Understanding of SKIROC performance

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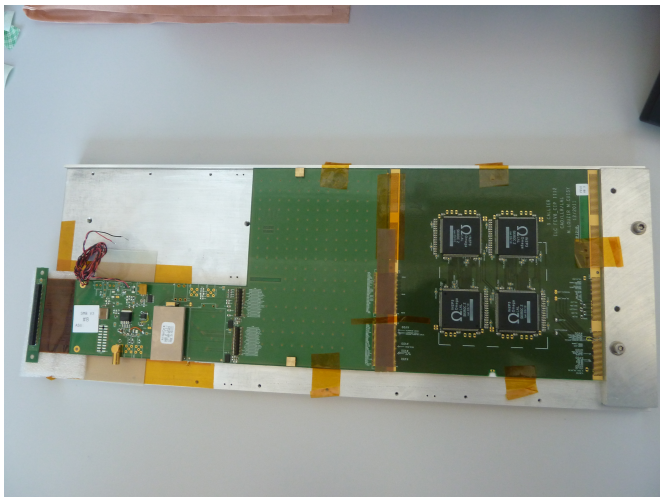
On behalf of the SiW ECAL team

Special thanks to the electronic and DAQ experts:
Stéphane Callier, Rémi Cornat and Frédéric Magniette
And to:
Romain De Abreu (Internship student)

The road to the technological prototype

Intermediate step: { First test in beam / Benchmark to go further

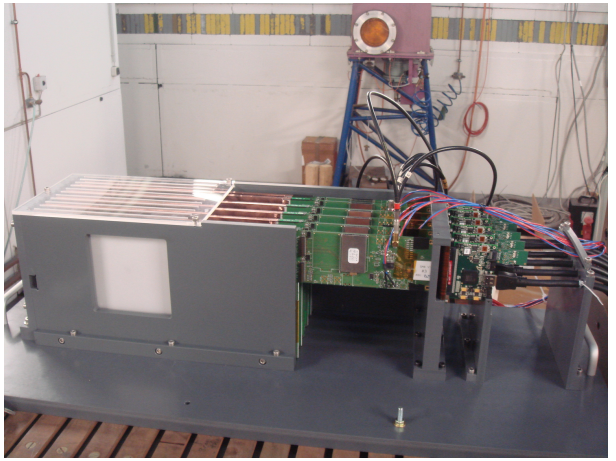


- U structure (single detection layer per slab)

- Si wafer:
  - 9x9 cm^2 – Thickness = 320 μm
  - **pixel size: 5x5 mm^2** :lateral granularity = 4 x better than physics prototype

- 4 SKIROCs per slab (1⁄4 final design)
  - 4 x 64 channels = 256 channels/slab

DESY : e- (1 - 5 GeV)

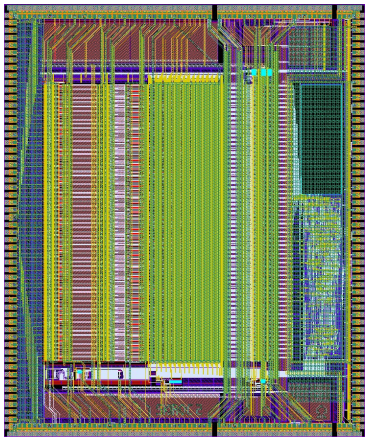


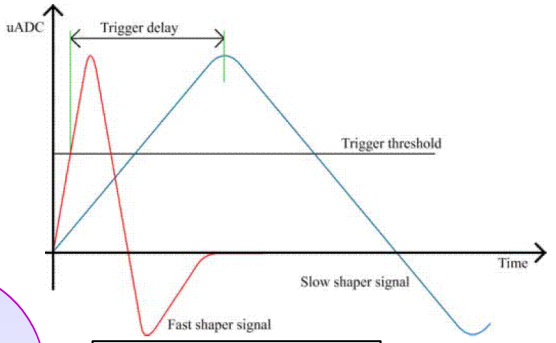
- Spring 2012 : 1 layer
- Summer 2012 : 6 layers
- Winter 2013 : 10 layers (see Vladik and Yuji talks)

Front end electronics: SKIROC

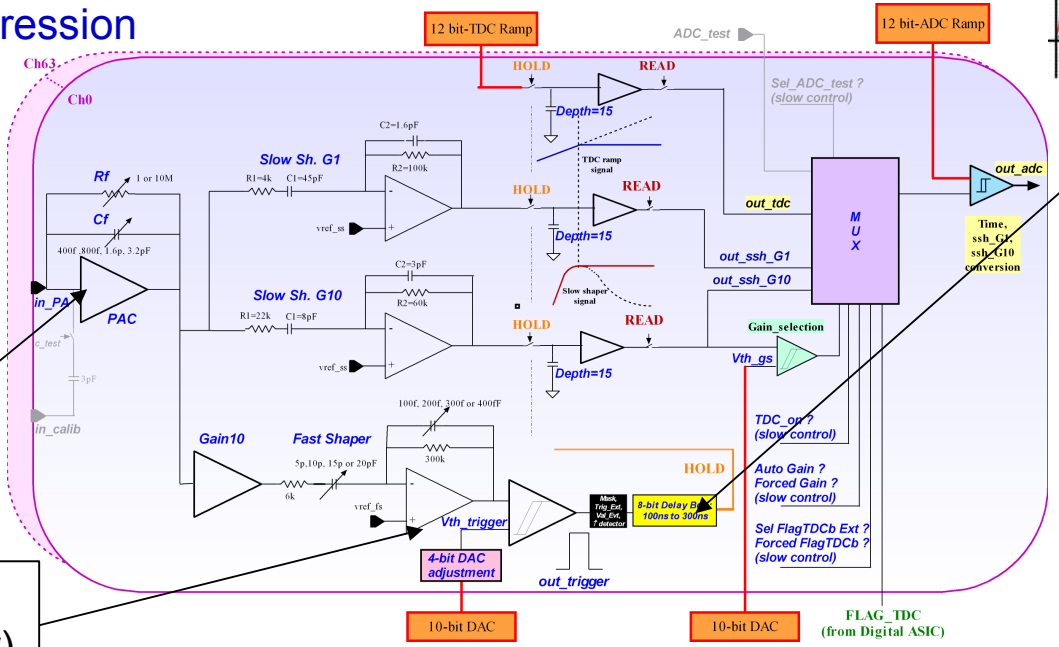
SKIROC (Silicon Kalorimeter Integrated Read Out Chip)

- SiGe 0.35µm AMS
- 7.5 mm x 8.7 mm
- High integration level (variable gain charge amp, 12-bit ADC, digital logic)
- 64 channels
- Large dynamic range (~2500 MIPS), low noise (0.4 fC – 10 pC)
- Auto-trigger at ½ MIP
- Low Power: (25µW/ch) power pulsing
- On chip zero suppression





Trigger delay



Preamplifier (adjustable gain)

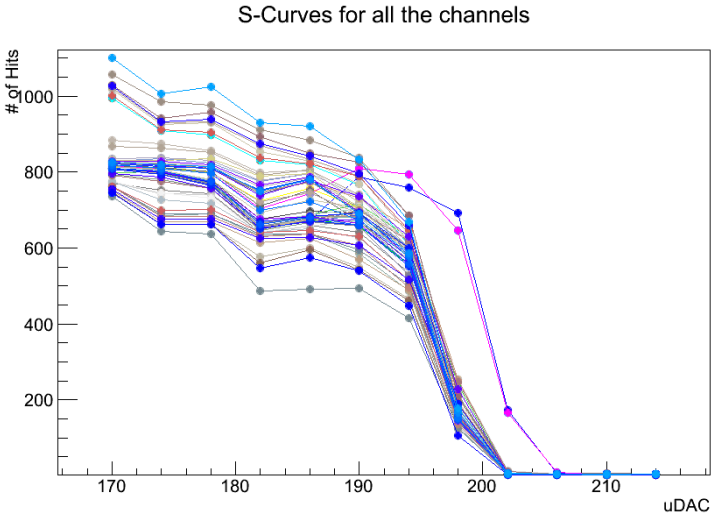
Internal trigger (self-triggering capability)

Calibration of SKIROC

Establishment of calibration procedure for a large number of cells

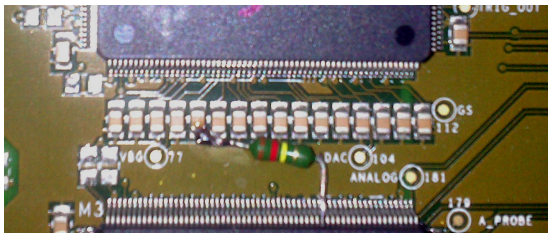
Trigger threshold

- depends on the gain



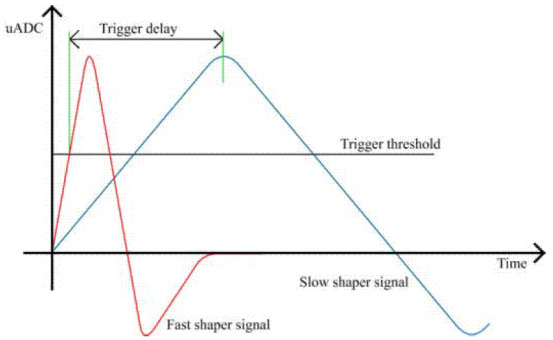
- Individual channel threshold adjustment

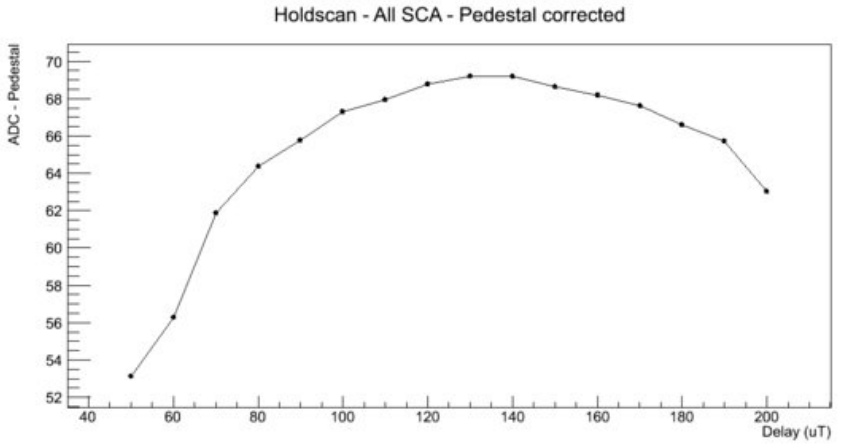
Range too small → R to increase current in the 4-bits DAC adjustment



OK on test bench → to be tested in beam (need new calibration procedure)

Trigger delay

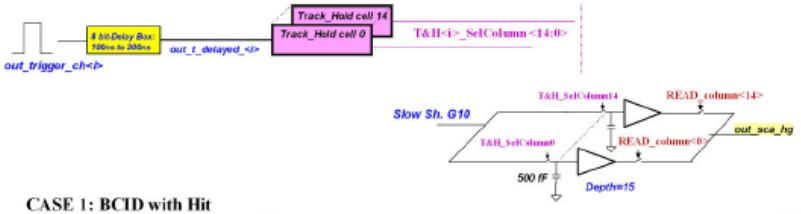


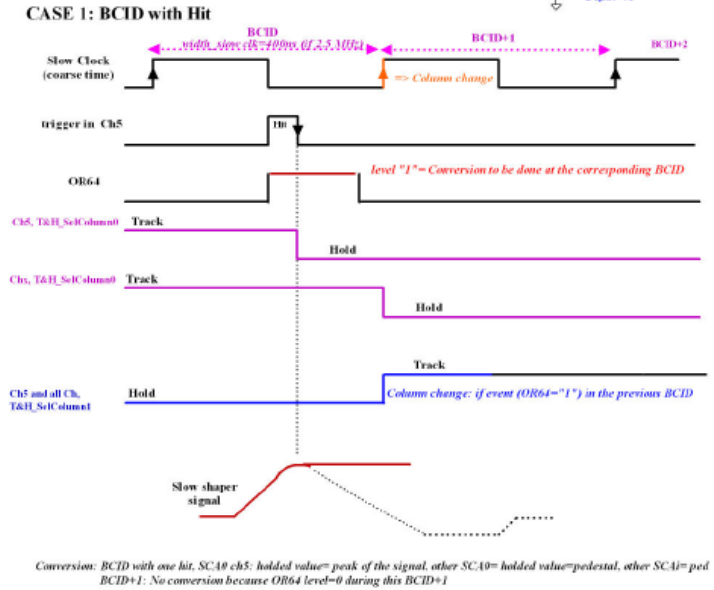


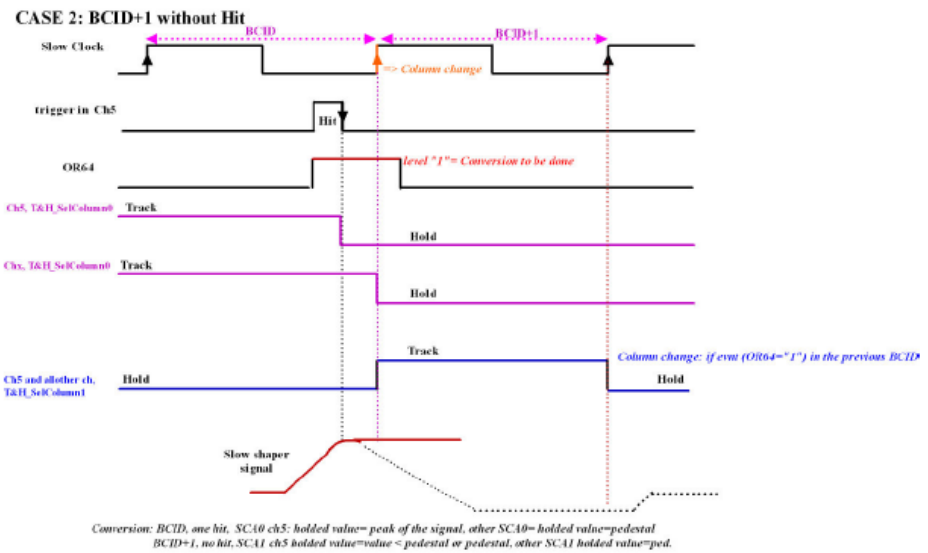
BCID+1 effect

Retriggering of the ASIC without hit

- Understood (see Nathalie and Stéphane talks)
- ~13% of the events (for $T_{slowclock}$ = 2.5 MHz):
  - ➔ Calculated: $T_{slowclock}/T_{nor64}$
  - ➔ Measured with test bench and test beam
- Easy to cut off-line



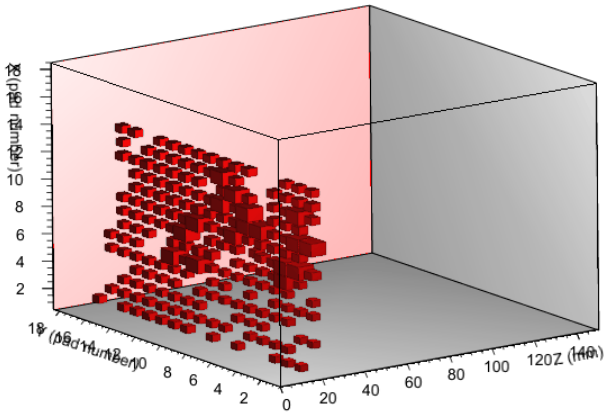


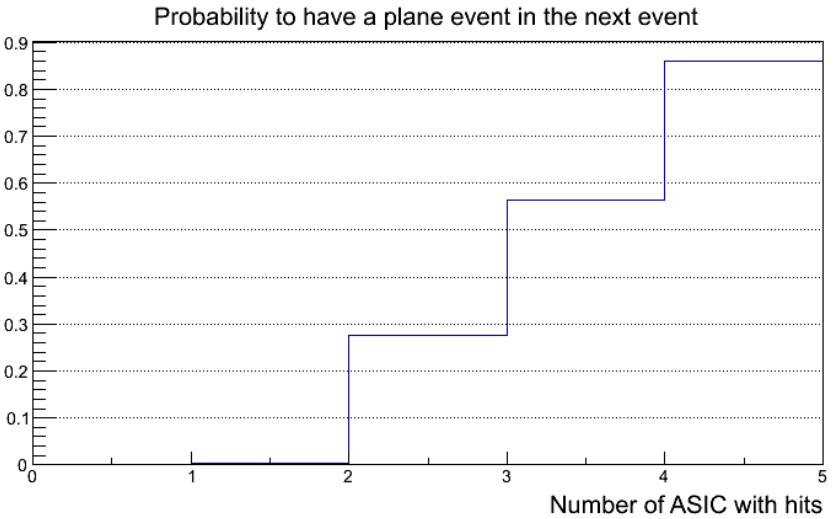


Plane events

PA is referenced to the analog power supply level
Instabilities of power supply level → fake events

- VDD_delay/sca plugged on analog power supply → increase instabilities of power supply level
- Analog power supply common to the 4 ASIC
- Self-sustained → sometimes filled all the 15 ASIC memories
- Highly dependant of the number of ASIC with hits, dependant of the number of triggered channels

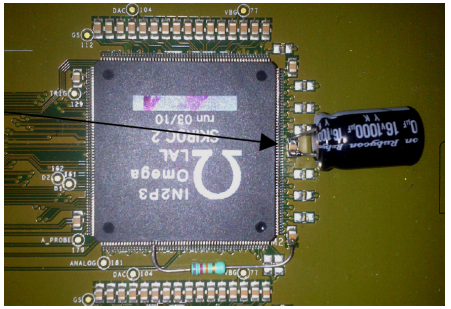




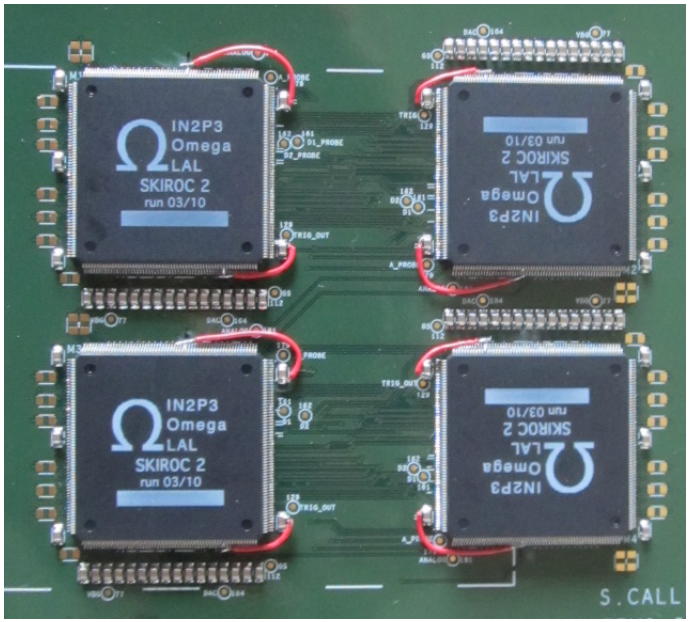
Plane events

Proposed patchs

- Bigger capacitance close to the ASIC to stabilize power supply



- 2 power supply lines: Modify VDD_delay/sca routing to protect PA power supply (pin-clipping)



First tests on test bench:

- Injection in the 4 ASICs
- Reduction of the plane events: ~80% → ~10% (both capa and pin-clipping)

2 slabs modified to be tested during the last test beam

- 1 slab with big capa
- 1 slab with pin-clipping

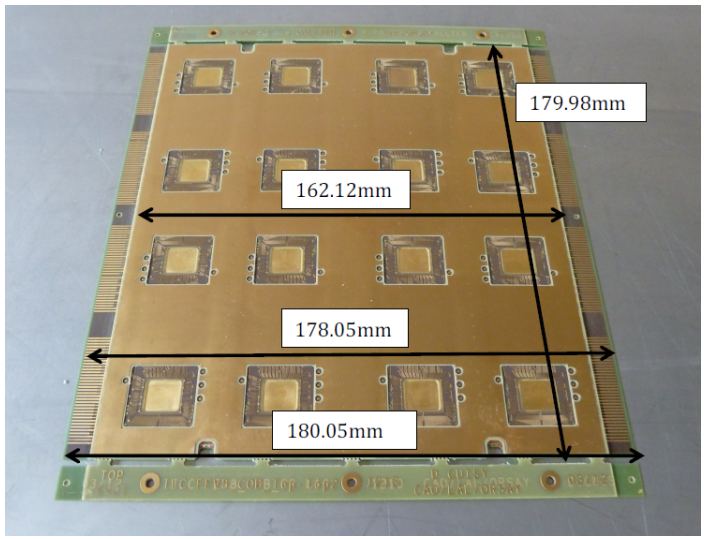
→ see Vladik and Yuji talks

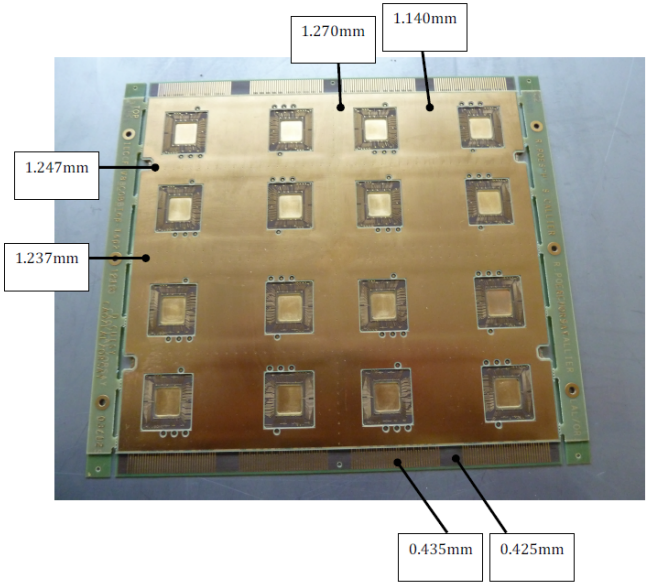
PCB

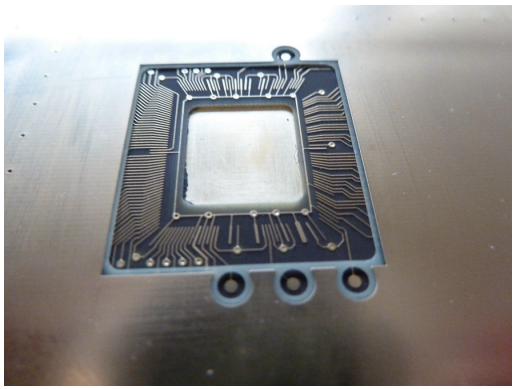
PCB is critical → Goal :1 mm thick, 8 layers, 1% flatness , ASICs bounded into

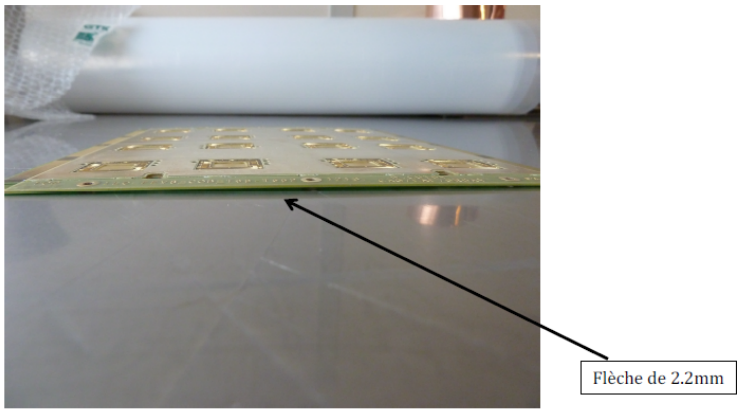
FEV COB

- Available since december 2012 (Boards from Exception and Protecno)
- First board for 16 ASICs (btw. Several proposal to assure planarity exist)
- Now equipped with 8 SKIROC ASICs (Boncing by CERN) → Needs testing
- However, bonding was not straightfoward, thin bonding pads can be improved







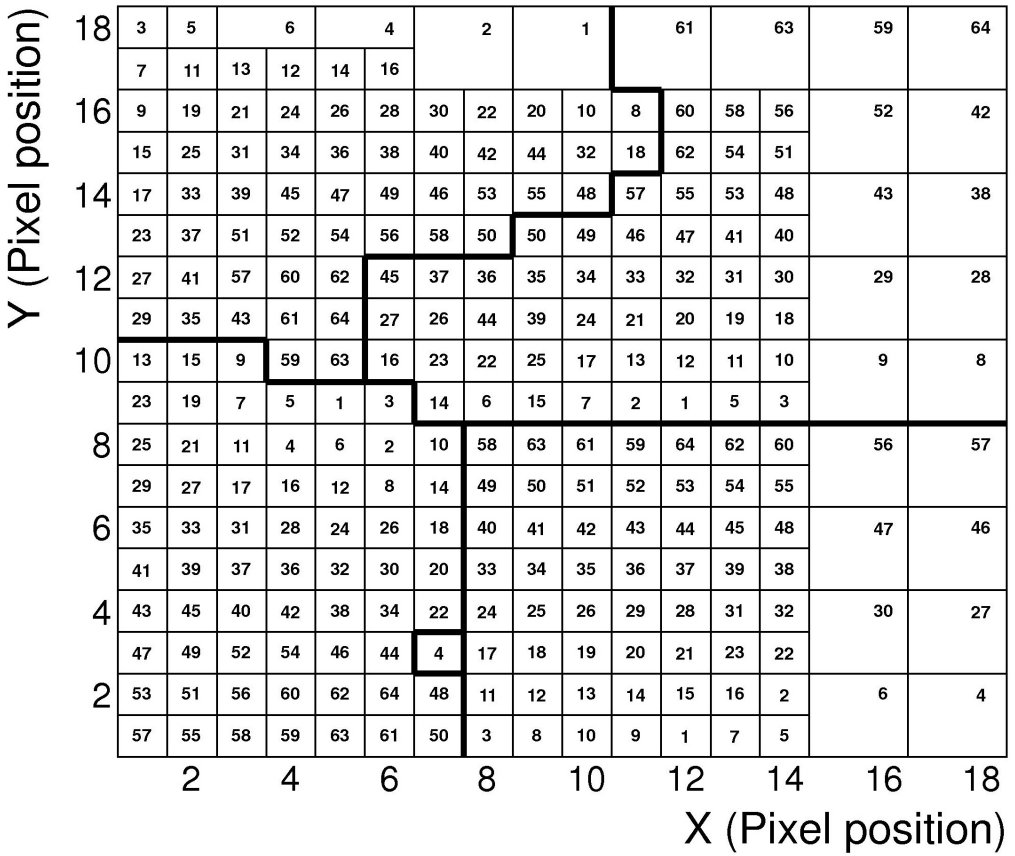


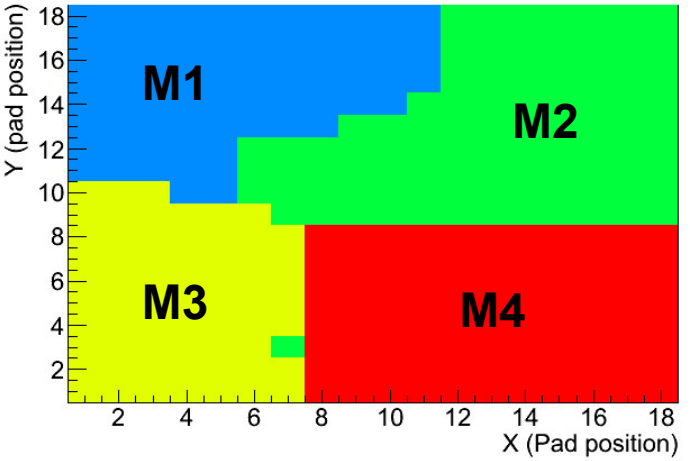
PCB

PCB is critical → Goal :1 mm thick, 8 layers, 1% flatness , ASICs bounded into
Current: FEV8 Chip in package, 1.4 mm thick

Line density in PCB ➔ routing is crucial

- Noise
- Cross talk (Digital / readout channels → readout channels)





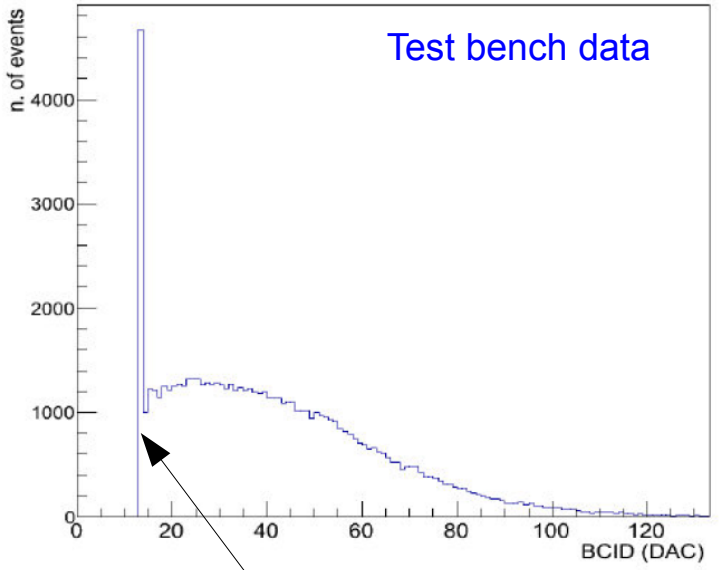
Switched off channels

Noisy channels + no individual channel adjustement → channels linked to several pixels

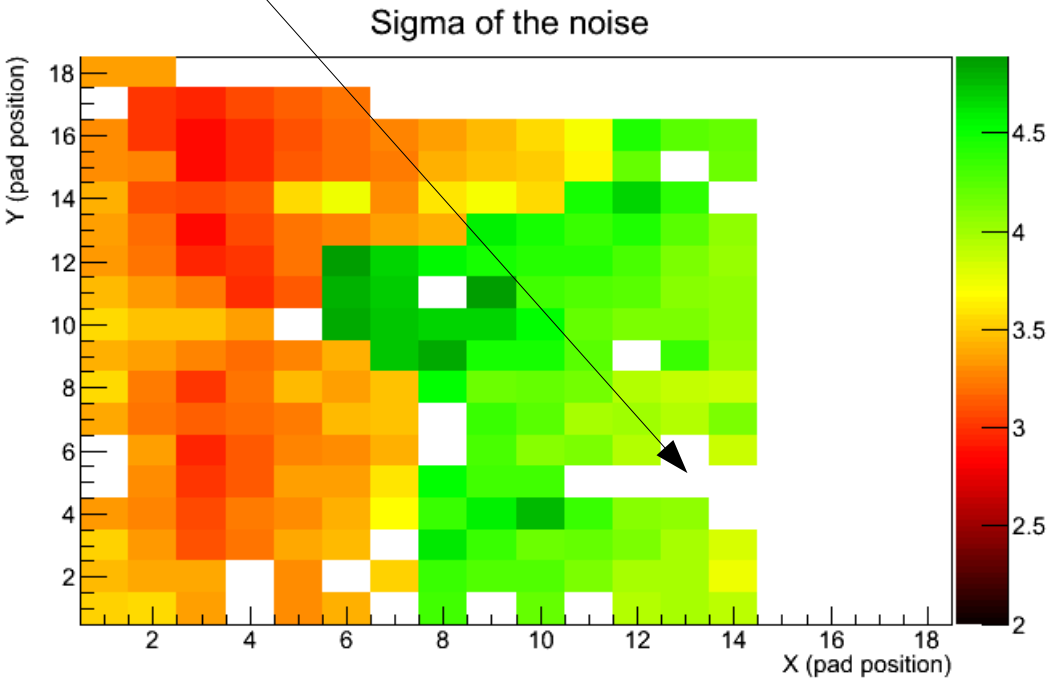
Cross talk with digital lines (valEvt, startAcq, clocks, injection line):

e.g.: ValEvt line close to M4 35-37: signal > 1 MIP

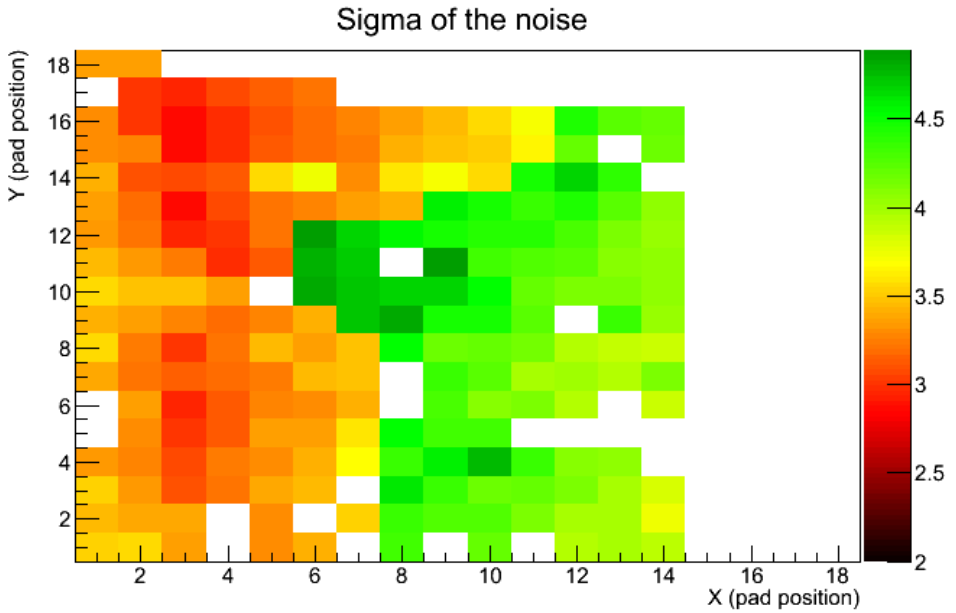
BCID distribution in channel 35 (M4)

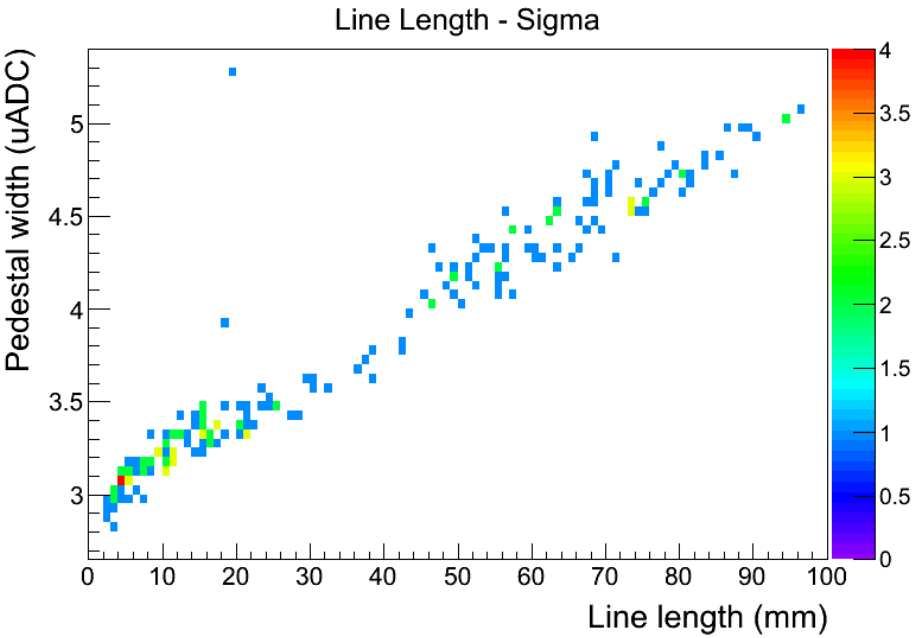


Synchronized with valEvt signal (13 BCID)



Noise studies





Noise ∝ Line length

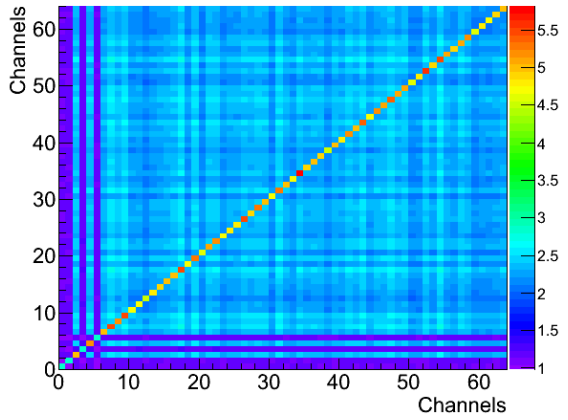
Already improved for the 16 ASIC version of the PCB

Coherent noise (general behavior)

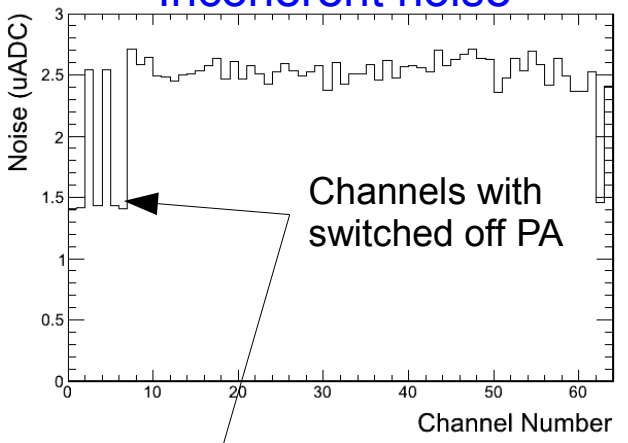
Development of algorithm to identify coherent noise (continuation of Roman studies)

e.g. : chip M1

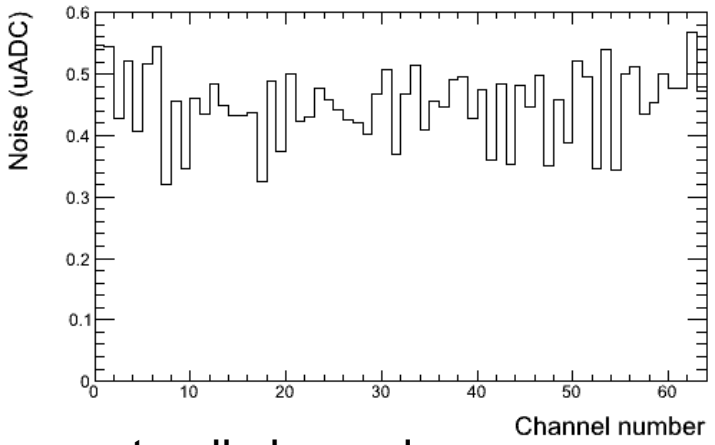
We extract incoherent noise + 2 sources of coherent noise:

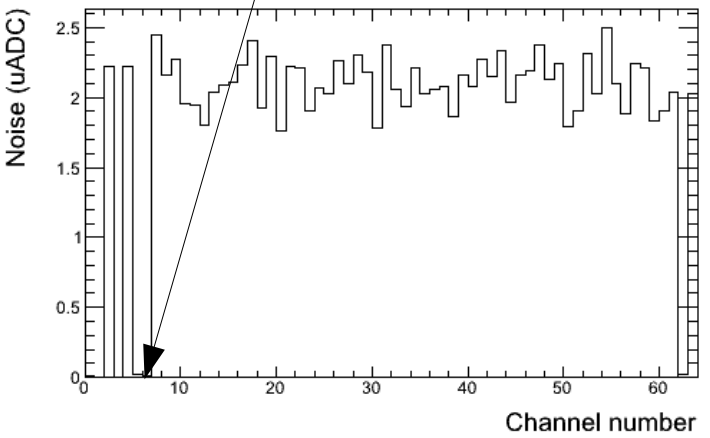


Incoherent noise



Coherent noises





Common to all channels:

- Due to the ramp? (Omega expects ~0.5 ADC)

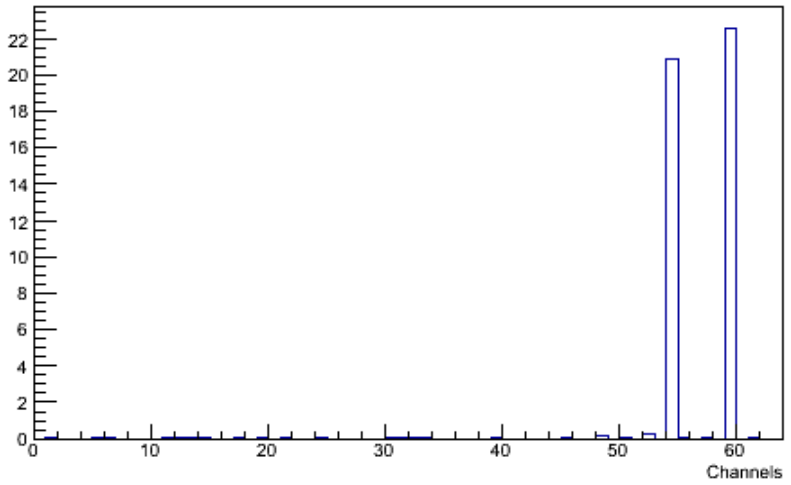
Common to channels with switched on PA:

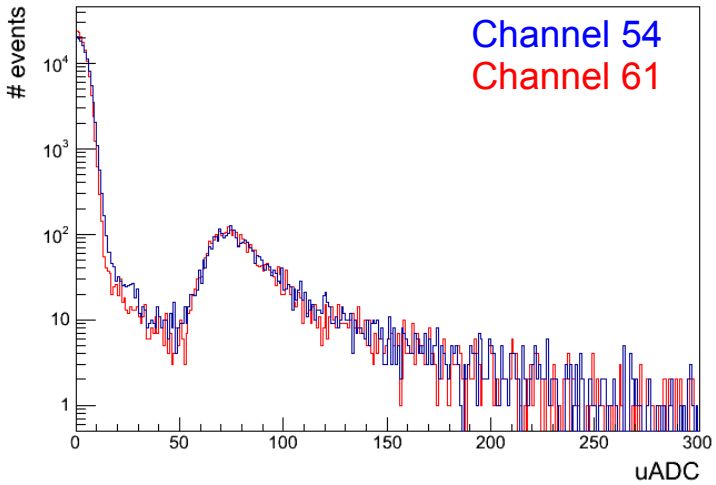
- Due to PA?
- To be clearly identified and reduced (if possible): under discussion with experts (Omega)

Correlation studies

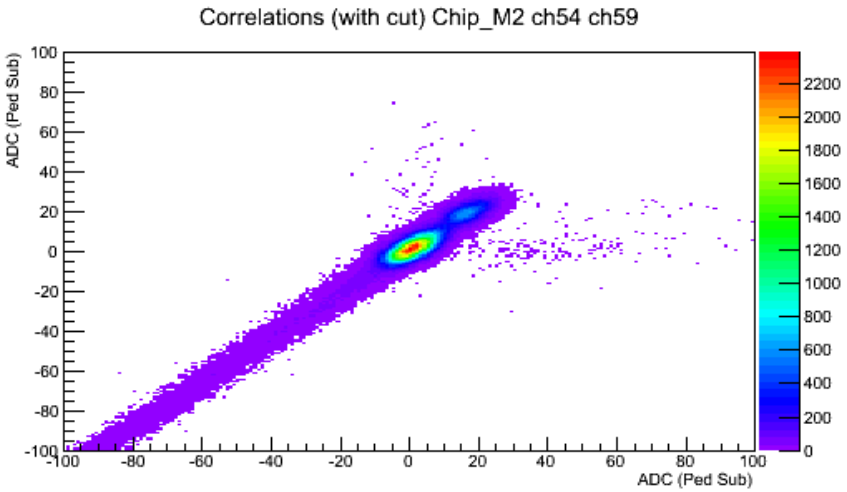
Chip M2 (all layers):

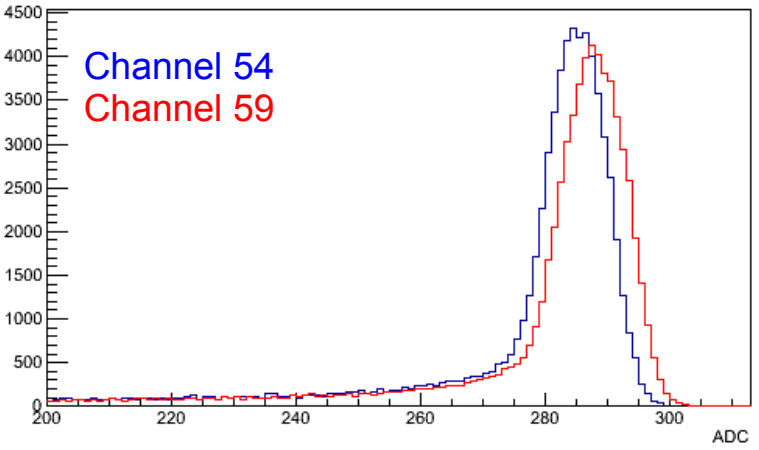
- Another coherent noise source → 2 highly correlated channels
- No clear idea of the source





We don't see an effect on MIP distribution

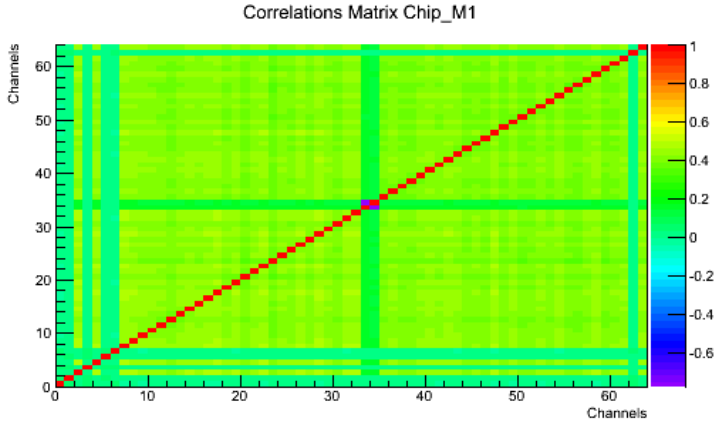


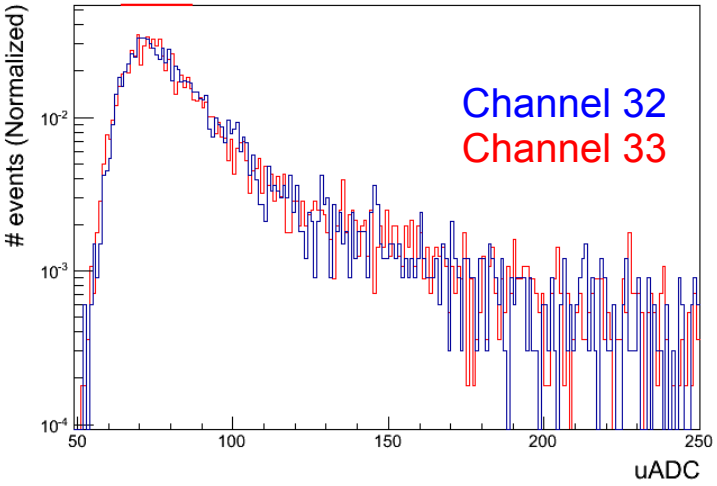


Correlation studies

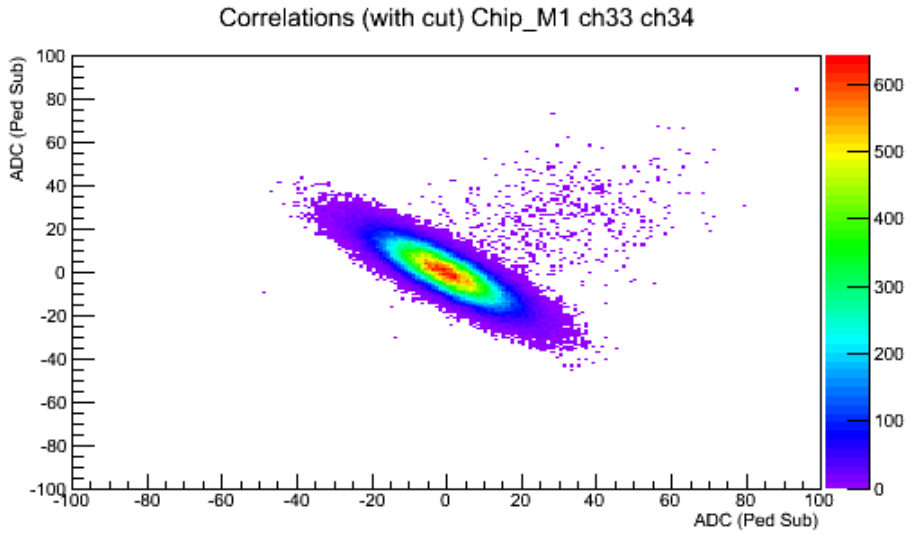
Chip M1 (only in slab3) :

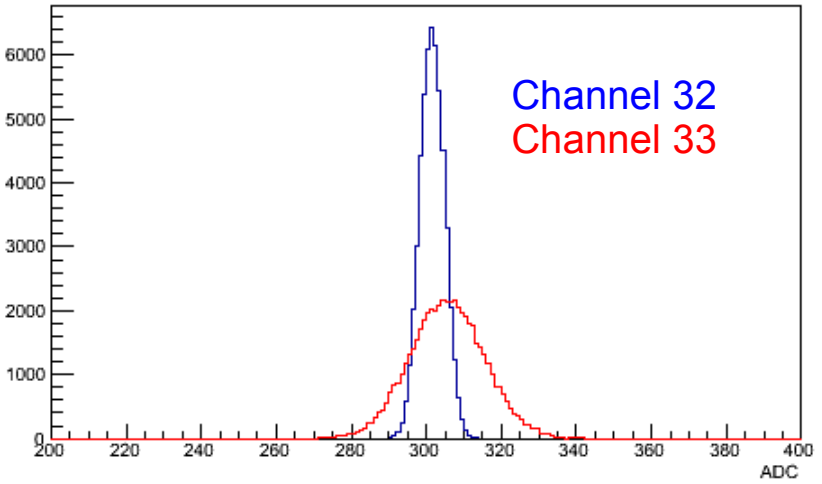
- Another coherent noise source → 2 highly anti-correlated channels
- No clear idea of the source of this behavior





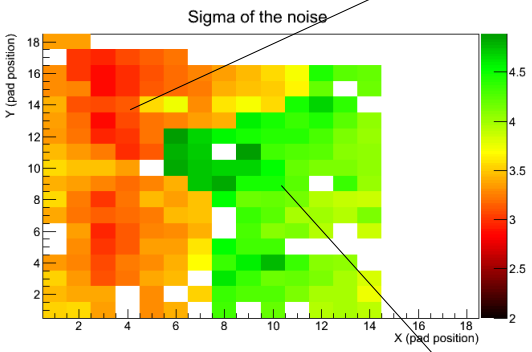
We don't see an effect on MIP distribution.
We should check the S/N ration @ low gain

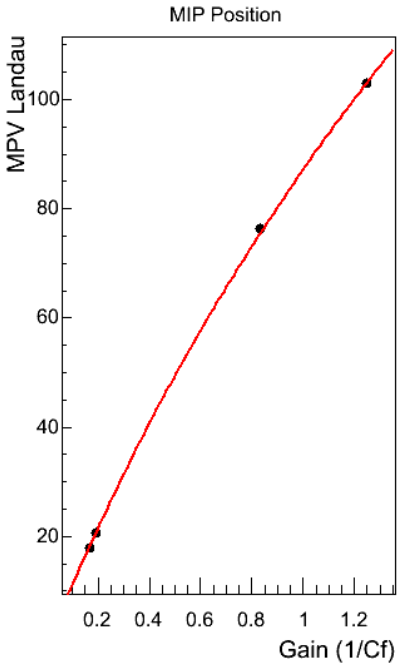


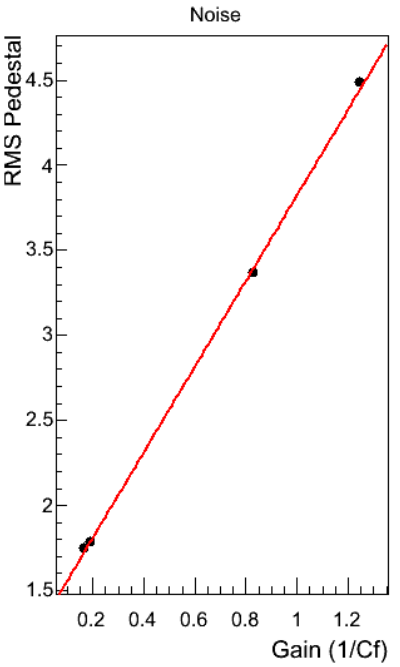


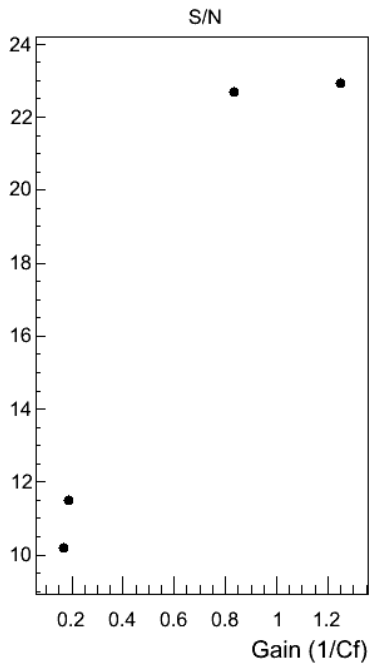
SKIROC results as a function of the gain

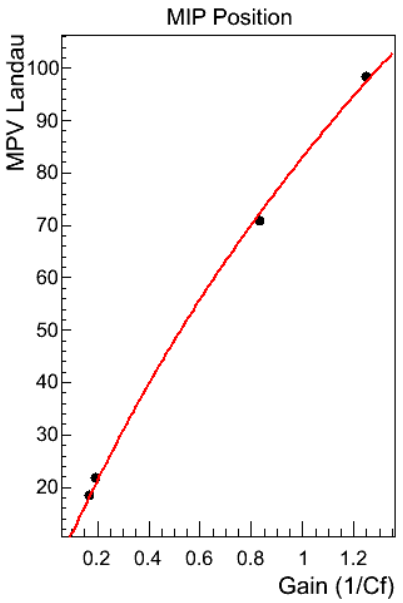
Gain $\propto$ $1/C_f$

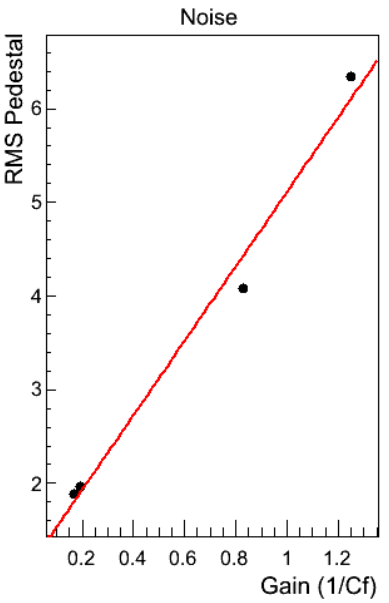


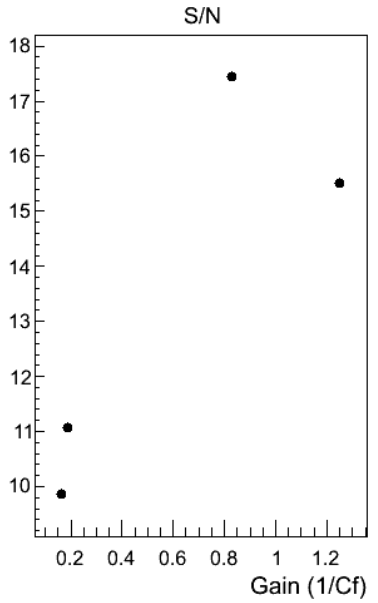






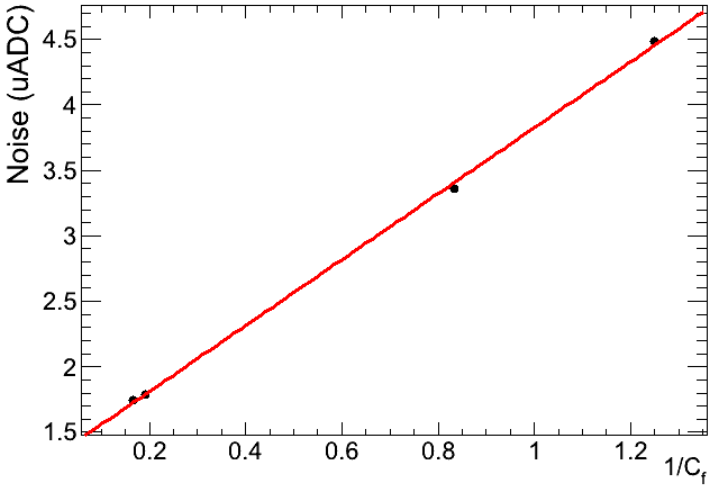


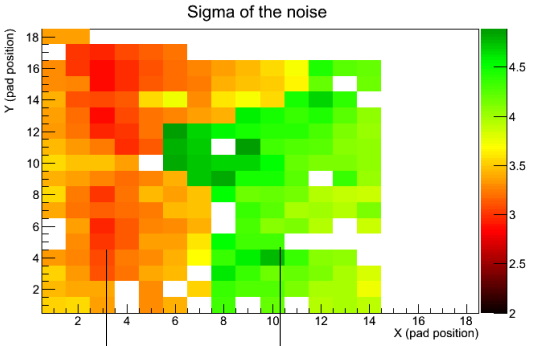




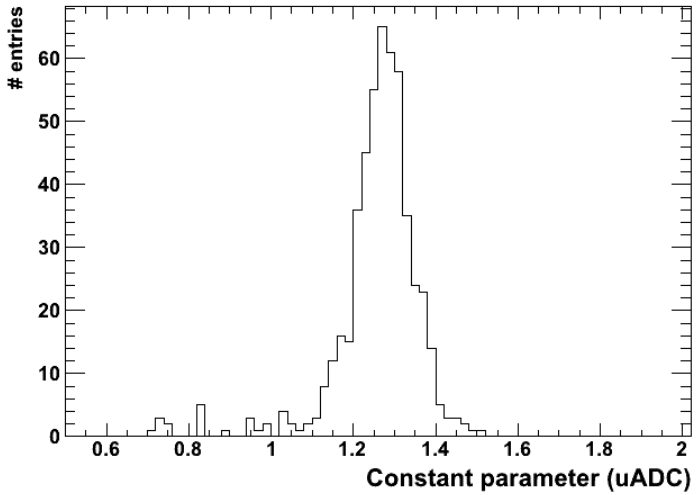
Saturation of the MIP position → bad holdscan calibration?

Fit of the noise as a function of the gain

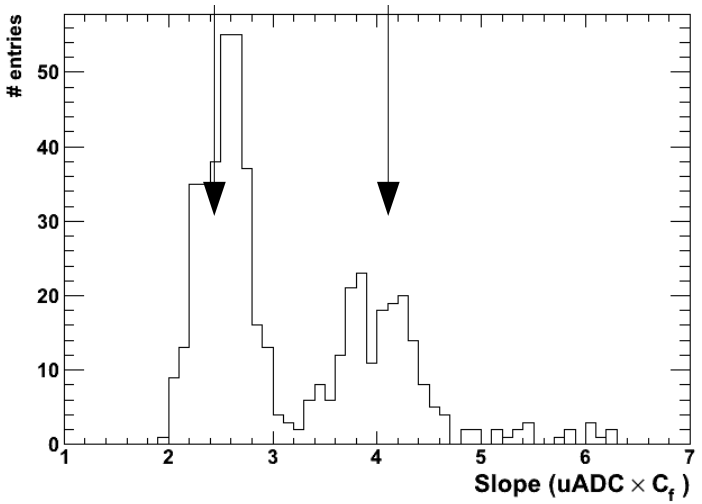




Constant parameter of the linear fit for all channels / ASICs / Slabs

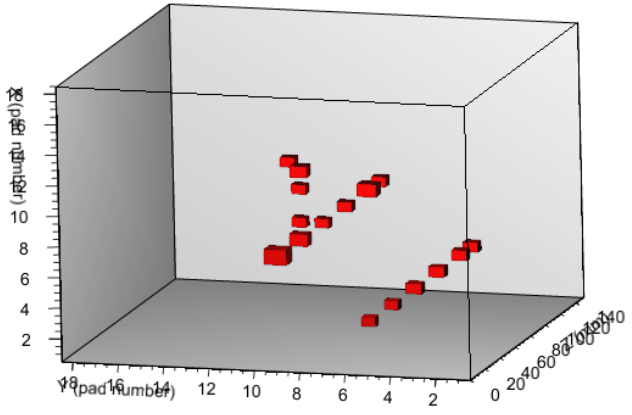


Slope of the linear fit for all channels / ASICs / Slabs

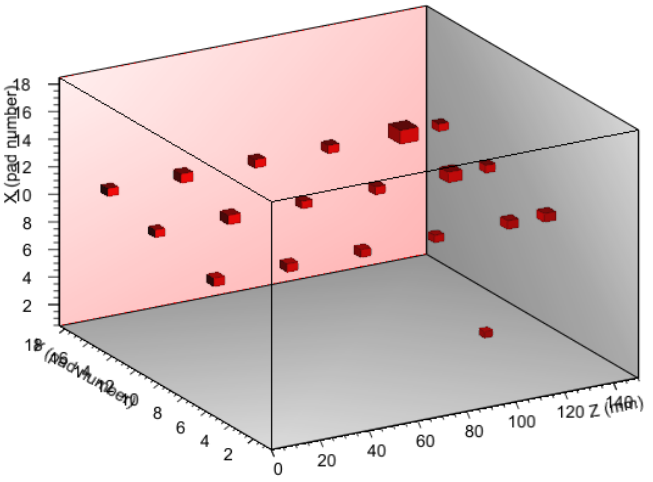


Event display

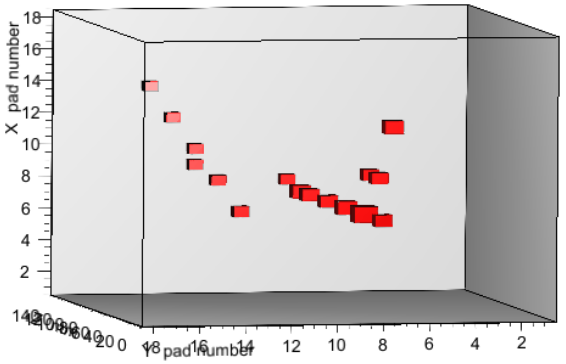
2 e- (3 GeV, no tungsten)



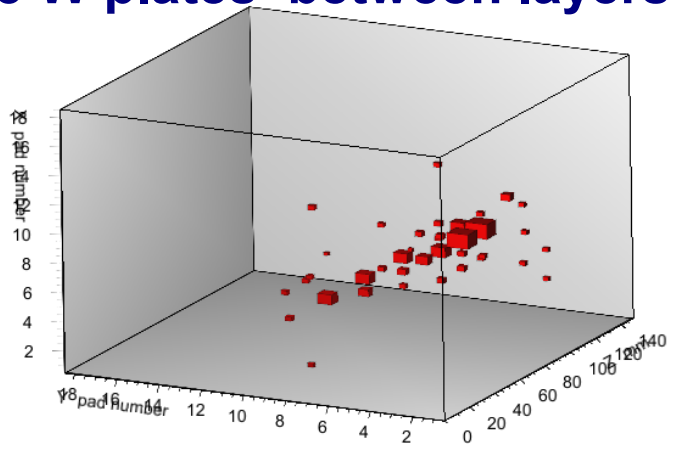
3 e- (3 GeV, no tungsten)



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



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



Summary

2012 test beams have provided useful data.

- Mainly thanks to the Frédéric's work on DAQ software

Major step forward in the understanding of the detector

- BCID+1
- Plane events
- Switched off channels due to crosstalk with digital line or readout channels
- Noise structure

To be continued with power pulsing studies

- See Nathalie, Vladik and Yuji talks

R&D in progress… first test beam shows promising results