Laboratoire Leprince-Ringuet

ILD Silicon-Tungsten Electromagnetic Calorimeter Full Scale Prototype

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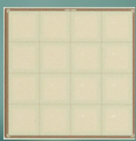
The "long slab" is a new prototype for the SiW-Ecal, a silicon tungsten electromagnetic calorimeter for the ILD detector near the future International Linear Collider. This prototype has been designed to demonstrate the ability to build a full-length detecting layer (1.60m for the ILD barrel) while relaxing the mechanical constraints, reveal difficulties and test solution to ensure clock and signal propagation and data integrity. Using EM simulation, the design initially optimised for short length slabs has been adapted. The long slab performance has been evaluated with cosmics, radioactive sources and with 3 GeV punch-through electrons in beam tests at the DESY facility, Hamburg; channel-wise calibration has been achieved, for normal and various incidence of the beam. With the latter, using the statistics and signal of particles traversing two adjacent pixels we could estimate the absolute value of the trigger threshold in units of mips. This new prototype provides us many hints on how to improve the design of the front-end electronics. It is also a convenient tool to estimate the critical characteristics of ILD SiW-Ecal (like power consumption, cooling, readout time, etc.) and to optimise the future design of the detector.

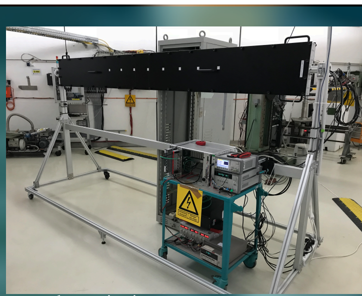
The long slab in the workshop

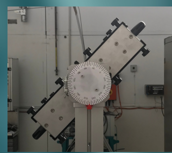
- First operational prototype for the Silicon-Tungsten Electromagnetic Calorimeter for the ILC/ILD
- Assembly of 8 ASU (detection units) of 180x180 mm²
- Equipped with baby wafers : 4x4 pixels silicon detectors (20x20 mm²)
- Typical size of a detecting layer in the barrel of the ILD
- Relaxed mechanical constraint (final detector) on thickness and spacing to gain ease of access and part replacement

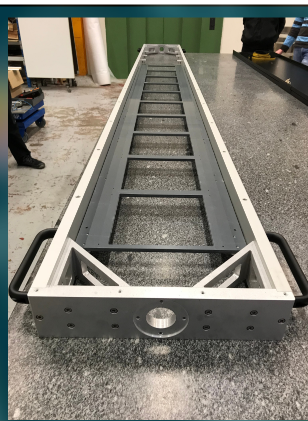
Goal : testing the extensibility of the detection unit



Baby-Wafer 4x4 pixels

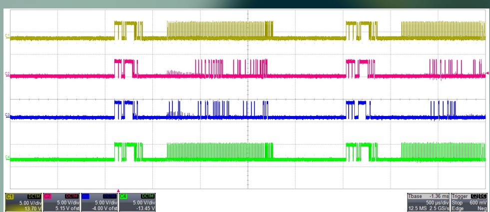






A dedicated mechanical structure

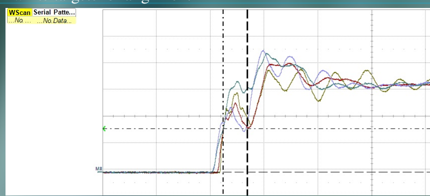
- Mechanical rigidity (1mm for 3m) to ensure sound operation in various conditions
- Shielding to ensure EMC and avoid light induced noises
- Directionnal blockable wheels
- Coarse grain adjustment in height + fine grain adjustment by screw
- Rotation system with a 1° precision
- Black hood for light insulation
- white targets for alignment



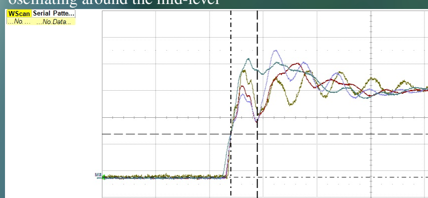
Due to electonic path length, reflections can appear especially on the clock lines. Some bits are missing in the configuration bitstream, generating inconsistency in measurements.

Future improvements

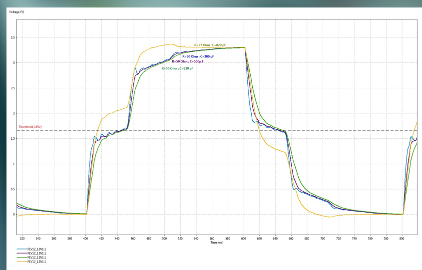
- Optimization of the clock lines to avoid reflection
- Adaptable impedance adaptation (depending on length)
- Use 4 partitions (for data & clocks)



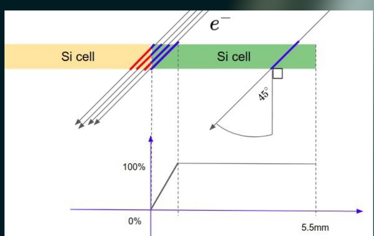
Configuration clock before adaptation : the level is oscillating around the mid-level



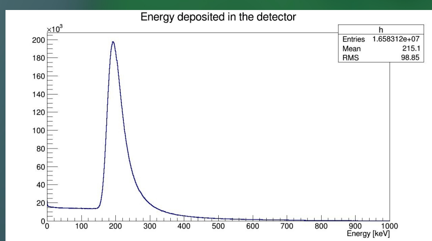
Clock line after adaptation with a RC filter : the oscillations are shifted above the mid-level



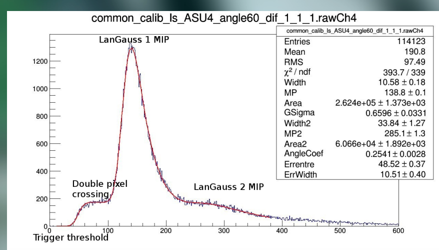
Sigrity Simulation of an isolated clock line (PCB physic specification + buffer characteristics) with different RC input filters : the yellow curve represents the choosen filter.



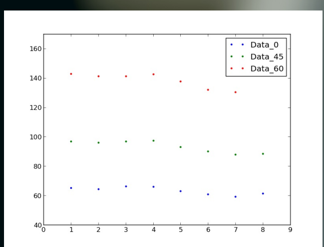
Angle effect : a particle can go through two different pixels adding a left component to the MIP spectrum.



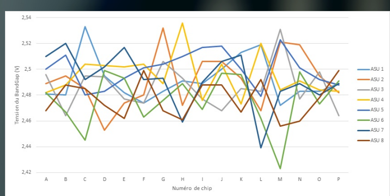
Geant4 Simulation of the double pixel crossing. This effect adds a left plateau to the Landau component.



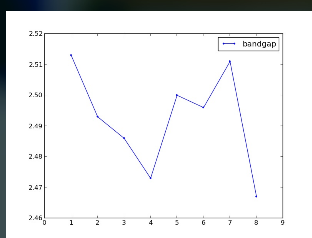
The energy deposit histogram can be fitted with 4 components :
- two Landau distributions convoluted with a Gaussian
- A plateau function to modelize the double pixel crossing
- An error function to modelize the trigger threshold



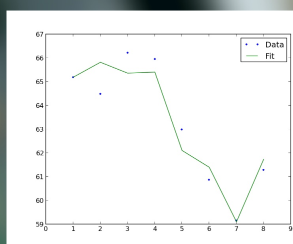
Fitted MIP MPv for the 8 ASU. The value is shifted by 1/cos(angle). All the curves show a common inflection on the length : ~10% of MIP value



The bandgap is a reference voltage for transistor polarization. Its fluctuations can explain a part of the MIP curve shape. As shown by this plot, the bandgap depends on the chip with no lenght effect (uniform random with RMS 0.19V)



Bandgap per ASU (cumulated variation of all ASICs on the ASU)



The observed inflexion can be fitted with a sum of a decreasing line (corresponding to power supply decrease) and bandgap multiplied by a constant factor.