

PAUL from the ANDES perspective

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How did I get here



Underground lab projet in Argentina as an example for an African project

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to bertou, [REDACTED]

Tue, 17 May 2022, 12:00



Dear Xavier,

Executive Committee:

- Dr Rob Adam (SKA International, Stellenbosch University)
- Dr Xavier Bertou (CNEA, Argentina)
- Prof. Trevor Haas (Stellenbosch University)
- Prof. Lerothodi Leeuw (Univ. of the Western Cape)
- Prof. Robbie Lindsay (Univ. of the Western Cape)
- Prof. Fairouz Malek (CNRS, France, and Stellenbosch University)
- Prof. Richard Newman (Stellenbosch University)
- Prof. Shaun Wyngaardt (Stellenbosch University)

20 months later...

ANDES

Agua Negra Deep Experiment Site

ANDES: Agua Negra Deep Experiment Site

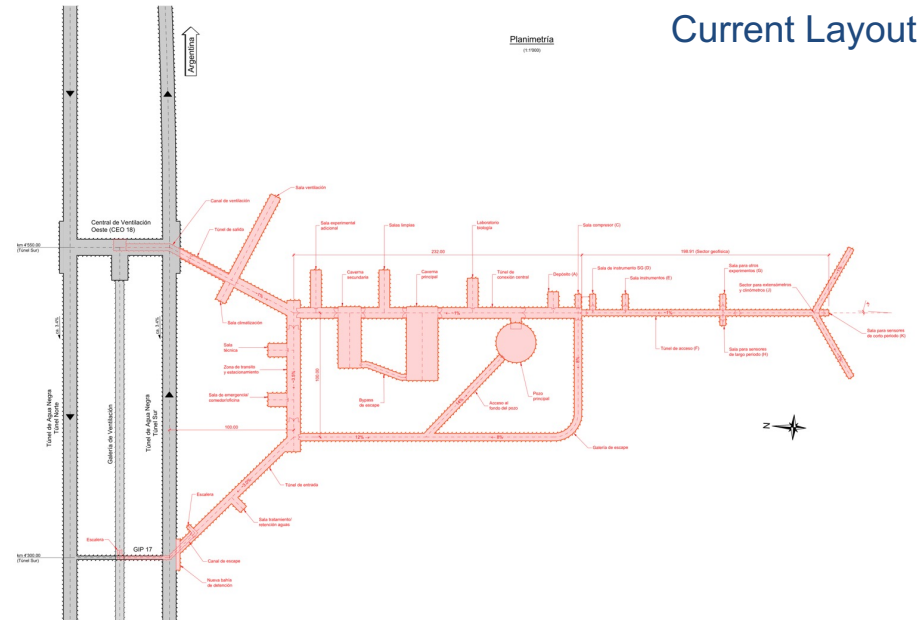
- Main hall (21 m x 23 m x 50 m)
- Secondary hall (16 m x 14 m x 40 m)
- Offices and small labs
- Large single experiment pit (~ \varnothing 30 m, 30 m tall)
- Geoscience area
- Vertical depth: 1775 m, omnidirectional: 1675 m
- Total: 70 000 m³ laboratory volume (+ 35 000 m³ access tunnels)

Rock Studies
(from test samples
~ 600 m deep)



Preliminary data (Bq/kg)

	Basalt	Andesite	Rhyolite 1	Rhyolite 2
²³⁸ U	2.6 ± 0.5	9.2 ± 0.9	14.7 ± 2.0	11.5 ± 1.3
²³² Th	0.94 ± 0.09	5.2 ± 0.5	4.5 ± 0.4	4.8 ± 0.5
⁴⁰ K	50 ± 3	47 ± 3	57 ± 3	52 ± 3



- ✓ Final exact location to be determined once geology is better known
- ✓ Proposed as an Internationally run laboratory
- ✓ Conceptual study finished by Lombardi in January 2015
- ✓ Detailed engineering design (0.5 M\$, 600 pages of documents) finished May 2019

ANDES: Agua Negra Deep Experiment Site

More than 70 documents to support ANDES:

- EBITAN (Entidad BI-nacional Túnel Agua Negra)
- CONICET/CNEA/Gob San Juan/MinCyT in Argentina
- CONICYT/CCHEN/Gob Coquimbo/MinRel in Chile
- Many underground lab directors, experiments, 2 Nobel laureates
- List at <http://andeslab.org/support.php>
- Established as a CLAF Unit since 2014 (CLAF is a class II UNESCO Institute)

ANDES foreseen as a structure similar to SESAME (small CERN)

- Strong Latin-American membership but not only
- Host to international experiments but also international laboratory

Considered a flagship for research infrastructure in the strategic document developed by the whole Latin-American HEP community (2020, <http://lasf4ri.org>):

Recommendation 2

Pursue the establishment of the flagship international laboratory, ANDES, that will enable the region as a global center for underground physics and other sciences.

Political green light for ANDES but final one depends on Agua Negra tunnel status

Is there
light at
the end
of the
tunnel?



Spoiler alert

- Tunnel frozen in 2017 by Chile and Argentina presidents
- New presidents of both countries didn't change the situation
- Unlikely to improve in the next few years
- ANDES in 2035 in the very best case



Lessons learned from these last 13 years

- DUL community is very helpful, little to no competition
- Genuine interest in expanding the underground science community
- Scientific community eager to support
- Politicians also happy to support (low cost when compared to the tunnel cost, high reward)
- International endeavour complex but rewarding
- Very high level politics (civil work)
- Small windows of opportunity to advance
- Hard to get support if there is no local science driven interest
- (Science)



Neutrino and Dark Matter



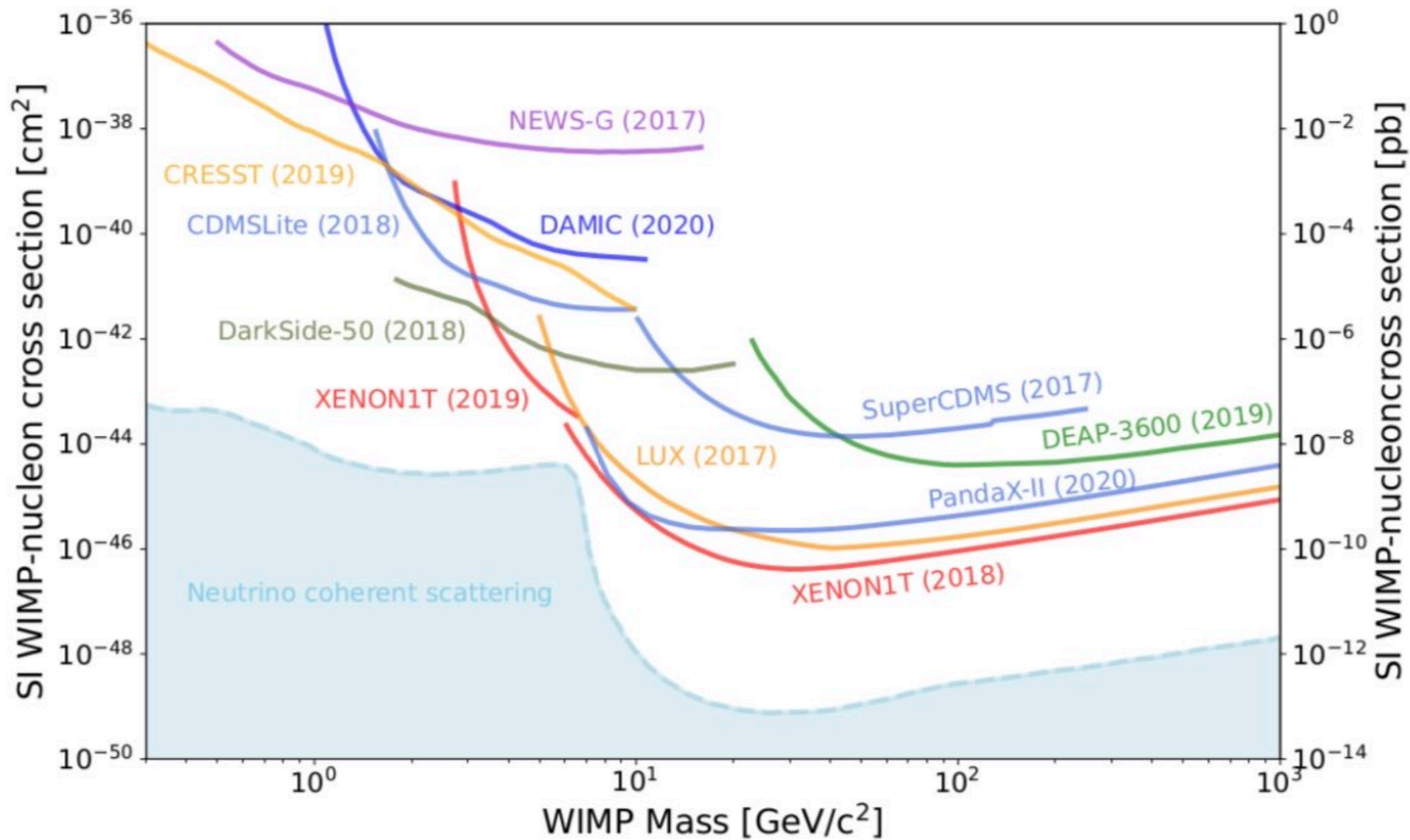
Neutrino

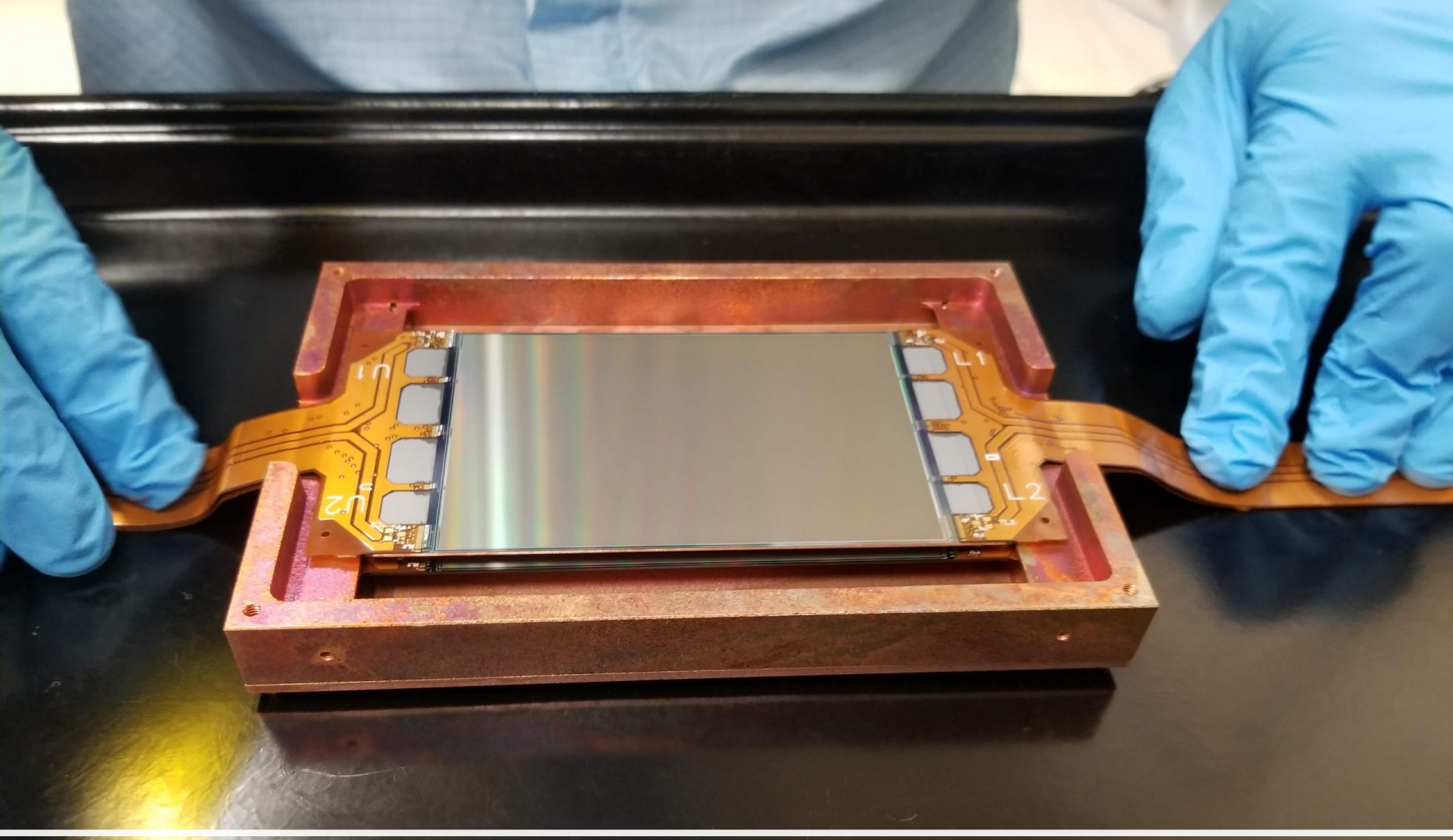
- Earth is transparent to Neutrinos
 - extra-solar source (MSW effect?)
- Neutrino detectors are usually huge
 - unless looking for coherent interaction
- 60 km from Koeberg nuclear power plant
 - too far to give a science worthy flux
- No current very (very) long baseline science motivation



Dark Matter

- Earth is transparent to Dark Matter
 - signal should not depend on location
- Dark Matter Detectors can be huge
- Earth movement around the Sun may induce a yearly modulation
 - Maximum expected in June, minimum in December
- Background is location dependant
 - Atmospheric effects are opposite in both hemisphere

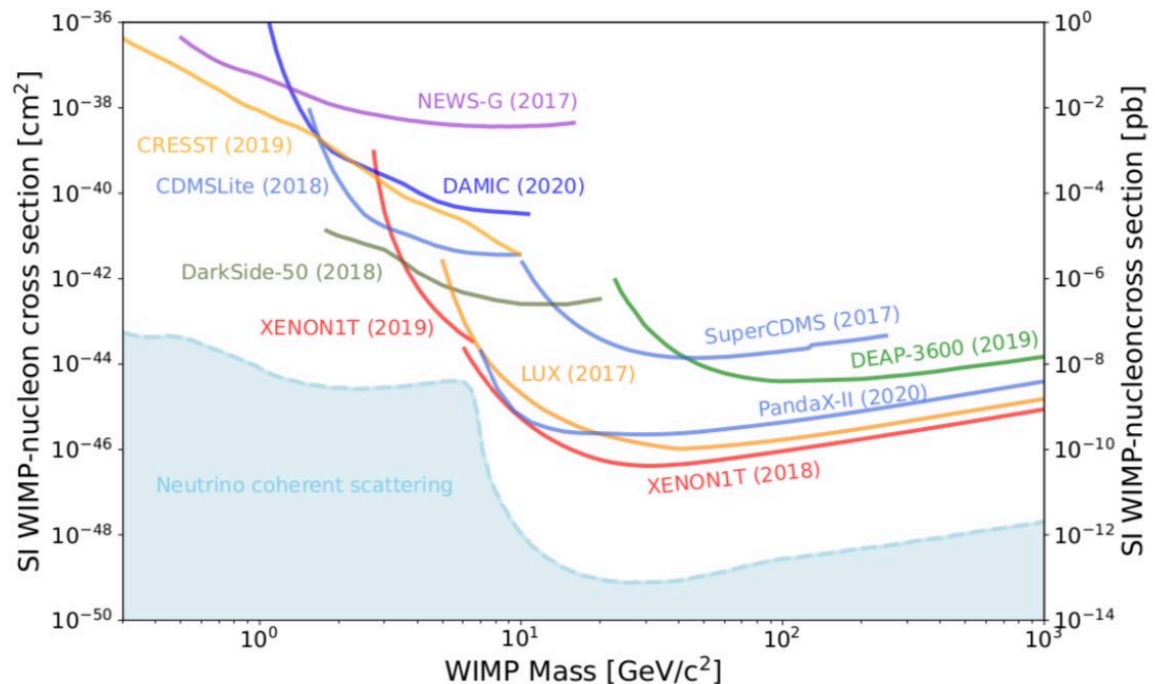




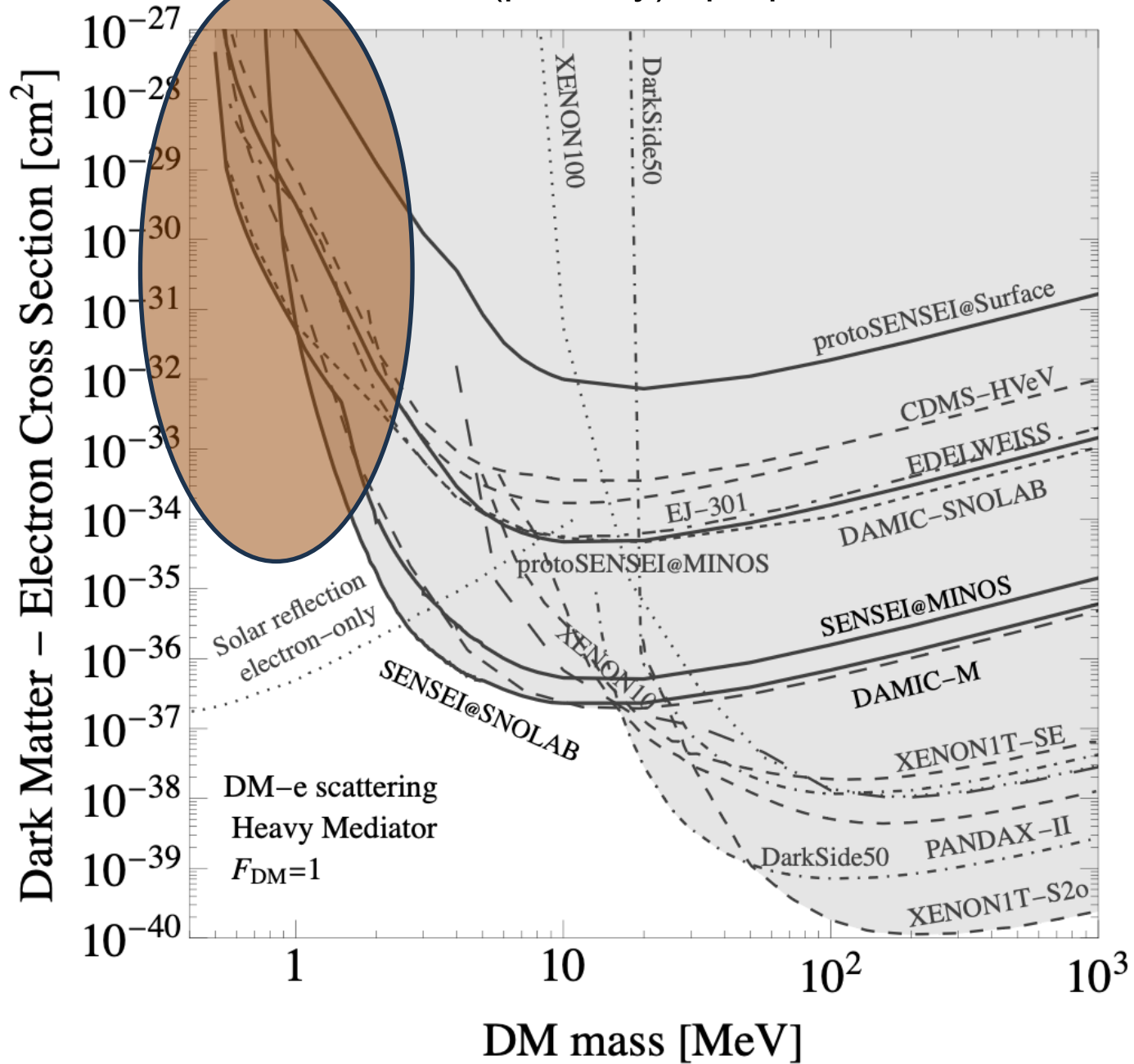
Low energy deposit sensitive detectors

Dark Matter

- Earth is transparent to Dark Matter... Or is it?
- Depending on interactions, you get the Earth transparent at maybe $1e-34\text{cm}^2$



Earth is (partially) opaque here

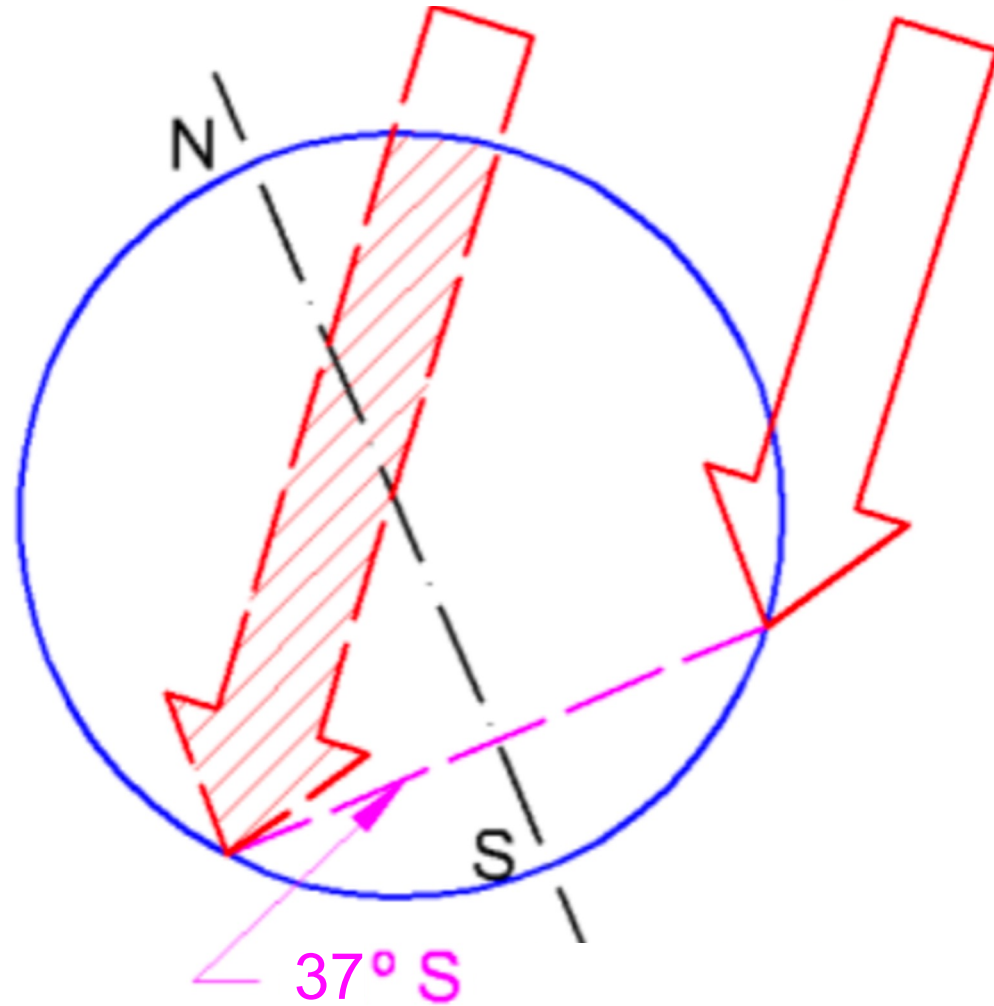




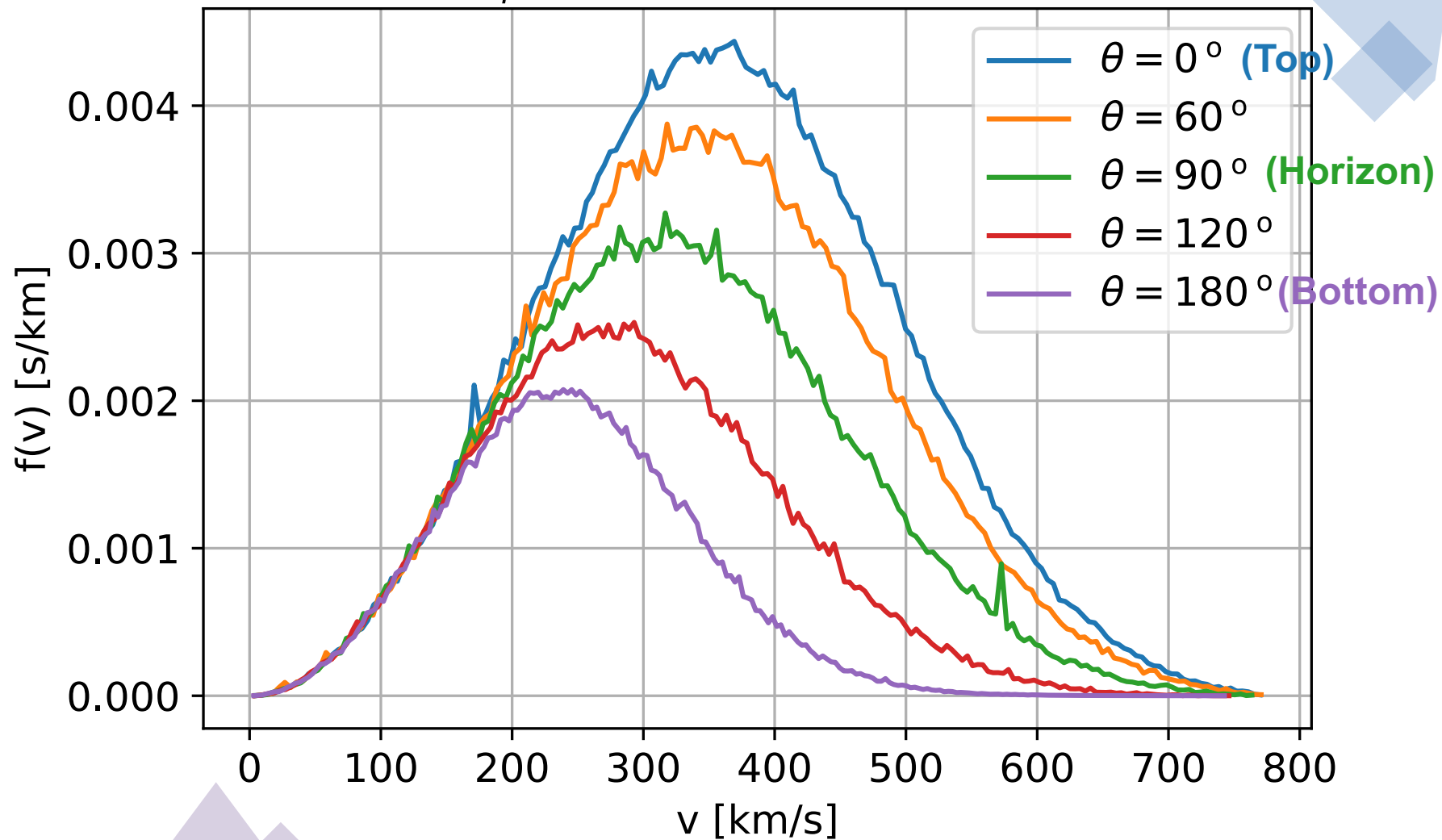
Earth partially opaque

- Would not matter if Dark Matter was isotropic
- But it is not
- A Dark Matter wind is expected to come from Cygnus ($\sim 40^\circ$ latitude north, where we move to inside the galaxy)
- Strong dipole in this specific direction

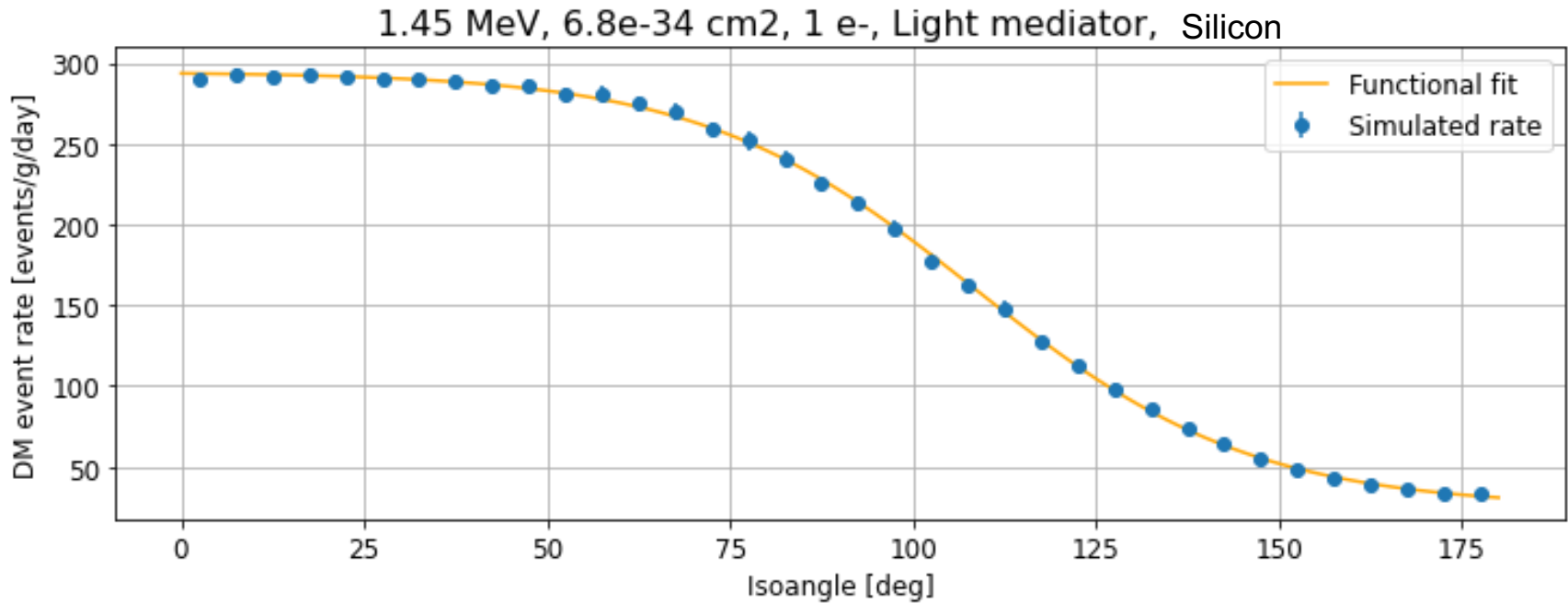
DM Wind (~40° N)

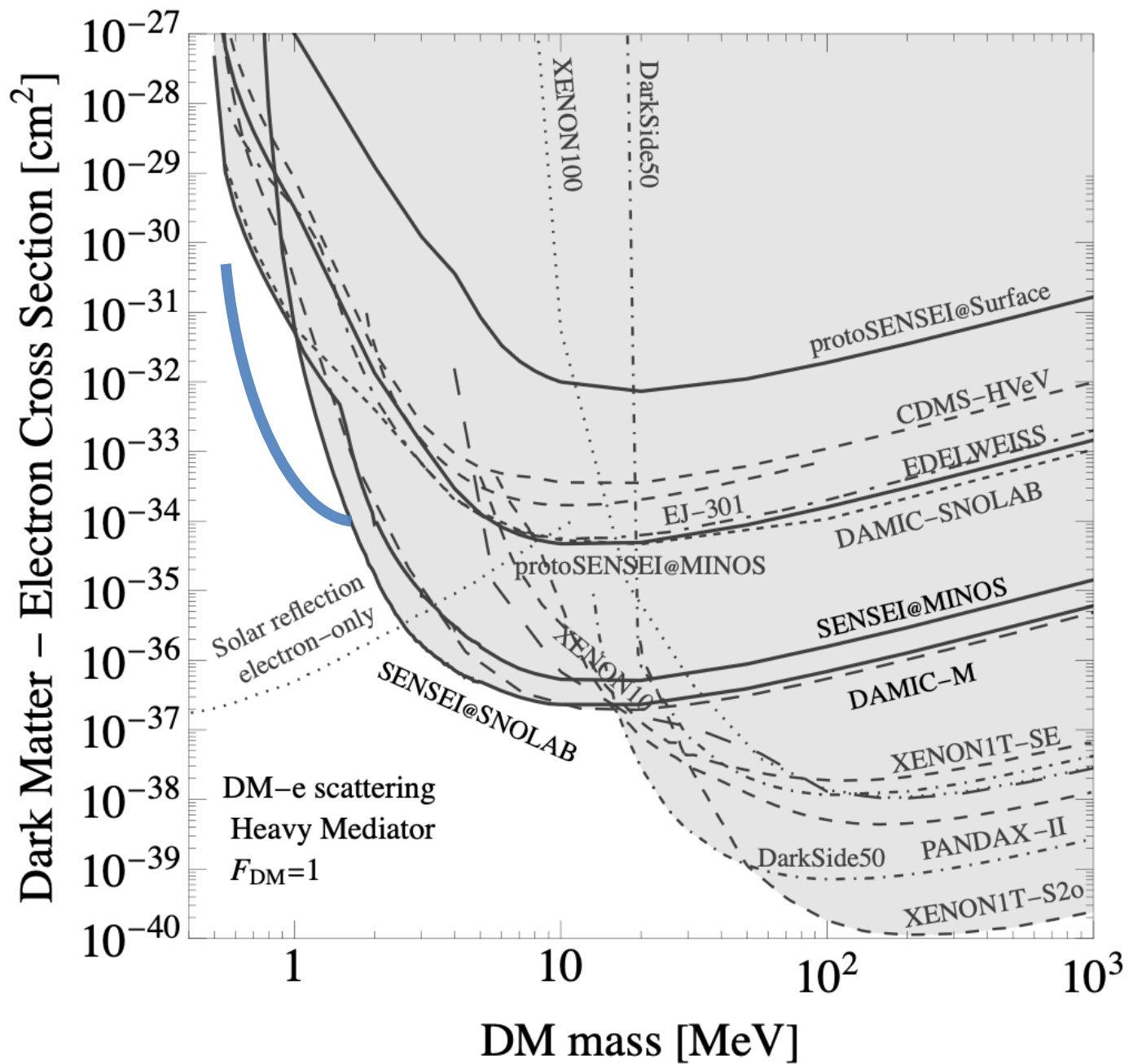


1 MeV, $\sigma_p = 1e^{-31}$ cm², Heavy mediator

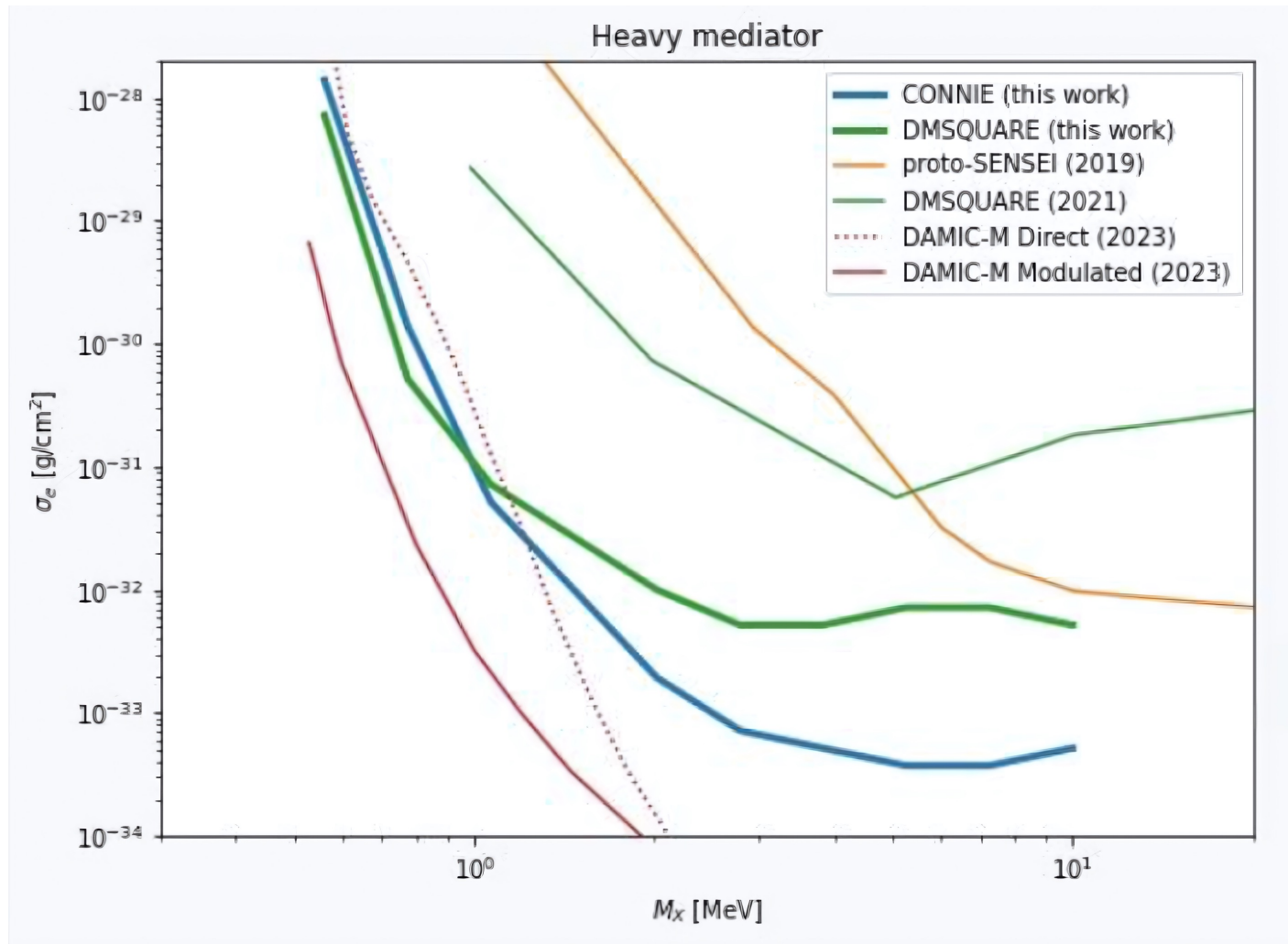


Dark Matter expected event rate

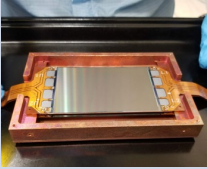




Dark Matter modulation limits... Detectors operating at surface!



Dark Matter @PAUL conclusions



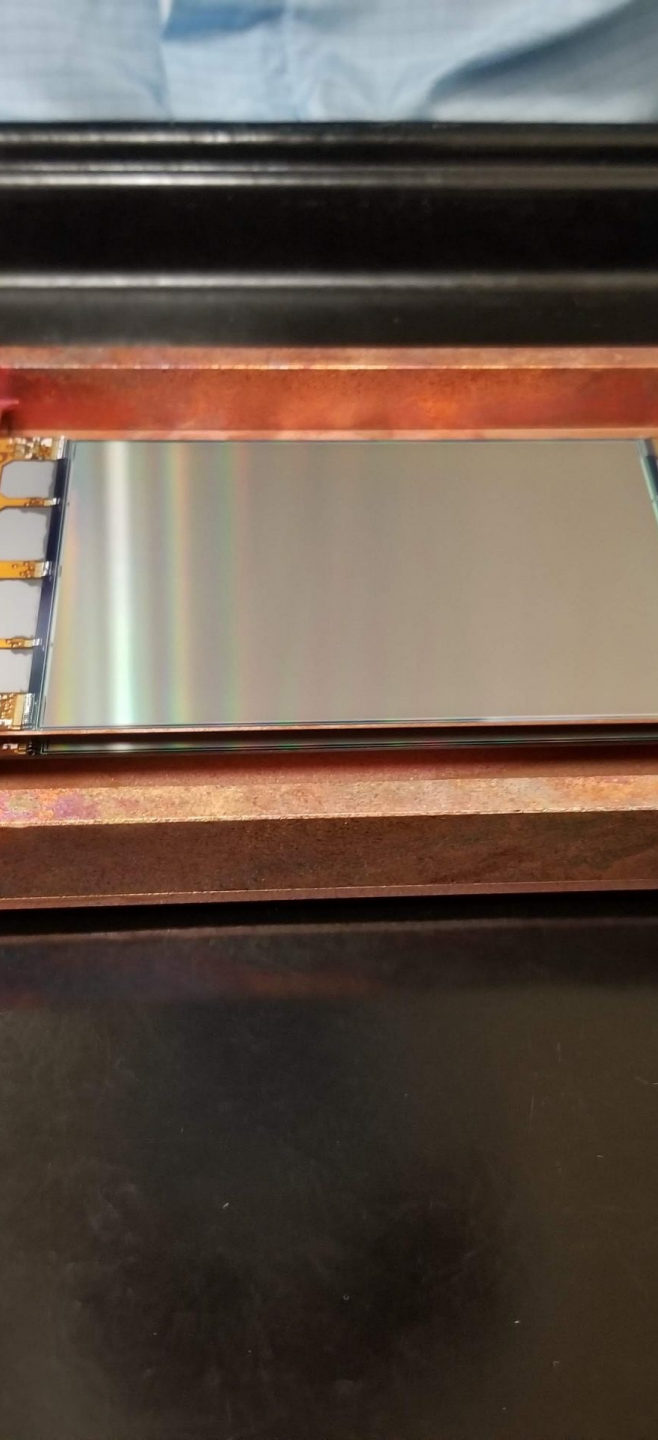
Dark Sector can be explored with small (grams) detectors



Daily modulation is (usually) more sensitive when operated in the southern hemisphere



Background is not a major issue



My personal perspectives for PAUL

Getting PAUL will imply a lot of politics

The window of opportunity is small

PAUL won't be huge or very deep

But there is still a lot of science to do
there, even Dark Matter searches

I'm ready to deploy detectors there in
2027!