

Task 14.2.2

Test benches for the characterisation of highly granular calorimeter elements with scintillator and SiPM readout

Frank Simon, MPI for Physics

AIDA-2020 WP14 Annual Meeting April 2019



- Goals:
 - Precision test of single cells with a radioactive source (Munich)
 - Mass tests of photon sensors (Heidelberg, as partner of DESY)
 - Large area tests with cosmic ray muons (Mainz)
 - Temperature stabilisation of bias voltage (Prague, Bergen)
- Milestone:
 - MS14.2: M12 (04/2016) - Specification of setup -> **DONE**
- Deliverable:
 - D14.2: M40 (08/2018) - Report on commissioning and usage of setup -> **DONE**

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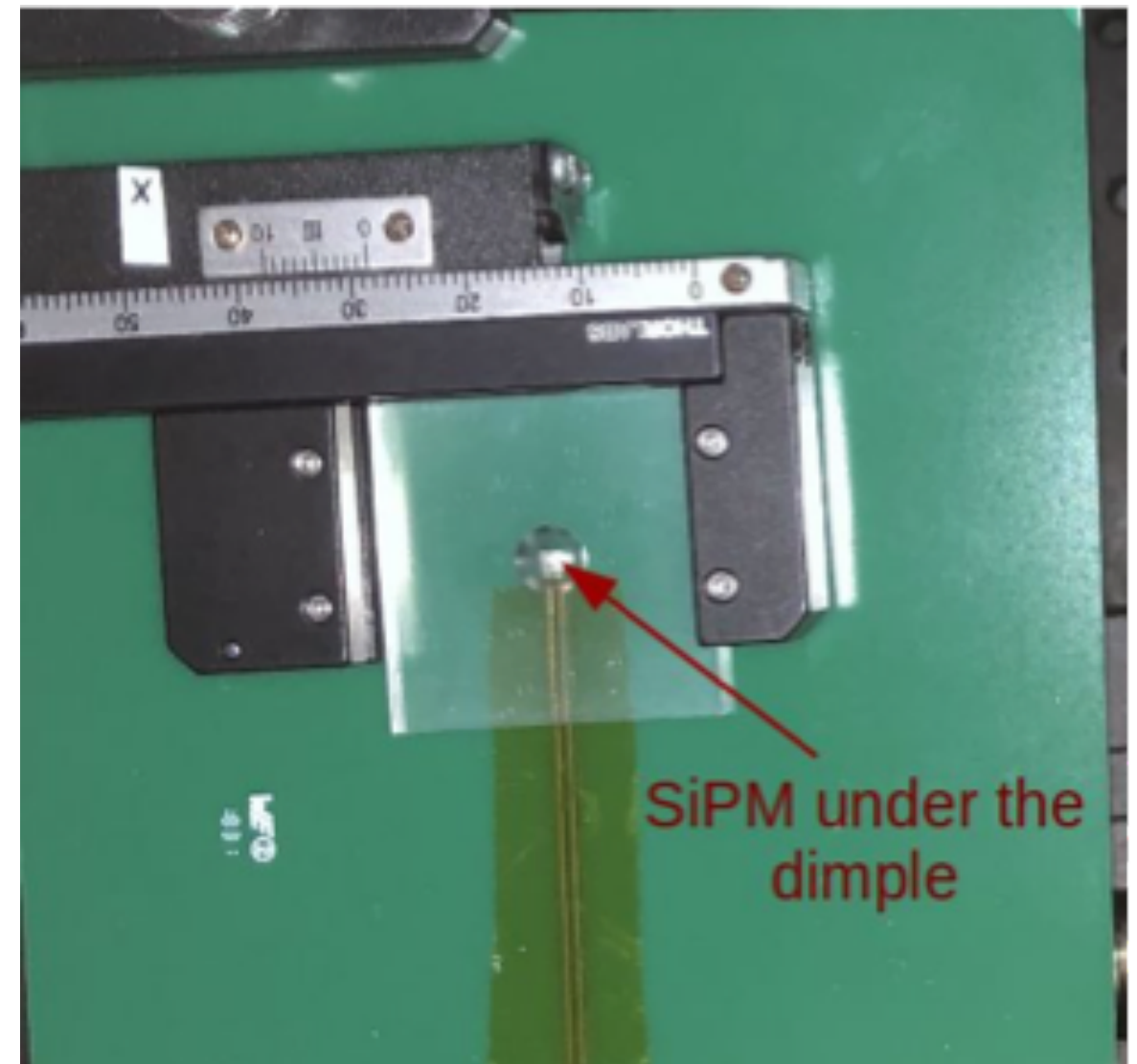
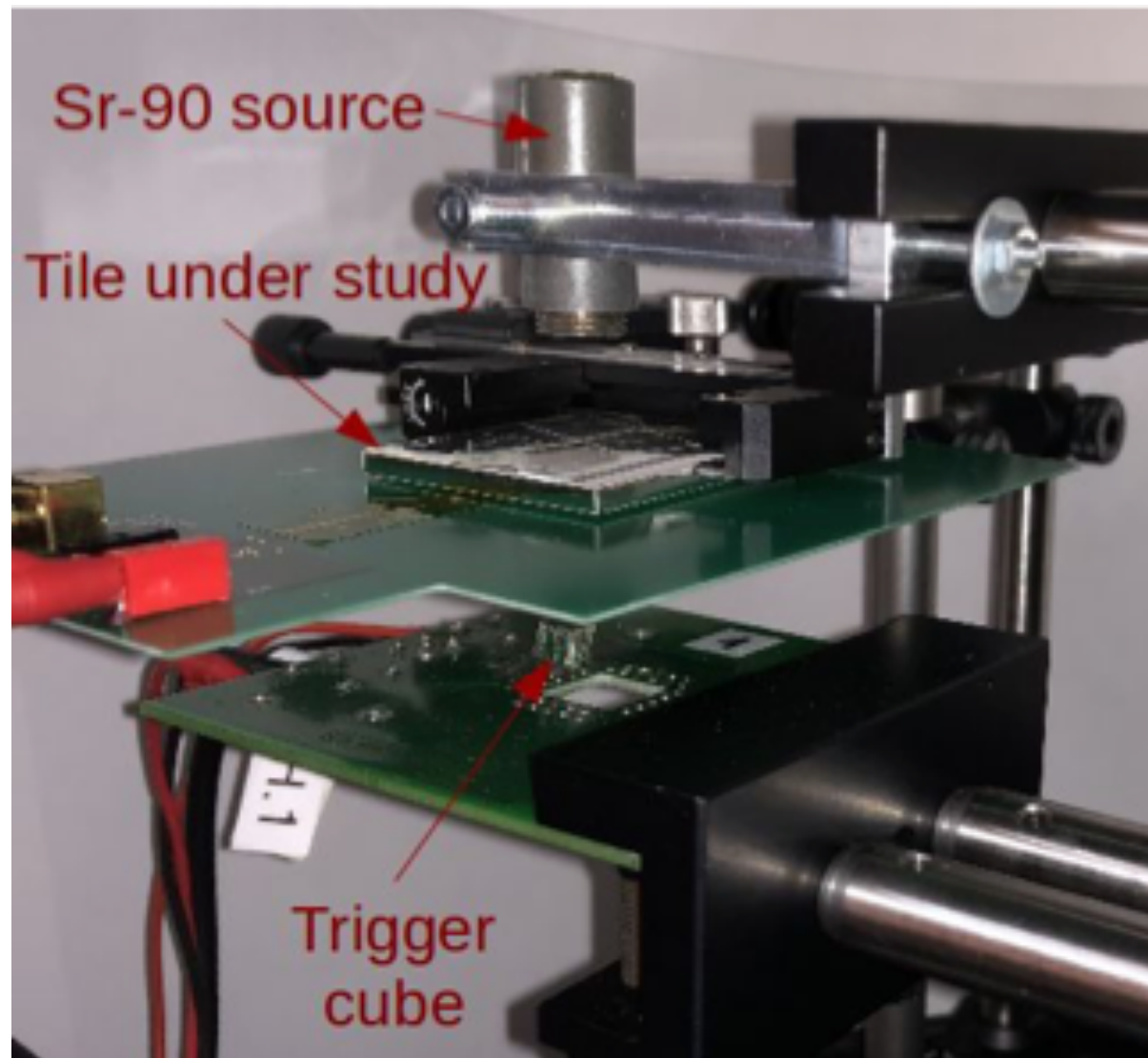
Activities now:

Use of infrastructure, development of new ideas beyond the original scope

MPP Activities

Misalignment in SiPM-on-Tile

- Extended tile scanning setup with precise tile position control and adjustment:
Explore impact of misalignment



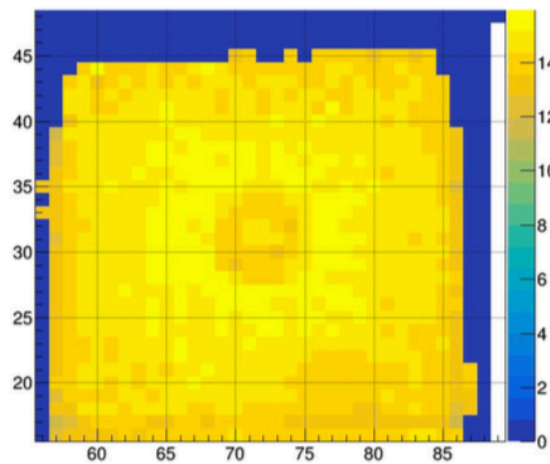
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Misalignment in SiPM-on-Tile

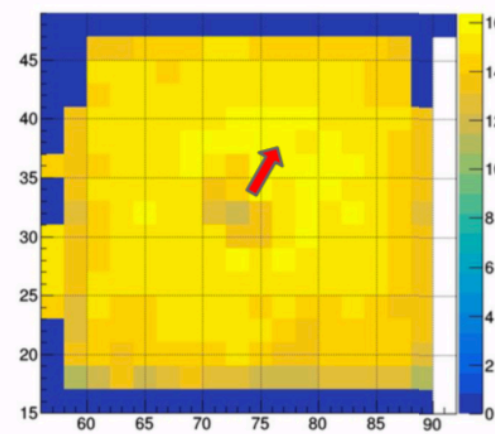
- Extensive studies of different tile geometries and sizes, for varying misalignments

Misalignment ~ 0

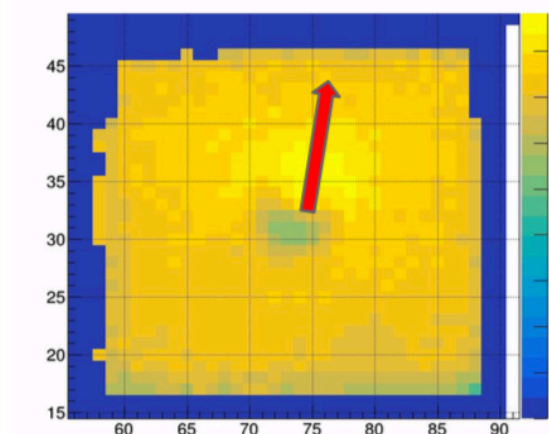
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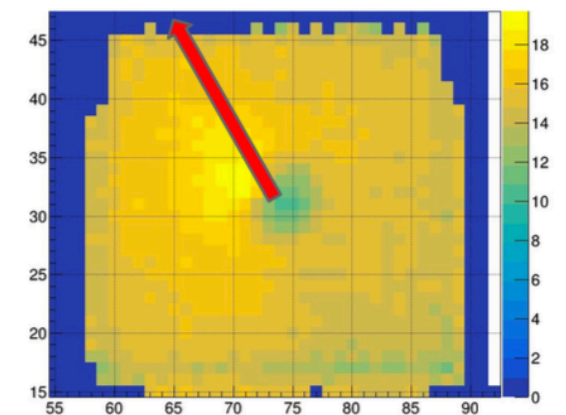
$x=+0.1$ mm, $y=+0.4$ mm



$x=+0.1$ mm, $y=+1.0$ mm



$x=-1.1$ mm, $y=-0.6$ mm



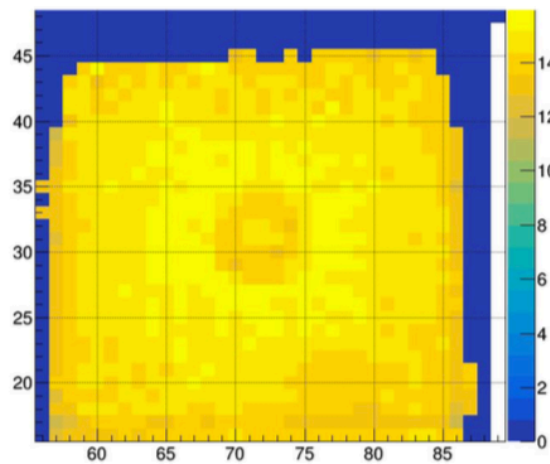
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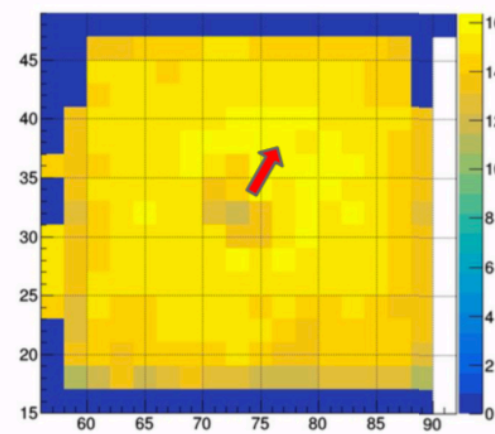
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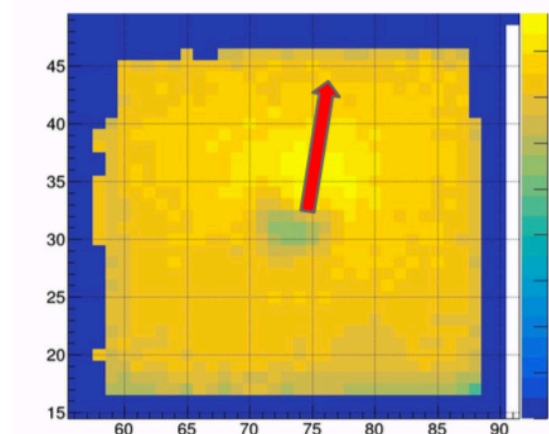
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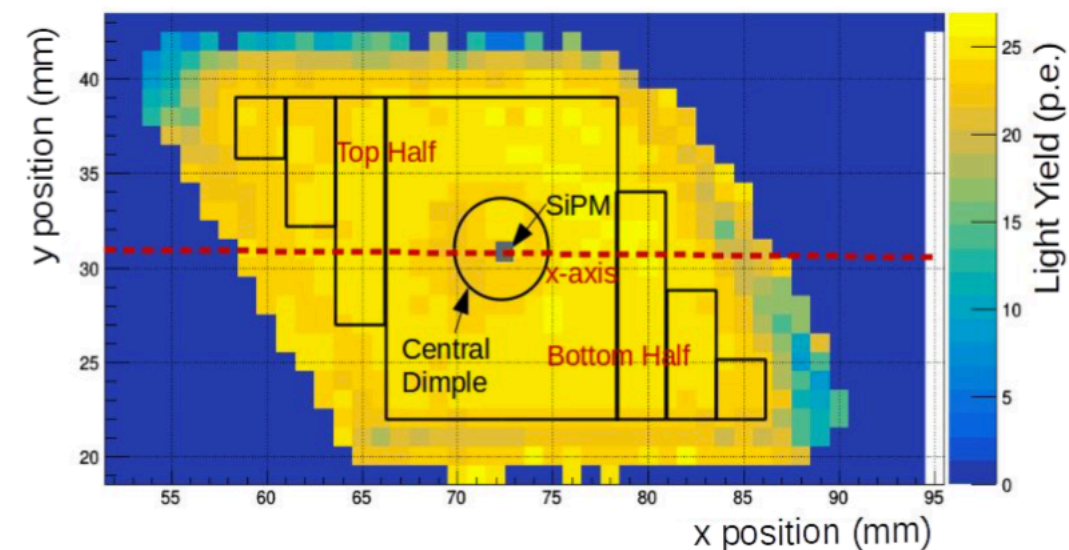
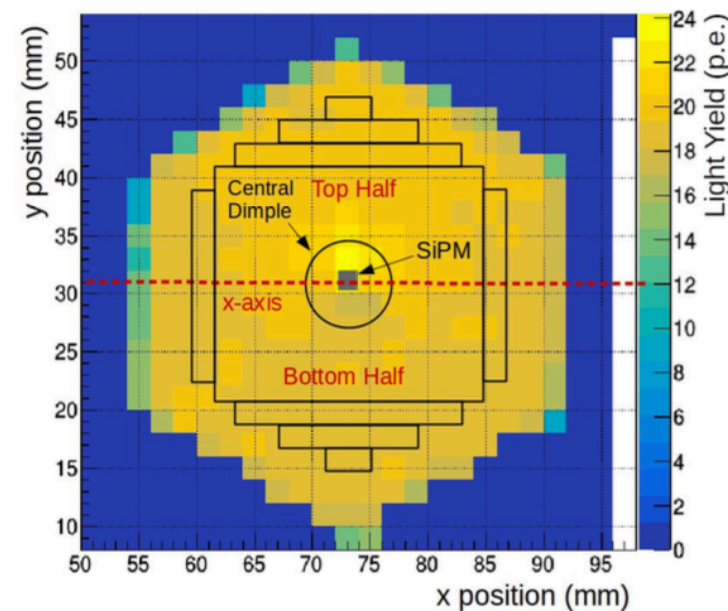
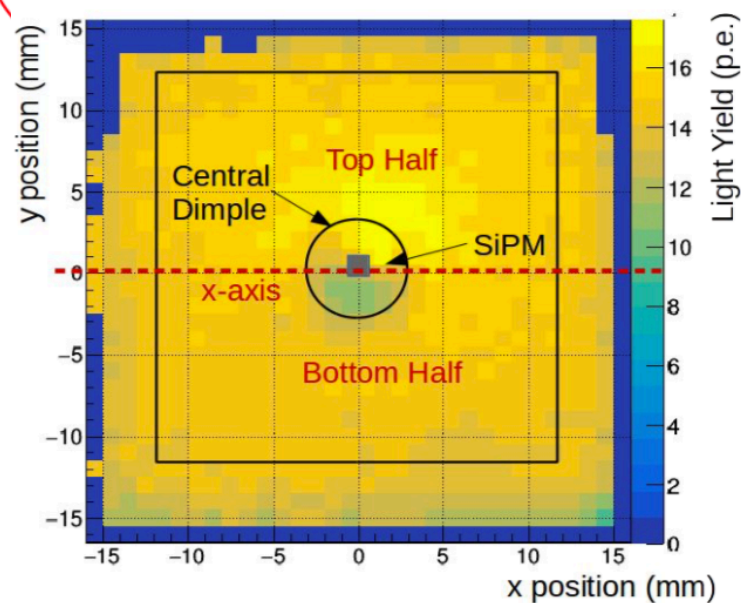
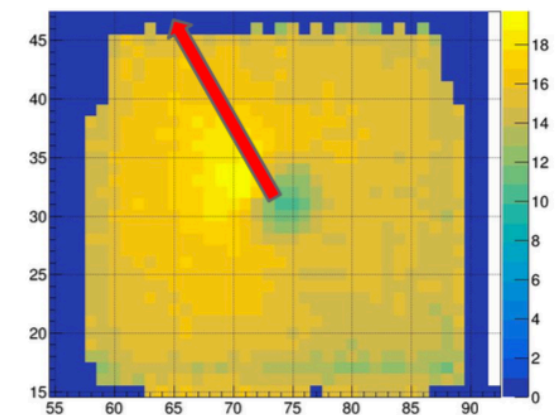
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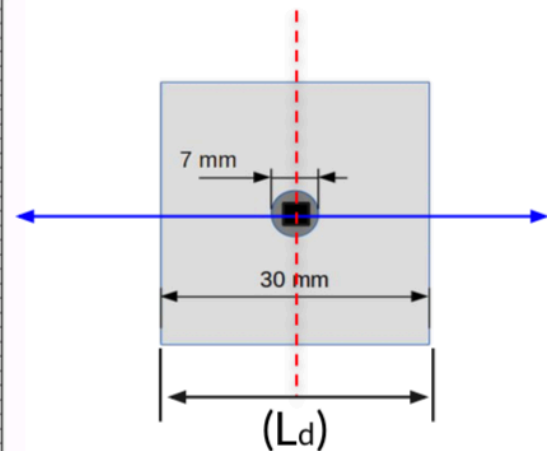
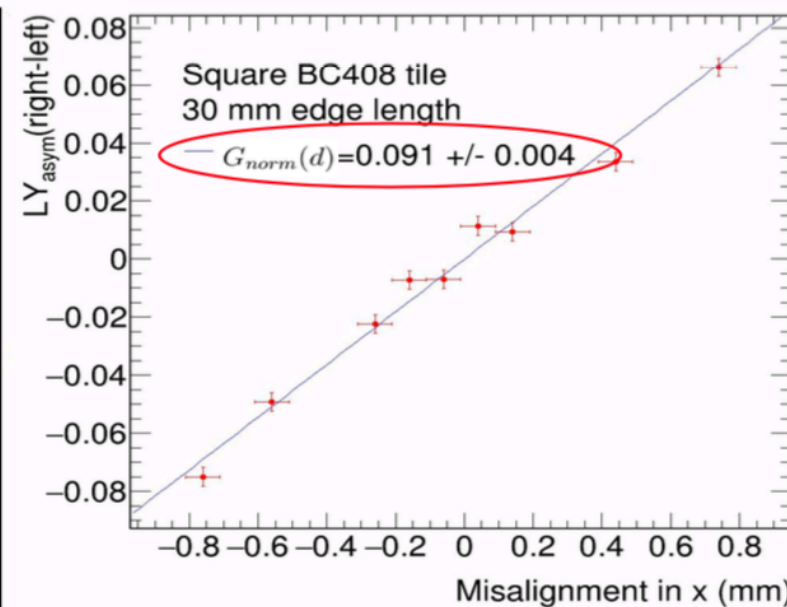
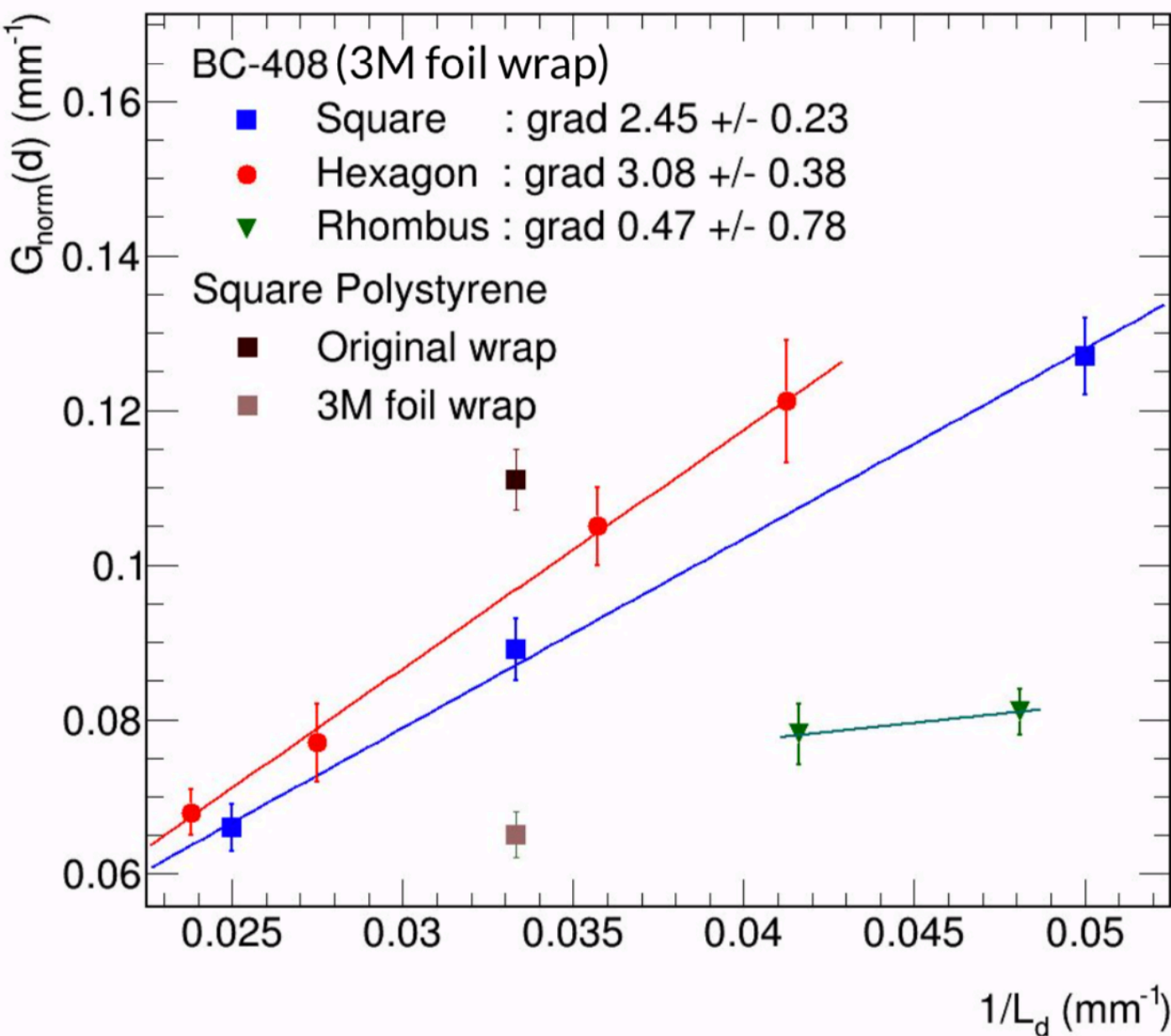


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MPP Activities

Misalignment in SiPM-on-Tile



- Misalignment-induced light yield asymmetry:
 - scales linearly with misalignment
 - scales with tile size
 - depends on material, wrapping, ...

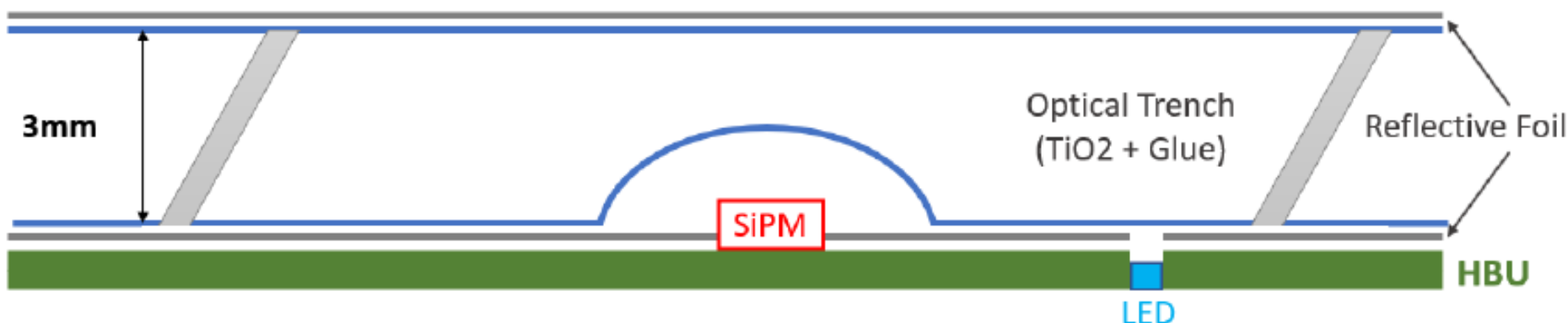
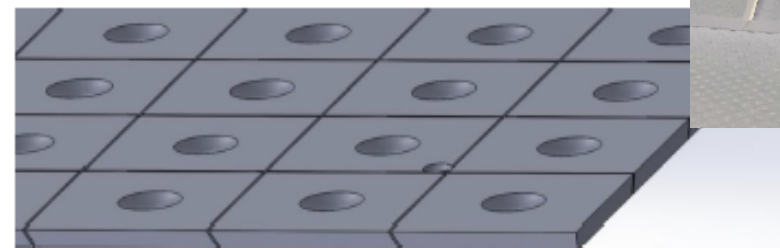
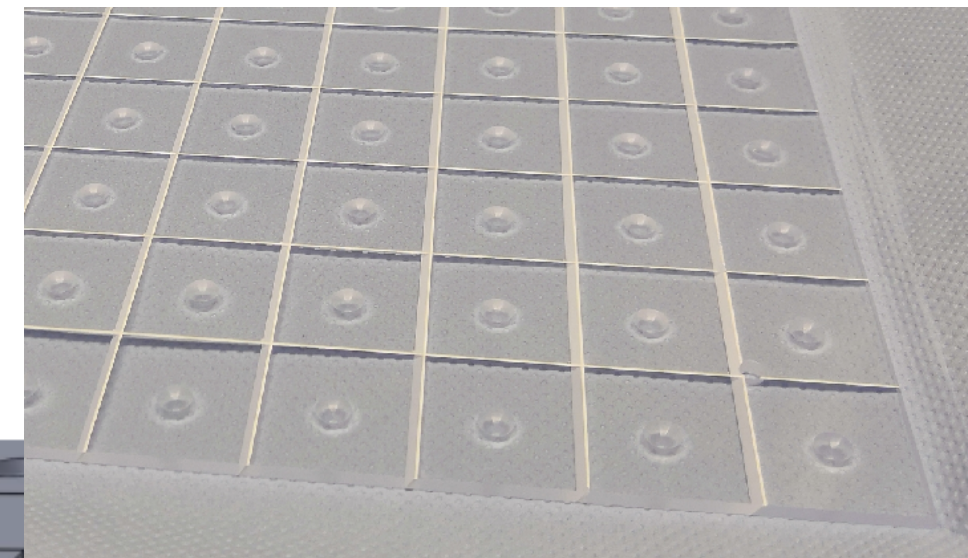
JGU Activities: Using the CR Test Stand

- 12 Scintillators with PMT readout for each top and bottom layer
- Up to 10 boards could be aligned in stack structure
- An air circulation system within the box is installed
- First 4 HBUs measured with 2 boards in parallel
- All other HBUs are measured with 4 boards in parallel
- Successful and consistent calibration of AHCAL Technological Prototype HBUs
- Currently used for optimization of Mainz Megatile Prototypes



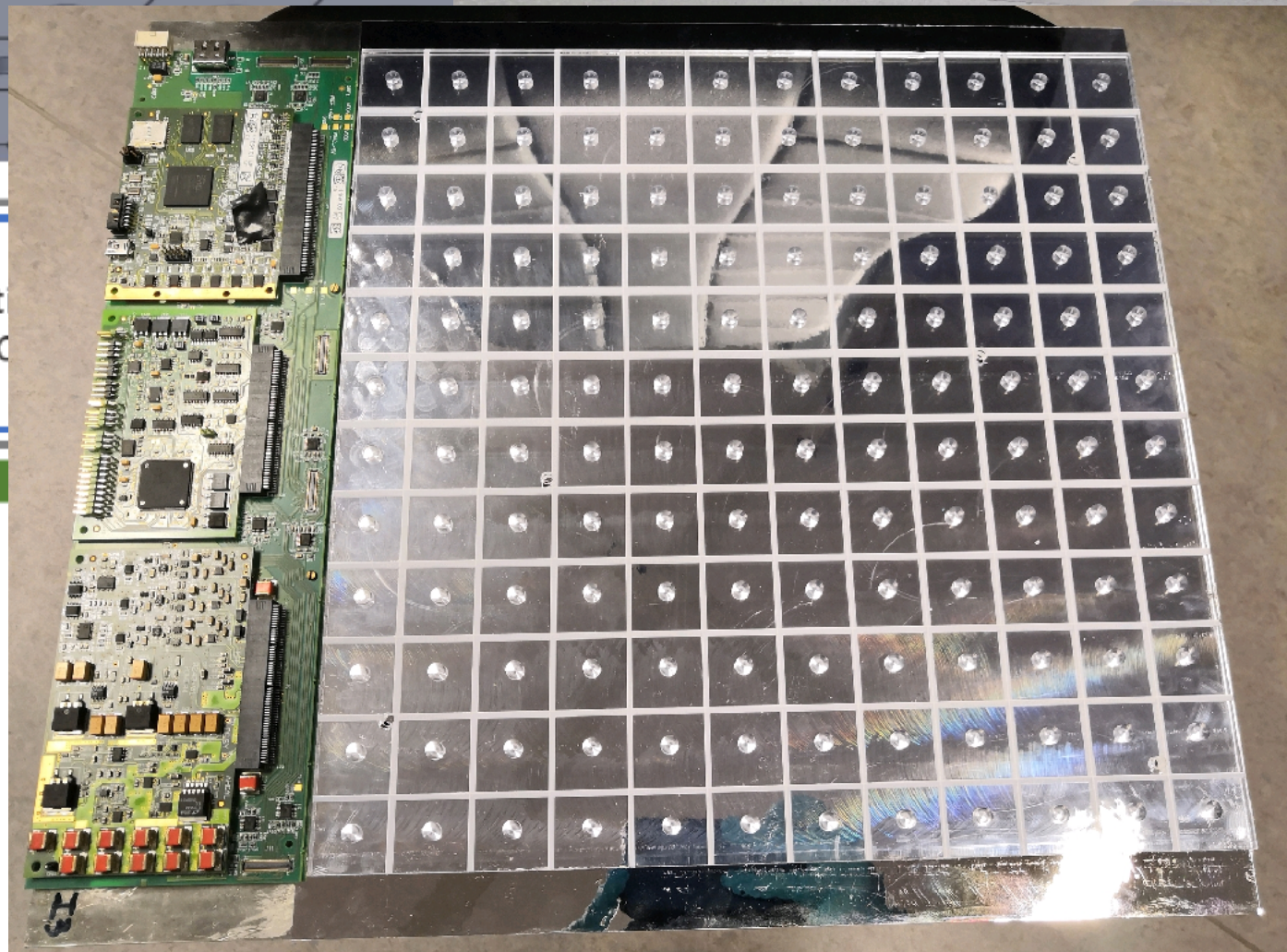
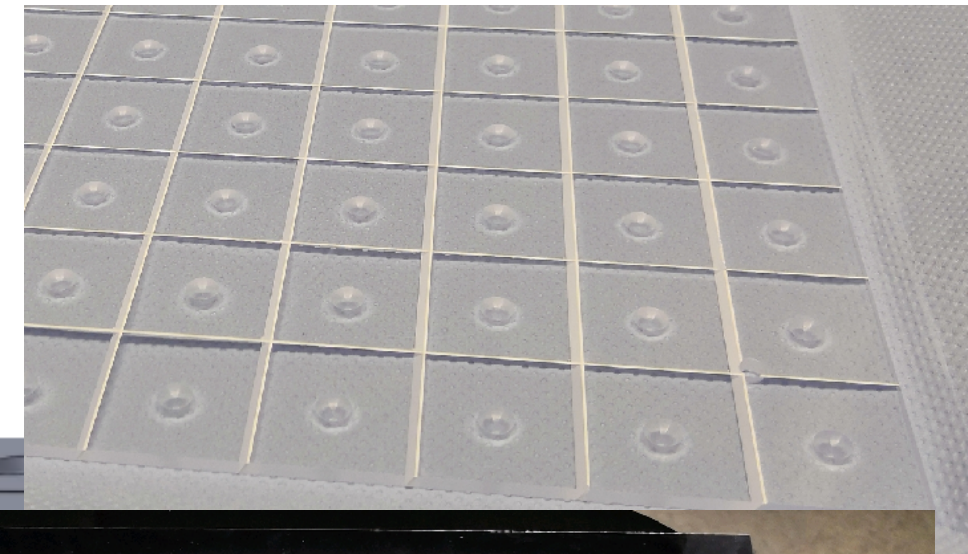
JGU Activities: The Megatile Concept

- Optically isolated channels in large scintillator plate
- Setup:
 - Scintillator covered by reflective foil at top and bottom, additional to total reflection
 - Channels are separated by trenches filled with reflective glue
 - Dimple maximizes light reaching SiPM
- Structure optimized by Geant4 simulation
 - MIP response, cell-to-cell crosstalk

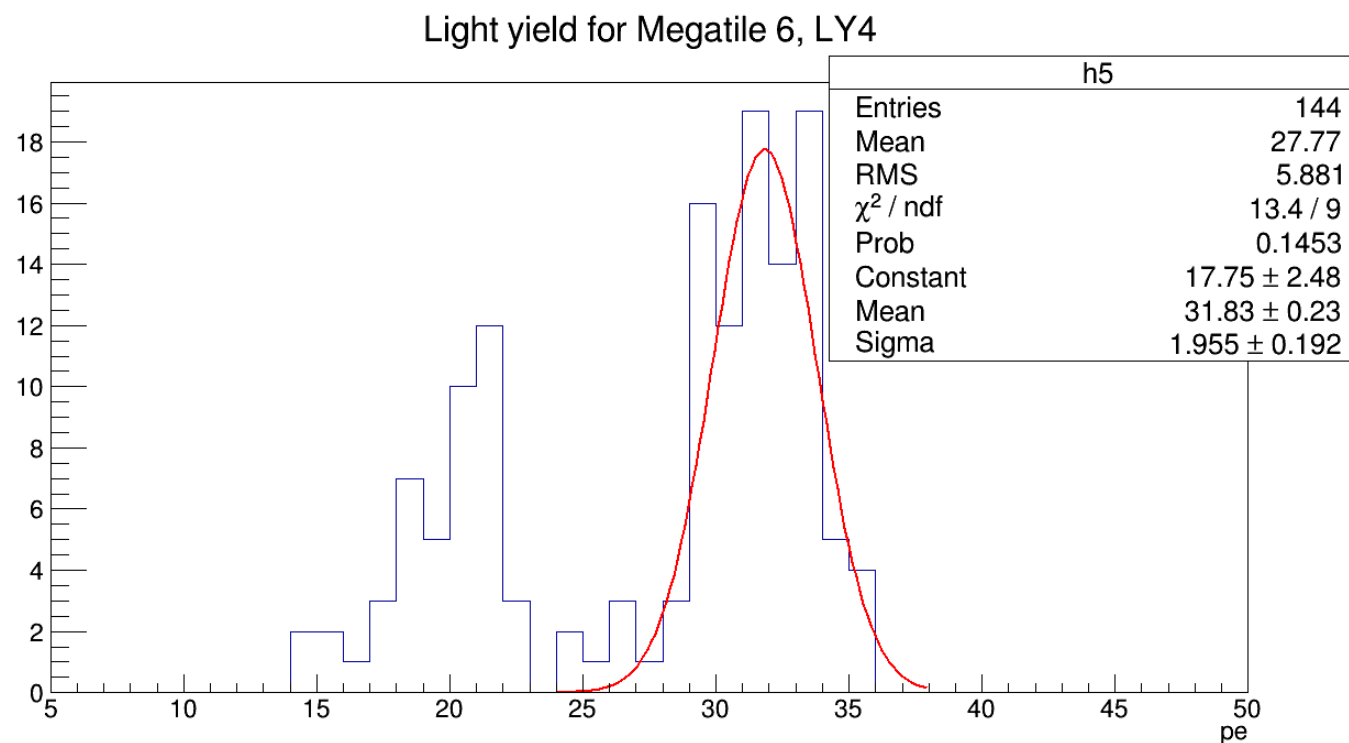


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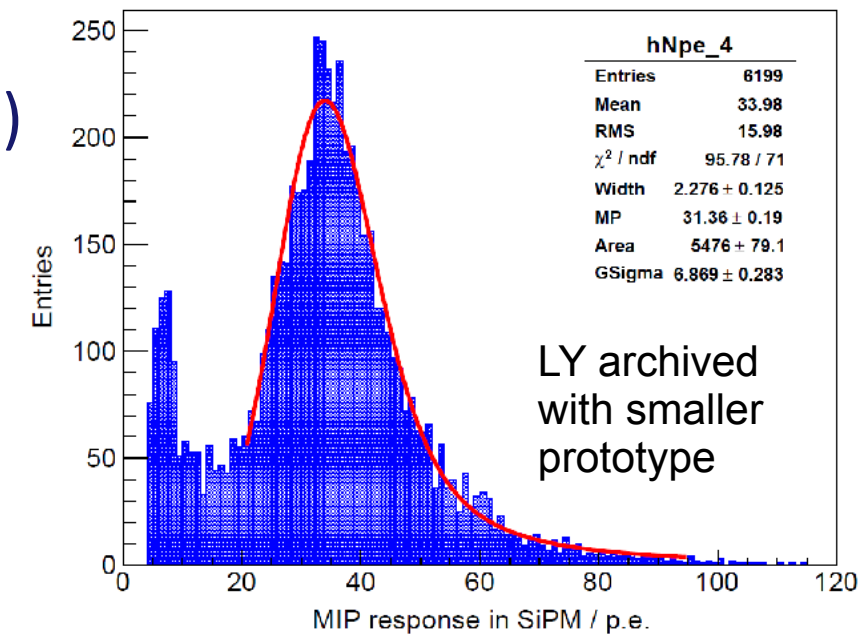
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- Excellent light yield performance for Megatile 6
 - Light yield meets expectations from earlier studies (~ 31 p.e)
 - Glue mixture easy to handle
 - Large difference between edge and central channels

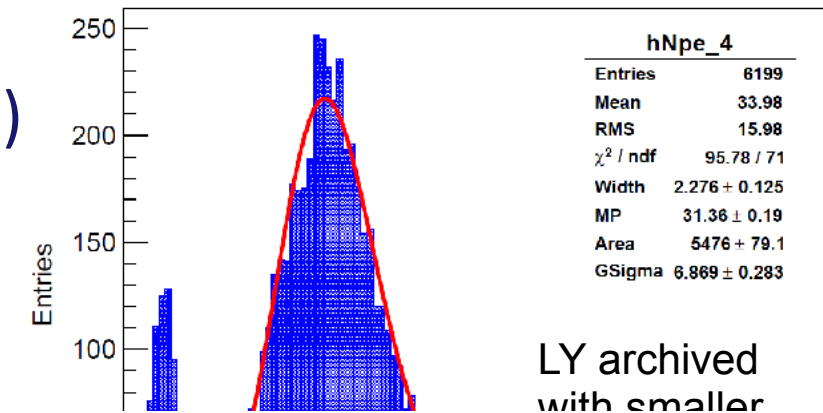


MIP Response in Cosmics Data at Channel 28

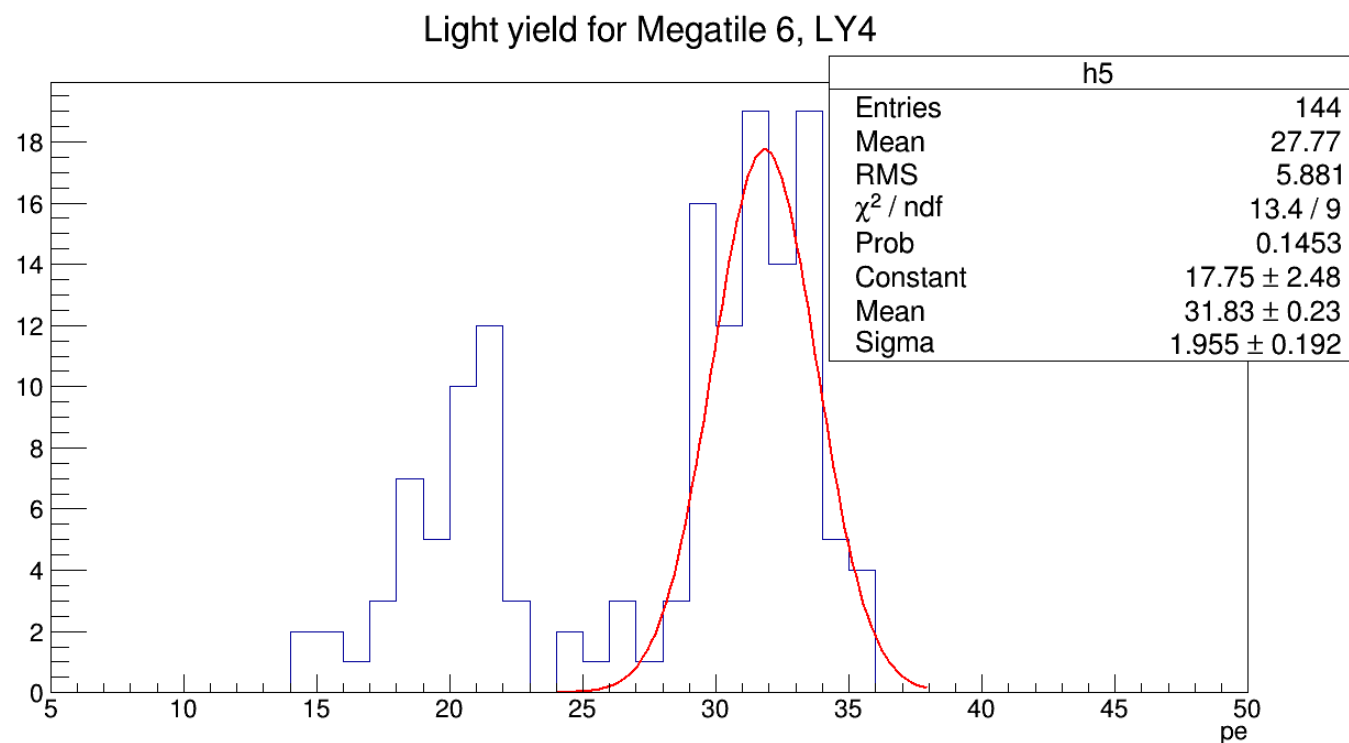


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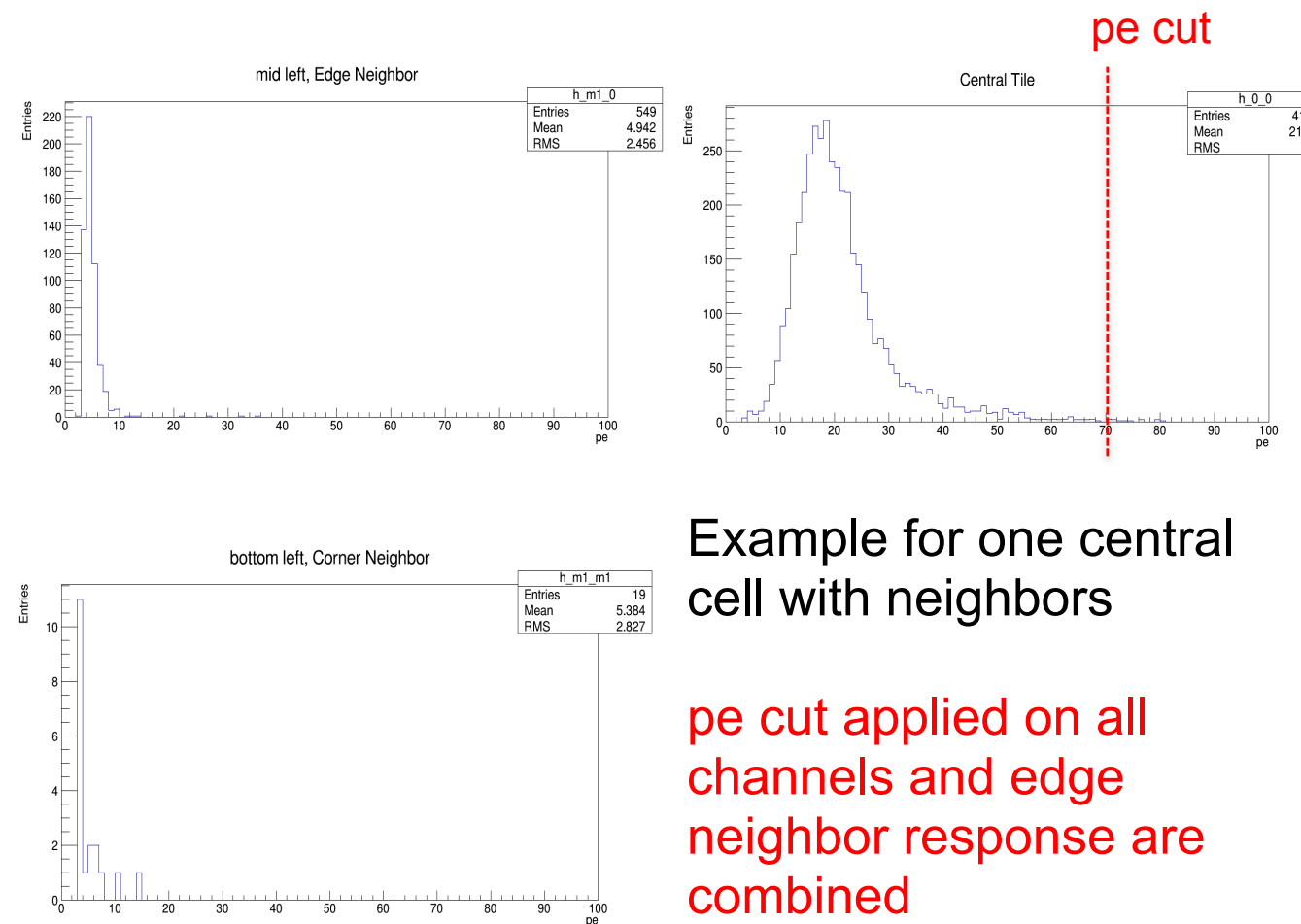
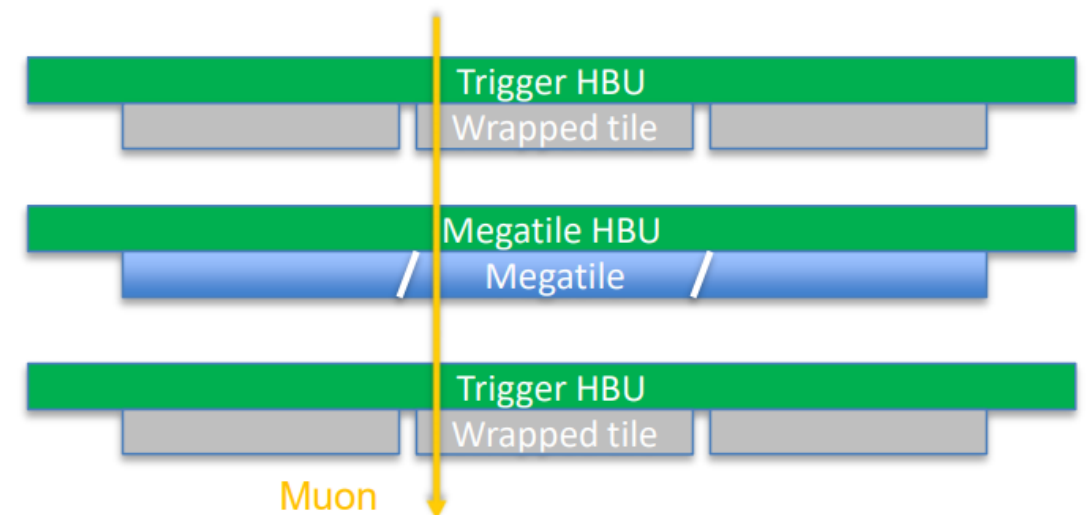


Light yield Map Megatile 6: unpolished surface and dimples, LY4



JGU Activities: Determining Cross Talk

- Estimation of upper limit for crosstalk with cosmic measurement
- Working principle:
 - Use single wrapped tiles to track path of muon in Megatile
 - Calculation of CT for central channel:
 - Hit in same channel in first and third layer
 - Only one hit in first and third layer
 - $CT = \text{value in neighbor channels} / \text{value in central channel}$
- Challenge:
 - Measure CT at %-level, MIP signal only 20 pe
 - Most CT entries below trigger threshold
 - Still possible to extrapolate upper CT limit!
 - Cut on pe value of central channel
 - Problem: low statistics caused by pe cut

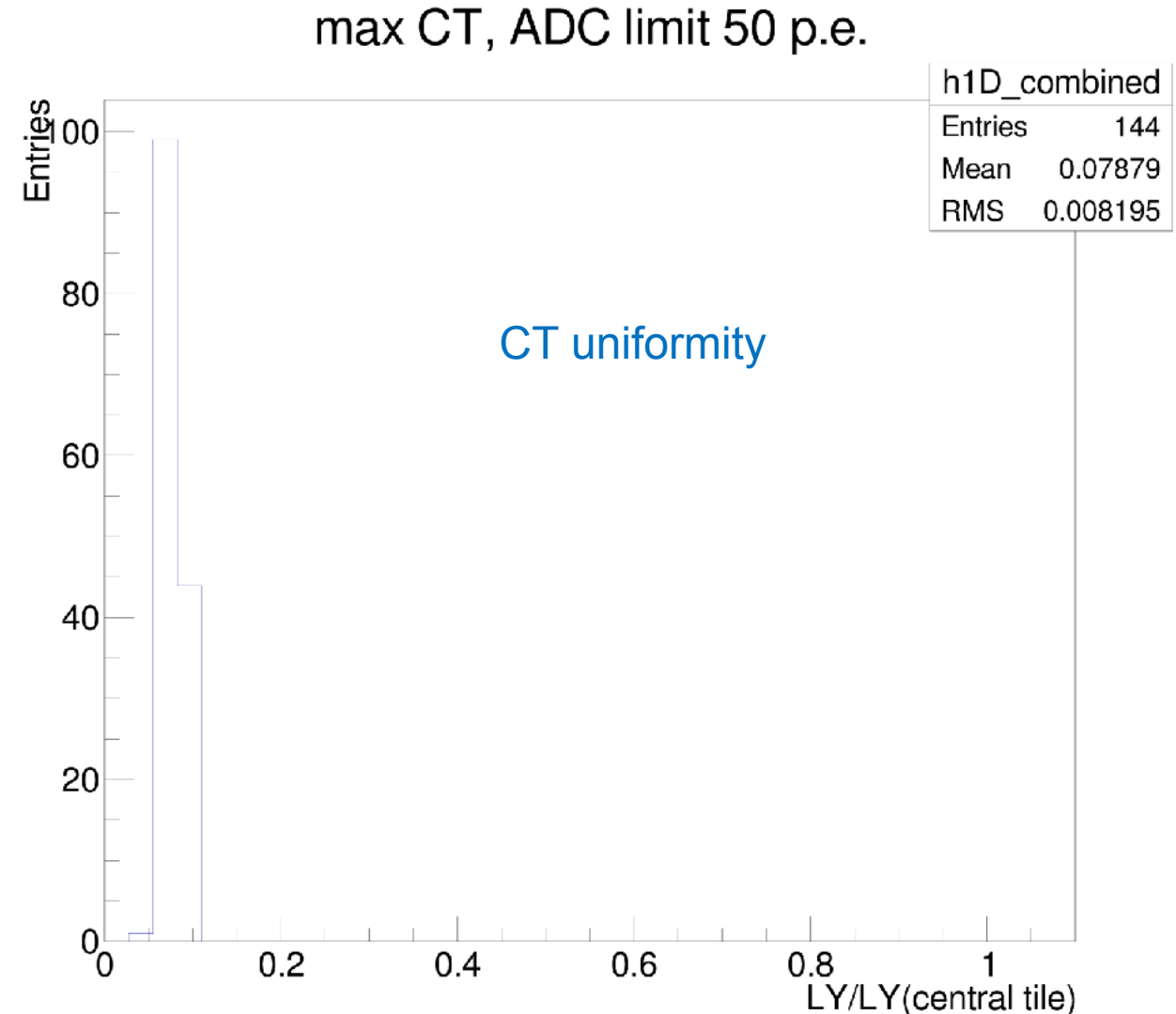
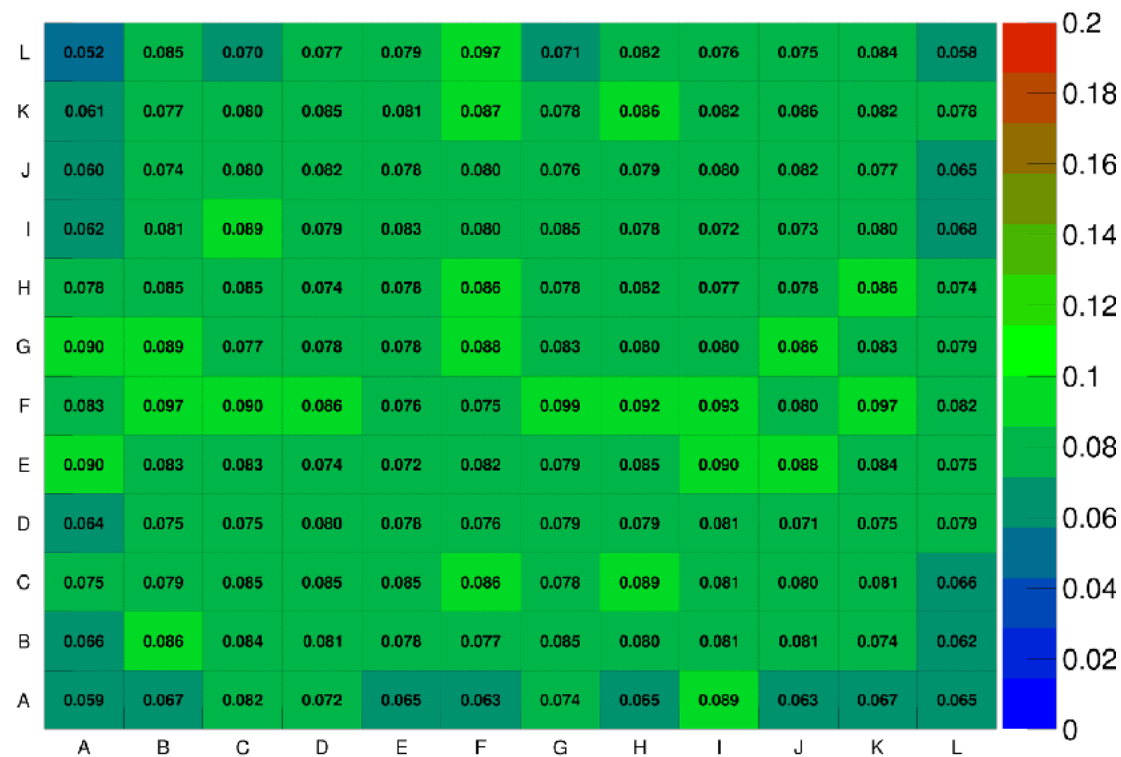


Example for one central cell with neighbors

pe cut applied on all channels and edge neighbor response are combined

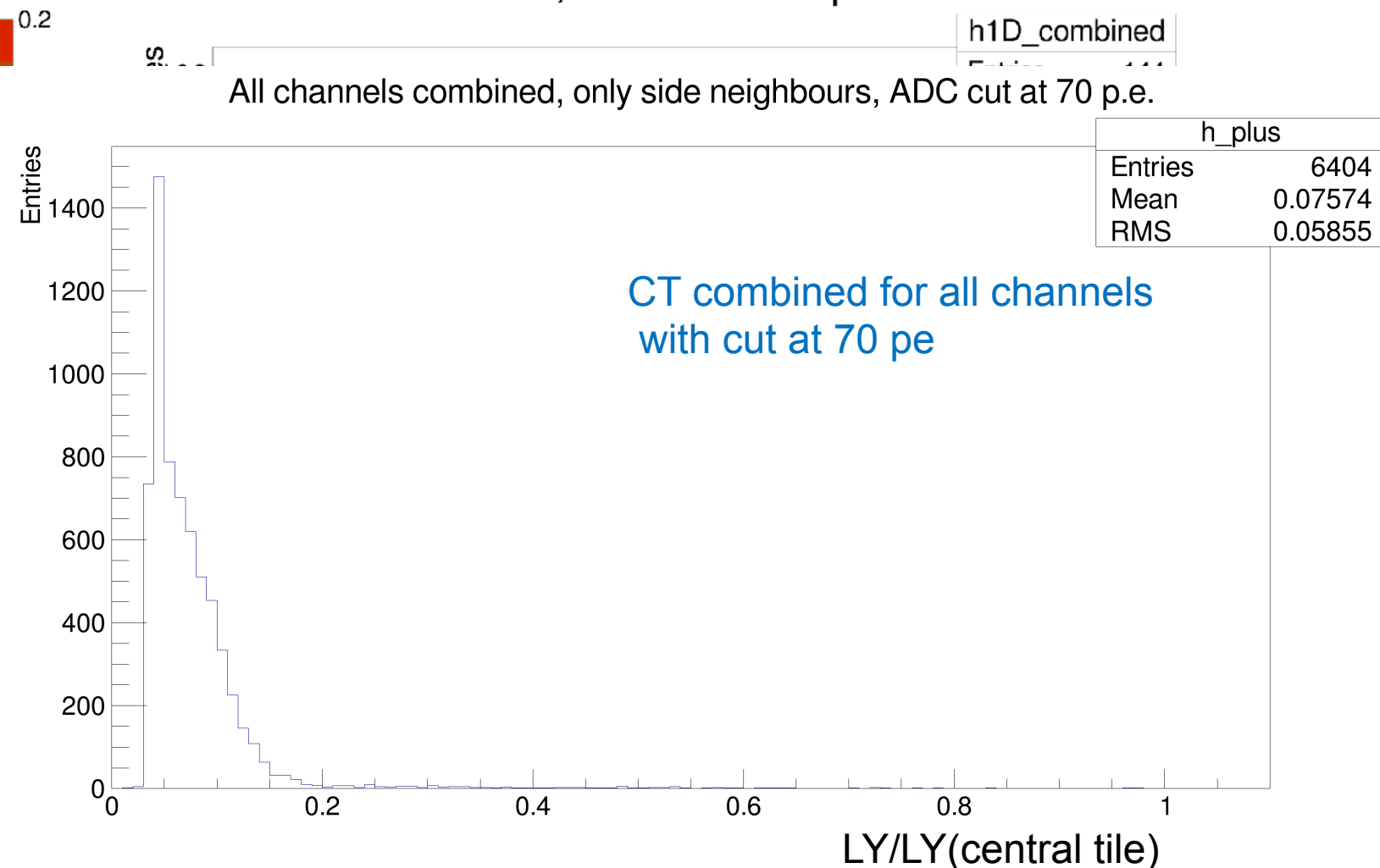
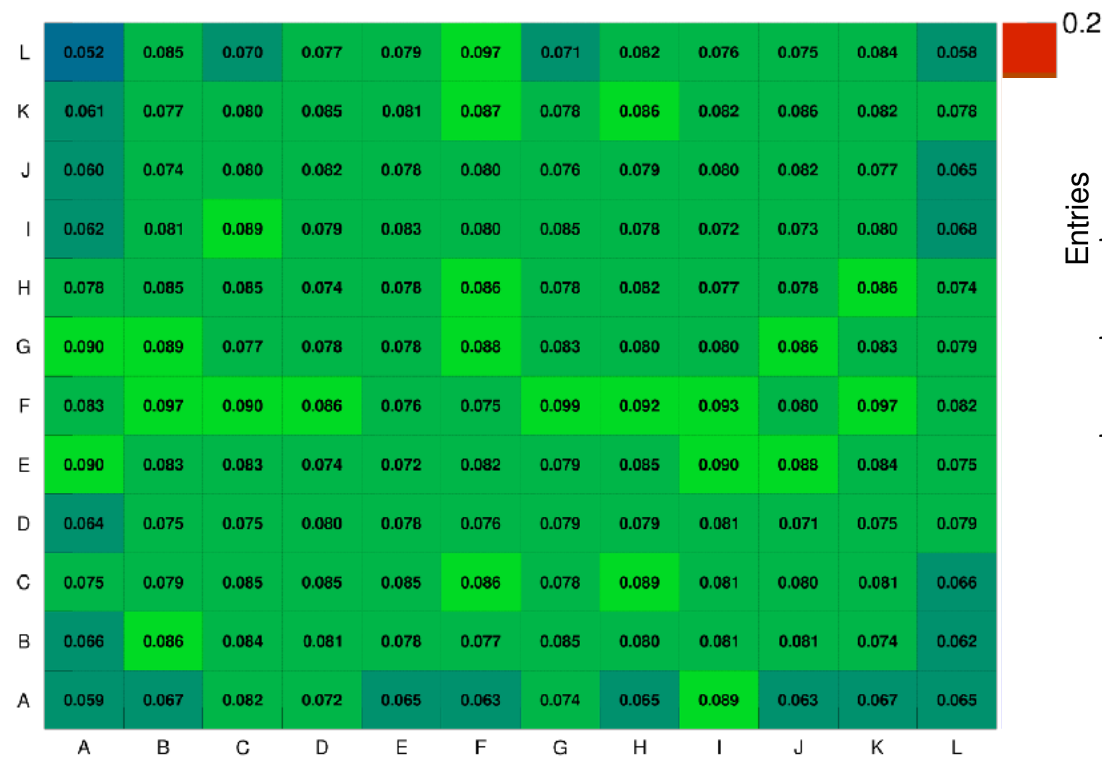
JGU Activities: Megatile Crosstalk Uniformity

- Maximal CT value successfully limited for each channel individually (considering only side neighbors)
 - Upper limit seems very uniform
 - In general max. CT seems to fit expectations with $< 8\%$
max CT, ADC limit 50 p.e.

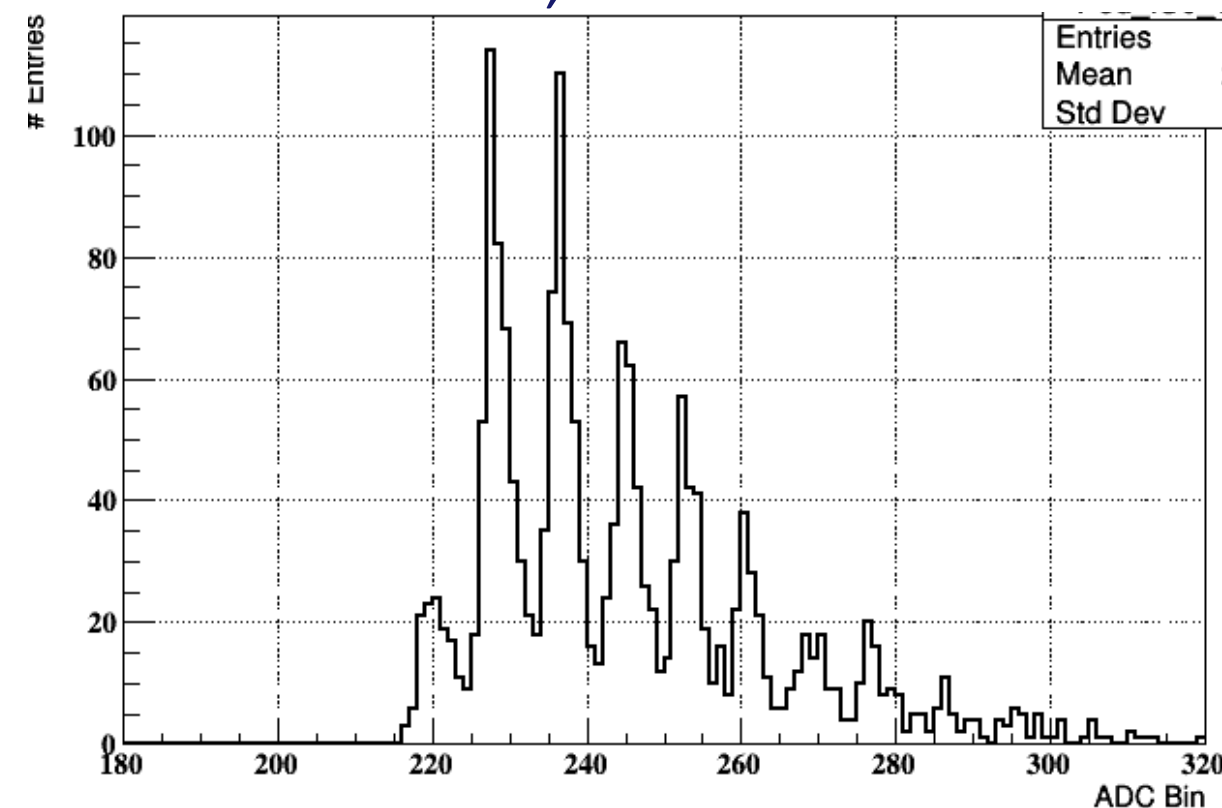
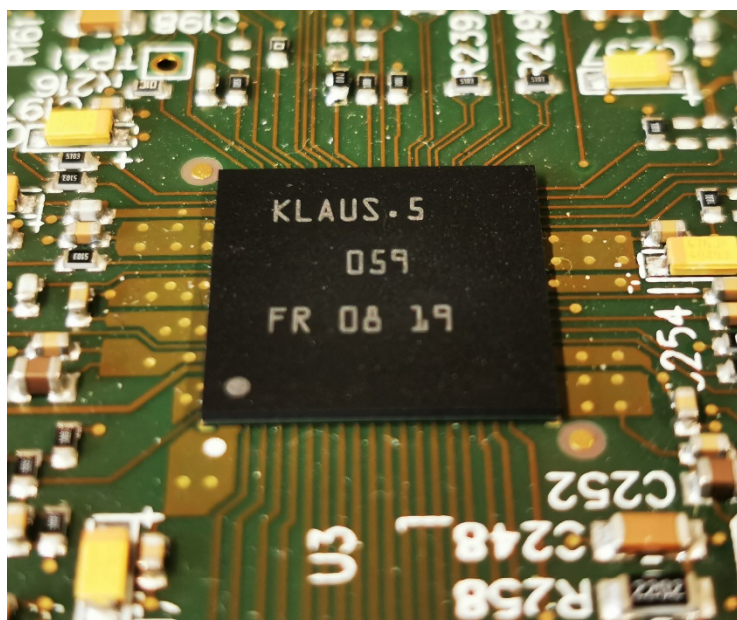


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- Progress on KLauS-6 ASIC
 - Low-power SiPM charge and timing readout ASIC for AHCAL, alternative to SPIROC ASIC
 - 200ps binsize channel-wise TDC implemented
 - Power-pulsing for the whole chip including the digital part
 - Expect new version back from fabrication in ~ 4 months
- Promising first tests with previous version using CALICE AHCAL HBU, HPK S14160-1315PS



Bergen / Prague Wrap-up of Activities

- The Bergen/Prague collaboration completed the task in WP 14.2 conducting a study on gain stabilization of SiPM
 - G. Eigen, A. Træet, J. Zalieckas (Bergen)
 - J. Cvach, J. Kvasnicka, I. Polak (FZU Prague)
- The goal was to show that several SiPM can be stabilized with one dV/dT setting
- Tested 30 SiPMs, 18 from Hamamatsu, 8 from KETEK and 4 from CPTA
- The results were published in JINST last year, JINST 14, no.5, P05006 (2019)
 - All Hamamatsu and all CPTA SiPMs could be stabilized
 - None of the KETEK SiPMs could be stabilized

- Task 14.2.2 has completed its Milestone and Deliverable - the infrastructure is now being used, already profiting from further extensions and improvements
- Two examples:
 - Detailed study of impact of misalignments on the response of scintillator tiles based on the SiPM-on-tile concept in Munich
 - Development of Megatiles at Mainz
- CALICE - inspired activities continue in Heidelberg - with preparations of active elements using a new readout ASIC
- Activities on gain stabilization of SiPMs concluded in Bergen and Prague