

Quality control for SiPM-on-tile section of the CMS HGCAL at DESY

Wrapped tile size and light yield test stands

Daria SELIVANOVA

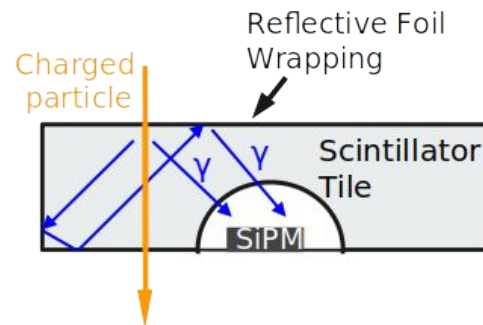
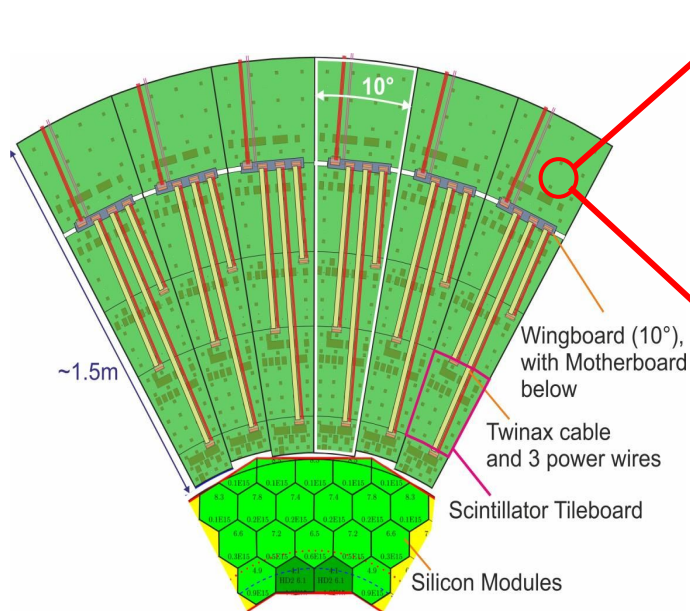
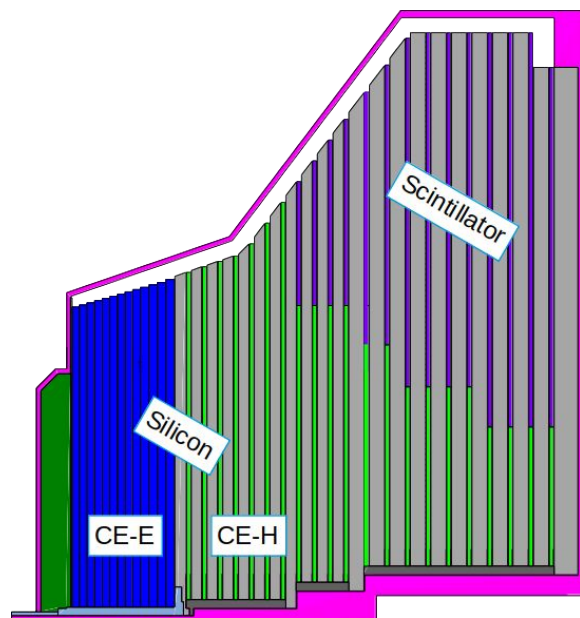
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T 97: Calorimeter / Detector Systems IV

Introduction

High Granularity for the High Luminosity LHC

High Granularity Calorimeter (**HGCAL**) to replace existing CMS endcap for upcoming HL-LHC
Scintillator part of CE-H based on SiPM-on-tile technology being developed



Introduction

TAC and QC

Tile Assembly Center (**TAC**) at DESY is one of only two centers performing tile module production and quality control (**QC**) at every stage

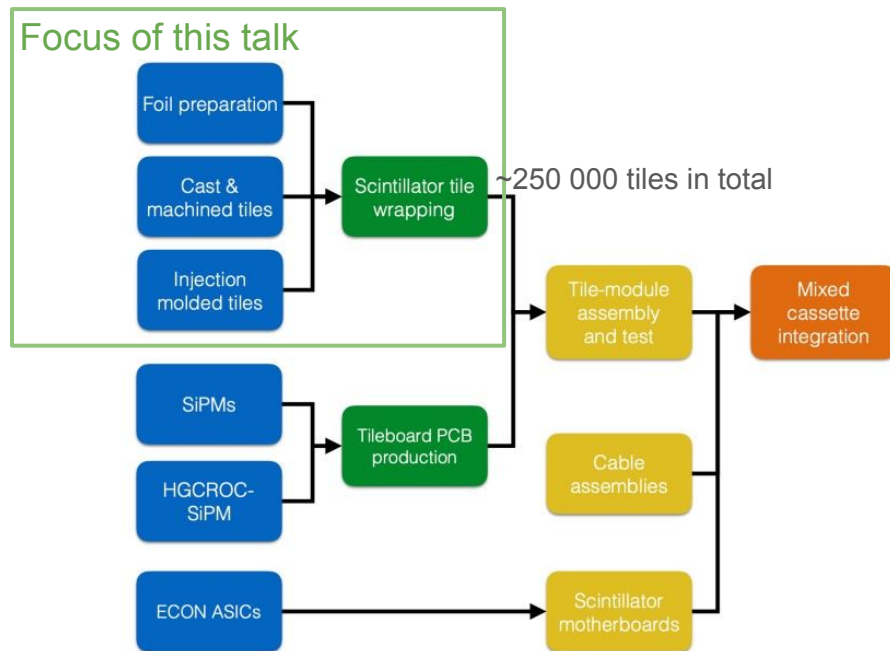
Objective is to assure top performance based on a small fraction (a spot sample) of all tiles

Developing test stands:

- Wrapped tile size
- Light yield (LY)

To achieve:

- High accuracy of measurements at fast pace
- Tile-to-tile wrapping and LY uniformity
- Speed of tile module assembly ~150/month (for 1800 in total)
 - With 4 tiles/min wrapping speed



Wrapped tile size test stand

Tile size test stand

Motivation and setup

Mechanical measurement (calliper) impossible:

- Wrapping is not rigid: could be bent to incorrect size (or even damaged)
- Trapezoidal shape is challenging, good precision is critical



Solution: perform optical measurements!
Bonus: better compatibility with pick-and-place machine for automatized assembly

Canon CanoScan 5600F scanner with:

- SANE backend drivers for Linux
- Scansimage command interface

External lighting is provided, scanner lamp is turned off to eliminate tile shadow

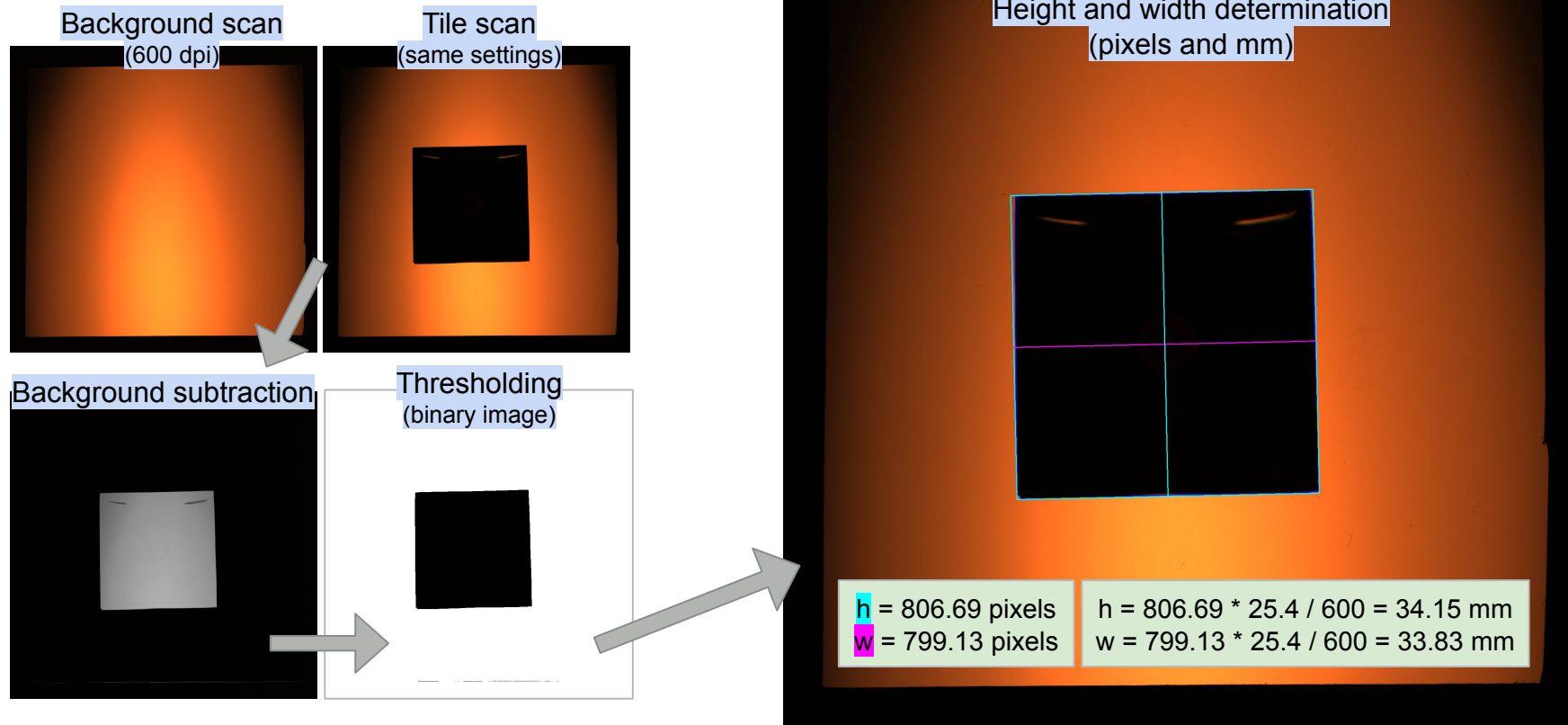
3D printed frame to center the tile in the middle of the scanner (12 cm x 12 cm)

SW written in Python using OpenCV library



Tile size test stand

Algorithm utilizing OpenCV functions



Tile size test stand

Goals and achievements

- Tile size determination with high precision
Below 30 μm

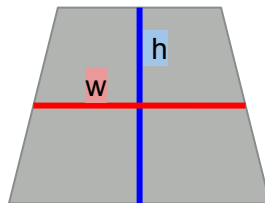
- Measurement reproducibility
Calculated corrections for angle
of placement variation

- Tile-to-tile uniformity checks
Within 200 μm

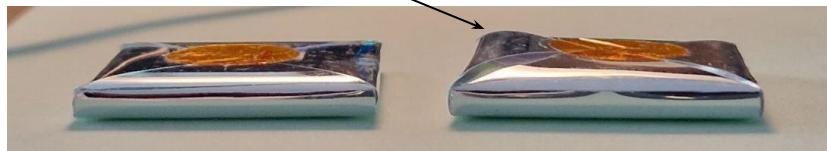
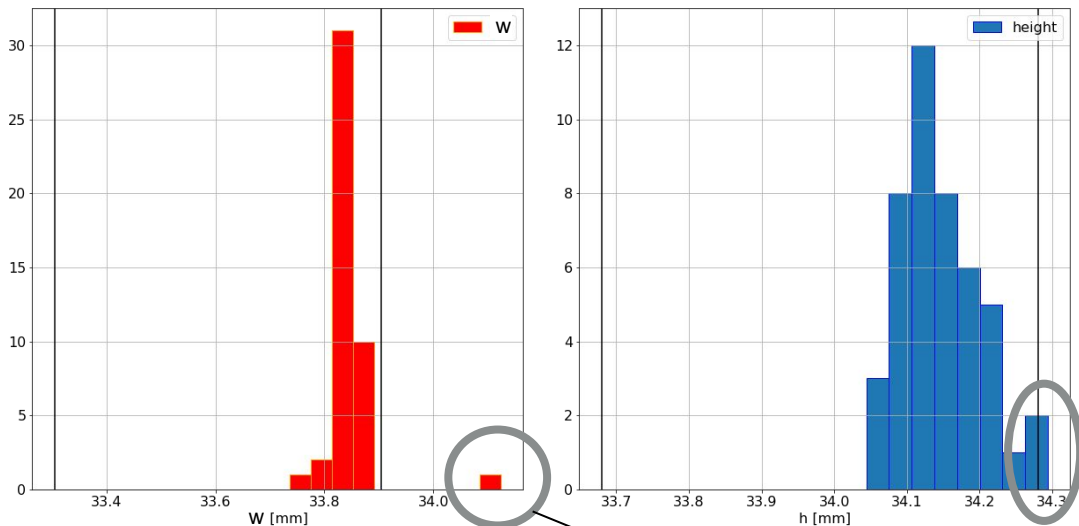
- Outlier detection
Can be detected with clearly defined
margins to the wrapped tile sizes

- Fast measurement times
Below 1 min/tile
Plans to go faster by measuring
multiple tiles at once

$$33.305 < w < 33.905$$



$$33.68 < h < 34.28$$

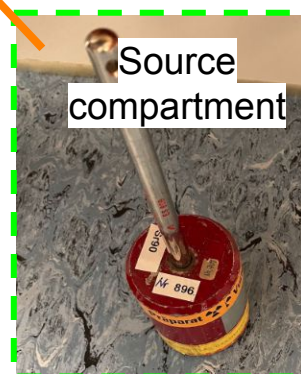
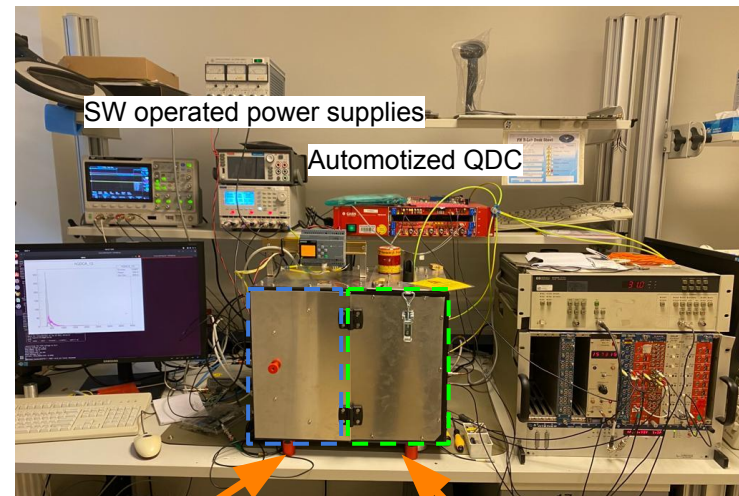
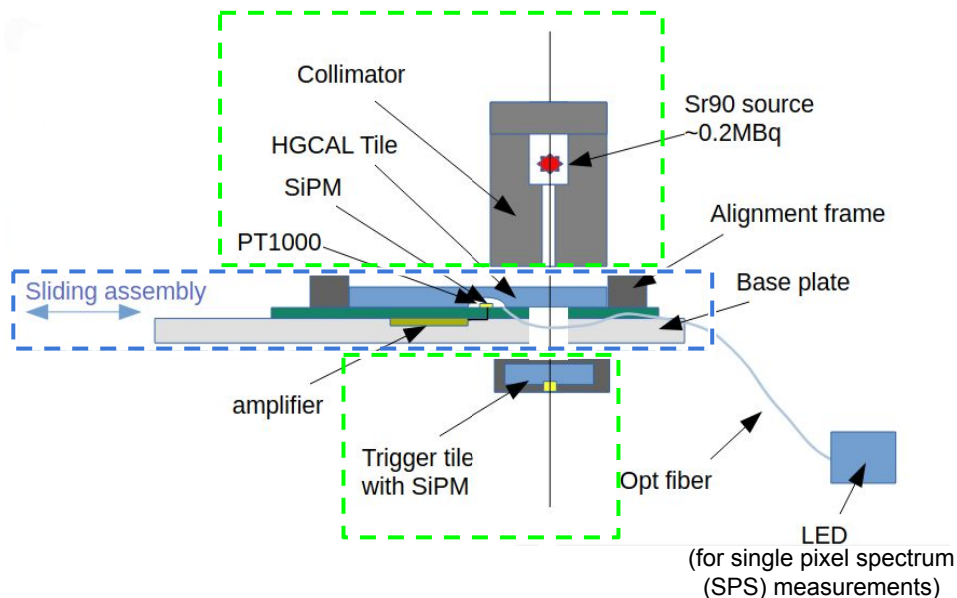


Light yield test stand

LY test stand

Motivation and setup

- Want to maintain high LY during production (critical for signal-to-noise ratio after irradiation)
- Ensuring uniformity will ease production

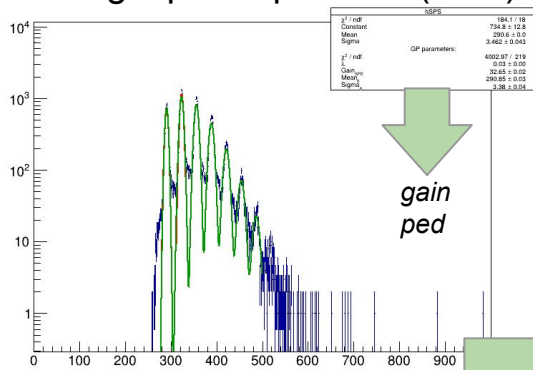


LY test stand

Goals and achievements

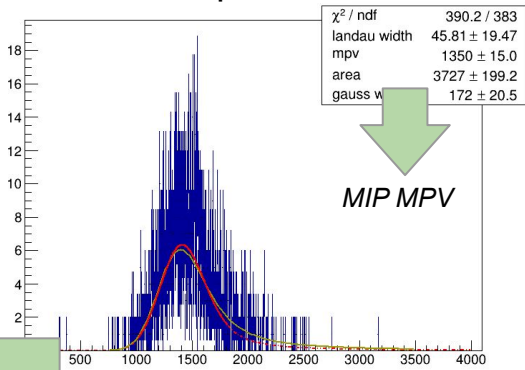
- Compatibility with all tile types
Various frames for different sizes
- Speed of measurement
Around 6 mins/tile for under 2% precision with current source
Plan for ~2min/tile with a stronger source
- Reproducibility
Different measurements of a single tile show low variation (~0.5%)
- Push-button operation for tests and (re)calibration
Dedicated scripts for voltage setting, spectra fitting, LY and Breakdown voltage calculation

Single pixel spectrum (SPS)



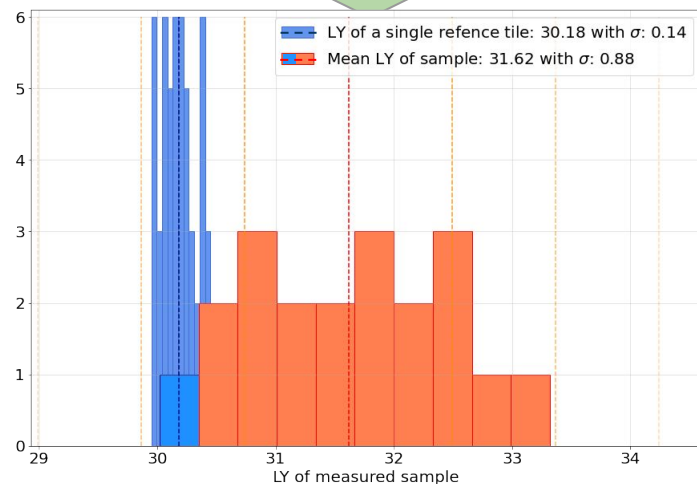
gain
ped

MIP spectrum



MIP MPV

$$LY = \frac{MIP \text{ MPV} - ped}{gain}$$

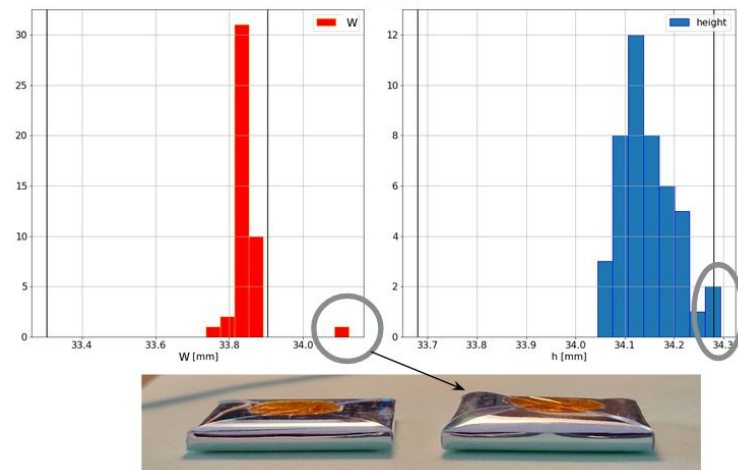
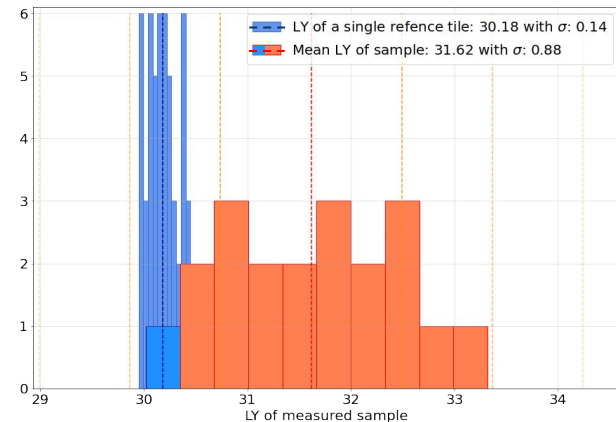


Conclusions

QC at DESY TAC for HGCal

Tile Quality control program at DESY TAC achievements so far:

- Test stands established
 - Tile size after wrapping
 - Light yield
- Results with high precision
- Minimum lag between production changes and evaluation of the quality of their outcome due to fast paced procedure
- Continuous upgrades based on communication with all steps of production to assure top performance



Contact

Deutsches Elektronen-
Synchrotron DESY

www.desy.de

Daria Selivanova

FH - FTX

daria.selivanova@desy.de