Contribution ID: **317** Type: **Poster**

SDR-based readout electronics for the ECHo experiment

Thursday, July 25, 2019 6:45 PM (15 minutes)

Due to their excellent energy resolution, the intrinsically fast signal rise time, the huge energy dynamic range and the almost ideally linear detector response, metallic magnetic calorimeters are very well suited for a variety of applications. In particular, the ECHo experiment aims to utilize large-scale MMC based detector arrays to investigate the mass of the electron neutrino. However, reading out such arrays is a challenging task which can be tackled using microwave SQUID multiplexing. Here, the detector signals are transduced into frequency shifts of superconducting microwave resonators which can be deduced using a high-end software-defined radio (SDR) system.

The ECHo SDR is a custom-made modular electronics. It provides 400 channels equally distributed in a 4 to 8 GHz frequency band where each channel has 1MHz bandwidth. The system consists of a two-stage RF mixing, a modular conversion, and an FPGA board. The mixing board combines/splits five 800 MHz base-bands to/from one single 4 GHz RF-band. For conversion, five two-channel 1 GSPS AD9680 ADCs and three four-channel AD9144 DACs are utilized. The digital signal processing is computed on the custom HiFlex-2 FPGA board. For channelization, a novel heterogeneous approach utilizing the integrated digital down conversion (DDC) of the ADC, a polyphase channelizer followed by another DDC for demodulation is proposed. This offers an efficient channelization resource wise while offering excellent channelization properties. After signal demodulation, on-FPGA flux-ramp demodulation processes the signals before streaming it to the ECHo-100k backend. Calibration and slow-control are handled by the Zynq's ARM processors, directly on the platform.

Within this contribution, we discuss the current development status of the individual system components of the ECHo SDR. This also includes demonstration experiments for which prototype setups has been built, e.g., for evaluating the novel channelization approach.

Less than 5 years of experience since completion of Ph.D

N

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N

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Session Classification: Poster session

Track Classification: Detector readout, signal processing, and related technologies