Signals from Neutrino Sources in GRAND

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How many neutrinos do we expect?

\[
N = \frac{dN}{dE dA dt d\Omega} \times \Delta t \Delta A \Delta E \Delta \Omega
\]

For GRAND, take

\[
\left( \frac{\Delta t}{10 \text{ yr}} \right) \left( \frac{\Delta A}{10^{12} \text{ cm}^2} \right) \left( \frac{\Delta E}{10^{18} \text{ eV}} \right) \left( \frac{\delta \Omega}{5\% \ 4\pi} \right)
\]

4000
1385

\( E^2 \frac{d^2 N}{dE d\Omega} \) [GeV cm\(^{-2}\) sr\(^{-1}\)]
Detecting A Source On Top of the Background
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Great resolution => low background

\[ \bar{N} = 4.8 \times 10^{-3} \left( \frac{N_{\text{tot}}}{1000} \right) \left( \frac{(0.1^\circ)^2}{5^\circ \times 4\pi} \right) \]

A doublet has a p-value $1.2e^{-5}$ to be from different sources => 4.2 sigma detection of a source on top of background

Doublet events are from the same source!
Events from One Source

Events from a nearby source

\[ N_{1s} = \frac{L_s}{4\pi D^2} \left( \frac{2 - \alpha}{E_{\text{max}}^{2-\alpha} - E_{\text{min}}^{2-\alpha}} \right) E^{-\alpha} \Delta t \Delta A \Delta E \]

Events from entire source population

\[ N_{\text{tot}} = \frac{\Delta \Omega}{4\pi} L_s n_s D_H \xi_z \left( \frac{2 - \alpha}{E_{\text{max}}^{2-\alpha} - E_{\text{min}}^{2-\alpha}} \right) E^{-\alpha} \Delta t \Delta A \Delta E \]

maximum source distance

Uniform: 0.5
SFR: 2.4
detector size, time, energy resolution

If all sources have the same Luminosity

\[ \frac{N_{1s}}{N_{\text{tot}}} = \frac{1}{D^2 n_s D_H \xi_z} \]
Possibility of Identifying the UHECR Source Location

$$\frac{N_{1s}}{N_{\text{tot}}} = \frac{1}{D^2 n_s D_H \xi_z}$$

Promising doublet events

Doublets can constrain source properties