Spin-Dependent Limits from DRIFT-IId and Plans for Scale-Up

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Directional Recoil Identification From Tracks (DRIFT) Collaboration

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DRIFT-IIId in Boulby

- Phenomenal Compton background rejection (AstroPle, 28 (2007) 409)
- DRIFT has been operating in Boulby since 2001
- DRIFT-I -> DRIFT-II (a-e)
- DRIFT-II volume = 0.8 m^3, distance = 50 cm
- MWPC readouts (NIMA, 555 (2005) 173)
- 40 Torr gas
- Negative ion drift to limit diffusion using CS2 (PRD, 61 (2000) 1)
- Many gas mixtures possible
- Currently (DRIFT-IIId) using a 30-10 Torr of CS2-CF4 to optimize for spin-dependent limits, 139 g target mass. (AstroPle, 35 (2007) 397)
- Relatively cheap, clean, stable and scalable technology
DRIFT-IId Data

CS2–CF4 Winter 09/10 Background Runs
47.4 days, 6152 events, 130 events per day

- 47.4 days of live time recorded
- A background of 130 events per day found

Radon Progeny Recoils

\[ {}^{222}\text{Rn} \rightarrow {}^{218}\text{Po} \ + \ \alpha \]

\[ {}^{218}\text{Po} \rightarrow {}^{214}\text{Pb} \ + \ \alpha \]

Range = 12 µm

DRIFT-IId Data

All Background–Neutron Runs
F equivalent energy vs Width

- Diffusion of the RPRs from the central cathode increases their width
- Use width as a crude discrimination parameter
- Black = Background
- Red = Neutron recoils

DRIFT-Ild Data

CS2–CF4 Winter 09/10 Background Runs
F Recoil Energies vs IWS RMST
47.4 days, 6152 events, 130 +/- 2 events per day

- Select an signal window
- Unfortunately for 100 GeV WIMPs the signal window => 8% efficiency of events passing the cuts

DRIFT-IId Spin-Dependent WIMP Limits

DRIFT

PICASSO
NAIAD
KIMs
COUPP

The problem

The 6 MeV Po-218 alpha can remain hidden in central cathode wires.
The solution – Part I

Give the alphas few places to hide in an aluminized Mylar thin film.

\[ ^{218}\text{Po} \rightarrow ^{214}\text{Pb}^+ \]

- Range = 37 µm

\( \mu \text{m scale} \)
Thin film deployed

- Thin aluminized Mylar is difficult to work with!
- Several iterations have been tested and deployed
- 0.9 micron thin film deployed on DRIFT-IIId in Boulby
- Several months of data taken
- The results show a dramatic drop from 130 events per day to a 6-8 per day.
- Expected 3 per day
- The difference is due to a manufacturing problem soon to be fixed.
The solution – Part II

Of course some alphas will find a way to hide
The solution – Part II

Give the alphas no place to hide in a texturized aluminized Mylar thin film.
Texturized thin film in progress

- Texturizing thin film is hard!
- Several ideas have been tested.
- We are nearing the end of this R&D process.
The solution – Part III

Remove the sources of RPRs

- Since 2005 the Rn level in our detectors has dropped by a factor of 11 through testing and replacement of Rn emitting components.

- Need to worry about contaminants in the thin-film as well now.

- Fortunately DRIFT detectors are also great alpha detectors (NIMA, 584 (2008) 114)

- Deployment of a clean, thin, texturized central cathode is planned for April of this year.
DRIFT-III

- Readout planes 4x bigger than DRIFT-II
- Same drift distance
- DRIFT-IIIa would have 10x the volume of a DRIFT-II class detector.
- Modular
DRIFT-IIe

We are funded to engineer a prototype of DRIFT-III called DRIFT-IIe.

- New, transparent MWPCs are built
- These allow the MWPC to “look both ways” doubling the volume readout per wire
- Inherently stackable
DRIFT-IIe

- Fiducialization of the events has been shown to work in the lab on small detectors.
- The “holy grail” of DRIFT
- This will be tested on DRIFT-IIe

![Diagram with expected delay of 1.5 milliseconds]
DRIFT-IIe

- New electronics being developed
- Capable of reading out every wire

Drift Front-End and Accumulator Boards rev0.2

- Analog Front-End (7xADA4891):
  - Transimpedance OpAmp @ 12MOhm
  - Amplification x1000
  - Gaussian Low-Pass Filter @ 500KHz (2us)
- Oscillator (EG-2121CA):
  - Supply Voltage 2.5 V
  - 200 MHz @ 50ppm
- SPI FLASH (W25Q64BVZIIG)
  - 8MBytes Flash, 5MBytes is taken by PLD code, the rest 3M is available.
  - Supply Voltage 3.3 V
  - 320 MHz Quad SPI
- 1 Gb Ethernet PHY
- CAN Transceiver ISO1050
- DDR2 Memory 125 MBytes
- Spartan 6 PLD (XC6SLX150-2FGG484I)
  - 600 KBytes Distributed RAM
  - 150K Logic Cells
  - Drives all ADCs and constantly stores data to DDR2 Memory
  - Along with simple threshold triggering able to do some simple trace analysis
  - Responsible for sending Traces through Data Link upon request

125MB DDR2 Memory (EDE1116ACBG 8E E):
- Supply Voltage 1.8 V @ 350mA MAX
- Stores digitized traces from all channels 2.5MB/channel or 25 x 50ms traces.
- Allows a readback of the particular trace on request

- 150Mhz Ultra PCIe
- 100Mhz SPI Interface
- 50Ghz Differential @ 200MHz

Digitalizing ADCs (AD7980):
- Sample @ 1MSPS max
- Input Voltage range: 2.9-5.5V
- Supply Voltage 2.5 V
- Serial output signal @ 48 MHz
- Digital 1.8V - 5.0V

High-pass AC Decoupling with 50 ms constant

Data Link

Time Sync Link

Trigger Link
DRIFT-IIe

• Another vacuum vessel is being commissioned for DRIFT-IIe

• Shielding is being constructed

• DRIFT-IIe will be commissioned this Summer and deployed in the Fall
Thanks