CYGNUS-RD - annual report

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The aim of the CYGNUS_RD was to develop gas detectors prototype for high precision tracking of low energy O(keV) nuclear recoils over large gas volumes (tens of liters). In particular it has been focus on a read-out technique based on Micro Pattern Gas Detector (MPGD) amplification of the ionisation and on the visible light collection with a sub-mm position resolution sCMOS (scientific COMS) camera. This type of readout in conjunction with a fast light detection allowed on one hand to reconstruct 3D direction of the tracks, offering accurate sensitivity to the source directionality and, on the other hand, a high particle identification capability very useful to distinguish nuclear recoils.

Today, CYGNUS_RD project from CSN5 became CYGNO from CSN2 and funded to design and realize a one cubic meter dimostrator to be assemble at the LNF and host next at LNGS. The purpose of the project was to explore the potentiality large volumes TPC to be apply in directional Dark Matter Search and detection of Coherent Scattering Neutrinos from Sun.

During 2018 the activities of the group where focused in characterize the LEMOn 7 liters 60:40 $HeCF_4$ atmospheric pressure TPC prototype [2]. The data collected at the BTF in 2017 run has been fully analyzed demonstrating very good tracking and sensitivity performance. In the same time measurements with ^{55}Fe where done to estimate the energy resolution and scale. Summarize from the triple GEM optical readout, we obtain:

- X-Y resolution around O(100 μm);
- 20%-30% precision on the evaluation of released energy already in the keV range;
- effect of electron diffusion can be exploited to determine the track depth with a 7% uncertainty;
- a diffusion of $\simeq$ 130 μm/sqrt(cm) @ 0.6 kV/cm

by the use of a PMT for a combined readout with the sCOMS camera we obtened:

- the 3D reconstruction of single clusters with O(100 μm) resolution;
- a concurrent evaluation of the event Z with 12% uncertainty;
- detection of light produced by the particle crossing to get the t0 of the event.

Moreover, PID looks to be very promising tools to lower the energy threshold and identify signal respect to background. In figure 1 a typical image collected with an AmBe neutron source is shown.

In conclusion, the CYGNUS-RD activities has been ended in 2018 has with successful and interesting results the brings the project to be considered for a PHASE-I [1] that foreseen the construction of the CYGNO demonstrator, a one cubic mater demonstrator to be design and assemble at LNF and host at the LNGS in the next future.

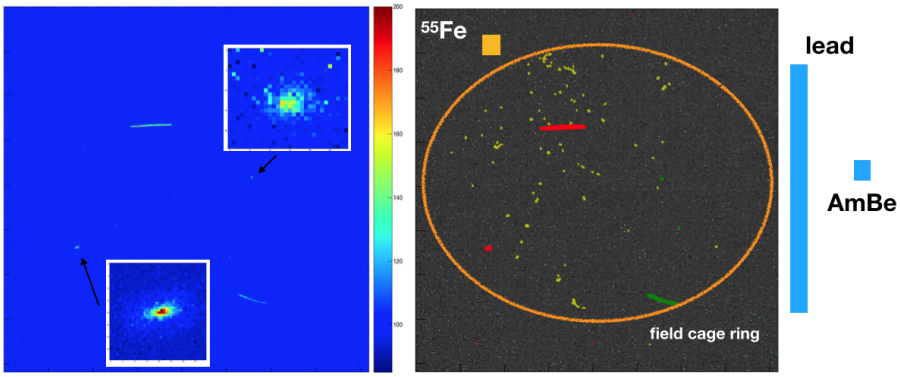

Figure 1: *L(left) example of row image collected with AmBe and ^{55}Fe sources; (left/box) a zoom of millimeters high ionizing recoil (about 105 keV and 17 keV); (right) cluster reconstruction and Particle identification - ^{55}Fe Compton electrons and radioactivity background (yellow), p (green), α (red) - by means of average photons detected per pixel.*

1 List of Conference Talks by LNF Authors in Year 2018

1. G. Mazzitelli - CYGNO: a CYGNUs Collaboration 1 m3 Module with Optical Readout for Directional Dark Matter Search, IEEE NSS/MIC 2018 Conference Proceedings, 10-17 November 2018, Sydnay, Australia `https://www.eventclass.org/contxt_ieee2018/online-program/session?s=NSS-WS2+I#e1668`
2. G. Mazzitelli - MPGD Optical Read Out for Directional Dark Matter Search, IEEE NSS/MIC 2018 Conference Proceedings, 10-17 November 2018, Sydnay, Australia `https://www.eventclass.org/contxt_ieee2018/online-program/session?s=N-45#e326`

2 List of Publications signed by LNF Authors in Year 2018

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. G. Mazzitelli *et al.*, MPGD Optical Read Out for Directional Dark Matter Search, Conference Record of 2018 IEEE NSS/MIC/RTSD [arXiv:1901.04192 [physics.ins-det]].
3. D. Pinci *et al.*, Cygnus: development of a high resolution TPC for rare events, PoS EPS **-HEP2017** (2017) 077. doi:10.22323/1.314.0077
4. Baracchini, E. and Cavoto, G. and Mazzitelli, G. and Murtas, F. and Renga, F. and Tomassini, S.", Negative Ion Time Projection Chamber operation with SF_6 at nearly atmospheric pressure, JINST (2018), 13,P04022, doi: 10.1088/1748-0221/13/04/P04022
5. V. C. Antochi *et al.*, "Combined readout of a triple-GEM detector," JINST **13** (2018) no.05, P05001 doi:10.1088/1748-0221/13/05/P05001 [arXiv:1803.06860 [physics.ins-det]].
6. D. Pinci, E. Baracchini, G. Cavoto, E. Di Marco, M. Marafini, G. Mazzitelli, F. Renga, S. Tomassini, C. Voena, High resolution TPC based on optically readout GEM, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2018, ISSN 0168-9002,https://doi.org/10.1016/j.nima.2018.11.085.