A Large Scale Prototype for a SiW Electromagnetic Calorimeter for the ILC - EUDET Module

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The CALICE collaboration is preparing large scale prototypes for highly granular calorimeters for detectors to be operated at the International Linear Collider, ILC. During the year 2010/2011 a prototype of a SiW electromagnetic calorimeter will be assembled which in terms of dimensions and layout meets already most of the requirements given by the ILC Physics Program and hence the detector design. In particular the very front end electronics will have to fit within alveolar layers with less than 1 cm in height. In this contribution the design of the prototype is presented and the steps towards the realisation will be presented.

1 Introduction

The next major worldwide project in high energy particle physics will be a linear electron positron collider a the TEV scale. This machine will complement and extend the scientific results of the LHC currently operated at CERN. The most advanced proposal for this linear collider is the International Linear Collider (ILC). Here, electron and positrons will be collided at centre-of-mass energies between 0.2 and 1 TeV. The detectors which will be installed around the interaction point are required to achieve a jet energy resolution of $30\%/\sqrt{E}$, thus a factor two better than the energy resolution achieved for a typical detector at LEP. The reconstruction of the final state of the e^+e^- will be based on so-called particle flow algorithms (PFA). The goal is to reconstruct every single particle of the final state which in turn demands a perfect association of the signals in the tracking systems with those in the calorimeters. As a consequence this requires a perfect tracking of the particle trajectories even in the calorimeters. To meet these requirements the detectors have to cover the whole solid angle and have to feature an unprecedented high granularity.

2 Towards a Technological Prototype for the SiW electromagnetic calorimeter

The application of PFA requires a perfect reconstruction of the particle trajectories in the calorimeter. For this the calorimeters have to be placed inside the coil of the super-conductive solenoid of the detectors. This puts tight constraints on the available space for the installation of the detectors. The design of the detector components and notably of the calorimeters have to take the following guidelines into account

- Optimisation of the number of calorimeter cells.
- Choice of the absorber material and the infrastructural components such as cooling, power supplies, readout cables and the very front end electronics.

For the electromagnetic calorimeter which surrounds the tracking chambers these criteria has lead to the choice of tungsten with a radiation length of X_0=3.5 mm,a Molière of R_M=9 mm and an interaction length of λ_I=96 mm.In the years 2005 and 2009 the CALICE collaboration has performed a test beam campaign at DESY, CERN and FNAL in order to demonstrate the principle of highly granular calorimeters and to confront the concept of Particle Flow with real data. The first results of the data analysis have been published in three articles [1, 2, 3]. The next prototype, also called EUDET Module, has been conceived during the year 2008 and enters now its construction phase. It addresses, more than the first prototype, the engineering challenges which come along with the realisation of highly granular calorimeters. The key parameters of the new prototype are

- Size of an individual cell of 5.5x5.5 mm^2.
- A depth of 24 X_0.
- Thickness of an individual layer of 3.4 mm and 4.4 mm according to the position within the calorimeter.

The Figures 1 and 2 show the mechanical housing and a cross section through two calorimeter layers which form a slab. The mechanical housing is realised by a tungsten carbon composite, which provides at the same the absorption medium and the mechanical rigidity of the detector. The silicon wafers are composed of high resistive silicon. While in principle the manufacturing of these wafers is a well known technique the challenge is to produce these wafers at small price in order to reduce the cost since a surface as large as 3000 m^2 will be needed for an ILC detector. The final calorimeter will comprise around 10^8 channels in total. In order to reduce the non-equipped space in the detector the very front end electronics (VFE) has to be integrated into the calorimeter layers, see Figure 2, which constitutes a major challenge for the construction of the calorimeter. The room available for the readout circuits (ASICs) and the interface boards between the ASICs and the silicon wafers is about a millimeter.

Each of the ASICs of the new prototype will readout 64 calorimeter cells and realises the measuring of the analog signal, the digitisation and the zero suppression such that only a limited number of channels are finally send to the data acquisition which is based on custom made components in order to allow for the employment of large quantities at reasonable prices for the experimentation at the ILC detector.

Due to the limited space available for cooling devices the heat dissipation of the ASICs has to be minimised. In addition to the cooling, the heat dissipation will be reduced by a novel technique called ”Power Pulsing”. Here, the VFE will only be switched on during the millisecond of a bunch train of particles. Such a bunch train contains about 3000 particle bunches separated by around 300 ns. During the around 200 ms between these bunch trains, the electronics will be switched off. Clearly, this novel technique will require detailed studies in order to assure that the signal quality of each channel remains constant after each powering cycle. The first ASICs which incorporate the power pulsing will be realised during 2009 and examined during the year 2010.

A calorimeter layer will have a length of about 1.5 m and will be composed by several units which carry silicon wafers as well as the VFE. The challenge is to integrate this fragile assembly into the alveolar structure which houses the calorimeter layers. The integration cradles are under development and a first integration test with a demonstrator has been successfully conducted in October 2010.

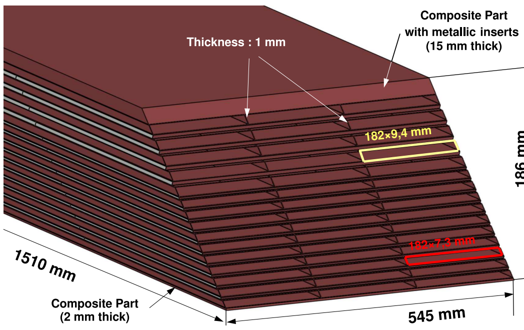

Figure 1: *Alveolar structure and its dimensions which houses the sensitive parts of the CALICE SiW electromagnetic calorimeter prototype.*

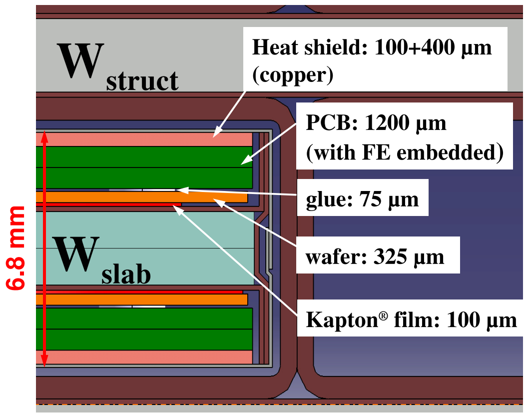

Figure 2: *Cross Section through a slab for the CALICE SiW electromagnetic calorimeter prototype.*

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3 Bibliography

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