

New DRIFT Results

Directional Recoil Identification From Tracks (DRIFT)



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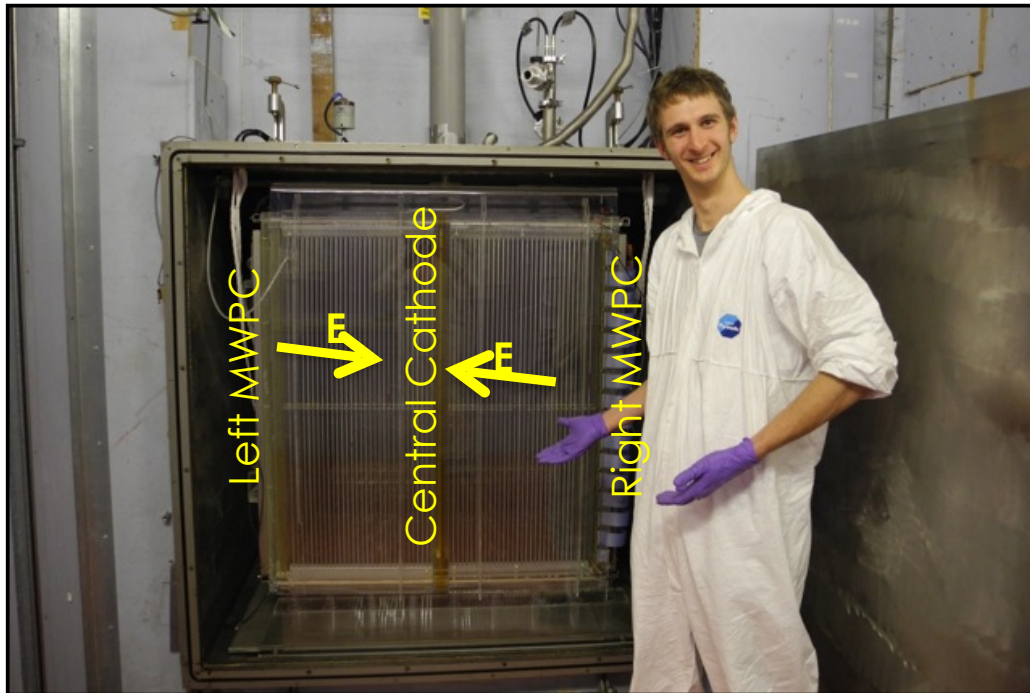


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Sven Vahsen – PI



Boulby Mine
Sean Paling – PI

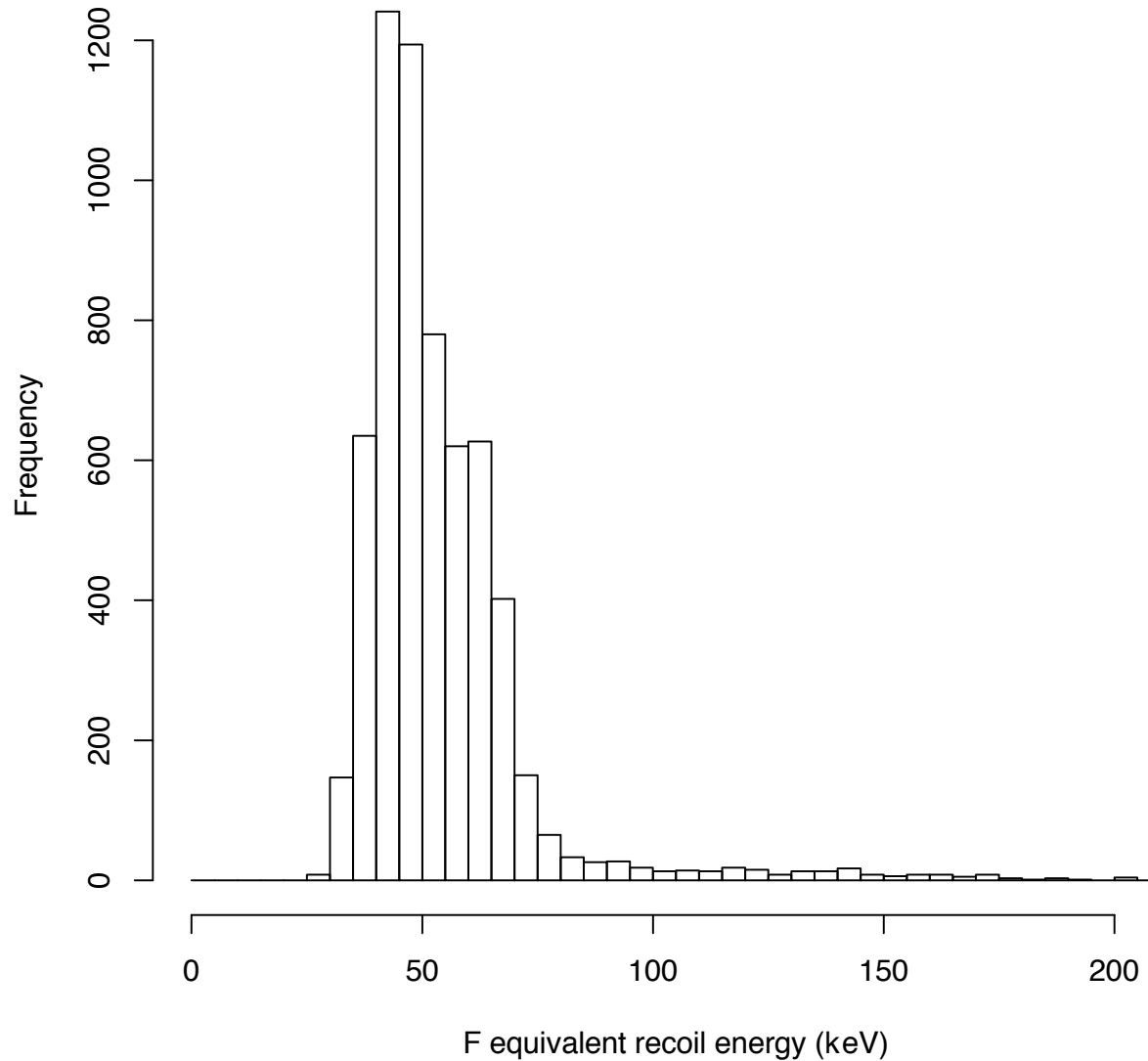
Introduction to DRIFT



- Directional Detector (PRD, **61** (2000) 1, NIMA, **600** (2009) 417, AstroPle, **31** (2009) 261)
- DRIFT has been operating in Boulby since 2001
- DRIFT-I -> DRIFT-II (a-e)
- DRIFT-IId volume = 0.8 m³, 40 Torr gas
- 50 cm drift region
- MWPC readouts (NIMA, **555** (2005) 173)
- Negative CS₂ anion drift to limit diffusion (PRD, **61** (2000) 1)
- Phenomenal Compton background rejection (AstroPle, **28** (2007) 409)
- Many gas mixtures possible
- DRIFT-IId used a 30-10 Torr of CS₂-CF₄ to optimize for spin-dependent limits, 139 g target mass.

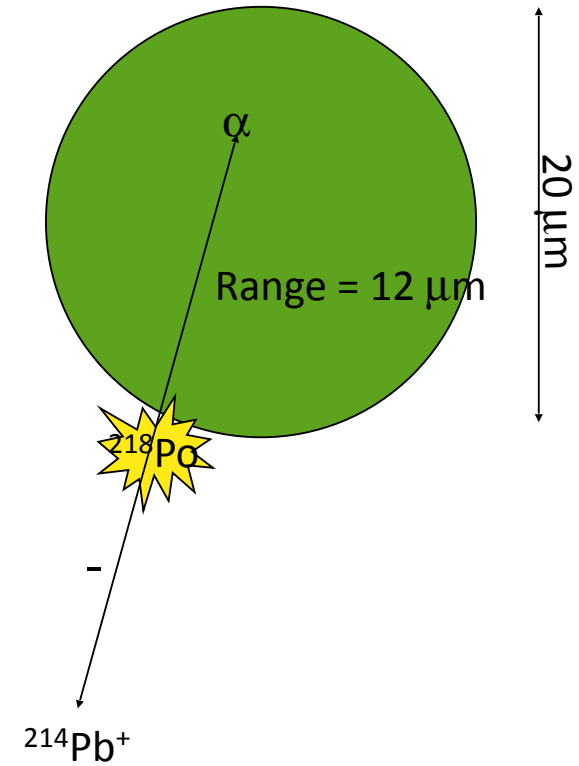
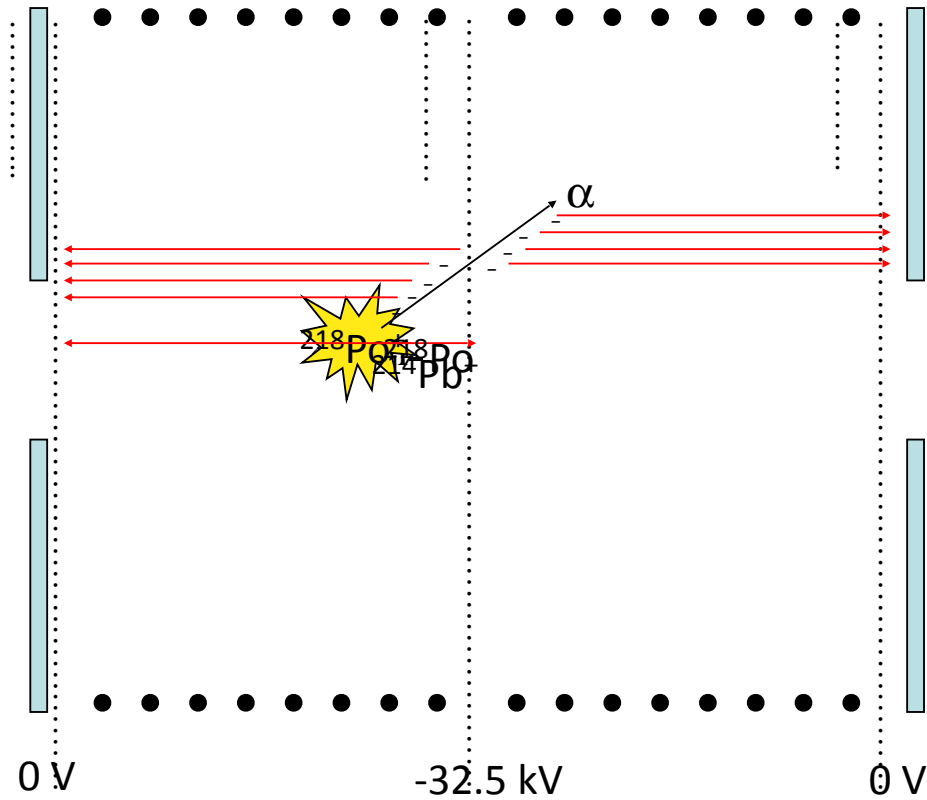
DRIFT-IIId Data

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



Texturized thin film



- Miraculously the guys at UNM managed to create a texturized 0.9 micron aluminized mylar thin film to replace the wire cathode.
- This means the alphas have “no place to hide.”
- This has been deployed on DRIFT-IIId in Boulby.
- The result was a drop from 130 events per day down to a few events per day.

Texturized thin film



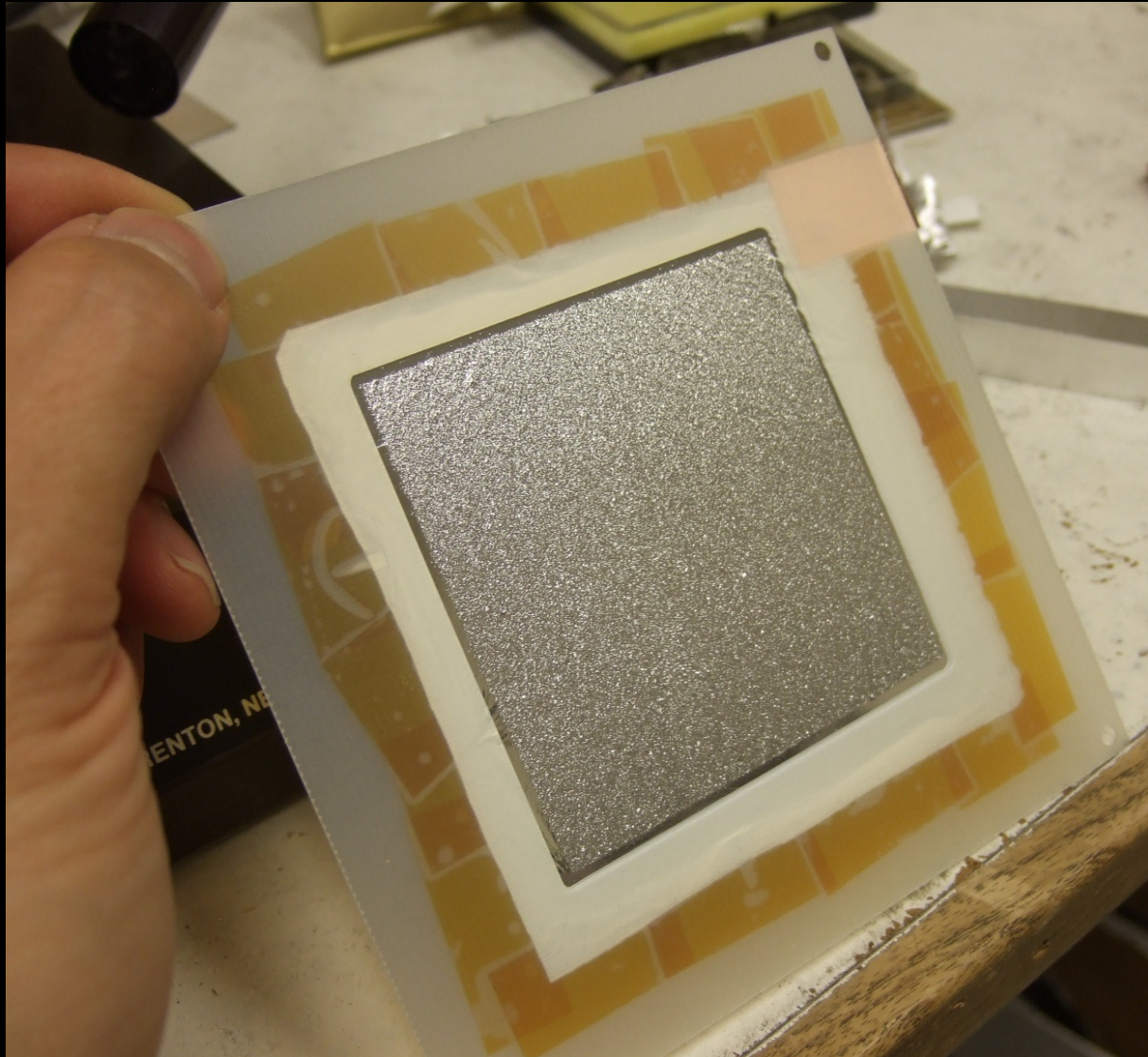
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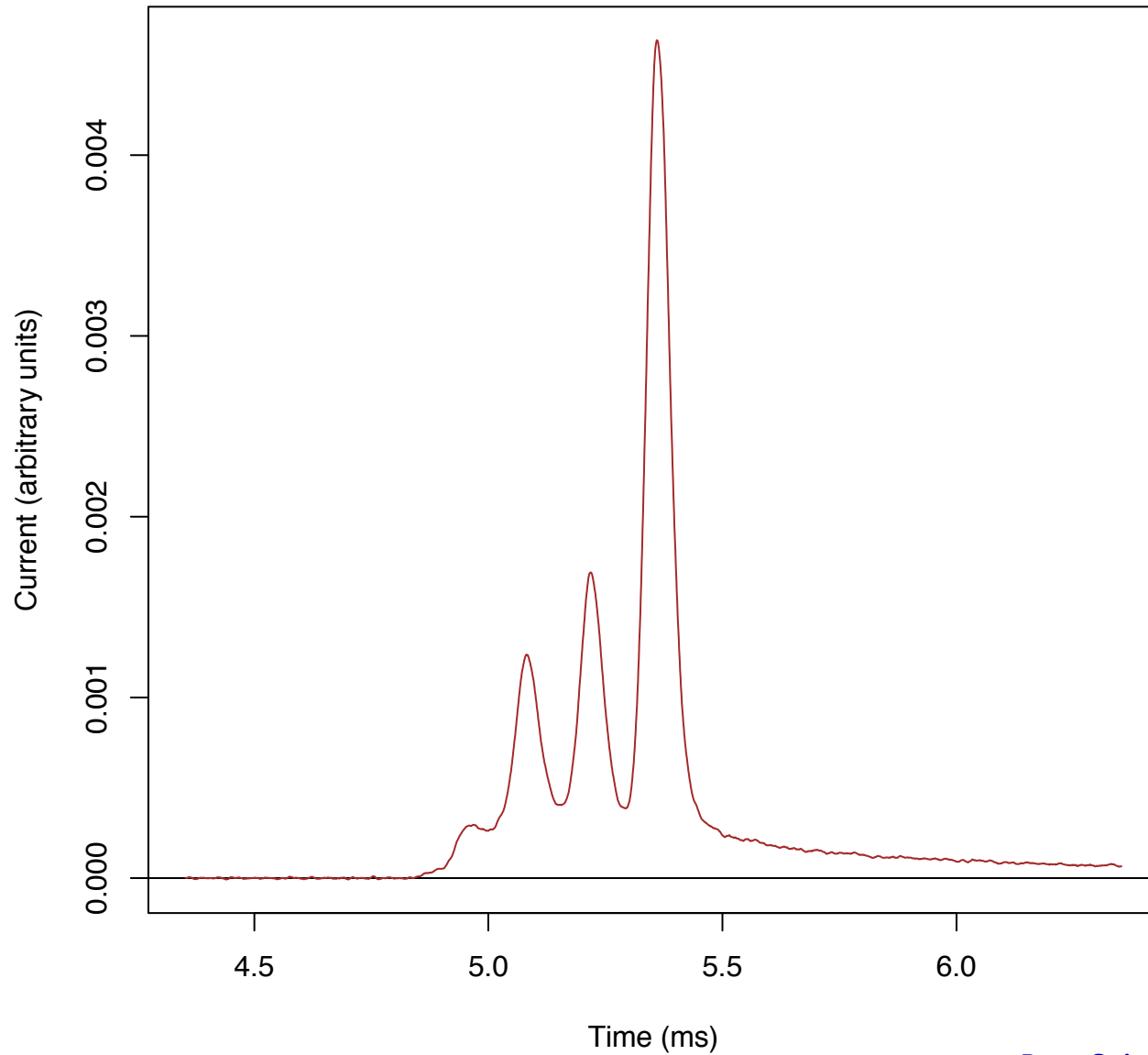
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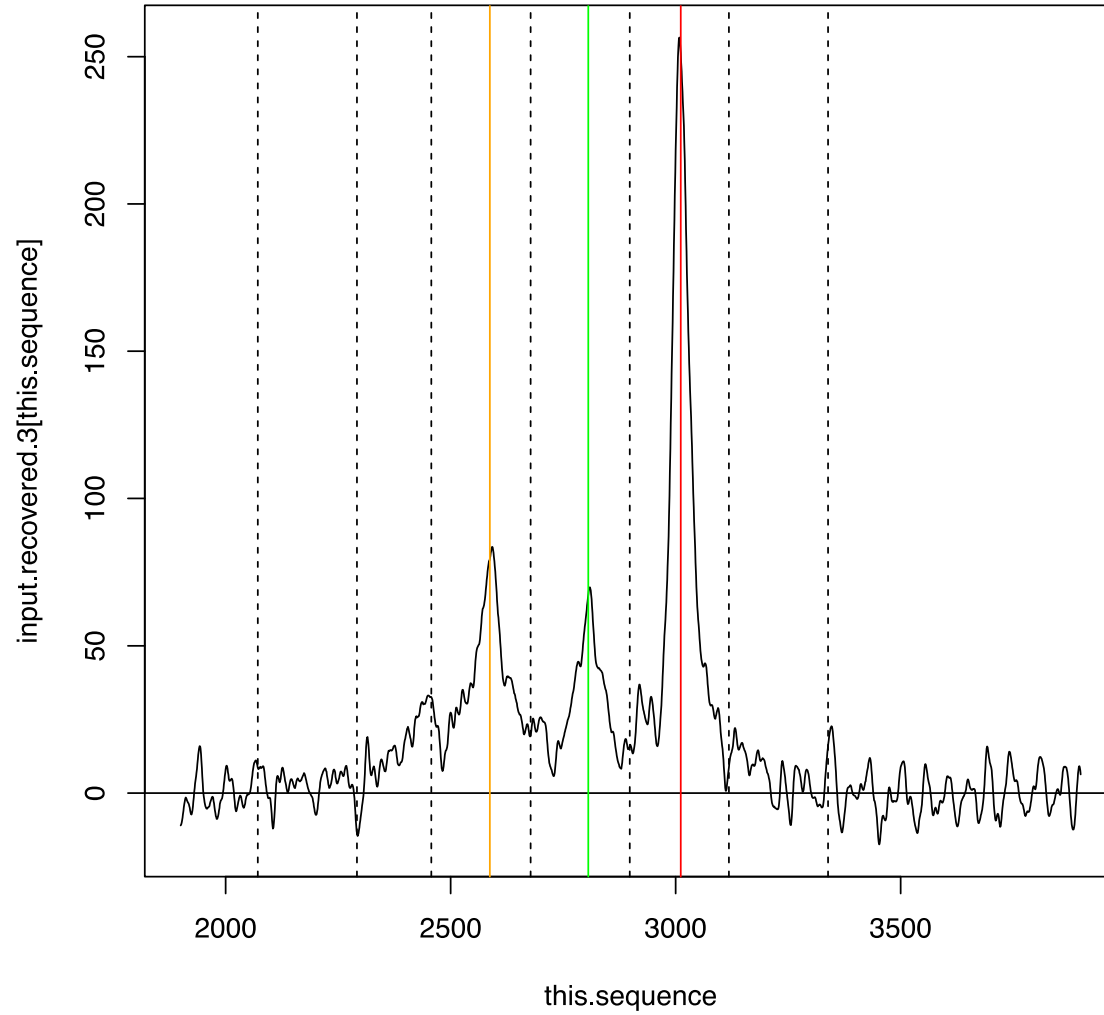
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Discovery of Minority Carriers in Mixtures of CS₂ and O₂



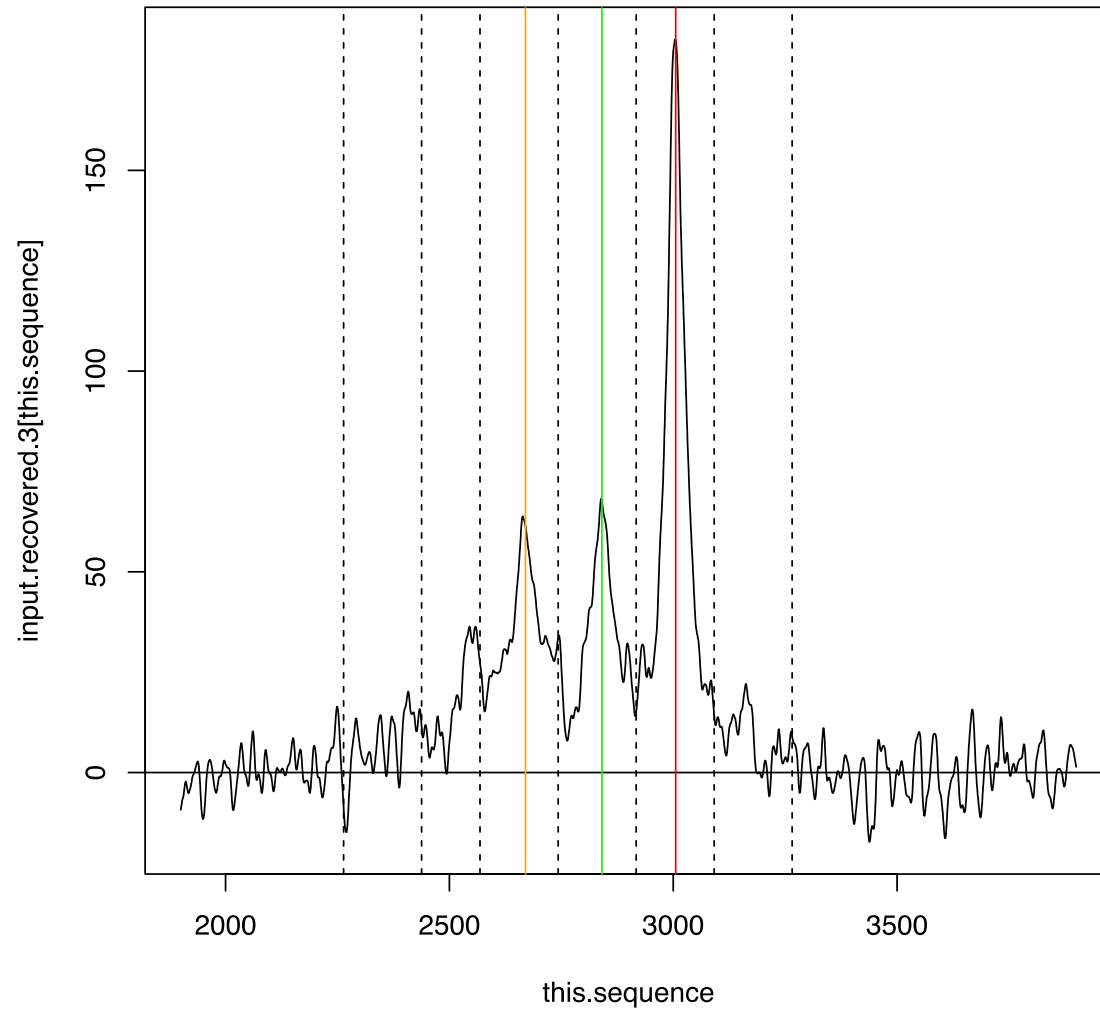
Examples

$z = 49.7 \text{ cm}$



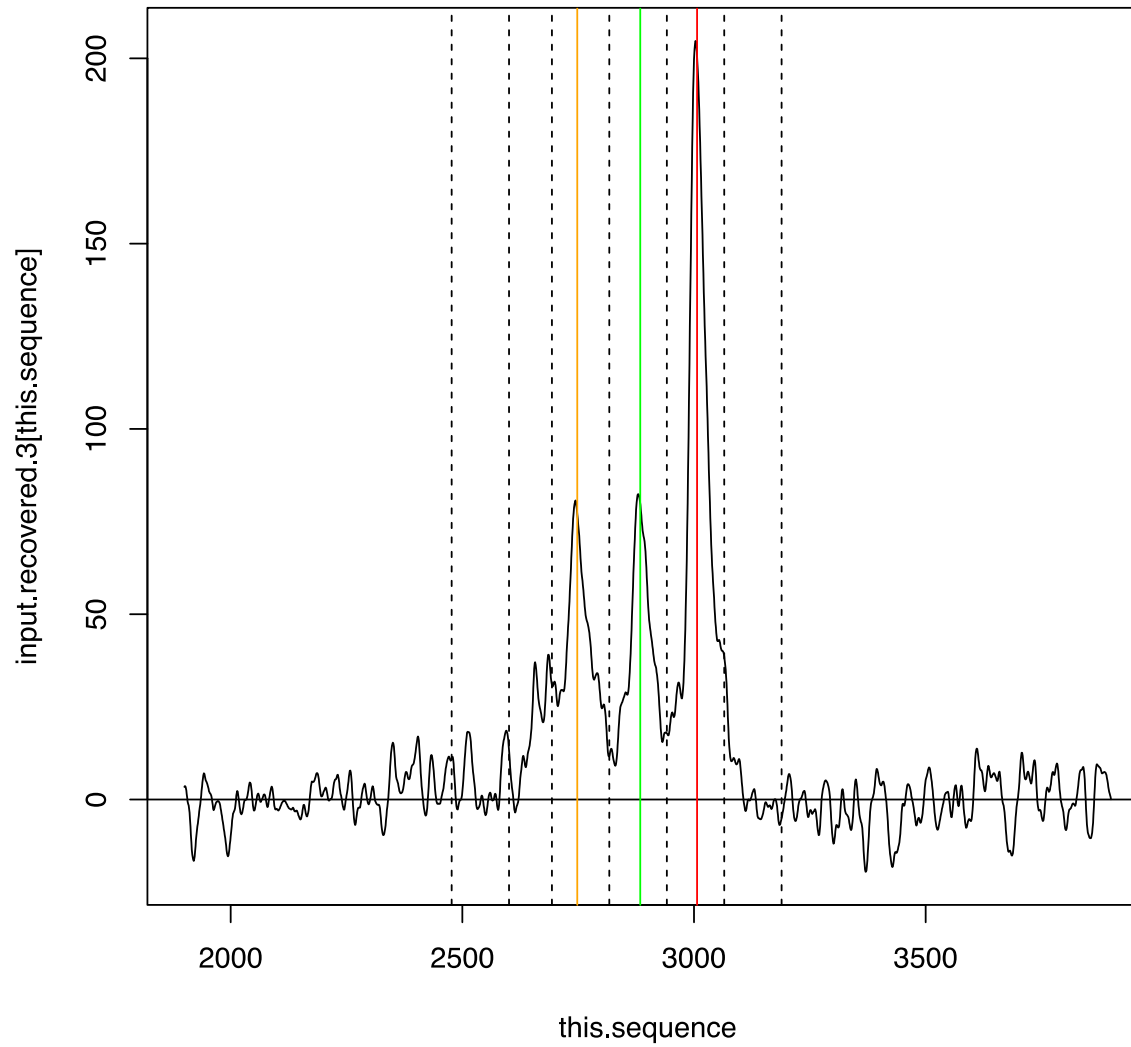
Examples

$z = 39.3 \text{ cm}$



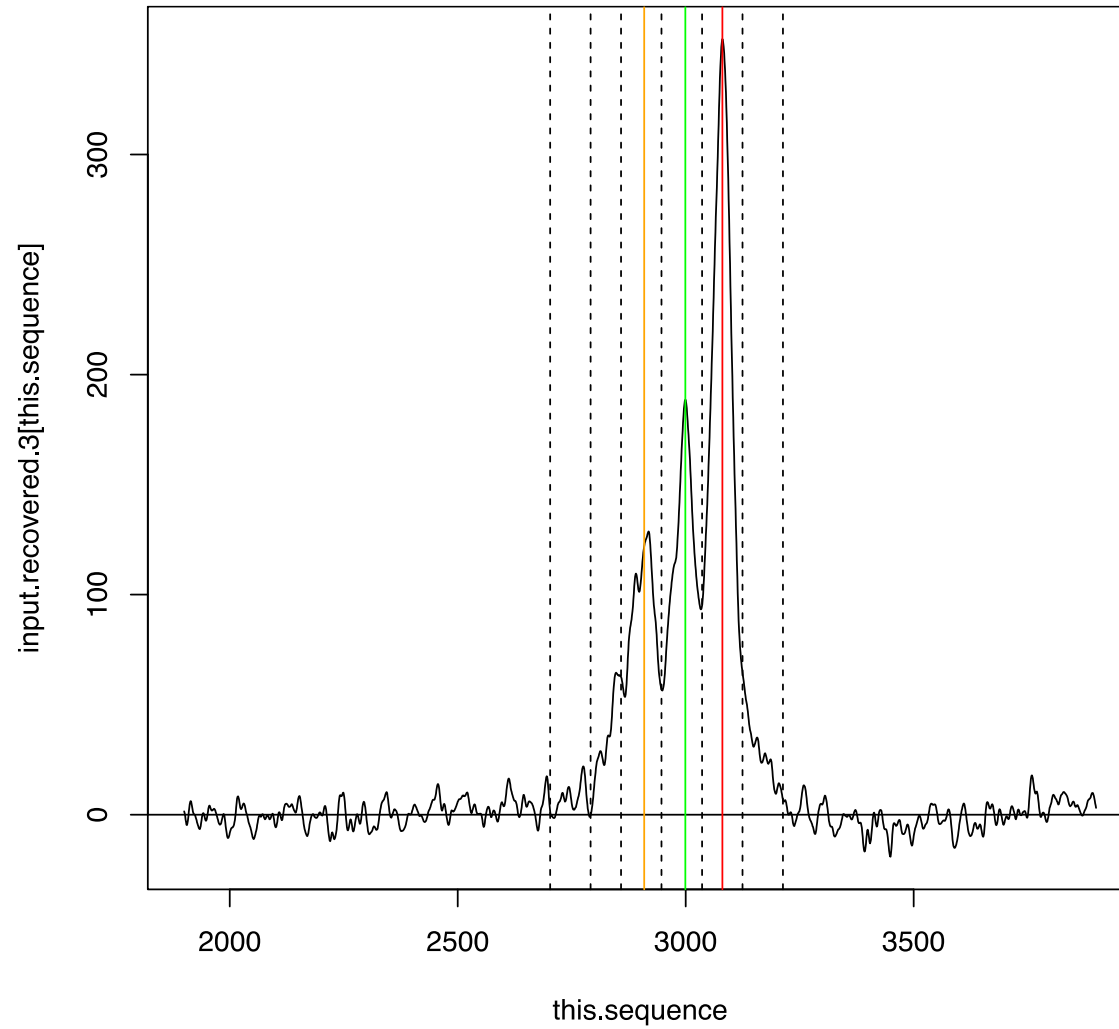
Examples

$z = 30.3 \text{ cm}$



Examples

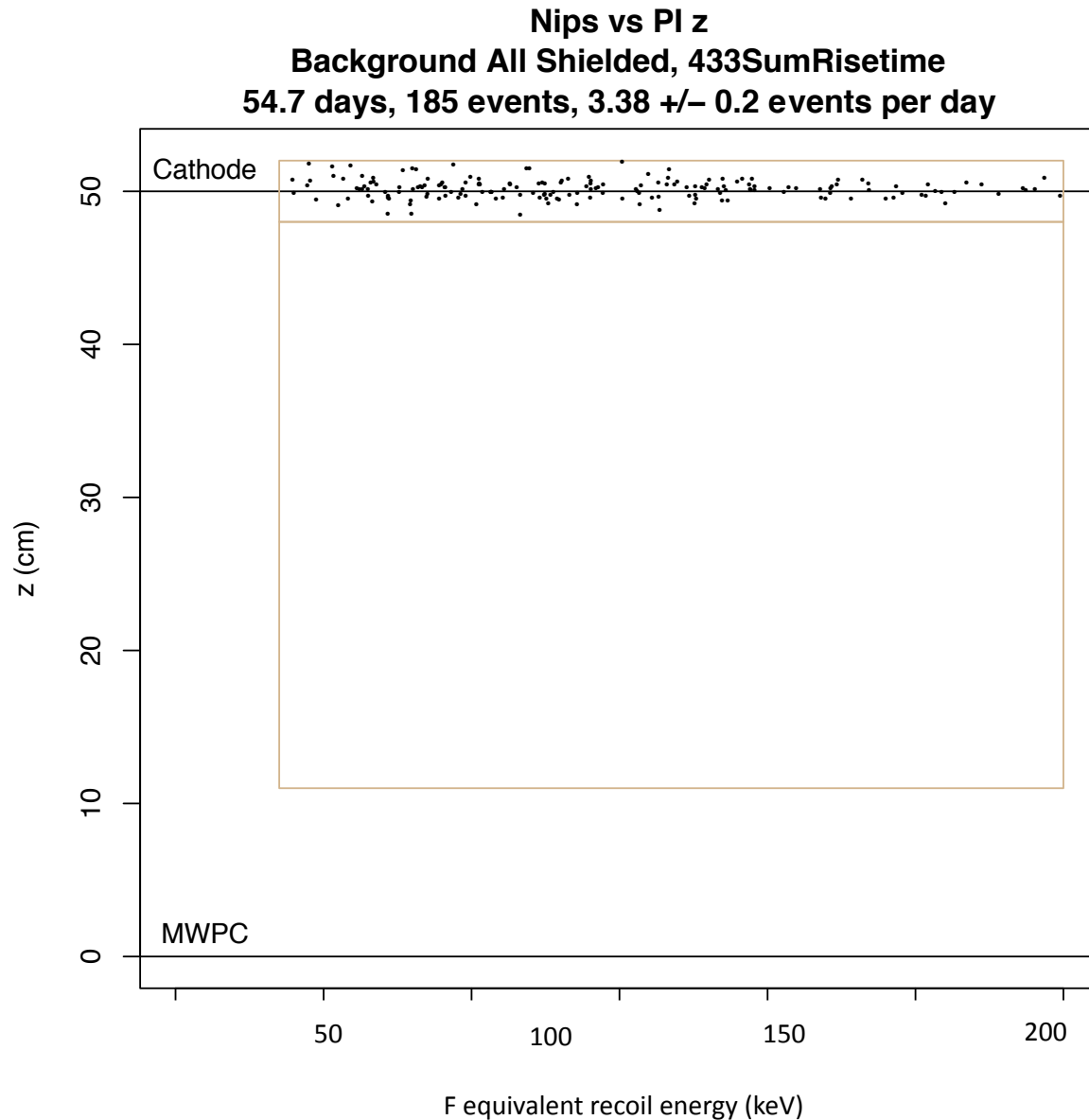
$z = 20.1 \text{ cm}$



Pellet Shielding

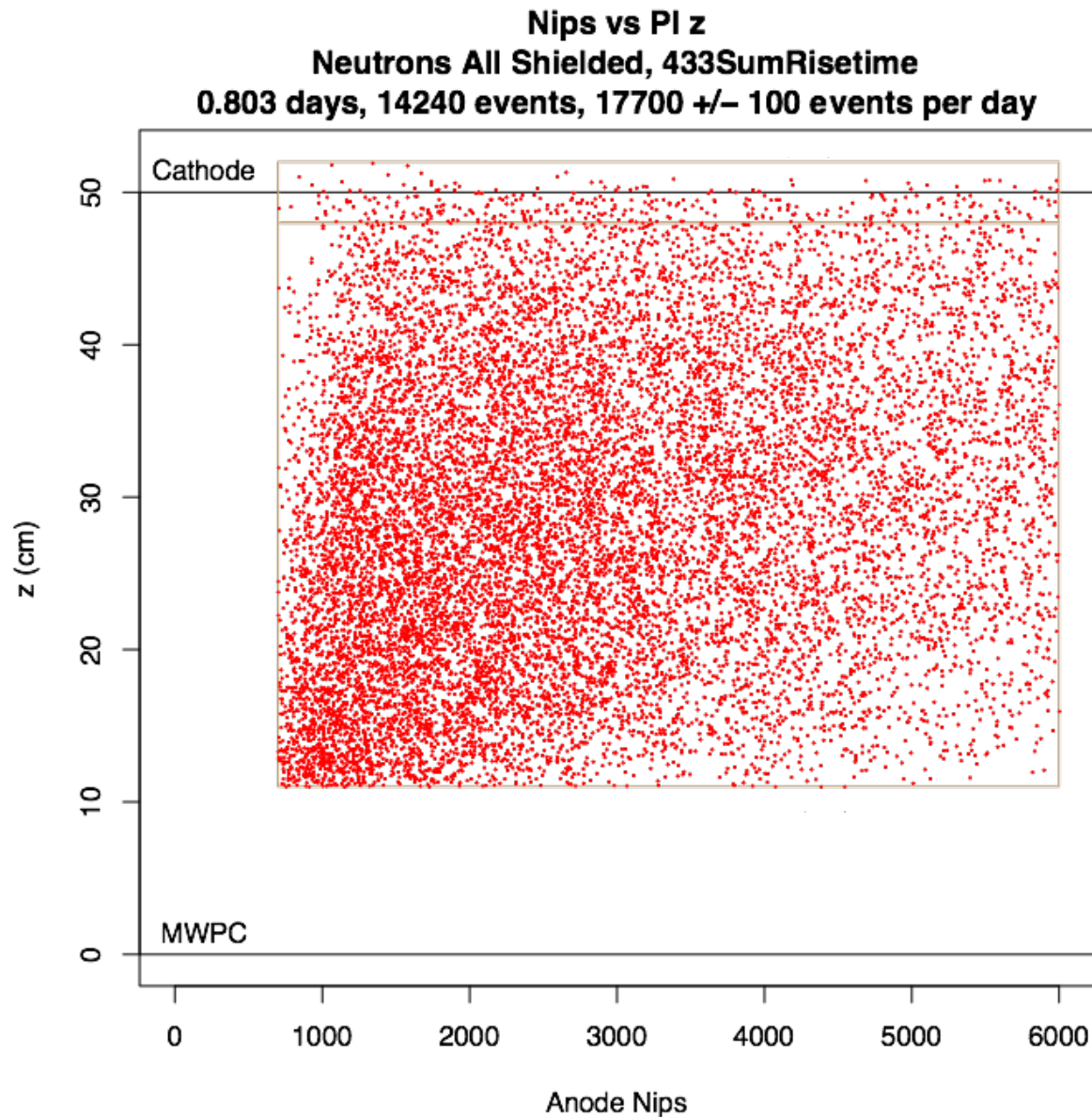


Shielded 30-10-1 CS₂-CF₄-O₂ Data



- 54.7 days of data analyzed
- 185 events found but as expected all were located at 50 cm away from the detector, i.e. on the central cathode.
- Define a background-free fiducial region.
- In order to interpret this as a limit need to calibrate the detector...

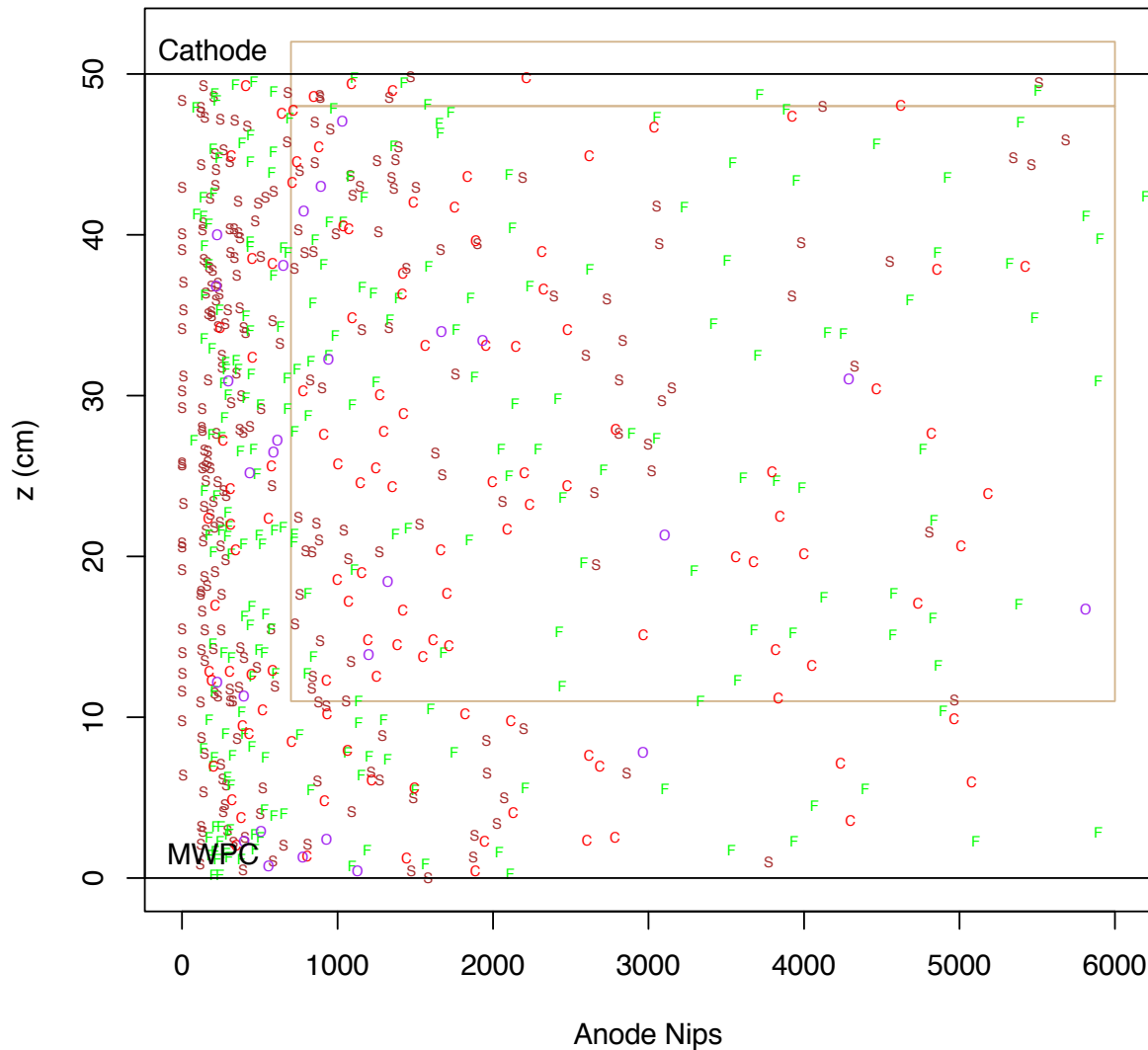
Cf-252 Neutron Calibration Data



- Exposed the detector to a Cf-252 neutron source
- As expected the neutrons distributed themselves more or less uniformly in z within the fiducial region
- Since neither the distribution in z nor *NIPs* (ionization) is truly uniform need to do this carefully...

GEANT Cf-252 Simulation Data

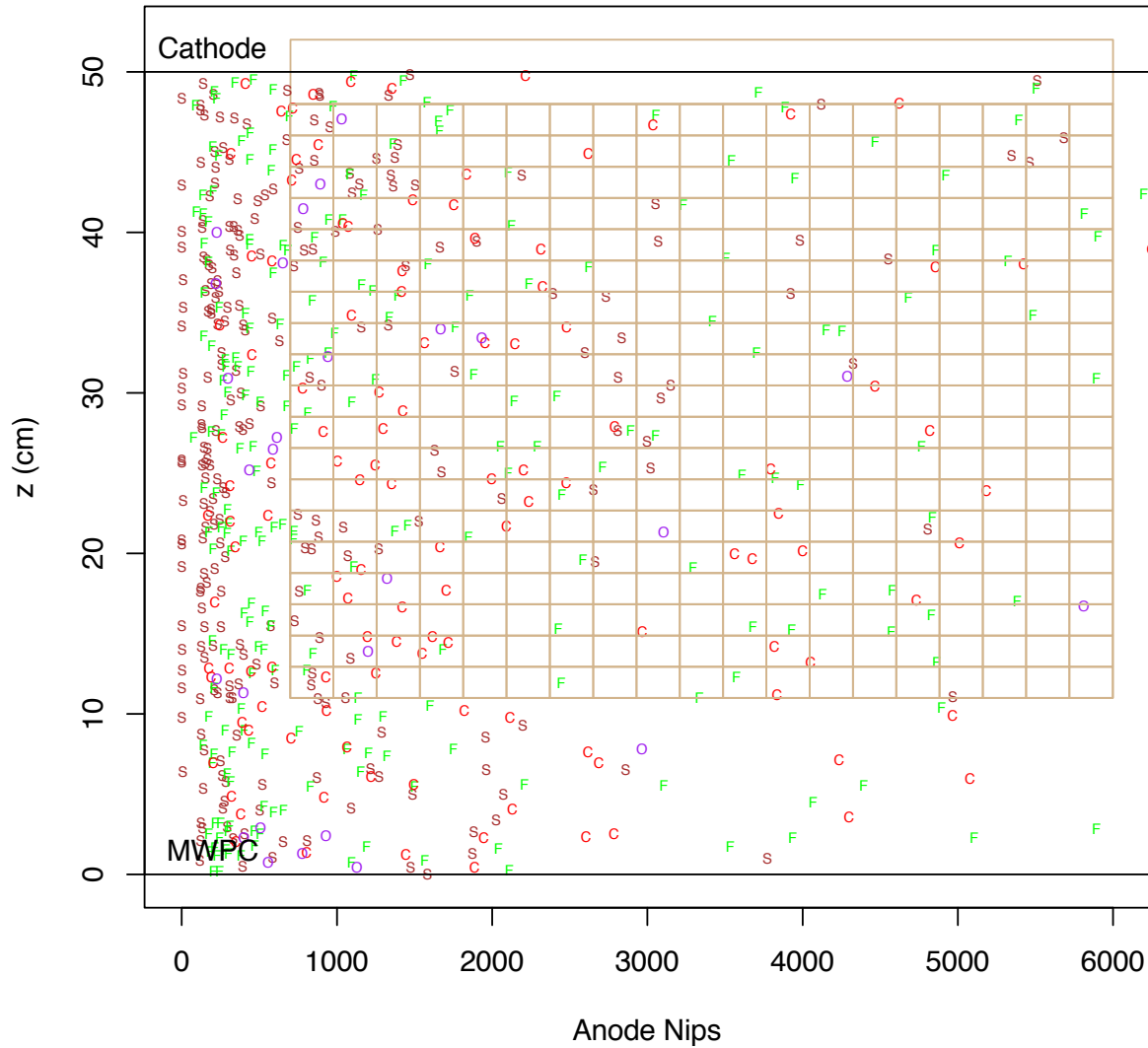
Nips vs PI z
DRIFT_run14_merged_900M
9.4 days, 829259 events, 88200 +/- 100 events per day



- Careful GEANT work was done in Sheffield to model these Cf-252 exposures.
- Simulation is more than 10x data.
- Only a sample is shown.

GEANT Cf-252 Simulation Data

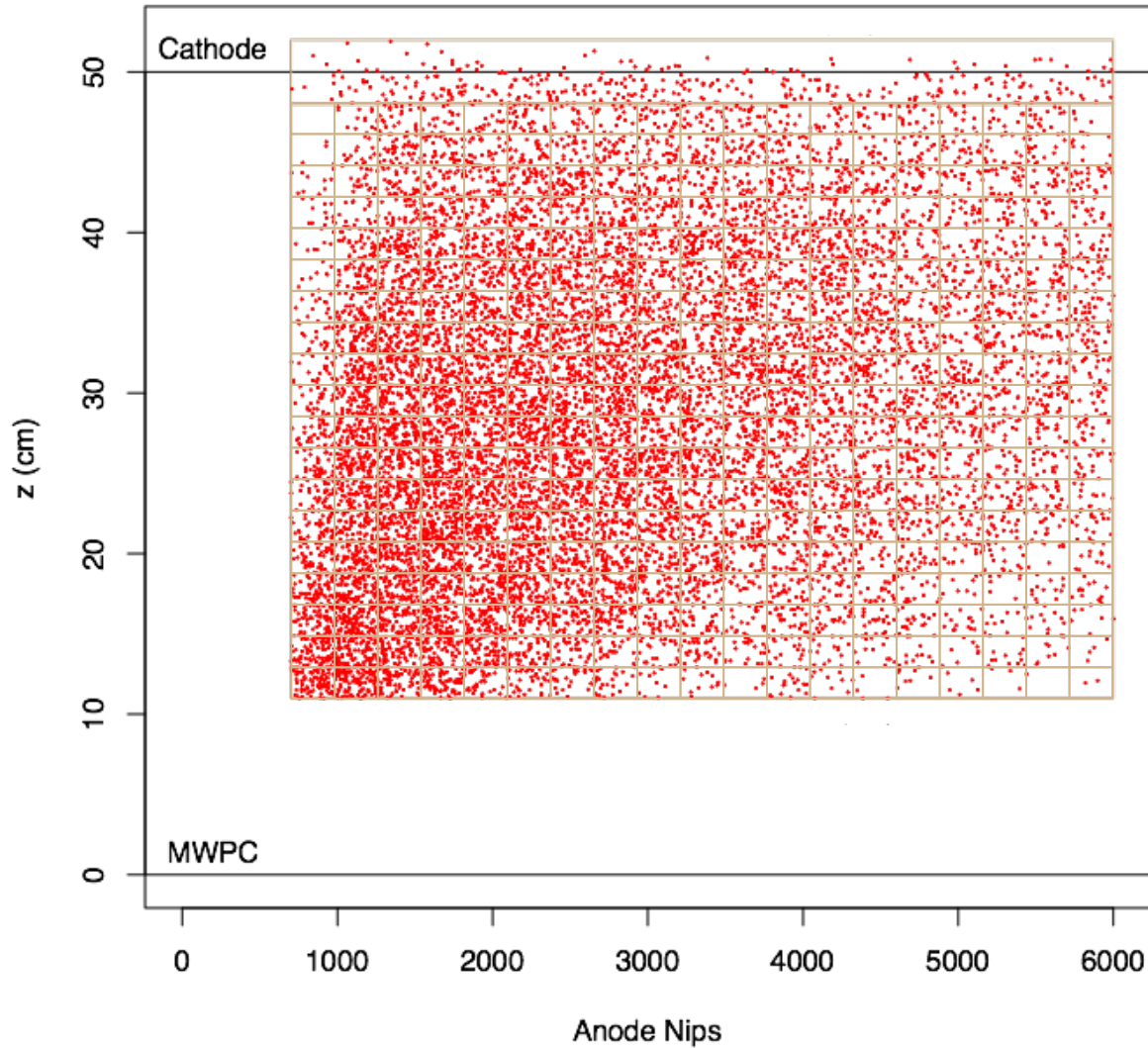
Nips vs PI z
DRIFT_run14_merged_900M
9.4 days, 829259 events, 88200 +/- 100 events per day



- Drew a fine grid in the *NIPs* vs *z* space.
- Counted the number of events in each bin.

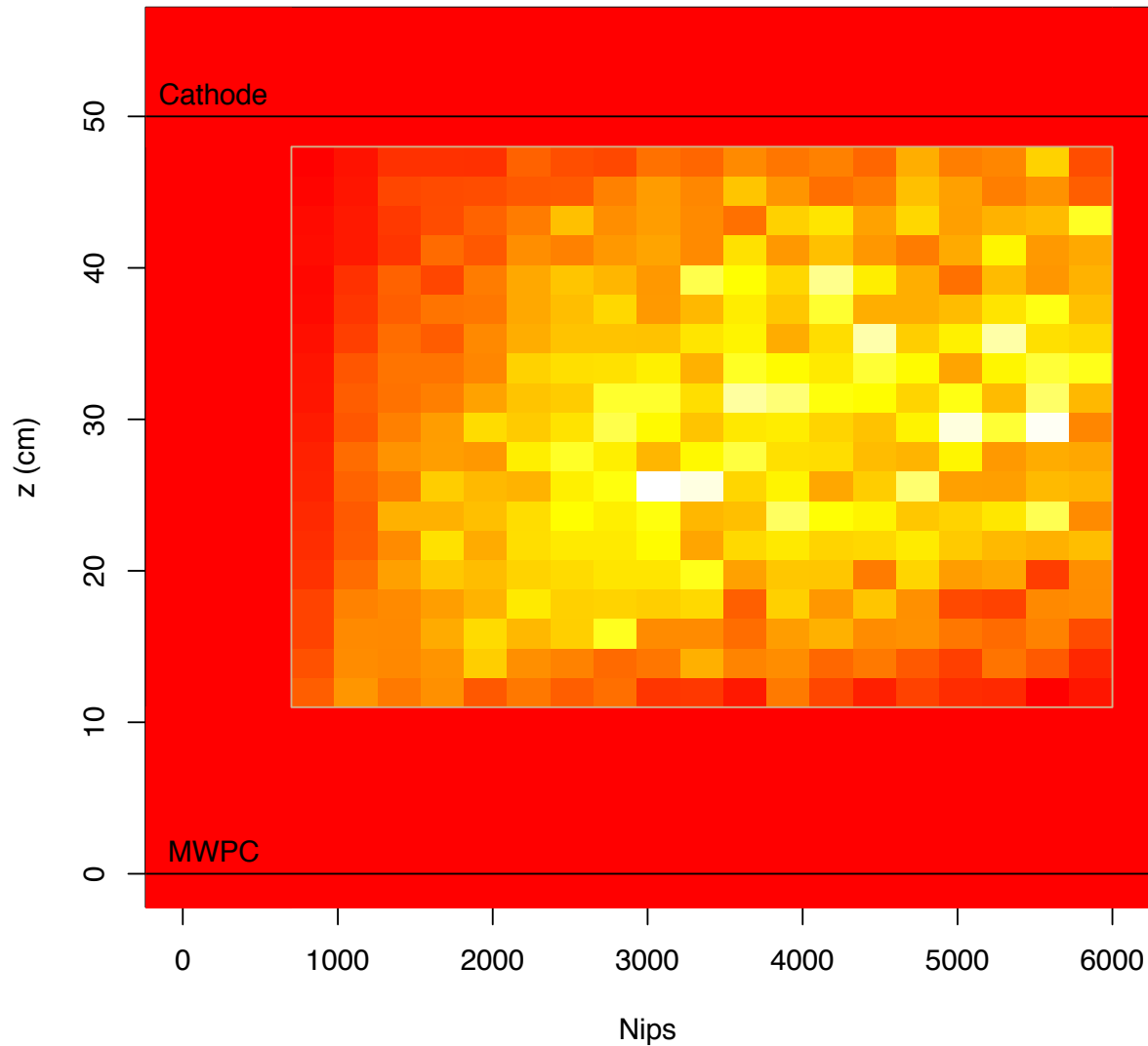
Cf-252 Neutron Calibration Data

Nips vs PI z
Neutrons All Shielded, 433SumRisetime
0.803 days, 14240 events, 17700 +/- 100 events per day



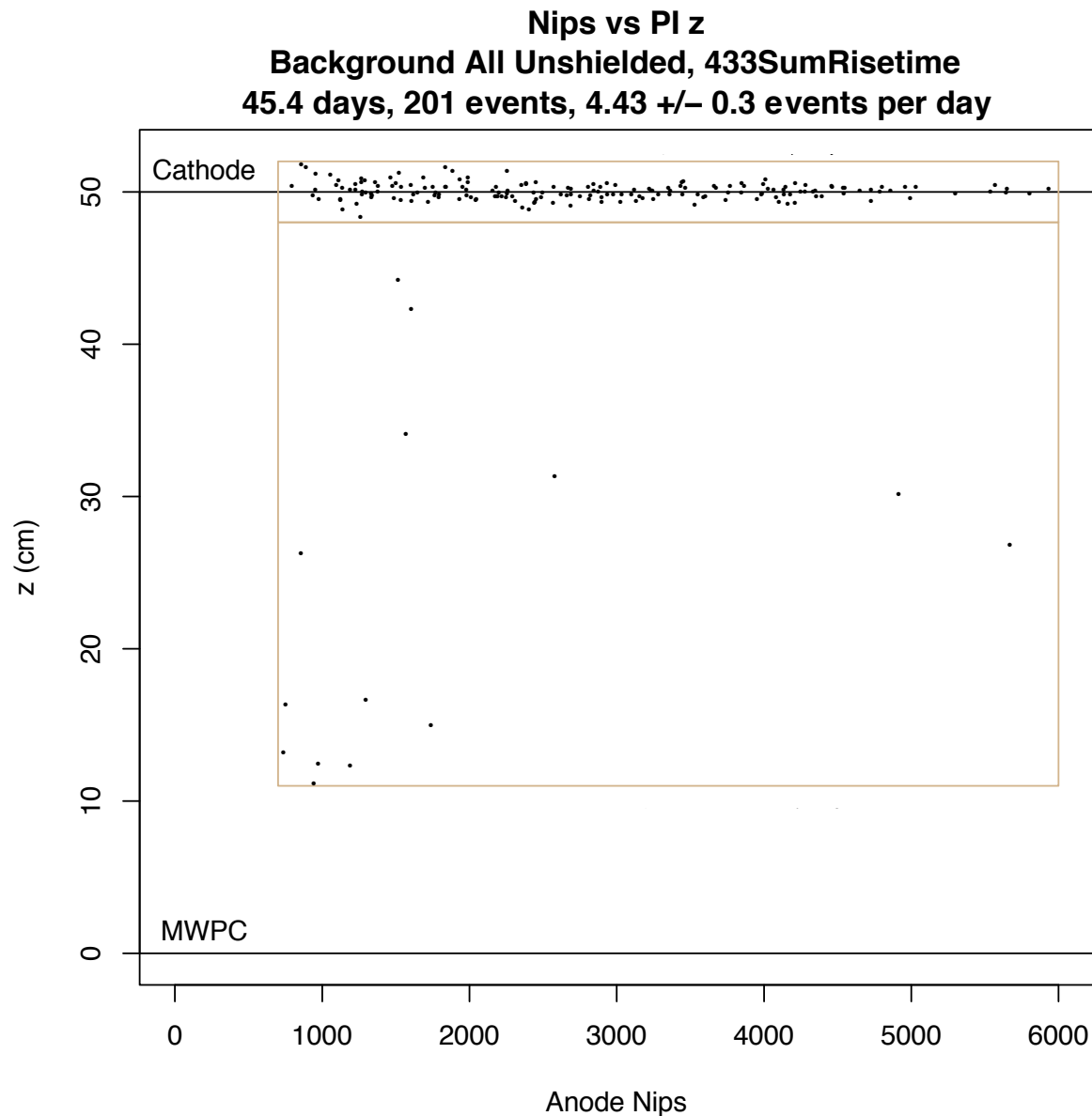
- Did the same for the experimental data.

DRIFT-II-d Detector Efficiency Map



- The ratio of Data/GEANT gives us nuclear recoil efficiency for each bin in this space.
- Red => 0%, White = 100%
- Take it out for a test run...

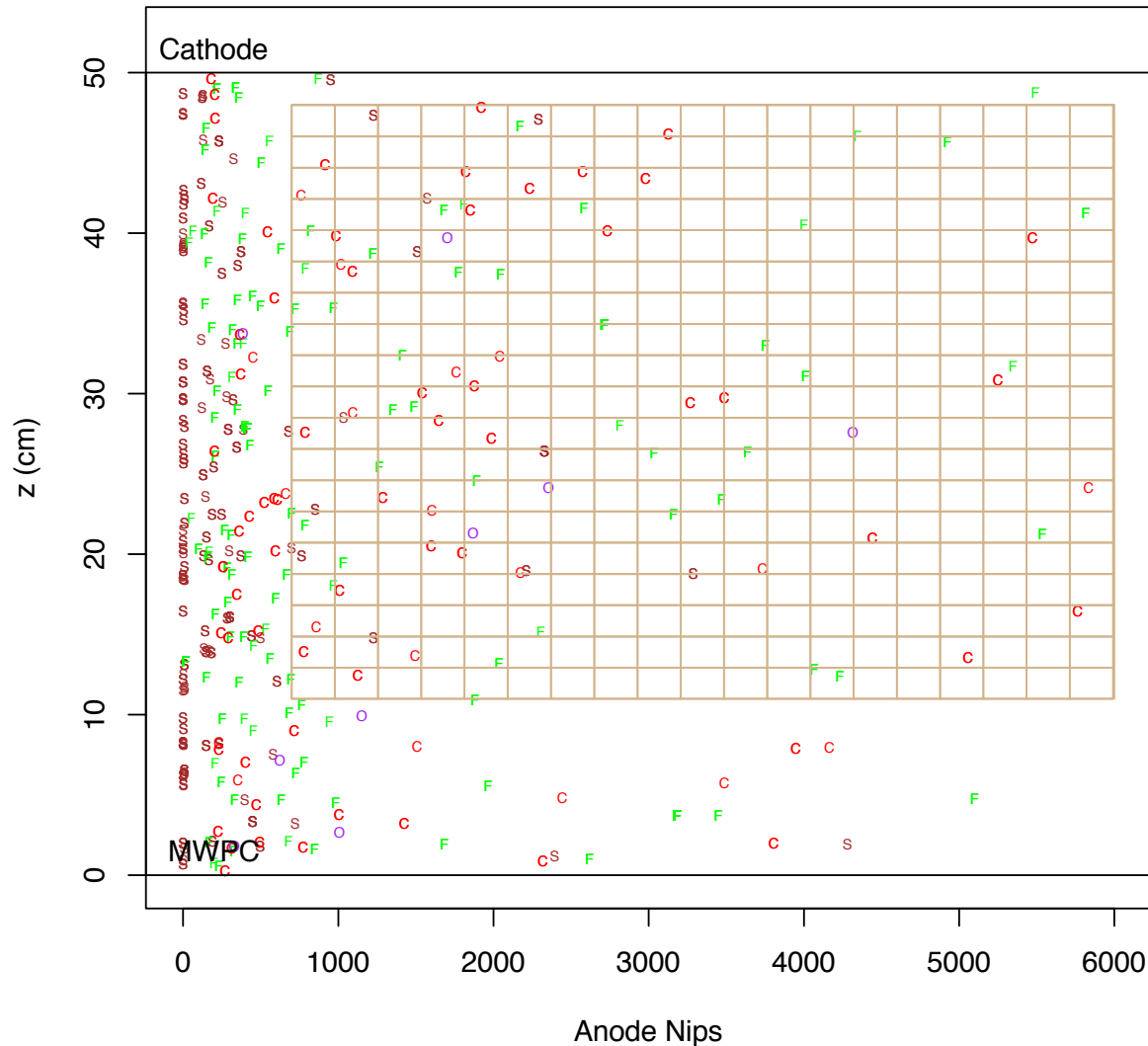
Unshielded Data



- Detector pellet shielding was removed before and after the shielded runs.
- 45.4 days of data analyzed
- 14 events found in the fiducial region.
- With a long Co-60 run we have ruled out rock-gammas as a source of these events.
- These are rock-neutrons detected at a rate of 0.31 ± 0.03 (sys) ± 0.08 (stat) events per day

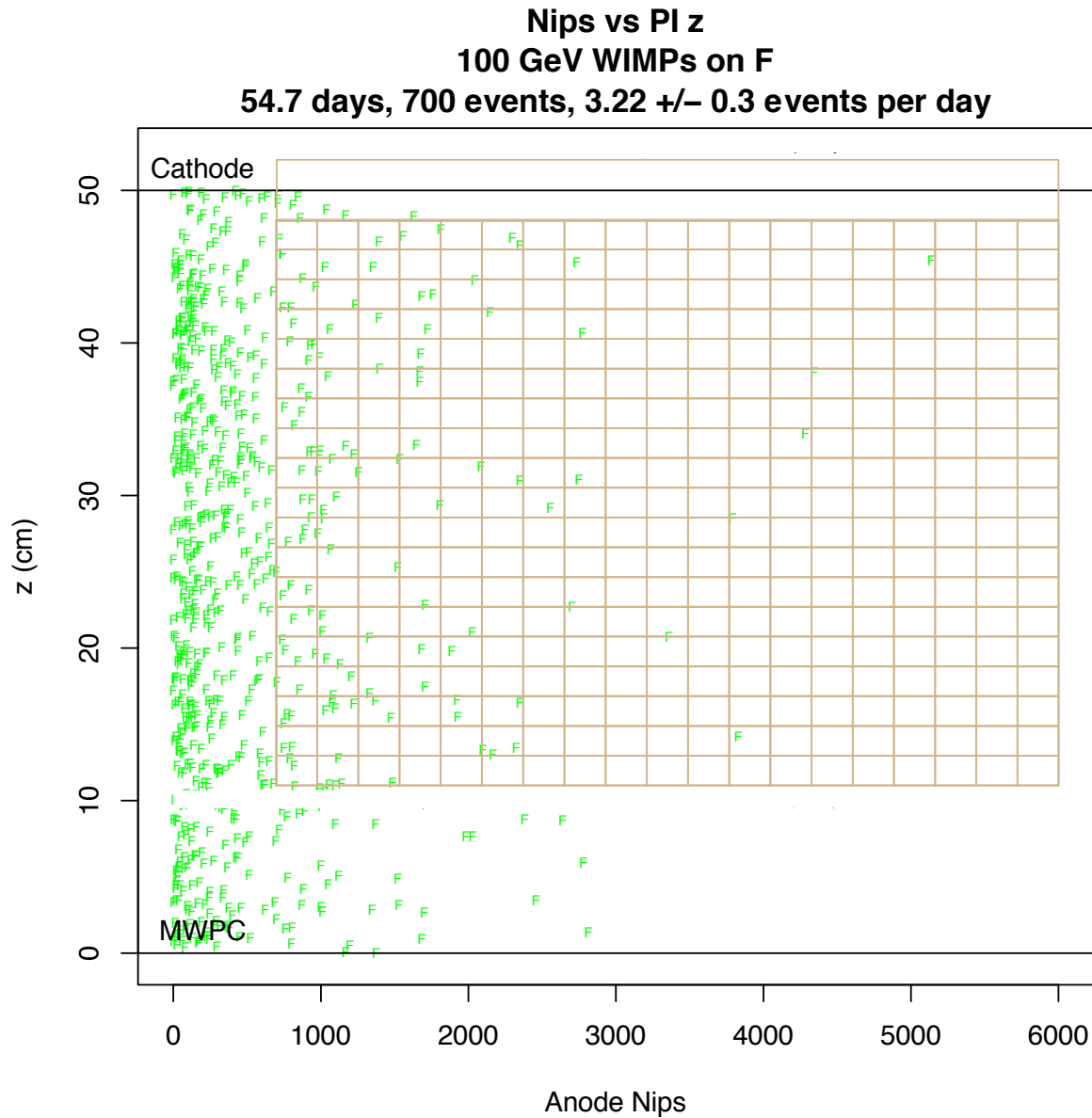
Unshielded Simulation

Nips vs PI z
DRIFT_rock_run28_gypsum_unshielded_1100M
458 days, 697 events, 1.52 +/- 0.06 events per day



- Sheffield simulated neutrons generated in the walls of the cavern and then tracked them into the detector.
- The GEANT data were then gridded and counted.
- This data was then multiplied by the efficiency map to give detected events.
- GEANT = 0.25 +/- 0.02 events per day
- Data = 0.31 +/- 0.03 (sys) +/- 0.08 (stat) events per day
- Good agreement!

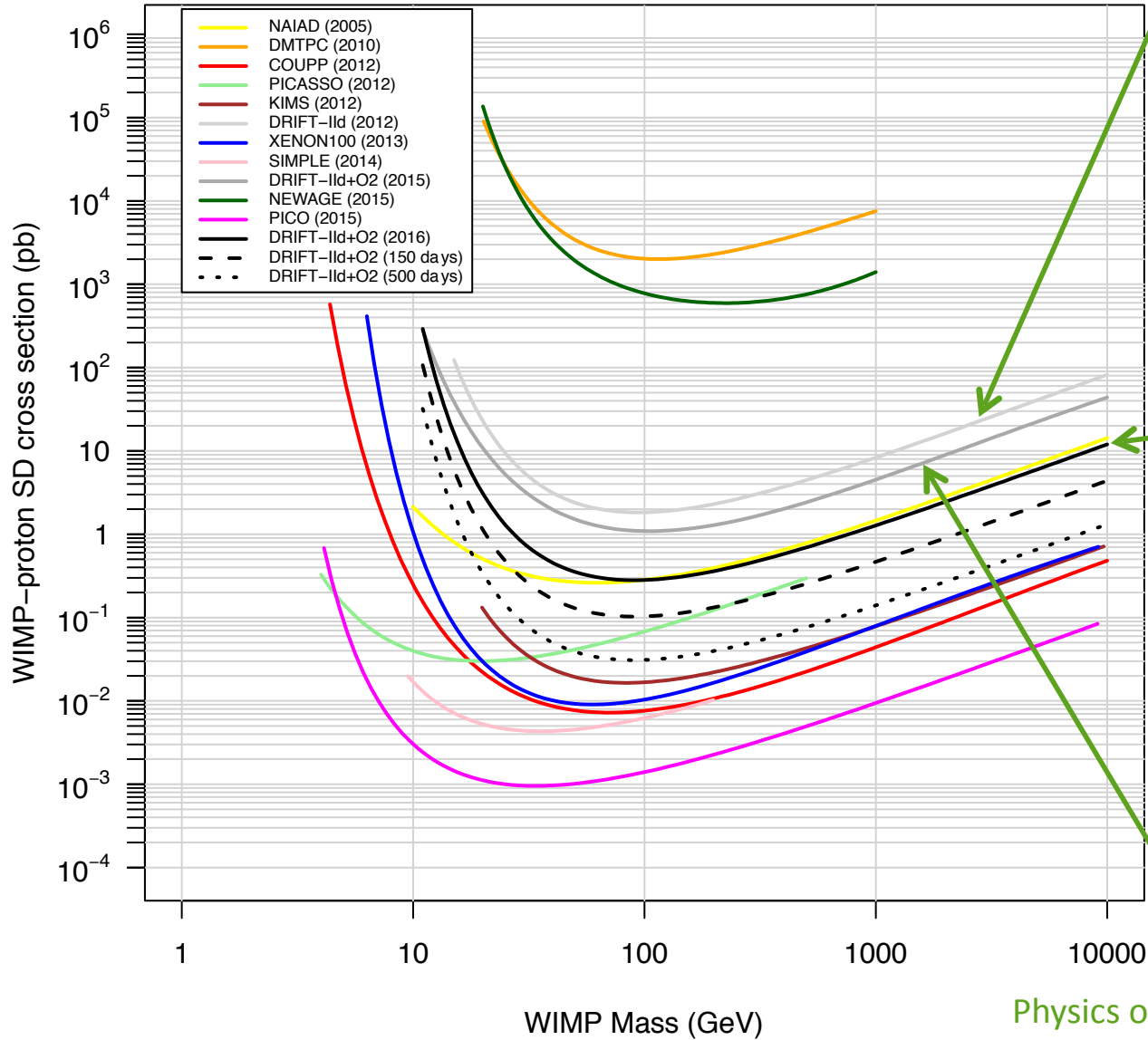
Unshielded Data



- Simulated WIMP events are created, binned, multiplied by the efficiency map to give detected WIMP rates.
- The resulting detected rate => cross-section limits.

SD Limits

Spin-Dependent WIMP-proton Limits



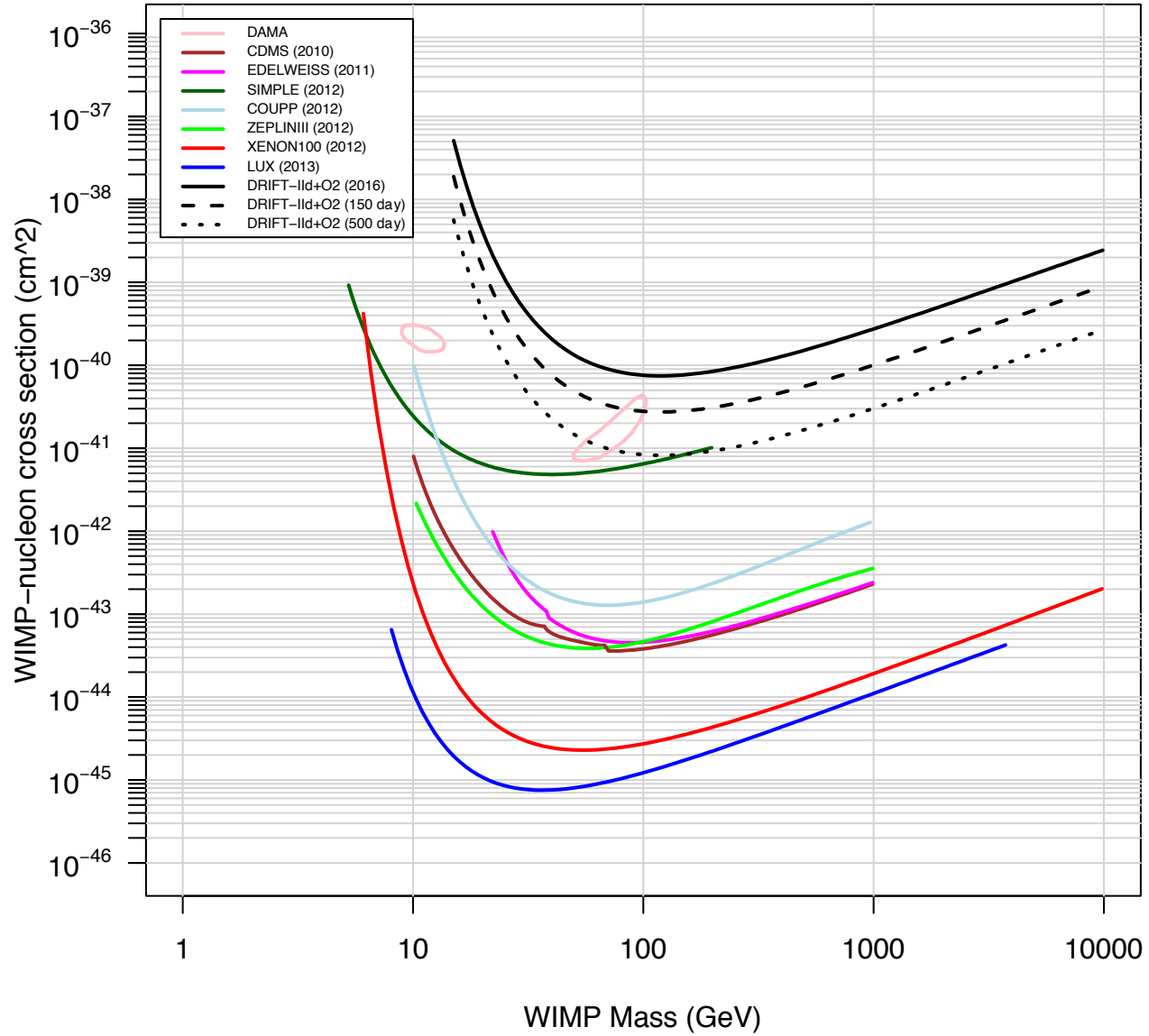
AstroPle, 35, (2012) 397.

This result 2016

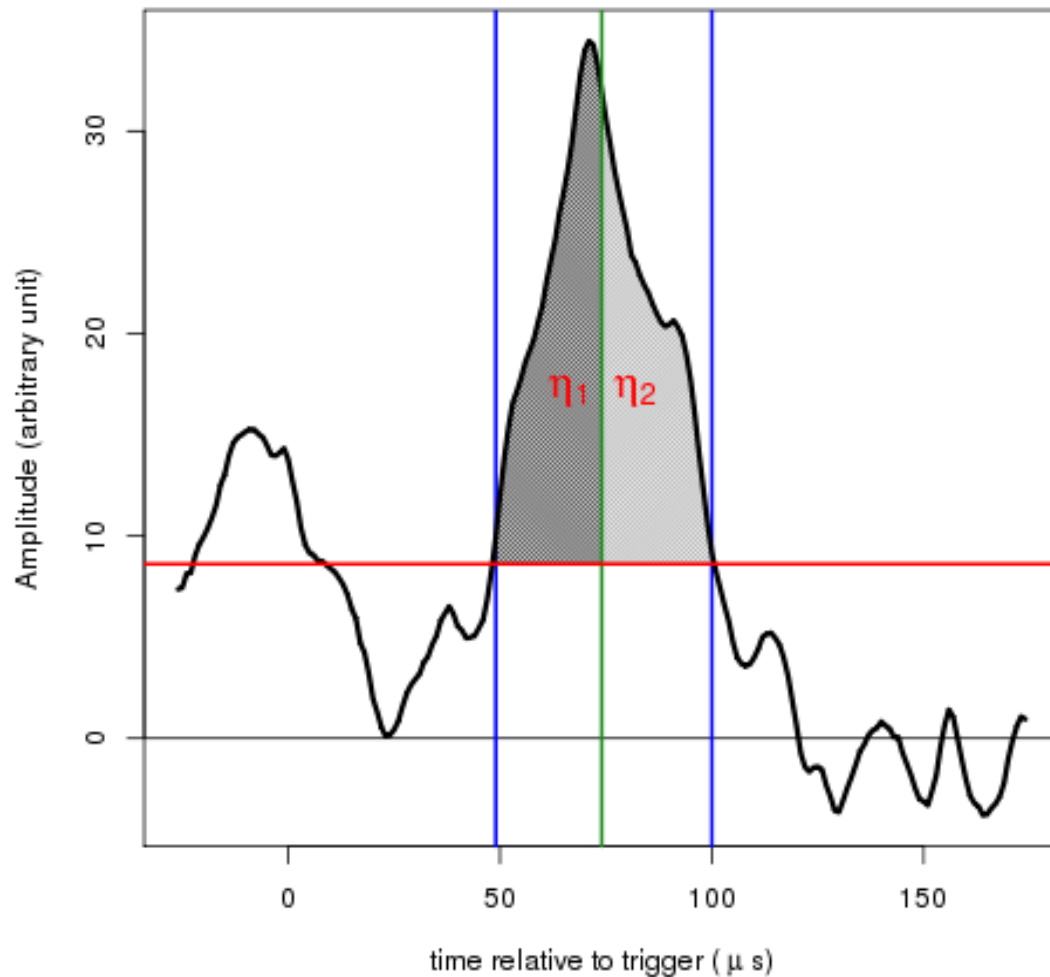
Physics of the Dark Universe, 9-10, (2015) 1.

SI Limits

Spin-Independent WIMP Limits

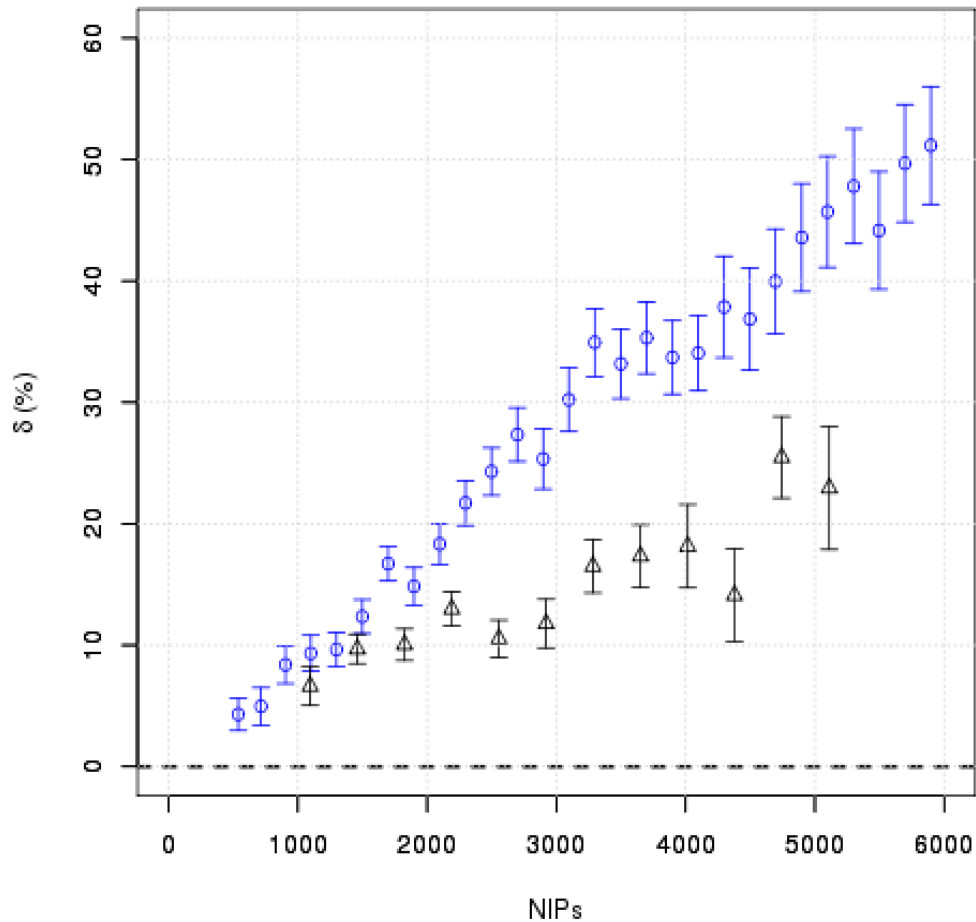


Head-tail analysis



- DRIFT sensitivity to HT in the new gas mode was investigated.
- Method of extracting the HT parameter from data has been discussed for DRIFT in *Astropart. Phys.*, 31 (2009) 261.
- Analyzed 7 days of directed source neutron data.
- Event by event measurement of the HT parameter was done using η_1 to η_2 ratio.
- Can now study HT z, thanks to fiducialization.

Head-tail results



- Improved HT sensitivity (as expected) due to longer recoil tracks from C and F-recoil components in this data set compared to shorter S-recoils in the old data.
- HT sensitivity at lower energy is due to lower hardware and analysis thresholds.
- HT paper in preparation.

- **Blue circle points:** New results including C and F-recoil components.
- **Black triangle points:** Results obtained with shorter S-recoils see *Astropart. Phys.*, 31 (2009) 261.

DRIFT Progress

- In 2007 we published results from DRIFT-IIa showing 500 accepted RPR events per day.
- In 2012 this had been reduced to 130 events per day.
- In 2014 with the thin film cathode this had been reduced to 3 events per day.
- And in 2016 with O₂ this had been reduced to 0 events in 54.7 days.
- In limit setting terms this is an improvement of x12,000 in 9 years, x2.8 per year beating Moore's Law as dark matter physicists do.
- DRIFT is background free.
- New directional results are coming.