

# Decaying Leptophilic Dark Matter at IceCube

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# Before we start: an abstract

We want to explain the IceCube Neutrino Observatory detected flux with a new approach, involving

## BOTH

bottom-up astrophysical sources  
and a top-down component  
(Decaying Leptophilic Dark Matter)

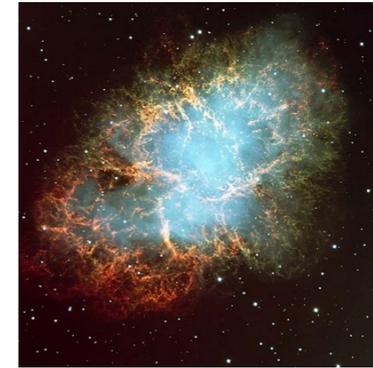
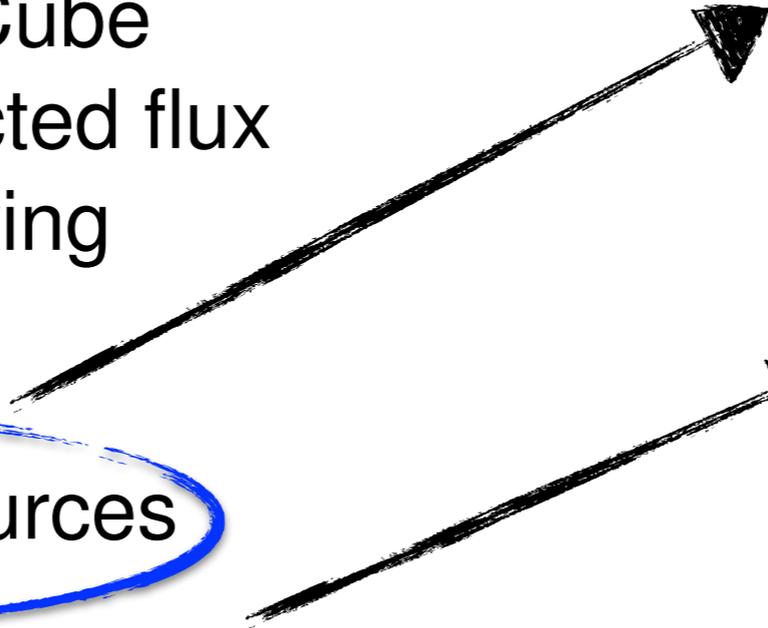


# Before we start: an abstract

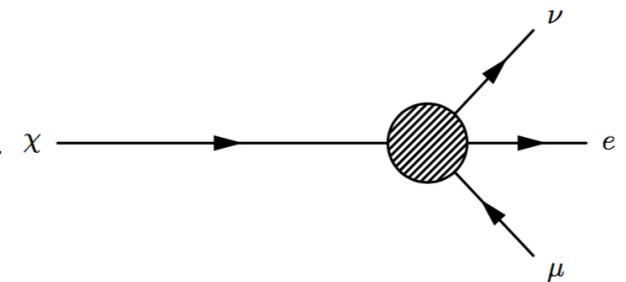
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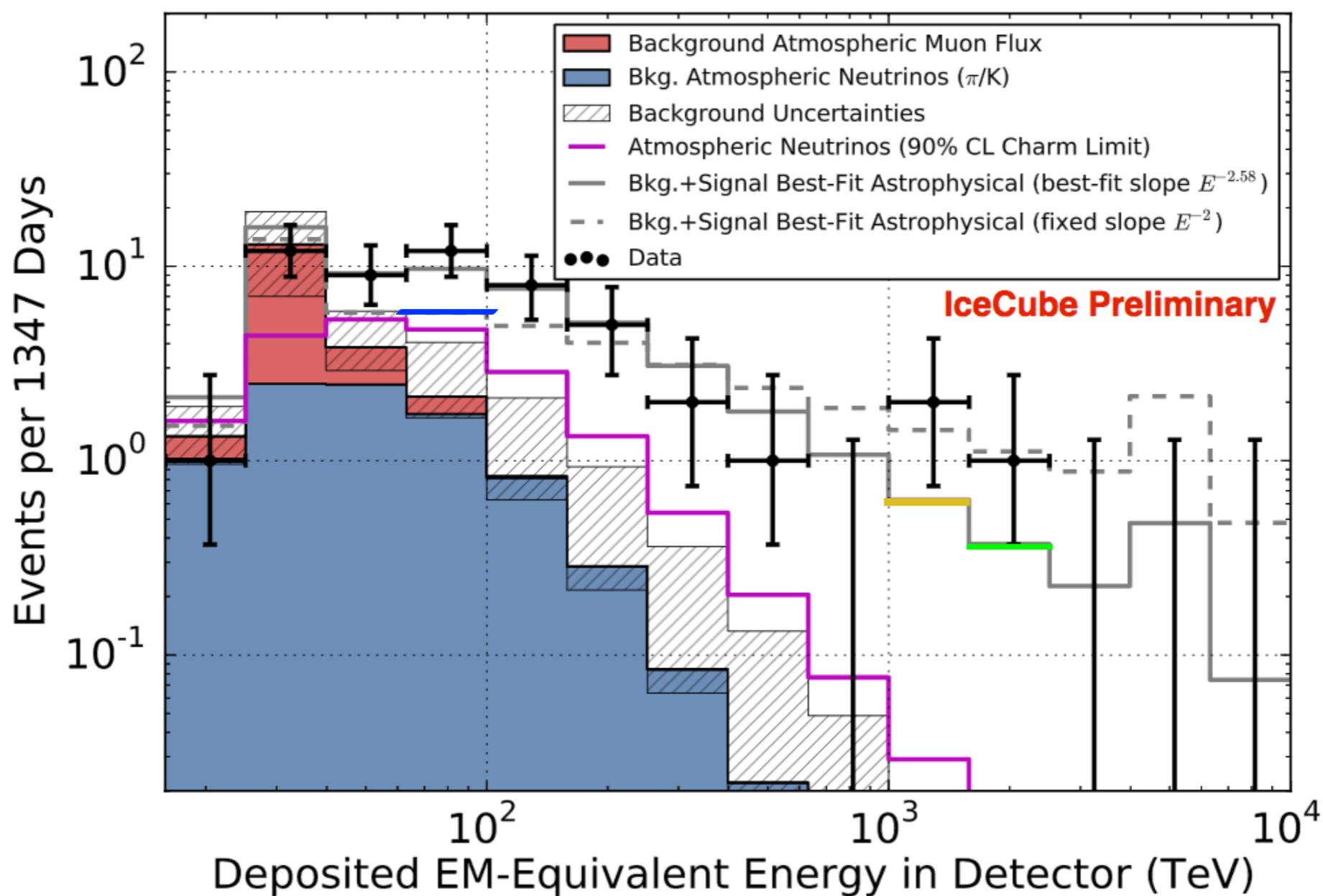


**ICECUBE**  
SOUTH POLE NEUTRINO OBSERVATORY



Max-Planck-Institut für Physik  
(Werner-Heisenberg-Institut)

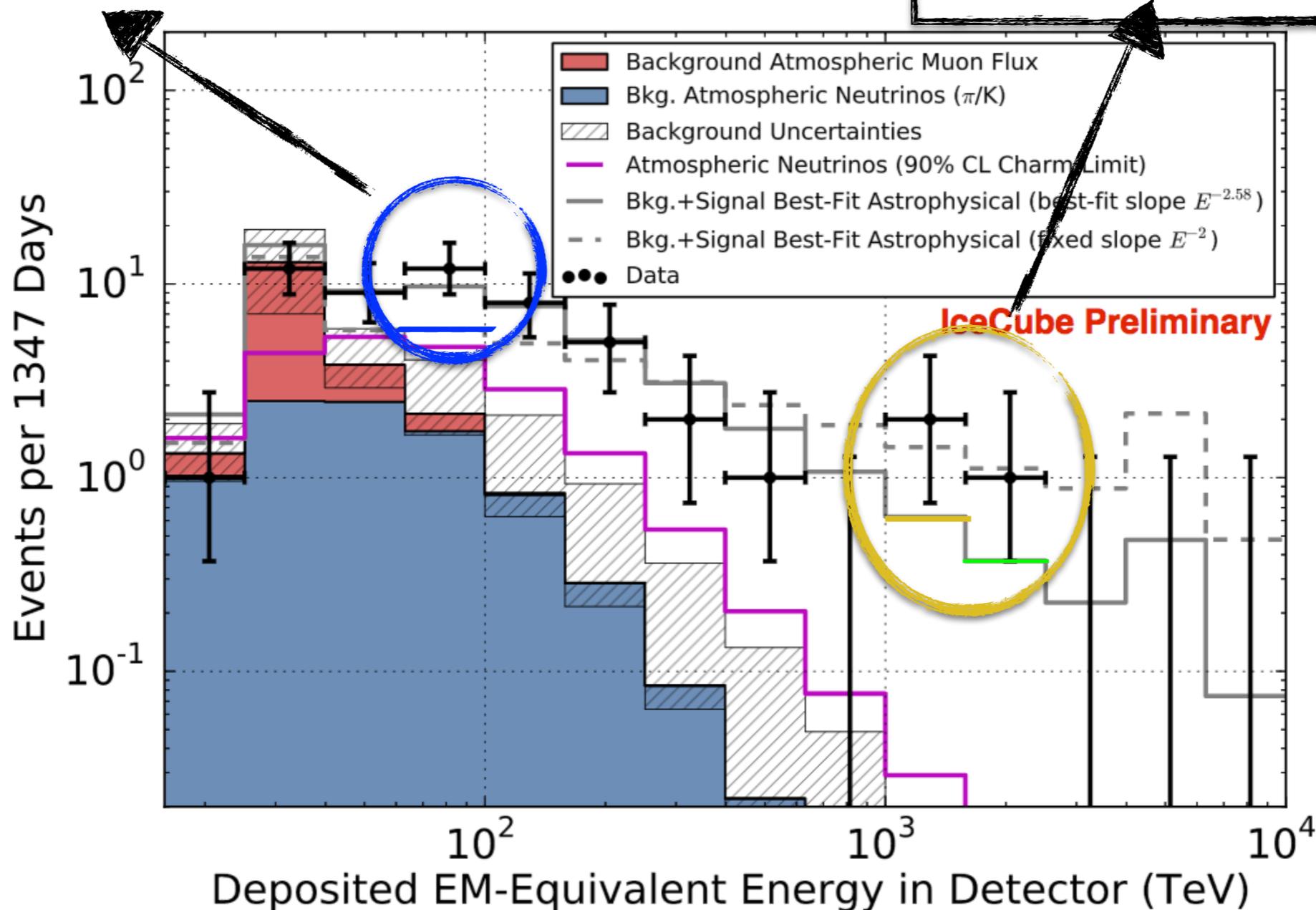
# After four years...



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arXiv:1601.02934

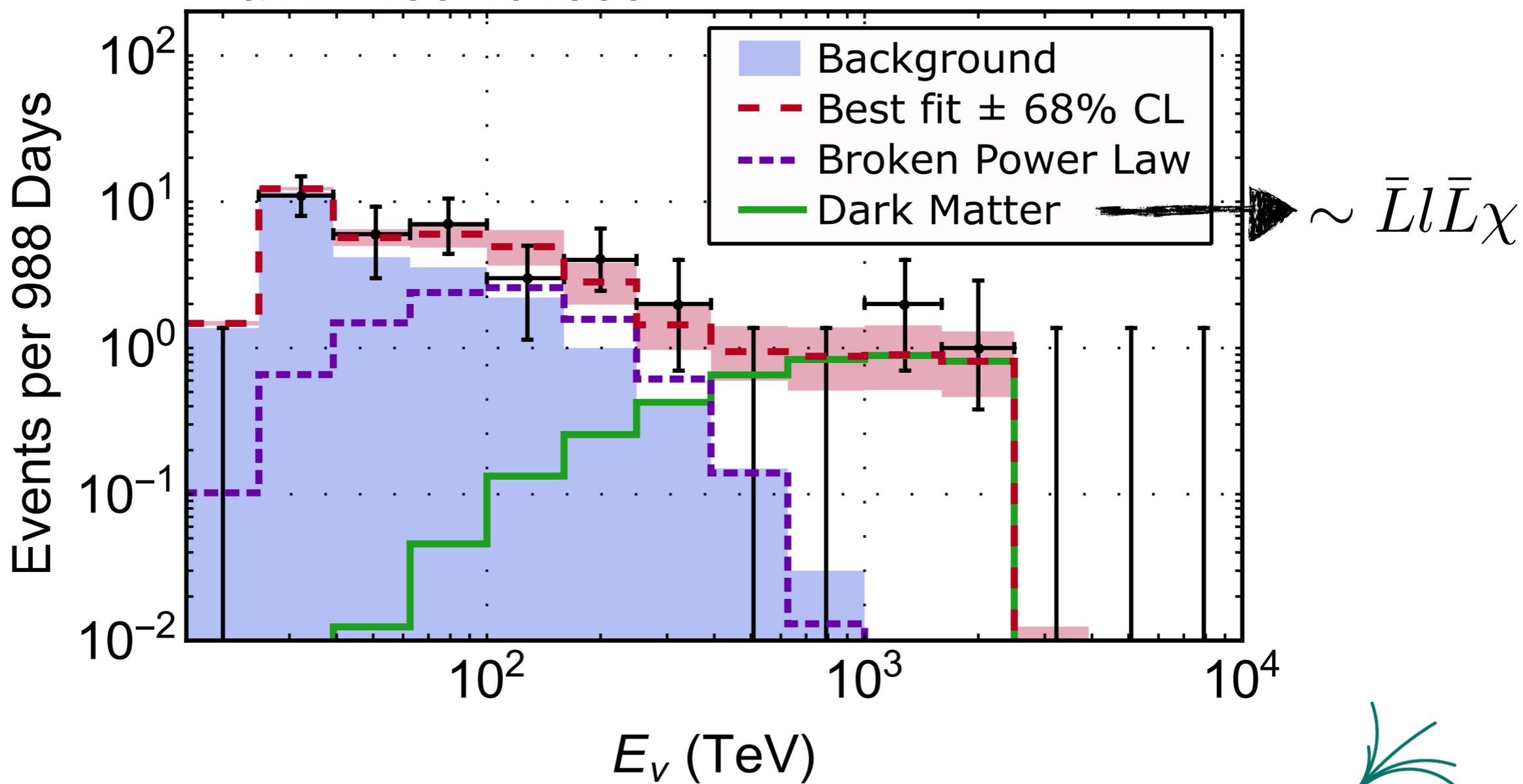
arXiv:1507.01000



# Our plot

Boucenna, Chianese, Pisanti, Mangano, Miele, Morisi, *E.V.*

arXiv:1507.01000



# Conclusions

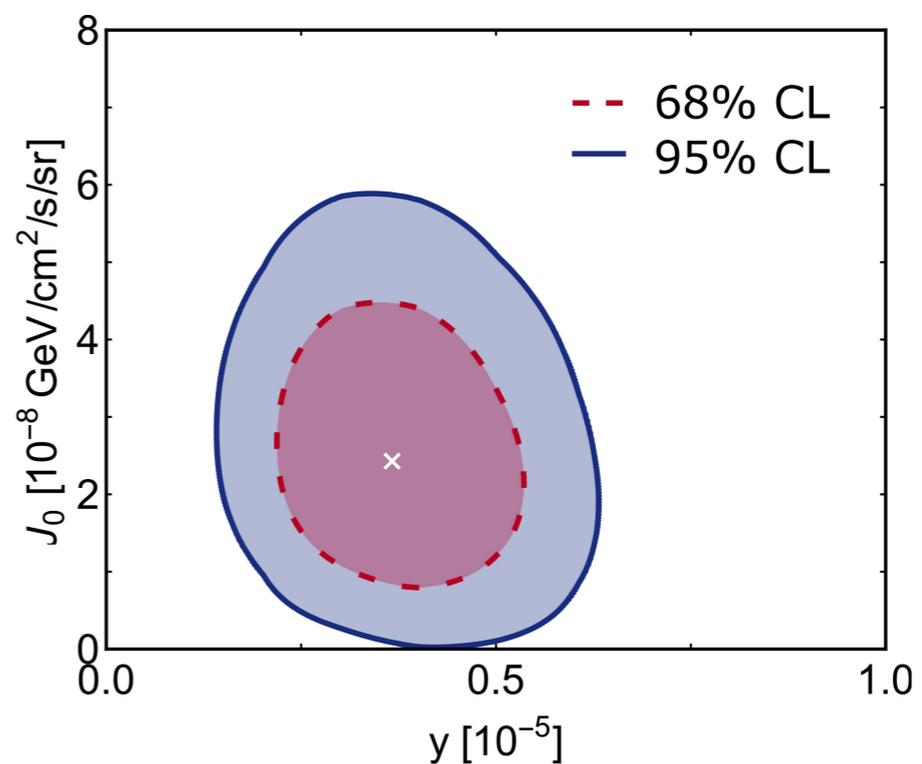
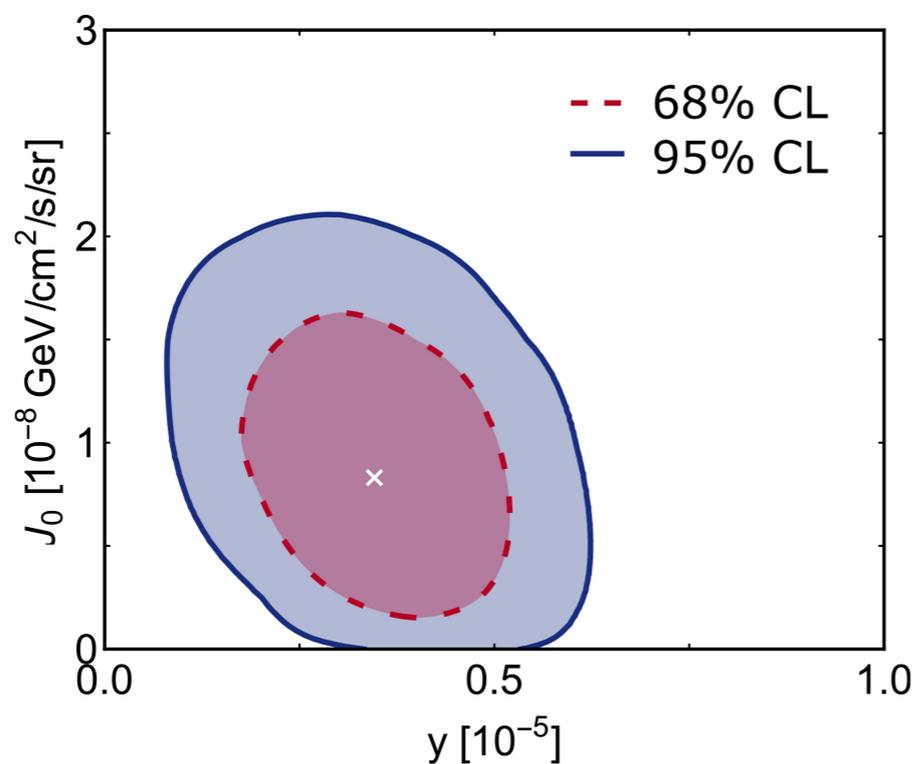
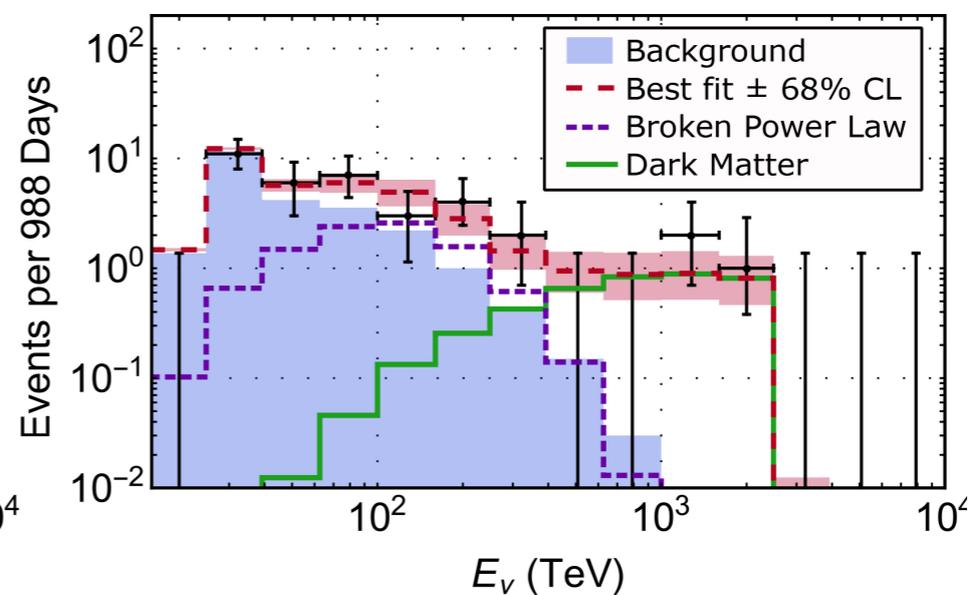
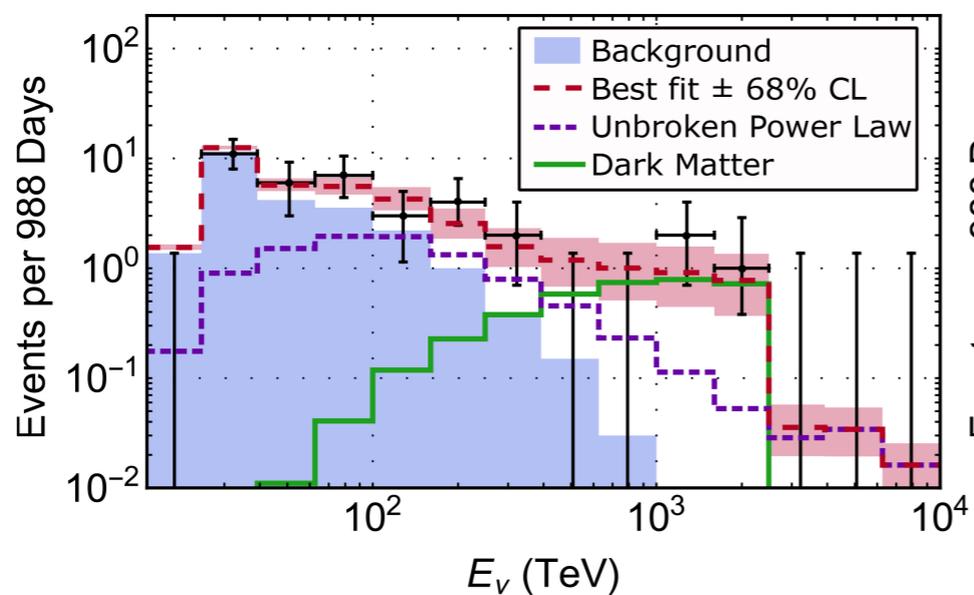
- The IC Observatory had the first evidence of **extraterrestrial high energy neutrinos**
- The detected flux is in **tension with standard bottom-up accelerators**
- The solution: **novel two-component scenario**: astro (60 – 300 TeV) + top-down decaying DM component (> 300 TeV)



Backup slides



# Likelihood

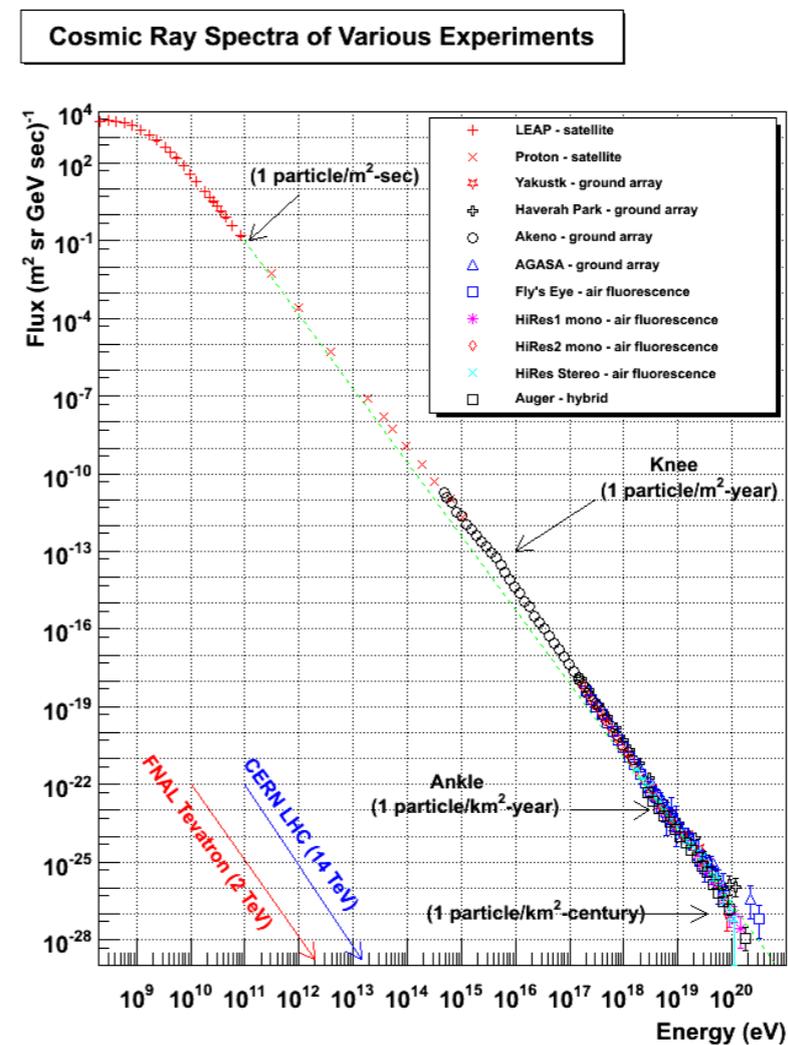


# Cosmic rays: primary particles

- Mostly protons
- Differential spectrum

$$\frac{d\phi_N}{dE} \propto E^{-(\gamma+1)}$$

- $\gamma$  dependent on energy (up to 3 PeV  $\approx 1.7$ , then  $\approx 2.0$ )



# Source flux from observed flux

- From observed to source flux

$$\frac{d\phi}{dE} \propto E^{-(\gamma+1)} \rightarrow \frac{d\phi_S}{dE} \propto E^{-(\gamma+1-\delta)}$$

- For example

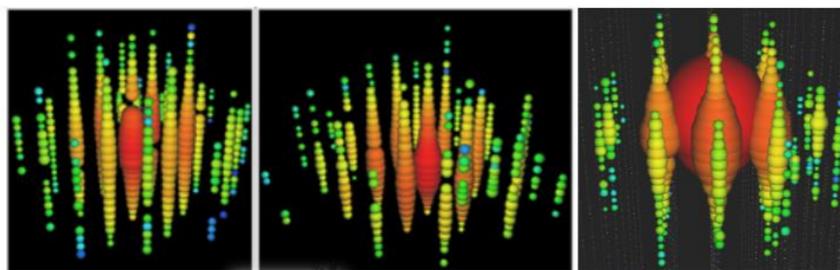
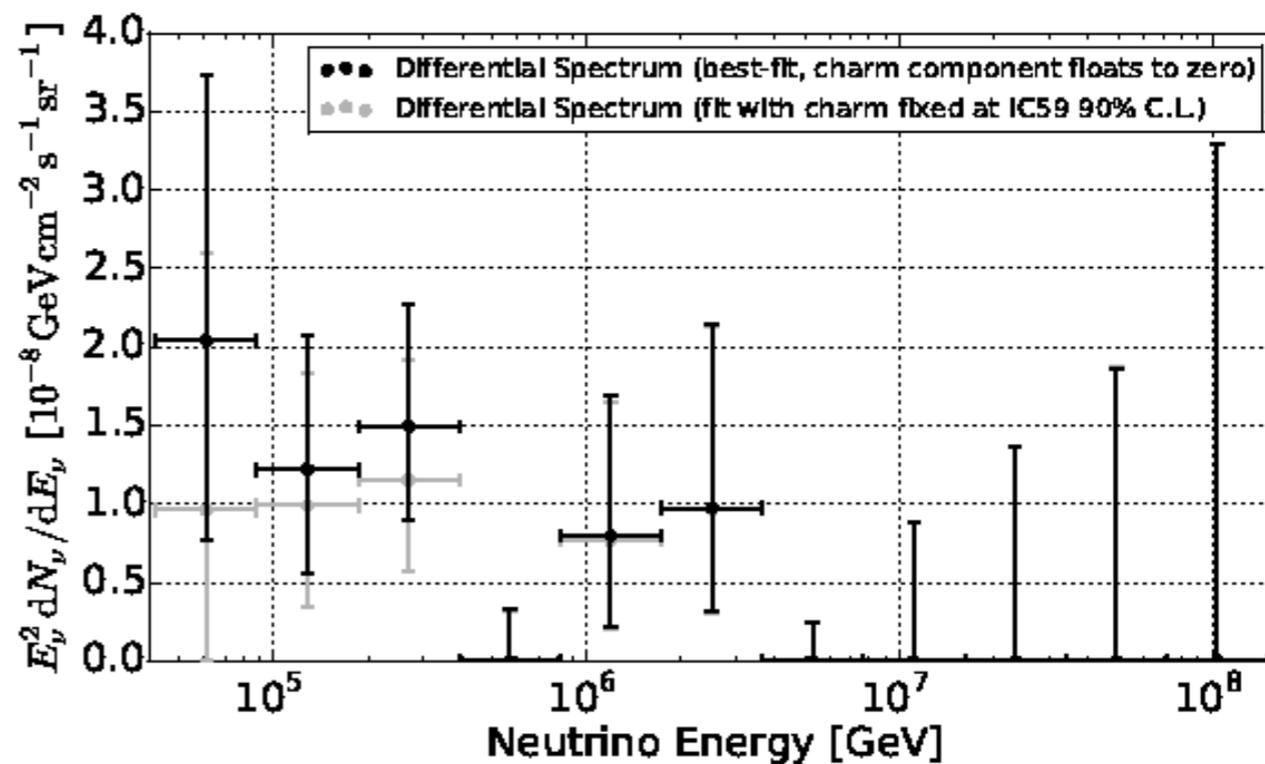
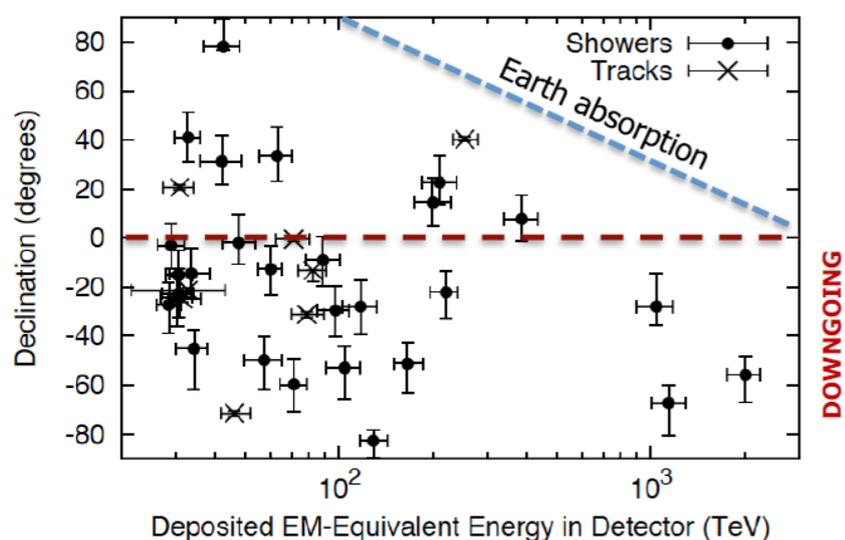
$$\frac{d\phi}{dE} \propto E^{-2.7} \rightarrow \frac{d\phi_S}{dE} \propto E^{-2}$$

- $\gamma = 2$  explained by the first order Fermi mechanism!

Neutrinos are not trapped by galactic magnetic fields



# Astrophysical neutrinos detected: energy spectrum



"Bert"  
1.04 PeV  
Aug. 2011



"Ernie"  
1.14 PeV  
Jan. 2012



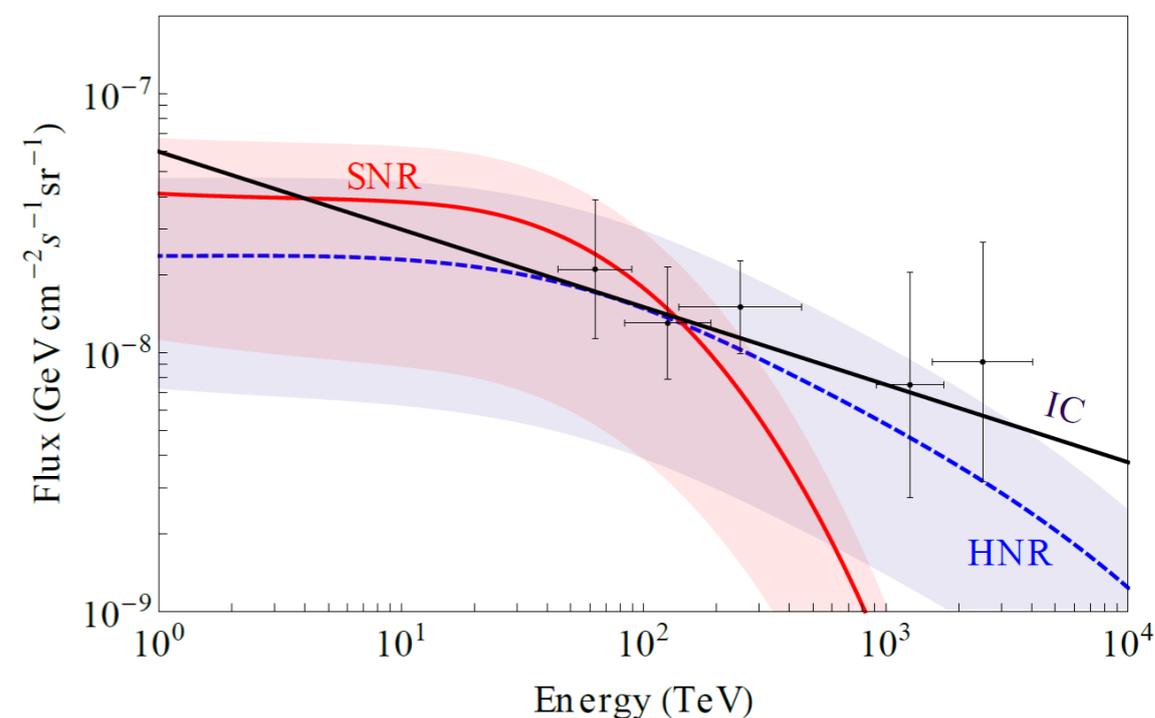
"Big Bird"  
2 PeV  
Dec. 2012



# Can bottom-up accelerators explain all data?

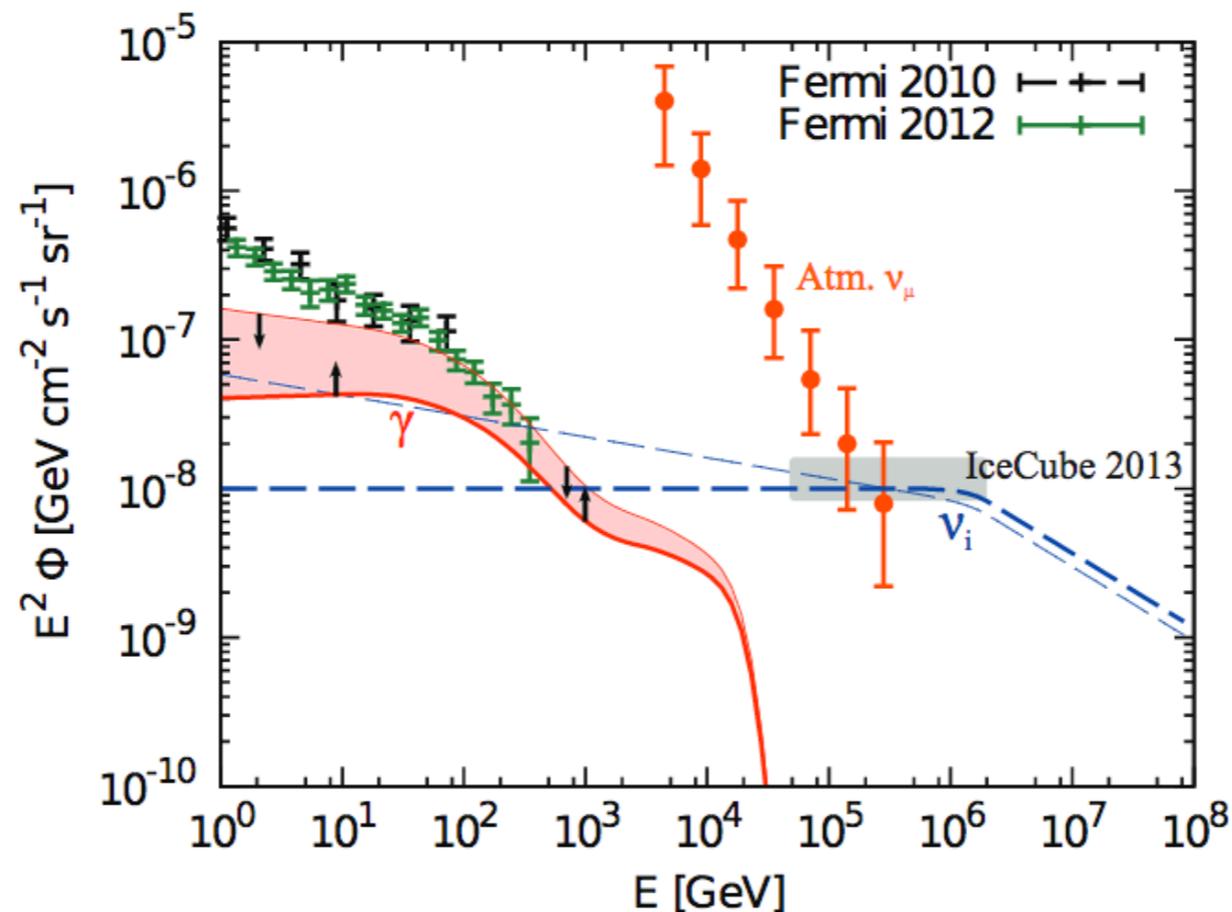
- BU accelerators have difficulties in explaining the data
- GRBs have the right shape profile but **an order of magnitude lower normalization**
- AGN can explain PeV events but are in **tension with lower energies data**
- SNRs have a **cut-off at  $\approx 100$  TeV** (maybe HNRs?)

- K. Murase, arXiv:1410.3680
- S. Chakraborty, I. Izaguirre, arXiv:1501.02615



# A Model independent constraint

- Back to the atmospheric neutrinos: production of  $\pi^\pm$ , but also  $\pi^0$   
Multimessenger approach 2 - Photons  $\rightarrow \gamma$  flux
- From Fermi-LAT data (Murase et al., arXiv:1306.3417)



The flux must be  $\propto E^{-2.1}$

