Minority carriers in DRIFT

Stephen Sadler on behalf of the DRIFT collaboration

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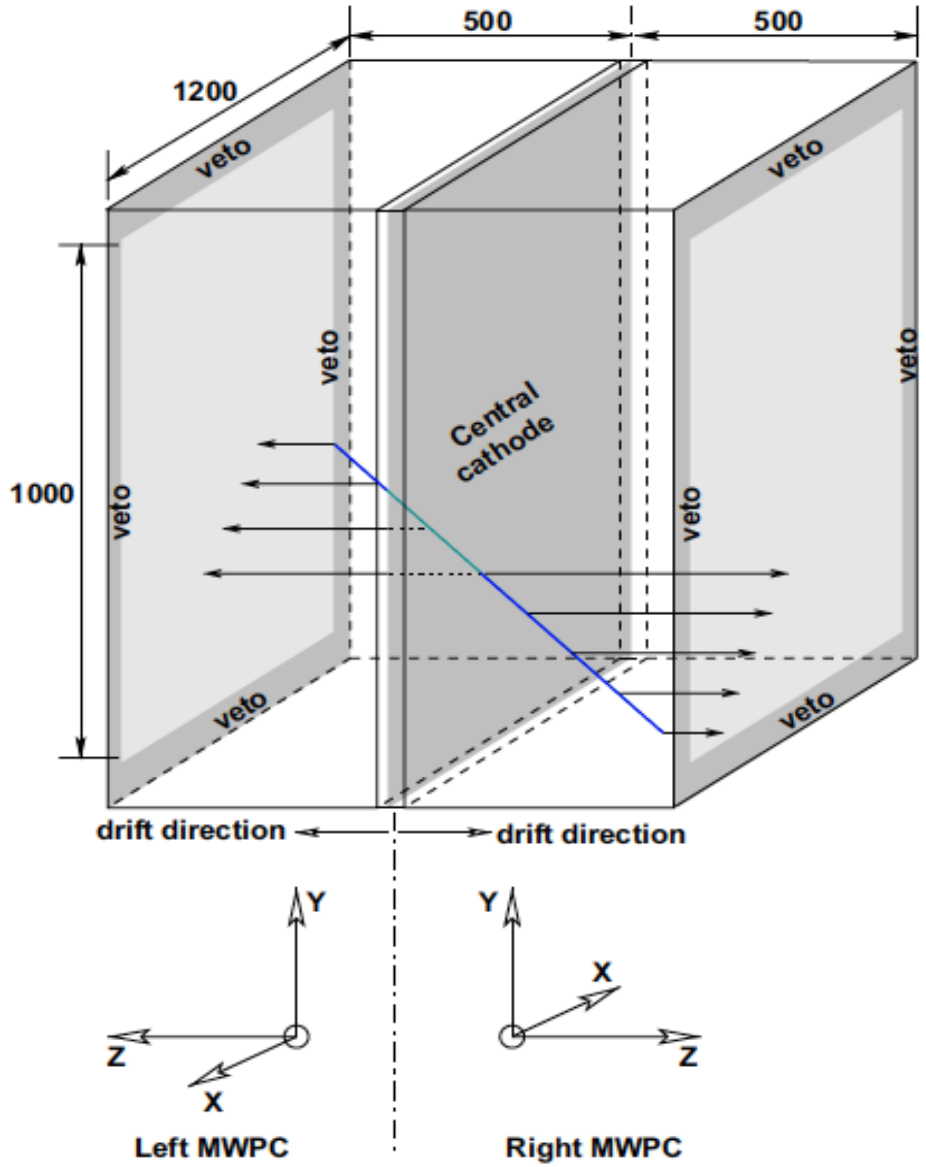
DRIFT concept



- 1 m^3 Negative ion TPC read out by two MWPCs.
- Electronegative drift gas (CS_2) with J=1/2 target gas (CF_4) to probe SD interactions whilst maintaining low diffusion.
- The shared central cathode defines two 624 V/cm drift regions.
- Every 8th wire grouped.
- > 67 cm polypropylene pellet neutron shielding on all sides.
- Current iteration: DRIFT-IId is running at Boulby Mine in Cleveland, UK.
- Next iteration: DRIFT-IIe being installed, with first data coming later this year.

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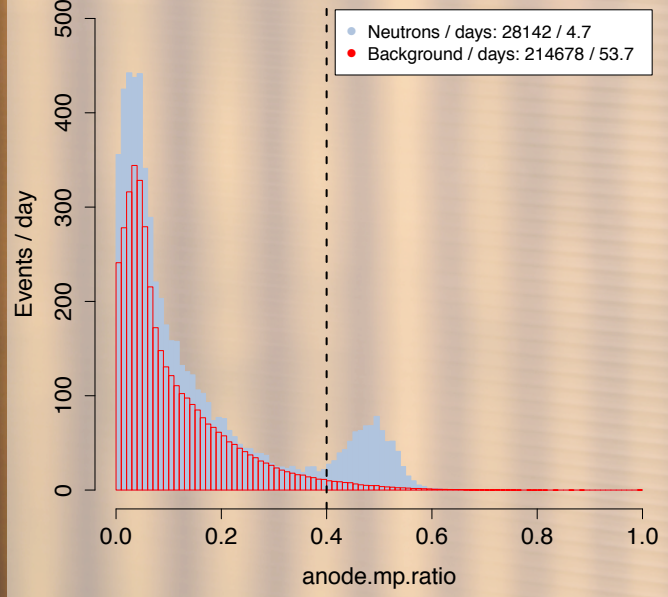
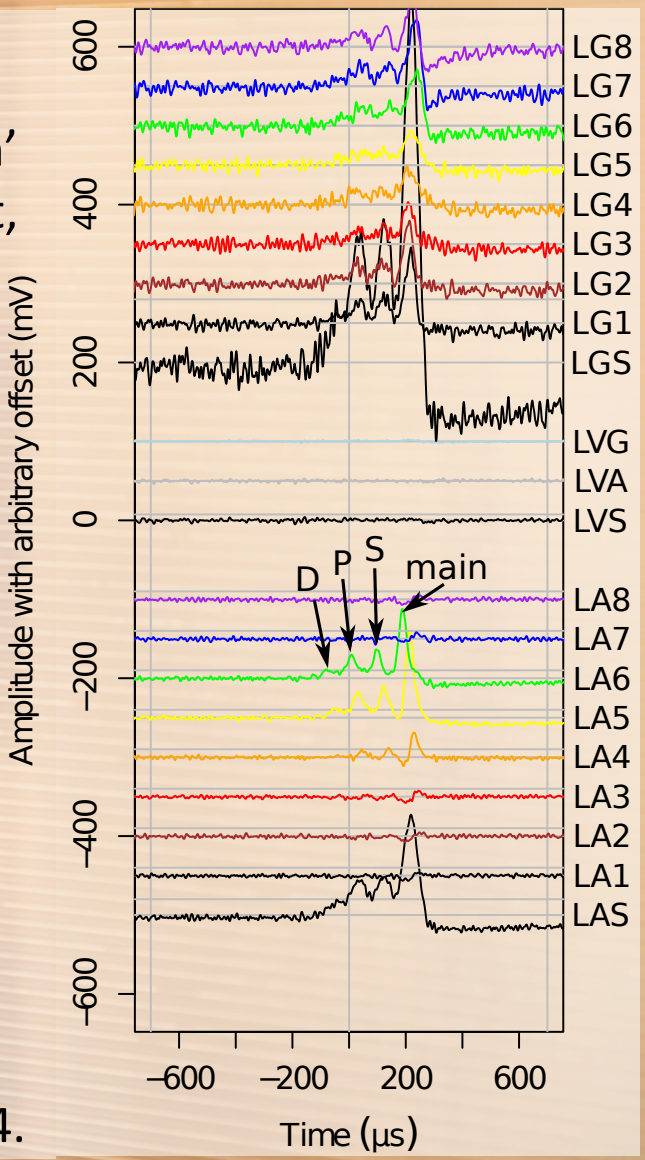
Minority carriers

- **1 Torr O_2** added to the regular 30:10 Torr CS_2:CF_4 mixture.
- Appearance of 'minority carrier' peaks **earlier** than the 'main' peak, and carrying ≈1/3 of the total charge (see Snowden-Ifft, Rev. Sci. Instr. 85 (2014)).
- Time difference between peaks yields **absolute z position**.
- Background events come from electrodes: cathode at z = 50cm or MWPC detector planes at z=0.



- New, simplified set of cuts.
- Basic cuts: 1 side only, contiguous hits, < 8 channels hit, risetime > 3µs.
- **mp.ratio**: ratio of charge in minority peaks to that in the main peak.
- Cut events with mp.ratio < 0.4.



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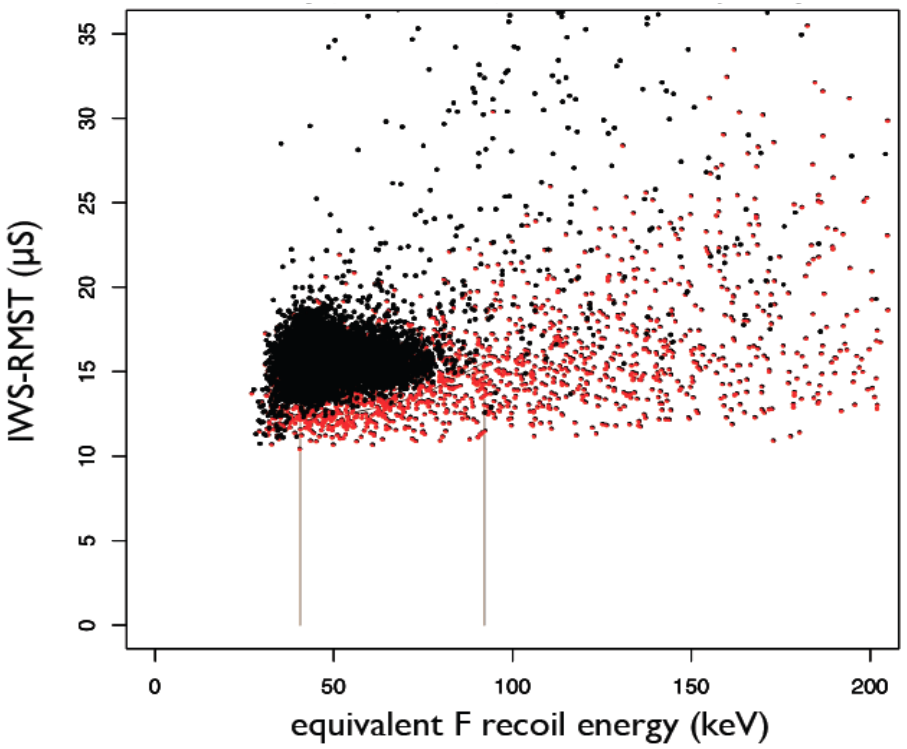
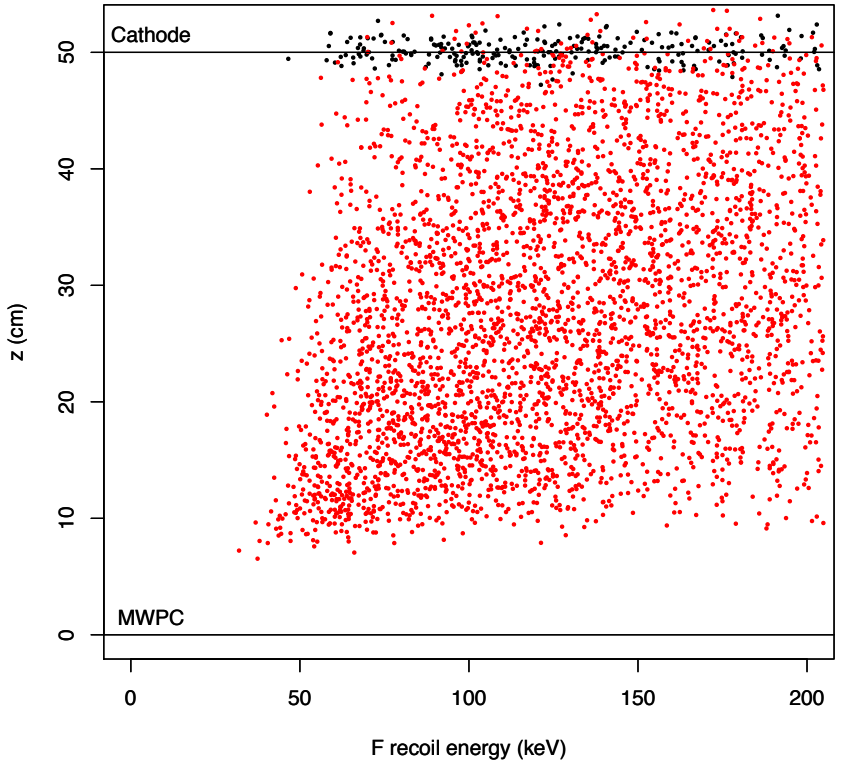
Signal region comparison





- Keep events in the bulk, and reject background from electrodes at edges.
- Efficiency drops at low z due to minority peaks overlapping.
- Simplified cuts and larger signal region result a factor ≈3 improvement in ^{252}Cf calibration neutron (red points) efficiency, whilst preserving background rejection (black points).

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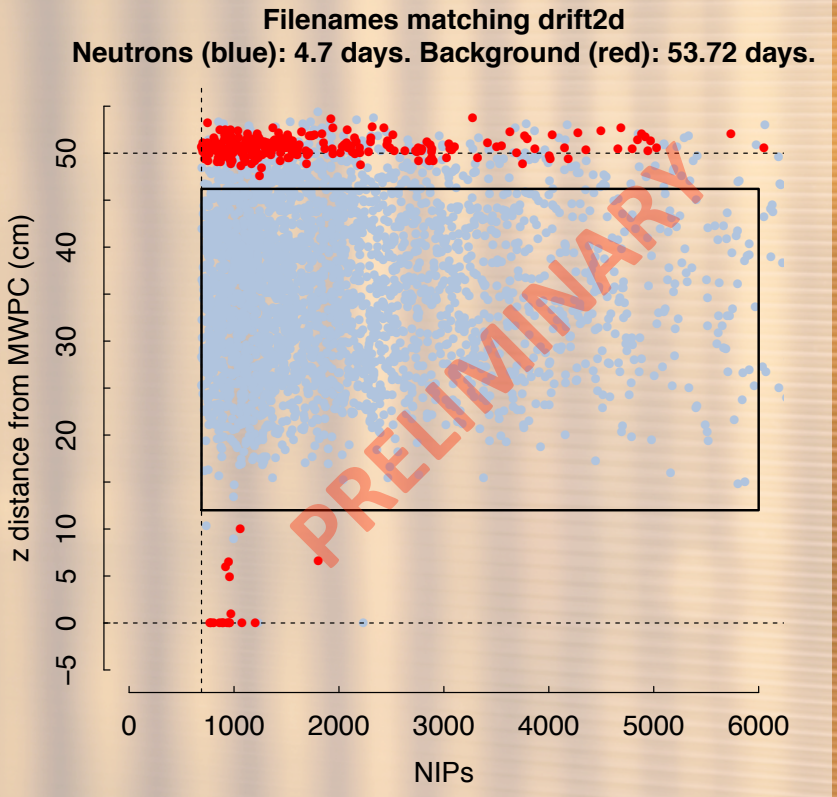
Automated analysis



Data collected with no gas flow and a high effective threshold. Currently running with gas flow for improved O_2 stability, and a lower threshold.

- Peak-finding algorithm being developed to pick out minority carrier events in data.
- Acceptance rate 'by eye': 789+/- 10 events/d
- Latest algorithm acceptance rate: ≈ 425 events/d
- Efficiency loss at low z, where peaks are closely spaced, and high z, where S peak is suppressed.
- Cuts to remove residual bg: ratio of P to main peak charge, and anode to grid charge ratio.
- Low E, low z events are mismeasured due to wandering baseline, and easily removed by eye.
- Calculate **efficiency improvement factor:** ratio of neutron acceptance rate in 'minority carrier' data to that in 'traditional' data.
- Combine with 53.7 days' bg-free livetime to estimate limits on SD WIMP-proton x section.

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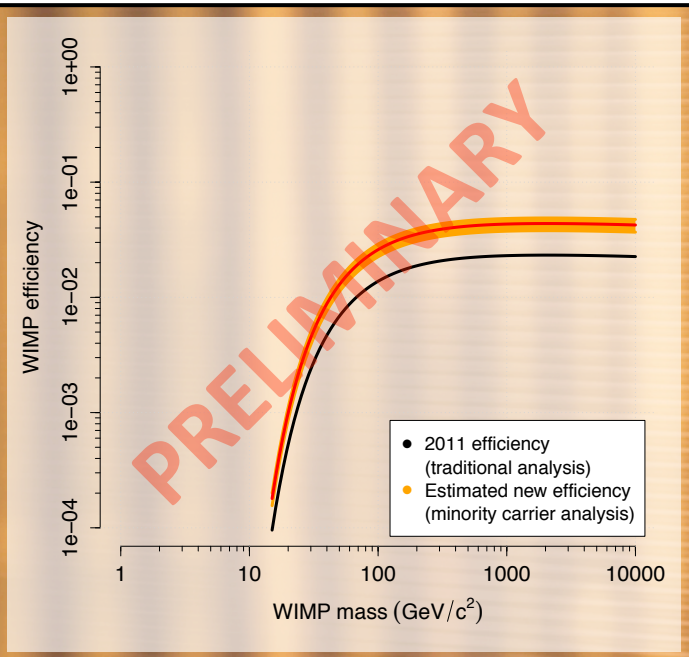
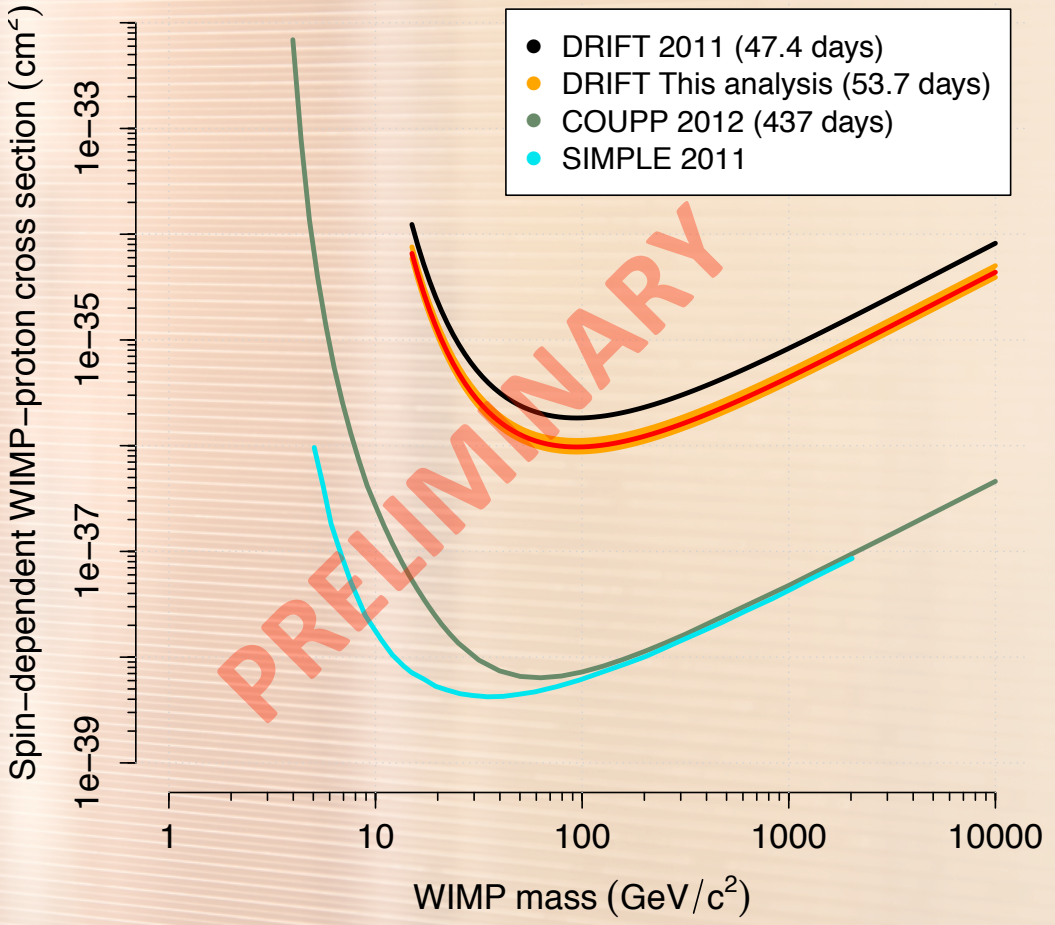
Estimated limit (automated)



- WIMP efficiency from previous work (Daw et al. Astro. Part. Phys. 35 (2012)).
- Scale up by ratio of neutron acceptance with 'traditional' and 'minority carrier' analyses (**improvement factor**) -> red line.



Estimated limit from minority carrier data. Orange bands due to uncertainty in the neutron acceptance used to calculate the improvement factor.

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Summary

- Minority carriers yield absolute z position of events in DRIFT.
- Select these events using ratio of charge in minority peaks (**mp.ratio**).
- Permits simplified set of cuts to be used, increasing neutron/WIMP acceptance.
- Backgrounds are all from cathode (maximal z) or MWPCs (minimal z).
- Define signal region in z vs energy space.
- Efficiency improves by a factor of ≈ 3 over old analysis (≈ 2 with auto. analysis).
- Early hints of efficiency improvement factor ≈ 6 with reduced threshold.
- Next: develop a full-chain simulation capable of generating minority carrier events, which will obviate the reliance on previous results for limit setting.

- Thanks!