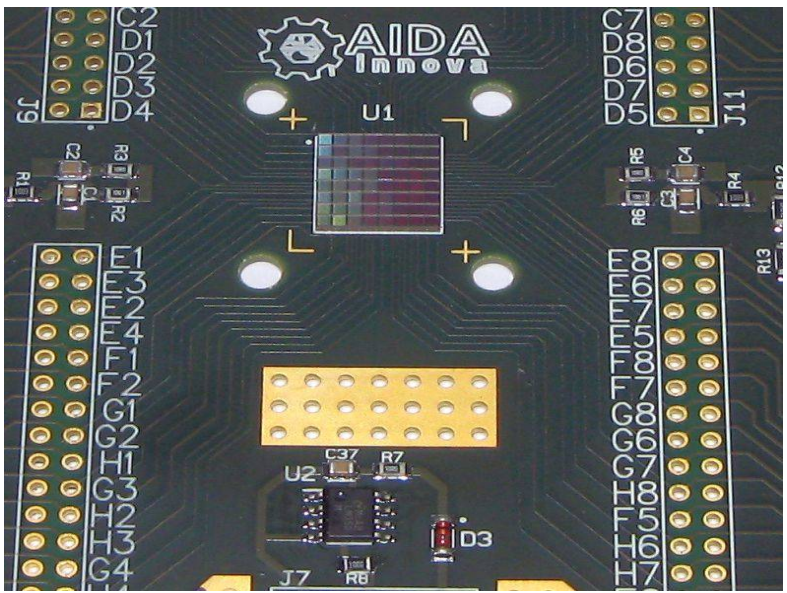
WP 8.4.1 AIDA innova 2024 annual meeting

SiPM array prototype for TileCal scintillators, ADApower and preamps

Under AIDAinnova collaboration we build a prototype system not only for the test of SiPM array with TileCal scintillators.

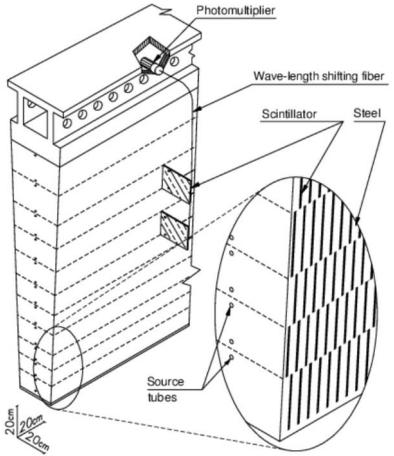
People:

- Gerald Eigen Uni Bergen / Uni Göttingen
- **Ivo Polák FZU Prague presenter**
- Jiří Kvasnička FZU Prague
- Jaroslav Moravec FOTON
- Matěj Řehák FOTON



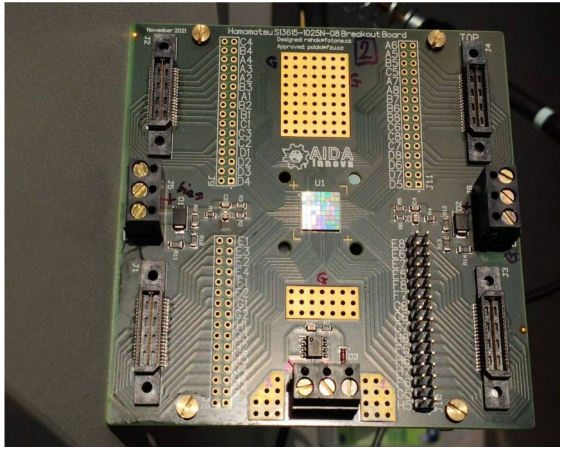
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA no 101004761.

WP8.4.1



- Ultimate aim: individual readout of WLS fibres

  in TileCal - like calorimeter
- Testing workhorse: 64 channel SiPM array (HPK S13615-1025) soldered on breakout board with temperature sensor onboard
  - 1×1 mm^2 active area per SiPM element
  - 25 µm pixel pitch
  - 0.2 mm gap between SiPM elements



- Several tests performed during 2023 and 2024 in the dark box in Göttingen

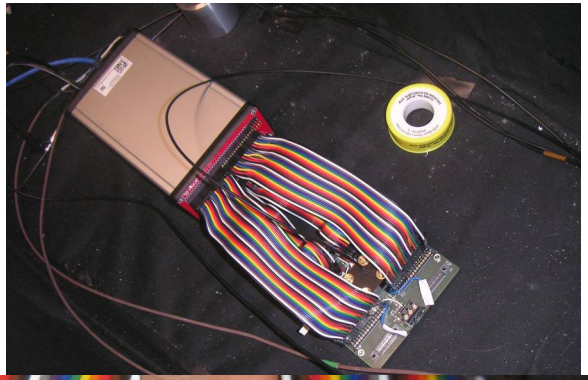
What we tested

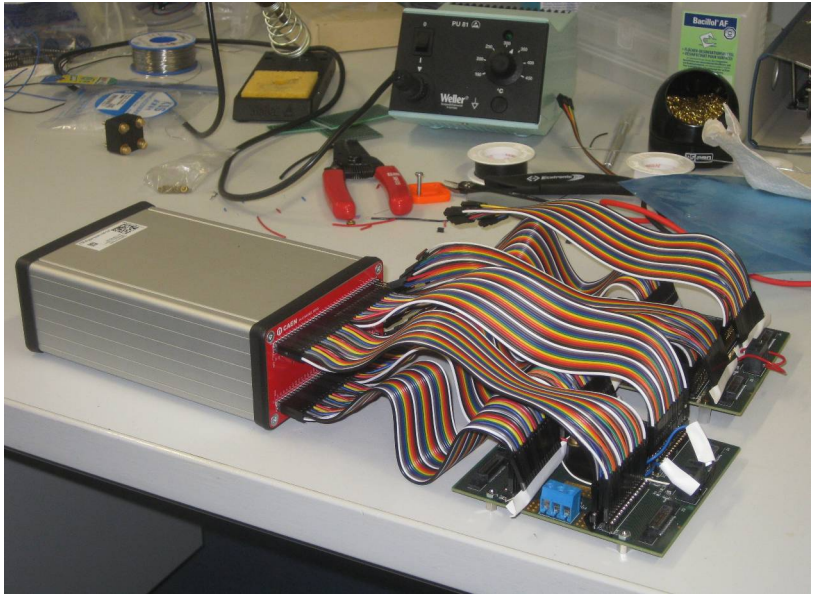
- integrating of multichannel DAQ Caen DT5202 64 CH and testing with UV-LED driven by a legacy QRLED pulser (3.5ns)
- Testing with **two types of flanges**, different distances of ends of fibre to SiPM surface, previous 0.5mm and 0 mm
- **Two fibres** tested, each 1mm Outer Diameter
  - Clear fibre
  - WLS green fibre TileCal type
- **Two SiPMs arrays** on expanding boards
- **Precise aligned pins** to place the flange over SiPM array with 0.1 mm precision

Setup with 64CH DAQ CAEN DT5202

- We used fast solution of connection with regular coloured flat dupont cables
- It is far from optimal solution on EMC
- We measured inside of metal dark box, it helps to reduce external noise pickup

This test we made in February 2024

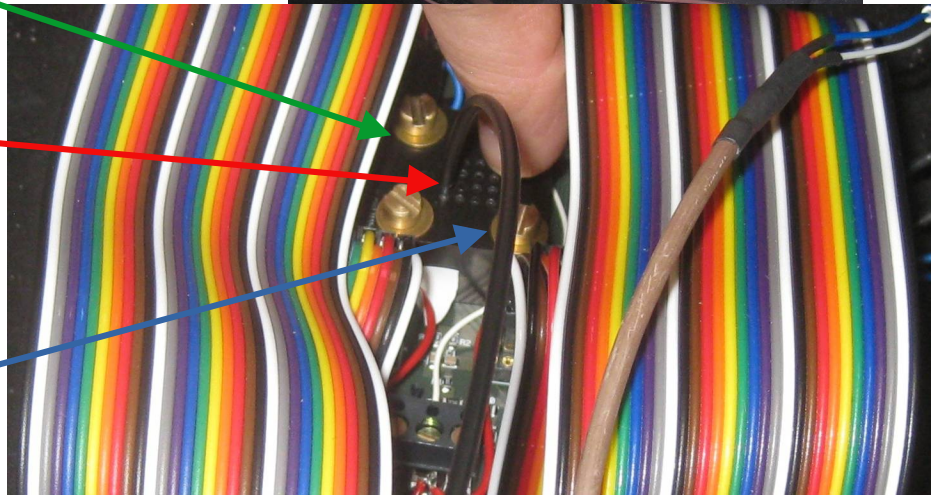




Precise (30μm) brass alignment pins

Holes in the flange

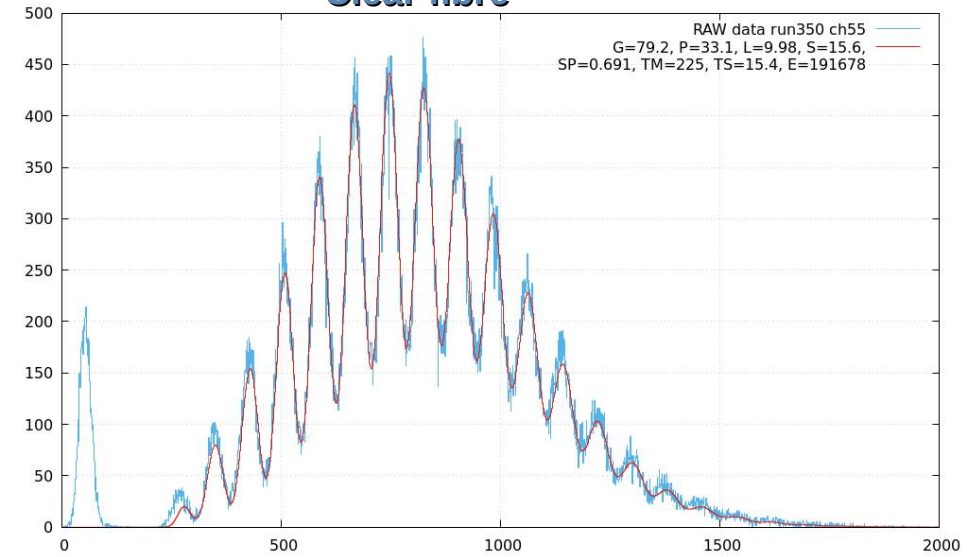
Fibre in a sleeve



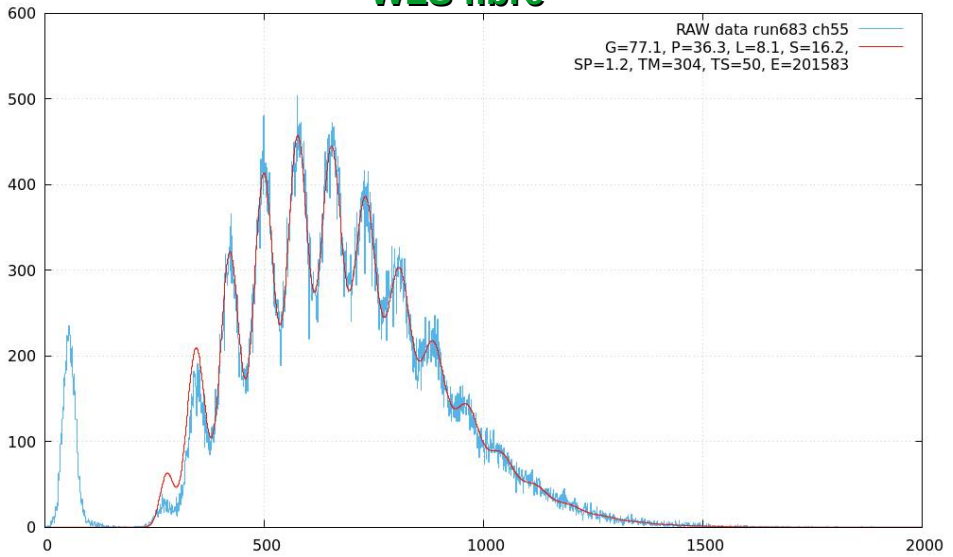
Gain extraction

by Jiri Kvasnicka

- Extraction via fitting + manual fit finetuning
  - **Clear fibre**: 100% of fits good, very nice SPS
  - **WLS fibre:** 90% of fits are good, rest needs manual constraints. Much noisier SPS
- Fit function: sum of 30 equidistant gaussians scaled according to poisson distribution and with progressively increasing sigmas
  - **Clear fibre**



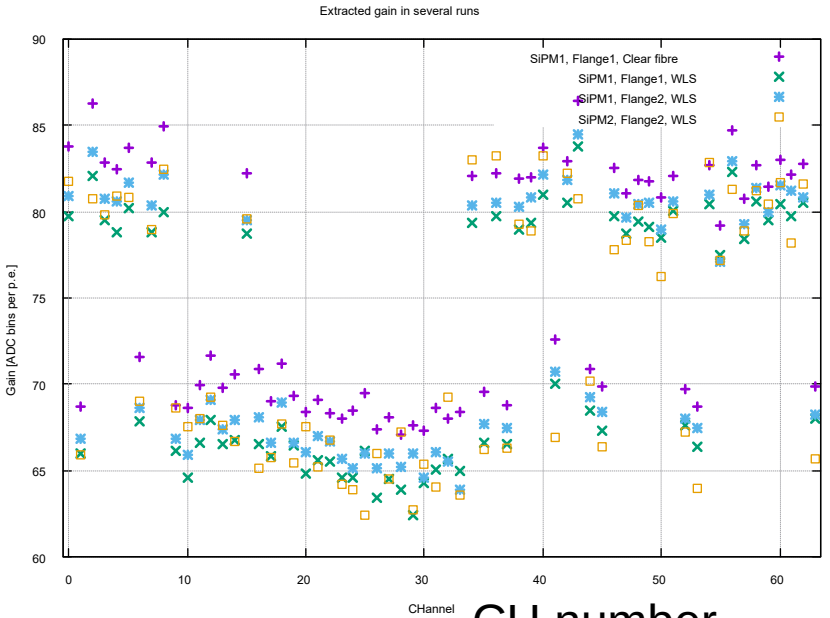
WLS fibre



Gain summary

by Jiri Kvasnicka

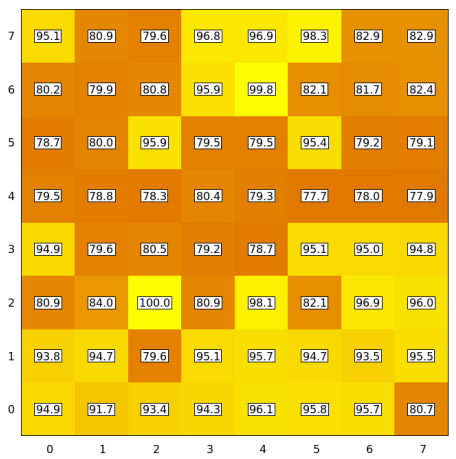
- Total variations come mostly from DAQ channel to channel gain variations



CH number

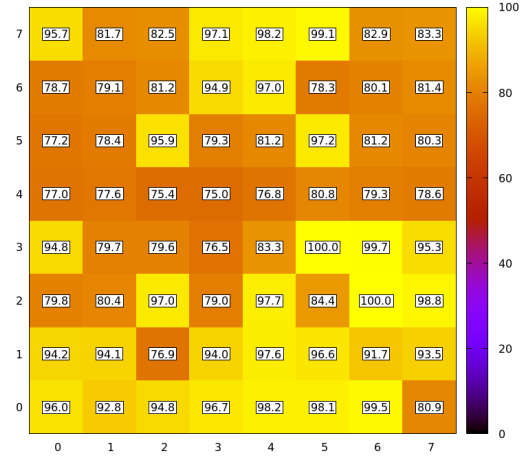
Gain variations in color code is in a range of 75 to 100

Gain SiPM1



Board 1

Gain SiPM2



Board 2

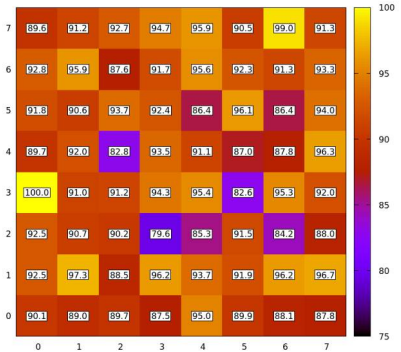
Measured signal

by Jiri Kvasnicka

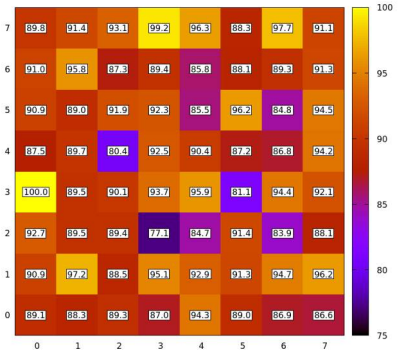
PRELIMINARY

- Light yield extracted via 3 methods with comparable result:
  - Lambda of the poisson distribution from the fit
  - **Mean of the low gain signal** (signal typically at ~160 p.e.) ← probably most stable result
  - Mean of the high gain (imprecise)
- All method requires good fit of gain, pedestal, HG/LG intercallibration

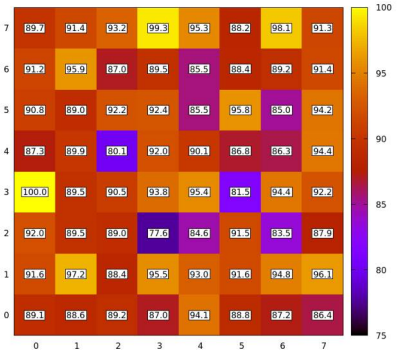
LY from Lambda

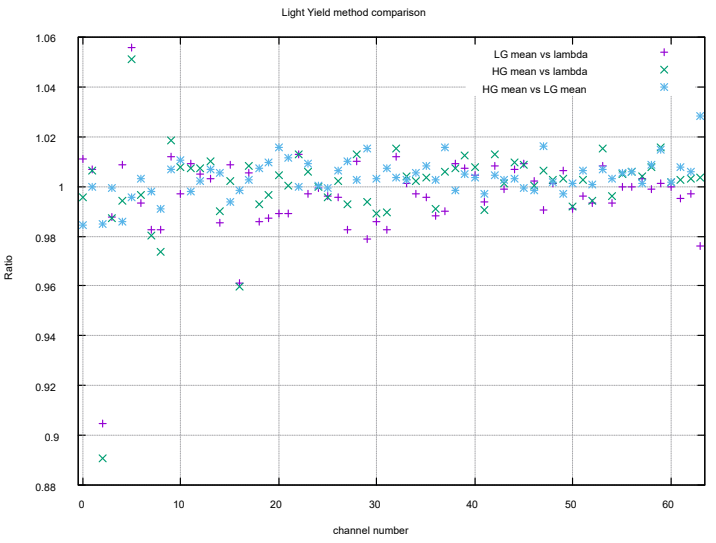


LY from LG



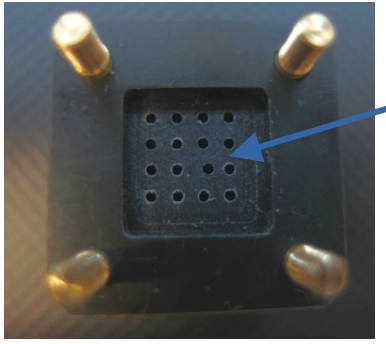
LY from HG





LY comparison for different setups

by Jiri Kvasnicka

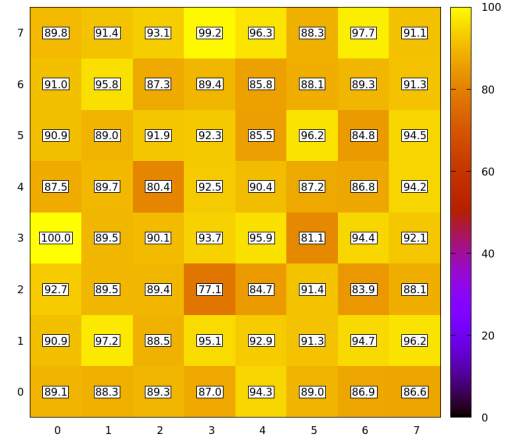


Flange 2
One hole has the offset!
That is the reason for small signal in four SiPM channels

with Air gap

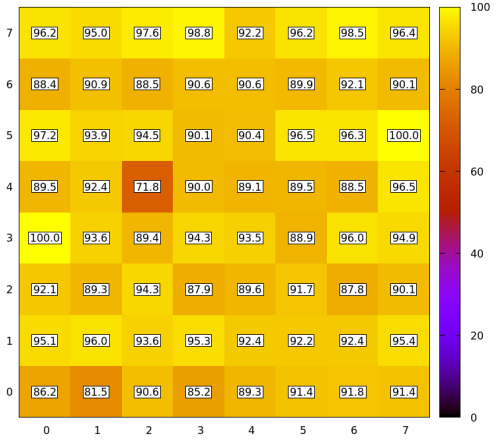
Range 77 to 100

SiPM1, clear fibre



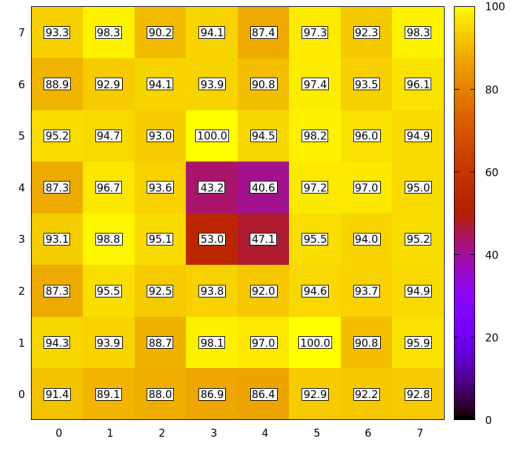
Range 72 to 100

SiPM1, WLS, Flange1



Range 43 to 100

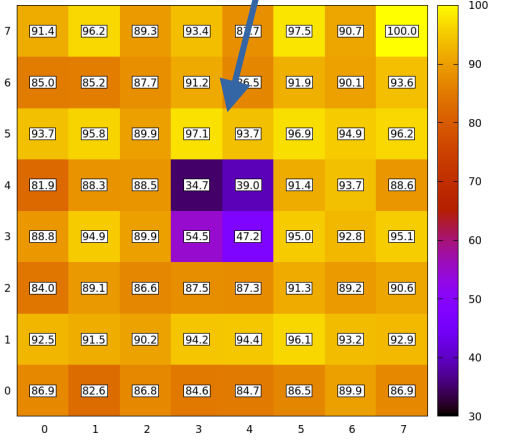
SiPM1, WLS, Flange2



no Air gap

Range 35 to 100

SiPM2, WLS, Flange2



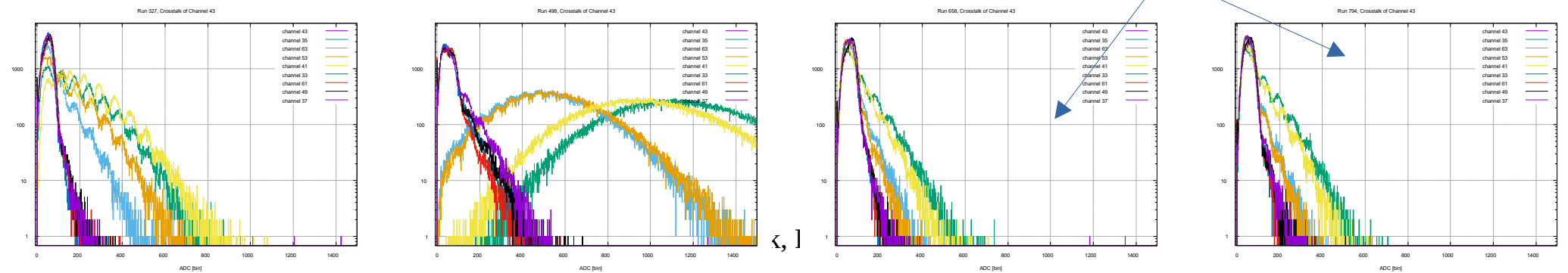
Crosstalk

by Jiri Kvasnicka

- 4 setups:
  - Setup1: SiPM 1, Flange 1 + clear fibre, Gap from SiPM
  - Setup2: SiPM 1, Flange 1 + WLS fibre, Gap from SiPM
  - Setup3: SiPM 1, Flange 2 + WLS fibre, close contact with SiPM
  - Setup4: SiPM2, Flange 2 + WLS fibre, close contact with SiPM
- Example at position **channel 43**.
  - Amplitude of signal ~160 p.e.
  - Pictures in same scale

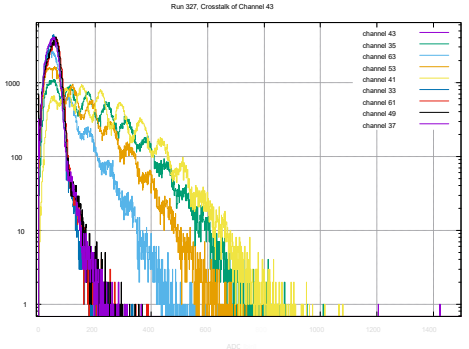
PRELIMINARY

Not possible to reliably evaluate **crosstalk <0.5%** due to massive pedestal shift: The error is several times higher then the signal



Crosstalk: setup 1 and 2 with Airgap

- Pedestal shift of several (!) p.e.
- Possibility for crosstalk measurement would be to decrease the gain of the main signal by trimming the high voltage using the IDAC
- With WLS fibre a small **misalignment** of the fibre or the flange creates large crosstalk to neighboring channel

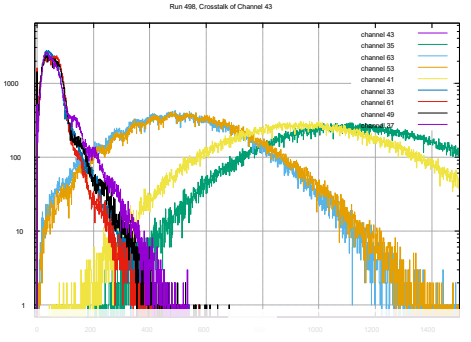


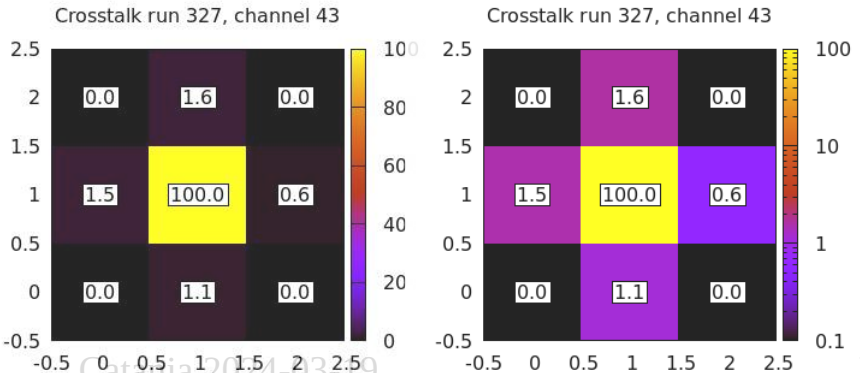
Clear fibre

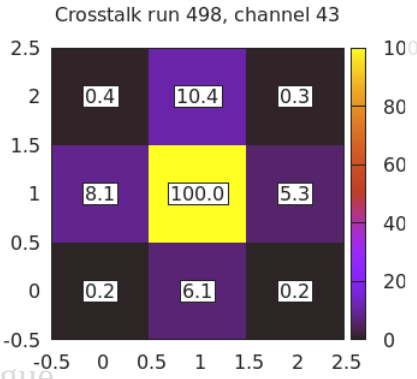
Crosstalk <1.6%

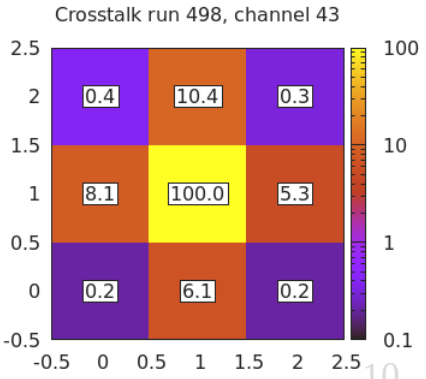
WLS fibre

Crosstalk < 11%

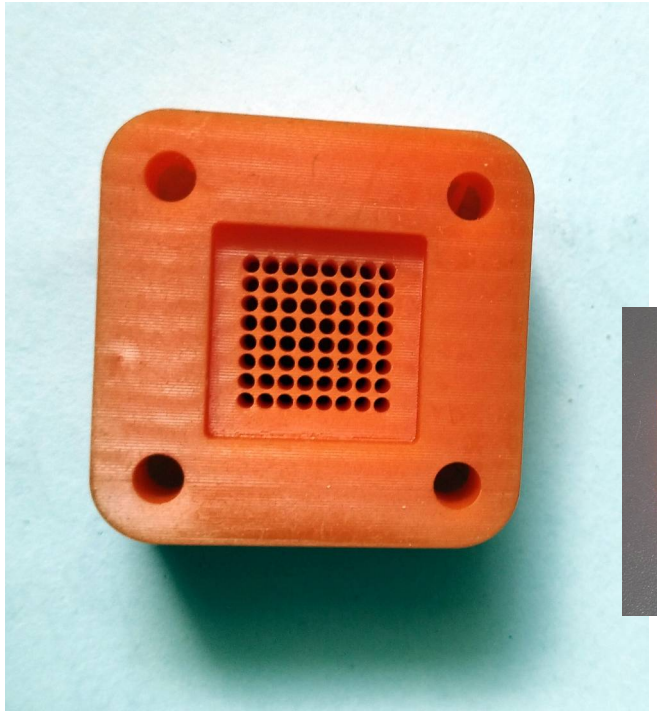








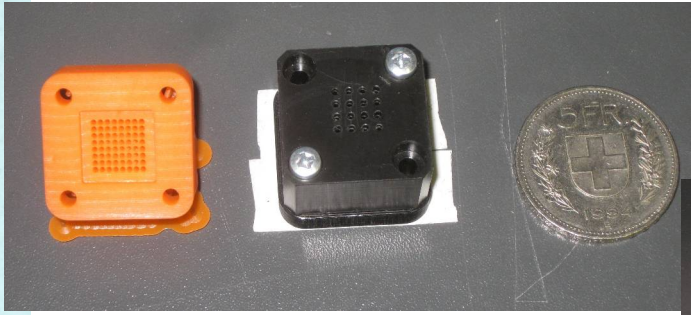
Most recent flange for 8 x 8 fibres



Printed on Prusa SL1S resin 3D SLA printer

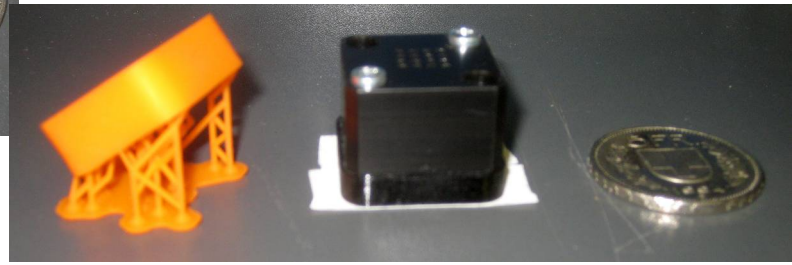
- Printed with UV 405nm resin for 1.05 mm OD fibres
- Thickness of the wall is about 150 μm only
- Holes needs some care with precise drill bit
- To be tested with fibres soon

PRUSA RESEARCH by JOSEF PRUSA



64 holes 16 holes in black

It was printed with a support structure

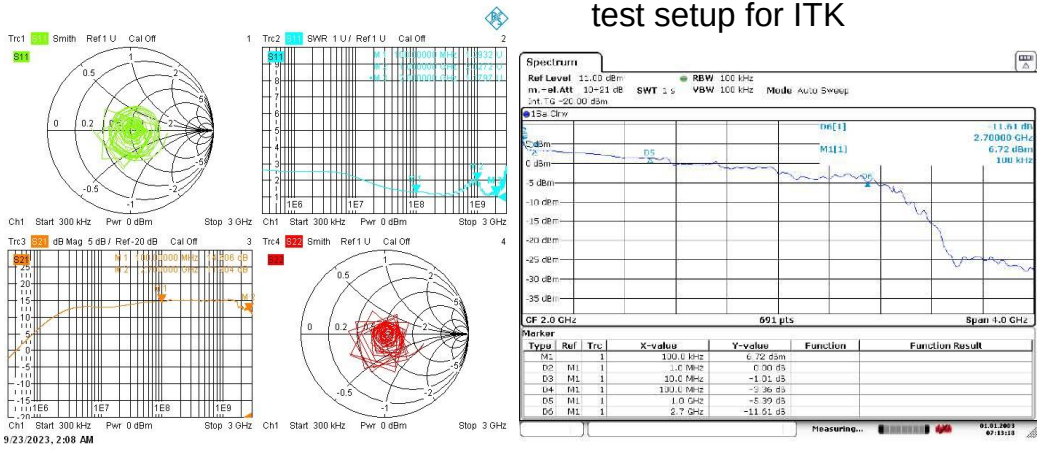


Instrumentation by Foton s.r.o.

WBA23 – WIDEBAND RF AMPLIFIER

Main parameters:

- 2 channels 50Ohm SMA
- Frequency range: 0.1 ÷ 2 GHz
- Nominal gain: 24 dB
- Max output power: +17 dBm
- Power: 12 VDC (200mA)
- tested
- We are optimizing lower frequency corner with coupling capacitors
- Possible application at silicon detector test setup for ITK



ADAPOWER 4100 - ADAPTIVE POWER SUPPLY FOR Si-PMs

- Main parameters (preliminary):
- 4 channels
- Output voltage: 0 ÷ 100 V
- Stabilized gain
- Temperature sensor inputs (common / individual)
- Analog / digital compensation
- Local / Remote operation
- Prototype is almost finished (debugging phase)

Summary of our last year activities

- Tested expanding PCB for 64CH SiPM array
  1. Campaign in 2023 single channel read by oscilloscope
  2. Campaign in 2024 February we used CAEN 64 channels parallel readout for first time (250 x more data than usually)
- Two types of black flanges for 16 fibres on SiPM array tested, 3D printed Orange 64 channel flange ready to test
- We measured SiPM arrays with two types of fibres (clear and WLS green) No optical grease
  - **We have preliminary results from LY, gain and crosstalk analyses**
  - Very little crosstalk when the WLS fibre is in touch with SiPM
- The alignment pins (30 μm) shows excellent placement precision and repeatability
- Testing phase of fast 2CH (BW 2.5GHz) preamplifier,
- The Prototype of ADApower supply is almost finished

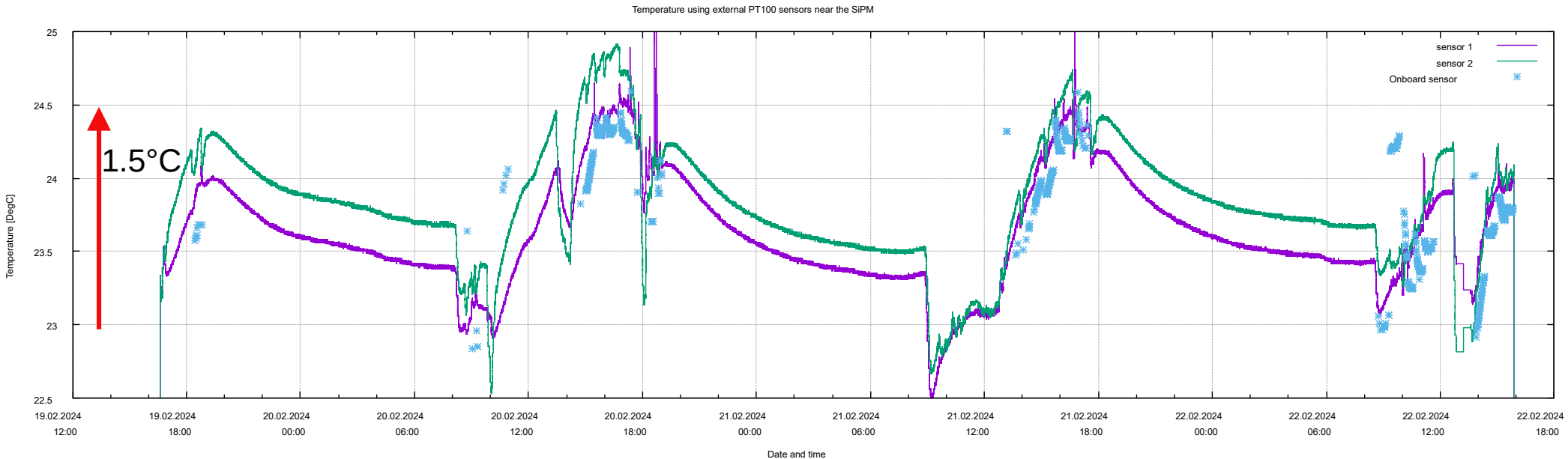
Plans:

- Testing of SiPM array setup with multi fibre system
- Analyses is ongoing for the recent test of SiPM array read by multichannel DAQ
- Build final version of ADApower

Backup slides

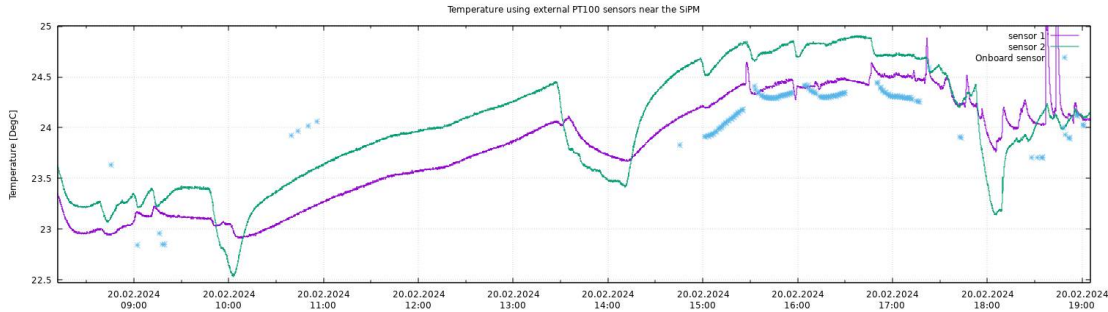
Temperature

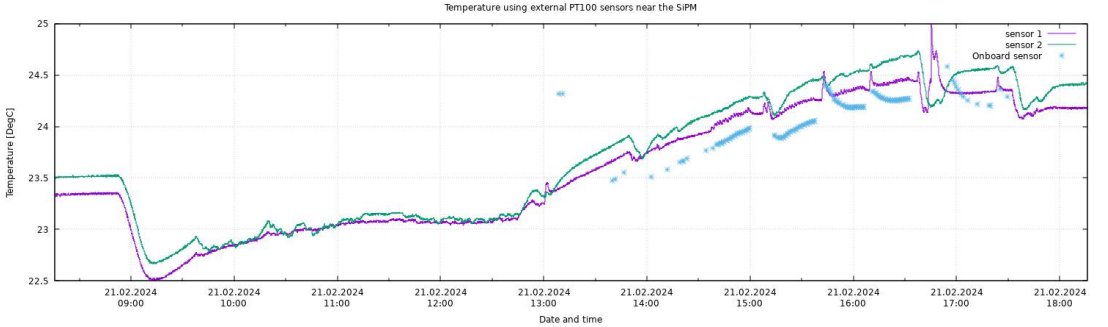
- Kept within 1.5 °C within 3 days campaign
- No temperature corrections applied
- Sensor 1 and 2 PT100 (green and violet) are placed on bottom of dark box, sensor onboard is LM35 (light blue)

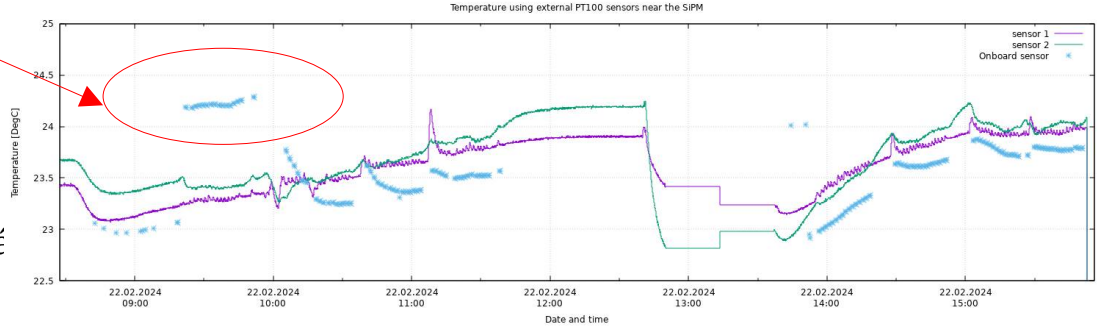


Temperature per day

- Pictures:
  - Day 2
  - Day 3
  - Day 4
    - Outliers: typo in logbook (24.xxx → 23.xxx)



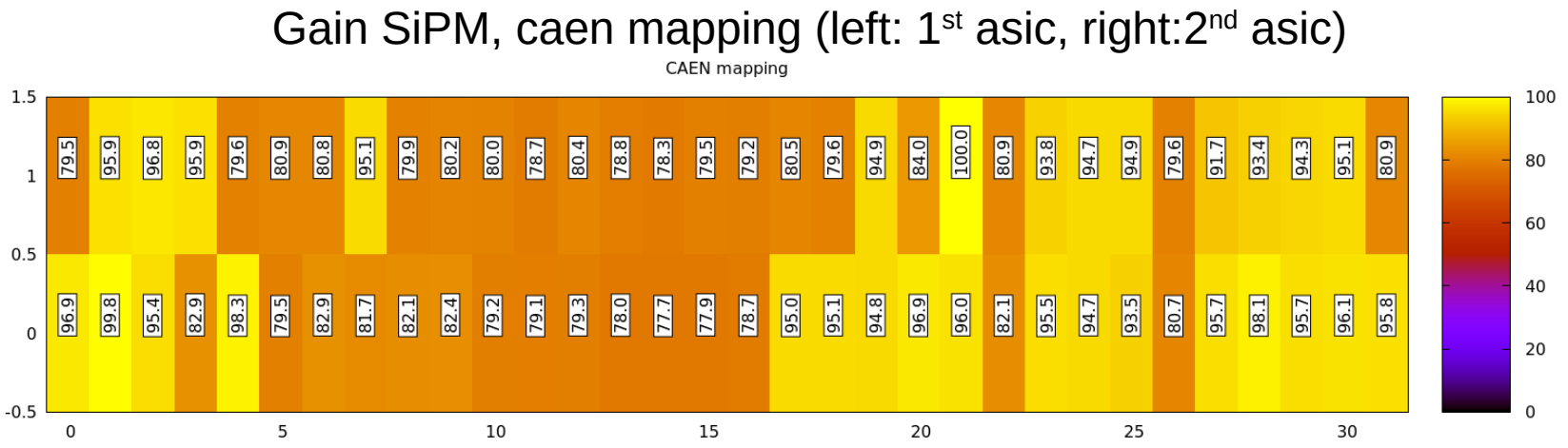




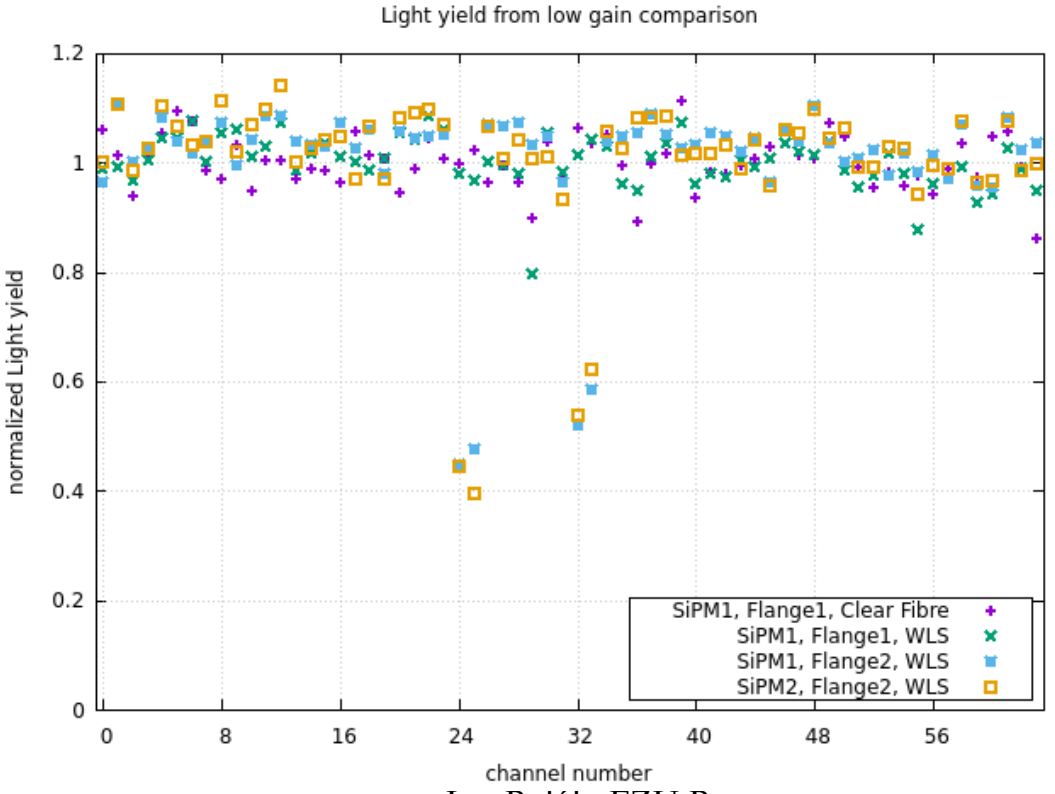
Gain summary (2)

by Jiri Kvasnicka

- 2 distributions of gain, though not linked to any key (?)
-



LY from low gain comparision

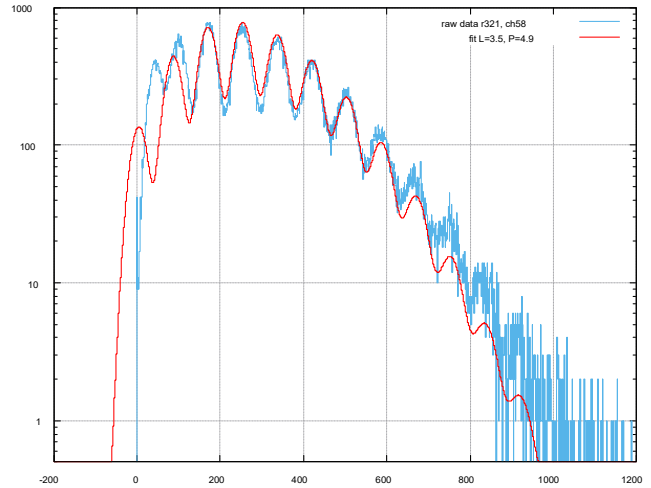


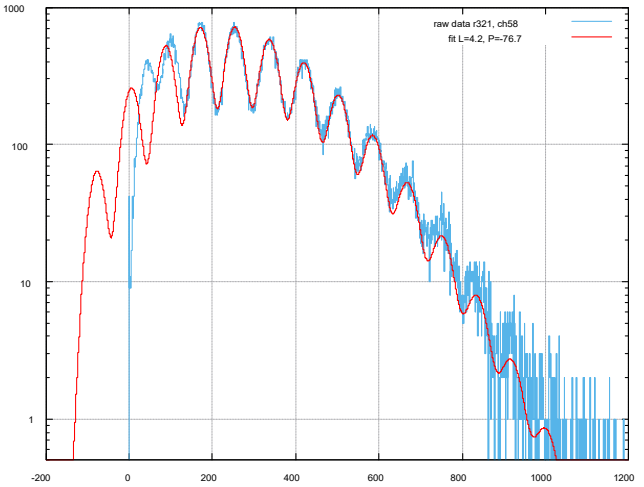
by Jiri Kvasnicka

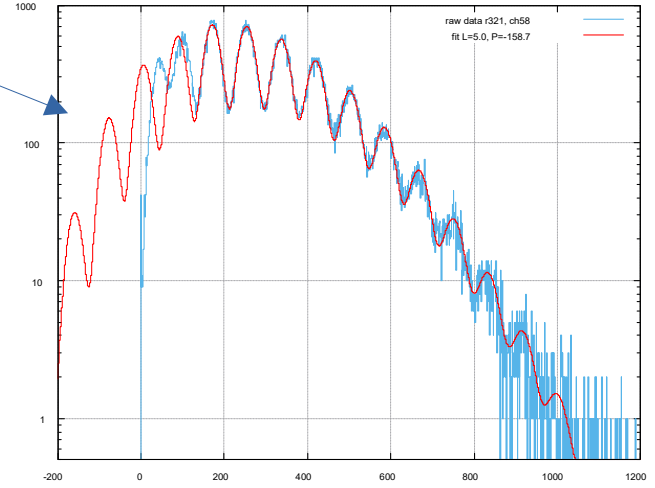
PRELIMINARY

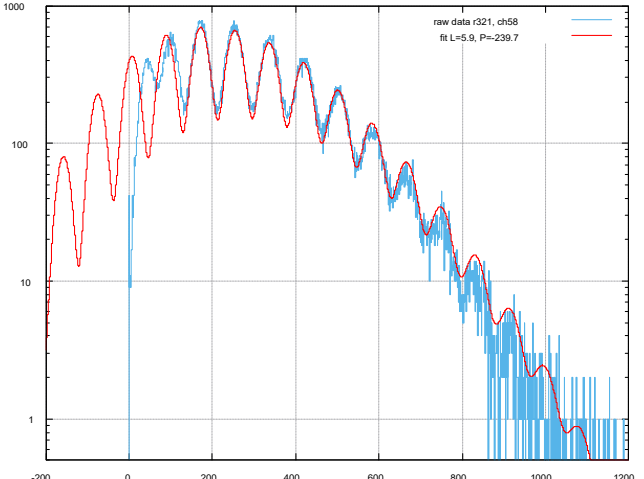
Crosstalk pedestal shift explanation

- “pedestal saturation visible
- Probably more peaks are hiding inside the “Pedestal peak”
- Pedestals on pictures shifted by 0, 1, 2 and 3 peaks
- Which one is correct?
  - Probably this one
  - (shifted by 2 peaks)
- Need to implement pedestal saturation function for proper fit









Catania 2024-03-19

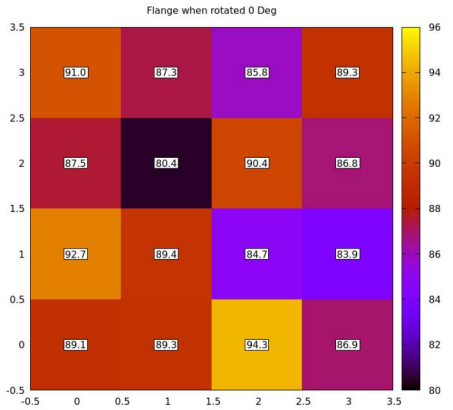
Flange rotation influence: Flange #1 **airgap**

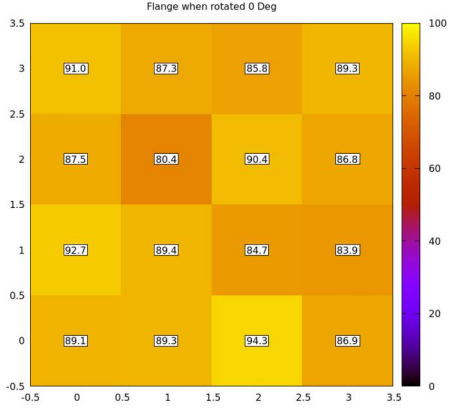
TOP line: Amplitude zoom

Bottom line: full scale

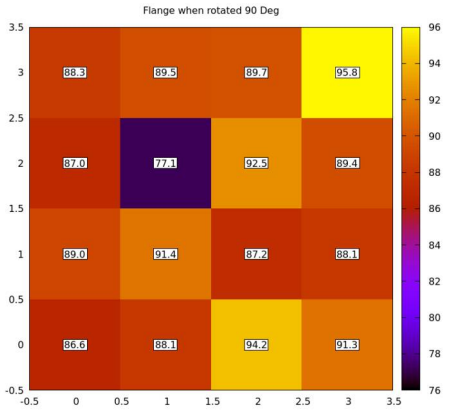
.

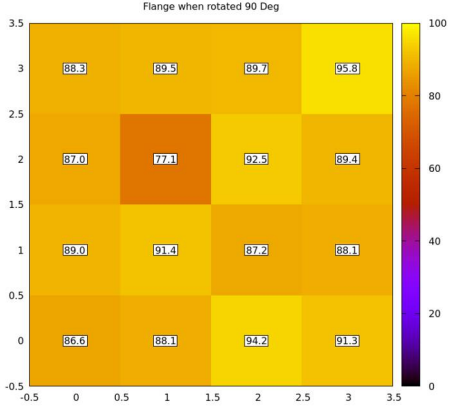
0 deg



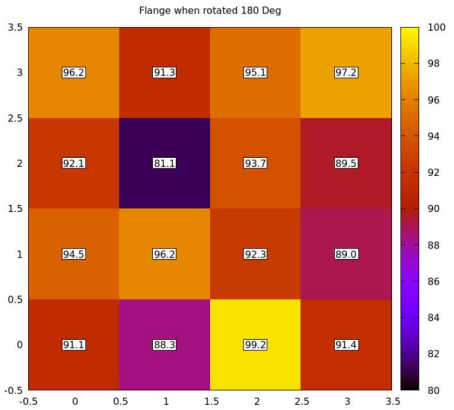


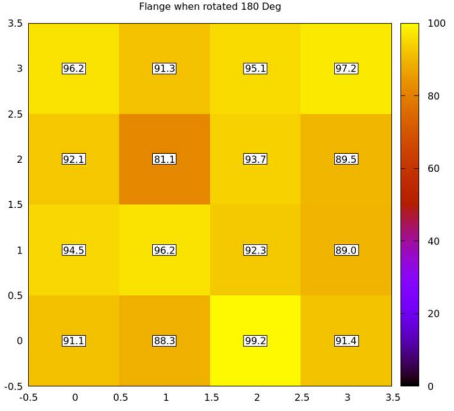
90 deg



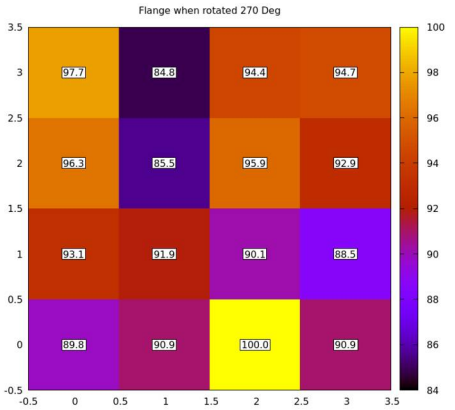


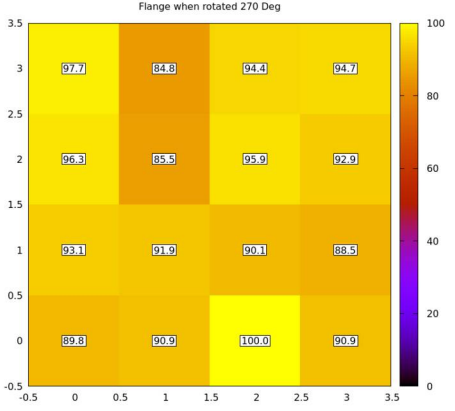
180 deg





270 deg

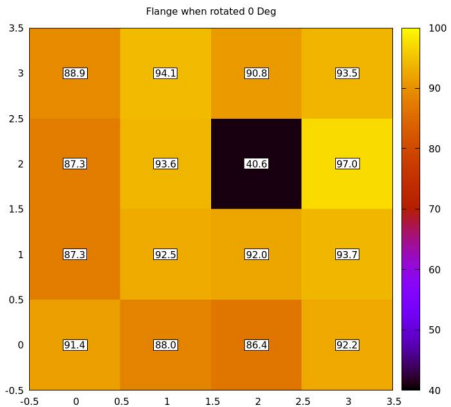


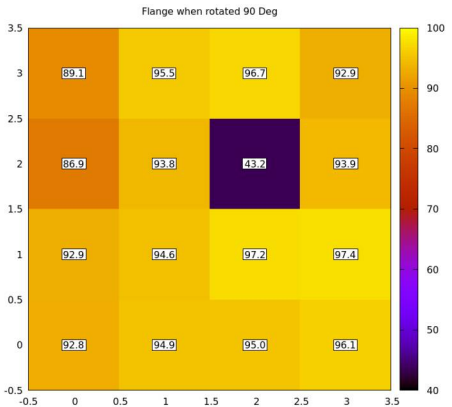


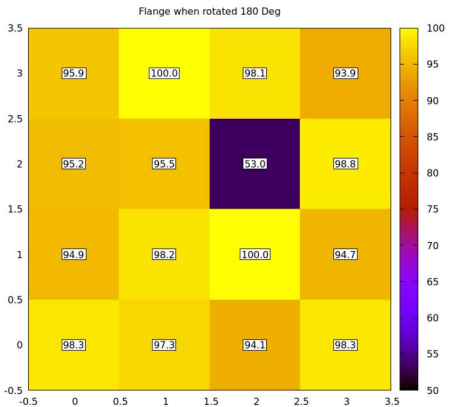
Flange rotation influence: Flange #2 **no gap**

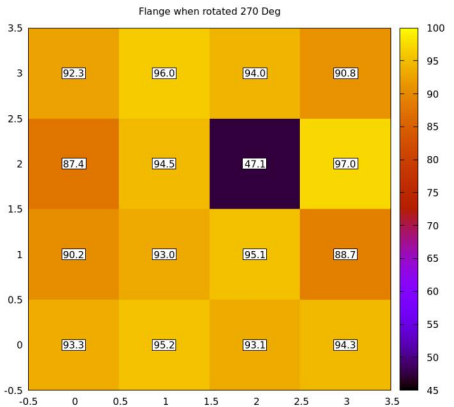
TOP line: Amplitude zoom
Bottom line: full scale

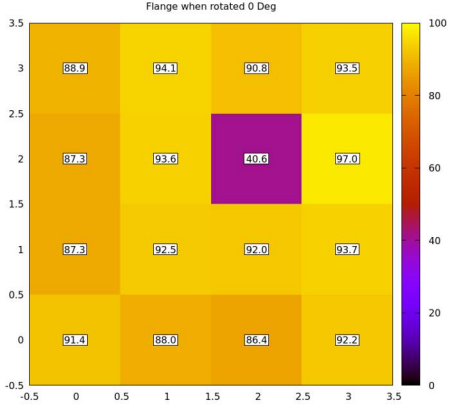
. 0 deg 90 deg 180 deg 270 deg

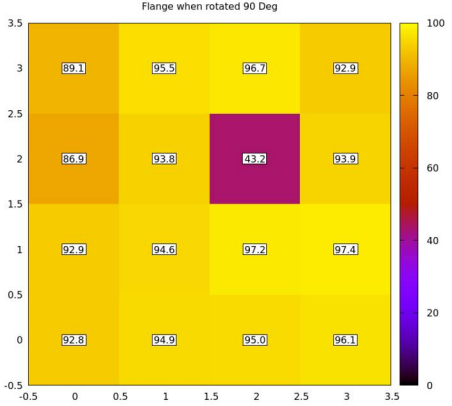




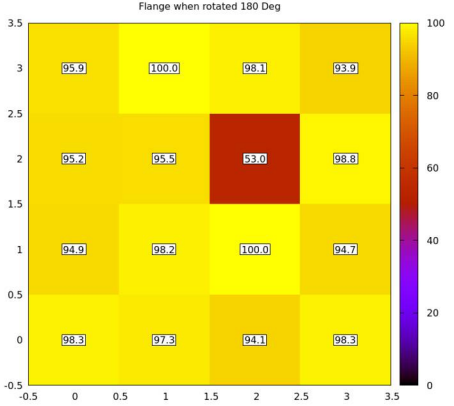


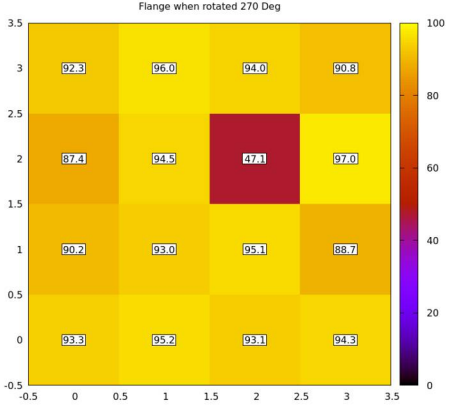






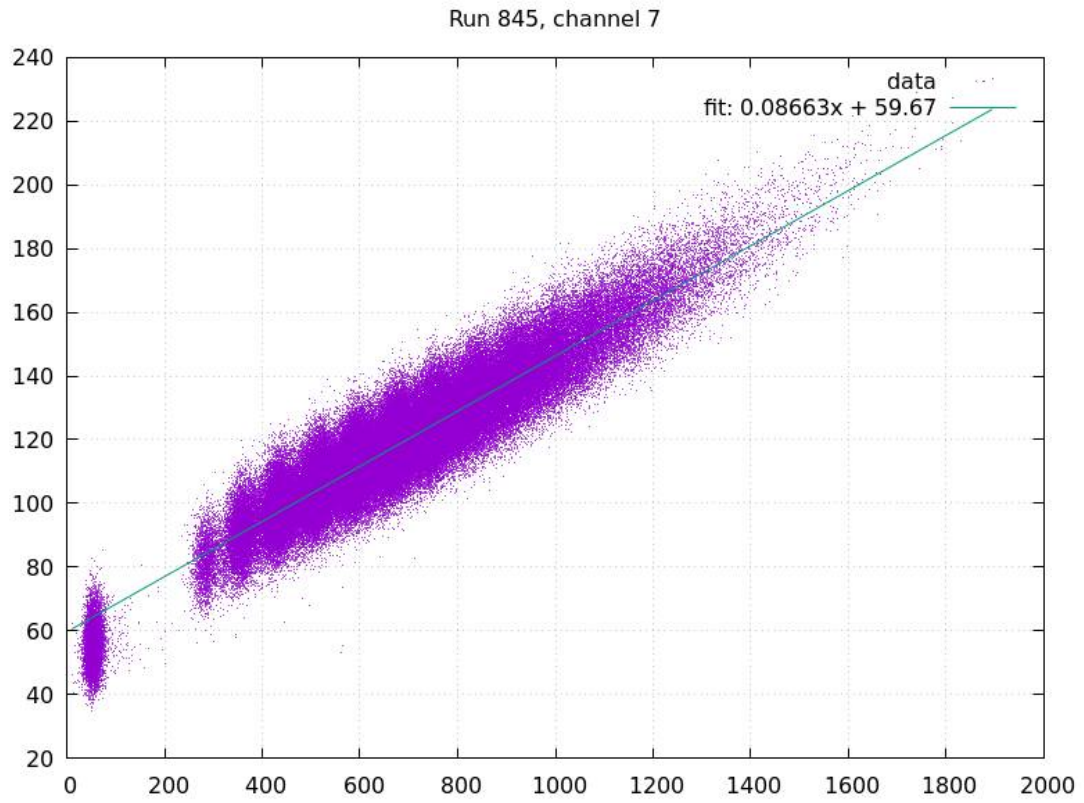
F





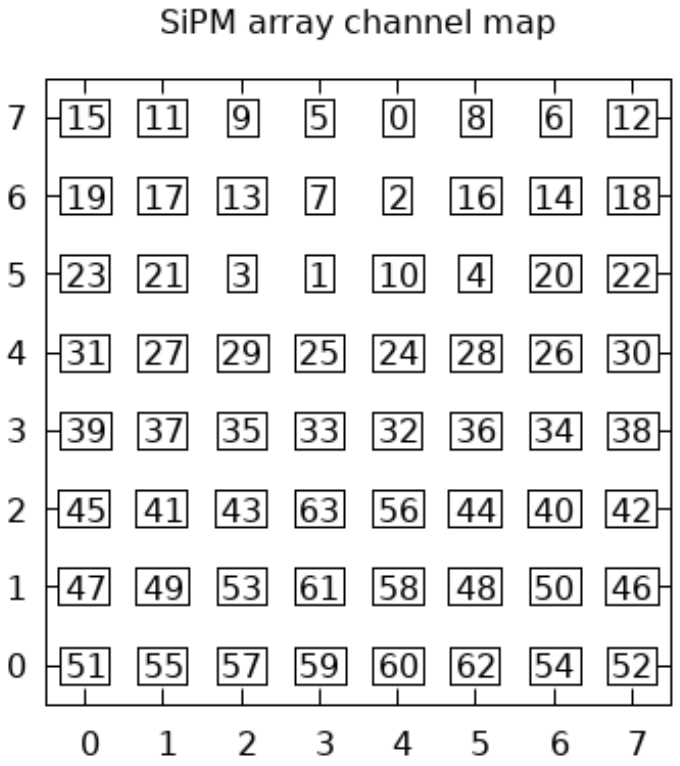
HG/LG Intercalibration

by Jiri Kvasnicka



- simple fit linear function f(x)=a*x+b in the range of [200:2000] (without forcing to go through the pedestal)
- Inter calibration in CAEN DT5202 DAQ seems to be good

CAEN channel mapping to SiPM



Expanding PCB for SiPM arrays

We use 64CH SiPM Hamamatsu S13615 – 1025 (U1)

- Small active footprint about 10 x 10 mm
- For the first test we use a few channels
- Temperature sensor LM35 onboard (U2)