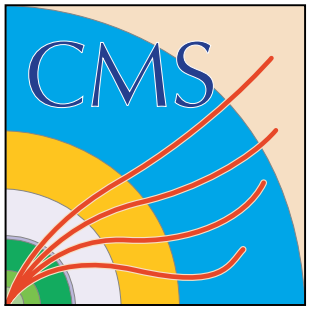
Hardware and Upgrade Activities of the DESY CMS Group



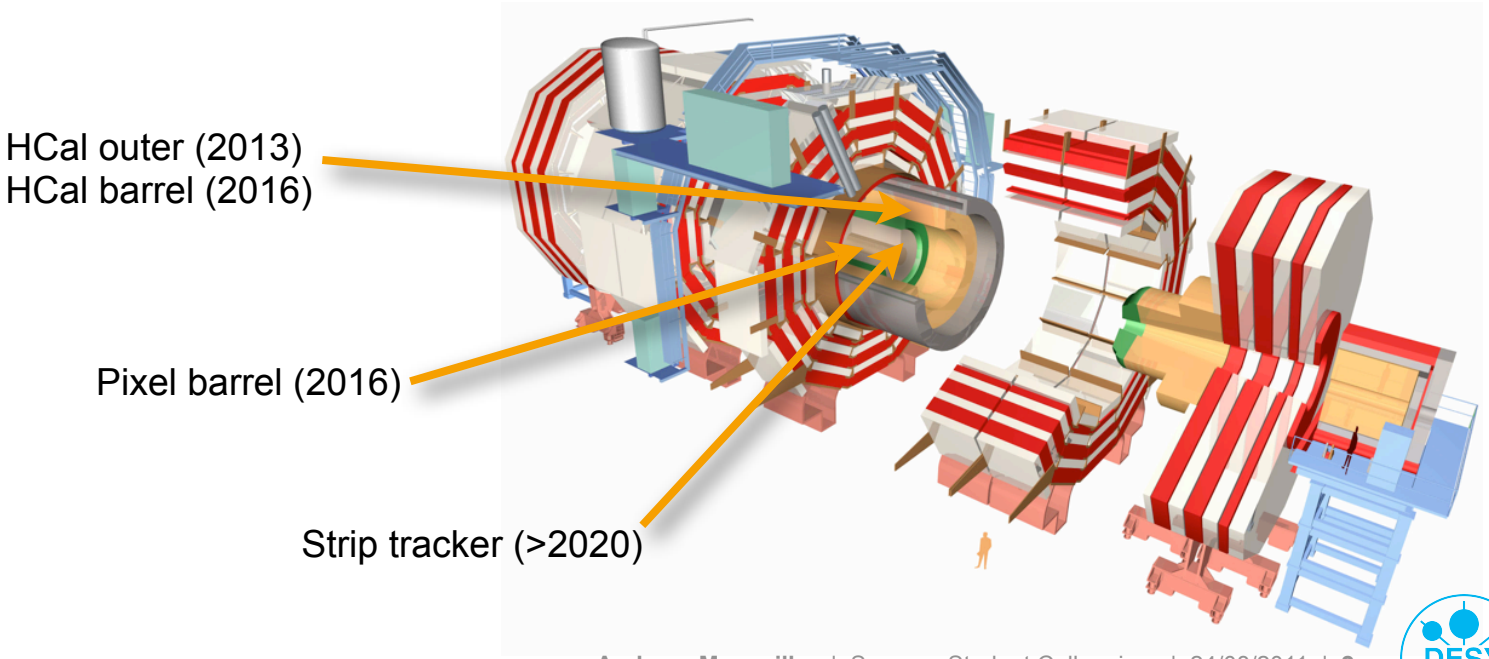
Andreas Mussgiller
Summer Student Colloquium
24/08/2011

HELMHOLTZ ASSOCIATION

DESY

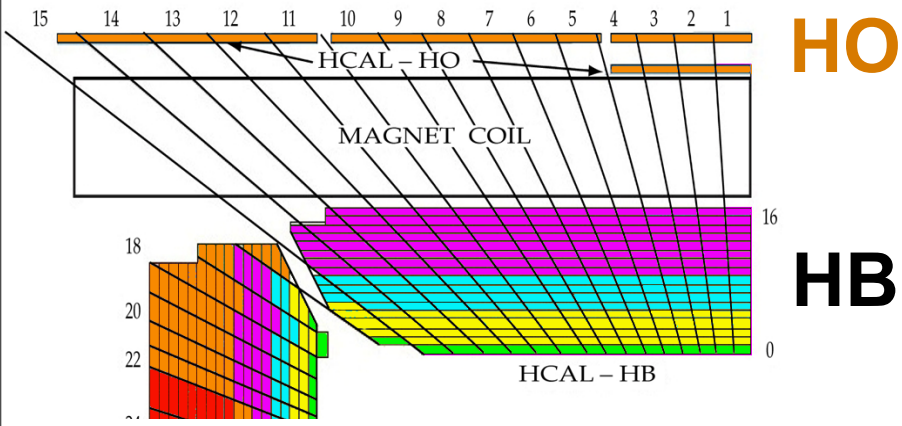
Why Upgrade something that is working?

- Improve performance of the detector components
  - HCAL benefits from logitudinal segmentation
  - Reduction of passive material in tracker improves tracking performance
- Replace components after the end of their life-time
  - Irradiation of sensitive detector elements degrades the detector performance
- Adjust to new operation conditions of LHC
  - Luminosity increase leads to increased occupancy on e.g. silicon sensors
  - Performance degrades because of increased occupancy



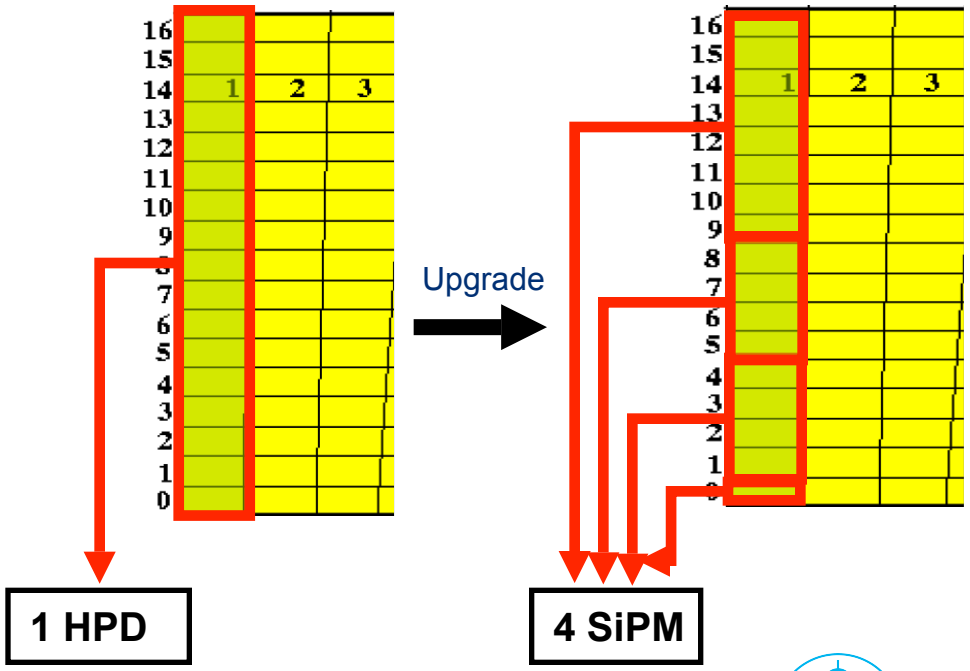
Upgrade of the Hadronic Calorimeter

- HCAL outer (HO) - increase signal to noise ratio
- HCAL barrel (HB) - add longitudinal segmentation
- Replacement of Hybrid Photo Diodes (HPD) with Silicon Photo Multipliers (SiPM)

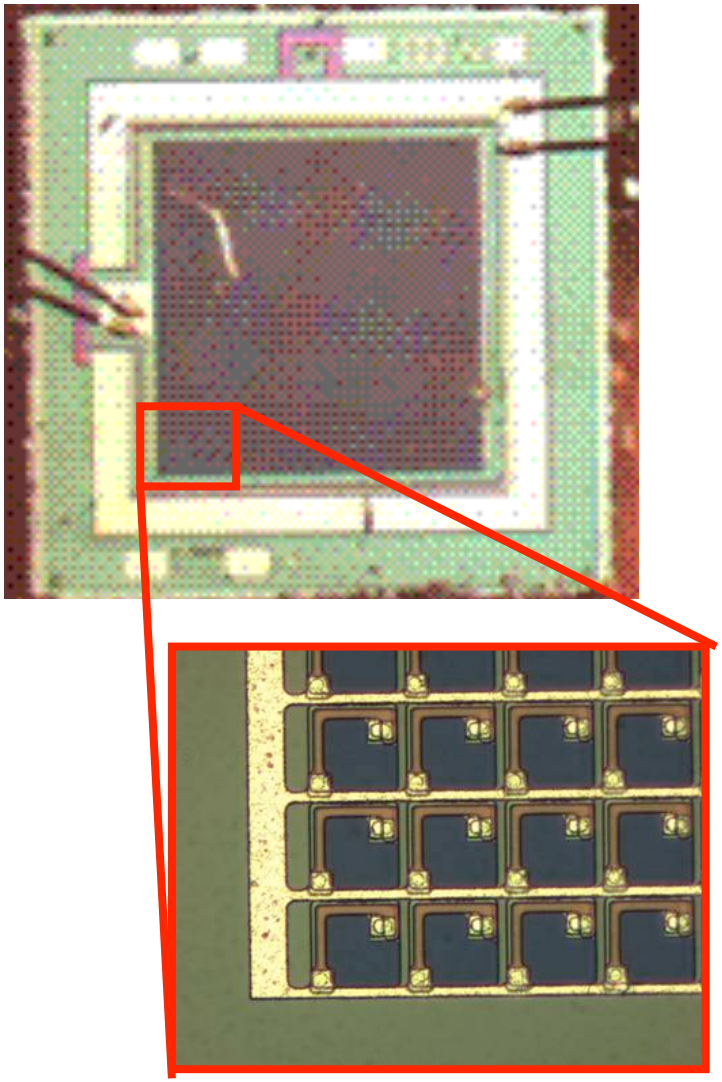


HO

HB



SiPMs for the HCAL Upgrades



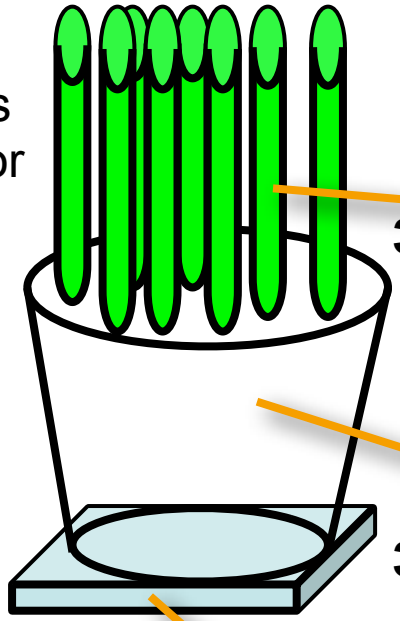
- Array of semiconductor Geiger counters
- Insensitive to magnetic fields
- Need homogenous distribution of light on surface
- Optimize optical coupling
  - Maximize signal
  - Minimize variations between fibers
  - Minimize saturation of SiPM

Optimization of Optical Coupling

optical fibers from detector

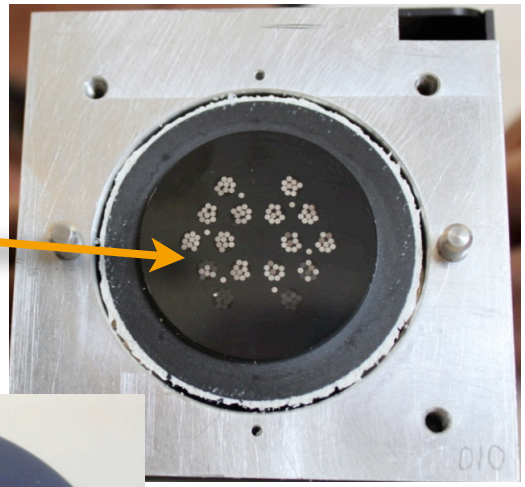
light-guide/ mixer

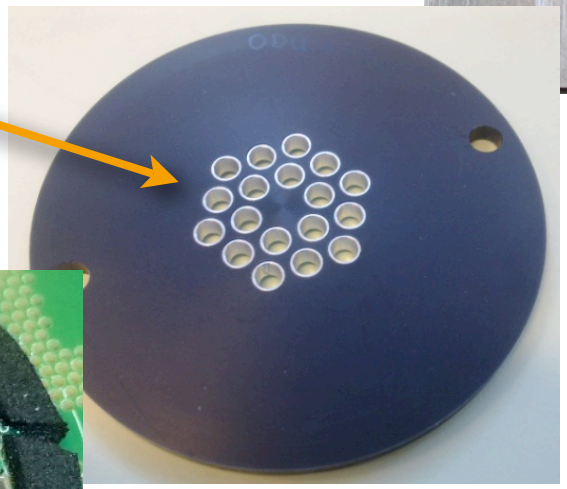
SiPM

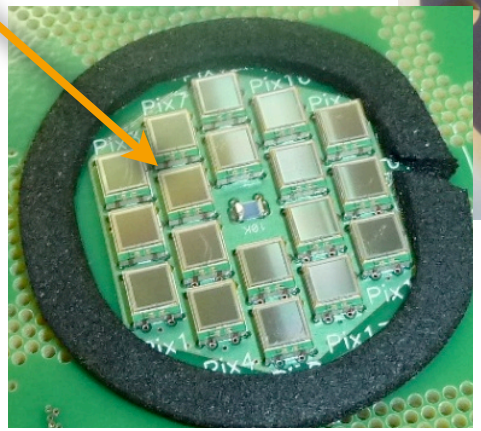


3.6 mm

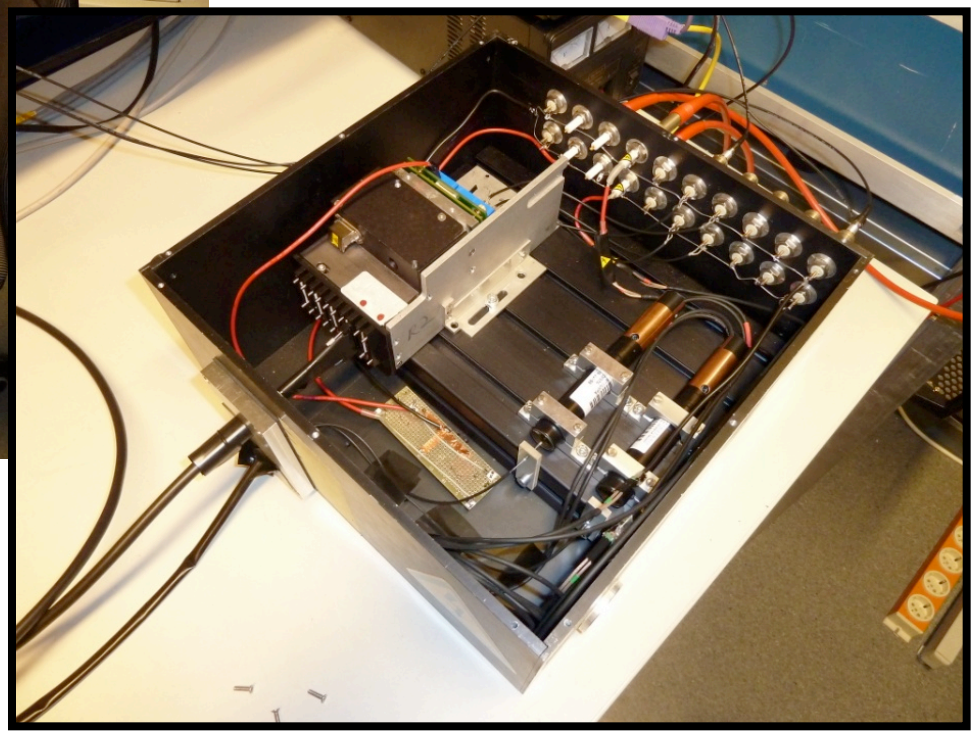
3 mm





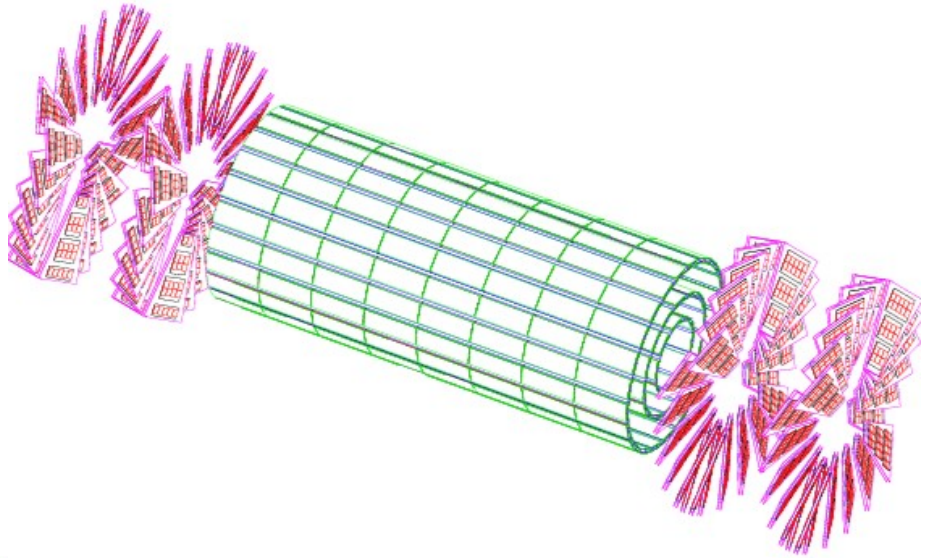


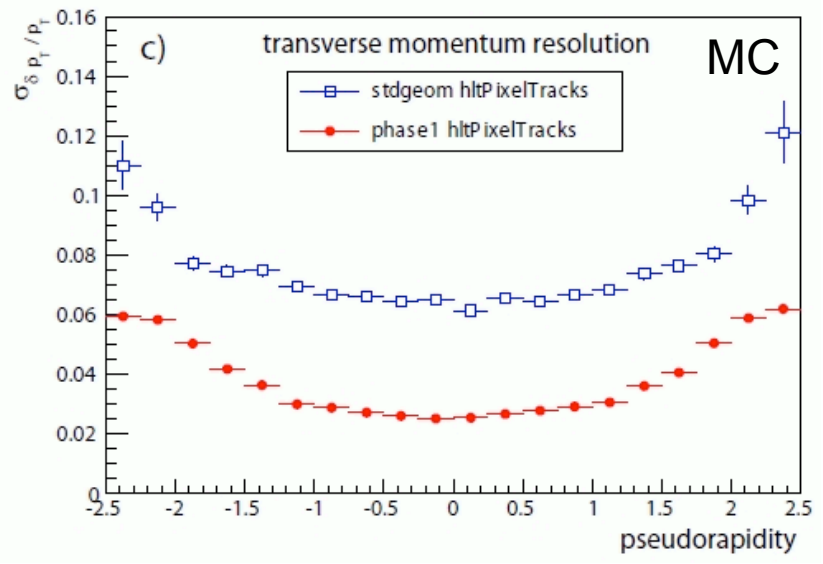
DESY Laboratory Setup

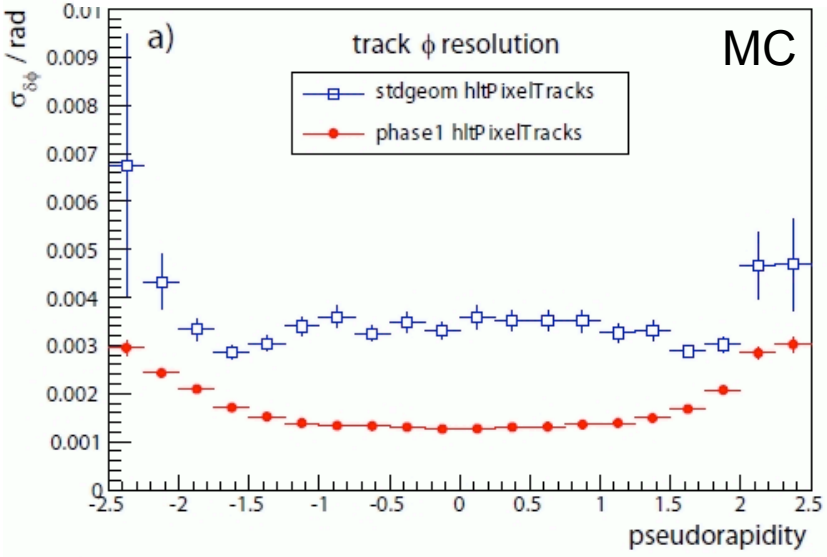


Tracker Pixel Upgrade or the Phase 1 Upgrade

- Current Pixel
  - 3 layers in barrel region
  - 2 layers in forward direction
- Future Pixel
  - 4 layers in barrel region
  - 3 layers in forward direction

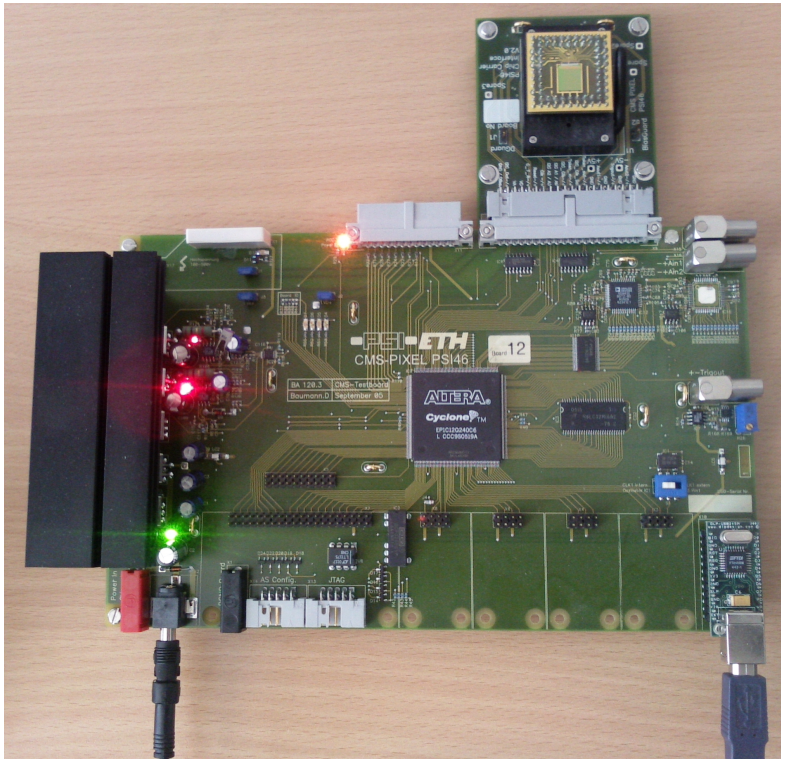


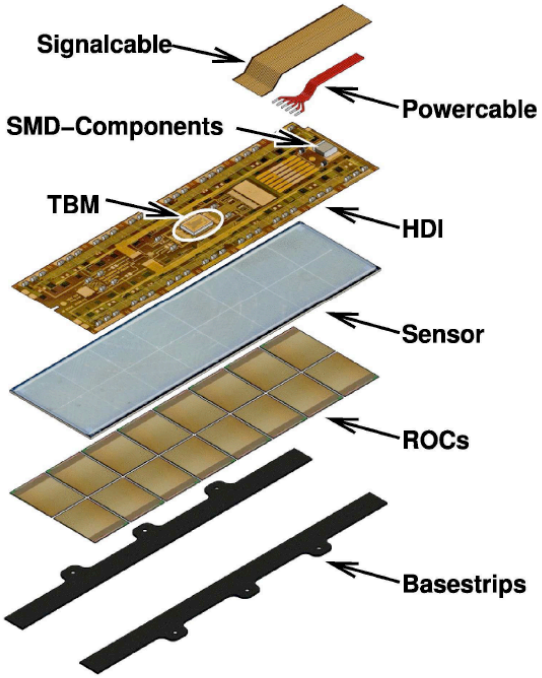


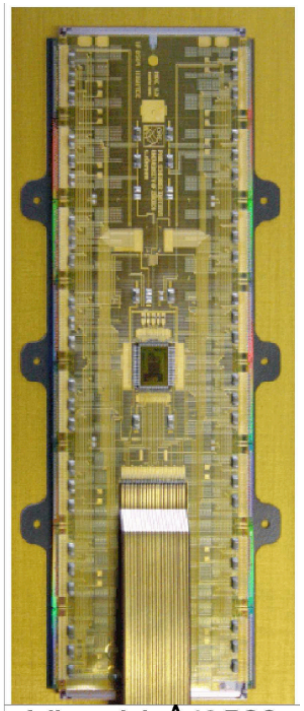


The Fourth Pixel Barrel Layer for the CMS Tracker

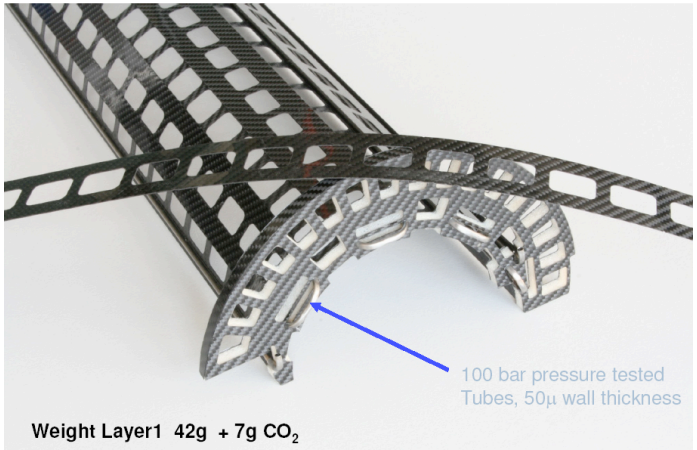
- will be built by DESY
  - Assembly of the modules
  - Extensive tests of the modules
  - Assembly on the support structure



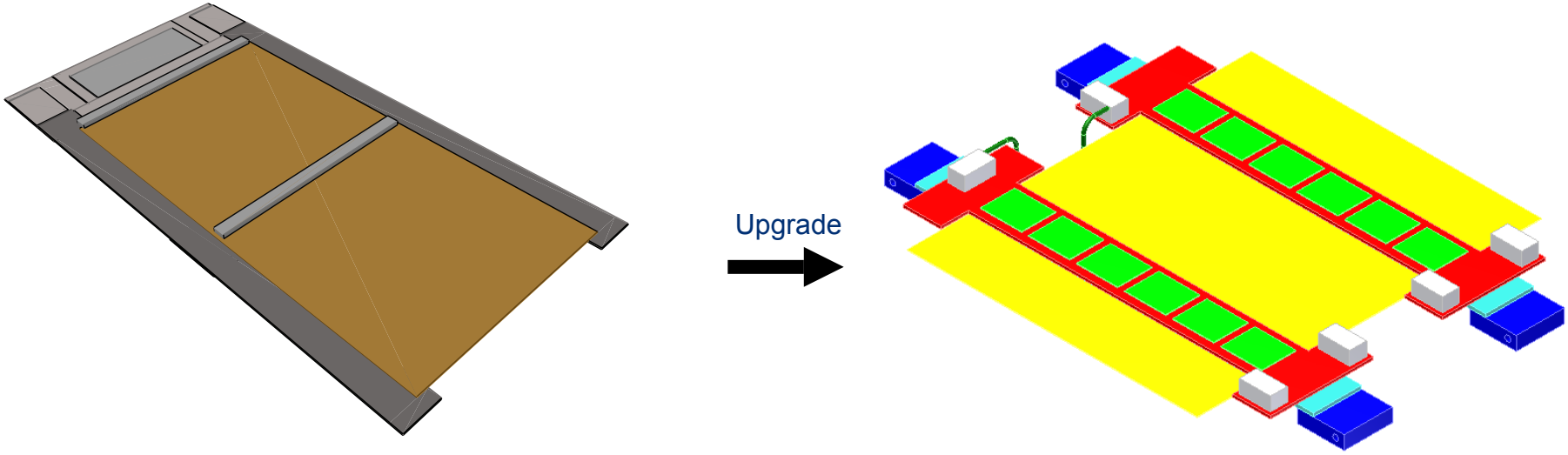




full–module ≙ 16 ROCs



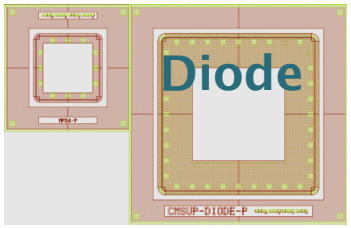
Phase 2 Tracker Upgrade

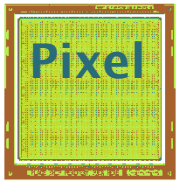


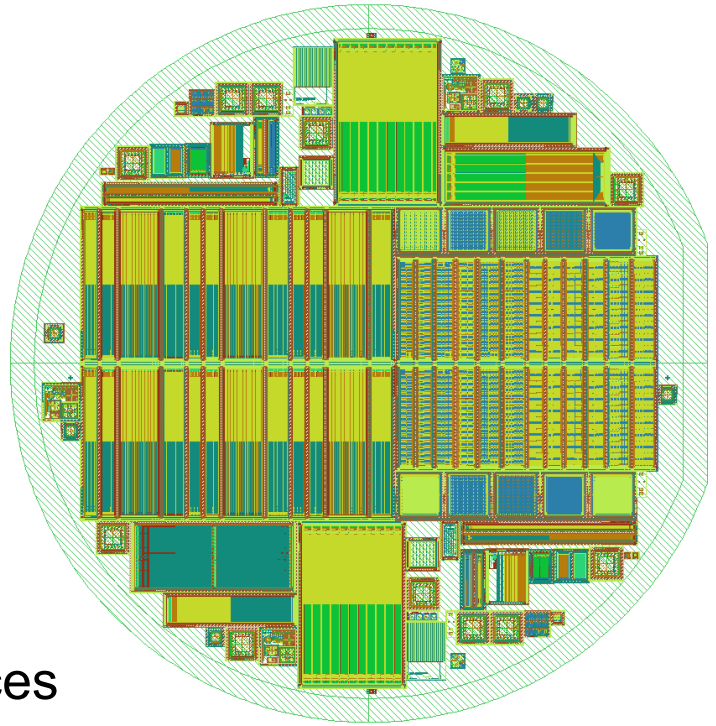
- Decrease length of strips to cope with occupancy
  - 2.5 cm at inner radii
  - 5.0 cm at outer radii
- Reduce material budget to improve tracking performance
  - minimize the effect of multiple scattering
- Operate sensors at -20°C to increase life-time and allow operation after irradiation
- Use radiation hard sensor material

Search for Radiation Hard Sensor Material

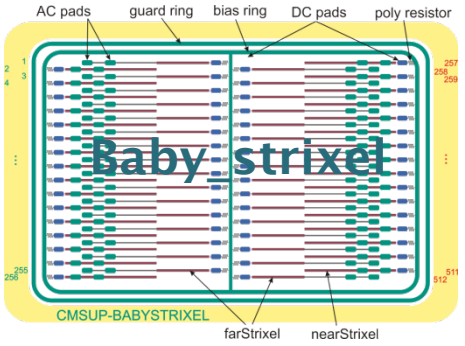
- Wafer of different materials with various test structures available for studies
  - Diodes for material studies
  - Pixel for material and layout studies
  - Strixel for layout studies







- Irradiation of test structures to defined fluences
- Electrical characterization of irradiated materials to find best material for future tracker

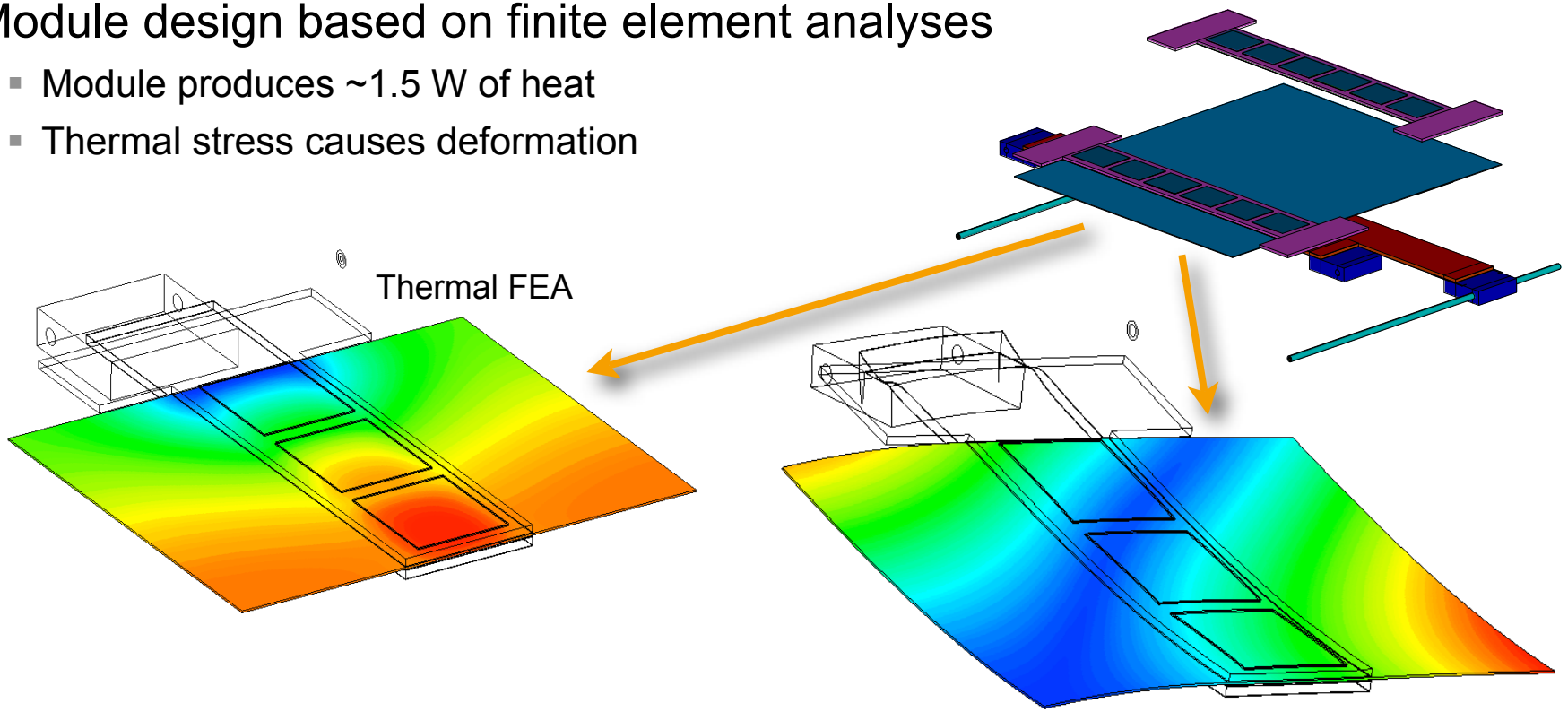


Module Design

- Sensor will be operated at -20°C
- Reduce material budget

Use of high-end materials with high thermal conductivity and mechanical strength

- Module design based on finite element analyses
  - Module produces ~1.5 W of heat
  - Thermal stress causes deformation



- FEA results will be confirmed by measurements

Summary

- The DESY CMS group is involved in wide variaty of R&D projects
  - There is something for everyone
- In close collaboration with institutes from all over the world
  - work with the best of the best of the best

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