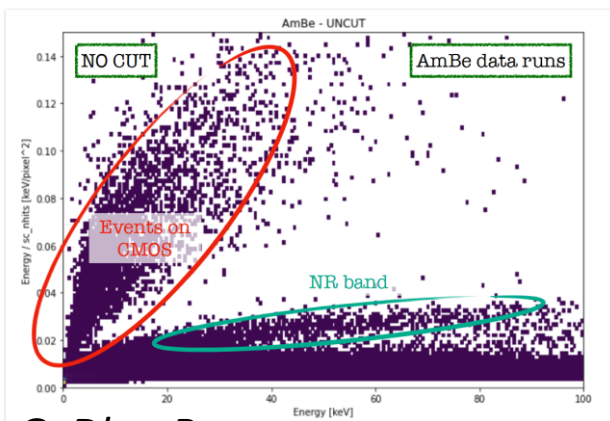
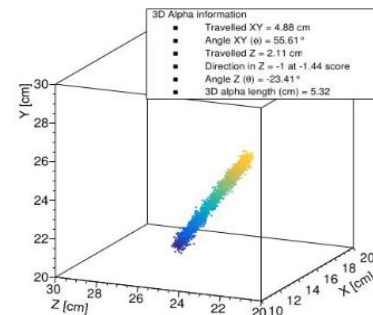


Status of Analysis (People and Topics)

Giorgio Dho

Istituto Nazionale di Fisica Nucleare (INFN-LNF), Frascati (RM), Italy



CYGNO WP1 meeting

G. Dho, Roma

June 17-18 2025

Who Are We

- People from different institutions joined the effort of analysis

G. Dho

D. Pinci

S. Piacentini

D. Fiorina

M. D'Astolfo

G. Oppedisano (Master)

V. Monno (Master)

E. Baracchini

F. Amaro

L. Gomes (Master)

G. Lopes

I. Pains

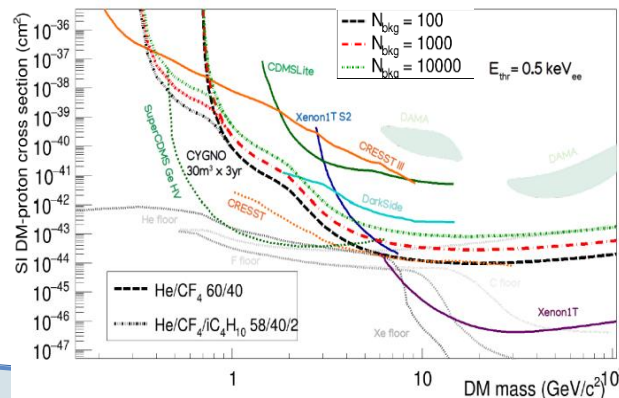
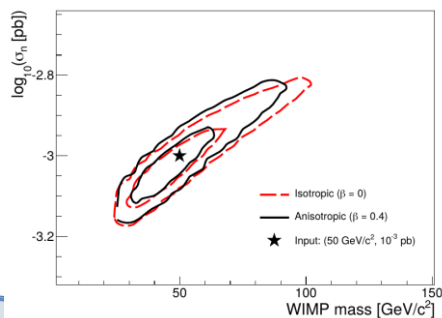
J. Venacio

F. Scamporlino (Master)

- We look a lot but almost no-one is full time on analysis
- We should focus on key elements for CYGNO science (spoilers ahead)

DM Analysis

- We aim to make measurements (.. Ok limits) of DM
- These limits and especially the **directional** ones (we are not Geiger counters) should be what drive physics feedback on detector development
- Other DM models and physics cases (found by WP1 like X-ray polarimetry, neutrinos) which induce recoils could be tested by CYGNO
- Stefano and I started this work, Samuele improved it and Rita recently put the basis for a statistical framework based on BAT



No one on this crucial topic

Done:

- BAT fit in place
- WIMP formula to estimate spectra
- Idea on how to combine E and angle

Missing:

- Implementation combination angle-E
- Implementation actual physics performances:
 - E_{thr} dependent on z
 - Resolutions variable with z

3D Reconstruction



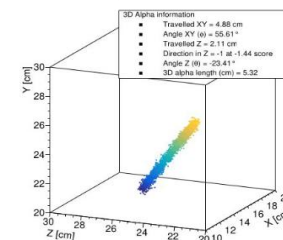
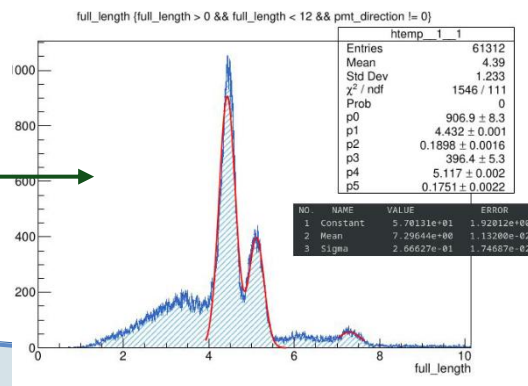
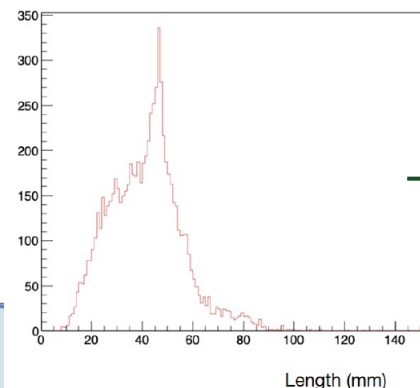
No one on this crucial topic

Done:

- BAT association fit
- 3D reconstruction code and concept

Missing:

- Integration in reconstruction flow (standardization)
- ER 3D reco
- Limit in energy (test on GS/s data)
- Short NR
- New 3D analysis



ER vs NR

On this topic:

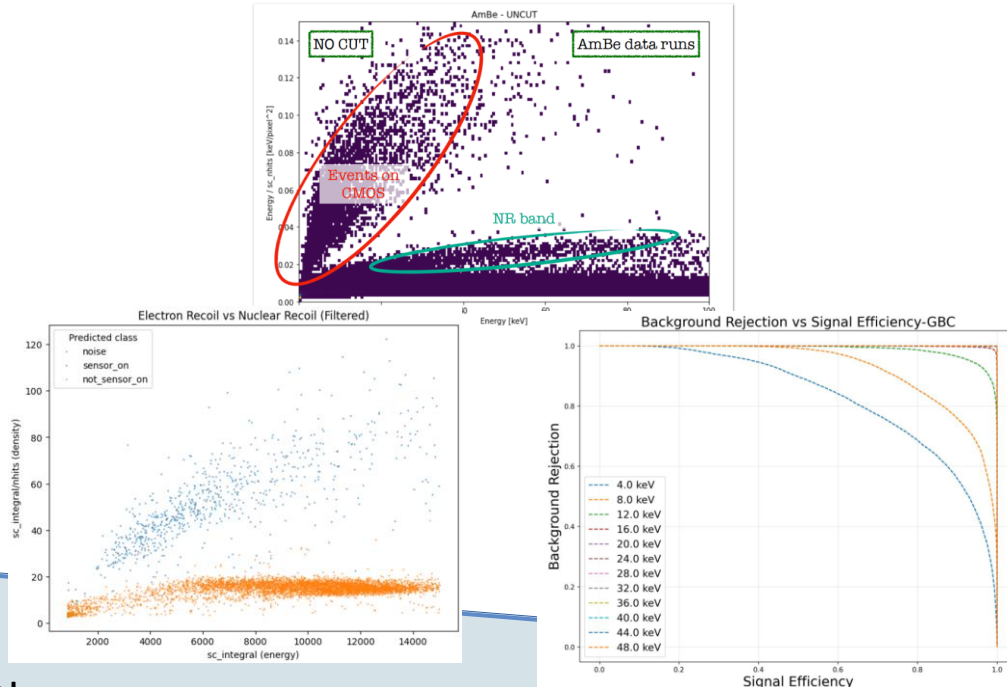
Oppedisano, Gomes, Trieste(??)

Done:

- Variables outside standard reco
- Concept and proof by Atul
- Beginning of a new anomaly method

Missing:

- Fully working method
- Trustful NR simulation (WP3)
- Rejection power estimation



Background Understanding

On this topic:

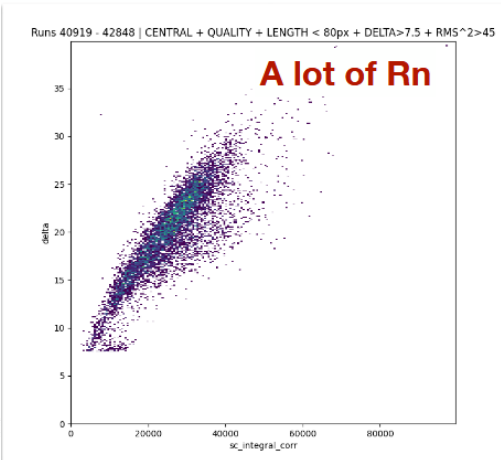
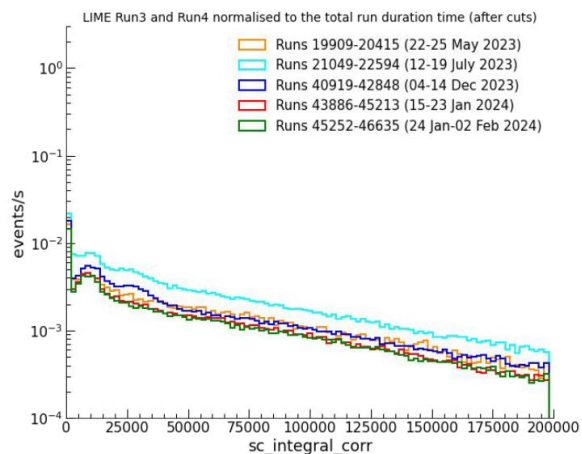
Pinci, D'Astolfo (sort of)

Done:

- Rn contamination
- Rn daughters
- Quality cuts on high gain
- Recognition of other elements (Cu from GEM)

Missing:

- Actual data-MC comparison of Run4
- Low energy Rn correlation



Head-Tail and Angular Resolution

On this topic:

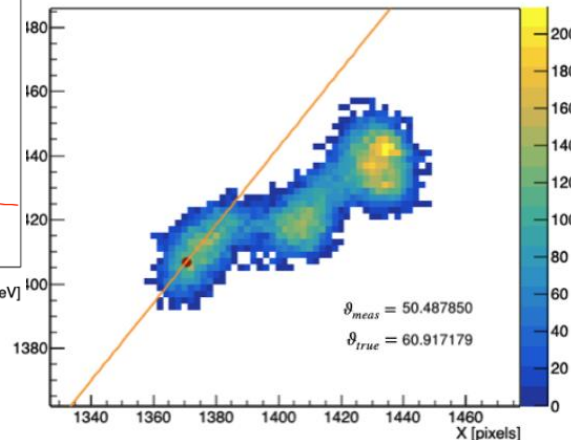
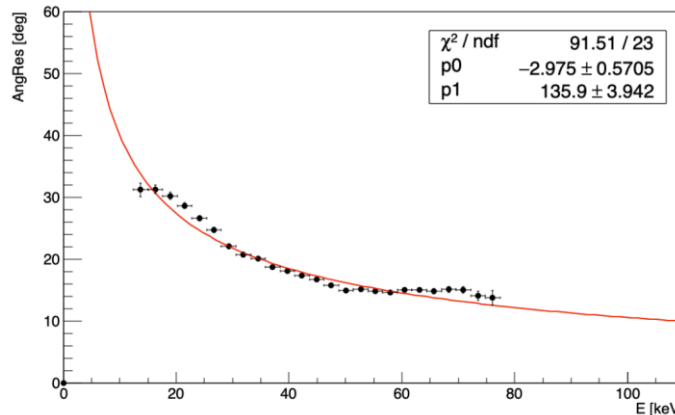
Fiorina (10%), Dho (5%)

Done:

- ER 2D direction vs E
- HT for ER
- Hints on 2D NR

Missing:

- 3D ER
- Everything on NR



Z-fiducialization

On this topic:

Scamporlino, Pinci, Monno

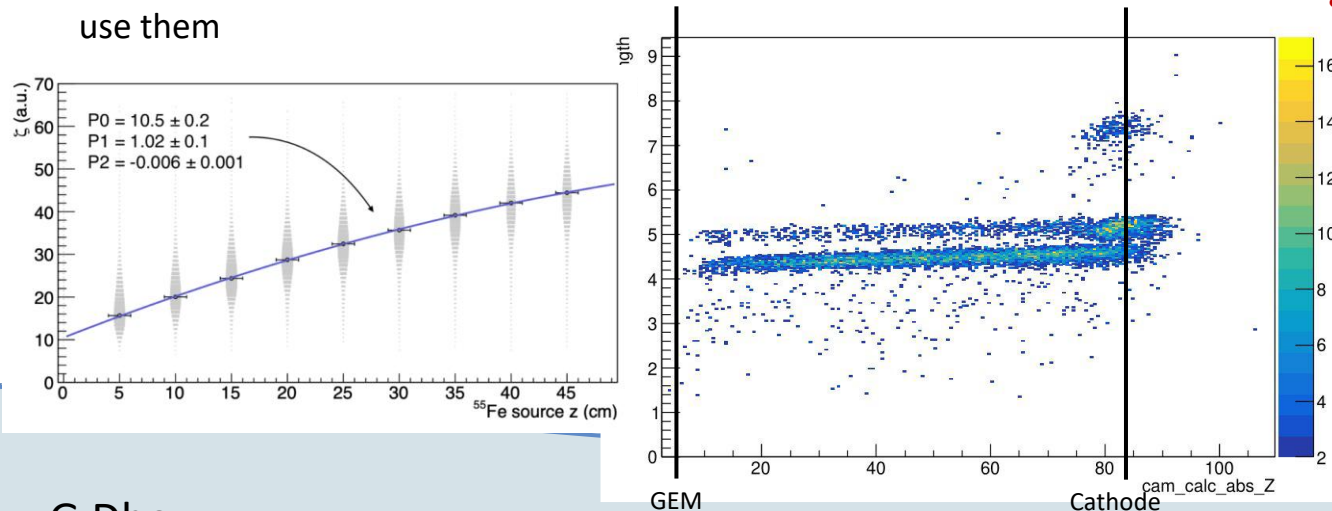
Done:

- Take multiple data set to work on
- Rough variable use to estimate z
- Beginning new ideas implementation (ML)

Missing:

- Improve z resolution

- Determination of absolute z is the only way to fiducialize the detector for events close to cathode or GEM
- Studies by Emanuele and Rita Roque and David suggested 4 cm resolution close to GEM and 8 cm close to cathode. **Should be improved**
- These variables turned out better than tgausssigma, we should at least use them



Energy Threshold and Efficiency

On this topic:

Noone (could Rafael do this?)

Done:

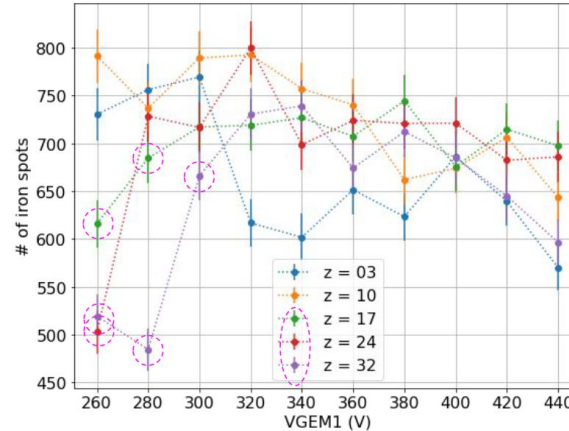
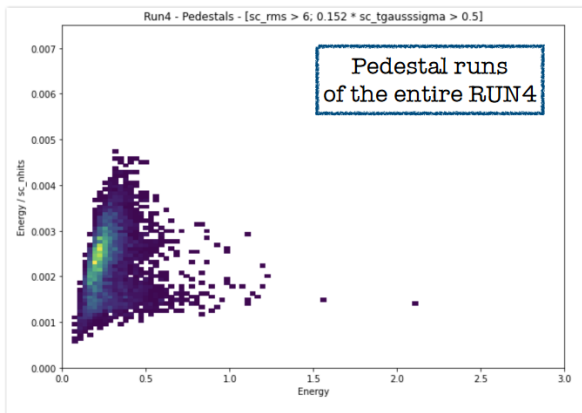
- Data scan now available
- PMT simulation close to be integrated into sim
- Everything is there

Missing:

- Produce plots of E_{thr} and efficiency vs z

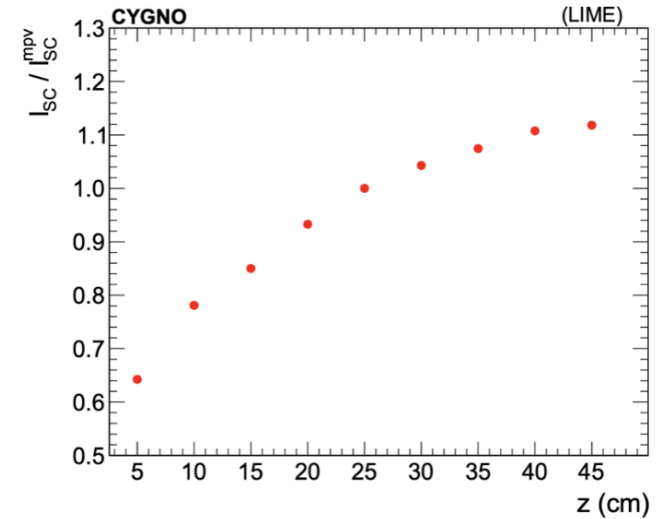
- Energy threshold and detection efficiency are required to determine where to look for signal

- Data used for saturation studies could help (Rafael last year)



Saturation

- We are saturating, the charge density is too large in GEM holes and space-charge effects limit the amplification
- This is terrible:
 - Energy threshold and response strongly depends on z
 - Detector non-linear at low energies
 - Z determination becomes fundamental with cm resolution
 - HT and angular resolution worsen at low energy
 - ER and NR are more similar



PAPER

Saturation: Solve

On this topic:

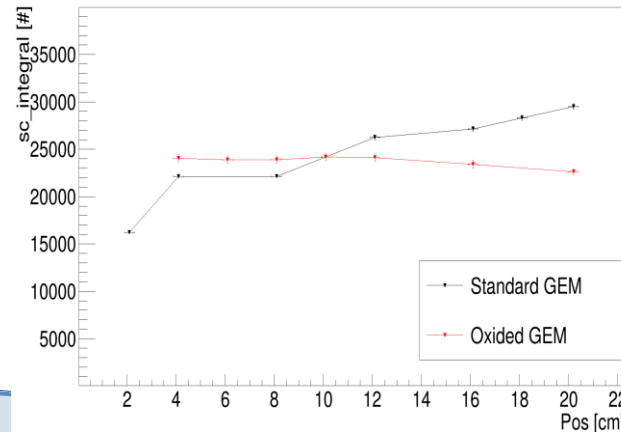
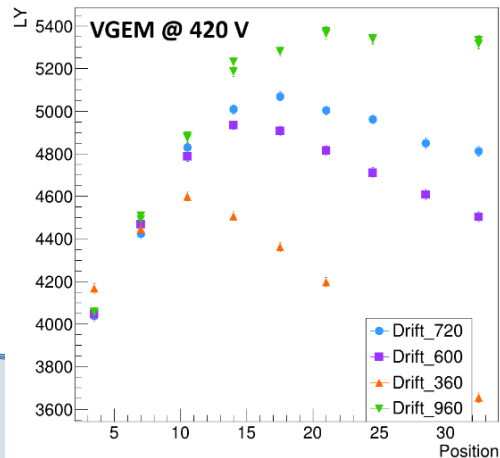
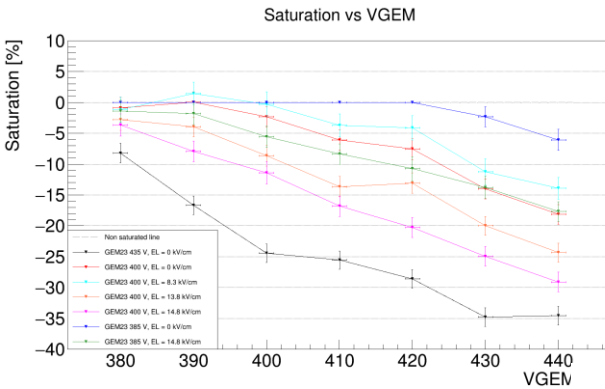
Dho , Fiorina, Future student LNF?

Done:

- Promising solution found

Missing:

- Find optimal E_{drift} + VGEM



Run5: Neutrons

On this topic:

D'Astolfo

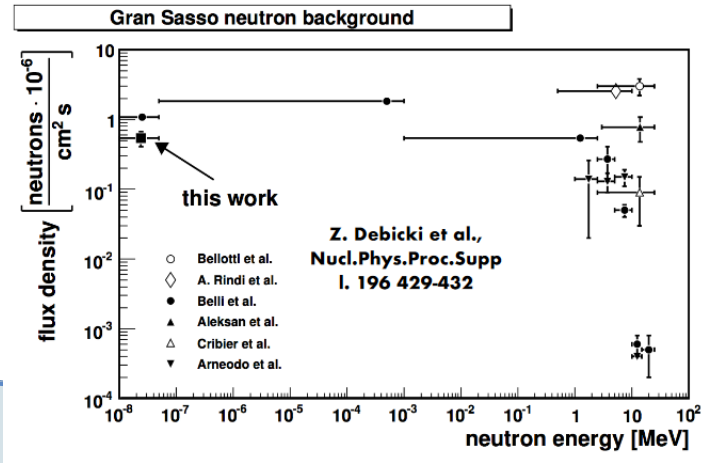
Done:

- Calibration with environmental variables (useful for future gain online correction WP5 and for all analysis on data)
- Data quality cuts on low gain (ongoing)
- Early tests on unfolding

Missing:

- Data analysis (several items)
- NR unfolding

Final quality and speed might depend on ER/NR rejection



Data Reduction and pixel selection

On this topic:

Pains

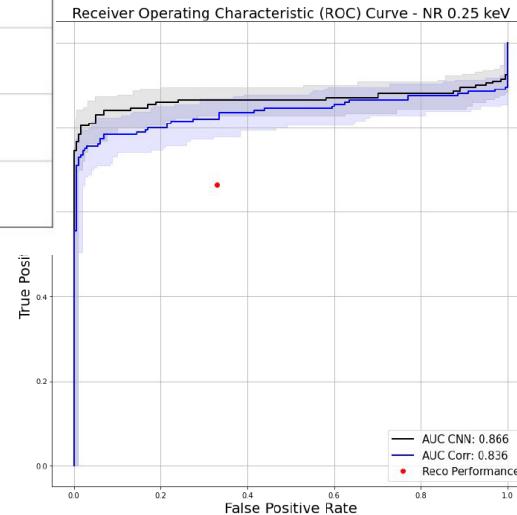
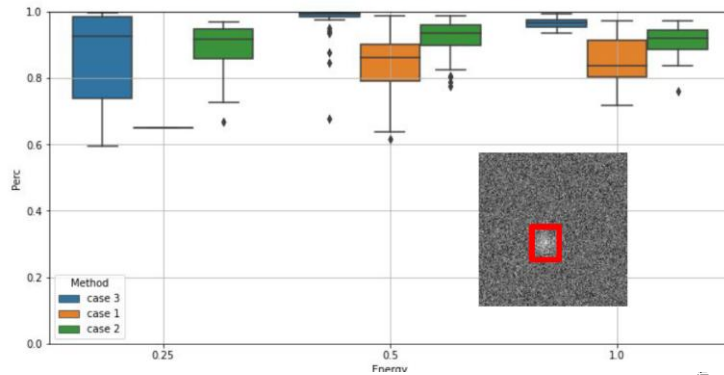
Done:

- Algorithm and strategy figured out
- Production of QUEST dataset

Missing:

- Integration in DAQ
- Test on data

(%) Truth pixels into xmin,ymin,xmax,ymax region



Reconstruction and Cloud

On this topic:

Dho, Mazzitelli, Lopes

Done:

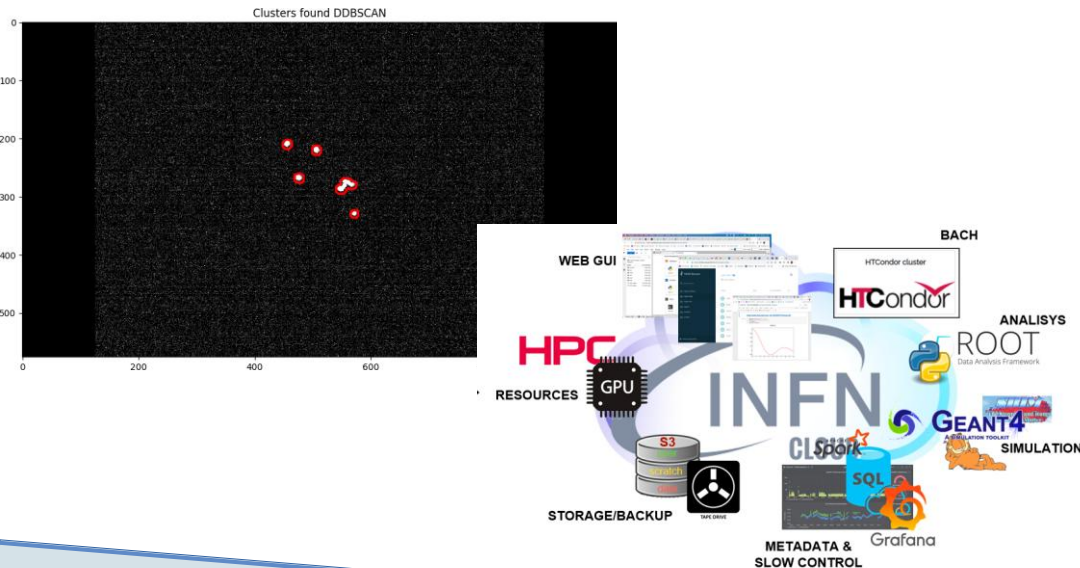
- Integration of software on faster more reliable queues
- Filters to improve reconstruction

Missing:

- Barrel correction
- Adaptation to new format of data (with WP5)

- The reconstruction code needs constant maintenance and improvements to avoid crashes and provide users with more information

- It will need a bit of overhaul for new data shape



Conclusion

- WP2 goal is to provide the framework to analyse data and transform it from images to physics and experimental results
- The number of FTE is quite limited for the amount of tasks to cover
- A lot of relevant and excellent work has been carried out
- Some important detector performances are still to be addressed or finalised and we should focus on these
ER/NR, 3D reconstruction, directional parameters, z-fiducialization
- Crucial for CYGNO-04 is the understanding of the saturation conditions we want to work on
- Secondary, works on R&D like NID and ITO are also very important for future developments