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Referee Report to the joint 52nd N.P. /P.P. PAC at JINR:
Annotation of the EDELWEISS/Ricochet

"Joint project for Direct Dark Matter search and precision study of CEvNS with new cryogenic detectors""

As reported previously, the EDELWEISS program, located at the LSM facility in Modane, searches for direct evidence of Dark Matter (DM) WIMP from the Milky Way galaxy through their scattering of Ge nuclei within cryogenic high purity Ge (HPGe) crystals. This is one of the many passive DM search programmes (largely located in various sites in the northern hemisphere with a few in the south being proposed). The current setup is built on the expertise obtained from the EDELWIESS-III program which showed a new exclusion limit in the low-mass WIMP region of 4-30 GeV. The next stages of this programme will focus on the low-mass WIMPs region of 10 GeV/c^2 (and below) which has attracted considerable interest following the non-detection of SUSY at the LHC – and seems to have gained favourable theoretical predictions of late.

The EDELWEISS scientific programs started as experiment directed to search for WIMP DM using natural HPGe detectors. The EDELWEISS detectors are cryogenic (work temperature is about 20 mK) Ge bolometers with simultaneous measurement of phonon and ionization signals. The comparison of the two signals provides a highly efficient event-by-event discrimination between nuclear recoils (induced by WIMP and also by neutron scattering) and electrons. For the past 25 years EDELWEISS is the leading experiment for direct Dark Matter search with Germanium detectors. In the present time there is an increasing gain of interest for the search of low-mass WIMPs (with mass below 10 GeV/c^2) arising on the one hand from non-evidence yet for SUSY at the LHC and on the other hand from new theoretical approaches which favour lighter candidates.

Presented in the report are results from the continuous data taking process at the LSM laboratory over the January to July 2020 period, which includes – among others – the following developments; 1) 11 different Ge detectors 2) comparison physics performance of 32g, 200g and 800 g detectors 3) performance of NTD and NbSi-TES heat sensor performances 4) attainment of single electron sensitivity on 32g and 200g detectors for the exploration of DM interactions with electrons and nuclei. Finally the new detectors allowed for hitherto unreachable energy resolutions of 10 keV as a result of the HPGe bolometers which take advantage of the Neganov-Luke effect of internal amplification of the heat signal. This development enabled the group to obtain lowest possible background levels (and world leading results) from measurements of light DM nucleon cross-section which were published in the PRL 1235, 141301 (2020) article. This article reported on first Ge-based constraints for sub-MeV/c^2 DM particle/electron-interactions and on dark photons down to 1 eV/c^2.

The next topic – project ROCOCHET – was on the investigations of coherent elastic neutrino-nucleus scattering (CEνNS) – using the EDELWISS bolometers for study of BSSM physics. This distinguishing feature of this project is that of attainment of a large (kg scale) experiment with significant background rejection to the level of O910) eV. These non DM measurements sought, at first phase, to utilise the ILL 58 MW reactor as a neutrino source with flux of 10^{19} ν/s with the aim of obtaining 20 scattering events per day encased within a detector setup that provides a cosmic background shielding of 15 m.w.e. At the core of the detector set-up is the CRYTUBE composed of 27x33 g detectors housed in a radio pure infrared-tight copper cube of 512 m^3 volume. The cryo-concept is based in the technique of a dilution fridge with staggered levels of cooling arranged in a vertical configuration to allow for the staggered cooling range (from top to bottom) of 50K to 10mK.

The construction phase of project (whose time line started at the end of 2019) is planned to run until 2024 with the expectation of the delivery of first sub-100 eV high-precision CEνNS measurements. In that regard the JINR group will play a crucial role in the experiment starting with the set-up, commissioning, data taking, calibration, MC and analysis. More specifically the group with take responsibility for – among others – radon control, calibrations, development of new low threshold detectors including the RICOCHET cryo- and veto systems.

The SWOT analysis the authors detail significant risks; among others including stability of running of all components of the experiment including cryosystem with dilution cryostat and its stability, electronics, acquisition system, subsystems. They also list the key scientific challenge, which is standard for these precision measure, namely that of background. They point out that the key to the success of the experiments is the possibility to identify with h**igh efficiency the background events, which can mimic the signal.** They further state that Ricochet experiment proper interpretation of results will be strongly depended on stability of the neutron background, especially for comparison of reactor ON/OFF runs

Notwithstanding these considerations, the DzLNP JINR group almost 50-year experience in high-precision nuclear spectrometry using semiconductor and scintillator detectors in general and 30- year experience of rare processes studies in underground environment. Therefore they have the aggregated expertise in surmounting the challenges posed by these experiments.

Furthermore, the reports of the referees A.M.Gangapshev and A.V. Glagyshev are strongly supportive of the project, and point to the expertise of DzLNP JINR group that has already gained experience in the problem of the Dark Matter searches and neutrino study with reactors and consists of highly qualified leading JINR scientists.

Finally, these projects seek to address some of the most topical areas in particle physics and are at the frontier of addressing some fundamental questions whose answers are still elusive and will decidedly make a contribution to the field. In that regard, I strongly support the project.

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