Highly Granular SiPM-on-Tile Calorimeter Development

FLC - Forschung mit Lepton Collidern
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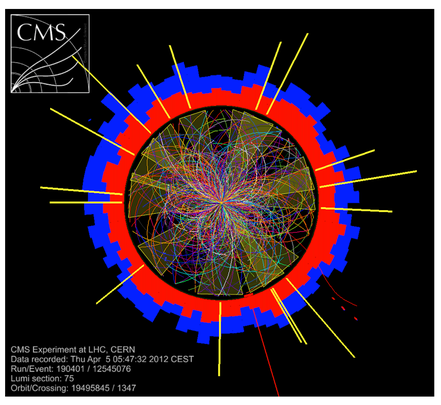
Motivation for Highly Granular Calorimeters

•High granularity = Very fine segmentation of channels within active calorimeter layers

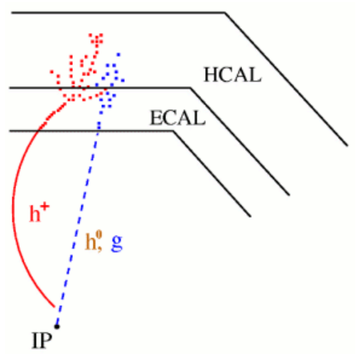
Conventional Calorimetry

•Simply add up energy measurements in coarse calorimeter segments



The Particle Flow Approach

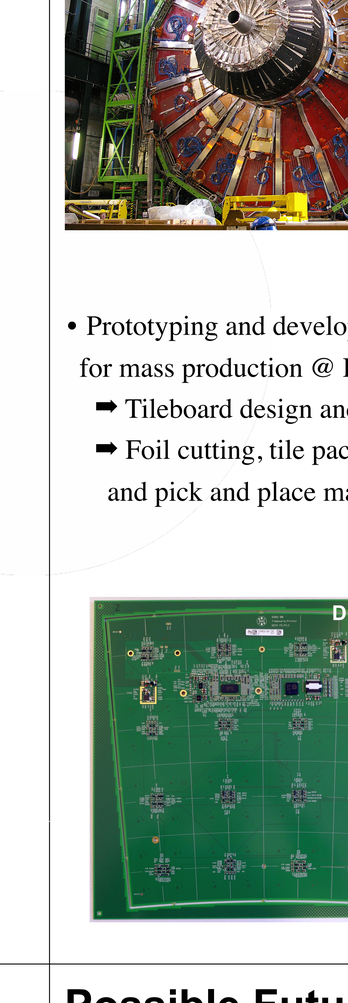
•High granularity allows to see and separate individual particles in the calorimeter which helps to improve the overall measurement precision



➡ Method used e.g. at a future e^+e^- collider (like ILC or CLIC)

Combination with Time Information

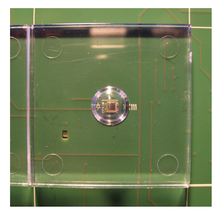
•High granularity + time information helps to remove background pile-up

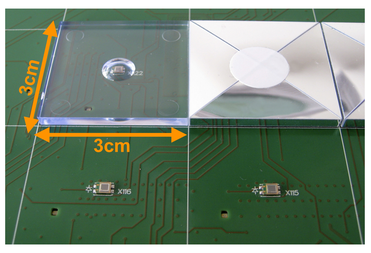


SiPM-on-Tile Technology

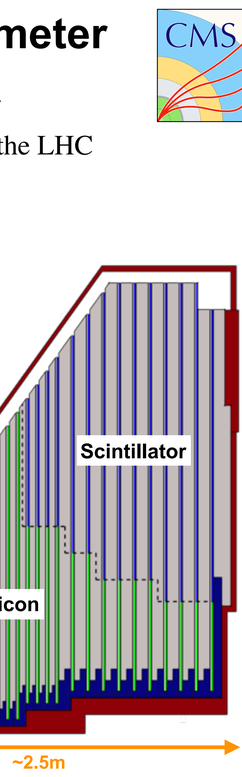
• Plastic scintillator tile produces light if a particle penetrates it

•Tile coupled to a Silicon-Photomultiplier (SiPM)
➡ Photo sensor converting light to electric signal, which is measured



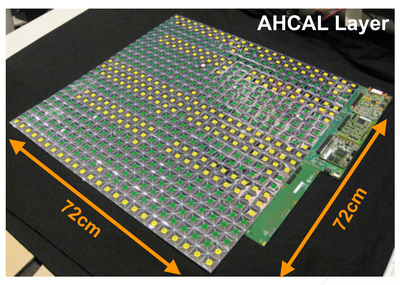


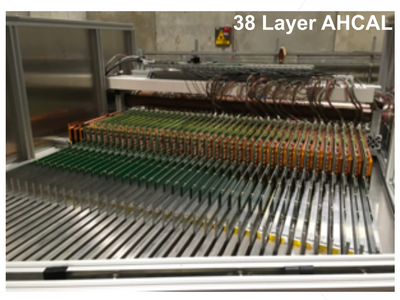
Detection Principle



Proof: The Analogue Hadron Calorimeter (AHCAL)

•A highly granular sampling calorimeter:
➡ Passive absorber layers of 1.72 cm steel
➡ Active layers: 576 SiPM-on-tile channels

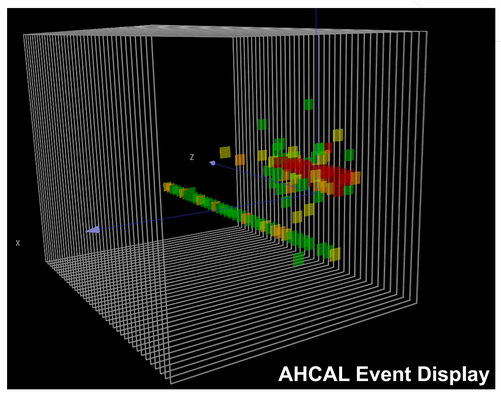




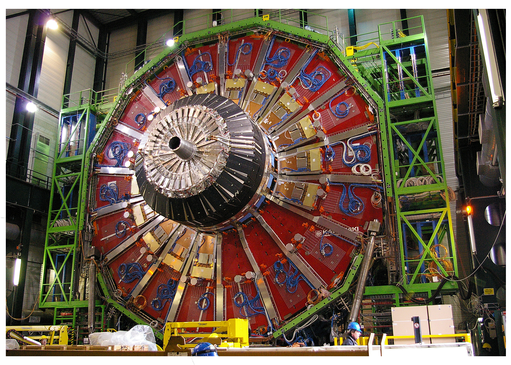
•**Total: ~22000 channels on 38 layers**
➡ Size: ~1 m^3
•Fully integrated readout electronics
•Integrated LED system for calibration

Imaging capabilities:
Large number of channels allows to „look into“ particle showers and study them in detail

Green hits = low energy
Red hits = high energy



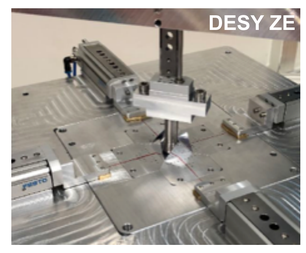
Application: The CMS High Granularity Calorimeter



•Upgrade of the end-cap calorimeter systems of the CMS experiment at the LHC

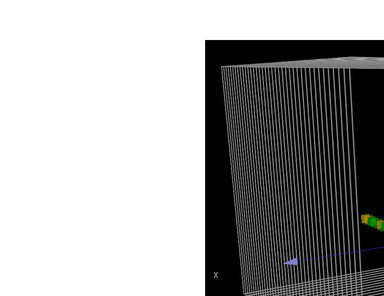
•Scintillator part: SiPM-on-tile technology
➡ ~240000 channels
➡ Cell sizes: From 2x2 cm^2 to 6x6 cm^2

• Prototyping and development of procedures for mass production @ DESY
➡ Tileboard design and testing
➡ Foil cutting, tile packaging, tile gluing and pick and place machine

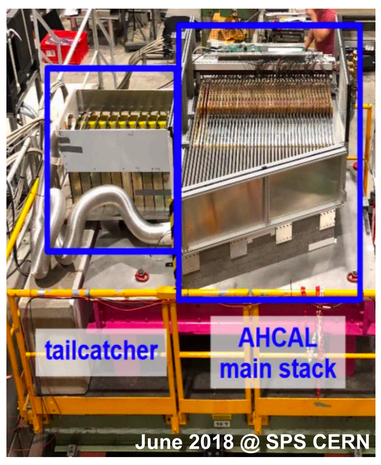


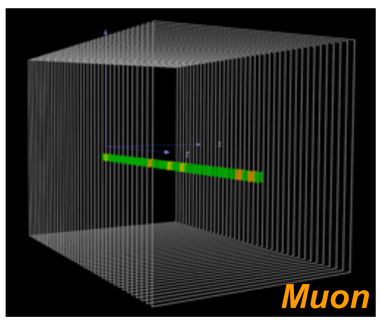
Test Beam Campaigns 2018 & 2019

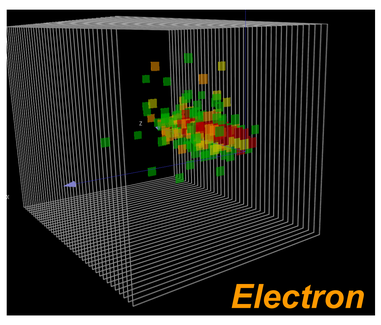
•Multiple weeks at SPS CERN and DESY
➡ Different AHCAL setups tested

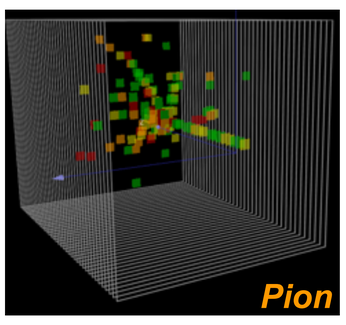


• Successful running and data taking:
➡ Several 10 million particles measured at different energies
➡ Muons, electrons, pions
➡ > 99.9% well working channels

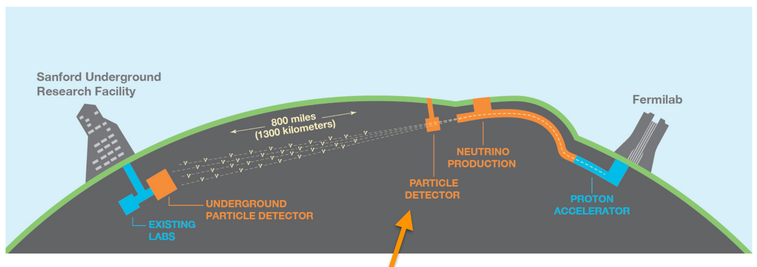






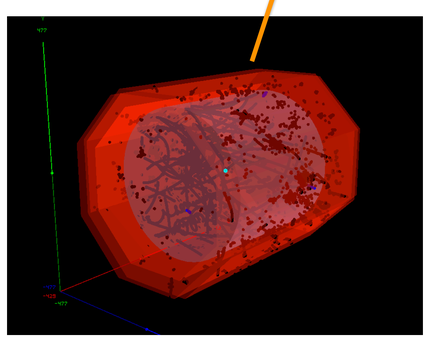


Possible Future Application: DUNE



•DUNE = Deep Underground Neutrino Experiment

•Goal: Discover CP violation in neutrino sector and study physics beyond the standard model



•DUNE Near Detector (ND)
➡ Characterise neutrino beam
➡ Reference measurements for far detector

•High intensity neutrino beam
➡ Issue: Multiple interactions, pile-up
➡ Need for high granularity calorimeter: SiPM-on-tile based electromagnetic calorimeter is one option

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