Cosmic-Ray Models of the Ridge-Like Excess of Gamma Rays in the Galactic Centre

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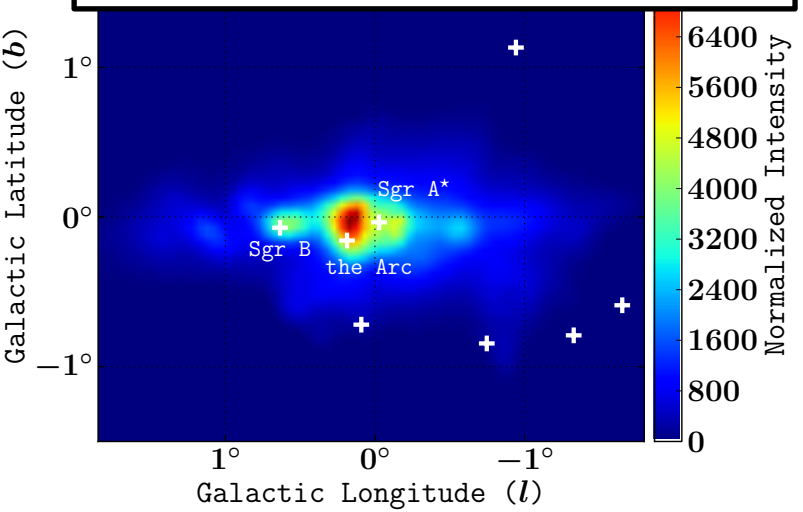
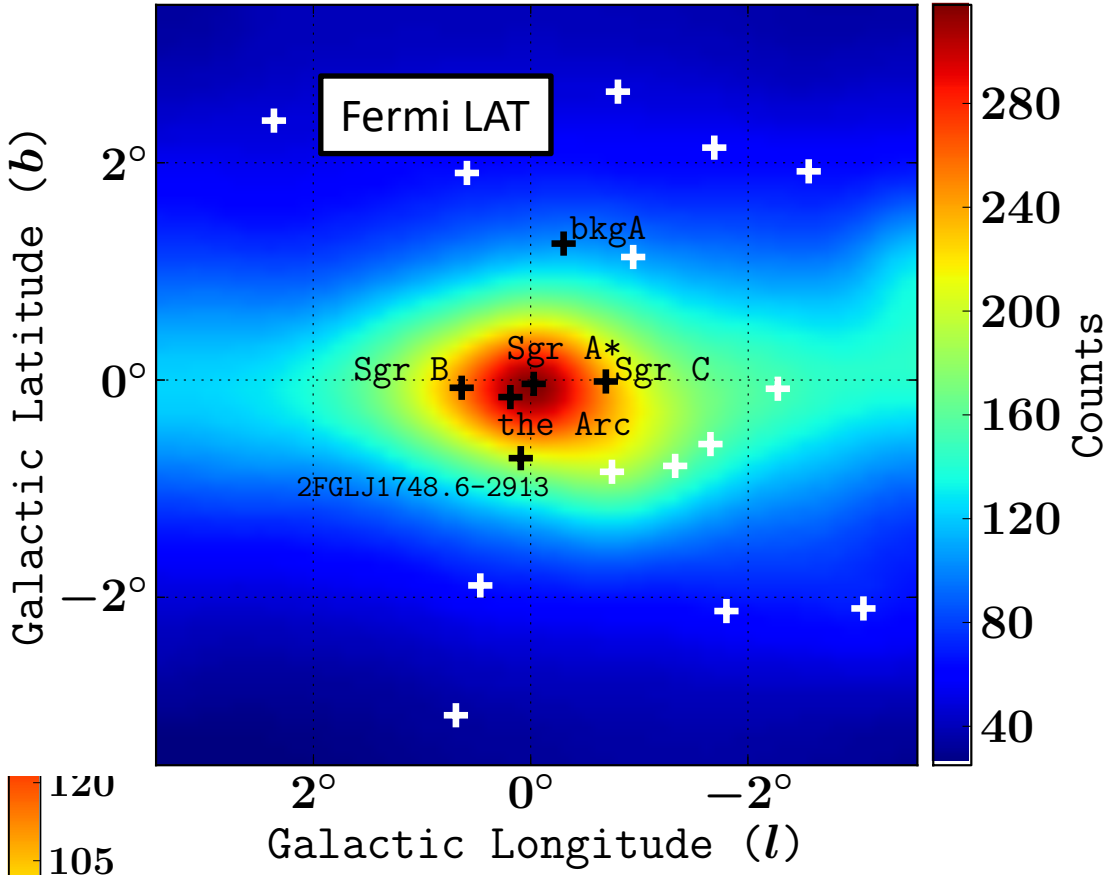
CG and O. Macias, Phys. Rev. D (2013)

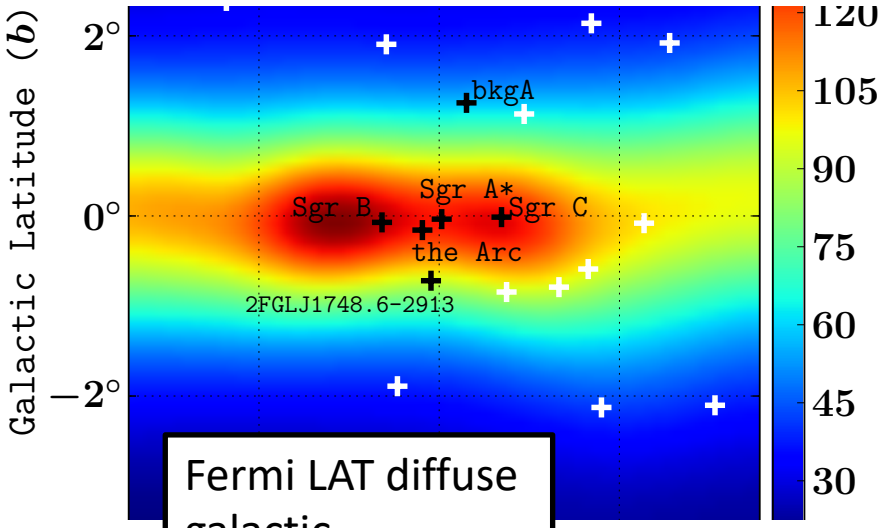
O. Macias and CG, Phys. Rev. D (2014)

O. Macias, CG, R. Crocker, S. Profumo, MNRAS (2015)

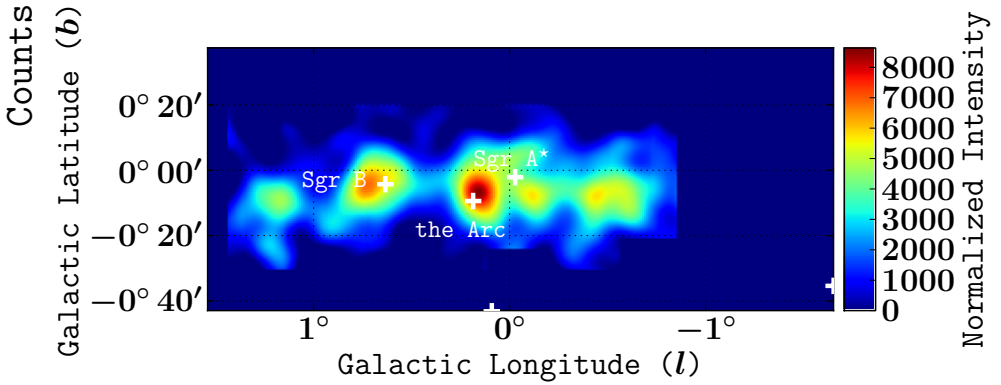
20 cm continuum, based on GBT continuum emission data which measures nonthermal and thermal plasma distributions.





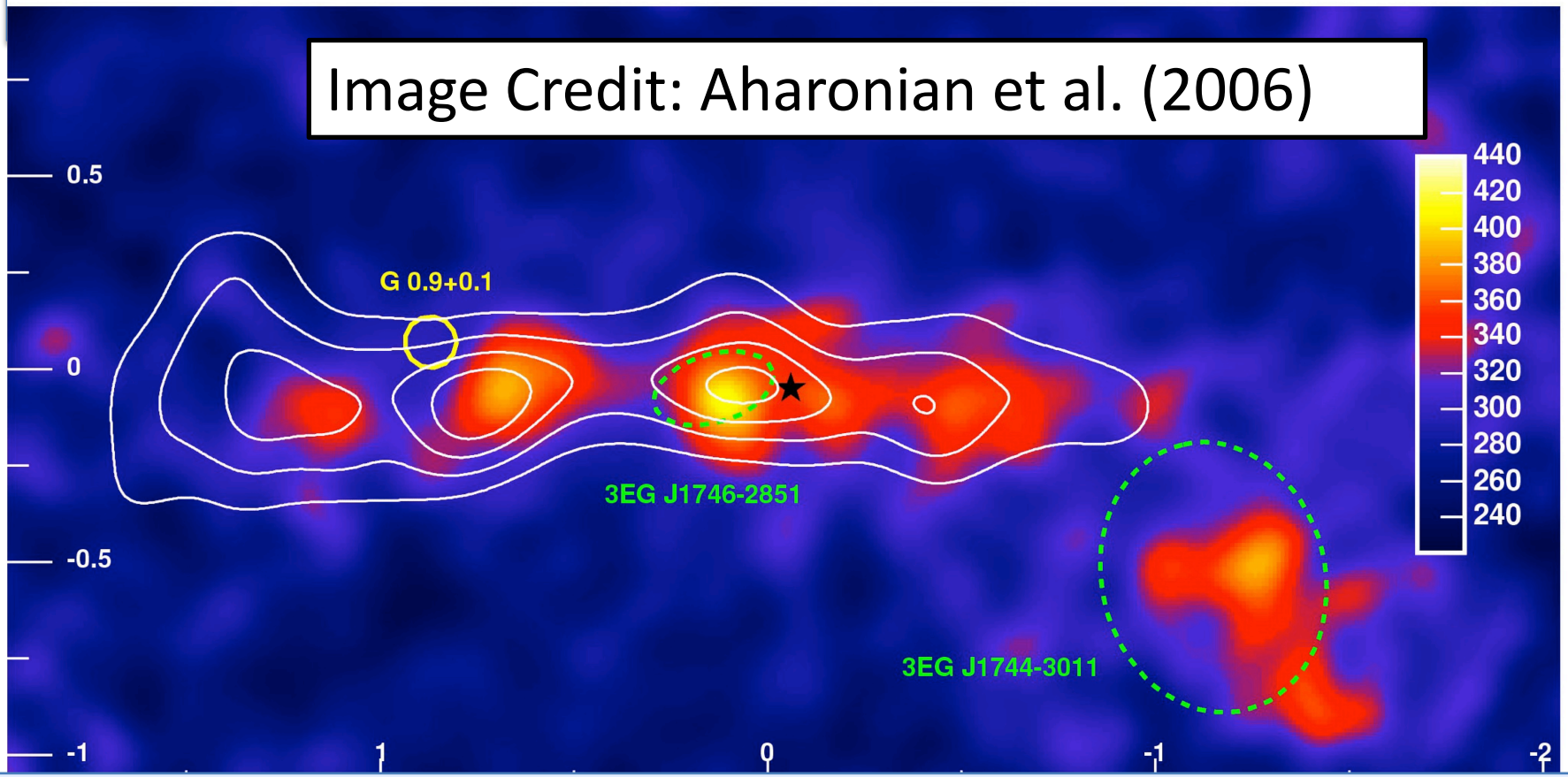


Fermi LAT diffuse galactic background



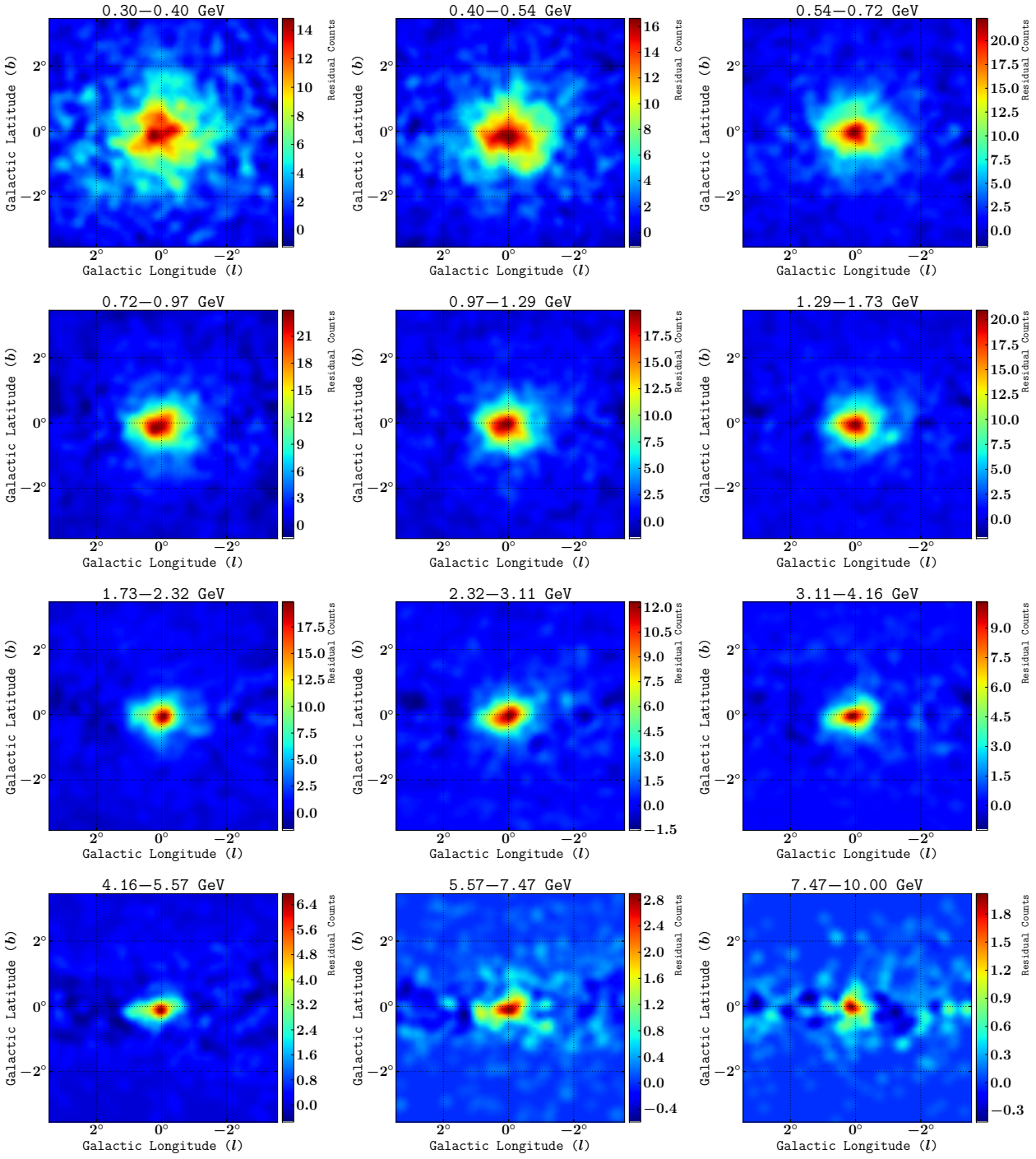
H.E.S.S.

Galactic Center Ridge

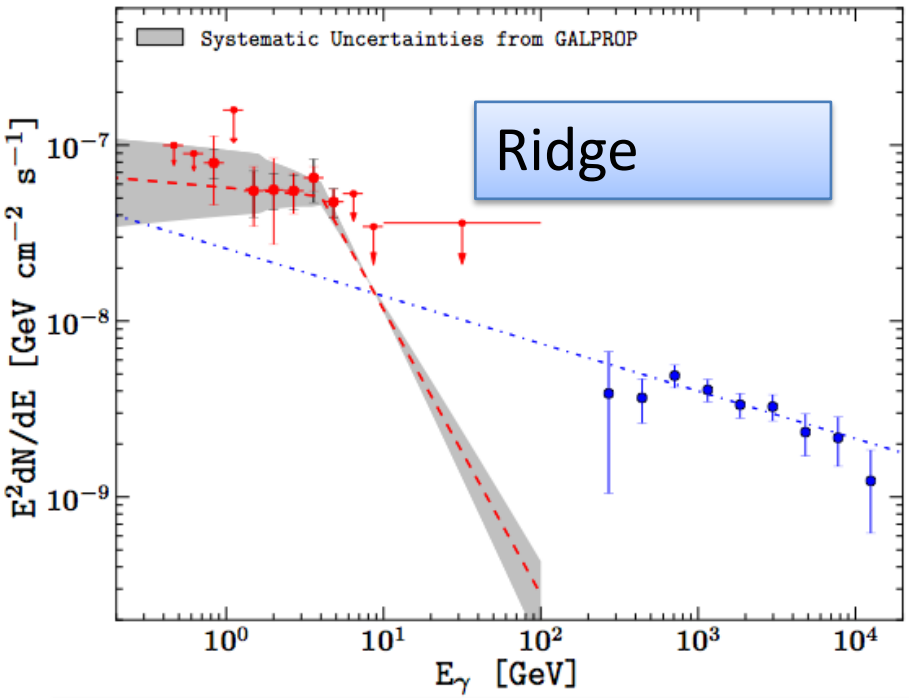


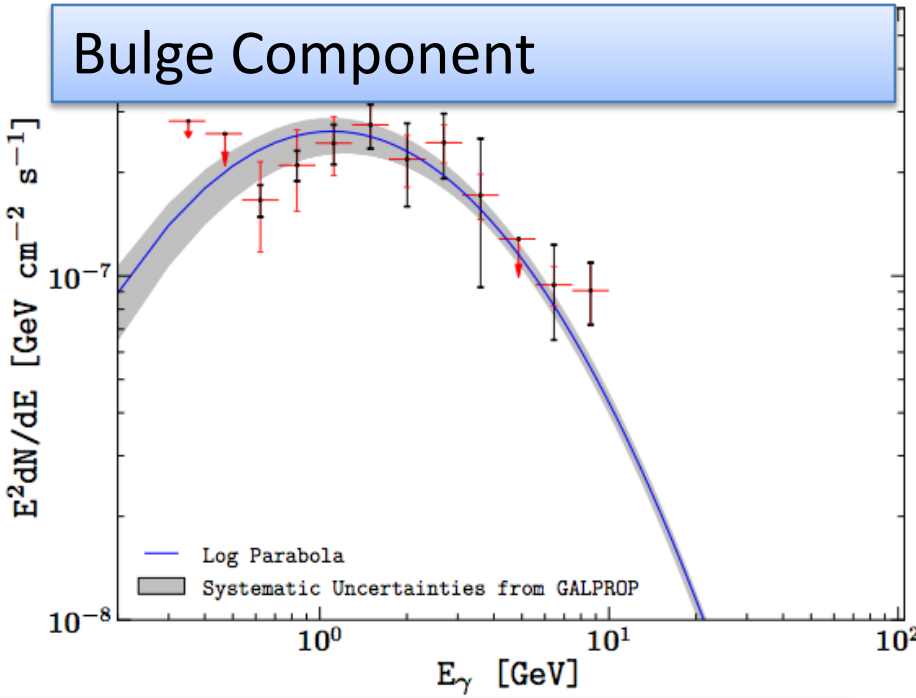
- Ridge seen in HESS TeV gamma-ray data.
- White contour lines indicate the density of molecular gas, traced by its CS emission.

Both a ridge and bulge component are needed to fit the excess.

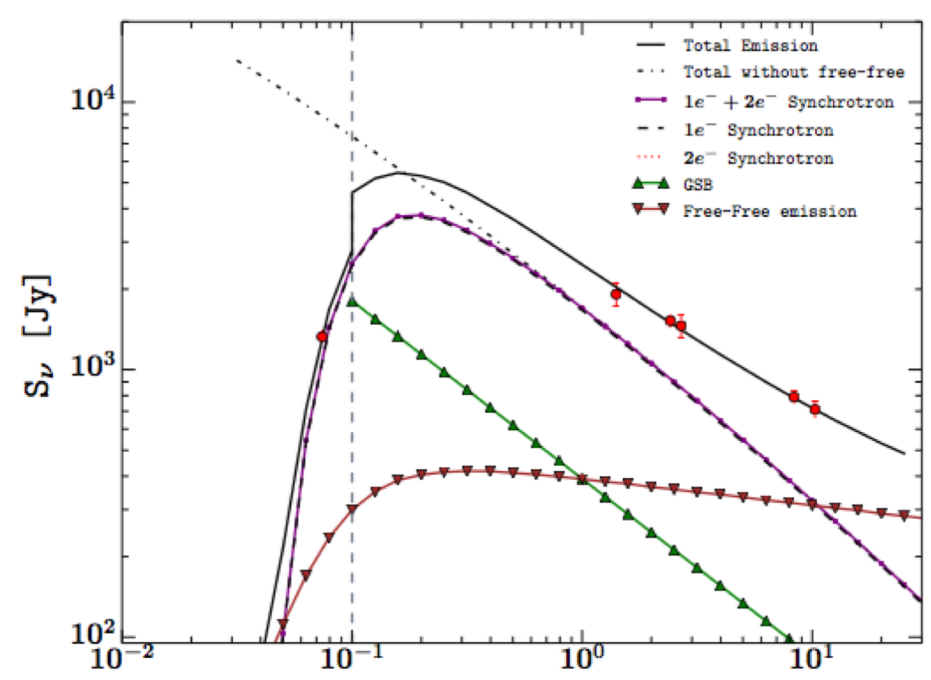


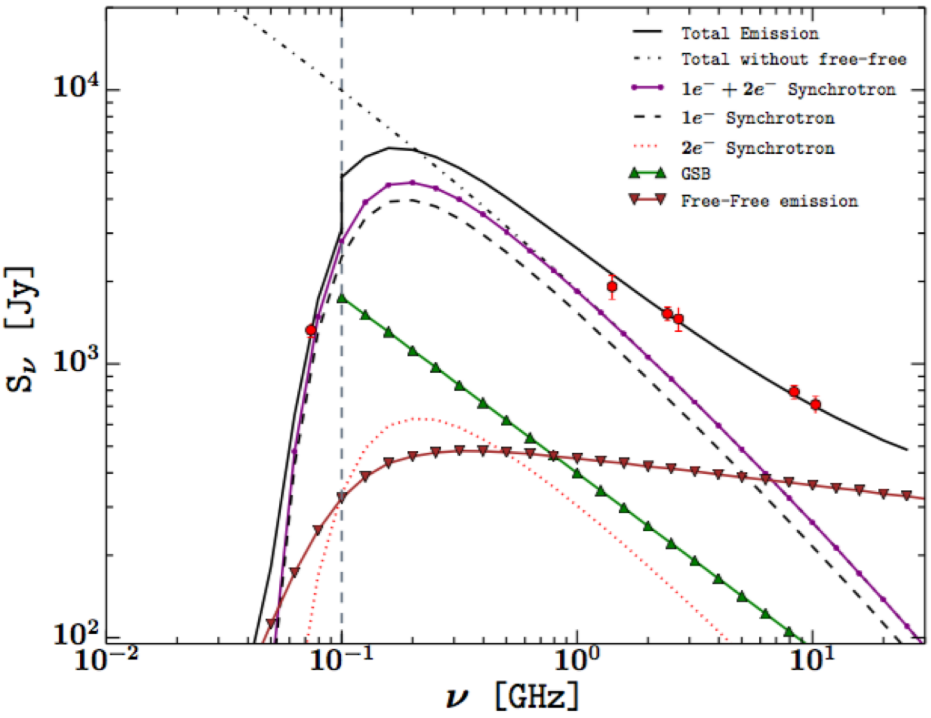
Spectra

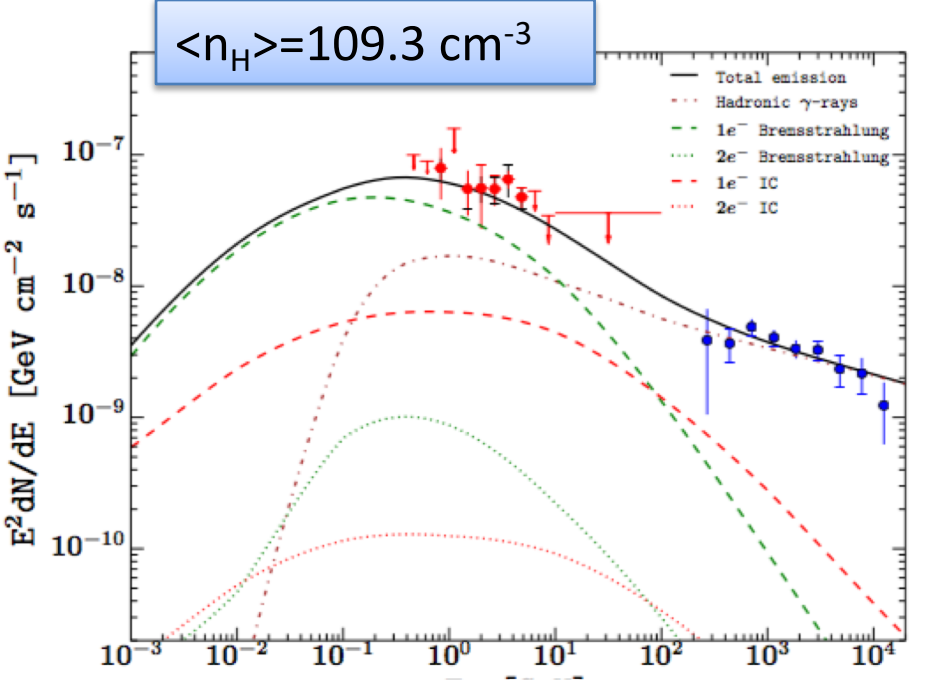


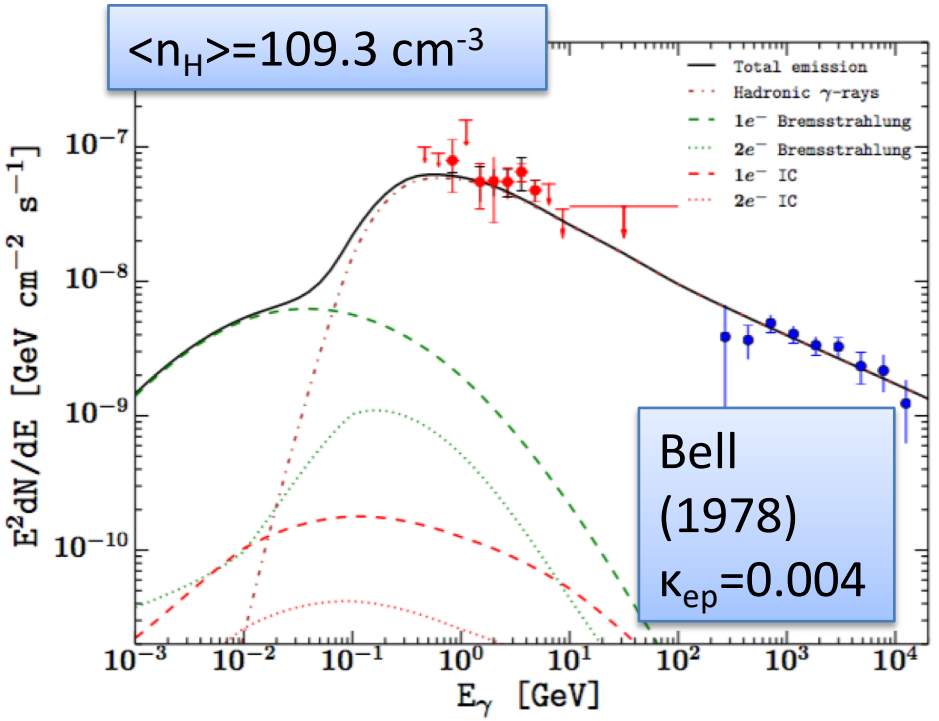


- Cosmic-ray models for the ridge: mainly pion decay (Crocker+2011) or mainly bremsstrahlung (Yusef-Zadeh+2012). See also Youst-Hull+2014.
- Proposals for bulge component: dark matter annihilation (Hooper&Goodenough, 2009), unresolved millisecond pulsars (MSPs) (Abazajian 2010), or DFGB error (Boyarsky+2011).


Total Emission
Total without free-free
1e⁻ + 2e⁻ Synchrotron
1e⁻ Synchrotron
2e⁻ Synchrotron
GSB
Free-Free emission
S_ν [Jy]


Total Emission
Total without free-free
1e⁻ + 2e⁻ Synchrotron
1e⁻ Synchrotron
2e⁻ Synchrotron
GSB
Free-Free emission
S_ν [Jy]
ν [GHz]


<n_H>=109.3 cm^-3
Total emission
Hadronic γ-rays
1e⁻ Bremsstrahlung
2e⁻ Bremsstrahlung
1e⁻ IC
2e⁻ IC
E²dN/dE [GeV cm⁻² s⁻¹]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Total emission
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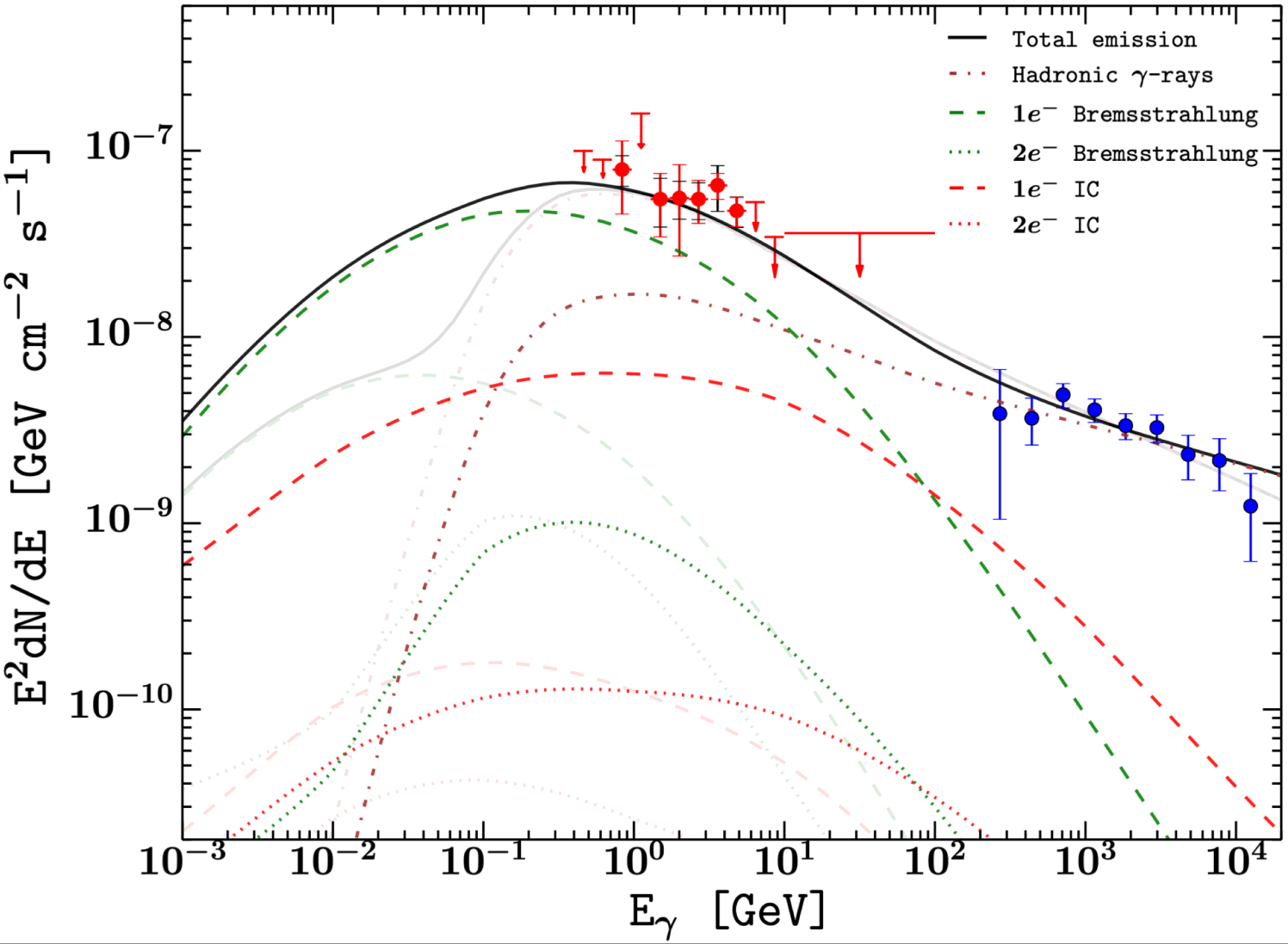
1e⁻ Bremsstrahlung
2e⁻ Bremsstrahlung
1e⁻ IC
2e⁻ IC
E²dN/dE [GeV cm⁻² s⁻¹]
E_γ [GeV]
Bell (1978)
κ_ep=0.004

Overlay of two models



- Mainly bremsstrahlung model = solid lines
- Mainly Pion decay model = faint lines

Conclusions

- Fermi-LAT data has excess extended emission in the Galactic Centre.
- Both a Galactic bulge and ridge component appear to be present.
- The bulge component may be due to MSPs, an incorrect DFGB model, or possibly dark matter self-annihilation.
- The ridge component may be explained by cosmic rays interacting with the ISM.

Steady-State Model	B [μG]	Γ_e, Γ_p	Γ_{GSB}	Normalization of protons at 1 TeV [$cm^{-3}\ s^{-1}\ eV^{-1}$]	κ_{ep}	t_{esc} [years]	free-free flux density at 10 GHz [Jy]
Bremsstrahlung solution with $\overline{\langle n_H \rangle}$ fixed	130 ± 20	$2.34^{+0.06}_{-0.07}$	0.7 ± 0.1	$(2 \pm 1) \times 10^{-38}$	0.2 ± 0.1	$(9 \pm 6) \times 10^4$	320 ± 20
π^0-solution with $\overline{\langle n_H \rangle}$ and κ_{ep}^{Bell} fixed	490 ± 80	2.47 ± 0.02	0.6 ± 0.1	$(11 \pm 7) \times 10^{-38}$	0.004	$(3 \pm 2) \times 10^4$	360 ± 20