

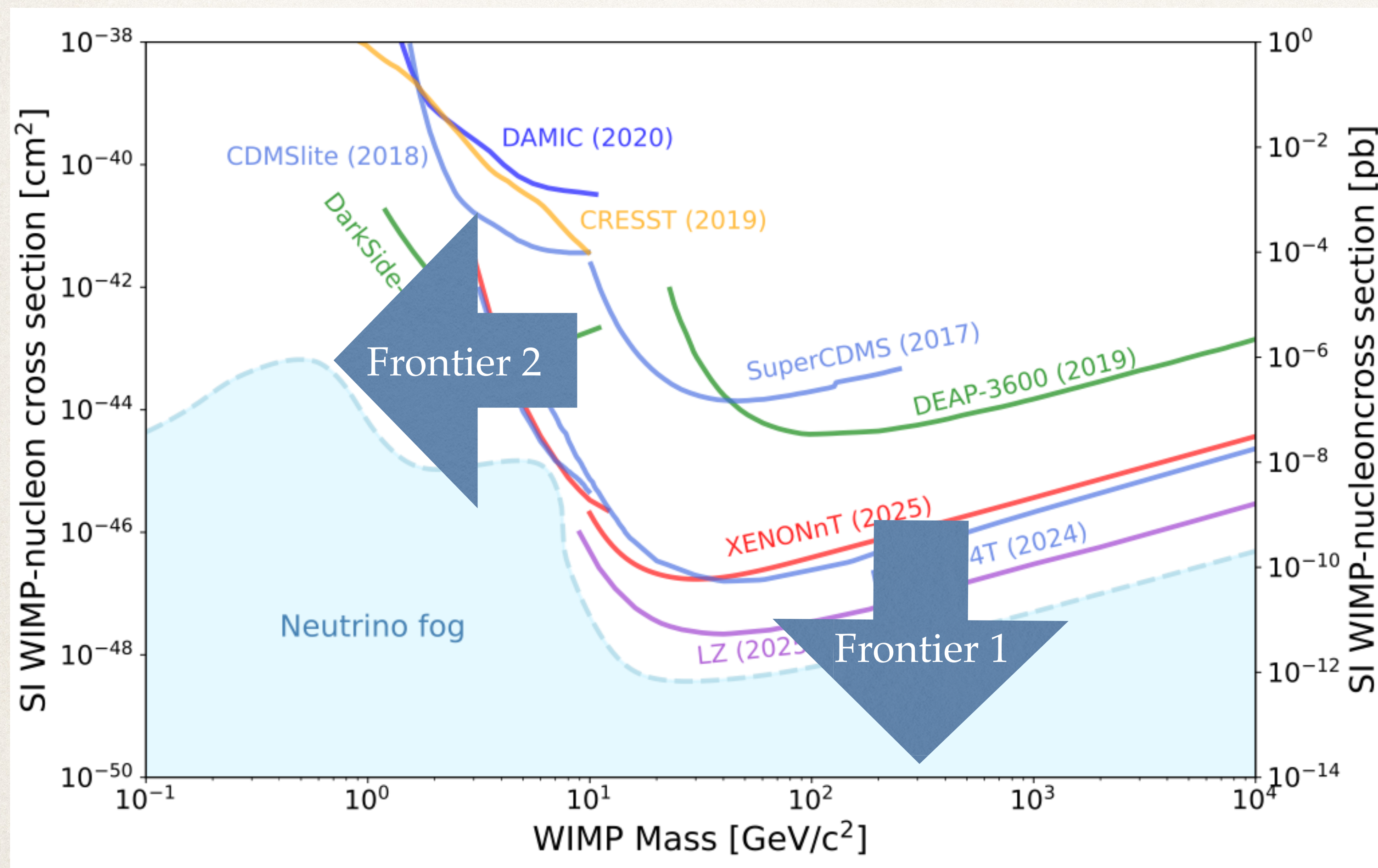


IDM 2026: experimental overview

Direct detection, axions searches & instrumentation

Teresa Marrodán Undagoitia (Max-Planck-Institut für Kernphysik, Heidelberg, Germany)

WIMP direct searches

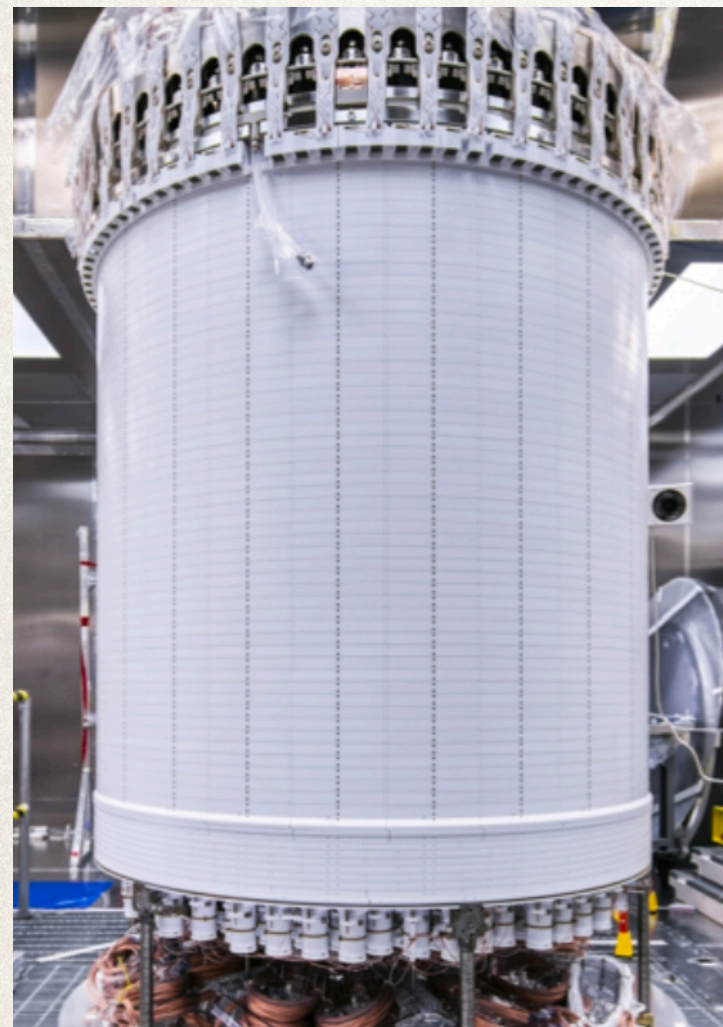


- ❖ Frontier 1:
high mass WIMPs
LXe & LAr
- ❖ Frontier 2:
low mass WIMPs
bolometers & silicon
& gaseous ...

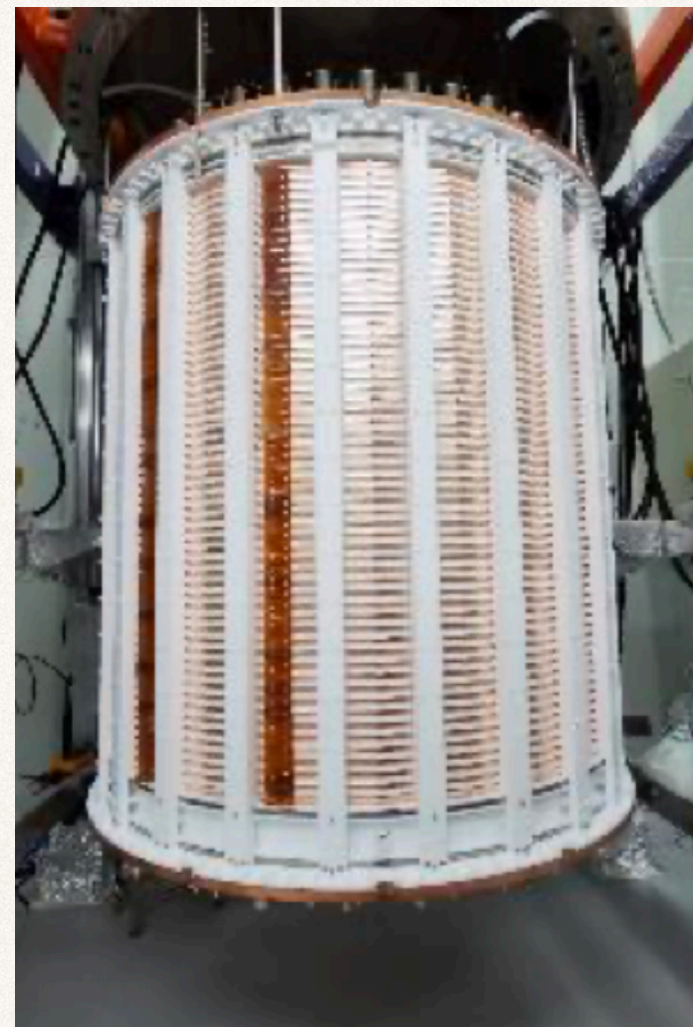
Figure from L. Baudis, updated from PDG, with frontiers inspired by Marco Cirelli

High mass WIMPs: LXe

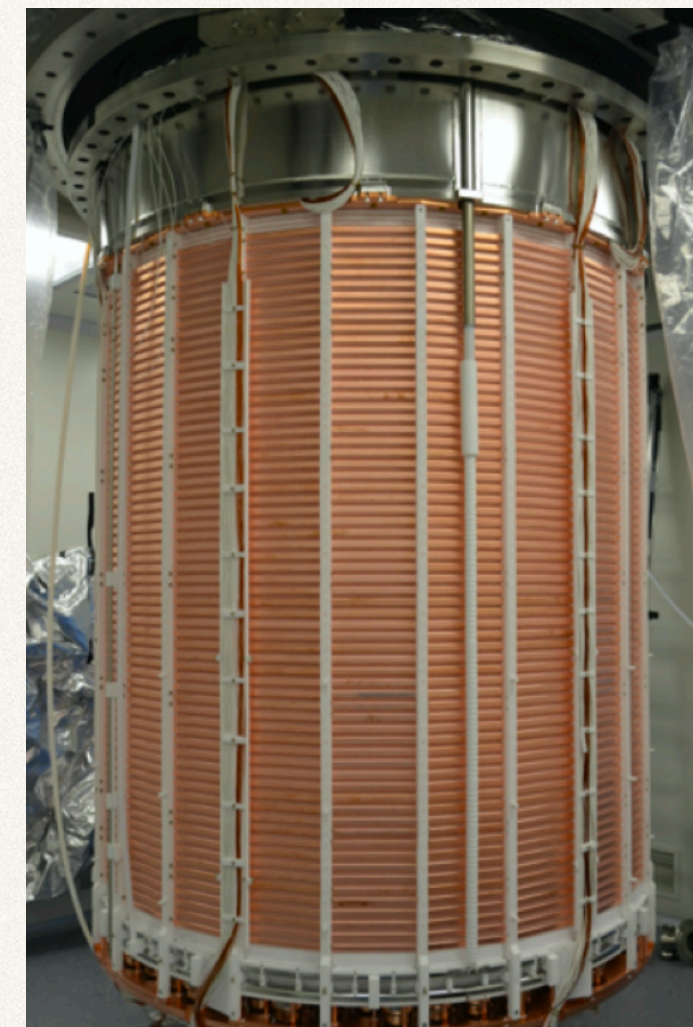
- ❖ [Latest results of the PandaX-4T experiment](#)
- ❖ [Recent results from the LUX-ZEPLIN \(LZ\) experiment](#)
- ❖ [New Dark Matter search results from XENONnT](#)
- ❖ [Probing the neutrino fog with XENONnT: CEvNS, light WIMPs, and BSM](#)
- ❖ [Rare Event Searches in the Electron Recoil Channel of XENONnT](#)
- ❖ [XLZD – the next generation of dark matter search](#)
- ❖ [PandaX-20T: the next generation xenon detector](#)



LZ



PandaX



XENON

- ❖ High mass WIMP limits $> 10 \text{ GeV}/c^2$
- ❖ CEvNS results (solar ^8B):
 4.5σ by LZ, 2.7σ by XENON, 2.6σ by PandaX
- ❖ Low WIMP mass & many other searches

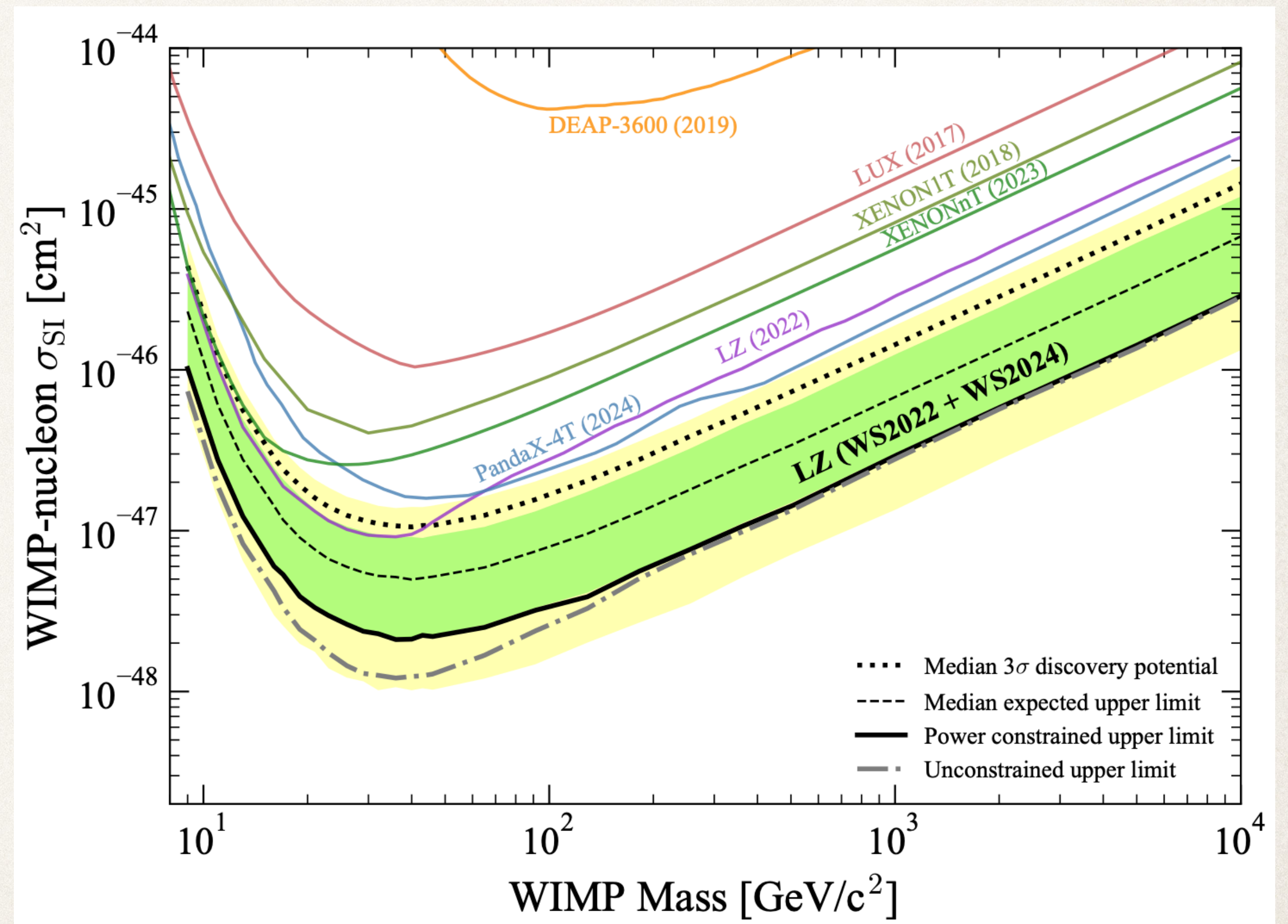
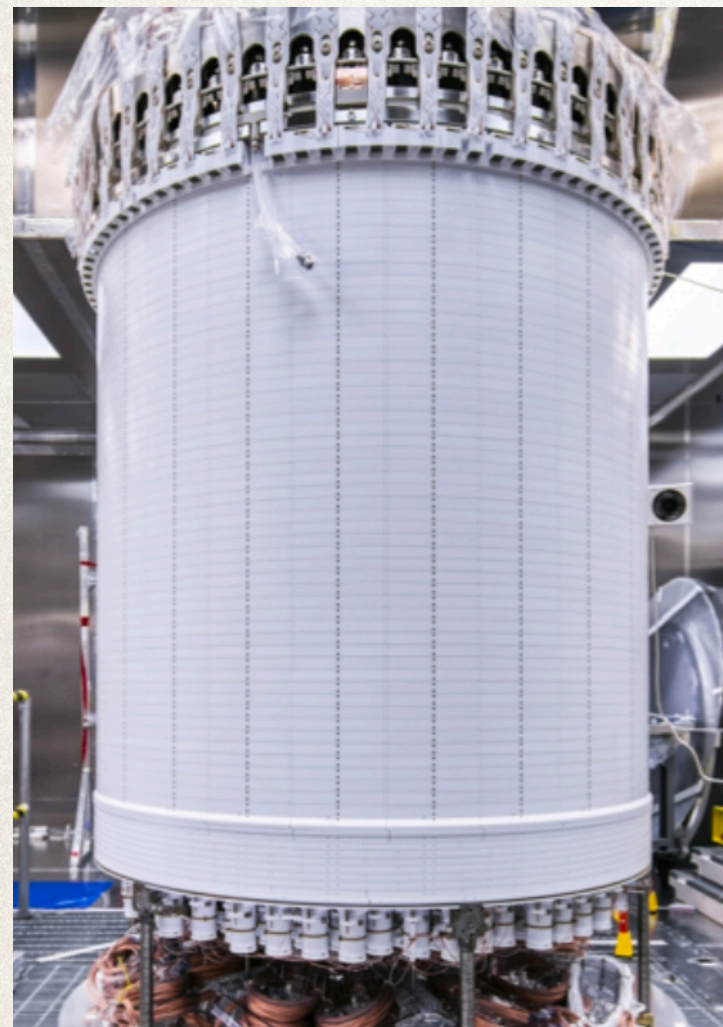


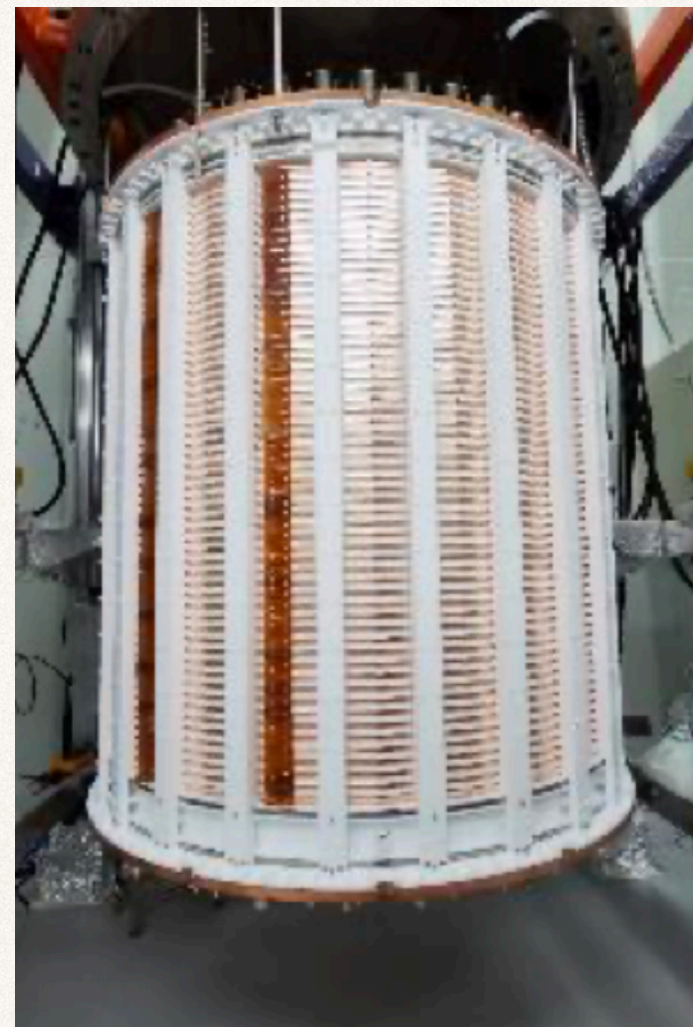
Figure from Alberto Uson's talk & *PRL* 135 (2025) 011802

High mass WIMPs: LXe

- ❖ [Latest results of the PandaX-4T experiment](#)
- ❖ [Recent results from the LUX-ZEPLIN \(LZ\) experiment](#)
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- ❖ [PandaX-20T: the next generation xenon detector](#)



LZ



PandaX



XENON

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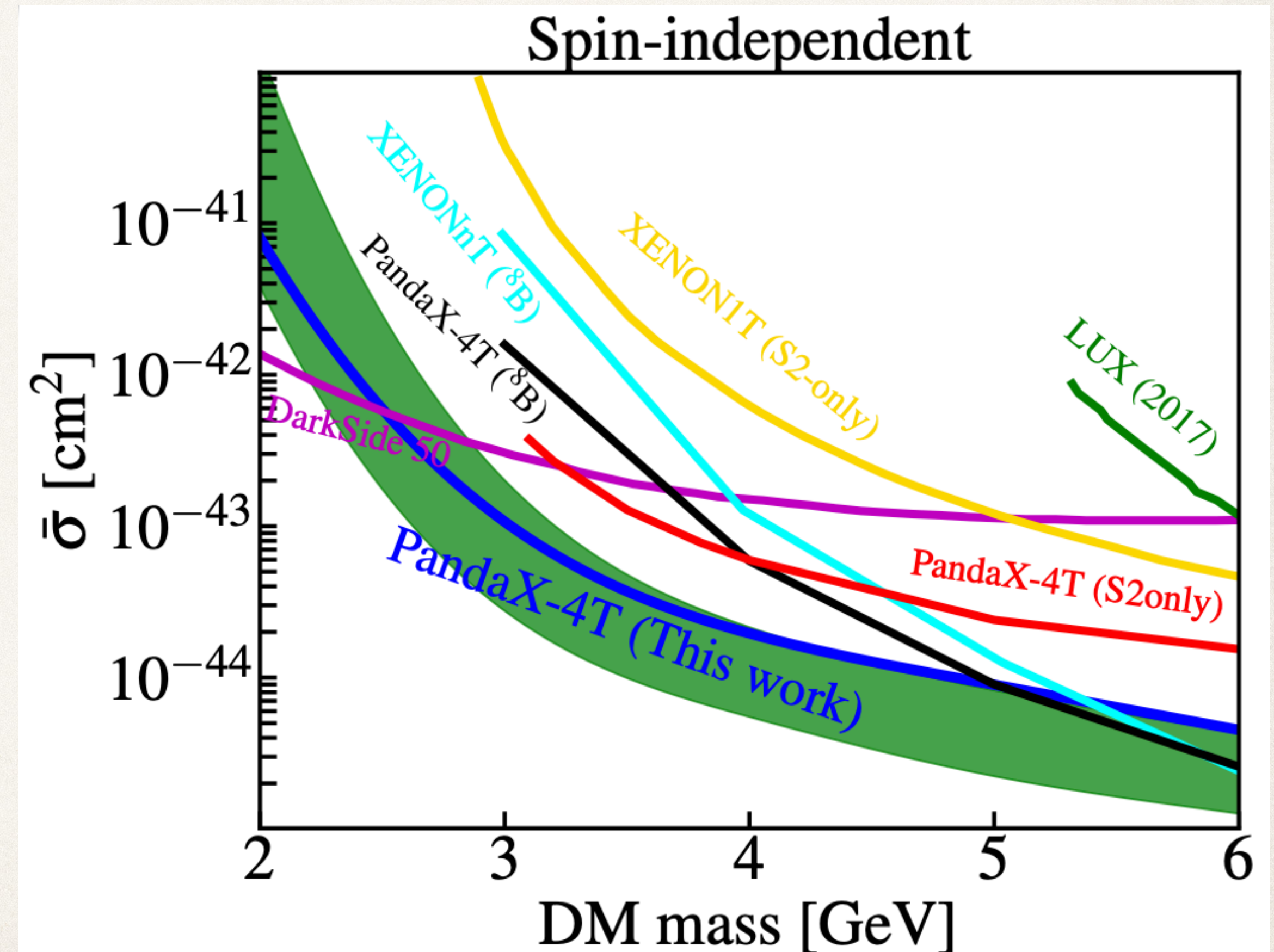
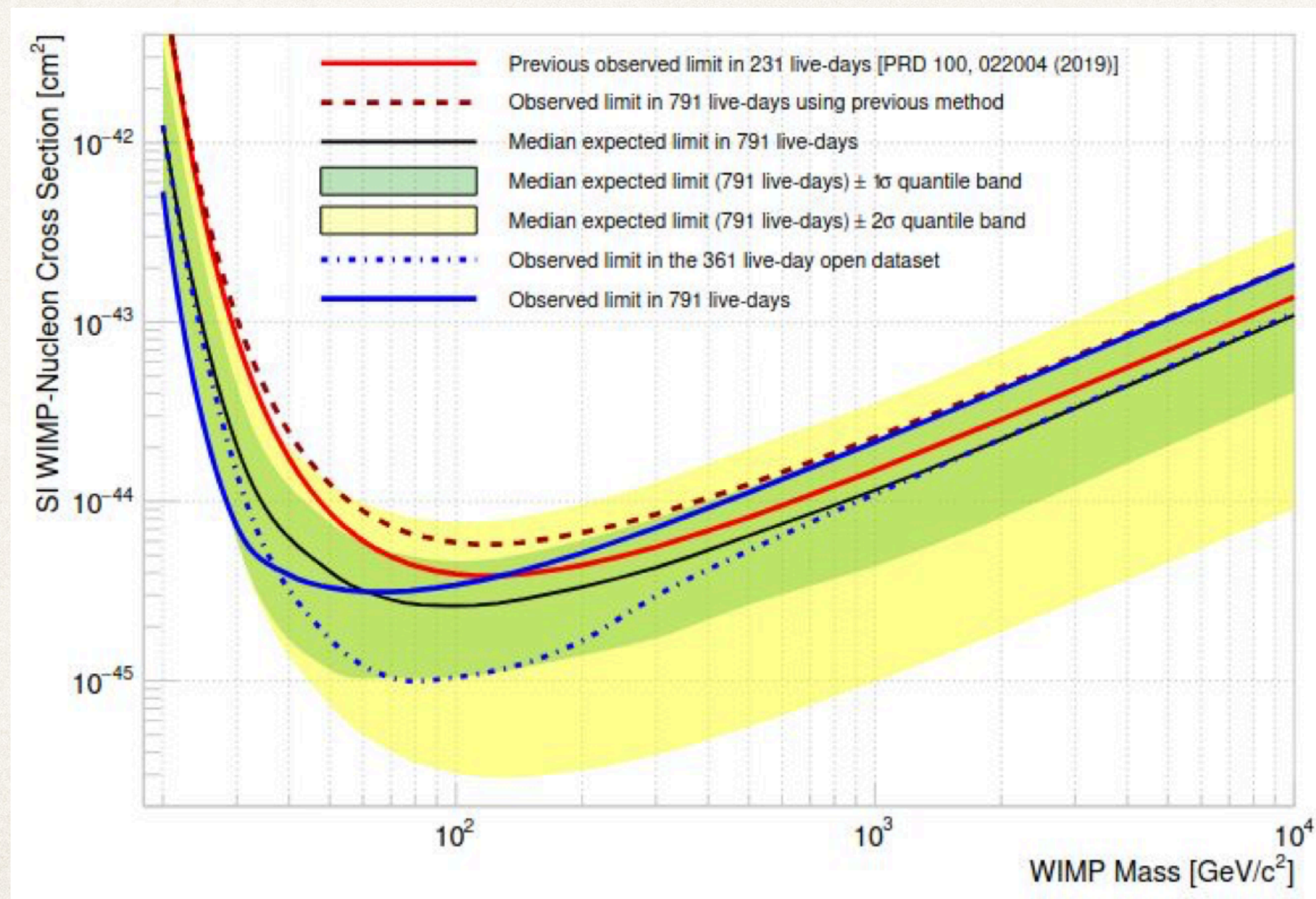


Figure from Xiaopeng Zhou's talk

High mass WIMPs: LAr

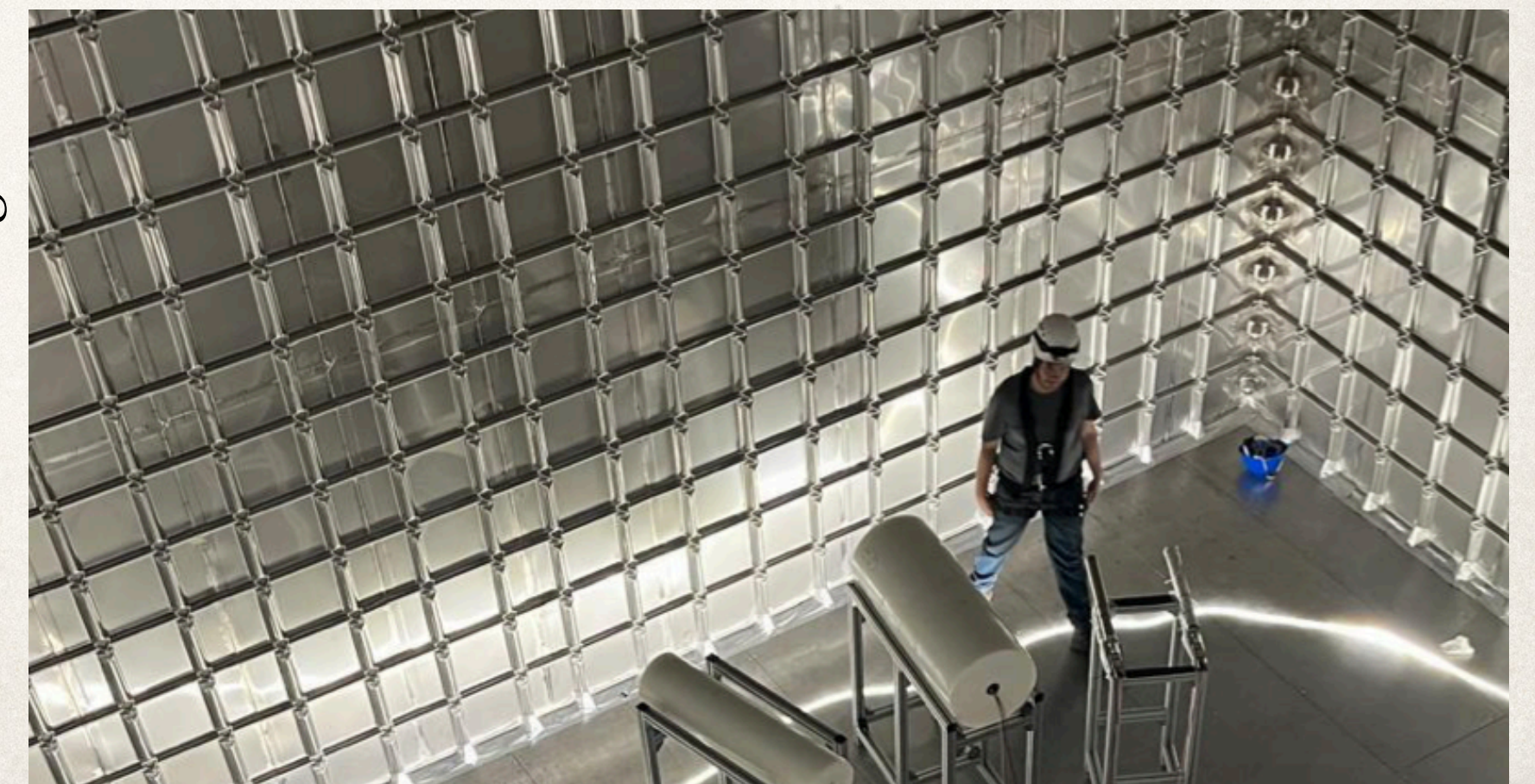
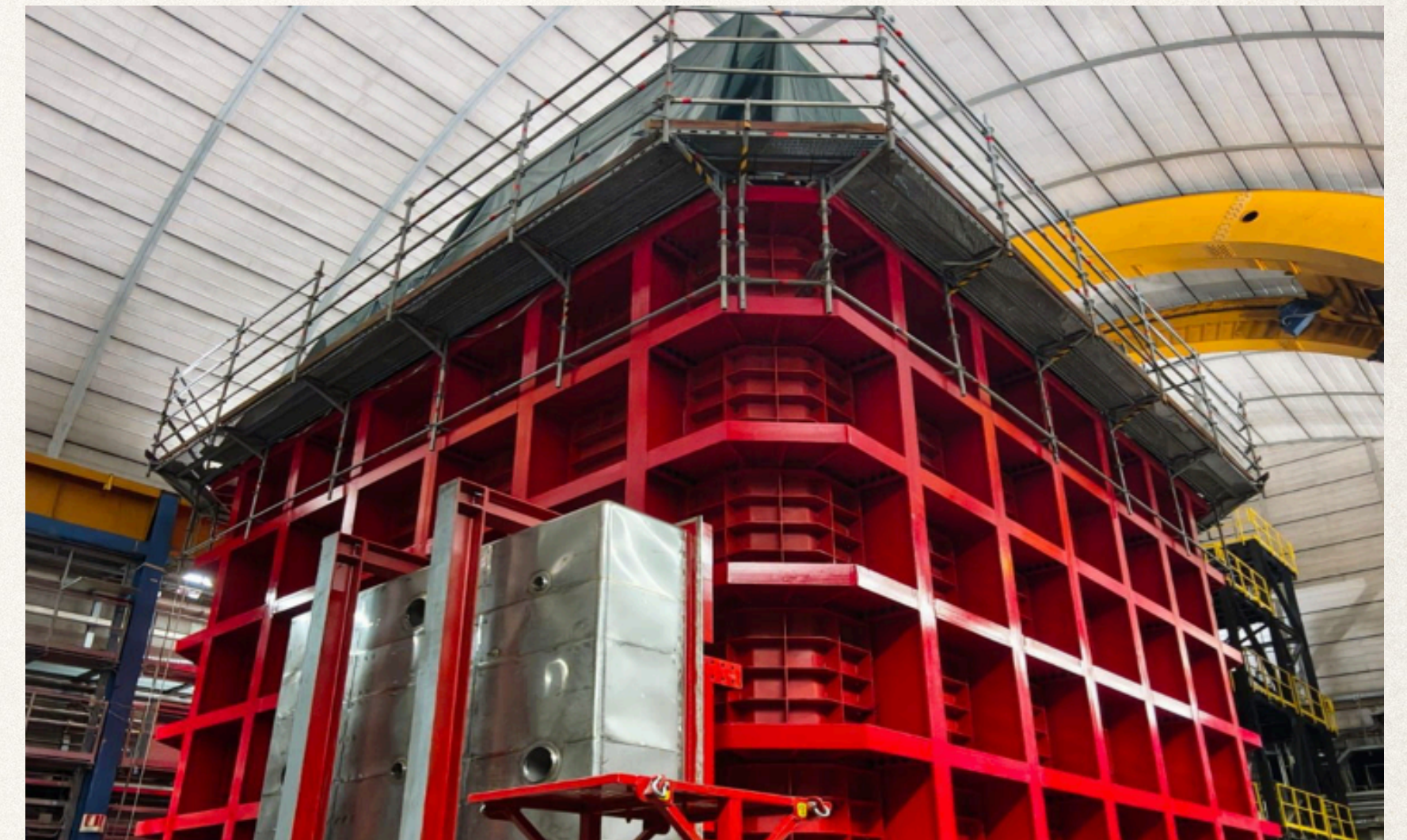
- ❖ [Status of the DarkSide-20k](#)
- ❖ [Prospects for Inelastic Boosted Dark Matter in DEAP-3600](#)
- ❖ [Program of the Global Argon Dark Matter Collaboration](#)

- ❖ DarkSide-20K construction ongoing
- ❖ TPC materials being machined/ assembled
- ❖ Detector filling planned for end of November 2028



Recent DEAP-3600 result. Figure from Guillermo Vera Díaz's talk

Figures from Vicente Pesudo's talk



Low mass: cryo-bolometers

- ❖ [Commissioning and Outlook of SuperCDMS SNOLAB](#)
- ❖ [Probing dark matter with RES-NOVA prototype detector](#)
- ❖ [First Results from a GaAs Calorimeter for DAREDEVIL](#)
- ❖ [BULLKID-DM: light WIMPs with a monolithic array](#)
- ❖ [The Tesseract Sub-GeV Dark Matter Experiment](#)
- ❖ [Progress and Results from HVeV@CUTE](#)
- ❖ [Searching for light dark matter with CRESST](#)

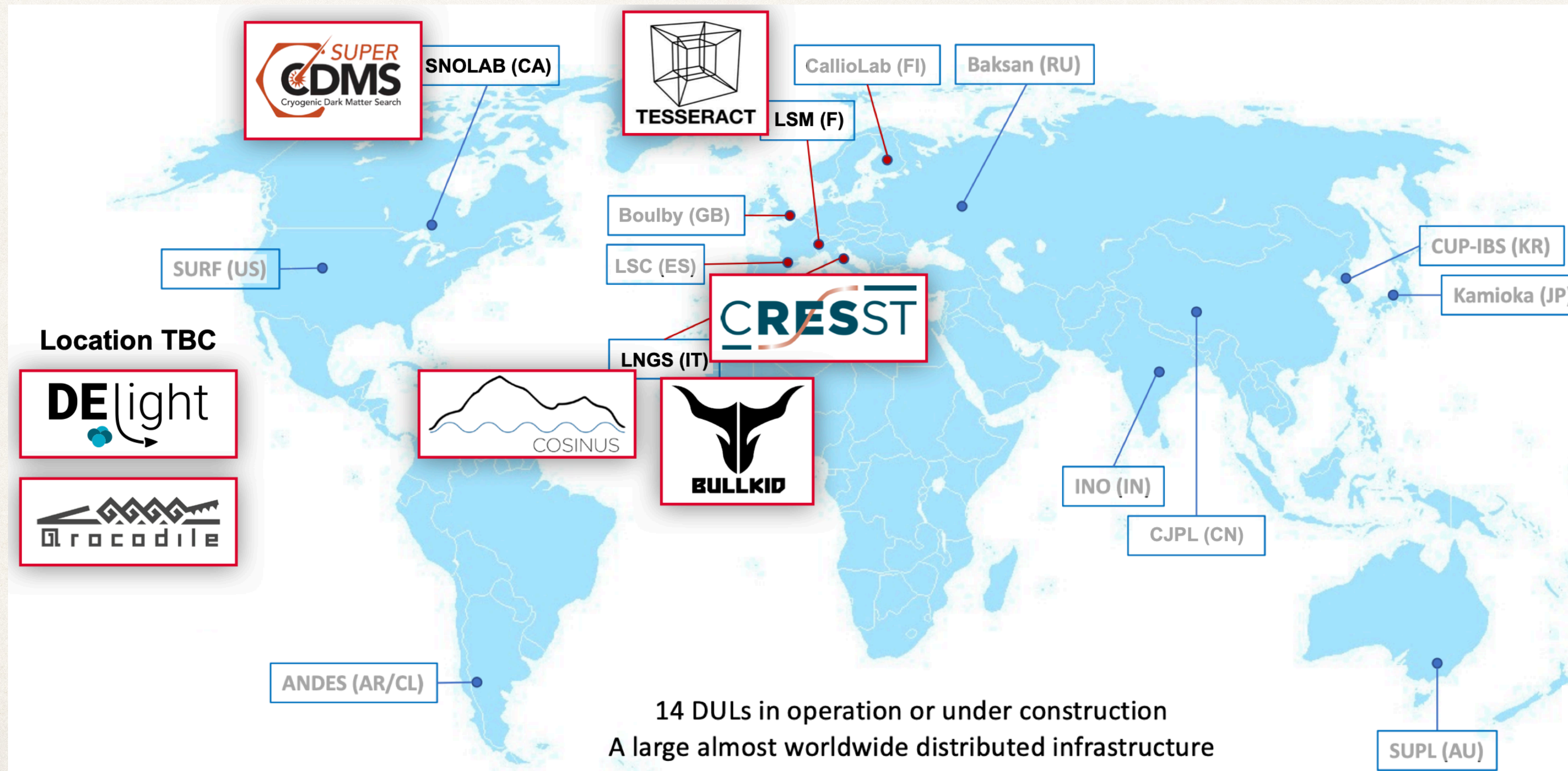
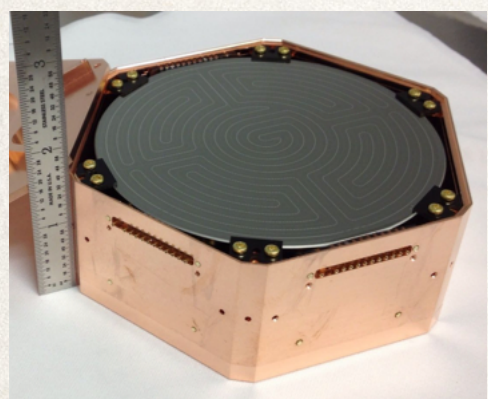


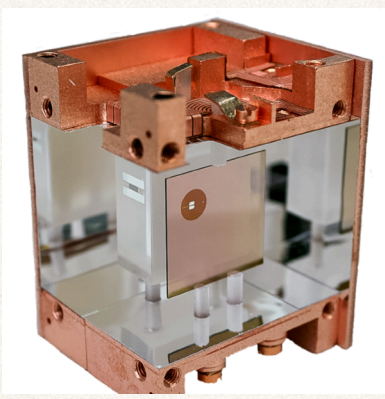
Figure from Belina von Krosigk's talk

Low mass: cryo-bolometers

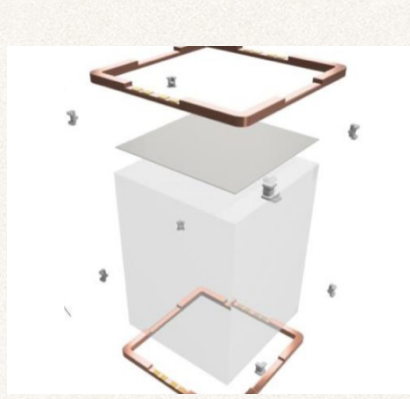
- ❖ [Commissioning and Outlook of SuperCDMS SNOLAB](#)
- ❖ [Probing dark matter with RES-NOVA prototype detector](#)
- ❖ [First Results from a GaAs Calorimeter for DAREDEVIL](#)
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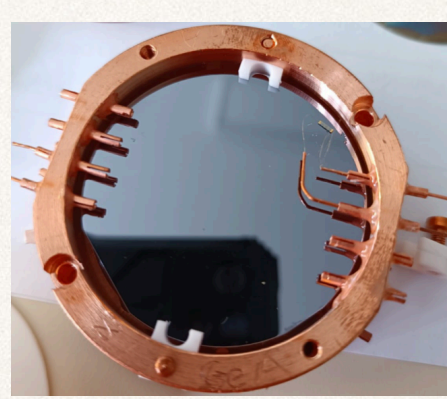
SuperCDMS



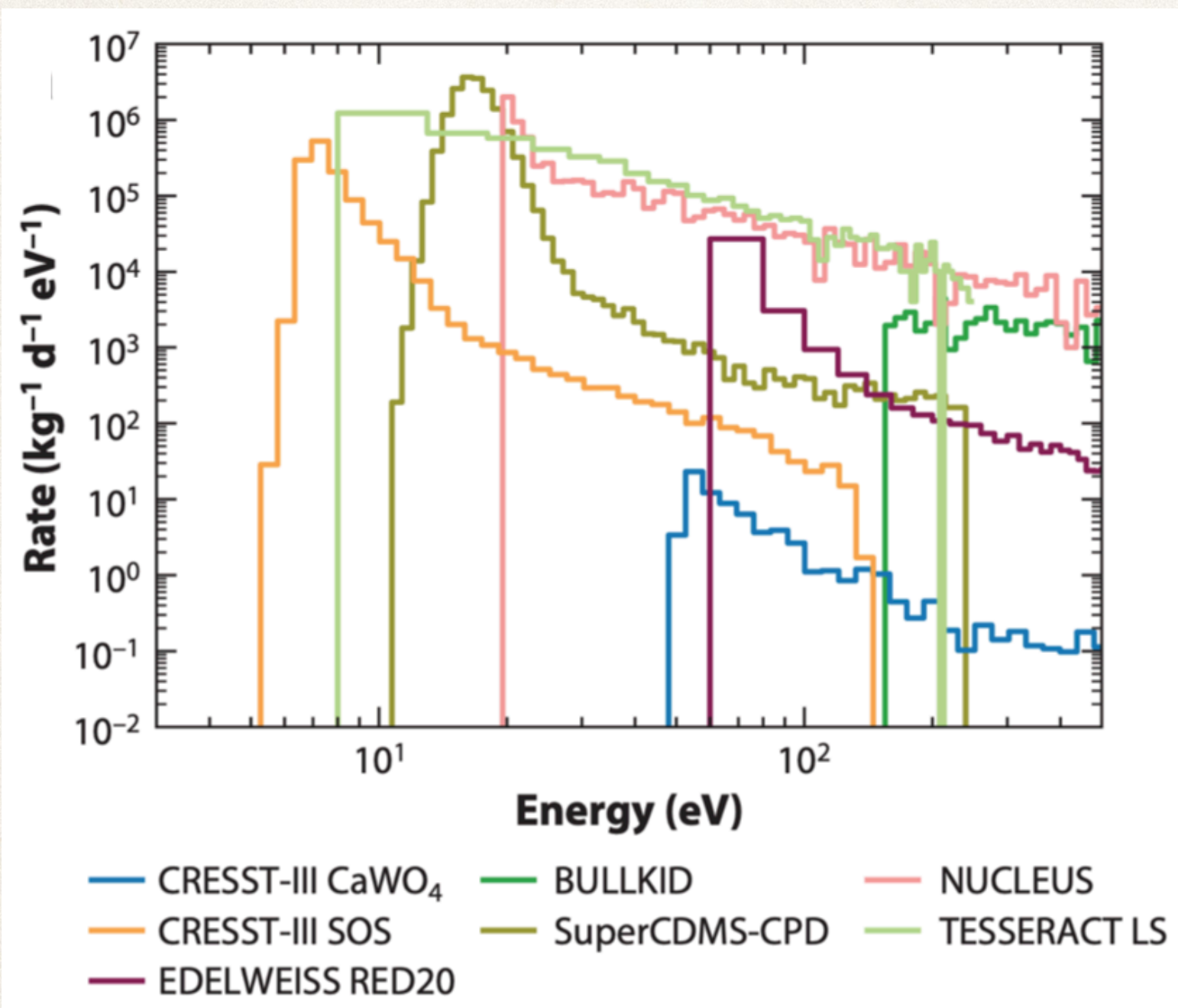
CRESST



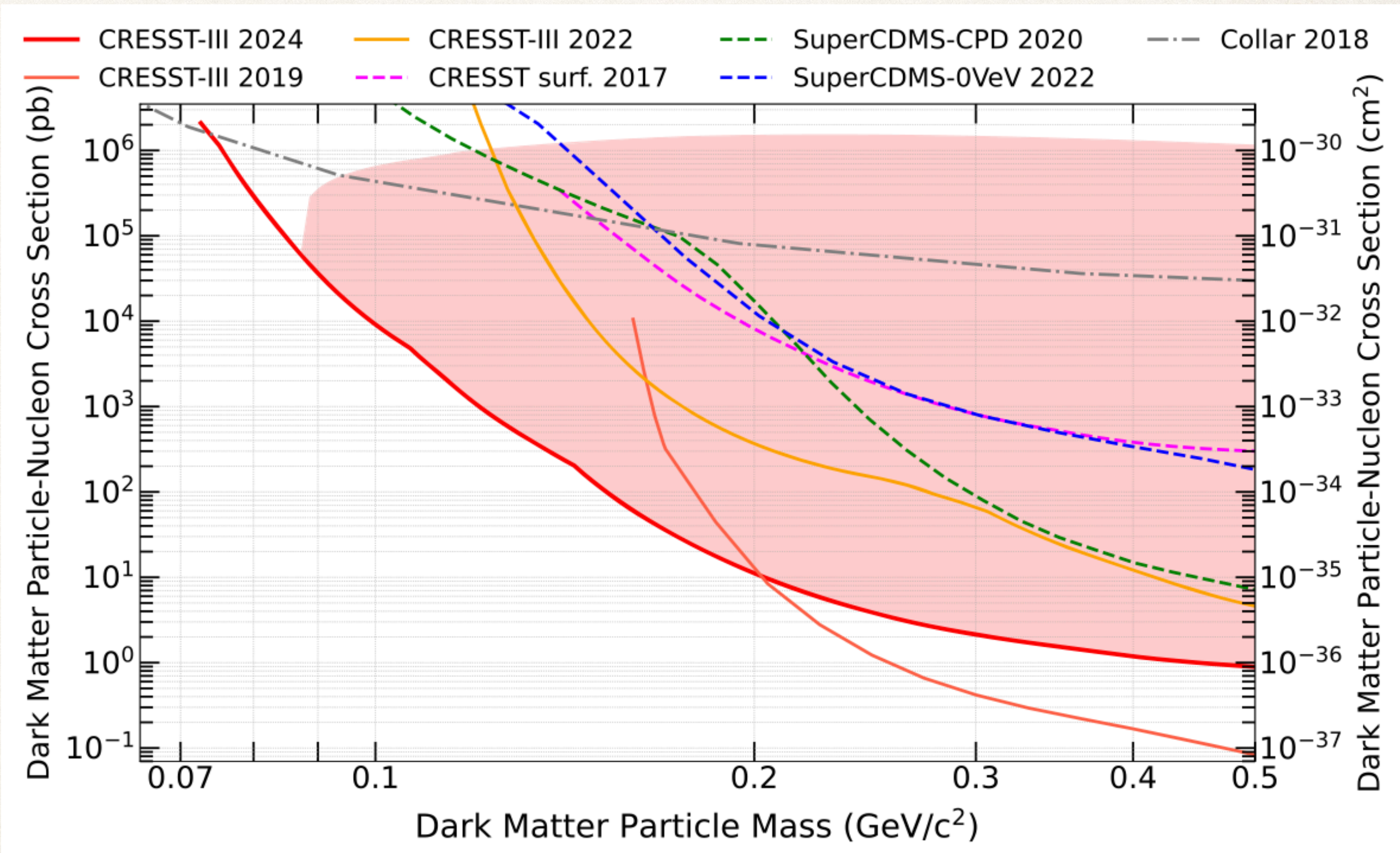
RES-NOVA



DAREDEVIL

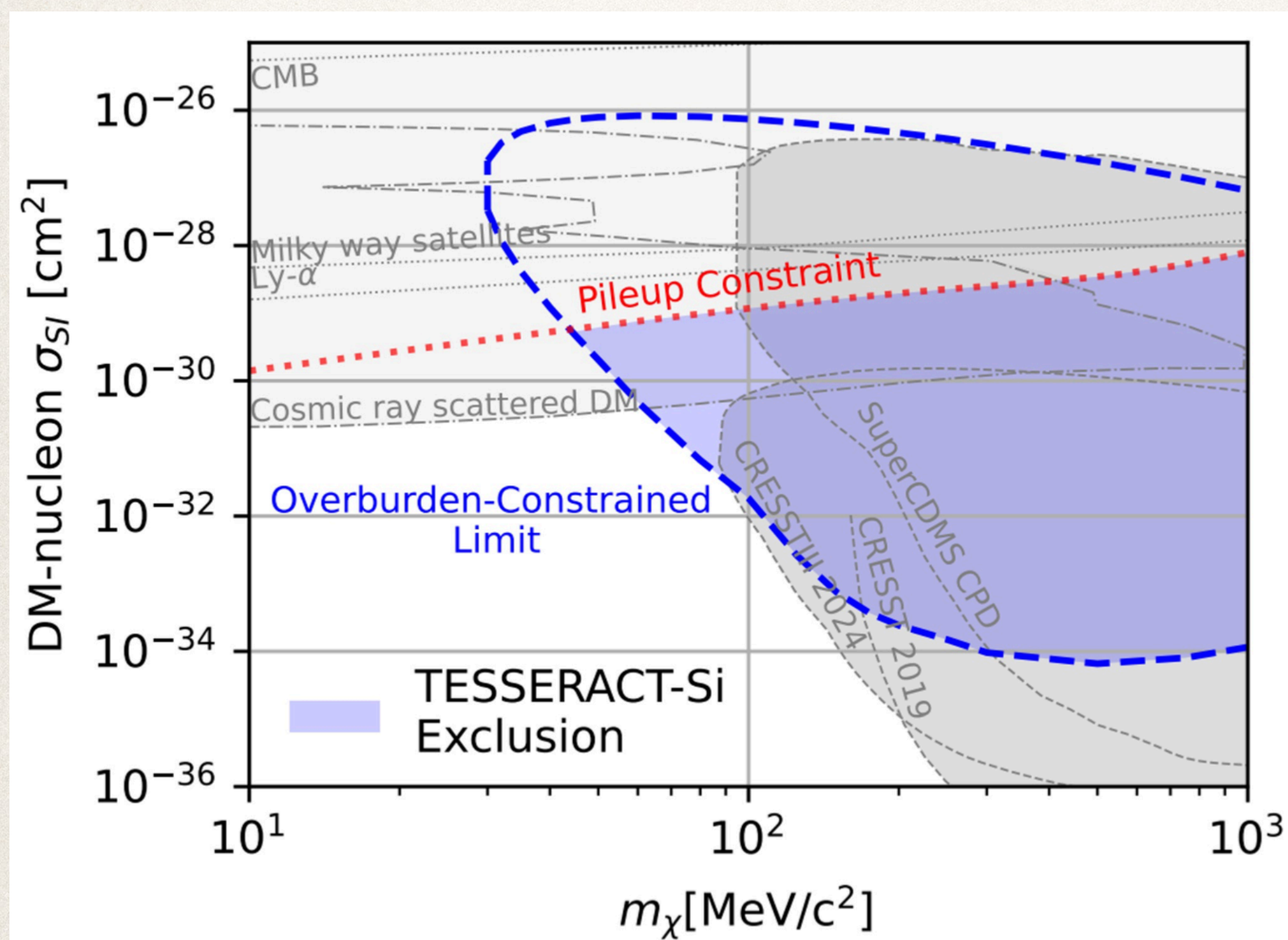


Low energy excess (LEE)

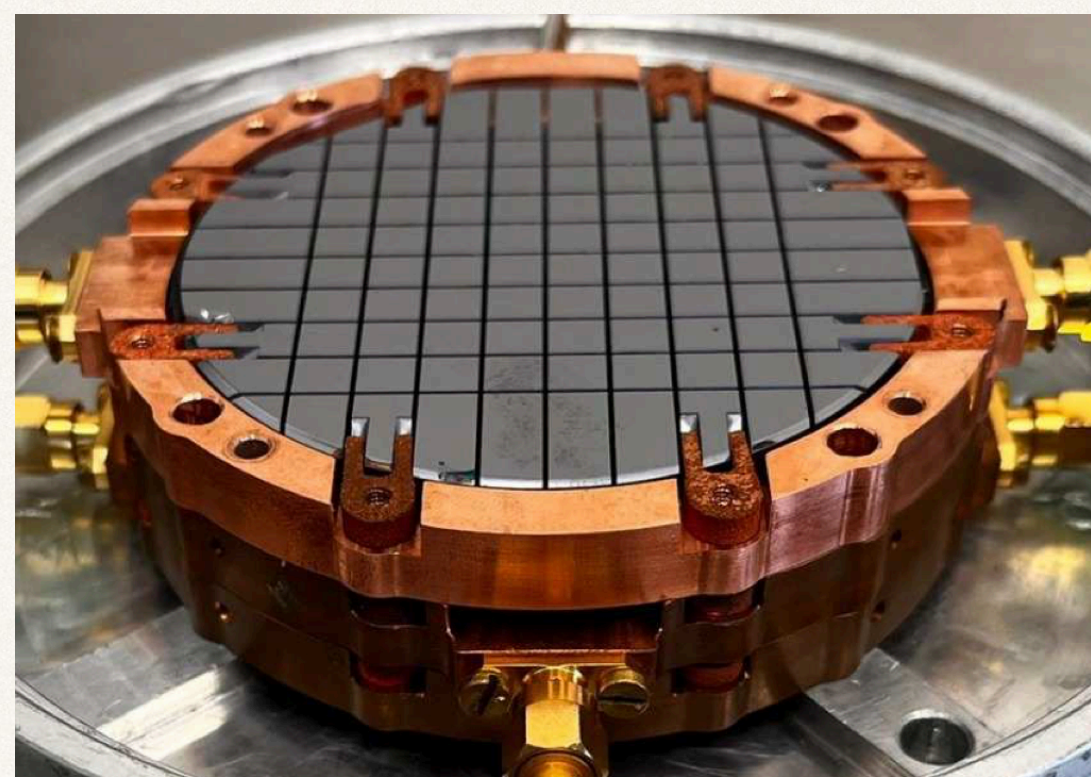


CRESST result. Figure from Francesca Pucci's talk

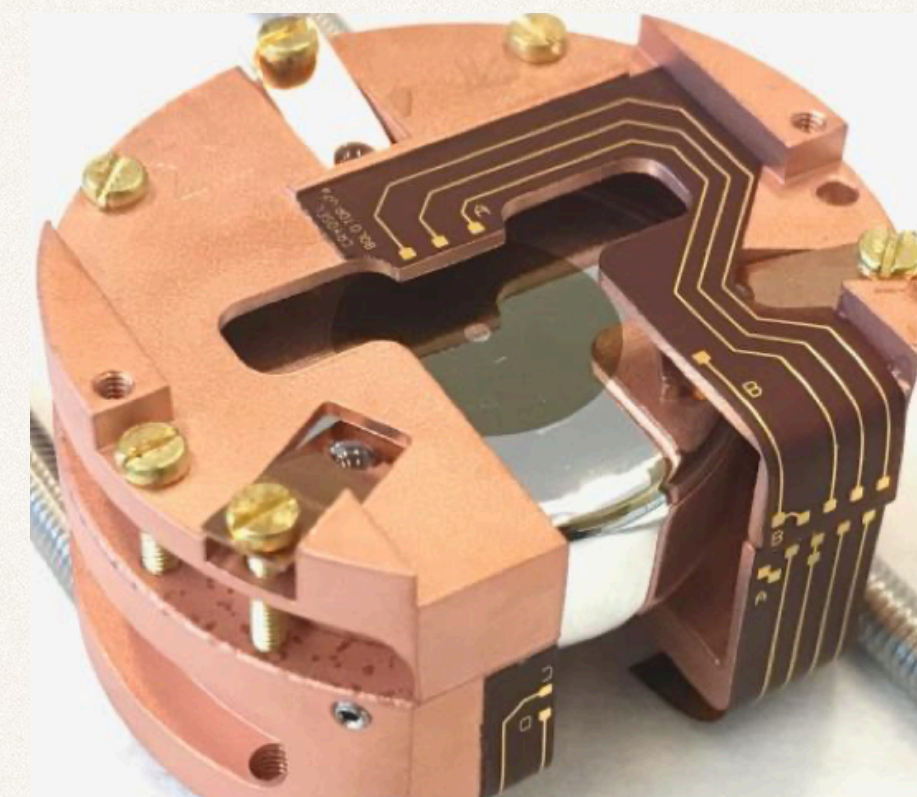
Cryo-bolometers II



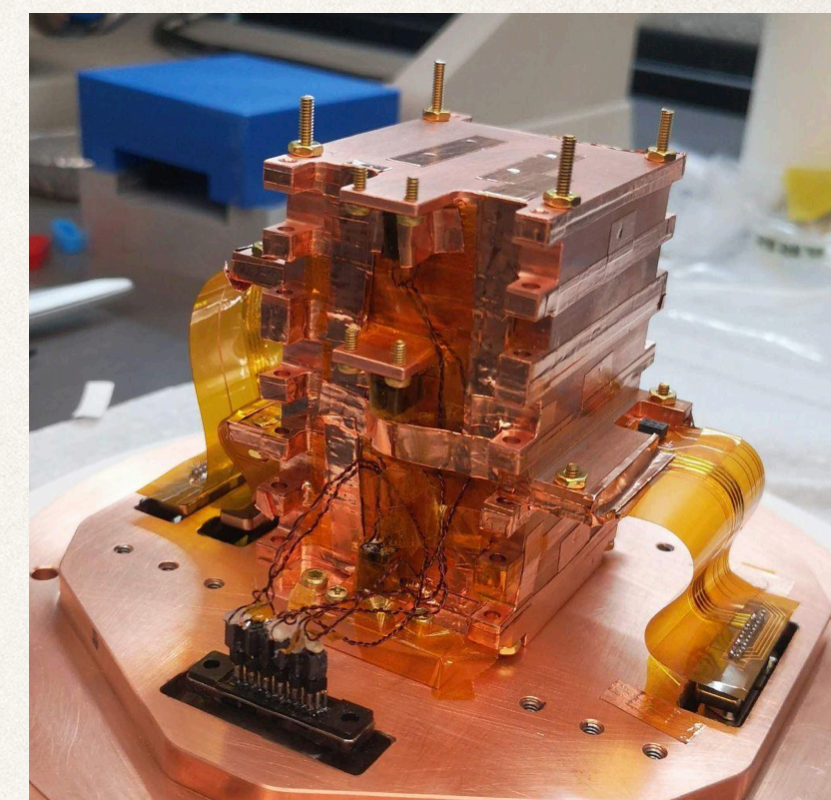
Tesseract Si result. Figure from Dan McKinsey's talk



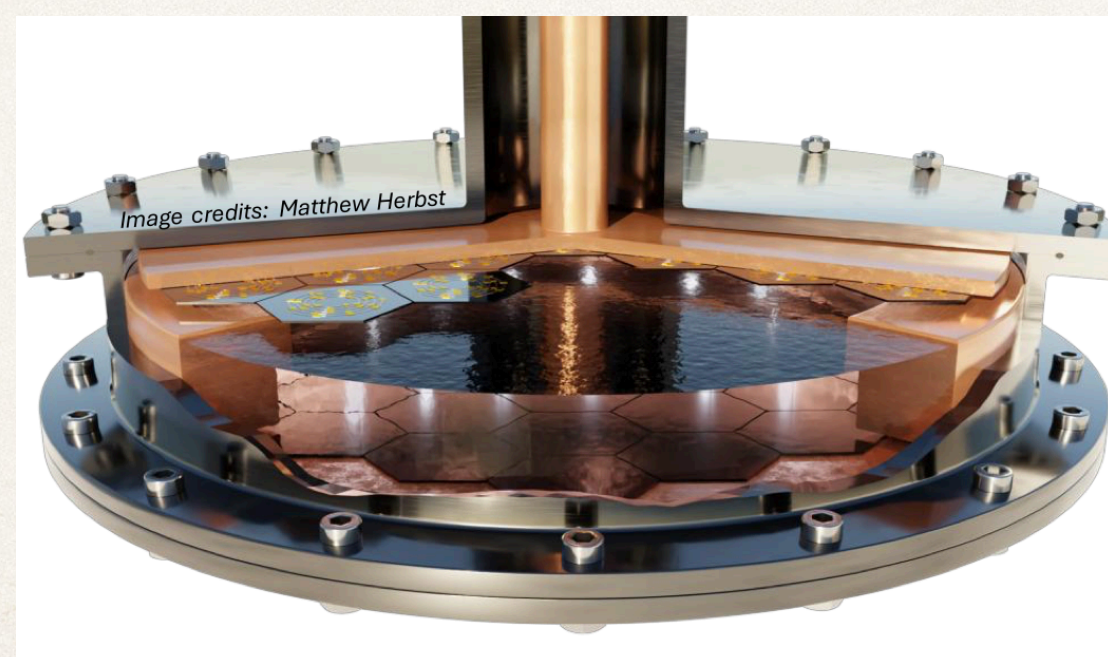
BULLKID-DM Si



Tesseract Ge



SuperCDMS HVeV



DELight

- ❖ [The Tesseract Sub-GeV Dark Matter Experiment](#)
- ❖ [The semiconductor technology for the Tesseract direct DM search at LSM](#)
- ❖ [Technology advances SuperCDMS HVeV program](#)
- ❖ [BULLKID-DM: light WIMPs with a monolithic array](#)
- ❖ [The DELight Experiment: First Results from a Superfluid He R&D Cell](#)

Spin dependent & low mass

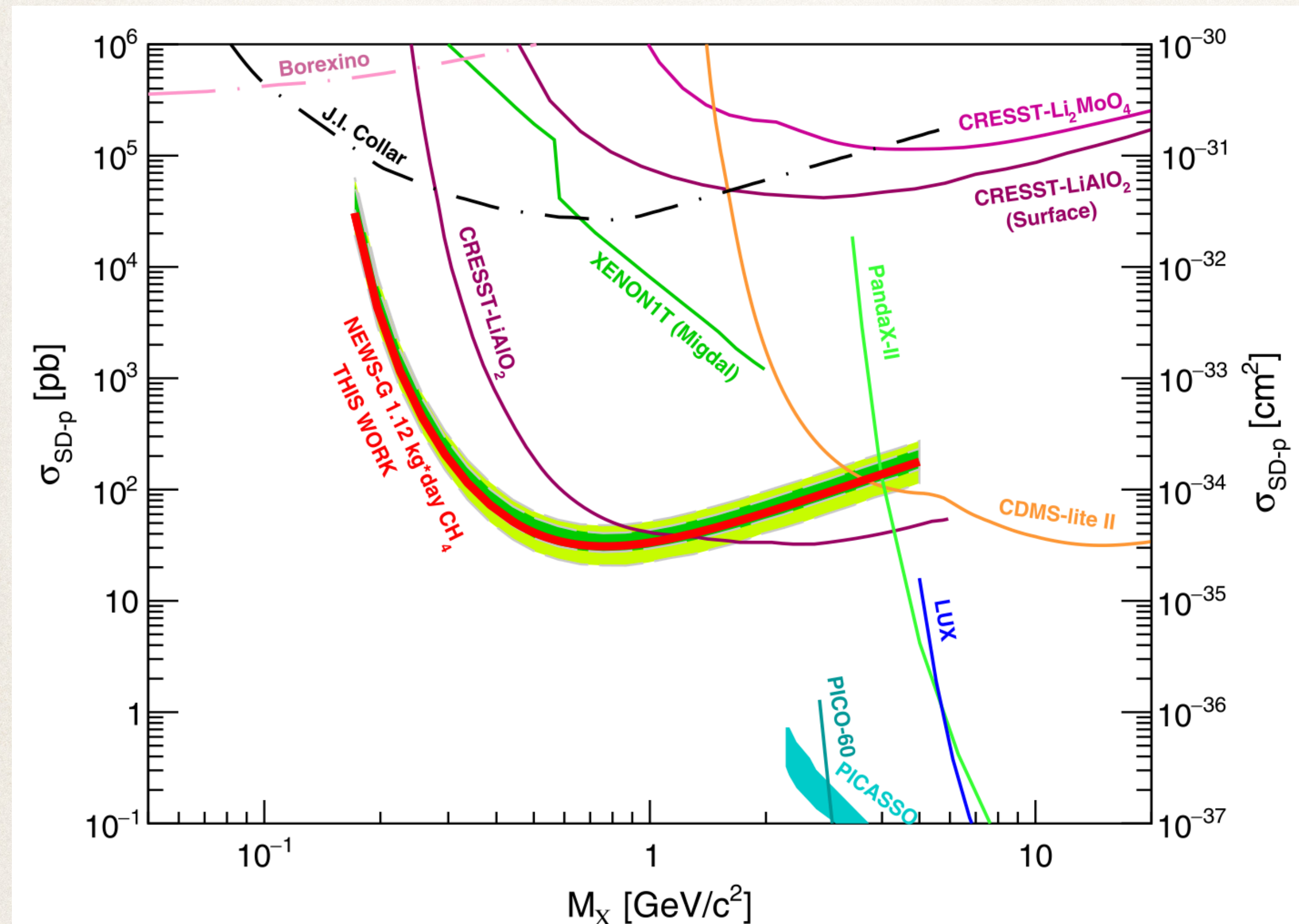
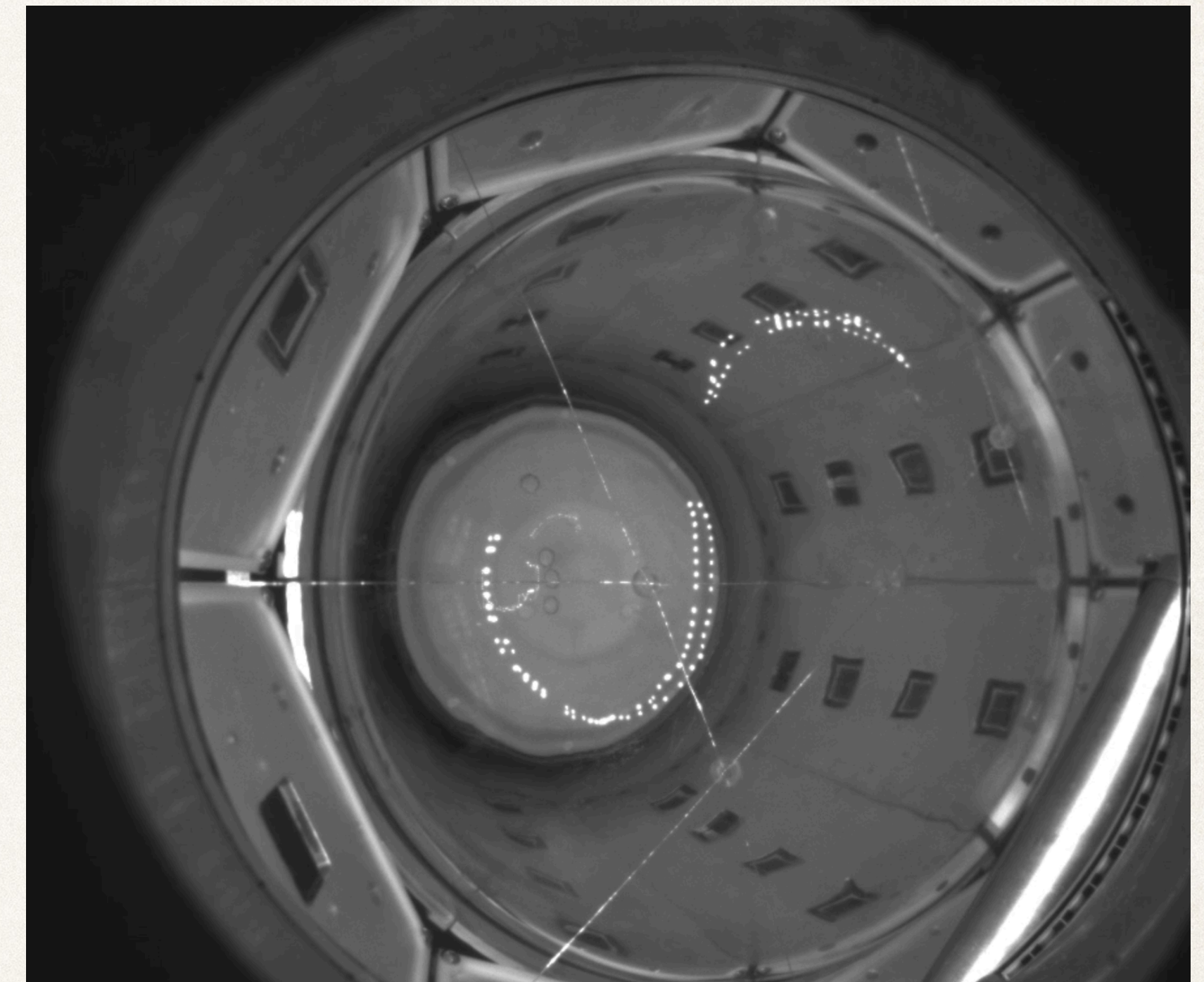


Figure from Guillaume Giroux's talk & PRL 134 (2025) 141002



Multi bubble event. Figure from Ben Broerman's talk

- ❖ [Search for low-mass dark matter with NEWS-G](#)
- ❖ [Low-mass WIMP search challenges with TREX-DM](#)
- ❖ [Searching for light dark matter with DarkSPHERE](#)
- ❖ [The Scintillating Bubble Chamber Experiment](#)

Low mass: silicon detectors

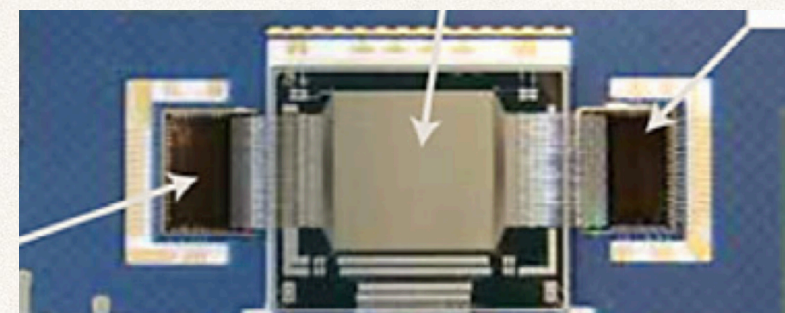
- ❖ [The DAMIC-M experiment: an Skipper CCD detector at LSS](#)
- ❖ [DAMIC-M analysis results from the LBC](#)
- ❖ [Latest Results and Prospects of the SENSEI experiment](#)
- ❖ [Time resolution for direct dark matter detection](#)



SENSEI



DAMIC



DANAÉ

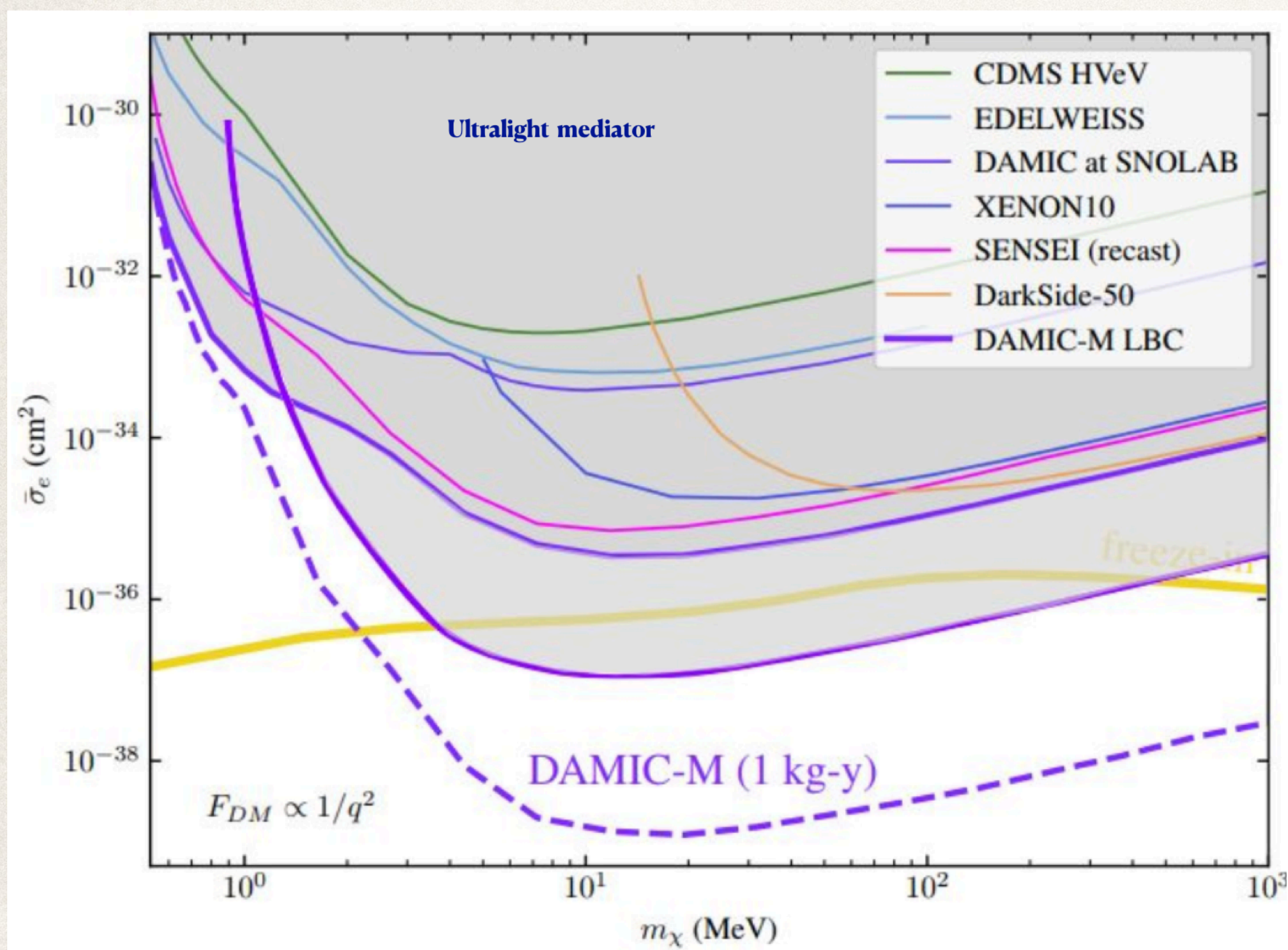


Figure from Rocio Vilar's talk

- ❖ Coupling to electrons
- ❖ Gram-scale detectors
- ❖ E_{th} of a few eV
- ❖ Great particle identification using particle tracks
- ❖ Diurnal modulation as powerful tool

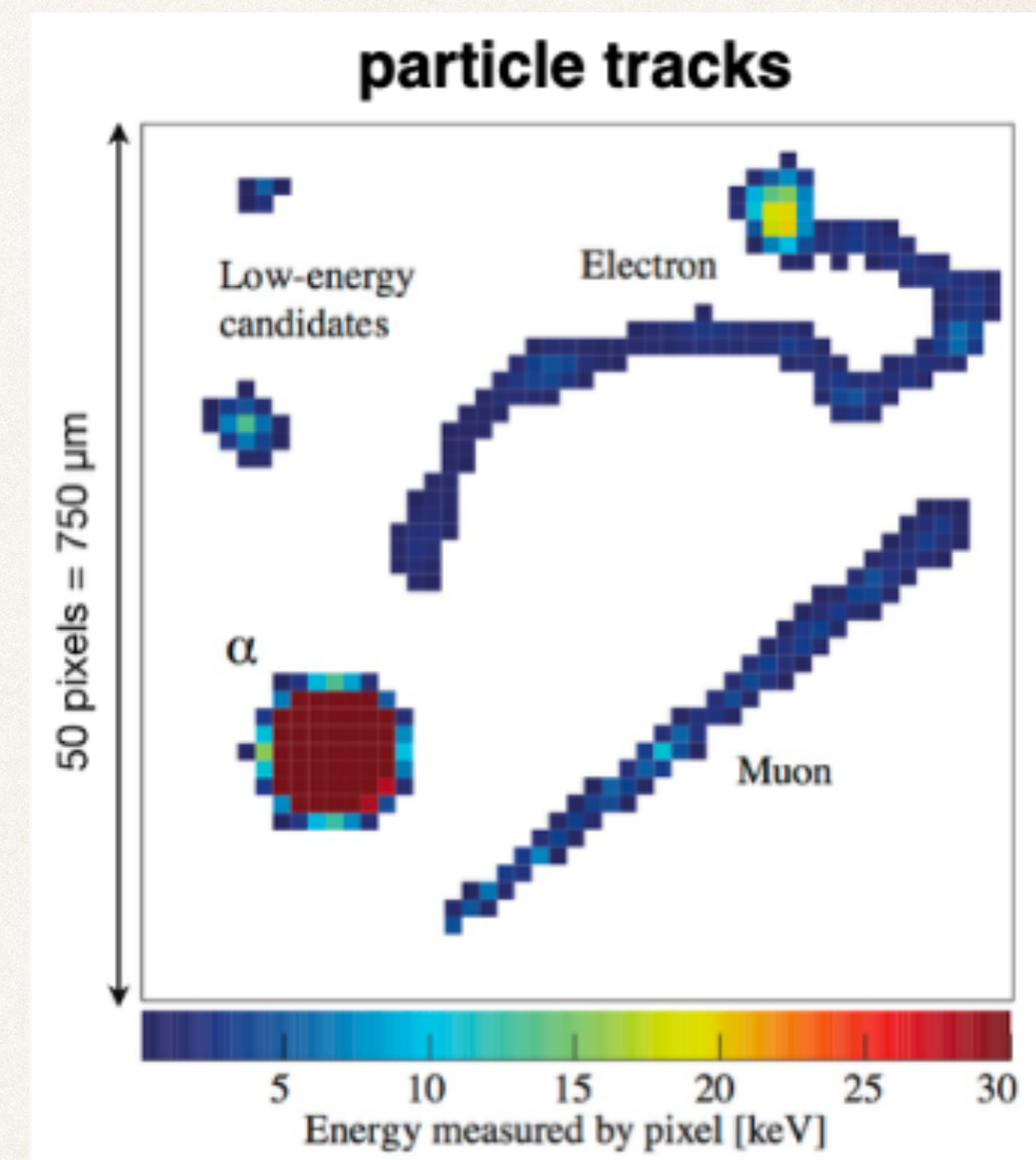


Figure from Nuria Castello-Mor's talk

Status of annual modulation

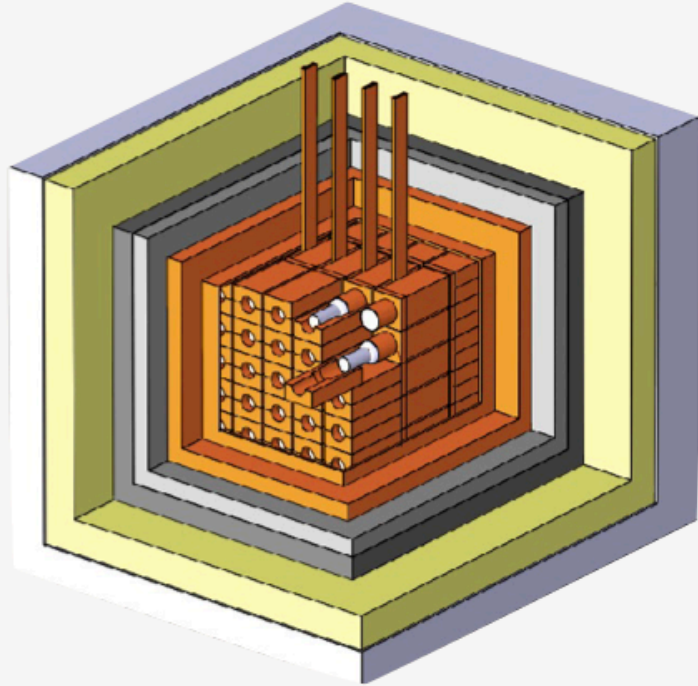
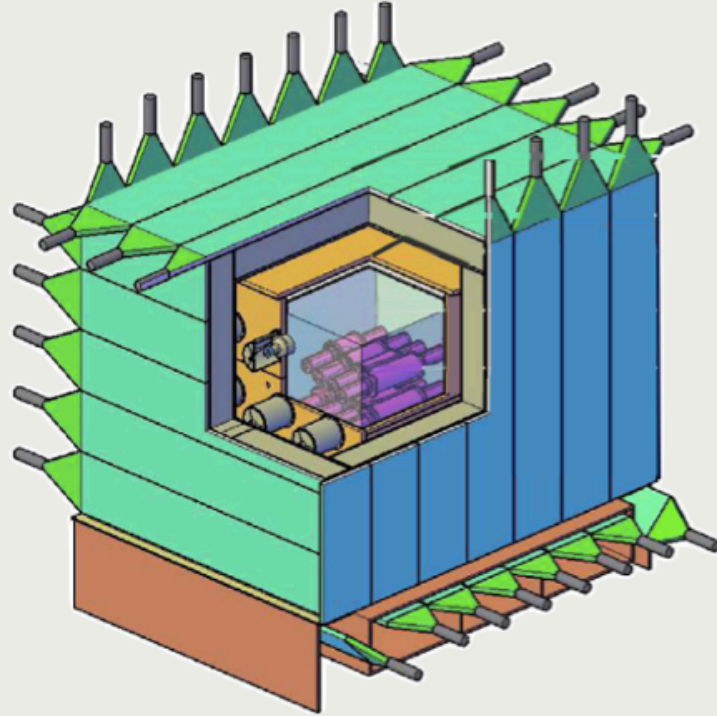
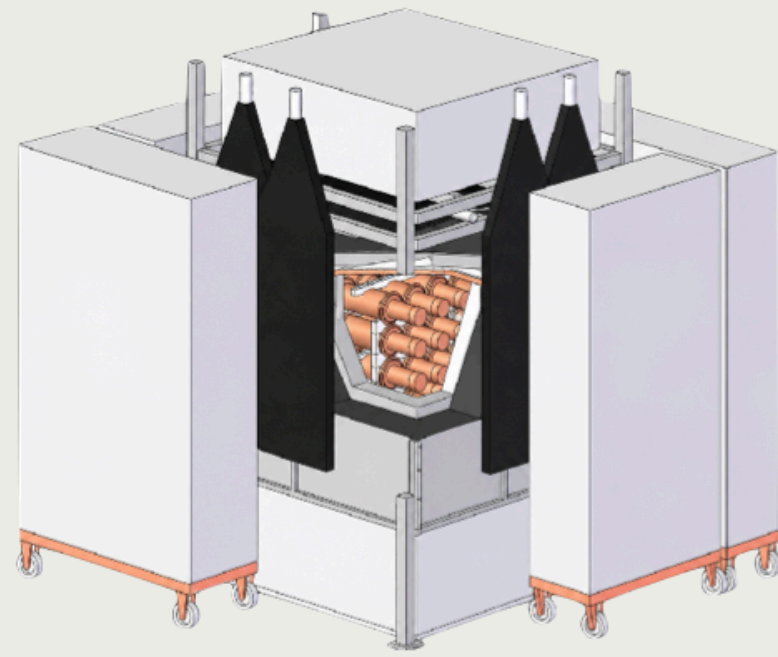
<i>decommissioned</i>	<i>taking data/upgrading</i>		<i>under construction</i>
DAMA/LIBRA* LNGS, Italy 	COSINE-100~ Y2L, South Korea 	ANAIS-112** LSC, Spain 	SABRE COSINUS PICO-LON
Mass = 250 kg Bkg. = 0.8 dru	Mass = 61.3 kg Bkg. = 2-3 dru	Mass = 112.5 kg Bkg. = 2.0-4.7 dru	expected background <1 dru
$S_{m, 1-6 \text{ keV}} = 0.0105 \pm 0.0011 \text{ dru}$ $S_{m, 2-6 \text{ keV}} = 0.0102 \pm 0.0008 \text{ dru}$	$S_{m, 1-6 \text{ keV}} = 0.0017 \pm 0.0029 \text{ dru}$ $S_{m, 2-6 \text{ keV}} = 0.0053 \pm 0.0031 \text{ dru}$	$S_{m, 1-6 \text{ keV}} = -0.0004 \pm 0.0025 \text{ dru}$ $S_{m, 2-6 \text{ keV}} = 0.0011 \pm 0.0025 \text{ dru}$	

Figure from Leonie Einfalt's talk

- ❖ [ANAIS-112: Model-Independent Test of DAMA/LIBRA](#)
- ❖ [WIMP search results from the full six-year COSINE-100](#)
- ❖ [Pioneering Sub-GeV Dark Matter Limits with COSINE-100](#)
- ❖ [Prospects of COSINE-100U: DM Search in Yemilab](#)
- ❖ [COSINUS at LNGS - Commissioning and Start of first Phase](#)
- ❖ [High pileup reconstruction and single photons in cryo scintillating calorimeters](#)
- ❖ [The SABRE experiment: status and prospects](#)
- ❖ [The SABRE South Experiment at the Stawell Laboratory](#)

Status of annual modulation

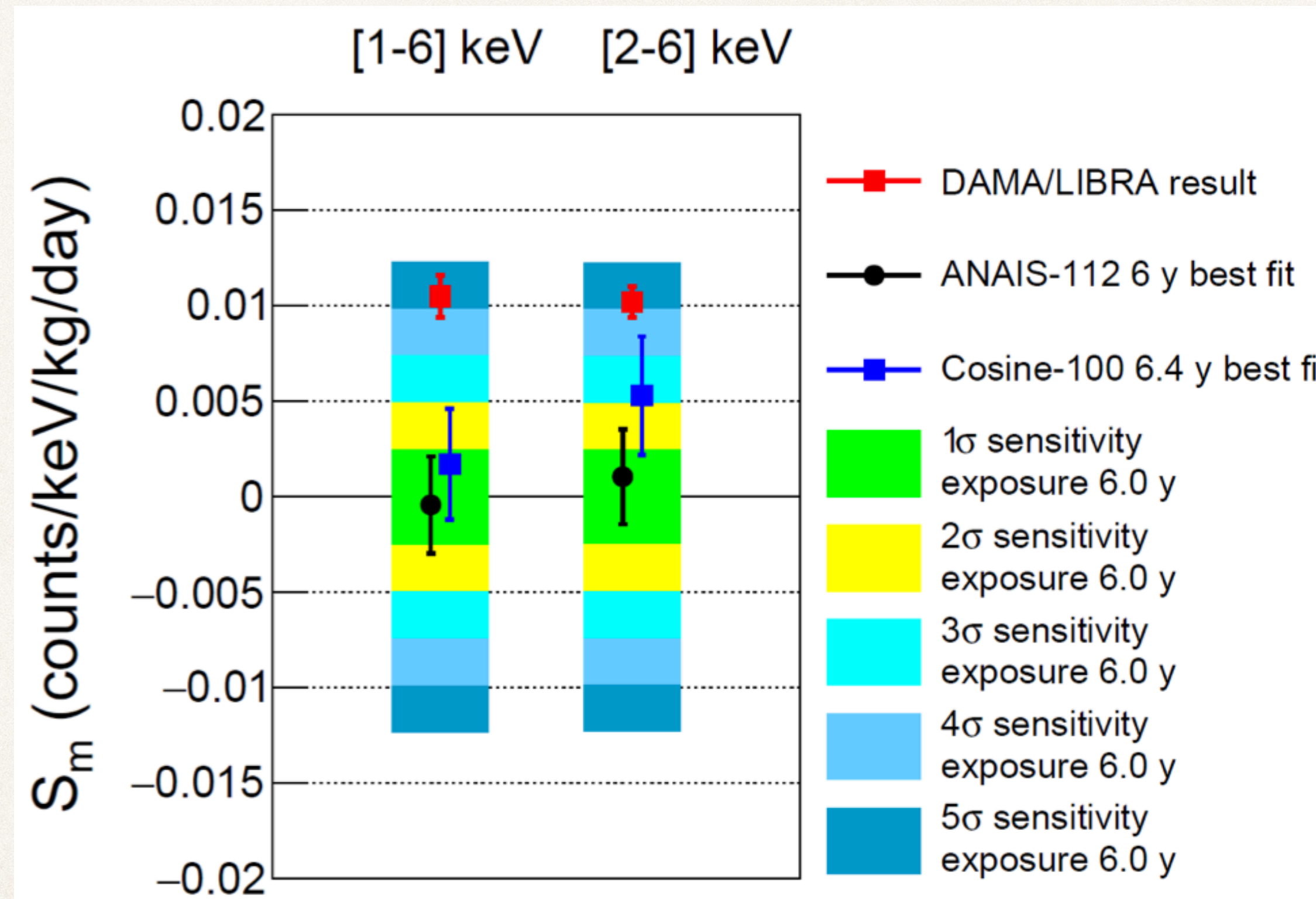


Figure from Iván Coarasa's talk

- ❖ [ANAIS-112: Model-Independent Test of DAMA/LIBRA](#)
- ❖ [WIMP search results from the full six-year COSINE-100](#)
- ❖ [Pioneering Sub-GeV Dark Matter Limits with COSINE-100](#)
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Directionality

- ❖ [Commissioning and design of the CYGNO-04 directional detector at LNGS](#)
- ❖ [NEWAGE: low BG experiment for direction-sensitive DM search](#)
- ❖ [High NI gain Micromesh Structures and the LARD Initiative](#)
- ❖ [Underground environmental neutron flux measurement with CYGNO](#)

❖ Gaseous directional detectors: current largest volume in $O(m^3)$

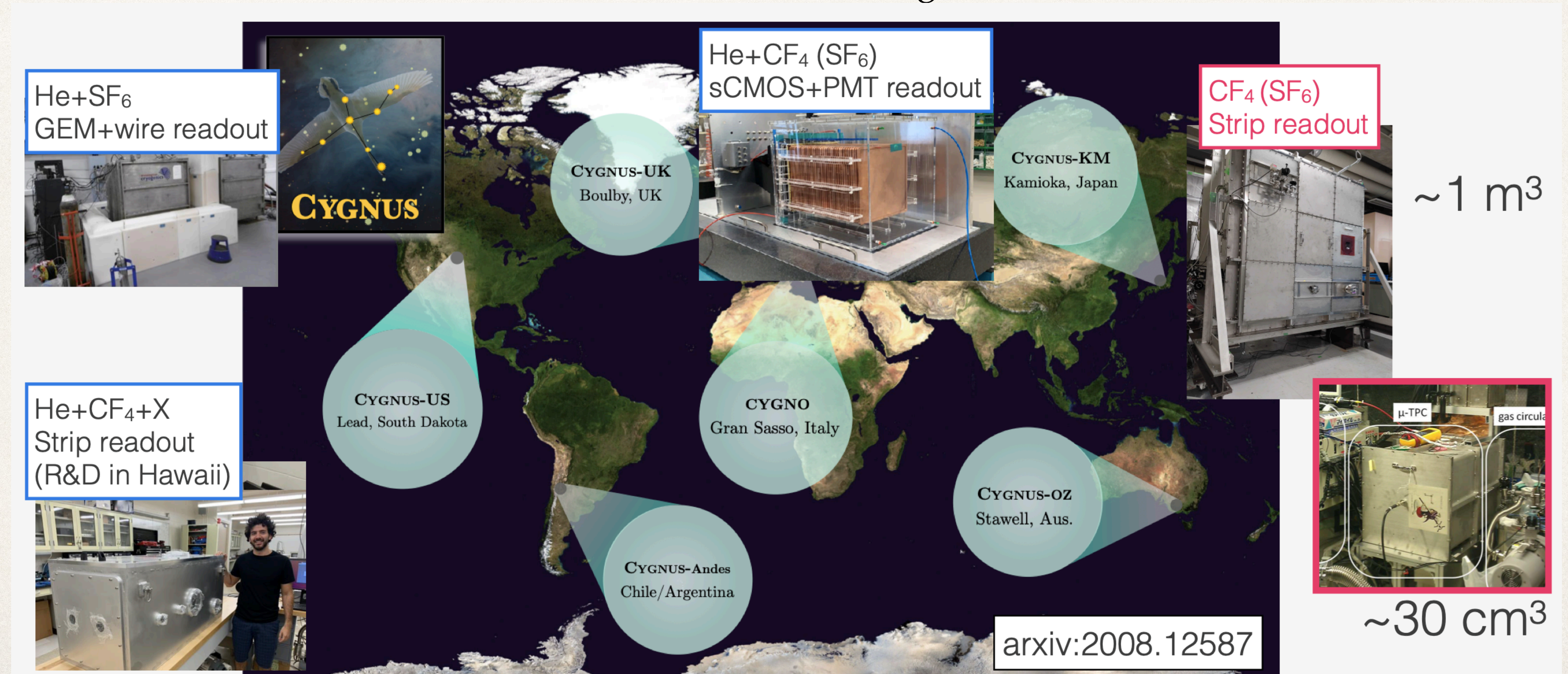
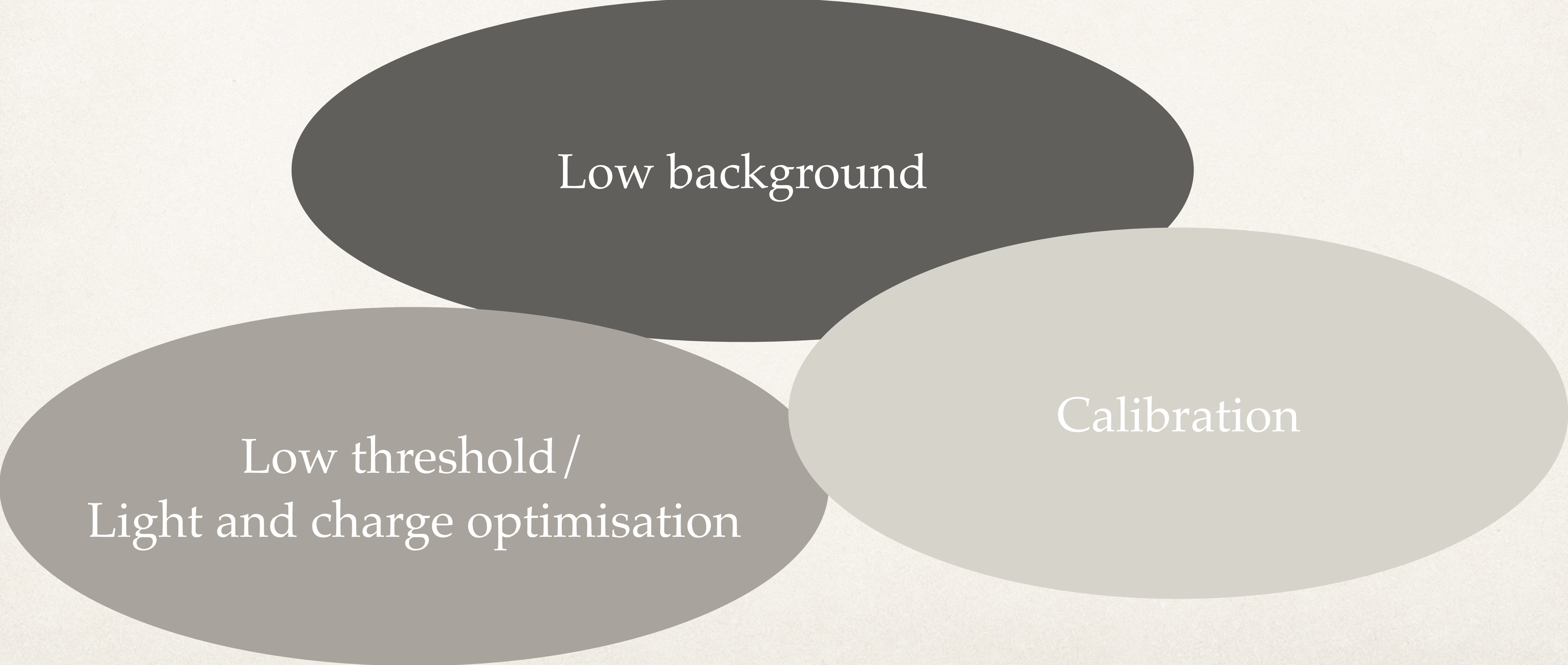


Figure from Satoshi Higashino's talk

Instrumentation



Low background

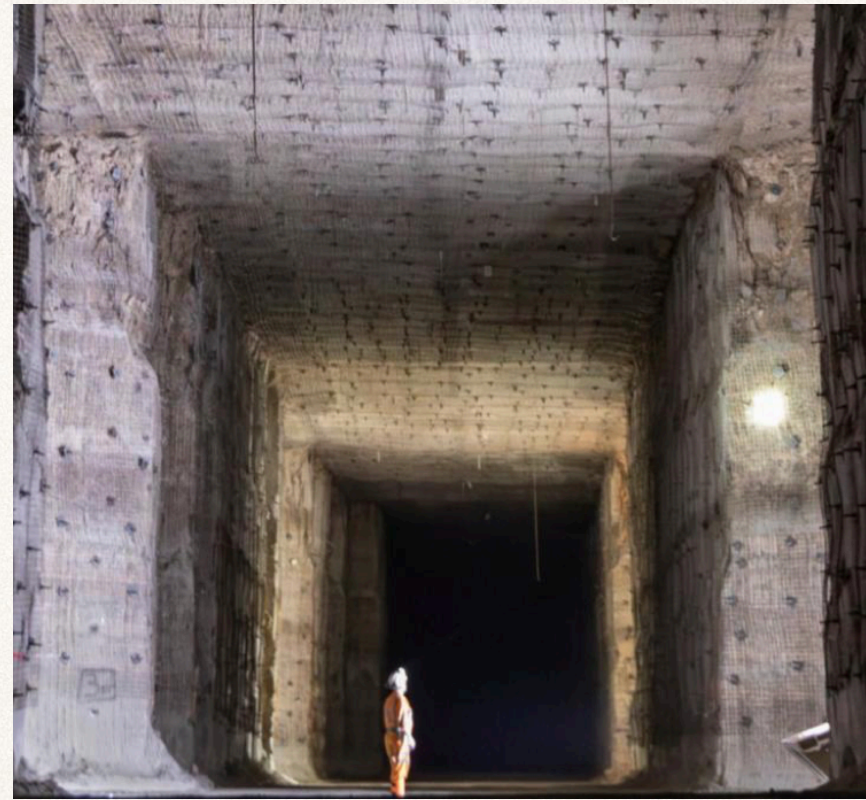
Calibration

Low threshold/
Light and charge optimisation

Low background: labs and vetos



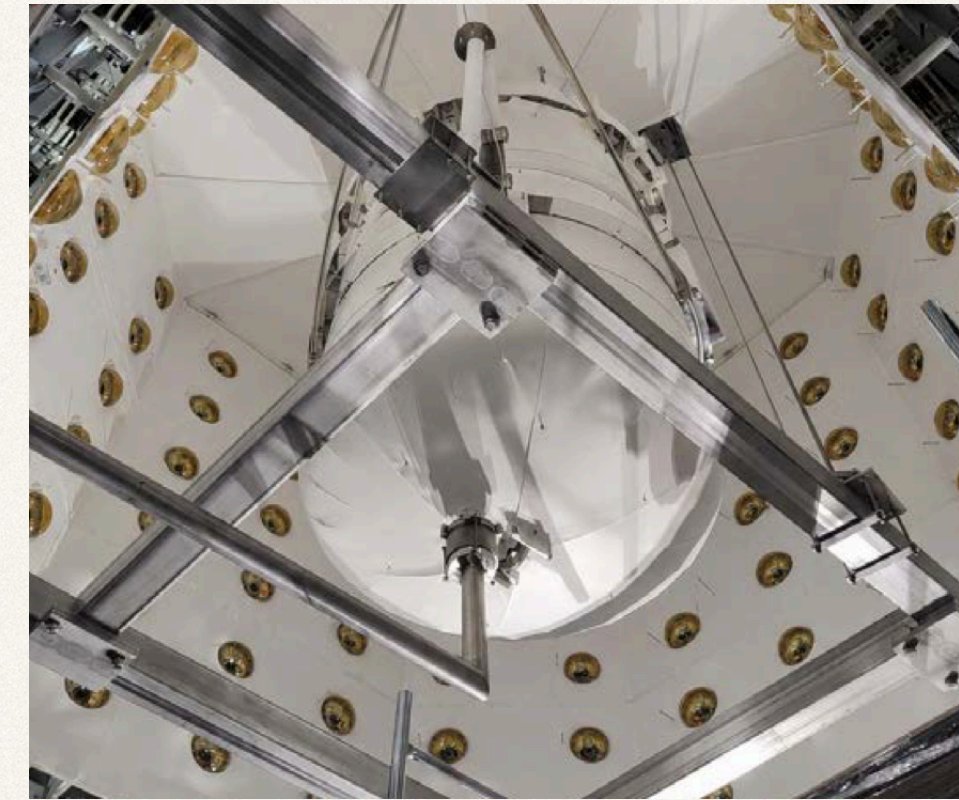
Bedretto



Boulby



Modane



Veto in XENONnT

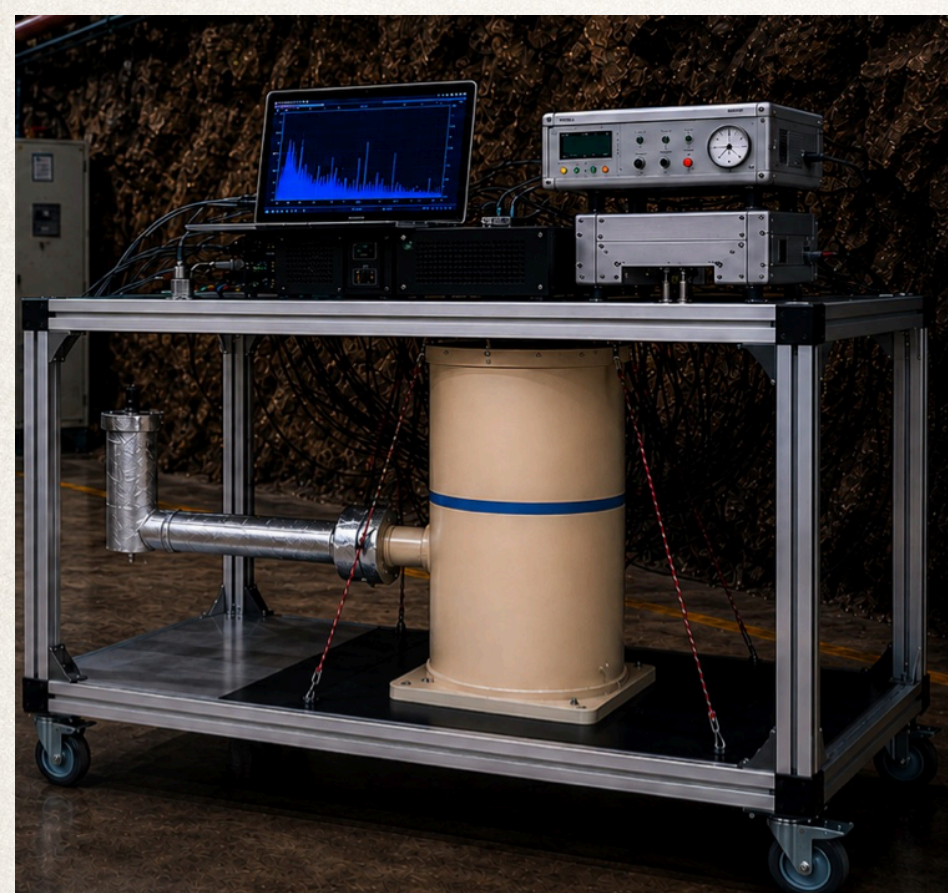


Veto in PandaX

- ❖ Underground labs:
updates on Modane, Boulby & Bedretto
- ❖ Additional veto systems required for muon-
and neutron tagging

- ❖ [Bedretto: Underground Laboratory for Fundamental Physics](#)
- ❖ [The Modane Underground Laboratory](#)
- ❖ [Boulby Underground Laboratory: Projects and plans](#)
- ❖ [Development and performance of the PandaX veto system](#)
- ❖ [Gd-loaded Water Cherenkov Neutron Veto in XENONnT](#)

Low background: radio-purity

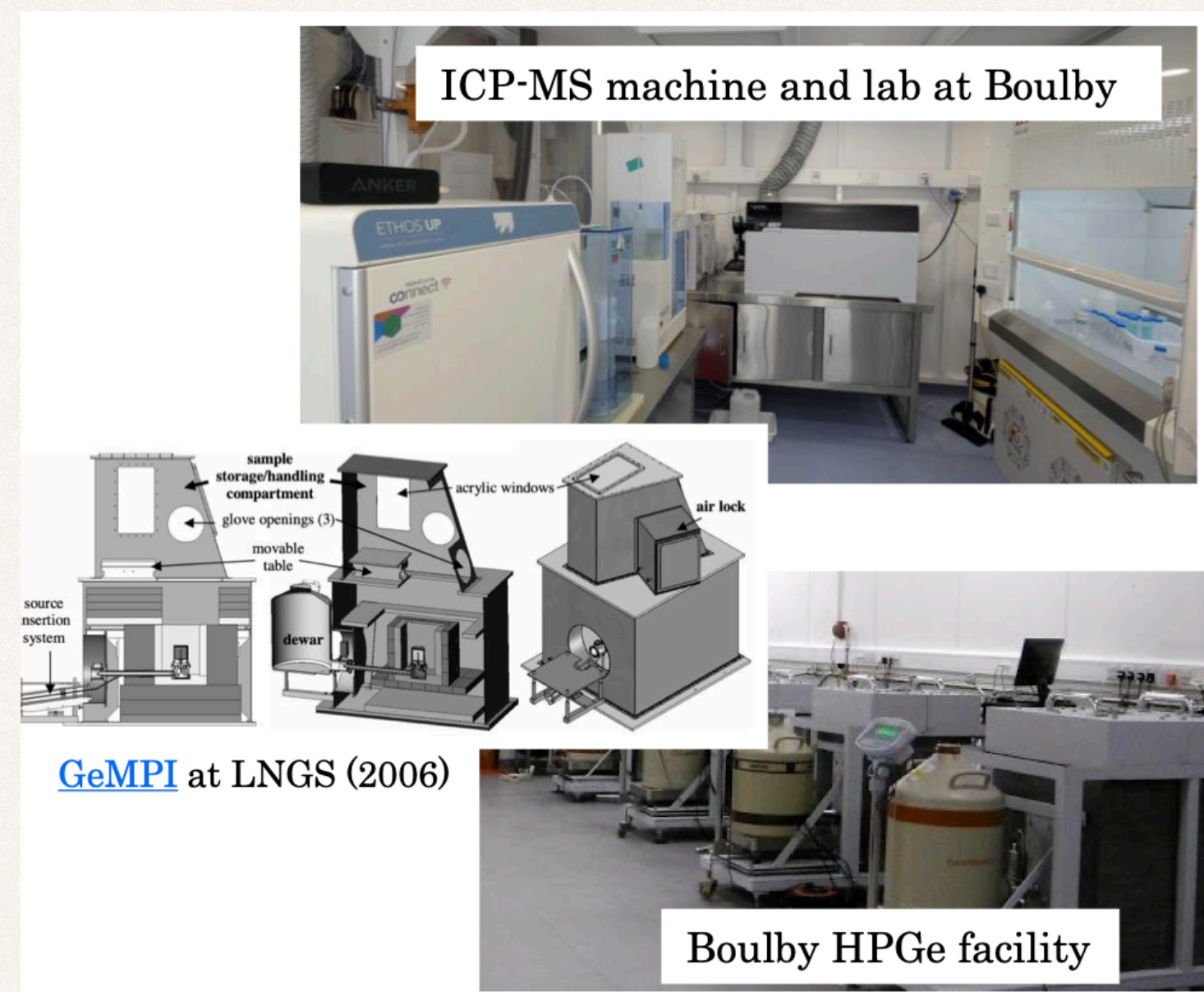


@ LNGS



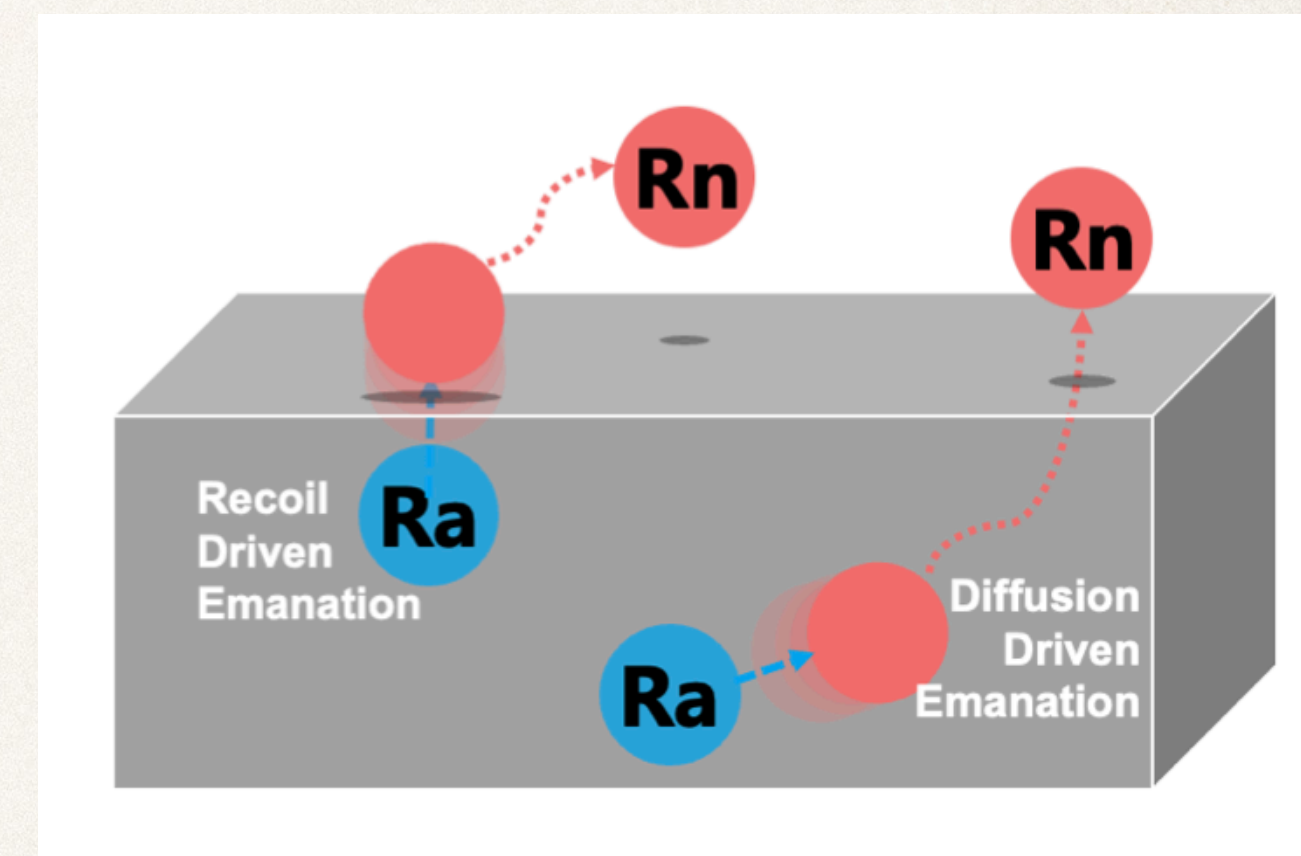
@ SURF

- ❖ Underground infrastructures
- ❖ Radioassays: neutron yields, γ -fluxes
- ❖ Cleanliness in future detectors
- ❖ Radon: measurements and mitigation



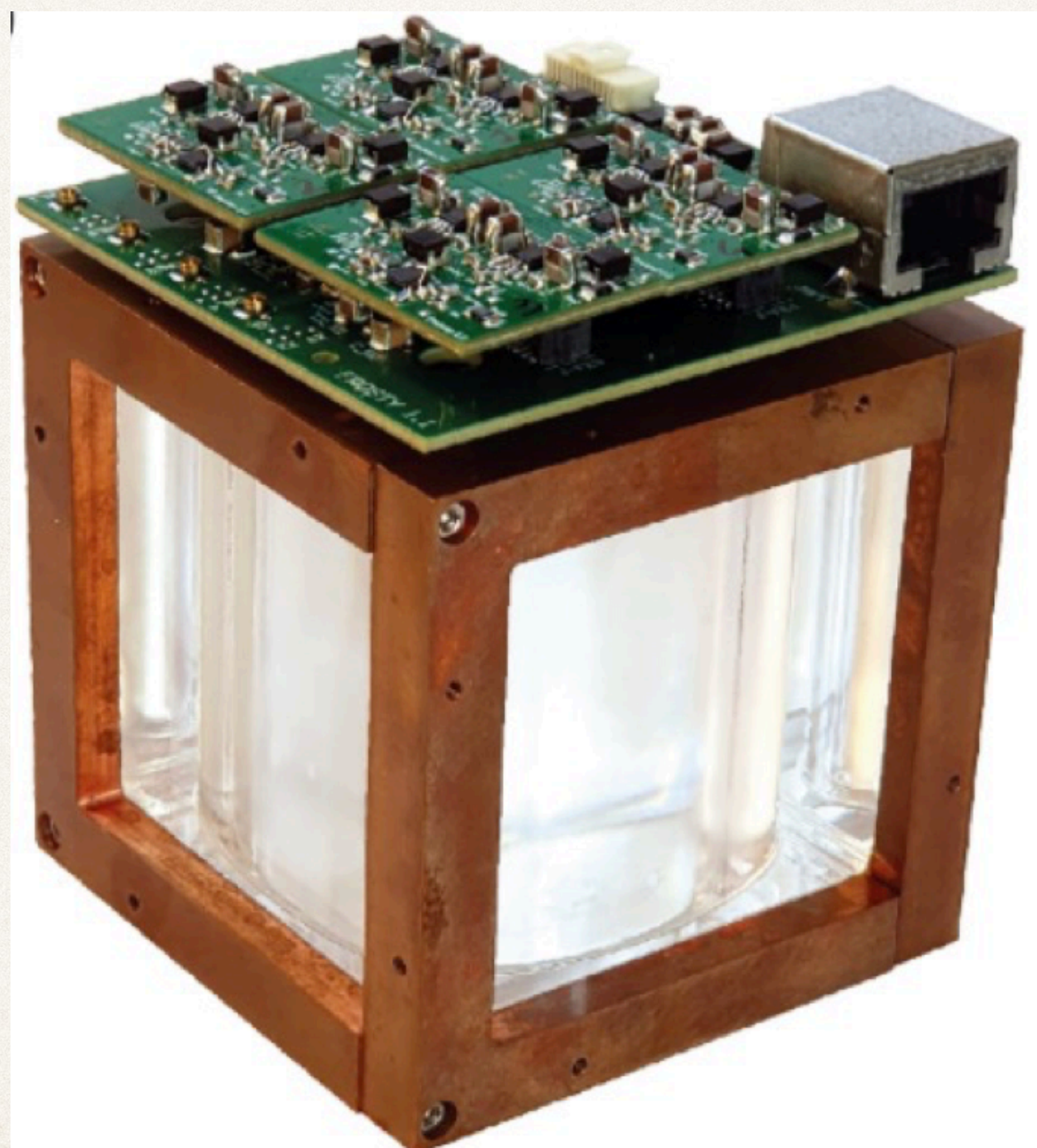
Cleanliness

- ❖ [International Radon Network for Dark Matter Experiments](#)
- ❖ [Uncertainties of the \$\(\alpha, n\)\$ in Ar and New Cross-Section](#)
- ❖ [Radiopurity and Cleanliness Control in XLZD](#)
- ❖ [Constraining Environmental Backgrounds with LZ](#)
- ❖ [Modeling the low-energy accidental background in LZ](#)
- ❖ [\$\gamma\$ -Ray Flux at LNGS: Toward a Systematic Framework](#)
- ❖ [Towards an International Radon Network for DM Experiments](#)
- ❖ [Background Assessment for COSINUS Run 1](#)



Radon network

Instrumentation: light and charge



ASTAROTH. Figure from Davide D'Angelo's talk

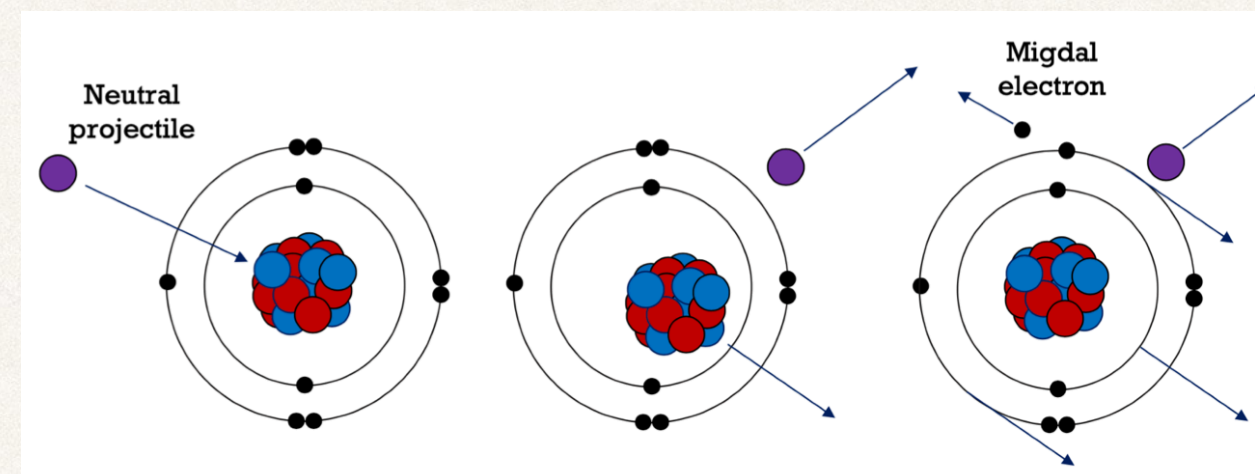
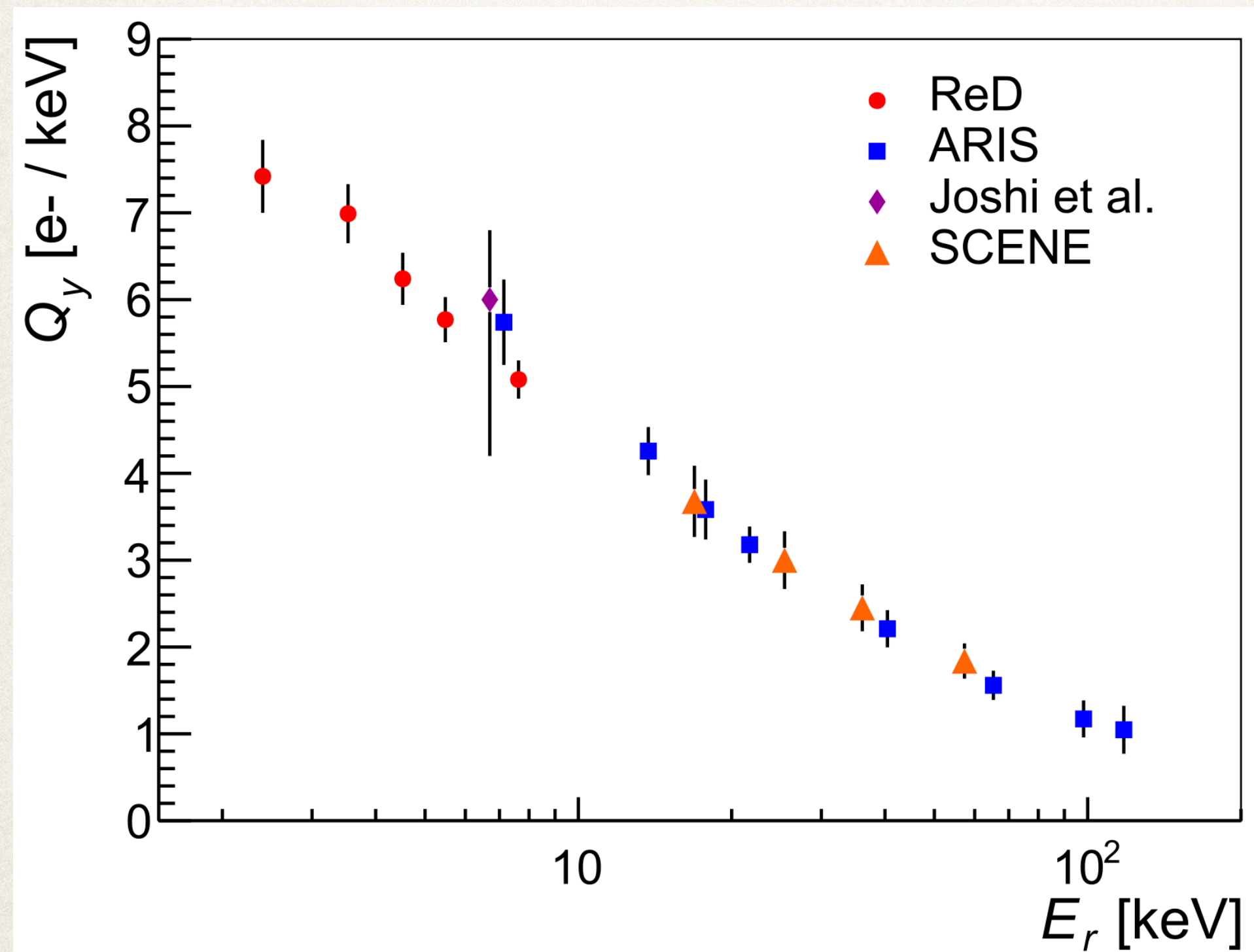


LXe prop. scintillation. Figure from Patrick Knights's talk

- ❖ [Cryogenic Single-Photon Detectors to Study the Light of NaI Crystals](#)
- ❖ [The ANAIS+ project: scintillation detectors at 100K](#)
- ❖ [Cryogenic SiPM readout of NaI\(Tl\) detectors within ASTAROTH](#)

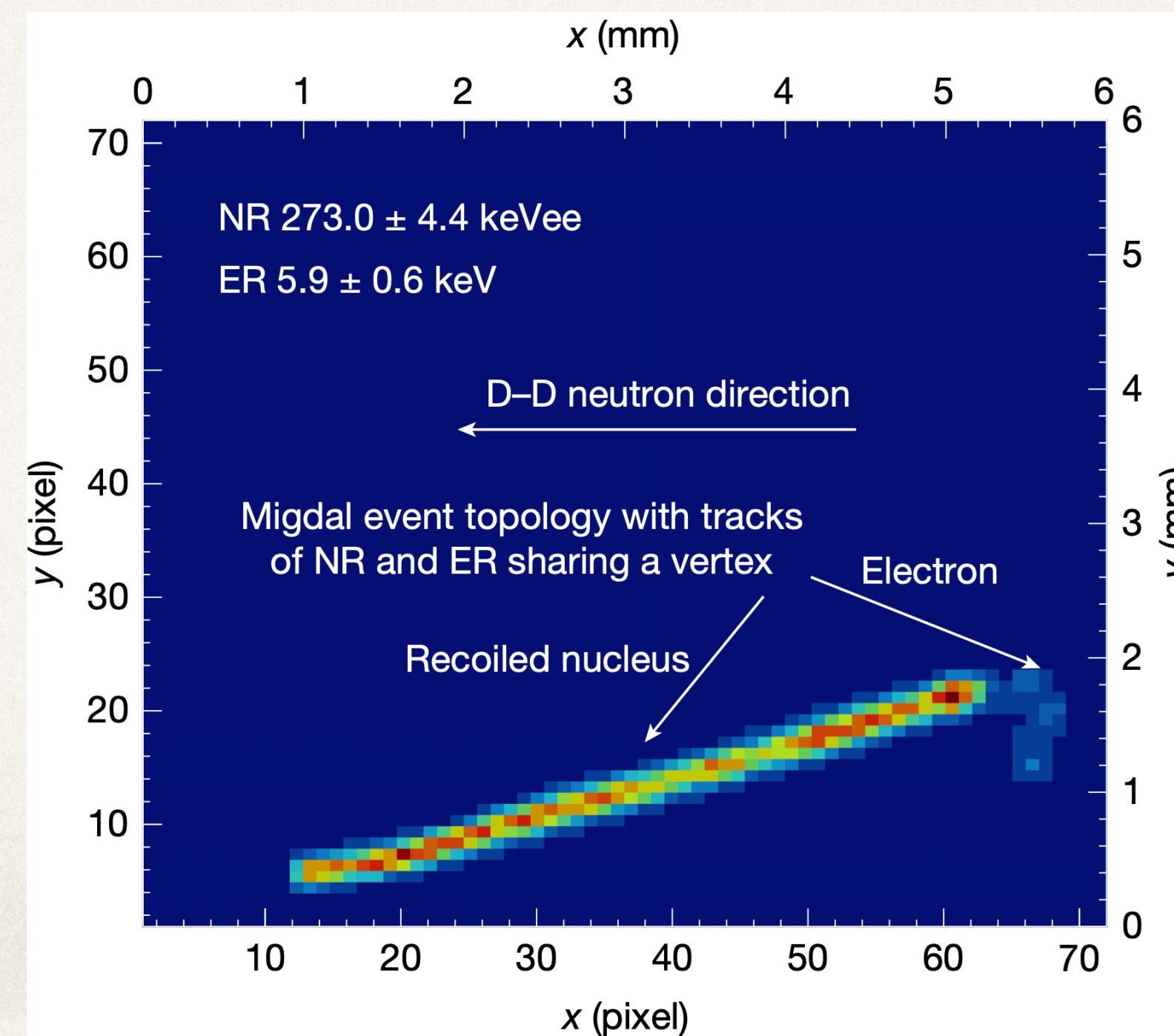
- ❖ [Ultra-cold Ar-based TPC with wavelength-shifting optical amplification](#)
- ❖ [Infrared scintillation light in xenon](#)
- ❖ [Scintillation from proportional electron multiplication in LXe](#)

Instrumentation: Calibration & Migdal



Scheme from Lex Millins's talk

- ❖ Detected at $> 5\sigma$ by MARVeL
- ❖ Not yet seen @ MIGDAL



Migdal event from Qian Liu's talk

- ❖ [Results from the MIGDAL experiment](#)
- ❖ [Sub-GeV Dark Matter via Migdal-Induced Electron Excitation](#)
- ❖ [Calibration of Graphene-based Josephson Junction Detector](#)
- ❖ [Characterization of Ar recoils @ keV scale: ReD and ReD+](#)

Axion searches

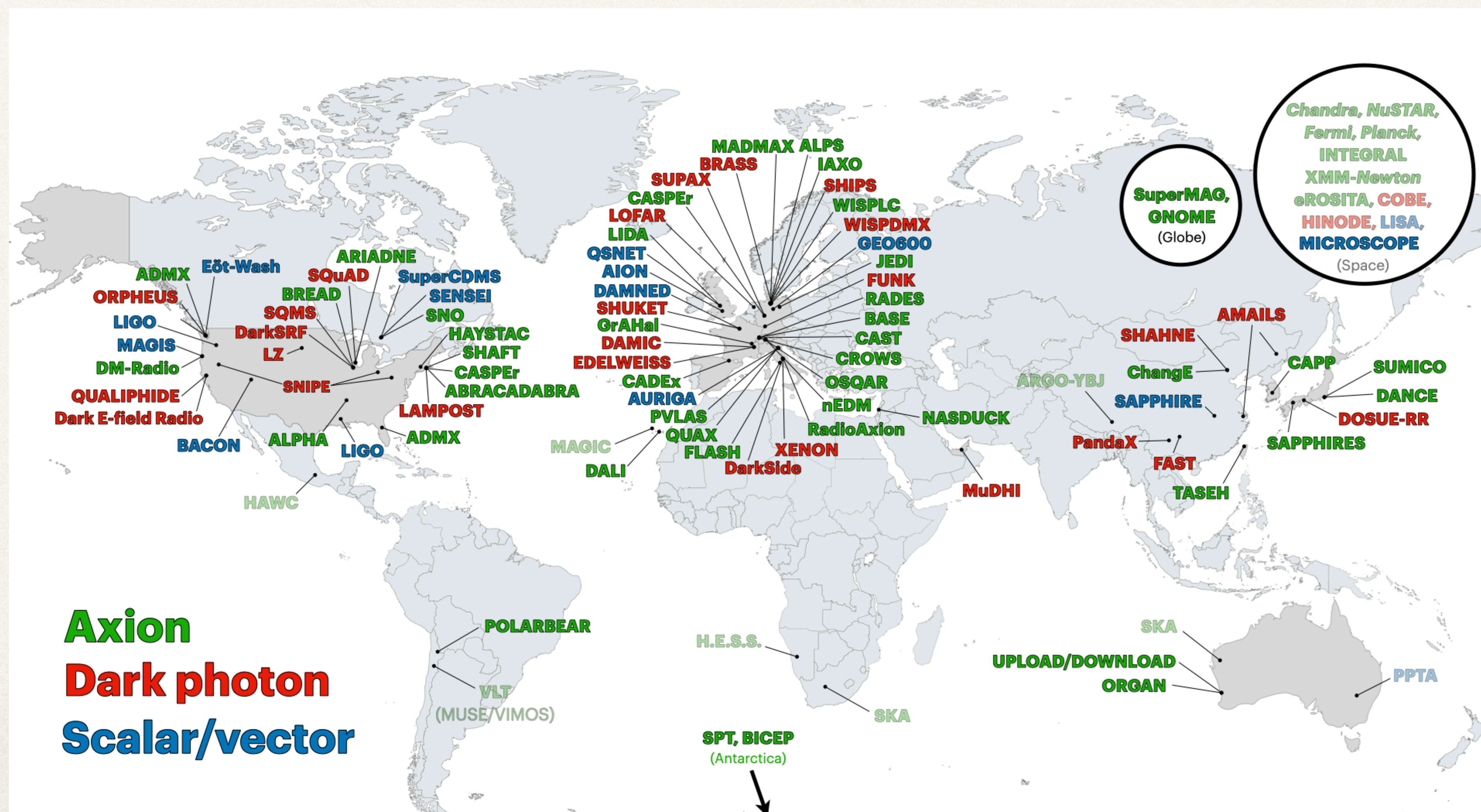
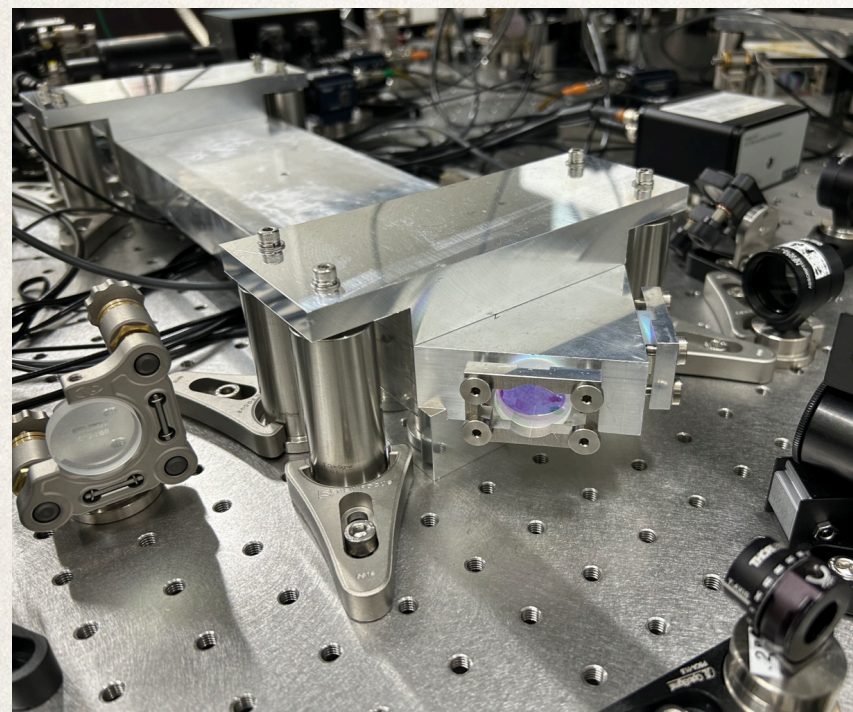


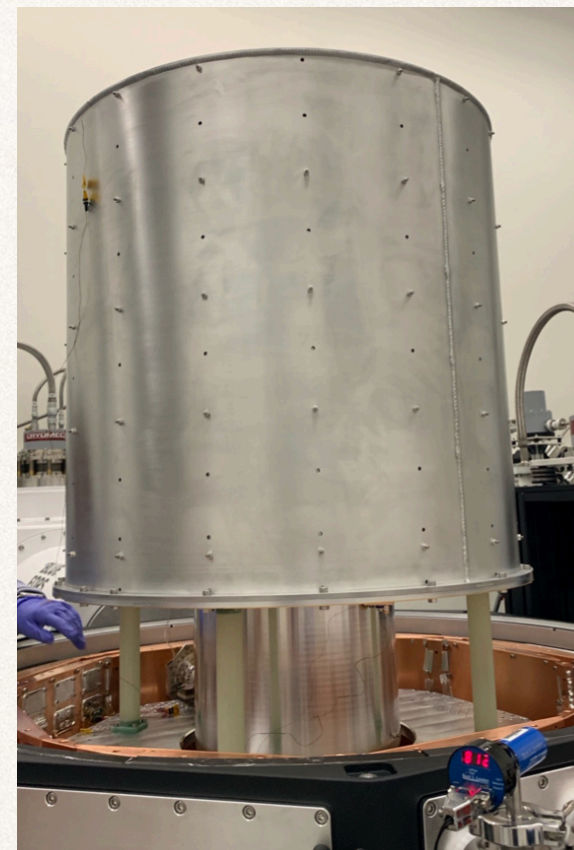
Figure from C. O'Hare

Axions: below ADMX

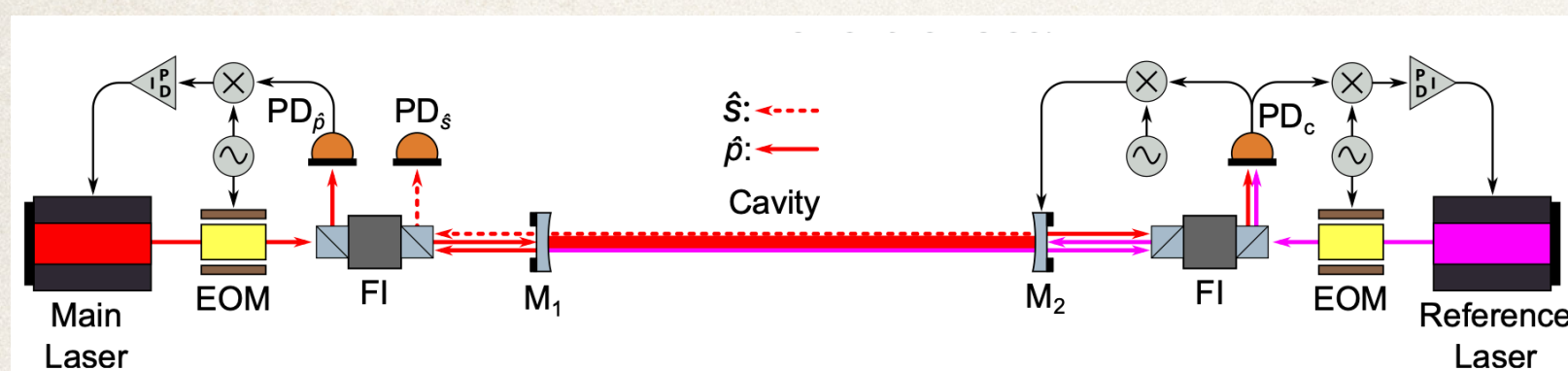
- ❖ [Commissioning the Dark Matter Radio 50L Experiment](#)
- ❖ [Dark matter Axion search with riNg Cavity Experiment \(DANCE\)](#)
- ❖ [Polarimetric Searches for Axion Dark Matter with Optical Cavities](#)



DANCE



DMRadio-50L



Polarimetric searches at ALPs II

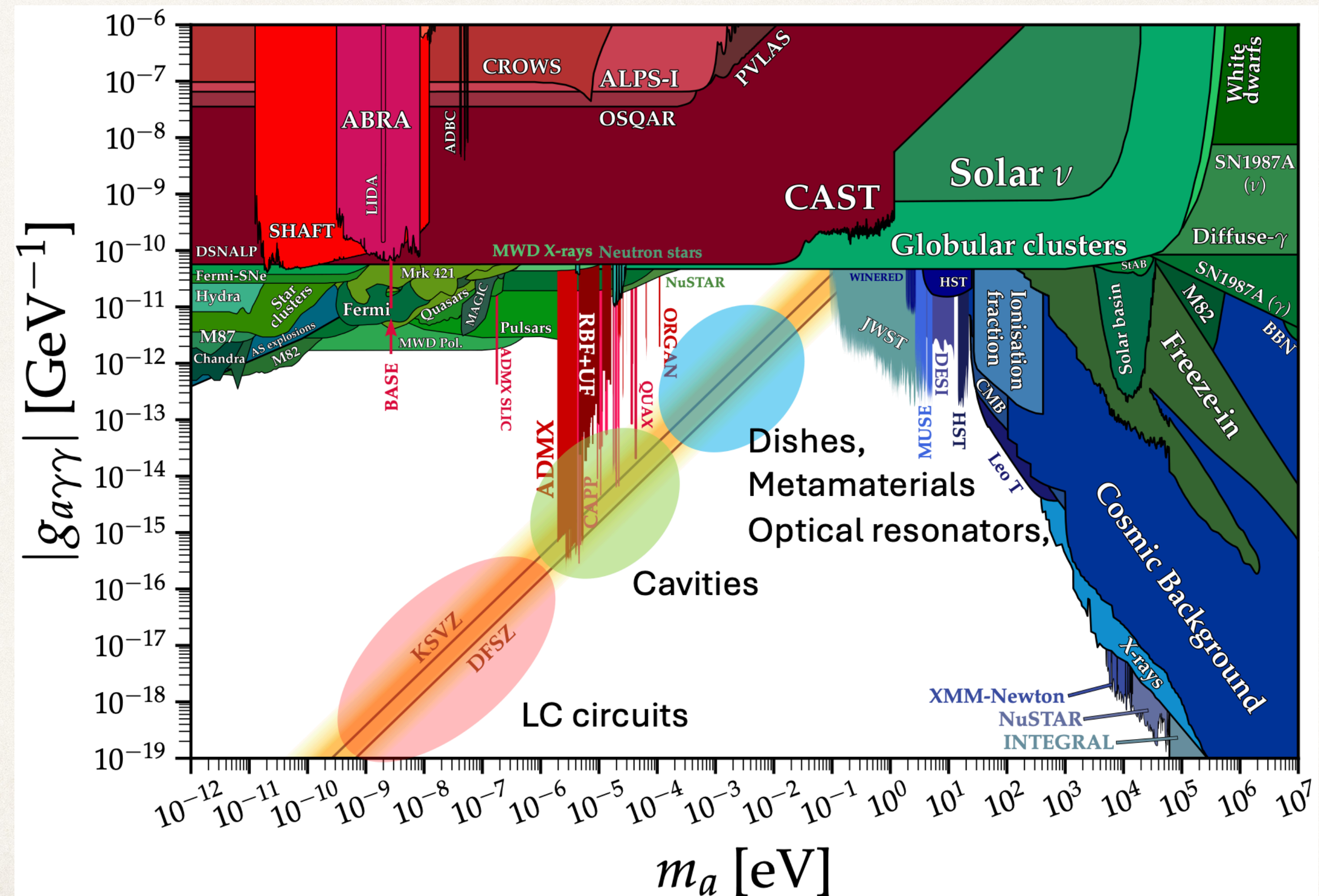


Figure from Karl van Bibber's talk using C. O'Hare's plots

Axions at & above ADMX

- ❖ First MADMAX searches for axion and dark photon dark matter
- ❖ High-frequency axion searches with quantum sensors at RADES
- ❖ Update on the ALPHA experiment
- ❖ Tuning plasma haloscopes with spirals and concentric rings
- ❖ Dielectric Fabry-Perot cavity and trapped e- single photon counter
- ❖ QUAX haloscope read out by a Single Microwave Photon Counter

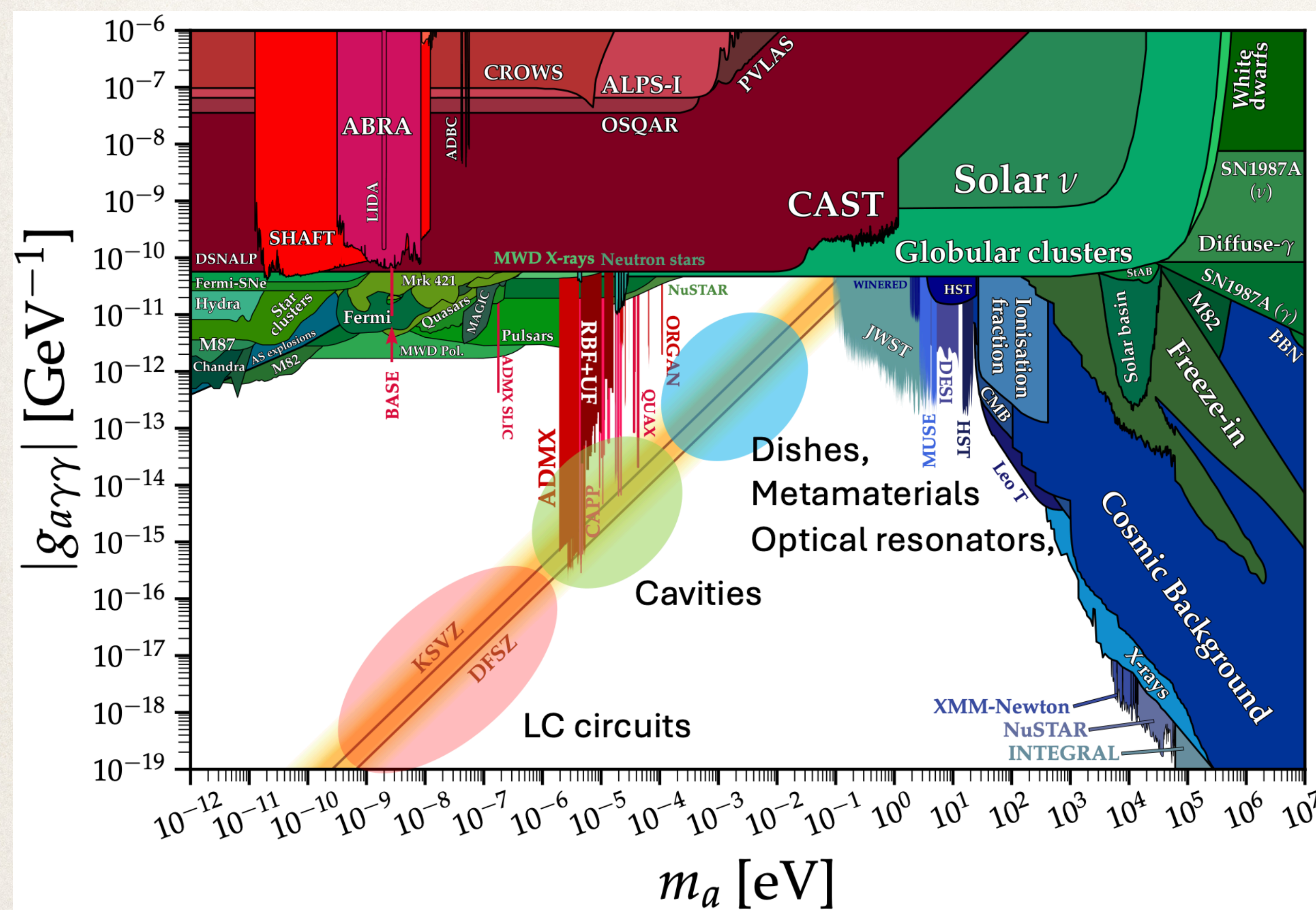
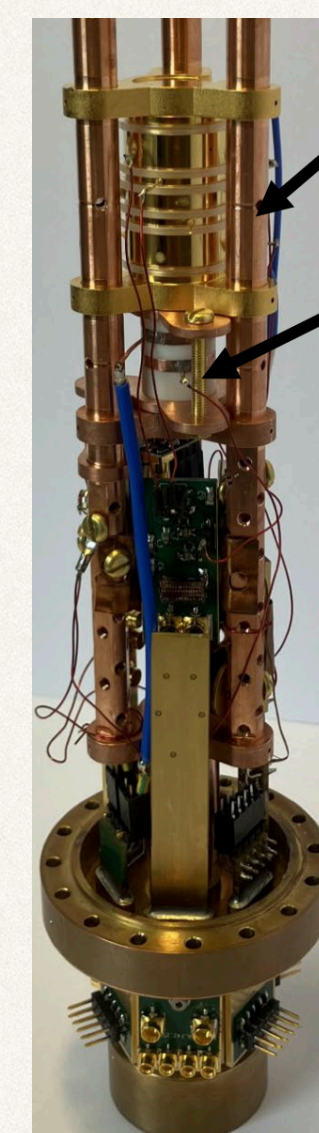


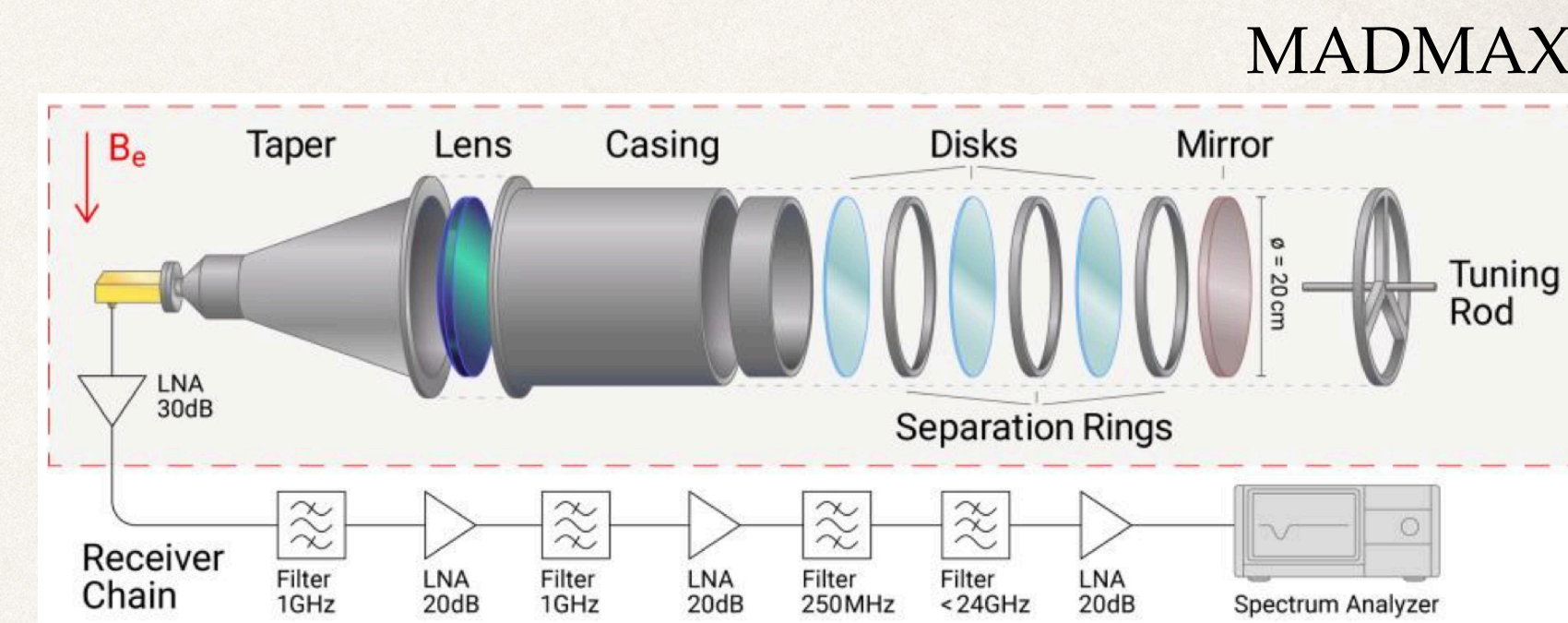
Figure from Karl van Bibber's talk using C. O'Hare's plots



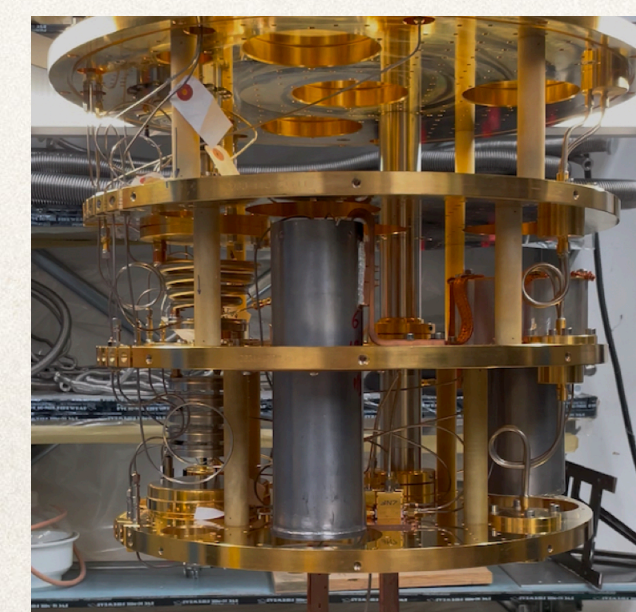
Fabry-Perot



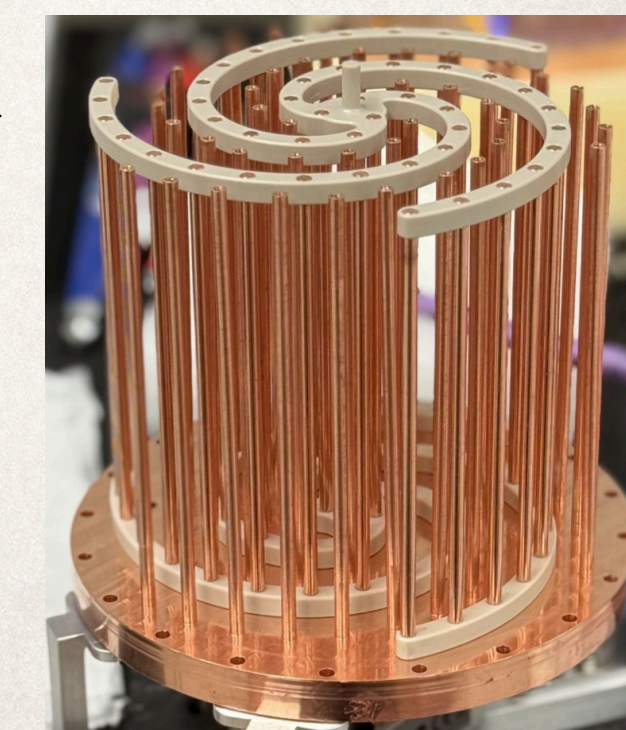
RADES



MADMAX



QUAX



ALPHA

Solar axions/WISPs and astrophysics constrains

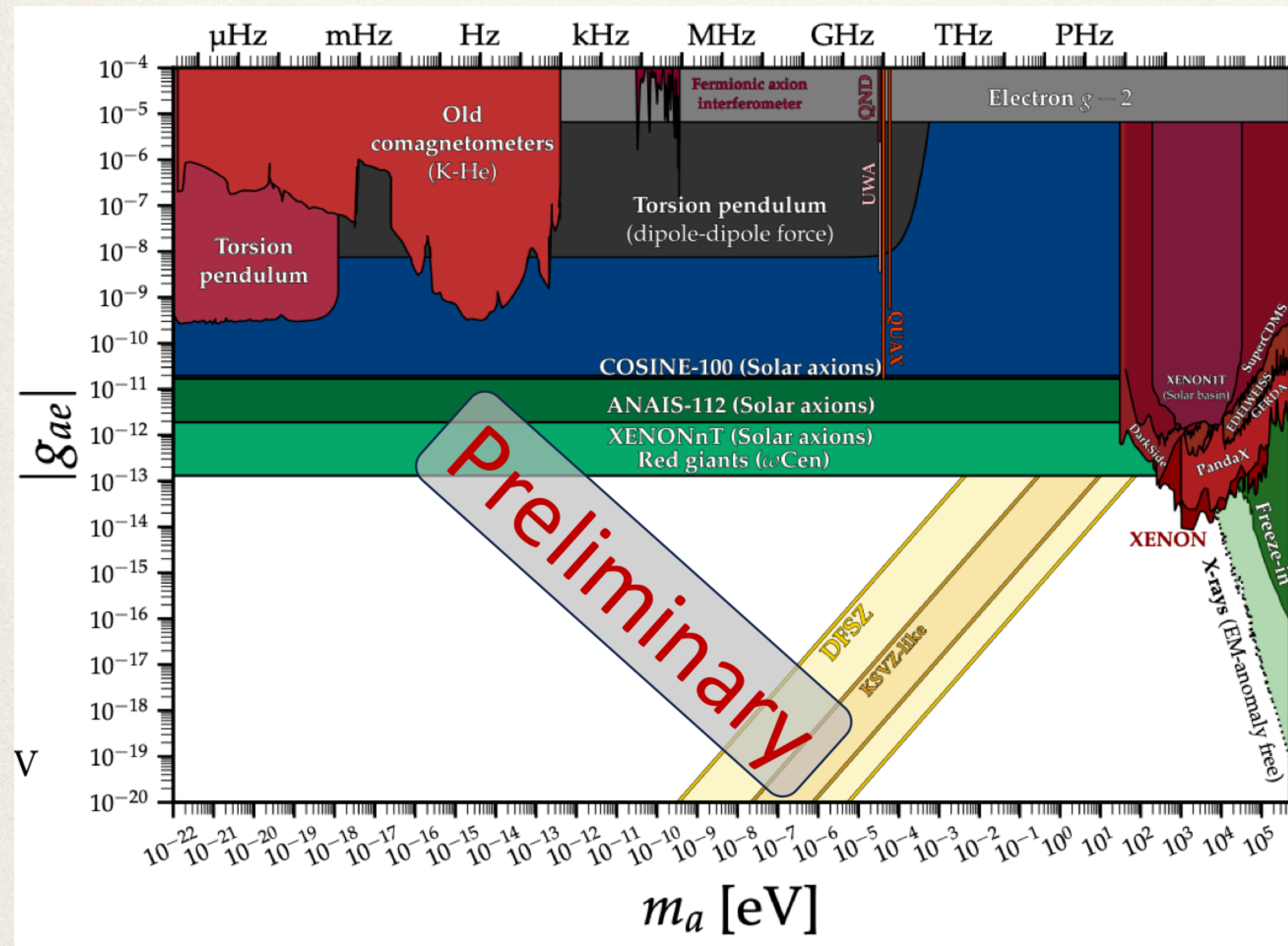


Figure from Sophia Hollick's talk using C. O'Hare's plots

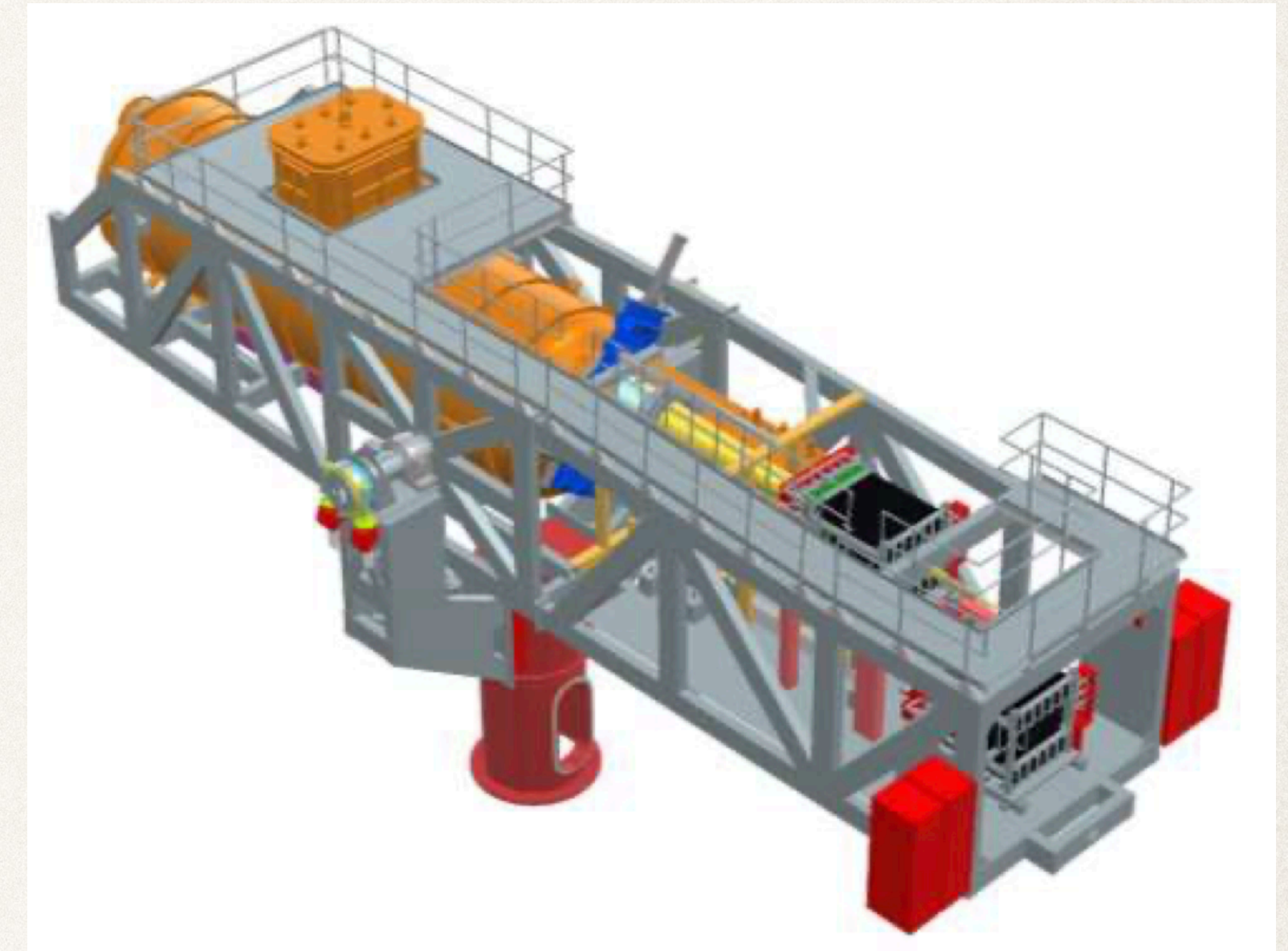
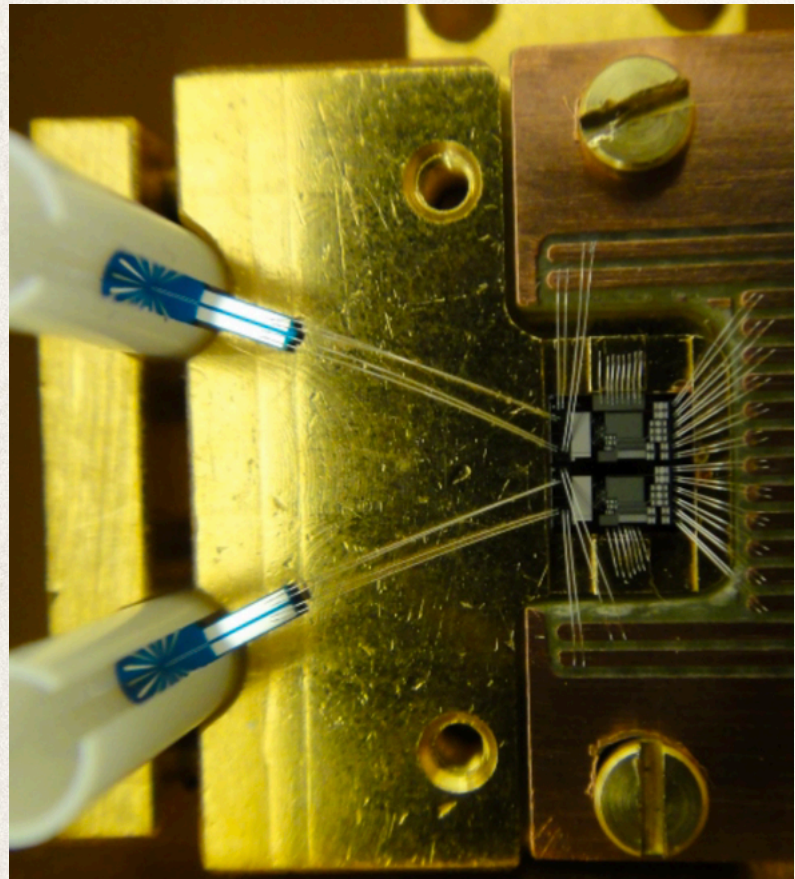


Figure from Ana Quintana García's talk

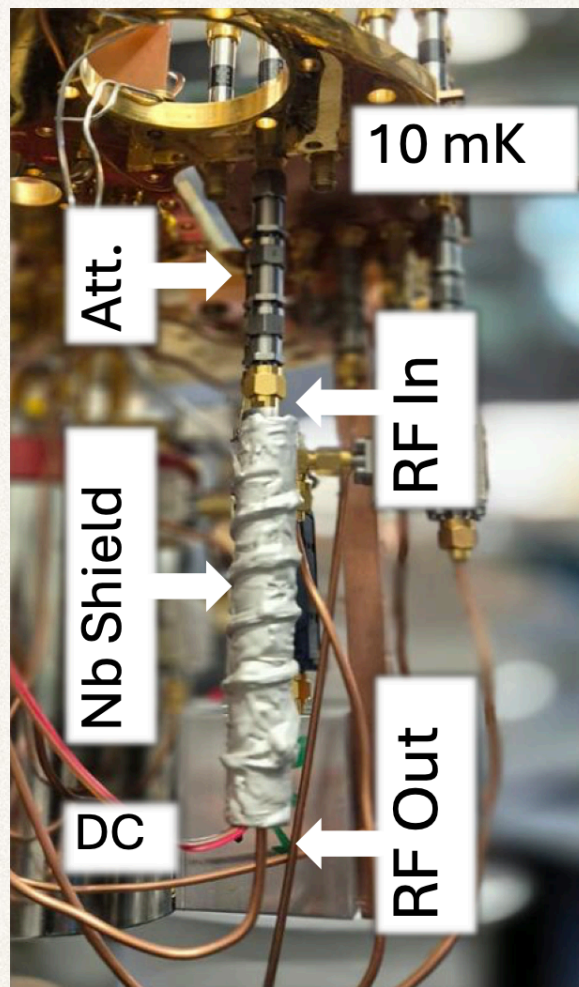
BabyIAXO getting ready

- ❖ [Solar Axion Searches with BabyIAXO](#)
- ❖ [Solar WISPs with Annual Modulation in ANAIS-112](#)
- ❖ [X-ray Telescopes for Axion Searches](#)

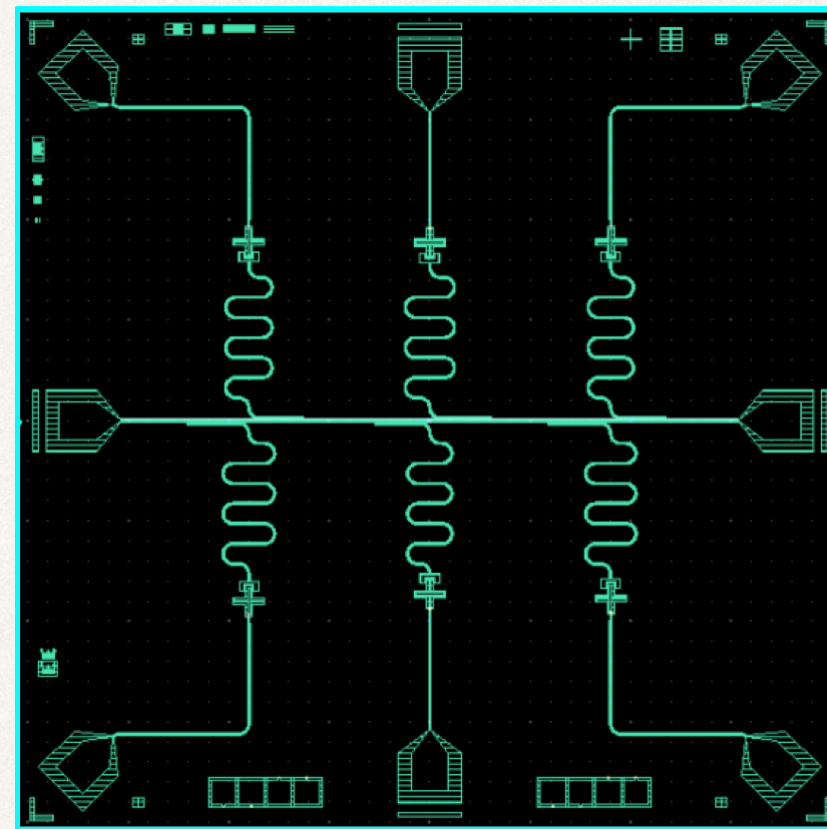
Instrumentation: axion & quantum sensors



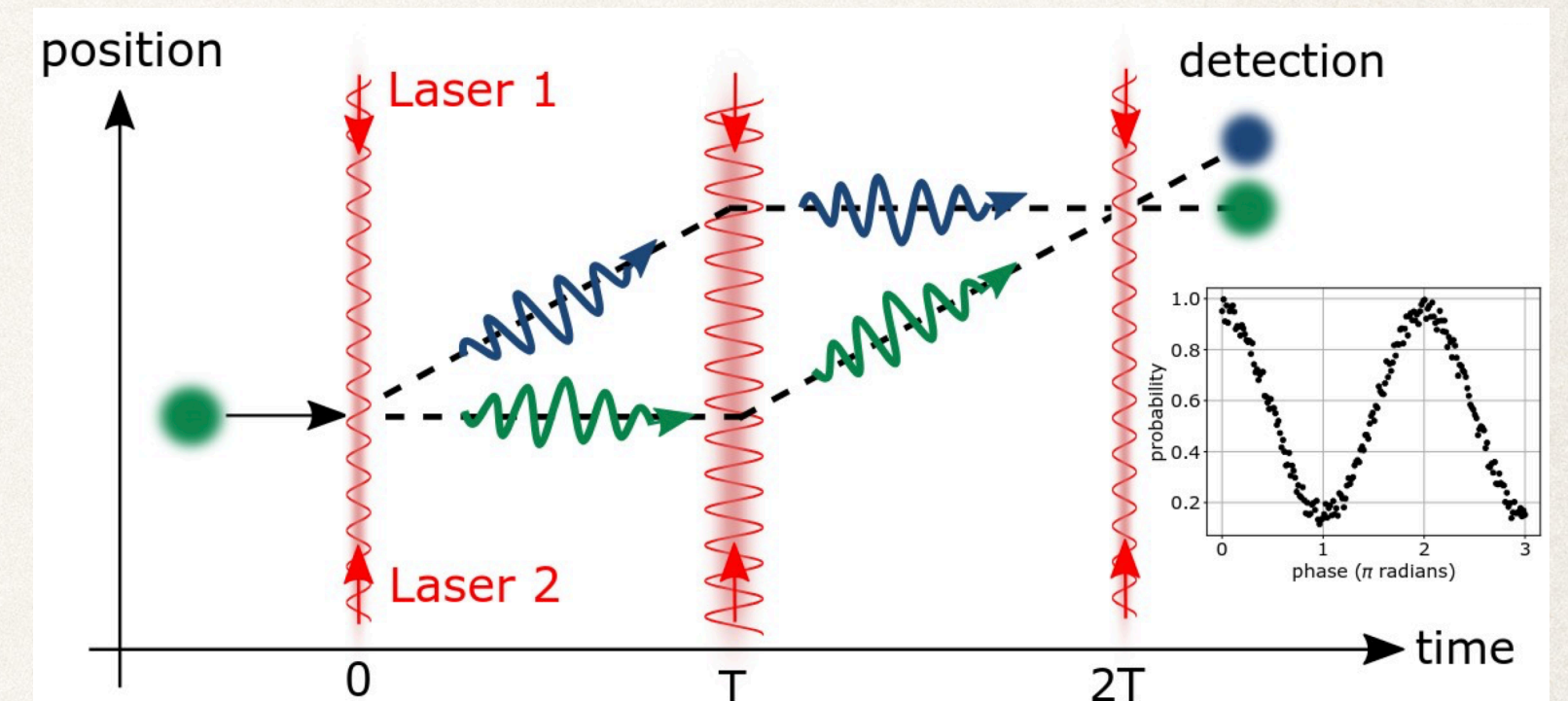
TES



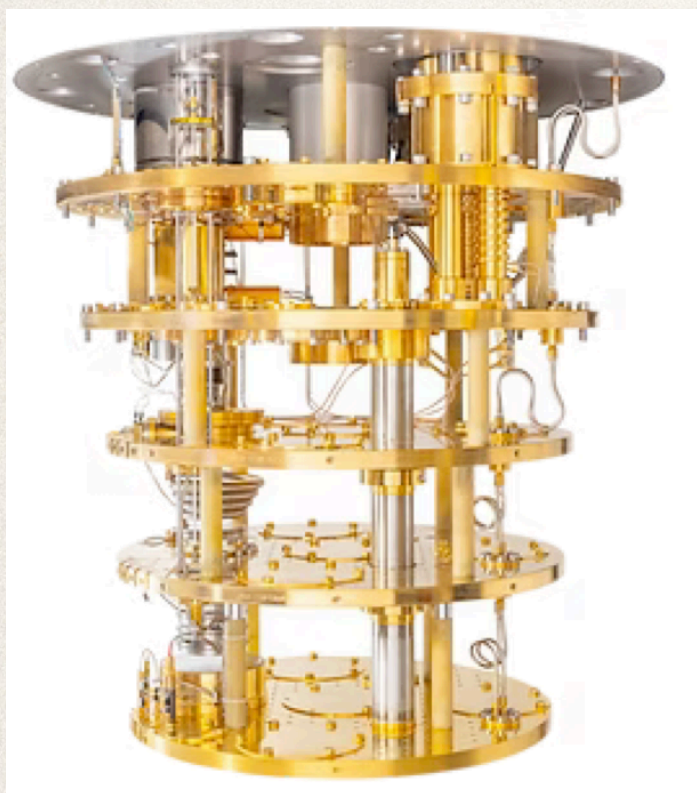
QLAD



Qubits for DM



Atom interferometers

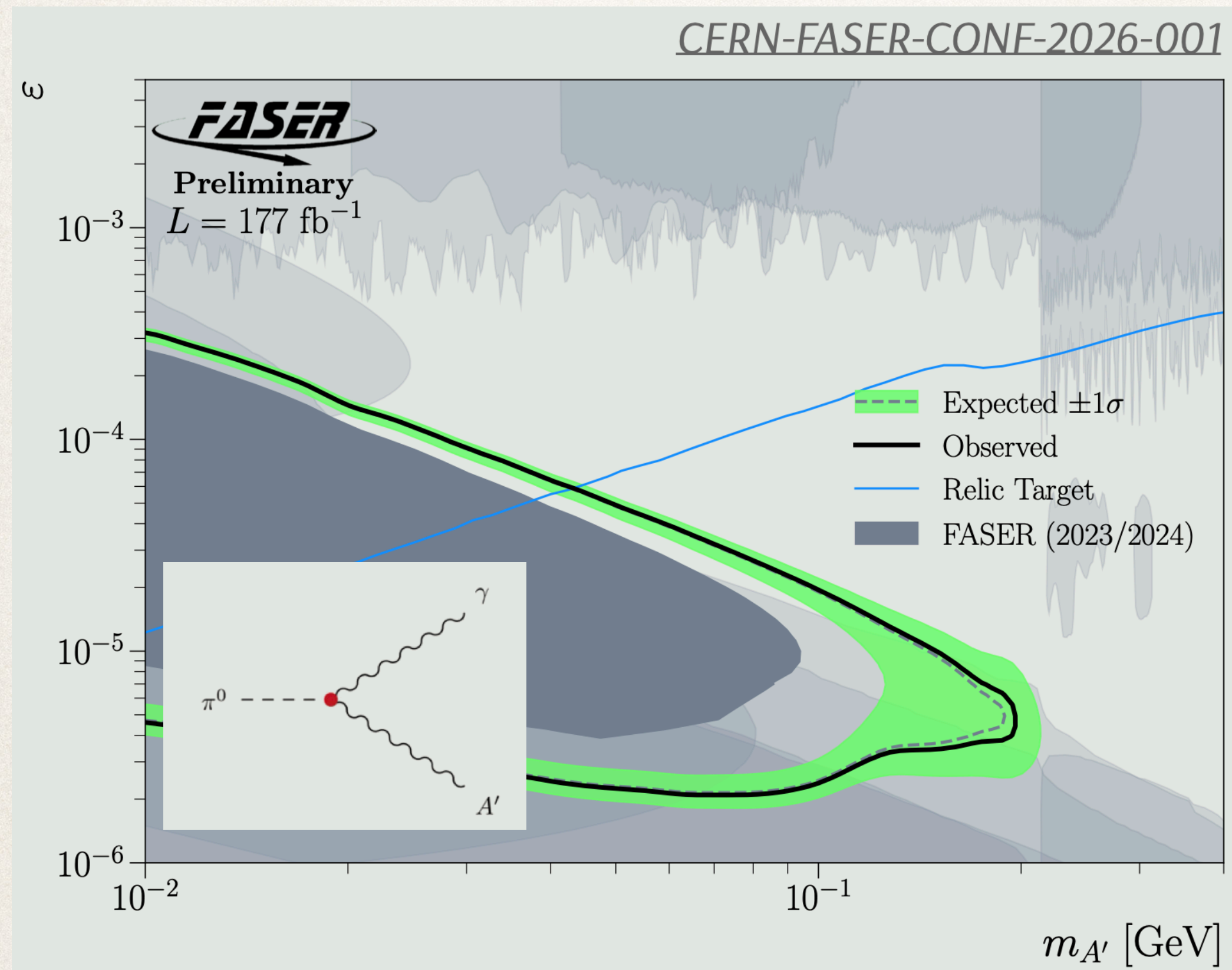


GravNet

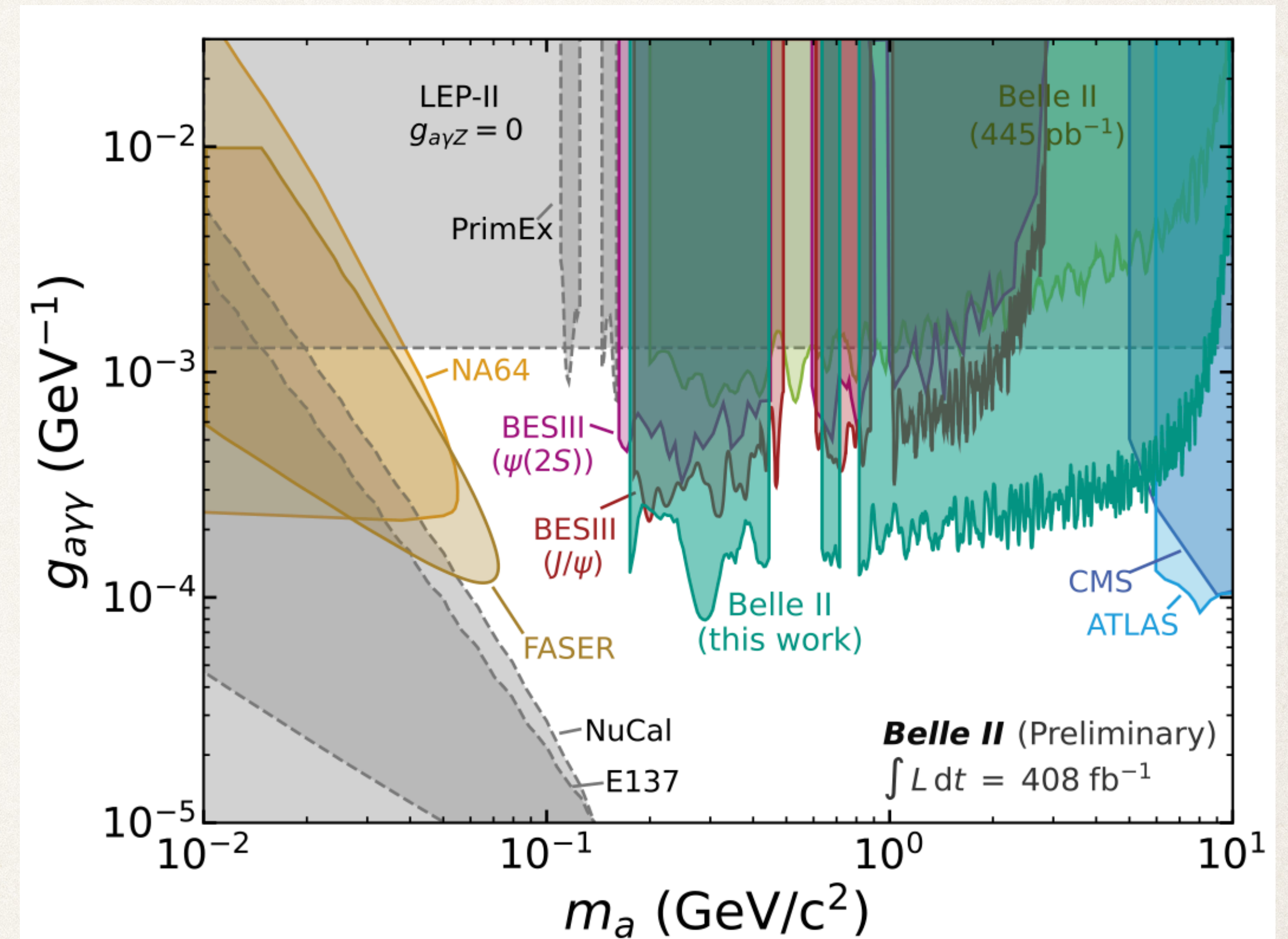
- ❖ [Low-Frequency Axion Searches with SQUID Amplifiers](#)
- ❖ [Towards ultra-low backgrounds for TESs in optical and IR axion searches](#)
- ❖ [Tuning plasma haloscopes with spirals and concentric rings](#)
- ❖ [SQUAT detector architecture for THz/meV sensing](#)
- ❖ [GravNet: a global network of HFGW detectors](#)
- ❖ [Understanding quasiparticle dynamics in a superconducting qubit through phonon burst-induced correlated errors](#)
- ❖ [Leveraging Quantum Sensors for Dark Matter Detection](#)
- ❖ [Dark matter detection with atom interferometers](#)

Searches at accelerators

- ❖ [New Dark Sector Results from FASER @ LHC](#)
- ❖ [Searches for dark sector particles at Belle and Belle II](#)
- ❖ [SHiP/NA67@ ECN3 high-intensity beam facility @ CERN SPS](#)
- ❖ [The Light Dark Matter eXperiment, LDMX](#)
- ❖ [Sub-GeV Dark Matter Searches at Spallation Neutron Sources](#)
- ❖ [Searches for dark sectors with the SBND experiment](#)
- ❖ [Searches for millicharged particles with skipper-CCD detectors](#)



FASER dark photon result. Figures from Ansh Desai's talk



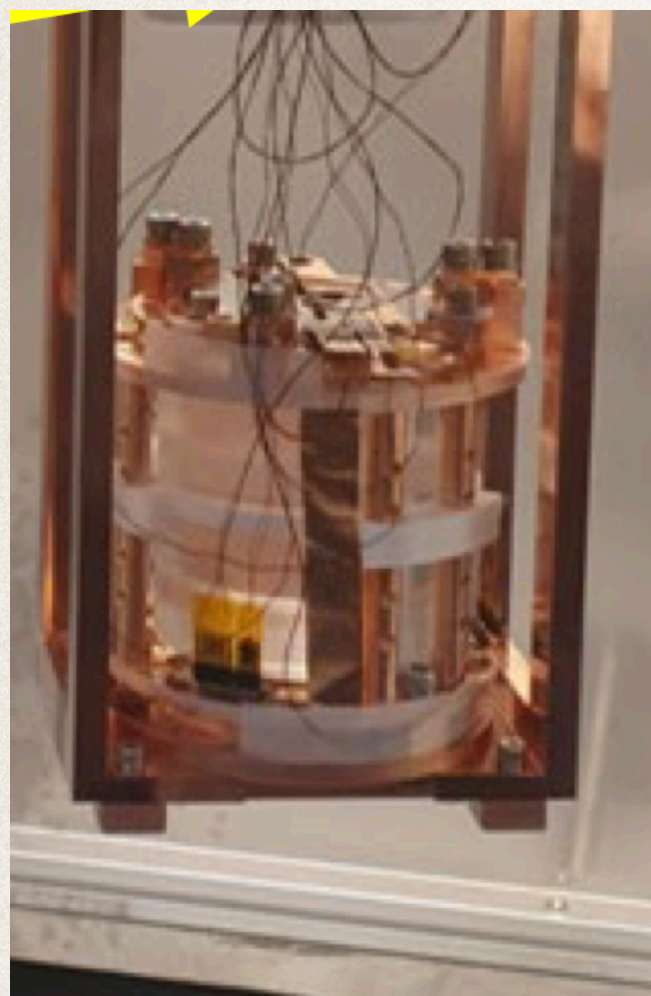
Belle II result. Figure from Youngjoon Kwon's talk

- ❖ Probing the dark sector: light dark photon, long-lived particles, axions & millicharged particles

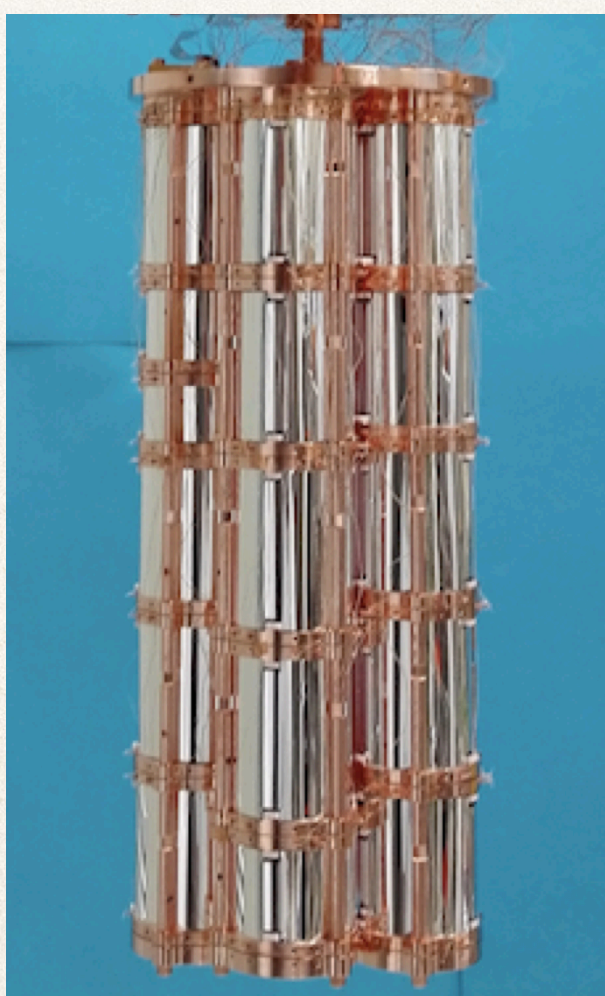
Searches in β and $\beta\beta$ experiments

- ❖ [The LEGEND experiment: From 0nbb to Dark Matter](#)
- ❖ [CUORE keV Frontier: Axion and Rare-Event Searches](#)
- ❖ [Search for Dark Matter candidates with CUPID-0](#)
- ❖ [keV-Scale Sterile Neutrino Search in Tritium \$\beta\$ Decay using LiF and an MMC Detector](#)

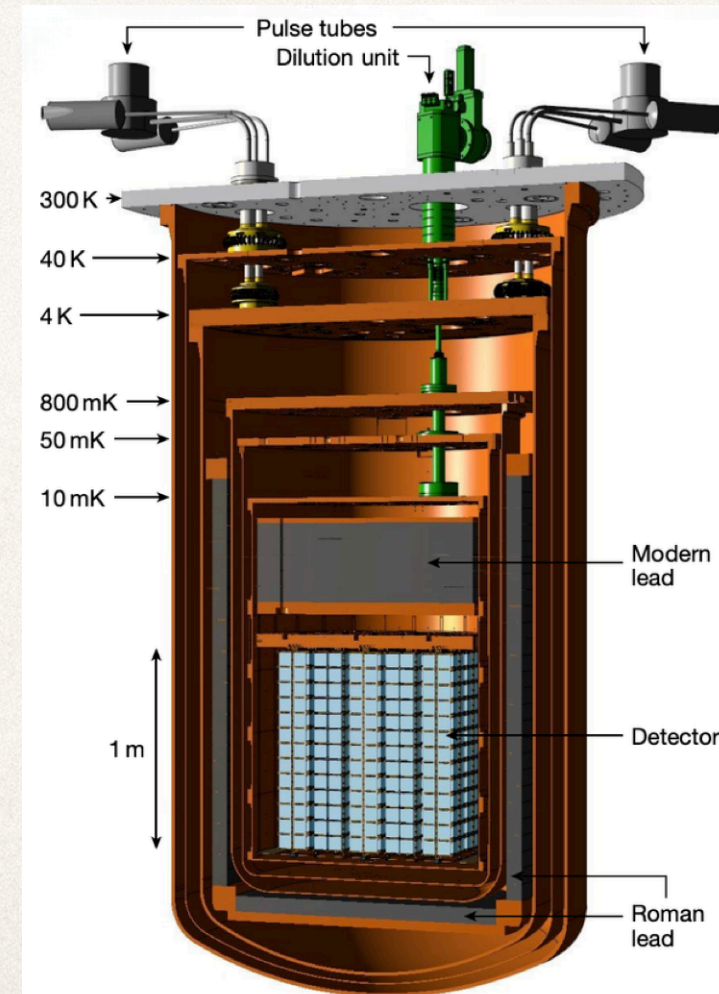
- ❖ Search for solar axions, galactic axions, annual modulation, ultra heavy DM & sterile neutrinos
- ❖ Sterile neutrino kink-like signature in tritium β -decay



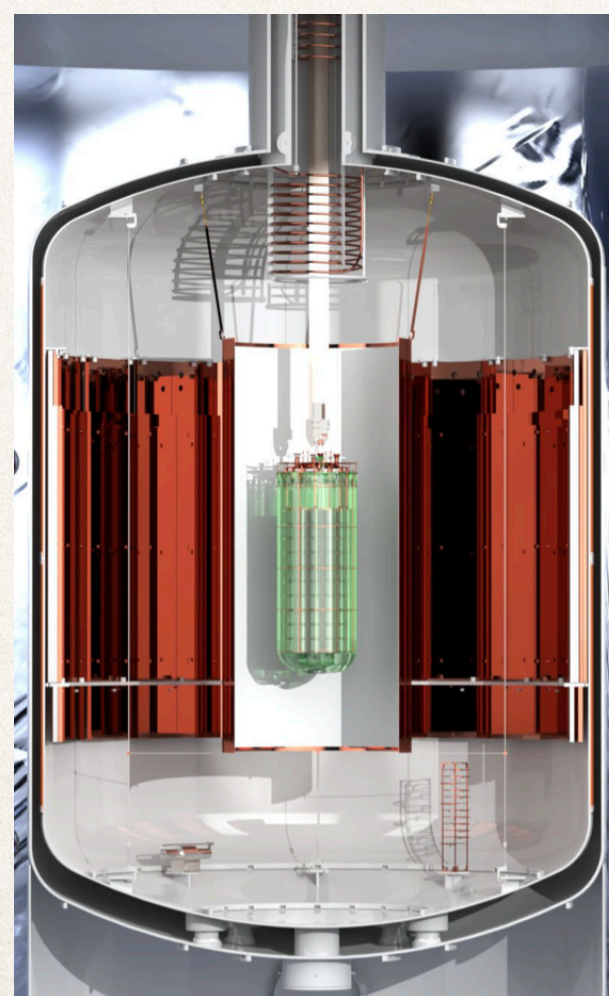
LiFE-SNS



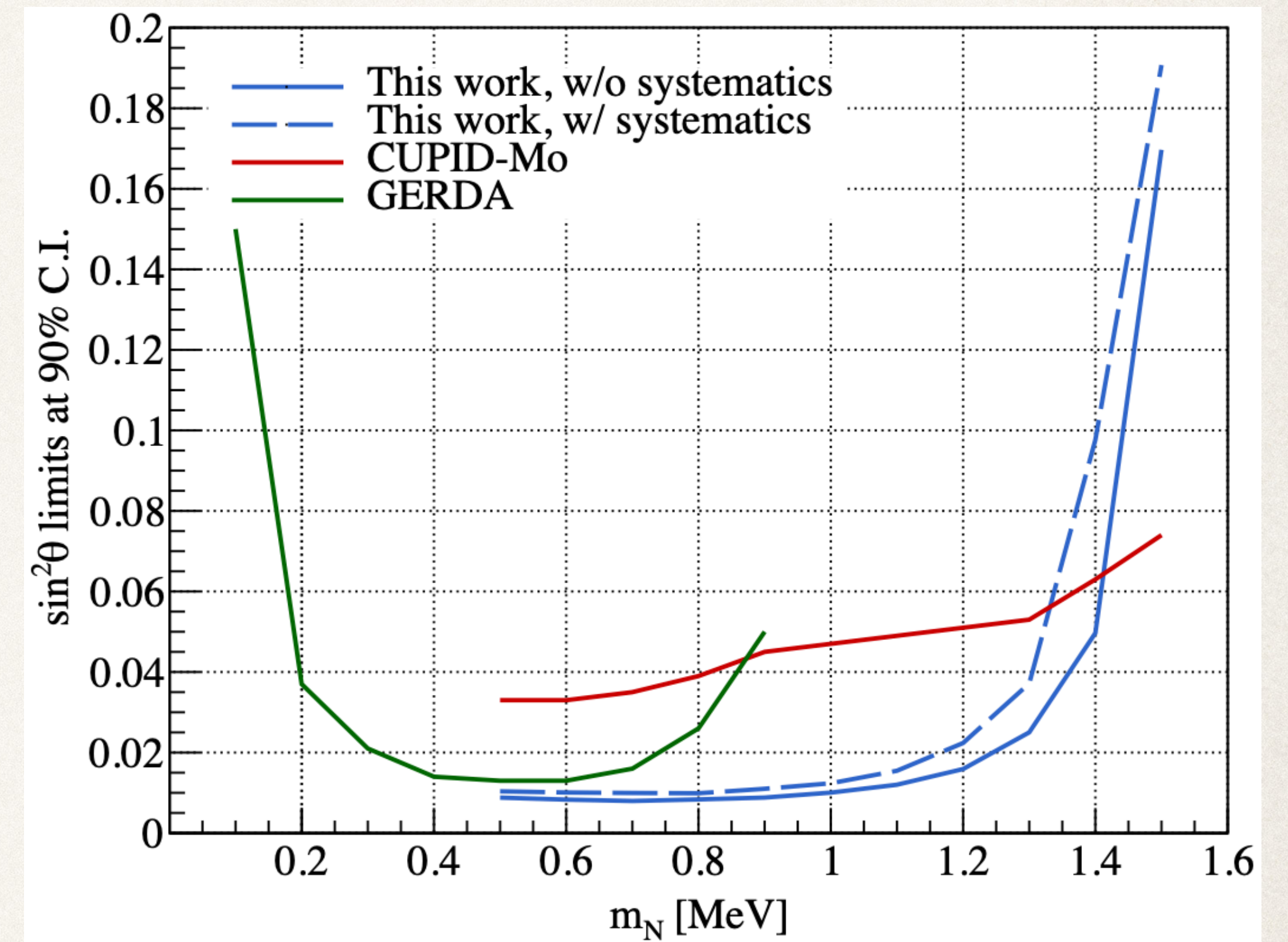
CUPID-0



CUORE



LEGEND



Constrains on sterile neutrinos from CUPID-0 based on $2\nu\beta\beta$ spectral distortion

Figure from Sylvie Pietrarota's talk

THANKS!

- ❖ Enormous amount of technical developments
- ❖ Looking forward IDM 2028
- ❖ Have a good trip to Canfranc or home!

