



Istituto Nazionale di Fisica Nucleare

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Large Scale γ -ray Diffuse Emission & Background Models

Galactic Sky

- VHE γ -ray diffuse emission from the GC
- alternative interpretation of observed emission \Rightarrow large scale CR-sea
- analysis & analysis simulations of HESS J1741-302
- analysis simulations of synthetic population in the CMZ

CTA Galactic Center WG

Extragalactic Sky

- Fast variability \rightarrow BL Lac flare May 2019 (MAGIC)
- EHBL sources \rightarrow RXS J081201.8+023735 (MAGIC)

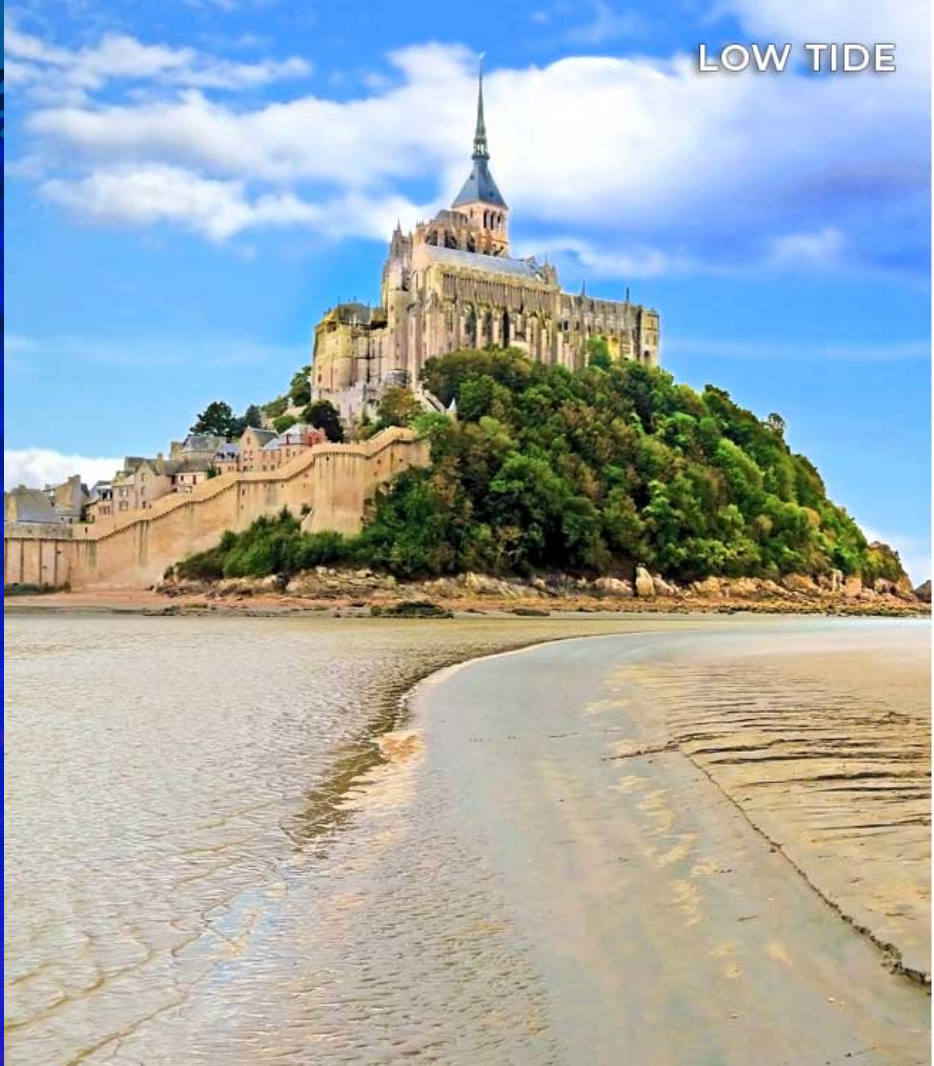
Large Scale Diffuse Emission & Background Models



EGRET

Fermi-LAT

Observation of γ -ray diffuse emission
 \Rightarrow large-scale background emission especially along the GP



It is crucial to not under/over estimate the galactic diffuse large-scale background emission

building increasingly realistic large-scale background models

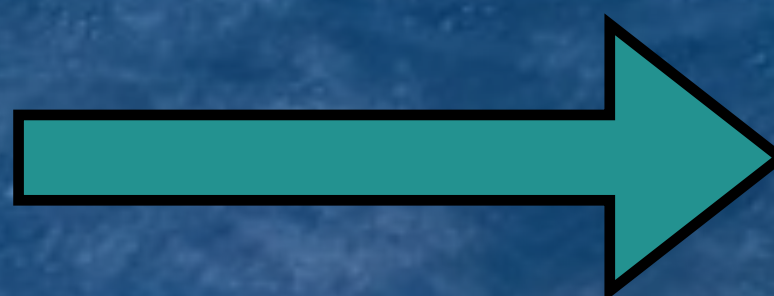
The nature of the Very High Energy (VHE)

gamma-ray diffuse emission

in the Galactic Center (GC) region is still unknown & debated

Two main scenarios:

- Local PeVatron
- Inhomogeneous Galactic CR-sea



SMBH (SGR A^{*})

Unknown population of
SNRs, PWNe & Stellar
Wind Cluster

Motivated by Fermi-LAT,
Milagro, HAWC, Tibet ASy,
LHAASO results



Extrapolation at the GC position of the
diffuse emission tuned on local
observations

Large Scale Diffuse Emission & Background Models

Large-scale background detected by Fermi-LAT explained in terms of galactic CR populations (CR-sea) diffusing within the Galaxy

Gamma Model

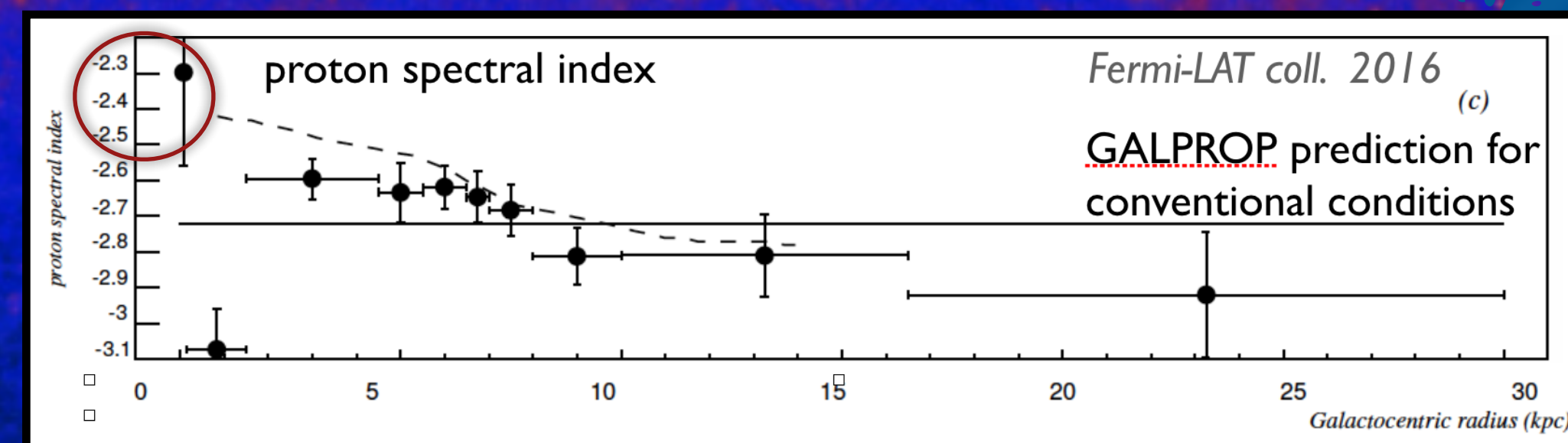
- CRs undergo to inhomogeneous diffusion
- Motivated by several independent analyses of Fermi-LAT data
- Additional hardening at 300 GeV/n (PAMELA, AMS-02, CREAM – Gaggero et al., 2015)

Reproduce 15 TeV Milagro anomaly

Due to large uncertainties on proton spectral index in the inner galaxy, this hypothesis represents an extrapolation for $R \sim 0$ of the trend between $8 < R < 3$ kpc

Linear dependence of diffusion coefficient with galactocentric distance & rigidity
(Gaggero et al., 2015)

Spectral index of γ -ray diffuse emission increase from $\Gamma \sim 2.8$ to $\Gamma \sim 2.3$ for R decreasing from 10 kpc to 0 kpc



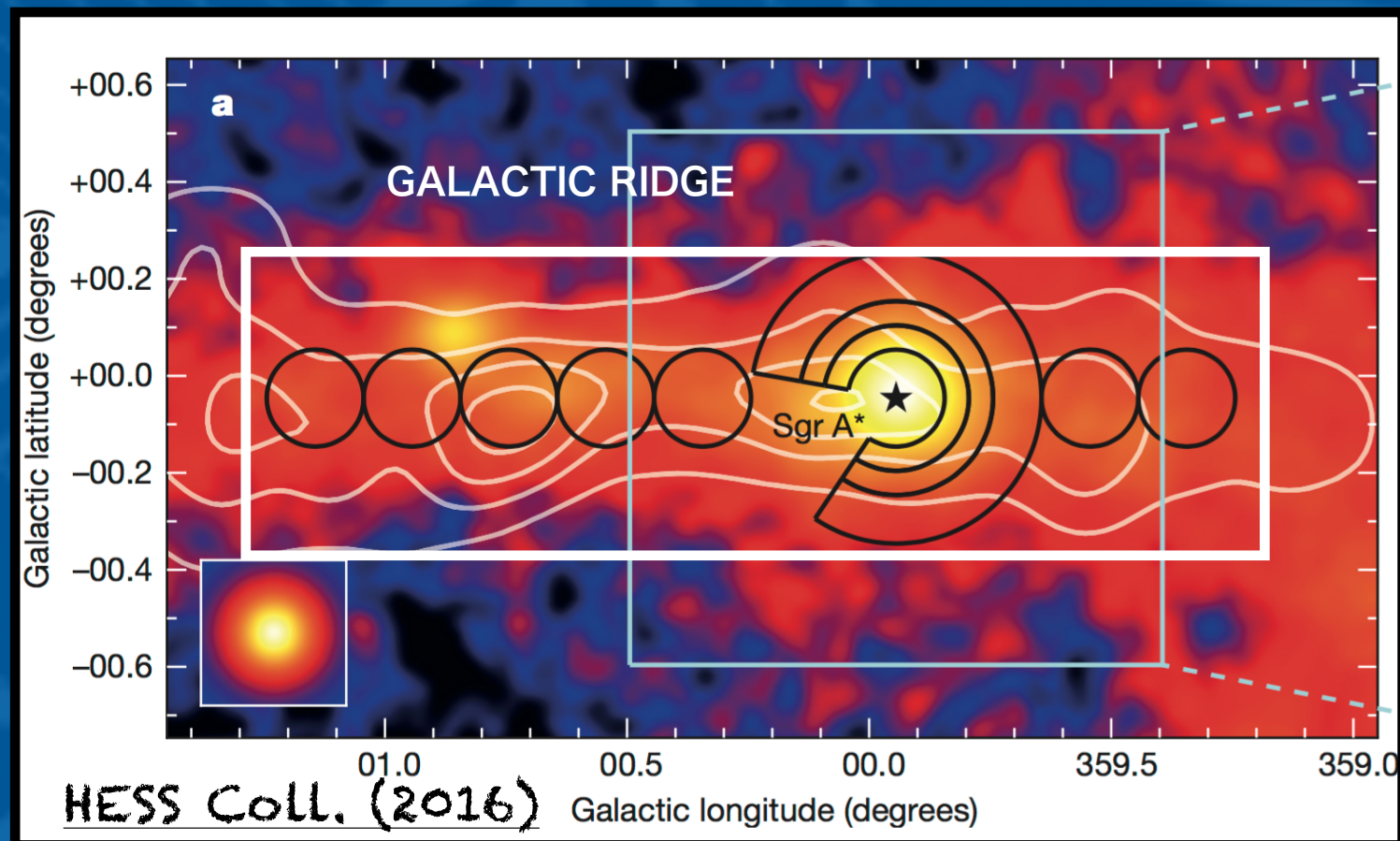
Acero et al. (2016)

$$D(E) = D_0 \left(\frac{E}{E_0} \right)^{\delta(r)}$$

$$\delta(r) = Ar + B$$

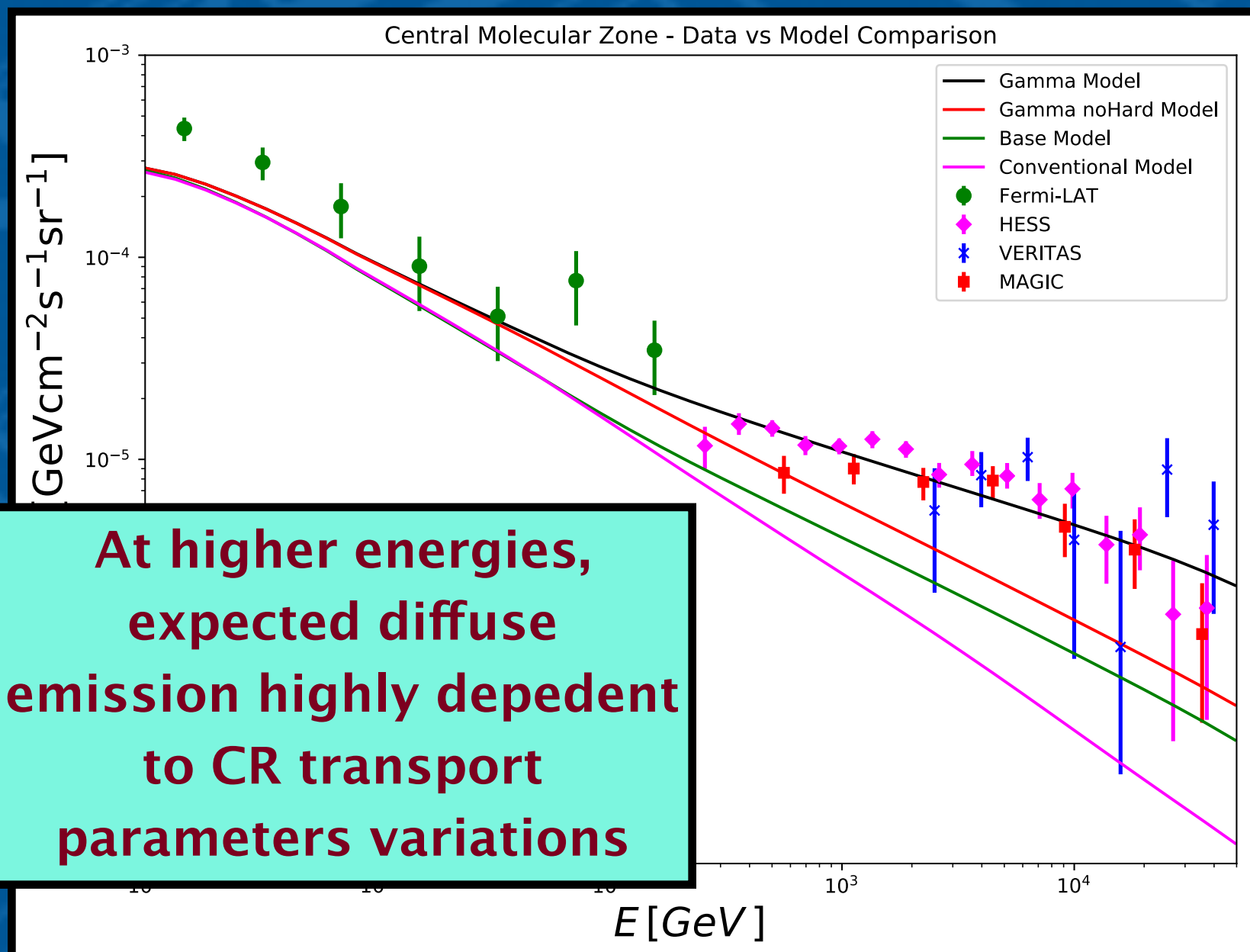
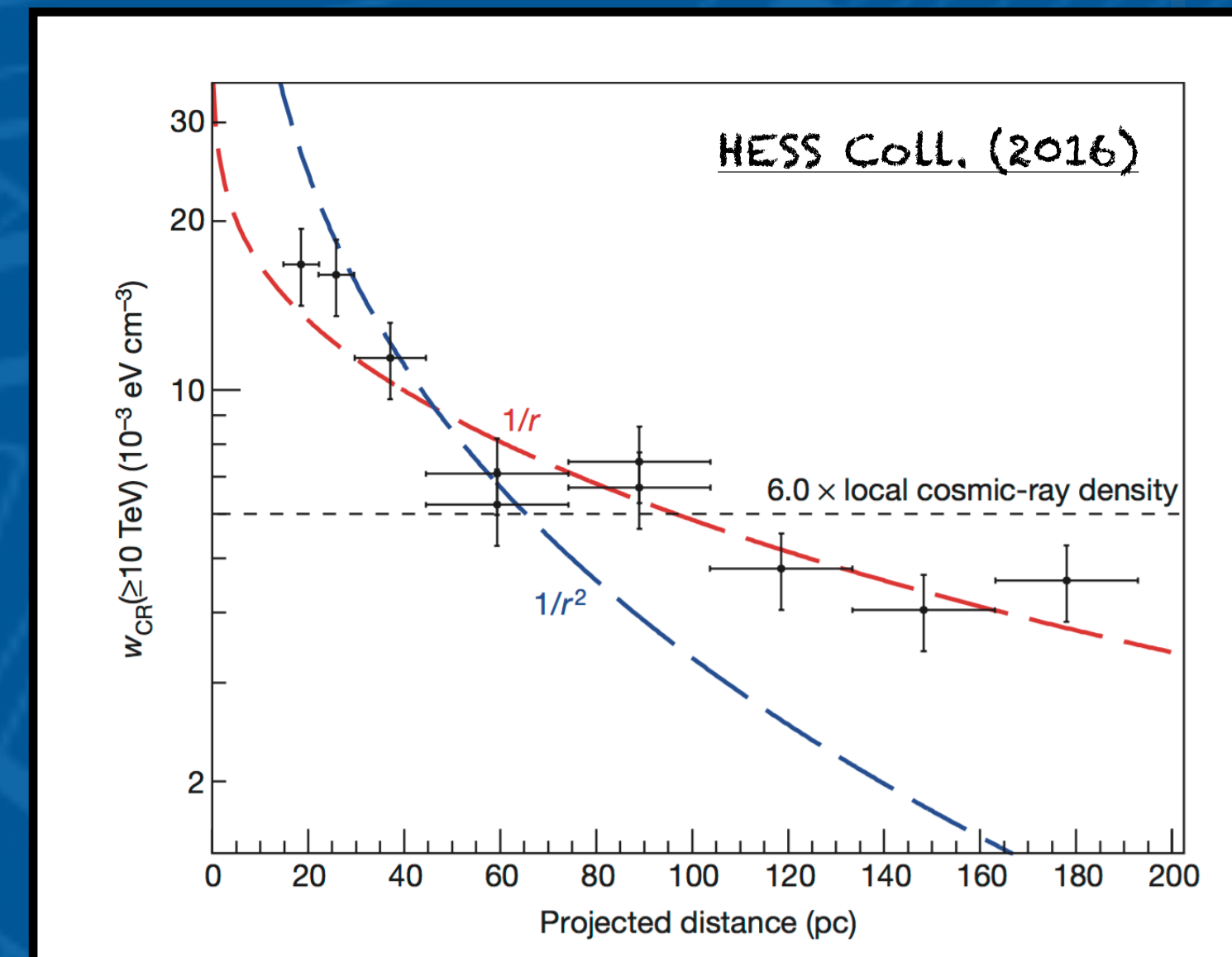


Large Scale Diffuse Emission & Background Models: CMZ



- VHE emission correlated with gas
- hard spectrum ($\Gamma \sim 2.3$, $\Gamma_{\text{Earth}} \sim 2.7$)
- Fresh accelerated CR hadron

Inferred CR density profile consistent with that expected from CR diffusing out stationary source & continuous CRs injection in the CMZ

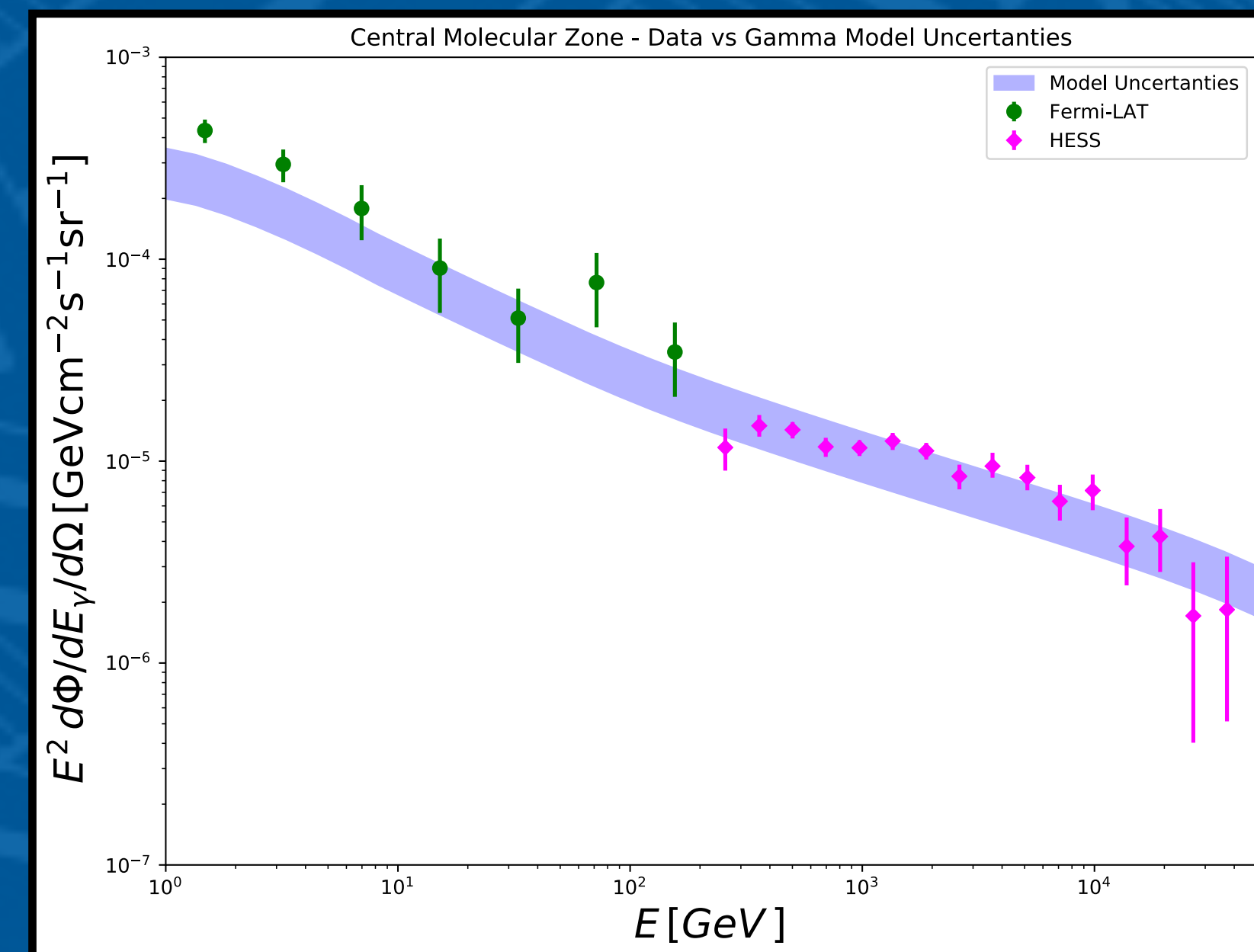


At higher energies, expected diffuse emission highly dependent to CR transport parameters variations

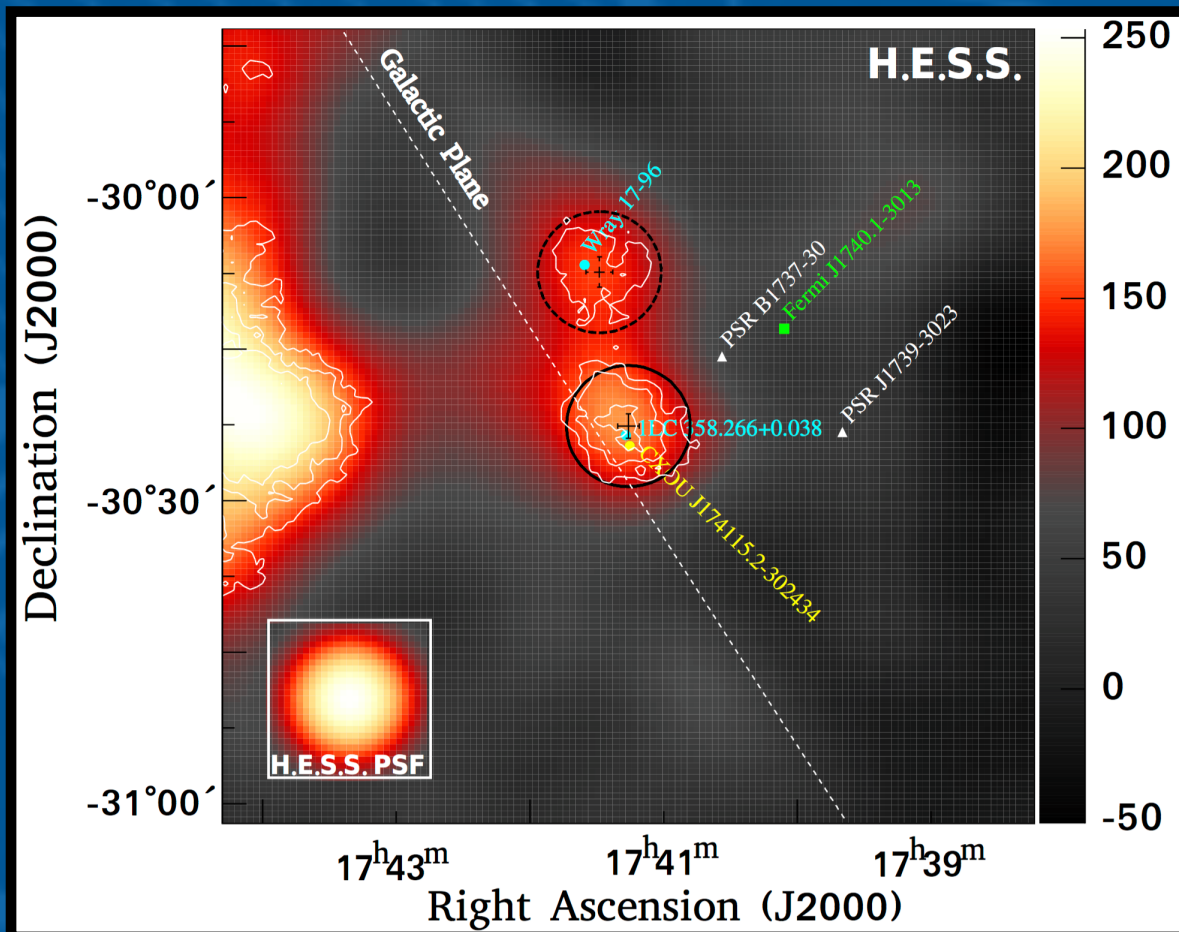
Alternative interpretation in terms of the large scale CR background (CR-sea) gets harder approaching the GC

$$\Gamma = 2.36 \pm 0.08$$

Presented @ ICRC2022, TAUP2023, TeVPA2023 by SV



Large Scale Diffuse Emission & Background Models: HESS J1741-302



$l = -1.7^\circ ; d \sim 260 \text{ pc}$
 $M = 6.8 \cdot 10^4 M_\odot$
 $\Gamma \sim 2.3$

HESS J1741-302 natural target to probe how/if CR population properties change with R

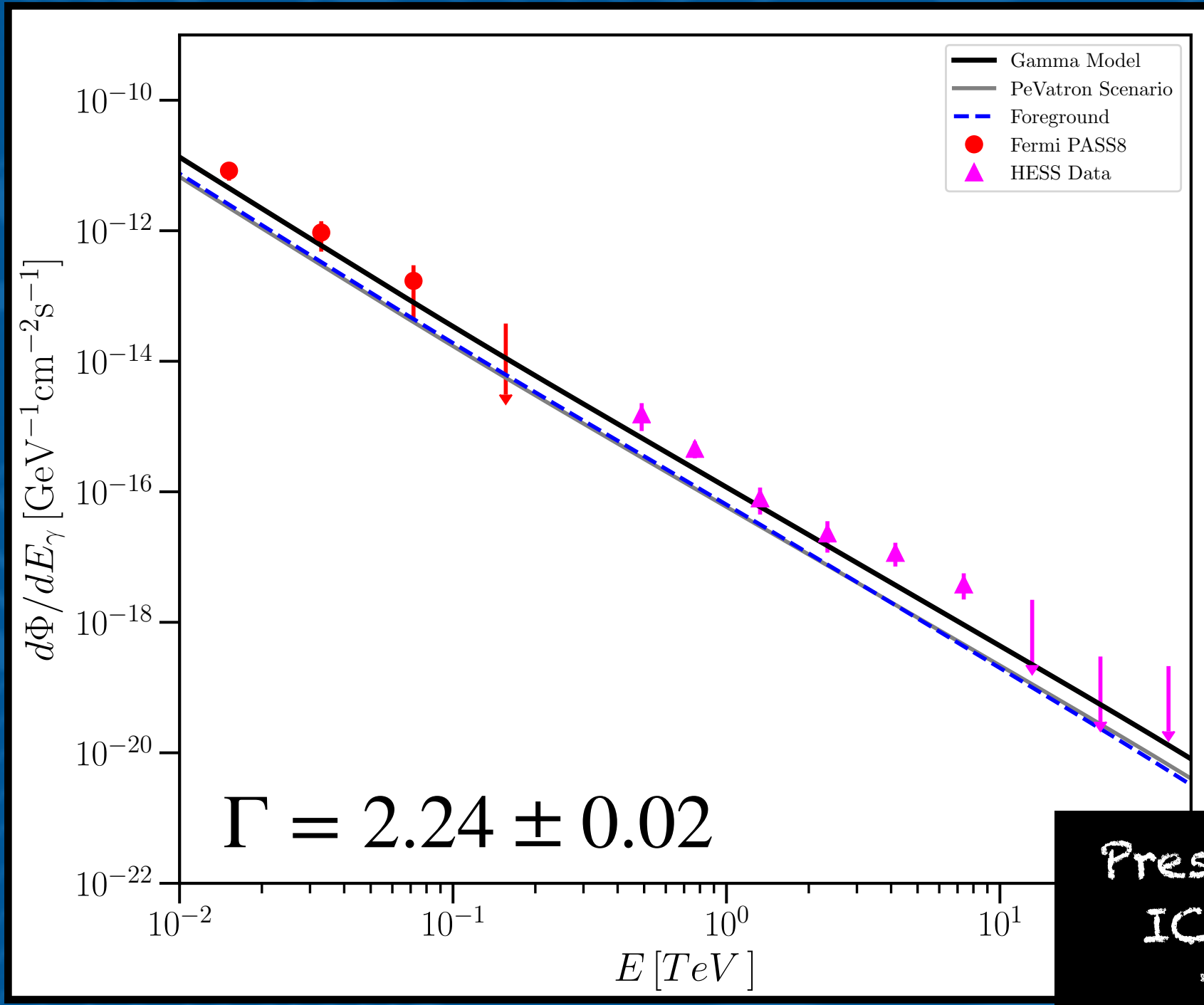
Spectrum extends up to 10 TeV, no evidence cutoff

Hadronic scenario favored
Active or passive source?

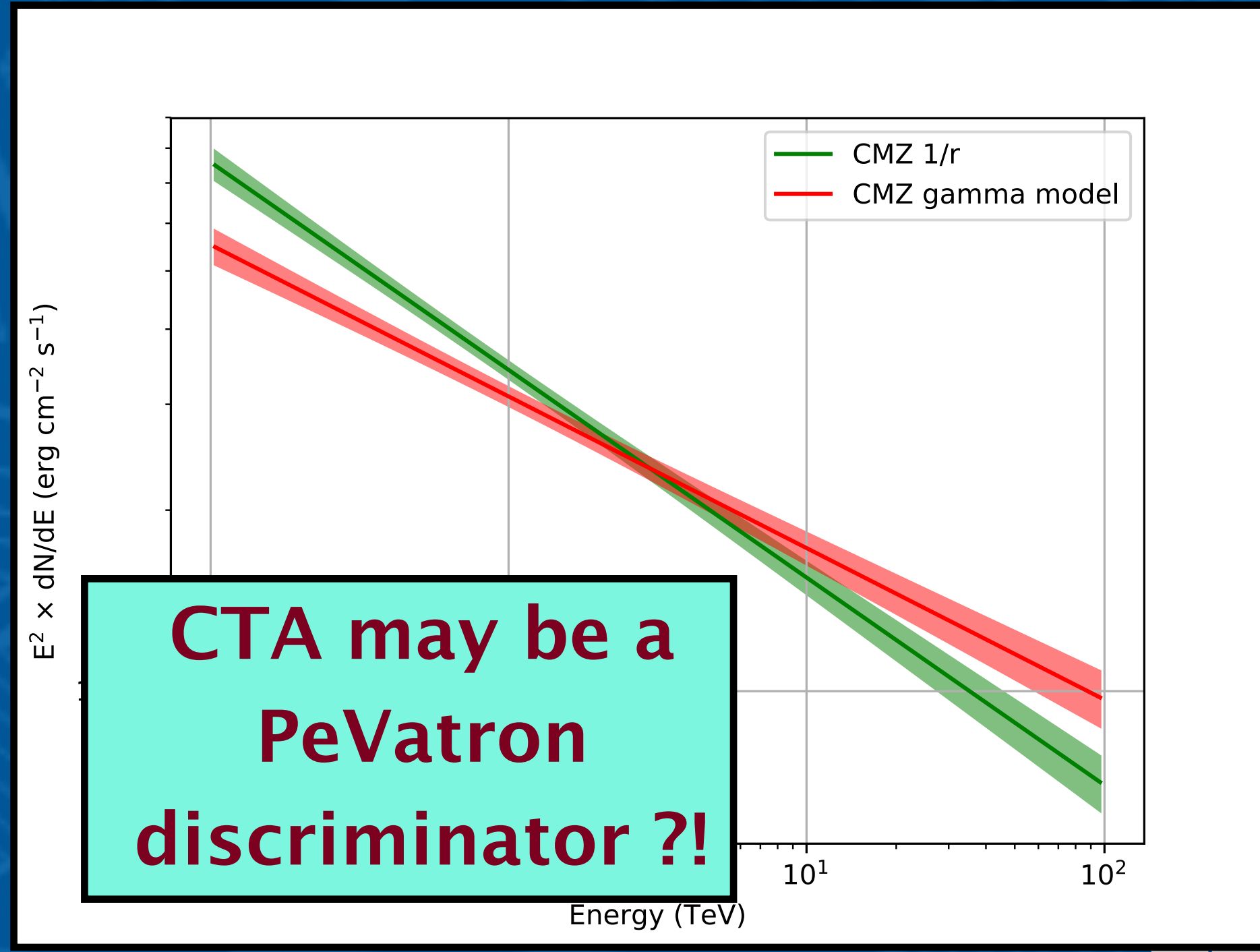
H.E.S.S. Collab. (2018)

In CMZ both scenarios explain VHE emission

Moving at CMZ edge for discriminating among interpretations

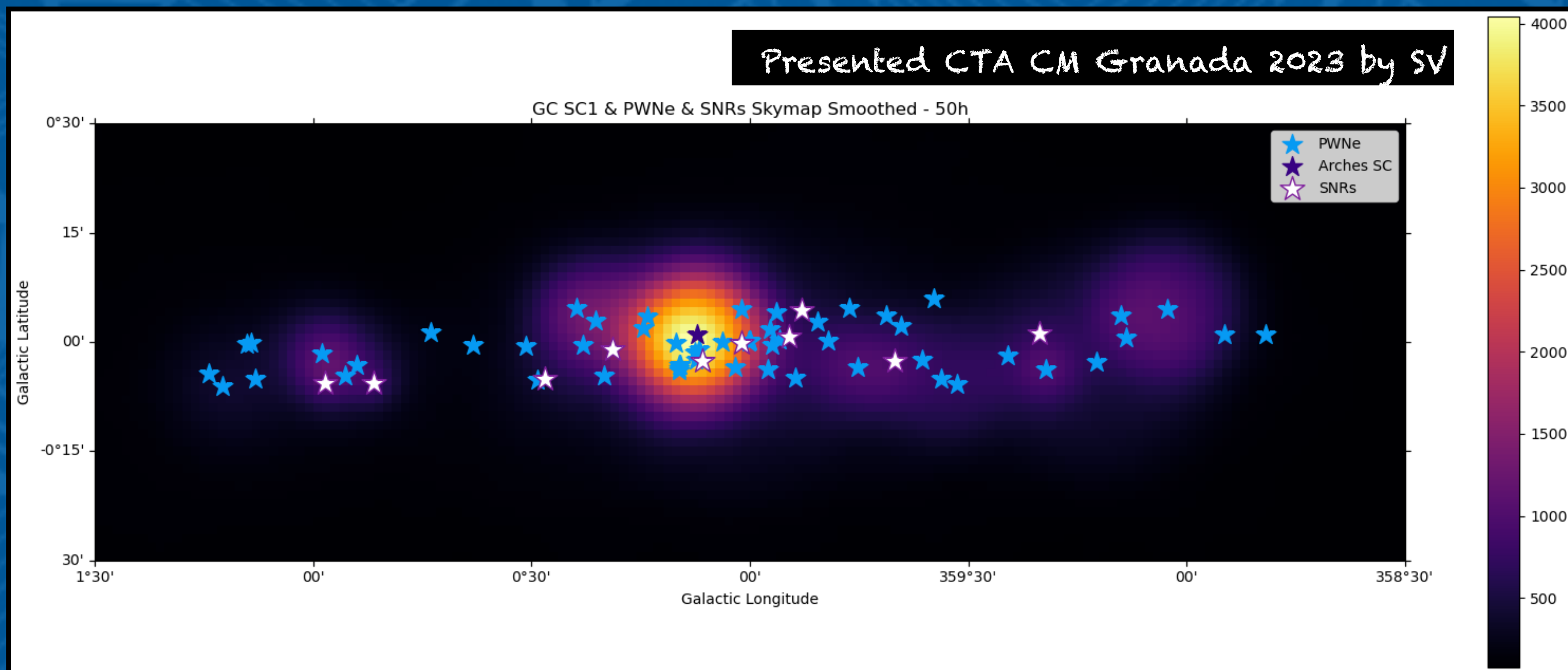


Presented @ ICRC2019, ICRC2022, TAUP2023, TeVPA2023 by SV

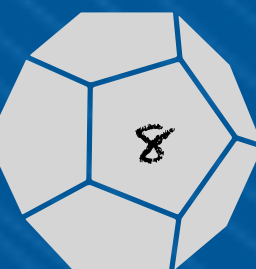


CTA may be a PeVatron discriminator ?!

- High SN rate in Galactic Center \Rightarrow many CR accelerators (Jovin et al – 2017)
- Multiple events sampling: 10 h and 50 h
- IRF: Prod 5 South
- Location: CTA South
- Pointing: $(l, b) = (0, 0)$ deg
- Software: gammapy v1.0
- Diffuse IEM template: IEM_VariableMin_Inter_fullErange_v1.fits.gz
- Stellar Cluster Arches 1 (1 source)
- PWNe synthetic population (68 sources)
- SNRs synthetic population (10 sources)



Synthetic population will be included in DC II



- Observational proposal: MAGIC + LST-1 of HESS J 1848-018 → potential young stellar cluster PeVaton
- LST GC WG
- Extragalactic WG: variability and extreme blazars



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