- Uses "INMAPS" technology in a 1 cm^2 grid (168x168 pixels).
- Contains all the electronics necessary for optimal readout.
- The TPAC DAQ is configured to readout every 400 ns and the TPAC will register all hits within this for readout later.

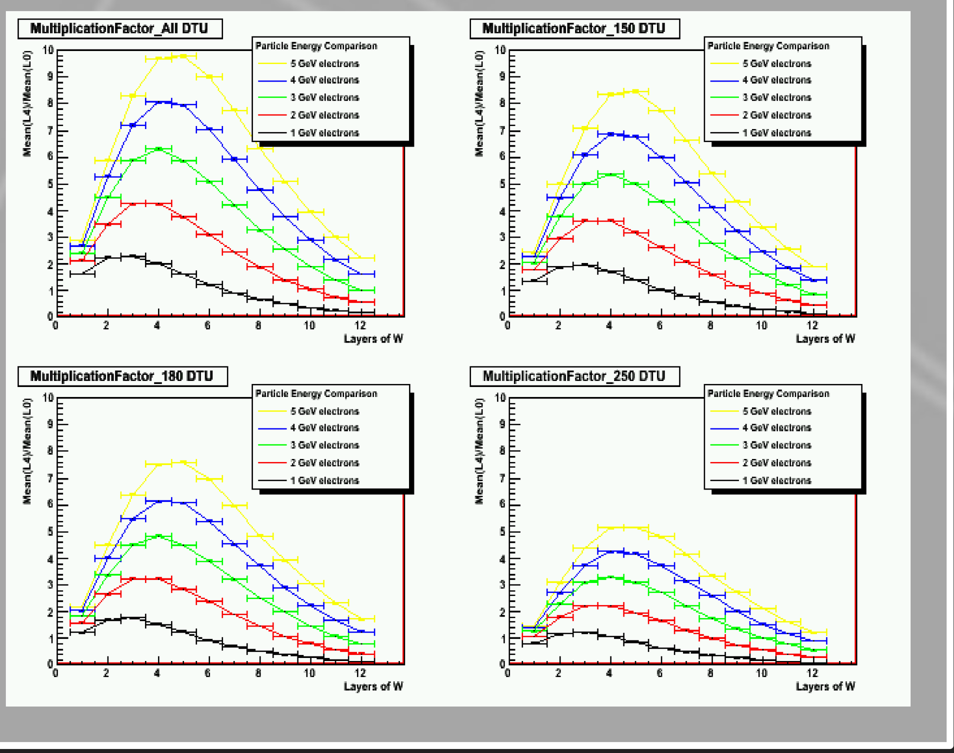
DESY Simulation Expectations

Geant 4 simulations of the TPAC stack used for the DESY beam test led to the particle multiplication plots below. The number of hits in the sensors downstream of the absorbing material are normalised to the number of beam particles.



Absorber constructed of multiple slabs of 3mm thick Tungsten (6/7 χ_0) kept constant distance from rear sensors. (beam arrives from left)

Distinct difference in the particle multiplication factor for different energies. The peak position of each energy changes as expected from theory. Possibility of low energy photons due to difference from all hits to 150 DTU and much reduced factor at 250 DTU.

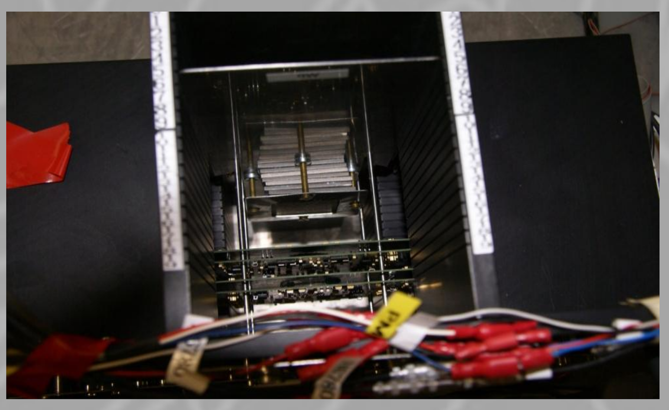


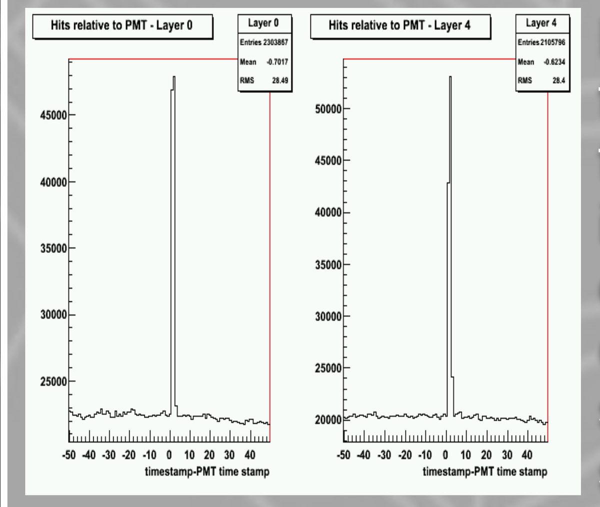
DESY Beam Test Shower Studies

In March 2010 members of the SPiDeR collaboration took a TPAC stack to DESY. Two of the main physics goals were :

1. To test sensor efficiency to electrons (1-5 GeV)
2. Study sensor response to showering (low energy photons, difference in materials, etc.)

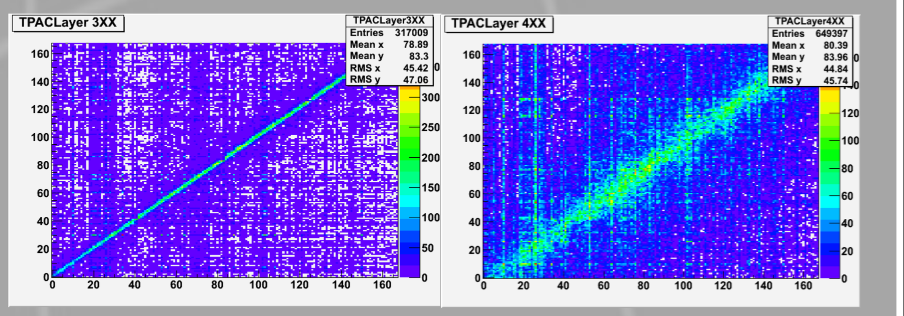
The TPAC stack consisted of six sensors, varying absorbing materials and three PMT's for triggering. The four sensors upstream of absorber are used for tracking and the two downstream for shower detection.

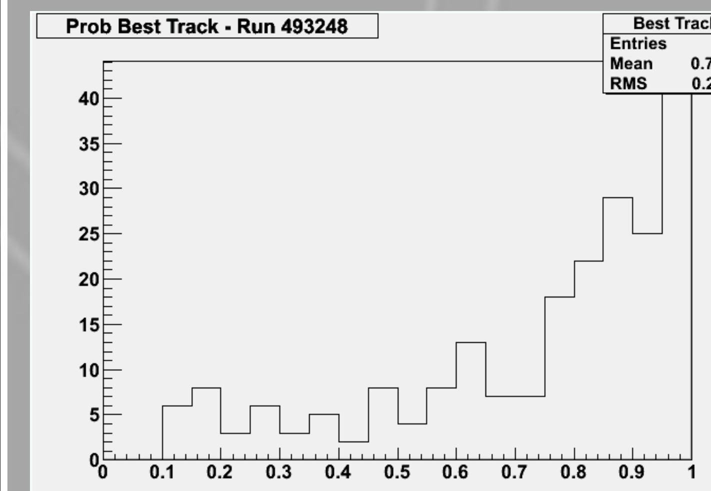




Beam led to coincident PMT signals and these events were written to disc. Within these bunch trains there is a large increase in hits when the bunch crossing corresponds to a PMT coincidence showing noise levels in the sensor are relatively low. This is true for sensors before and after the absorber.

Hits in x co-ord for layer directly before (3) absorber and directly after (4) show a definite spread in beam when compared to first layer.

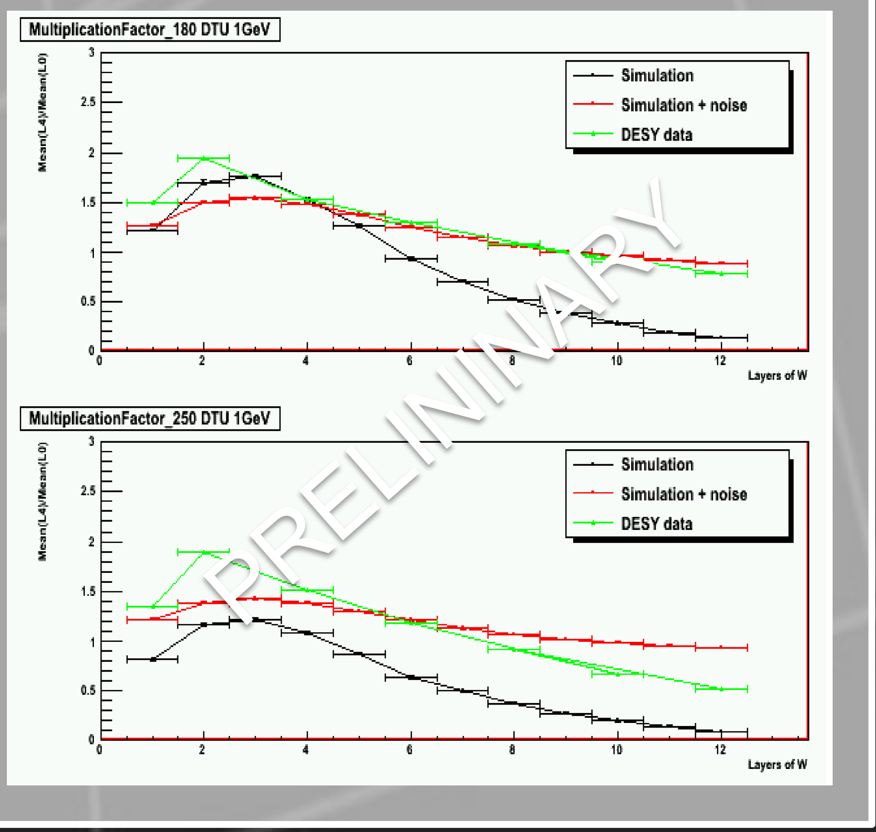




The track from first four layers is projected through the absorbing material to get the shower centre in the downstream sensors.

Noise tracks are reduced by a factor of 20,000 by requiring clusters in more than one sensor.

For 180 DTU simulation + noise agrees with data at >5 Tungsten layers but there is poor agreement at 250 DTU. The higher threshold runs agree with the particle multiplication peaking between two and four Tungsten layers but the actual peak value is higher than simulation. For 180 DTU the peak value from DESY is in better agreement.



Future Work

To achieve the goal of measuring shower density from DESY the treatment of noise in the simulations needs to be improved, digitisation needs to be implemented, and the downstream sensors need to be accurately aligned to find the shower centre. It will also be interesting to look for the effect of changing the absorbing material and utilising all of the data taken.