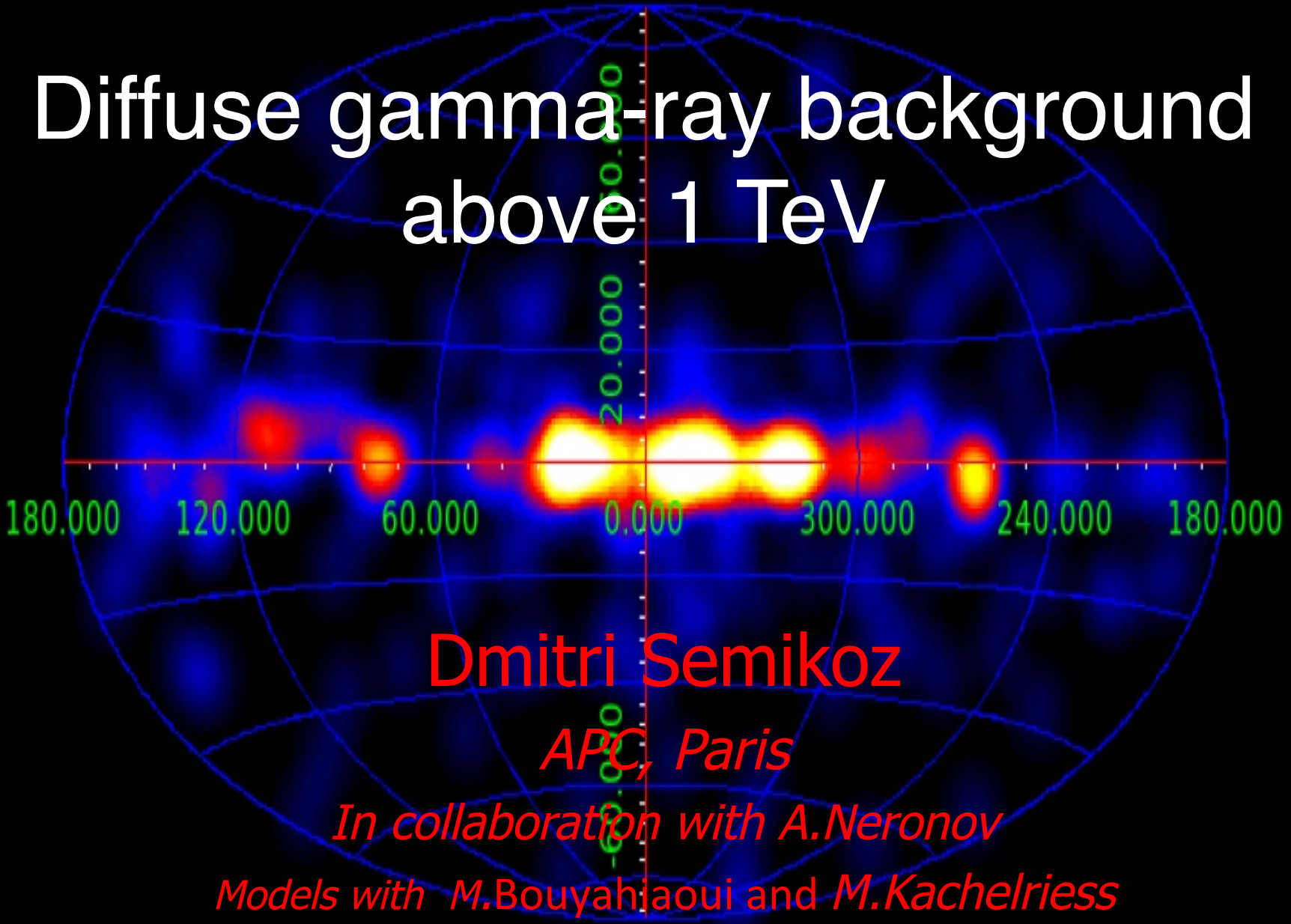
Diffuse gamma-ray background above 1 TeV



Dmitri Semikoz

APC, Paris

In collaboration with A.Neronov

*Models with M.*Bouyahiaoui and *M.Kachelriess*

Overview:

- *Introduction: astrophysical neutrinos: where are gamma-rays?*
- *Diffuse gamma-ray background in Fermi at 1 TeV*
- *Diffuse gamma-ray background measurement by Cherenkov telescopes and LHAASO*
- *Neutrinos and gamma-rays from local MW halo/Super-Heavy Dark Matter/ CR sources*
- *Conclusions*

Astrophysical neutrinos and extragalactic gamma-rays

Pion production

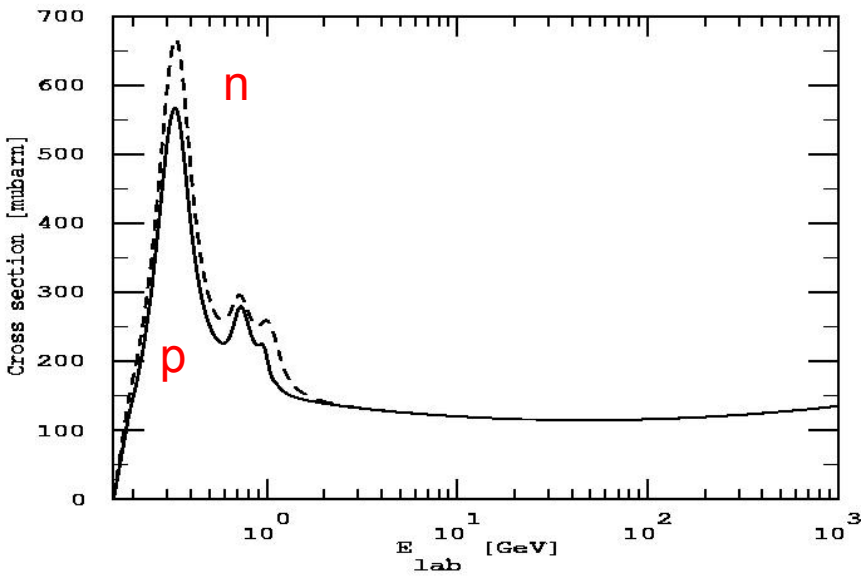
$$N + \gamma_b \Rightarrow N' + \sum \pi^i$$

$$N + A_b \Rightarrow N' + \sum \pi^i$$

$$\pi^0 \Rightarrow 2\gamma$$

$$\pi^{\pm} \Rightarrow \mu^{\pm} + \nu_{\mu}$$

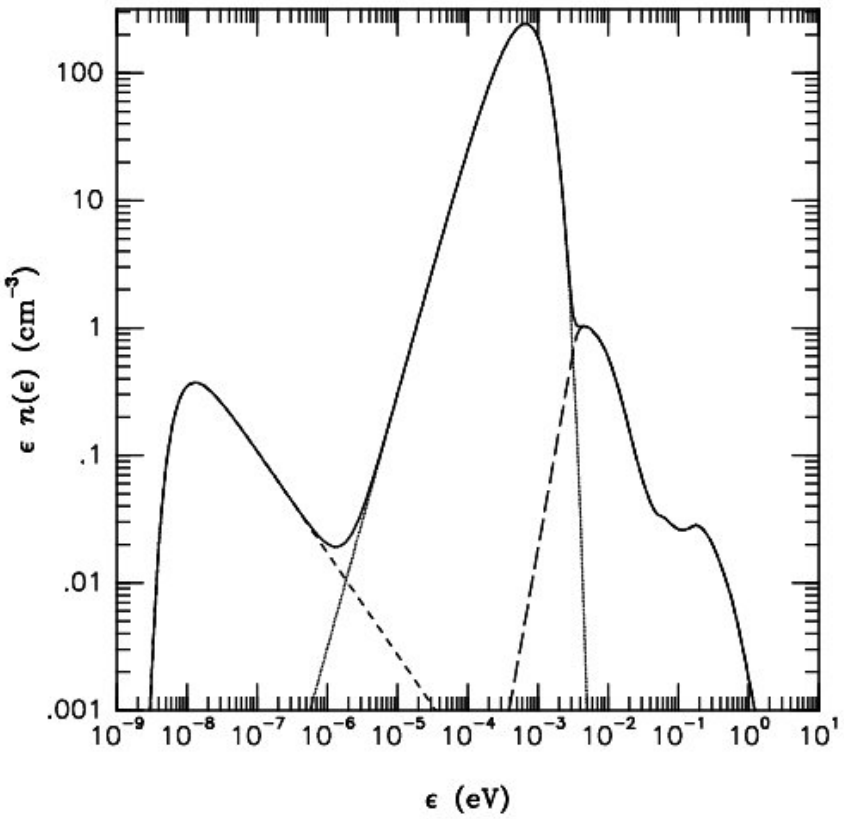
$$\mu^{\pm} \Rightarrow e^{\pm} + \bar{\nu}_e + \nu_{\mu}$$

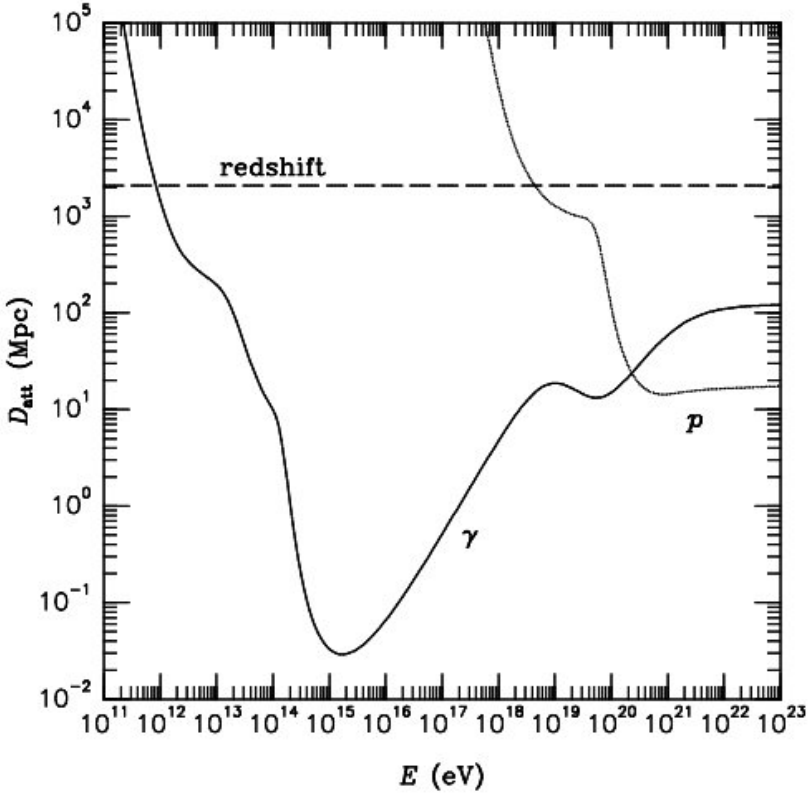


$$n \Rightarrow p + e^- + \bar{\nu}_e$$

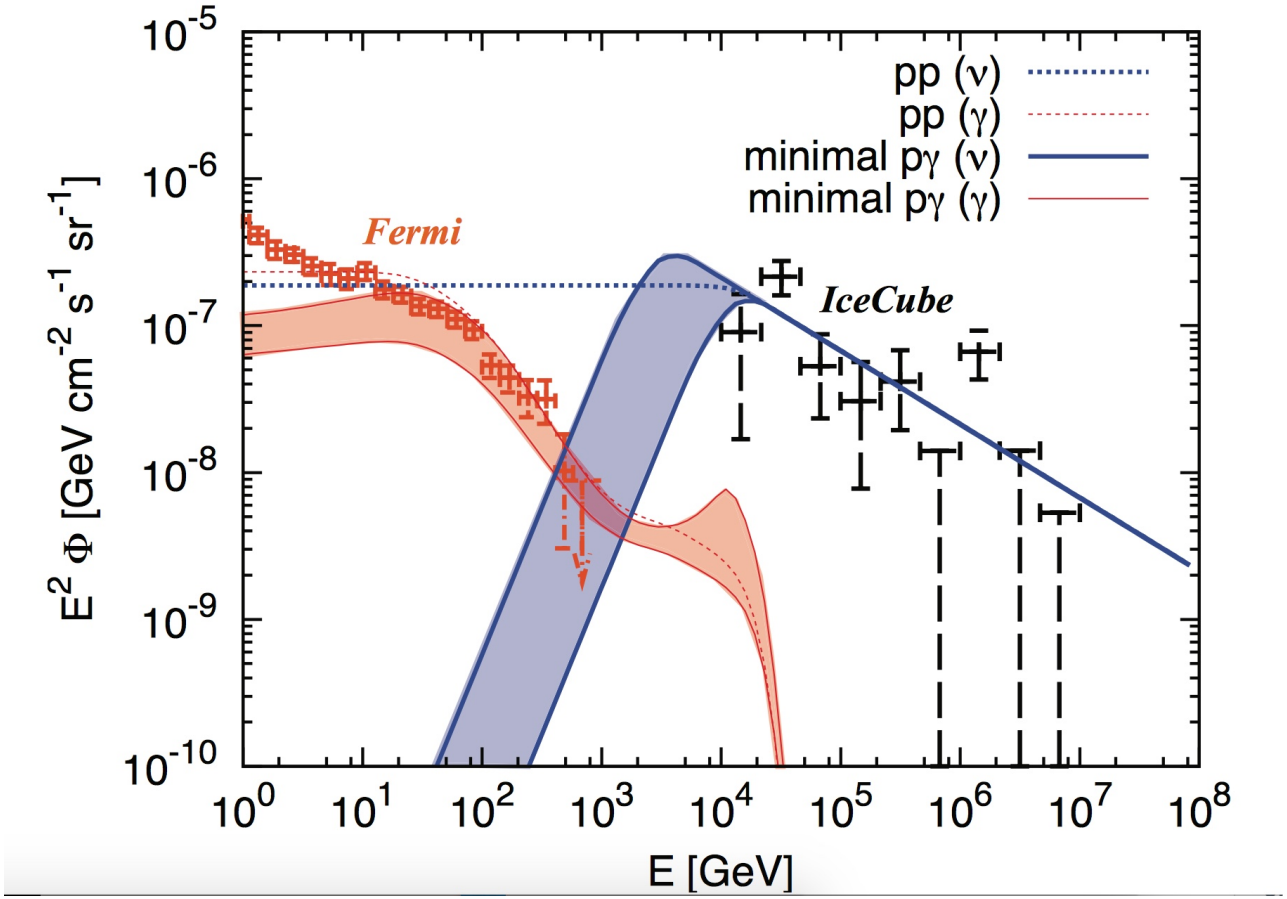
Conclusion: proton, photon and neutrino fluxes are connected in well-defined way. If we know one of them we can predict other ones: $E_{\gamma}^{tot} \sim E_{\nu}^{tot}$

Diffuse backgrounds



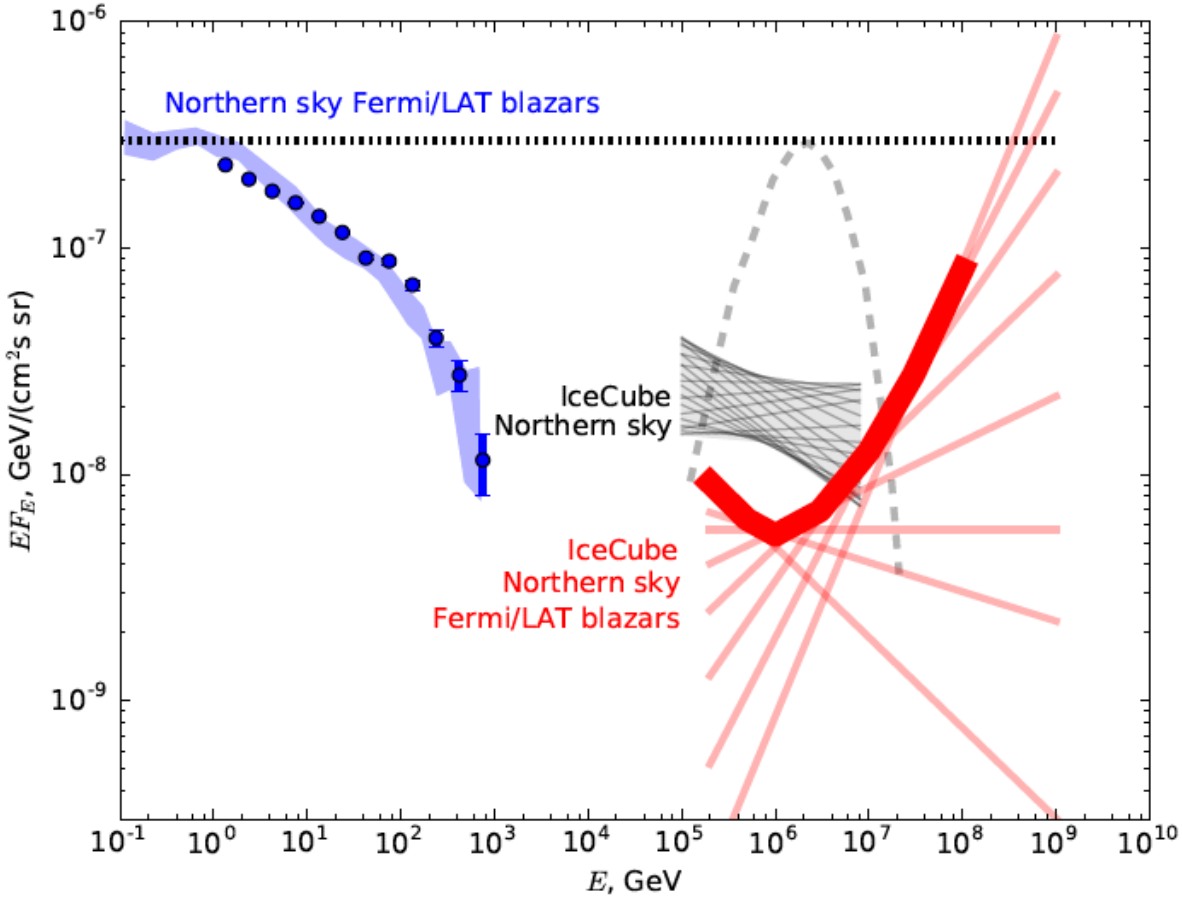


Self-consistent extragalactic



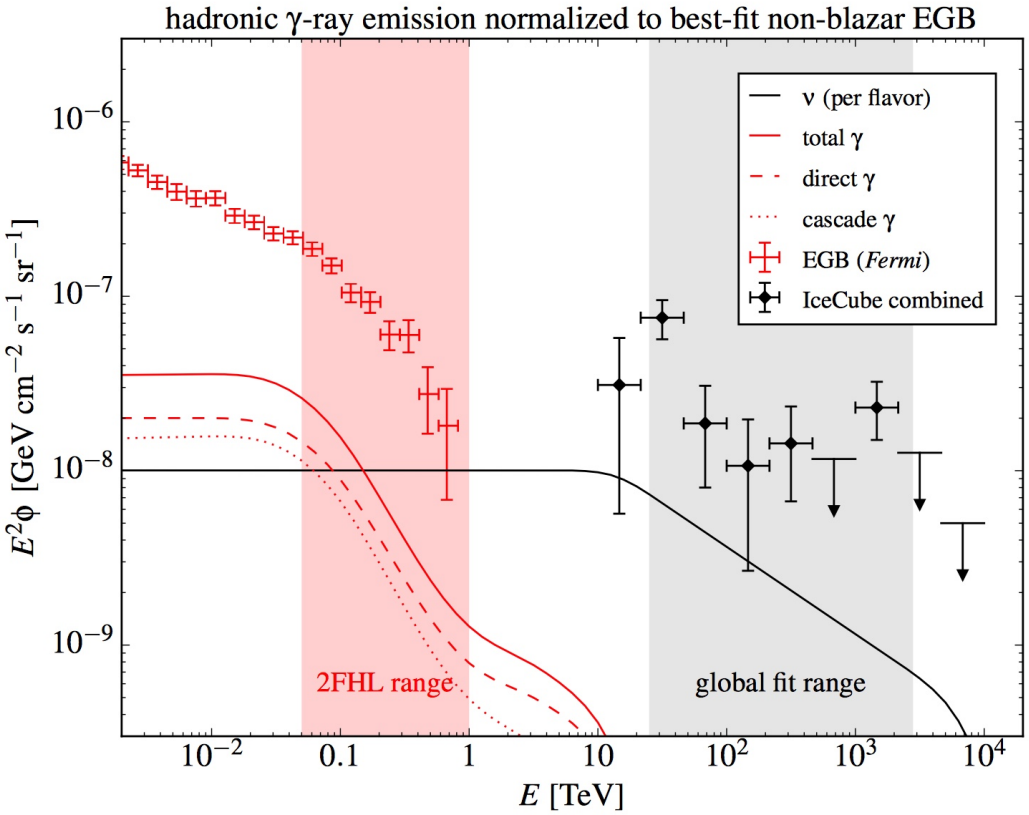
From M.Ahlers

Neutrinos not from Fermi blazars



IceCube arXiv:1611.03874

Self-consistent extragalactic sources: not BL Lacs



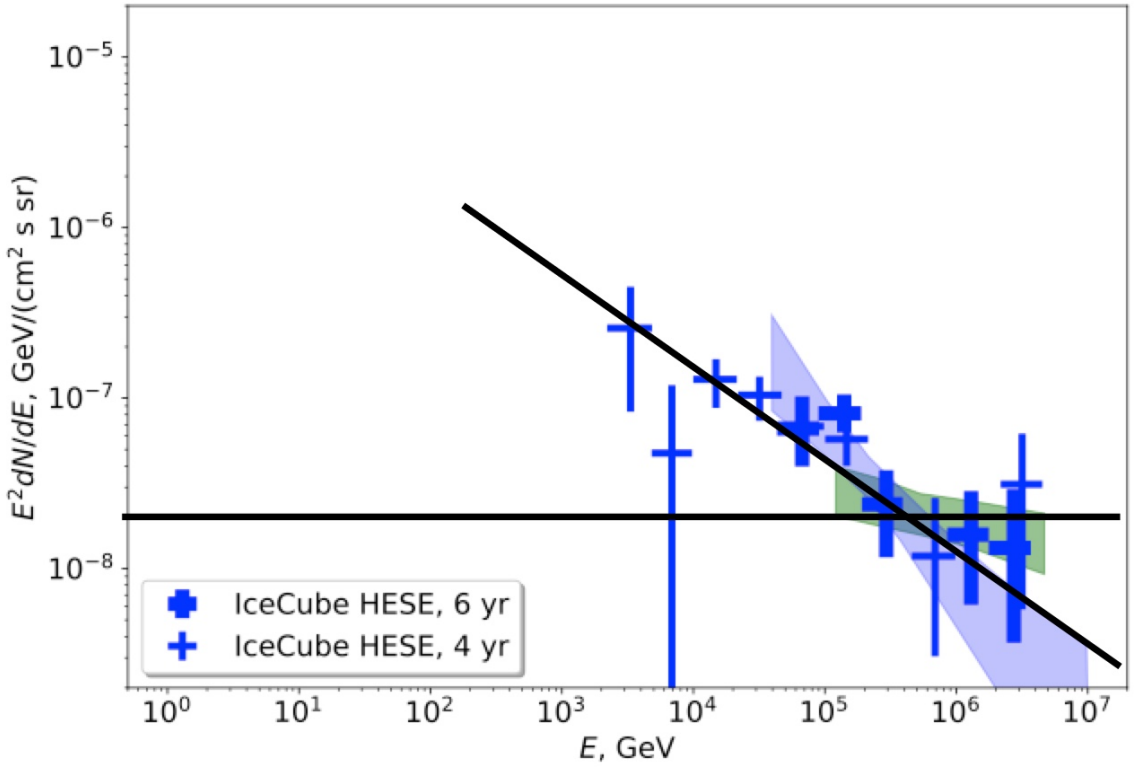
[Bechtol, MA, Ajello, Di Mauro & Vandenbroucke'15]

IceCube data: too high neutrino flux at E< 100 TeV

1) IceCube systematics

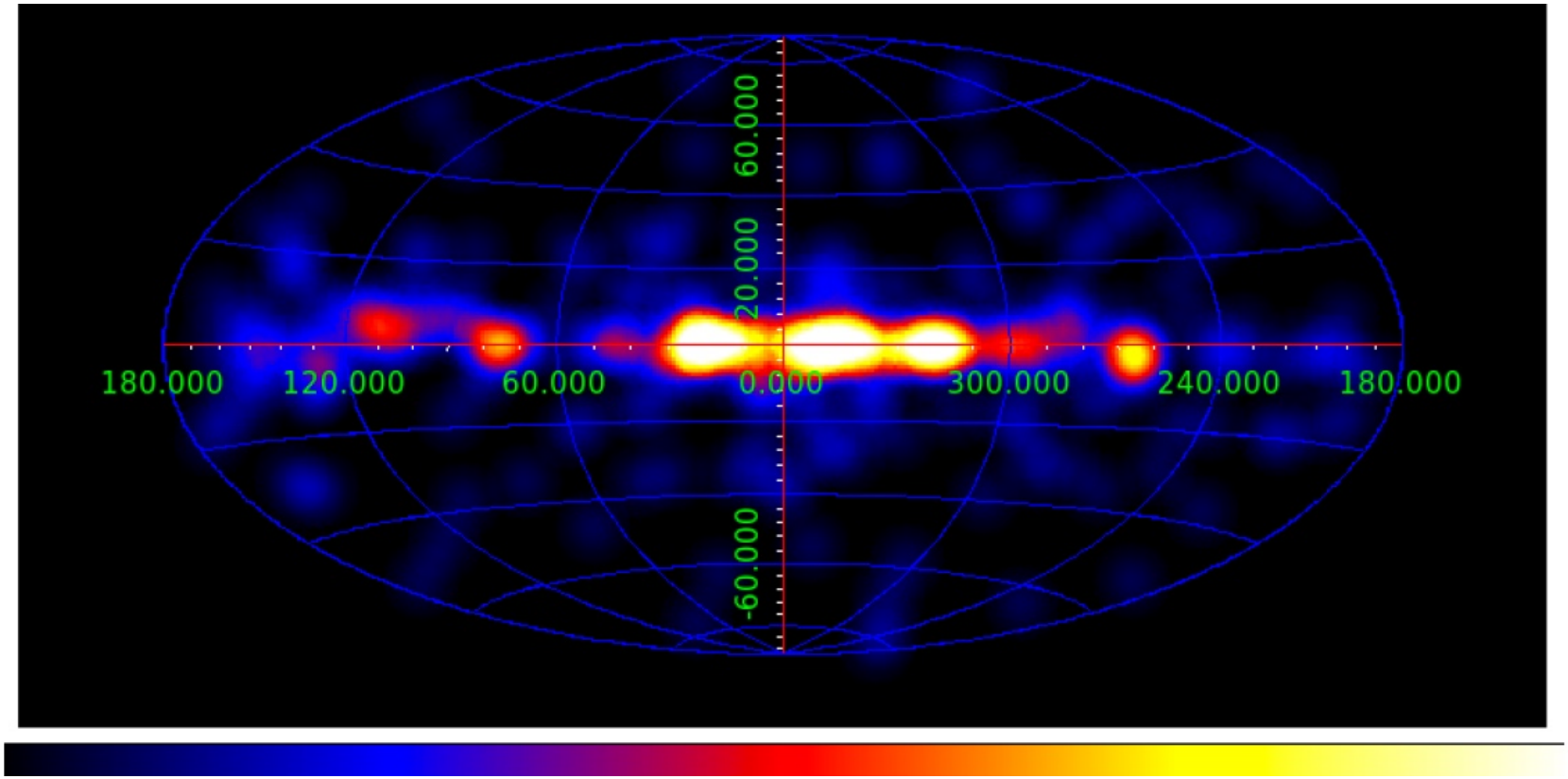
2) Galactic diffused contribution

3) Hidden sources



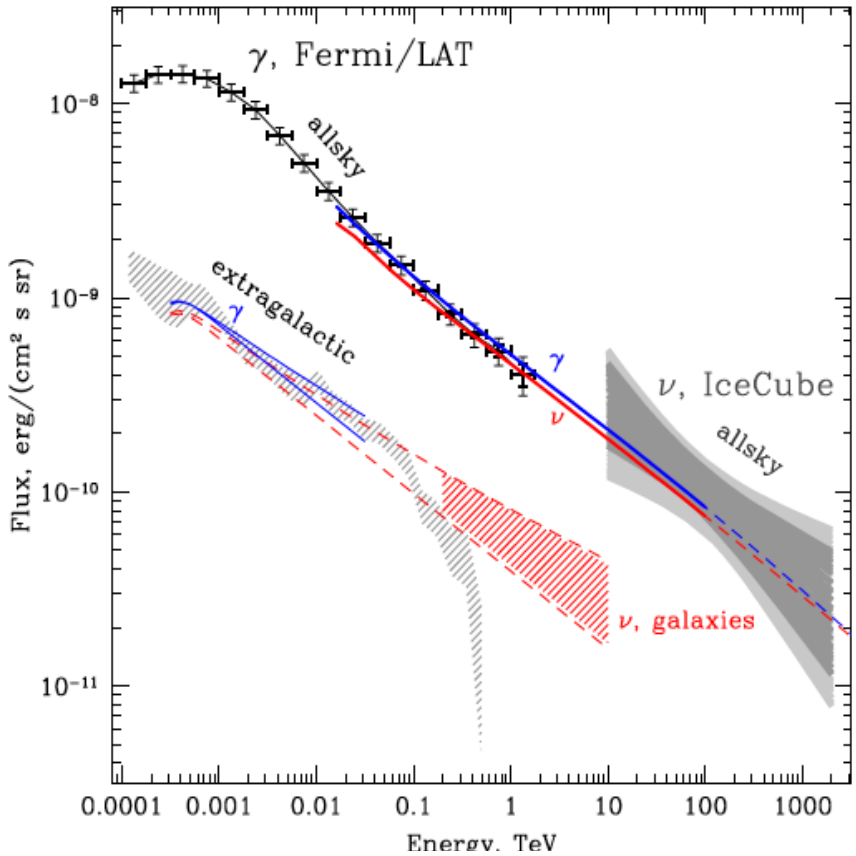
Gamma-ray sky at TeV

Sky map E> 1TeV Fermi



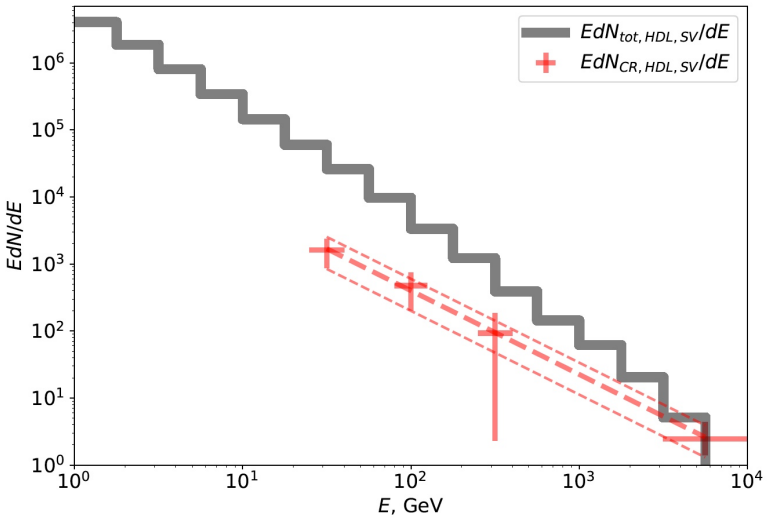
A.Neronov and D.S. , 1907.06061

IceCube + Fermi LAT all sky: protons 1/E^2.5

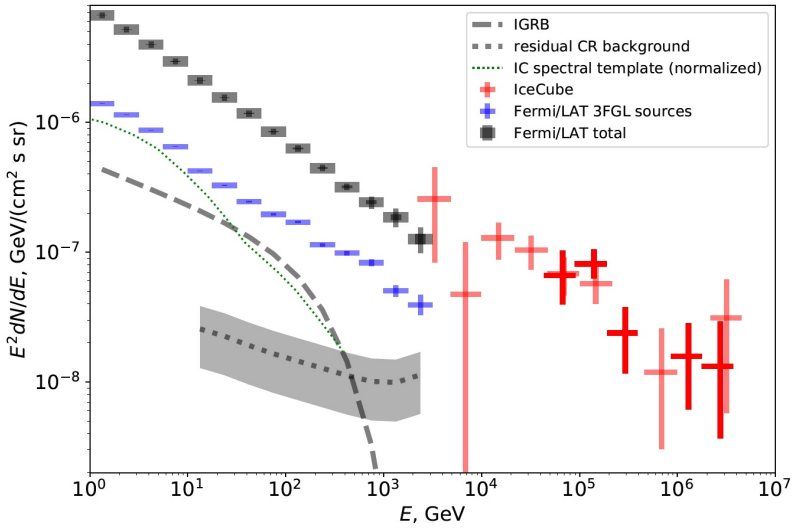


A.Neronov, D.S. arXiv:1412.1690

Fermi TeV: new pass SOURCEVETO works up to 3 TeV



Cosmic ray background,
Red points Fermi collab. Analysis
P.Bruel et al, arXiv:1810.11394



All sky signal

A.Neronov and D.S., 1907.06061

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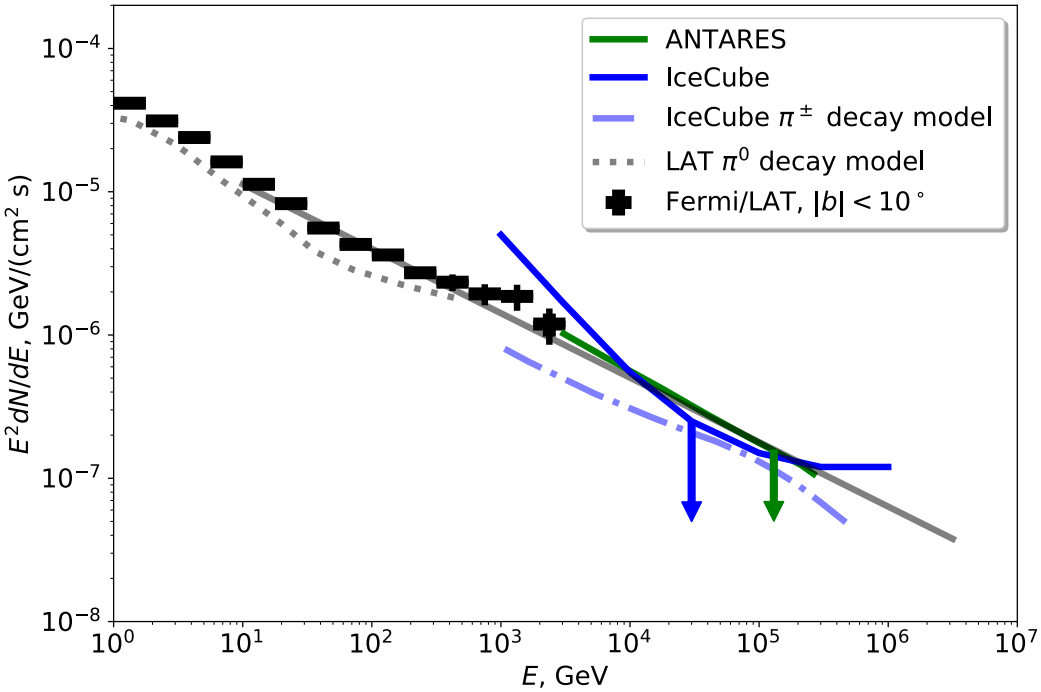
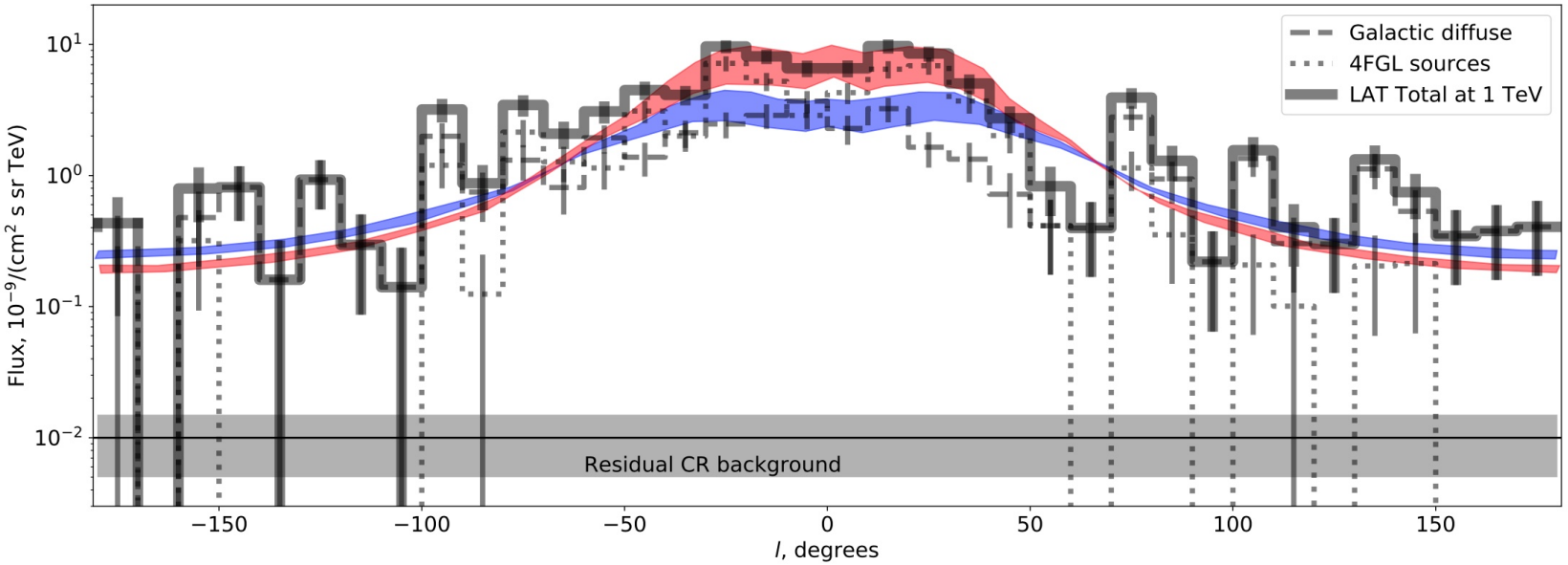
IceCube + Fermi LAT Galactic plane



A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

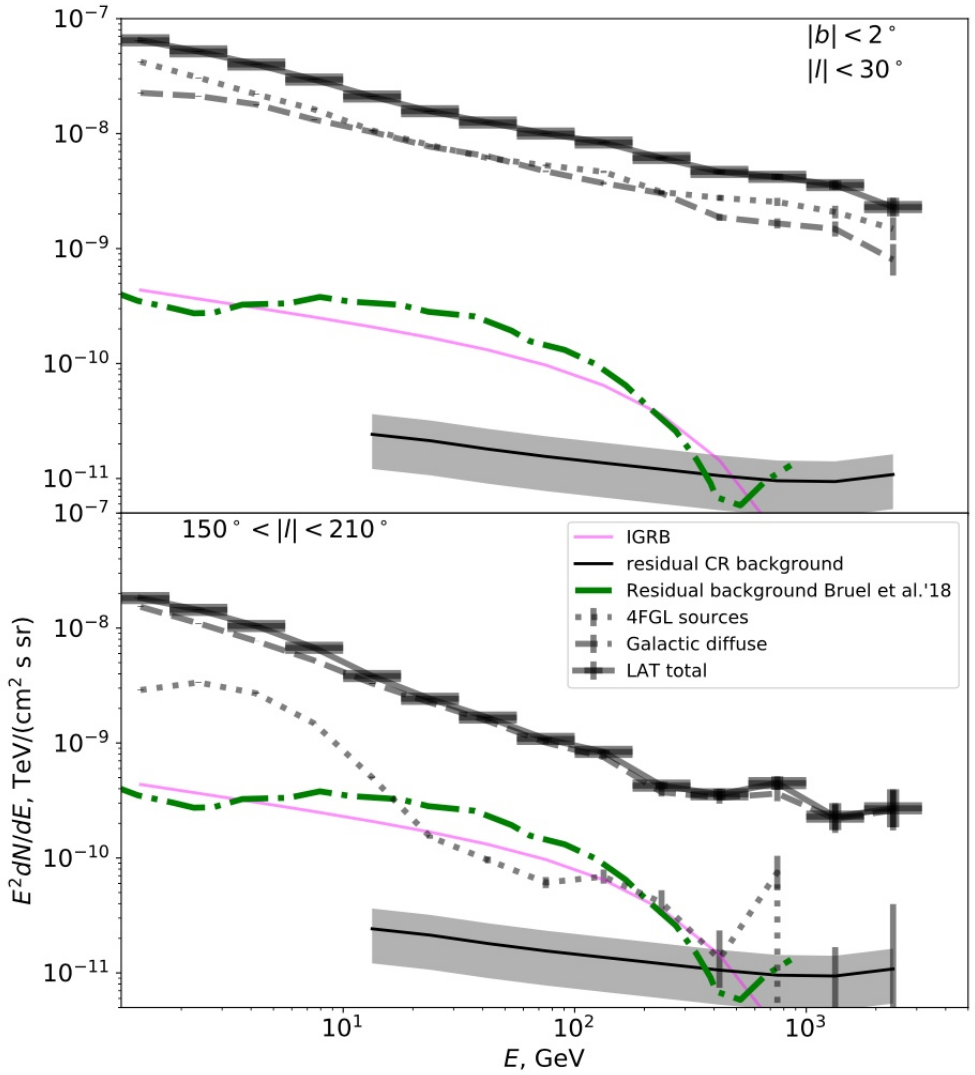
Galactic Plane |b|<2 deg, 1 TeV



Red and blue lines: model predictions from Cataldo et al , 1904.03894

A.Neronov and D.S. , 1907.06061

Galactic Plane, spectrum

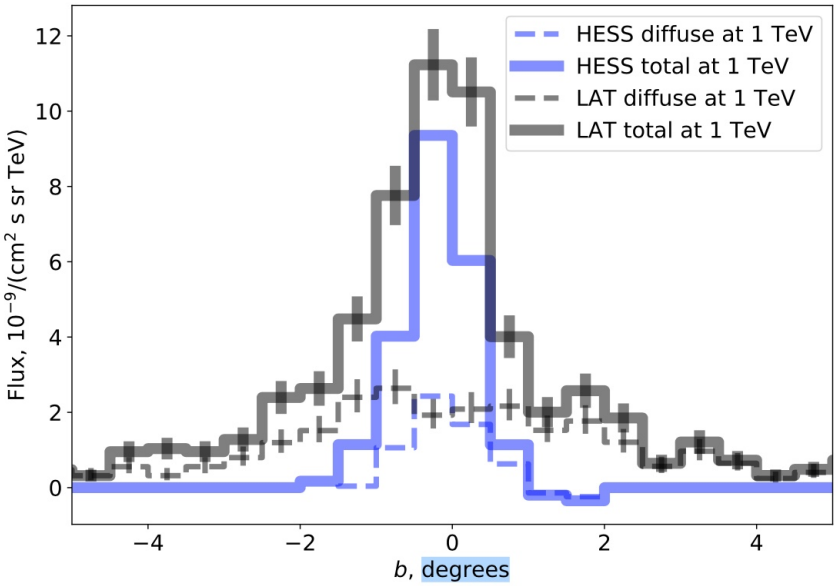


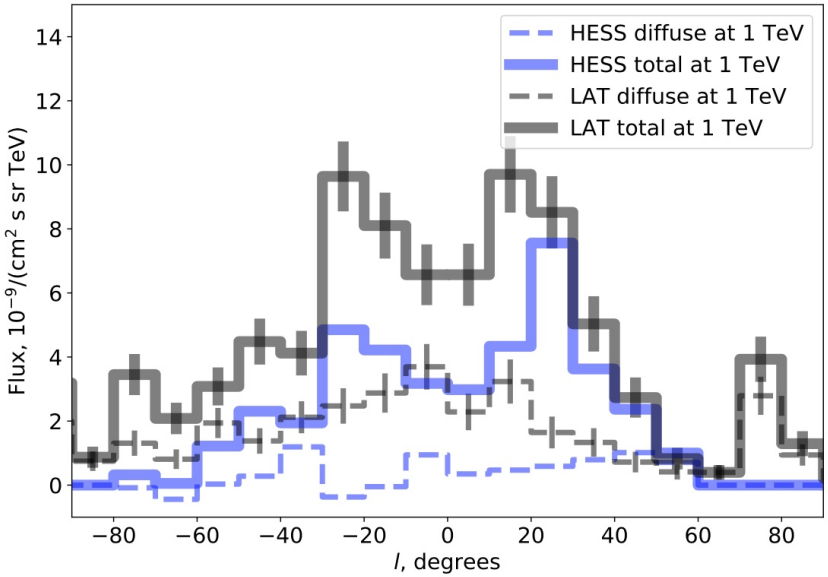
Inner galaxy 2.4

Outer Galaxy
2.7 break 200 GeV and 2.2

A.Neronov and D.S. ,
1907.06061

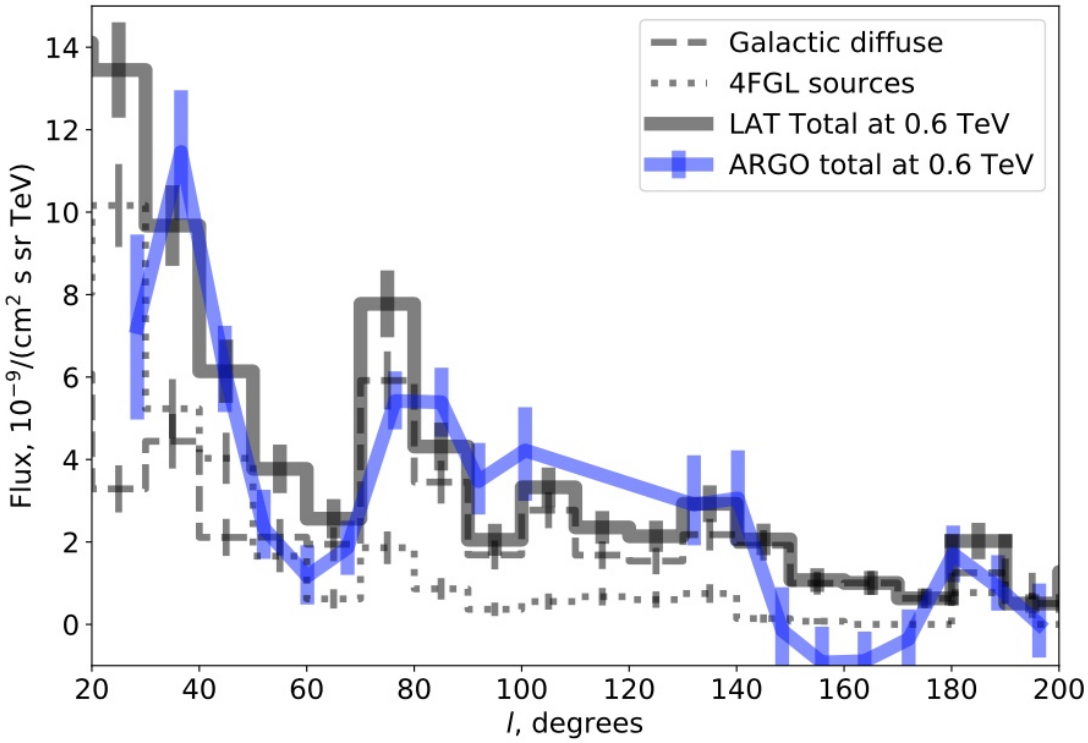
Galactic Plane, Fermi and HESS





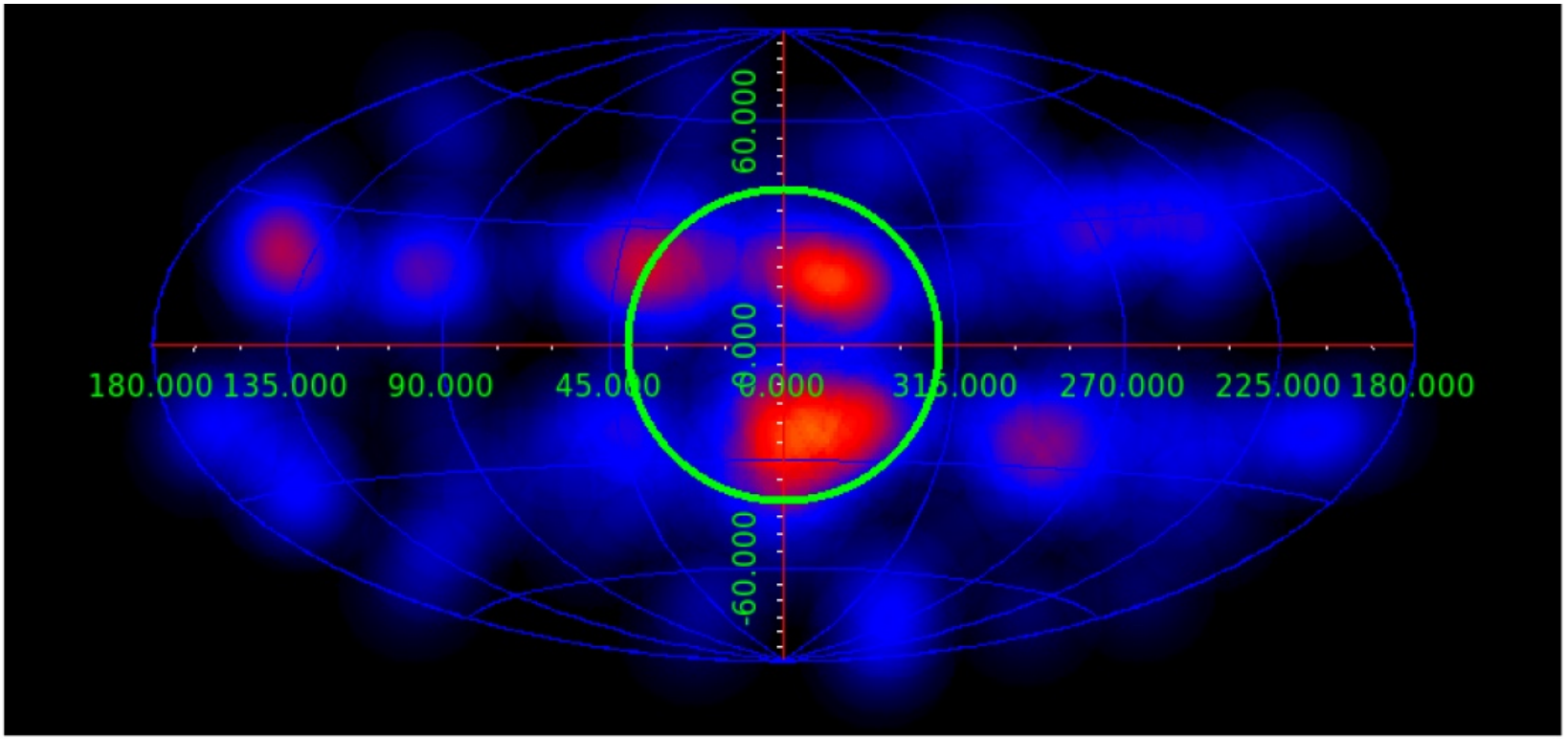
A.Neronov and D.S. , 1907.06061

Galactic Plane, Fermi and ARGO



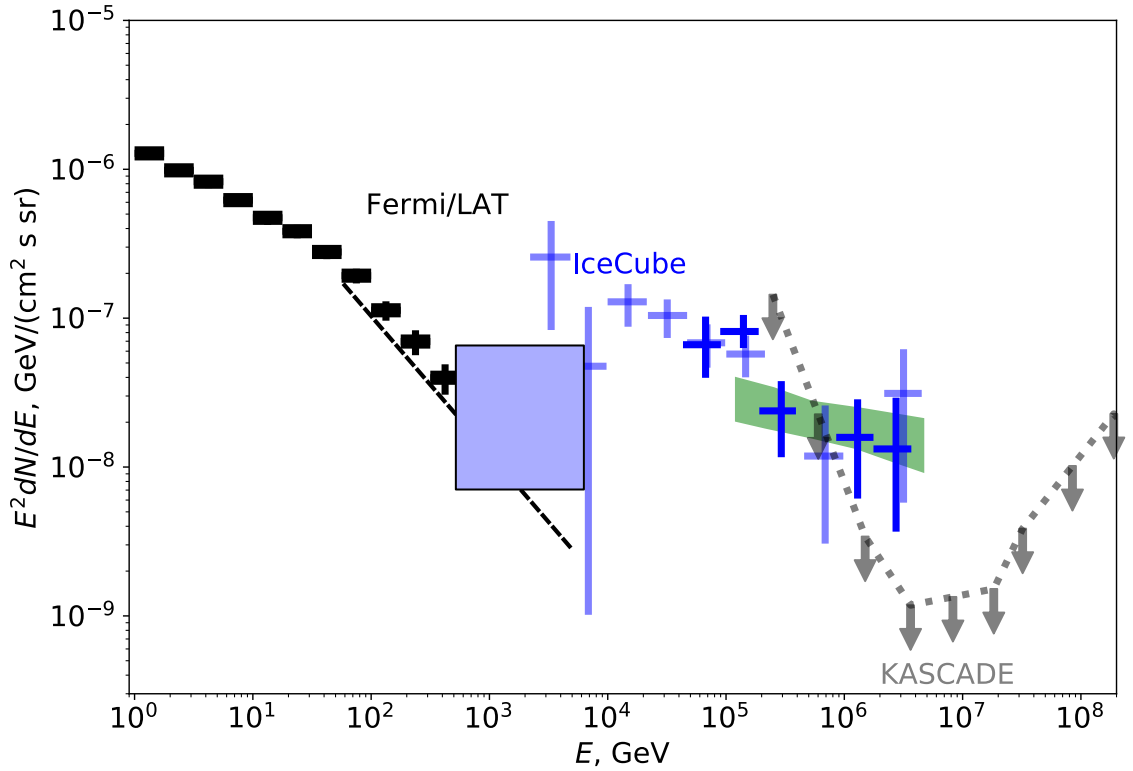
A.Neronov and D.S. , 1907.06061

Sky map E> 1TeV
no galactic plane |b|> 10 deg



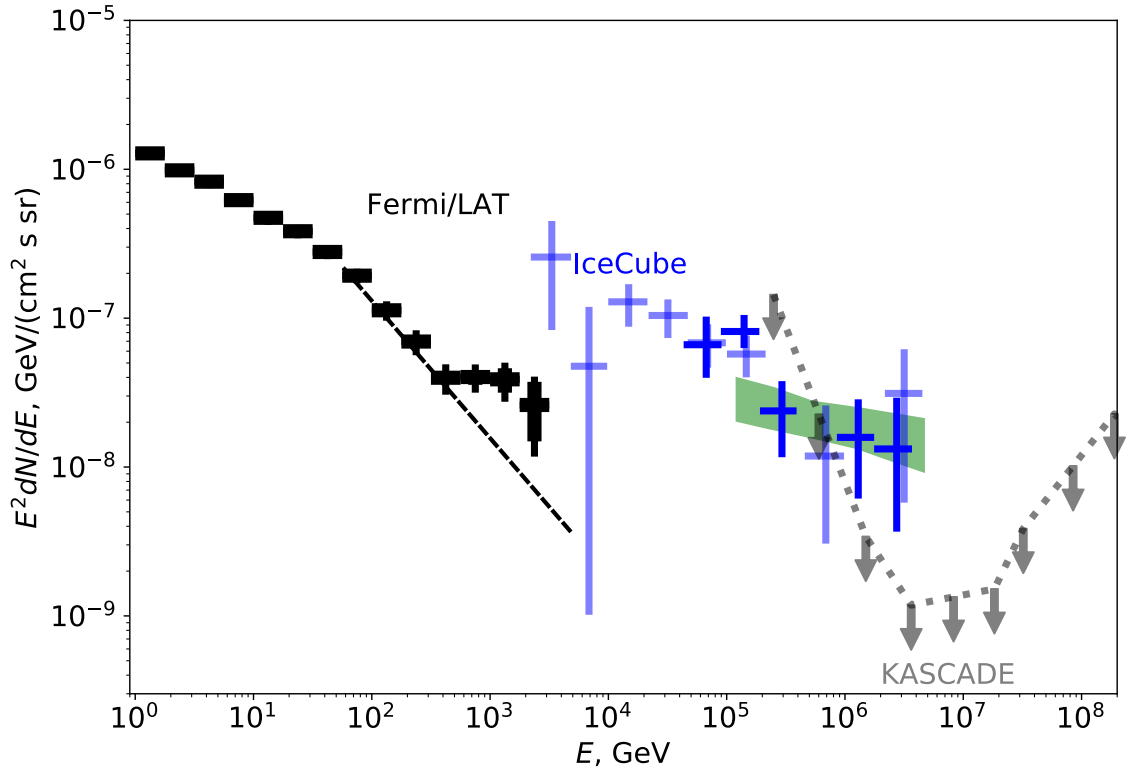
A.Neronov and D.S. , 1907.06061

IceCube + Fermi LAT high galactic latitude |b|>20 deg



A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

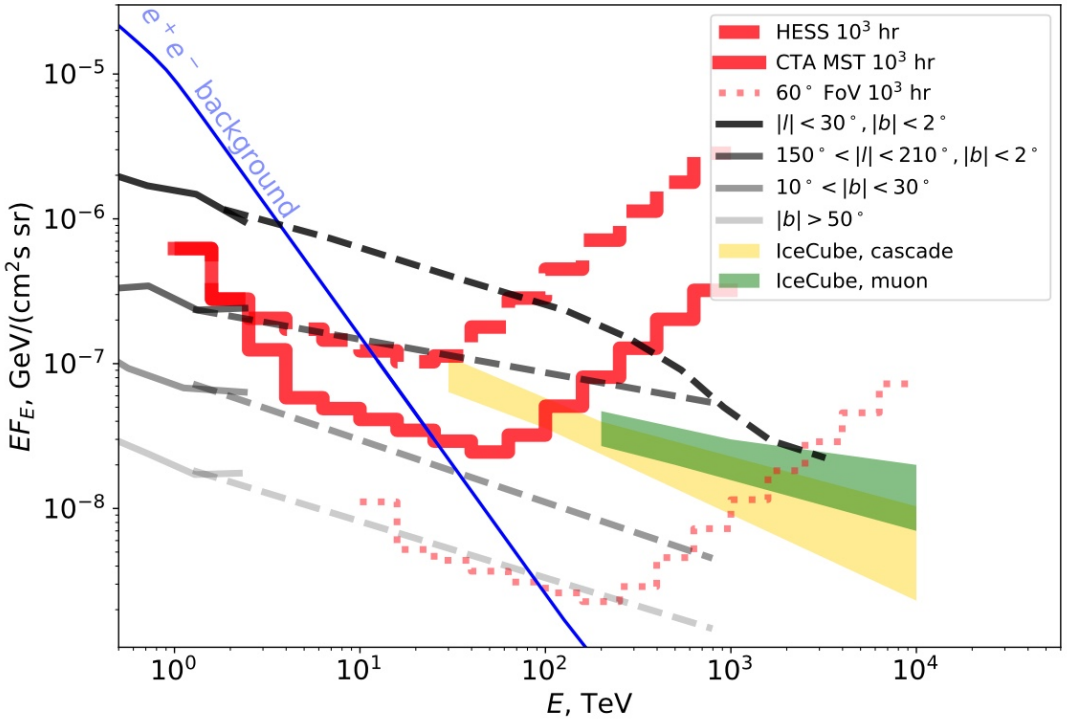
IceCube + Fermi LAT high galactic latitude |b|>20 deg



A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

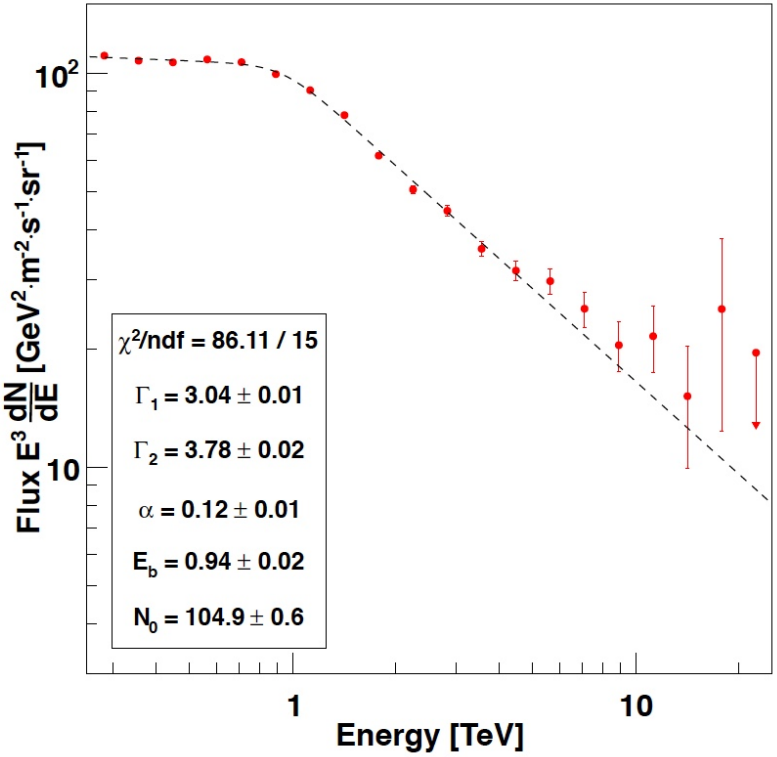
Gamma-ray sky at 10-100 TeV with Cherenkov telescopes

Galactic diffuse flux at 10-100 TeV energies with Cherenkov



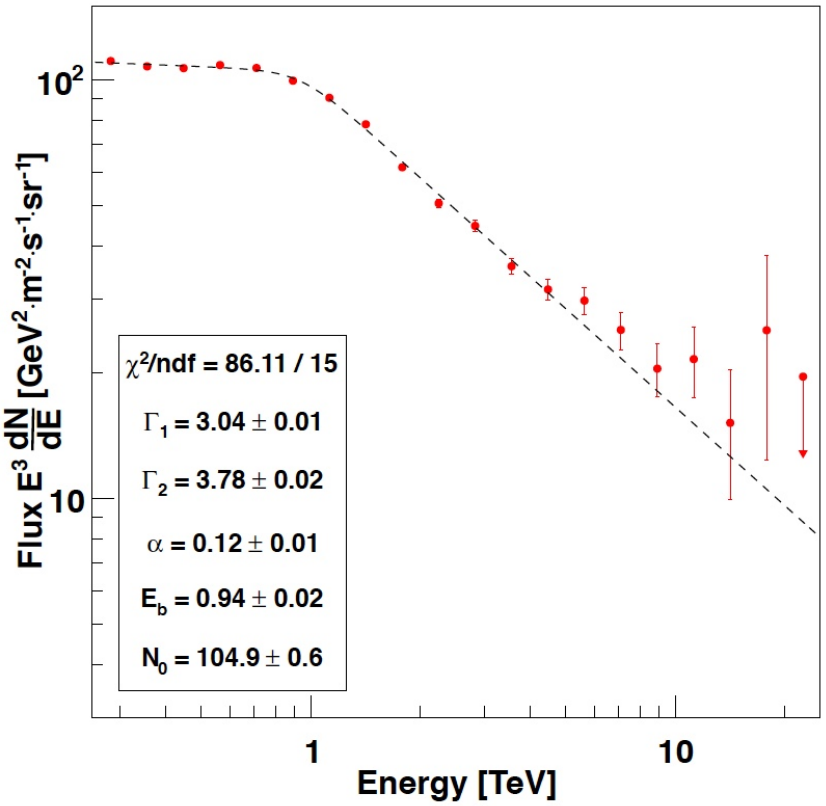
A.Neronov and D.S. , astro-ph/2001.00922

Electron + positron measurements by HESS 2004- March 2010



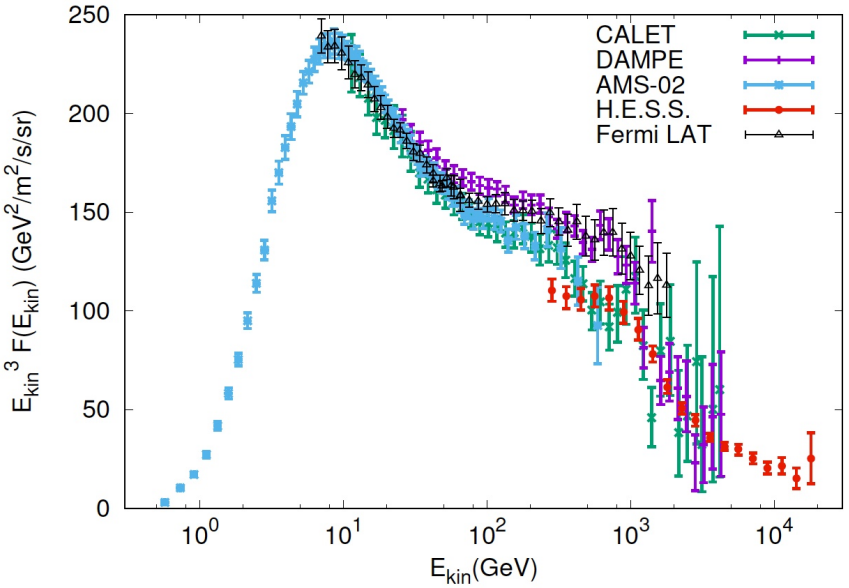
HESS collab. 2017

Electron+ positron+ diffuse gamma measurements by HESS 2004- March 2010

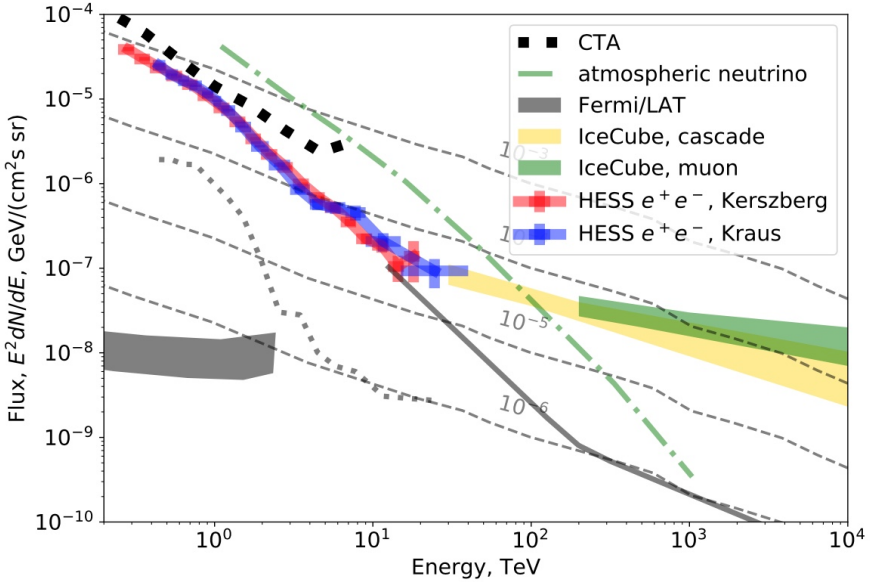


HESS collab. 2017

Electron+ positron+ diffuse gamma measurements by HESS 2004- March 2010

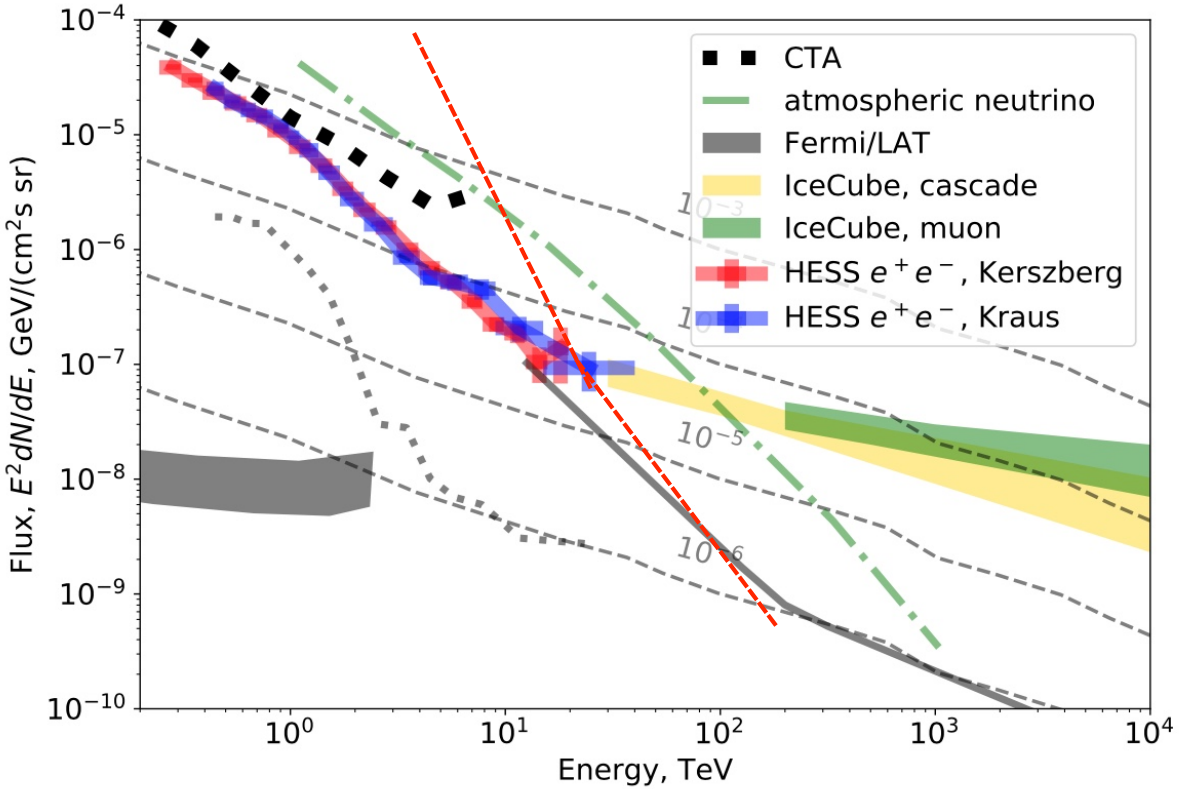


M.Kachelriess and D.S.,
Cosmic ray models,
review astro-ph/1904.08160



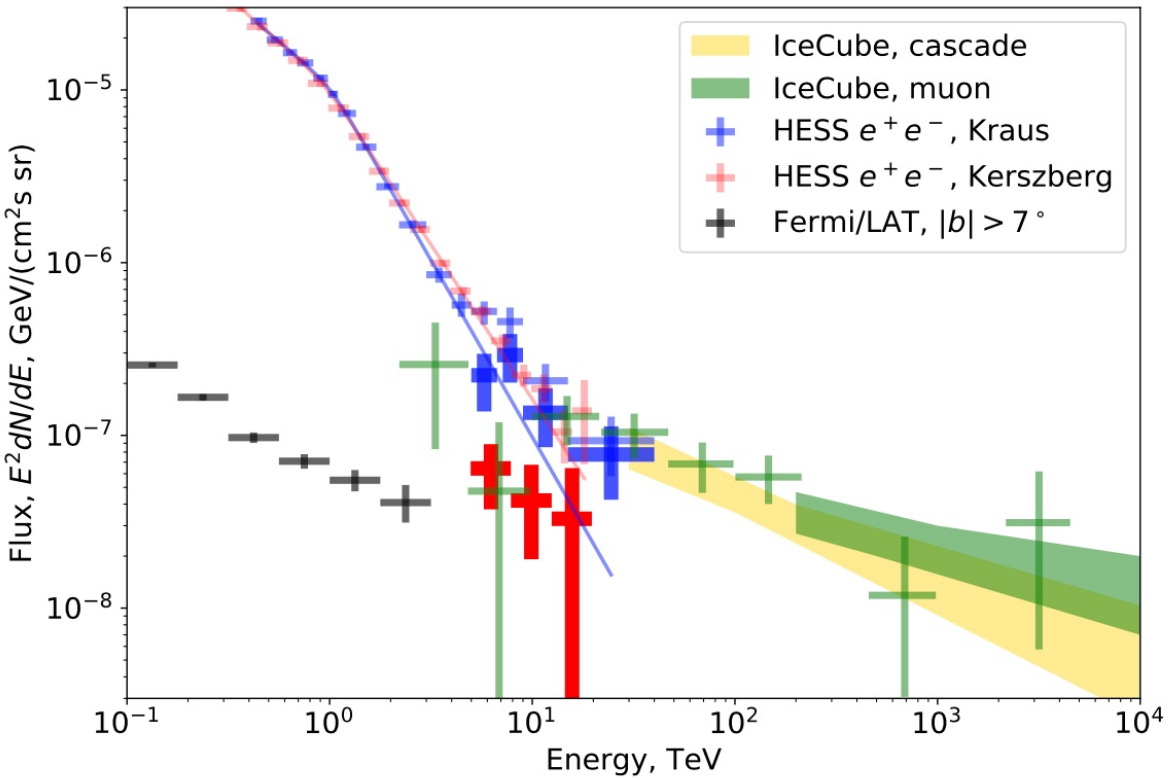
A.Neronov and D.S. ,
astro-ph/2001.00922

LHAASO sensitivity from 1905.02773



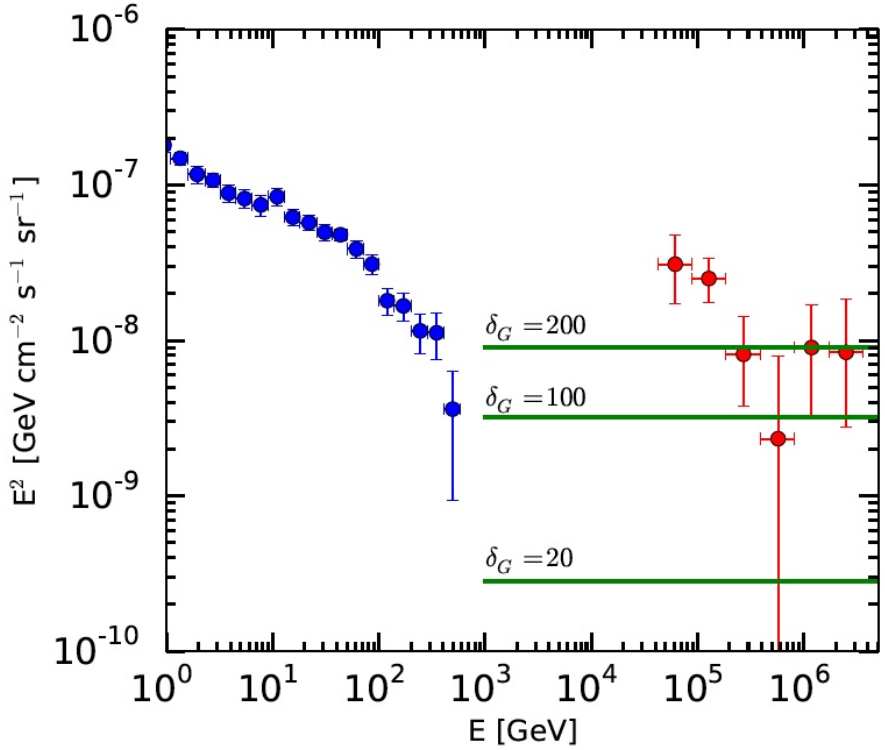
A.Neronov and D.S. , astro-ph/2001.00922

New component in HESS data



A.Neronov and D.S. , astro-ph/2001.00922

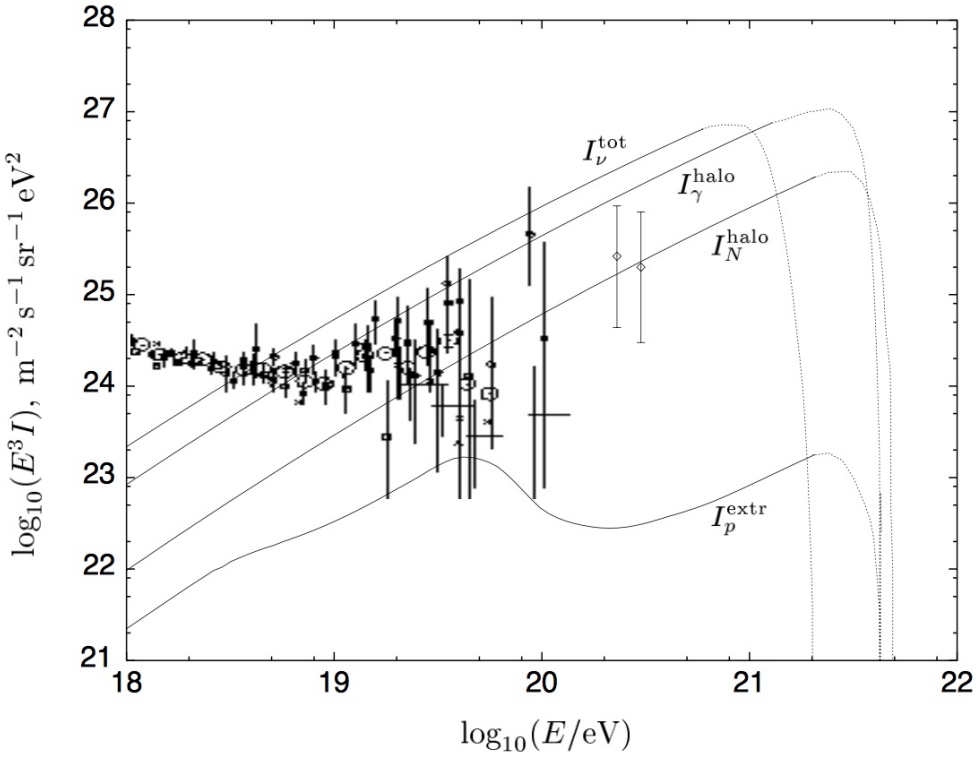
Neutrinos from Galactic Halo CR



A.Taylor, S.Gabici and F.Aharonian, 1403.3206
P.Blasi and E.Amato , 1901. 03609

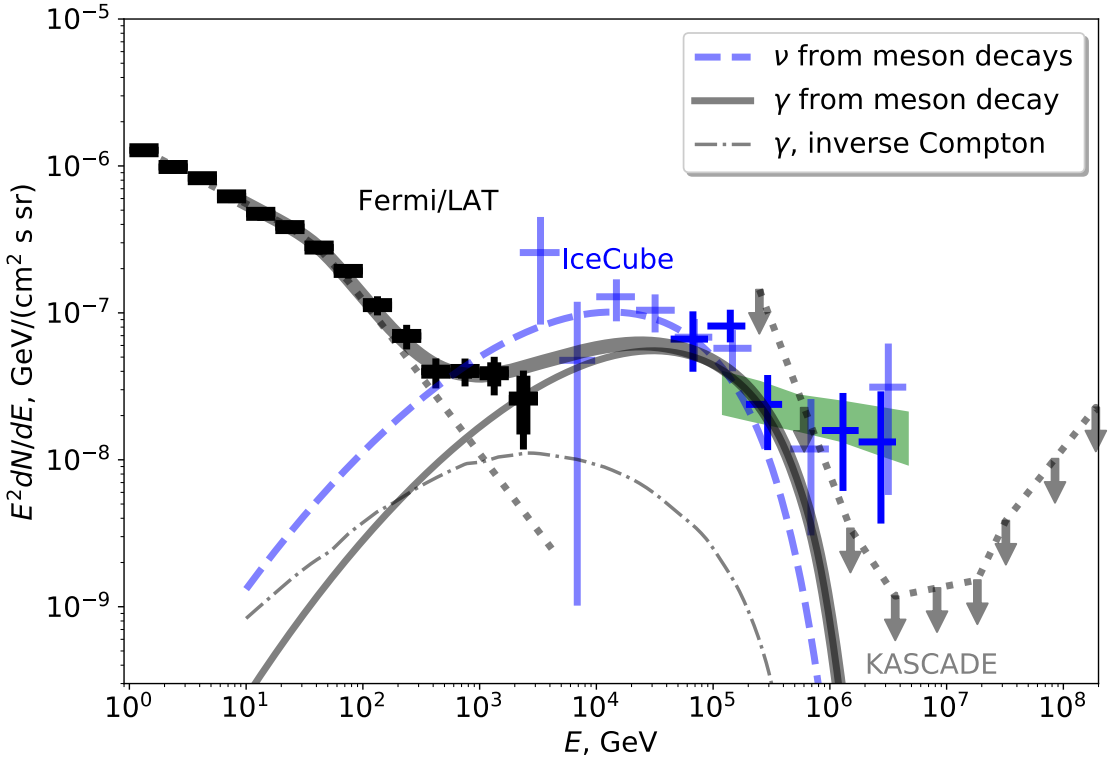
Super-Heavy Dark Matter

For SHDM galactic flux dominates in neutrinos and gamma-rays



V.Berezinsky, M.Kachelriess and A.Vilenkin, 1997

IceCube + Fermi LAT
Dark Matter m=5 PeV



A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

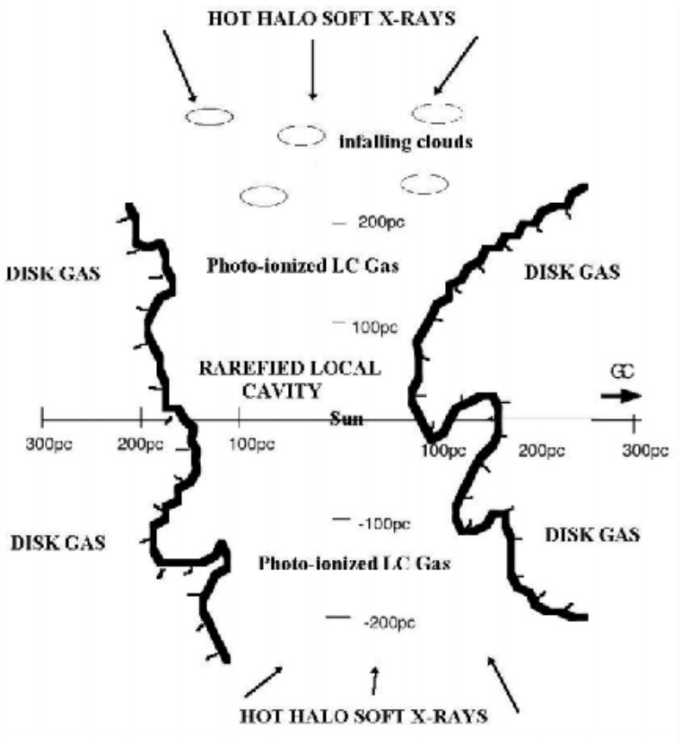
Galactic CR interaction with Local bubble

Model of propagation (Motivations for Local MF)

The immediate Galactic vicinity of the Sun is dominated by a low density, ionized structure, commonly referred to as the "Local Bubble". It is bounded by relatively higher density material as traced by Sodium and Calcium absorption line measurements, as well as extinction data (Lallement et al. 2003; Welsh et al. 2010; Lallement et al. 2014). Such measurements show a roughly cylindrical structure with a typical radius of about 100-175 pc, with missing ends towards the north and south Galactic poles. This structure is generally interpreted as being due to strong stellar winds and supernovae evacuating the space, with "blow-outs" in the directions out of the Galactic plane (Lallement et al. 2003).

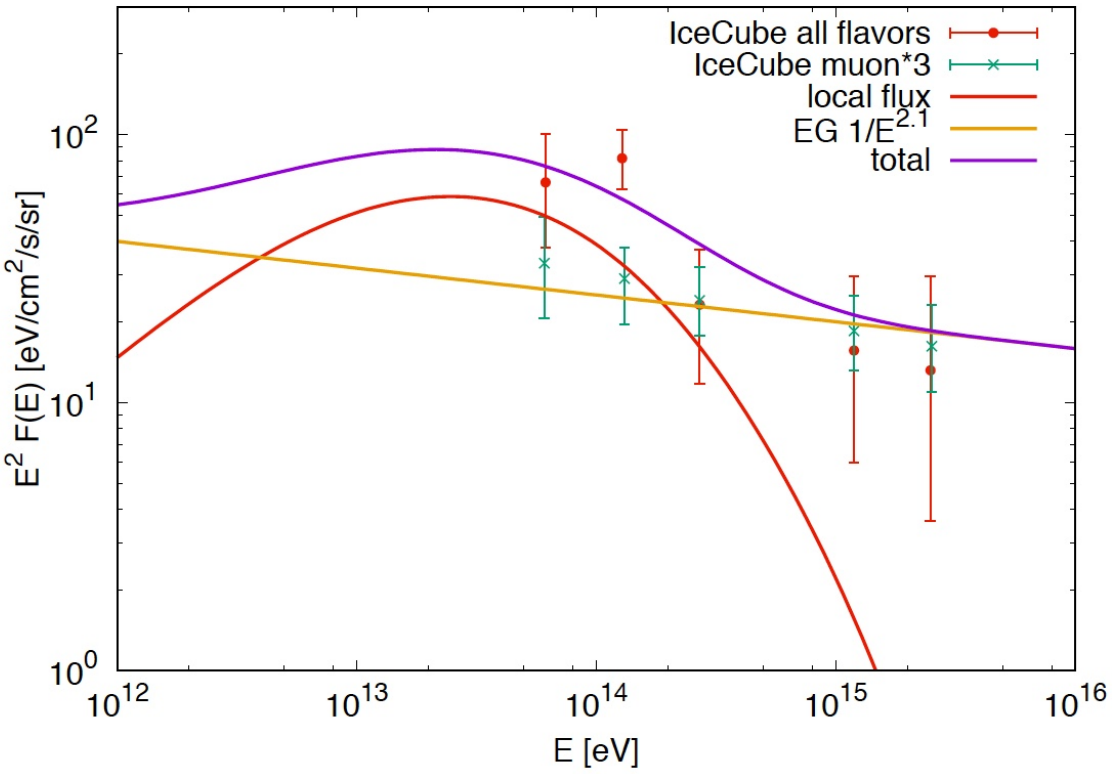
analysis from Lehner et al. (2003) to estimate the gas pressure, density and turbulence, they derived a magnetic field strength of $B_\perp = 8^{+5}_{-3}\mu$G, equivalent to a magnetic pressure of $P_B/k \approx 18,000$ K cm^{-3}, consistent with the results from the X-ray and the EUV observations.

Ilija Medan & Anderson 2019
arXiv 1901.07692



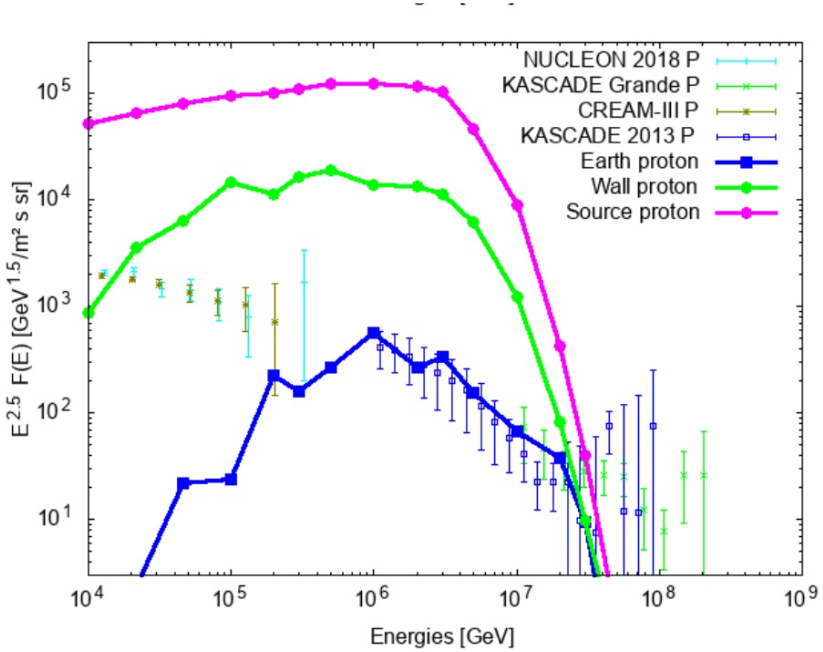
Welsh & Shelton 2009 arXiv
0906.2827

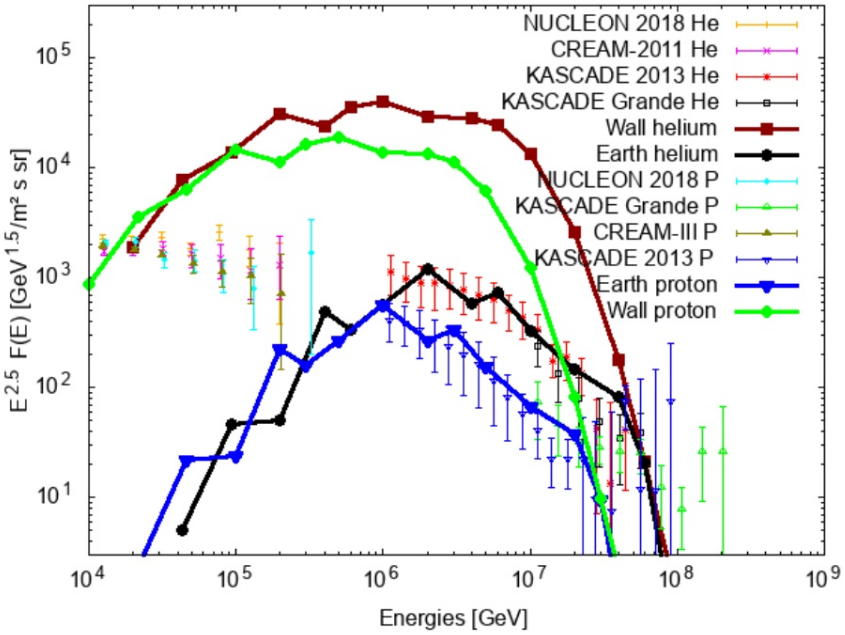
Local bubble neutrino flux



K.Andersen, M.Kachelriess and D.S., arXiv:1712.03153

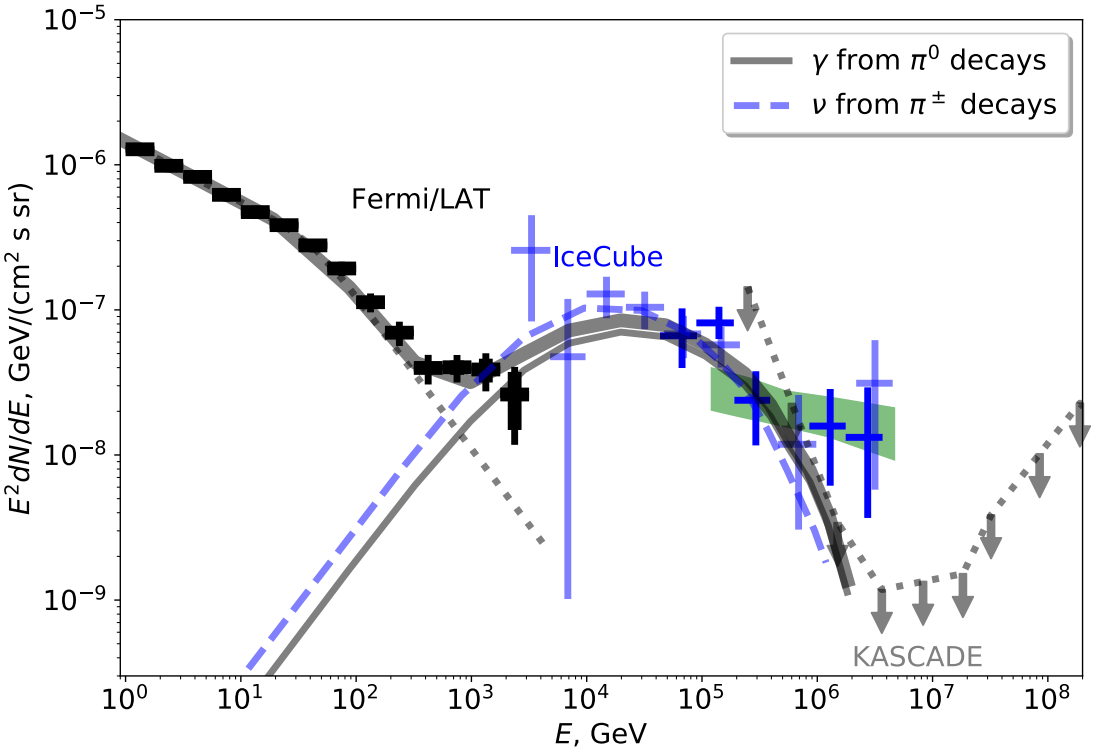
Spectrum in presence of Local bubble





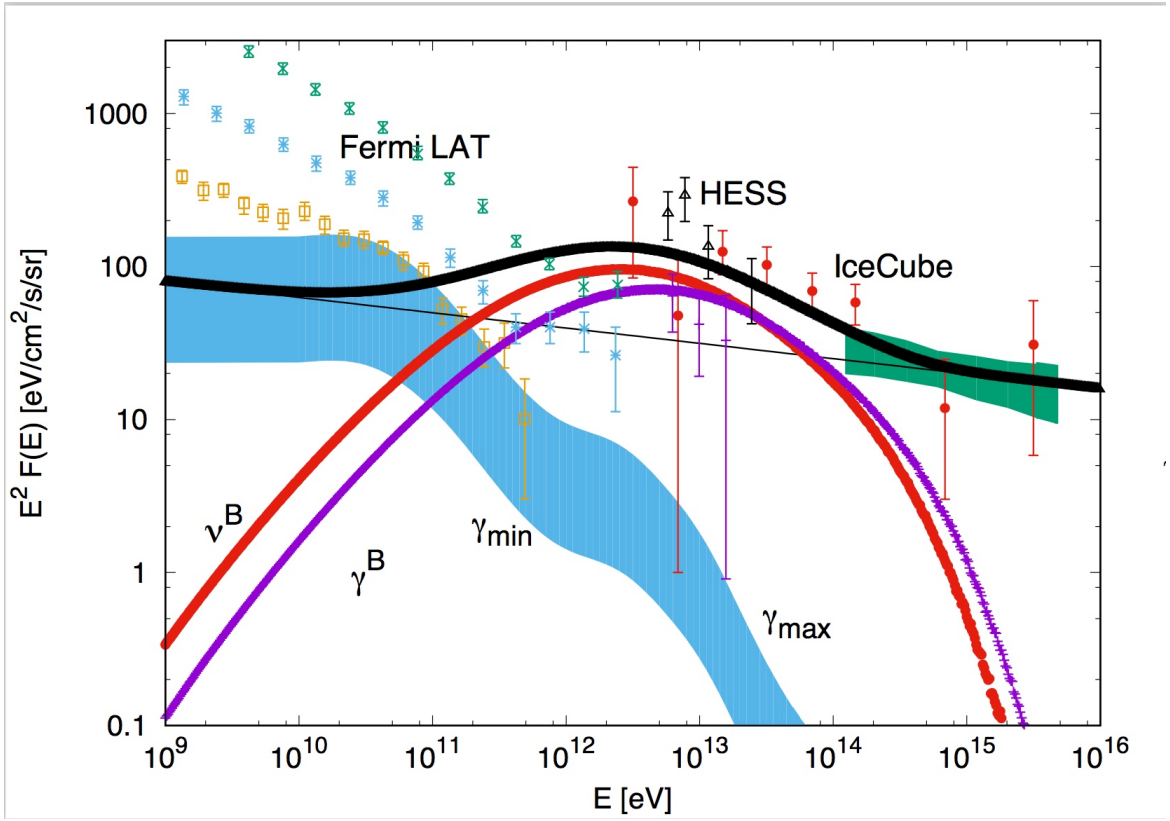
M.Bouyahiaoui, M.Kachelriess and D.S., arXiv:1812.03522, 2001.00768

IceCube + Fermi LAT : local source



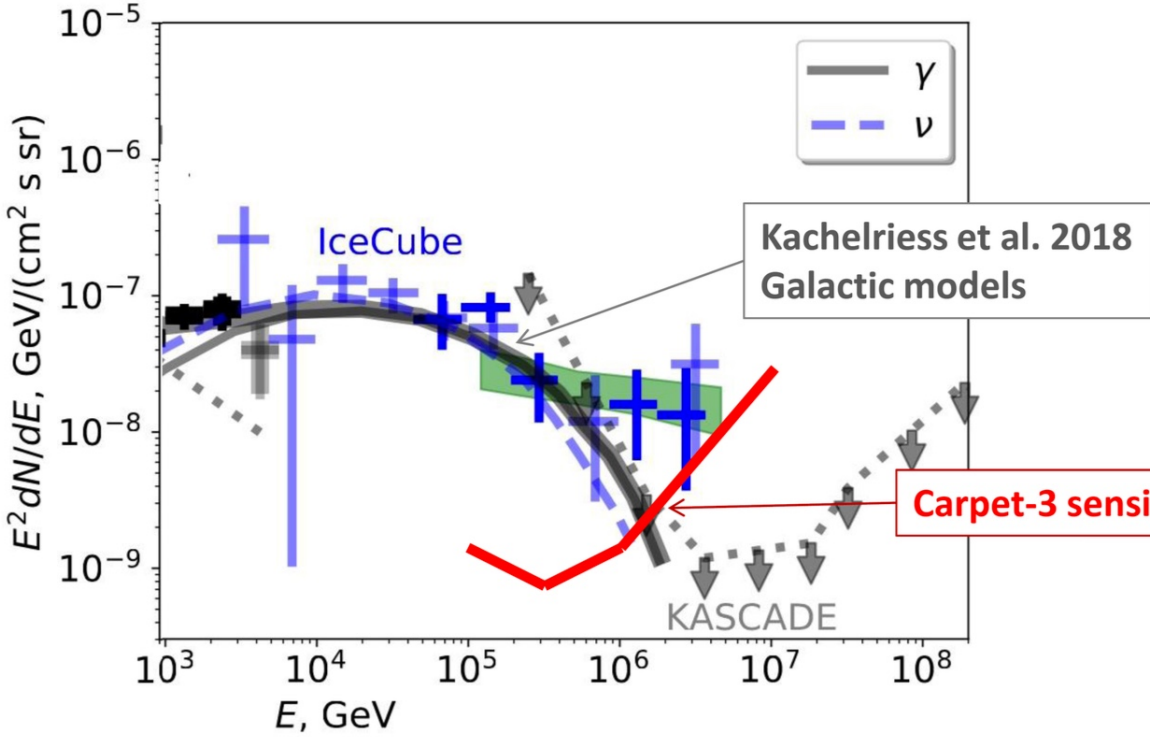
A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

IceCube + Fermi LAT+HESS : local source



M.Bouyahiaoui, M.Kachelriess and D.S. , arXiv:2001.00768

Carpet-3 can check it in gamma-rays



D. D. Dzhappuev et al, arXiv:1812.02663

Summary

- *Extragalactic sources can not explain too high astrophysical neutrino flux at E< 100 TeV*
- *Fermi flux in galactic plane at 1 TeV can be used as template for galactic plane scans*
- *Fermi flux outside of galactic plane has new Galactic component in multi-TeV energy range*
- *Electron measurements by Cherenkov telescopes are sensitive to diffuse gamma-ray flux at E> 10 TeV. HESS probably start to see new component above 10 TeV.*

SUMMARY

- *Astrophysical model: local source CR interactions with Local Bubble*
- *Alternatively: halo of cosmic rays or Dark Matter with 5 PeV mass*
- *Alternatively: large scale halo of Milky Way*
- *One need to study LHAASO possibilities to detect diffuse gamma-ray flux above 30 TeV*