Latest Results from DRIFT

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On behalf of the DRIFT collaboration

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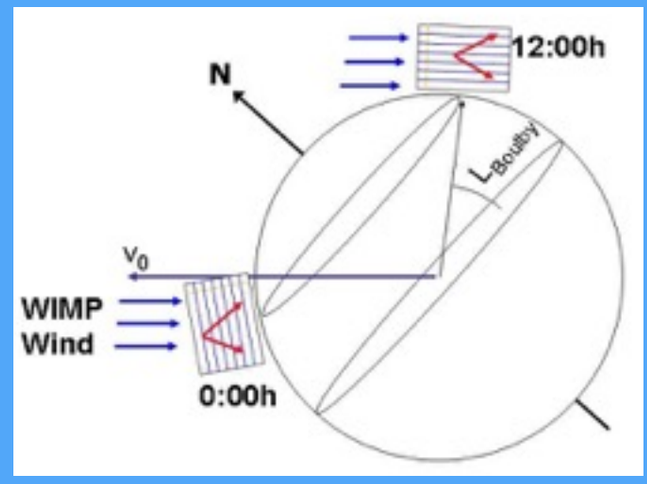
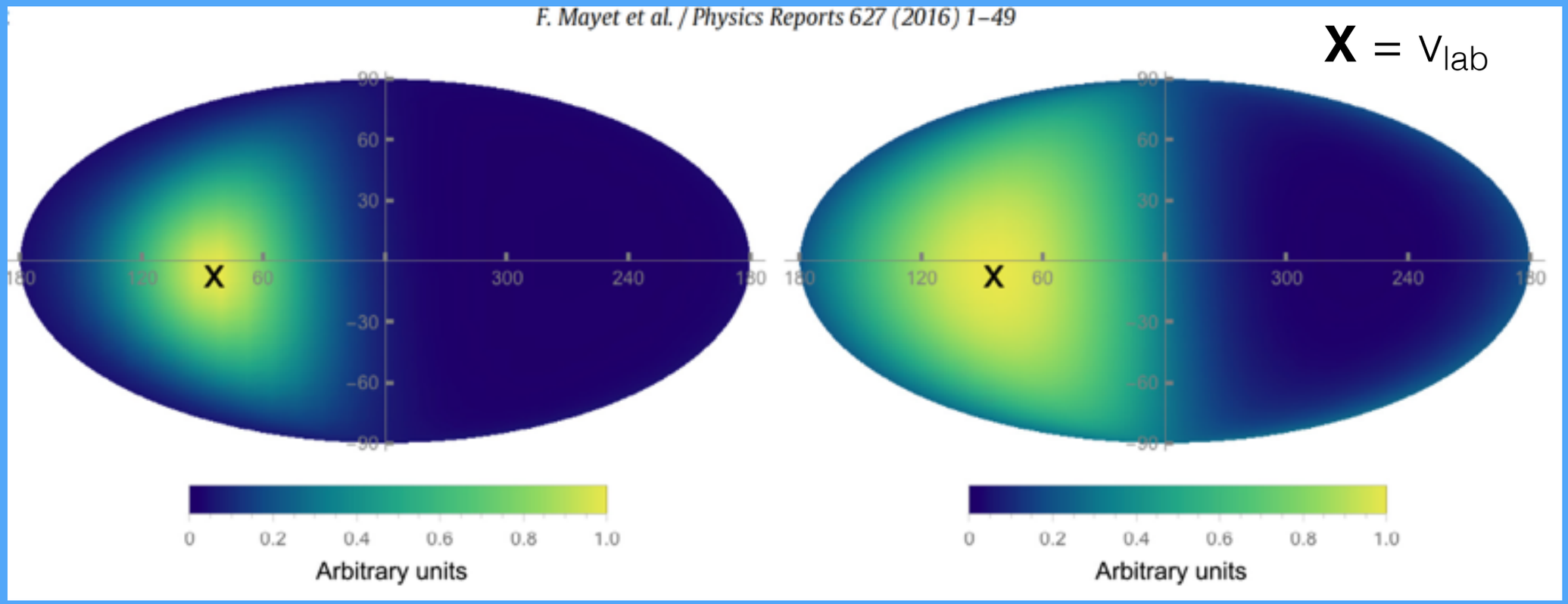
Directional Detection

- DRIFT is a directional DM detector.
- See ‘WIMP wind’ from motion around galaxy, roughly towards Cygnus constellation.
- Dipole anisotropy peaking in the direction of motion of the Sun.
- Need to reconstruct energy and direction of nuclear recoils from WIMP interactions.
- This signature provides an unambiguous separation of signal and backgrounds.



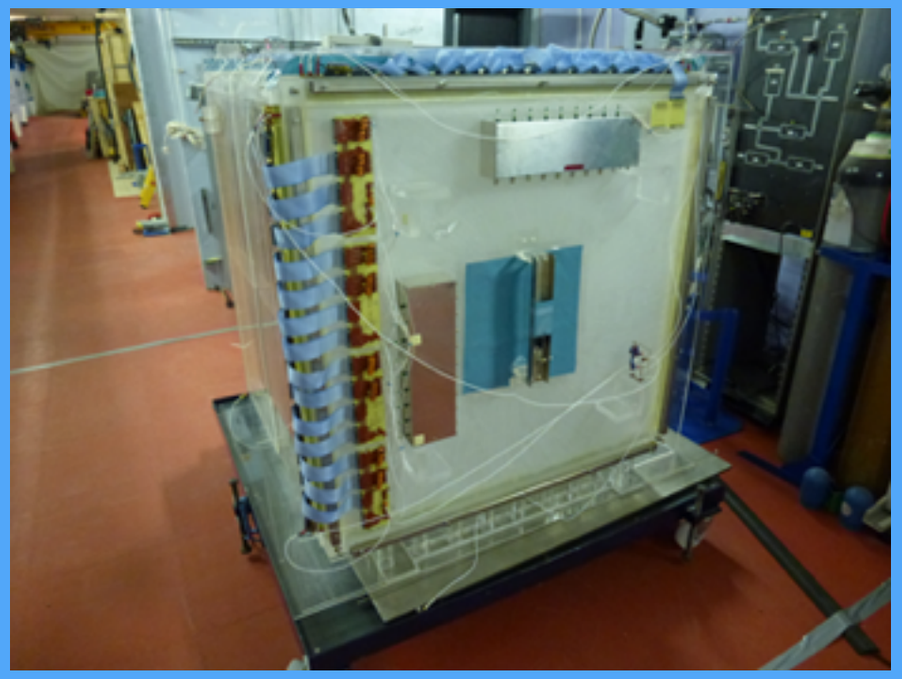
Direction of incoming WIMPs (Galactic co-ordinates)

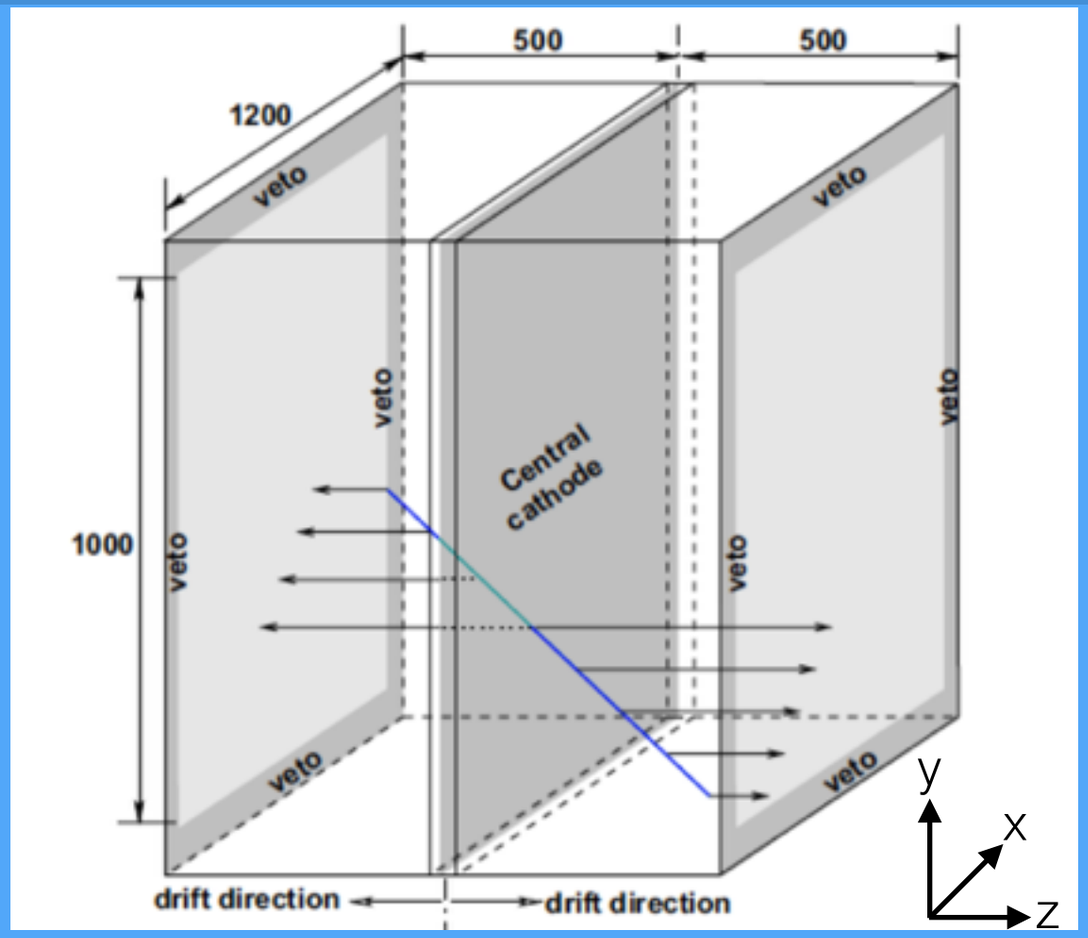
Direction of nuclear recoils (Galactic co-ordinates)



DRIFT

- Current detector (DRIFT-IId) running at Boulby Underground Laboratory.
- $1m^3$ negative-ion TPC using two MWPCs for readout.
- Target gas (41 Torr):
  - CS_2 (30 Torr)
  - CF_4 (10 Torr)
  - O_2 (1 Torr)



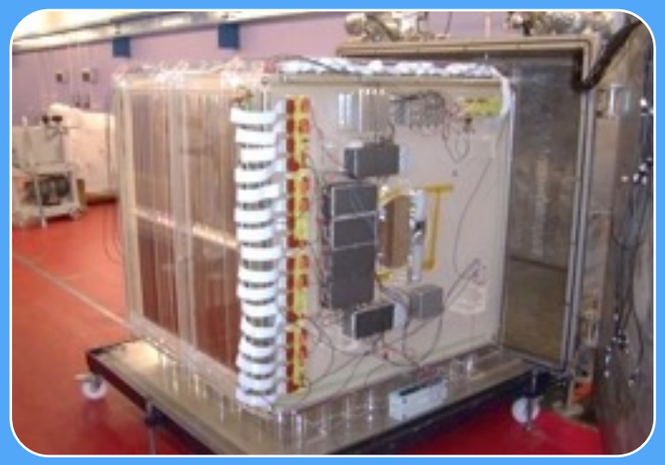


- MWPCs contain 3 planes of wires.
- 20 μm anode wire plane - 2 mm separation.
- Orthogonal 100 μm grid wire planes 1 cm from anode on either side.

Boulby Underground Laboratory

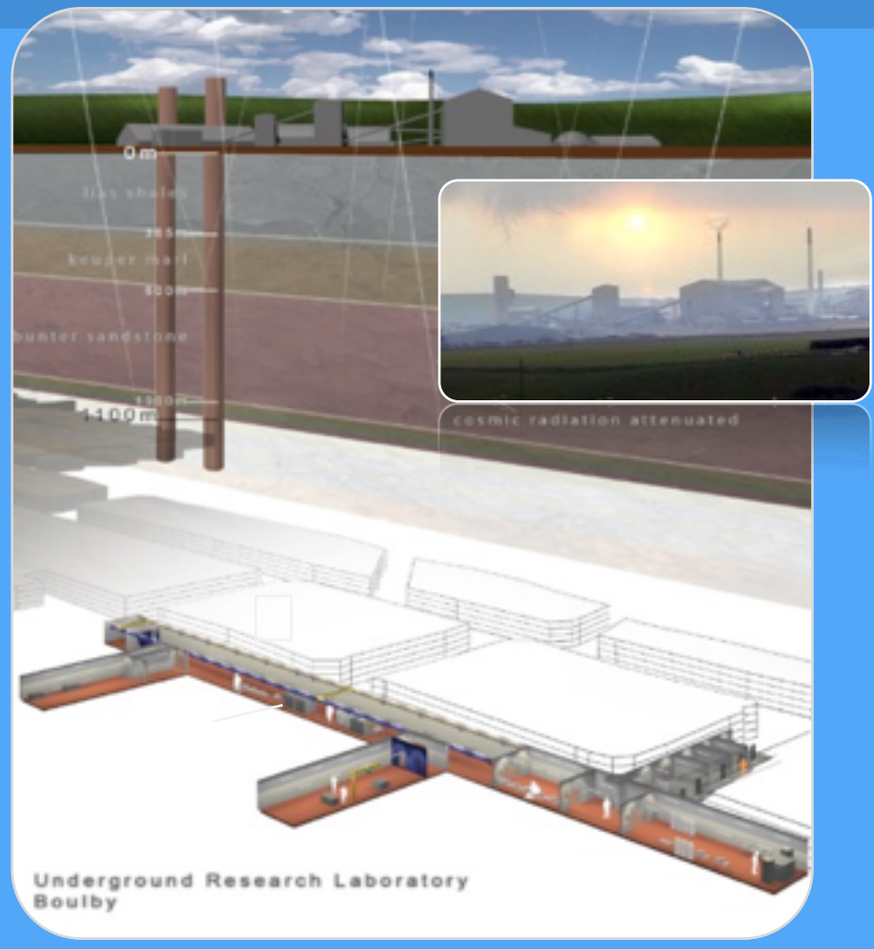
The UK's deep underground laboratory. In a working potash & salt mine in the NE of England.

1.1km depth (2805 mwe). With low background surrounding rock-salt.



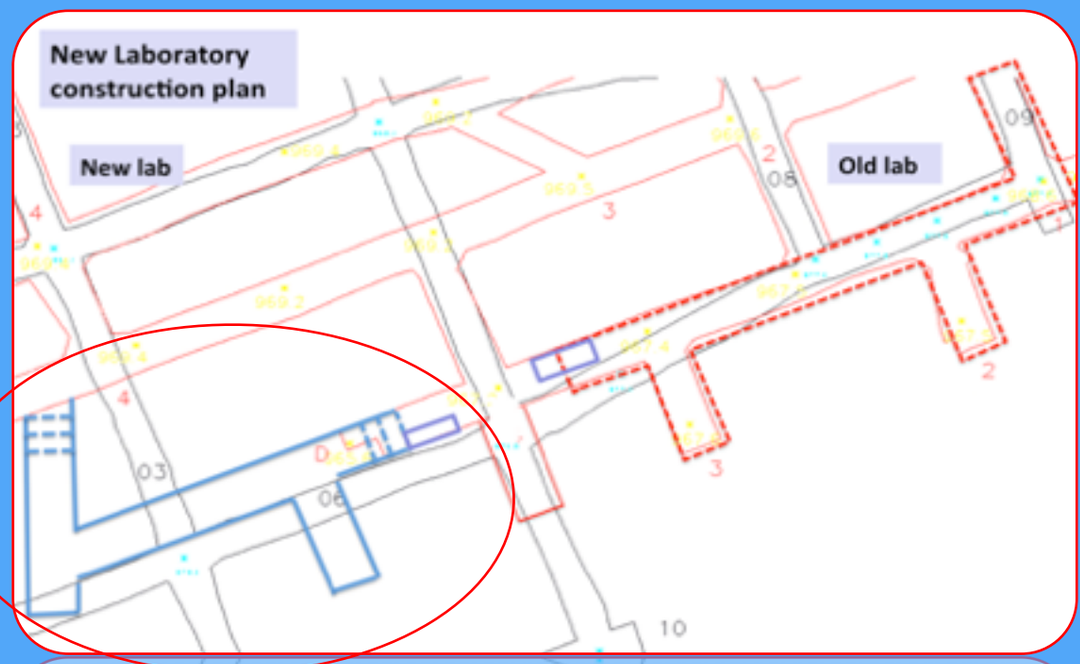
DRIFT in the old Palmer Lab

ICL Fertilizers

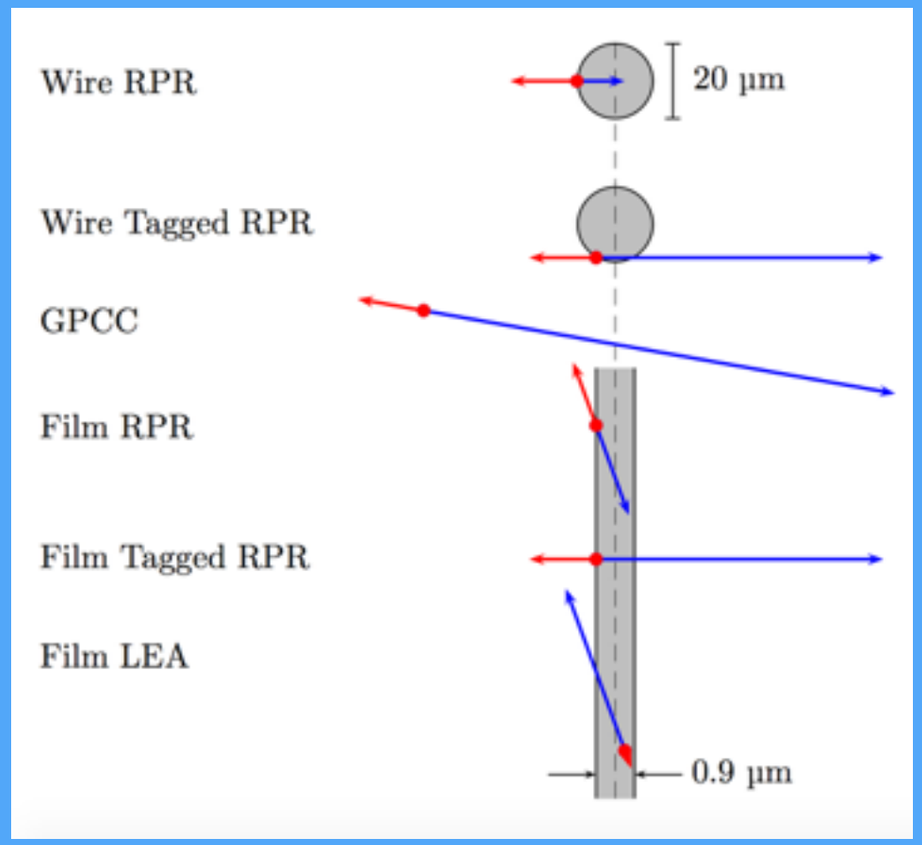


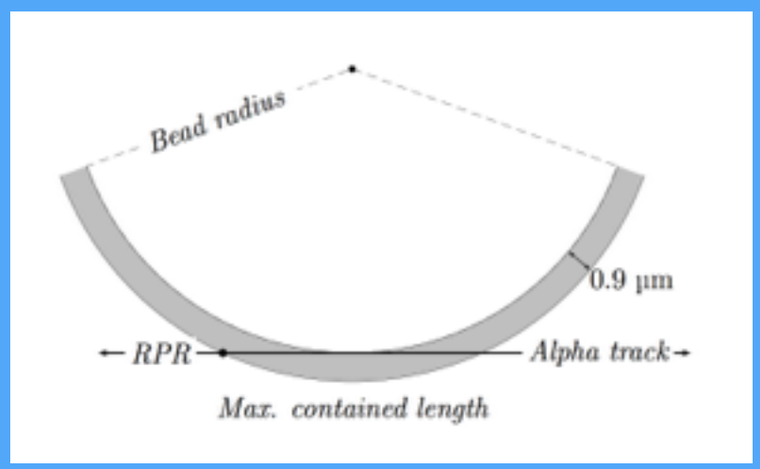
Science & Technology Facilities Council

Now a new 4000m³ laboratory at Boulby



Zero Background





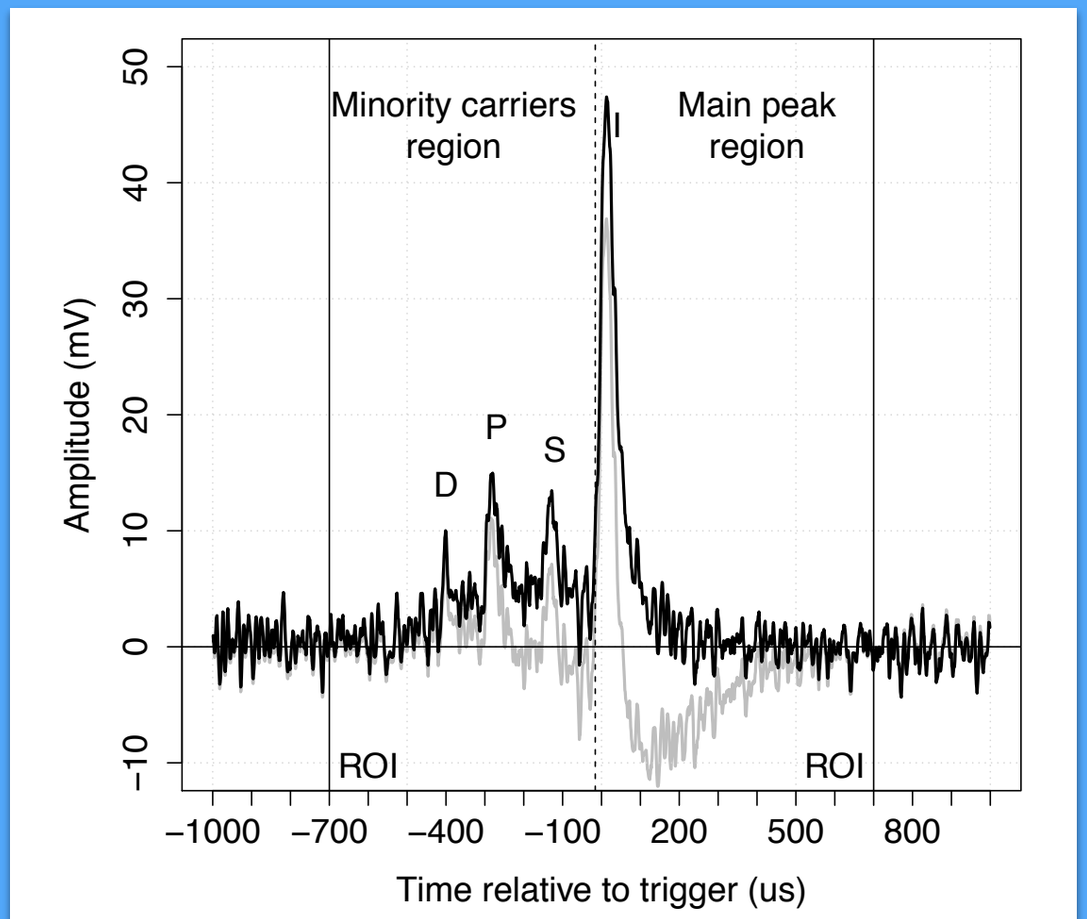
arXiv:1502.03535

Zero background achieved through combination of two methods.

1) Texturised thin-film cathode

- 0.9 µm aluminised-mylar.
- Bead-blasted to reduce max. contained alpha length.
- Factor 70 ± 20 reduction in probability of producing RPRs.
- Rejection via α-tagging = 99.97%

Zero Background



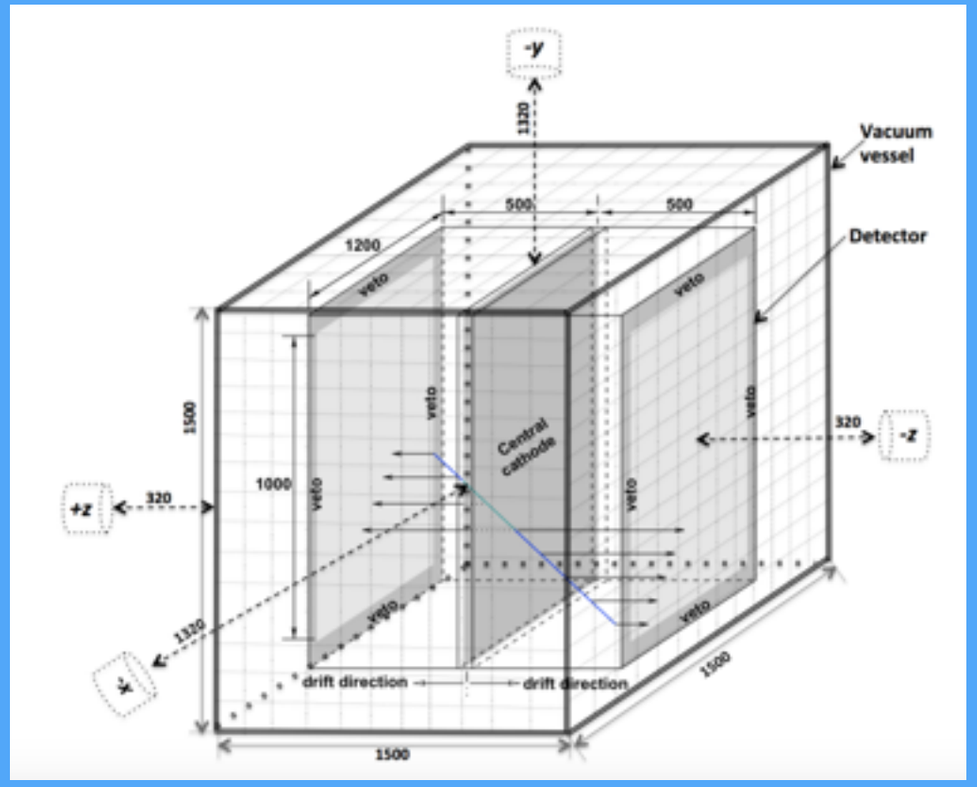
arXiv:1308.0354

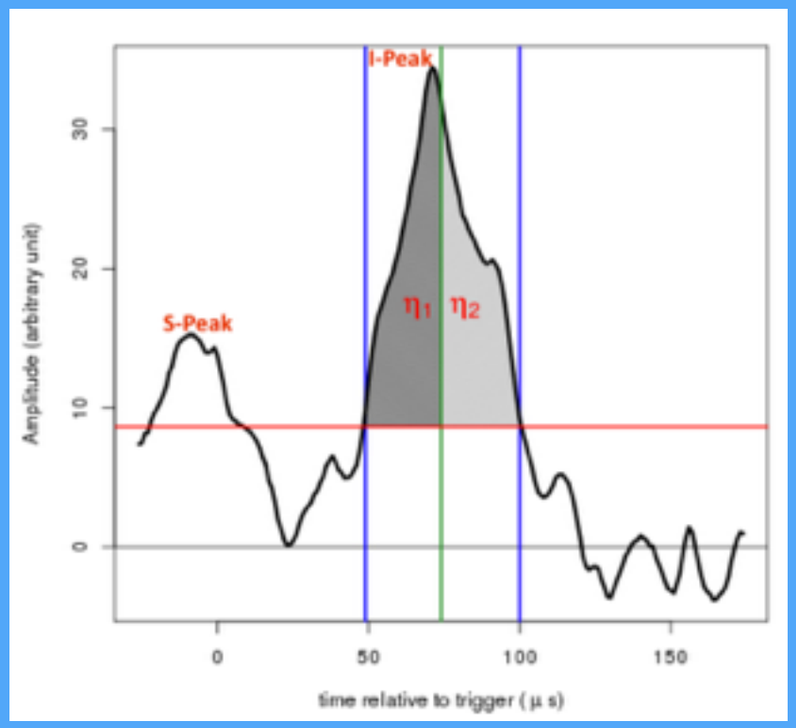
2) z-fiducialisation

- Addition of O2 produces minority carriers.
- Separation in peaks proportional to distance travelled.
- Allows full fiducialisation of detection region in z dimension.
- Cut in z removes remaining RPRs

Directional Sensitivity

- Directed neutron runs made to probe directional sensitivity.
- First measurement since minority carriers introduced.
- Looking for head-tail in optimal direction (± z).
- Look for ratio of charge in beginning and end of the ionisation peak.
- Although not full reconstruction, head-tail can still be used to show anisotropy of recoil direction.





arXiv:1606.05364

Directional Sensitivity

- α calculated for each event, where $\alpha = \eta_1/\eta_2$.
- Mean α calculated for left and right detectors, $\langle\alpha\rangle_L$ & $\langle\alpha\rangle_R$.
- Due to shaping effects we take combination of left and right detectors for each run.
- δ = is the ratio of $|\Delta\alpha|$ to the mean of $\langle\alpha\rangle_L$ & $\langle\alpha\rangle_R$, expressed as a percent.
- The magnitude of δ parameter is equivalent to the amplitude of the head-tail effect.

$$\alpha \equiv \frac{\eta_1}{\eta_2}$$

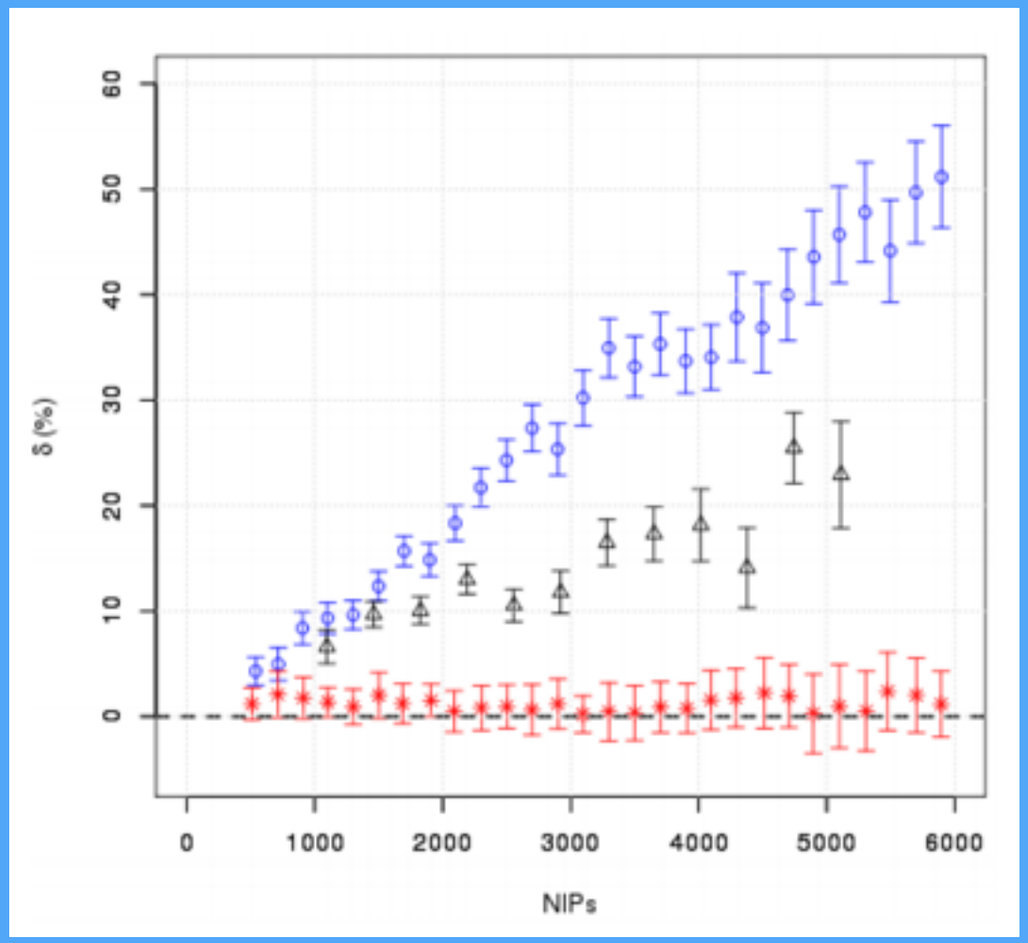
$$\Delta\alpha \equiv \langle\alpha\rangle_L - \langle\alpha\rangle_R$$

$$\delta = 100\frac{|\Delta\alpha|}{\frac{1}{2}\left(\langle\alpha\rangle_L + \langle\alpha\rangle_R\right)}$$

Directional Sensitivity

- See head-tail in optimal direction and none in anti-optimal as expected.

- Result appears higher than pre-O_2 result but that is due to seeing longer C & F recoils - where previous result used only S recoils.

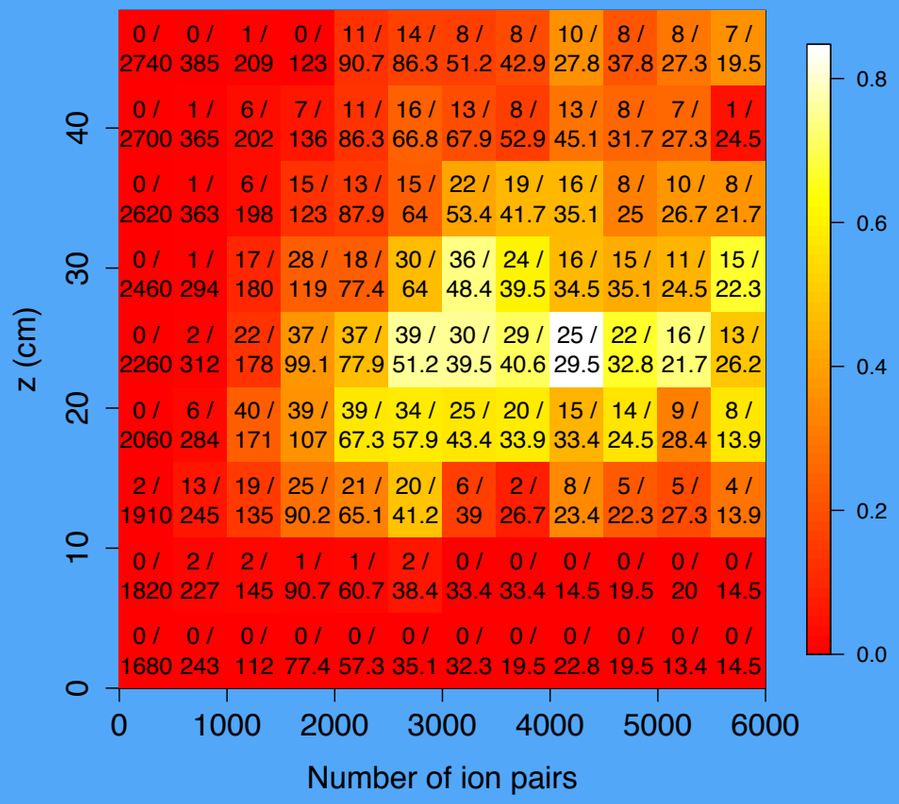


Blue = Optimal Direction
Red = Anti-Optimal
Black = Pre-O2 Data

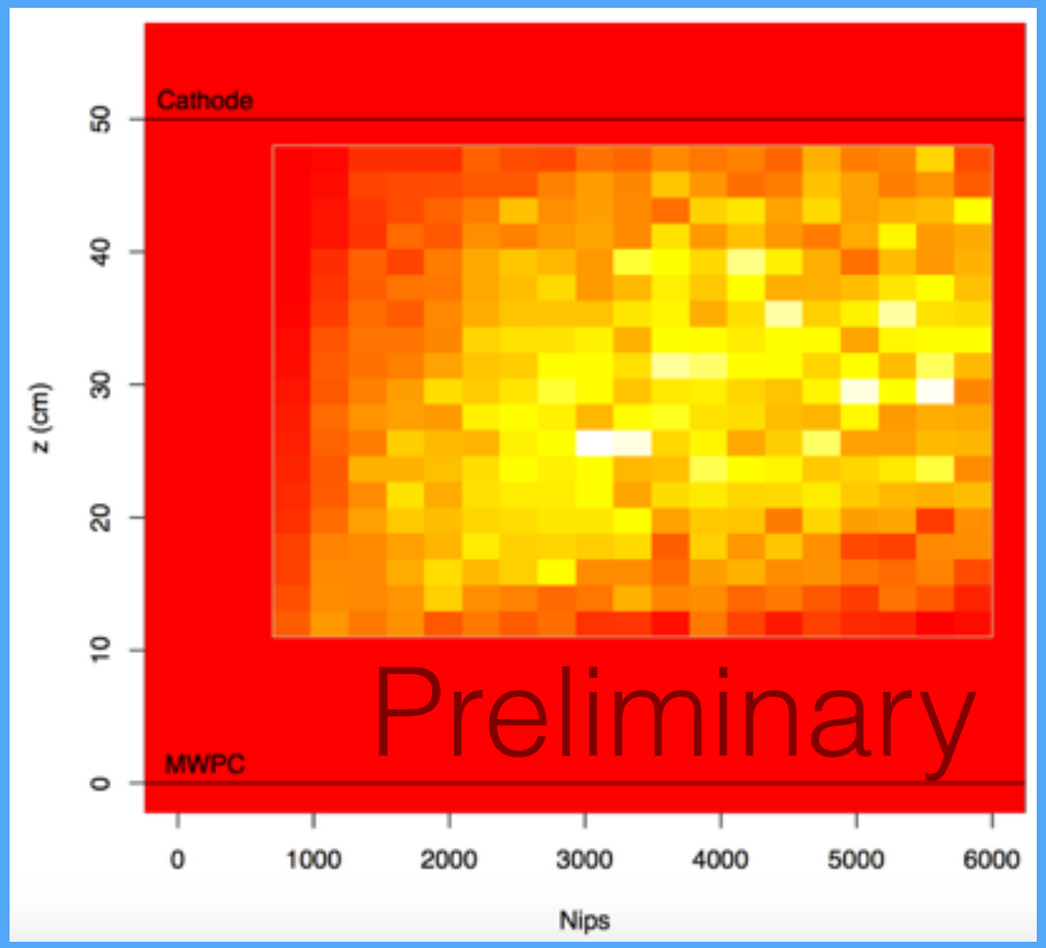
arXiv:1606.05364

Low Threshold Data

- Minority carriers ‘steal’ ~50% of charge from main I-peak.
- Effectively doubled our threshold in last set of data. (arXiv:1410.7821)
- We have now halved the threshold which increased efficiency.



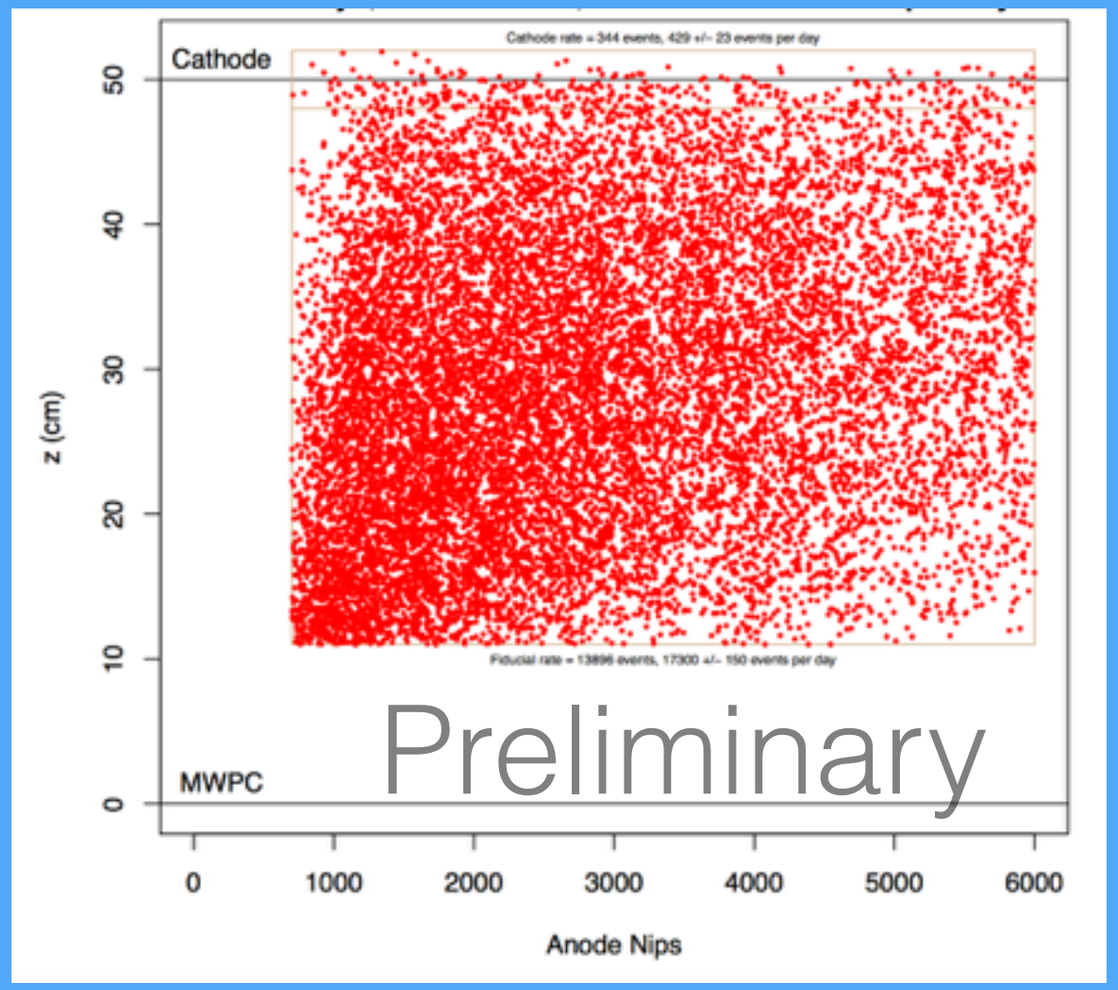
Old efficiency map



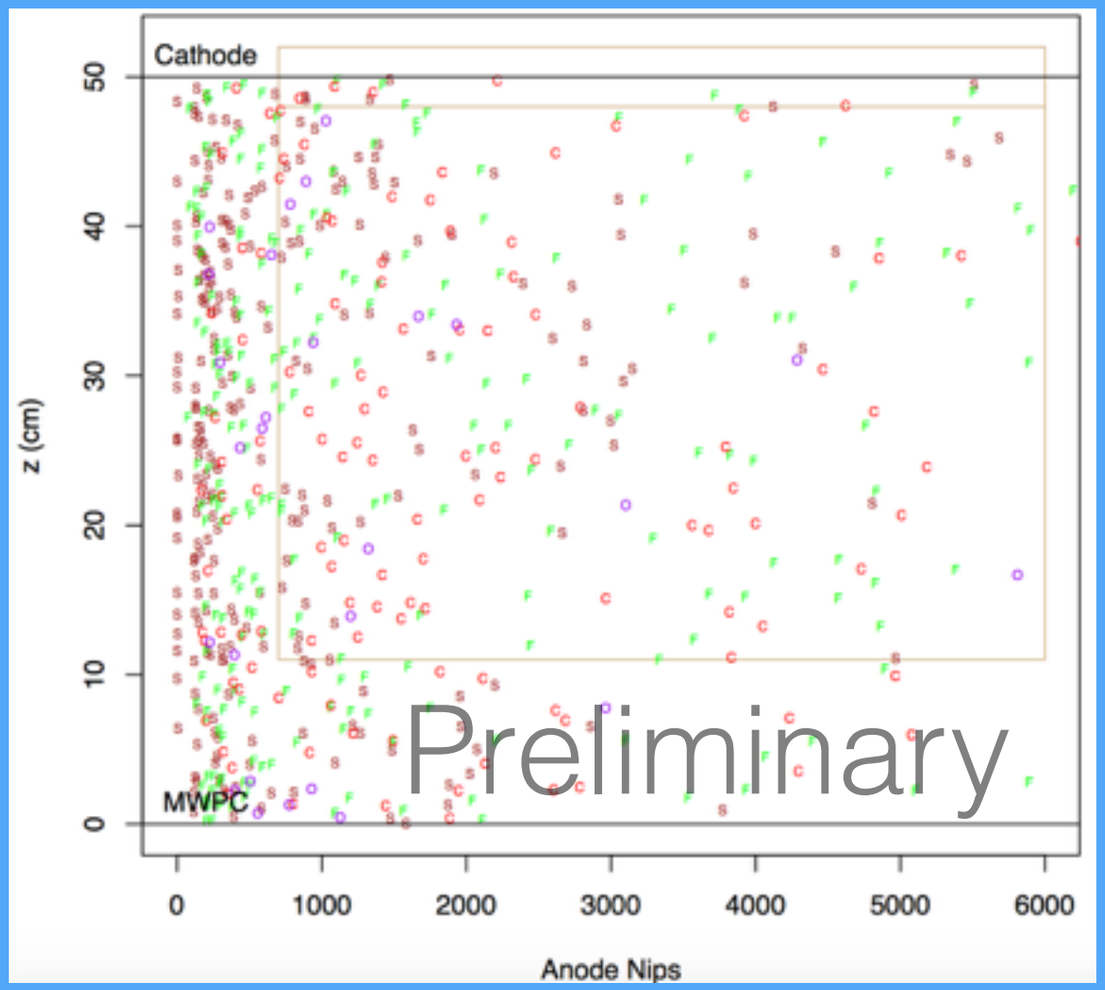
New efficiency map

Efficiency Calculation

- Expose detector to Cf-252 neutron source then simulate same exposure.
- Take a ratio of detected/expected for different parts of the detector.



Data

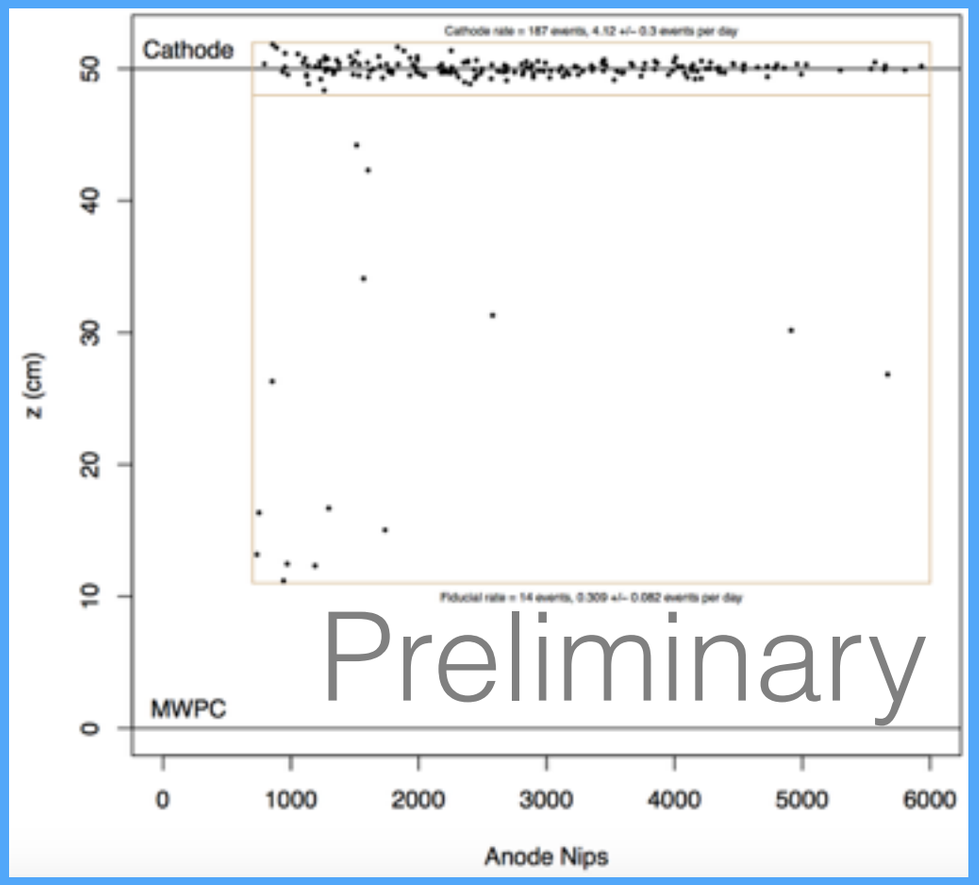


Geant4

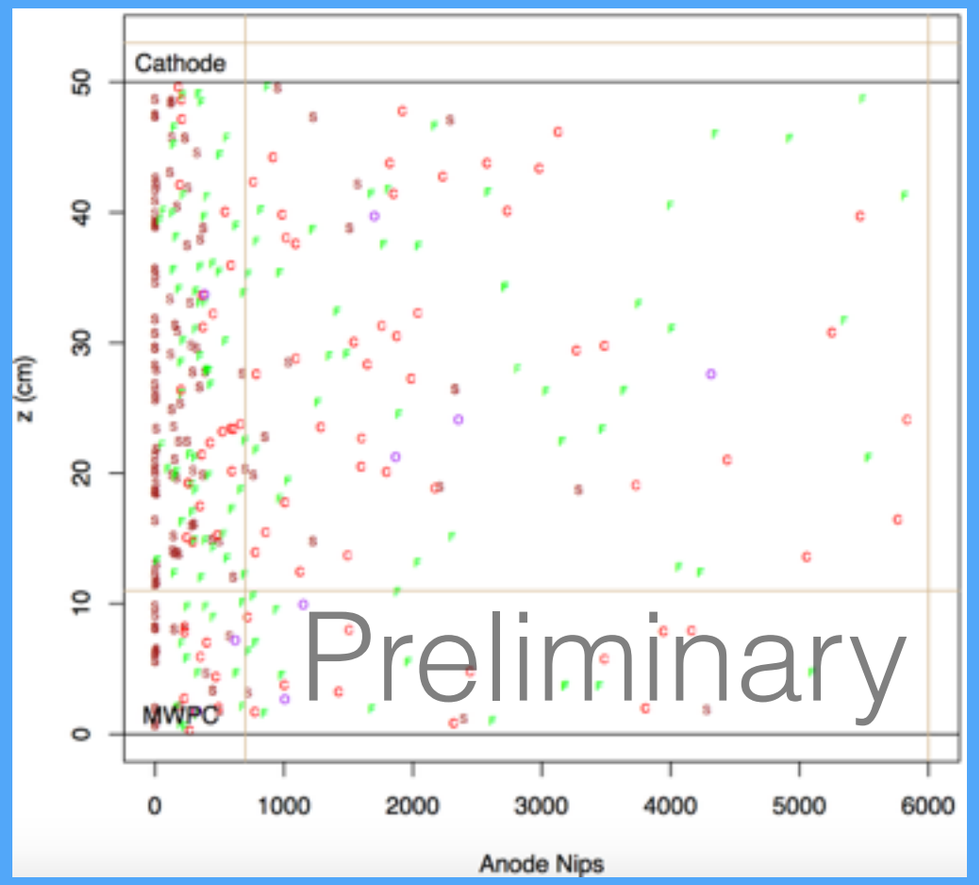
Sensitivity to Rock Neutrons

- Detector run unshielded for 45.4 live days to test sensitivity to rock neutrons.

- 14 events seen. Result in agreement with GEANT4 simulation.



Data: 0.31 ± 0.08 events/day.



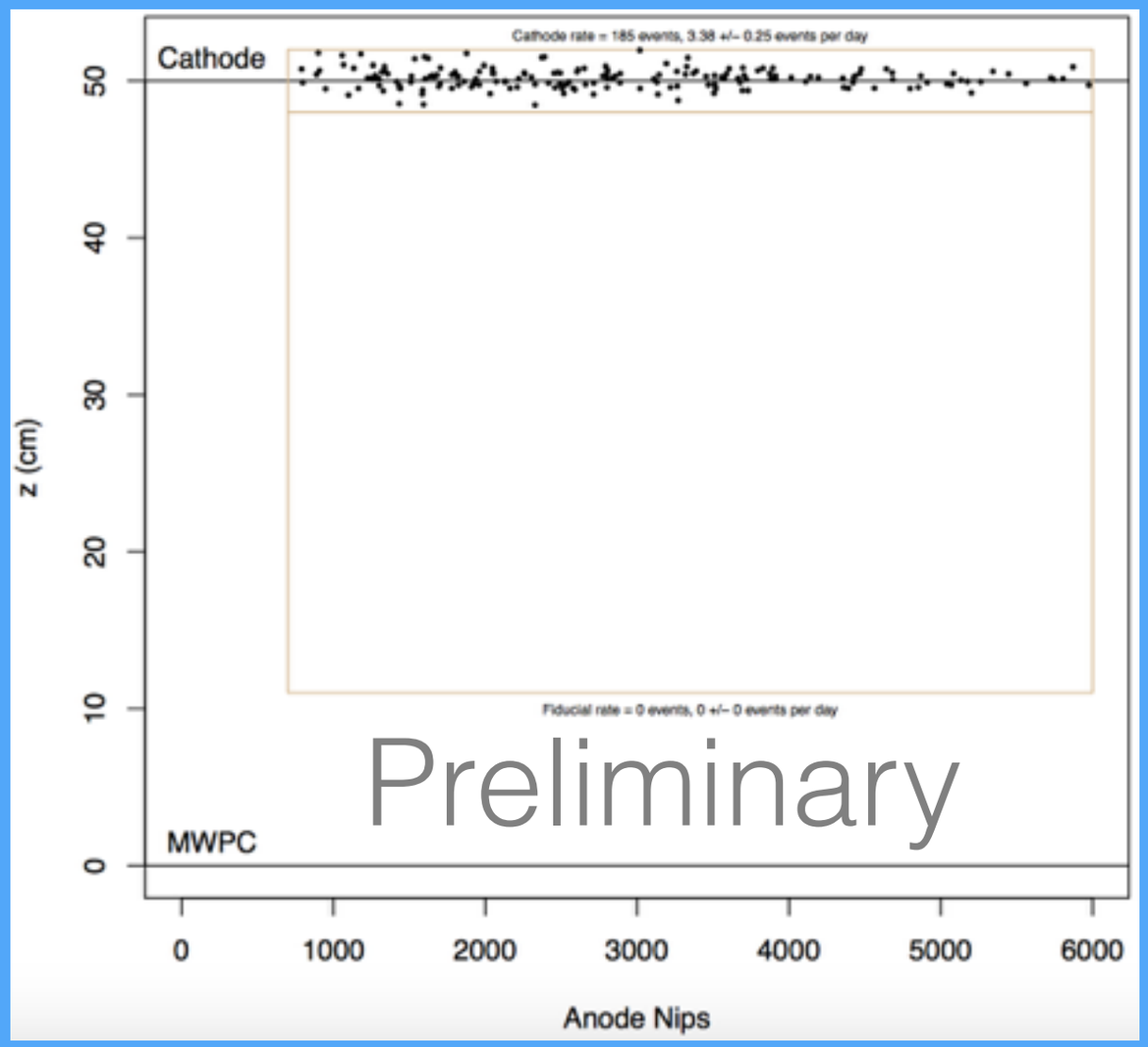
Geant4: 0.23 ± 0.02 events/day.

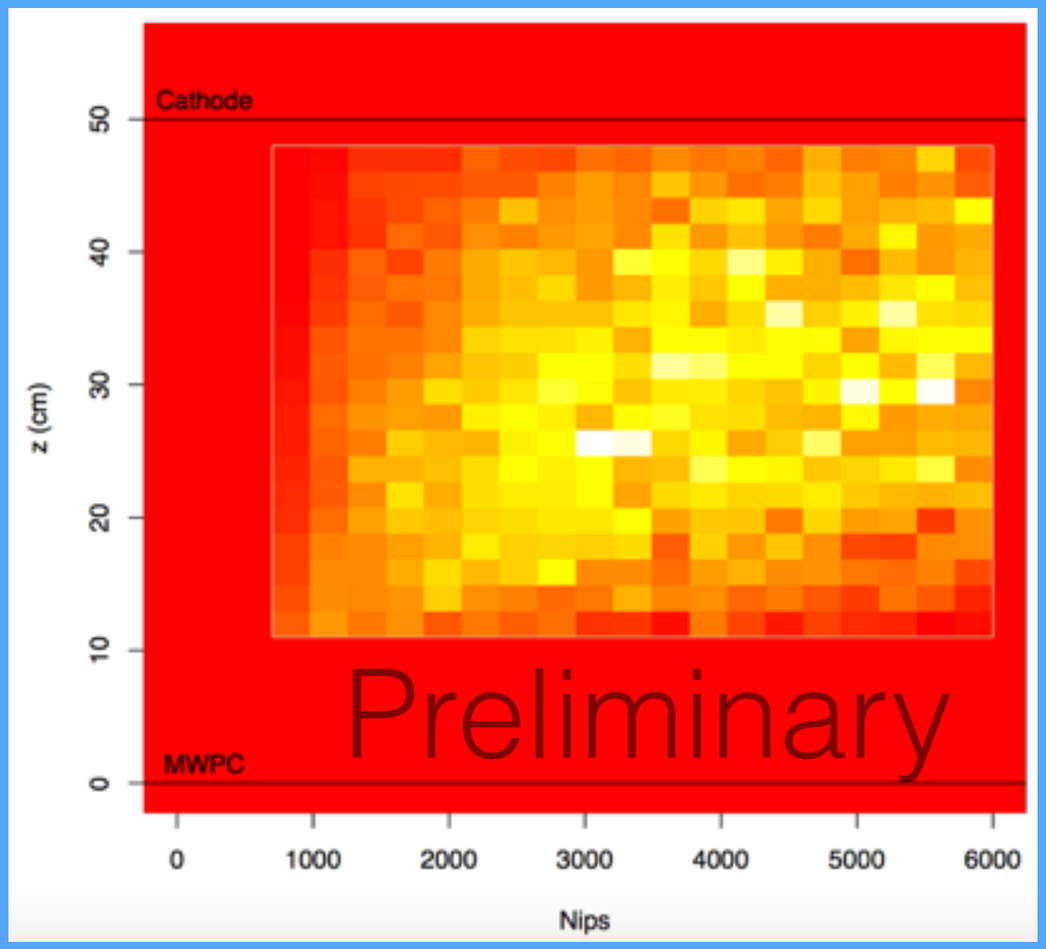
Gamma Rejection

- The 14 events seen may be from gammas.
- Tested by exposing detector to 3 x 37 kBq ^{60}Co sources for 2.90 live days.
- No events seen so we can calculate a gamma rejection factor.
- Within the fiducial window the Geant4 simulation predicts a rate of 46.26 ± 0.07 Hz.
- New (preliminary) rock-gamma rejection factor of **1.98×10^{-7}** (90% C.L.).
- Gives upper limit (90% C.L.) on gamma contamination of 3 events.
- This shows most events were not from rock gammas.

Shielded running

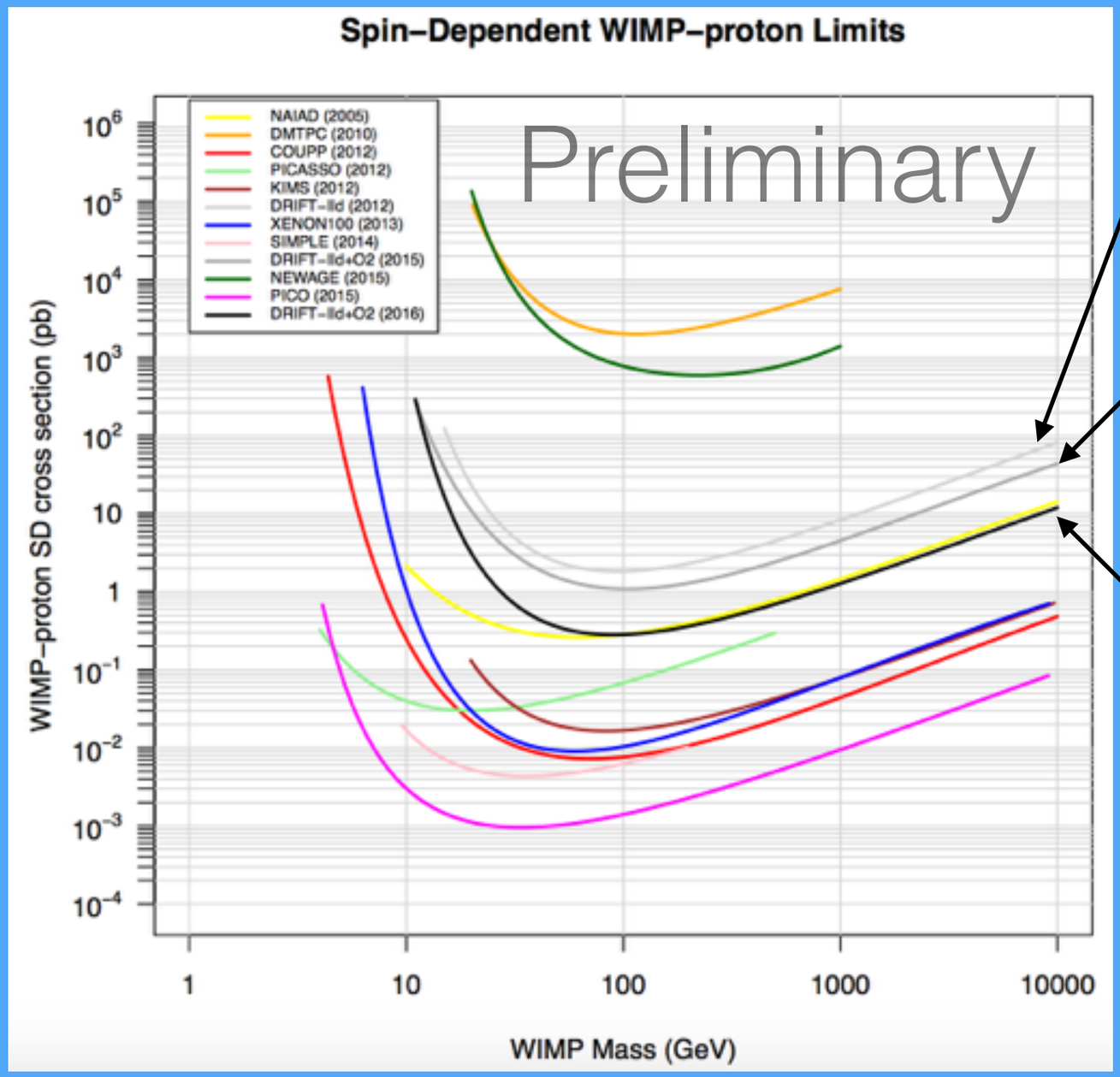
- Run fully shielded for 54.7 live-days.
- No events seen in fiducial region so WIMP limit can be set.





WIMP Limits

- SD limit 3x lower than previous publication.
- More data on file so further improvements still to come.



Summary

- DRIFT is running background free.
- It has been shown that DRIFT is still sensitive to head-tail.
- A new measurement of background neutrons has been made in Boulby.
- The rock-gamma rejection factor has been improved from previous publications to 1.98×10^{-7} (90% C.L.).
- An improved dark matter limit has been set, 3x better than the previous DRIFT limit.

Thanks for listening!

Backup - Z calculation