

2025/02/04

Oscura (DAMIC and SENSEI)

Juan Estrada

Oscura Project Manager (DOE PI)
DAMIC and SENSEI Collaborator

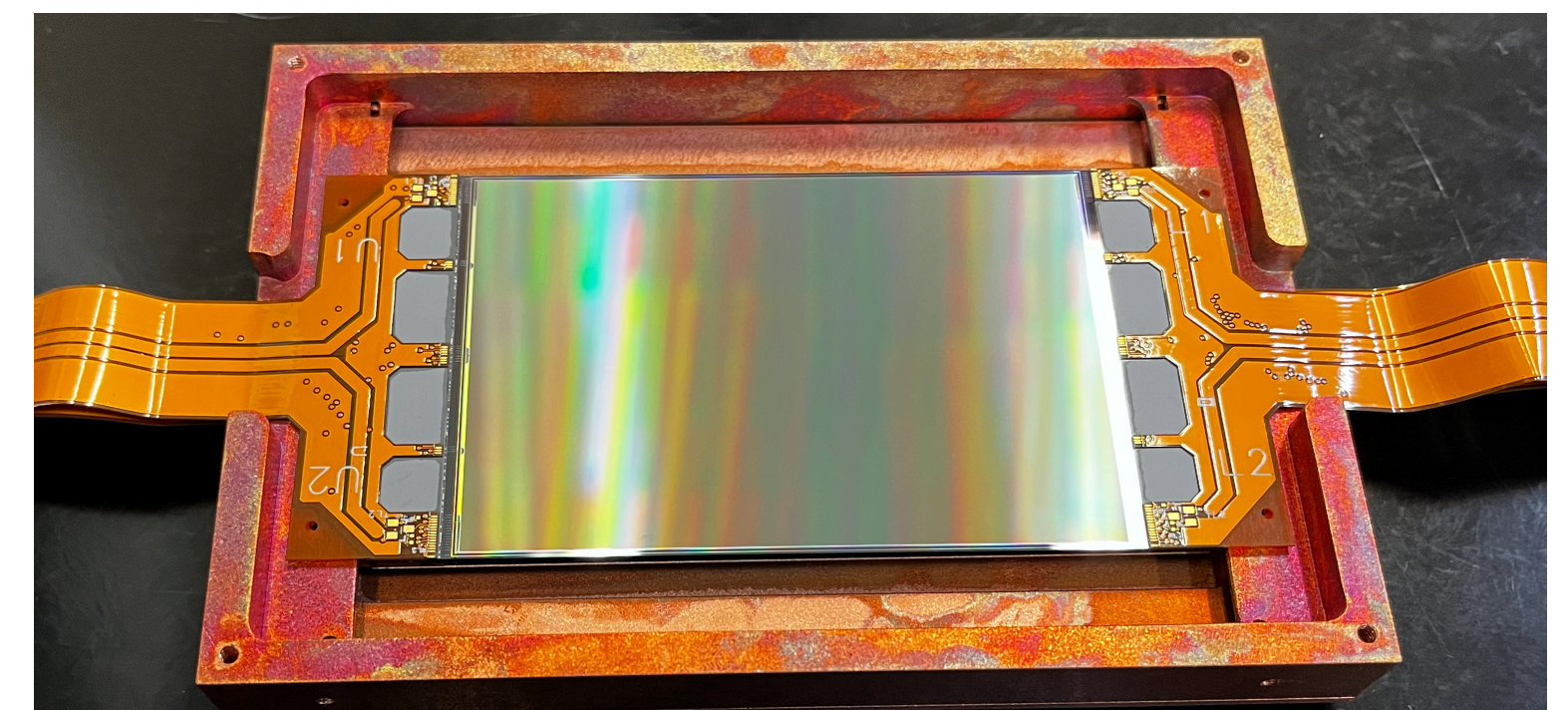
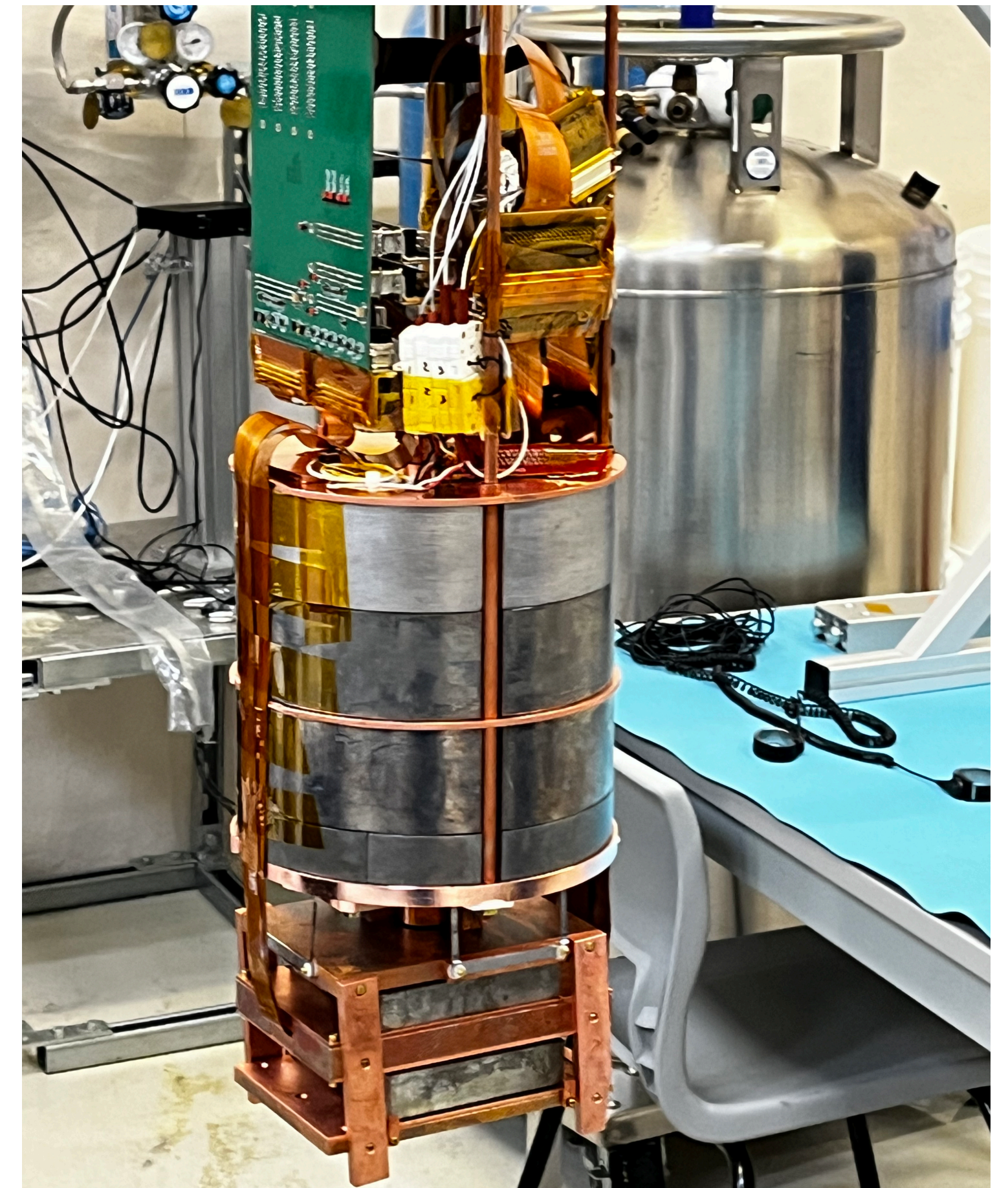


This talk

- DAMIC Experiment – from Alvaro Chavarria
- SENSEI Experiment – from Javier Tiffenberg
- Oscura - from Juan Estrada

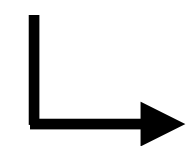
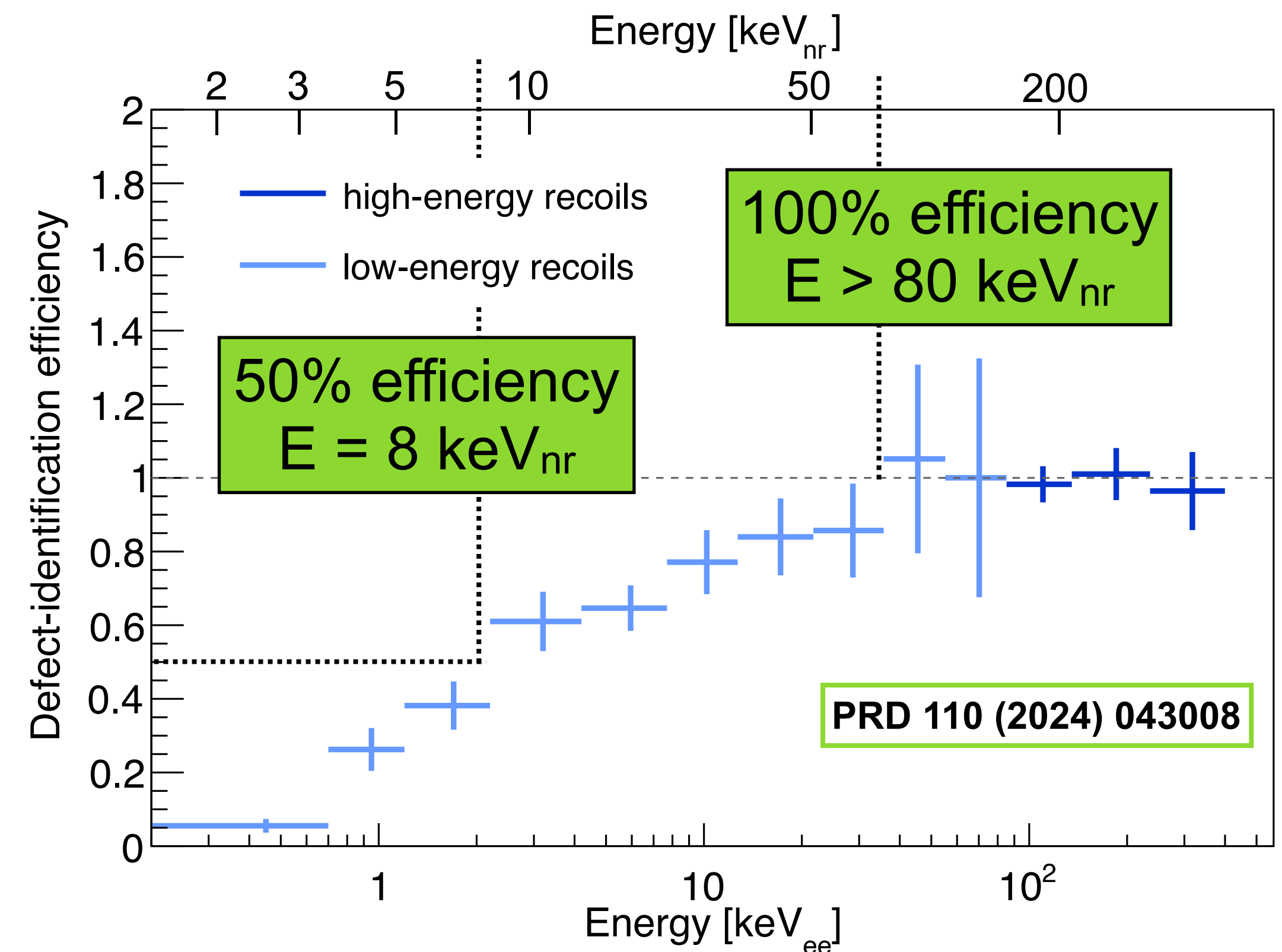
DAMIC: 2023-2024

- Two back-thinned 24 Mpix skipper CCDs installed in July 2023.
- Performed several background studies:
 - 1) Demonstrated that surface backgrounds come from the copper facing the CCDs and not the CCD surfaces.
 - 2) No measurable increase in dark current from the back thinning process.
- Developed readout mode to identify columns that contribute most single-electron events.



DAMIC: 2025

- UW group demonstrated capability of CCDs to discriminate between NR/ER by thermal stimulation of crystal defects left behind by NRs. →
- Proposing to improve and extend technique to lower energy
- + implement and demonstrate NR/ER discrimination in DAMIC with minimal hardware intervention.
- A final science run could check whether the “DAMIC Excess” are ERs on NRs.



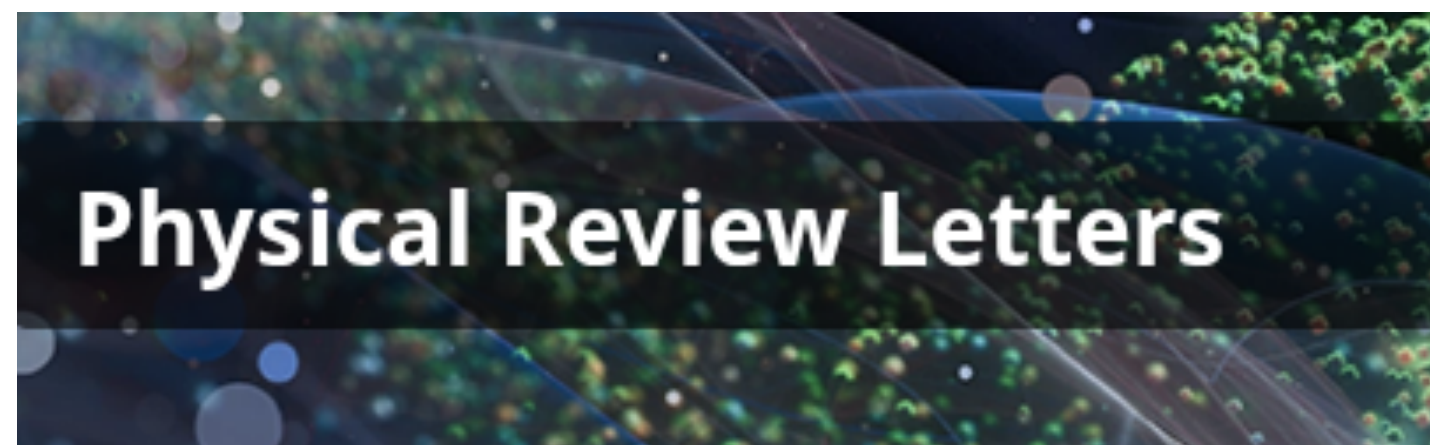
PRL 125 (2020) 241803

PRD 105 (2022) 062003

PRD 109 (2024) 062007

Highlighted results from SENSEI @ SNOLAB:

PRL Editors' suggestion

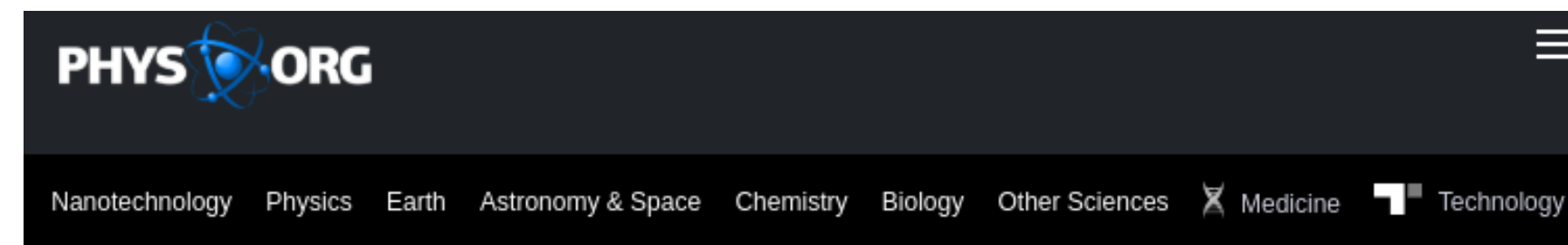


EDITORS' SUGGESTION

First Direct-Detection Results on Sub-GeV Dark Matter Using the SENSEI Detector at SNOLAB

[Prakruth Adari](#)^{1,2}, [Itay M. Bloch](#)^{3,4}, [Ana M. Botti](#)⁵, [Mariano Cababie](#)^{6,5}, [Gustavo Cancelo](#)⁵, [Brenda A. Cervantes-Vergara](#)⁷, [Michael Crisler](#)⁵, [Miguel Daal](#)⁸, [Ansh Desai](#)⁹ *et al.* (SENSEI Collaboration)

PHYS.ORG Featured



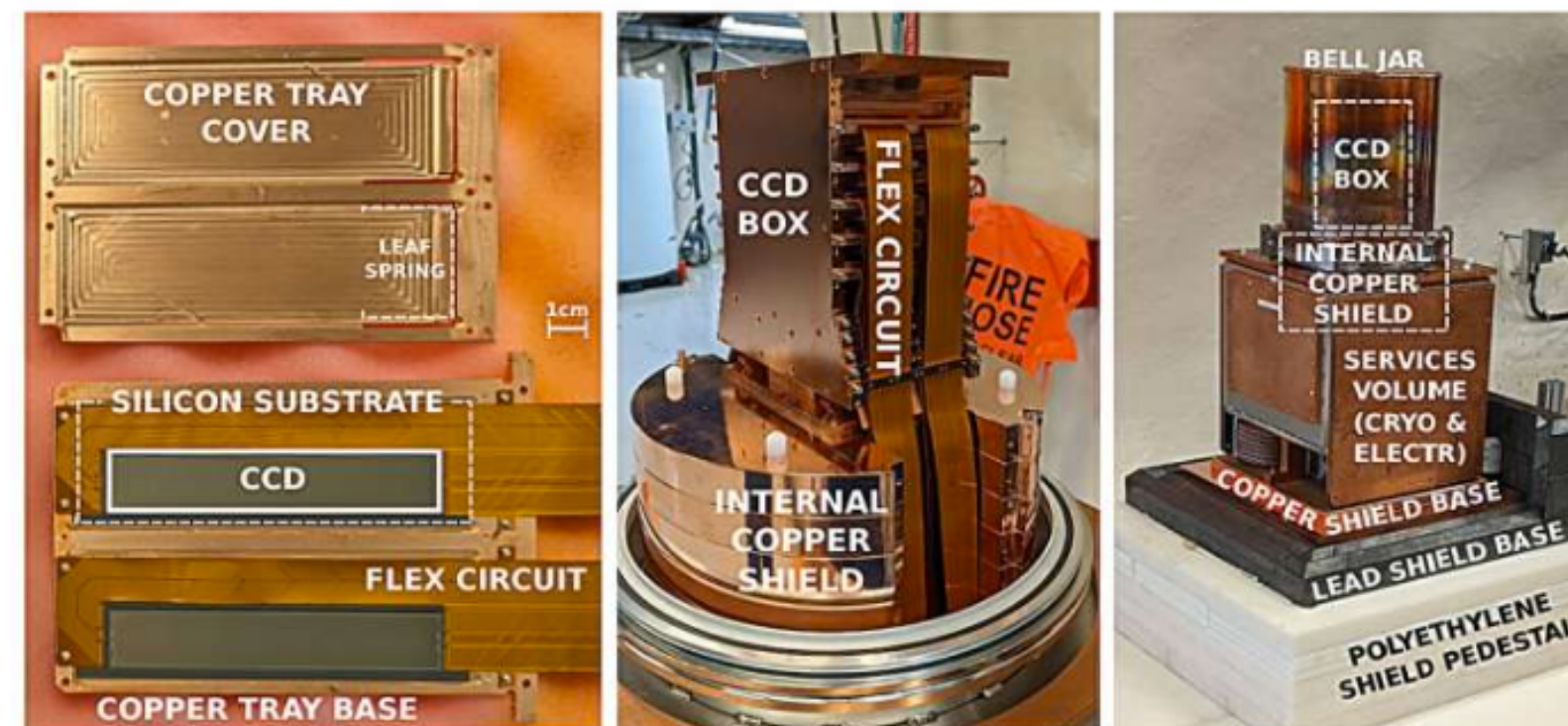
Home / Astronomy & Space / Astronomy

JANUARY 30, 2025 **FEATURE**

The GIST **✓** Editors' notes

Sub-GeV dark matter hunt: SENSEI collaboration reports first findings

by Ingrid Fadelli, Phys.org



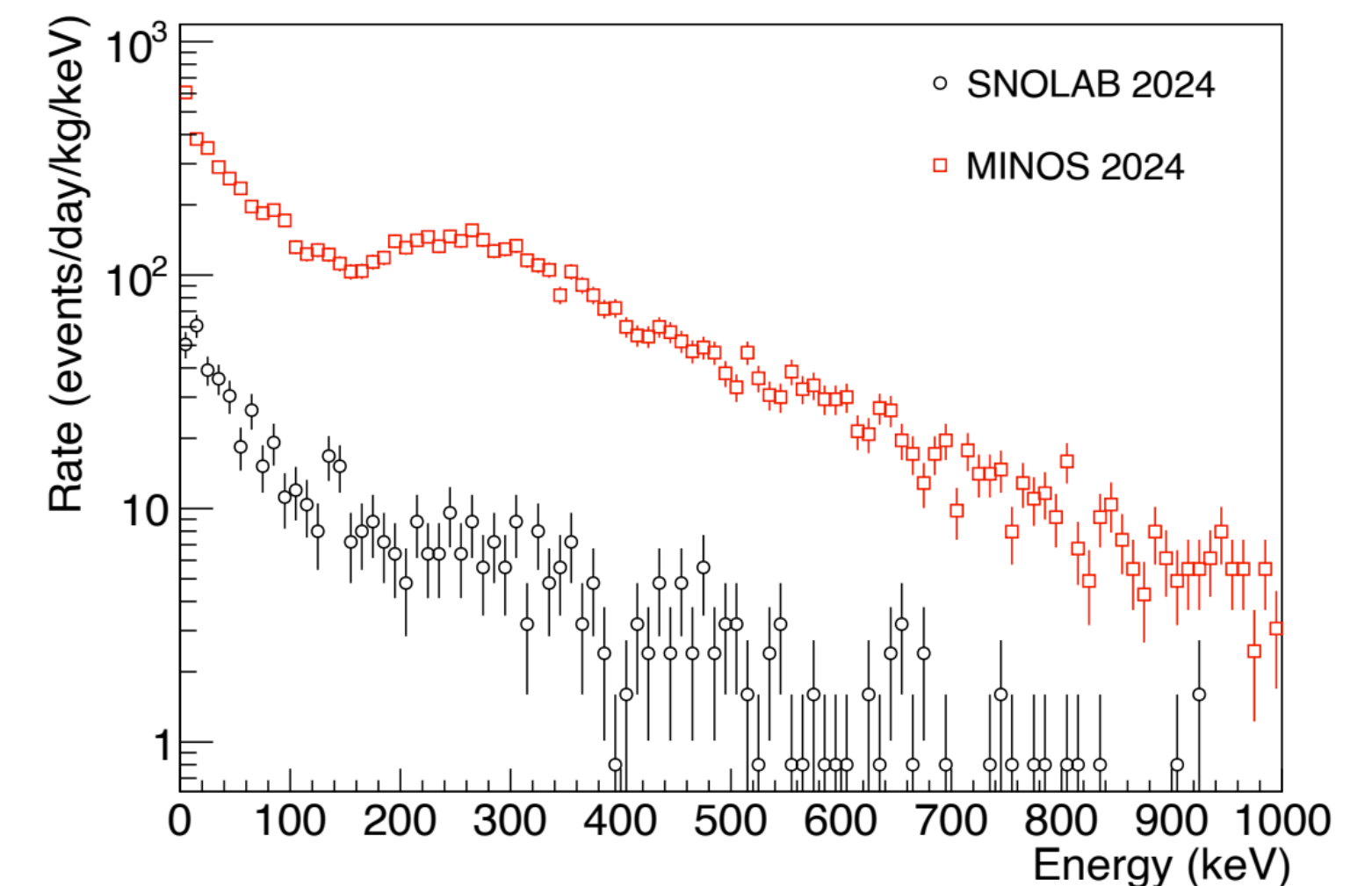
Lowest Dark Count rate (1 e⁻/pix every 200 yrs!)

arXiv:2410.18716 (astro-ph)

[Submitted on 24 Oct 2024]

SENSEI at SNOLAB: Single-Electron Event Rate and Implications for Dark Matter

[Itay M. Bloch](#), [Ana M. Botti](#), [Mariano Cababie](#), [Gustavo Cancelo](#), [Brenda A. Cervantes-Vergara](#), [Miguel Daal](#), [Ansh Desai](#), [Alex Drlica-Wagner](#), [Rouven Essig](#), [Juan Estrada](#), [Erez Etzion](#), [Guillermo Fernandez Moroni](#), [Stephen E. Holland](#), [Jonathan Kehat](#), [Ian Lawson](#), [Steffon Luoma](#), [Aviv Orly](#), [Santiago E. Perez](#), [Dario Rodrigues](#), [Nathan A. Saffold](#), [Silvia Scorza](#), [Miguel Sofo-Haro](#), [Kelly Stifter](#), [Javier Tiffenberg](#), [Sho Uemura](#), [Edgar Marrufo Villalpando](#), [Tomer Volansky](#), [Federico Winkel](#), [Yikai Wu](#), [Tien-Tien Yu](#)



World-leading results using data collected at Snolab

Status and plans:

- **New cryo-cooler has arrived to Snolab**
 - Preparations being made to replace it (Thanks to Ian and Steffon)
 - Plan is to resume data taking as soon as possible
(data was great when the previous cryocooler broke)
- **Packaging of additional sensors ongoing at Fermilab**
 - We plan is to deploy additional sensors mid-2024
- **SENSEI original Space Allocation Request has expired**
 - Requested extension until mid-2026

As always we deeply thank Snolab for all the support

Oscura

Skipper-CCD DM program



Experiment	Mass [kg]	#CCDs	Radiation bkgd [dru]	Instrumental bkgd [e-/pix/day]	Commissioning
SENSEI @ MINOS	~0.002	1	3400	1.6×10^{-4}	late-2019
DAMIC @ SNOLAB	~0.02	2	~10	3×10^{-3}	late-2021
DAMIC-M LBC	~0.02	2	10	3×10^{-3}	late-2021
SENSEI-100	~0.1	50	10 (goal)		mid-2022
DAMIC-M	~1	200	0.1 (goal)		~2023
OSCURA	~10	20,000	0.01 (goal)	1×10^{-6} (goal)	~2028

Oscura is an ambitious program that brings together the DAMIC, SENSEI and DAMIC-M teams for the development of ultimate DM experiment with skipper-CCDs.

Skipper-CCD DM program



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DAMIC @ SNOLAB	~0.02	2	~10	3×10^{-3}	late-2021
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THIS IS A SNOLAB PROGRAM!

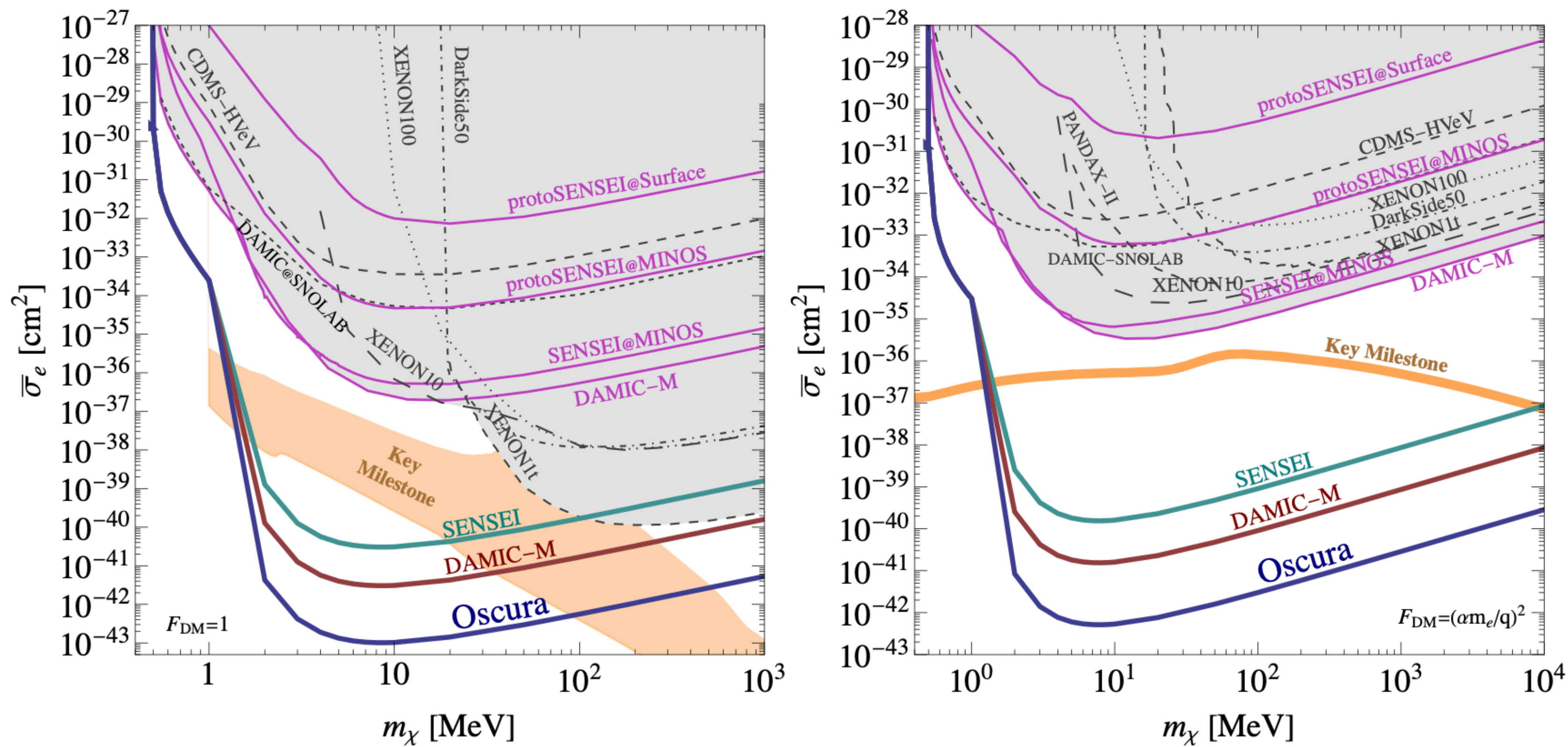
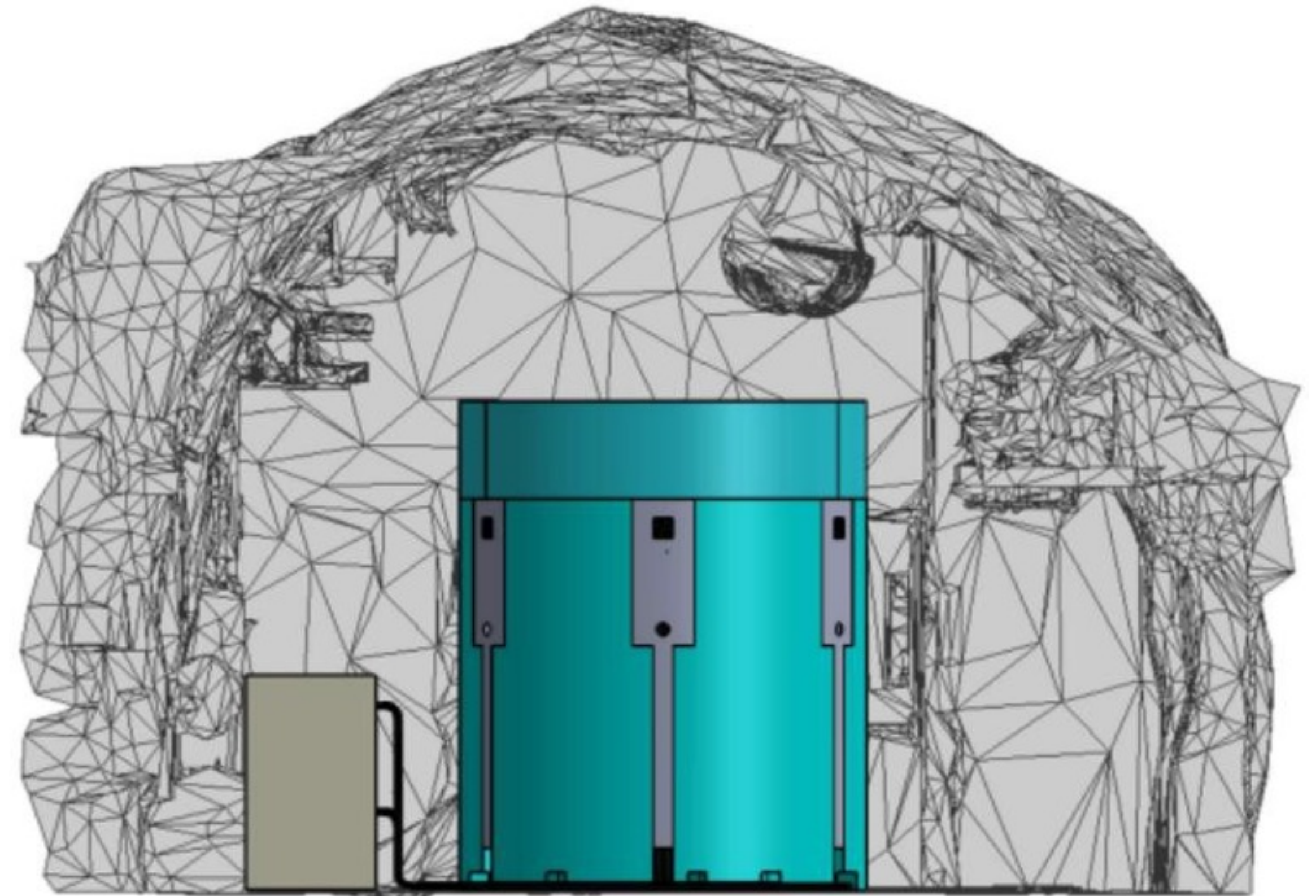
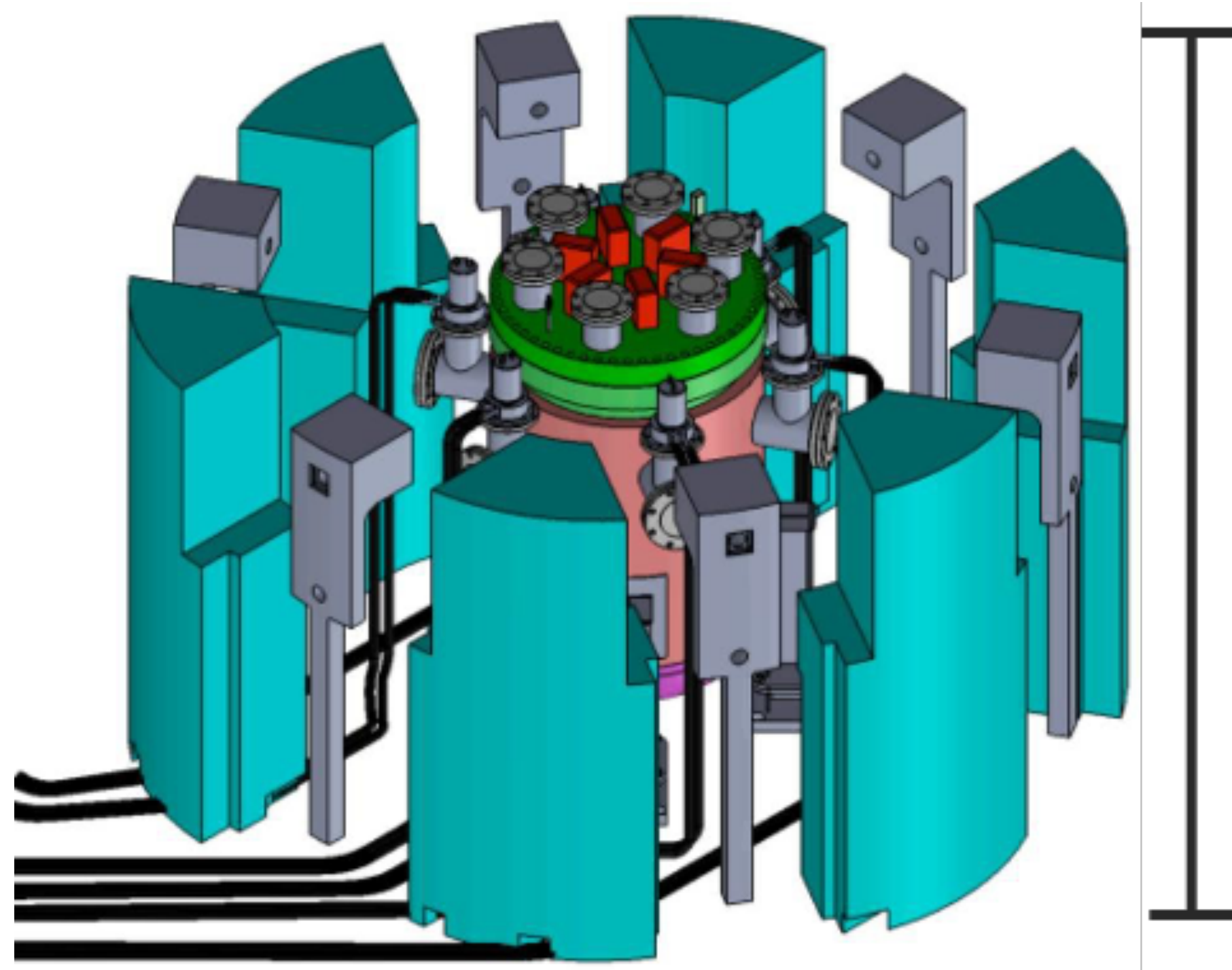


Figure 1. Approximate projected sensitivity for Oscura to DM-electron scattering at 90% C.L. assuming a 30 kg-year exposure, zero background events with $2e^-$ or more, a $1e^-$ threshold and a fixed $1e^-$ event rate of $10^{-6}e^-/\text{pix}/\text{day}$ (blue). To build this curve, 100% efficiency was assumed for the reconstruction of events above $2e^-$. The left (right) plot assumes a heavy (light) mediator in the DM-electron interaction. Approximate projected sensitivities for SENSEI (DAMIC-M) are shown in cyan (red) [1, 5, 12, 18, 21, 22]. Existing constraints from skipper-CCDs from SENSEI [13–15] and DAMIC-M [16] are shaded in pink. Shaded gray regions are constrained by several other experiments (some shown explicitly) [19, 23–33]. Existing limits come directly from publications; reader should look at them for specific assumptions. Orange regions labeled “Key Milestone” represent well-motivated sub-GeV DM models, highlighted in the recommendations of the Basic Research Needs report [5].



**We have been working with SNOLAB engineering team to plan installation
at SNOLAB (Paul Gryll main contact)**

Technical progress last year



Mechanical

- New vessel demonstrated for Oscura Integration Test

Sensors

- Oscura sensors deployed in CONNIE (Reactor)
- Oscura sensors being deployed in MINOS beam (mCP)

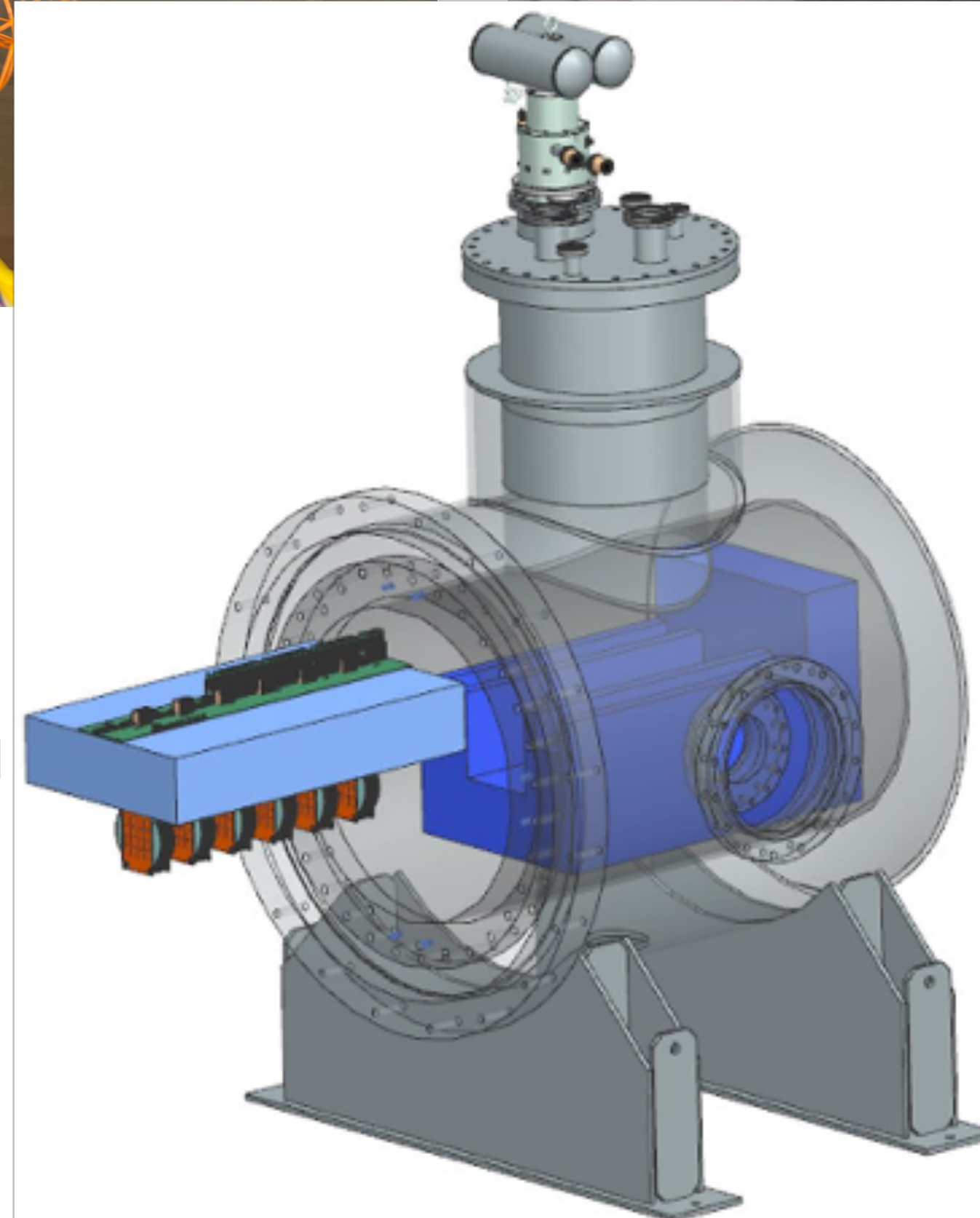
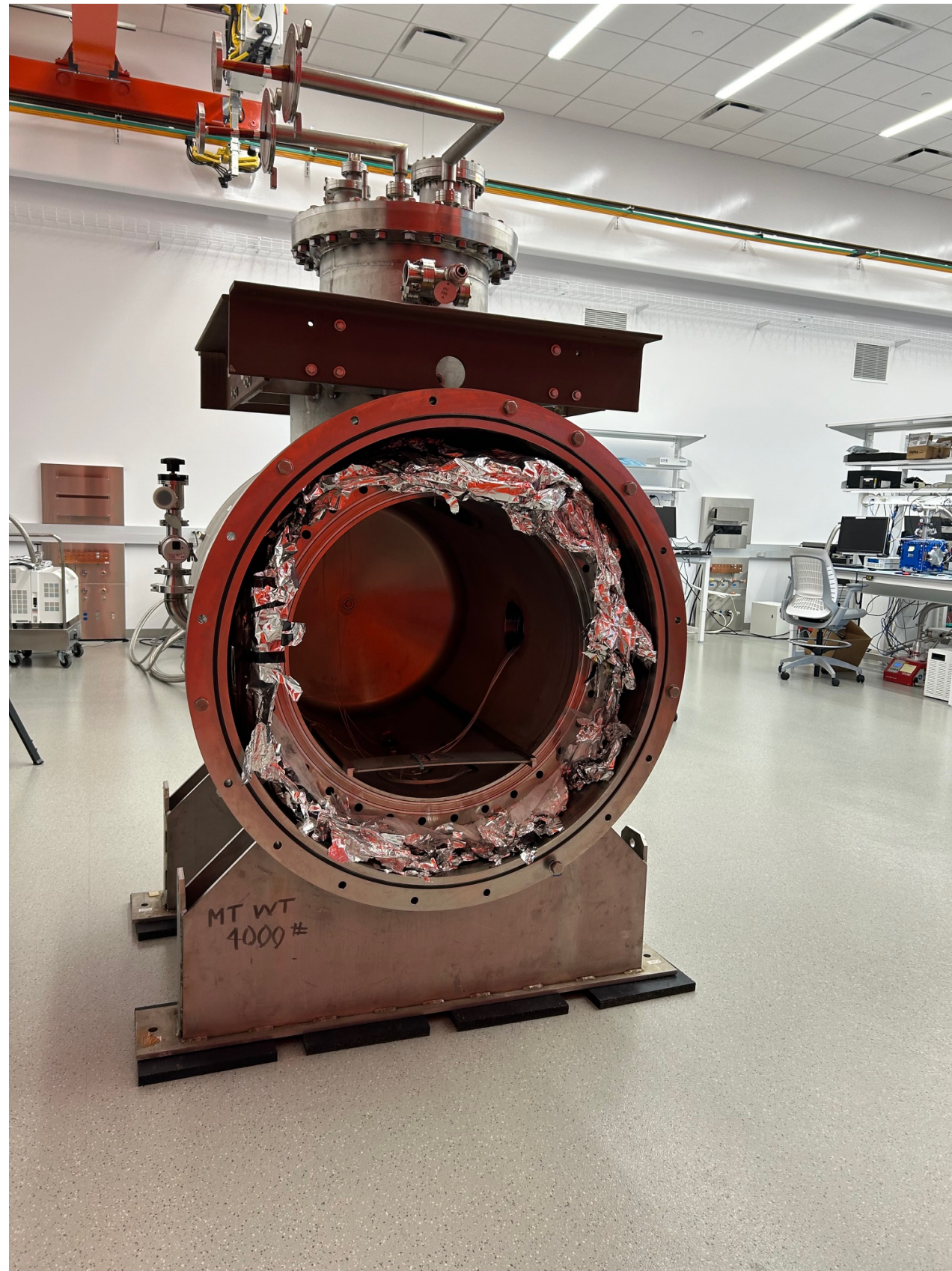
Electronics

- 16 channel MIDNA ASIC (partially funded by microelectronics initiative)
demonstrated with skipper-CCDs

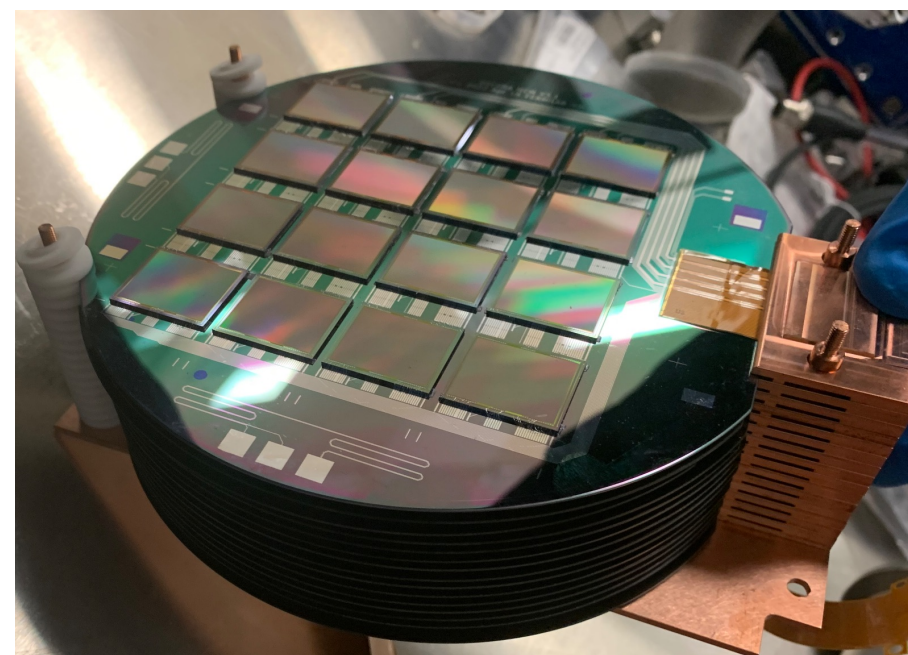
Integration

- System with 256 sensors demonstrated at the FNAL CCD lab

“New” vessel



Demonstrated to operate cold with Nitrogen gas at 15 PSI. For the moment using a recycled cryocooler PT415. The plan is to get an AL630 to get the full capacity. Need about 50W from the sensors + electronics inside.



This can fit upto 6 supermodules with 6" of lead shield. Maybe a bit more if we take advantage of MIDNA3.

The detector

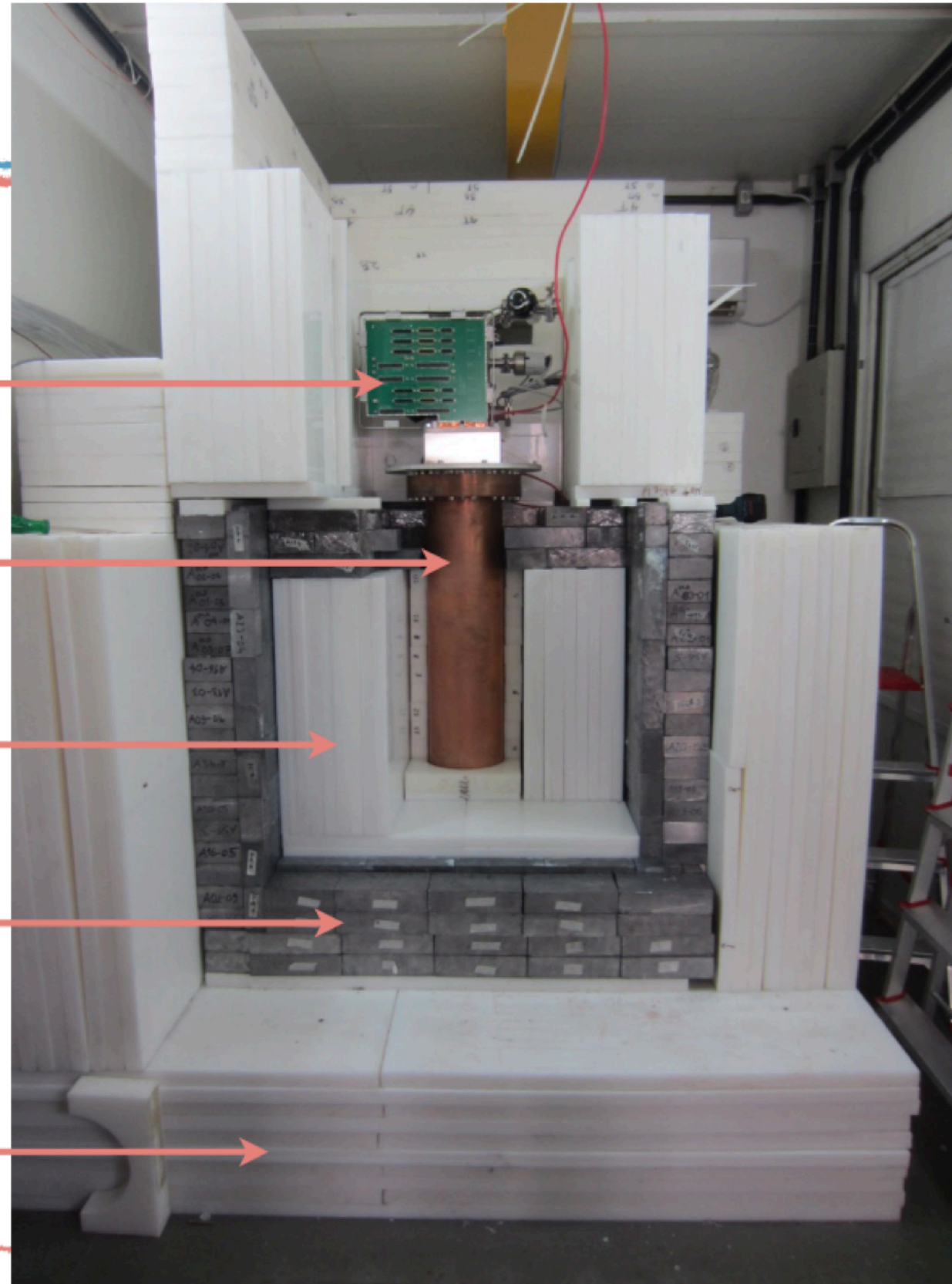
ViB board
(signals transport)

Dewar
(hold vacuum)

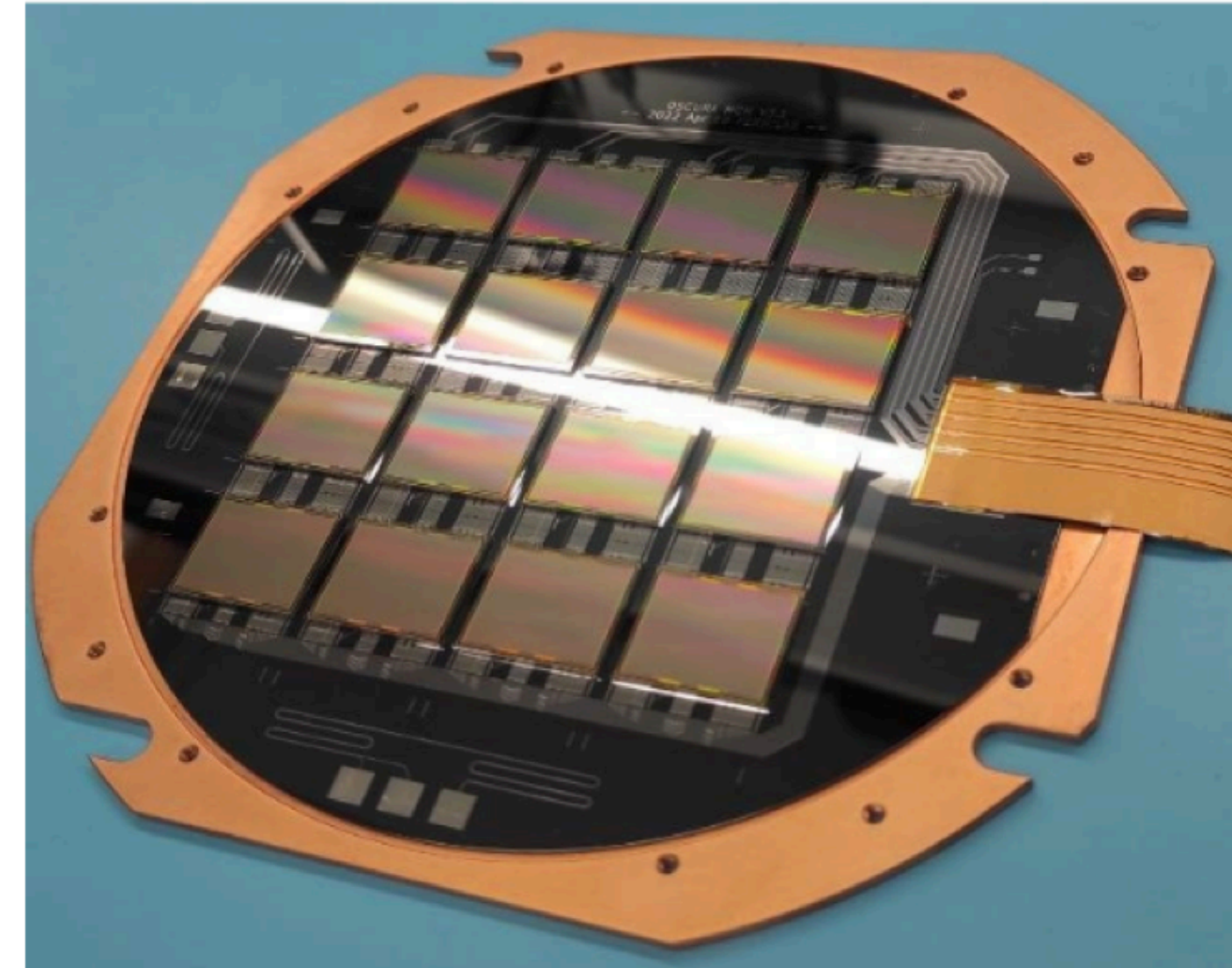
Inner
polyethylene (30 cm)

Lead (15 cm)
~ 800 bricks (Fermilab, USP-Galvão,
CBPF and bought to Aurea)

Outer
polyethylene (30 cm)



CONNIE detector at Reactor in Brazil.

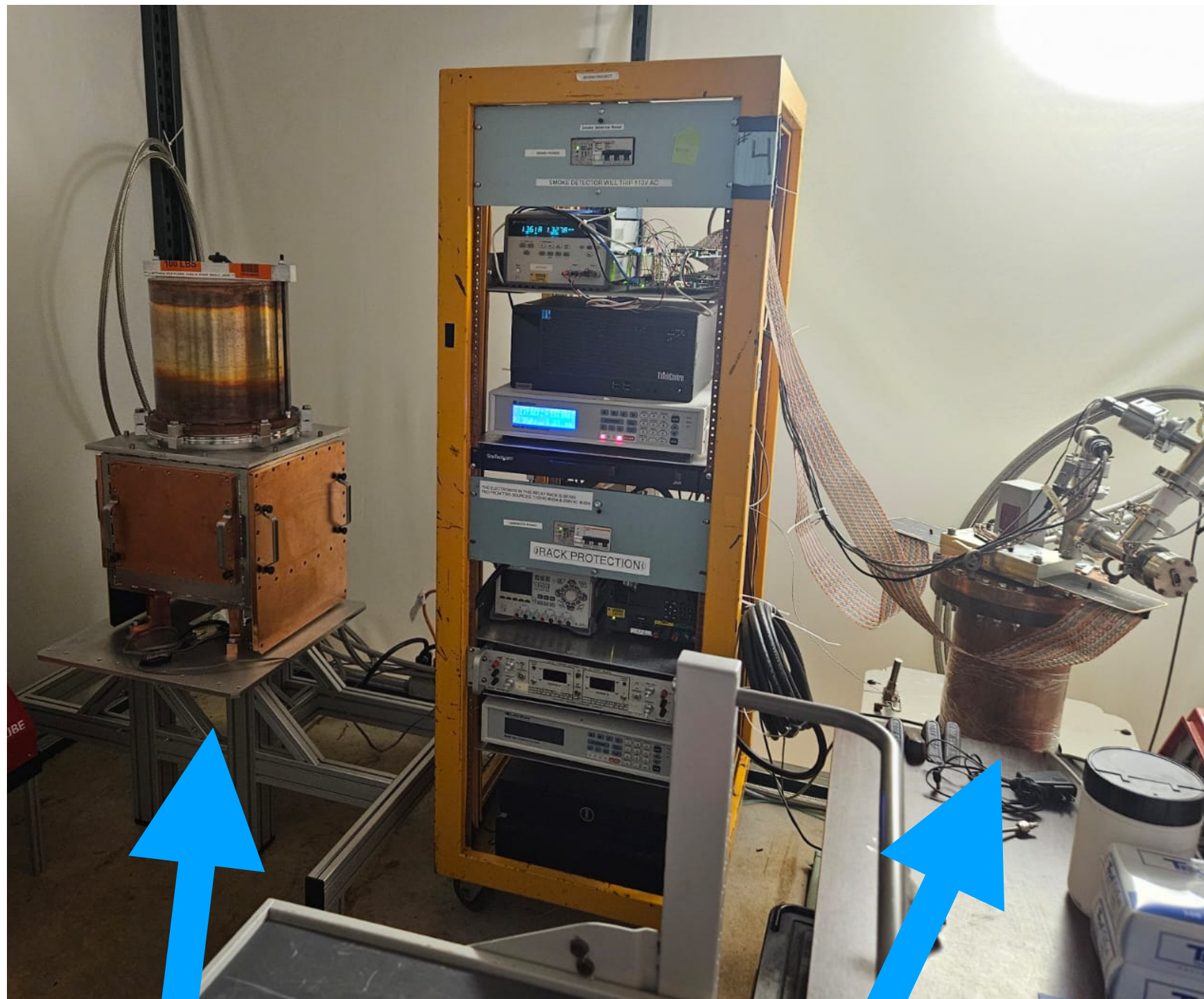


CONNIE detector at Reactor in Brazil. First science test of Oscura sensors and electronics. Not low background!

Should be familiar to SNOLAB, it is a “copy” of your DAMIC.



DarkBeats in MINOS(FNAL)



DarkBeats

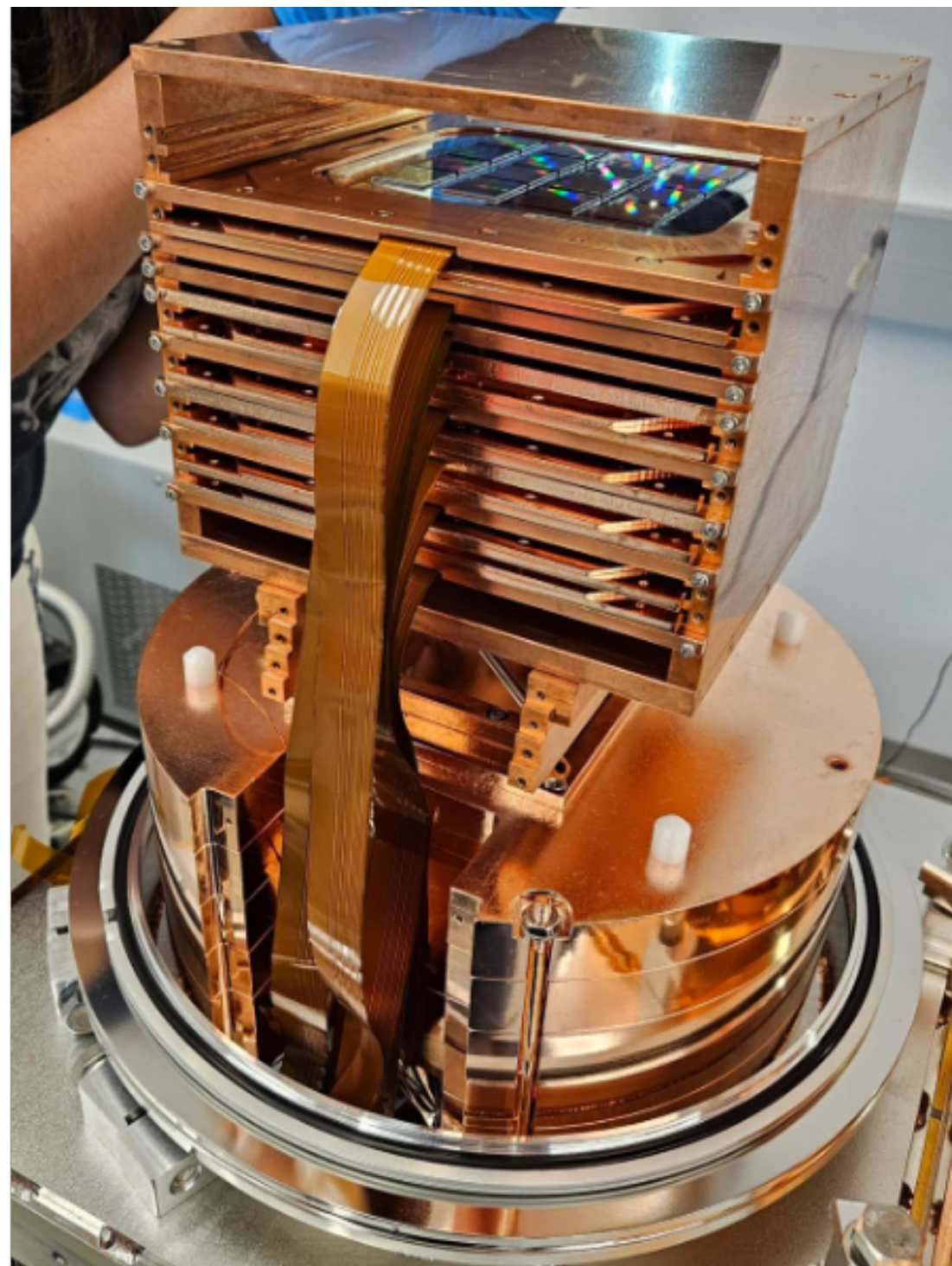
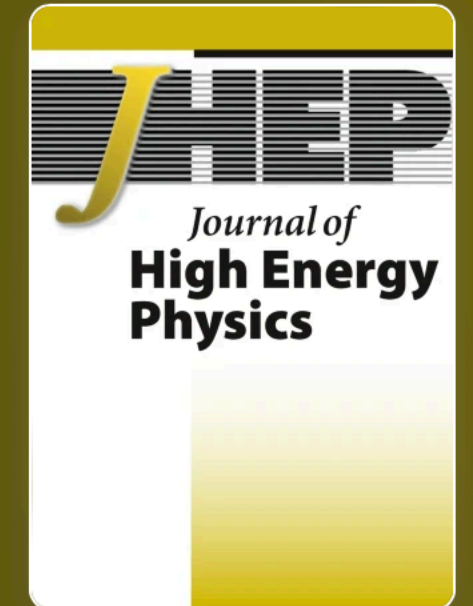
SENSEI@MINOS

[Home](#) > [Journal of High Energy Physics](#) > [Article](#)

Searching for millicharged particles with 1 kg of Skipper-CCDs using the NuMI beam at Fermilab

Regular Article – Experimental Physics | [Open access](#) | Published: 13 February 2024

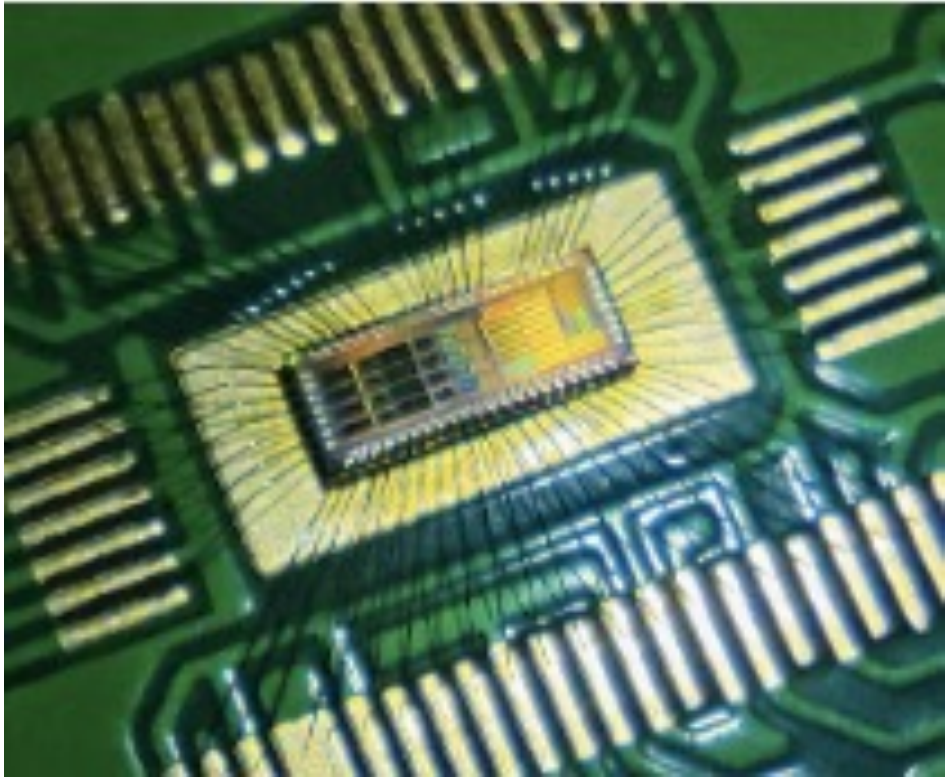
Volume 2024, article number 72, (2024) | [Cite this article](#)



Experiment to search for mCP in the beam, also daily modulations. Should be familiar to SNOLAB, it is a “copy” of your SENSEI.

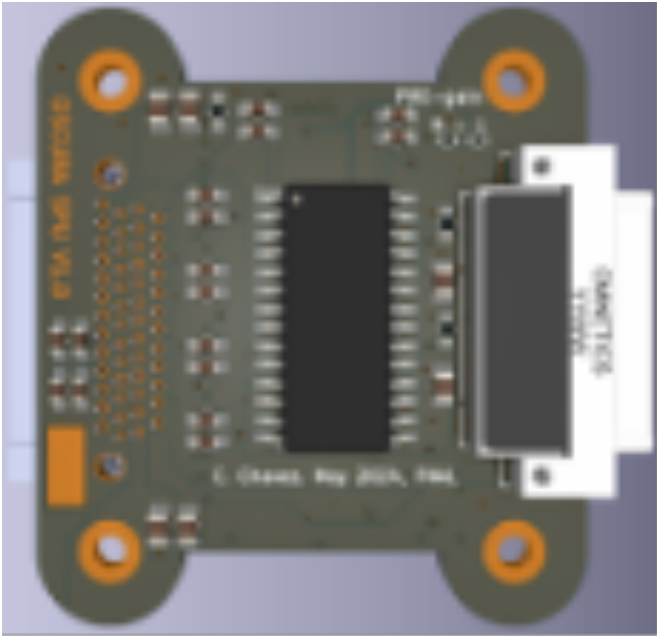
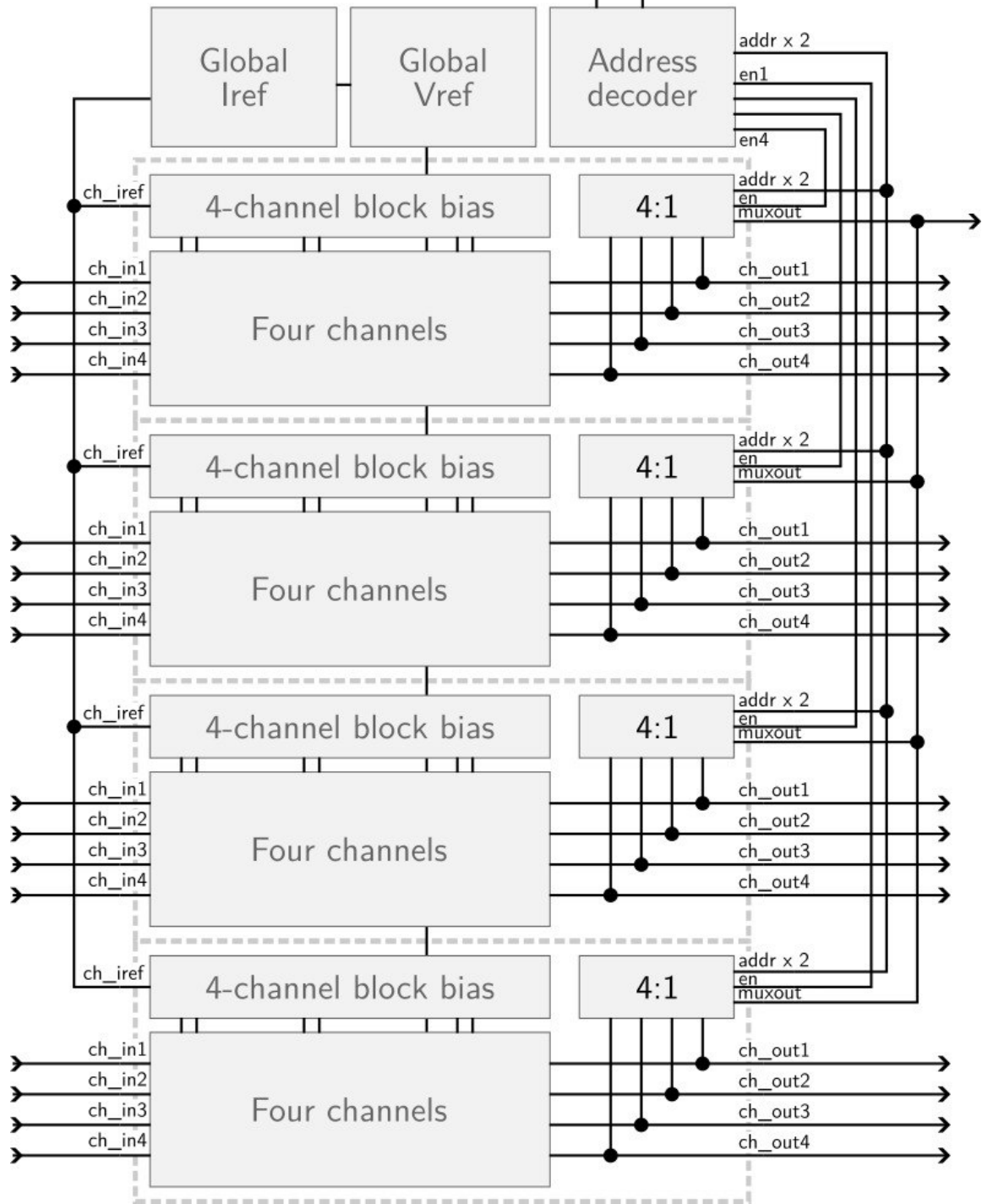
To start running in the coming month. Beam will be back on in 2026.

MIDNA v2 : 4 per MCM

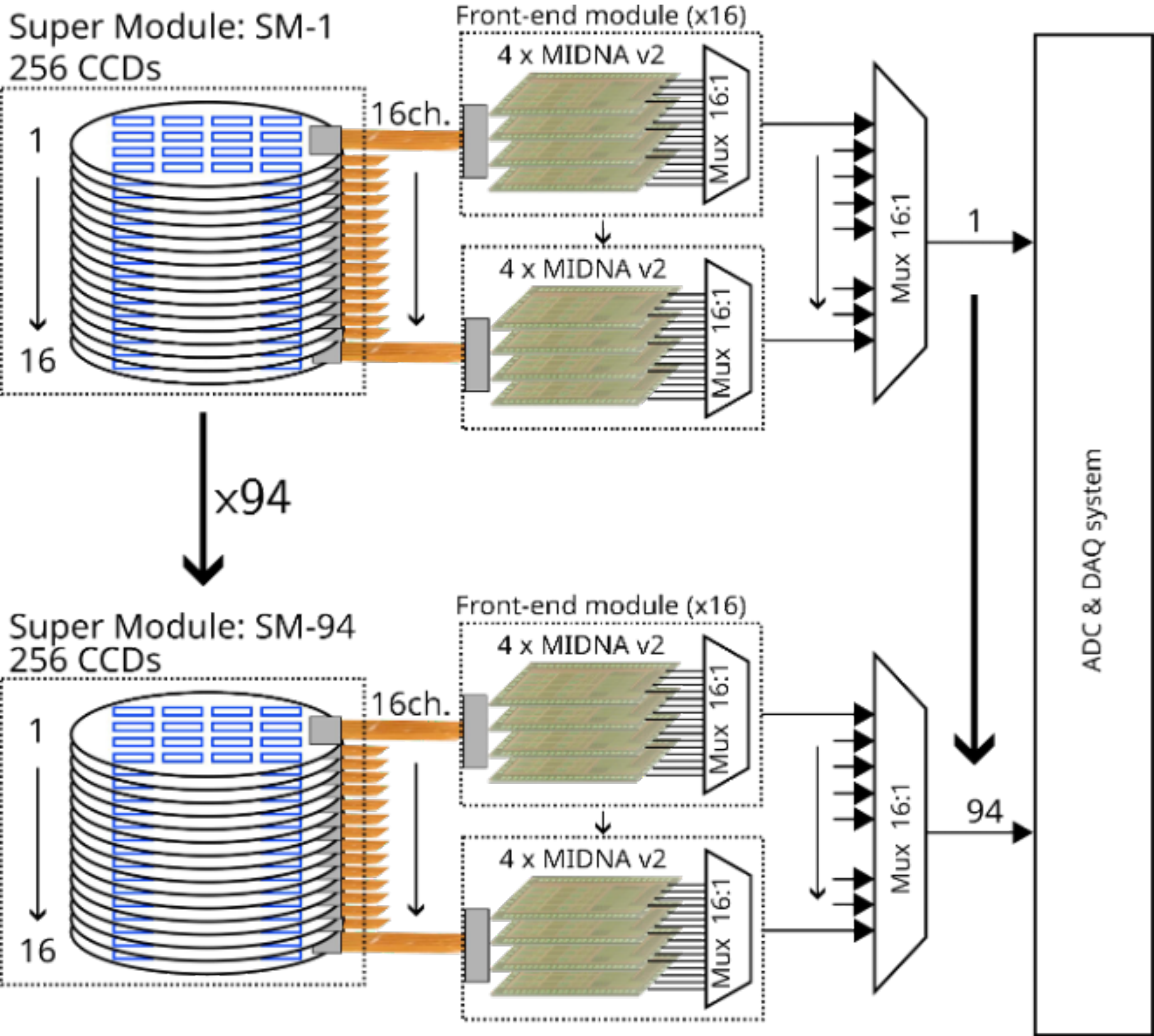


MIDNA v3 has been tested and works. This makes all our electronics simpler.

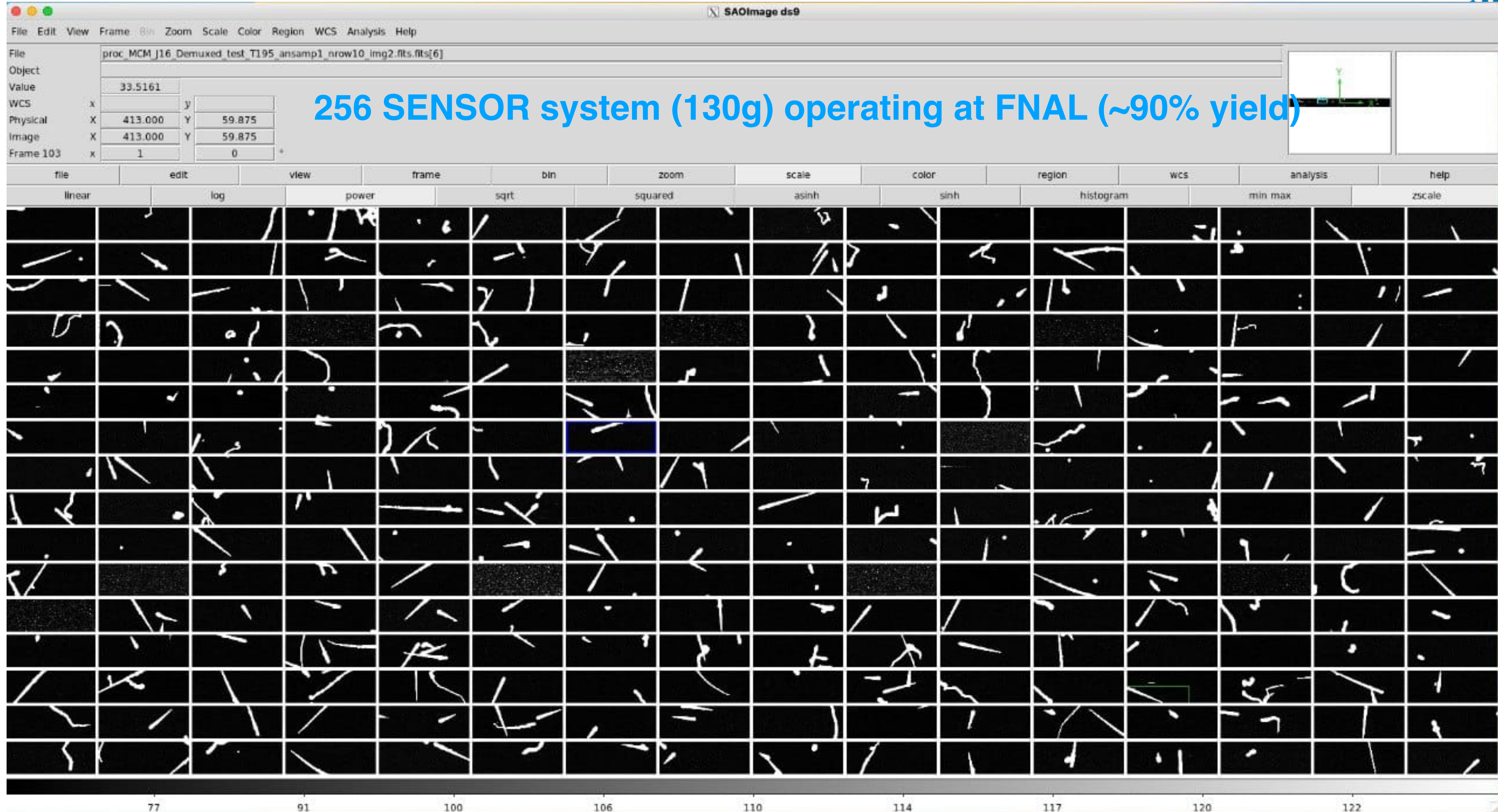
MIDNA v3



1 per MCM



Integration Test (one full Super module)



333 Mpixel camera!! Most massive array built so far with CCDs...

Budget/Project plans



- April 2024 review (FNAL/SNOLAB). Main outcome:
 - Technically good (more work needed in cryogenics)
 - Lots of work is needed to have a solid Project Execution Plan.
- DOE funding:
 - Until now, DOE has provided ~\$500k/year R&D funding with DMNI
 - Now that we believe we are ready to start construction.
 - Need to finish Project documentation/planning.

Right now we do not have a clear path towards funding the construction.

Las 6 months waiting from some guidance from DOE. It is not going to be in
Fy25!

Next



- Is it clear that the \$12M for the low background 10kg version of the experiment will not come for a while.
- Thinking about smaller versions of the experiment taking advantage of all the technical developments. Many options... (300g, 1kg, etc)
- Considering new partners to help fund the smaller versions. Careful discussion with FNAL and DOE in this direction.

