Vela X-1 and sgHMXB: hydro driven hard X-rays

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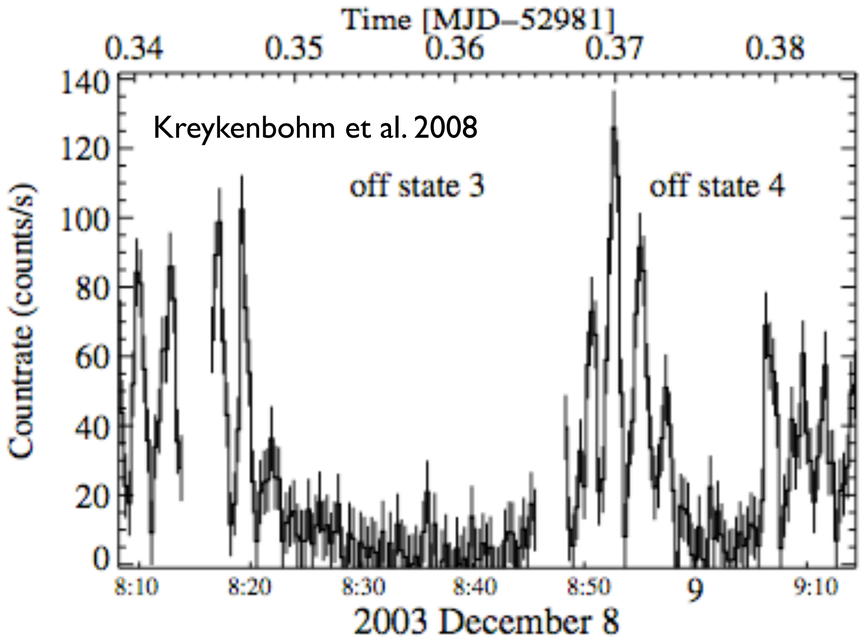
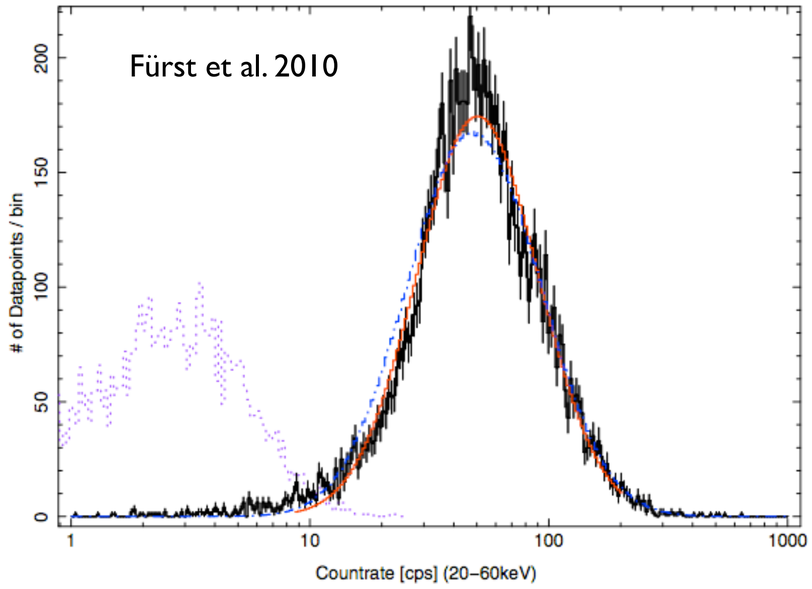
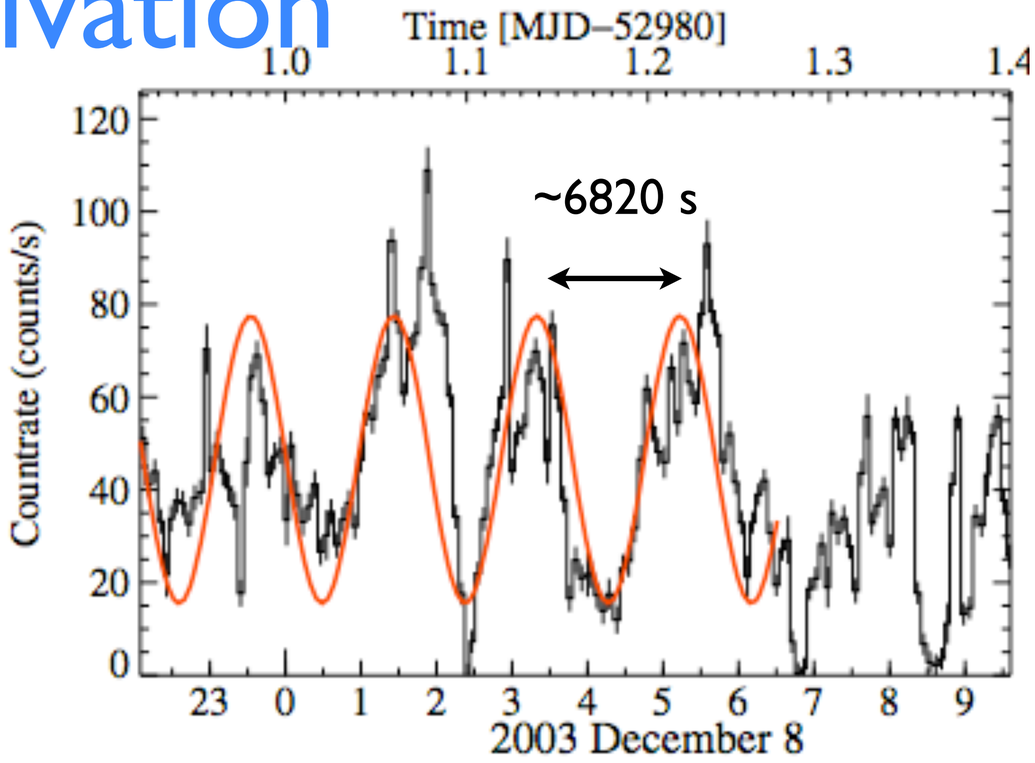
Motivation



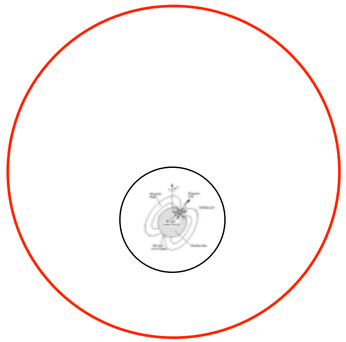




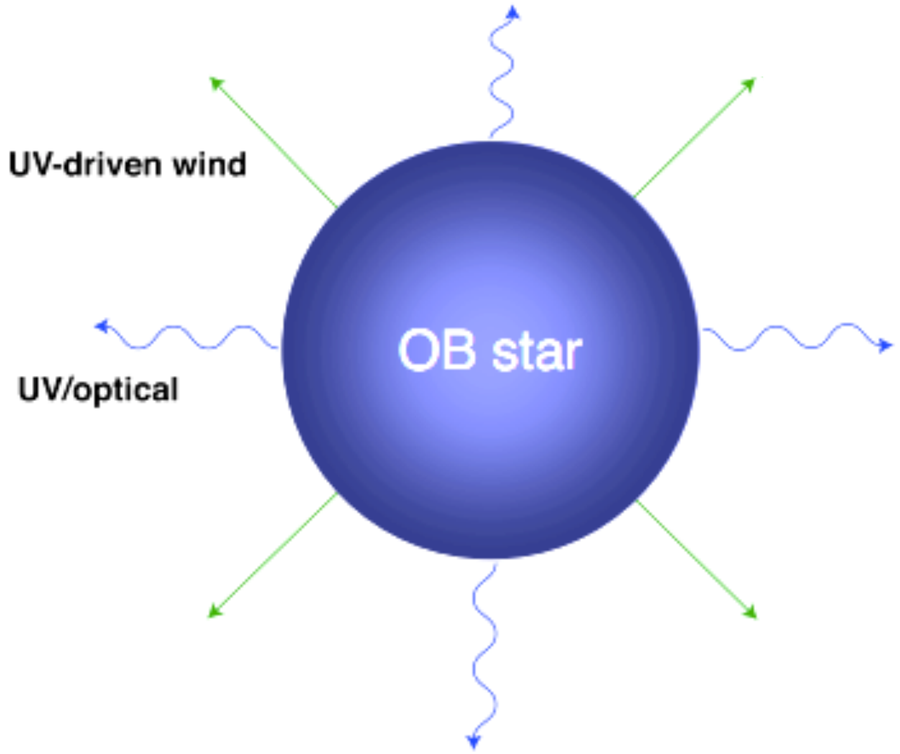
- Variability
- off states
- pseudo-period of ~7000 sec
- log normal flux distribution

Can this be understood ?

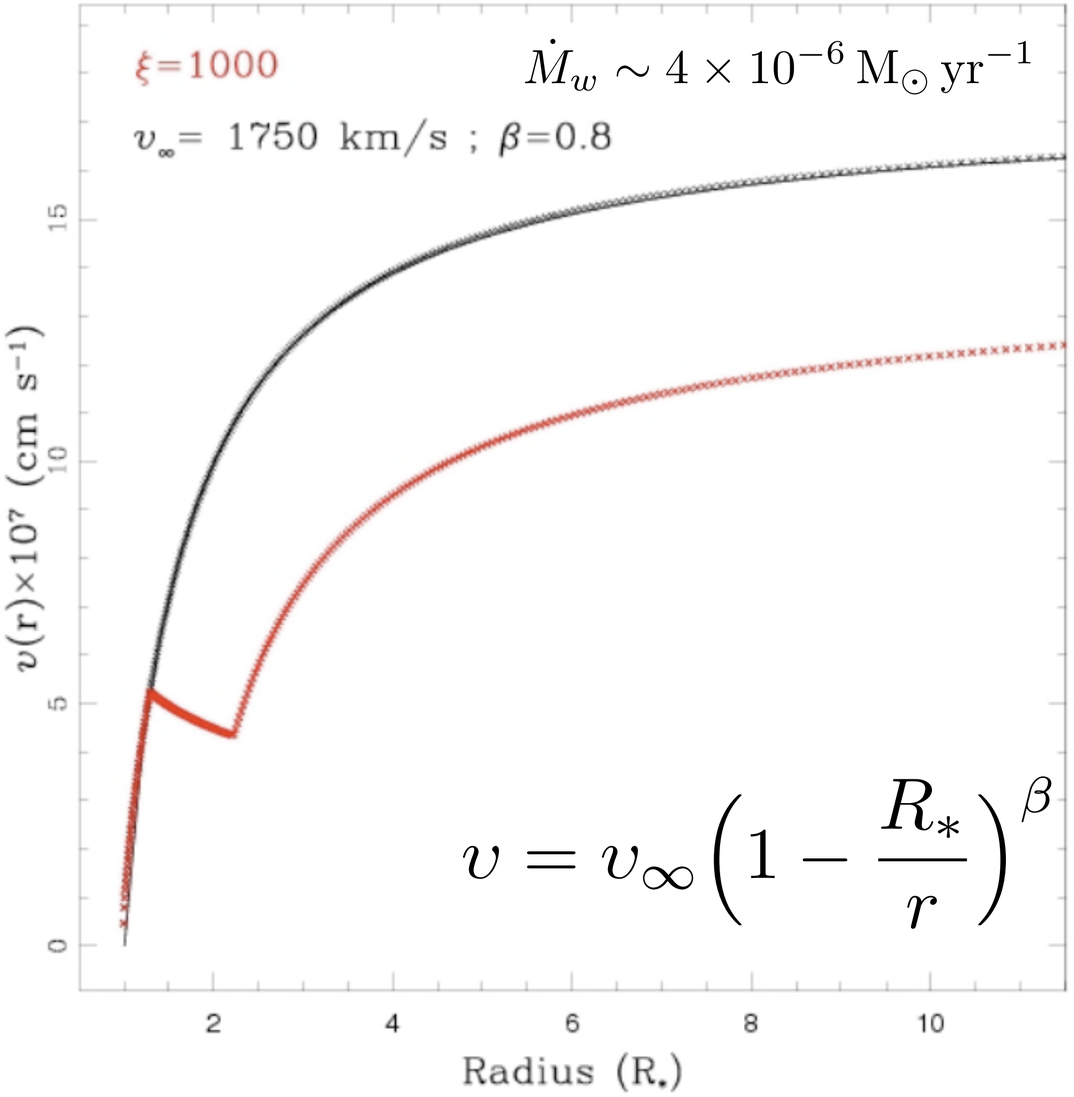
Stellar Winds + X-ray source



$L_X \sim 4 \times 10^{36}\,\mathrm{erg\,s^{-1}}$



Castor, Abbot and Klein (1975): CAK



$$v = v_\infty \left(1 - \frac{R_*}{r}\right)^\beta$$

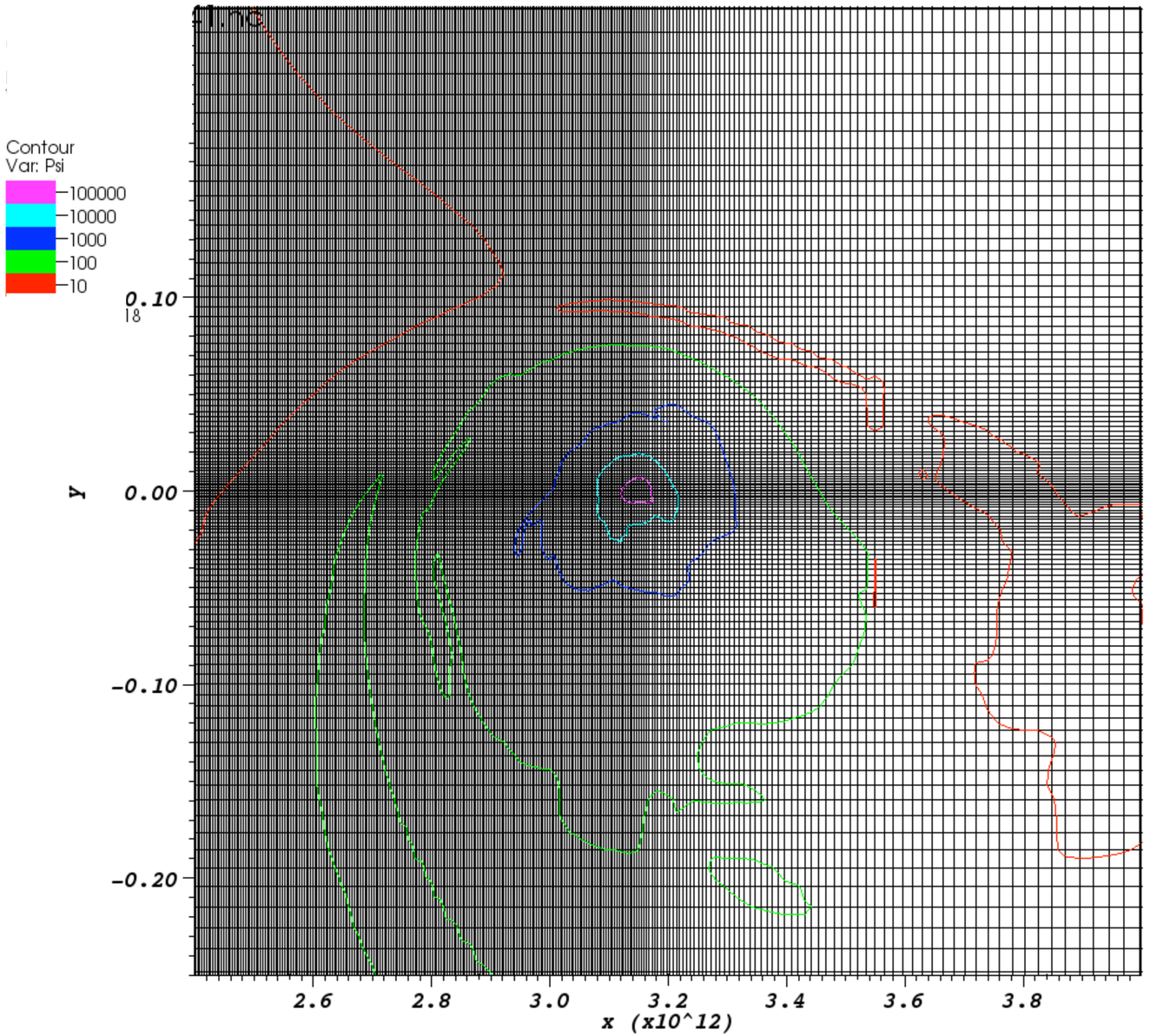
Hydrodynamics

- ☑ Use of VH1 (developed by J. Blondin at NCSU)
- ☑ Radiatively driven stellar winds (CAK)
- ☑ Photoionization
- ☑ Tested on Vela X-1 and IGR J17252-3616

Parameters

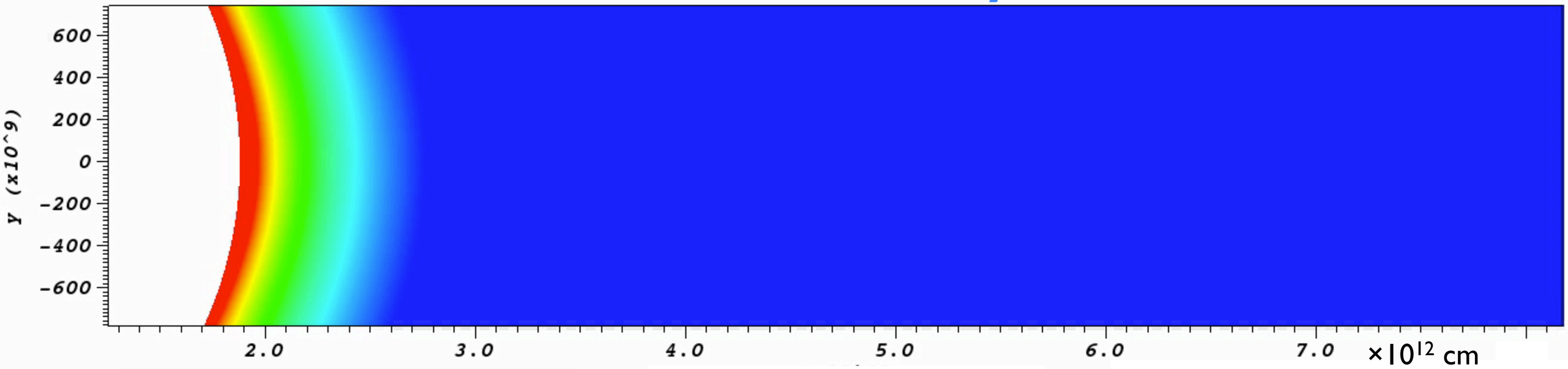
L_*, R_*, M_*, T_*	Derived from optical/IR
α	Orbital solution
ρ_0, CAK-α, CAK-k	Fixed from v_∞ and $\dot{M}_w$
ξ_{crit}	Photoionisation model
L_X	IGR/BAT/XMM obs.
M_{NS}	1.88 $M_\odot$

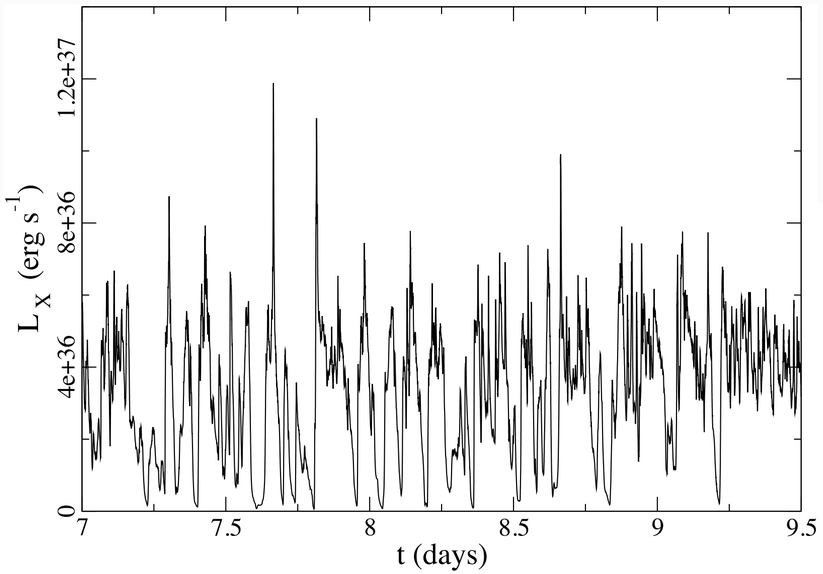
Resolution @ NS: $\sim 10^9\ cm$

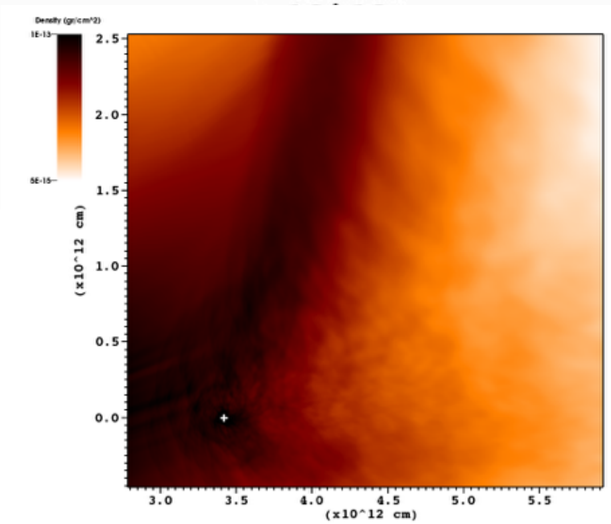


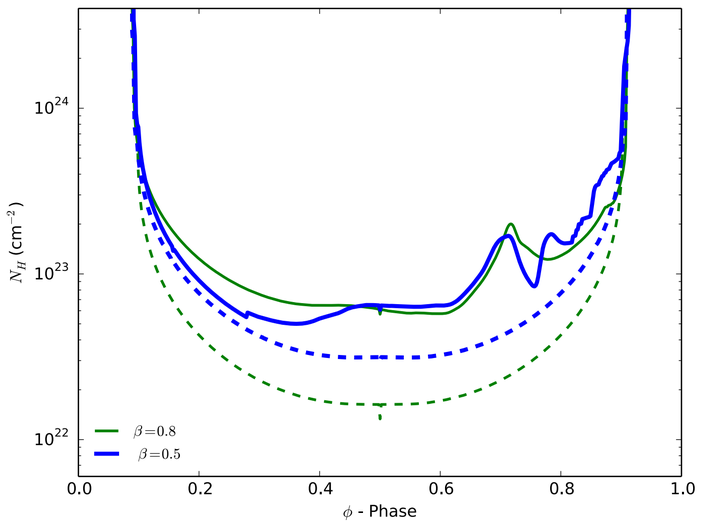
Manousakis & Walter A&A 2015, 575, 58 and A&A 2015, 584, 25

Stellar Winds + X-ray source

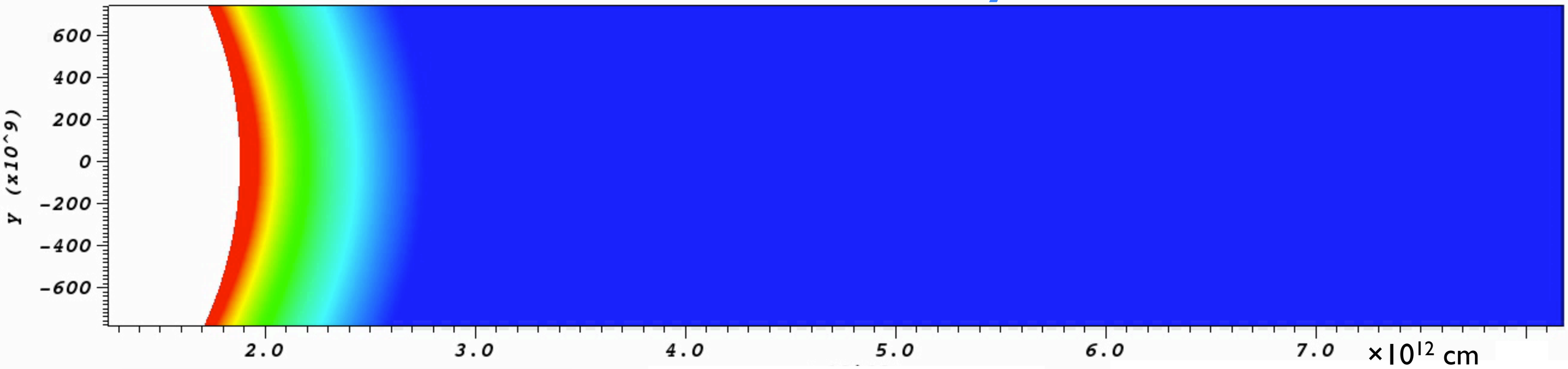


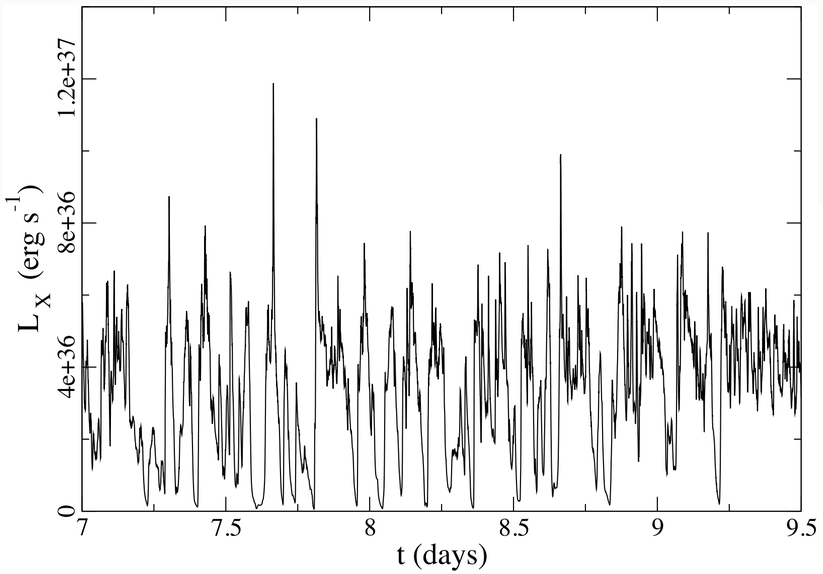


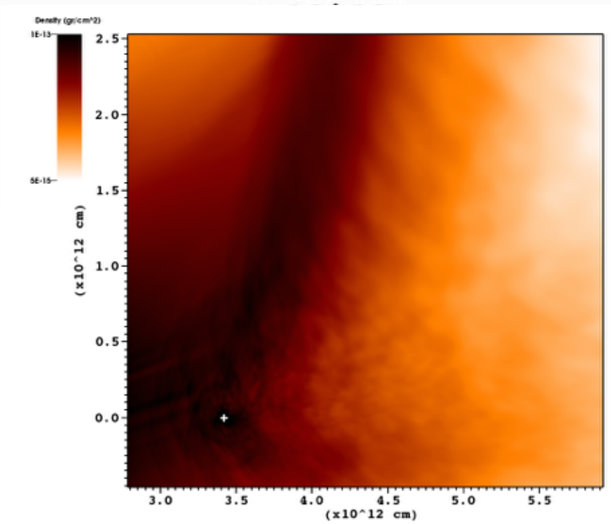


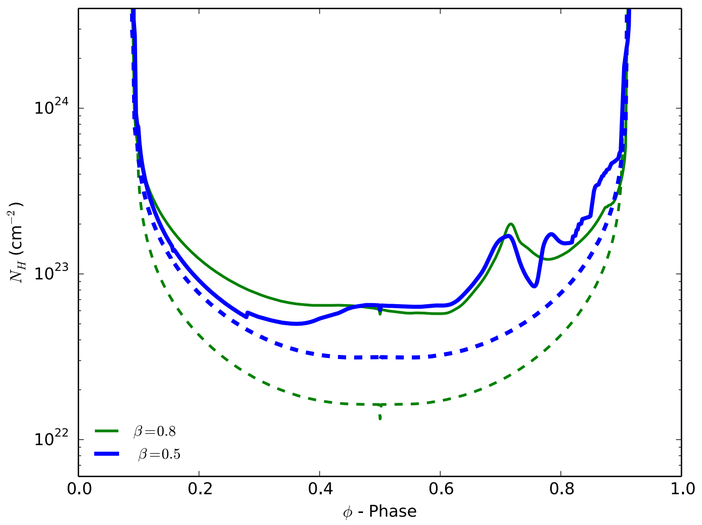


Stellar Winds + X-ray source

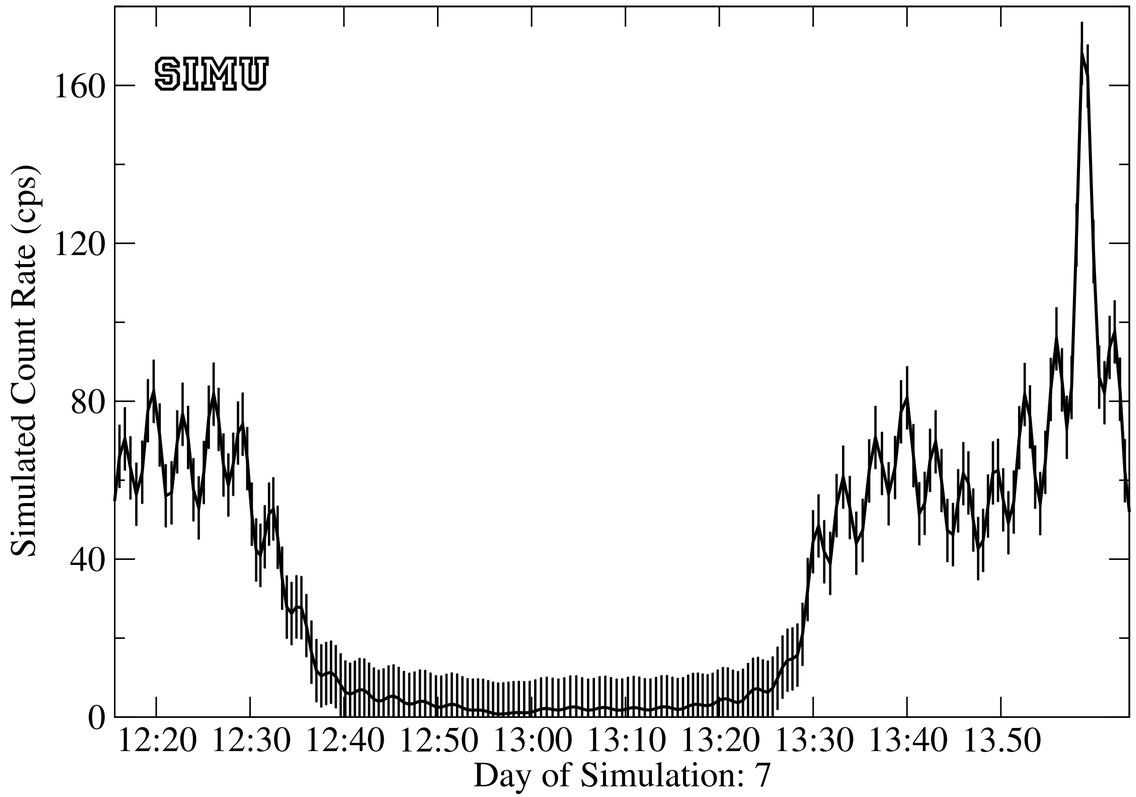








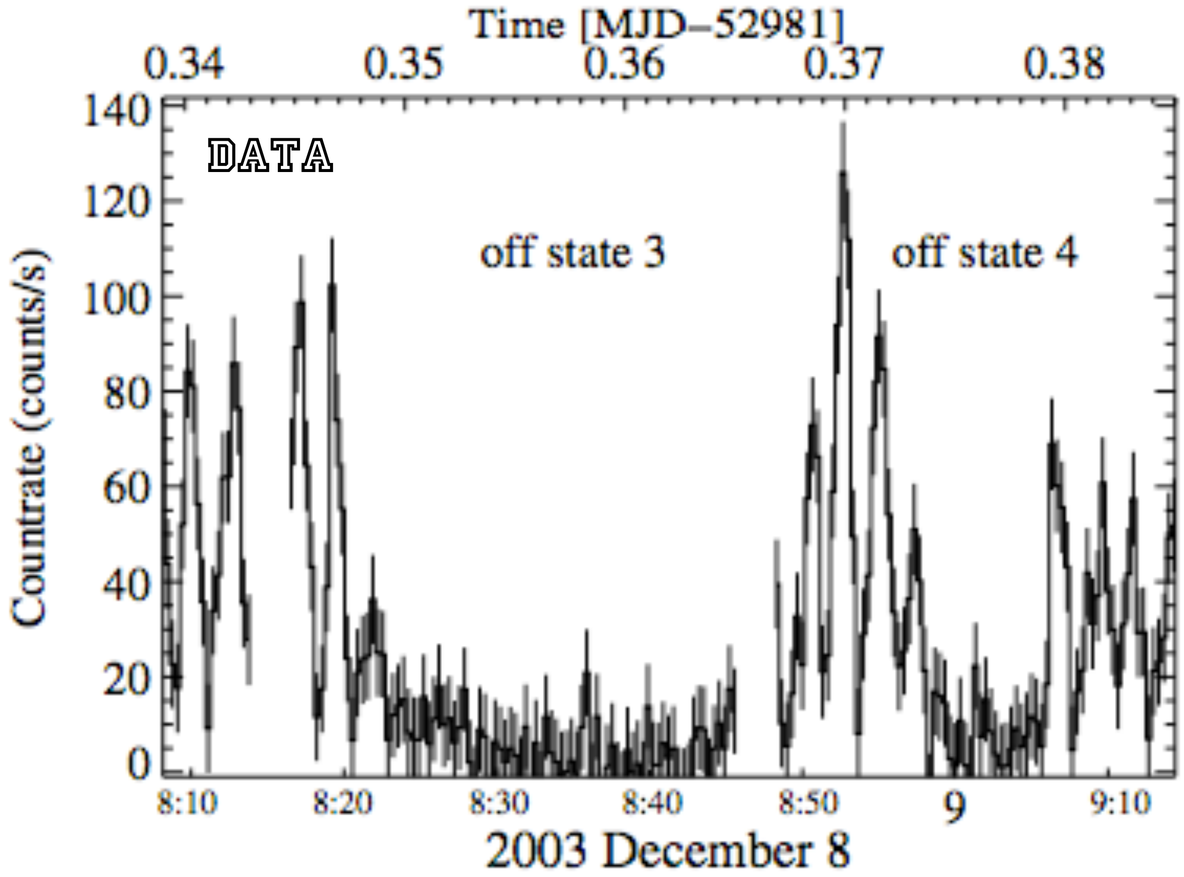
Off-states: cavities in the bow shock



~~Clumps~~

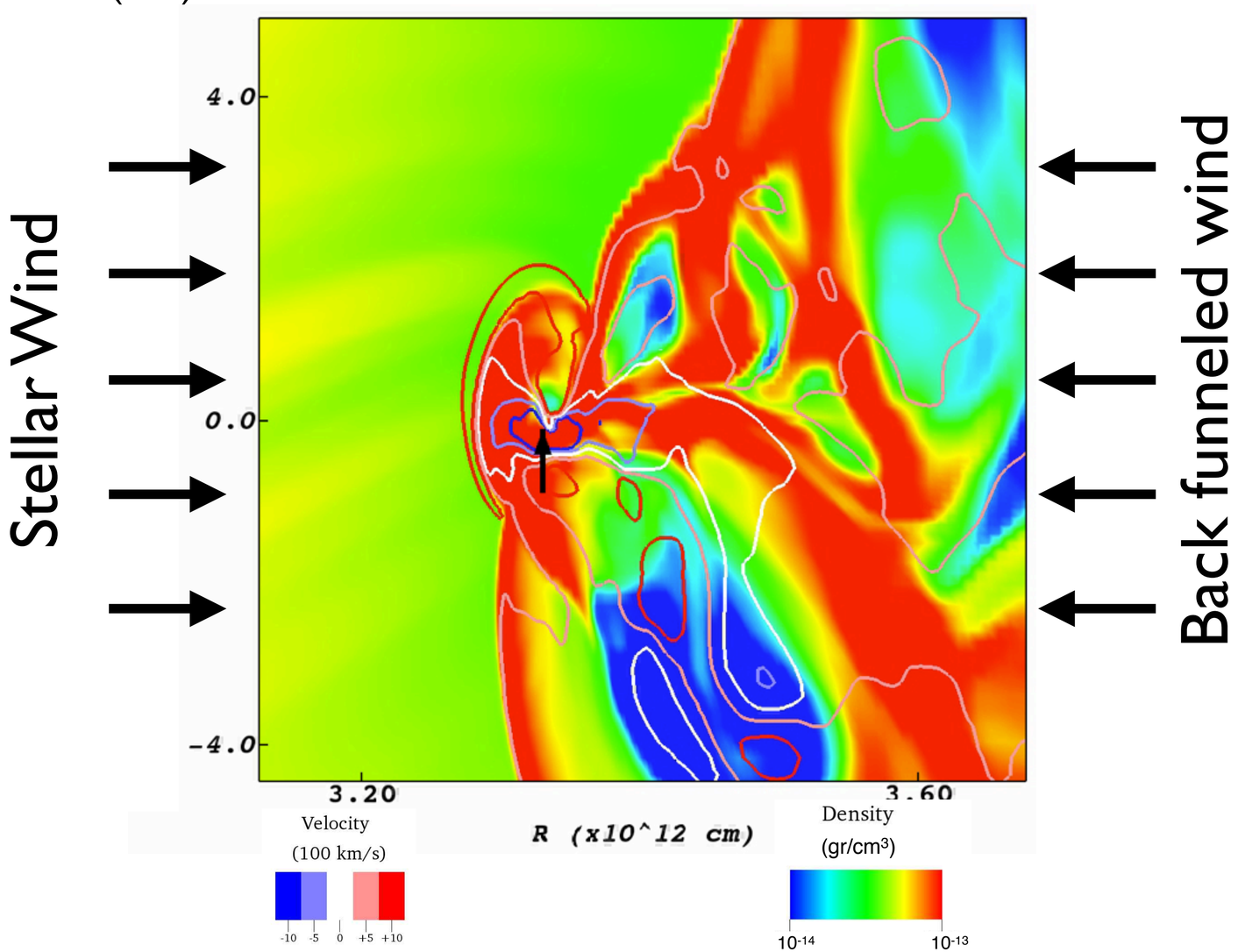
~~Propeller~~

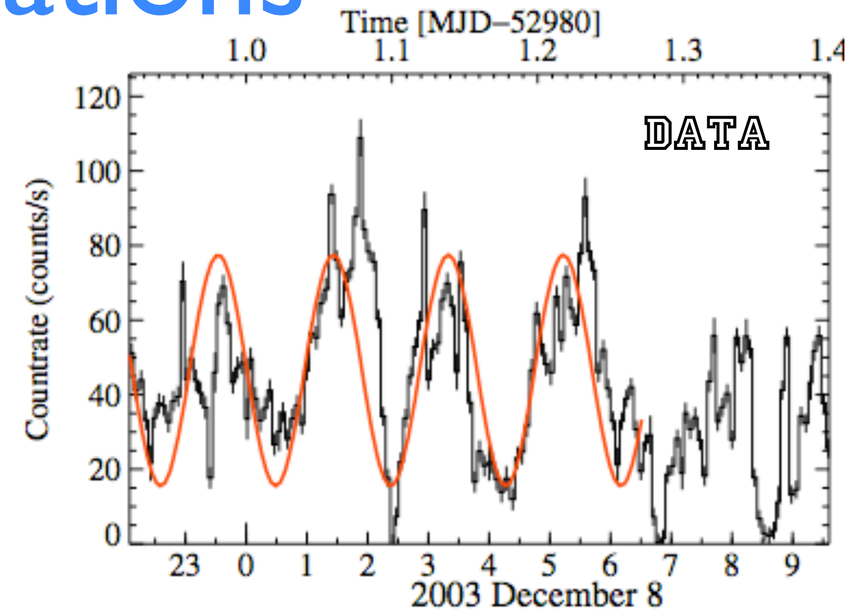
Off states as a consequence of hydrodynamics

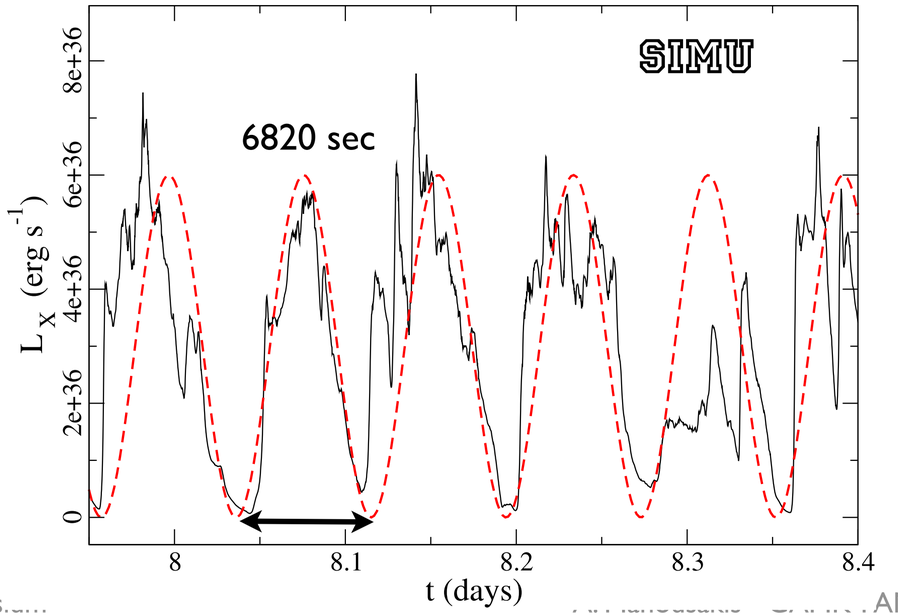


Bow shock oscillations

$t_{ff}(r_A) \sim 0.1$ s
$t_{ff}(r_{acc}) \sim 60$ s
$t_{ff}(R_{BS}) \sim 6000$ s







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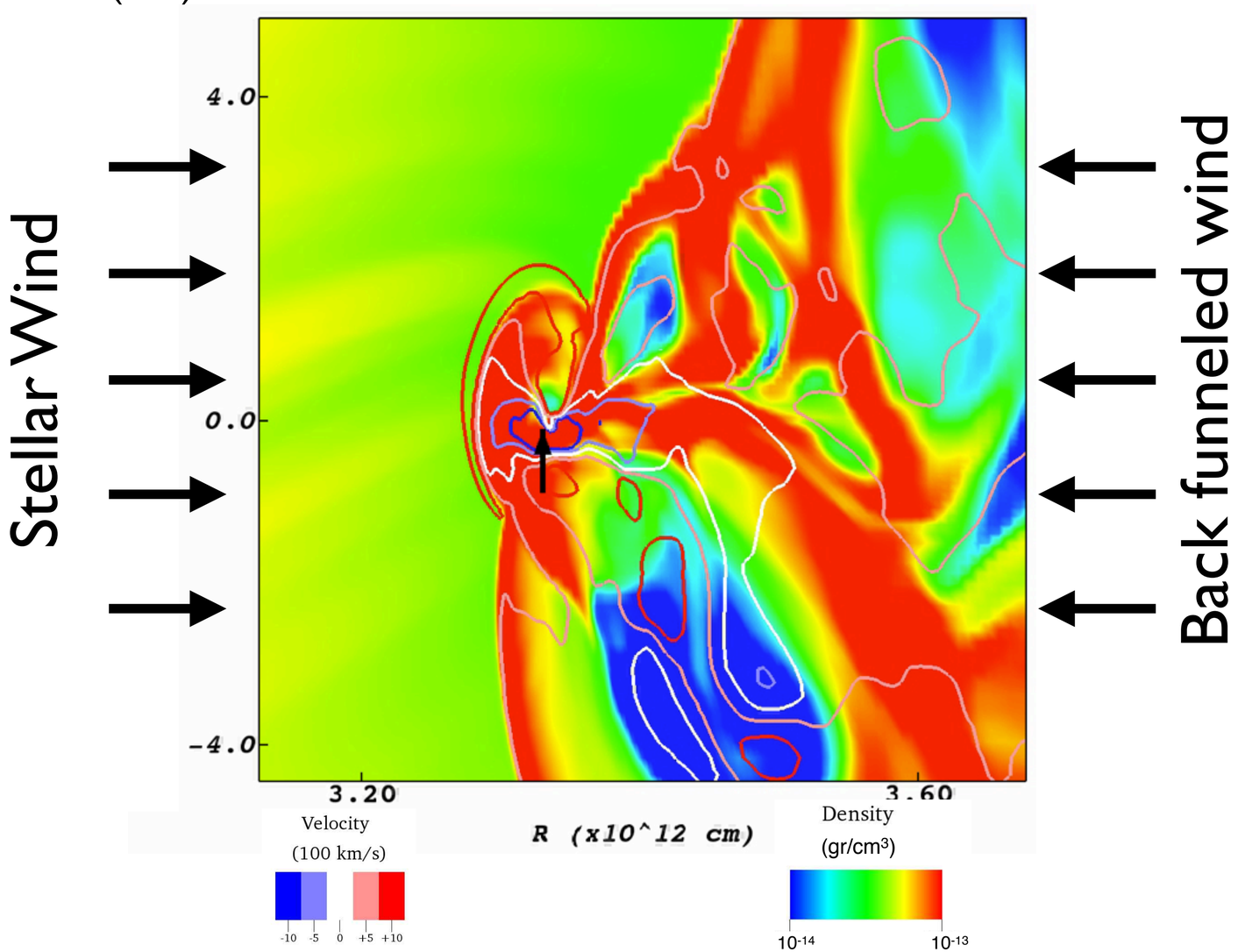
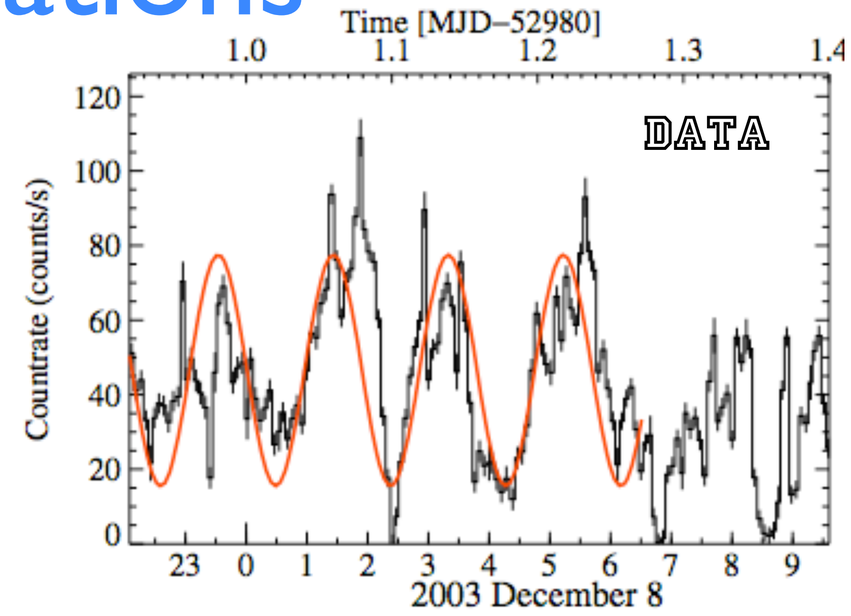
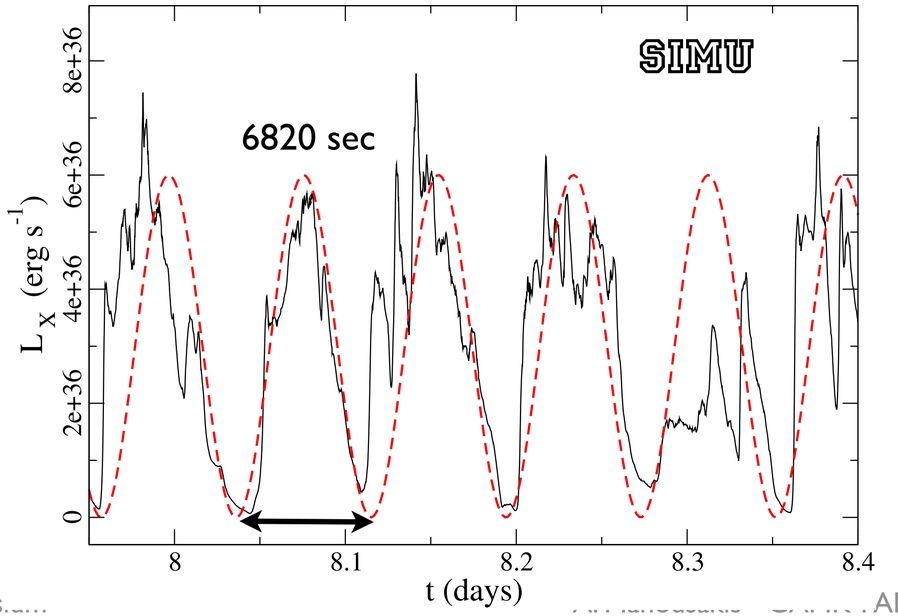
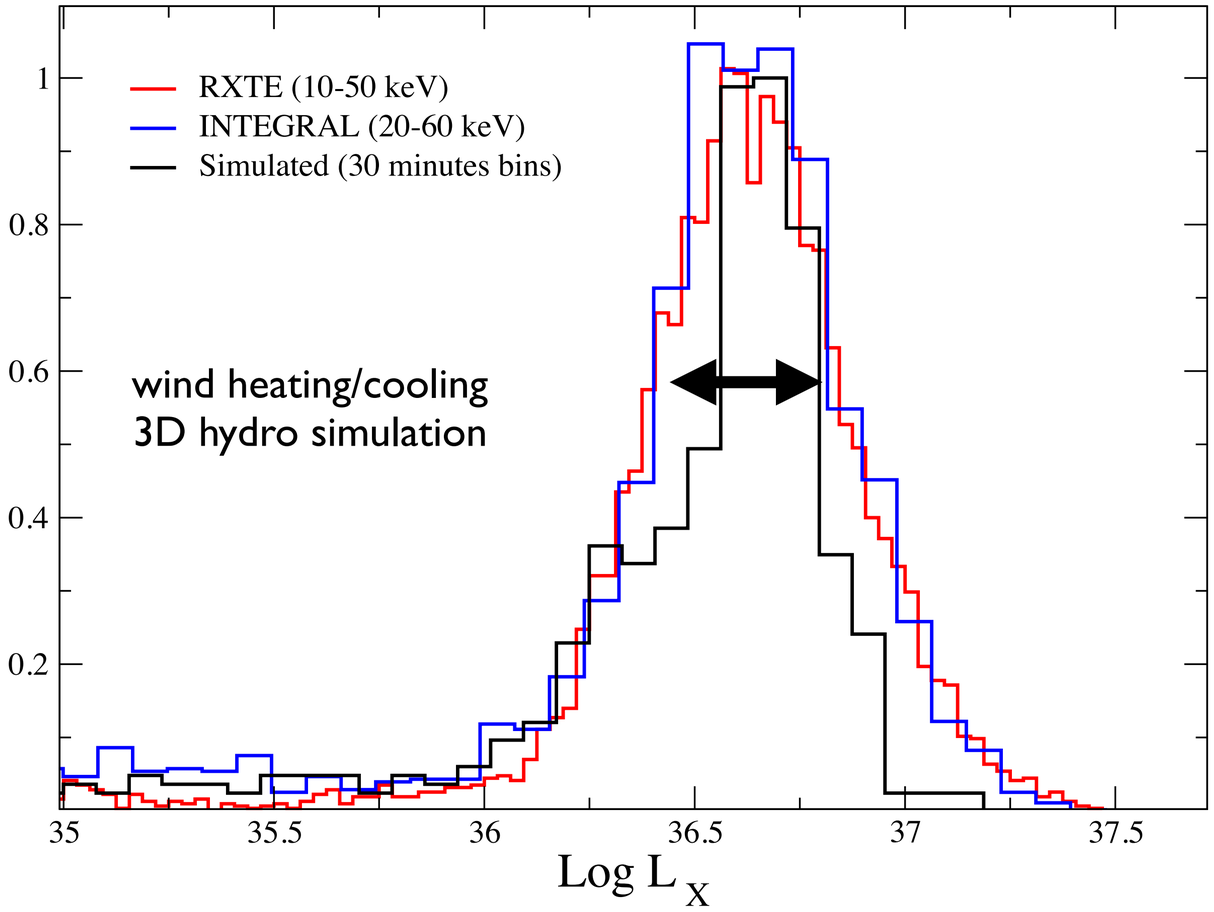






Variability: self-organized criticality



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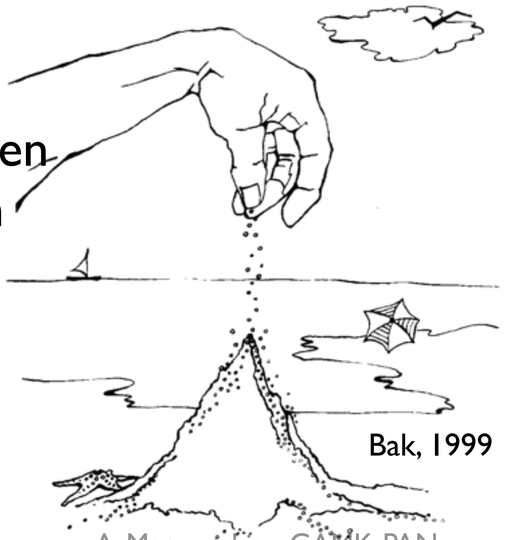
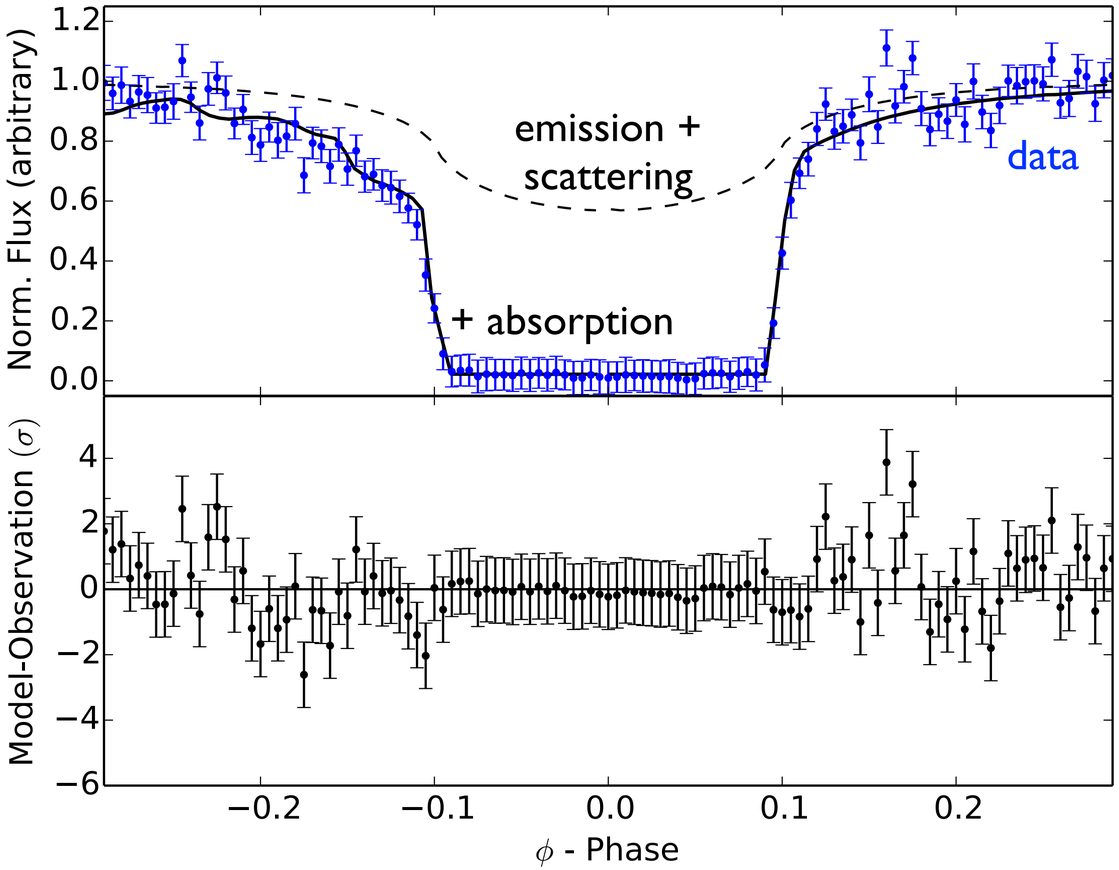
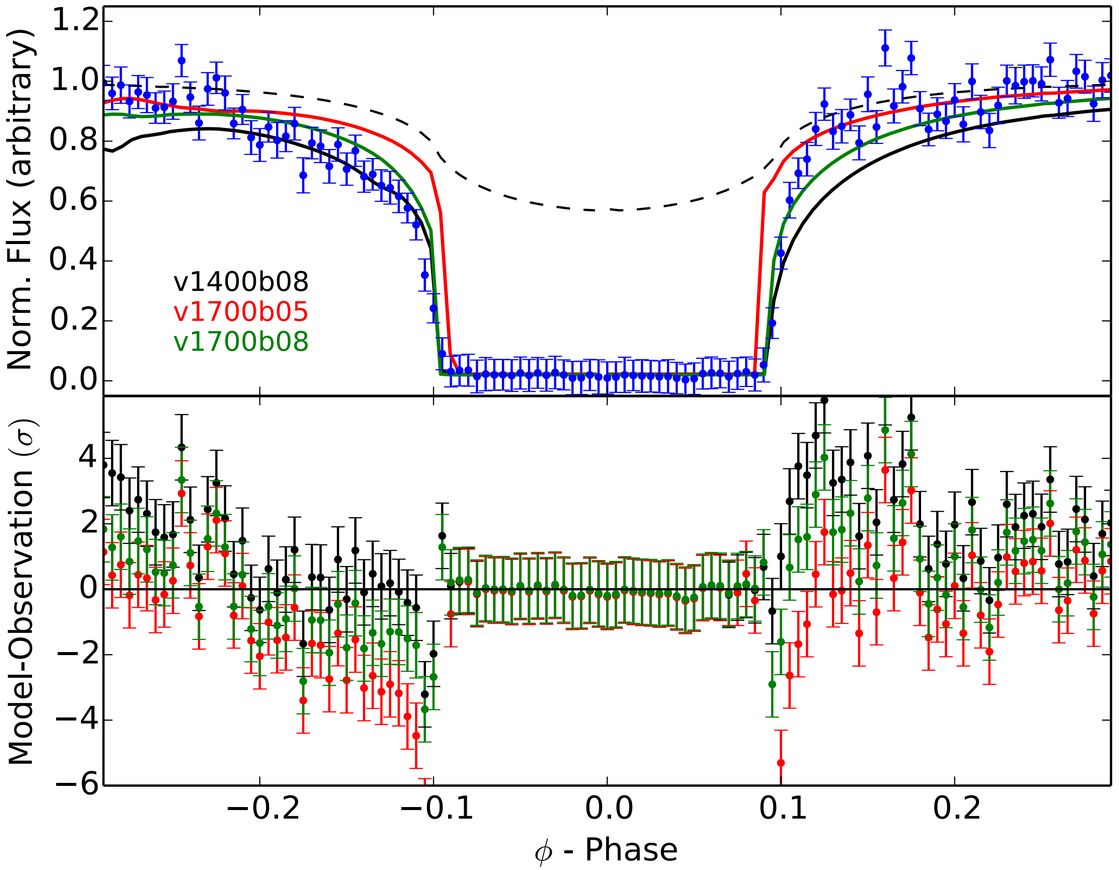
Log-normal distributions:

- income in Switzerland
- GRB peak fluence (Li,1996)
- Coronal Mass Ejection (Aoki, 2004)
- X-ray flux of IRAS 13244 (Gaskell, 2004)
- X-ray flux of Cyg X-1 (Uttley, 2005)
- X-ray flux of BL Lac (Marsher, 2008)
- X-ray flux of Vela X-1 (Fuerst, 2010)
- airborne bacteria density
- size of crystals in ice creams
- age of marriage of Danish women
- duration of phone conversation
- farm size in England
- age of Alzeimer onset



Inner stellar wind velocity field





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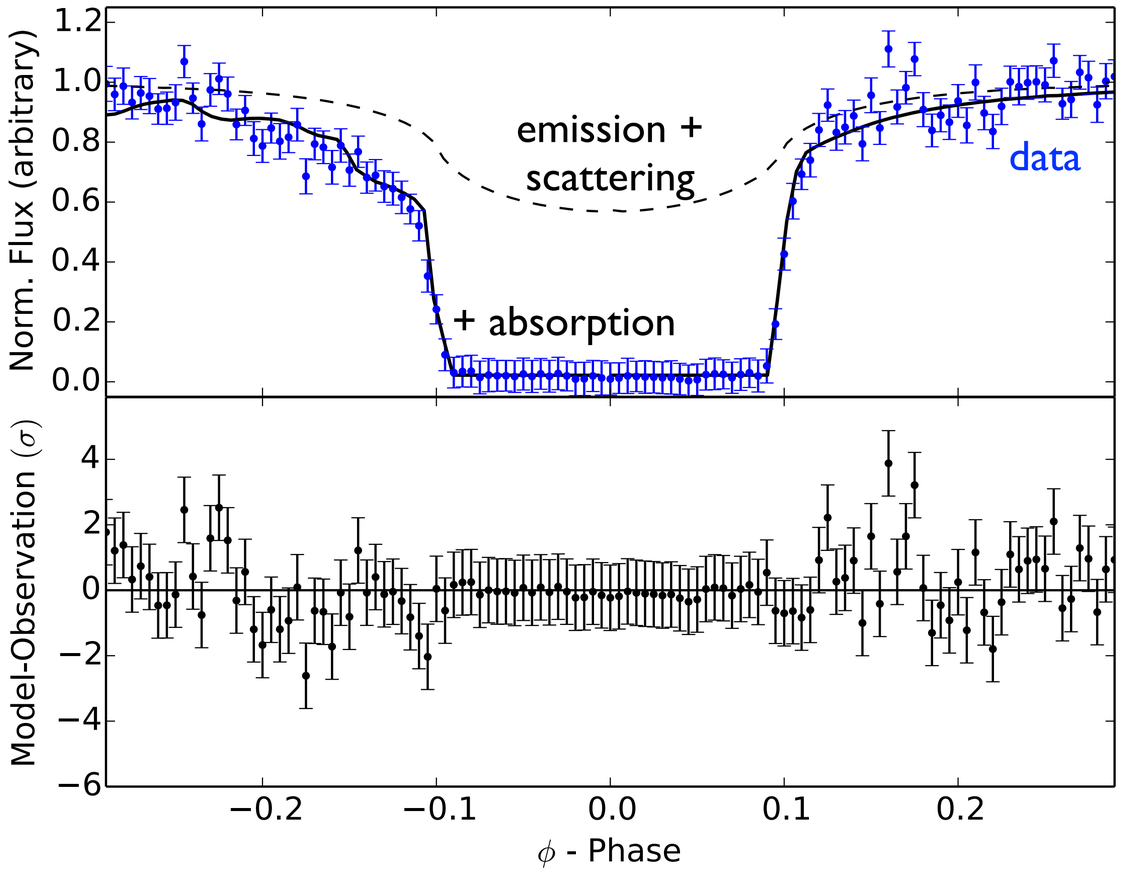
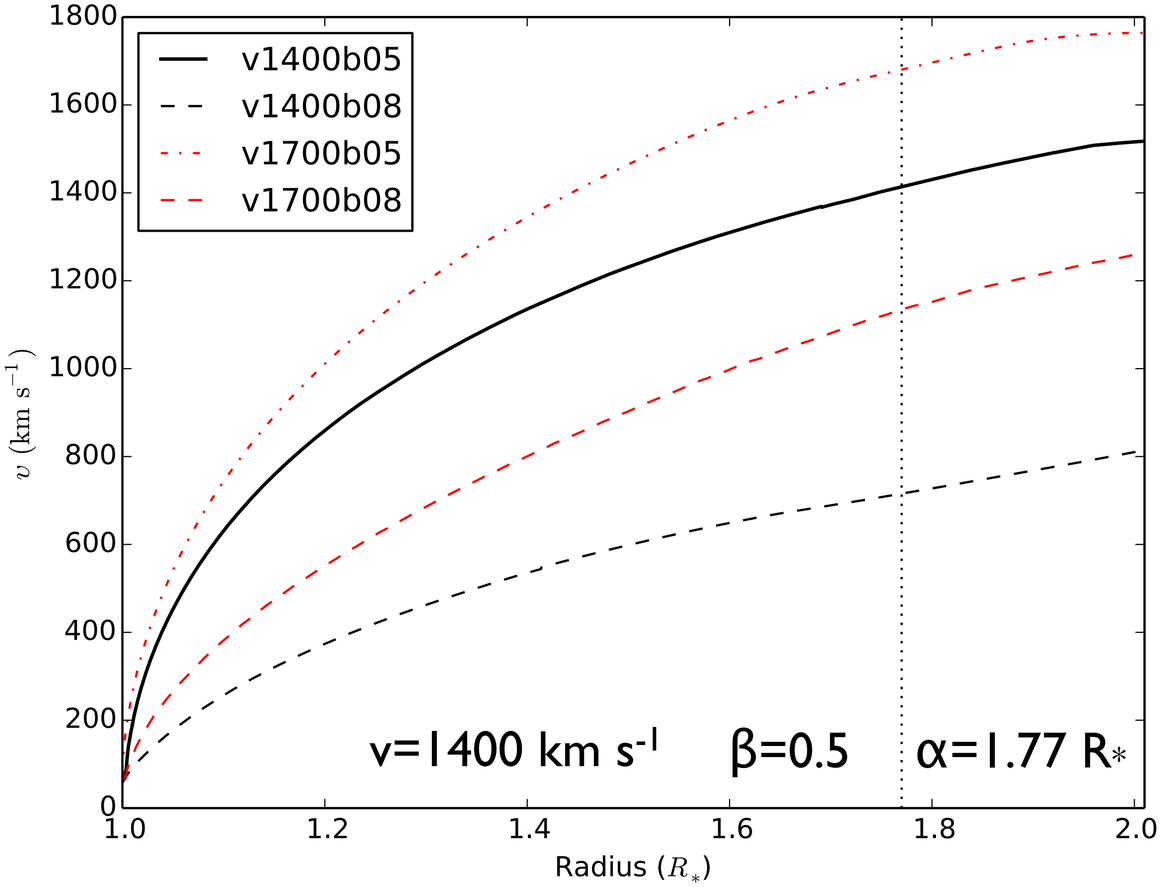




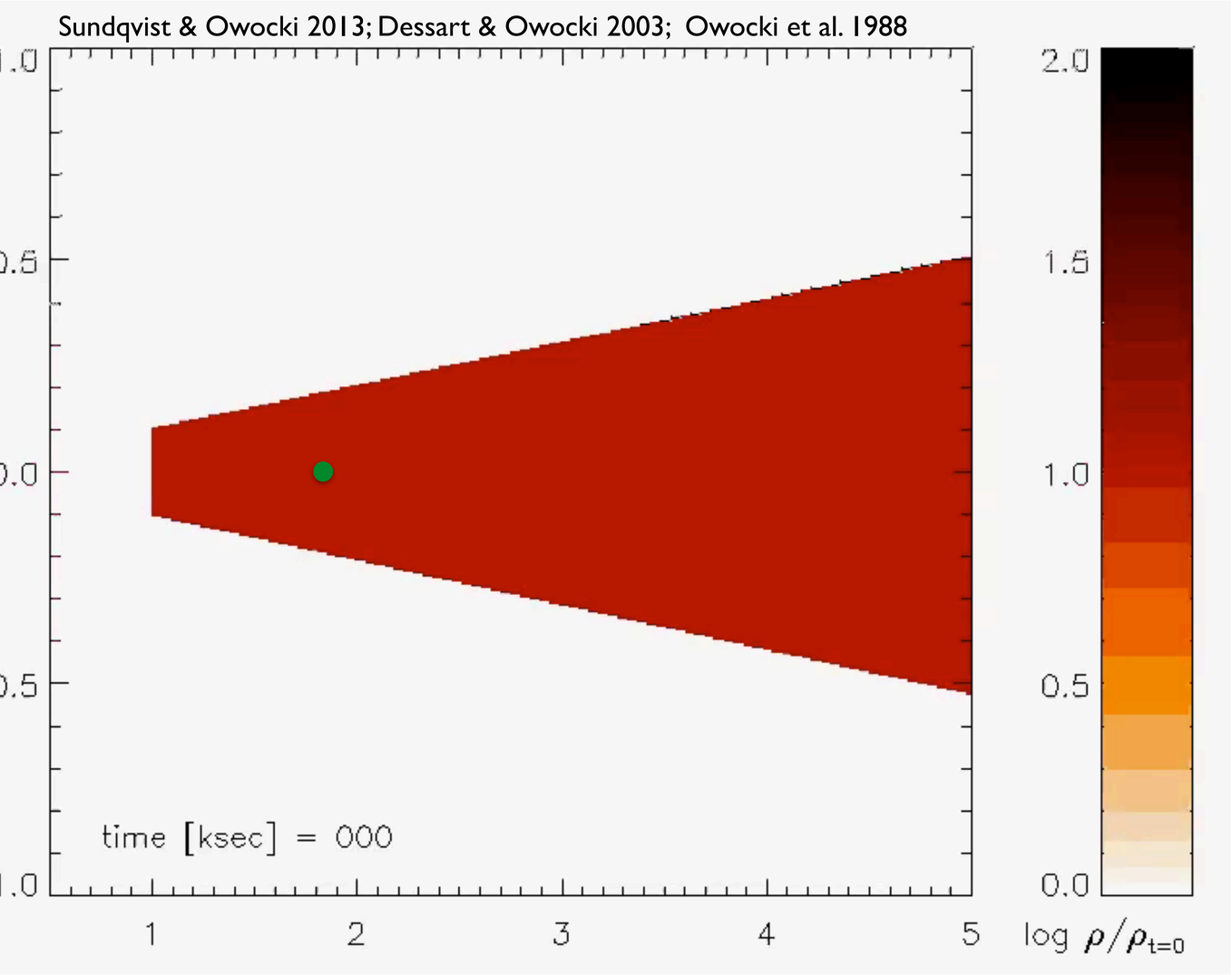
Conclusions

- Hydro simulations work well:
  - Variability
  - log-normal distribution of the accretion rates
  - off-states & flares
- Variability amplitude matches the observations
- Bow-shock variability time scales matches the observed oscillations
- A steep inner stellar wind velocity field is favored
- Future (work) realistic (physics) simulations (CPU time) are needed and coming out soon!!

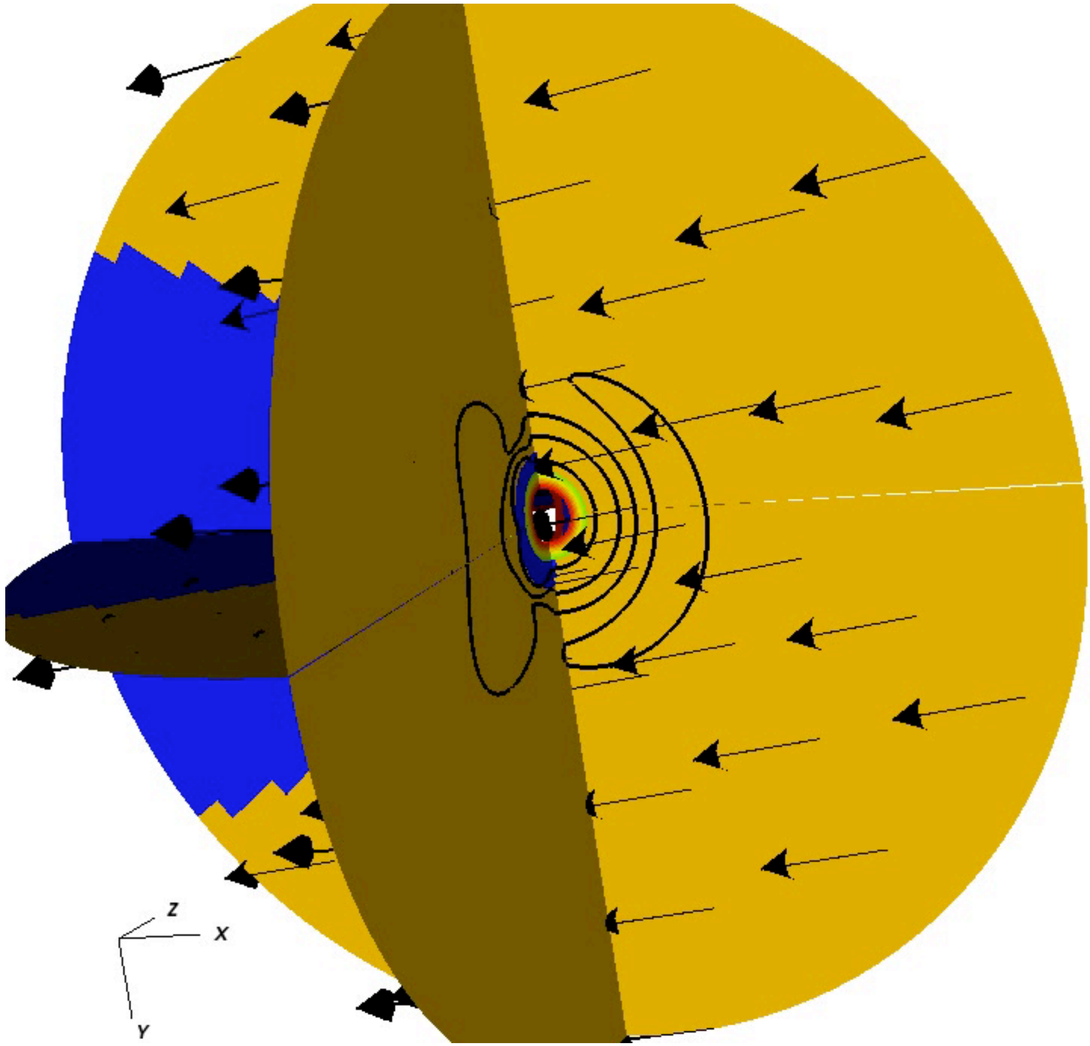
Future Perspectives

Realistic Stellar Wind with NS/BH

Sundqvist & Owocki 2013; Dessart & Owocki 2003; Owocki et al. 1988



Gating mechanisms



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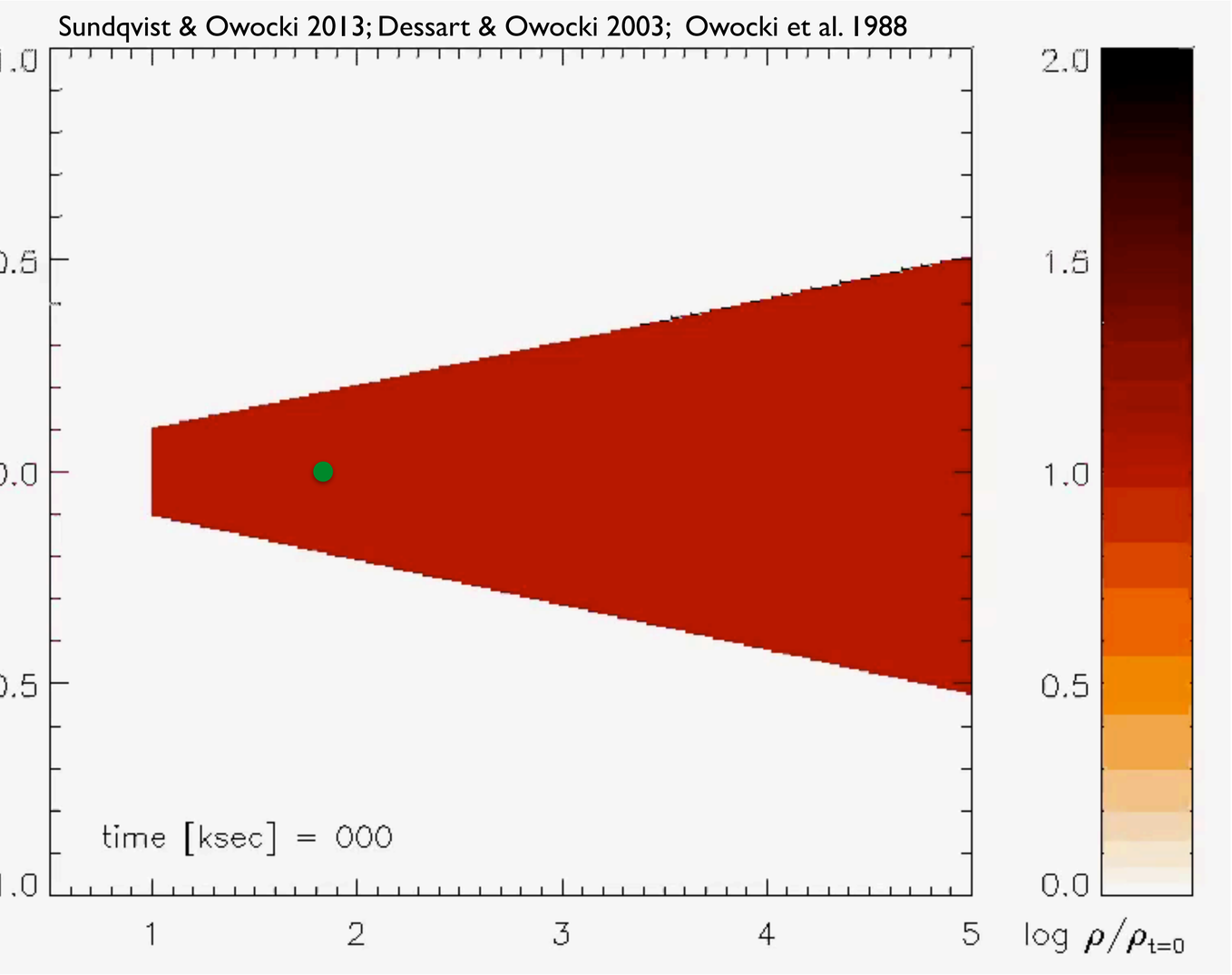

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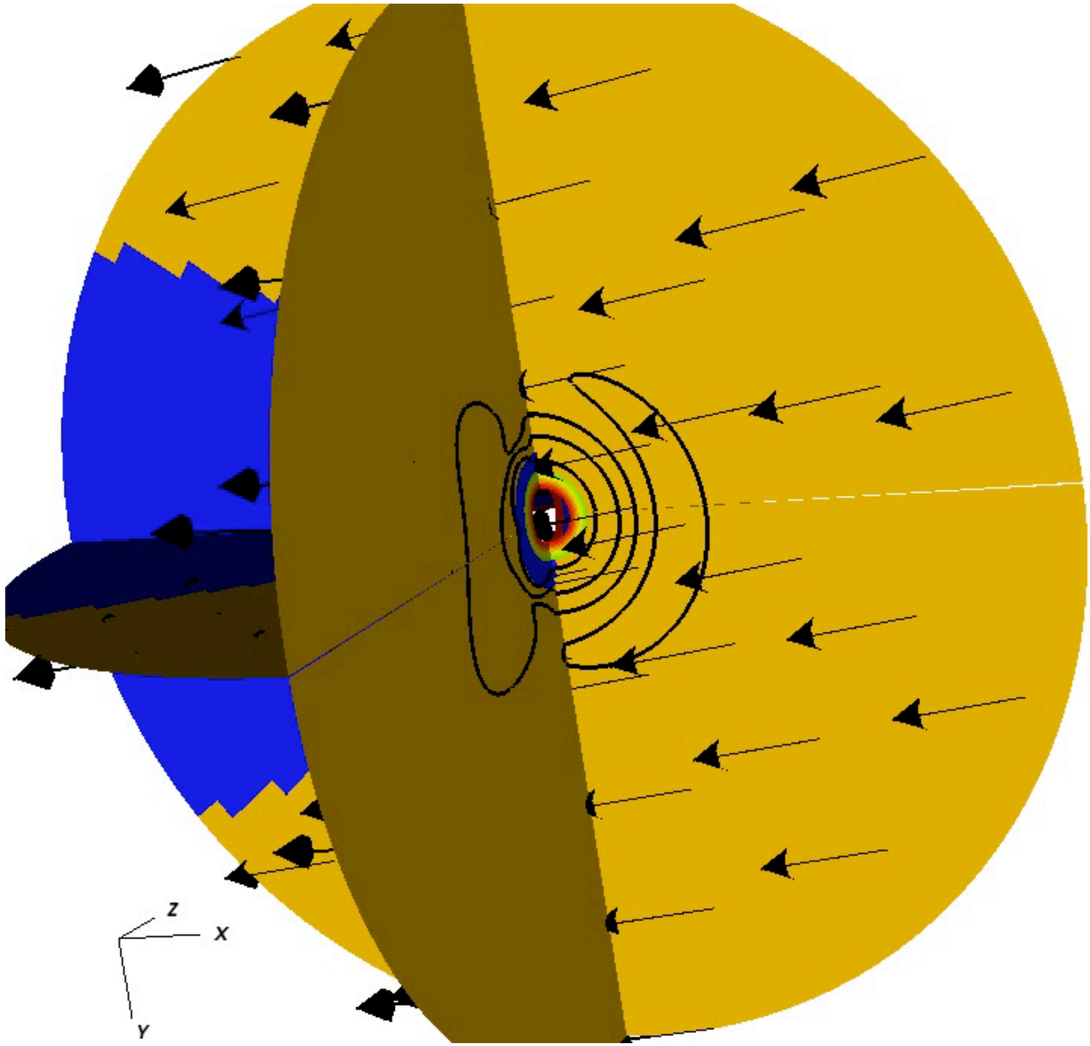


Thank you for your attention
Questions?