

Towards understanding contributions to the Galactic neutrino flux

[L. Seen and K. Fang, 2026, arXiv: 2608.09849](https://arxiv.org/abs/2608.09849)

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IPA 2026



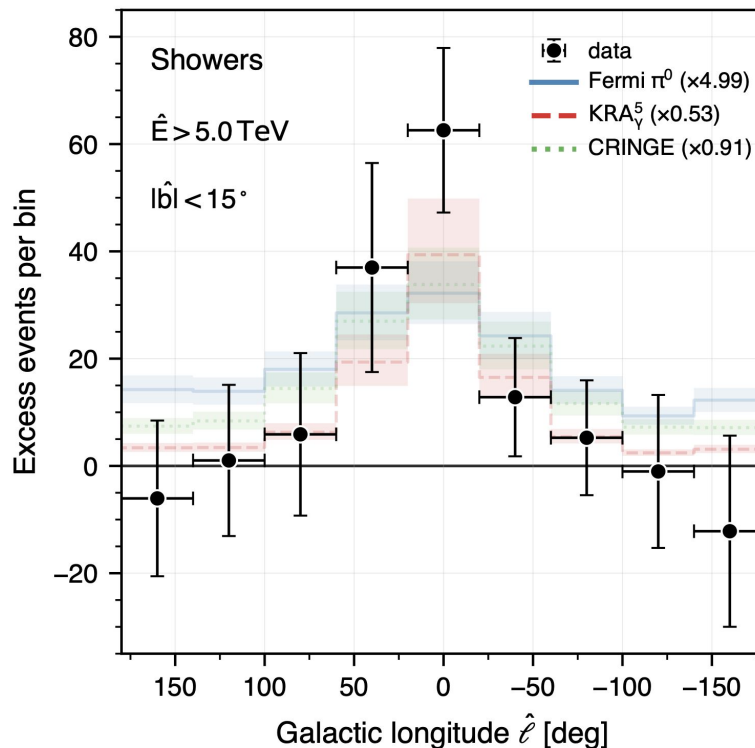
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ICECUBE
NEUTRINO OBSERVATORY

Motivation

- 5.7σ observation of neutrinos from the Milky Way
- Diffuse models require normalization factors
- Pronounced excess in data towards the inner Galaxy
 - Hints at the potential contribution from sources



Galactic ν emission

- Galactic cosmic rays can undergo proton-proton or proton-photon interactions to produce γ -rays and neutrinos
- Neutrino emission can be modeled by three separate components

$$\Phi_{\text{galactic}} = \Phi_{\text{diffuse}} + \Phi_{\text{resolved sources}} + \Phi_{\text{unresolved sources}}$$

- Differentiating source and diffuse emission is challenging
 - No Galactic neutrino sources identified yet
- Goal: Understand relative contributions to the Galactic neutrino flux

Galactic ν diffuse modeling

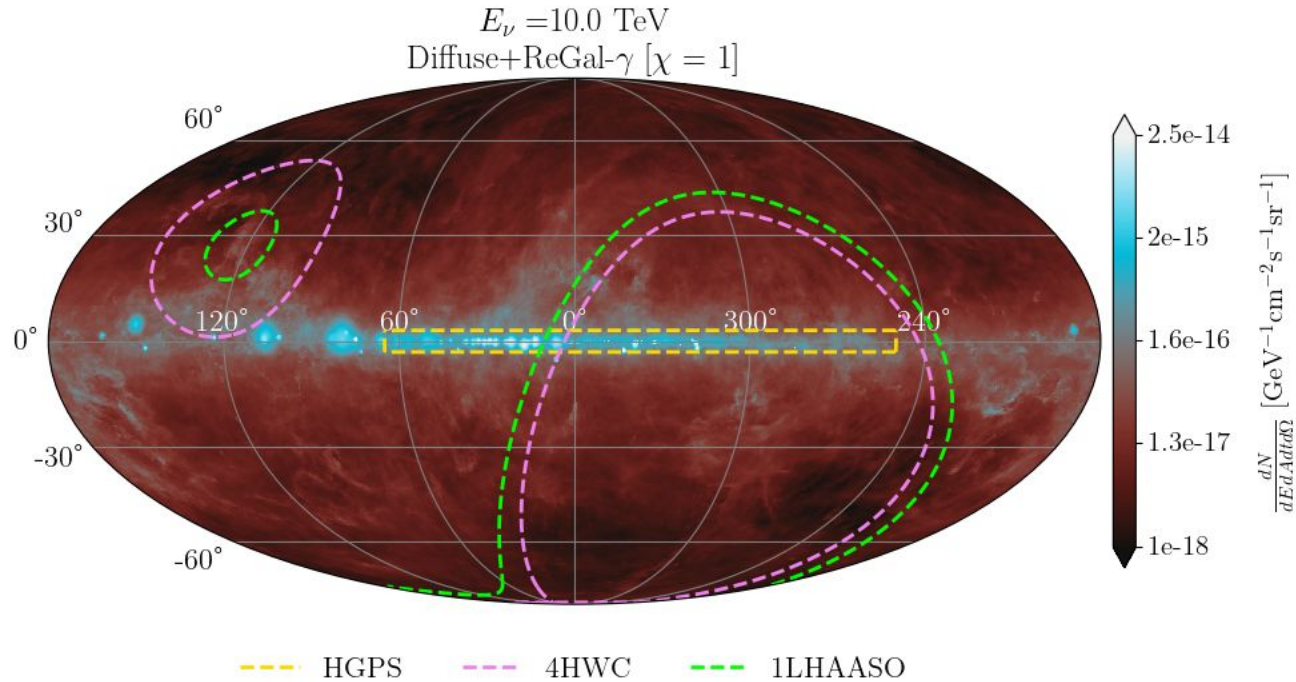
- Numerous models that predict Galactic ν emission
- Fermi- π^0 [Fermi-Lat Collaboration, 2012, arXiv: 1202.4039](#)
 - π^0 -component of Galactic γ -ray diffuse model
 - Fit to 0.1-100 GeV Fermi data
- CRINGE [G. Schwefer, P. Mertsch, C. Wiebusch, 2022, arXiv: 2211.15607](#)
 - Solves the Galactic cosmic-ray transport equation and fit to local cosmic-ray data
 - Requires additional unresolved source population to explain measurements by LHAASO and TibetAS γ
- KRA $_{\gamma}$ [D. Gaggero, A. Urbano, M. Valli, P. Ullio, 2014, arXiv: 1411.7623](#)
 - Invokes radially dependent cosmic-ray diffusion
 - Fit to γ -ray data
 - Harder cosmic-ray spectrum as suggested by Fermi toward inner Galaxy

Resolved source modeling

$$E_\nu^2 \frac{dN_\nu}{dE_\nu}(\text{per-flavor}) = \chi \left[\frac{1}{2} \left(E_\gamma^2 \frac{dN_\gamma}{dE_\gamma} \right) \Big|_{E_\gamma=2E_\nu} \right]$$

- ReGal- γ : A GeV-PeV neutrino source template made from resolved γ -ray sources
 - Includes HGPS [65 sources], 1LHAASO [KM2A: 42 sources, WCDA: 35 sources], 4FGL (DR4) [262 sources]
 - Source catalogs are applied in discrete energy ranges
- SWGO/CTAO: A neutrino source template derived from γ -ray template built for SWGO/CTAO simulations
 - Includes gamma-cat, 3FHL, 2HWC, HGPS, and synthetic source population
 - Remove PWN/Pulsars/Extragalactic/Synthetic sources
 - Total of 100 sources after filtering
- Remove PWN/Pulsars and extragalactic sources

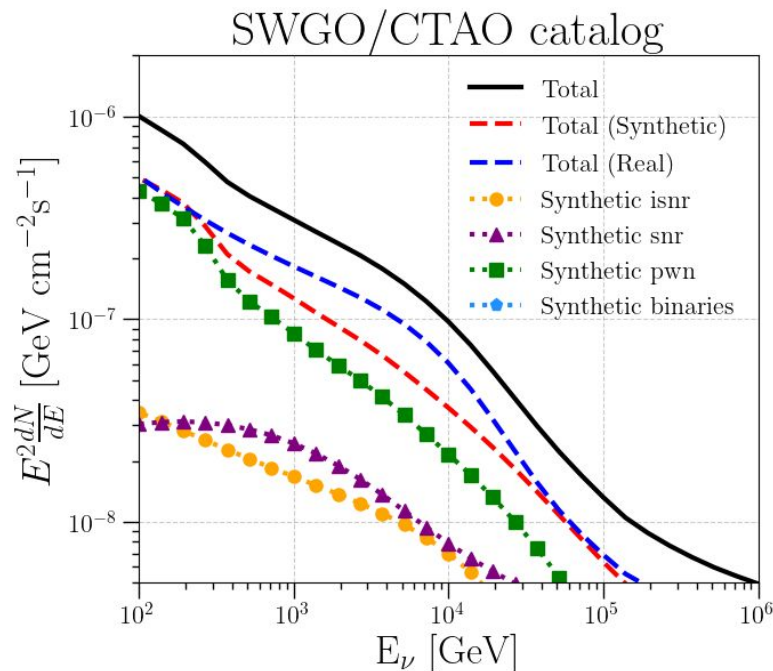
ReGal- γ skymap



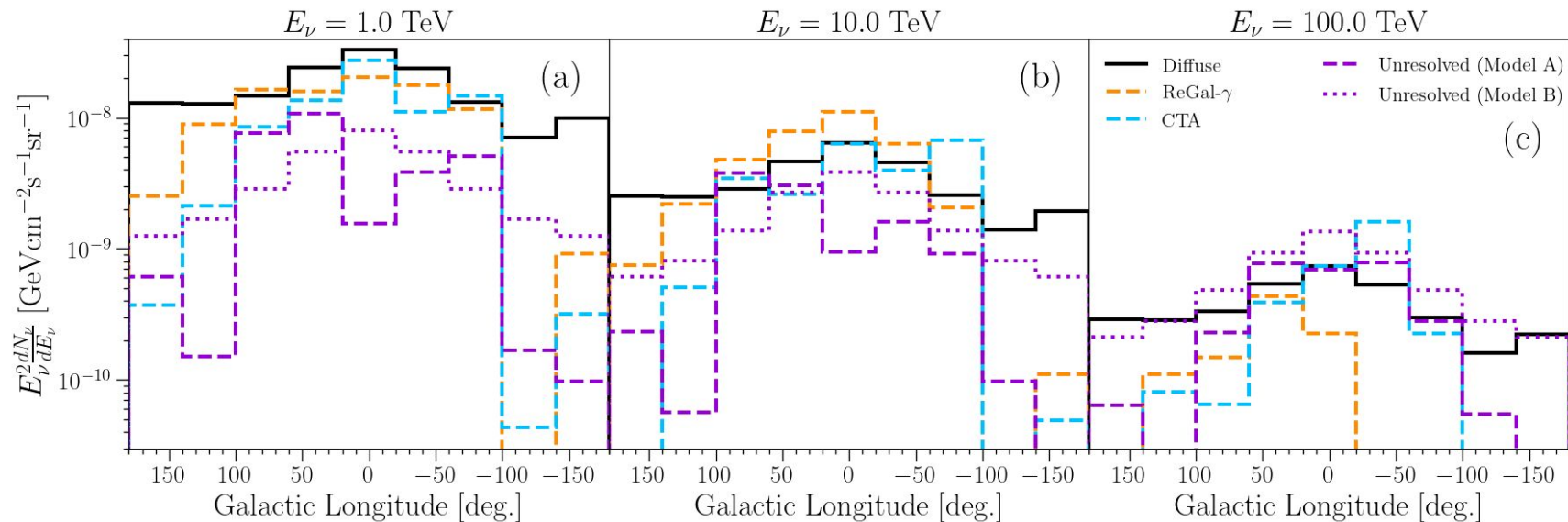
- Sources can be seen above diffuse contribution

Unresolved source modeling

- SWGO/CTAO synthetic sources
 - 3 source classes - SNRs, γ -ray binaries, and Pulsar wind nebulae (PWNe)
 - Based on birth rates and spatial distributions
 - We remove PWNe, consistent with our treatment of resolved sources
- CRINGE unresolved
 - Based on Pulsar and PWNe populations
 - Fluxes derived from extrapolations of luminosity and γ -ray spectra from TeV observations
 - We rescale by 0.5 to account for approximate contributions from PWN-like sources



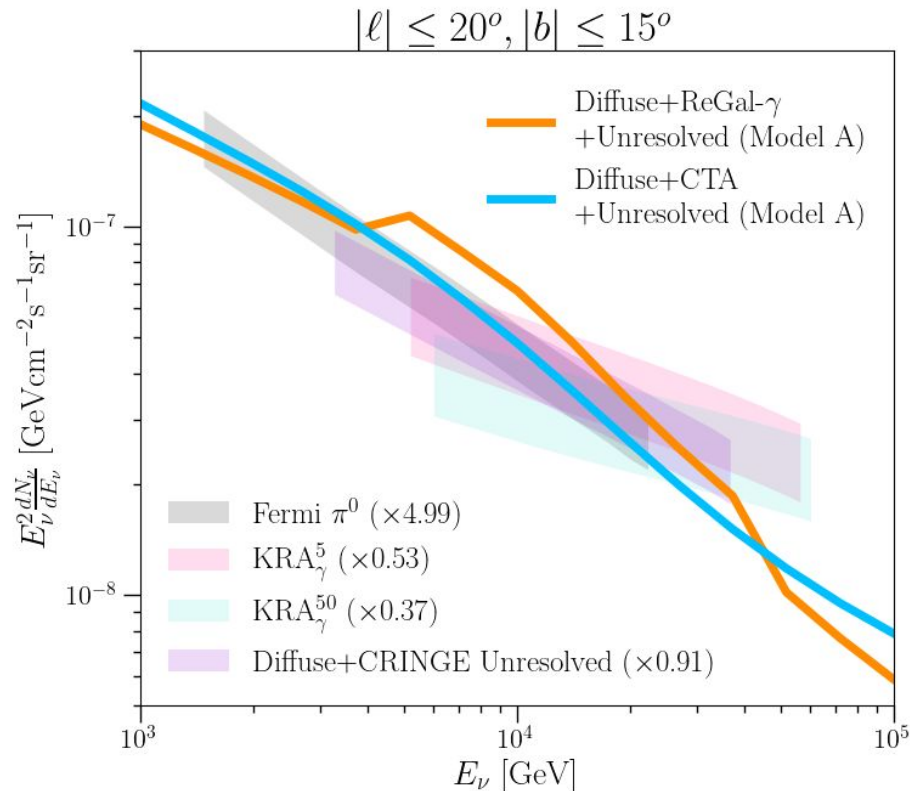
Longitudinal flux distributions



- Emission from resolved γ -ray sources can exceed diffuse emission at 10 TeV
- Lack of γ -ray emission at higher energies due to absence of air shower observatories in the southern sky

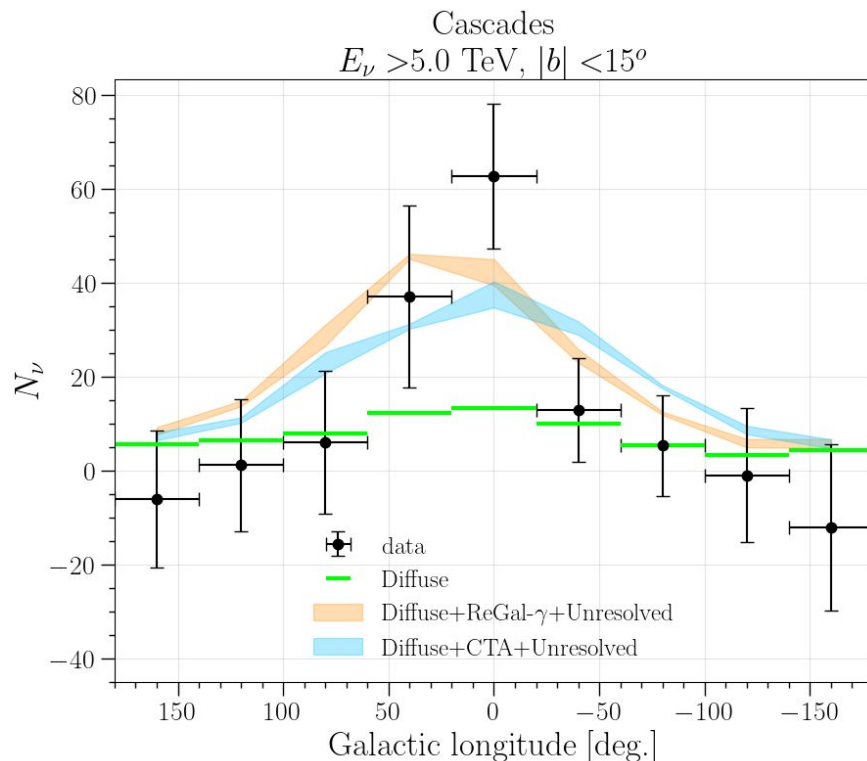
Inner Galaxy flux spectrum

- All-sky Galactic diffuse fit is driven by inner Galaxy
- Kinks in ReGal- γ spectrum due to discrete energy ranges selected during template construction
- Model predictions are consistent with measured fluxes assuming $\chi \sim 0.5-1$



Longitudinal count predictions

- Can convert flux to number of neutrinos
- Apply smearing to account for angular uncertainty
- Resolved γ -ray sources produce a more peaked longitudinal distribution towards the inner Galaxy

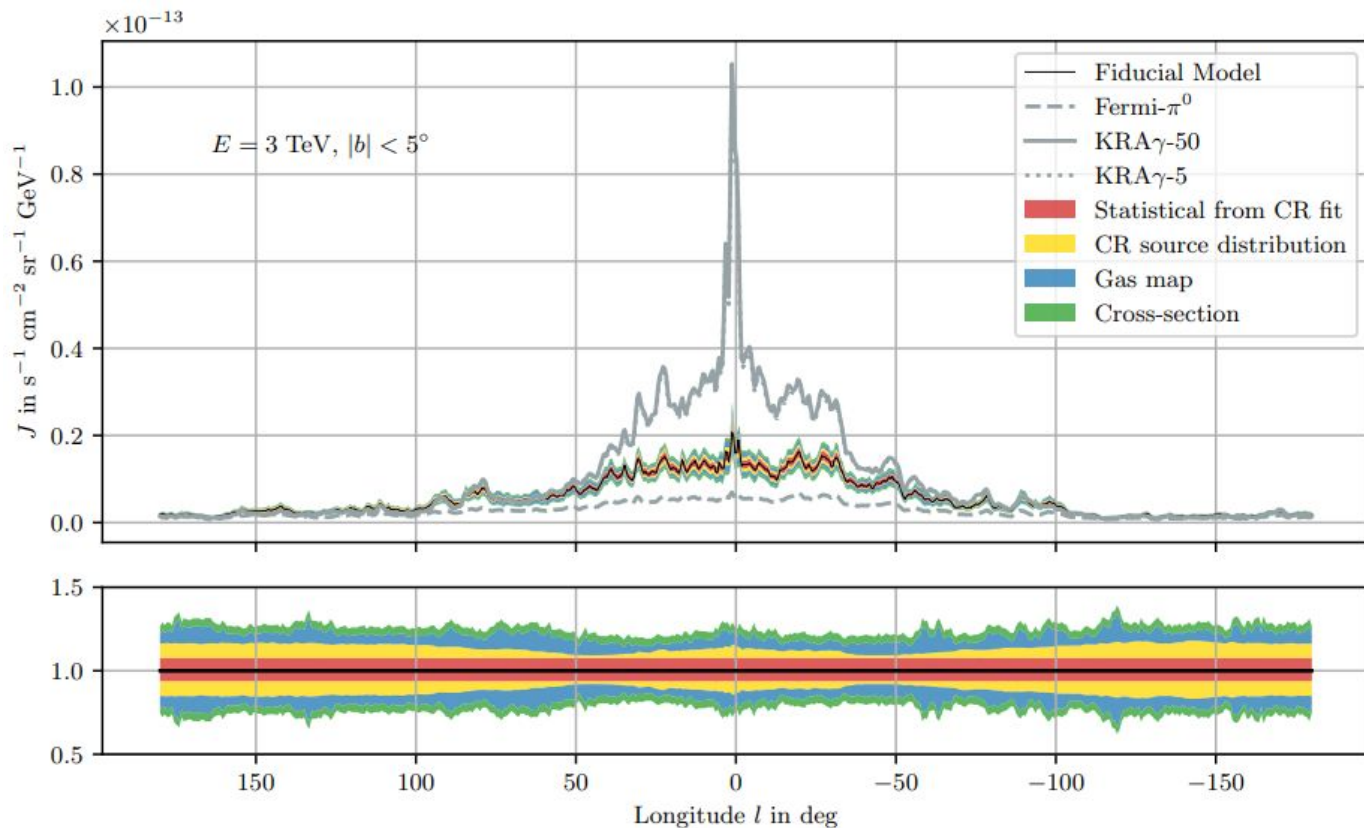


Conclusion

- ReGal- γ : A neutrino source template made from resolved γ -ray sources
- Resolved γ -ray sources can explain the inner Galactic ν excess
- Results are robust against both resolved and unresolved model uncertainties
- Future observations in the southern sky by future air shower observatories will provide a more complete catalog

Backup

Diffuse model comparisons

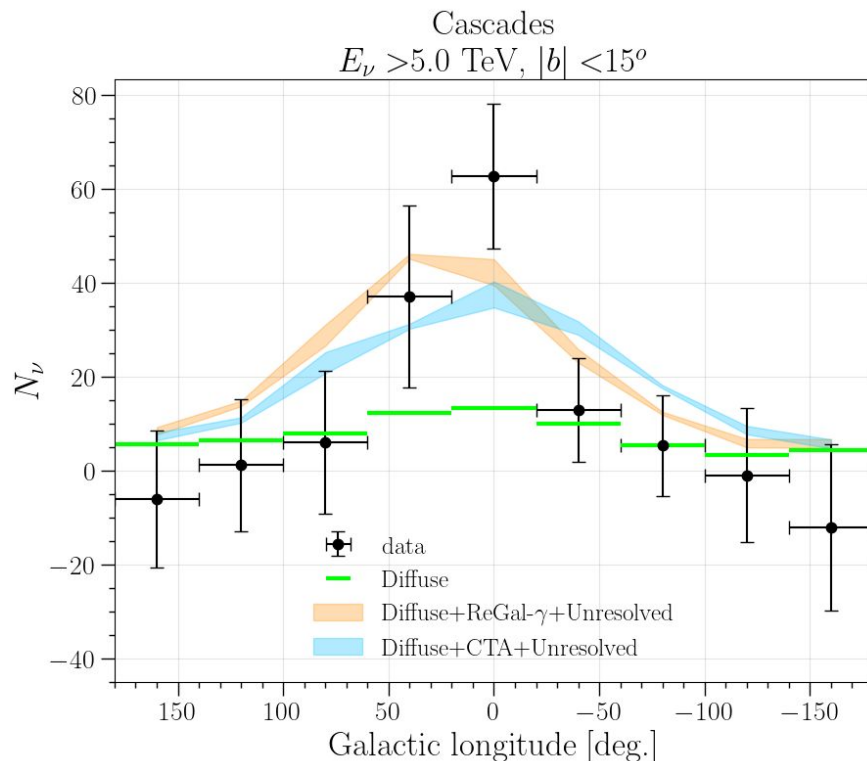


Longitudinal count predictions

- Can convert flux to number of neutrinos

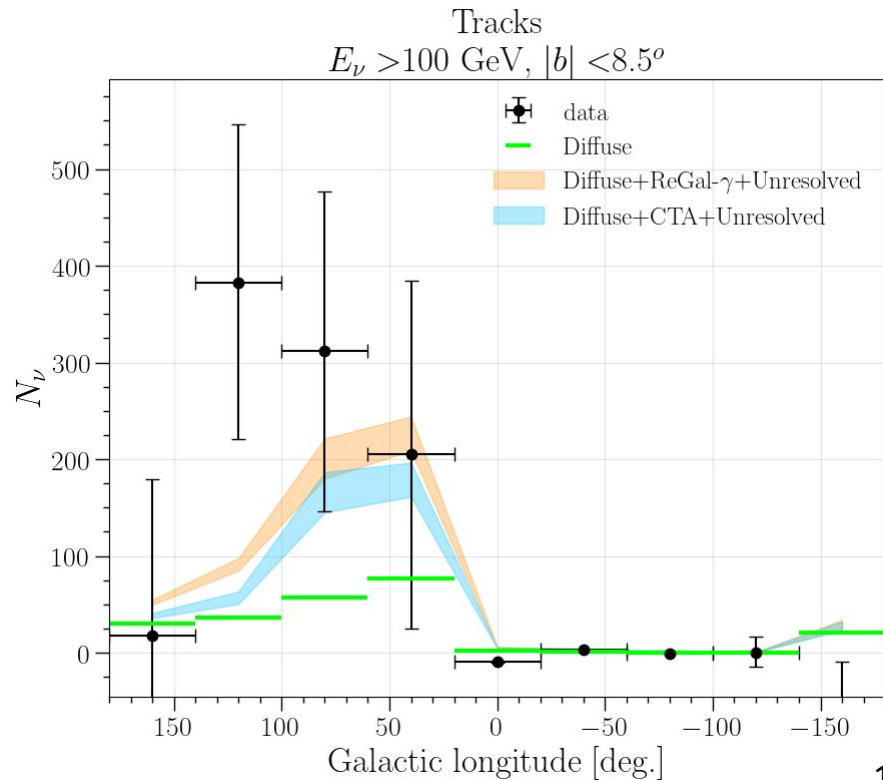
$$N_\nu(l, \Delta l) = \int \frac{dN_\nu}{dE_\nu dA dt d\Omega}(l, b) A_{\text{eff}}(E_\nu, \delta) t_{\text{live}} dE_\nu d\Omega$$

- Effective area is split into northern and southern skies
- Apply 17.5° smearing to account for angular uncertainty
- Resolved γ -ray sources produce a more peaked longitudinal distribution towards the inner Galaxy



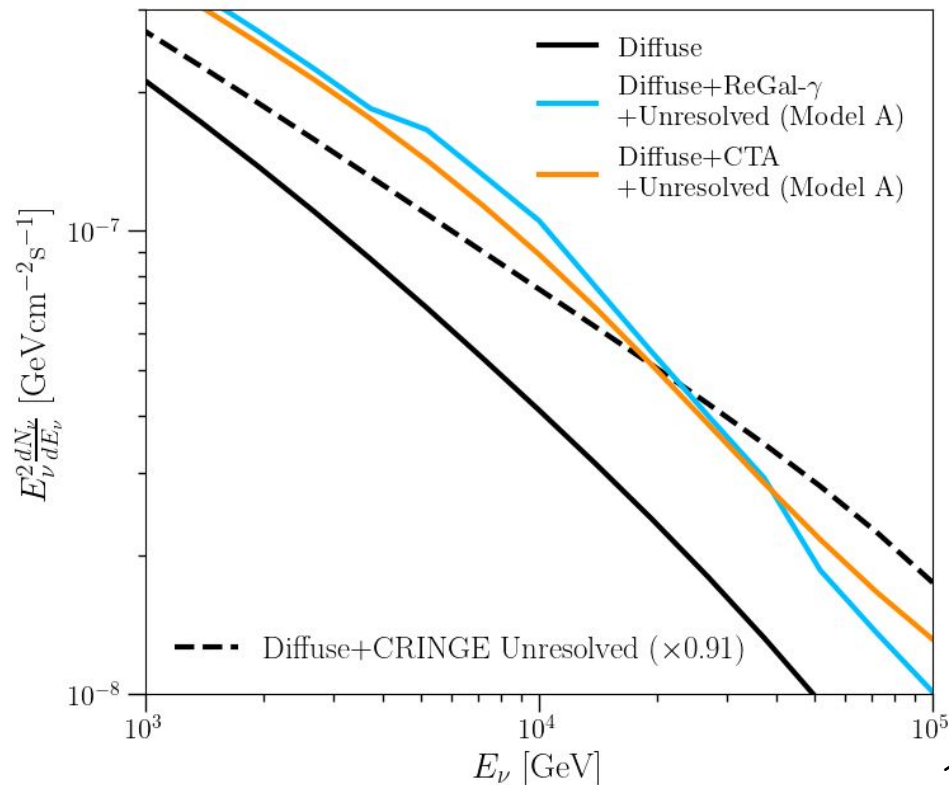
Longitudinal counts profile

- Large error bars
- Potential for additional sources in $l = 120^\circ$ bin
- Very low sensitivity in southern sky due to NT hard cut

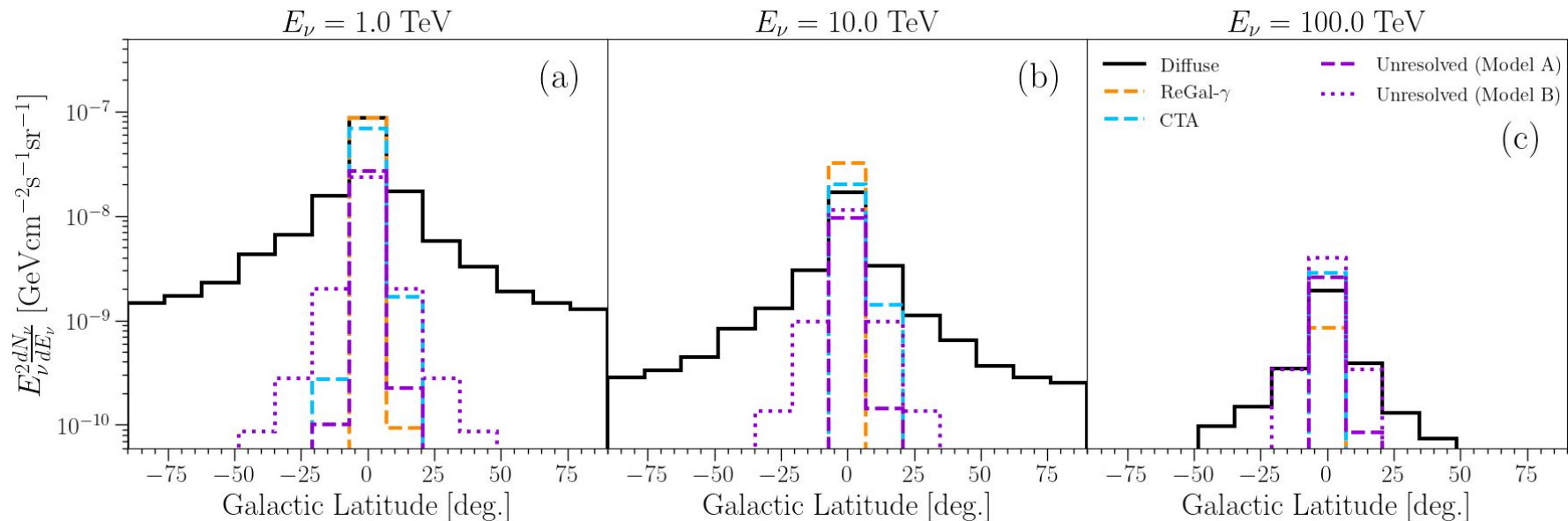


All-sky flux spectrum

- All-sky model predictions overpredict at low energies and underpredict at high energies
- Diffuse flux fit is not sensitive to outer Galaxy regions



Latitudinal flux profiles



- Galactic sources are peaked in Galactic latitude and exceed diffuse flux at some energies