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CYGNO: Light Dark Matter search with an optically readout TPC

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Summary. — CYGNO is a project realising a cubic meter demonstrator to study the performance of the optical approach for the readout of large-volume, GEM-equipped TPC. This is part of the CYGNUS proto-collaboration which aims at constructing a network of underground observatories for directional Dark Matter search. The combined use of high-granularity sCMOS and fast sensors for reading out the light produced in GEM channels during the multiplication processes was shown to allow on one hand to reconstruct 3D direction of the tracks, offering accurate energy measurements and sensitivity to the source directionality and, on the other hand, a high particle identification capability very useful to distinguish nuclear recoils.

The TPC technology, developed for High Energy Physics experiments, can provide a complete information about interaction events occurring in the sensitive gas volume:

- 3D reconstruction of the particle tracks;
- evaluation of the energy release profile along the particle trajectory;
- acquisition of large volumes with a relative small amount of readout channels.

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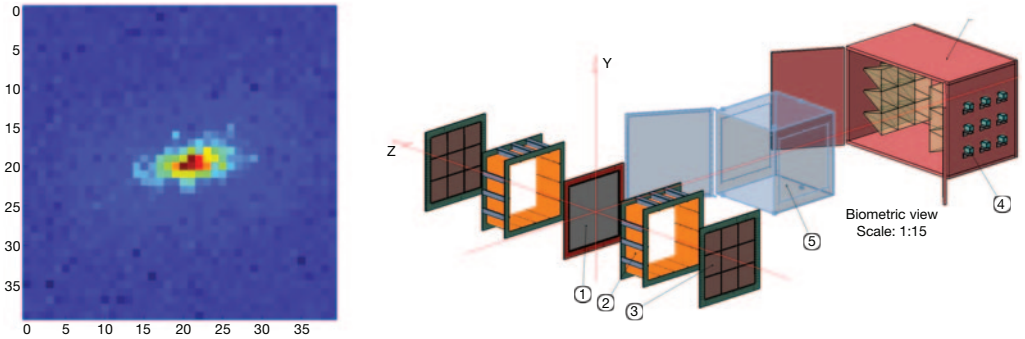

Fig. 1. – Left: example of an event of helium nuclear recoil induced by neutron scattering acquired with a 10 l prototype developed within the CYGNO project. Right: drawing of the 1 cubic meter CYGNO apparatus.

A recent proposal [1] aims to develop an Optical Readout of Gas Electron Multipliers (GEM) [2] based on CMOS sensor for the gas TPC. The large granularity and very high sensitivity of the CMOS technology allows the detection of few photons per pixel. A sensitivity to events with an energy release in the gas in the keV range has been recently demonstrated [3].

The use of helium-based gas mixtures allows an efficient momentum transfer for DM particles with a mass in the GeV range.

The application of this technology in the DM search will provide high efficiency in the identification of nuclear recoils induced in the gas by DM scattering. Moreover, the possibility of reconstructing the recoil direction offers a crucial way to reject background events due to natural radioactivity [4]. After about two years of R&D activity, during 2019 the CYGNO Collaboration is finalising the design of the $1\,m^3$ detector (fig. 1, right) and will start its construction in 2020.

The apparatus will be composed by a $1\,m^3$ gas volume filled with a He/CF_4 60/40 gas mixture (1.6 kg total mass) kept at atmospheric pressure and subdivided in two 50 cm long parts separated by a central cathode with a drift electric field of about 1 kV/cm. Each gas volume is equipped with a 3×3 matrix of triple-GEM structures and a CMOS sensors. The active apparatus will be contained in a massive structure meant to shield it from the external gamma rays and neutrons. The installation underground at the National Laboratories of Gran Sasso is foreseen for 2022. CYGNO will behave as a demonstrator in order to prepare a proposal for a 30–100 m^3 experiment.

This activity is carried on in the framework of the CYGNUS-TPC project that aims at building a system of multi-ton gas targets distributed in underground laboratories around the world using the TPC-based techniques for Directional Dark Matter searches.

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