Working Group Overview: Diffuse

Maxwell Nakos

IceCube Summer School 2024

IceCube Working Groups

This presentation -> **Diffuse**

Working groups

Analysis		
Oscillations	(calls)	(mail)
Cosmic rays	(calls)	(mail)
Diffuse/Atmospheric ν	(calls)	(mail)
Supernova	(calls)	(mail)
Beyond the Standard Model	(calls)	(mail)
Neutrino Sources	(calls)	(mail)

Link to working group pages
https://wiki.icecube.wisc.edu/index.php/Main_Page

Diffuse Working Group Information

Conveners

Brian Clark

Claudio Kopper

Technical-Lead

Max Meier

Working Group Information

- Diffuse Wiki
- Slack Channel: #diffuse
- Mailing List: diffuse-atmos@icecube.wisc.edu

Diffuse Working Group Information

Wednesday weekly meetings [Central Time (Madison Time)]

- A Slot (9:00 AM)
- B Slot (4:30 PM)
- C Slot (12:00 AM)

Diffuse Call Time A

Region	Local Time (Nth. Winter)	Local Time (Nth. Summer)
Europe	Wed 16:00	Wed 16:00
East US	Wed 10:00	Wed 10:00
Central US	Wed 9:00	Wed 9:00
West US	Wed 7:00	Wed 7:00
Japan	Thu 0:00	Wed 23:00
Australia	Thu 1:30	Wed 23:30
New Zealand	Thu 4:00	Thu 2:00

Diffuse Call Time B

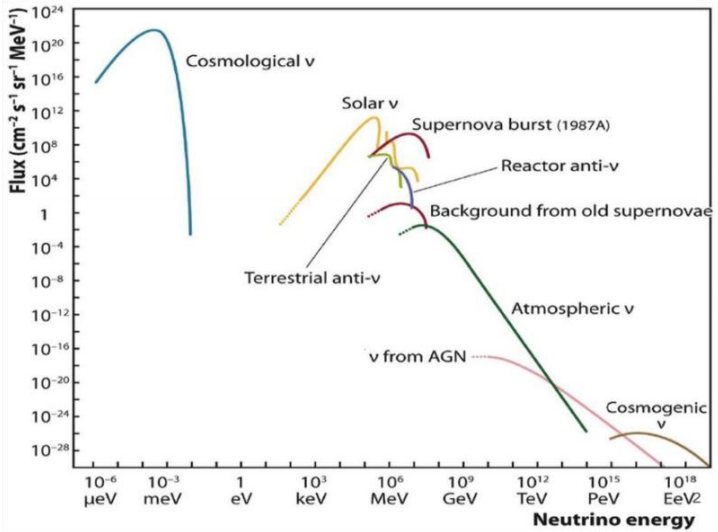
Region	Local Time (Nth. Winter)	Local Time (Nth. Summer)
Europe	Wed 23:30	Wed 23:30
East US	Wed 17:30	Wed 17:30
Central US	Wed 16:30	Wed 16:30
West US	Wed 14:30	Wed 14:30
Japan	Thu 7:30	Thu 6:30
Australia	Thu 9:00	Thu 7:00
New Zealand	Thu 11:30	Thu 9:30

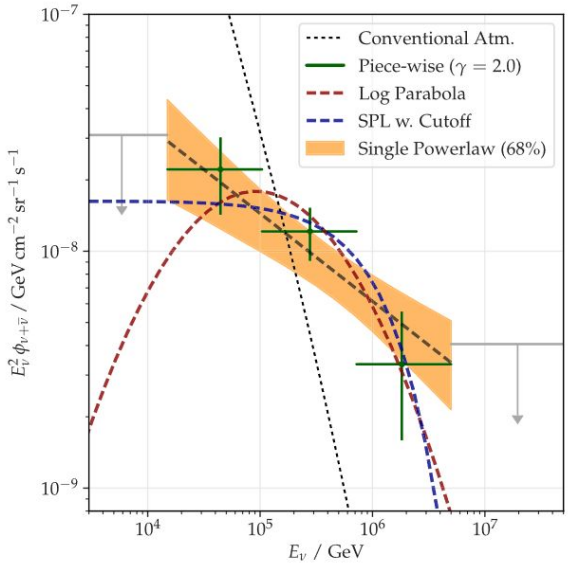
Diffuse Call Time C

Region	Local Time (Nth. Winter)	Local Time (Nth. Summer)
Europe	Thu 7:00	Thu 7:00
East US	Thu 1:00	Thu 1:00
Central US	Thu 0:00	Thu 0:00
West US	Wed 22:00	Wed 22:00
Japan	Thu 15:00	Thu 14:00
Australia	Thu 16:30	Thu 14:30
New Zealand	Thu 19:00	Thu 17:00

Diffuse Overview

- Measures astrophysical and atmospheric neutrino fluxes from the entire sky
- Measurements of the atmospheric and astrophysical spectrum from TeV to EeV
- Particle physics measurements: cross-section and inelasticity





Science Goals

- Astrophysical Source Properties
  - Measurement of Energy Spectrum
- Long-distance Neutrino Propagation
  - Flavor Measurements
- Neutrino/Nucleon and P-P Interactions
- Cross-Sections
- See Lu's talk Thursday for more information on diffuse physics

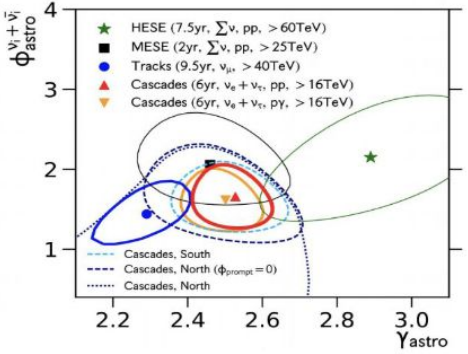
Diffuse Physics Analyses

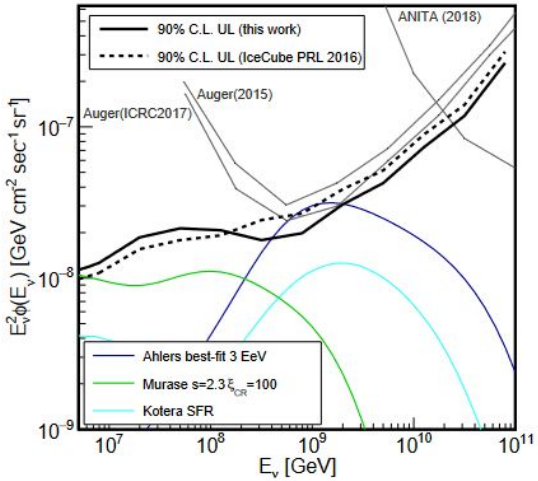
Diffuse Astrophysical Neutrino Flux
- Flux measurement (9.5 Year Northern Track)
- Astrophysical Neutrino Flavor Ratio

Atmospheric Neutrinos
- Measurement of atmospheric neutrino flux
- Seasonal Variations (Also Cosmic Ray WG)

Cosmogenic Neutrino Flux
- Limit on Extremely-High-Energy Neutrino Flux

Particle Physics
- Glashow Resonance (6.3 PeV) $\bar{\nu}_e + e^- \rightarrow W^- \rightarrow X$
- Inelasticity: Ratio of hadronic cascade to total neutrino energy
- Cross-Section: Neutrino-nucleon interaction cross-section measurement

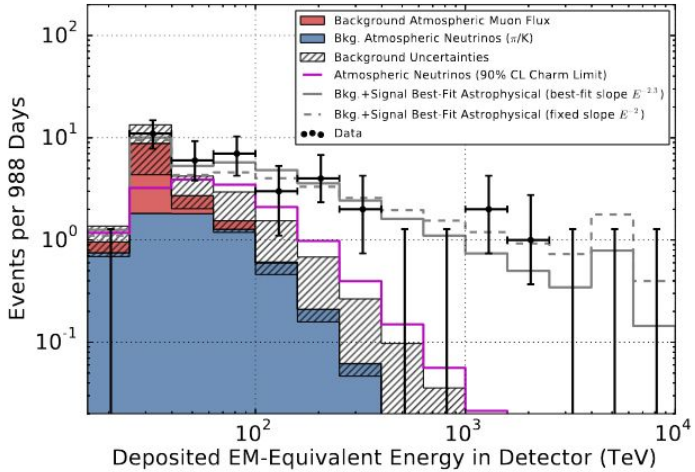




Diffuse Astrophysical Neutrino Flux (2014)

Observation of High-Energy Astrophysical Neutrinos in Three Years of IceCube Data

A search for high-energy neutrinos interacting within the IceCube detector between 2010 and 2012 provided the first evidence for a high-energy neutrino flux of extraterrestrial origin. Results from an analysis using the same methods with a third year (2012-2013) of data from the complete IceCube detector are consistent with the previously reported astrophysical flux in the 100 TeV - PeV range at the level of 10^{-8} GeV cm^{-2} s^{-1} sr^{-1} per flavor and reject a purely atmospheric explanation for the combined 3-year data at 5.7σ. The data are consistent with expectations for equal fluxes of all three neutrino flavors and with isotropic arrival directions, suggesting either numerous or spatially extended sources. The three-year data set, with a livetime of 988 days, contains a total of 37 neutrino candidate events with deposited energies ranging from 30 to 2000 TeV. The 2000 TeV event is the highest-energy neutrino interaction ever observed.

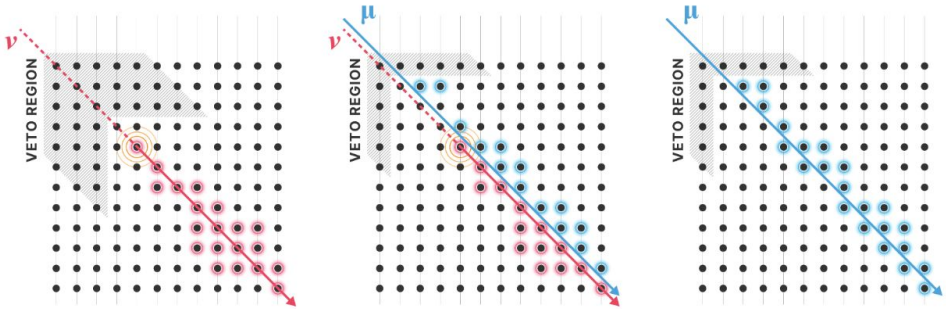


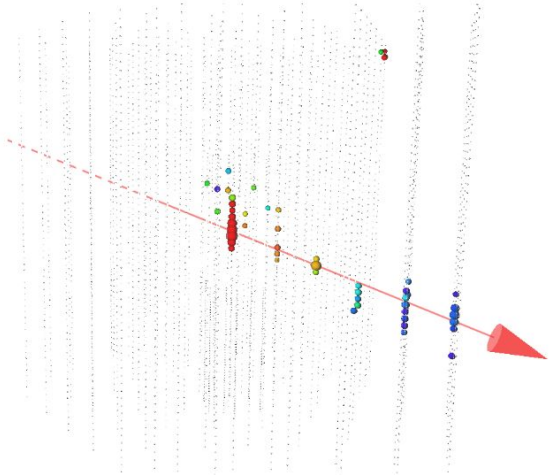
Diffuse Event Selections

- Selecting events for physics analyses (See Zoe's Talk Wednesday)

Event Selections in Diffuse

- HESE (High-Energy Starting Events)
- MESE (Medium Energy Starting Events)
- Northern Tracks
- ESTES (Enhanced Starting Track)
- PEPE (PeV Energy Partially Contained Events)
- Combined Selection: GlobalFit

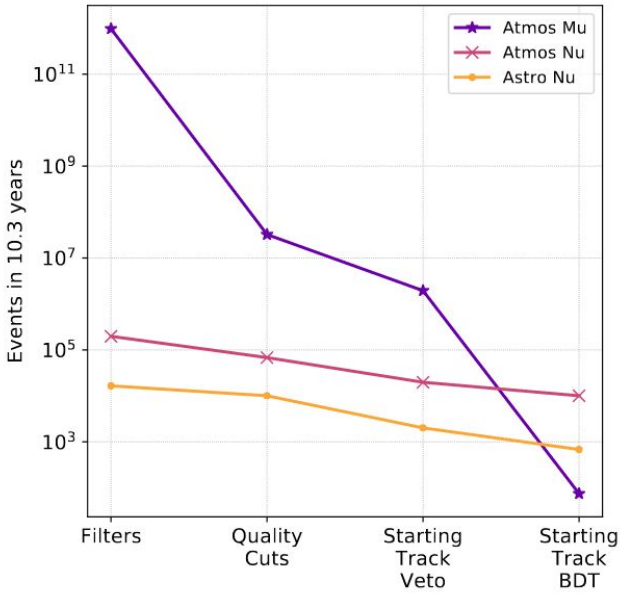


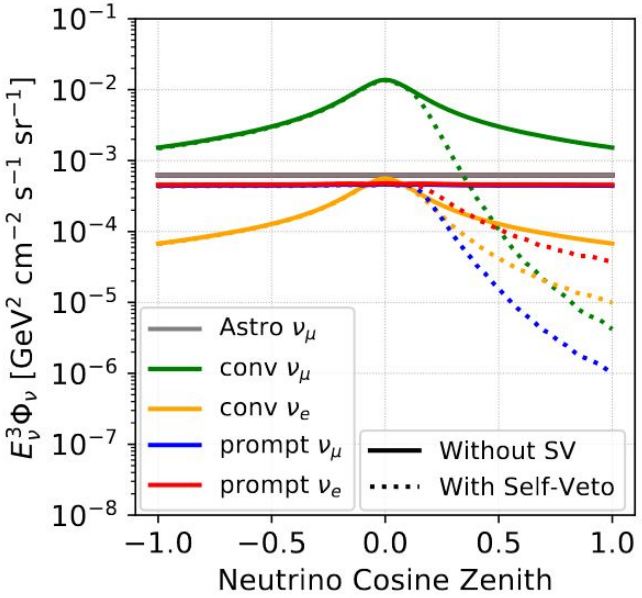


ESTES Starting Event

Recent Results - ESTES

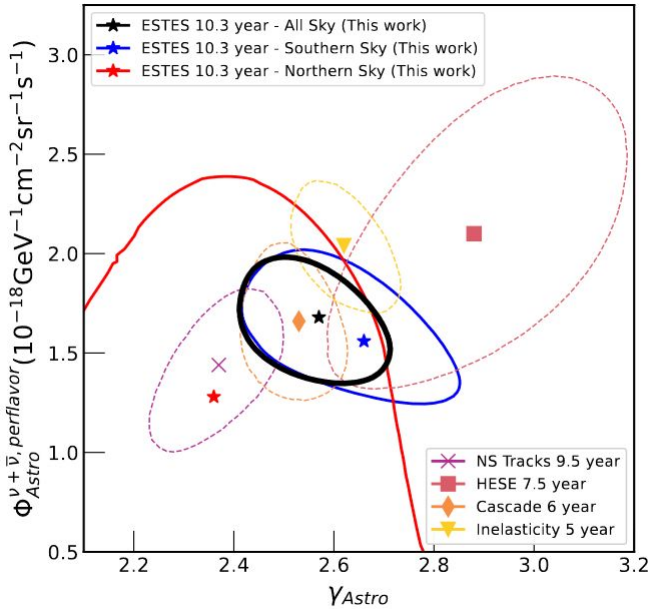
Event Selection

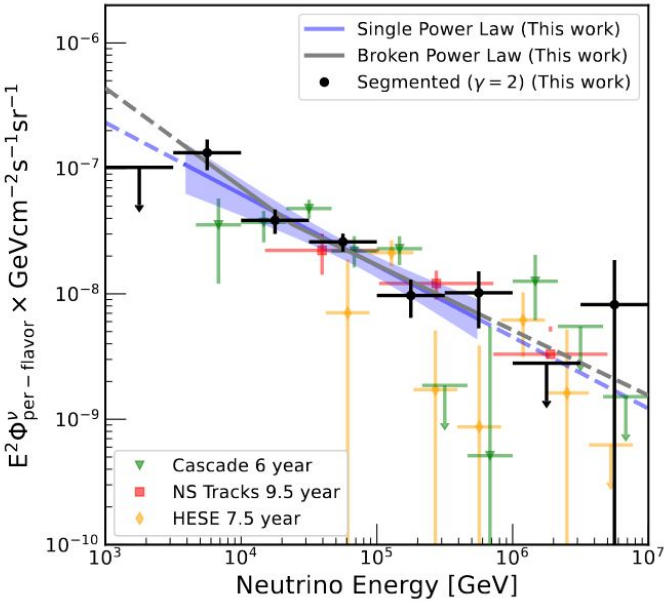




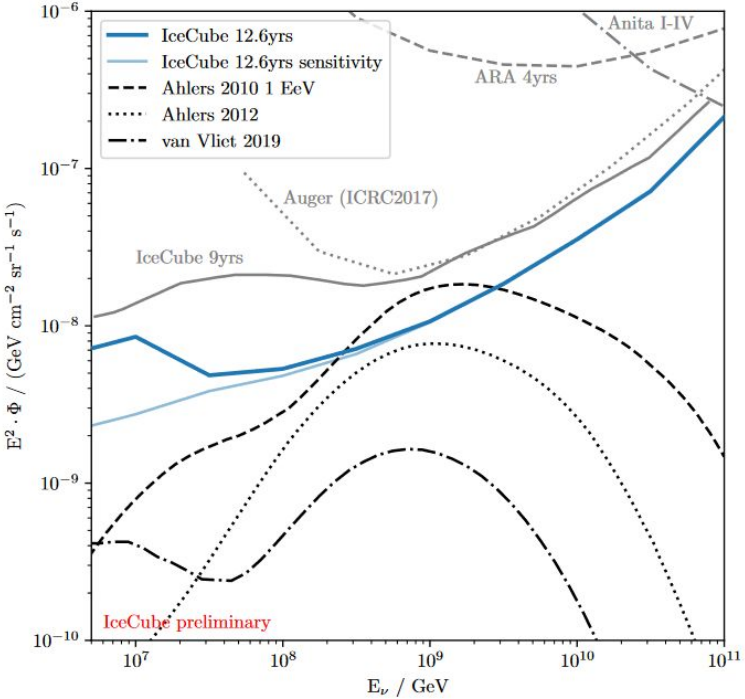
Recent Results - ESTES

Diffuse Astrophysical Flux Measurement

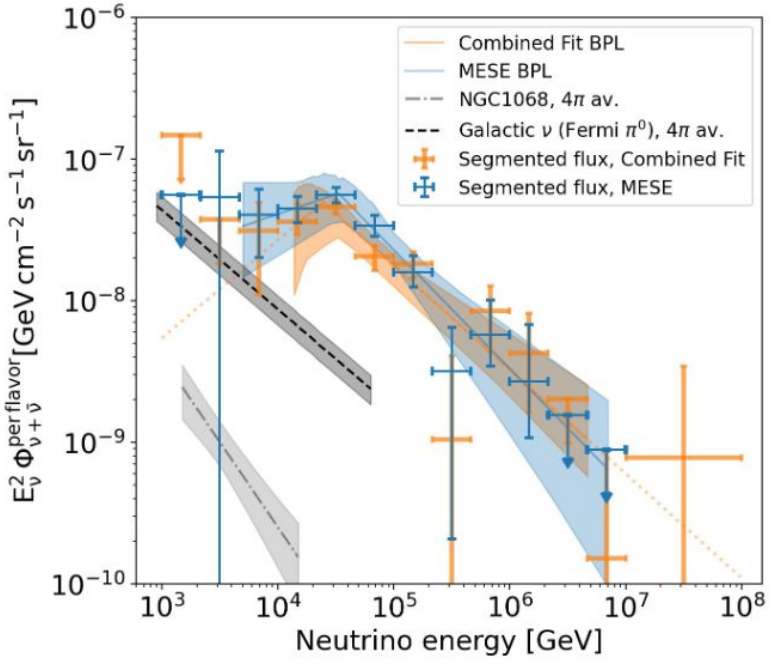




Recent Results



EHE NextGen



MESE + GlobalFit

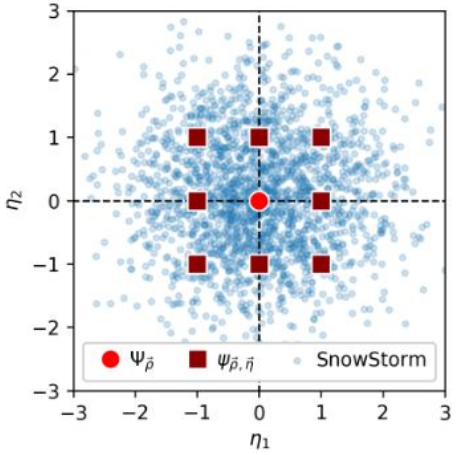
Technical Information

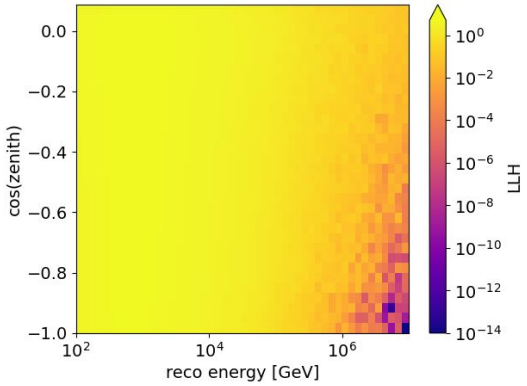
[Diffuse Technical Wiki]

Simulation
- [Snowstorm MC]: Monte Carlo varied over nuisance parameters

Reconstruction:
- Reconstructing event energy and direction

Fitting Tools:
- [NNMFit]: Software package for performing diffuse fits
  - Forward-folding fits using binned likelihoods





Doing a Physics Analysis in Diffuse

Ongoing physics analyses: Link

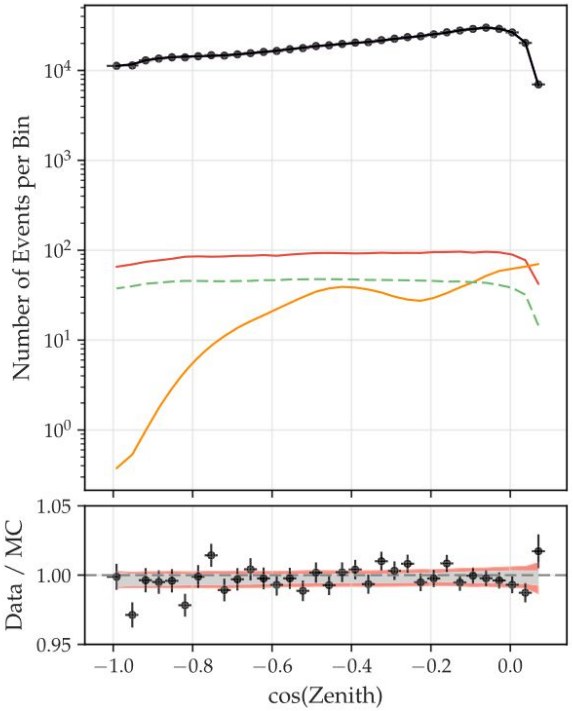
Overall Analysis Process:

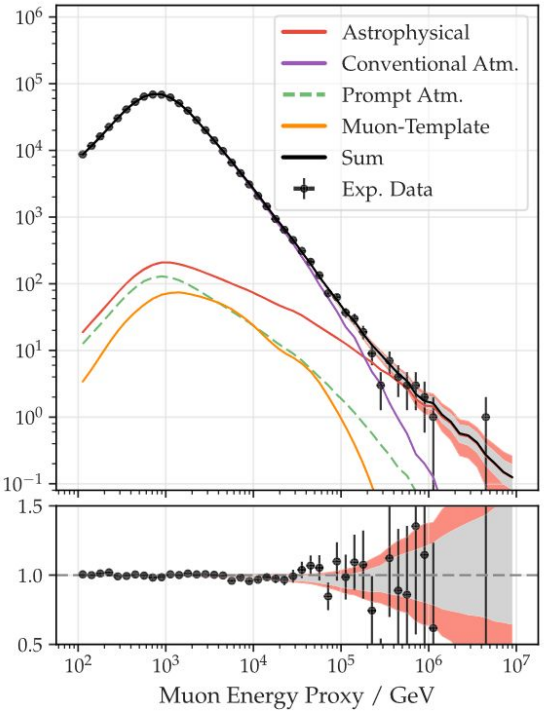
- Present Analysis Idea
- WG Reviewer
- Collaboration Review
- Unblinding Request
  - Need completed reviews, up-to-date wiki, code on github
  - Need working group and collaboration approval
- Present Results

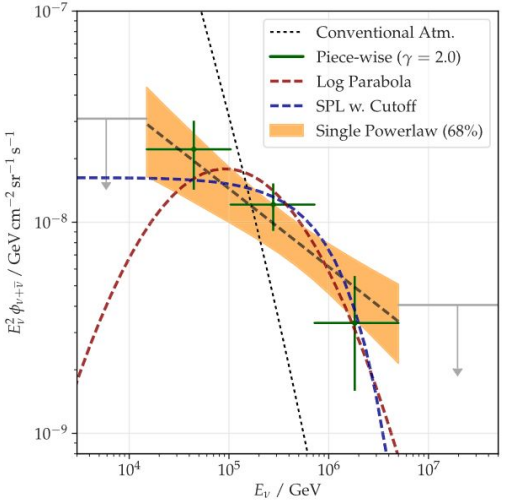
Extra Information

(2022)

Improved Characterization of the Astrophysical Muon–neutrino Flux with 9.5 Years of IceCube Data







Systematic Parameter Descriptions

Name	Description	Prior
Δ_{γ}^{CR}	Accounts for the uncertainty in the spectral index of the primary cosmic ray flux	None
λ_{model}^{CR}	Allows for the interpolation between H4a and GST4 models which show distinct shape differences in the CR flux	$\mu = 0$, $\sigma = 1$
Φ_{conv}	Allows scaling the normalization of the atmospheric background	None
Φ_{prompt}	Allows scaling the normalization of the background from charmed interactions	None
$H^{\pm}$,$W^{\pm}$,$Y^{\pm}$,$Z^{\pm}$	Represent the uncertainty of the hadronic interactions in the atmosphere according to the Barr-Scheme [23]	$\mu_{all} = 0$, $\sigma_H = 0.15$, $\sigma_W = 0.4$, $\sigma_Y = 0.3$, $\sigma_Z = 0.12$
λ_{abs}, λ_{sat}	The uncertainty of the absorption and scattering length	None
p_0, p_1	Models the refreezing of the ice holes after drilling which induced air-bubbles which differ from the other ice	None
DOM-eff	Scales the efficiency with which the DOMs in the ice can detect photons	None

Glashow Resonance