AIDA

Advanced European Infrastructures for Detectors at Accelerators

Presentation

SiW ECAL Technological Prototype - Test beam results

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SiW ECAL Technological Prototype
Test beam results

Thibault Frisson (LAL, Orsay)

on behalf of the CALICE collaboration

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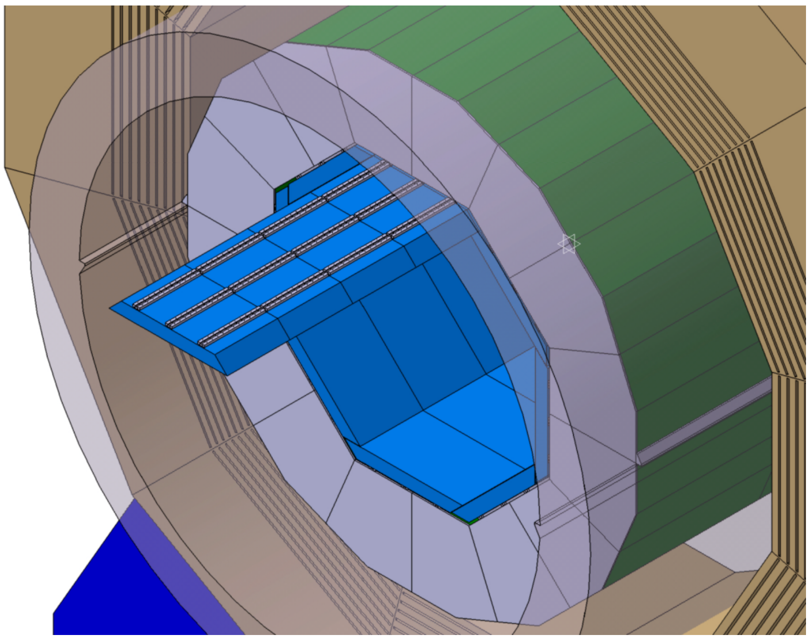
AIDA

Advanced European Infrastructures for Detectors at Accelerators

SiW ECAL for a future LC

SiW ECAL is one of the prototypes for future LC detectors

→ Optimized for Particle Flow Algorithm:



The SiW ECAL in the ILD Detector

Basic Requirements:

- Extreme high granularity
- Compact and hermetic

Basic Choices:

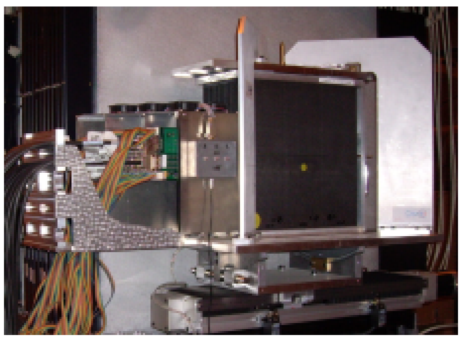
- Tungsten as absorber material
  - X_0=3.5mm, R_M=9mm, λ_I=96mm
  - Narrow showers
  - Assures compact design
- Silicon as active material
  - Support compact design
  - Allows for pixelisation
  - Large signal/noise ratio

SiW ECAL R&D

Physics Prototype

Proof of principle

2003 - 2011



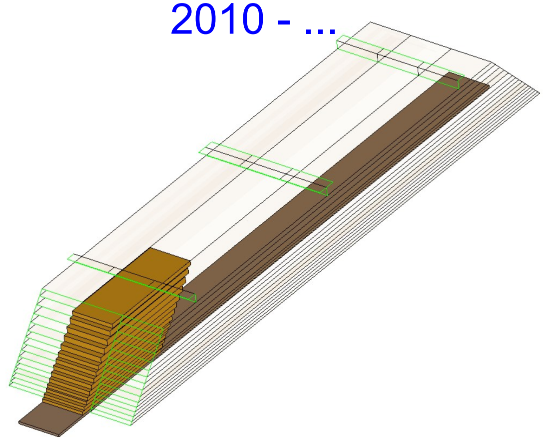
Number of channels : 9720

Weight : ~ 200 Kg

Technological Prototype

Engineering challenges

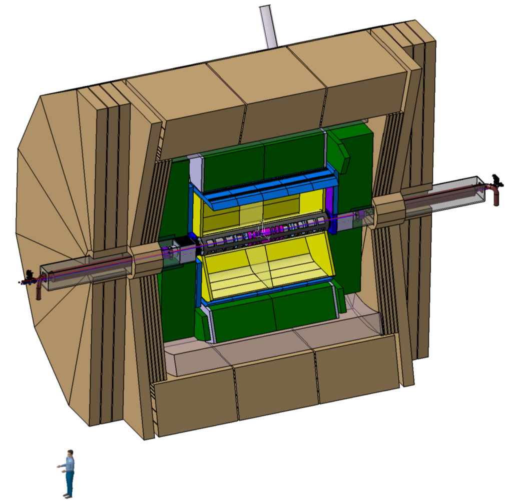
2010 - ...



Number of channels : 45360

Weight : ~ 700 Kg

LC detector



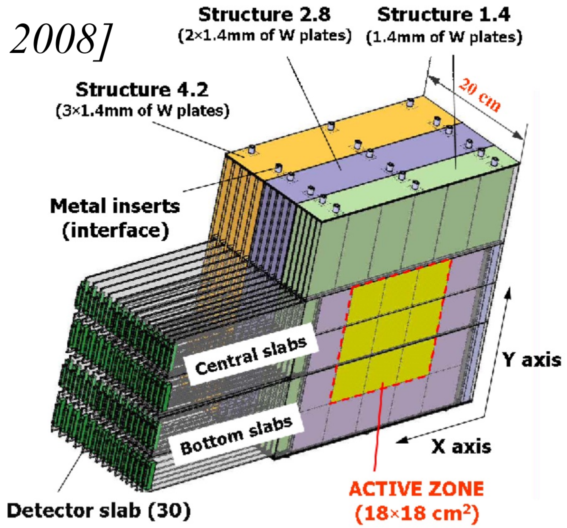
ECAL :

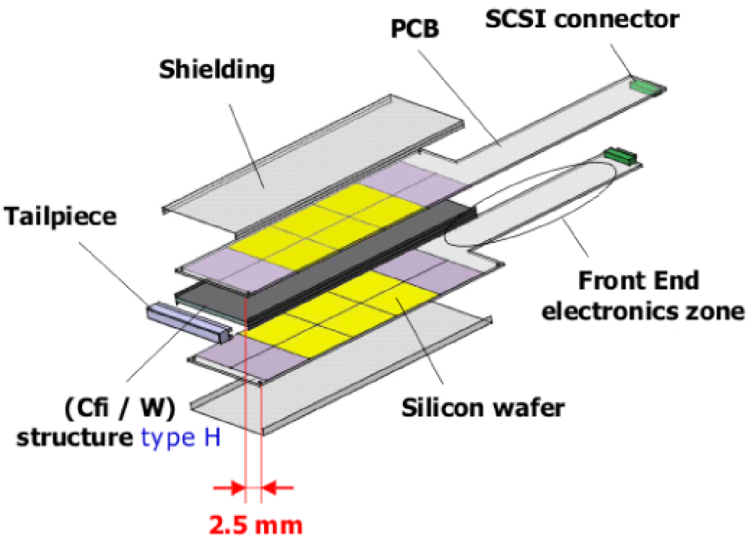
Channels : ~100 10^6

Total Weight : ~130 t

Physics prototype

[JINST 3, 2008]





Carbon-fibre mechanical structure

30 layers of tungsten: 24 X_0, 1 λ_I

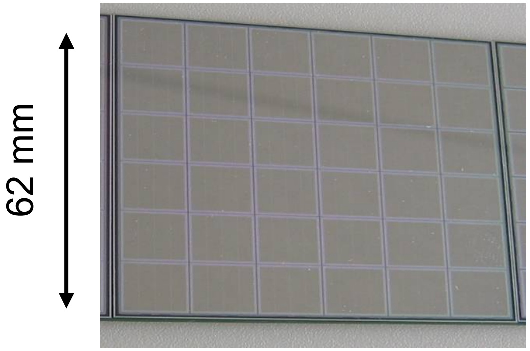
S/N ~ 8

$\sigma_E / E = 16.5/\sqrt{E(\text{GeV})} + 1.1\ \%$

10k channels

6x6 PIN Diode Matrice – **1 x 1 cm²**

Résistivity: 5kΩcm - 80 (pairs e/hole)/μm



Thickness:

525μm

➡ Studied in various test beam facilities

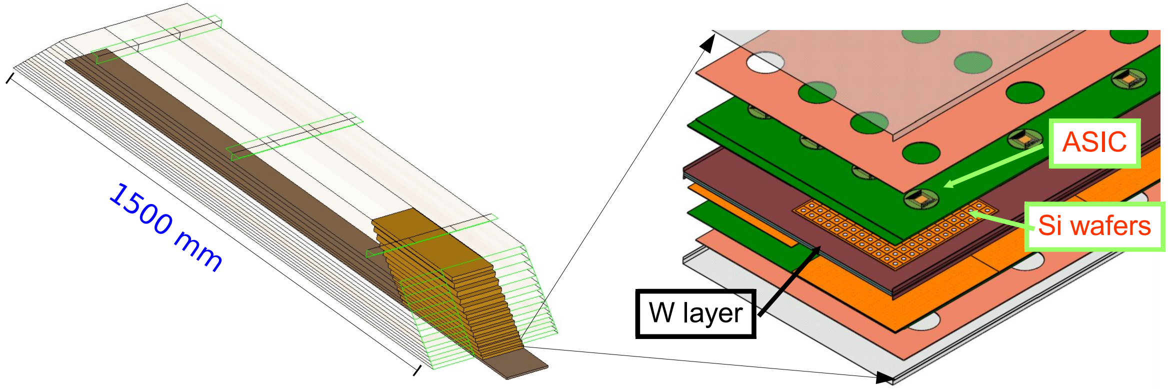
2006-2011: DESY, CERN, FNAL, e-, π, μ, p (1 → 180 GeV)

Technological prototype

Technological solutions for the final detector

Construction start: 2010

Test beam: 2012



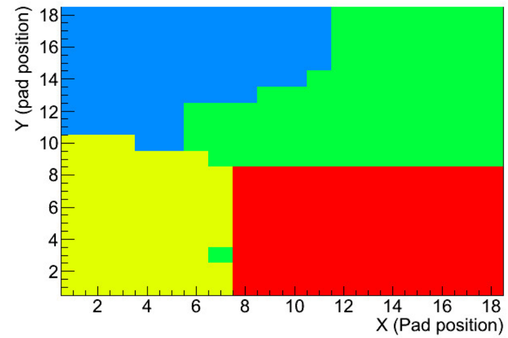
- Realistic dimensions
- Integrated front end electronic
- Small power consumption (Power pulsed electronics)

The road to the technological prototype

Intermediate step: (See Rémi Cornat's Talk)

➡ First test in beam

➡ Benchmark to go further



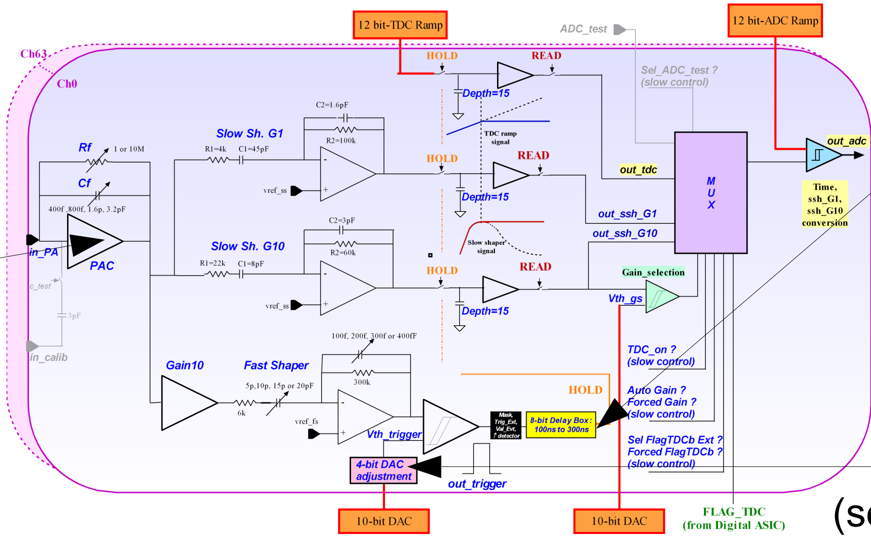
- U structure (single detection layer per slab)
- Si wafer:

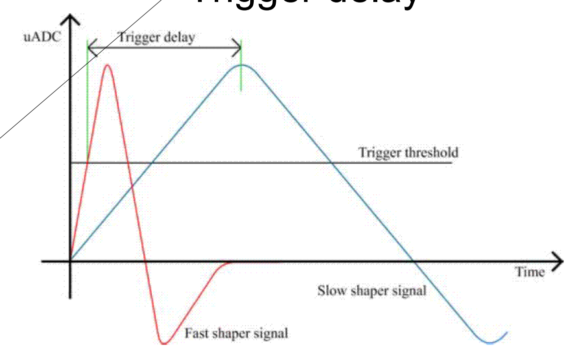
  9x9 cm^2 – Thickness = 320 µm

  pixel size: 5x5 mm^2 :lateral granularity = 4 x better than physics prototype
- SKIROC2 ASICs
- 4 ASICs per slab (1⁄4 final design)

  4 SKIROCs x 64 channels = 256 channels/slab

Trigger delay





Preamplifier (adjustable gain)

Internal trigger (self-triggering capability)

First test beam with the technological prototype

DESY – April and July 2012

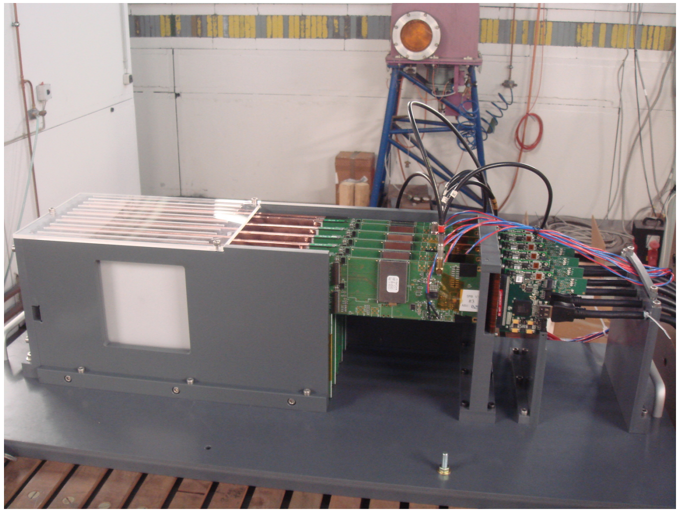
e- (1 - 5 GeV)

- 6 layers (FEV8)
  - Internal trigger

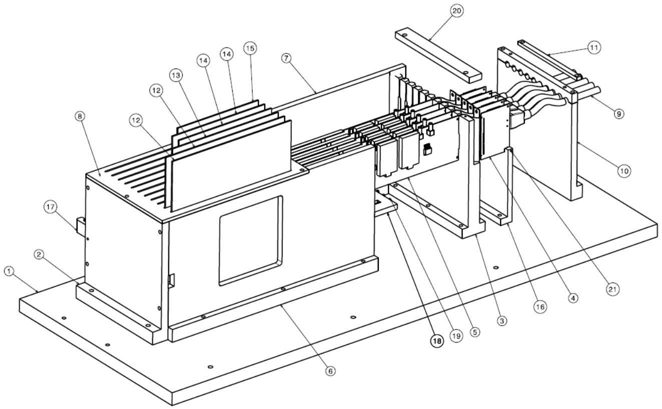
Total = 1536 channels

PreAmplifiers of noisy channels are switched off

total active channels = 1278



- PVC structure
  - position for tungsten plates (2.1 mm)



Goals:

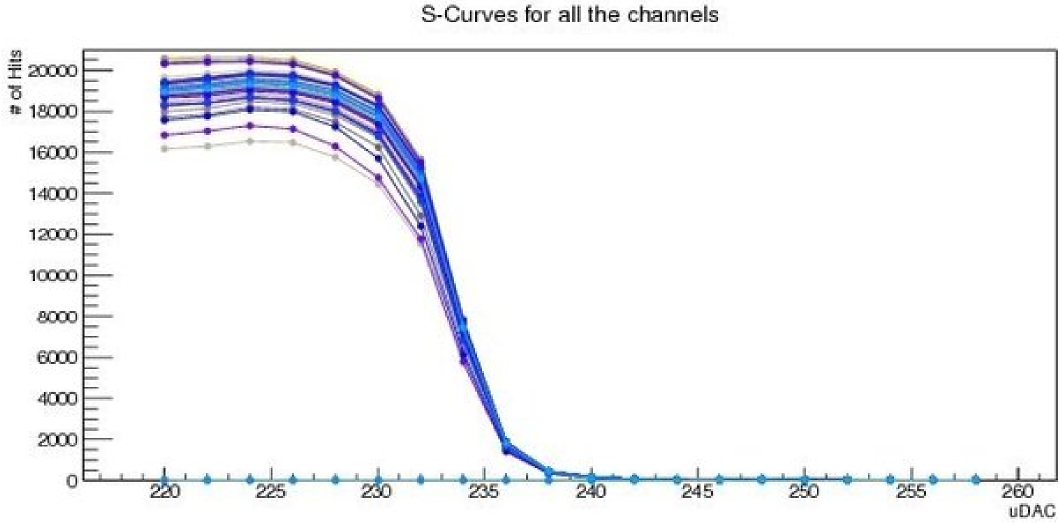
- **Determine signal over noise ratio of the detector**
- Operate first layers of the technological prototype
- Establishment of calibration procedure for a large number of cells
- Homogeneity of response (x,y scan of detector)

Calibration of ASICs

Establishment of calibration procedure for a larger number of cells

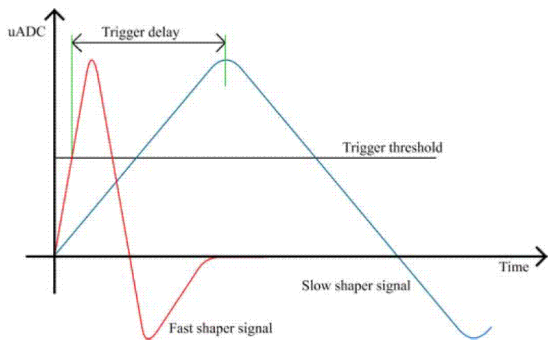
Trigger threshold

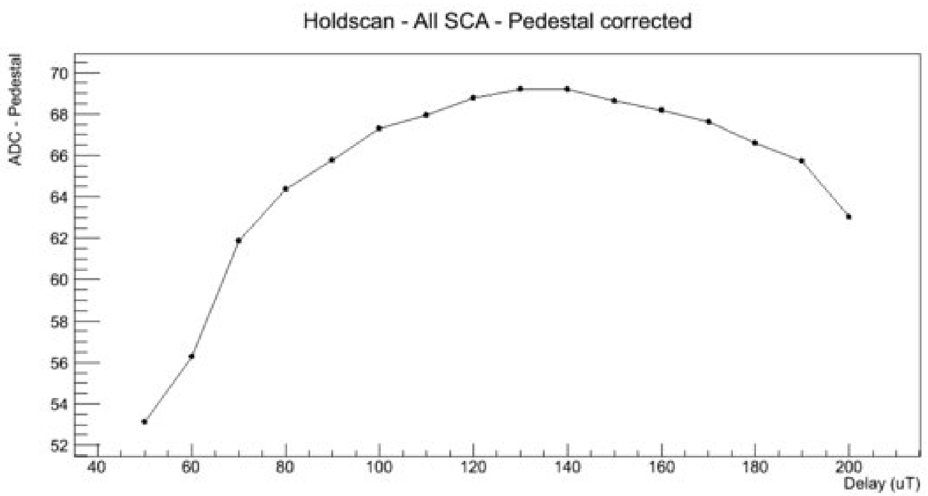
- depends on the gain



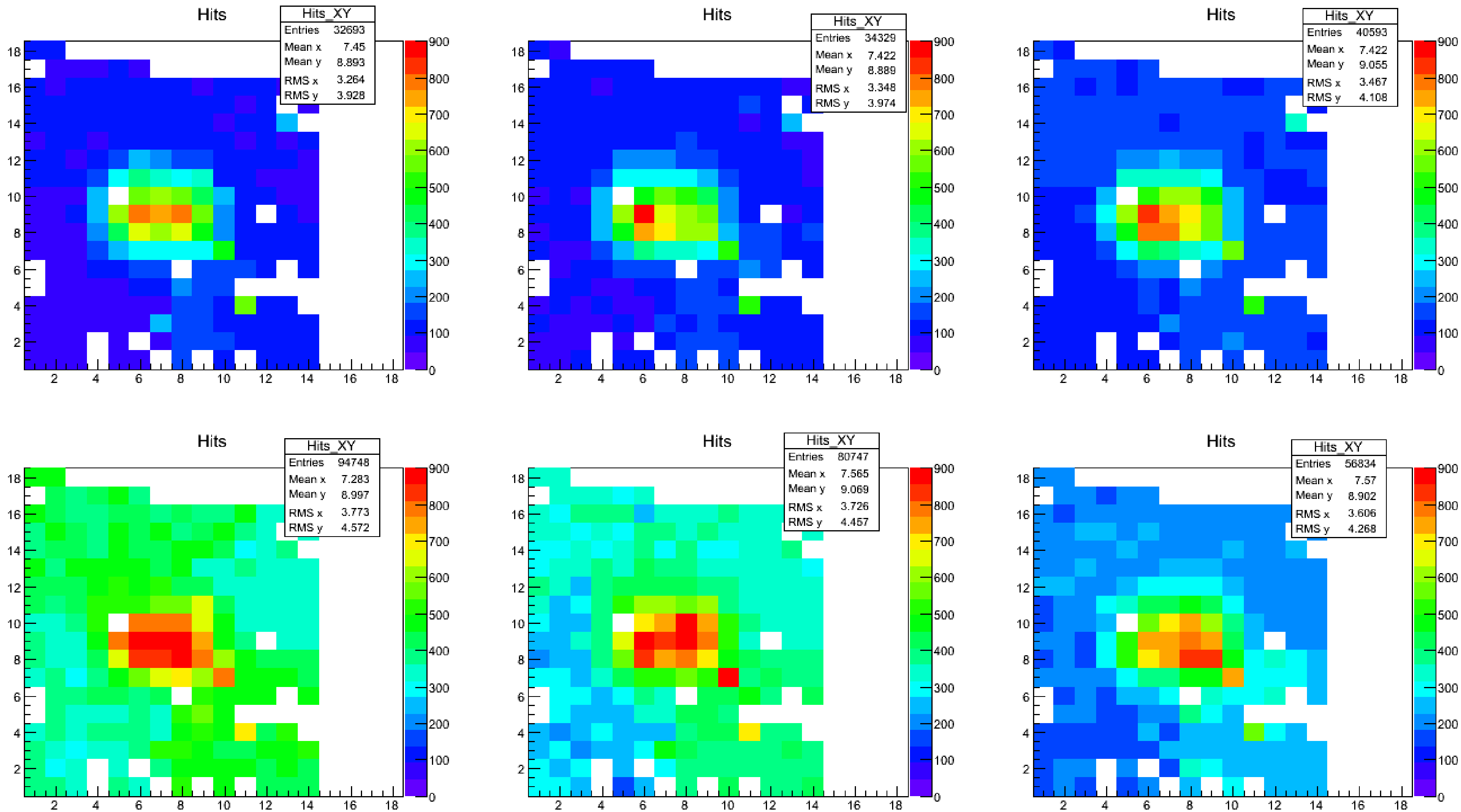
Trigger delay

- depends on the trigger threshold





Beam spot



Hits
Hits_XY
Entries 32693
Mean x 7.45
Mean y 8.893
RMS x 3.264
RMS y 3.928
Hits
Hits_XY
Entries 34329
Mean x 7.422
Mean y 8.889
RMS x 3.348
RMS y 3.974
Hits
Hits_XY
Entries 40593
Mean x 7.422
Mean y 9.055
RMS x 3.467
RMS y 4.108
Hits
Hits_XY
Entries 94748
Mean x 7.283
Mean y 8.997
RMS x 3.773
RMS y 4.572
Hits
Hits_XY
Entries 80747
Mean x 7.565
Mean y 9.069
RMS x 3.726
RMS y 4.457
Hits
Hits_XY
Entries 56834
Mean x 7.57
Mean y 8.902
RMS x 3.606
RMS y 4.268

Detection efficiency

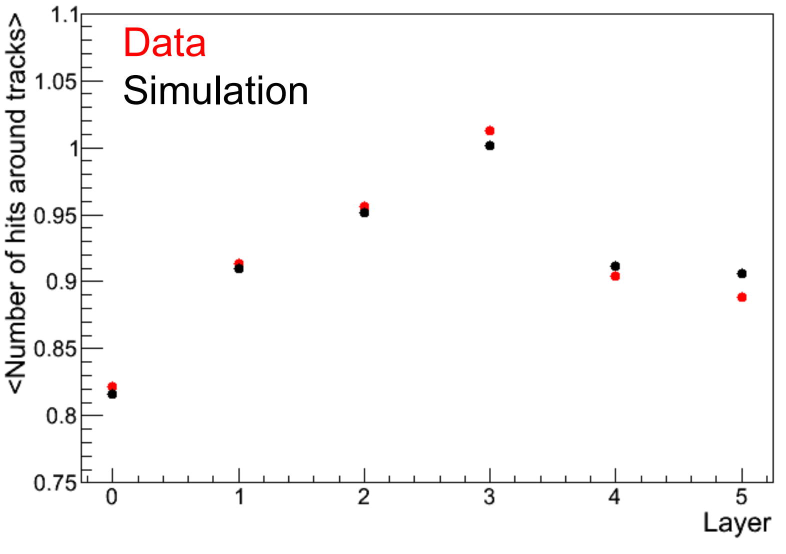
Data: 3GeV – No W – XY scan
Total number of events: $2{,}3.10^6$
Track selection:

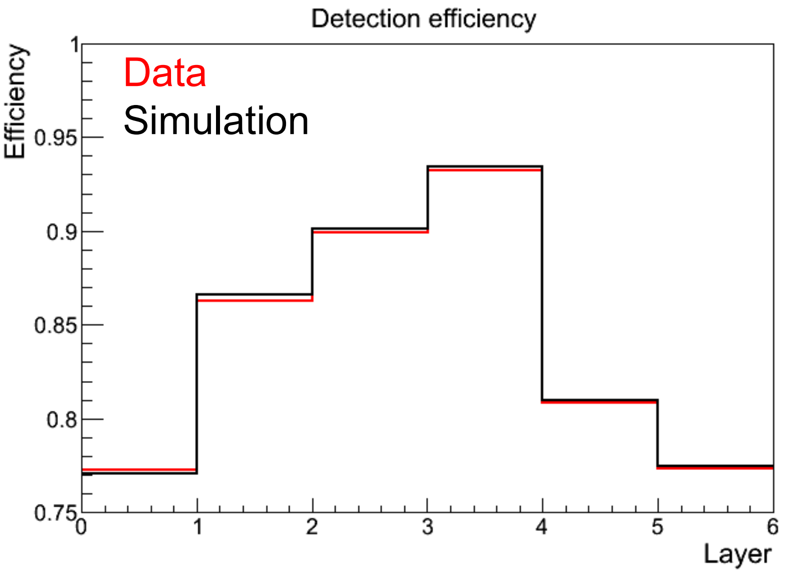
- At least 3 layers with hits
- Linear fit of the e- track
- Nhits<10

Inefficiencies due to:

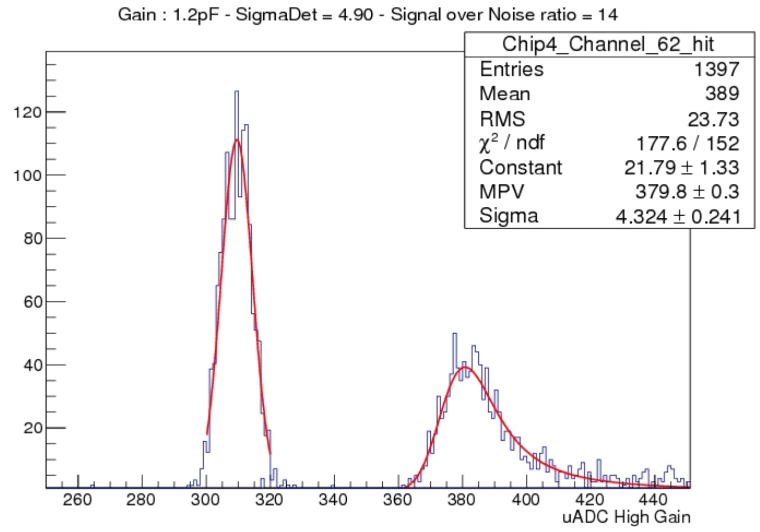
- Switched off channels
- Too high trigger thresholds (80%-95% of the MIP)

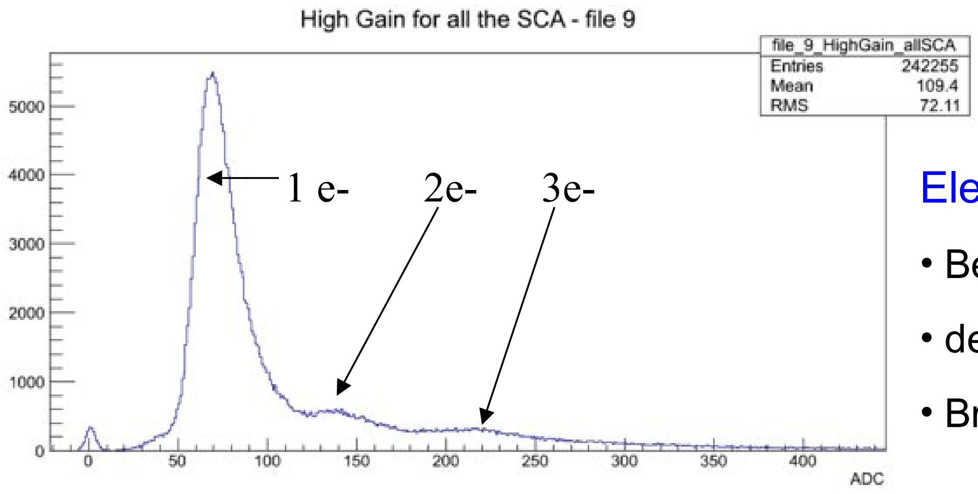
➡ Should be improved with the next test beam (December)





Energy measurement





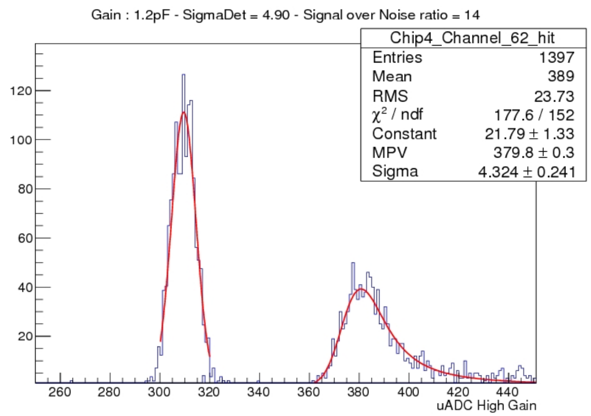
Electron sources:

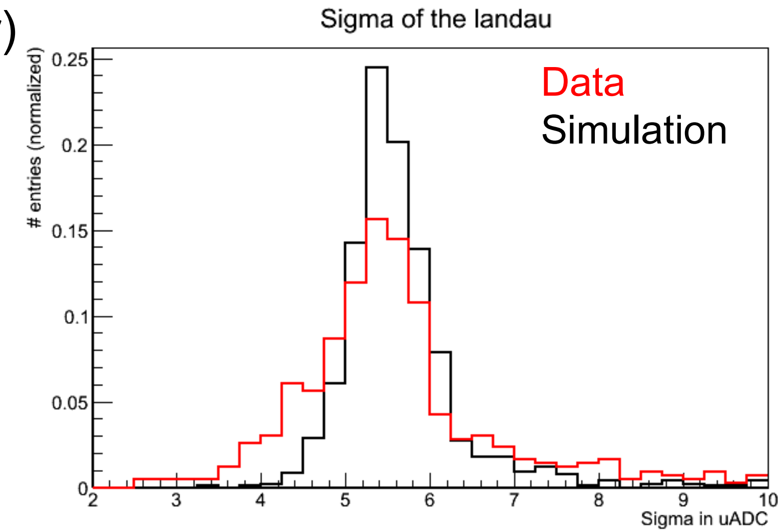
- Beam
- delta rays
- Bremsstrahlung + gamma conversion (2e-)
  + Compton

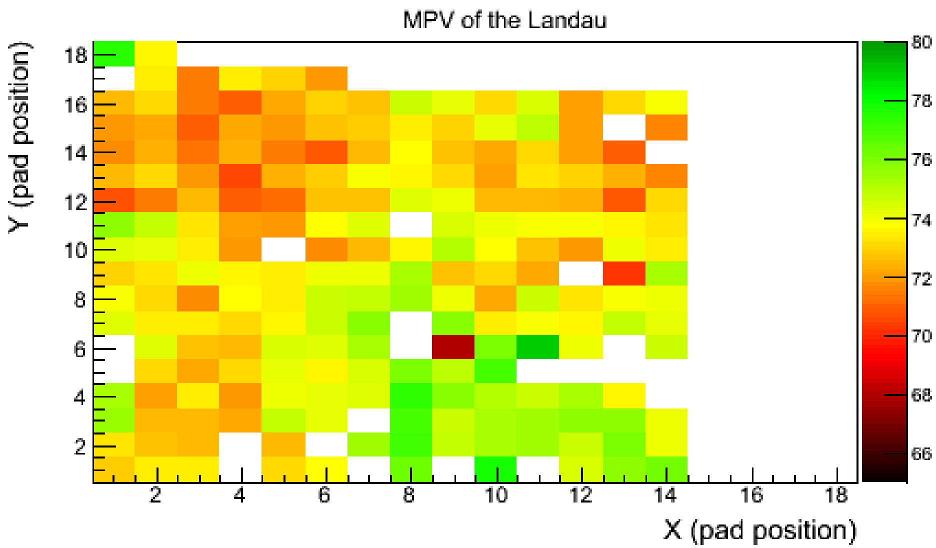
Energy calibration

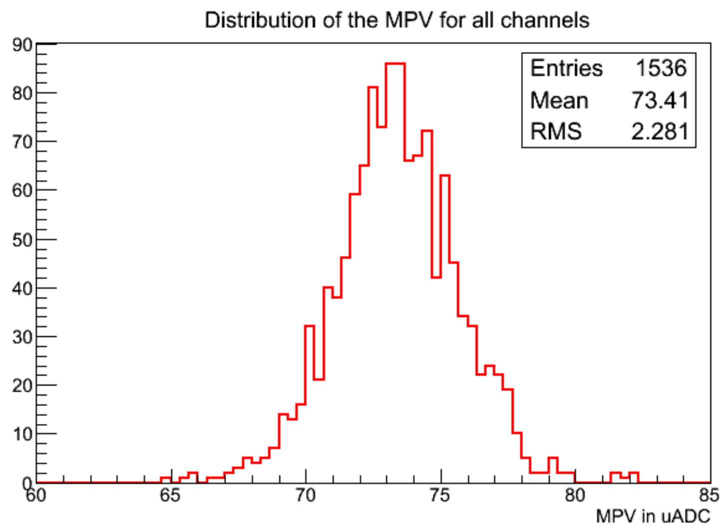
Establishment of calibration procedure for a larger number of cells

Homogeneity of response (x,y scan of detector)

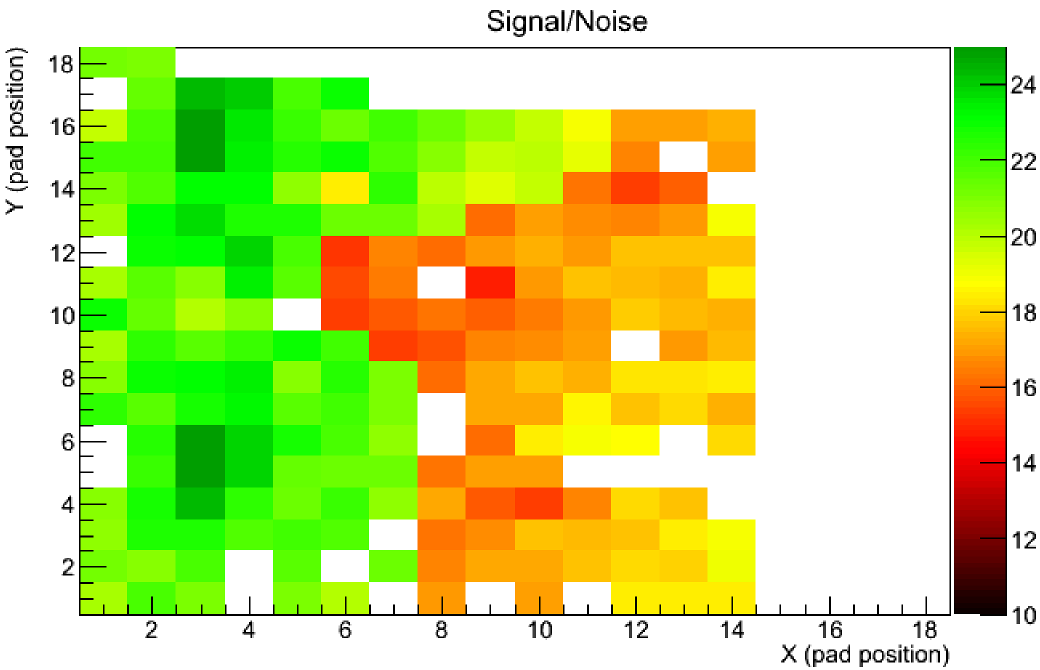








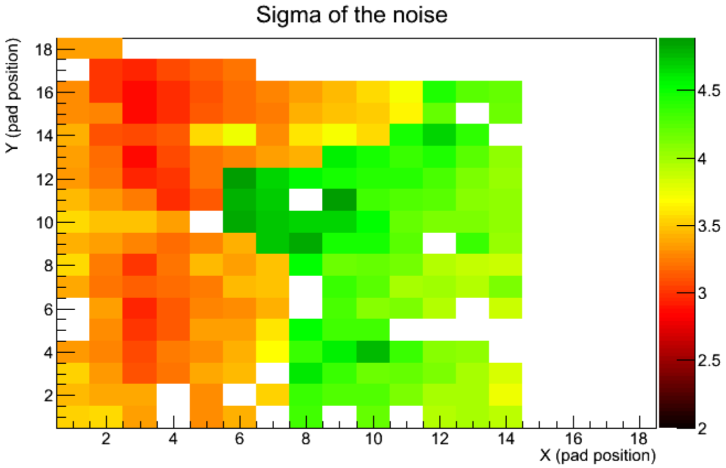
Signal over noise ratio



R&D target is 10:1

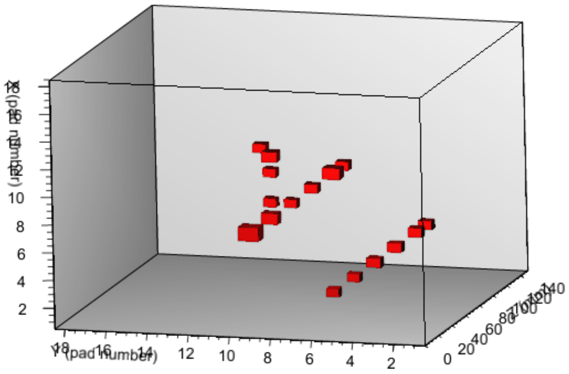
S/N > 10

(for all gains available with SKIROC2)

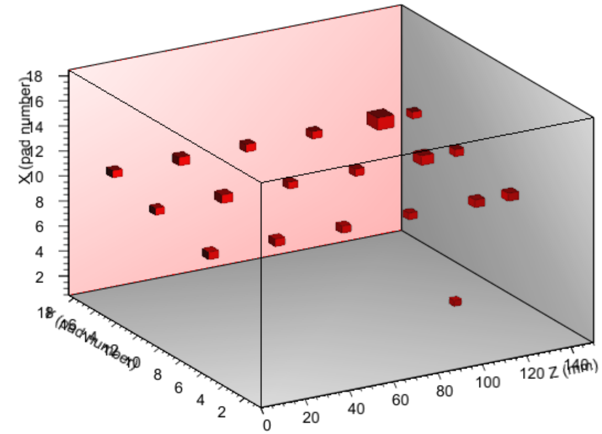


Event display

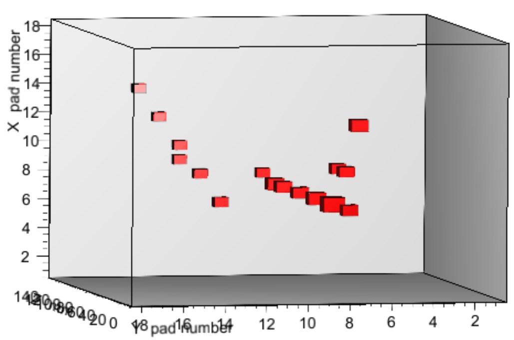
2 e- (3 GeV, no tungsten)



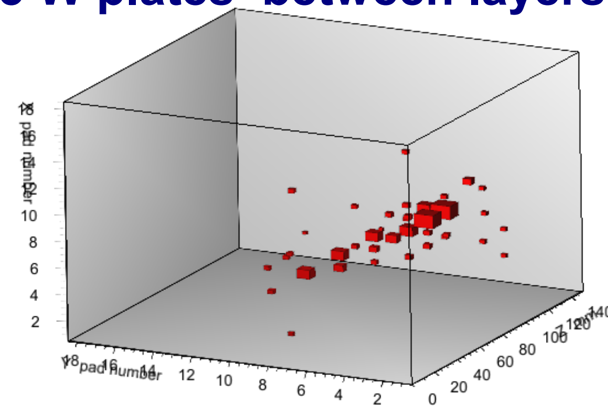
3 e- (3 GeV, no tungsten)



1 cosmic + 1 e- (3 GeV, no tungsten)



1 e- (5 GeV)
5 W plates between layers



Conclusion

Successful beam test

Excellent stability of the DAQ
Stable operation of the wafers and the electronic

Establishment of calibration procedure for a larger number of cells
Homogeneity of response studies

- Energy calibration
- Detection efficiency

Determination of the signal over noise ratio: S/N > 10

Hardware effects revealed.
Data and detector about to be understood.

Test beam in December ➡ Power pulsing

Thanks

Special thanks to our experts:

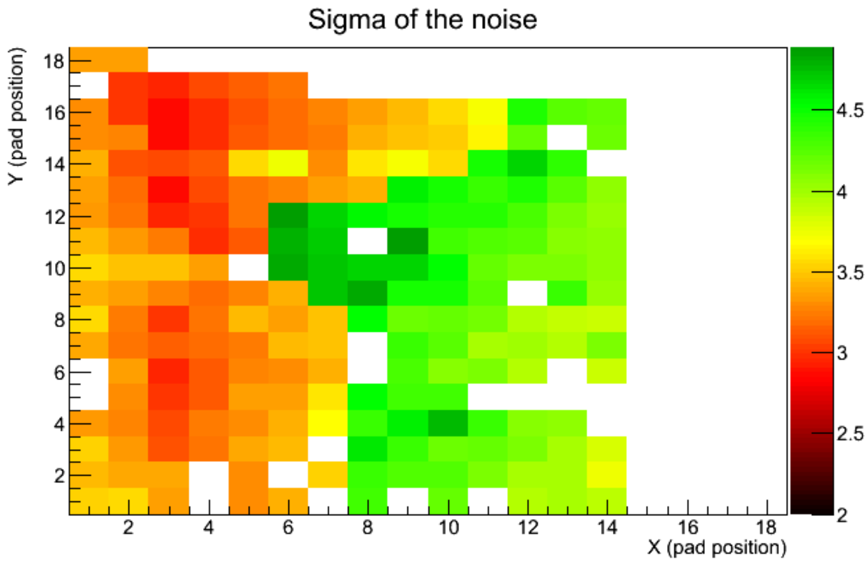
Frédéric, Mickael, Patrick, Rémi and Stéphane

And to everyone who took part in the preparation of the test beam:

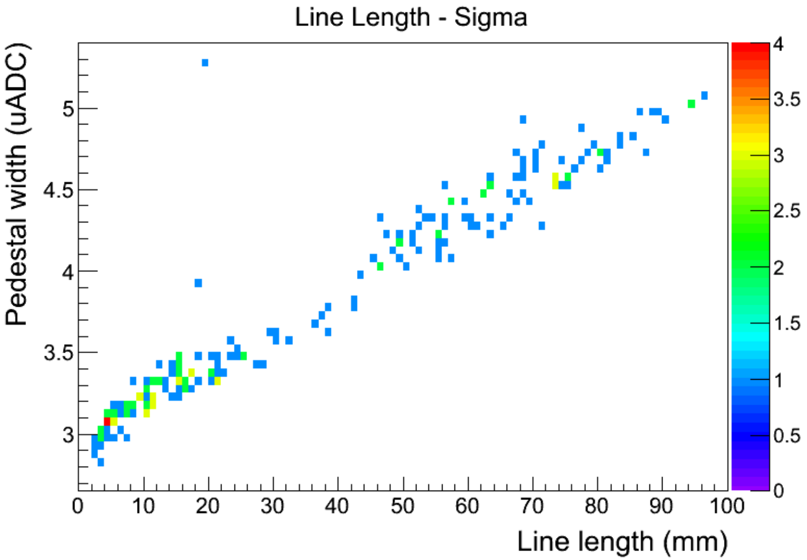
- LLR, LAL+OMEGA, LPNHE
- Kyushu University, Tokyo University, Nippon Dental University
- SKKU

Back up

Noise width



Sigma of the noise
Y (pad position)
X (pad position)



Line Length - Sigma
Pedestal width (uADC)
Line length (mm)