

# CdS Roma Tre Discussione dei preventivi



F. Petrucci

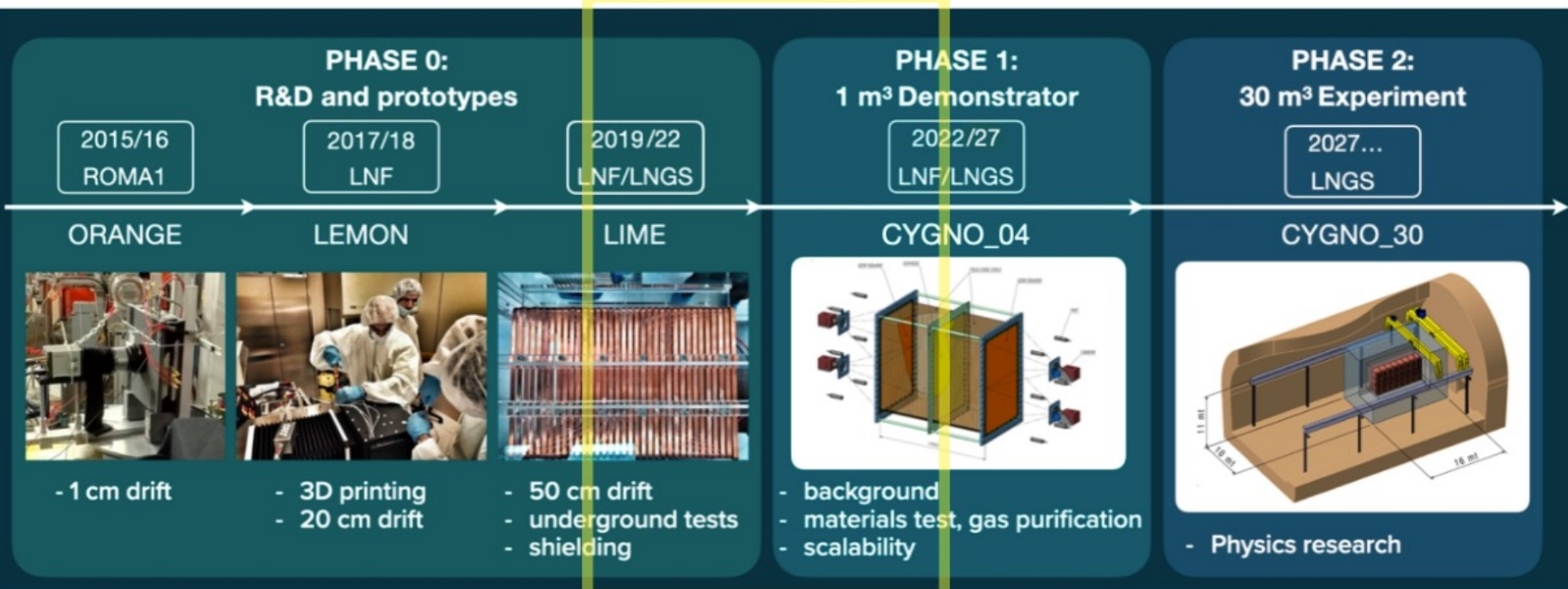


The University  
Of Sheffield.



European Research Council  
Established by the European Commission

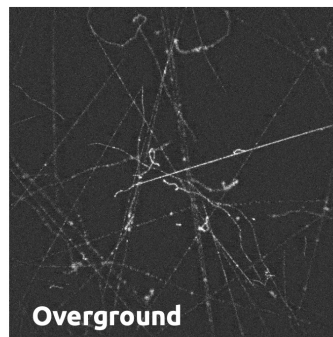
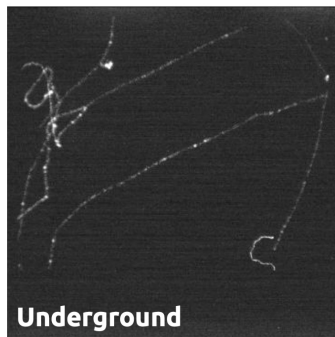
# The CYGNO roadmap



# LIME underground@LNGS

LIME installed underground at National Laboratories of Gran Sasso (3600 m.w.e.) early in 2022:

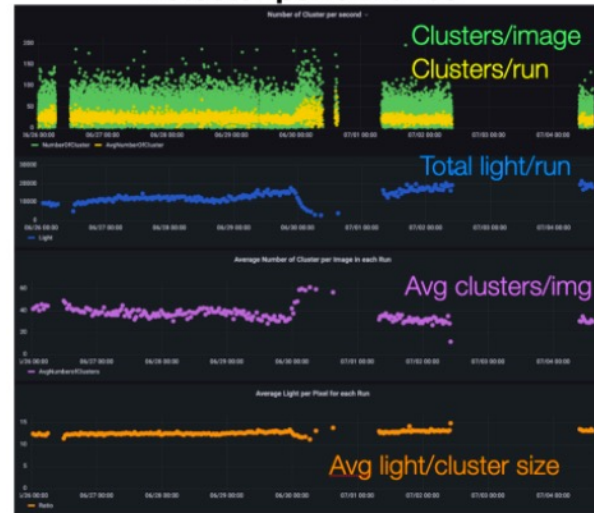
- Automated system allows to control remotely the gas system, environmental sensors, HV, and data acquisition system allowing a continuous data taking → stability tests;
- Data underground (different shielding configurations) are being analysed to be compared with MC simulations.



## Gas and environmental parameters



## Detector performance



# Lime background studies

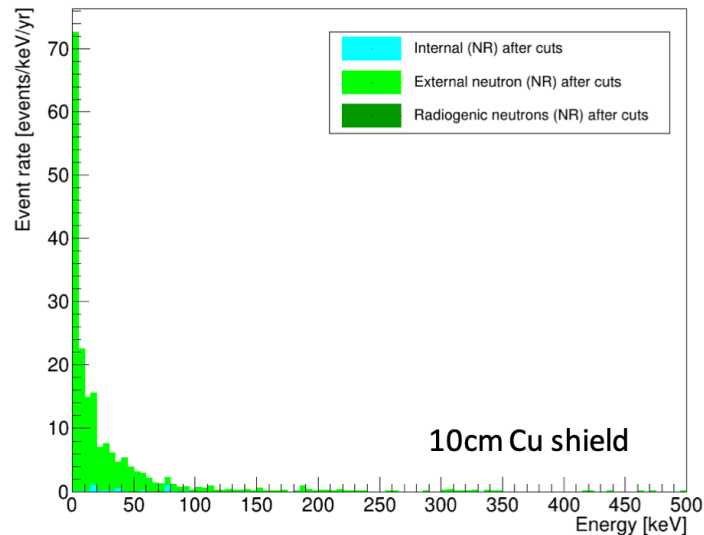
Aiming at the characterization of the background in different phases:

- **No external shielding**: external background measurement
- **Copper shielding (10 cm)**: reduced external gamma background → neutron background measurement
- **Water tanks (40 cm) + copper shielding**:
  - Internal background measurement
  - Final test in low background and low pile up conditions

## Neutron flux measurement.

After fiducial cuts (next slide):

- **772 NR/yr** from neutrons (+16 NR/yr from other sources) above 1 keV
- **316 NR/yr** from neutrons (+11 NR/yr from other sources) above 20 keV

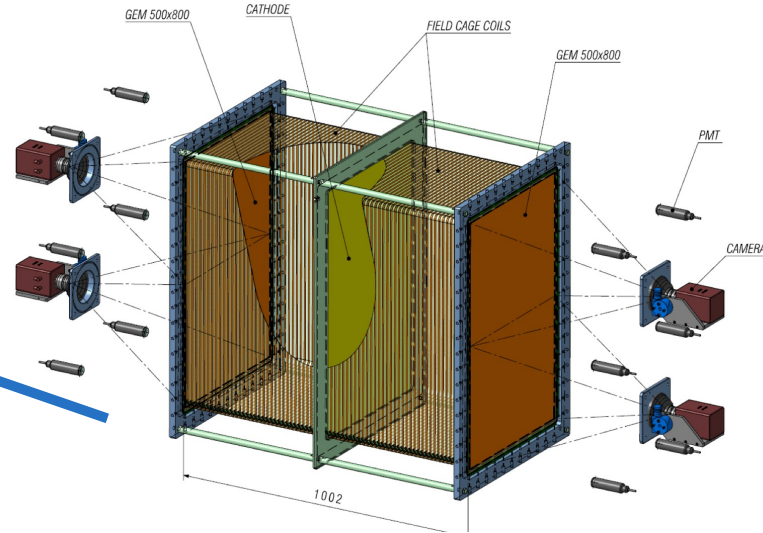
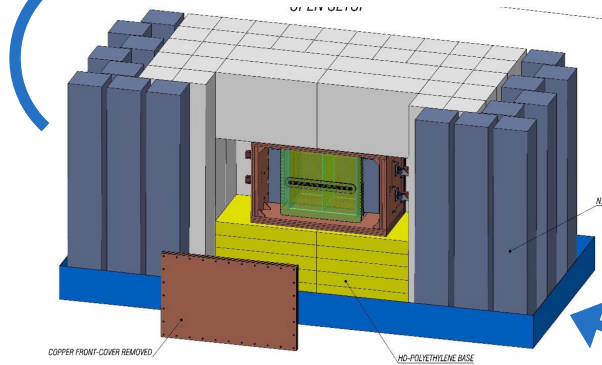
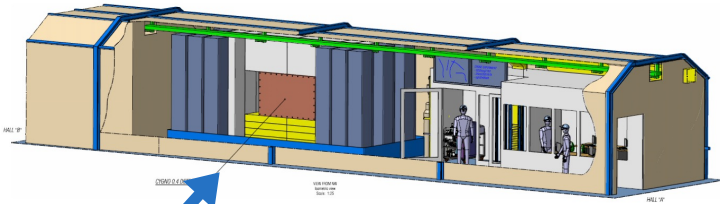




# The CYGNO\_04 demonstrator

## Phase 1 - CYGNO\_04: Funded and TDR ready!

- 0.4 m<sup>3</sup> detector in LNGS hall F
- 50 x 80 X 100 cm<sup>3</sup> volume
- Common cathode
- Readout by 4 sCMOS and 12 PMTs
- Demonstrate the full scalability of the technique

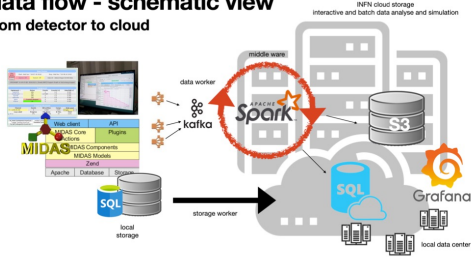


### Internal background reduction:

Building low radioactivity camera sensors, lens and windows (Suprasil, PMMA, polycarbonate)

# Attività del gruppo

## data flow - schematic view from detector to cloud

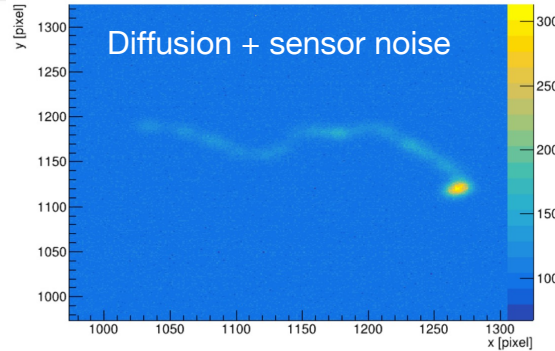
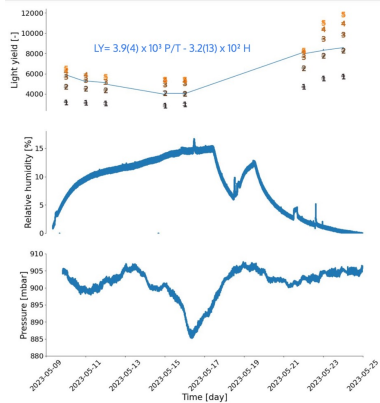
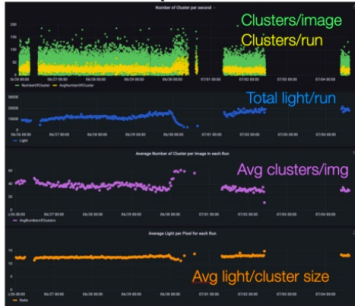


- Simulazione/Digitizzazione (Fabrizio, Pietro)
- Ricostruzione (Igor, Pietro)
- Slow control (Rita)
- “Middleware” (Igor)
- Detector stability (Rita, Fabrizio)

### Gas and environmental parameters



### Detector performance

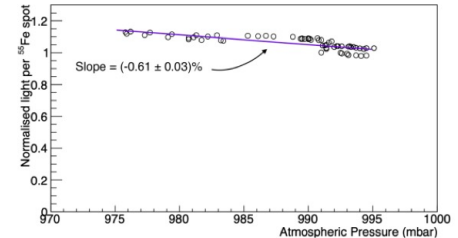


Run Status			
Run #14	Start: Wed Jun 8 16:33:52 2022	Running time: 0h00m47s	
Running	Alarms: On	Restart: Sequencer	Data dir: /data01/data/
Stop	Pause		
1654698833 16:33:53.343 2022/06/08 [Sequencer,INFO] Run #914 started			

Equipment				
Equipment #	Status	Events	Events/(s)	Data[MB/s]
Trigger	cygnus_dag@localhost	5	0.2	2.243
CATHODE	Ok	1	0.0	0.000
GasSystem	Ok	1	0.0	0.000
HV	Ok	1	0.0	0.000
Environment	Partially disabled	0	0.0	0.000

Logging Channels				
Channel	Events	MB written	Compr.	Disk Level
#0: run00914.mid.gz	10	23.593	36.9%	7.6%
Lazy Label	Progress	File Name	# Files	Total

Clients			
mhtp@localhost	cygnus_dag@localhost	Logger@localhost	
Sequencer@localhost	SC Frontend@localhost	db_producer_v0.1@localhost	



# Papers & Talks

F.Petrucci chair of the Cygno publication committee

## **Publications Submitted (since July last year):**

- *Noise assessment of CMOS Active Pixel sensors for the CYGNO Experiment*, E.Baracchini et al, Meas. Sci. Technol.
- *Directional DBSCAN to detect cosmic-ray tracks for the CYGNO experiment*, E.Baracchini et al, Meas. Sci. Technol.
- *A 50 liter Cygno prototype overground characterization*, E.Baracchini et al, Meas. Sci. Technol

## **Presentations at conferences (18 since July last year):**

- F. Petrucci: *The CYGNO Experiment: A Directional Dark Matter Detector with Optical Readout*, MPGD 2022
- I. A. Costa: *INFN-Cloud solution for CYGNO computational model*, IEEE 2022
- R. Antonietti: *Directional dark matter searches with CYGNO experiment*, SIF 2022
- P. Meloni: IFAE 2022

## Gruppo (2.4 FTE):

- Fabrizio 0.4
- ~~Igor Abritta Costa 0.5 (Post Doc)~~
- Rita Antonietti 1 (Ph.D)
- Pietro Meloni 1 (Ph.D)

## Missioni:

- 3 kE for (expert) shifts @LNGS

## Richieste servizi:

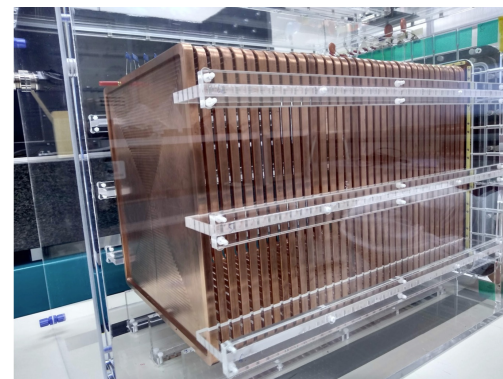
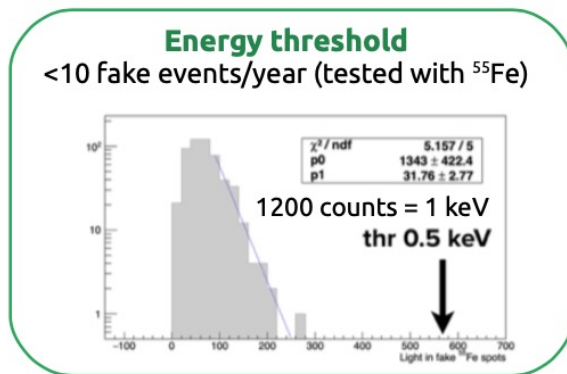
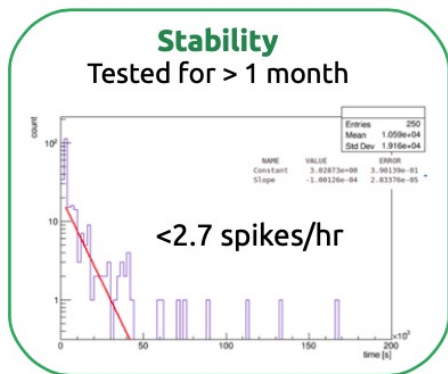
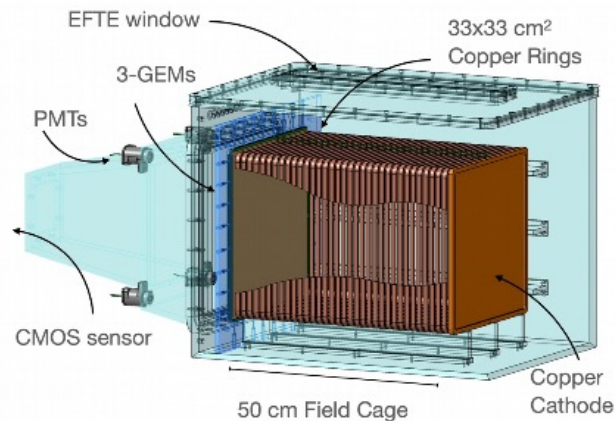
- Calcolo 1 m.u.



# BACKUP MATERIAL

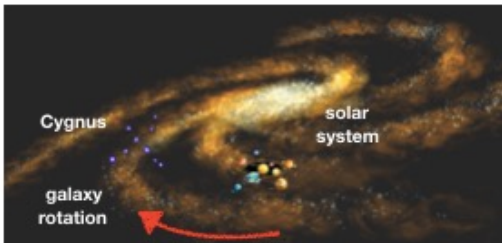
# The Long Imaging Module - LIME

- Our largest prototype: 50L sensitive volume
  - 33x33 cm<sup>2</sup> thin (50 μm) GEMs, 50 cm drift;
- Optical readout:
  - 4 PMTs at the corners;
  - 1 sCMOS camera (Hamamatsu ORCA Fusion);
  - 2304×2304 pixels, low noise (1 ph/pixel), high granularity  
160×160 μm<sup>2</sup>, 2 counts/photon;
- Operated for few months @INFN LNF.



# DM detection and directionality

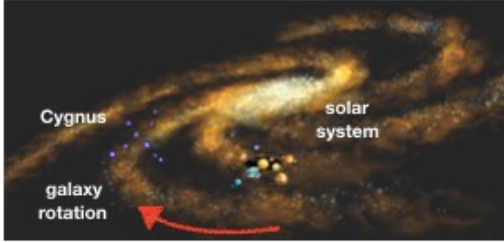
WIMP flux  
( $\langle v \rangle \sim 220 \text{ km/s}$ )



# DM detection and directionality

WIMP flux  
 $\langle v \rangle \sim 220 \text{ km/s}$

few % DM flux  
 annual  
 modulation

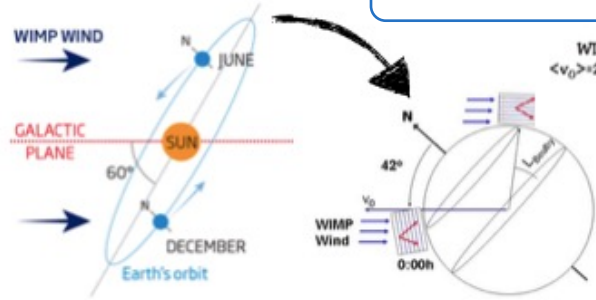
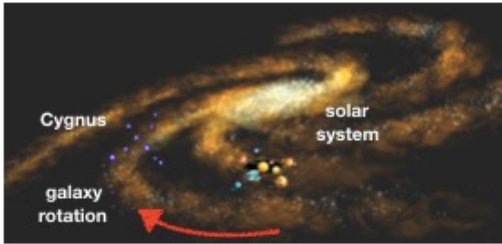


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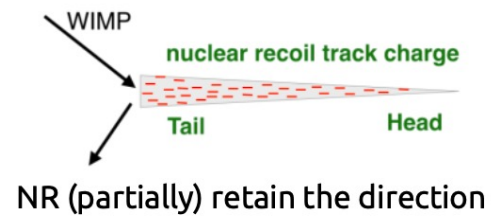
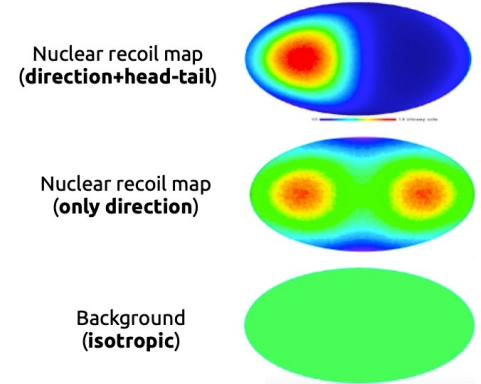
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few % DM flux  
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 modulation

- anisotropy in the angular distribution of nuclear recoils;
- no background can mimic it.



A. M. Green et. al, Astropart. Phys. 27 (2007) 142



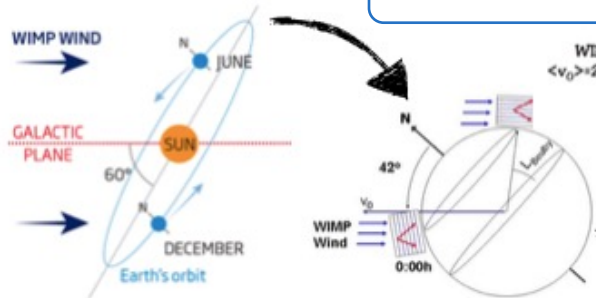
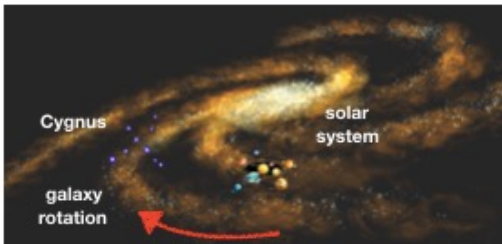


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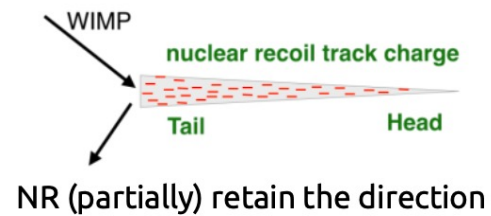
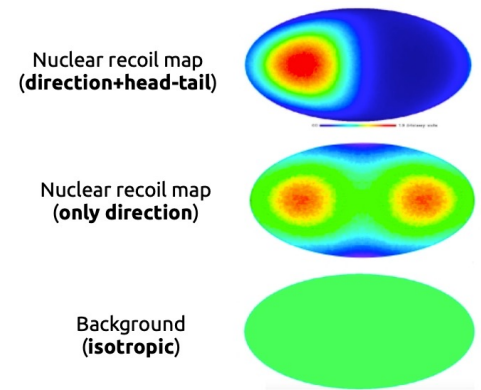
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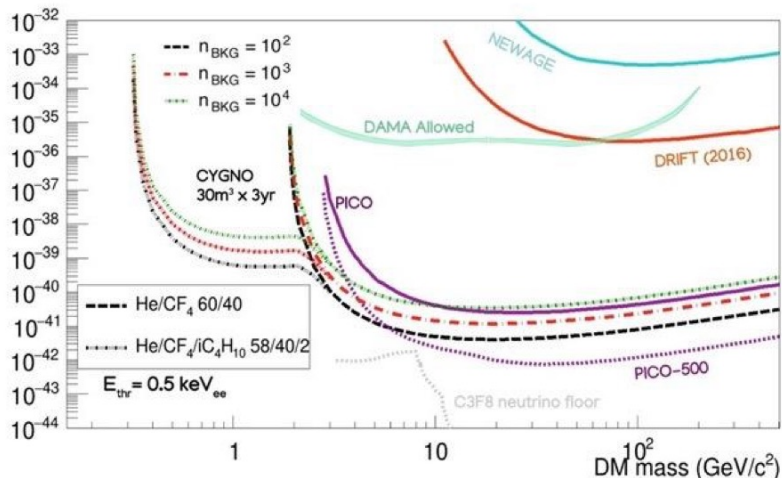


**Directional discrimination** is the only way to:

- unambiguously identify a DM signal
- Searching beyond the neutrino floor
- Moreover:
  - Properties of the solar neutrino flux;
  - DM halo properties (DM astronomy).

# DM searches with CYGNO

## Spin Dependent



### To observe light (<10 GeV/c<sup>2</sup>) WIMPs:

- Less energy transferred to the recoiling nucleus  
→ lower the detectable signal threshold
- Exploit light target nuclei to maximize energy transfer.

### Gas mixture

**Helium:** light target for low mass WIMPs

**Fluorine:**

- Heavier target for intermediate masses
- Sensitive to SD couplings

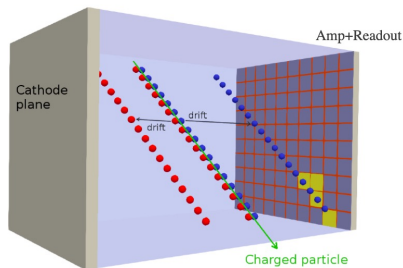
**Low density** (atmospheric pressure)

- Allows several mm tracks at few keV
- Direction and energy deposit topology

# The CYGNO technique *(in 1 slide...)*

A TPC with He/CF<sub>4</sub> at atmospheric pressure:

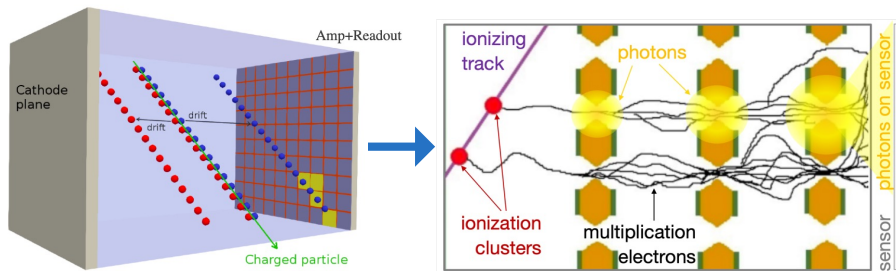
- Primary ionization electrons are transported by the drift field and multiplied by a 3-GEM stack.



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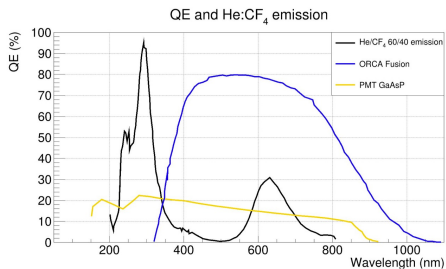
sCMOS



PMT



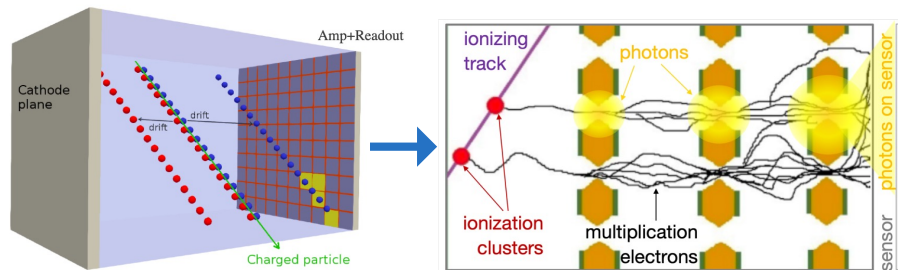
Light produced by the de-excitation of the gas molecules during electron multiplication; significant yield at the camera's QE peak.



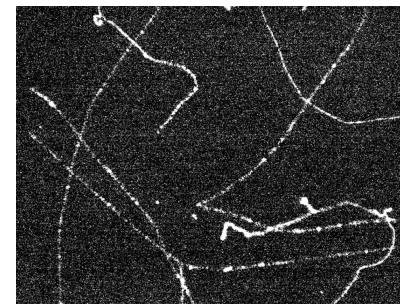
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A TPC with He/CF<sub>4</sub> at atmospheric pressure:

- Primary ionization electrons are transported by the drift field and multiplied by a 3-GEM stack.



- X-Y position in the GEM plane
- Energy deposition topology:
  - Direction;
  - Head-tail asymmetry;
  - Background rejection.



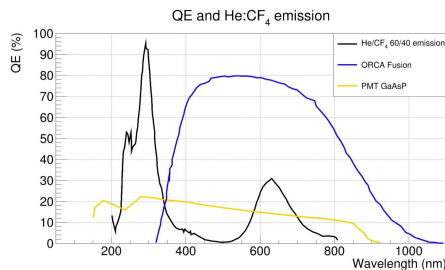
sCMOS



PMT



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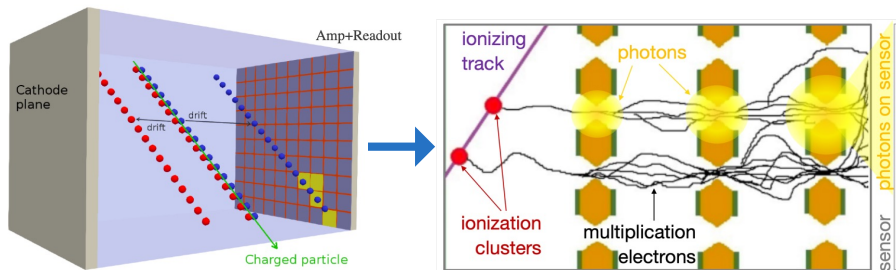




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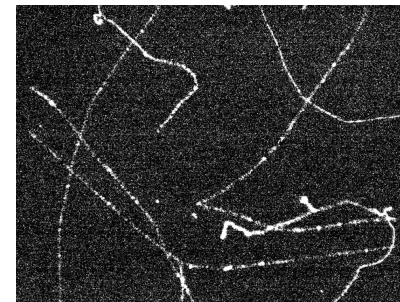
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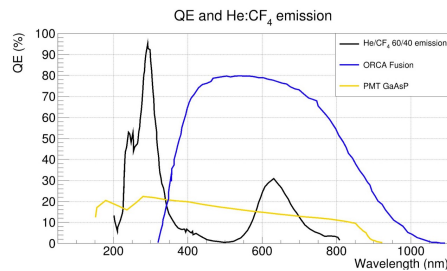


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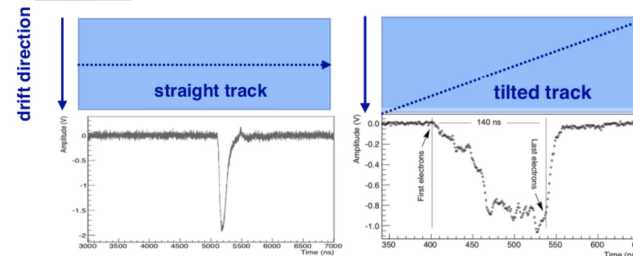
Light produced by the de-excitation of the gas molecules during electron multiplication; significant yield at the camera's QE peak.



PMT



- Integrated energy
- Ionization electron's time of arrival  
→ track tilt (dZ)



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