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MGPA++ A Pre-Amplifier for CMS Barrel ECAL at HL-LHC

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Upgrades are planned for the for the CMS barrel ECAL readout electronics . One option for an upgraded pre-amplifier is an improved version of the existing multi-gain pre-amplifier (MGPA). The upgraded MGPA is designed for shorter shaping time to optimize noise performance with photo-detectors damaged by radiation. It also has the ability to identify pulses generated by charge deposited directly in the photo-detectors rather than resulting from scintillation light.

Initial studies in ASIC design for an upgraded MGPA, together with work to evaluate the performance of the design are presented.

Summary

The CMS barrel ECAL uses Avalanche Photo-diodes (APDs) attached to lead tungstate scintillating crystals. Signals from the APDs are amplified by a charge sensitive pre-amplifier with multiple outputs (MGPA). The outputs are sampled at 40 MSample/s by ADCs with 12-bit resolution.

Upgrading the CMS barrel ECAL pre-amplifier will maintain performance at a high-luminosity LHC. Radiation damage in the APDs will increase the leakage current so the shaping time will need to be reduced to optimize the signal to noise ratio. In addition it is necessary to identify pulses generated by charge deposited directly by ionising radiation in the APDs rather than resulting from scintillation light. Currently these pulses are identified and rejected offline with little rejection possible on-line. At a high-luminosity LHC pulses from direct charge deposition would result in an unacceptably high trigger rate.

The current MGPA has three outputs with a relative gain of 1:6:12 with the amplitude of the output pulses being proportional to the total charge of the input pulse . The outputs of the MGPA is sampled at 40 MSample/s by ADCs with 12-bit resolution. Advances in ADC technology mean that it will be possible to design the upgraded MGPA with only two outputs charge sensitive outputs and use ADCs with a higher sample rate and possibly higher resolution.

Charge deposited directly in the APD results in pulses that are shorter in time than pulses generated by scintillation light. By having an additional output that responds to the peak height of the pulse, in addition to the outputs that respond to the total charge of the pulse, the upgraded MGPA allows pulses from direct charge deposition to be identified.

Initial design studies into ASIC design of an upgraded MGPA are presented together with initial results from both simulation and laboratory tests.

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