MIND Reconstruction

Tapasi Ghosh
Anselmo Cervera Villanueva

IFIC - Valencia

Ryan Bayes
Paul Soler

University of Glasgow

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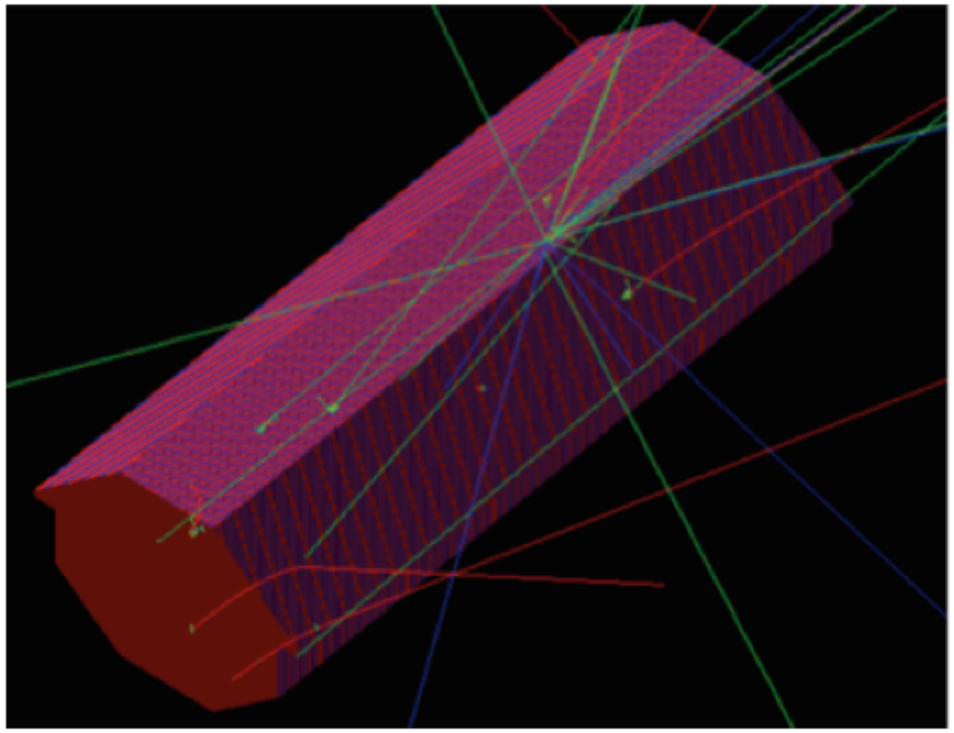
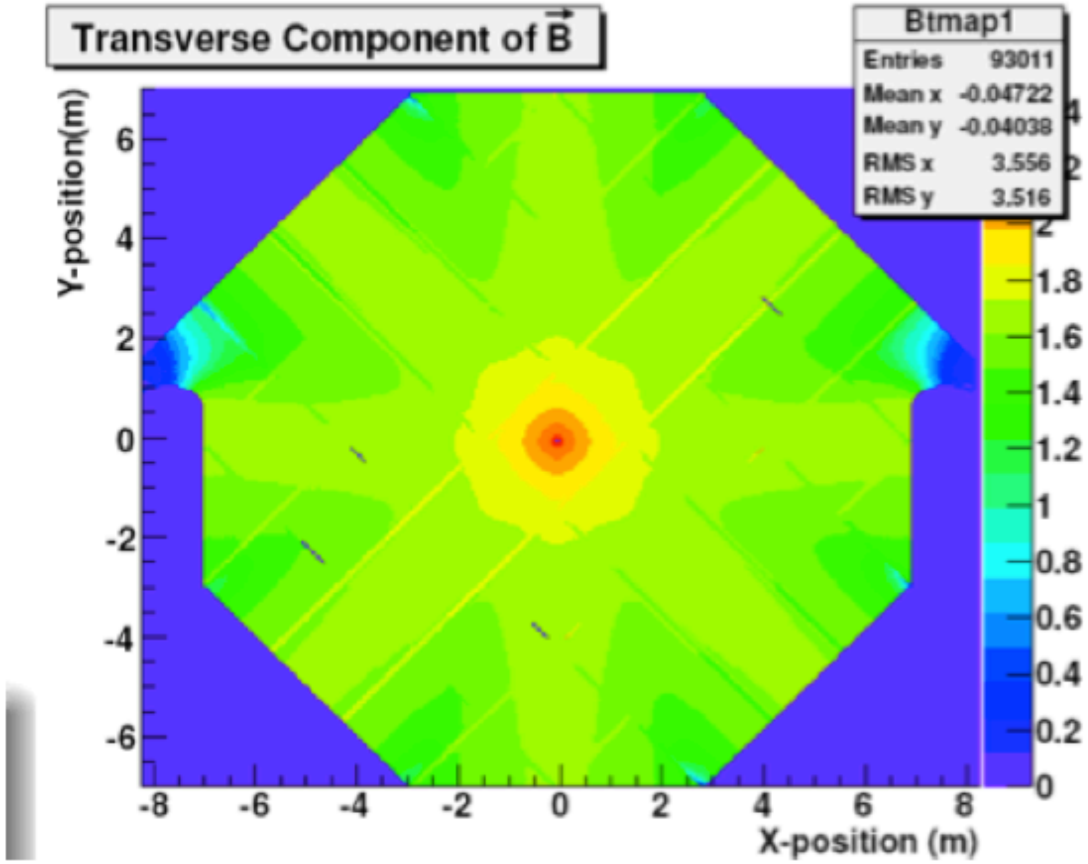
Analysis flow

- Neutrino interactions are simulated by GENIE.
- Detector geometry simulation by Geant4.
- Digitized hits are passed to the Reconstruction.
- Pattern recognition performs track finding by incremental Kaman Filtering or by Cellular Automata.
- Selected track is fitted by Kalman Filter (RecPack).
- Finally ν_μ is identified as signal, while other neutrino flavours diagnosed as ν_μ are the background.

Realistic Geometry

- The octagonal geometry and toroidal field map has been implemented (by Ryan Bayes).

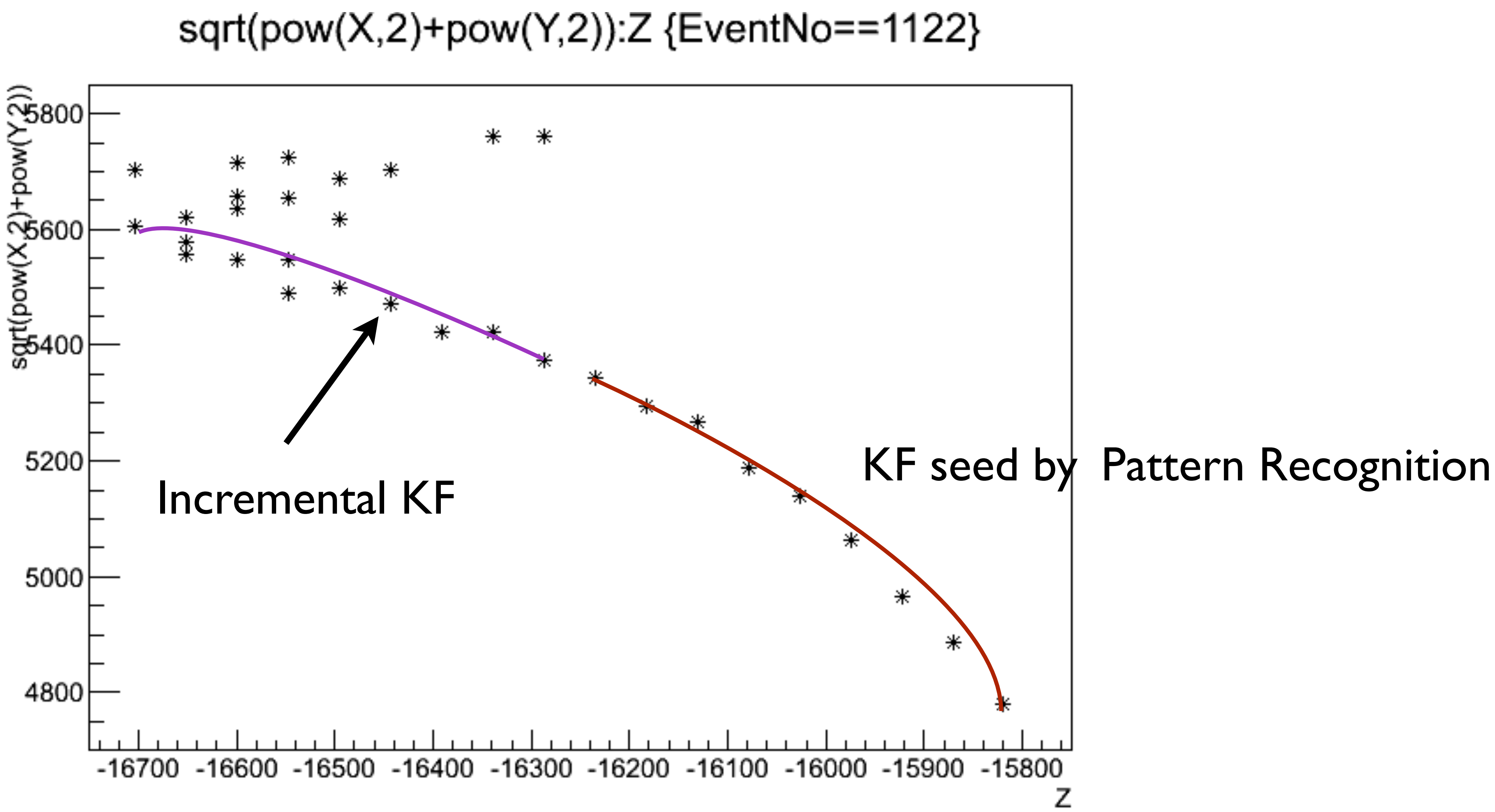




- Reconstruction has been improved to deal with new geometry and the toroidal field.

Reconstruction strategy

- At first, looks for the plane occupancy along Z planes (neutrino direction) and search for longest ´free section´ which contains single occupancy planes.
- Seed for track finding obtained from Pattern Recognition.



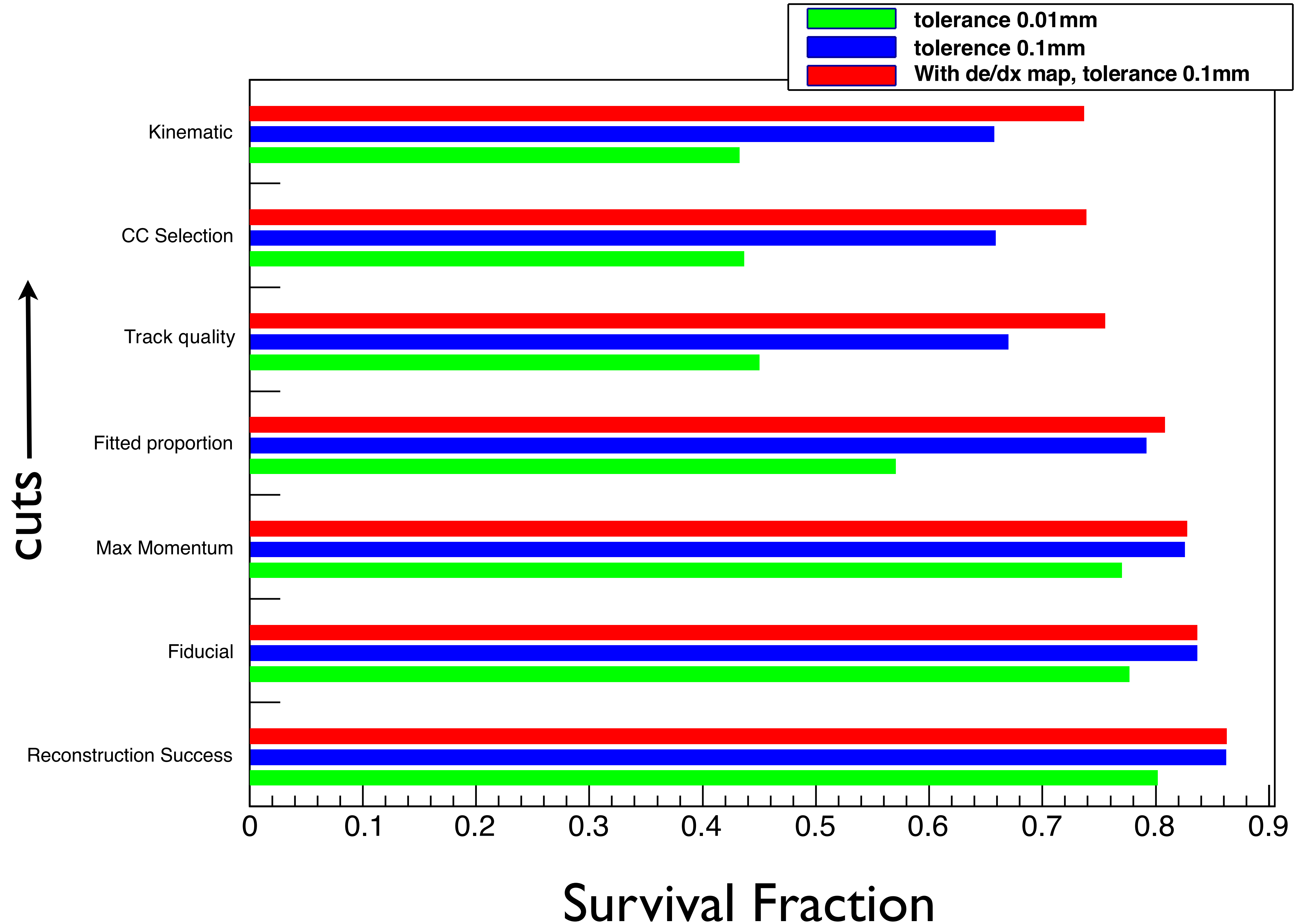
Reconstruction strategy

- Depending on the number of free planes either of KF or CA methods are chosen for track finding.
- After incremental filtering, tracks are passed on the fitter and if required, depending on $\chi 2$ value tracks are re-fitted.
- ROOT tree is filled with requisite event and corresponding track informations.

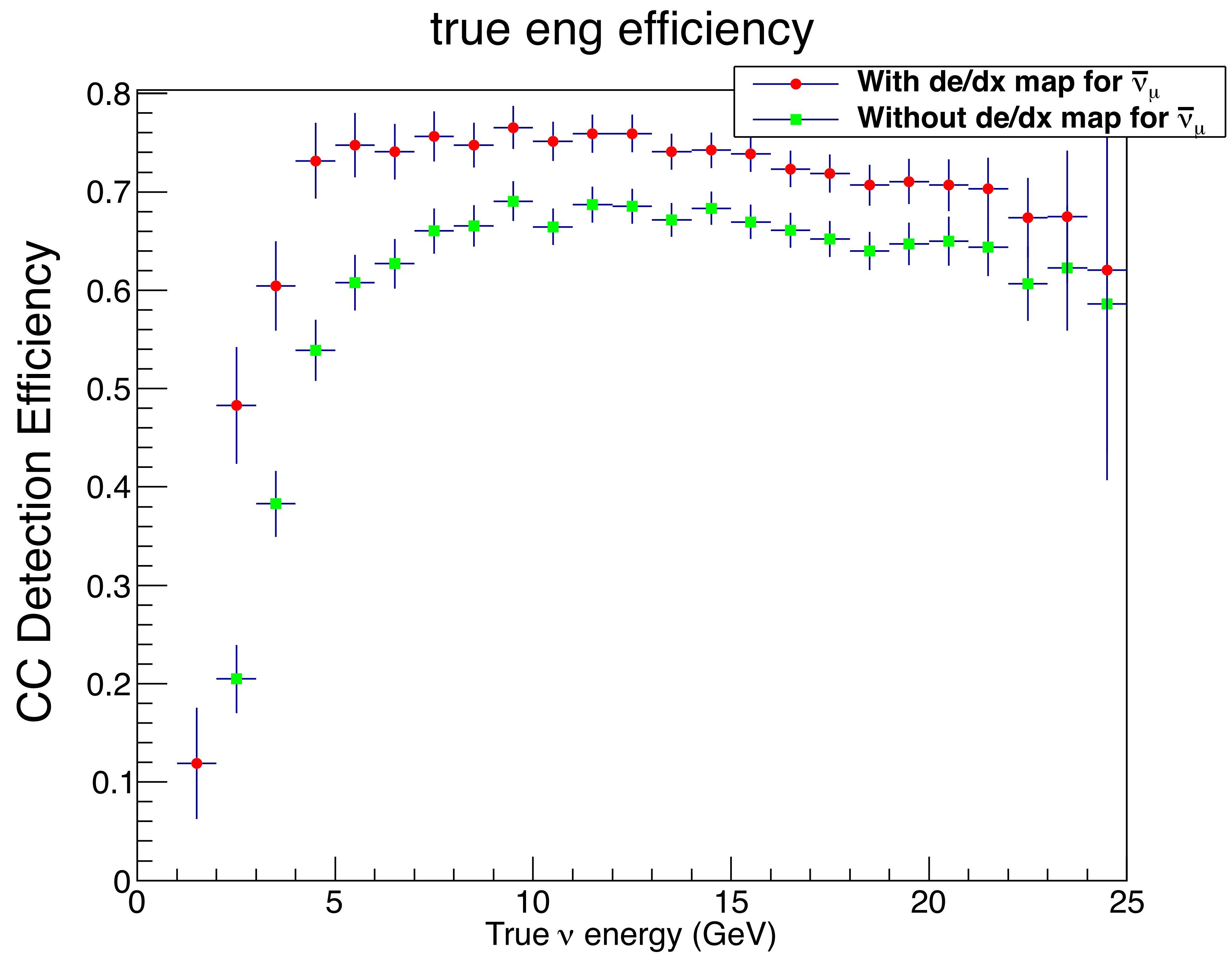
New Reconstruction

- Reconstruction has been improved to deal with the octagonal geometry and the toroidal field.
- Since field is not uniform anymore, to avoid a large number of steps (>100) tolerance for extrapolation between the target surface and the helix propagator is increased inside RecPack (from 0.01 to 0.1 mm).
- Energy loss (de/dx) map is introduced.
- During each extrapolation RecPack updates energy loss according to momentum at corresponding extrapolation.
- Energy loss correction is crucial for momentum reconstruction of low energy tracks as well.

New Reconstruction Result



Result

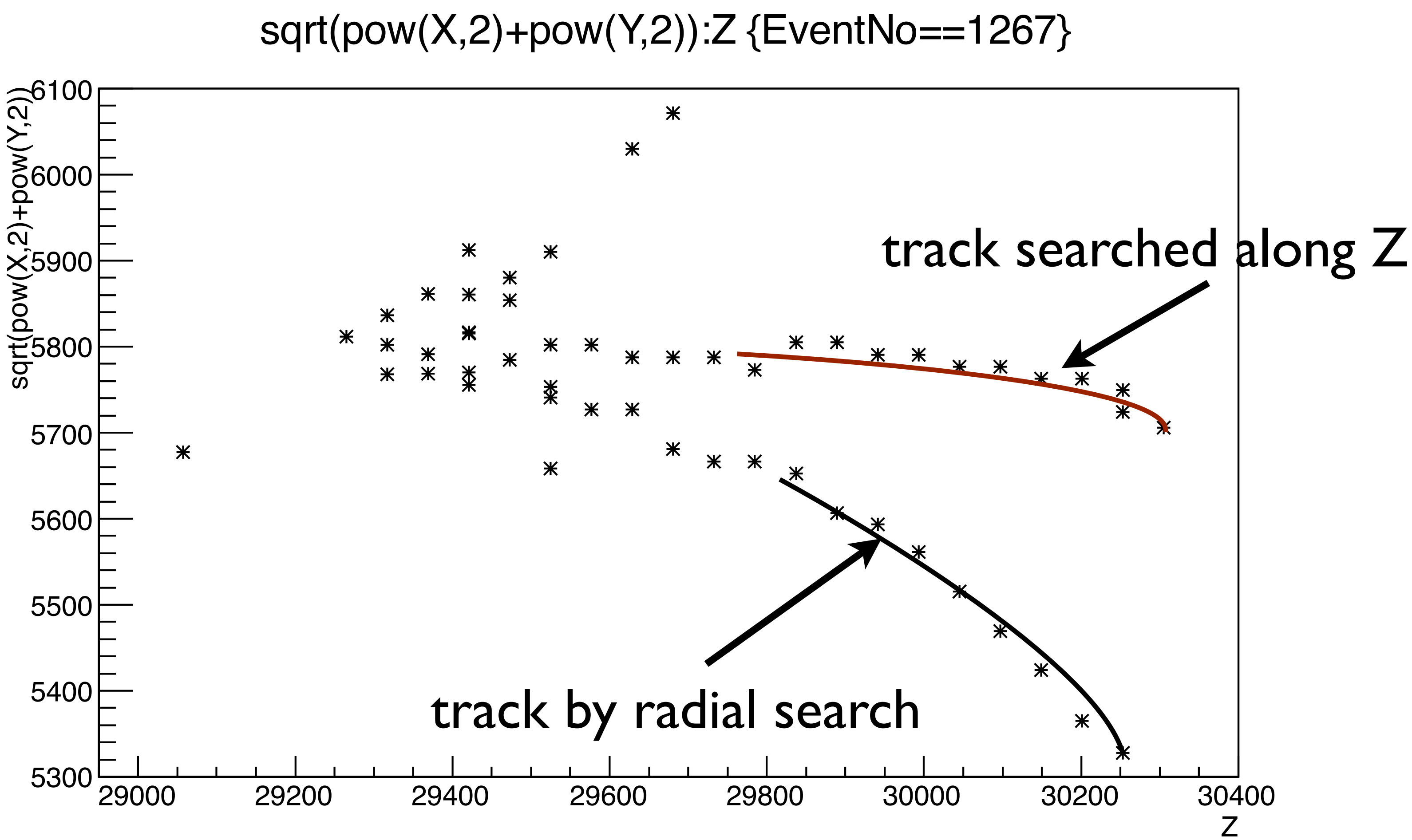

true eng efficiency
With de/dx map for $\bar{\nu}_\mu$
Without de/dx map for $\bar{\nu}_\mu$
CC Detection Efficiency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
5
10
15
20
25
True ν energy (GeV)

Next steps

- Multiple track search
- Momentum by range
- 2D-view matching
- Shower reconstruction

Multiple Track Search

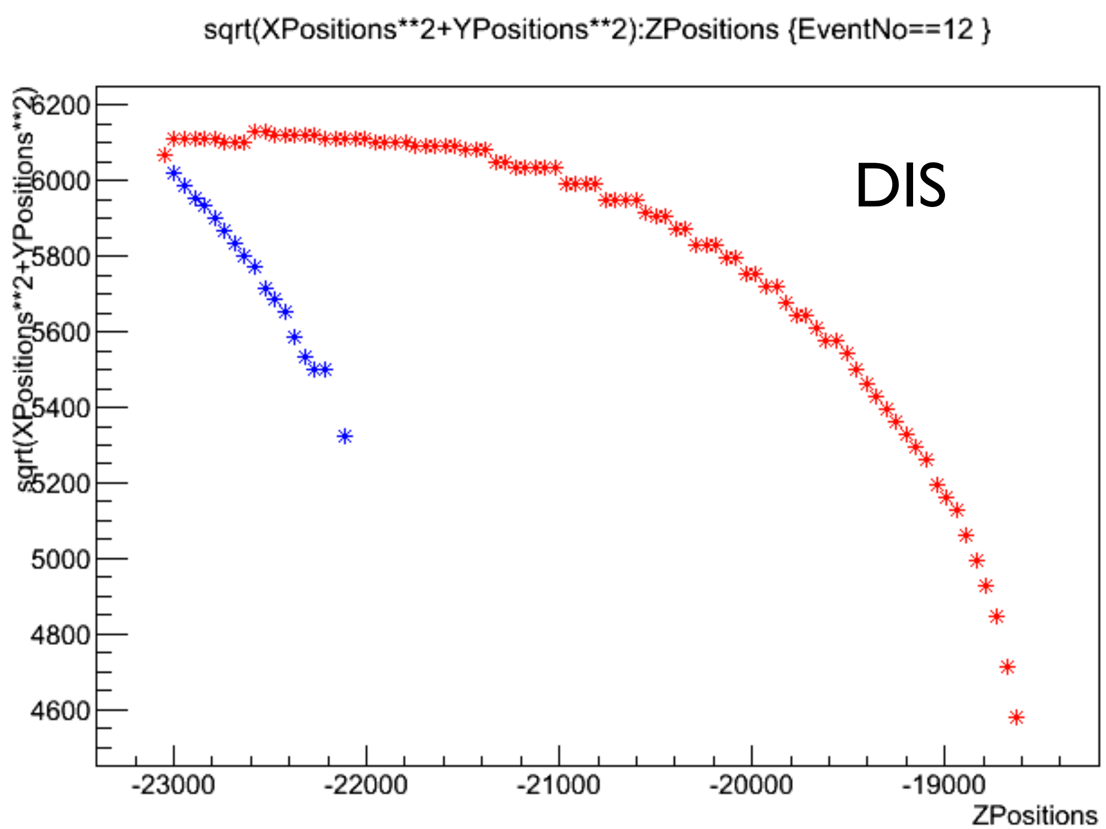
- For low energy NF, need to improve the pattern recognition to obtain more than one track from each event (CCQE, RES).

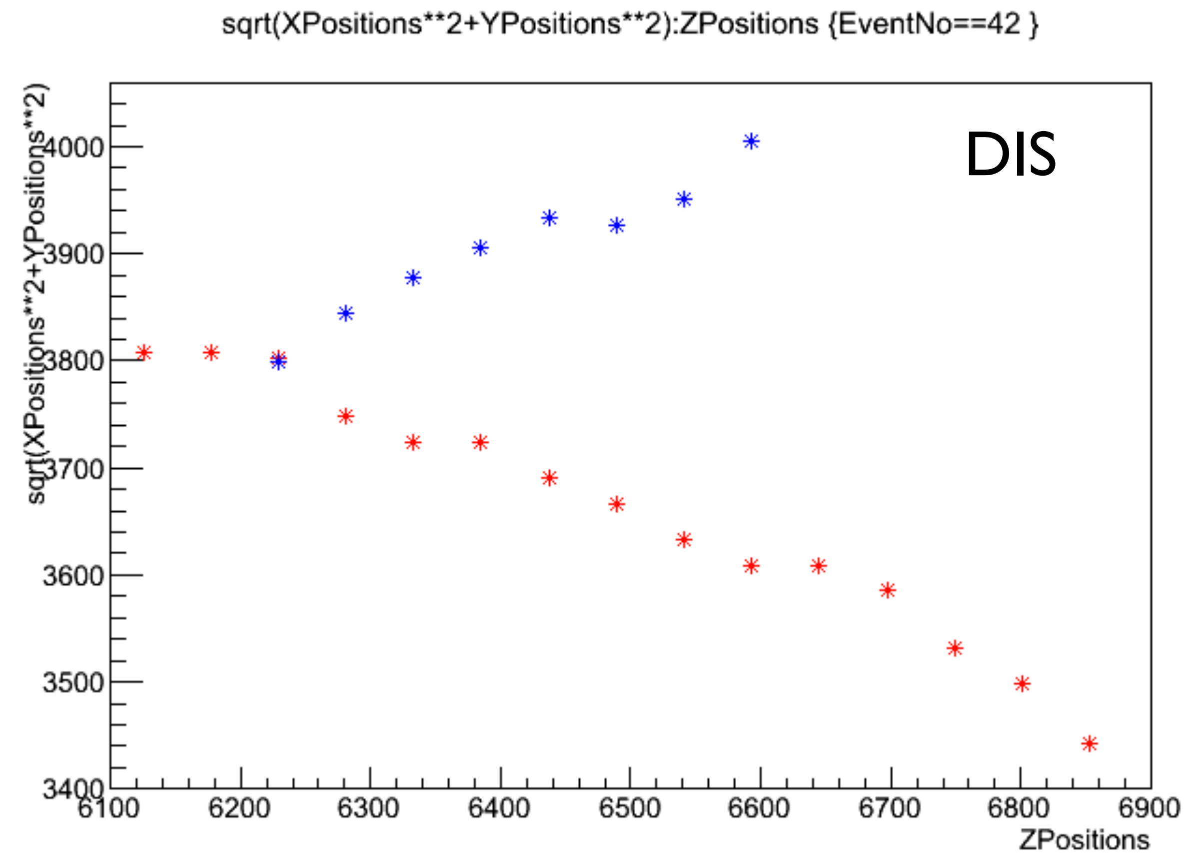


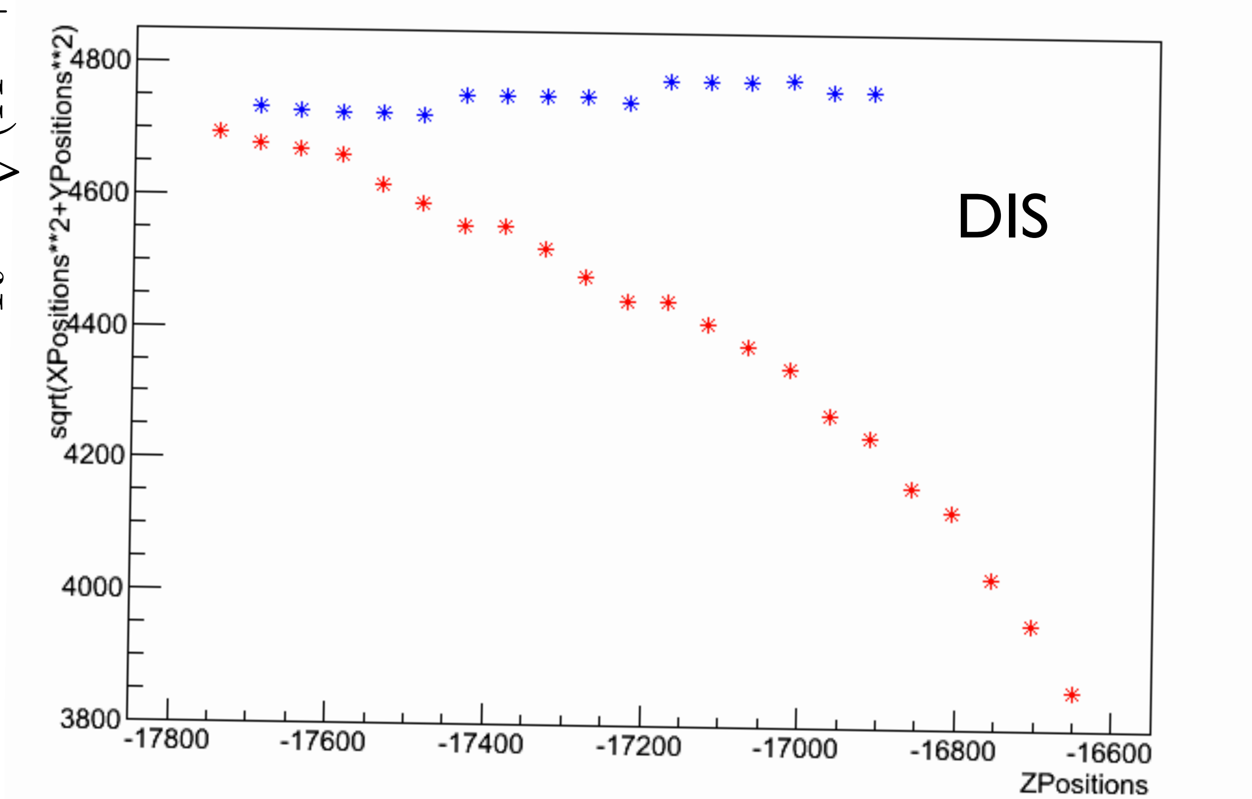
- Searching free section of track both along Z and radially enhance multiple track searching.

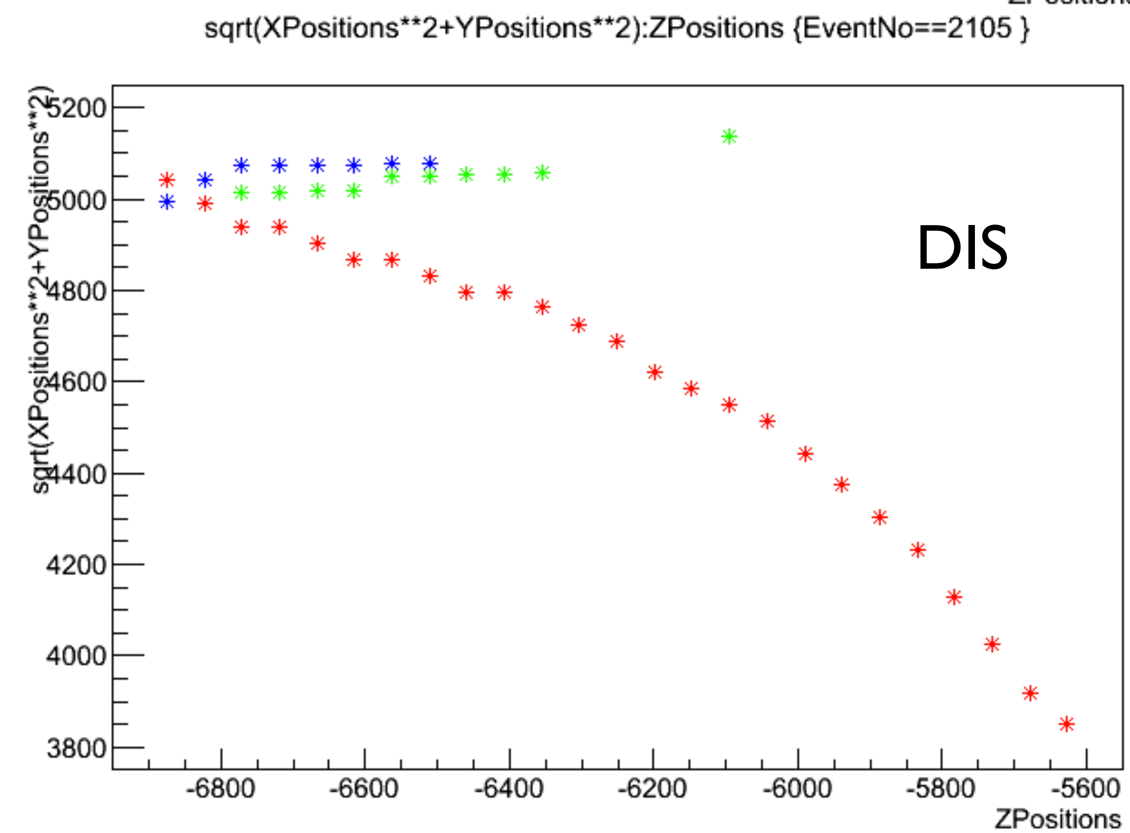
Some events

$R = \sqrt{(X^2 + Y^2)}$

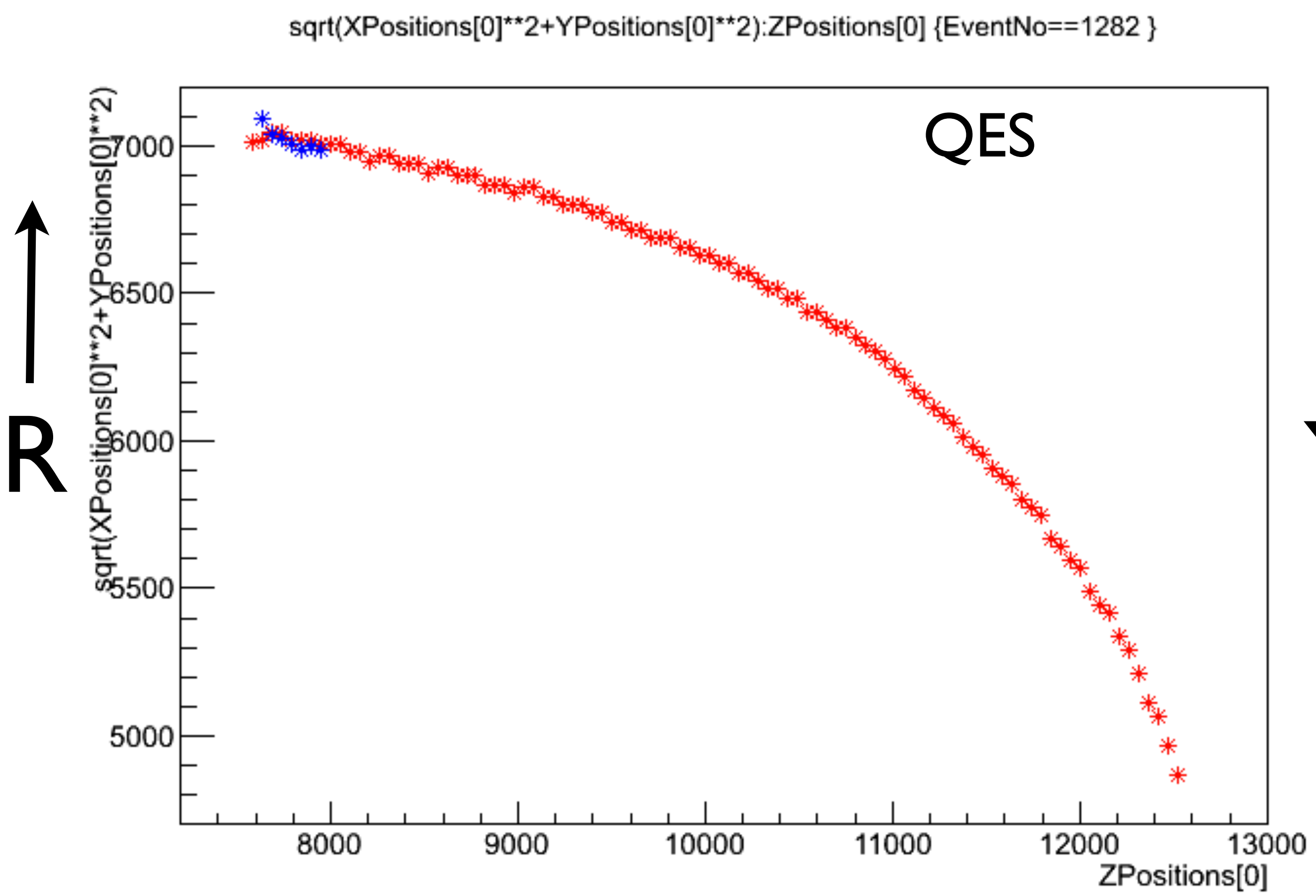


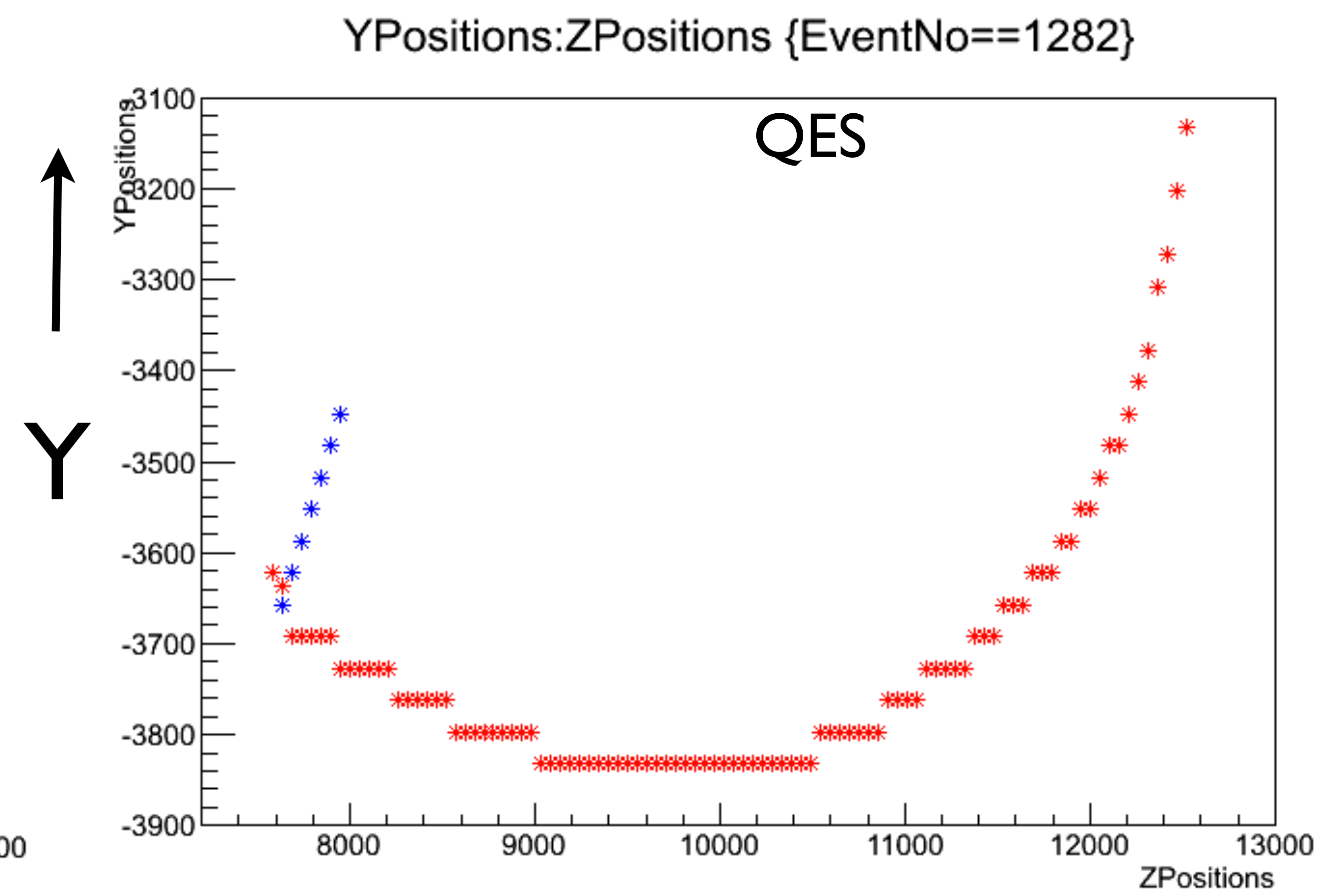






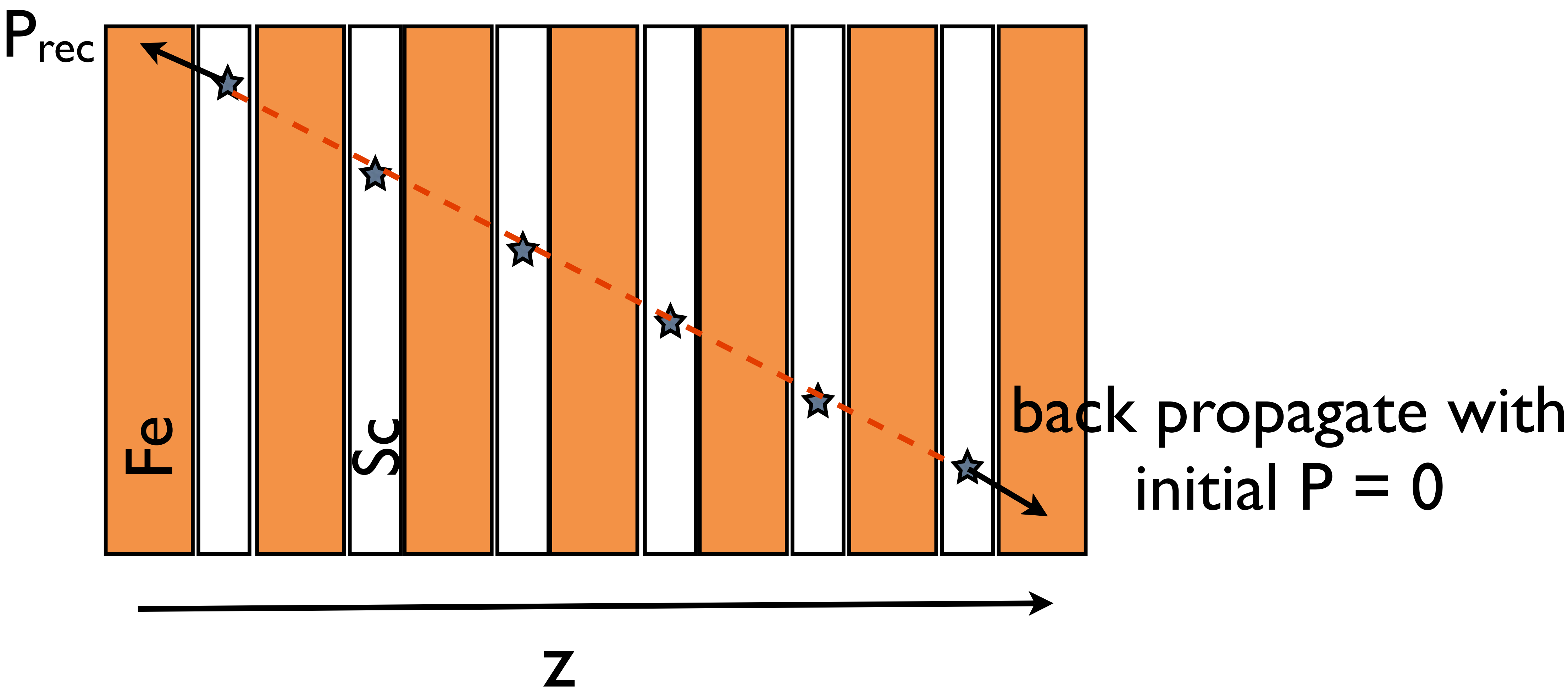
Some Events


sqrt(XPositions[0]**2+YPositions[0]**2):ZPositions[0] {EventNo==1282 }
QES
R
sqrt(XPositions[0]**2+YPositions[0]**2)
7000
6500
6000
5500
5000
8000
9000
10000
11000
12000
13000
ZPositions[0]


YPositions:ZPositions {EventNo==1282}
QES
Y
YPositions
-3100
-3200
-3300
-3400
-3500
-3600
-3700
-3800
-3900
8000
9000
10000
11000
12000
13000
ZPositions

Momentum from Range

- Sometimes short tracks are straight, so need to calculate momentum from range.

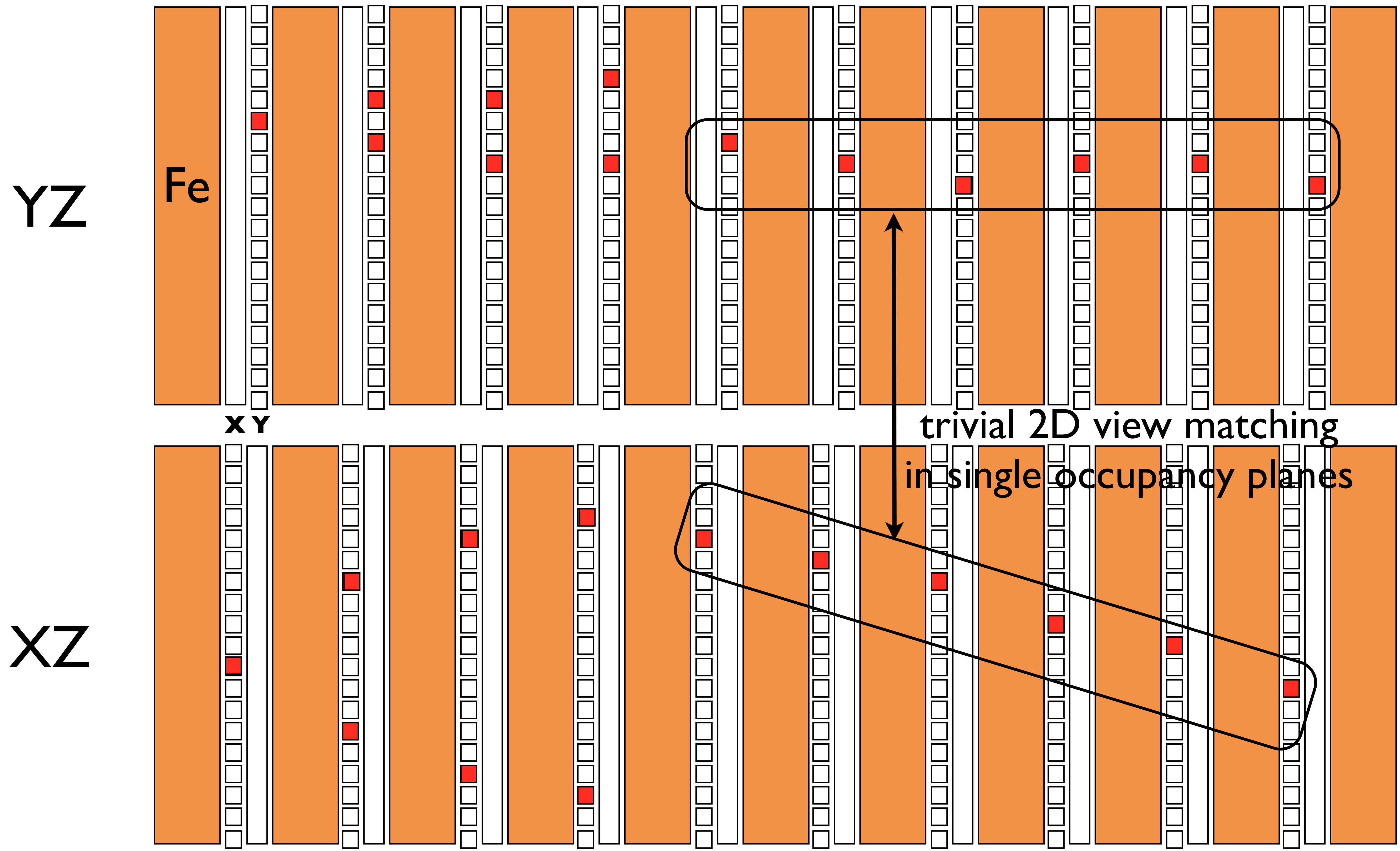


2D View Matching

- Two orthogonal layers of scintillator bars (14m x 3.5cm x2cm) between two iron plates.
- At the moment we assume perfect view matching (each voxel is 3.5cm x 3.5 cm x 2cm) at present.
- We should change each 2cm plane into 2x1 cm planes for both side view.
- Matching of the 2D views should be introduced in the reconstruction
- A seed track (free part) can perform incremental filtering with the 2-D informations.

2D view matching strategy

2D kalman filter incremental matching with 3D seed



Conclusions

- Reconstruction has adopted toroidal field of MIND.
- New reconstruction (energy loss map, tolerance) improves reconstruction efficiency.
- For 10 GeV MIND, pattern recognition as well as fitter has improved in order to recover low energy events and to find several tracks.
- This will help in shower reconstruction as well.
- Momentum from range calculation and 2-D view matching has to be incorporated.

Back up

Cuts

Cut	Acceptance level	Eff. after		main back. ($\times 10^{-3}$)	
		ν_μ	$\overline{\nu}_\mu$	ν_μ	$\overline{\nu}_\mu$
Fiducial	$z1 \leqslant 18000$ mm where $z1$ is the lowest z cluster in the candidate	0.85	0.91	120 (ν_e)	100 ($\overline{\nu}_e$)
→ Track quality	$\mathcal{L}_{q/p} > -0.5$	0.76	0.85	20 (ν_e)	20 ($\overline{\nu}_e$)
Max. momentum	$P_\mu \leqslant 40$ GeV	0.76	0.84	20 (ν_e)	20 ($\overline{\nu}_e$)
→ CC selection	$\mathcal{L}_1 > 1.0$	0.74	0.83	0.49 (ν_e)	1.6 (ν_μ)
Fitted proportion	$N_{fit}/N_h \geqslant 0.6$	0.73	0.83	0.46 (ν_e)	1.2 (ν_μ)
→ Kinematic	$E_{rec} \leqslant 5\ GeV$ or $Q_t > 0.25$ $E_{rec} \leqslant 7\ GeV$ or $P_\mu \geqslant 0.3E_{rec}$	0.63	0.77	0.65 ($\overline{\nu}_\mu$)	0.59 (ν_μ)
Displacement	$dispX/dispZ > 0.18 - 0.0026N_h$ $dispZ > 6000\ mm$ or $P_\mu \leqslant 3dispZ$	0.59	0.72	0.38 ($\overline{\nu}_\mu$)	0.38 (ν_μ)
Quadratic fit	$qp_{par} < -1.0$ or $qp_{par} > 0.0$	0.58	0.71	0.07 ($\overline{\nu}_\mu$)	0.07 (ν_μ)