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LTD·18 LOW TEMPERATURE DETECTORS

Lithium-containing crystals for light dark matter search

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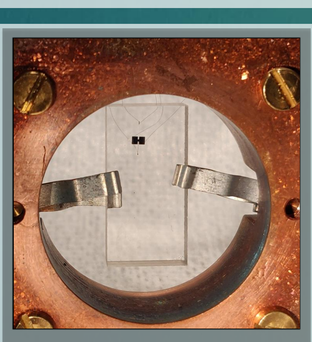
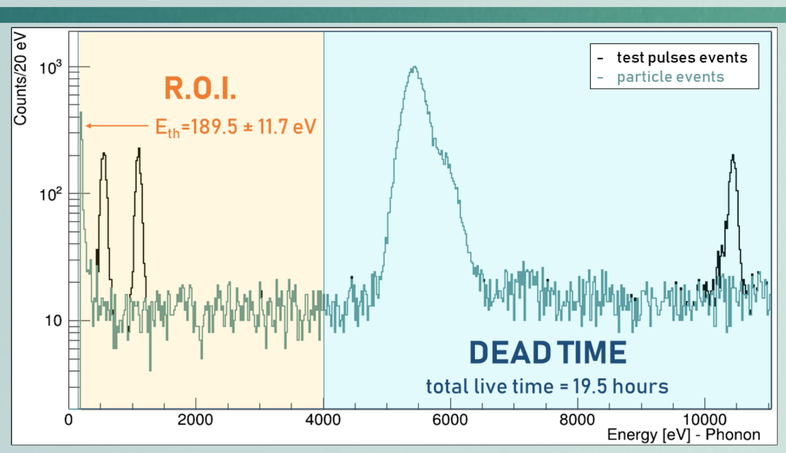
Abstract

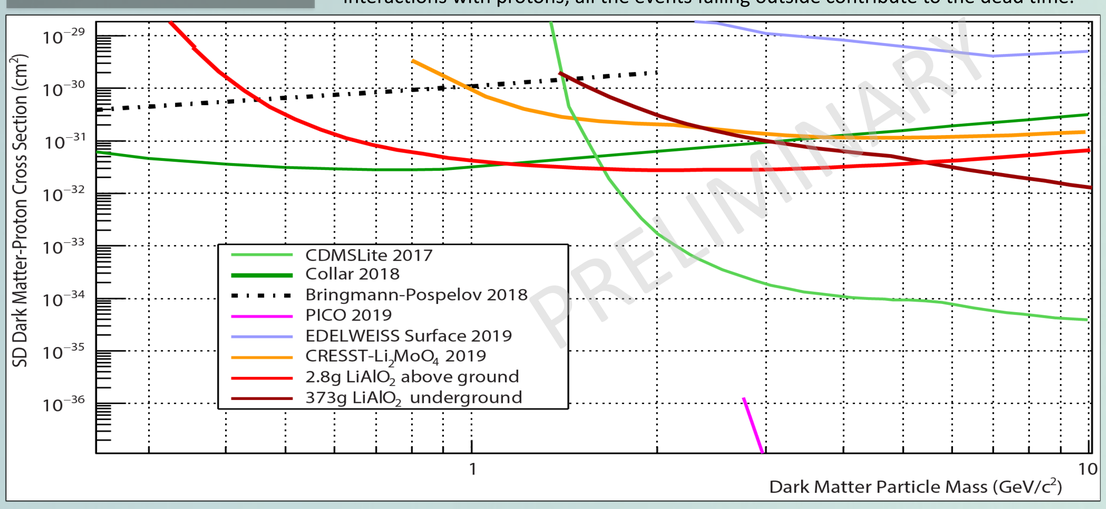
In the current direct dark matter search landscape, the leading experiments in the sub-GeV mass region mostly rely on cryogenic techniques which employ crystalline targets. One attractive type of crystals for these experiments are those containing lithium, due to the fact that ^{7}Li is an ideal candidate to study spin-dependent dark matter interactions in the low mass region. Furthermore, ^{6}Li can absorb neutrons, a challenging background for dark matter experiments, through a distinctive signature which allows the monitoring of the neutron flux directly on site. In this work we show the results obtained with three different detector modules based on $LiAlO_2$, a target crystal never used before in cryogenic experiments.



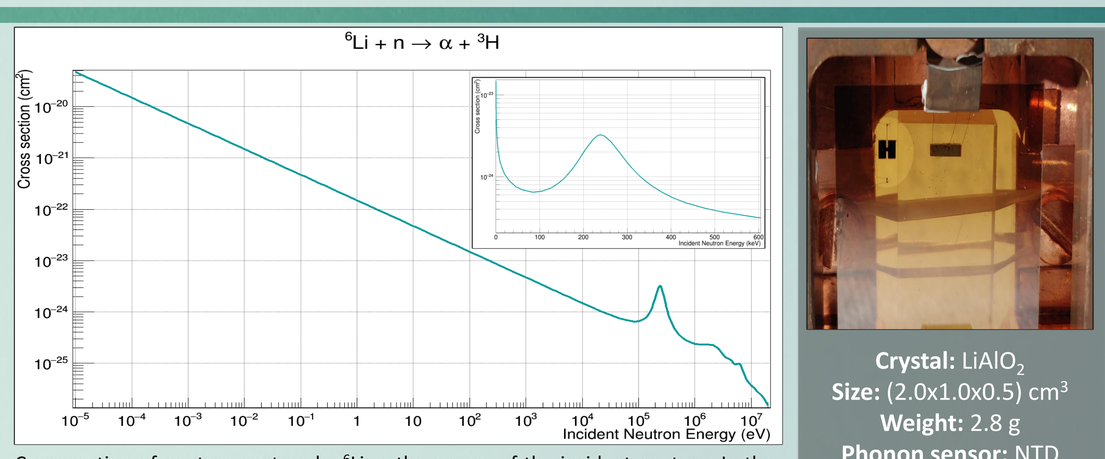
Crystal: $LiAlO_2$
Size:(2.0x1.0x0.5) cm^3
Weight: 2.8 g
Phonon sensor: TES
Light Detector: -
Calibration Source: ^{55}Fe
Lab: above ground



Energy spectrum acquired during 23 hours of measurement using a TES sensor evaporated on a 2.8g crystal of $LiAlO_2$ with an energy threshold of 189.5 eV. At 5.9 keV there is a peak induced by the ^{55}Fe calibration source. In yellow we show the R.O.I. used to compute the dark matter limit for spin-dependent dark matter interactions with protons; all the events falling outside contribute to the dead time.

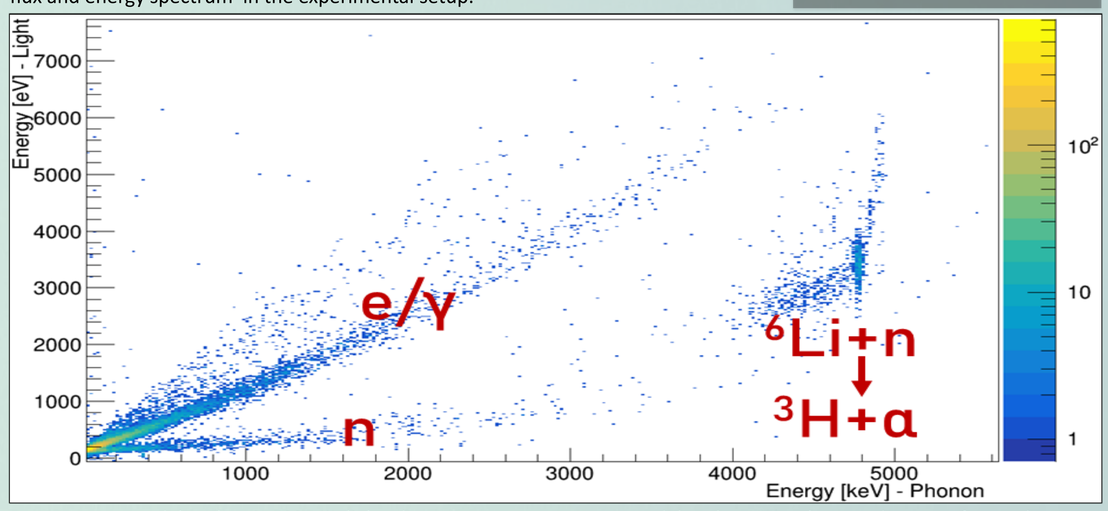


Exclusion limits set by various experiments for spin-dependent interactions of dark matter particles with protons.
The result obtained with Li_2MoO_4 is shown in orange. The new limits obtained with a 2.8 g and a 373 g $LiAlO_2$ are shown in red and brown, respectively.



Cross section of neutron capture by ^{6}Li vs the energy of the incident neutron. In the inset it is possible to see in detail the resonance centered around ~240 keV of incident neutron energy. Taking into account this cross section and a measured spectrum with a lithium-containing crystal it might be possible to extrapolate the incident neutrons flux and energy spectrum in the experimental setup.

Crystal: $LiAlO_2$
Size: (2.0x1.0x0.5) cm^3
Weight: 2.8 g
Phonon sensor: NTD
Light Detector: TES
Calibration Source: -
Lab: above ground



Energy measured by the CRESST-III light detector vs energy measured by the NTD phonon detector for each event registered in a 2.8g crystal of $LiAlO_2$. Data was collected over 9.44 hours in the presence of an AmBe neutron source.

^{7}Li
Spin-Dependent Dark Matter

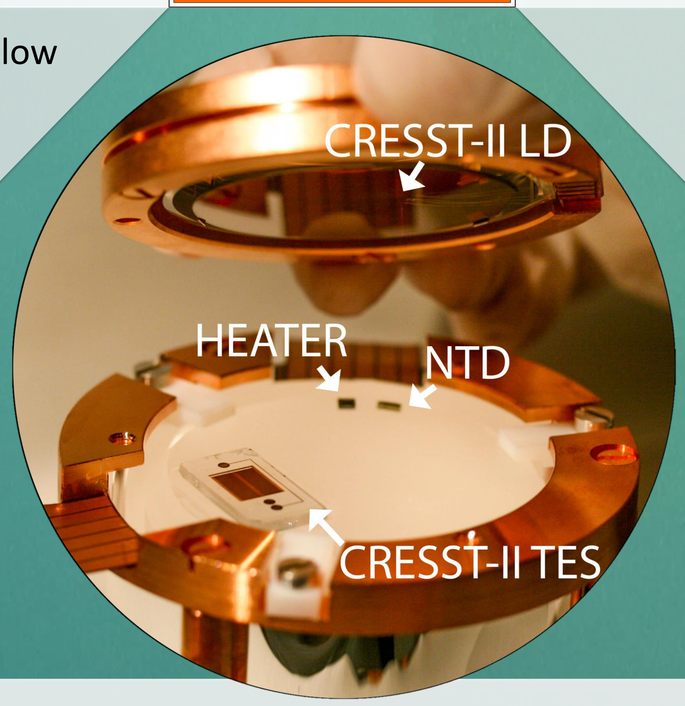
3 Li Lithium 6.94 2, 1

An ideal candidate to study dark matter interactions in the low mass region with cryogenic detectors.

It is the lightest element we can employ to study dark matter interactions using the CRESST technology while also having the largest cross section for spin-dependent dark matter interactions with protons.

The first competitive limit was obtained using Li_2MoO_4 and one NTD as phonon sensor, see DOI: **10.1140/epjc/s10052-019-7126-4**

Now we show for the first time an improved dark matter limit using $LiAlO_2$ crystals with CRESST TESs.



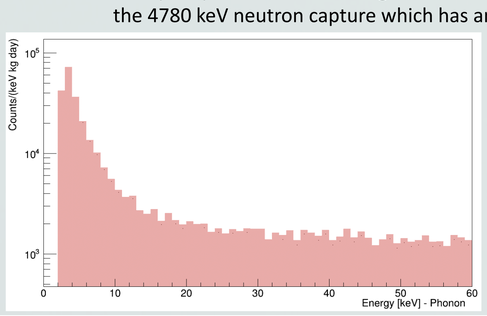
^{6}Li
Neutron Flux Monitor

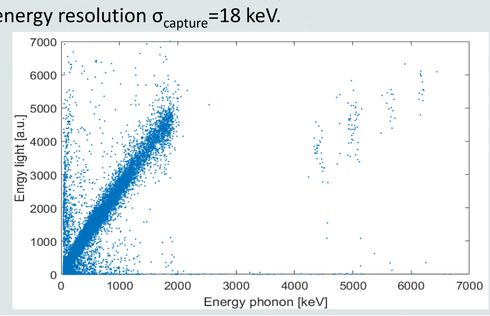
The estimation of the neutron flux is a significant piece of information for the construction of the background model of a dark matter experiment.

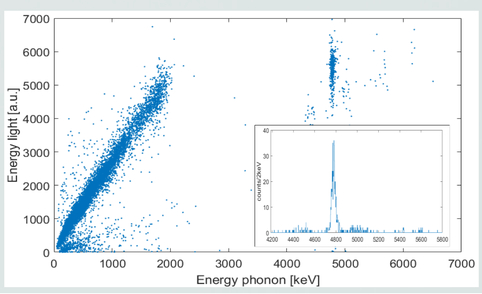
^{6}Li has a relatively high cross section for the neutron capture, which is easily identifiable in scintillating bolometers thanks to a distinctive signature at 4.78 MeV.

We plan to assemble a cryogenic detector based on a crystal containing lithium to measure the neutron flux directly inside the CRESST experimental setup at LNGS. A similar detector was operated at LNGS in 2019 in an underground test facility.

Left: spectrum measured by the CRESST-II phonon sensor glued on a 373 g $LiAlO_2$ crystal. The lowest energy threshold achieved by this sensor is equal to 2.6 keV. From this spectrum we can calculate a dark matter limit (see above, left). The background level on the flat part of the spectrum is equal to ~10^3 counts/(keV kg day). **Center:** Energy measured by the CRESST-II light detector vs energy measured by the NTD phonon sensor for a background data campaign of 92 hours with a 373 g crystal of $LiAlO_2$. Data was collected in an underground test facility at LNGS in order to assess the radiopurity of the material. **Right:** same as previous, but this time with the presence of a weak AmBe neutron source. In the inset is possible to see the 4780 keV neutron capture which has an energy resolution $\sigma_{capture}$=18 keV.







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