LMXB and Pulsar Constraints on MSP Interpretations of the GCE

Tim Linden

What are the physical interpretations of the nuclear and boxy bulge?

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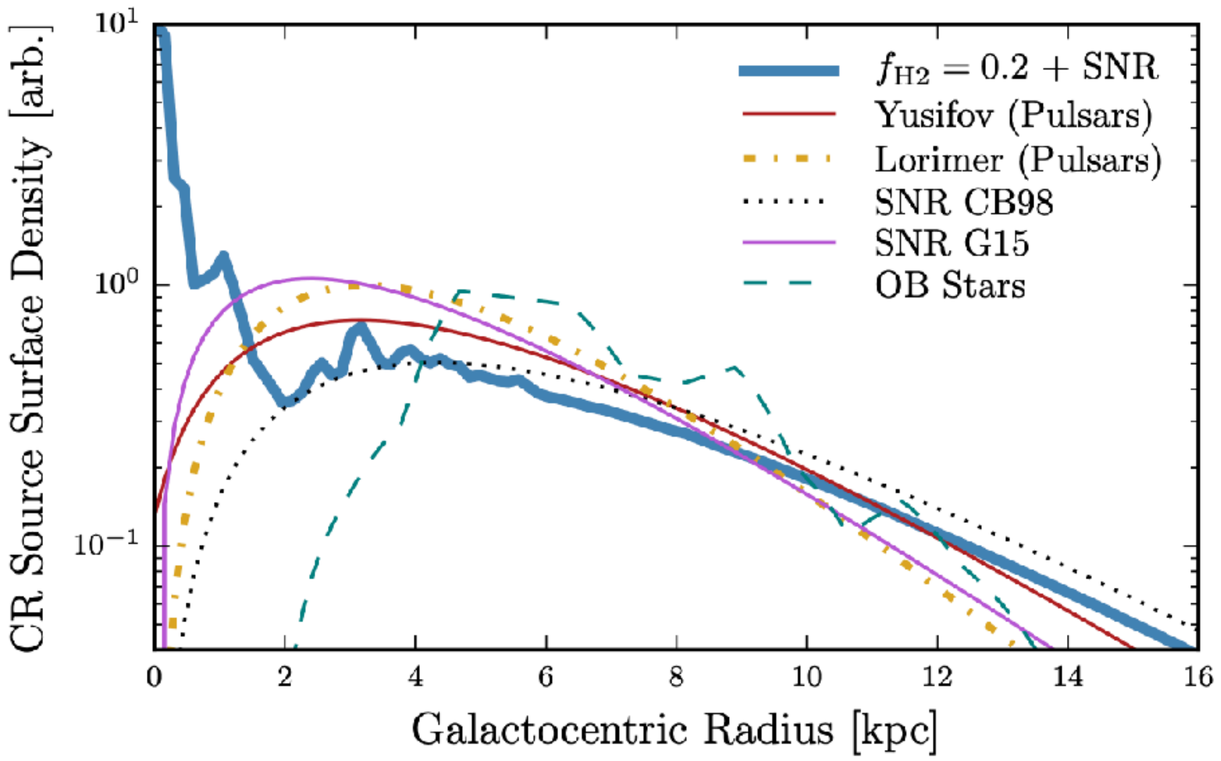
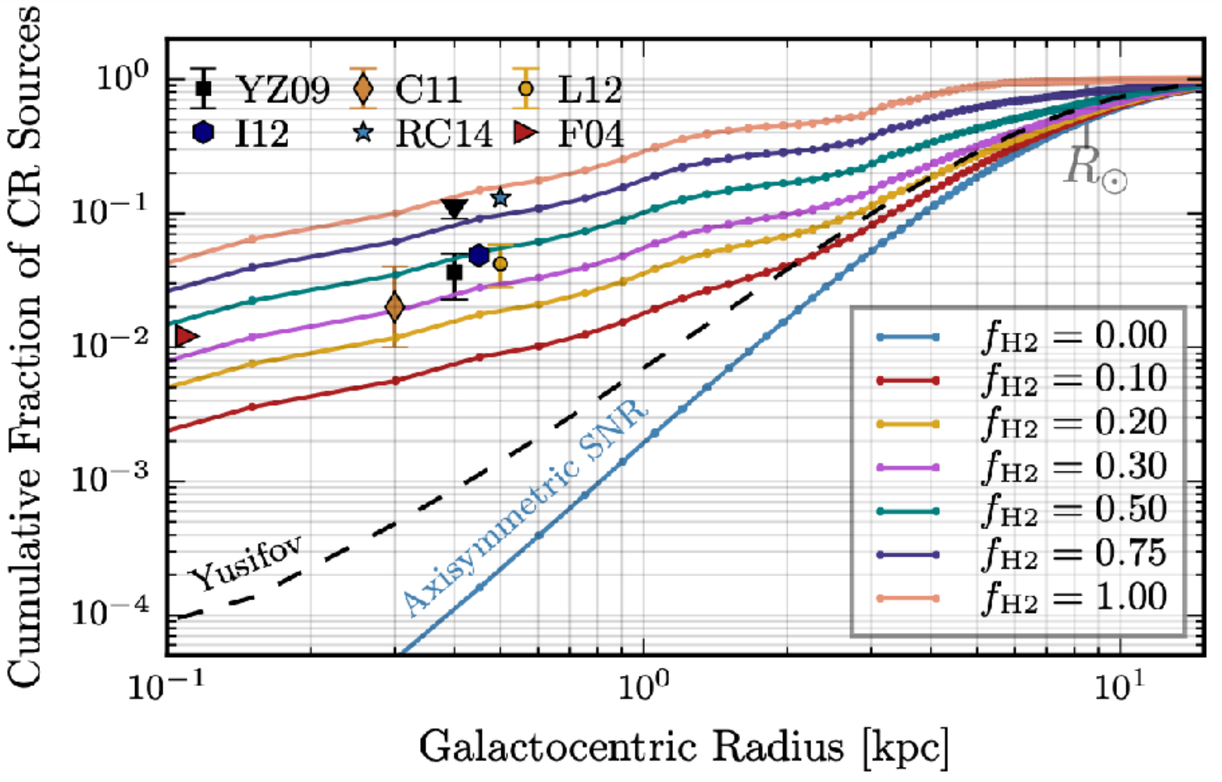
A Physical Interpretation for the Nuclear Bulge





We have strong observational evidence that this is the right answer.

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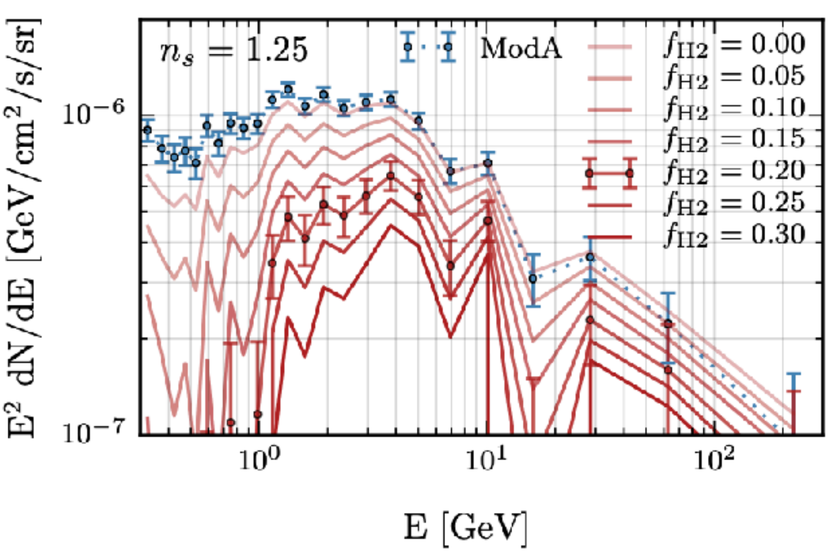
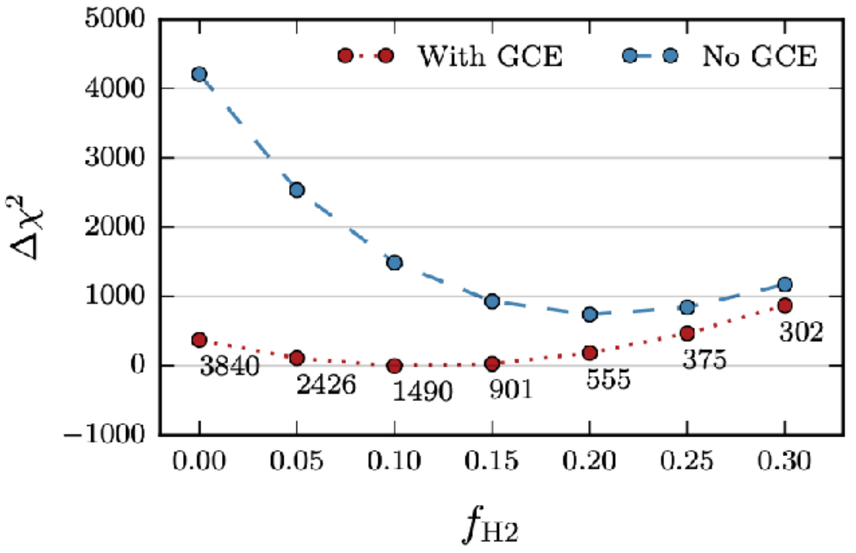
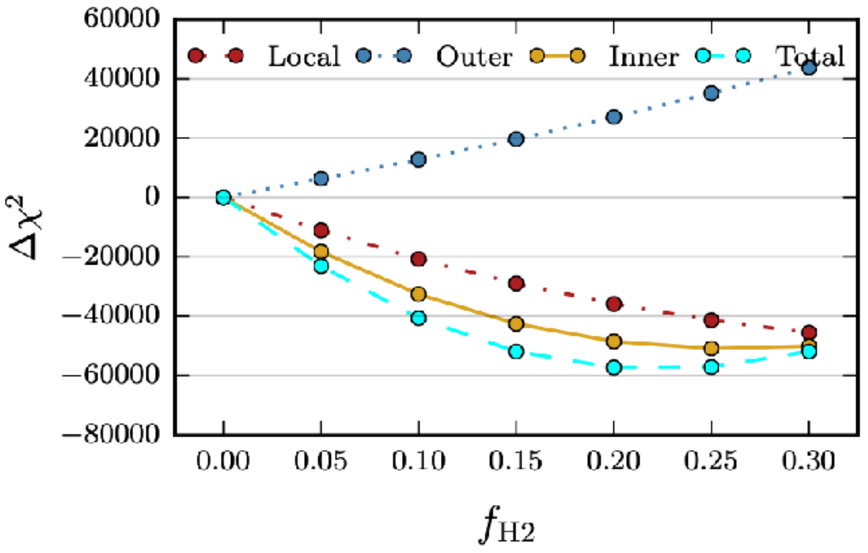
A Physical Interpretation for the Nuclear Bulge







Better fit to data - but oversubtraction at low energies.

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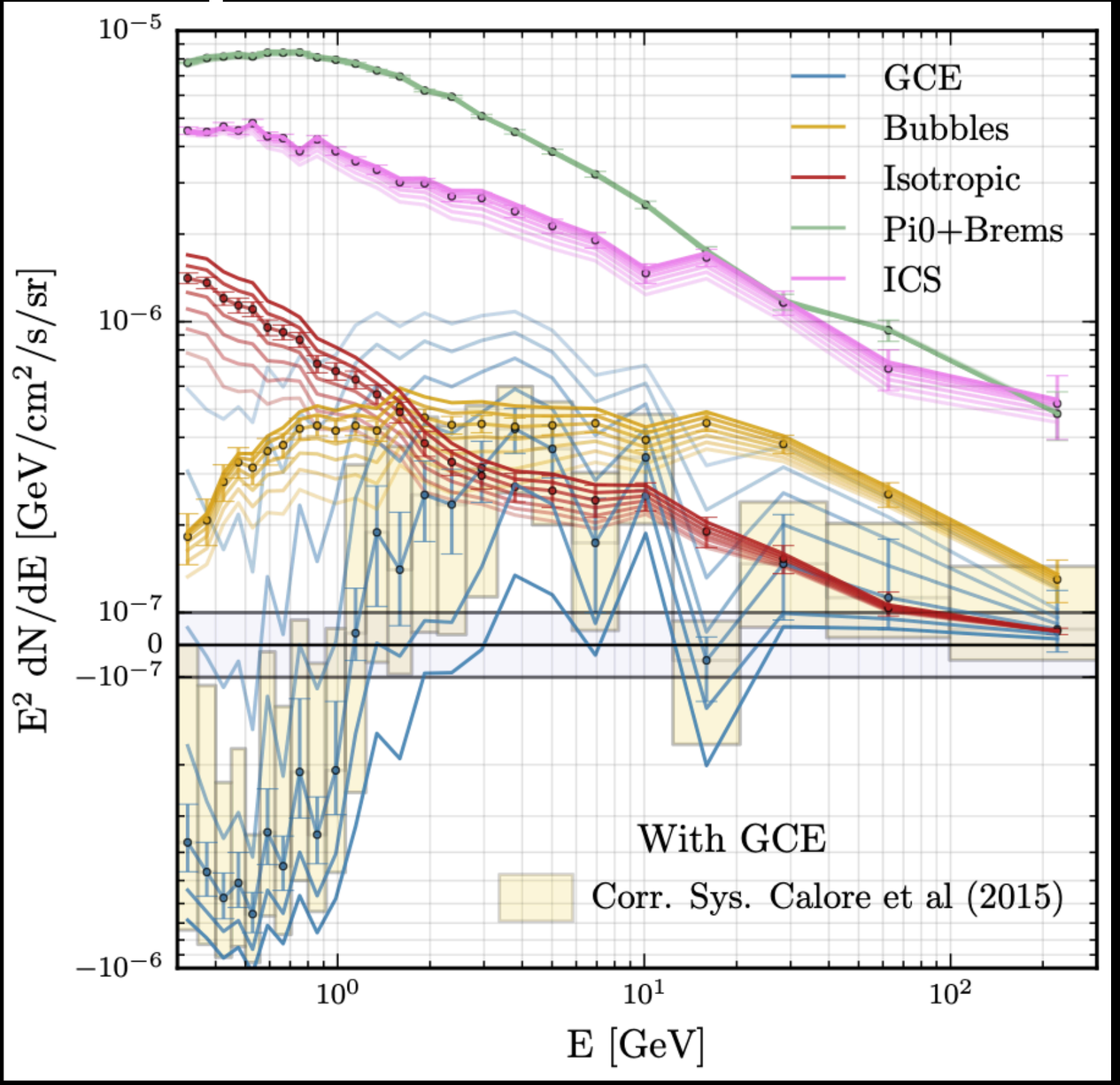
A Physical Interpretation for the Nuclear Bulge



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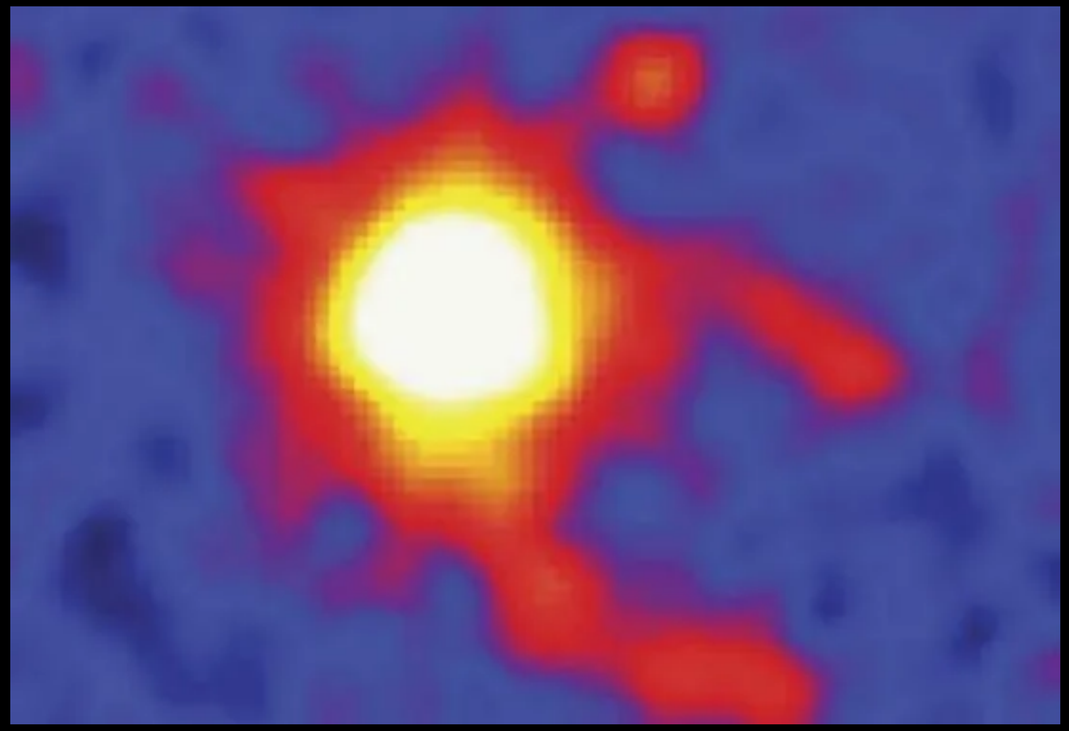
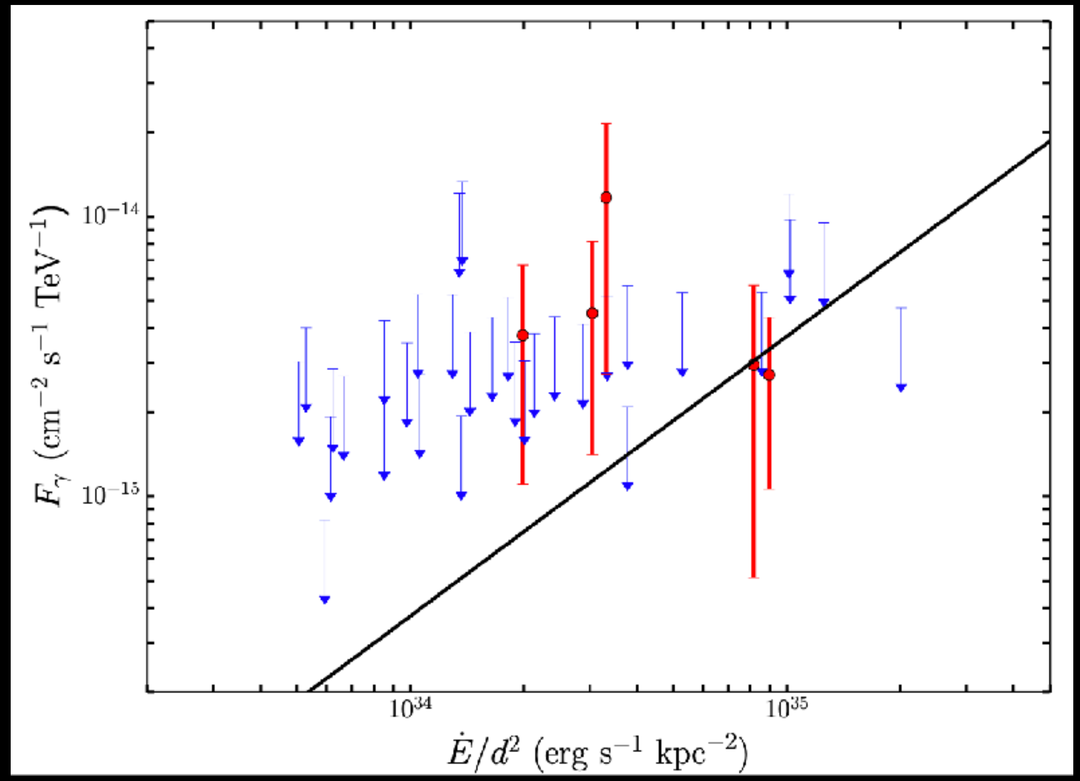
TeV Halos and the GCE





1LHAASO J0216+4237u	0.33	ATNF PSR J0218+4232	$\dot{E} = 2.44 \times 10^{35}$ erg s^{-1},$\tau_c = 476000.0$ kyr,$d = 3.15$ kpc
	0.33	4FGL J0218.1+4232	PSR J0218+4232;MSP;

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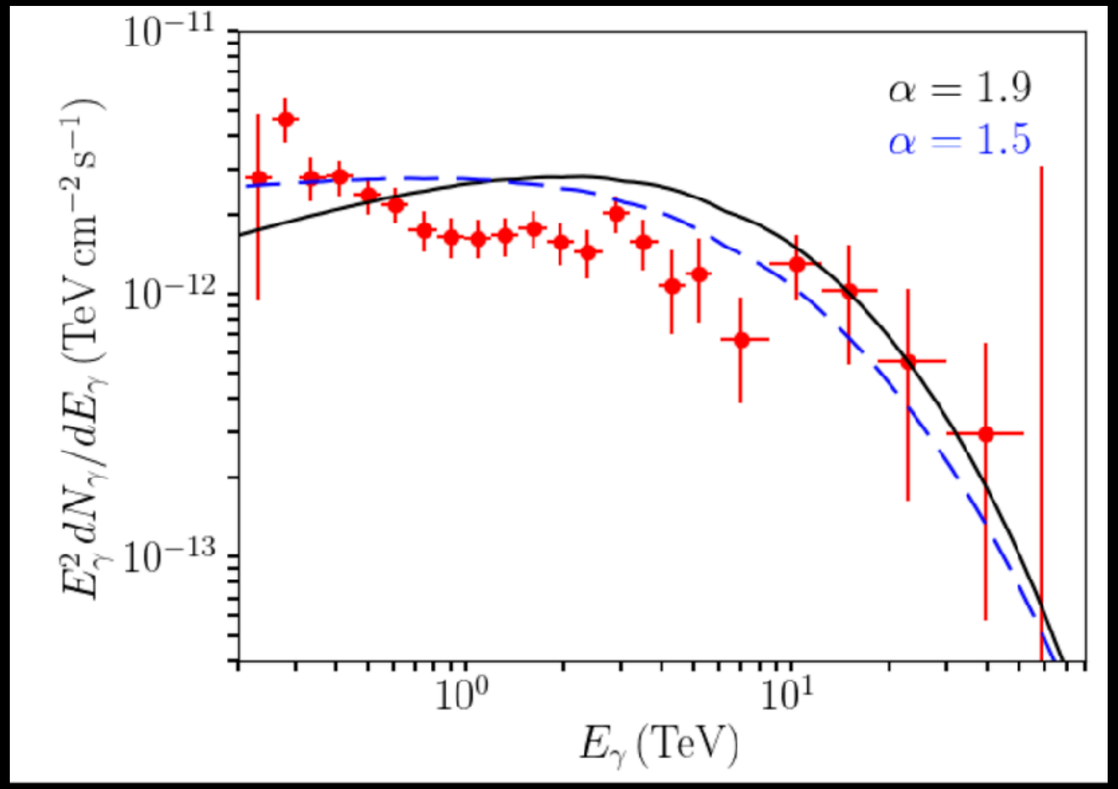
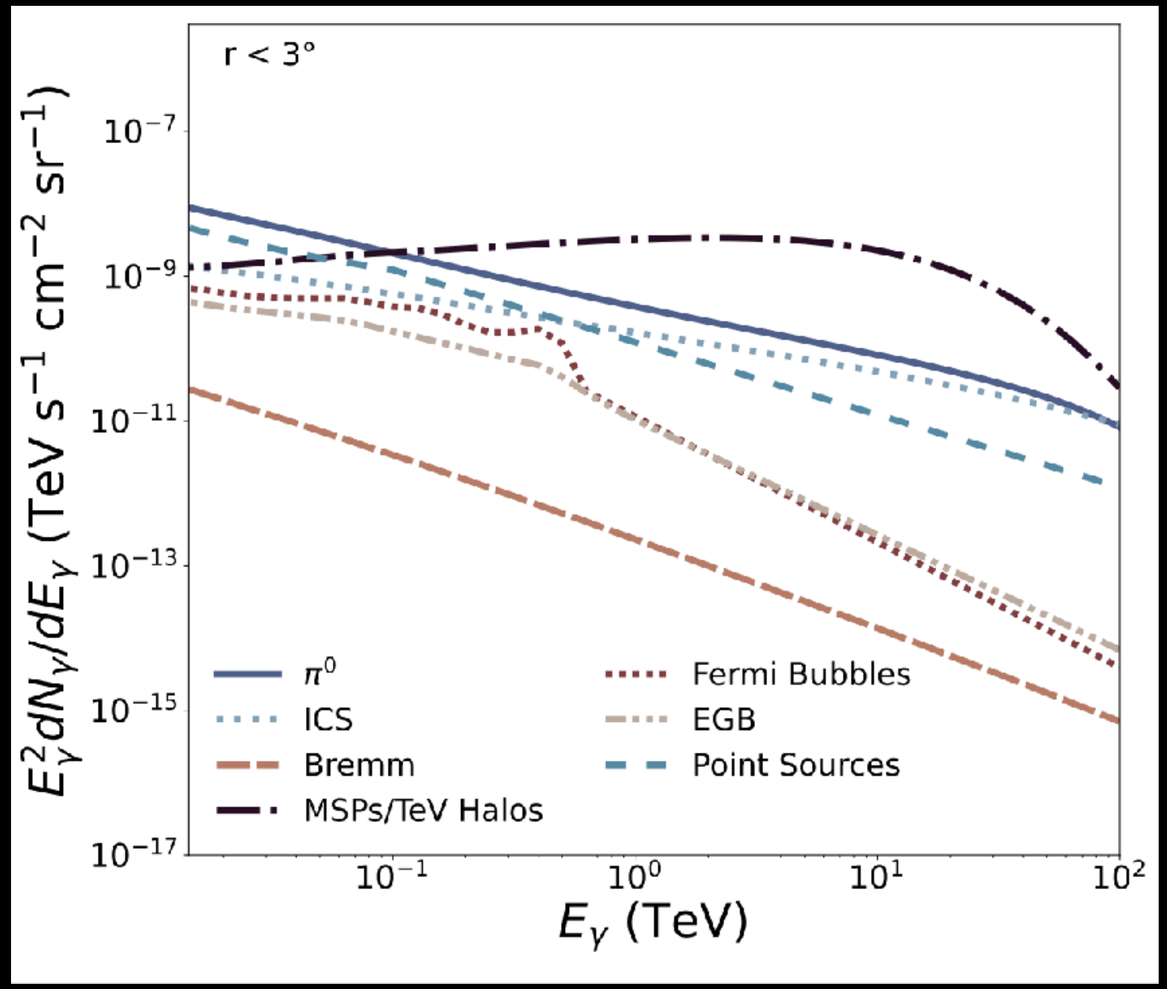
TeV Halos and the GCE

$$\dot{E}_{\rm tot} \sim 3.3 \times 10^{37}\,{\rm erg/s} \times \left(\frac{0.12}{\eta_\gamma}\right)\left(\frac{0.5}{f_{\rm beam}}\right)$$



This fits/overproduces the HESS data — assuming that MSPs produce 100% of the HESS galactic ridge.



CTA will be strongly sensitive if MSPs produce halos in the nuclear bulge

TeV Halos and the GCE

Note: Dim MSPs like AIC systems may not produce TeV halos.

- **OTOH — Formation of TeV halo not necessarily important for generation of diffuse signal.**

$$D\left(E_e\right) = D_0 \times \left(\frac{E_e}{1\,\mathrm{GeV}}\right)^{\delta}$$

$$\begin{aligned} L_{\mathrm{TeV}} &= \dot{E}_{\mathrm{tot}}\,\eta = \frac{L_{\mathrm{GeV}}\,\eta}{\langle\eta_{\mathrm{GeV}}\rangle f_{\mathrm{beam}}} \\ &= f_{\mathrm{GCE}}\,\frac{L_{\mathrm{GCE}}\,\eta}{\langle\eta_{\mathrm{GeV}}\rangle f_{\mathrm{beam}}}, \end{aligned}$$

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LMXBs and the GCE

Globular Cluster	Flux (erg/cm^2/s)	Distance (kpc)	Stellar Encounter Rate	TS
NGC 104	$2.51^{+0.05}_{-0.06} \times 10^{-11}$	4.46	1.00	3995.9
NGC 362	$6.74^{+2.63}_{-2.46} \times 10^{-13}$	8.61	0.74	9.69
Palomar 2	$< 2.69 \times 10^{-13}$	27.11	0.93	0.0
NGC 6624	$1.14^{+0.10}_{-0.10} \times 10^{-11}$	7.91	1.15	455.8
NGC 1851	$9.05^{+2.92}_{-2.67} \times 10^{-13}$	12.1	1.53	14.4
NGC 5824	$< 4.78 \times 10^{-13}$	32.17	0.98	0.0
NGC 6093	$4.32^{+0.57}_{-0.53} \times 10^{-12}$	10.01	0.53	91.9
NGC 6266	$1.84^{+0.07}_{-0.10} \times 10^{-11}$	6.83	1.67	850.7
NGC 6284	$< 2.85 \times 10^{-13}$	15.29	0.67	0.0
NGC 6441	$1.00^{+0.09}_{-0.07} \times 10^{-11}$	11.6	2.30	210.9
NGC 6652	$4.84^{+0.51}_{-0.52} \times 10^{-12}$	10.0	0.70	128.3
NGC 7078/M15	$1.81^{+0.40}_{-0.39} \times 10^{-12}$	10.4	4.51	29.7
NGC 6440	$1.57^{+0.10}_{-0.11} \times 10^{-11}$	8.45	1.40	311.2
Terzan 6	$2.18^{+1.20}_{-0.90} \times 10^{-12}$	6.78	2.47	5.1
NGC 6388	$1.77^{+0.06}_{-0.09} \times 10^{-11}$	9.92	0.90	778.4
NGC 6626/M28	$1.95^{+0.13}_{-0.13} \times 10^{-11}$	5.52	0.65	749.8
Terzan 5	$6.61^{+0.17}_{-0.13} \times 10^{-11}$	5.98	6.80	2707.1
NGC 6293	$9.39^{+5.69}_{-5.45} \times 10^{-13}$	9.48	0.85	3.98
NGC 6681	$9.91^{+4.14}_{-3.86} \times 10^{-13}$	9.01	1.04	7.2
NGC 2808	$3.77^{+0.48}_{-0.48} \times 10^{-11}$	9.59	0.92	96.7
NGC 6715	$6.02^{+4.15}_{-3.77} \times 10^{-13}$	26.49	2.52	2.6
NGC 7089	$< 4.50 \times 10^{-13}$	11.56	0.52	0.0

LMXB	Notes	Globular Cluster	References
4U 1820-30	P	NGC 6624	[69–71]
4U 0513-40	P	NGC 1851	[72–74]
4U 1746-37	P	NGC 6441	[69, 75, 76]
XB 1832-330	P	NGC 6652	[75, 77, 78]
M15 X-2	P	NGC 7078/M15	[79–81]
AC 211	P	NGC 7078/M15	[69, 80, 82]
SAX J1748.9-2021	T, XP	NGC 6440	[75, 83, 84]
GRS 1747-312	T	Terzan 6	[85–87]
Terzan 6 X-2	T	Terzan 6	[88]
IGR J17361-4441	T	NGC 6388	[89, 90]
IGR J18245-2542	T, XP	NGC 6626/M28	[91, 92]
EXO 1745-248	T	Terzan 5	[93, 94]
IGR J17480-2446	T	Terzan 5	[95–97]
Terzan 5 X-3	T	Terzan 5	[98]
MAXI J0911-635	T	NGC 2808	[99]

$$L_\gamma^{\rm IG} = L_\gamma^{\rm clusters} \times \left(\frac{N_{\rm LMXB}^{\rm IG}}{N_{\rm LMXB}} \right)$$

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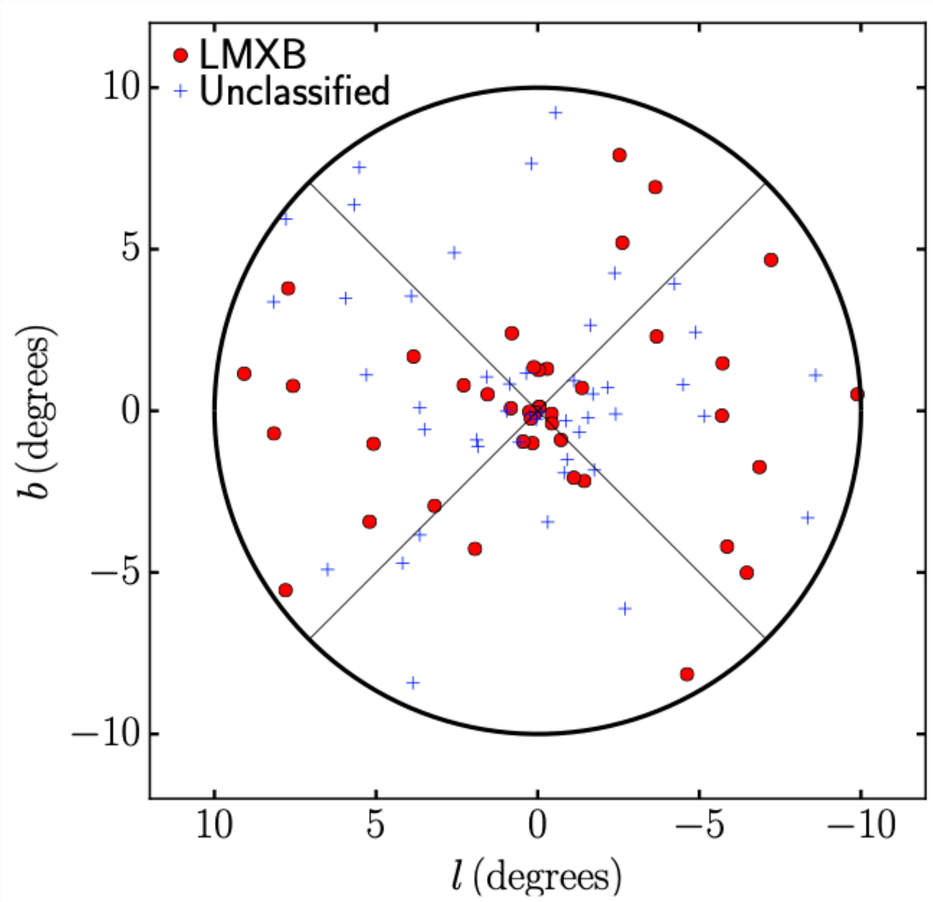
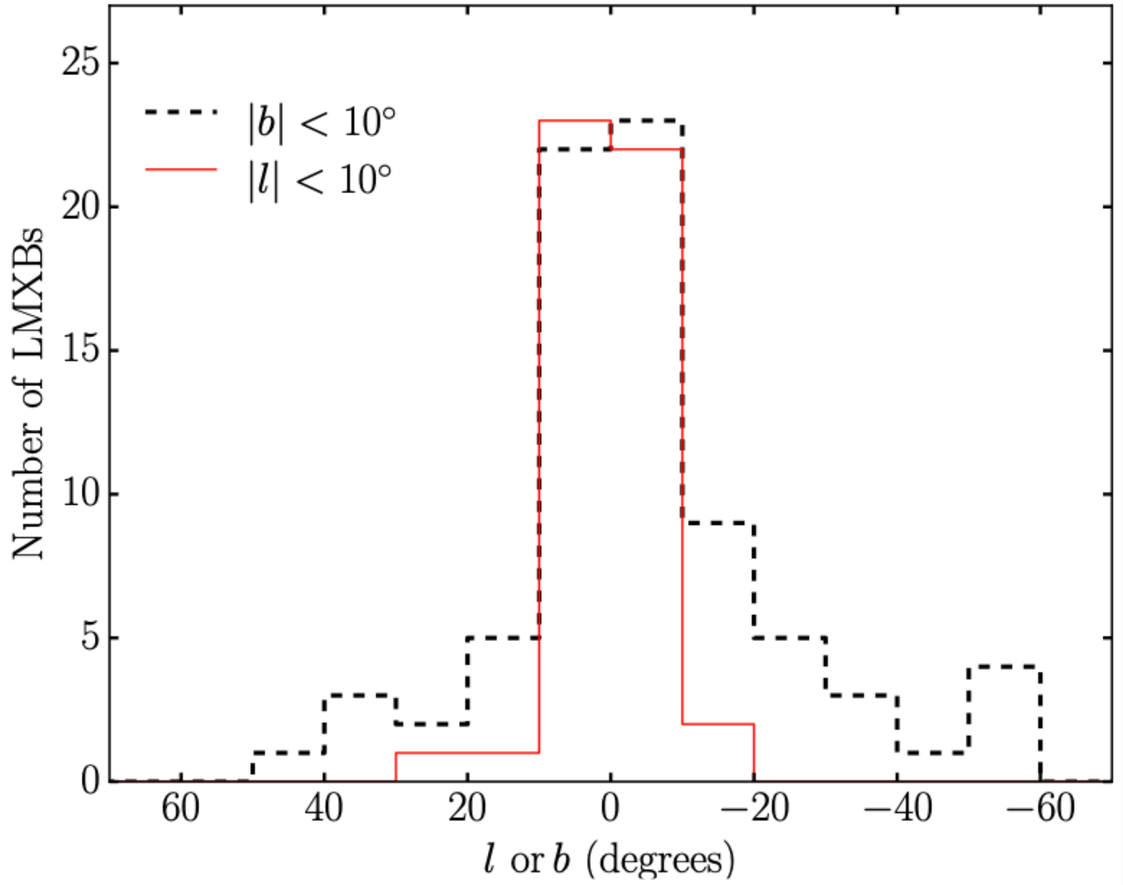
LMXBs and the GCE





$$L_\gamma^{\rm IG} = (1.50^{+0.65}_{-0.54}) \times 10^{36}\,{\rm erg/s}, \qquad \text{Only Sources Classified as LMXBs}$$
$$L_\gamma^{\rm IG} = (3.15^{+1.37}_{-1.12}) \times 10^{36}\,{\rm erg/s}, \qquad \text{Including All Unclassified Sources}, \qquad (4.3)$$

which corresponds to $7.5^{+3.6}_{-3.1}\%$ (only LMXBs) or $15.7^{+7.5}_{-6.4}\%$ (LMXBs and unclassified) of the emission associated with the Galactic Center excess. We further conclude that no more

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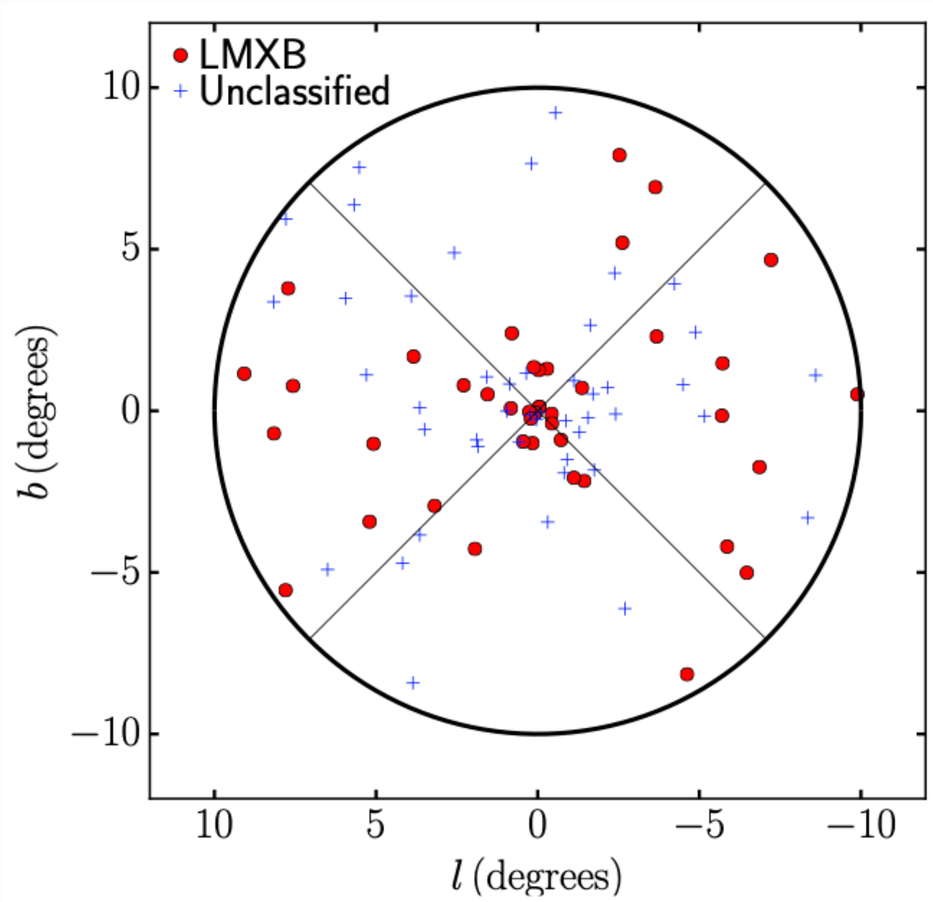
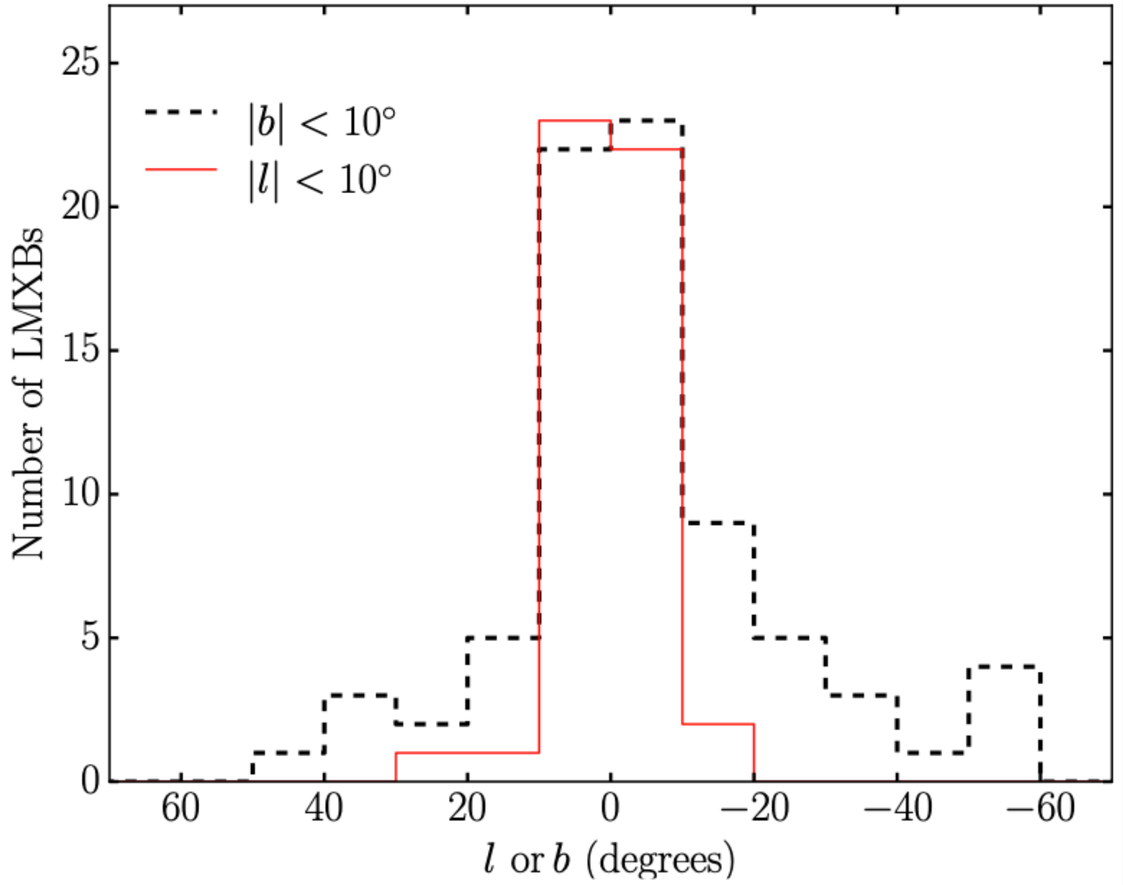
LMXBs and the GCE





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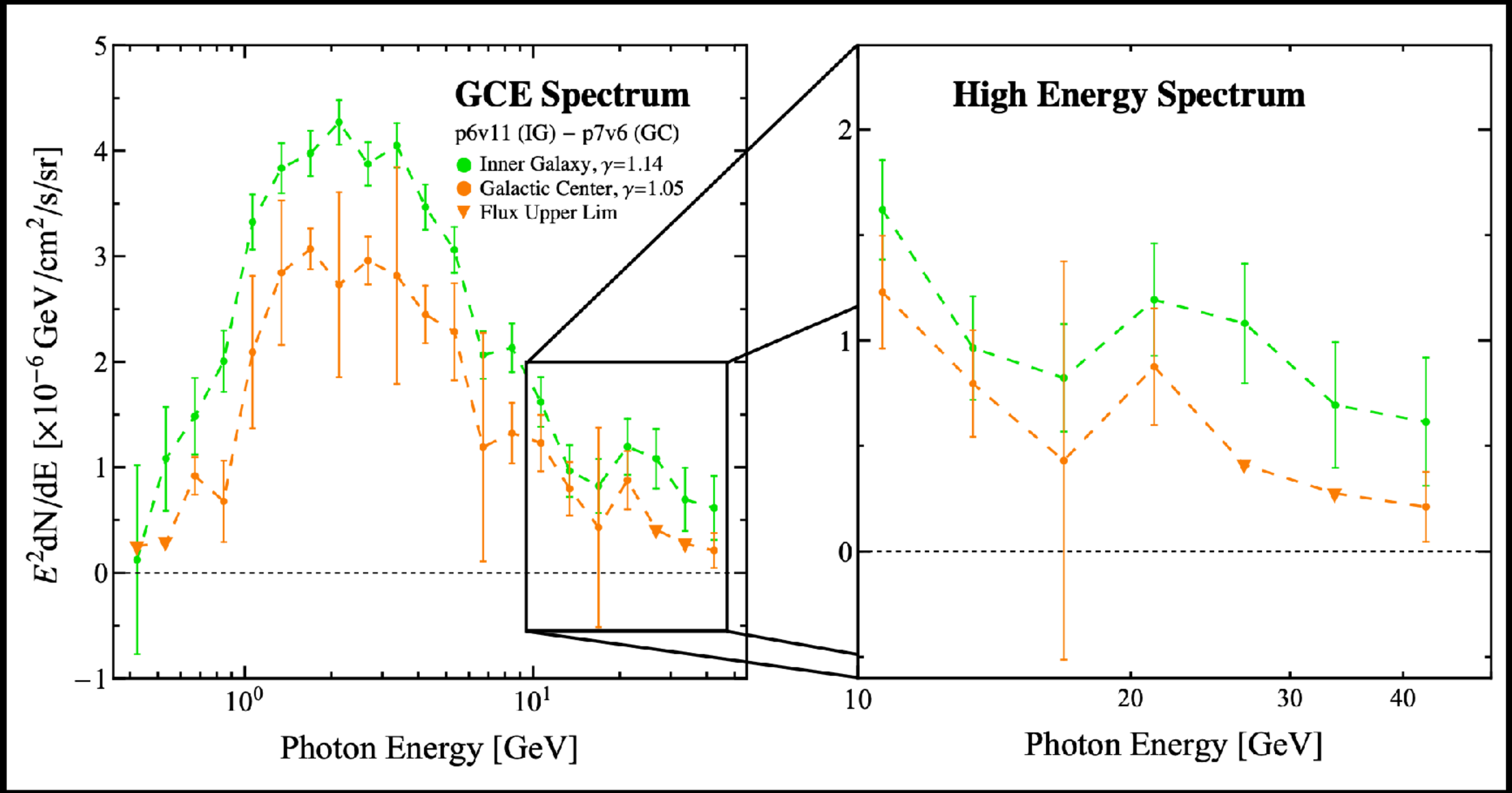
High Energy Excess



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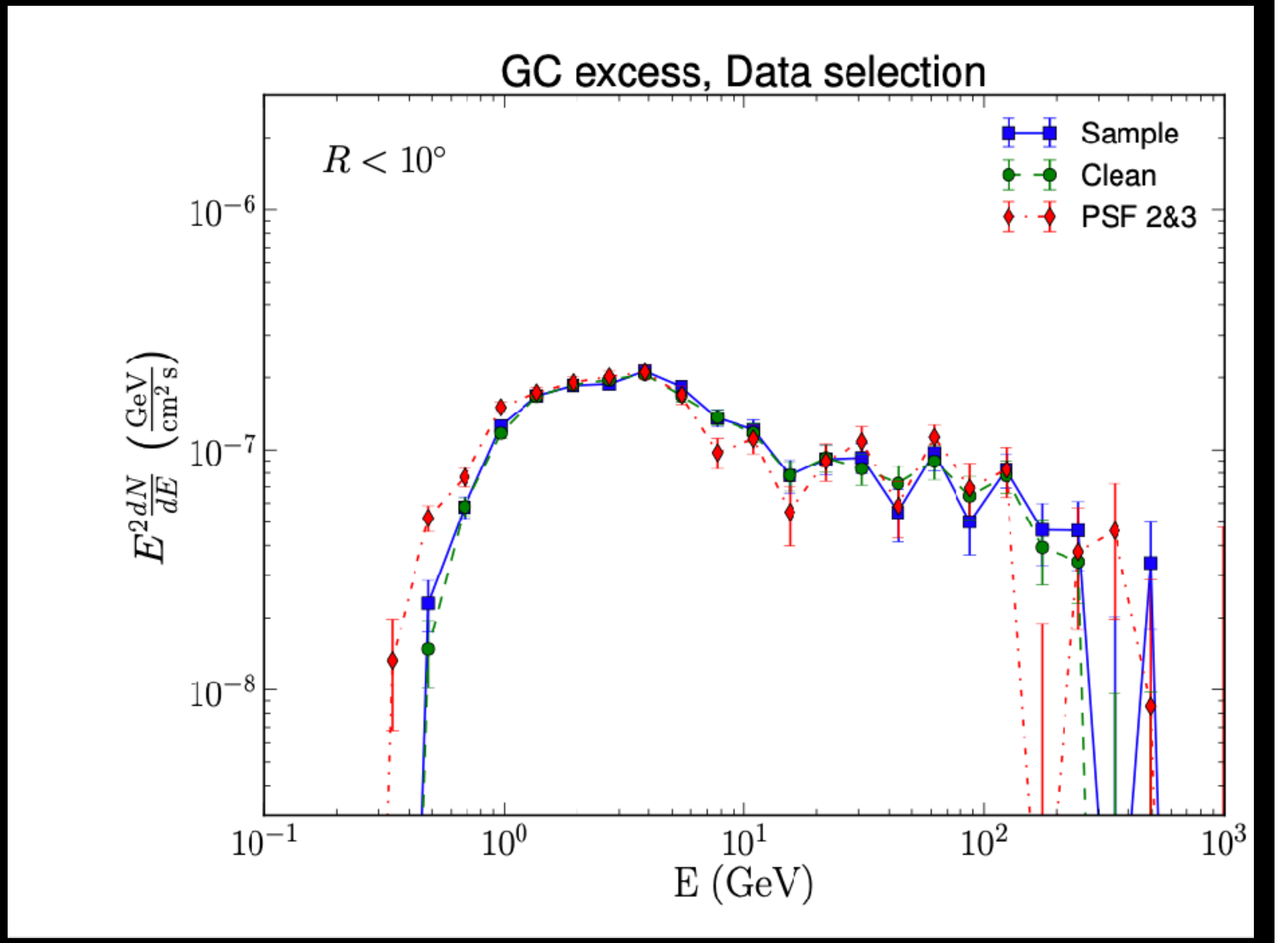
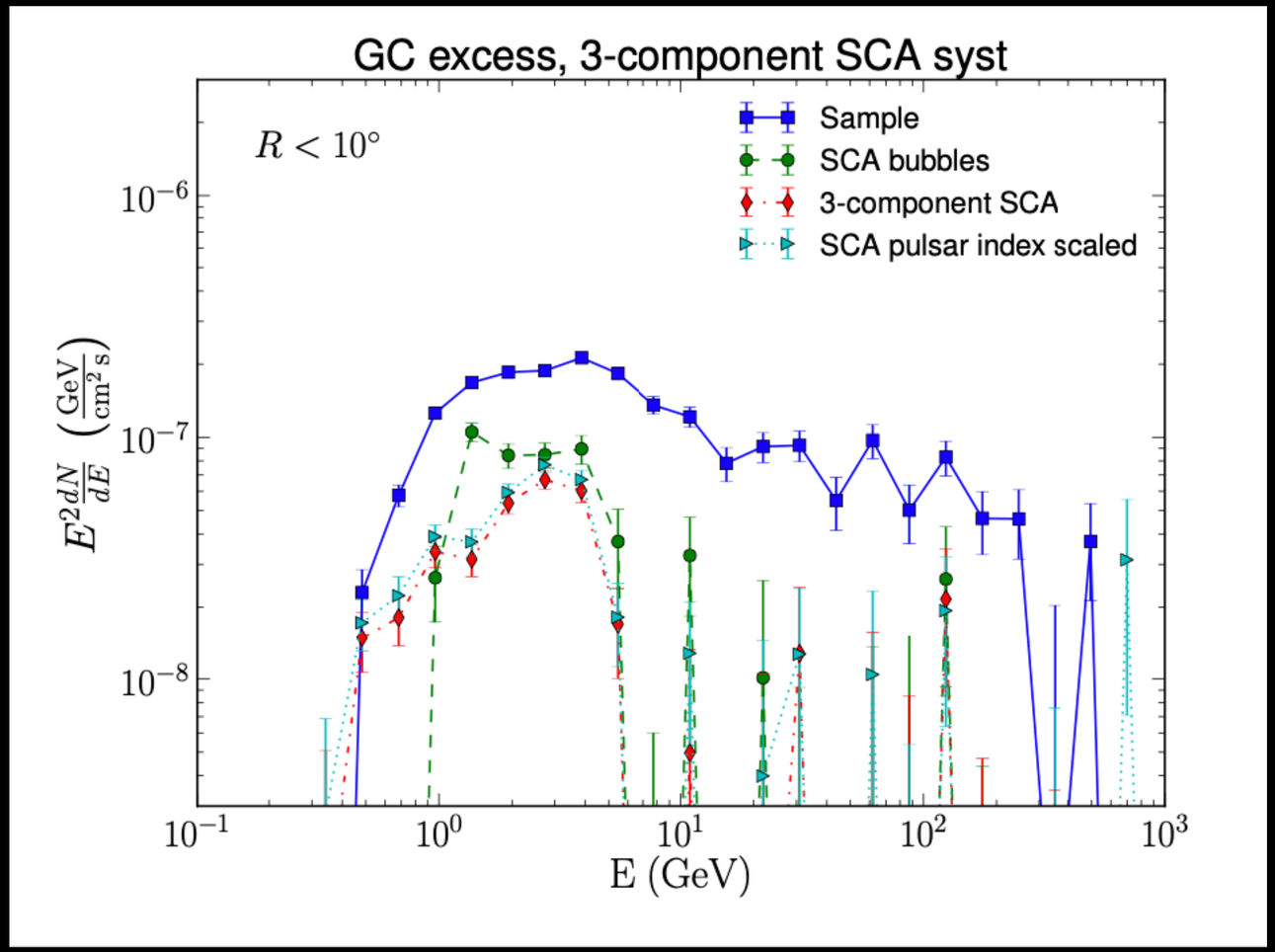
High Energy Excess





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