Dark Matter
Experimental Direct Detection Summary

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Fermi National Laboratory

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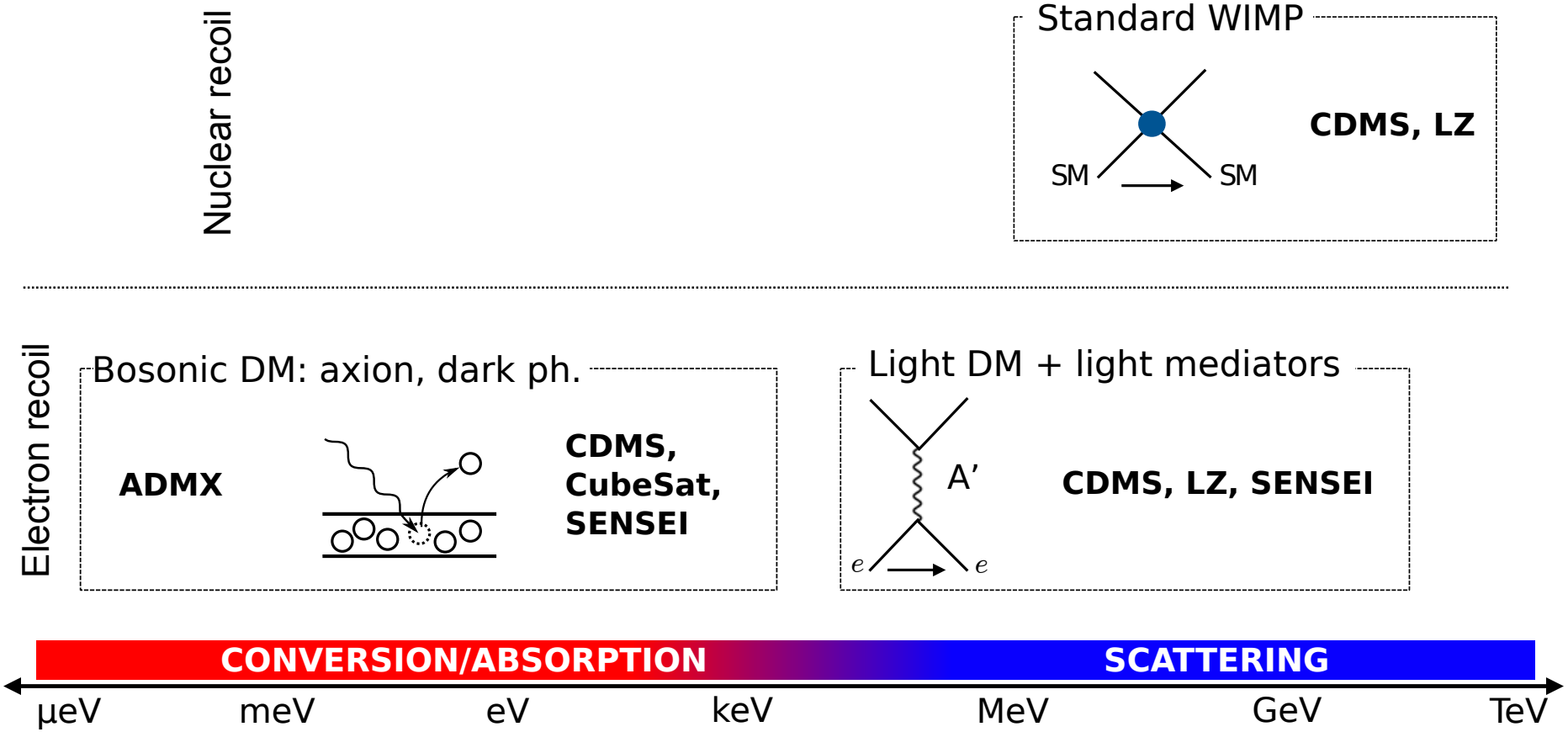
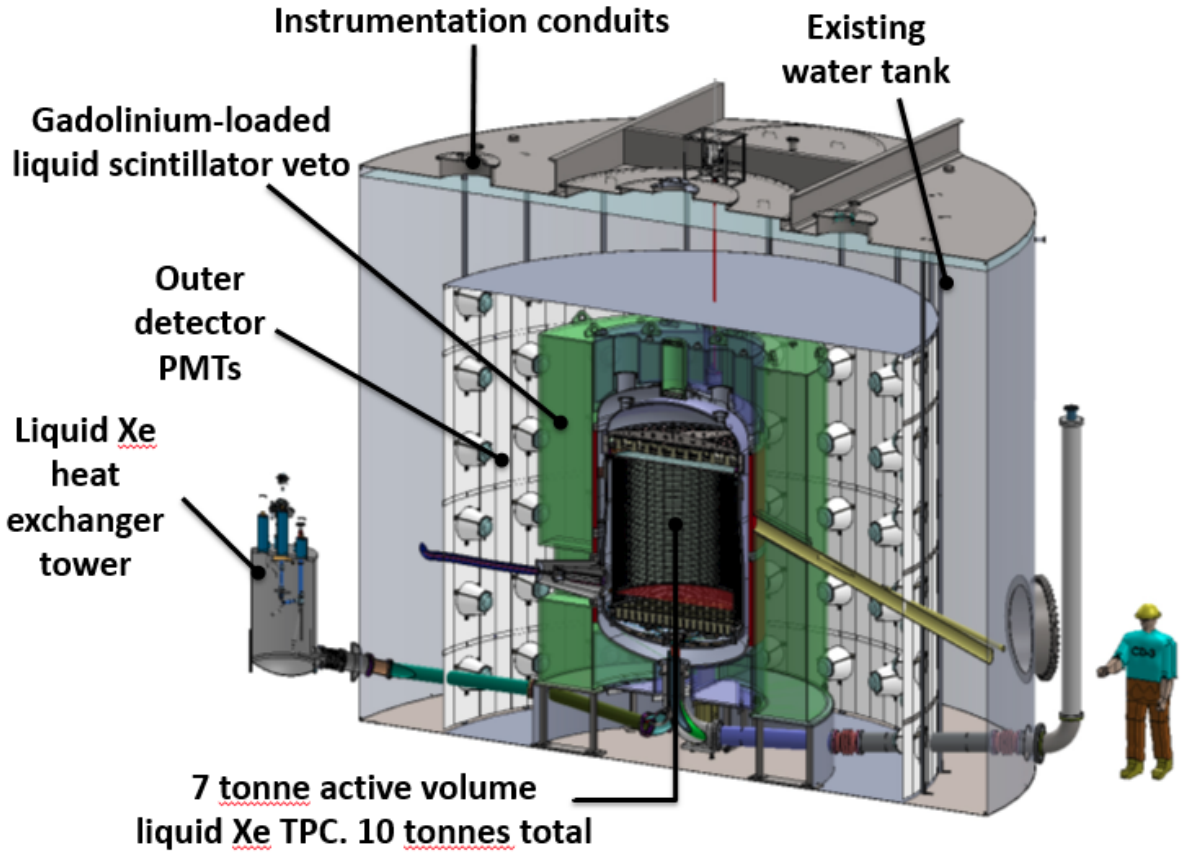
Fermilab DM - Direct Detection landscape for 2018+



- Fermilab has a strong paricipation in the three G2 experimets
  - ADMX, CDMS & LZ
- Broad program covering a wide spectrum of DM candidates

LZ: giant Xe Time Projection Chamber

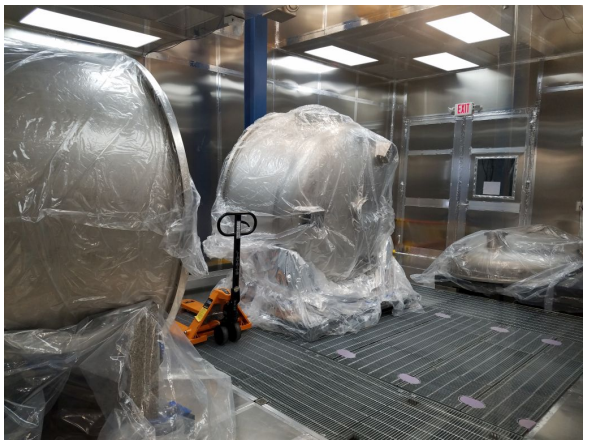


- Lots of mass - 7 tonnes in TPC, 5.6 tonnes fiducial
- D494 3" PMTs in TPC
- Extensive internal and external calibration program

LZ: giant Xe Time Projection Chamber

Project on schedule:

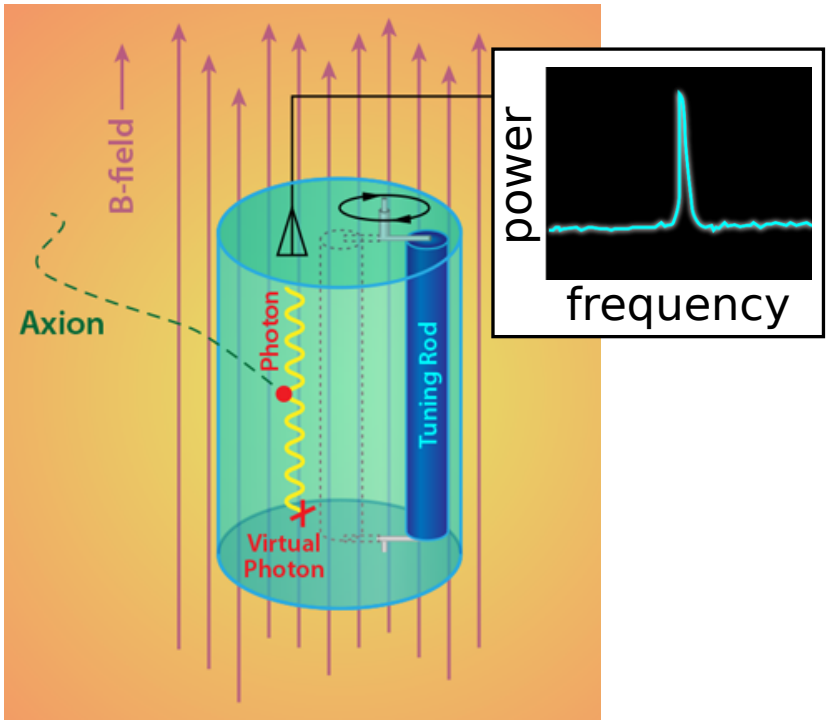
- TPC installation Spring-Summer 2019
  - Cryostat already on site.
    Arrived May 14.
- Cooldown planned for Winter 2019
- First physics data - Spring 2020

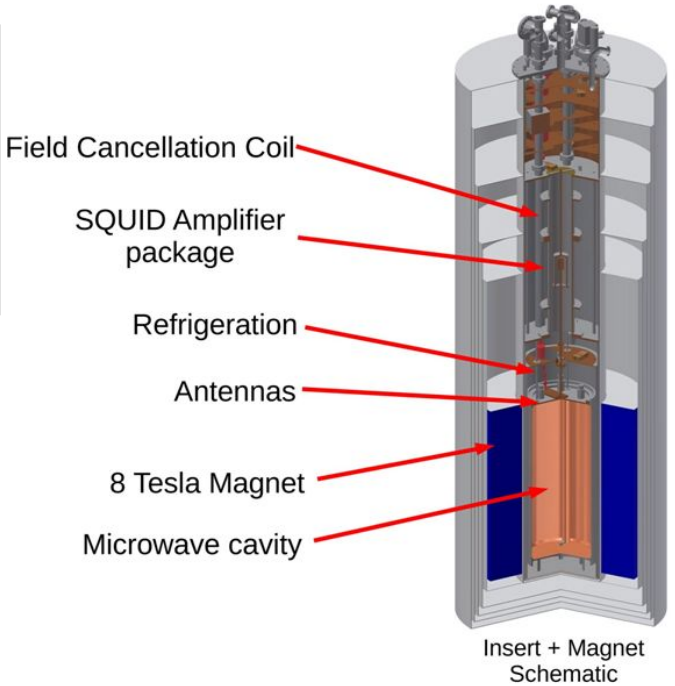


Fermilab

- In charge of cryogenics, xenon circulation and controls
- Currently hosting cryo and xenon circulation installation planning meeting
- Strong involvement with full time Scientist and Postdocs

ADMX: superconducting cavity resonator



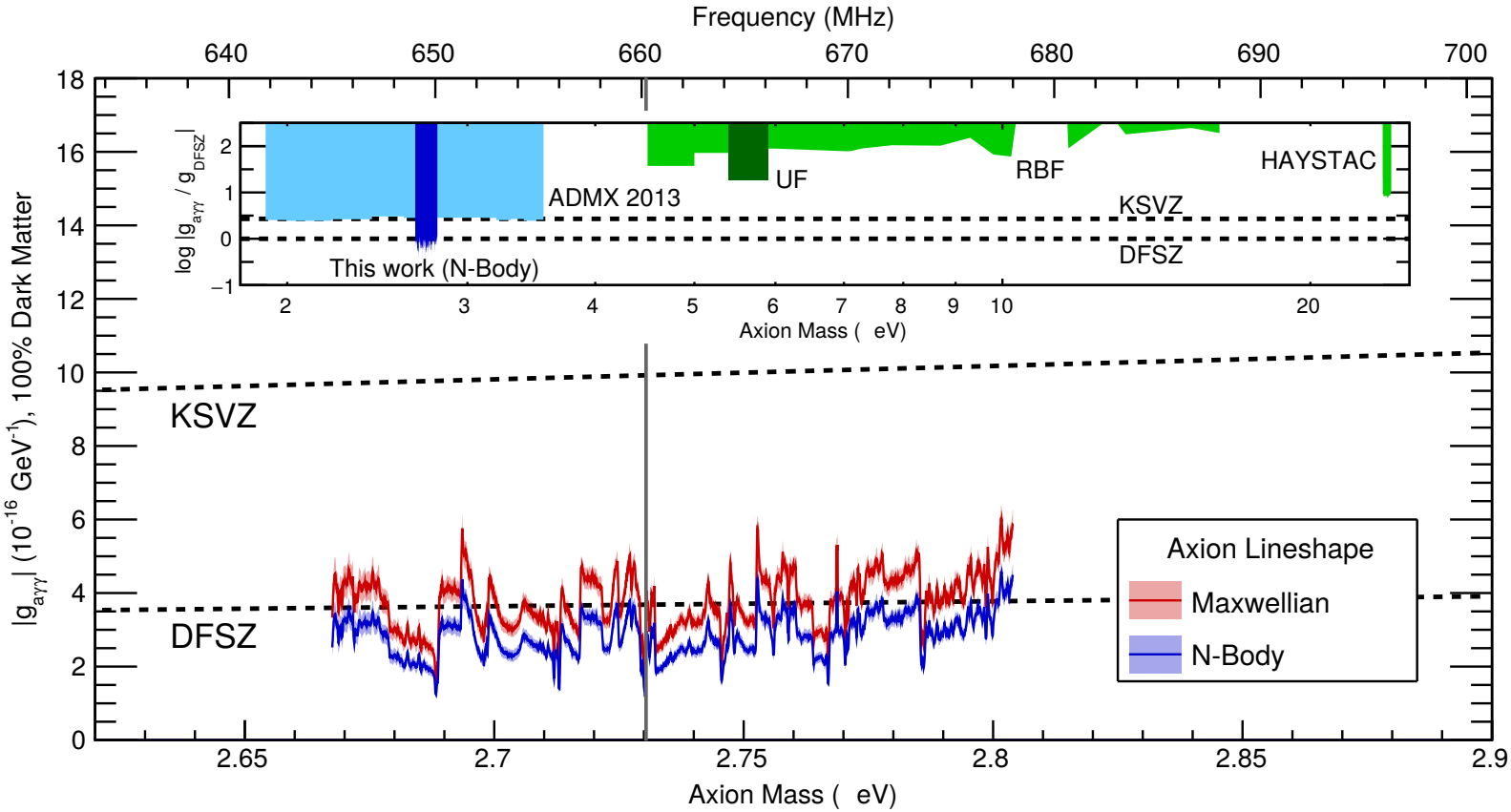


Insert + Magnet Schematic

Insert extraction from magnet

- Fermilab is the DOE's lead Lab for ADMX.
- Strong group at Fermilab and many R&D project within the lab
- The experiment is operating at university of Washington with a plan to scan up to 2 ghz over three years.

ADMX: superconducting cavity resonator



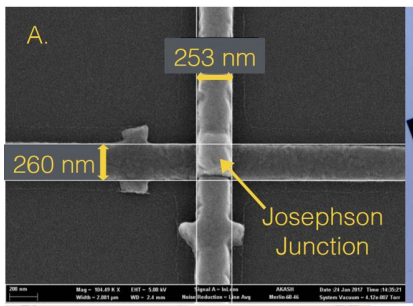
- Phys. Rev. Lett. 120, 151301 (2018).
- Did not find an axion, but could have.
- First measurement at the DFSZ frontier.

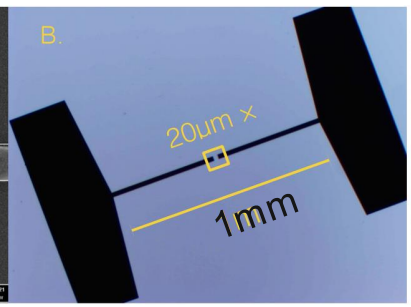
Improving Axion detectors

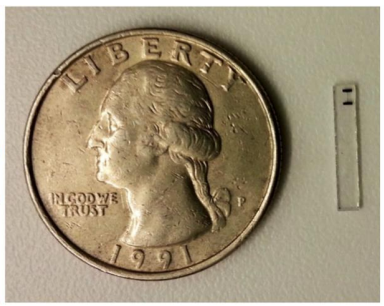
Quantum non-demolition single microwave photon detectors based on superconducting qubits

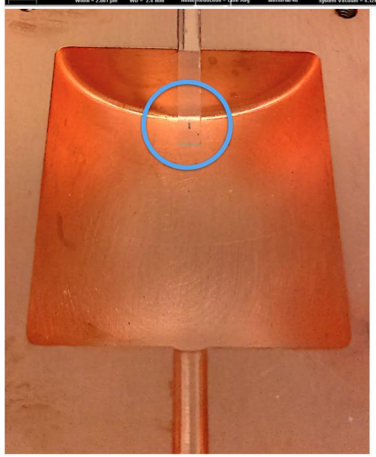
Aaron Chou, Daniel Bowring (FNAL),
David Schuster, Akash Dixit, Ankur Agrawal (UChicago)

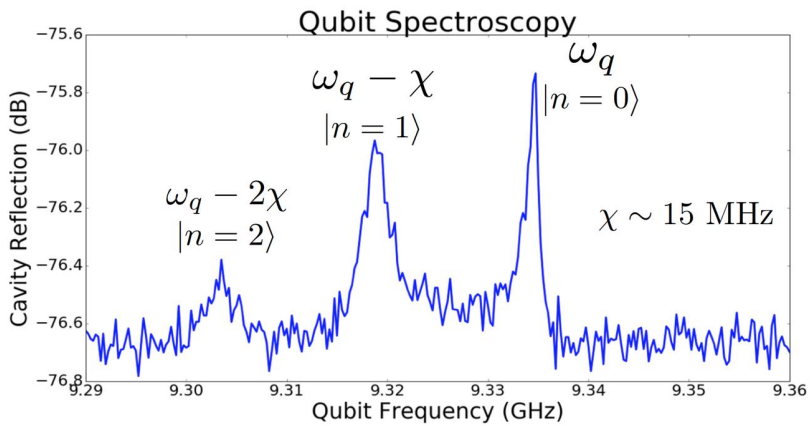
HEISING-SIMONS FOUNDATION











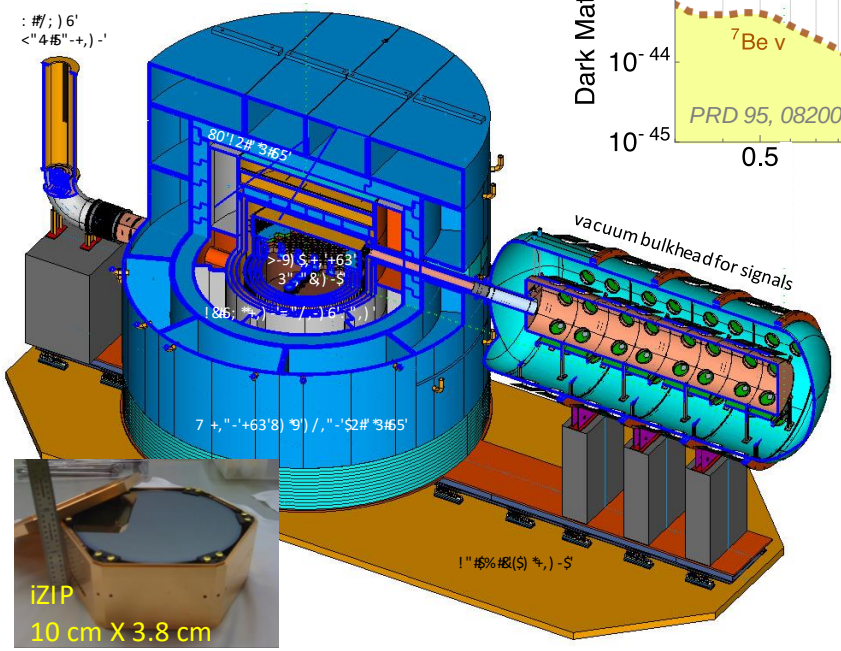
Photon amplitude is non-destructively mapped onto the qubit's frequency.
Reduce noise levels in axion detectors by evading the quantum back-action.

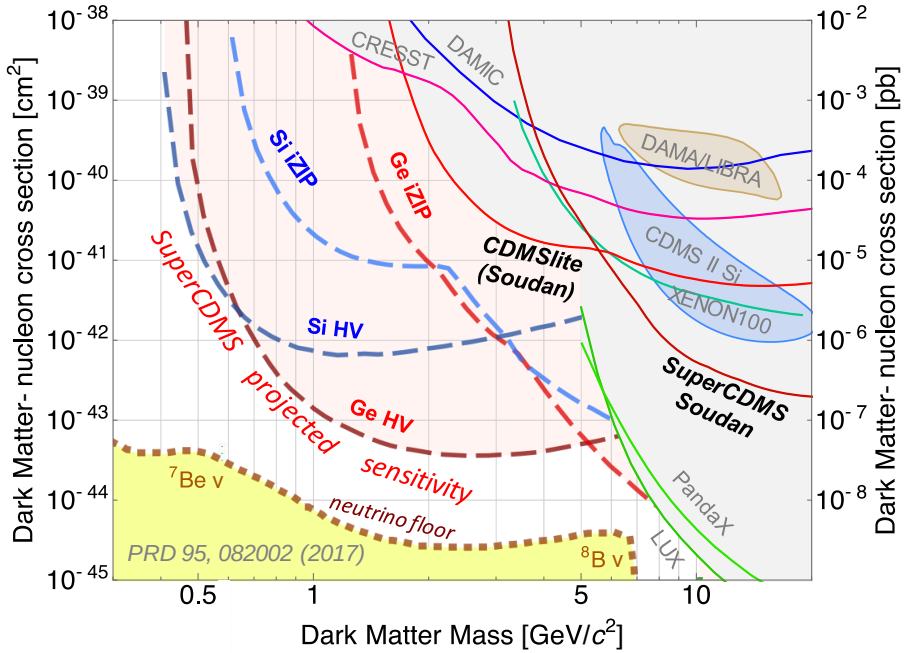
Fermilab

CDMS: cryogenic crystal

SuperCDMS SNOLAB

Will provide superb sensitivity to low mass WIMPs with Ge and Si operated in both HV and iZIP modes



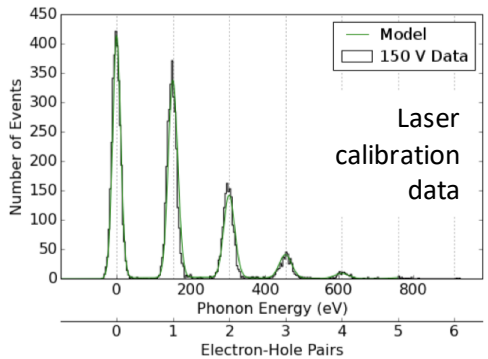


- One of three experiments in U.S. "suite" of Generation 2 dark matter experiments
- Expected to begin operation in early 2020 and run for ~5 years
- Facility designed for future upgrade to reach neutrino floor

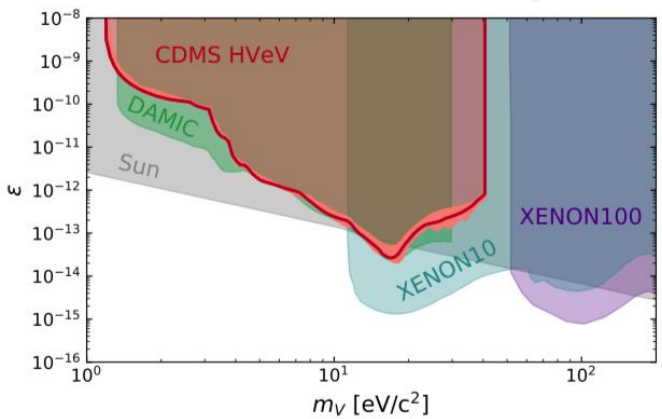
CDMS: cryogenic crystal

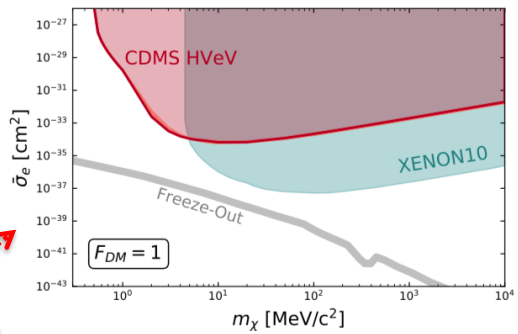
Early science with single-charge sensitive detectors

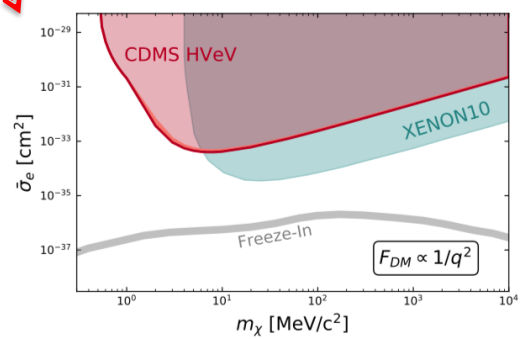
SuperCDMS recently demonstrated first HV device that measures single e/h pairs.



Surface running of prototype Si device constrains dark photons and electron-scattering dark matter

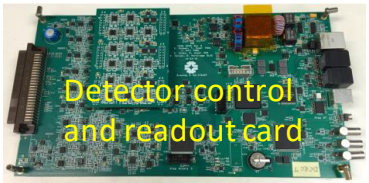


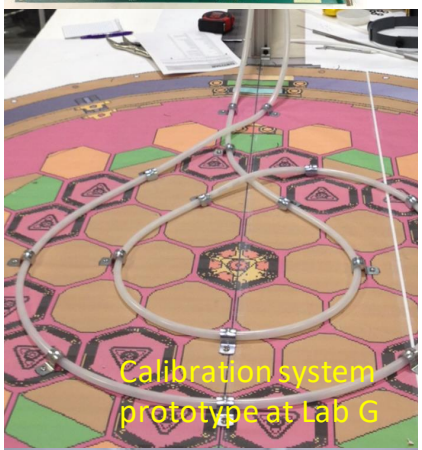




arXiv: 1804.10697

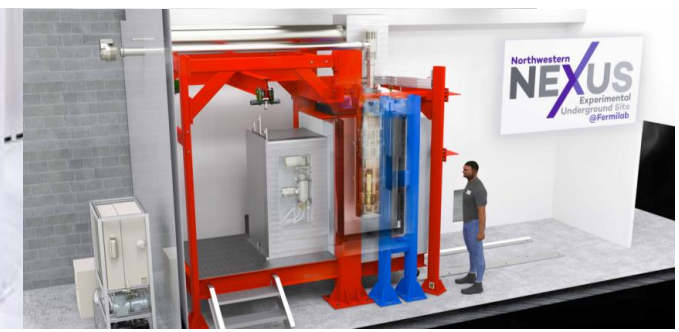
CDMS: cryogenic crystal





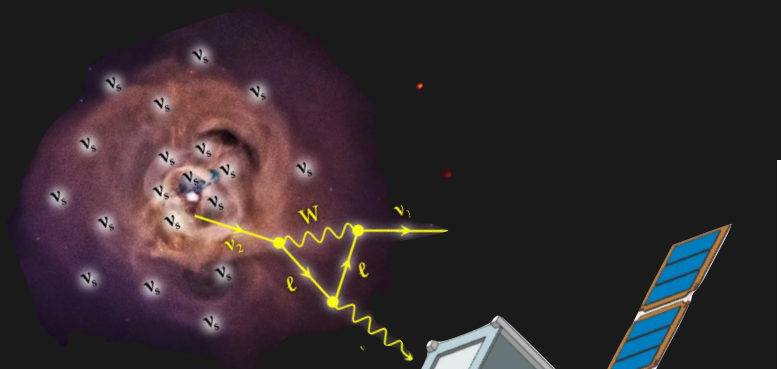
SuperCDMS at Fermilab

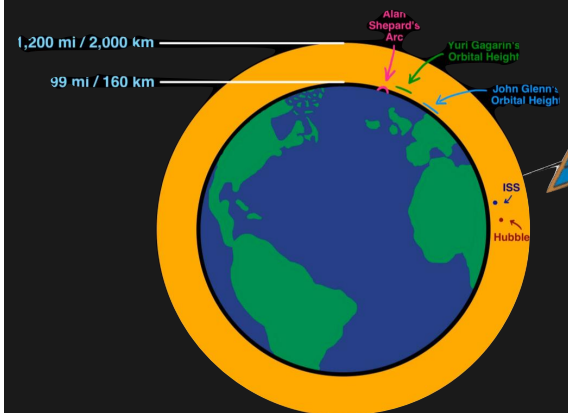
- FNAL continuing 20 years of involvement with SuperCDMS with major roles in G2 project:
  - Cryogenic design
  - Warm electronics design and fabrication
  - Calibration system design
  - Infrastructure and Integration for whole experiment
- Lab-G is home-base for SuperCDMS efforts at FNAL; will commission cryogenic and calibration systems here.
- Northwestern cryogenic testing facility (NEXUS) to be installed in MINOS near detector hall
  - *Allows low background testing of "beyond G2" detectors*
  - *Installation to take place this summer*
  - *Developed in collaboration with FNAL SuperCDMS group and with support from FNAL detector R&D funds*



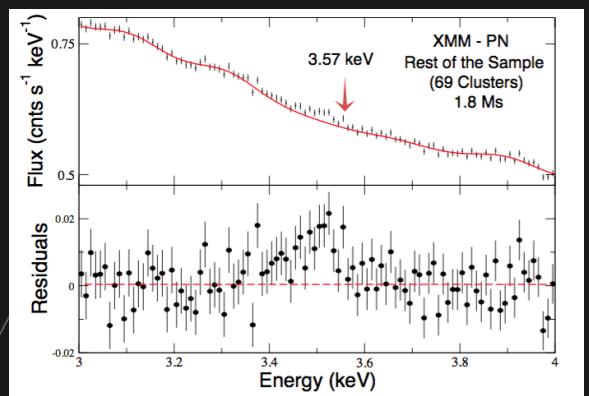
CubeStat: X-ray detector in space

cubeSat for detecting
the decay of dark matter in our own galaxy.





3.5 keV lines seen in clusters of galaxies Bulbul et al 2014.

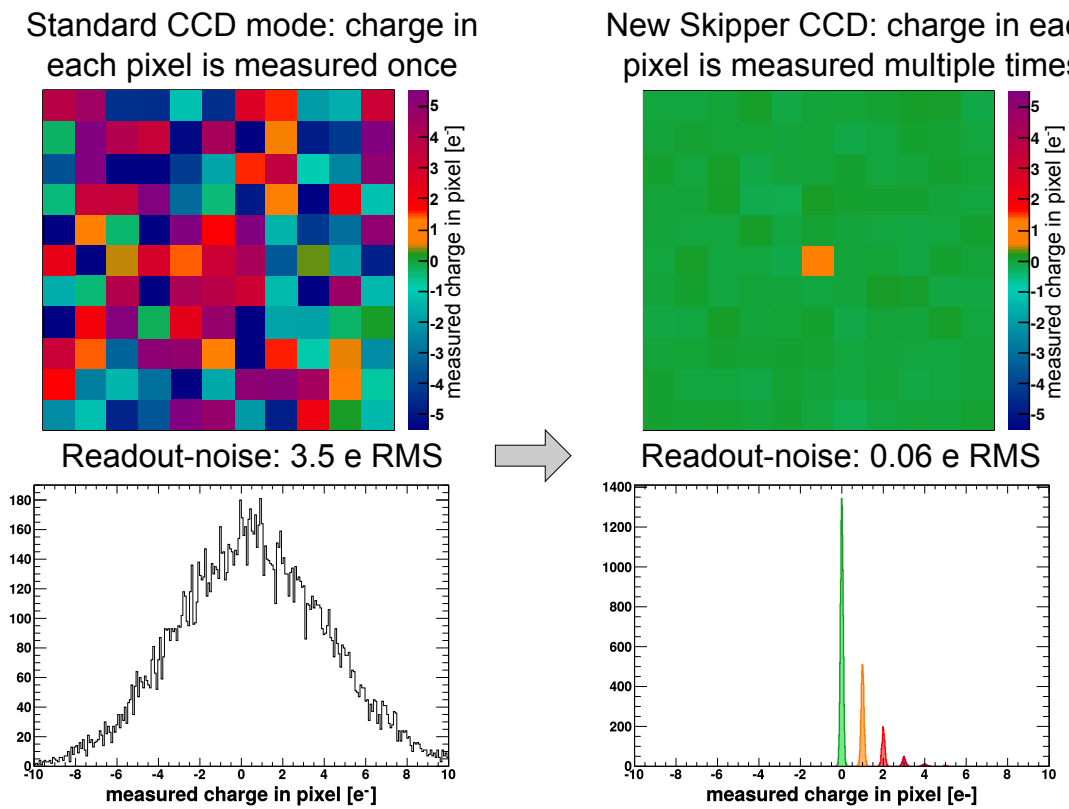


it may come from 7 keV sterile neutrino DM decay.

Plan: Build a cubesat and look for this signal in our galaxy. LDRD 2018.
PI: S. Timpone.

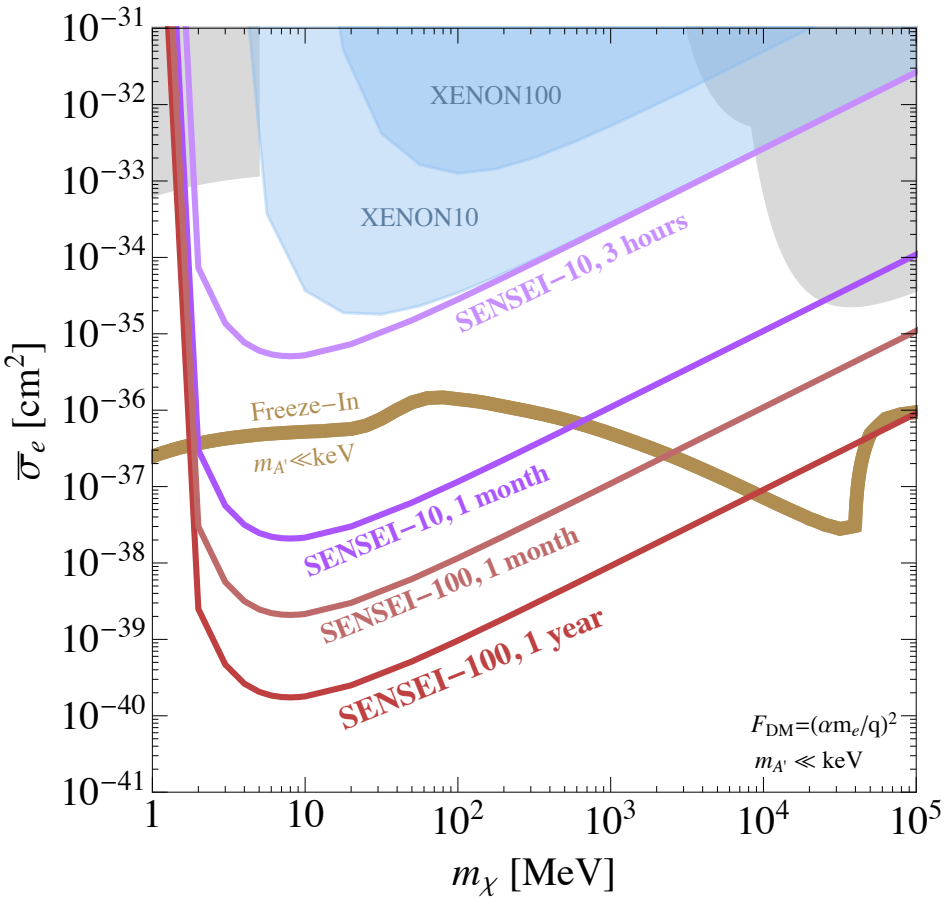
SENSEI: silicon Skipper-CCDs

- Techology developed at the Lab through LDRD award
- First dedicated experiment looking for DM-electron interactions
- Fully funded: 10g & 100g design/construction started.
  - Grant from Heising-Simons Foundation technical support from Fermilab

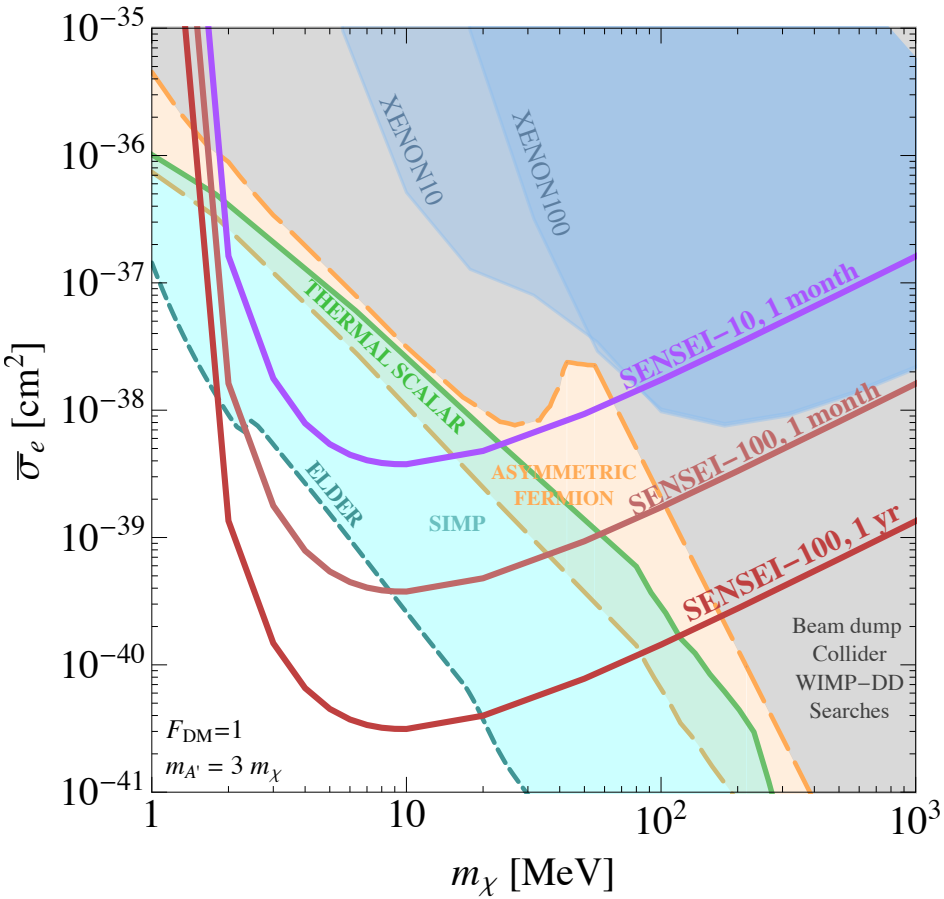


SENSEI: expected sensitivity

Light Dark Photon

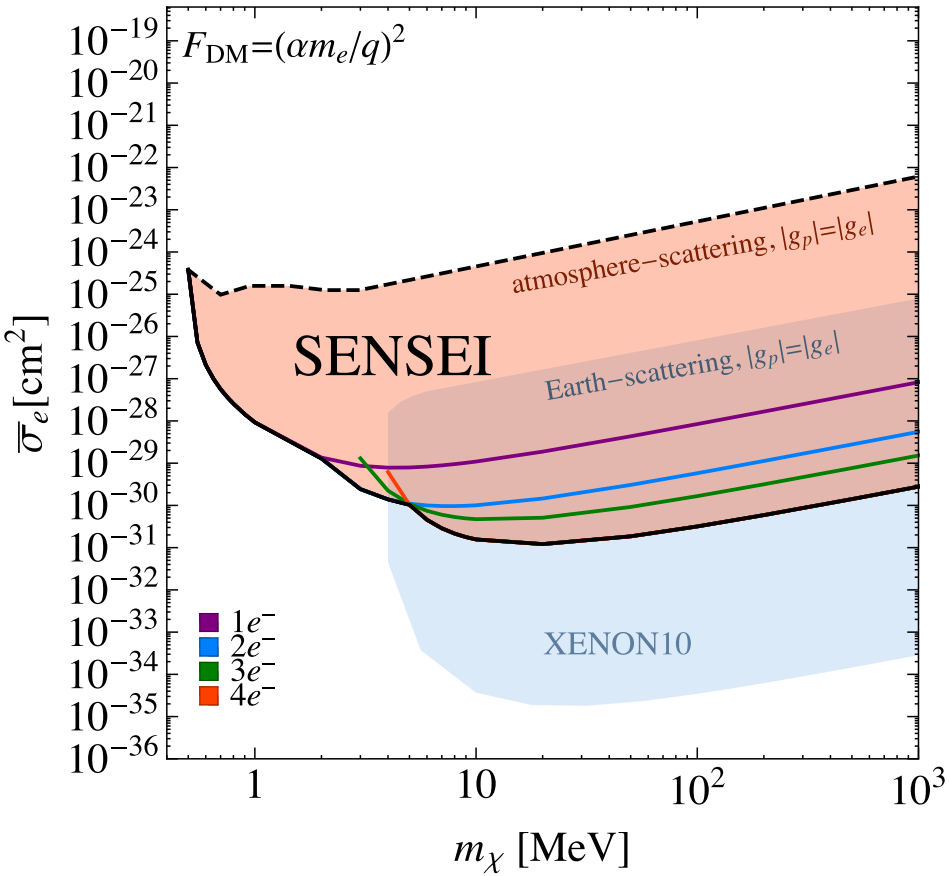


Heavy Dark Photon



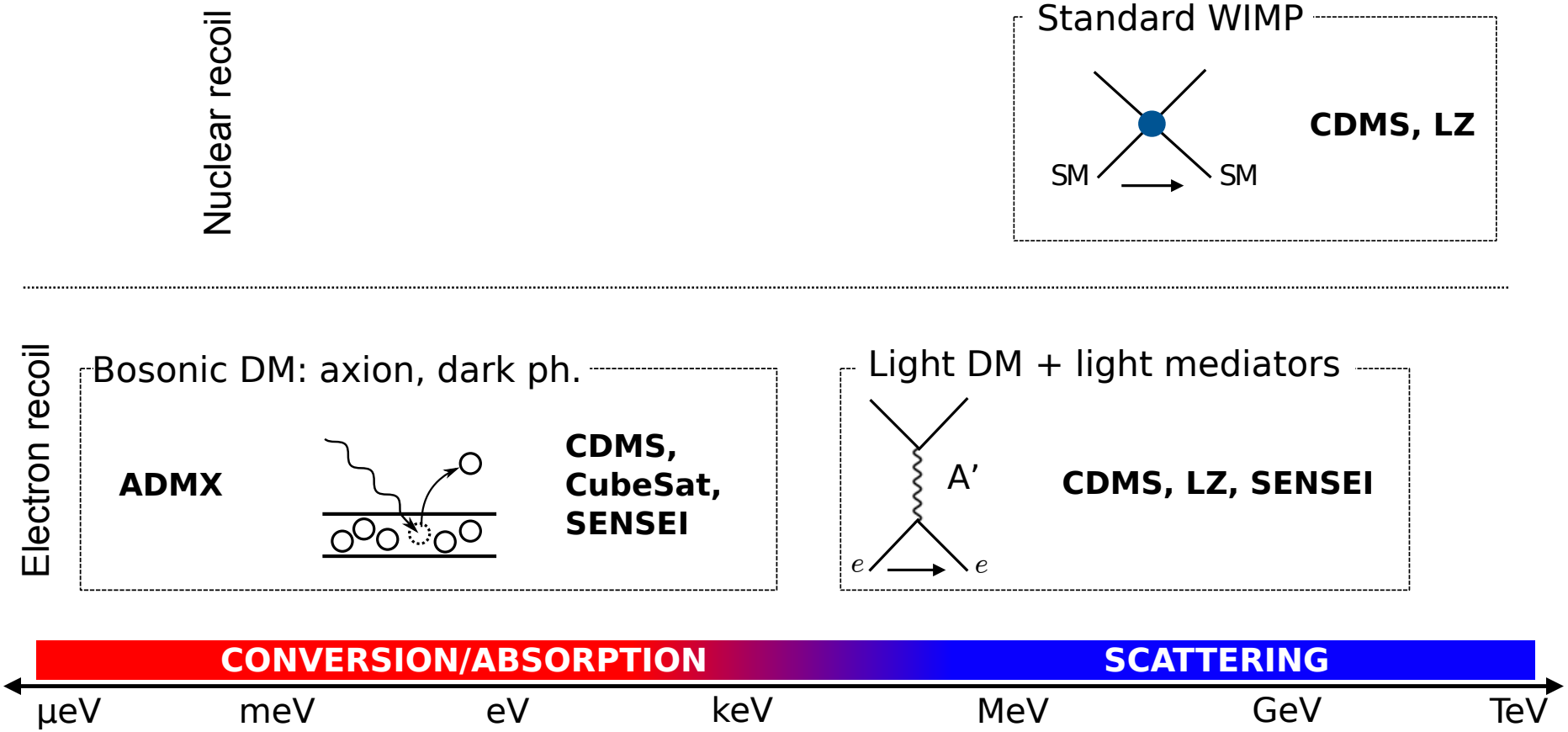
SENSEI commissioning run at surface: arXiv:1804.00088

First direct-detection constraints between ∼500 keV to 4 MeV



Explored 3 orders of magnitude of large-xs DM candidates using data from an engineering surface run (tiny exposure: 0.02 g-dat)

Fermilab DM - Direct Detection landscape for 2018+



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