CYGNO/INITIUM - annual report

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2019 has been the first year of the CYGNO project in CSN2 after 2 years of R&D in CSN5 where the optical read-read out was investigate, whit the aim to build a 1 cubic meter demonstrator to locate under the LNGS [1, 2]. The CSN2 funded the initiative for 2019 in order to complete the R&D on the other components of the detector and propose a complete Technical Design Report (TDR). In the meantime, the project start to be supported by an ERC grant (E. Baracchini ERC-INITIUM-818744) and it is partially funded by the PRIN project Zero Radioactivity in Future Experiments in collaboration with GSSI and LNGS.

The LNF group is in charge of designing and constructing the final detector and all the R&D prototypes, gas studies and GEM development. It's moreover the site where all the tests are ongoing, is participating in data analysis and design of DAQ and IT infrastructure.
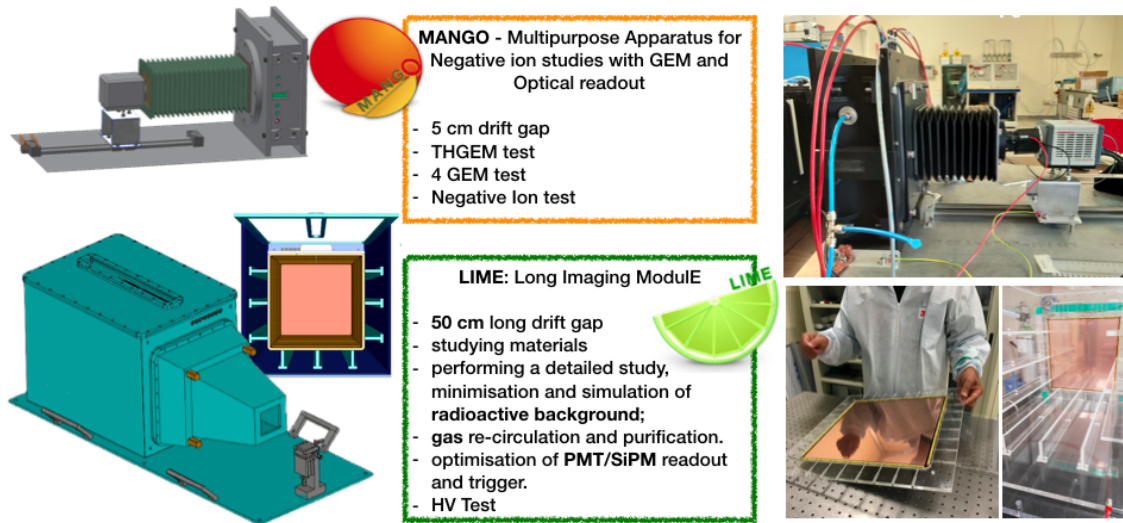

Figure 1: *Prototypes under constriction and test at LNF.*

In 2019 two prototypes (see figure 1) have been designed and realized. The first one, MANGO (Multipurpose Apparatus for Negative ion studies with GEM and Optical readout), was aimed to test gas mixture, and optical readout performance; the second one, LIME, Long Imaging ModulE, 1/18 of the final detector was designed with the scope to test materials and read out in the operative
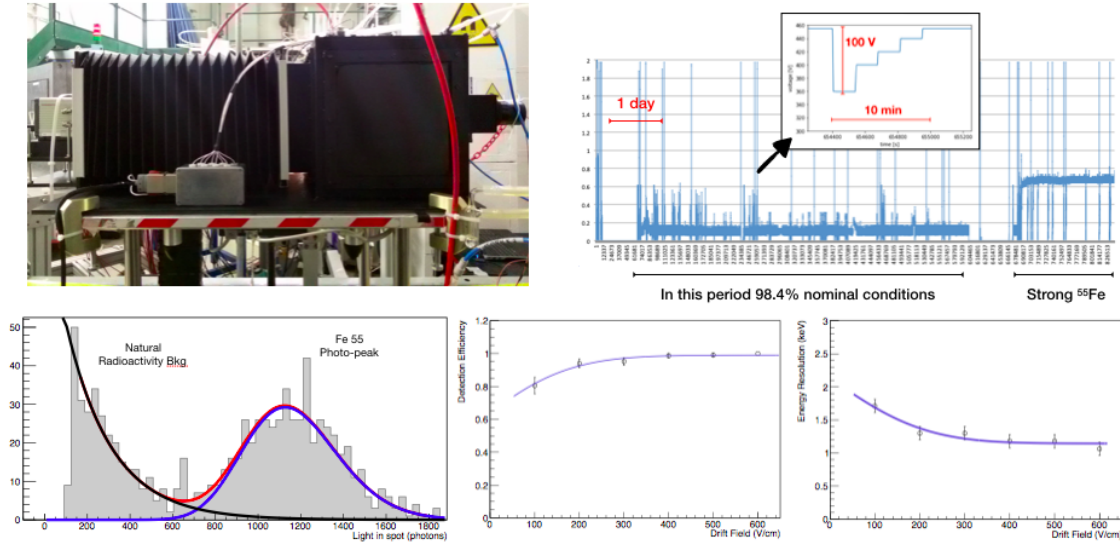
condition. MANGO, as well as the previous prototypes, ORANGE and LEMON, is contributing to the optimization of the readout and many studies on those prototypes are ongoing and presented in international conferences [3, 4, 5].

Figure 2: *Shielding: Water tank and copper vessel, designed for CYGNO demonstrator at LNGS.*

In the meantime, the design of the large demonstrator and the interaction with the LNGS were started in order to find out the optimal solution to start the underground test and host the final detector. In particular, most of the efforts are devoted in the shielding (see figure 2) design that plays a fundamental role to dump down the external background (γ, n) of factor 10^6 as required to achieve the foreseen performances.

Finally, Frascati is involved in data taking and analysis of the prototypes data. Thanks to FISA service, many neutron tests and gamma measurement campaigns have been performed. The tested detectors show good energy resolution and discrimination, in agreements with the requests as well as long term stability performances (see figure 3).

1 List of Conference Talks by LNF Authors in Year 2019

1. D. Piccolo - Tests of eco-friendly gas mixtures in GEM based detectors with optical read-out, CYGNUS 2019 conference 10-12 Jul 2019, Rome, Italy `http://www.roma1.infn.it/conference/CYGNUS_2019/home.html`

Figure 3: *left up: LEMON prototype; right up: long term stability measurements and recovery time after GEM accidental discharge; left down: Fe^{55} calibration source in LEMON, 2 keV energy threshold can be estimated with 18% energy resolution @ 5.9 keV for events at 20 cm drift distance; right down: detector efficiency and energy resolution respect to primary electron drift field.*

2. G. Mazzitelli - Exchange collaboration program with Universidade Federal de Juiz de Fora, Brasil. Mini Course of Astro-Particle physics - lesson 5: The CYGNO experiment

3. G. Mazzitelli - The CYGNO/INITIUM TDR Status Report, CYGNUS 2019 conference 10-12 Jul 2019, Rome, Italy `http://www.roma1.infn.it/conference/CYGNUS_2019/home.html`

2   List of Publications signed by LNF Authors in Year 2019

1. G. Mazzitelli *et al.* CYGNO: a CYGNUs Collaboration 1 m^3 Module with Optical Readout for Directional Dark Matter Search, Conference Record of 2018 IEEE NSS/MIC/RTSD [arXiv:1901.04190 [physics.ins-det]].

2. E. Baracchini *et al.* CYGNO Conceptual Design Report INFN -19-06/Roma1

3. I. Abritta Costa *et al.*, CYGNO: Triple-GEM Optical Readout for Directional Dark Matter Search, arXiv:1910.07277 [physics.ins-det].

4. D. Pinci *et al.*, High resolution TPC based on optically readout GEM, Nucl. Instrum. Meth. A **936** (2019) 453. doi:10.1016/j.nima.2018.11.085

5. I. A. Costa *et al.*, Performance of Optically Readout GEM-based TPC with a 55Fe source, doi:10.1088/1748-0221/14/07/P07011 arXiv:1905.04066 [physics.ins-det].