VHE Neutrino Expectations from the Central Molecular Zone

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In collaboration with
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A special Laboratory for Astrophysical Mechanisms

Hewitt et al. arXiv:1206.6882

Several hundreds of parsecs surrounding the central SMBH

- Density of Gas $10^4$ cm$^{-3}$ (2 orders of magnitude the average Galactic density at high scales)
- Total Molecular gas reservoir $\sim 4 \times 10^4$ M$\odot$ (~5% of the total gas in the Milky Way)
- Star formation rate less than expected (higher activity in the past), high temperature, turbulent region, emitting radio, optical, UV, X and gamma, $\nu \rightarrow$ way not?
The region with the most accurate gas description

Twisted ring of molecular clouds in the inner 200 parsecs with period of few $10^6$ years

Characteristics of CMZ very similar to ULIRGS and Starbust galaxies!

Possible extrapolation of ν expected to EG objects.
Explanation of the previous CMZ flux up to VHE

Hardening of the proton spectral index in the CMZ region

2006Natur.439..695A (HESS coll.)

10^{2.5}\, E_\text{GeV}^2\, d^2\Phi/dE^2/d\Omega \, \text{cm}^{-2}\, \text{sr}^{-1}\, \text{s}^{-1}

Casandjian [Fermi coll.] Oct.2014, 5th Fermi symp

Galactic ridge

Conventional diffusion

Hard diffusion

We explain it naturally with the Gamma model (non homogeneus CR transport)

Standard scenario was not enough to account for the measured flux

To appear in PRL this Friday: Gaggero D., Grasso D., Marinelli A., Taoso M., Urbano A.

Look at the talk of Dario Grasso in GR session!!

Antonio Marinelli - 13 July 2017

35# ICRC 부산 광역시 BEXCO
New analysis of HESS for the central 200 parsecs


New morphological and spectral analysis of the gamma-ray emitting region with 250 hours of data

Spectral features of new GR 2017 similar to the ones of “Pacman” region

HESS coll -> Same population of fresh CRs from Pevatron
Our analysis -> Booth produced by CR sea hardening close to the GC
We produce neutrino spectra following the parameters able to explain gamma-ray observation from GeV up to tens of TeV:

- The cosmic-ray transport obtained through DRAGON code (arXiv:1607.07886) with a radially dependent CR diffusion.
- The gamma SKY code produces neutrino and gamma with the parameters of gas and source distributions.
- For the gas: we set the Xco able to reproduce the gas column density obtained by HESS in the observation of the “Pacman” region (2016).
- For the source distribution parameters we used the one able to account for the whole SED measured for the 200 pc around the galactic center (HESS 2017).
- For primary CRs still open the possibilities of two possible cutoffs: 5 and 50 PeVs
Fixing the parameters of source and gas distribution

Gamma & Base models with Case and Battarchaya ('98)

Comparison with HESS 2017

Gamma & Base models with Ferriere source distribution ('01)

Comparison with HESS 2017

Preliminary:
Gaggero, Grasso, Marinelli, Taoso, Urbano, Ventura

\[ \Phi_{GR} = 1.181 \times 10^{-5} \left( \frac{E_\gamma}{1\text{TeV}} \right)^{-2.42} \text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \]
Regions of CMZ where we compute $\nu$ expectation

**Regions of gamma diffuse**

**Preliminary**

CMZ HESS 2017 $|l| < 1^{\circ}$, $|b| < 0.3^{\circ}$
Sagittarius B $0.4^{\circ} < |l| < 0.9^{\circ}$, $-0.2^{\circ} < b < 0.3^{\circ}$
Pacman, annulus $0.15 < \theta < 0.4$

**Fermi-LAT point like sources**

**Preliminary**

SEDs of possible PLS (without 2FHL1745-290) from Fermi in the CMZ region of 200 pc
Better PLS sensitivity needed: look at the contributions of Rosa Coniglione (KM3NeT) and Giulia Illuminati (ANTARES)
Sagittarius B far to be detected as a single PL source if the emitting region is only the one of HESS. Only one PeV HESE event gives not a strong limit however the extrapolated flux seems more compatible with a 5 PeV cutoff instead of 50 PeV.
Neutrino from the 200 pc of the CMZ (HESS 2017)

Integrating the flux of the full 200 parsecs better chances to see the signal for IceCube and ANTARES

Good visibility for KM3NeT/ARCA: Look at the contribution of Agata Trovato

The extrapolated max flux from IC14 (1041 TeV) still more compatible with 5 PeV cutoff, we expect more HESEs in this region of the sky!
More HESE events can give good hints on HiRes and HEGRA

cutoff expected for Galactic CR, we expect

can constrain

the model of Galactic

CR propagation

with v observations

Can constrain

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with v observations

Diffuse from CMZ

look at Baret &

Haack contributions

Constraints on the Galactic CR cutoff and model of $\nu$
SUMMARY & CONCLUSIONS

• With the Gamma model we predict the neutrino produced by Galactic CR sea in the CMZ optimizing the parameters of source and gas distributions from gamma-ray observations.

• In the CMZ region we have a hardening of the SED (model+ Fermi obs.) and the most dense region of Galactic molecular gas (5% of the total) -> We expect enough neutrino production to be seen (even without local PS contribution).

• The PeV HESEs compatible with the CMZ can constrain the Galactic CR cutoff while a point-like analysis of the CMZ can be a interesting addition to the already dedicated ones of the Galactic Plane to pose limits on the model of Galactic ν
Thanks for the Attention!