

Development of scalable production techniques for SiPM-on-tile modules at DESY

CALICE Meeting Everywhere

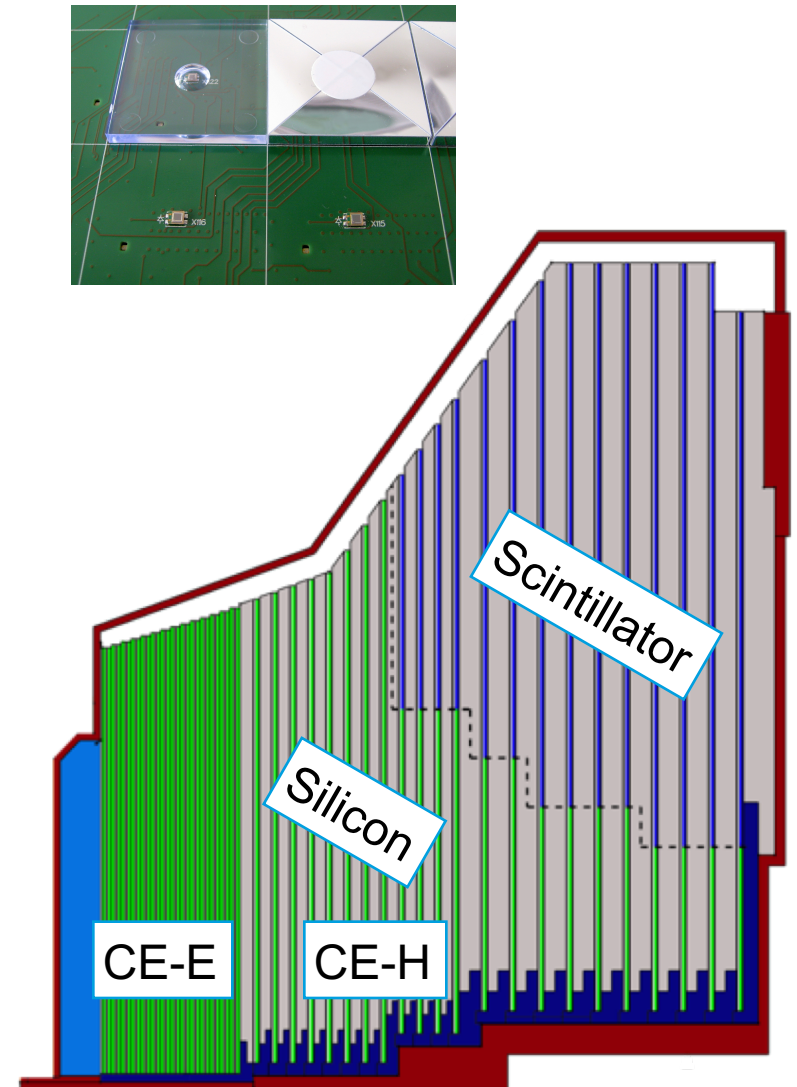
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Introduction

From AHCAL to HGCAL

- CMS calorimeter endcap will be replaced for HL-LHC by **High-Granularity calorimeter**
- Synergy with high granularity calorimeter concepts developed for electron-positron colliders
 - Use scintillator wherever radiation levels allow
- Design of scintillator part strongly inspired by AHCAL
 - SiPM-on-tile
- Production & assembly procedures following AHCAL technological prototype example, but adapted because of
 - Differences in size & design
 - AHCAL distributed between many institutes, HGCAL scint in two “clusters”: Russia+DESY, US (NIU+FNAL)

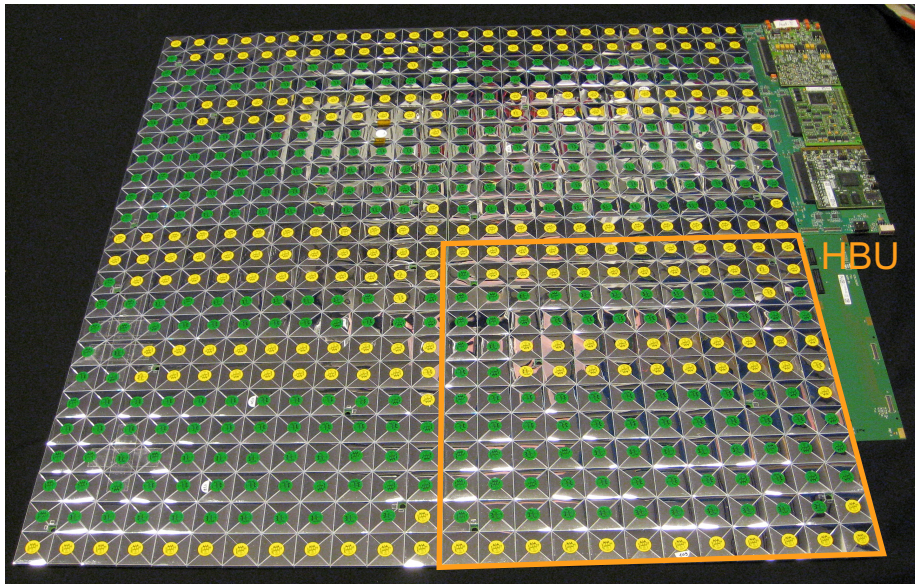


Differences between AHCAL and HGCAL

New challenges

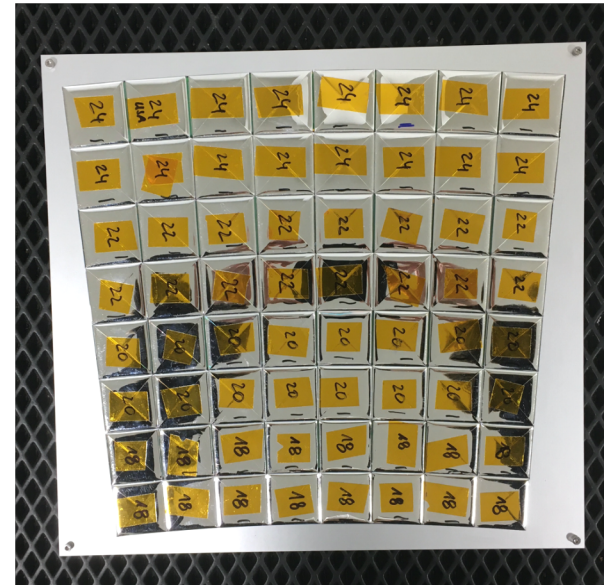
AHCAL Technological Prototype

- ~24 000 channels
- Tiles are squares
- All tiles have the same size
 - 30 mm side length
- All boards (HBUs) have the same size

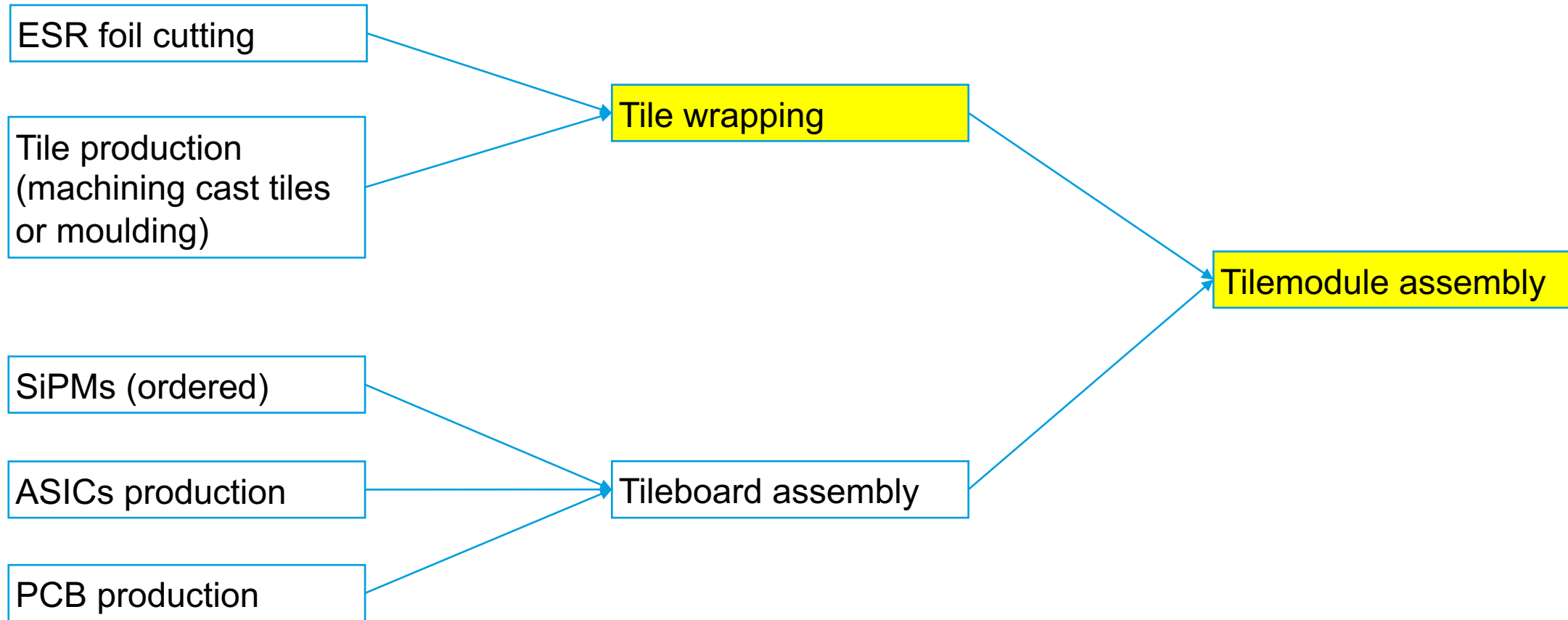


HGCAL

- ~240 000 channels
- Tiles are trapezoidal
- 21 different tile sizes
 - 23 to 55 mm side length
- 7 tileboard types, ~20 variants in total



Tile Module Assembly Process



Tile Wrapping

Wrapping Station

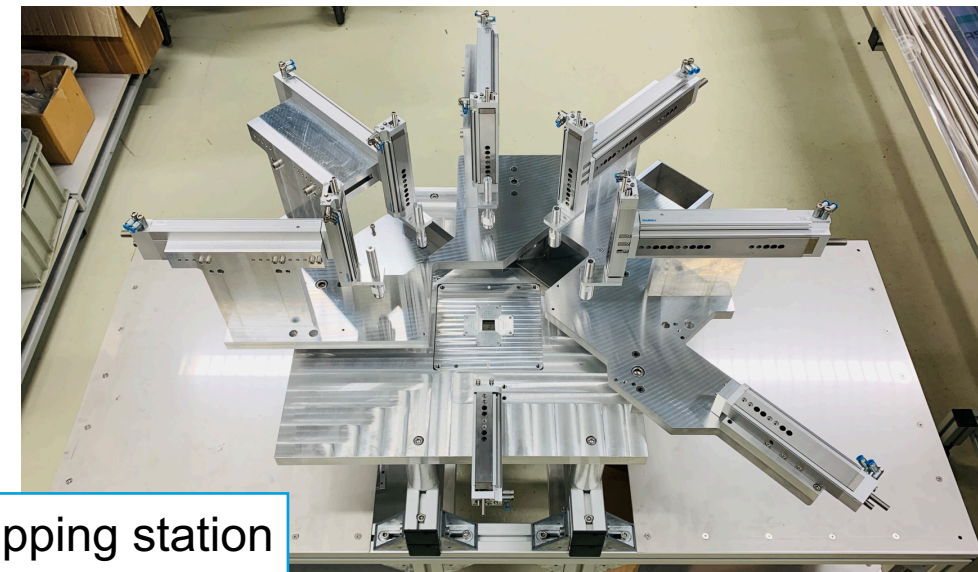
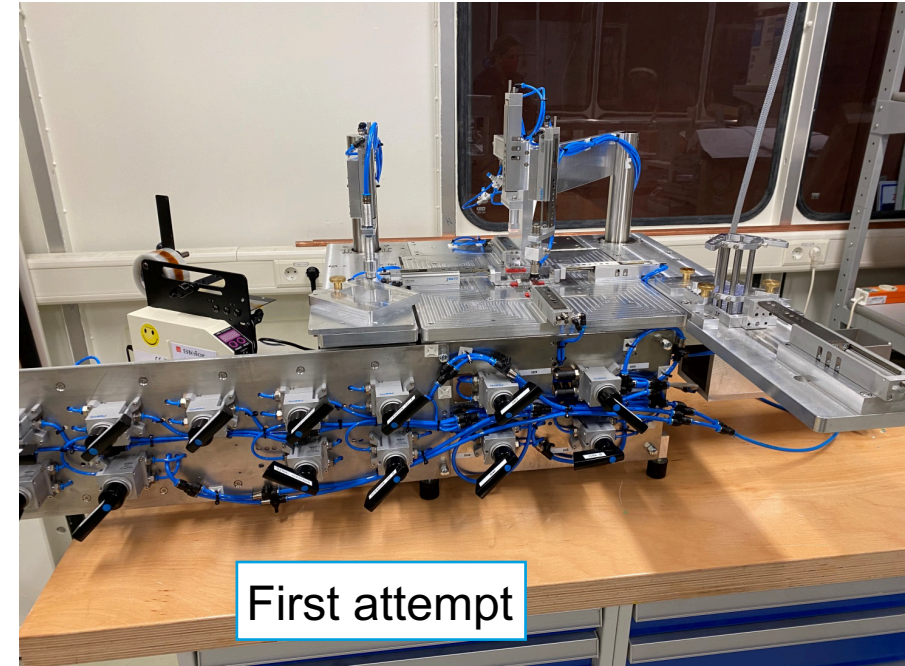
Improved Accuracy, Reliability and Speed

First attempt

- Following closely the CALICE Uni HH design
- Various tile sizes require removable inner part
- Rotational moves
- Valves operated manually
- Not really suitable for ~200 000 tiles
 - Used for all tiles in DESY testbeam so far

New Wrapping Station

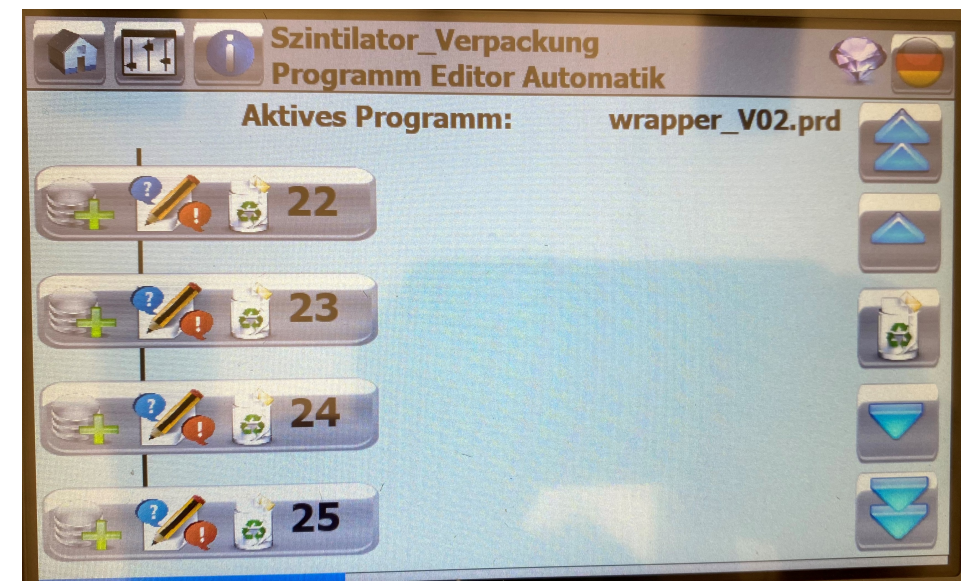
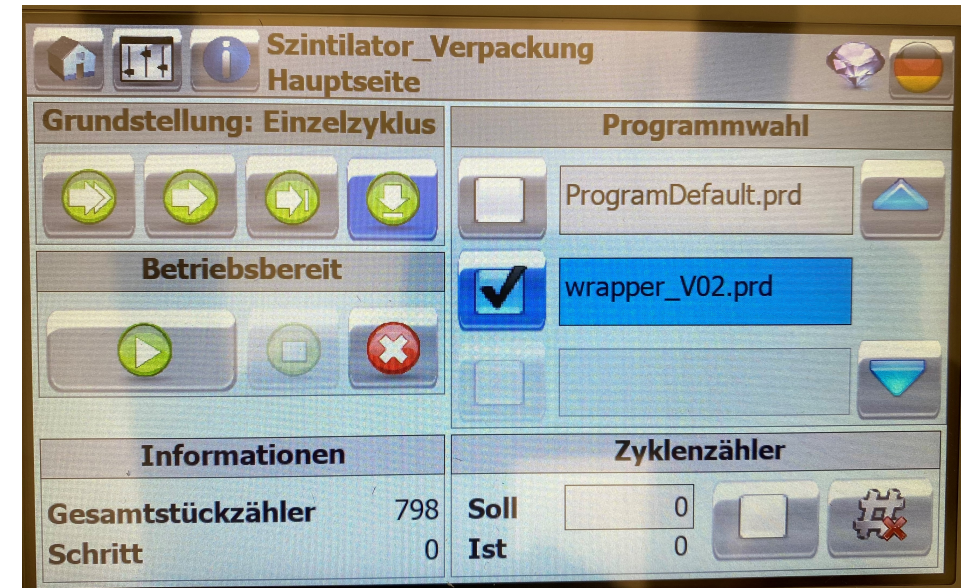
- Translational moves for better position reproducibility
 - Side remark: design developed by NIU based on servo motors: translations
- Electric valves with programmable control unit
- Designed and built during Corona period



New Wrapping Station

Components

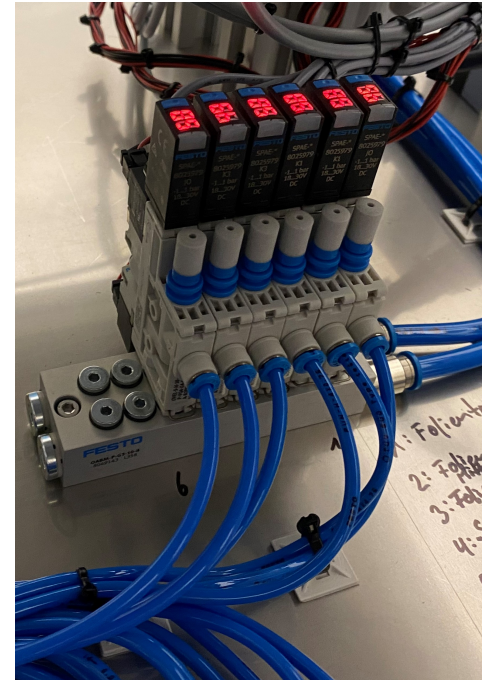
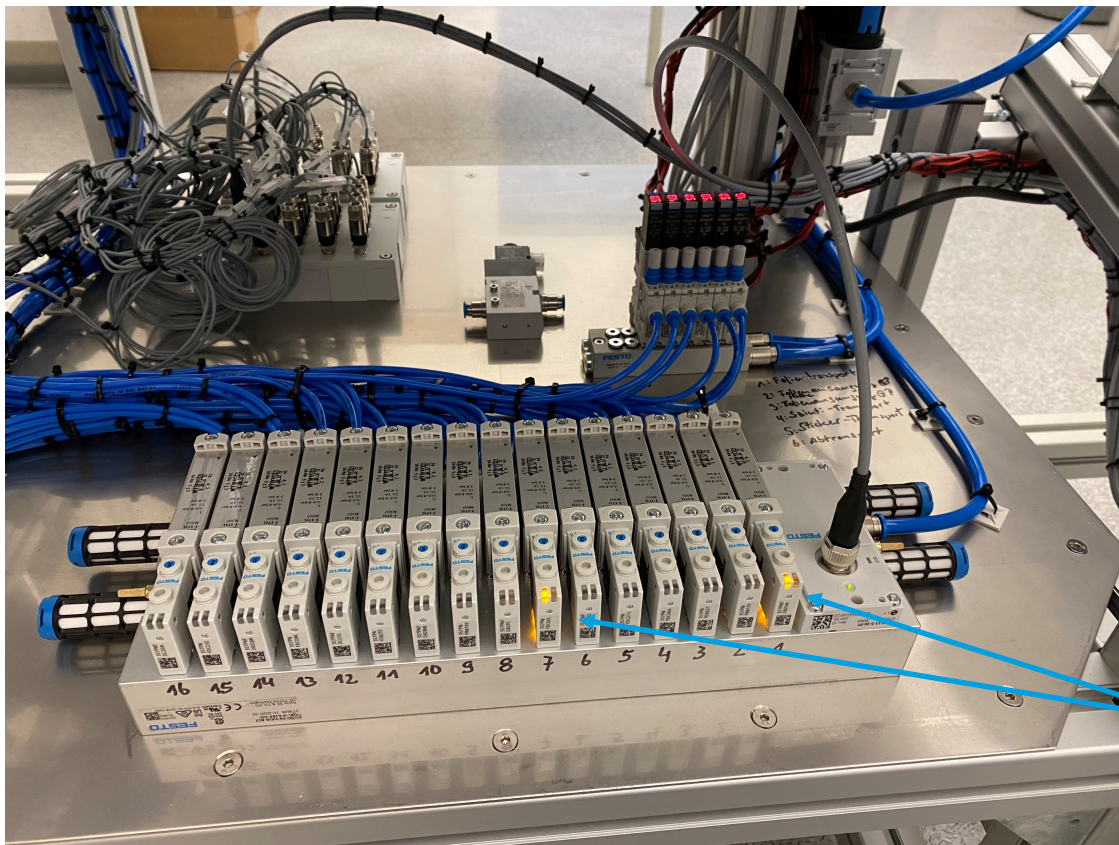
- Programmable control unit
 - Step-by-step automatic procedure



New Wrapping Station

Components

- Electric valves, nozzles and end position sensors



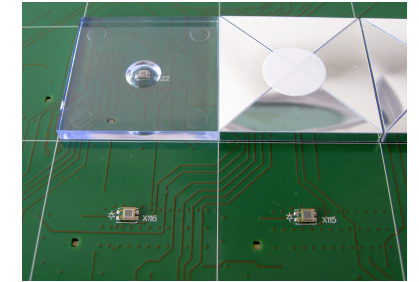
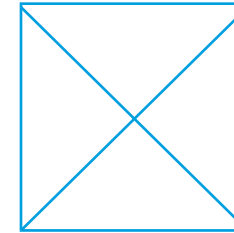
Valve island:
Light on = valve in operation

Wrapping Design

Long flaps and envelopes

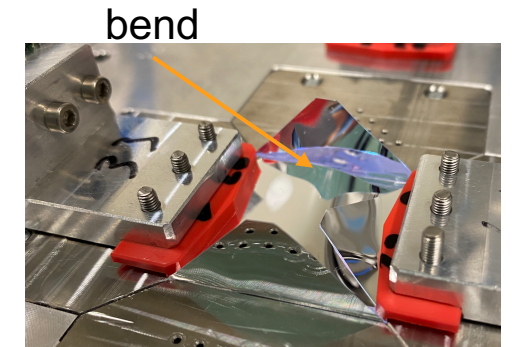
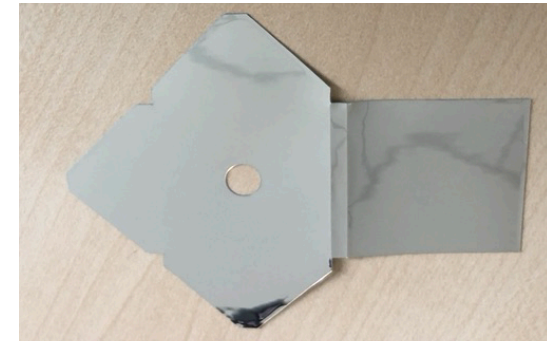
CALICE design: no overlap of ESR foil

- Pro: minimum height
- Con: light leakage through gaps possible (tolerances!)



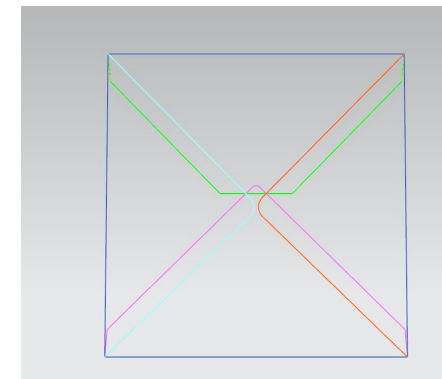
US proposal: long flap

- Pro: higher light yield (tested)
- Con: unsatisfactory results in automatic wrapping



New design: envelope

- Pro: no gaps with minimal overlap, works in automatic wrapping
- Con: none so far



Wrapping procedure

Open Points and Next Steps

Reflector foil feeding from a pile

- Very smooth surface: strong friction
- Measured electro-static charging effect, up to 17kV
- Initial tests with ionisation gun encouraging
- In the process of choosing device

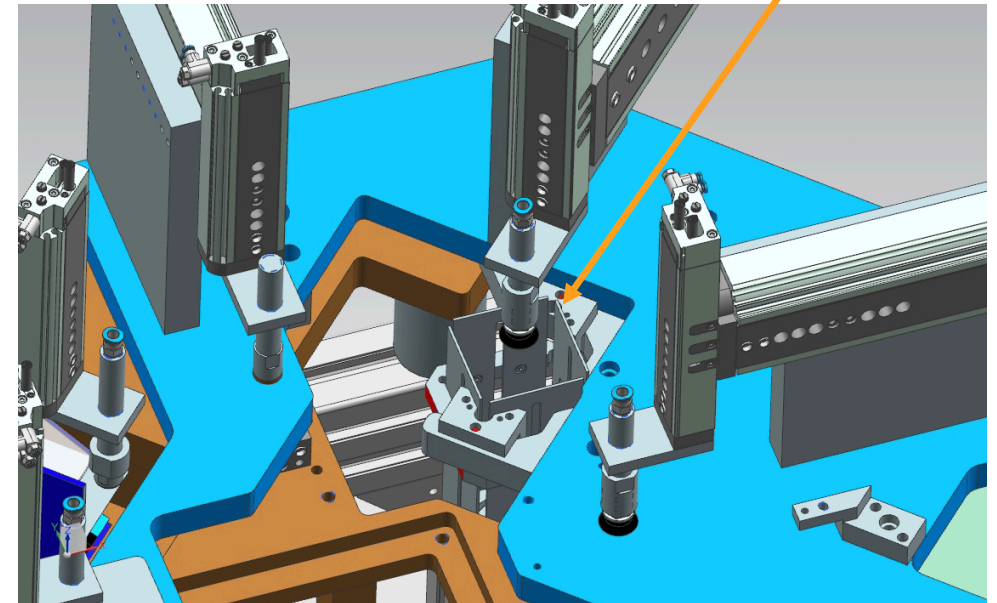
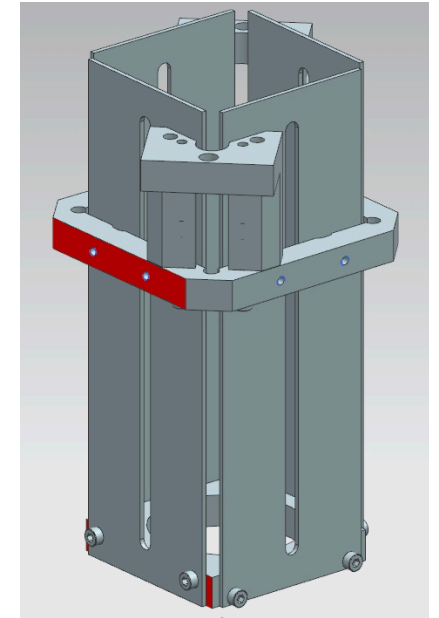
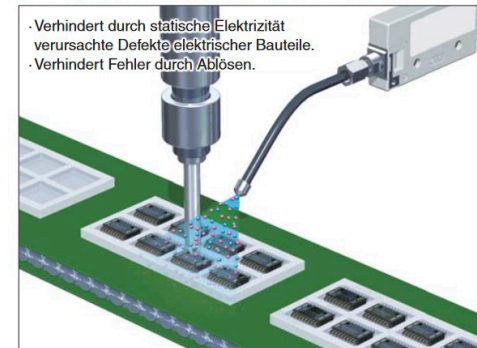
Tile output

- So far wrapped tiles slide into a basket
- Designing output container to preserve orientation
 - Exchangeable for different tile sizes

Next steps

- Finalize programming
- Implement interlock (safety)
- Improve sticker design to indicate tile size&orientation
- Fine-tune for best wrapping quality

Punktgenauer Abbau statischer Elektrizität



Tilemodule Assembly

Tile Assembly Procedure

Adjustments

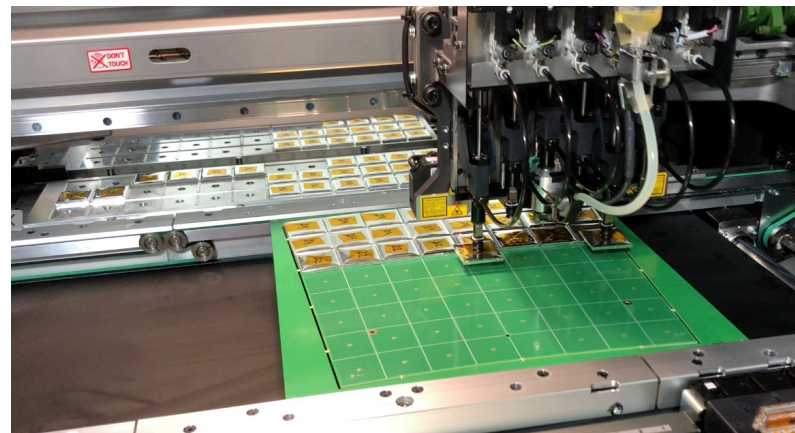
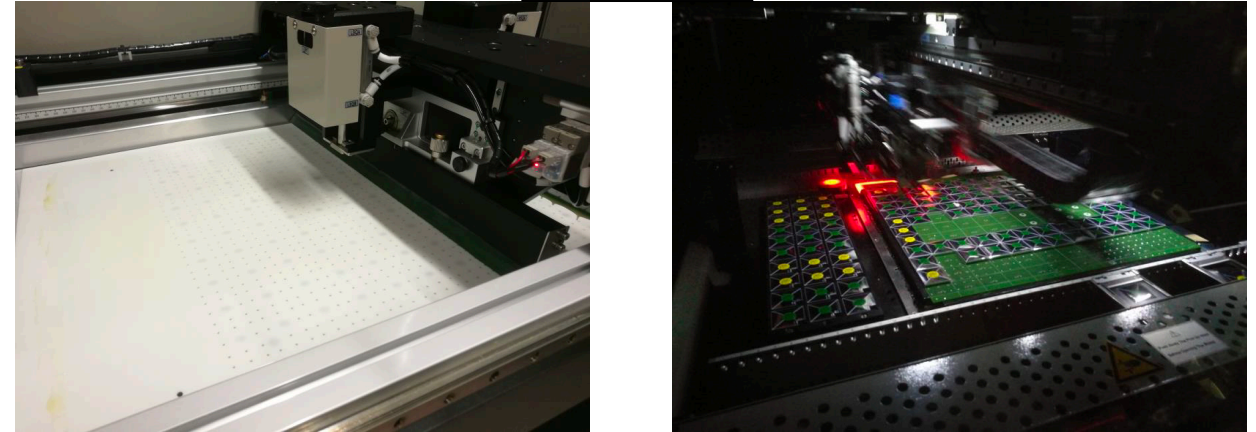
CALICE procedure in 2 steps

- Glue dispensing by screen printing
 - Cleaning of screen rather tedious
- Tile assembly with pick-and-place machine

HGCAL procedure using only pick-and-place machine

- Dedicated head with glue dispenser
 - Changed glue pattern for better reproducibility: lines instead of dots
- Tile assembly as for CALICE

Uni Mainz



DESY

Pick-and-place machine

Status

- Delivered and installed in November 2020 in the Detector Assembly Facility at DESY
- Two test assemblies of dummy boards with “production” tiles in November and December 2020
 - MEPhi moulded tiles (slightly out of tolerances)
 - wrapped on (old) wrapping machine with “envelope” foil design



Tile Assembly

Step-by-step

Preparation of the P&P machine

- Preparation and loading of glue and of tiles

Tilemodule Assembly

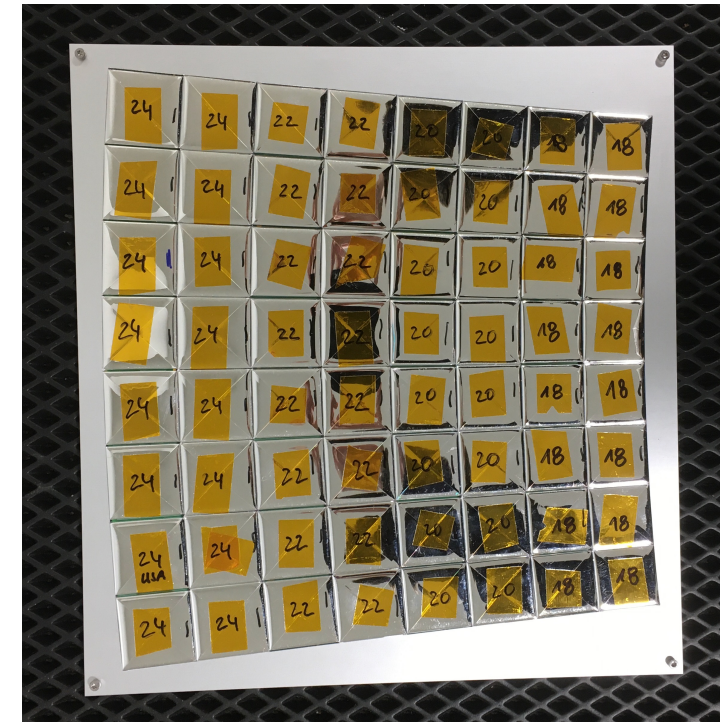
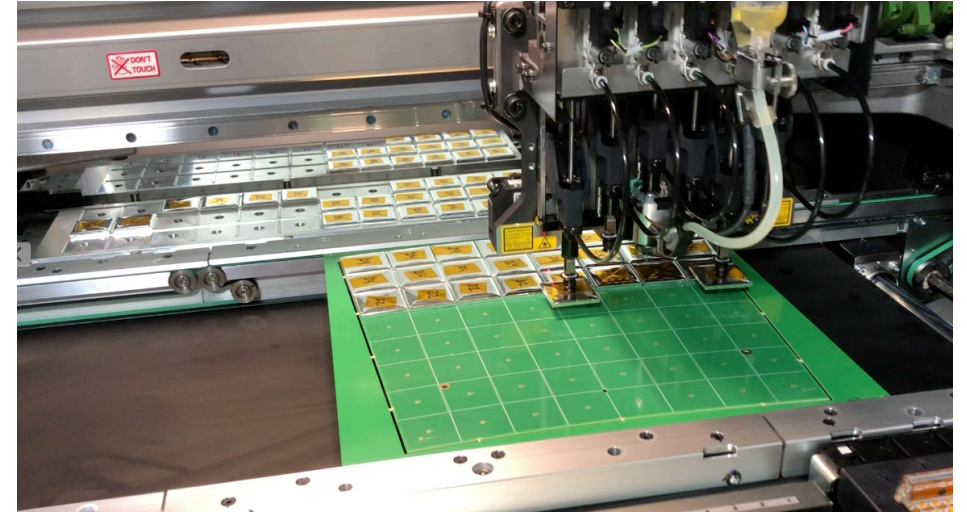
- Loading of the PCB (~10 s)
- Measurement of the PCB flatness (~35 s)
- Testing of the glue (~5 s)
- Glue dispensing (~6 minutes)
- Tile placement (~80 s)
- Total: < 10 minutes / module

Curing

- Metal frame to prevent tiles from moving

Cleaning!

Still some optimization to be done



Pick-and-place machine

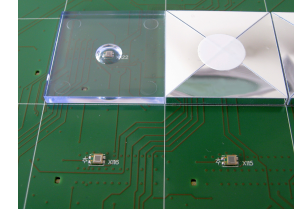
Working!



Summary

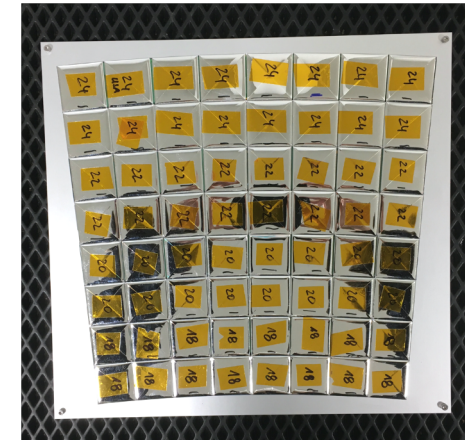
And Outlook

HGCAL SiPM-on-tile module production follows AHCAL technological prototype example

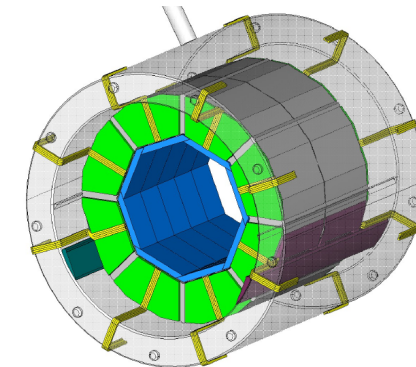


Scaling up by one order of magnitude (and differences in design) required some changes in the assembly procedure

First tests done, working on improvements and “infrastructure”: QA/QC setups, database, climate chamber, storage, ...



Collider Detector AHCAL construction will need scaling up by more than another order of magnitude!



Backup

New Wrapping Station

Working!

