

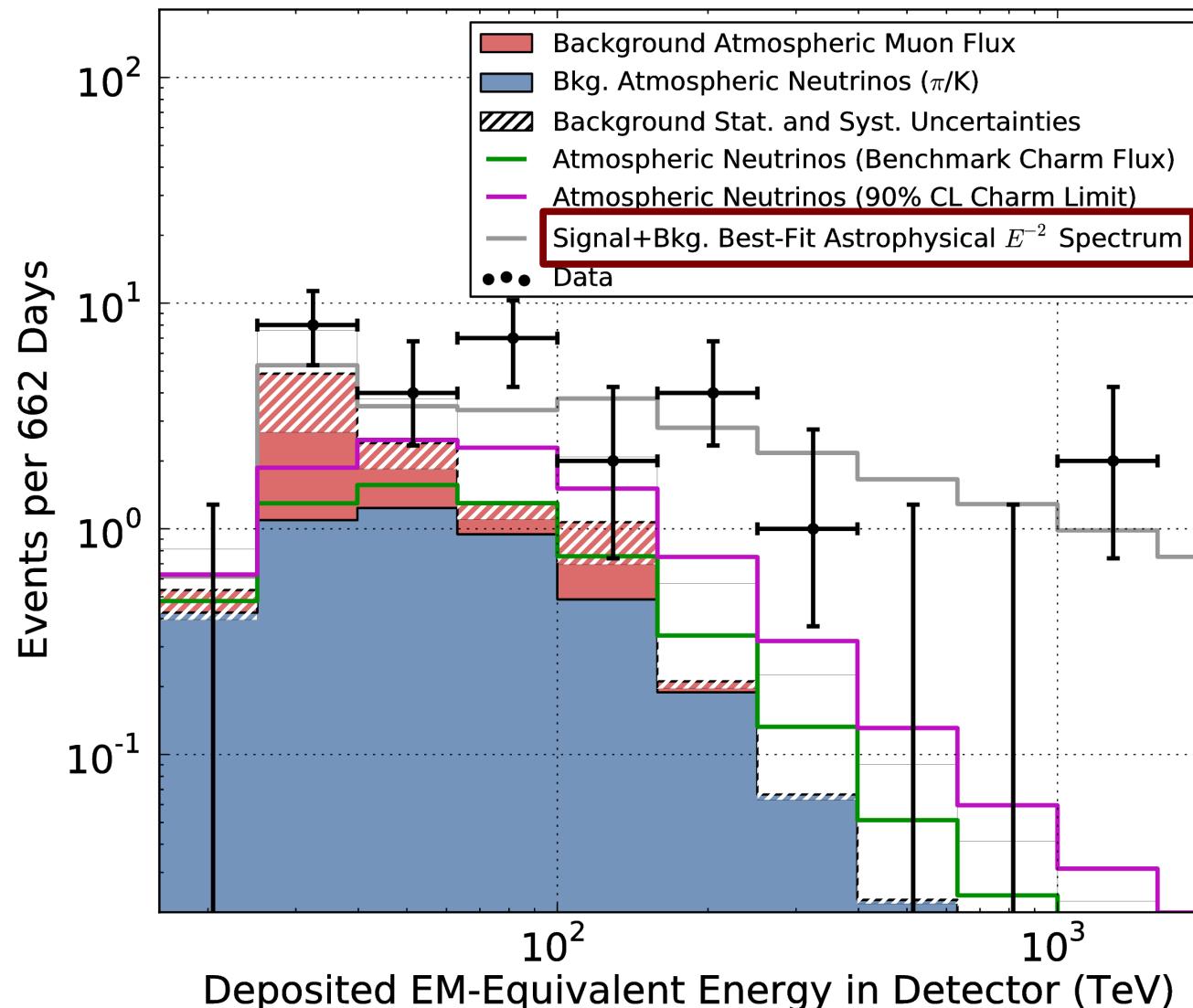
# Decaying Dark Matter And IceCube TeV-PeV Neutrinos

Ran Lu

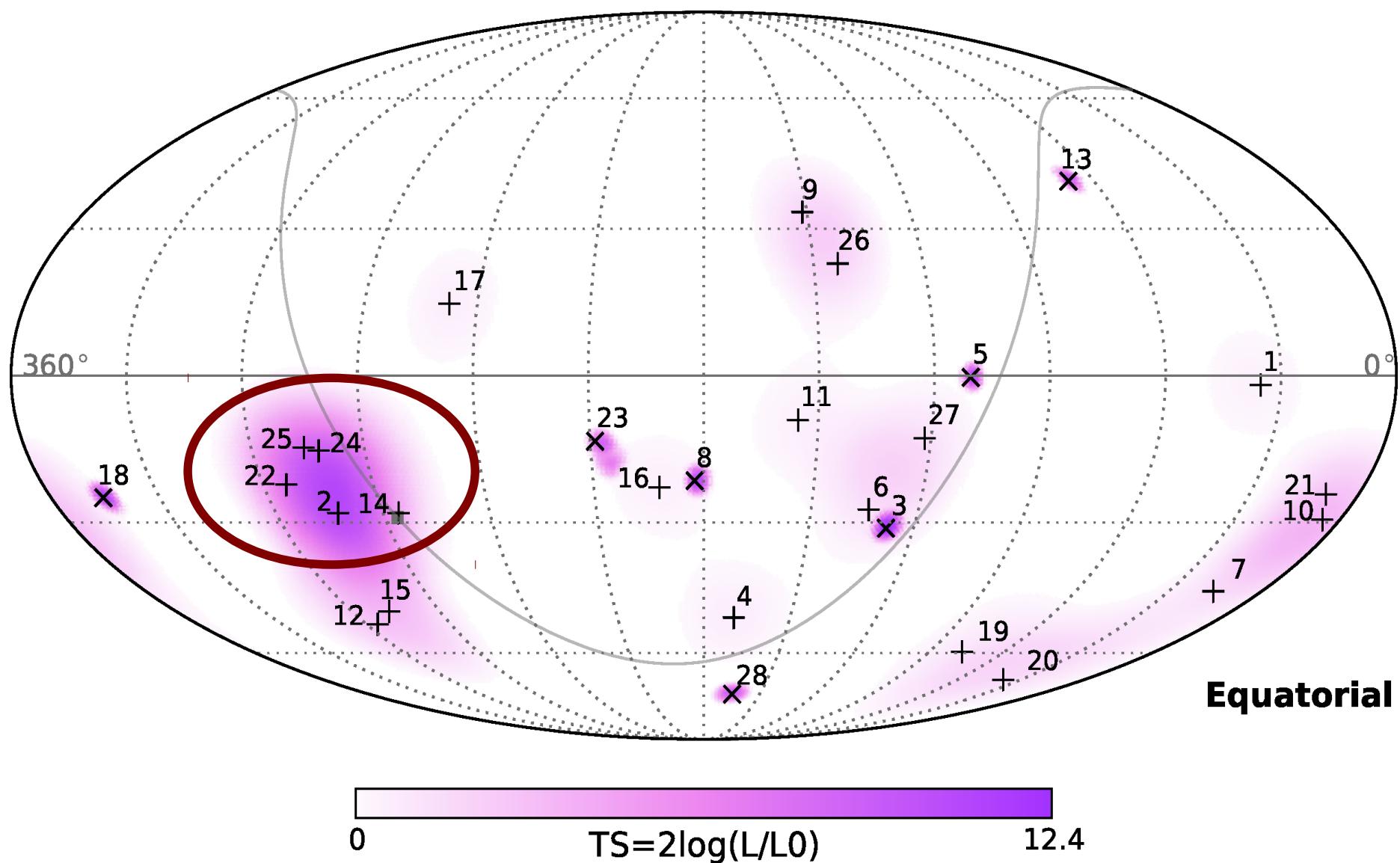
1311.5864 with Yang Bai and Jordi Salvado

2014-5-6

# IceCube Results



# IceCube Results



# Interpretation

- Astrophysics
  - GRBs, AGNs, Starburst Galaxies...
- New Physics
  - Leptoquark, Dark Matter...
- Jordi's Talk, Plenary Talks

# Dark Matter vs IceCube?



# Decaying Dark Matter

- Why not annihilating?
  - Unitarity Bound on the Cross Section
  - Event Rate
    - Annihilating Dark Matter  $\sim \rho^2$
    - Decaying Dark Matter  $\sim \rho$
- Galactic Dark Matter
  - Comparing with homogeneous “background”

# Decaying Dark Matter

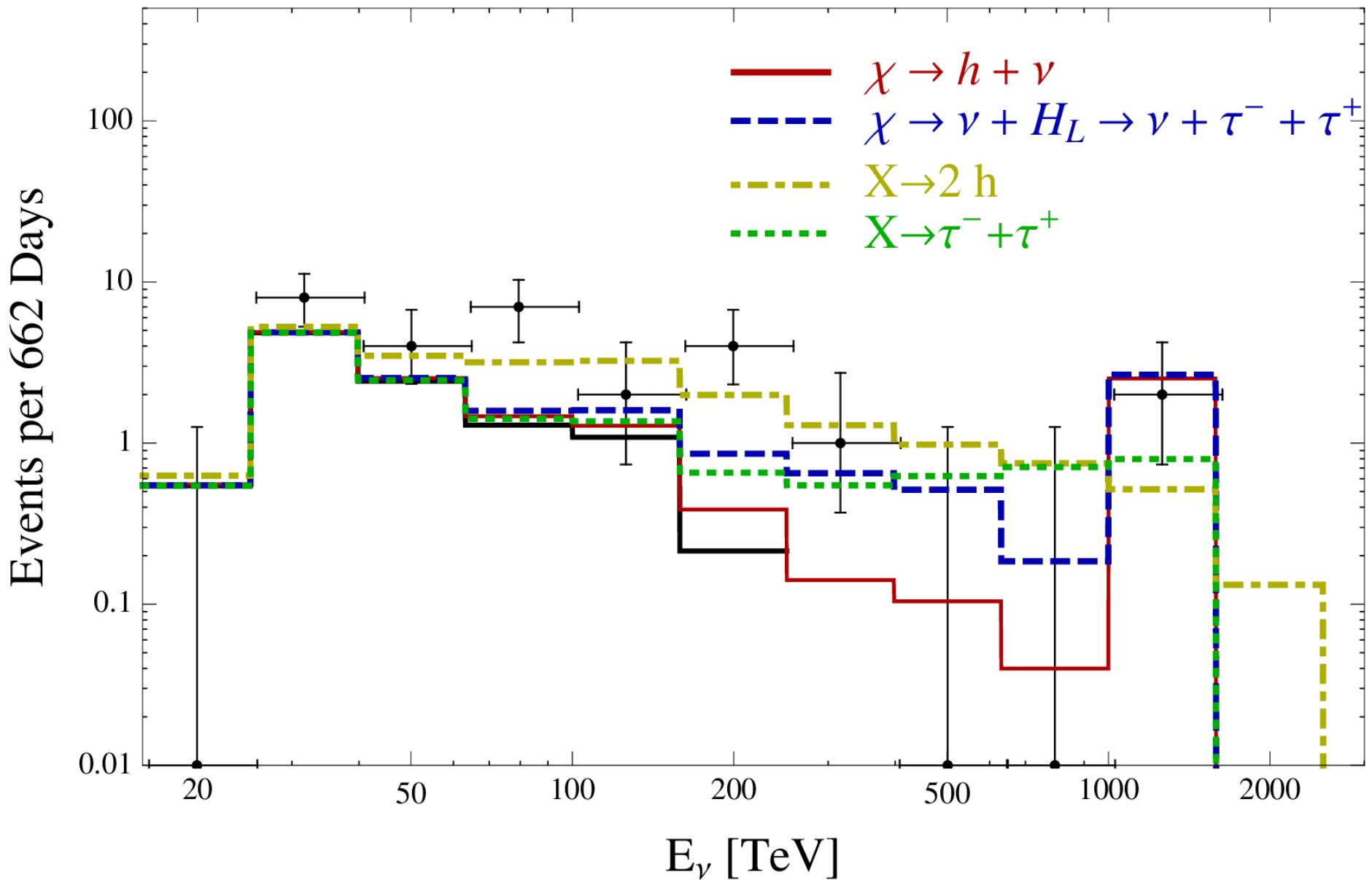
- Fermionic DM

- $\chi \rightarrow h + \nu$   $M_\chi = 2.2 \text{ PeV}, \tau_\chi = 3.5 \times 10^{29} \text{ s}$
- $\chi \rightarrow H_L + \nu \rightarrow \tau^+ + \tau^- + \nu$

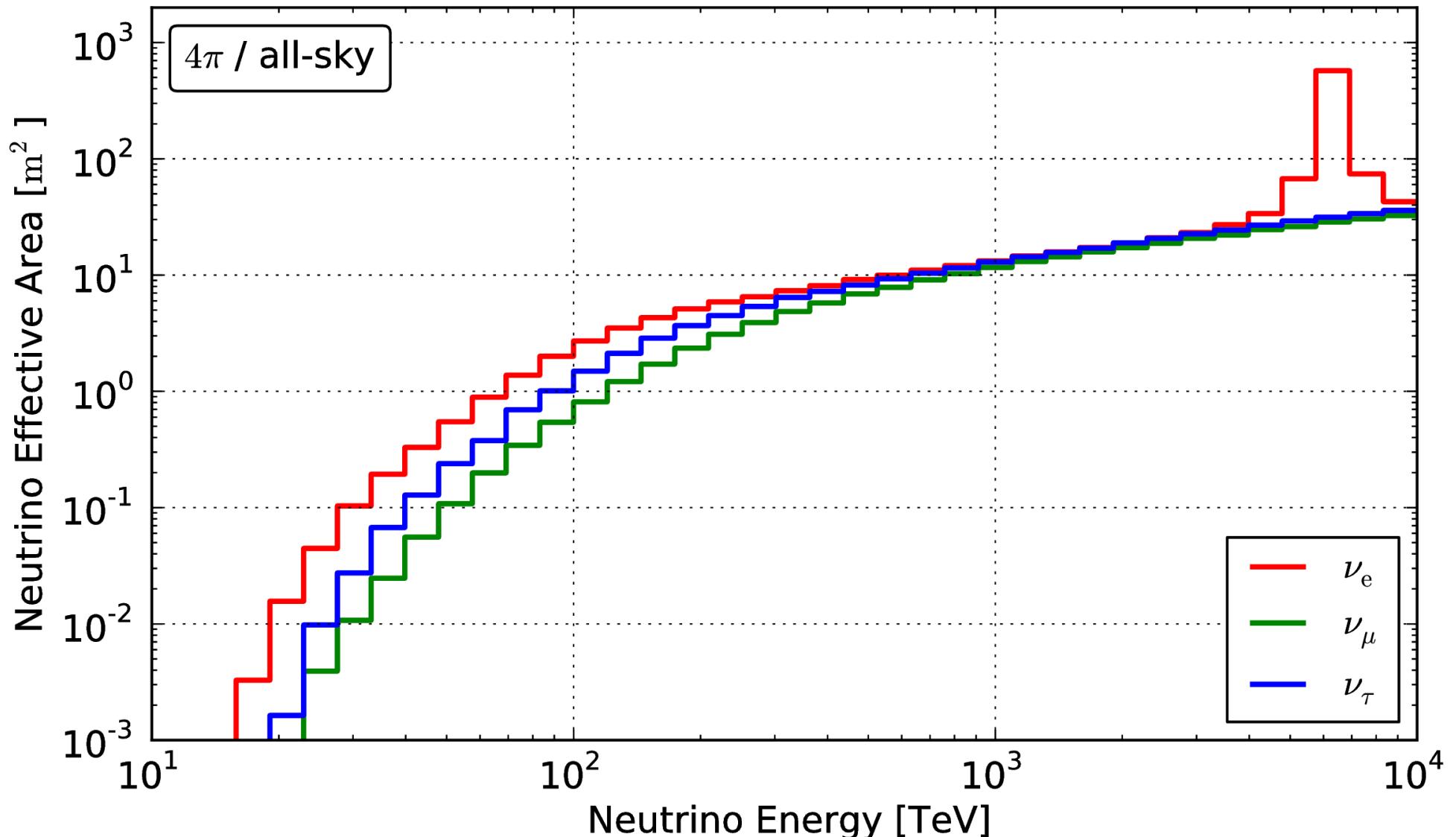
- Scalar DM

- $X \rightarrow h + h$   $M_X = 5 \text{ PeV}, \tau_X = 0.9 \times 10^{29} \text{ s}$
- $X \rightarrow \tau^+ + \tau^-$   $M_X = 5 \text{ PeV}, \tau_X = 4.6 \times 10^{29} \text{ s}$

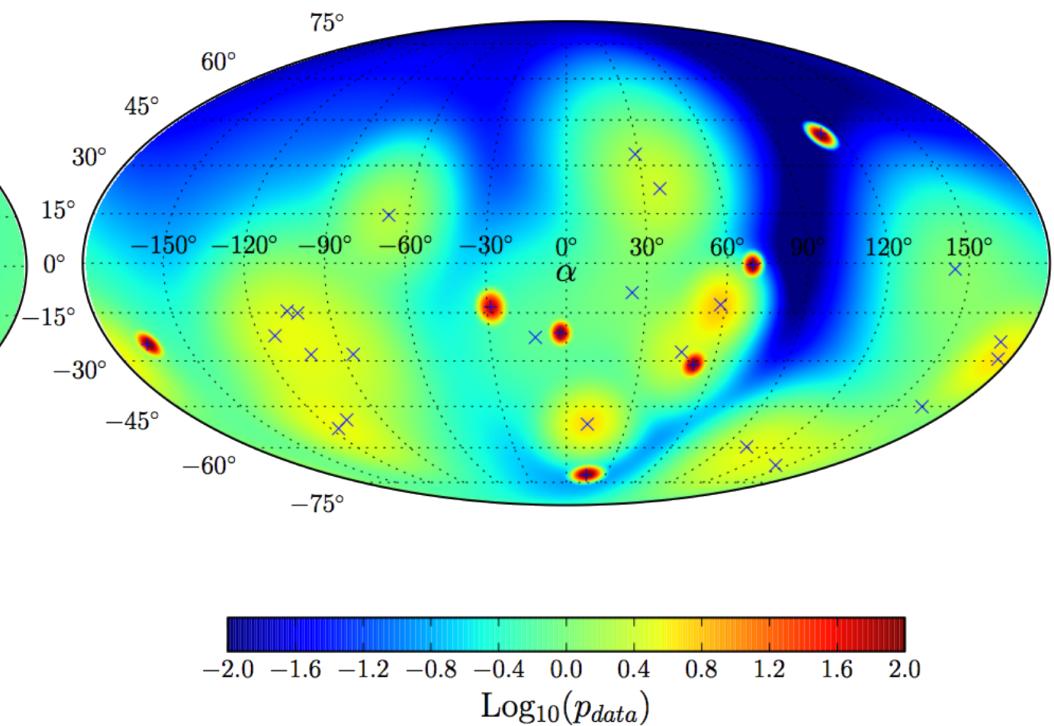
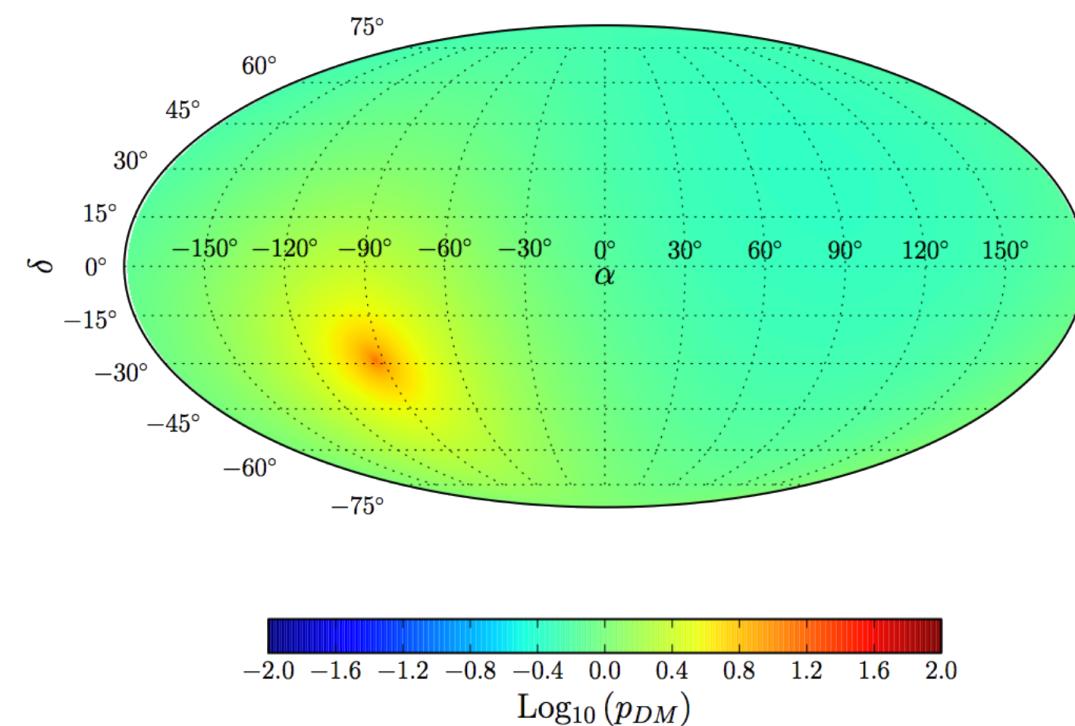
# Spectrum



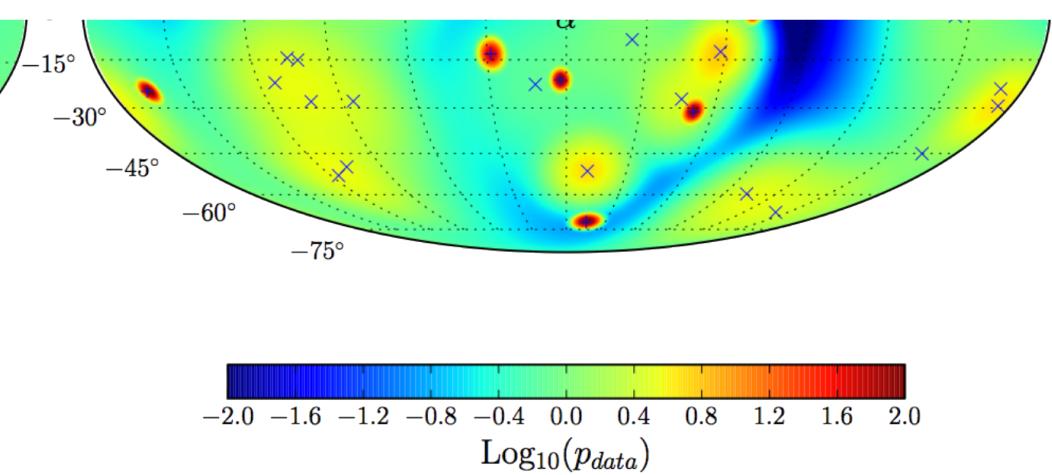
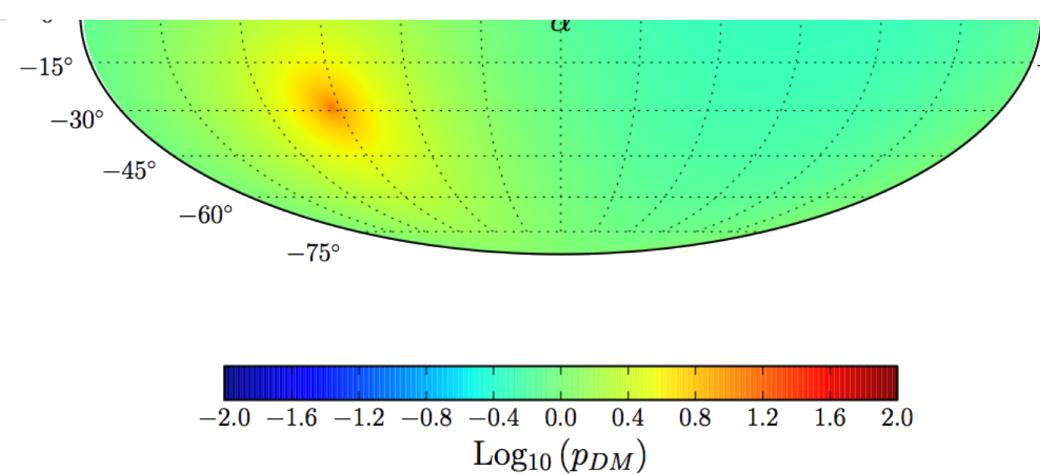
# Effective Area



# Geometric Distribution

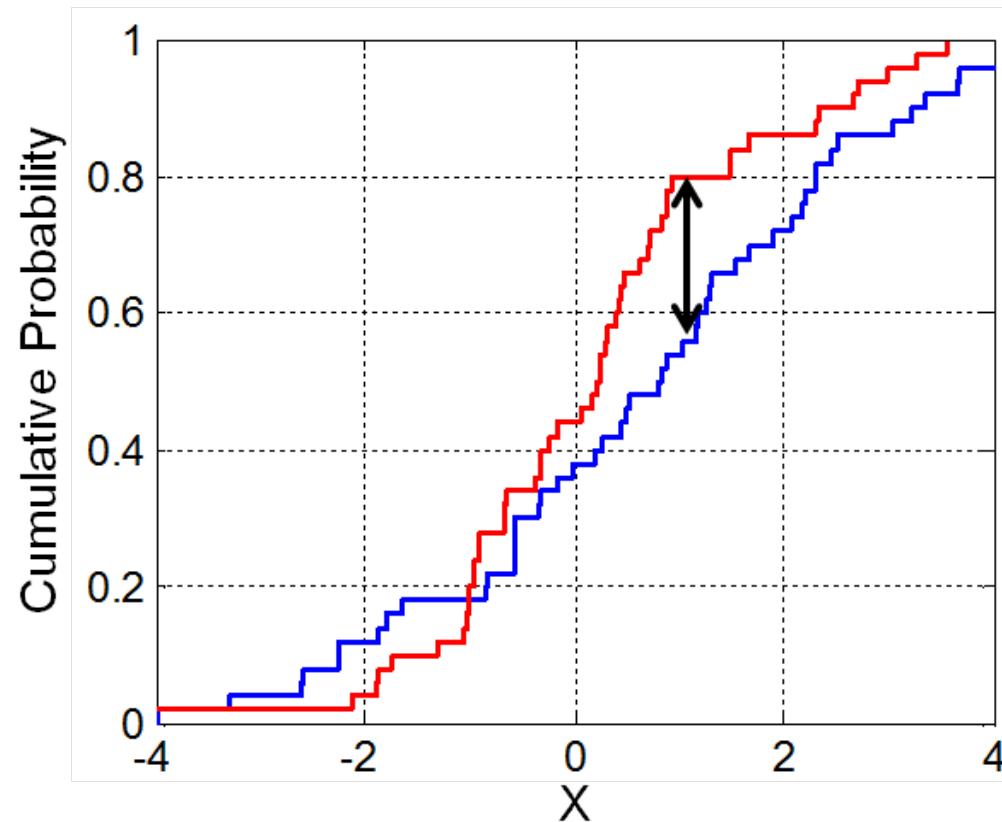


# Geometric Distribution



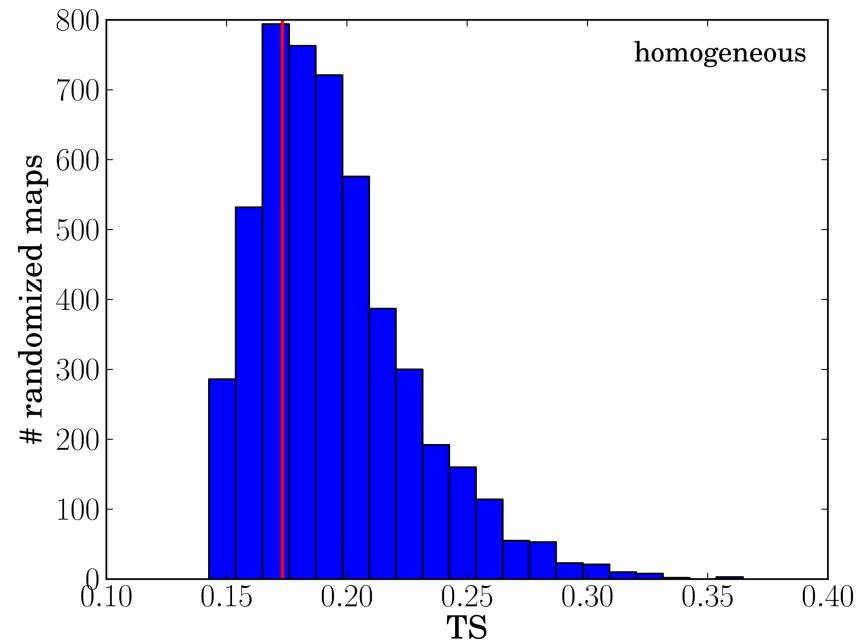
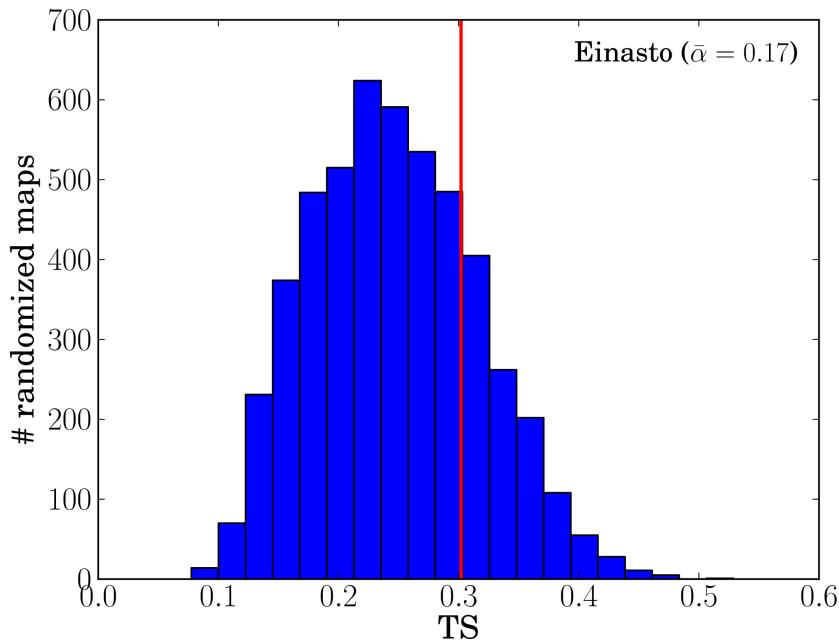
# 2D-KS Test

- Kolmogorov-Smirnov Test



- More than one dimension:  $2^d - 1$  ordering

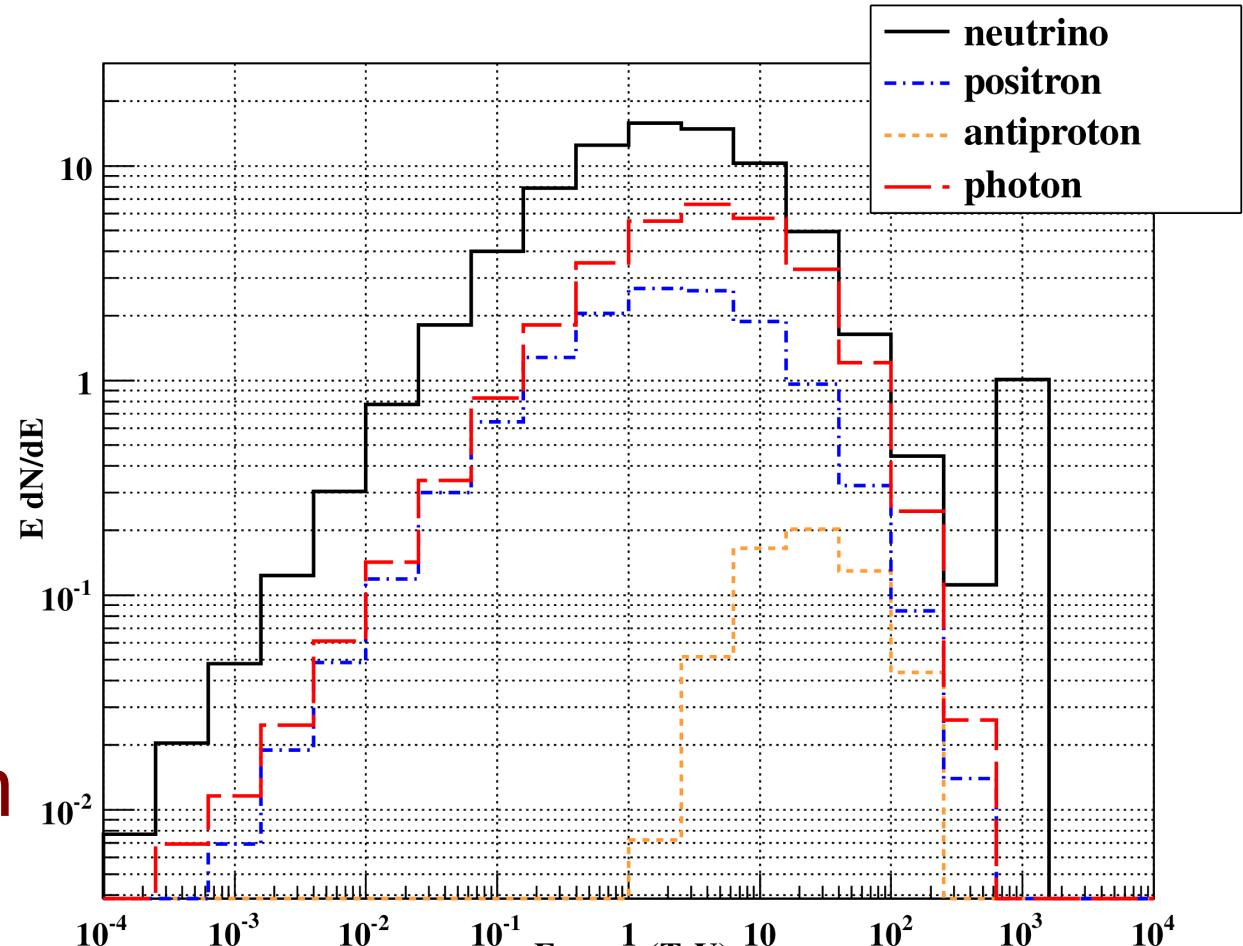
# P-value



	$\bar{\alpha}=0.17$	$\bar{\alpha}=0.25$	Homogeneous
All 28 Events	22.0%	20.3%	72.1%
18 Events with $E \geq 50$ TeV	35.5%	31.8%	84.2%
21 Cascade Events	41.9%	38.8%	95.4%

# Other Constraints

- Collider
- Direct Detection
- Indirect Detection



$$\chi \rightarrow h + \nu$$

# Summary

- IceCube: 28 TeV-PeV Events
- Dark Matter Interpretation:
  - Fit the energy spectrum
  - Not ruled out by geometric distribution (yet)
  - No constraint from other experiments
- Need More Data