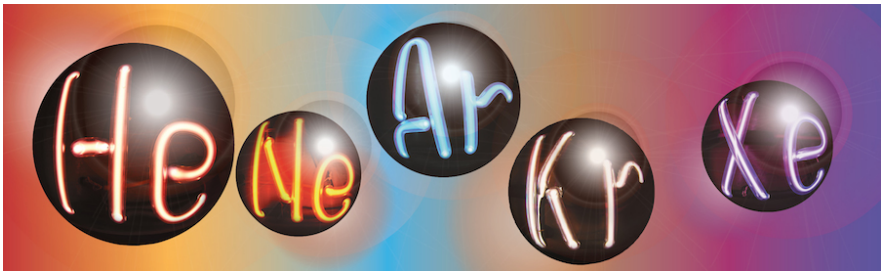

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CHARMS250: A Cryogenic Front-End ASIC for Low-Noise Readout of Light or Charge Signals

Monday 26 August 2024 12:15 (20 minutes)

In this talk we present CHARMS250, a next-generation cryogenic front-end application specific integrated circuit (ASIC) designed in a 65 nm process for low-noise readout of charge or light signals generated within noble liquid time projection chambers (TPCs). The design of CHARMS250 is evolved from the LArASIC chip, which was manufactured in a 180 nm process and has been selected as the first component in the 3-ASIC readout solution for Phase I of the Deep Underground Neutrino Experiment (DUNE). CHARMS250 comprises of 16 channels of programmable pre-amplification and pulse shaping stages that provide a voltage readout proportional to the input signal. It is designed for operation at temperatures ranging from room temperature (RT) down to liquid nitrogen temperature (LNT), i.e., 77 K, with large capacitance detectors (up to hundreds of picofarads). The charge gain fo r the pre-amplification stages can be set to 60, 100, 180, or 320, corresponding to voltage-to-charge gain after the pulse shaping filter of 4.7, 7.8, 14 or 25 mV/fC, for reading out input signals up to 300 fC, 180 fC, 100 fC, and 56 fC, respectively . The pulse peaking time can be set to 0.25 µs, 0.5 µs, 1.0 µs, or 2.0 µs. Additionally, features such as local generation of bias voltages and extended digital assistance of analog functions provided over an I2C interface are included in CHARMS250 for improved robustness against process variability. Simulations with both RT and cryogenic temperature transistor model parameters indicate that CHARMS250 provides a highly linear voltage readout (INL < 0.1%) for input charge up to 300 fC with a power consumption ranging between 6-11 mW per channel, depending on the choice of the output buffering. The simulated baseline equivalent noise charge (ENC) at liquid argon temperature is less than 500 electrons for a detector capacitance of 160 pF and all supported pulse peaking time values. Potential applications for CHARMS250 include light/charge readout of the Far Detector (FD) 3/4 in Phase II of DUNE, charge readout in the future circular lepton collider (FCC-ee), light readout in nEXO, and the silicon-based active target and liquid xenon calorimeters in PIONEER.

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