SiECAL Technological prototype Test Beam at DESY

Tokusui meeting 2013

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Tokyo Univ.   LAL   LLR CALICE

SiW ECAL R&D

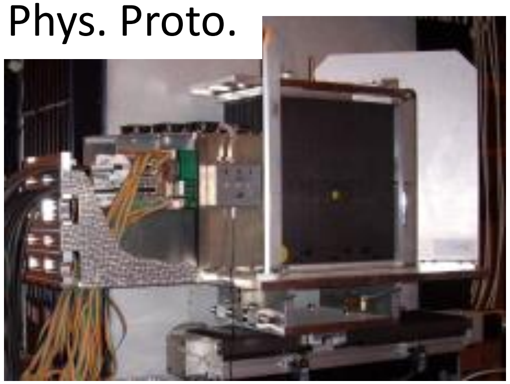
Physics Prototype 2003 - 2011

Proof of principle

Number of channels : 9720

Weight : ~ 200 Kg

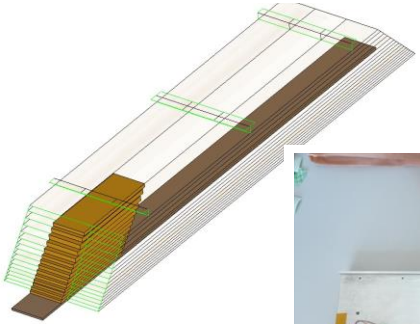
Phys. Proto.

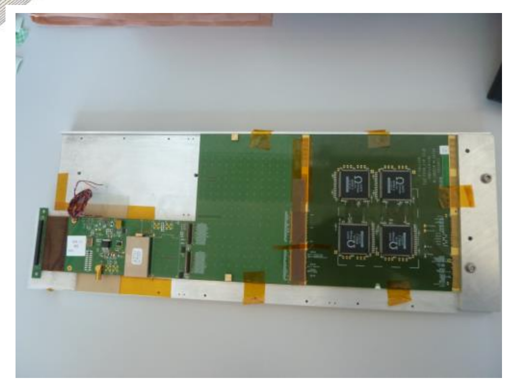


Technological Prototype 2010 –

Technological solutions for the final detector

Tech. Proto.

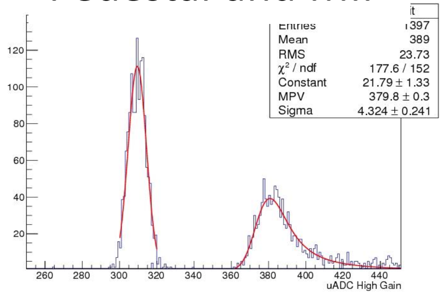




Test program

- 2012: Commissioning
  - Test of highly integrated electronics in continuous power mode
- 2013: Test of power pulsing
  Test in magnetic field

2012 result
Pedestal and MIP

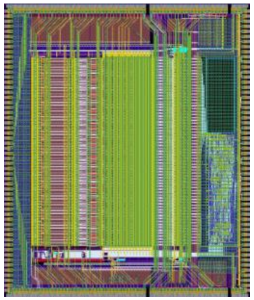


S/N > 10 (for all gains available with SKIROC2)
R&D target is S:N = 10:1

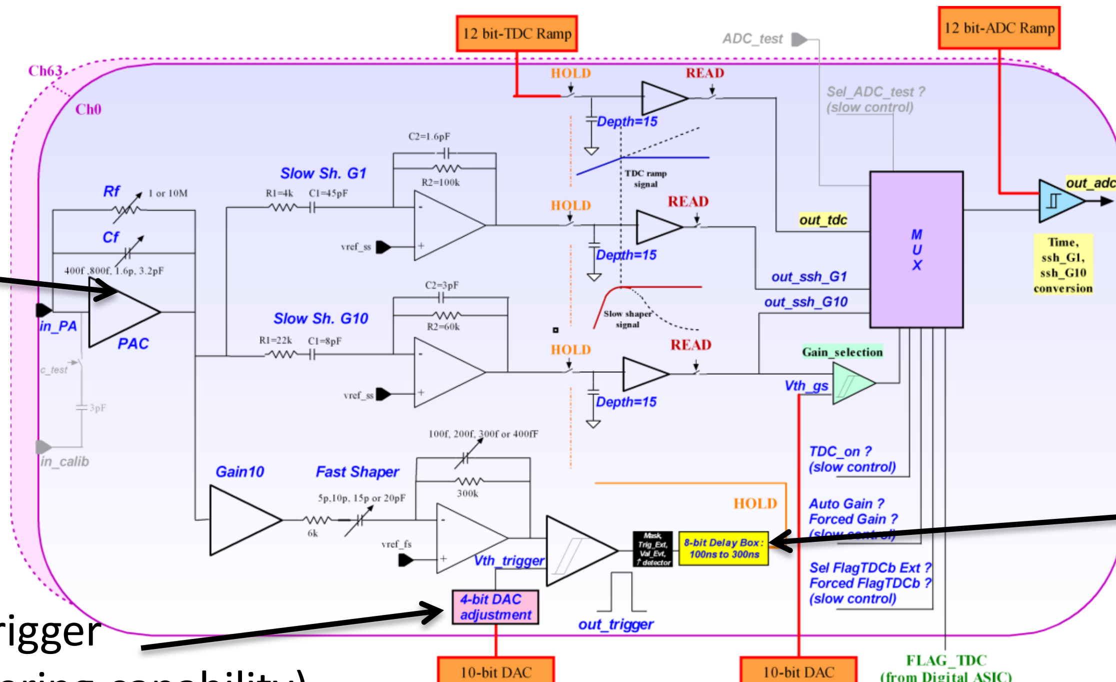
Front end electronics: SKIROC

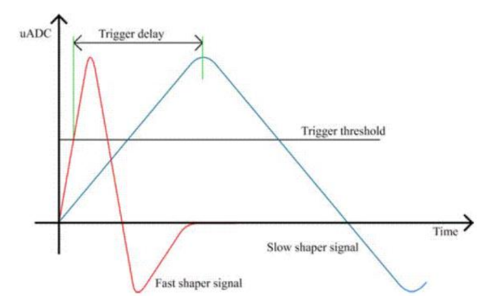
<u>SKIROC (Silicon Kalorimeter Integrated Read Out Chip)</u>

- Size 7.5 mm x 8.7 mm, 64 channels
- Variable gain charge amp, 12-bit Wilkinson ADC, digigal logic
- Large dynamic range (~2500 MIPs), low noise (~1/10 of a MIP)
- Self-trigger
- Low Power: (25 µW/ch) power pulsing



Preamplifier





Trigger delay

Internal trigger
(self-triggering capability)

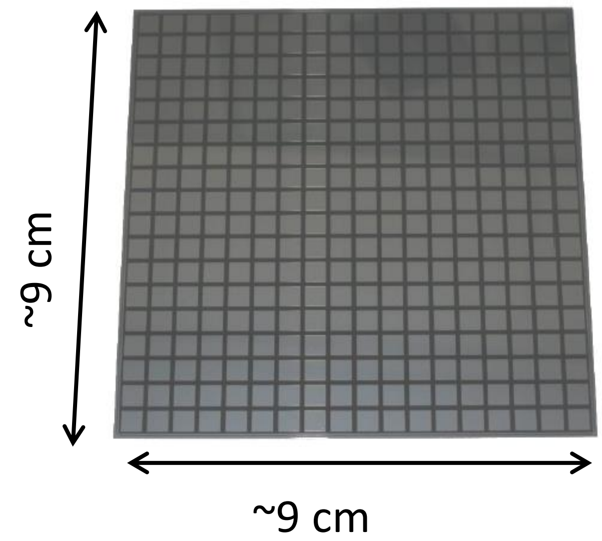
Test beams with fabricated layers

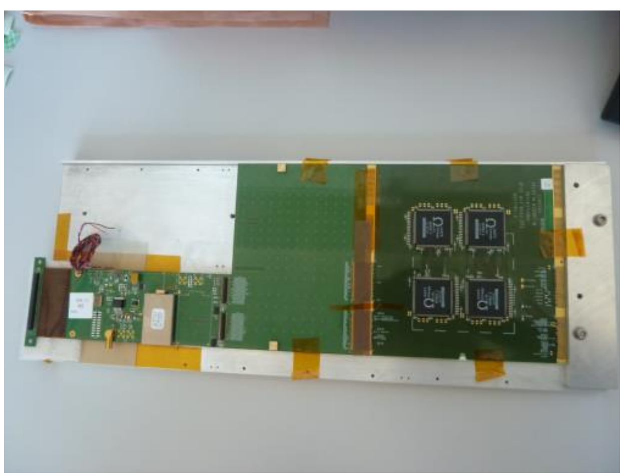
<u>Layer design for beam tests</u>

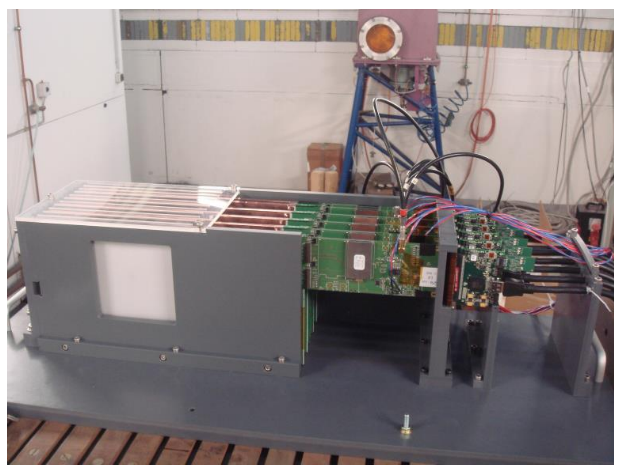
Integrated FE electronics

Conservative ASU design for beam test

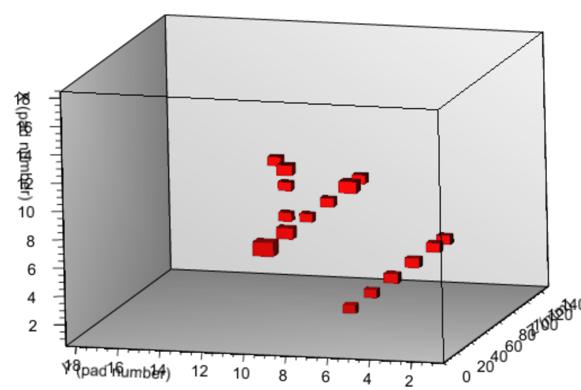
- Si Sensor :5x5 mm^2 pixel and thickness of 325 μm
- 256 ch readout/layer
- 4 ASICs in PQFP package
- Up to 10 layers







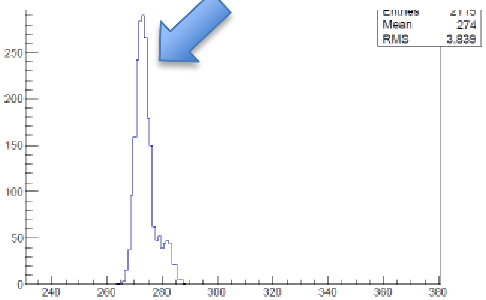
2 e- (3 GeV, no tungsten)

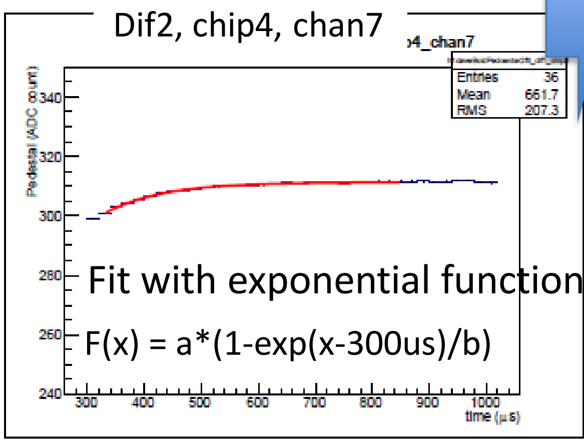


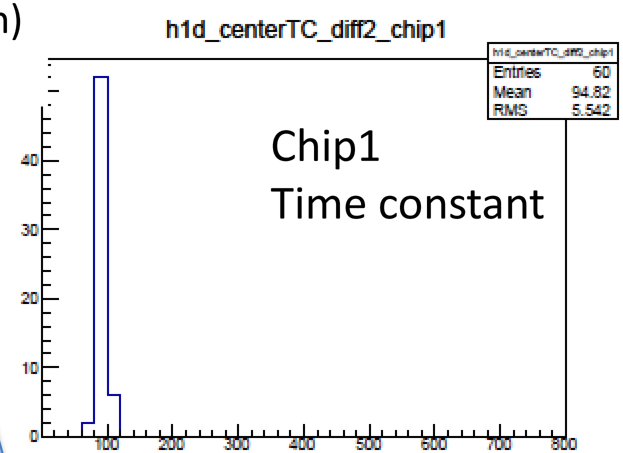
Time constant of pedestal (center value)

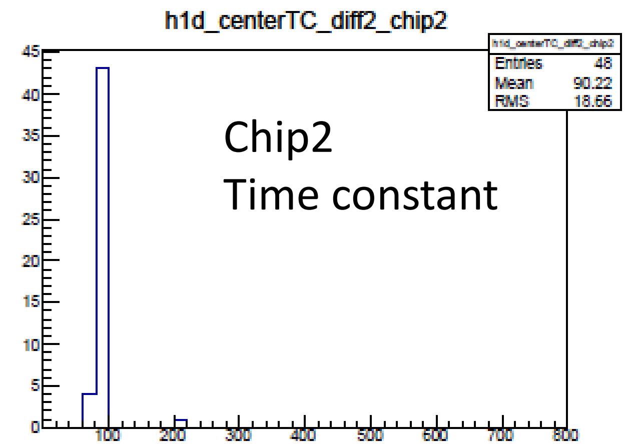
- MIP event (Power Pulsing)

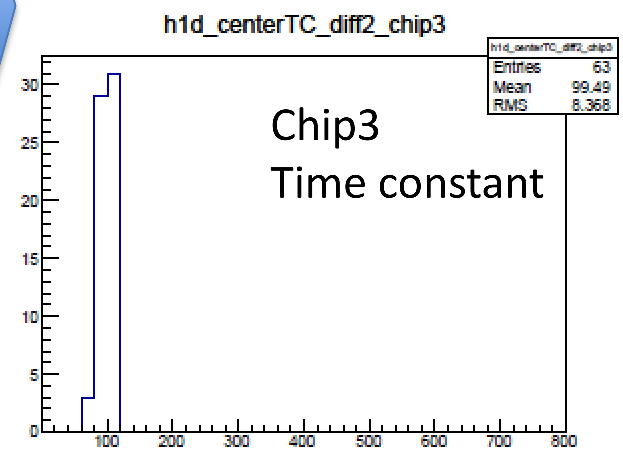
Fit with Gaussian around (+-5bin)
Pedestal peak for each channel

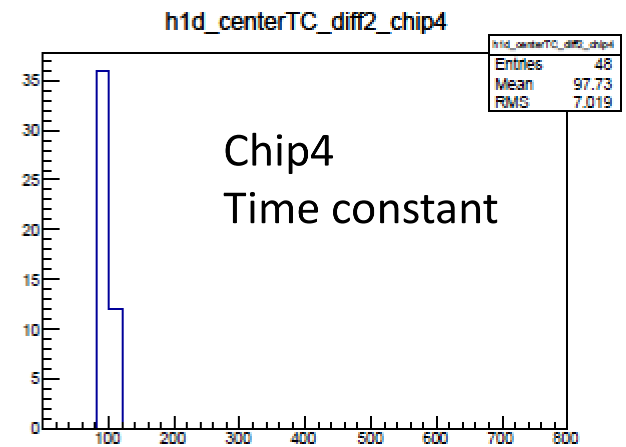








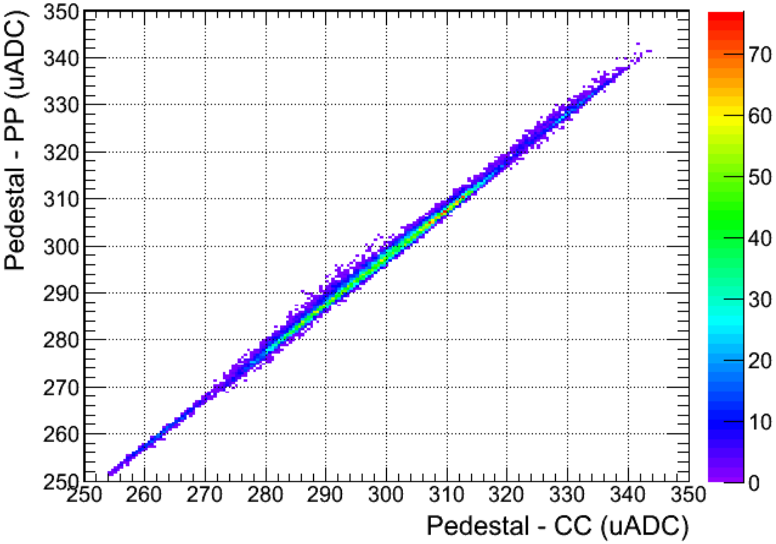


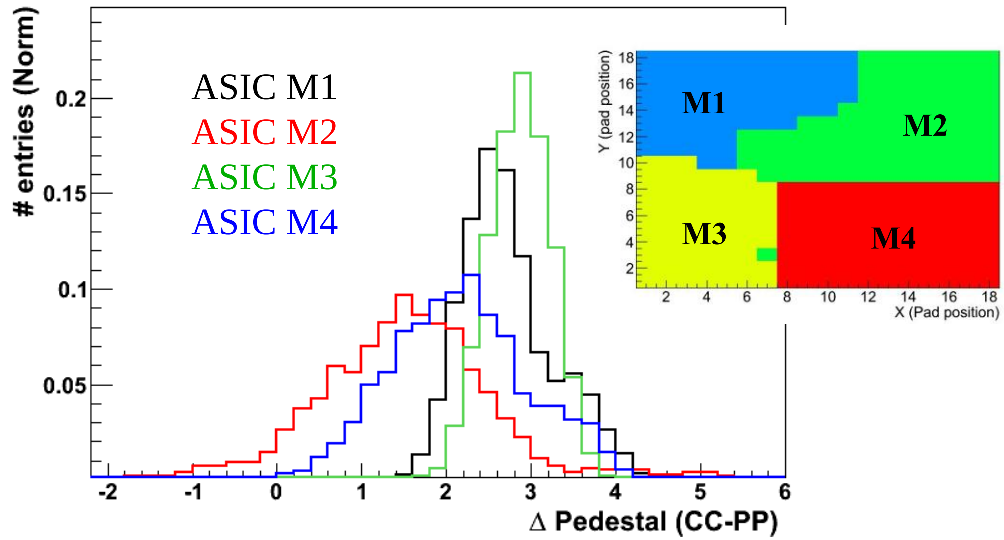


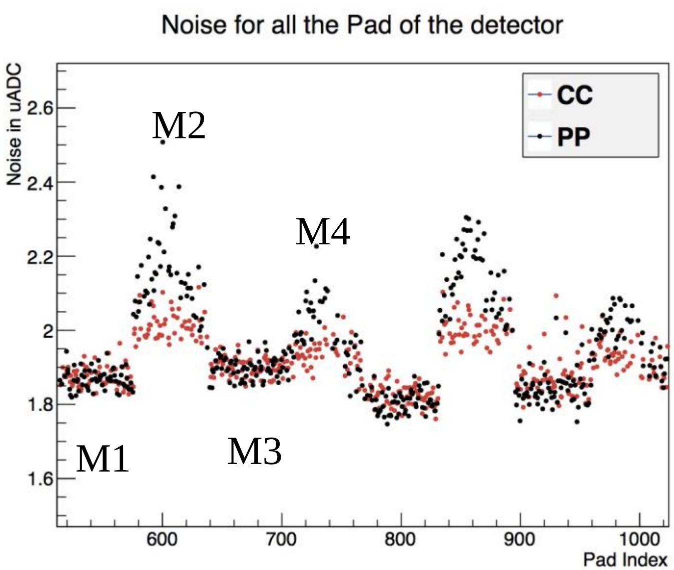
uADC

- Stable pedestal after around 600 μs.
- Time constant of pedestal ~100 μs.
- Time dependence of pedestal width is also ~100 us.
- It can be solved by changing FPGA firmware setting.

Power pulsing – Pedestal analysis







Clear pattern for ASICs M1, M3

Pedestal shift of ~1% in PP mode

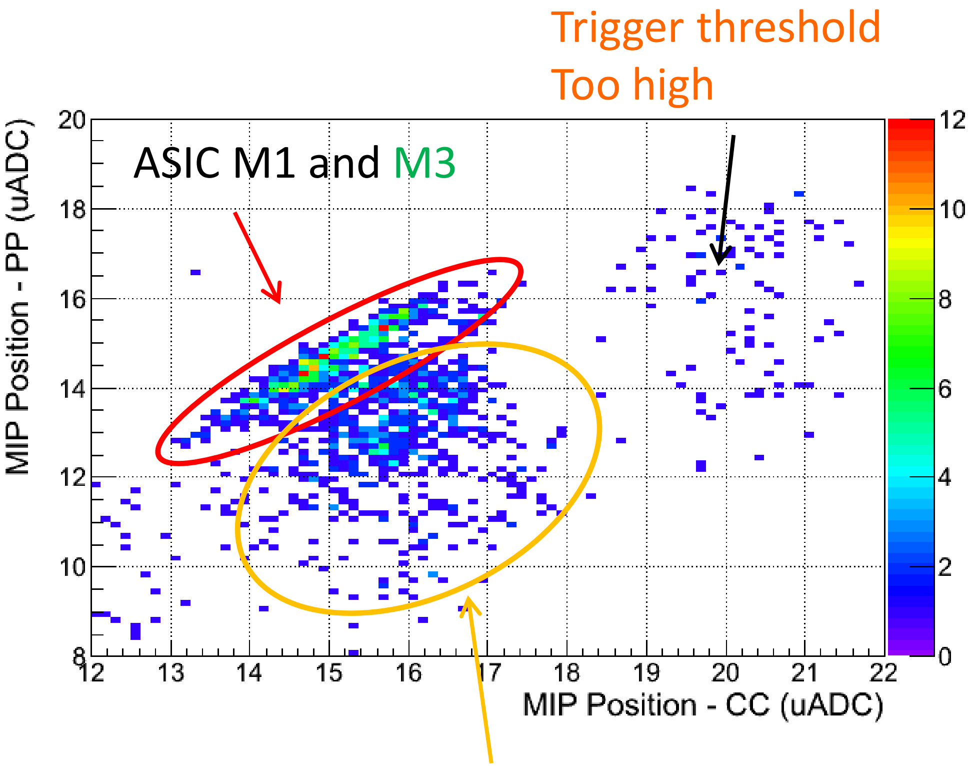
Pedestal width constant

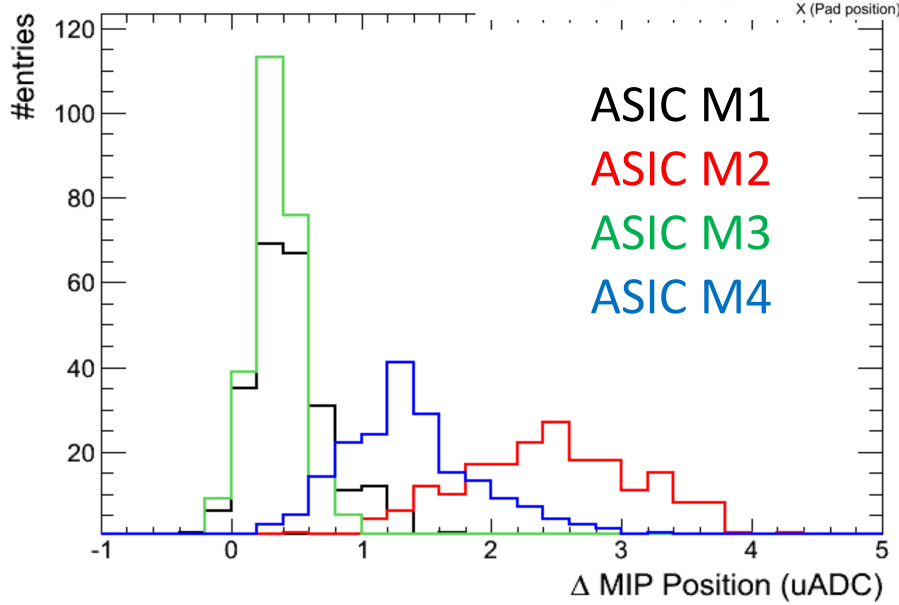
Less clear situation for M2, M4

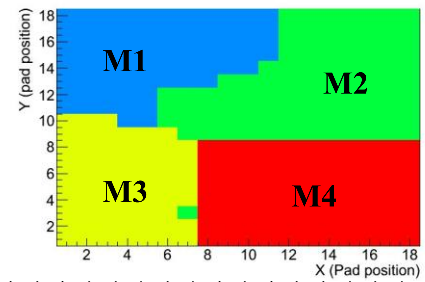
PCB routing seems to distort pedestal spectra

Power pulsing – MIP analysis

- Fit energy distribution: Landau convoluted with a Gaussian
- Sigma of the Gaussian is fixed to the noise

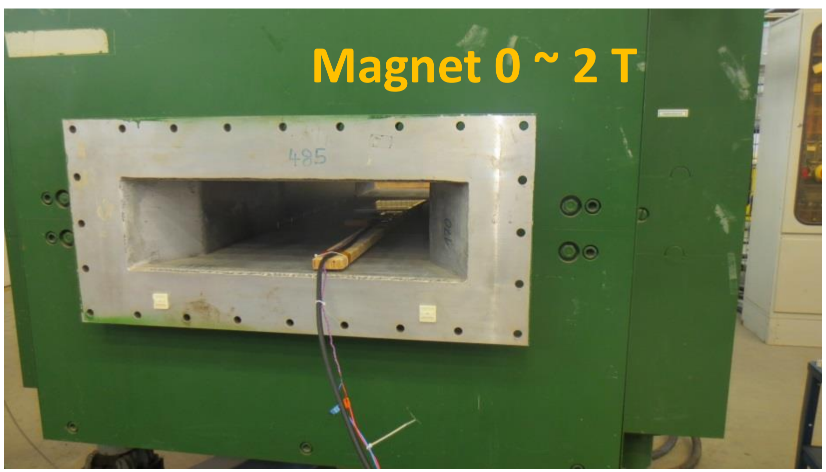


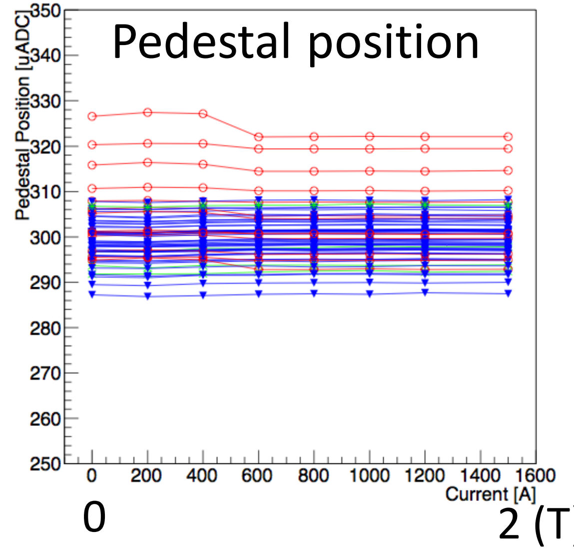


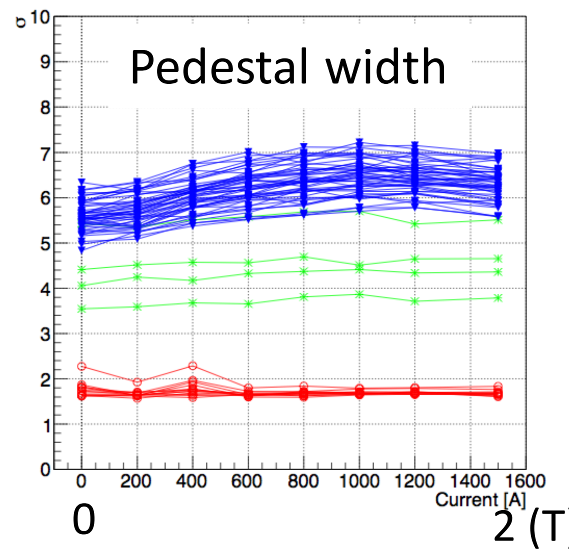


- ASIC M1 and M3 are ok under power pulsing operation.
- The activity of digital lines disrupts ASICs M2 and M4.

Power pulsing tests in magnetic field







- Active channels are stable up to 2T B field

Conclusion and outlook

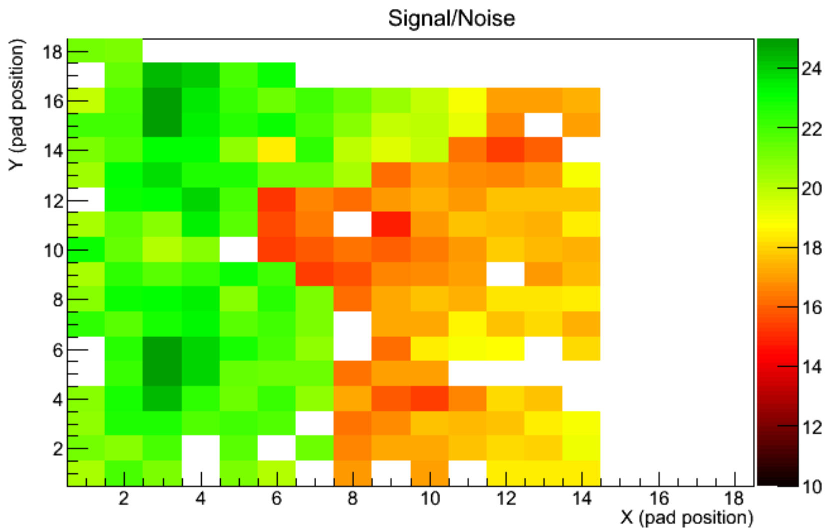
- 2013: We successfully operated tech. proto. in power pulsing mode and tested in 2T magnetic field.

- Two beam test with conservative design ASU
  - Detailed evaluation of performance of system
  - A number of observed odd behaviors were actually related to peripheral devices or non optimal power supply
  - Self-triggering ASICs require very careful power management
  - Active channels are stable up to 2T B field (pedestal study)

- Addressing now issues of a real calorimeter system

Large ASU : 16 ASICs par layer
Long Slab : 10 ASUs
Cooling
Test in strong B field

Data Analysis 2012 – Signal over Noise ratio



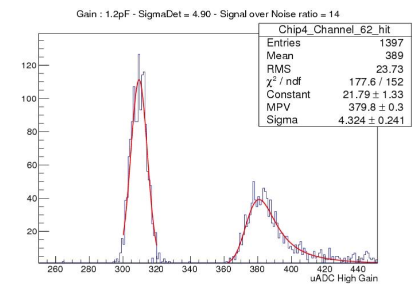
Results after setting of trigger thresholds and event filtering

White cells (noisy channel) : high threshold

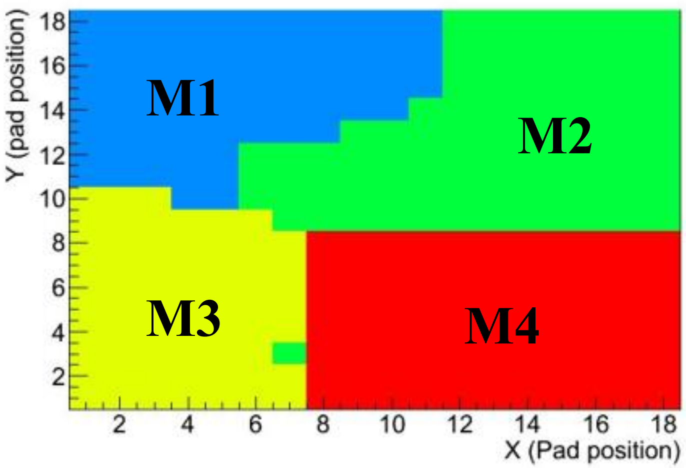
Correlation between noise and PCB routing

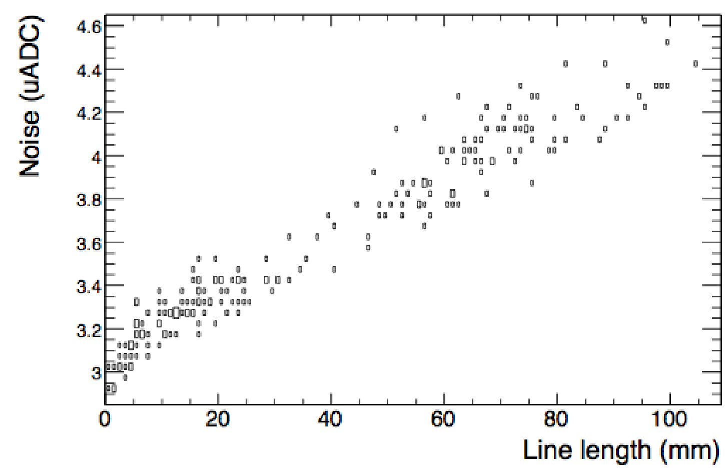
S/N > 10 (for all gains available with SKIROC2)

R&D target is S:N = 10:1



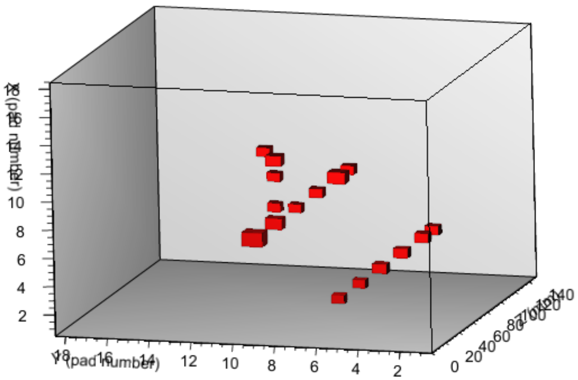
4 ASICs are mounted on a layer



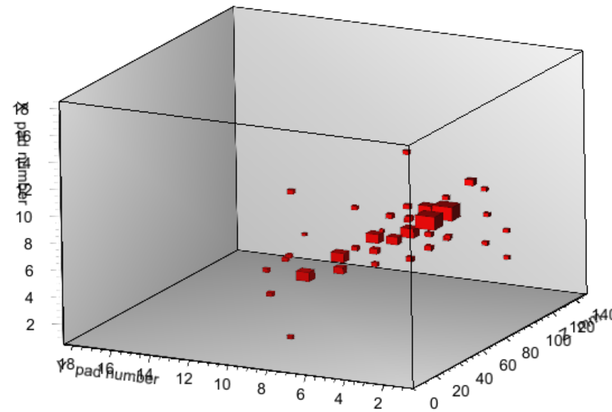


Event displays

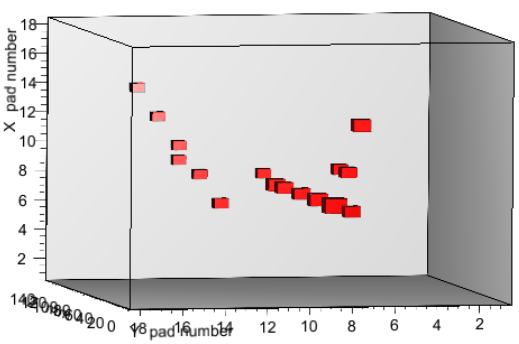
2 e- (3 GeV, no tungsten)



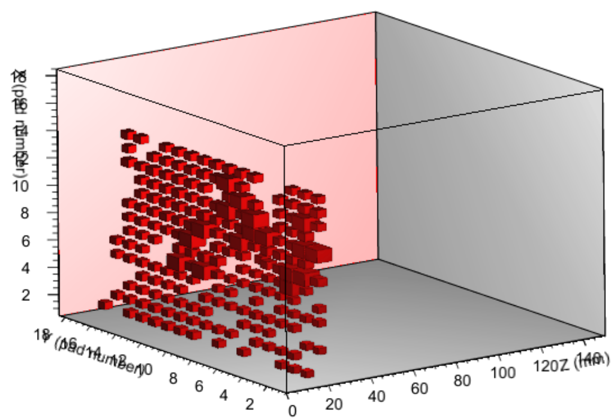
1 e- (5 GeV)
5 W plates between layers



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

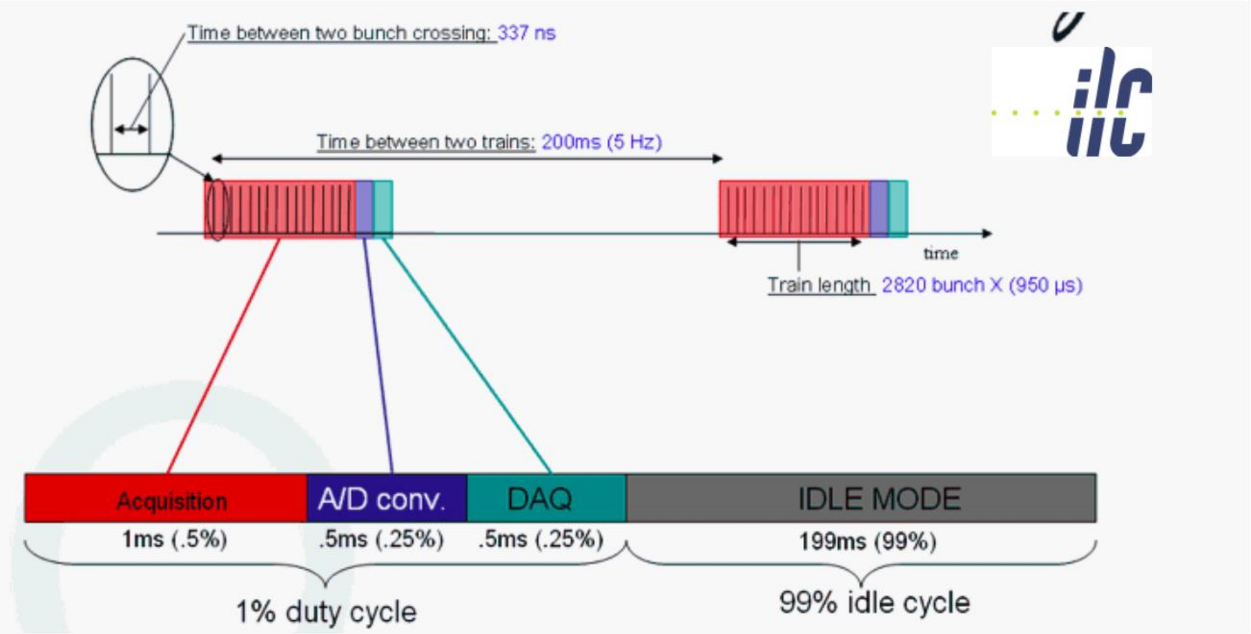


'Plane events???'



Observed in 2012 with significant frequency
can be remedied by correct PreAmplifier reference

Power pulsing



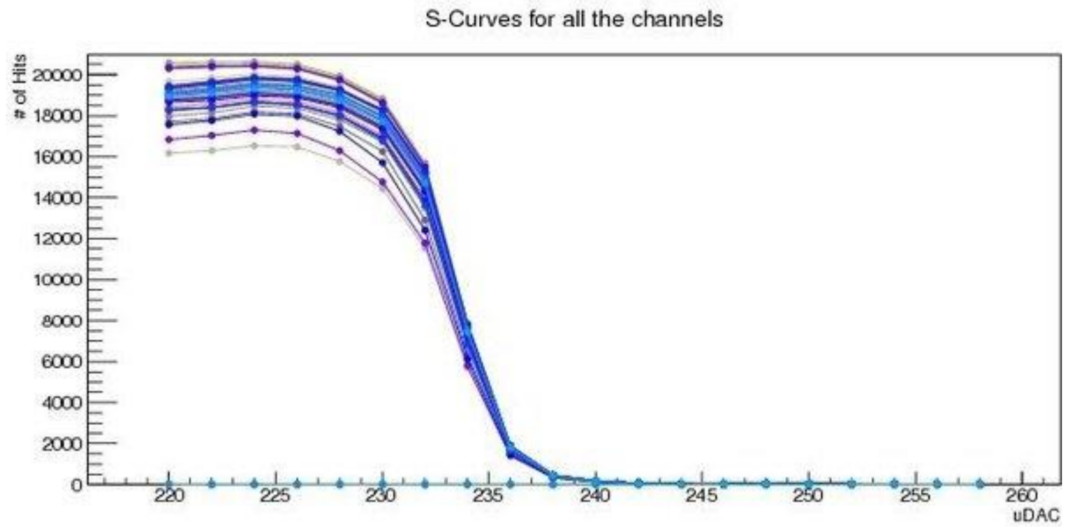
N.B. Final numbers may vary

- Electronics switched on during > ~1 ms of ILC bunch train and data acquisition
- Bias currents shut down between bunch trains

Mastering of technology is essential for operation of ILC detectors

Calibration of ASICs

Establishment of calibration procedure for a larger number of cells

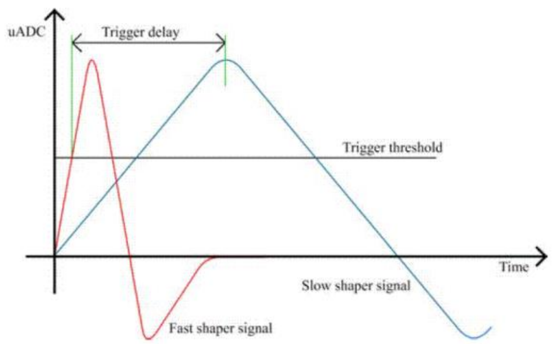


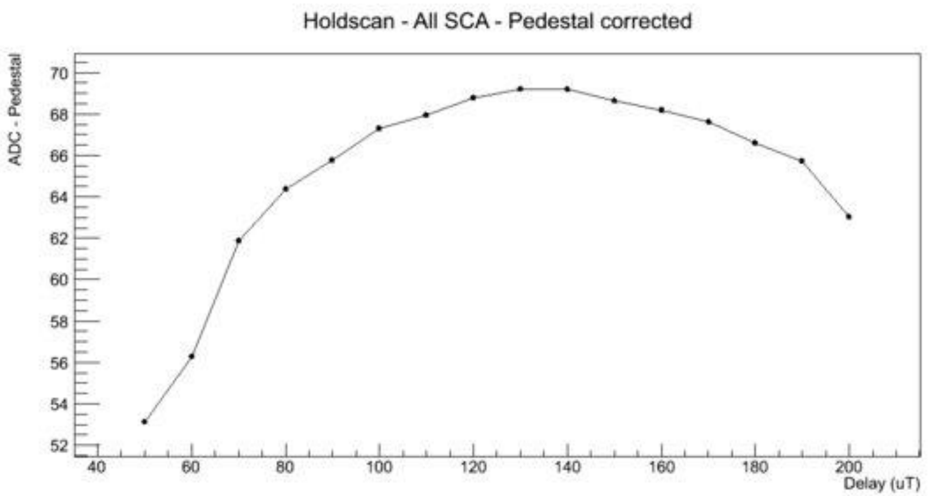
Trigger threshold

- depends on the gain

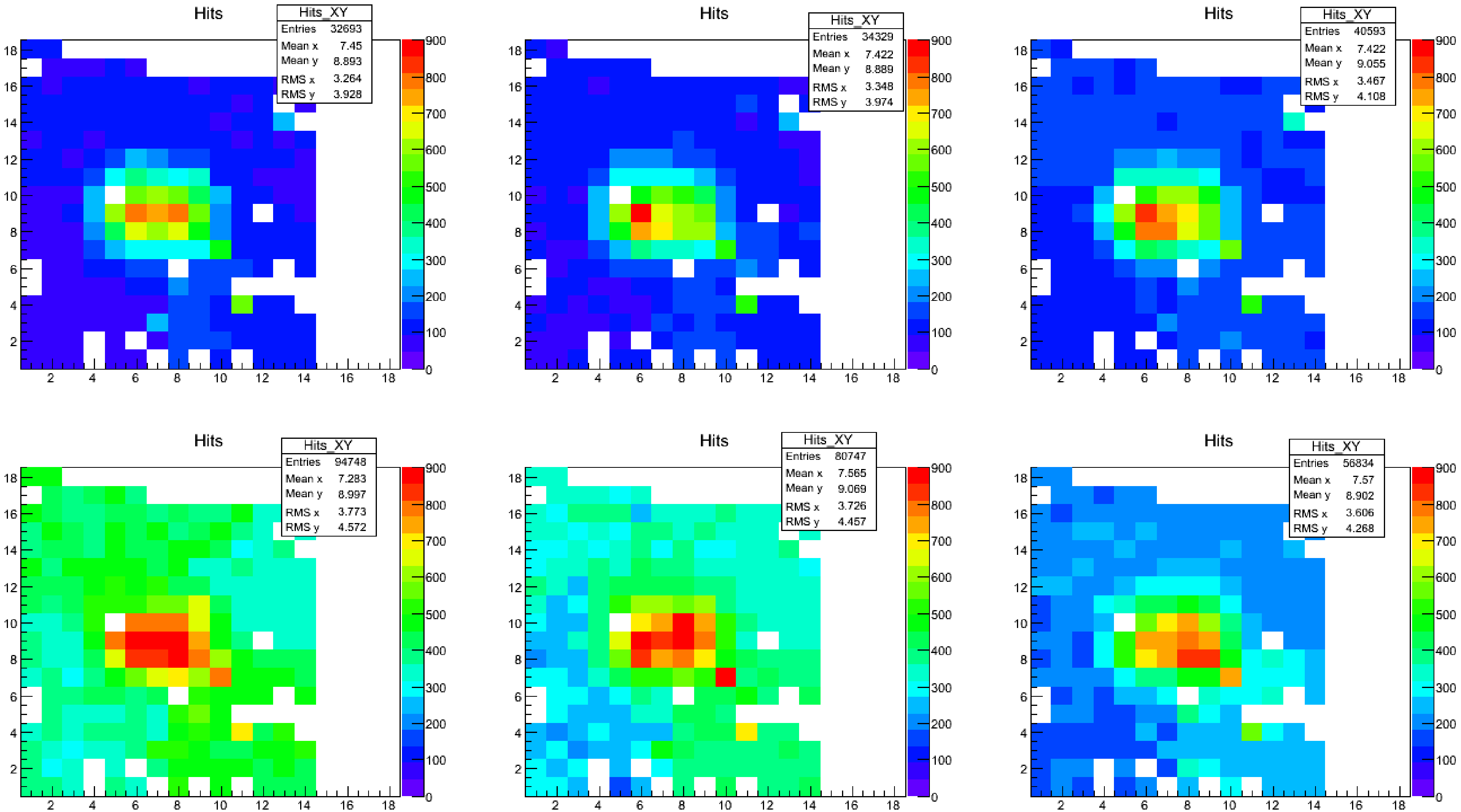
Trigger delay

- depends on the trigger threshold





Beam spot

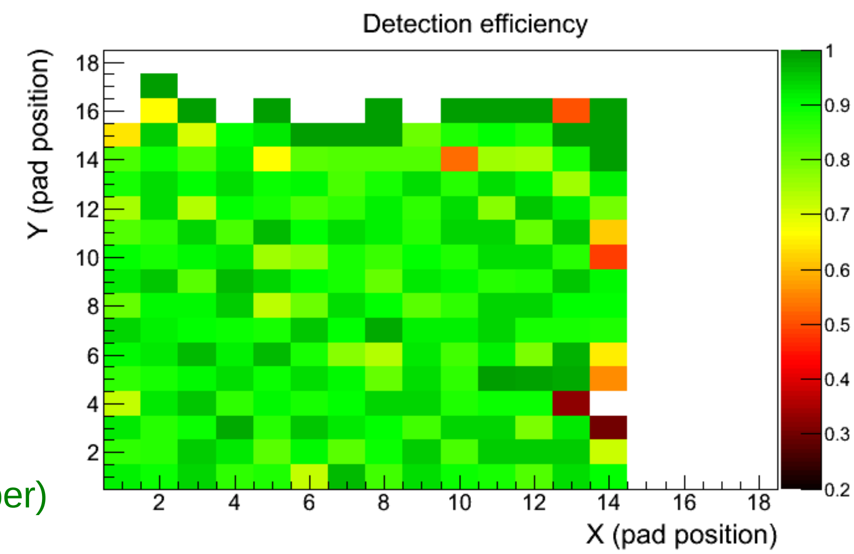

Hits
Hits_XY
Entries 32693
Mean x 7.45
Mean y 8.893
RMS x 3.264
RMS y 3.928
Hits
Hits_XY
Entries 34329
Mean x 7.422
Mean y 8.889
RMS x 3.348
RMS y 3.974
Hits
Hits_XY
Entries 40593
Mean x 7.422
Mean y 9.055
RMS x 3.467
RMS y 4.108
Hits
Hits_XY
Entries 94748
Mean x 7.283
Mean y 8.997
RMS x 3.773
RMS y 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

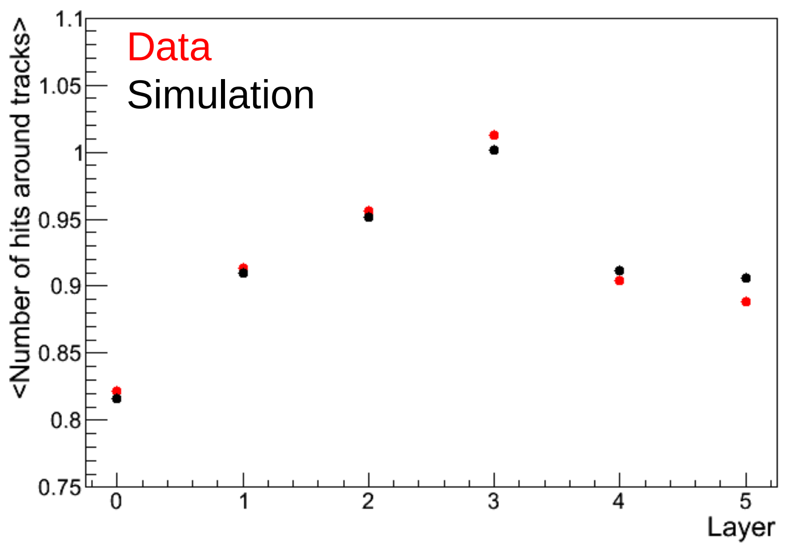
Detection efficiency

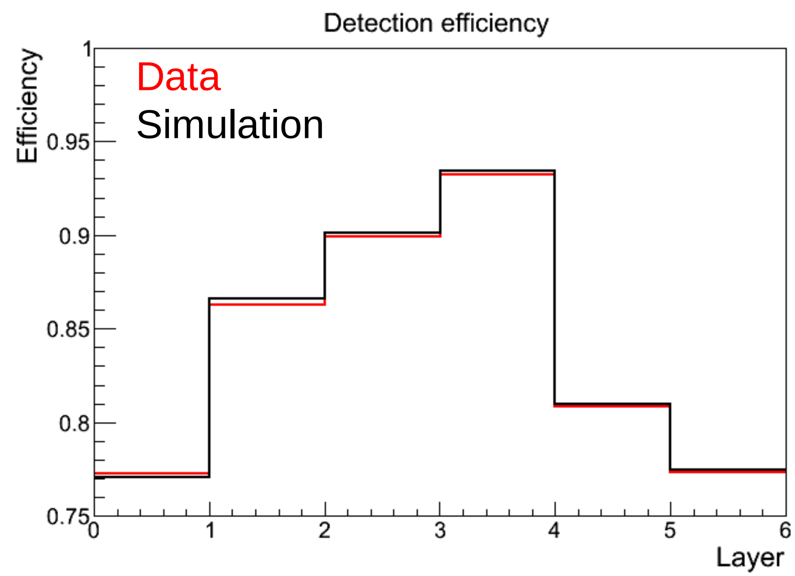
Data: 3GeV – No W – XY scan
Total number of events: $2,3.10^6$
Track selection:

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

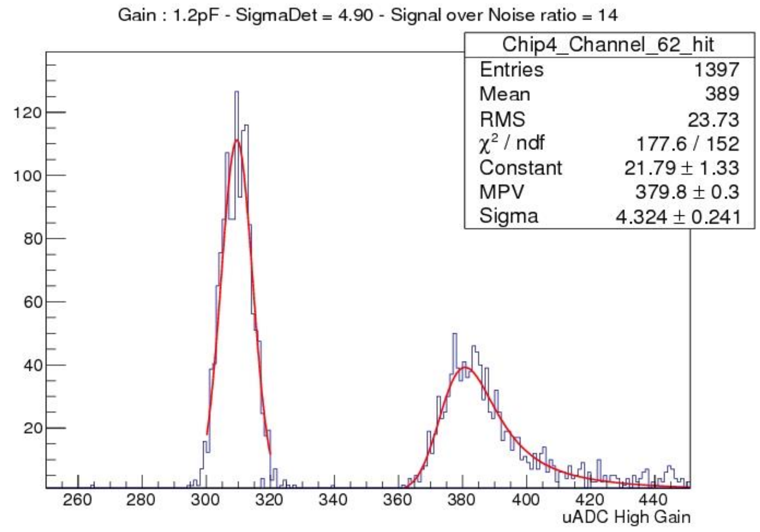
Inefficiencies due to:
Switched off channels
Too high trigger thresholds (80%-95% of the MIP)
Should be improved with the next test beam (December)

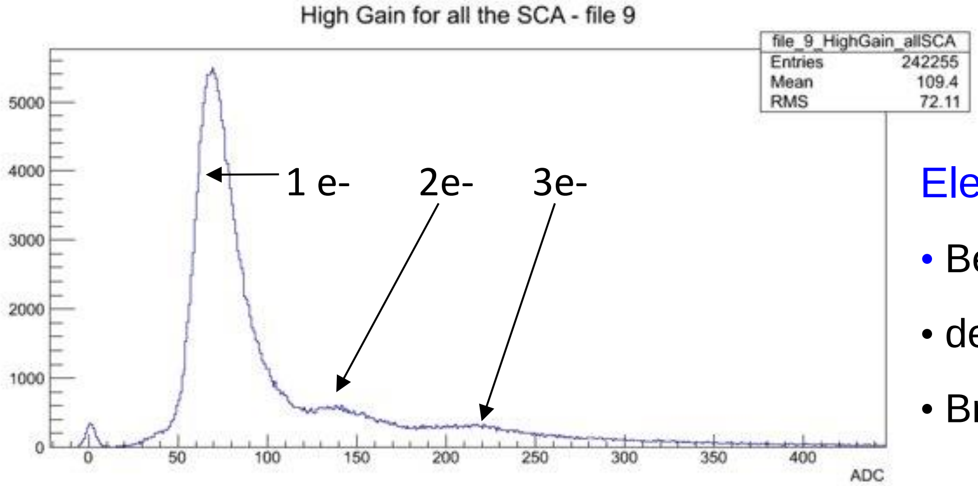






Energy measurement





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)