Scintillator Tiles Uniformity Studies

CLIC Detector and Physics Collaboration Meeting

1-2 October 2013, CERN

Samir Arfaoui [CERN/PH-LCD]
samir.arfaoui@cern.ch
on behalf of the CLIC Detector and Physics Study

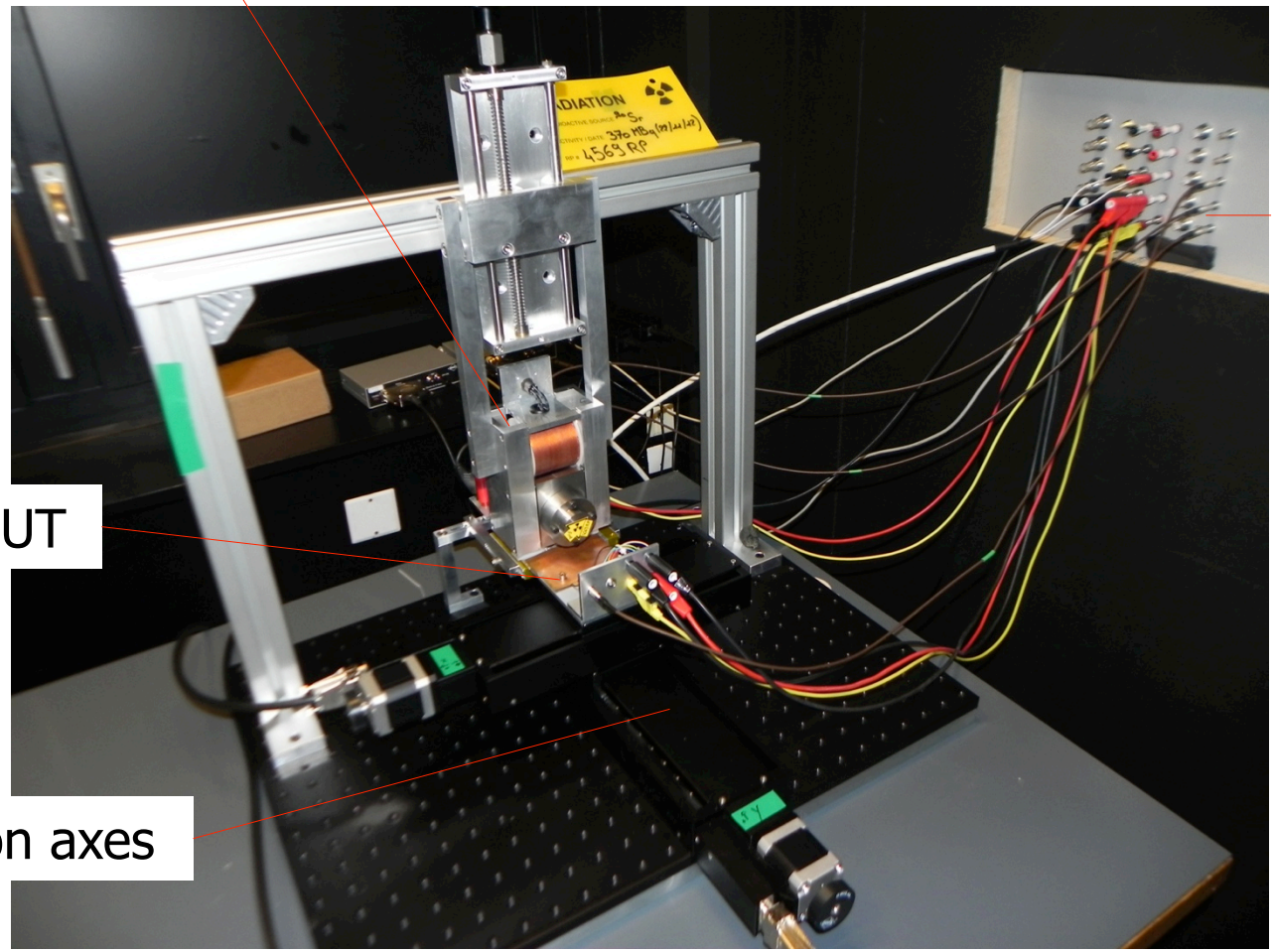
Introduction, outline

- Goal: R&D on CLIC ScECAL with tiles at CERN
- Phase I: develop scintillator scan setup to charaterise various tile geometries, packaging, and SiPM couplings
- In this talk: assess scintillator tiles response uniformity to MIPs, reproduce results from previous studies
- Outline
  - Experimental setup, readout, and data acquisition
  - Measurement and analysis procedure
  - Scan results
  - Non-uniformity assessment
  - Summary and outlook

Setup

Electron gun

Inside AC regulated dark room



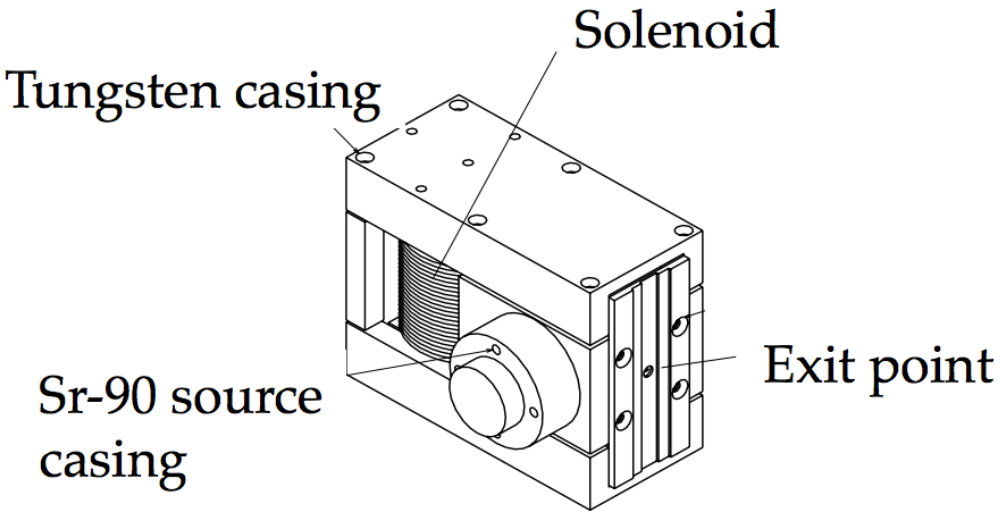
Feedthrough to lab next door

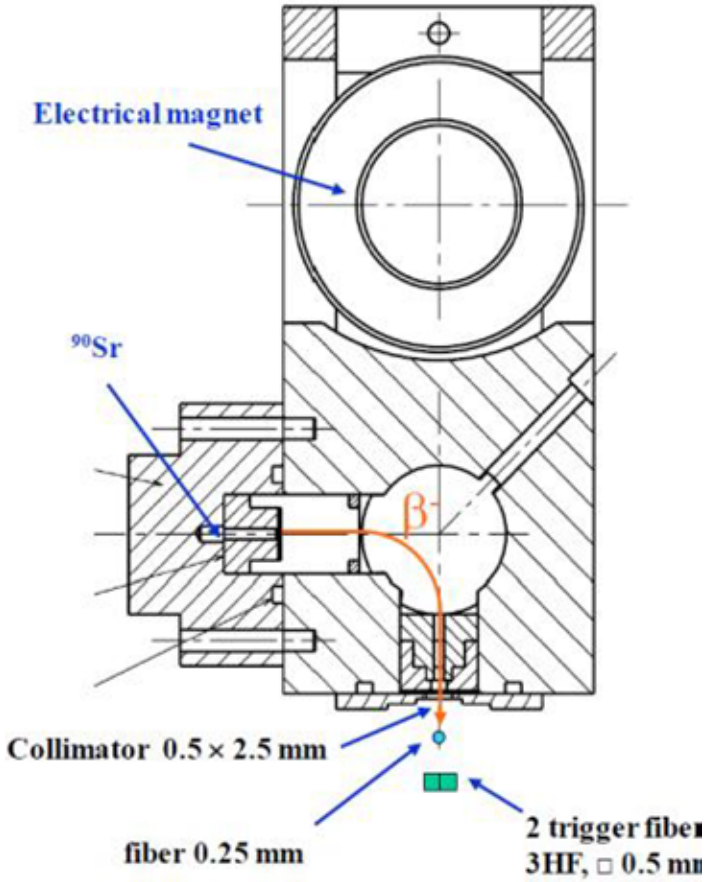
DUT

Translation axes

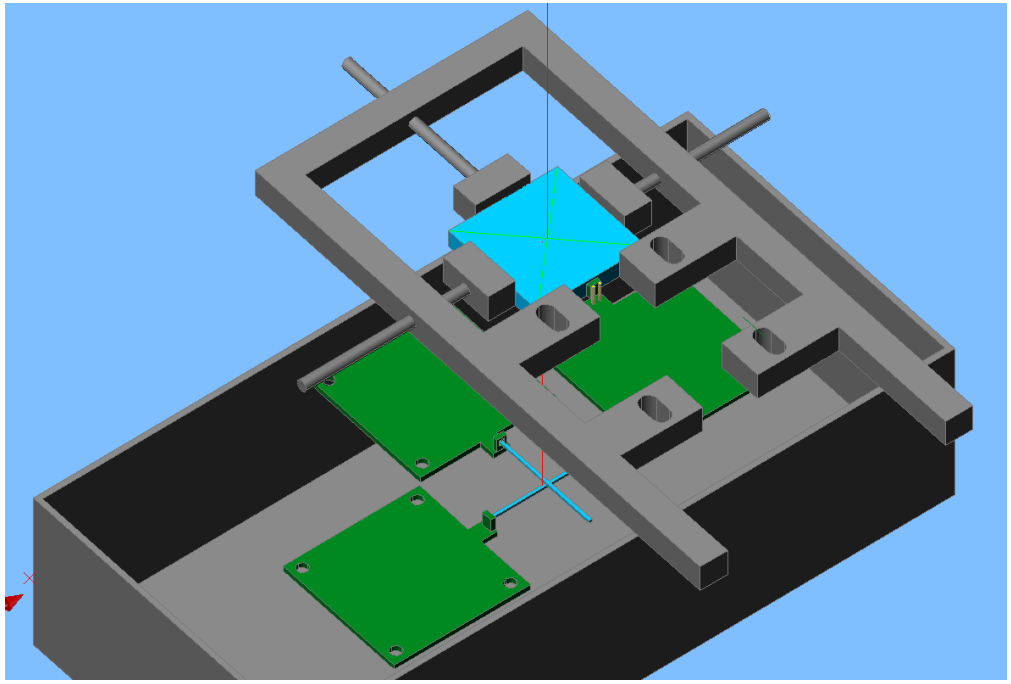
Electron gun

- ~350 MBq Sr90 source
- Double beta emission
- Selectable energy up to ~2.2 MeV

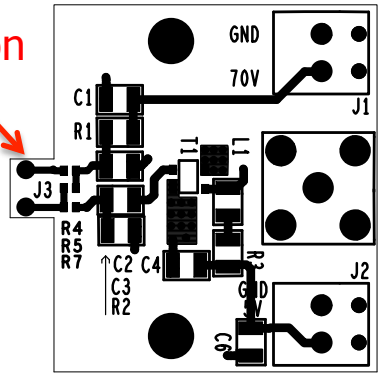




Trigger and Readout



SiPM connection



Bias V

Signal

5V

Same as MPI board, with Infineon BGA 614 amplifier, redesigned to 25x22 mm^2.

- Crossed scintillating fibers (20x1x1 mm^3) as trigger, fixed underneath DUT.
- Positioned Hamamatsu MPPC (50 um pitch) on a nose, sticking out 2 mm beyond the edge, for readout of tiles with dimples
- Including surface-mounted Pt1000 probe near SiPM.

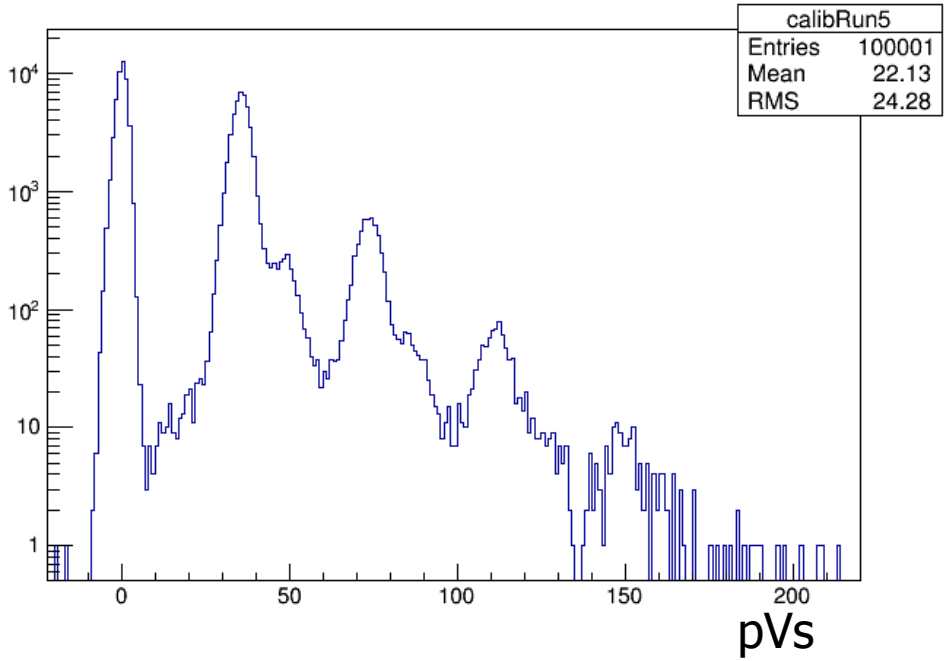
DAQ and Calibration

- Data acquisition:
  - Digital oscilloscope: 4 GHz 4-channel picoscope
  - LabView VI → readout trigger by trigger
    - Rate is limited by electron gun & tile thickness to O(20) Hz.

Calibration:

- With the gun off, acquire Single Photon spectrum run
- At the center of tile, define gain at nominal temperature

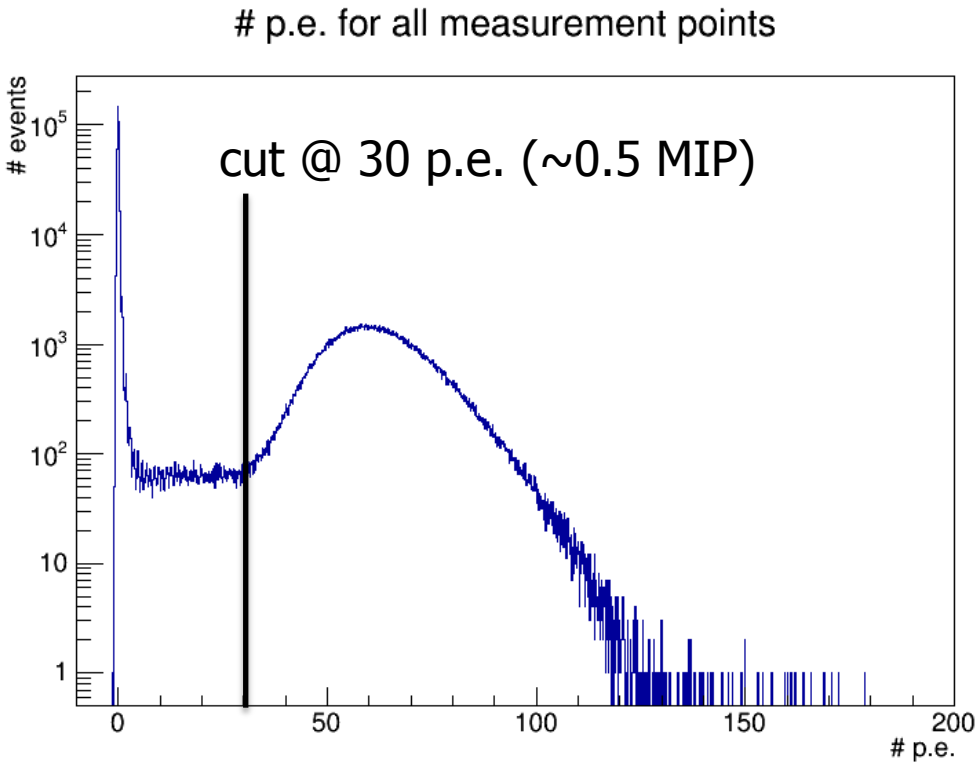
First tile scanned: 30x30x3 mm^3 →

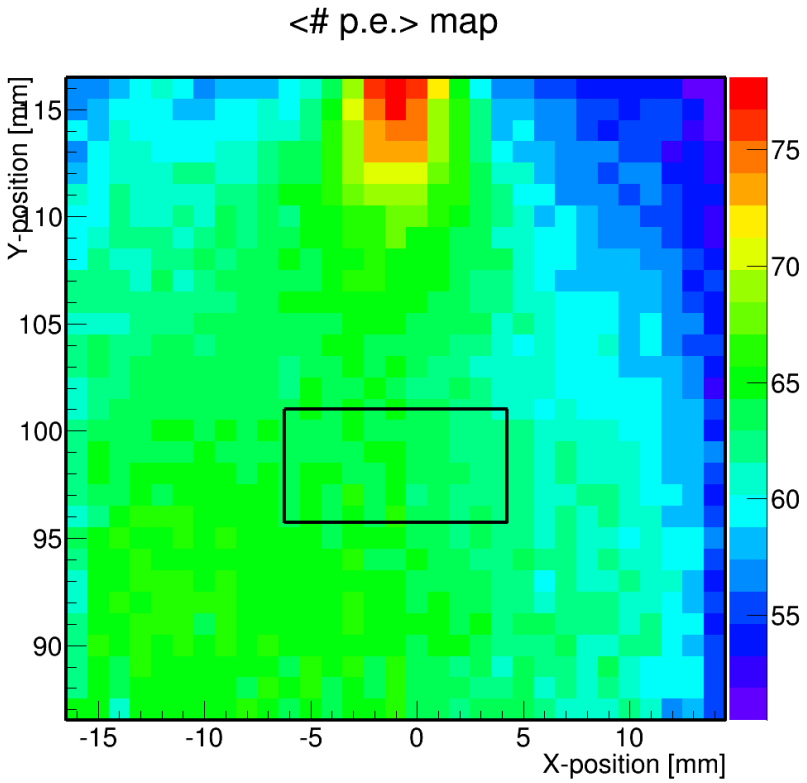


Measurement and analysis procedures

- Measurement
  - Place selected tile in setup, coupled to the SiPM by direct contact to side face using optical grease
  - Perform self-triggered calibration run to measure gain at reference temperature
  - Switch electron gun ON, start automated tile scan with pre-selected positions
  - At each scan step (~60 sec):
    - Measure temperature (surface-mounted PT1000)
    - Record DUT SiPM waveform integral for each crossed-fibres coincidence signal
- Analysis
  - Correct each waveform integral by relative temperature offset w.r.t. calibration run
  - Convert waveform integral into #p.e.
  - Define tile area at the centre to calculate average response
  - For each scan position, compute deviation from <#p.e.>
  - Estimate effective tile areas within +/- 5, 10, and 20% of the average response to assess response non-uniformity

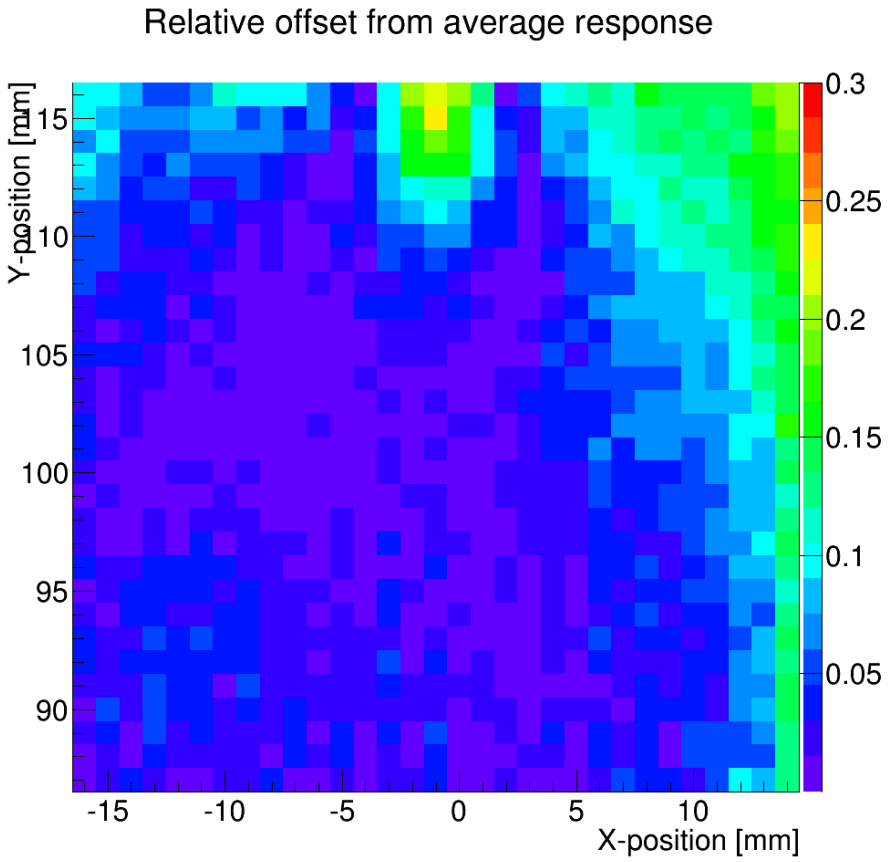
30x30x3 mm tile results

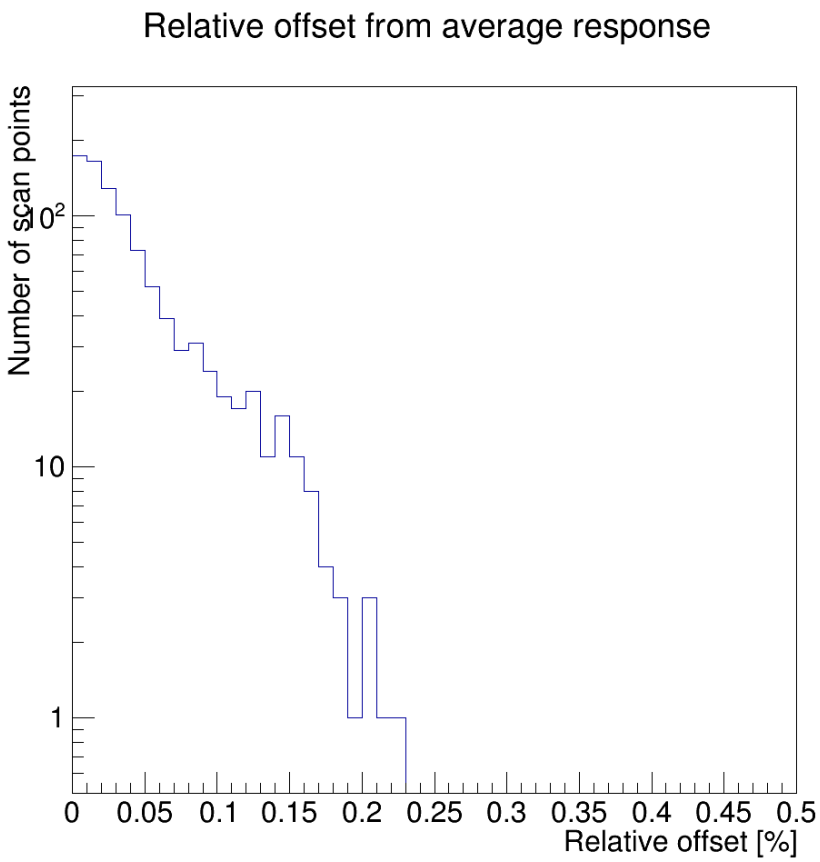




- Tile wrapped in 3M reflective foil
- Left-right asymmetry observed: probably tile-SiPM coupling
- <#p.e.> in reference area: 63.5

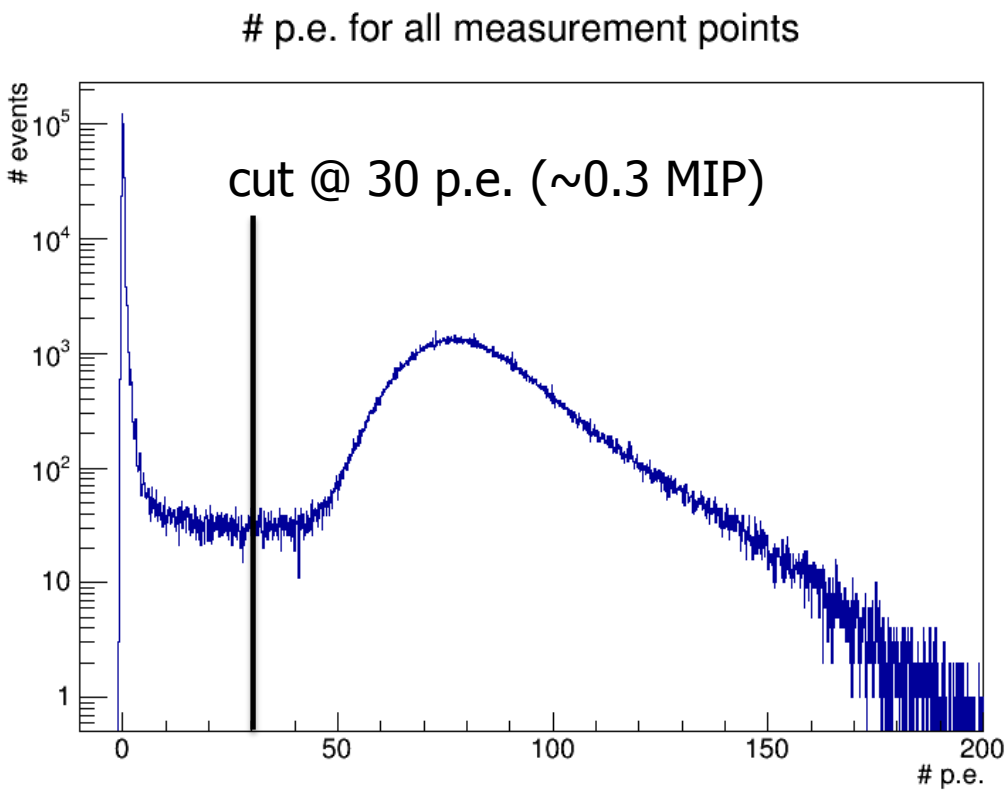
30x30x3 uniformity

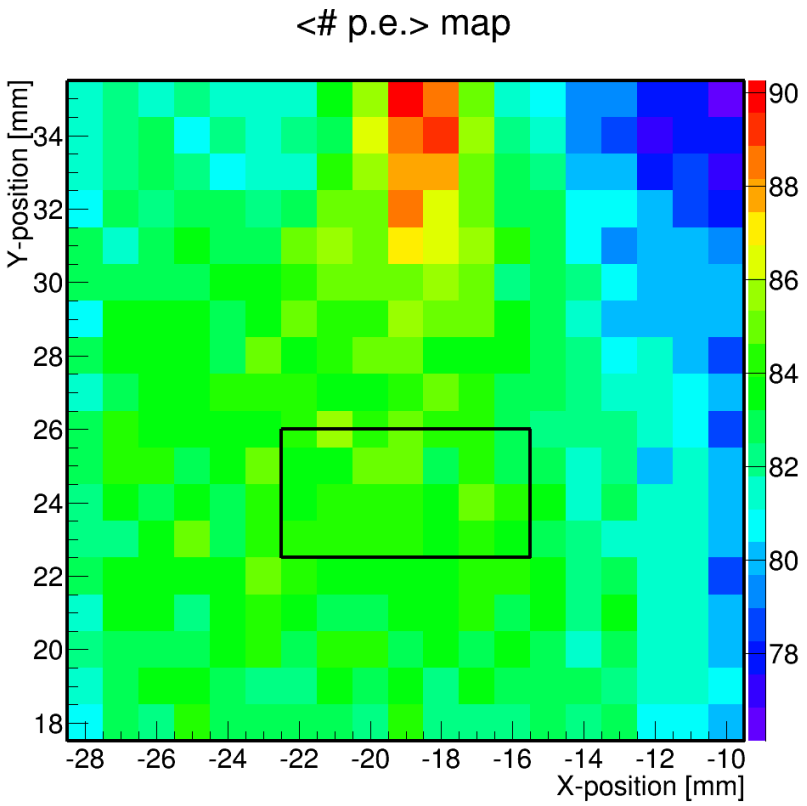




<#p.e.>	+/- 5%	+/- 10%	+/-20%
63.5	68.8	87.6	99.5

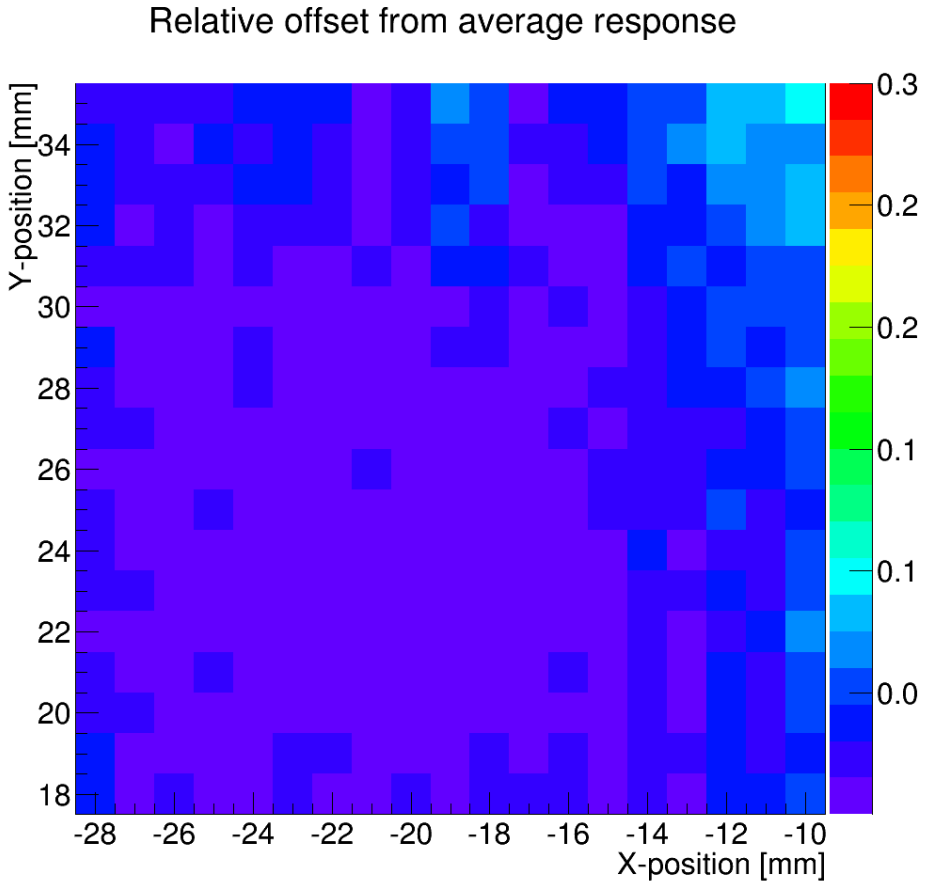
Wrapped 20x20x2 mm tile results

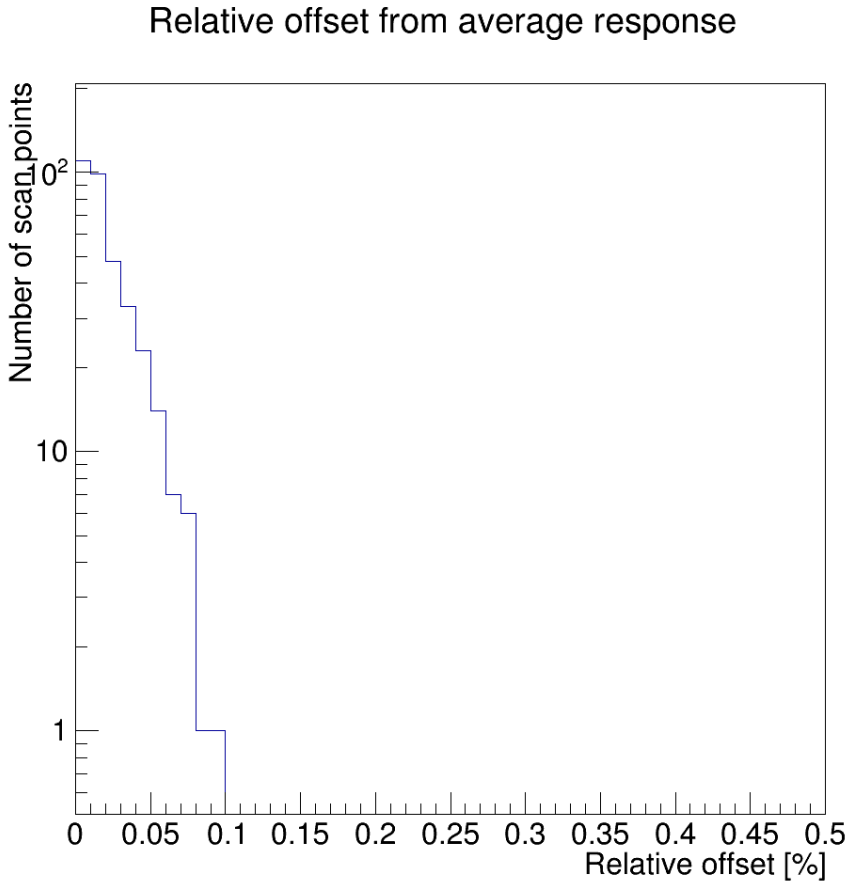




- Tile wrapped in 3M reflective foil
- Left-right asymmetry observed: probably tile-SiPM coupling
- <#p.e.> in reference area: 84

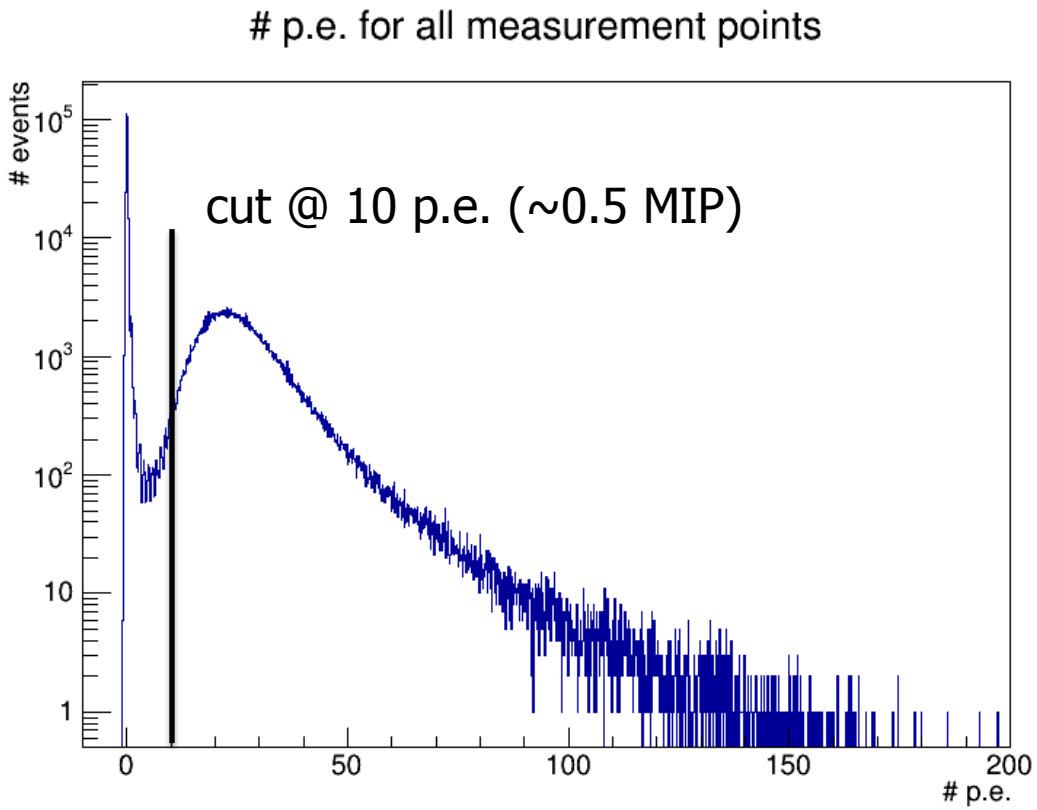
Wrapped 20x20x2 uniformity

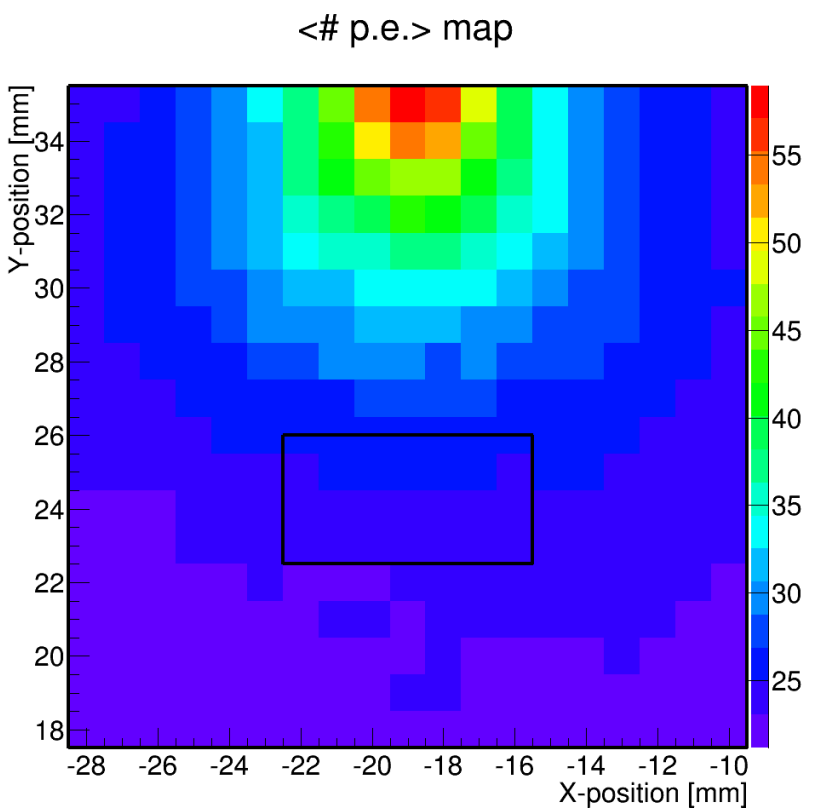




<#p.e.>	+/- 5%	+/- 10%	+/-20%
84	91.5	100	100

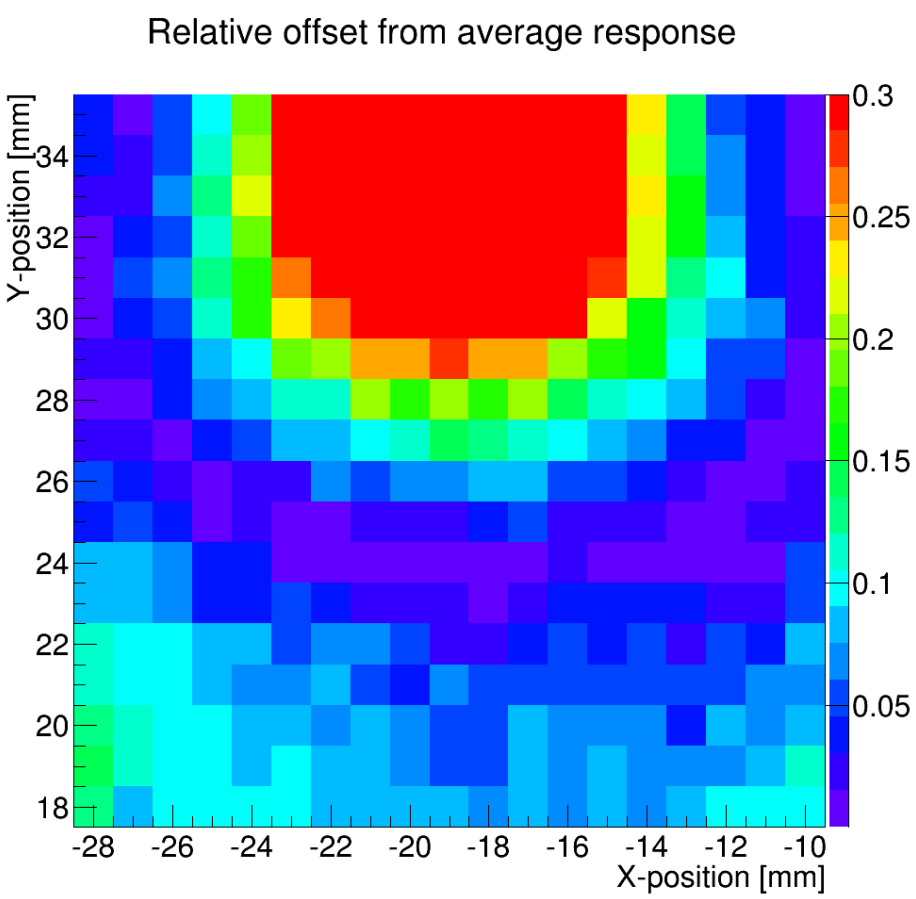
Painted 20x20x2 mm tile results

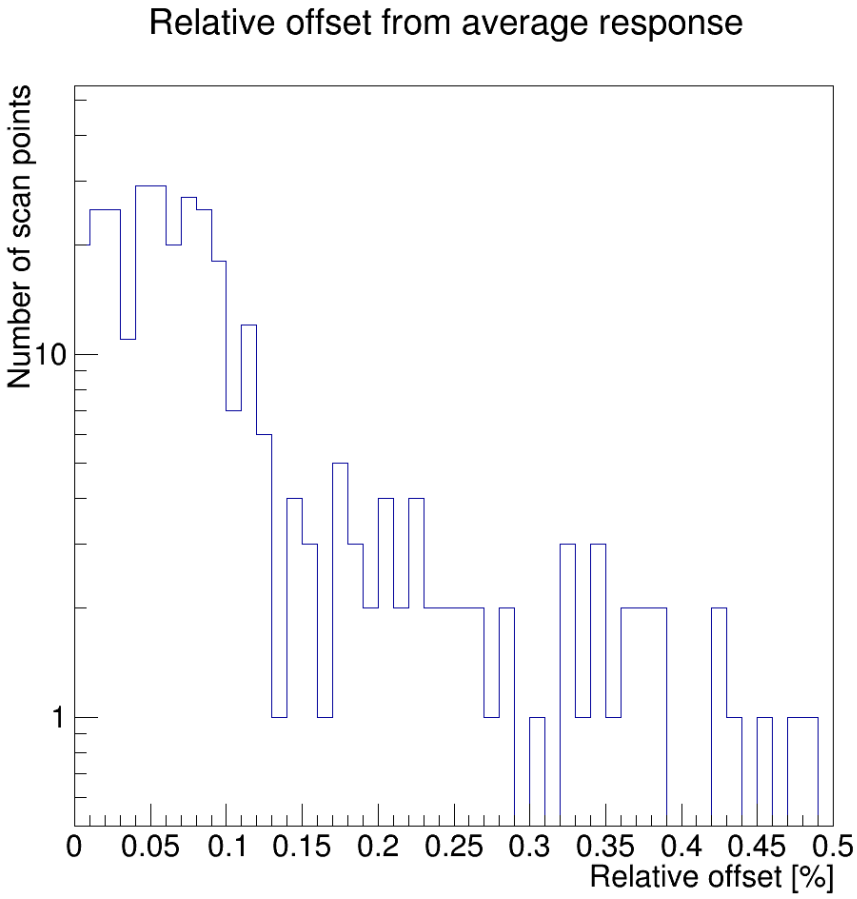




- Tile painted with white reflective paint
- Much less signal than wrapped tile: less light containement with paint
- <#p.e.> in reference area: 24.5

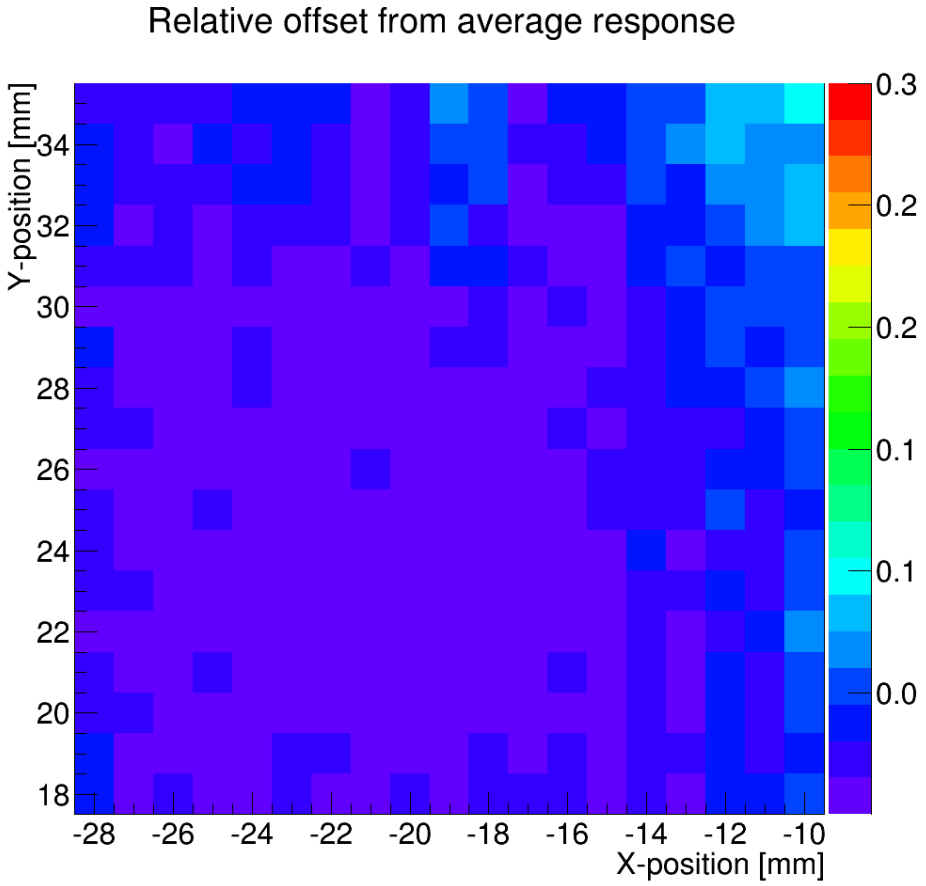
Painted 20x20x2 uniformity

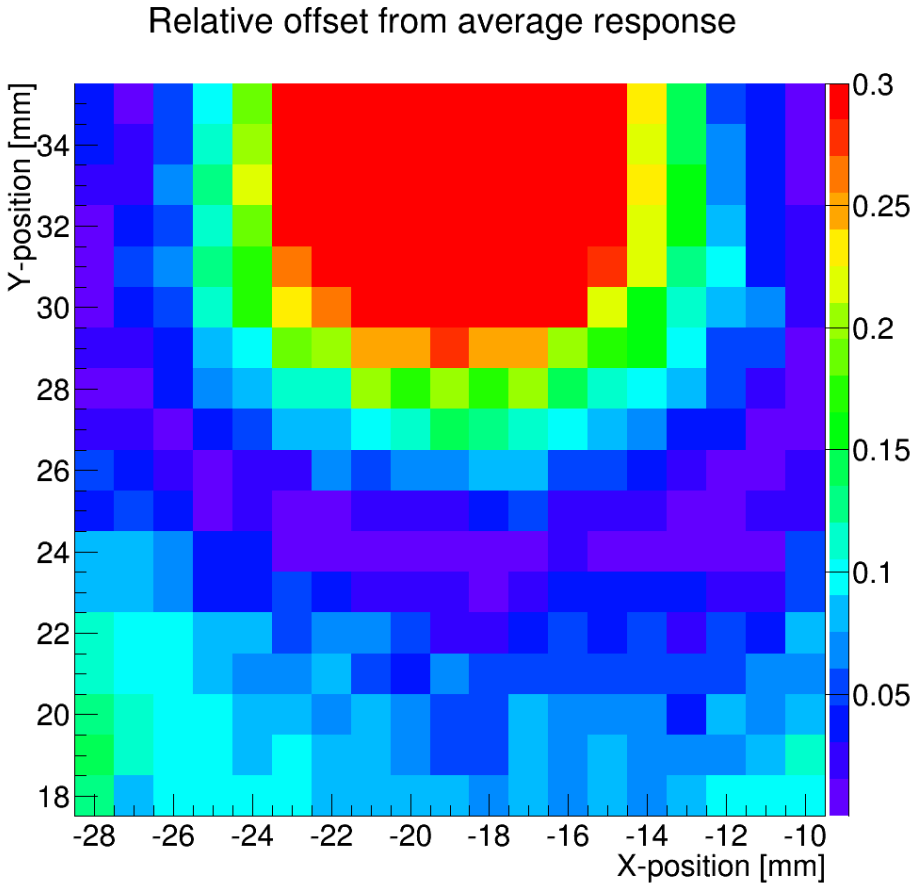




<#p.e.>	+/- 5%	+/- 10%	+/-20%
24.5	32.2	67.0	79.9

Foil vs. Paint





Size [mm]	Wrapping	<#p.e.>	+/- 5%	+/- 10%	+/-20%
20x20x2	3M ESR	84	91.5	100	100
20x20x2	Paint	24.5	32.2	67.0	79.9

Summary

- A tile-scan setup has been assembled at CERN in view of performing scintillator and SiPM studies for the CLIC ECAL R&D
- Scintillator samples of various sizes have been scanned, their uniformity assessed
  - with reflective foil and paint
  - with direct SiPM coupling to side face
- MIP response is lower with paint, but much less uniform

- Next steps:
  - Perform scan with exact same tile as MPI for direct comparison
  - Systematically scan more tiles, more sizes
  - Improve mechanical coupling between tile and SiPM for better reproducibility
  - Better look at tile edges (e.g. scan two tiles side-by-side)
  - Start exploring solutions with dimples