



CYGNUS: Status and future plans

Lachlan McKie

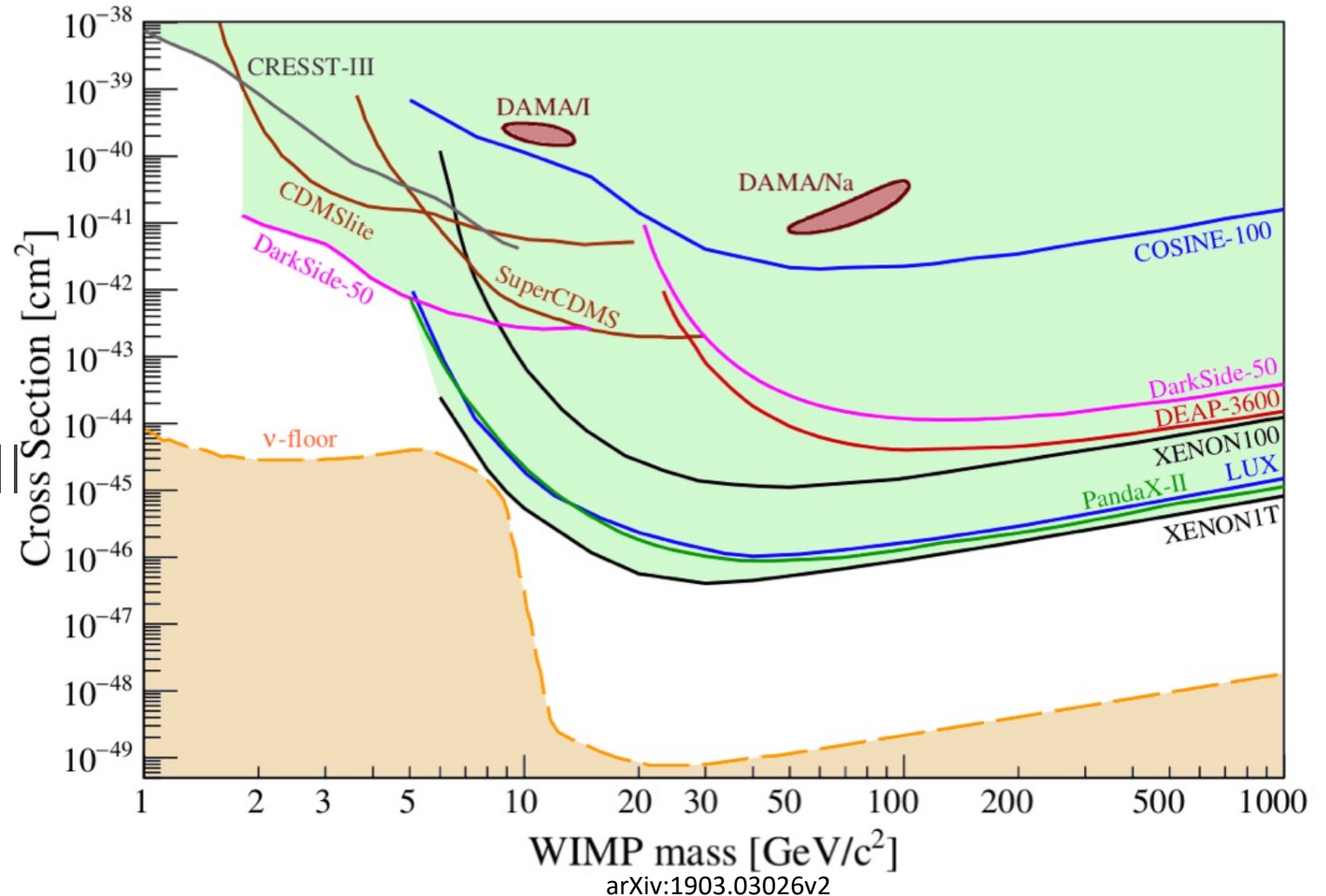
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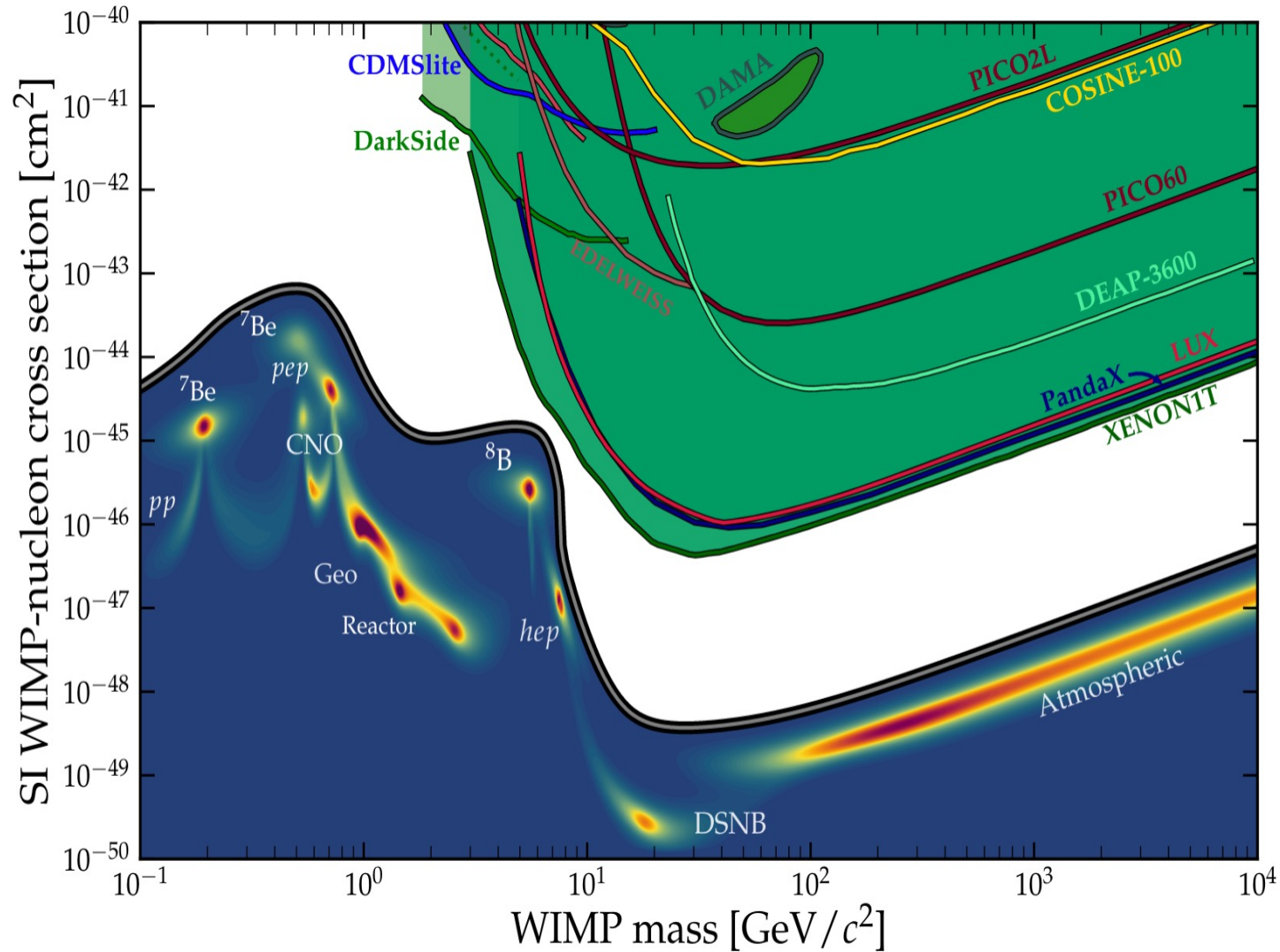
The future of WIMP direct detection

- Direct detection experiments are approaching the neutrino floor
- Background neutrino events will impede dark matter searches.



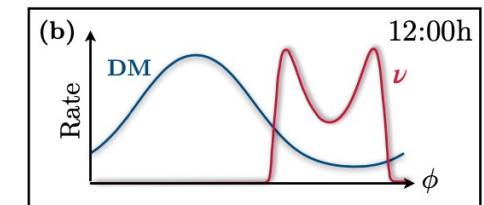
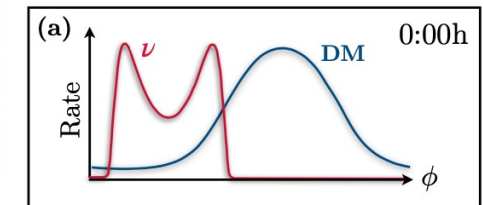
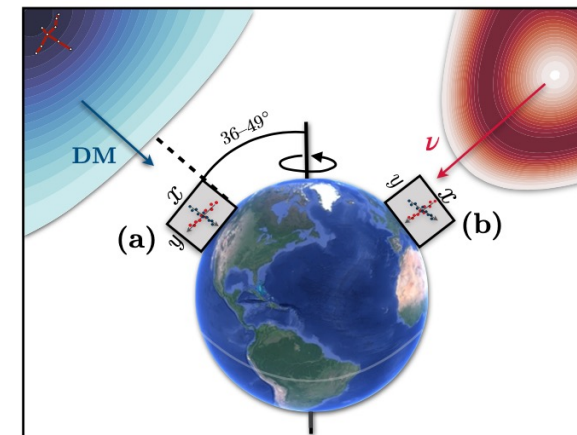
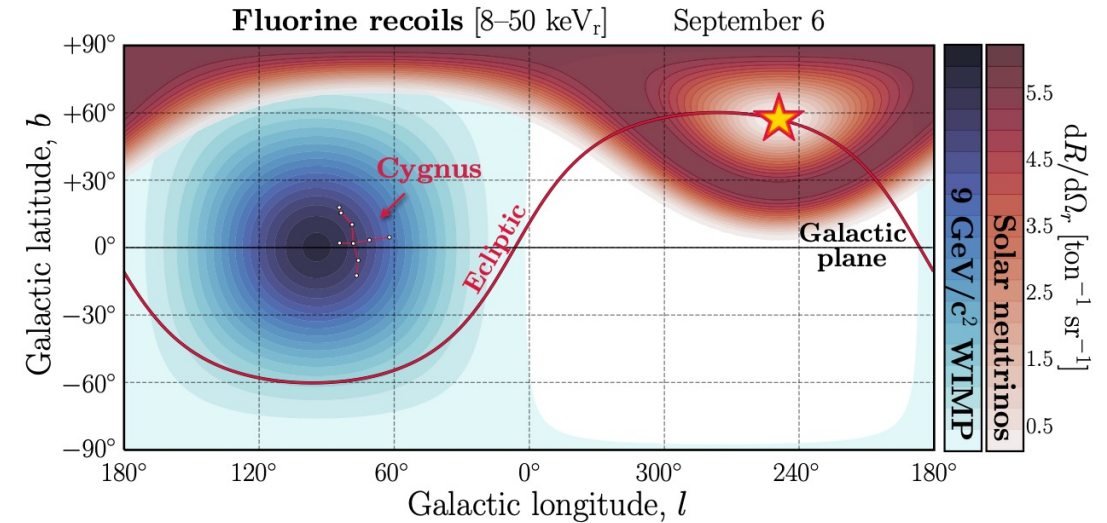
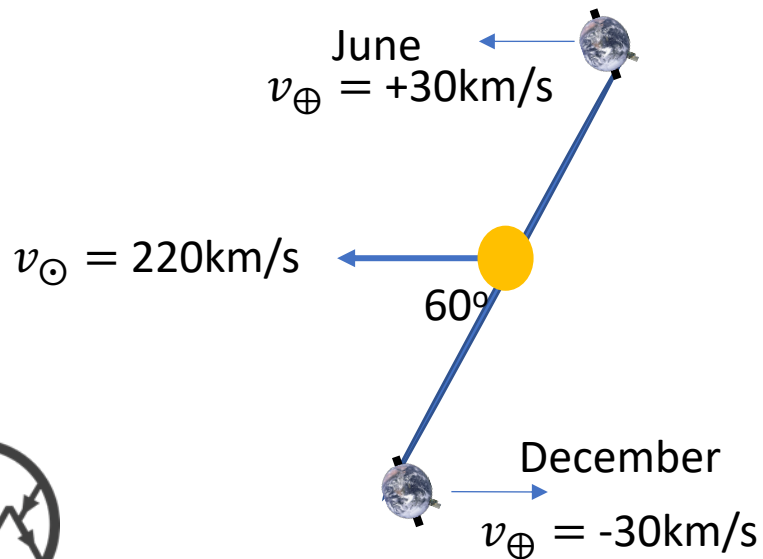
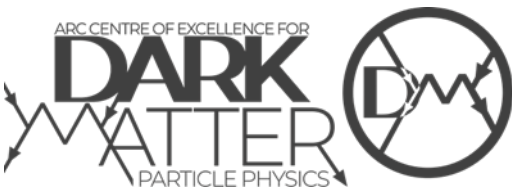
The Neutrino floor

- Comprised of multiple neutrino sources.
- High energy neutrinos can transfer enough momentum to mimic low mass WIMPs



The Neutrino Floor Fog

- Neutrino background distinguishable with significantly high statistics
- In directional detection low statistics can distinguish between a DM event and a solar neutrino

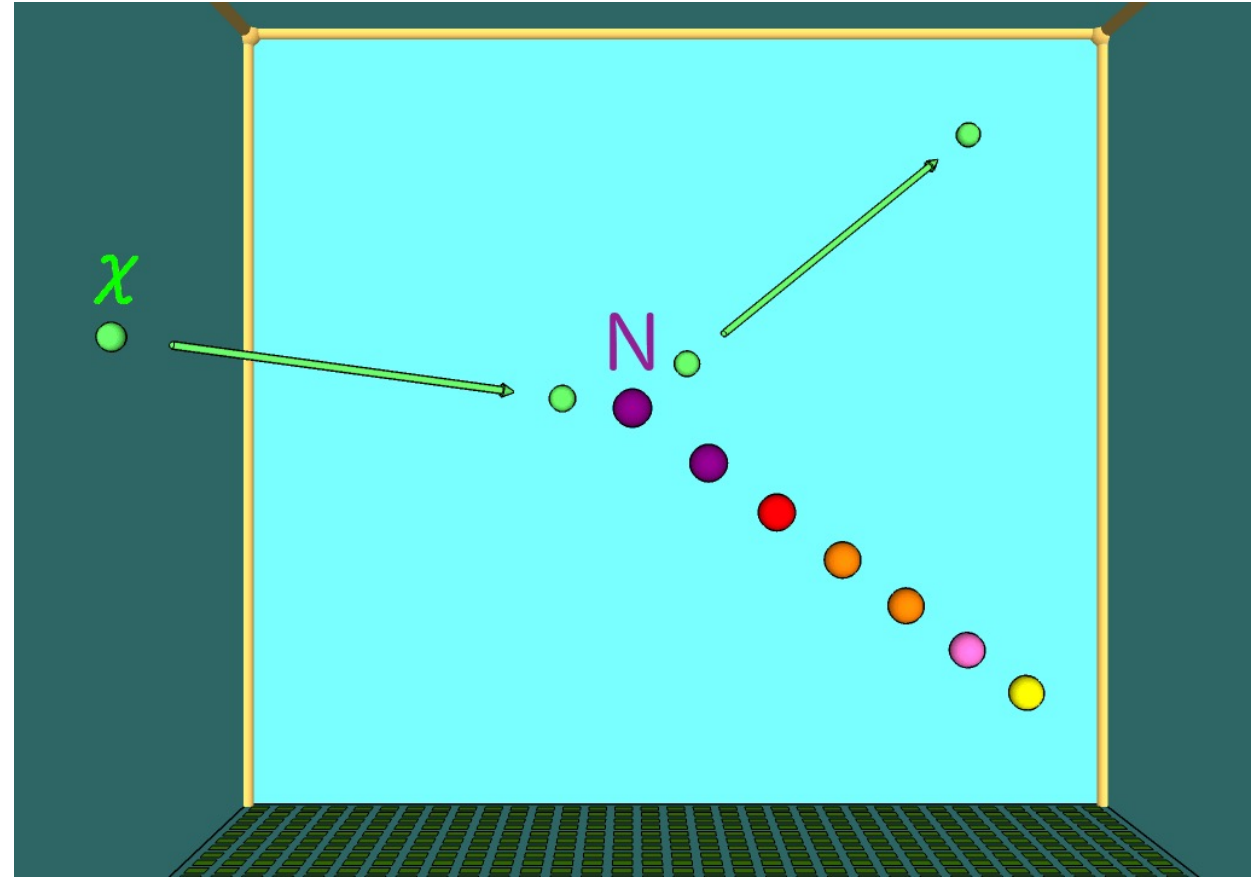


Time projection chambers

- Event by event
3-dimensional recoil
tracks
- Gas volume with an
applied electric field
- Need to increase in
volume for competitive
search

Time projection chambers

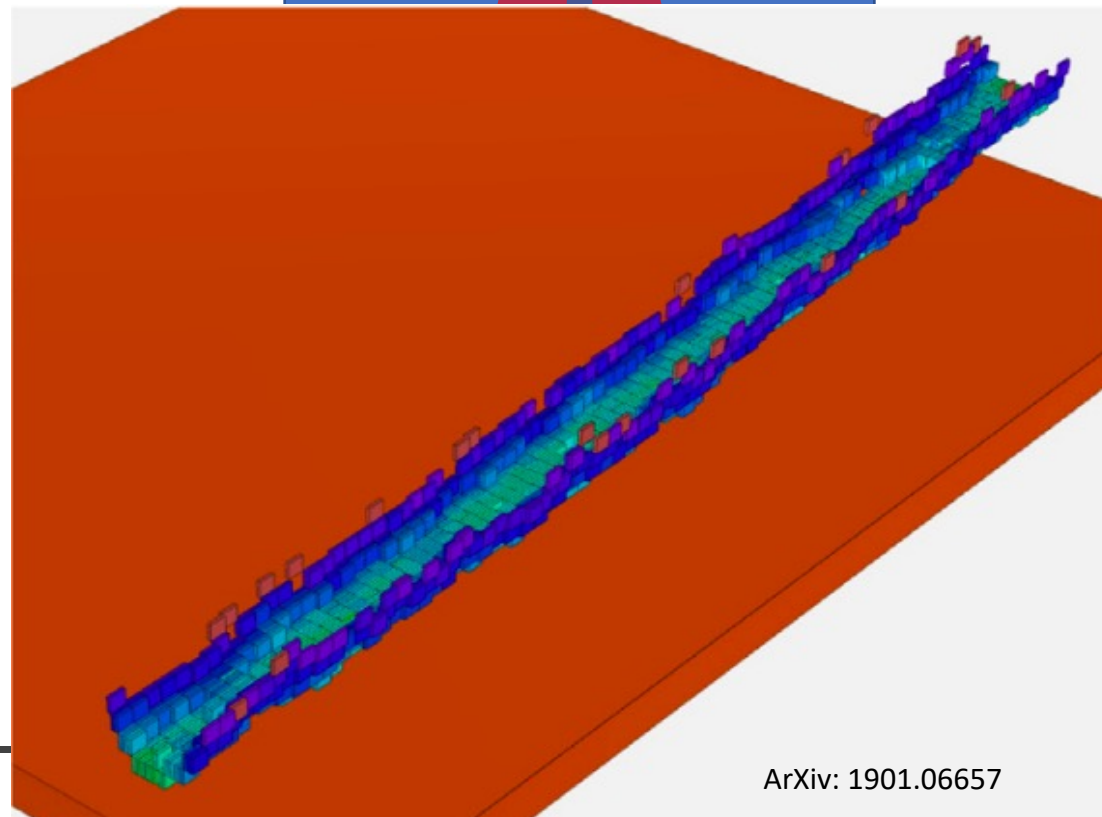
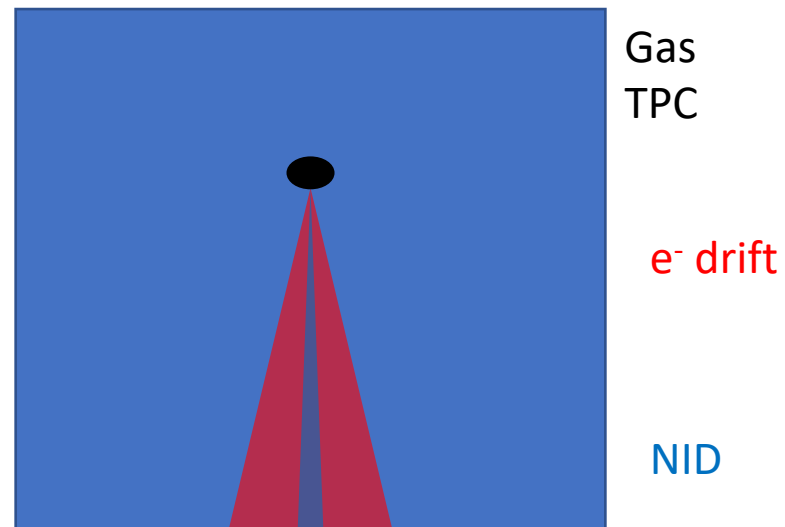
- Event by event 3-dimensional recoil tracks
- Gas volume with an applied electric field
- Need to increase in volume for competitive search



Shan, 2020

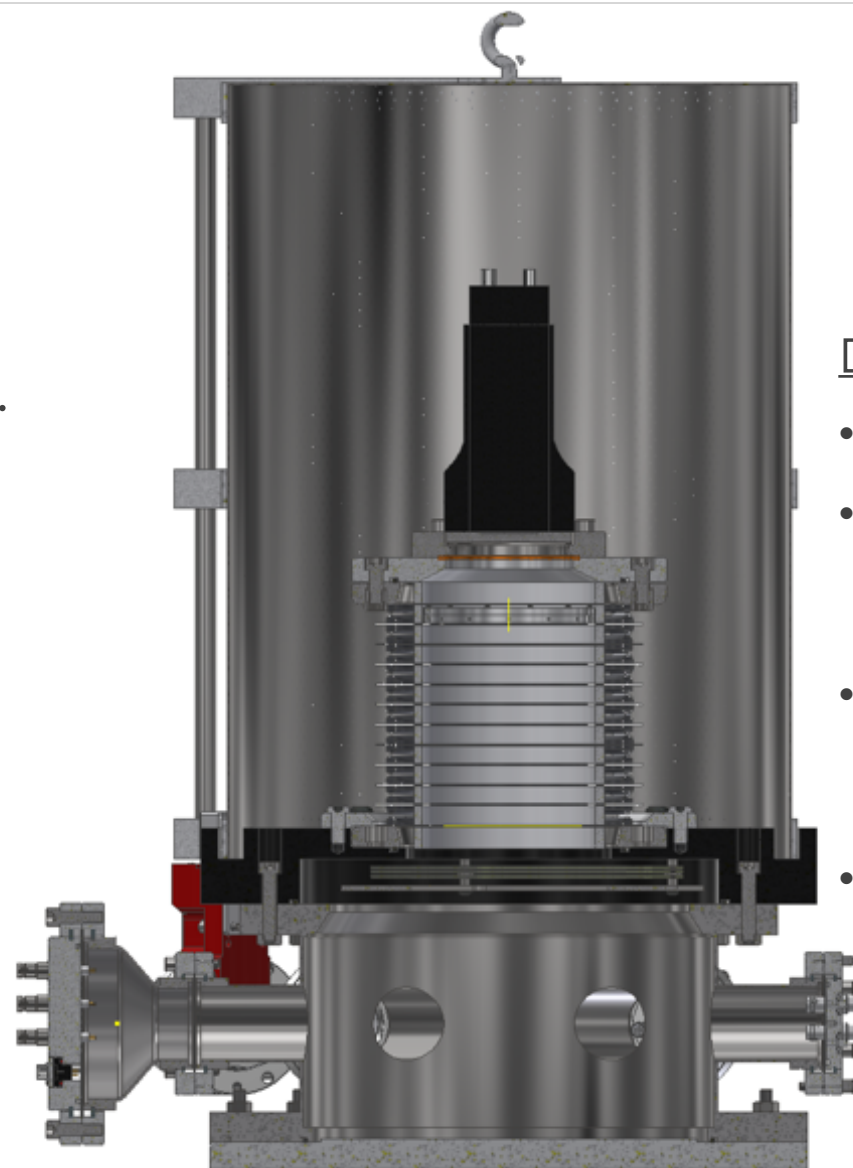
TPC open questions

- Need to increase in volume for competitive DM search
- Gas diffusion over large drift distances
 - Negative ion drift
- Economical High- resolution readout
 - Investigate possibility of combined charge/optical readout
 - How do we best use the available information



CYGNUS-1

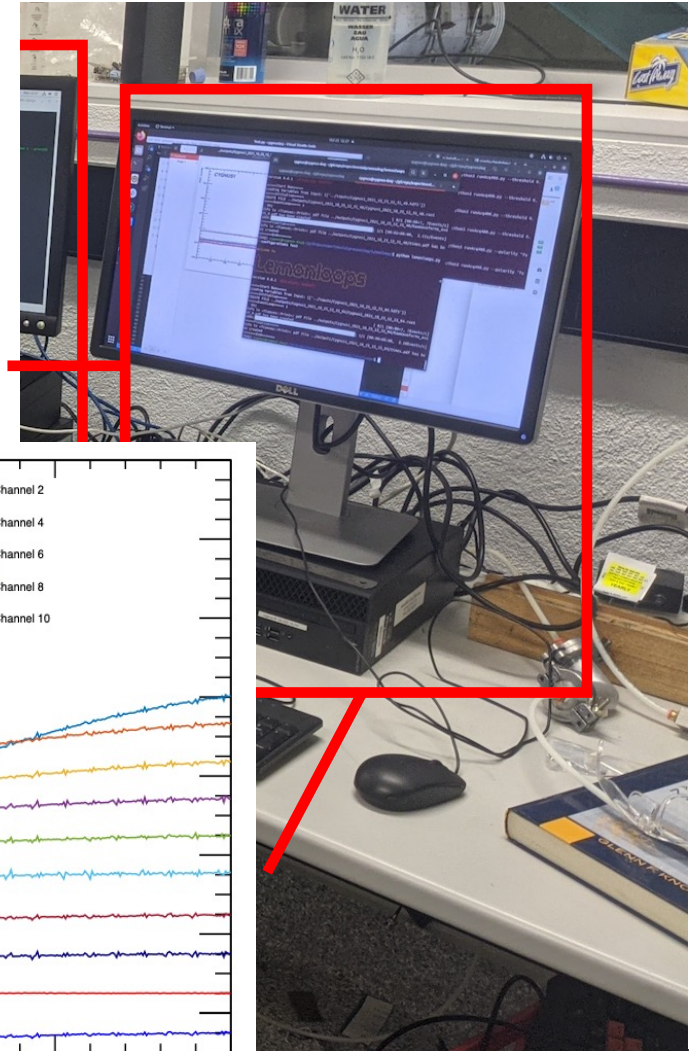
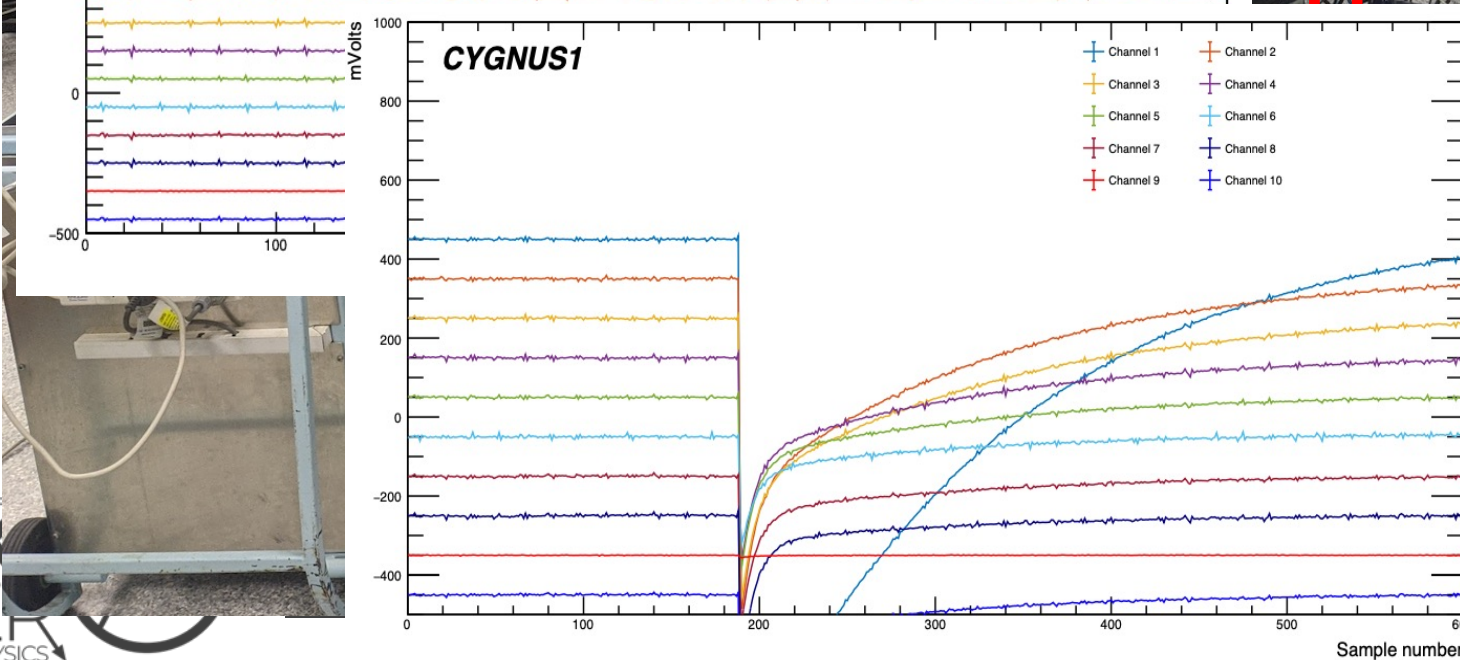
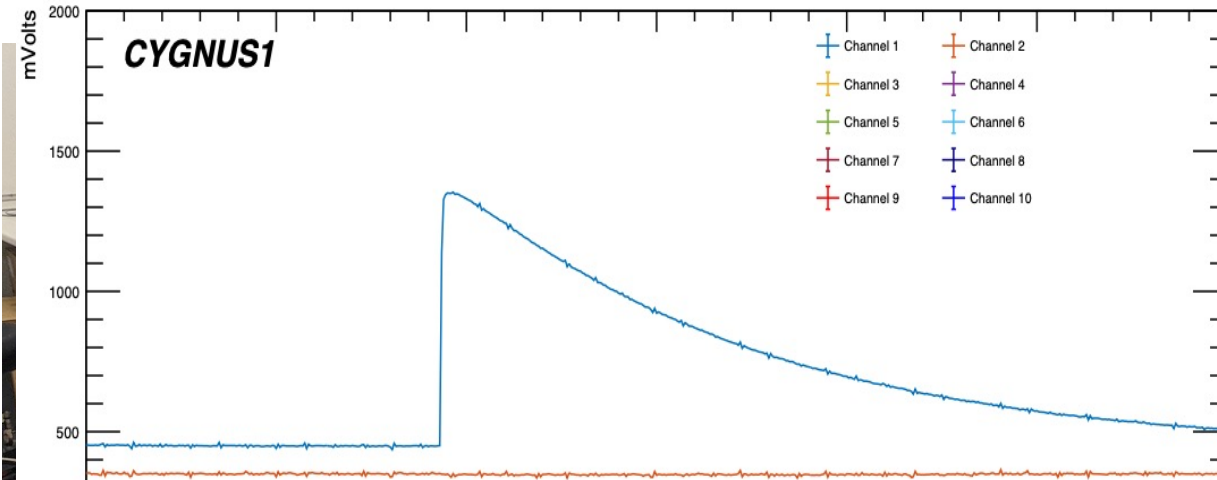
- Prototype TPC for initial dark matter investigations.
- Successor to CYGNUS-lite
- 2 gas mixtures
- 10 Torr to 1 Atm operating pressure
- Combined charge and light measurements



Detector Specs

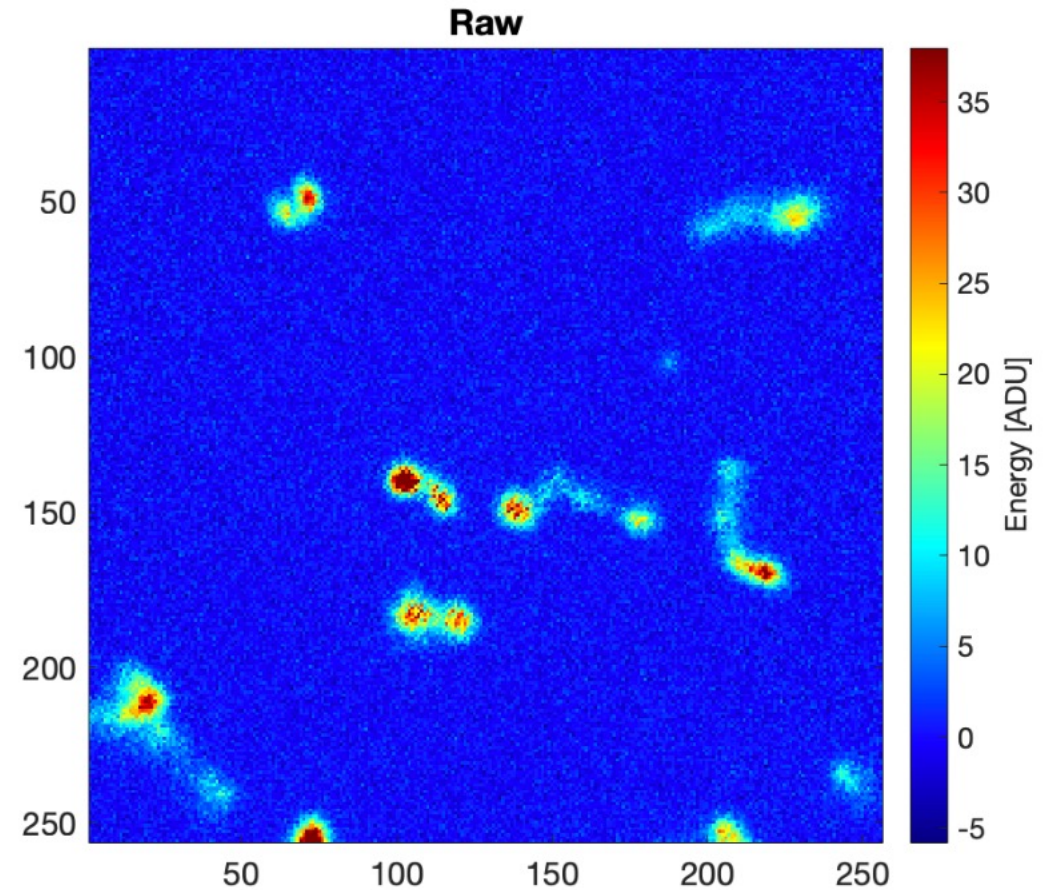
- 18 cm drift field
- Triple stacked thin GEMs for $\sim 10^4$ gain
- 10 wire MWPC with 10 mm spacing
- PMT

CYGNUS-1 experimental update



CYGNUS-1 Experimental plans

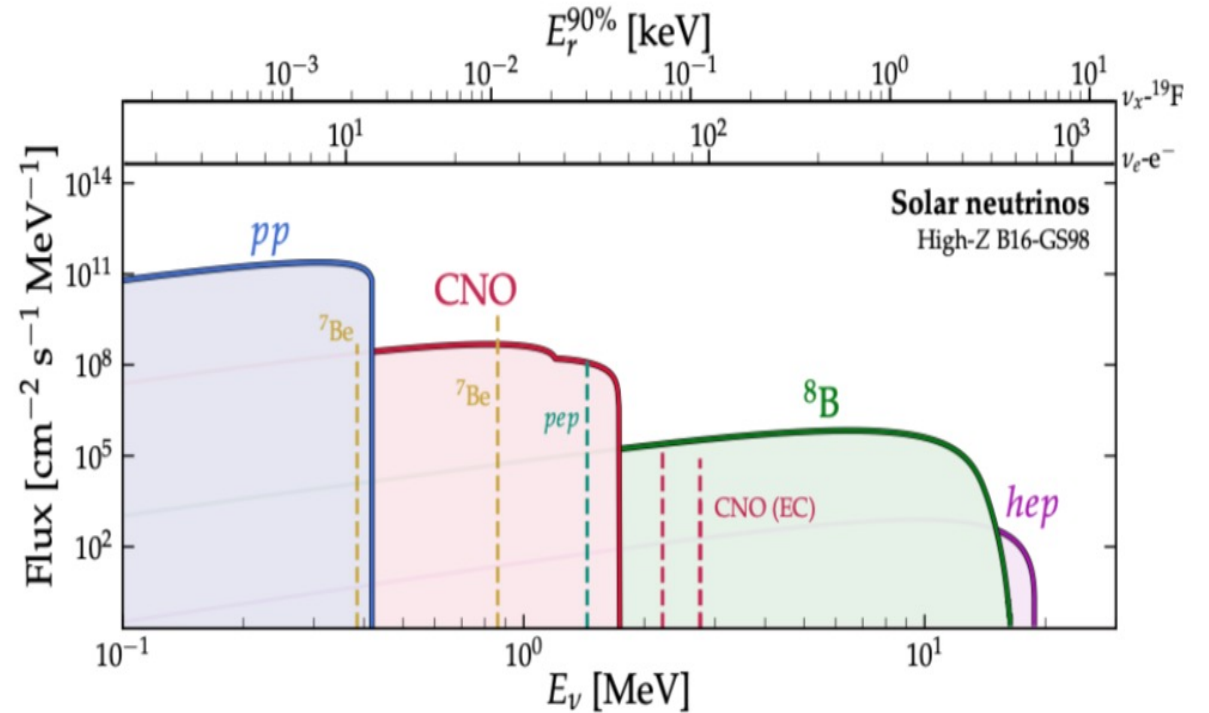
- Early 2022: Gas investigations
 - Gas management system
 - Conventional drift gases
 - Negative ion gases
 - Charge/Light NID gases
- Late 2022: Readout upgrades
 - Camera readout
 - High density charge readout



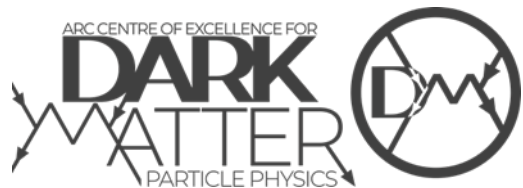
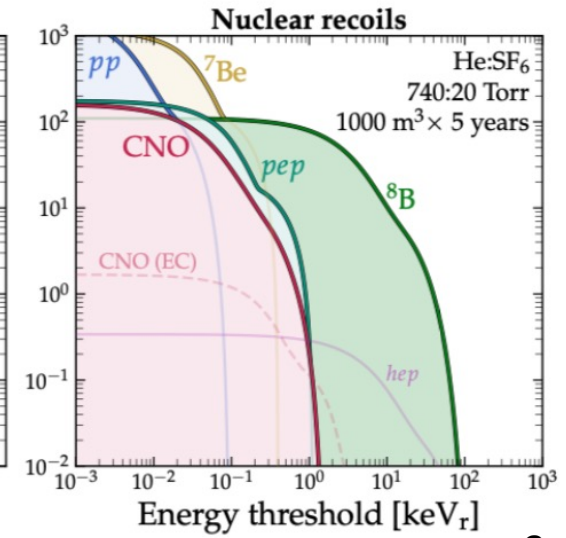
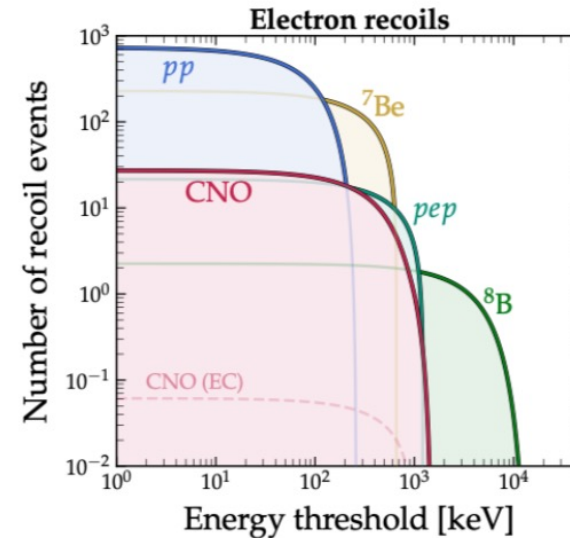
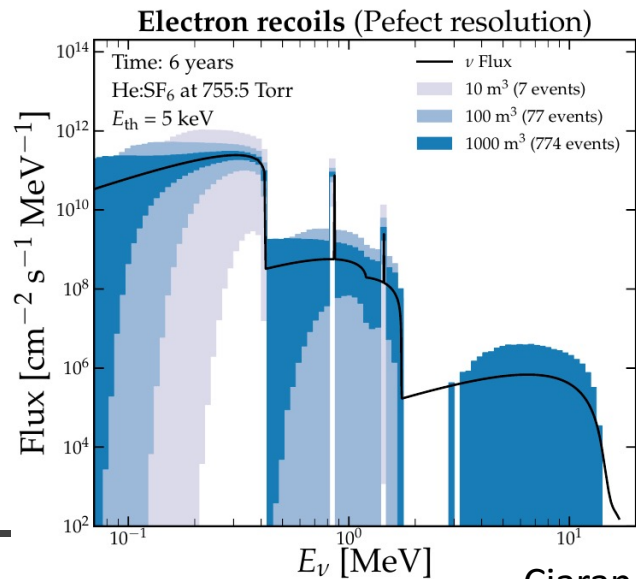
Alex Mills, MIGDAL collaboration
RD-51 MPGD presentation 2021

Solar Neutrinos

- Further understanding backgrounds
- Contribution to solar models
- CE ν NS observation
- Requires energy/angular resolution information

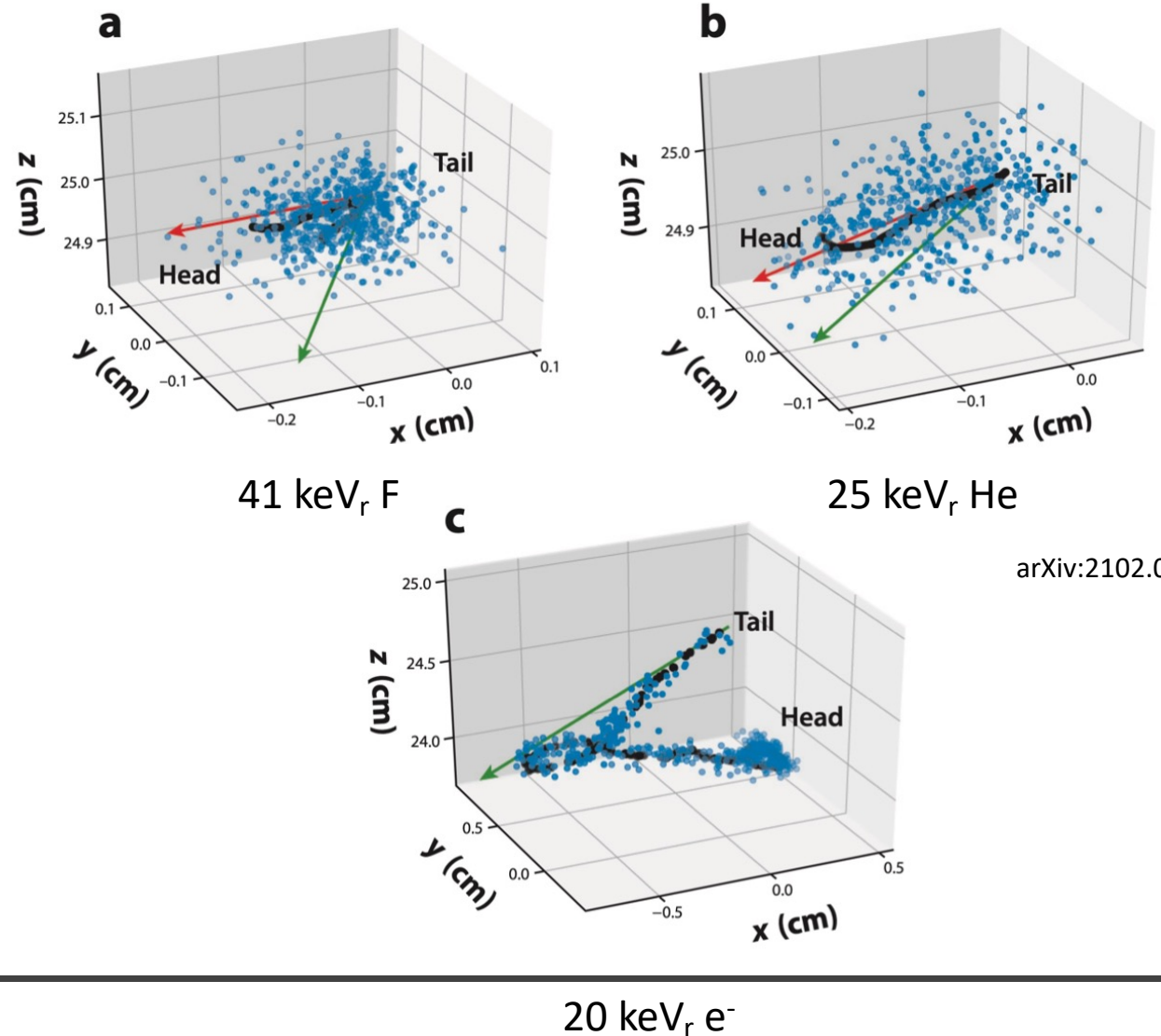


See Ciaran's paper on this topic coming this month!



Track identification

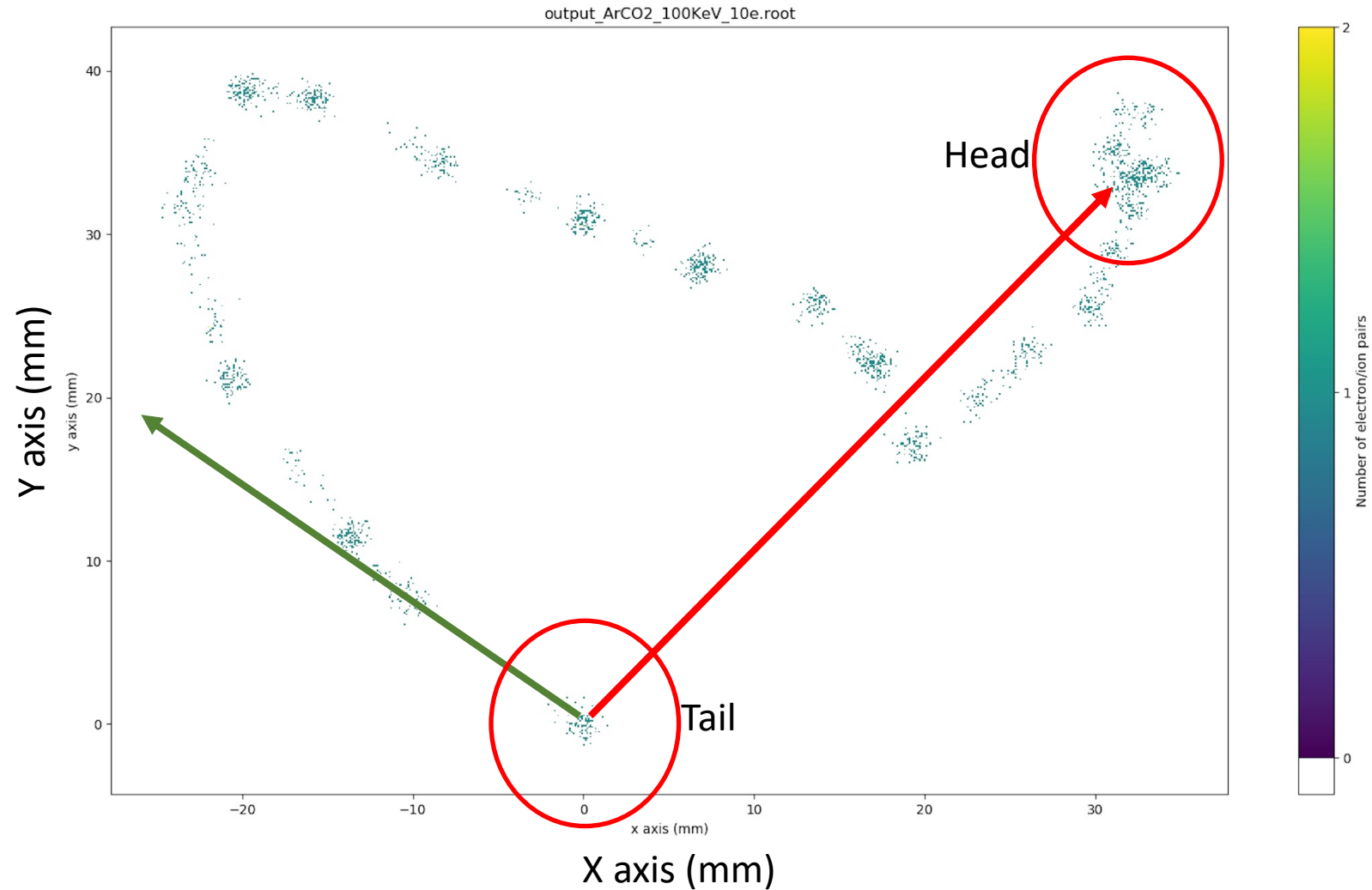
- Previous research focus on nuclear recoils
- Limited historic research on electron recoil tracks
- Combined recoil measurements possible?



arXiv:2102.04596v2

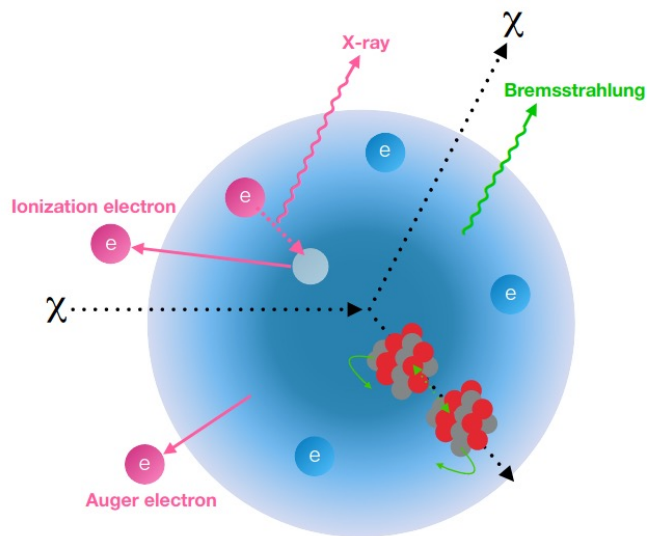
Electron recoil simulation

- Initial Track
 - GEANT4
- Electron/Ion pairs
- Drift/diffusion
 - Magboltz
- Gain
 - Garfield++

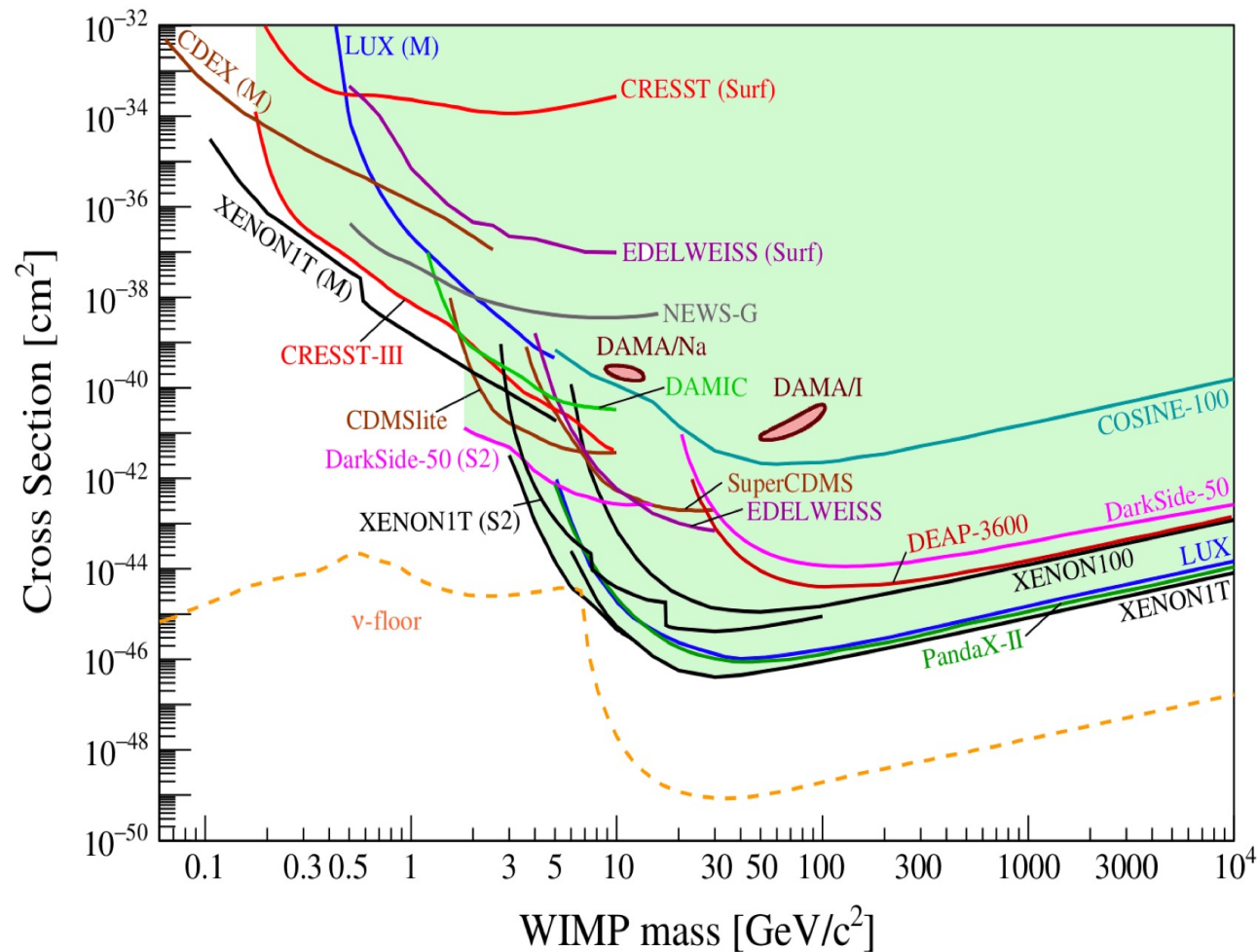


Migdal Effect

- Interaction releasing an electron when a nucleus recoils
- Currently unobserved experimentally



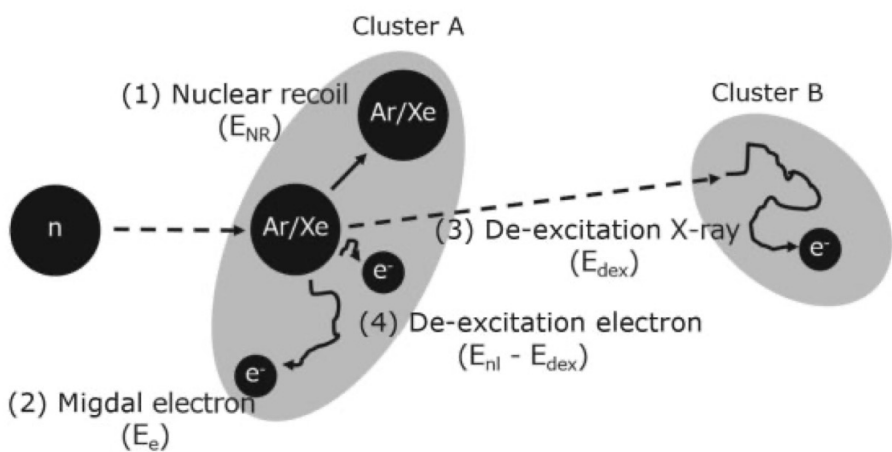
arXiv:1907.12771v4



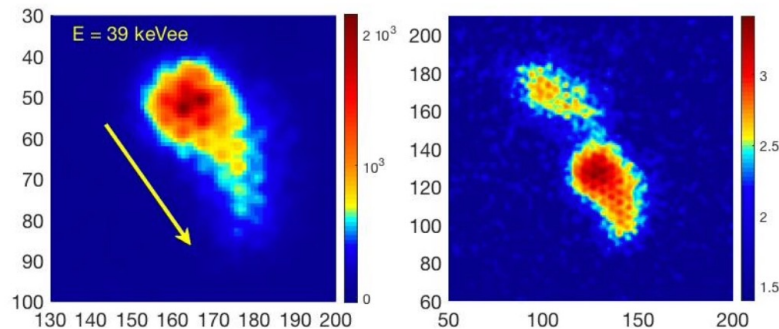
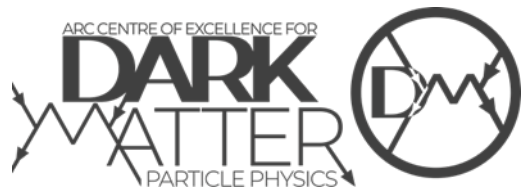
arXiv:2104.07634v1

Migdal Effect

- Gas TPC may be ideal detector to observe Migdal effect

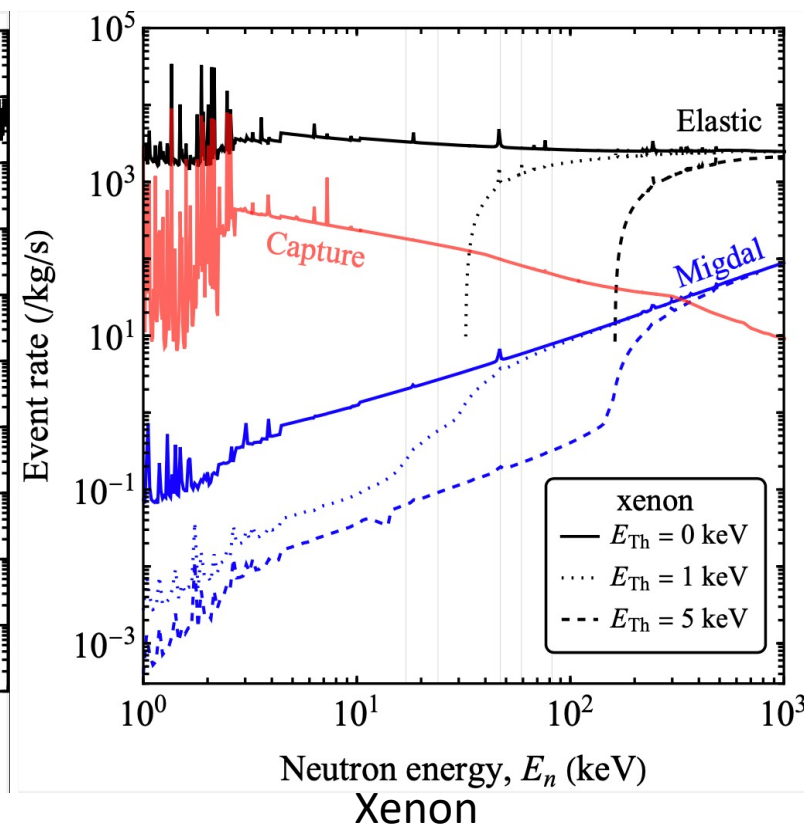
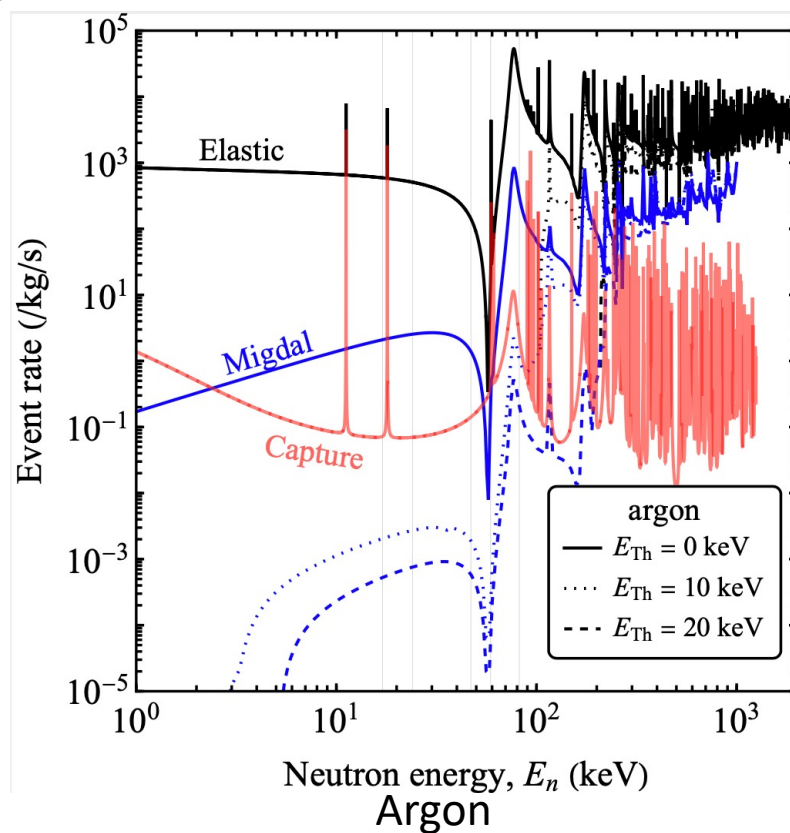


[arXiv:2009.05939](https://arxiv.org/abs/2009.05939)



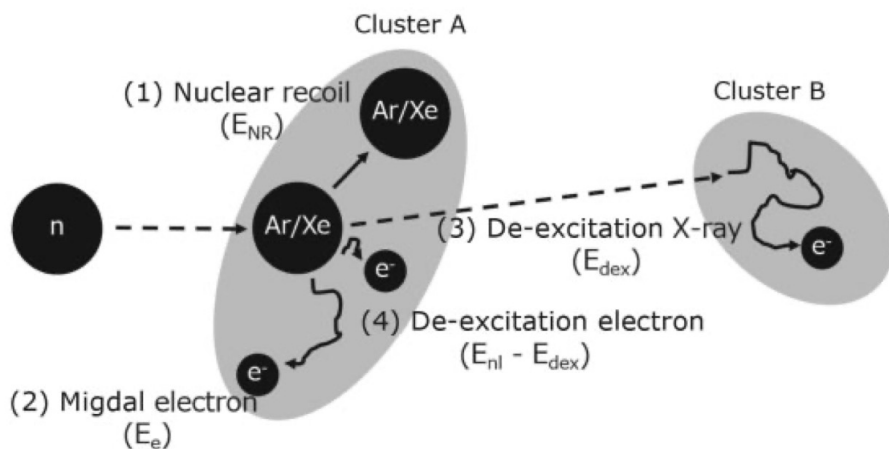
Composite image of Migdal event

Alex Mills, MIGDAL collaboration
RD-51 MGD presentation 2021

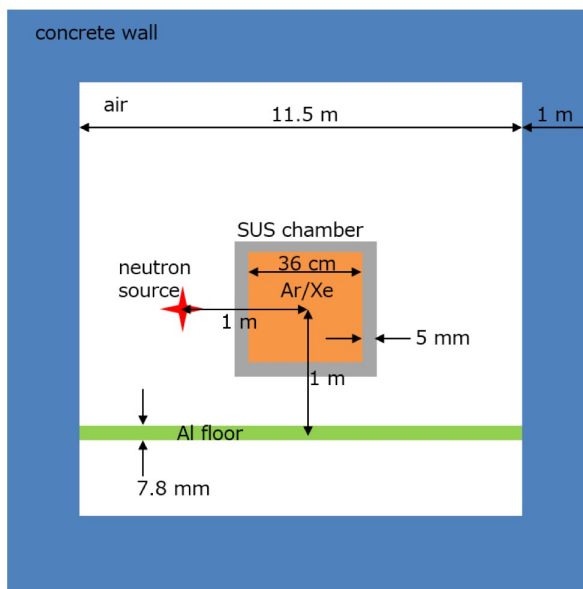


Migdal Effect

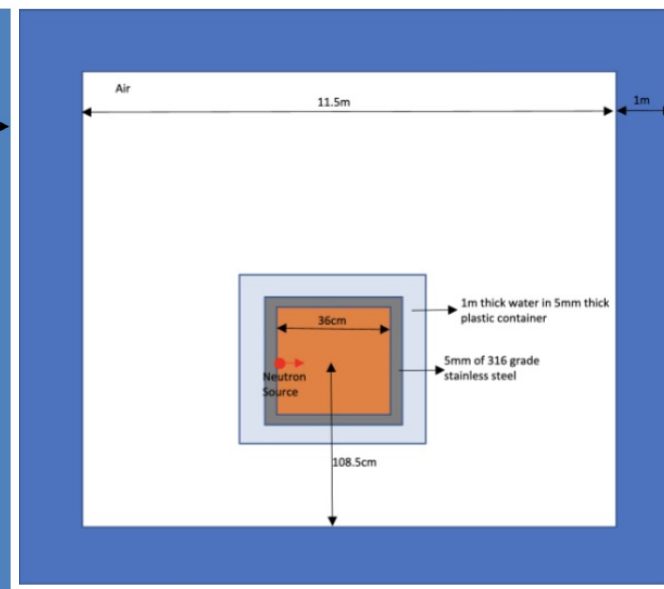
- GEANT4 simulation to observe feasibility of pulsed neutron beam at ANU
- Background induced gamma from (n, γ) in the lab



[arXiv:2009.05939](https://arxiv.org/abs/2009.05939)



[arXiv:2009.05939](https://arxiv.org/abs/2009.05939)



Victoria Bashu, ANU node

Add mass fraction of ${}^6\text{Li}$ will reduce room backgrounds by a factor of 10

CYGNUS Australia - News

- Ciaran O'Hare convening a whitepaper for Snowmass 2021 Instrumentation Frontier 5 (IF5) on MPGD for recoil imaging of DM and neutrinos
- International CYGNUS workshop in Australia ~Sep 2022
- Fortnightly Meetings
 - Thursday 1330 (AEDT) via zoom
 - <https://anu.zoom.us/j/9144339051?pwd=WnIDeFNkaGgySl!ONG9-Xbzc5RnIxUT09>
 - ALL WELCOME!



NATIONAL PARTNER ORGANISATIONS:



INTERNATIONAL PARTNER ORGANISATIONS:



Gas electron multiplier (GEM)

- Amplifies signal at lower operating voltages
- Maintains spatial resolution

