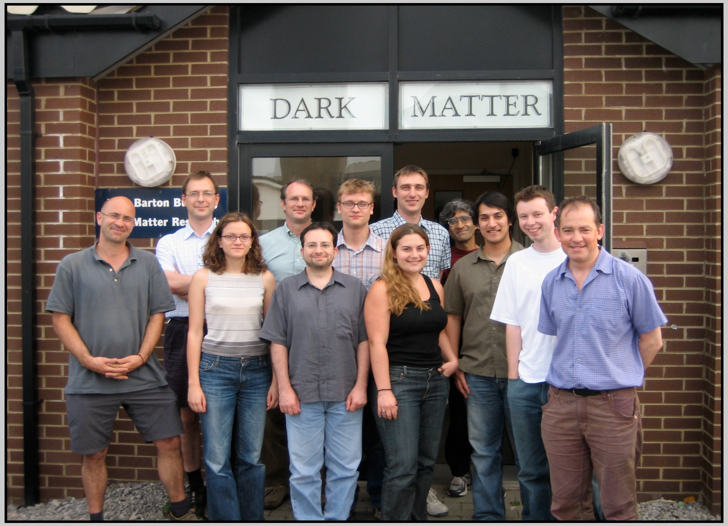
Directional Recoil Identification From Tracks

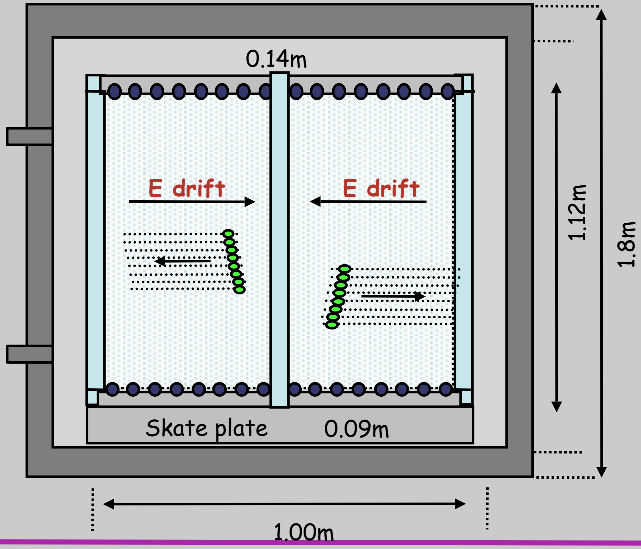
On behalf of the DRIFT collaboration

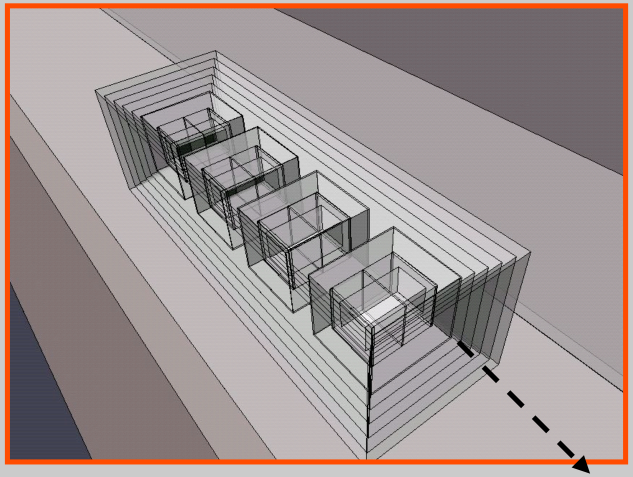


Burgos et al. arXiv:0707.1488 – first DII data
Burgos et al. arxiv:0707.1758 – DII alpha analysis

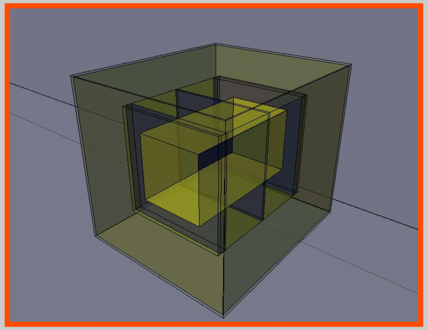
DRIFT IIa design & dimensions

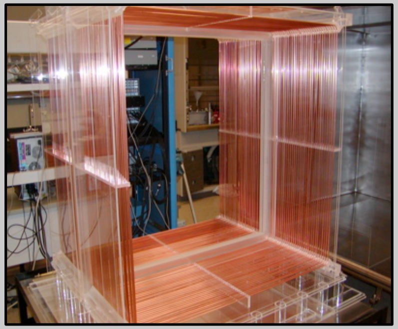
- 1 m^3 active volume - back to back MWPCs
- Gas fill 40 Torr CS_2 => 167 g of target gas
- 2 mm pitch anode wires left and right
- Grid wires read out for Δy measurement
- Veto regions around outside
- Central cathode made from 20 μm diameter wires at 2 mm pitch
- Drift field 624 V/cm
- Modular design for modest scale-up

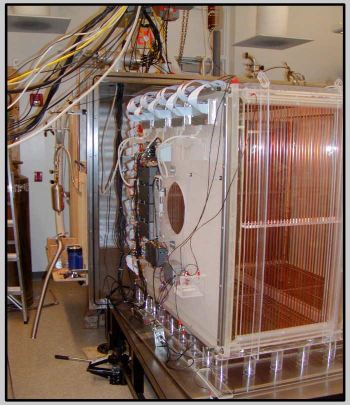




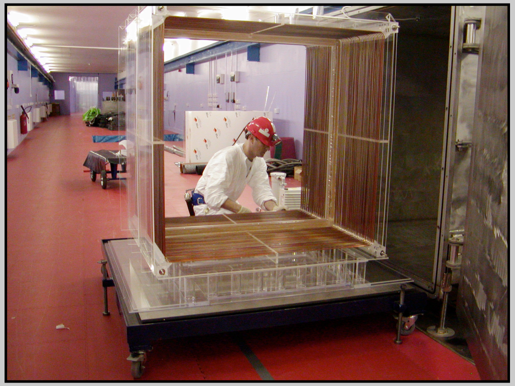
DRIFT IIa, built & run in 1 yr



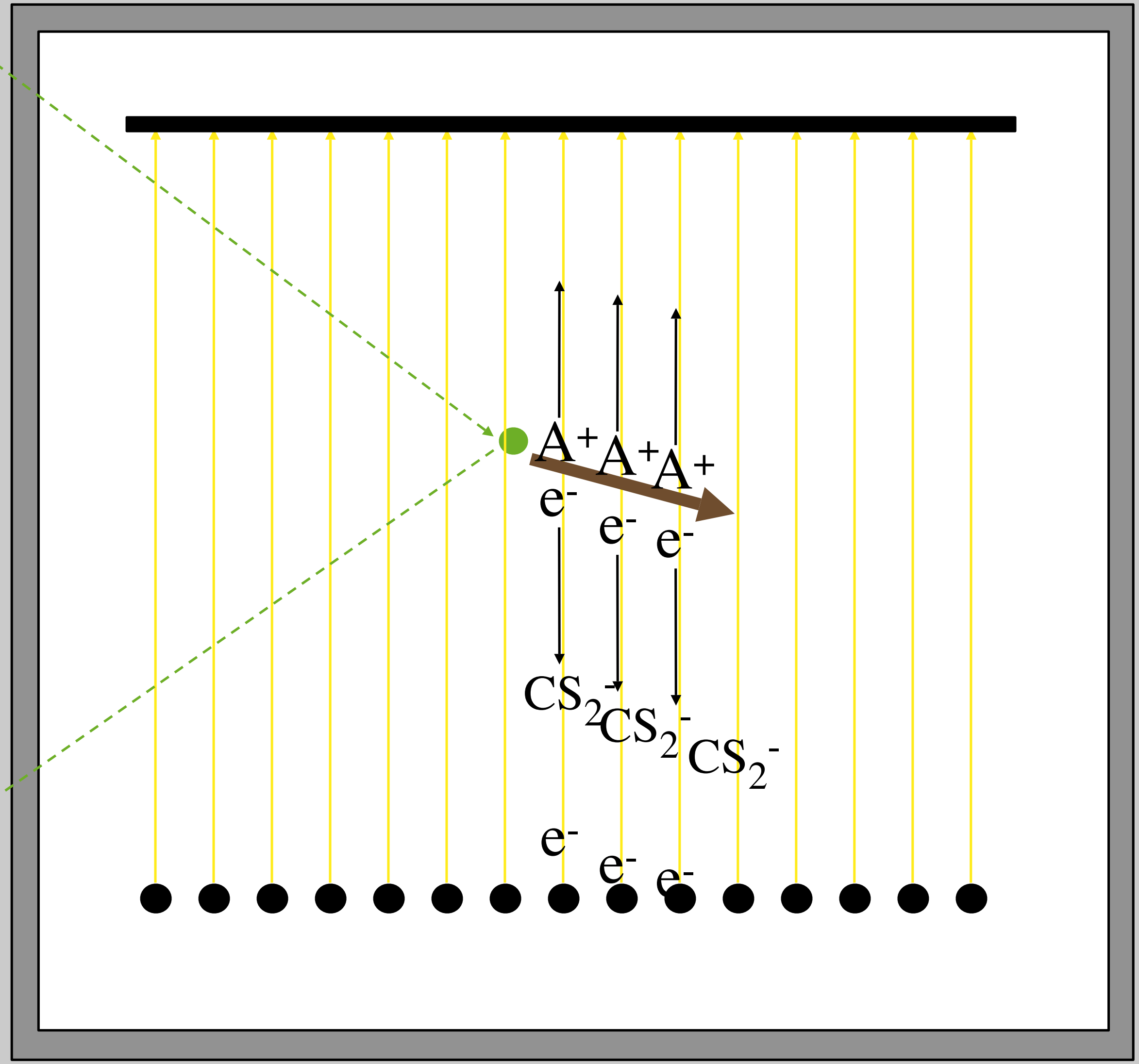




at the Boulby laboratory



DRIFT



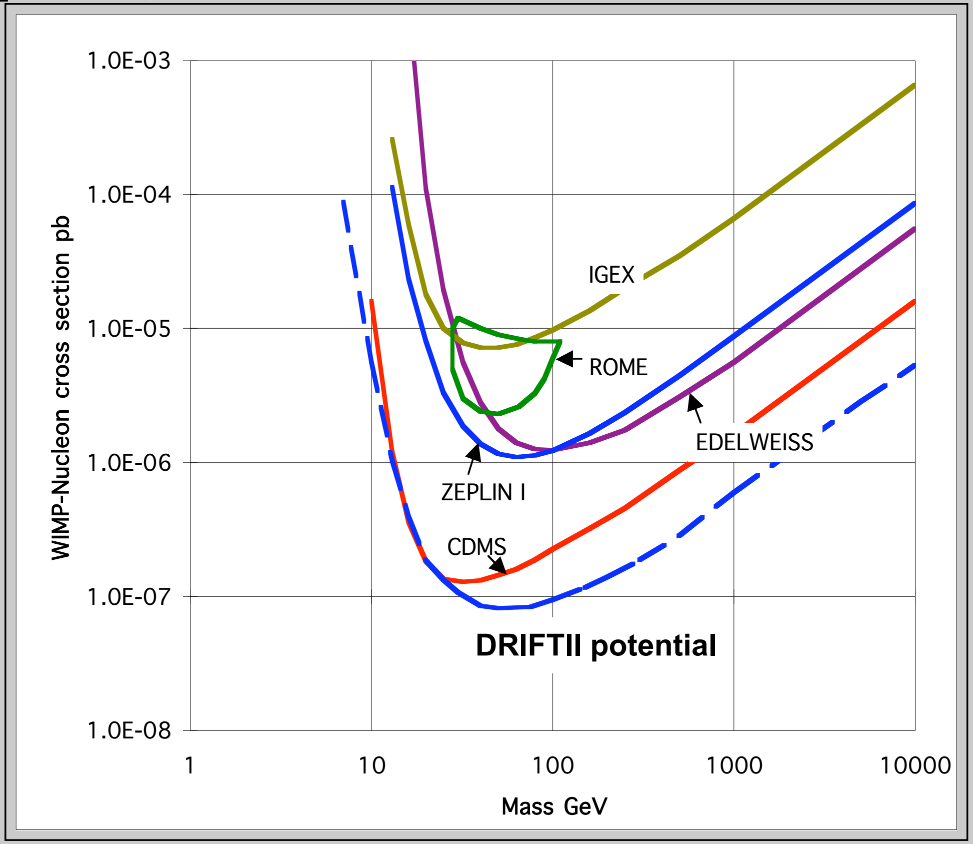
concept

Negative
Ion
Time
Projection
Chamber

Jeff Martoff

Potential (detection) Sensitivity

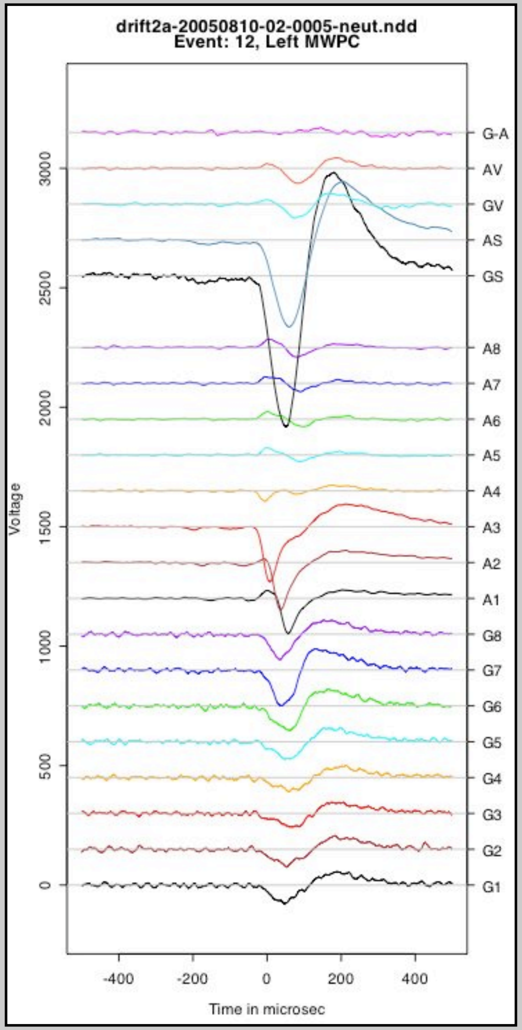
3 m^3 of CS_2 - 3.4 years - 40 Torr - 20 keV S recoil energy threshold



At 160 Torr (an achievable pressure increase) a 1 tonne target would for instance be ~25% smaller than MINOS

DRIFT analysis

2 mm



Vetos

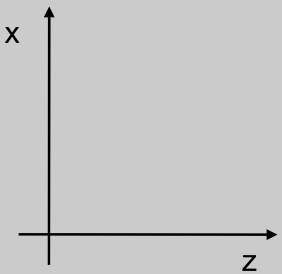
Anodes

Grids

$$R_3 = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}$$

$$R_2 = \sqrt{\Delta x^2 + \Delta y^2}$$

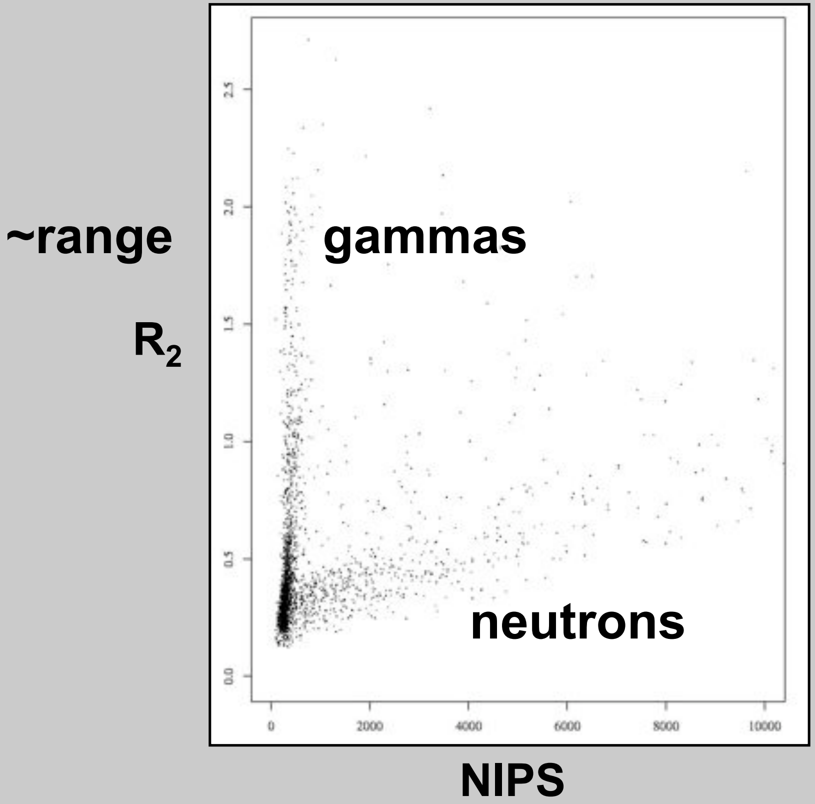
Nips = Number of ion pairs
= ionization
$\propto \int V(t)dt$



dE/dX discrimination

Old $1ft^3$ data

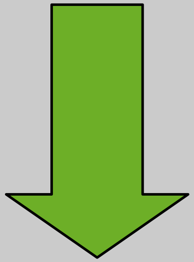
Threshold



dE/dX discrimination

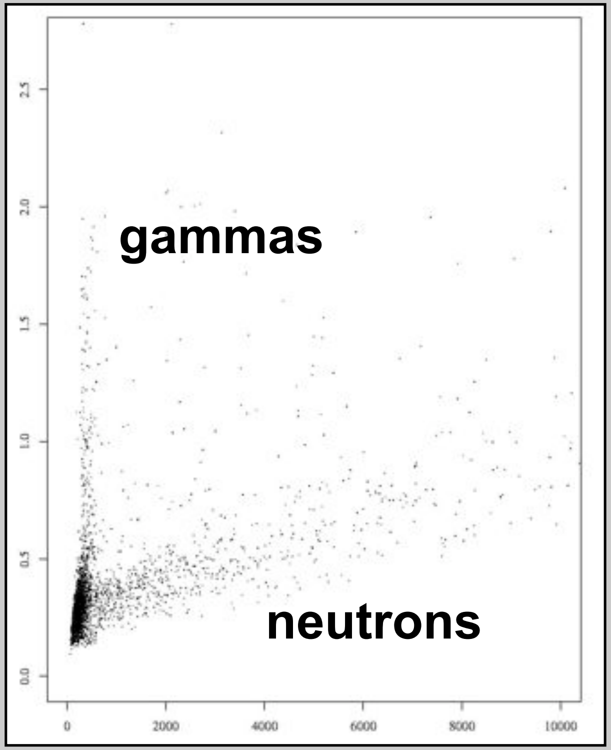
Old DRIFT
$1ft^3$ data

Threshold



~range

R_2



NIPS

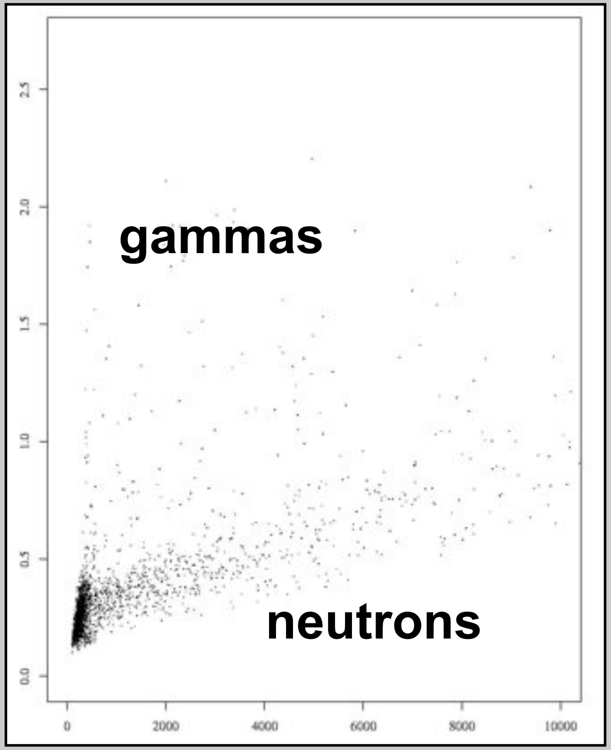
dE/dX discrimination

Old 1ft^3 data

Threshold

~range

R_2



NIPS

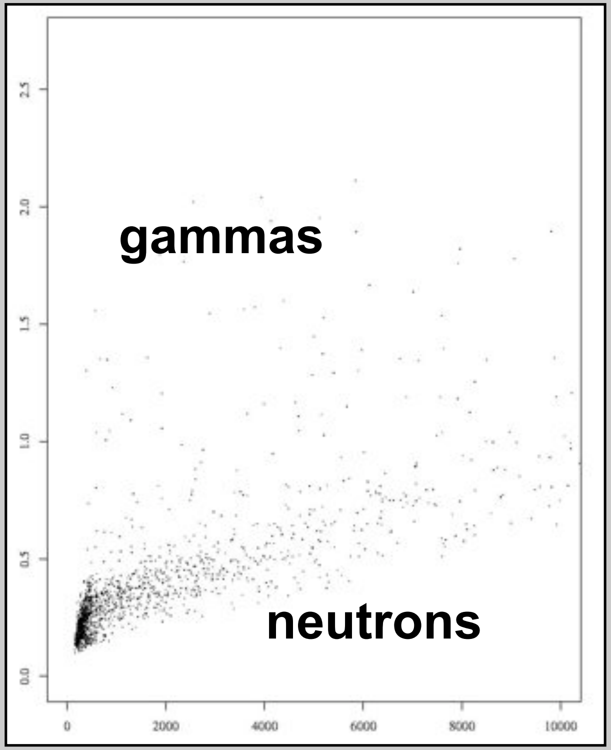
dE/dX discrimination

Old 1ft^3 data

Threshold

~range

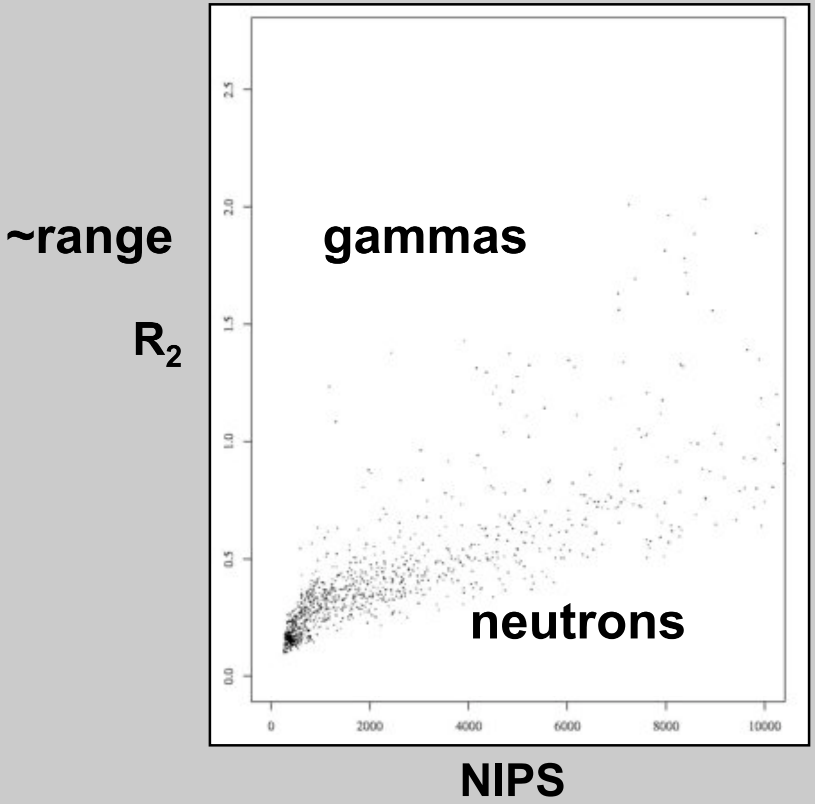
R_2



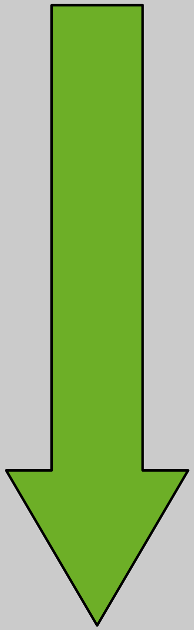
NIPS

dE/dX discrimination

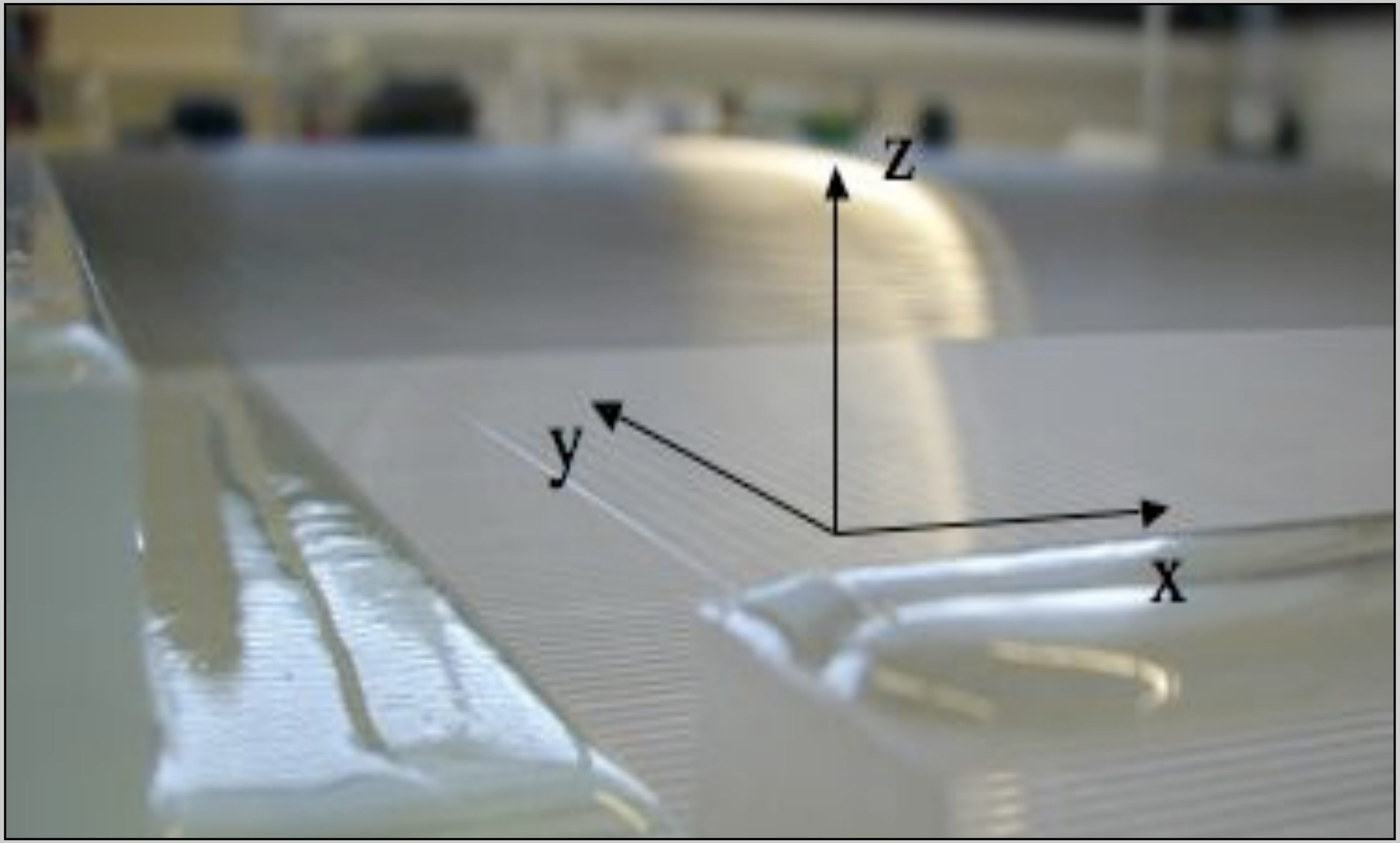
Old 1ft^3 data



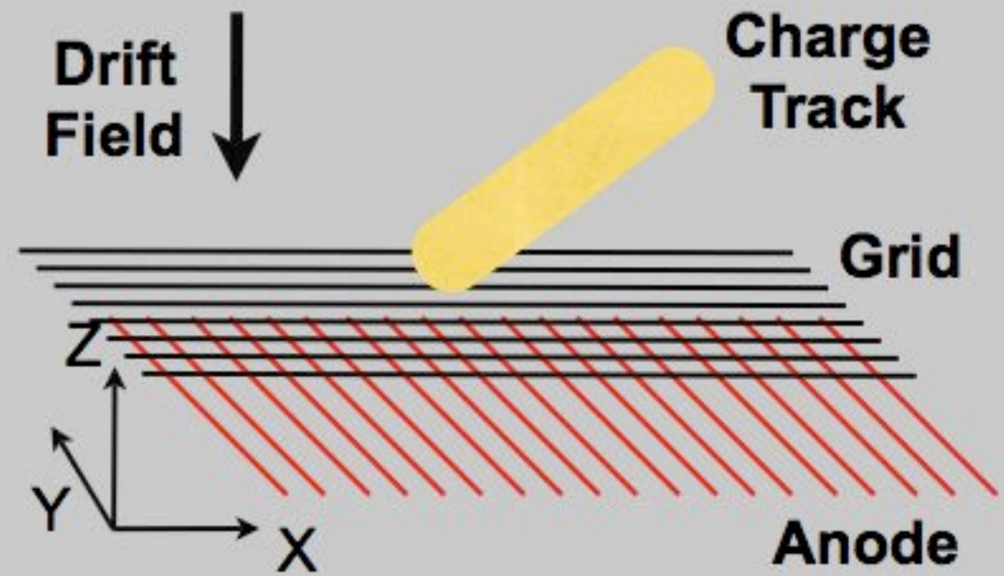
Threshold

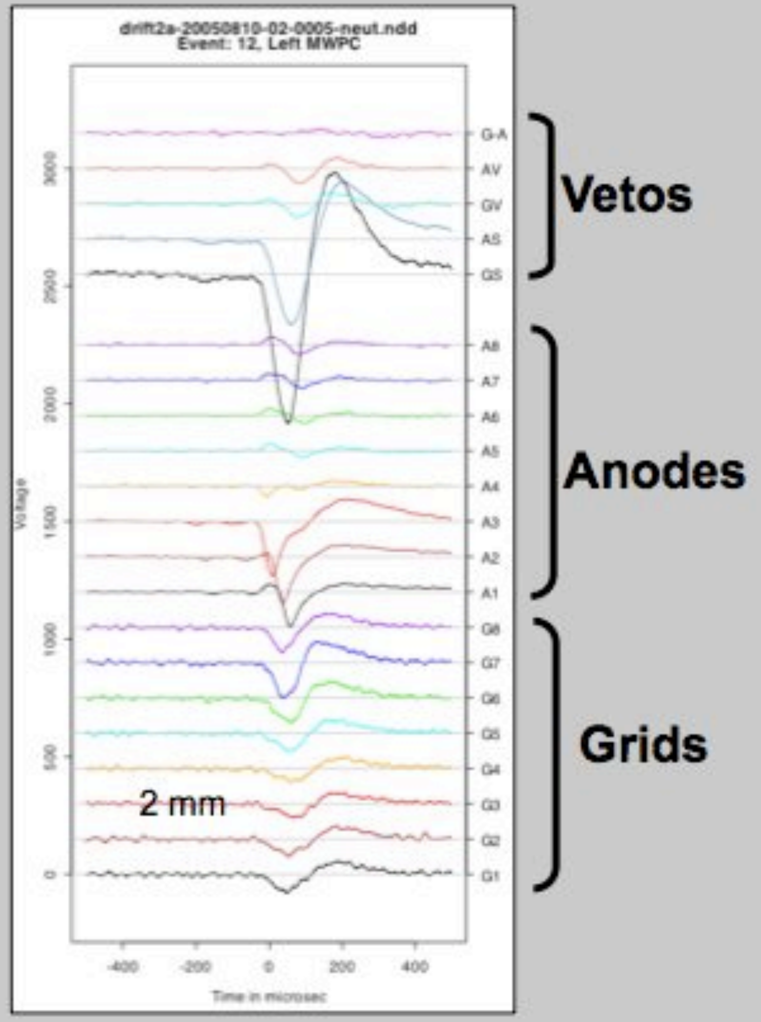


DRIFT - 3D readout



Directional Analysis

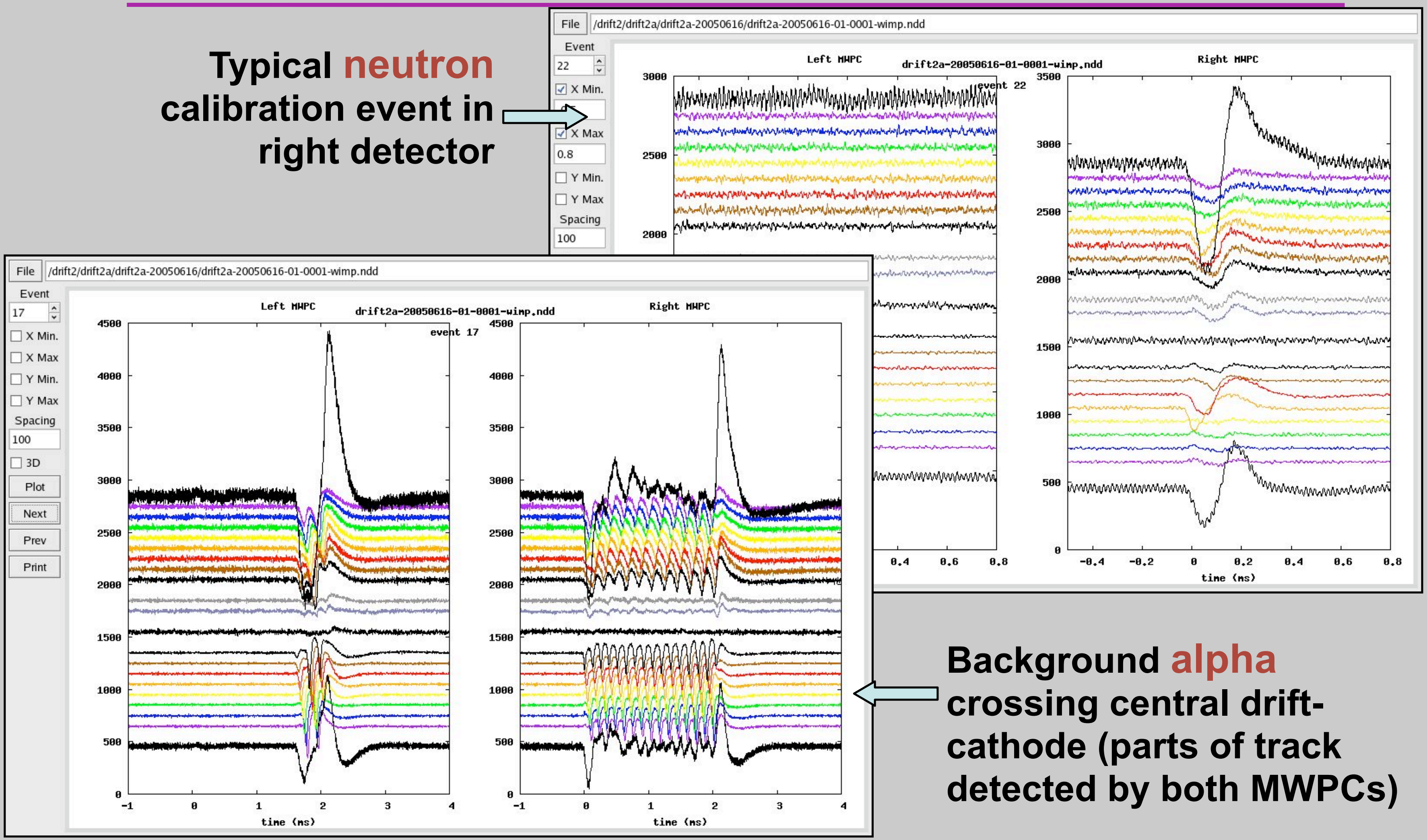




ΔX: Number of Anode Wires Crossed
ΔY: Progression across Grid Wires
ΔZ: Drift Time difference between start and end of track

DRIFT IIa - typical events

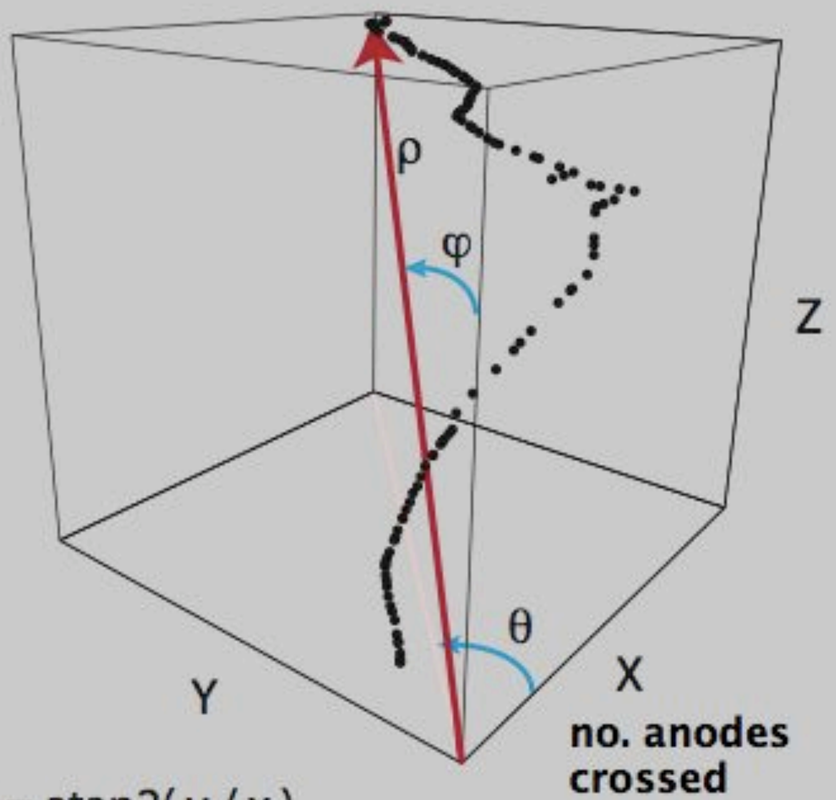
Typical neutron calibration event in right detector



Background alpha crossing central drift-cathode (parts of track detected by both MWPCs)

Track reconstruction

Minimum cuboid



$\theta = \mathrm{atan2}(y/x)$
$\varphi = \mathrm{acos}(z/\rho)$

x, y, z

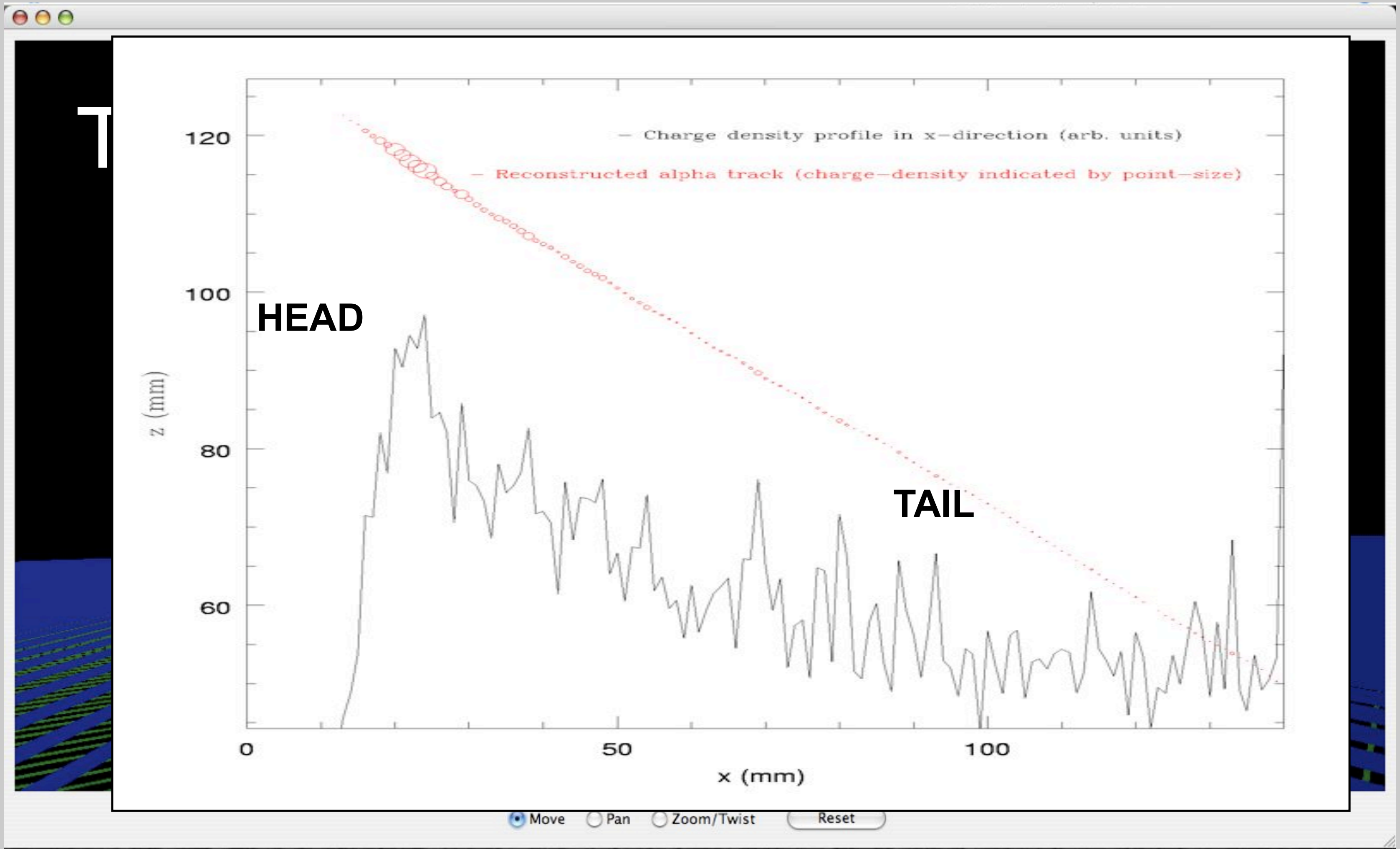
↓

θ, φ

↓

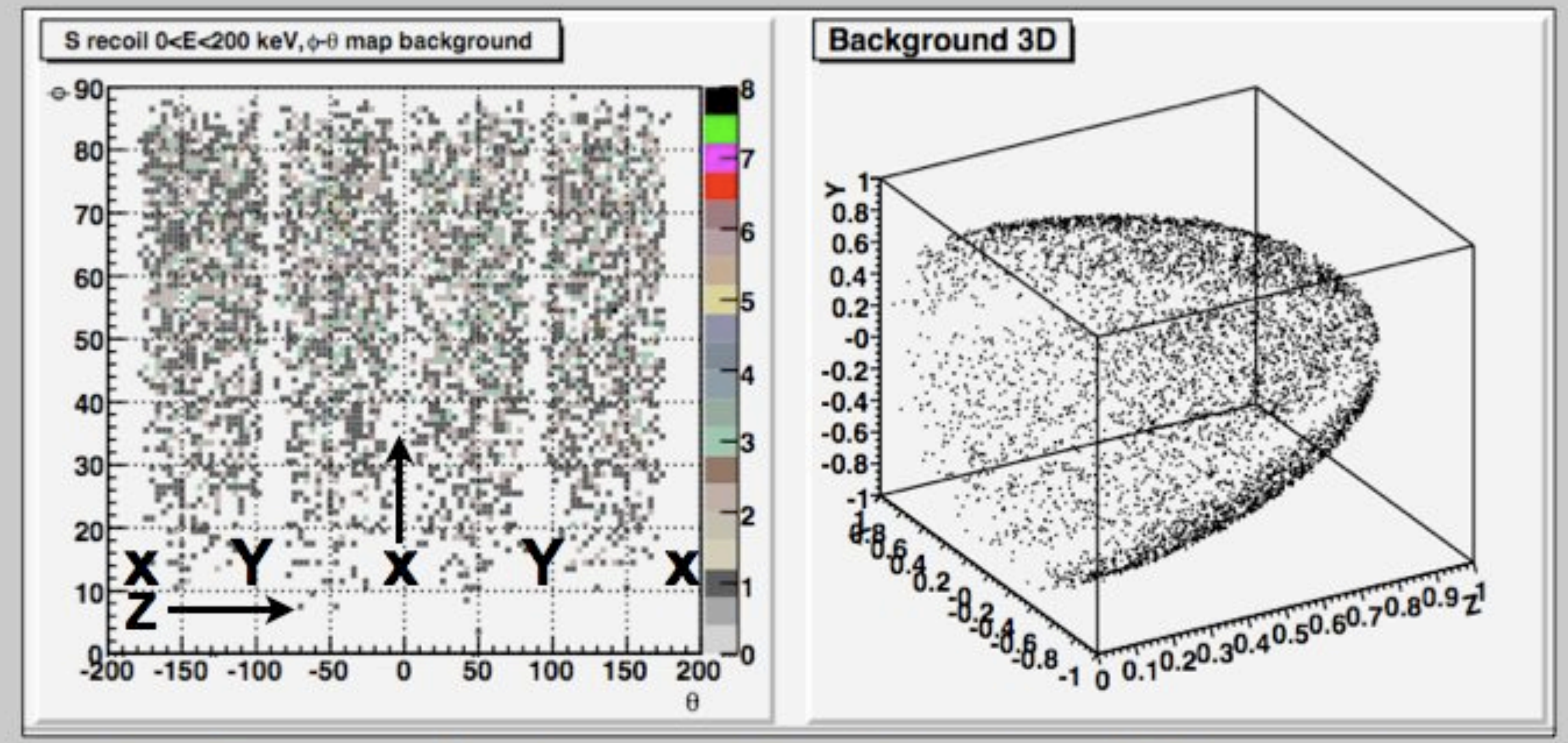
sky map

DRIFT track images



3d (θ, φ) sky maps (simulation)

Output for random s-recoil directions of 0-200 keV



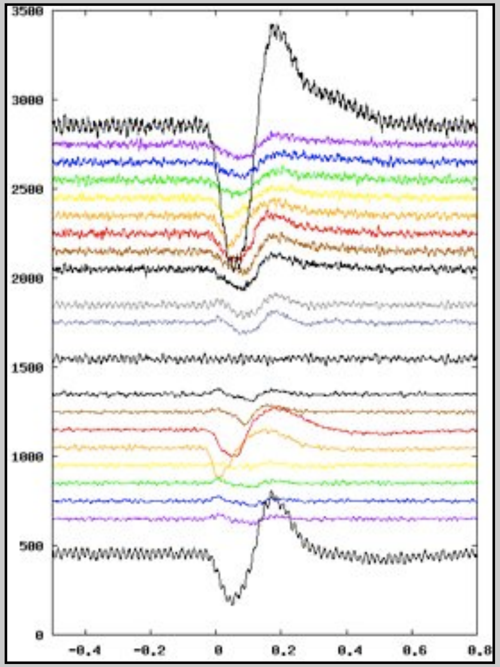
- gaps for events along x,y,z axis due to minimum cuboid
- depletion at low φ (cos φ effect)

DRIFT IIa - recoil cuts

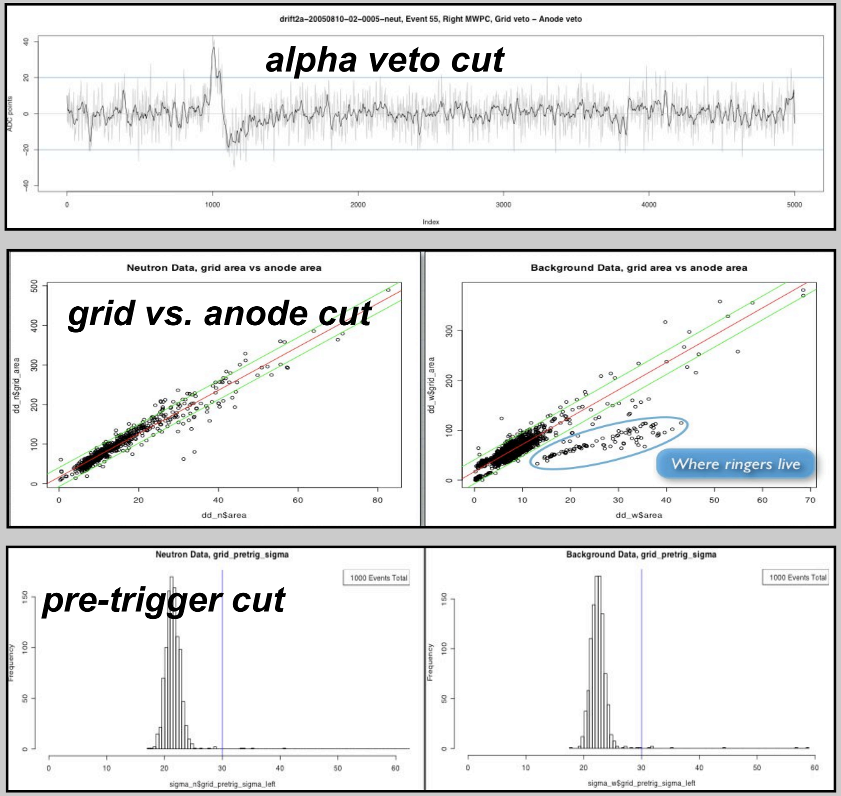
A large number of primary cuts reduced the raw background by a factor x20.

Neutron event (left detector)

- Alpha (2 cuts)
- Event in pretrigger
- Veto
- Ringer
- Overshoot
- Sparks
- Narrow fwhm
- Non consec wire
- Simultaneity
- Sum Sum
- ……



Example cuts



etc, etc….

What effect do these cuts have on neutron-induced and WIMP recoils?

Gamma rejection efficiency

Five x 0.52 mCi Co-60 sources placed on top of DRIFT-IIa unshielded vacuum vessel and 0.575 days of live time data were recorded.

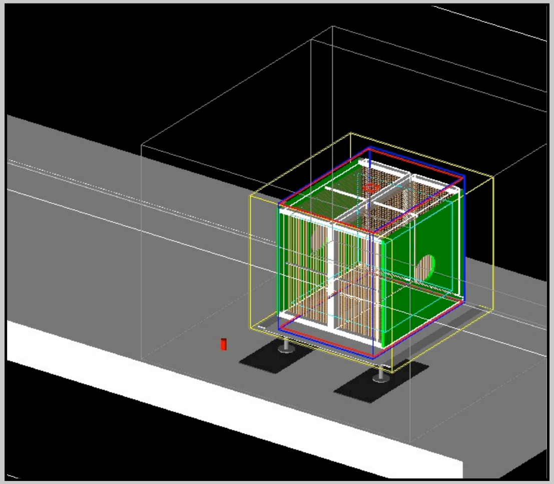


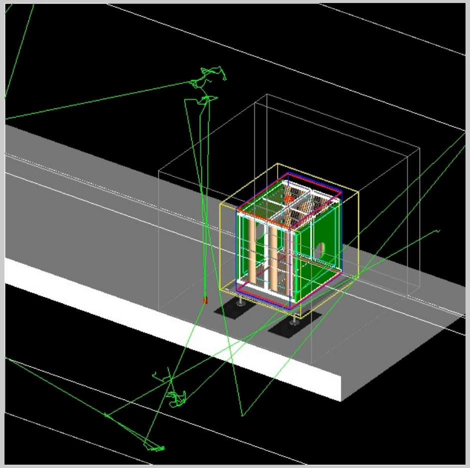
Table [Co-60 Results]

Nips Window	^{60}Co rate minus Background rate (Hz)	MC rate (Hz)	Rejection Factor Limits (90% C.L.)
1000-2000	$(-2+/-5)x10^{-4}$	77+/-1	$< 8x10^{-6}$
2000-3000	$(-1+/-1)x10^{-4}$	24.8+/-0.5	$< 5x10^{-6}$
3000-10000	$(2+/-6)x10^{-5}$	27.2+/-0.3	$< 3x10^{-6}$
1000-10000	$(1+/-3)x10^{-4}$	125.2+/-0.7	$< 3x10^{-6}$
1000-6000	$(1+/-3)x10^{-4}$	128.9+/-0.7	$< 3x10^{-6}$

Neutron detection efficiency

GEANT 4 used to determine the sensitivity to ^{252}Cf and rock neutrons - this has allowed the sensitivity of DRIFT to nuclear recoils to be accurately determined.

- **For the experiments place <u>minimal cuts</u> on data from ^{252}Cf neutron exposure runs: 2 timing cuts; clipped event cuts; vetoed events cut**
- **Same for background data immediately before or after the neutron run**
- **The difference between the two rates is due to neutron source**



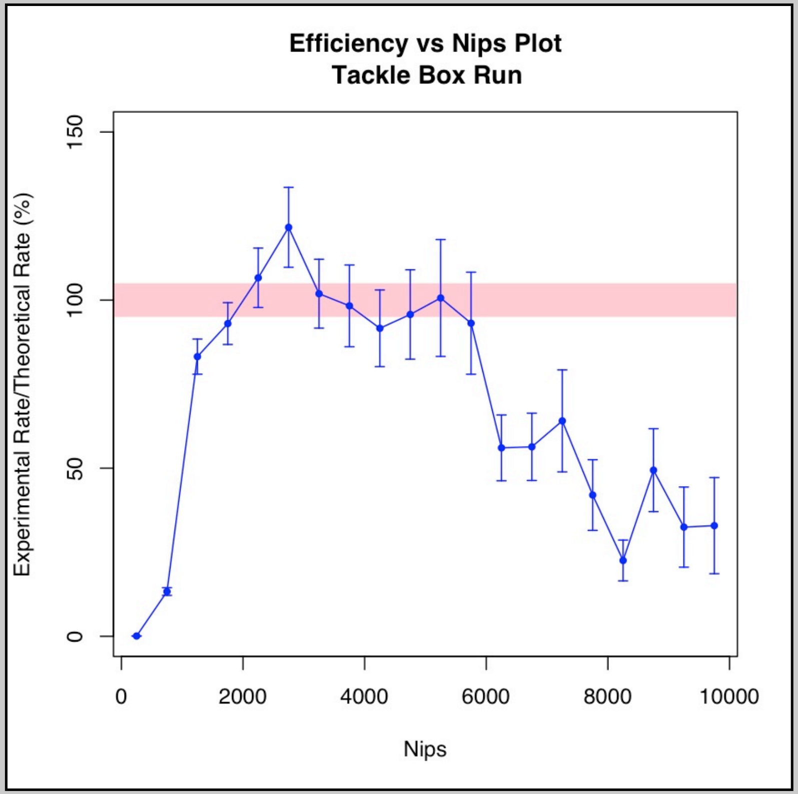
Example for events of 2500 - 5000 NIps

Comparisons			
Run type	Experimental Rate (on source - off source) (Hz)	Theoretical (GEANT) Rate (Hz)	Experiment / Theory
X-neutrons 20/06/05	0.038 +/- 0.003	0.040 +/- 0.004	95 +/- 10%
Y-neutrons 20/06/05	0.035 +/- 0.003	0.033 +/- 0.004	106 +/- 15%
Tackle Box 12/07/05	0.145+/-0.002	0.157 +/- 0.006	92 +/- 4%
Pre-shield neutrons 10/08/05	0.129+/-0.007	0.11+/-0.02	100 +/- 8%
Fully Shield Neutrons 03/11/05	0.177+/-0.002	0.162+/-0.007	109 +/- 4%

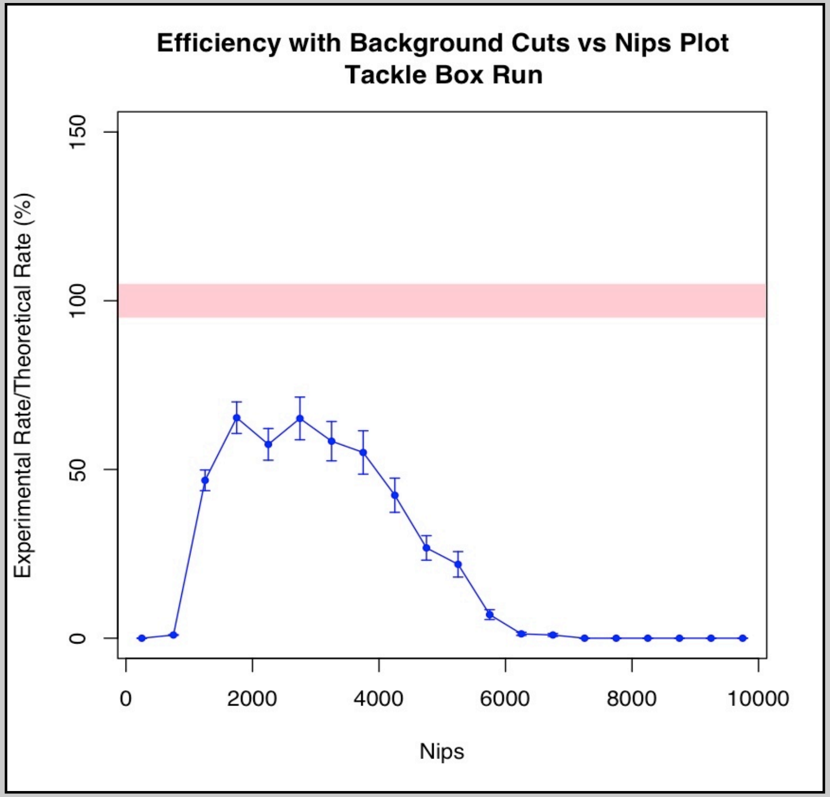
Excellent agreement between measurements and GEANT for many different configurations

Neutron efficiency with cuts

Efficiency vs NIPs with simple cuts



Efficiency vs NIPs with "background reducing" cuts

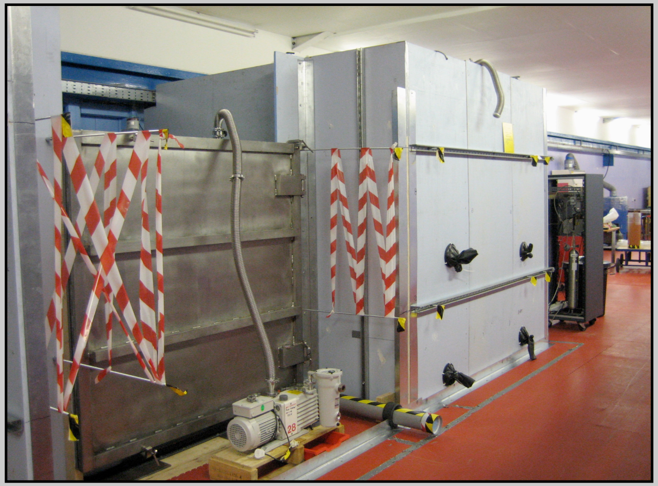


DRIFT IIa - background status

For typical analysis run - 4.36 days background, neutron run 0.97 hours

calibrated recoil efficiencies

Nips	Rate (Hz)	Efficiency (%)
1000 - 5000	0.075 ± 0.005	39 ± 3
2000 - 5000	0.066 ± 0.004	60 ± 7
2500 -5000	0.055 ± 0.004	70 ± 11



remaining rates

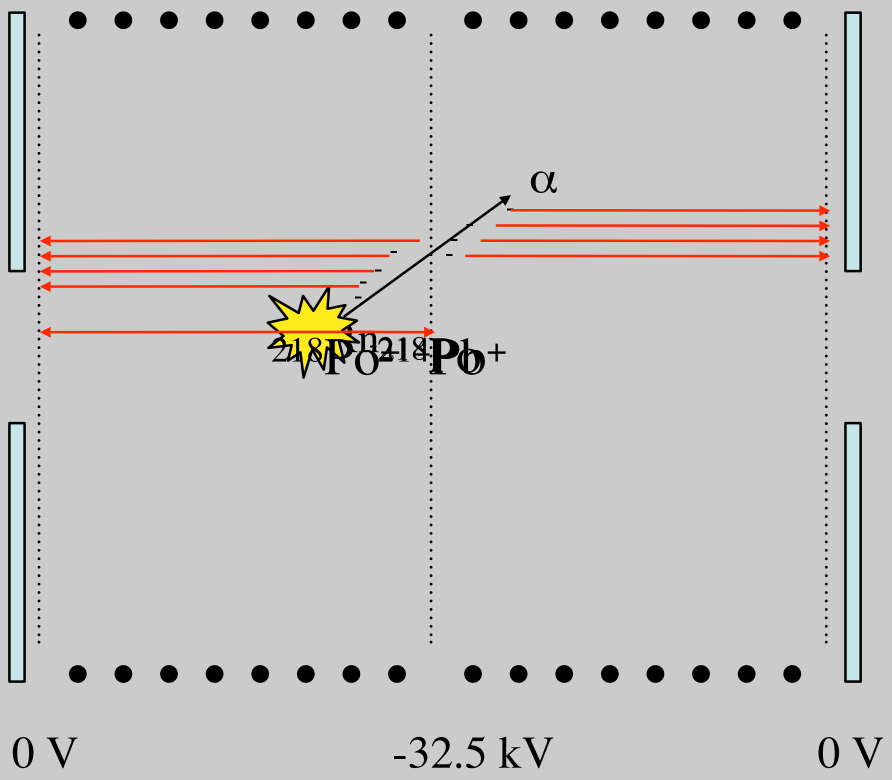
Nips	Rate (/day)
1000 - 5000	20 ± 2
2000 - 5000	15 ± 2
2500 -5000	7 ± 1

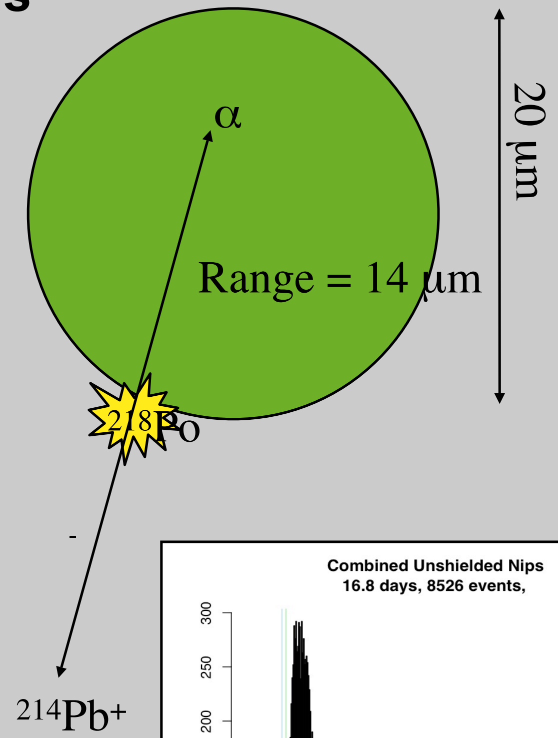
remaining events are <u>recoils</u>

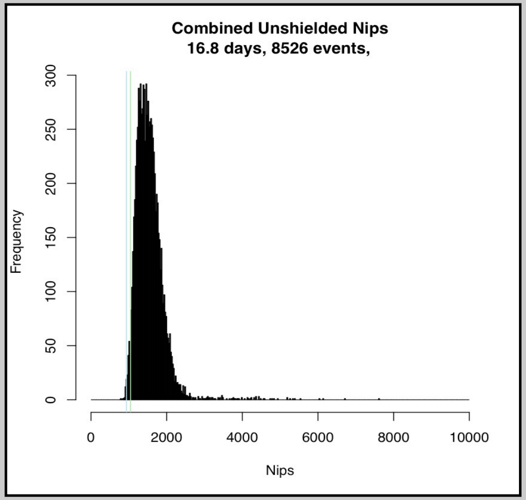
identified as radon progeny recoils (RPR)

Radon Progeny Recoils

The Radon Progeny Recoil (RPR) Hypothesis

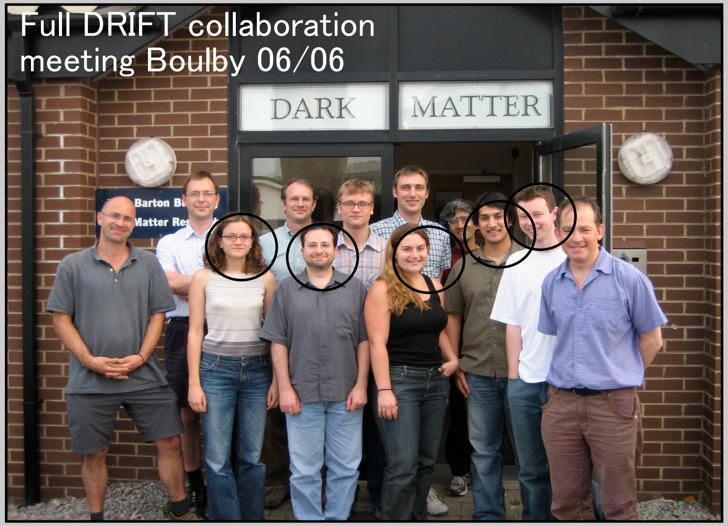






DRIFT IIb - in 5 days

DRIFT IIb with new radon control and RPR control



NB: students are very active on DRIFT

Conclusion

Great progress in WIMP searches

But we will need a directional gas TPC detector to show definitively that WIMPs exist in the galactic halo!