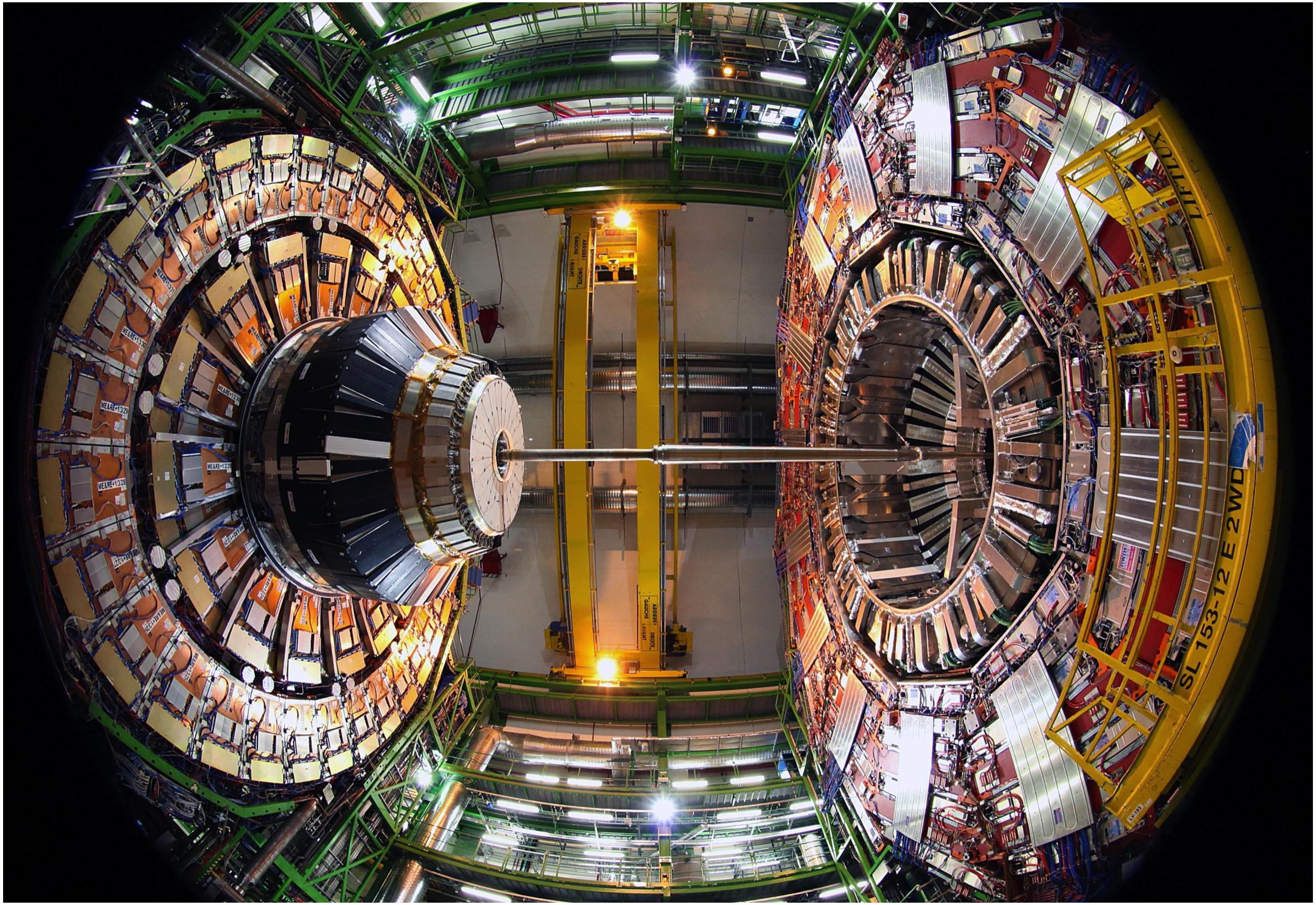
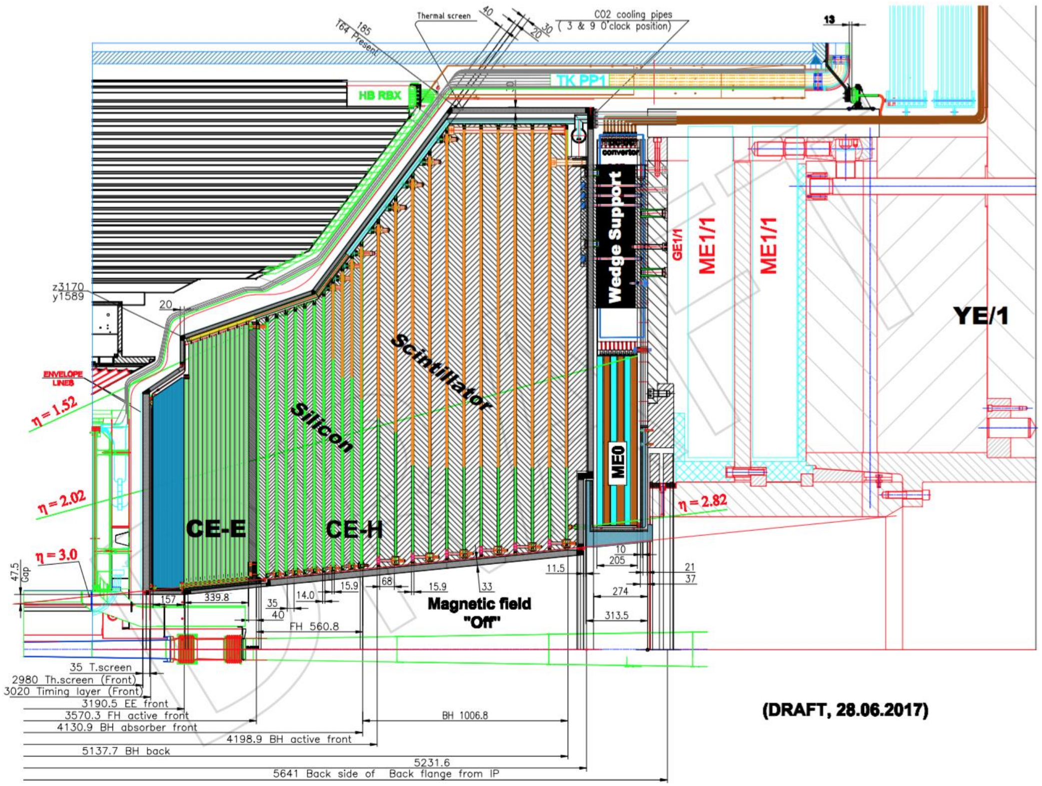
Phase II Endcap Calorimeter Upgrade: HGCAL



HGCAL Calorimeter Design: In Numbers



Construction:

- *Hexagonal Si-sensors built into modules.*
- *Modules with a W/Cu backing plate and PCB readout board.*
- *Modules mounted on copper cooling plates to make wedge-shaped cassettes.*
- *Cassettes integrated into absorber structures*

Key parameters:

- *600 m^2 of silicon*
- *6M ch, 0.5 or 1 cm^2 cell-size*
- *22000 modules (8" or 2x6" sensors)*
- *92,000 front-end ASICS.*
- *Power at end of life 120 kW.*

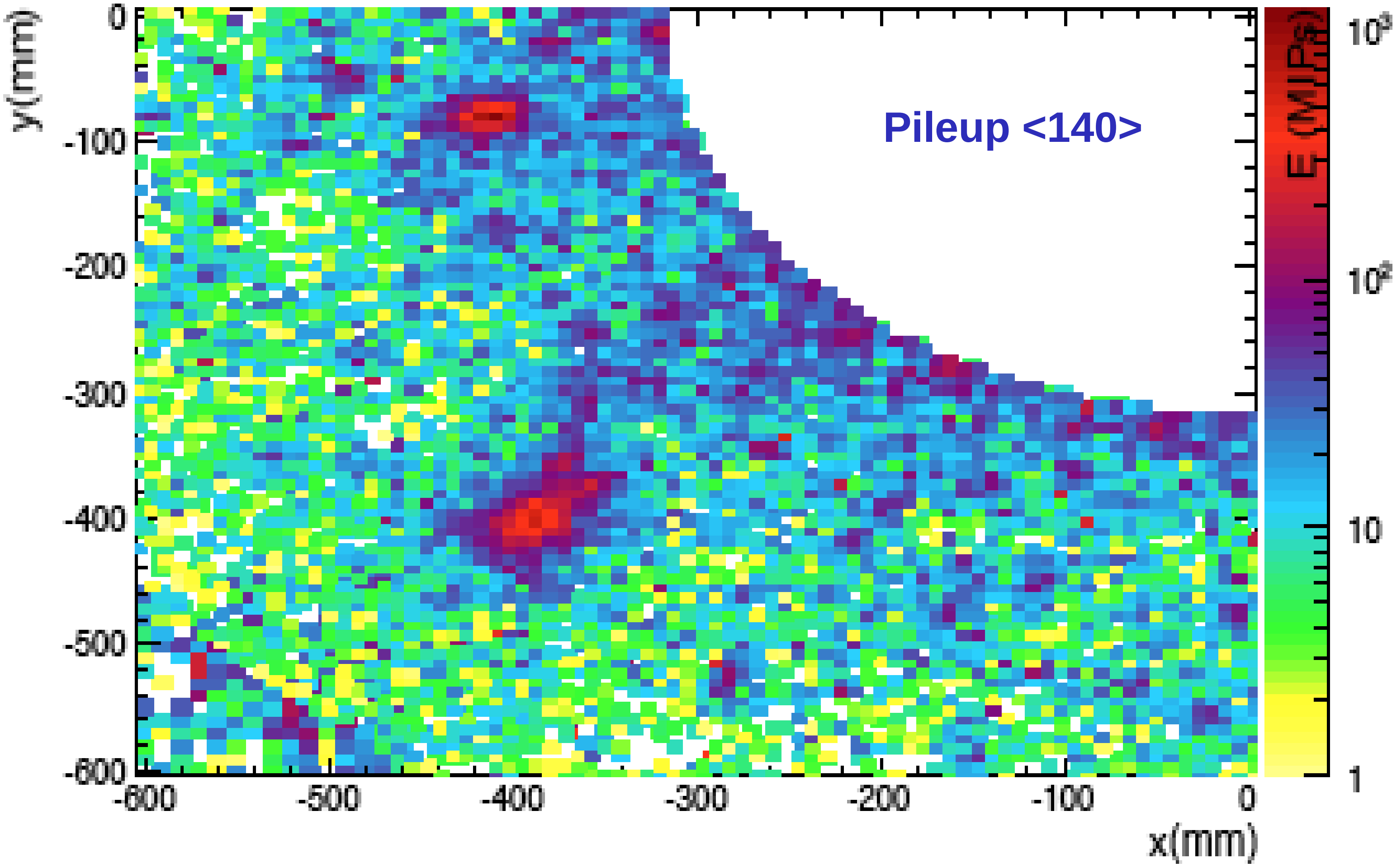
System Divided into three separate parts:

em calo (CE-E) – Silicon with tungsten/Pb absorber – 28 sampling layers – 25 X_o + ~1.3 λ

Hadronic (CE-H) – planes of Silicon OR silicon and scintillator tiles sandwiched between SS absorber plates – 24 sampling layers – 9 λ

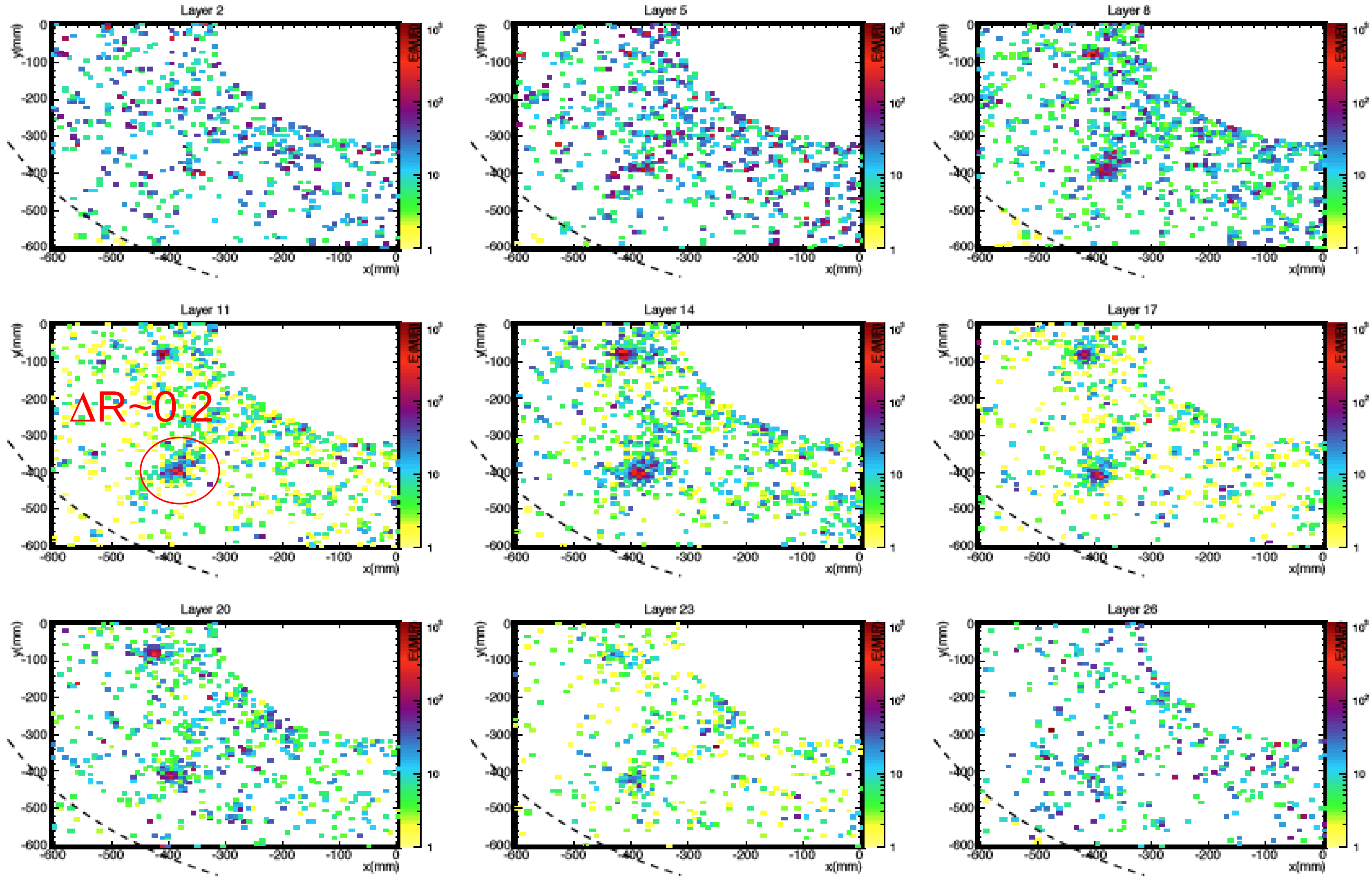
All the calorimeter is maintained at – 30ºC

Event Display of VBF Jets (VBF H→γγ)

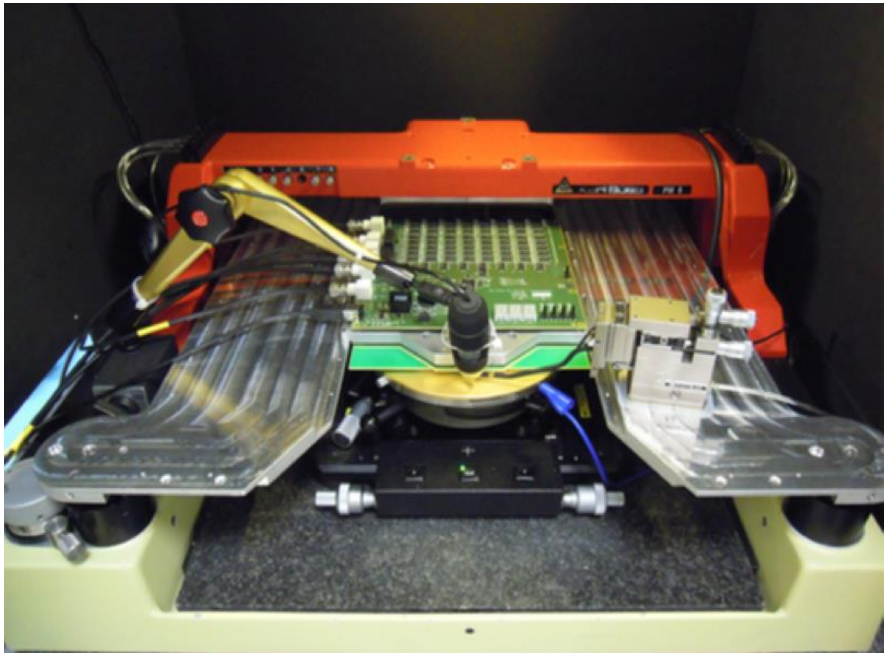


Event Display of VBF Jets (VBF H→γγ)

Standalone simulation: Taking Slices through ECAL section

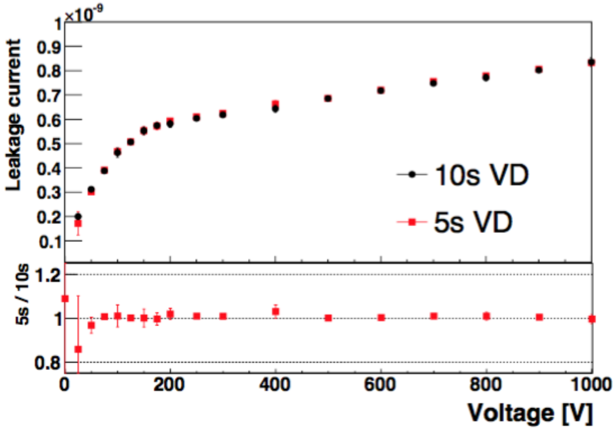


Example Of Si Sensors Testing
Probe-card

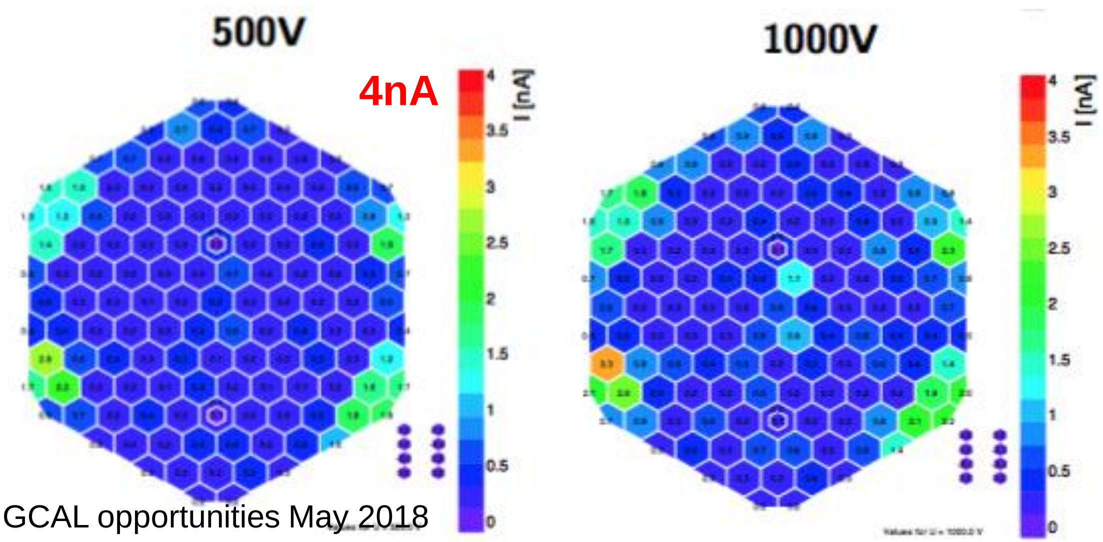


IV curve for one cell

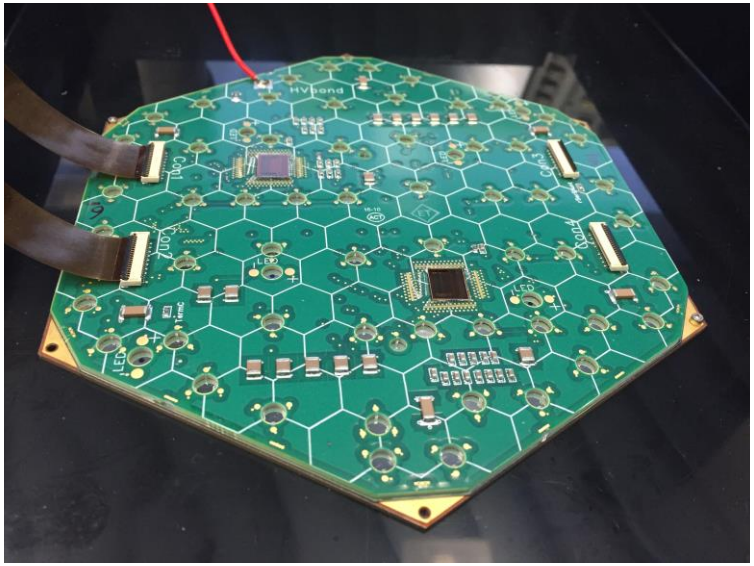
- Connect cells with probe card and make single cell scans
- Identify stable measurement settings:
  - Time to wait after change of voltage (VD)

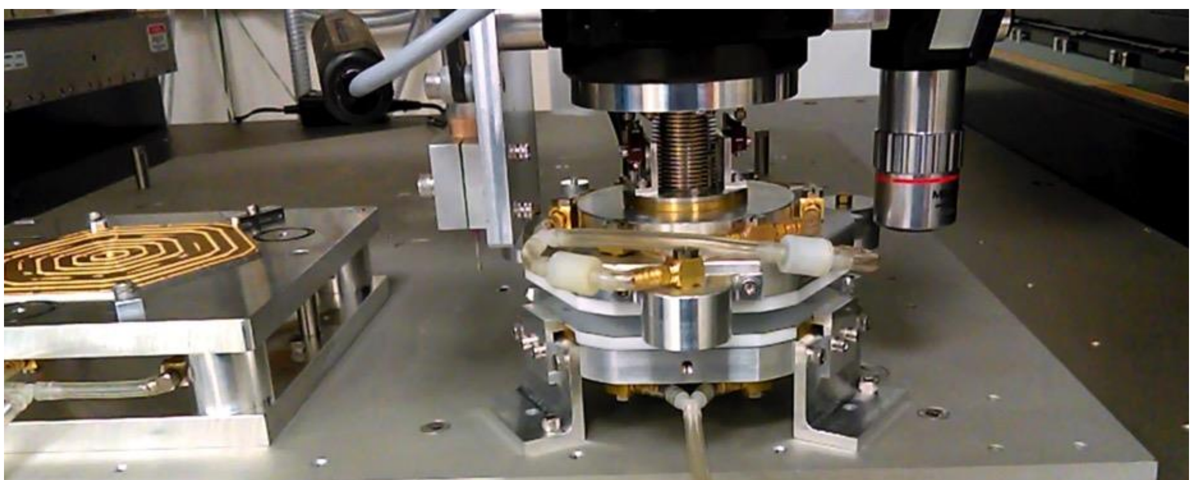


Whole wafer scans



Si Modules: Automated Assembly

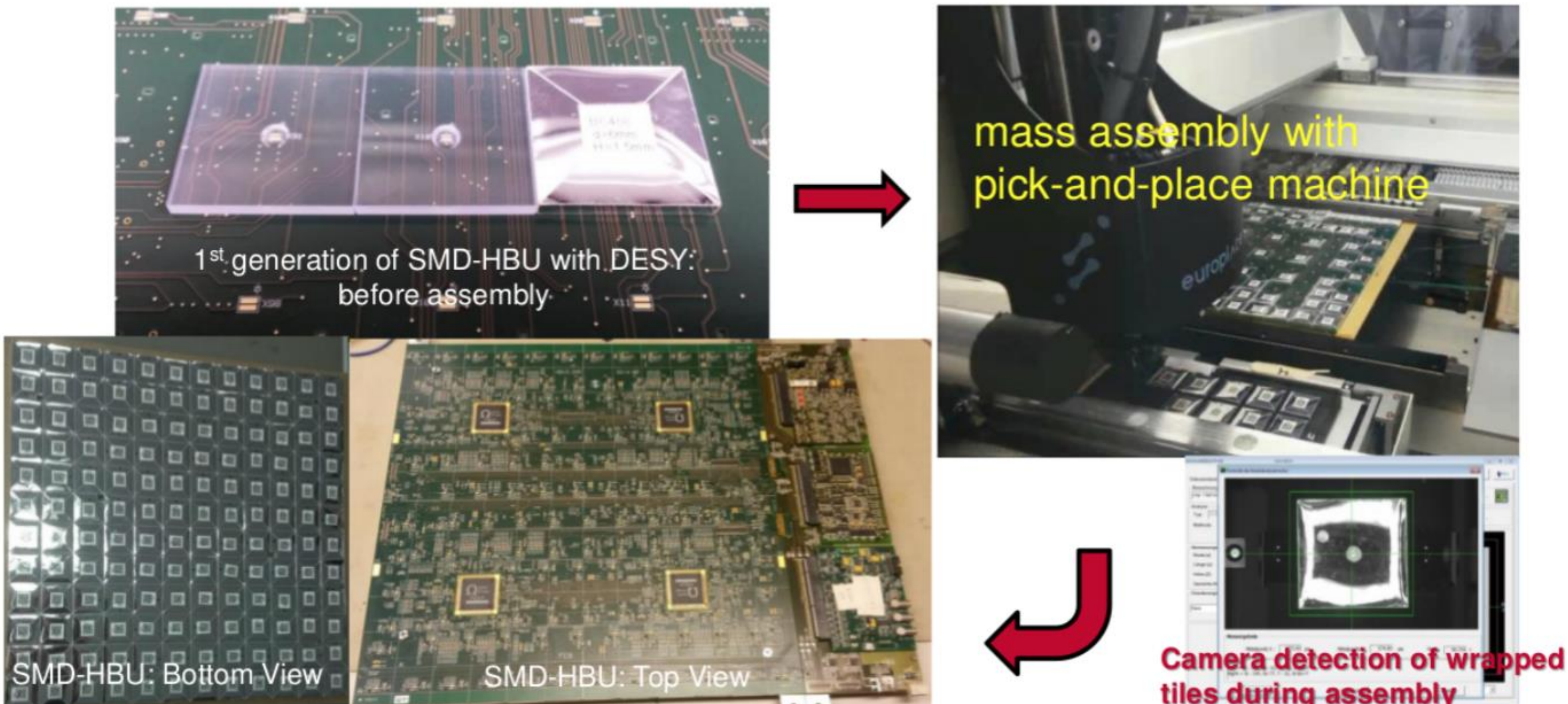




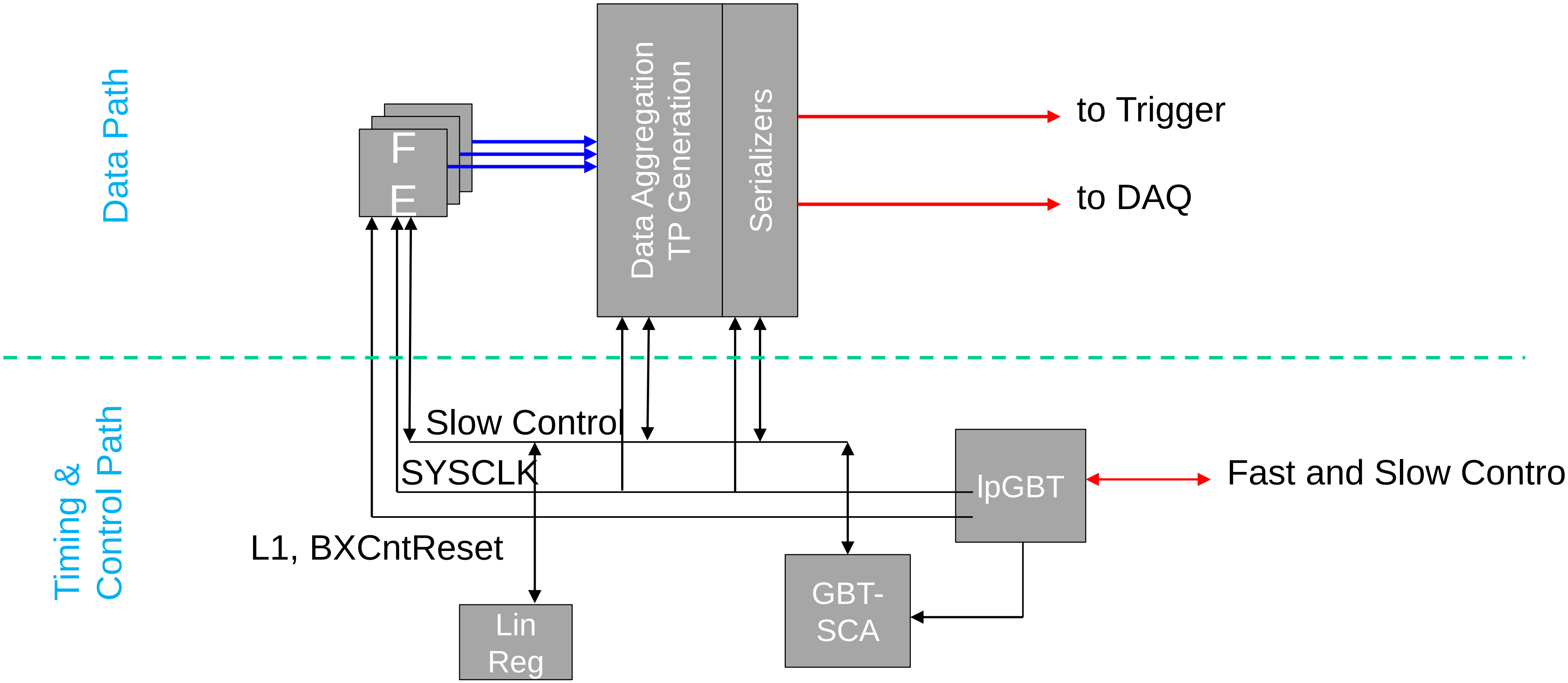
e.g. glue dispensed on aluminum baseplate with kapton

Wirebonder

Plastic Scintillator Hadronic Part: SiPM-on-Tile Modules

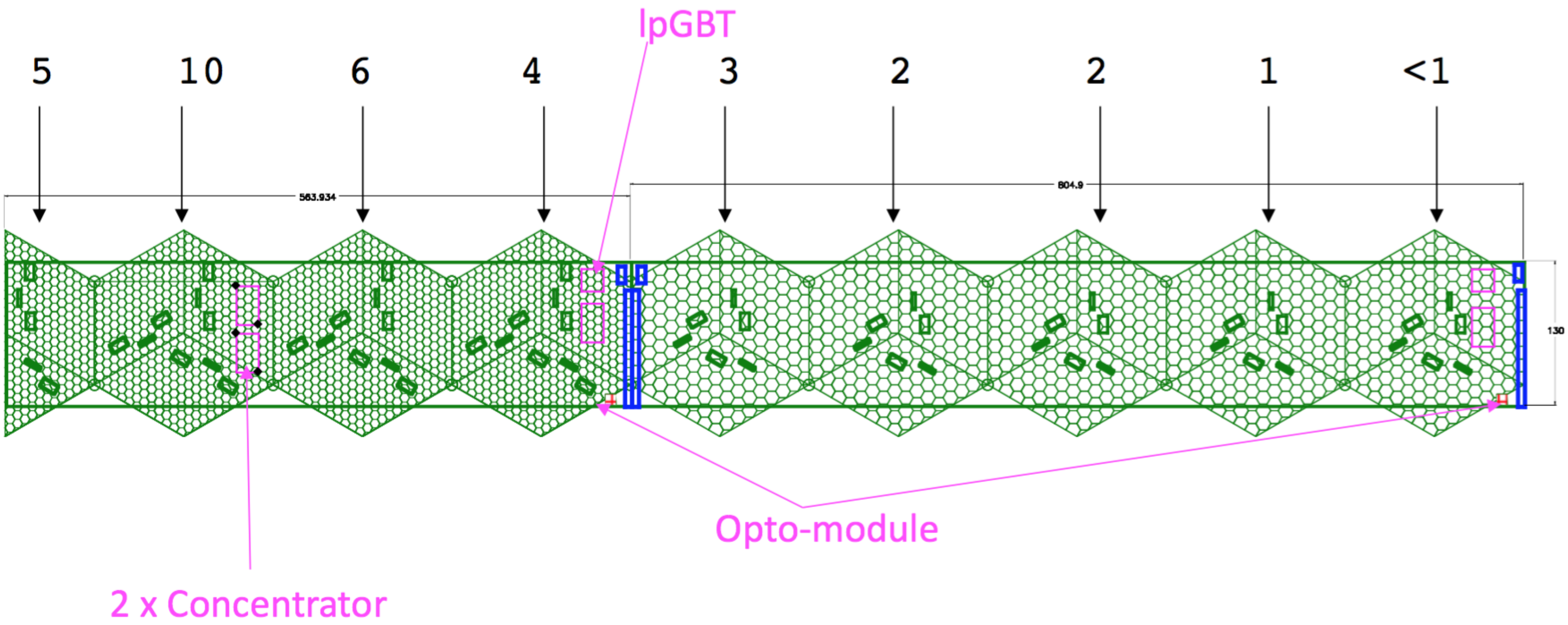


HGCAL FE Readout Architecture

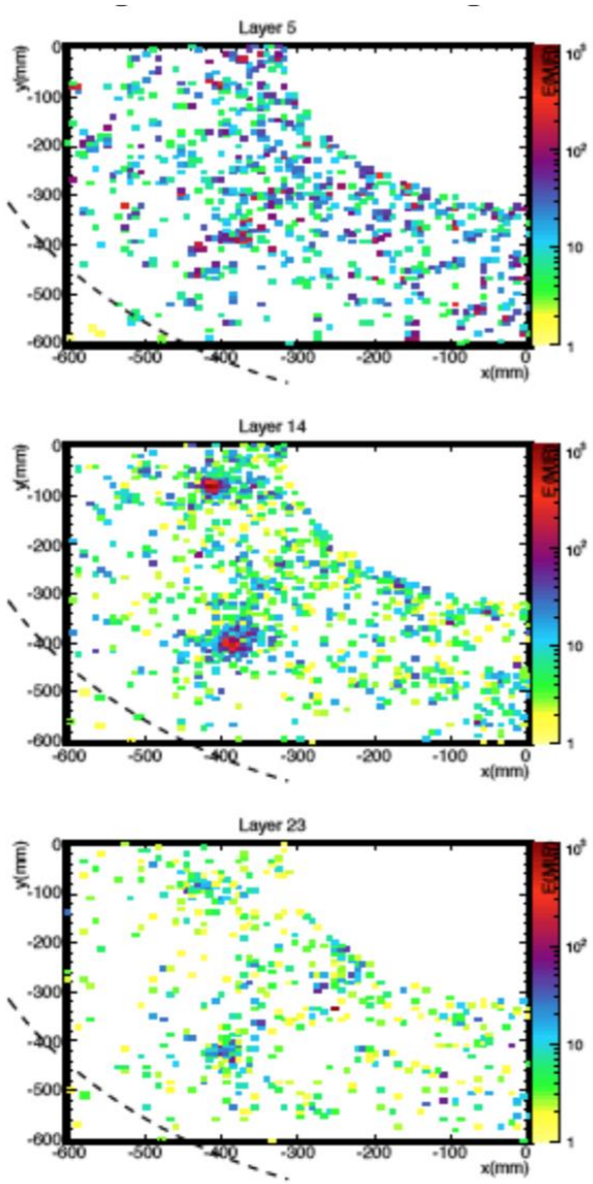


String of panels (2)

Rates (Gbit/sec):

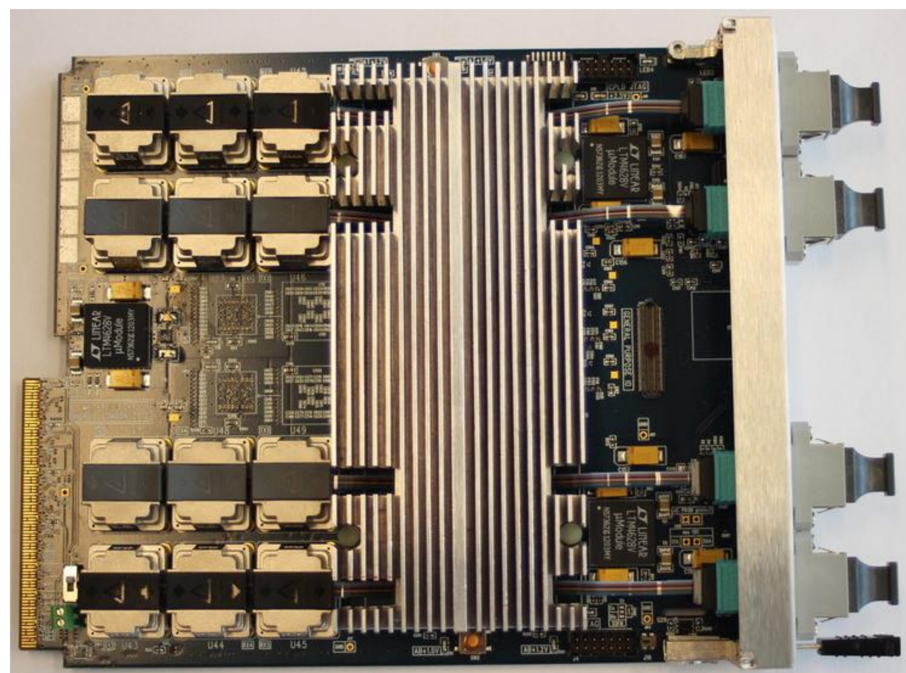


Trigger and Backend

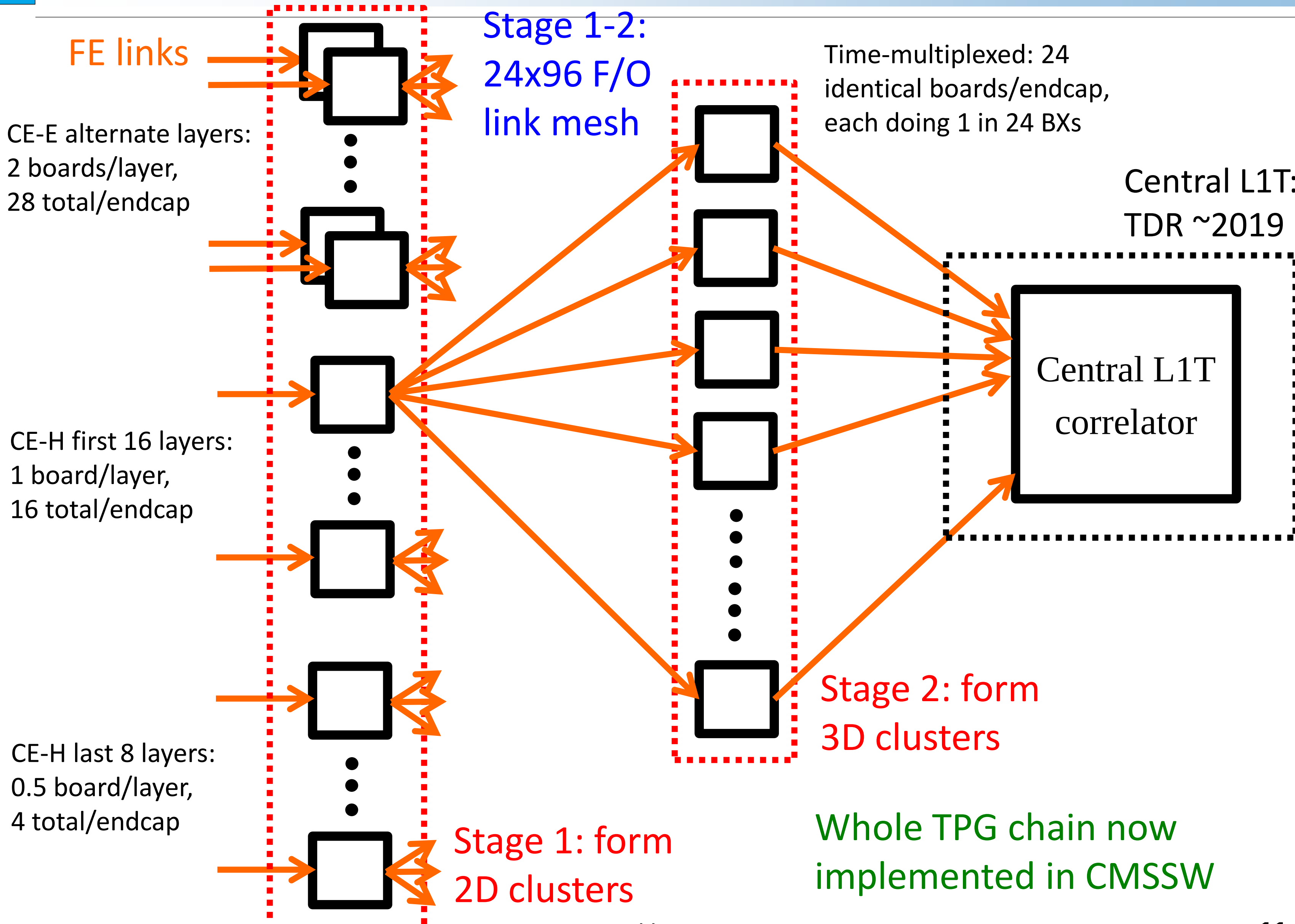


Particles seen in 3 planes (Layer 5, 14 and 23 out of 28 in the electromagnetic section)

A board in the current calorimeter trigger using an advanced FPGA



Overview of TDR architecture



Whole TPG chain now implemented in CMSSW

Summary - Possibilities

Mechanical Engineering

Participate in design, and manufacture

Electronics and Electrical Engineering

Design and testing, power systems (LV and HV)

Off-detector electronics

FPGA-based, design, firmware, software, machine learning,….

Active Elements (silicon sensors and SiPM-on-tile technology

Testing and characterization – design and operate test benches

Module assembly and testing

Simulation, Reconstruction and Test Beam studies

Pattern recognition, machine leaning, …

Ph.D. students, young postdocs etc.

Engineers, postdocs and students highly welcome to work with us at CERN

Physics Outlook: Questions for the LHC

1. SM contains too many apparently arbitrary features - *presumably these should become clearer as we make progress towards a unified theory.*

2. Clarify the e-w symmetry breaking sector

SM has an unproven element: the generation of mass

Higgs mechanism ->? or other physics ?

Answer will be found at **LHC energies**

e.g. why $M_\gamma = 0$

M_W, M_Z ~ 100,000 MeV!

Transparency from the early 90's

3. SM gives nonsense at LHC energies

Probability of some processes becomes greater than 1 !! Nature's slap on the wrist!

Higgs mechanism provides a possible solution

4. Identify particles that make up Dark Matter

Even if the Higgs boson is found all is not completely well with SM alone: next question is "Why is (Higgs) mass so low"?

If a new symmetry (Supersymmetry) is the answer, it must show up at O(**1TeV)**

5. Search for new physics at the TeV scale

SM is logically incomplete – does not incorporate gravity

Superstring theory ⇨dramatic concepts: supersymmetry , extra space-time dimensions ?

What makes it worthwhile to run longer an HEP experiment ?

1. Higher centre-of-mass energy
2. Higher integrated luminosity
3. Qualitatively better detectors