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Poster Session – Submission of Abstract

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Summary: The purpose of the CALDER project (Cryogenic wide-Area Light Detector with Excellent Resolution) is to develop new cryogenic light detectors which to be used in CUORE to improve the sensitivity in the search of Neutrinoless Double Beta Decay (0νββ). The sensitivity of CUORE can be increased by a factor of 3, thanks to the reduction of the α background, obtained by detecting the Cherenkov light (~100 eV) emitted by βs events and not by the α-background.
This new light detectors must have an active area of 25 cm^2, a baseline energy resolution of ~ 20 eV RMS and a working temperature of 10 mK. The technology chosen is based on the phonon-mediated Kinetic Inductance Detectors (KIDs), a superconductive device already used in Astronomy. This poster presents the results of the first prototypes tested.

Abstract Text: The experiments searching for rare events, such as neutrino-less double beta decay, need to operate in low noise conditions. The bolometers are among the best tools in this field, because they have a good resolution and the modular design allows for very high masses; they are limited only by the lack of an active background rejection tool. A very effective background suppression could be obtained by identifying the interacting particles through the simultaneous measurement of the bolometric signal and the particle light yield. In scintillating crystals the nature of the interacting particles is discriminated using the different yield of scintillation; however, for not scintillating crystals, the background can be reduced detecting the Cherenkov light produced by electrons and not by α particles. For this reason, next generation experiments needs cryogenic light detectors with excellent sensitivity, that could operate in a wide range of temperatures. The CALDER project aims to develop cryogenic light detectors with high sensitivity to UV and visible light, to be used for particle tagging in massive bolometers like CUORE.

CUORE is a bolometric experiments, designed to search for the 0νββ decay, which will begin taking data in 2015 at the Laboratori Nazionali del Gran Sasso (LNGS).
The CUORE experiment is designed to search for the 0νββ decay of the ^{130}Te (Q = 2528 keV [5]). For this process we expect a monochromatic line at the Q-value of the decay in the spectrum of the two electrons, as neutrinos don't subtract energy. A detector with high resolution and efficiency is required to separate the 0νββ signal from the 2νββ background, for this reason in CUORE we use crystals grown by Tellurium as bolometers. The detector of CUORE consists of 988 crystals of Tellurium dioxide (TeO_2) in which 34% of Tellurium is ^{130}Te; each crystal is a 0.75 kg cube with

5 cm of side, the total mass is 741 kg (208 kg of ^{130}Te). The expected sensitivity on the half-life of the $0\nu\beta\beta$ decay of ^{130}Te is about 10^{26} years in 5 years of data taking. The CUORE sensitivity can increases by a factor 3 measuring the Cherenkov light emitted by electrons, which are above the threshold (~ 50keV), in contrast to α- particles. By applying the current NTD light detectors to the crystals of CUORE the separation of β/γ from α-background is not satisfactory due to the light detectors noise (~100 eV RMS). Therefore we require a low noise (10-20 eV) light detector which allow to tighten the α-band and separate the signal from the background.

The CALDER detectors are a superconductive light detectors based on Kinetic Inductance sensors (KID), in which the interacting photons are converted in phonons, that break the Cooper Pairs in a LC superconductor circuit.

The KIDs work only when excited by micro-wave signals, this limits their size to a few mm^2, then in order to achieve the required active area it needs a mediator, which in this case is given by the silicon substrate on which the KIDs are deposited. In this way the incoming photons are absorbed by a 300 μm thick silicon substrate, where they are converted into non-thermal phonons. Then the non-thermal phonons will be sampled by few lumped element KIDs deposited on the substrate.

In the first part of the project single pixel design has been optimized, also configuration of the cryostat and the electronics are tested. The main goal is to obtain a configuration that maximizes the quality factor of the resonators, the sensitive area, the sensitivity and reproducibility of the response. In the prototypes until now Aluminium is used as a superconductor, since it is the most studied one in the literature; however, when the link between the geometry of the sensors and factors of merit will be clear, a prototypes will be realized using TiN (titanium nitride) as a superconductor, characterised by a kinetic inductance from ten to hundred times greater than Aluminium; also their lower critical temperature contribute to improve the energy resolution of the detectors.

Starting from next year, we will begin also testing at the Laboratori Nazionali del Gran Sasso (LNGS), in which the new light detectors will be expose to the CUORE crystals to assess its performance.