Electronics for Highly Granular Scintillator Calorimeters.

Applications in the CALICE AHCAL and ScECAL

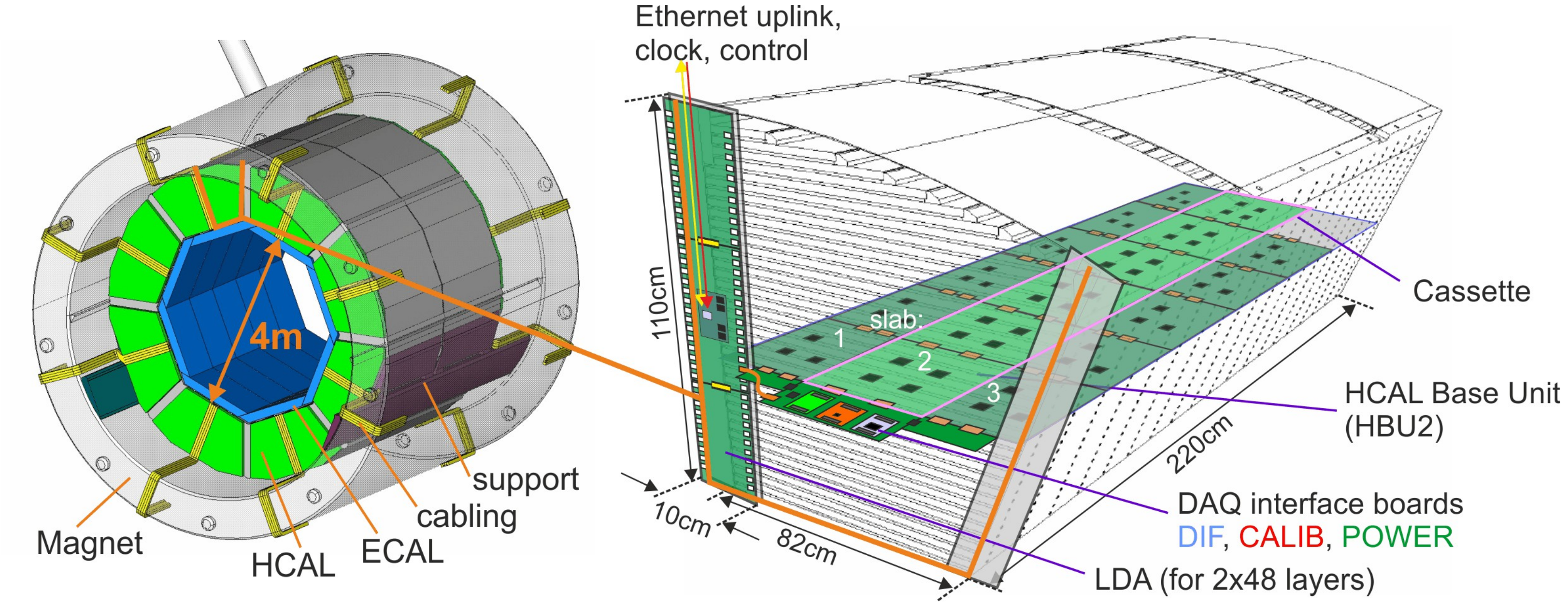
- HCAL Base Unit (HBU) and Surface Mounted HBU
- ECAL Base Unit (EBU)
- Power Pulsing
- Data Acquisition System (DAQ)

Aliakbar Ebrahimi - DESY
LCWS 2013
Tokyo, Nov 11-15 2013

CALICE Analog Hadron CALorimeter (AHCAL)

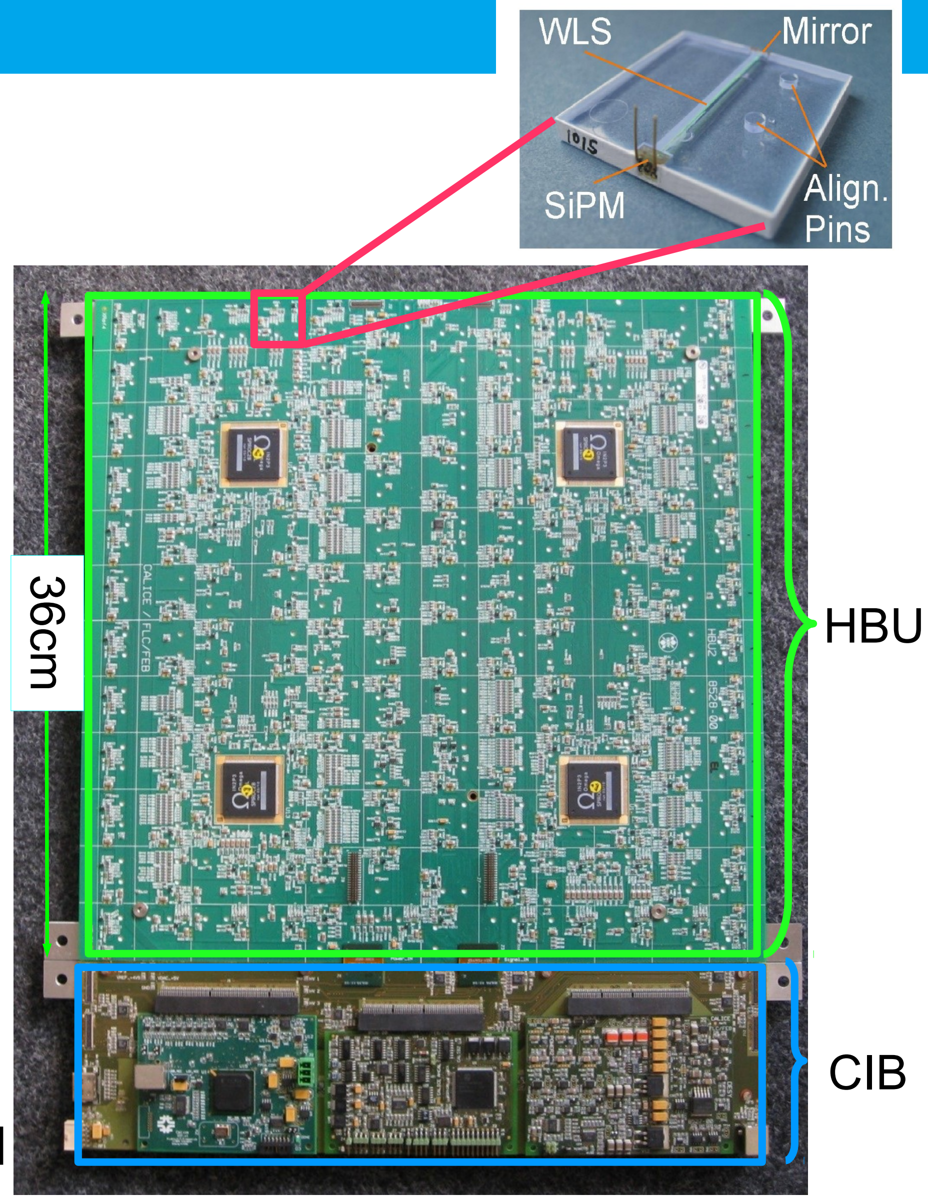
> A highly granular calorimeter for ILD

- Iron or Tungsten absorbers
- 3x3cm^2 plastic scintillator tiles
- Read out by individual Silicon PhotoMultipliers (SiPM)
- 8 millions channels, 50k PCB → Readout fully integrated into the layers

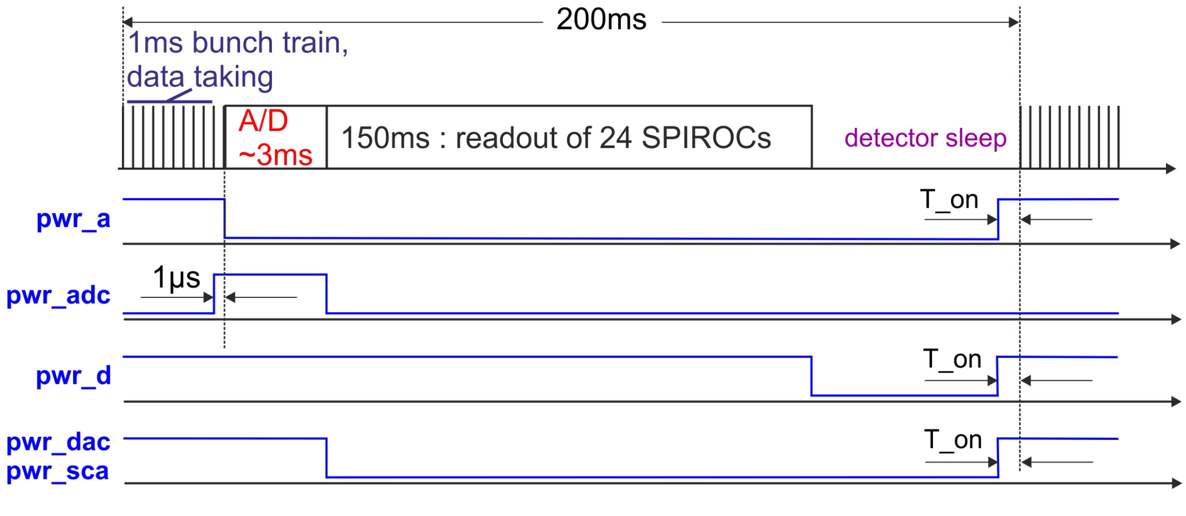


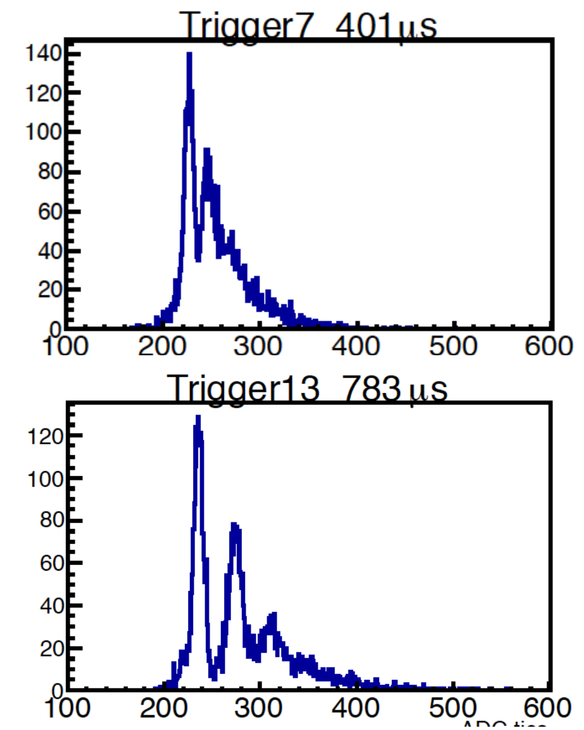
HCAL Base Unit (HBU)

- 144 detector channels
- 4 SPIROC2b ASICs
  - Designed by OMEGA (France)
  - 36 channels per ASIC
  - **12 bit ADC and TDC**
  - Auto trigger
  - **Power pulsing (25 µW/channel)**
- Integrated SiPM calibration system
  - 1 LED per channel
- Each layer has a Central Interface Board (CIB)
  - DAQ interface, Calibration board, Power board
- 5 HBUs in use, more to be equipped with tiles by the end of the year



Power Pulsing

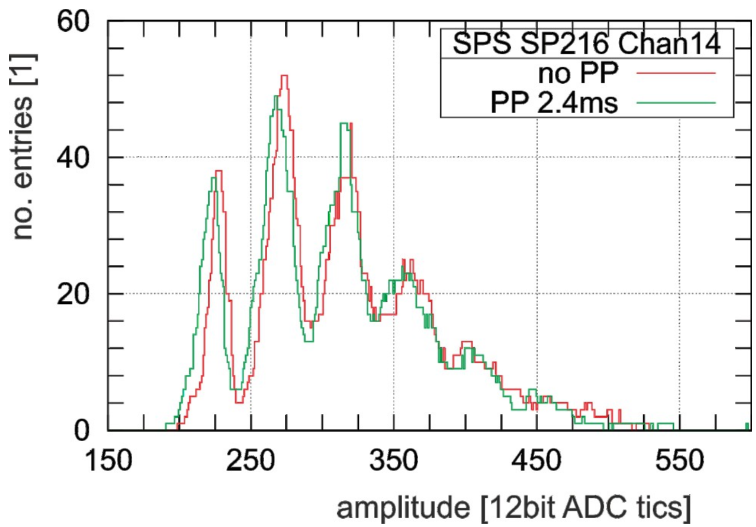


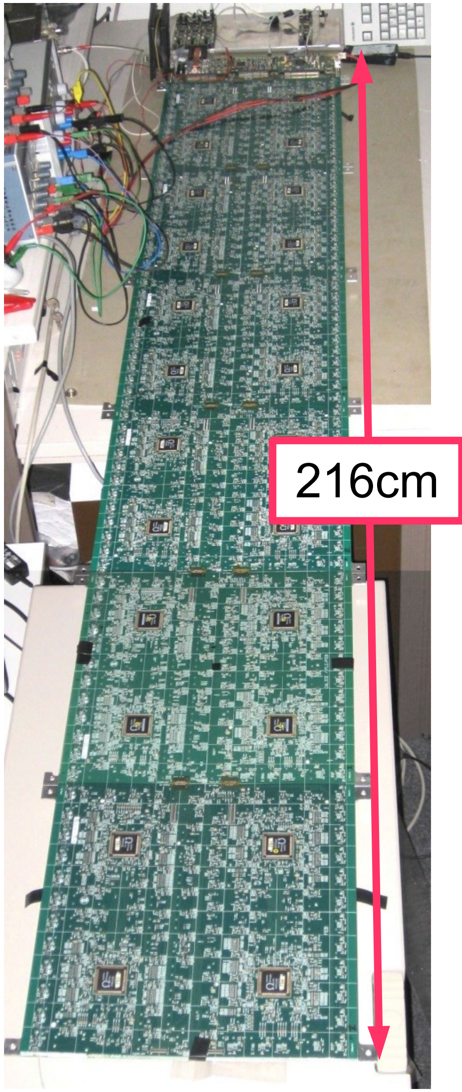


- No active cooling inside absorber gaps
- Switch off the detector between bunch trains
- How long T_on should be to save maximum power without limiting detector performance?
- HBU Power pulsing tested successfully using LED calibration system
- T_on time is longer than ASIC design expectation
- Too short Switch-on time → Low gain and high noise

Power Pulsing: Full Extension Test

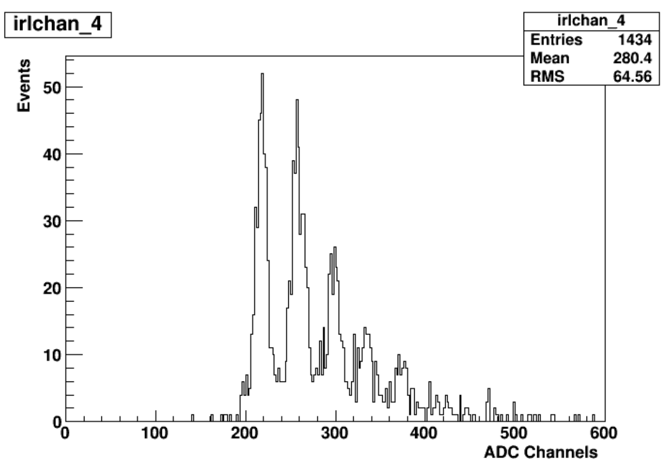
- Power pulsing tested in a full slab
  - 6 HBUs in a serial configuration
- Additional block capacitors are needed to compensate voltage drop across 216cm
- With 6mF, ~2ms T_on gives excellent agreement between performance with and without power pulsing

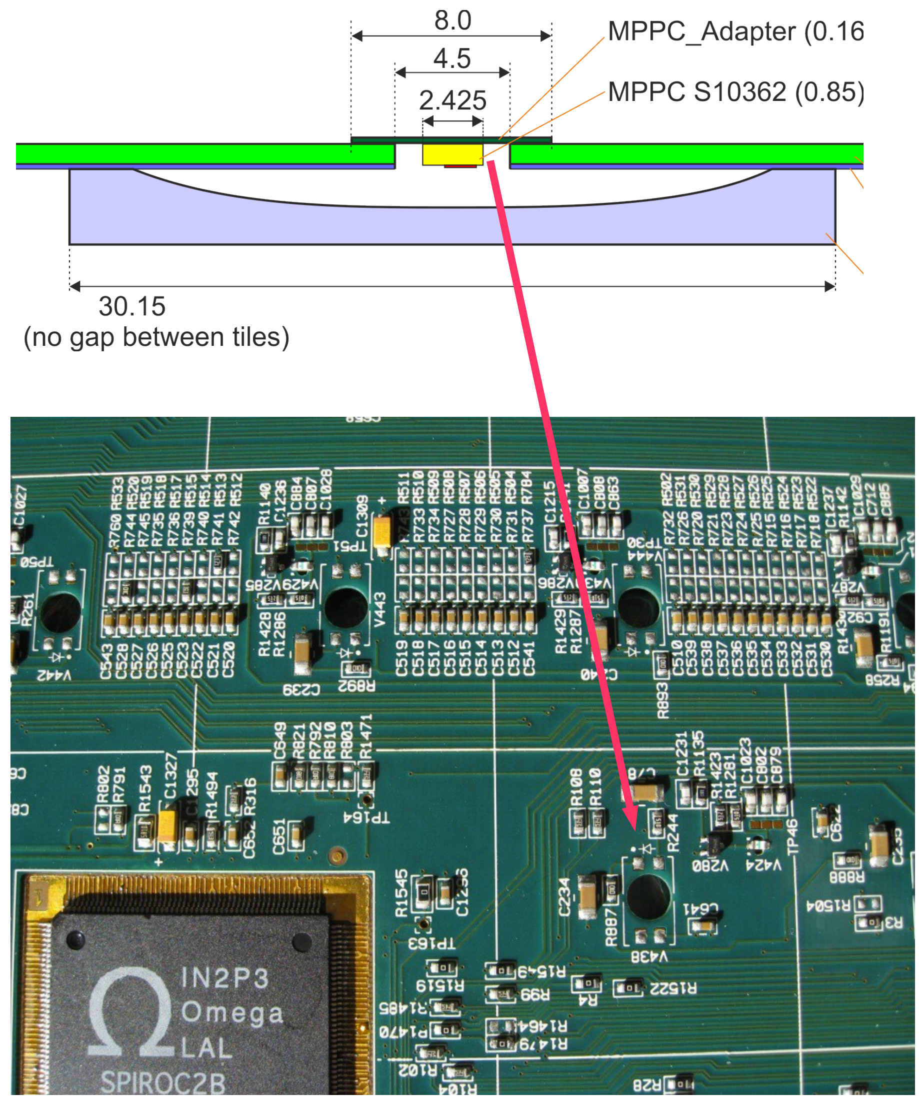




Surface Mounted HBU (SM_HBU)

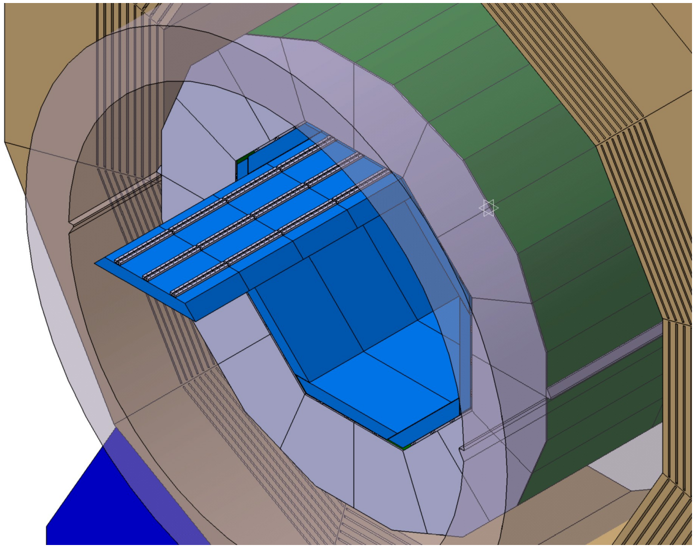
- Collaboration with Northern Illinois University
- Tiles with concave cavity to improve uniformity
- One “megatile” per HBU
- SiPM is mounted on the PCB
- Two SM_HBU are produced
- Tested at NIU

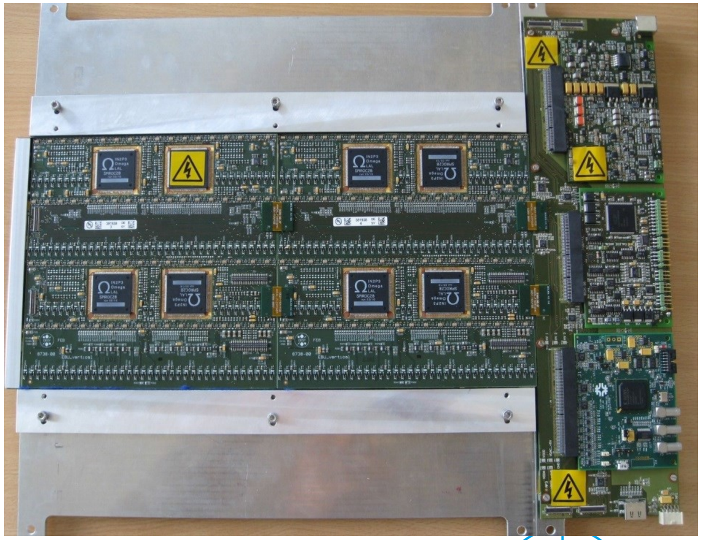




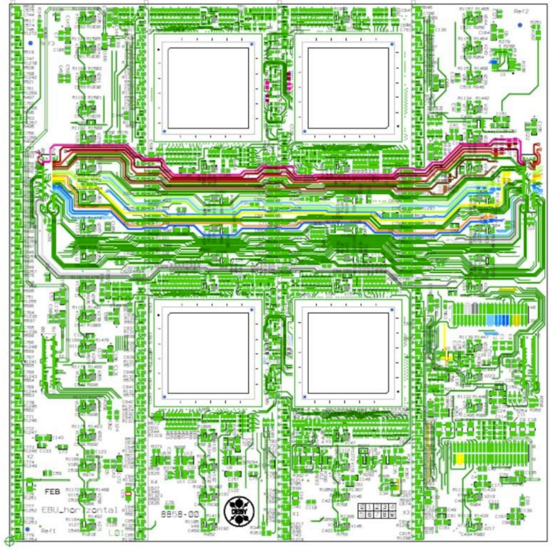
ScECAL Base Unit (EBU)

- In collaboration with Universities of Shinshu, Kyushu and Tokyo
- ScECAL uses scintillator strips
- HBU Architecture
- Two different PCB designs needed
- One orientation is produced and tested
- Second orientation in production



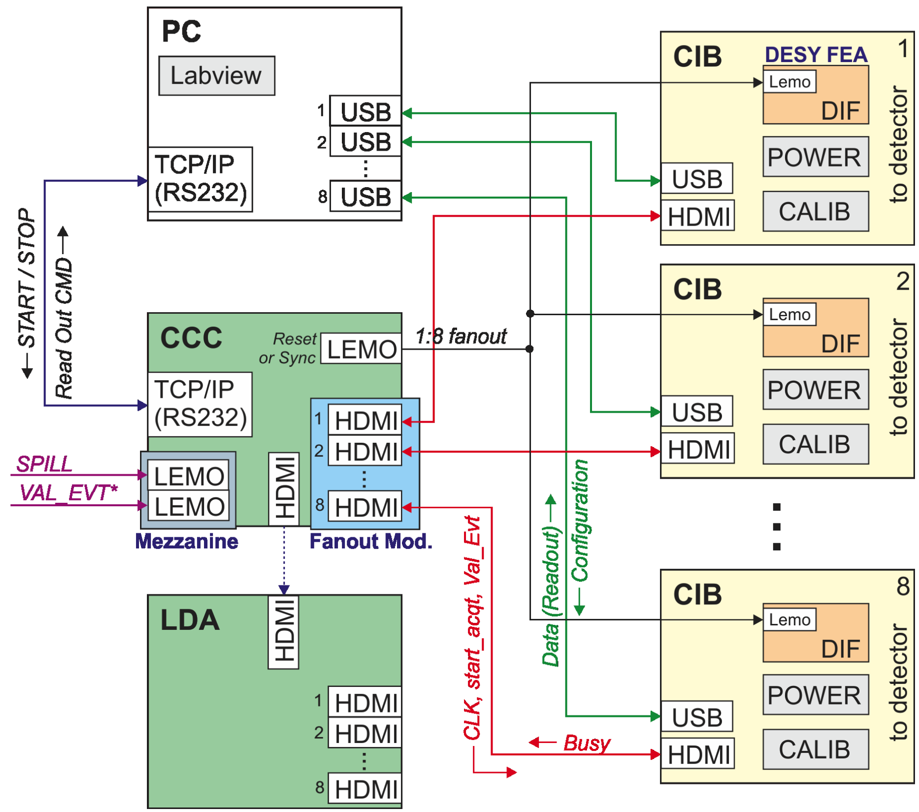


Horizontal EBU Layout



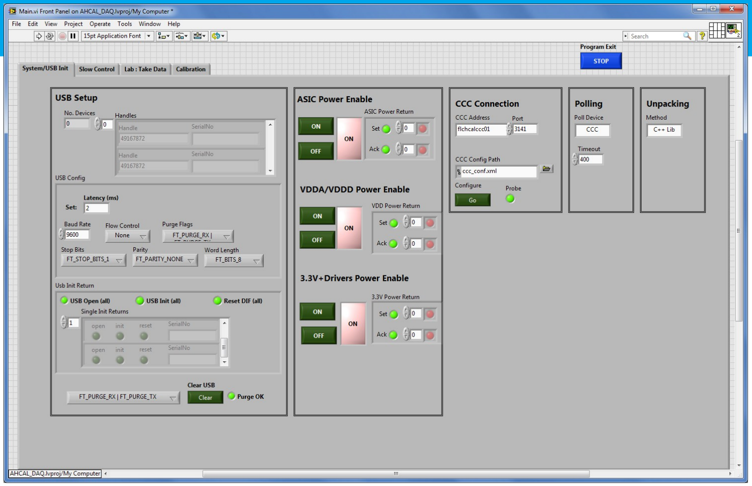
AHCAL Data Acquisition System (DAQ)

- New multilayer DAQ based on the original CALICE DAQ concept
  - Multithreaded software
  - Global clock and control
  - Data aggregator
  - Multiple-DIF configuration
  - Parallel readout
  - Scalable
- HDMI interface to detector layers
- Data will be transferred via HDMI once the LDA is ready

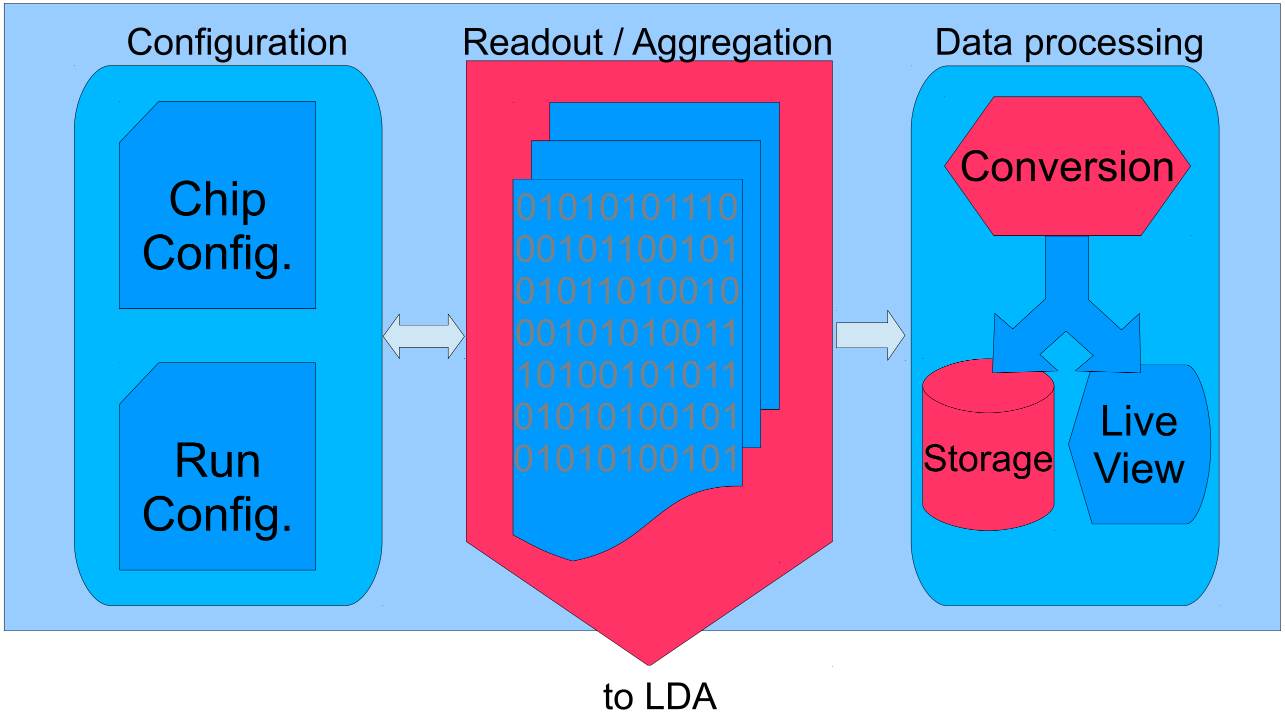


DAQ Design Concept

AHCAL DAQ Software

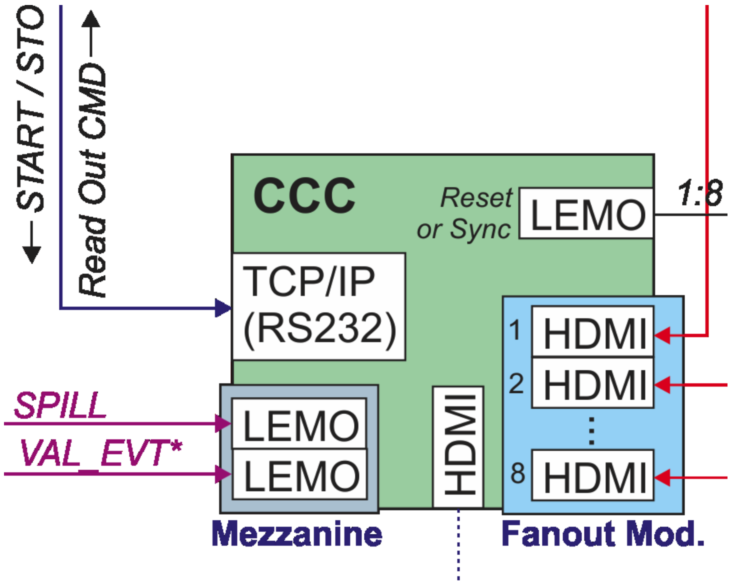


- Based on LabView
  - Live monitoring
- Some tasks done using C++ libraries
- Multithreaded
- Modular

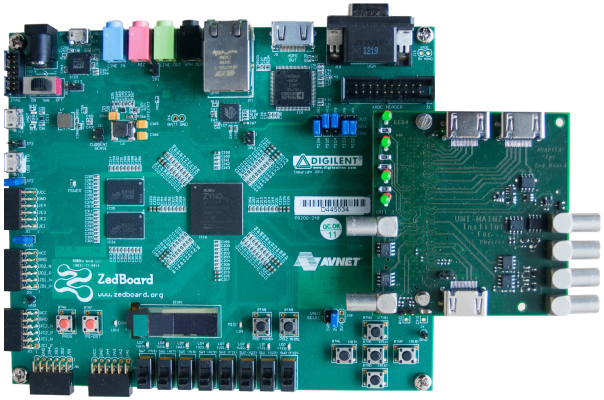


Clock and Control Card (CCC)

- New CCC design by university of Mainz
  - Compatible with CALICE DAQ
- Based on Xilinx Zynq FPGA/SoC
  - Very flexible
  - Powerful on-board processing
  - There are two options
    - ZedBoard
    - MarsBoard



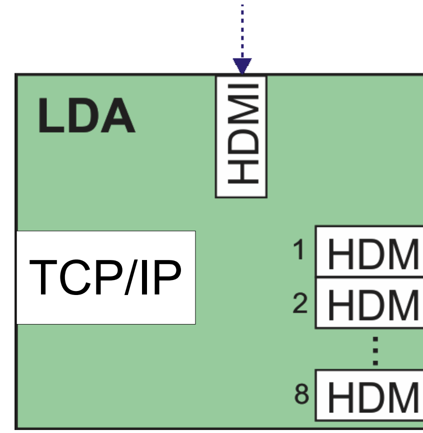
- Ethernet connection to PC for Start/Stop/Readout
- In temporary setup while LDA is being developed
  - 8 layers can be controlled using an 1:8 HDMI fanout
- Parallel data path thorough HDMI is tested successfully

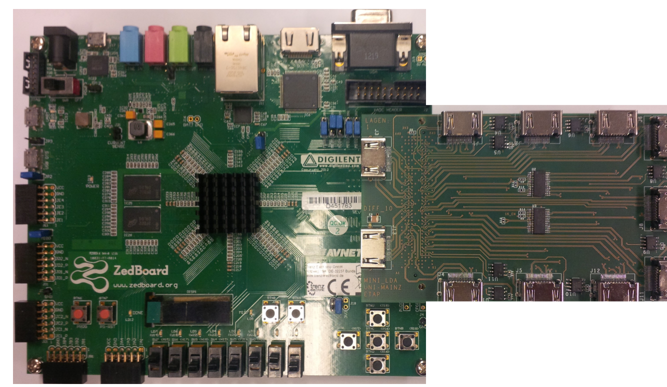


ZedBoard and Mezzanine

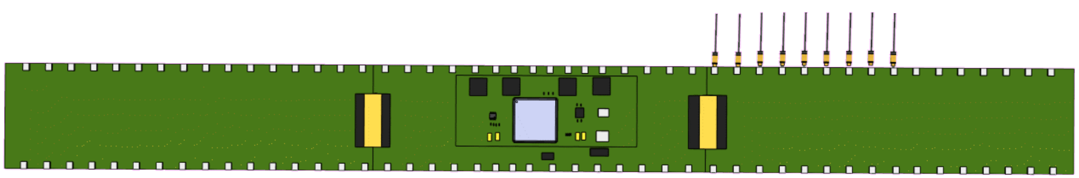
Link and Data Aggregator (LDA)

- New LDA design by university of Mainz
  - Compatible with CALICE DAQ
- Based on Xilinx Zynq FPGA/SoC
  - ZedBoard or MarsBoard
- There are two options
  - Mini-LDA: ZedBoard + Mezzanine → Generic
  - Wing LDA → AHCAL geometry specific
- Interfaces
  - 1 ethernet connection to PC
  - 1 HDMI connection to CCC
  - XX HDMI connection to DIFs



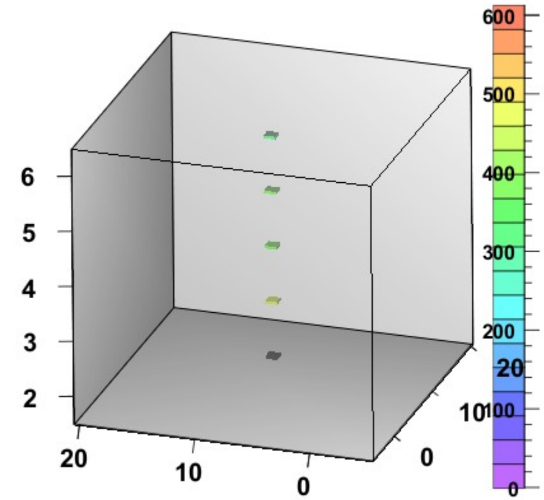


Mini-LDA and Mezzanine

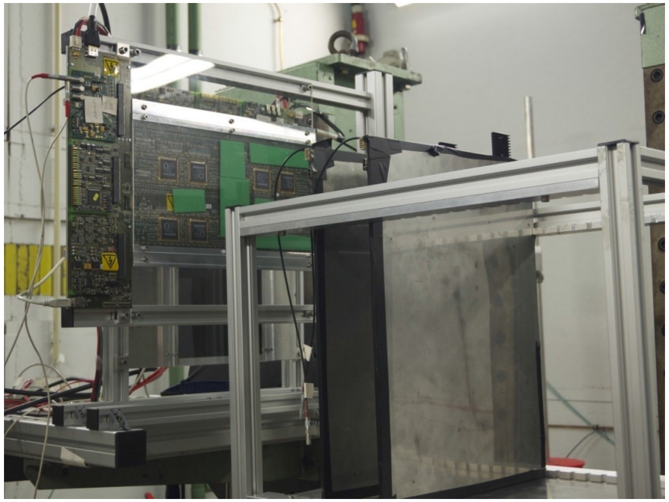

Wing LDA

Performance of the DAQ system

- Current version of the DAQ tested in different setups
  - Lab Setup, Cosmic Muon run, Test beams
- Fully synchronous operation of 5 layers
- Very stable operation
  - 72+ hours cosmic Muon run
- Faster than ever
  - ~9Hz readout frequency
  - ~150Hz sustained trigger rate
- Successfully tested in a two detector setup
  - 2xHBU + 2xEBU
- It could be used for the other calorimeters



A track in 5 layers at test beam


HCAL+ECAL

Next Steps and Summary

Next steps

- To test power pulsing with particle beam
- Incorporate LDA into DAQ system
- More HBUs to be equipped to enlarge the system

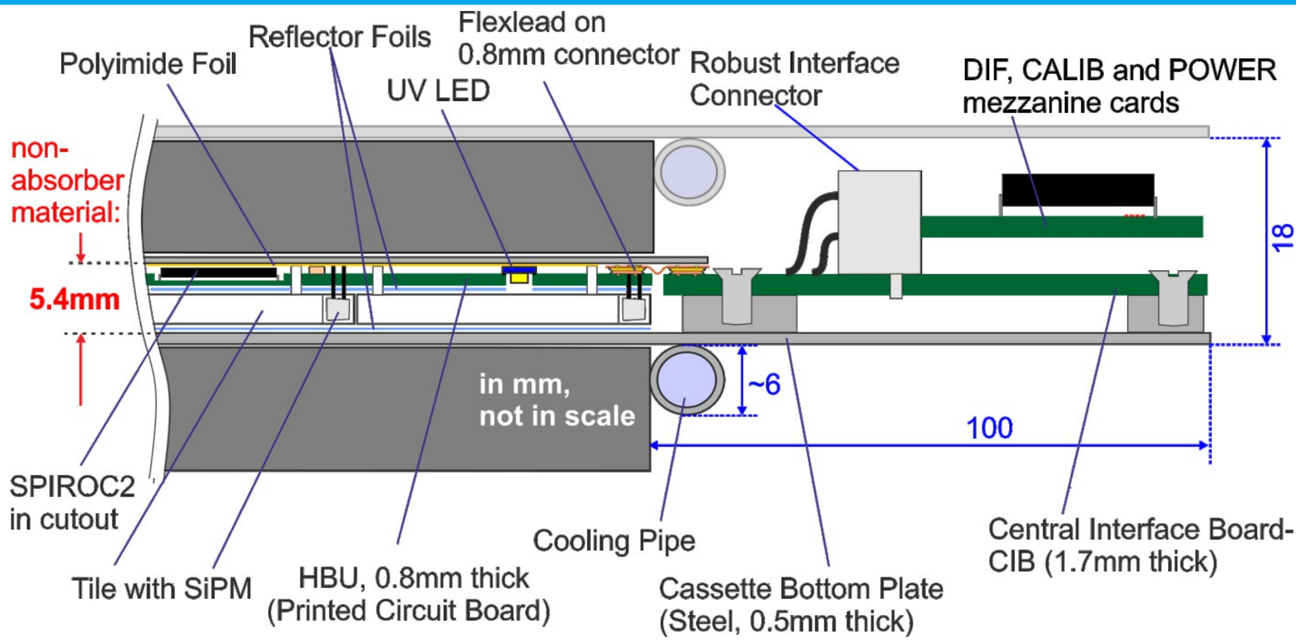
Summary

- Flexible electronics for scintillator calorimeters
  - Two versions of HBU for scintillator tile AHCAL with different SiPM mounting
  - Two versions of EBU for scintillator strip ECAL with different strip orientation
- Power pulsing is being tested, so far successfully
- DAQ system for scintillator calorimeters is being developed and tested
- Ready to integrate ScECAL in AHCAL test beams

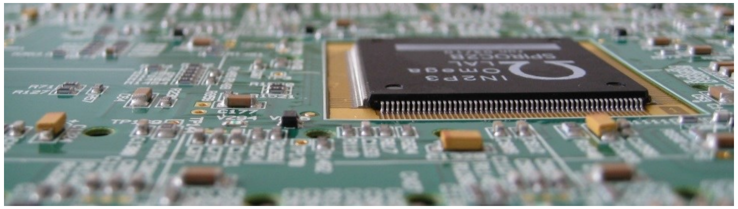

We wish for a prosper ILC with
excellent data quality,
lots of Higgs self-coupling
and an integrated DAQ
for all calorimeters!
Ali & Claude & Oskar...
願意

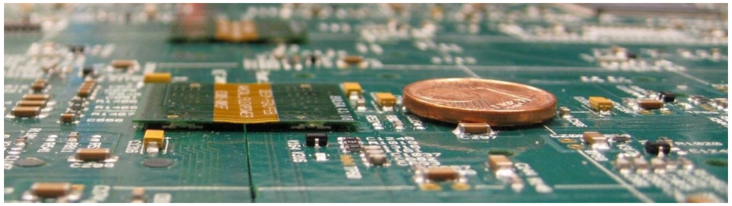
Backup

AHCAL Layer Cross-Section



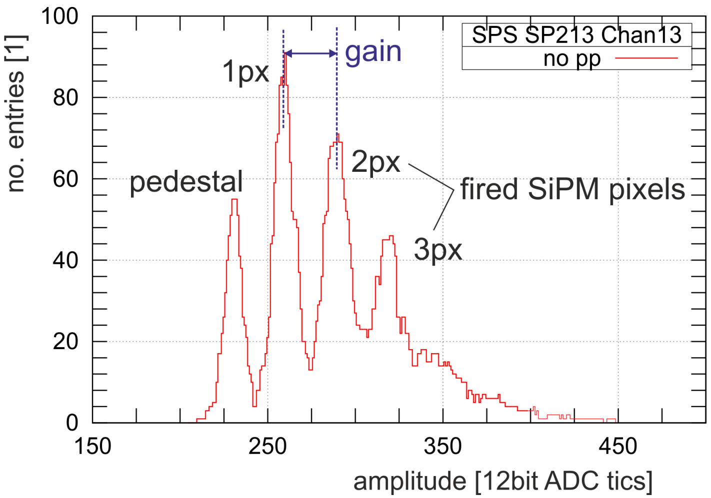
> Tight space between absorbers
  - 5.4 mm thick slits
  - 3 mm is used by the plastic scintillators
> Extra thin PCB
> ASICs are placed in cavities on PCB
> 0.8 mm connectors are used

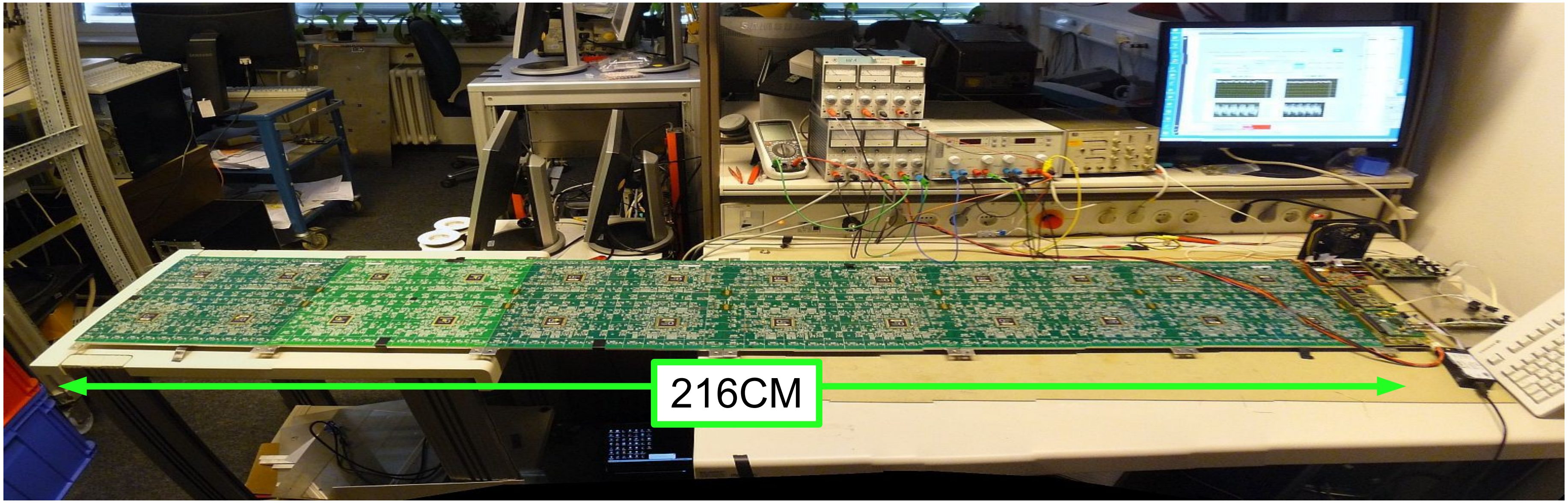




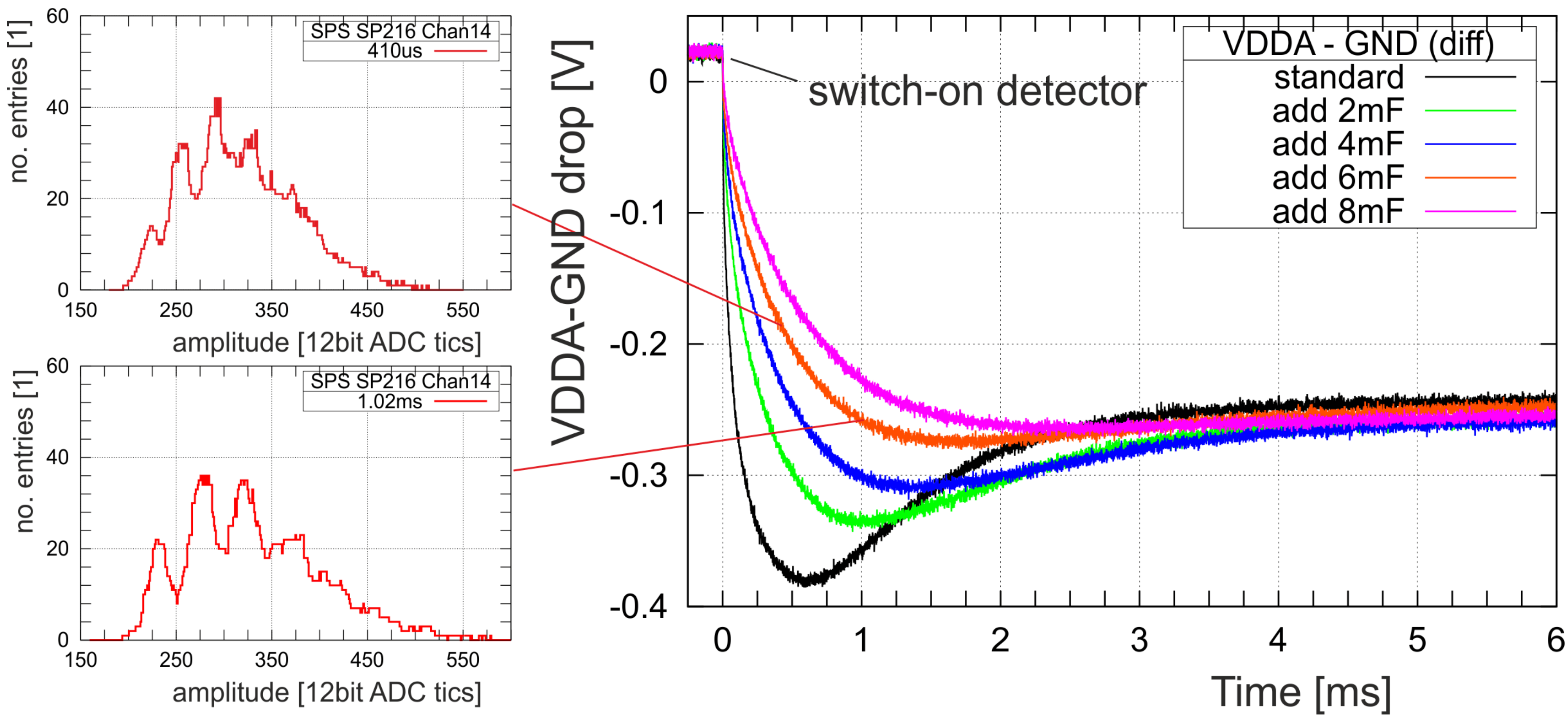
Full Extension Slab: 6xHBU in a row

- Signal transportation over 216 cm is challenging
  - Power, 40 MHz LVDS clock, LED trigger
- Single-Pixel Spectra measured on the last HBU
- First results prove suitability of the solution



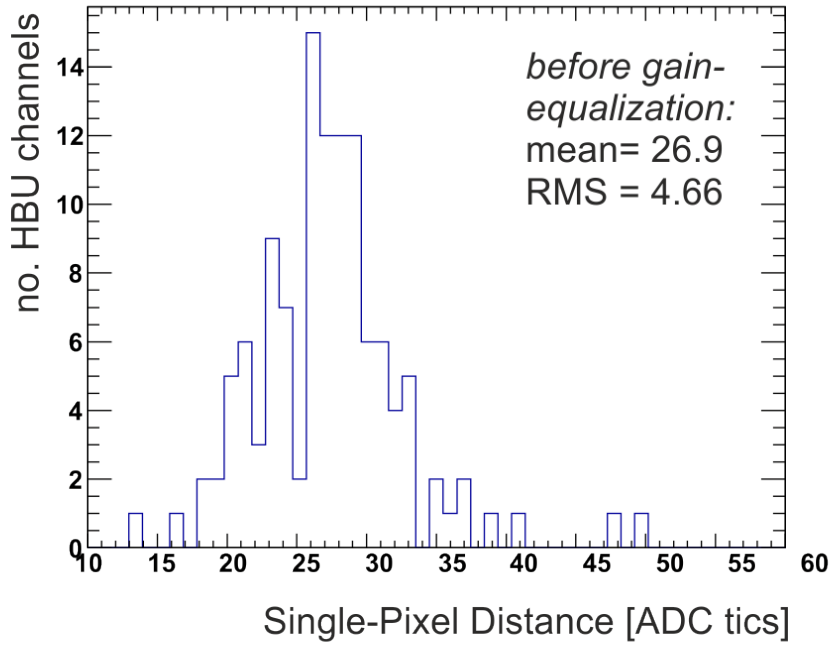


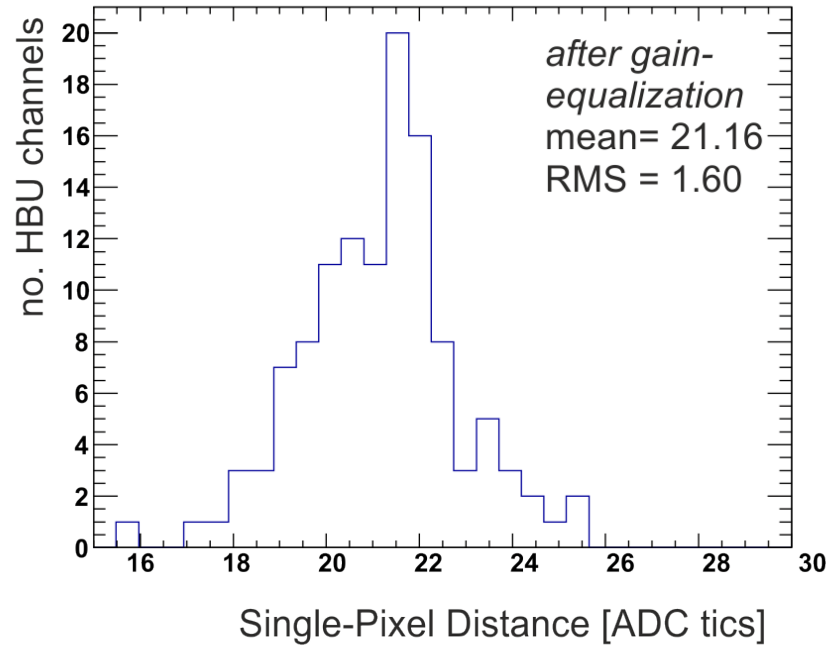
Voltage drop across a slab



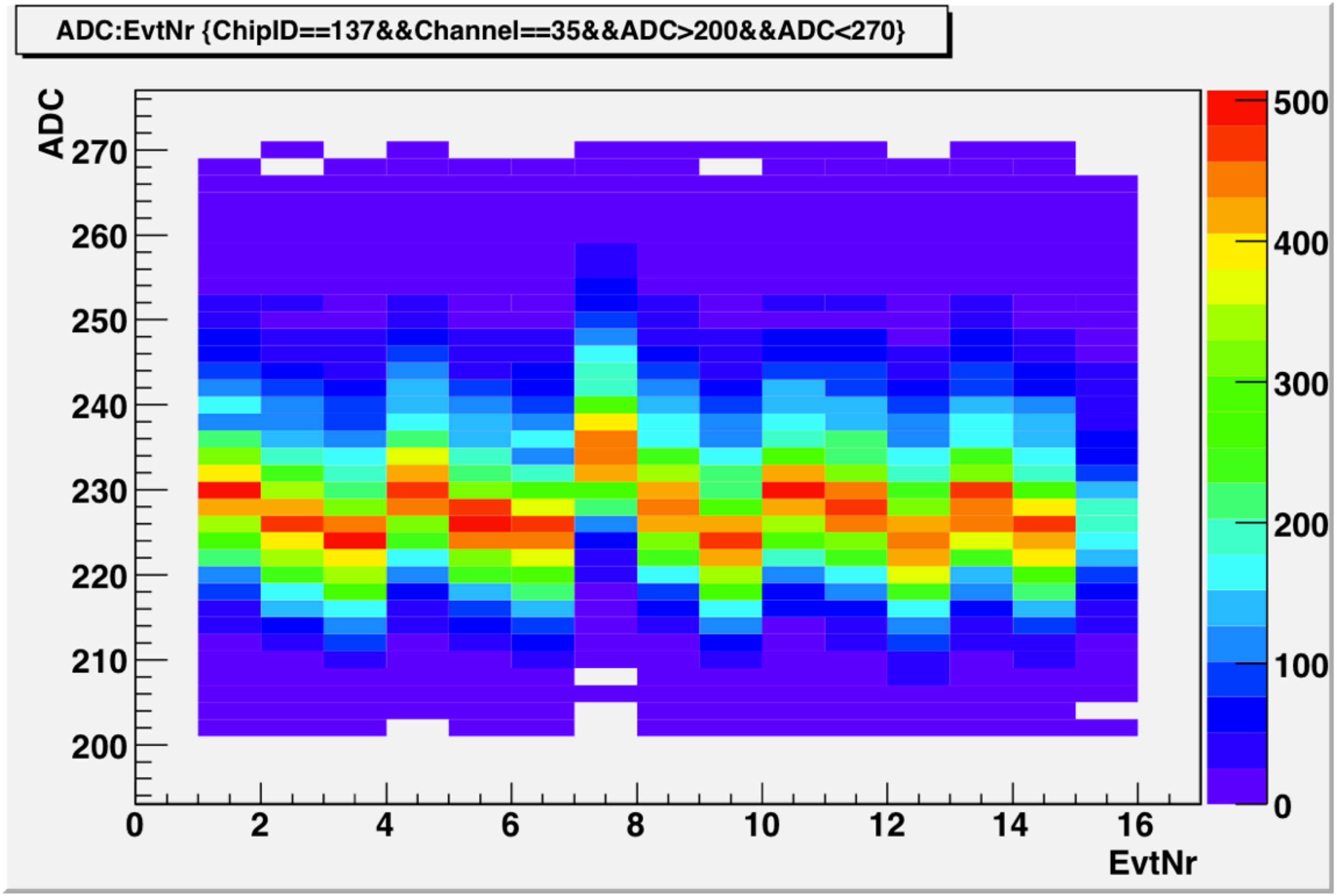
Gain Equalization

- SPIROC2b allows preamplifier gain setting per channel
- Gain equalization works fine and improves single-pixel distance distribution of the channels



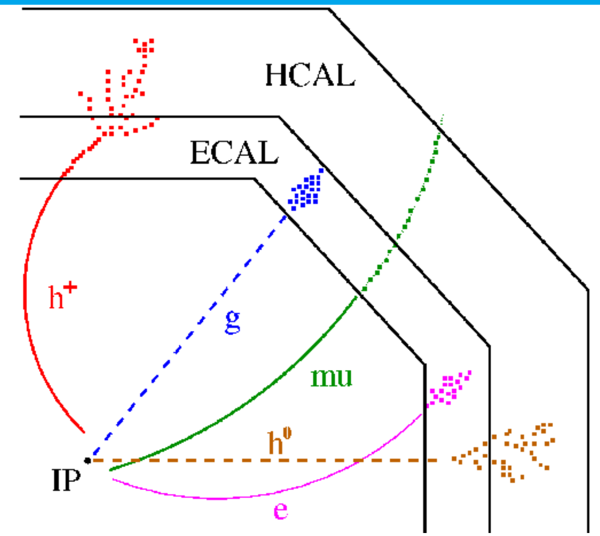


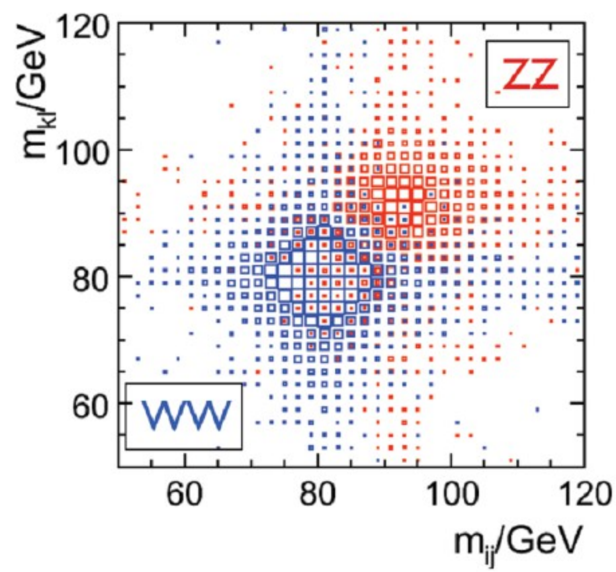
Memory cell dependence of pedestal



PFA

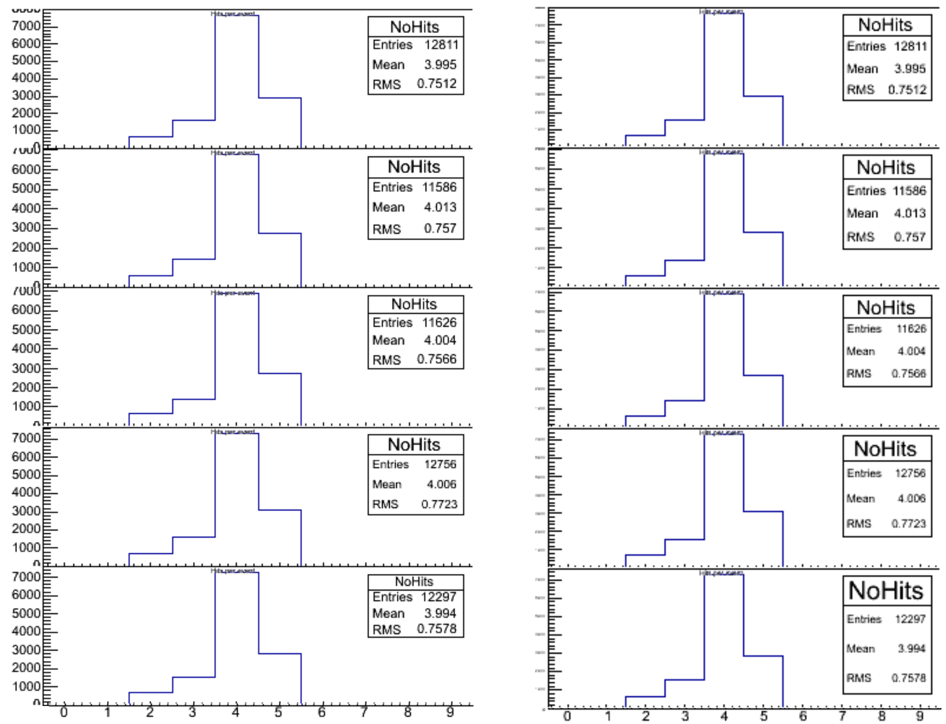
- International Large Detector(ILD)
  - The goal is to reconstruct energy of individual particles
- Particle Flow Approach(PFA)
  - Tracking detector → Charged Hadrons
  - EM calorimeter → Photons
  - Hadronic calorimeter → Neutral Hadrons
- PFA Performance is sensitive to detailed structure of hadronic showers
  - HCAL should be able to distinguish between W and Z decays
- Requires excellent tracking and highly-granular calorimeters





Multilayer Synchronicity

- During July test beam we tested synchronicity
- For the same run, number of hits was checked in two different event builders
  - Accepting only the same bunch crossing IDs
  - Accepting bunch crossing IDs +/- 1
- Absolutely no difference is observed



Same BunchX ID

BunchX ID +/- 1

- We have a true synchronous detector ✓