AHCAL beam tests

- > AHCAL technological prototype
 - concept
 - production, assembly, QA
- Testbeams at SPS
 - first look into the data



Katja Krüger CLIC Detector and Physics Collaboration meeting 29. August 2018



AHCAL technological prototype

- highly granular scintillator SiPM-on-tile hadron calorimeter, 3*3 cm² scintillator tiles
- > fully integrated design
 - front-end electronics, readout
 - voltage supply, LED system for calibration
 - no cooling within active layers
- scalable to full detector (~8 million channels)
- HCAL Base Unit: 36*36 cm², 144 tiles, 4 ASICs
 - slabs of 6 HBUs
 - up to 3 slabs per layer



AHCAL active layers for testbeam

- > 38 active layers of 72*72 cm²
- > 4 HBUs per module
 - 16 ASICs, 576 channels
 - in total: 608 ASICs, ~22000 channels
- > all modules with surface-mount MPPCs
 - S13360-1325PE
 - 2668 pixels
 - operated at 5V overvoltage
 - nominal operation voltage within 200mV in a module -> use same voltage
- all modules are interchangeable, so positioning in stack according to quality (worst modules in the back)







Mass production

- > design optimized for mass production
 - SMD SiPMs soldered automatically
 - injection-moulded polystyrene tiles, no further surface treatment
 - automatic wrapping in ESR reflector foil
 - glueing of tiles with screen printer and pick-and-place machine









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Quality assurance and calibration

- > SiPM sample tests
- tile sample tests
- test of all ASICs
- > all individual HBUs tested and calibrated with LEDs and cosmics
- > all modules (2*2 HBUs) tested with cosmics
- all modules calibrated with LEDs and DESY beam (3 GeV electrons as MIPs)
 - calibrate 4 modules in parallel, ~1 day per set
 - automated scan with automated control of the moving stage
 - many technical tests: gain switching, ...
- result: overall quality very good







Goals of SPS testbeam

technical

- demonstrate capabilities of SiPM-on-tile calorimeter concept with scalable detector design
- reliable operation of large prototype
- scientific
 - energy linearity and resolution for electrons and pions up to ~100 GeV
 - hit time correlations
 - shower profiles
 - shower separation
- > data sets
 - wide muon beam for (cross check) of MIP calibration
 - energy scan electrons & pions
 - data at shifted beam positions



Testbeam setup 9. – 23. May 2018 in H2 at SPS



> 38 active layers of 72*72 cm² in steel absorber with 1.7 cm layer thickness (~4 λ)

- > mounted on the movable platform ("scissors table") in H2
- beam instrumentation: wire chambers, trigger scintillators, Cherenkov detector



Testbeam setup 27. June – 4. July 2018 in H2 at SPS



> as in May, plus:

- added one module with 6*6 cm2 tiles
- added CMS HGCAL "thick stack" (12 layers of 1 HBU, 7.4 cm steel absorber) as tailcatcher
- added single HBU in front of absorber as "pre-shower" detector





Data taking

- very stable running
- > all 38 layers working well, <1‰ dead channels</p>
- muons for calibration
 - several position scans
- electrons: energy scan
 - energies: 10, 20, 30, 40, 50, 60, 80, 100 GeV
 - · with and without power pulsing
 - typically 200,000 to 400,000 ev. per energy
- negative pions: energy scan
 - energies: 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 160, 200 GeV (+ test at 350)
 - with and without power pulsing
 - typically 400,000 to 600,000 ev. per energy
 - shifted positions for particle separation studies
- > additional technical tests
- in total collected several 10^7 events









Very first look into data



Very first look into electron data



> May:

- clear tail to smaller number of hits and earlier center-of-gravity
- present for all electron energies

- > June:
 - changed beam steering
 - tail gone, nice and narrow energy distributions



Electrons during beam tuning in June



Very first look into pion data





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Pions in June: importance of tail catcher



DESY.

Timing analysis



> first attempt of calibration of the hit time measurement

- promising resolution in core (~8 ns FWHM, with slow testbeam clock)
- > additional peaks at ~28 ns under study
 - probably the whole event is shifted, so can be corrected in reconstruction



Temperature compensation



gain and photon detection efficiency of SiPMs depend on temperature
can avoid changes by stabilizing temperature or adapting bias voltage (HV)

temperature compensation: use mean temperature in a layer to adjust HV

used routinely, HV changes as expected, gain stays stable



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Analysis effort

- just had a 3 weeks analysis workshop in Tokyo
 - harmonize analyses
 - first round of data quality checks and calibrations
- very successful, great progress, analyses gained momentum









Universität Hamburg Der Forschung | der Lehre | der Bildung



Thank you to all!



Thank you for your attention!



Summary of the 2018 Tokyo Analysis Workshop - Saiva Huck











August 2018

Summary

- first beam tests with full new prototype, very smooth and successful
- May data taking:
 - full dataset with muons, electrons, pions
 - many technical cross checks
- June data taking:
 - added important clean data sets
 - tail catcher
- have started to make use of the data
- October 2018: combined testbeam with CMS HGCAL





Backup



AHCAL technological prototype: Integrated Electronics

- HCAL Base Unit: 36*36 cm², 144 tiles, 4 SPIROC2 readout ASICs
- Central Interface Board: DIF, Calibration, Power for 1 layer
- > 5.4 mm active layer thickness
- 1 layer has up to 3*6 HBUs









CIB

Contamination in low energy pions



ahc_nHits:ahc_cogZ

- beam rate for 10 and 15 GeV pions rather low (few hundred Hz)
- > clear contamination with electrons and muons (~30% pions)
- > attempts to clean the beam with absorber did not work

