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Directional Dark Matter searches and the CYGNO/INITIUM project

ELISABETTA BARACCHINI
GRAN SASSO SCIENCE INSTITUTE

Abstract: The importance of directly detect and experimentally probe the nature of Dark Matter (DM) is universally and incontrovertibly recognised as one of the most compelling tasks of today's fundamental physics. The measurement of the DM scattering directionality not only offers a powerful handle to deal with backgrounds (including neutrinos), but it grants a unique key for a positive unambiguous identification of a DM interaction by establishing its Galactic origin. We will review the discovery potential of directional experimental approaches to detect and characterise WIMPs, and illustrate how this can also leap beyond the "Neutrino Fog" bound, actually promoting solar neutrinos from background to a signal with attractive physics cases. We will illustrate the main experimental techniques employed in the development of directional DM experiments and we will focus on the Gaseous Time Projection Chambers (TPCs), currently representing the most mature approach to this problem. We will present in details the CYGNO/INITIUM project, an high precision 3D tracking TPC with optical readout currently under development at Laboratori Nazionali del Gran Sasso. We will illustrate the commissioning and the underground operation of the 50 L prototype LIME, the largest developed so far by the collaboration, and its capability to measure and identify low energy nuclear and electron recoils. We will outline the design and prospects for the development of the already funded O(1) m³ demonstrator to be hosted in Hall F of LNGS and illustrate the physics reach of a possible future O(30) m³ experiment emerging from these developments. We will furthermore discuss the R&D results obtained by the collaboration towards the maximisation of the CYGNO potentialities, and in particular the recent demonstration of negative ion drift operation at atmospheric pressure with optical readout obtained in synergy with the ERC Consolidator Grant project INITIUM.



Elisabetta Baracchini is Full Professor and Researcher at the Gran Sasso Science Institute in L'Aquila. She began her scientific activity with BaBar, one of the most advanced particle physics experiments for the study of the asymmetry between matter and antimatter on an electron-positron accelerator. She continued her career as a postdoctoral fellow and researcher for UC Irvine, the KEK laboratory in Tsukuba, and the University of Tokyo, at MEG, on a high-precision experiment on a fixed target to search for signals beyond the standard model, in which it expanded its know-how in the detection of charged particles in gas detectors. In 2015 she received a Marie Skłodowska-Curie Individual Fellowship for her original proposal for NITEC, a negative ion detector for directional searches for dark matter. In 2018 she obtained an ERC Consolidator Grant of about 2 MEUROS from the European Research Council of the European Union for the INITIUM (Innovative Negative Ion Time projection chamber for Underground dark Matter searchers) project, which represents the consolidation of all these recent activities in an innovative experiment for dark matter research. Thanks to this and to the INFN support for the development of the synergic project CYGNO, a directional DM TPC experiment of which she is the Spokesperson, is currently under construction by an international collaboration at Laboratori Nazionali del Gran Sasso. She more recently received two additional grants (PRIN2020 and FARE2020) to optimise the experimental technique under development for DM searches for alternative innovative physics cases, namely x-ray polarimetry in space and the measurement of the Migdal effect.