

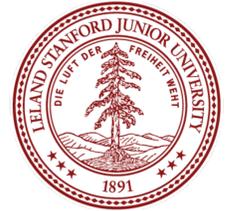
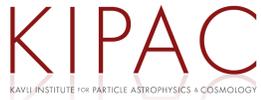
Diffuse Neutrino Emission from the Milky Way

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Introduction

- IceCube recently detected the Milky Way (MW) in neutrinos.
- The detection of the MW relies on input models based on Galactic cosmic-ray (CR) diffusion to increase the significance.
- One of the models used by the collaboration was a 13-year-old GALPROP model extrapolated from GeV pion-decay gamma-rays (γ -ray) emission to hundreds of TeV neutrinos.
- We have updated GALPROP to directly compute the neutrino emission.
- We compare our new results from GALPROP to the model-dependent results from IceCube, and make comparisons to estimates obtained from the LHAASO results.

Predicted Neutrino Emission

- We compute the neutrino flux by calculating the emissivity and then performing line-of-sight integrals.
- Neutrino production cross sections are from AAFrag202 [8, 9], and we include the pp , $p\text{He}$, $\text{He}p$, and HeHe interactions.
- Due to neutrino oscillations on parsec-scale distances, the observed per-flavour flux is equal to a third of the total emission produced in hadronic collisions.
- Limited only by the resolution of the gas – can compute up to ninth-order HEALPix files (pixel sizes of $0.115^\circ \times 0.115^\circ$).
- Also smooth the map by the directional uncertainty of IceCube ($\sigma = 7^\circ$). While there is a good qualitative agreement with the IceCube significance map, testing with the IceCube pipeline is required.

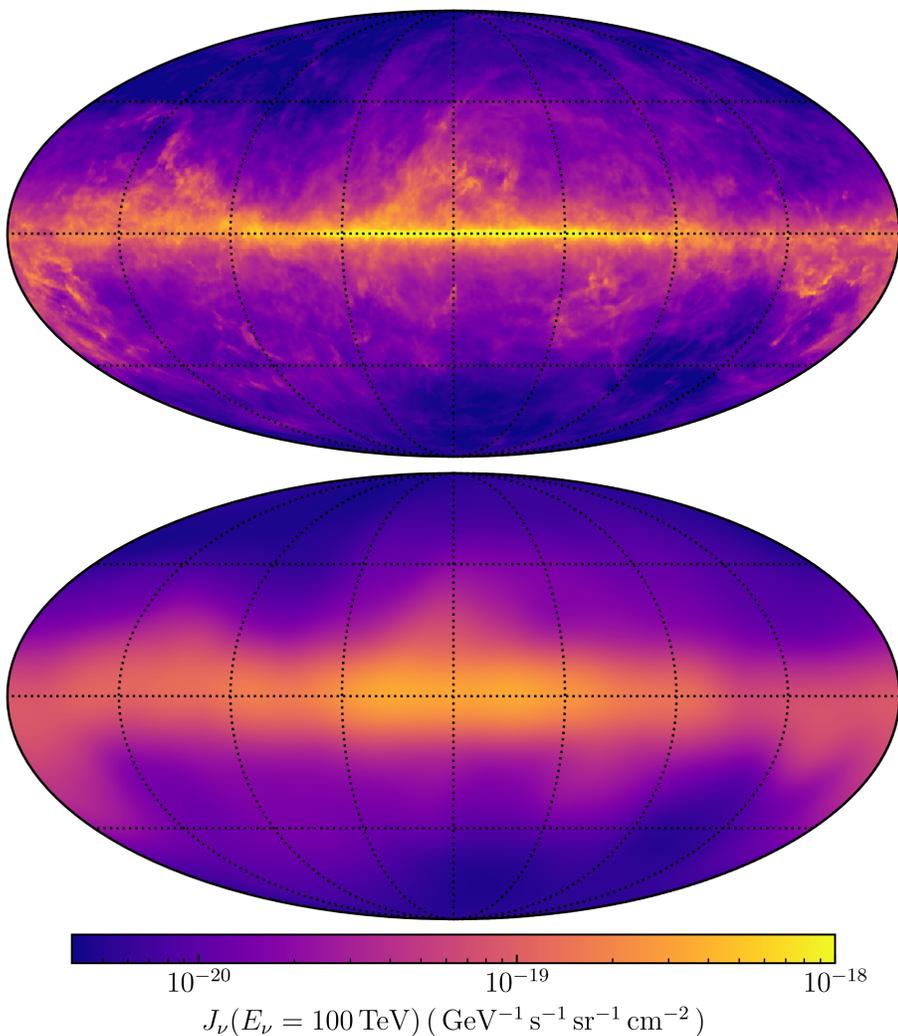


Fig. 1: Skymap of the predicted Galactic diffuse per-flavour neutrino prediction from GALPROP at 100 TeV is shown in the top panel. The bottom panel shows the skymap after applying a $\sigma = 7^\circ$ Gaussian blur corresponding to the IceCube event uncertainty at 100 TeV.

References and Acknowledgements

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GALPROP development is partially funded via NASA grants 80NSSC22K0477, 80NSSC22K0718, and 80NSSC23K0169. We thank S. Sclafani for guidance on interpreting the IceCube results and K. Fang for useful discussions. Software packages: astropy [1, 2], HEALPix [4], matplotlib [6], numpy [5], and scipy [12].

IceCube Comparison

- The IceCube observations are unable to resolve individual neutrino sources within the MW.
- While not individually detected, these unresolved sources still contribute to the total observed flux.
- We estimate from [3, 10, 13] that purely diffuse models, such as GALPROP, should underpredict the IceCube fluxes by factors in the range ~ 1.5 – 5 . GALPROP underpredicts by a factor of ~ 4 .
- We simulate over three source distributions [see 11] to determine the modelling variance.

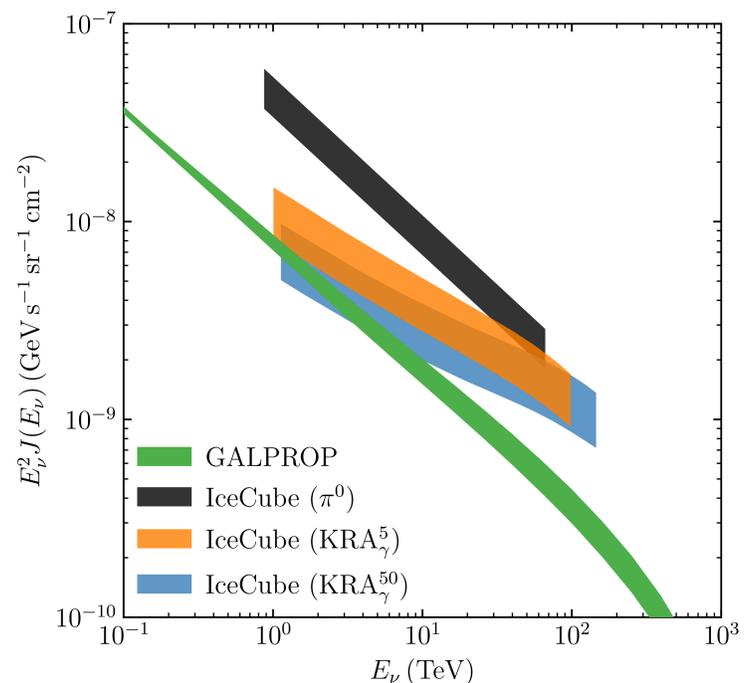


Fig. 2: All-sky differential per-flavour neutrino spectrum predicted by GALPROP across three source distributions is shown in green. Also shown are the three model-dependent IceCube measurements [7]: π^0 (black), KRA_γ^5 (orange), and KRA_γ^{50} (blue).

LHAASO Comparison

Can convert between π^0 -decay emission and neutrino emission via:

$$\frac{1}{3} \sum E_\nu^2 \frac{dN_\nu}{dE_\nu dt}(E_\nu) \approx \frac{1}{2} E_\gamma^2 \frac{dN_\gamma}{dE_\gamma dt}(E_\gamma).$$

- Applying this equation to the LHAASO observation assumes all of their large-scale flux measurements are both hadronic and diffuse. We take this as an upper limit on the expected neutrino emission.
- Create a lower limit by assuming some source contamination (resolved but improperly masked or unresolved emission) and/or some leptonic component.

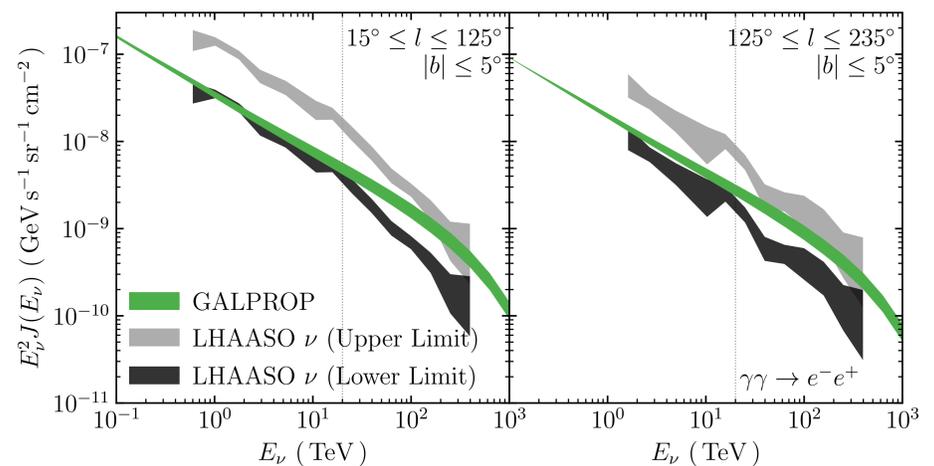


Fig. 3: Differential per-flavour neutrino flux towards the LHAASO inner and outer regions across three source distributions (green). Also shown are the LHAASO diffuse γ -ray results after converting to expected neutrino fluxes, assuming 100% of sources are resolved and that the observed emission is hadronic (upper limit, grey) and a fraction of 25% of the emission being hadronic/unresolved (lower limit, black), with the statistical and systematic uncertainties added in quadrature. The vertical dotted lines at $E_\nu = 20$ TeV ($E_\gamma = 40$ TeV) denotes the region where pair-absorption effects reduce the accuracy of the γ -to- ν conversion.

Summary

CR diffusion codes must simultaneously reproduce both the γ -ray emission and neutrino emission from the MW. Our previous results show that GALPROP successfully reproduces the TeV–PeV γ -ray emission, though both the modelling and observational uncertainties are large. We show here that GALPROP also reproduces both the diffuse neutrino emission observed by IceCube and the estimates that can be obtained from the γ -ray observatory LHAASO without any alterations to the models.

For more detail see PoS 1112 or email pmarinos@stanford.edu