Towards Realistic Implementations of Large Imaging Calorimeters

The CALICE Program
Development of highly granular electromagnetic and hadronic calorimeters for particle flow reconstruction in future collider experiments. Key steps:

- Validation of the concept of high granularity with physics prototypes
- Technical realization of detector systems satisfying collider constraints
- Technological prototypes with fully embedded electronics tested in particle beams
- Application of CALICE expertise and technology in running experiments

A key element: Use of common technologies and infrastructure, such as a common ASIC family (SKIROC, SPIROC, HARDROC) to facilitate combined running.

Silicon Readout
ECAL with tungsten absorber (SiW ECAL):
- Silicon pixels as active material
- 9x9 cm² wafers with 5.5x5.5 mm² cell size
- Single base units (ASU's) validated at low energies
- 16 ASICs and 1024 channels per ASU
- Full QA and assembly chain

Achievements
Signal to Noise ratio = \( \frac{MIP_{v_{MPPC}}}{\delta_{\text{noise}}} \approx 20 \) in the SiW ECAL:
- Ability to trigger on and read out small signals (MIPs) demonstrated

Beam Tests of Technological Prototypes
Assembly of ~1 m² prototypes with fully embedded electronics

Gaseous Readout
GRPC based hadronic calorimeter (SDHCAL):
- Binary and two bit readout
- 1 cm² pad size

Integration
Small scale detector interfaces (DIF) as link between ASICS and DAQ system

Particle Flow Calorimetry
- High sampling frequency and granularity in calorimeters to separate particle showers
- Avoid dead material between tracker and calorimeters

- Calorimeters have to be inside the magnet coil
- Requires the design of very compact service electronics and active layers sensitive to the MIP level
- Requires precise mechanical assembly of the calorimeter structure allowing only small tolerances over large areas

Achievements
Signal to Noise ratio = \( \frac{MIP_{v_{MPPC}}}{\delta_{\text{noise}}} \approx 50 \)

Successful single cell MIP calibration of the full AHCAL prototype:
- Good overall detector response
- Signal to Noise ratio = \( \frac{MIP_{v_{MPPC}}}{\delta_{\text{noise}}} \approx 50 \)

Beam Tests of Technological Prototypes
Assembly of ~1 m² prototypes with fully embedded electronics

Rigorous testing of all technologies at TB facilities at CERN/DESY

Testing of binary versus multi threshold mode of the GRPCs:
- Two bit multi threshold mode improves energy resolution in SDHCAL

Integration
Small scale detector interfaces (DIF) as link between ASICS and DAQ system

Compact SL-board and low profile connectors as interface for slow control and readout of up to 15 chained slabs

Precision mechanics to assemble structural components, e.g. Electron beam welding of absorber structure for excellent surface flatness and minimal deformation over large areas

Improved gas flow for new 1x2 m² GRPC plates

Development of flat interconnections between detector modules to facilitate compact layers

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