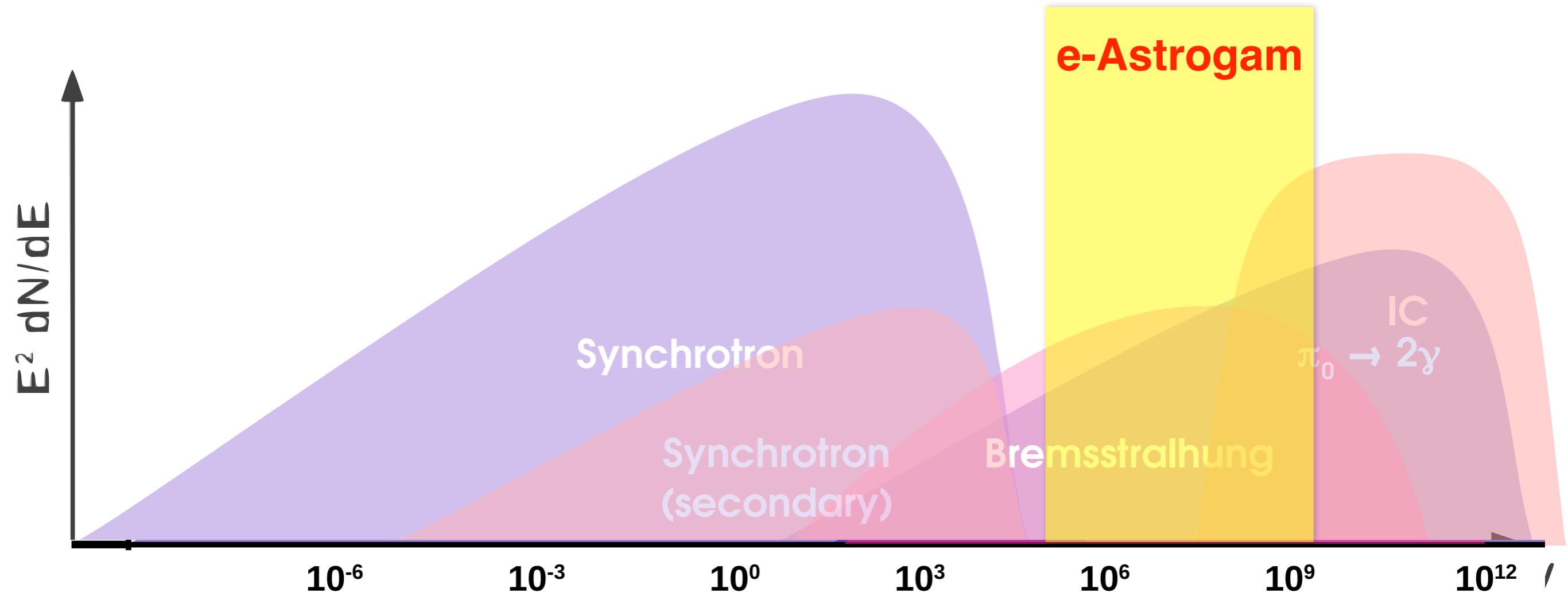


Fermi acceleration in extreme environment

**2nd e-ASTROGAM Workshop & AMEGO Workshop:
towards a White Book on MeV γ -ray Astrophysics**

13 - 14 October 2017, Munich

Matteo Balbo & Roland Walter



Fermi acceleration in extreme environment

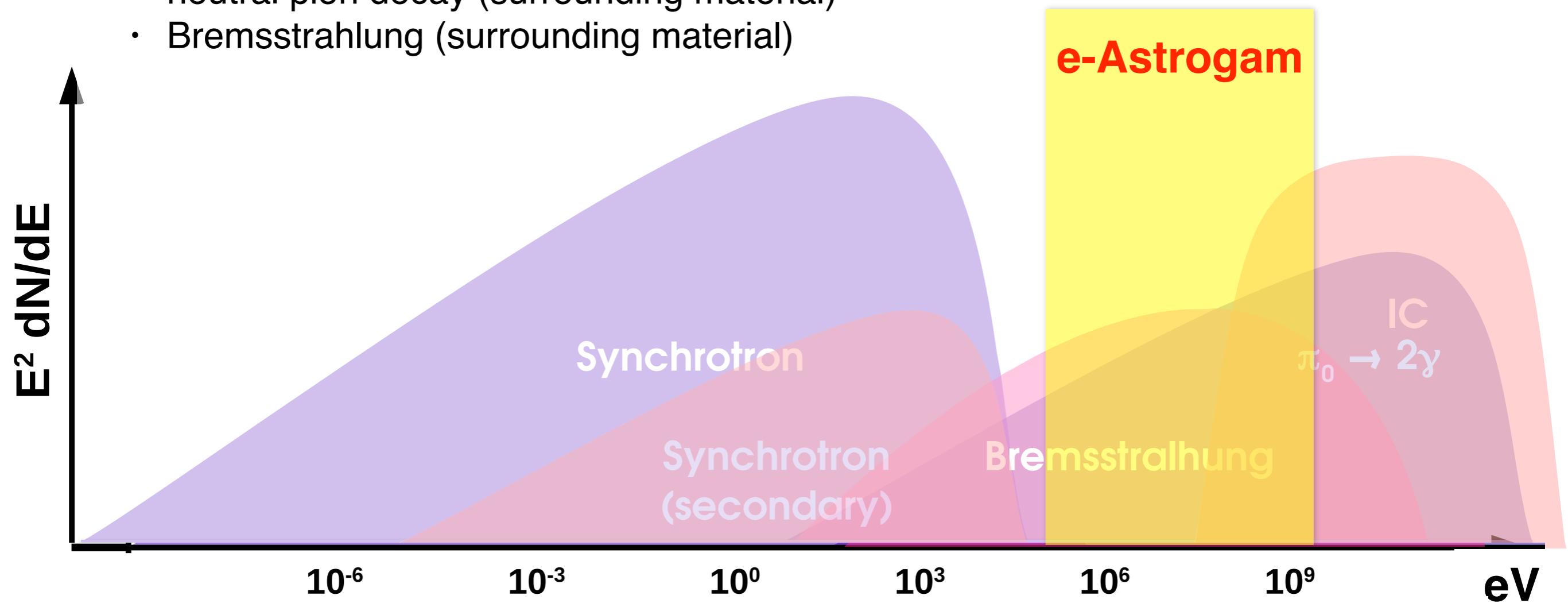
Produced by ultra-relativistic charged particles

Leptons:

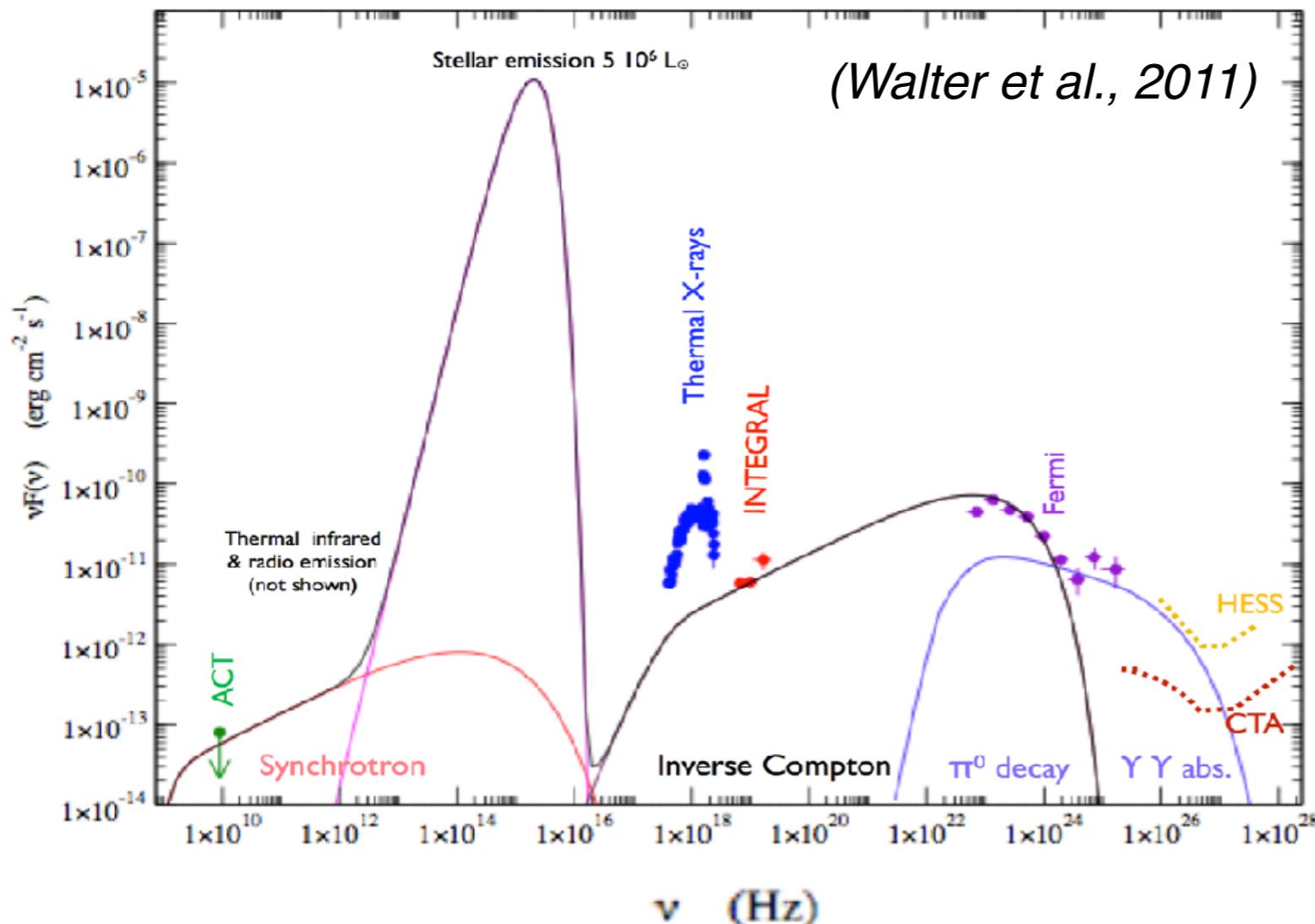
- Inverse Compton on ambient radiation field
- Bremsstrahlung (surrounding material)

Hadrons:

- neutral pion decay (surrounding material)
- Bremsstrahlung (surrounding material)

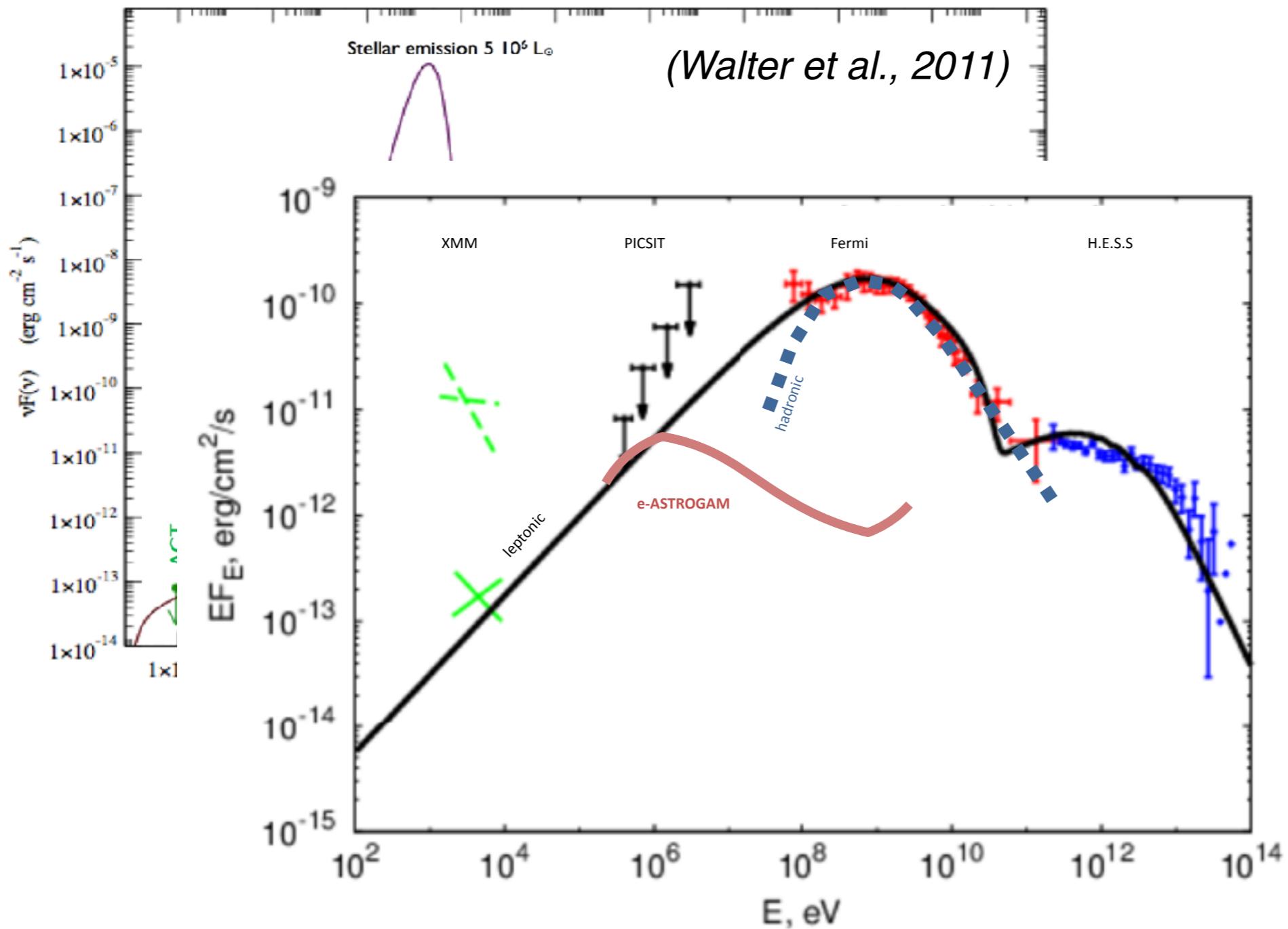


A common problem



η Carinae

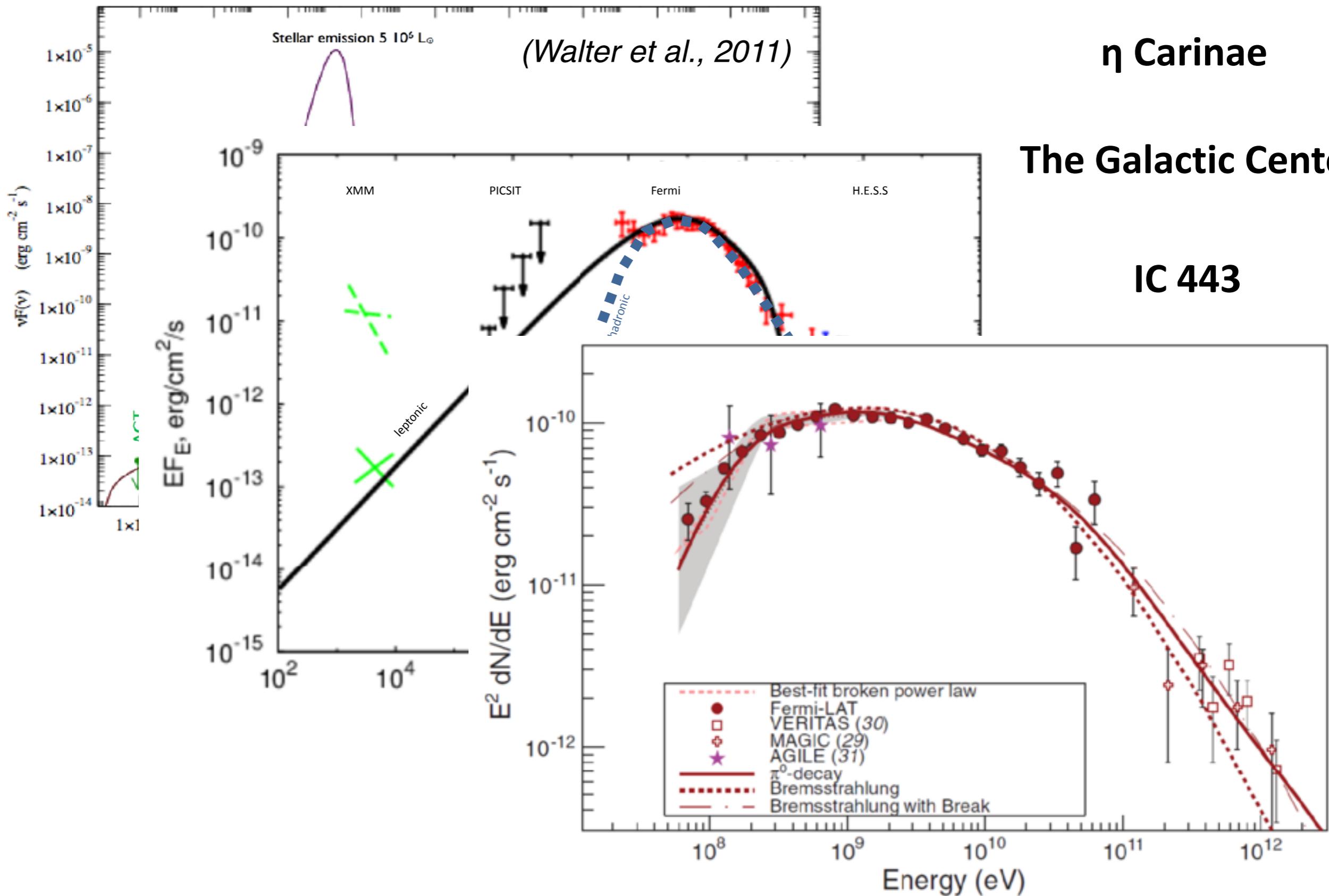
A common problem



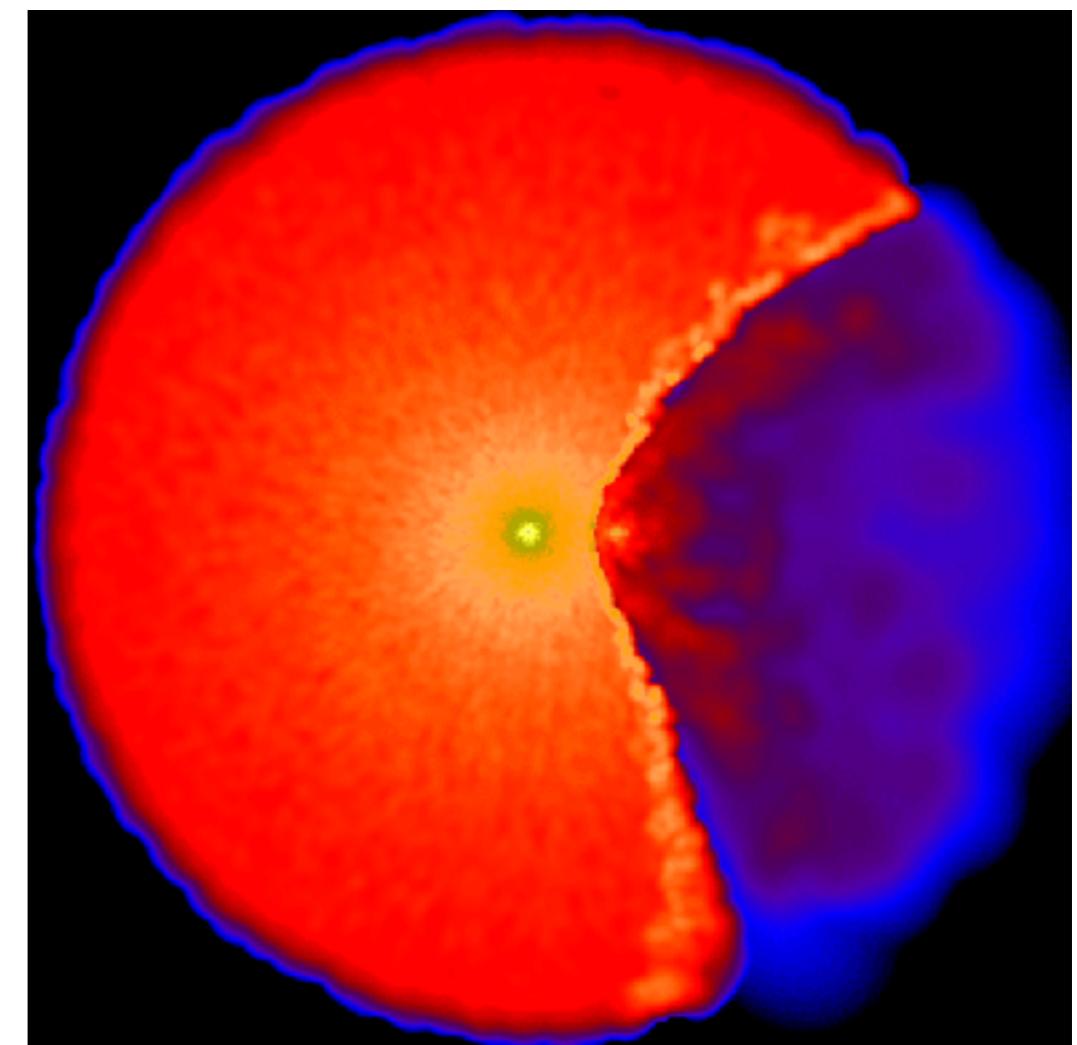
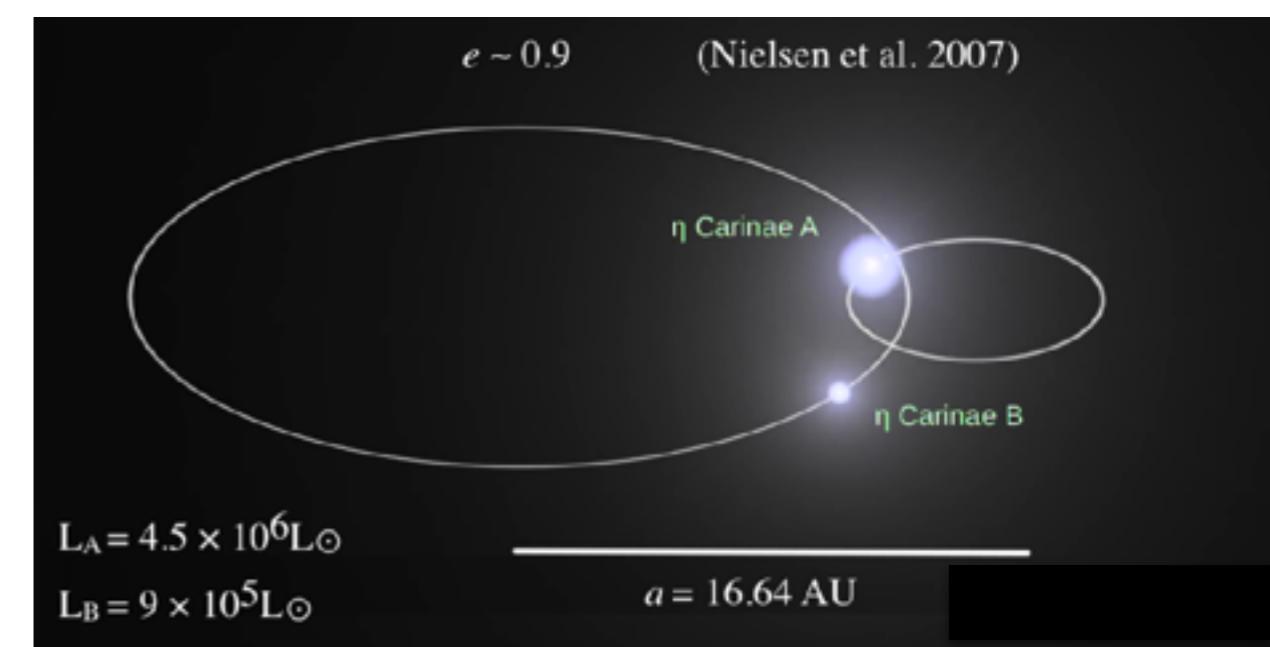
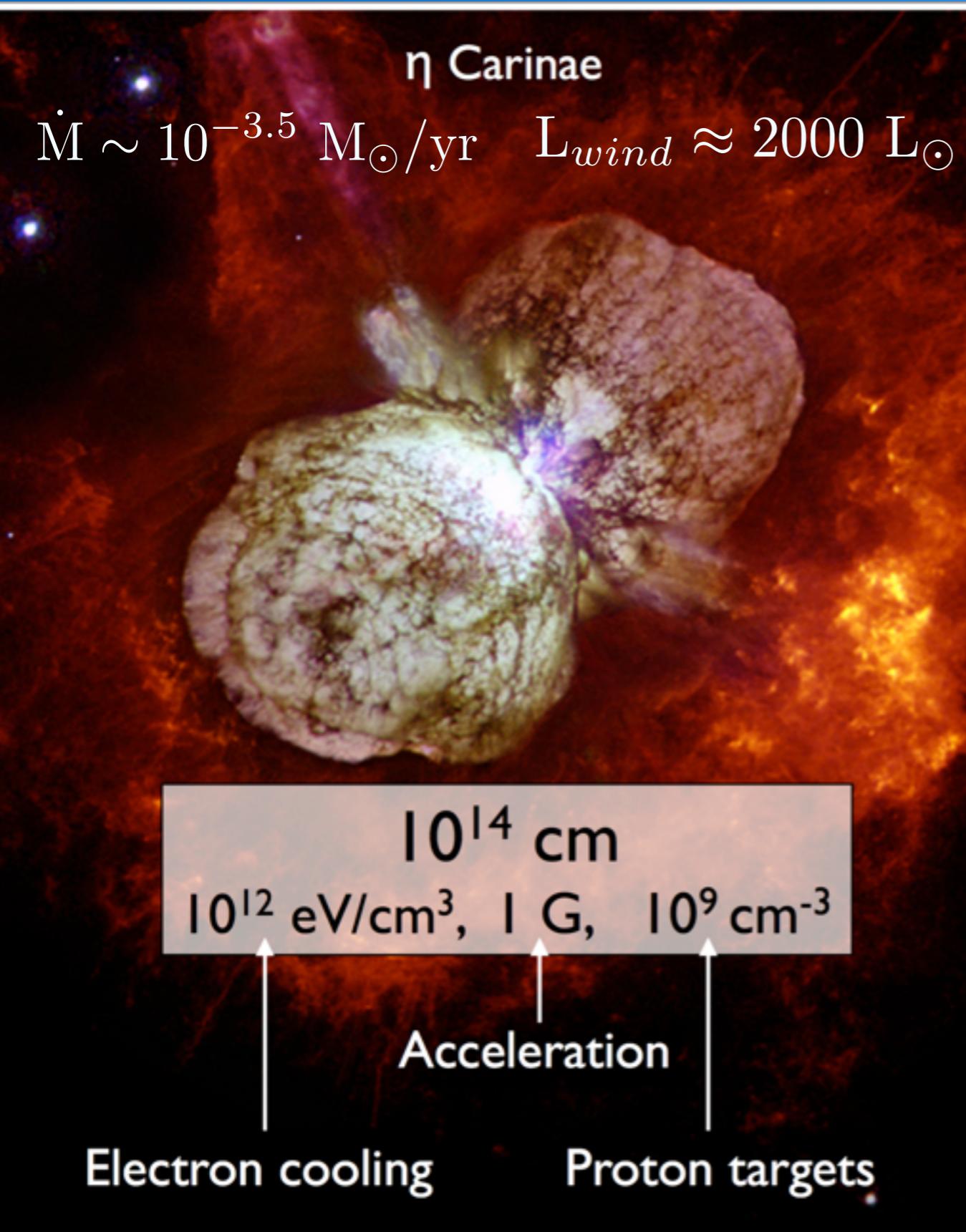
η Carinae

The Galactic Center

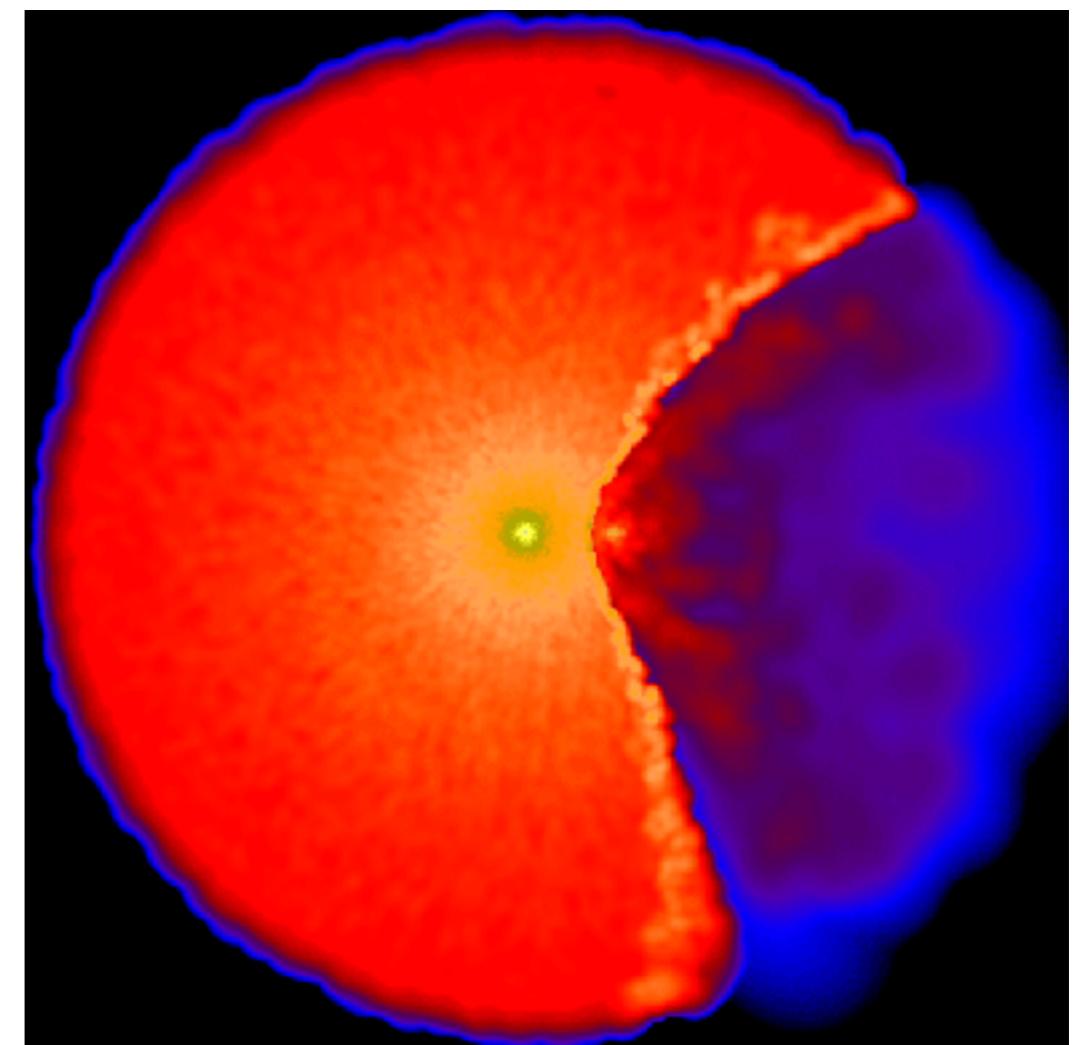
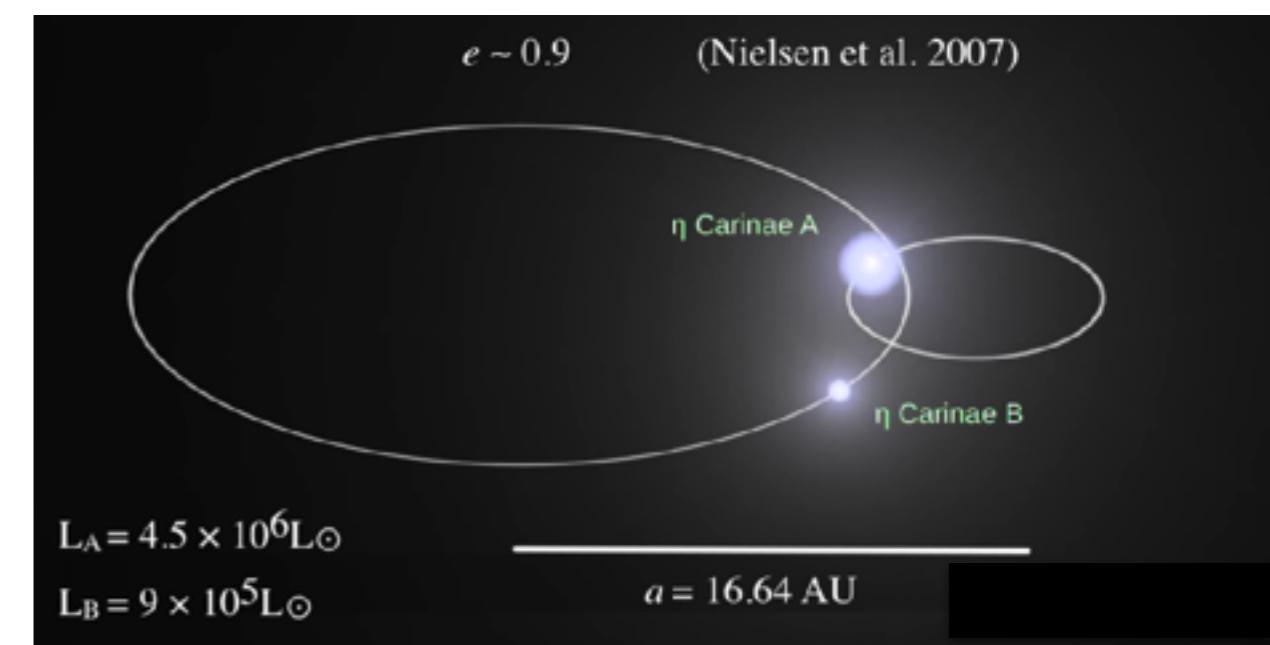
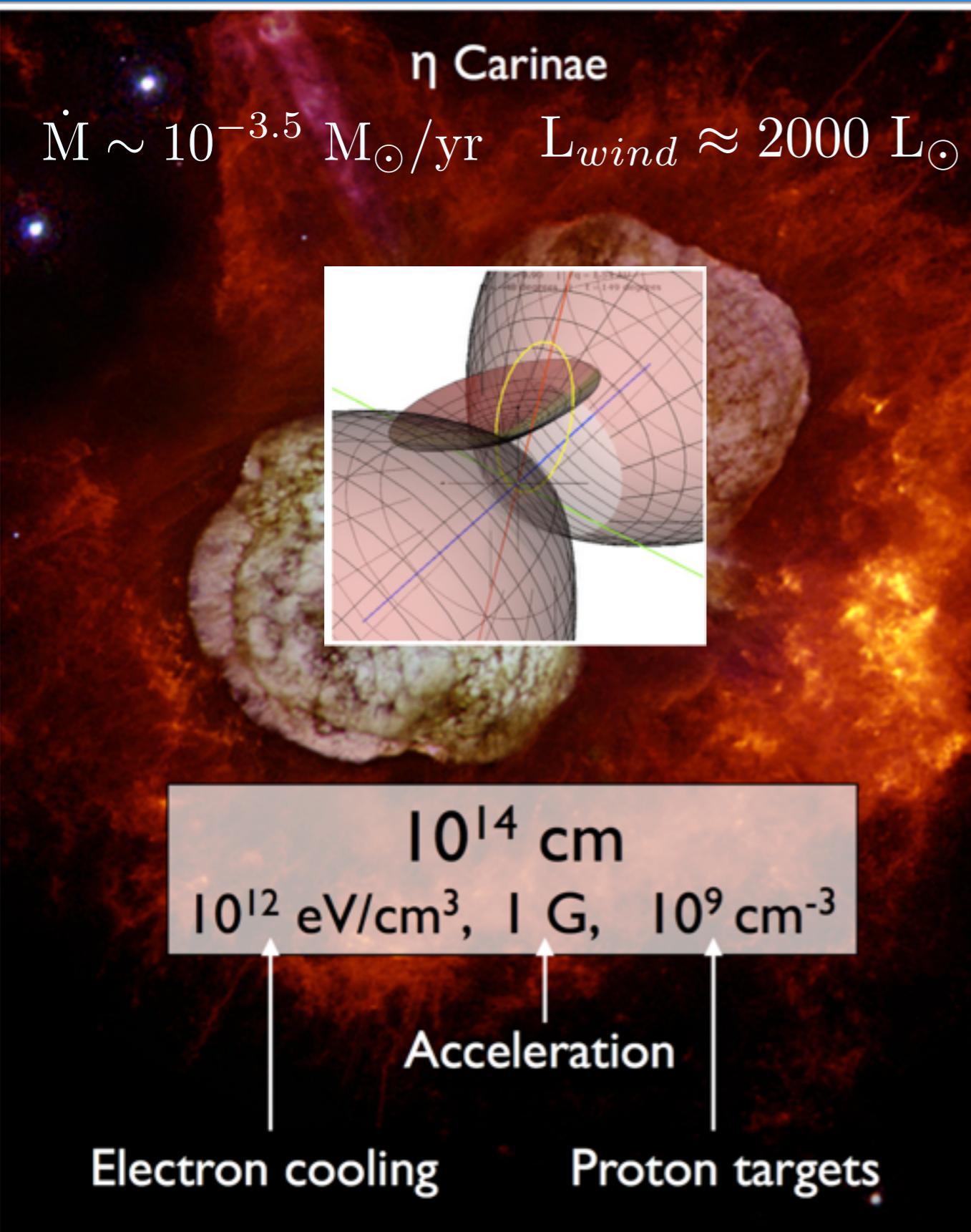
A common problem



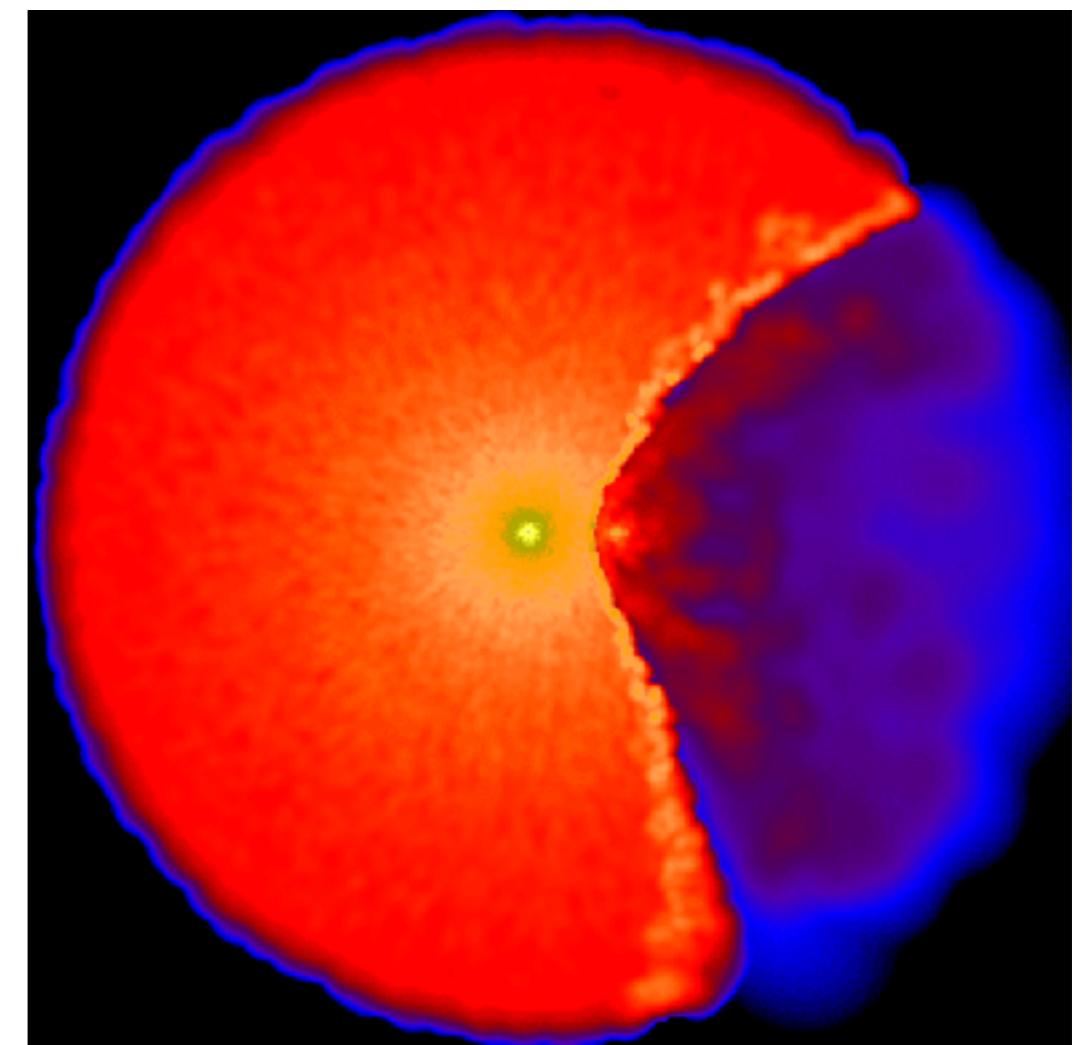
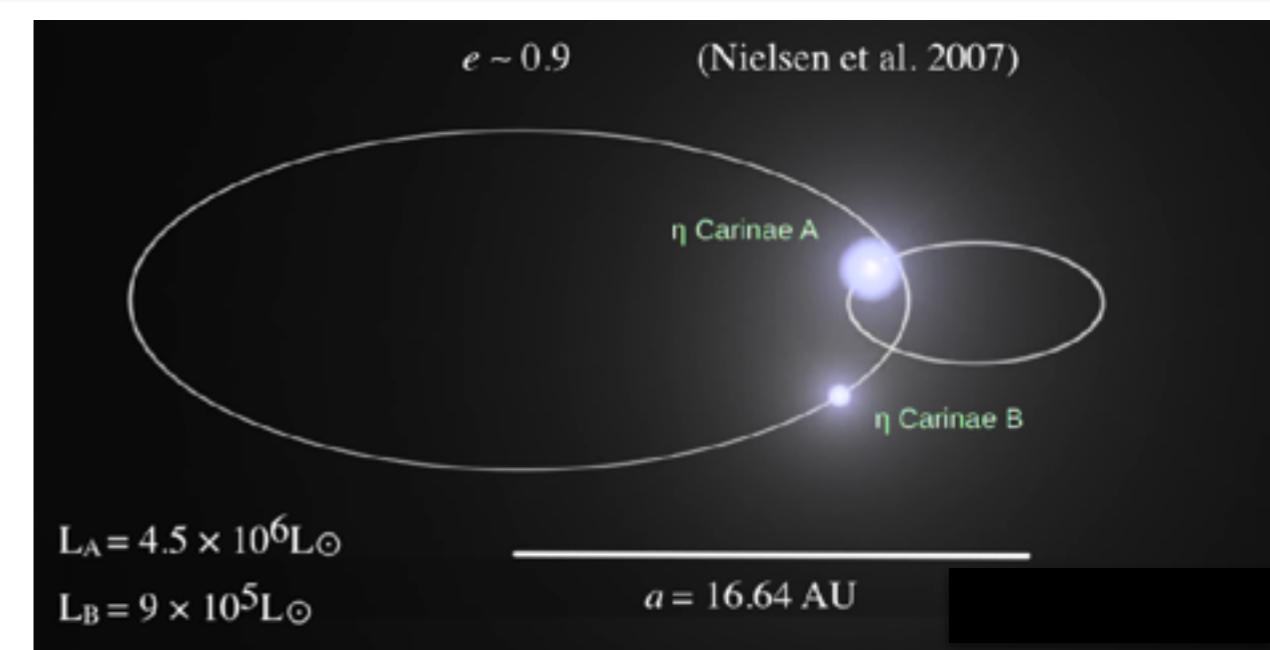
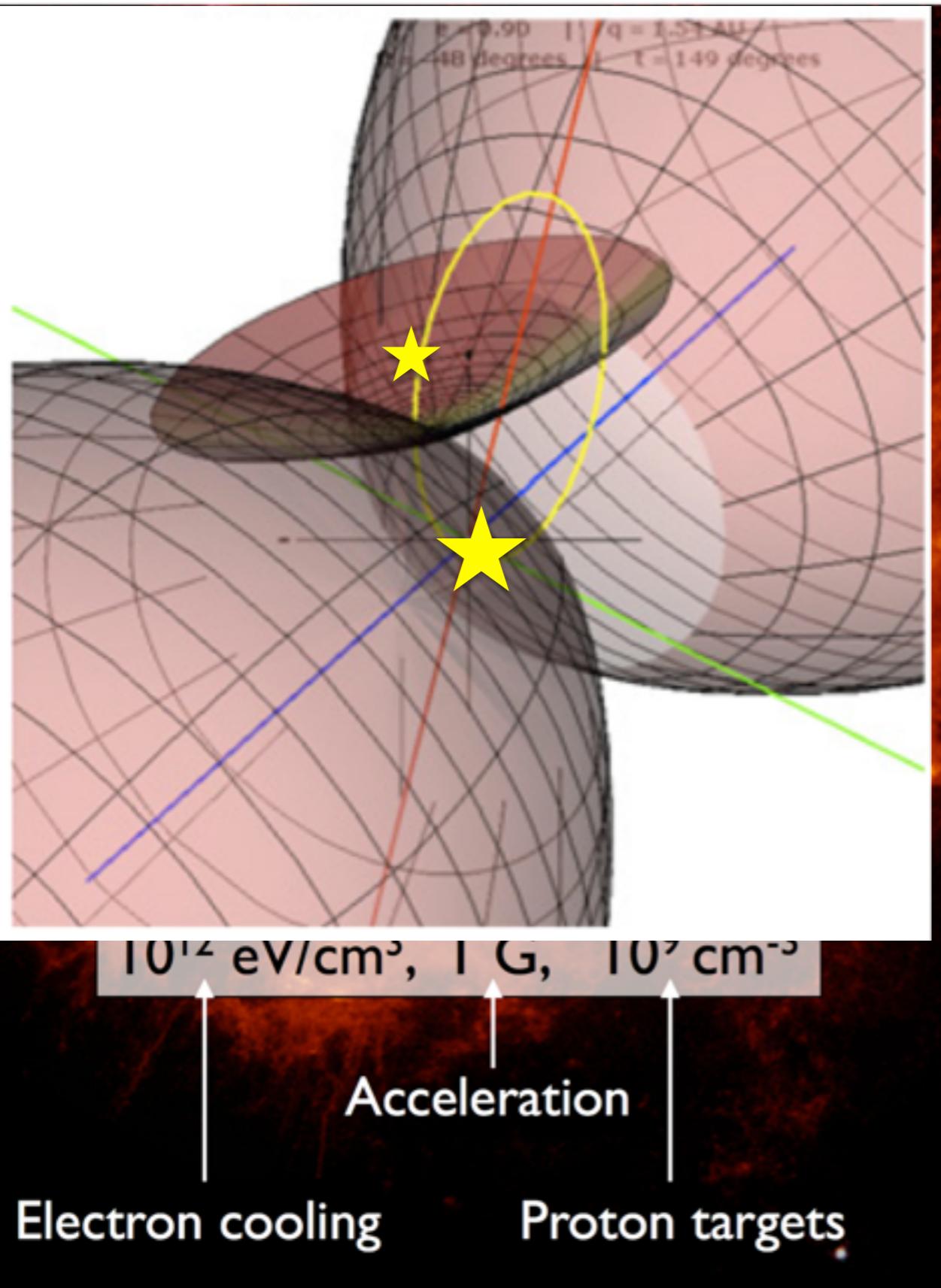
Who is η Carinae ?



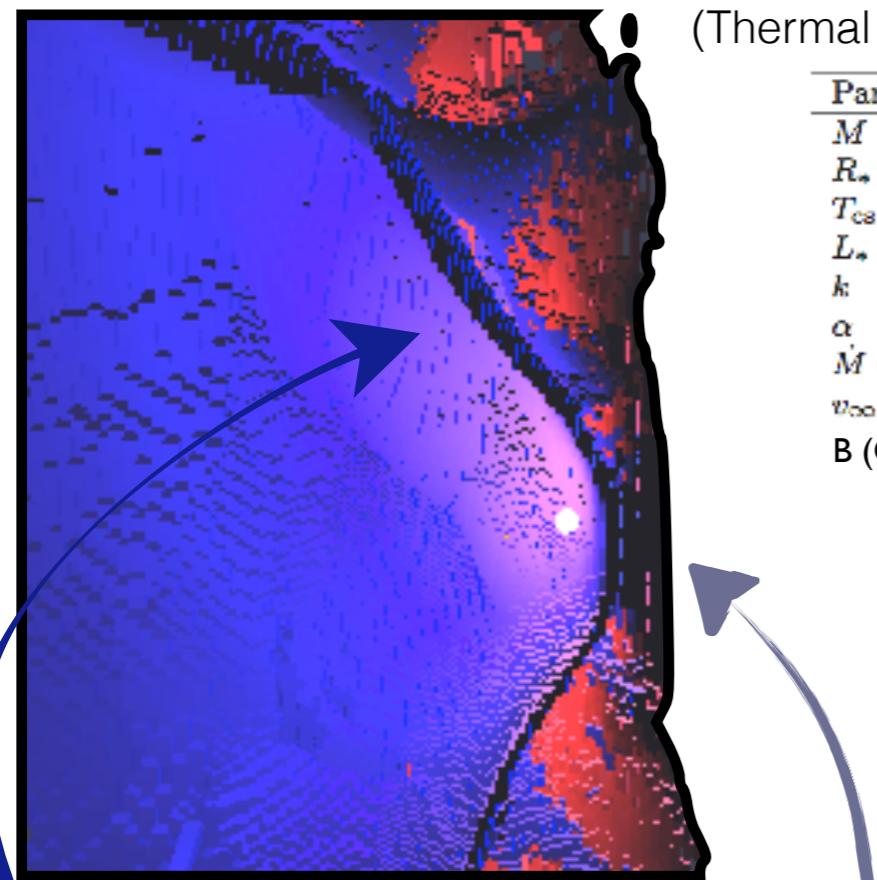
Who is η Carinae ?



Who is η Carinae ?

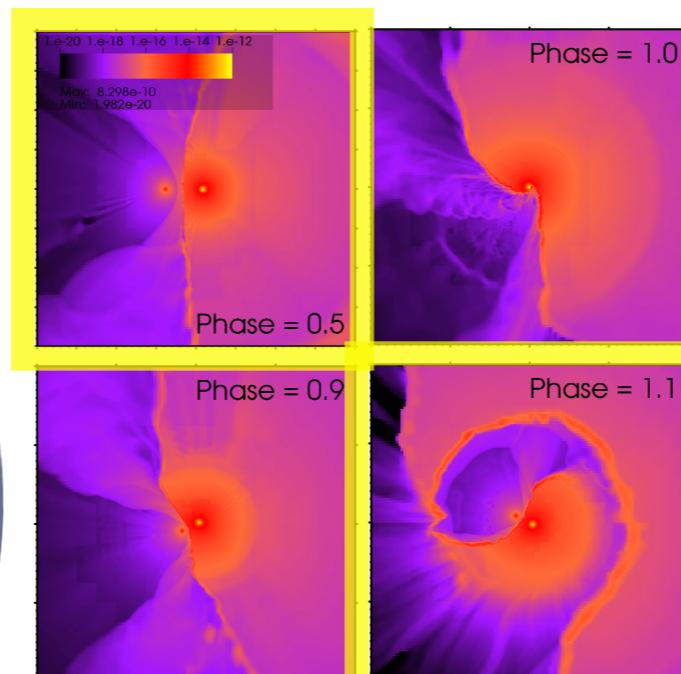


3D hydro simulations (Flash)

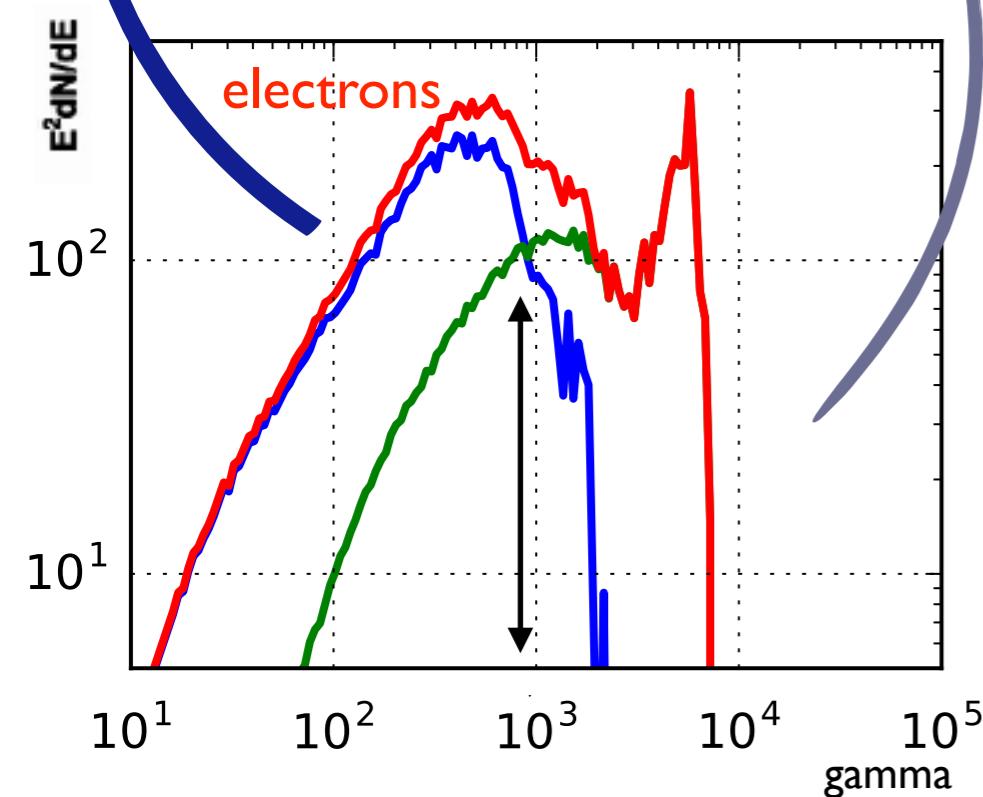


(Thermal simulation from Parkin et al. 2011)

Parameter	Primary	Secondary
$M (M_\odot)$	120	30
$R_\star (R_\odot)$	100	20
$T_{\text{ce}} (\text{K})$	25,800	30,000
$L_\star (10^6 L_\odot)$	4	0.3
k	0.30	0.50
α	0.52	0.68
$\dot{M} (M_\odot \text{ yr}^{-1})$	4.8×10^{-4}	1.4×10^{-5}
$v_\infty (\text{km s}^{-1})$	500	3000
B (G)	2000	

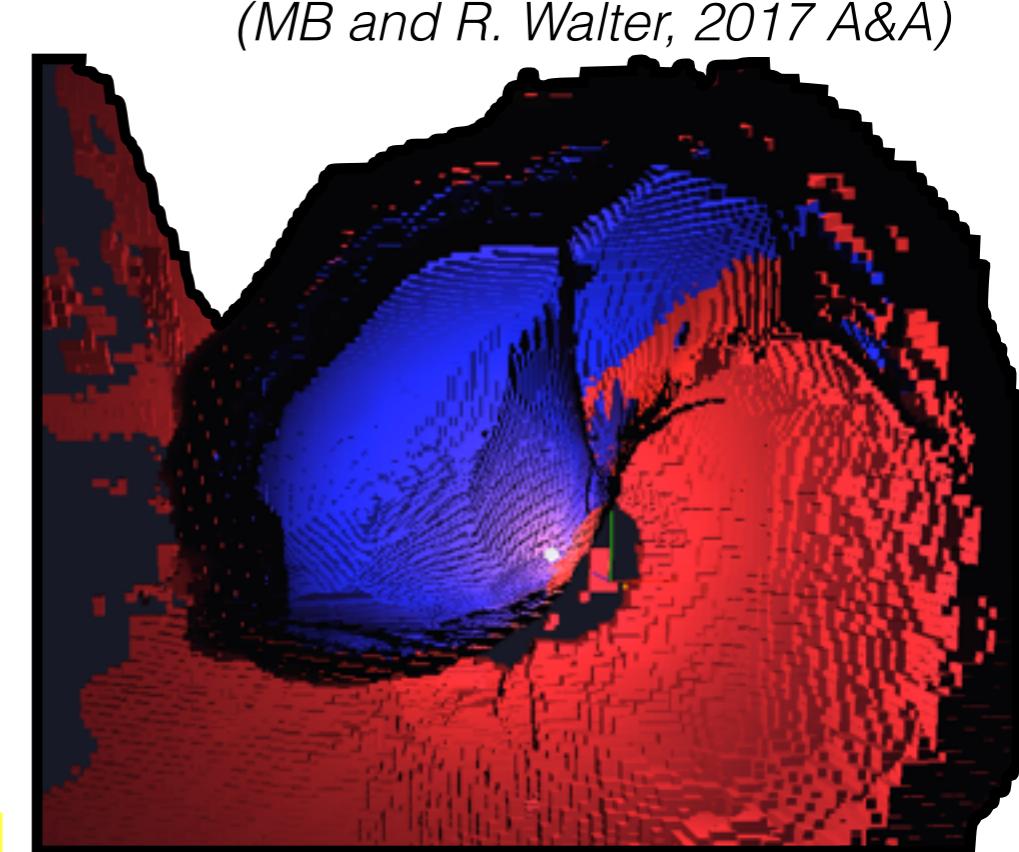
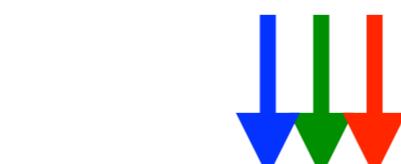


Parkin et al, 2011

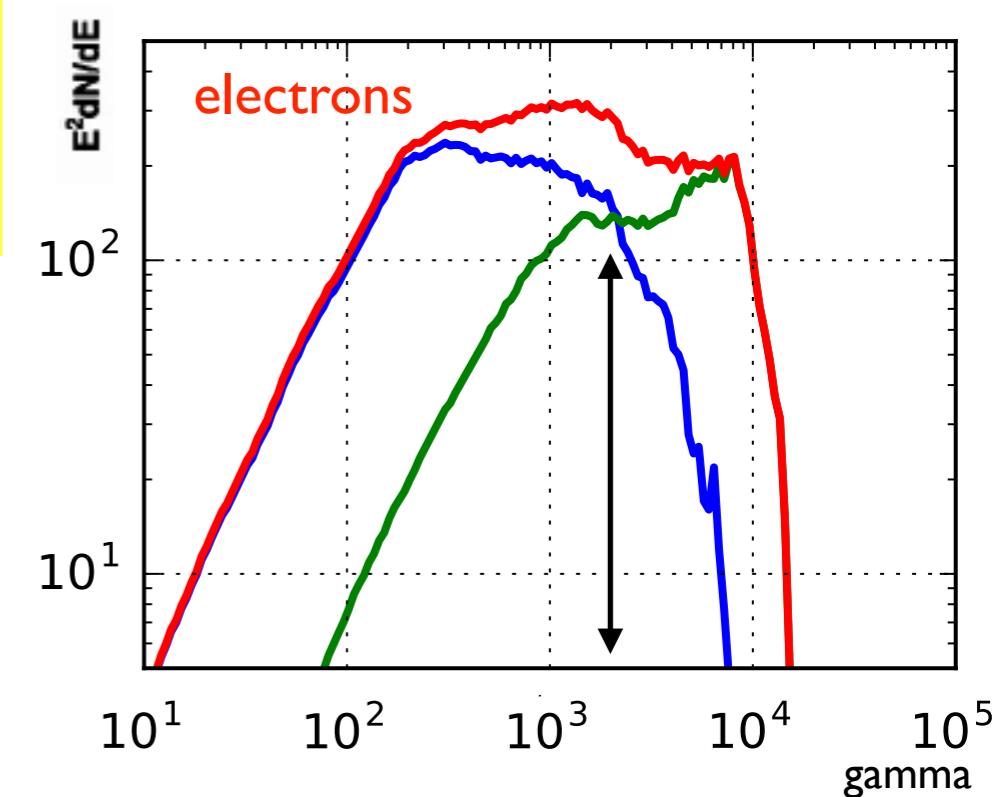


smooth IC spectrum

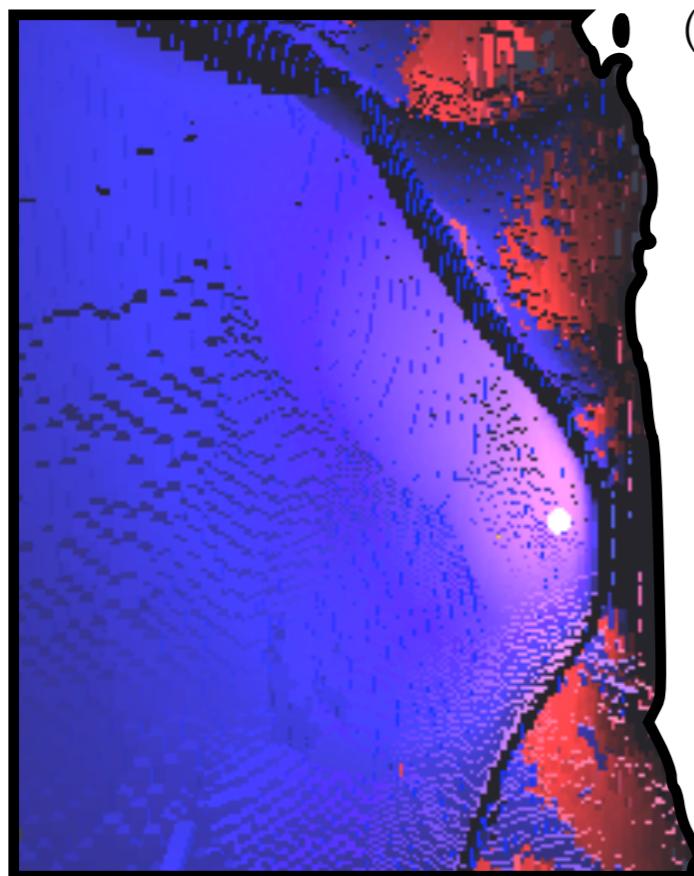
e⁻ spectrum



(MB and R. Walter, 2017 A&A)

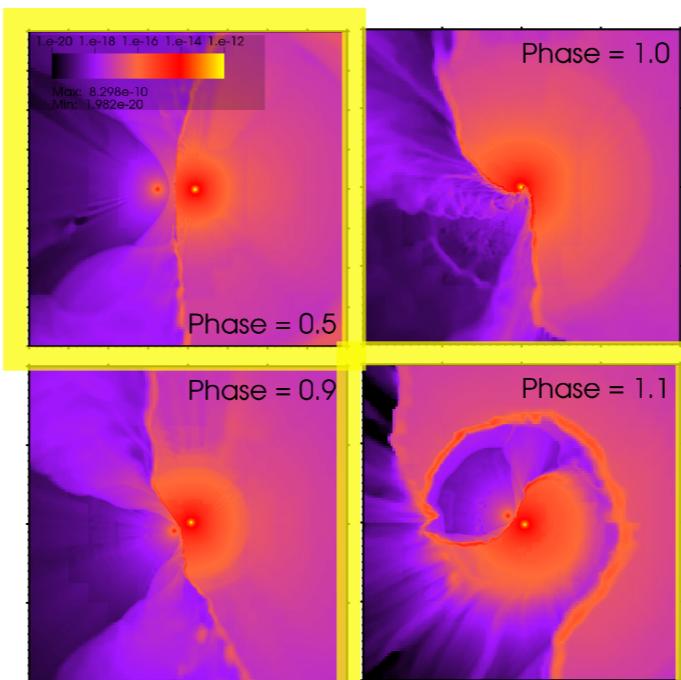


3D hydro simulations (Flash)

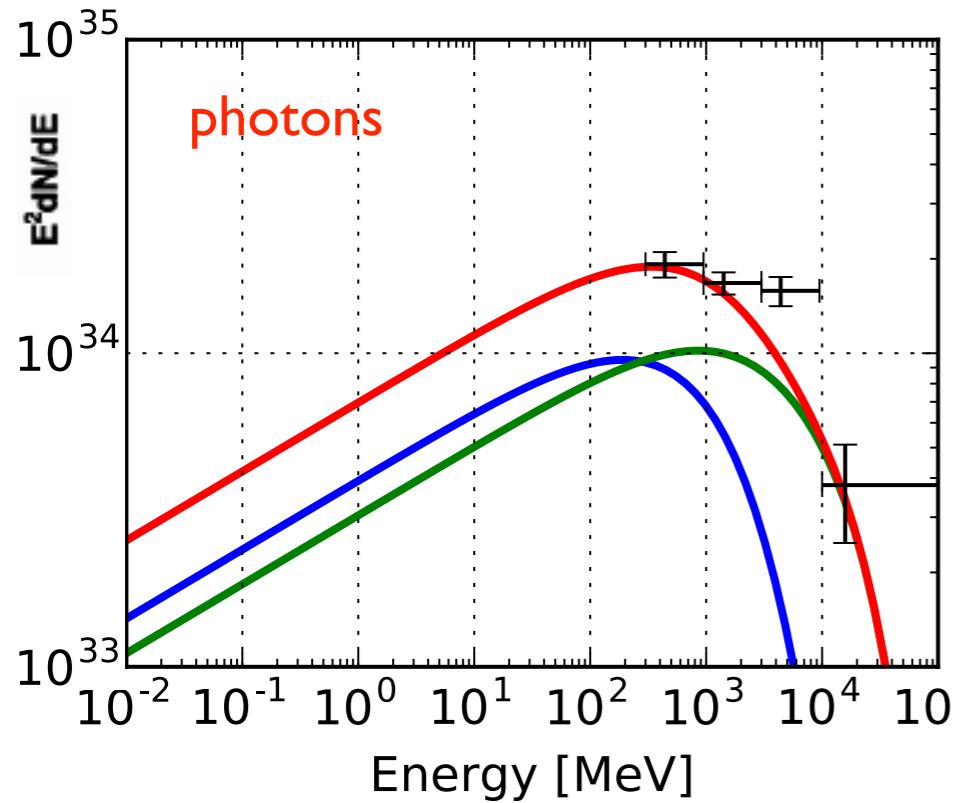


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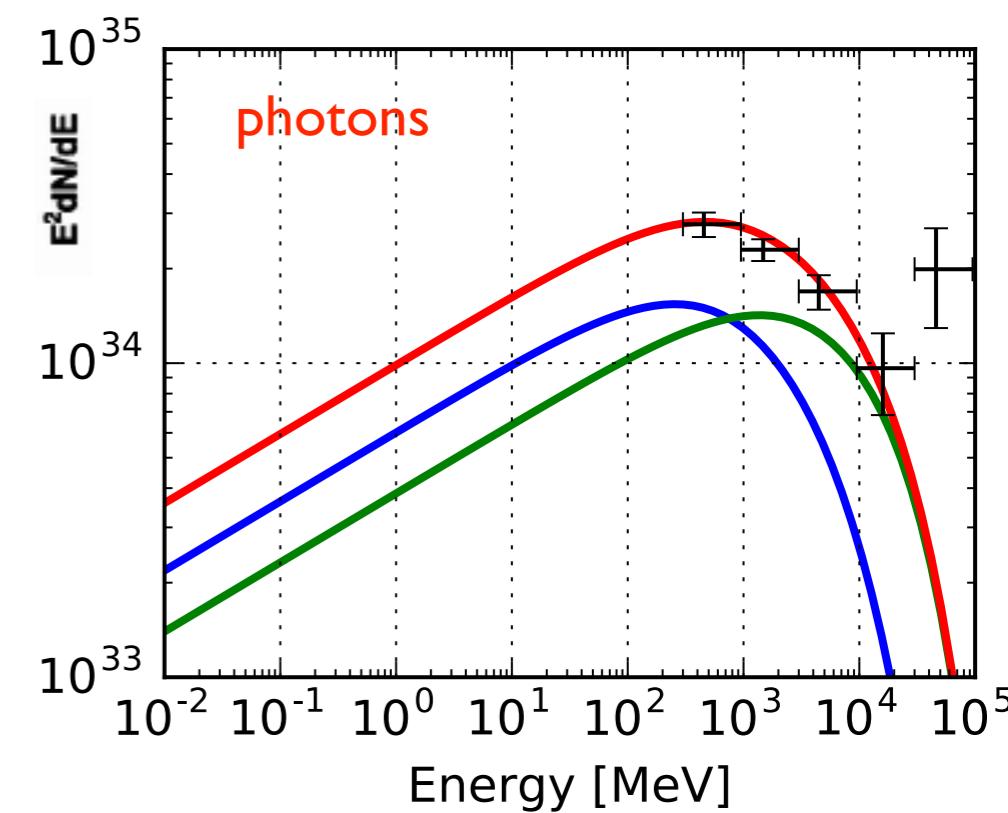
Parkin et al. 2011



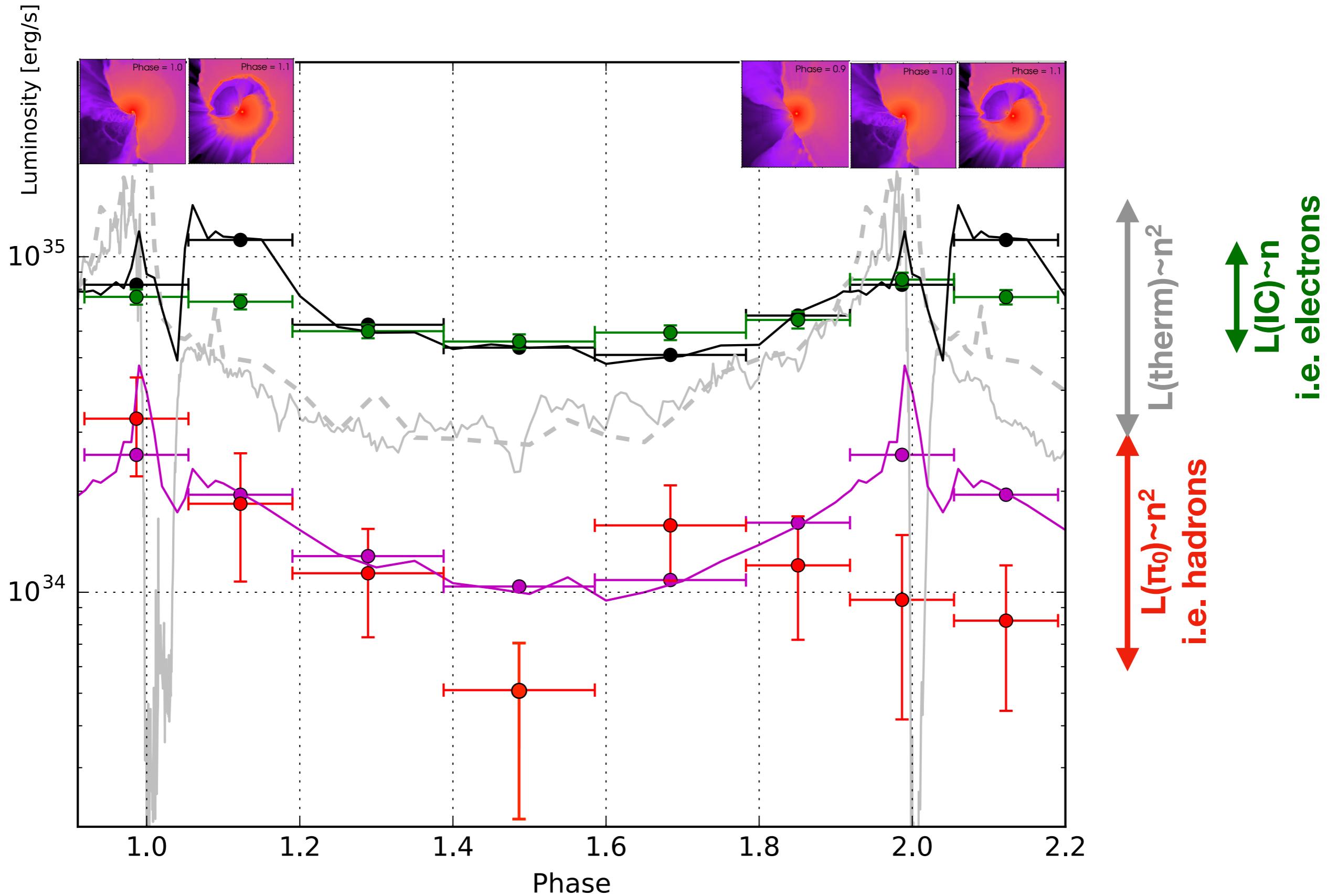
photons

e⁻ spectrum

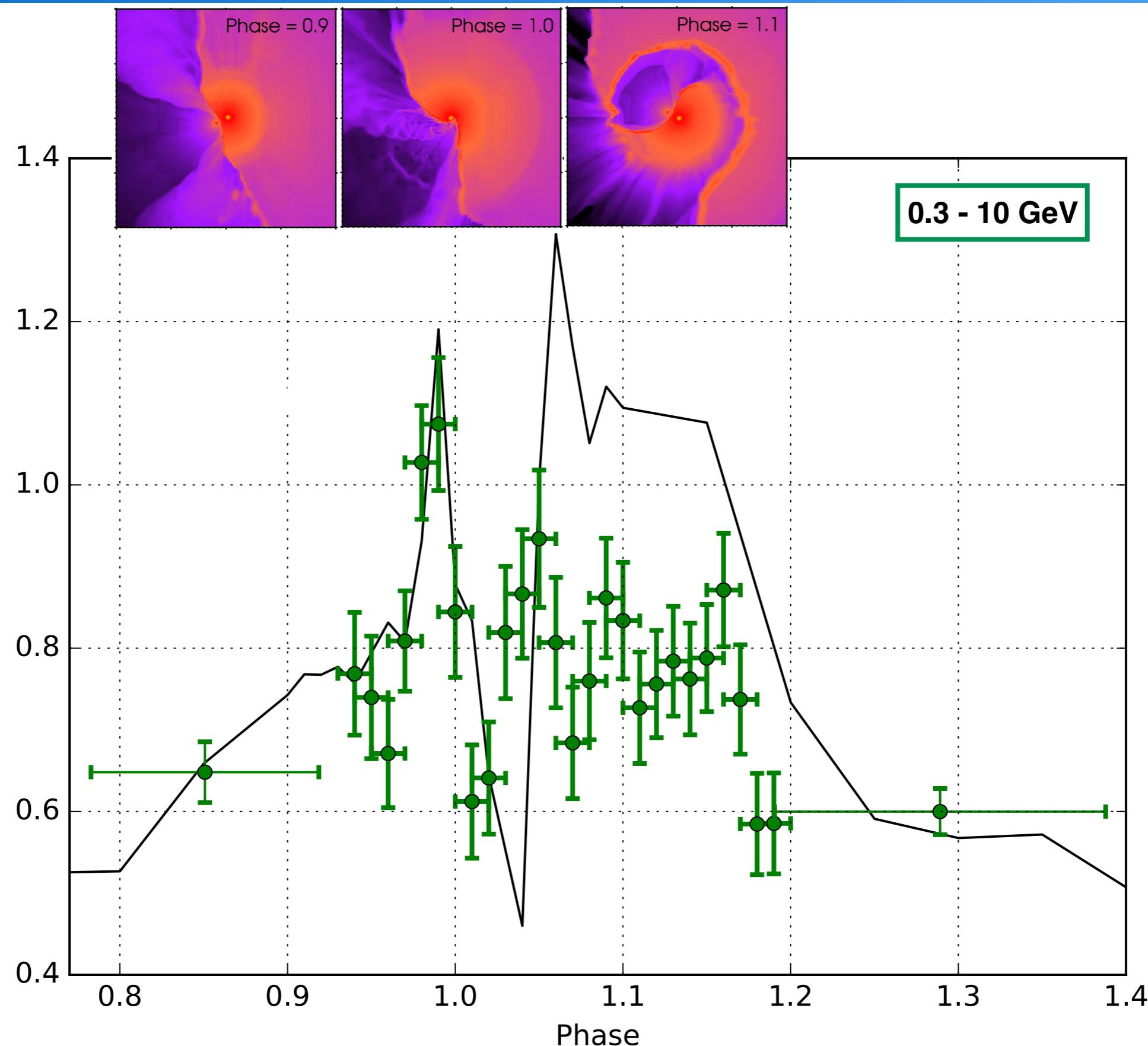
smooth IC spectrum



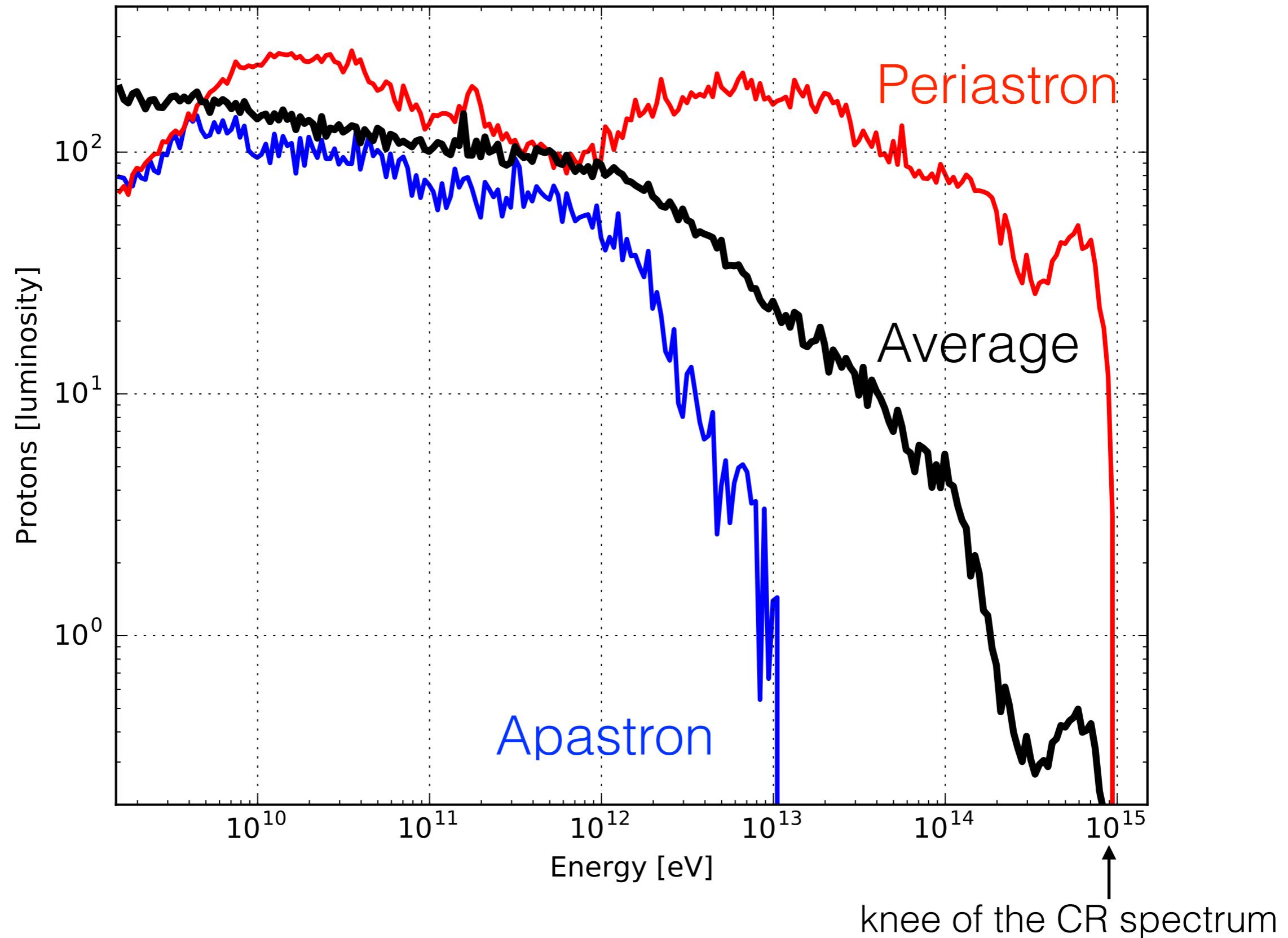
η Car γ -ray light-curves



η Car γ -ray light-curves



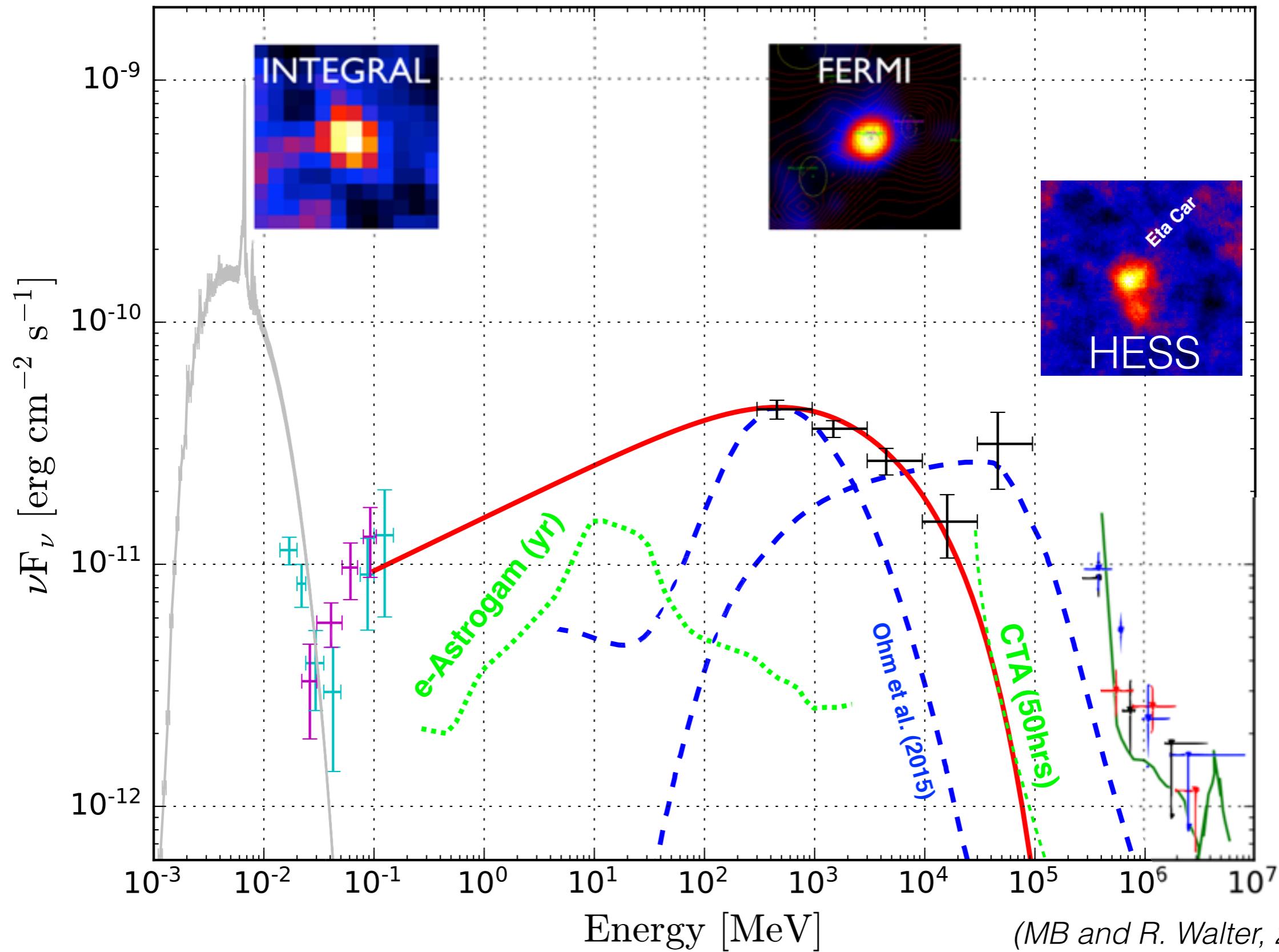
Protons spectrum



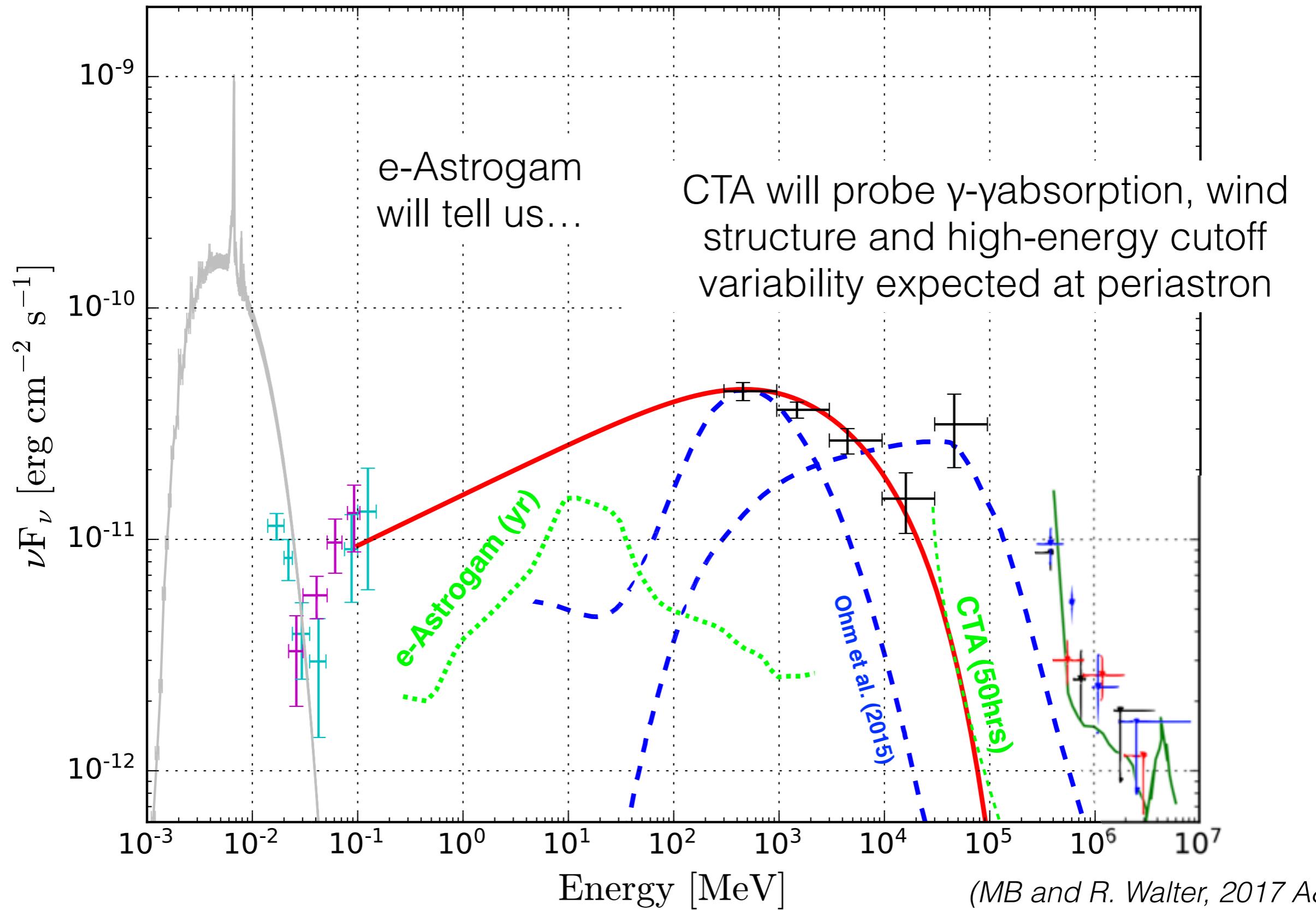
* Thermal X-rays:	25 L_\odot ($\sim 2\% L_{\text{shock}}$)
* Synchrotron:	< 0.1 L_\odot
* Electron acceleration:	50 L_\odot ($\sim 6\% L_{\text{mec}}$)
* π^0 emission:	10 L_\odot ($\sim 1\% L_{\text{mec}}$)
* neutrino:	$\sim 10^{-9} \text{ GeV s}^{-1} \text{ cm}^{-2}$ (above 10 TeV)

- * 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** $\sim 5\%$ (Spitkovsky's simulations: 10%)

With this efficiency, a massive star could accelerate $\sim 10^{49}$ ergs of CR, as much as an average SNR



(MB and R. Walter, 2017 A&A)



- Some consensus for **hadronic** acceleration occurring in **ηCarinae**
 - CWB** could accelerate as much **cosmic-rays** as an average **SNR**
 - ηCarinae** and other **galactic accelerators** are prominent **target** for **e-Astrogam**
-
- e-Astrogam** is at the sweetest point to **disentangle** the signatures of **leptonic** or **hadronic** acceleration in many types of galactic accelerators (**GC, SNR, CWB, shocks,...**)

