The νBDX-DRIFT Detector for CEvNS Physics at Fermilab

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The νBDX-DRIFT Collaboration

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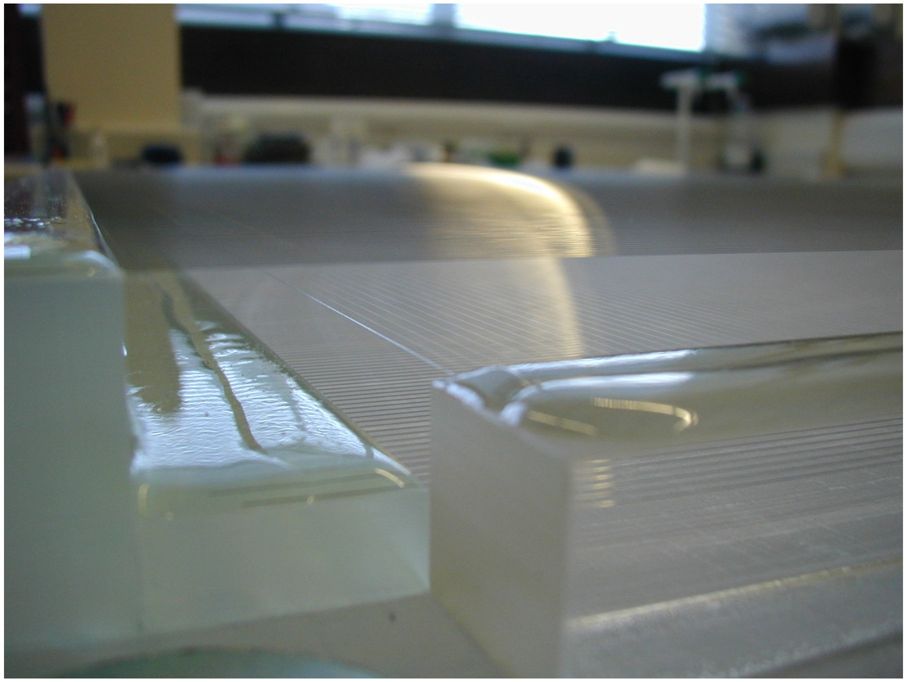
DRIFT: Lightning Summary

Started = 1998, US/UK

Directional, halo WIMP dark matter detector

40 Torr, 1 m^3 gaseous detector



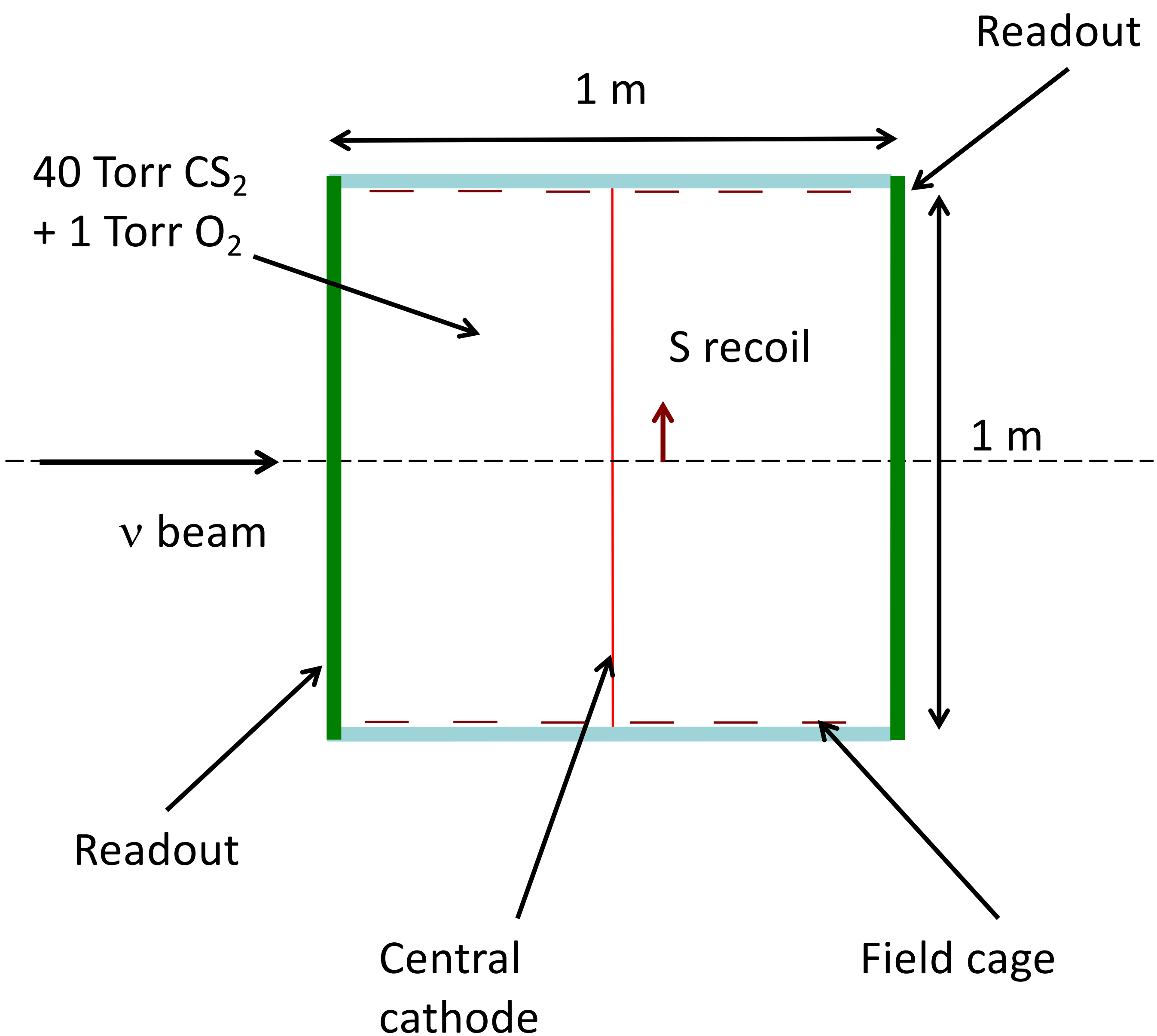
Unique and robust technology

Low energy (35 keV) threshold for nuclear recoils

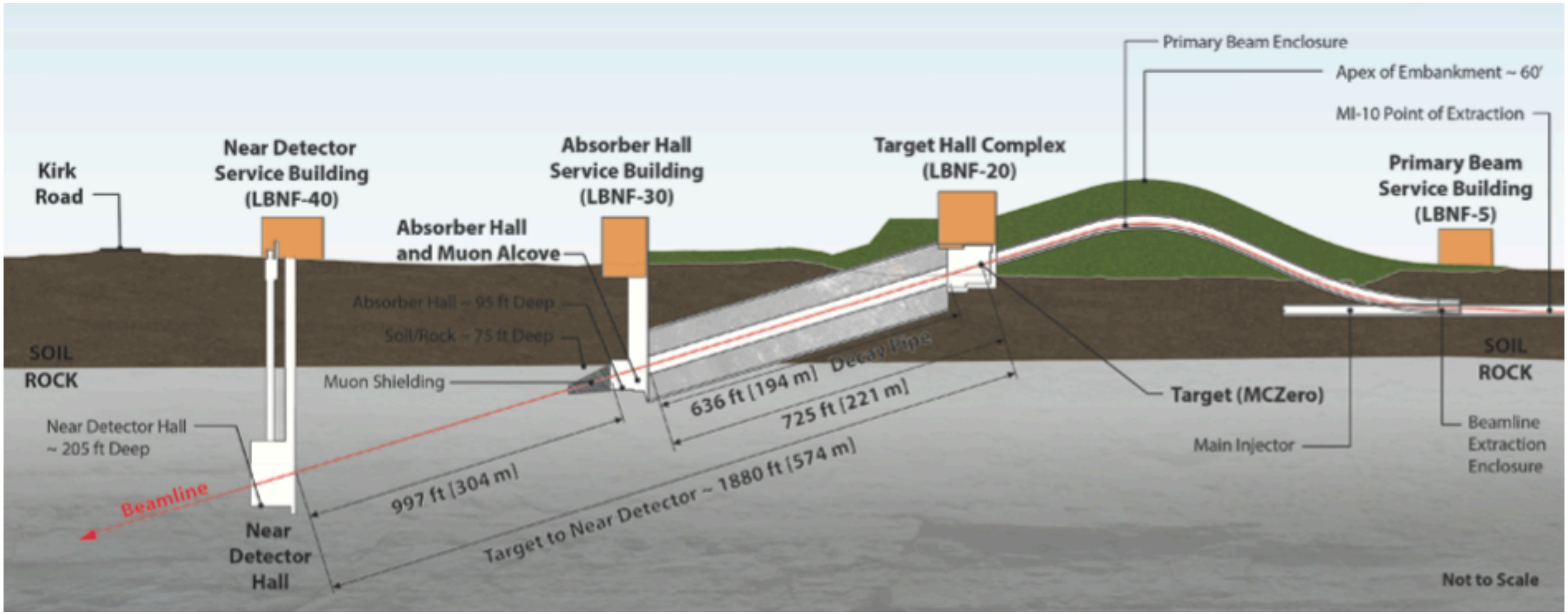
Low background

AstroPle, 91, 2017

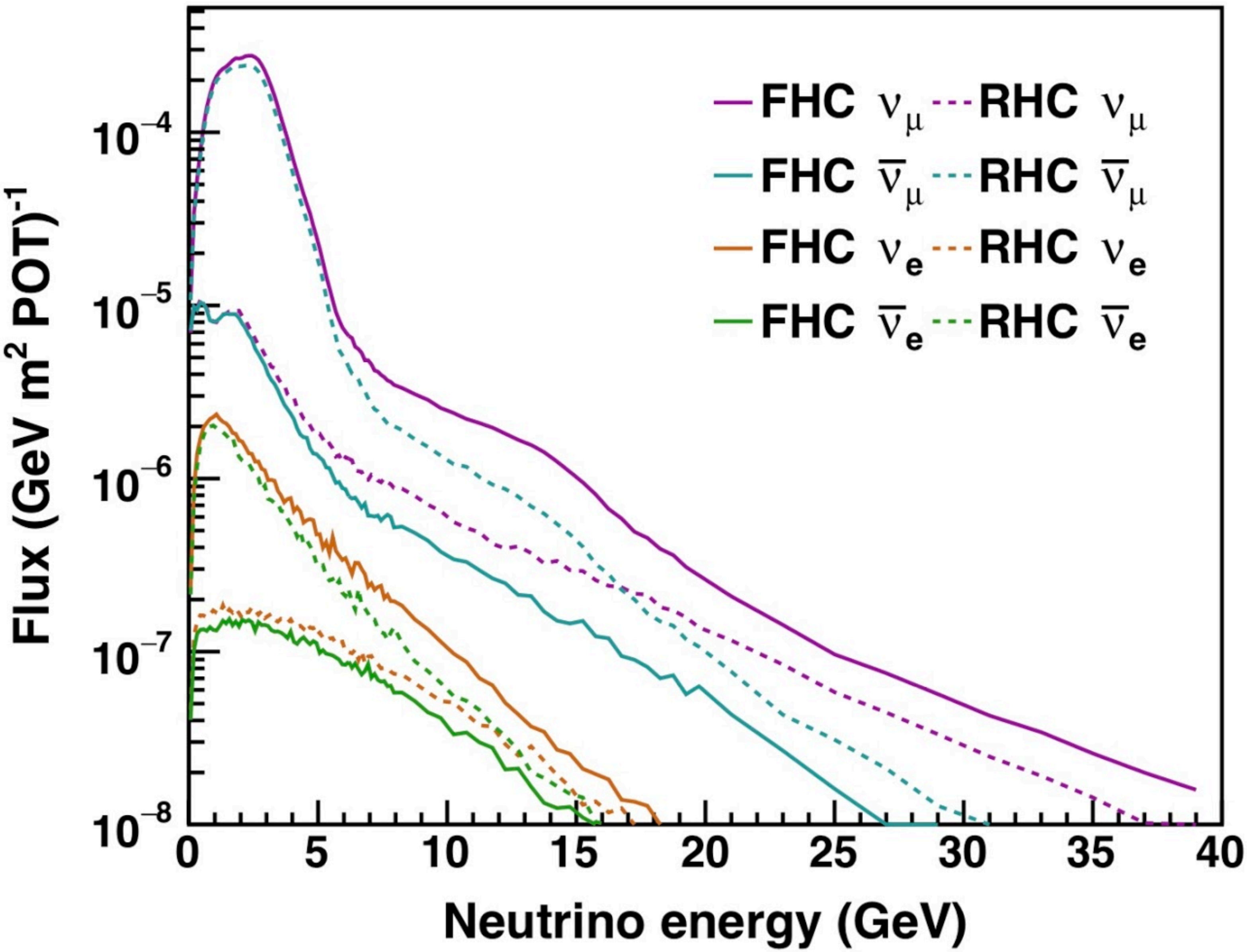
BDX-DRIFT-1m Module



Fermilab and DUNE



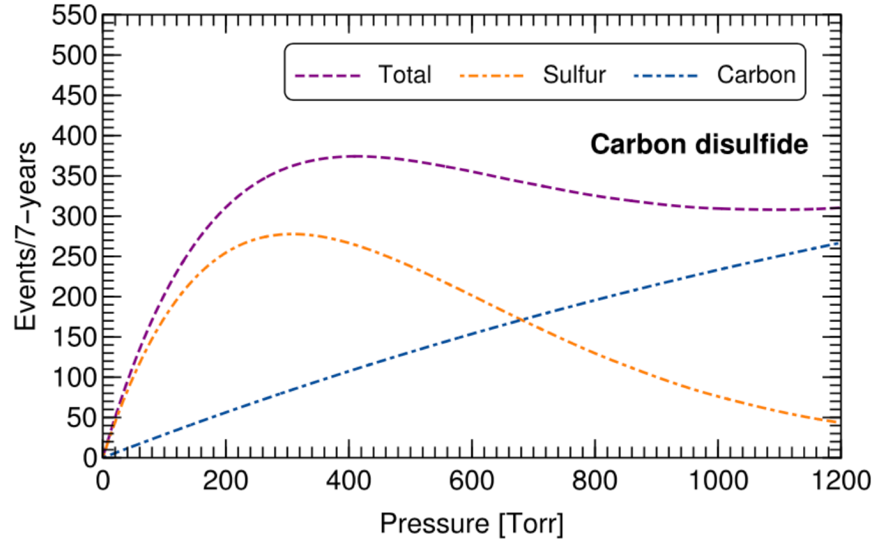
Near Detector Hall ν Flux

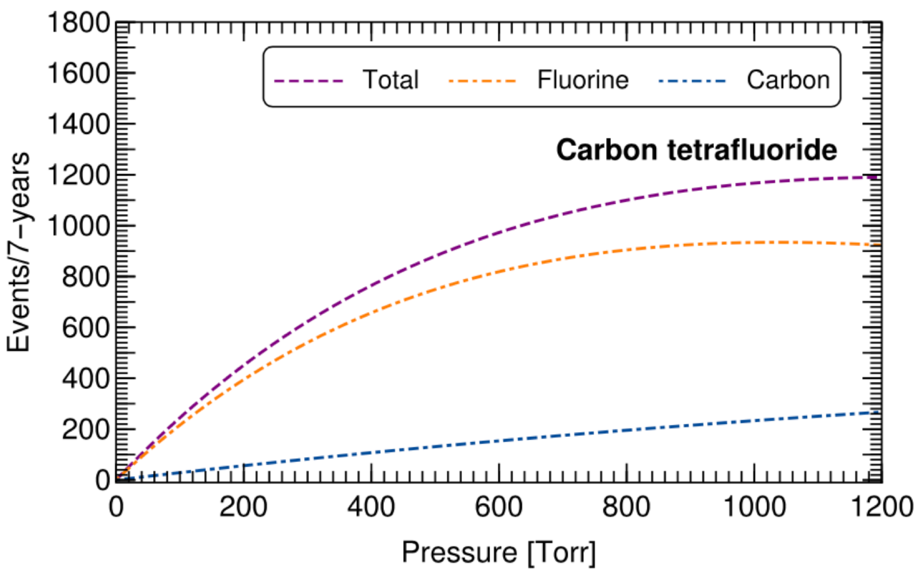


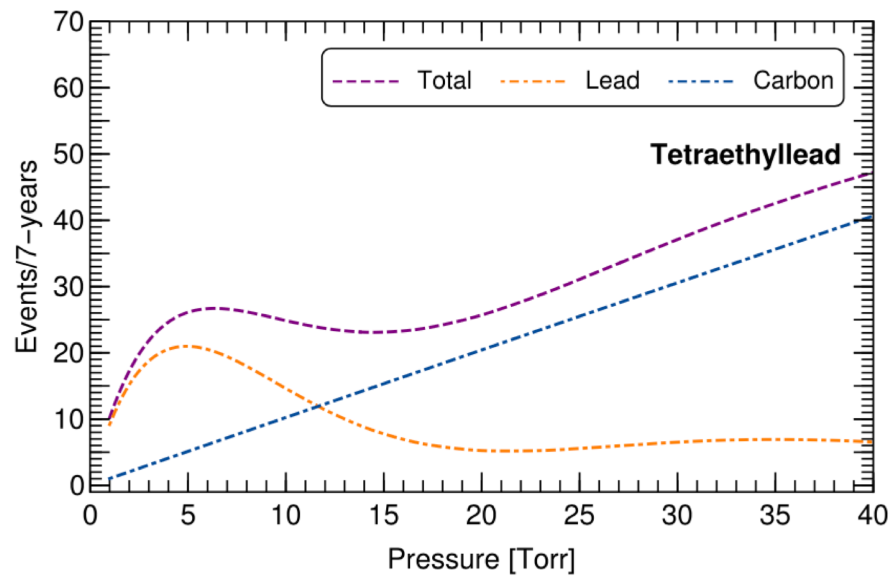
PRD, 101, 2020

CEνNS Physics – Event Rates

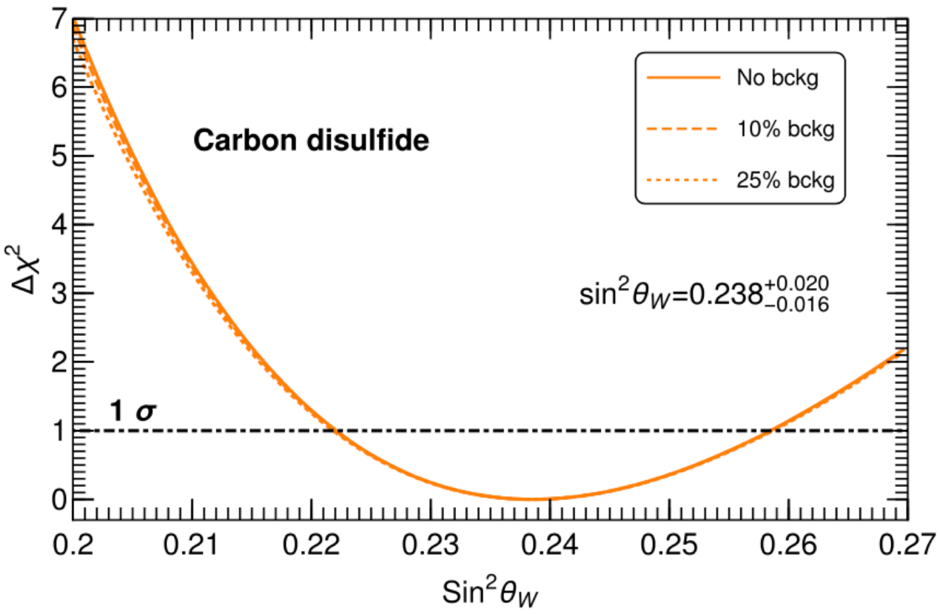
- Optimal pressure and threshold indicated
- Ability, in principle, to look at any nuclei in gaseous form
- Significant detections
- PRD 104, 2021, arXiv:2103.10857, Aristizabal





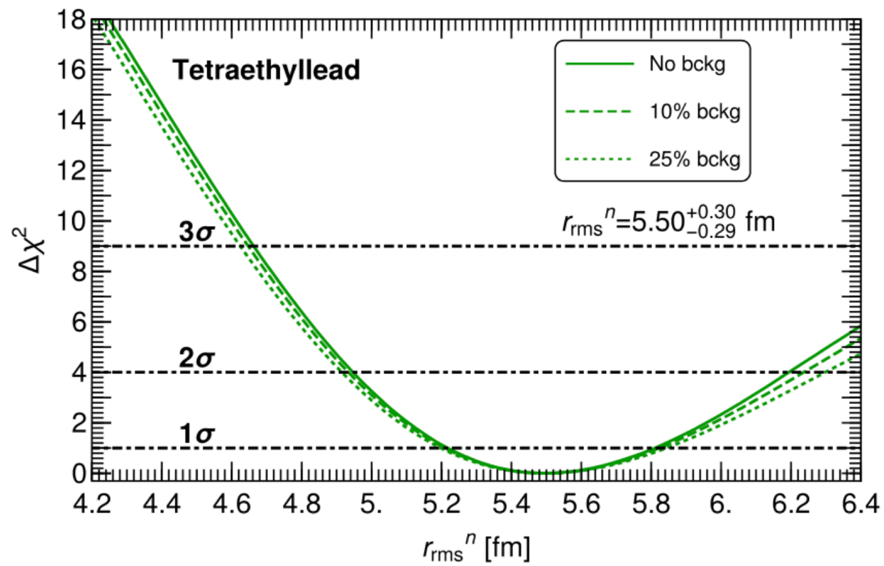


CEνNS Physics - Measurements



- Measurement of the weak mixing angle on S to 8%

- Measurement neutron distribution in Pb to 5%
- Larger neutrino energy => Sufficient stats at high Q
- Systematics on form factor are small
- Comparison with PREX



PRD, 101, 2020

Backgrounds - Benchmarking

- Need to simulate "rock neutrons" produced in coincidence with the ν beam pulse
- Started with ν flux, shown earlier
- Used Genie to generate end-state particles coming from ν - nuclei interactions
- Used GEANT to simulate the nuclear recoil resonse of the COUPP experiment in the NuMI beam in 2009
- GENIE/GEANT predict

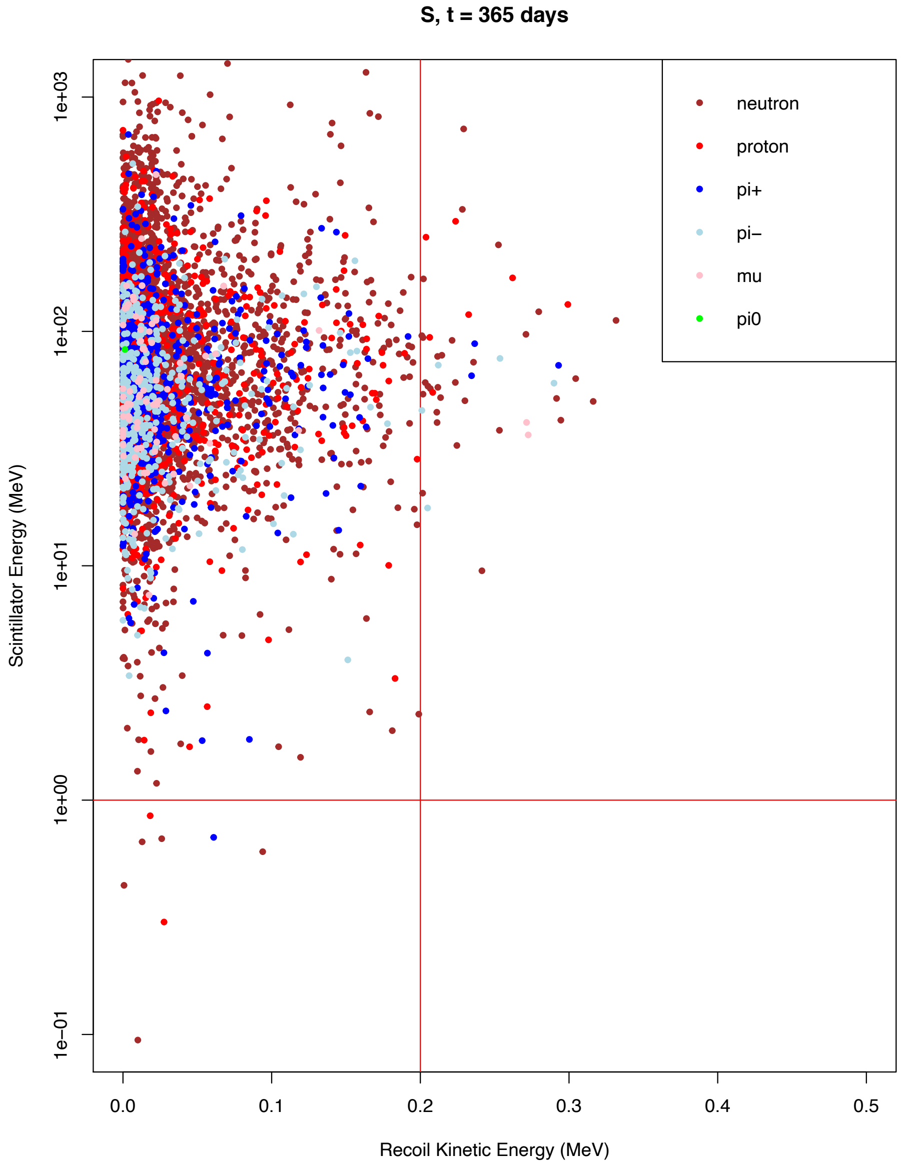
  4.5 to 5.1 +/- 0.3 events/kg/day
- COUPP (unpublished) measured

  5.9 +/- 0.2 events/kg/day
- Accurate to ~25% (preliminary)

Zuckerman Fellow
Josh Barrow

Backgrounds - Predictions

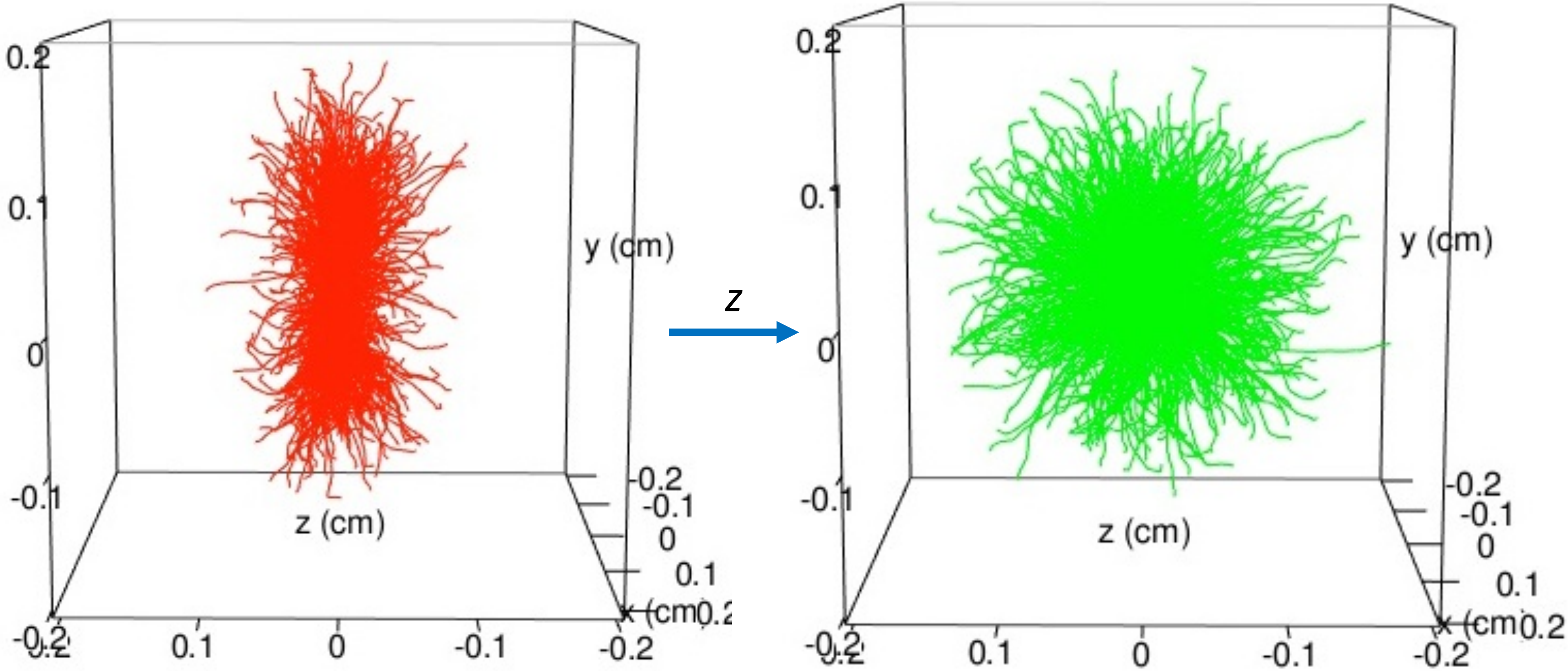
- 1 m^3 νBDX-DRIFT detector filled with 400 Torr CS_2
- 0.16 +/- 0.02 events per day above νBDX-DRIFT thresholds (200 keV S, 123 keV C)
- This rate can be significantly reduced by adding a Gd-loaded scintillator around the νBDX-DRIFT detector



Directional Signal and Background

1,000 50 keV
signal events

1,000 50 keV
background events



One of the easiest things to measure is the RMS in z.

PRD, 99, 2019

Conclusion

- νBDX-DRIFT brings a unique, proven, halo-dark-matter detector to CEνNS research.
- A 10 m^3 νBDX-DRIFT detector in the Near Detector hall in DUNE could detect 10s of CEνNS events per year.
- Measurements of WMA and n distribution available.
- Backgrounds are expected to be minimal.
- In the near term we hope to deploy a 1 m^3 νBDX-DRIFT prototype in the NuMI beam at Fermilab to test these ideas out.
- Simultaneously we plan on exploring what such a detector could do in the search for BSM physics, including light dark matter and ALPs.

The End