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Book of Abstracts

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Welcome

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Review on Low-Energy Excess Signals Observed in Cryogenic Rare Event Search Experiments

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Review on Low-Energy Excess Signals Observed in Cryogenic Rare Event Search Experiments

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Review on Excess Signals Observed in CCD Detectors

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Review on Excess Signals Observed in CCD Detectors

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Ionization efficiency at sub-keV energies for crystals and noble liquids

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We study the ionization and light yields produced by nuclear recoils at low energies in pure crystals and noble liquids in the context of Lindhard's integral equation, incorporating the effects of binding energy, improved modeling of the electronic stopping, and electronic straggling. We consider three different models for the electronic stopping power that incorporate Coulomb repulsion effects at low energies, and Bohr electronic stripping for high energies. Finally, we discuss possible new effects near threshold.

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Background discrimination for low quanta events with NEWS-G

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The New Experiment With Sphere-Gas (NEWS-G) employs spherical proportional counters (SPC) filled with gas to search for elastic scattering of WIMPs off light target nuclei, reaching sensitivities down to single ionisation electrons. The new-generation detector consists of a larger sphere of 140 cm diameter, equipped with a new multi-anode sensor, "ACHINOS", developed to ensure a sufficiently strong electric field at large radii while maintaining the capacity to achieve high gain. Due to the increased detector size, at low interaction energies the quantised nature of the ionisation process generates visible structure in the detector response. This can be exploited to identify and reject backgrounds with the goal to improve our sensitivity to WIMP recoils. In this talk, we will describe the background-rejection processing of low energy data from NEWS-G's S140, and the characterisation of its performance based on laser and Ar37 calibrations.

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Low-energy event excess in SuperCDMS HVeV detectors

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The 1-gram silicon HVeV detectors developed within the Super Cryogenic Dark Matter Search (SuperCDMS) collaboration have achieved single-photon sensitivity and a baseline resolution of $\sigma = 2.7$ eV. These cryogenic calorimeters can be operated in two configurations: (1) as phonon-assisted charge amplifiers by exploiting the Neganov-Trofimov-Luke (NTL) effect; (2) without NTL voltage (0V) by simply measuring recoil energies. The HVeV detectors observed an excess of events in the low energy region, as have several other experiments in the field. In this talk, I will present a study of the low-energy event excess through a comparison of the NTL-amplified data and the 0V data. The observed excess is consistent with a scintillation/luminescence hypothesis from the material holding the device.

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Latest results on the low energy excess in CRESST-III

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CRESST, similarly to many other experiments, observes an unexpected excess of events at low energies. So far no conclusive explanation of its origin was found. The current CRESST-III data

taking campaign is dedicated to study and possibly identify the nature of this Low Energy Excess (LEE). We are operating a variety of detector modules differing in target materials, geometries and holding structures, designed to narrow down the list of hypotheses. In this work we show the current status of the investigations of the ongoing CRESST-III measurements, focusing on the comparison of time, energy and temperature dependence of the LEE in several detectors. The preliminary results strongly exclude dark matter, radioactive backgrounds and intrinsic sources related to the crystal bulk as a major contribution.

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Heat-only background in the EDELWEISS detectors with NbSi TES sensor

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The EDELWEISS collaboration has extensively studied the population of events with no ionization signal ("Heat-Only" events) in its cryogenic germanium detector equipped with Ge-NTD sensors. It recently developed and operated in an low-radioactivity underground environment a new generation of cryogenic germanium detectors equipped with NbSi thin-film sensors able to detect out-of-equilibrium phonons. The population of Heat-Only events in such a device has been measured, using the Neganov-Luke-Trofimov effect to resolve it from electron recoil events. Significant differences from the population observed in detectors equipped with Ge-NTD sensors have been observed.

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Stress Induced Background in Cryogenic Crystal Calorimeters

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A number of low mass dark matter direct detection experiments have observed an excess rate of events, rising sharply below energies of around 100 eV. A similar source of background energy has been observed to shorten the coherence time of superconducting quantum bits by creating excess quasiparticles in the qubit circuit. The relaxation of stress in detector materials has been shown to cause low energy backgrounds in previous dark matter experiments, and has been proposed as a source of the current "low energy excess." By comparing detectors in high and low stress states, we have shown that stressing silicon detectors can cause excess event rates of over 80 Hz/gram below 20 eV, compared to a rate of under 0.5 Hz per gram in a low stress calorimeter. Measurements of the background rate as a function of time will be described, as well as implication for the design and operation of future cryogenic low threshold calorimeters.

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Low energy excess in MAGNETO R&D Data

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MAGNETO is developing dark matter and neutrino detectors using magnetic quantum sensors with sub-microsecond timing resolution for phonon pulse shape discrimination in eV region. Such fast timing resolution improves separation of electron recoil background, microphonic noise, and thermal noises due to events from substrates and surrounding materials. I will discuss findings from MAGNETO R&D data regarding the low energy excess phenomenon.

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Dark matter detectors and understanding of glasses

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Interest in detecting coherent elastic scattering of low-energy neutrinos, dark matter particles and physics beyond the standard model brings numerous experiments involving low-temperature solid-state Detectors. The excess low-energy background was found in numerous experiments, with a wide range of detector mass, and using various readout channels: luminescence, conductivity, temperature, or phonon emission spikes. Another often present effect is glass-like relaxation processes in detector materials. We argue that in systems out of equilibrium, including glasses, processes of energy accumulation and unsteady, burst-like releases could lead to excess noise and backgrounds. Moreover, there is a long-standing contradiction in understanding the role of interactions between states bearing excess energy in the description of glasses in solid-state physics and the description of systems with energy flow in chemical physics and physics of complex systems. While these interactions consider not important in glasses, in systems with energy flow interactions bring to life important physical effects. The same problem is present in understanding material sources of noise and decoherence in quantum sensors and qubits. Joint efforts to resolve these contradictions should help to increase the sensitivity of searches for rare low-energy interactions of particles and better understand material sources of decoherence which remains one of the central problems in quantum information science.

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Energy loss due to defect creation in solid state detectors

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The threshold displacement energy in solid state detector materials varies from several eV to ~ 100 eV. If a stable or long lived defect is created as a result of a nuclear recoil event, some part of the recoil energy is stored in the deformed lattice and is therefore not observable in a phonon detector. Thus, an accurate model of this effect is necessary for precise calibration of the recoil energy measurement in low threshold phonon detectors.

Furthermore, the sharpness of the defect creation threshold varies between materials. For a hard material such as diamond, the sharp threshold will cause a sudden onset of the energy loss effect, resulting in a prominent peak in the observed recoil spectrum just below the threshold displacement energy. We describe how this effect can be used to discriminate between nuclear and electron recoils using just the measured recoil spectrum.

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Impact of crystal lattice defect quenching on coherent neutrino scattering experiments

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Future experiments on coherent neutrino scattering near nuclear reactors using cryogenic solid-state phonon-mediated detectors have their global signal for the energy transferred to the target nucleus in the range of a few tens to a hundred electron volts. In this range, the creation of permanent or long-lived crystal defects can have a significant effect on the reconstruction of the true energy of the incident neutrino. I will present a study of the impact for future generations of experiments (such as Nucleus-10g) and discuss a possible envelope for the associated systematic uncertainty for future searches of physics beyond the Standard Model.

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Discussion

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Skipper-CCDs performance in CONNIE

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The Coherent Neutrino-Nucleus Interaction Experiment (CONNIE), located at sea level at about 30 m from the core of the 3.8 GW Angra 2 nuclear reactor in Brazil, aims to detect the coherent elastic scattering of reactor antineutrinos (CEvNS). The experiment has operated from 2016 to 2020 using 12 fully depleted high-resistivity 4k x 4k CCDs (Charge Coupled Devices) with 6 g each, with a readout noise better than 2 electrons RMS and a single electron rate of about 1e-/pix/day. Recently, two Skipper-CCDs were installed in the experiment, together with a new electronics developed for those sensors, to characterize their capability to lower down the detection threshold and to study the background response. The first data collected show a readout noise of 0.16 electrons RMS and a single electron rate better than 0.09 e-/pix/day. In this presentation we will discuss the performance and stability of the Skipper-CCDs, and also will show the measured background spectrum above 15 eV and discuss the prospects for detecting CEvNS with this new detector technology.

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t.b.d.

topic still under discussion