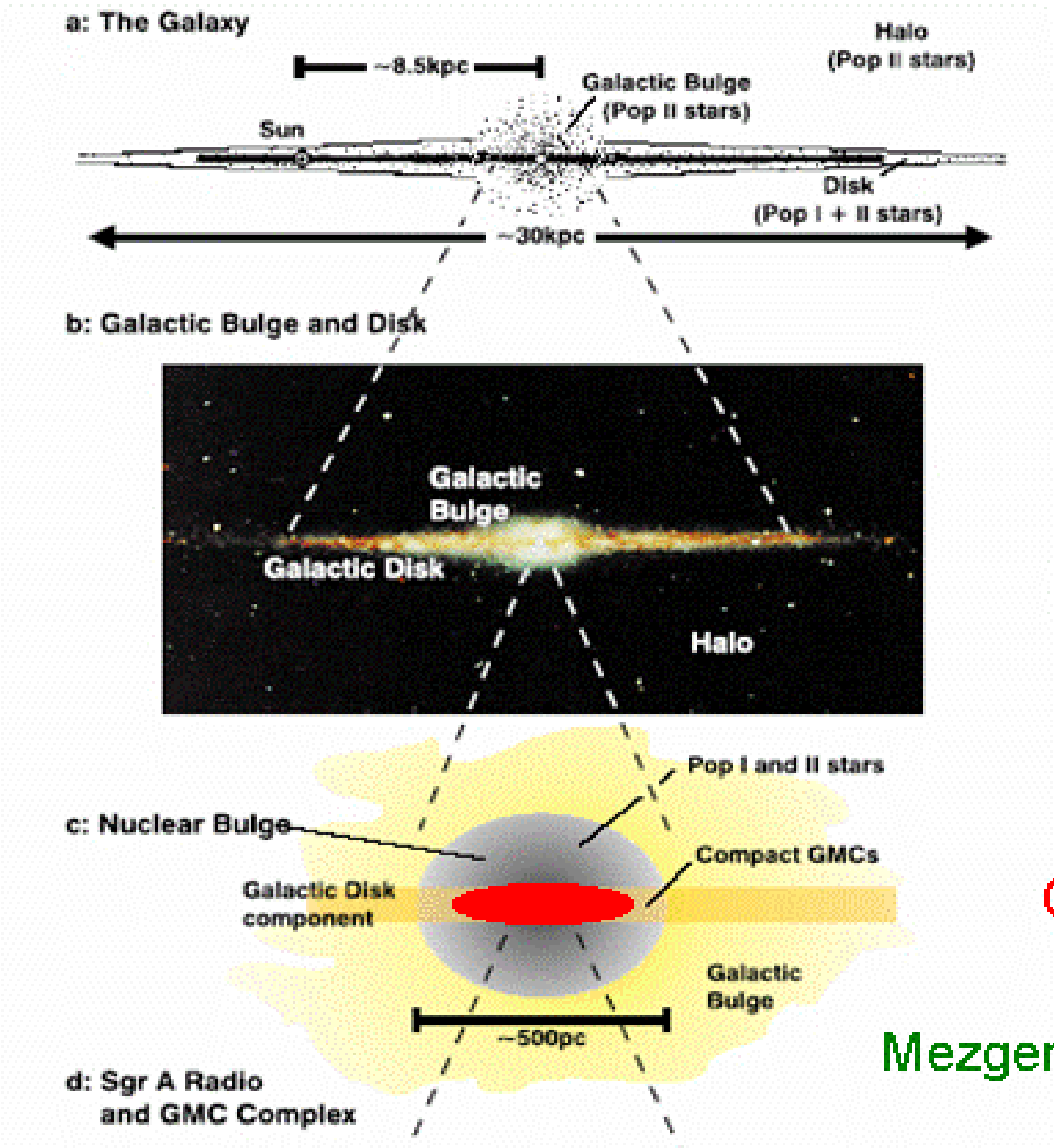
The Central Molecular Zone (CMZ)



~10% Galaxy's molecular gas

$M \sim 5 \times 10^7 M_\odot$
Dominantly molecular
Dense clouds, $n(H_2) > 10^4$ cm^{-4}
Volume filling factor 0.1
Hot gas T ~ 300 K
High velocity dispersion -turbulent!
Low dust temperature T ~ 20-30 K

Morris, Serabyn, ARA&A (1996)

CMZ

Mezger, Duschl, Zylka, A&A Rev. (1996)

Credit: T. Oka

Galactic Center Region at 90 cm ~ 300 pc

Nonthermal (radio-emitting) filaments **NTFs**

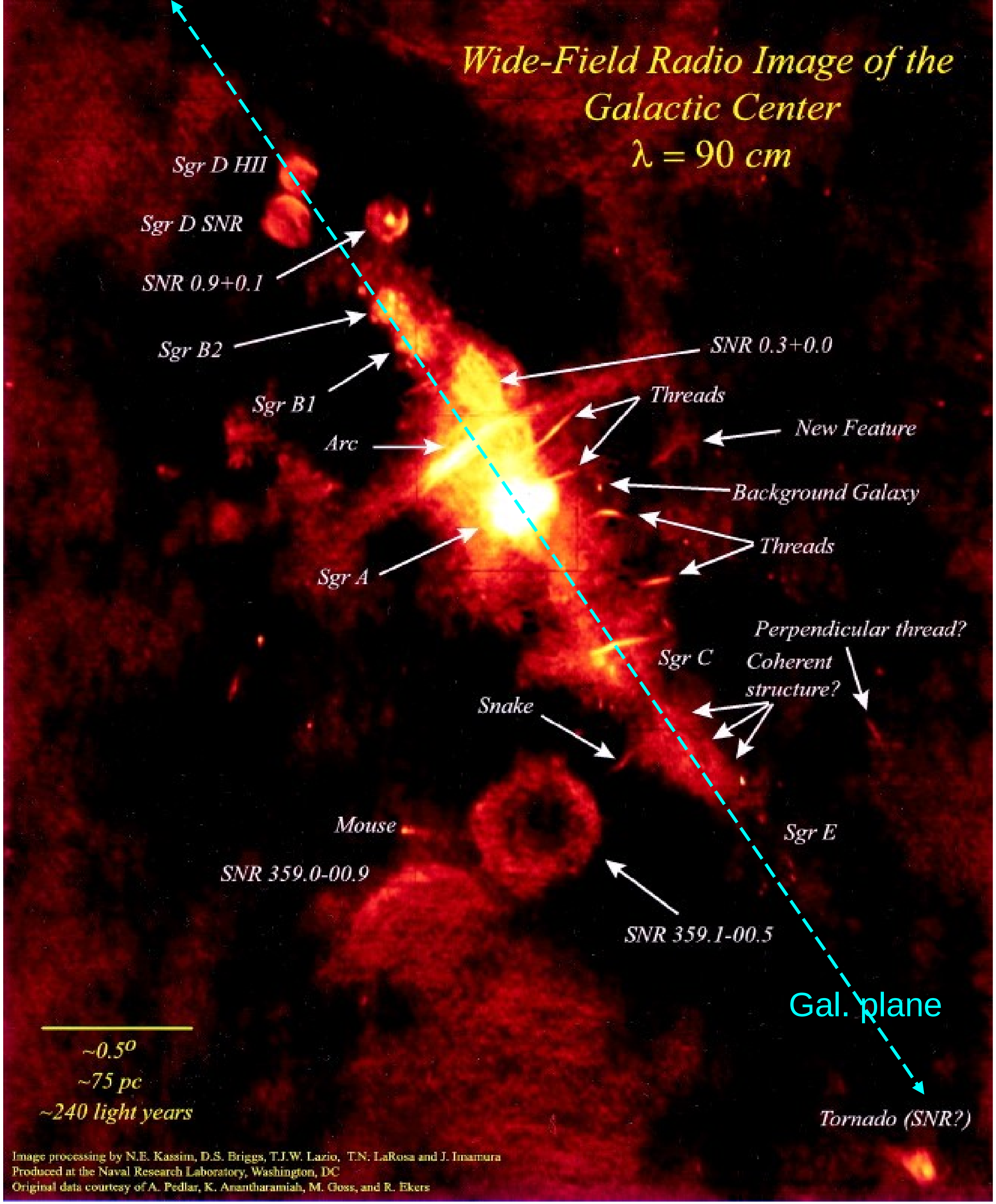
Large scale magnetic fields and relativistic electrons

SNRs, HII regions

Poloidal magnetic field within ~100 pc of nucleus

Sgr A: compact radio sources at nucleus of Milky Way (3×10^6 solar mass BH)

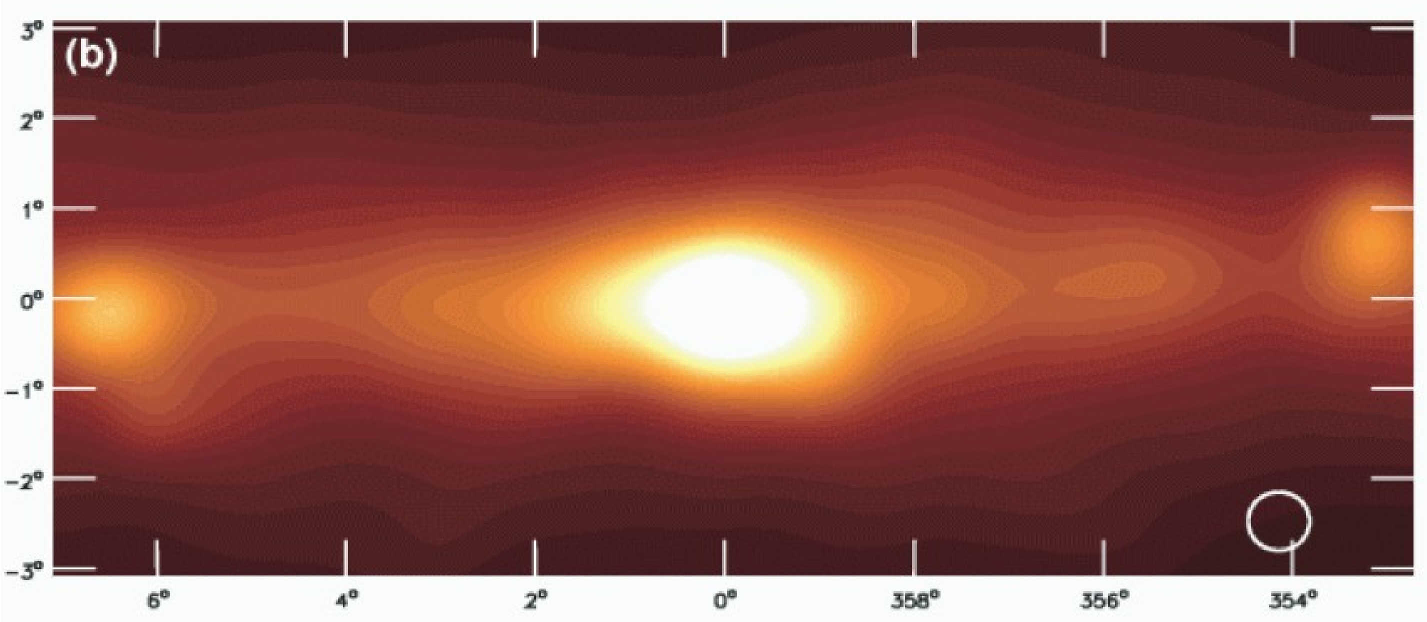
LaRosa et al. (2000)



Credit: Dermer and Atoyan

Magnetic Field?

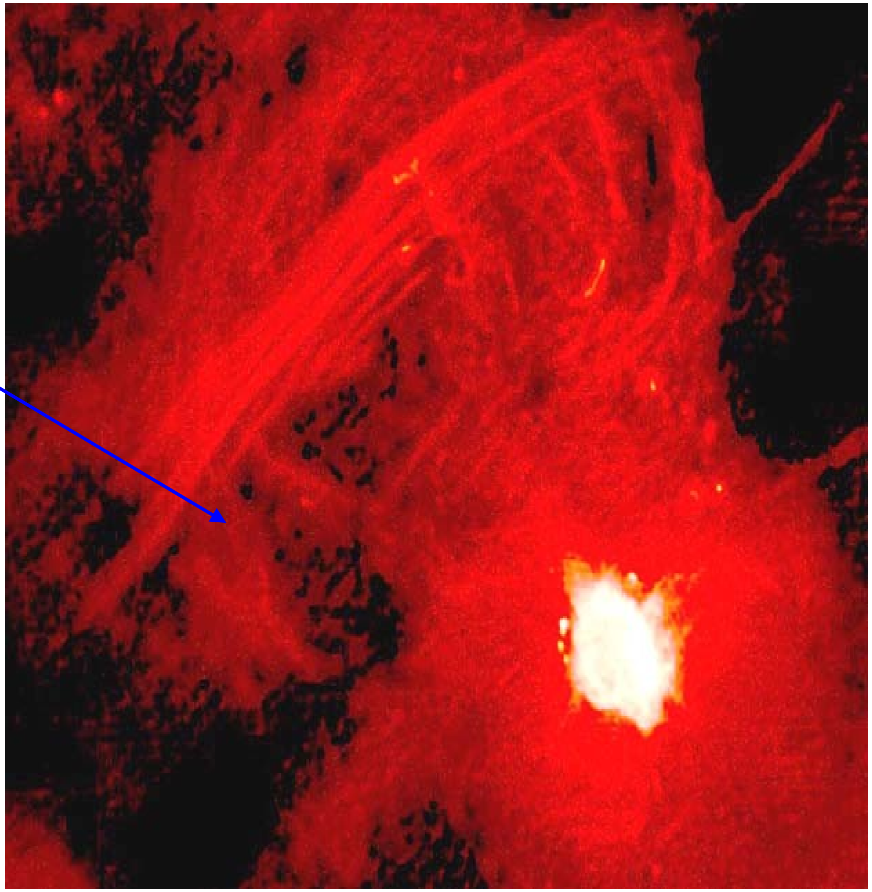
- Large-scale magnetic field amplitude is uncertain by two orders of magnitude
- "Equipartition" between CR and magnetic energy densities favours ~10 μG field (e.g. LaRosa et al 2005). On the other hand…



330 MHz GBT

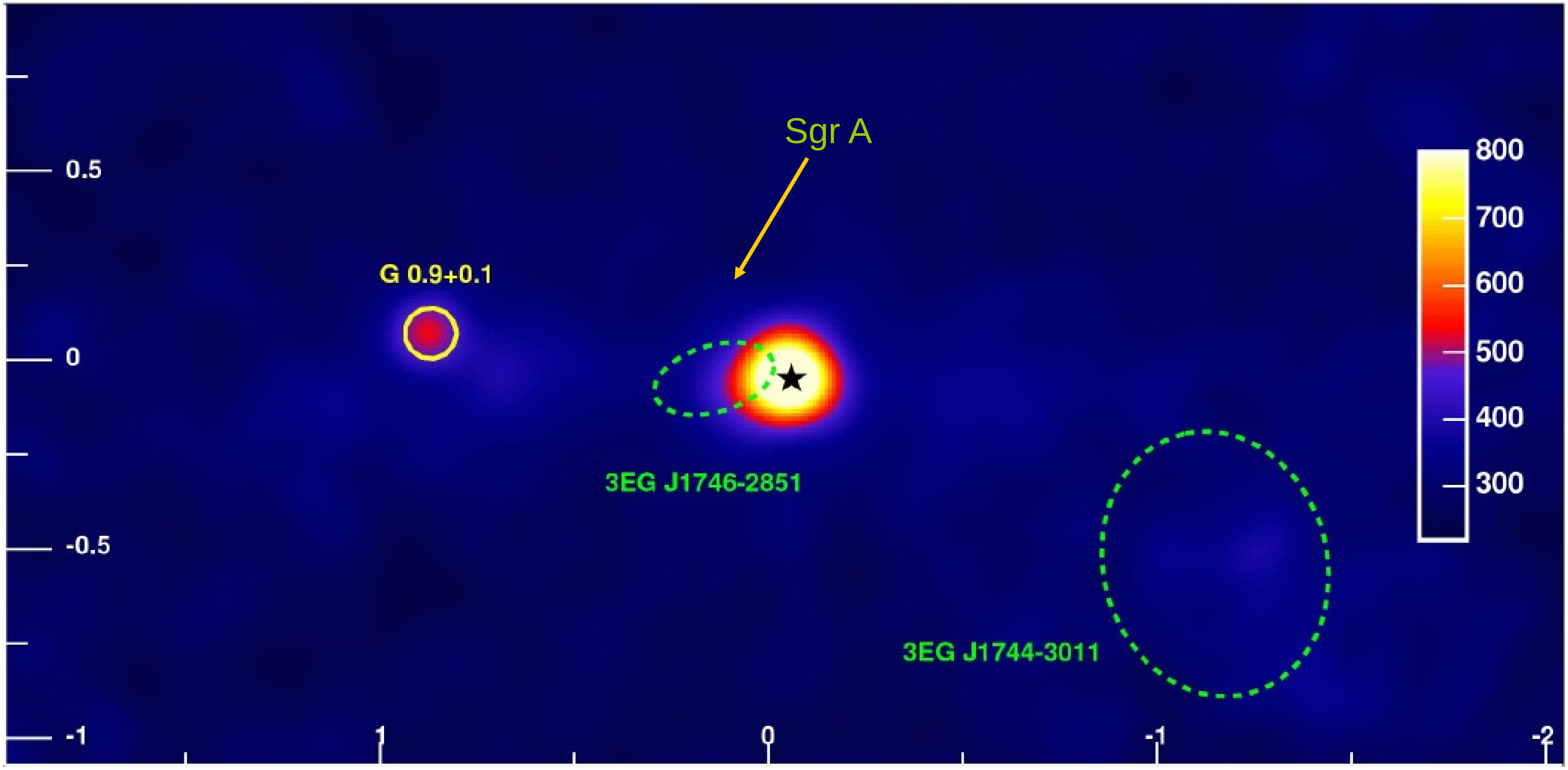
Magnetic Field?

- Non-thermal filament observations favour ~mG field (Morris and co-workers).



Credit: Yusef-Zadeh/VLA

HESS GC Observations



- 50 hour H.E.S.S. Observation of GC in 2005
- Need to subtract the two bright sources

Credit: HESS Collab

What is the mechanism for gammaray production?

1. *Leptonic models* - high-energy electrons (10 TeV+) inverse-Compton scatter ambient light to TeV energies
2. *Hadronic models* - protons (and heavier ions) collide with ambient gas (H_2) and produce pions
3. Dark matter annihilation?

What is the mechanism for gammaray production in Sgr A?

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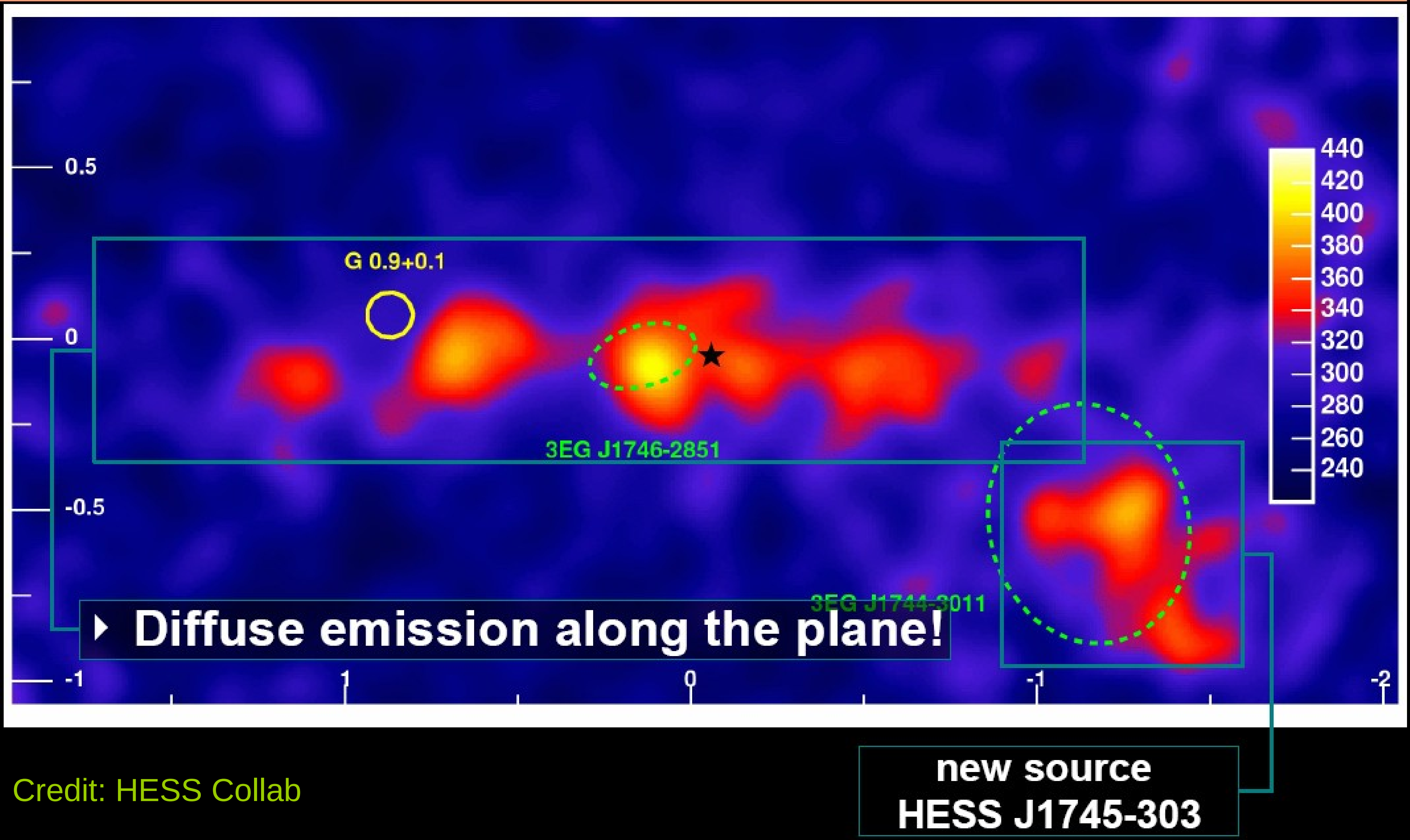
?

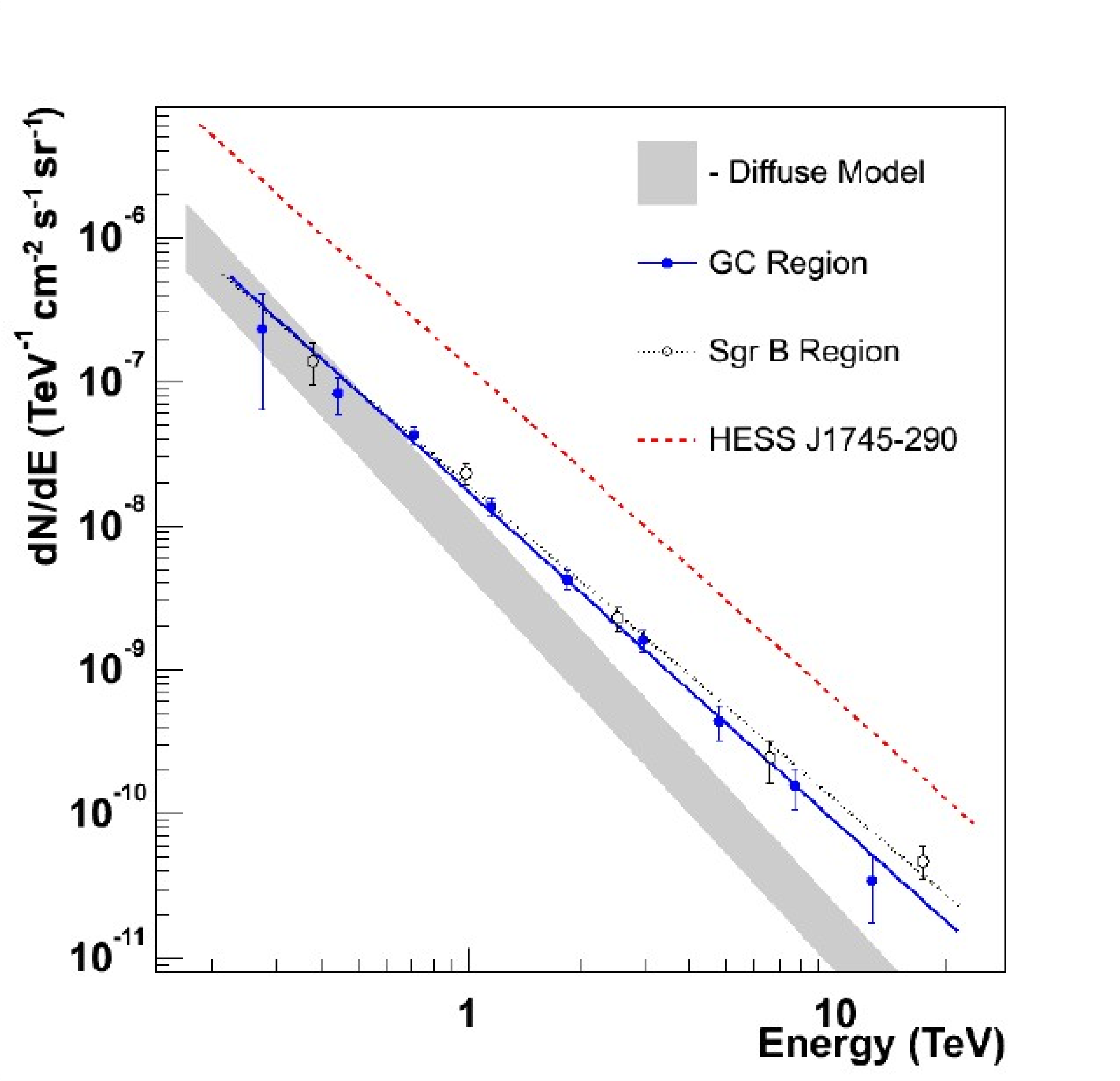
Residuals after source subtraction



Credit: HESS Collab

Energy Spectrum

- The Galactic Centre Source: HESS J1745-290
  - (solid angle is integration radius used – source looks point-like)
- All emission in the GC has
  - $\Gamma_\gamma \approx 2.2$



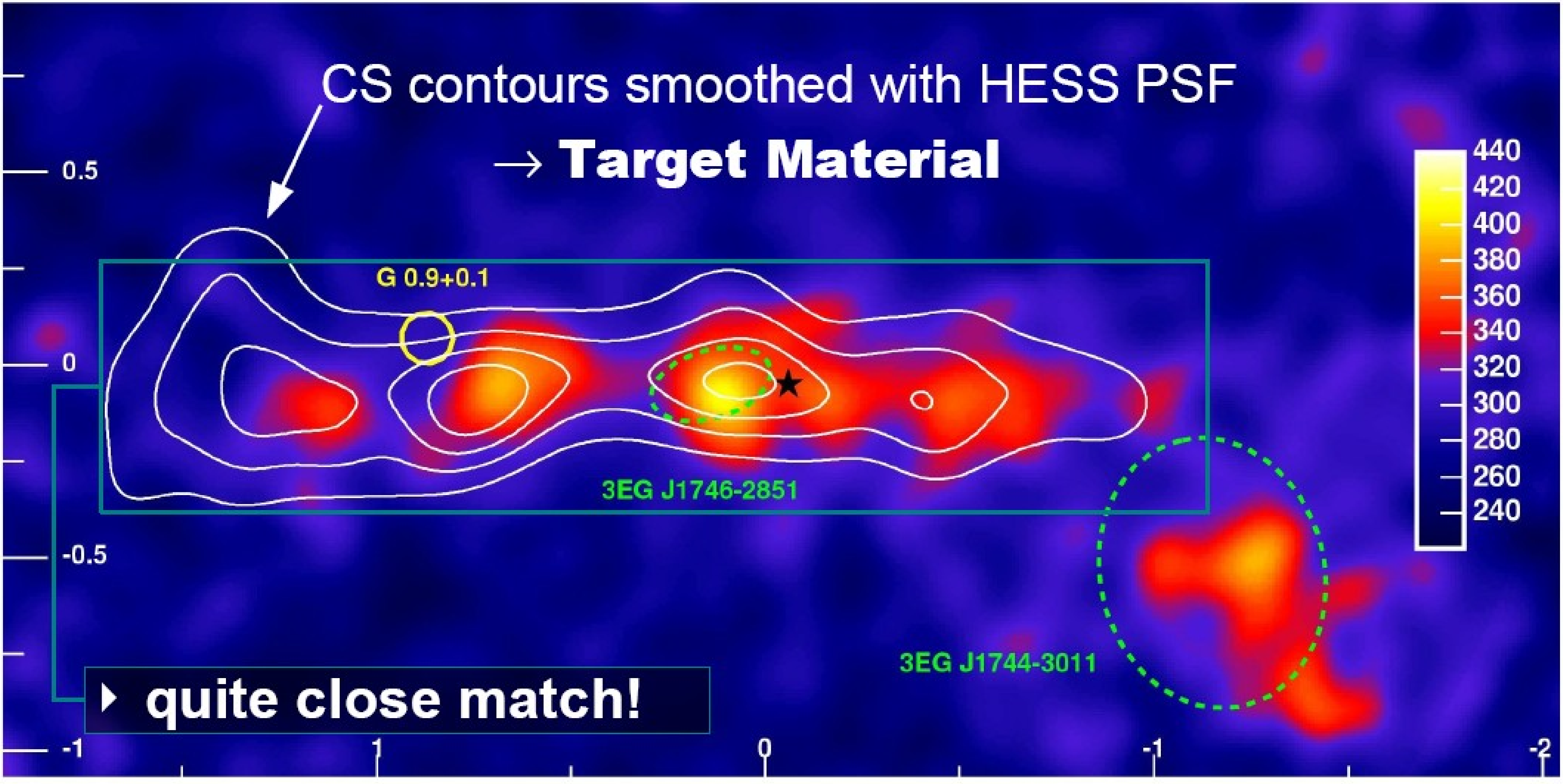
Credit: HESS Collab

Protons or electrons for CMZ emission?

- If electrons
  - Why the correlation with the molecular material?
  - Strong magnetic fields ⇒ short cooling times ⇒ compact sources with X-ray counterparts…*not seen*

- If protons
  - Angular correlation between gas and γ-rays naturally explained

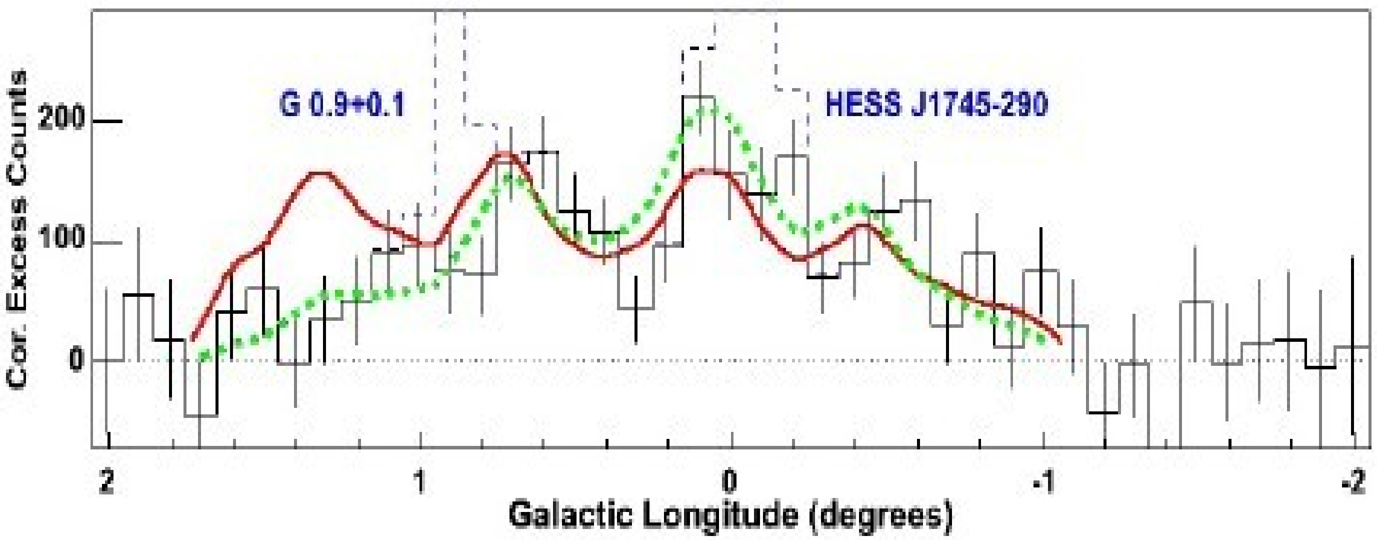
CS contours over H.E.S.S. map



Credit: HESS Collab

CS contours from Tsuboi et al. (1999)

Galactic Ridge



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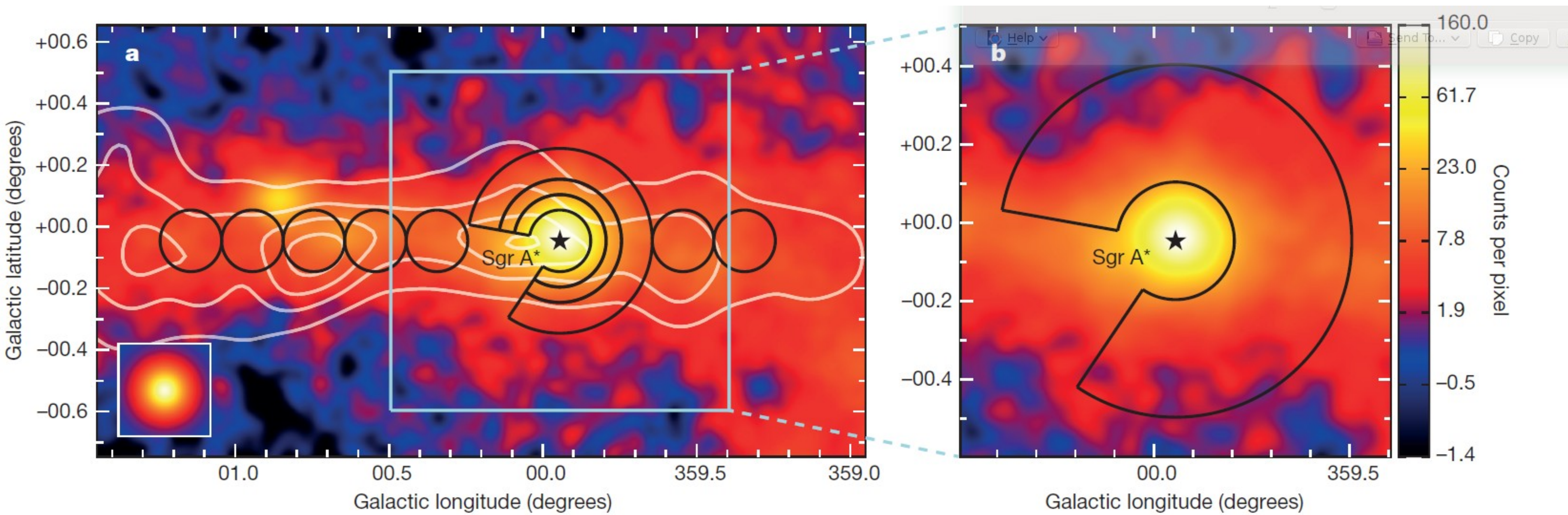
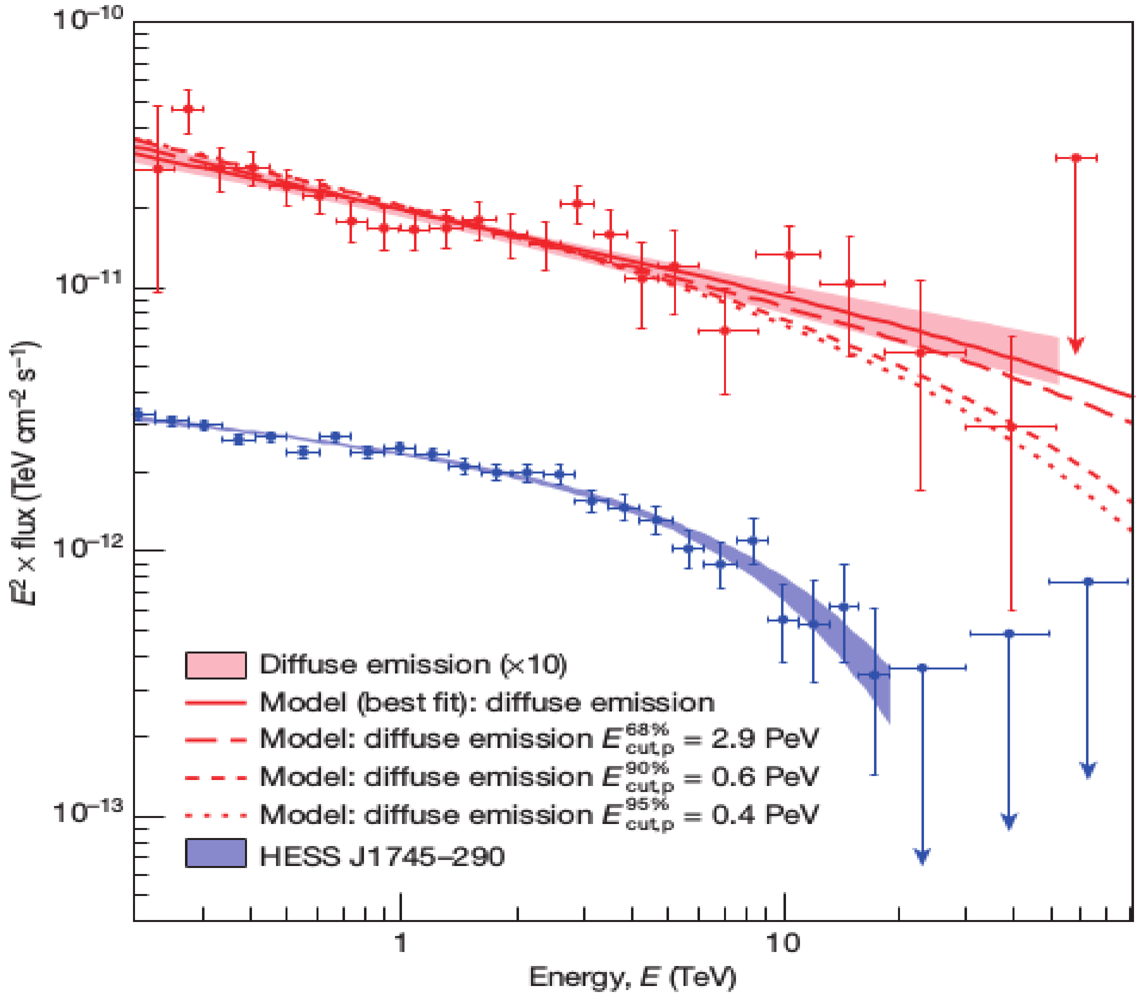
Where are the requisite CRs coming from?

- Spectrum much harder than local CR population
- Spectral index of the diffuse emission and the GC point source are so similar $\Rightarrow$ common accelerator?
  - (at Sgr A*?)

HESS Galactic Center



HESS Galactic Center



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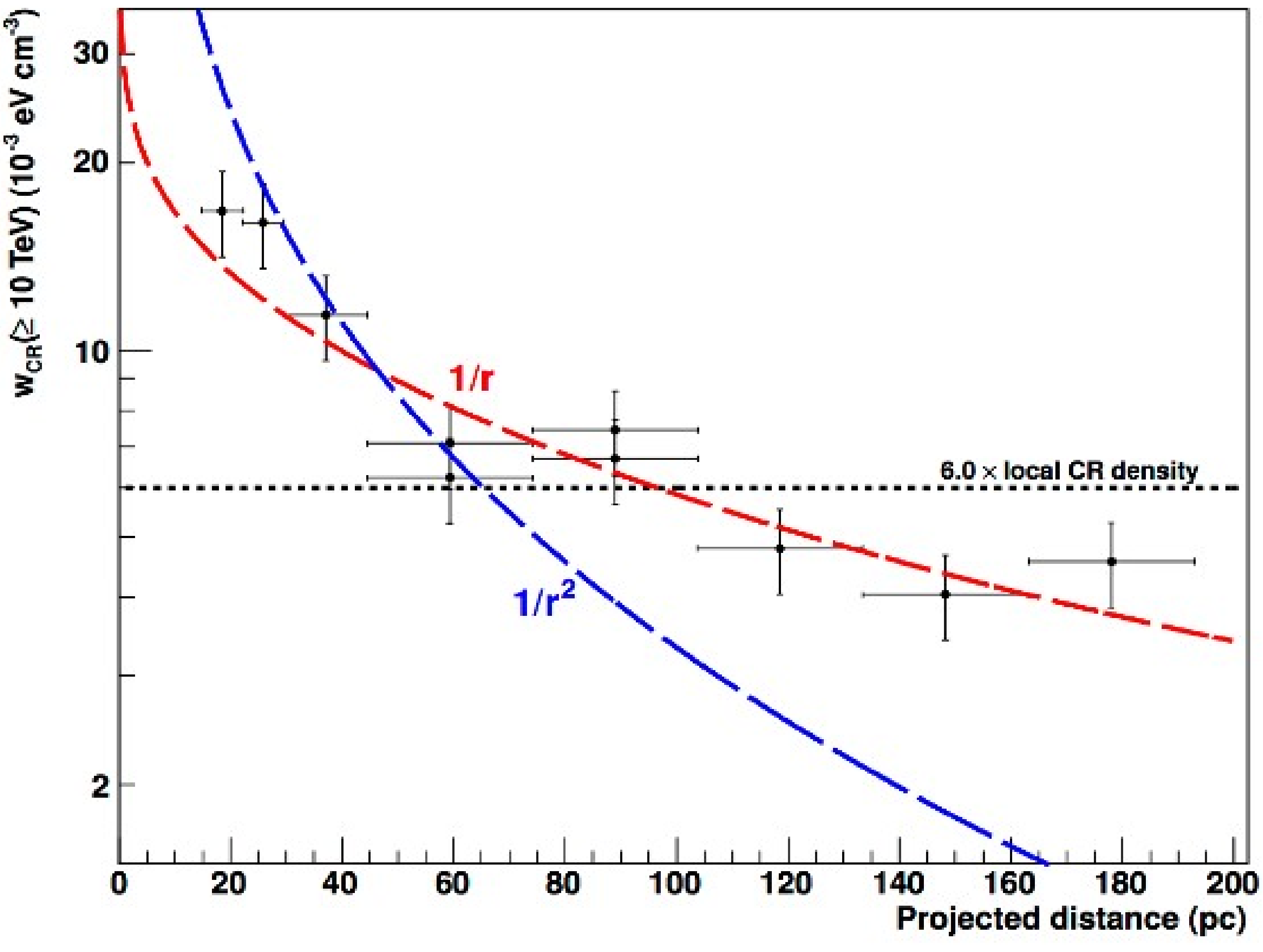

Diffusion of CR in the ISM

$$\frac{dn(E,r)}{dt} = D(E)\nabla^2 n(E,r) - \frac{\partial}{\partial E} n(E,r) b(E) + Q(E,r)$$

Diff. in physical space

Energy losses

Source

Diffusion of CR in the ISM

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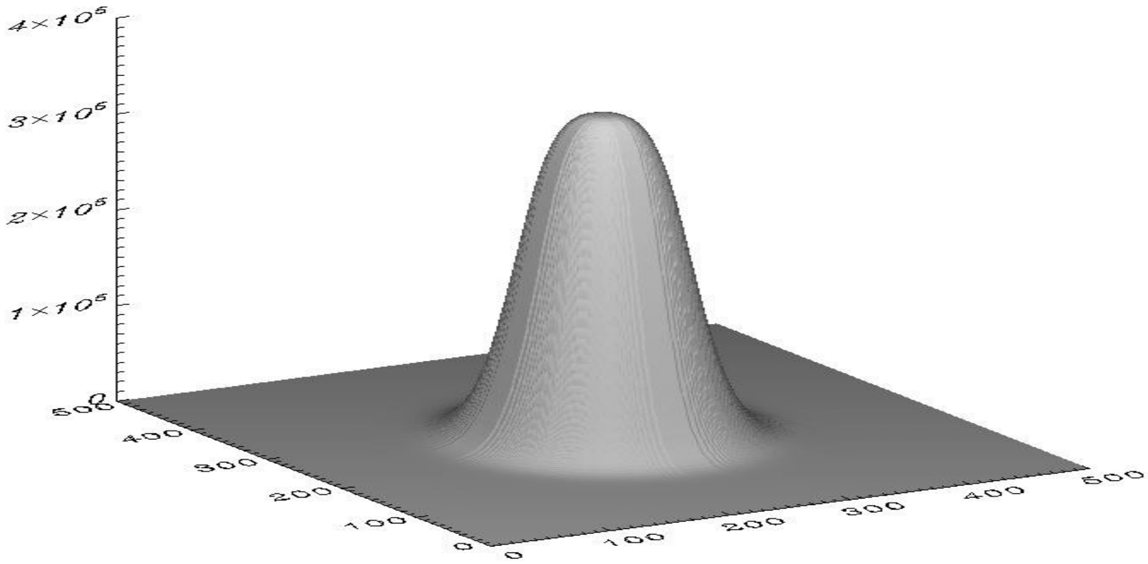
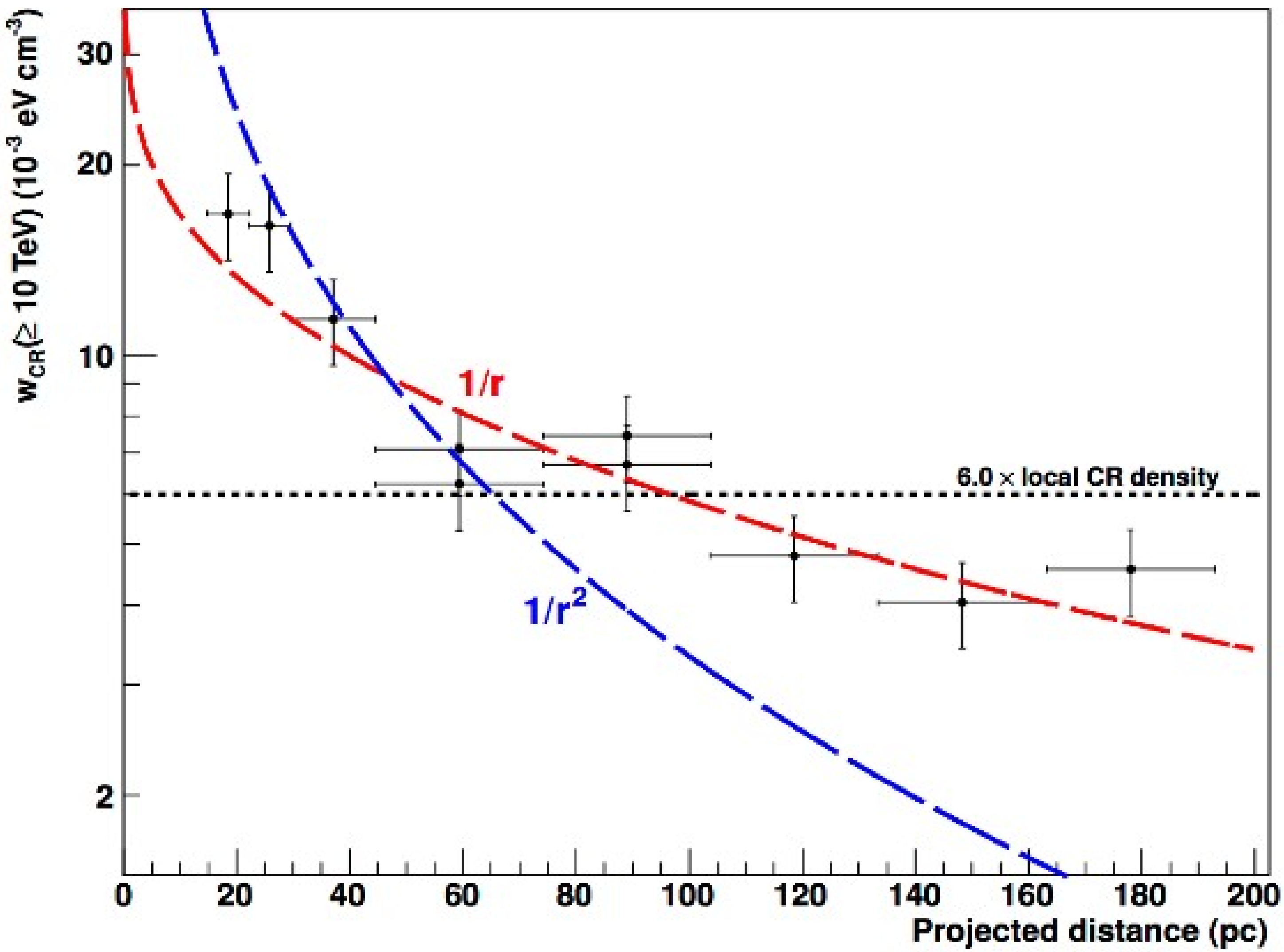


For an impulsive source and ignoring E losses :

$$n(E,r) = \frac{S}{\sqrt{\pi D t}} \exp\left[\frac{-x^2}{4Dt}\right]$$

$$R_{diff}(E,t) = 2\sqrt{D(E)t}$$

HESS Galactic Center

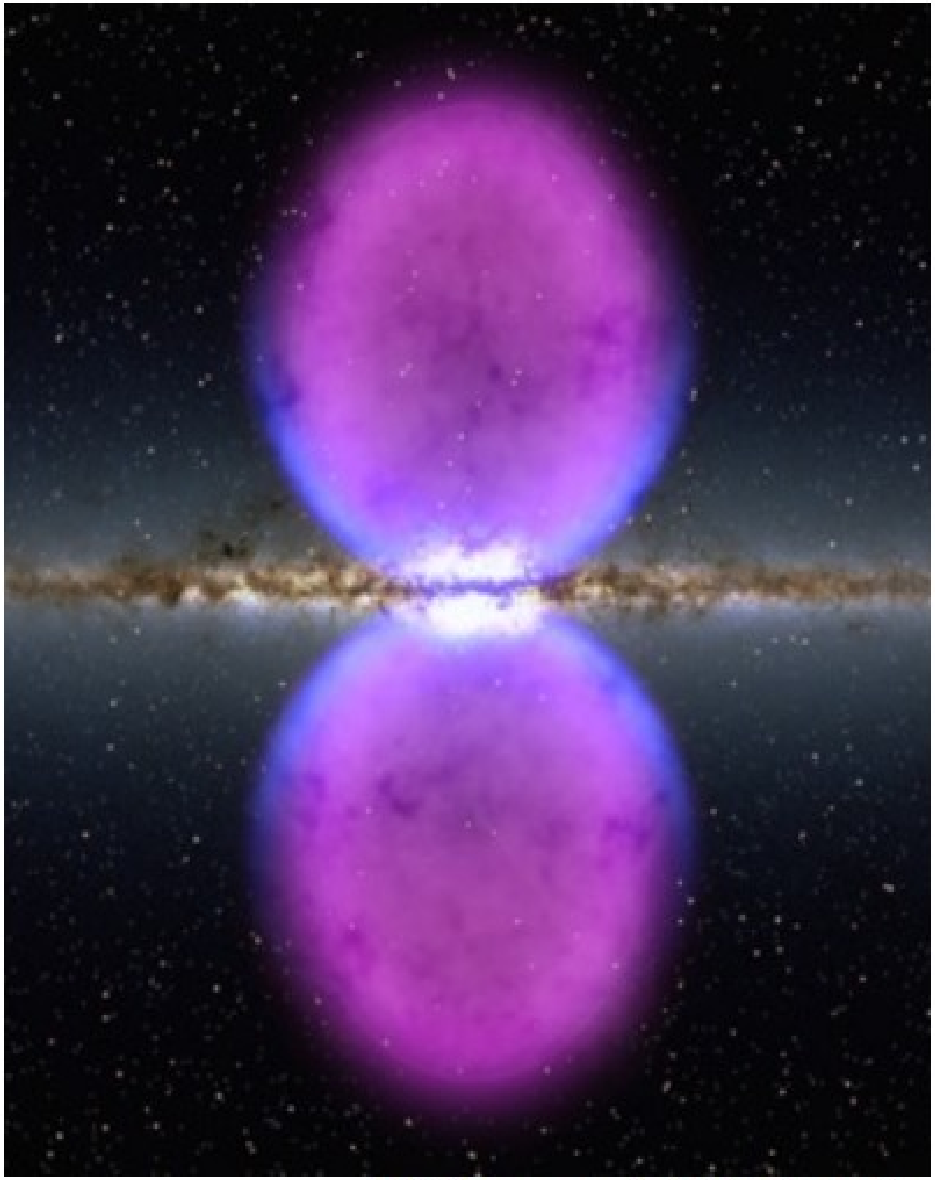


Fermi Bubbles: a new *galactic* structure

- Fermi-LAT discovery
  - spheroids, D≈8 kpc
  - 0.5 – 500 GeV γ rays

Su, Slatyer & Finkbeiner, ApJ. 724, 1044 (2010)

- possible origins
  - exotic
  - leptonic
  - *hadronic → neutrino counterpart!*



Artist's concept, NASA/GSFC