Challenges of high-energy observations : η Carinae as seen by the European γ-ray observatory

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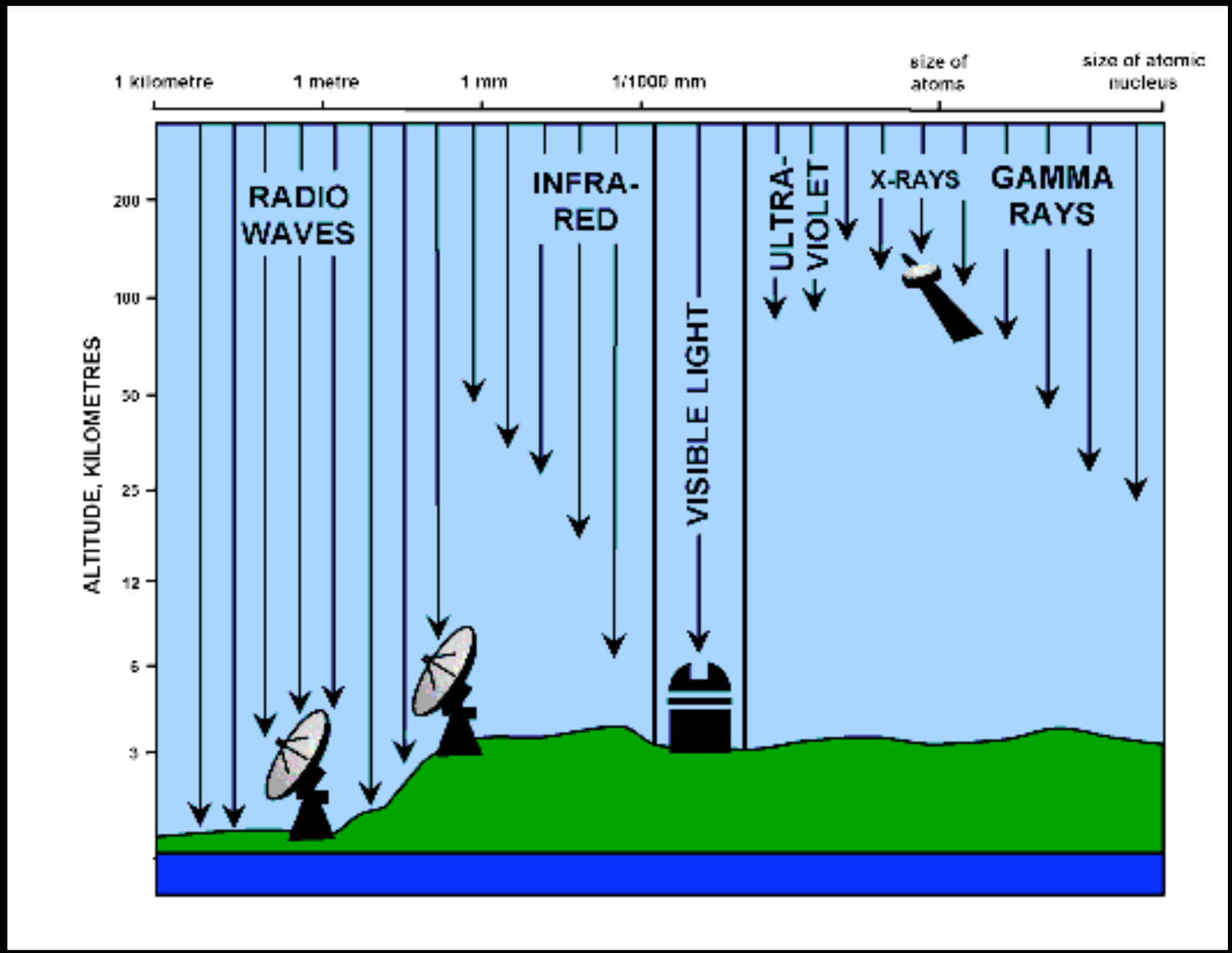
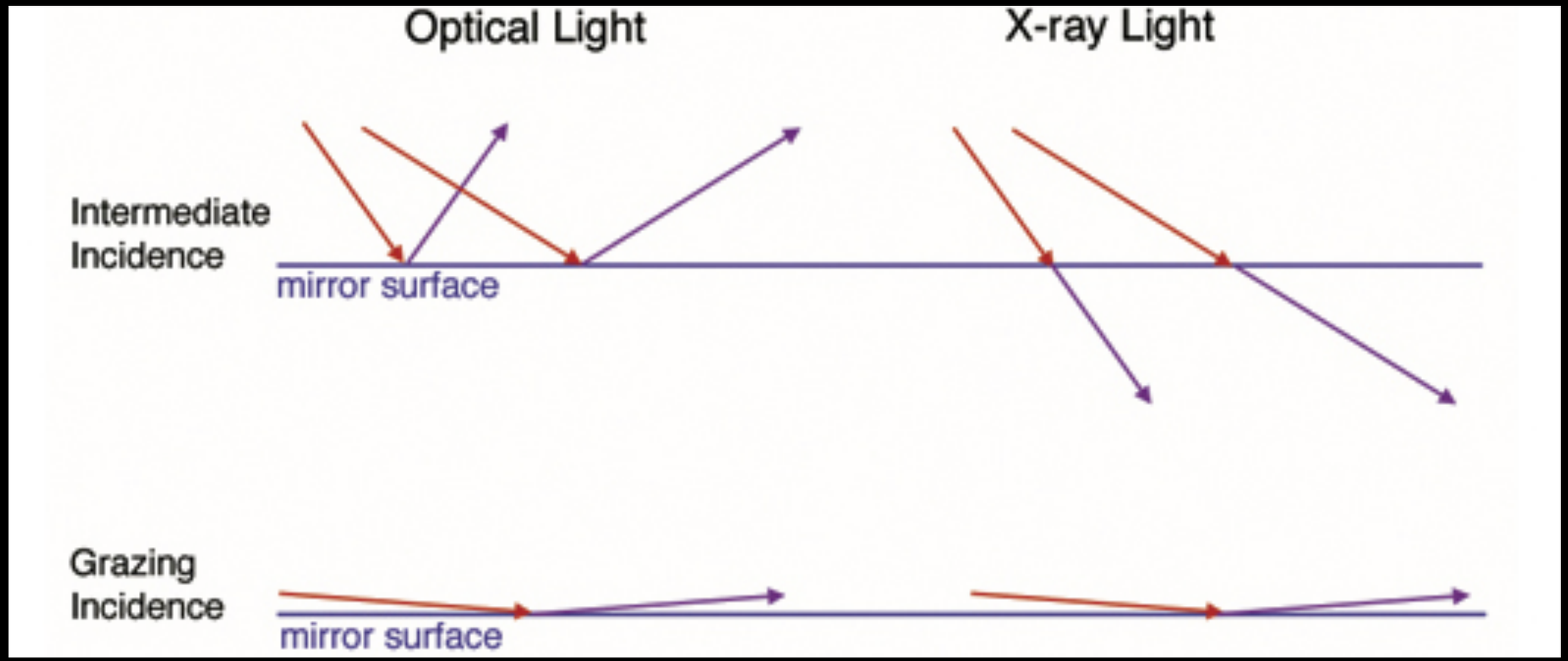
Outline

- X-ray and gamma-ray satellites
- High-energy emission from colliding-wind binaries
- INTEGRAL observations of Eta Carinae
- Future prospects

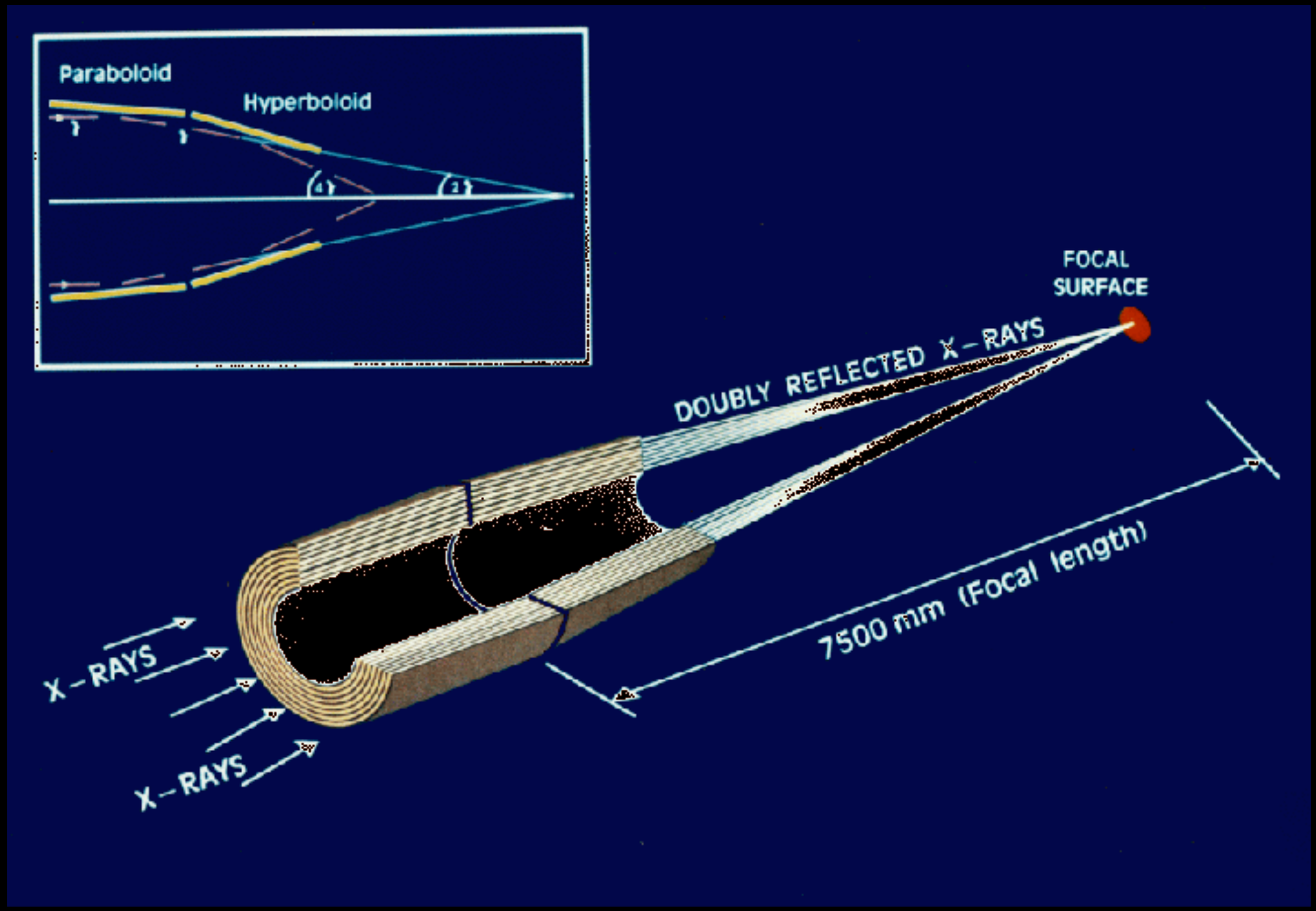
Multi-wavelength observations



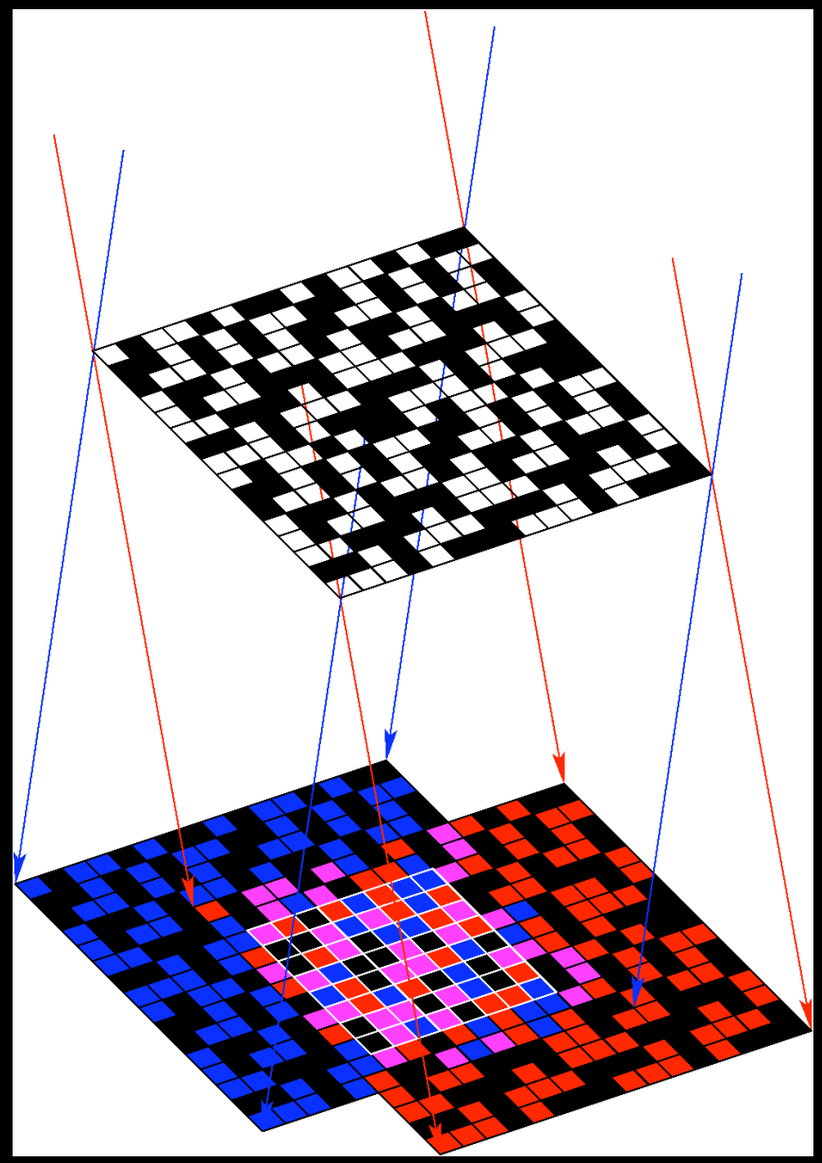
Focusing photons in X-rays



Focusing photons in X-rays

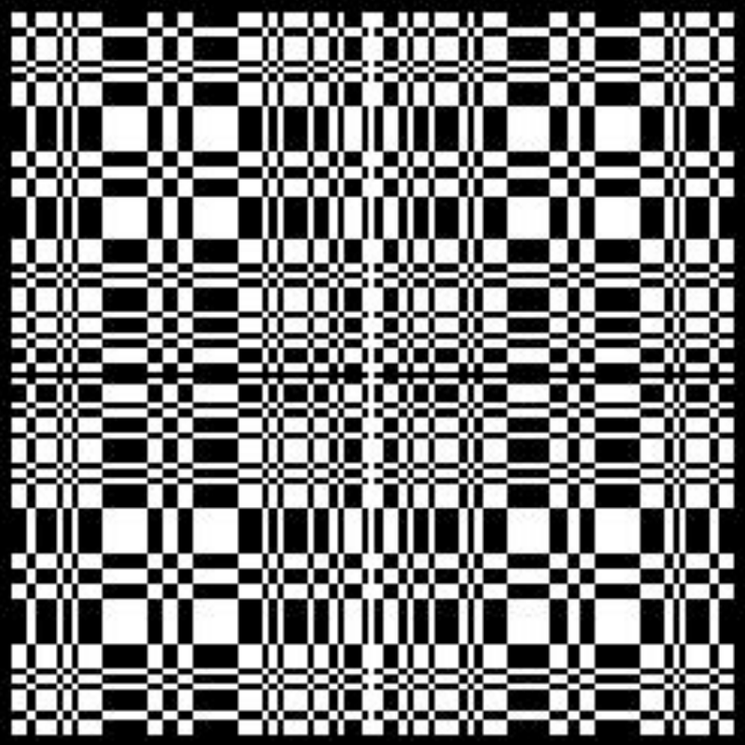


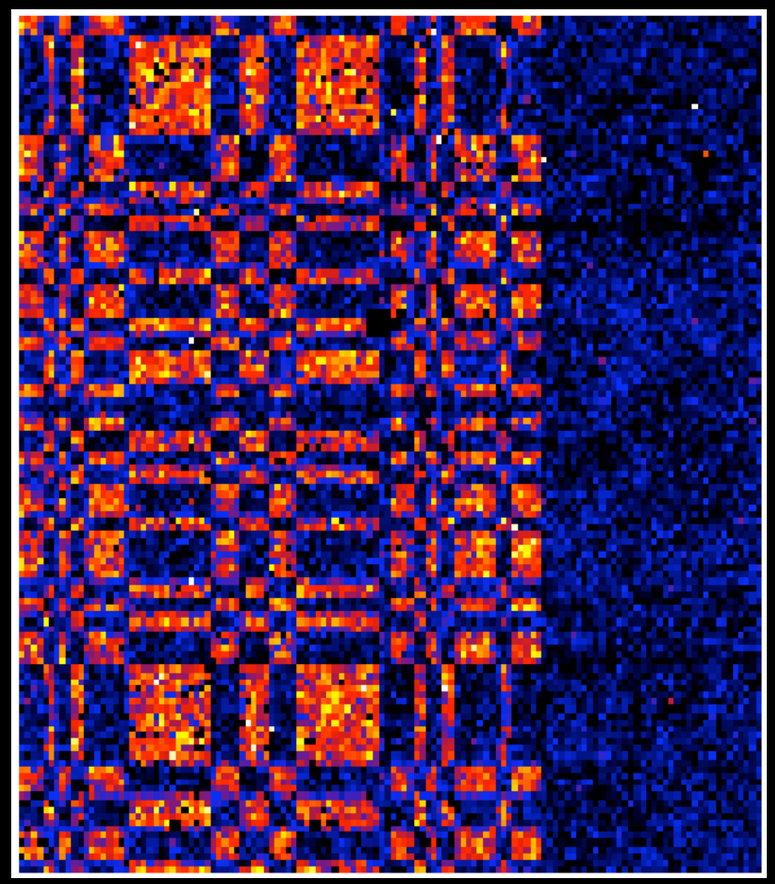
Imaging in gamma-rays : INTEGRAL

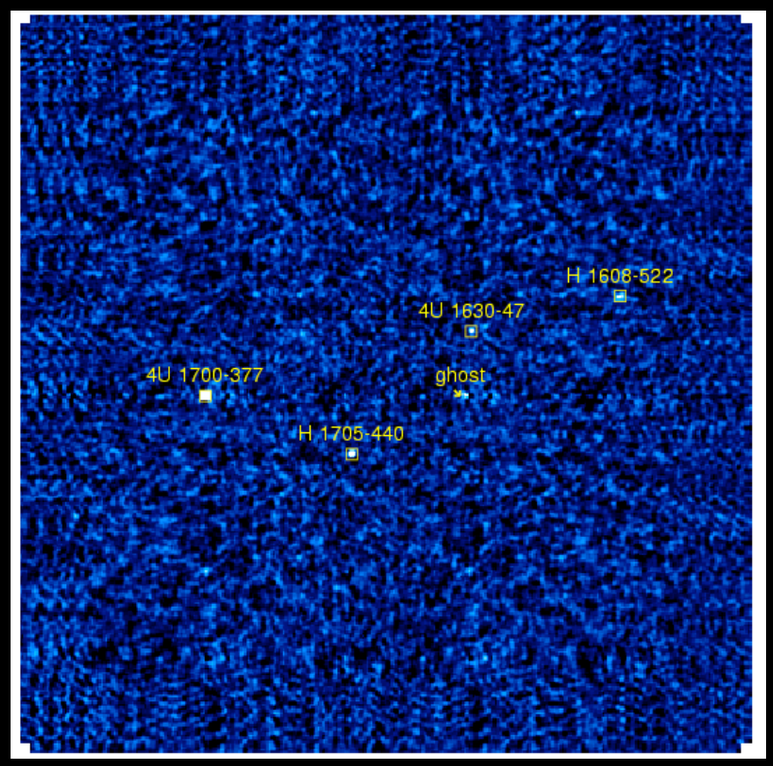


"Coded masks"

Imaging in gamma-rays : INTEGRAL







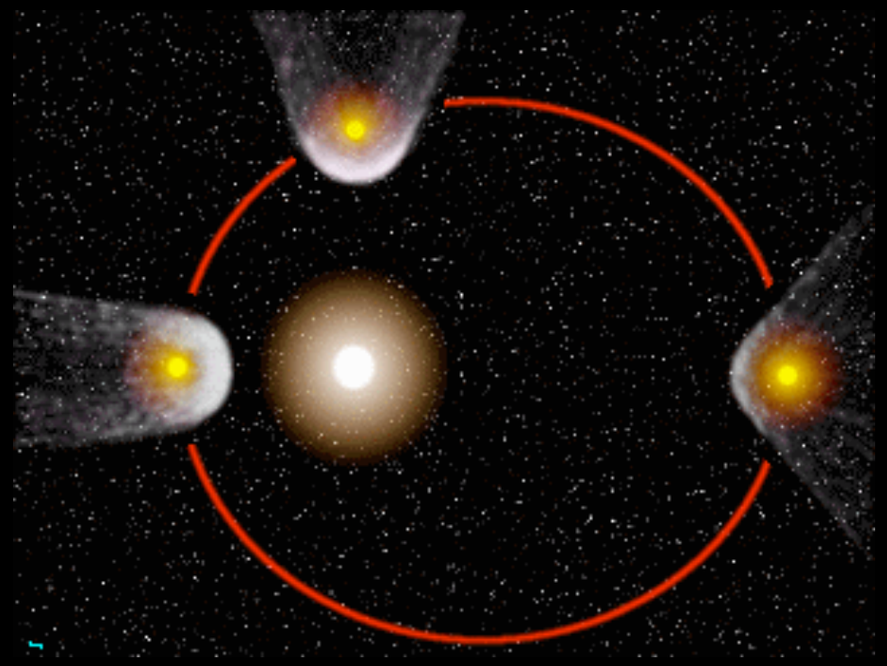
Coded mask

Shadowgram

Image

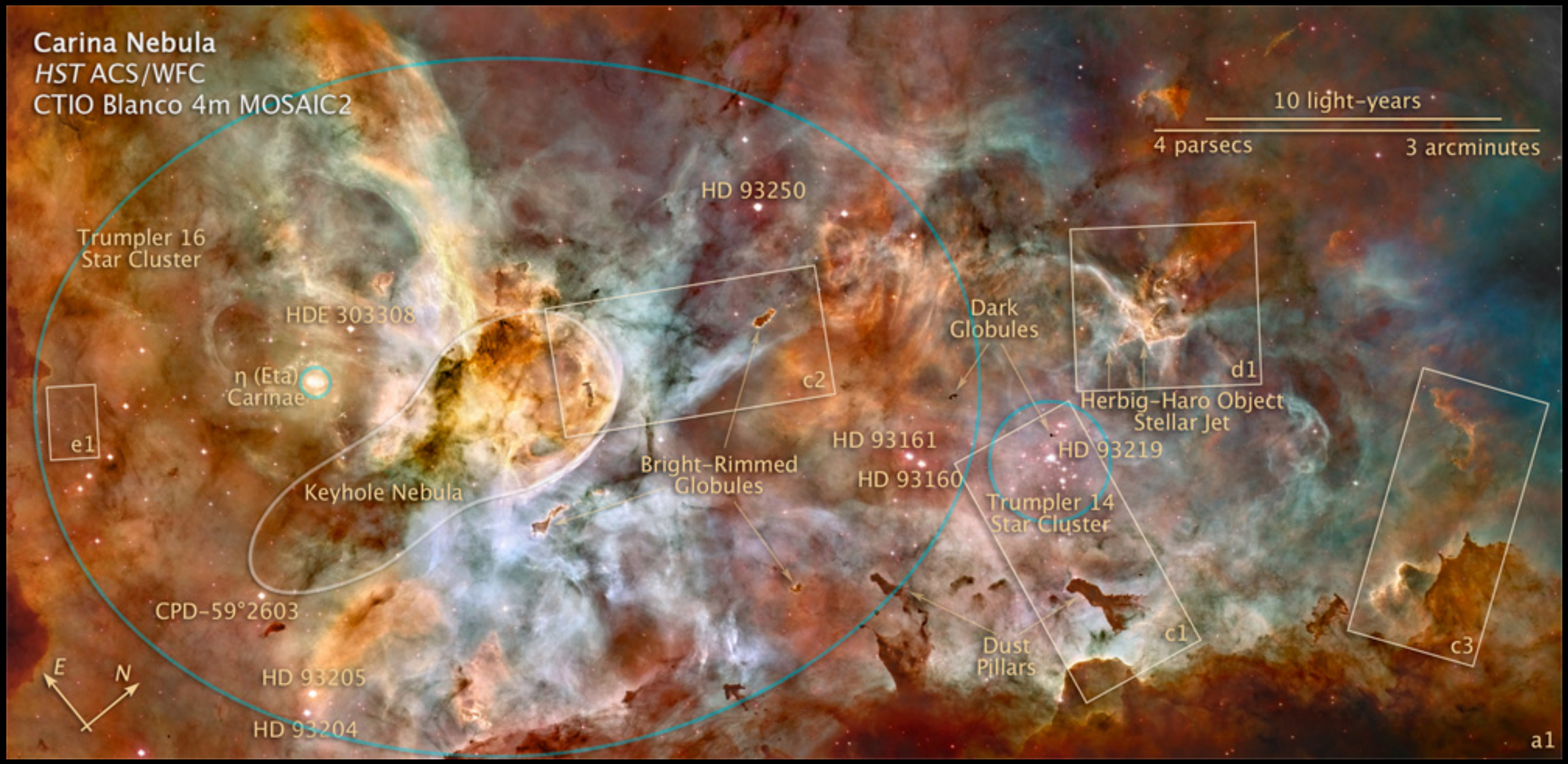
Hard X-ray and ϒ-ray emission from colliding-wind binaries

- Colliding-wind binaries
  - ⇨ Hydrodynamical shock
  - ⇨ Acceleration of particles
  - ⇨ Relativistic electrons
- Early-type stars
  - ⇨ Huge UV radiation field
- Inverse Compton scattering
  - ⇨ Hard X-rays and soft gamma-rays

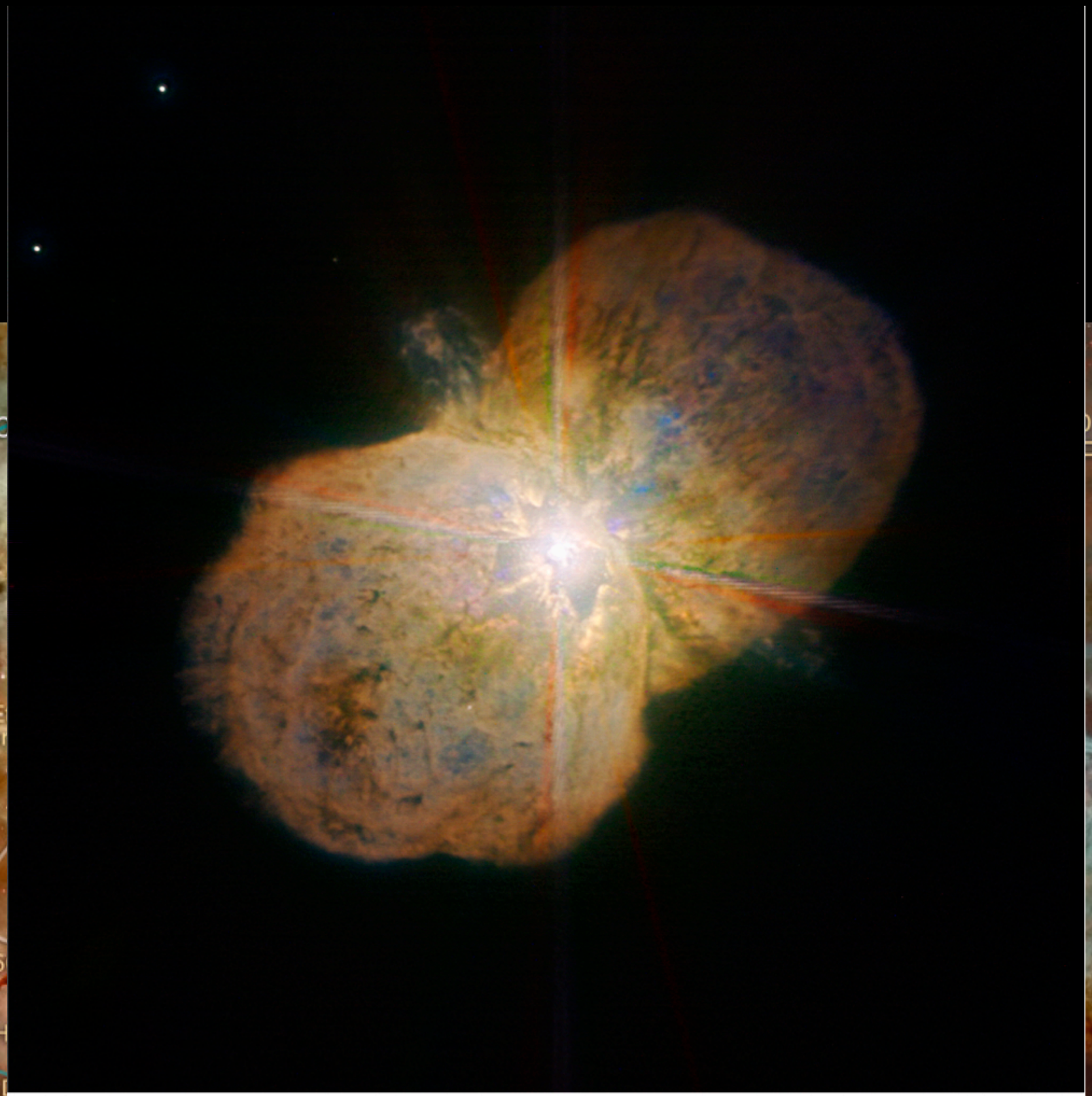


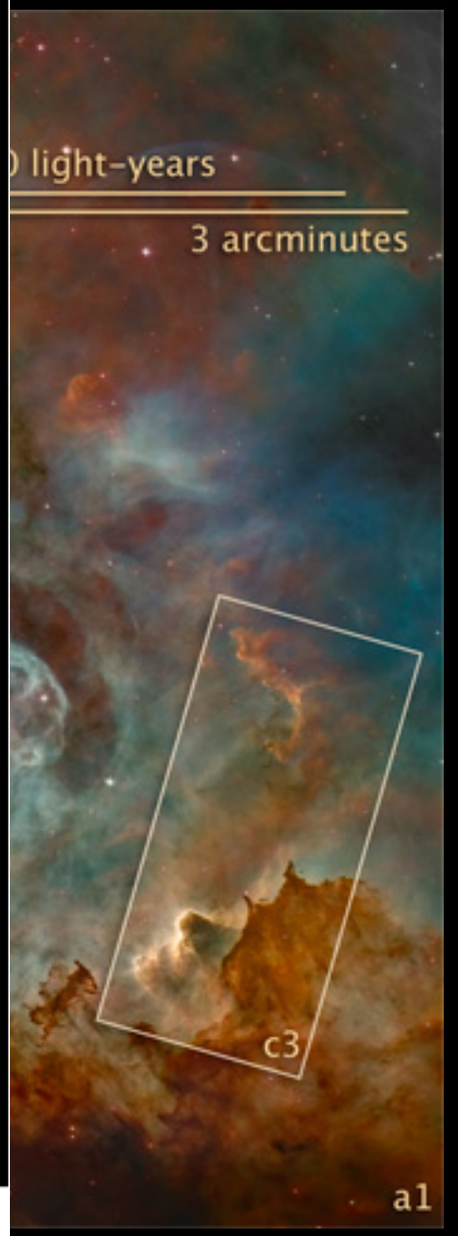
Bell 1978, Pittard & Dougherty 2006

Eta Carinae



NASA, ESA, UCB, STScI/AURA 2007





Eta Carinae (NACO/VLT)

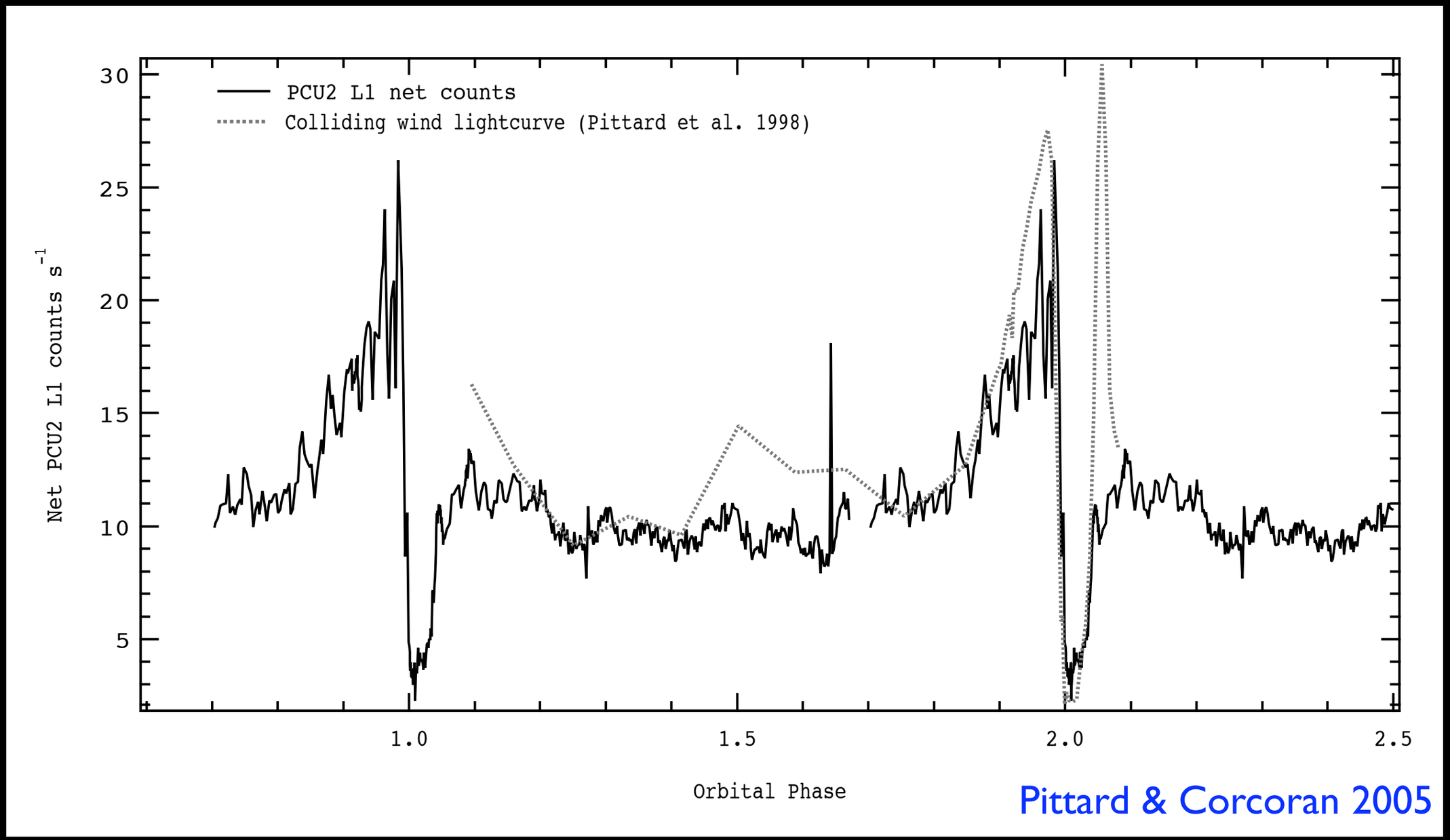
ESO Press Photo 17a/08 (27 May 2008)

TScI/AURA 2007

Eta Carinae

- Known for its eruption in 1843 (Viotti 1995)
- Mass-loss rate of $10^{-3} - 10^{-4}\ \mathrm{M}_{\odot}/\mathrm{year}$
- Period of 5.5 years in :
  - optical observations (Damineli et al. 2000)
  - infrared observations (Whitelock et al. 2004)
  - X-ray observations (Corcoran 2005)

Eta Carinae



Pittard & Corcoran 2005

Eta Carinae as a colliding-wind binary

- Binary system made of :
  - a Luminous Blue Variable
  - a less extreme (O or WR) star (Iping et al. 2005)
- High eccentricity (0.9) (Corcoran et al. 2001)
- X-ray spectrum ⇨ Colliding-wind binary (Corcoran 2005)

BeppoSAX observations

4 observations with PDS (Viotti et al. 2004) :

- High-energy excess (13-20 keV) at $\Phi = 0.83, 1.37, 1.46$
- No excess at $\Phi = 1.05$

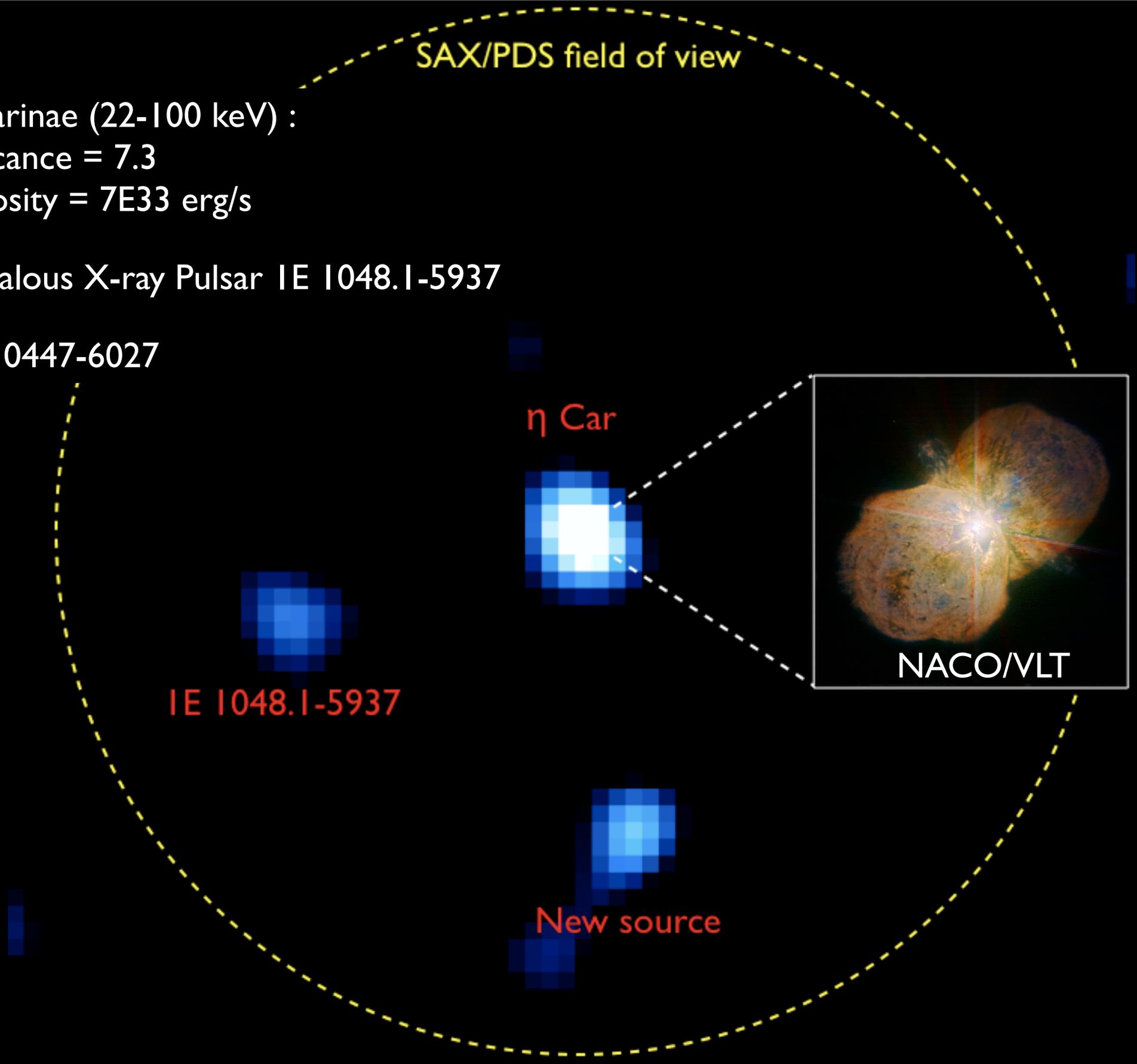
... but this needs confirmation...

- High-energy tail up to 50 keV (June 2000)

INTEGRAL observations : image

- 1131 pointings, i.e. 3.3 Ms
  ⇨ Effective exposure time of 1.1 Ms
- 3 sources in the PDS field

- Eta Carinae (22-100 keV) :
  significance = 7.3
  luminosity = 7E33 erg/s
- Anomalous X-ray Pulsar 1E 1048.1-5937
- IGR J10447-6027



Hard X-rays (INTEGRAL/IBIS) Leyder, Walter & Rauw 2008

INTEGRAL observations : spectrum

- Up to 100 keV
- `wabs*mekal` (kT = 5.1 keV, NH = 4.3E22)
- `powerlaw` ⇨ photon index of 1 ± 0.4

BeppoSAX

INTEGRAL

keV/cm² s keV

0.01

10^{-3}

10^{-4}

10^{-5}

10^{-6}

- `wabs*mekal` (kT = 5.1 keV, NH = 4.3E22)
- `powerlaw` ⇨ photon index gamma of 1 ± 0.4

2 5 10 20 50 100

channel energy (keV)

Leyder, Walter & Rauw 2008

INTEGRAL observations : mechanism

- High-energy non-thermal emission from a colliding-wind binary
- Inverse Compton scattering of UV or optical photons by high-energy electrons accelerated in the collision zone (Benaglia & Romero 2003)
- Total power in stellar wind interactions

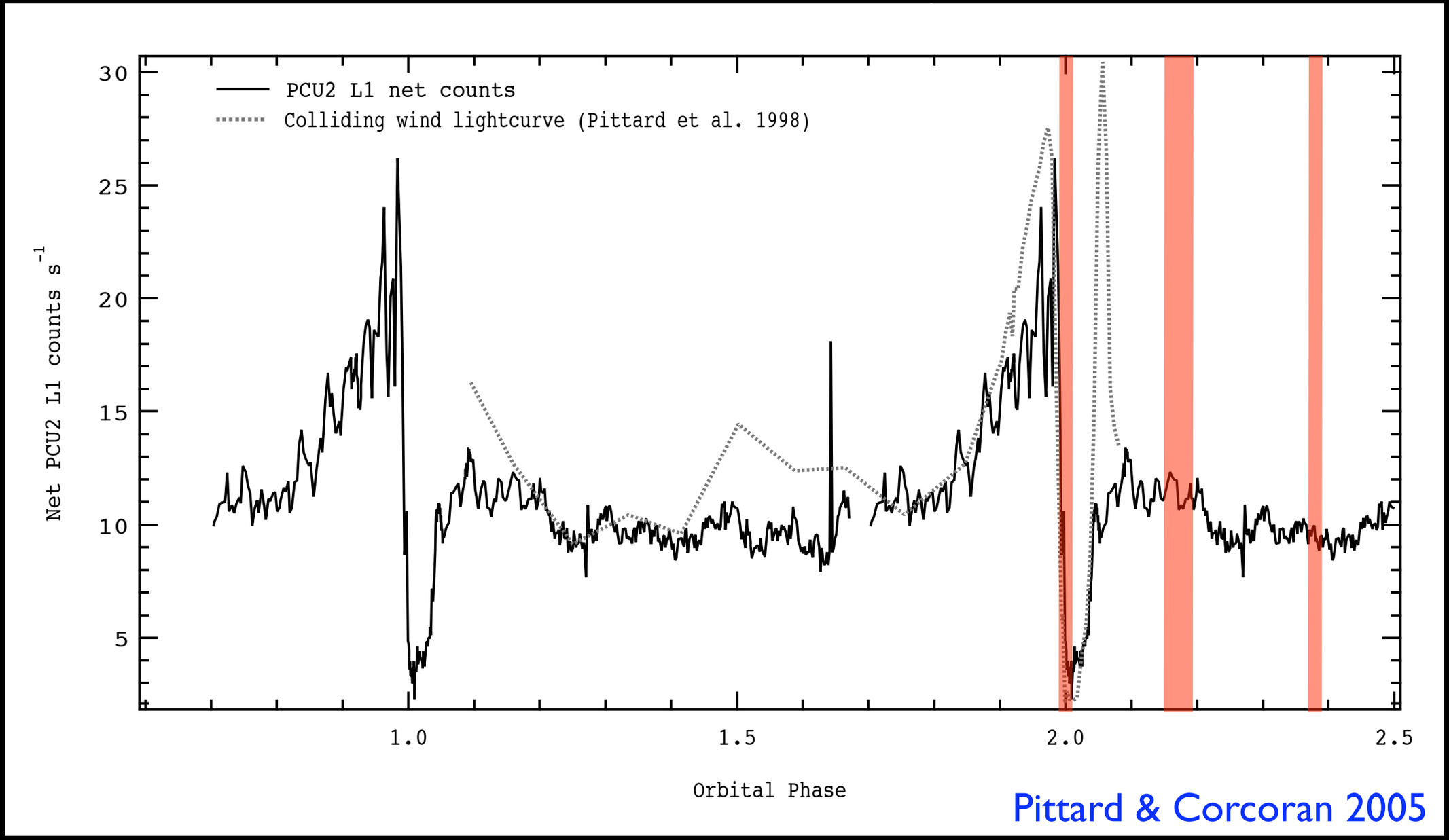
$$L = \frac{1}{2}\Theta \dot{M} v^2 \qquad \text{(Pittard \& Stevens 2002)}$$

$$L_1 + L_2 \simeq 10^{37} \mathrm{erg/s}$$

INTEGRAL observations : variability?

- 3 major periods of observations :
  - Φ = 1.99-2.01; 122 ks; significance = ---
  - Φ = 2.16-2.19; 717 ks; significance = 6.2
  - Φ = 2.35-2.37; 180 ks; significance = 3.3
- X-ray lightcurve

INTEGRAL observations :



Pittard & Corcoran 2005

Colliding-wind binary

⇨ Increase in column density

⇨ Decrease in plasma emission measure

Future prospects

- Systematic search for :
  - Wolf-Rayet stars
  - non-thermal radio emitting early-type stars
  - O-type stars (magnitude V < 8)
- Variability of Eta Car in gamma-rays?
  - 1 Ms of observations during next periastron