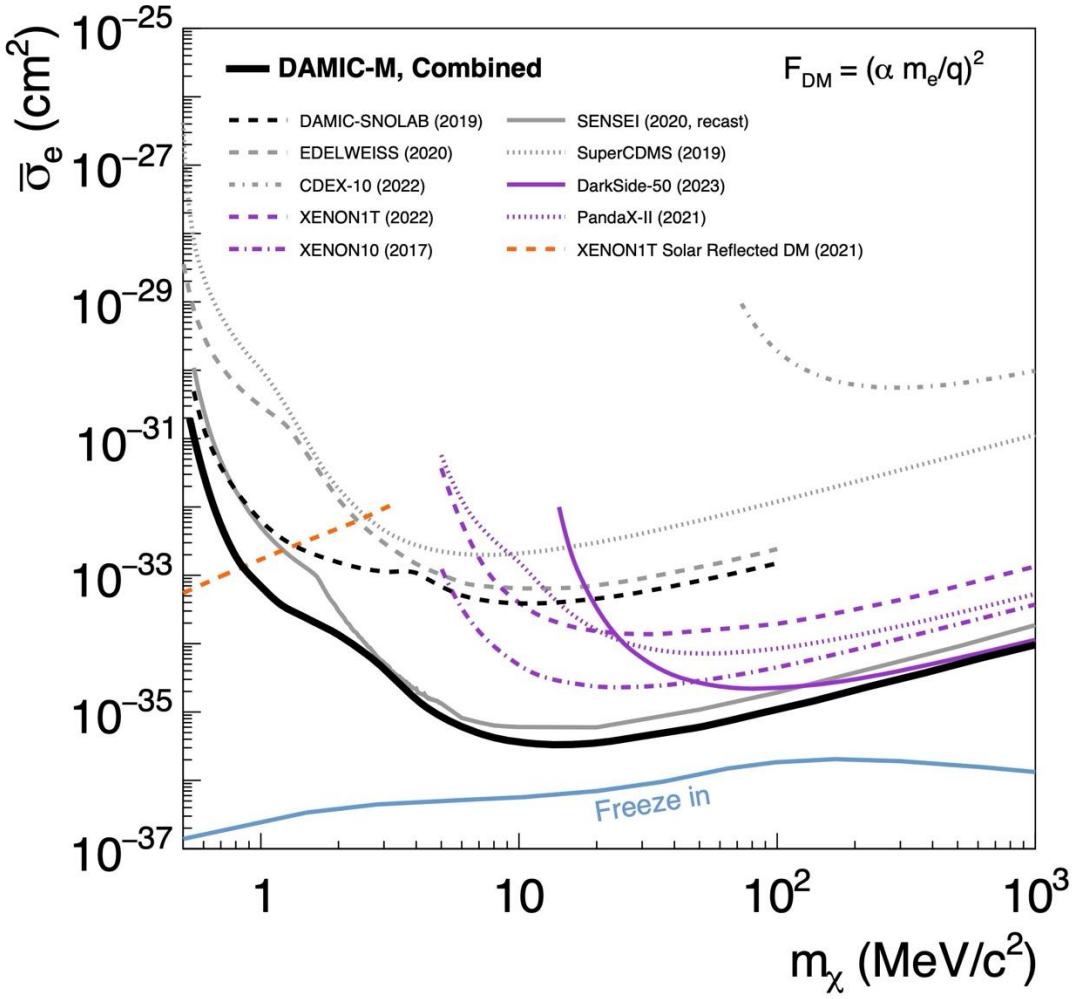
Looking for Dark Matter at the DAMIC-M experiment

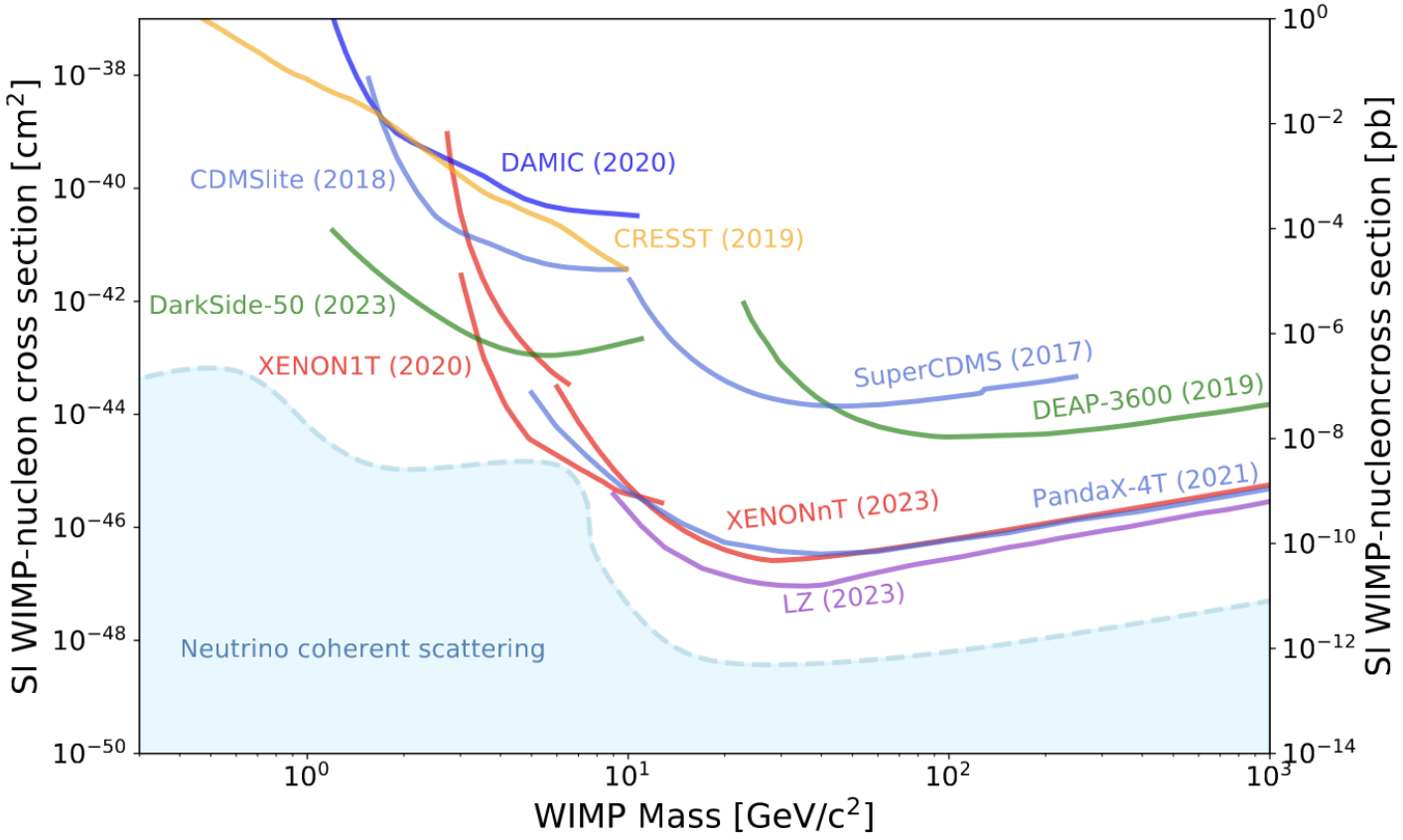
X. Bertou

on behalf of DAMIC-M

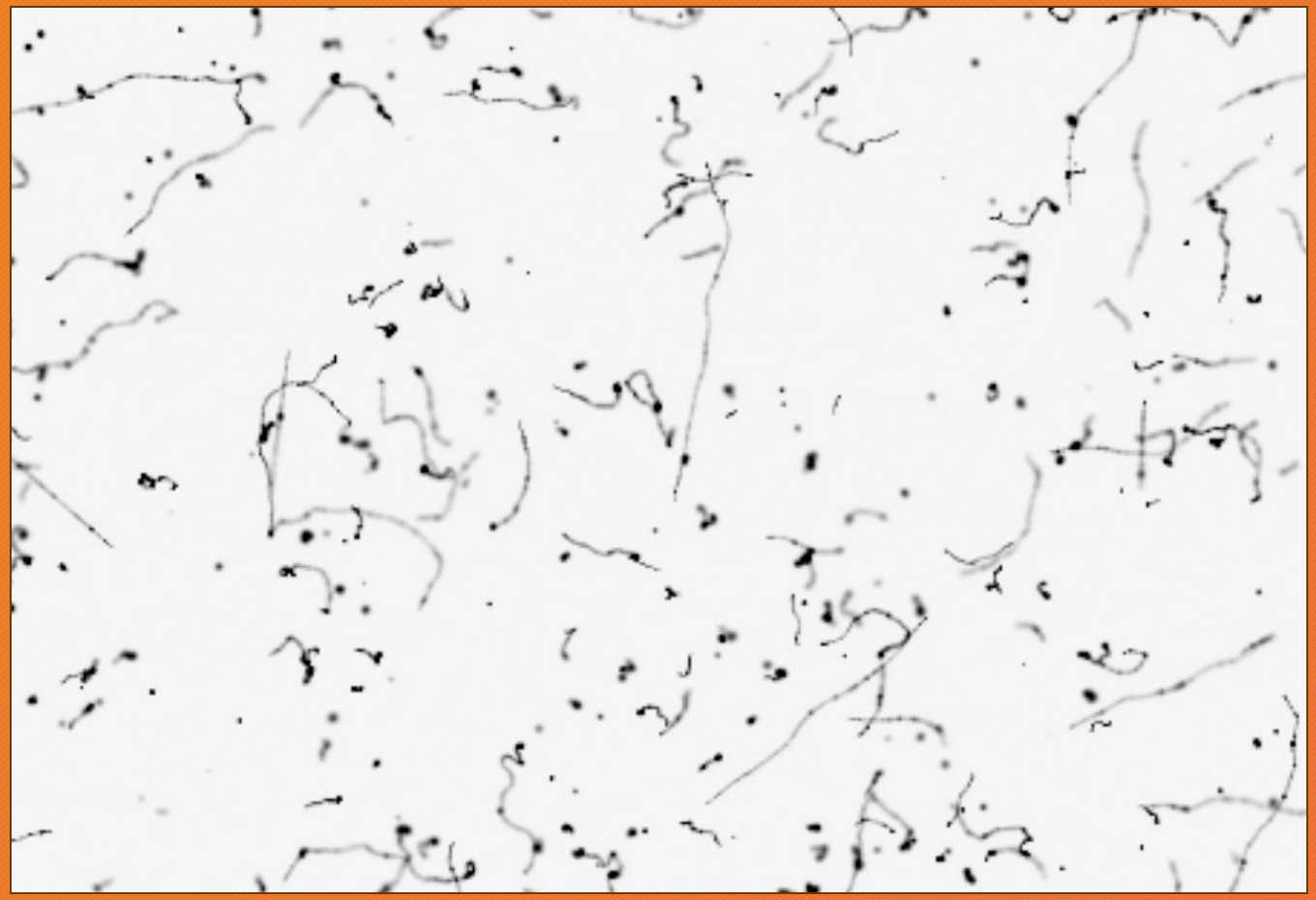
XV Latin American Symposium on High Energy Physics

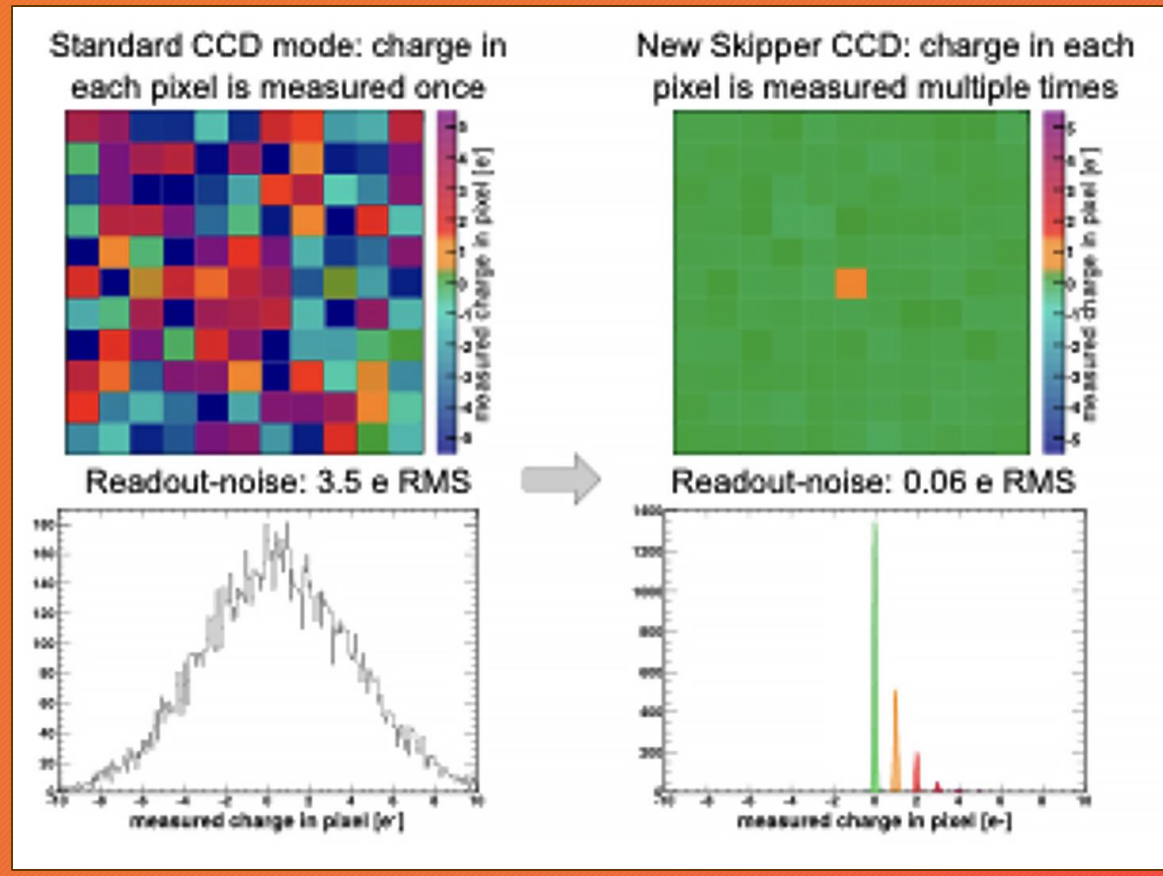
Direct search for Dark Matter



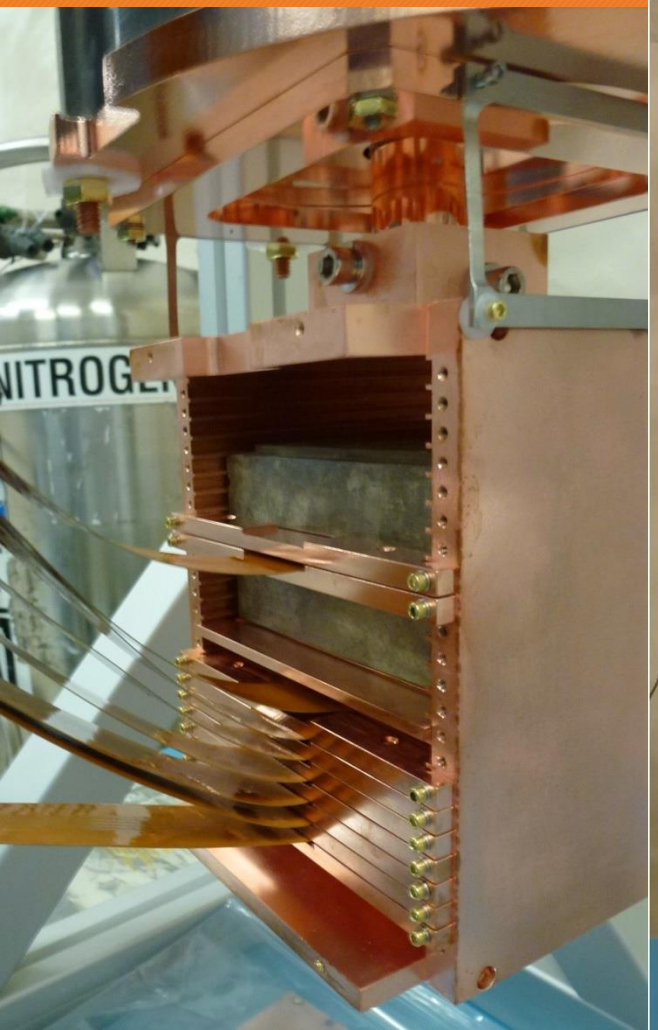


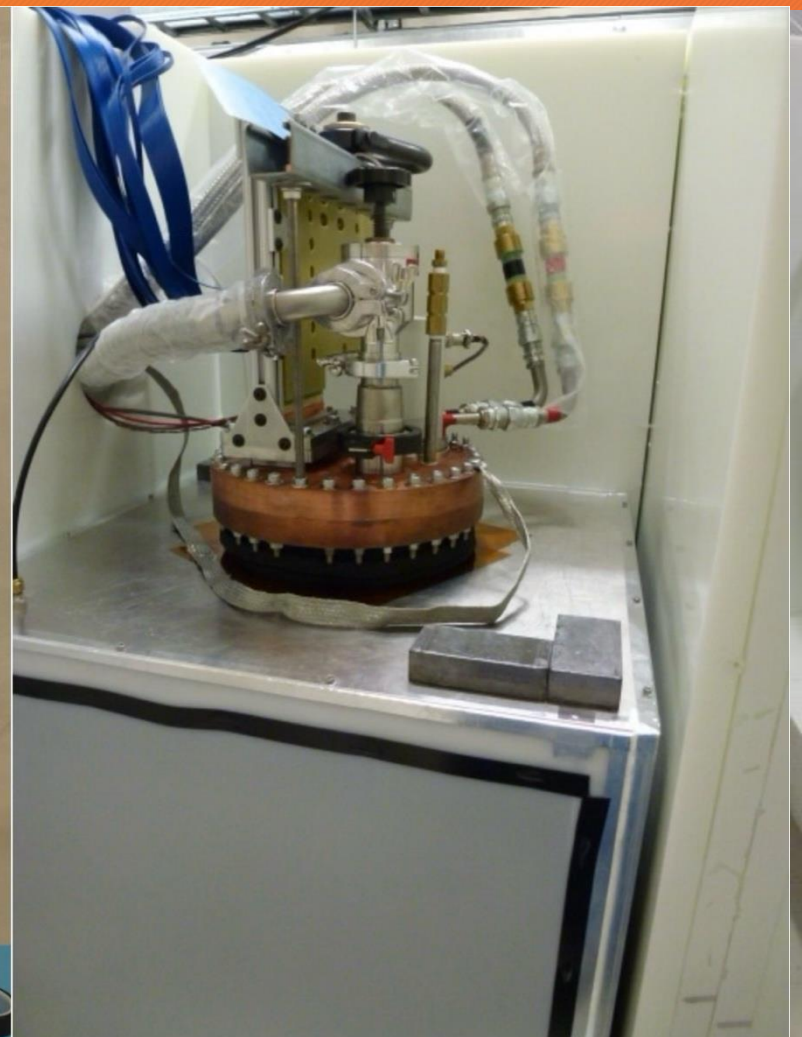
Skipper CCDs as Dark Matter detectors





Dark Matter in CCD (DAMIC) @SNOLAB



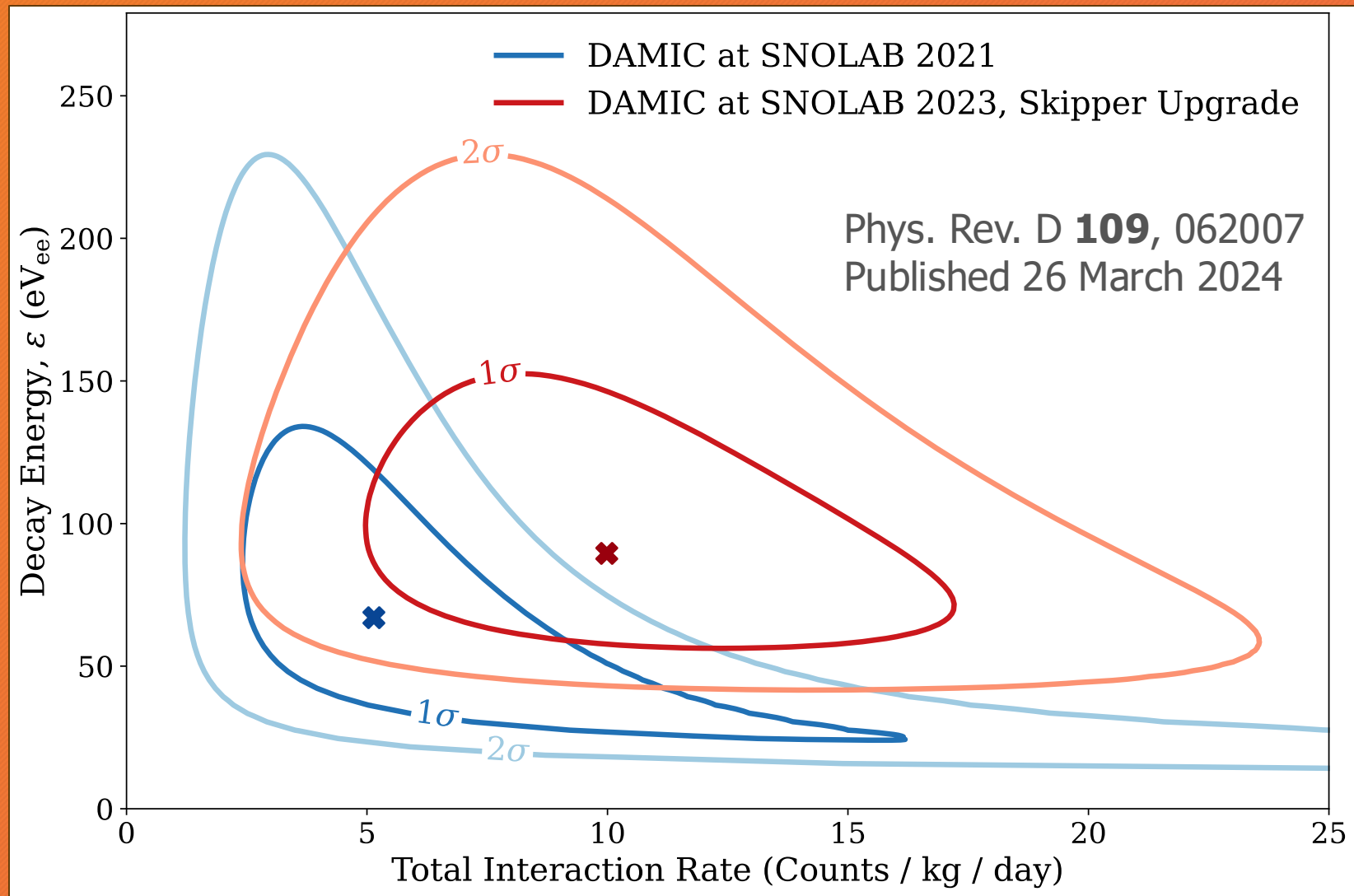


DAMIC @ SNOLAB excess

Regular CCD:
- 11 kg.day

Skipper CCD:
- 4.8 kg.day

Unexpected new source of background (potential signal incompatible with Dark Side limits)



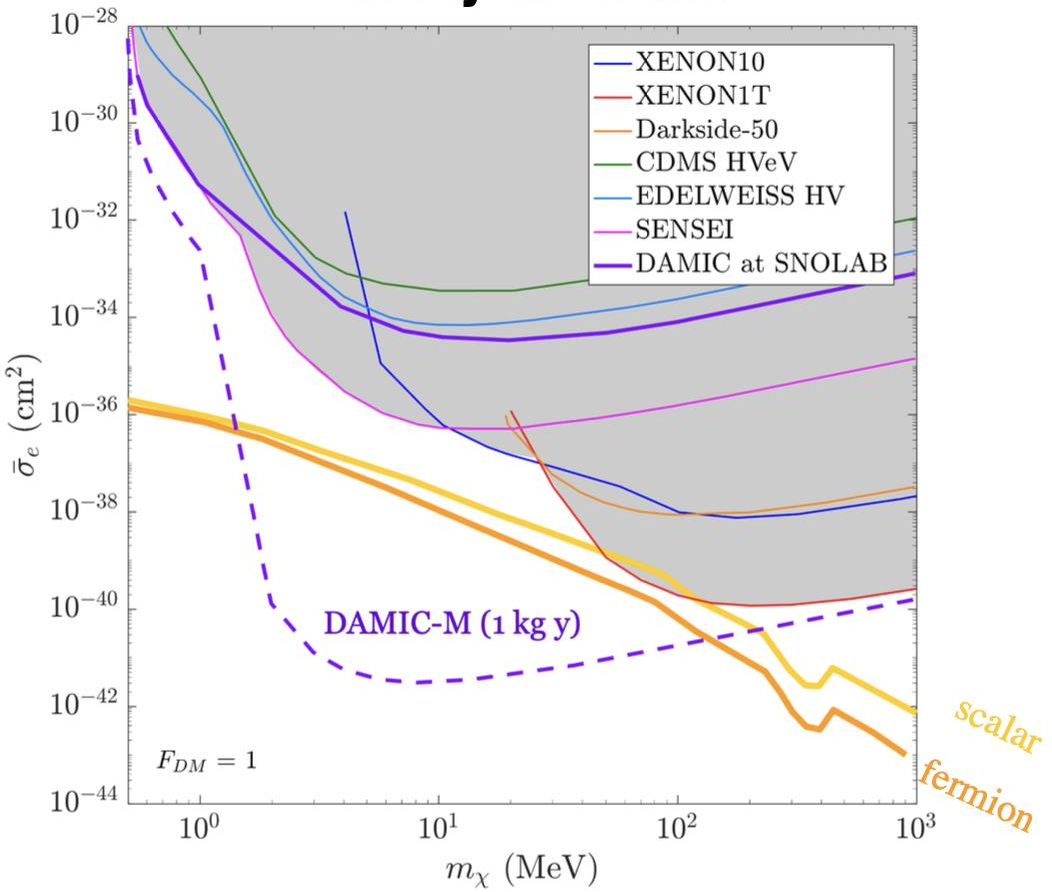
SNOLAB
LPNHE
PARIS
IJCLab
Irène Joliot-Curie
Universität
Zürich[UZH]
UNIVERSITY OF WASHINGTON
1861
JOHNS HOPKINS
UNIVERSITY
LSM
Laboratoire Souterrain de Modane
Pacific Northwest
NATIONAL LABORATORY
THE UNIVERSITY OF CHICAGO
1890
Subatech
CNEA
Comisión Nacional
de Energía Atómica
IFCA
Instituto de Física de Cantabria
erc
European Research Council
Established by the European Commission
NSF
DAMIC-M

Dark Matter in CCD at Modane

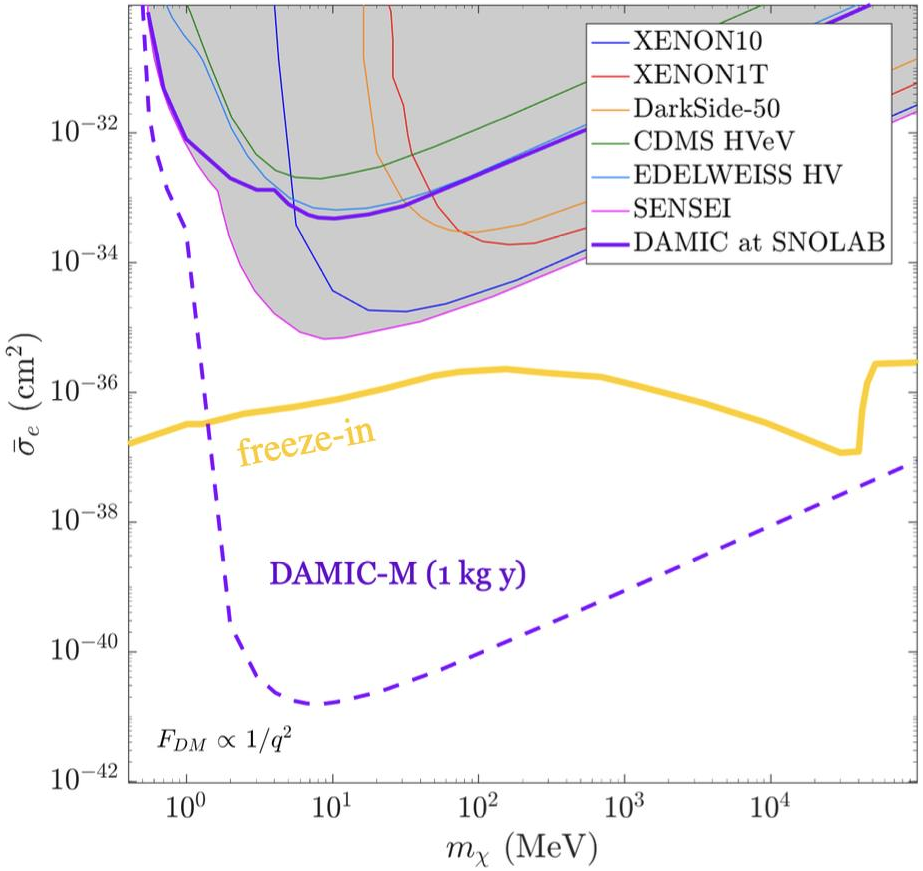
- Physics goal: detect nuclear and electron recoils to search for light dark matter candidates (eV to GeV)
- LSM (1700 m of rock overburden, 4800 mwe)
- Mode of operation:
  - Use thick (675 um), massive (~ 3.4 g), 9 Mpix skipper CCDs
  - skipper guarantees calibration and single electron threshold
  - CCD gives imaging technique for defect rejection
  - Array of 212 CCDs for kg-scale mass
  - Achieve ~ 0.5 dru background rate (0.5 event/keV/kg/day)
  - 1kg-year exposure to reach discovery potential

Electron recoil: DAMIC-M and Dark Sector

heavy mediator



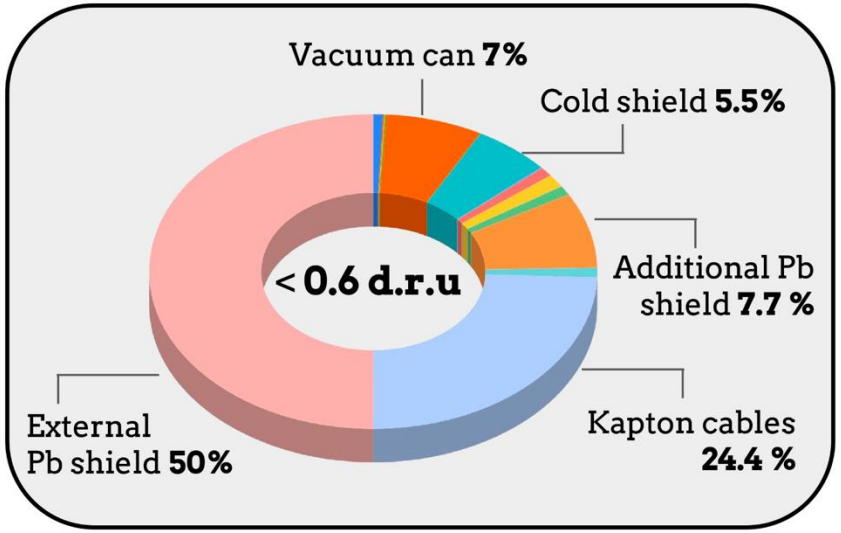
ultra-light mediator



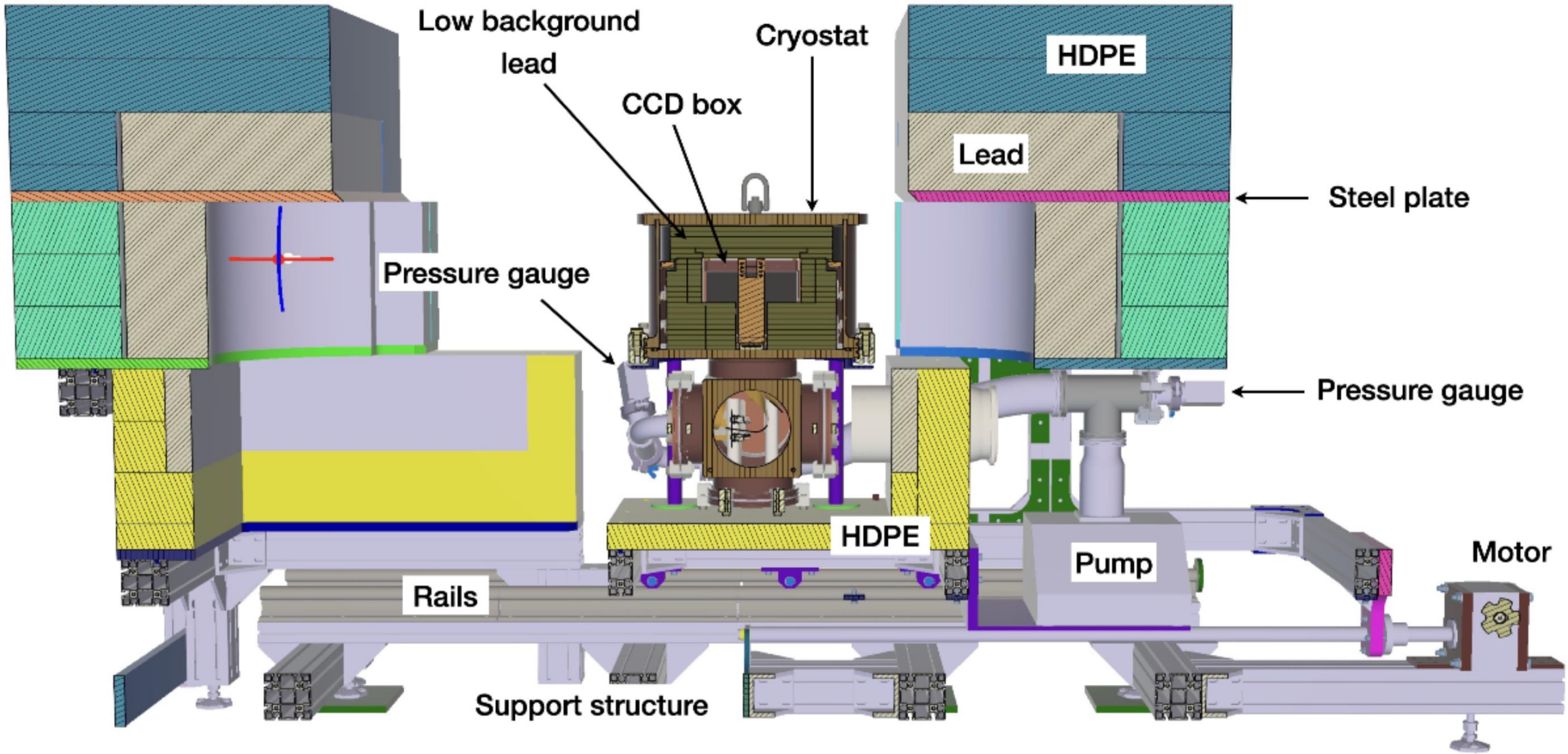
Background mitigation challenge

- Reduce silicon activation (expedite production, underground storage, transport in a container with 16-ton iron shielding)
- Strict control of exposure to Radon and dust, chemical cleaning
- Ultra-clean flex cables
- Underground machined electro-formed copper
- Ancient lead + low activity lead shielding

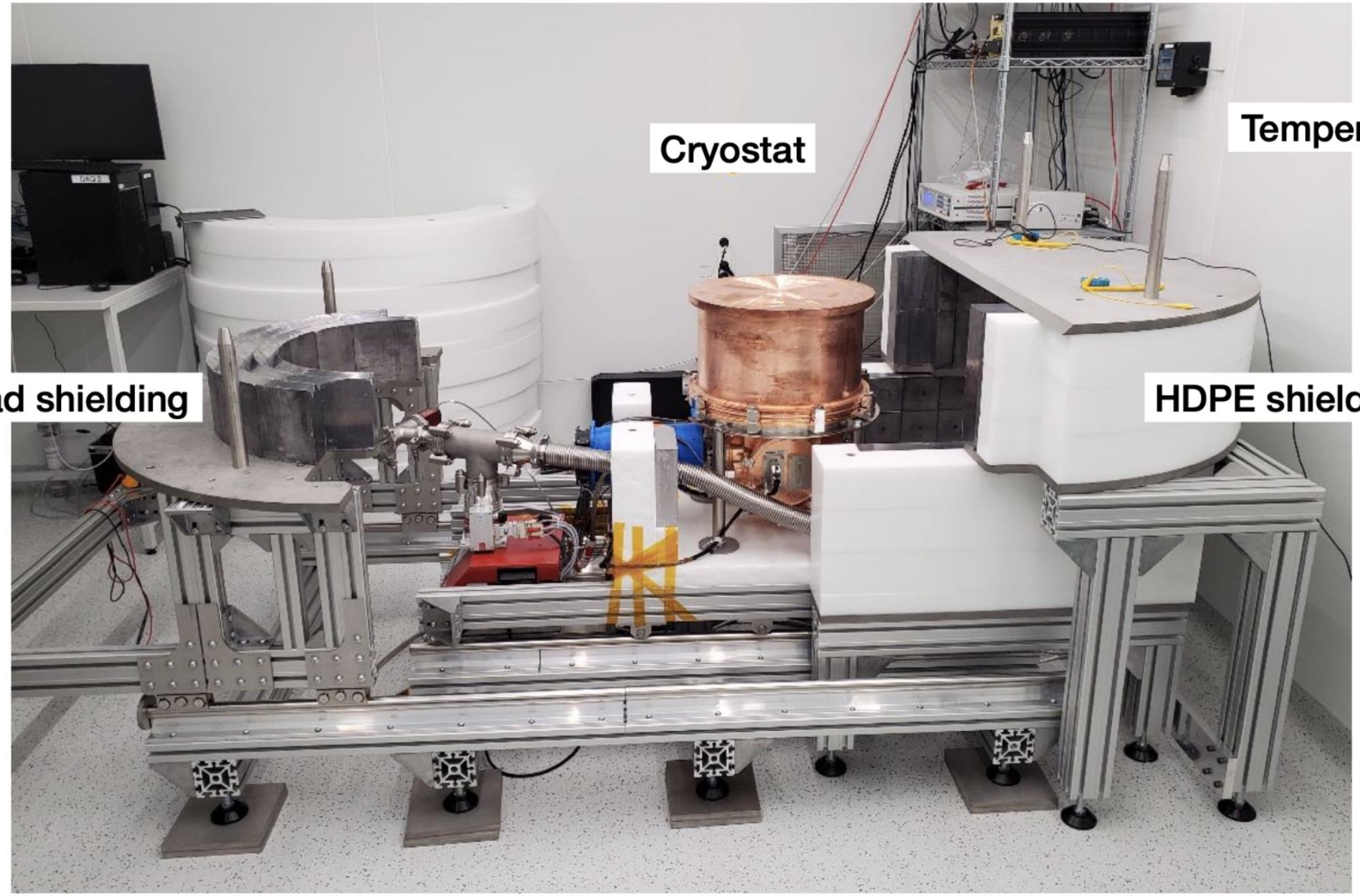
- Design validation with Geant4



Low Background Chamber (LBC)


Low background
lead
Cryostat
CCD box
HDPE
Lead
Steel plate
Pressure gauge
Pressure gauge
HDPE
Pump
Motor
Rails
Support structure

CCD controllers and power supplies



DAQ and slow control PCs

Cryostat

Temperature controller

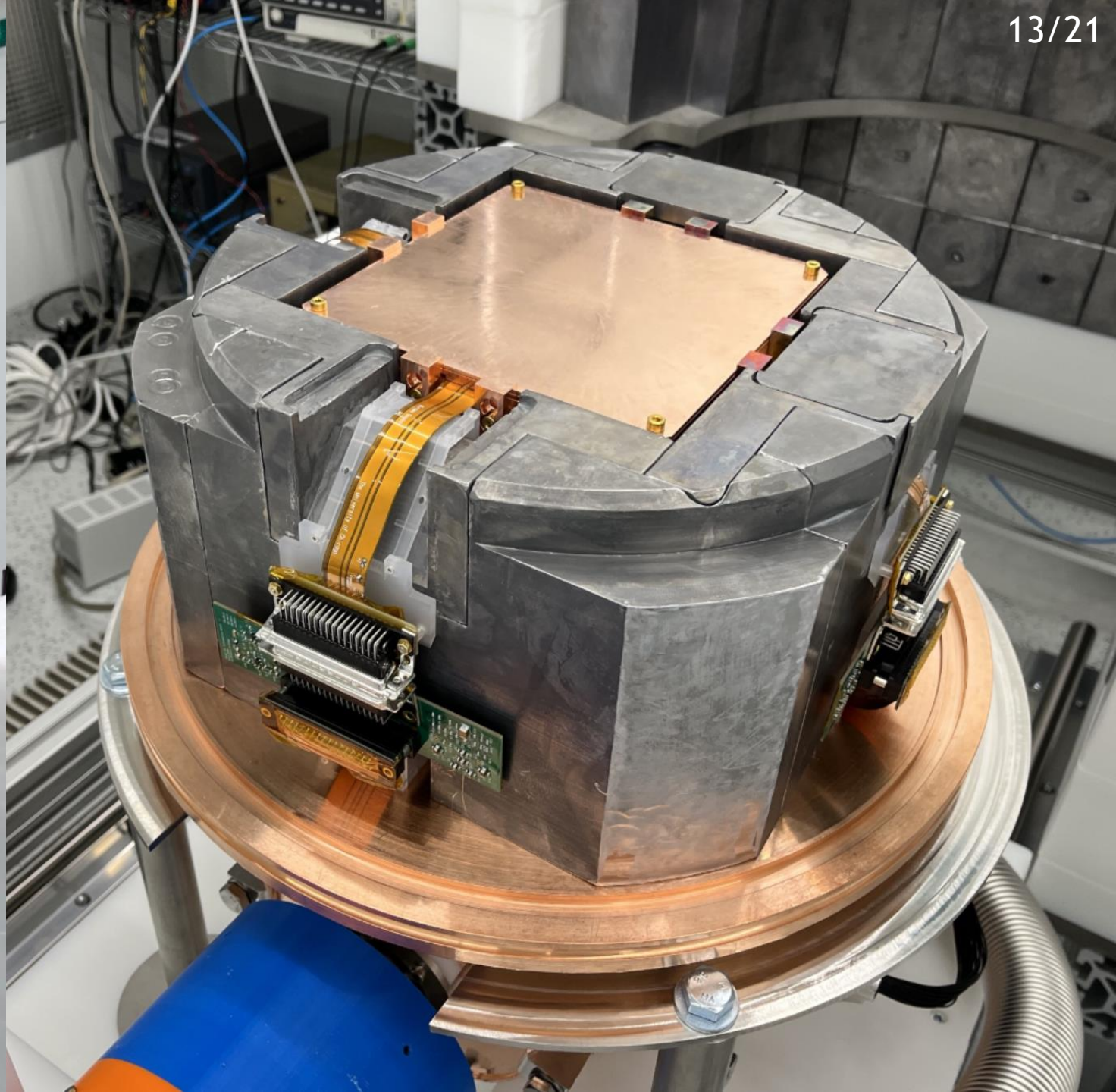
External lead shielding

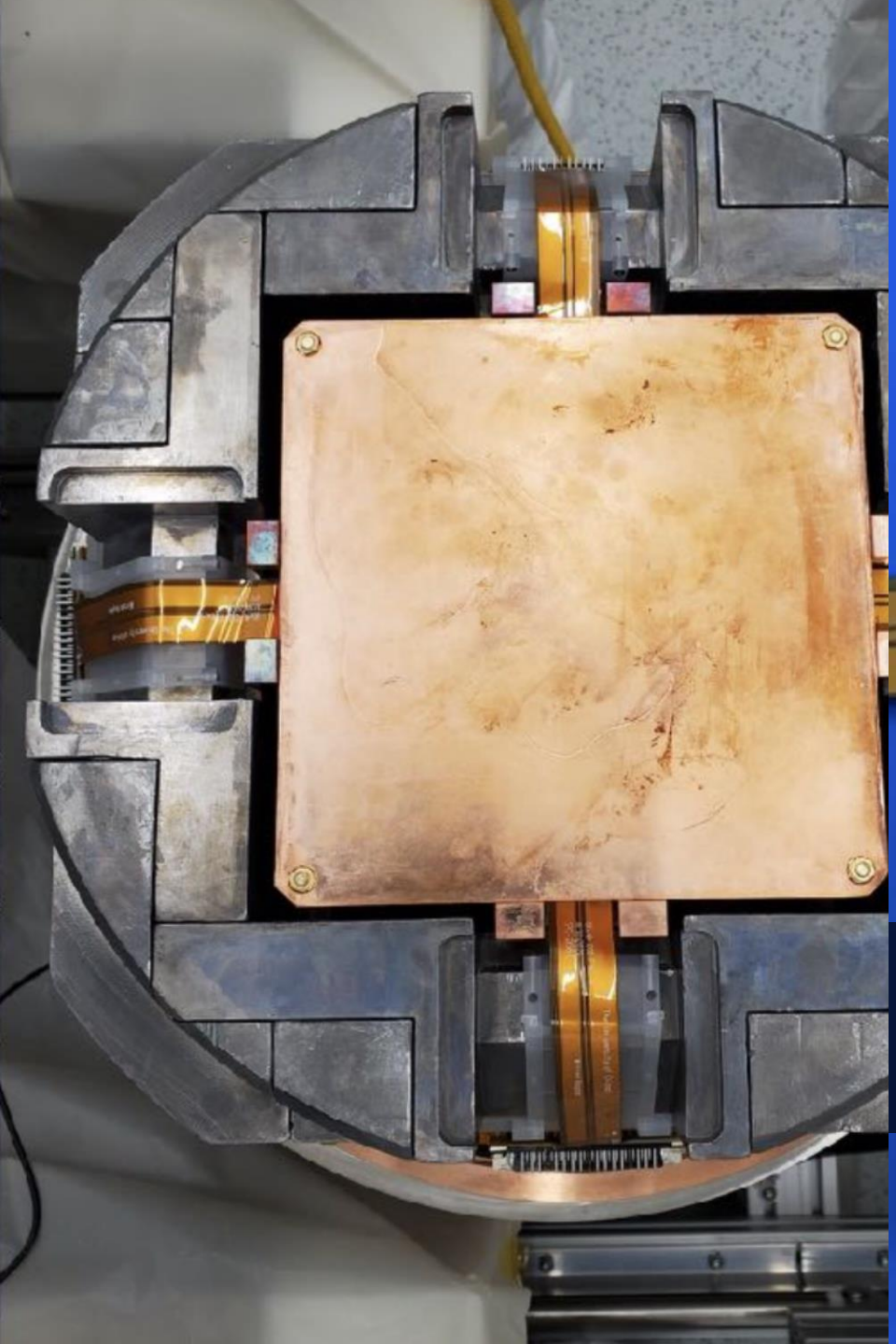
HDPE shielding

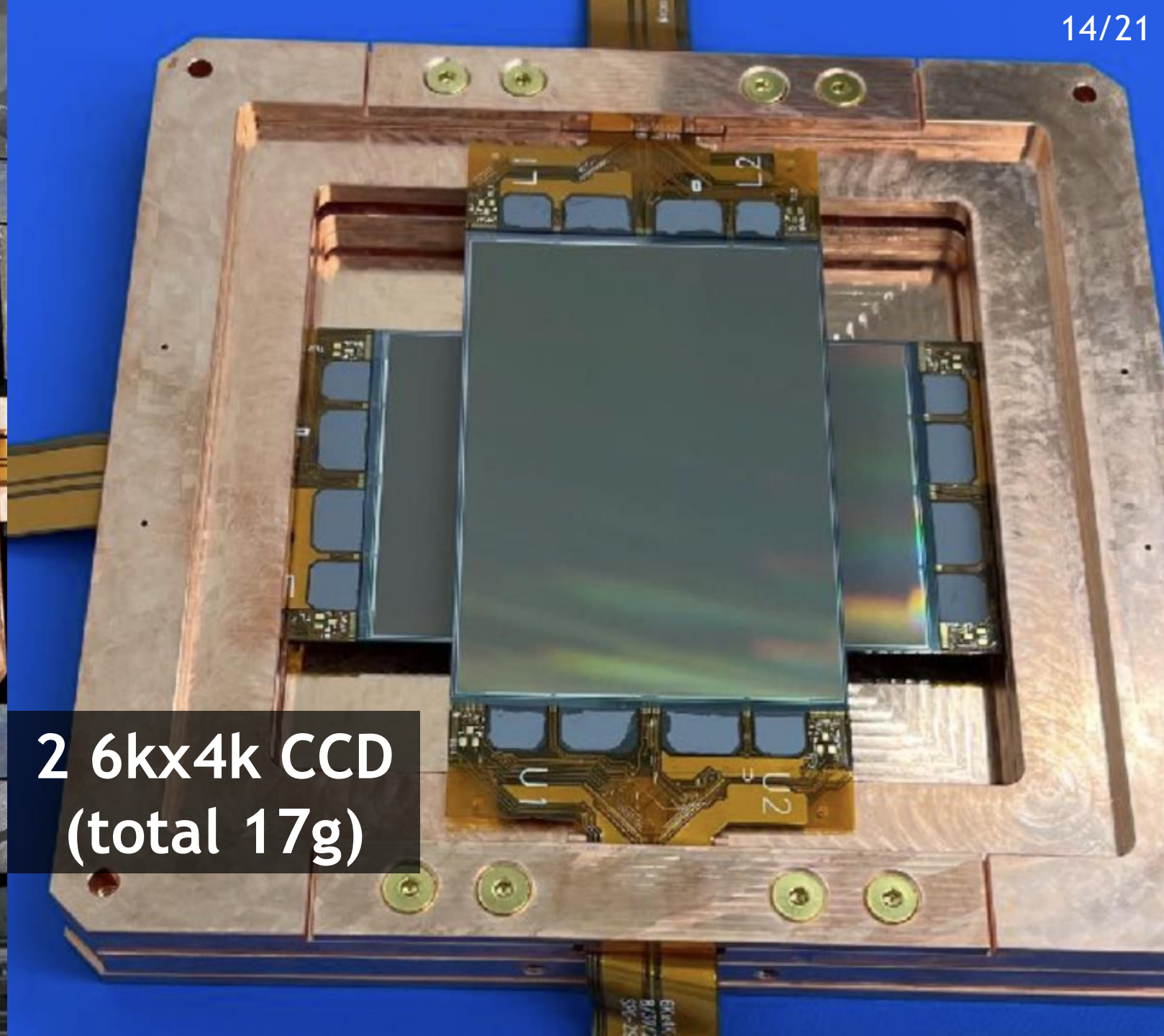
Support structure

Vacuum pump and pressure gauges

Temperature



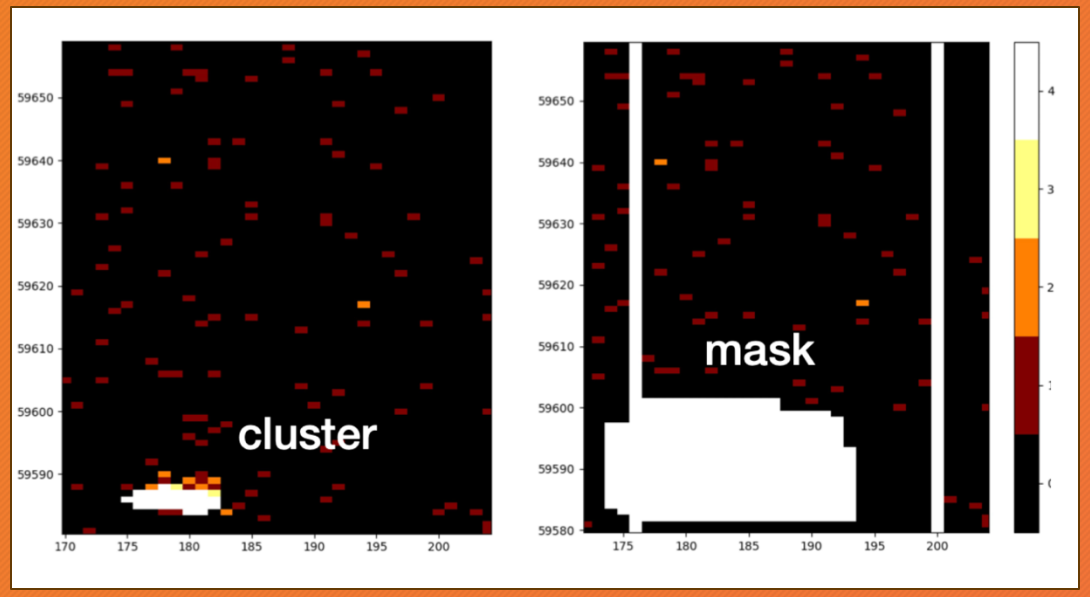


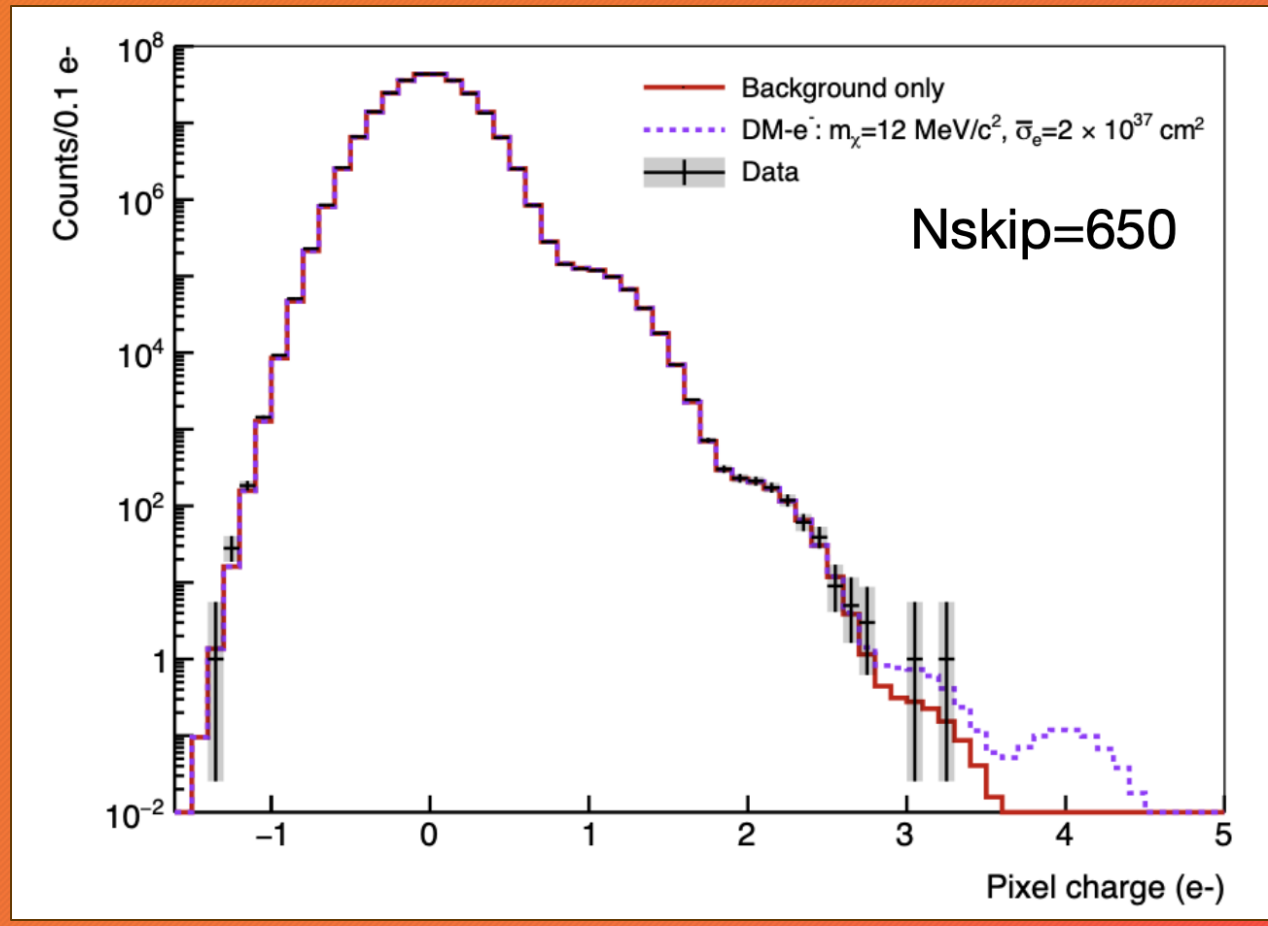


2 6kx4k CCD
(total 17g)

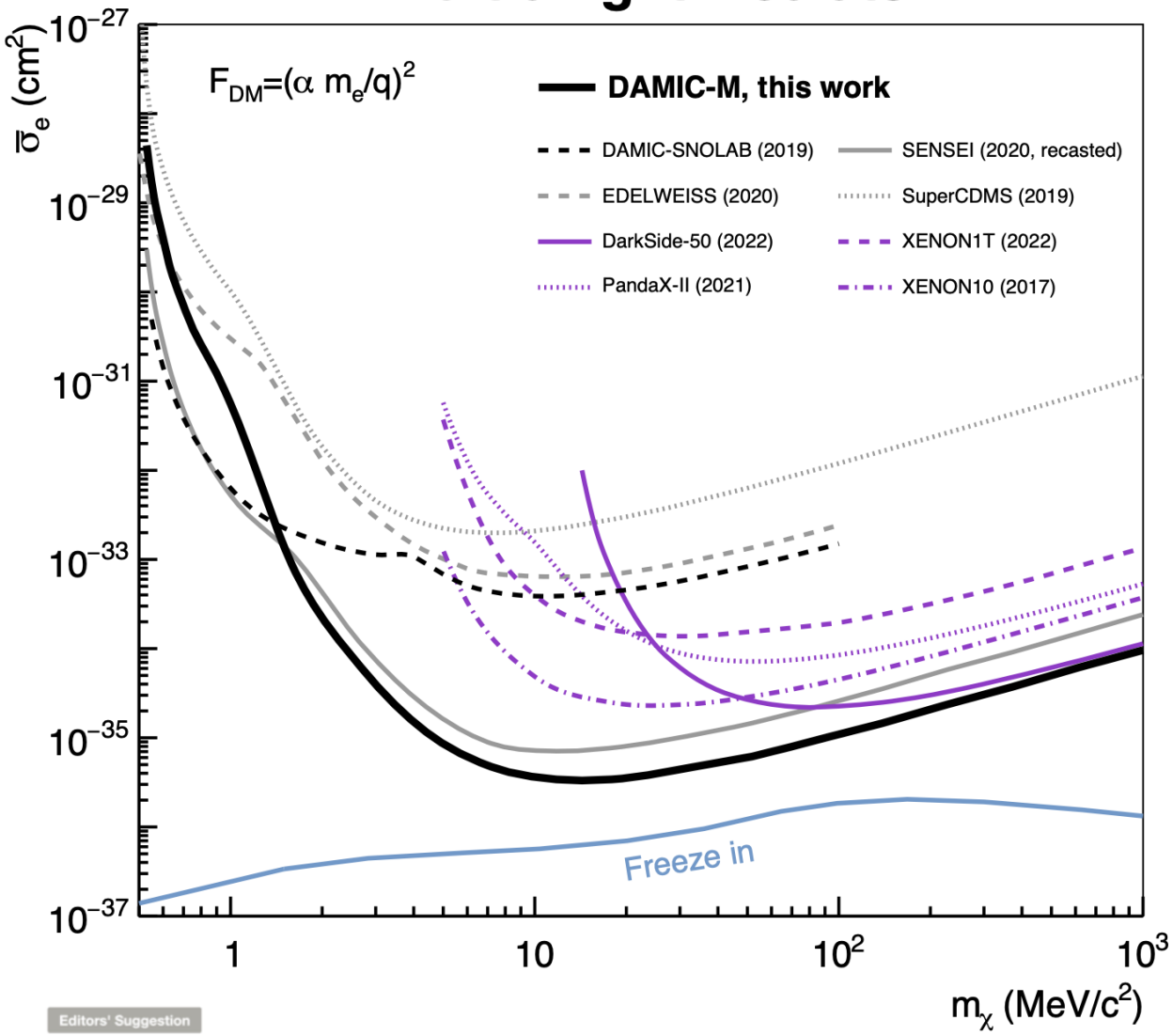
LBC science run

- Cluster and CTI removal (less that 1% of data)
- Hot columns removal (~30% of data)

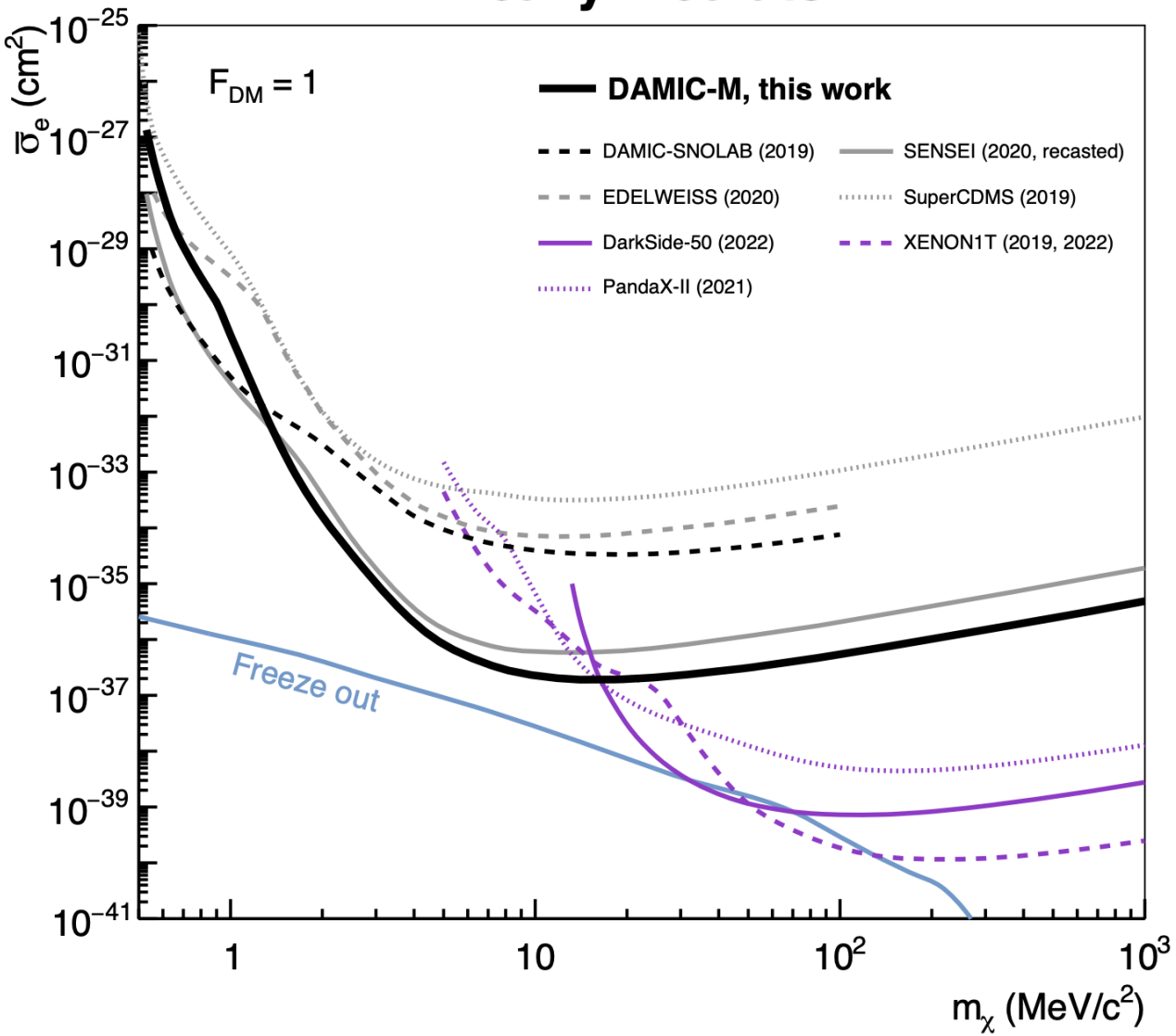




ultra-light mediator



heavy mediator

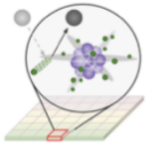


Editors' Suggestion

First Constraints from DAMIC-M on Sub-GeV Dark-Matter Particles Interacting with Electrons

I. Arnquist *et al.* (DAMIC-M Collaboration)

Phys. Rev. Lett. **130**, 171003 (2023) – Published 28 April 2023



World-leading constraints are placed on electron interactions with dark matter in the MeV to GeV range by the first underground operation of a new CCD detector.

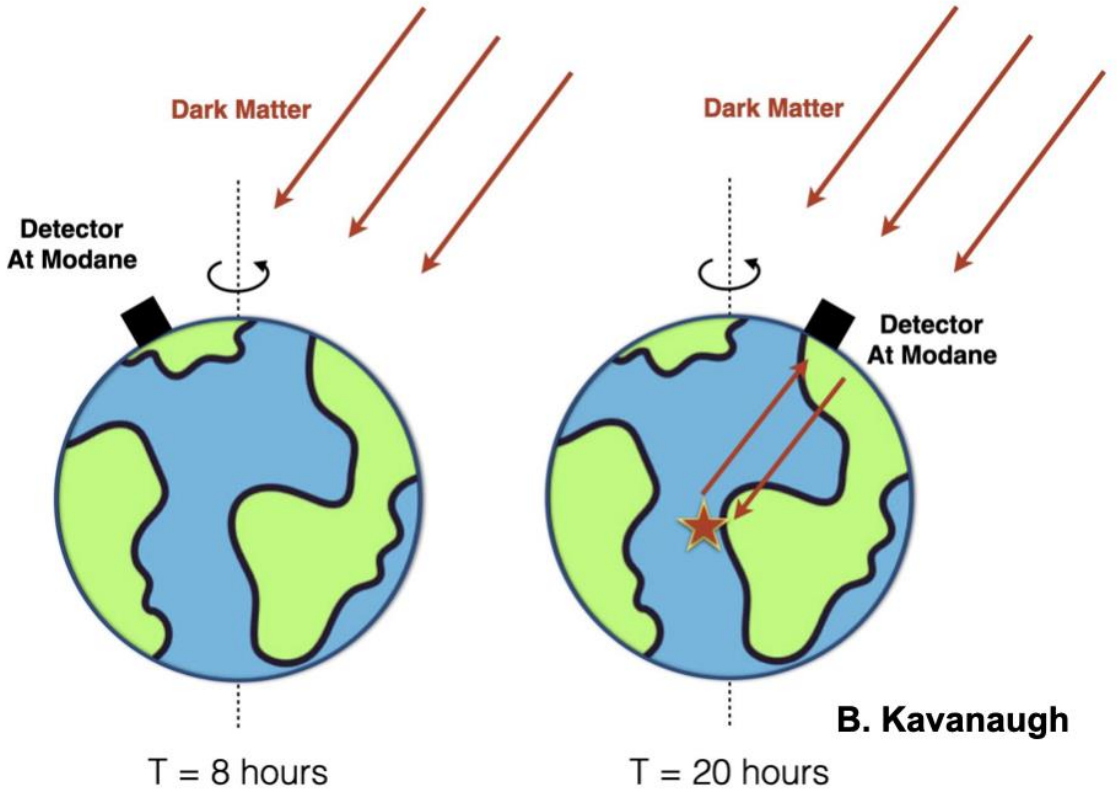
Show Abstract +

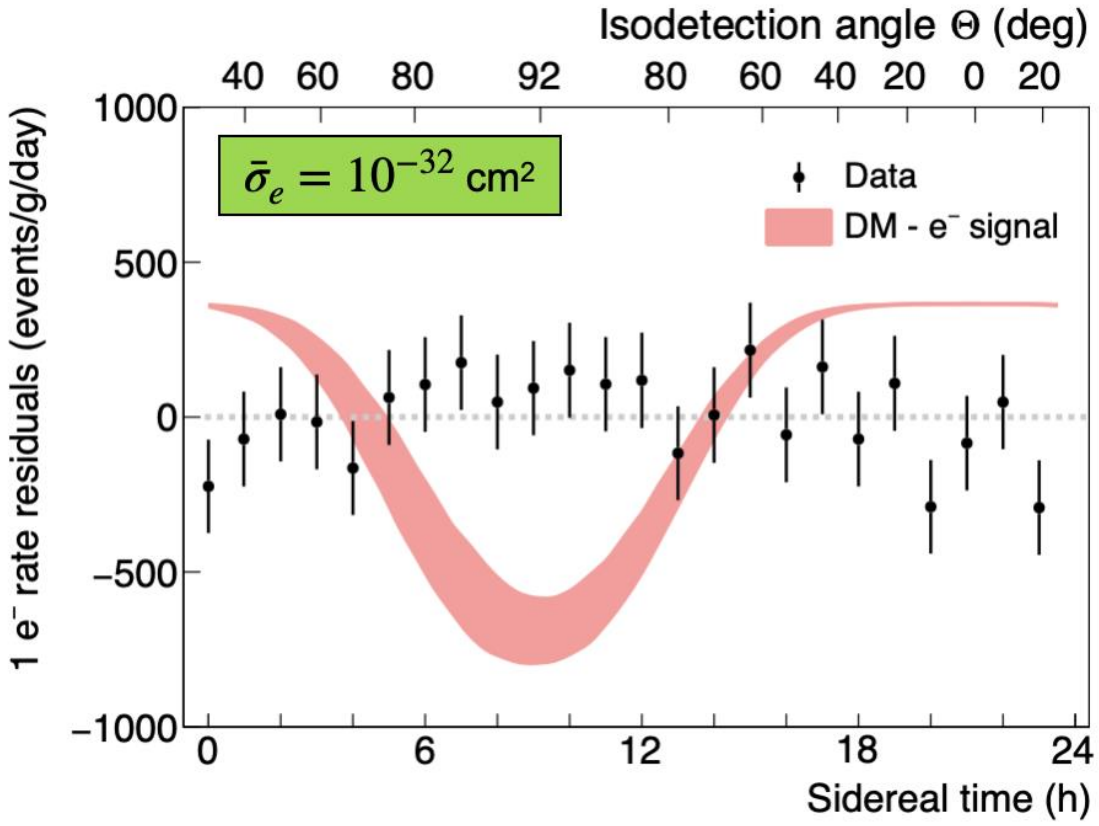
Current world-leading peer reviewed limits for dark sector in most of the mass range

Phys. Rev. Lett. **130**, 171003 – Published 28 April 2023

Dark Matter daily modulation signal

In the currently explored parameter space, the Earth is not transparent and a daily modulation is expected due to the dark matter wind





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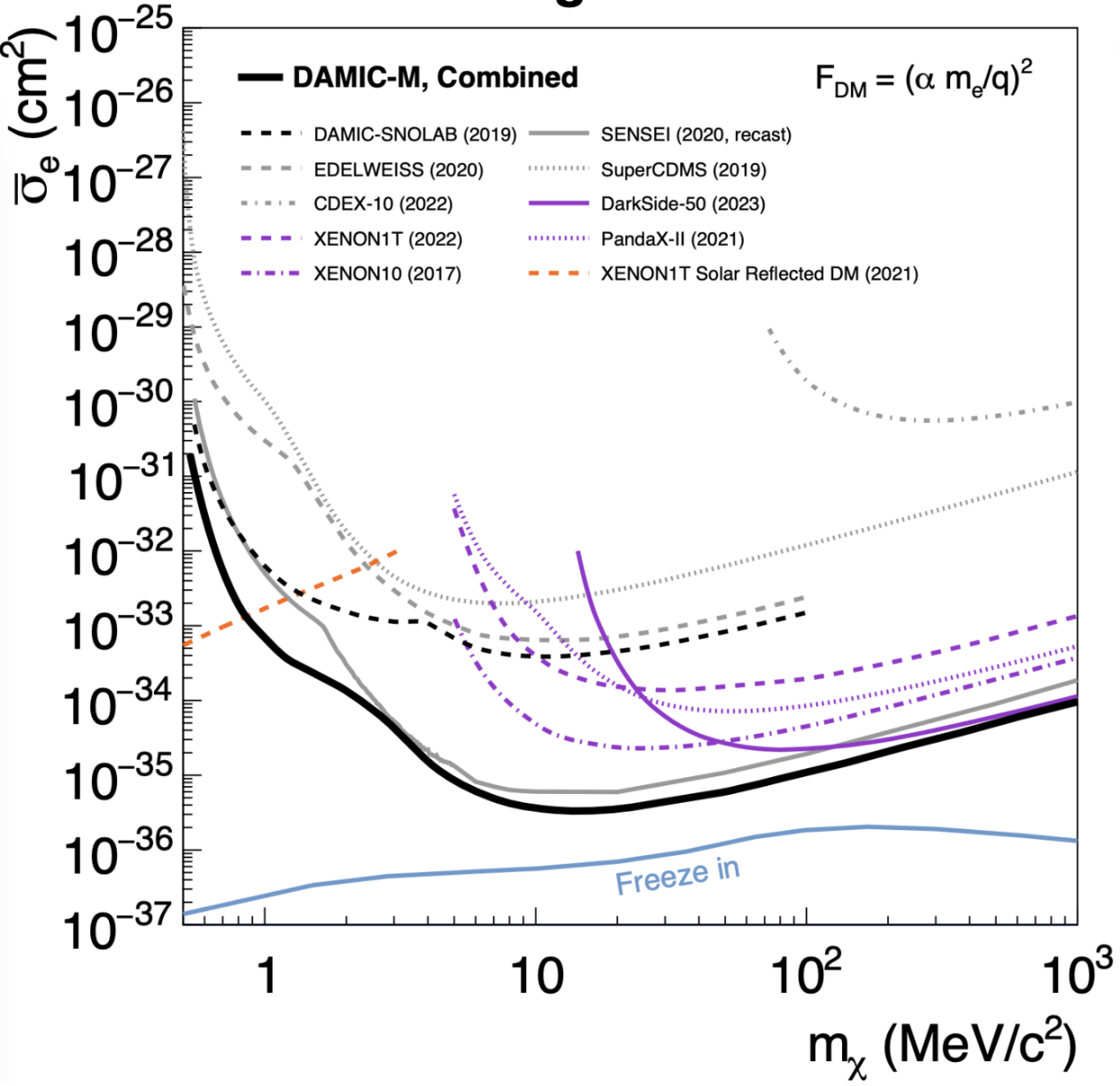
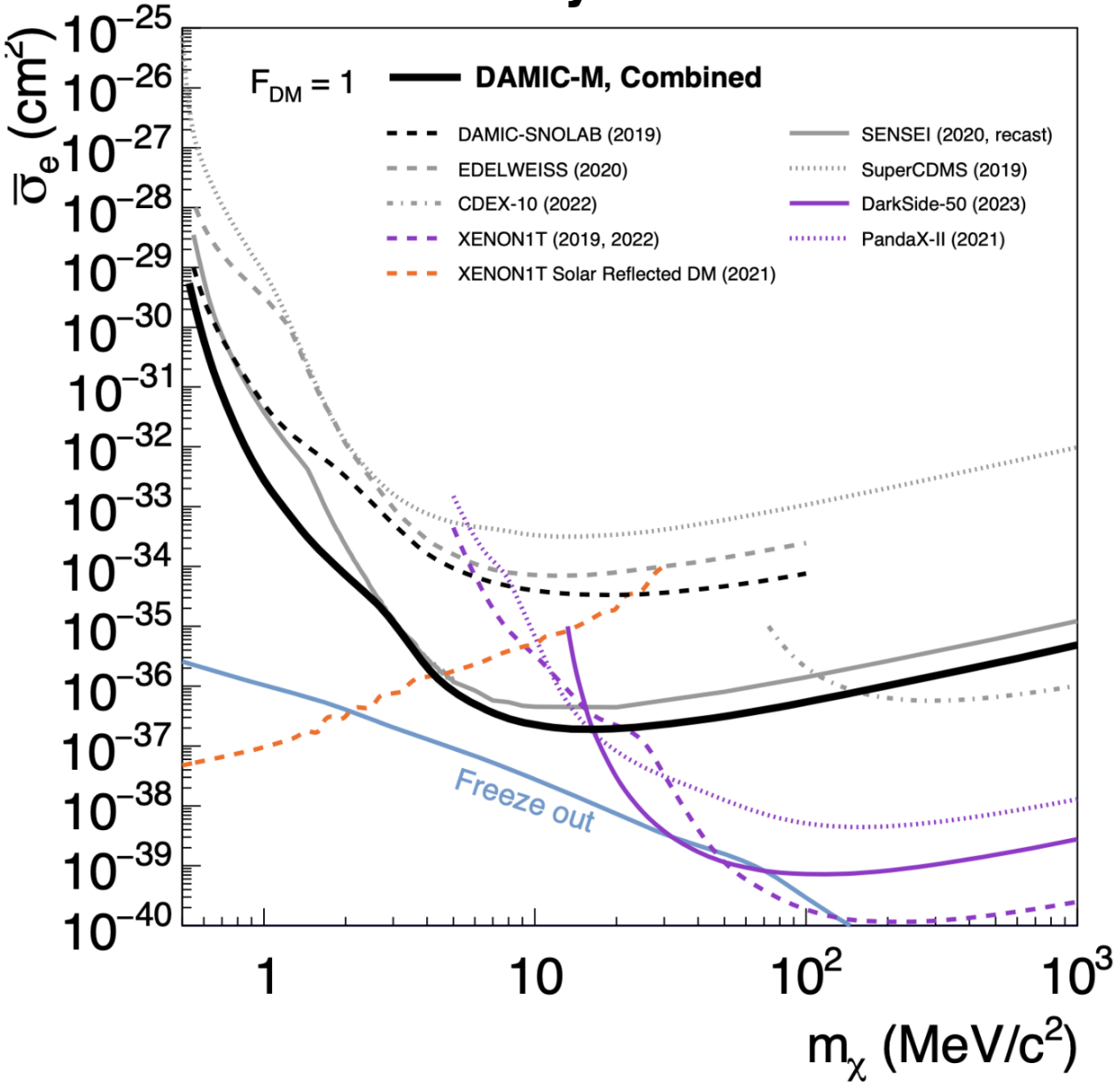
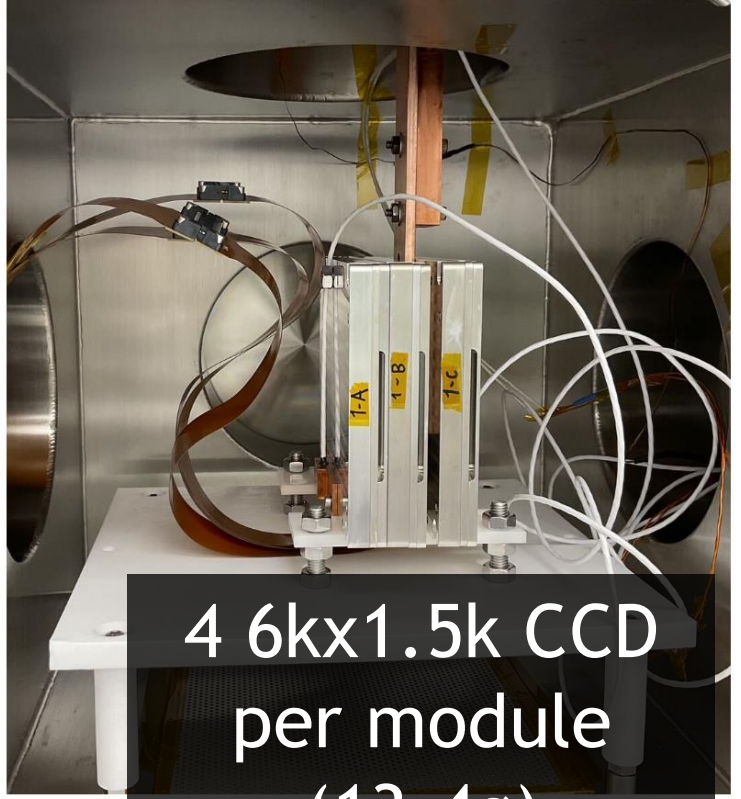


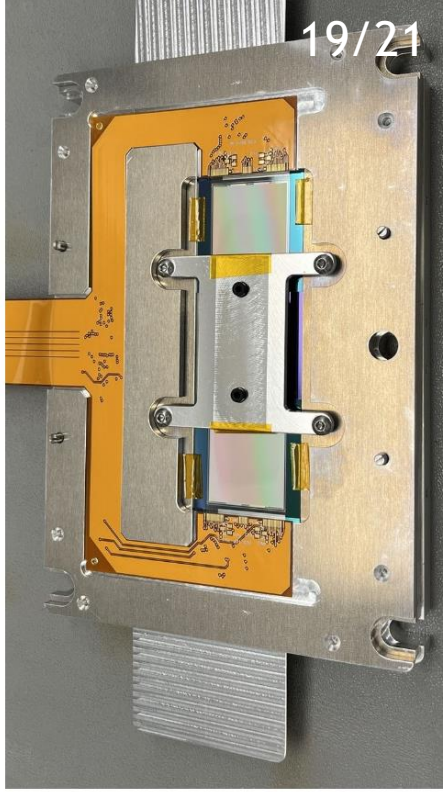
heavy mediator

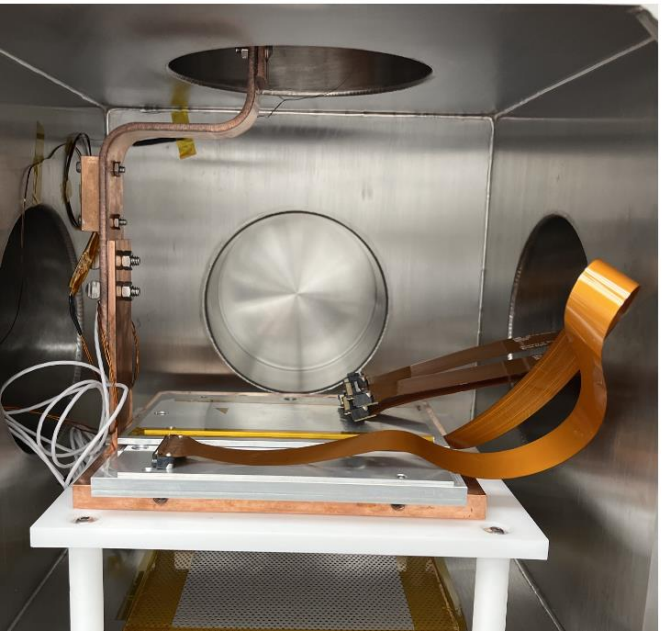


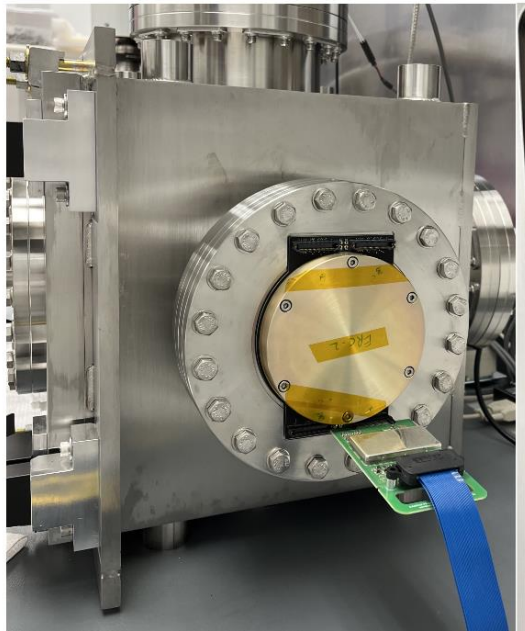
Phys. Rev. Lett. **132**, 101006 – Published 7 March 2024

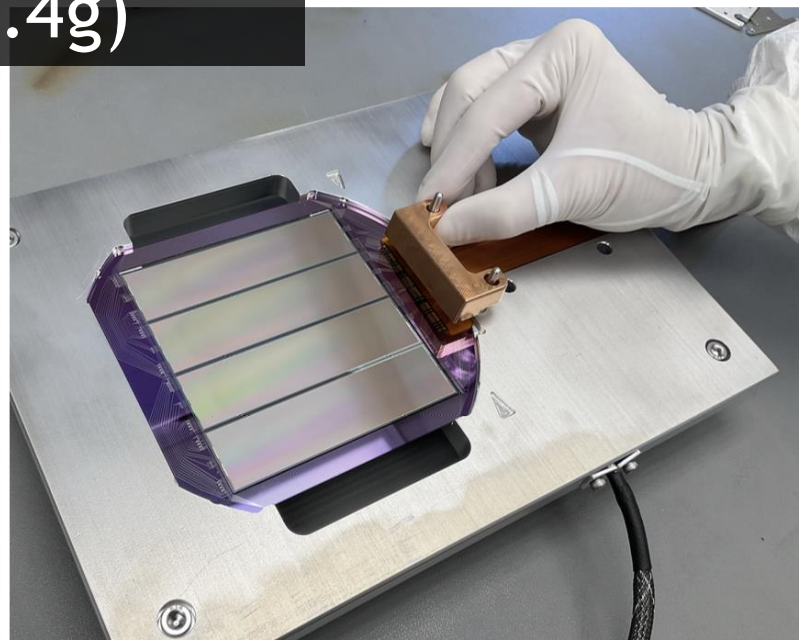


4 6kx1.5k CCD per module (13.4g)









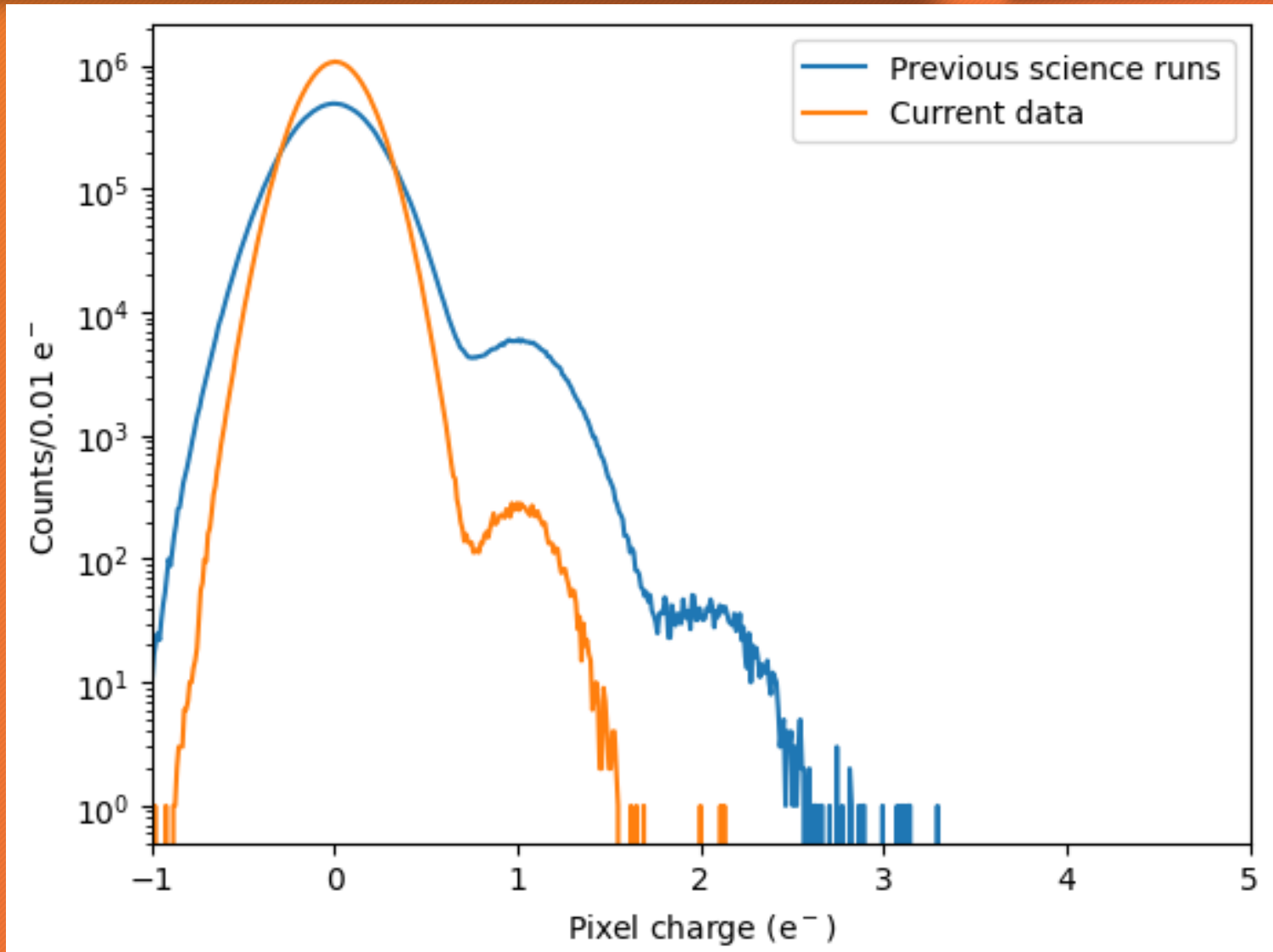
First 2 modules installed at LBC

- New CCDs
- Lower DC
  - Improved cabling
  - Improved readout
  - Better IR photon shield

DC down by a factor 20

~ 500 e^-/g.day

(in constant readout mode on most of the CCD)



Conclusions

- DAMIC-M will explore the region of parameter where dark sector is expected (freeze-in/freeze-out) within 2 years
- It will also explore the current DAMIC@SNOLAB excess
- Current LBC prototype operated with great success
  - Best peer reviewed Dark Sector limits in most of the mass range
    - Spectral analysis of the observed charge histograms
    - Daily modulation of the 1 e^- rate at lowest masses
- DAMIC-M CCDs are being packaged
  - First data are promising (DC lowered by 20)
  - Stay tuned for first results very soon