CYGNO/INITIUM - Annual Report

L. Benussi, S. Bianco, C. Capoccia (Tecn.), M. Caponero (Ass.),
G. Maccarrone, G. Mazzitelli (Resp.), E. Paoletti (Tecn.), L. Passamonti (Tecn.),
D. Piccolo, D. Pierluigi (Tecn.), F. Rosatelli (Bors. Tecn.), A. Russo (Tecn.),
G. Saviano (Ass.), C. Reggio (Lau). R. Tesauro (Tecn) , S. Tomassini, D. Tozzi (Lau)

CYGNO collaboration: INFN (LNF, RM1, RM3),
La Sapienza Dip di Fisica and Dip di Ing. Chimica,
Università di Roma Tre, GSSI, Centro Fermi
University of Sheffield (GB), University of Coimbra (PT)
and University of UFJF and CBPF (BR)

The objective of the CYGNO project is to realise a large gaseous Time Projection Chamber (TPC) for Dark Matter and Solar neutrino search. Using GEM as active detector and profiting by a significant progress in commercial scientific Active Pixel Sensors (APS) based on CMOS technology, a possibility of using optical readout instead of electronics in being investigating. The project funded by CSN2, ERC-INITIUM-818744 and by the PRIN project *Zero Radioactivity in Future Experiments* in collaboration with GSSI, INFN Rome1, INFN Rome3, University of Sheffield (GB), University of Coimbra (PT) and University of UFJF and CBPF (BR) and foresees the construction of a large demonstrator, named CYGNO, to be located at LNGS.

the LNF are responsible for the integration and main duty are:

- design, construction and test of R&D prototypes and LNGS detector
- setup and coordination of overground R&D and facilities
- technical support to the overground LNGS R&D on INITIUM project.
- setup and coordination of the underground sites at LNGS
- design and develop the cloud computing infrastructure for CYGNO experiment
- design and develop the middle ware for the "quasi online" analysis

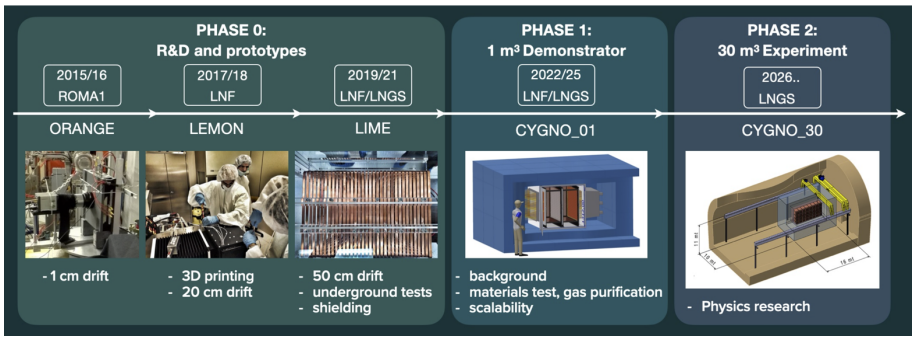

Figure 1: *CYGNO project road-map, from R&D (Phase 0) to the experiment (Phase 2)*

The road-map of the project is divided in three phases (see figure 1). The phase 0, R&D, have to validate the readout scheme, based on optical readout of a triple Gas Electron Multiplier (GEM), qualify and test log TPC drift field, and realize a first prototype, named LIME, to locate at LNGS where is expected to:

- testing low background site "environments" not only from the physics point of view but also to evaluate real costs, and logistic issue for CYGNO project.
- testing and developing low radioactivity constructive materials and devices
- measuring neutrons and gamma shielding and/or rejection capability
- validating Montecarlo simulation
- testing DAQ, computing infrastructure, 3D clustering reconstruction and analysis
- testing gas system (flux, recycle, purification, recovery of exhausted), optimal and echo gas mixture, negative ion

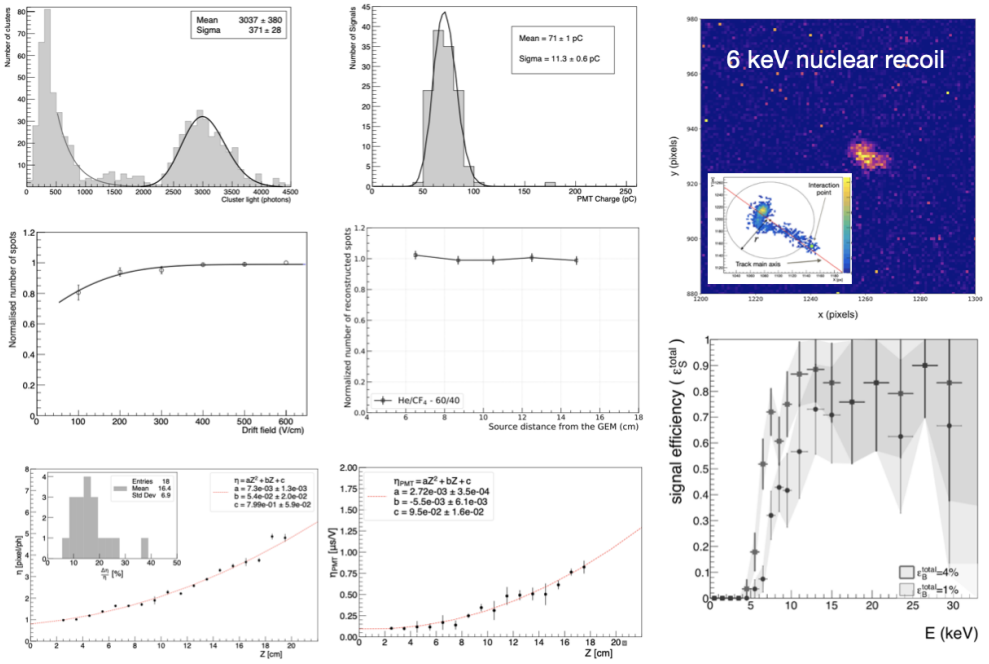

Figure 2: *Distribution of the light content of the 55Fe events reconstructed from the sCMOS images (up left), and distribution of the charge measured by the PMT signals (up right); behaviour of the normalised number of 55Fe spots as a function of the drift electric field (center left) and event depth in the sensitive volume (center right); dependence of η on the bottom left and ηPMT on the bottom right as a function of the track distance from the GEM detection; efficiency for nuclear recoils (ϵtotal) as a function of their detected energy for electron recoils efficiency of 4% (squares) and 1% (circles).*

LIME prototype, Long Imaging ModulE 1/18 of the CYGNO demonstrator, was designed and constructed at LNF and has been put in operation in 2020. In 2021 an intense campaign of calibration and performance study has been done (see figure 2) [3]. In the mean time Frascati personnel starts to prepare the experimental site at LNGS. Following the LNGS rules the first step was the definition of the Preliminary Risk Evaluation, Environmental Evaluation and all the infrastructure need and safety requirements, a TDR has been written with the support of an external company. After the approval of the TDR by the LNGS in May, the responsibility to follow the civil work needed to adequate the site and the control room was again assigned to LNF people. The installation ended at the beginning of 2022 and the collaboration is now starting to take data underground.

Frascati also follow R&D test on innovative, low radioactivity, field cage and tested, calibrate and put in operation the PMTs needed for the signal time shape and longitudinal track evaluation. The developed field cage was made by an acrylics resistive foil already tested in a small device by the CYGNUS Japanese colleague. Although the uniformity and stability where perfect an aging issue appears when running the prototype for long period. Many attempt to understand and solve the problem has been done whiteout success up to now.

Finally, LNF are involved in data taking and analysis of the prototypes data as well as in the design and implementation of the computing infrastructure on the INFN Cloud. Moreover, we are in charge of the of the middle ware. The middle ware is the software package between the DAQ (MIDAS based) and the analysis to realize: a RDP (Raw Data Presenter); a MWP (MiddleWare Worker and Presenter) that retrieve and present raw online data and histories, pre-elaborate data, present and make histories of macro-variables, qualify and validate by means of a fast pre-analysis, validate data storage, integrity, and take care of preservation (integrity, backup).

The Frascati group also hosted in 2021 two degree thesis, one fellow LNF, one fellow CSN2-INFN and three students of the La Sapienza Phys Lab II course.

Acknowledgements

We are very thankful for the inexhaustible support to the Servizio Progettazione e Costruzioni Meccaniche LNF-INFN and Servizio Meccanica LNF-INFN and in particular to A. Oralandi, retire in 2021. Moreover, we have to mention to the exceptional support Servizio Fisica Sanitaria e Medicina del Lavoro LNF-INFN in the person of M. Chiti and A. Esposito always available to help and coordinate measurements involving radioactive sources.

List of Publications signed by LNF Authors in Year 2020

1. A. Messina *et al.* [CYGNO], PoS **EPS-HEP2021** (2022), 799 doi:10.22323/1.398.0799

2. F. D. Amaro, E. Baracchini, L. Benussi, S. Bianco, C. Capoccia, M. Caponero, D. S. Cardoso, G. Cavoto, A. Cortez and I. A. Costa, *et al.* Instruments **6** (2022) no.1, 6 doi:10.3390/instruments6010006 [arXiv:2202.05480 [physics.ins-det]].

3. F. D. Amaro, E. Baracchini, L. Benussi, S. Bianco, C. Capoccia, M. Caponero, D. S. Cardoso, G. Cavoto, A. Cortez and I. A. Costa, *et al.* PoS **EPS-HEP2021** (2022), 159

doi:10.22323/1.398.0159

4. F. D. Amaro, E. Baracchini, L. Benussi, S. Bianco, C. Capoccia, M. Caponero, G. Cavoto, A. Cortez, I. A. Costa and E. Dané, *et al.* Particles **4** (2021) no.3, 343-353 doi:10.3390/particles4030029