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

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DRIFT lightning summary

Started = 1998, US/UK

Directional WIMP dark matter detector

Continuous R&D for 18 years

Current detector = DRIFT-IIId

Low energy (~20 keV) threshold for nuclear recoils

Low background

Unique and robust technology

PRD, 61, (2000) 1
Strawman DRIFT LDMA detector – DRIFT-BDX

1 m

beam

Readout

Central cathode

Field cage

40 Torr CS$_2$

30 cm
DRIFT-BDX - Signal

\[
\frac{d\sigma}{dT} \sim \frac{8\pi \alpha \alpha_D \epsilon^2 Z^2 M}{(m_A^2 + 2MT)^2}
\]
DRIFT-BDX - Limits

Drift-BDX limits (90% C.L.)

\[ m_{\chi} = 10 \text{ MeV}, \alpha_D = 0.1, \text{EOT} = 1e+22 \]

0 background, 20 keV threshold

\[ \varepsilon^2 \]

\[ 10^{-11} \]

\[ 10^{-10} \]

\[ 10^{-9} \]

\[ 10^{-8} \]

\[ 10^{-7} \]

\[ 10^{-6} \]

\[ 10^{-5} \]

\[ 10^{-4} \]

\[ 10^{-3} \]

\[ 10^{-2} \]

\[ 10^{-1} \]

\[ 10^{0} \]

\[ 10^{1} \]

\[ 10^{2} \]

\[ 10^{3} \]

\[ m_{\Delta'} \text{ (MeV)} \]
Background results – 55 days

Radon Progeny Recoils on Central Cathode

Background free
Backgrounds
40 keV Ar recoils from WIMPs
500 NIPs

13 keV e⁻s from Compton scatters
500 NIPs

EGS4/Presta - 13 keV e⁻ in 40 Torr Ar

SRIM97 - 40 keV Ar in 40 Torr Ar

20 mm
Negative Ion Drift

- \( \text{CS}_2 \) is highly electronegative
- \( \text{CS}_2^- \) drifts with minimal, thermal diffusion

\[
\sigma^2 = \frac{2kTL}{eE}
\]

- e.g. rms = 0.65 mm over 50 cm drift
- After drift the negative ion releases its electron for a normal avalanche at the detector
Surface Beam-Unrelated Backgrounds

- Nothing from the detector.
- Nothing from the walls of the lab.
- Muons are minimum ionizing so we can reject them.
- Cosmic ray neutrons are a problem unless we go ~8 m underground.
Surface Beam-Related Backgrounds

- No $\nu$ backgrounds, for better or for worse.
- We have not explored other beam-related backgrounds at length yet but...
- Beam related backgrounds are measureable in a highly segmented detector.
Scalable fiducial volume

DRIFT-BDX detector plane

36x signal volume

9x signal volume
The signature -
One of the easiest things to measure is the RMS in $z$. 
Directional Signal vs Isotropic Background

Comparison of RMS z
N = 1000

RMS z (cm)

Frequency

0 100 200 300 400 500 600 700
Directional Signal and Isotropic Background

Detection (90% C.L.) after 16 events if no background and 50 keVr threshold.
Conclusions

• High Z/Low threshold gives a signal enhancement enough to make even a 1 m long DRIFT-BDX detector competitive.
• Background suppression is expected to be good.
• Simple directionality ideas are promising

• Questions and/or comments are welcome!