BDX-DRIFT: A low-energy, low-background, directional search for LDMA

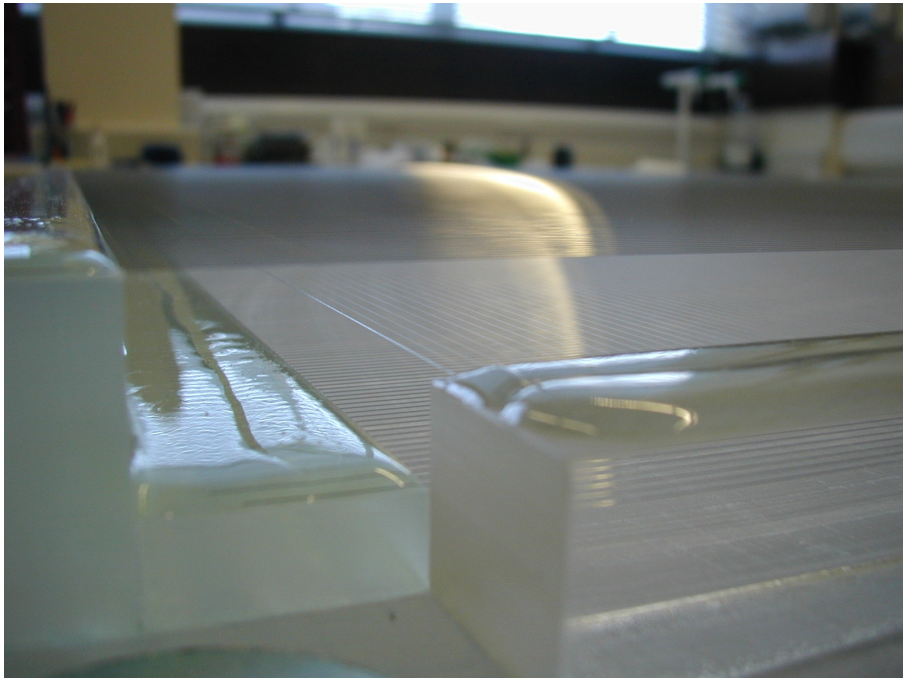
Dan Snowden-Ifft
Occidental College, Los Angeles, CA USA
Dark Matter 2018, UCLA, Los Angeles, CA, USA
February 22, 2018

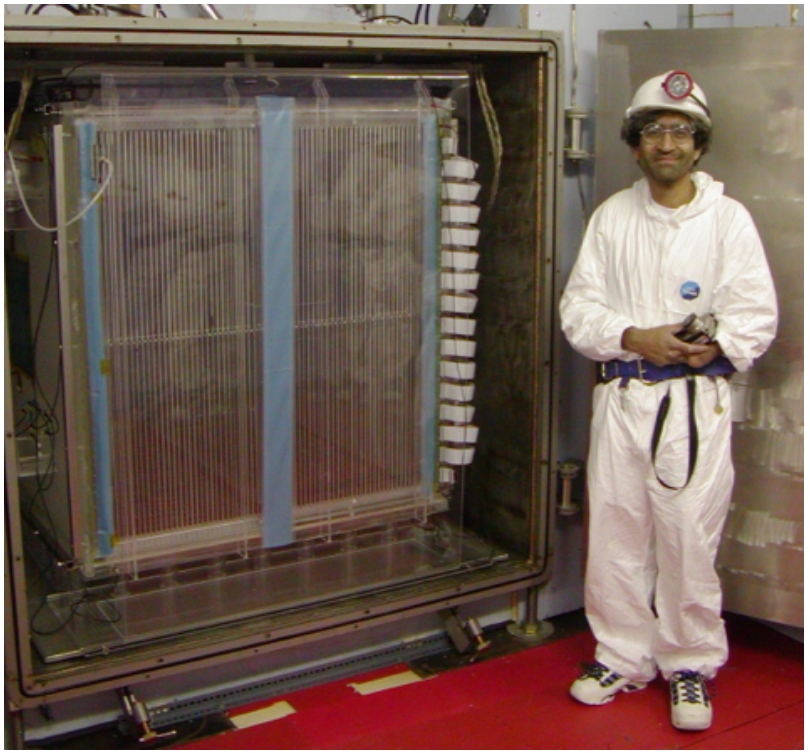
DRIFT lightning summary

Started = 1998, US/UK

Directional WIMP dark matter detector

1/20 atm, 1 m^3 gaseous detector





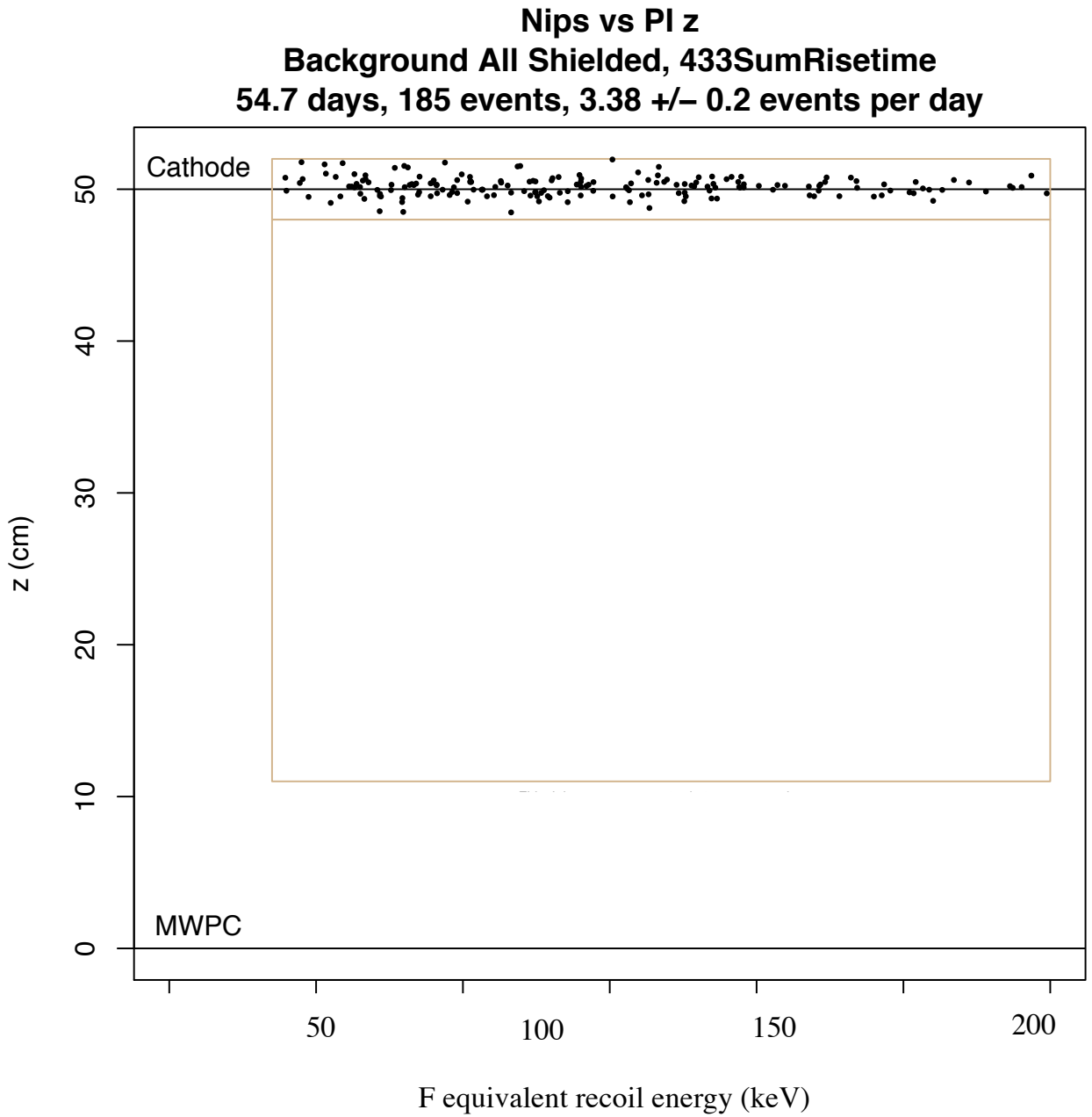
Unique and robust technology

Low energy (~35 keV) threshold for nuclear recoils

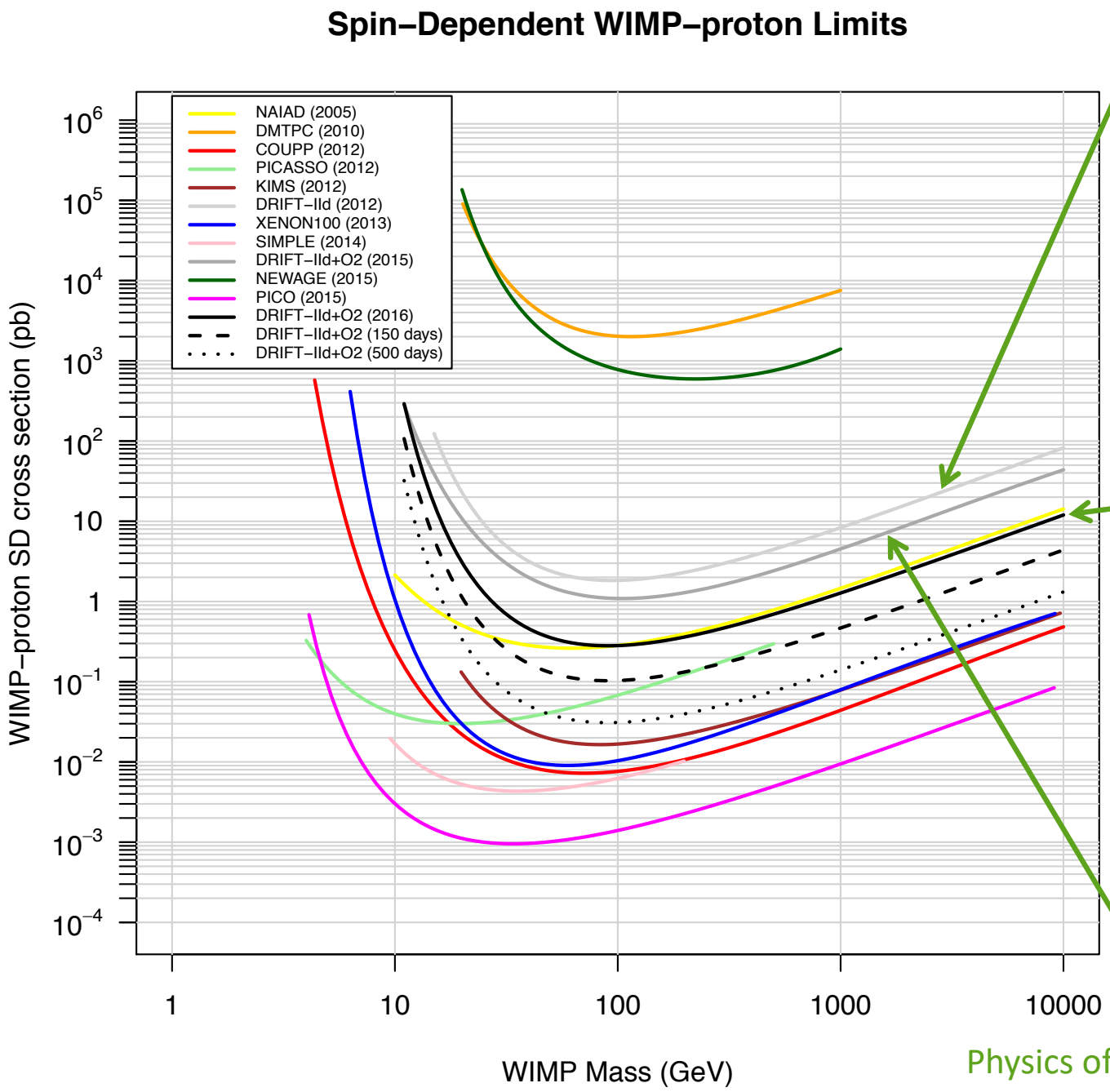
Low background

PRD, 61, 2000

Shielded 30-10-1 CS_2-CF_4-O_2 Data



SD Limits

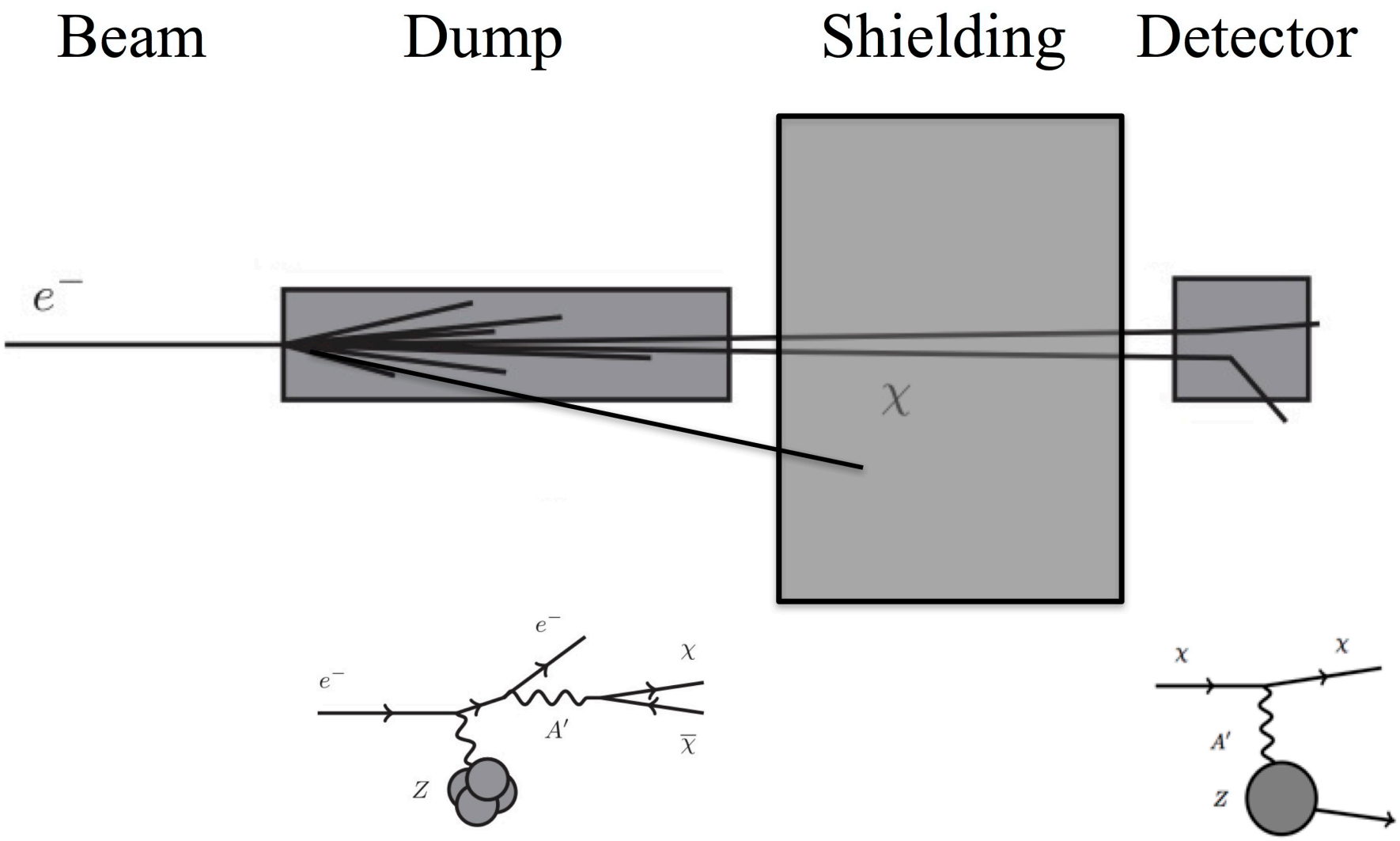


AstroPle, 35, (2012) 397.

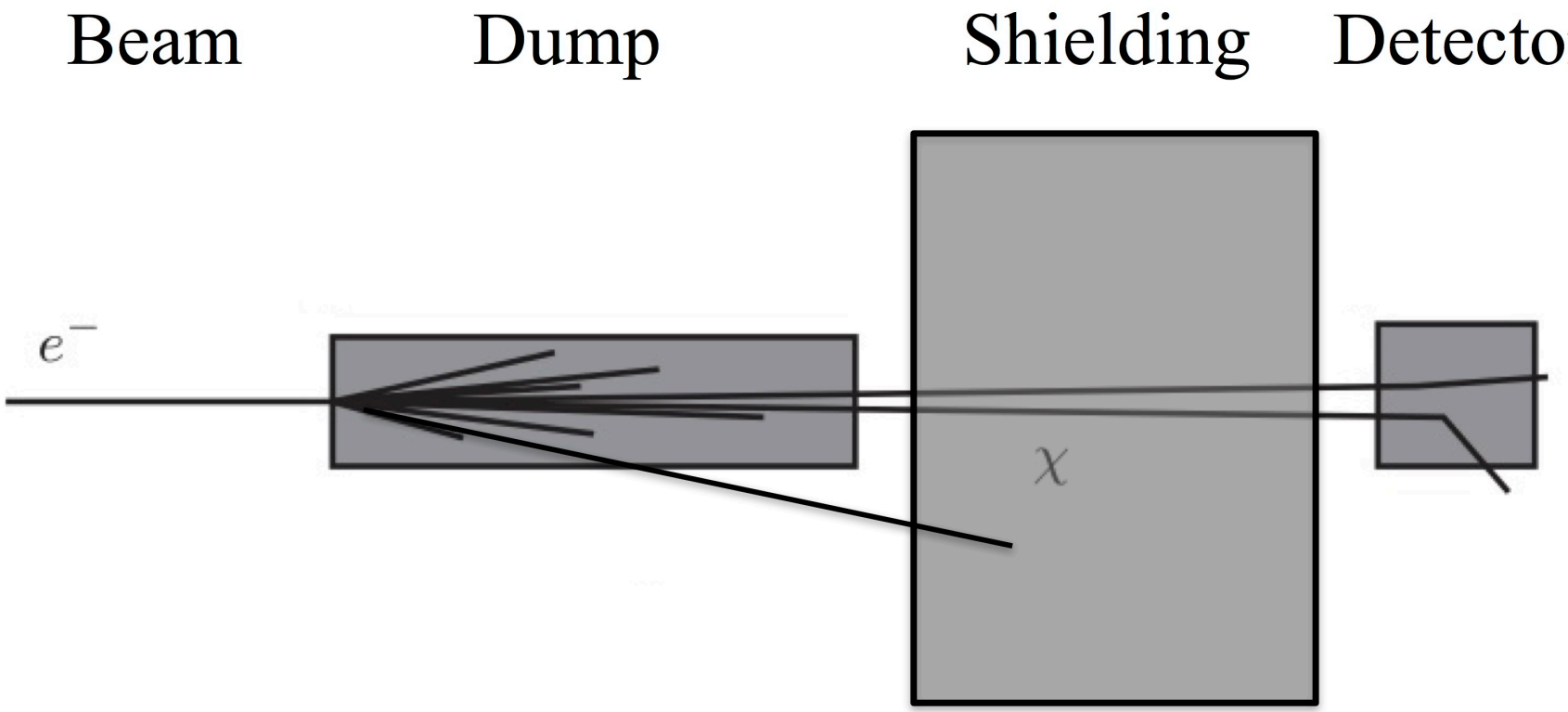
This result 2016

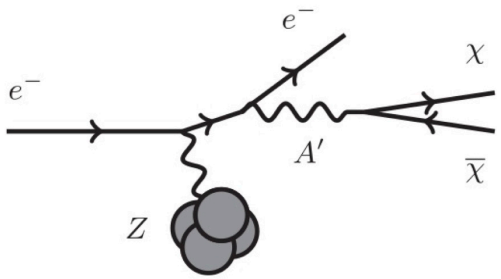
Physics of the Dark Universe, 9-10, (2015) 1.

Detecting Light Dark Matter at Accelerators



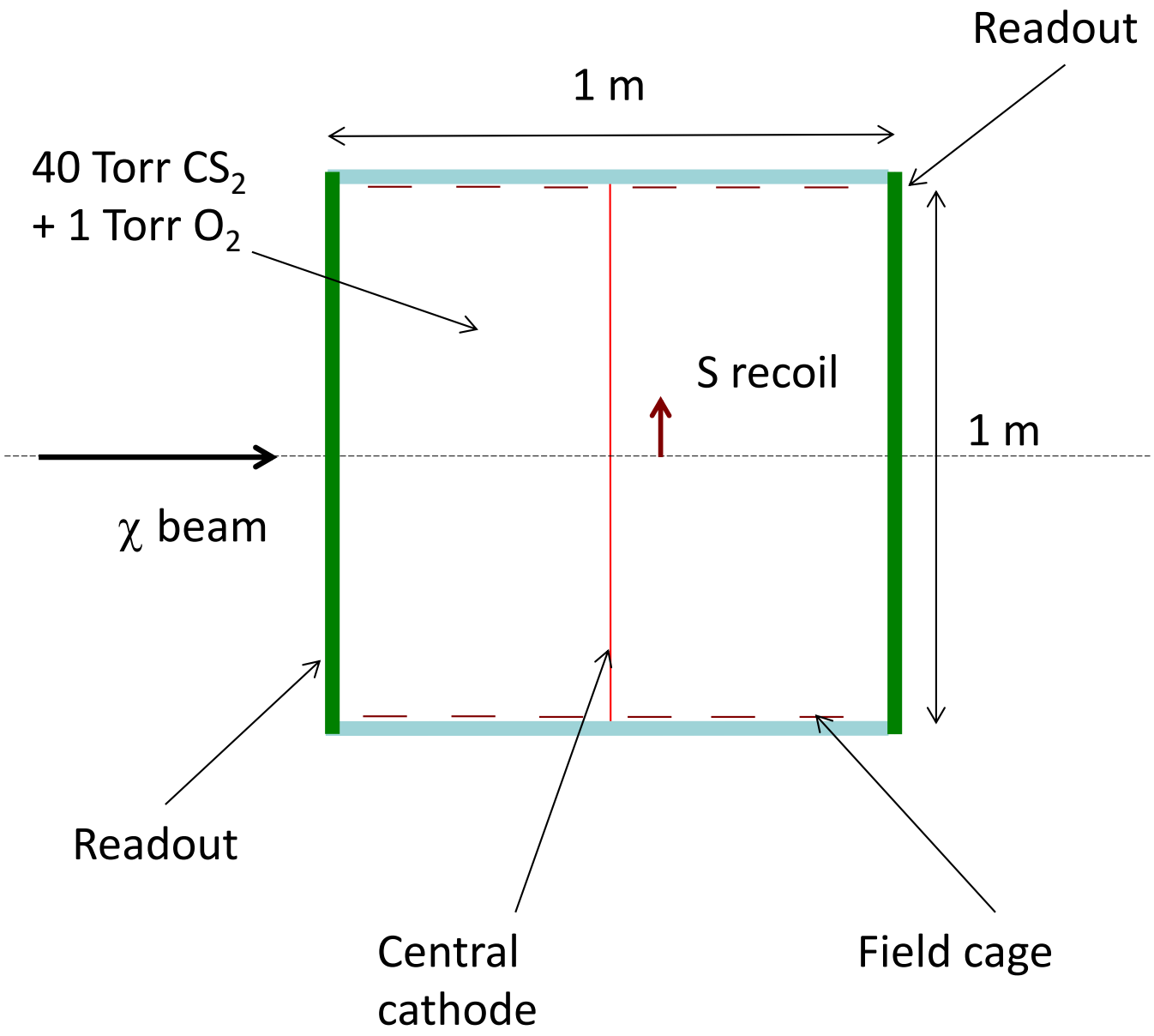
Detecting Light Dark Matter at Accelerators



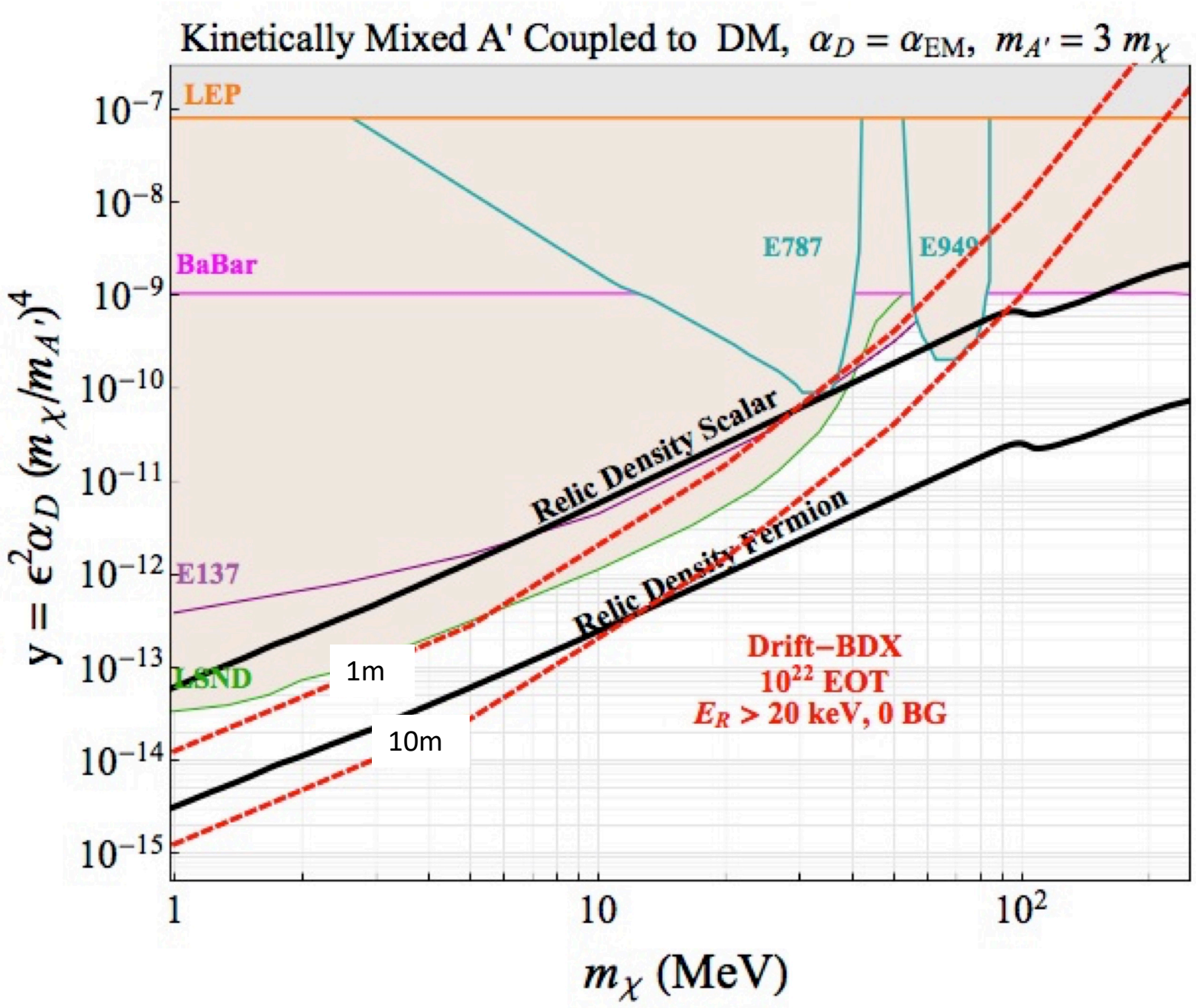


$$\frac{d\sigma}{dT} \cong \frac{8\pi\alpha\alpha_D\epsilon^2 Z^2 M}{\left(m_{A'}^2 + 2MT\right)^2}$$

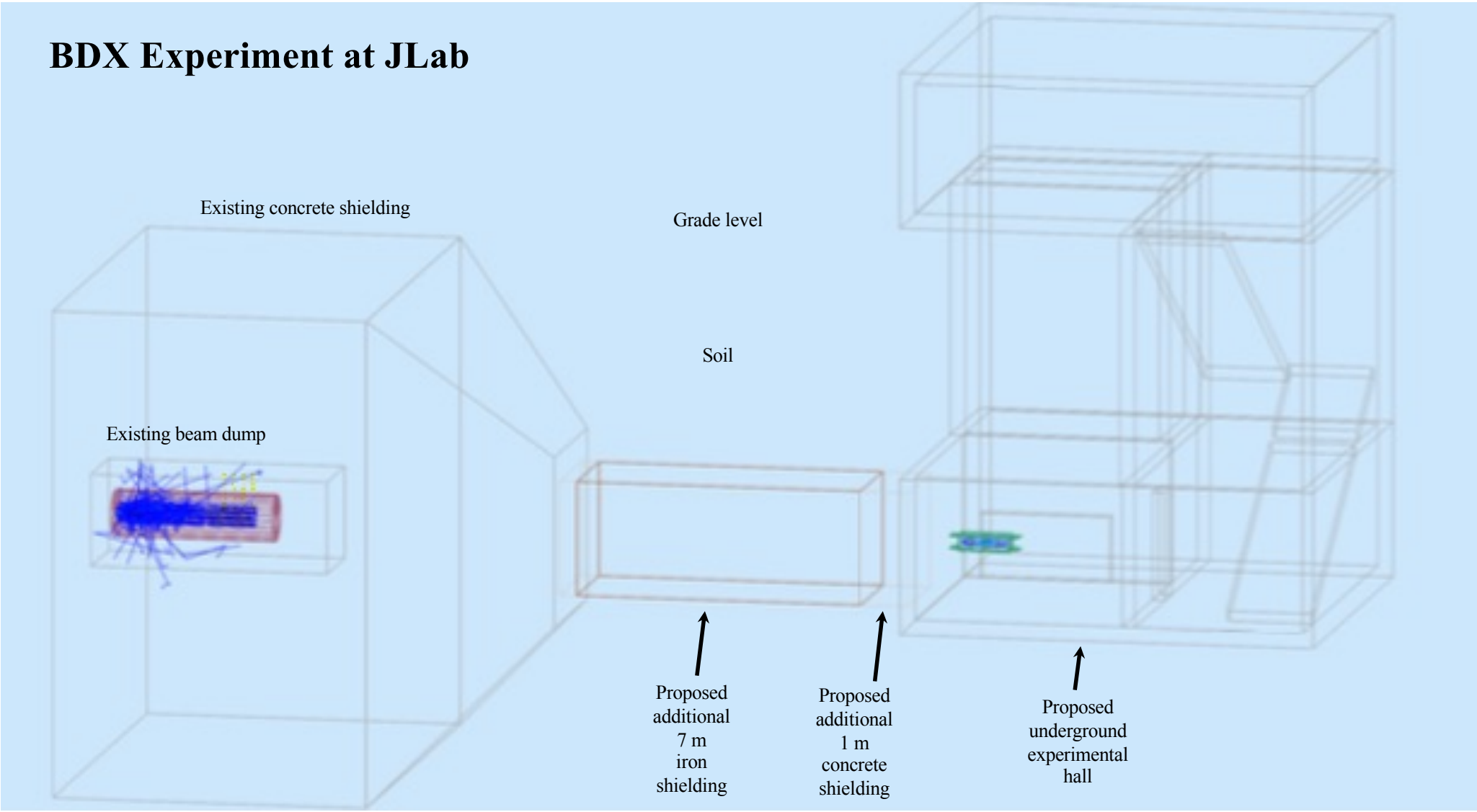
BDX-DRIFT-1m


Readout
1 m
40 Torr CS_2
+ 1 Torr O_2
S recoil
1 m
χ beam
Readout
Central
cathode
Field cage

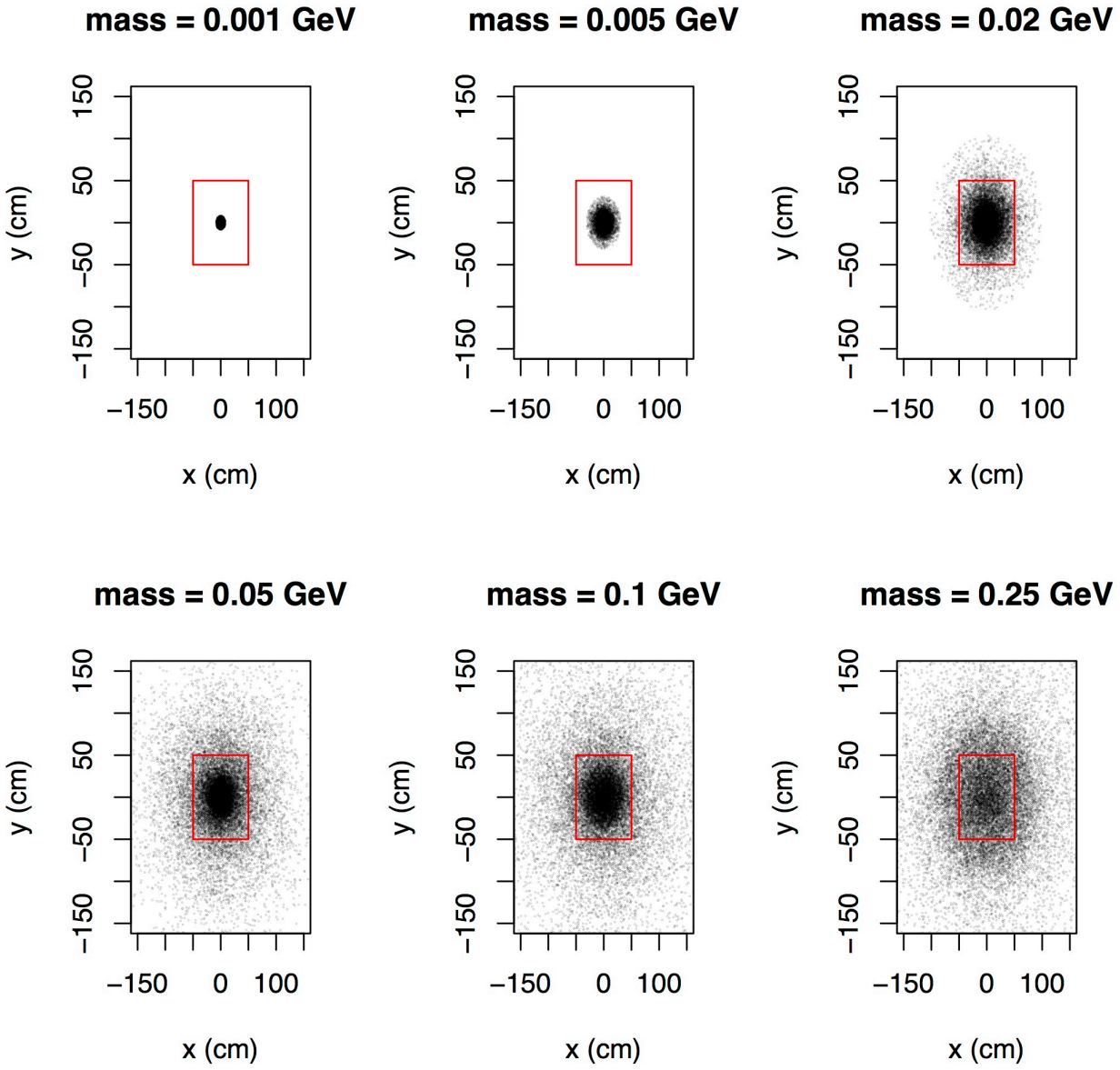
BDX-DRIFT - Sensitivity



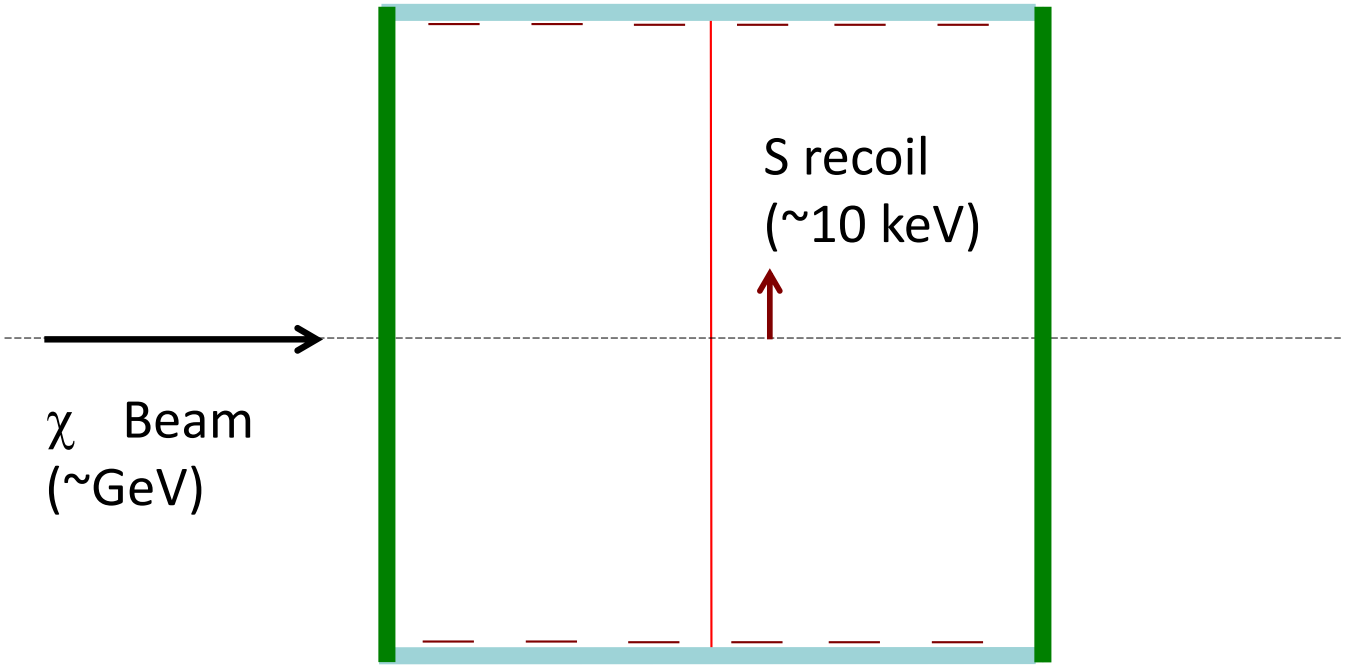
BDX @ JLab


BDX Experiment at JLab
Existing concrete shielding
Grade level
Soil
Existing beam dump
Proposed additional 7 m iron shielding
Proposed additional 1 m concrete shielding
Proposed underground experimental hall

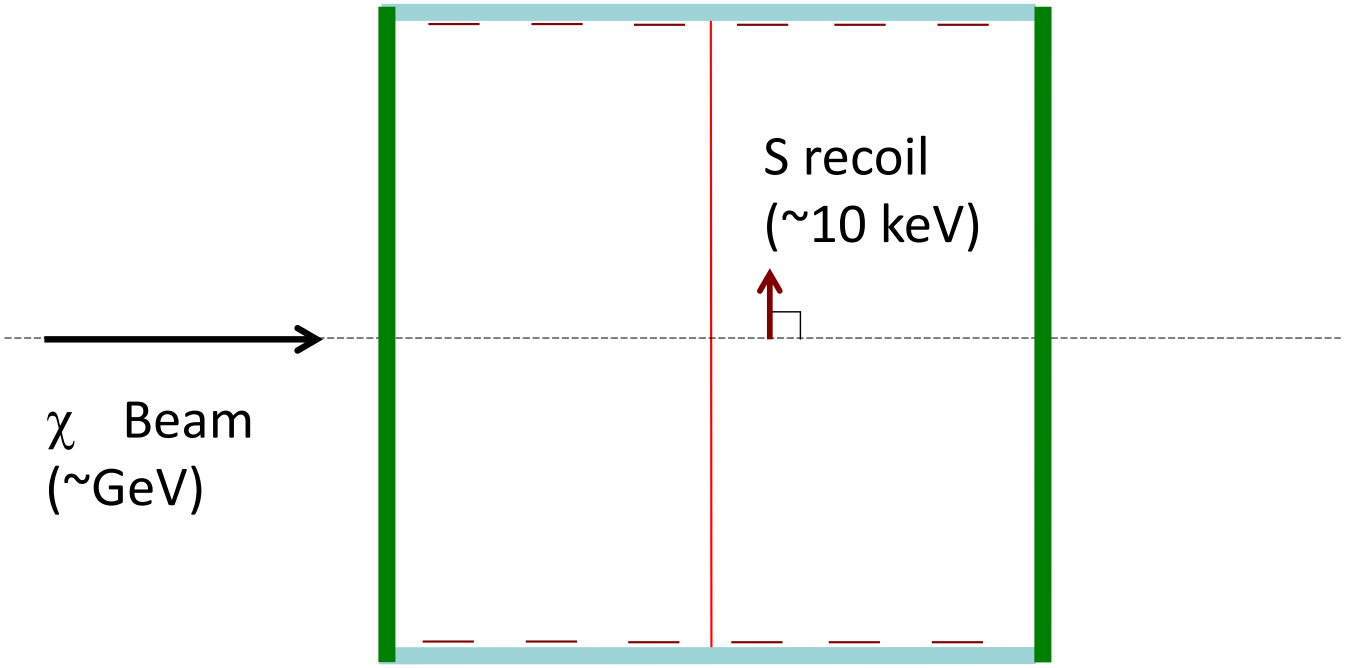
BDX-DRIFT Signatures



BDX-DRIFT Signatures

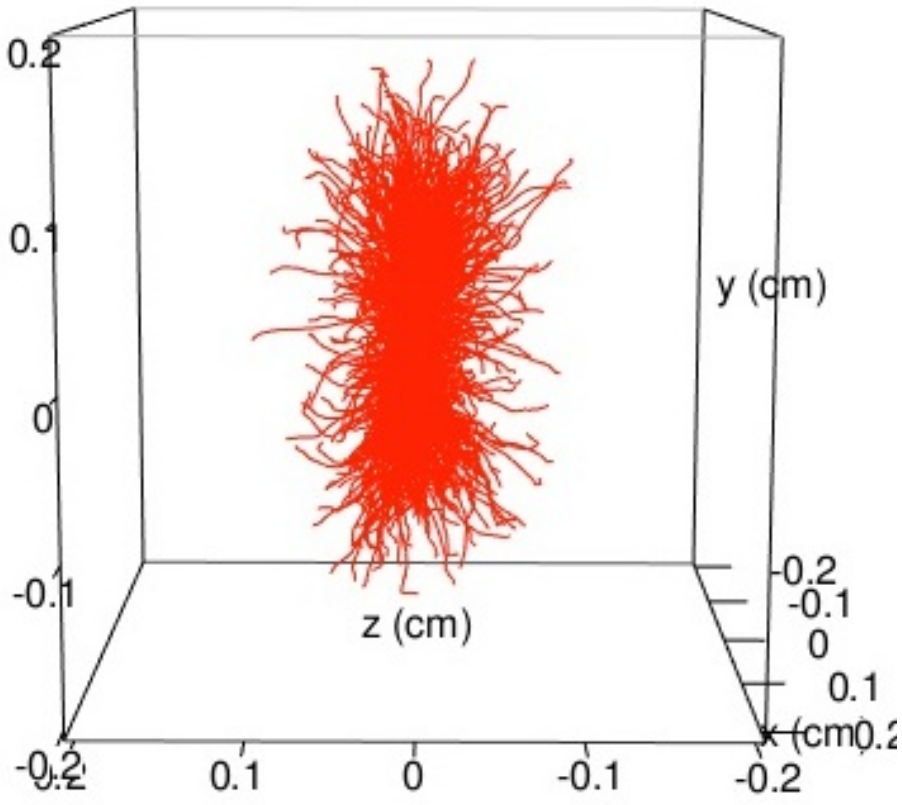


BDX-DRIFT Signatures

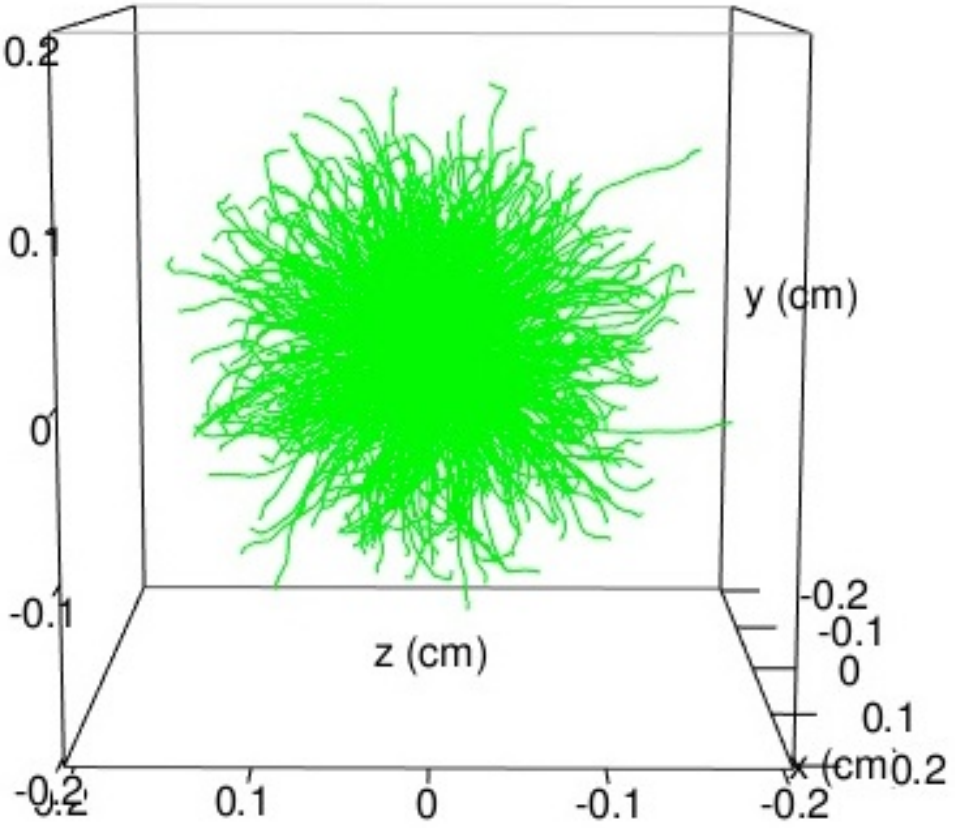


Directional Signal and Isotropic Background

1,000 50 keV
signal events

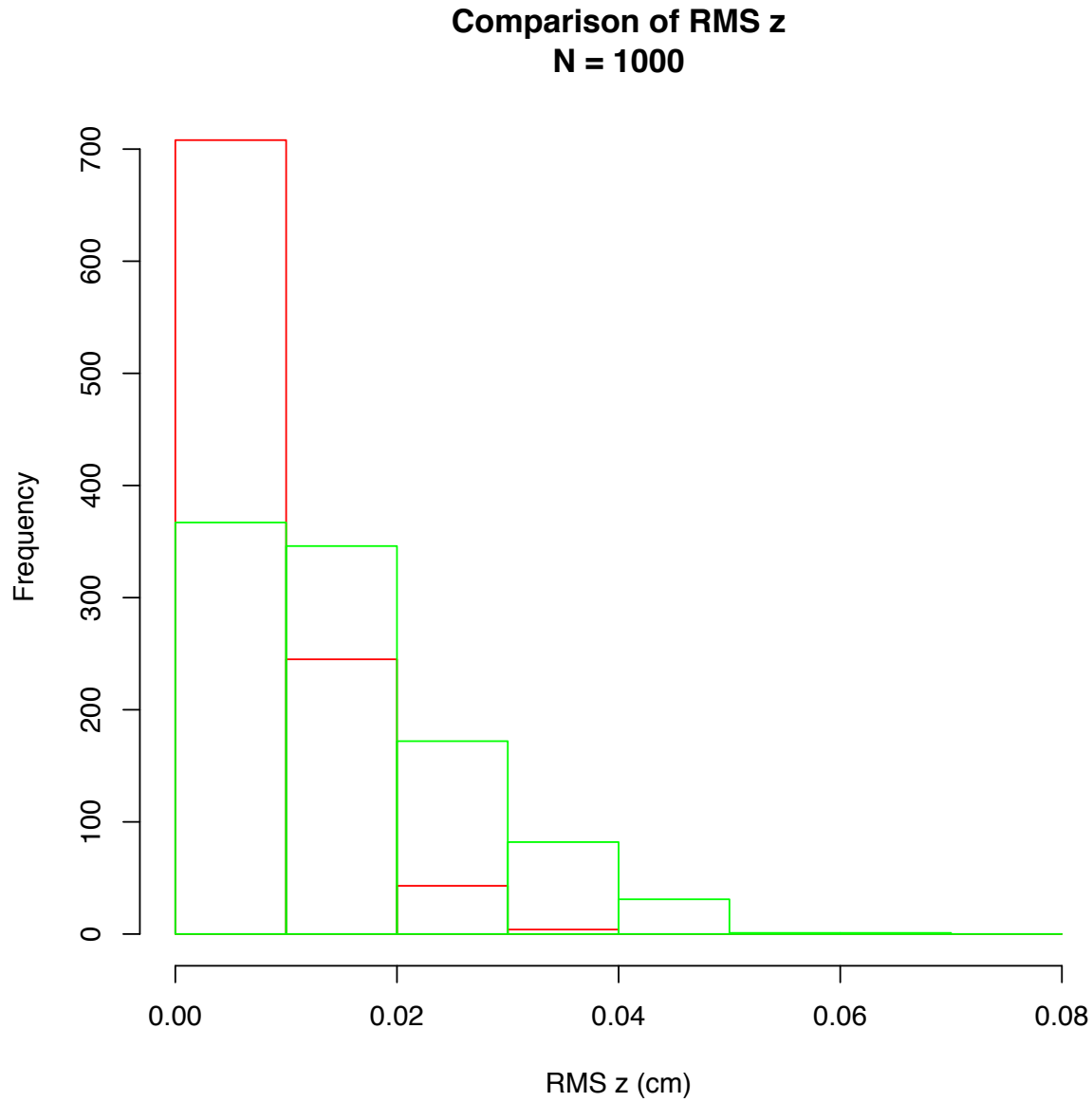


1,000 50 keV
background events

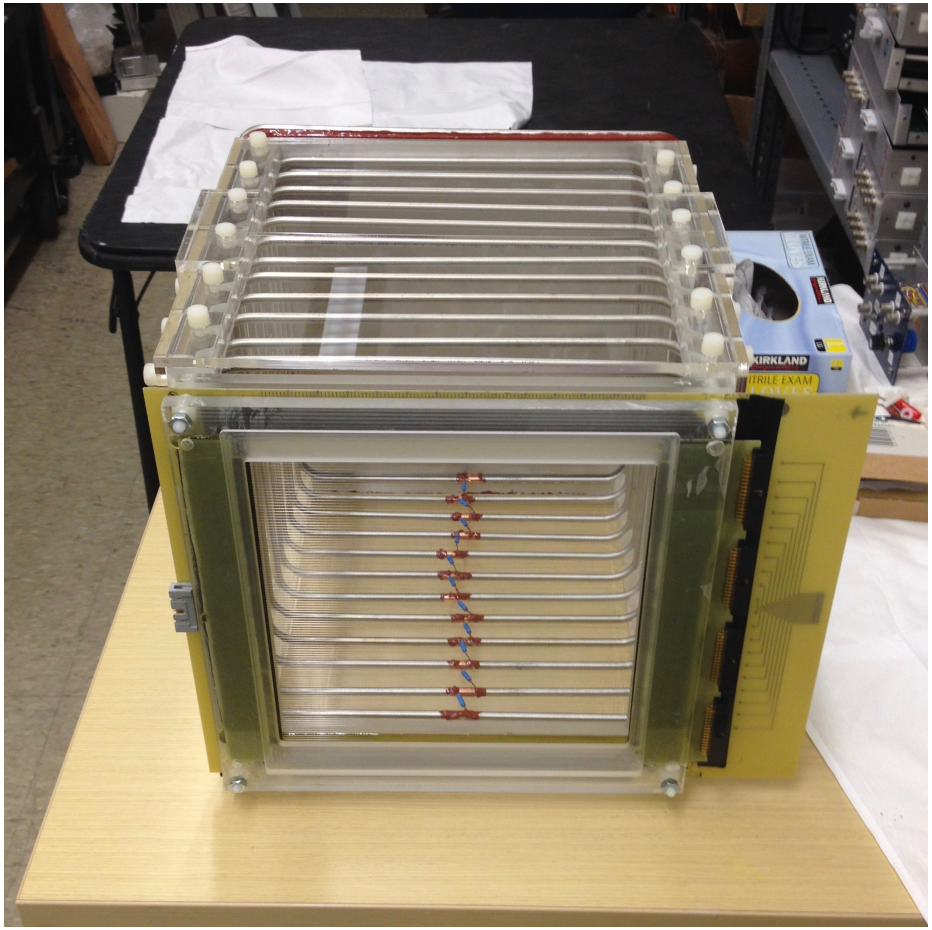


One of the easiest things to measure is the RMS in z.

Directional Signal vs Isotropic Background

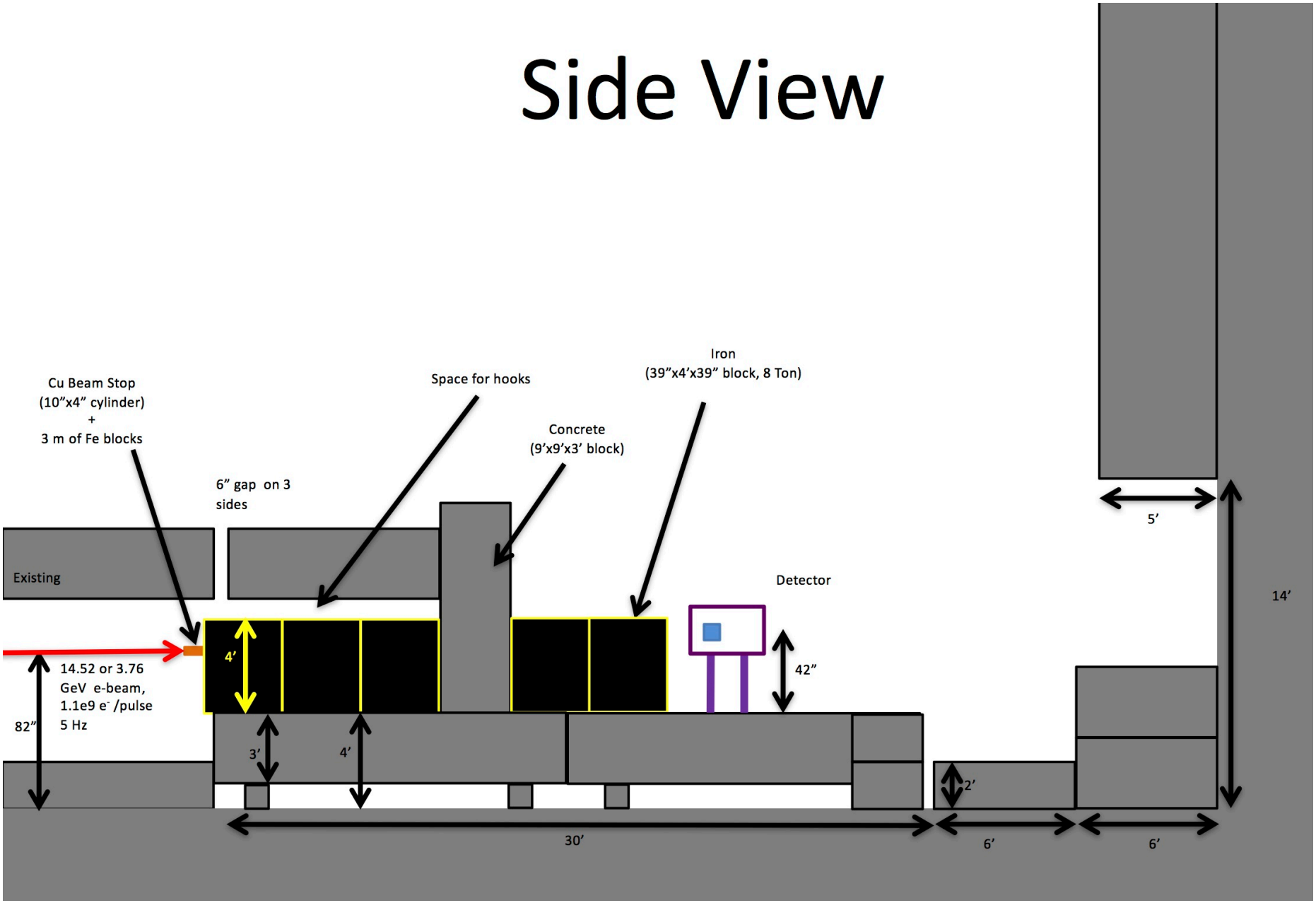


Initial Tests - Background



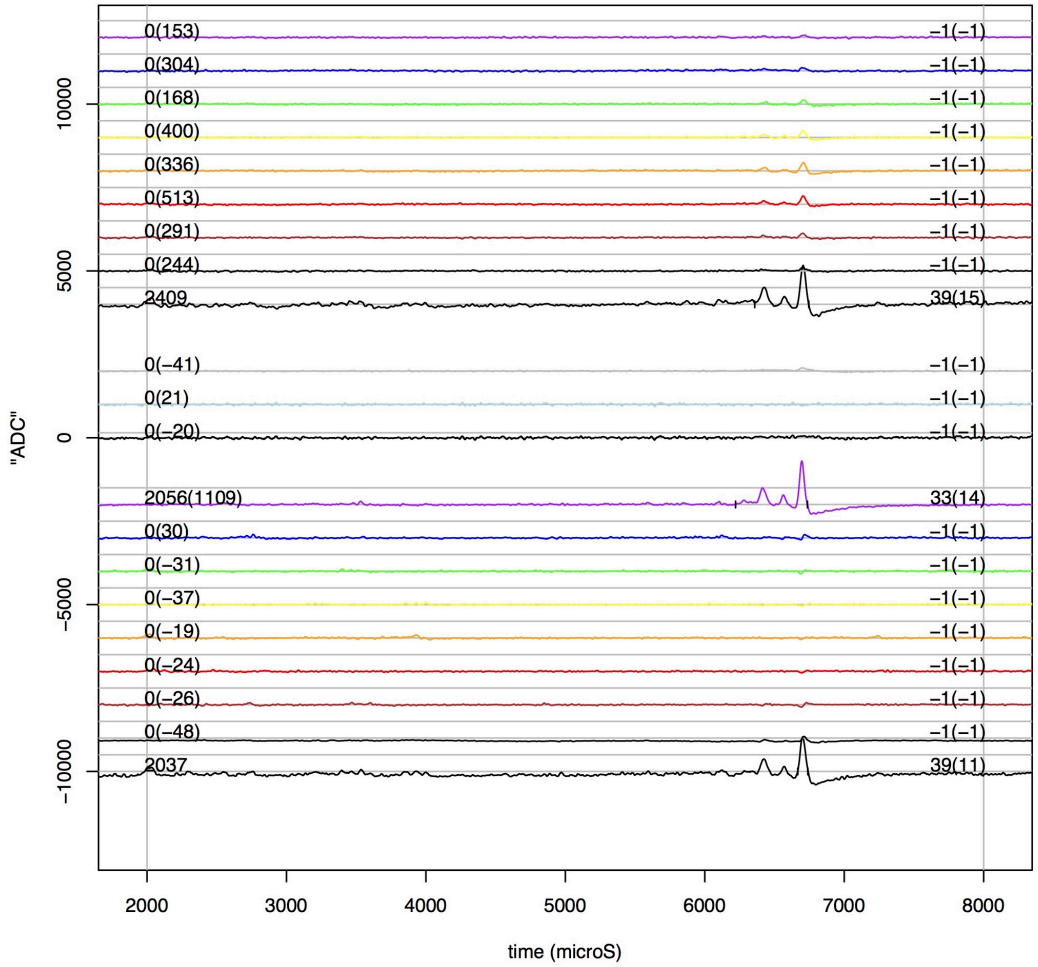
- Despite 4 Hz of cosmic ray muons passing through the fiducial volume of the detector, after nuclear recoil analysis we get only ~1 event per day, roughly what we would expect from cosmic ray neutrons on the surface. *Backgrounds are low, even on the surface of the Earth.*

Initial Tests – SLAC Beam Run



Initial Tests – SLAC Beam Run

Initial Tests – SLAC Beam Run



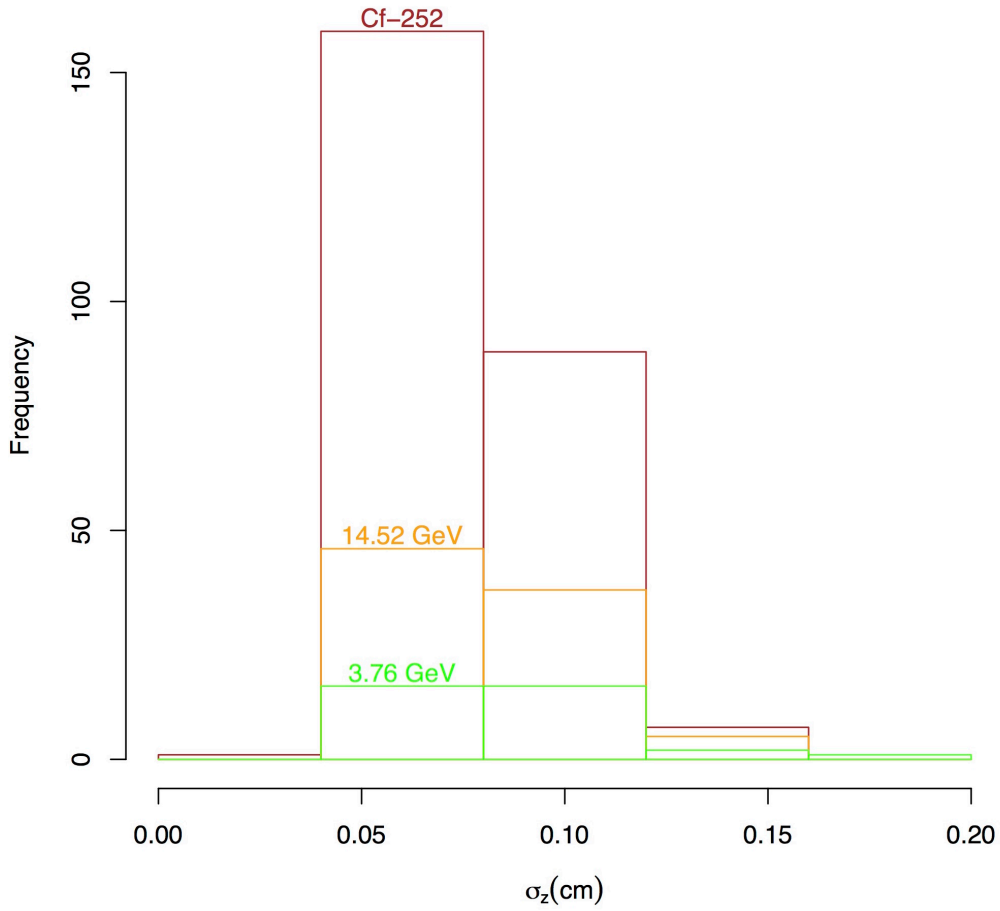
- Despite a crack in the shielding and an associated gamma flash, the performance of the detector was nominal. *You can operate a low-pressure TPC within 6 m of a beam-dump, even with poor shielding, at a nominal trigger rate.*

Initial Tests – Giant Dipole Resonance (GDR) Neutrons

Number of EOT to produce one neutron through the detector		
Run Energy	GEANT4	Data
3.76 GeV	$(5.6 \pm 0.7) \times 10^6$	$(6.6 \pm 0.4) \times 10^6$
14.52 GeV	$(1.5 \pm 0.2) \times 10^6$	$(2.65 \pm 0.09) \times 10^6$

- Several hundred nuclear recoils were detected for each beam energy in agreement GDR neutron recoils from GEANT4 simulation. *Results agree with simulations.*

Initial Tests – Directionality Tests



- The 2 GDR neutron distributions (3.76 GeV and 14.52 GeV) agree (KS test) with 96% confidence. They "agree" with the Cf-252 distribution with only 7% and 2% confidence. *The BDX-DRIFT detector has the expected directional capabilities.*

The End