Activities in Task 14.3.1: Infrastructure for Silicon Calorimeters

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Oxford, UK
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TNA support + WP14

DESY-2017 beam test

7 SLAB's FEV11 ⊃ 325 µm Wafers

Commissioning paper ready submitted (NIM + ArXiv: OpenAccess)

- Editor: Adrián Irles [LAL/P2IO]
- Limited to «low energy» response: mip and noise
- Submitted to NIM (Jan); in discussion with referees
  - Includes AIDA-2020 and labex P2IO acknowledgement
  - related to procedure of DQ of WP14.3.1

Commissioning of the highly granular SiW-ECAL technological prototype

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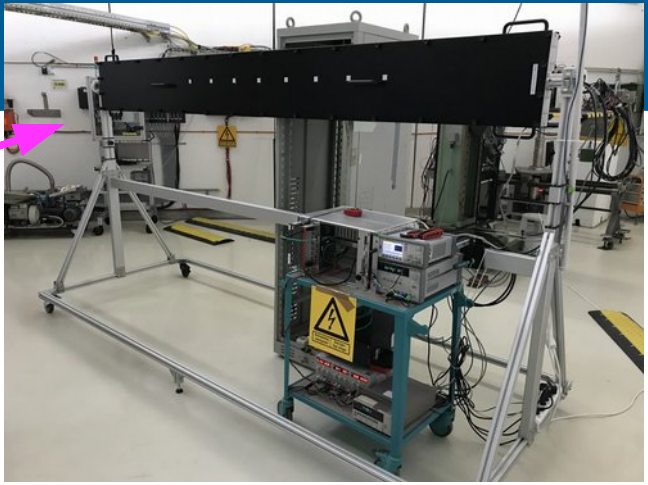
ABSTRACT: High precision physics at future colliders as the International Linear Collider (ILC) require unprecedented high precision in the determination of the final state of the particles produced in the collisions Thia precission will be achieved thanks to the Particle Flow algorithms (PF) which require compact, highly granular and hermetic calorimeters systems. The Silicon-Tungsten Electromagnetic Calorimeter (SiW-ECAL) technological prototype design and R&D is oriented at the baseline design of the ECAL of the International Large Detector (ILD) for the ILC. In this article we present the commissioning and the performance of the prototype in a beam test carried at DESY in June 2017.

KEYWORDS: Calorimeter methods, calorimeters, Si and pad detectors

arxiv.org/abs/1902.00110

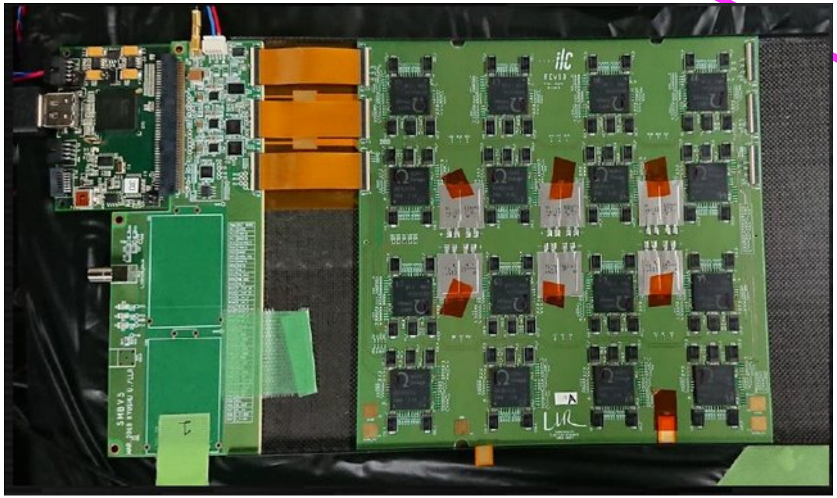
DESY-2018 beam test

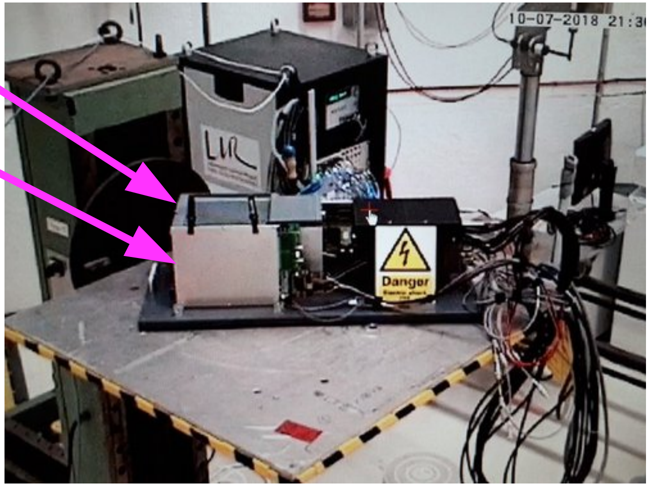


2 weeks beg of July

- Electric long slab: 8 FEV12 + babywafers
- "Stack" = 7 FEV11 Shorts slabs

  + 1 FEV13 (with SMBv5)
  - with 650 µm wafers, SK2A, new design

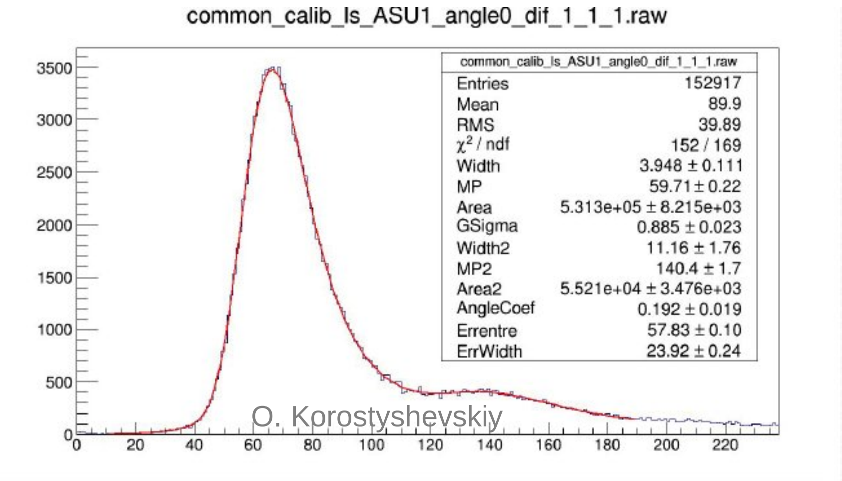


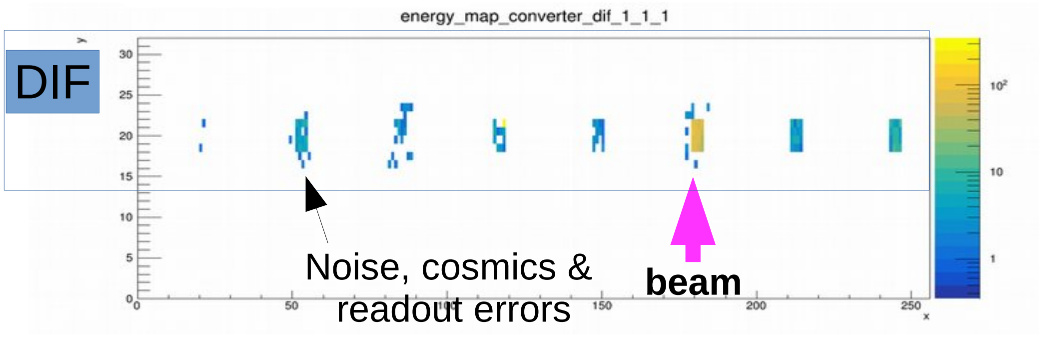


Electric “long slab”

2 weeks beg of July: full test of all prototypes:

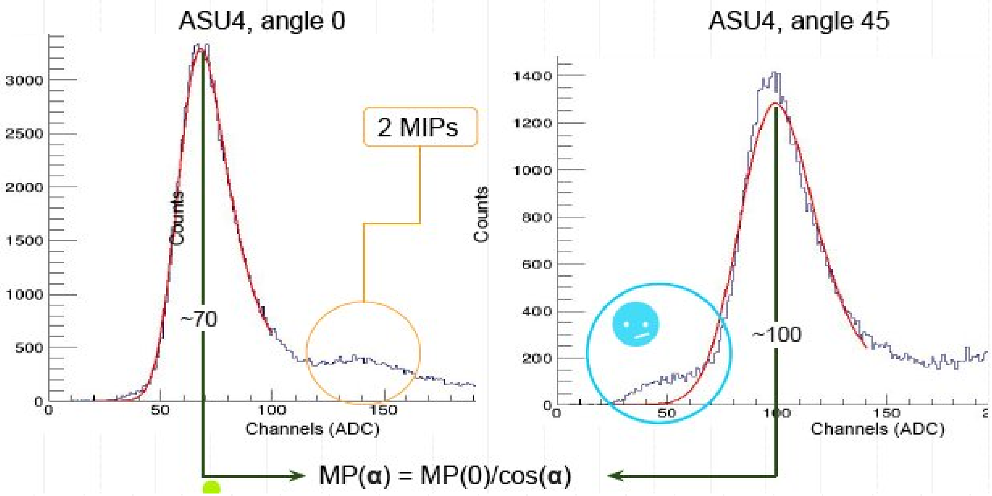
- Electric long slab: **8** FEV12 + baby-wafers (320µm 2×2cm²):
- RC Filtering of HV between (every second) boards required
- Very clean response to “mip” (punch through e-)

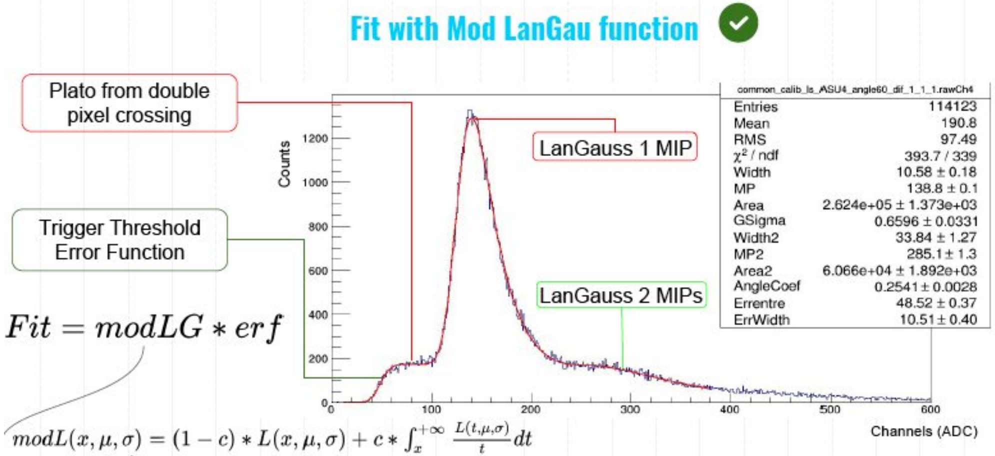




Mip analysis

O. Korostyshevskiy



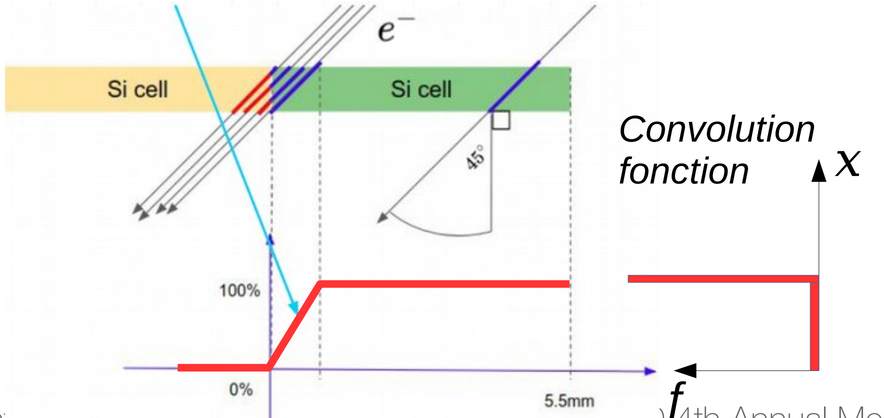


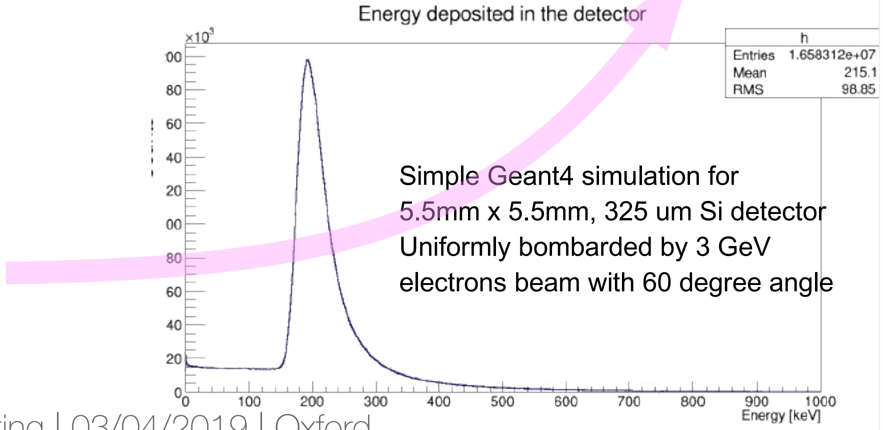
$$Fit = modLG * erf$$

$$modL(x,\mu,\sigma) = (1-c) * L(x,\mu,\sigma) + c * \int_x^{+\infty} \frac{L(t,\mu,\sigma)}{t} dt$$

$$modLG = \int_{-\infty}^{+\infty} modL(t,\mu,\sigma) * G(x-t,\mu_G,\sigma_G) dt$$

Pixel energy fraction depends linearly on crossing position





Simple Geant4 simulation for 5.5mm x 5.5mm, 325 um Si detector Uniformly bombarded by 3 GeV electrons beam with 60 degree angle

MIP response vs position

mip MPV *cos(θ) vs ASU#

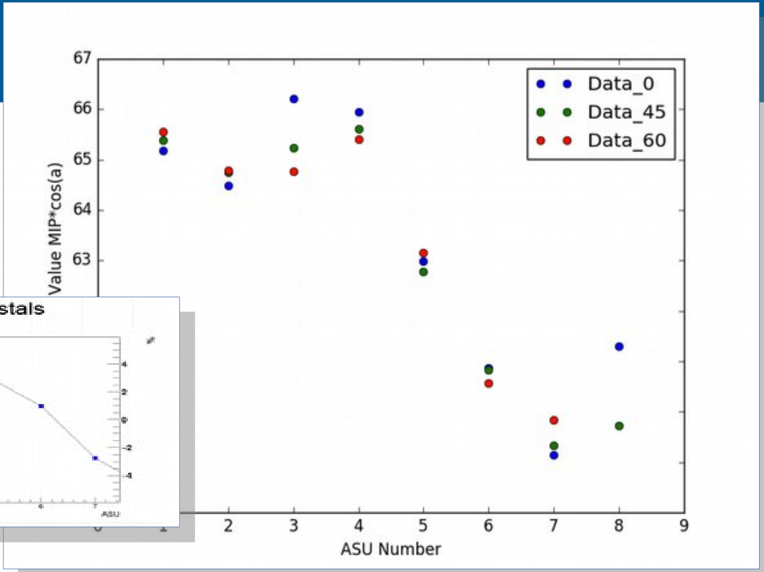
- OK for 4 1st ASU's + Small drop ~of signal ~2%/ASU for ≥ ASU#5
- Also hints similar drop on σ_{ped}

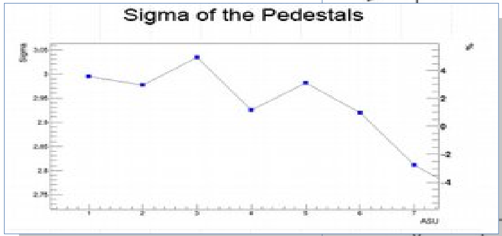
⇒ Voltage or Gain drop ?
Power pulsed mode with ballast et end of slab
or just random build-up effect from chip variability ?

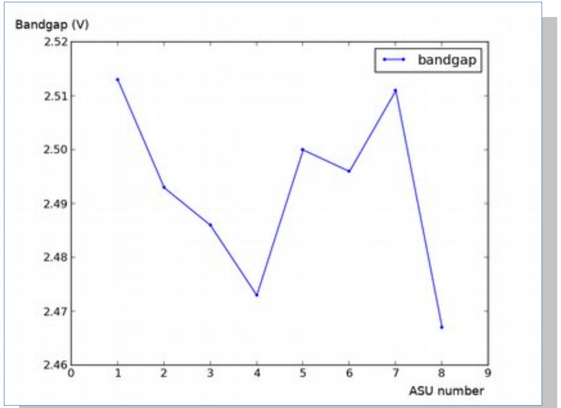
- Answer: Voltage↘ + Band-gap variability
  Data fitted with
  - linear voltage drop (vs distance)
  - BG variability

Presented @ VCI'2019; paper submitted this week

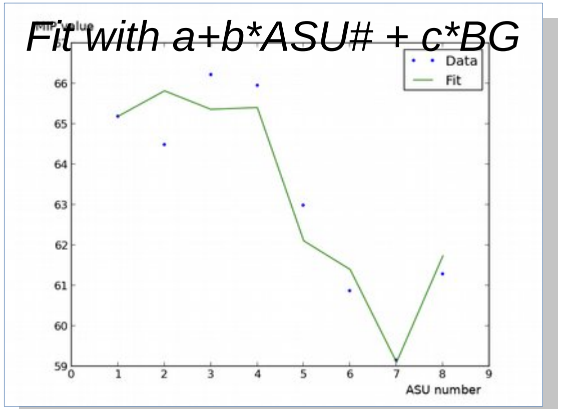
⊃ ack't of support from AIDA-2020 and P2IO







*Fit with a+b*ASU# + c*BG*



FEV13

Only a few masked channels!

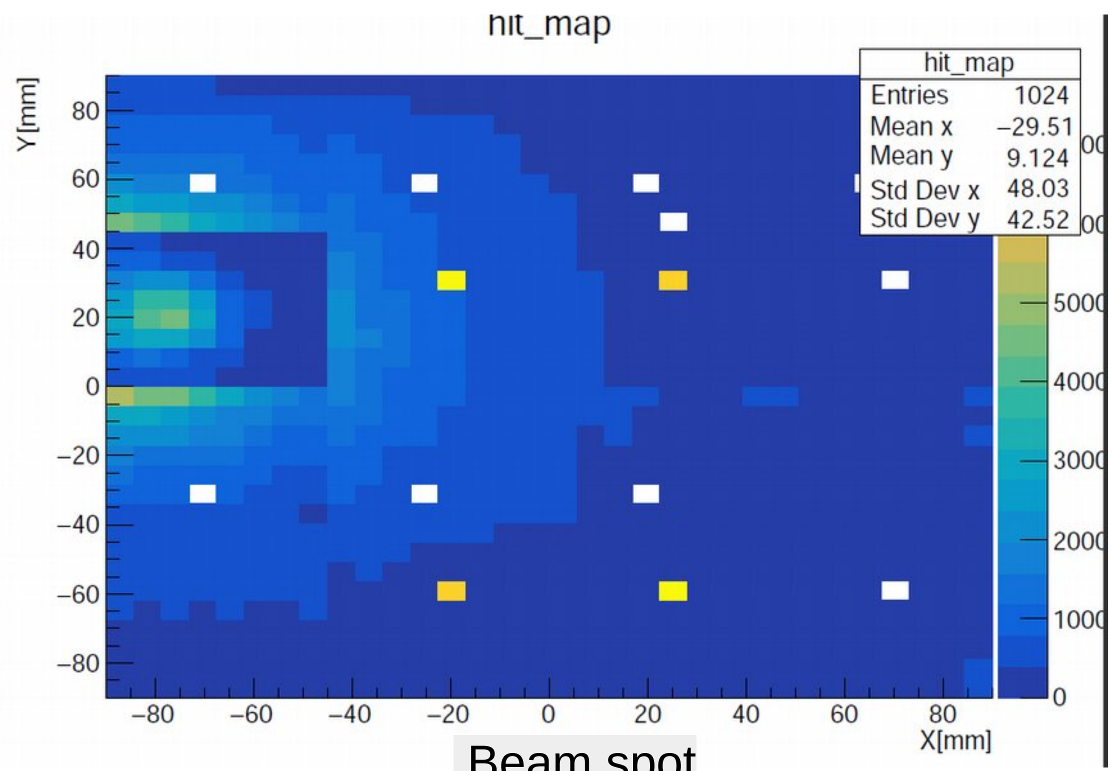
- worked «out of box»

but instabilities after a couple of days

- 4 new layers produced in Kyushu.
  - 3× 650 μm + 1 × 320 μm wafers

improved S/N handling, TDC enabling

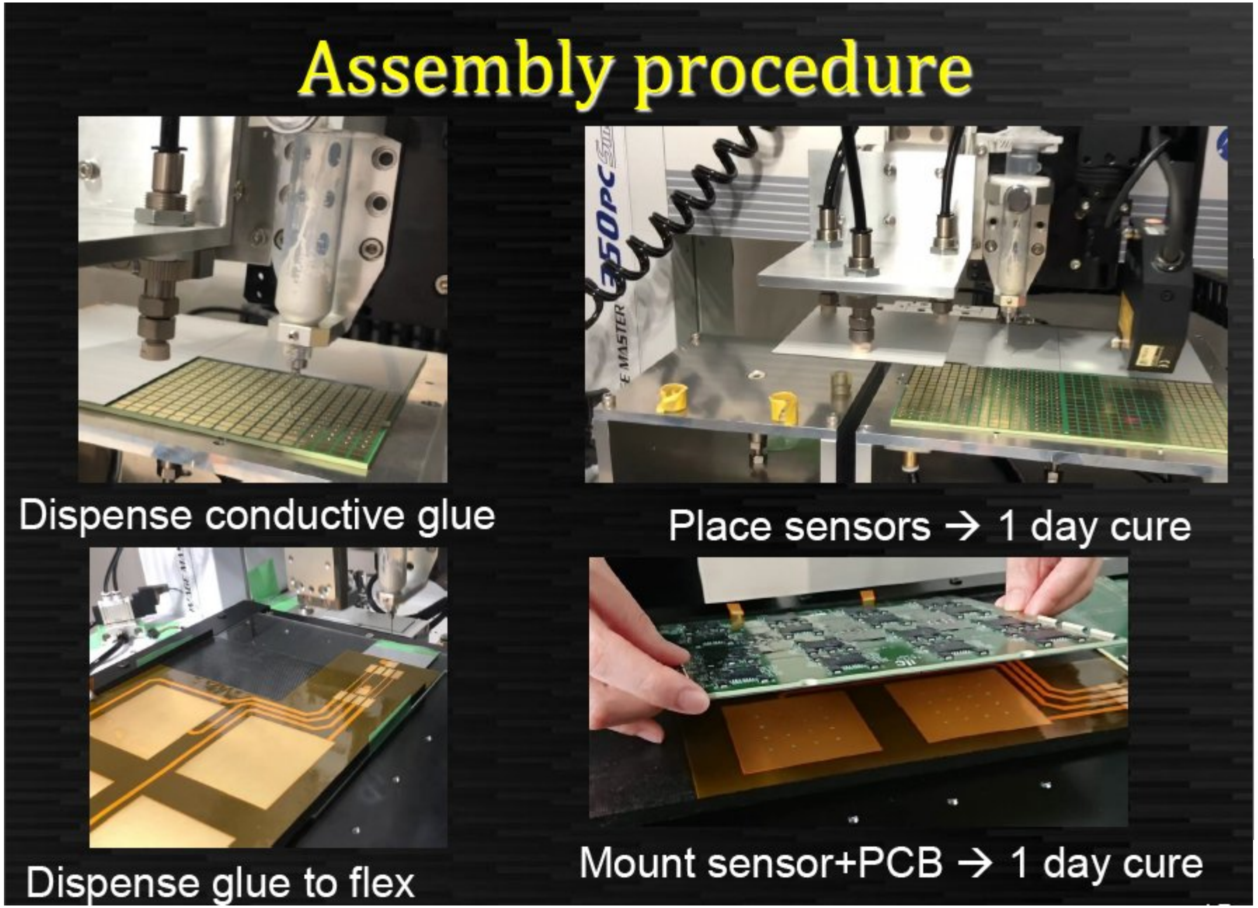
- individual thr adj.
- better noise adjustment → ~ only ch 37 excluded



Beam spot

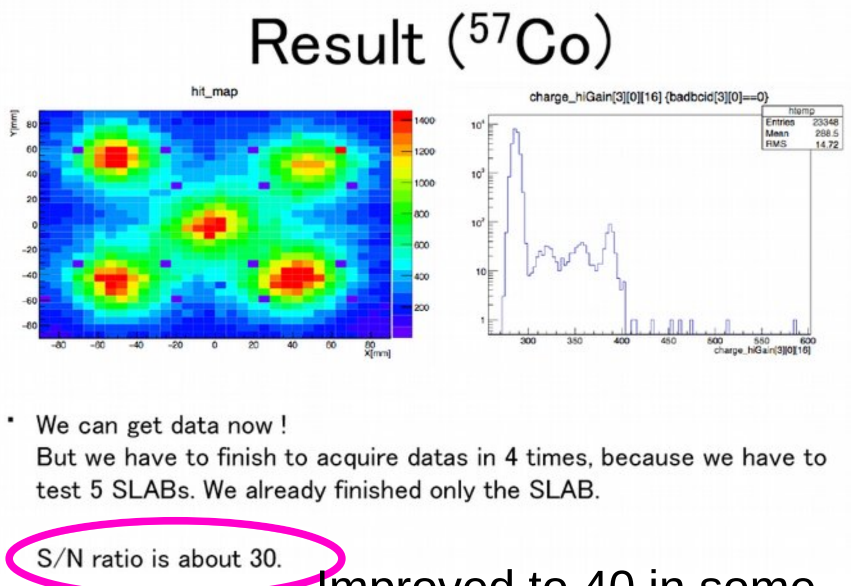
(not corrected to memory fill-up)

FEV13 assembly in Japan



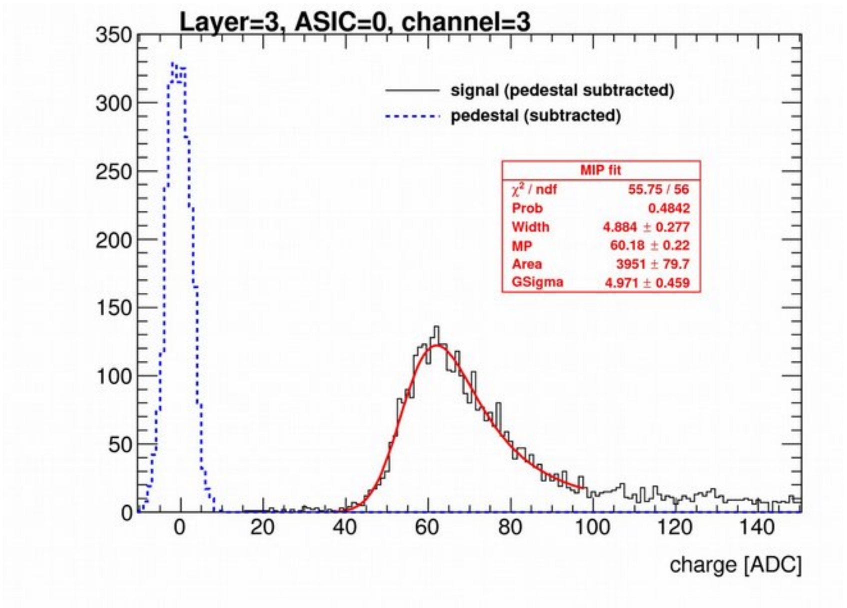
Similar to production in Paris region

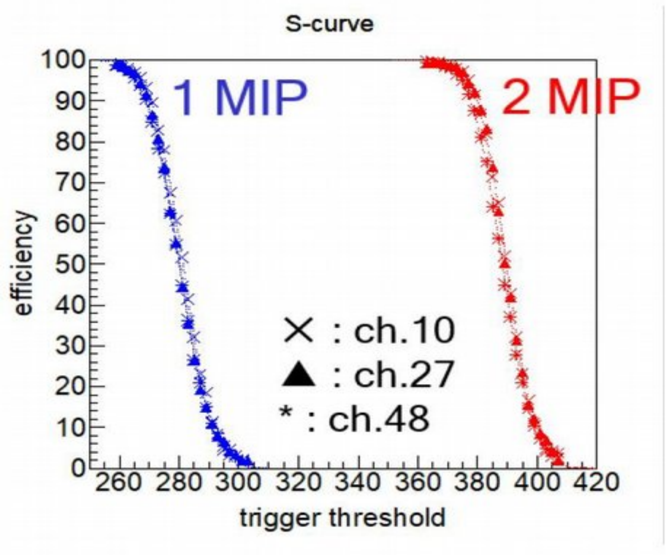
(AIDA-2020 benches)



Improved to 40 in some cases

Stack: S/N on the trigger line from thr. scan





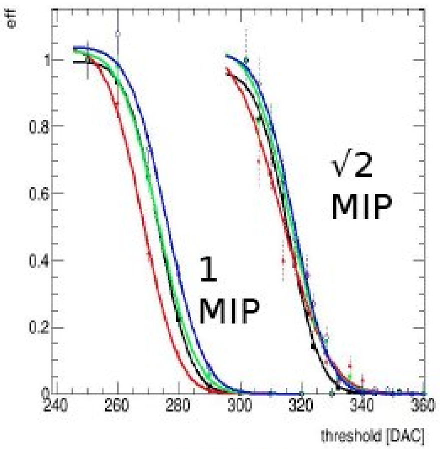
Injected signal → MIP

S/N ~ 20 in ADC branch

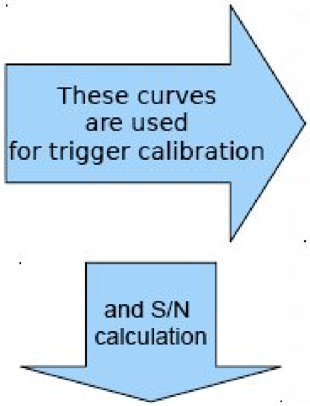
S/N ~ 12 in Trigger Branch.
Trigger at 50% mip with 6σ
or 1/3 mip with 4σ

S/N in the trigger line

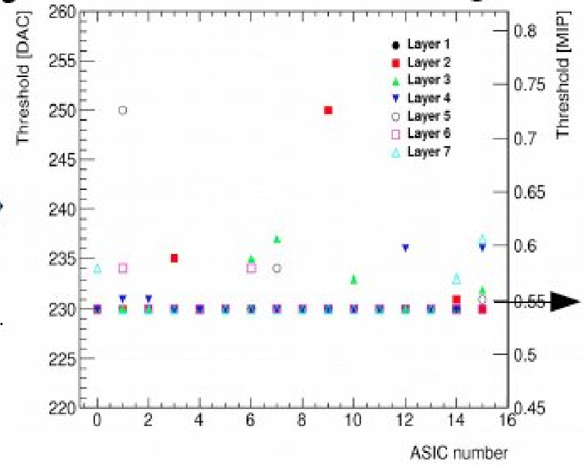
- For autotrigger data taking, a S/N is to be defined by the study of the trigger line (fast shaper in Skiroc) → threshold scans with different signals
  - The threshold scan curve is interpreted as the integral of the gaussian distribution of the noise.



Slab 17, 18, 19, 20
(FEV11)



Trigger thresholds used in DESY@2017&2018



230DAC
≈ 5σ
distance
of the MIP

S/N = 11.6 ± 0.7 (ILD baseline requirements: S/N=10)

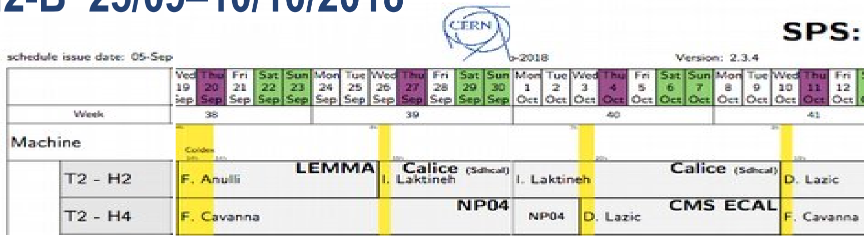
Trigger threshold at ~0.5 MIP

First S/N (trigger) measurements in beam test.

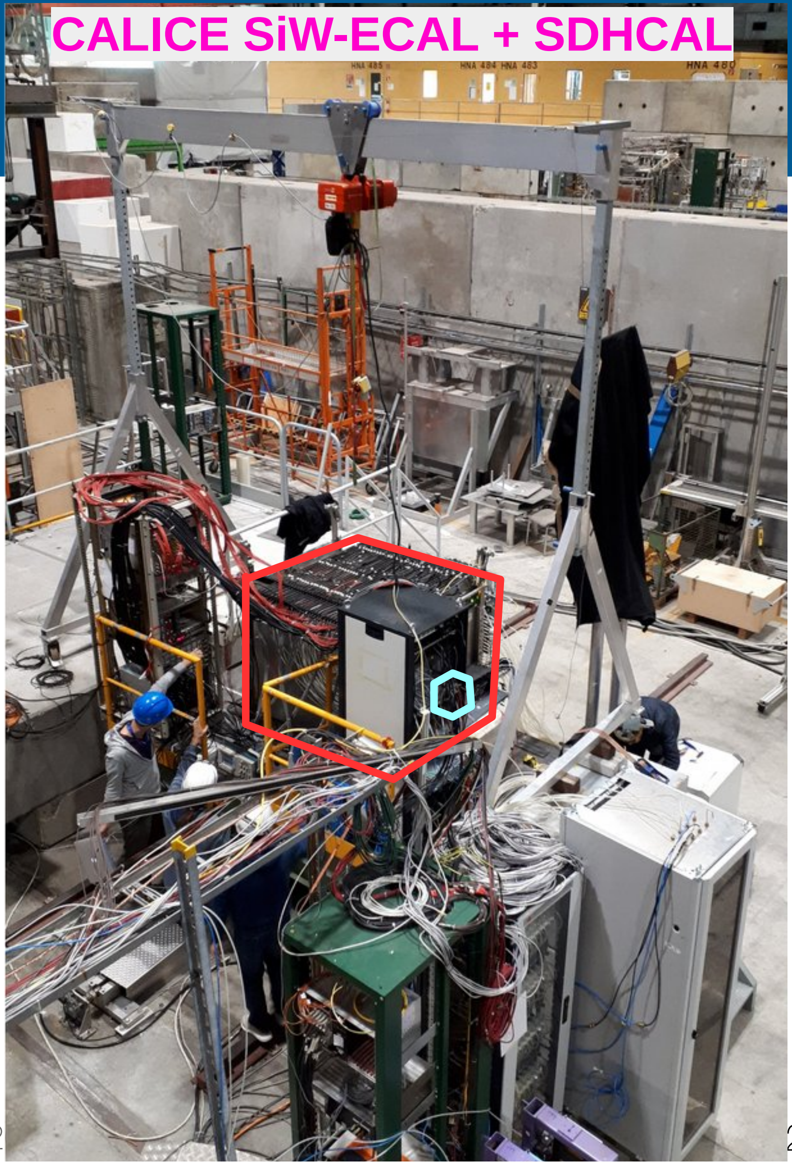
© A. Irles, at P2IO day

Combined BT at CERN 2018

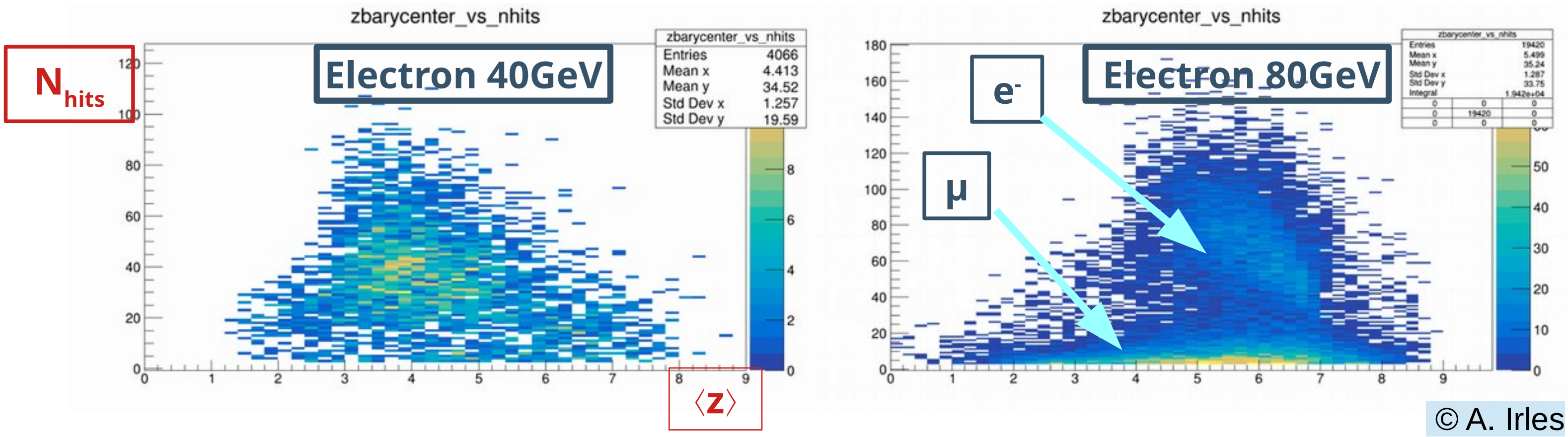
2 weeks on H2-B 25/09–10/10/2018



- 37 layers of SDHCAL RPC, 5MHz clock
- 10 layer of SiW-ECAL : 6 FEV11 and 4 FEV13.
  - 2.5 MHz (all FEV11 but 1) and 5.0 MHz (FEV13+1FEV11)
  - many issues with FEV13:
    - partial commissioning at LLR bef. BT
    - insecure transport (in plane) → repair on-site, esp. HV connections
  - 1 FEV13 has been working reliably



Standalone runs



Muons and electrons run

- low contamination, except @ High E.
- shower analysis still to be done (also for DESY tests)

These are the statistics for electron data. Obtained from the zbarycenter vs nhits plots.

energy	total events	electrons shower like events
10 GeV	630	~630 (very low contamination)
20 GeV	4060	~3480
40 GeV	2023	~1800
80 GeV	19420	~8000
150 GeV	8474	~1000

CERN-2018 Combined runs

Required some work on DAQ:

- HW and SW synchronisation
- Solution of CERN-2016 + 40 MHz clock on both
- first combined test this week (since 2016)
  but very limited manpower availability
  - shared Spills (and event number), separate clocks

Reconstruction:

- Data:
  - ECAL = #sp, #bx_e
  - SDHCAL = cc (absolute bx@sp_start), #sp, #bx_h
- Procedure (to be done)
  - 1. Extract cc form SDHCAL event
  - 2. rec. times in ECAL and HCAL
    - time_in_sp = cc + f_$f$req * #bx_i + Δs
  - 3. check linarities (Δf + Δsyst.)
  - 4. rec. ECAL + HCAL

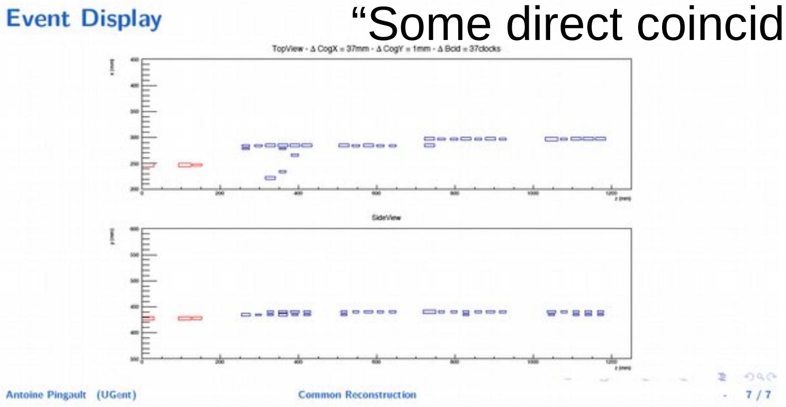
1st common meet 18/12/18

- Selection: nslabs_with_hit≥3
- Plot for PiPlus_50GeV (offset from e-log)

VERY PRELIMINARY

Common runs (selection = nslabs with hit >3)		
run	events (offsets elog)	events (offsets twiki)
PiPlus_40GeV	28299	not calculated
PiPlus_50GeV	3241	not calculated
PiPlus_60GeV	2365	not calculated
PiPlus_70GeV	12727	not calculated
PiPlus_80GeV	5484	not calculated
Muon_200GeV	108729	89506
Electron 150 GeV	not copied to the cern eos	
Standalone last muon ruon	not copied to the cern eos	

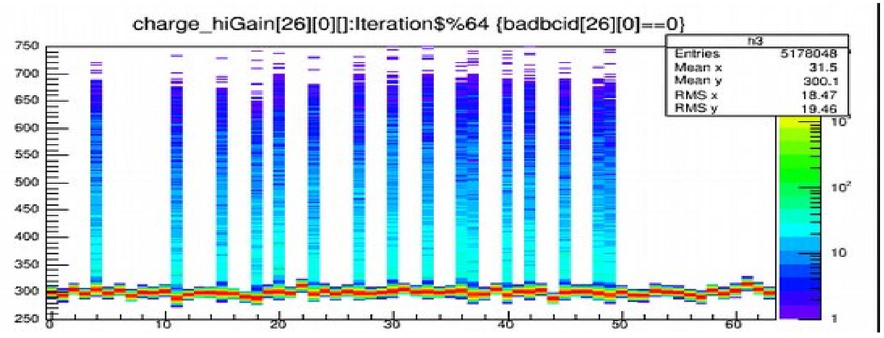
"Some direct coincidences"

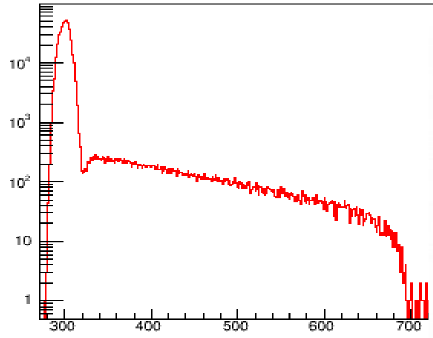


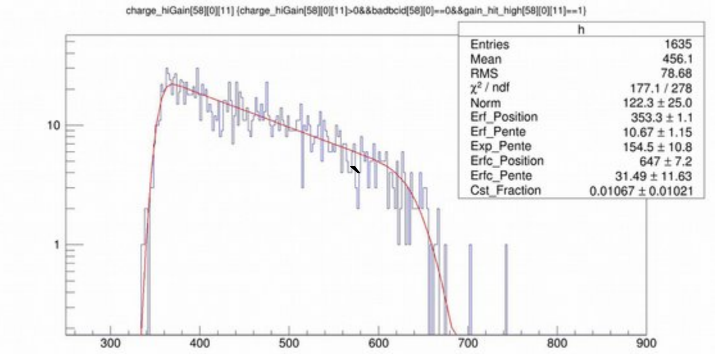
Test with 137Cs source

$^{137}\mathrm{Cs} \rightarrow {}^{137}\mathrm{Ba}^* + \beta$;

$^{137}\mathrm{Ba}^* \rightarrow$ **^{137}Ba + γ (662 keV) or X (32keV)**

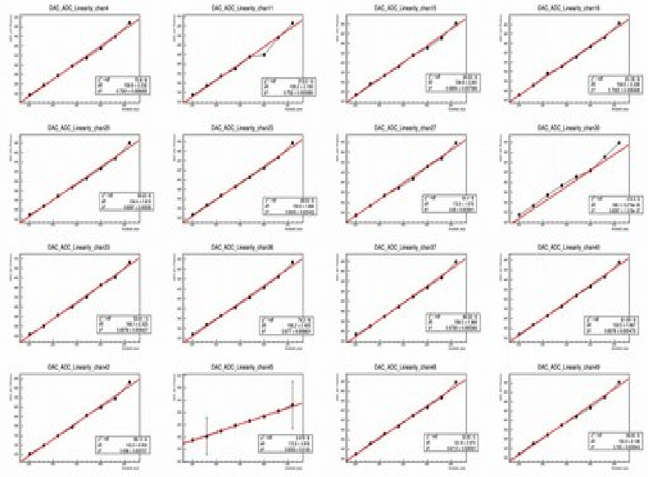






Allows for thres. scans down to noise

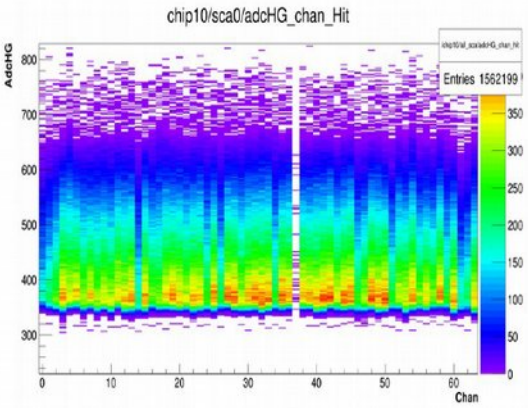
Calibration on Compton edge (477keV ~ 4 mips)



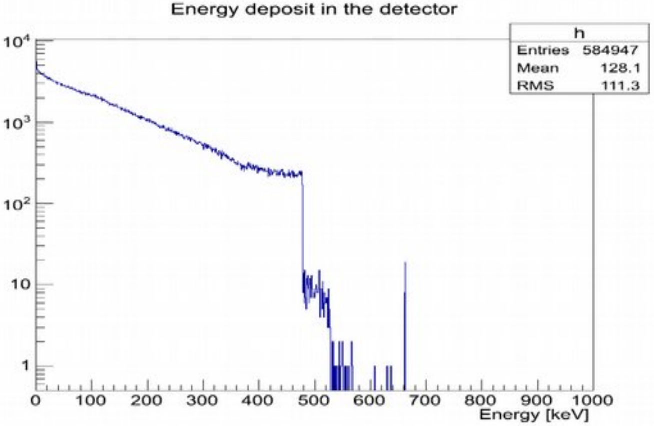
Spectrum in hours with 250kBq source

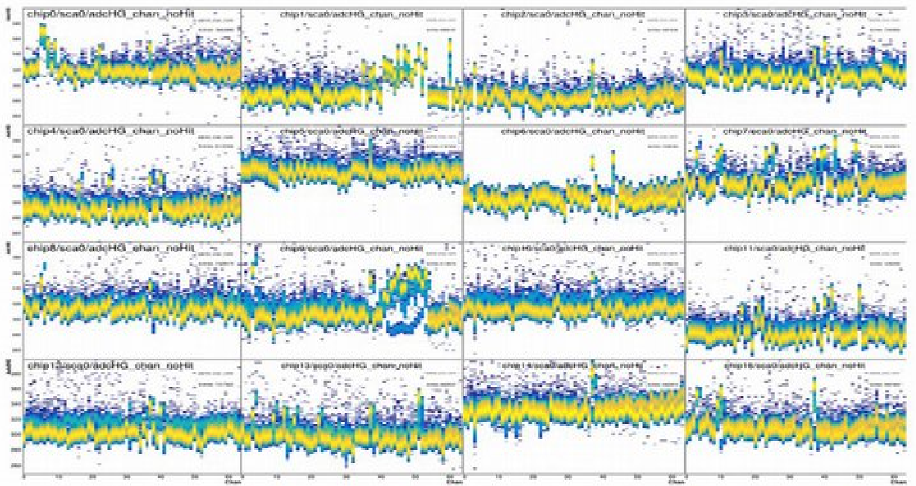
– calibration at ~5 mips in all chans + pedestal

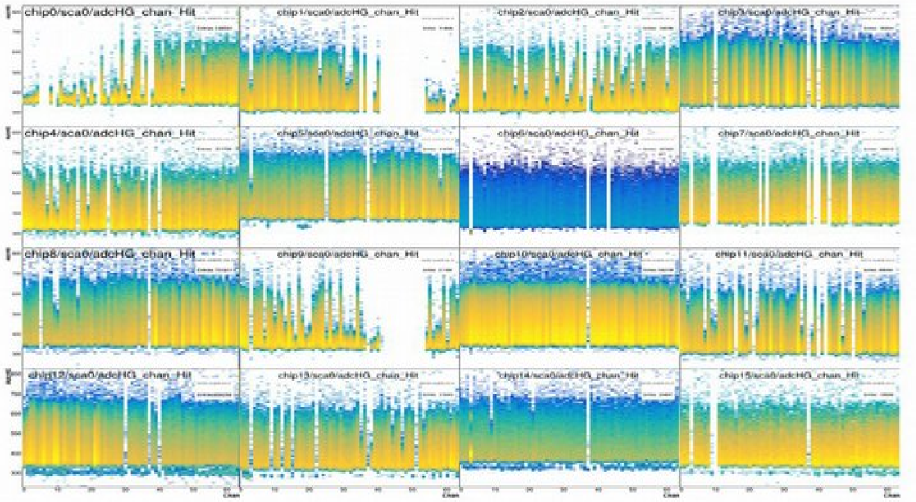
Full stack irradiation with 37MBq source



- Source 137Cs, 37MBq
- D~10 cm
- Acquisition time = 60000 s
- Threshold 240







Ultra thin PCB: Chip On Board

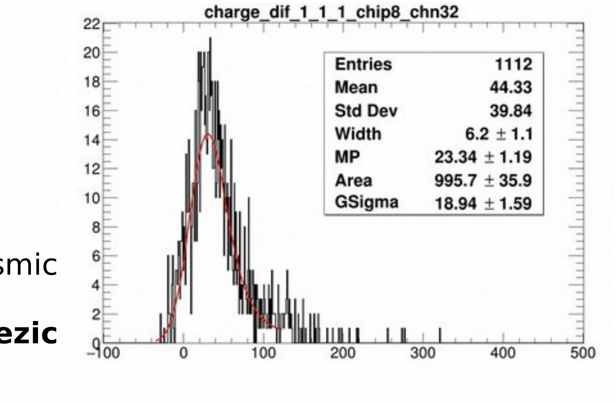
LAL/OMEGA collaboration with Corean Group of SKKU (EOS company for the PCB)

- FEV11_COB: 10 boards of 1.2mm, good planarity and good electrical response.
- SK2a wirebonded at CERN (Study by LPNHE and P2IO Platform CAPTINNOV)

Successful debugging w/o sensors:

- (~4% of noisy channels, good response to injected signals)

Example of MIP spectrum from cosmic ray (3.6pF)
Plot from V. Lohezic

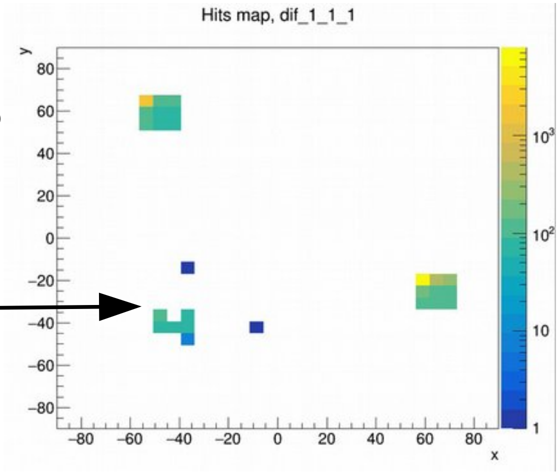


Debugging with sensors (baby wafers 3×3 px)

- The system was not ready for test at DESY@2018.
- New wafer testbench setup in LAL borrowed from LPNHE.
- Duplication ongoing at LAL (using the CAPTINOV platform)

Hit map with for cosmic runs (different mapping to BGA versions**)**

Baby wafer tested in DESY. Some glue is spilled.

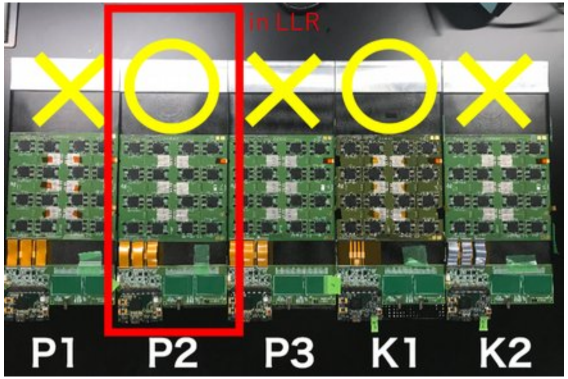


- 3 baby wafers characterized, glued and tested with cosmics. Test with radioactive sources are in preparation.

Other news

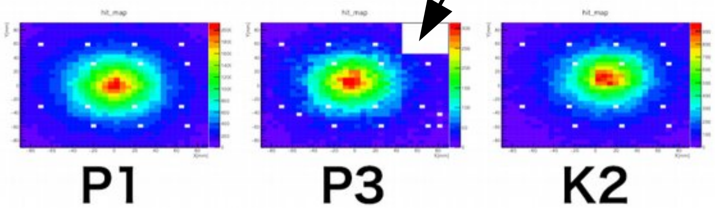
FEV13 with improved mechanics
(FEV13 slab dismounted and repaired in Kyushu)

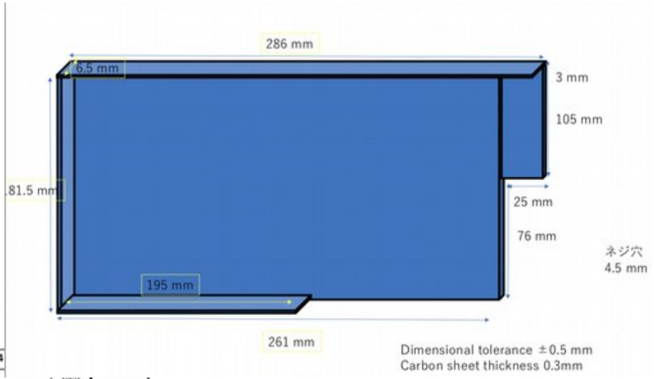
- all HV faults due to repairs



Ba133 source

Noisy chip





2 weeks of BT at DESY in 2019:

- 24/06 – 07/07/2019
  - COB tests
  - FEV13

DESY TEST BEAM.

DESY Test Beam Schedule 2019 - Version 2 15/11/2018

Ralf Diener, Norbert Meyners, Marcel Stanitzki - DESY Test Beam Coordinators

	Week		TB21		TB22		TB24/1		TB24	
				DATURA		DURANTA	PCMAG	Telescope in PCMAG		[illegible]
10-Jun-19	24		CLIC PIXEL	X	ATLAS-ITk-Strips	X	T2K			
17-Jun-19	25		TBMST	X	ATLAS-ITk-Strips	X	T2K			
24-Jun-19	26		CMS-Pixel-Phase2	X	AFP-TOF	X	CALICE-SiW-ECAL			
1-Jul-19	27		CMS-Pixel-Phase2	X	Mu3e	X	CALICE-SiW-ECAL			
8-Jul-19	28		GammaMeV	X					CALICE AHCAL	
15-Jul-19	29		CLIC PIXEL	X					CALICE AHCAL	
22-Jul-19	30		X-Ray-Crystal-Rad	X						

Way forward (2019)

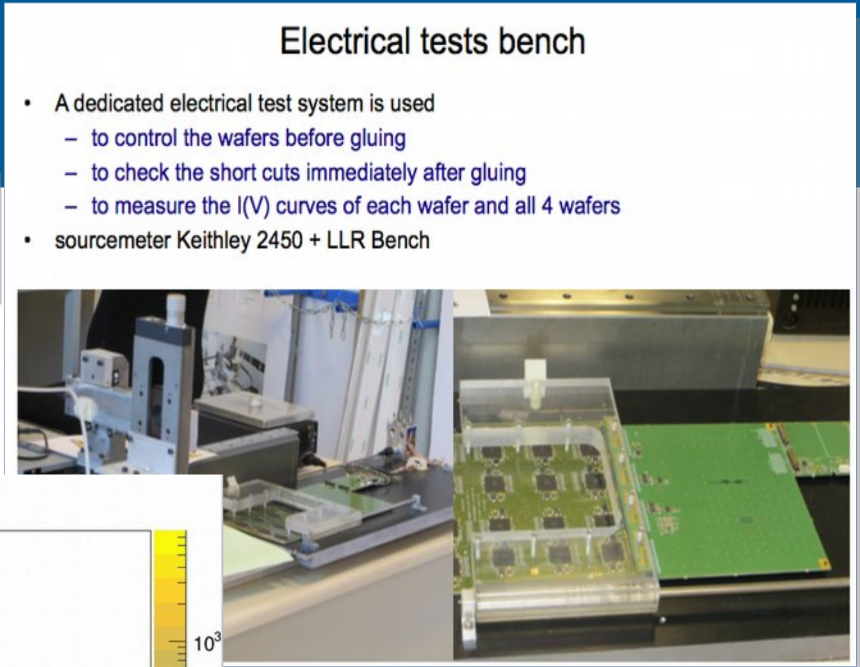
COB adaptations → for June BT

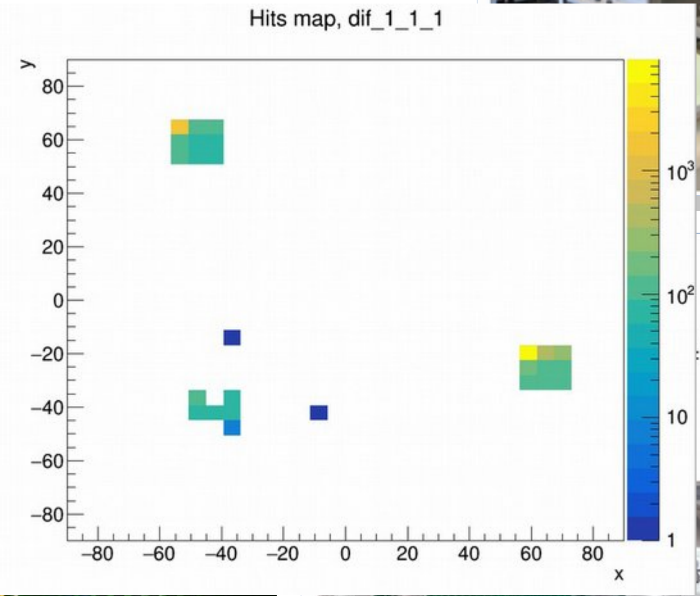
- Gluing of wafer(s) on COB PCB's [@LPNHE]
  - requires the adaptation of the gluing bench
- Testing of boards [@LAL]
  - requires the adaptation of the "versatile bench"
    - for GradConn Connectors

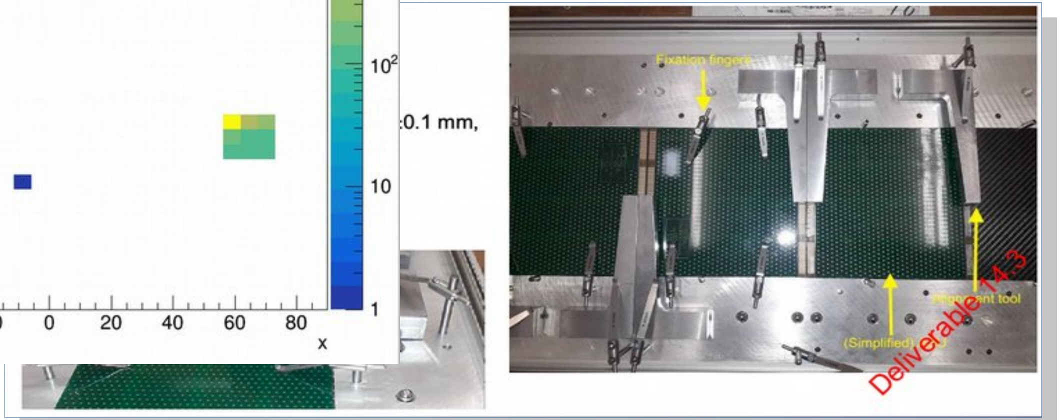
Work on assembly bench

- Check alignment option with connectors (was Kaptons)
- 2 producers:
  - GradConn
  - Antalec (near Orsay)

Improve testing procedures







DAQ improvement: FW & SW

Fast Clock

- adjustable at 40 or 50MHz (Collab with HGCAL)
- off during acquisition

Unique Hardware identification
(from Yu Miura, Kyushu)

Spill number injection from outside

EUDAQ2 module (in collaboration with Adrian)

online DD4HEP monitoring

to be done.

Back-up

New design for "electronic long slab support"

M. Anduze, F. Magniette, J. Nanni,
Realisation: G. Fayolle

Scale to support electronics

- 2+6+4 ASUs = ~3.2 m
- Support of SMB
- Total access to upper and lower parts
  - Baby wafers (4×4 pixels) on the bottom

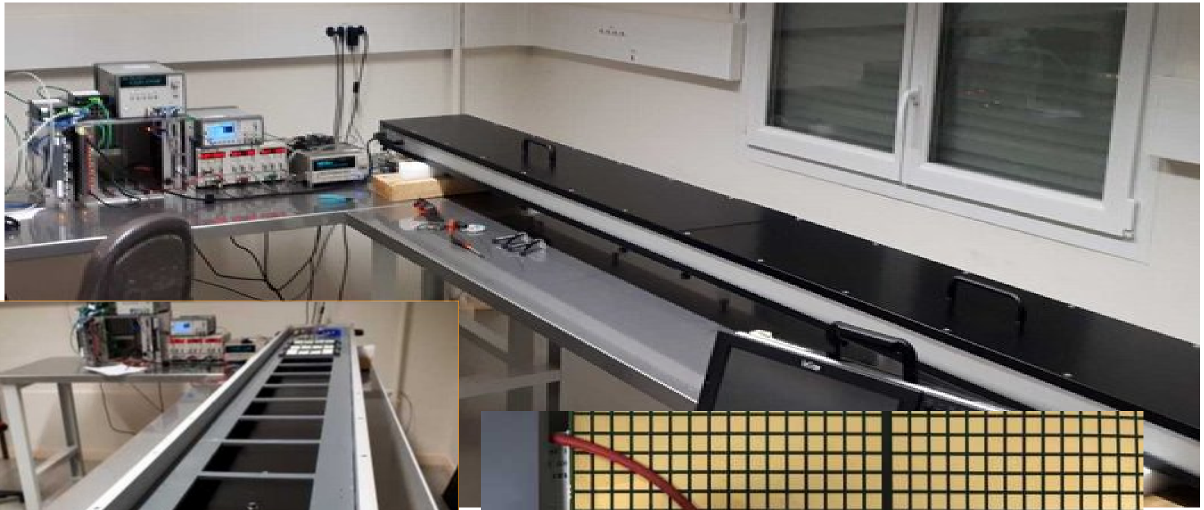
Mechanical characteristics

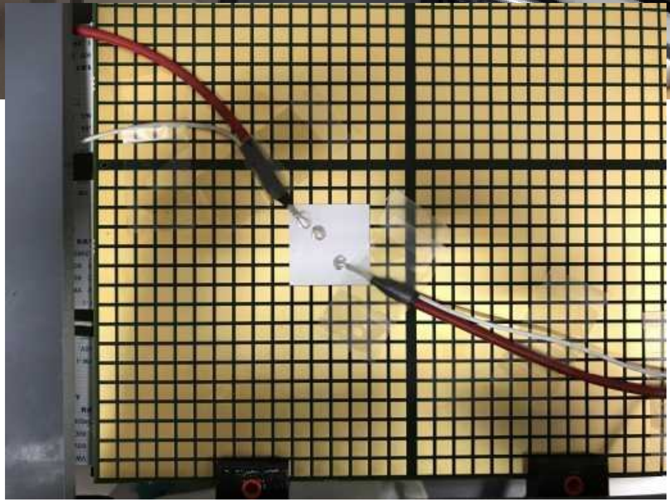
- Movable: table and to beam test
- Rotatably along long axis (for beam test)

  Rigidity : ≤ ~1 mm per ASU
- No electrical contacts scale / cards

Shielding

- vs Light and CEM





2 weeks program with support from AIDA-2020

7 SLABs in 2–5 GeV electron beam, on movable stage

- with and with W absorbers (3 ≠ configurations) @ 0 & 45°
- 1 SLAb with 0–1 T magnetic field
- Conservative commissining > Masking of noisy channels : 6-8% of channels + 1 @ 24% (1 Wafer)

MIP Scan

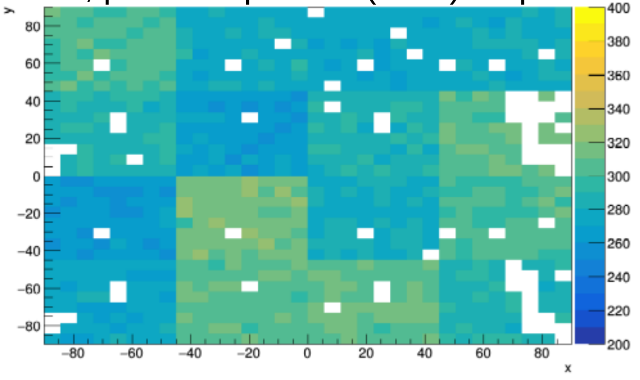
- Pedestal correction, Energy calibration channel wise
  - 45° run: MIP value scaling as expected → good thresholds choices.
- Fit the 98% of available channels. Channel dispersion of 5%.

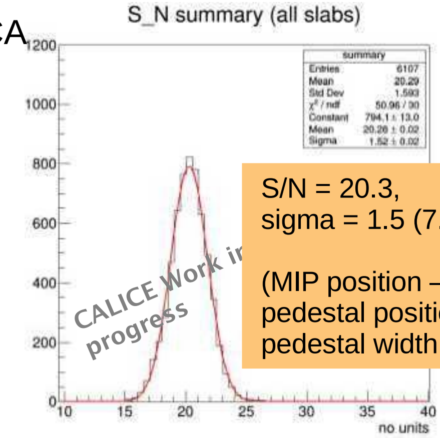
Construction & Commissioning paper(s?) – technical mid 2018 ?

- By layer analysis: mips+noise → noise, S/N, uniformity, …
  - Presented at CHEF’2017, LCWS’2017, Poster @ IEEE. ⇐ **with AIDA support**

Electron showers to be analysed

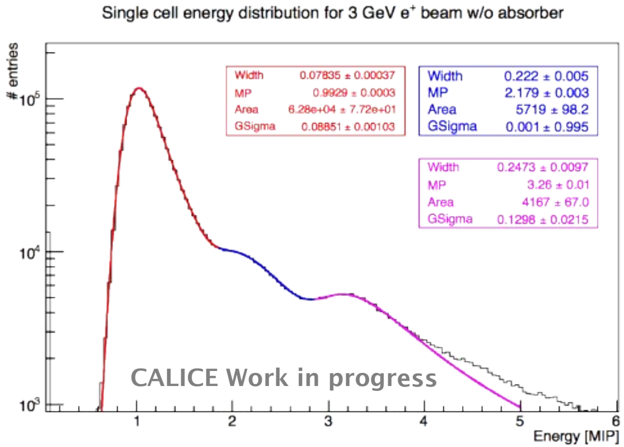
Layer #6, pedestal postion (ADC) map for SCA = 0



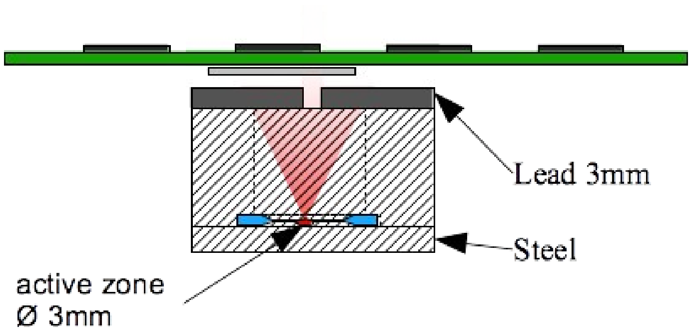


S/N = 20.3,
sigma = 1.5 (7.4 %)

(MIP position – pedestal position) / pedestal width

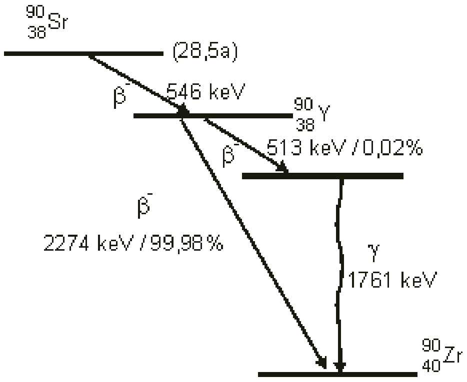


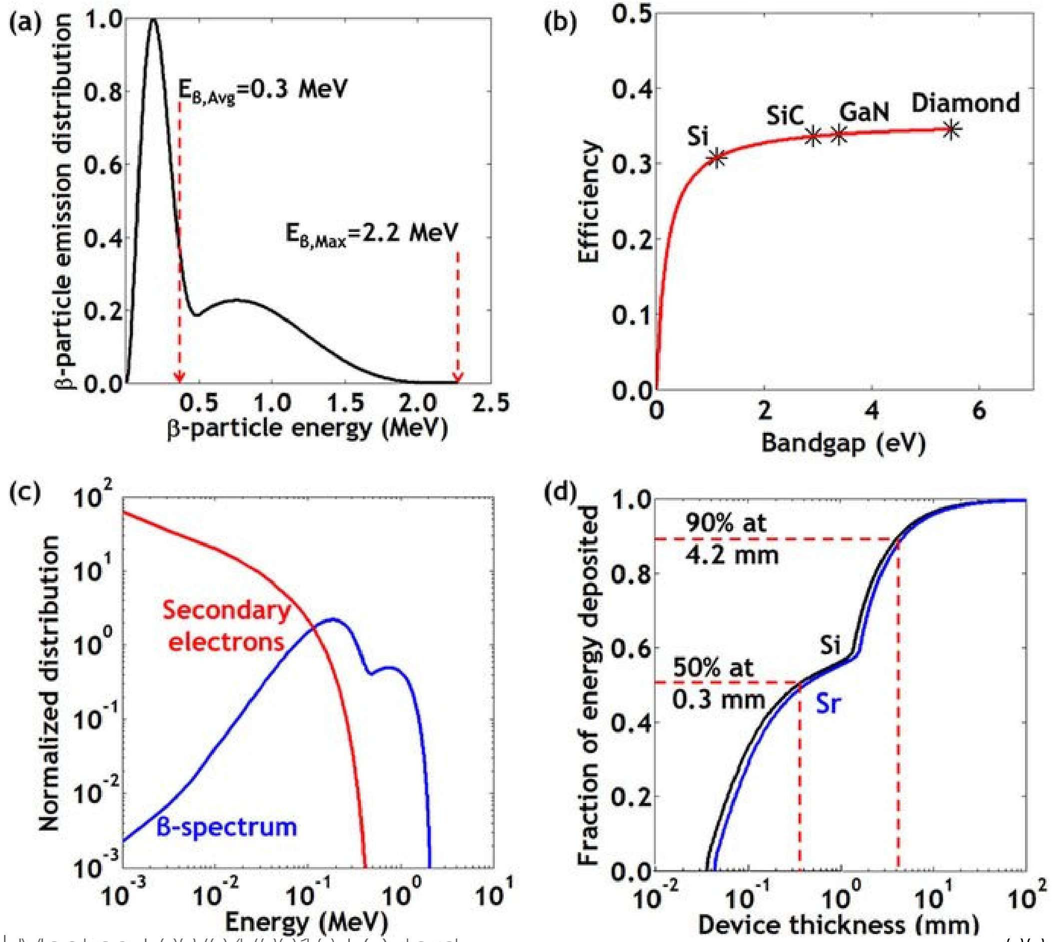
Test with ^{90}Sr source



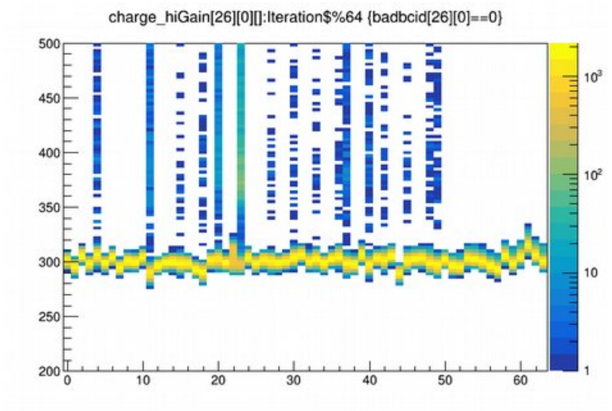
2.2 + 0.546 MeV electrons

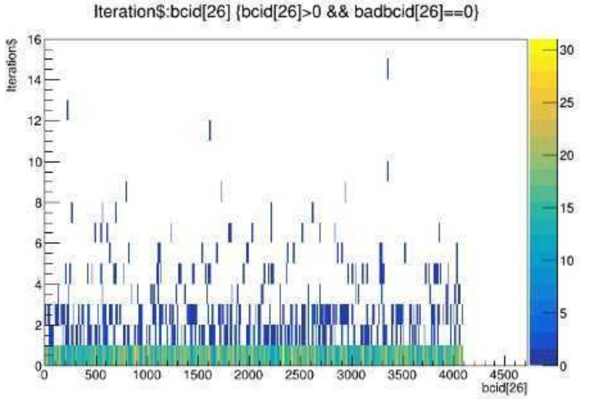
– no straightforward mip but fine...

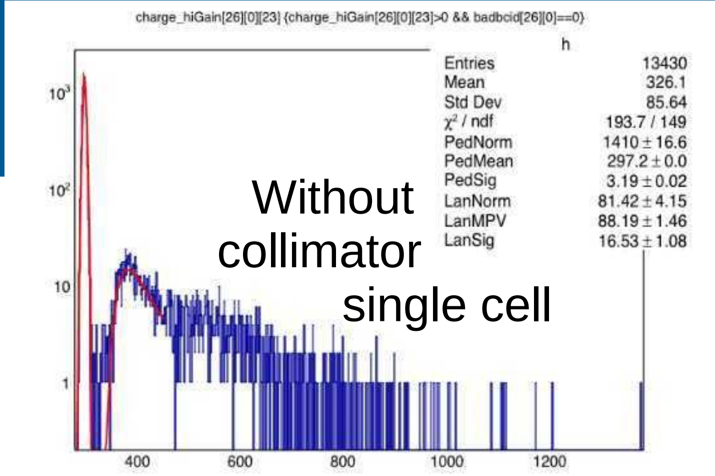


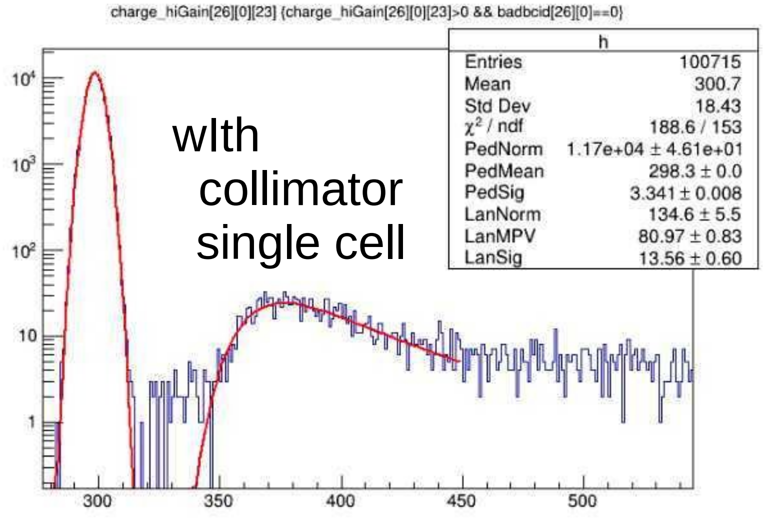


Test with ^{90}Sr source









Some prelim conclusions:

- Perfect noise cellwise
- punch through electron ~ mip like
- Signal is ~30% higher than in BT (scattering)

Tested on first 4 ASU's

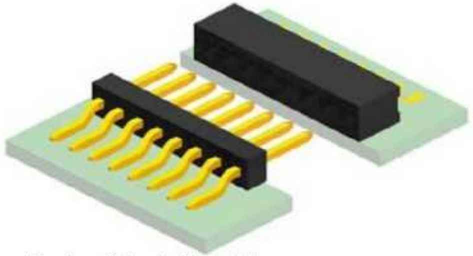
problem with 5th : under investigation

On interconnection: alternative solutions

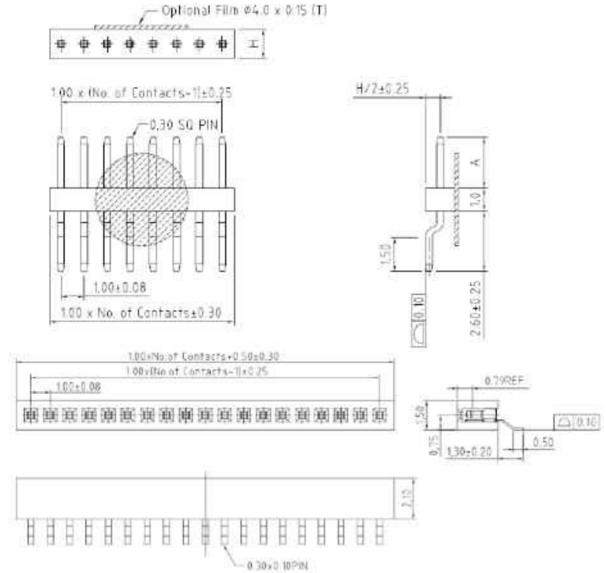
"Real" but flat connector

To replace the interconnection kaptons on top of board

Height : 1.5 mm (female)
1.27 – 1.5mm (male)
Pin distance 1 mm



Breton/Maalmi/Jeglot



https://www.gradconn.com/Products/BoardToBoard/MatingHalves/BB02-YN/BB02-WF

Note that connector is compatible for mounting on existing (BGA type) PCB

Studies on connectors also carried out at LLR (J. Nanni) and LPNHE (R. Cornat)

Expected delivery: Beginning December (1000 units)