Atmospheric neutrino self-veto

MANTS 15/10/2013

Tom Gaisser

Rationale

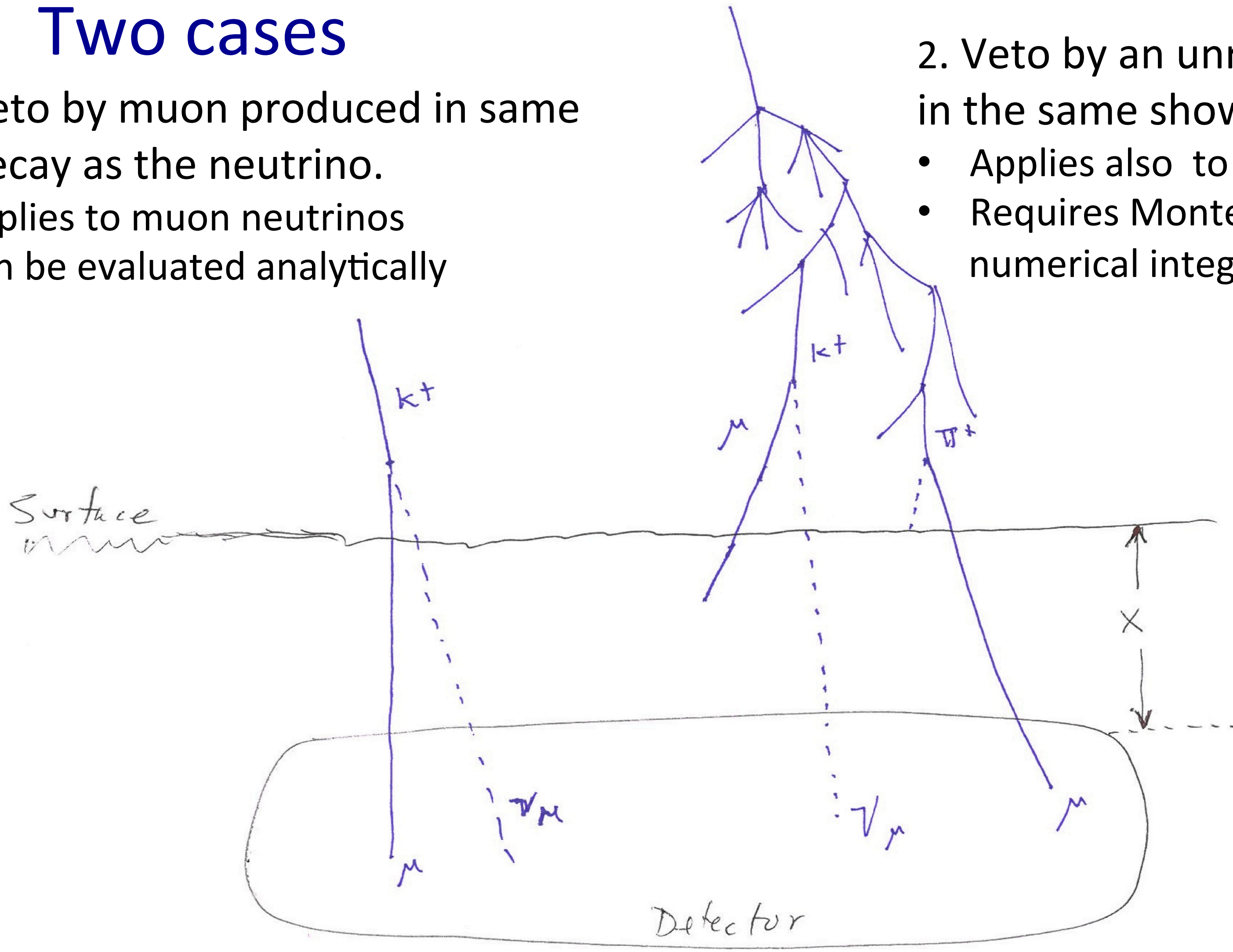
- A downward atmospheric ν will be excluded from a sample of neutrinos
  1. If the neutrino sample selects events starting inside a fiducial volume and
  2. If the neutrino has sufficiently high energy and sufficiently small zenith angle so that a muon from the same event will enter the detector in the same time window as the neutrino
- Such an event will be classified as an atmospheric μ and rejected

Atmospheric neutrino self veto

Two cases

1. Veto by muon produced in same decay as the neutrino.

- Applies to muon neutrinos
- Can be evaluated analytically



2. Veto by an unrelated μ in the same shower

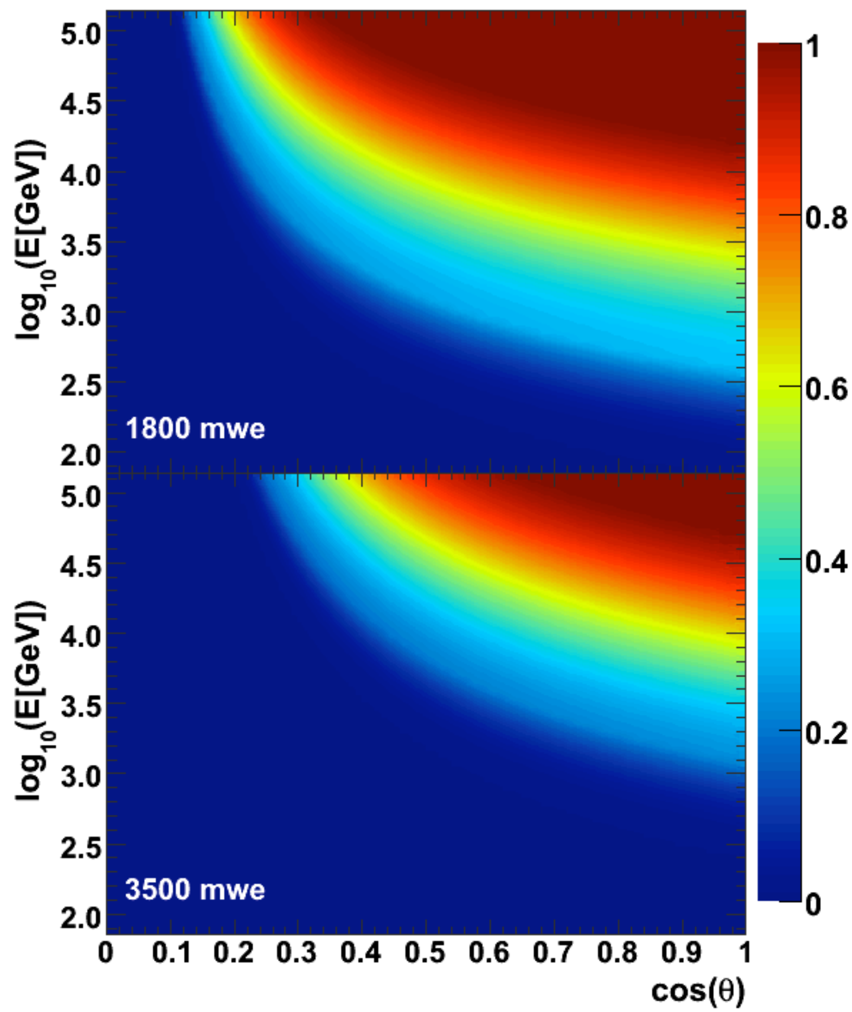
- Applies also to ν_e
- Requires Monte Carlo or numerical integration

1. Analytic calculation for ν_μ

- Conditional integration of ν production spectrum:

$$\phi_\nu^*(E_\nu) = \int H_{(E_\mu > E_{\min})}\, P_\nu(E_\nu, X, \theta)\mathrm{d}X$$

- Gives spectrum of ν accompanied by a μ where E_{min} is the energy required for the μ to reach the detector with sufficient energy to be detected



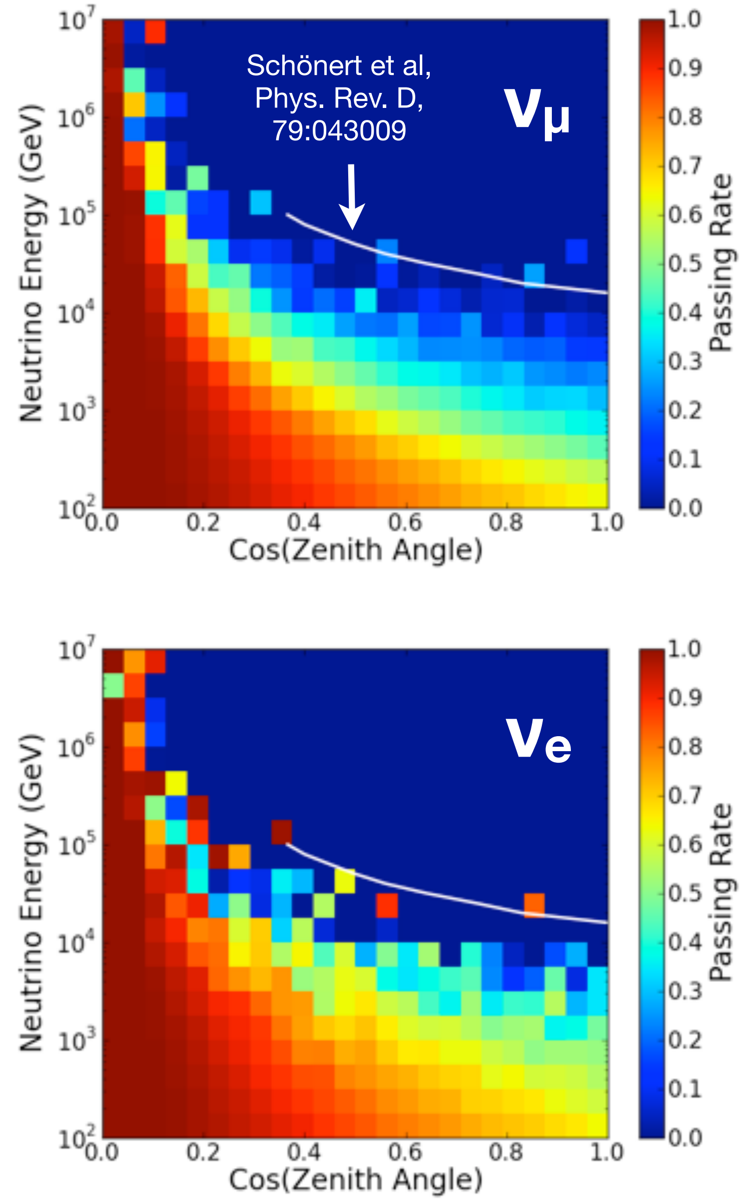
Schönert, TG, Resconi, Schulz. PR D79 (2009) 043009

2. Full Monte Carlo

- A full Monte Carlo calculation of ϕ_ν with all muons, including correlated $K^{\pm} \rightarrow \nu_\mu + \mu$
  - 2 or 3 calculatios in IceCube, e.g. K. Jero, J. van Santen, G. Binder, L. Gerhardt
- Problem: very hard to produce >100 TeV ν
  - Mesons do not like to decay at high energy
  - Need charm production in the Monte Carlo
- Use a numerical approximation to check and extrapolate

Full MC

- Statistics limited at high energy
- Future possibility:
  - – weighted simulation, while preserving correlations



Plots courtesy of K. Jero (UW-Madison)

2a. Numerical calculation

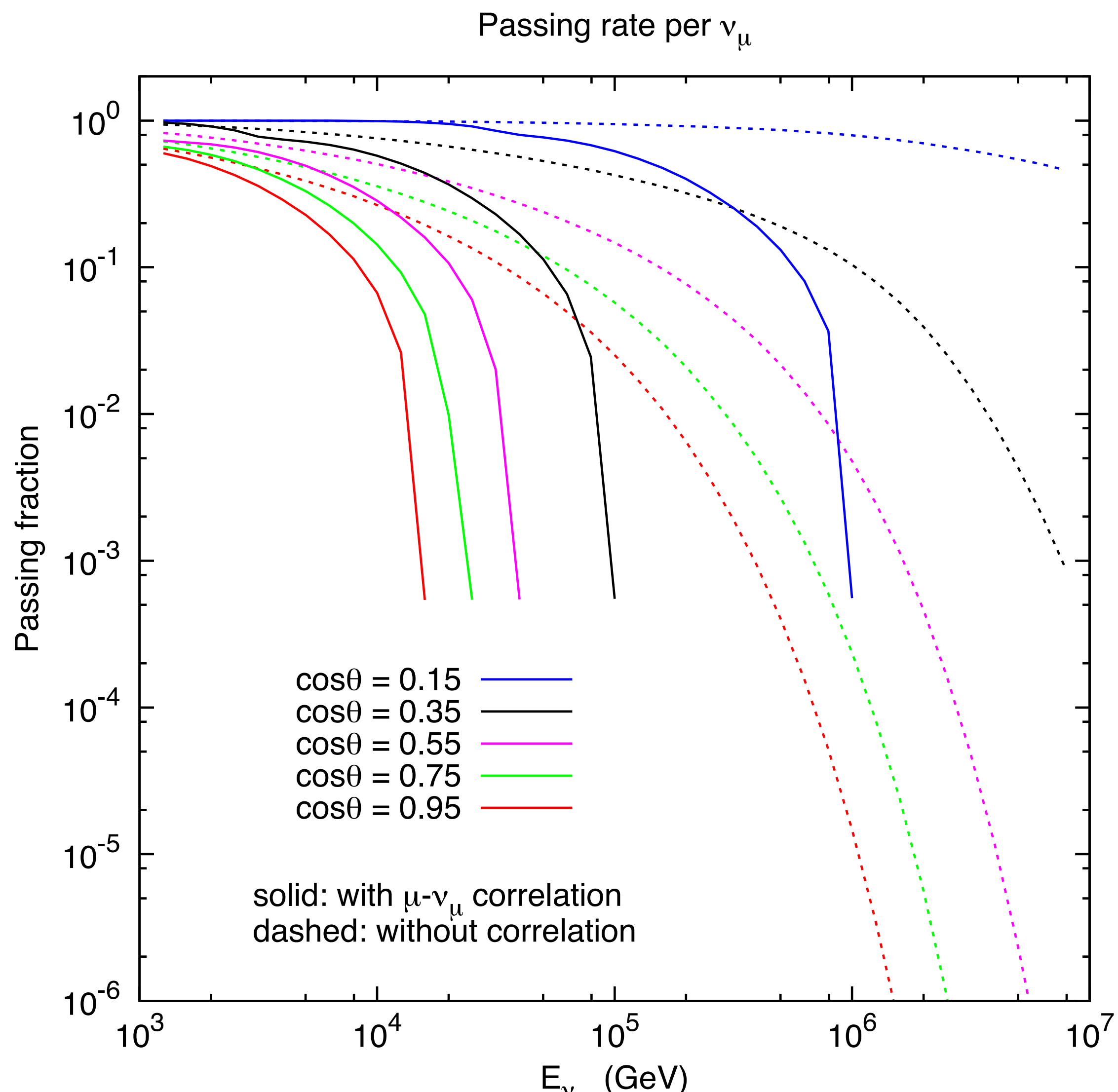
- Yields: $Y_\nu(A, E_0, E_\nu, \theta)$ and $Y_\mu(A, E_0, E_\mu, \theta)$
  - Use analytic approximations ("Elbert formula")
- Response (ν): $R(A, E_0, E_\nu, \theta) = \phi_A(E_0) \cdot Y_\nu(A, E_0, E_\mu, \theta)$
- Passing rate:

$$P_\nu(E_\nu, \theta) = \Sigma_A \int \mathrm{d}E_0 \, R_\nu(A, E_0, E_\nu, \theta) \, e^{-Y_\mu(A, E_0, E_{\min}, \theta)}$$

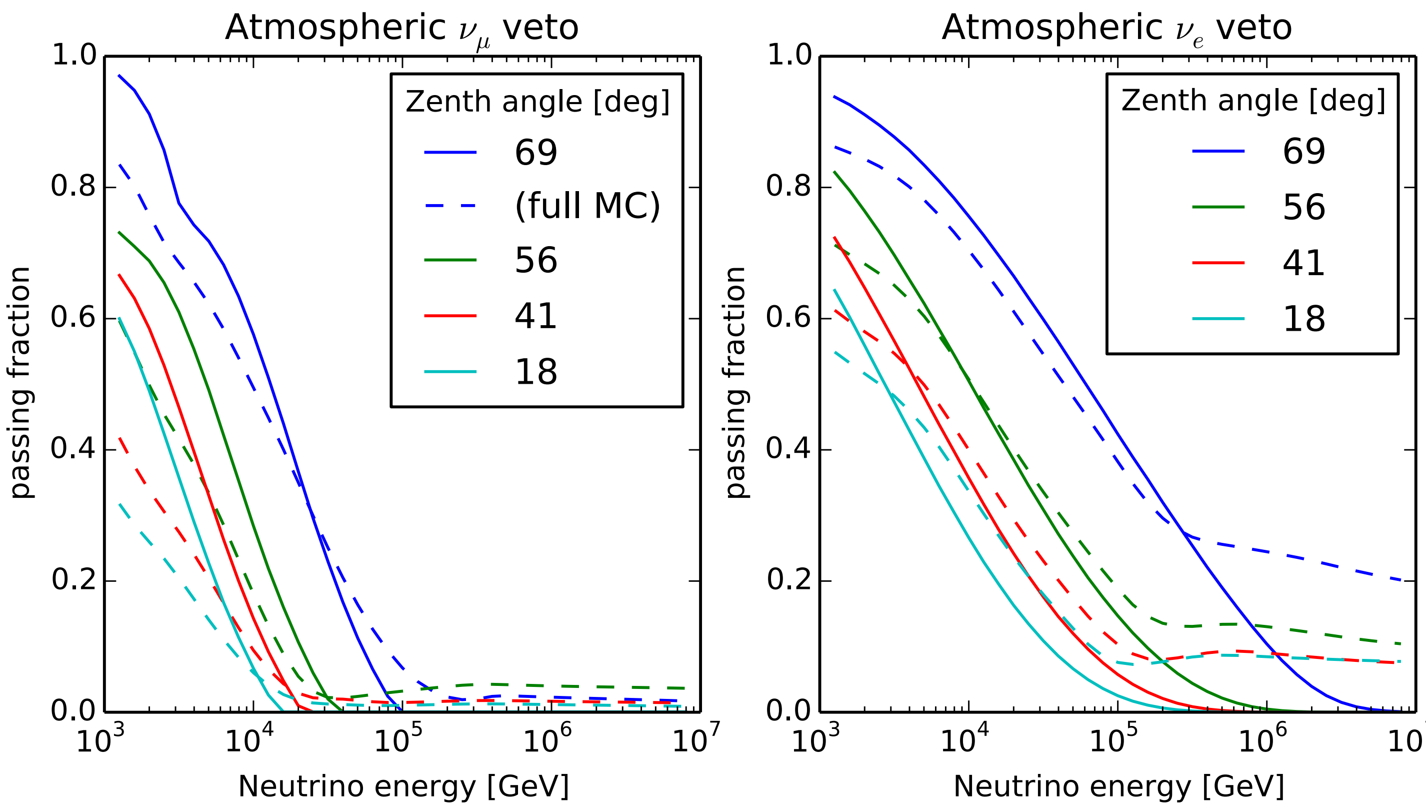
- Check against full Monte Carlo and extrapolate

Compare correlated/uncorrelated

Uncorrelated similar for ν_e



Comparison with full MC

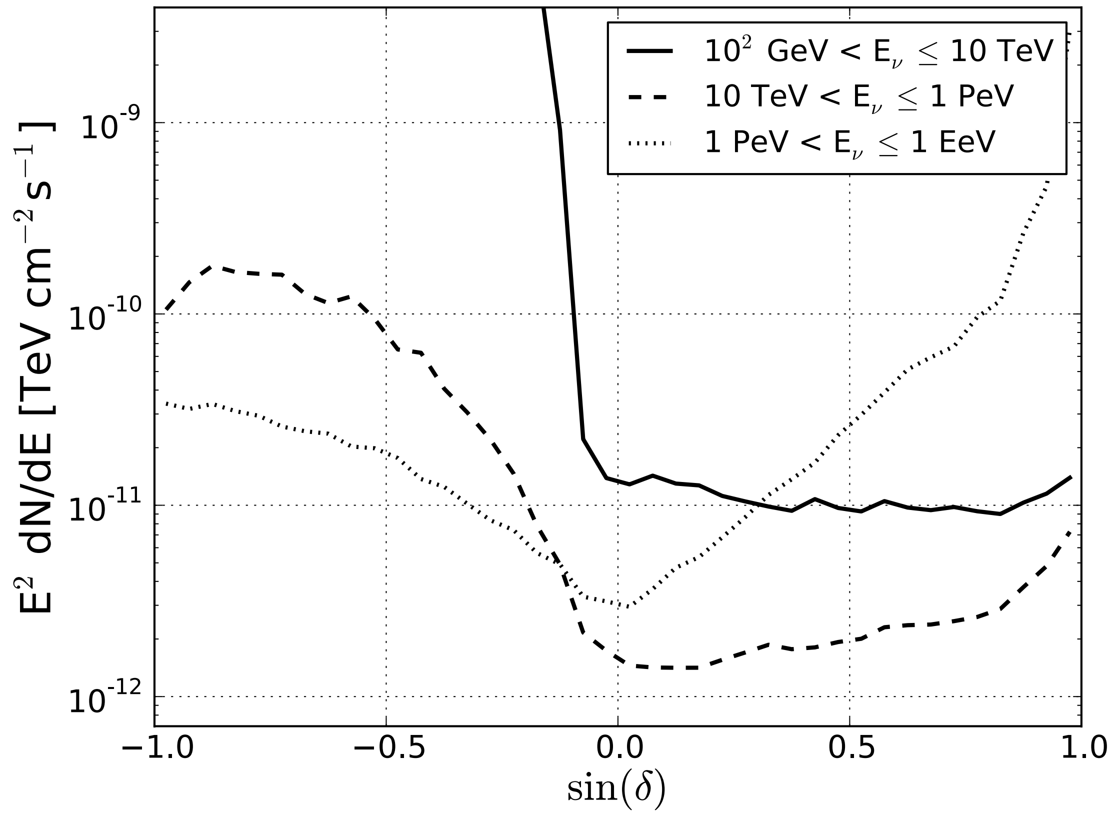


Dashed lines: full MC;
Solid lines: numerical calculation

Thanks to J. van Santen

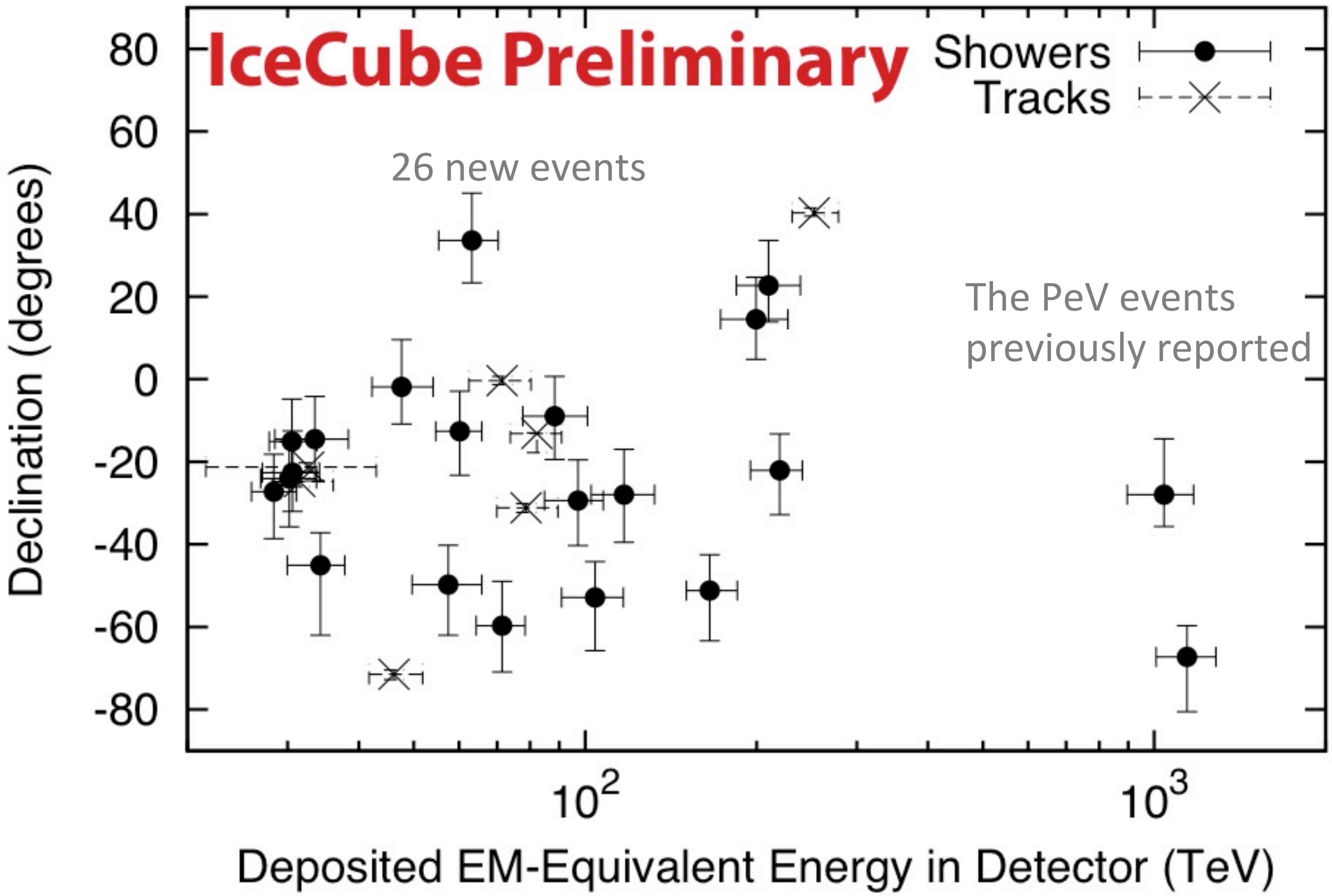
Self-veto in point source search

Improves sensitivity
For high energy in
Southern sky
Next talk by J Feintzeig

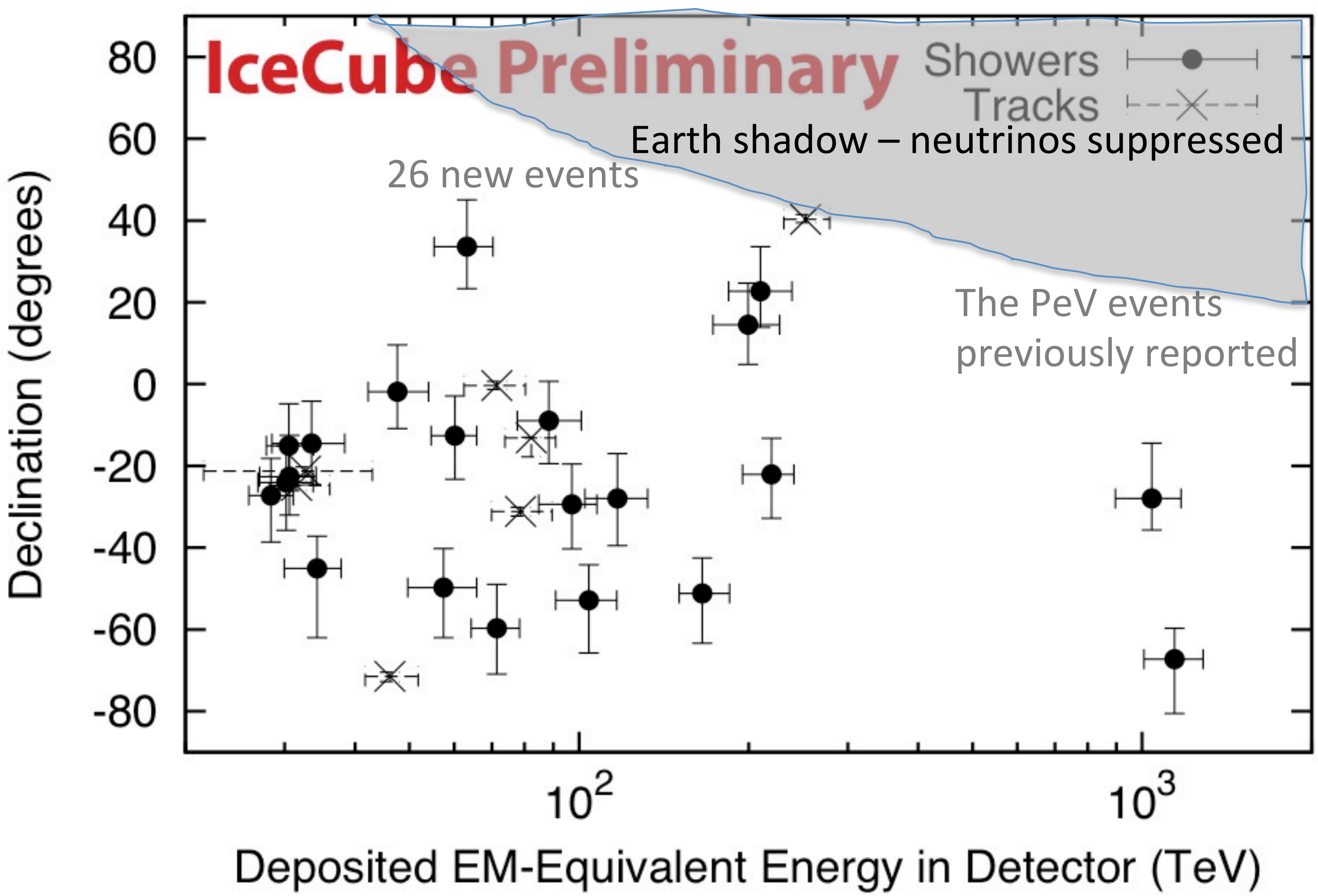


IceCube Collaboration: 1307.6669v2

Results revisited



Results revisited



Results revisited