Timing Semi-Digital Hadronic Calorimeter (T-SDHCAL)

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February 25, 2025

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1 Introduction

The Semi-Digital Hadronic CALorimeter (SDHCAL) was the first technological prototype[1] developed and studied by the CALICE collaboration. Made of 48 active units, each made of 1 m1 m RPC detector read out by electronic board assembled to host on one face 9216 pads of 1 cm $\times$ 1 cm and on the other face 144 HARDROC ASICs with each of the ASIC having 64 channels and each channel equipped with 3 independent circuits allowing to discriminate the signal following three different values of threshold. The 48 layers were put into cassettes and inserted into a self-supporting mechanical structure. The excellent energy reconstruction of hadronic showers of this highly granular prototype validated the 4D concept of this PFA-based calorimeter[2]. Here we intend to explore the possibility to transform the SDHCAL into a 5D calorimeter by exploiting the time information the Multi-gap version of the RPC detector provides.

2 Goals and General Concept

To separate hadronic showers created by charged hadrons from the neutral ones to apply successfully the PFS concept, high granularity calorimeters like SDHCAL can achieve an excellent separation of nearby hadronic showers when the distance separating them exceeds 10 cm [3]. To do better one can exploit the time information provided by the RPC.
Indeed time information allows not only to tag delayed neutrons and treat them a part for energy reconstruction, it also provides an appropriate tool to build the skeletons of the showers before they start to develop and overlap leading to a clear identification of the number of showers. It then contributes with the excellent spatial resolution provided by the high granularity to associate the hits in the calorimeters to each of these showers.
To demonstrate the interest of exploiting the MRPC fast timing behavior we propose to conceive and build MRPC detectors of 1 m$\times$ 1 m each and to equip them with a new board that is in principle similar to the pad-based boards used to read out the SDHCAL RPCs but in which HARDOROC ASIC is replaced by a new one that provides a precise time measurement. The new ASIC will be a version of the OMEGA PETIROC ASIC[4] that was tested successfully to read out RPC chambers for the CMS-RPC upgrade project [5].

3 Next Steps

Here after a few developments in the coming years to prepare for the construction of a technological T-SDHCAL prototype.

- Although 4-gap RPC of 1m x 1m fulfilling the stringent technological requirements of SDHCAL were recently built with success, the conception of larger detectors with large gaps is still needed. The conception should not only minimize the dead zone but also ensure excellent homogeneity to guarantee the same timing performance everywhere. The new MRPC needs also to stand high rate of a few thousands of particles per second. Yes electrode materials with low resistivity will be used in the future to achieve this goal
- The PETIROC has an excellent preamplifier with low timing jitters (less than 15 ps for a charge exceeding 300 fC) but its internal TDC with its 100 ps resolution can not reach this performance and more importantly it introduces dead time of 12.5 μs. Therefore a development to include a more precise TDC will be needed if a time resolution of better than 100 ps is required. The PETIROC provides an analog readout of the charge in addition to the time information. This analog information could be either exploited or be reduced to a multi-threshold version. Therefore a modification of the PETIROC will be envisaged.

- The DAQ system used in SDHCAL prototype needs to be revisited. The time in addition to the charge information represents a huge amount of data that needs to be digested in a clever way before to be transmitted. A new smart DAQ scheme based on neural network could be developed and embedded on the detector level to address this issue.
- Finally, an active cooling system is needed to extract the heat produced from the continuous readout of the electronic system to allow the MRPCs to maintain their excellent performances.

References

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