# Review of the “EDELWEISS/Ricochet: Joint project for Direct Dark Matter search and precision study of CEνNS with new cryogenic detectors”

The authors of the project provide extensive information about the EDLEWEISS experiment and the associated experiment Ricochet together with a comprehensive review of the research field and the main results achieved so far.

The EDELWEISS experiment will continue its searches for WIMPs from the Milky Way galaxy. It uses arrays of high purity Ge mono-crystal bolometers operated at a temperature of ~20mK and equipped with electrodes and thermal sensors. Applying a small (few V/cm) external field, a simultaneous measurement of ionization and heat signals allows efficient identification of nuclear (caused by WIPM or neutron) and electron (induced by β− or γ− radioactivity) recoils. The main objective of the experiment is now shifted to the low-mass WIMPs region (1 GeV/c2 and below). This mass region became accessible thanks to the improved energy resolution (below 20 eV) of the new bolometers where the Neganov-Trofimov-Luke effect (internal amplification of the heat signal) is used.

The Ricochet experiment (reactor neutrinos) will use the same technology and detector for precision measurements of coherent elastic neutrino-nucleus scattering (CEνNS) in the region of full coherency. During the first phase an array of 3x3x3 bolometers (each 33g) in a “dry cryostat” will be deployed at ILL (Grenoble, France) site, at about 8 m from the 58 MW nuclear reactor. With a total neutrino flux 1х1019 ν/sec, the experiment expects to register 20 events of CEνNS per day. Possibility of further phases of the experiment at a Nuclear power plant (a 3.2 GW reactor) in Russia is under investigation. The additional physics goals of Ricochet include search for neutrino magnetic momentum, for new massive mediators, for non-standard interactions, and for sterile neutrinos.

JINR team is expected to contribute to the both experiments in the following: 1) Development of new low threshold Ge detectors; Assembly and commissioning; 2) New cryo-system development and running; 3) Development of methods for low background measurements; 4) Data taking (this includes daily routine procedures, as well as regular and special calibration runs); 5) Low background study and development of methods of neutron and radon detection; 6) Detector simulations and data analysis; Publication of results. 7) Preparation of a NPP site for possible further phases of the Ricochet project.

The group consist of 5 engineers, who contribute 2.5 FTE to the project, and 20 researchers with total FTE of 4.2. The number of researchers is tripled compared to the previous phase of the EDELWEIS project and their involvement will sharply increase when the Ricochet experiment moves from preparation to operation.

In the period 2015-2020 the EDELWEISS experiment published 8 articles in high impact journals. In addition, the members of the JINR group published 4 articles on the R&D results.

The plans of the JINR group within the EDELWEISS program are:

2022: Using of new detectors in special detection modes for reduction of heat-only events. Building and testing of new HPGe crystals with different thermistors, holders, crystal treatments, delivery of the detectors to LSM, measurements.

2023: Results with accumulated data. Decision about further EDELWEISS detectors design. Selection of materials for improved EDELWEISS setup at LSM.

2024: Upgrade of EDELWEISS setup at LSM with new cryo-system/shields.

The plans of the JINR group within the Ricochet program are:

2022: Complete building of all Ge detectors (~1 kg), their tests, building and commissioning of the cryo-system, shields, supplementary systems. Start the Ricochet implementation at ILL site.

2023: Start of data taking. Background measurements, calibrations. Improved MC model based on real data. Implementation of Zn detectors. First results.

2024: Data taking, results. Finalizing characterization of NVNPP site for possible further Ricochet implementation.

The requested budget for 2022-2024 is 411 kUSD, where 336 kUSD are for networking, materials, equipment and common fund, and 75 kUSD are for travel expenses. Additional 30 kUSD are expected from external grants. The total amount matches well the needs of the project.

Thew SWOT analysis focuses on the strengths and challenges of the experiment and lists the main technical risks: the stability of the cryogenic system, the limitation of contaminations, and reduction of vibrations. The main scientific challenge is the identification of the background.

The main competitors of the Ricochet are the MINER and NuCLEUS experiments. They also come from DM searches and use different cryogenic bolometers. In this respect, the Ricochet hast the following advantages: 1) Expertise in HPGe detectors’ technology; demonstrated use of massive Ge detectors to do measurements in the desired energy range; 2) available experimental hall at ILL near the reactor; 3) background and neutrino spectrum (extremely important for precise measurements!) at that place are known from the STEREO experiment; ongoing refinment of the background with dedicated detectors. 4) the reactor On/Off often cycles allow to obtain first results in timely manner 5) the low background / low noise dilution cryo-system will be available in March 2021. These circumstances are favorable to measure for the first time the CEνNS in the region of full coherency, and also to produce first precise measurement, probably already in 2025.

The main competitor for the EDELWEISS measurements in the lowest mass region is DAMIC@SNOLAB experiment. It has better sensitivity in the analysis of DM particles scattering on electrons. EDELWEISS has higher background from the so called “heat only” events in the lowest mass region. In the mode that was used for the recent data taking (amplification of the heat signal by higher bias on electrodes) these background events were the main limitation of the experiment. Their origin is not yet known. To target the background the group will use different thermistors, glues, detector's holders, new first amplification channels, etc. The ultimate goal is sufficient sensitivity to detect the solar neutrino signal (nuclear recoils). The investigation of electron recoils will continue as well, but since the background source(s) in the lowest energy region is unknown, it is impossible to predict if the results there will be improved.

**The reports of the referees A.M.Gangapshev and A.V. Glagyshev are positive and strongly support the approval of the project.** They indicate the scientific quality of the project, the strong expertise of the JINR group, the successful participation of the key members in the previous stages of the EDELWEISS experiment.

**I completely agree with the opinion of both referees and propose to approve the EDELWEISS/Ricochet project in 2022-2024**. As referee I would like to thank E.A.Yakushev for his help in clarifying several questions.

Peter Hristov

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