

2023/06/04 嶺重先生退官記念研究会
山田研究会「宇宙における降着現象 ～活動性・多様性の源～」

降着円盤は常に不安定か？ — 激変星から活動銀河核まで —

根來 均（日大）

共同研究者: 嶺重先生, A Dobrotka (Slovak University),
笹田真人（東工大）、山田真也（立教大）ほか

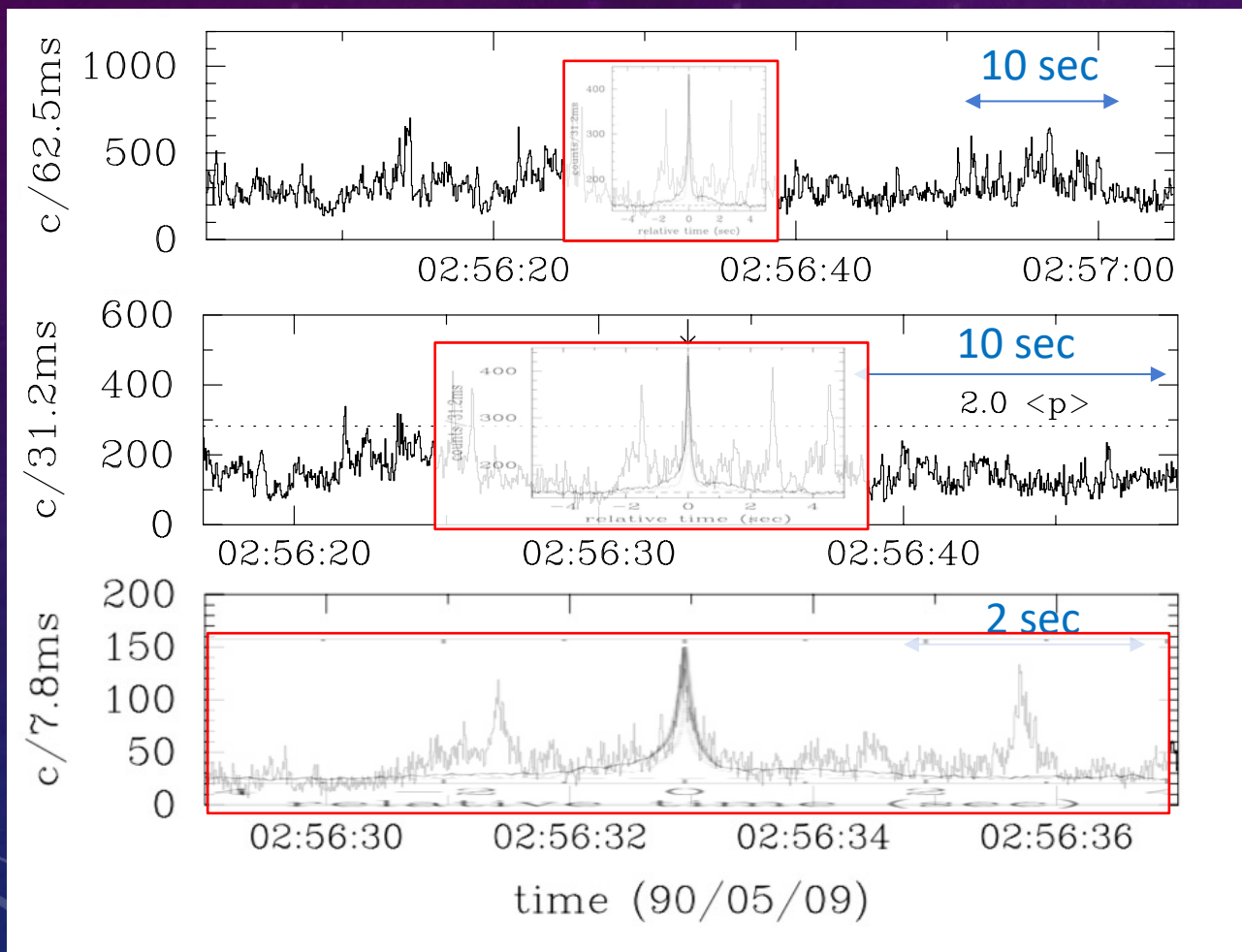
研究会主催の皆様、心より御礼申し上げます。

SHOT ANALYSIS

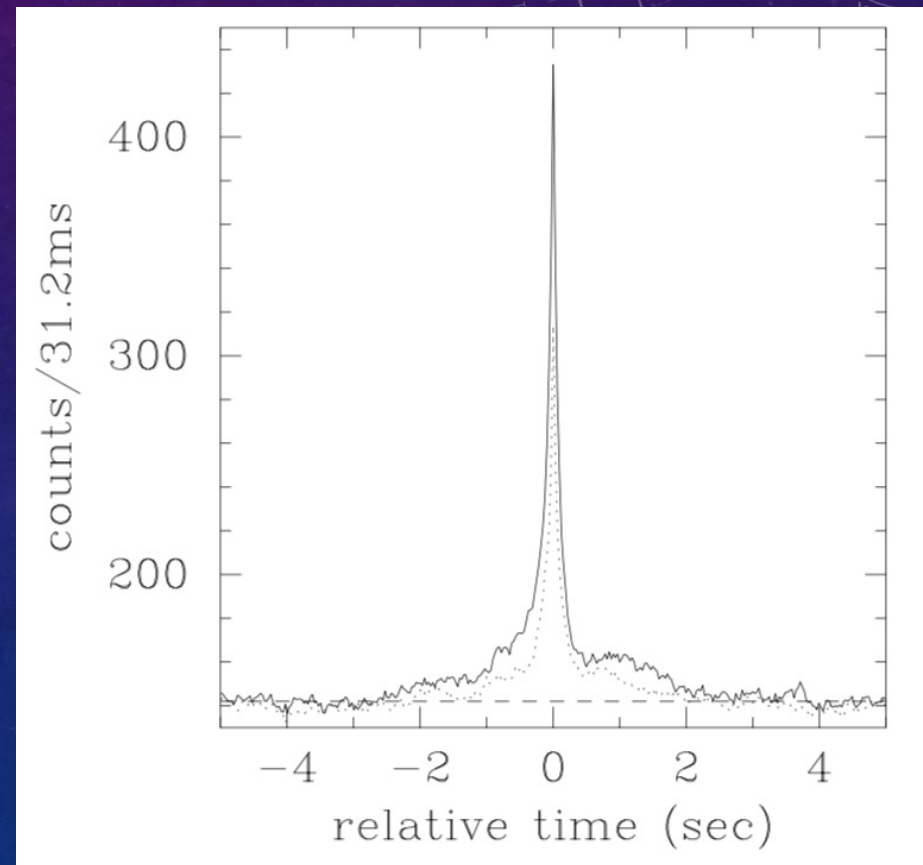
Negoro et al. 1994, ApJL, 423, L127 (Ginga data)

STELLAR BLACK HOLE: CYGNUS X-1

Mean profiles of 265 (solid line) and 313 (dashed) shots.



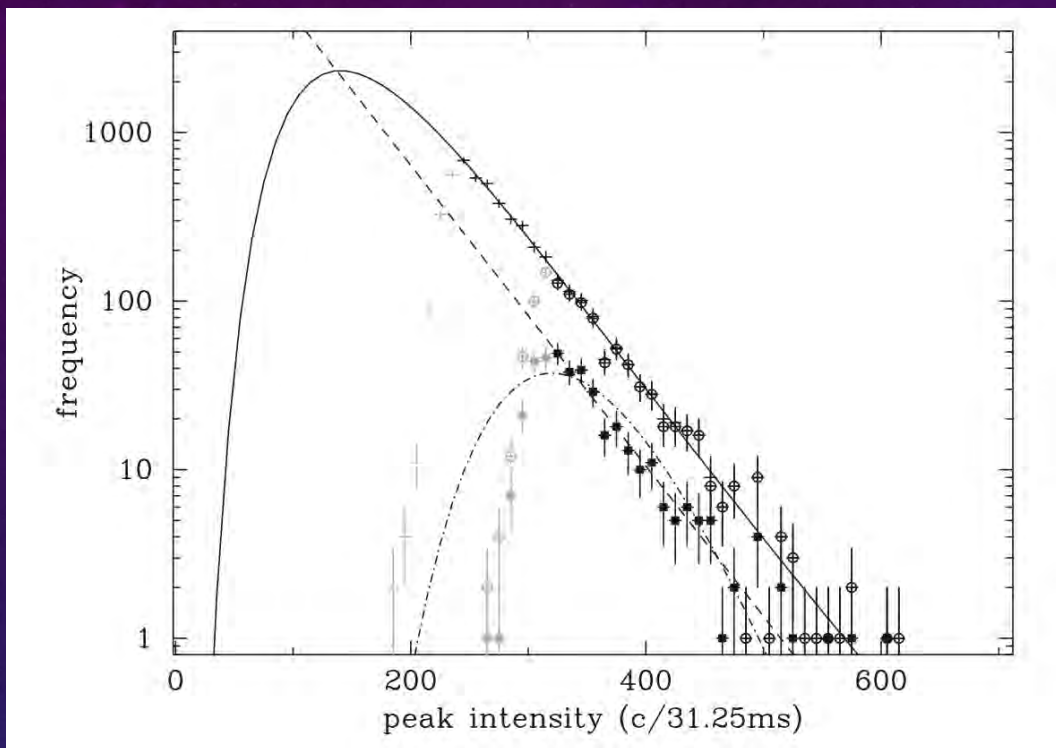
Negoro (1995) Doctoral Thesis



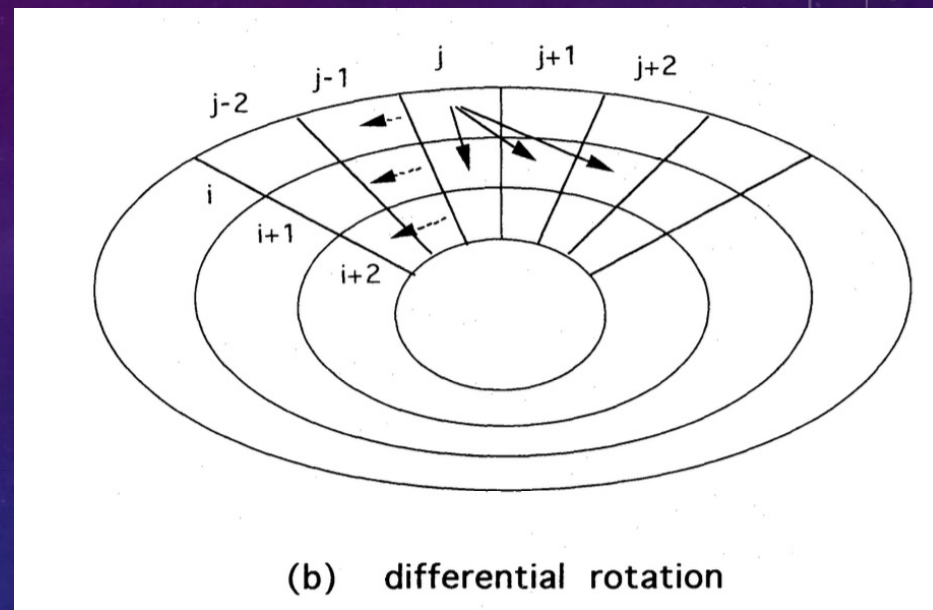
$\tau_{\text{rise}} \sim 0.083 \text{ s}$, $\tau_{\text{decay}} \sim 0.075 \text{ s}$

wing: $\tau_{\text{rise}} \sim 0.72 \text{ s}$, $\tau_{\text{decay}} \sim 1.13 \text{ s}$

ちょっと脱線しますが LOG-NORMAL DISTRIBUTION



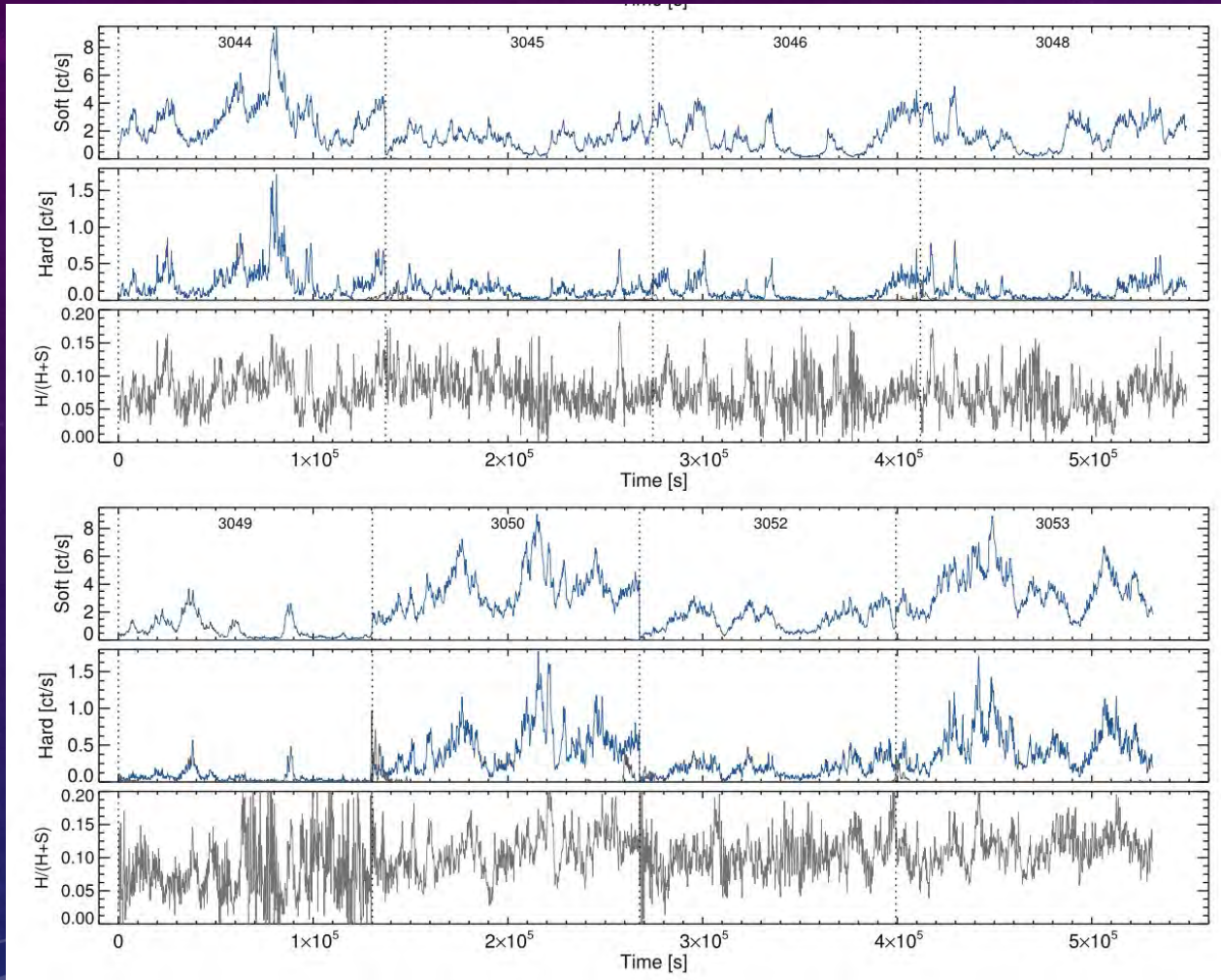
Negoro & Mineshige 2002, PASJ, 54, L69



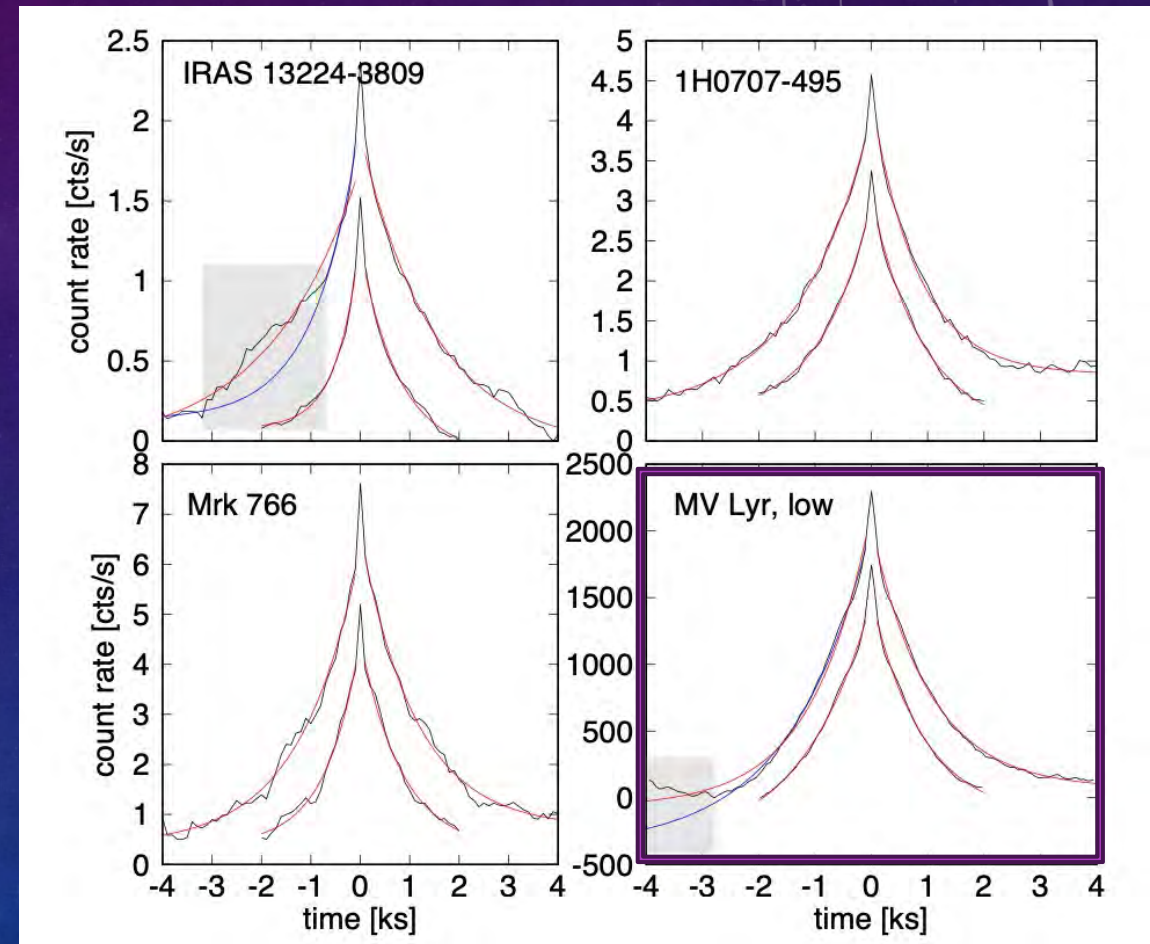
(+ Mineshige+ 1994 SOC, Takeuchi, Mineshige & Negoro 1995)
→ Non-linear X-ray Variability in X-ray binaries and active galaxies, Uttley, McHardy, Vaughan 2005 (Citation 331)
rms-flux linear relation -> ショットモデルを否定

variable AGN. That variability process must be multiplicative (with variations coupled together on all time-scales) and cannot be additive (such as shot-noise), or related to self-organized criticality, or result from completely independent variations in many separate emitting regions.

NLSY 1 IRAS 13224–3809 他

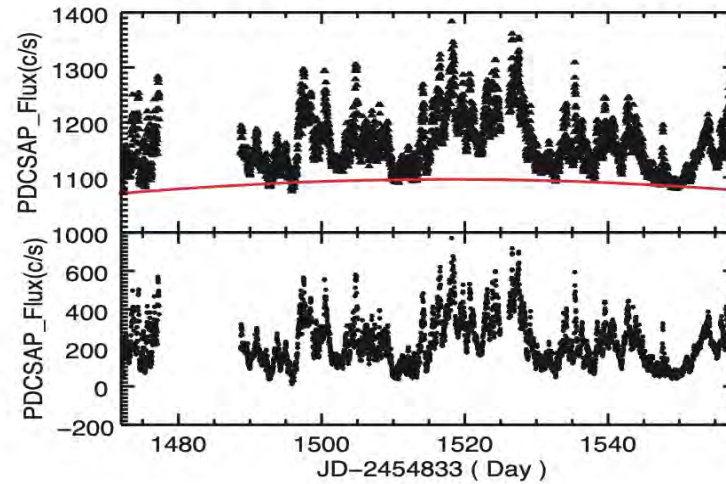
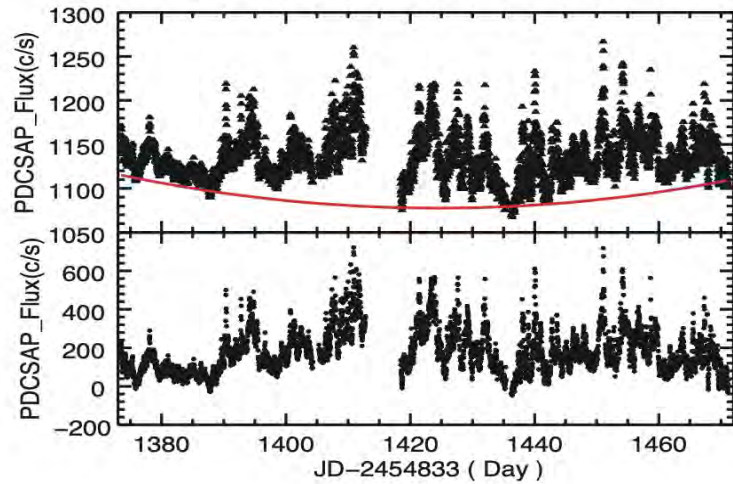


Alston et al. 2019

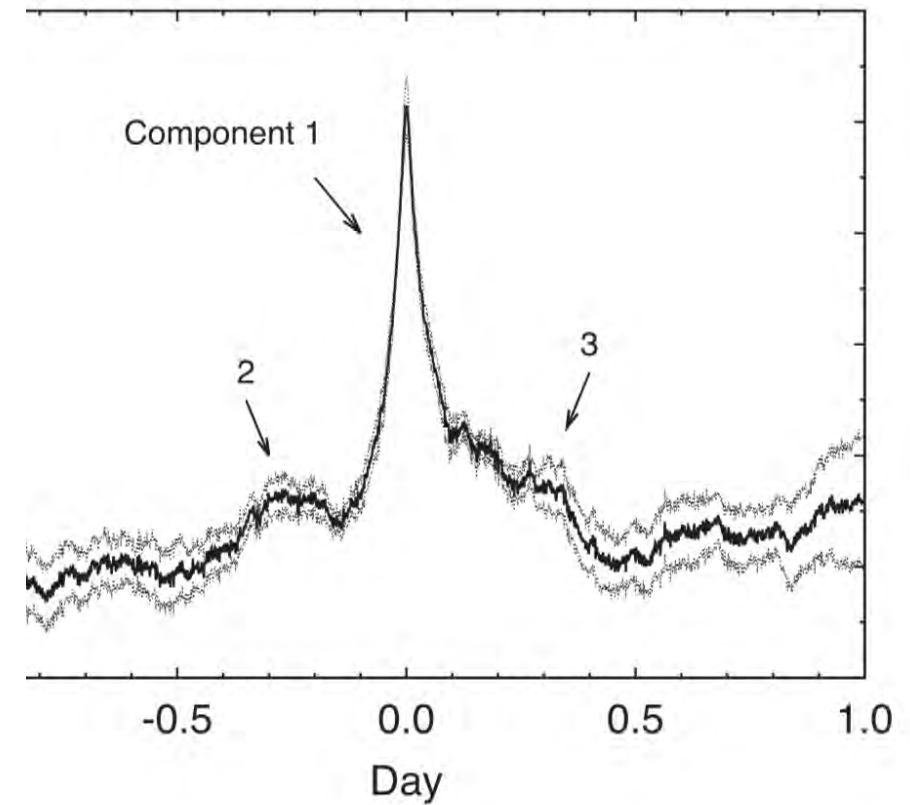


Dobrotka, Negoro and Bezák (in prep.)

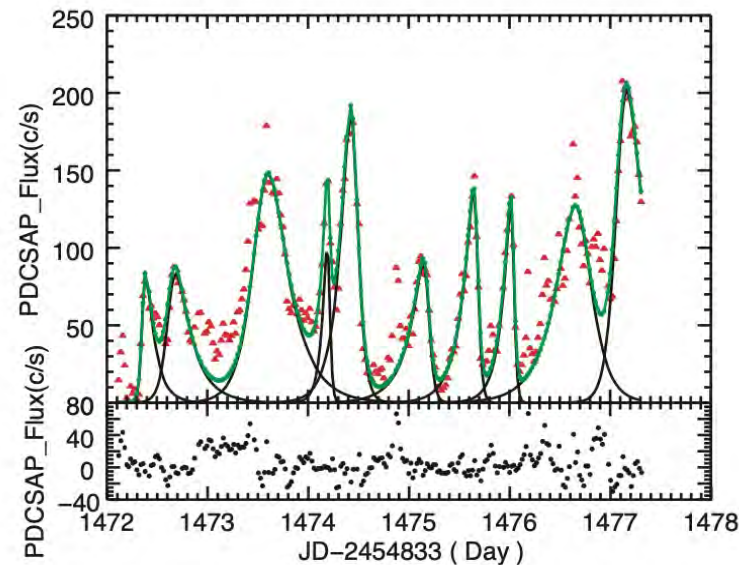
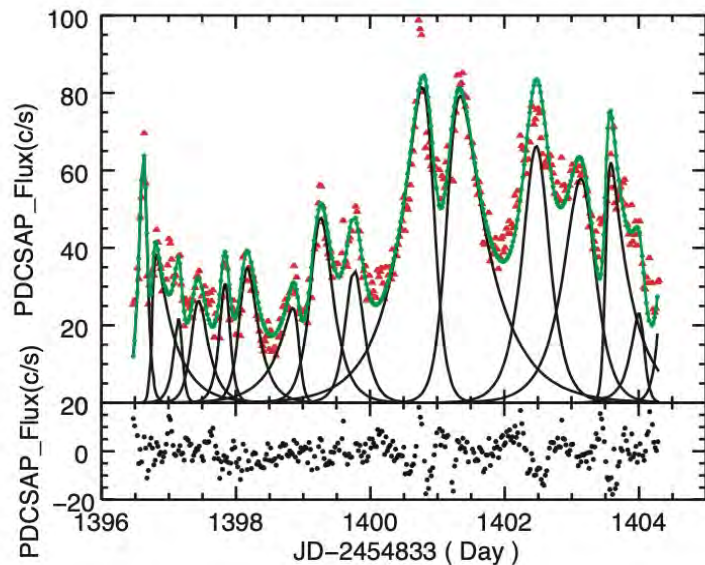
BLAZAR: W2R1926+42



profile of 195 flares (Sasada+ 2017)



Li et al. 2018

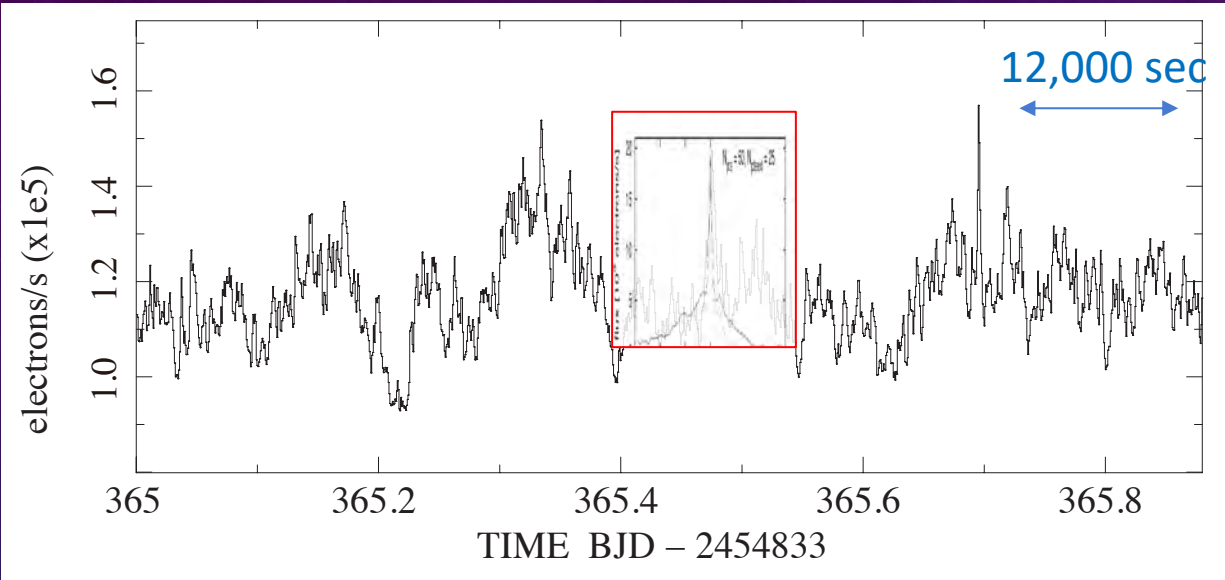


~ 0.043 d, $\tau_{\text{decay}} \sim 0.061$ d

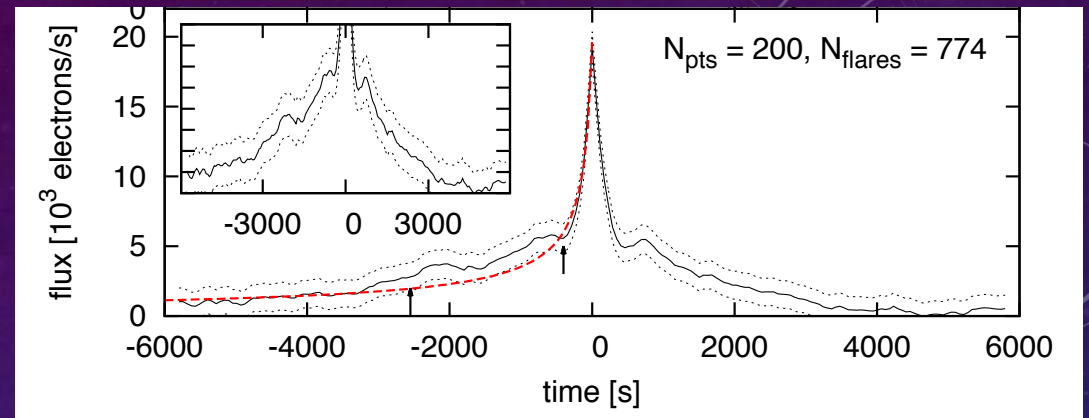
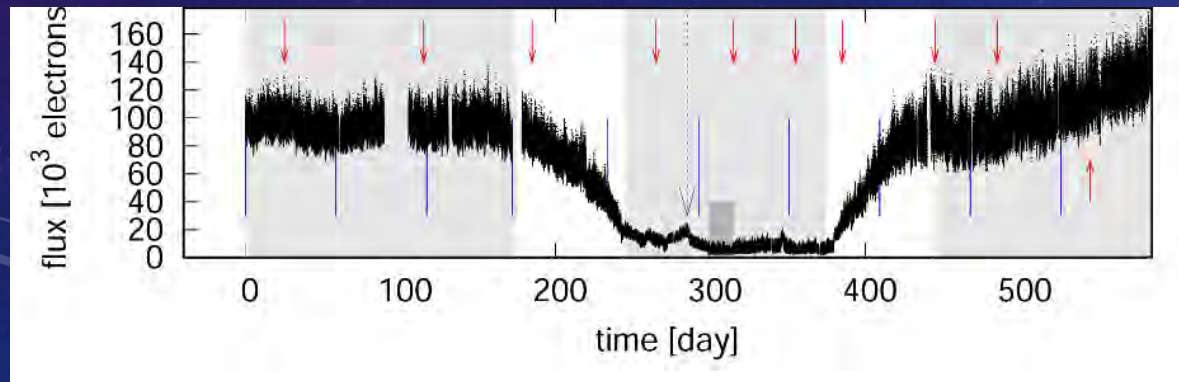
CV: MV LYRAE

Dobrotka, Negoro & Mineshige 2019, A&A, 631, 134

Dobrotka, Negoro & Konopka 2020, A&A, 641, 55

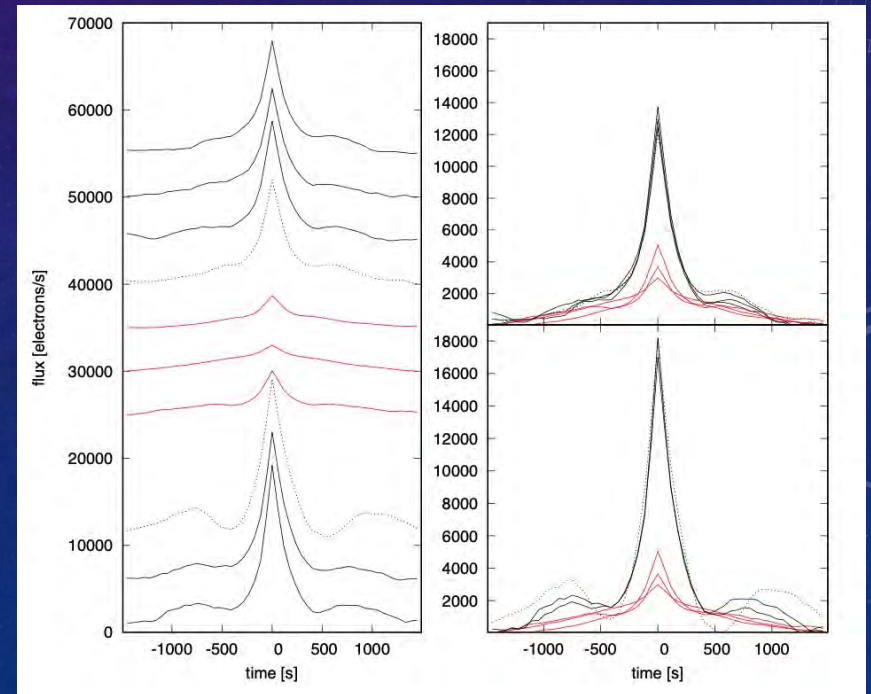


Kepler data (Scaringi et al. 2012)



Dobrotka et al. 2019

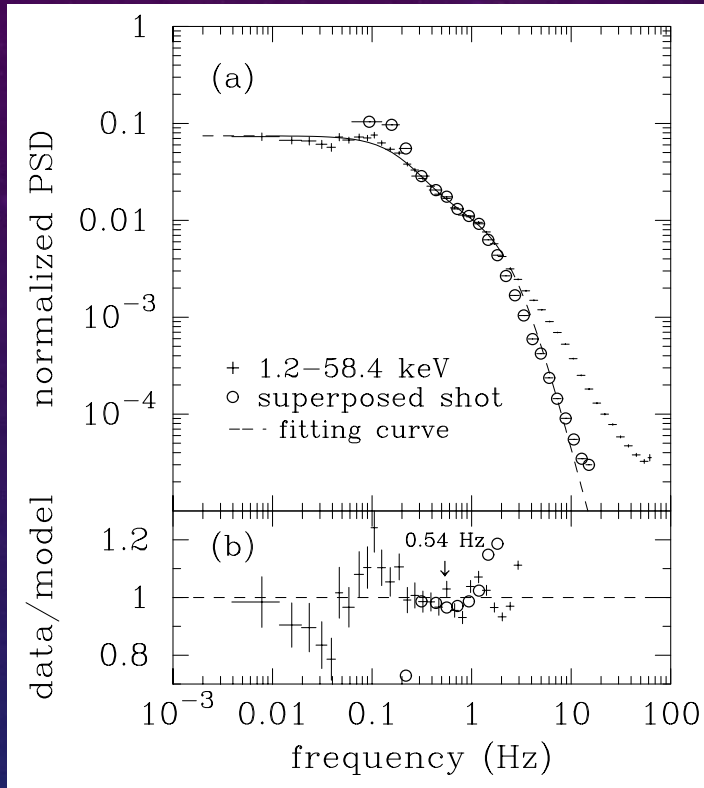
$\tau_{\text{rise}} \sim 164 \text{ s}, \tau_{\text{decay}} \sim 226 \text{ s}$



Dobrotka et al. 2020

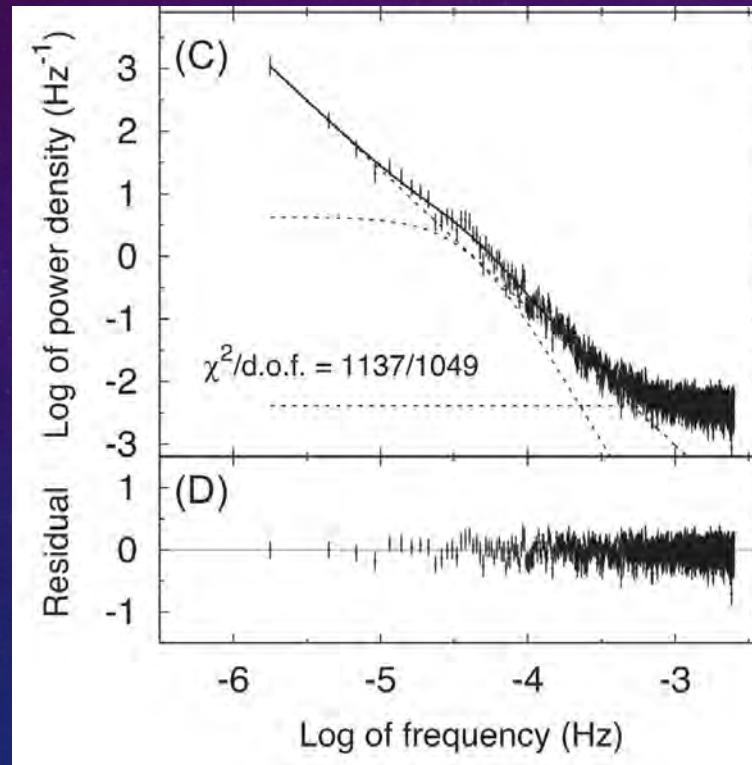
SHOT COMPONENTS IN PSDS OR ACF

Cyg X-1



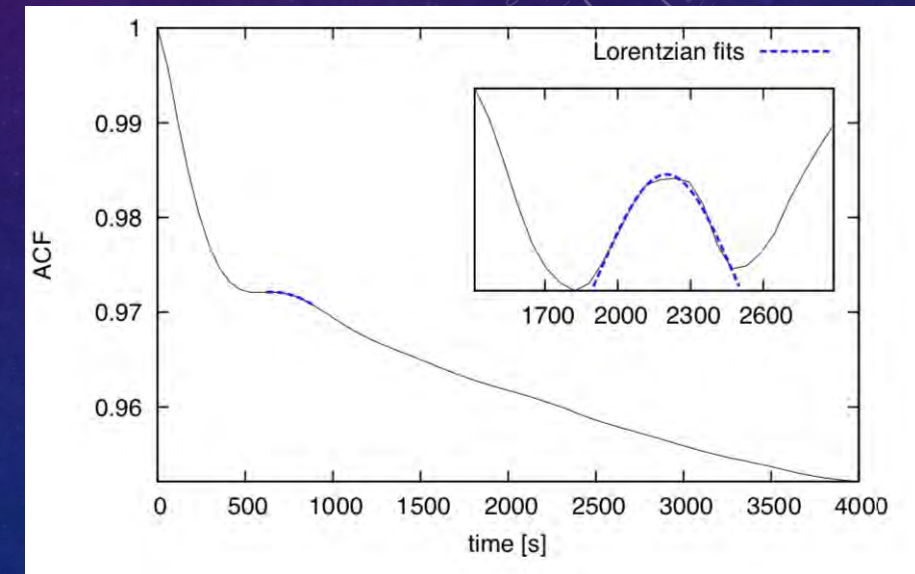
Negoro, Kitamoto, & Mineshige
2001, ApJL, 554, L528

W2R1926+42



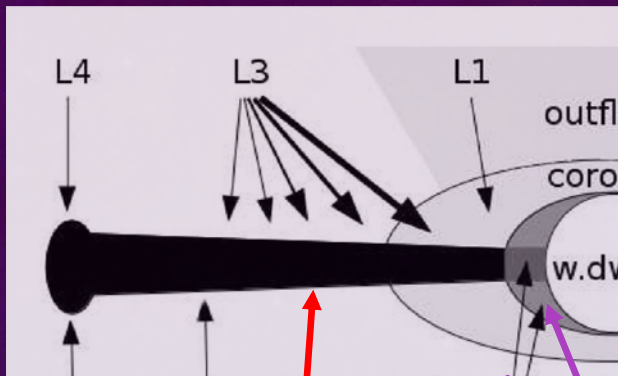
Sasada et al. 2017, PASJ, 69, 15

MV Lyrae



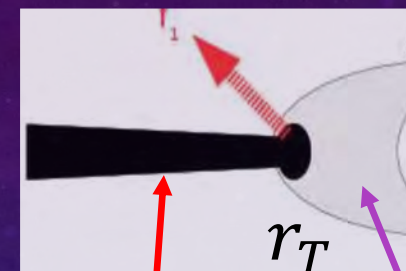
Dobrotka et al. 2019, A&A, 631, 134

Peak time \sim entering the Corona (boundary Layer) or ADAF region

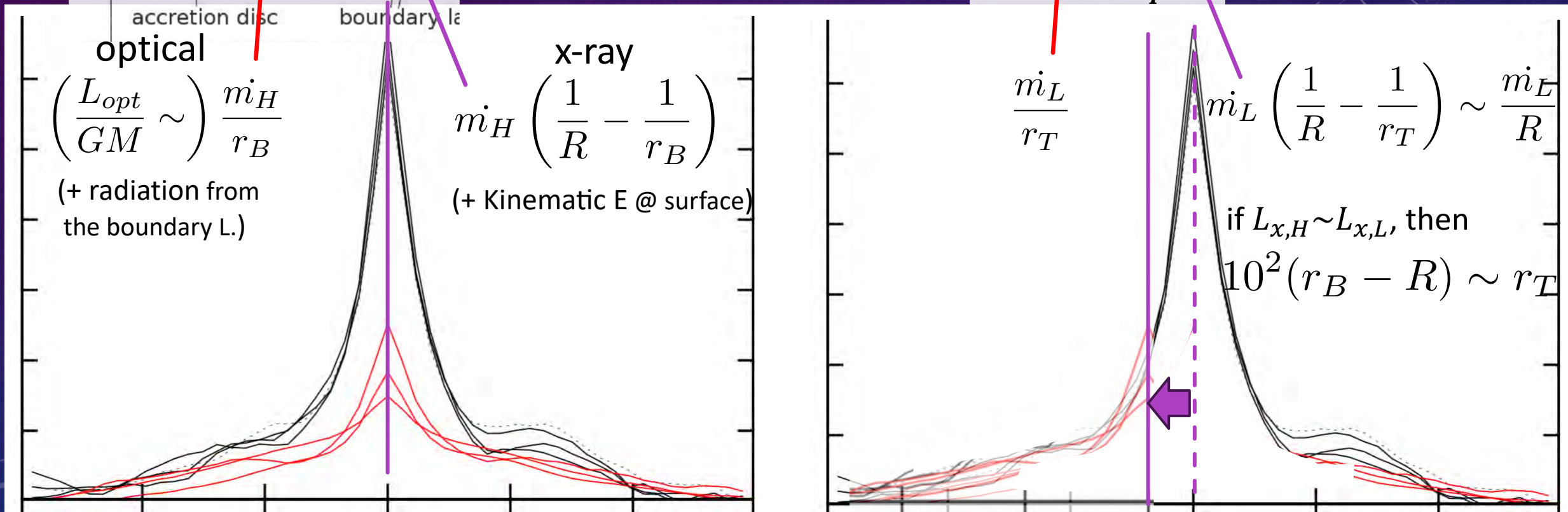


R : WD radius
 r_B : boundary layer radius
 r_T : transition radius

High State



Low State



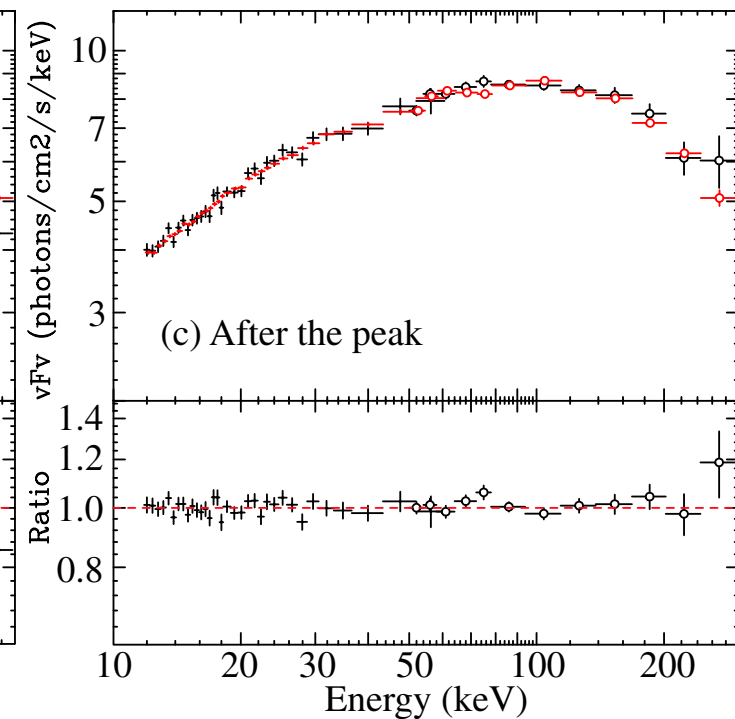
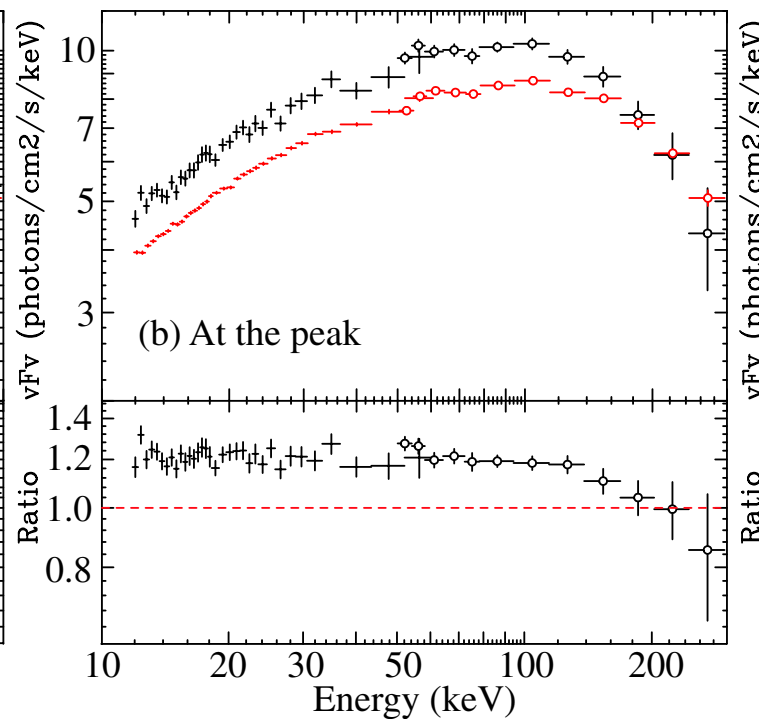
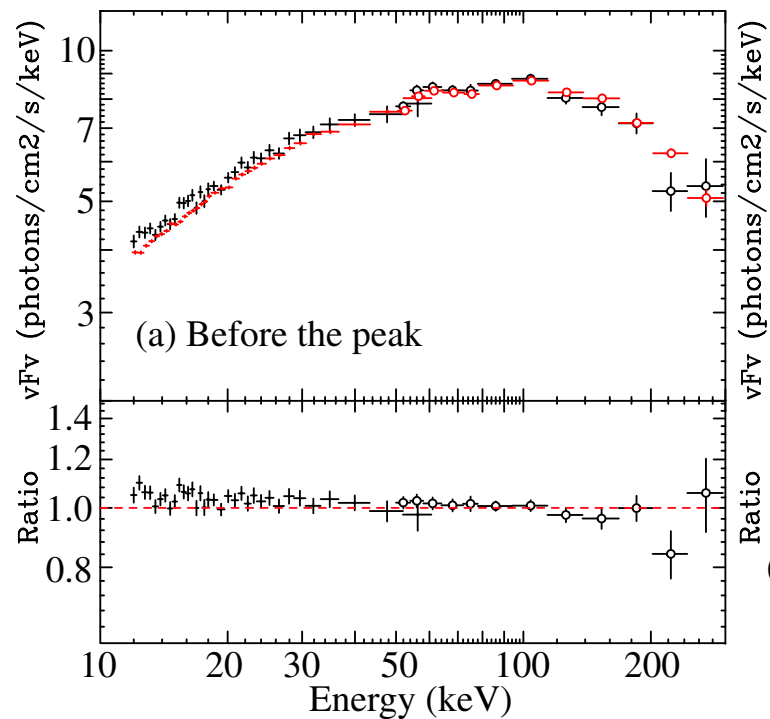
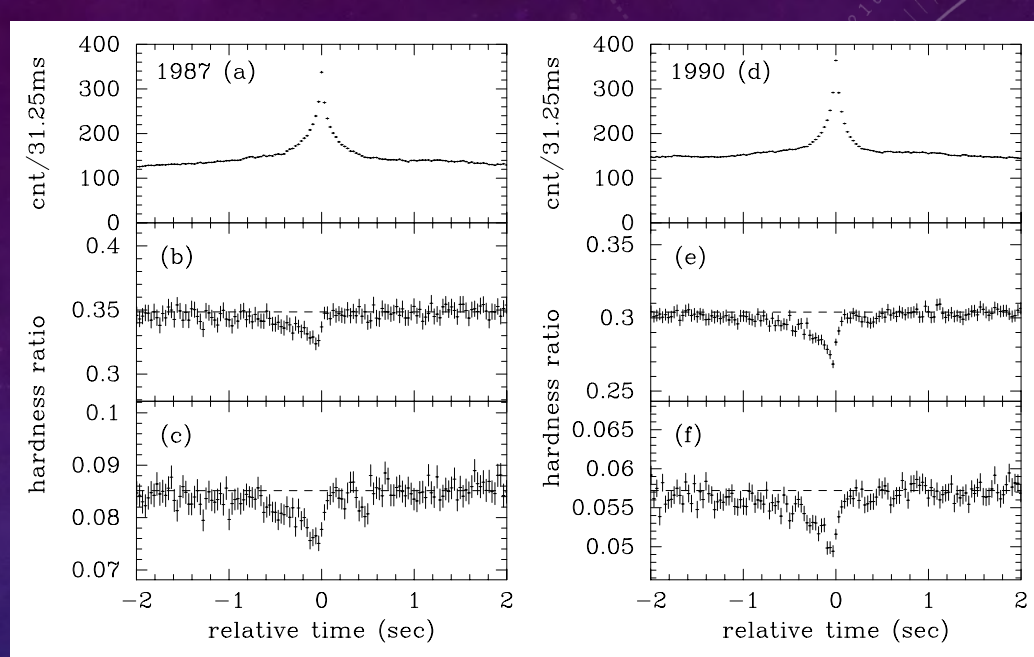
しかし、Tomo-e + NICER のデータを用いた SS Cyg (Nishino+ 2022) は可視の遅れを示す

SPECTRAL EVOLUTION

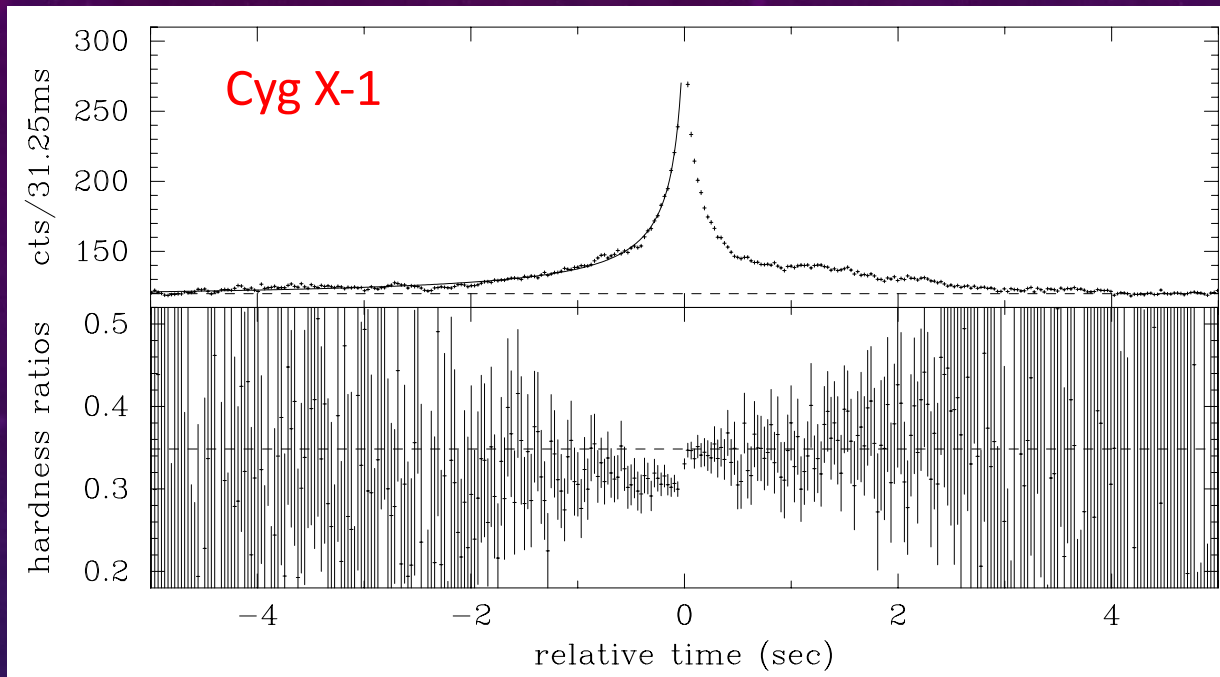
Negoro et al. 1994 (Ginga data)

Negoro 1995

Yamada et al. 2003, ApJL, 767, L34 (Suzaku data)



APERIODIC MASS ACCRETION



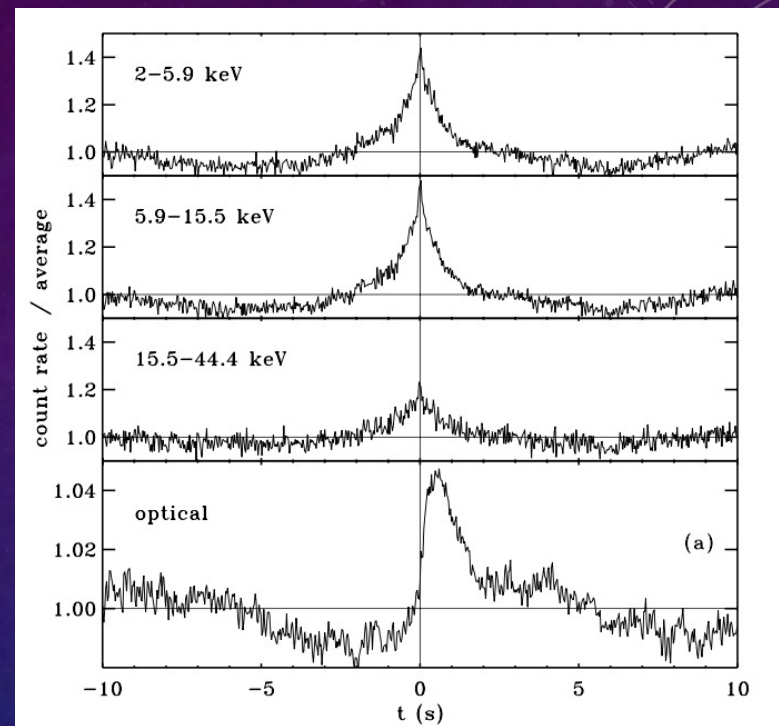
Negoro 1996, Proc. “Basic Physics of Accretion Disks”,
Gordon & Breach, Eds Kato et al.

Expected flux increase from dense matter drifting inward
(Negoro 1995).

$$L(t) \propto \frac{1}{(t_0 - t)^\alpha}$$

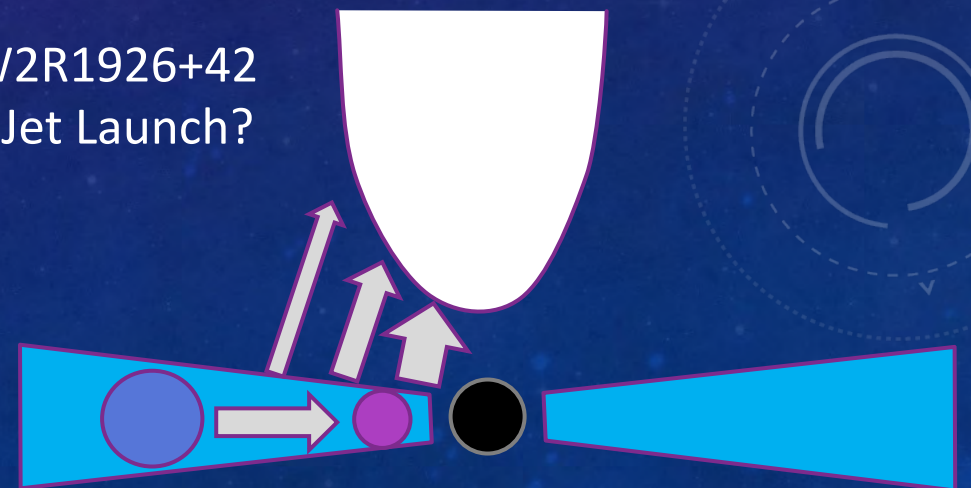
ADAF simulation:

Manmoto, Takeuchi, Mineshige, Matsumoto & Negoro 1996



XTE 1118+480: Malzac et al. 2003

W2R1926+42
Jet Launch?



まとめと残された課題

不安定性の原因

- BHBX では hard state で不安定性が顕著

- ADAF – Standard disk 境界から？
- 何からの SOC or Instability?
- 磁気再結合 (cf. hardening: Machida & Matsumoto 2003)

- Rin と shot profile の関係は？

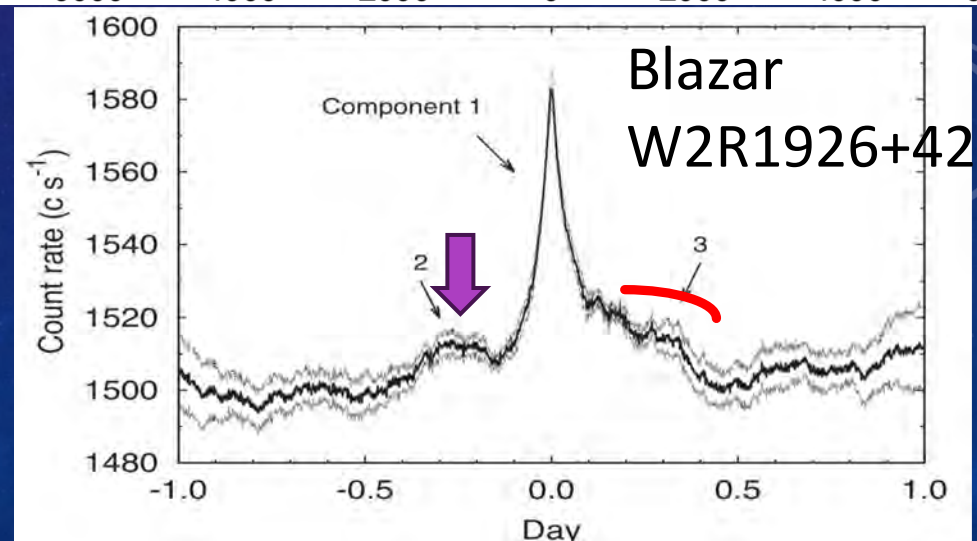
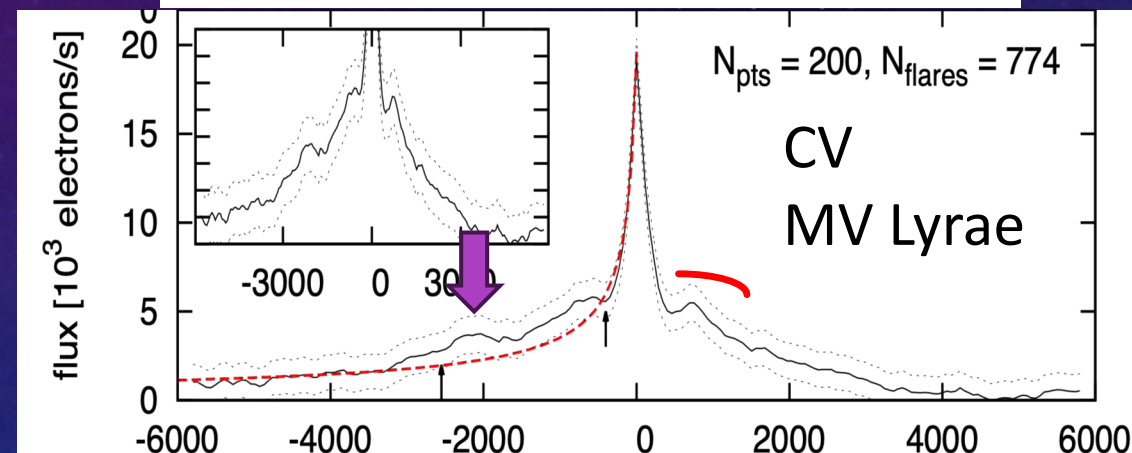
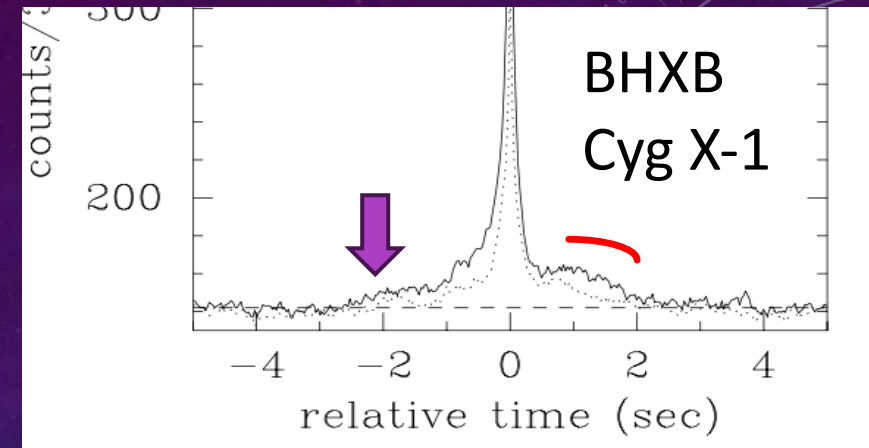
- CV では (optical) high state でも不安定

- Standard disk ではないのか？
- peak 前後でのスペクトル変化

- AGN, BHBX (very high state) などでも不安定

- ディスクコロナでの表層雪崩？
 - cf. disk line との整合性

- rms-flux 関係との整合性



ORIGIN OF THE TIME VARIATIONS

	Cyg X-1	W2R1926+42 (Sasada+)	MV Lyrae (Dobrotka+)
Mass	14.8 Mo (Orosz+ 2011)	1e7.8 Mo (Sasada+2017)	0.73 Mo (Hoard+ 2004)
Shot Time Constants $\tau_{shot}(\equiv \langle \tau \rangle)$	0.08 sec (+1 s)	0.05 day (~ 4000 sec)	200 sec
Dynamical Timescale, τ_{dyn}	$\sim 1 \left(\frac{r}{3r_s} \right)^{3/2} \text{ ms}$ $\sim \frac{\tau_{shot}}{80} \left(\frac{r}{3r_s} \right)^{3/2}$	$\sim 4600 \left(\frac{r}{3r_s} \right)^{3/2} \text{ sec}$ $\sim \frac{\tau_{shot}}{5} \left(\frac{1}{\delta/6} \right) \left(\frac{r}{3r_s} \right)^{3/2}$	$\sim 10 \left(\frac{r}{10^{10} \text{ cm}} \right)^{3/2} \text{ sec}$ $\sim \frac{\tau_{shot}}{20} \left(\frac{r}{10^{10} \text{ cm}} \right)^{3/2}$

$$\tau_{dyn} \left(\equiv \sqrt{\frac{r^3}{GM}} = 0.073 \left(\frac{r}{3r_s} \right)^{\frac{3}{2}} \frac{M}{M_o} \text{ ms} \right) \sim \tau_{hydro} \sim \alpha \tau_{thermal} \sim \alpha \left(\frac{h}{r} \right)^2 \tau_{drift}$$

(Lightman 1974)