Results of the Megatile prototype for the CALICE AHCAL

Anna Rosmanitz

On behalf of the JGU team:
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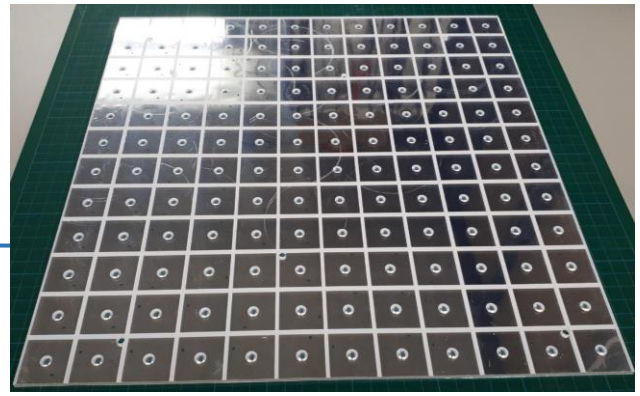
Including the PRISMA detector lab team:
Peter Bernhard, Anastasia Mpoukouvalas, Quirin Weitzel

Calice Collaboration Meeting

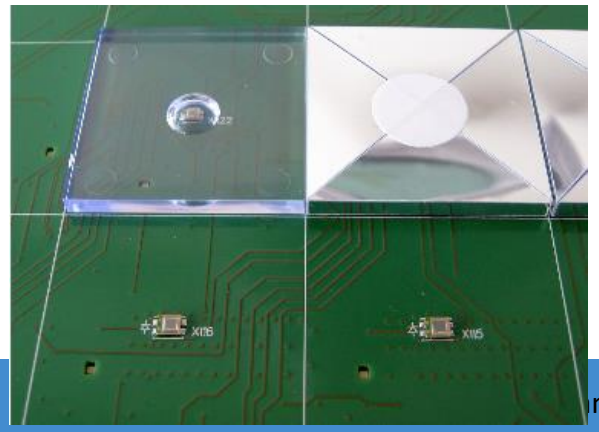
30.03.2023

Reminder: AHCAL Designs



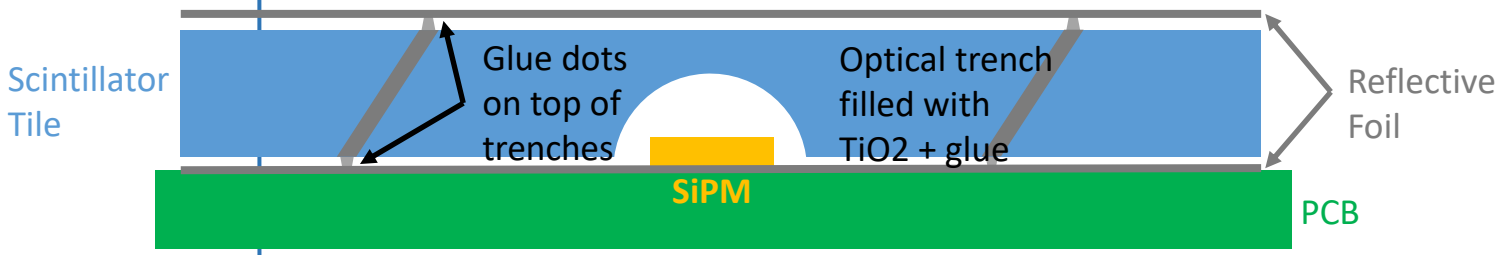
Single Tile Design

- Scintillator tiles individually wrapped in reflective foil
- Glued to board one by one
- Pro: Light tighness
- Con: High object count; dead area between tiles



Megatile Design

- Large scintillator plate with optically separated trenches filled with reflective TiO2
- Plate wrapped in reflective foil
- Pro: Easier assembly; No dead areas
- Con: Not fully light tight



Megatile Under Test

- Several versions with continuous improvement
- Continuously tested in cosmic test stand at Mainz detector lab

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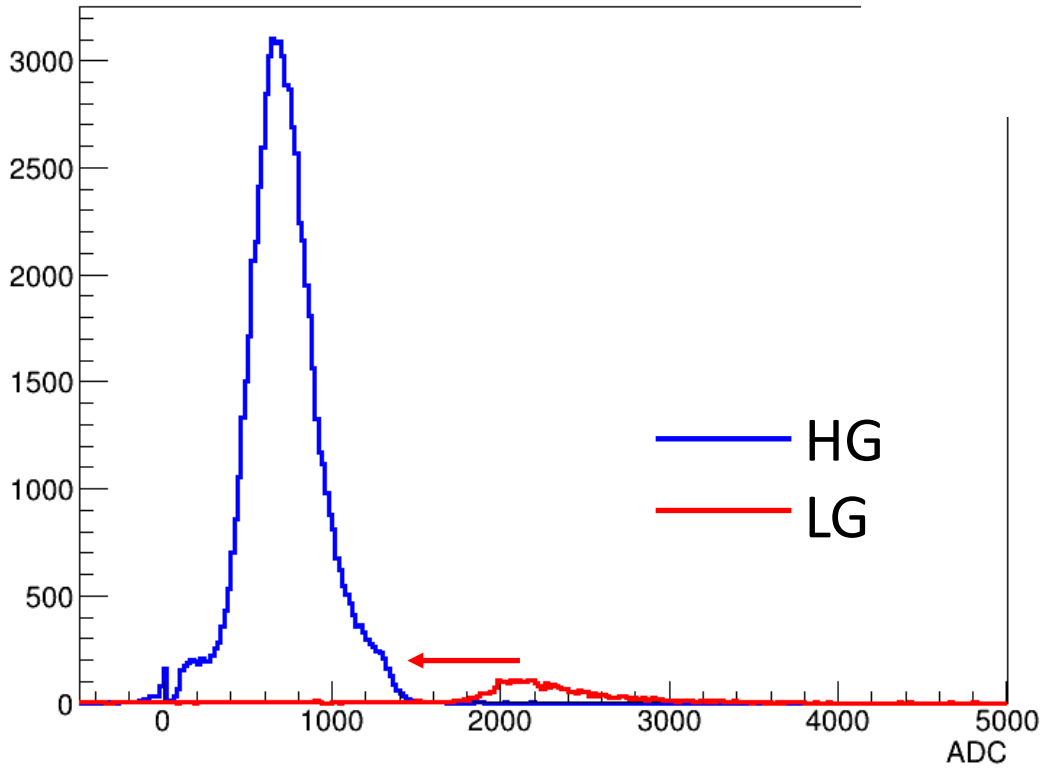
- Several versions with continuous improvement
- Continuously tested in cosmic test stand at Mainz detector lab
- 5 test beams at DESY II + one at CERN
- Setup for following analysis
  - Megatile (newest version)
    + 3 single tile layers
    + beam telescope in front
  - Electrons at 3 and 5 GeV

The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF).

Light Yield: HG/LG Intercalibration

- Problem: Missing calibration data for HG/LG intercalibration
- Shift LG into HG distribution stepwise
- Landau-Gaussian Fit
- Optimal shift: Minimise χ^2



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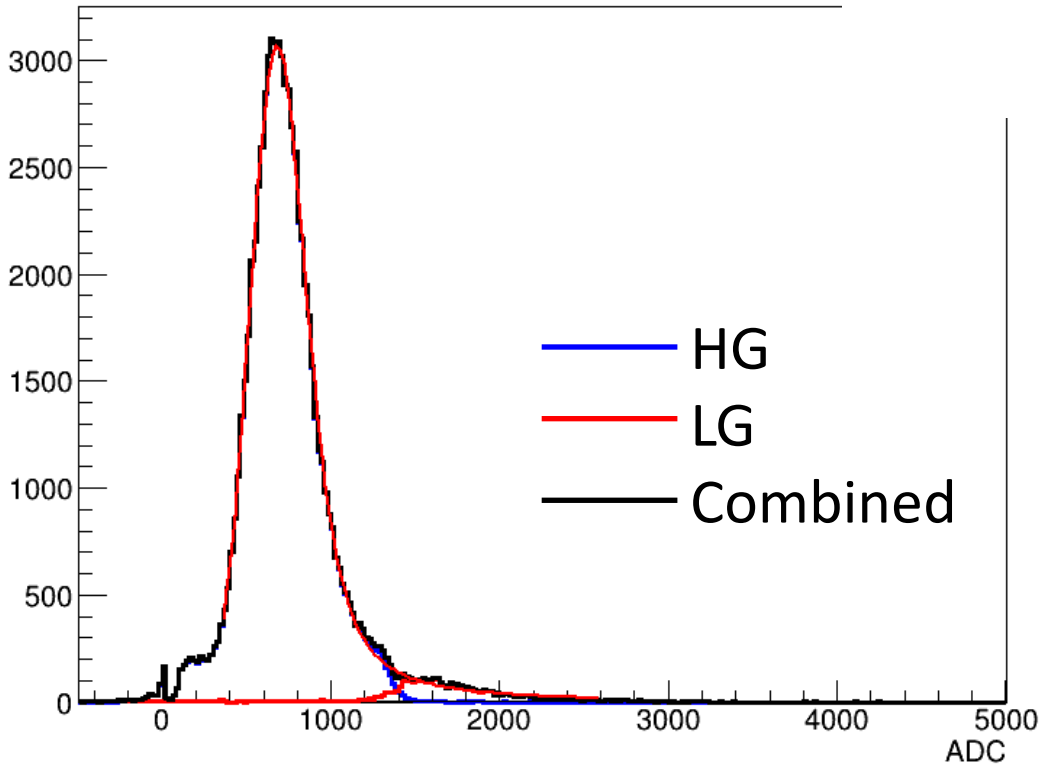
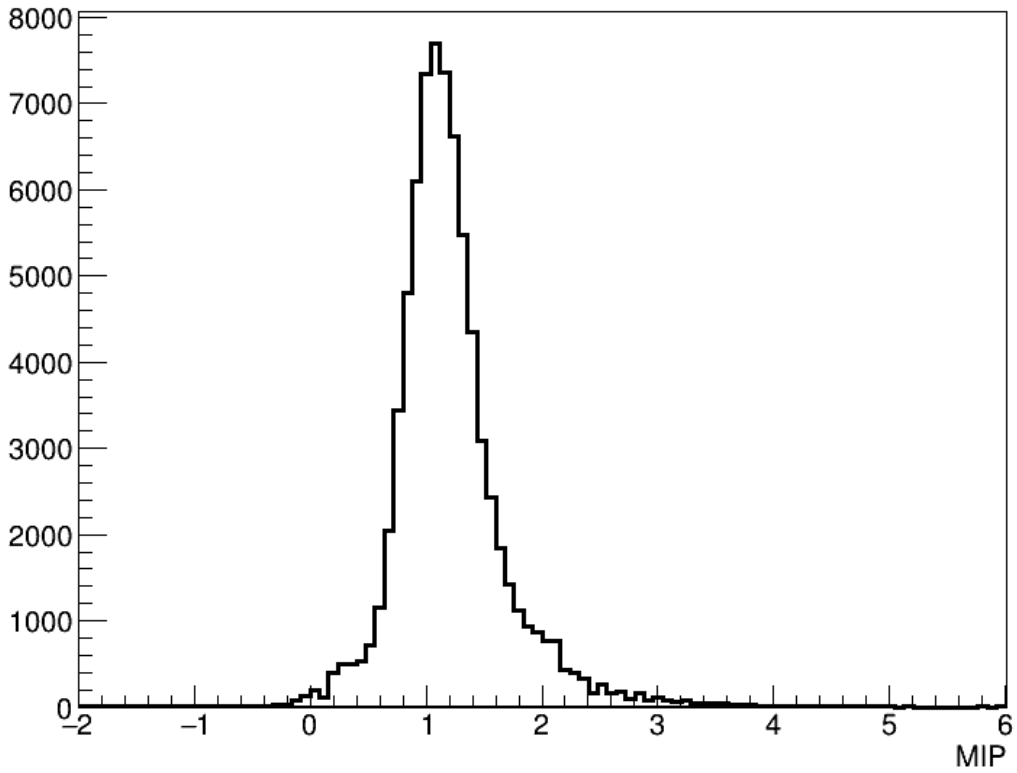


Light Yield: HG/LG Intercalibration

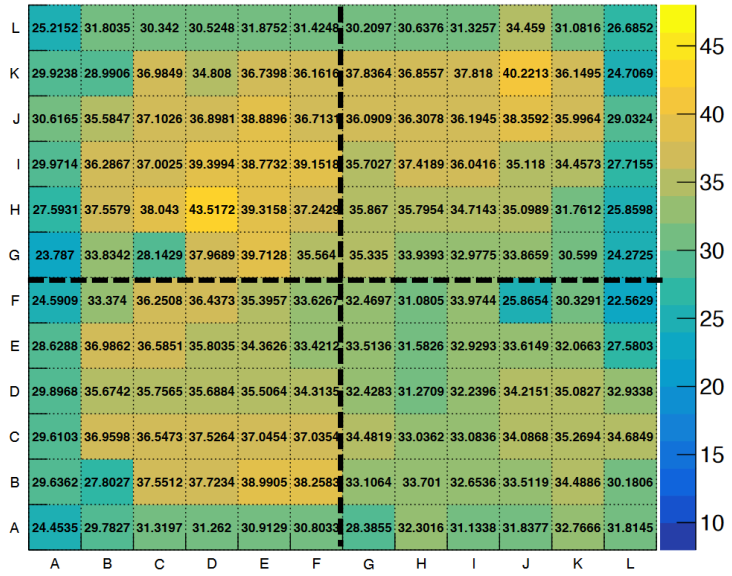
- Problem: Missing calibration data for HG/LG intercalibration
- Shift LG into HG distribution stepwise
- Landau-Gaussian Fit
- Optimal shift: Minimise χ^2
- Smooth distribution
- After calibration: MIP signal peaks at 1



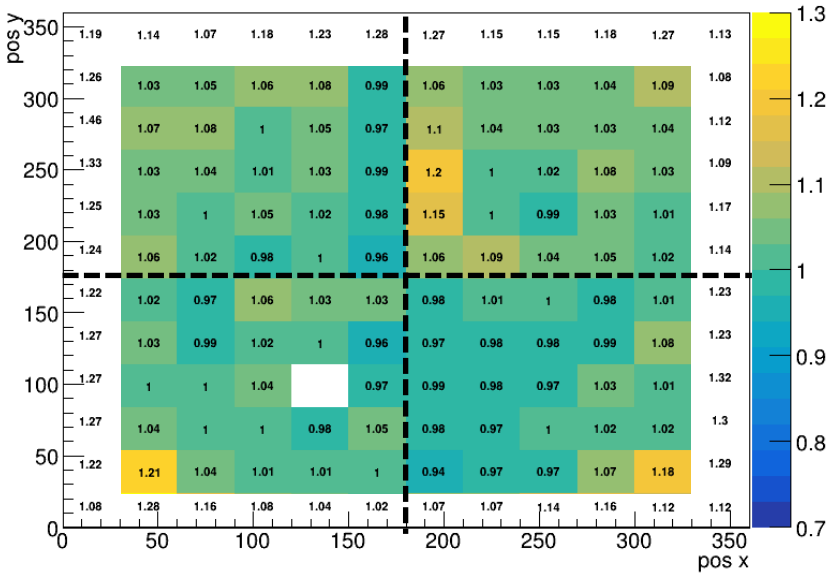
Light Yield Results

- LY in test stand very uniform
- Comparison with test beam (data taken 1 week apart):
  - Good compatibility in center
  - LY in edge channels lower in TB: Mostly due to cassette

LY in test stand

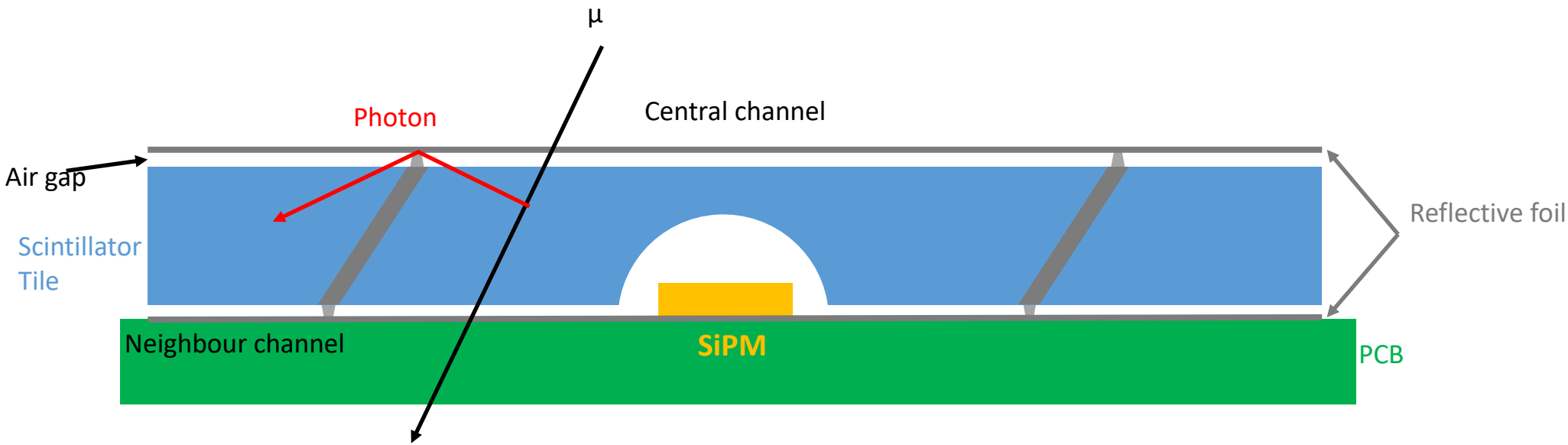


Ratio (LY test stand (27.08.2021)/LY TB)



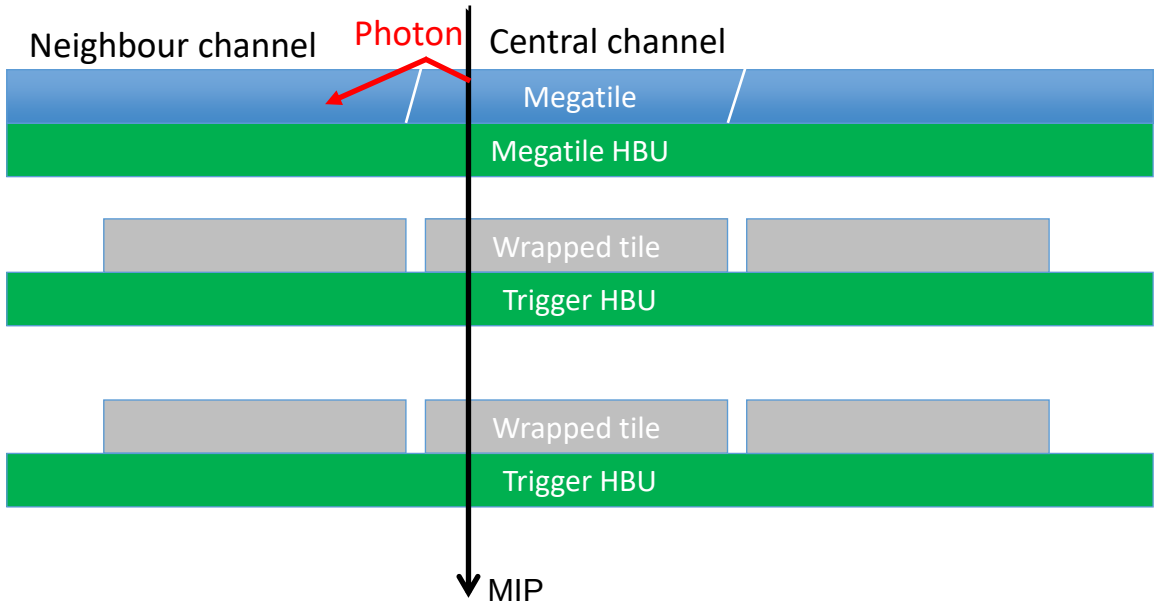
Cross Talk

- Light escaping central cell trough air gap (~100 µm)
- Signal partially recorded in neighbouring channel



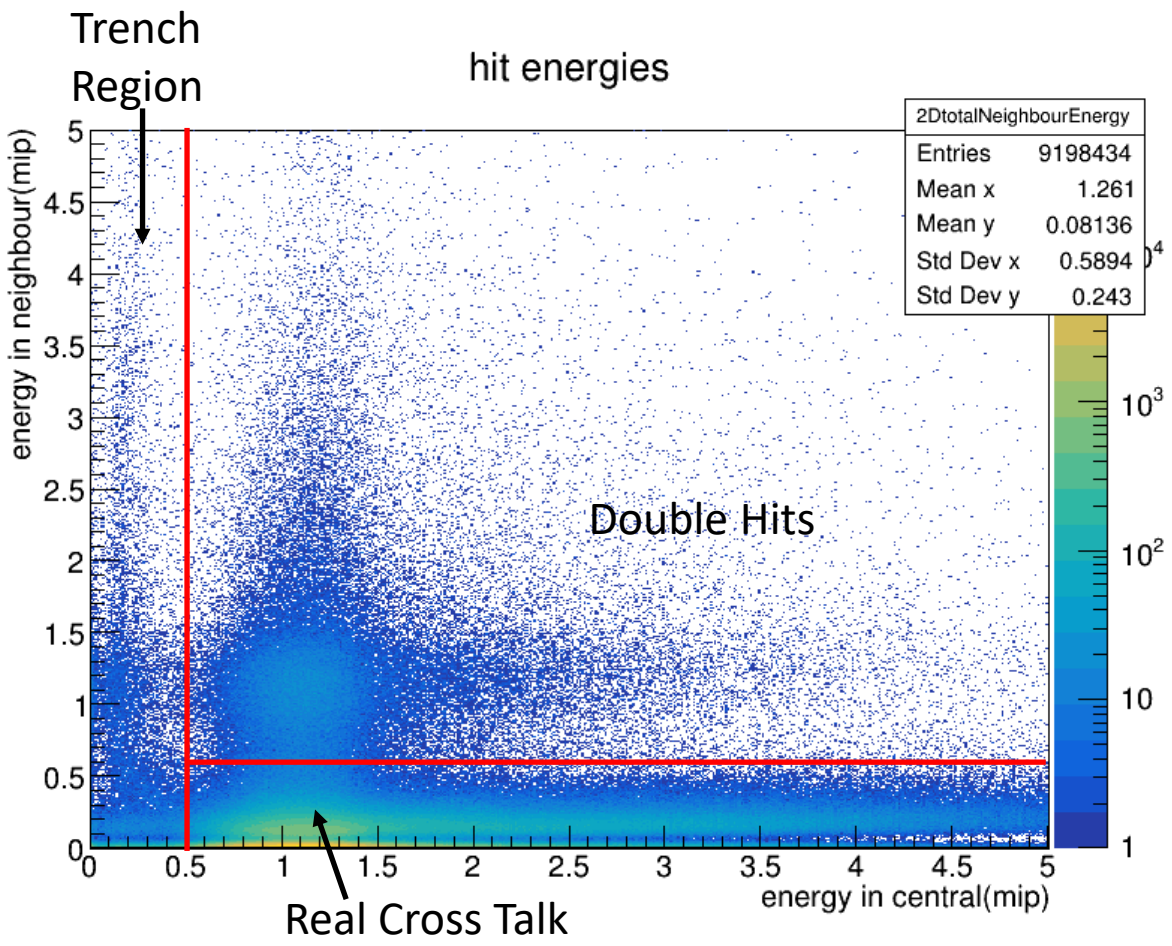
Measurement of Cross Talk

- Central channel of MT defined by coincidence in single tile layers
- CT = energy in neighbour channel / energy in central channel



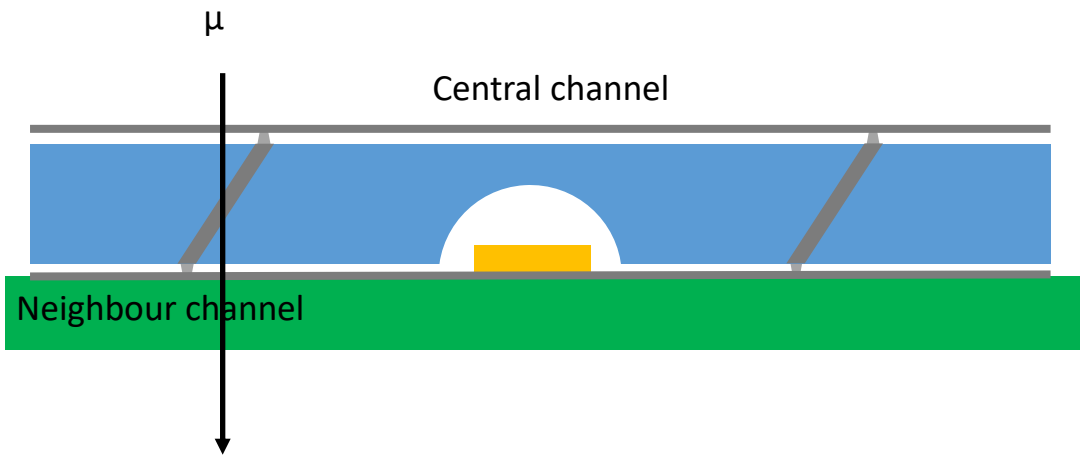
Measurement of Cross Talk

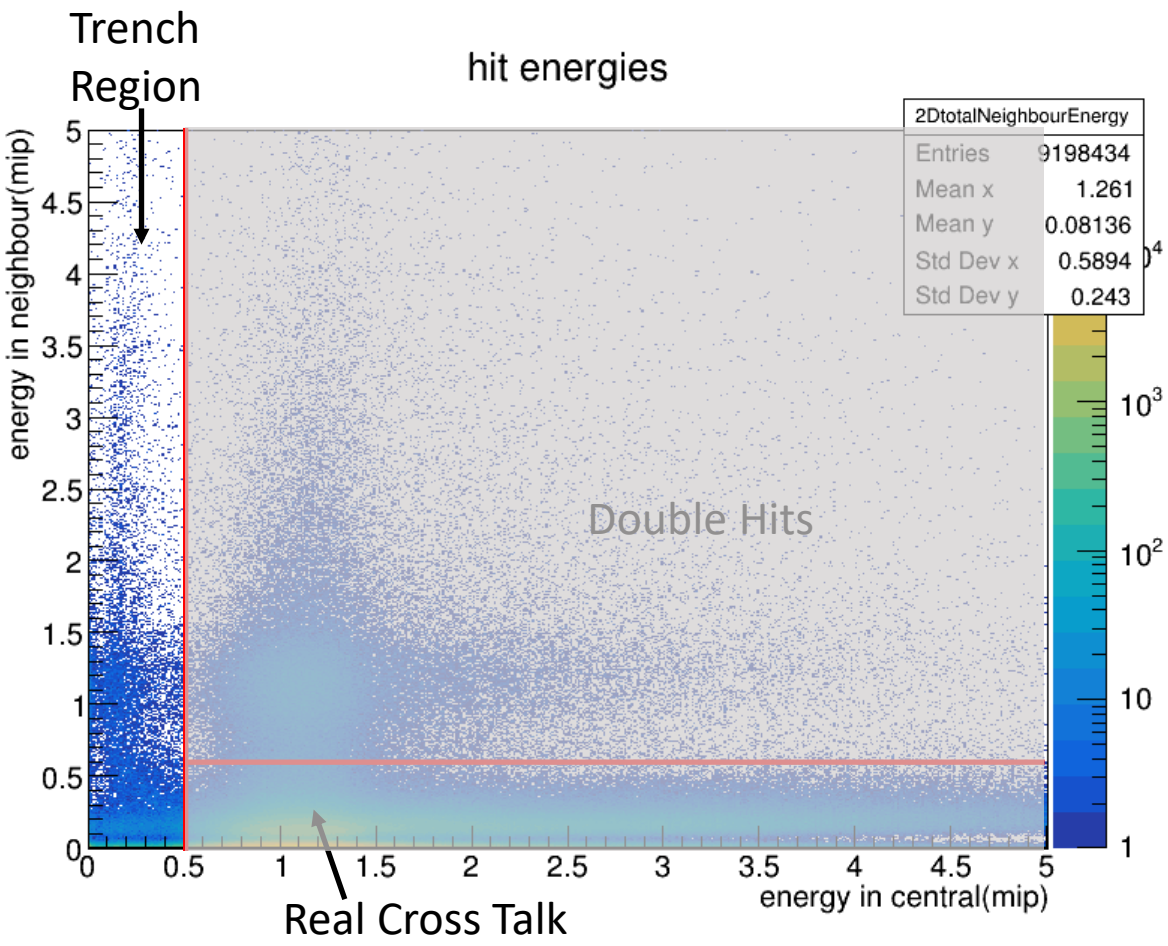
- 3 areas visible in plot of energy in central channel vs energy in neighbour channel



Measurement of Cross Talk

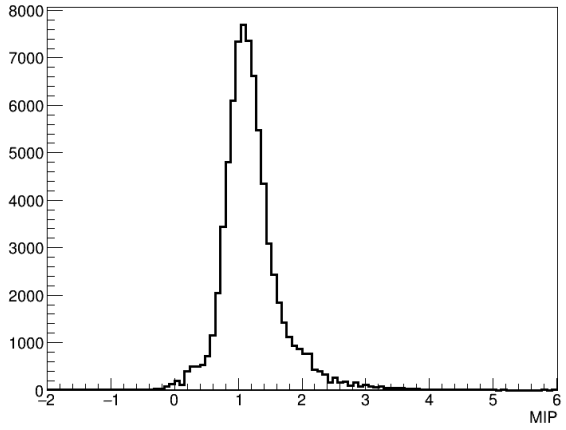
- 3 areas visible in plot of energy in central channel vs energy in neighbour channel
- Trench Region:
  - MIP passing through trench
    => signal split between two tiles

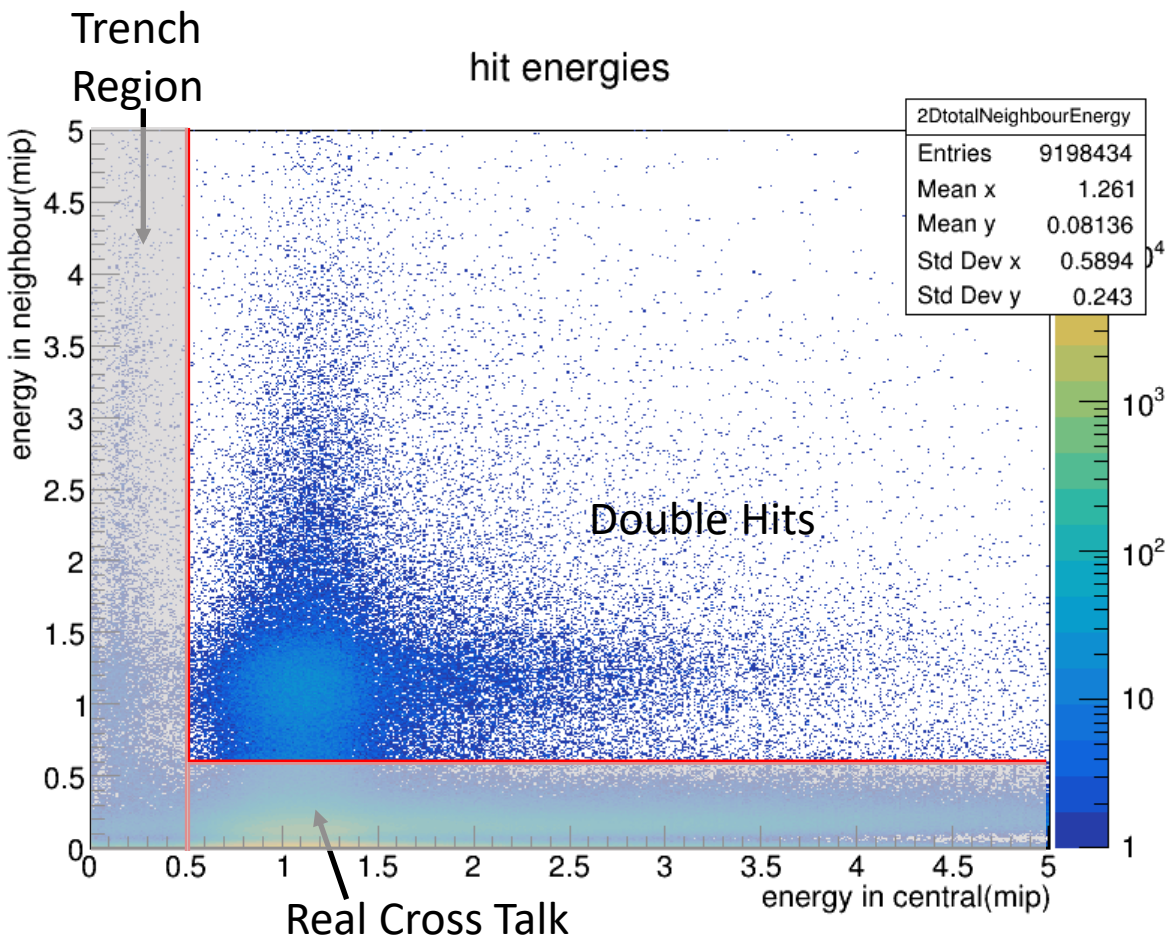




Measurement of Cross Talk

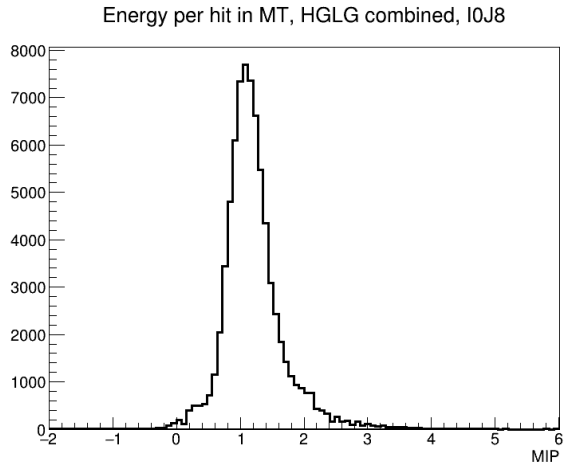
- 3 areas visible in plot of energy in central channel vs energy in neighbour channel
- Double Hits:
  - Two particles crossing through central and neighbour tile
  - Can be reduced with timing cut (not applied here)

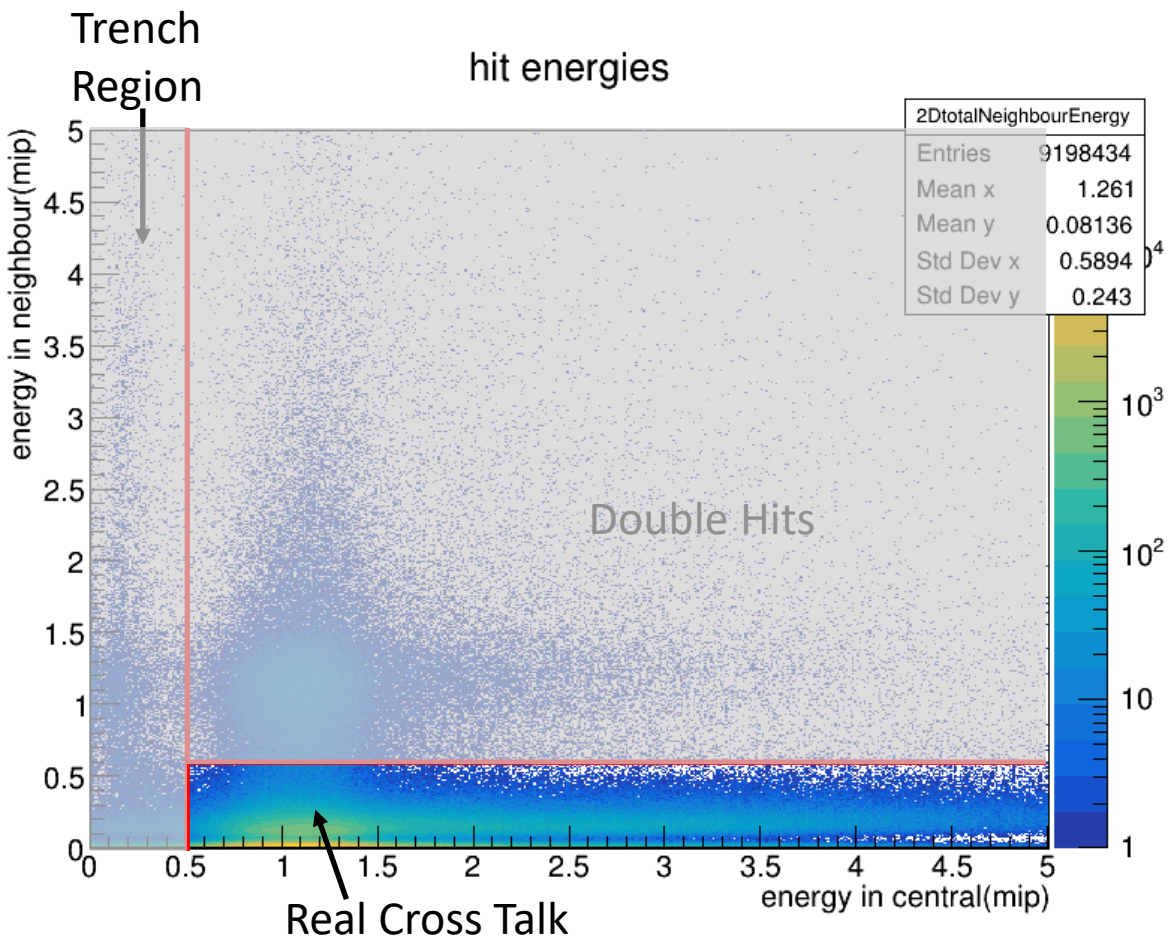




Measurement of Cross Talk

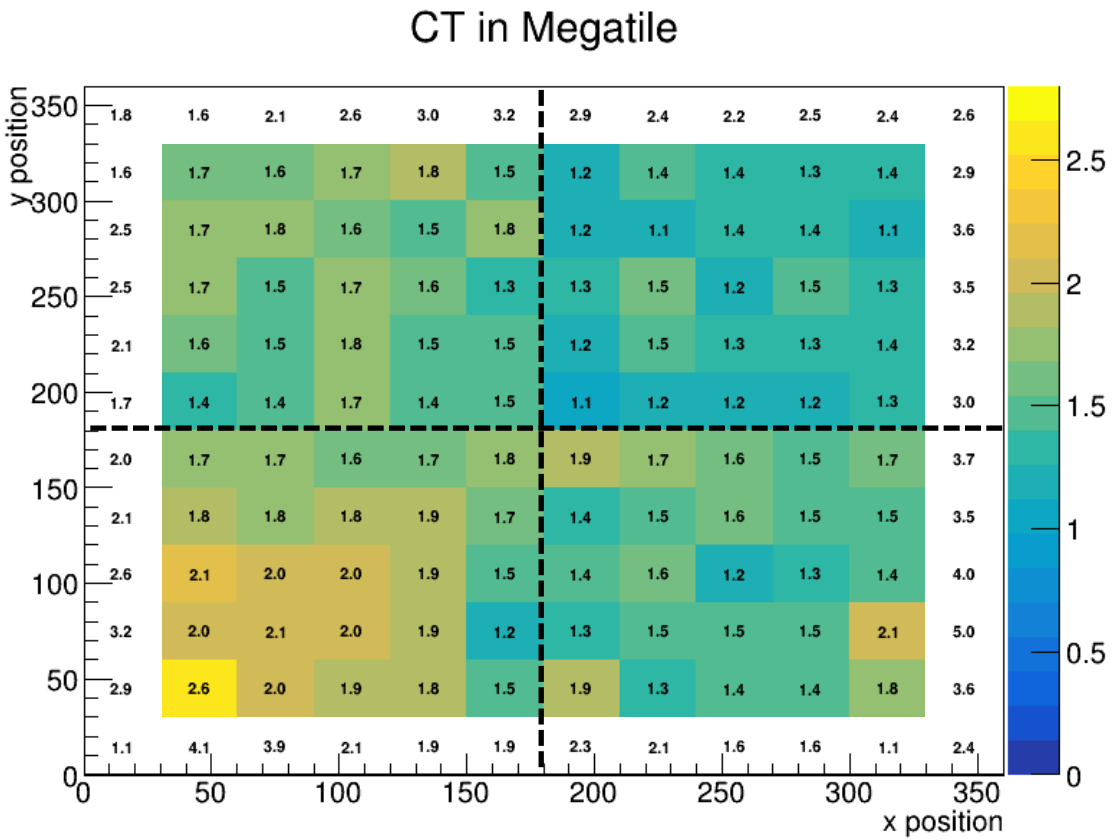
- Plot energy in central channel vs energy in neighbour channel
- 3 areas visible
- Real Cross Talk:
  - Full MIP in central channel;
    at most 0.7 MIP in neighbour





Measurement of CT

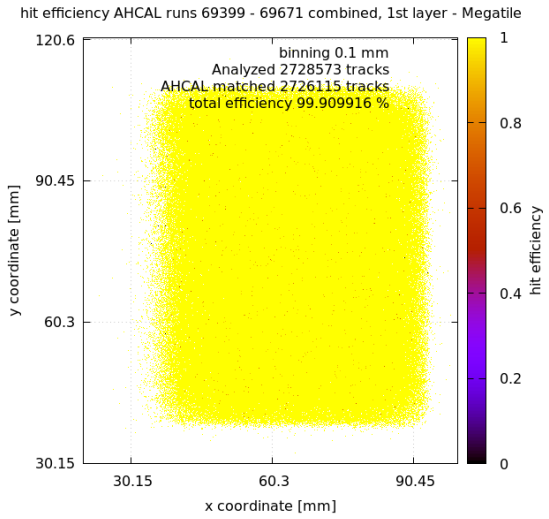
- CT<2.6% in central channels: well within requirements
- Small amout of CT acceptable because of showering in calorimeter
- CT in edge channels higher due to lower LY



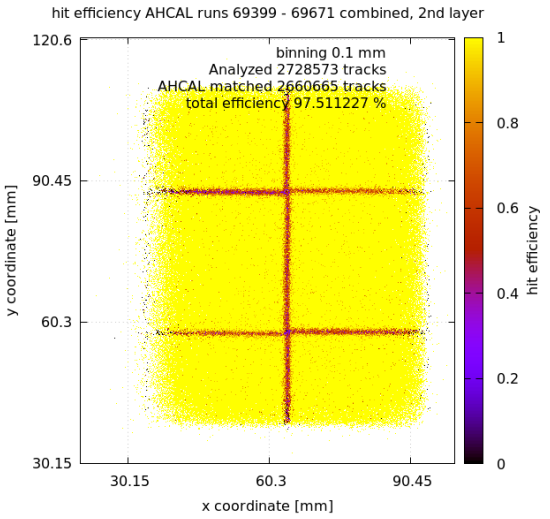
Beam Telescope

- Efficiency plots with telescope:
  - $\frac{\#\ \text{telescope tracks with hit in layer}}{\#\text{telescope tracks}}$ at each position
  - Uniform efficiency in Megatile (no drops due to trenches)
  - In single tiles: gaps are visible
- Software by Jiri Kvasnicka

Megatile



Single Tiles



Conclusion and Outlook

- Megatile: promising concept
  - Thoroughly tested in cosmics test stand and at test beams
  - Simplifies mass production
  - Uniform LY, low cross-talk and improves uniformity of hit efficiency

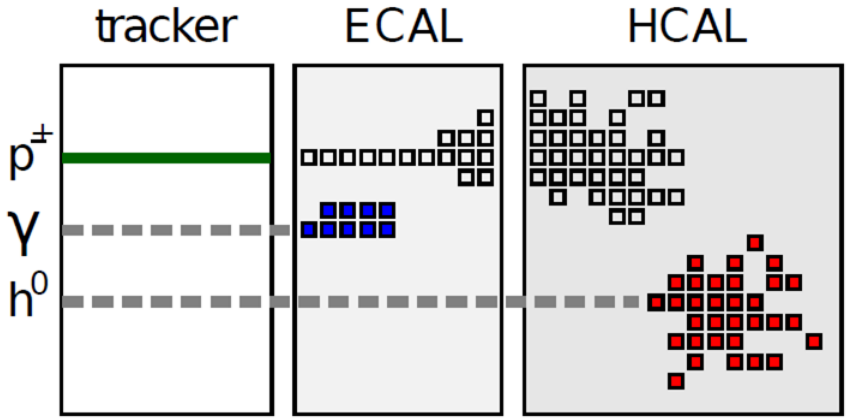
- More in depth analysis of cross talk and trench region with telescope data

Thank you for your attention!

Back Up

Particle Flow Algorithms (PFA)

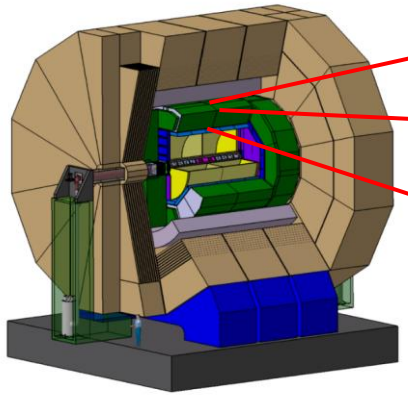
- PFA uses most precise detector component for measurement of different particles:
  - Tracker: charged particles
  - ECAL: photons
  - HCAL: neutral hadrons
- Resolution degrades when particle clusters overlap
- Highly granular calorimeters necessary for use of PFA



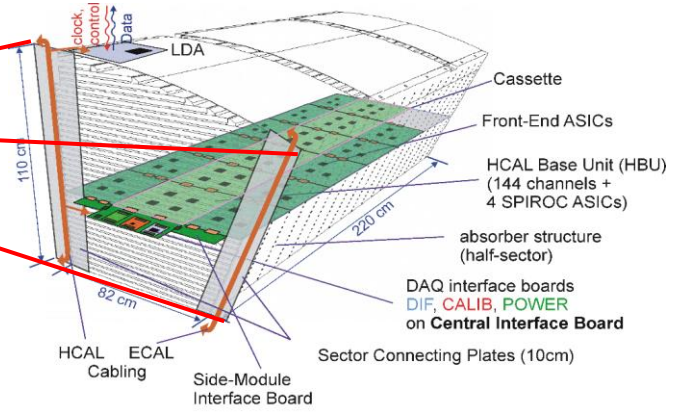
Oskar Hartbrich - Commissioning and LED System Tests of the Engineering Prototype of the Analog Hadronic Calorimeter of the CALICE Collaboration

CALICE AHCAL

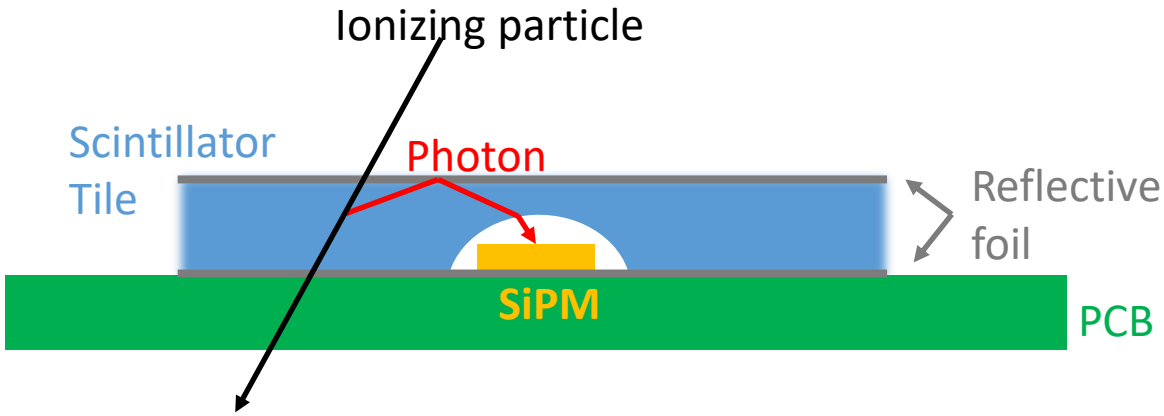
- Development of calorimeter prototype: **A**nalogue **H**adronic C**al**orimeter (AHCAL)
- Plastic scintillator as active material
- Read out with Silicon Photomultipliers
- Channel size of 3 x 3 cm2



ILD-Letter of Intent



ILC-Technical Design Report-Vol 4



Gain

- Need to convert electronics unit (ADC) to comparable global unit
- Channelwise factor
- On-board LED provides few-photon light pulses
- Each peak in spectrum corresponds to integer number of photo electrons (pe)
- Constant distance between peaks = Gain
- Factor to transform from ADC to pe (about ~25)