

# The CYGNO experiment for Dark Matter direct detection

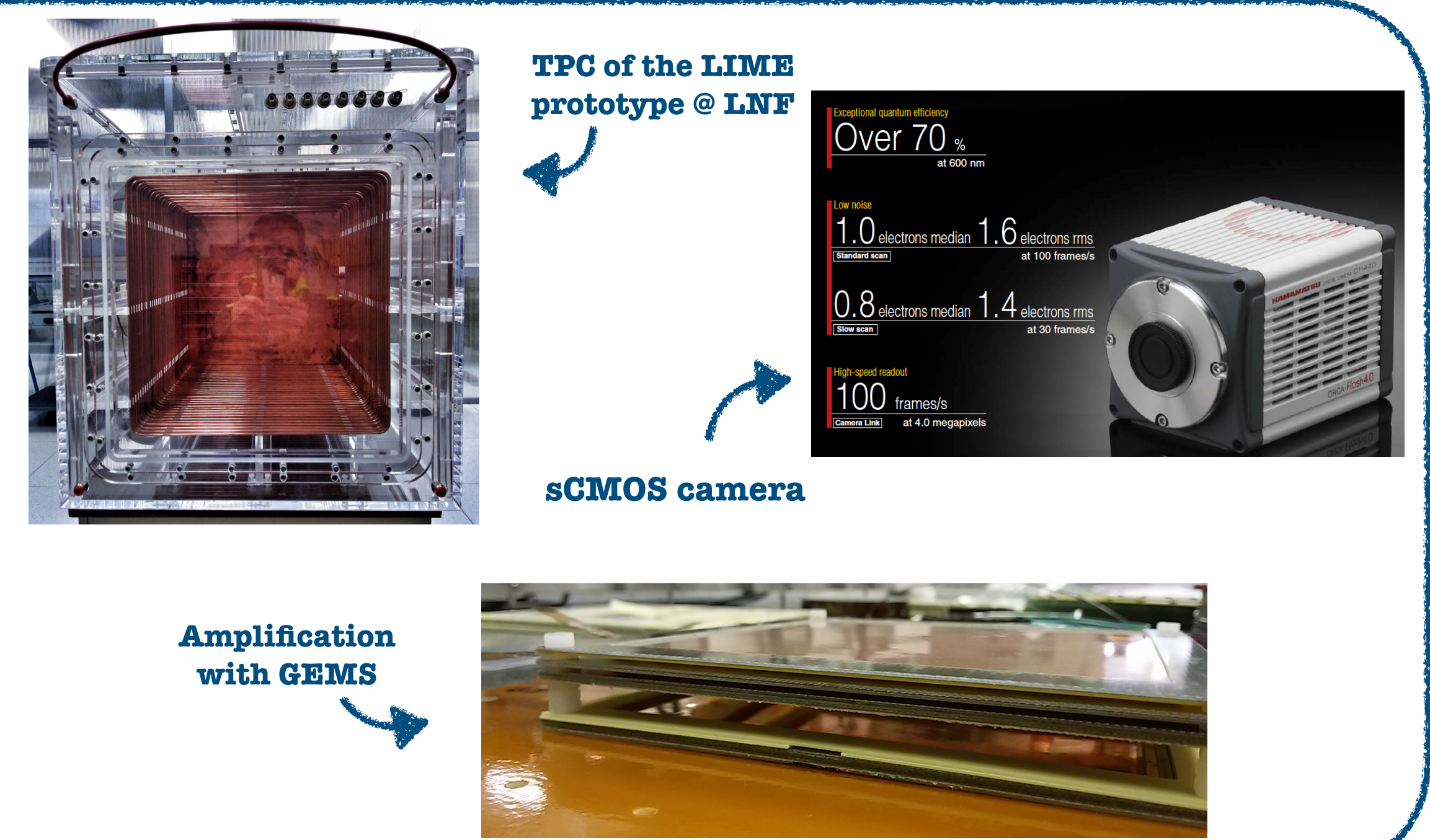
Stefano Piacentini - Sapienza Università di Roma & INFN Roma1  
on behalf of:

## The CYGNO Collaboration:

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## The CYGNO project

- Aiming at** a large detector for high precision **3D tracking of rare low energy nuclear recoils (keV)** as for example WIMPs.
- Experimental challenges:** rate O(evt/kg/day), background rejection, and energy threshold (keV)
- Strategy:** **photograph nuclear recoil** in a (1 atm) He:CF<sub>4</sub> TPC with a GEM amplification stage
  - 3D tracking: position, direction and fiducialization
  - total released energy, dE/dx (head/tail)
  - optical sensors:** high granularity, very low noise, and high sensitivity
  - optical coupling:** sensors outside the sensitive volume, acquire large surfaces with small sensors



**TPC of the LIME prototype @ LNF**


**sCMOS camera**

**Amplification with GEMS**

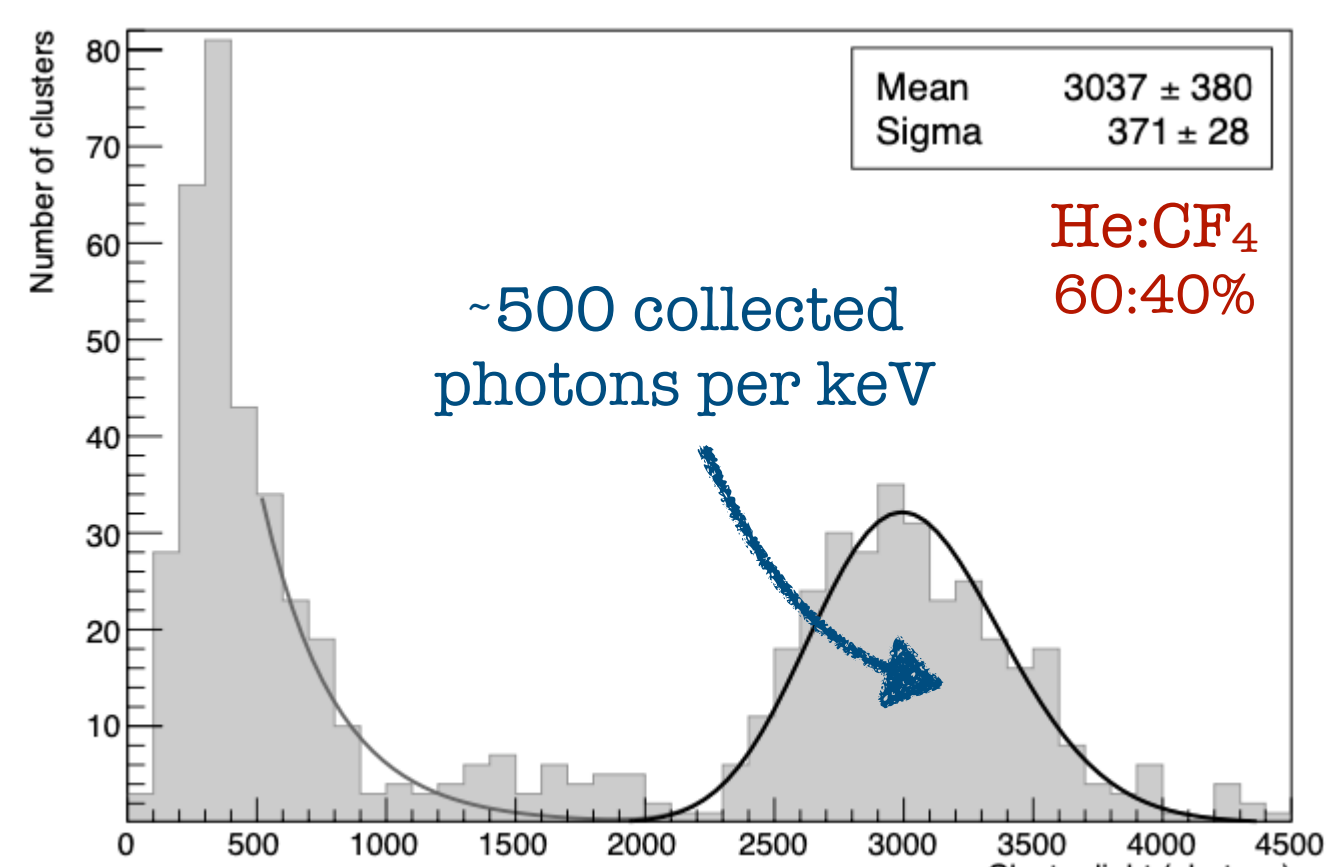
Over 70%  
1.0 electrons median 1.6 electrons rms at 100 frames  
0.8 electrons median 1.4 electrons rms at 50 frames  
100 frames at 4.8 megapixels

### Energy resolution

**55Fe X-ray signal**

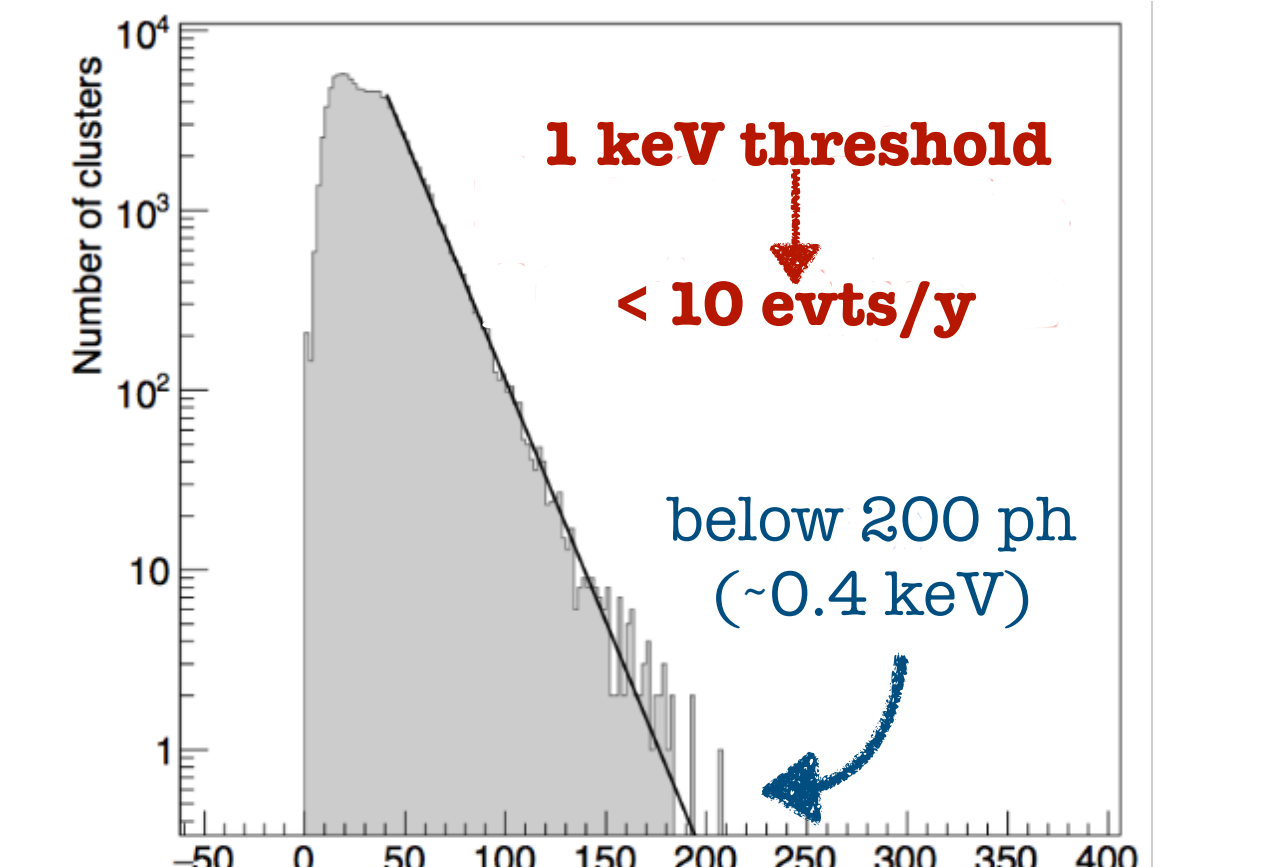


**Energy resolution**



Mean 3037 ± 380  
Sigma 371 ± 28  
He:CF<sub>4</sub> 60:40%  
~500 collected photons per keV

**sCMOS sensor noise**

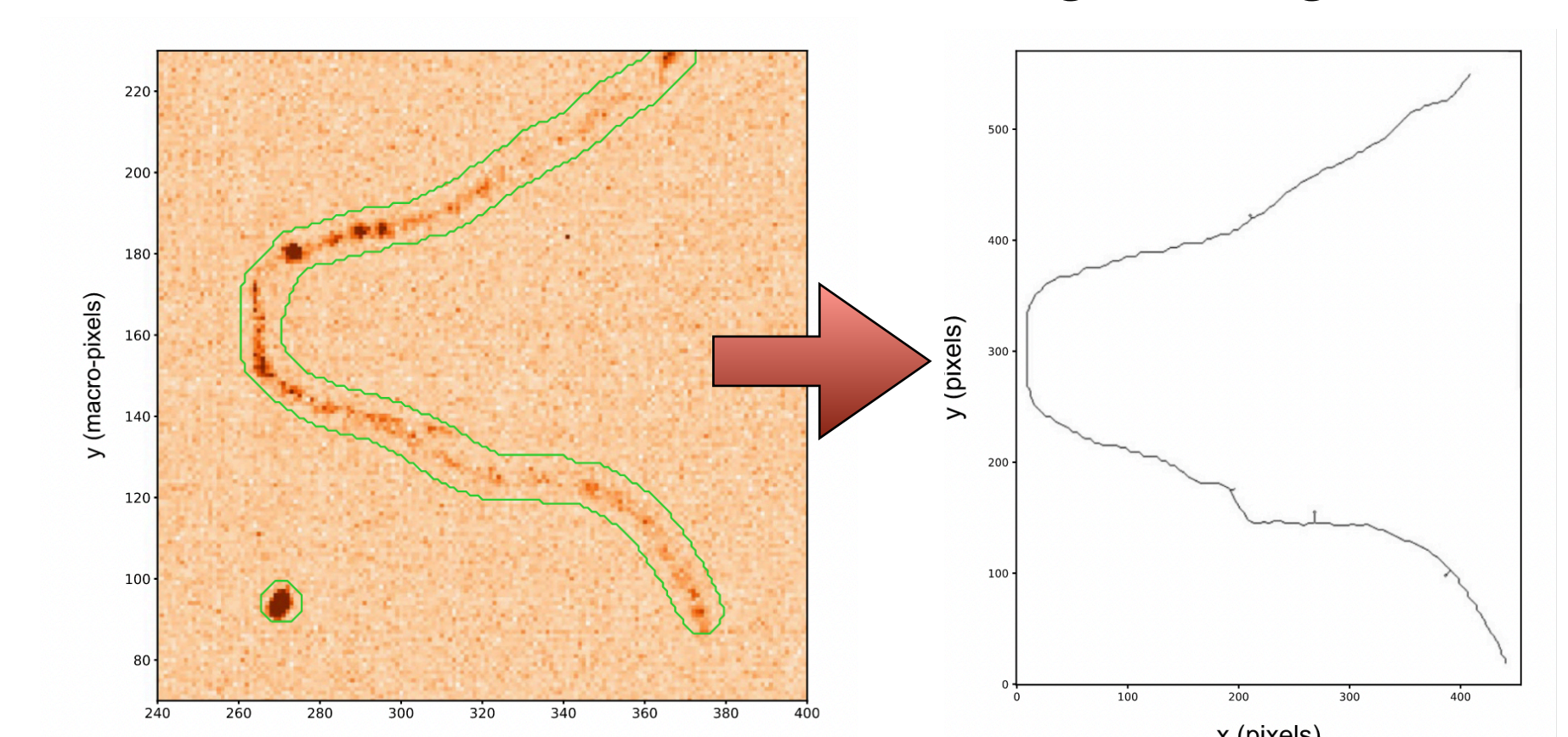


1 keV threshold  
< 10 evts/y  
below 200 ph (~0.4 keV)

Energy resolution of **15% at 5.9 keV<sub>ee</sub>** with both sCMOS and PMT

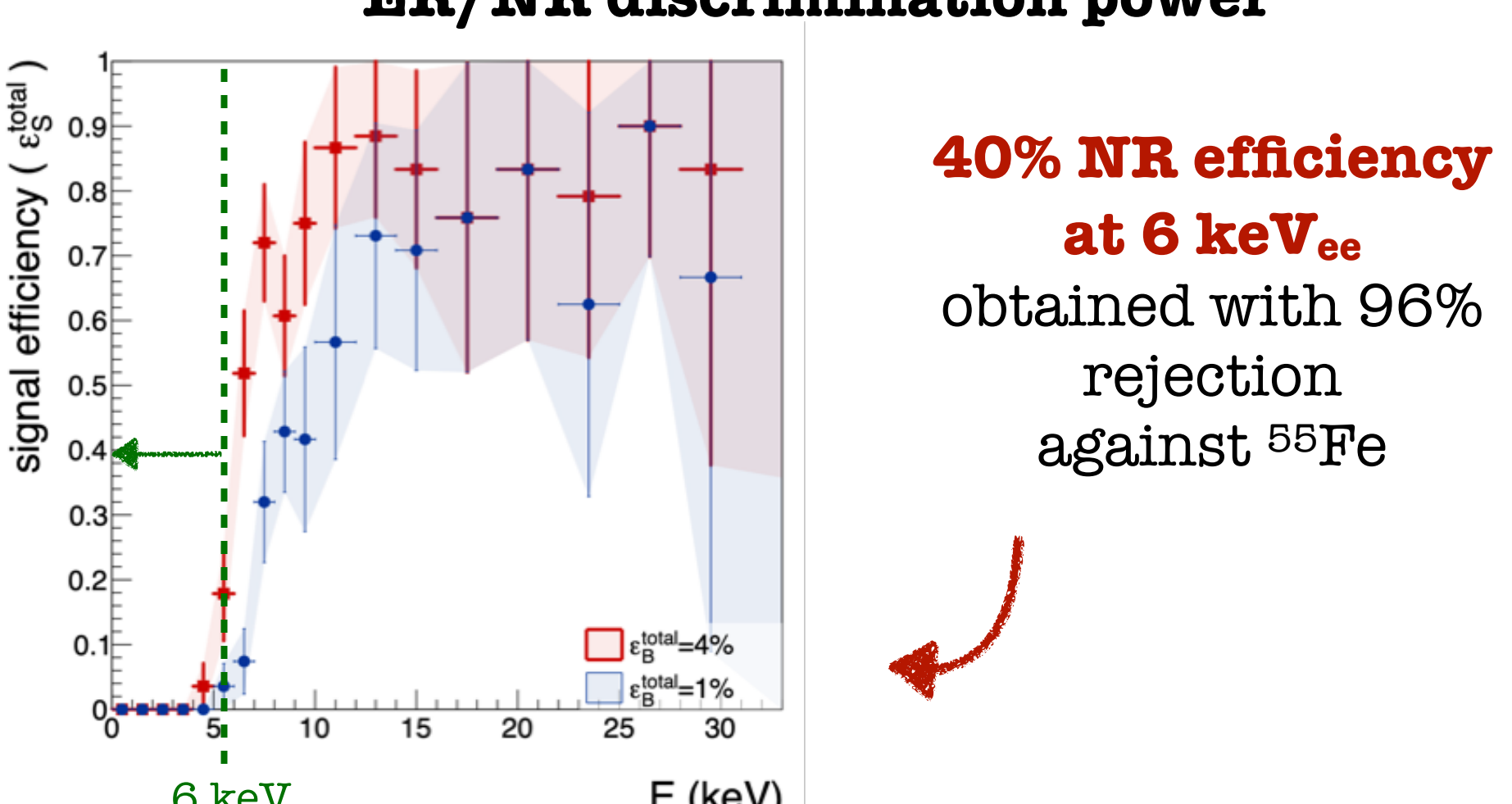
### Reconstruction efficiency

**Multiple DBSCAN + GAC\* pattern recognition algorithm**



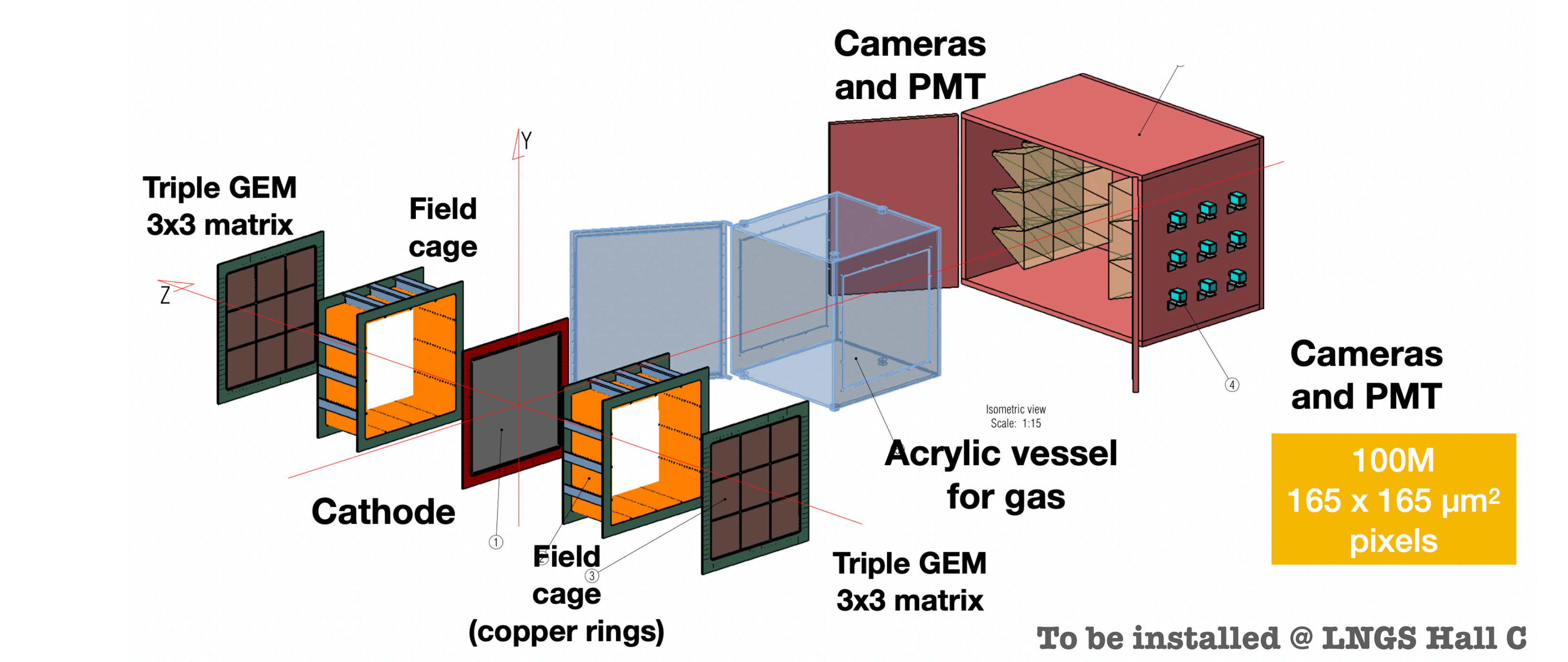
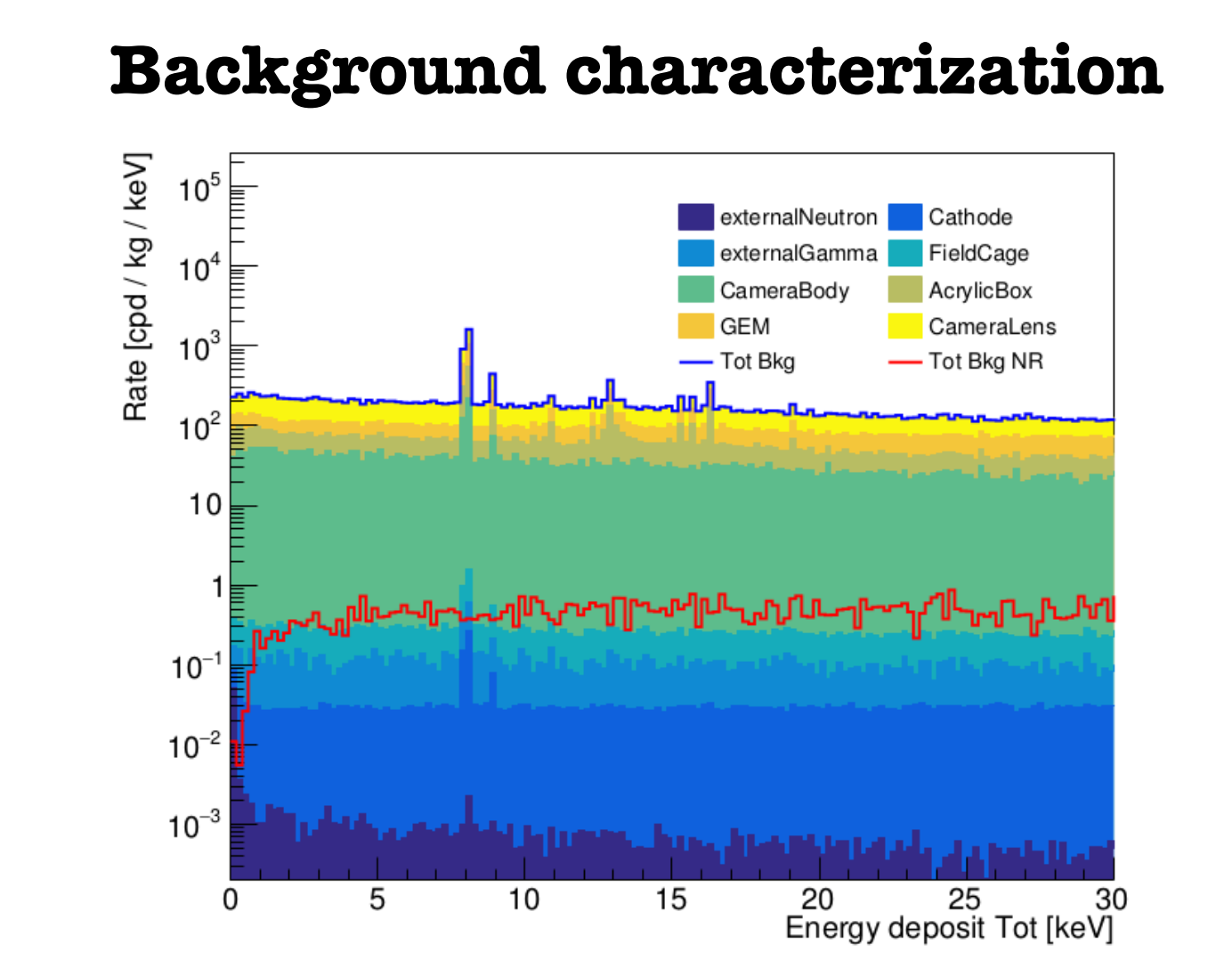
\* Geodesic Active Contour

**ER/NR discrimination power**

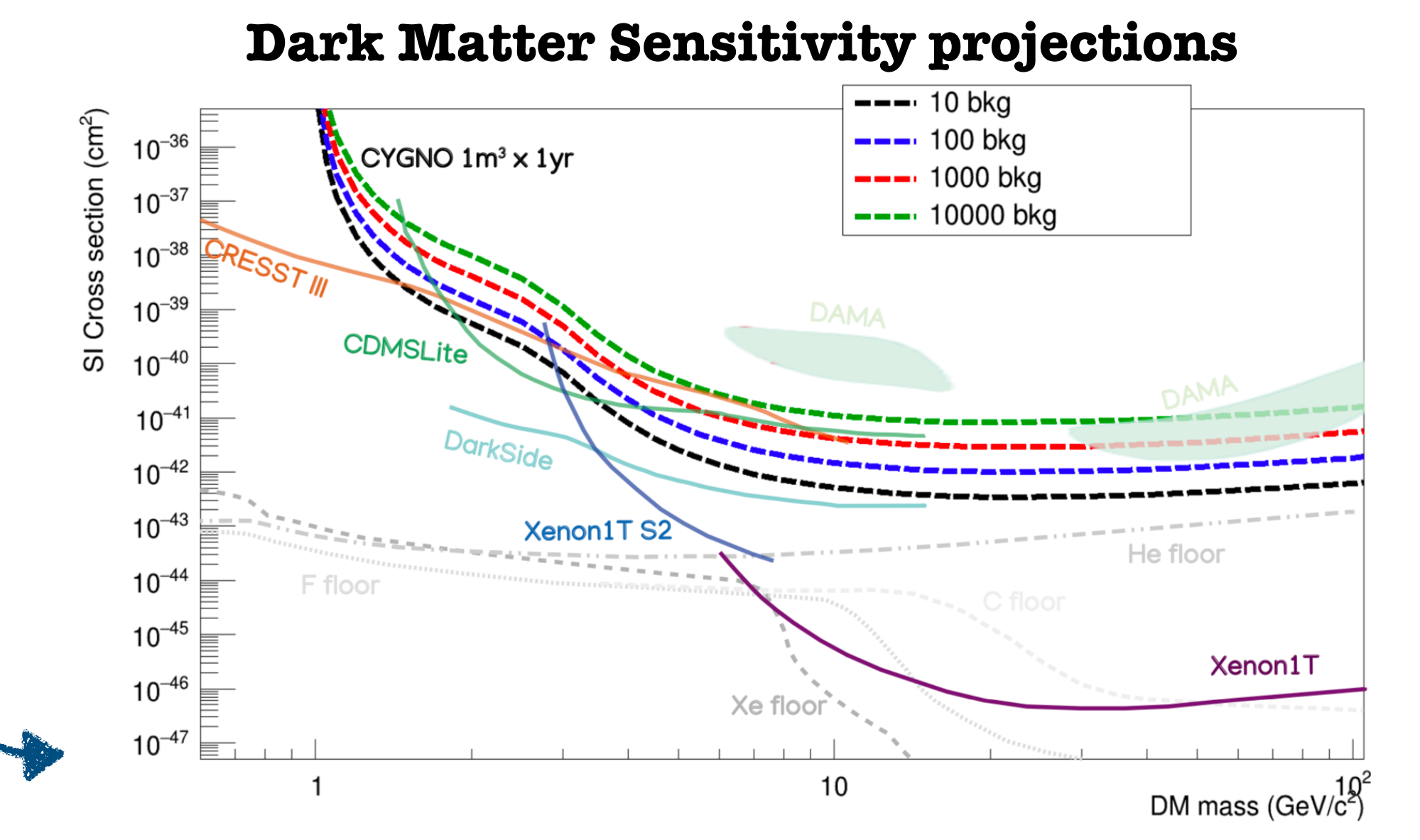
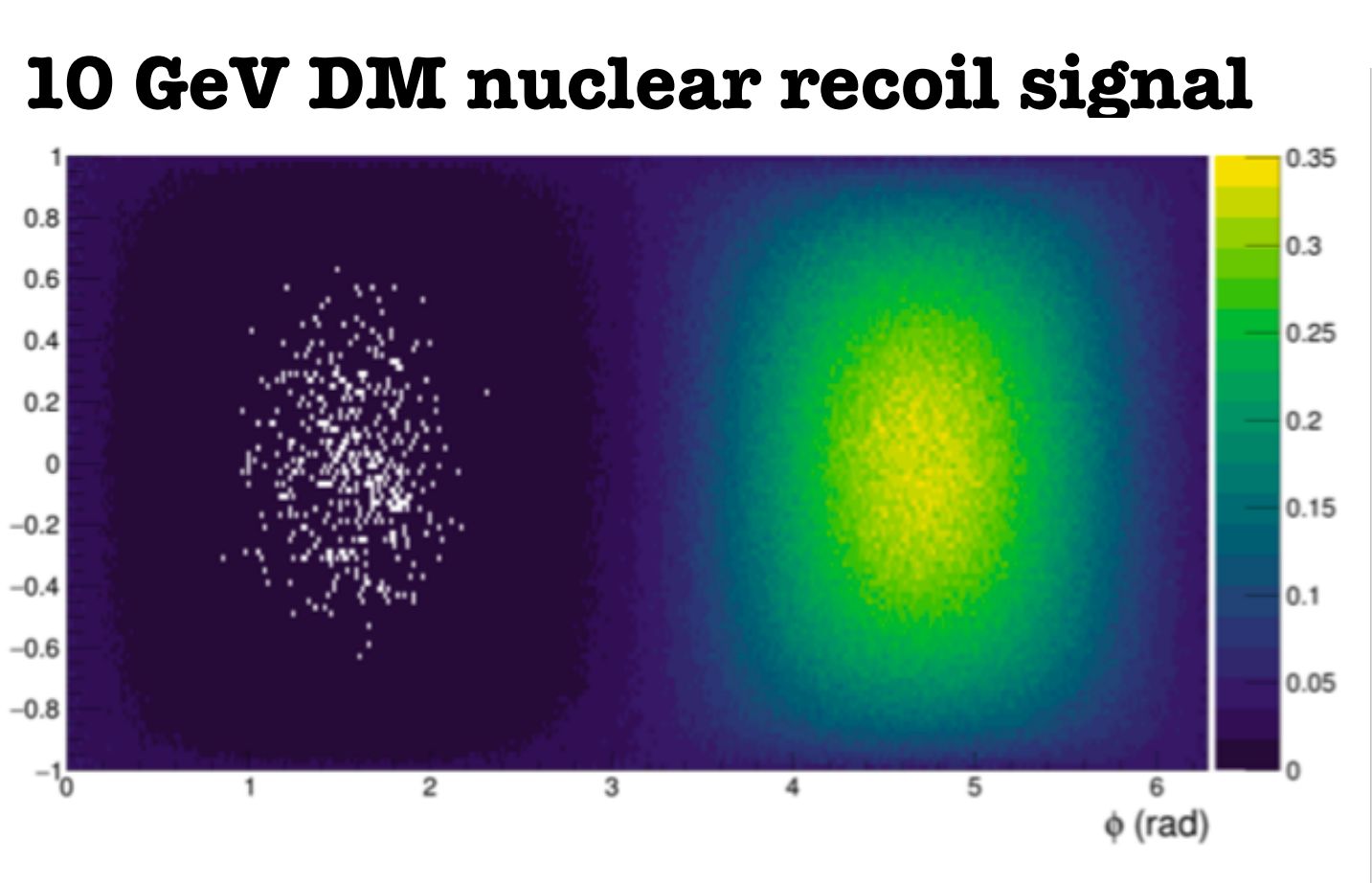


**40% NR efficiency at 6 keV<sub>ee</sub>** obtained with 96% rejection against <sup>55</sup>Fe

## The 1m<sup>3</sup> CYGNO demonstrator

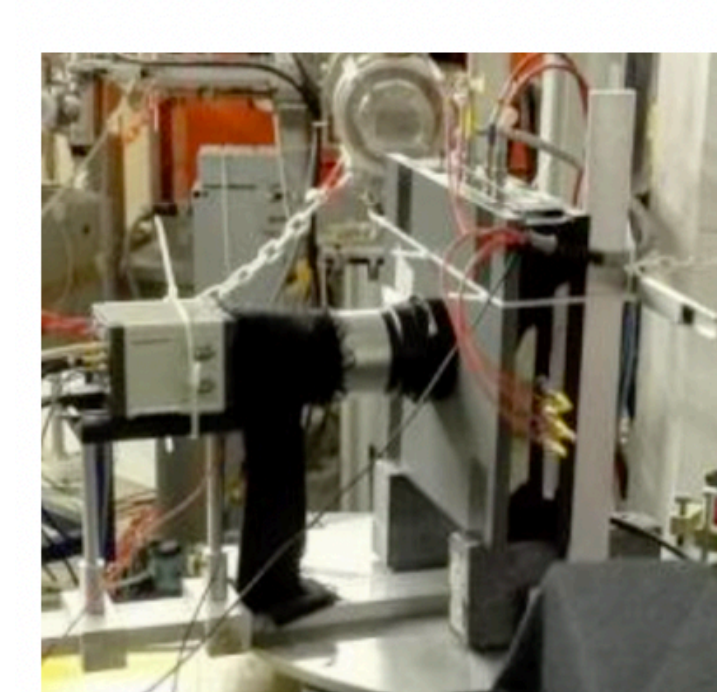

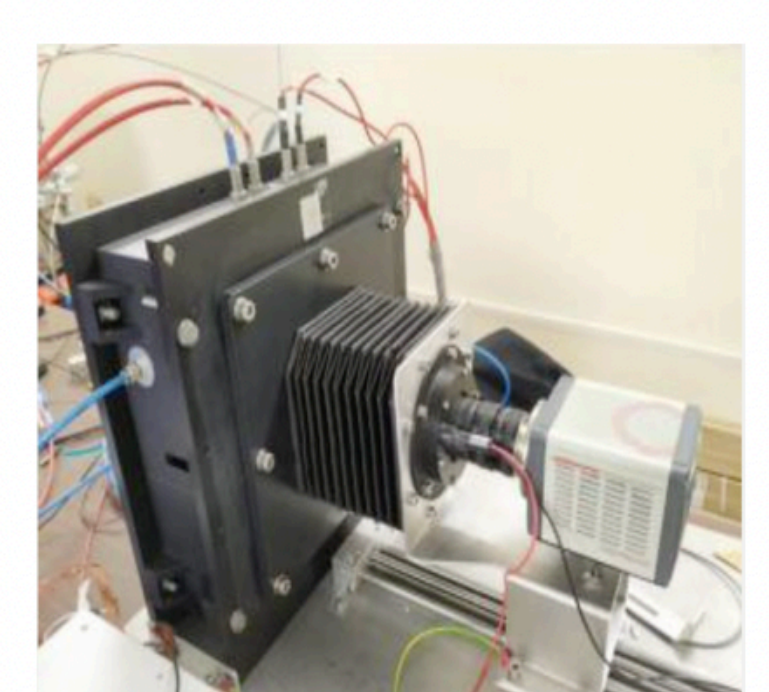

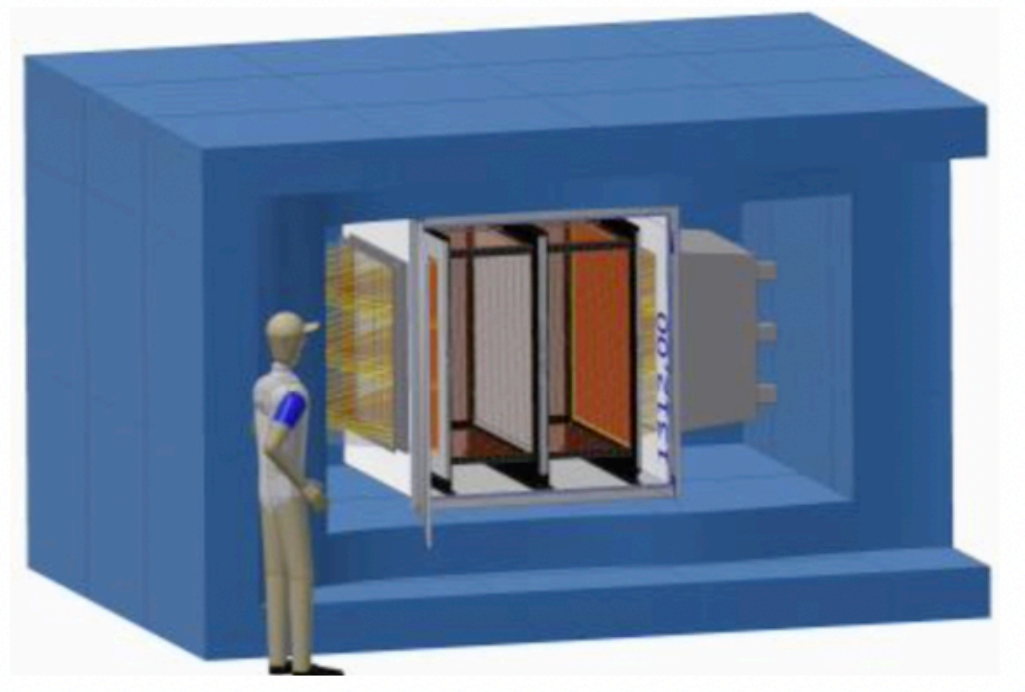


- Access to the **angular distribution** of the events:
  - signal/background discrimination thanks to a full head/tail recognition
  - 30 deg resolution
- Threshold set to 1 keV<sub>ee</sub>
- Quenching factor evaluated with SRIM



## The CYGNO timeline

References: • JINST 14 (2019) P07011 • JINST 15 (2020) T12003  
• JINST 15 (2020) P08018 • Measur.Sci.Tech. 32 (2021) 2, 025902  
• JINST 15 (2020) P10001 • NIM A 999 (2021) 165209

CYGNO R&D			PHASE 0	PHASE 1	PHASE 2
<b>ORANGE @ ROMA1</b>	<b>LEMO<sub>n</sub> @ LNF</b>	<b>MANGO @ LNF / LNGS</b>	<b>LIME @ LNF / LNGS</b>	<b>CYGNO demonstrator @ LNF / LNGS</b>	
<ul style="list-style-type: none"> <li>10x10 cm<sup>2</sup> GEMs</li> <li>1 cm drift</li> <li>100 cm<sup>3</sup> volume</li> </ul>	<ul style="list-style-type: none"> <li>20x24 cm<sup>2</sup> GEMs</li> <li>20 cm drift</li> <li>0.01 m<sup>3</sup> volume</li> <li>3D printing</li> </ul>	<ul style="list-style-type: none"> <li>10x10 cm<sup>2</sup> GEMs</li> <li>variable drift</li> <li>performance studies</li> <li>gas mixture tests</li> </ul>	<ul style="list-style-type: none"> <li>30x30 cm<sup>2</sup> GEMs</li> <li>50 cm drift</li> <li>0.05 m<sup>3</sup> volume</li> <li>performance and stability test</li> <li>underground</li> <li>shielding</li> <li>data-taking</li> </ul>	<ul style="list-style-type: none"> <li>9x2 back-to-back LIME modules</li> <li>1 m<sup>3</sup> volume</li> <li>material tests</li> <li>background assessment</li> <li>underground installation &amp; commissioning</li> <li>gas purification</li> <li>scalability</li> </ul>	
2015-2016	2017-2018	2019-2021	2021	2022	2023
					

**CYGNO 30-100 m<sup>3</sup>**