

# The CYGNO Experiment: A Directional Dark Matter Detector with Optical Readout

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We are going to discuss the R&D and the prospects for the CYGNO/INITIUM project, towards the development of an innovative, high precision 3D tracking Time Projection Chamber with optical readout using He:CF<sub>4</sub> gas at 1 bar. CYGNO uses a stack of triple thin GEMs for charge multiplication, this induces scintillation in CF<sub>4</sub> gas, which is readout by PMTs and sCMOS camera. High granularity and low readout noise of sCMOS along with high sampling of PMT allows CYGNO to have 3D tracking with head tail capability and particle identification down to O(keV) energy for directional Dark Matter searches and solar neutrino spectroscopy. INITIUM, which is an ERC Consolidator project, aims at developing negative ion drift operation within the CYGNO optical TPC approach. We will present the most recent R&D results from the CYGNO/INITIUM project, and in particular the overground commissioning of the largest prototype developed so far, LIME with a 33x33 cm<sup>2</sup> readout plane and 50 cm of drift length, for a total of 50 litres active volume. We will illustrate the LIME response characterisation between 3.5 and 35 keV by means of multiple X-ray sources, and the data Monte-Carlo comparison of simulated sCMOS images in this energy range. We will discuss the expected background rejection capabilities evaluated on simulated data using multivariate techniques and Machine Learning models. We will finally present current LIME installation, operation and data taking at underground Laboratori Nazionali del Gran Sasso (LNGS), serving as demonstrator for the development of a 0.4 m<sup>3</sup> CYGNO/INITIUM detector. We will conclude by illustrating the technical choices and the prospects of the 0.4 m<sup>3</sup> detector towards a O(30)m<sup>3</sup> project, as laid out in the Technical Design Report (TDR) recently produced by our collaboration.

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