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Towards quantum limited read-out of cryogenic detectors

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Thanks to their excellent energy resolution, cryogenic microcalorimeters are a particularly suitable detector choice for calorimetric neutrino mass experiments, where the ability of precisely resolving decay spectra is essential. Transition Edge Sensors (TESs) and Magnetic Microcalorimeters (MMCs) are employed in the HOLMES and ECHo experiments, respectively. In order to increase the sensitivity of these experiments, the number of microcalorimeter pixels needs to be scaled up, requiring a multiplexed read-out approach. Typically, this is implemented via a Microwave SQUID Multiplexing (μMUX) approach, coupling each microcalorimeter pixel to a superconducting microwave resonator, respectively. These resonators are coupled to one common transmission line and their responses are monitored via a frequency domain multiplexing technique, which allows for a reconstruction of the events in each single detector pixel. In state-of-the-art μMUX set-ups, the read-out noise is ultimately limited by the HEMT amplifier stage. Such limitation inevitably compromises the detectors'intrinsic energy resolution of about

1.5 eV, worsening it up to 10 eV. This limitation can be overcome by introducing a (quasi) quantum limited microwave amplifier between the μMUX and the HEMT, featuring high gain (≥ 20 dB), large bandwidth (several GHz), and high saturation power (≥ -50 dBm). In this contribution, we present the development of superconducting parametric amplifiers, such as Travelling Wave Parametric Amplifiers (TWPAs) based on high kinetic inductance NbTiN artificial transmission lines. This work has been performed in the framework of the DARTWARS project (2020-2024), funded by INFN and MSCA, and it will continue within the MiSS project (2024-2027), funded by Horizon Europe. The design, microfabrication and cryogenic characterisation of these parametric amplifiers are discussed and the most recent results are presented, paving the way towards quantum limited read-out of cryogenic microcalorimeter detectors for neutrino mass experiments.

Poster prize

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