Fermi acceleration under control: η Carinae

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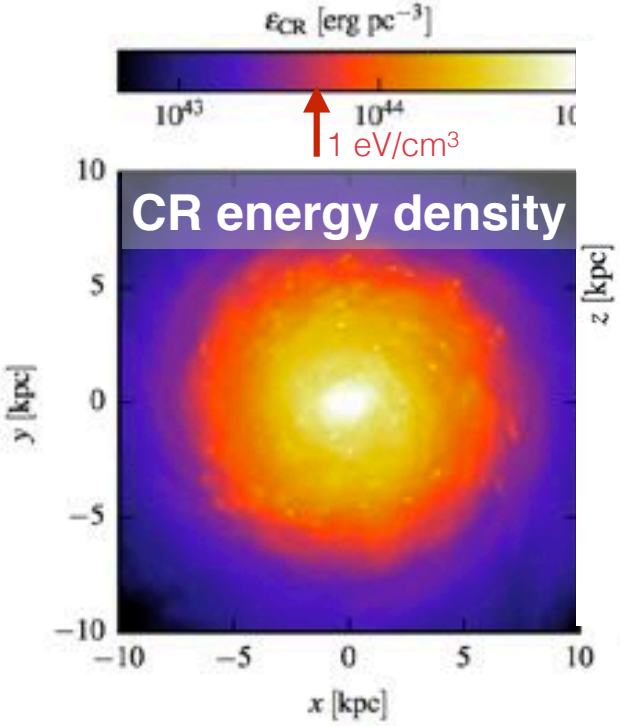
submitted to A&A

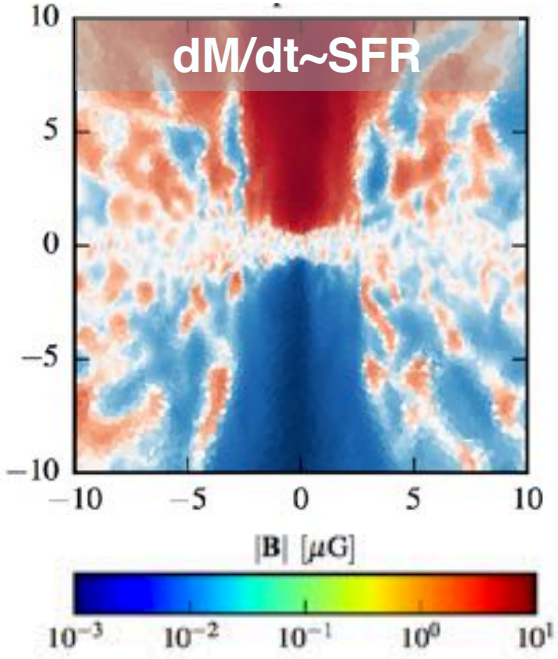
UNIVERSITÉ DE GENÈVE

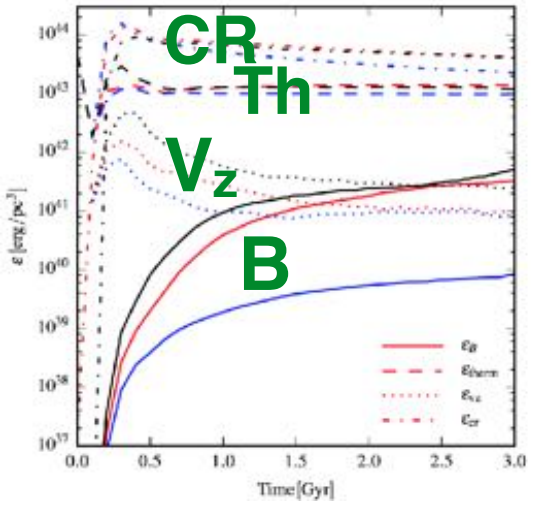
- Particle acceleration shaping the galaxy
- Fermi acceleration in η Carinae

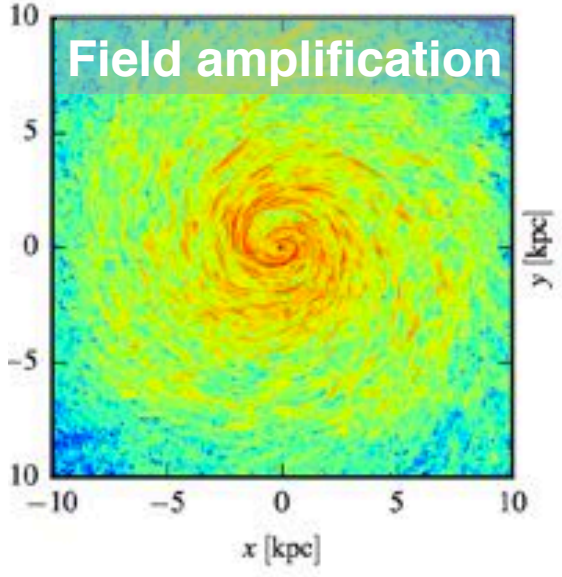
Acceleration and feedback

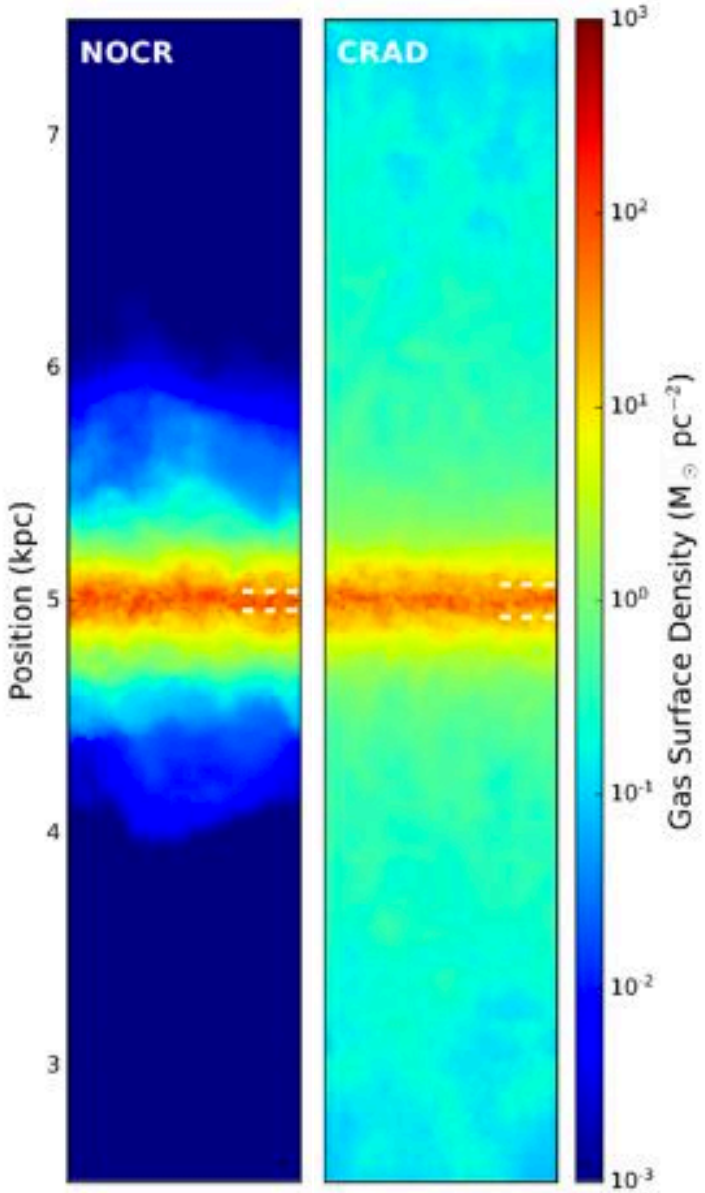
Anisotropic CR diffusion (Pfrommer & Springel groups, 2016)



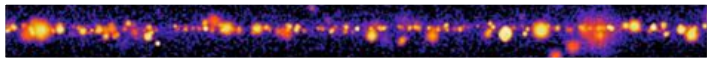


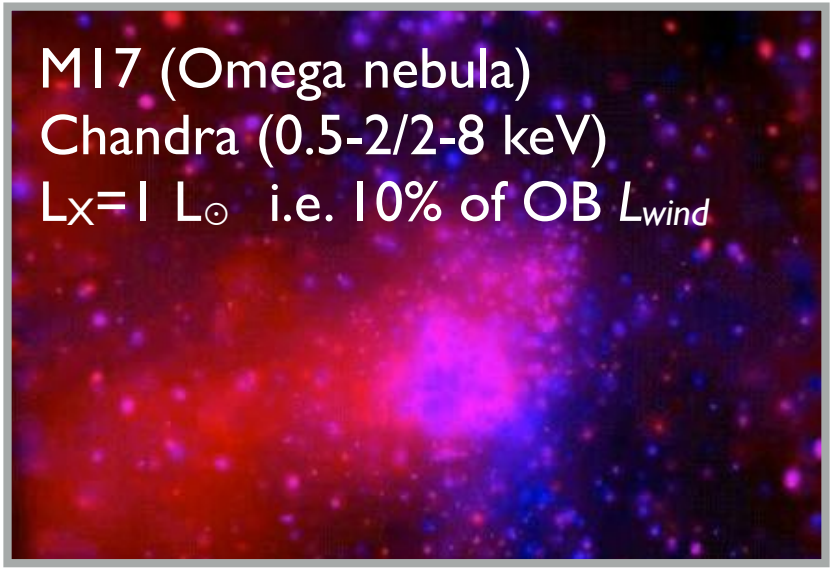






Acceleration and feedback

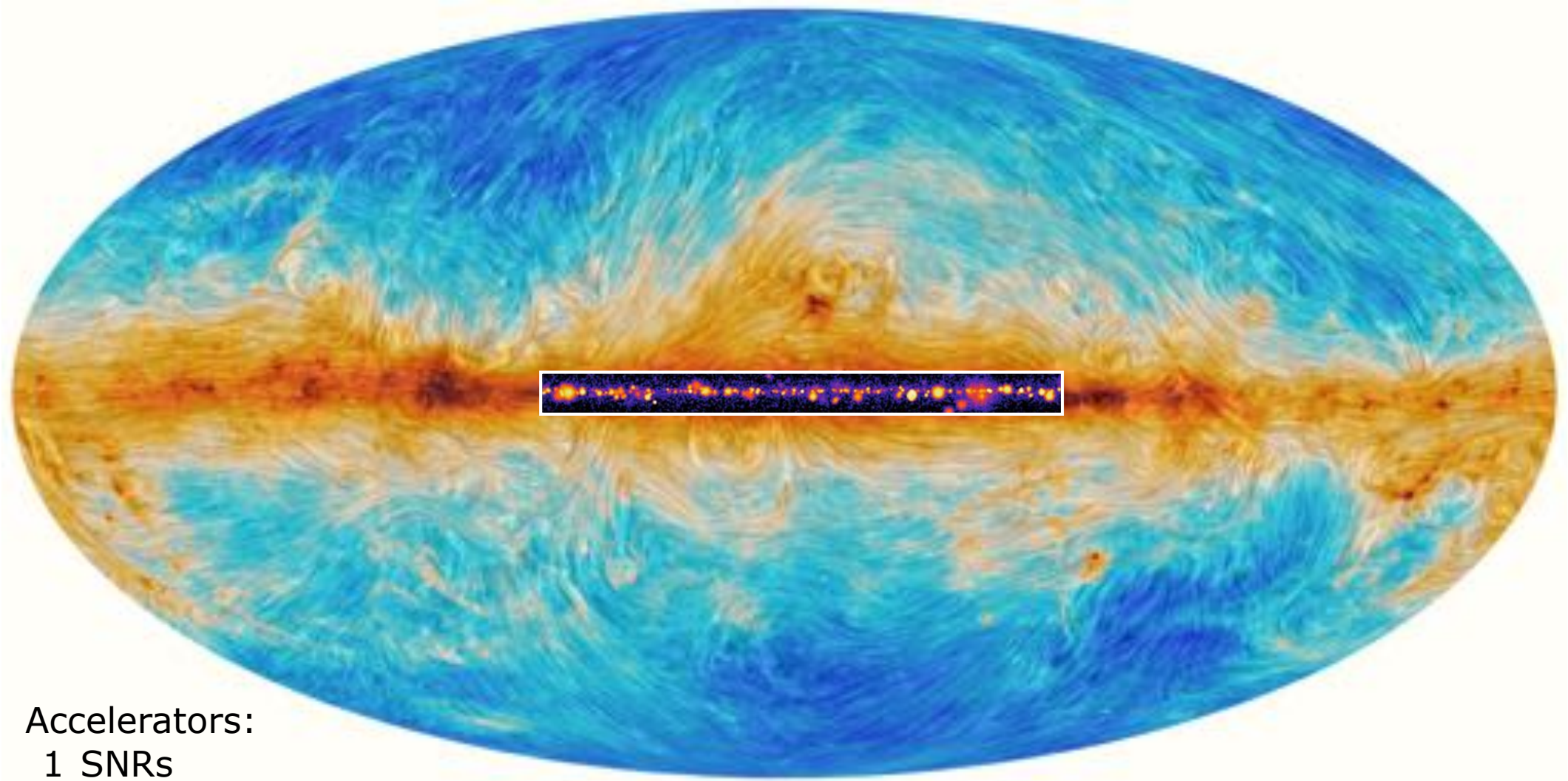




Accelerators:

1 SNRs
2 Wind collisions in OB regions
3 ….

Acceleration and feedback



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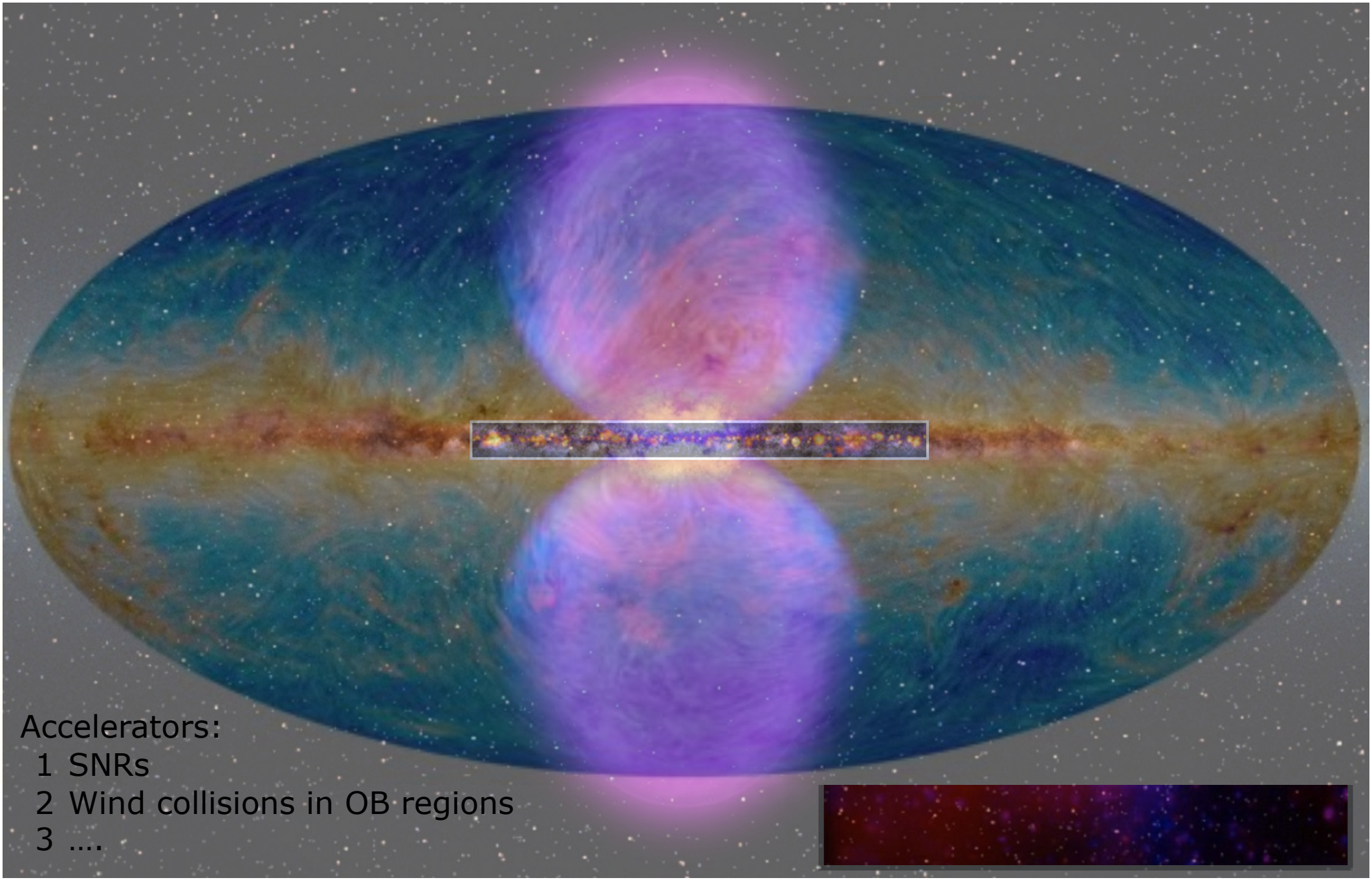

Accelerators:

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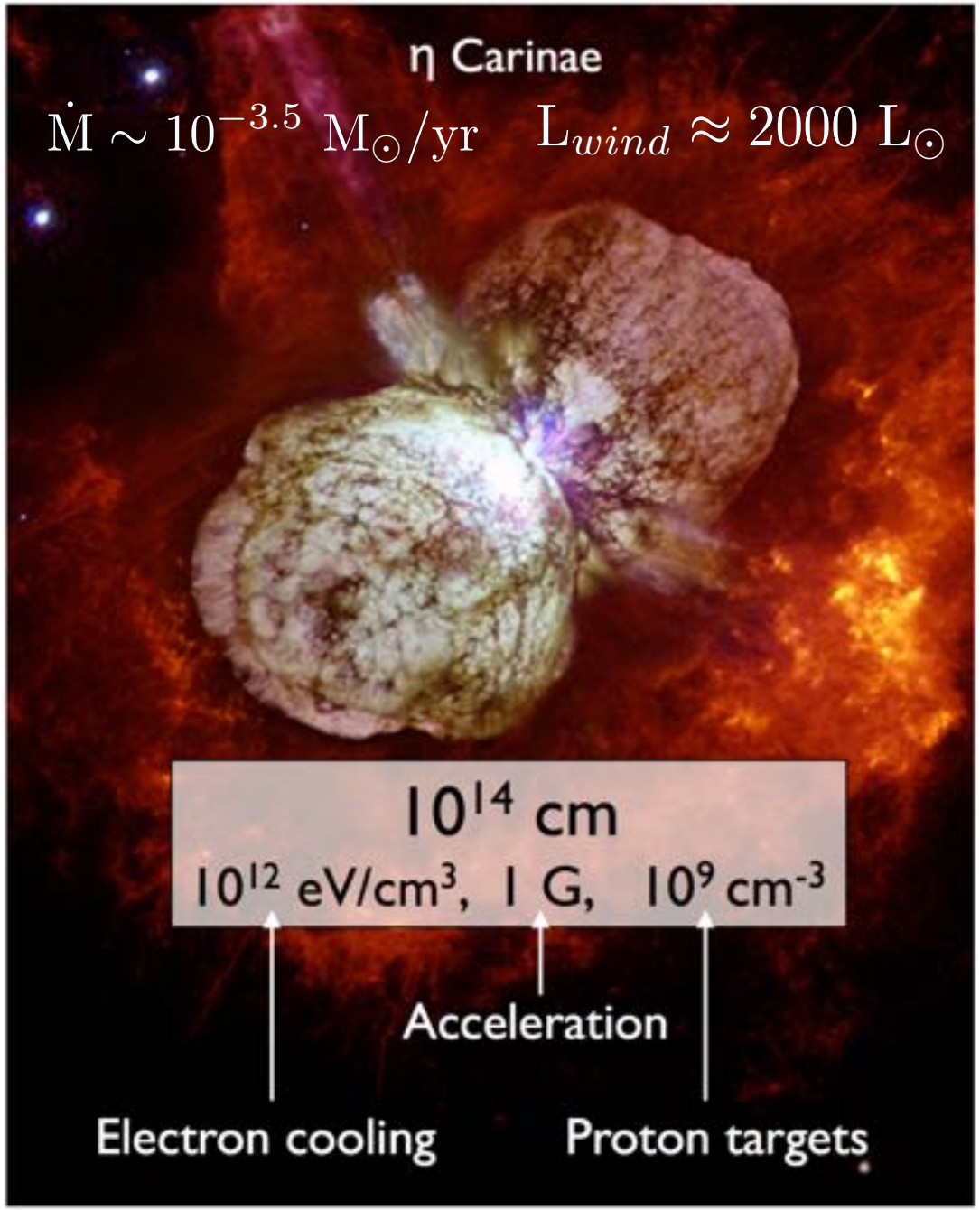
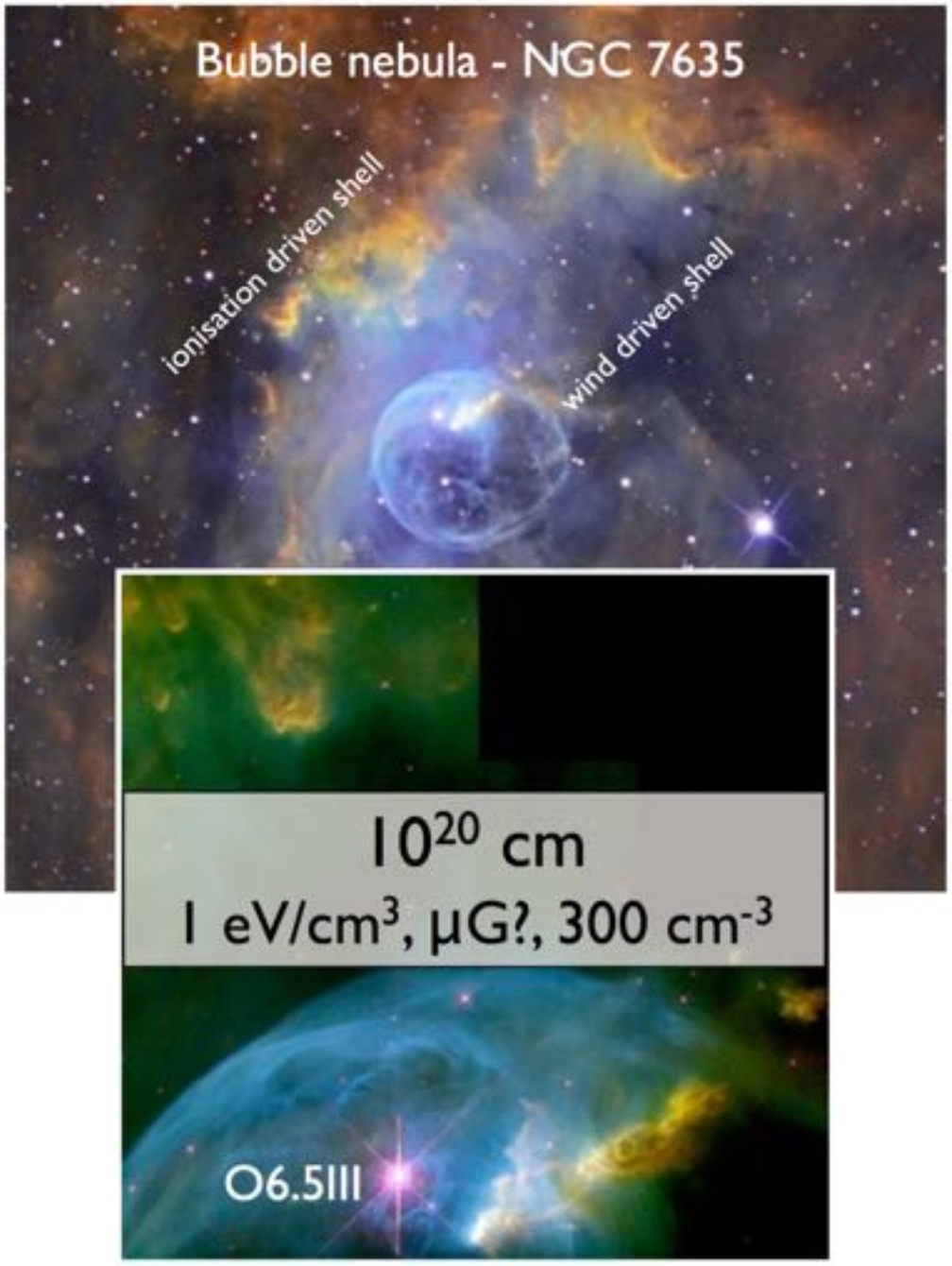
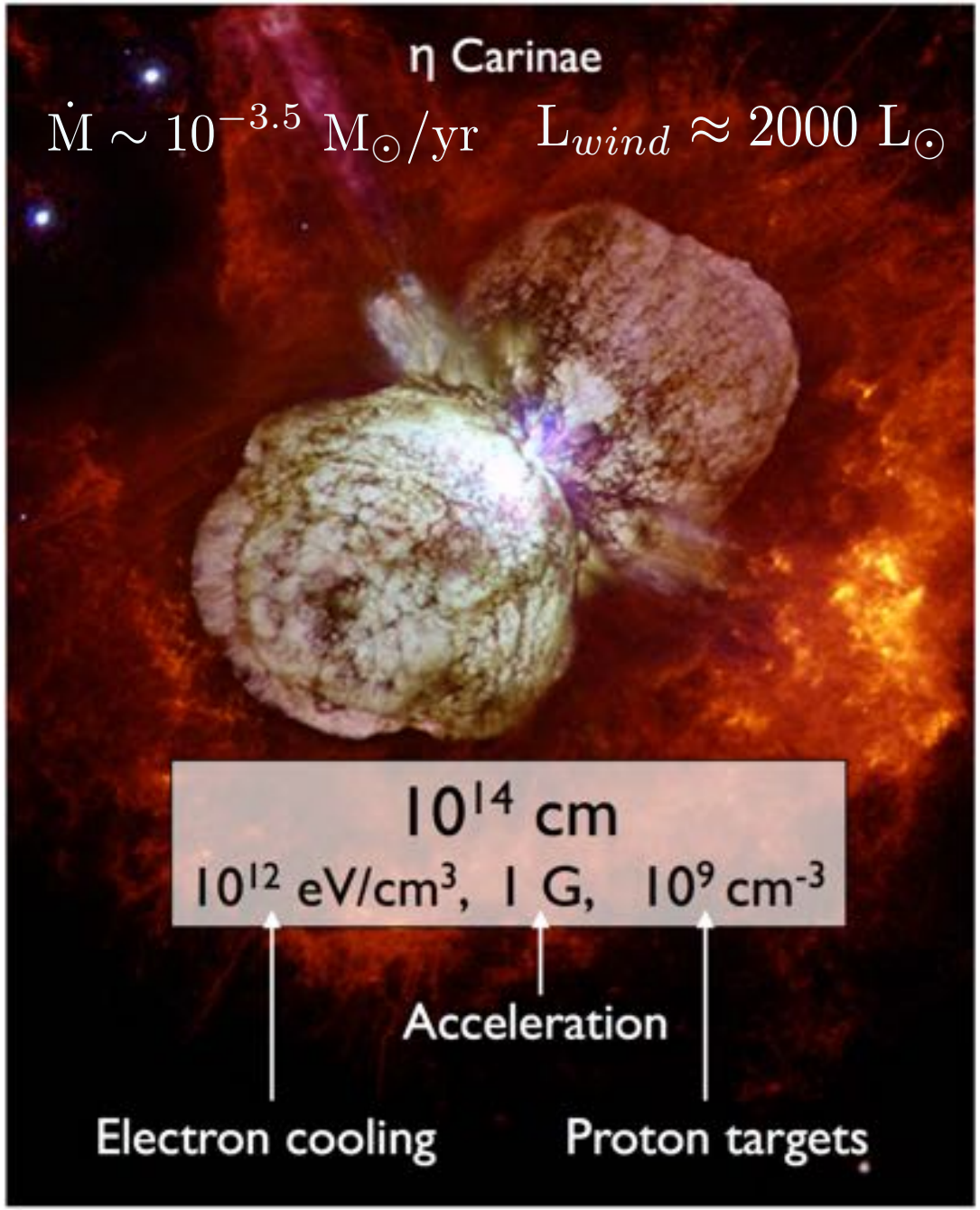
Acceleration in colliding winds





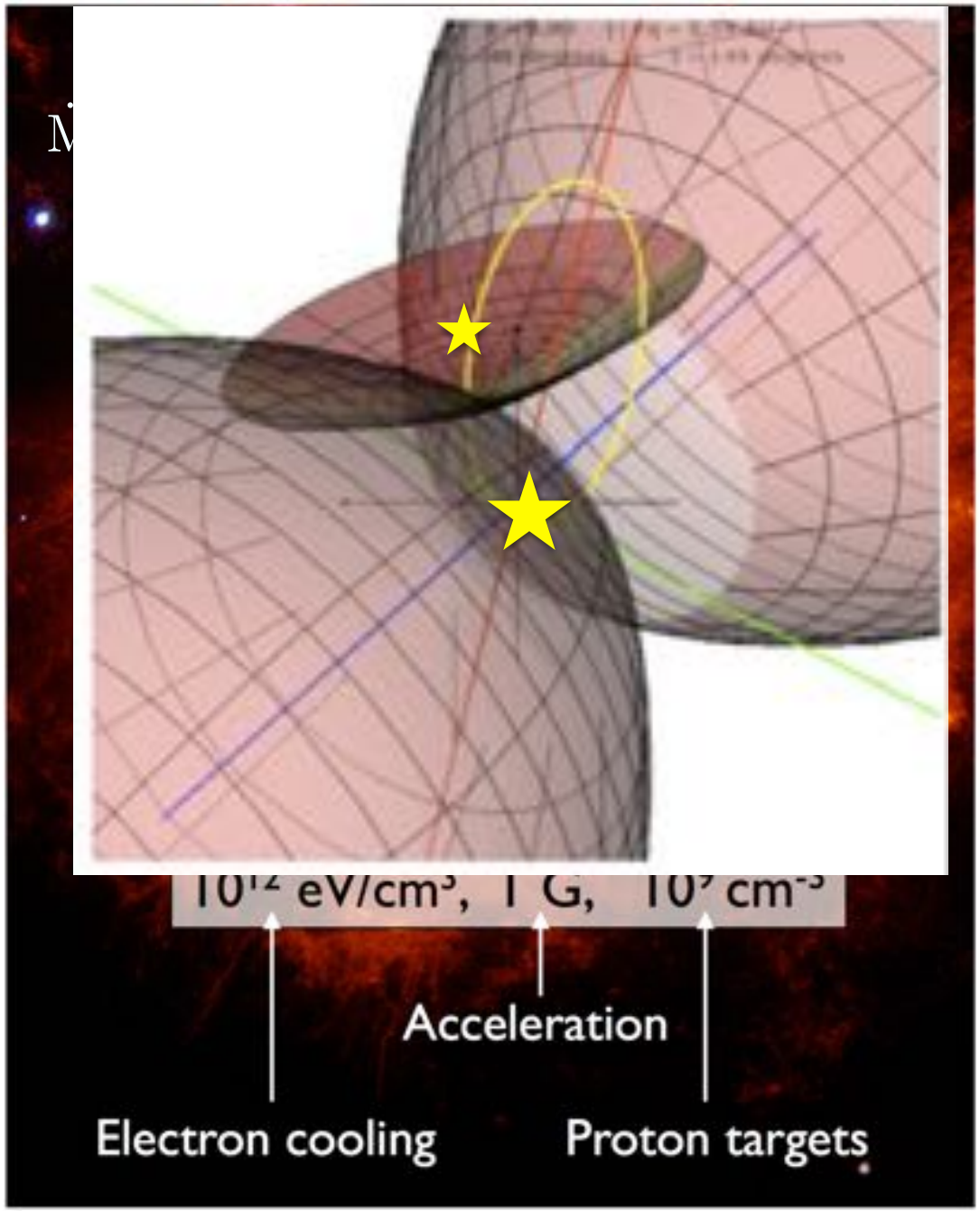
Acceleration in colliding winds



Colliding Wind Binaries are predicted to be potential sites of HE γ-ray emission through strong shocks due to colliding winds

Eichler & Usov (1993) ApJ 402, 271

Acceleration in colliding winds



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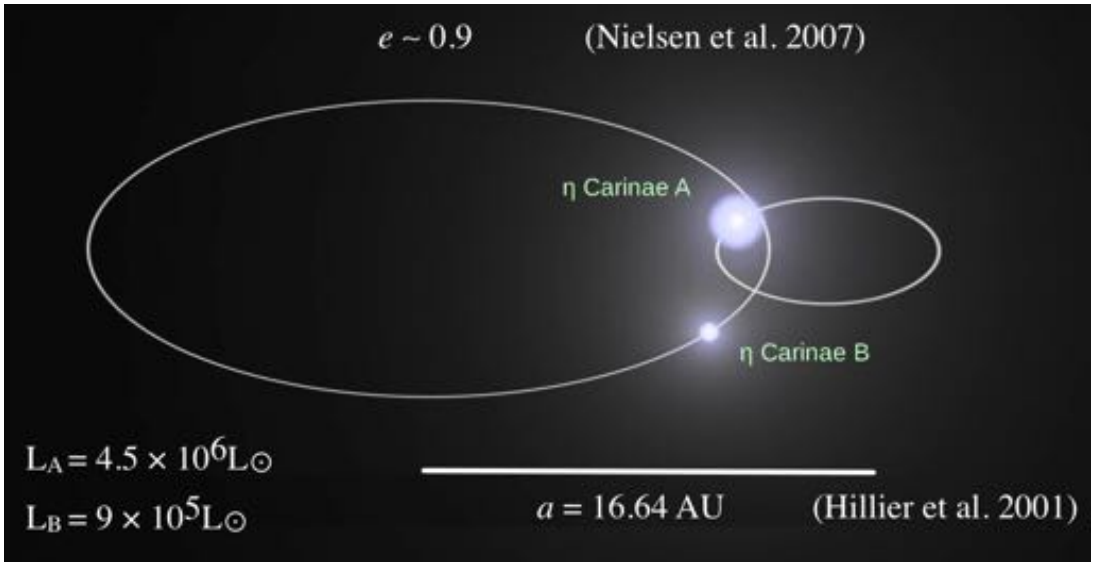
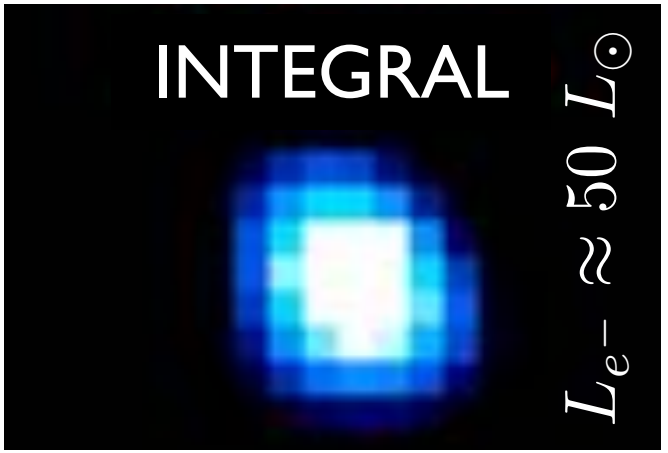
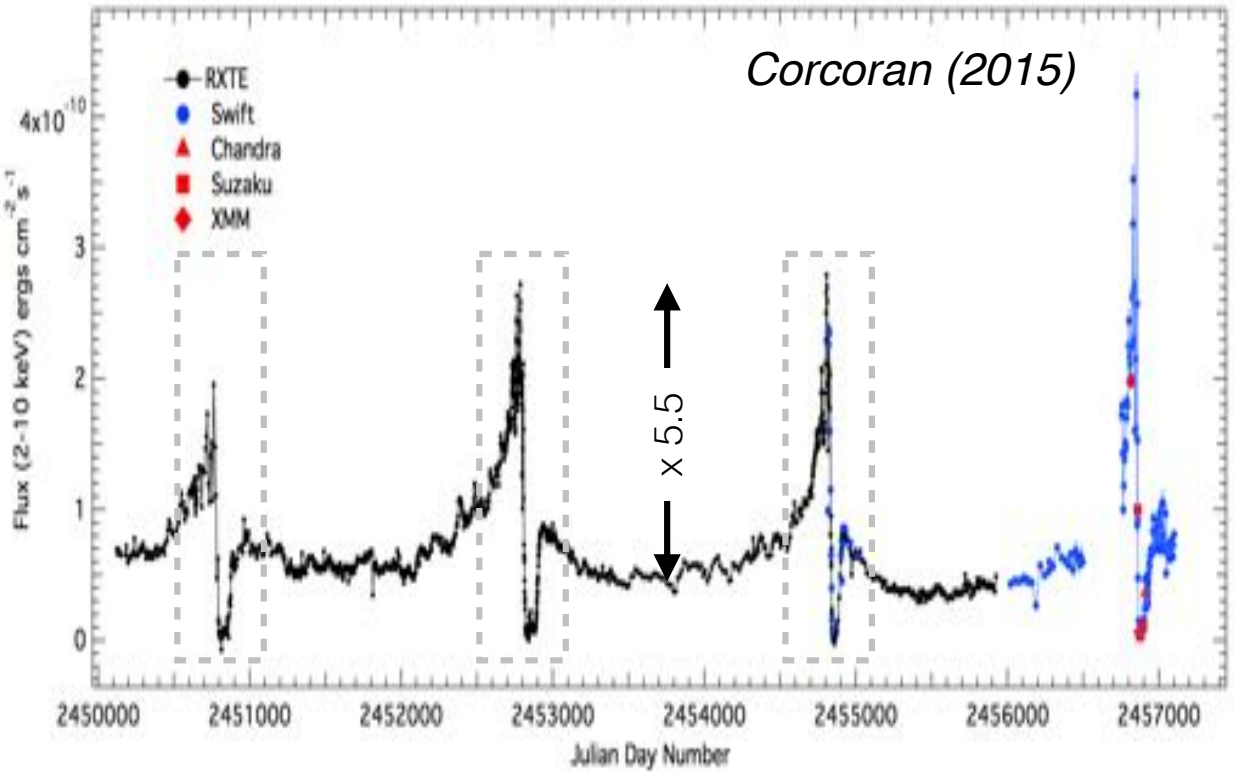
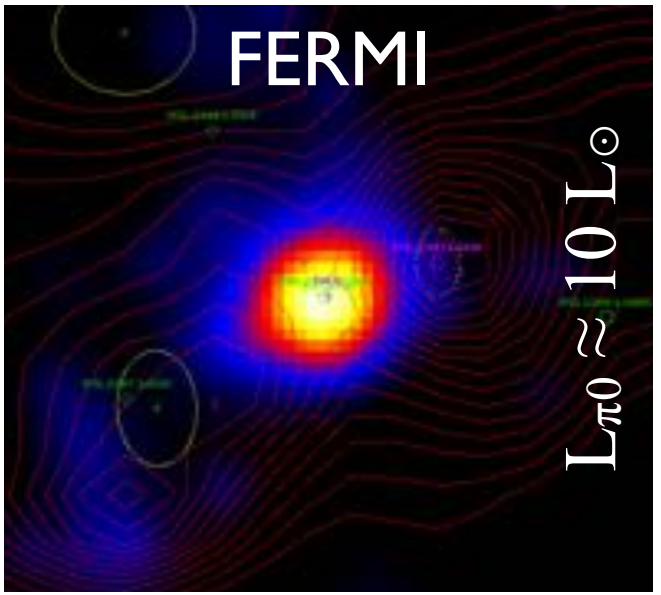
Who is η Car ?





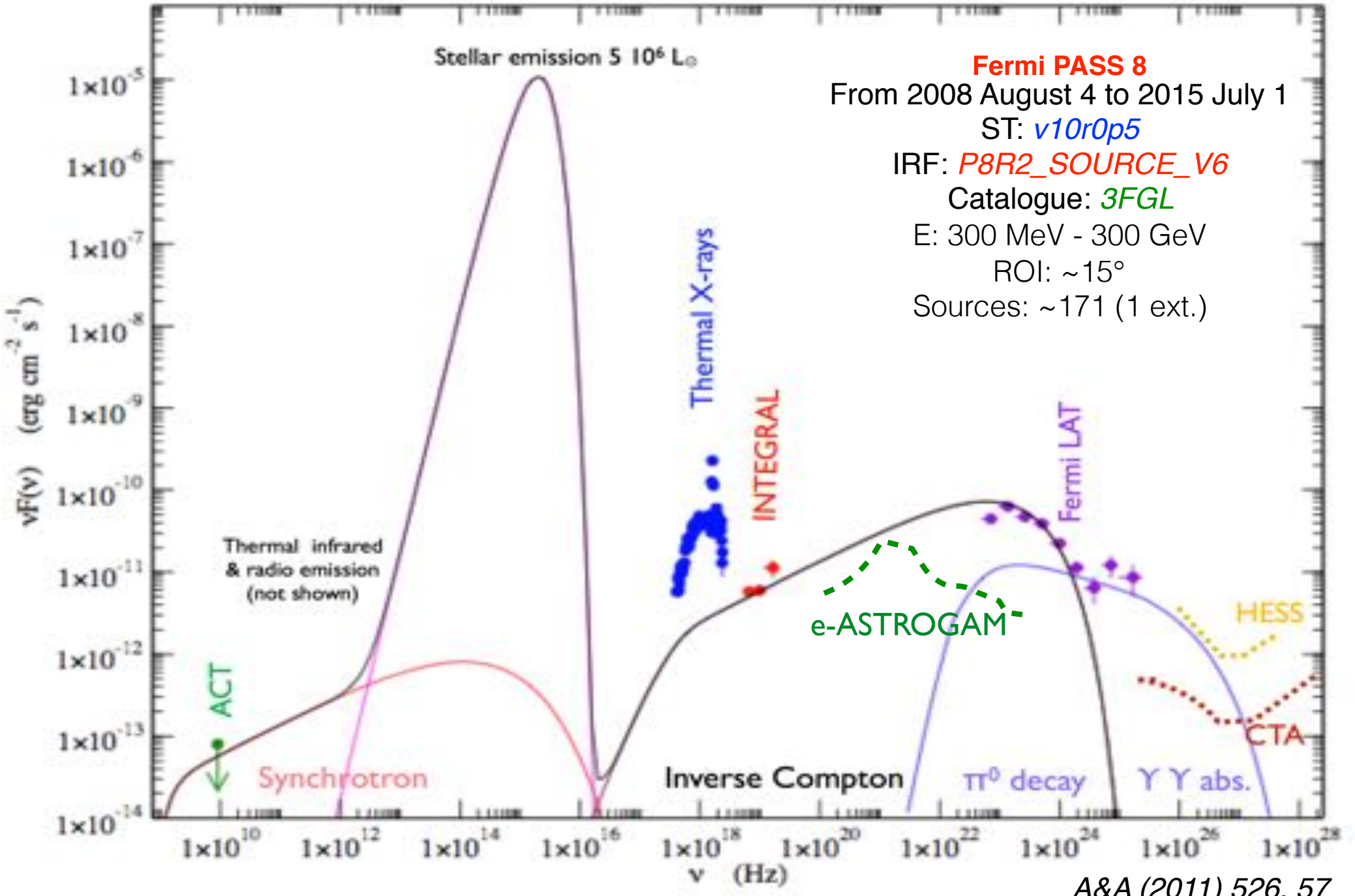
A&A (2008) 477, L29
A&A (2010) 529, 59





A&A (2011) 526, 57

Non thermal emission of η Car

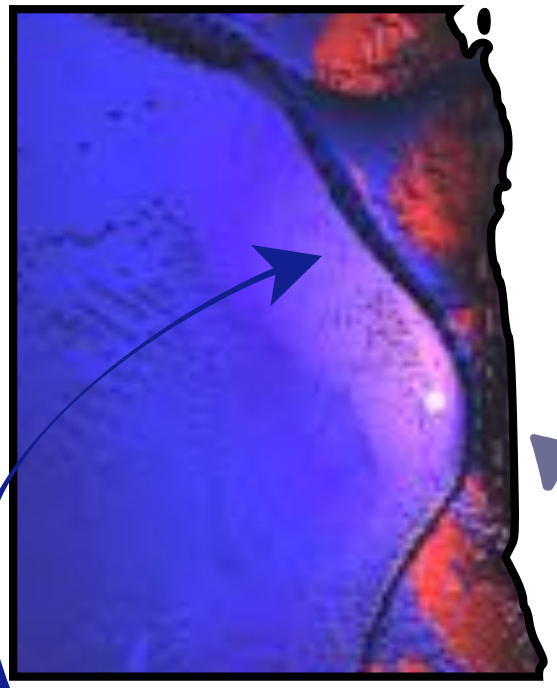


Fermi PASS 8
From 2008 August 4 to 2015 July 1
ST: *v10r0p5*
IRF: *P8R2_SOURCE_V6*
Catalogue: *3FGL*
E: 300 MeV - 300 GeV
ROI: ~15°
Sources: ~171 (1 ext.)

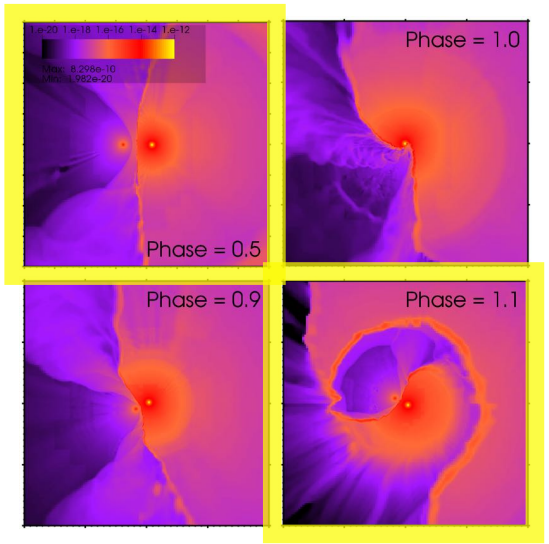
A&A (2011) 526, 57

3D hydro simulations

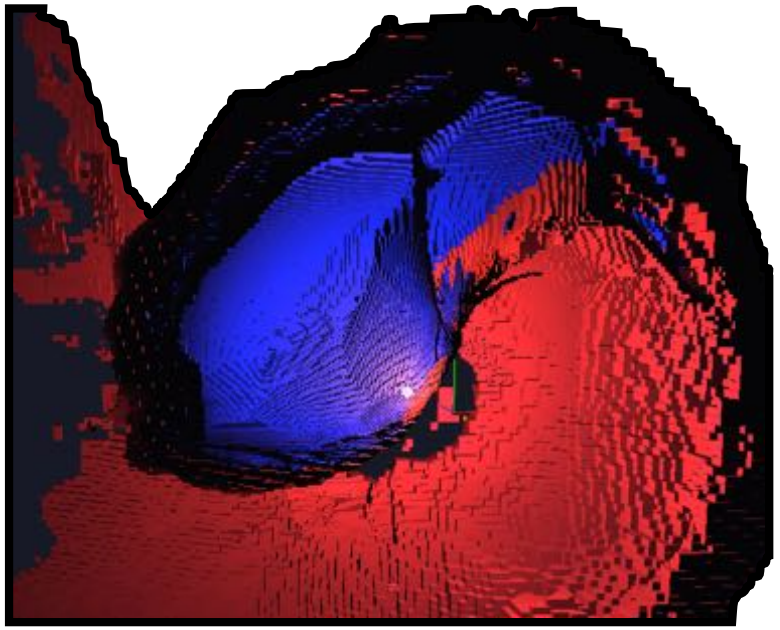
(Thermal simulations from Parkin et al, 2011)

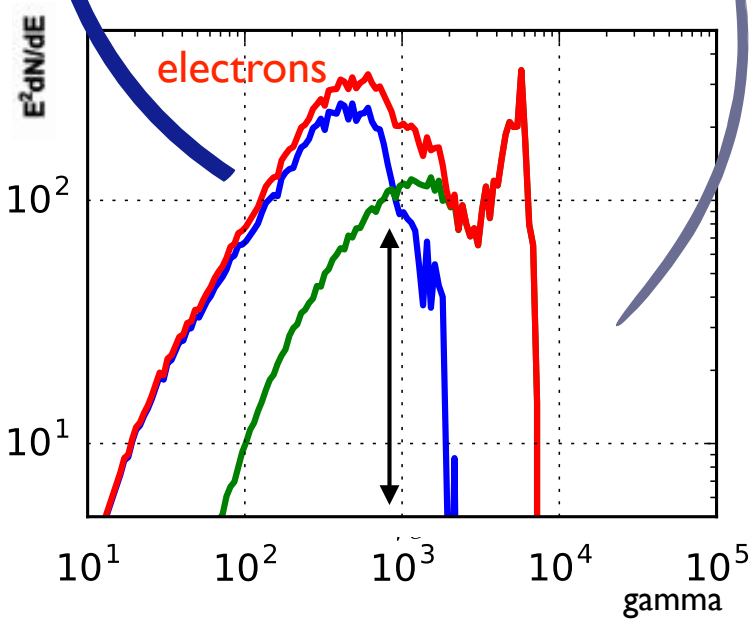


Parameter	Primary	Secondary
M ($M_\odot$)	120	30
R_* ($R_\odot$)	100	20
T_{cs} (K)	25,800	30,000
L_* ($10^6 L_\odot$)	4	0.3
k	0.30	0.50
α	0.52	0.68
$\dot{M}$ ($M_\odot$ yr^{-1})	4.8×10^{-4}	1.4×10^{-5}
v_∞ (km s^{-1})	500	3000
B (G)	400	



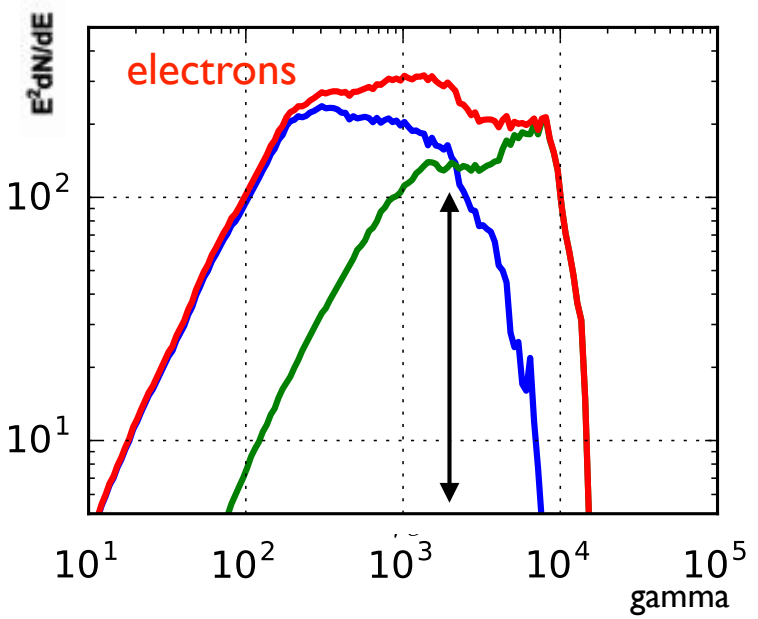
Parkin et al, 2011





e⁻ spectrum

smooth IC spectrum



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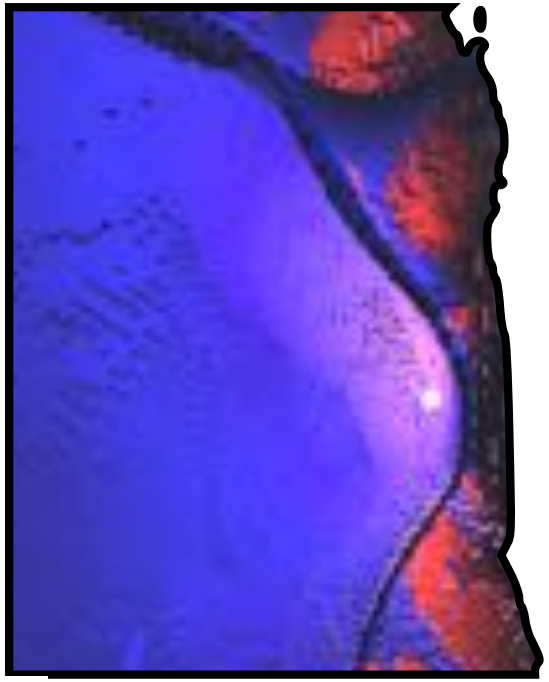

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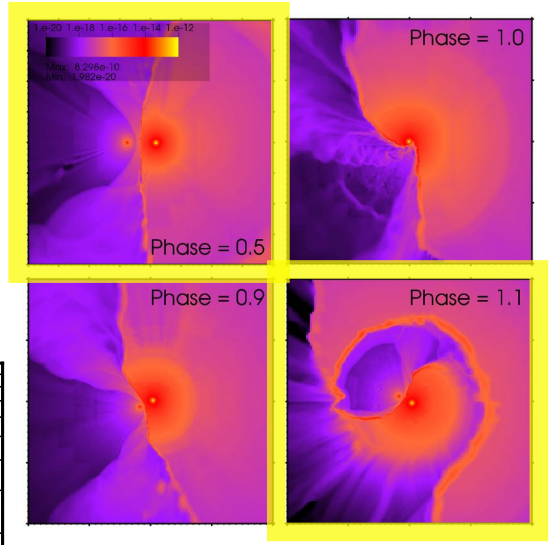

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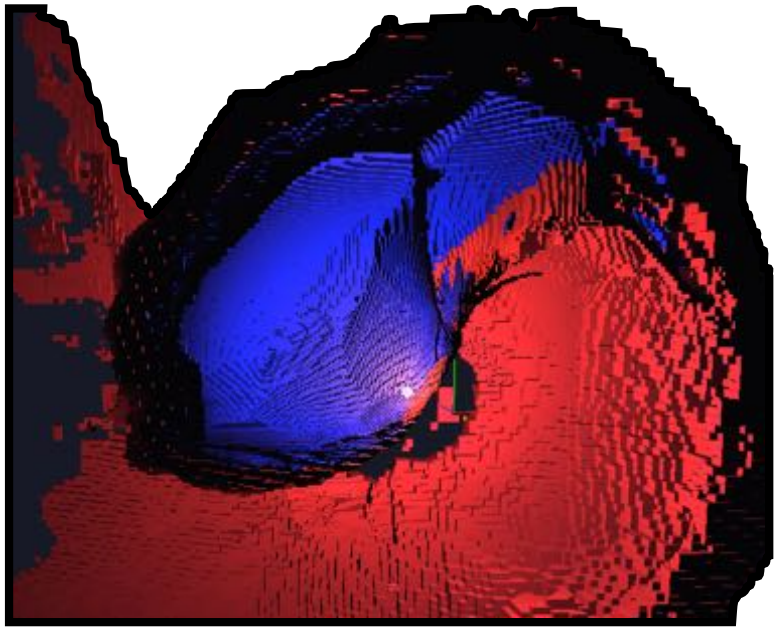

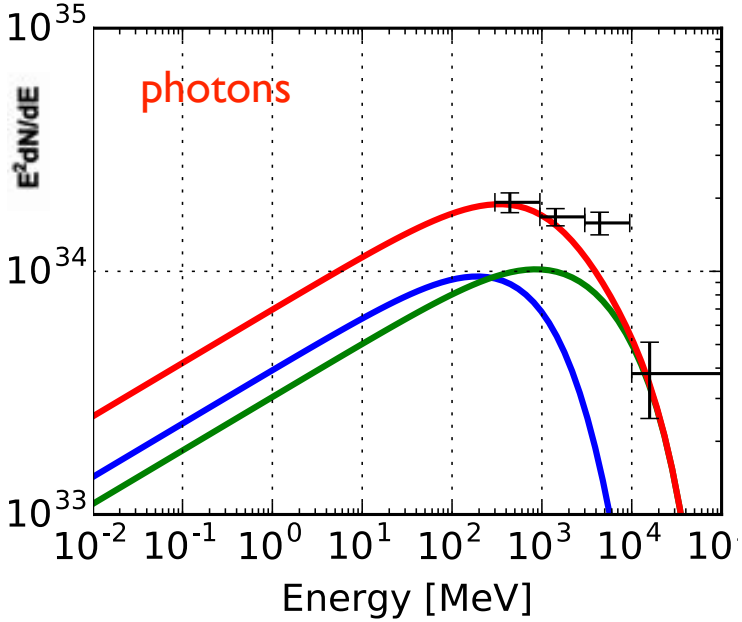

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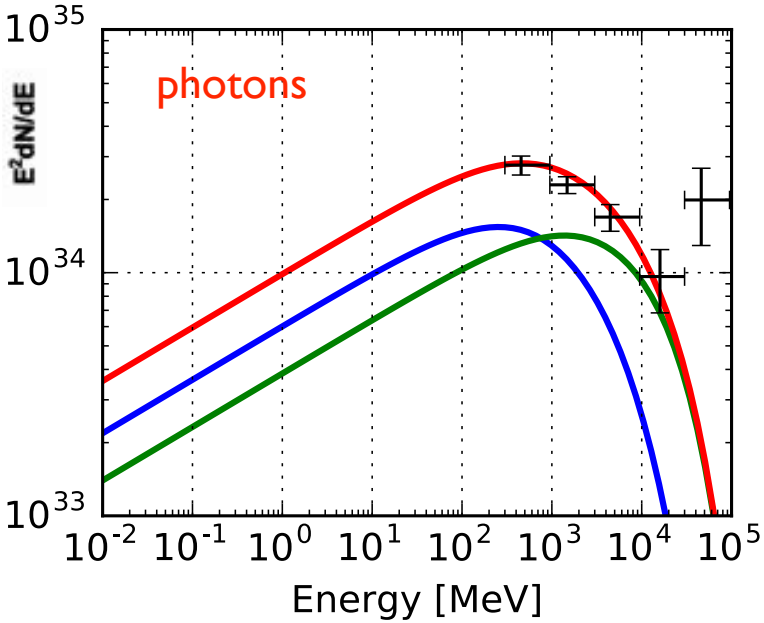
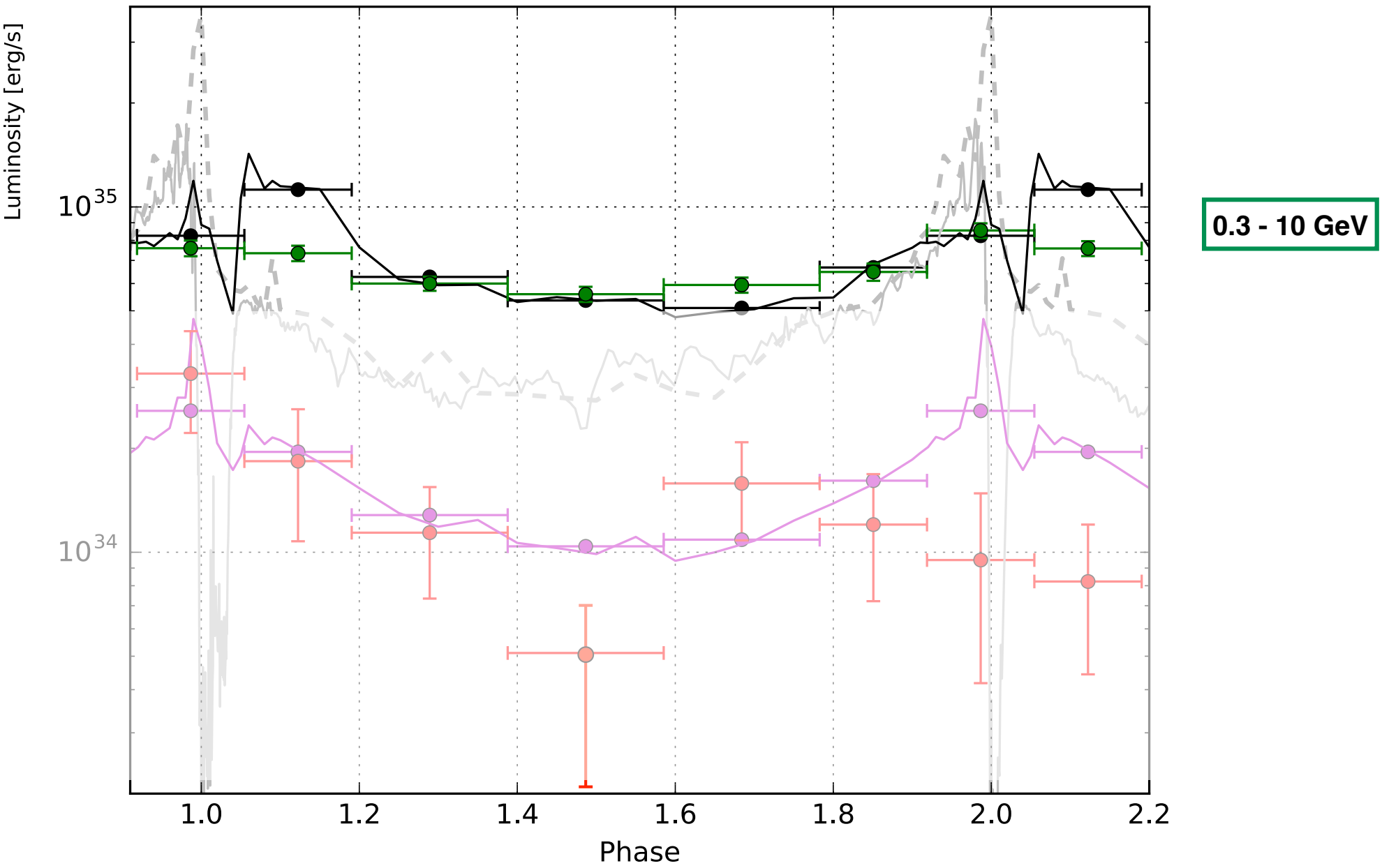


η Car γ-ray lightcurves



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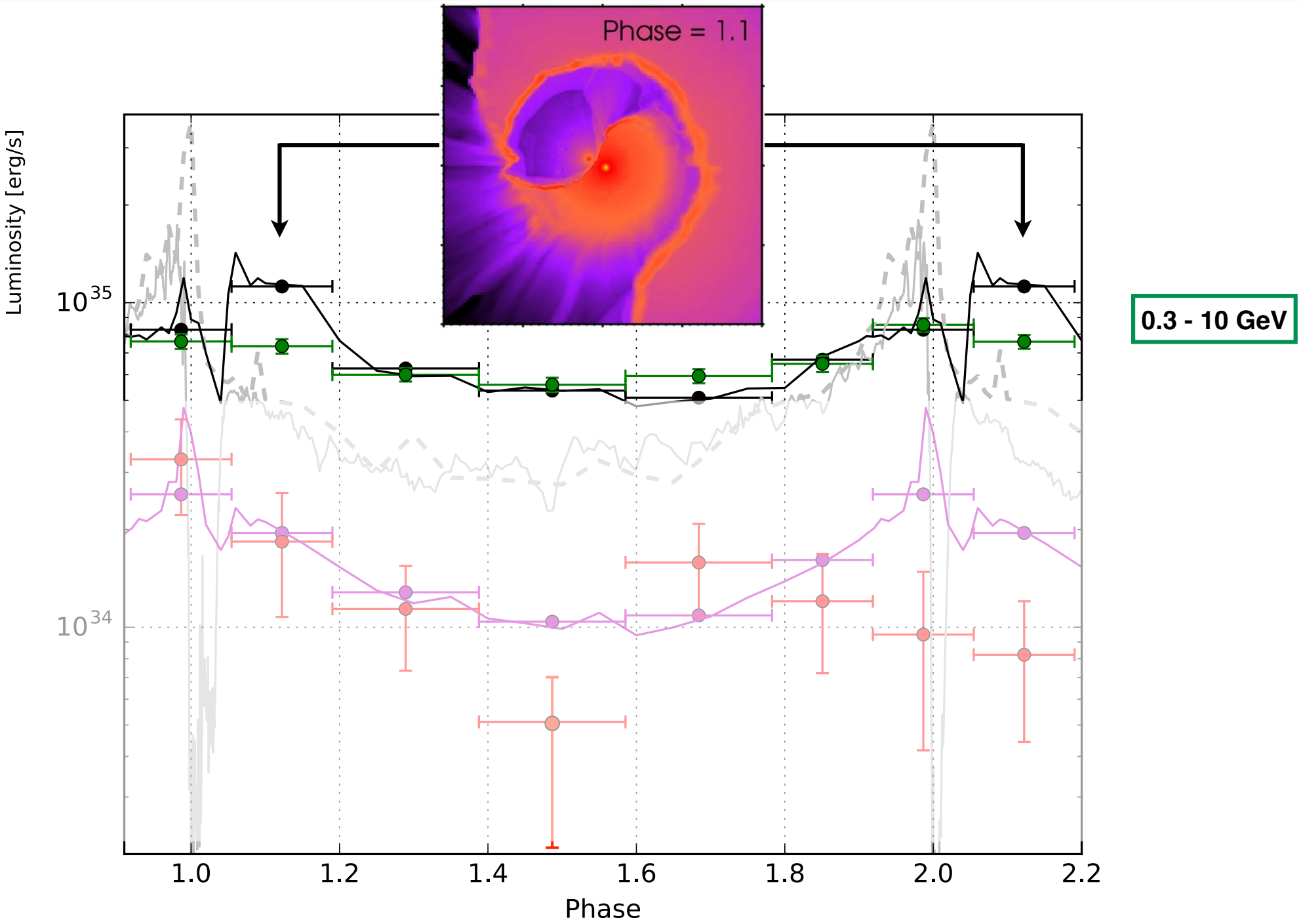

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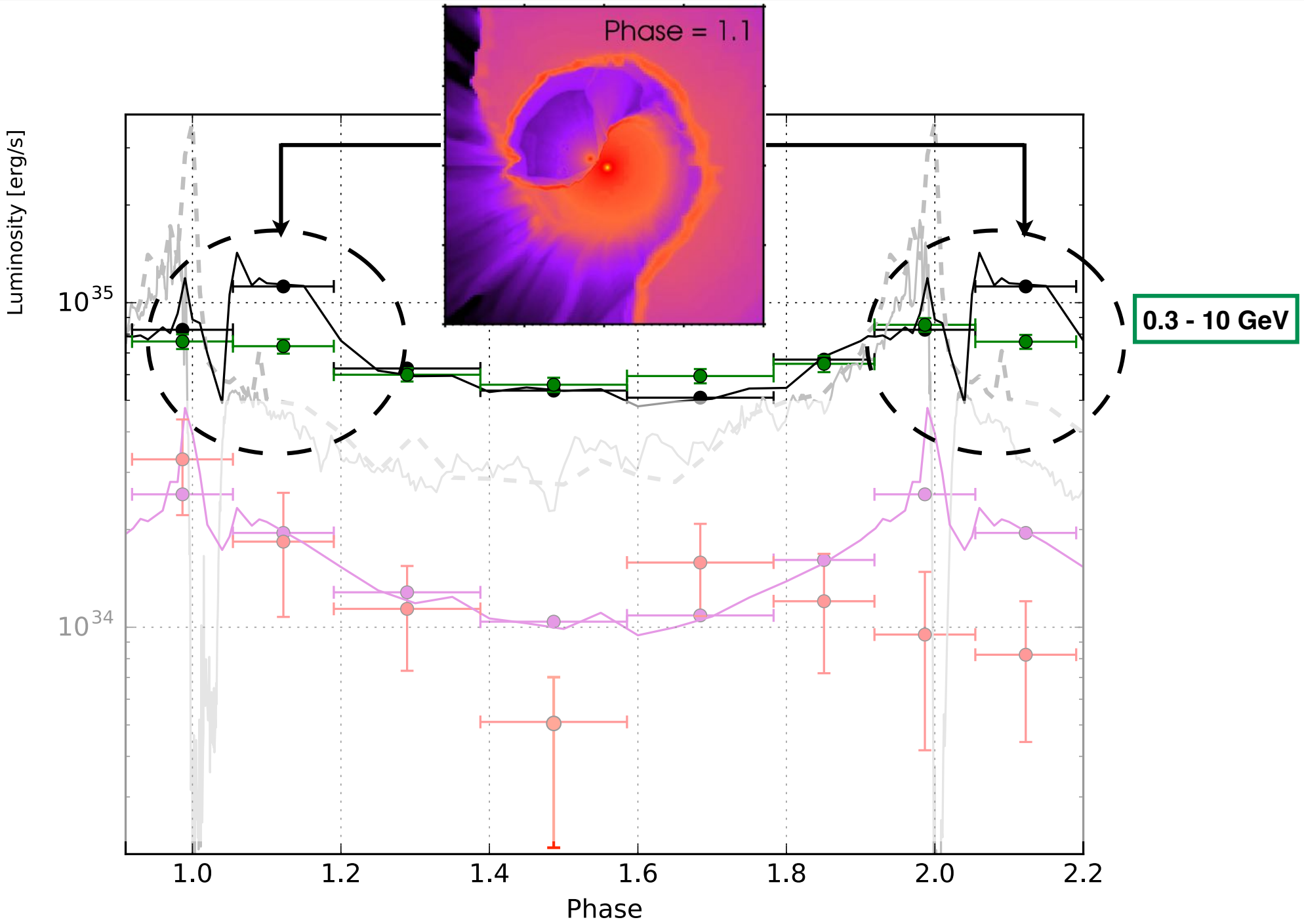
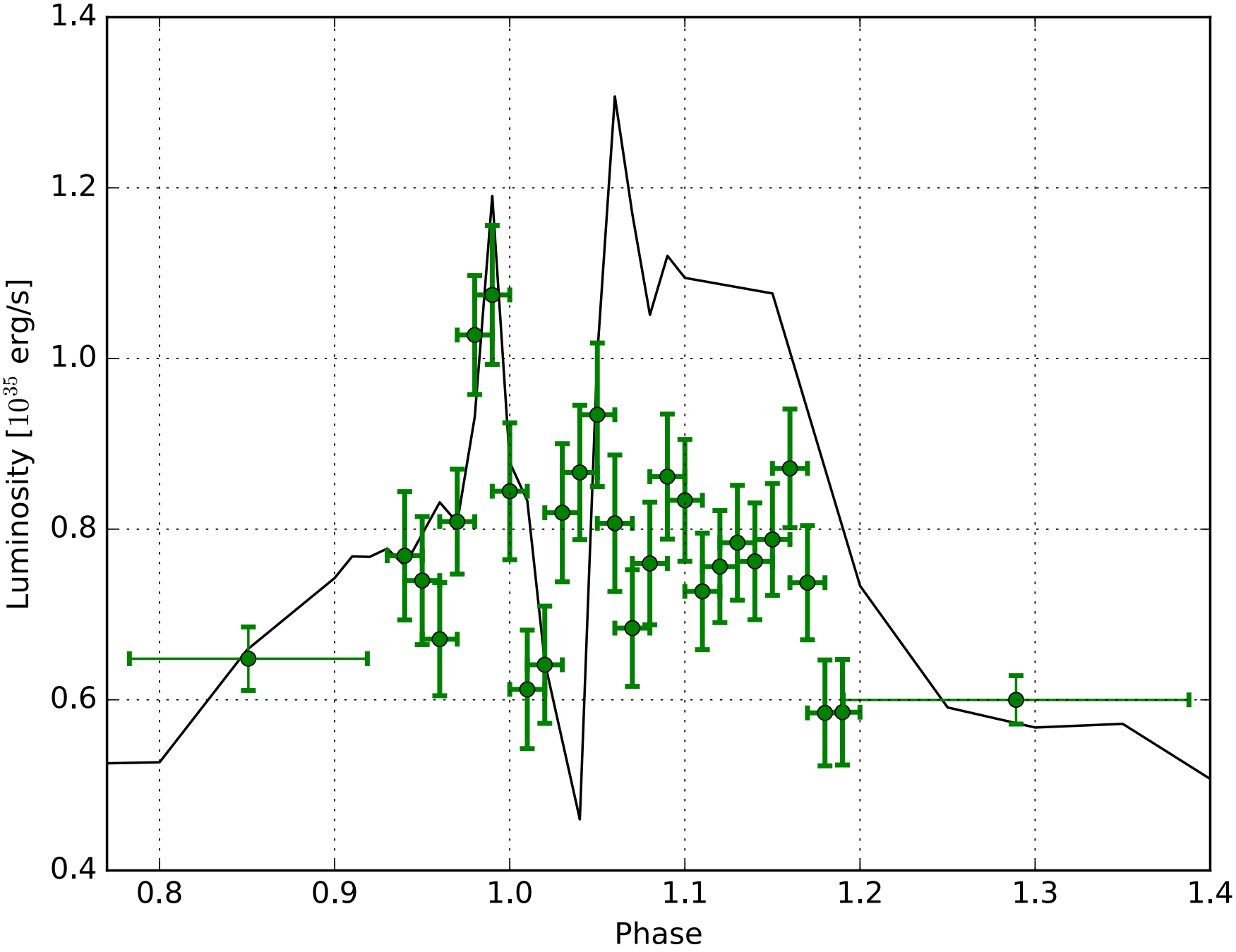


Merged analysis



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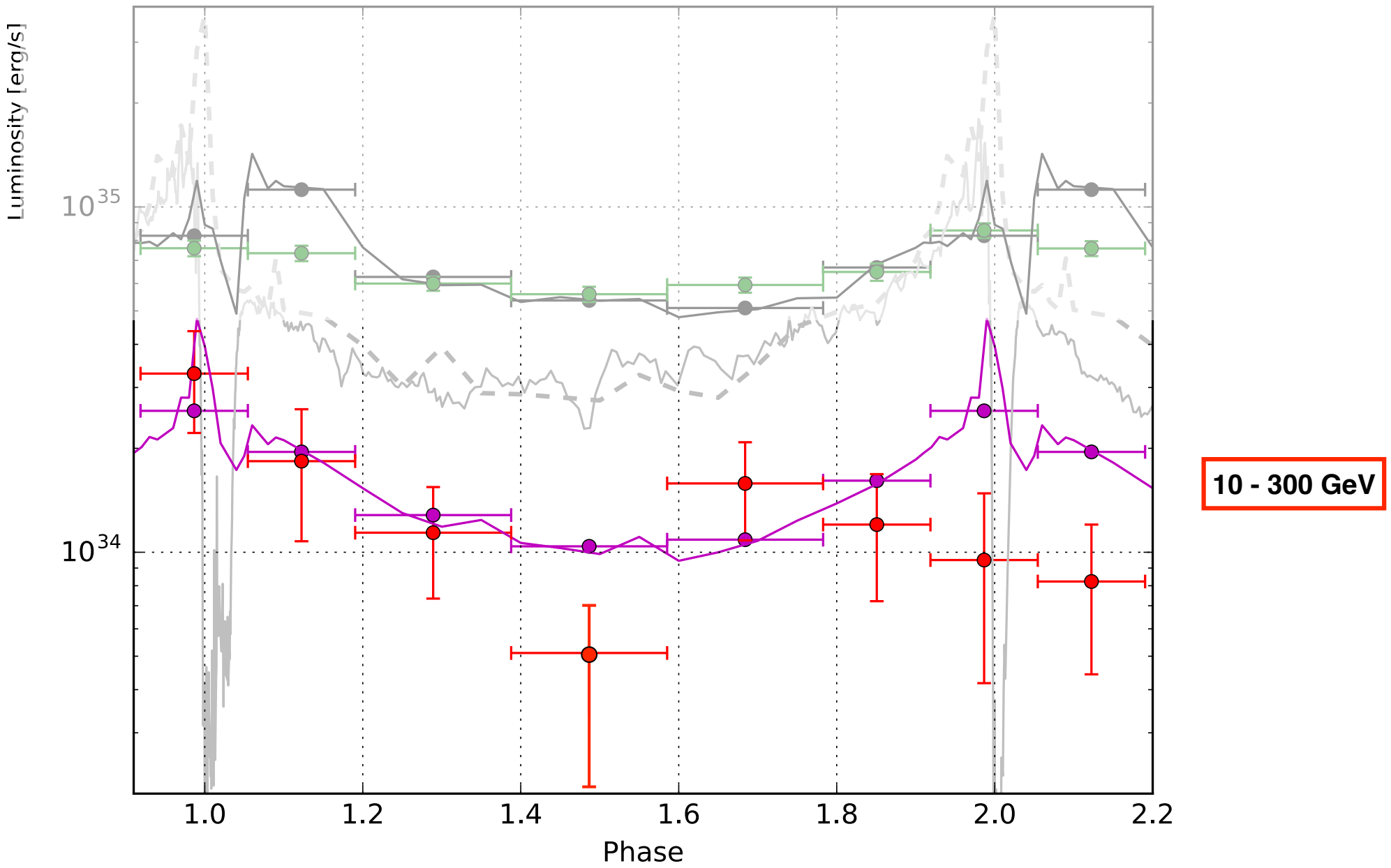
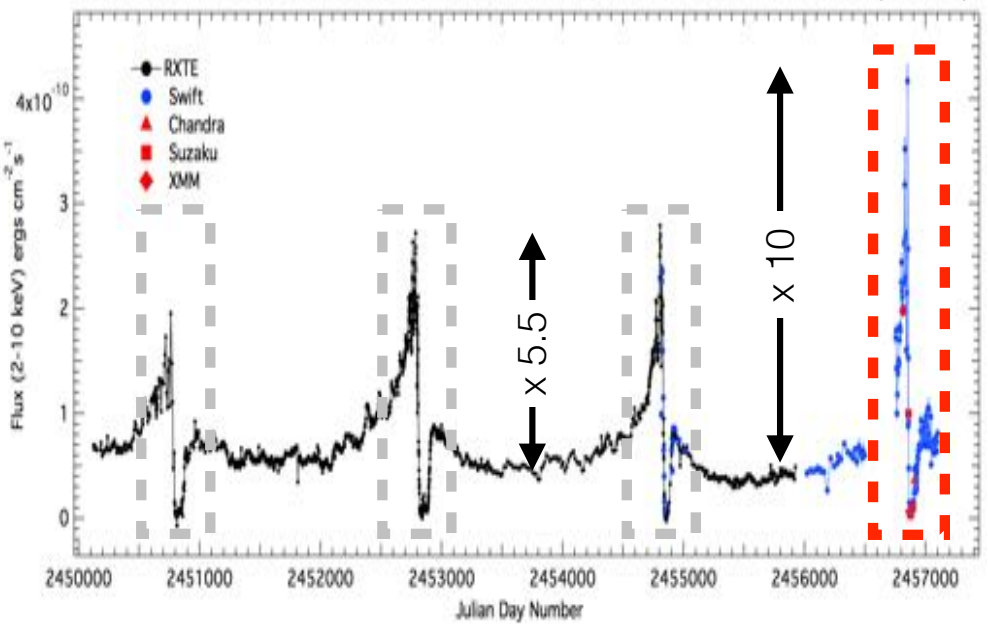
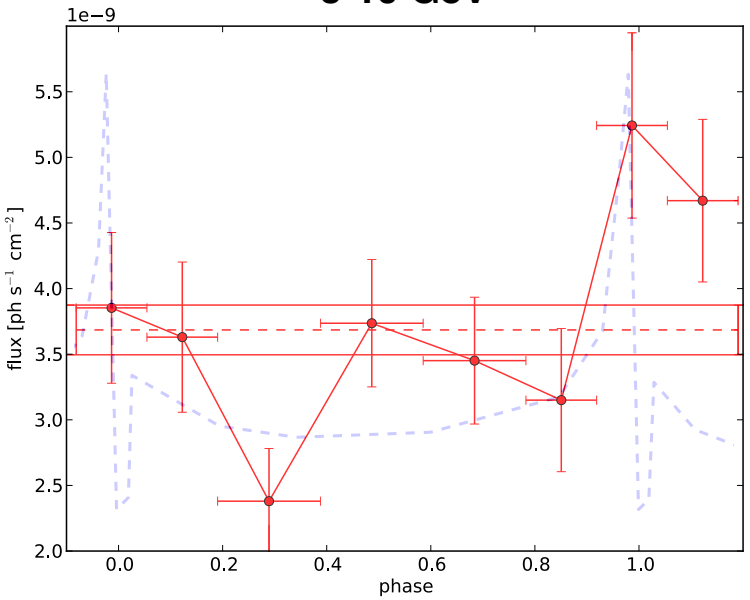


η Car γ-ray lightcurves

Corcoran (2015)



3-10 GeV



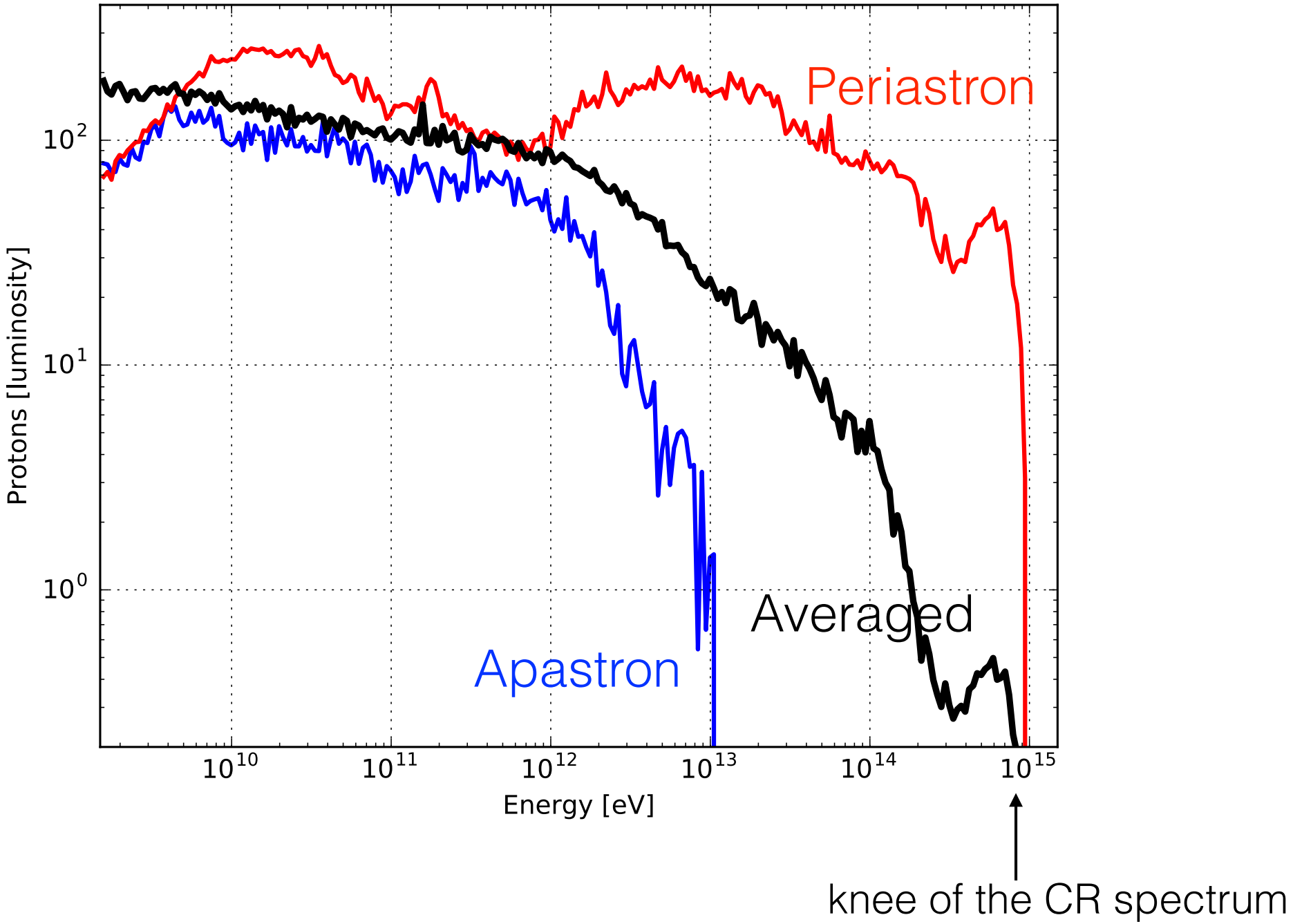
Possible interpretation

Larger wind clumpiness or dM/dt
➞ Stronger thermal emission (~ n^2)

$$\gamma_{max,p} = \frac{4\pi R^2 eB}{\sigma_{pp}\delta\dot{M}}\left(\frac{V}{c}\right)^3$$

➞ lower $\gamma_{max,p}$
➞ higher *γ-γ opacity*

Protons spectrum

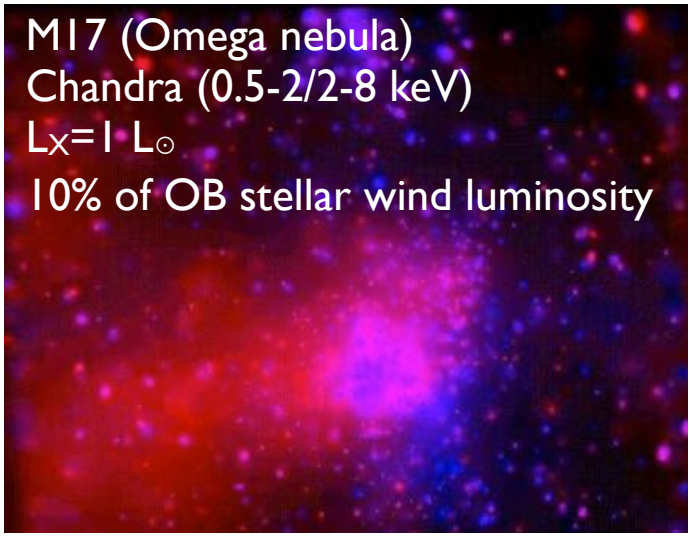


Energetics

- **Thermal X-rays:** 25 $L_\odot$
- **Synchrotron:** < 0.1 $L_\odot$
- **Electron acceleration:** 50 $L_\odot$
- **π^0 emission:** 10 $L_\odot$
- **neutrino:** $\sim 10^{-9}$ GeV s^{-1} cm^{-2} (above 10 TeV)

- **η Carinae** shows evidences for **electronic** and **hadronic** acceleration
- *Electron **spectral index** is compatible with 2.25*
- **Proton cutoff energy** $\gtrsim 10^{13}$ eV, *higher than measured in middle aged SNR*
- **Efficiency** of particle **acceleration** ~ **1%** (Spitkovsky's simulations: 10%)

With this efficiency, a massive star could accelerate $5\% \cdot \dot{M} \cdot t_{WR} \cdot V_w^2 \approx 10^{50}$ erg



(Townsley et al., 2005)