Status of Ecal-e

Roman Pöschl

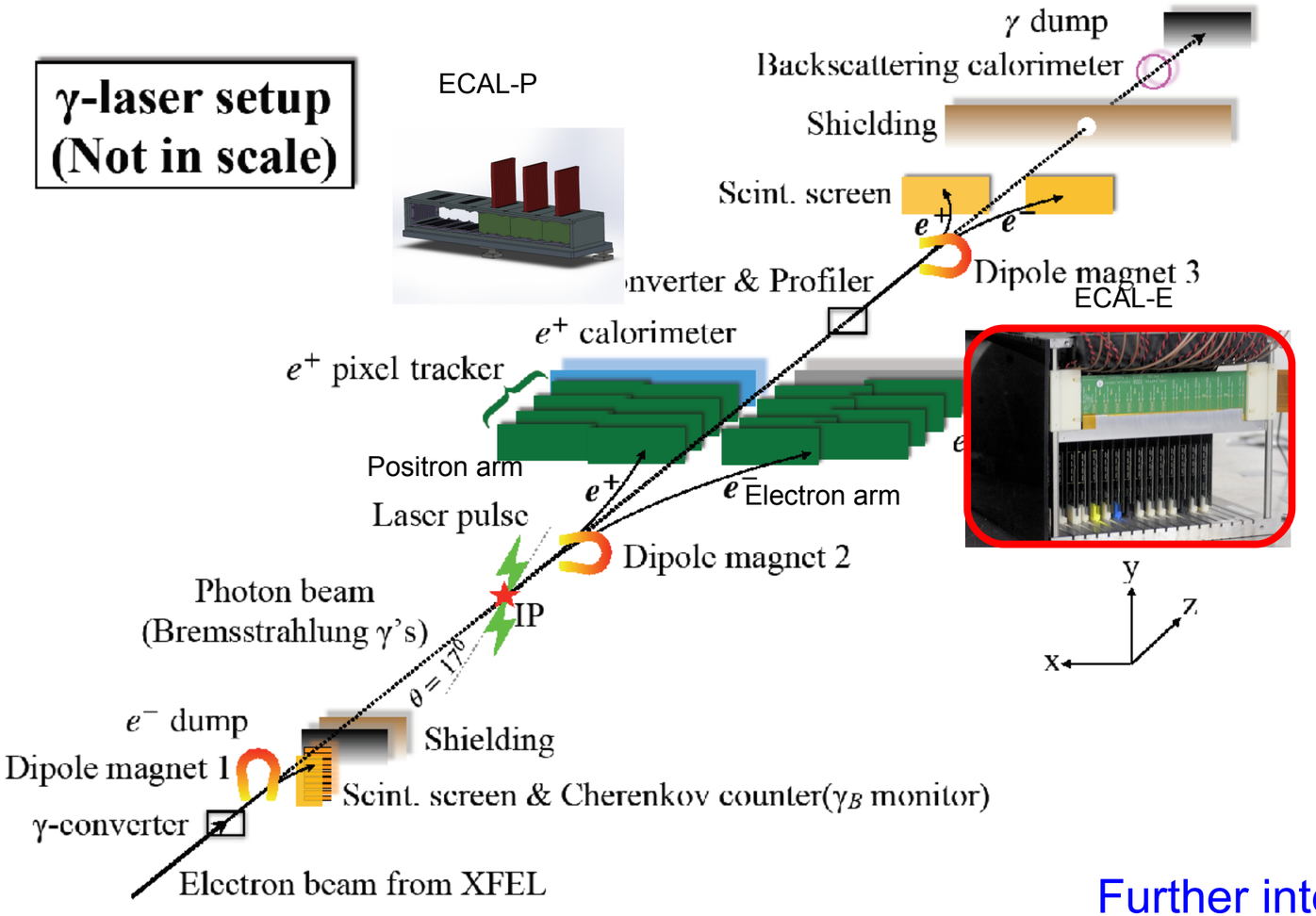
On behalf of

+ More groups that are not LUXE Members

LUXE Ecal Meeting – Valencia February 2024

“Early Applications” of CALICE Technologies - LUXE

Laser Und Xfel Experiment – QED in extreme fields



CALICE meets LUXE

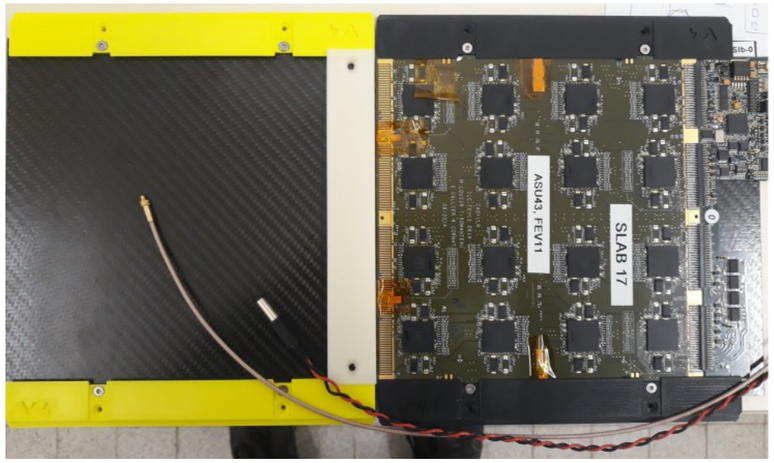
Granular calorimeters in positron and electron arms of spectrometer

- Our focus ECAL-E
- Main application electron measurement of Breit-Wheeler process in γ-laser setup
- Could also be used in early LUXE phase in case of delays of ECAL-P
  - *Dark photon search next to γ dump could be further option*
  - *Note here that already our short layers would have (almost) sufficient acceptance*
- Ideal application(s) of CALICE SiW Ecal technological prototype

Further interest by dark photon experiments EBES (KEK) and Lohengrin (Uni Bonn)

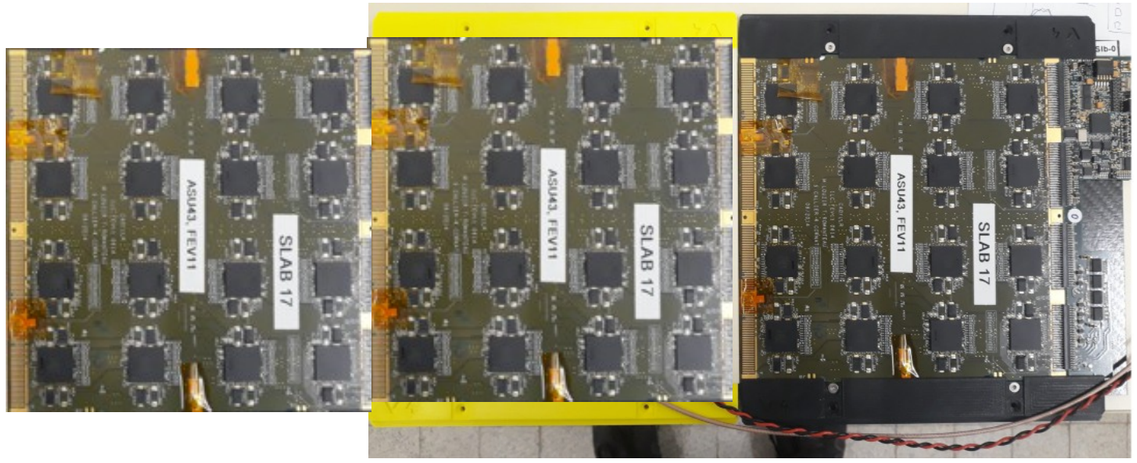
Plans (not only) for LUXE

Current: Tower of 15 18x18cm^2 layers



- Stack under revision
- Revision possible with small amount of funding
- Revised stack should/could be available during 2024

Future: Lateral extension to up to 18x54cm^2 layer (three towers), up to 15 layers of this type



- Straightforward application of work for CALICE
- **Details of implementation in LUXE requires simulation study**
- **=> need dedicated funding including person power!**

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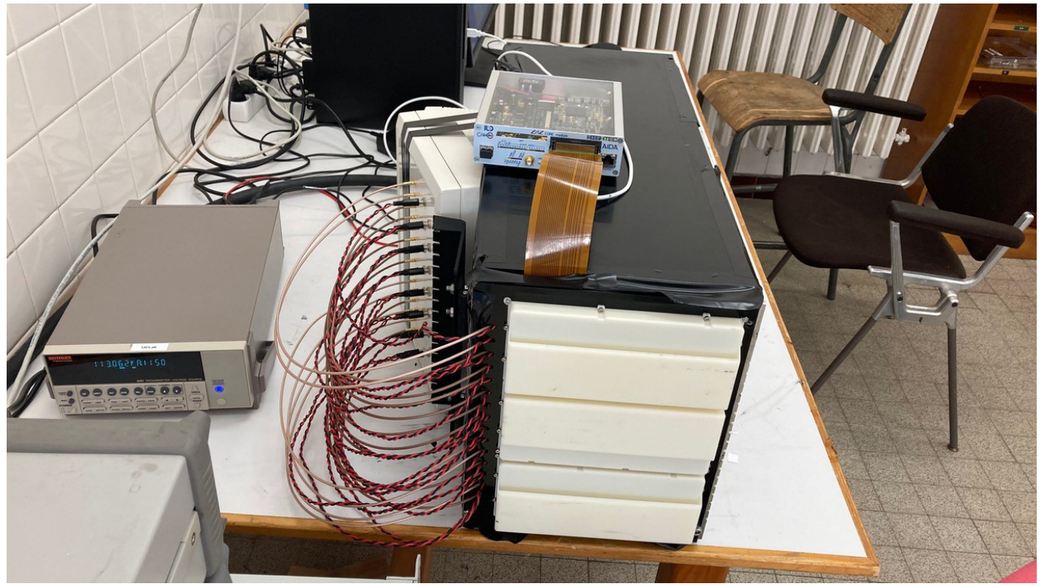
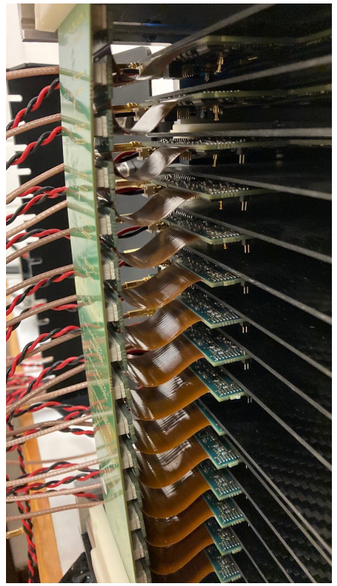
- LUXE stack = v0 of SiW ECAL engineering prototype

SiW ECAL: 2022

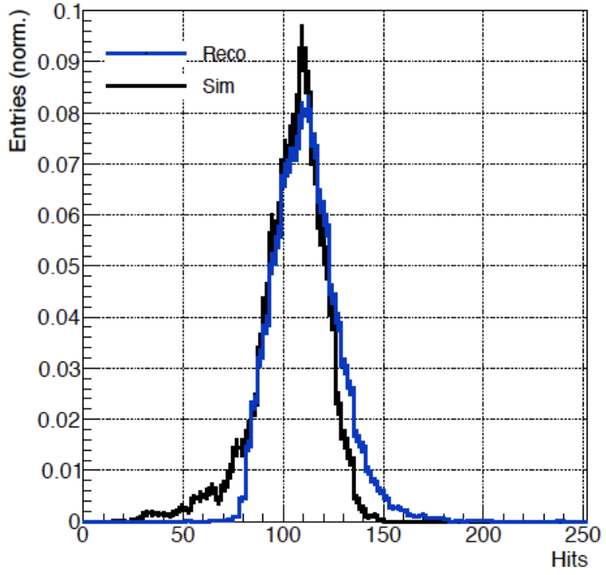




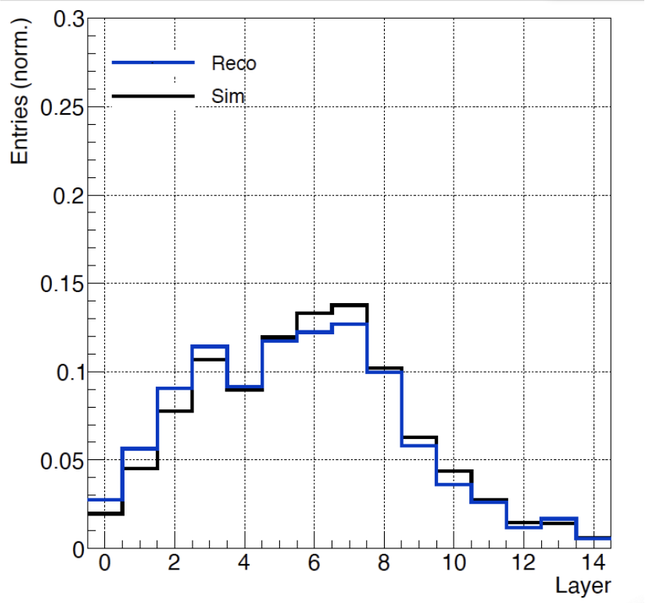
- 15 short layers equivalent to 15360 readout cells
  - Up to 21 X_0
  - Overall size 640x304x246mm^3
  - Flexible mechanical structure to adapt to beam conditions
  - Most of the layers produced 2016 - 2017
- Commissioned 2020-2022
  - ~450000 calibration constants for one ASIC feedback capa setting
- Testbeams (finally) in November 2021 and during 2022
- Mainly technical tests but also first real showers

CERN Data – Analysis 10 GeV e-

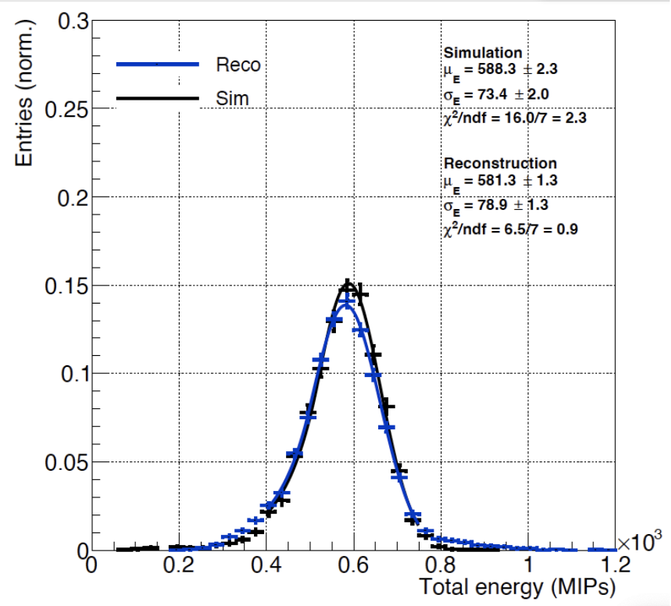
Total #of hits



Hits/layer

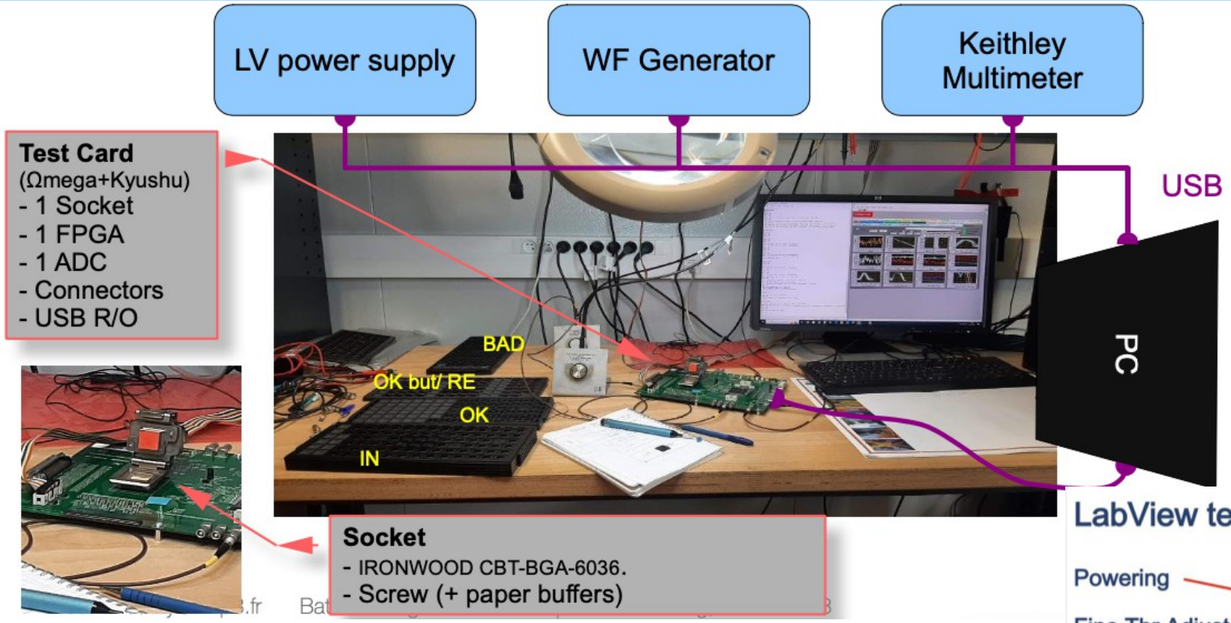


(Total Energy)/MIPS



- Reasonable agreement betqeen data and MC
- Energy resolution in ball park expected from simulation
- ILD: σE/E~15%/√E here ~12-13%
  - reason: ~factor 2-3 worse sampling ratios, “small” number of hits
- More analysis work required (including combined analyses)
  - Yuichi finished thesis -> person power needed

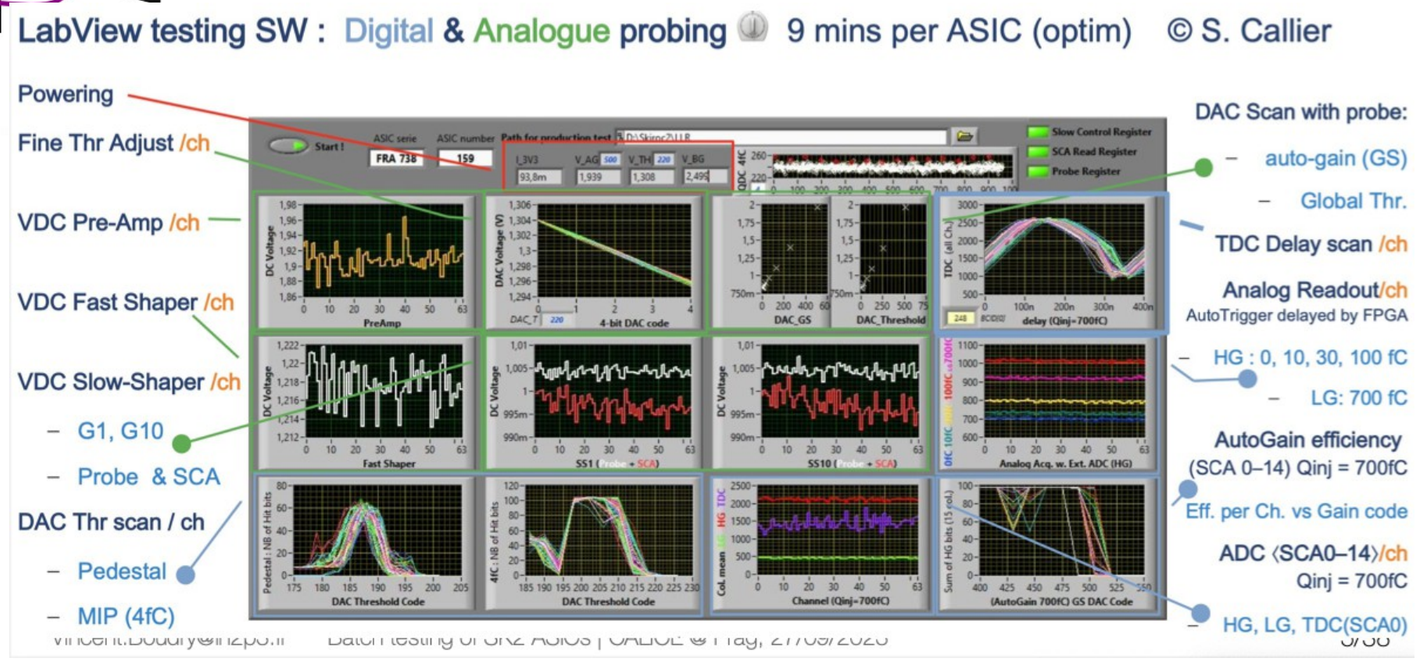
Towrard revised stack - ASIC Tests in 2023



Testbench at LLR

- 151/400 SKIROCs tested until September 2023 (more since?)
- Satisfactory yield
  - Should be enough for
  - 9 18x54 cm2 layers (to be verified)
- For more funding is needed
- DRD Calo run ?

Testprotocol by OMEGA



Towards revised stack - New PCB Version

New FE boards

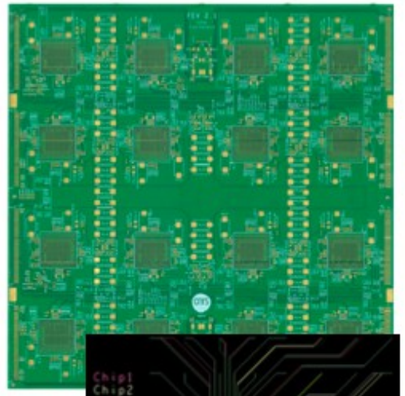
LLR, IJCLab, LPNHE, OMEGA

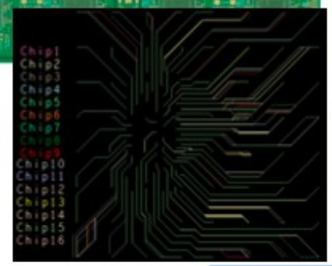
Improvements:

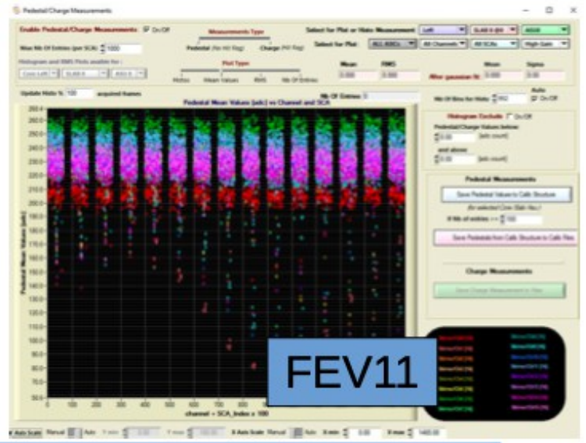
- Power distributions
  - Local power regulation
  - Local High Voltage filtering & Supply
- Signal distribution (buffering), data paths
- Monitoring (single ID, temp, probe analogue line)
- ASIC shielding/routing

Status:

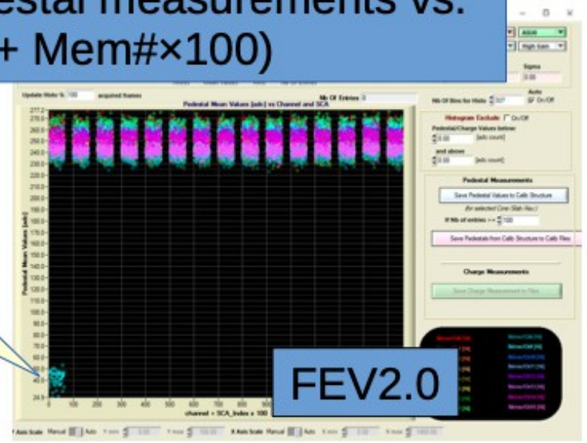
- pre-version 2.0 tested, minor corrections needed
  - Noise uniformity dramatically improved (ex: outliers in thr. / 20 !)
- version 2.1 produced, … in metrology
  - before cabling, 2nd metrology, gluing, …
  - All material available : ASICs being tested







Pedestal measurements vs. Ch# + Mem#×100)



SIngle channel → the fault on the ASIC/packaging

Goal: build 15 layer stack for 2024 based on these Boards

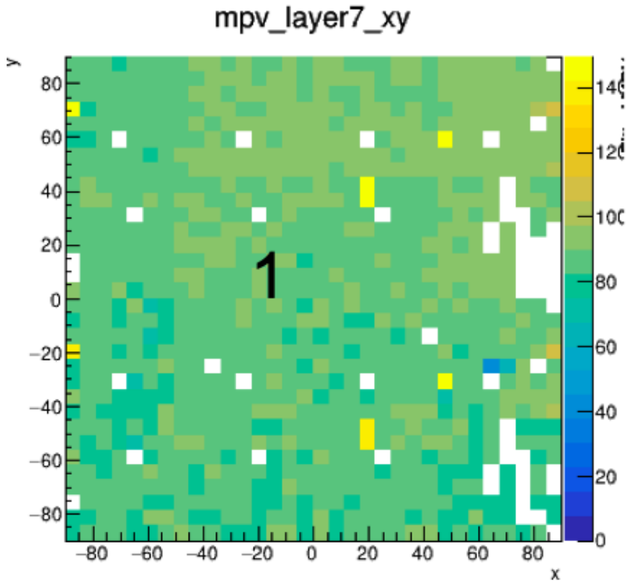
Toward new ASUs – Supplementary remarks

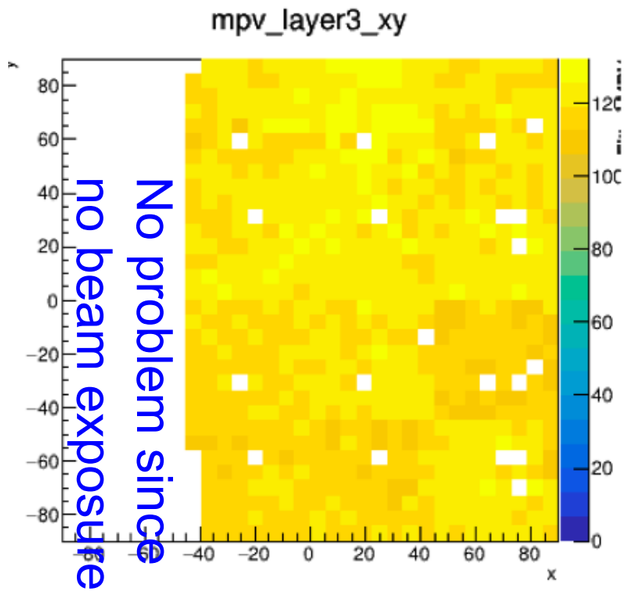
- Beam test at DESY in June
  - At least two new boards

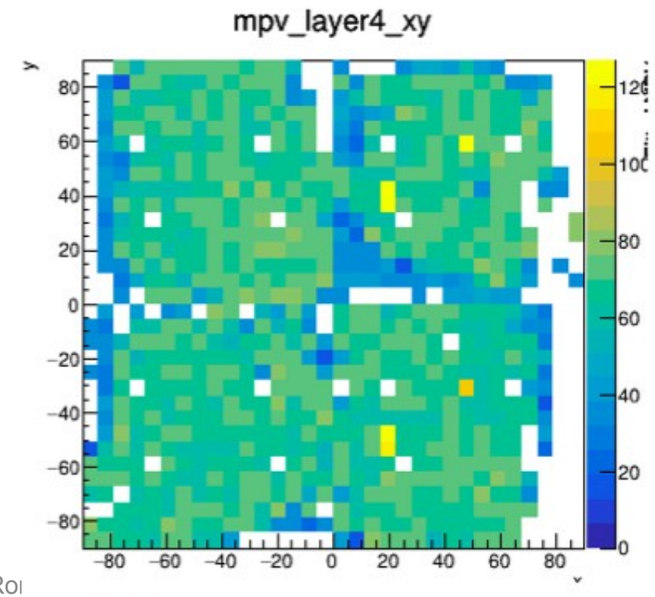
- Four fully equipped PCBs available for (electronics) tests
  - One at IFIC (as far as I remember)

- Apart from « conclusion » on gluing (see later) need to ramp up with work in lab
  - Restart of test benches
  - Clarify issues with e.g. HV Kapton
  - Firmware modifications to test analogue probes
  - Tests could be carried out by internship (approved for ~May – June) under guidance of PostDoc

Sensor delamination







We have good layers ...

- Homogeneous response to MIPs over layer surface
- > 90% efficiency for MIPs
- Here white cells are masked cells due to PCB routing
  - understood and will be corrected

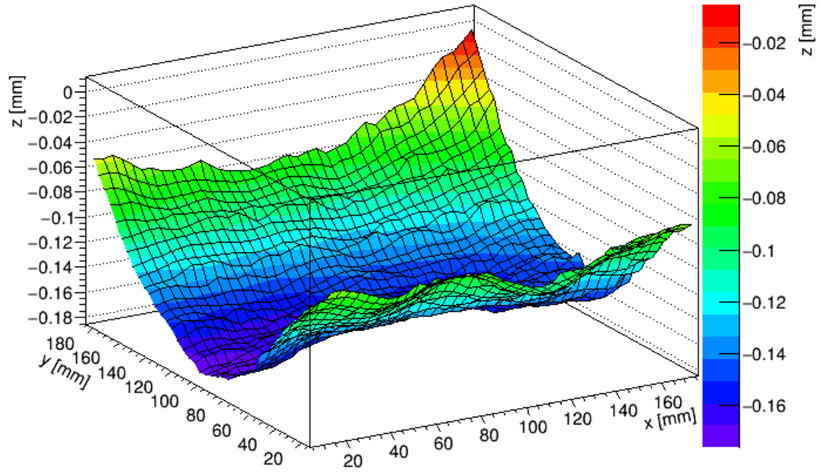
... and bad layers

Inhomogeneous response to MIPs

- Partially even no response at all, in particular at the wafer boundaries
- Visusl inspection confirmed with electrical tests show that the sensor
- Got delaminated from the PCB -> glus dots have failed
- ***Intensive topic of study***

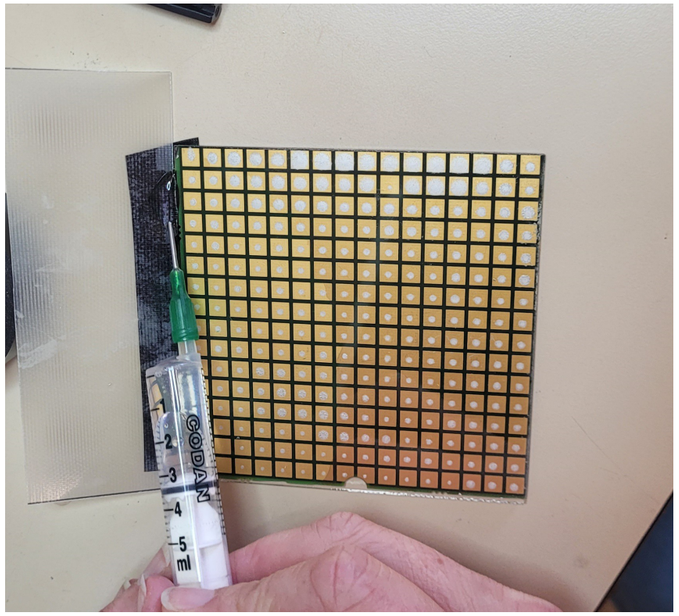
Systematic studies to avoid delamination – “Hybridisation”

Control of PCB Deformation



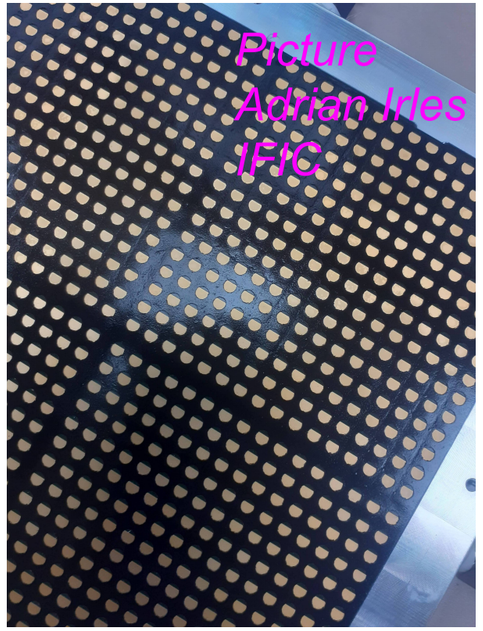
- We suspect mechanical deformation of PCB to be at the origin of the delamination
- => Control PCB shape at different steps of manipulation
- (e.g. After heating during component mounting)
- Work on consistency of measurements between IJCLab and IFIC

“Underfill”



- Low viscosity glue flows around glue dots
- Development in close contact with Epotek
- Seems to work -> “Solid piece”
- Requires second curing step at 80°C

“Double sided tape”



- Undrfill “replaced” by double-sided tape
  - Holes with laser
- Encouraging first experience
- Details see Adrian's talk

Mechanical tests at IJCLab

Setup for mechanical tests

After breaking the glass

- Cards supported with underfill seems to resist better to external force than w/o
- Tests with double sided scotch started

Summary and Conclusion

- Slow but steady progress on SiW Ecal
  - Visible progress on data analysis
    - Need to ensure knowledge transfer since PhD student(s) are on leave
  - New PCBs available
  - Limited amount of ASICs available
  - Sensors for revision of CALICE stack available

- Bottleneck is solution of wafer delamination issue
  - Two solutions are studied in close cooperation between IFIC and IJCLab
  - ... plus support by DESY thanks to DMLAB

- Funding
  - Some funding available for stack revision
  - Limited additional person power due to recently approved French-German project CALO5D on machine learning and timing for granular calorimeters
  - Would be rather for Ecal core business, not particular for LUXE
  - Some results of project (might be) transferrable to LUXE

- Dedicated work for LUXE would need supplementary funding of the order of 150-250 kEUR plus person power
  - Difficult to spot at this moment
  - Minor support for prototyping by labs and local funding calls (lottery but not impossible)
  - Therefore, only commitment is that we'll do our best to revise the existing CALICE stack
  - May benefit from activities in DRD Calo (e.g. ASIC purchase)

Backup