

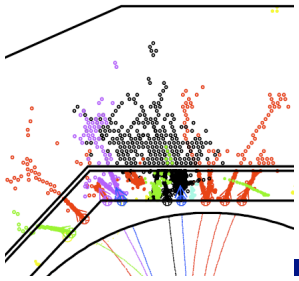
AHCAL developments

Felix Sefkow

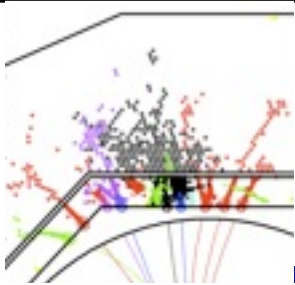


CLIC workshop
CERN, February, 2014

Outline

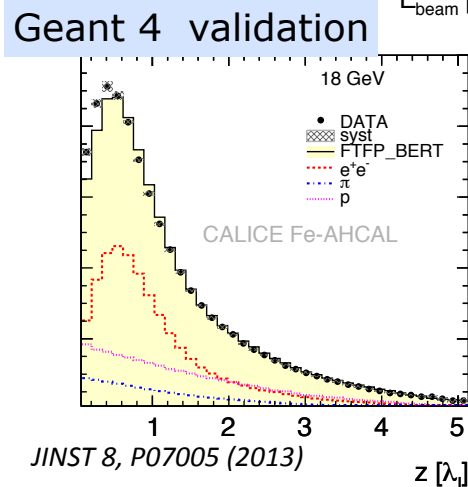
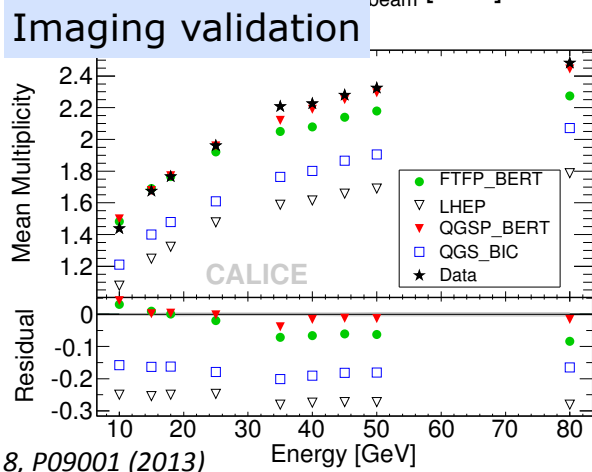
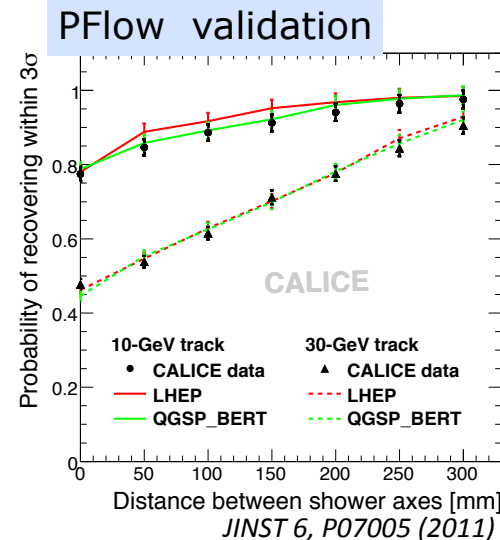
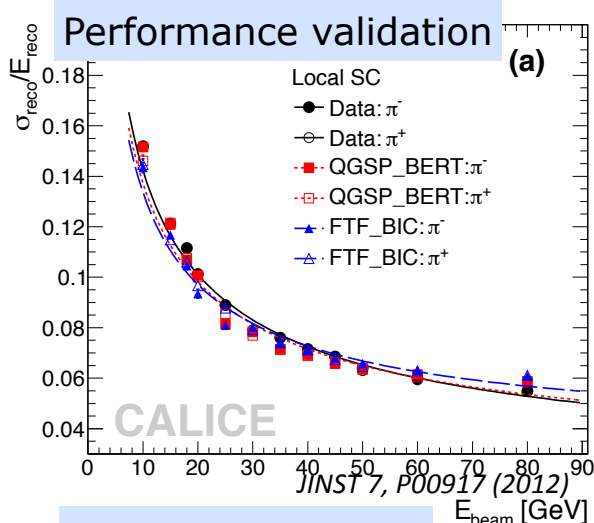
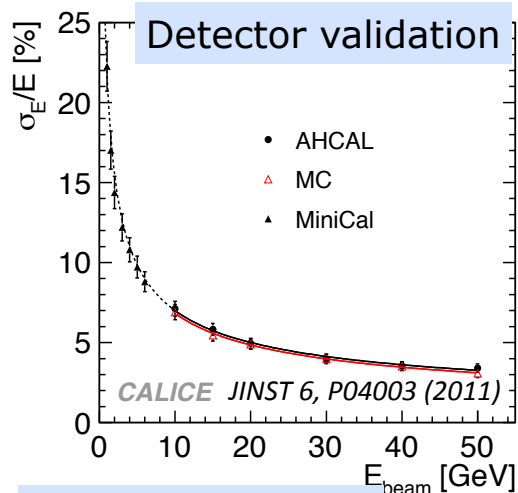


- Physics prototype analysis
- Technical prototype test beam
- R&D directions

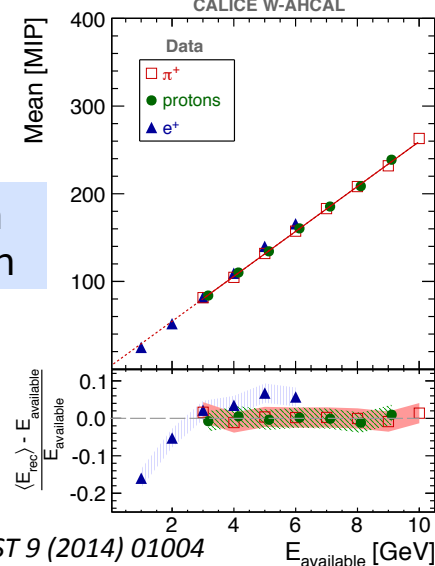


Validation of Simulation

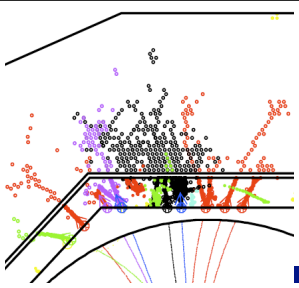
- Validation with first generation prototype
- Published



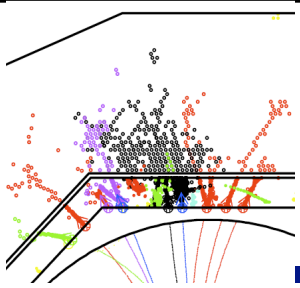
Tungsten validation



Analysis



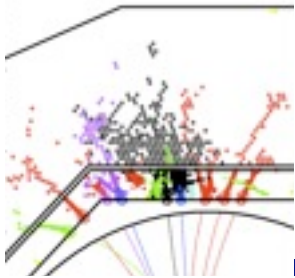
- 3 papers in 2013
 - track segments , pions vs Geant 4, tungsten < 10 GeV
- 3 more in the pipeline
 - tungsten < 150 GeV, T3B, protons, ECAL+HCAL s/w-comp
- More: spatial resolution, semi-digital study, W @ 300 GeV
- FNAL all scintillator analysis re-started
- Analysis nearing reaching completion
- Time to care about fresh data...



Hardware: Outlook Dec 2012

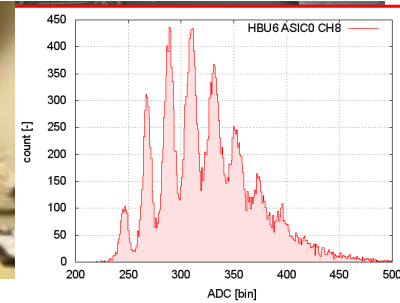
- Proceed at the integration frontier
- while remaining open for different sensor options
- Electronics is versatile
- and ready to make a start



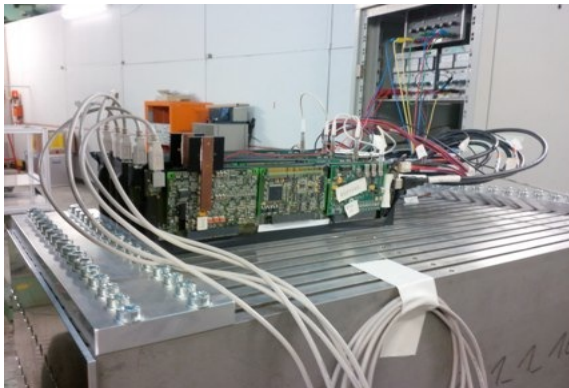
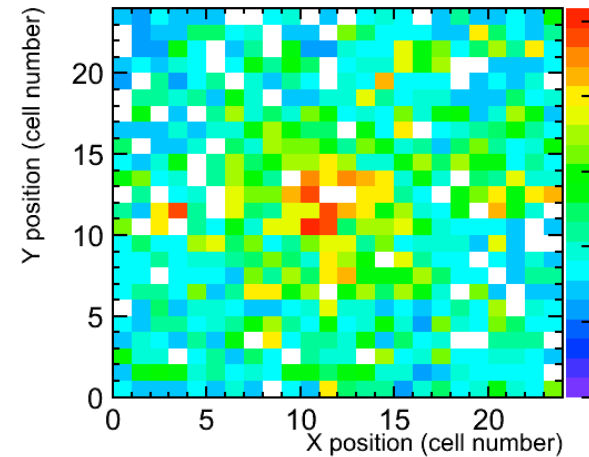
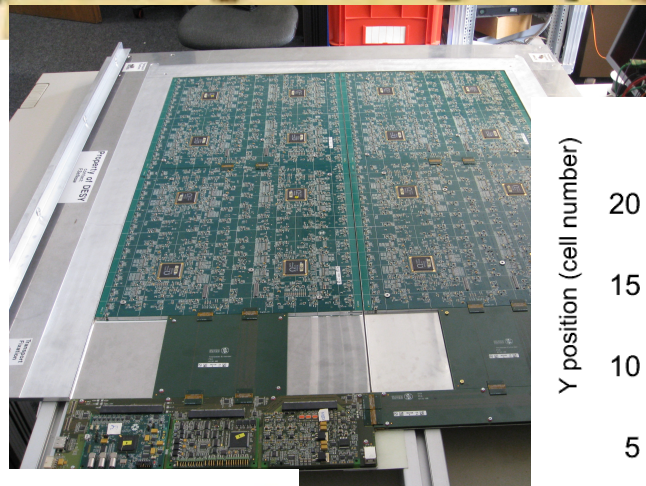


2nd generation prototype

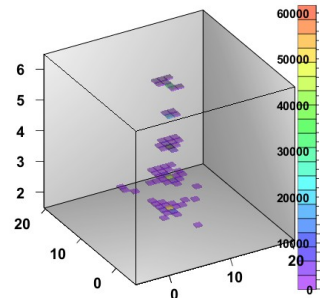
- Full slab: signal integrity



- Full layer: hadrons
- First stack: electrons



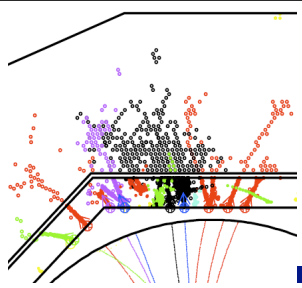
Scintillator HCAL



synchronous!



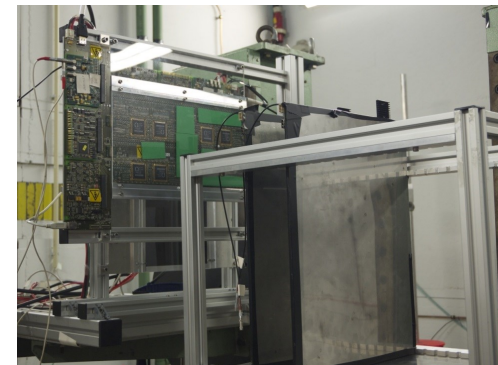
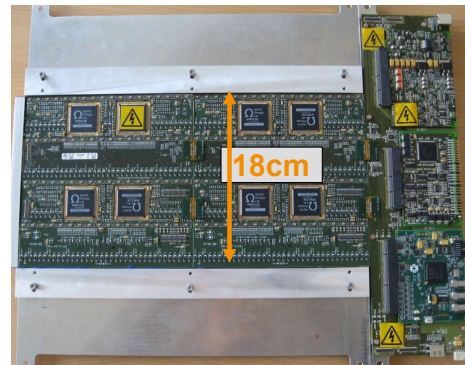
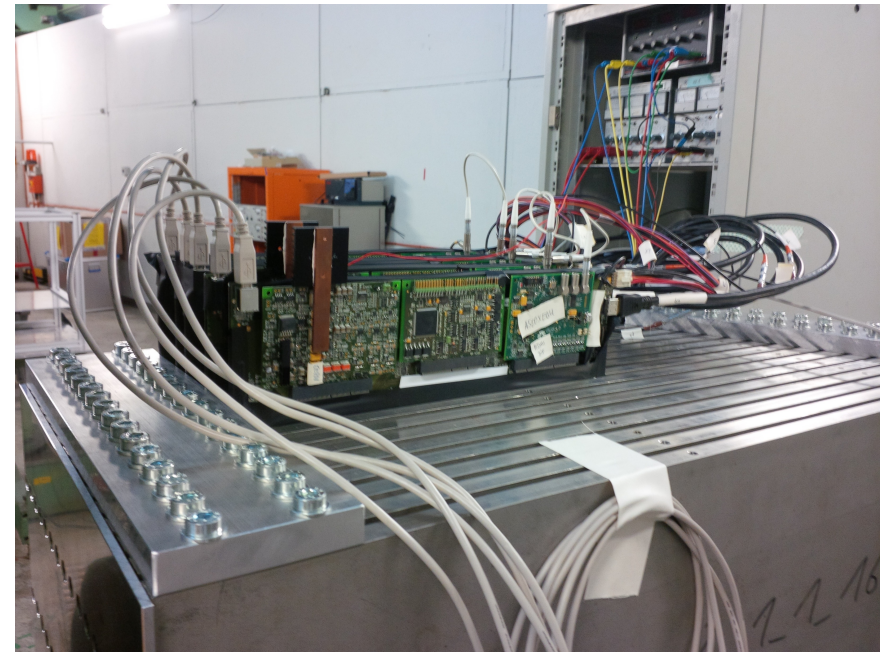
pions @ SPS 2012

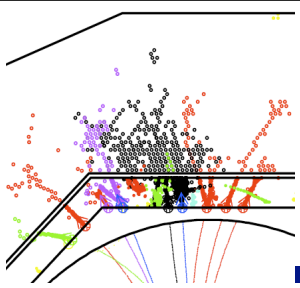


2013: first stack

- breakthrough in summer: synchronous 5 layer operation
- intermediate DAQ: USB, HDMI
- using new CCC
 - clock & control card
- Next: integrate LDA and gradually evolve to full HDMI

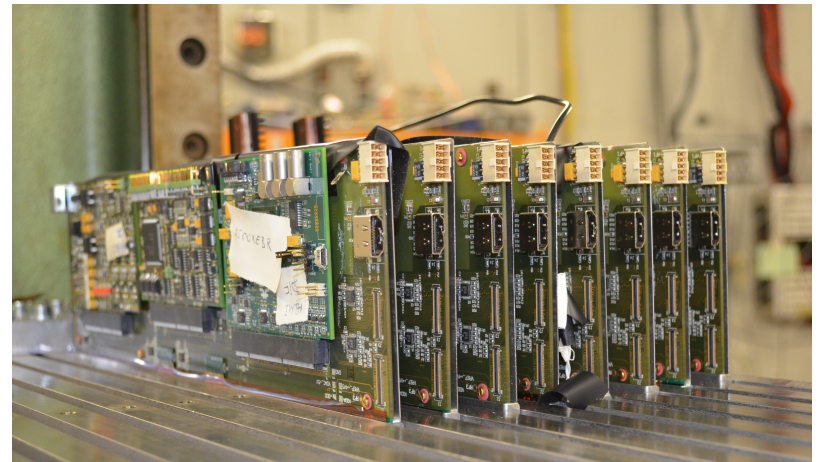
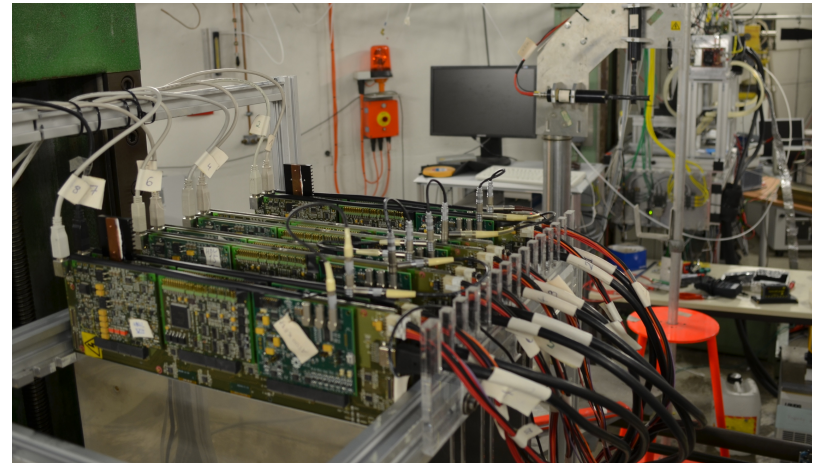
- also worked with ECAL and HCAL layers together
- ECAL group expressed interest to join next HCAL test beam





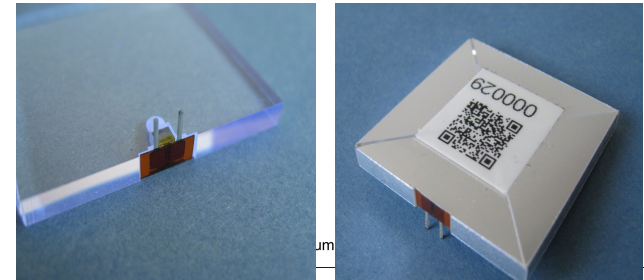
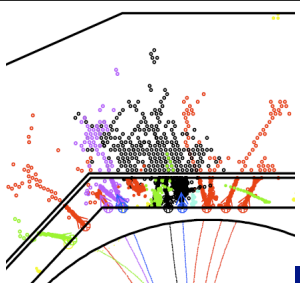
2014 test beam (DESY)

- 3 weeks in Dec 13 - Jan 14
 - DESY, HH, HD, MZ
- 8 layers: 4x ITEP, 4x U-HH
 - 1200 channels
- MIP calibration in air stack
 - 8 layers simultaneous
- Electromagnetic showers in the ILD wedge
 - stainless steel, 8mm gap
- Use of new DAQ LDA (module concentrator) from U-MZ
 - in mixed mode: USB & HDMI

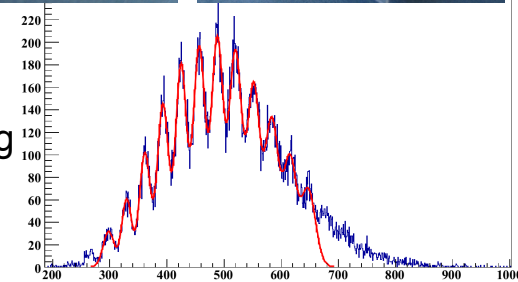


2014 DESY data

- Commissioning on test bench
- MIP calibration
 - run at low threshold (typ. 0.2 MIP)
 - use TDC timing to select simultaneous hits
- Electromagnetic showers
 - 1 - 5 GeV
 - autom. gain selection

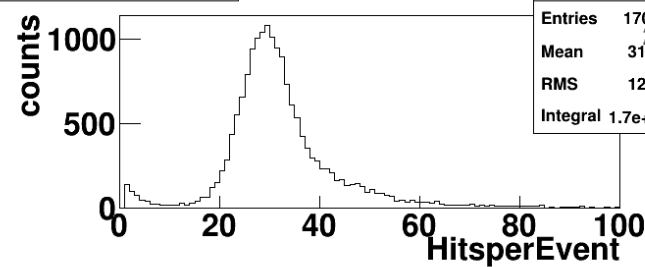


UHH tiles
design MPI
test Heidelberg



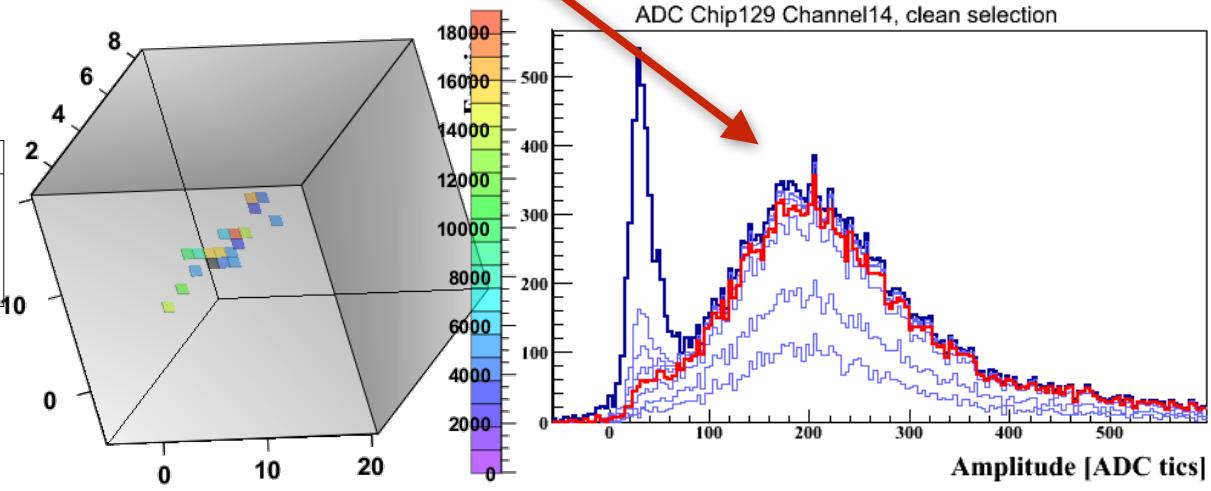
ADC Chip129 Channel14, clean selection

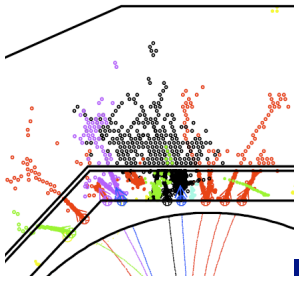
HITSPEREVENT



HITSPEREVENT

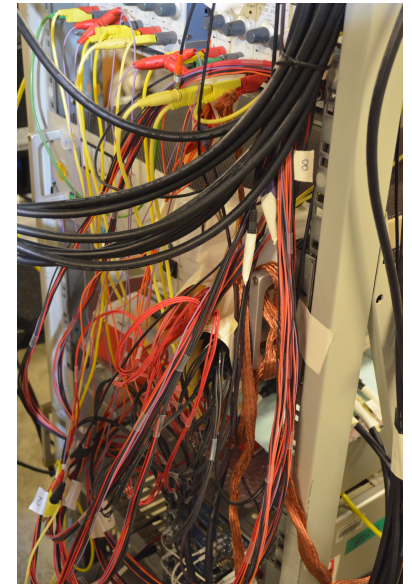
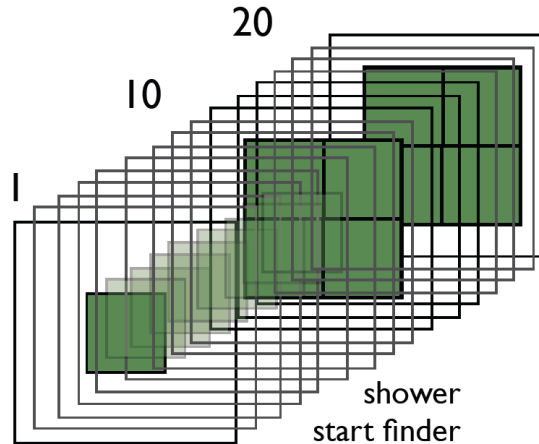
Entries	17062
Mean	20
RMS	12.03
Integral	1.7e+04



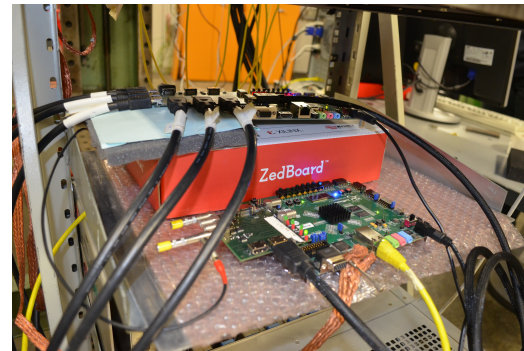


Towards CERN test beam

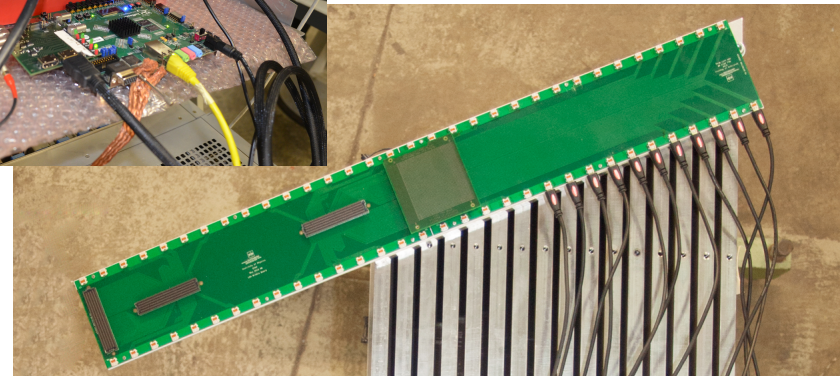
- applied for 2x 2weeks @ PS in fall 2014
- first look into hadron shower timing with Fe and W
- Sensors in the pipeline
 - 300 ITEP (delivered)
 - 600 U-HH (production)
 - 1200 SensL (ordered)
 - 3 EBUs for 1st layers
 - 1-2 from NIU (tbc)
- > 20 HBU in total
 - shower start + 3 full planes
- A lot of commissioning work ahead
- Power distribution
- DAQ development



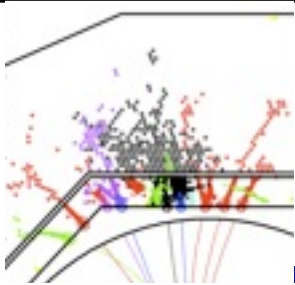
Delivery of HV modules delayed



mini-LDA

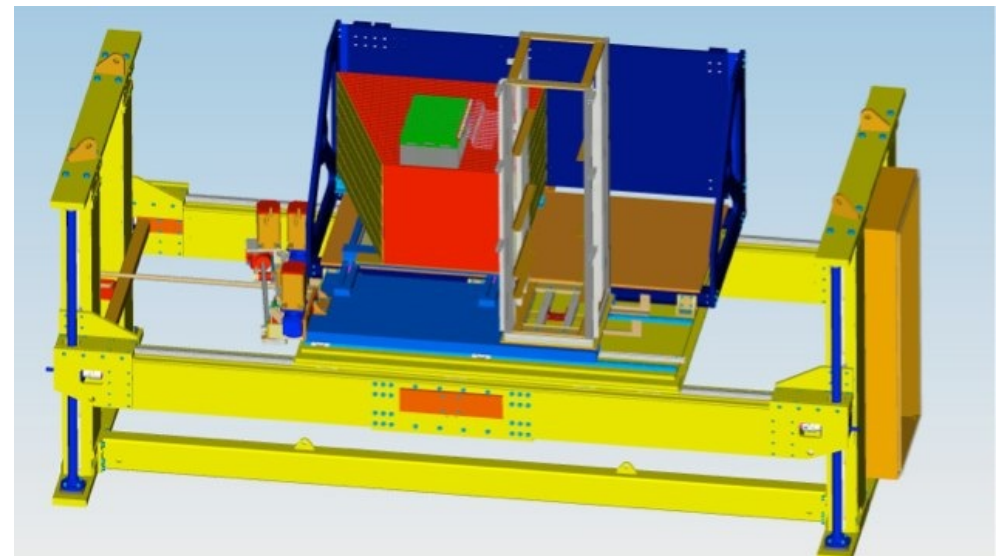
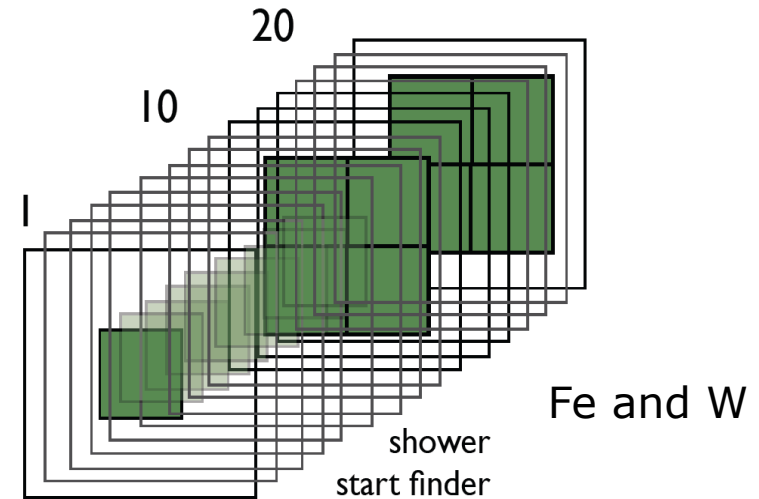


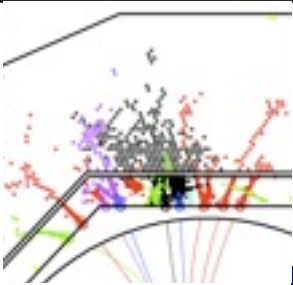
wing-LDA



Flexible test beam roadmap

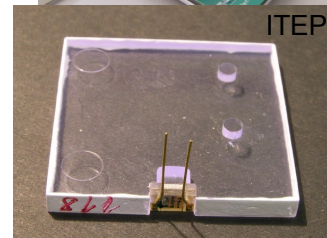
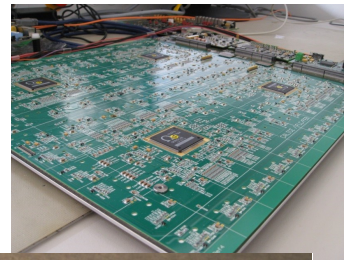
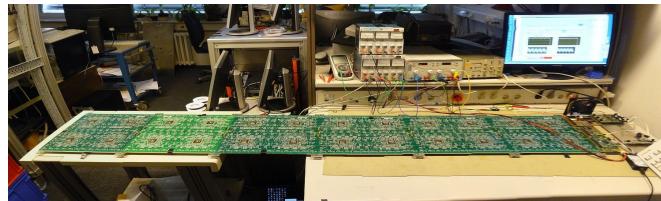
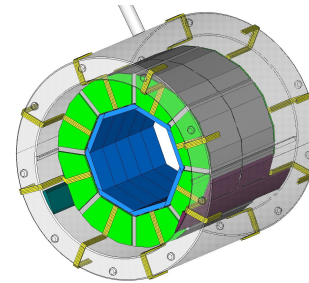
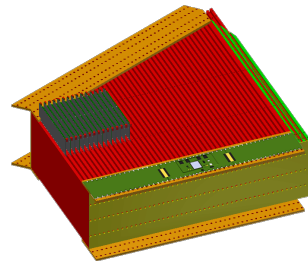
- 2013-14:
 - e.m. stack, 10-15 layers, ~1200 ch
- 2015-16:
 - hadron stack with shower start finder, 20-30 HBUs, ~4000 ch
- 2017-18:
 - hadron prototype, 20-40 layers, 10-20,000 ch
- Gradual SiPM and tile technology down-select
- Exercise mass production and QC procedures



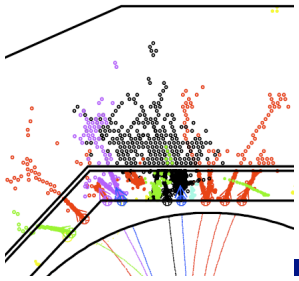


Industrialisation: Numbers!

- The AHCAL
- 60 sub-modules
- 3000 layers
- 10,000 slabs
- 60,000 HBUs
- 200'000 ASICs
- 8,000,000 tiles and SiPMs

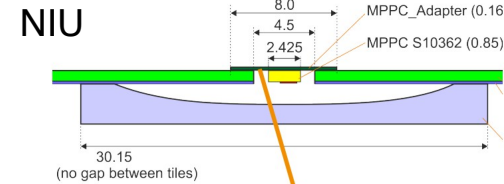


- One year
- 46 weeks
- 230 days
- 2000 hours
- 100,000 minutes
- 7,000,000 seconds

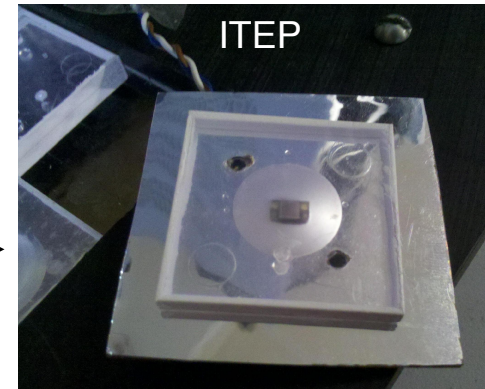
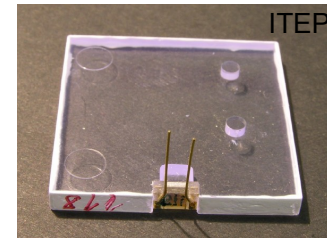


Directions in tile and SiPM R&D

- Revise tile design in view of automatic pick&place procedures
- Inserting SiPM pins into PCB and soldering from component side not easy
- Consider SMD approach, originally proposed by NIU group
- Light yield becomes an issue again
 - but bit better uniformity
- Very different assembly, QC and characterisation chain

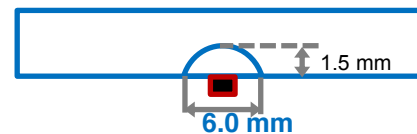


board coming to life



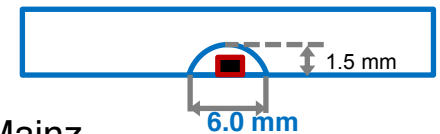
1.2 × 1.2 mm SiPM

Mean 67 p.e.



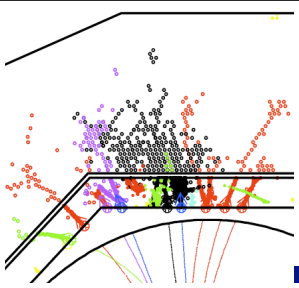
1.2 × 1.2 mm SiPM

Mean 47 p.e. ↓

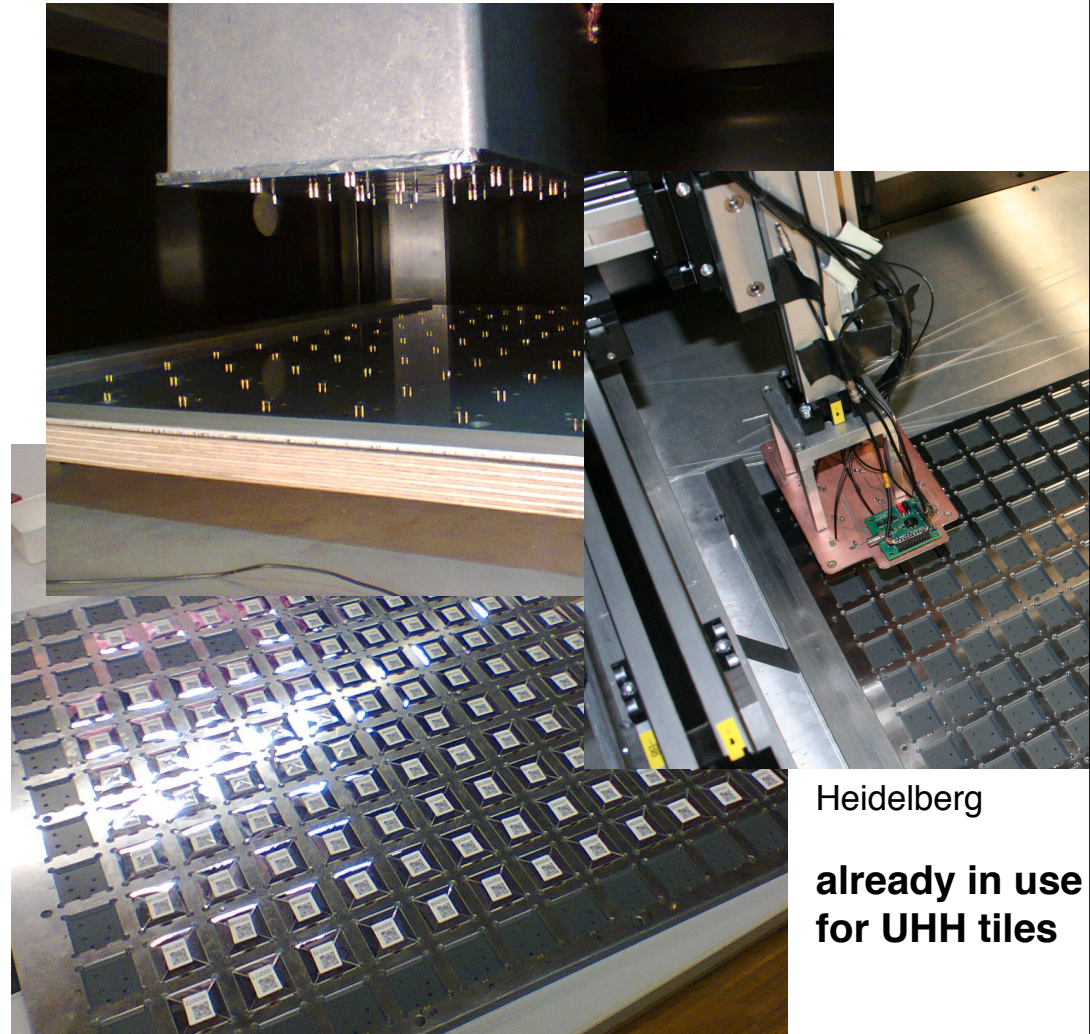


Mainz

Mass tests



- For a full hadronic prototype (20k channels) already need to automatise some of our procedures
 - SiPM and tile tests
 - ASIC tests
 - LED tests
 - DAQ and interface tests
- and evolve them from pin to SMD design
- gain realism:
 - costing
 - timing

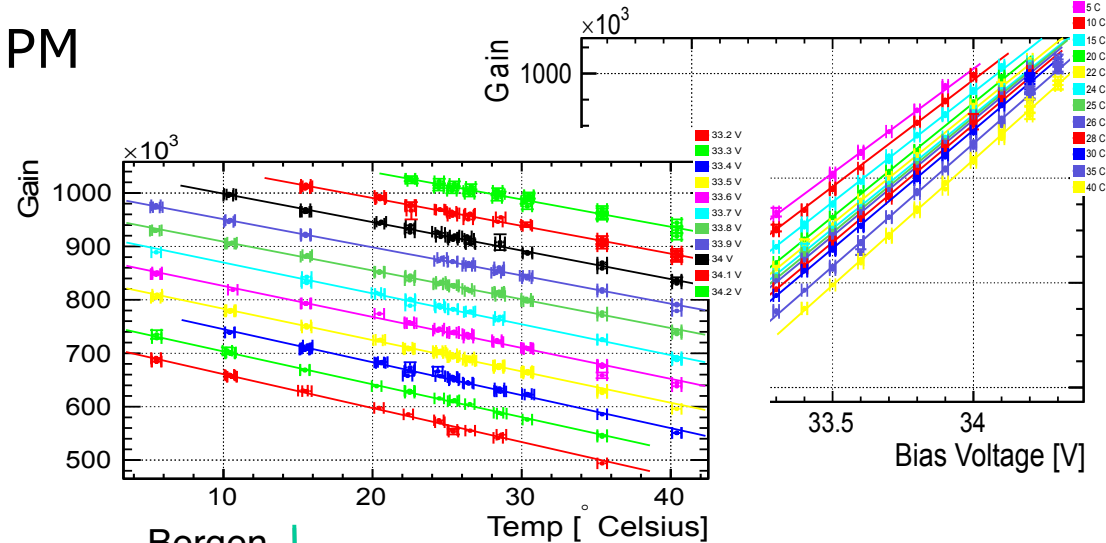


Heidelberg

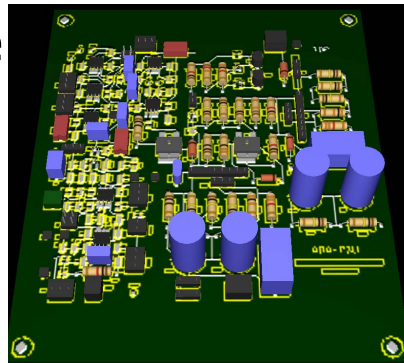
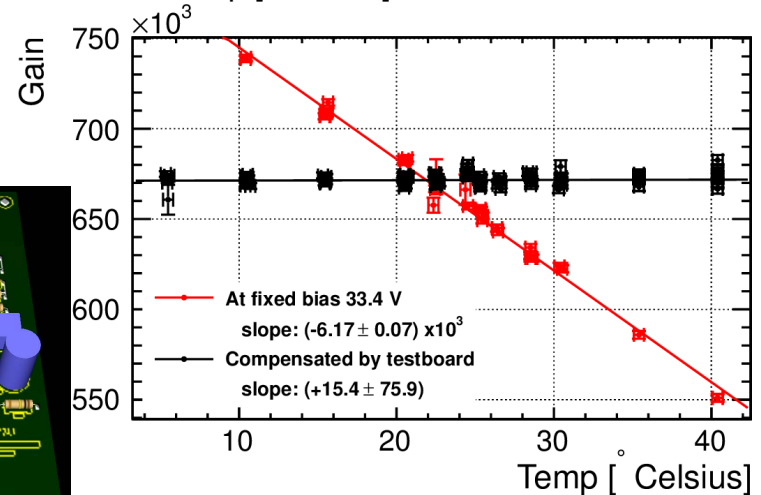
**already in use
for UHH tiles**

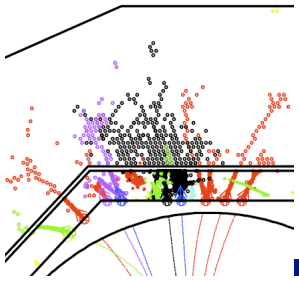
Adaptive power supply

- already used in other SiPM applications
- proof-of principle done
- feasibility in practice depends on
 - accuracy
 - device uniformity
 - range
- requirements understood
 - LCD note
- realisation in hardware
- realisation in software pending



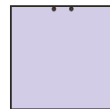
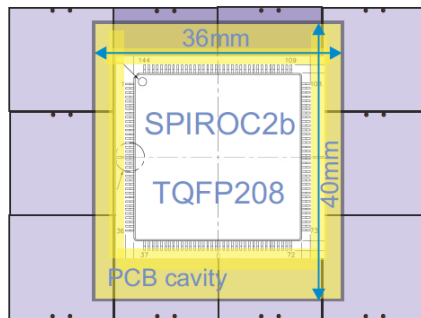
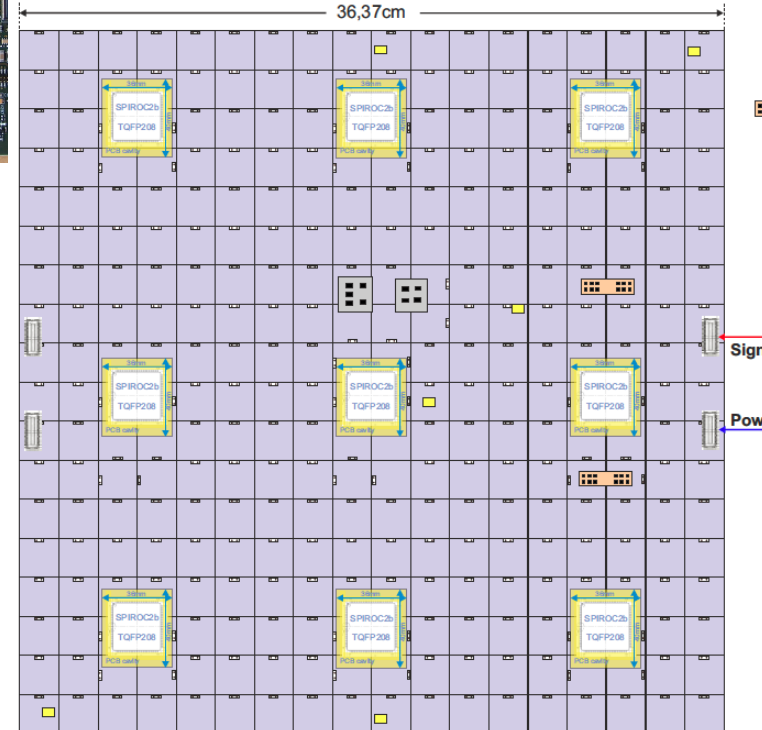
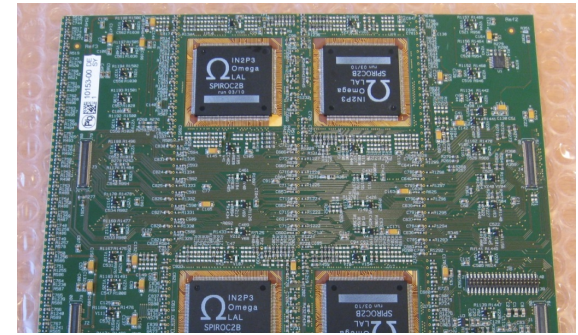
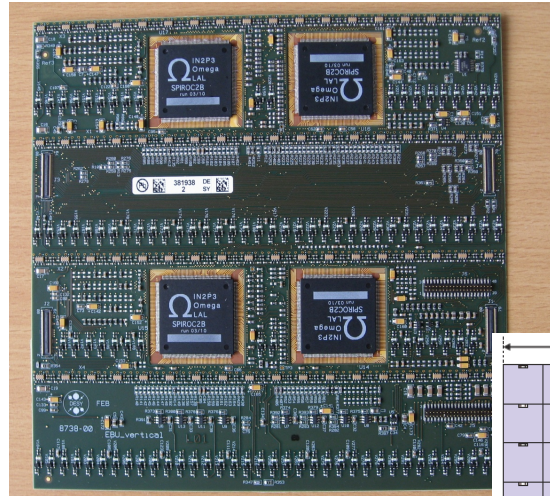
Bergen
CERN
Prague





Synergies with ECAL

- EBU
 - x and y orientation
- design study for 20mm tiles
- options for 15mm tiles



standard tile
(15 x 15 mm²)



long tile
(30 x 15 mm²)
with 8 long tiles on board.

Sign
Pow



Summary

- Physics prototype analysis reaching completion
- Technical prototype made the step to stack
- Interesting challenges ahead once we face the numbers
- Almost unlimited flexibility in geometry
- Proceed in parallel with optimisation studies