Application for Transnational Access to the DESY Testbeam and usage of the EUDET telescope

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Multiple scattering and photo-conversions are the main sources of background at the planned International Linear Collider (ILC). The material per measurement layer is a crucial parameter if multiple scattering is not to spoil the measurement of track angles. Thin layers of silicon plus supports can be realised with a material budget of ∼0.1% radiation lengths (X_0) provided the required power can be restricted to sufficiently low levels so that liquid cooling is not required.

In the UK the "Low-mass Support Structures for Silicon Detectors" project is aiming to develop these very thin supports from SiC foams with 3 to 8% relative density. This work is not only of high importance for the ILC, but also CMS and ATLAS have expressed an interest for their upgrade programmes.

1 Introduction

The ILC will be colliding electrons with positrons up to a centre of mass energy of 500 TeV allowing precision measurements of the standard model and what may lay beyond it. One of the major physics goals is the measurement of the Higgs boson, should it be found to exist by the LHC. A disadvantage of a pp-collider is the composite nature of the proton, which makes it hard to know the initial states to a high precision, unlike in a e^+e^--collider. With this extra information precision measurements of the decay modes of unstable particles, such as the Higgs, and hence how they interact can be made. These measurements can be compared to standard model predictions allowing the theory to be tested. One measurement that can be made is the branching ratio which is the fraction of all decays leading to one particular final state. To measure any branching ratio the final states of the decay products need to be identied. If these modes are to be measured excellent flavour tagging is required. One condition needed to attain this is high impact parameter resolution. The resolution of the impact parameter is dependent on the spatial resolution of the sensor, the geometry and the material of the detector and can be approximated by

$$\sigma = \sqrt{a^2 + \left(\frac{b}{p \sin^{\frac{3}{2}} \theta}\right)^2} \tag{1}$$

Where a is dependent on the resolution of the sensor, the layout of the detector and its stability and b is dependent on multiple scattering and θ is the angle under which the particle enters the sensor. The multiple scattering angle θ is approximated Gaussian distributed with a width of

$$\theta_0 = \frac{13.6\ MeV}{\beta c p} z \sqrt{\frac{x}{X_0}} \left[1 + 0.038 \ln \frac{x}{X_0}\right] \tag{2}$$

where p, βc, and z are the momentum, velocity, and charge number of the incident particle, and x/X_0 is the thickness of the scattering medium in radiation lengths.

2 Low mass materials

For the ILC thin layers of silicon plus supports are foreseen with a material budget of ~0.1% radiation lengths (X_0). One way of achieving this is to make ladders from foam materials. In figure 1 a photograph of a SiC foam is shown with 8% relative density corresponding to a X_0 of 108.7 cm. For comparison the X_0 of Beryllium is 35.4 cm.
We have produced ladders of this low mass material and are in the process of studying their behavior.

3 Simulation studies

In most full detector simulations, the material is spread out evenly and for every track scattering on the average amount of material is used. The question arises whether this is actually accurate for these very low relative density materials. The particles only very seldomly see a strut of the foam. Very naively one would simulate this by adding a percentage of scattering in Si and scattering in C. For a foam of relative density 8% (with 66% Si and 34% C) the radiation length is approximately 93 cm. This is calculated in Geant4 using the information of the elements along with the percentage of each, the scattering angle is 0.40 degrees for 1 GeV electrons passing through 250 mm of foam. When modelling this in Geant4 using small steps

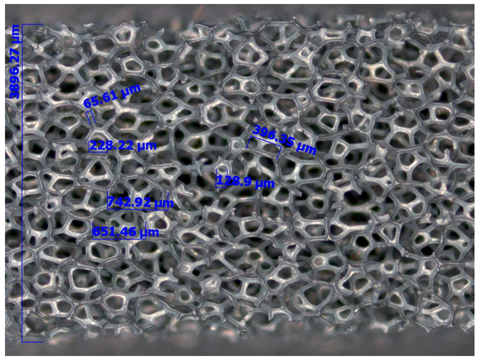

Figure 1: *Microfilm of SiC foam of 8% relative density.*

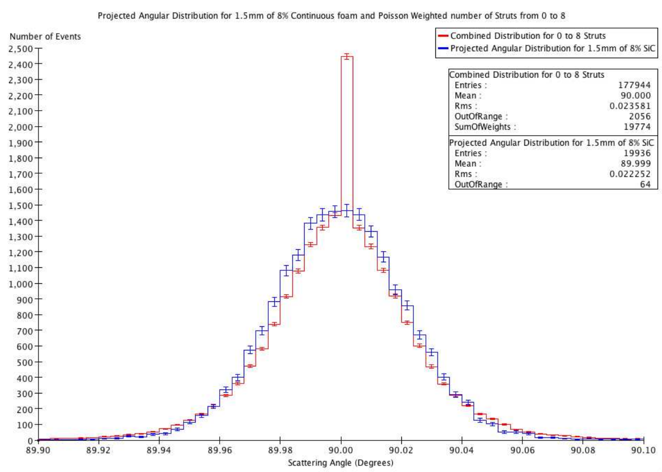

Figure 2: *Angular scattering distribution obtained considering every individual strut in the material.*

a value of 0.43 was obtained.
A more realistic simulation should be obtained by considering every strut in the material individually. Some tracks will not hit any material and some will hit up to 8 struts over 1.5 mm thickness. The resulting angular distribution can be seen in figure 2. There are much more undeviated particles compared to a naive simulation.

4 Proposed measurements

Clearly, the result using a naive simulation yields different results from considering every individual strut. We have requested a week of beam time to

measure the angular scattering of our foam material.
We will place large pieces of foam with varying density inside the EUDET telescope and measure the angular deviation of each track. We will compare it with thin pieces of material with a known X_0 and air.
As θ_0 depends on the momentum, we will perform an energy scan using the DESY electron beam.
These measurements will reveal whether the naive simulation is good enough to describe this complicated material.

5 Beam test request

LowMass has been granted 1 week of beam time at the DESY beam test facility starting Thursday the 11th of March 2010. We request usage of the EUDET telescope. The telescope is needed to provide precision tracks to reconstruct the scattering angles. We also request travel support for 5 people for 9 days to come to DESY and take the data.
We also request to rent a van to transport the LowMass, the FORTIS and the TPAC equipment. This is the easiest, cheapest and safest way of transporting our equipment In this aplication we ask for half of the rental costs which comes to 800 Euros.

So the total estimated cost for this beam test are 3900 Euro including the rental of the van. This is calculated based on staying in the DESY hostel and a per diem of 25 Euros.