Revealing G150.3+4.5 as a dynamically young supernova remnant with gamma-ray data

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On behalf of the Fermi-LAT collaboration

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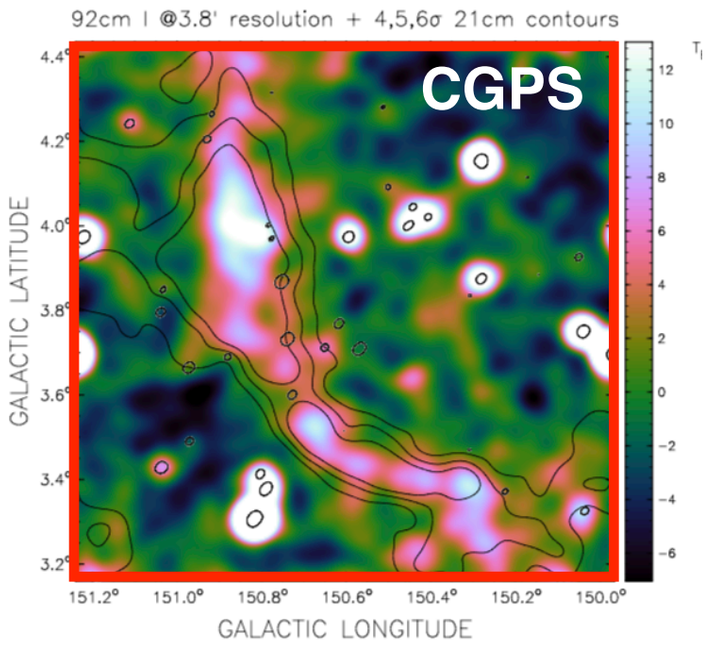
The SNR G150.3+4.5

- **First detection in radio**



[Gerbrandt et al. 2014]

Radio spectral index:

$$\alpha = -0.62 \pm 0.07$$

$$\alpha = -0.38 \pm 0.10$$ (region size: 1.07° x 0.31°)

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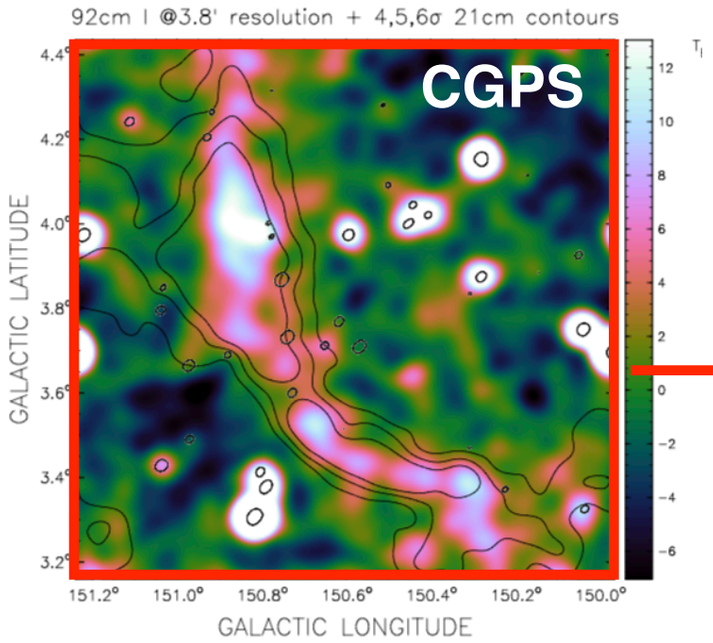

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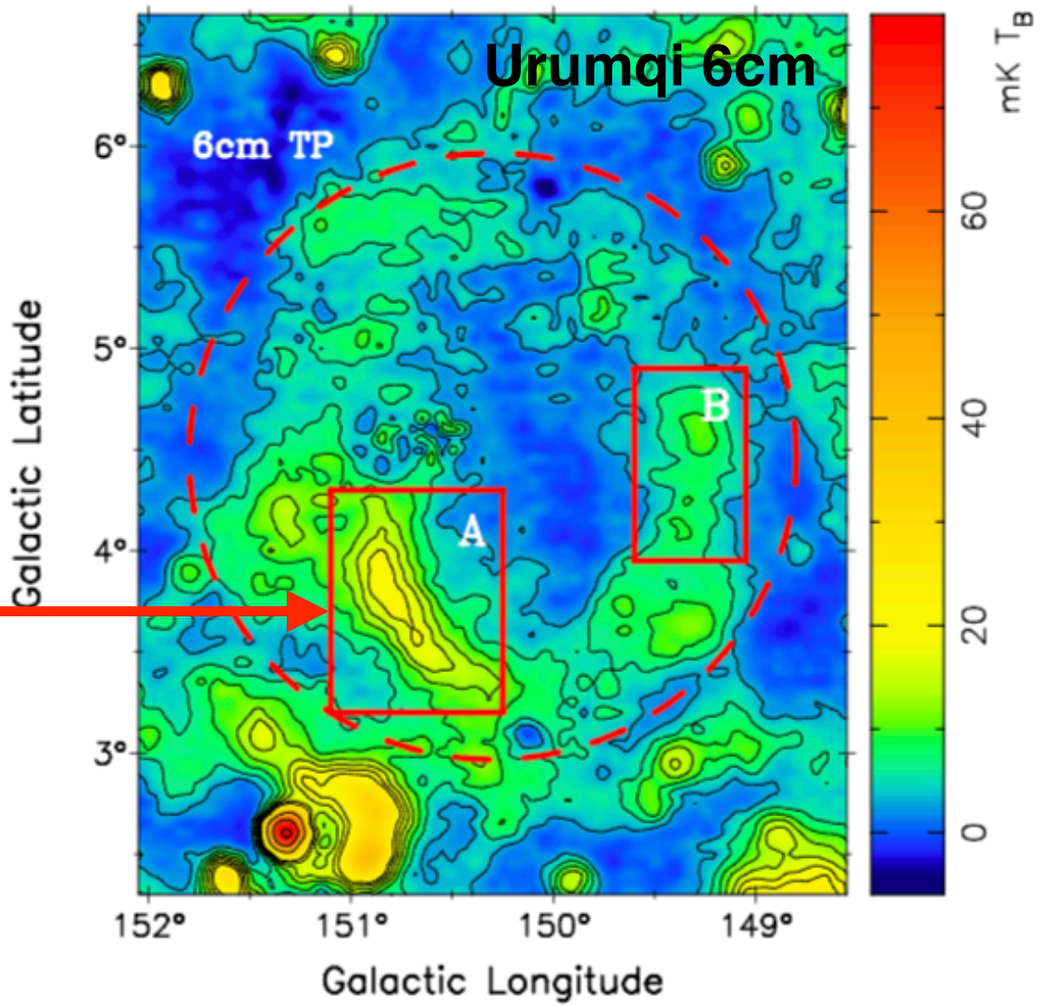

[Gao & Han 2014]

Radio spectral index:

$$\alpha = -0.62 \pm 0.07$$

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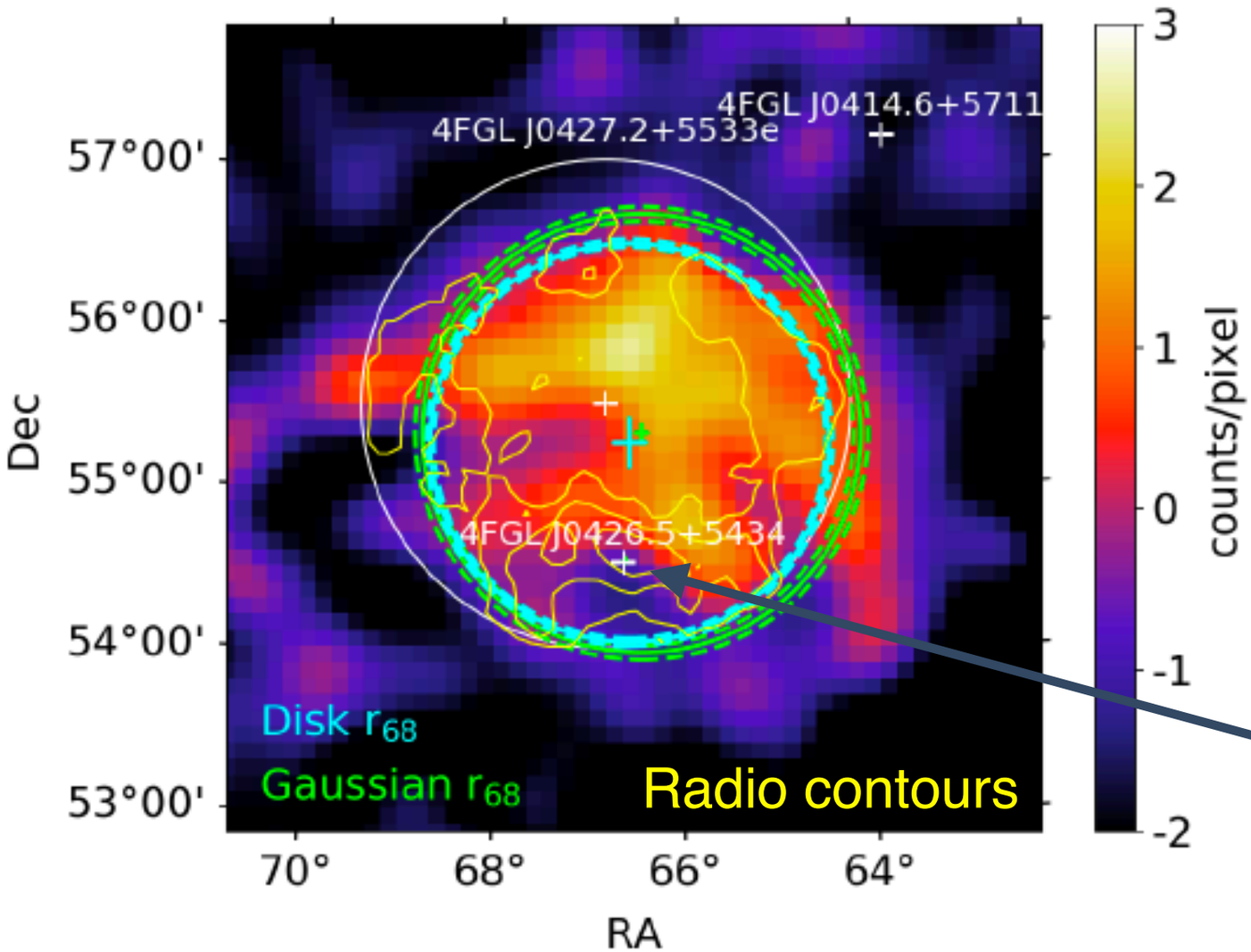
SNR extent ~ 3°

Old or a nearby SNR?

Fermi-LAT data analysis

- **Morphological analysis (1 GeV — 3 TeV)**



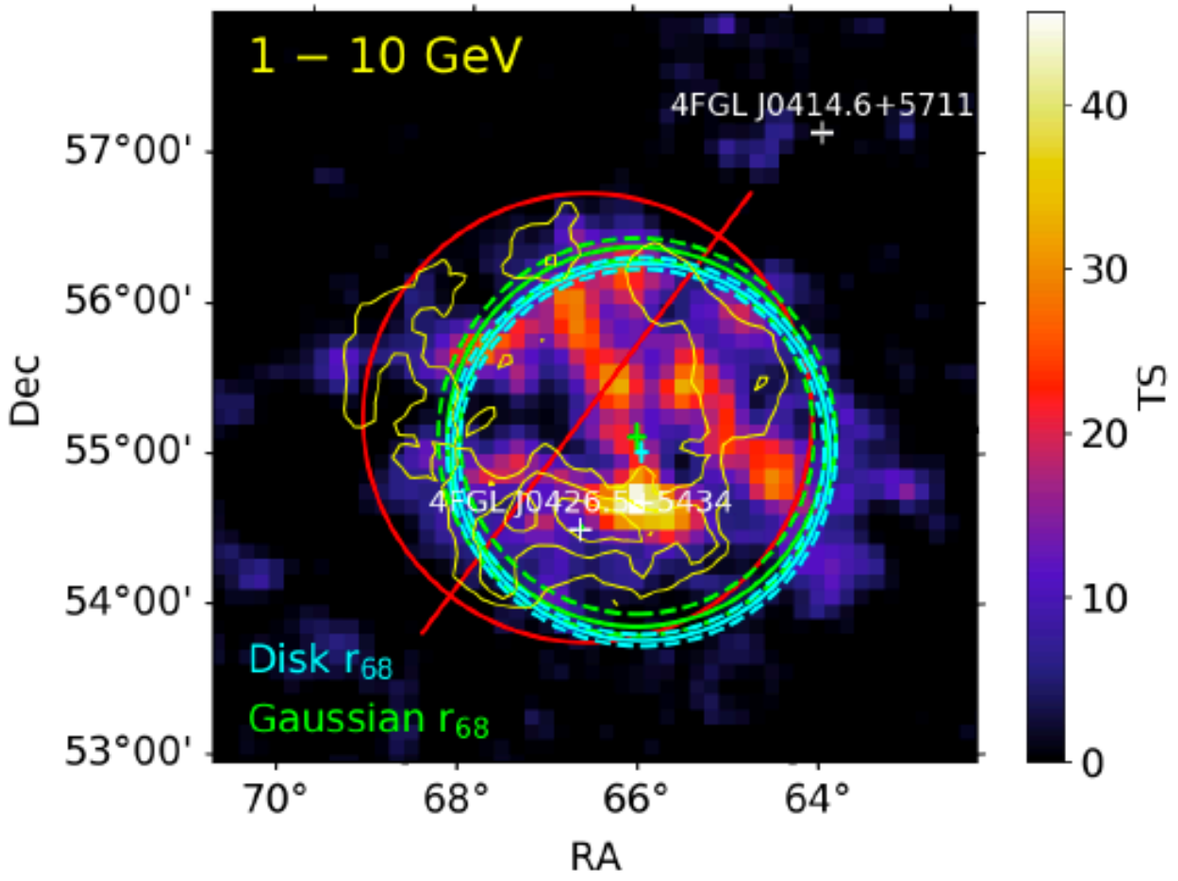
Gamma-ray emission adequately described by an extended component (Gaussian model preferred)

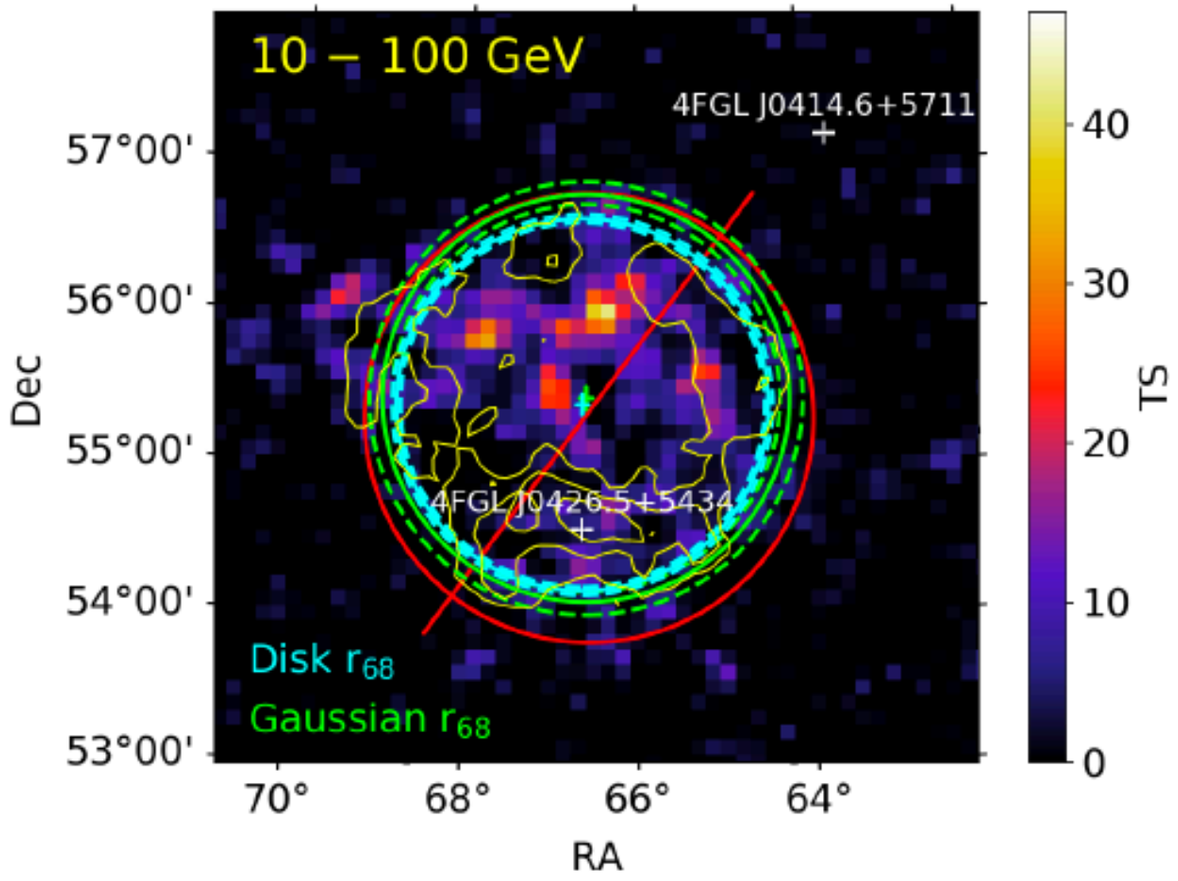
➡ **spatially coincident with the radio emission**

4FGL J0426.5+5434: point source

Fermi-LAT data analysis

- **Energy-dependent morphology?**



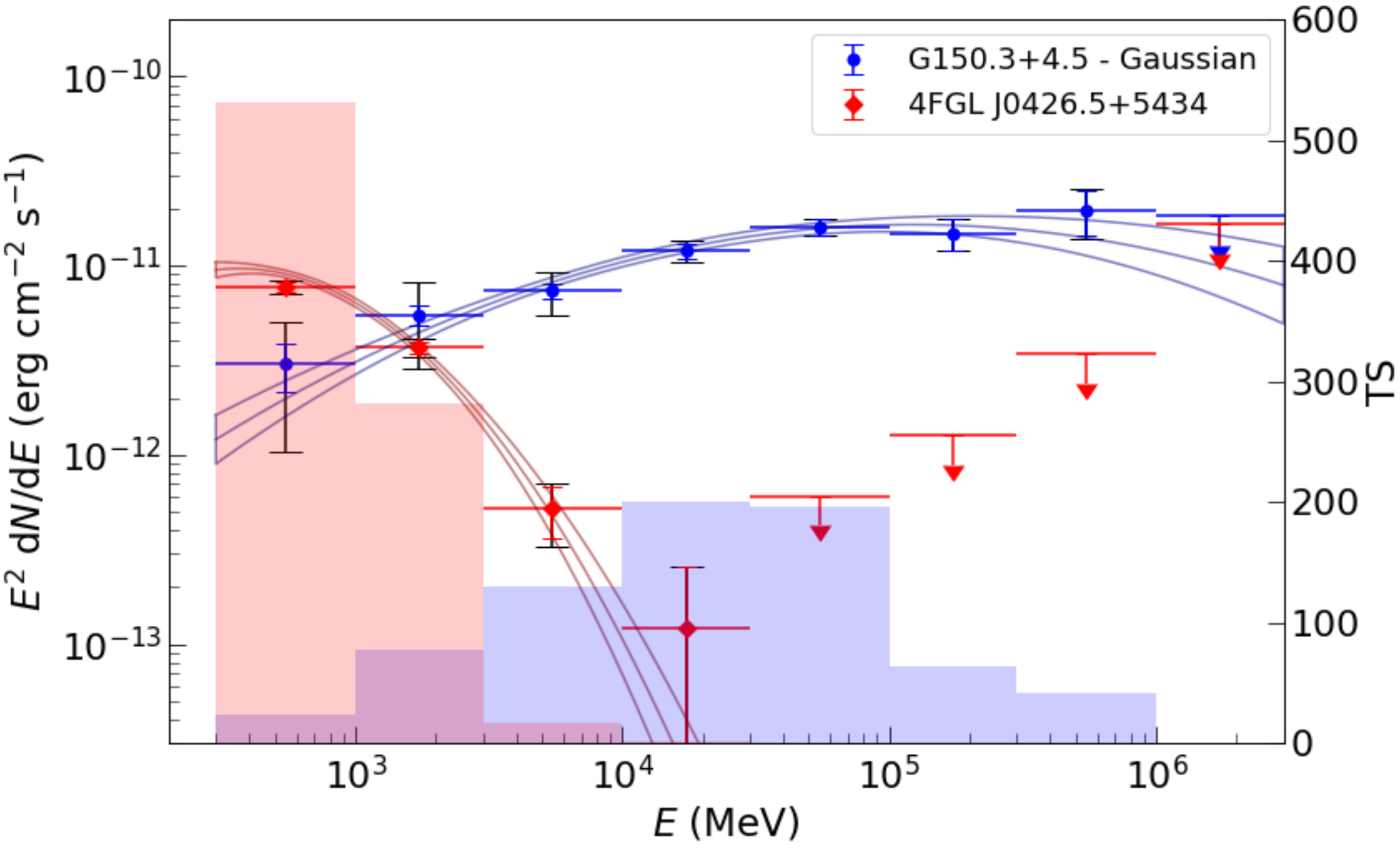


➡ **Gamma-ray morphology does not shrink at higher energies**

Displacement of the centroid may be due to a possible contamination from 4FGL J0426.5+5434 at low energy

Fermi-LAT data analysis

- **Spectral analysis (300 MeV — 3 TeV)**



Fermi-LAT data analysis

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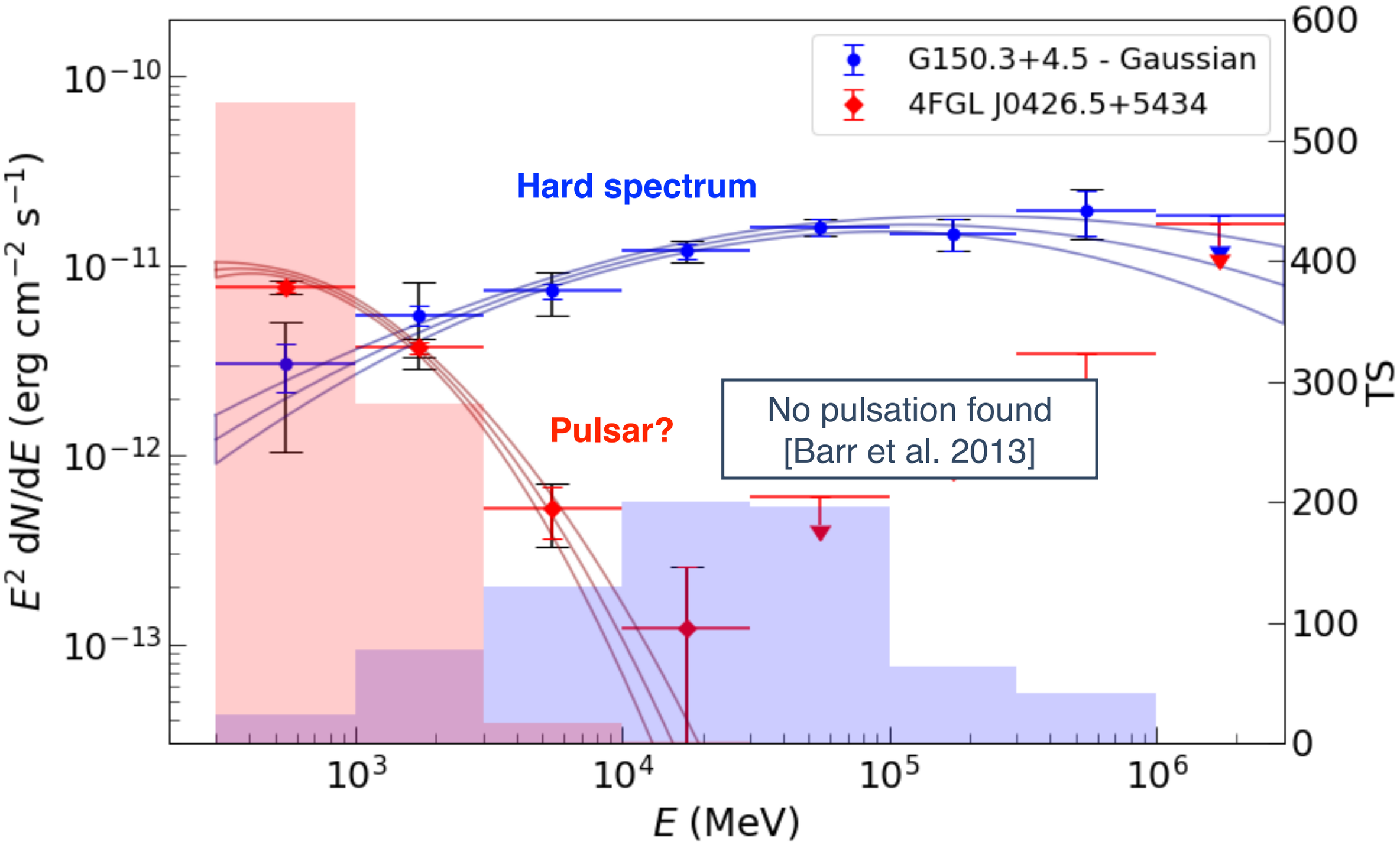

Fermi-LAT data analysis

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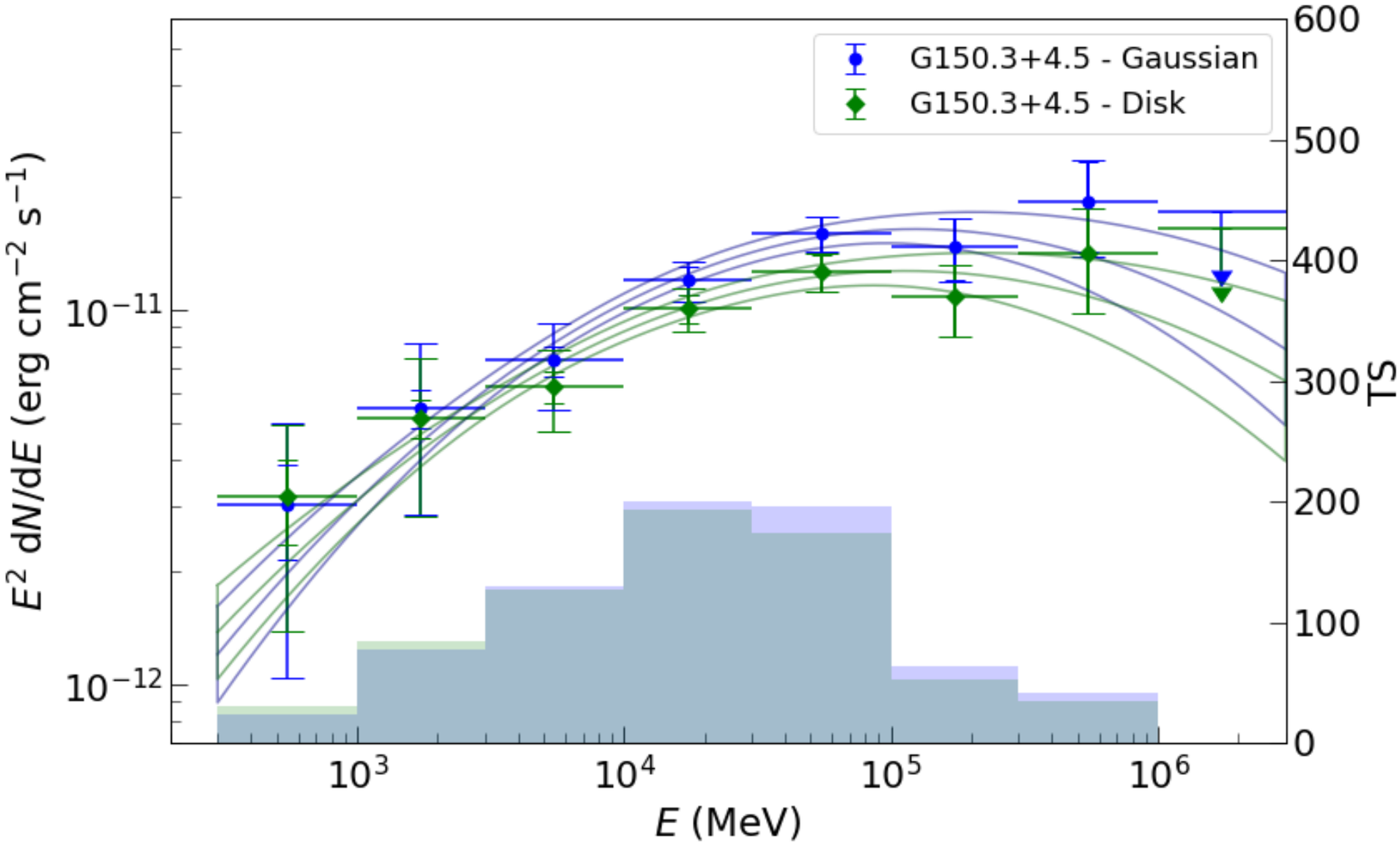


Spatial model (Gaussian or disk) has a negligible impact on the spectral analysis

➡ **We used the morphological and spectral properties of the disk**

X-ray observations and distance estimate

- **ROSAT all-sky survey (0.1 — 2.4 keV)**

➡ **No significant thermal and nonthermal emission**

Sedov-Taylor self-similar solution:

$$R_{\rm ST} \approx 0.314 \times \left(\frac{E_{51}}{n_0}\right)^{1/5} t_{\rm yr}^{2/5} \ \ {\rm pc}$$

Assuming E_{51} = 1 and knowing the angular size of G150.3+4.5, we used different combinations of *d* and *t* to **calculate the corresponding ambient density**

➡ Emission modeled as an absorbed thermal NEI plasma for each combination of *t*, n_0, N_H and T_e/T_p

➡ For each *d*, we calculated the corresponding N_H and we obtained an **upper limit on n_0**.

➡ **The maximal ambient density allowed by ROSAT data is $n_0 = 3.6 \times 10^{-3}$ cm^{-3}**

X-ray observations and distance estimate

- **Minimal distance estimate**

At Dec ~ 55°, a SNR younger than 1 kyr should have been reported in historical records (t_{min} = 1 kyr)

➡ d_{min} = 0.7 kpc

for an ambient density $n_0 = 1.5 \times 10^{-3}$ cm^{-3} compatible with ROSAT data

- **Maximal distance estimate**

$$\mathcal{M}^2 > 10 \longrightarrow \rho_0 v_s^2 > 10\rho_0 c_s^2 = 10\gamma P_{\rm ISM}$$

$$\rho_0 v_s^2 = \left(\frac{2}{5}\right)^2 \zeta^5 \times \frac{E}{R_s^3}$$ (Sedov model)

$$R_s < 1.69 \times \left(\frac{P_{\rm ISM}}{k}\right)^{-1/3} \ {\rm kpc}$$

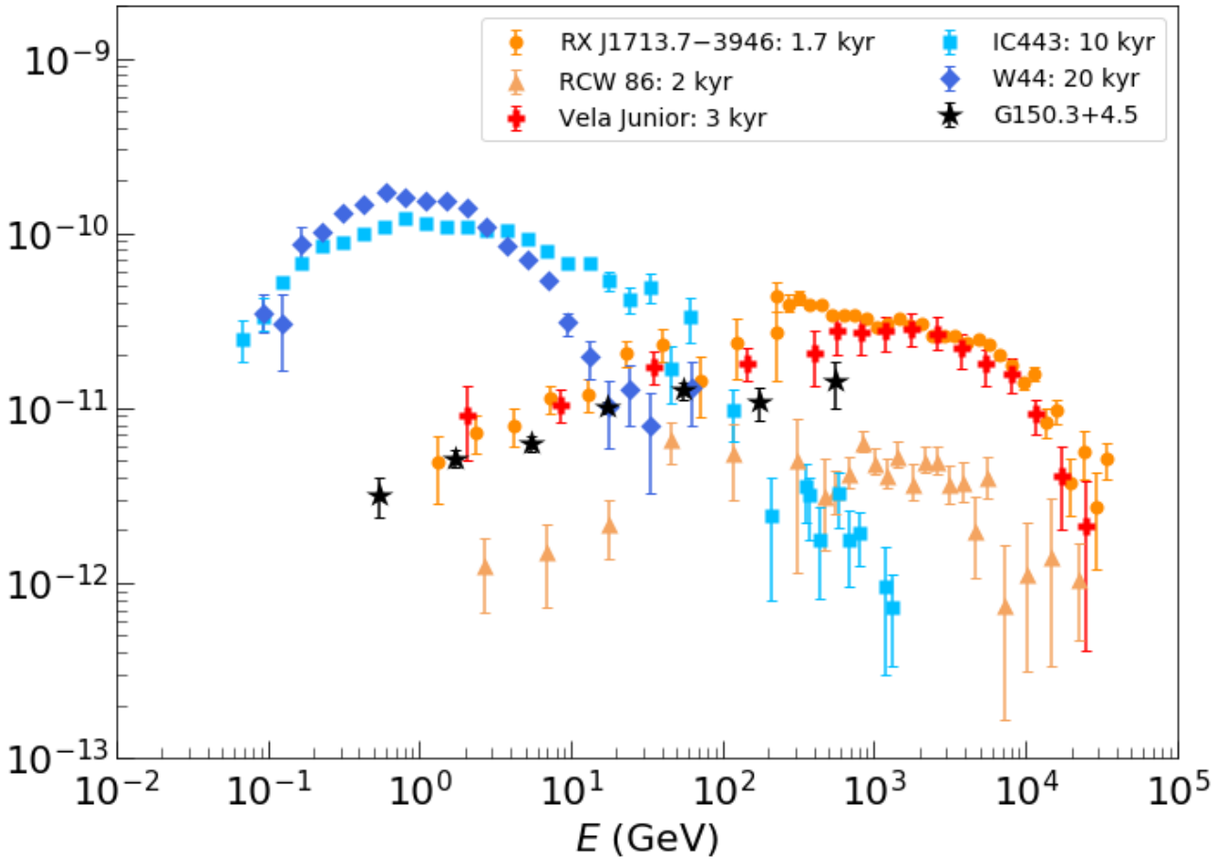
$$(P_{\rm ISM}/k) = 2.3 n_0 T_{\rm ISM} = 3000 \ {\rm K \ cm^{-3}}$$

$$R_s < 117 \ {\rm pc}$$

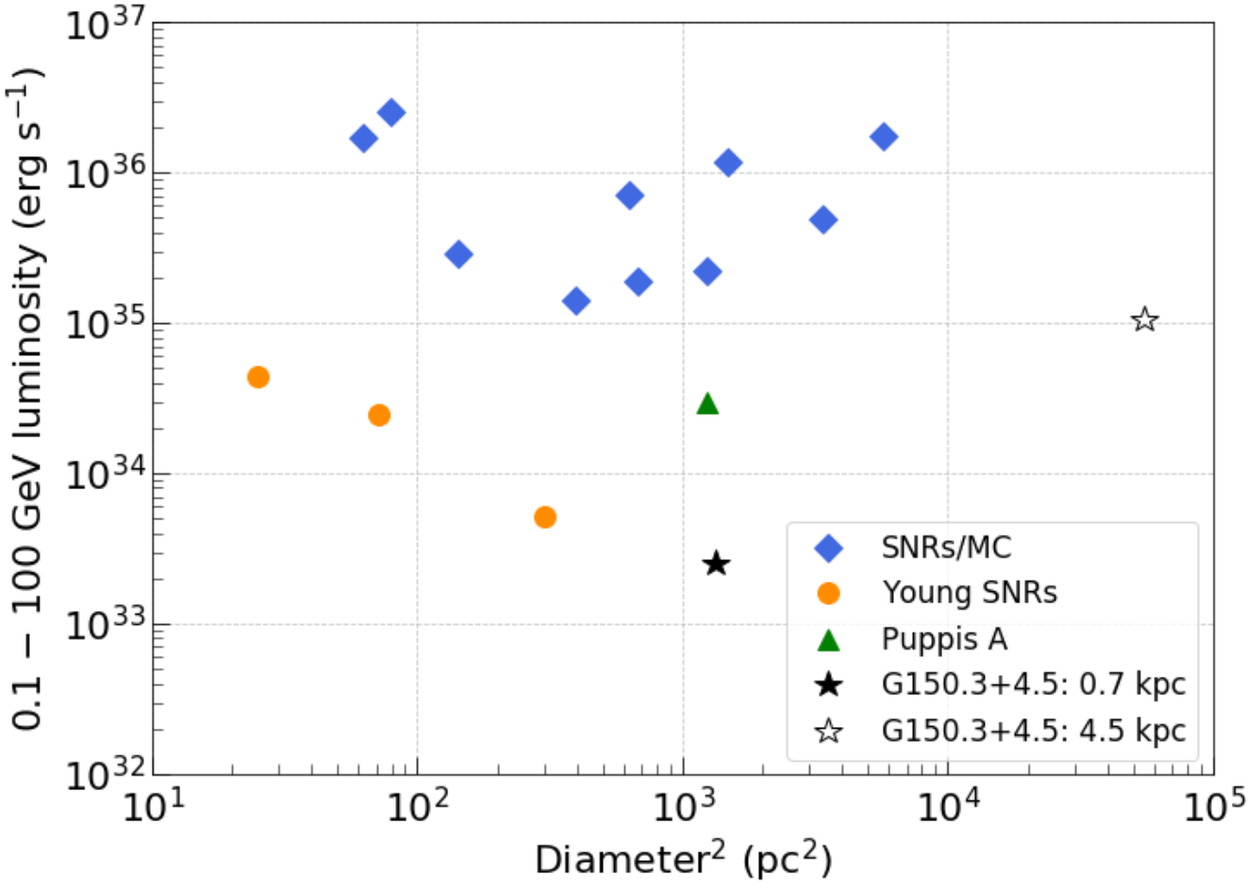
➡ d_{max} = 4.5 kpc

Origin of the gamma-ray emission

- **Evolutionary stage of G150.3+4.5**



G150.3+4.5 is **spectrally similar to the dynamically young and shell-type** SNRs



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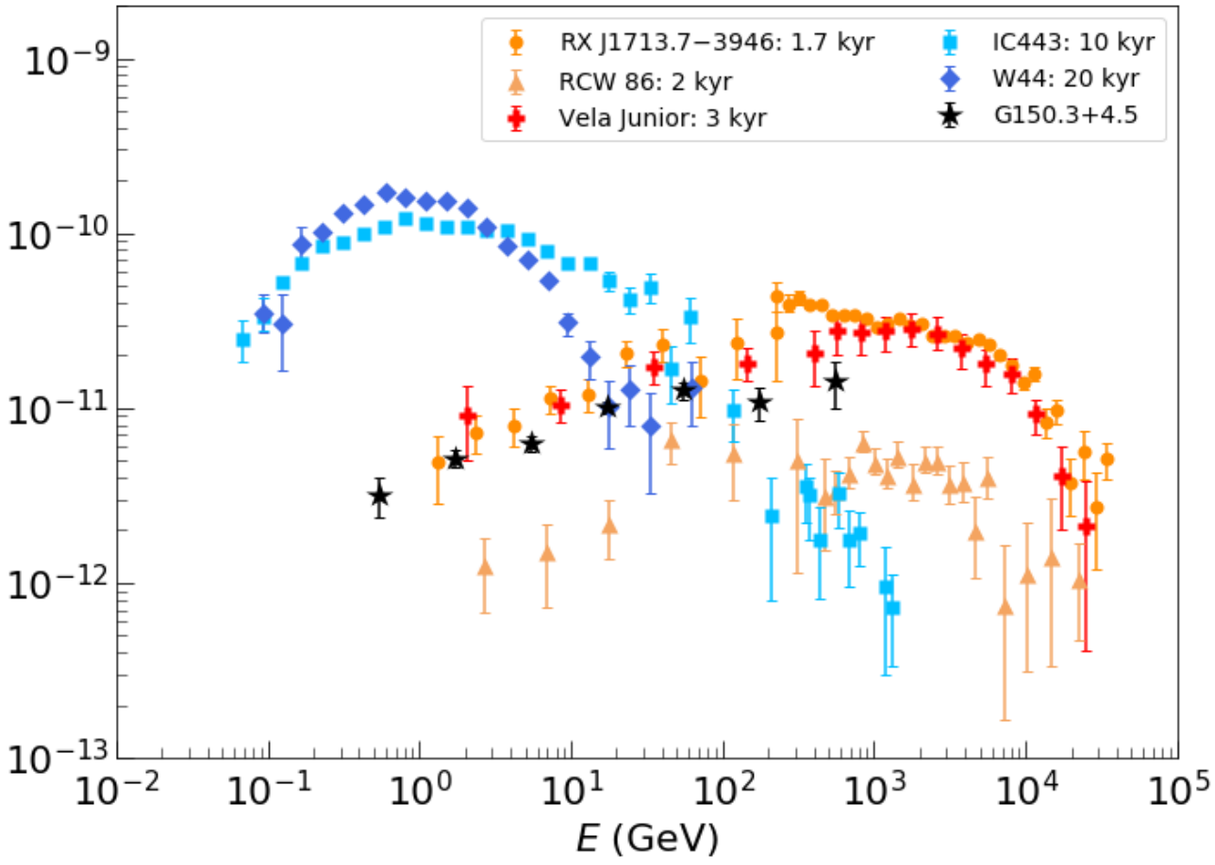

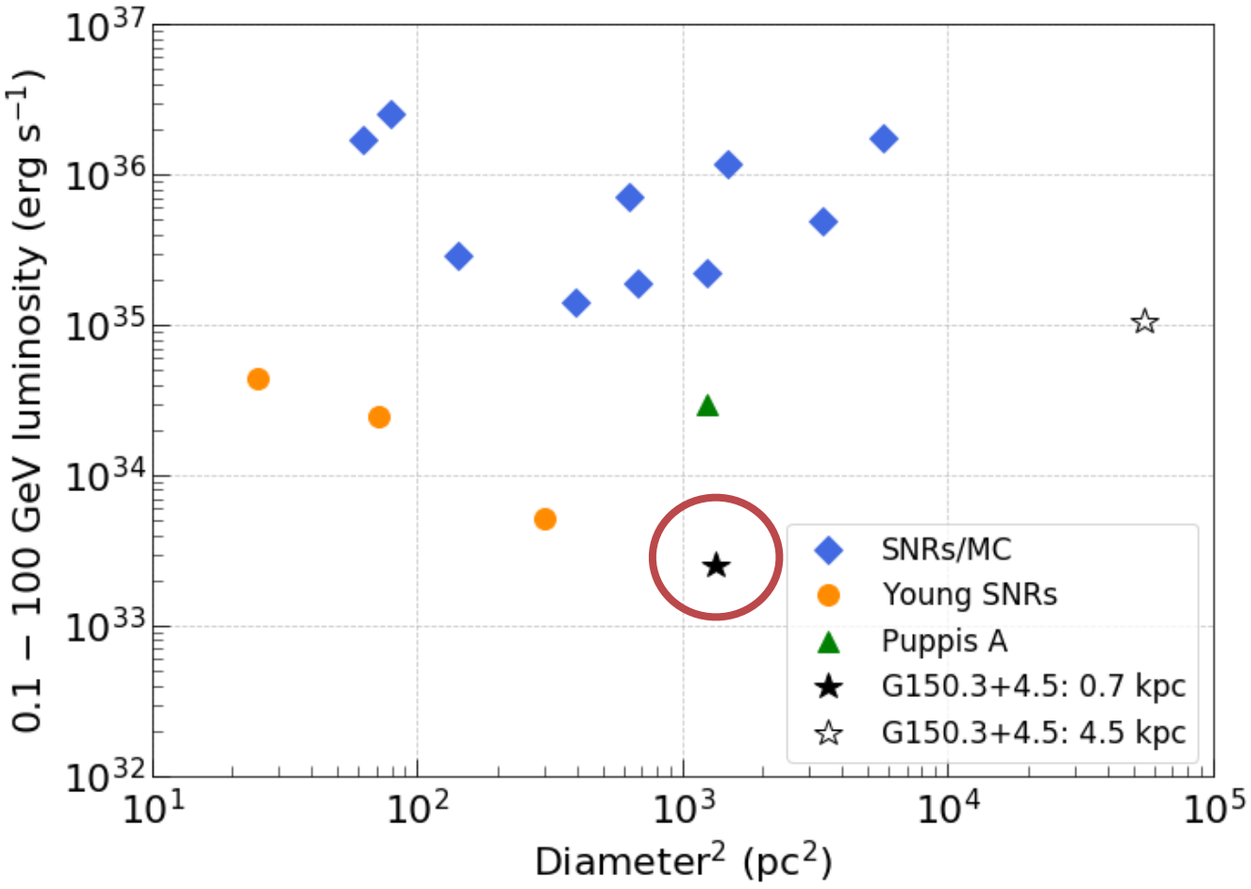

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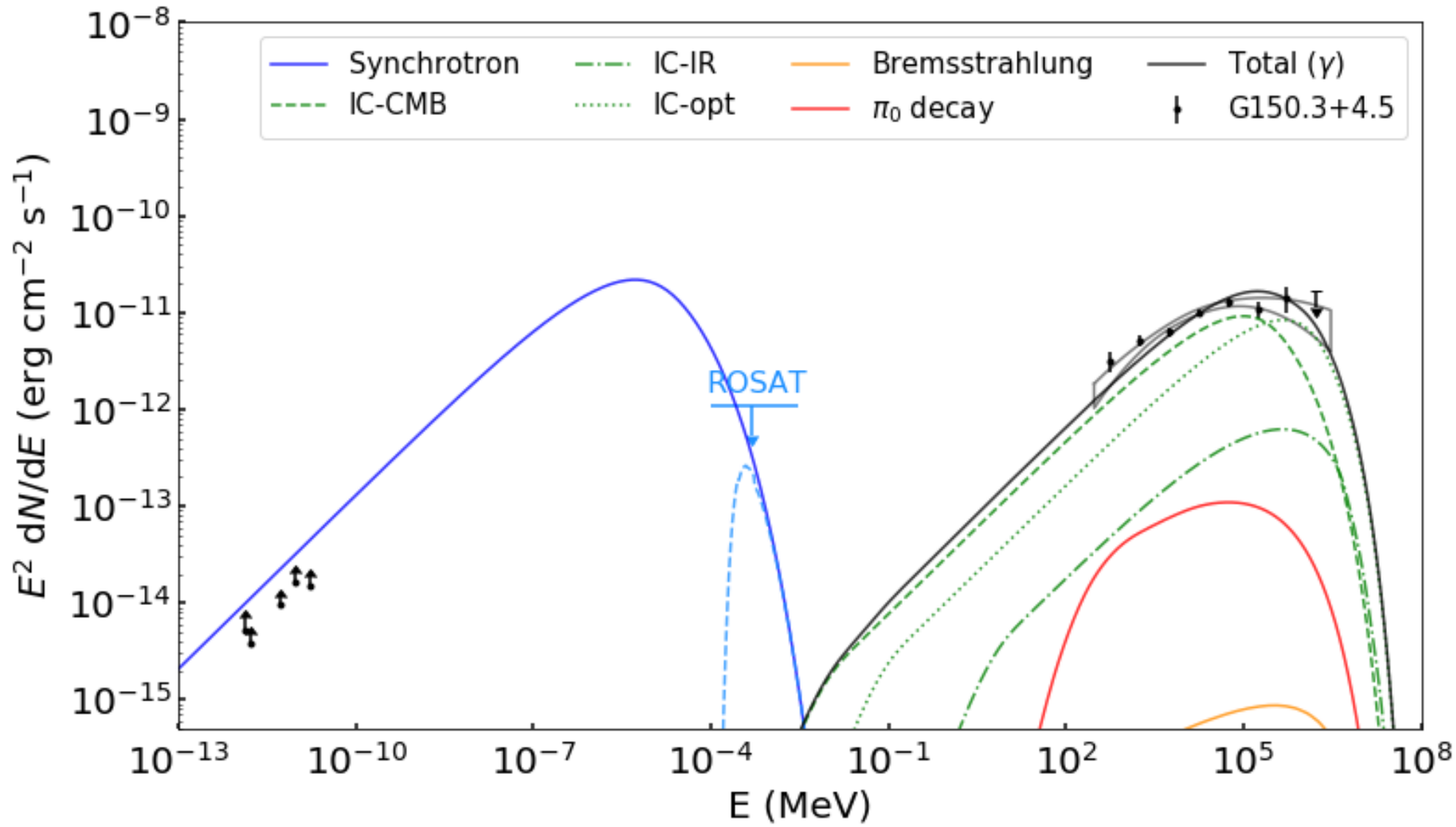
The hard spectral shape of G150.3+4.5 and its likely low luminosity supports the dynamically young and non-interacting scenario, and therefore a near distance

Origin of the gamma-ray emission

- **Broadband nonthermal modeling**

d (kpc) / t (kyr)	B (μG)	W_p (erg)	K_{ep}	$s_{e,1} = s_{e,2}$	s_p	n_0 (cm^{-3})	$E_{max,e}$ (TeV)	$E_{max,p}$ (TeV)	k_0	v_s (km s^{-1})
0.7 / 1.0	5	10^{50}	1×10^{-3}	1.8*	1.8	1.5×10^{-3}	5.2	5.2	16	7163



➡ **Leptonic scenario and E_{max} > few TeV for the two extreme distances**

Conclusions

➡ Extended gamma-ray emission **spatially coincident with the radio SNR G150.3+4.5**, and with a hard spectrum

➡ **No significant thermal and nonthermal emission** is detected with ROSAT data and we estimated a minimal and maximal distances of 0.7 kpc and 4.5 kpc

➡ **G150.3+4.5 is spectrally similar to the dynamically young and shell-type SNRs**

➡ Broadband nonthermal emission explained with a **leptonic scenario**, with B = 5 muG and acceleration of particles up to few TeV energies

Deeper multi-wavelength observations are required: distance? Environment of G150.3+4.5 and its synchrotron spectrum? Maximal energy reached by particles?

[Devin et al. 2020, A&A, 643, A28]

✓ Observations at very-high energy needed !
✓ Deeper pulsation searches on 4FGL J0426.5+5434