The DAMIC-M Experiment

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(on behalf of the DAMIC-M collaboration)

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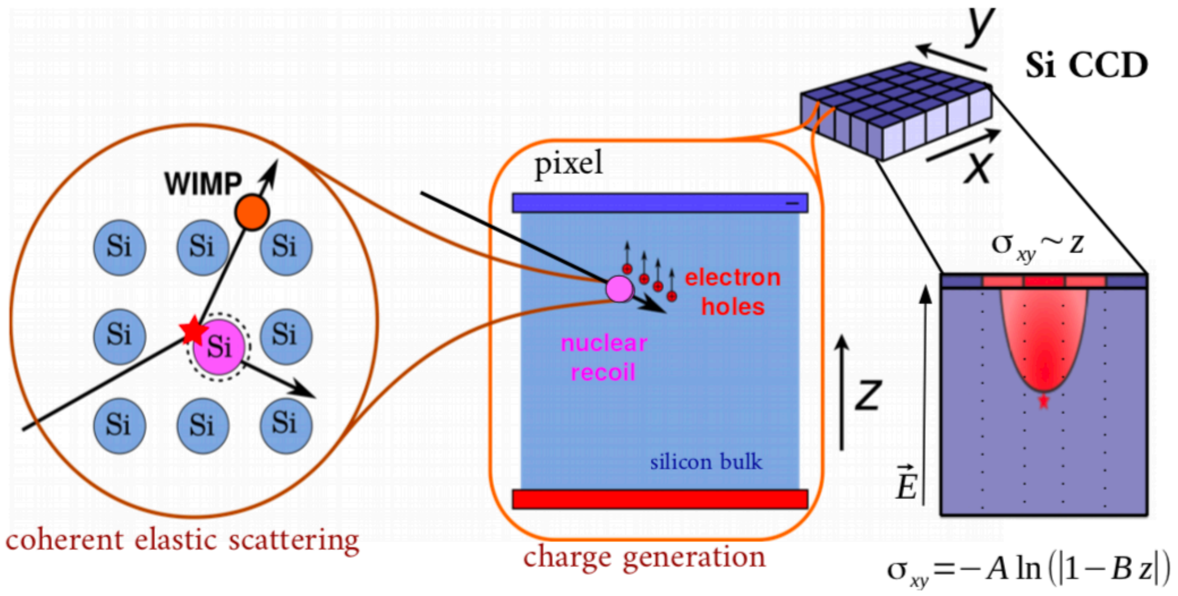
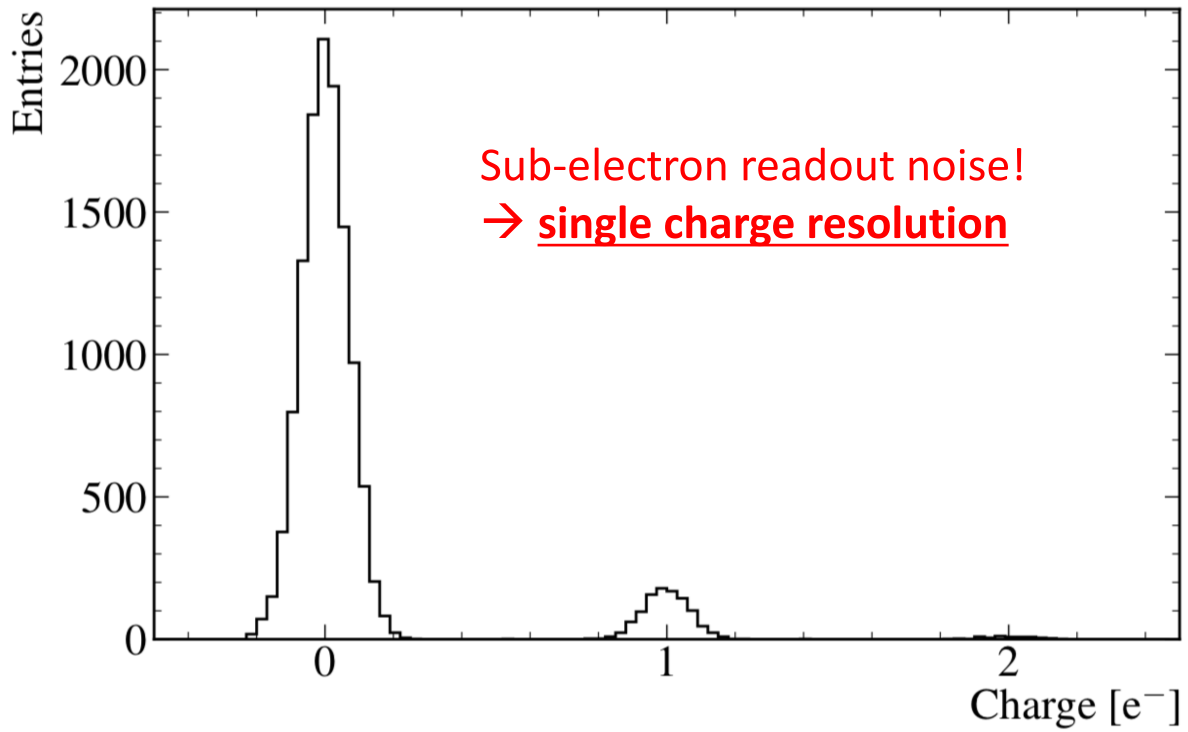
Charge-Coupled Devices

- Non-destructive ionization readout of sub-keV energy deposits in bulk silicon (675 microns thick)
- Charges are drifted and collected in 15x15 micron pixels before being read out
- Charges are moved from pixel-to-pixel until readout with low charge transfer inefficiency



J. Tiffenberg *et al*, Phys. Rev. Lett. **119**, 131802 (2017) [arXiv:1706.00028]

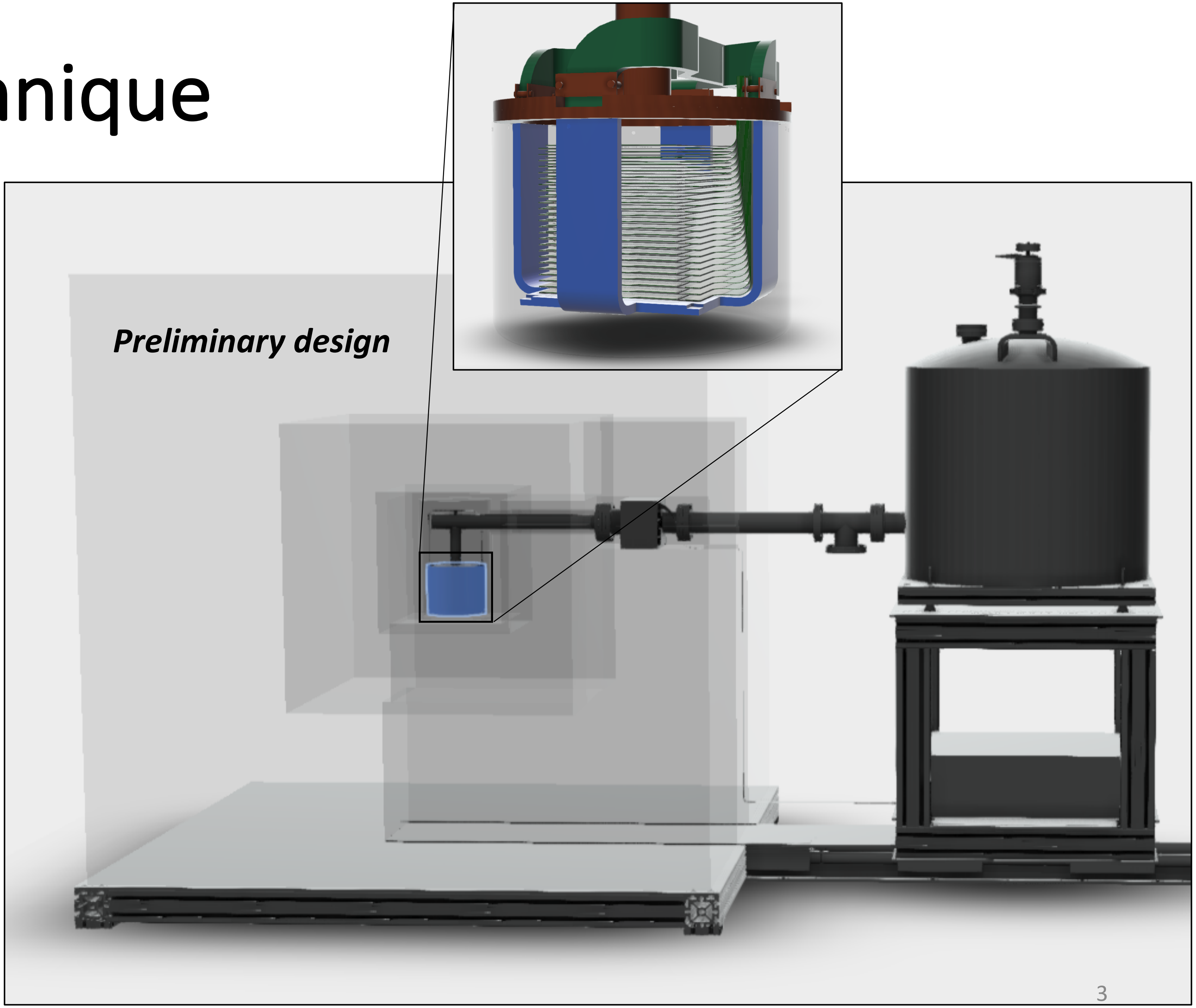


- DAMIC@SNOLAB has already demonstrated the capability of fully-depleted silicon CCDs to search for dark matter:
  - A. Aguilar-Arevalo *et al*, Phys. Rev. Lett. 118, 141803 (2017) [arXiv:1607.07410]
- new Skipper CCDs (shown above) allow consecutive non-destructive readout of a single pixel

→ sub-electron readout noise

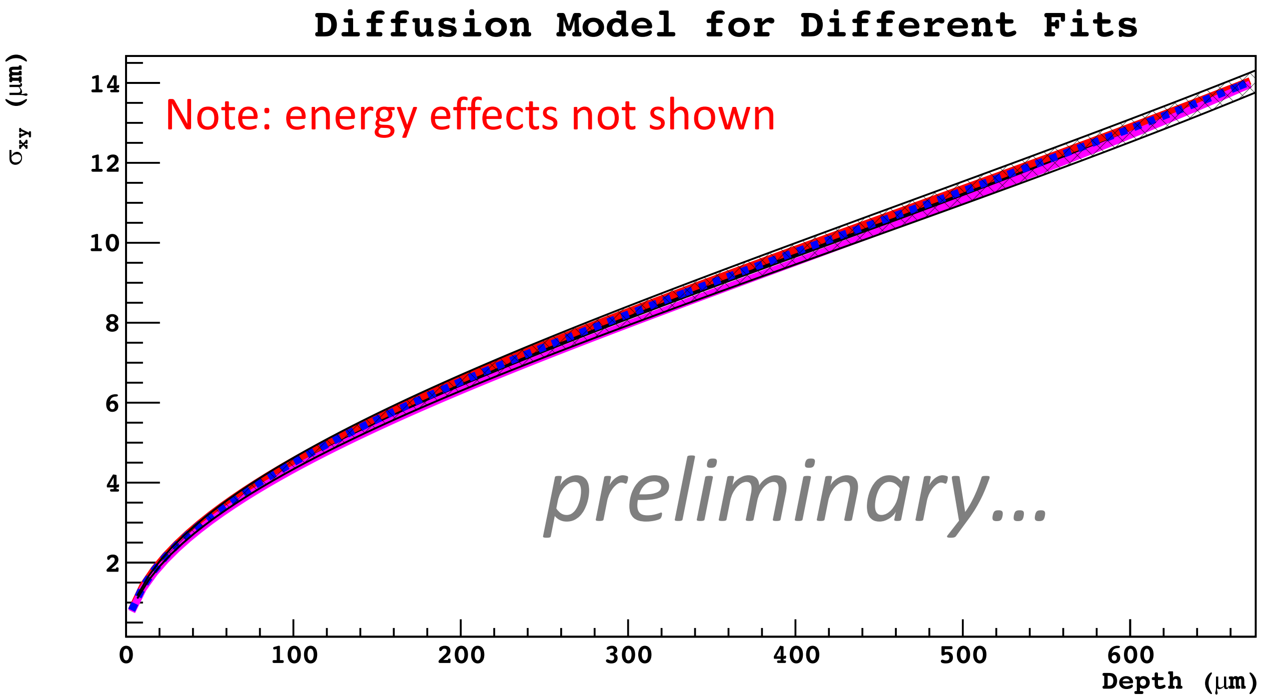
Detection Technique

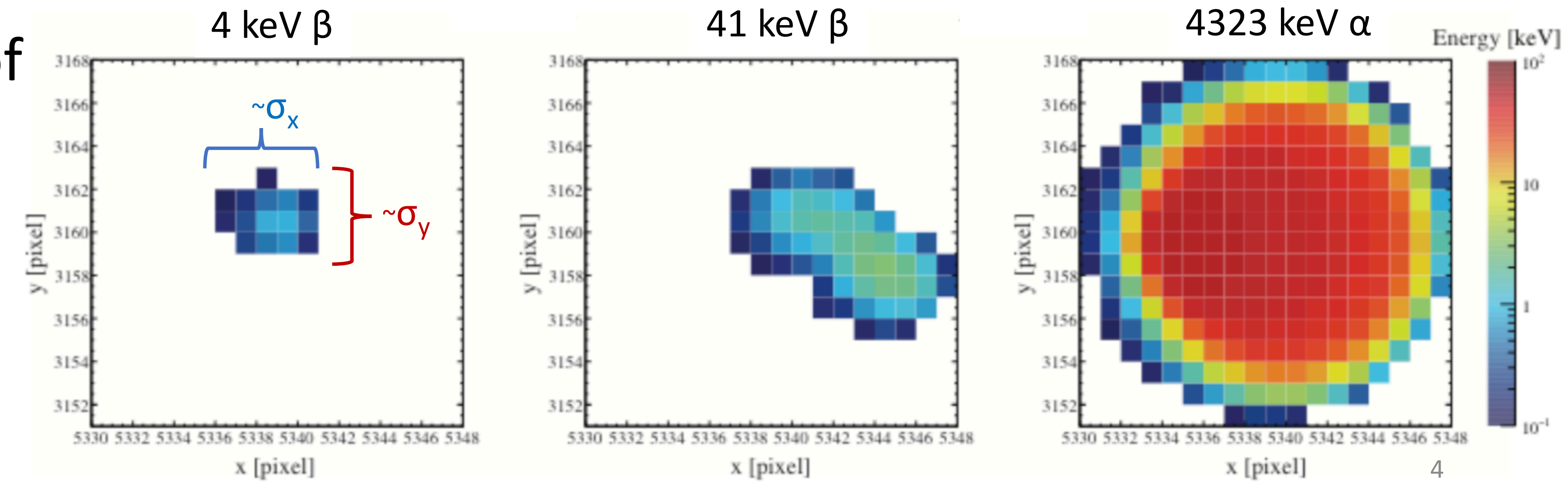
- **DAMIC at Modane (DAMIC-M)**
- DAMIC-M will be constructed from 50 low background Skipper CCDs (~1 kg)
- Sub-electron resolution allows for a 2-3e$^-$ threshold (~3 eV)
- Continuous readout minimizes leakage current and deadtime
- Target background rate of <0.1 dru



Event Reconstruction

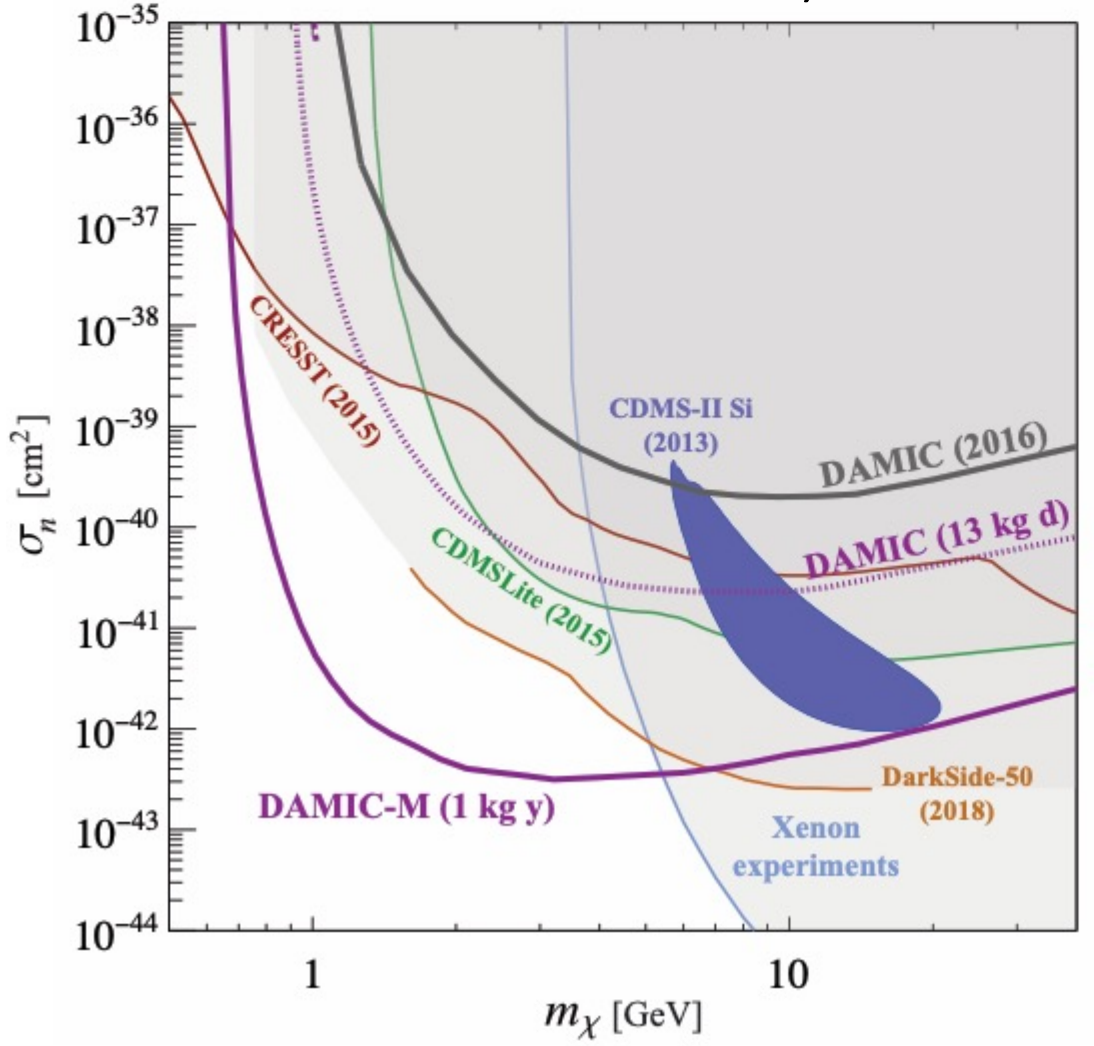
- As charges diffuse across the CCD, they drift apart
- The dispersion of collected charges (σ) carries information about the depth of an event
- The distribution of energy over the pixel array tells the event type



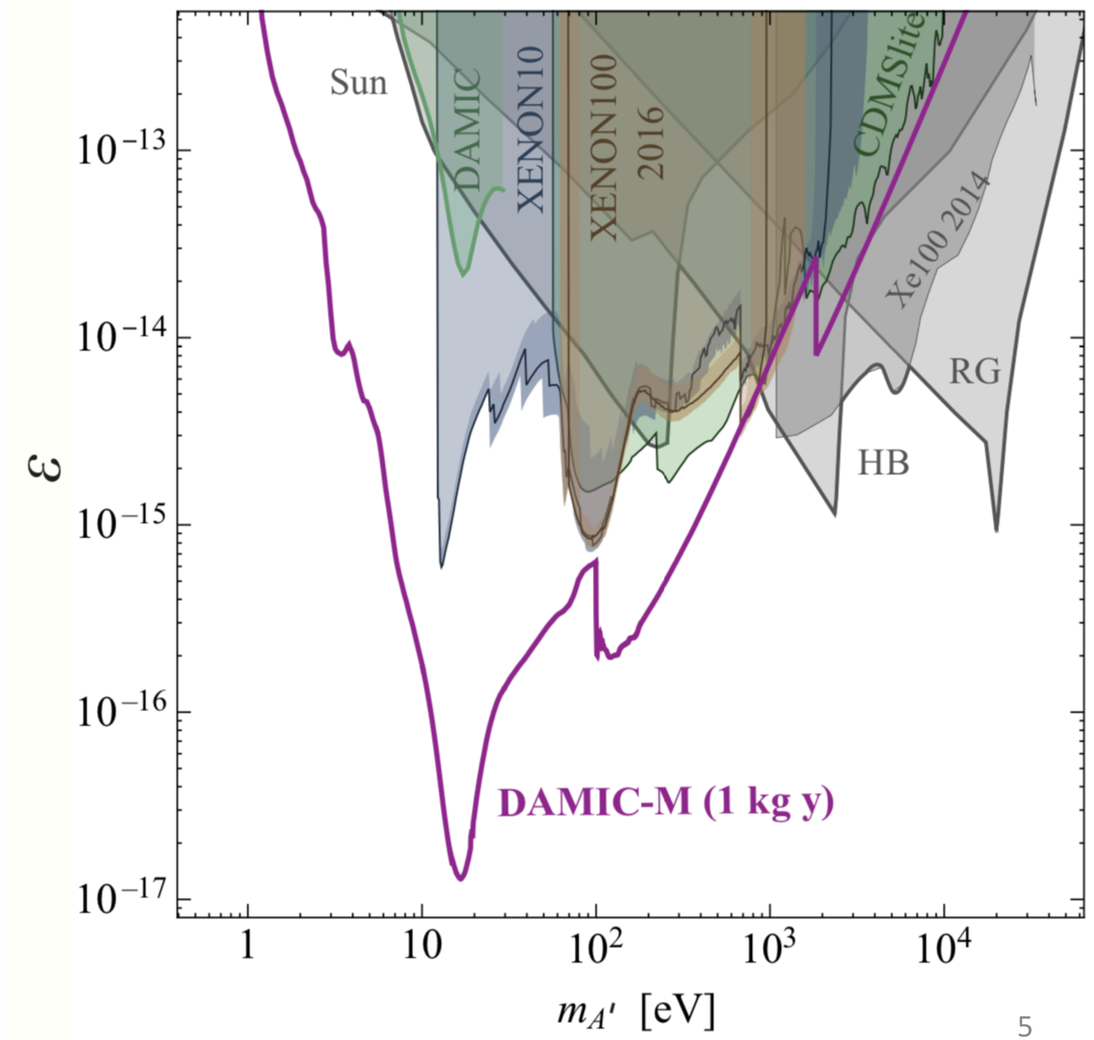


DAMIC-M Sensitivity

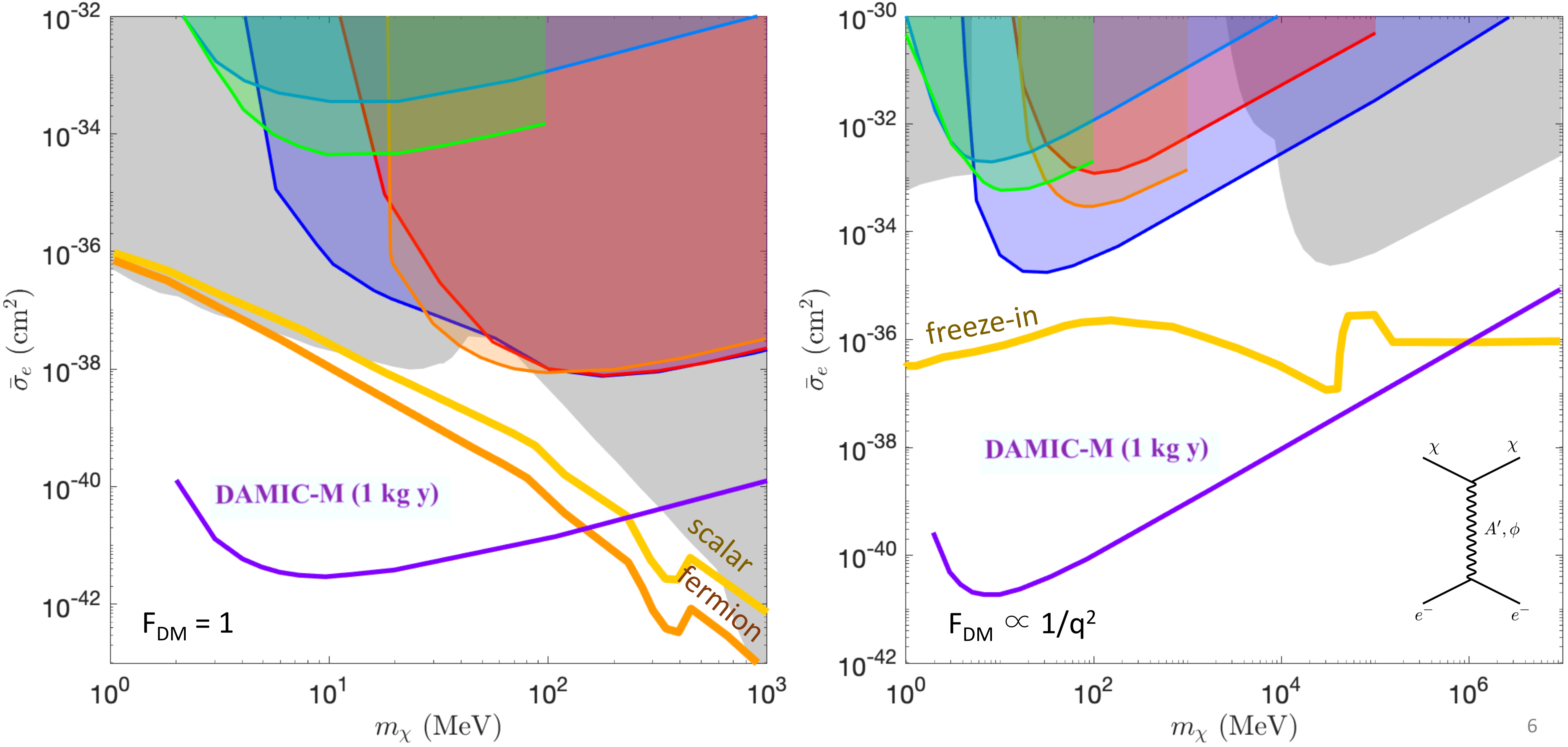
Nuclear Recoil Sensitivity



Hidden Photon Sensitivity

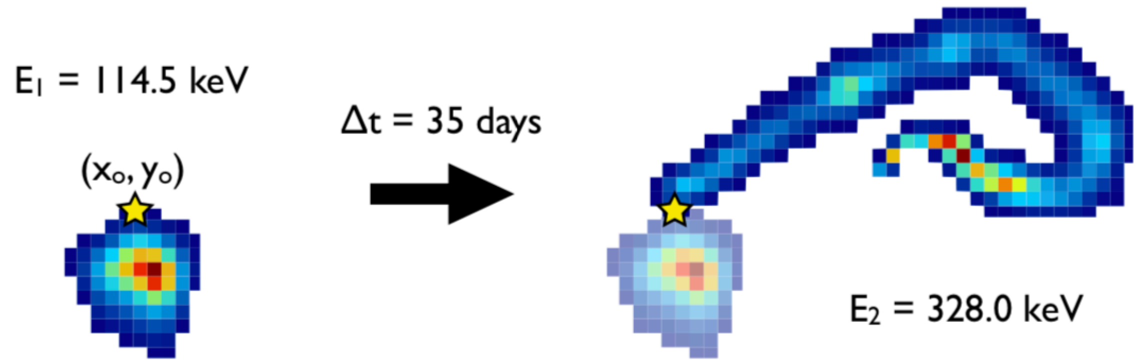


DAMIC-M Sensitivity (DM-electron scattering)



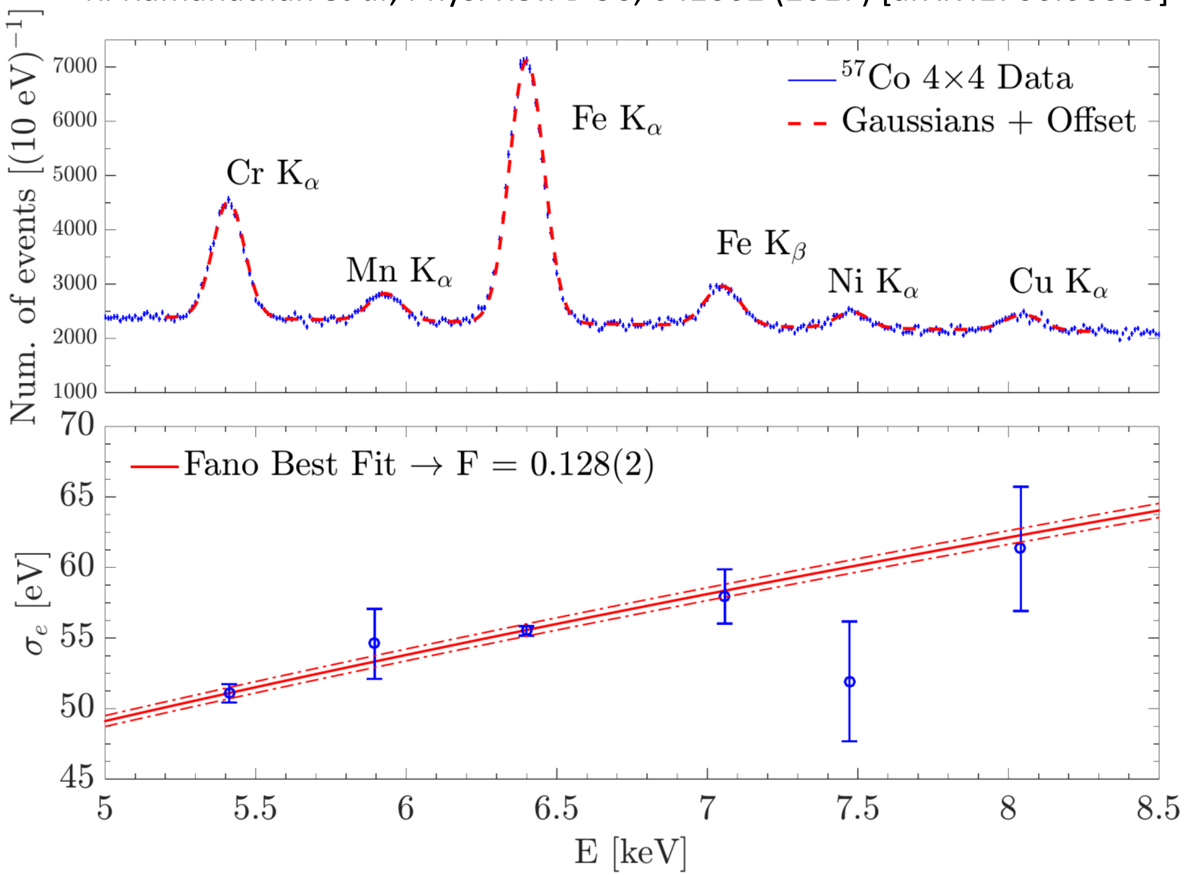
Advantages

- **Dark current**: demonstrated in DAMIC@SNOLAB
  - $< 10^{-3}$ $e^{-}pix^{-1}day^{-1}$ at operating temperature of ~140K
- **Background Rejection**: isolation of certain radioisotopes by observation of multiple decay chain processes
  - Example of a likely ^{32}Si-^{32}P coincidence with half life of 14.3 days (below)



A. Aguilar-Arevalo *et al*, JINST 10 (2015) P08014 [arXiv:1506.02562]

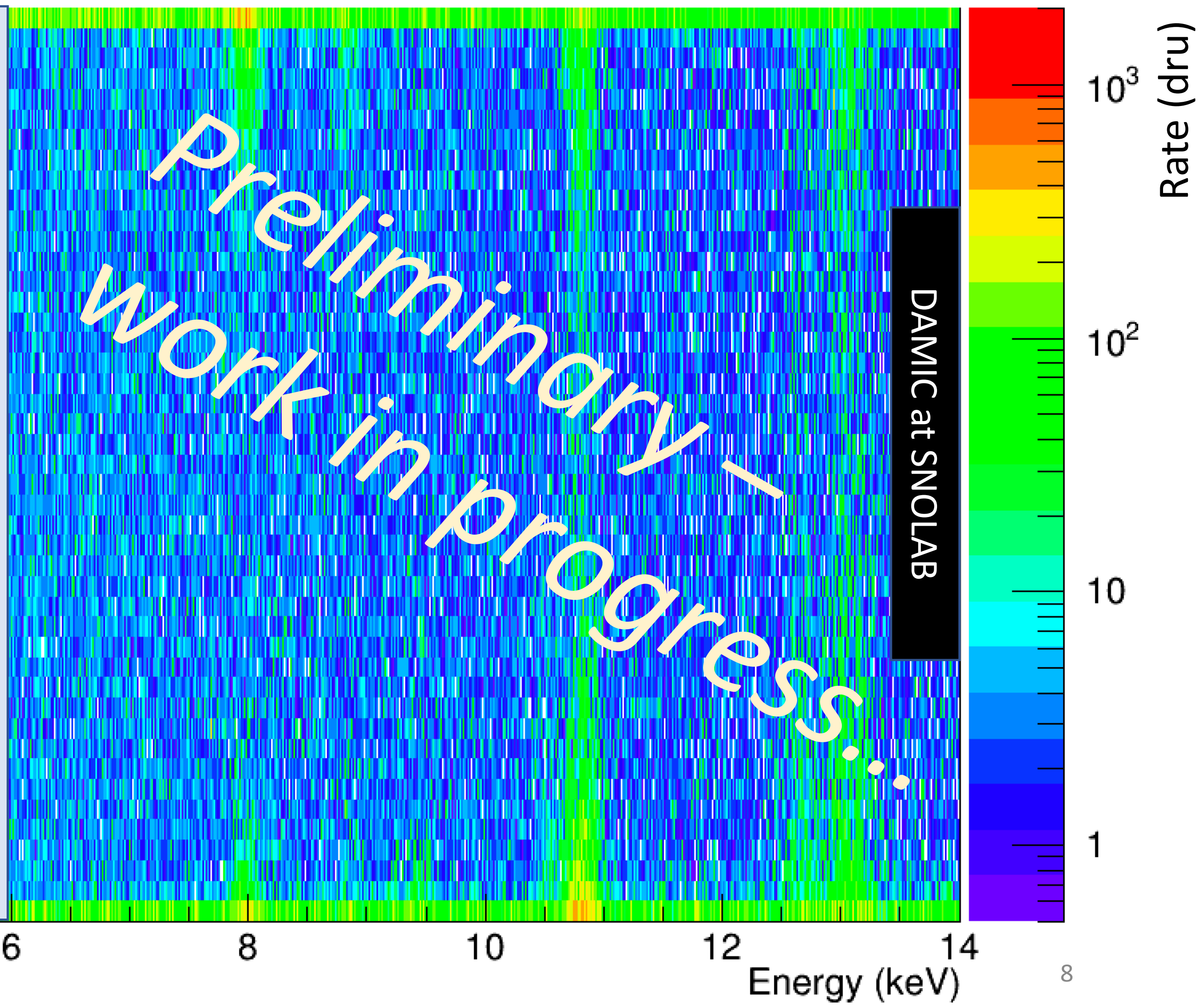
K. Ramanathan *et al*, Phys. Rev. D 96, 042002 (2017) [arXiv:1706.06053]



- **Energy Response:** linear down to very low energies (above)
  - Linear within 5% down to 40 eV, or 10 electrons

Challenges - Background Modeling

- DAMIC@SNOLAB acts as an exceptional test-bed for understanding and mitigating background sources
- We are well underway in producing a complete background model for DAMIC@SNOLAB (*stay tuned…*)
- Dominant backgrounds for DAMIC-M expected to come from
  - ^{32}Si (can be rejected through coincidence with ^{32}P)
  - Tritium from silicon activation (can be mitigated through shielding during transport/storage)



Future Prospects

- Design and CCD Manufacturing underway
- Background controls and modeling progressing
- Construction at Modane begins 2020
- **Physics data in 2023**
  - Goal: 1 kg-year at 0.1 dru background
- **<u>Funded</u>** by ERC and NSF (2018 – 2023)

European Research Council
Established by the European Commission

1. Switching to electroformed copper

→eliminate ^{238}U, ^{232}Th, ^{210}Pb contributions

2. Careful handling procedures

→ reduced ^{210}Pb surface contributions

3. Clean cabling

→ reduced ^{238}U, ^{232}Th, and ^{40}K contributions

4. Shielding during transport/manufacturing

→ Reduced ^{3}H, ^{22}Na, and Copper activation products

… and more to achieve 0.1 dru

http://damic.uchicago.edu/