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# Dark Matter

## leaving no stone unturned

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DAVID CERDEÑO

<https://projects.ift.uam-csic.es/thedeas/>

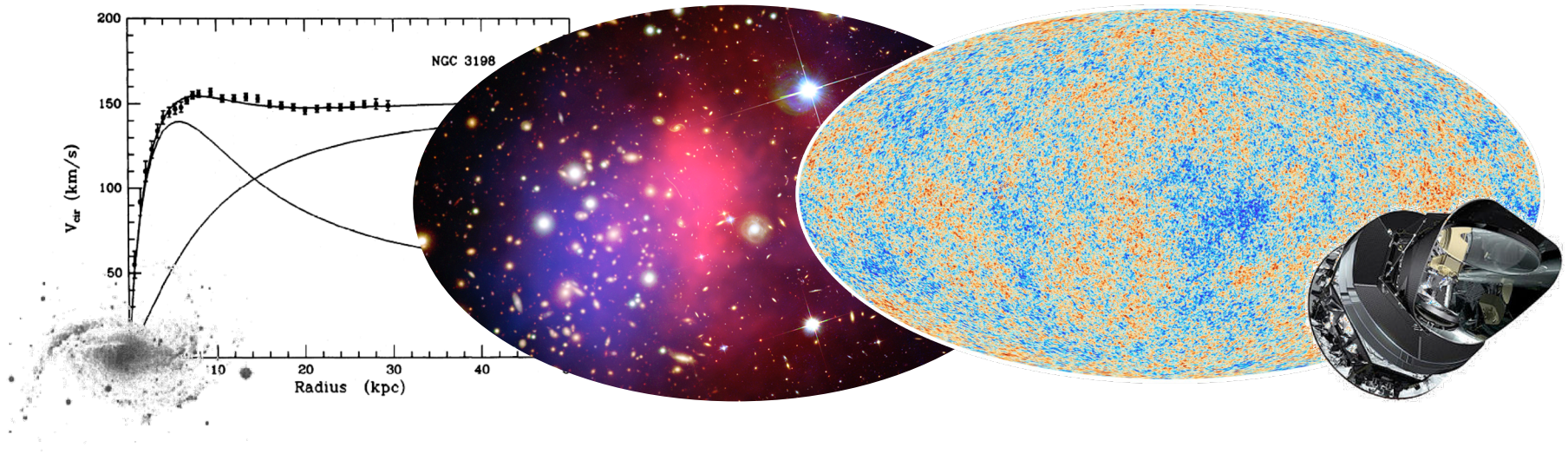


22/09/2025 RENATA

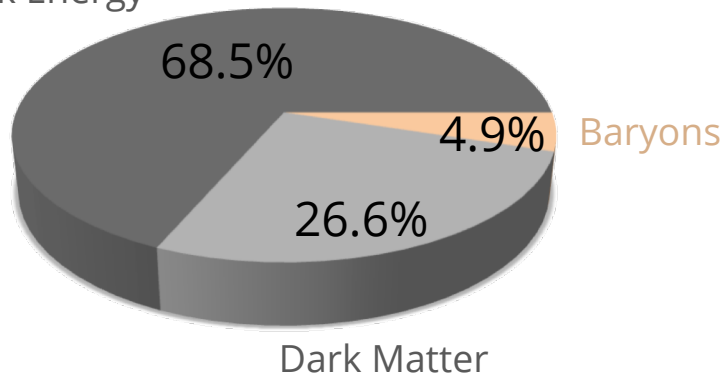
Energies, not forms, not figures (chant)

# Dark Matter is a necessary and very abundant component in our Universe

We have observed its gravitational effects at different scales



Dark Energy



A **plausible** hypothesis is that dark matter is a **new type of particle** (stable, neutral, weakly-interacting).

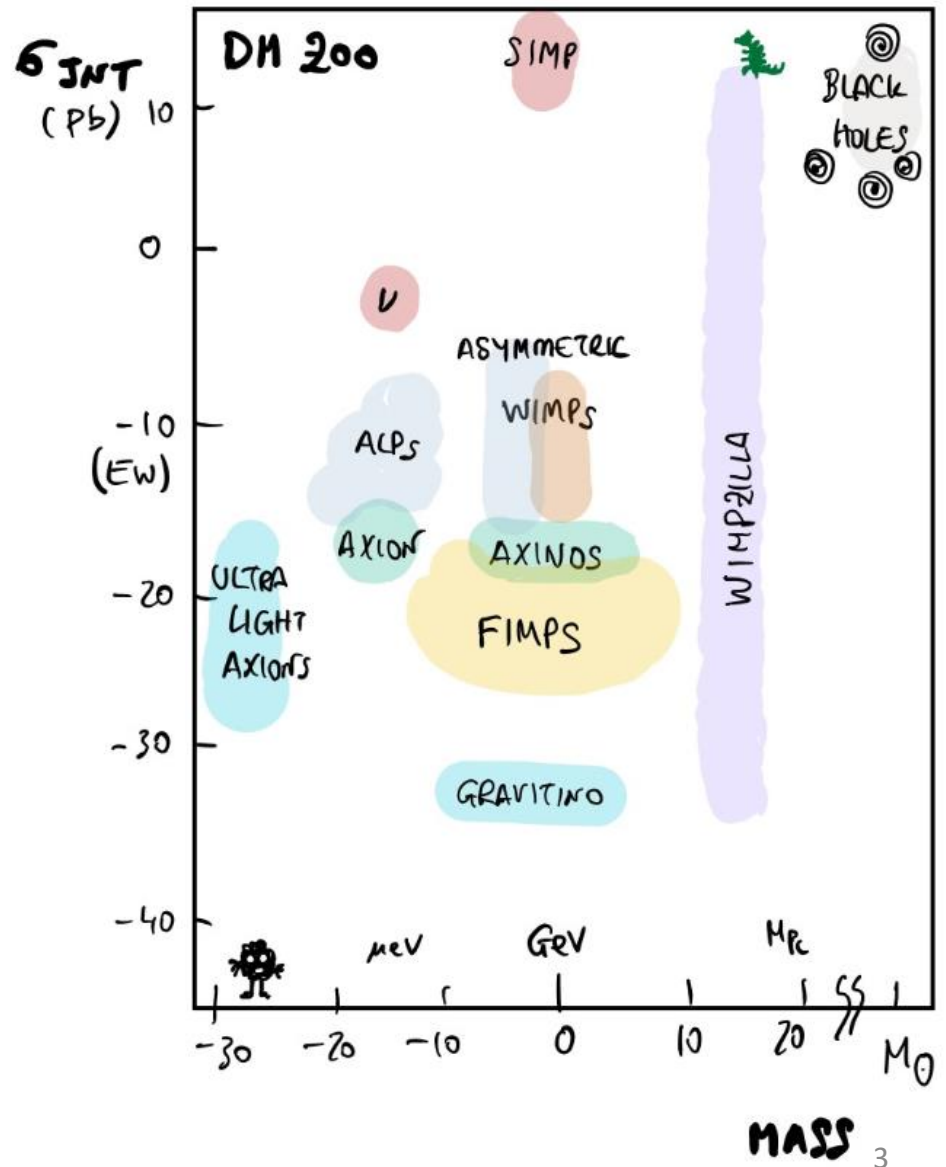
But it might also be in the form of **primordial black holes** (formed before BBN).

We should not rule out the possibility that DM is **multicomponent**.

There are plenty of viable candidates, which imply very different **cosmological histories**

- “Thermal” candidates: **WIMPs** (weakly-interacting massive particles)
- Out of equilibrium production
- Axions
- Asymmetric Dark Matter
- Ultra-light Dark Matter
- Primordial Black holes

Finding the dark matter might give us information about **how the Universe came to be**



waves

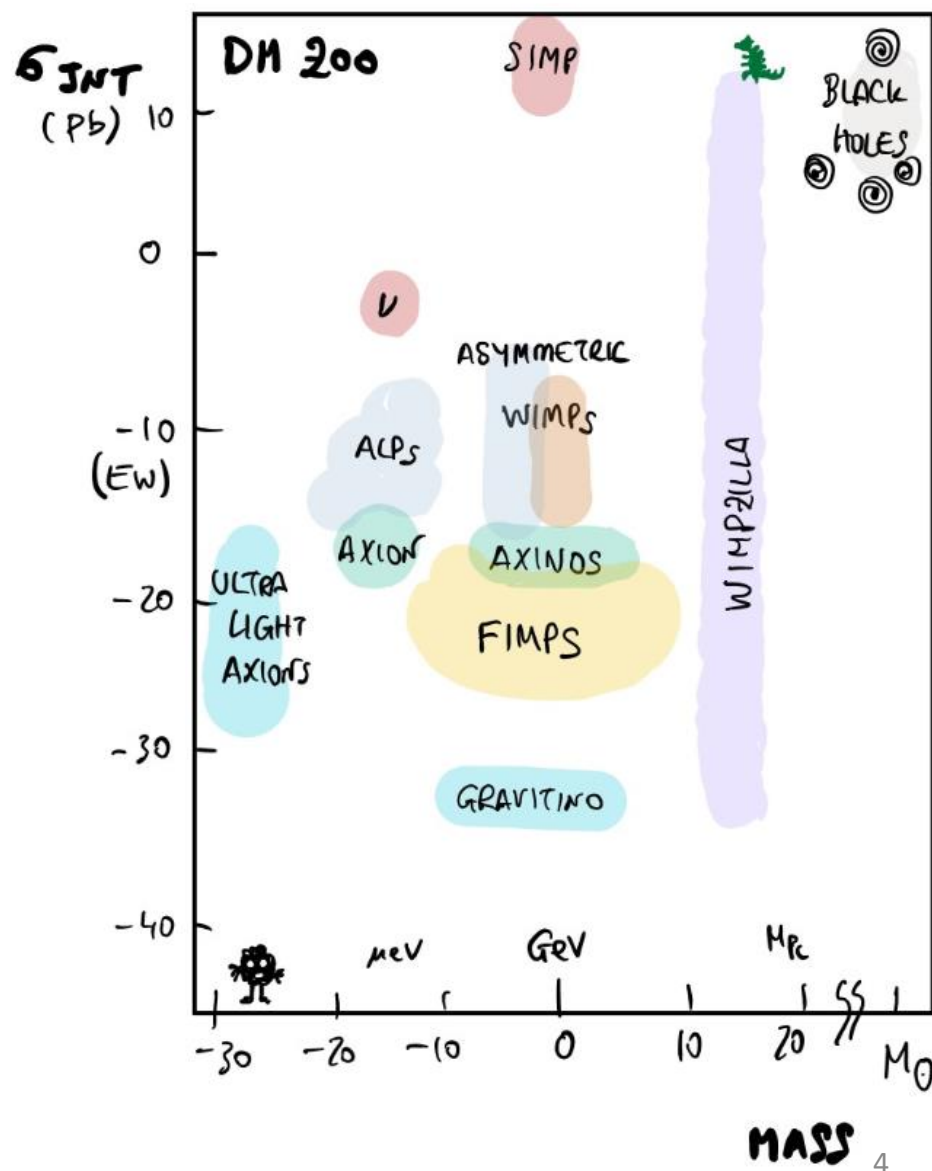
particles

objects

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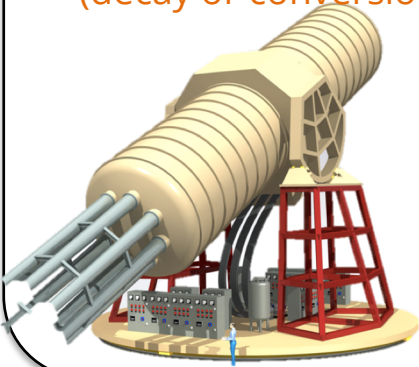




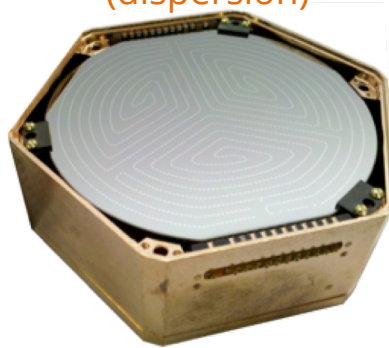
## Dark matter can be searched for in different ways

These explore **complementary** properties of dark matter particle models

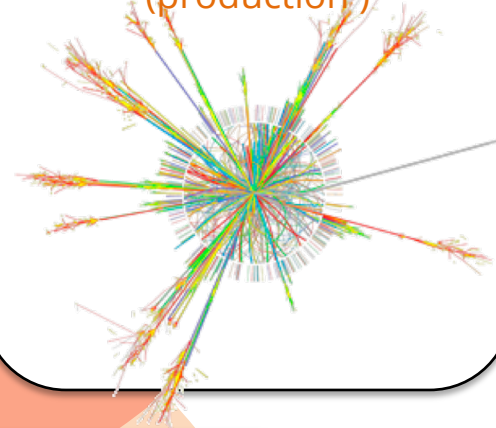
Axion Searches  
(decay or conversion)



Direct Detection  
(dispersion)



Accelerators (LHC)  
(production)



Astrophysics and Cosmo  
(production)



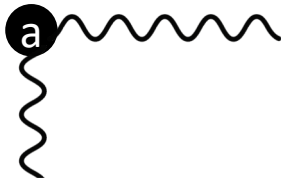
Indirect searches  
(annihilation or decay)



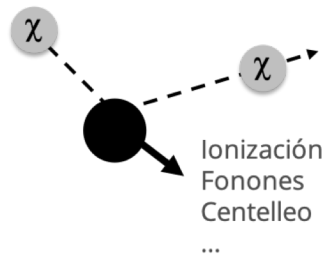
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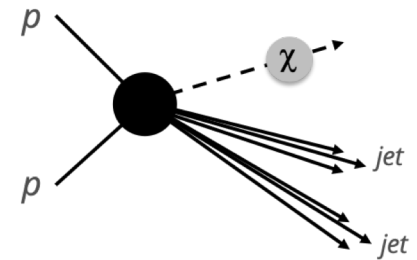
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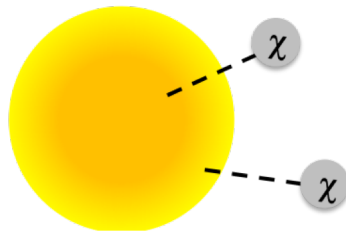
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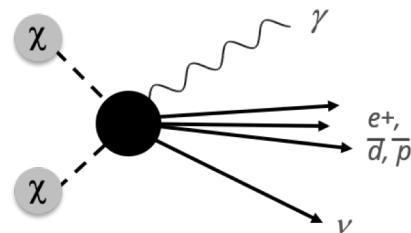
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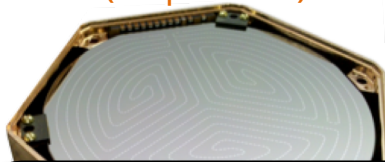
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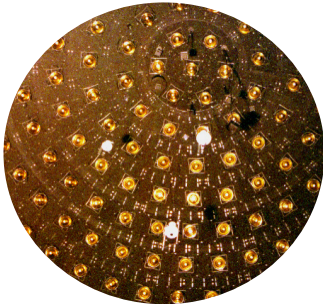
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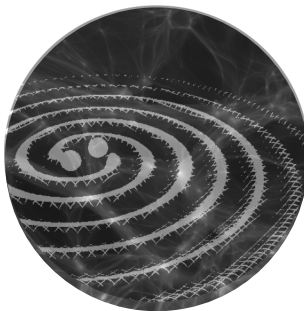
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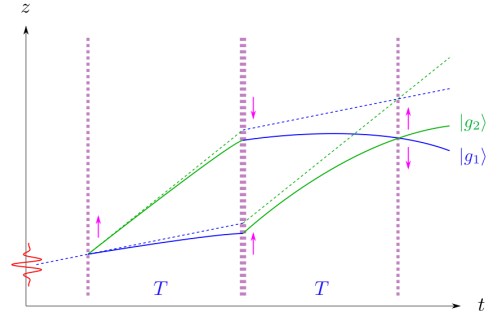
Neutrino detectors



Gravitational waves



Quantum Technologies

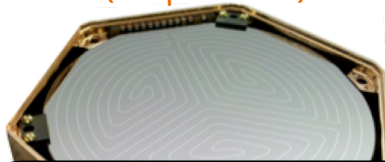


The search for DM is inextricably linked to the efforts in other areas (and benefits from advances in them)

Axion Searches  
(decay or conversion)



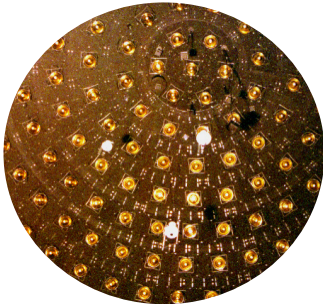
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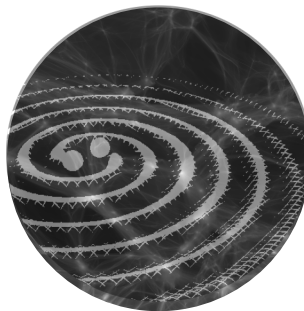
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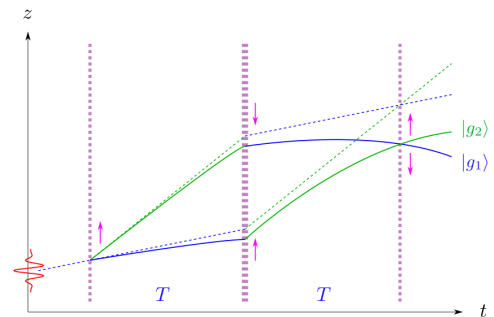
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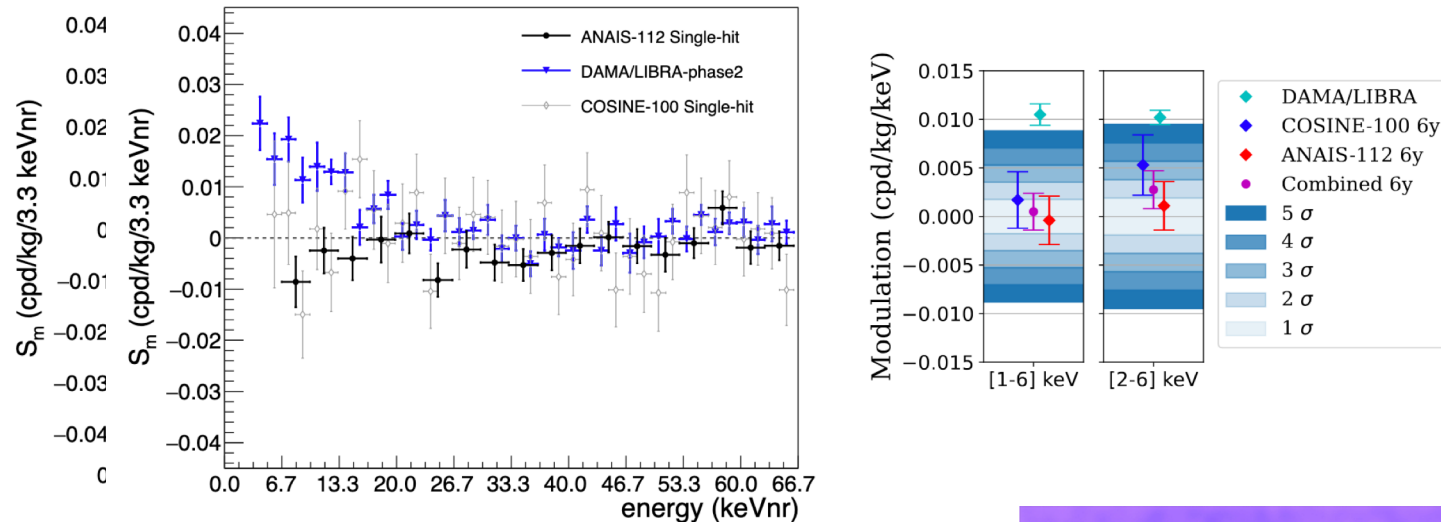


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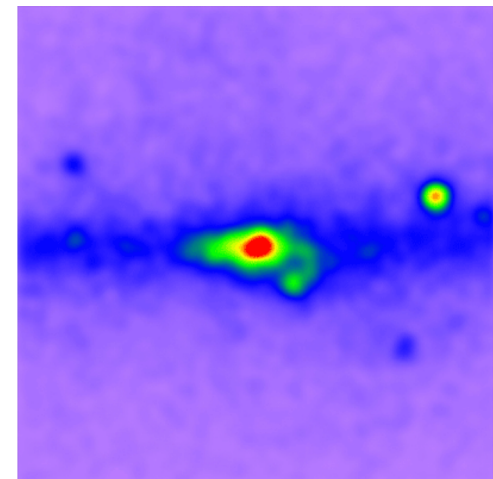


## There is no confirmed hint for DM (other than gravitational)

The ANAIS collaboration has done an excellent job in putting the DAMA/LIBRA signal to the test and virtually excluded the DM interpretation of its annual modulation.



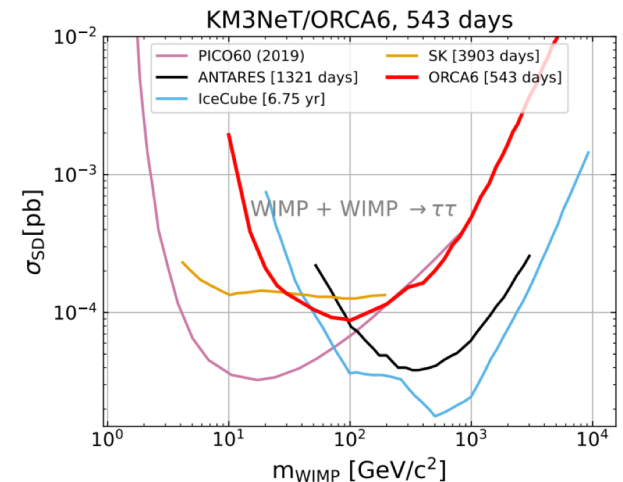
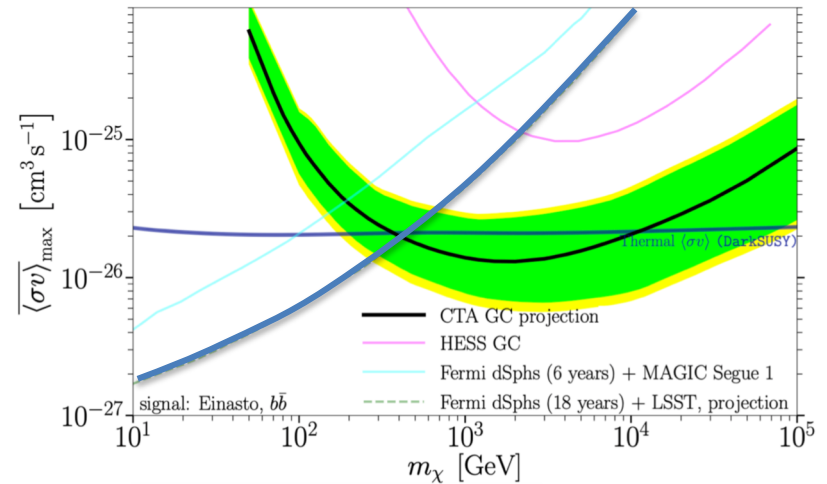
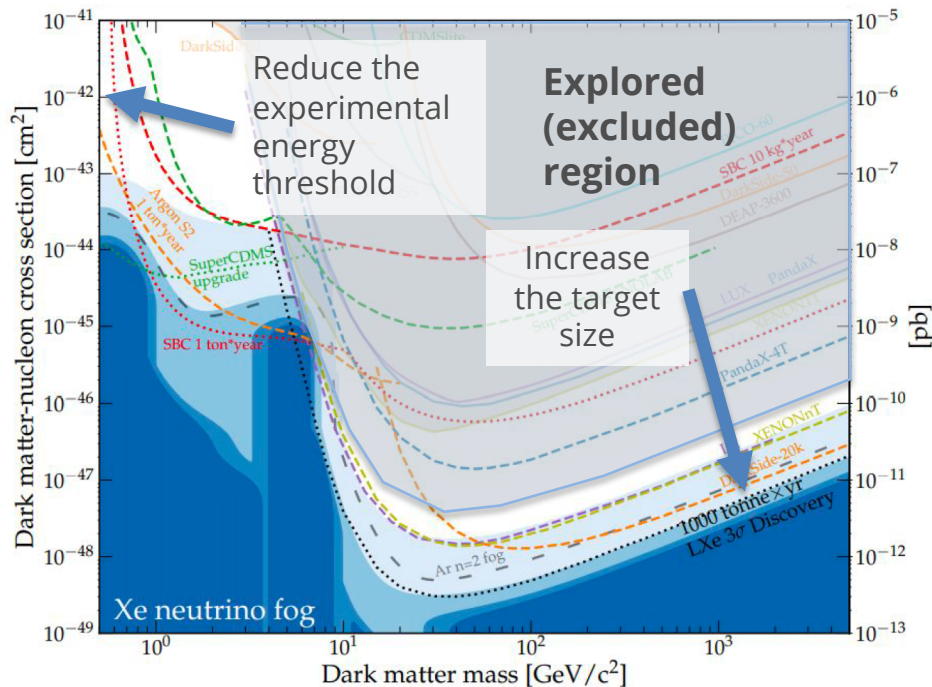
Persistent Galactic Centre Excess in gamma rays (Fermi-LAT)  
but DM interpretation is unclear and constrained by  
searches in other objects (e.g. dSphs)





## Some considerations and prospects

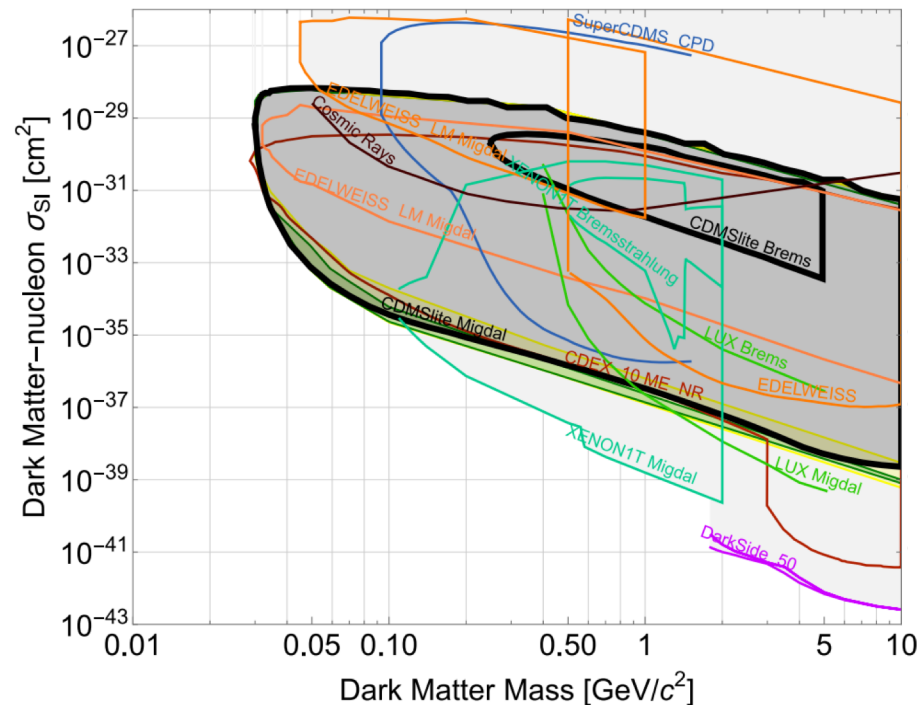
- Effort in closing (as much as possible) the WIMP window (combined larger direct + indirect + collider). Pushing towards the "neutrino fog" – investigating effective operators – annual modulation – directionality





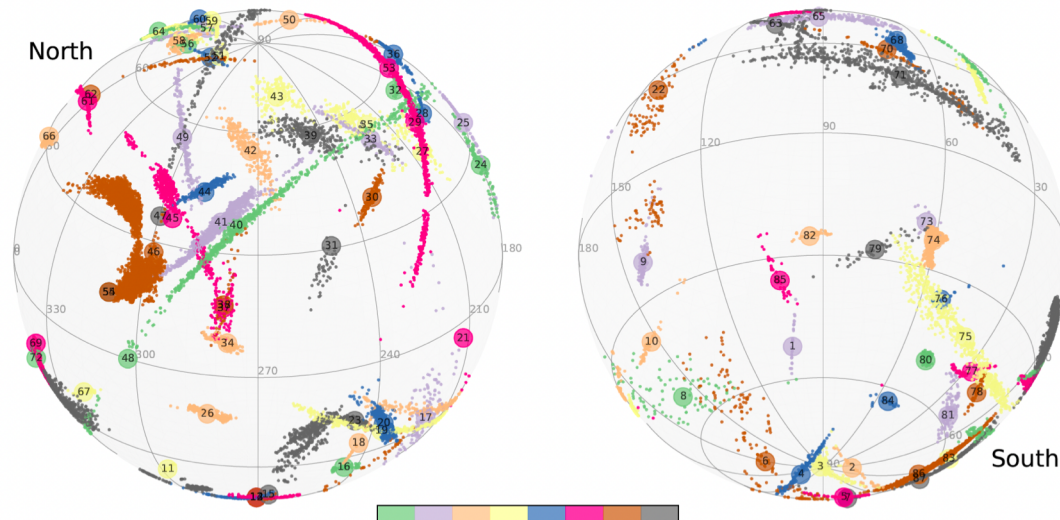
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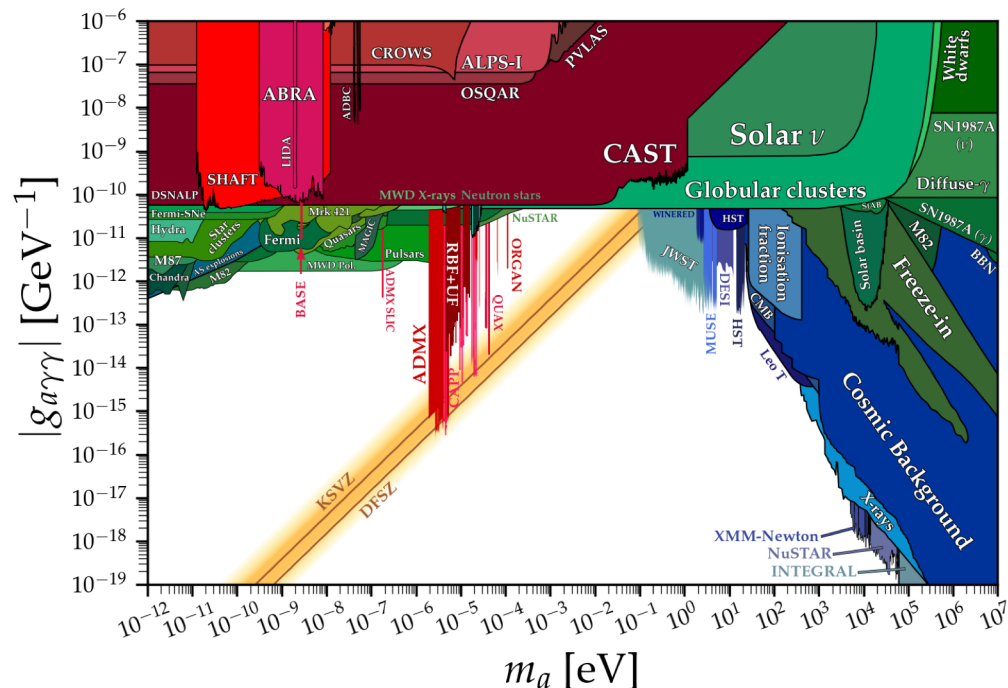
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- Ultralight DM search with Gravitational Wave technologies and atom interferometry
- Effect of DM in stellar objects – supernovae, neutron stars, white dwarves: can they contain DM? Can they boost DM?

## **UPDATES FROM**

- Axion Searches: Igor Irastorza
- Direct Detection: Vicente Pesudo
- Indirect Searches: Bryan Zaldívar (online)

