IC40 Cascade Analysis Unblinding Proposal

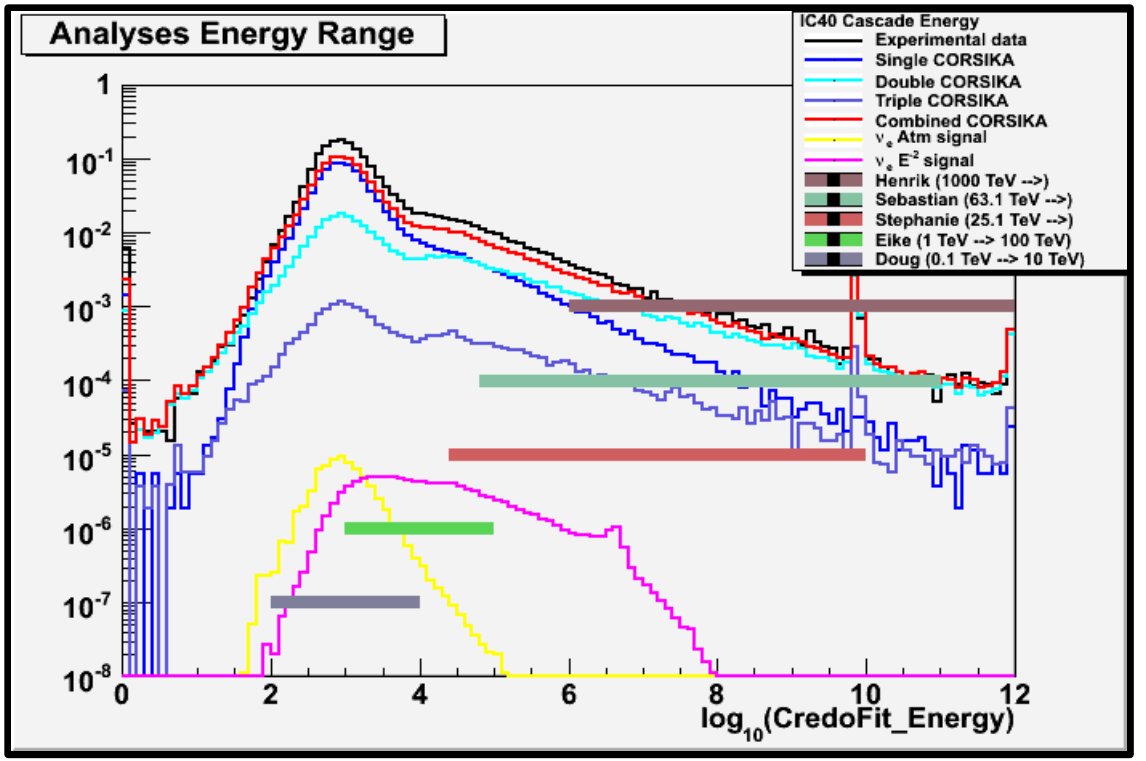
Analysis Call
Friday 15th April, 3:30am

Stephanie Hickford

Purpose

To discover an E^{-2} flux of neutrino-induced cascades in IC40

- Other analyses using the cascade stream:
  - Henrik → unblinded
  - Sebastian → unblinded
  - Eike → in progress
  - Doug → in progress

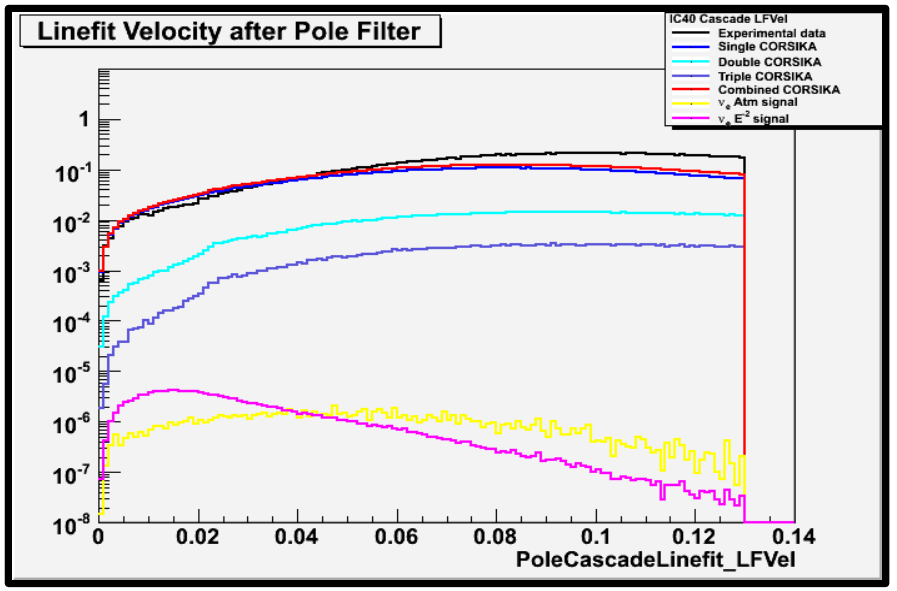


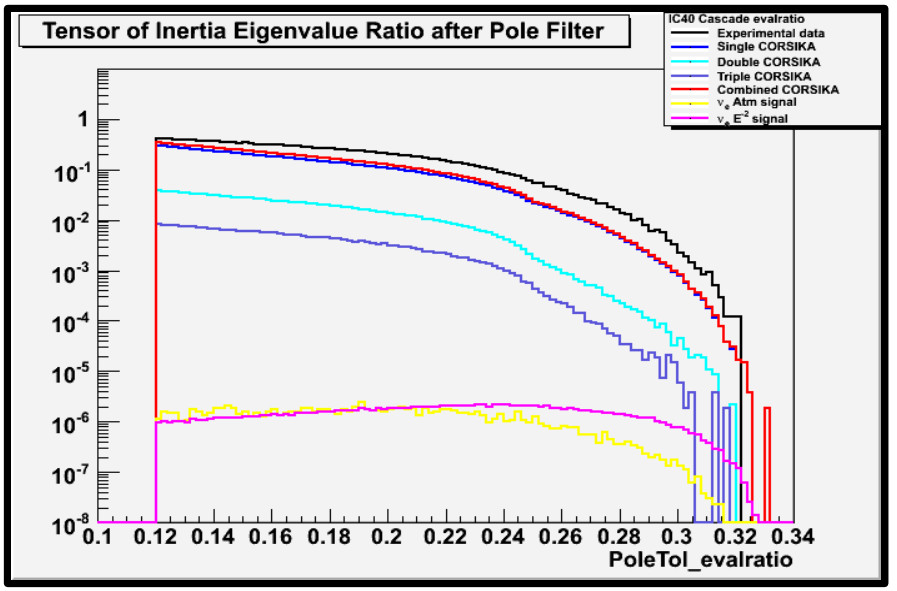
Data and Simulation

- Experimental Data, 6th April 2008 to 20th May 2009
  - Burn Sample → 10% defined by run number ending in zero
- Neutrino Generator
  - $E^{-1} \rightarrow \nu_e, \nu_\mu, \nu_\tau$
- CORSIKA
  - Single → 134,000 files
  - Double → 46,000 files
  - Triple → 7,000 files
  - Weighted Single → 166,000 files
  - Weighted Double → 7,000 files
  - 2-component polygonato → 600 proton files, 600 iron files

Trigger and Pole Filter

- Simple Multiplicity Trigger > 8
  - ➔ 8 DOMs hit within 5,000 ns





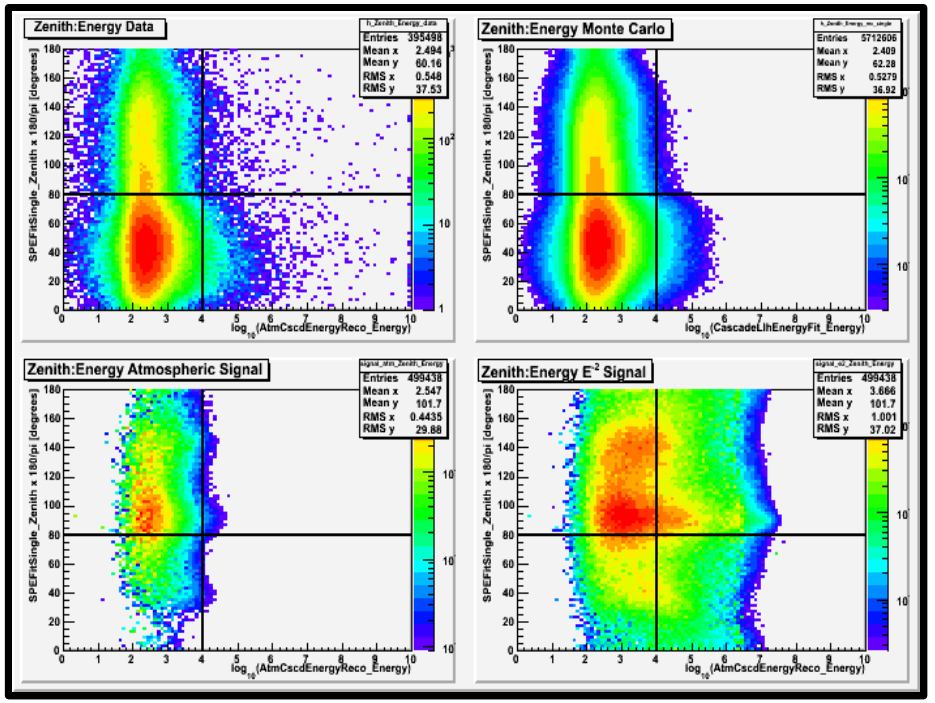
- Linefit Velocity < 0.13
  - ➔ Event has low velocity
- Tensor of Inertia Eigenvalue ratio > 0.12
  - ➔ Event has spherical topology

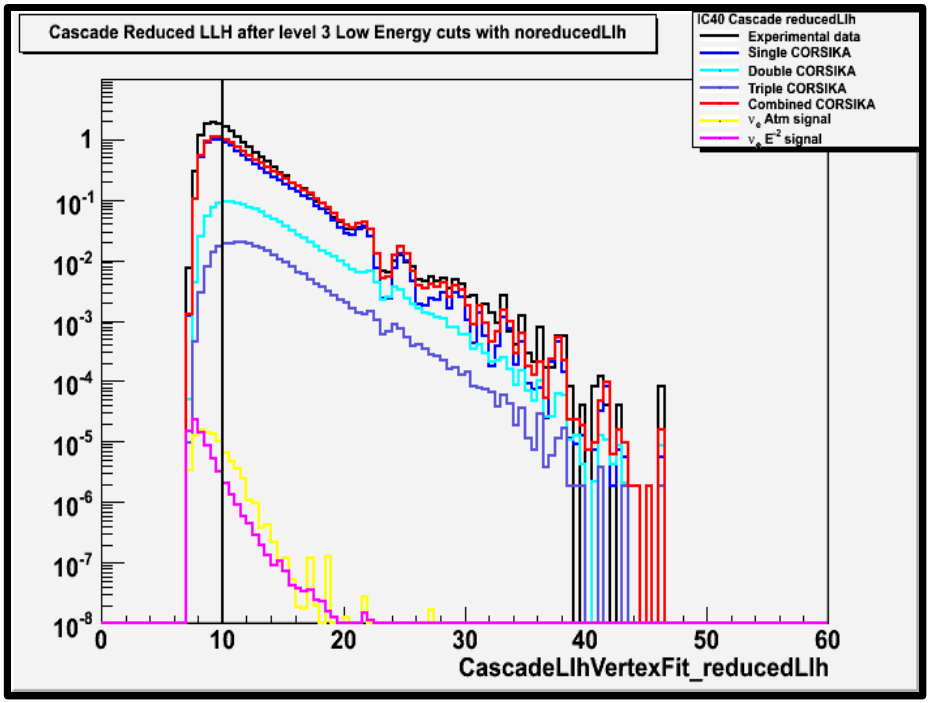
Level 3 (working group)

For only events with Energy < 10 TeV :

- $\text{Zenith}_{(\text{track})} > 80°$
- $\text{Reduced log likelihood}_{(\text{cascade})} < 10$

followed by many additonal reconstructions

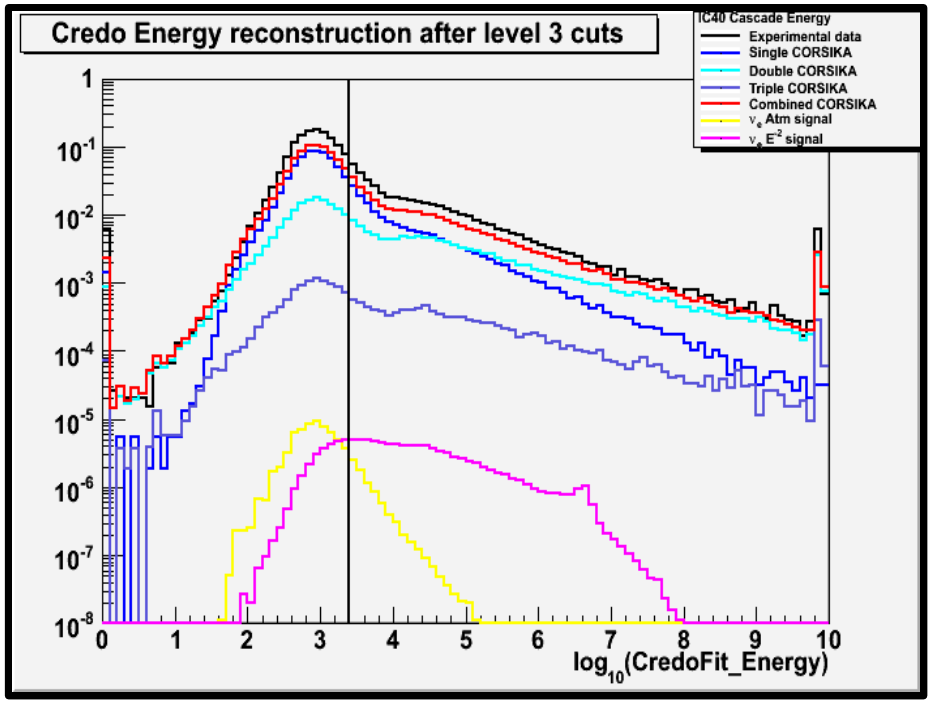


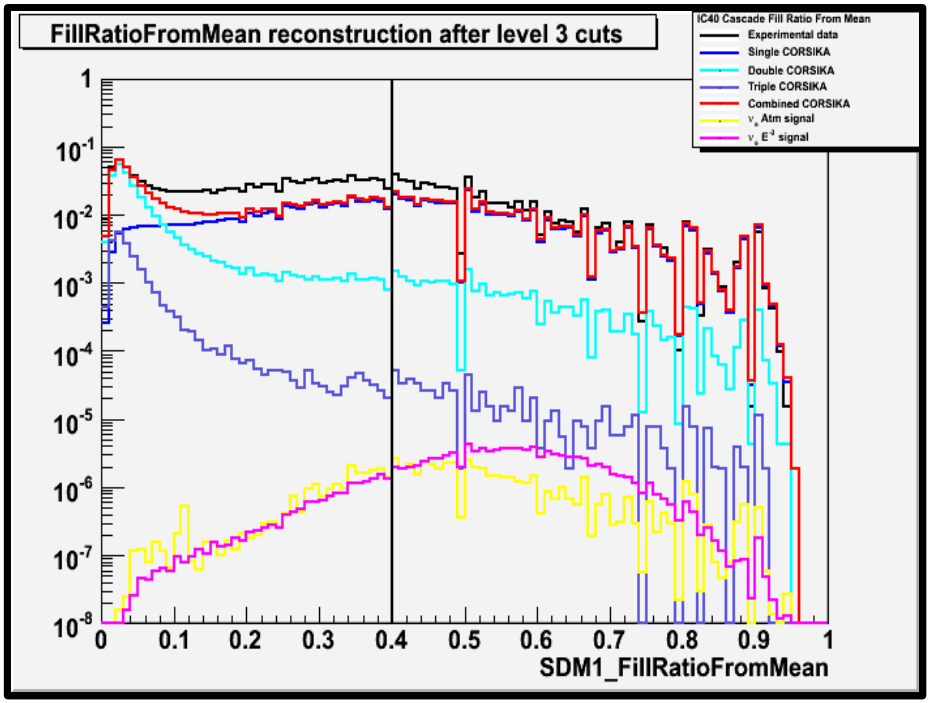


Level 4

Three cuts:

- Energy > 2.5 TeV
  - ➔ Since this aims to be a high energy analysis
- Fill Ratio > 0.4
  - ➔ Ratio of DOMs hit over total numer of DOMs in sphere

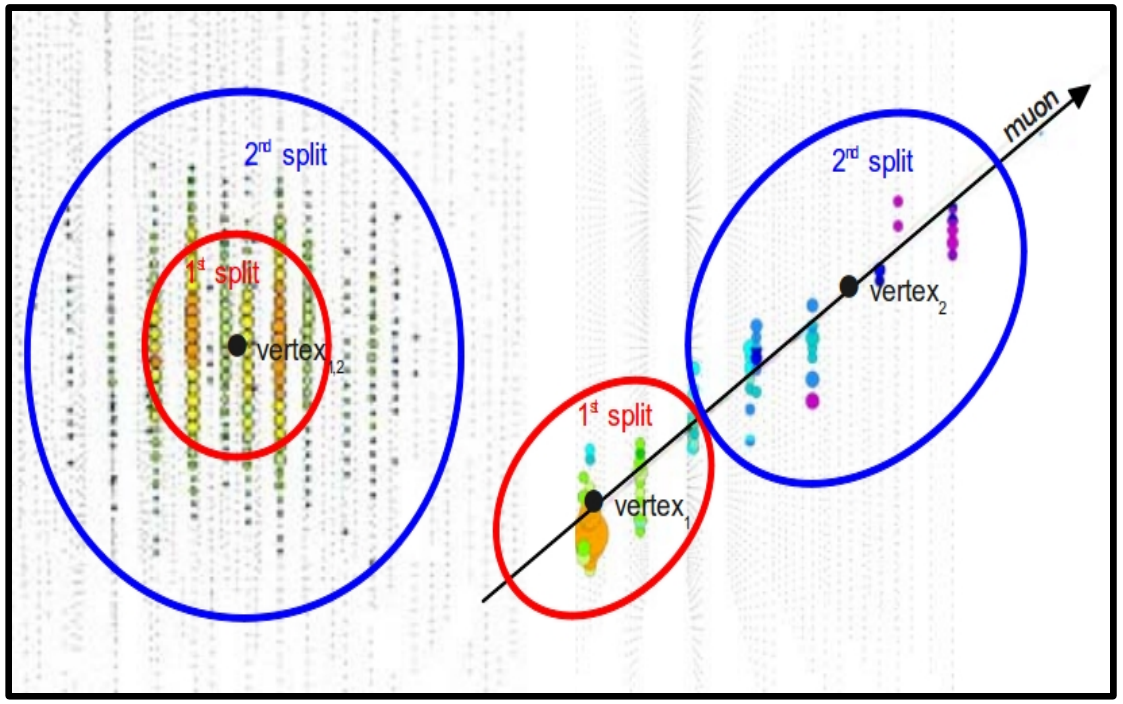


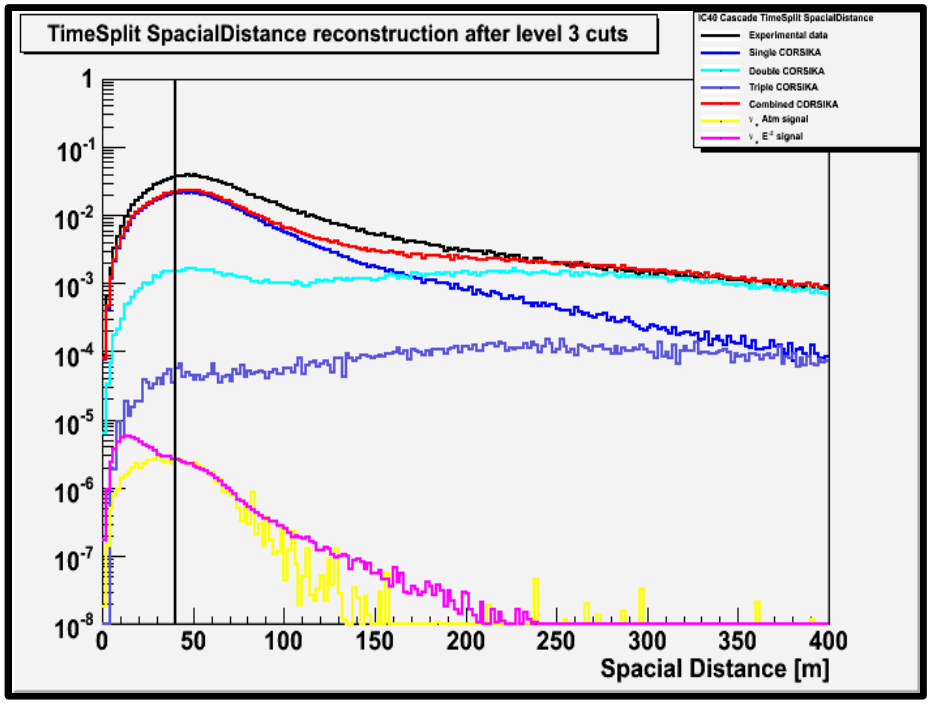


Level 4, cont.

- Spacial Distance < 40 metres
  - ➔ Split vertices must be close together

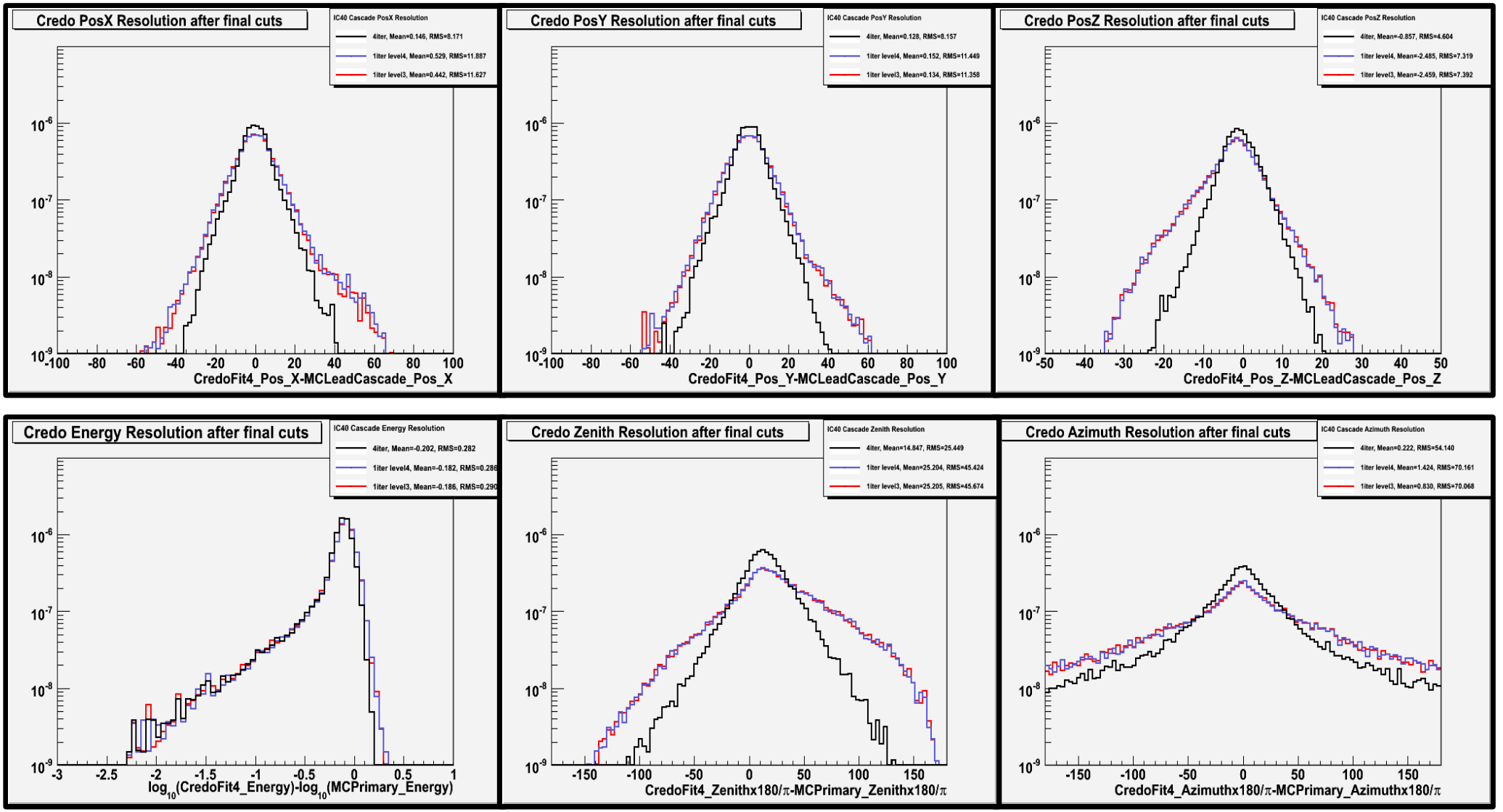
followed by additonal 4 iteration Credo reconstruction





Resolution Plots

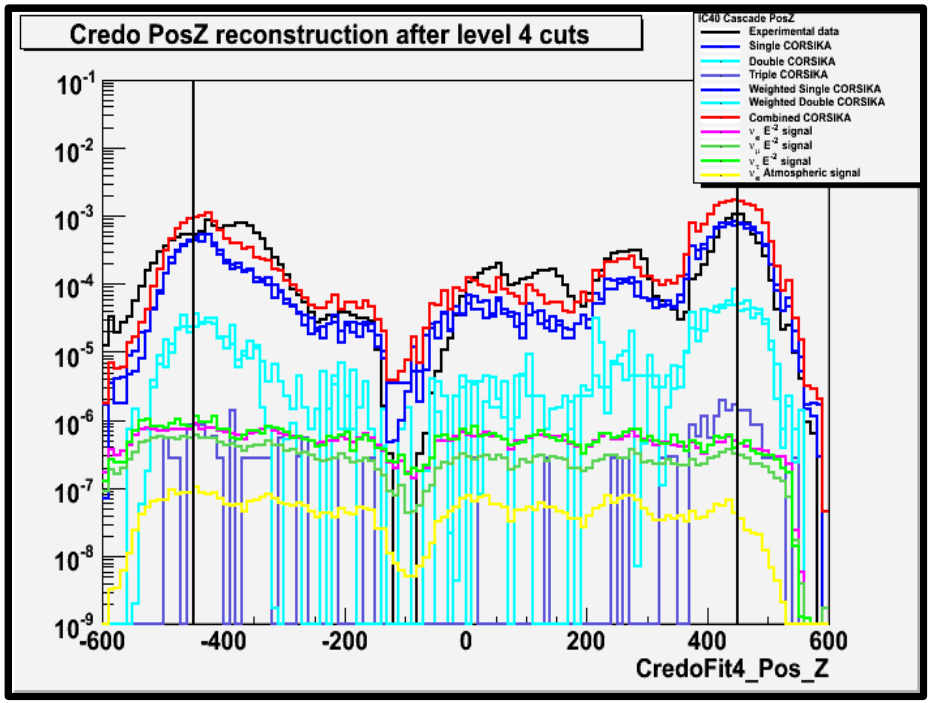
- 4 iteration Credo has significant improvement:



Level 5

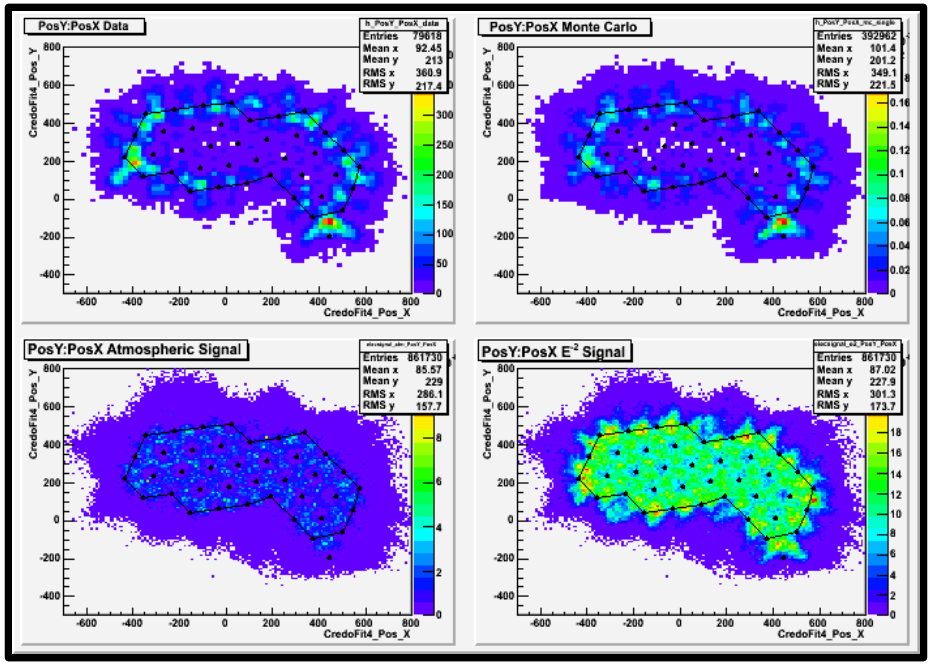
Three precuts for TMVA:

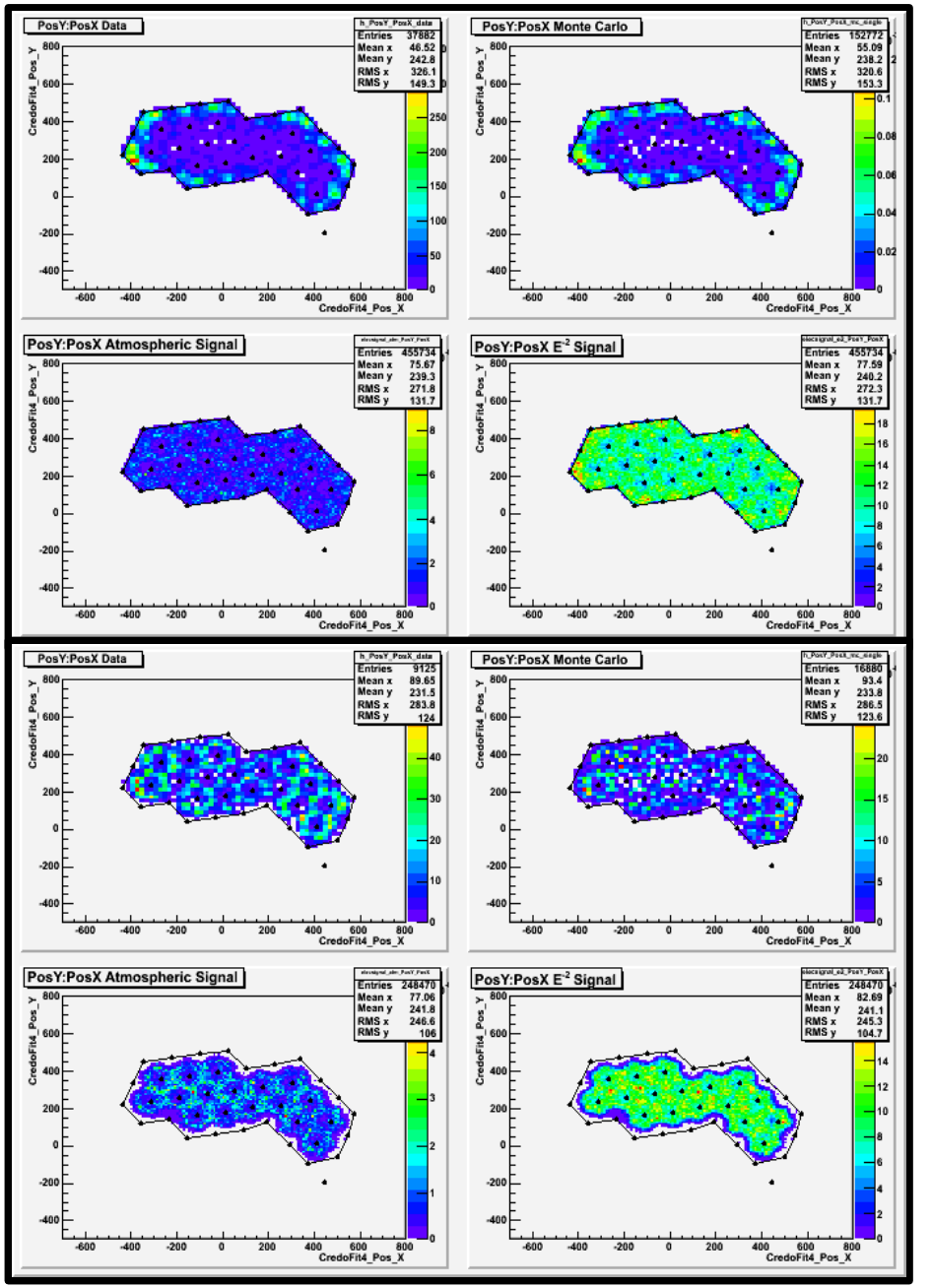
- Z vertex position > -450 metres && < 450 metres
  - ➔ Vertex must be inside 50 metres of the detector



Level 5, cont.

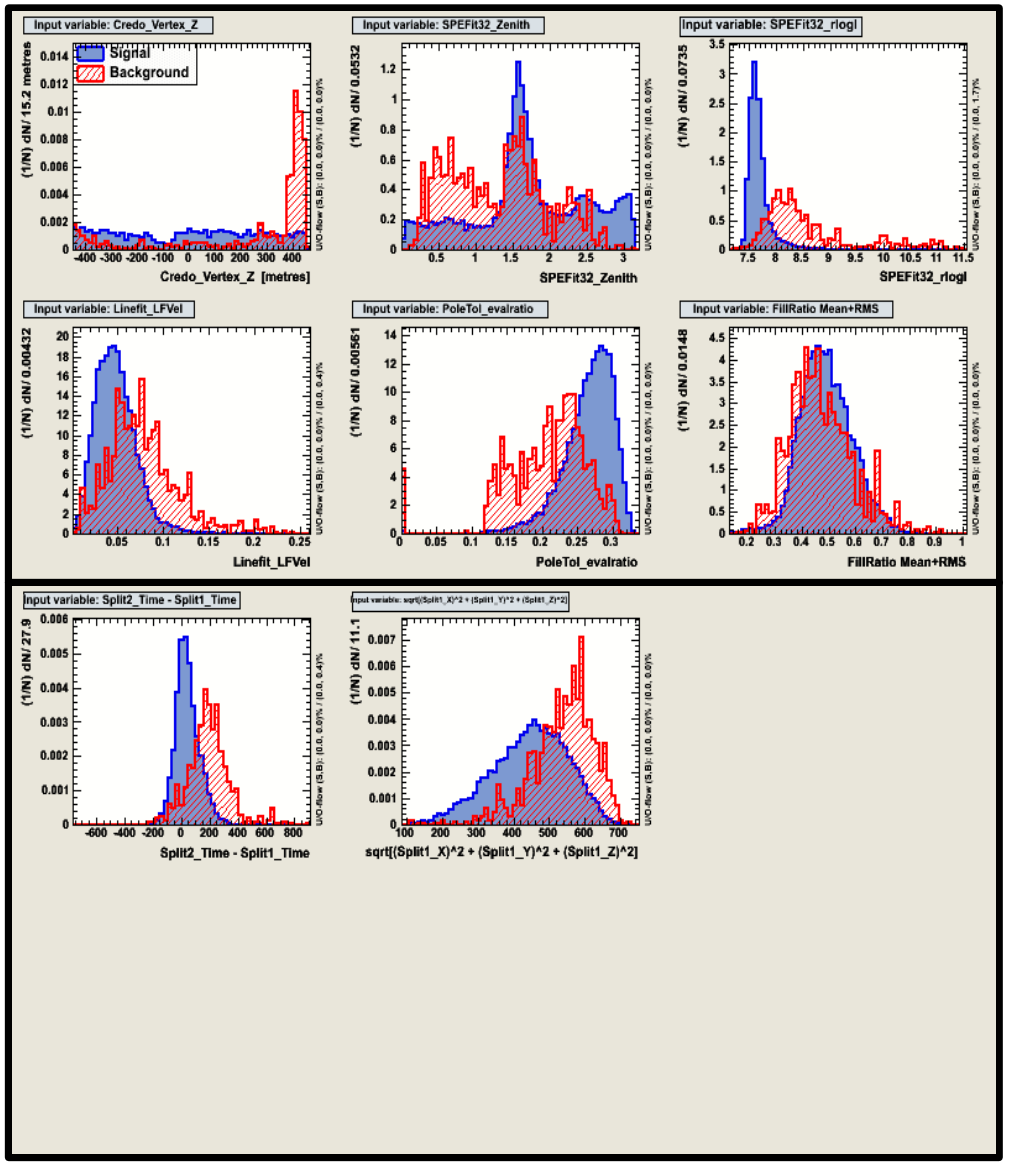
- String containment
  - ➔ Vertex must be inside detector area
- DOM Charge containment
  - ➔ DOM with largest charge must be on an inner string





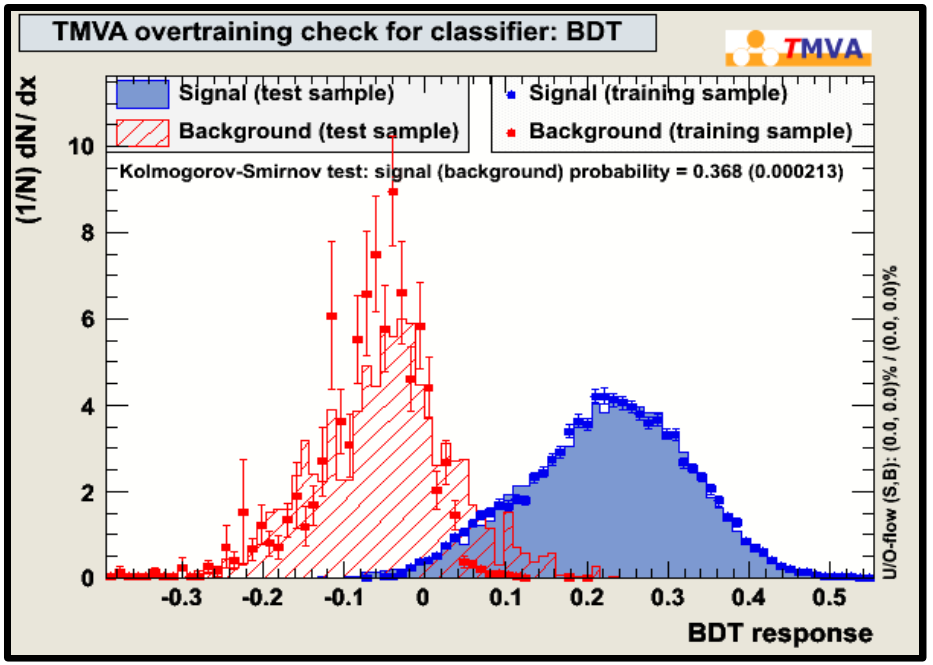
TMVA

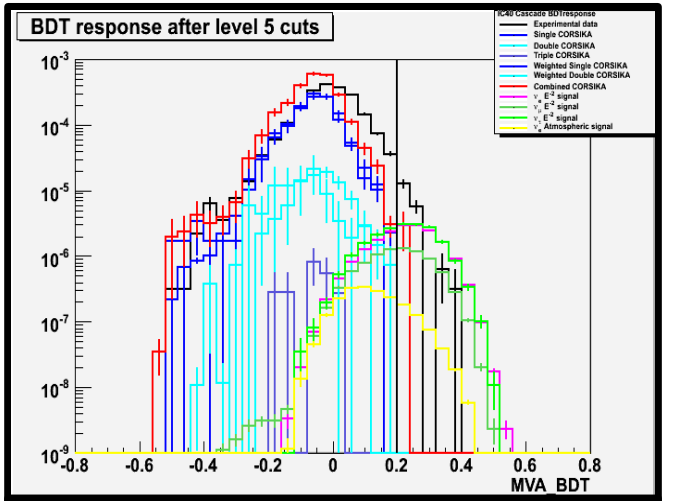
- Multivariate analysis is run with 8 variables:
  - Z vertex position
  - Zenith track direction
  - Track reduced log likelihood
  - Linefit velocity
  - Eigenvalue ratio
  - Fill ratio
  - Time vertex split
  - Split containment

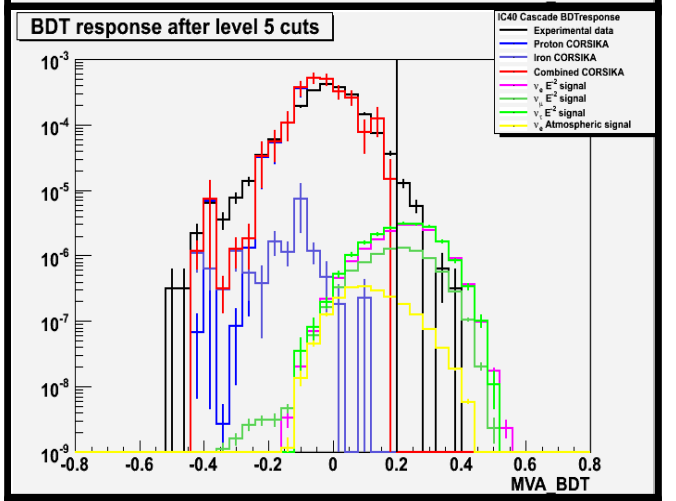


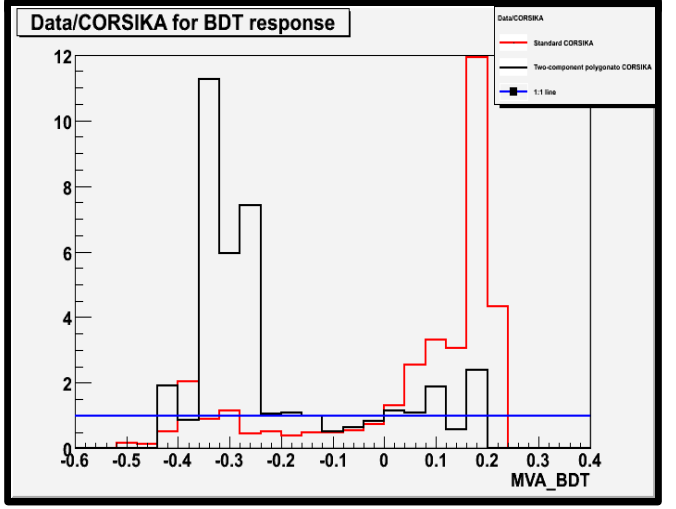
TMVA, cont.

- Gives BDT response:
  - ➔ Some overtraing in background (due to statistics)
  - ➔ Good background rejection and signal efficiency



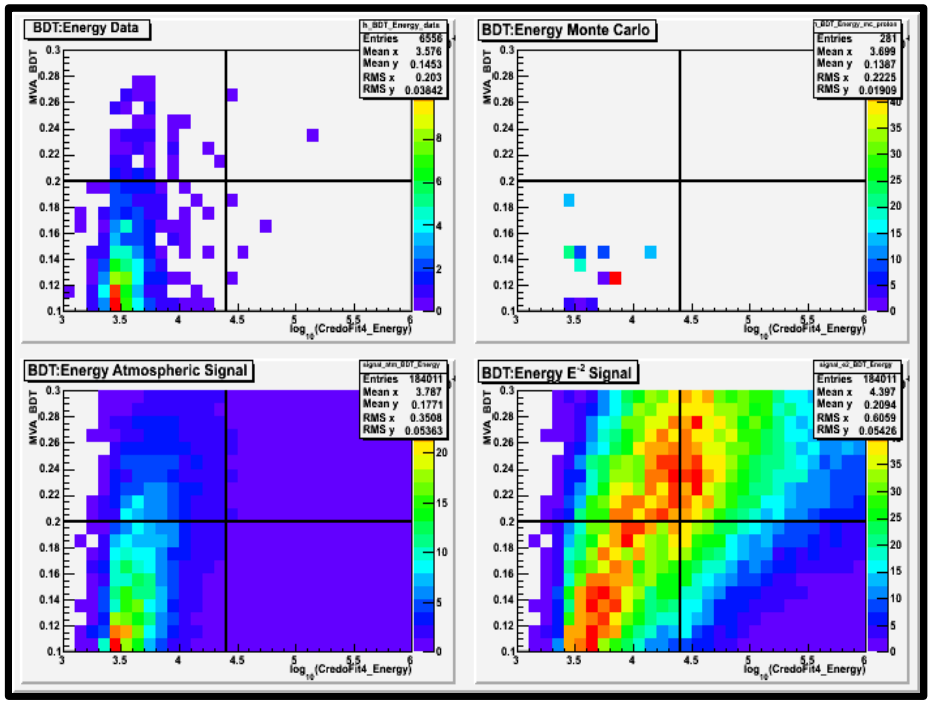


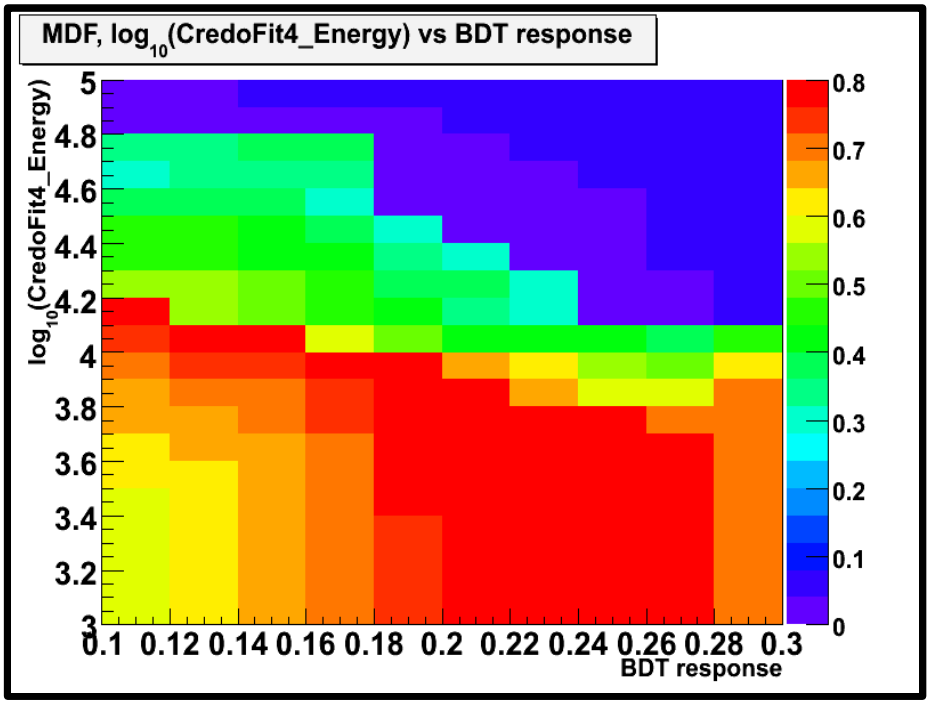




Optimisation of Level 6

- CORSIKA is too limited in signal region to use for optimisation so use data
  - ➔ Exclude signal like events so that optimisation permits an observation of signal

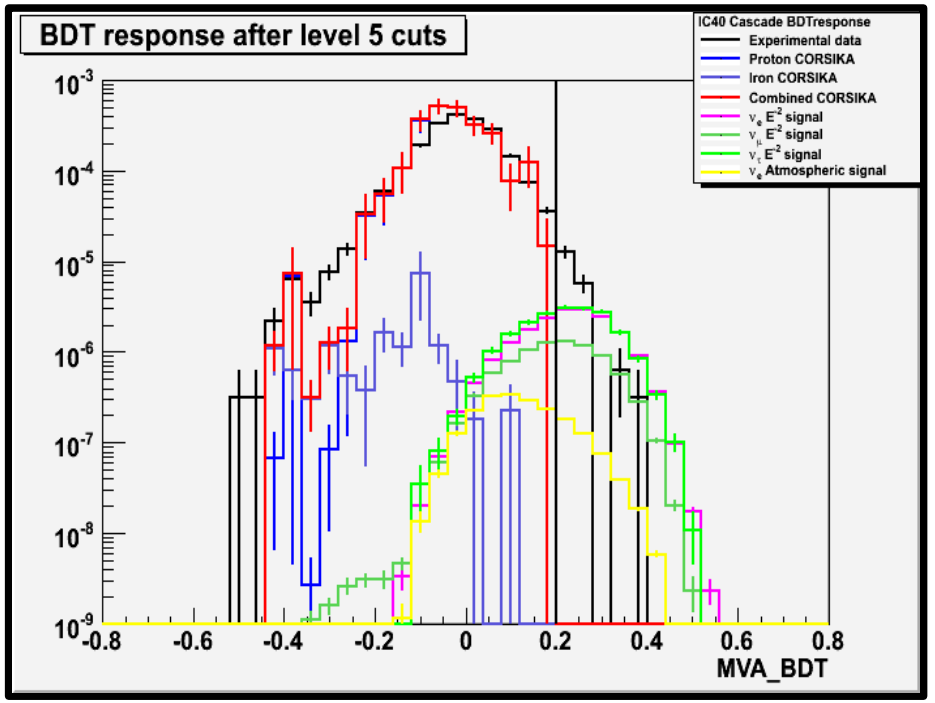


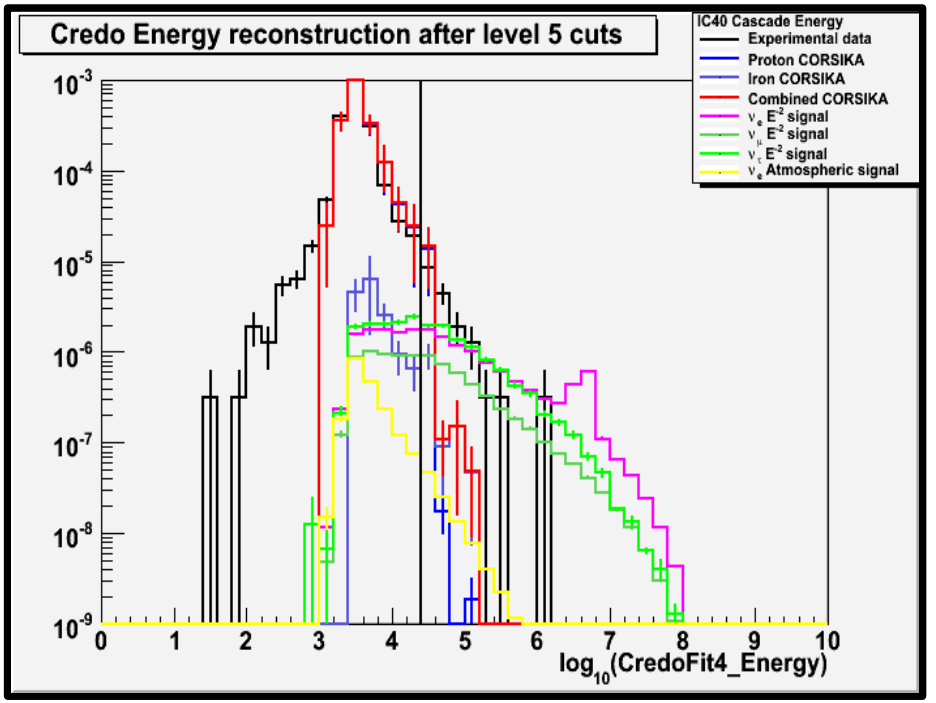


Level 6

Final level of cuts:

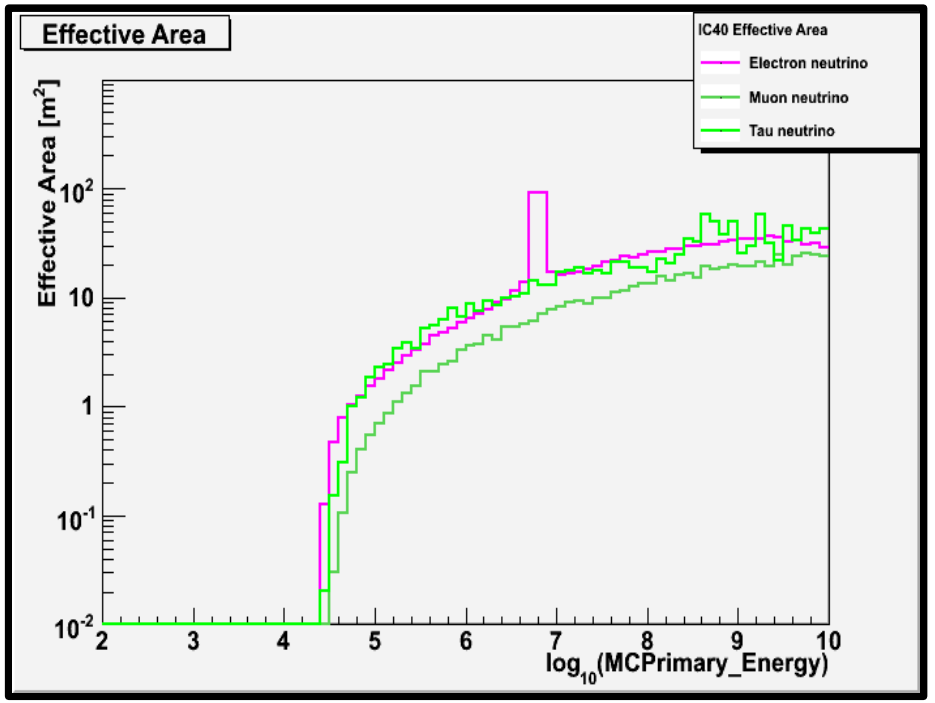
- BDT response > 0.2
- log_{10}(Energy) > 4.4 (~25 TeV)

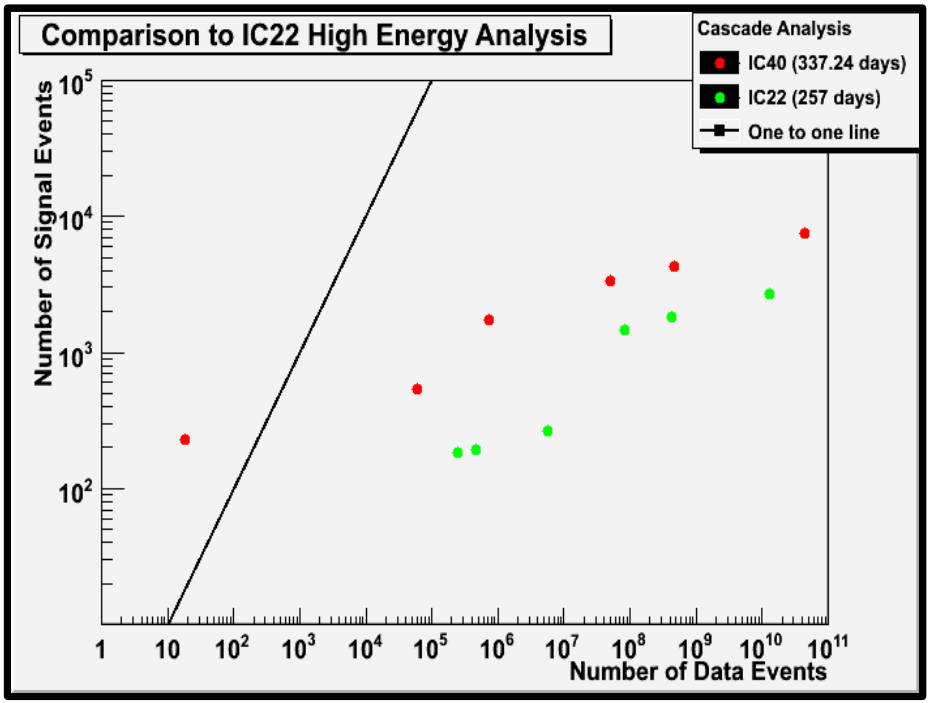




Final Plots

- Effective Area
- Comparison to high energy IC22 cascade analysis





Remaining Events

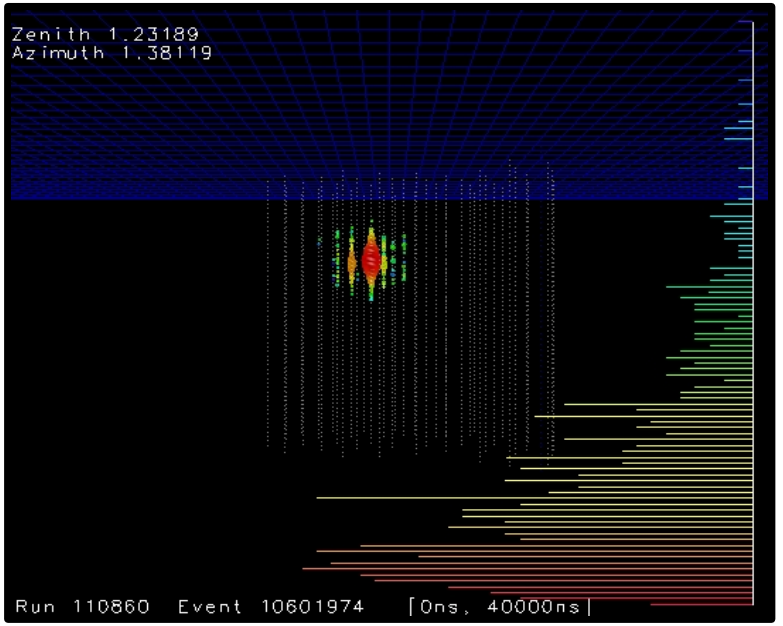
- Data
  - 2 events remain → 18.55 events for entire IC40 livetime (this rate is consistent with the IC22 limit)
- Background
  - 0 CORSIKA events
  - 2.28 electron neutrino atmospheric events
  - 1.63 muon neutrino atmospheric events
- Signal (assuming flux of 3.6×10^{-7} $GeV sr^{-1} s^{-1} cm^{-2}$)
  - 81.17 electron neutrino events
  - 28.46 muon neutrino events
  - 77.26 tau neutrino events

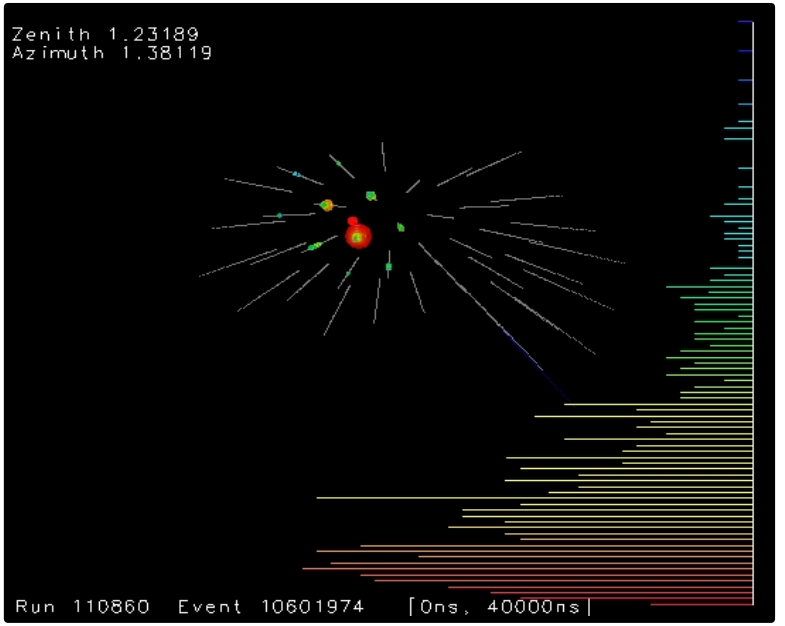
Sensitivity

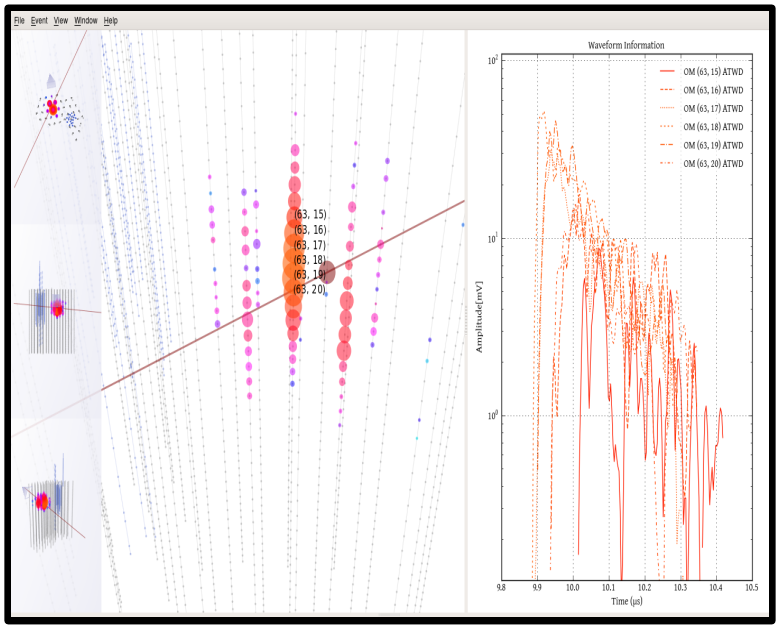
- Using Feldman-Cousins:

Number of Signal events	62.4838 events
Number of Background events	3.91332 events
Number of Critical events (5σ)	18 events
Least Detectable Signal (90% CL)	19.7 events
Upper Limit	4.78079 events
Model Rejection Factor	0.0765124
Model Discovery Factor	0.315282
Sensitivity Flux	2.75445×10^{-8} GeV sr^{-1} s^{-1} cm^{-2}
Discovery Flux	1.13501×10^{-7} GeV sr^{-1} s^{-1} cm^{-2}

Burn Sample Event 1

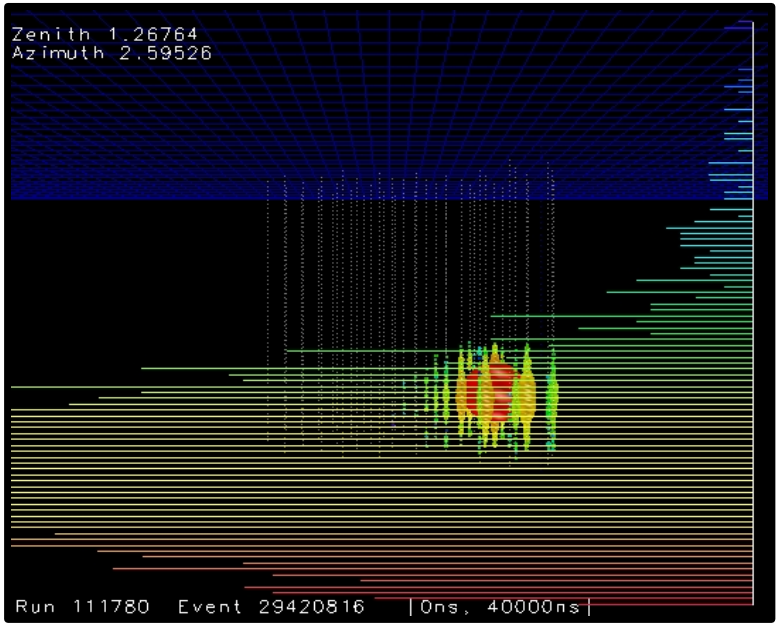


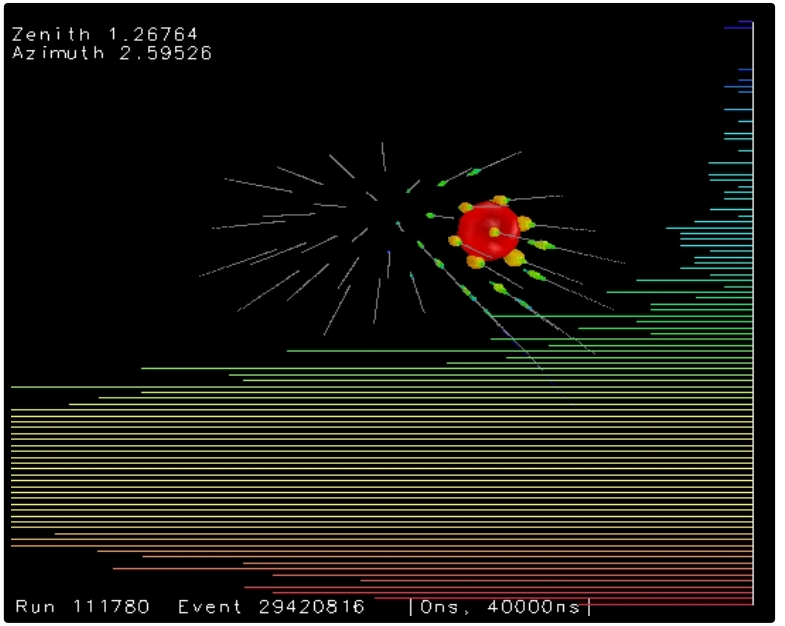


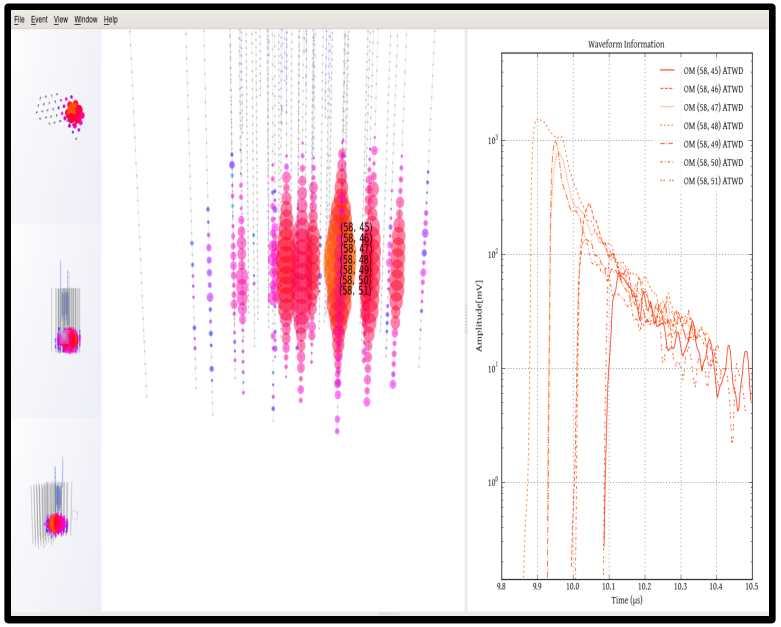


- Run: 110860, event 10601974
- Date: 18th April 2008, 9:56:42am
- Energy: 29.13 TeV
- BDT response: 0.2675667
- NCh: 88

Burn Sample Event 2







- Run: 111780, event 29420816
- Date: 16th October 2008, 11:32:47am
- Energy: 144.20 TeV
- BDT response: 0.2361462
- NCh: 359

Systematics

	E^{-2} Signal	Atmospheric Background	CORSIKA Background
Ice Properties			±10.4%
DOM Efficiency	-25.6% +3.6%	-14.6% +15.9%	
Neutrino Cross-sections	±9.2%	±10.8%	n/a
Seasonal Variation			
Total			

- See webpage for details on datasets used, etc.

Unblinding

- Look at full IC40 dataset:
  - See no events
    - Set a very good limit
  - See small number of events (consistent with atmospheric background)
    - Investigate events further to be convinced they are not muons
    - Set a very good limit
  - See large number of events (significantly above background)
    - Investigate events further to be convinced they are not muons
    - Further systematic studies can be carried out if required to be confident of background prediction
    - Further CORSIKA simulation can be carried out if required to be confident of background prediction
    - Claim a discovery ?