

THE CYGNO EXPERIMENT, A

DIRECTIONAL DETECTOR FOR DIRECT DARK

MATTER SEARCHES

G. Dho on behalf of CYGNO coll.

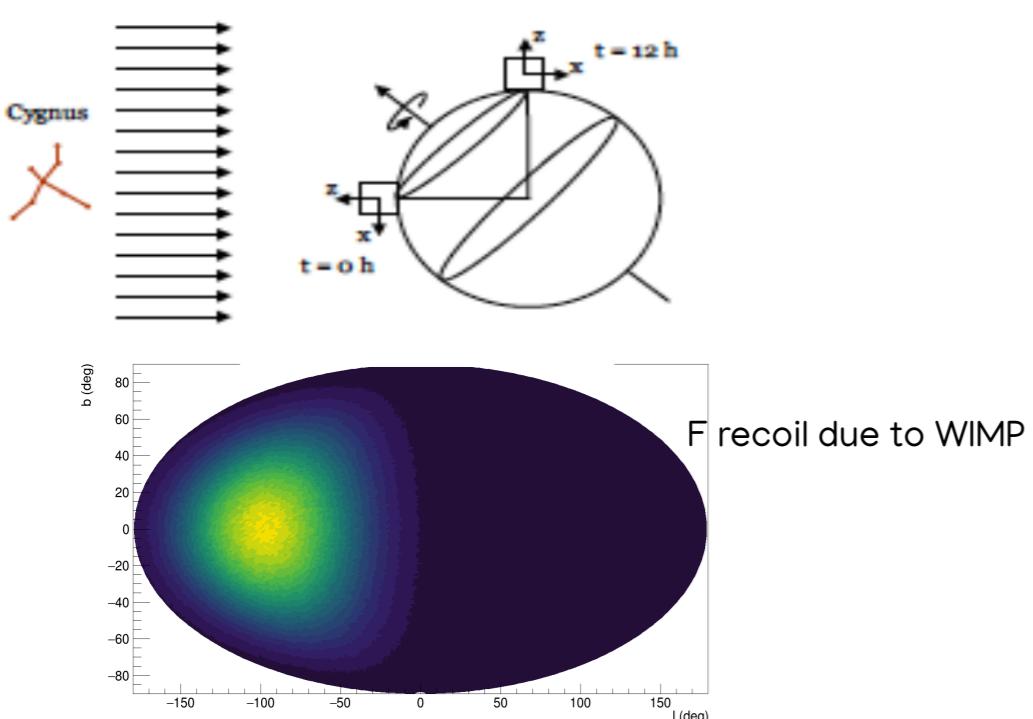
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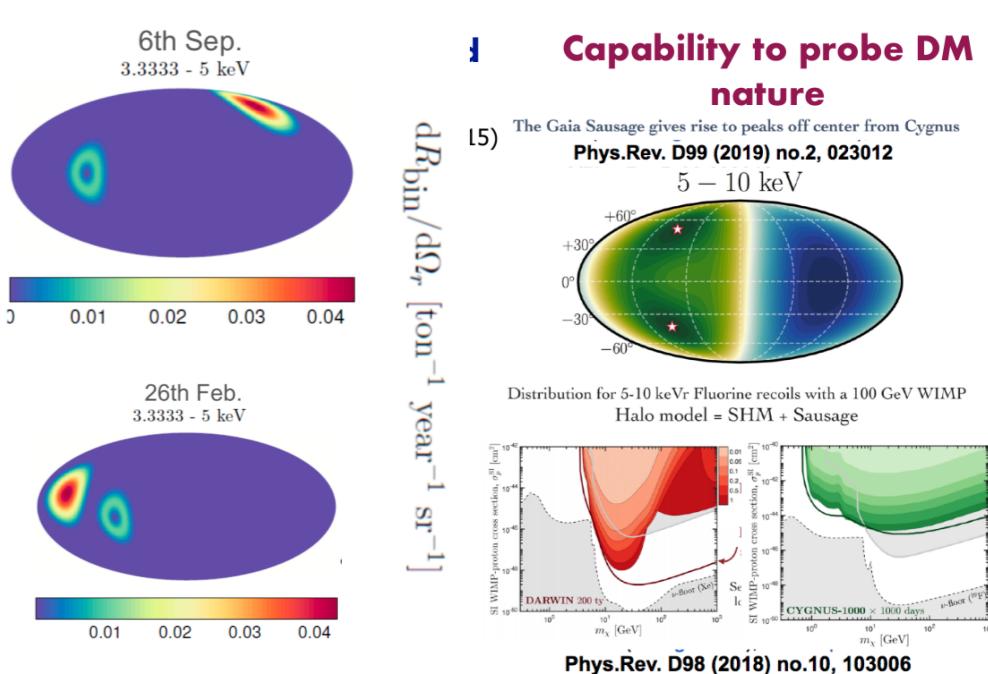
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F. Amaro, E. Baracchini, L. Benussi, S. Bianco, C. Capoccia, M. Caponero, G. Cavoto, I. A. Costa, E. Dané, E. Di Marco, G. D'Imperio, G. Dho, F. Di Giambattista, R. R. M. Gregorio, F. Iacoangeli, A. S. L. Júnior, H. P. L. Júnior, G. Maccarrone, R. D. P. Mano, M. Marafini, G. Mazzitelli, A.G. McLean, A. Messina, C. M. B. Monteiro, R. A. Nobrega, I. Pains, E. Paoletti, L. Passamonti, S. Pelosi, F. Petrucci, S. Piacentini, D. Piccolo, D. Pierluigi, D. Pinci, A. Prajapati, F. Renga, R. J. C. Roque, F. Rosatelli, A. Russo, J. M. F. dos Santos, G. Saviano, N. Spooner, R. Tesauro, S. Tomassini, S. Torelli

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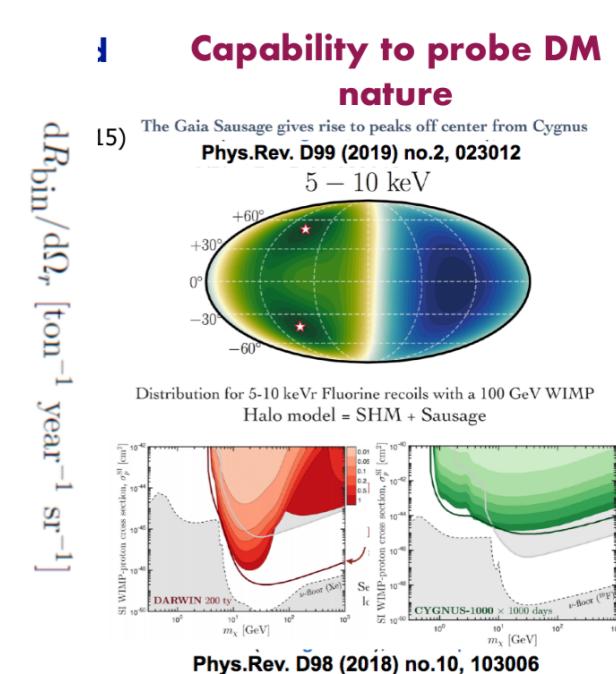


- Our Galaxy is believed to reside in a halo of Dark Matter (DM)
- The motion of the Earth together with the Sun produces an apparent wind of DM particles.
- DM of about $1\text{--}10 \text{ GeV}/c^2$ can induce nuclear recoils of light elements of few keV
- The angular distribution will have a clear dipole structure, key for positive identification of DM, fundamental for discrimination vs neutrinos and DM astronomy



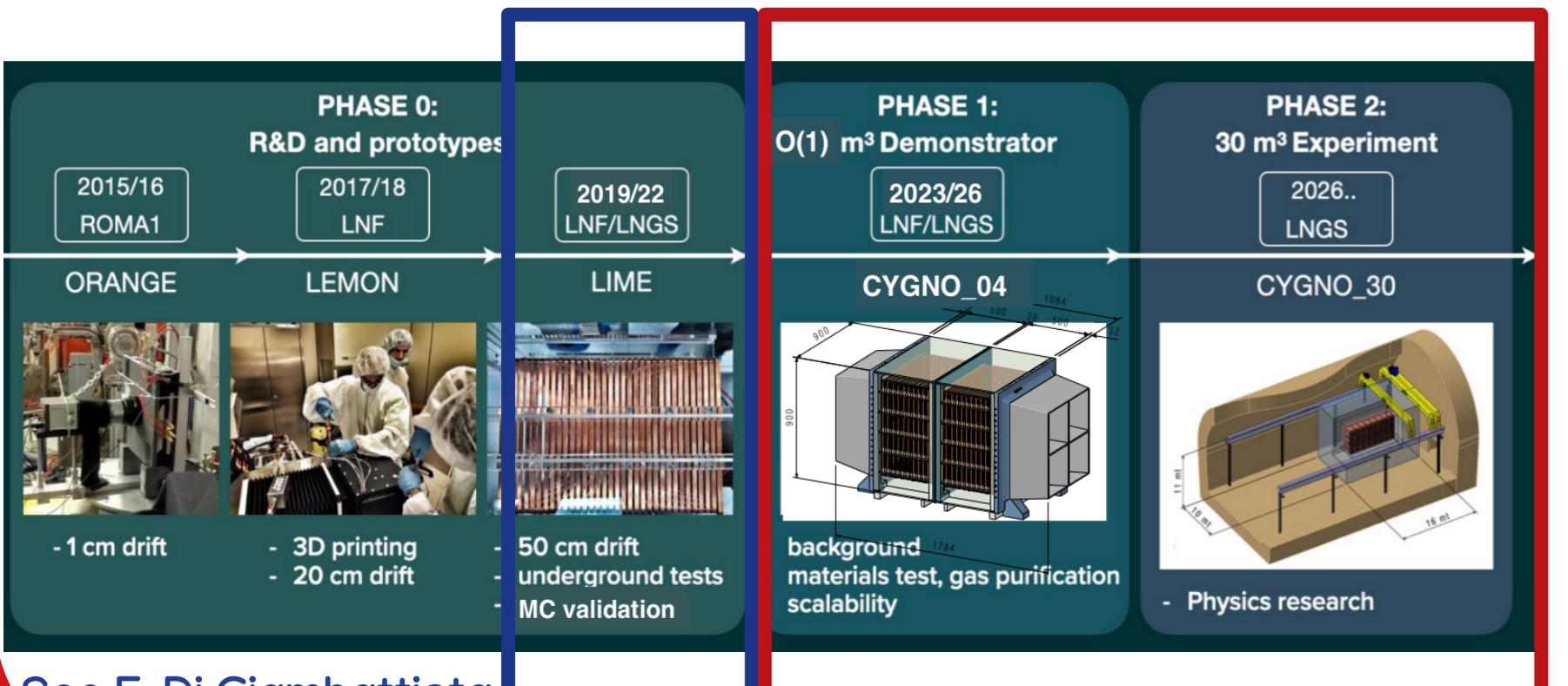
- Physics Reports Volume 627, 20 April 2016, Pages 1–49

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- F. Mayet et al., Phys. Rept. 627 (2016)

Gaseous TPC based detector



See F. Di Giambattista poster today

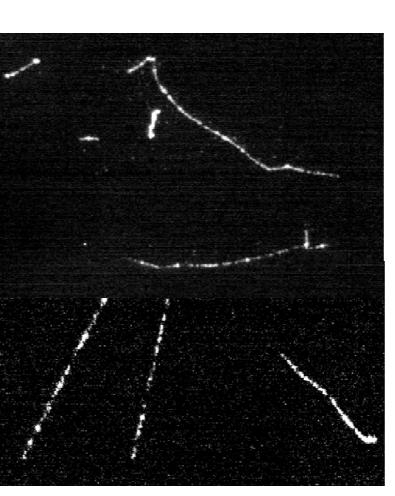
Future

OPTICAL READOUT

- Operated at atmospheric pressure and room temperature
- Gas mixture of He:CF_4 (60/40)
- Nice match of CF_4 emission and the sCMOS camera sensitivity
- 3D reconstruction with combined use of the camera and PMTs

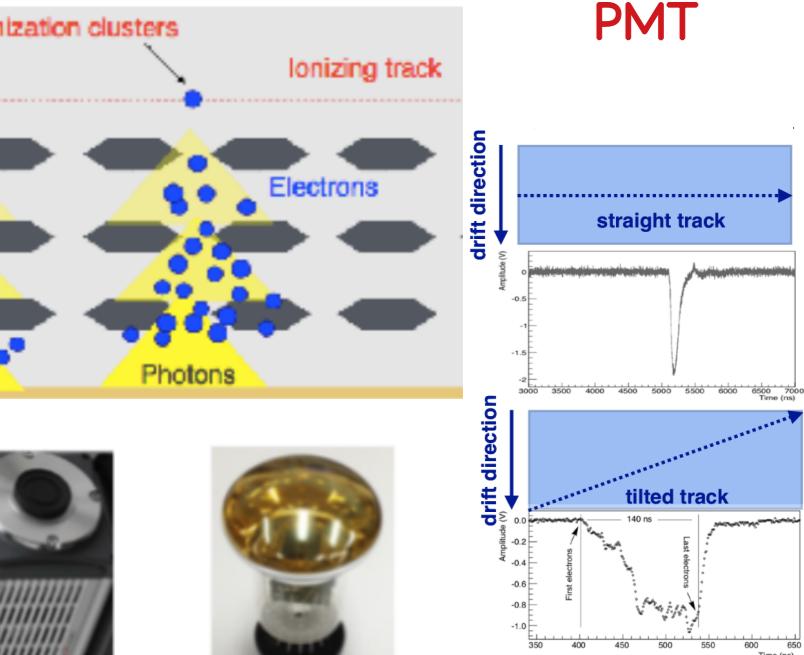
sCMOS camera

- Single photon sensitivity
- High granularity (2304x2304 pixels)



Energy x-y coordinate

Triple Gas Electron Multiplier stack

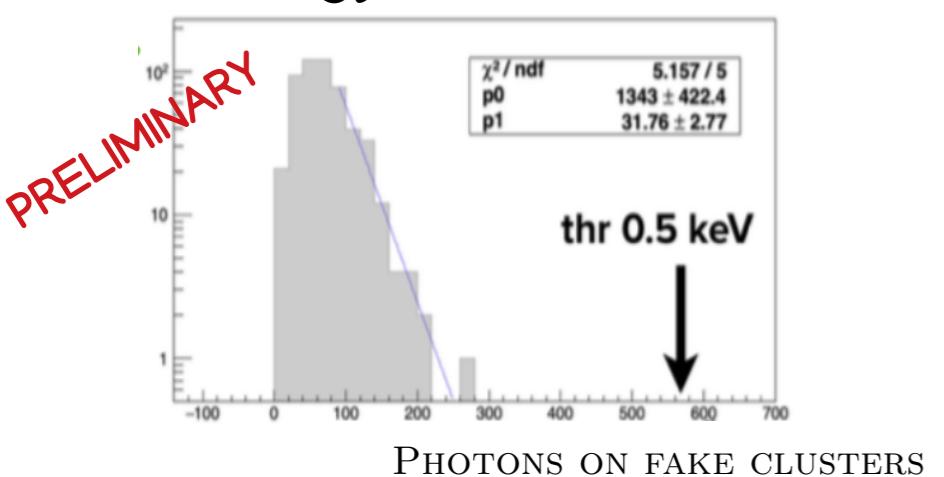


PMT
Full 3D reconstruction

Energy z coordinate

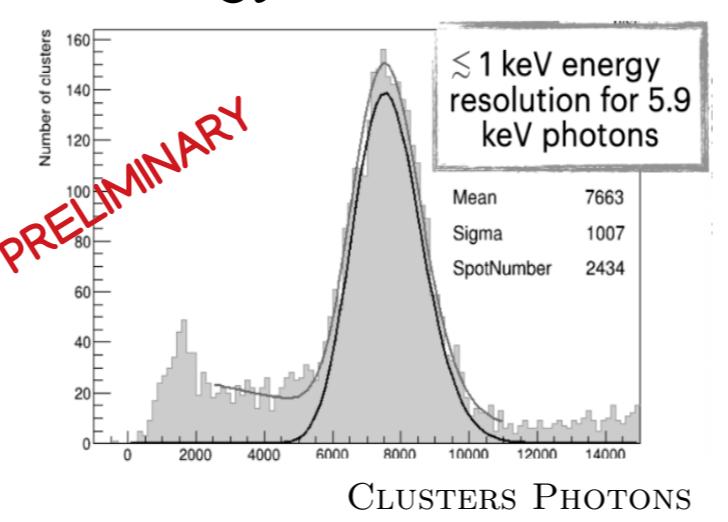
Experimental Results

Energy Threshold



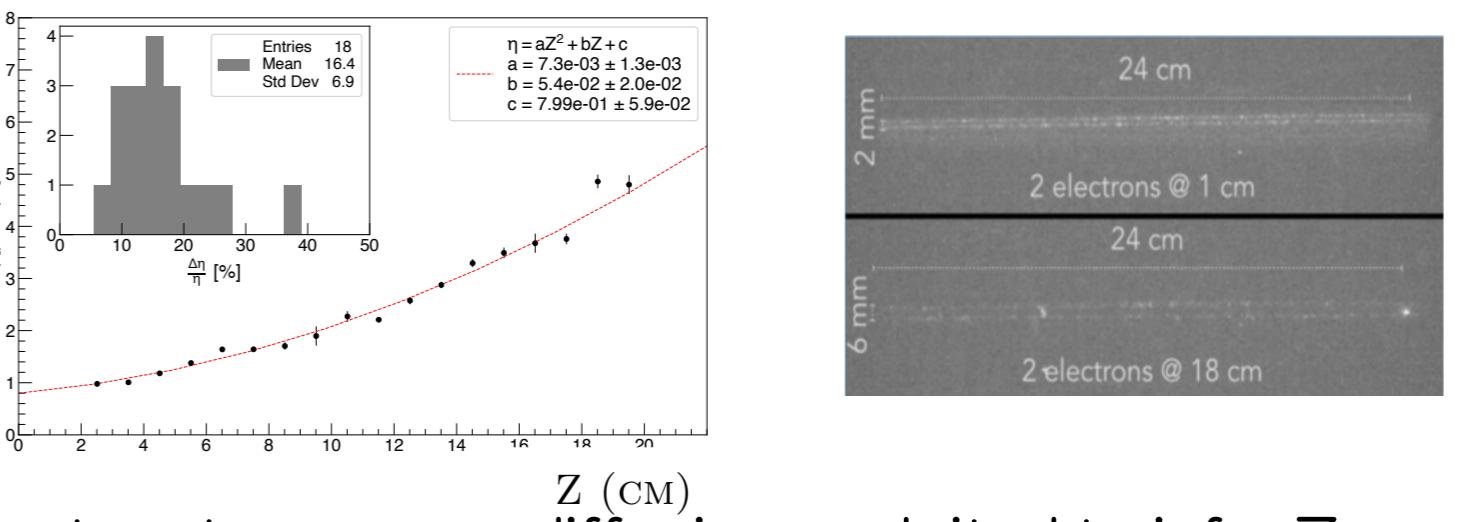
- Clusters found due to electronic noise:
- Clusters containing >600 photons (0.5 keV) are less than 10 per year
- Energy threshold assumed 0.5 keV_{ee}

Energy Response



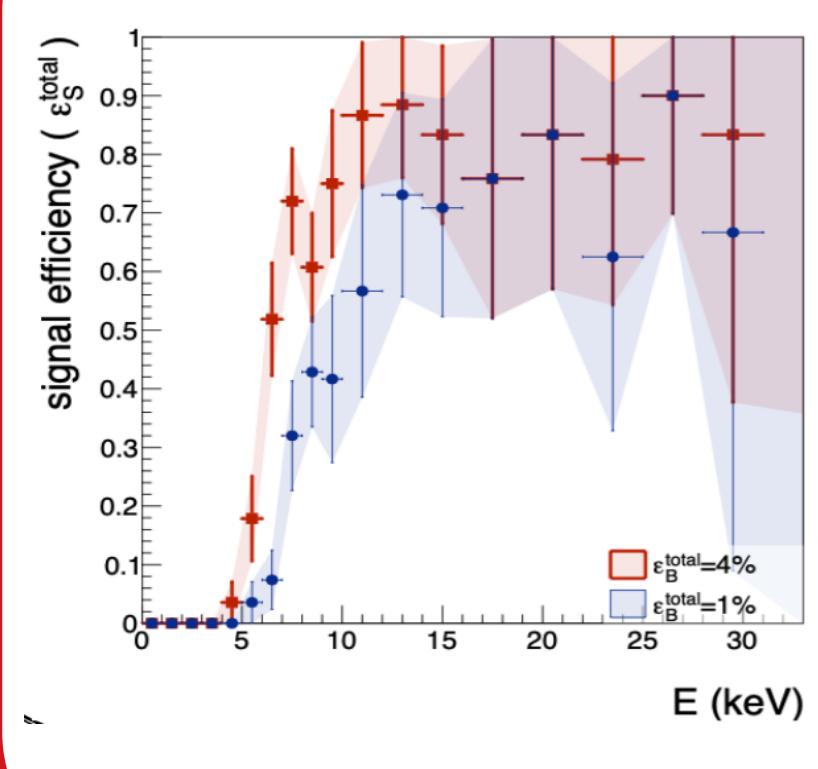
- Roughly 1200 ph/keV
- $\sim 15\%$ energy resolution @ 5.9 keV

Z-fiducialization



- Electron transverse diffusion exploited to infer Z coord.
- Track transverse light profile measured to have gaussian shape growing with Z
- Under study the method using a PMT

ER/NR discrimination



E. Baracchini et al., Measur. Sci. Tech., 32 (2021) 2, 025902

- Signal (NR) efficiency as a function of the energy, with bgk efficiency @ 5.9 keV set at 1% and 4%
- 50%(40%) efficiency on signal 96.5%(99.2%) bkg rejection
- Discrimination based on clusters light density
- Efficiency can improve by using a multivariate approach for NR identification and CNN

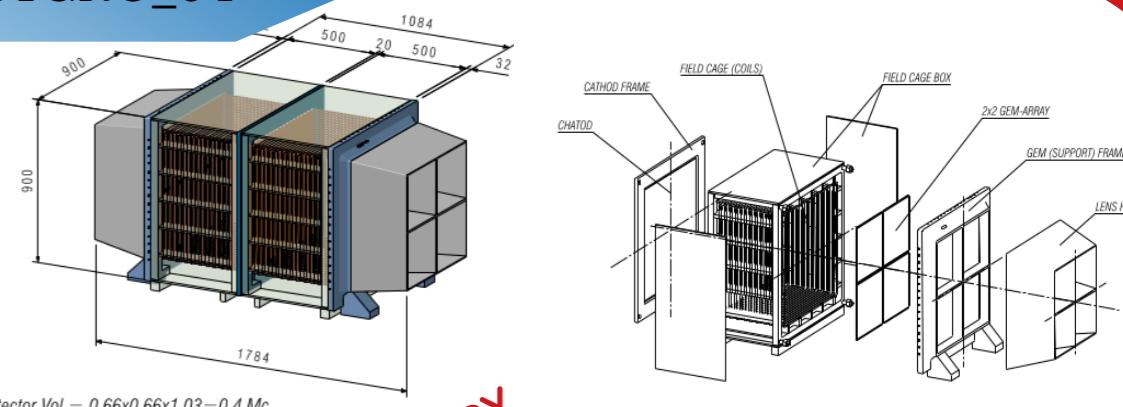
Designing started

Made by 4x4 modules equivalent to LIME to prove scalability

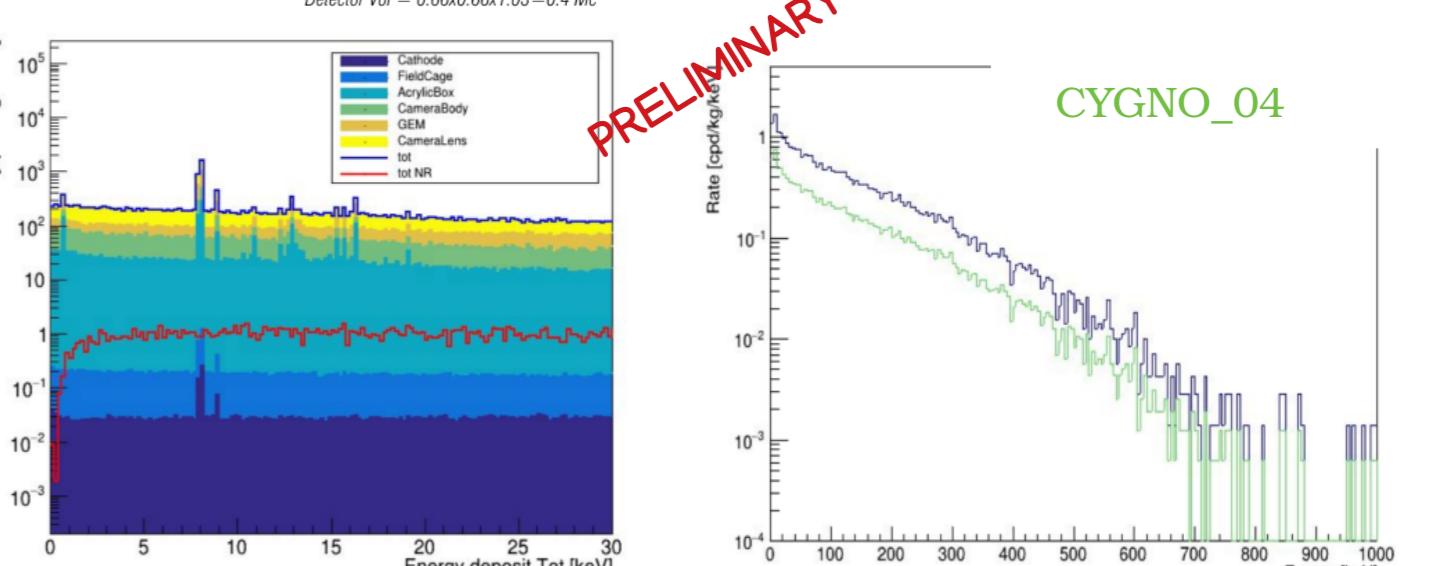
Background studies

- Shielding of 110 cm water +10 cm Cu
- Relevant background from internal sources
- Internal NR mostly from GEMs

Near Future: CYGNO_04



Internal ER background



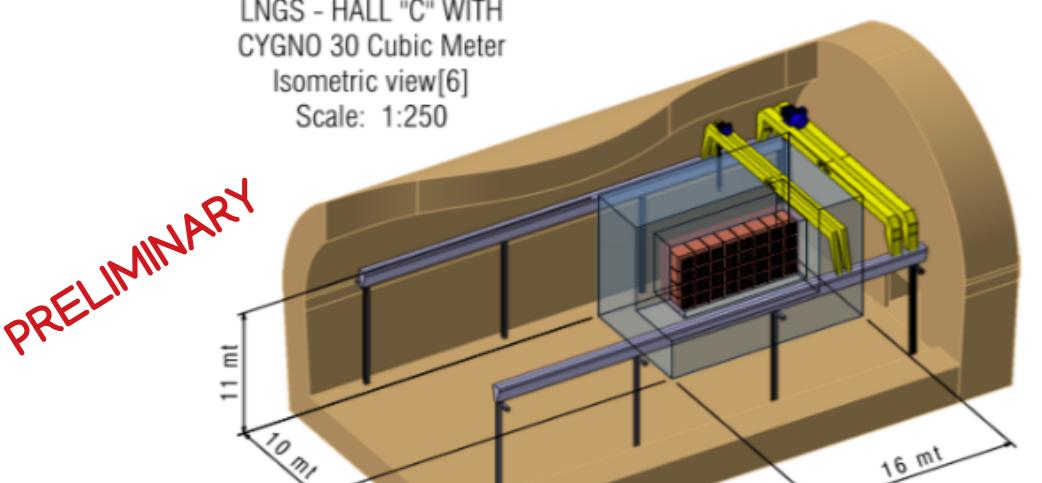
Total external background

Large volume detector

- For actual physics search
- Limits obtained with Bayesian technique

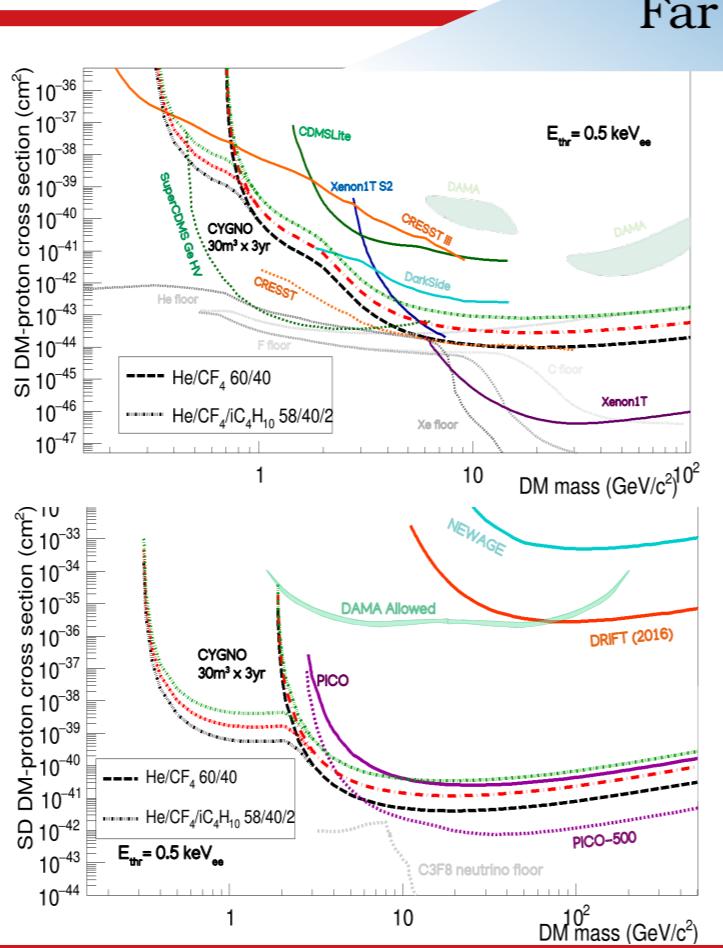
LNGS - HALL "C" WITH CYGNO 30 Cubic Meter Isometric view[6]

Scale: 1:250



- Lowering DM mass sensitivity with lighter element

See R. Roque poster tomorrow



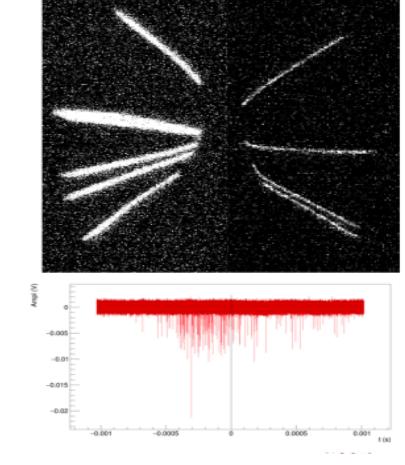
F. Amaro et al., Instruments, 6 (2022) 103390/instruments6010006

R&D
TOWARDS
FUTURE

- Improving signal formation
 - Negative Ion Drift
 - Electroluminescence

- Lowering internal radioactivity (lens, GEMs...)

	Minimum detectable DM mass for 0.5 keV_{ee} energy threshold	Minimum detectable DM mass for 1 keV_{ee} energy threshold
H	$300 \text{ MeV}/c^2$	$500 \text{ MeV}/c^2$
He	$700 \text{ MeV}/c^2$	$1 \text{ GeV}/c^2$
C	$1.4 \text{ GeV}/c^2$	$1.9 \text{ GeV}/c^2$
F	$1.9 \text{ GeV}/c^2$	$2.5 \text{ GeV}/c^2$



PRELIMINARY