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

Wrapped tile size and light yield test stands

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DPG SMuK 2023, Dresden, 22/03/23

T 97: Calorimeter / Detector Systems IV

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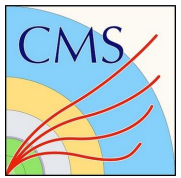
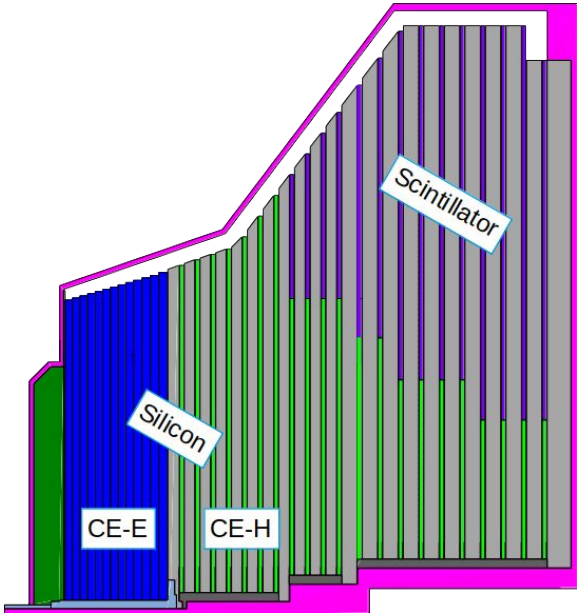
HELMHOLTZ

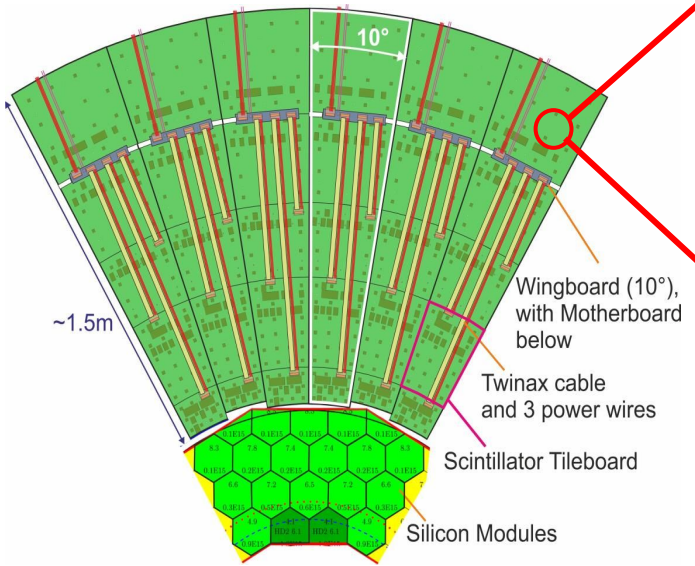


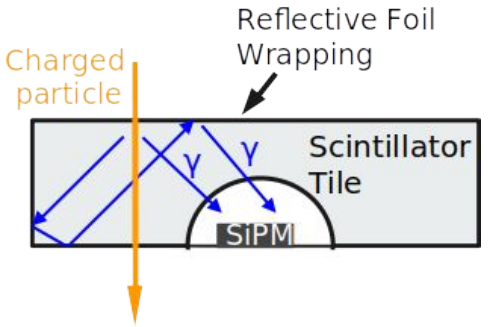
Introduction

High Granularity for the High Luminosity LHC

High **G**ranularity **Cal**orimeter **(HGCAL)** to replace existing CMS endcap calorimeter for upcoming HL-LHC
Scintillator part of CE-H (hadronic calorimeter) based on SiPM-on-tile technology being developed







Introduction

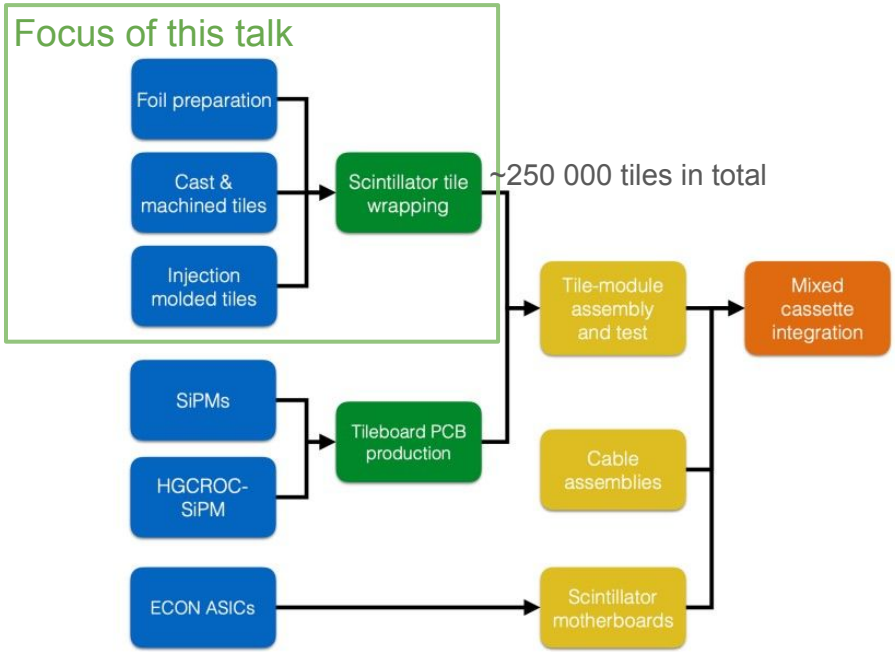
TAC and QC

Tile Assembly Center (**TAC**) at DESY is one of 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 light yield uniformity
- Speed of tile module assembly ~150/month (for 1800 in total)



Introduction

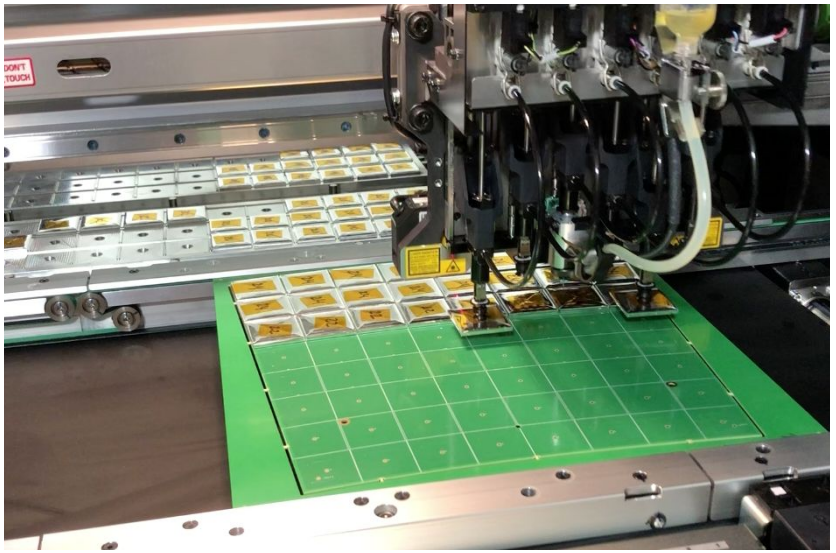
Assembly and QC

Wrapping machine

4 tiles wrapped per minute

Pick-and-place machine

Small tolerance for tile acceptance



Efficiency of tile module assembly motivates improvements to speed and precision of QC stands

Ask for demonstration of these machines at work (backup). Warning: very cool!

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

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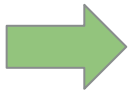

Solution: perform optical measurements!
Bonus: better compatibility with pick-and-place machine for automatized assembly

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Canon CanoScan 5600F scanner with:

- SANE backend drivers for Linux
- Scanimage command interface

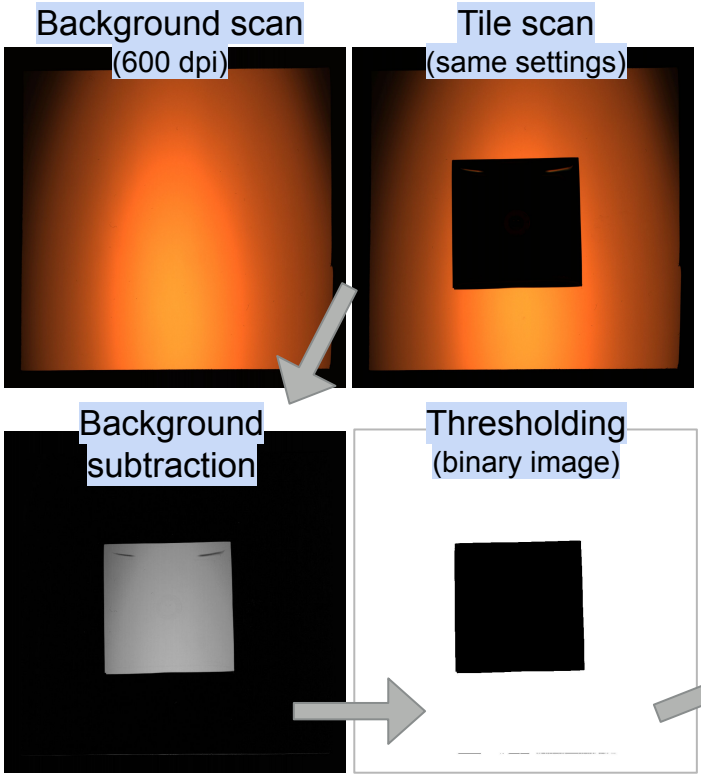
External lighting is provided, scanner lamp is turned off to eliminate tile shadow

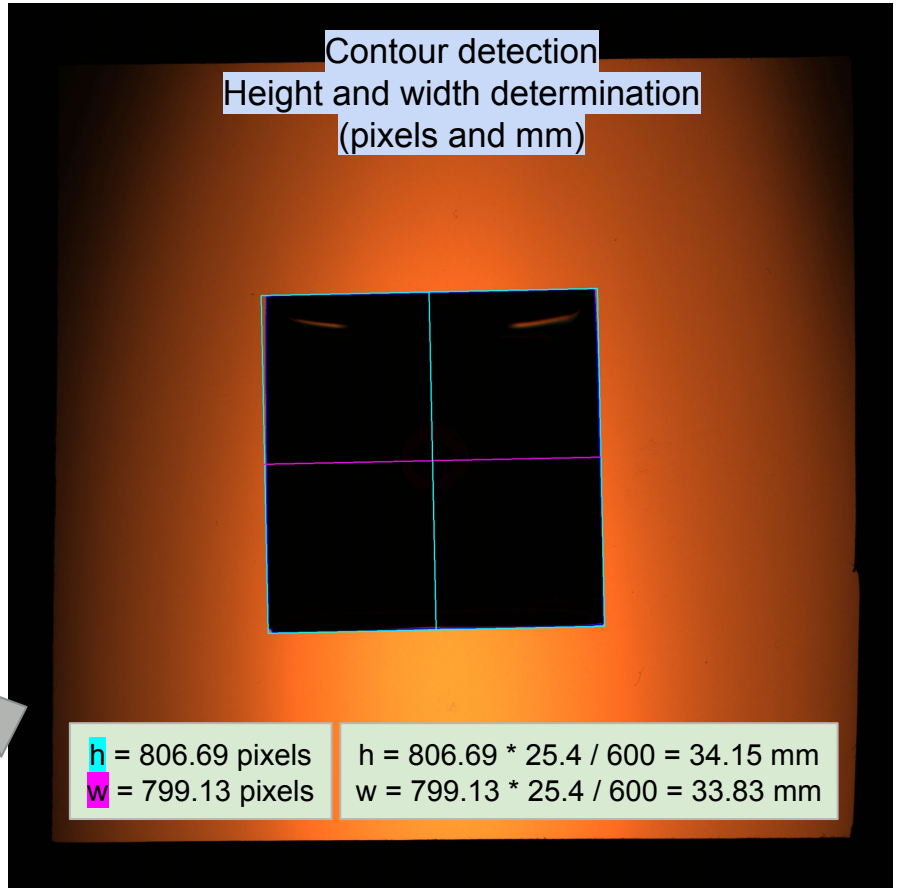
3D-printed frame to help position the tile in the middle of the scanner (12 cm x 12 cm)

SW written in Python using OpenCV library

Tile size test stand

Algorithm utilizing OpenCV functions



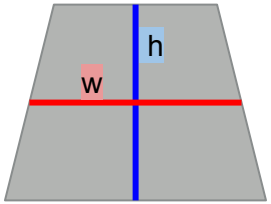


Tile size test stand

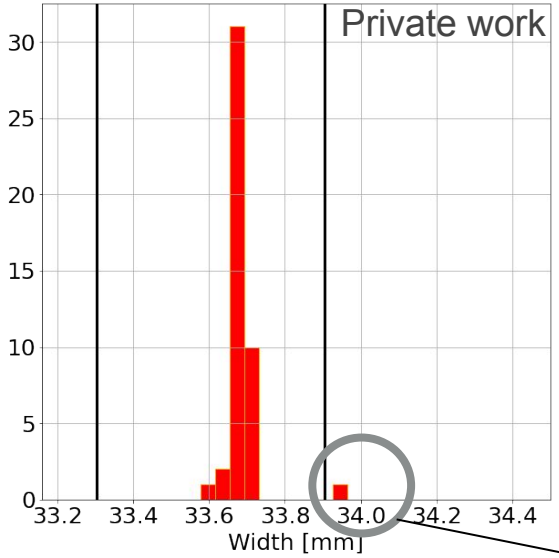
Goals and achievements

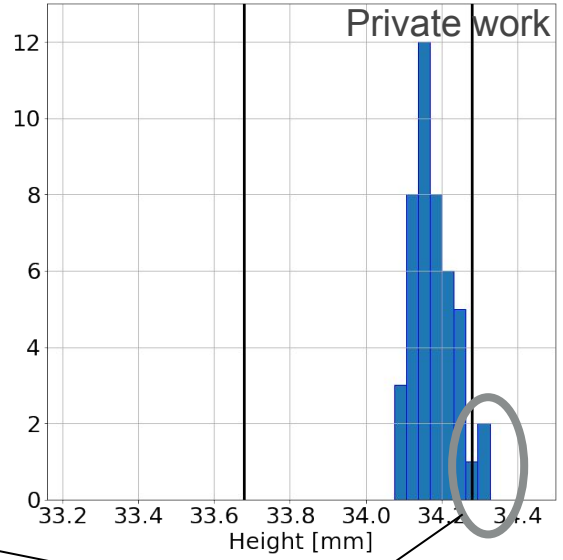
- Tile size determination with high precision
  - Better than 30 μm
- Measurement reproducibility
  - Calculated corrections for angle of placement variation
- Tile-to-tile uniformity checks
  - Within 200 μm
- Outlier detection
  - Can be detected with clearly defined margins to the wrapped tile sizes
- Fast measurement times
  - Below 1 min/tile
  - Plans to go faster by measuring multiple tiles at once

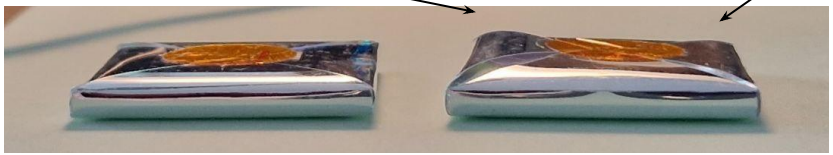
33.305 < w < 33.905



33.68 < h < 34.28





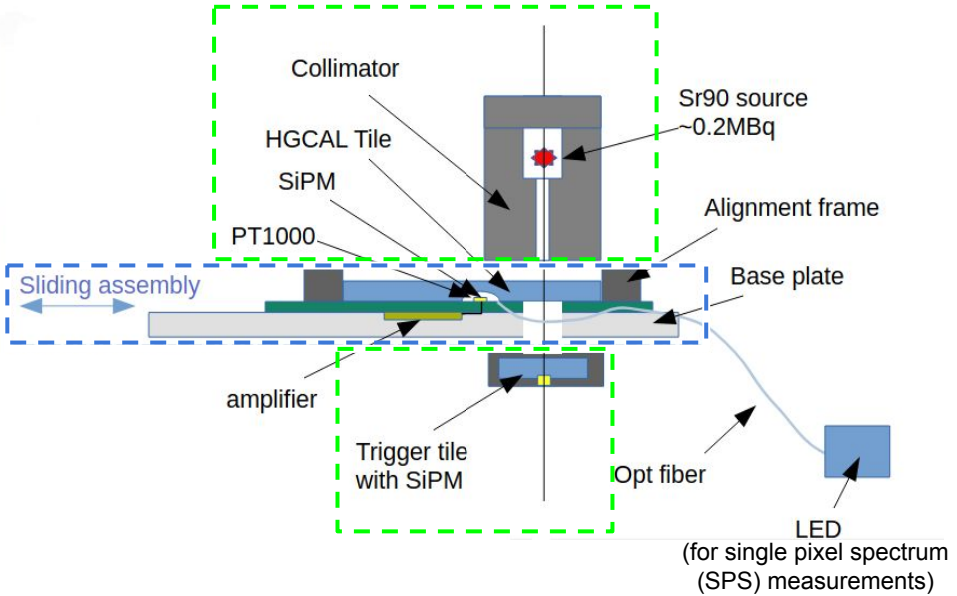


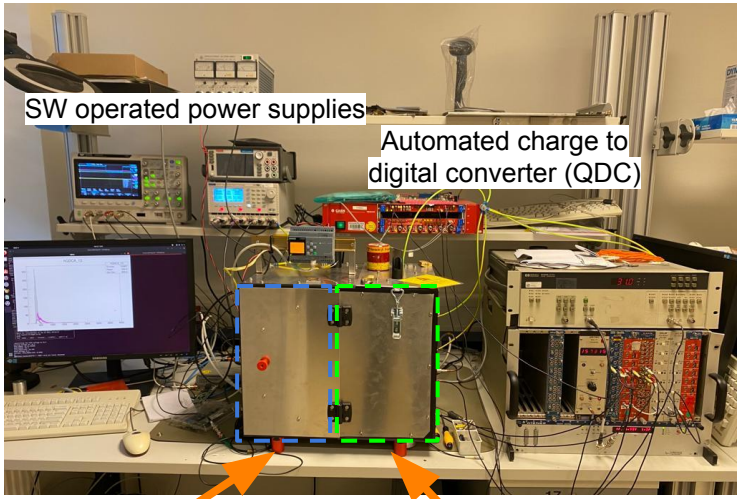
Light yield test stand

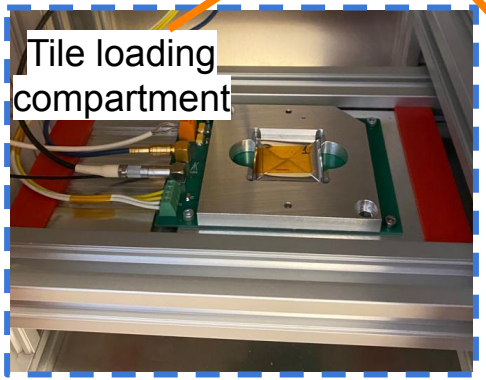
LY test stand

Motivation and setup

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



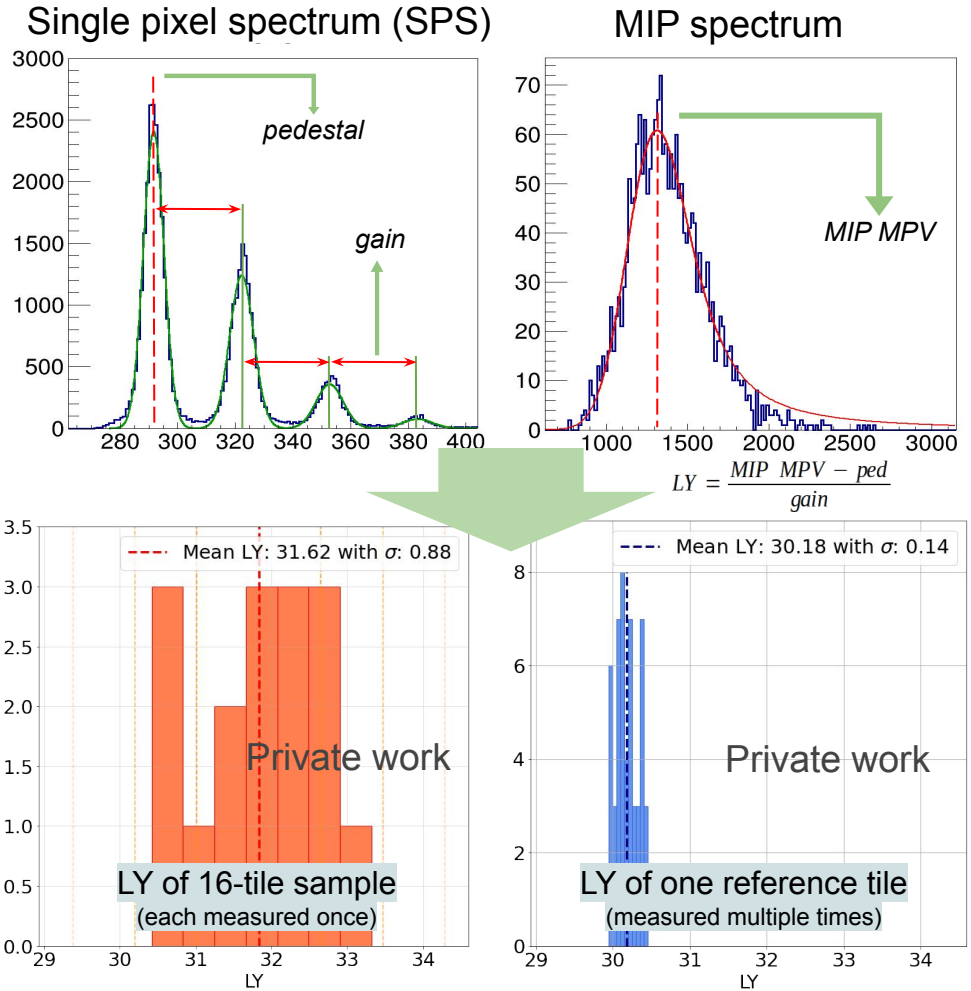




LY test stand

Goals and achievements

- Compatibility with all tile types
  - Various frames for different sizes
- Speed of measurement
  - Around 6 mins/tile for better than 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

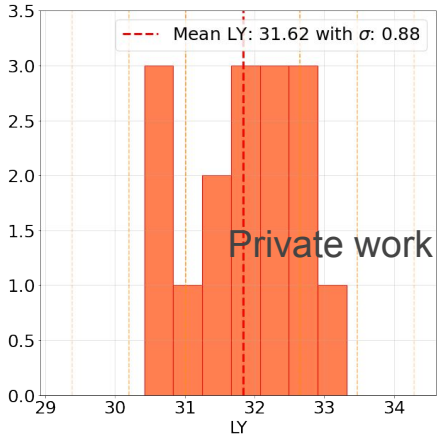


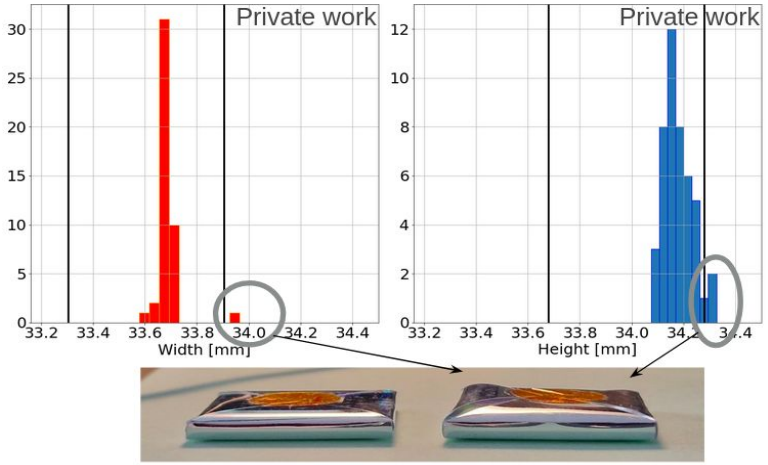
Conclusions

QC at DESY TAC for HGCAL

Tile Quality control program at DESY Tile Assembly Center 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





Backup

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Tile wrapping machine

Backup

Pick-and-place machine