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Software-Defined Radio Readout System for the ECHo experiment

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Metallic Magnetic Calorimeters (MMCs) are calorimetric low-temperature particle detectors that are currently strongly advancing the state-of-the-art in energy-dispersive single particle detection. MMCs are typically operated at temperatures well below 100 mK and make use of a metallic, paramagnetic temperature sensor to transduce the temperature rise of the detector upon the absorption of an energetic particle into a change of magnetic flux. An efficient readout of large MMC arrays can be achieved through Microwave SQUID multiplexing. One of the pioneering applications of large MMC arrays is the "Electron capture in Holmium-163 experiment" (ECHo), which aims to investigate the electron neutrino mass in the sub-eV/c^2 range. ECHo will use up to 10^4 detectors running in parallel to acquire a high statistics spectrum in finite time. The readout of these detector arrays will be conducted using 15 independent FPGA based software-defined radio (SDR) systems, each connected to one microwave SQUID multiplexed readout line with 400 detector channels equally distributed between 4 and 8 GHz. This results in an input data rate of 2.4 Tb/s, which is processed in cascaded stages to channelizes the signals online. Afterwards, the event specific information is extracted in parallel for each channel and eventually stored in the backend server storage. The SDR consists of a two-stage RF mixing electronics, various high-speed, high-resolution DACs/ADCs, as well as a Zynq Ultrascale+ FPGA for the digital processing. This contribution will describe the SDR electronics for ECHo in detail and present the challenges associated with the integration of such heterogeneous systems.

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