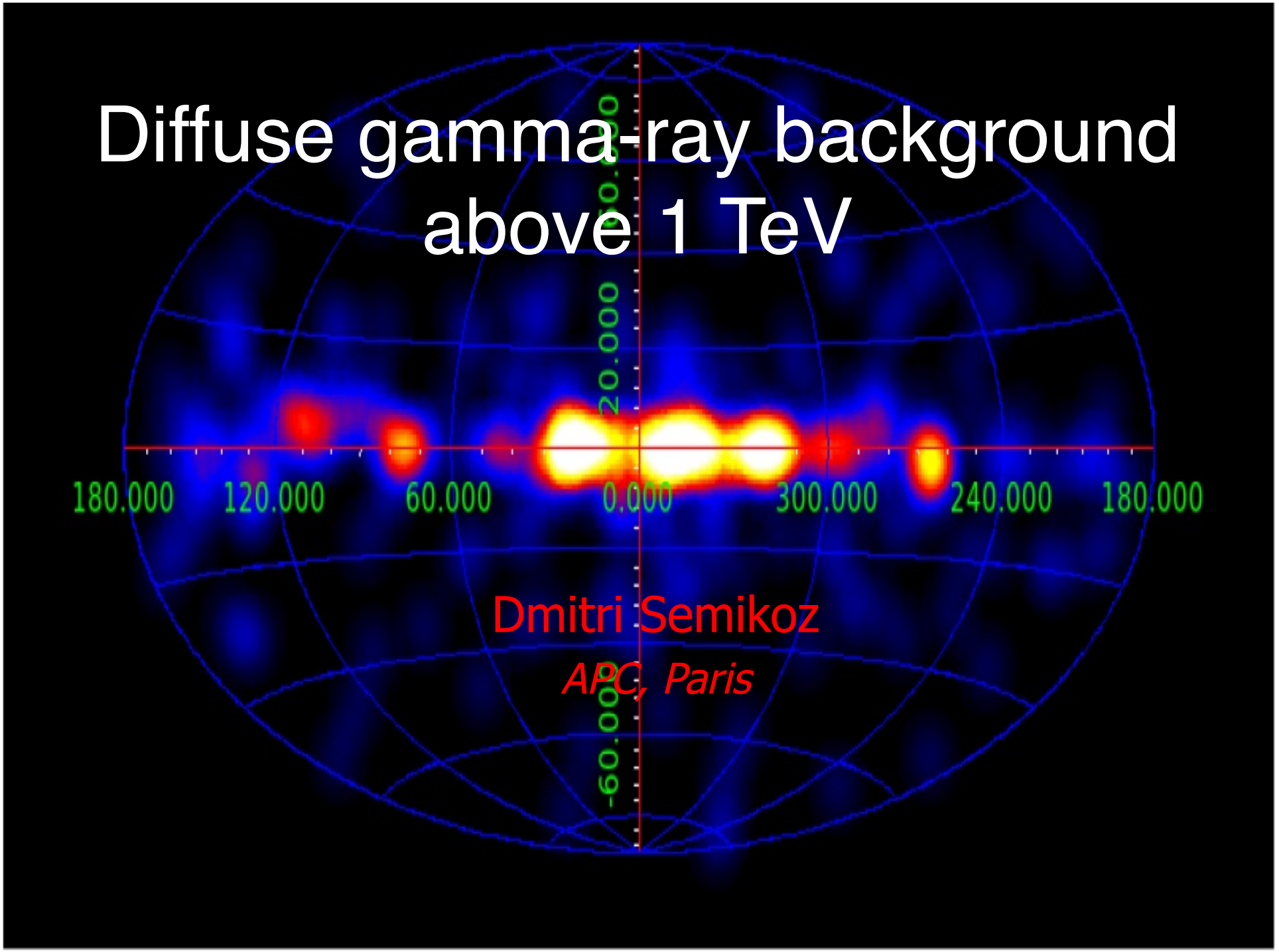
Diffuse gamma-ray background above 1 TeV



Dmitri Semikoz

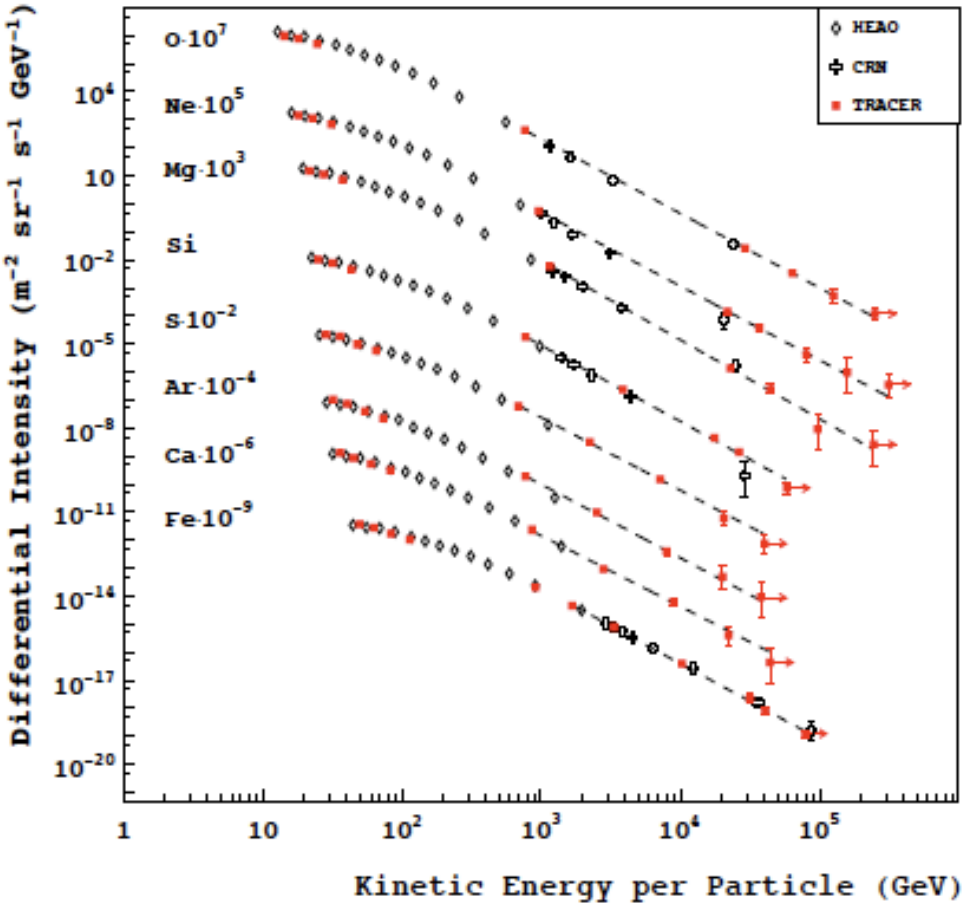
APC, Paris

Overview:

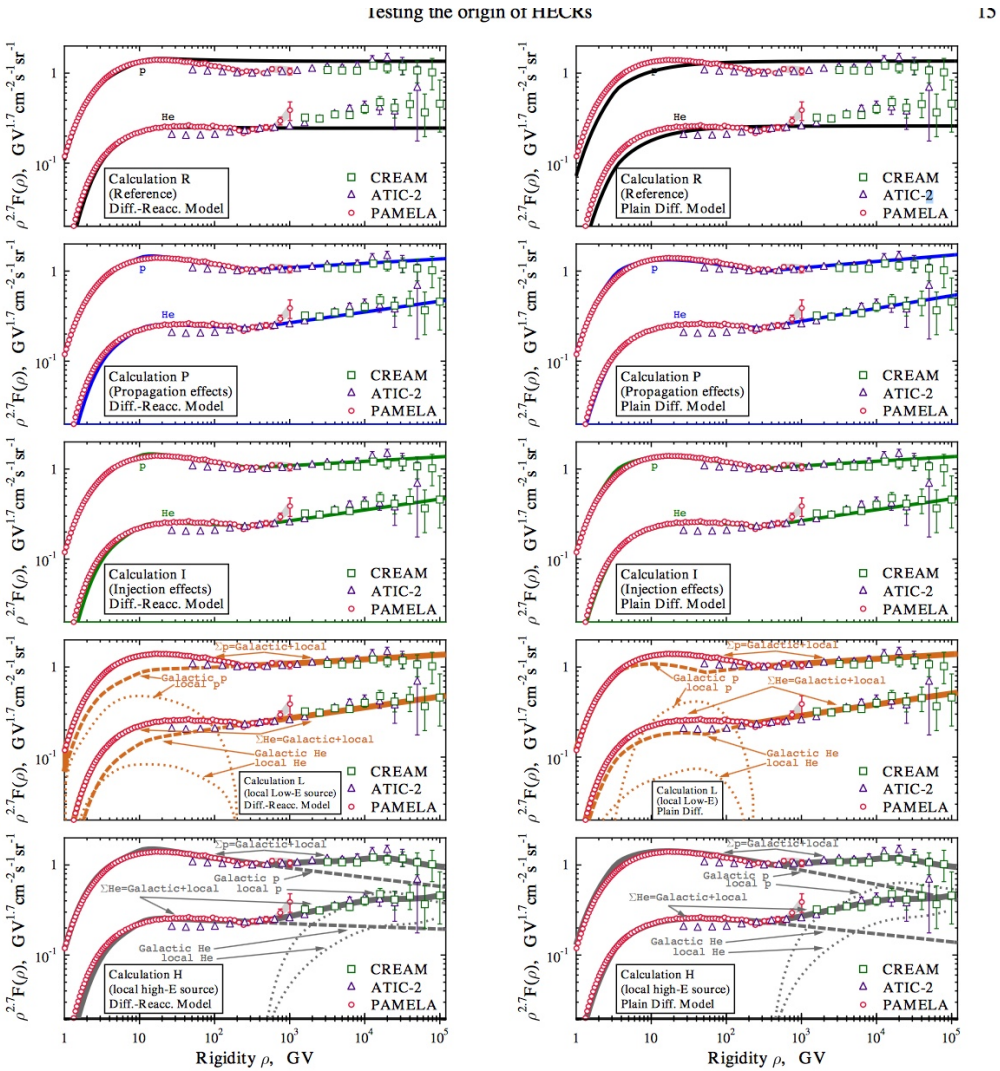
- *Introduction: CR propagation in Milky Way*
- *Diffuse gamma-ray background in Fermi at 1 TeV*
- *Diffuse gamma-ray background measurement by Cherenkov telescopes*
- *Diffuse gamma-ray background measurement by HAWC and LHAASO*
- *Conclusions*

CR propagation in Milky Way

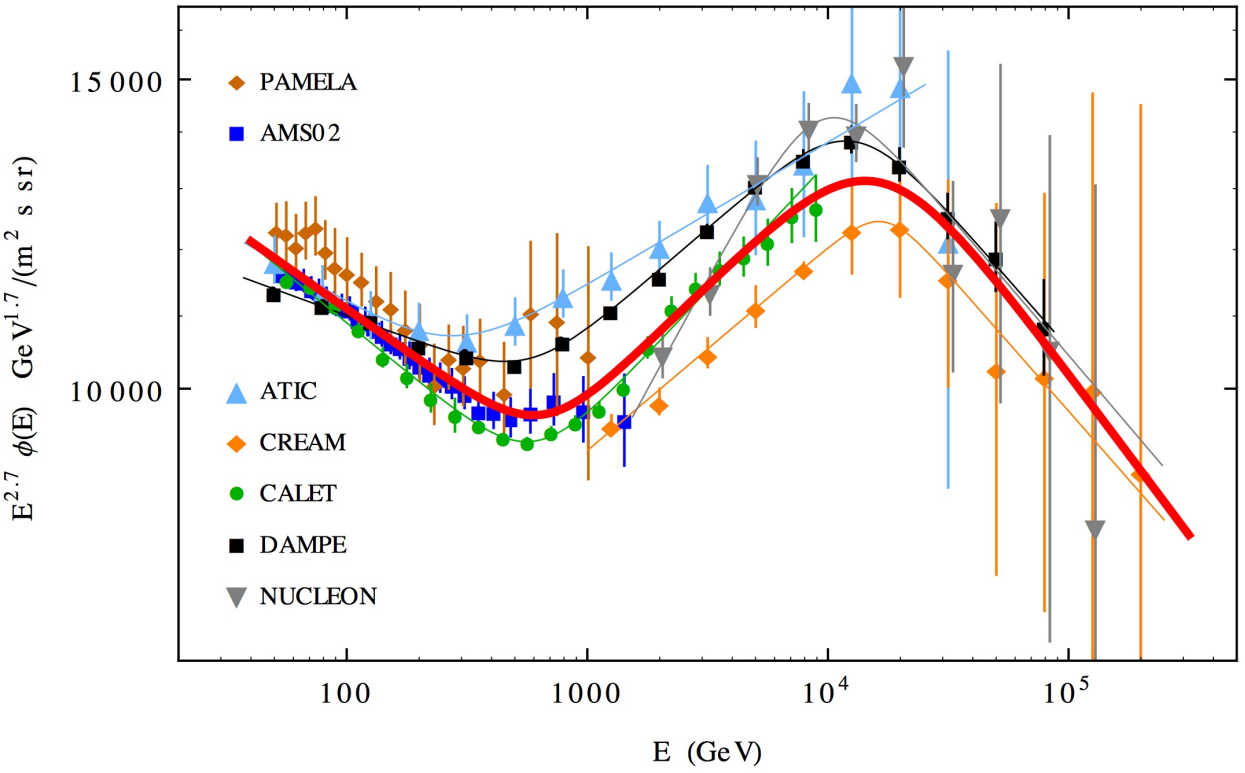
Spectra of individual nuclei



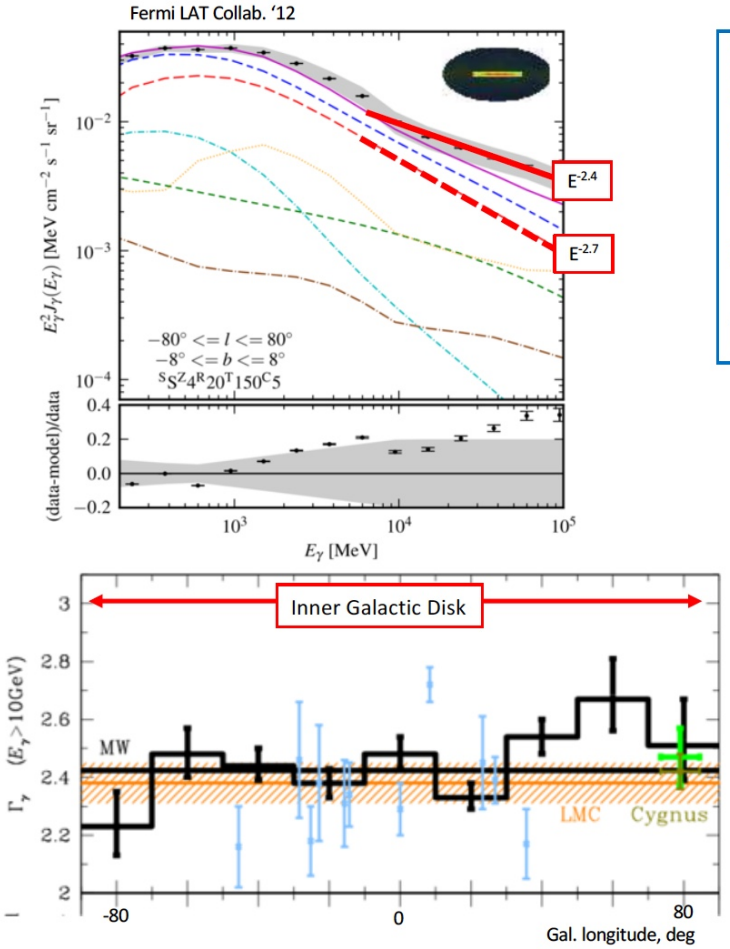
GALPROP 2011



From P.Lipari



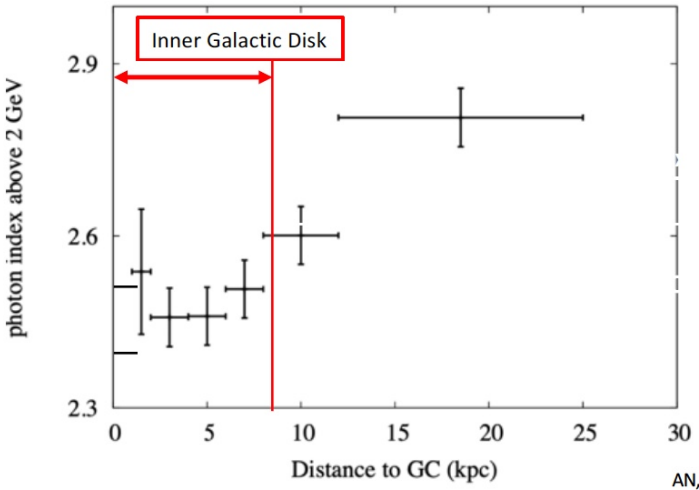
Diffuse neutrino flux



Fermi/LAT gamma-ray data suggest that average cosmic ray spectrum in the Galactic Disk is different from the locally measured one. Average spectrum of cosmic rays residing in the inner Galactic Disk (within the distance of the Sun) has the slope $\frac{dN}{dE} \propto E^{-\Gamma}$, $\Gamma = 2.4$, rather than $\Gamma \simeq 2.7$.

Similar slope is found for cosmic rays residing in the Large Magellanic Cloud.

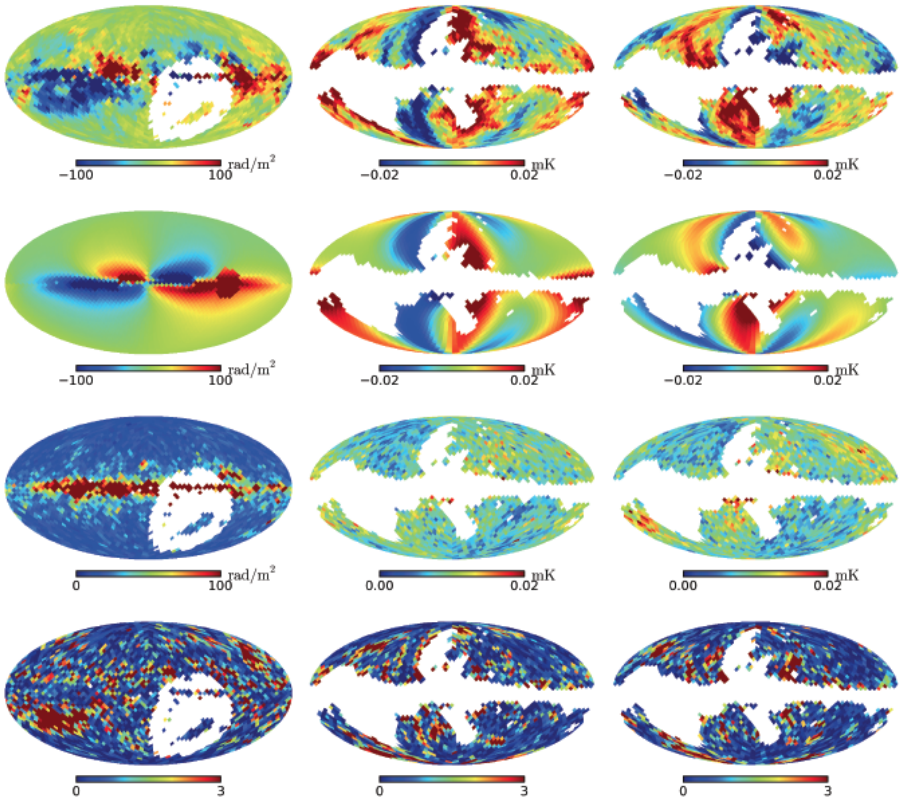
This slope is consistent with that of the astrophysical neutrino spectrum.



AN, Malyshev, arXiv: 1505.07601
Fermi LAT Collab. arXiv: 1602.07246
Yang, Aharonian, Evoli, 1602.04710

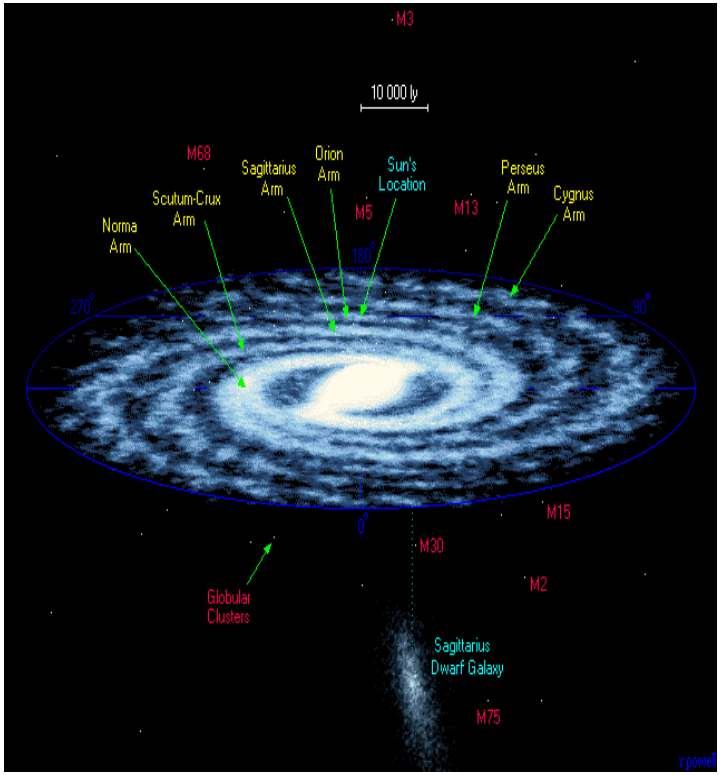
From A.Neronov's talk/ see C.Evoli talk

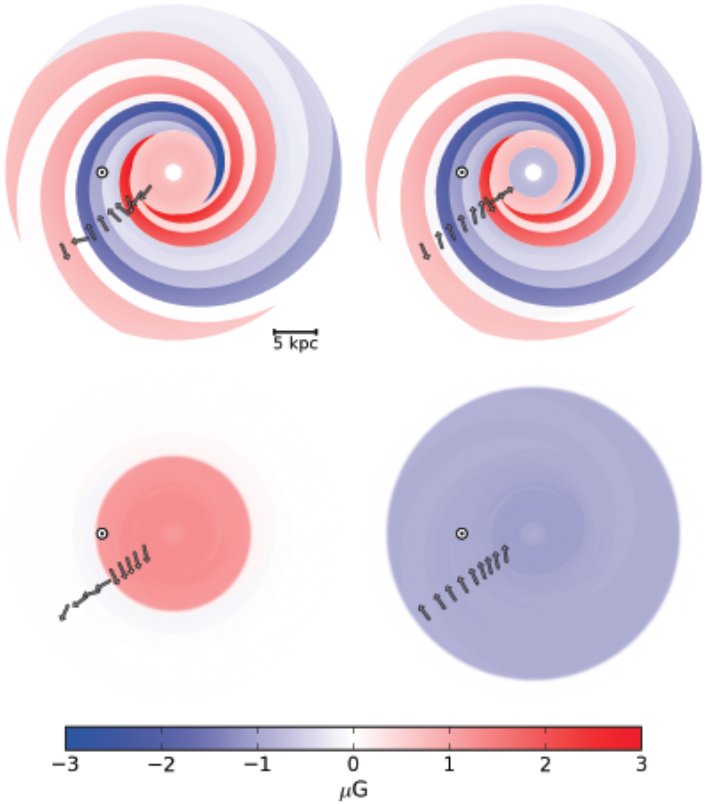
Synchrotron/RM maps



From R.Jansson & G.Farrar, arXiv:1204.3662

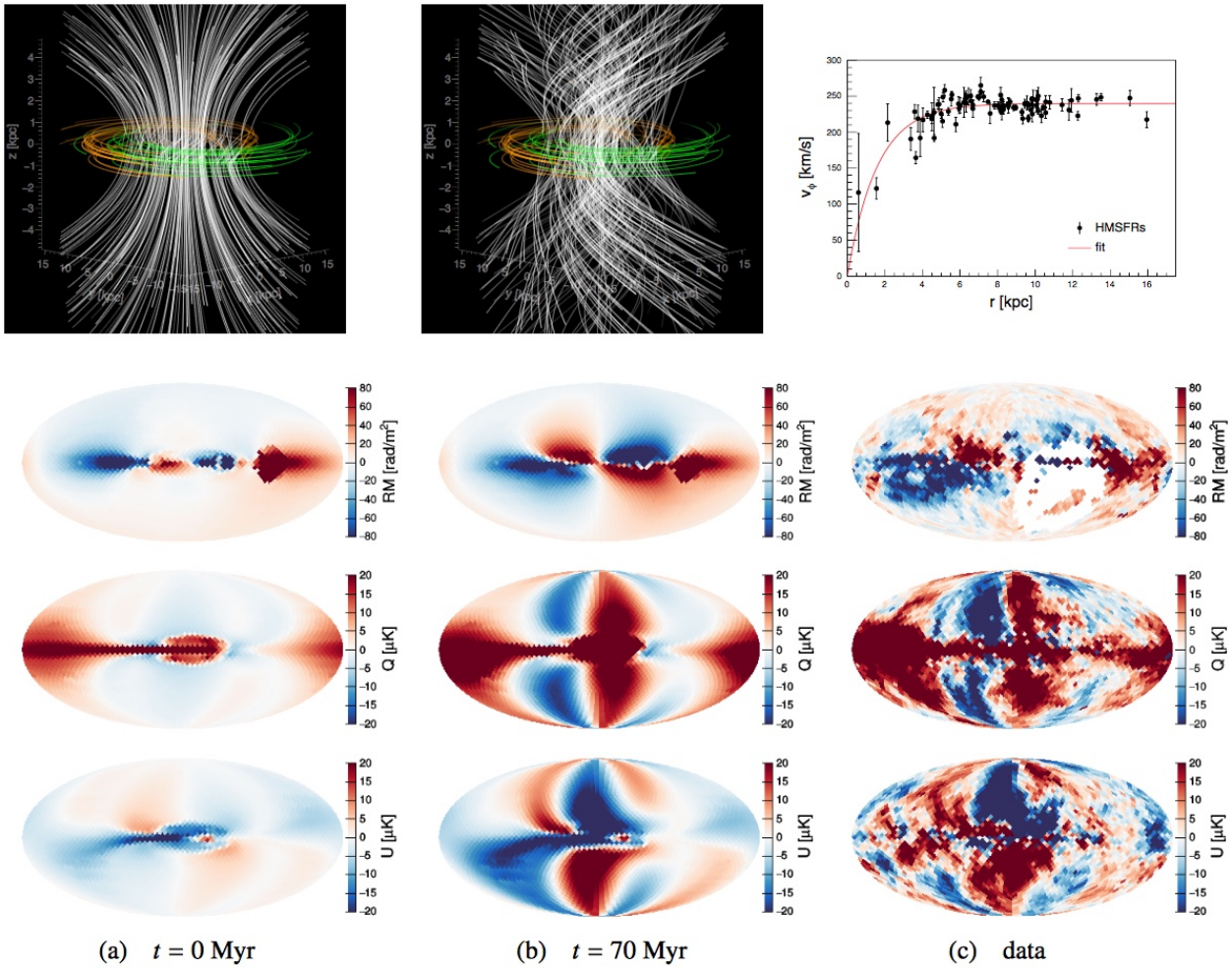
Galactic magnetic field: disk





R.Jansson & G.Farrar, arXiv:1204.3662

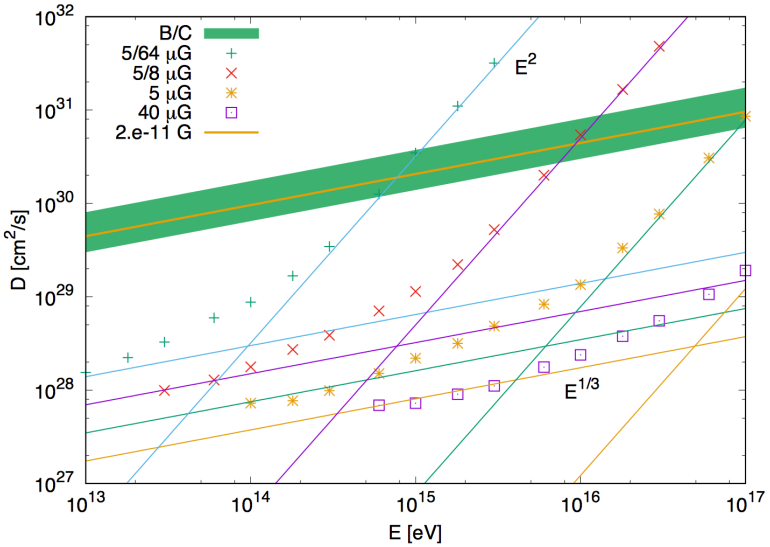
GMF model Unger-Farrar 2019

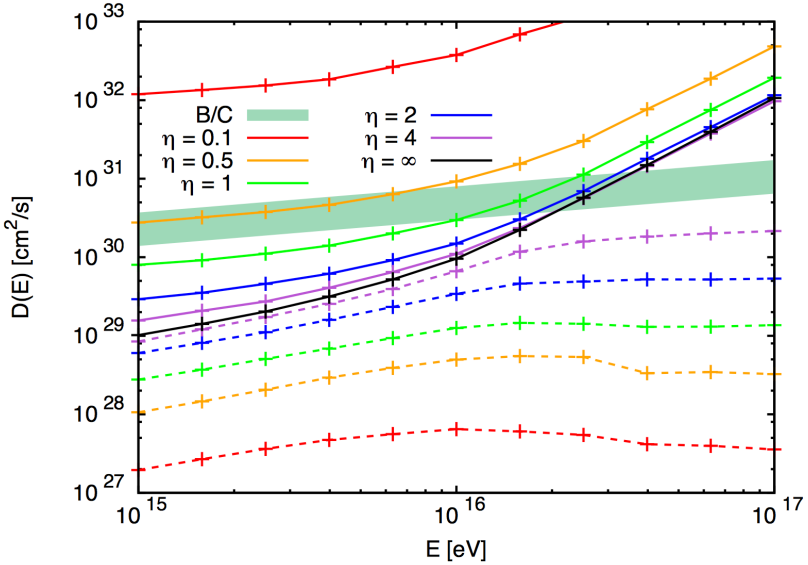


M.Unger and G.Farrar, 1901.04720

Isotoropic and anisotropic diffusion

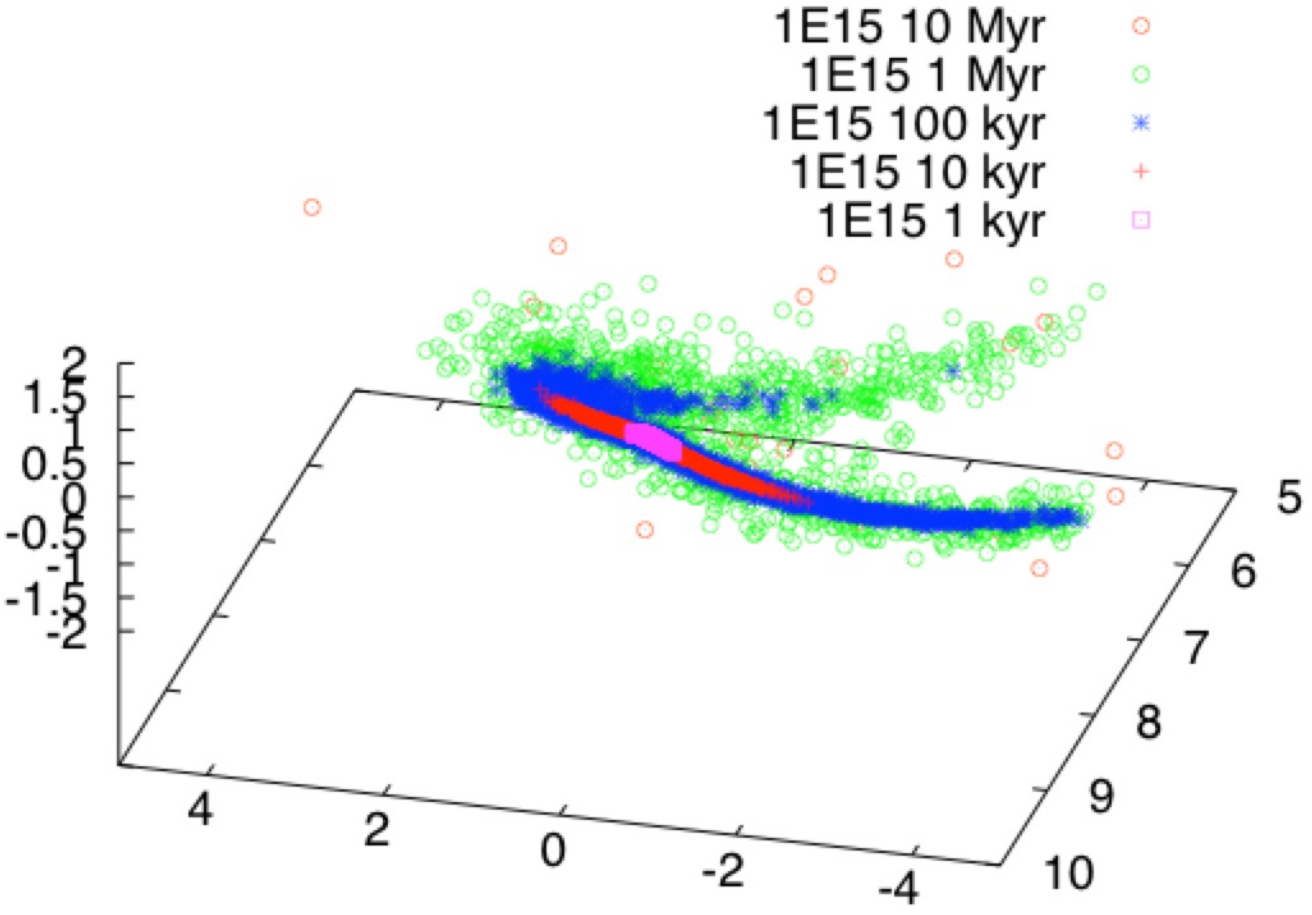
See talk of G.Giacinti



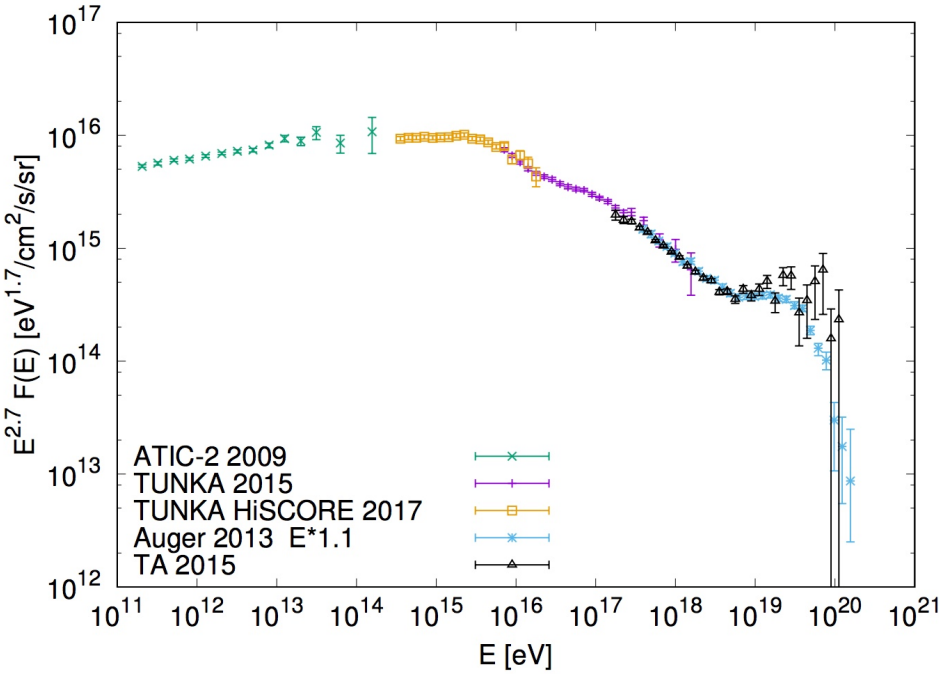


Giacinti et al, 1710.08205

Proton flux from SN at 1 PeV



Knee in CR spectrum



Knee was discovered by Kulikov and Khristiansen in data of MSU Experiment in 1958
It was confirmed by all new independent eperiments

For long time it was 2 explanations: astrophysical and particle physics one. In partile physics explanation it was assumed that either interaction changes or new particle dominates. Tevatron and LHC finally killed this interpretation.

Astrophysical interpretation of knee

Knee is due to maximal energy of dominant sources. Problem: knee is too charp

Escape model: Knee due to change in the propagation properties in interstellar medium

Problem: Sources with 1/500 SN rate have to accelerate above knee

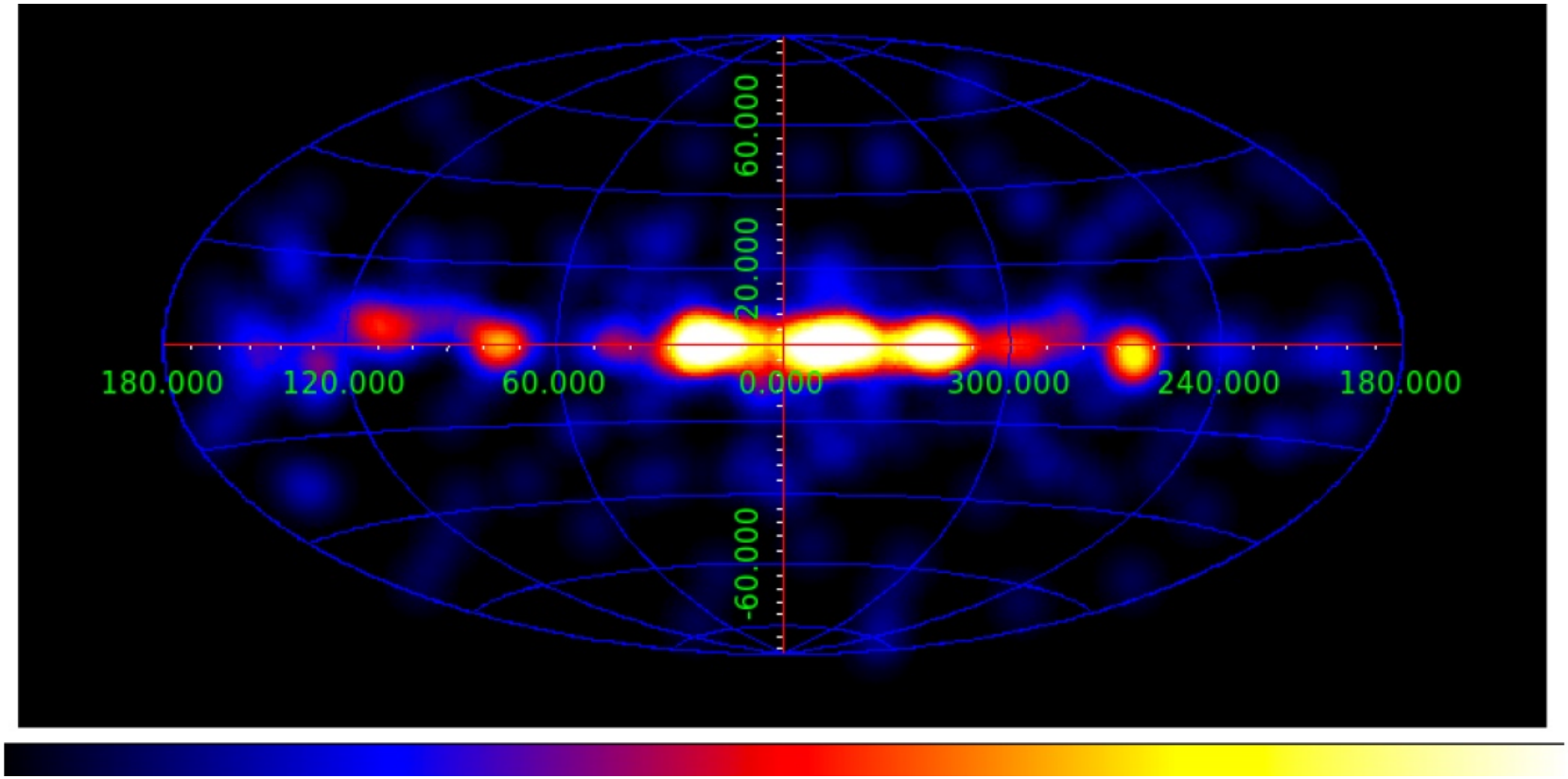
Single source dominate everything around knee

Problem: dipole anisotropy is too small

Gamma-ray sky at TeV

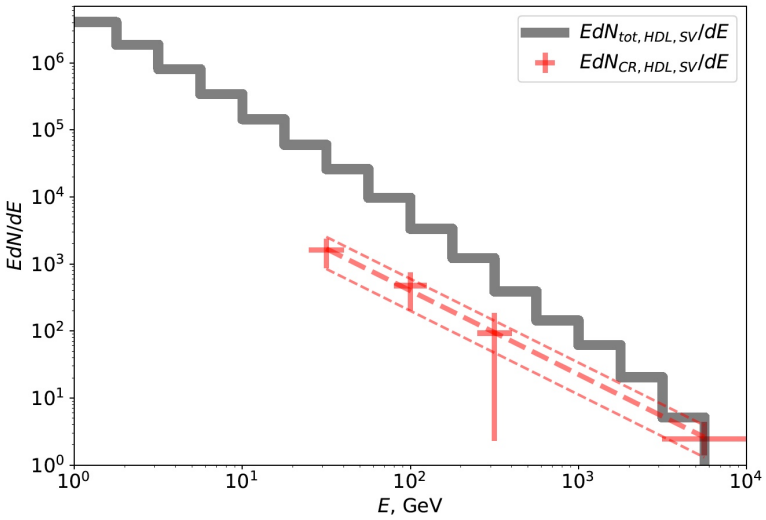
Sky map E> 1TeV

10 years Fermi

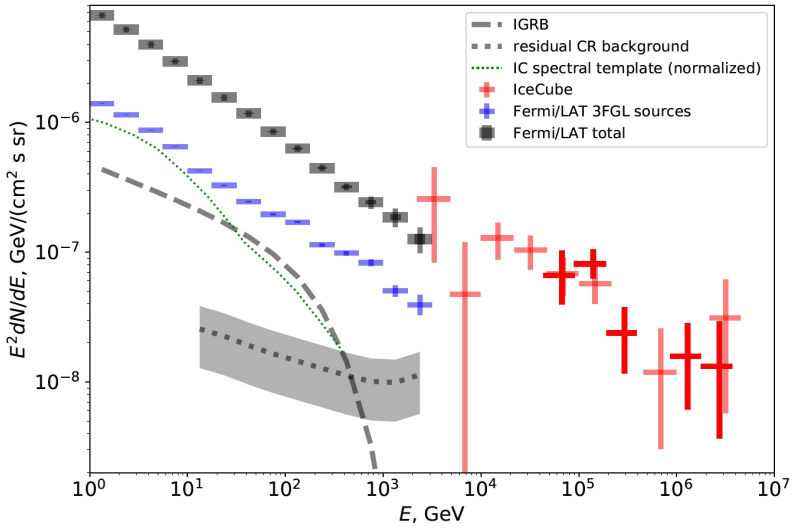


A.Neronov and D.S. , 1907.06061

Fermi TeV: SOURCEVETO works up to 3 TeV



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

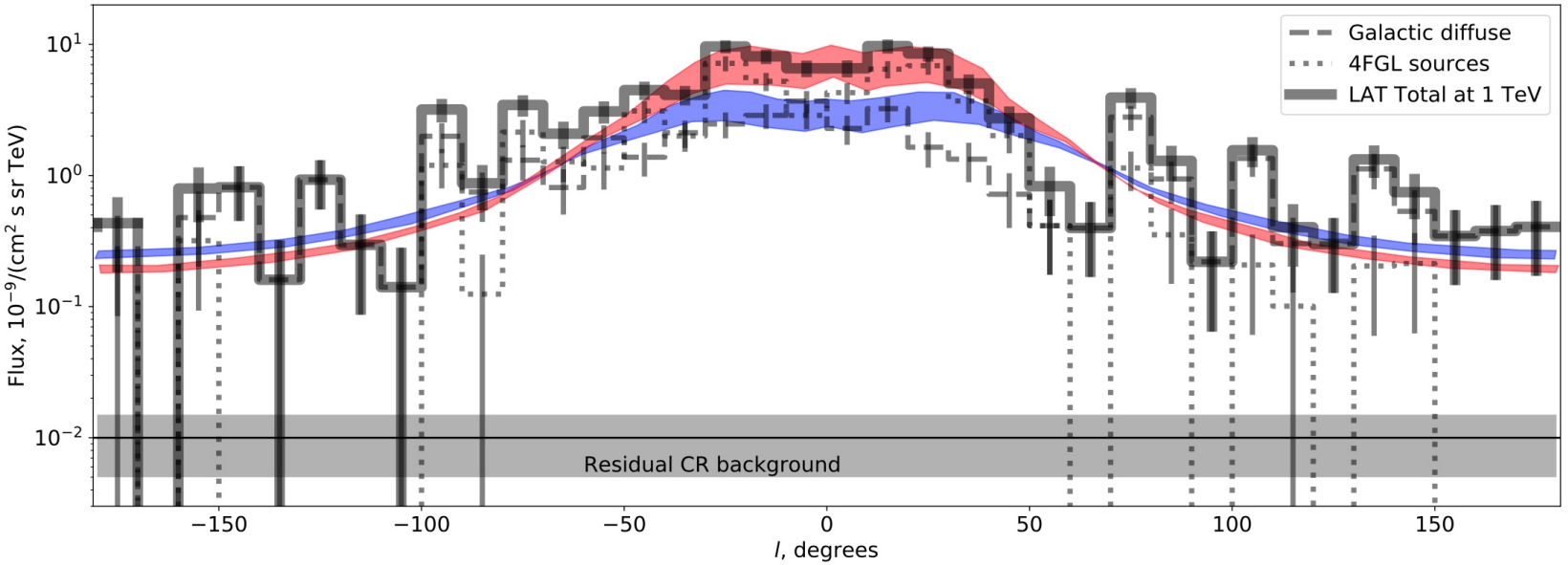


All sky signal

A.Neronov and D.S., 1907.06061

,

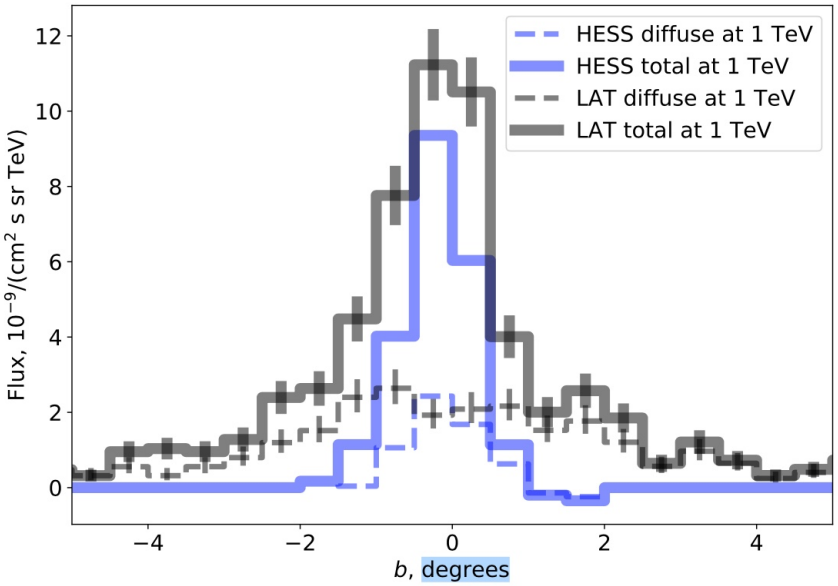
Galactic Plane |b|<2 deg, 1 TeV

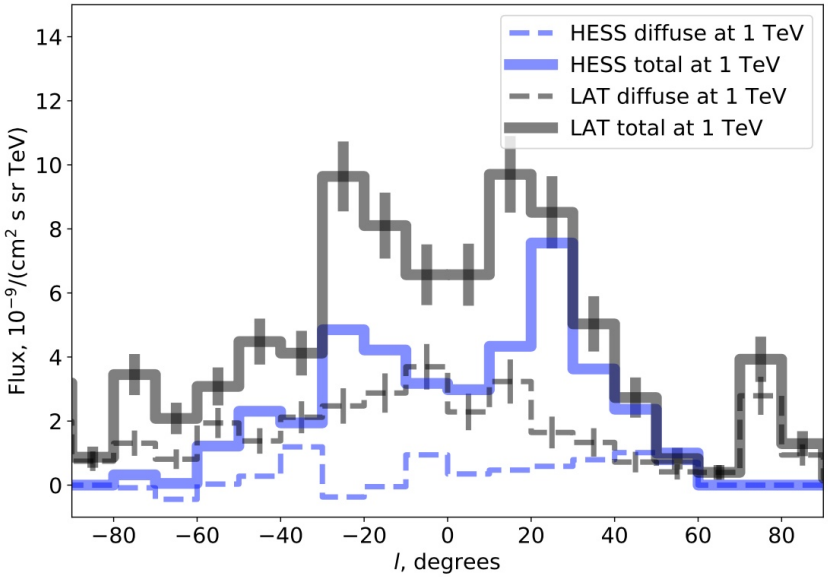


Red and blue lines: model predictions from Cataldo et al , 1904.03894

A.Neronov and D.S. , 1907.06061

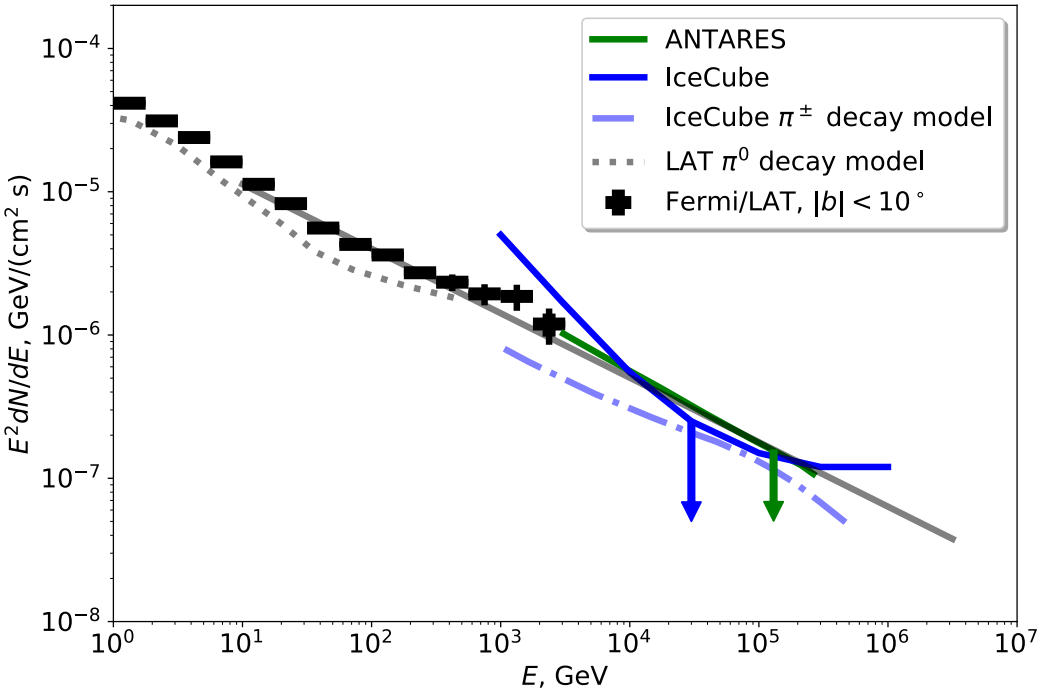
Galactic Plane, Fermi and HESS





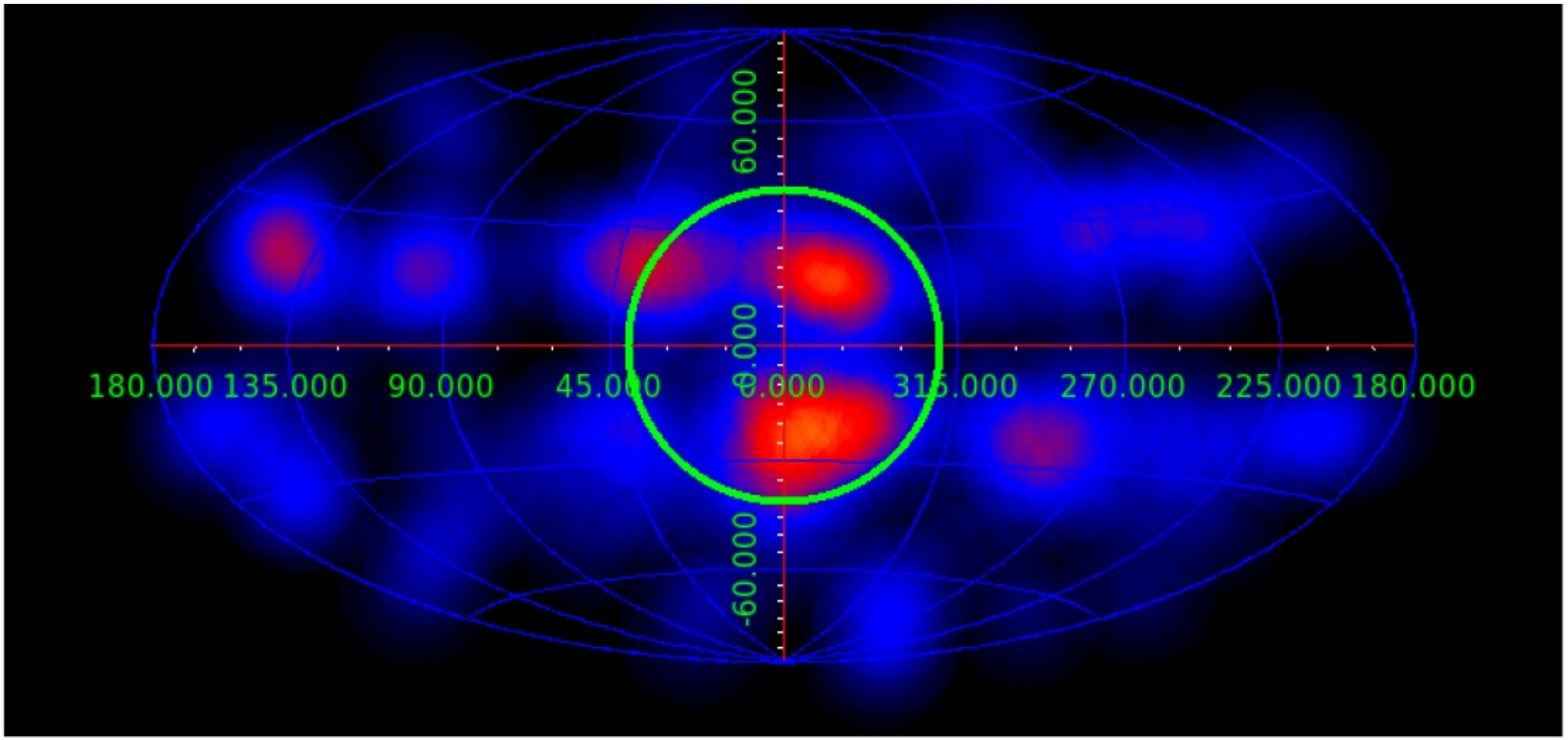
A.Neronov and D.S. , 1907.06061

IceCube + Fermi LAT Galactic plane



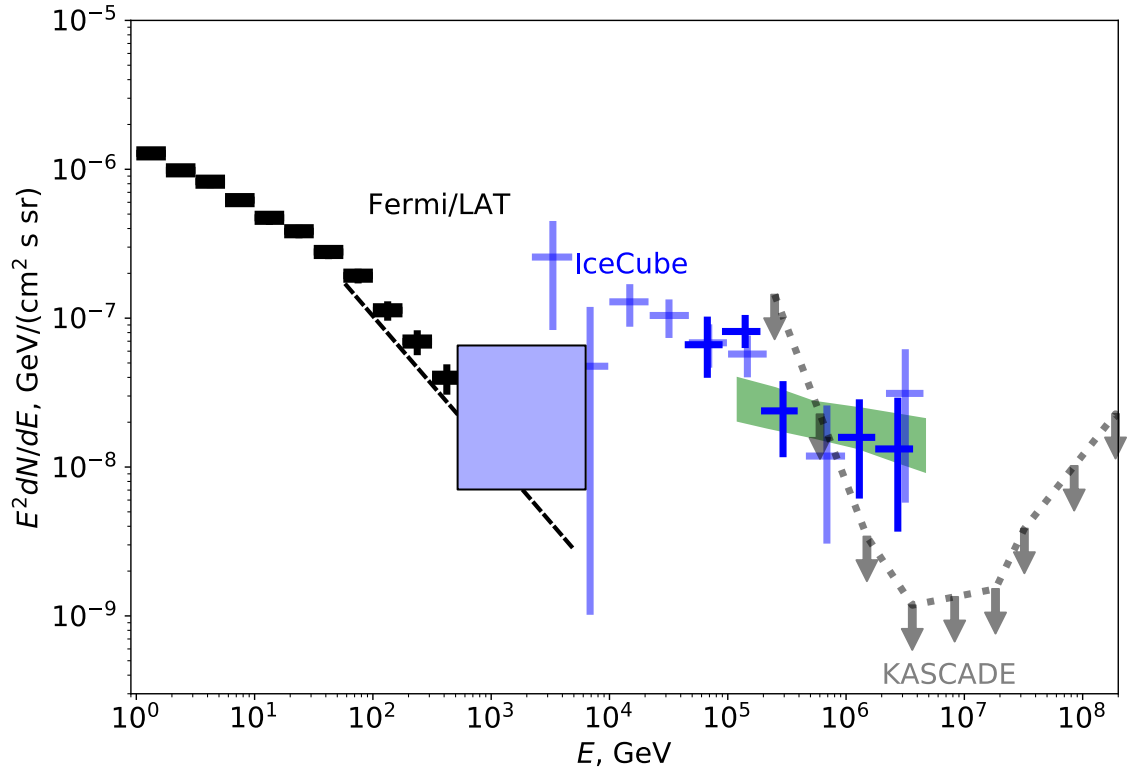
A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

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



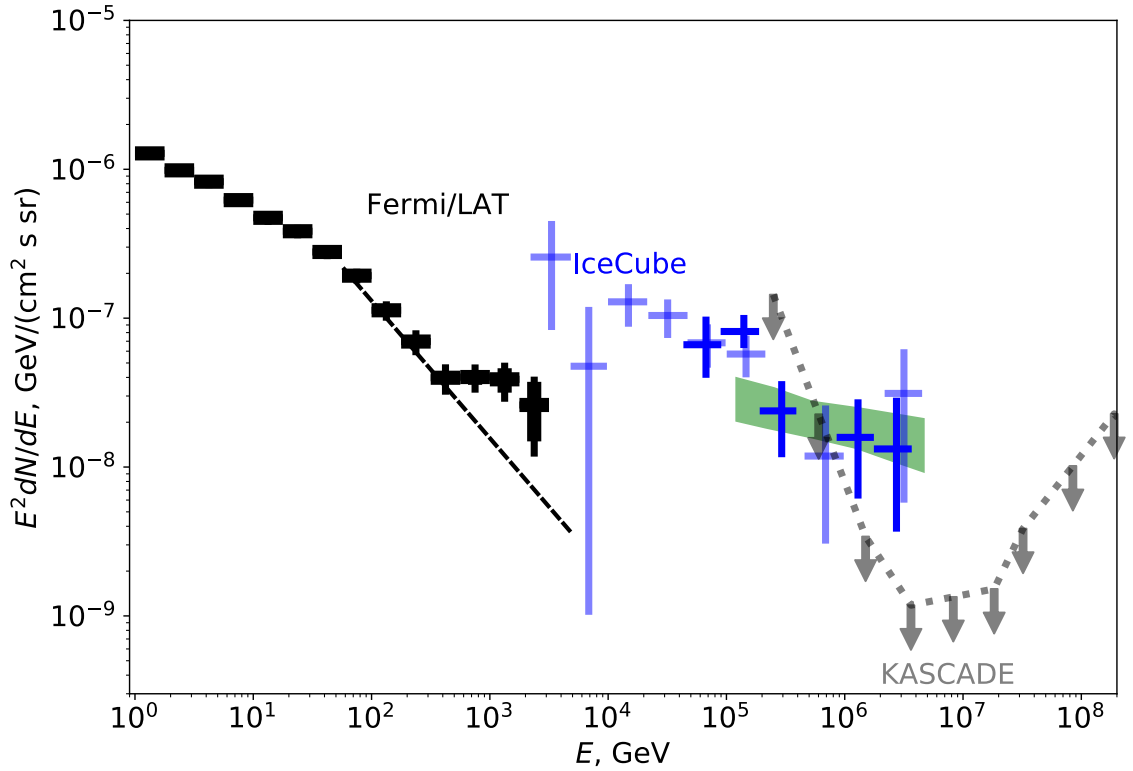
A.Neronov and D.S. , 1907.06061

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

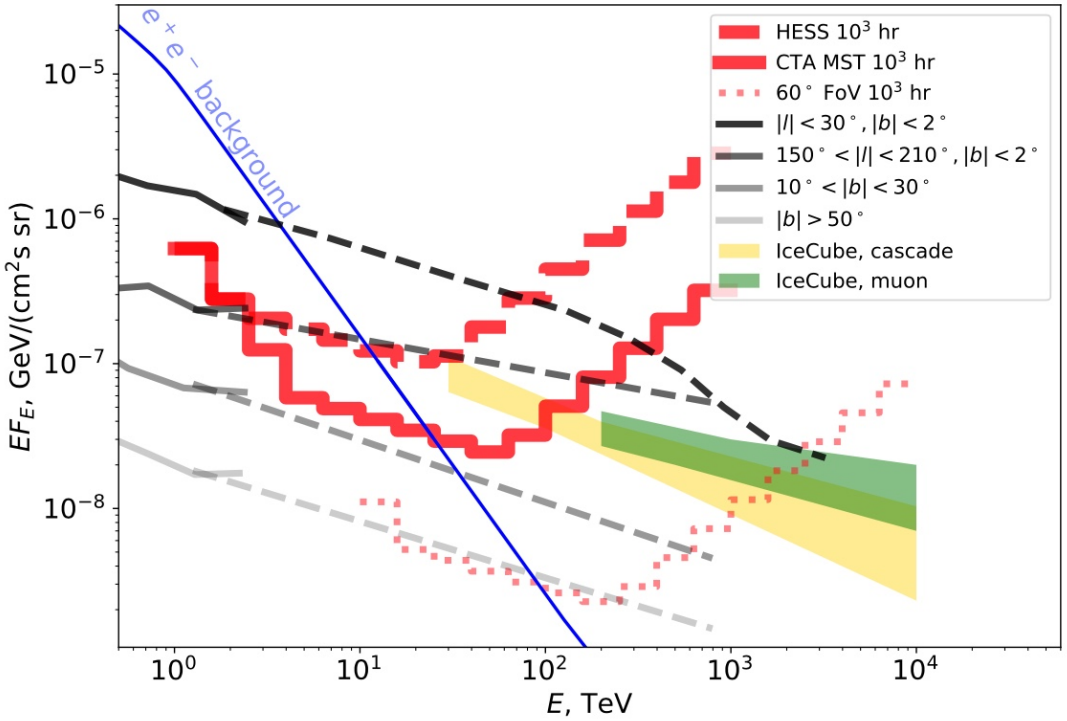


A.Neronov, M.Kachelriess and D.S. , arXiv:1802.09983

A.Neronov and D.S. , 1907.06061

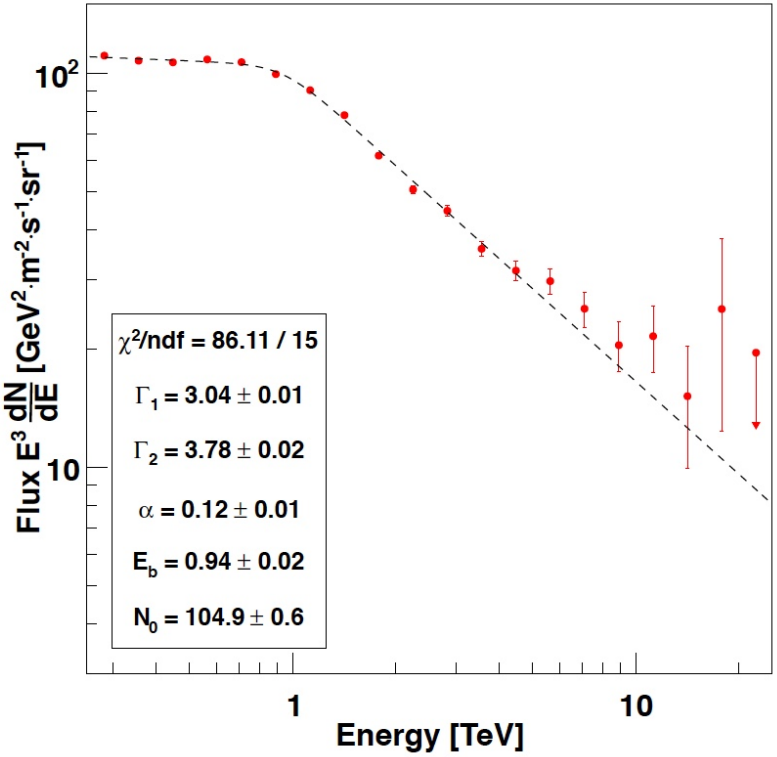
Gamma-ray sky at 10-100 TeV with Cherenkov telescopes

Galactic diffuse flux at 10-100 TeV energies with Cherenkov



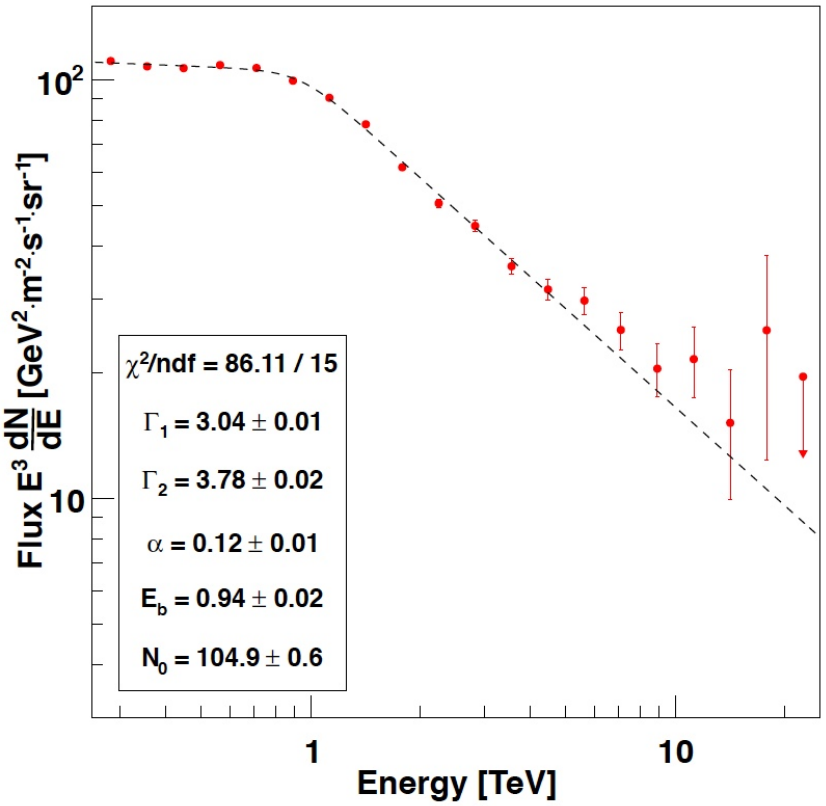
A.Neronov and D.S. , astro-ph/2001.00922

Electron + positron measurements by HESS 2004- March 2010



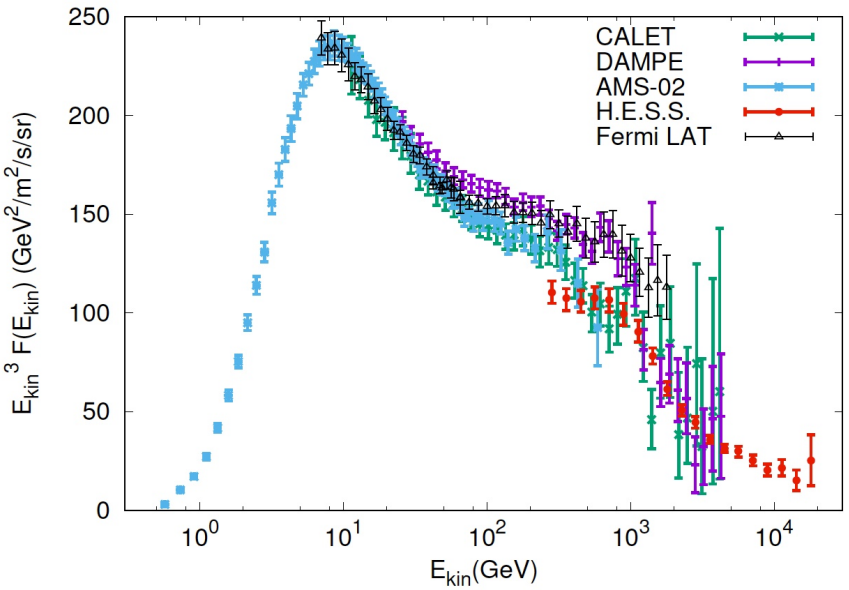
HESS collab. 2017

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

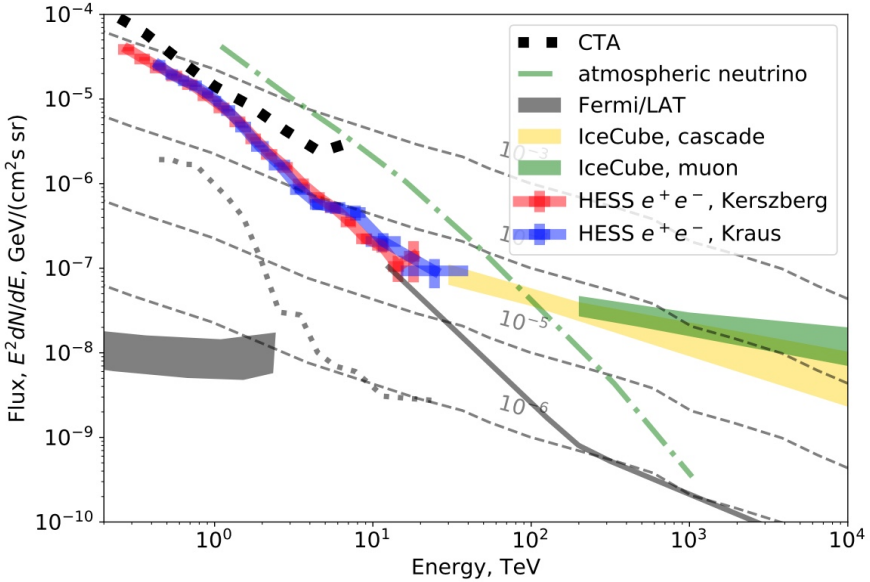


HESS collab. 2017

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

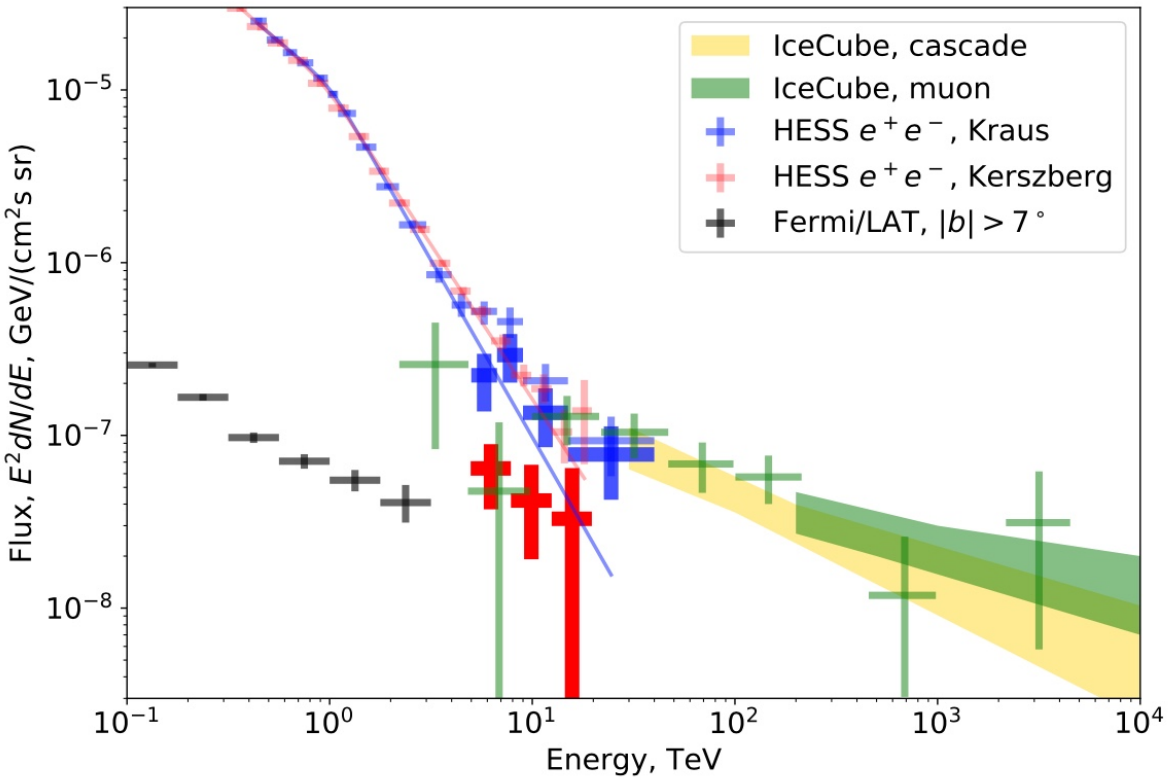


M.Kachelriess and D.S.,
Cosmic ray models,
review astro-ph/1904.08160



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

New component in HESS data

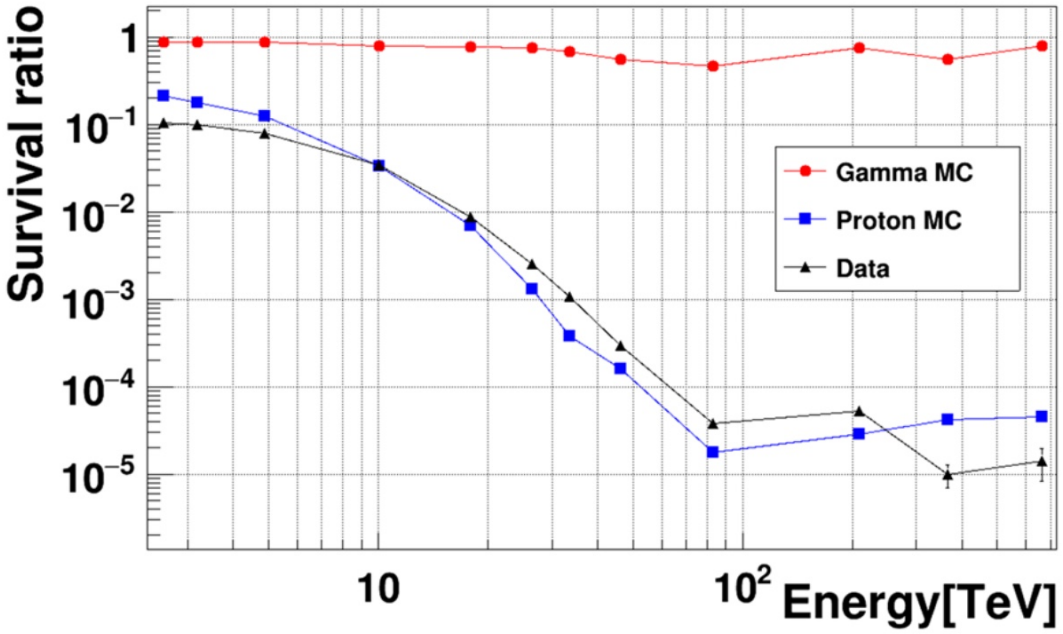


A.Neronov and D.S. , astro-ph/2001.00922

Gamma-ray sky at 10-100 TeV with HAWC and LHAASO

γ/P discrimination of ¼ KM2A

Background rejection >10^4@100 TeV

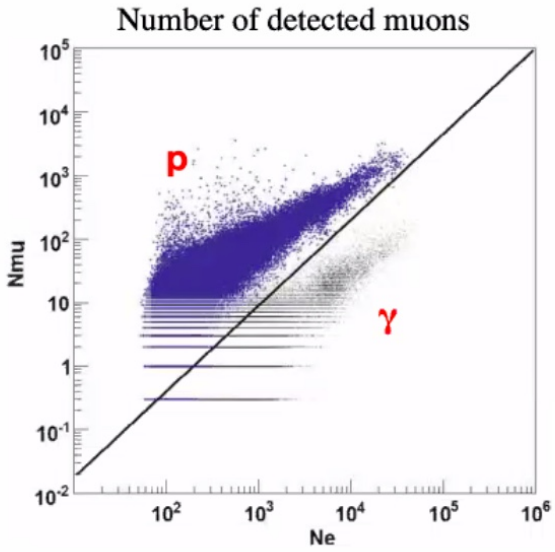


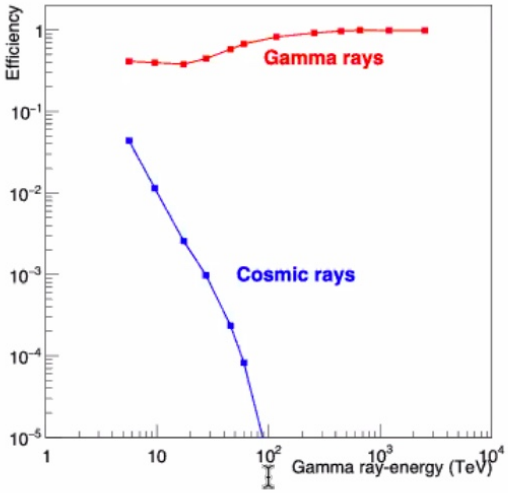
LHAASO meeting Jan 2020

KM2A performance - 3

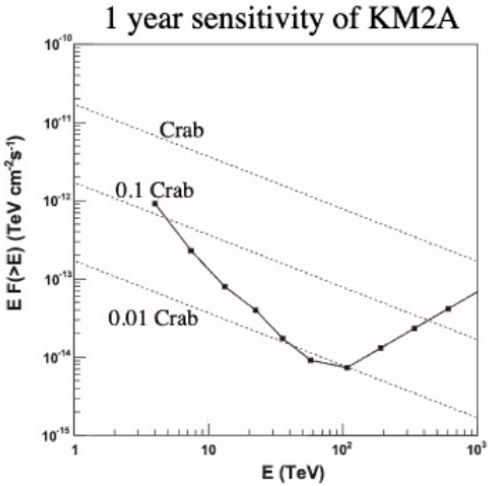
Pino talk Yesterday

S. Cui et al./Astroparticle Physics 54 (2014) 86–92





Fraction of surviving gamma and p-induced events after the selection cut.



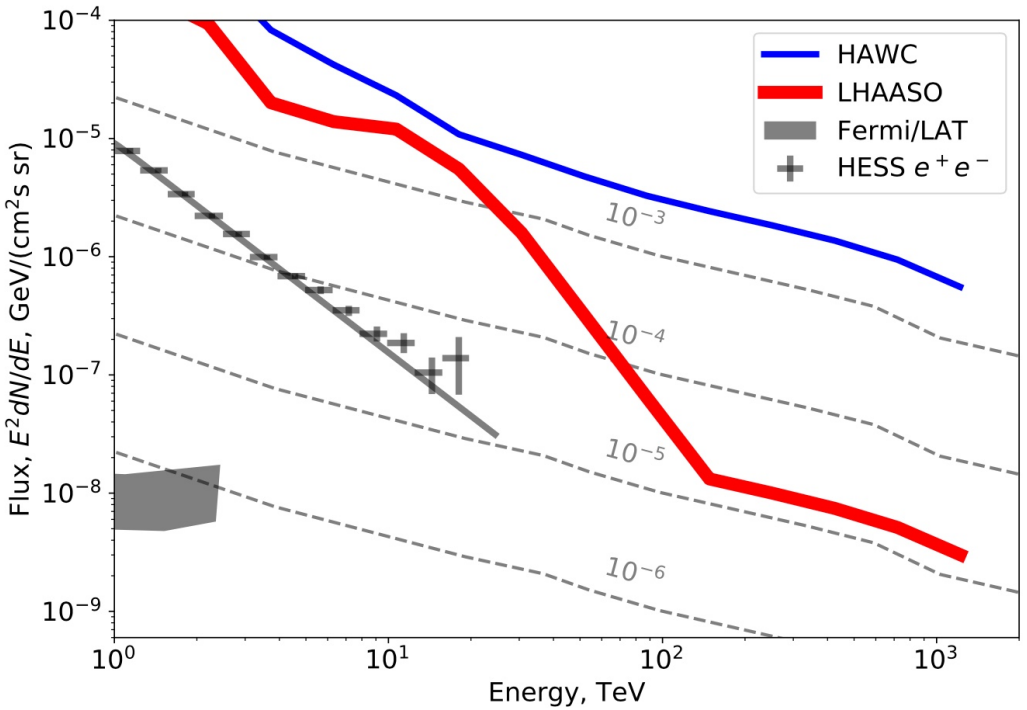
The large area of the MD array of KM2A allow *rejection of cosmic ray background at a level of 10^{-5} at about 100 TeV*.

Above 100 TeV, in the *'back-ground free'* regime, 10 signal events are taken to measure the sensitivity of array.

At 50 TeV 1,700 events from Crab, expected

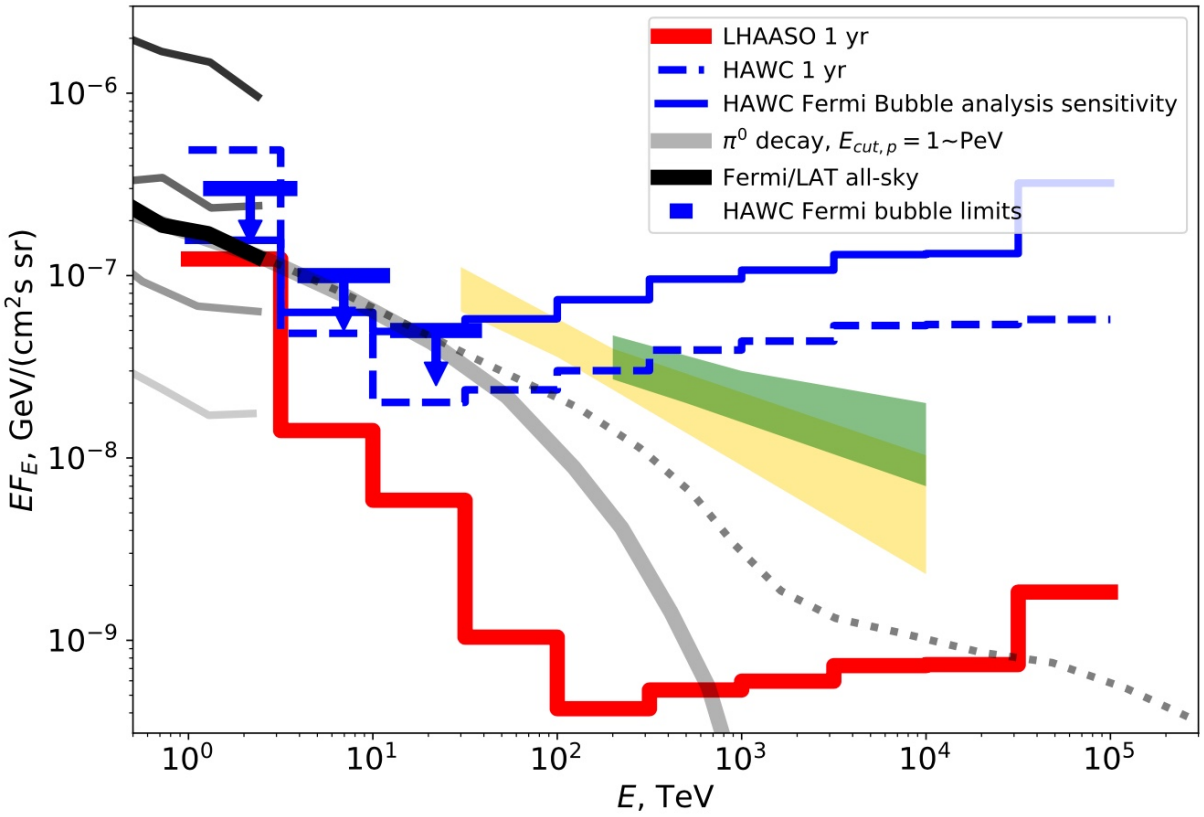
LHAASO meeting Jan 2020

HAWC and LHAASO hadron cut



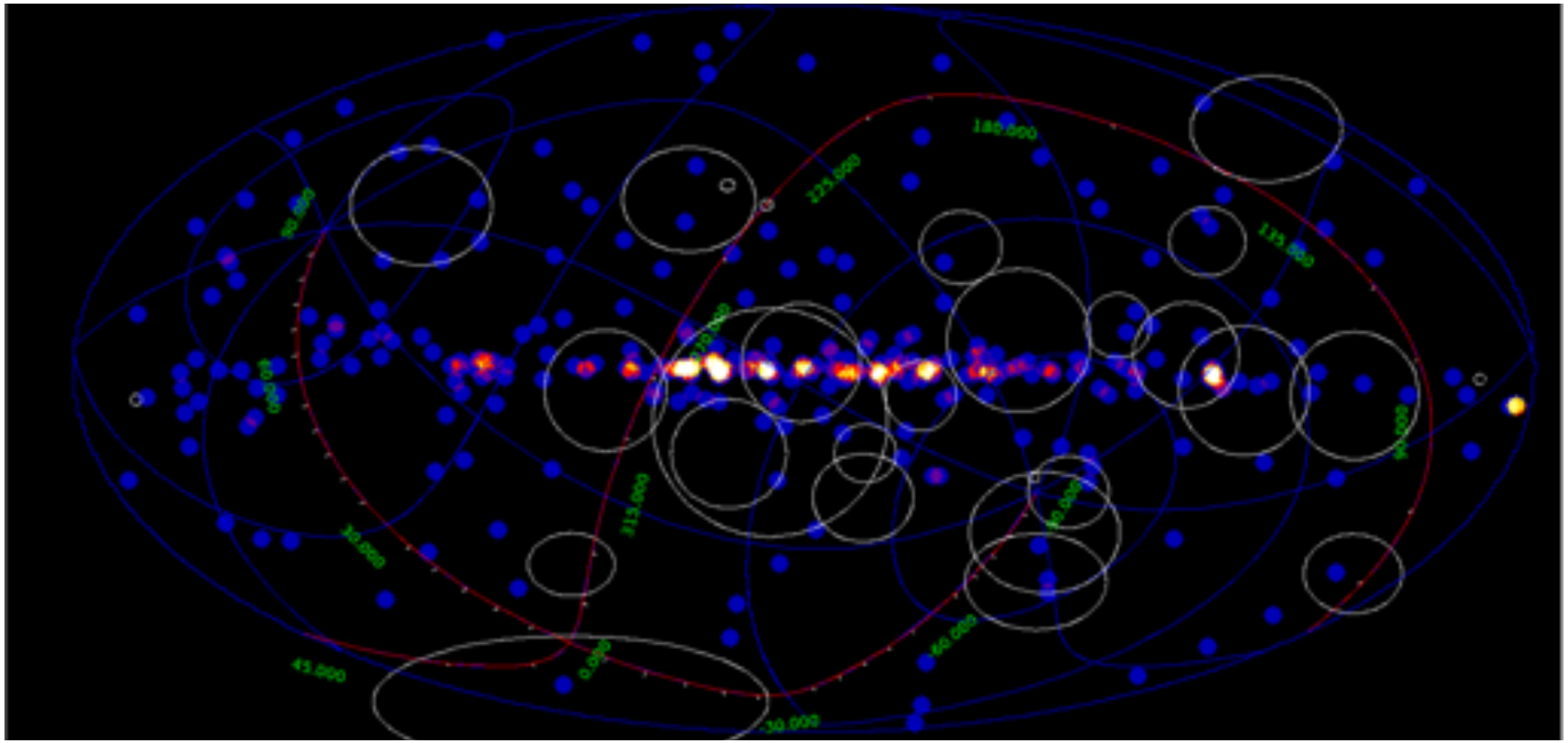
A.Neronov and D.S. , astro-ph/2001.11881

HAWC and LHAASO sensitivity to diffuse gamma



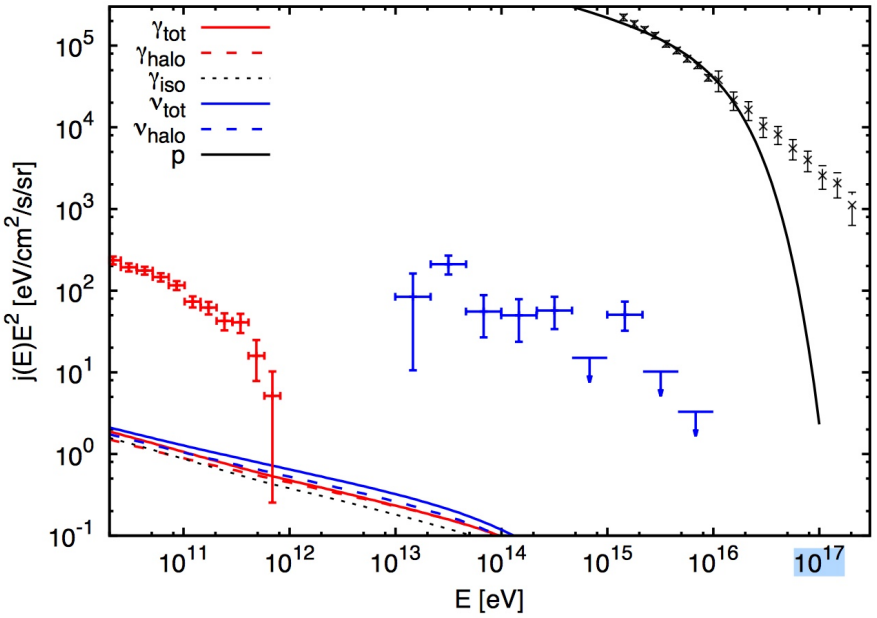
A.Neronov and D.S. , astro-ph/2001.11881

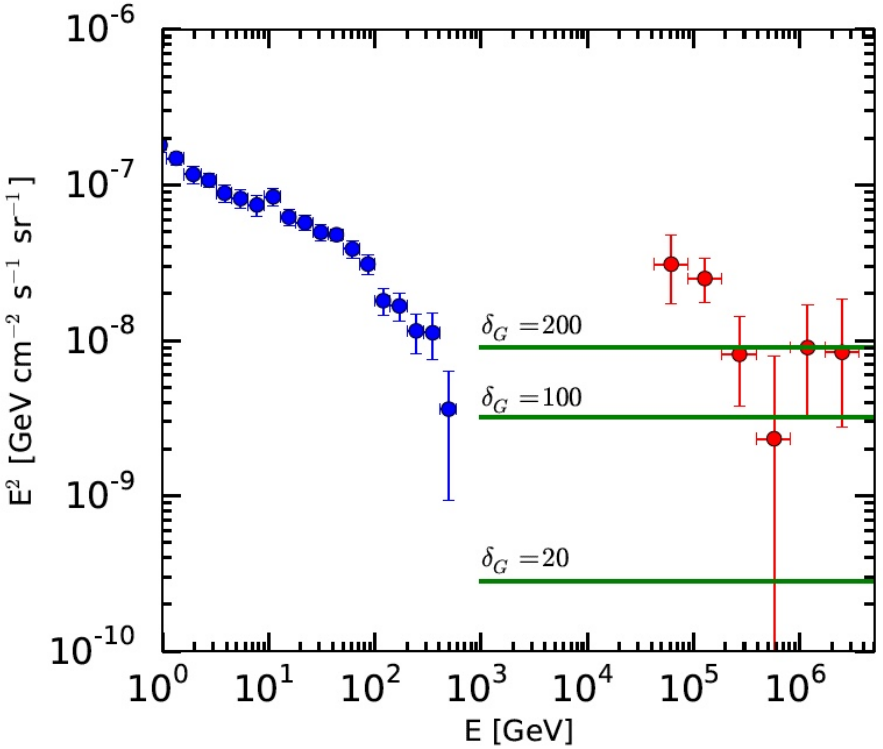
Neutrino and gamma



Neutrinos from Galactic Halo CR

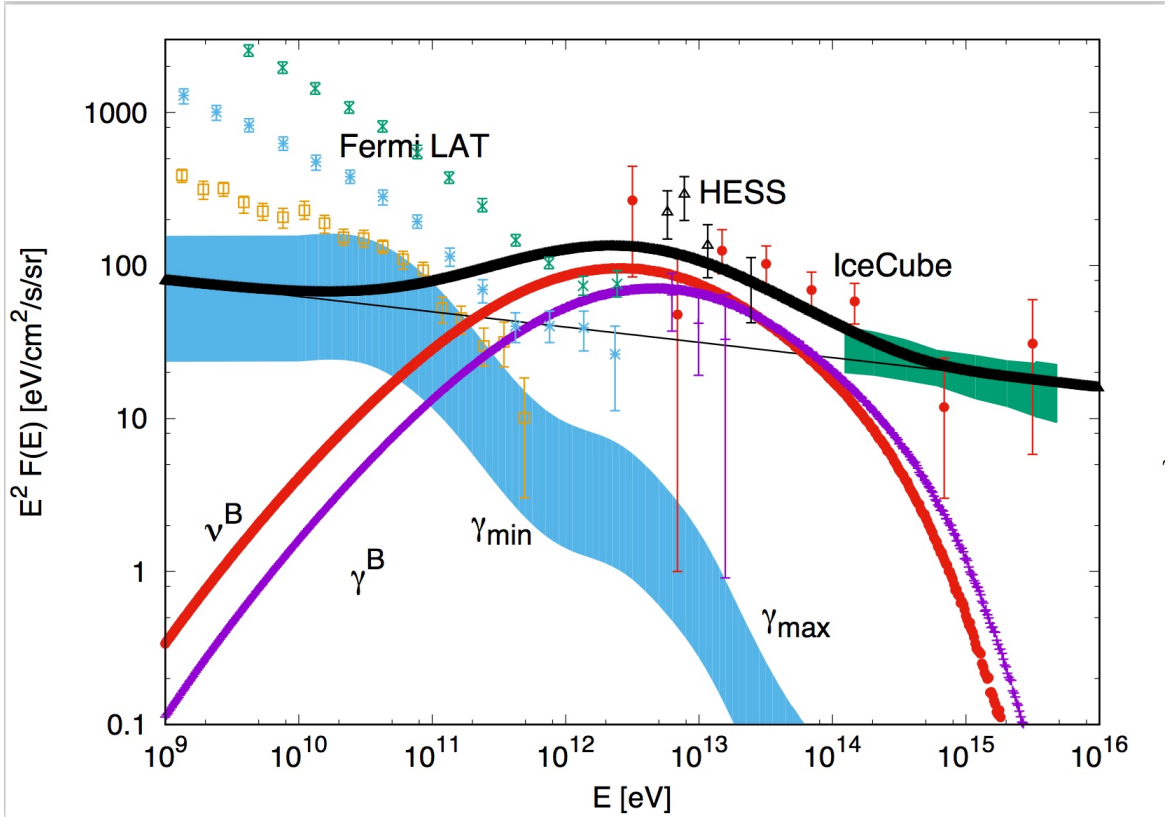
Talk of A.Taylor





A.Taylor, S.Gabici and F.Aharonian, 1403.3206
S.Troitsky and O.Kalashev 1608.07421
P.Blasi and E.Amato , 1901. 03609

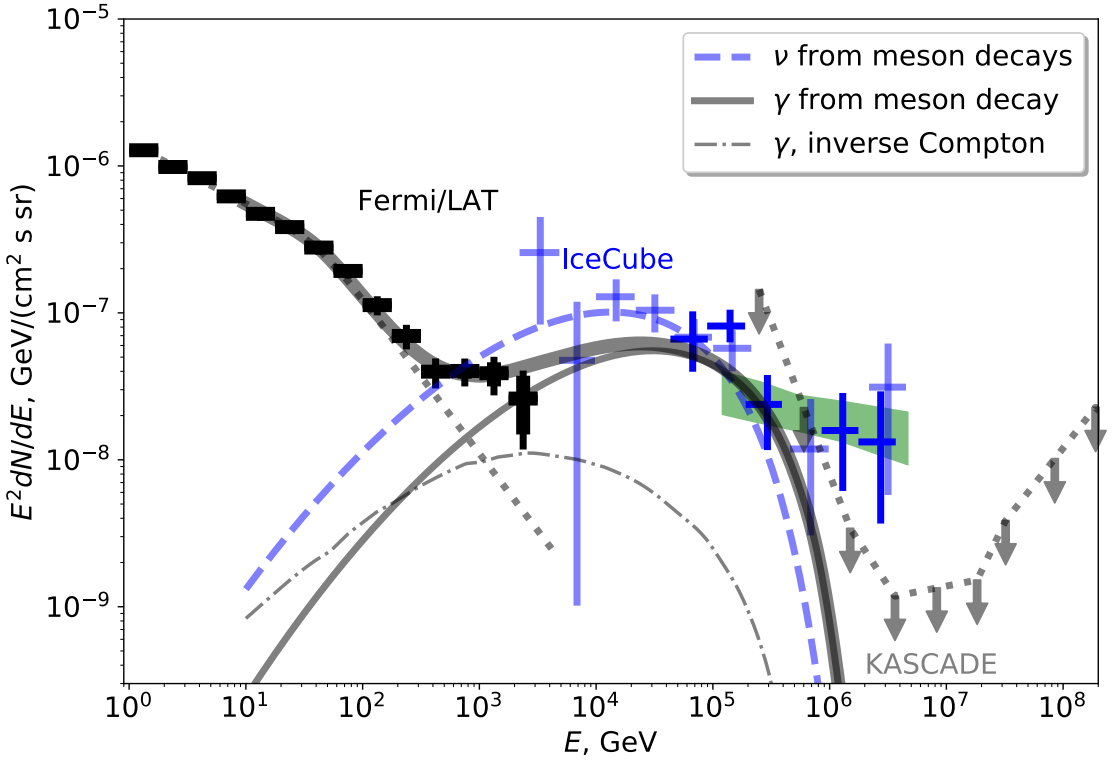
IceCube + Fermi LAT+HESS : local source+Local superbubble



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

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

IceCube + Fermi LAT
Dark Matter m=5 PeV



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

Summary

- *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.*
- *We measure cosmic rays at knee: imprint of PeVatron(s) contribution(s) in one point of Galaxy*

SUMMARY

- *LHAASO start to see PeVatrons in other locations in Galaxy*
- *With diffuse gamma-rays in galactic plane at E>100 TeV we can study propagation of cosmic rays in Galaxy from PeVatrons and find nature of knee. Background of extended sources can be important.*
- *Outside of plane diffuse gamma-ray emission can test models explaining astrophysical neutrinos: large scale halo of Milky Way, local source CR interactions with Local Bubble or halo of cosmic rays or Dark Matter with 5 PeV mass*