Searching for Dark Matter in the Southern Cone with Skipper CCDs

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UNIVERSIDAD NACIONAL DE CUYO
IN SPIRITUS REMIGIO VITA
MENDOZA ARGENTINA

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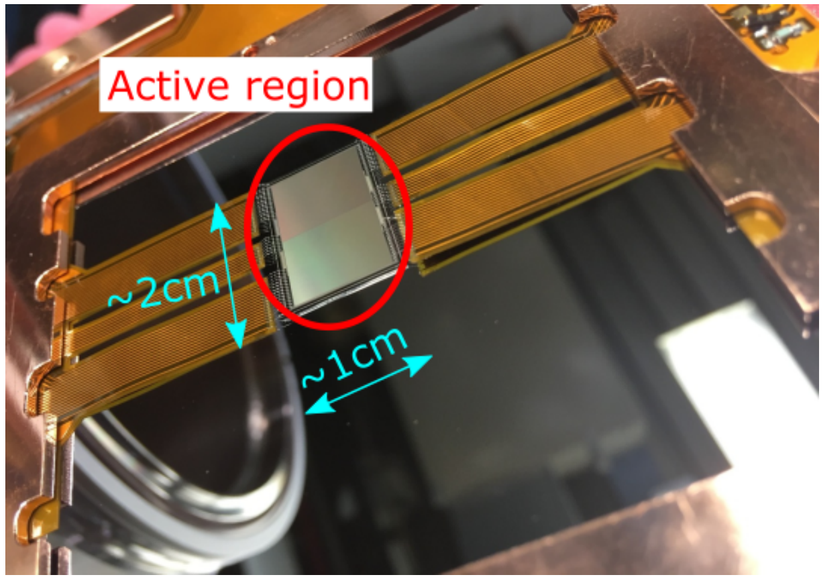
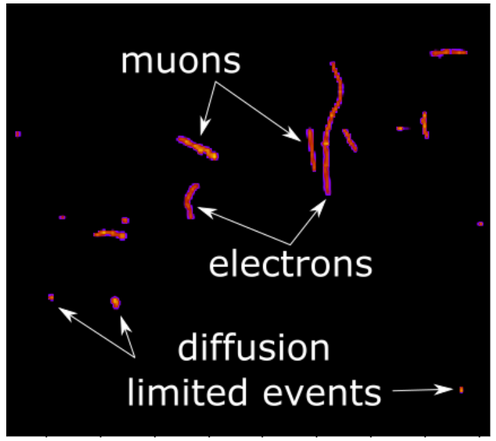
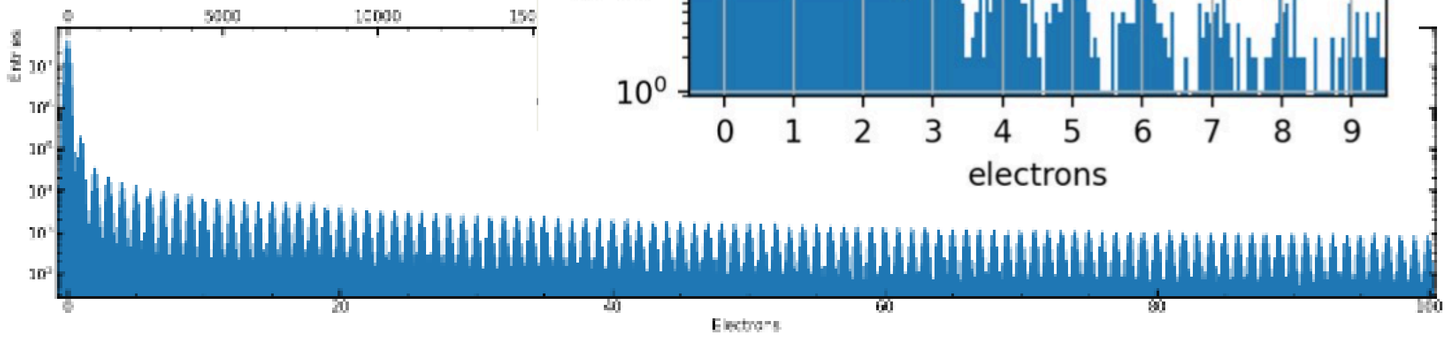
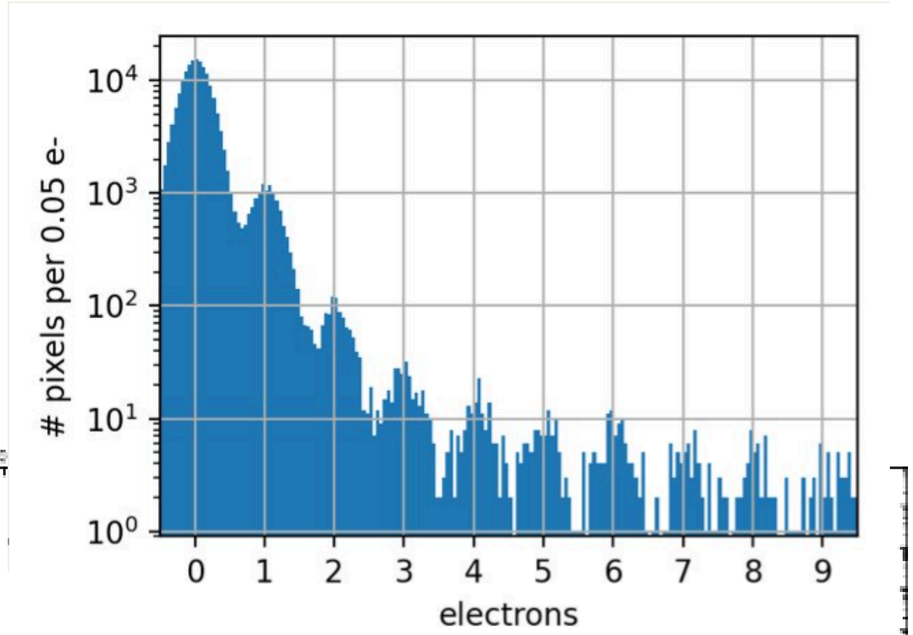
III JOINT ICTP-SAIFR/ICTP-TRIESTE SUMMER SCHOOL ON PARTICLE PHYSICS

Skipper CCDs are pixelated, silicon detectors that have very low energy threshold (1.2 eV)









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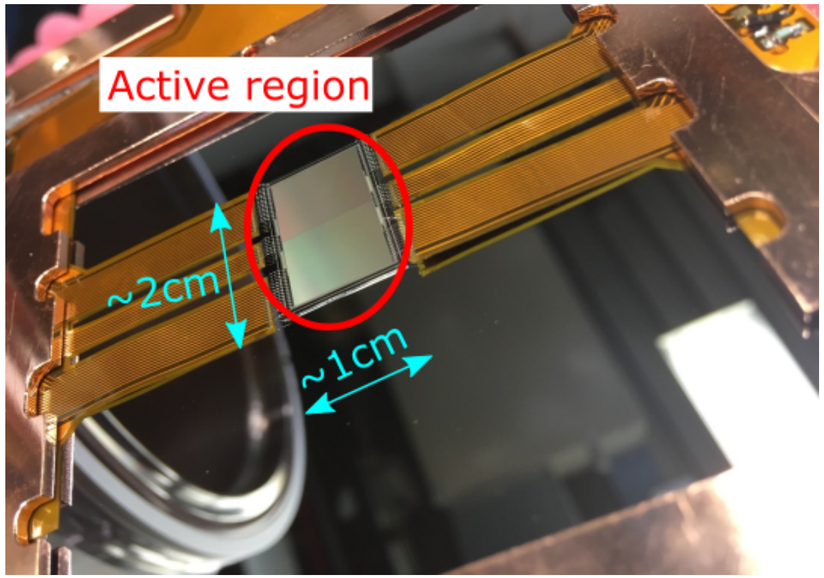

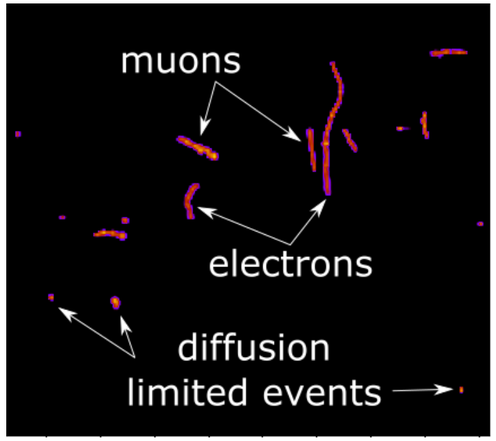

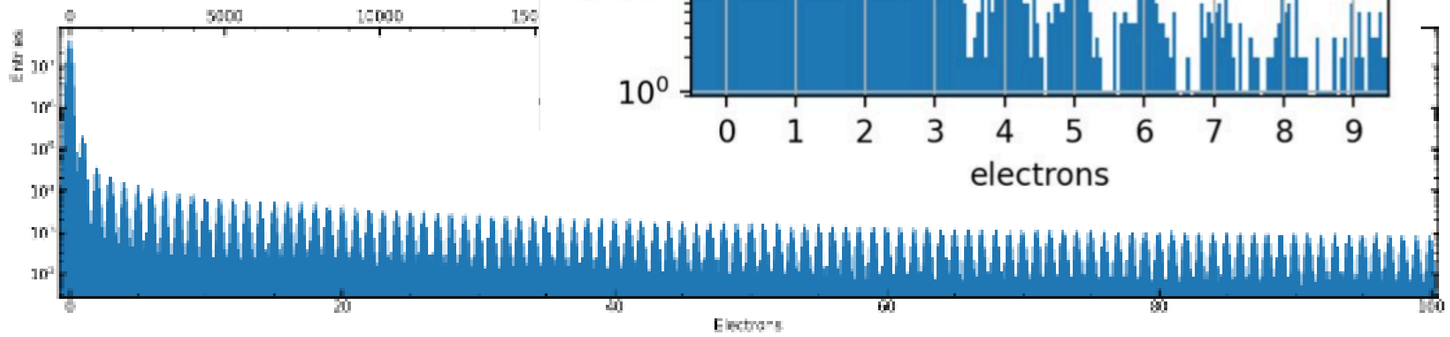

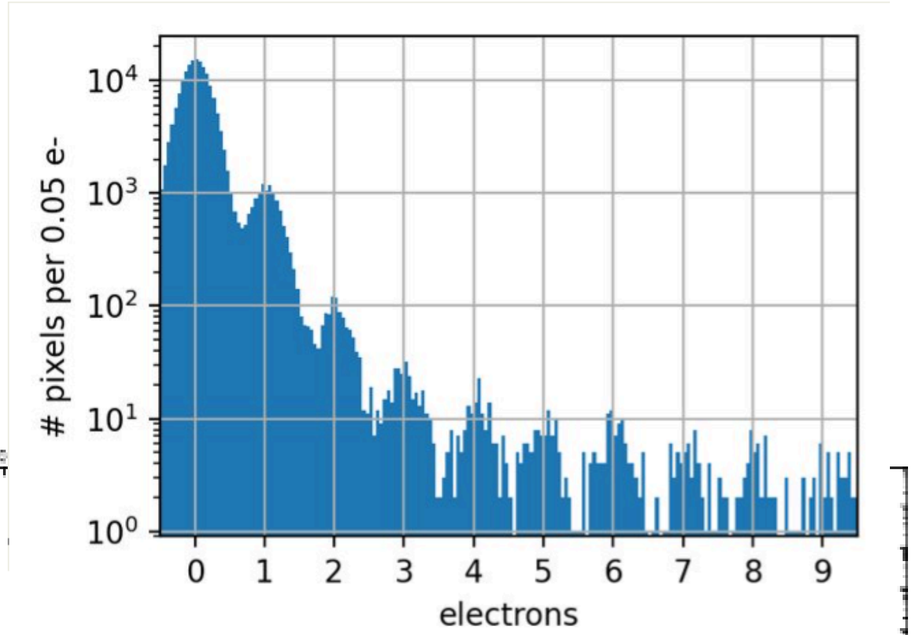

Theoretical work suggested that certain region of the parameter space could be better probed in the southern hemisphere (specifically at a latitude of 40°S)

We have a Skipper CCD and our lab is located at 41° S (Bariloche).

We search for Dark Matter because we can.

Background

DAMIC was the first experiment to search for DM interactions using CCDs (~2012)
SENSEI was the first to use the Skipper CCD technology (~2020)

Both experiments are located in the northern hemisphere and in underground laboratories

We don’t have (yet)* an underground laboratory to place our experiment in

*See the ANDES (Agua Negra Deep Experimental Site) initiative

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Can we somehow get rid of the annoying cosmic ray background?

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Search for a modulation: a signal above your irreducible background

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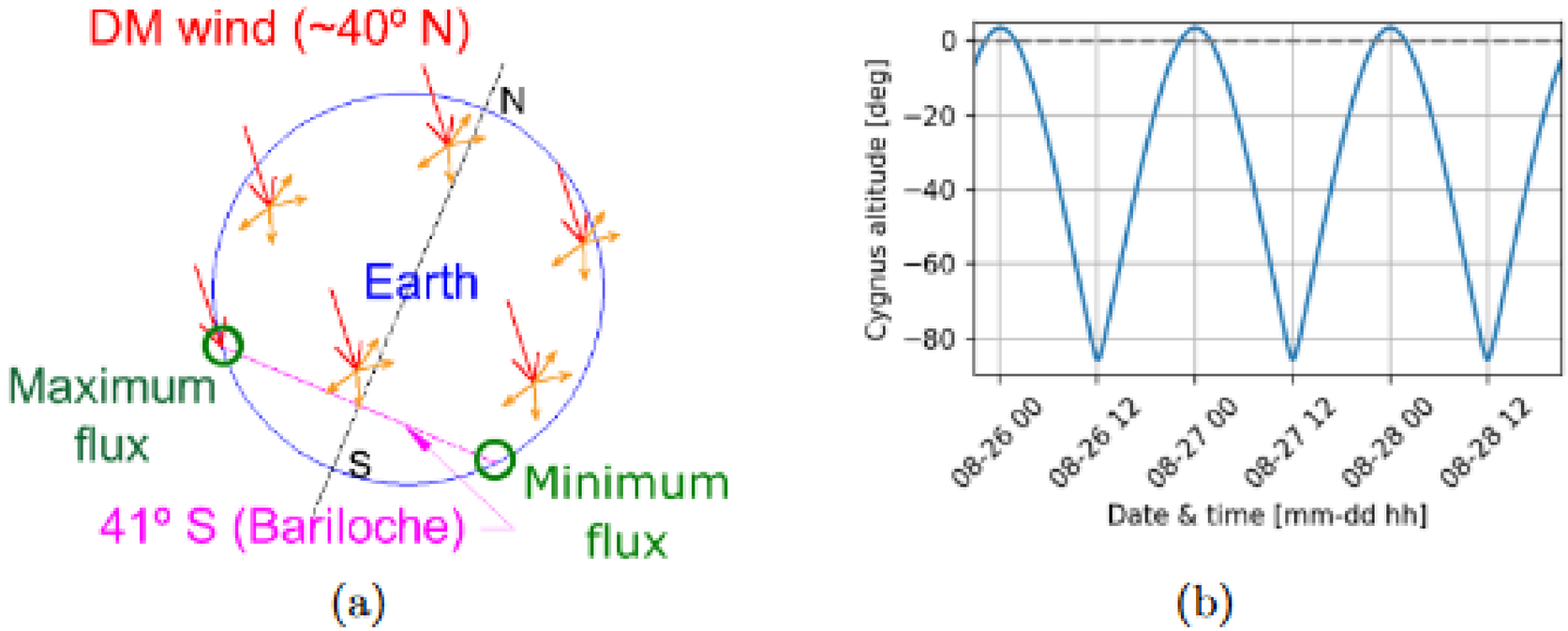
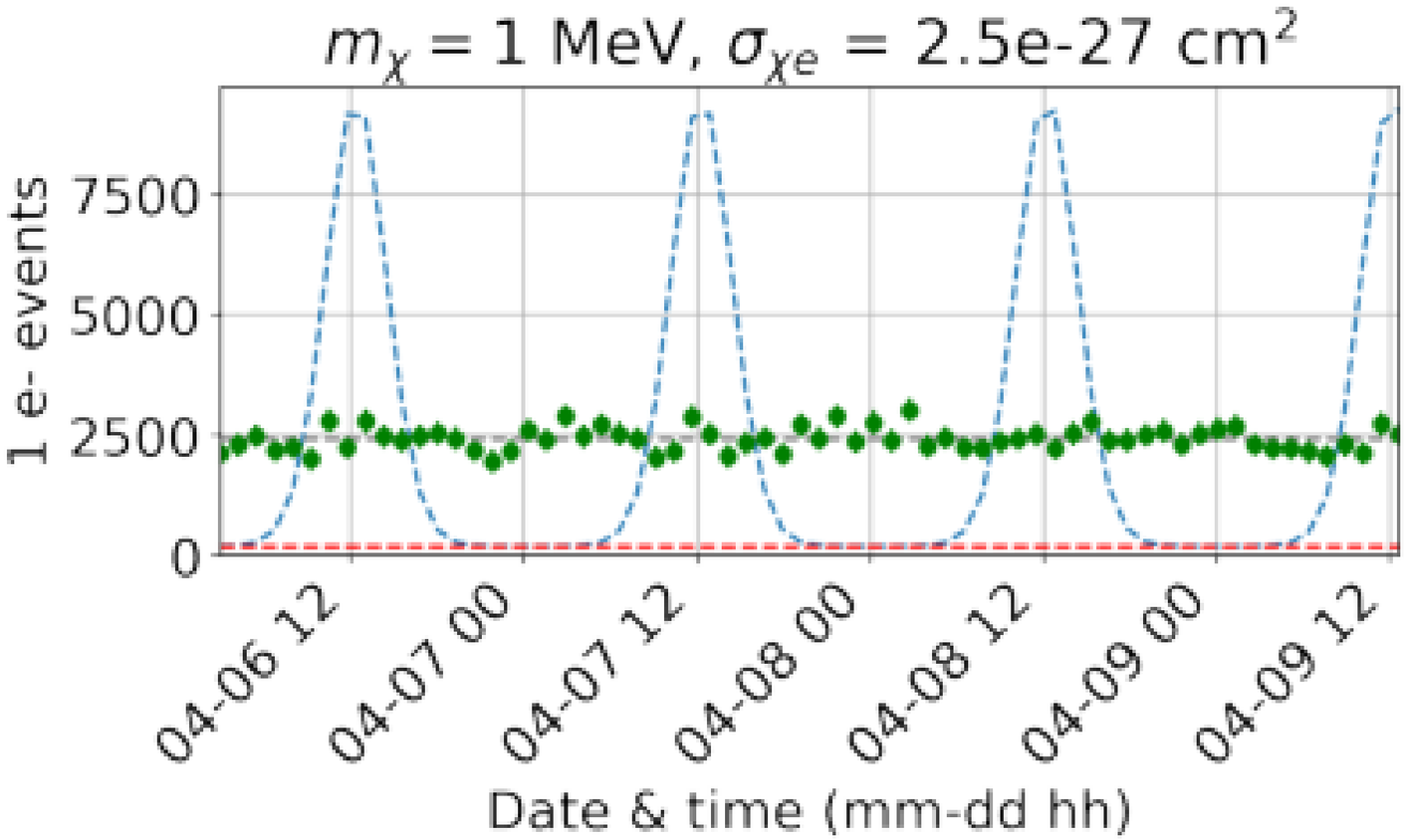
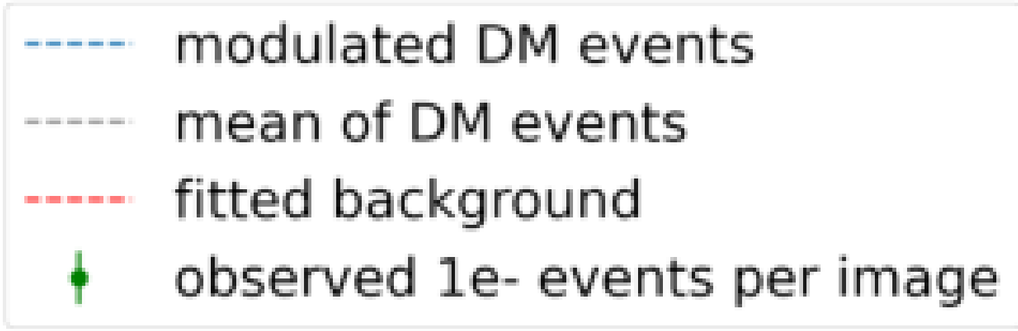


Figure 1: (a) Schematic of the main direction of the DM wind and the scattering of its particles when getting accross the Earth. A detector located in Bariloche would receive a maximum flux when Cygnus is barely above the horizon and a minimum flux 12 hours later. (b) Altitude of Cygnus for a certain time and date in August. Six months later the altitude will be shifted by 12 hours.

DMSQUARE collaboration, **Skipper CCDs for the search of a daily modulation of Dark Matter signal in the DMSQUARE experiment**

Search for a modulation: a signal above your irreducible background



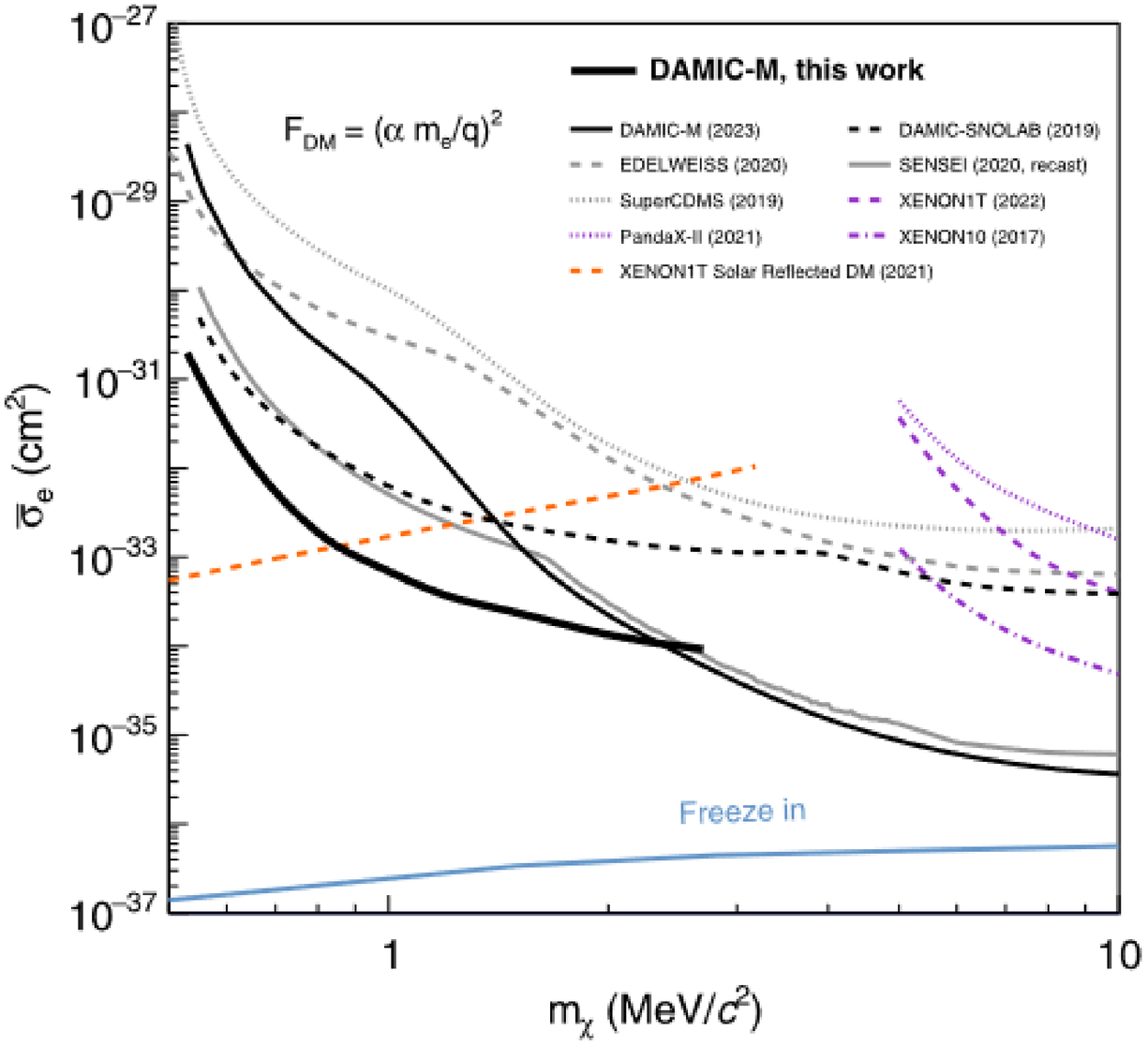


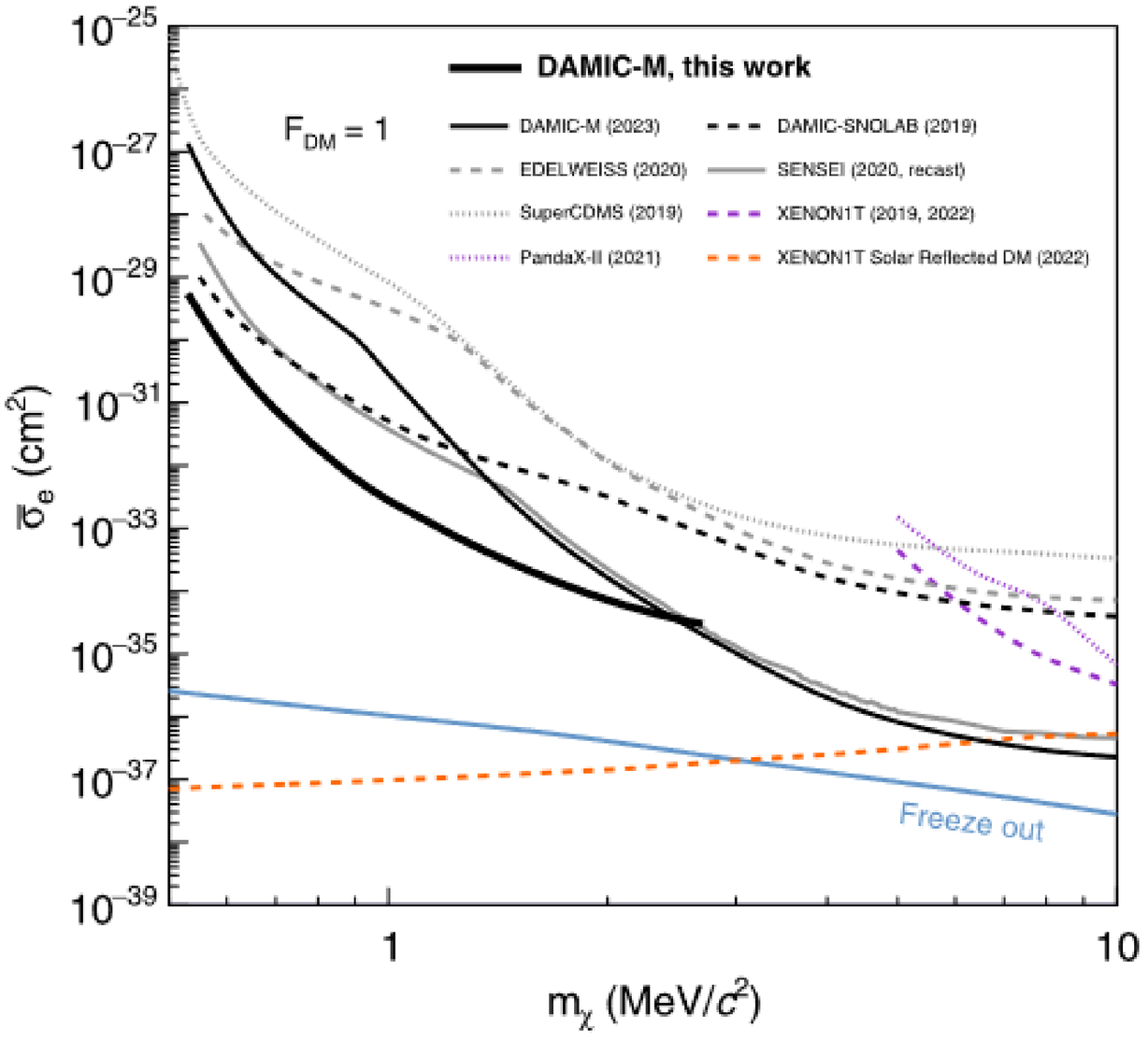
Model rejected by modulation search

DMSQUARE collaboration, **Skipper CCDs for the search of a daily modulation of Dark Matter signal in the DMSQUARE experiment**

Apparently a good idea in the northern hemisphere too

DAMIC-M is located at Laboratoire Souterrain de Modane, France

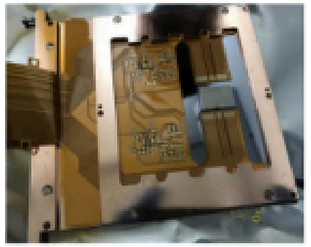




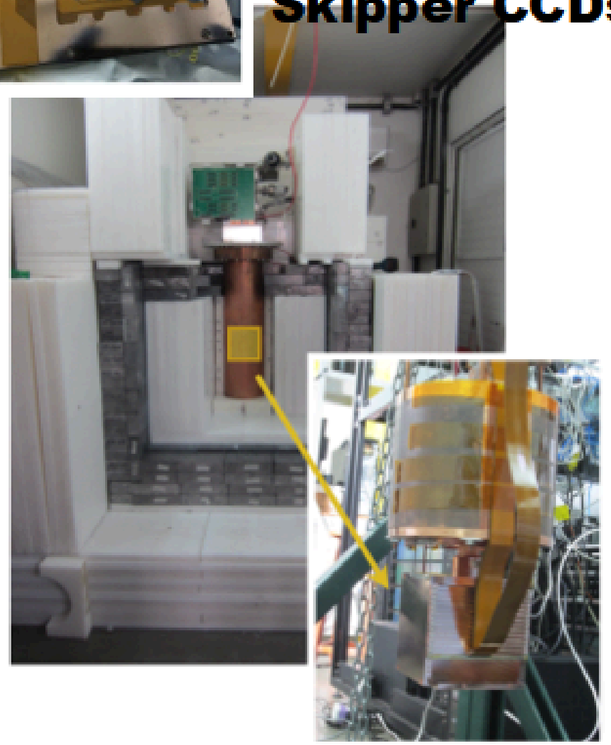
DAMIC-M Collaboration, Search for Daily Modulation of MeV Dark Matter Signals with DAMIC-M

The power of friendship: CONNIE and a dark matter search

CONNIE is a coherent neutrino-nucleus scattering search located at Angra nuclear power plant (Angra dos Reis, Brazil)



Two 0.7k x 1.2k pixel, 675 um thick Skipper CCDs



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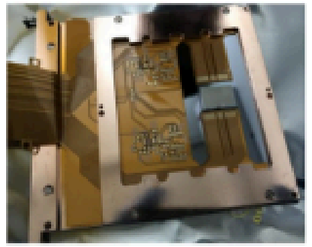

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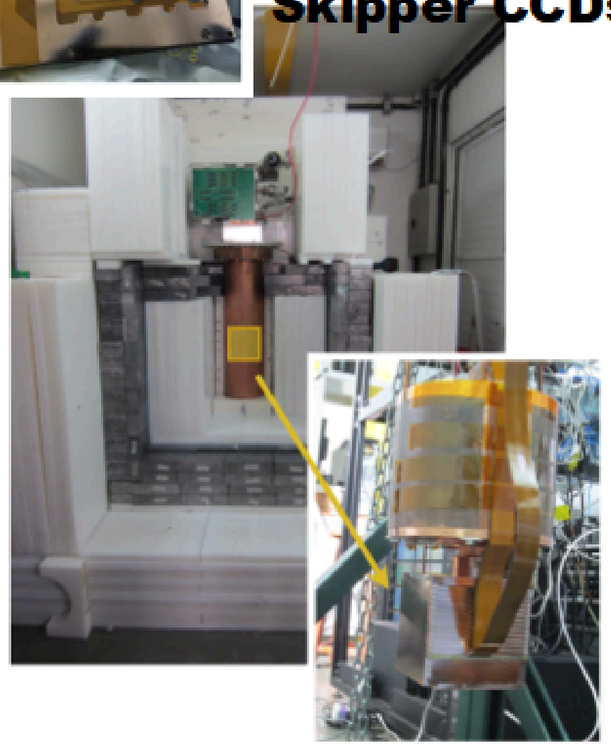
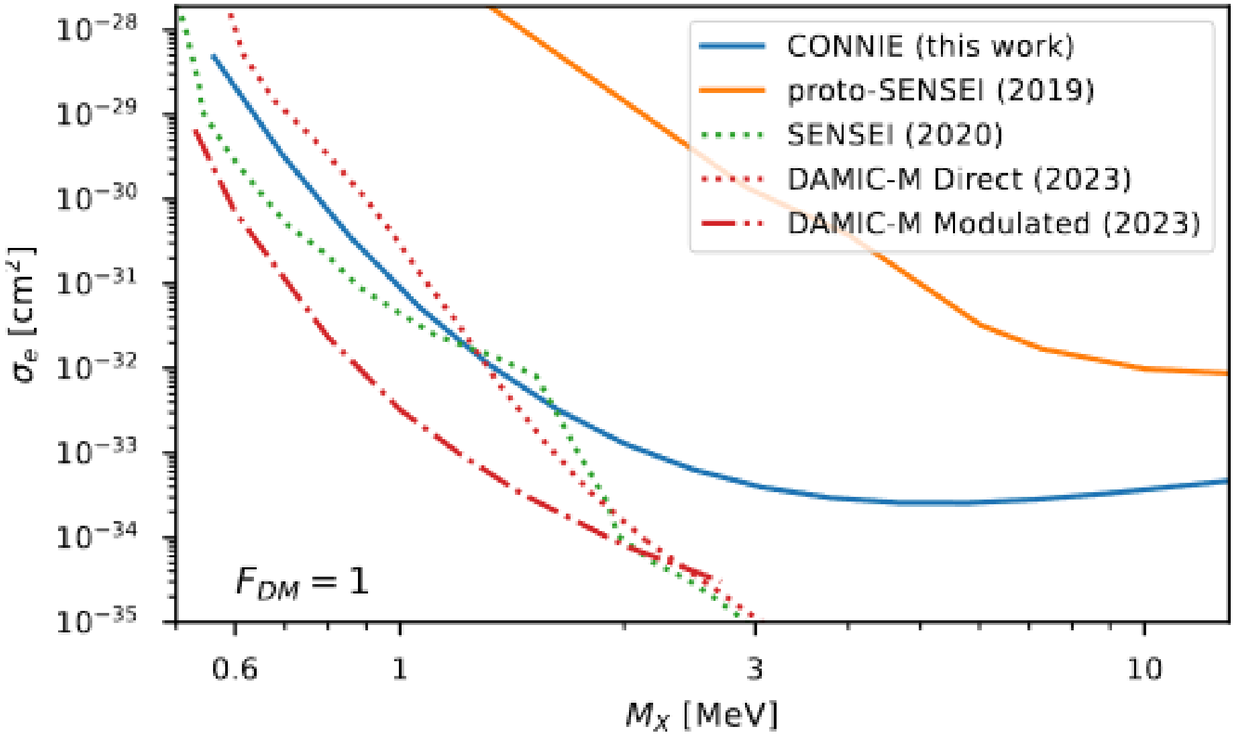
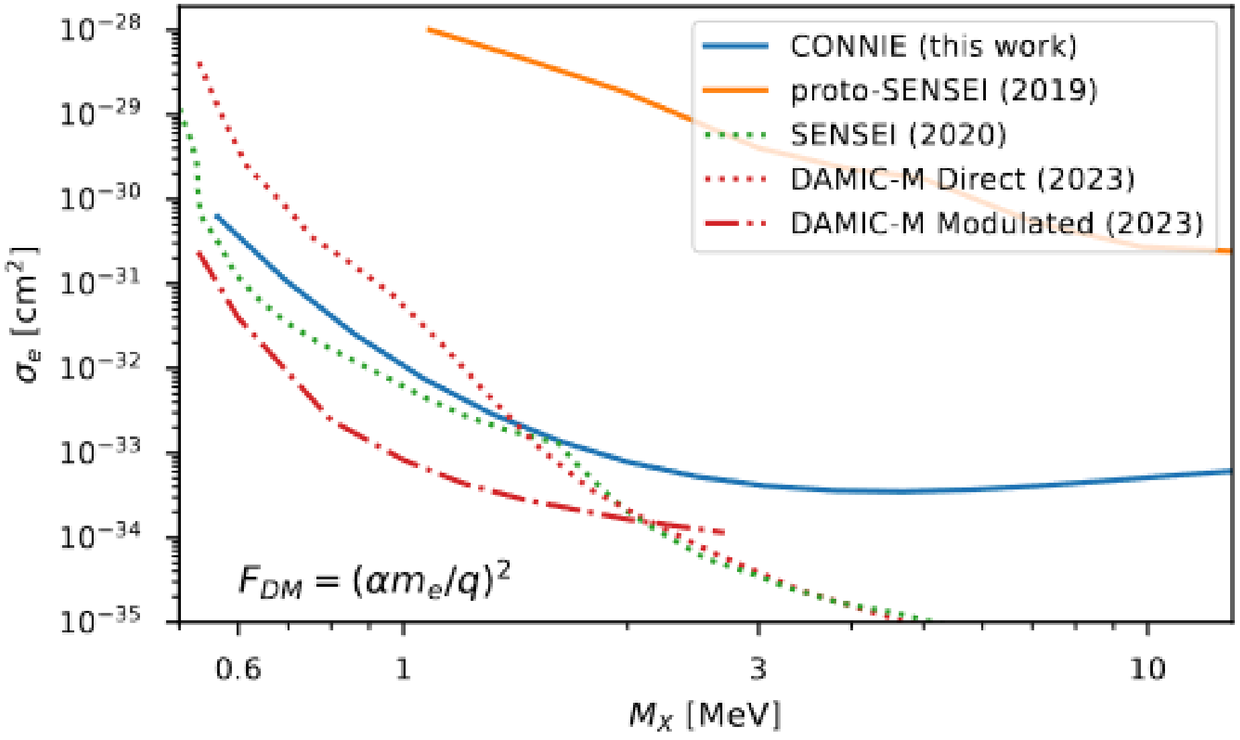


They recently replaced their CCDs by Skipper CCDs, lowering the detection threshold

So... what if we repeat the search with CONNIE Skipper data?

Pretty good for an experiment performed at surface level

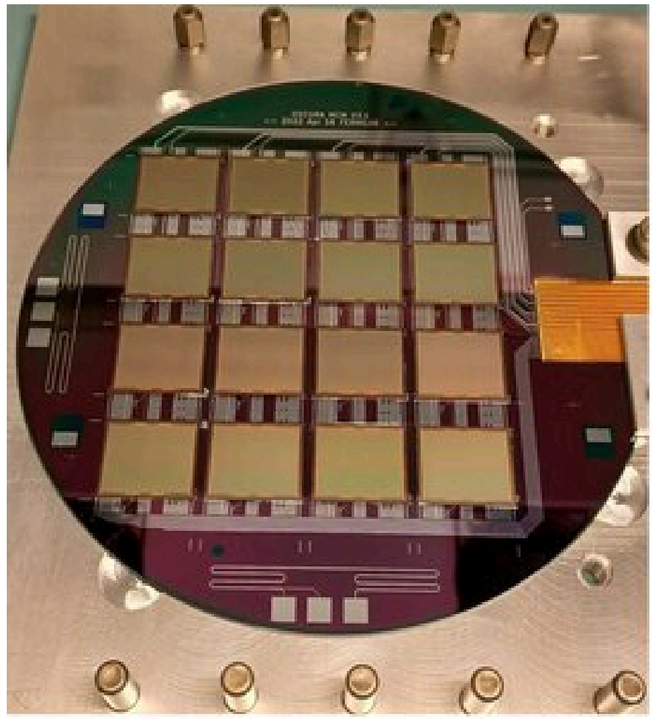




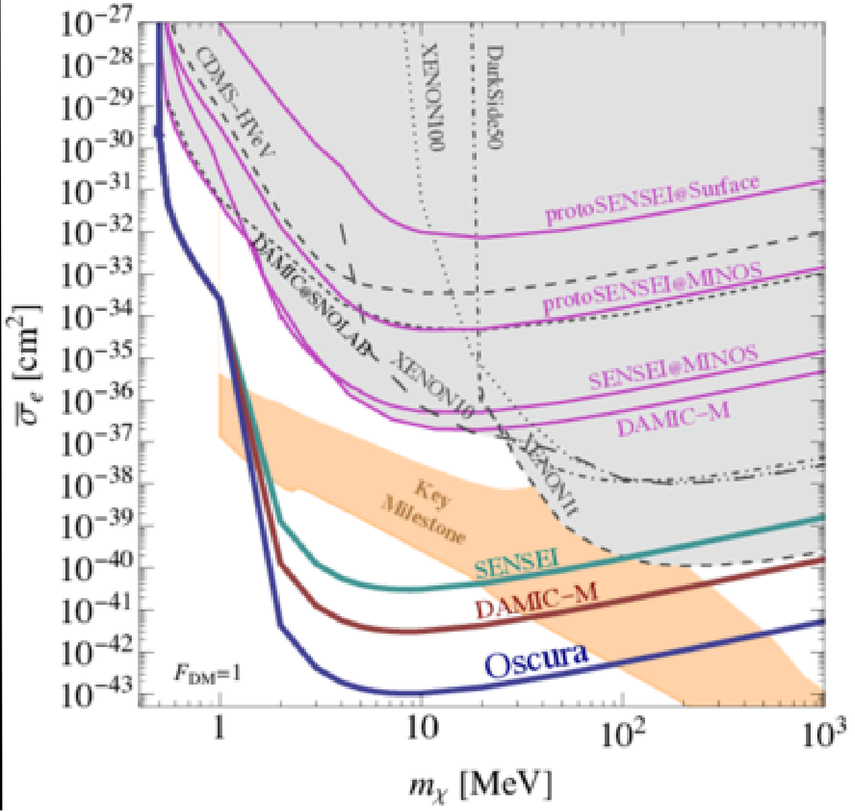
CONNIE Collaboration, *Searches for CEvNS and Physics beyond the Standard Model using Skipper-CCDs at CONNIE*

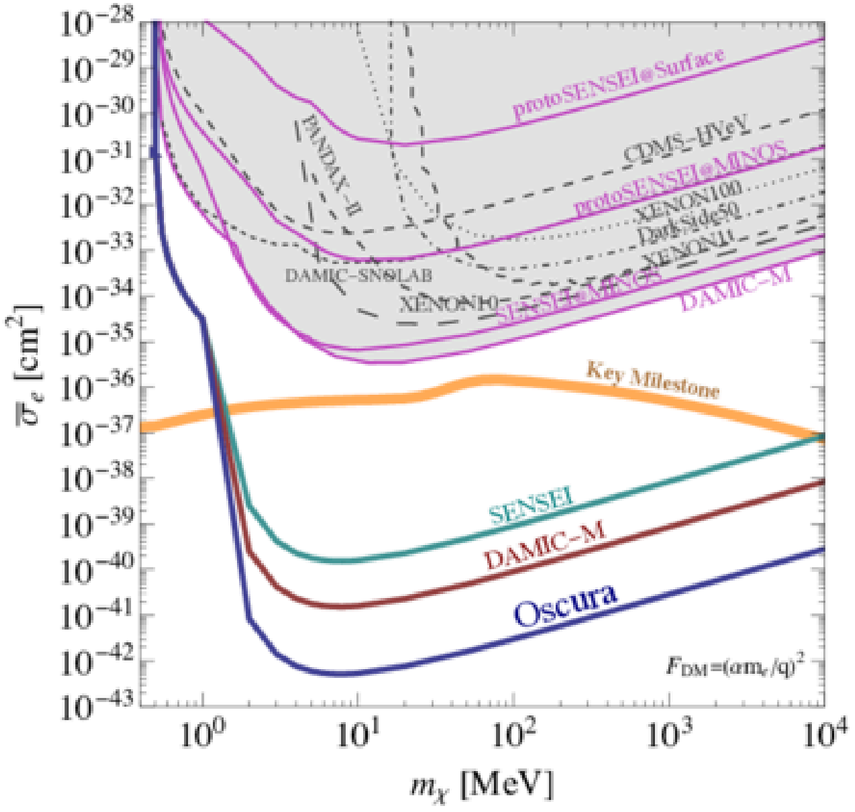
The future: CONNIE with MCMs, DAMIC-M full experiment, OSCURA

Multi-chip module (MCM)



Projected sensitivity





Cervantes-Vergara, Brenda *et. al.* (2023). *Skipper-CCD sensors for the Oscura experiment: requirements and preliminary tests*

Summary

Combined power of Skipper CCDs and modulation searches yield the best constraints in the parameter space for O(MeV) DM mass

Infinite possible models, infinite work to be done

Stay tuned for the future: CONNIE upgrade, DAMIC-M, OSCURA (& hopefully my PhD thesis before)

Thank you for listening

(Now prove it and ask questions)

Message to fellow (or future) PhD students

- **All ideas are worth checking out (especially in Dark Matter detection)**

- **There are many things to be done:**
  - **Software (analysis, data acquisition)**
  - **Simulations**
  - **Statistical analysis**
  - **Understand new DM models implications**
  - **Public outreach & communication**
  - **...**

- **Make contacts!**