

# Status of the CALICE analog hadronic calorimeter:

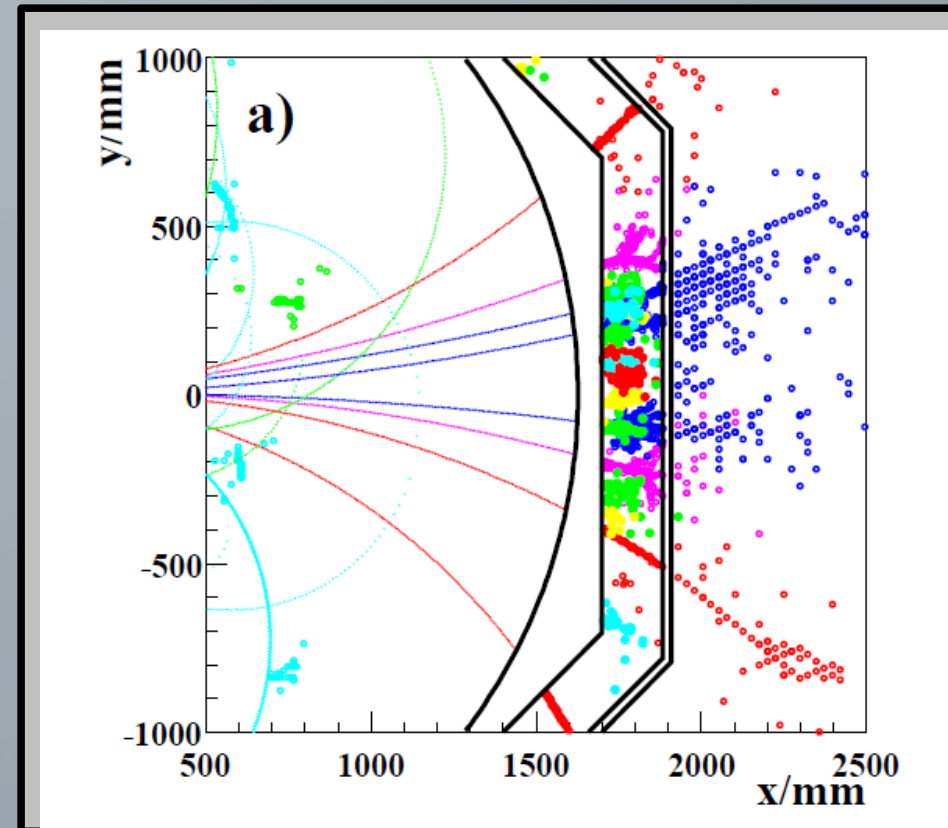
Hardware R&D and progression  
towards a 2nd Generation Prototype

Helmholtz Alliance Workshop  
7<sup>th</sup> December 2011, Bonn  
Julian Sauer

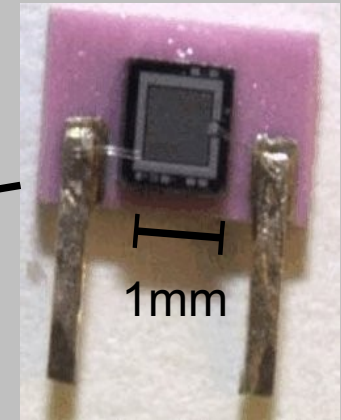
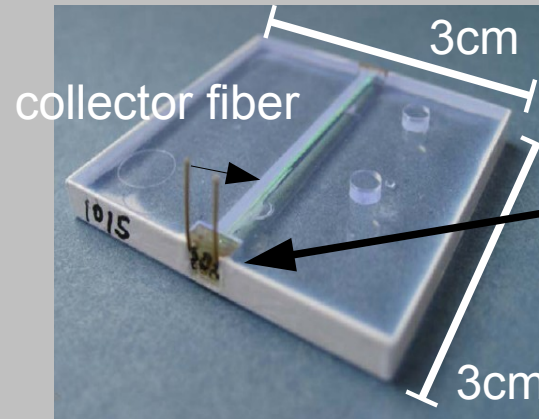
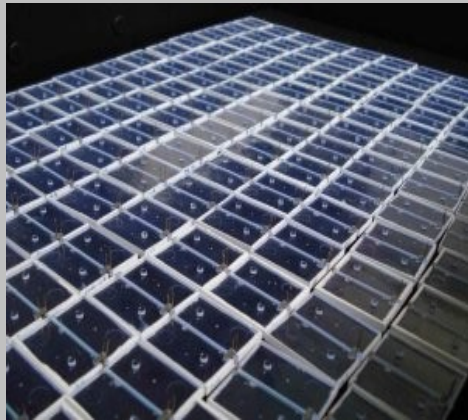


- Particle Flow driven design of the analog hadronic calorimeter (AHCAL)
- Measurements with 1<sup>st</sup> Prototype: Proof of principle and adaptability towards different collider scenarios
- Towards a 2<sup>nd</sup> Prototype: goal, status and milestones towards a realistic prototype
- Conclusion

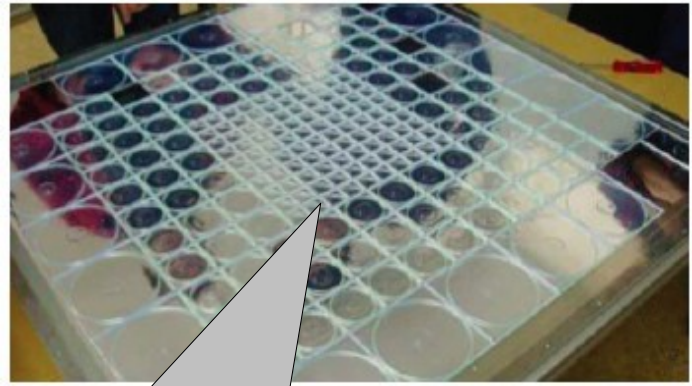
- Optimize energy resolution: measuring all particles in best suited subdetector
- Hadron calorimeter: primarily for **neutral hadrons**
- Energy deposition in HCAL: combination of charged and neutral hadrons  
→ high granularity allows **separation** of energy deposition:  
**charged and neutral hadrons** and e/m fraction from secondaries



- Main Focus in Germany: AHCAL – Granularity is achieved by  $8 \cdot 10^6$  scintillator tiles
- 48 tile layers alternate with steel absorber layers



- Tile readout by **attached Silicon Photomultipliers (SiPM)**
  - Pixel based photon counters: output voltage proportional to number of photons (analog devices → AHCAL)
  - Insensitive to magnetic fields: calorimeter **placeable inside tracker coil**, minimizes “dead” material



Layer of the physics prototype,  
only central tiles have the  
final 3.3cm<sup>2</sup> size

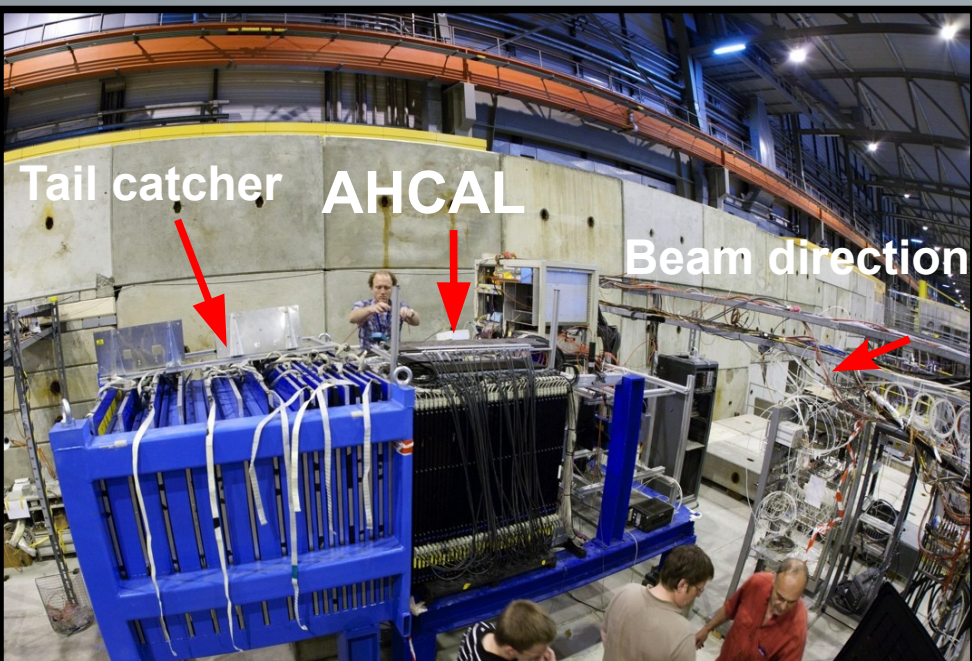
- Proof of principle for tile and SiPM design
  - Prototype specific readout and DAQ
- Built in '06, housing up to 38 Layers and 7608 tiles+SiPM in total
- Successful in several **testbeams at FNAL, CERN, DESY**
- Analysis of testbeam data by all participating institutes
  - ongoing



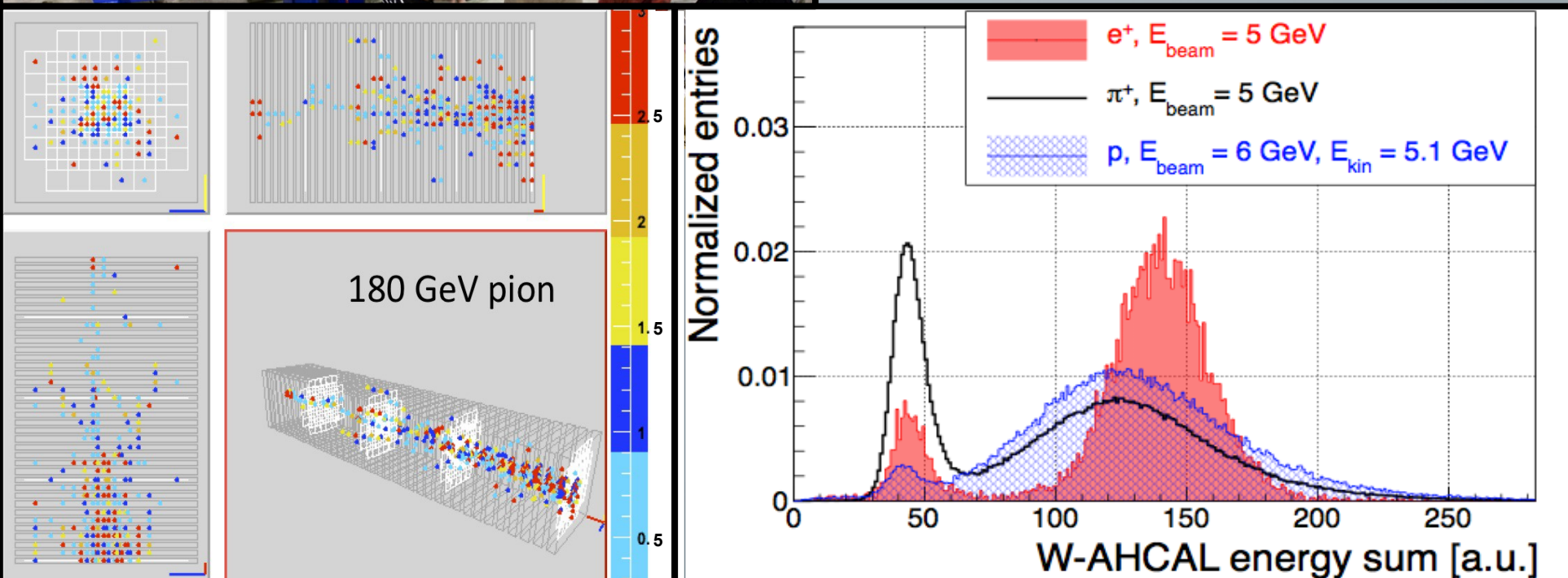
# Testbeam '10/'11 at CERN PS&SPS



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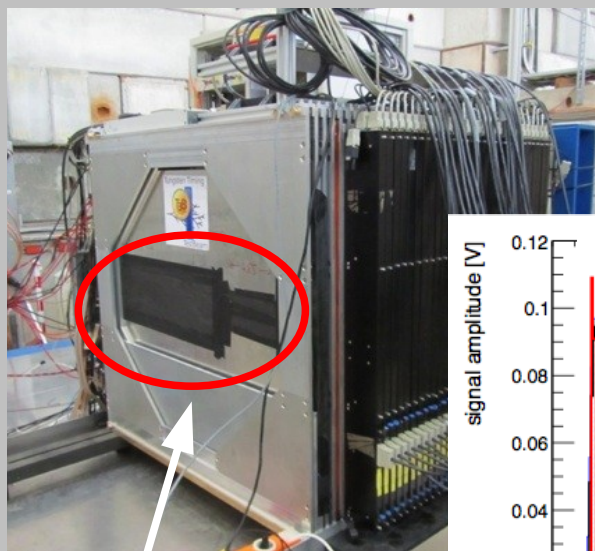


- Testing of the calorimeter concept in a CLIC scenario
  - Tungsten absorber  $4.8 \lambda$
- First look into data
  - Work ongoing



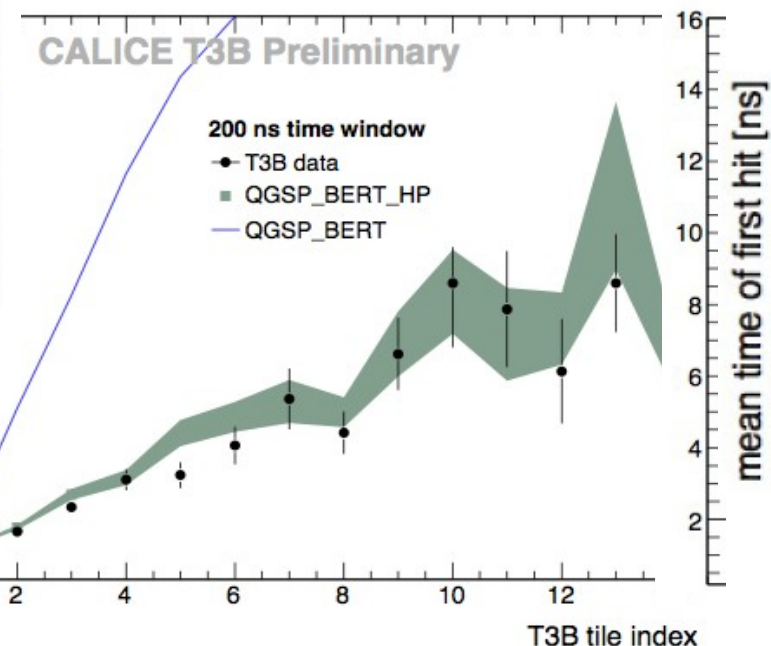
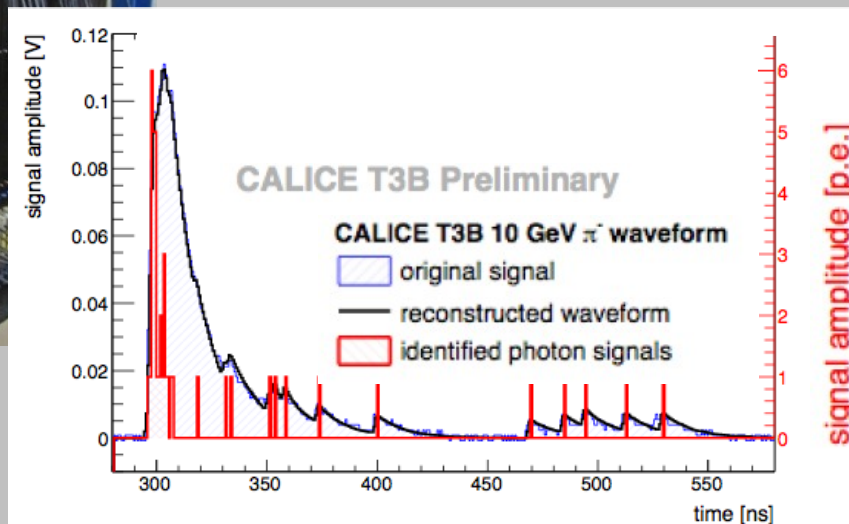


MPI Munich: Dedicated detector behind the prototype  
– 15 cells with fast digitizer readout



The “hidden”  
T3B-layer

Detailed reconstruction of SiPM signals:  
Identification of arrival time of individual  
photons



- Crucial information  
for analysis of testbeam data

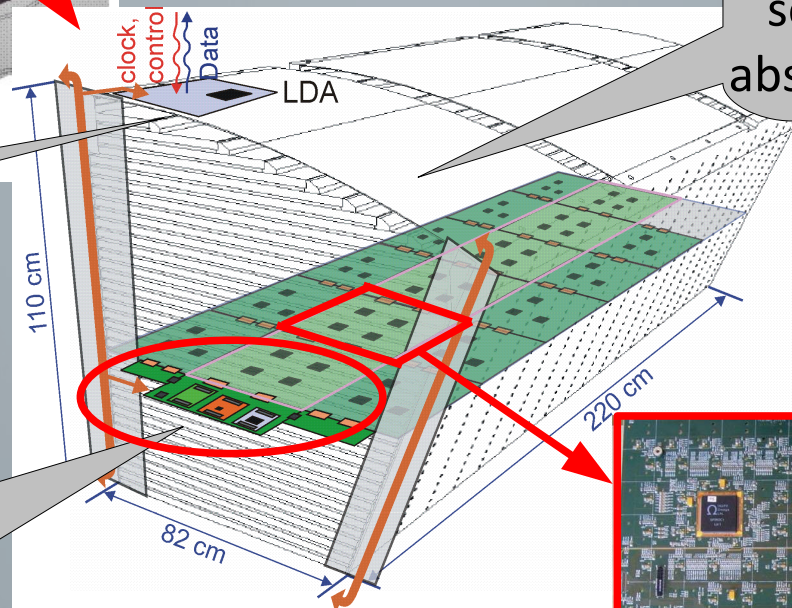
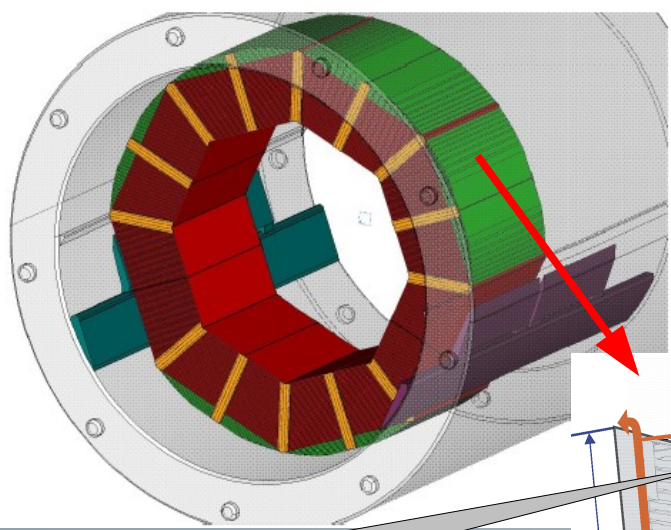


# Aiming at a 2<sup>nd</sup> Generation Prototype



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- German CALICE groups combine their experience on the first prototype with the **embedded front-end and back-end electronics** to a **full-featured scalable AHCAL prototype**



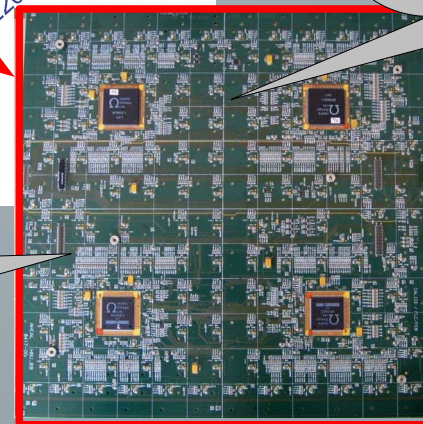
**DESY:** Mechanics self-supporting absorber structure

**DESY:** Hcal Base Unit (HBU) Tiles and readout chips

**Mainz:** "Outside world" communication

**DESY:** Central Interface Board with 2 side modules control 6 HBU each

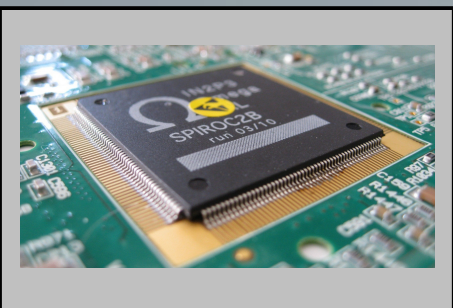
**Wuppertal** SiPM Calibration System



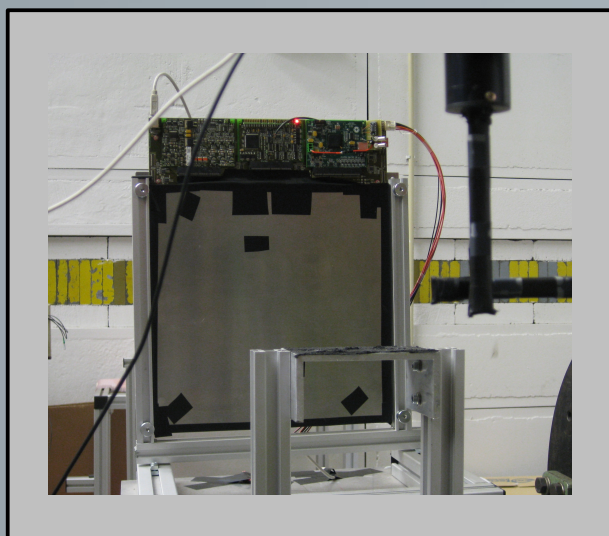
**Munich:** alternative tile options  
**Heidelberg:** SiPM qualification



# Milestone I: Hcal Base Unit



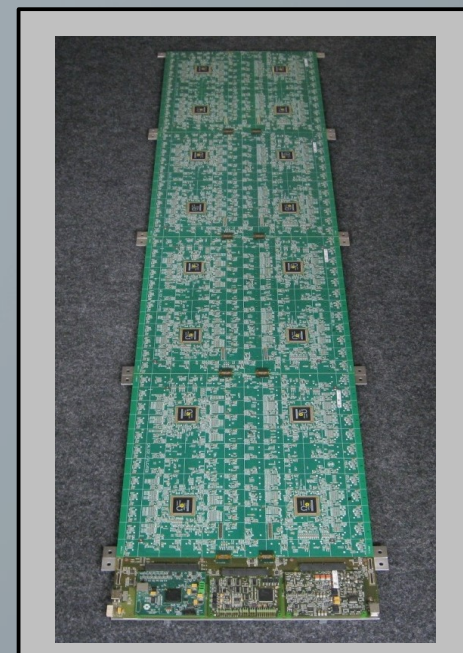
- Contains 4 readout chips (SPIROC, Orsay)
- SPIROC features: readout including AD-conversion, self-trigger, hit timing information



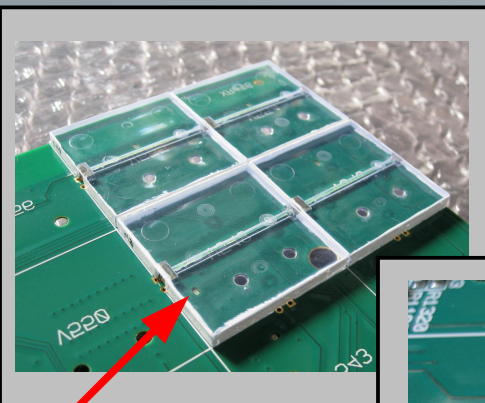
- All components in commissioning
- First operation in **DESY testbeam**
- 4 HBU of latest generation, more follow soon!

Next steps:

- **Milestone II**: operate HBU-SLAB setup
- **Milestone III**: build multi layer setup

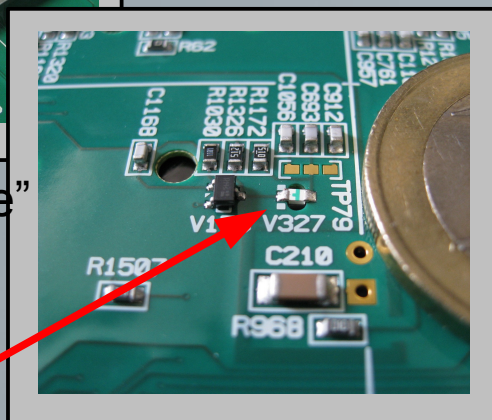


# Further developments



Tiles on "top-side"

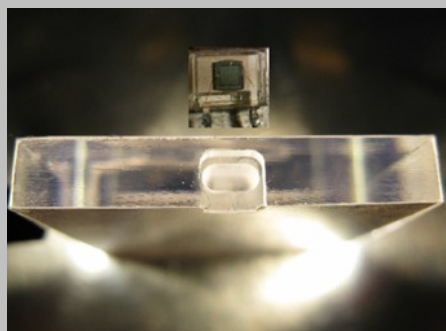
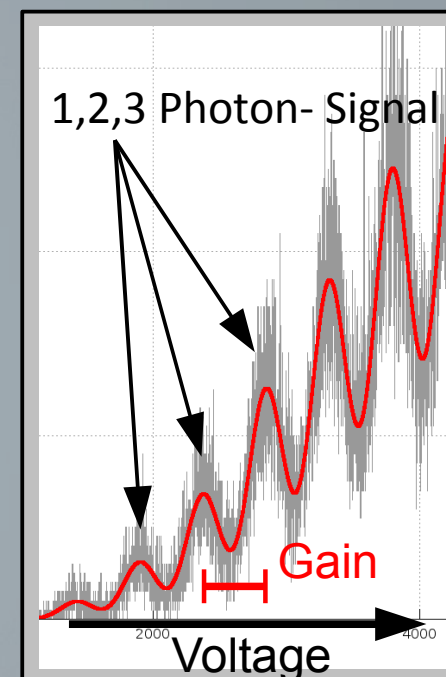
Pulser + LED on  
"back-side"



- **Wuppertal**: HBU-embedded LED based gain-calibration system for SiPM

- Gain depends on voltage & temperature
- Gain varies between SiPM

- Pulse circuit + LED behind each tile to couple few photons into SiPM → extract from histogram

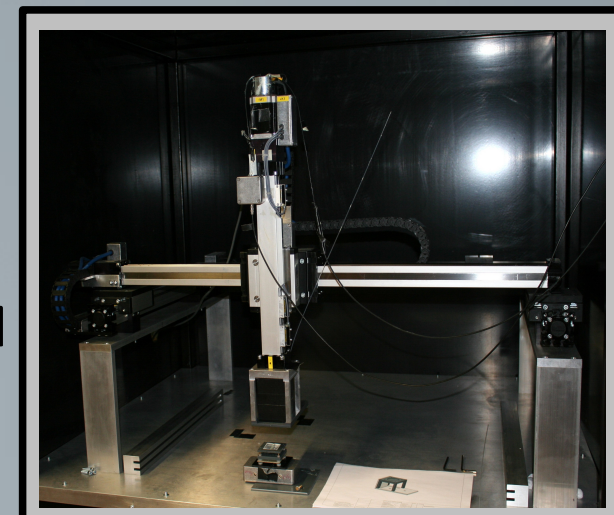


- **Munich**: development of tiles without collector fiber + mass production techniques
- Future: assembly of an HBU with fiberless tiles

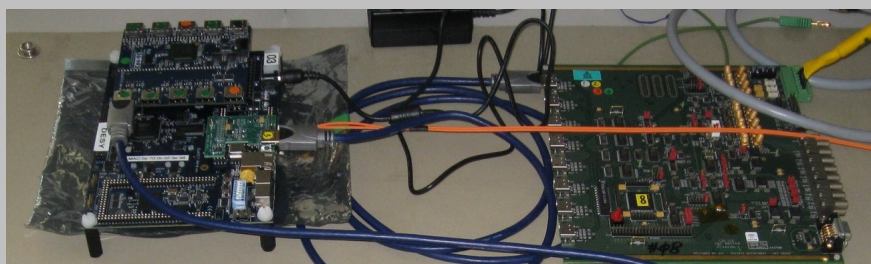
# Towards larger setups



- Important goal of 2<sup>nd</sup> gen. prototype
  - Confirm HBU scalability and mass production
- **Heidelberg**: R&D of large scale tile tester
  - Characterization & quality control of tile & SiPM
  - Challenge:  $8 \cdot 10^6$  tiles for final detector
  - Parallel measurements,  $\sim 1$ s per measurement

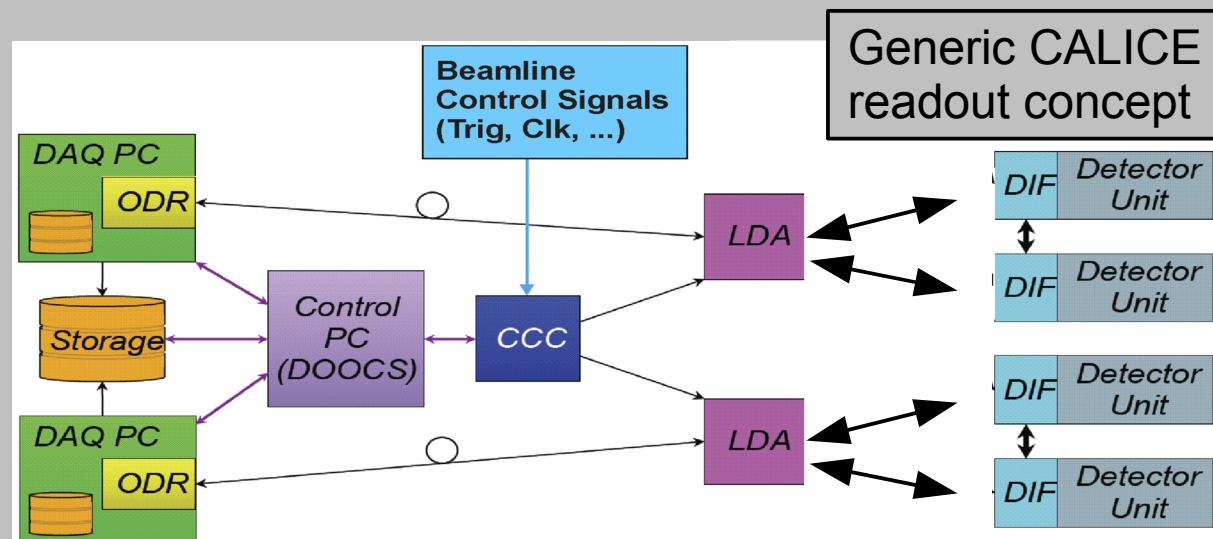


- **Mainz**: just joined CALICE, re-design of back-end electronics:



Link&Data  
Aggregator  
(LDA)

Clock & Control  
Card (CCC)





- CALICE AHCAL design: successful proof of principle with 1<sup>st</sup> prototype in different testbeam scenarios
- A 2<sup>nd</sup> Generation prototype is under developement to prove feasibility of building a realistic calorimeter
- In parallel R&D of specific components is ongoing
- German institutes play an important role and are engaged in many different aspects of the AHCAL development
  - Mechanics, readout, calibration, back-end, ...