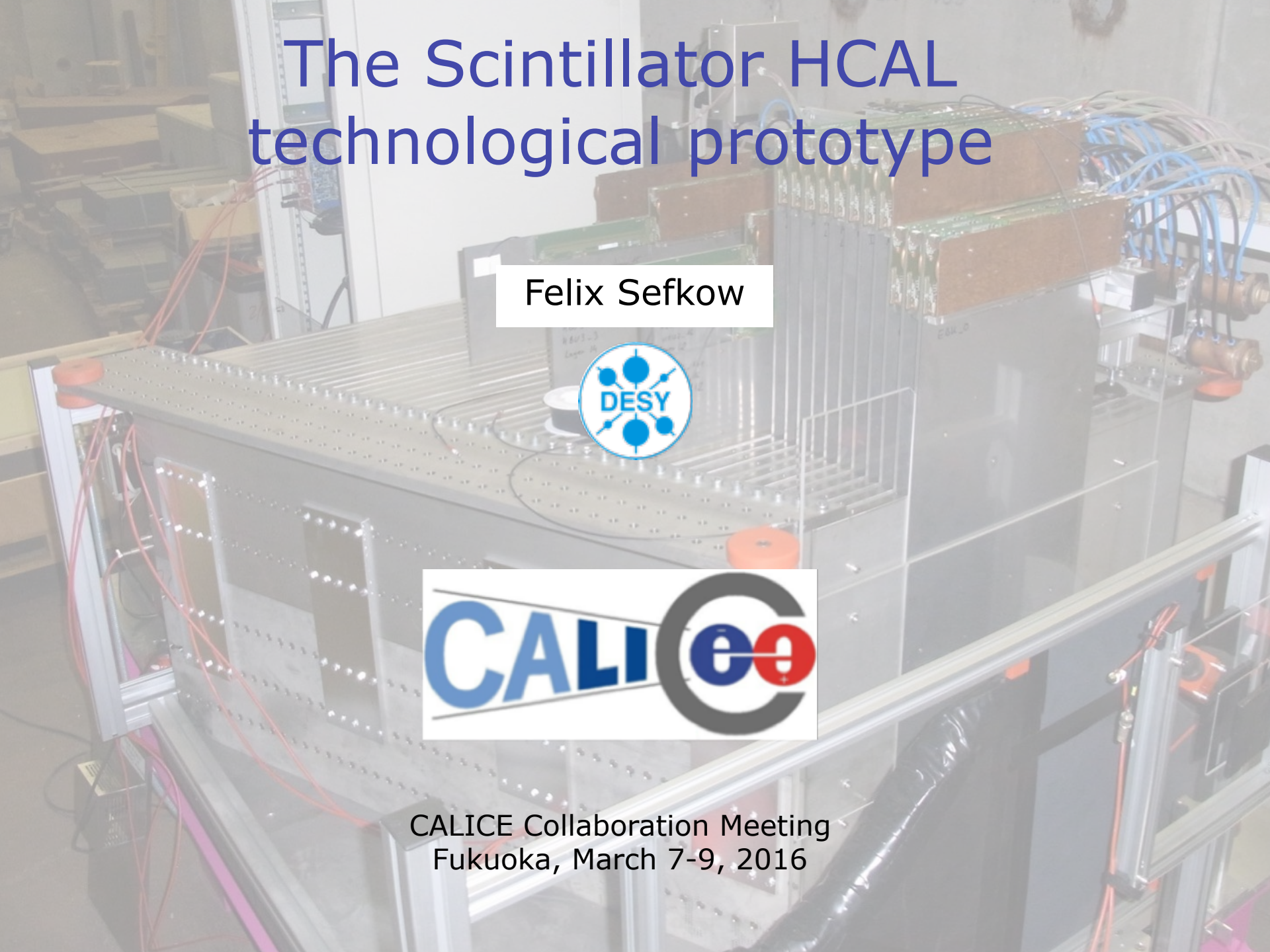
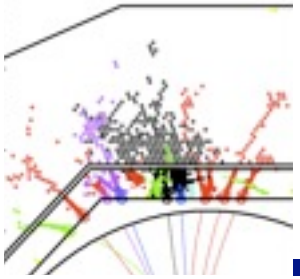
The Scintillator HCAL technological prototype

Felix Sefkow

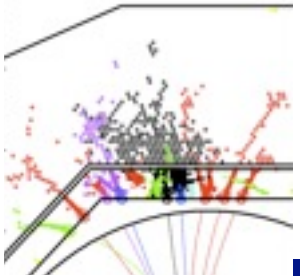


CALICE Collaboration Meeting
Fukuoka, March 7-9, 2016



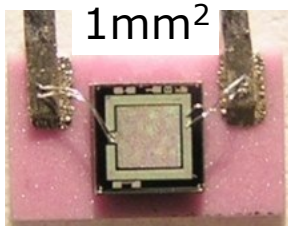
Outline

- Motivation
- Components
- System
- Timeline

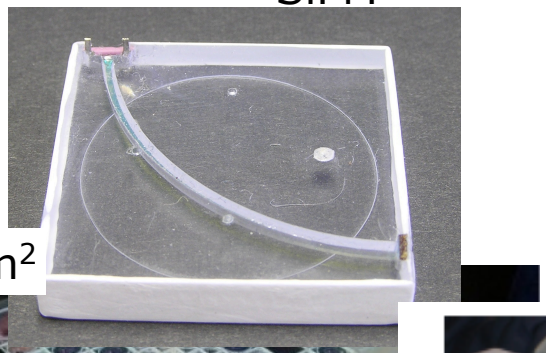


AHCAL physics prototype

7608 channels
38 layers
Fe & W

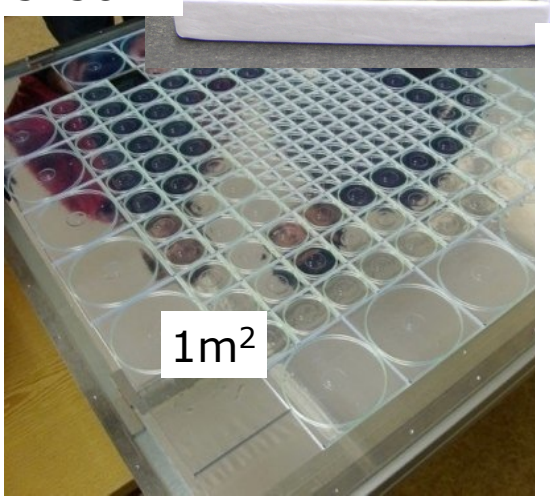


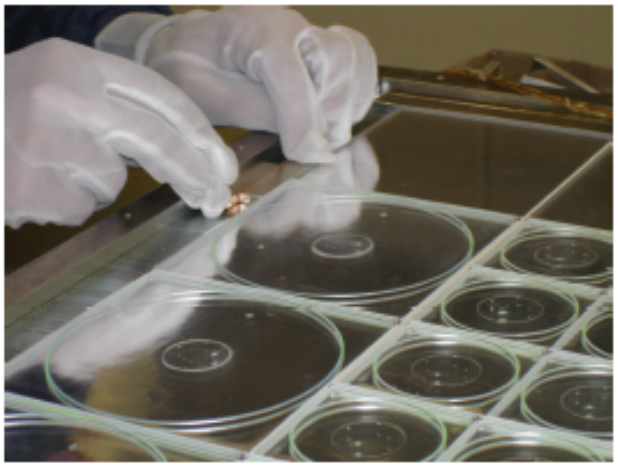
SiPM

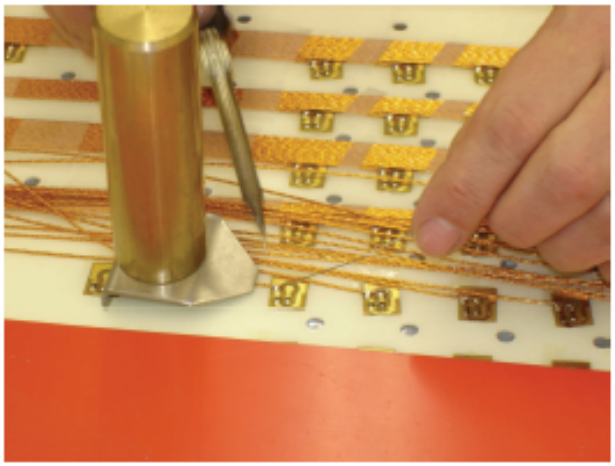


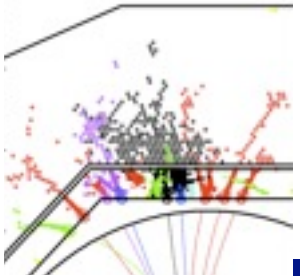
- Constructed in 2005-06: very first device using SiPMs at large scale
- External front end, remote digitiser
- External optical calibration system
- Labor-intensive assembly

Assembly 2005 at DESY



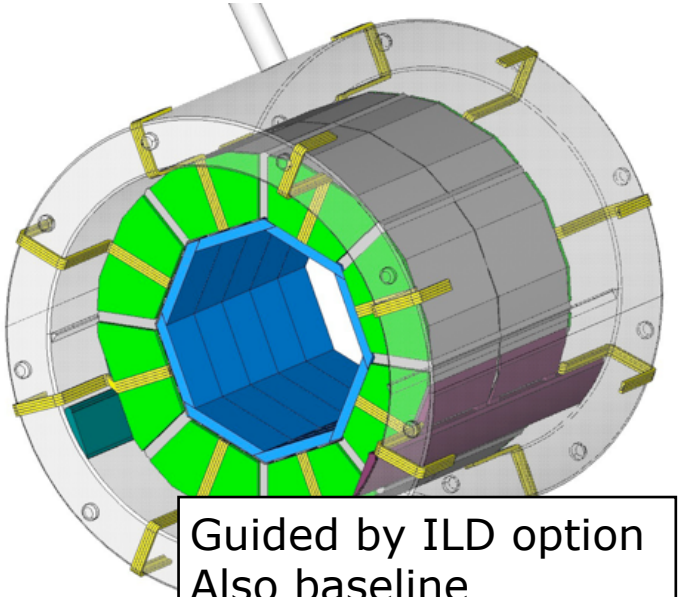




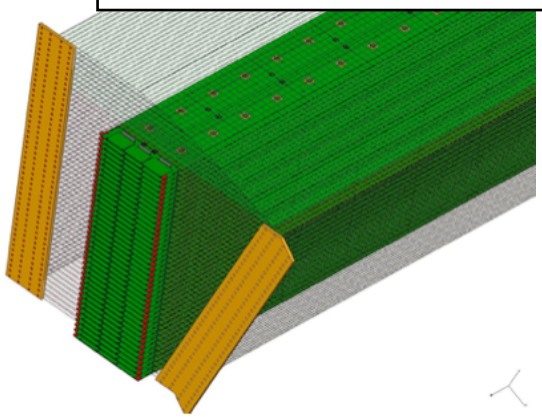


Goals of next stage

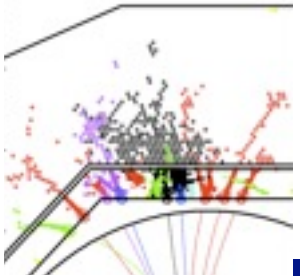
- Demonstrate the scalability
  - mechanical structure, tolerances and cost
  - FE electronics integration, power pulsing
  - optical monitoring system integration
  - Auto-trigger, zero-suppression and DAQ
  - Integration of services and cooling
  - Mass production and quality assurance
- Capitalise on progress from 10 years of SiPM development
  - enhances performance, leaves room for design simplifications
- Made choices for a demonstrator now, keep R&D open



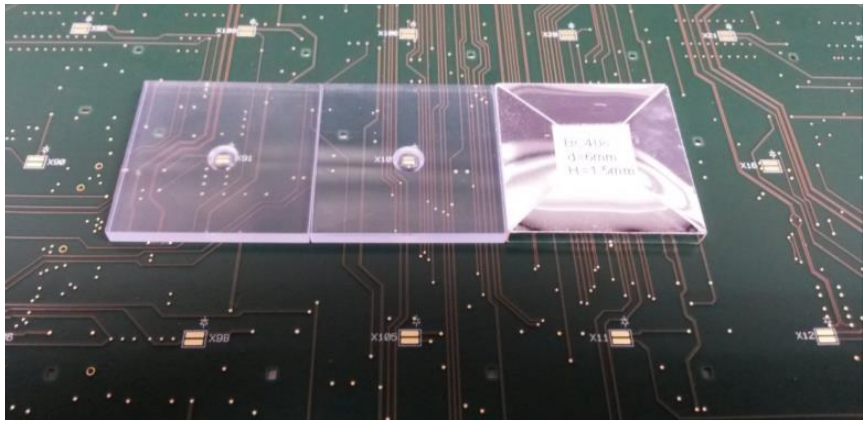
Guided by ILD option
Also baseline
for SiD and CLICdp

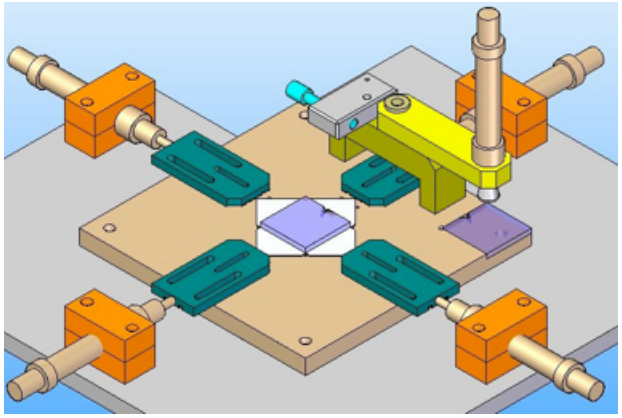


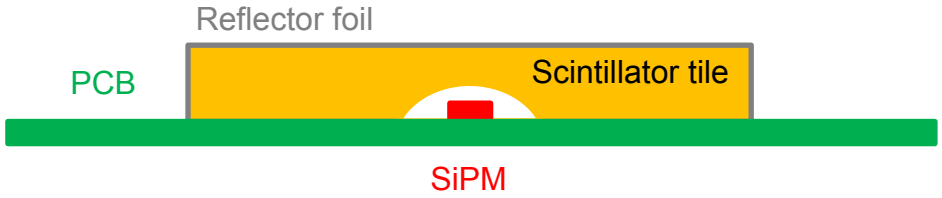
Components

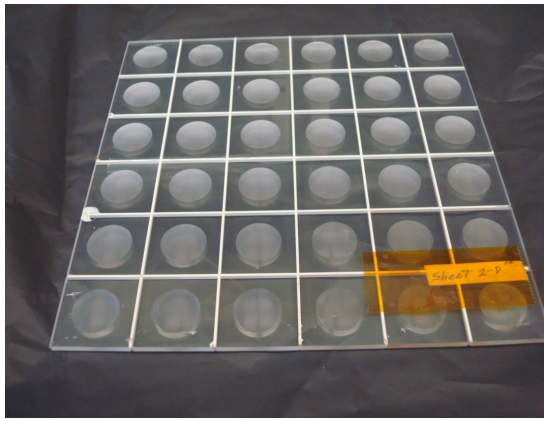


Scintillators



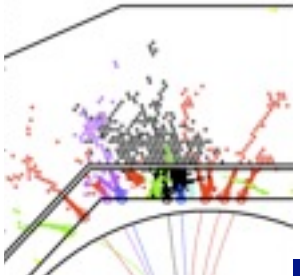






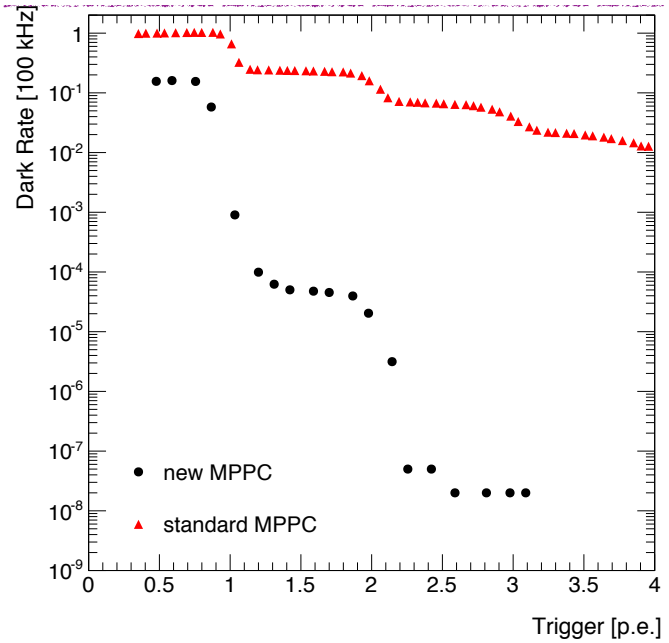
- Surface-mount design with dimple (NIU, Mainz)
- Semi-automatically wrapped in reflector foil
- Pre-series Hamburg (BC type, cut)
- Mass production Russian groups (PS, moulded)

- R&D on other options continues (Mega-tiles, PET,…)



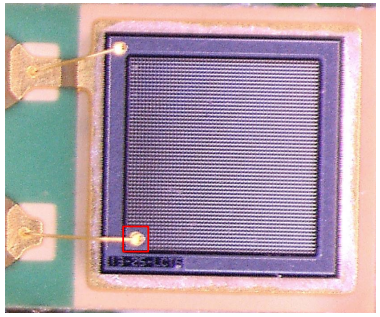
SiPMs / MPPCs

- Dramatic leaps in performance in past few years
- Device uniformity: simplification of commissioning procedure
  - no need anymore to equalise LY with individual bias and gain with preamp, and still common trigger threshold
- Low noise: auto-trigger works
- Higher over-voltage possible - reduce temperature dependence

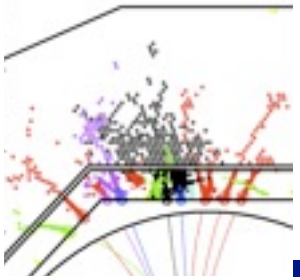


Cf. physics prototype:
DCR 2 MHz, XT 30%

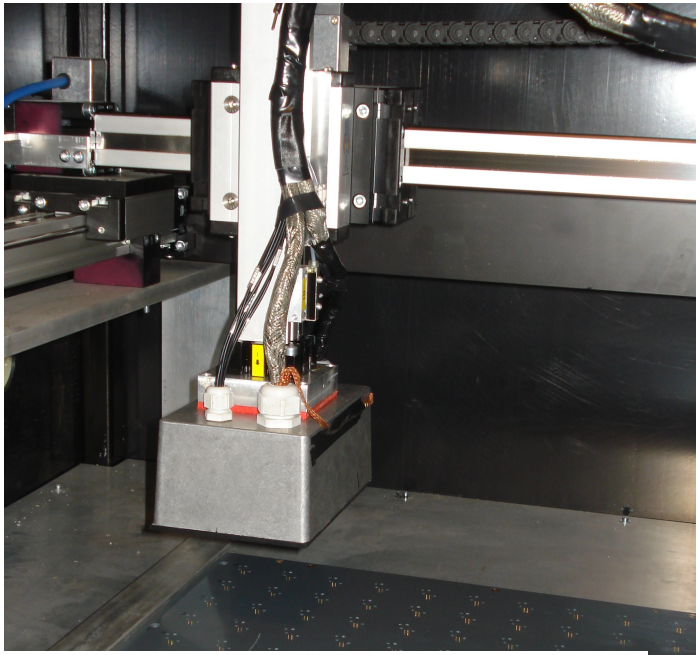
- Existing devices from different vendors fulfil our wishes
- Specs being drafted for tender for large sample



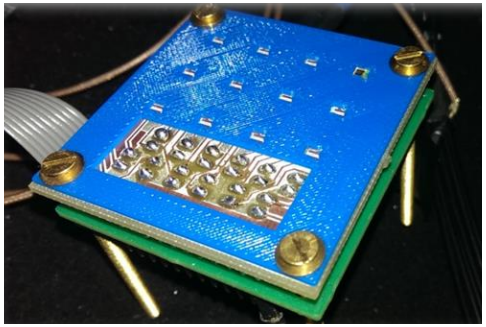
HPK LCT 5
1.3x1.3mm^2
2700 px



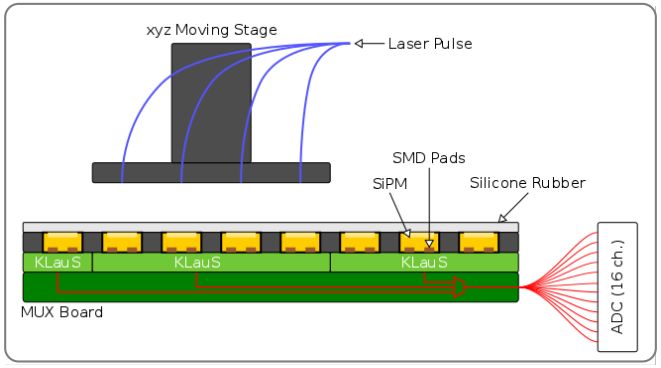
SiPM characterisation

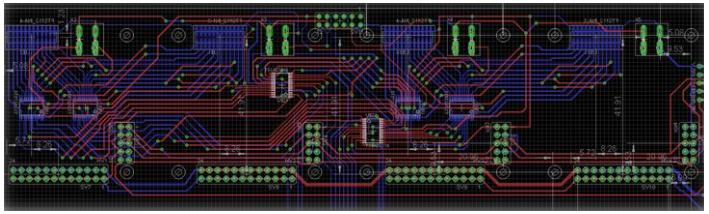


- Automatic set-up with multiple UV source
- adapted to SMD package
- 12 x 12 ch. parallel read-out
- strategy to be optimised after experience with pre-series

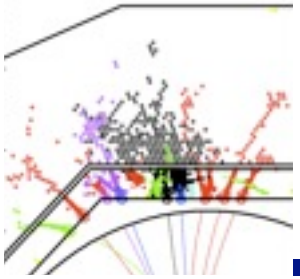


SMD SiPM Setup (as planned)



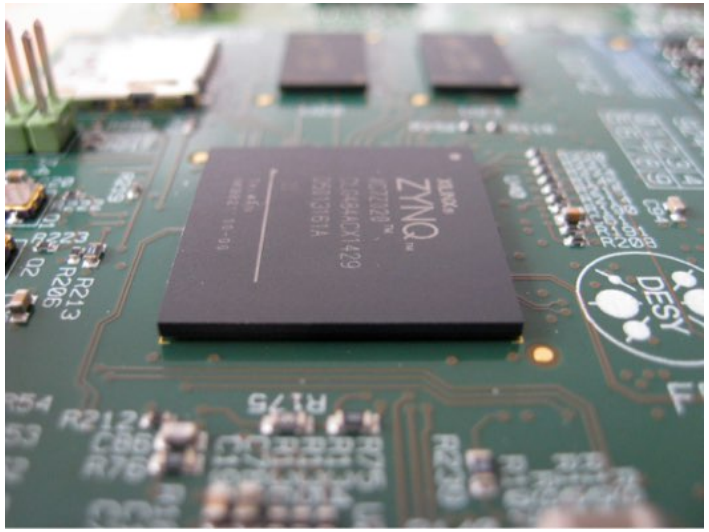


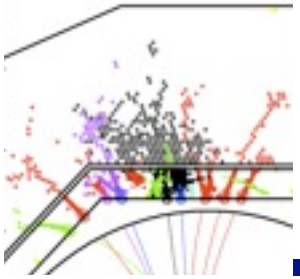
Heidelberg



Readout ASICs and tests

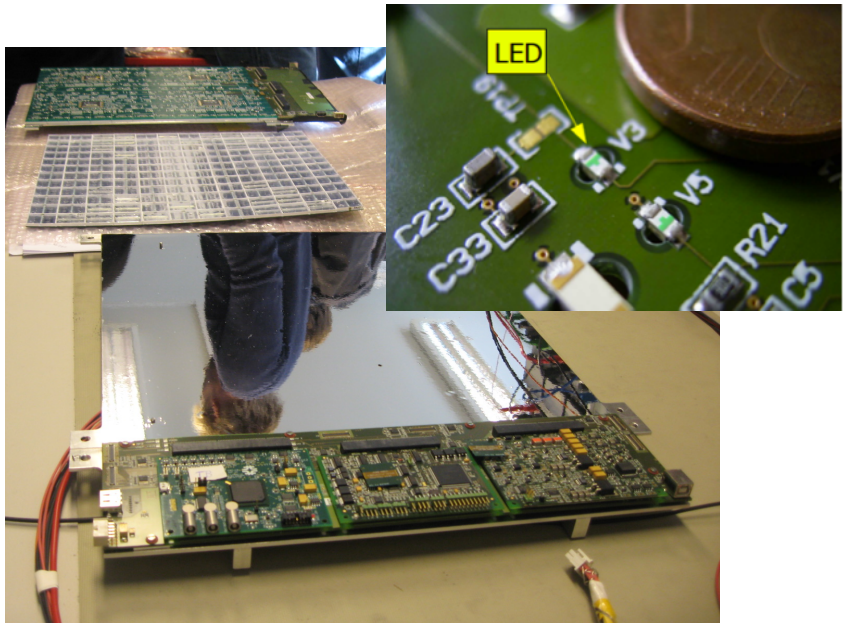
- Working horse since: SPIROC2B (OMEGA)
  - some unwanted features, but successfully used in many beam tests since 2012
- Currently being characterised: 2D
  - many fixes and improvements verified, but unfortunately not useable due to trigger bug
- In production: 2E
  - available in summer in TQFP package for characterisation, and in BGA package
- BGA interposer in preparation
- New test board for automatic ASIC tests being developed (Wuppertal)

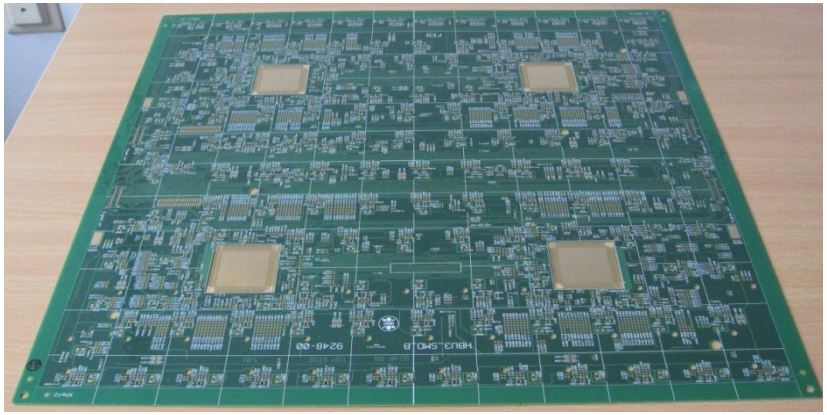


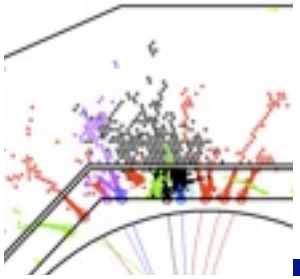


Electronics integration

- Basic unit: 4 ASICs 144 tiles, 36x36cm^2
- Compact design
  - 5.4mm incl 3mm scintillator
  - layout optimised for automatic tile placement
- Embedded LED system optimised for uniformity
- One of the cost drivers: established contacts to Korean vendor (via SKKU Seoul)
  - prototypes show good quality, will go to assembly step
- Redesign for BGA started

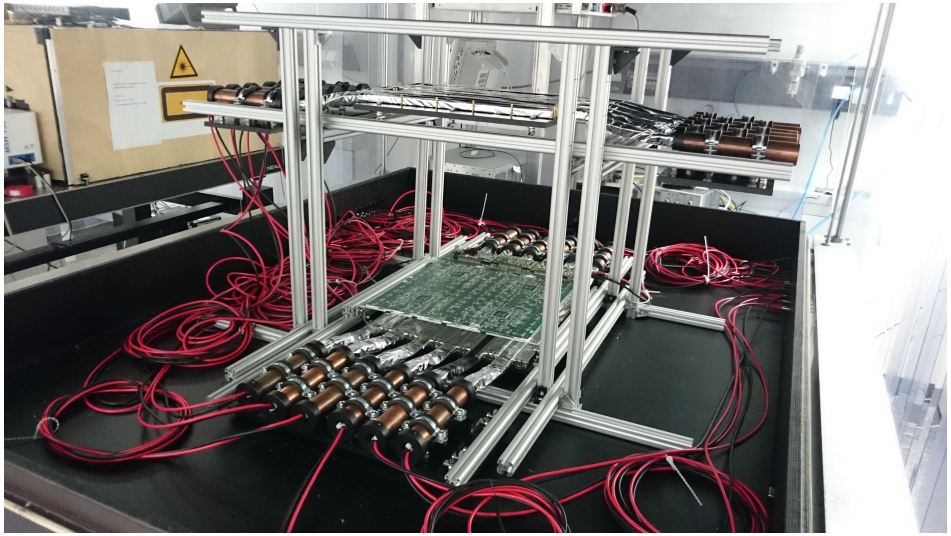




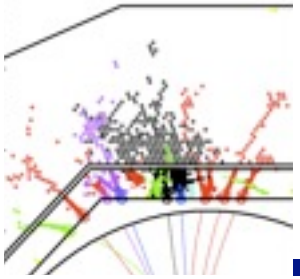


Tile integration

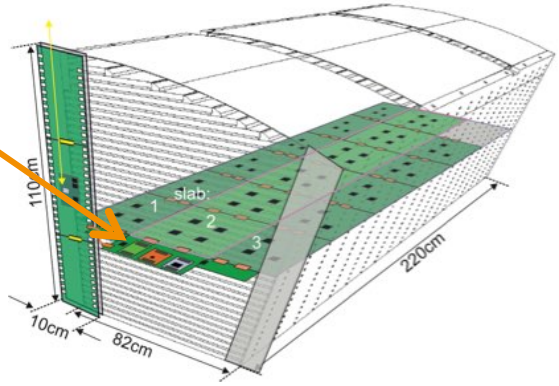
- Automatic placement with pick and place machine established
  - first board worked well in 2015 TB
- Can be done together with electronics components or independently
- Cosmic test stand for quality control and initial MIP calibration



Uni Mainz

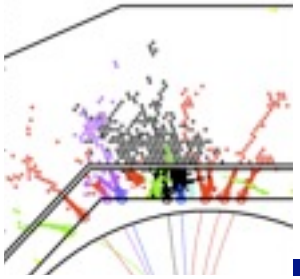


Interfaces: DAQ, LED, POWER



- Redesign of all interfaces finished
- Firsts tests with prototypes look promising
- New power module will allow to test active temperature compensation

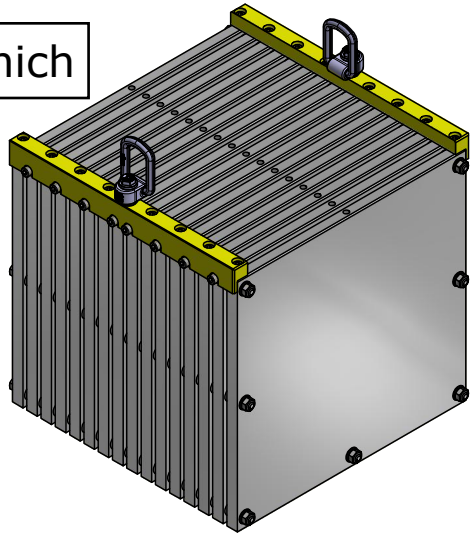
System integration

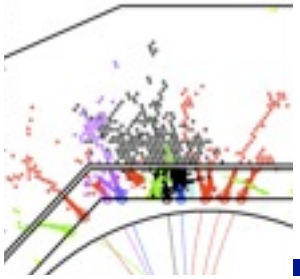


Mechanical structures

- Vertical structure for test beam
  - and earthquake stability tests
- New cassettes of right size in preparation
- Horizontal structure for thermal test of full layer
  - Tolerances verified: 1mm flatness over full area with roller levelling
- New "minical" for electron beam tests

MPP Munich



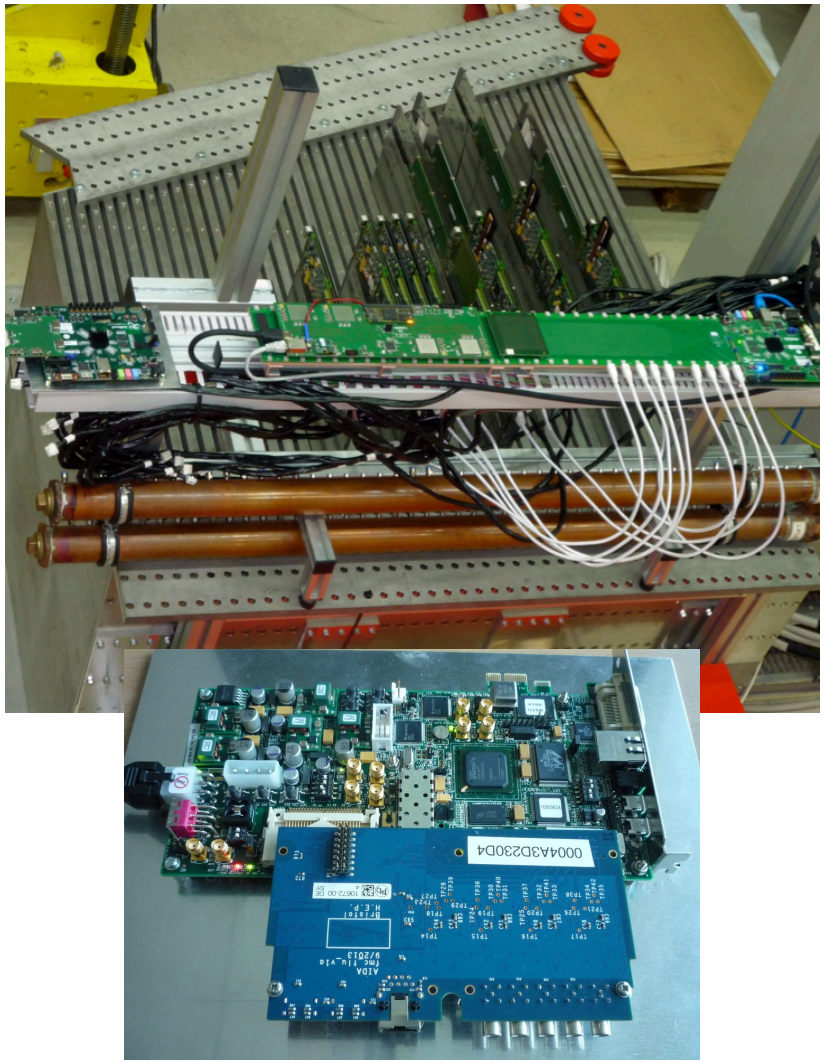


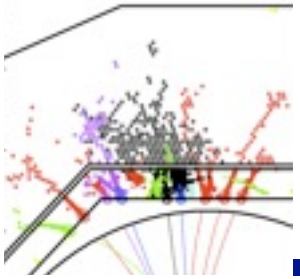
Data concentration and DAQ

- Data concentrator for 2x48 layers
- Worked well in 2015 TB, performance still improving

- EUDAQ used as high level DAQ and run control
  - Upgrade to EUDAQ 2.0 planned
- Further integration of monitoring and event building in EUDAQ

- New beam interface BIF: reference timing from independent scintillator and read-out chain

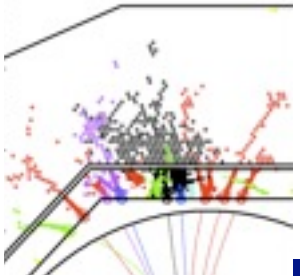




Power supply and distribution

- 3 voltages: FE, LED, SiPM
- Power supplies for 48 layers
- Distribution box for full sector
- More compact supply units under development (JINR)

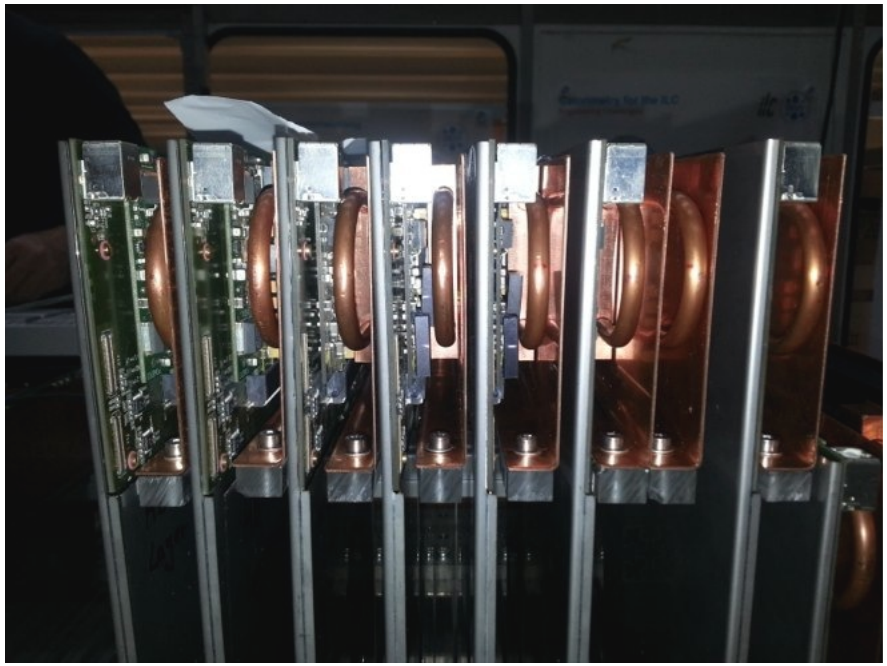
scalable

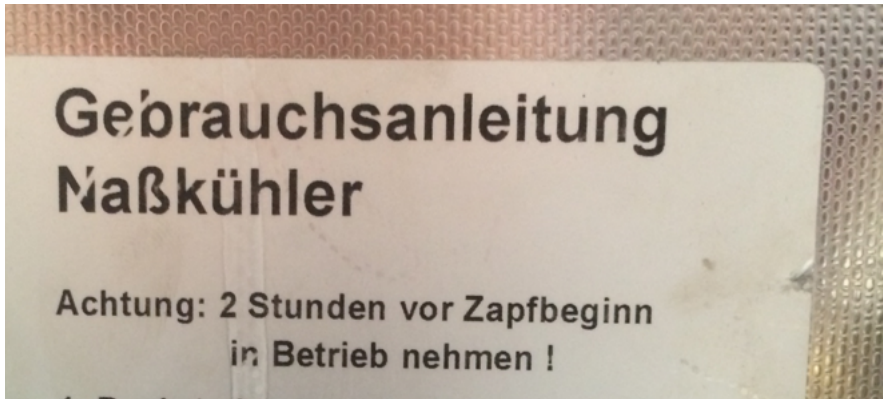


Cooling of the interfaces

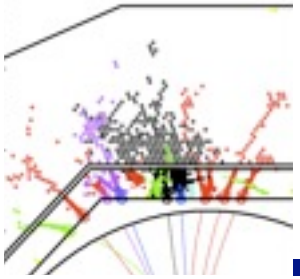
- With power pulsing, very little heat produced in the stack
- Interfaces need cooling, though
  - power regulators
  - FPGAs on DIF
- First version for full sector test beam
  - being adapted to new cassettes and interfaces
- More compact and leakless system planned (AIDA-2020)

scalable





Time line

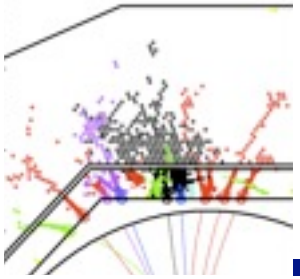


Electronics driven timeline

- Summer 2016: SPIROC2E
  - production, dicing and packaging
- In parallel
  - BGA interposer
  - HBU5 for BGA
  - test board (Wuppertal)
- Until end of 2016: validation of SPIROC2E and HBU5

- Large production of HBUs early in 2017
- Sets time line for scintillators and SiPMs / MPPCs

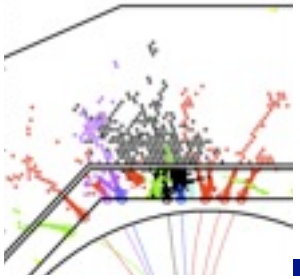
- 2017: layer integration
- 2018: stack integration



Beam tests

- Essential for establishing and streamlining the procedures
- 2016 at DESY:
  - May: commissioning and calibration of new HBUs
  - June: new minical stack with power pulsing
  - fall: further tests, DAQ integration
- 2017 at DESY:
  - commissioning and calibration of active layers
- 2018 at CERN:
  - hadron beam test
  - combination with ECAL if possible

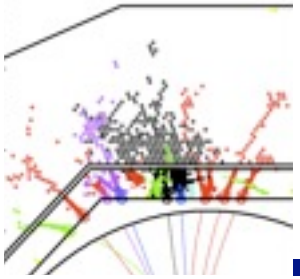
- late 2017 at SLAC (pending on funding):
  - minical with power pulsing and LC bunch structure



Summary

- Progress in SiPM development
  - simplify design, construction, commissioning, operation
- New AHCAL prototype on its way
  - choices made or imminent
- Aiming at hadron test beam in 2018
  - Electronics driven timeline
- R&D on components and integration concepts goes on

Back-up



AHCAL groups in CALICE

thanks, Katja!