SiW-ECAL 2018 DESY Beam Test:
comments on commissioning and a first look to data

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Outline

- Some comments on commissioning + debugged setups/settings

- DESY BT2018 run summary.
- Long Slab performance → **great success!! :D**
- S/N calculation on the trigger line for short slabs (FEV11)
- FEV13 performance

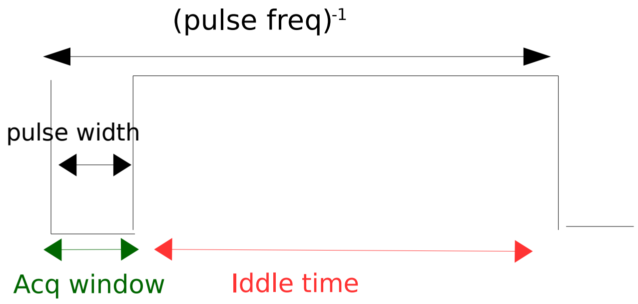
Notes on the commissioning procedure

- For the FEV11, running in Power Pulsing, the generation of the configuration file starts from this file: /opt/calicoes/config/all_on_1pF_FA_CC6pF.SC.txt
  - 0xFE000031FE2F8A80828000000000000000444444444444444444444444444444444444444444444444444444444444442842AA0000000000000000000000000000000000000000000000019D
  - Which is a modification of the historical file /opt/calicoes/config/all_on_1pF_FA.SC.txt
  - 0xFE000031FE2F8A808280000000000000004444444444444444444444444444444444444444444444444444444444444442842AA00000000000000000000000000000000000000000000000195

- This slow control has to be used as starting point for the commissioning.
- All the **configuration files of 2017** are in https://twiki.cern.ch/twiki/bin/view/CALICE/SiWDESY201706Commissioning
- The commissioning scripts are in **Calicoes**, branch **features/calicoes3_commissioning**

Notes on the commissioning procedure

- The results of the deep commissioning and debugging work done last year at LAL&LLR was summarized with the following optimal spill configuration for data taking in high rate particle beams



Frequency 5Hz

Acq window: 3.7ms

Readout time (iidle time) = 196.3 ms

(going to 4Hz would automatically increase this time to 246,3 and 1Hz to 996,3)

- This selection is independent of the noise bursts but it is noise burst safe
- We also **agreed** to **use BT mode and not ILC mode** since it is much better tested and give us the flexibility to define spill windows → remember that for beam test we don't need more than 2-4 ms in order to not saturate the DAQ

Notes on the commissioning procedure

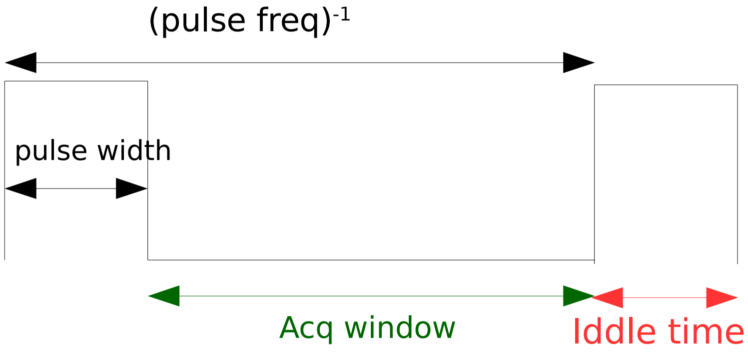
- The commissioning procedure relies in 4 steps. The first two with very large thresholds ~0.8-3 MIPs
- 1→ **1st masking** of noisy channels (not only the channel 37 and similar, but all noisy channels).
  - This step MUST be always the first because to understand the scurves we need an "homogeneously nosiy" slab --> this is true for FEV11 and FEV13, BGA or COB.
  - For this we need special and dedicated runs with specific spill configurations → because if the detector is flooded by noise, the data integrity can be compromised unless the readout time is large enough.
- 2 → **2nd masking** of noisy channels: using long spills and comparing the given rates channel per channel wrt the expected cosmic rates →
  - If a channels receives x5 or 10 times more hits than expected by cosmics, it is masked.
- 3 → **Threshold choice from scurves** with the remaining non masked channels. This step should be **never done before the others!**
- 4 → the **final masking** procedure with the optimally defined thresholds.
  - This step (and maybe also the 2nd) may be refined to include fine tunning of the individual thresholds.

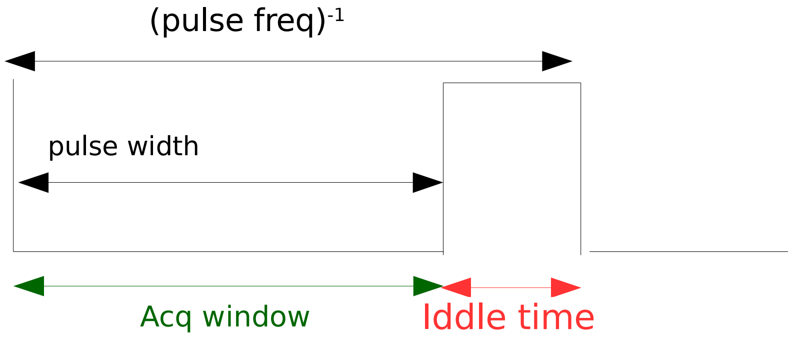
https://twiki.cern.ch/twiki/bin/view/CALICE/CommissioningProcedure

Different spill configurations are used during the full procedure!

Notes on the commissioning procedure

- Playing with the spill configuration with Pyrame allows to perform the commissioning of the detector. The pulse signal can be obtained from the pulse generators in two ways:
- Not inverted or inverted





- Of course, both can be equivalent with a smart choice of the pulse width but ...

Notes on the commissioning procedure

- ... but **pyrame assumes** that the pulse width is the spill width
  - reconfigure("spill","set_pulse_width_signal",str(spill_width))

    to set the length of the acquisition window in find noisy algorithms since 2015 (and all the new commissioning)
- Since the beginning of the preparation of BT2017, the spill was used inverted (pulse width = spill width) as instructed by Remi.

Spill used in beam test 2018

- TB21: Setting the **spill not inverted** with 1Hz and 100ms of iddle time, means that we will take data during 900ms (90% of the time)
  - TB24: 2Hz, with 300 ms of acquisition window

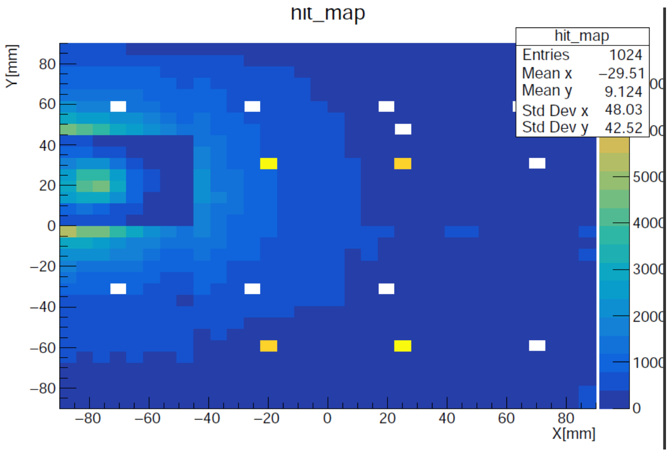
Some numbers:

- The DAQ (Skiroc+DIF) needs ~12ms to process the data of a chip with full memory → 12x16 ~ 190ms (with 2.5 MHz)
- **3KHz beam** hitting the channels of one chip will **fill up the 15 SCAs in 5ms.**
  - If the acq window is 900ms and we have a noisy slab (or the beam spot is large), the chances of having 16 chips with full memory is maximal

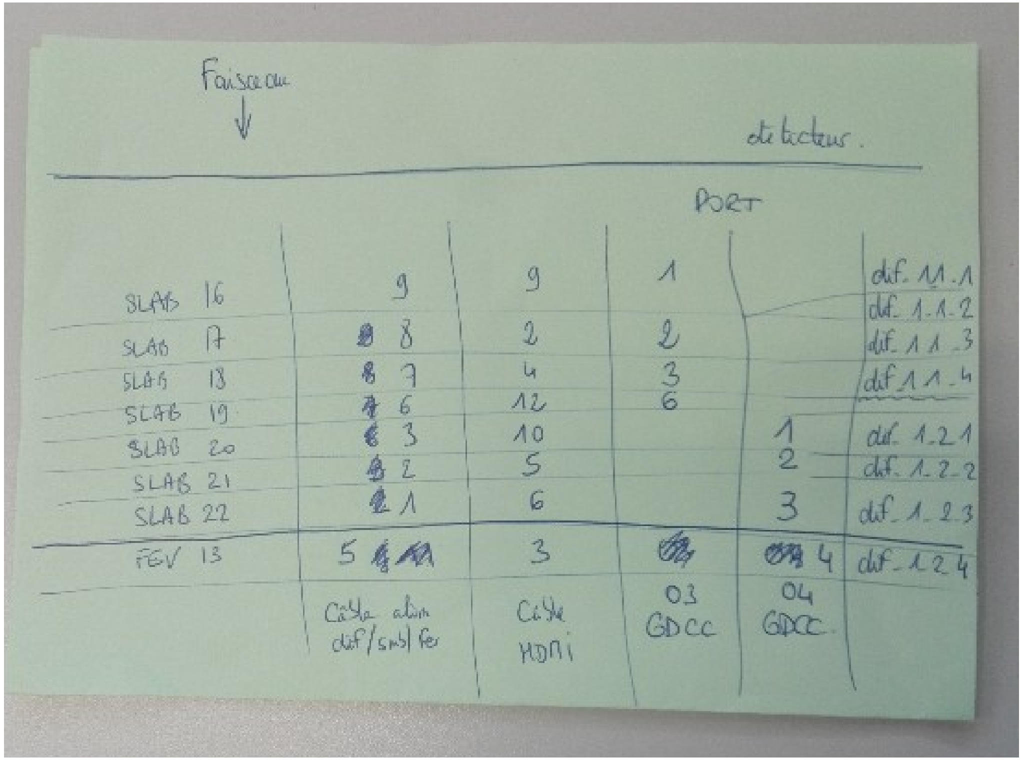
- So with these settings we saturate the DAQ and we maximize the chances of data corruption (spill arrives in the middle of the conversion)

Spill used in beam test 2018

- What was the impact of changing the pulse configuration for this beam test?
  - At least the **two** rounds **commissioning** of the FEV11 performed in DESY were **wrong** → so we moved to the old files from 2017 (modifying it due to a different slab sorting) (**not dramatic** since testing FEV11 was not the goal of the TB)
  - We were constrained to use 1Hz (factor 5 lower than last year) → **5 times slower data taking**.
  - Most **scurves** runs from the 6th to the 7th of Juy should be studied with care since the **spill configuration** was **changed automatically** in the scripts, assuming a different output signal from the pulse generator.
  - Continuously **saturated DAQ** (even in TB24)



Data Taking Summary



	2017 setup		2018 setup	
layer position	*slab*	*dif*	***slab***	***dif***
1st	21	1_1_1	**16**	**1_1_1**
2nd	16	1_1_2	**17**	**1_1_2**
3rd	17	1_1_3	**18**	**1_1_3**
4th	18	1_1_4	**19**	**1_1_4**
5th	19	1_1_5	**20**	**1_2_1**
6th	20	1_2_1	**21**	**1_2_2**
7th	22	1_2_2	**22**	**1_2_3**
8th			**FEV13**	**1_2_4**

Data Taking Summary: TB21

	run type	data	time	comments
TB21, short slabs	commissioning	2.3GB	1-2 days	
	MIP scan (1)	147GB	~4days	From 2018/07/03 15:48:27 to 2018/07/06 11:01:43, long stop on wednesday
	MIP scan (2)	15G	12h	Why ? : some points missing in the FEV13 (beam spot ouside of the slab) + chips 8-11 with low stats and (les important) the FEV11 wrongly configured in several runs
	Scurves with signals (1MIP)	9.2GB	20h	For each point, we run a MIP scan + a scurve. Start 20180706_154816 end 20180708_062533 plus a run in the sunday evening.
	Only used as reference for long slab	5.3GB	1day	Fixed position
total	**6 days**			
total (with long)	**3.5days**			

	run type	data	time	comments
TB21, long slabs	Commissioning + debugging	28Gb	3.5days	
	Runs before debugging	?		
	Scan of positions (angle 0)	46GB	2.5day	The Long slab became fully operative on thursday afternoon → after the RC filters https://llrelog.in2p3.fr/calice/1774 data taking in parallel by the short slabs
	Angle Scan (ASU8)	2.3GB	1day	together with short slabs
Total (with shorts)	**3.5 days (from thursday noon)**			

- Long slab and short slabs always taking data in paralell.
  - Until thursday afternoon, the FEV13 MIP scan was run while the long slab debugging was ongoing (barely some data quality checks for the FEV11s was done)
- Long slab became fully operative on thursday afternoon.
- Short slabs unoptimally configured for several days → fixed ~ when long slab became operative.
- FEV13 MIP scan time went from 1-2 days to 5-6 (5Hz vs 1 Hz)

Data Taking Summary: TB24

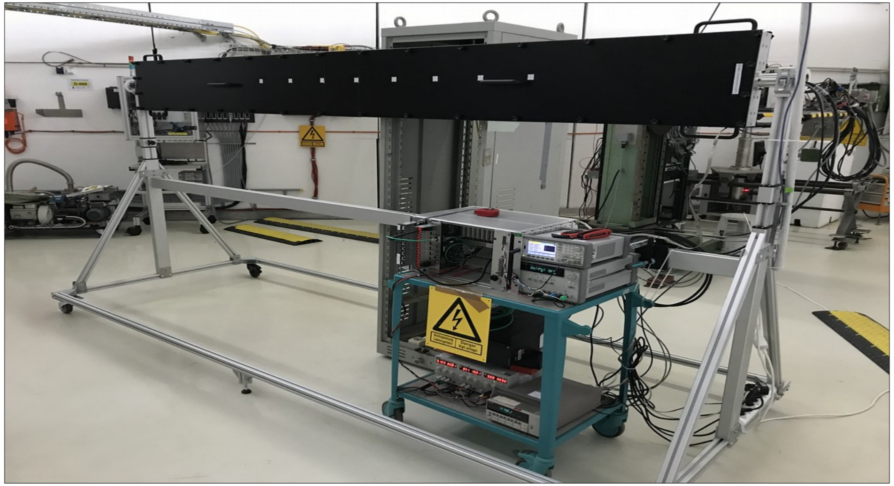
	run type	data	time	comments
TB24, short slabs	common runs with long slab	99GB	2days	Angle 0 and several up to 60. Finished on the night of the tuesday to wednesday
	Scurve with 60 degrees	2.2GB	2.5h	Before the W program (the DESY machine development took shorter than expected)
	Showers, 5X0 in front of the detector	74GB	~0.75day	Wednesday noon until wednesday evening
	TDC studies	48GB	20h	Wednesday evening and thursday daylight
	Last scurve with optimal spill	1.3GB	6h	Thursday evening + night
total	**4 days**			
total (with long)	**2 days**			

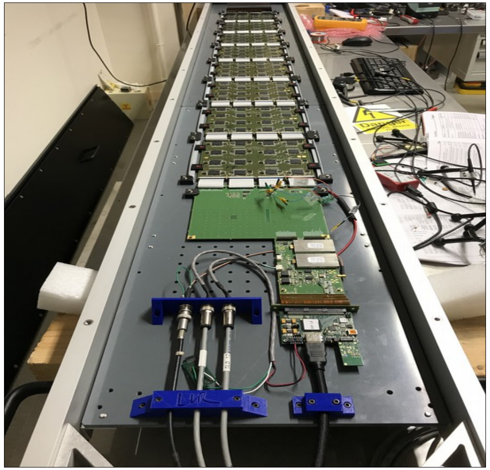
	run type	data	time	comments
TB24, long slabs	common runs with short slabs		2days	Angle 0 and several up to 60. Finished on the night of the tuesday to wednesday
	Showers, 5X0 in front of the detector		~0.25day	Wednesday morning after machine development
total	**2.25 days**			
total (with short)	**2 days**			

- Some playing with the spill to make it a bit more optimal.
- Long slab + short slab angle run until wednesday.
- Showers ~ 0.7 days.
- First tests of the TDC → although the non-linear scale makes the data suboptimal for studies.
- Last run (scurves) on thursday night.

Long Slab performance

- The great success of this beam test. **Congrats** to all and **specially to Fred and Jerome!**

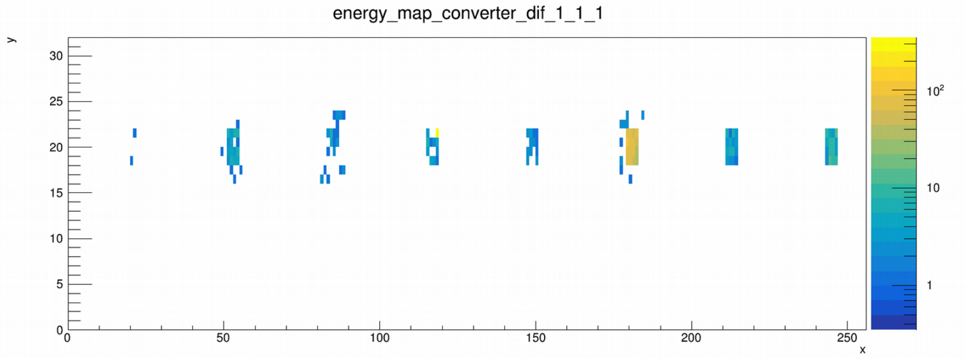




- First beam spot farther than ASU2-3 seen on thursday afternoon

  https://llrelog.in2p3.fr/calice/1774

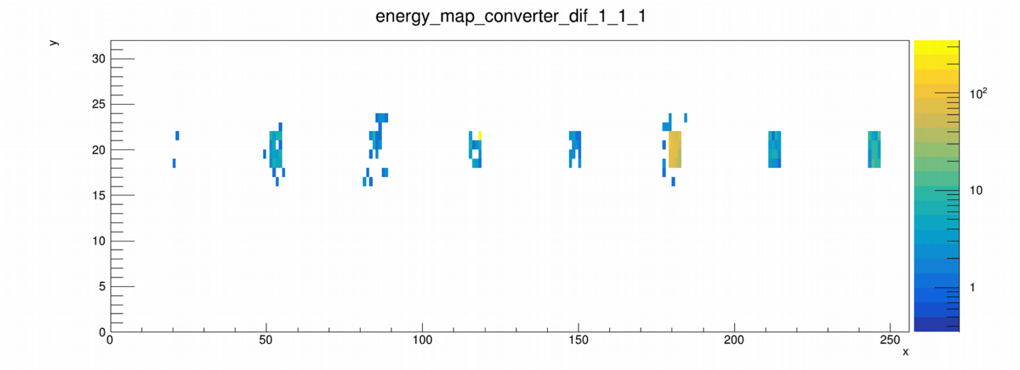
- ASU 6



Long Slab performance

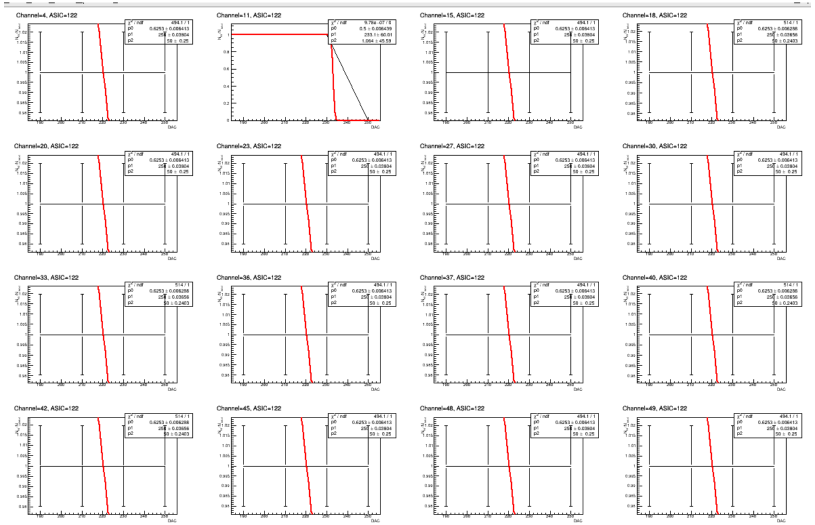
- The great success of this beam test. **Congrats to all and specially to Fred and Jerome!**
- In situ commissioning: the root scripts are not appropiate for the long slabs
- First beam spot farther than ASU2-3 seen on thursday afternoon

  https://llrelog.in2p3.fr/calice/1774
- We got enough data to test the performance of the slab
  - all ASUs scanned and several angles with MIPs
  - Shower studies also in one ASU (5X0 of lead in front)

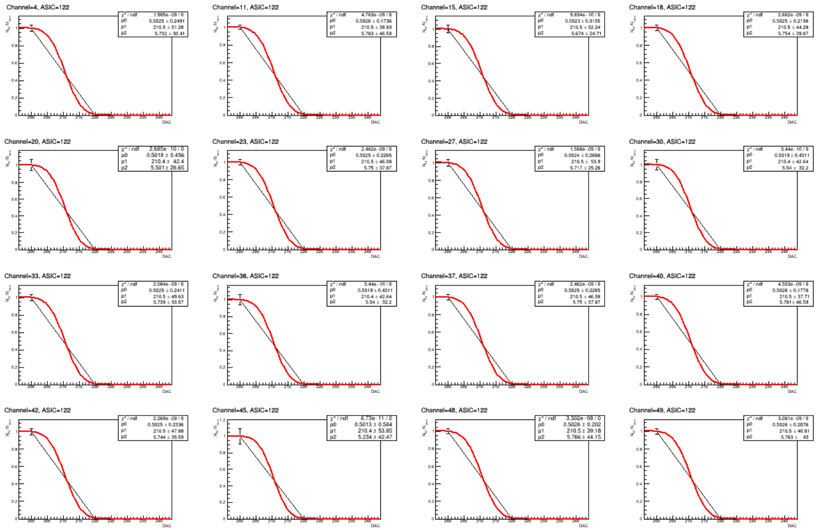


Long Slab performance

- The commissioning tools were not optimized (too slow) for long slab.
  - We should have started from what we have learn in the past:
  - Mask all channel 37 & all noisy channels (in the worst case it can be done by hand for 128 channels) and then choose a ~230DAC.
- We did it at DESY: starting from quick scurves of individual channels. By simple visual inspection we saw what were the noisy channels



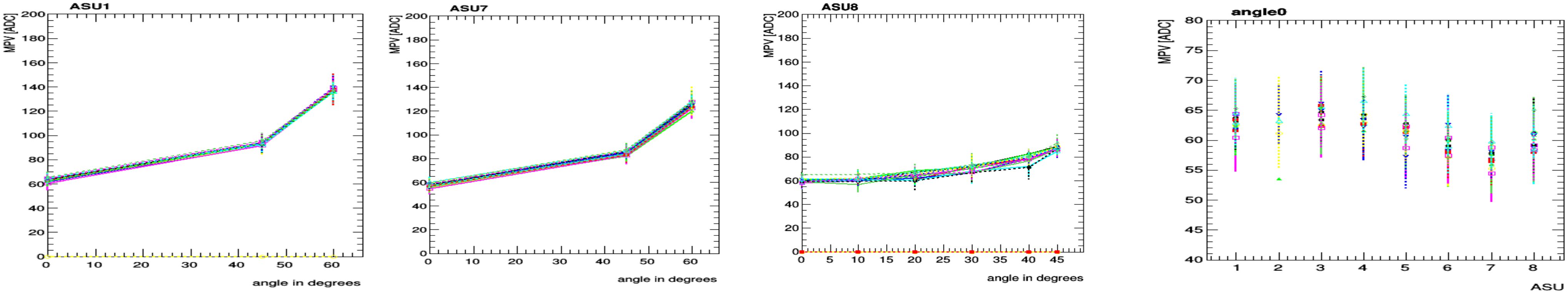
After RC filters were added between ASU To improve to the HV supply



Last ASU

Long Slab performance

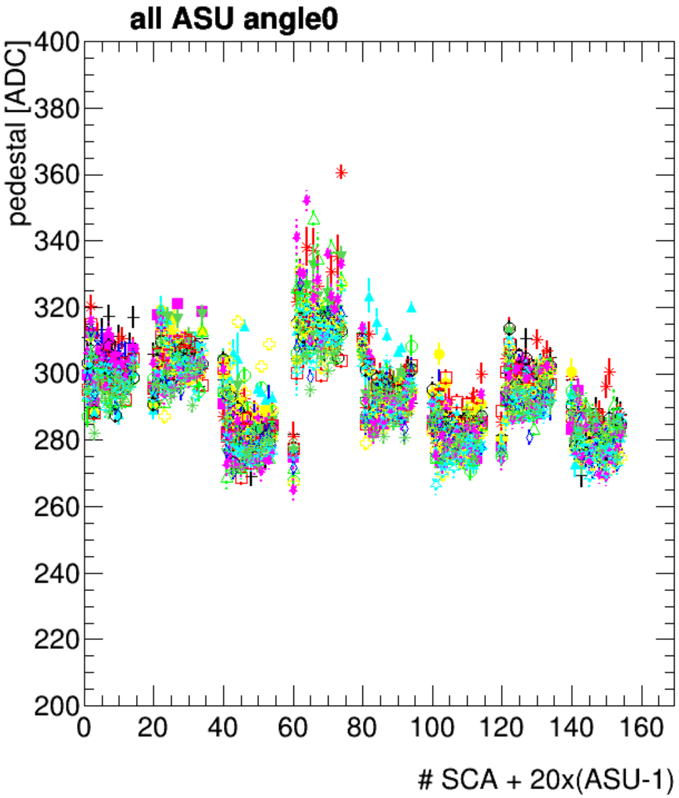
- In a first look, the results look very reasonable for all ASUs and angles
  - When moving to TB24 the ASU2 became very noisy… some issue with the HV?
  - The errors in the plot are not error of MPV but the width of the LandauGauss

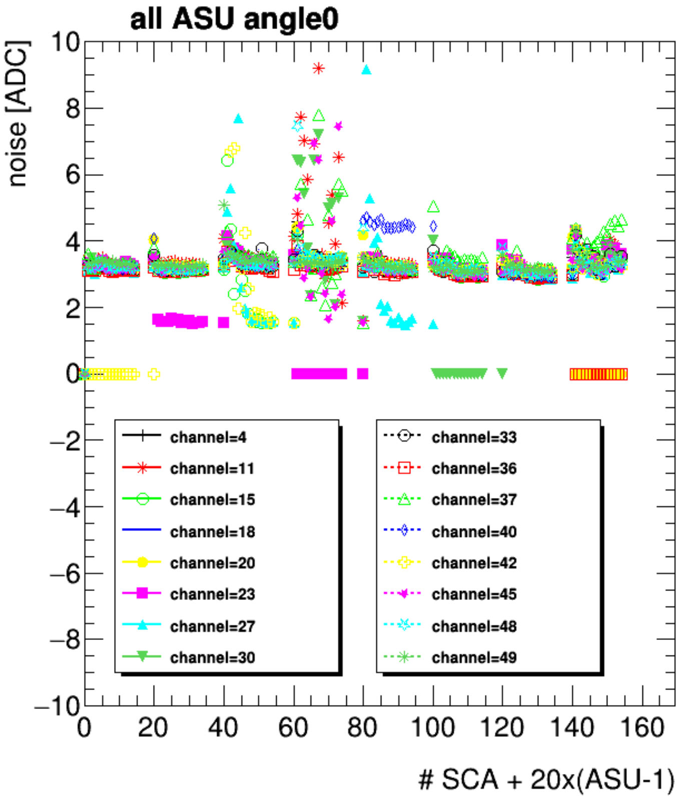


E. Mestre & V. Lohezic

Long Slab performance

- Pedestals (TB24)



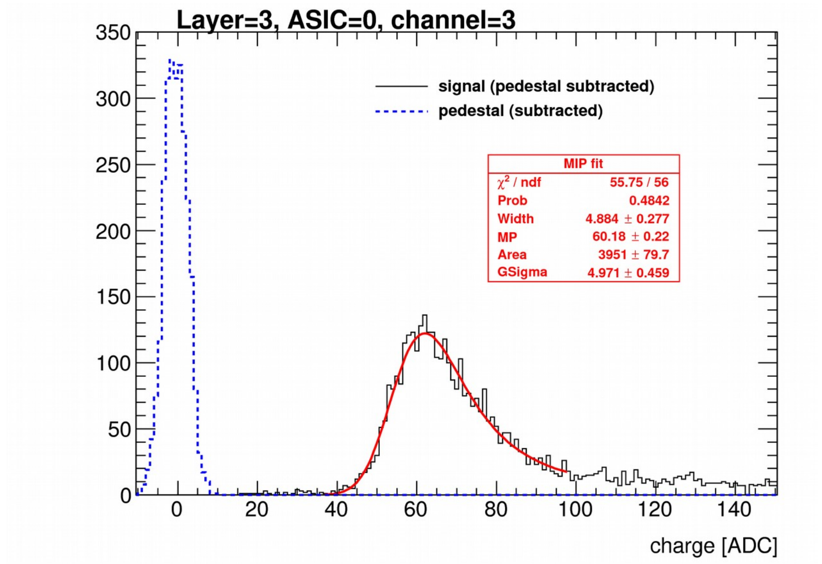


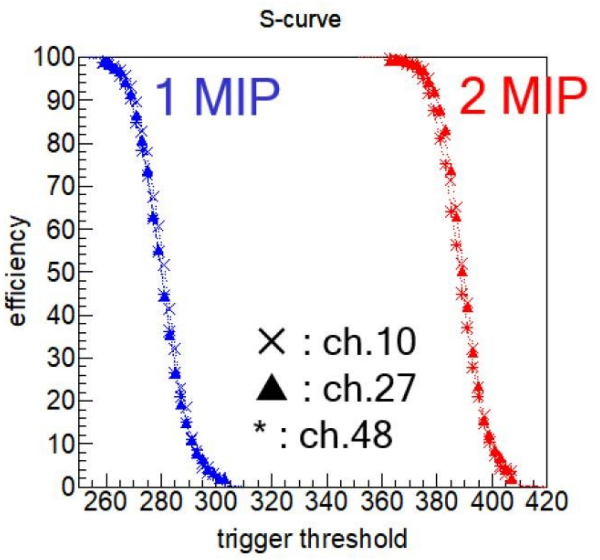
Short slabs stack

- **Good news:** In the first look, **we didn't see any noise burst!**
  - It is also true that we didn't inserted tungsten plates between all slabs but the new plastic structure seems to work quite well.
- **Bad news**, we lost the slab 21 :(
- We have enough data for:
  - Get calibration on the 16 chips of FEV13 and on FEV11 for comparisons
  - Noise+pedestal+retriggers studies
  - Some simple shower studies (5 X0 of Tungsten in front)
  - Scurves with MIP signals.
  - Very first tests of new features of the SK2a. (TDC)

S/N in the trigger line

- For the physics prototype, we worked with externally triggered events → the S/N was measured only in the ADC.
- Skiroc has two lines: the trigger decision (fast shaper) + signal measurement (slow shaper)



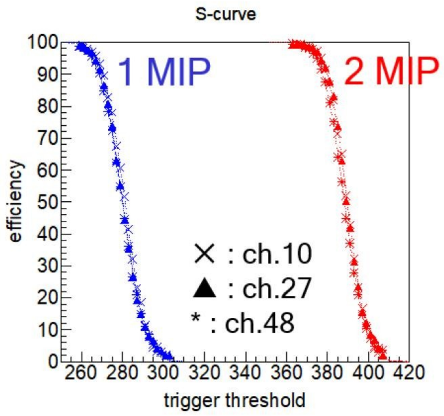


Injection tests in SK2/2a testboard by Taikan et al (SiW-ECAL proceeding)

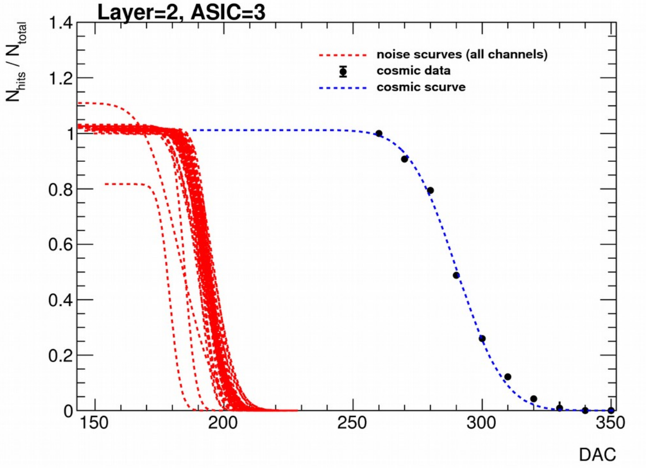
https://arxiv.org/abs/1801.02024

- S/N(ADC) = MPV / width_ped ~ **20**
  - *à la external trigger*
  - If we have a trigger, we are able to measure very low energies in the others
- S/N(trig) = 2MIP(50%) - 1MIP(50%) / width = **12.9**
  - ***Trigger using low energy signals (0.5MIP)***

S/N in the trigger line



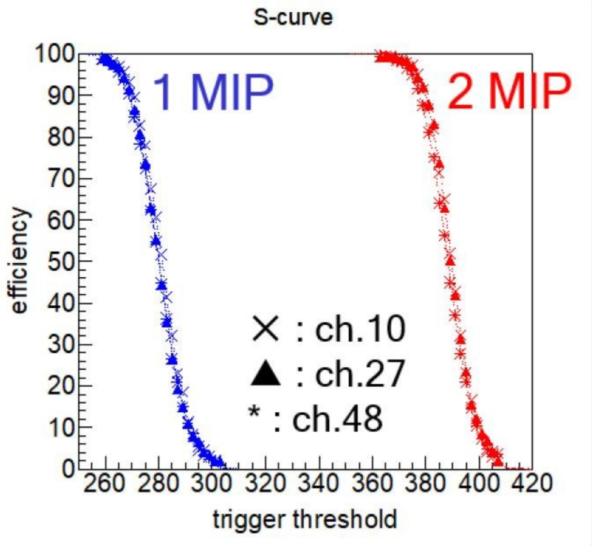
- Open questions:
  - What is the right width to use? It is this plot the same for real external signals in a fully assembled slab?
- First try to solve these questions → threshold scan using cosmics
  - Low stats + broad range of angles + spread of energies around 1 MIP
  - Force us to calculate average s-curves per chip
  - No external reference used but always same length of runs.

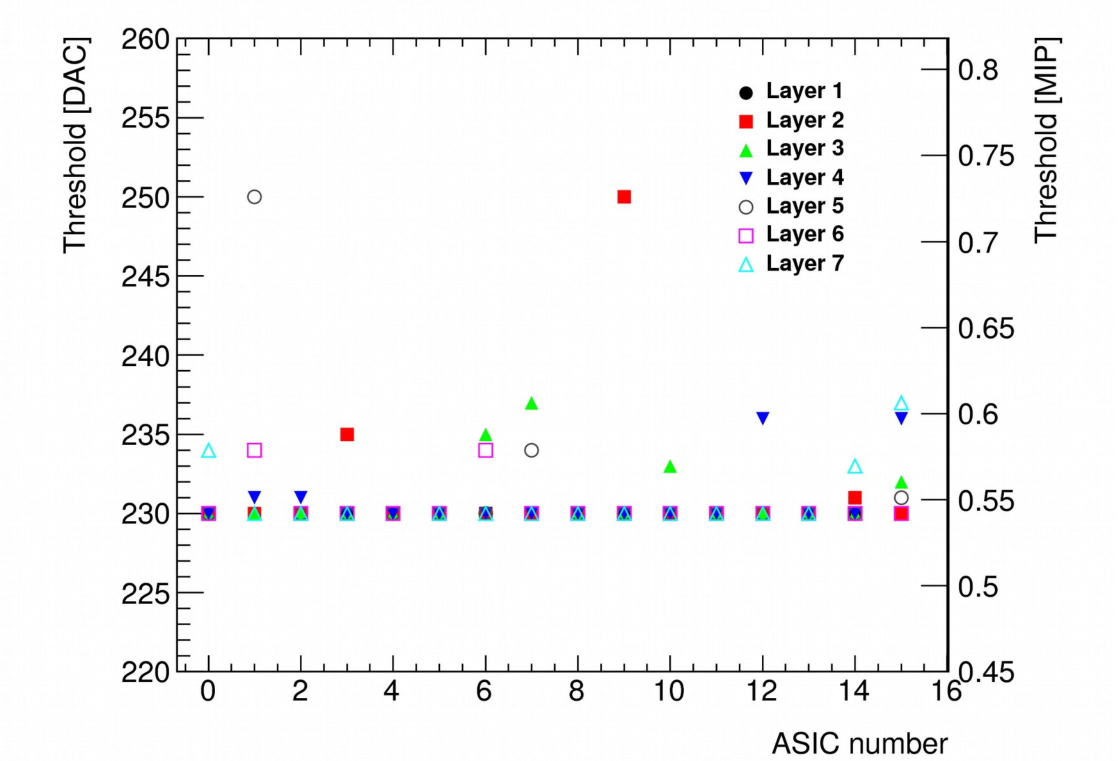


- The s-curve from cosmics is similar to the injected charge s-curve but not equal: it is broader and slightly shifted.
- **Nominal S/N** value: using the distance from the injection charge plot and the width of the 1MIP curve = **12.9**
- **Uncertainty:** using the width of the 2MIP and the central position and width of the cosmic s-curve **3.4**
  - 26% !!

S/N in the trigger line

- The signal S-curves and **S/N(trigger)** ratio is **crucial** to **know the distance of the threshold to the noise**





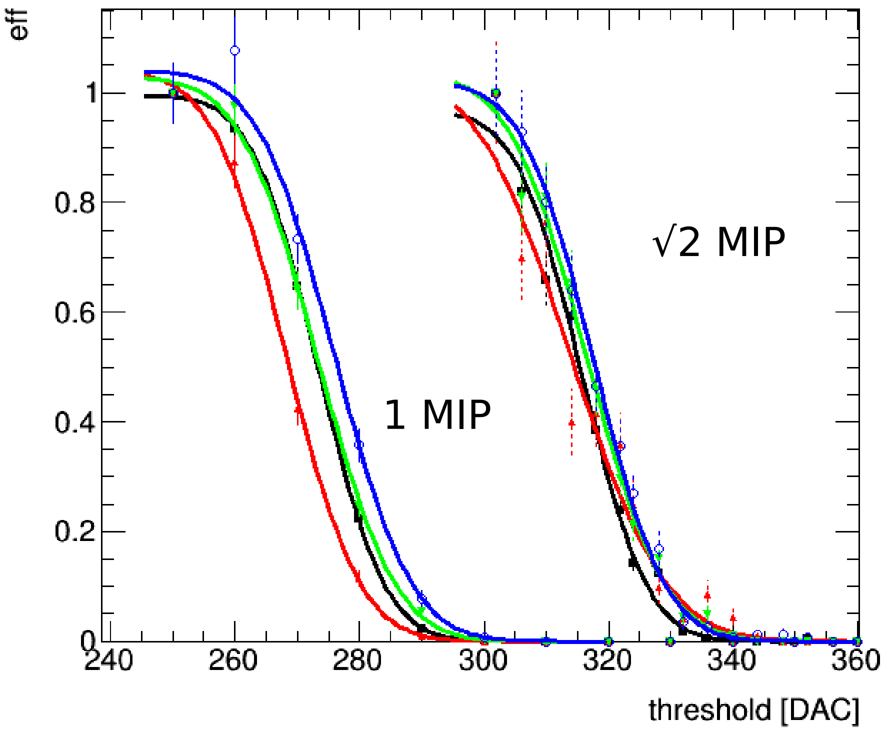
Please notice that previous versions of the circulated plot had an error in the y-axis [MIP] value

S/N in the trigger line: analysis

- Dedicated runs have been taken during last beam test to repeat these s-curves with different size signals (1MIP, 1.4MIP and 2 MIP)
  - The scripts assumed the default spill configuration…
  - Data at 1 and 1.4 MIP on the last day is okay (the rest: to be checked)
- Run settings
  - The first slab is always at a low threshold → used as reference
  - Single cell calibration is done in all slabs for the lowest threshold run.
  - Event building + filtering is done.
- The analysis is repeated for every slab after the first. An event is accepted if:
  - the first slab has only a hit with E>0.5
  - The studied slab hasn't an event outside (MPV-wLandau,MPV+wLandau)
- Then all events within (MPV-wLandau,MPV+wLandau) are counted for each threshold value
- The S/N is not calculated per cell (since different cells are used in every runs) but per SLAB.

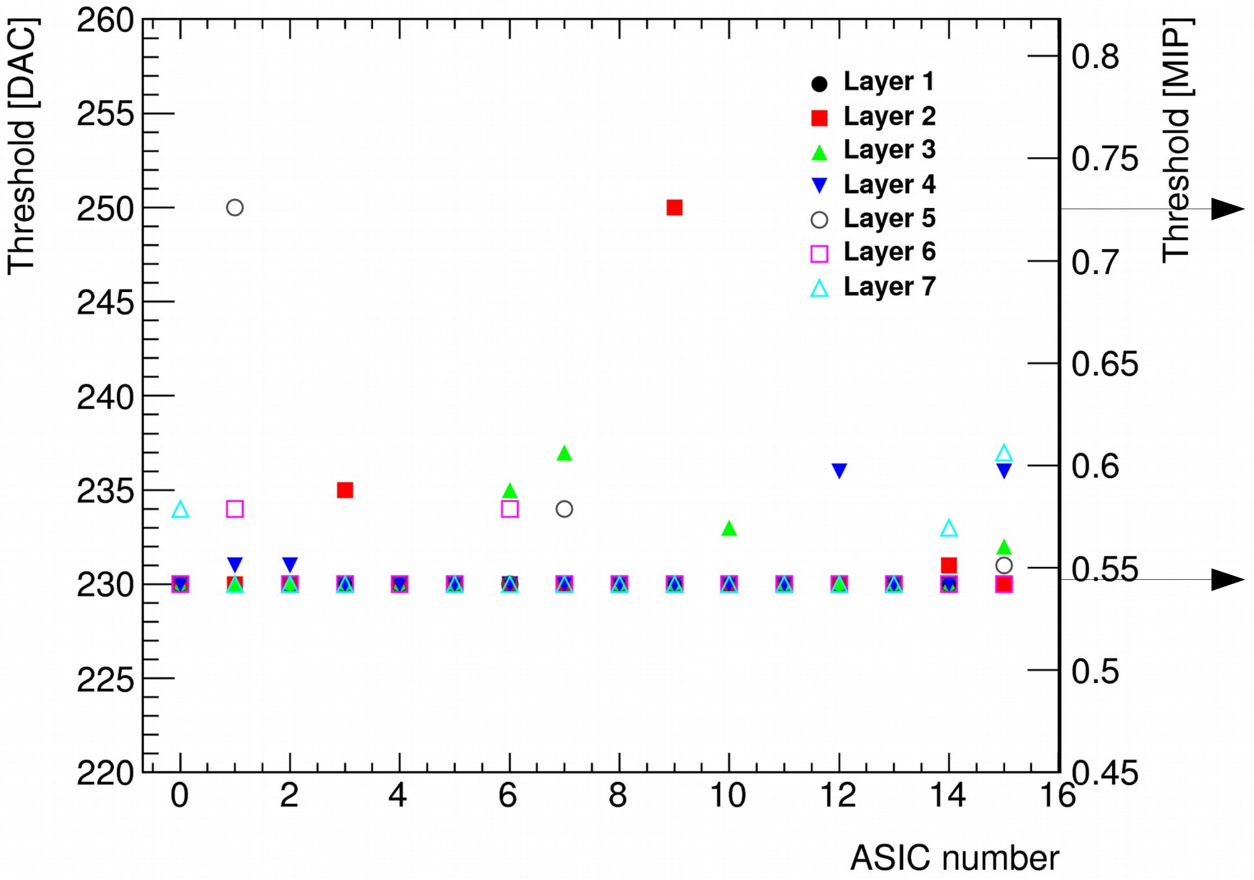
S/N in the trigger line

- Results for 1 & 1.4 MIP signals.



- Slab **17**, **18**, **19**, **20**
- **S/N = 11.6 ± 0.7**
  - 6% unc estimated includes the differences from different slabs and the different widths of 1MIP and 1.4MIP
- Results compatible with previously published results
- We can repeat the threshold ADC – MIP plot using the information from here...

S/N in the trigger line



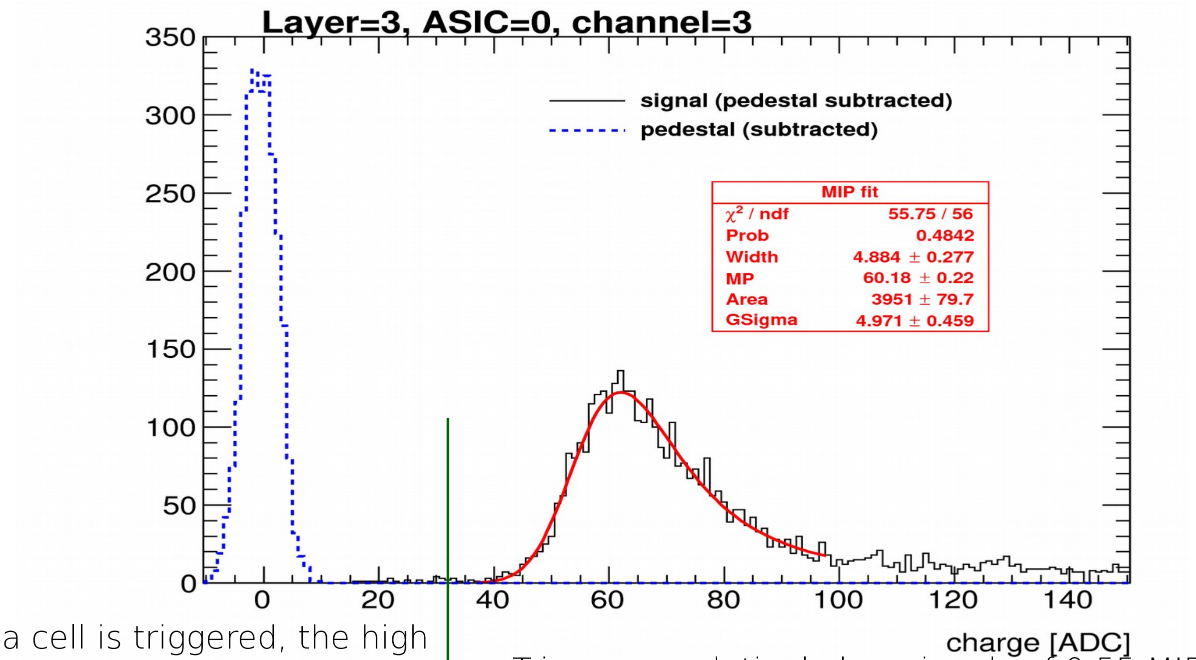
Distance to MIP in σ_{noise}

250DAC ≈ 2.8σ of the MIP

230DAC ≈ 5.1σ of the MIP

S/N in the trigger line

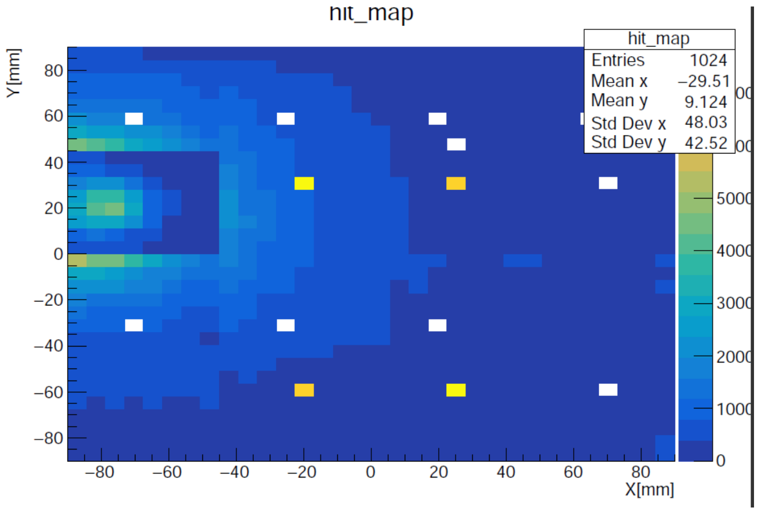
- The 5 sigma distance to the MIP seems reasonably
  - Using the S/N=20 from the ADC, the 5 sigma → 10 sigma which seems non-compatible with the presence of noise (even low).



If a cell is triggered, the high S/N(ADC) allows for low energy measurements. ←

→ Trigger on relatively low signals of 0.55 MIP

- Only few channels masked… but **among them, repetitively, the 37 !!**
- Individual thresholds applied
- Enough data for all cells calibration (?)

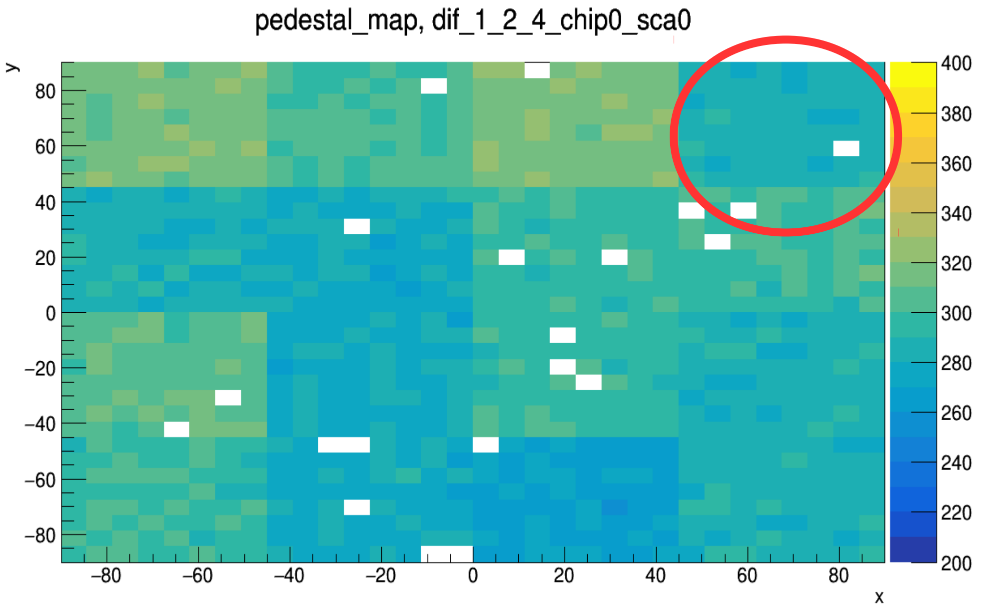


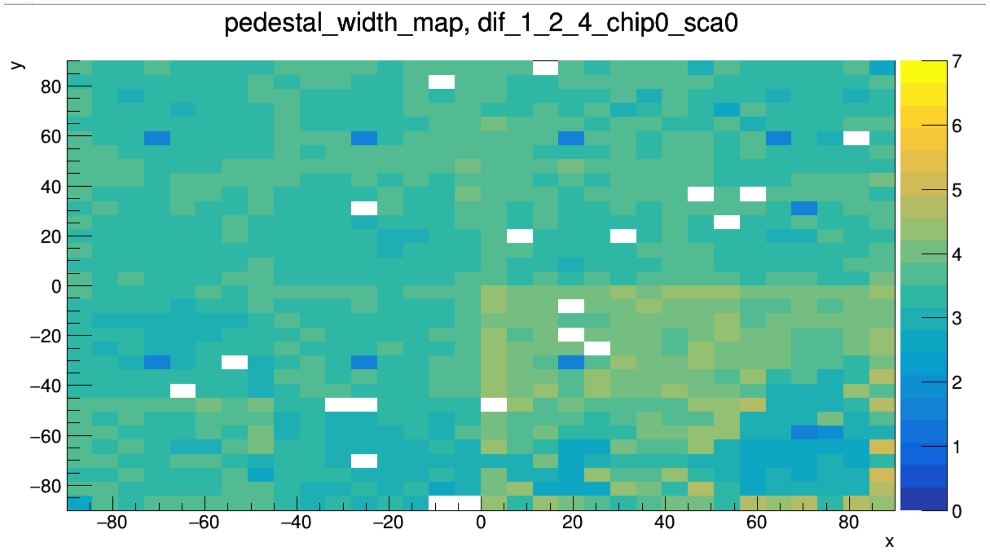
Not presented here

- Full pedestal and MIP calibration studies → Taikan et al?
- TDC studies in shower-like events → non-linear scale of the TDC issues → data not suited for analysis.

FEV13: absence of double pedestal peaks

- The pedestal distribution looks very similar to FEV11 and SK2. (beam spot inside the red circle)
- At the beginning, it seems that the double pedestal for events tagged as retriggers were not present or at very lower levels. Retriggers were observed.

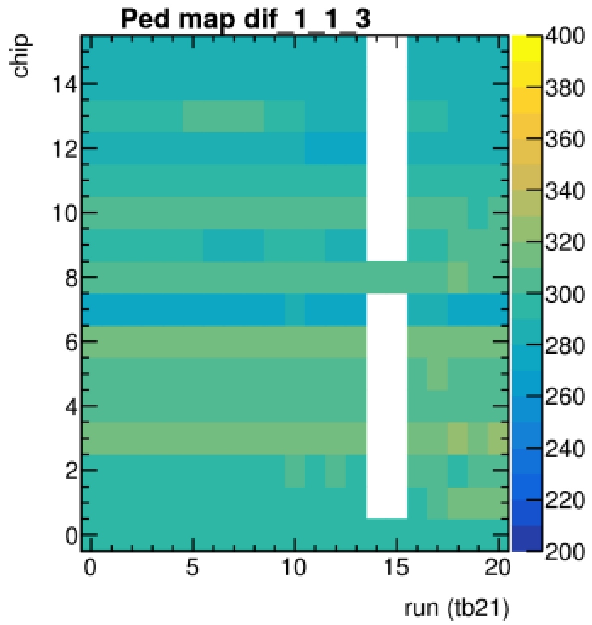


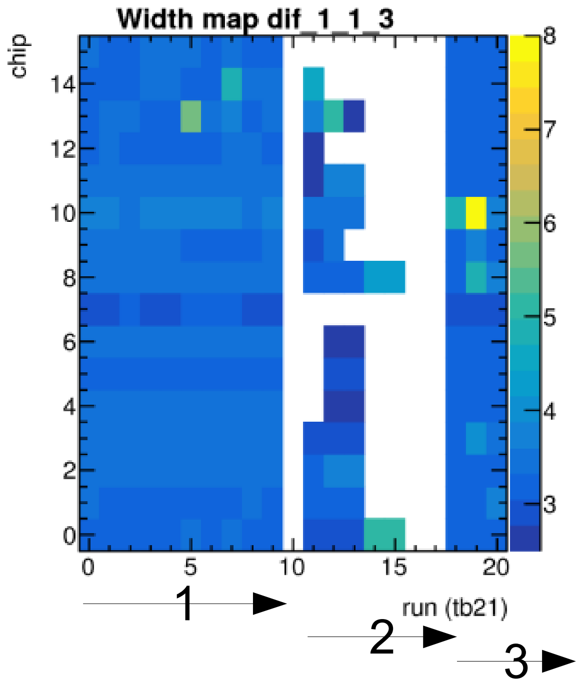


FEV11 & FEV13: Pedestal width

- Plot summary for the first part of the run in TB21 (X axis shows the run order (chronollogically), Y-axis the analyzed chip number, Z-axis averaged pedestal)
  - Set 1: outdated FEV11 commissioning + standard FEV13 commissioning
  - Set 2: wrong FEV11 commissioning + standard FEV13 commissioning
  - Set 3: standard commissioning for both + spill tests

- FEV11

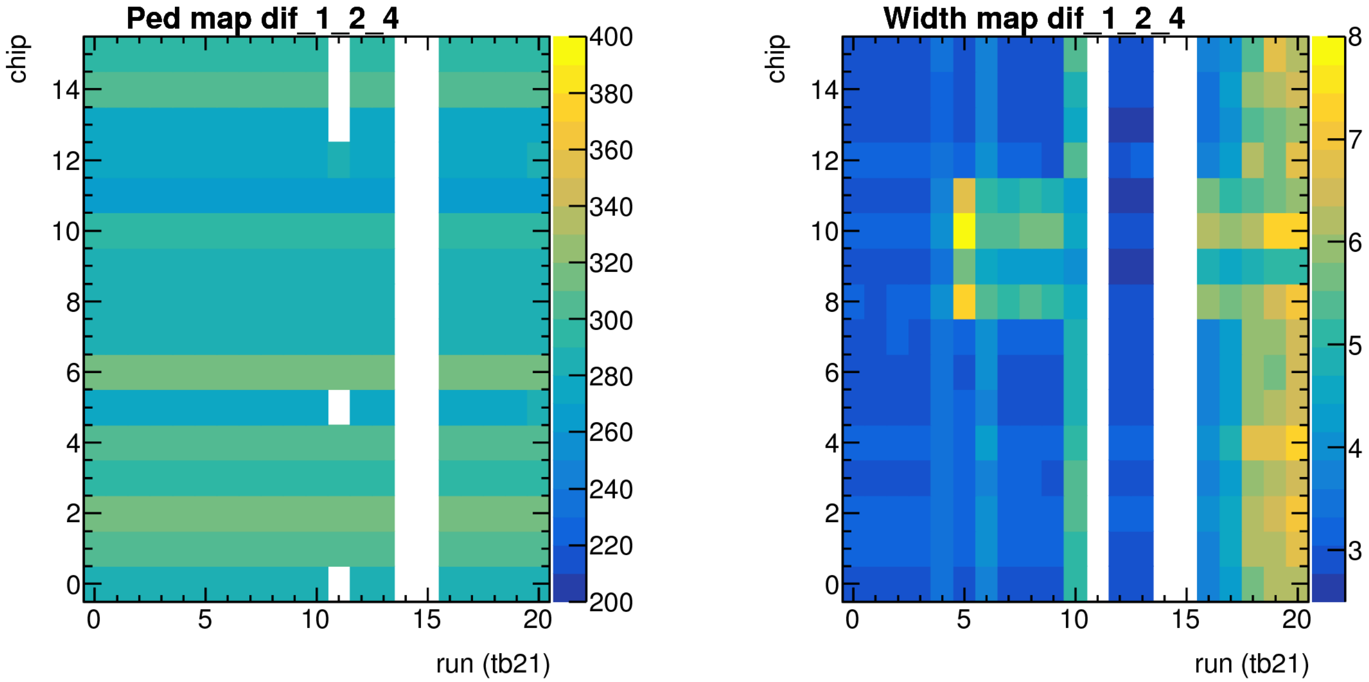




FEV11 & FEV13: Pedestal width

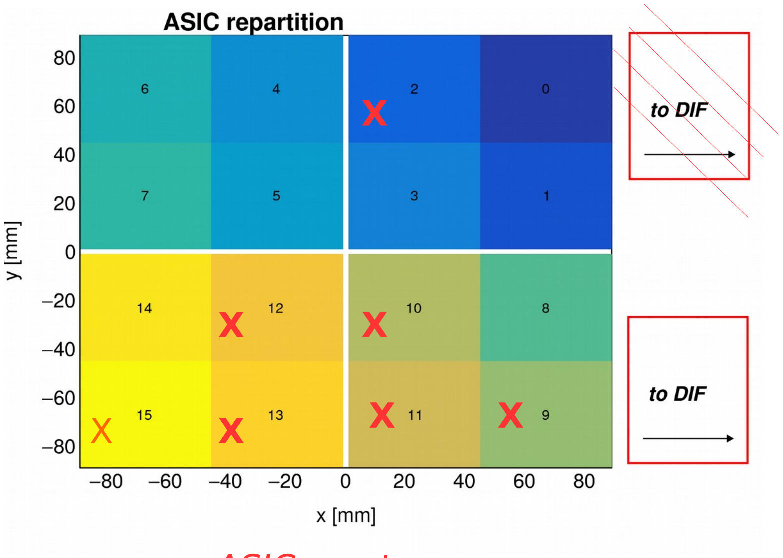
- For FEV13, the pedestal width is not stable on time… with unchanged FEV13 configuration.

  - FEV13

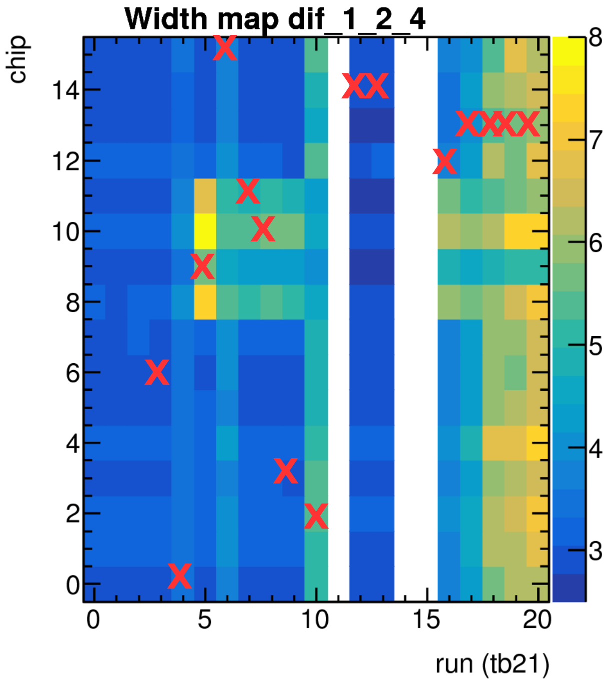


- For FEV13, the pedestal width is not stable on time… or depends on the beam position ?

X → beam position



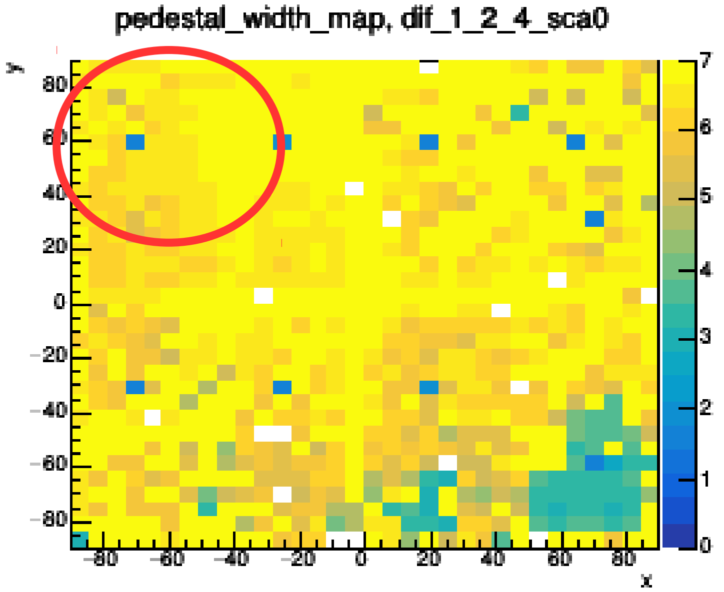
ASICs on top



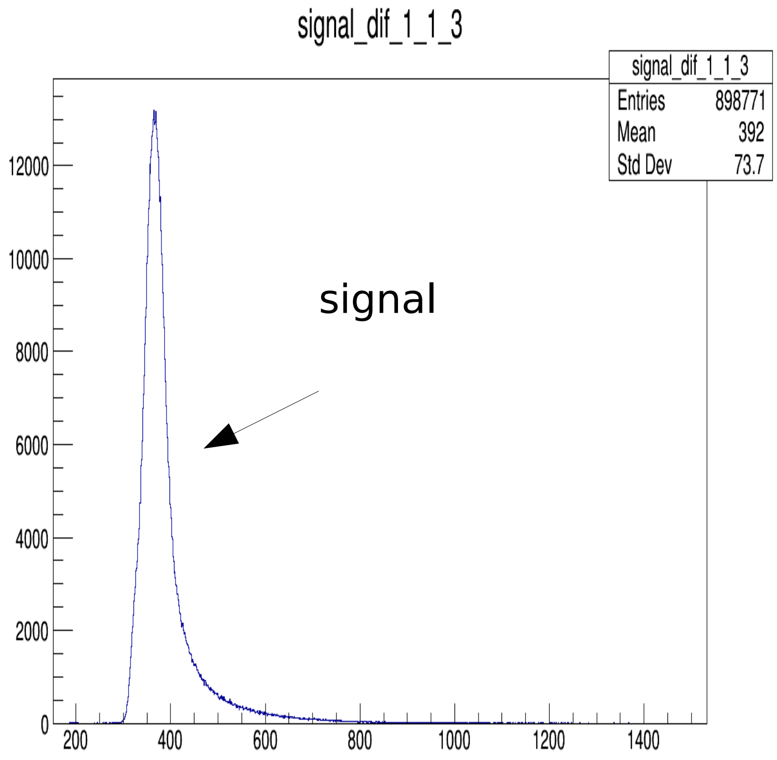
Only mark the bad ones in the map

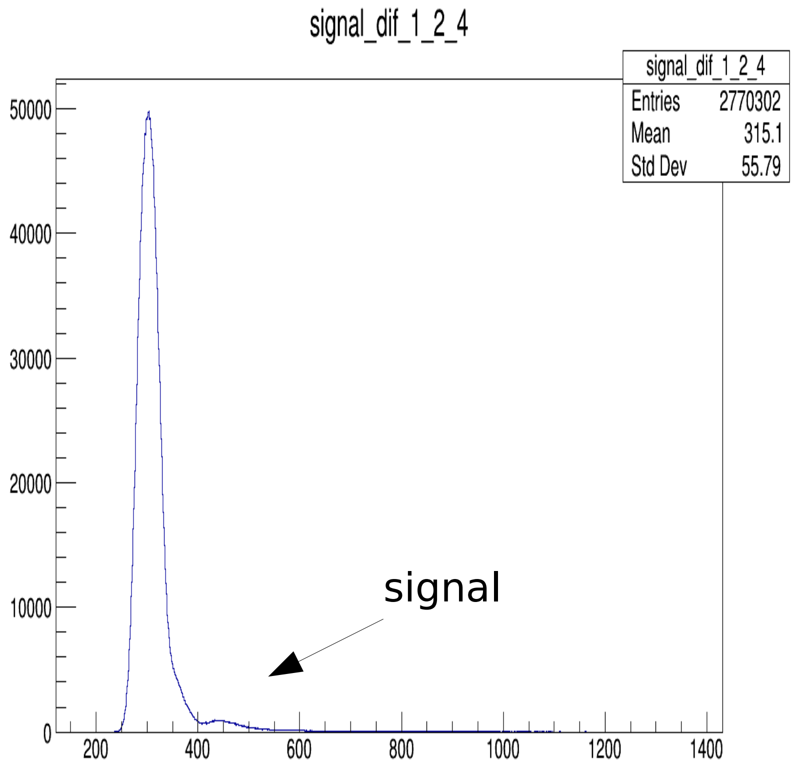
Pedestal width

- This situation continued during the data taking in TB21 and 24
  - https://llrelog.in2p3.fr/calice/1835
  - For me it is still not clear if is an "aging" issue or depends on the pcb sector were we shoot the beam.
  - Noise due to gluing issues usually become better with time… not worst
- Also double peaks appeared back.
  - at similar levels than FEV11?
- Run: common_calib_ss_ASU6_angle0



- Signal events vs noise events ratio ? (TB24, common run with long slab, beam in ASU7 for the long and chip 6-7, angle0)





Tracking efficiency

- From last year we know that the tracking efficiency was 100% for the short slabs.
- We do a similar exercise to study the FEV13 but more relaxed in terms of selection:
  - We perform event building (+-1 bcid).
  - We select a high purity sample of tracks: tracks incident to the slabs within a cylinder of 2x2 px with at least 4 of the FEV11 with a hit inside the cylinder.
  - Then we look in the FEV13 if there is any hit anywhere in the slab (so we only require time correlation).

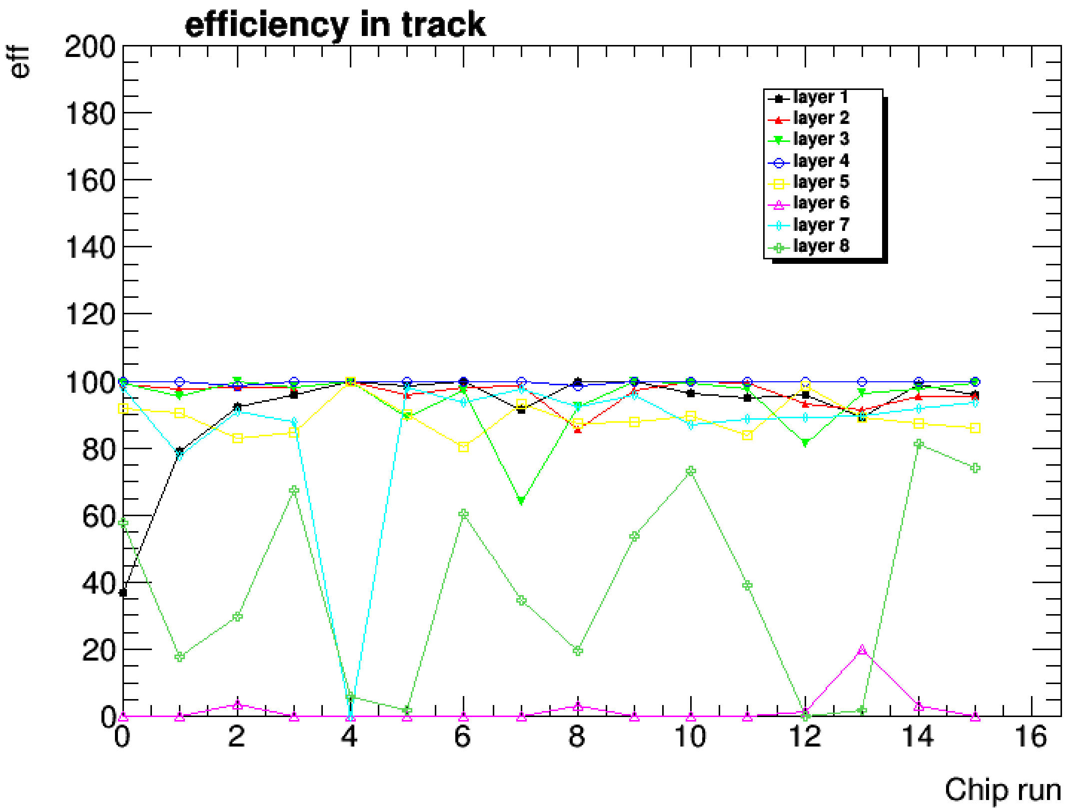
  - X-axis → the chip covering most of the beam spot
  - Data used: TB21 (shown in the table before + weekend runs). I chose 16 runs where in each one we shot to different chip areas.

  - Note: For the efficiency of FEV11, we count only hits inside the cylinder (and we do not take into account the masked channels nor the missworking chips/wafers) so we can expect smaller values than 100% depending on the area of analysis.

Tracking efficiency

- Slab 21 is almost dead.
- The others FEV11 show quite reasonable results, taking into account that we don't account for masked channels.

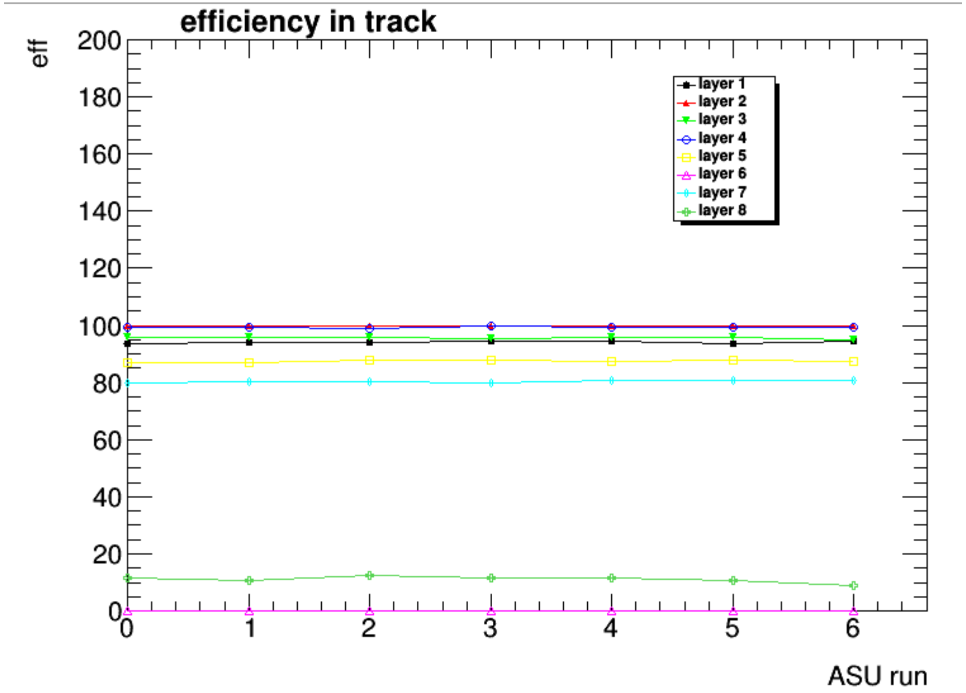
- FEV13, two sets of data:
  - Eff ~40-80%
  - Eff <<40%!!!



Tracking efficiency

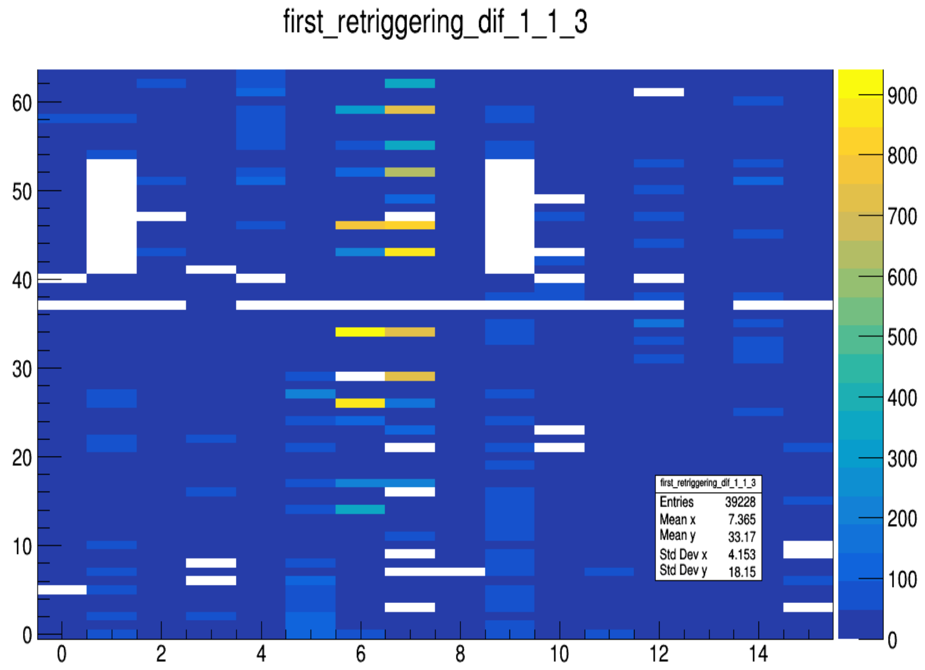
- What about in TB24, where the spill was a bit better optimized ?
  - 2Hz, 200ms of iddle time, 300ms of acq window, TB24, common run with long slab, shooting in different ASUs at angle0
  - Shooting in chips 6 and 7

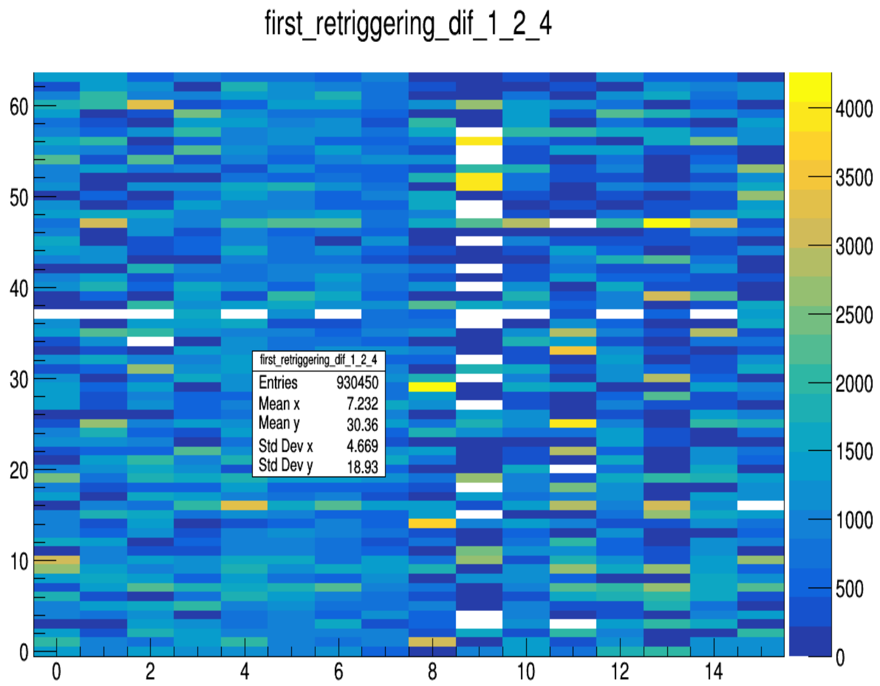
    But beam is wide open



Retriggers

- 2-D map of the cells starting a retrigger train in a MIP run. (TB24, common run with long slab, beam in ASU7 for the long and chip 6-7, angle0)

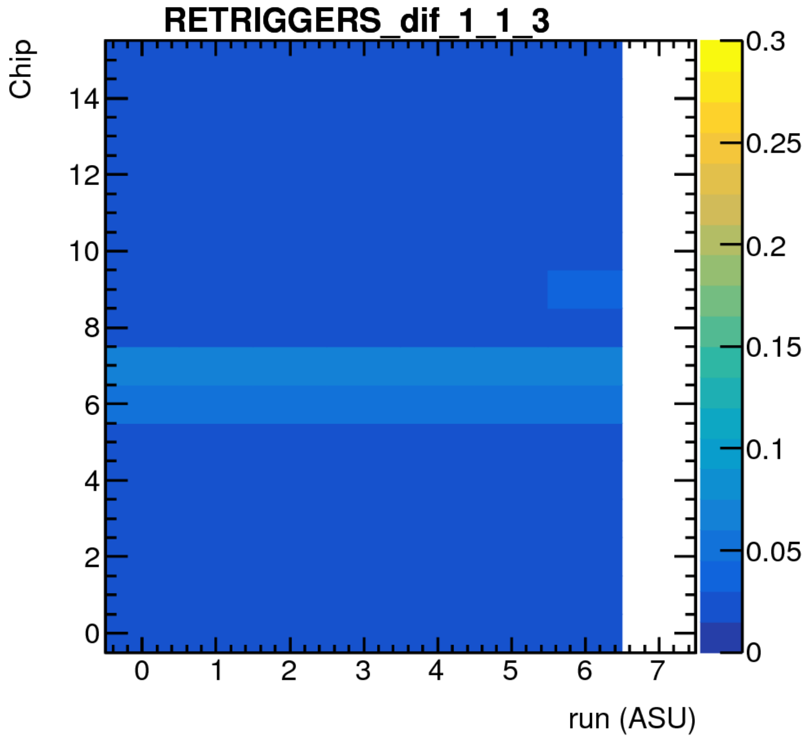


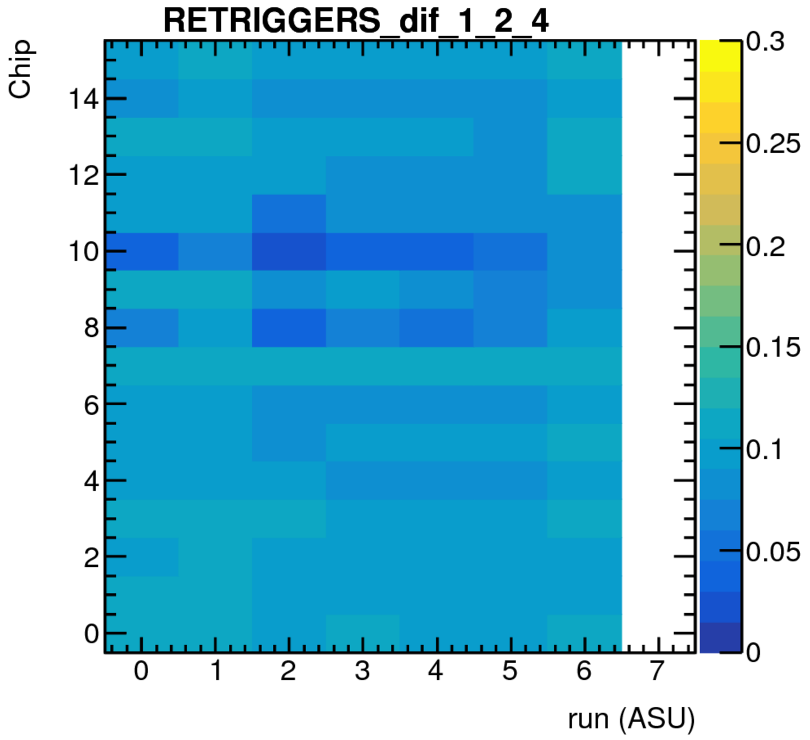


~ x 23 !!

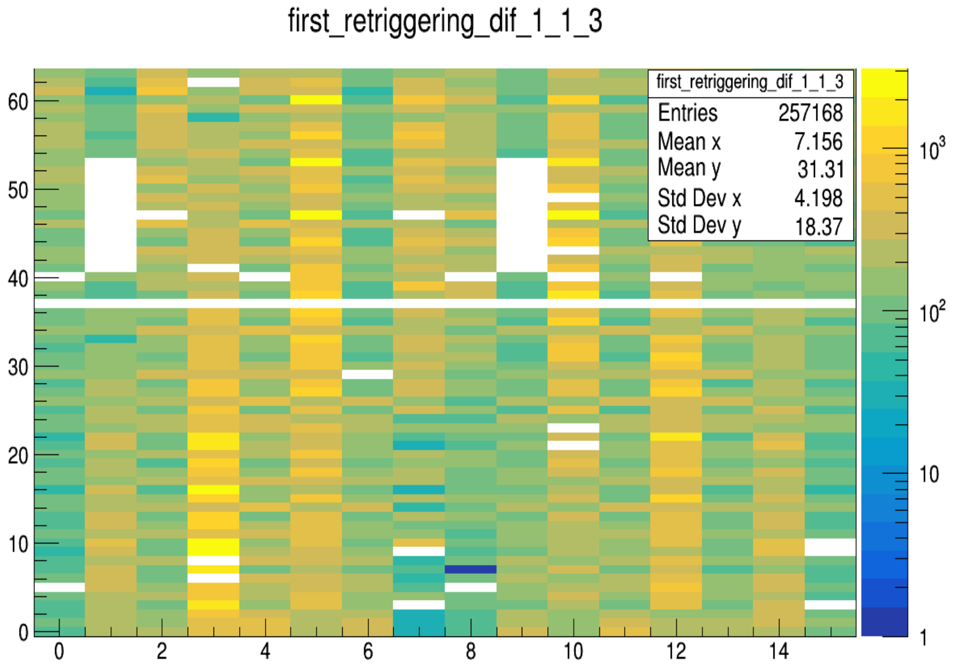
Retriggers

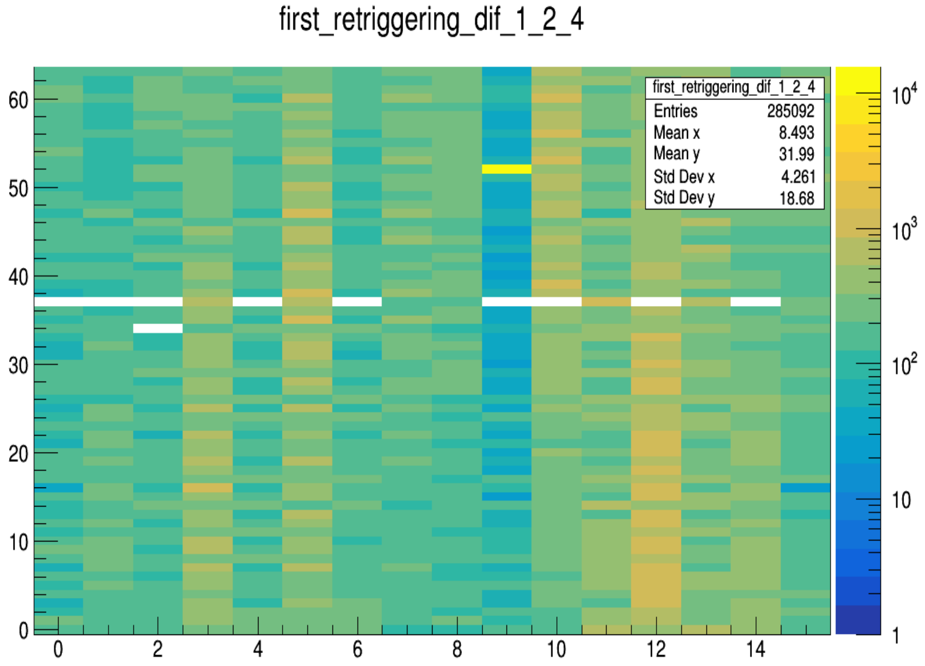
- Rates (from 0-1) of retriggers trains events in tracks (FEV11 vs FEV13) per chip in dedicated short + long slab runs





- 2-D map of the cells starting of the retriggers in a **shower** run.

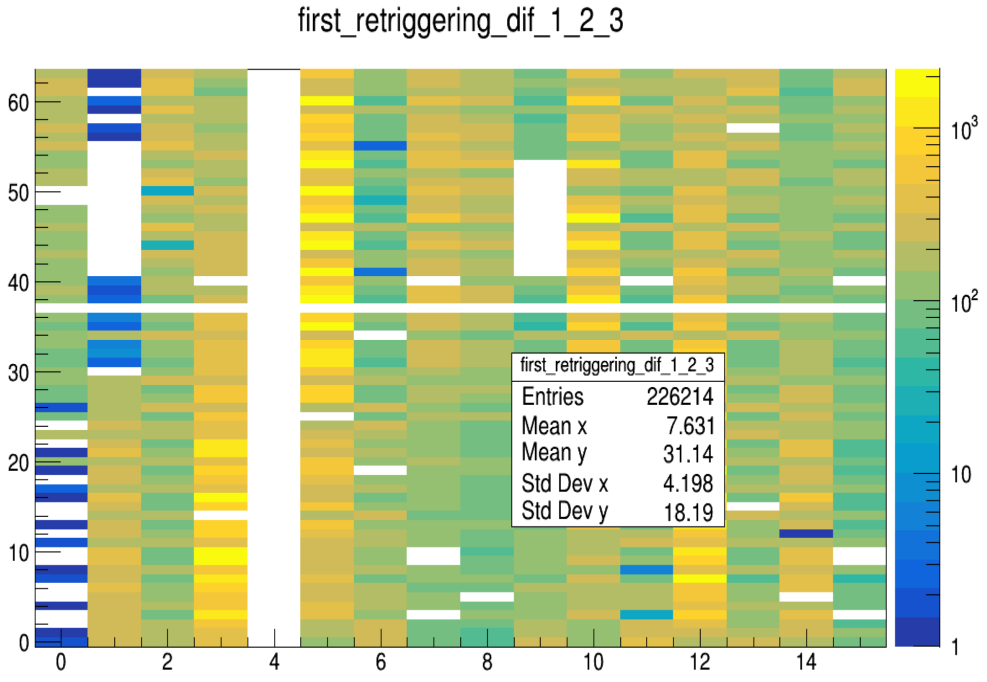


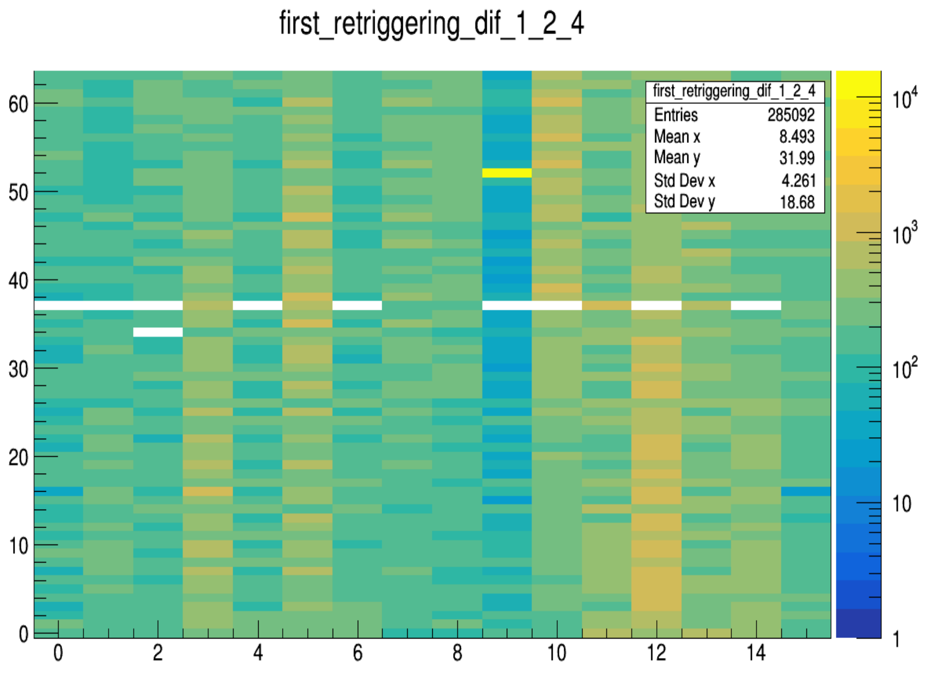


~ x 1.1

Retriggers

- 2-D map of the cells starting of the retriggers in a shower run.





~ x 1.3

Summary

- Although the complexity of the beam test itself (rather techical), the unforeseen issues as the spill-issues and the tight schedule for both commissioning and beam time, **we had achieved all data taking goals** except
  - holdscans: for this we required to have precommissioned all systems + a full 81 points mip calibration which was out of the table. → not prioritaire in any case
  - Pedestal oscillation studies, foreseen for the last saturday.
  - We didn't manage to test the COB :(
- **The long slab was a big success and a major step forward!**
- For FEV11 we have enough data to crosscheck last year results but we lost a full slab.
- The FEV13 was well integrated and responding but we observed some important issues:
  - Still there are channels systematically noisy… only the 37? To be checked with the standard commissioning.
  - The pedestal width (the noise!) is unstable and very large.
  - The retrigger rates are larger or equal than in FEV11.
  - The tracking efficiency is very low since we record much more noise than signals.

Back-up & extra material

Test beam info

- Wiki page: https://twiki.cern.ch/twiki/bin/view/CALICE/SiWDESY201807
  - Commissioning procedure https://twiki.cern.ch/twiki/bin/view/CALICE/CommissioningProcedure
- E-log
  - https://llrelog.in2p3.fr/calice/
- Analysis tools:
  - https://github.com/SiWECAL-TestBeam/SiWECAL-TB-analysis

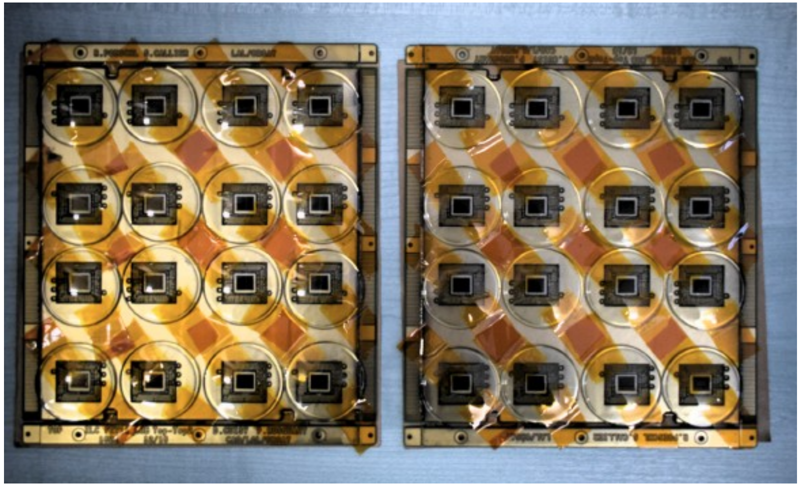
    Branch: TB201807_long for the long slab
    Branch TB201807 for the short

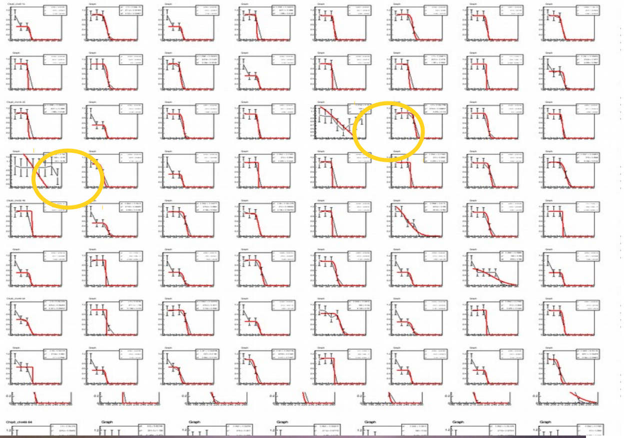
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

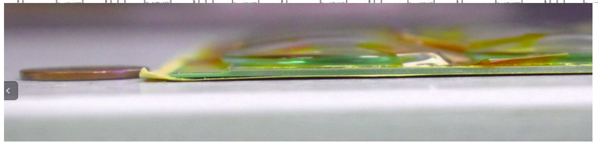
PRESTIGE
POSTDOCTORAL RESEARCH FELLOWSHIPS IN FRANCE
A MARIE CURIE FELLOWSHIP PROGRAMME

Ultra thin PCB with Chip On Board

- ParticleFlow requires high density of channels in the SiW-ECAL for the ILD: ~6000 px/dm³
  - This limits the PCB thickness to 1.2mm
- Good performance in terms of noise and signal injection ~ 4% of noisy channels
  - In the lab :-(
- No signals observed in DESY: Equipping the board with a baby wafer just before the beam test didn't work well. First studies on site (and back in France) show some problem with the wafer itself &/or the gluing.







1.2mm
including chips