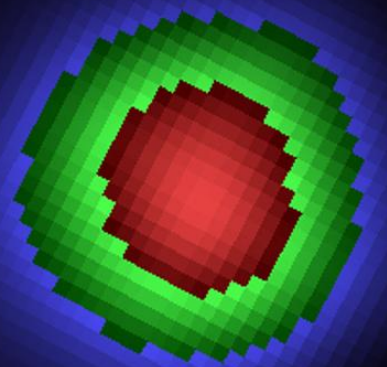
A gamma-ray source at the position of η Carinae



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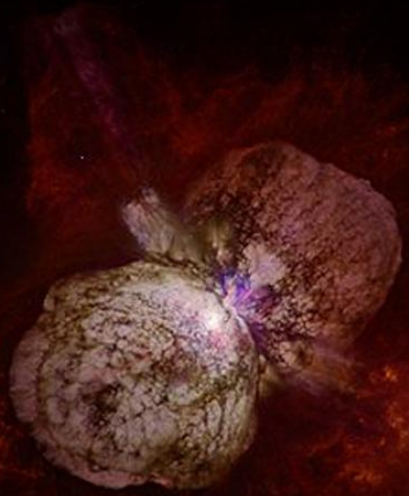
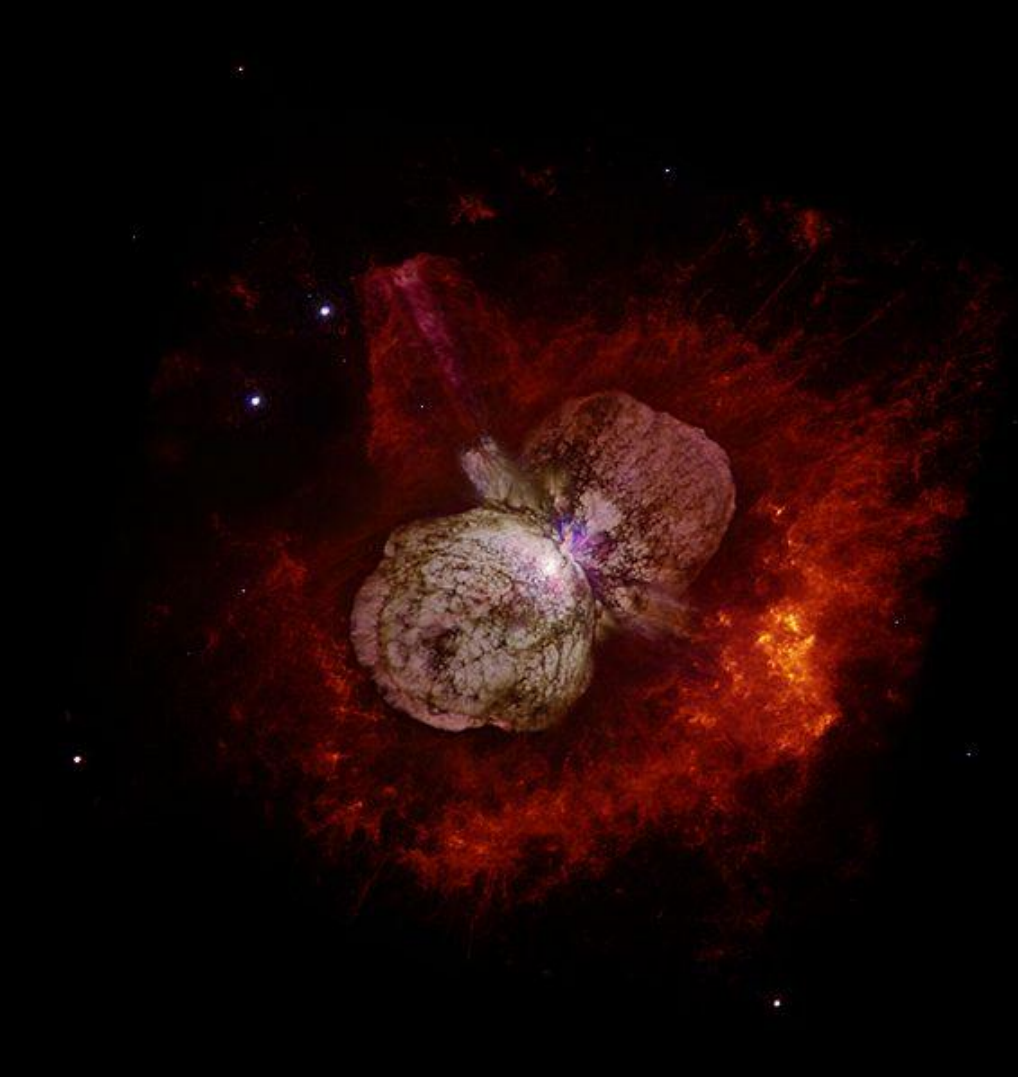


Contents

- History: What is the nature of η Car?
- Theory: Why should we expect η Car to be a source of γ -rays?
- Observation: What do we see there at high energy γ-rays?
- Conclusions: What might be the true origin of our γ-ray signal?
- Outlook: What can be done to settle this issue?

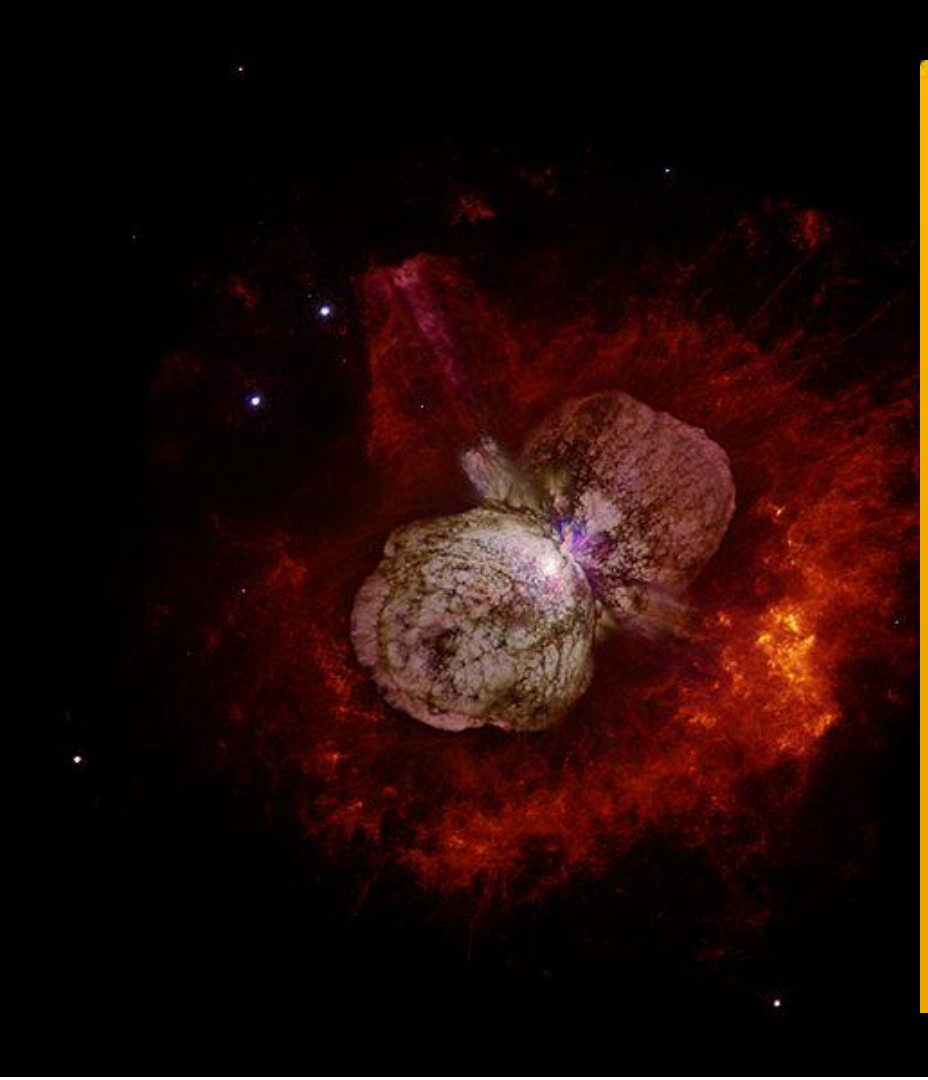


List of Superlatives:

- most luminous evolved star that can be studied closely
- survivor of greatest documented non-terminal stellar explosion
- one of the brightest stars in the sky for 20 years in 19th century
- brightest extrasolar infrared source in the sky (20 µm)
- produced one of the most pronounced bipolar nebulae

η Carinae

image (left): η Carinae (optical) - HST
list (right): Davidson & Humphreys, 1997



η Carinae is a binary system!

(Damineli, 2008)

5.5 year cycle in X-rays, radio, IR and optical wavelengths

The primary star is a Luminous Blue Variable!

Mass approximately 80 – 120 M_s

The secondary is a Wolf-Rayet-star

(Pittard & Corcoran, 2002)

Mass approximately 30 M_s

η Carinae

image (left): η Carinae (optical) - HST
list (right): Davidson & Humphreys, 1997

Why do we expect η Carinae to be a source of γ -rays?

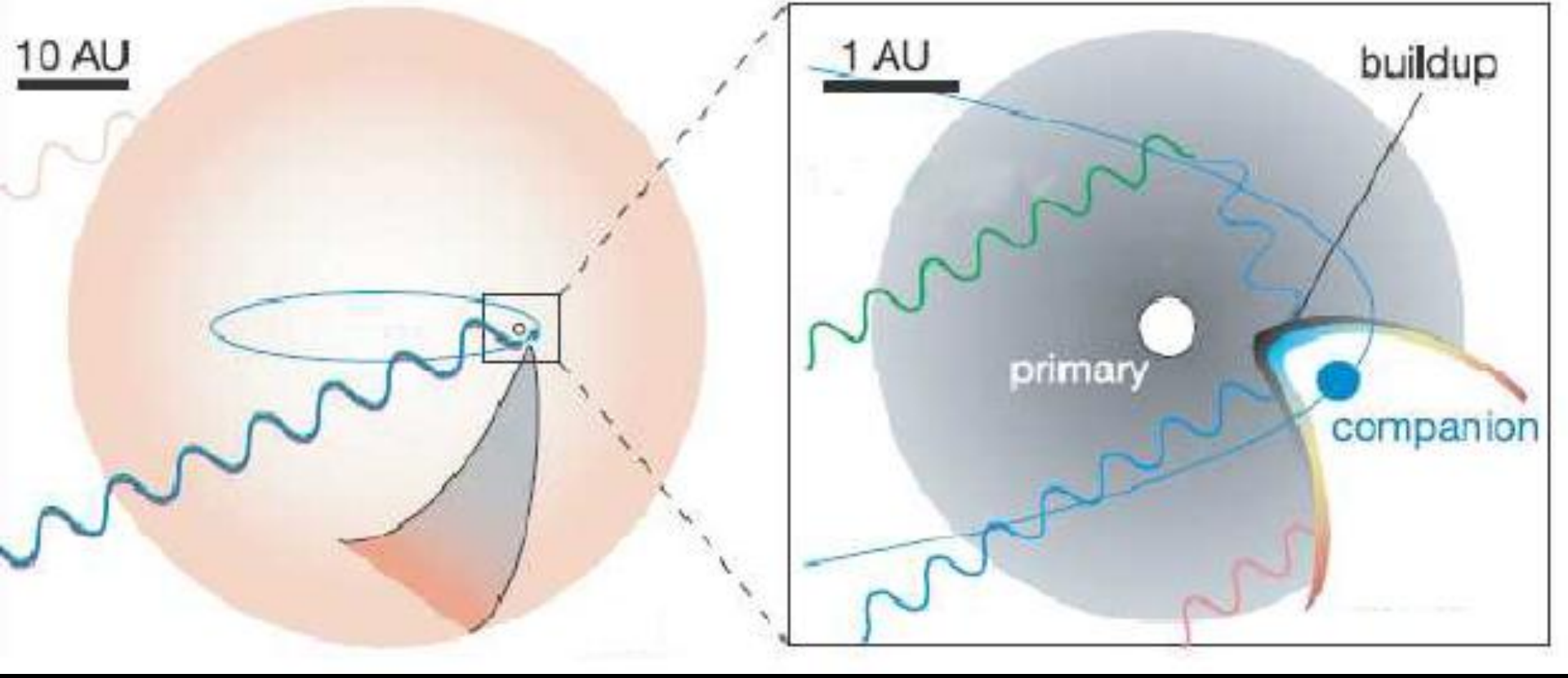
Scenario A: γ -ray origin in wind-wind collision region

(Reimer et al. 2006)

Scenario B: γ -ray origin in expanding blast wave

(Ohm et al. 2010)

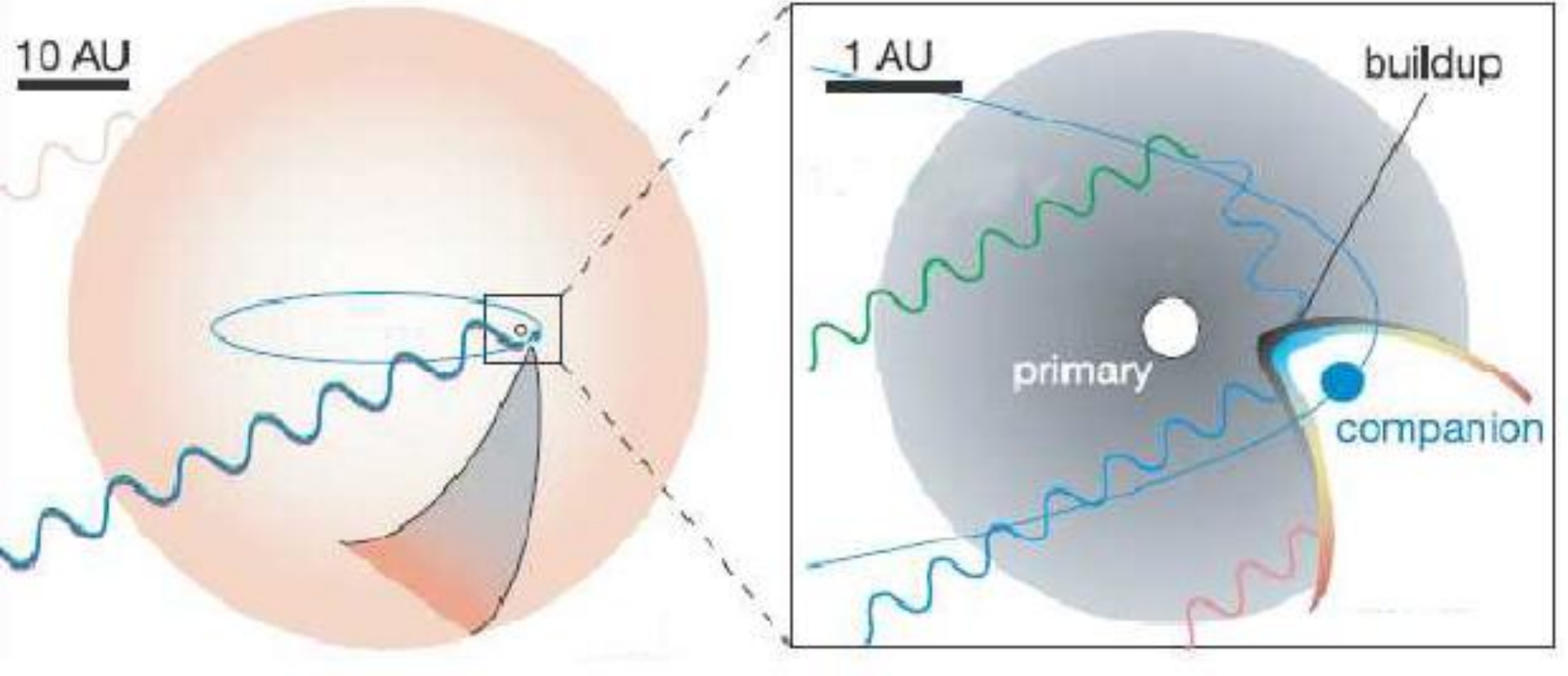
Theory



hot, shocked gas → contact discontinuity

γ -ray origin in wind-wind collision region

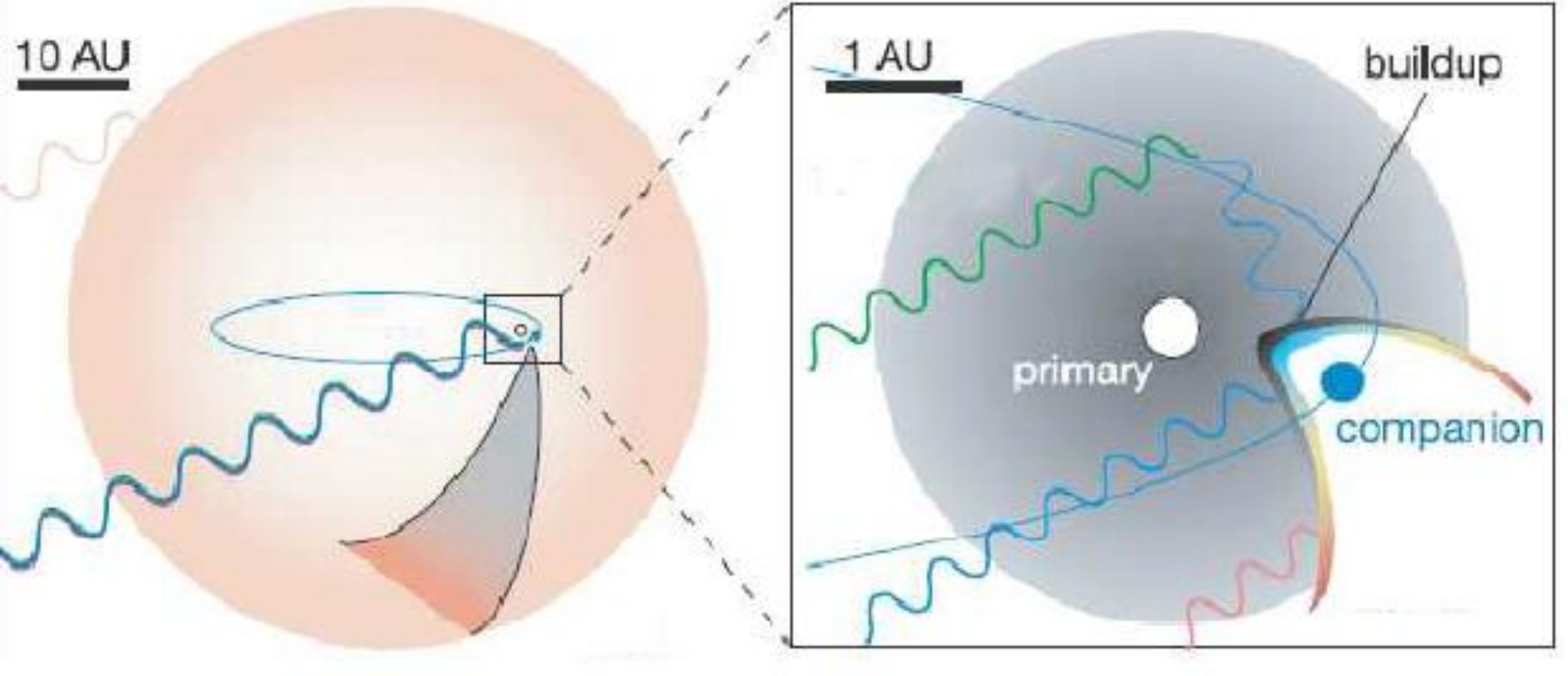
image: Hamaguchi et al, (2007)



acceleration of charged particles (1st Fermi)

γ -ray origin in wind-wind collision region

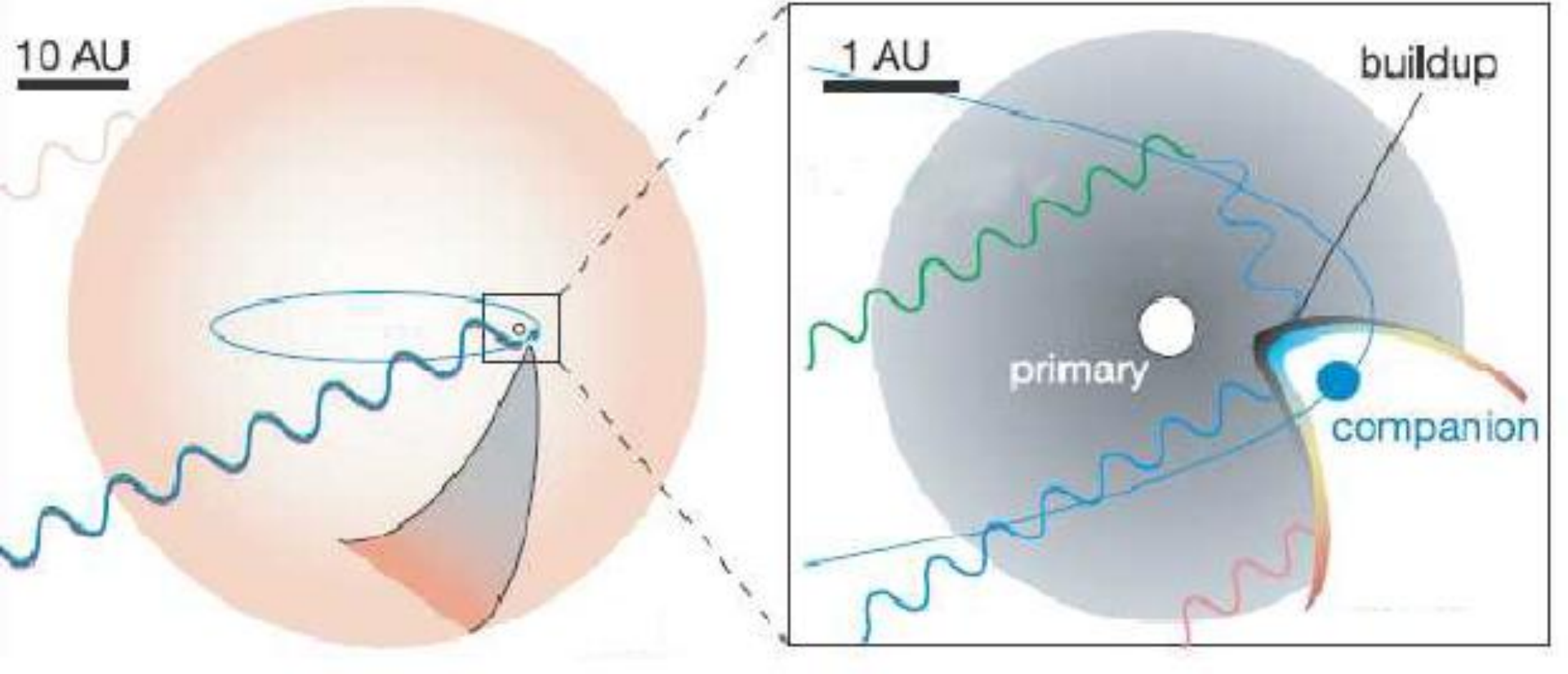
image: Hamaguchi et al, (2007)



for leptons: various channels for energy-loss:

γ -ray origin in wind-wind collision region

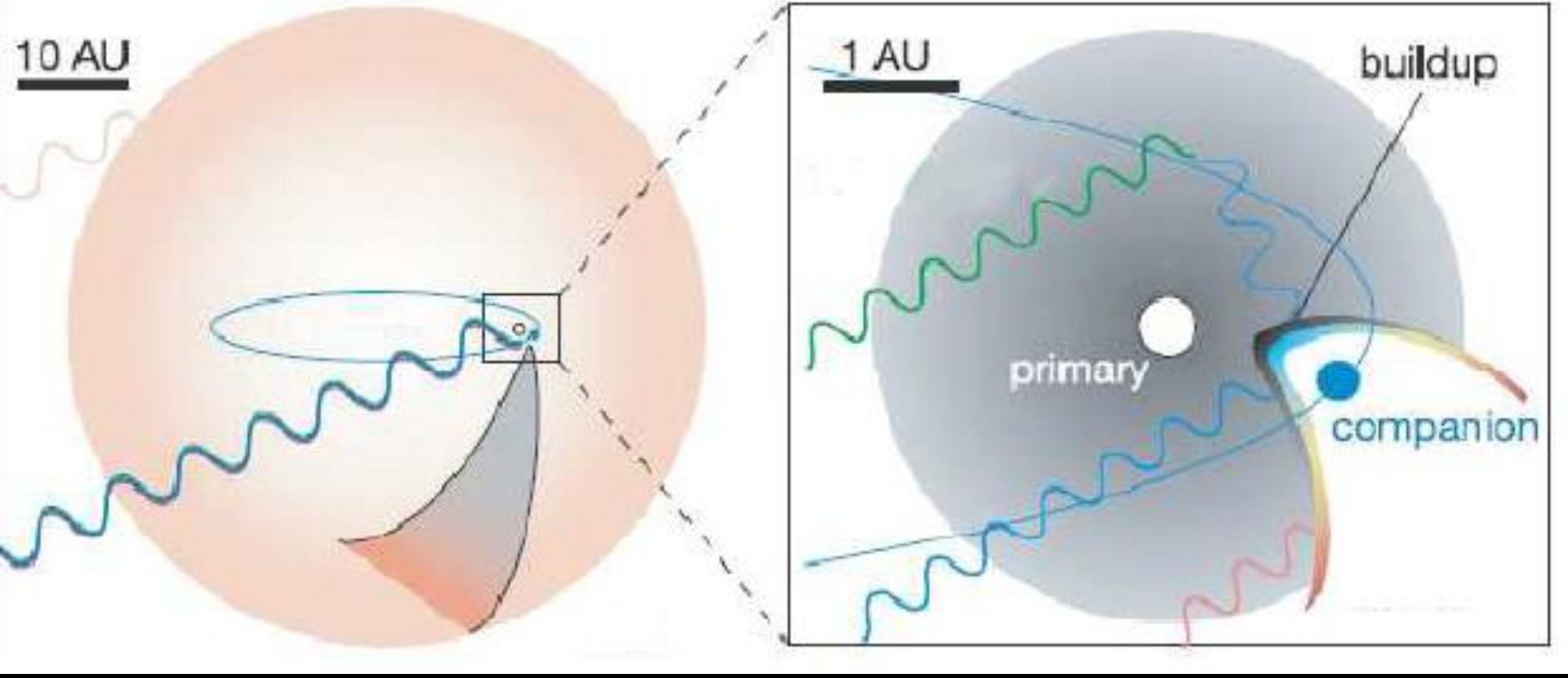
image: Hamaguchi et al, (2007)



(bremsstrahlung, inverse Compton, synchrotron)

γ -ray origin in wind-wind collision region

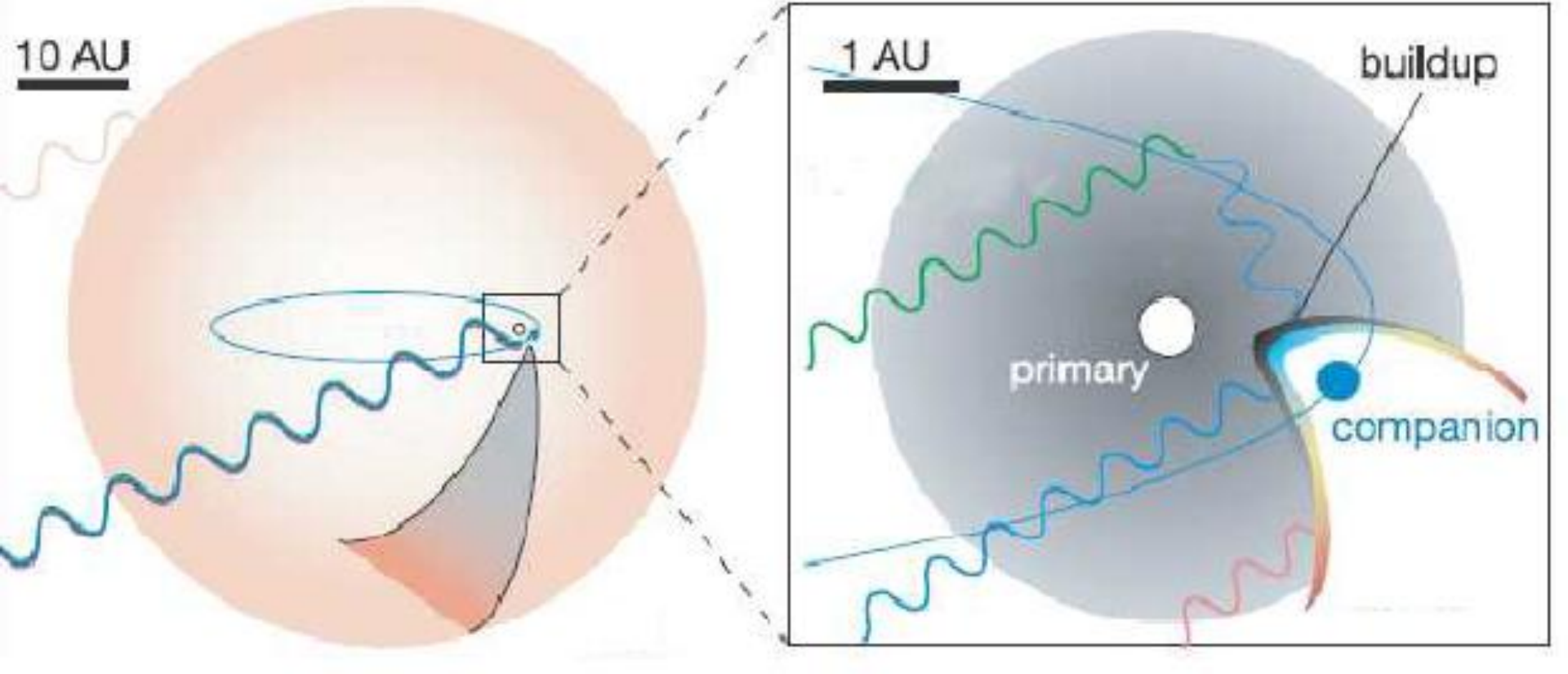
image: Hamaguchi et al, (2007)



for nucleons: $p+p \rightarrow p+p+\pi^o$, $\pi^o \rightarrow 2\,\gamma$

γ -ray origin in wind-wind collision region

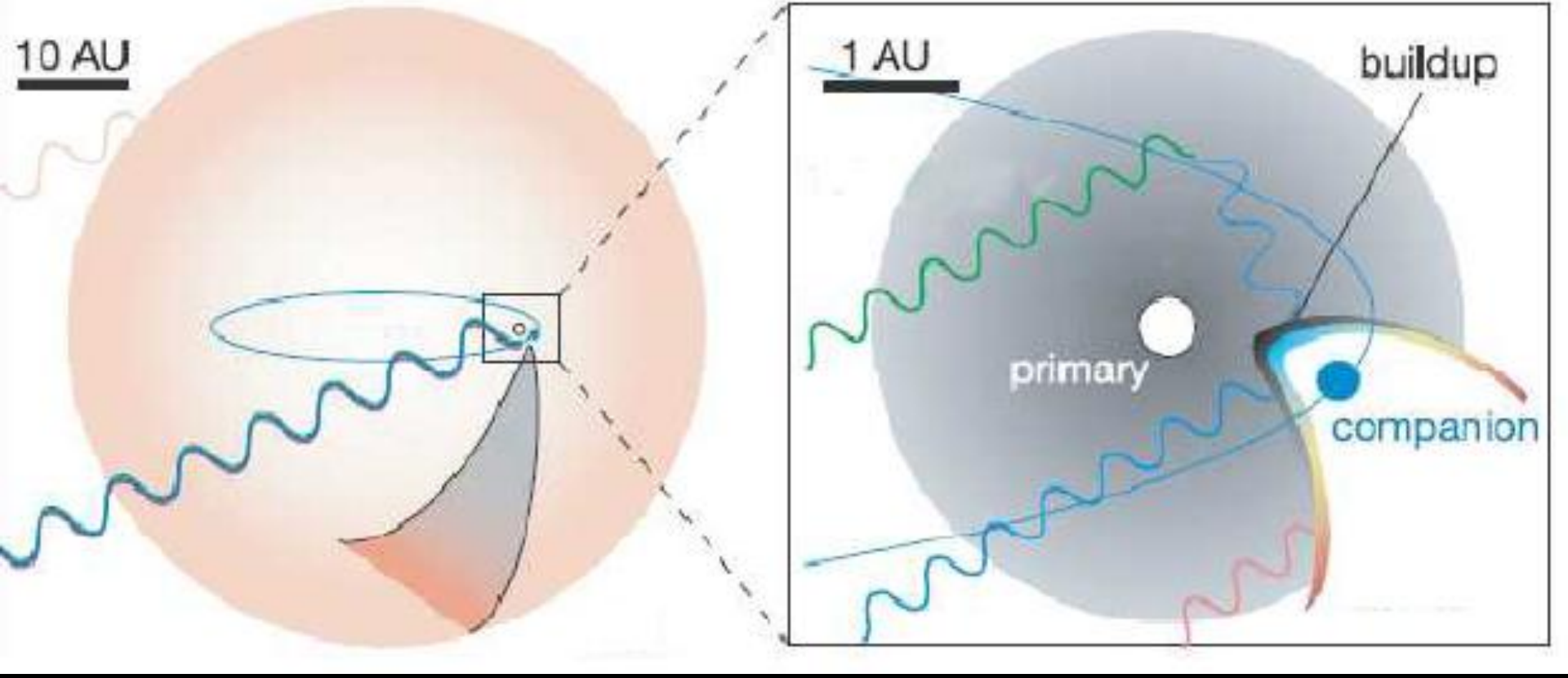
image: Hamaguchi et al, (2007)



Inverse Compton scattering dominates

γ -ray origin in wind-wind collision region

image: Hamaguchi et al, (2007)

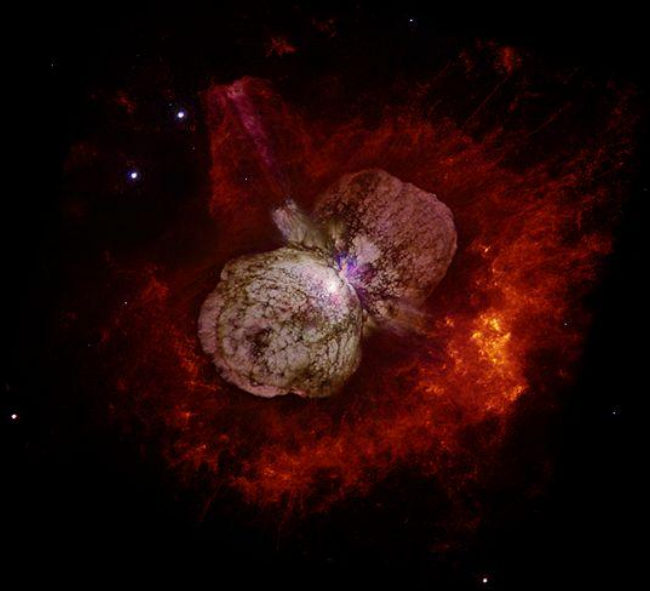


strong variability on orbital time scales expected

γ -ray origin in wind-wind collision region

image: Hamaguchi et al, (2007)

Scenario B



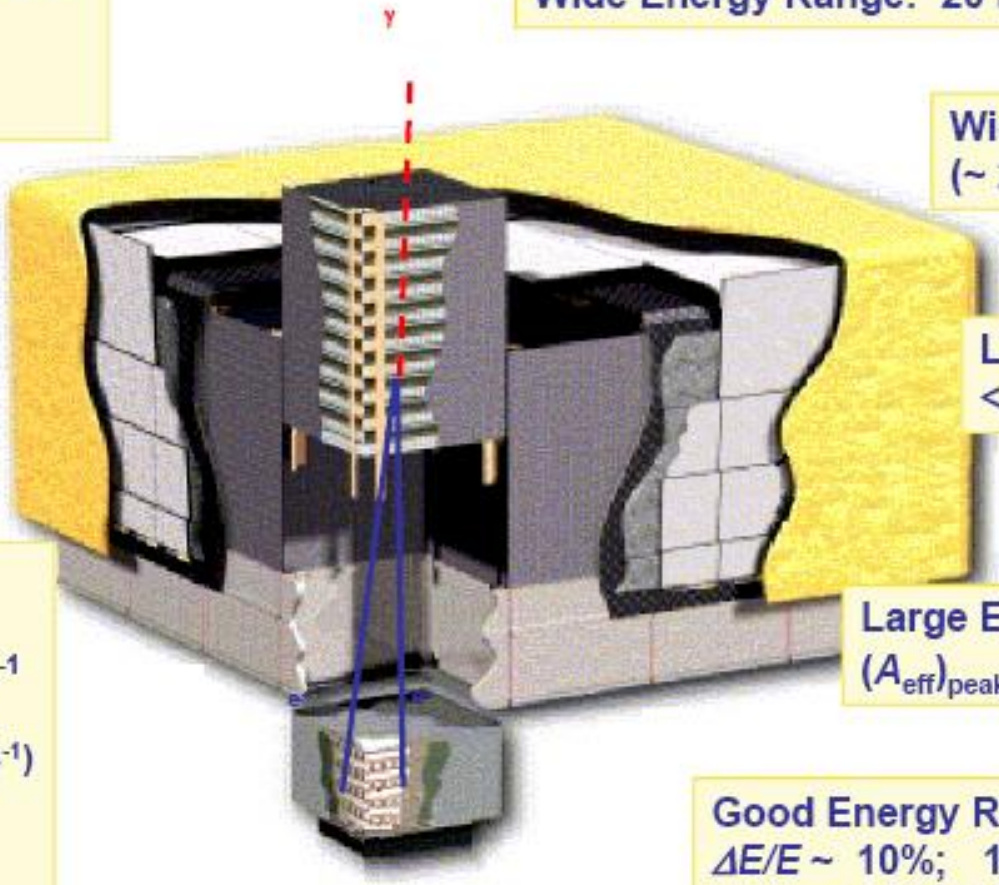
- particle acceleration at shock front of a blast wave that originated at the „Great Eruption" of 1843
- no need for variability in Inverse Compton signal
- too low matter-density for hadronic component

γ -ray origin in expanding blast wave

image: S. Ohm et al. (2010)

Single Photon Angular Resolution
3.5° @ 100 MeV
0.15° @ 10 GeV

Wide Energy Range: 20 MeV … ~300 GeV



Wide Field of View
(~ 2.4 sr)

Low dead time:
< 100 μs/event

Point Source Sensitivity:
$< 6 \times 10^{-9}$ ph cm^{-2}s^{-1}
(est. performance:
$< 3 \times 10^{-9}$ ph cm^{-2}s^{-1})

Source Localization:
0.3' – 1'

Large Effective Area
$(A_{eff})_{peak} > 8{,}000$ cm^2

Good Energy Resolution
$\Delta E/E$ ~ 10%; 100 MeV – 10 GeV
~ < 20%; 10 GeV – 300 GeV

FERMI - LAT

- high significance detection of a source at the position of η Car
- better positional agreement as amount of data increases
- γ-rays up to more than 100 GeV → hard high-energy tail in the spectrum
- no variation on orbital time scales (no change at periastron)

Observational results

- high
- bette
- γ-ray
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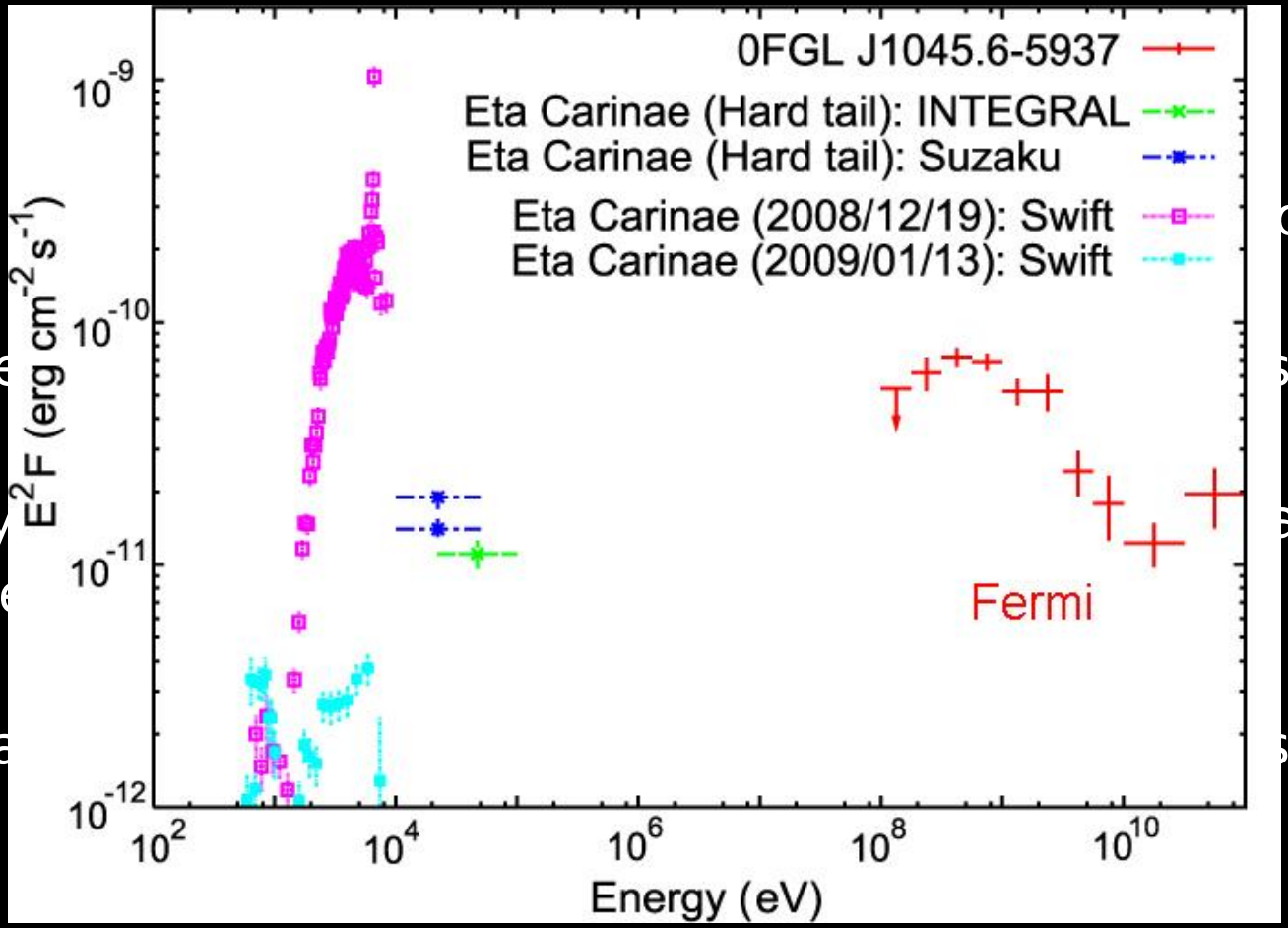
- no va



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Observational results

Abdo et al, (2010)

- the model for γ-ray origin in wind-wind collision region predicts strong variability on orbital time scales.

  → We do not see any variability.

- the model for γ -ray origin in the expanding blast wave cannot account for a hard tail in the energy spectrum.

  → We do see a hard tail.

Conclusions

An object as unique and complex as η Car might require even more sophisticated models for high-energy γ-ray emission:

- multiple sites of particle acceleration?
- dominant role of other γ-ray emission mechanisms (such as bremsstrahlung)?

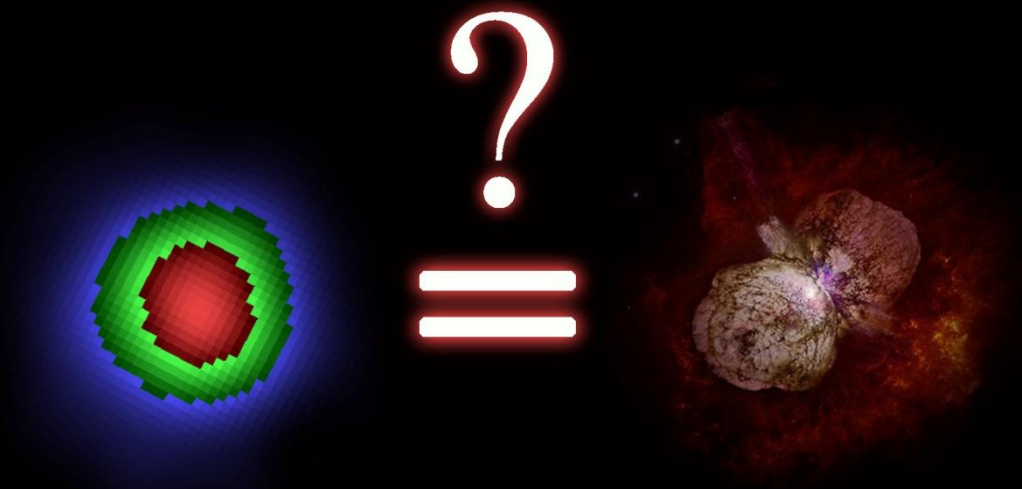
Or maybe:

A different source after all?

Conclusions

- **If it ain't η Car, what else can it be?**
  - ***Background Blazar***
    - low probability $7*10^{-05}$
    - most blazars show time variability, this source does not (so it seems)
    - spectrum does not look like a blazar
  - ***Pulsar wind nebula***
    - cluster Tr16 may host young energetic pulsars
    - no pulsar or PWN known near η Carinae
    - Where is the pulsation?
  - ***Superposition of two separate sources***
    - soft and hard component might arise from different origin
    - Unlikely, the positions are too close

Conclusions



The pathway to an answer

- gather more data to reduce uncertainties
- search for VHE γ -rays (promising candidate for HESS)
- closer look at possible time variation in different energy bands

Outlook