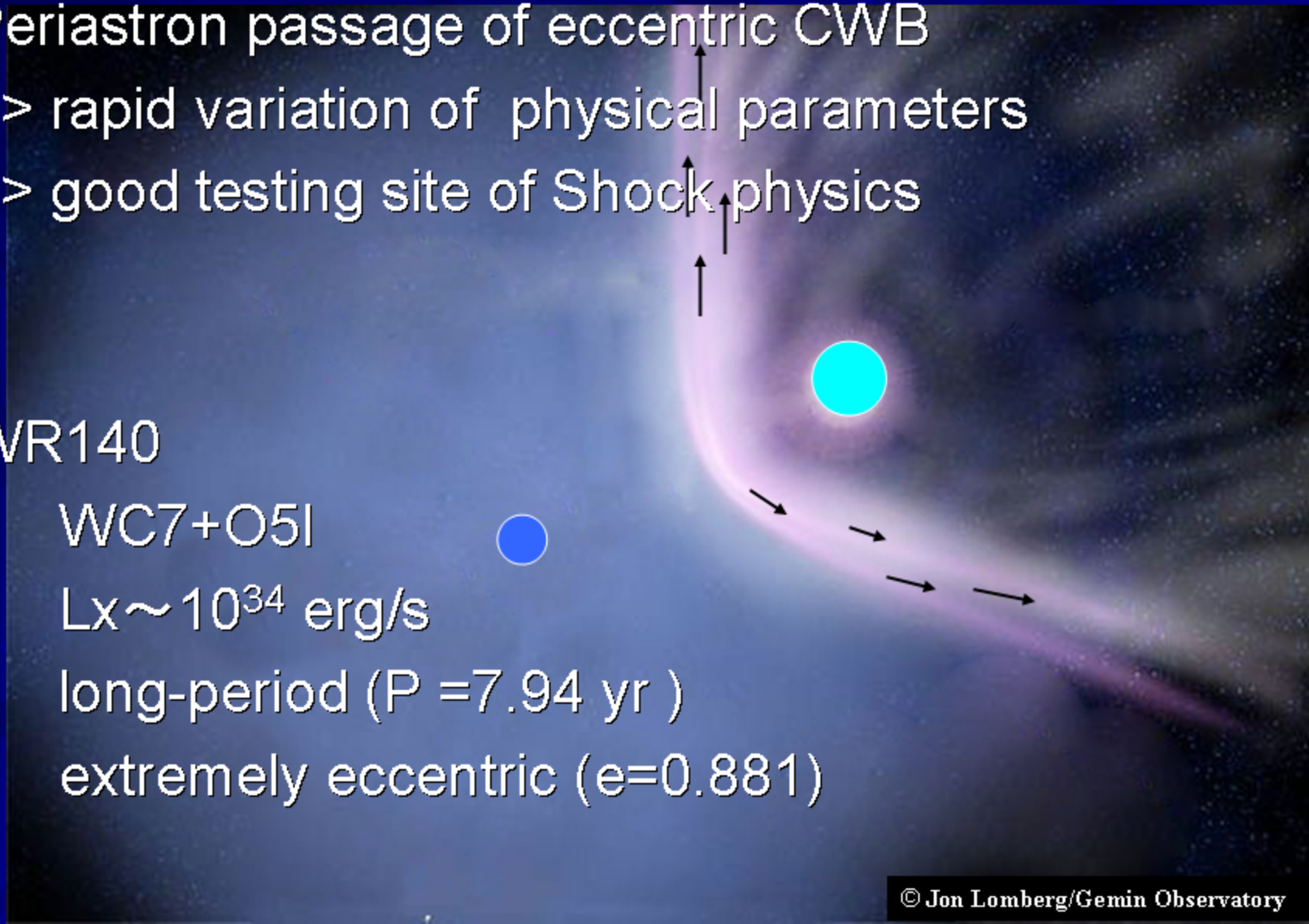
Suzaku monitoring of the Wolf-Rayet binary WR140

Y. Sugawara (Chuo Univ.),
Y. Maeda (JAXA), Y. Tsuboi (Chuo Univ.),
K. Hamaguchi (NASA/GSFC and UMBC)
With Suzaku WR140 team

Colliding wind binary (CWB)

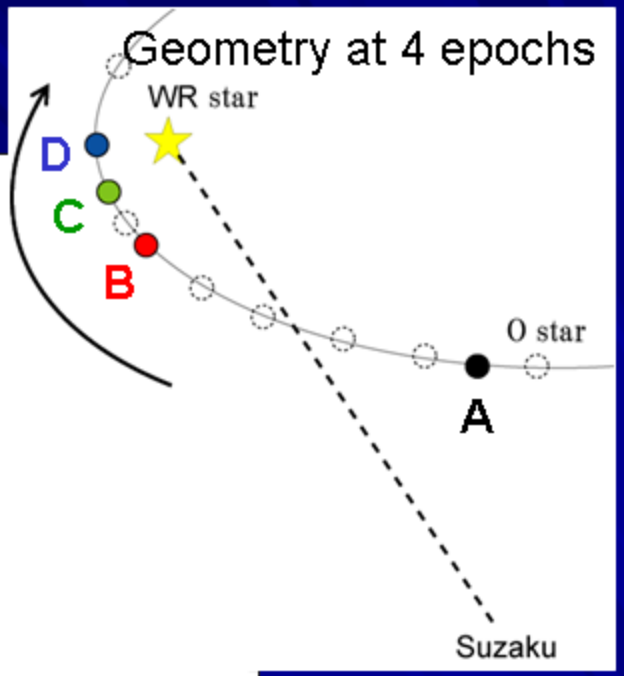
- Periastron passage of eccentric CWB
  => rapid variation of physical parameters
  => good testing site of Shock physics

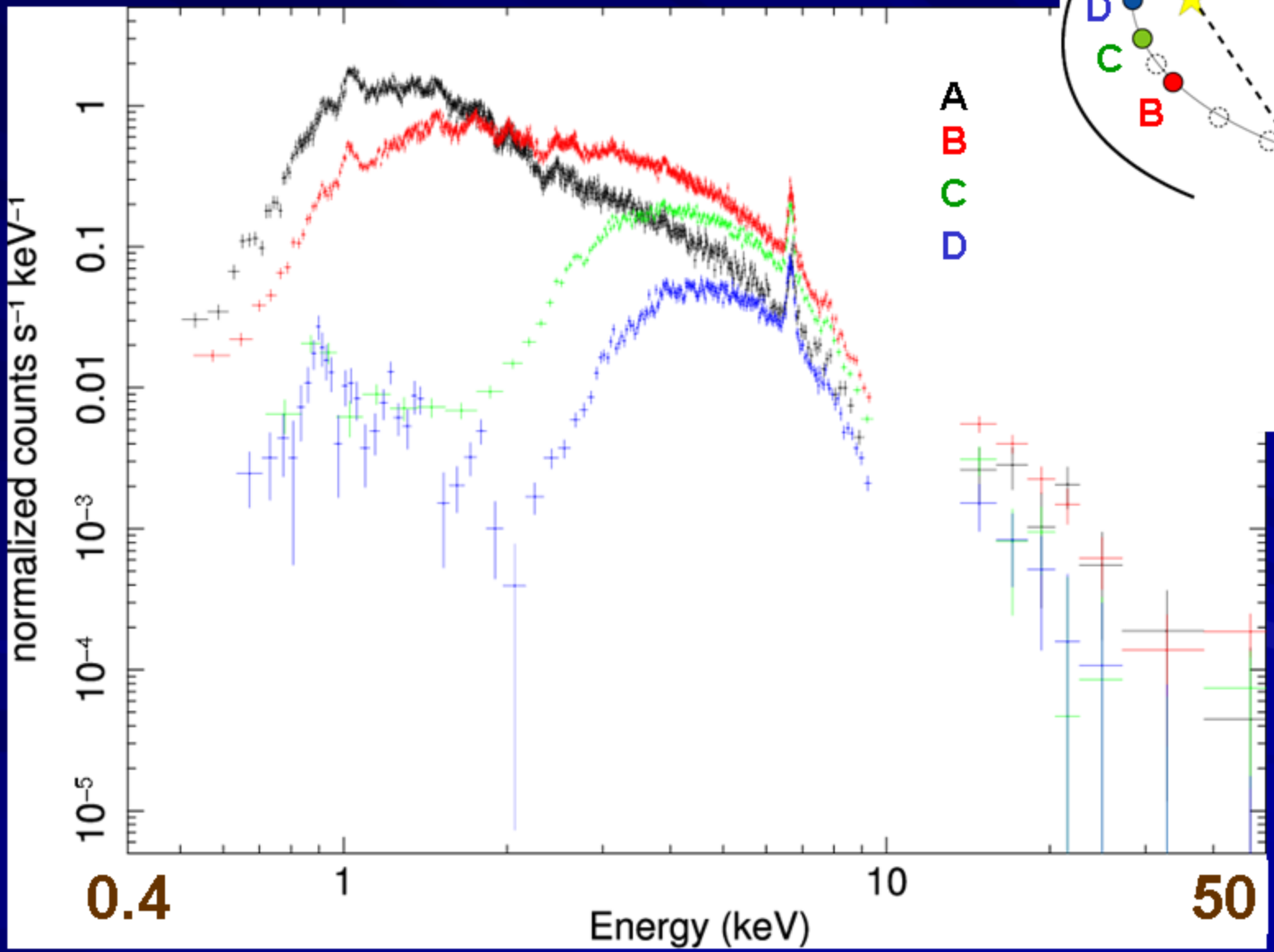


- WR140
  - WC7+O5I
  - Lx~10^{34} erg/s
  - long-period (P =7.94 yr)
  - extremely eccentric (e=0.881)

Suzaku 2009 campaign of WR140

- Total exp.T ~ 210 ksec

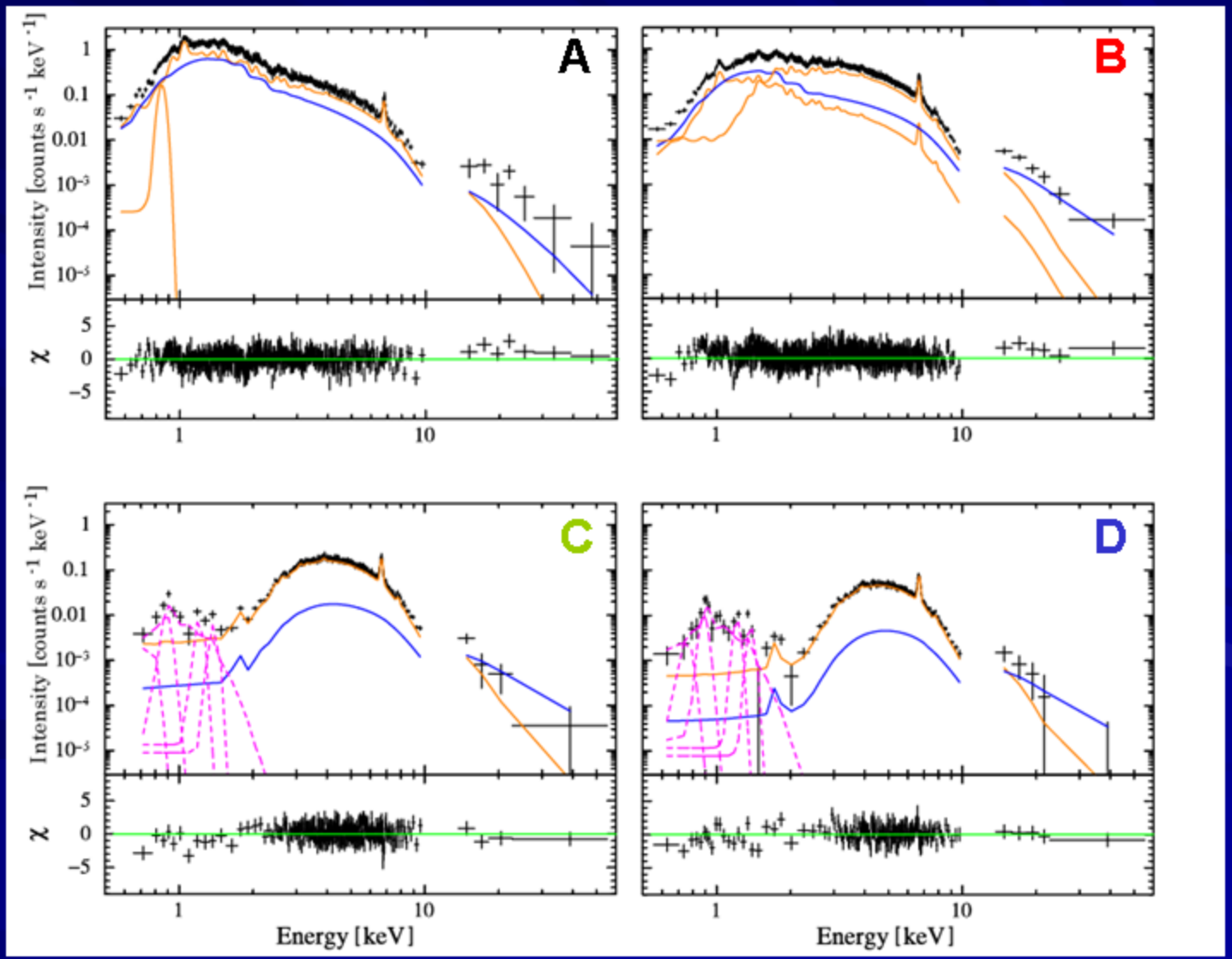




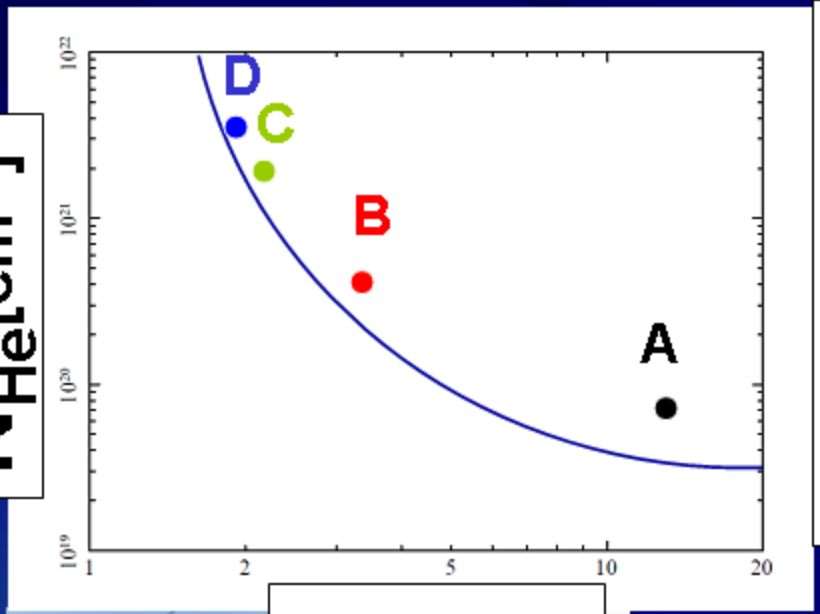
Results1: Spectrum fitting

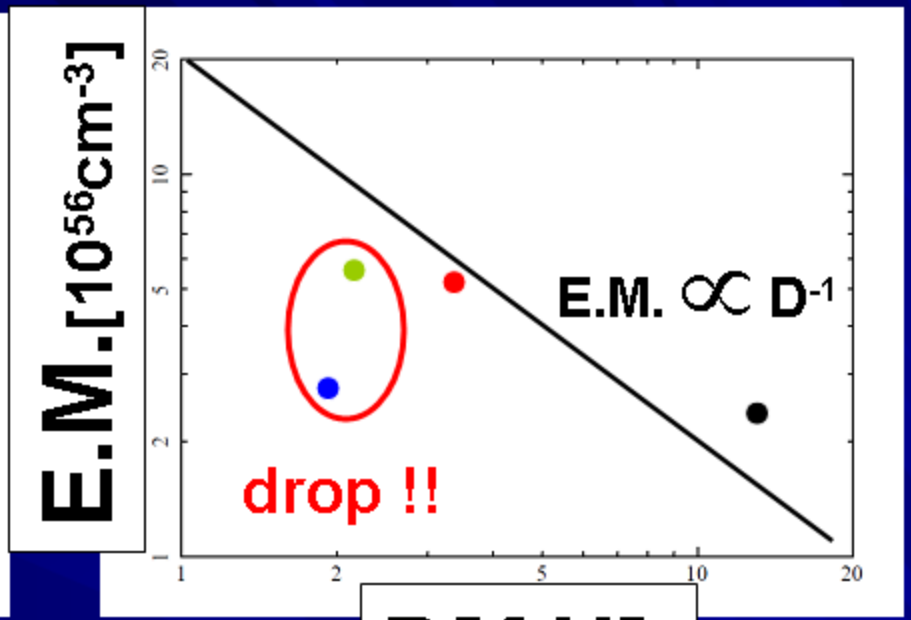
Thermal1 (stationary) + Thermal2(variable) + powerlaw(variable)

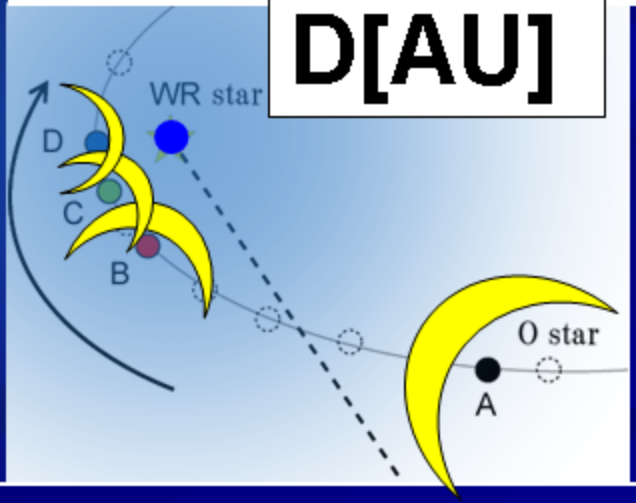
(kT~0.1keV) (kT~3 keV)



Results2: Abs. & E.M. variation







The theory of colliding wind

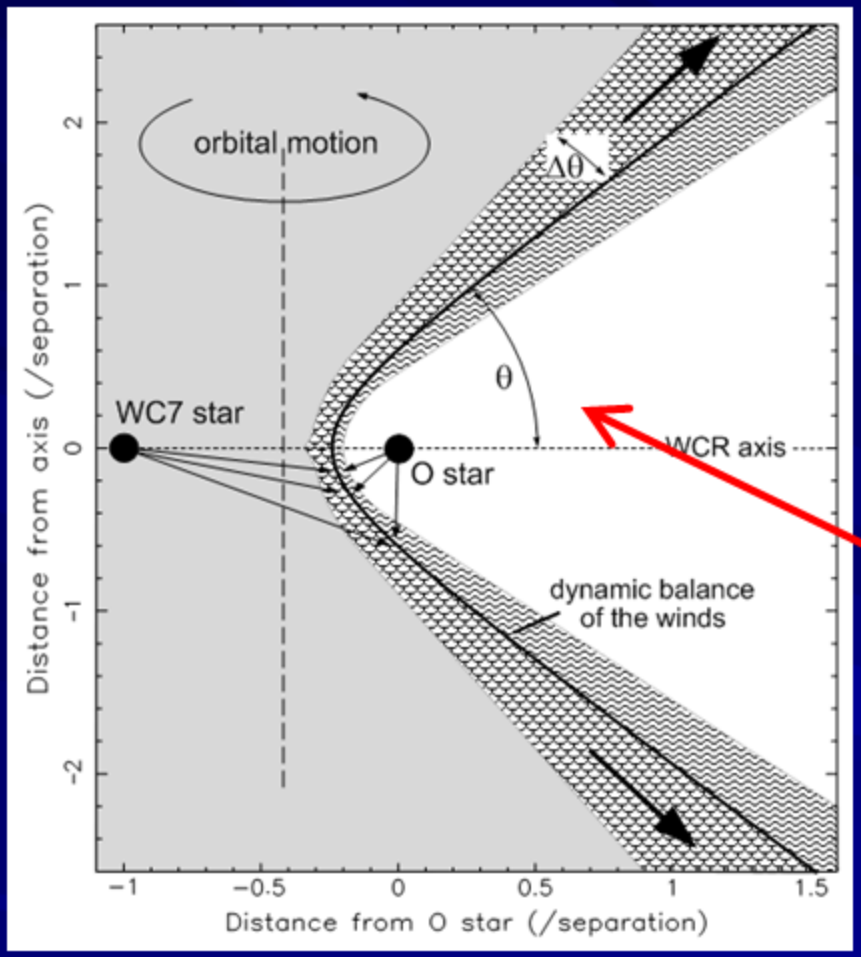
E.M. ≡ $n^2 \times V$

$(D^{-2})^2 \times D^3 = D^{-1}$

self-absorption of the WR wind

Why E.M. ∝ D^{-}

Possible contribution: Opening angle



(Williams+ 2009)

$v_o = v_\infty (1 - r_o/r)^\beta$

$< v_\infty$

$v_o \sim 0.6\ v_\infty$ (Williams+ 2009)

$$\eta = \frac{\dot{M}_O v_O}{\dot{M}_{WR} v_{WR}}$$

(Hill+ 2002)

$$\theta(\mathrm{deg}) = 120\left(1 - \frac{1}{4}\eta^{2/5}\right)\eta^{1/3}$$

=> $\theta = 0.85\ \theta(v_\infty)$ at periastron

=> E.M. $\propto D^{-1}\ \theta^2$

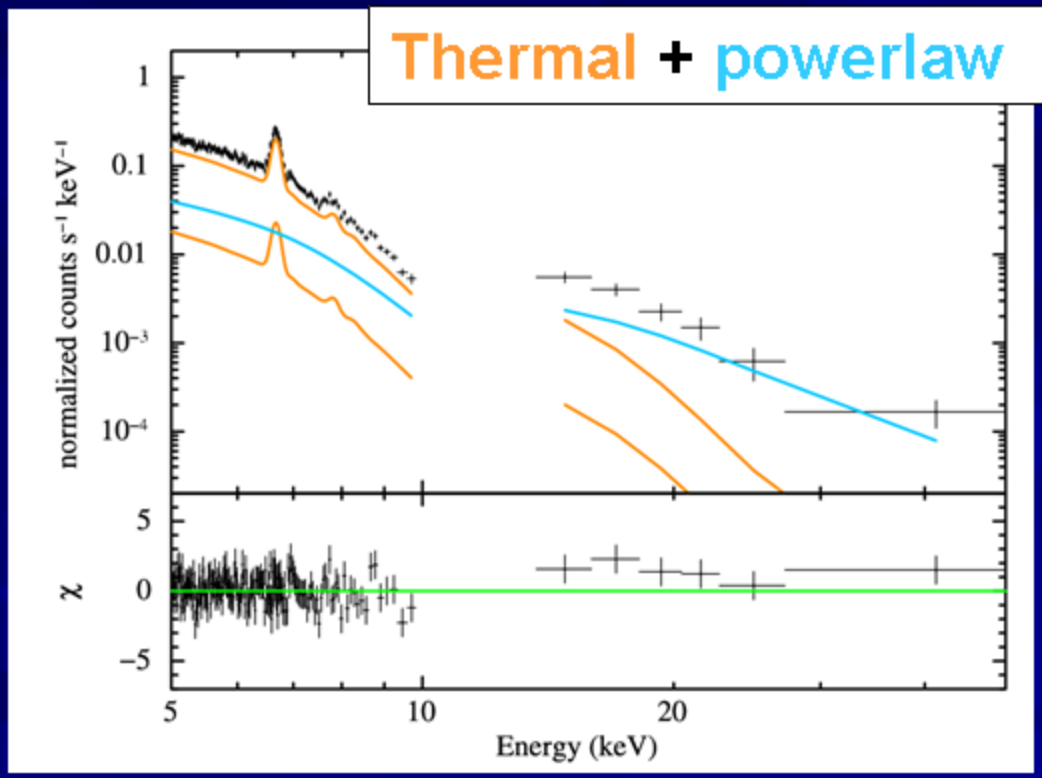
$= 0.7 \times$ E.M. (v_∞)

at epoch D

A part of the E.M. drop near the periastron can be explained with the small cone angle.

Results3:Hard tail

The first hard-tail for WR binary !!
The second hard-tail for CWB (after Eta Car.)



In epoch B
$\Gamma = 2.1$ (+/-0.1)
=> superhot comp.
or inverse Compton ?

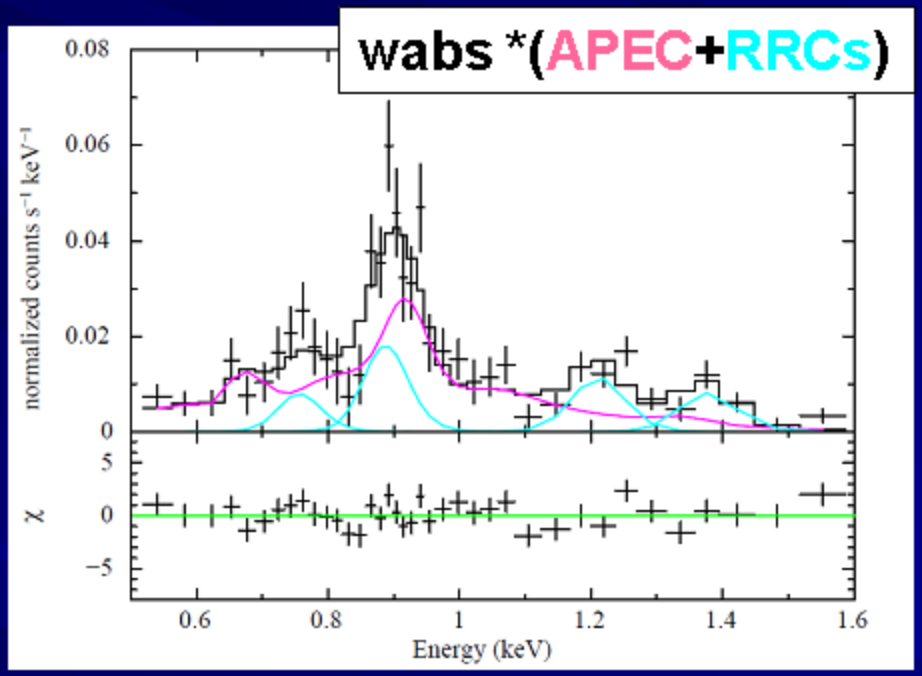
Flux **(10-50keV)**
~ $1.3e^{-11}$ (erg/s/cm^2)
=> F_{hard} / $F_{thermal}$
~ 2.5 (> Eta Car.)

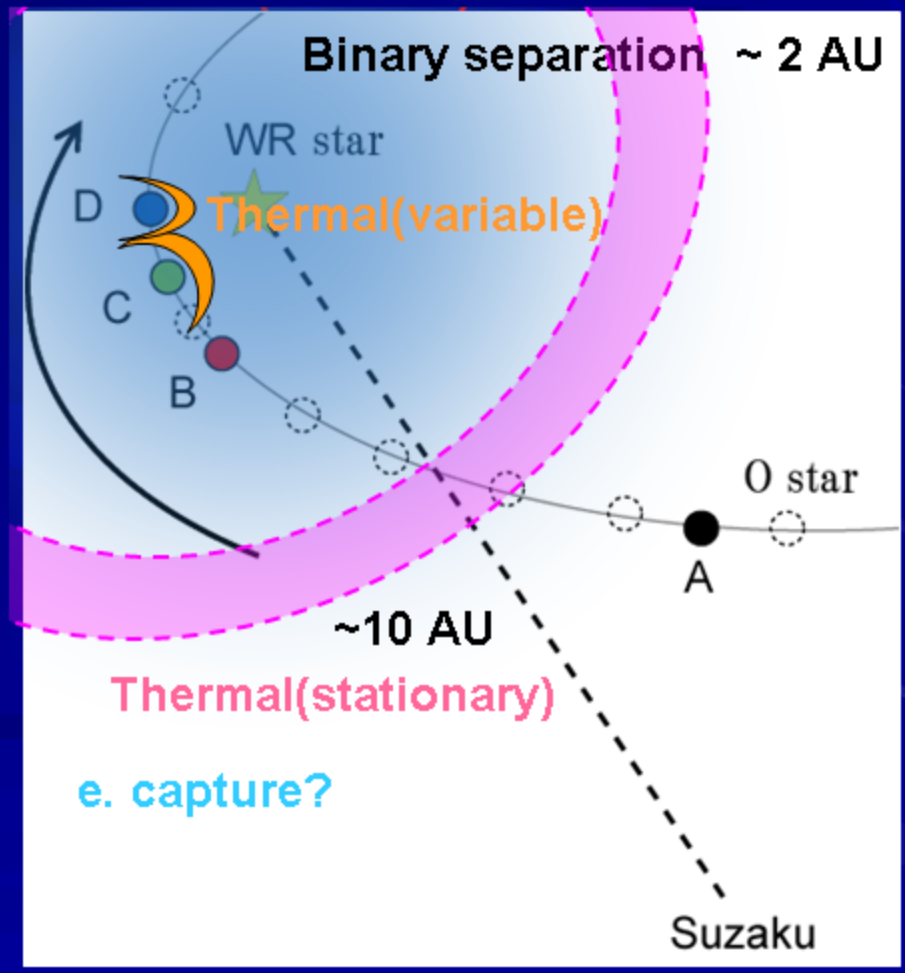
Results4: Stationary components

In epoch C & D

$N_H \sim 8.8e^{21}$ cm^{-2}

$kT \sim 0.1$keV, $kT_{RRC} < 0.02$ keV





Brand-new component of WR binary

Summary

Unexpected E.M. variation (NEW!!)

Hard-tail comp. (NEW!!)

Stationaly thermal comp. (NEW!!)