CALICE
R&D for compact readout systems for highly granular calorimeters

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Abstract

Granular calorimeters play a central role in the concepts of future detectors for particle physics. Compact highly performant readout techniques are essential for a successful operation of theses calorimeters. Coordinated developments foster the common data taking with different CALICE prototypes and facilitate the comparison of the performance of different proposals. This LoI sketches the main aspects of the R&D on compact readout in the CALICE Collaboration.

1 State of the art

High precision measurements in modern particle physics detectors require a close-to full coverage of the solid angle to ensure a large lever arm for angular distributions or to enhance sensitivity for processes with missing energy. For example only 40 - 70 mm are available between electromagnetic and hadronic calorimeters in detector concepts for Higgs factories for the circuitry for detector control, readout and power supply. This design requirement implies space- and power-economic solutions for services such as readout or detector control. The R&D on detector readout in CALICE is aimed to progressively meet the tight space constraints and progress has been made for electromagnetic and hadronic calorimeters [1]. The most compact implementation so far is the so-called SL-Board for the CALICE silicon tungsten electromagnetic calorimeter (SiW ECAL), which has a length between 10 and 42 mm and a width of 180 mm and is conceived to serve up to 10000 calorimeter channels of a detector layer [2]. The cards are connected to a data concentrator system, able to serve up to 30 layers. A first beam test at DESY with partially equipped layers has been conducted successfully in 2019. The cards are currently tested with a stack of fifteen layers with 1024 channels each that will be brought to a beam test at DESY in November 2020. This beam test will be crucial for a comprehensive validation of the concept.

2 Plans

The CALICE collaboration strives for a homogeneous readout system for all the prototypes. It is envisaged to adapt the system of the SiW ECAL to other calorimeters. This task is facilitated by the fact that all calorimeters use a similar type of front-end ASIC [3]. On

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the other hand electromagnetic and hadronic calorimeters differ in size and layout. Moreover additional functionality needs to be taken into account. The analogue hadronic calorimeter and the scintillator electromagnetic calorimeter for example use a LED system for the calibration of the scintillating tiles and the silicon photomultipliers. The interface card for these calorimeters has to drive this LED system. In principle electromagnetic and hadronic calorimeters can share the same type of concentrator unit. However, detailed design work is still needed to understand how to transfer the concept in place for the SiW ECAL to for example hadron calorimeters. A major difference is the typical size of the prototypes and final systems. This may require modifications in the way how for example clock and control signals have to be propagated within the individual systems.

The number of cells readout by an individual SL-Board will progressively increase. With more cells per layer, the heat dissipation will require the progressive integration of cooling. Cooling systems do exist [4] but serious integration work has to start in the near future. The SL-Board is designed for the integration of a cooling system for the SiW ECAL.

In the coming years we plan also to investigate the timing in highly granular calorimeters. The digital readout systems will have to cope with new requirements while at the same time keep the same level of compactness.

3 Conclusions

CALICE is developing highly compact readout systems that meet tight space requirements and further system aspects in future detectors for Higgs factories. We will work on a harmonisation of the readout system for the different calorimeter prototypes. At the same time new requirements imposed by precision timing will have to be integrated into the systems.

Let us finally add that the readout systems developed for the CALICE prototypes may serve experiments beyond Higgs factories as for example the calorimeter of the near detector of the DUNE experiment.

References

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