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dSpec, dead-time free spectrometer for WISP searches using 5G telecommunication technologies

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In the WISP search, the broad coverage of the mass region is crucial because we know neither dark matter mass nor coupling to standard model particles. In particular, many Axion or dark photon experiments search the conversion photon signal in radio wave range (O(1 GHz) - O(100 GHz)), and the signal is expected to be observed as a narrow peak. Therefore, ideal specifications of the spectrometer are wide frequency coverage (e.g., 4 GHz bandwidth) as well as dead-time-free. However, in the case of commercially available spectrometers, they have ~1% efficiency in time (i.e., time fraction of measurement) or only a few MHz bandwidth typically. We solved this situation by developing a spectrometer, "dSpec", which is optimized for the WISP search (i.e., optimized for measuring the narrow frequency peak over a wide range). dSpec is built on a single RFSoC 2x2 board (AMD Xilinx), which has a CPU, an FPGA, two DACs, and two high-speed ADCs. This board has made for 5G telecommunications. We developed 16 paralleled FFT architecture on the FPGA. It allows us to construct the spectrometer with a wide bandwidth (4 GHz) and fine frequency resolution (31kHz). We evaluated the performance of dSpec, and we confirmed the good performance for the WISP search, e.g., nonlinearity < 0.5%, time efficiency > 99.9%. We will present the design of the dSpec as well as its performance test results.

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