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The highly granular Silicon-Tungsten Electromagnetic Calorimeter technological prototype for the International Large Detector.

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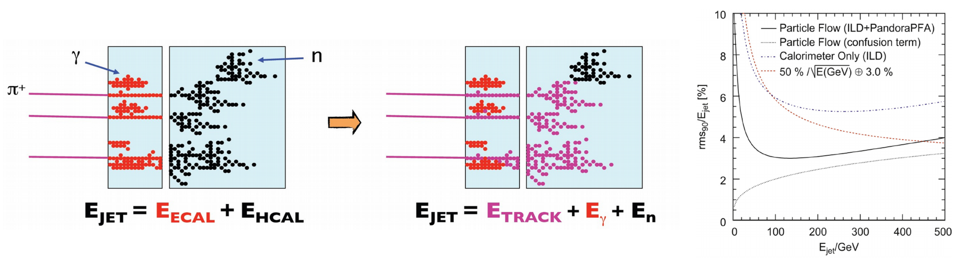
Particle Flow Calorimetry for future Linear Colliders

- **Particle Flow (PF)** is based on **high granularity calorimeter** to **identify single particles** and choose the better energy measurement of them.
- Compactness and full hermeticity is required.

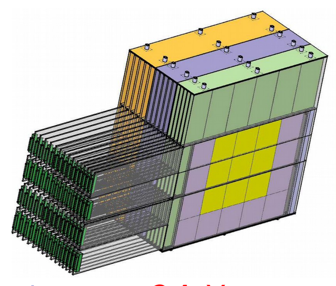


- This introduces several **technological challenges:**
  - Huge amount of cells requires auto-triggered front-end electronics (i.e. only the ECAL barrel will have 10^8 channels)
  - Hermeticity leaves litte space for digital readout and active cooling.
  - Power pulsed front-end electronics.
  - Self-supporting mechanical structures.

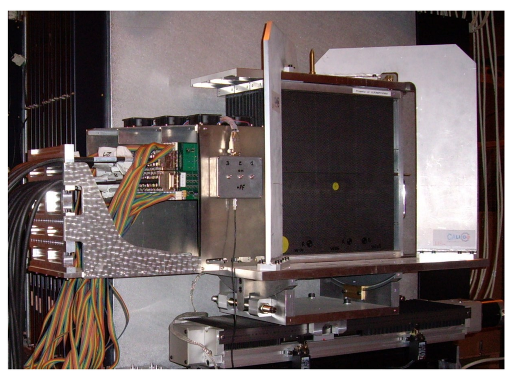
SiW-ECAL : an ECAL for ILC

Physics Prototype (2005-2009)

Validation of Particle Flow (running together with the Analogue HCAL of CALICE at Fermilab and CERN)

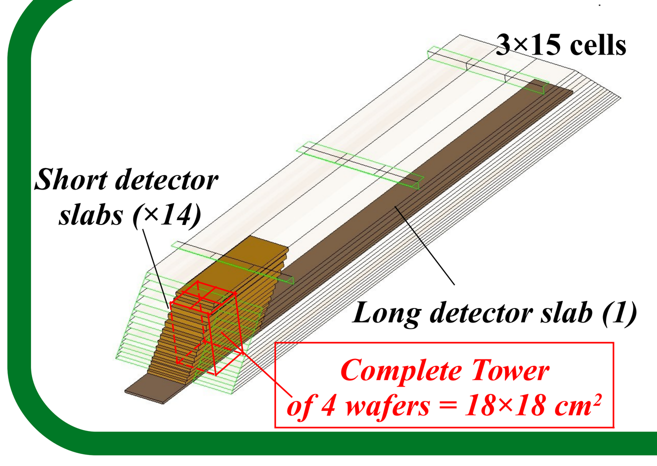


- 3 structures : 24 X_0 (10×1,4mm + 10×2,8mm + 10×4,2mm)
- Sizes : 380×380×200 mm3
- Thickness of slabs : 8.3 mm (W=1,4mm)
- VFE outside detector
- Number of channels : 9720 (10×10 mm²)
- Weight : ~ 200 Kg



Technological Prototype

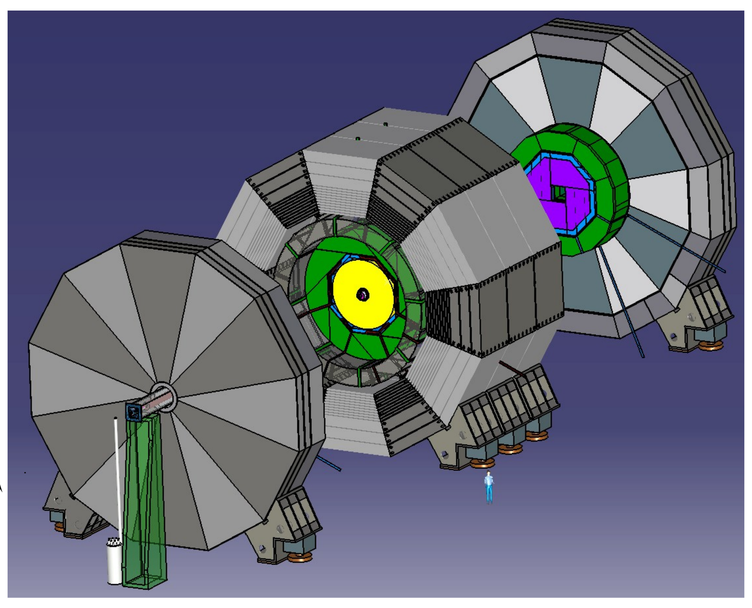
Establish the technology, provide shower data to test PF in deep, tune MonteCarlo models and address main technological challenges.



- 1 structure : ~ 23 X_0 (20×2,1mm + 9×4,2mm)
- Sizes : 1560×545×186 mm3
- Thickness of slabs : 6 mm (W=2,1mm)
- VFE inside detector
- Number of channels : 45360 (5×5 mm²)
- Weight : ~ 700 Kgstructures : 24 X_0

LC detector

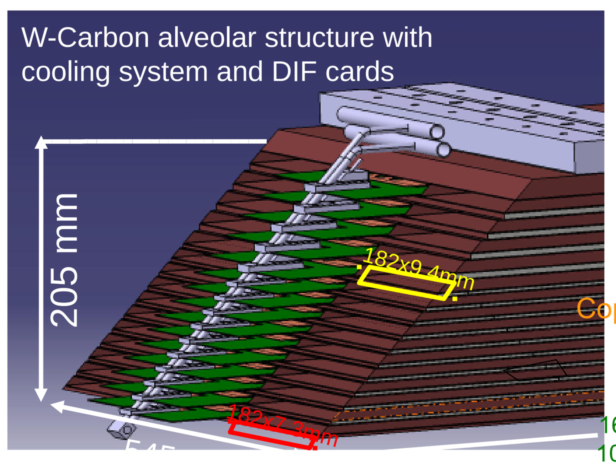
Combining Physics and Technological Prototype (see ILD poster by W. Oonari)



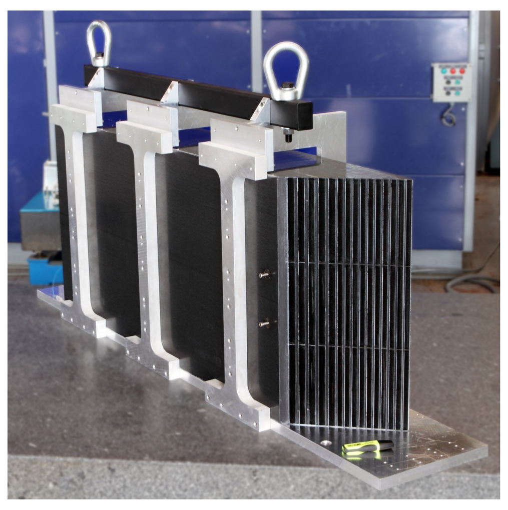
- Electromagnetic Calorimeter :
  - **Cells : 110 10⁶**
  - **Total Weight : ~130 t**

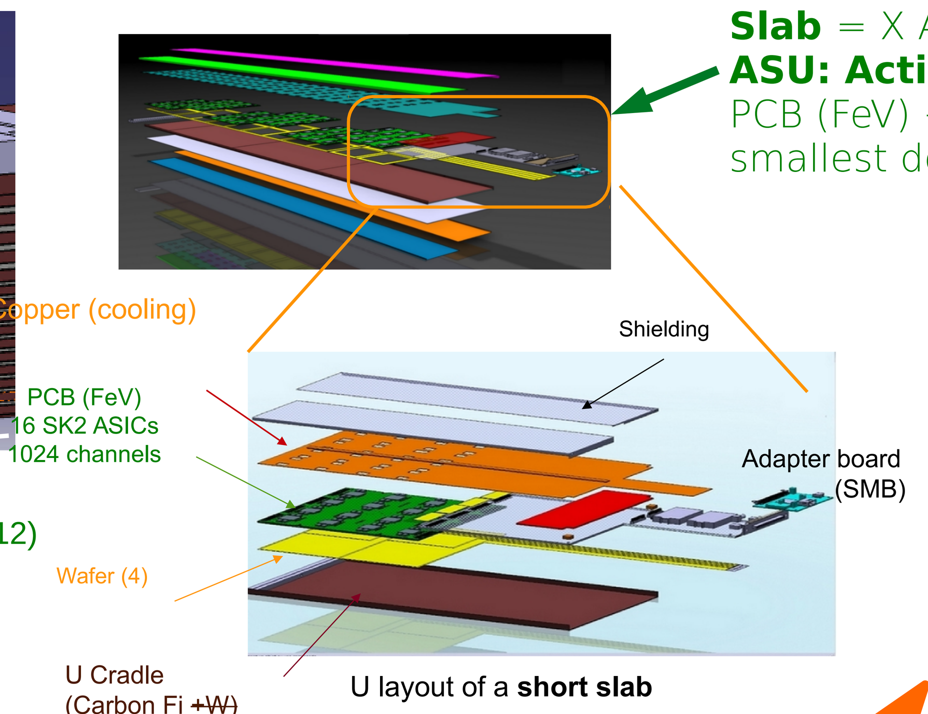
Calorimeters placed inside a magnetic coil

The SiW-ECAL technological prototype



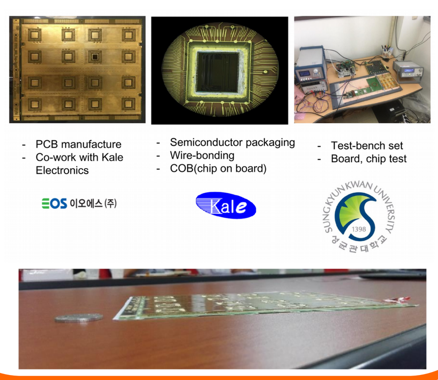
Alveolar structure (Completed 2012)





Slab = X ASU + front end electronics
ASU: Active Signal Unit. Consists in a PCB (FeV) + 16 ASICS and 4 wafers. Is the smallest detector module.

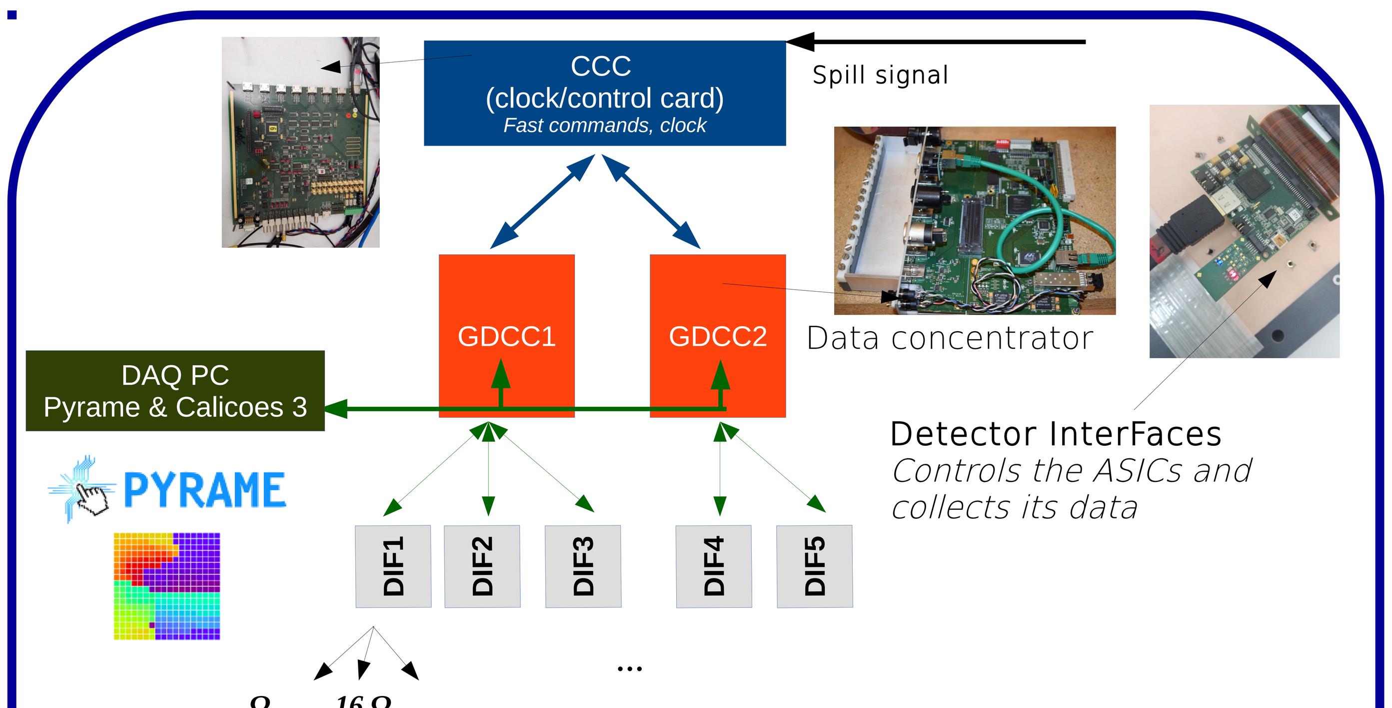
Investigating ultra thin PCB solutions (Chip On Board, COB):
Syst req. : 1.2mm max. thickness



Design guidelines :
compactness and full hermeticity

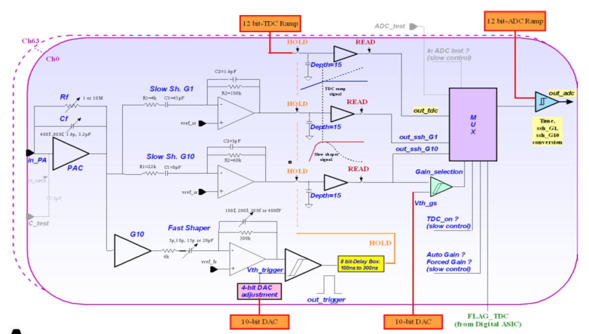
DAQ

Generic DAQ and concentrated Electronics



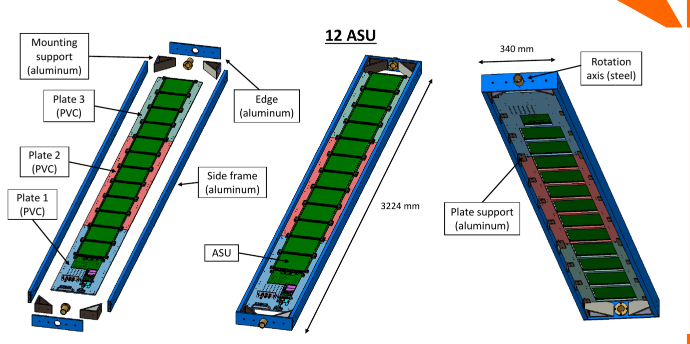
Detector InterFaces
Controls the ASICs and collects its data

- SKIROC2 is a 64-channel front-end chip
  - Dual gain charge ADC (1/10 factor)
  - Autotrigger chain → high gain fast shaper
  - 15 memory buffers.

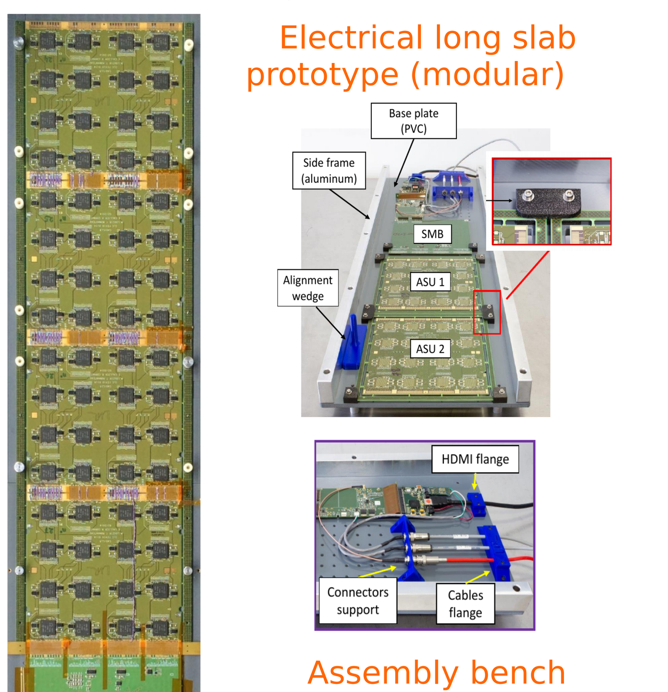


SiW-ECAL TP

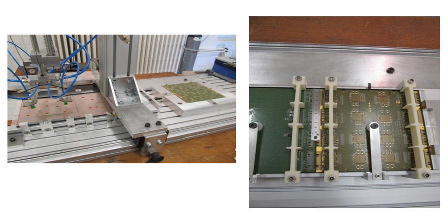
Long slabs of ~ 2m for the barrel region
: mechanical, electrical and electronical challenges.



Electrical long slab prototype (modular)



Assembly bench
→ towards mass production

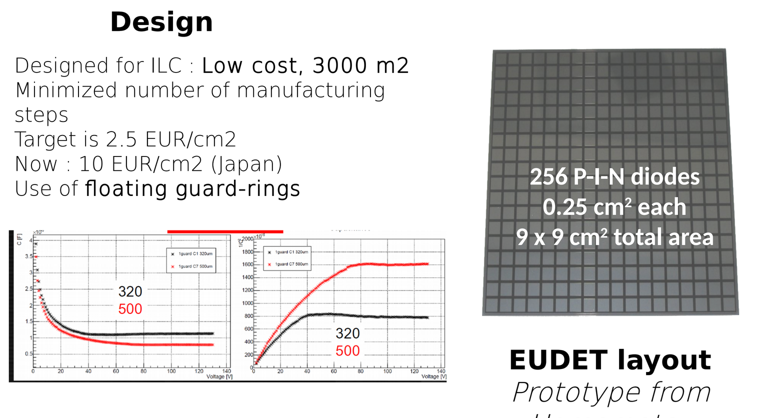


Interconnectivity as a major challenge

P-I-N Diodes Silicon Sensors

Design

Designed for ILC : Low cost, 3000 m2
Minimized number of manufacturing steps
Target is 2.5 EUR/cm2
Now : 10 EUR/cm2 (Japan)
Use of floating guard-rings

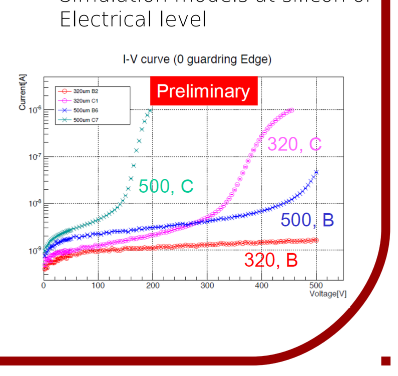


EUFET layout
Prototype from Hamamatsu

I(V) and C(V) characterization
Breakdown voltage >500V
Current leakage <4 nA/pixel (chip is DC coupled)
Full depletion at <100 V
(~40 V with 320 um, ~70 V with 500um)
Null C(V) slope to avoid dC/dV noise

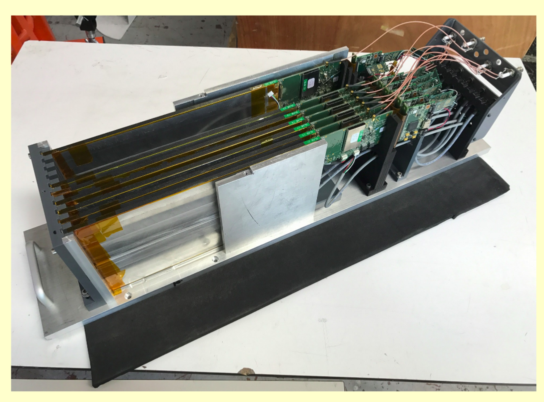
R&D on crosstalk
Segmented guard-rings layout as an option.
Simulation models at silicon or Electrical level

Integration
Glued on a PCB
Glue compatibility is studied
Automated procedure for glue deposition
256 glue dots, 75 µm thick, 3 mm diameter

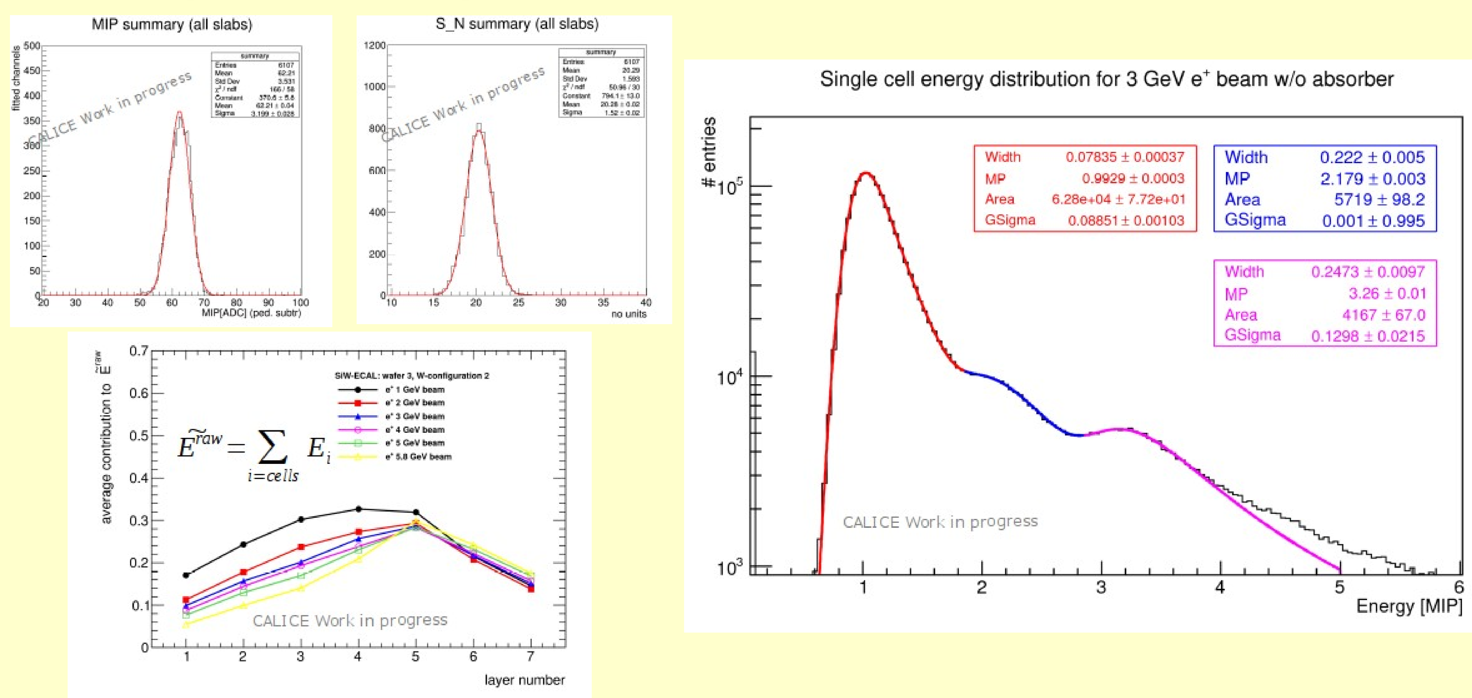


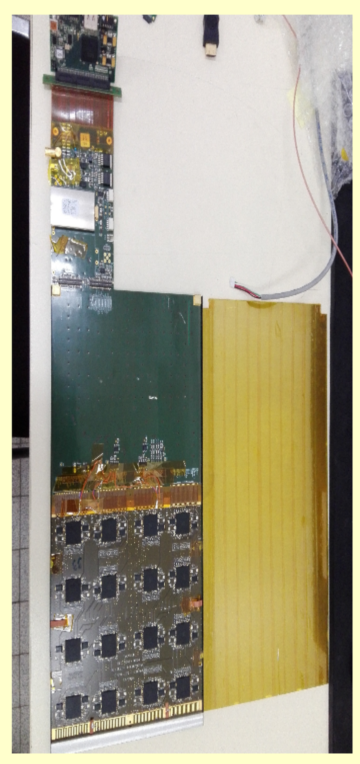
Performance in Beam Test

- **June 2017, TB24 1 & 2(PCMag) at DESY**
- 7 shorts slabs : 7168 channels
  - Running in PowerPulsing and ILC spill mode.



- **Calibration using 3 GeV positrons as MIPs.**
- **Run in Magnetic field (up to 1 T)** → no failures or loss of performance observed.
- **Tungsten Program** Positrons with energies 1-5.8 GeV





Very good S/N performance in all the SLABs with and without magnetic field : S/N ~ 20, calibration homogeneity per cell of 5 %
First peek at shower response looks very promising

Ready for analysis, more integration and data taking !

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