Interpreting the high-energy neutrino sky through an angular power spectrum analysis

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ONLINE ICRC 2021 THE ASTROPARTICLE PHYSICS CONFERENCE Berlin | Germany 37th International Cosmic Ray Conference 12–23 July 2021

arXiv:1811.02576

arXiv:1910.12917

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Angular Power Spectrum

Use anisotropic features to constrain source populations

- Bright source classes & decaying/ annihilating DM from the galactic centre will show anisotropies on the neutrino sky.
- Through Monte Carlo simulations, test model against isotropic sky

Conclusion

Angular power spectrum is a powerful tool to constrain contributions from source populations:

- Stringent limits on DM cross-section and lifetime using angular information only. With future neutrino observations, the current best-fit DM scenario from IceCube (HESE) observations [3] can be tested.
- See talk by Andrew Cheek on Dark Matter Phenomenology with Angular power Spectrum analysis
- Bright astrophysical source populations like BL Lacs and FSRQs will be significantly constrained if an isotropic distribution will be observed in future. Current 10-yr IceCube data [6] limits $N_\star < 600$ at 95CL.

References

[1] J. Stettner, IceCube Collaboration, ICRC 2019 [arXiv:1908.09551].

[2] A. Schneider, IceCube Collaboration, ICRC 2019 [arXiv:1907.11266].

[3] M. Chianese, D. F. G. Fiorillo, G. Miele, S. Morisi, and O. Pisanti, JCAP 1911 (2019) [arXiv:1907.11222].

[4] A. U. Abeysekara et al. (HAWC), JCAP 1802, 049 (2018) [arXiv:1710.10288].

[5] T. Cohen, K. Murase, N. L. Rodd, B. R. Safdi, and Y. Soreq, Phys. Rev. Lett. 119, 021102 (2017) [arXiv:1612.05638].

[6] IceCube Collaboration, Phys. Rev. Lett. 124, 051103 (2020) [arXiv:1910.08488]

Current and Future Sensitivities

Dark Matter

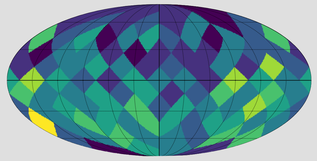
Tension in observed energy spectrum between data-sets in IceCube [1,2]

$$\frac{d\Phi_\nu}{dE_\nu} = \Phi_0 \left(\frac{E_\nu}{100\text{TeV}}\right)^{-\gamma}$$

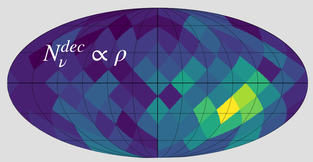
$$\gamma^{TG} = 2.28, \quad \gamma^{HESE} = 2.89$$

Motivates for a second component in the HESE data-set, possibly from DM

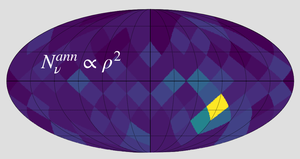
Null hypothesis (Astro)



Model (Astro + Decaying DM)

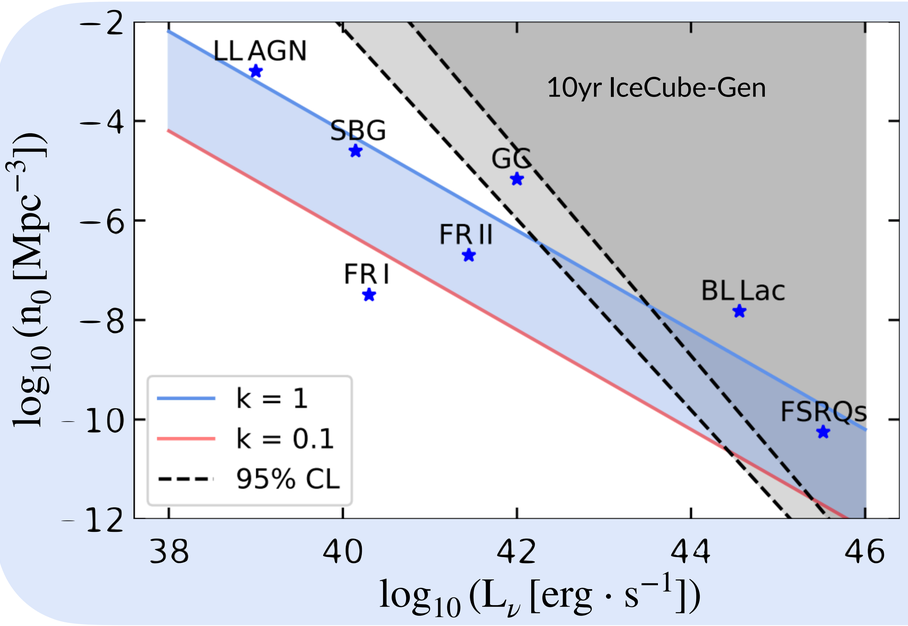


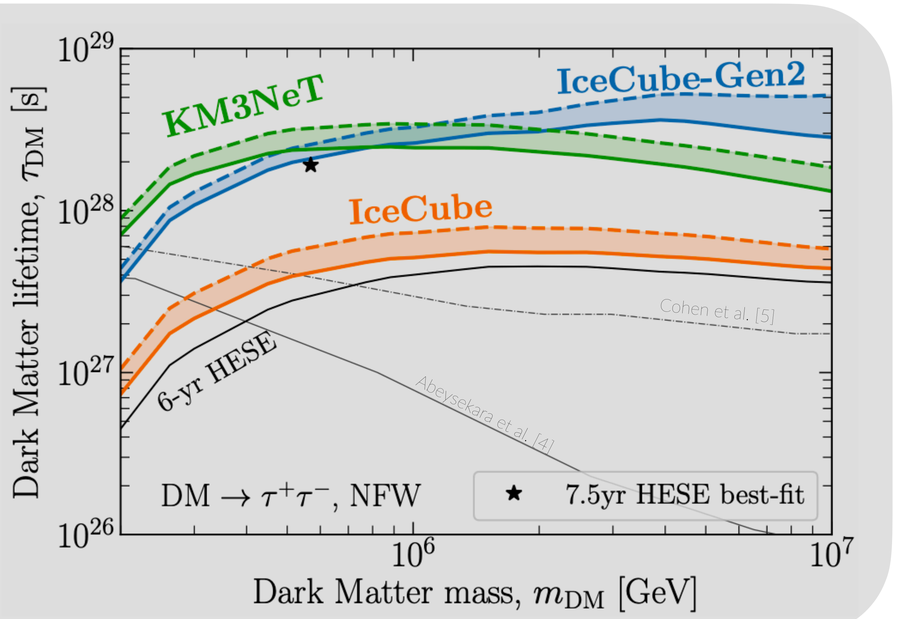
Model (Astro + Annihilating DM)



Anisotropic features
- DM from Galactic Centre

Isotropic features
- DM from EG origin
- EG astrophysical sources
- Atmospheric neutrinos





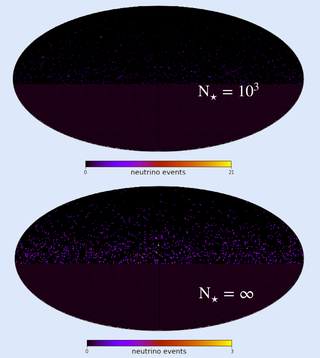
Astrophysical sources

High-energy neutrinos observed with IceCube (TG) mainly from EG astrophysical sources.

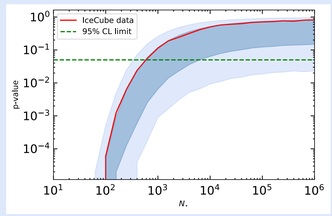
We apply statistical distribution for flux of each source:

$$\frac{dN_s}{dF} = N_\star \times \begin{cases} \frac{F}{F_\star}^{-2.5} & F_\star < F \\ \frac{F}{F^{-1.5}}^{-2.5} & F_0 < F < F_\star \end{cases}$$

Leave $N_\star \propto \frac{I_\nu}{F_\star}$ as free parameter



With current IC data (10-yr, TG) exclude $N_\star < 600$ at 95%CL



Anisotropic features
- Bright, few source populations e.g. blazars ($N_\star = 600$)

Isotropic features
- Faint, numerous source populations e.g. starburst galaxies ($N_\star = 10^7$)
- Atmospheric neutrinos