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Timing Semi-Digital Hadronic Calorimeter (T-SDHCAL)

I.Laktineh
for the SDHCAL groups of the CALICE Collaboration*

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1 Introduction

The Semi-Digital Hadronic CALorimeter (SDHCAL) is the first technological prototype[1] developed and studied by the CALICE collaboration. The SDHCAL comprises 48 active units, each made of 1 m×1 m RPC detector read out by an electronic board hosting on one face 9216 pads of 1 cm × 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 PFA-based calorimeters[2]. Here we intend to explore the possibility to transform the SDHCAL into a 5D calorimeter by exploiting the precise time information the Multi-gap version of the RPC detector can provide.

2 Goals and General Concept

To separate hadronic showers created by charged hadrons from the neutral ones to apply successfully the PFA 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. Preliminary simulation studies have recently confirmed the advantage of having time information to improve the PFA performance.
To demonstrate the interest of exploiting the MRPC fast timing behavior we propose to conceive and build MRPC detectors of 1 m×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 is a new version of the OMEGA PETIROC ASIC[4] that was tested successfully to read out RPC chambers for the CMS-RPC upgrade project[6].

3 Next Steps

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

- Although several 4-gap RPC of 1m × 1m fulfilling the stringent technological requirements of SDHCAL have been successfully built and tested[5], the conception of larger detectors with even

*Contacts: Imad Laktineh(laktineh@in2p3.fr)

more 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 PETIROC has an excellent preamplifier with low time jitters (<15 ps for a charge exceeding 300 fC) but its internal TDC with its 100 ps resolution can not reach this performance. 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 could 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.

References

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