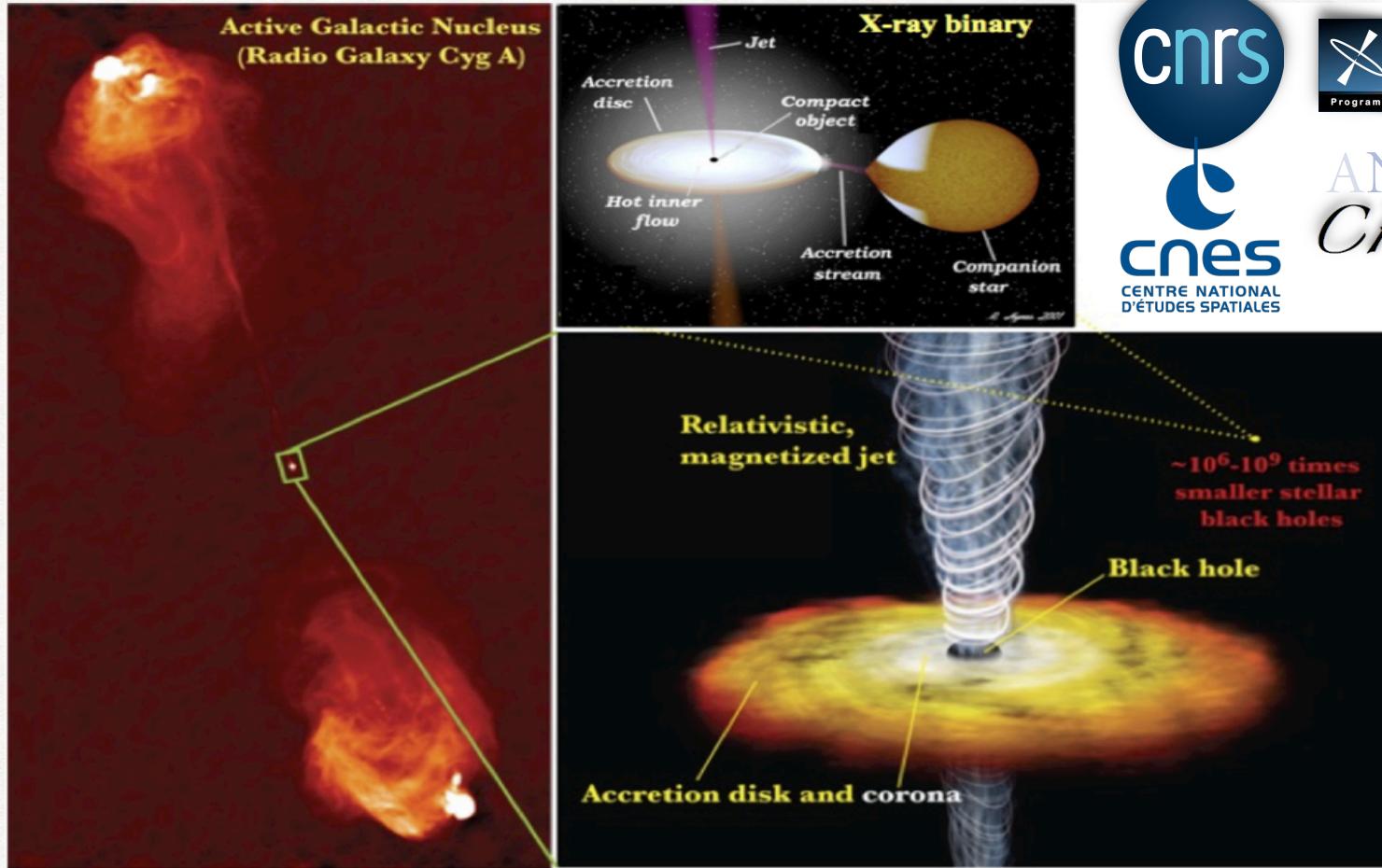


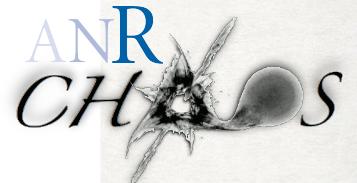
An Accretion-Ejection Paradigm for Compact Objects

P.O. Petrucci

Institute of Planetary science and Astrophysics of Grenoble, France



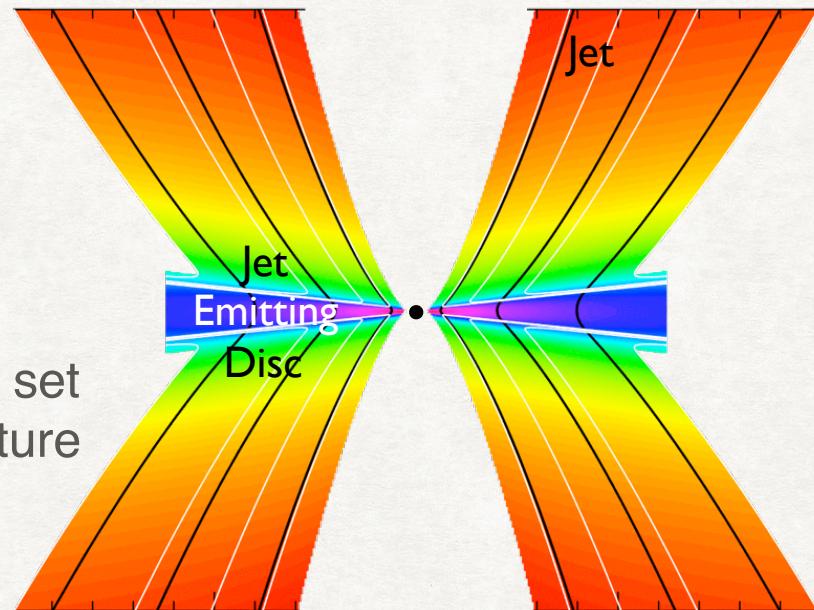
Collaborators: G. Marcel, T. Benitah, S. Barnier, F. Ursini, R. Middei, J. Ferreira, R. Belmont, J. Malzac, J. Rodriguez, F. Cangemi, M. Clavel, S. Corbel, M. Coriat, G. Henri,



Jet Emitting Disk

- ✓ Assume a large-scale magnetic field
- ✓ Baryonic jet emitted by the accretion disk through MHD mechanism (Blandford & Payne, 1982)
- ✓ First self-similar solution of the complete set of equations of an accretion-ejection structure (Ferreira & Pelletier 1995; Ferreira 1997)
- ✓ Some characteristics:
 - $\dot{M}_{acc} \propto r^p$ **but p not a free parameter!**
 - **Due to the jet torque, $V_{acc} \sim C_{sound}$!**

Ferreira (1997),

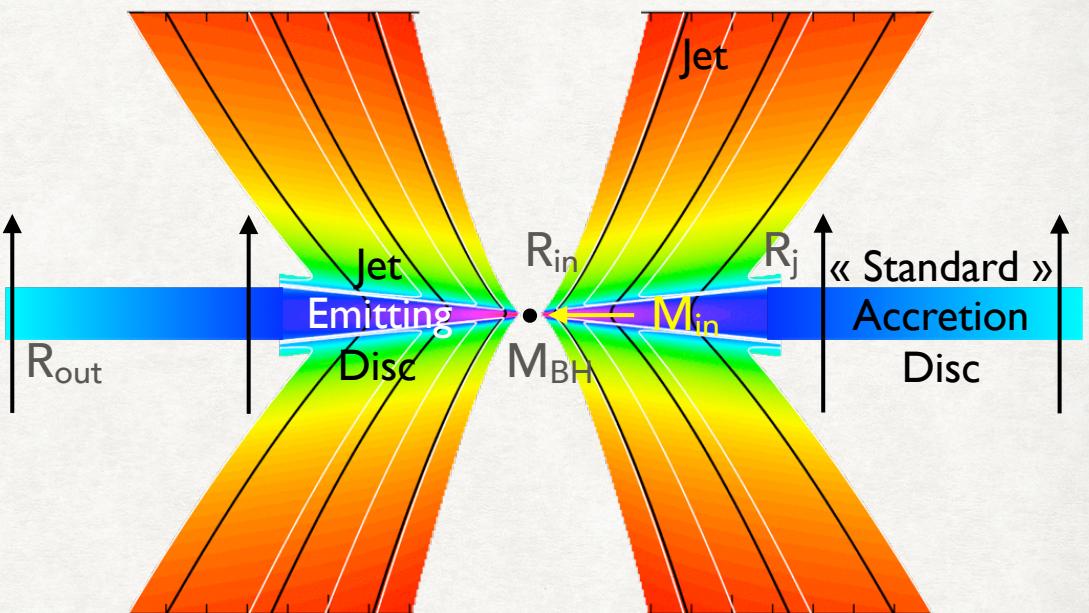


Hybrid JED-SAD configuration

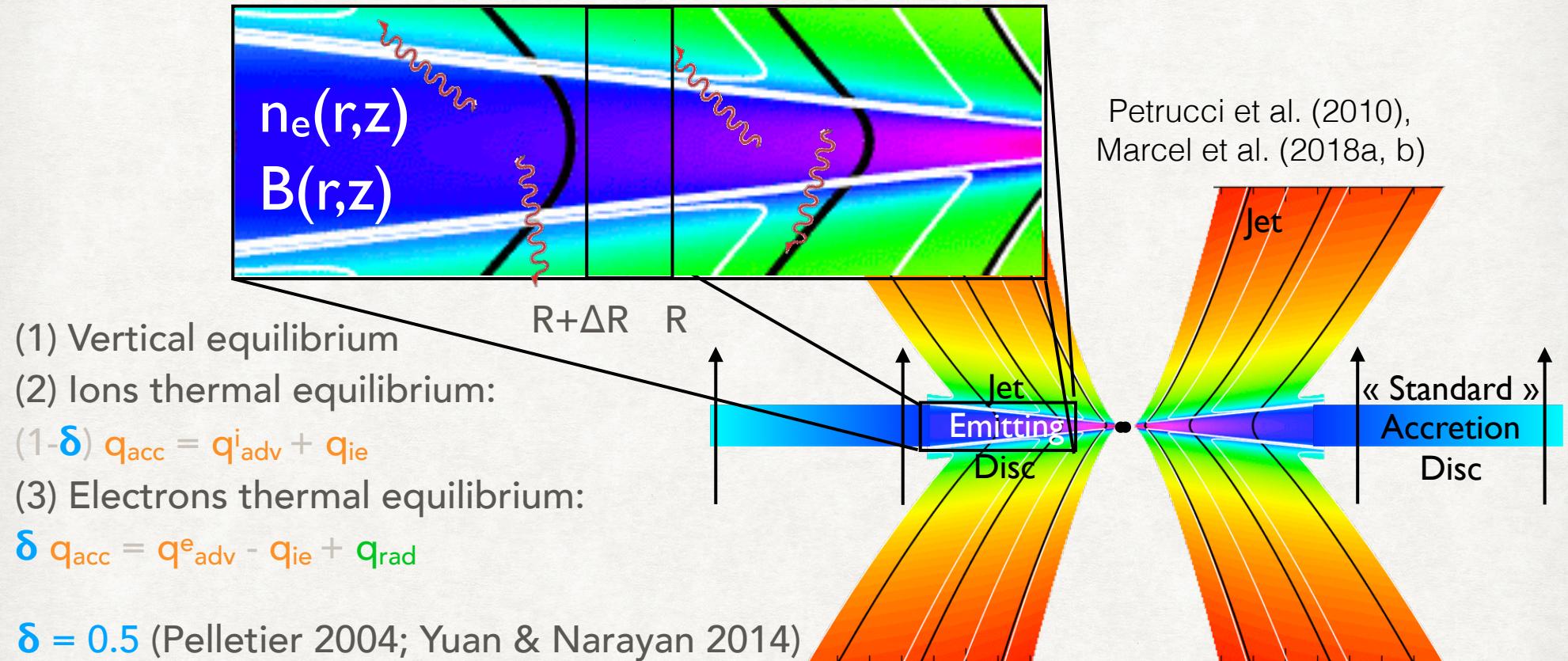
« à la » Esin et al. (1997)

- ✓ high magnetised inner region = JED
- ✓ low magnetised outer region = SAD
- ✓ A given configuration is defined by:
 - the transition radius R_j
 - the inner radius R_{in}
 - the inner accretion rate \dot{M}_{in}
 - the black hole mass M_{BH}
 - the SAD outer radius R_{out}

Ferreira et al. (2006),



JED Thermal Equilibrium



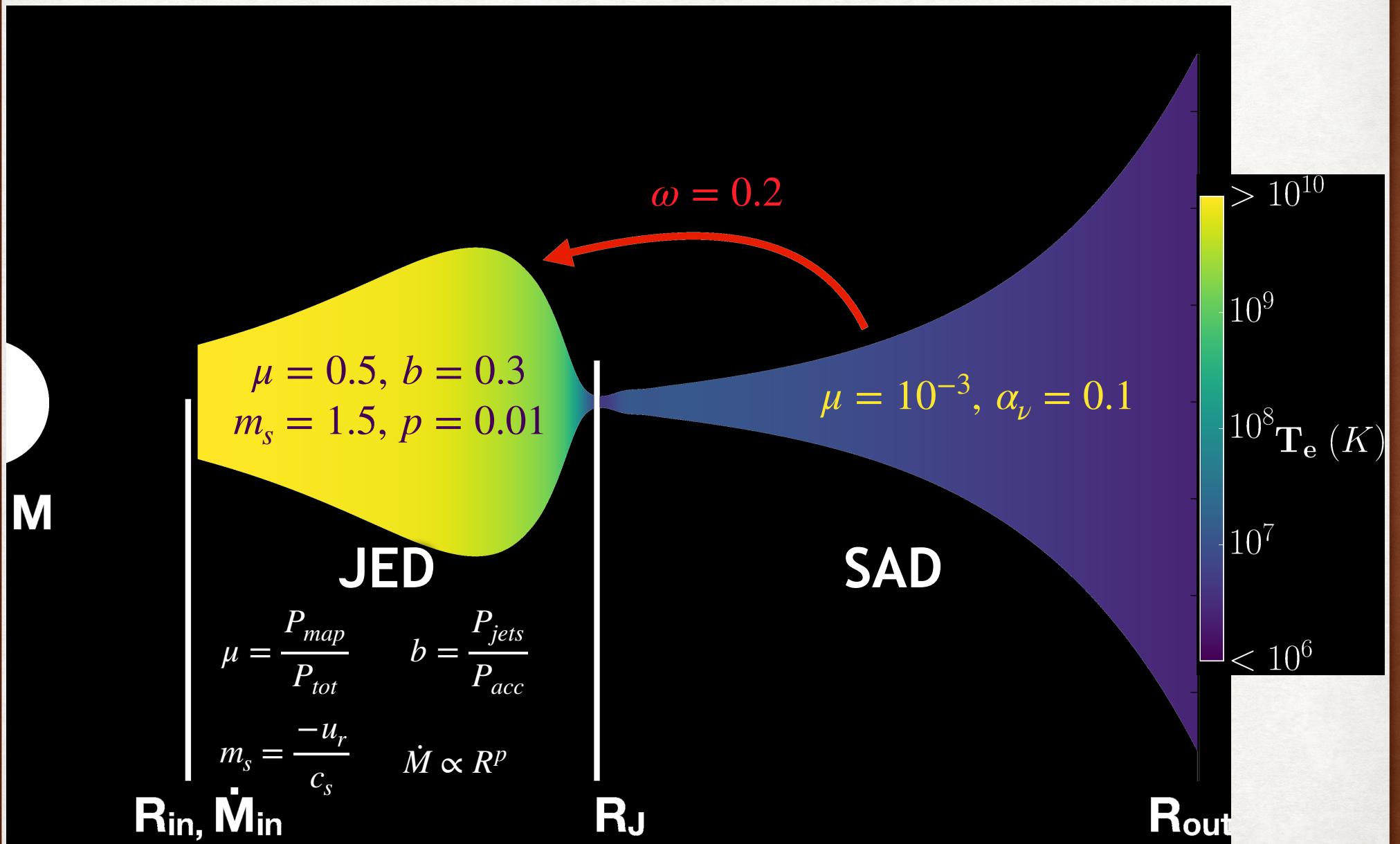
Radiative cooling as a bridge formula between:

- Thick: Blackbody radiation,
- Thin: Synchrotron, Bremsstrahlung and Compton processes as well as inverse-Compton illumination from the SAD onto the JED using BELM (Belmont+08,09).

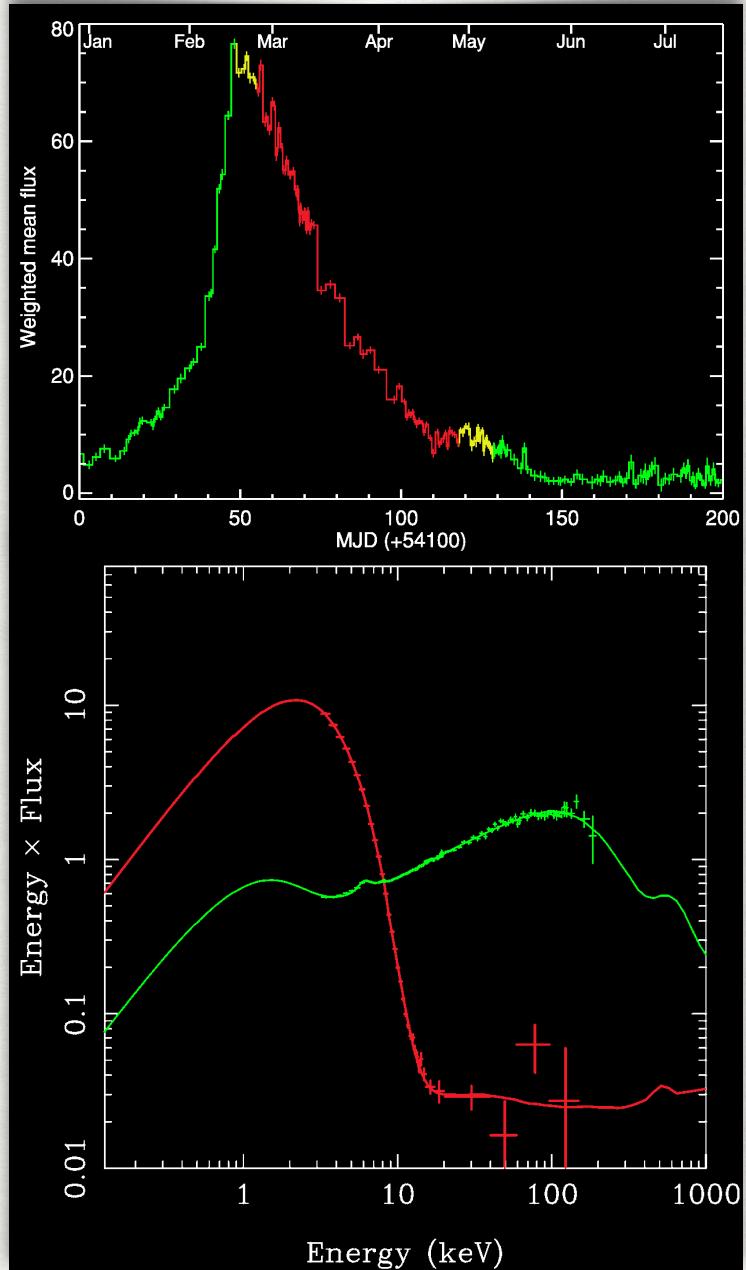


$T_e, \tau, \epsilon = h/r$: thermal structure at any given radius!

Parameter space

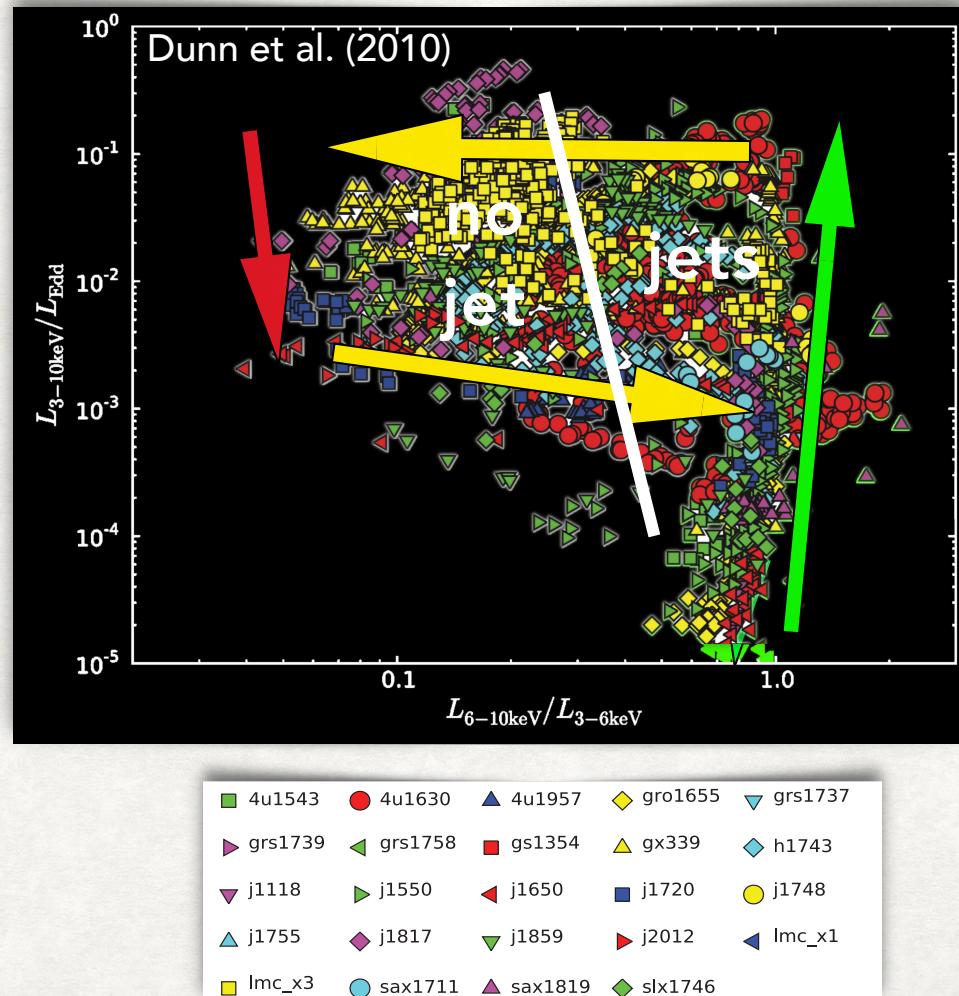


Application to X-ray Binaries

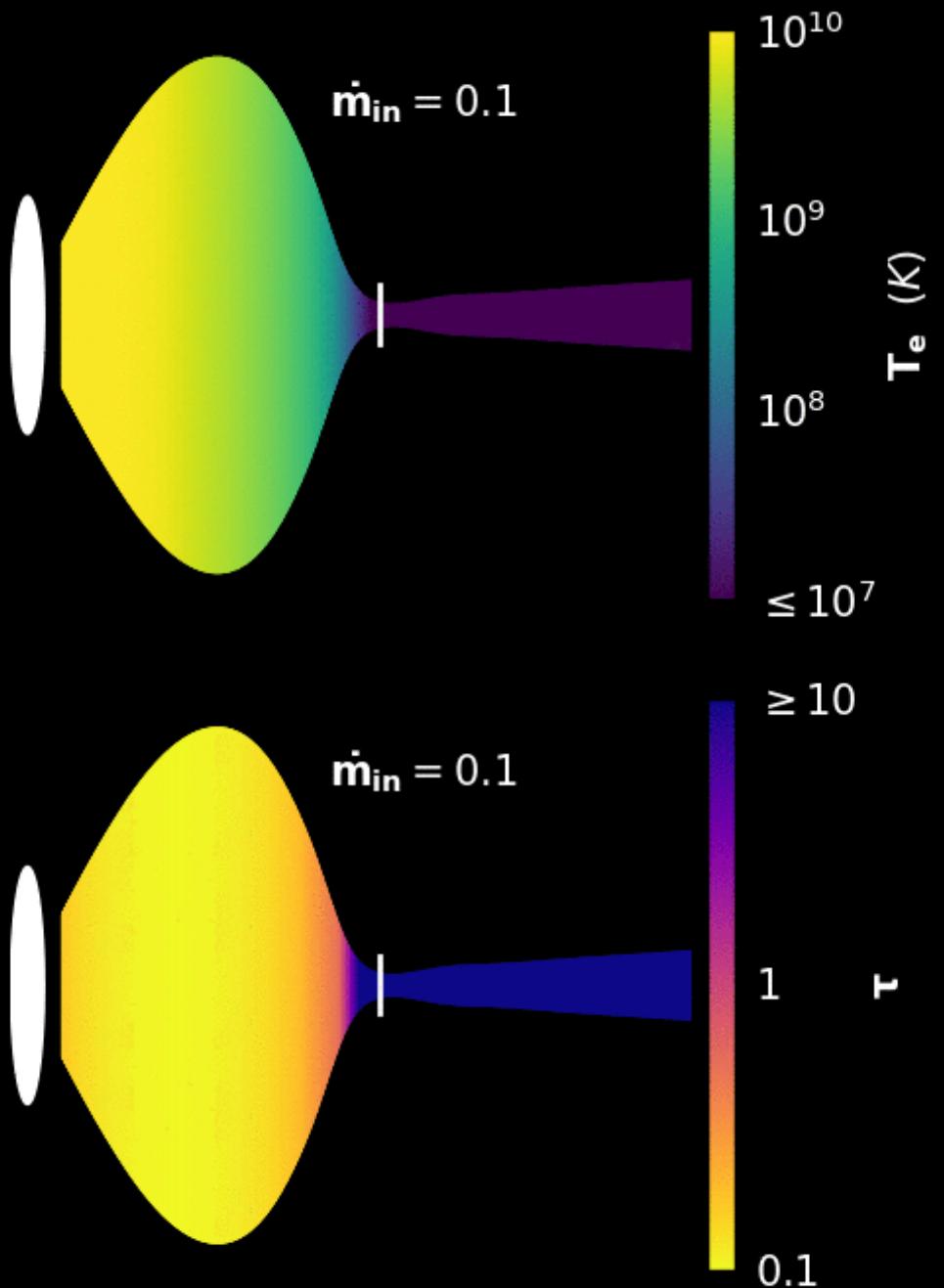
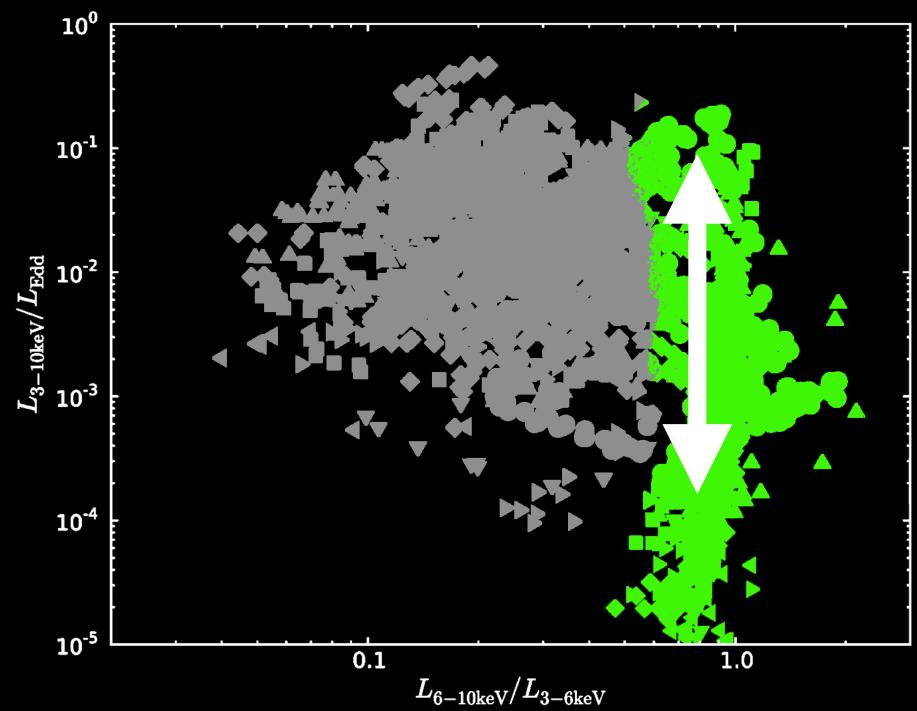
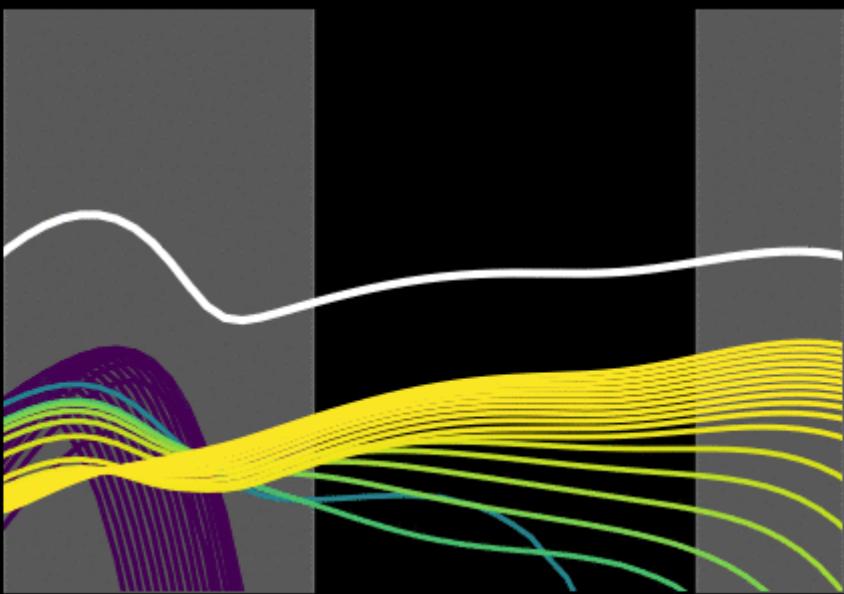


A spectral and dynamical hysteresis

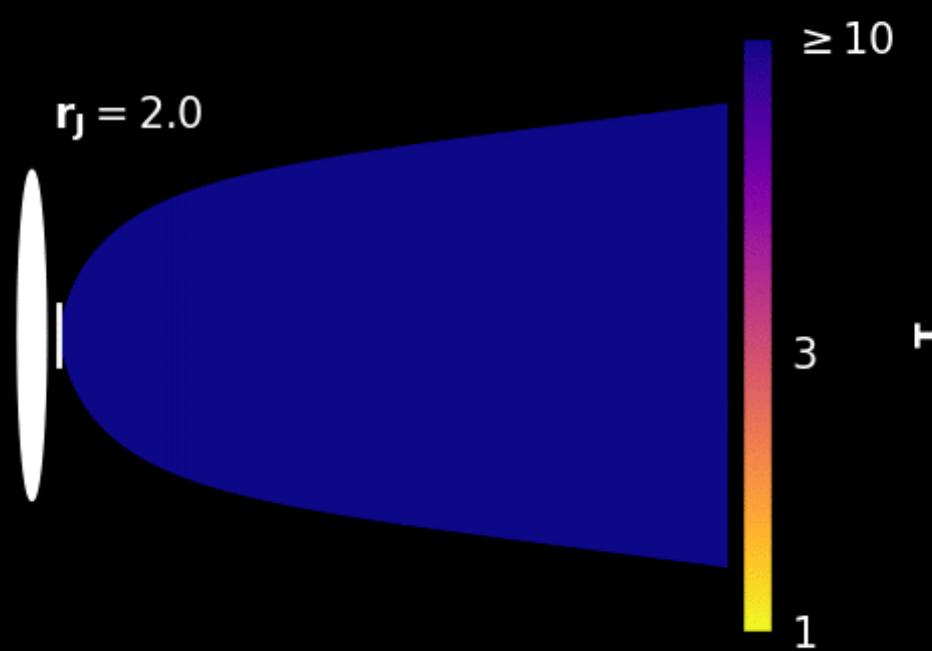
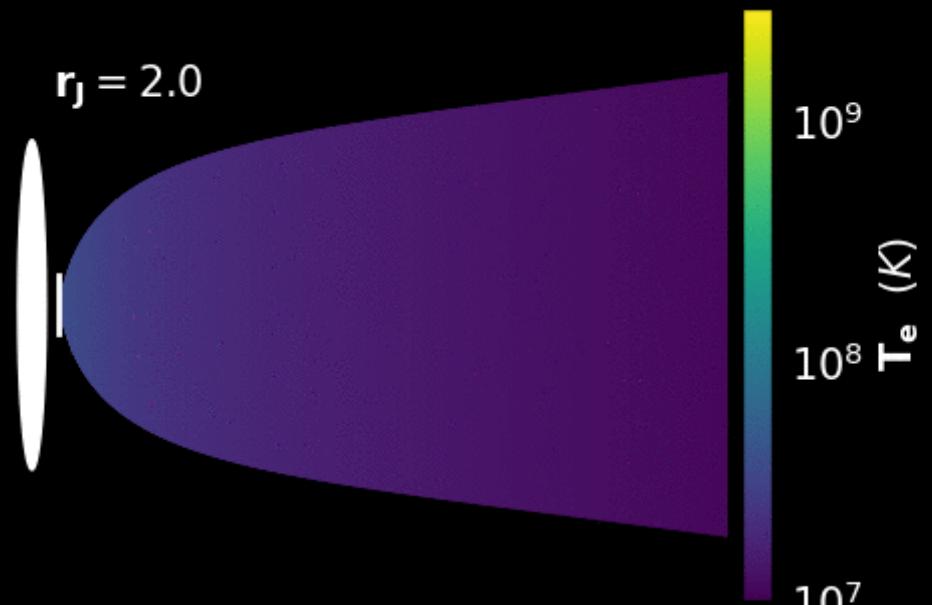
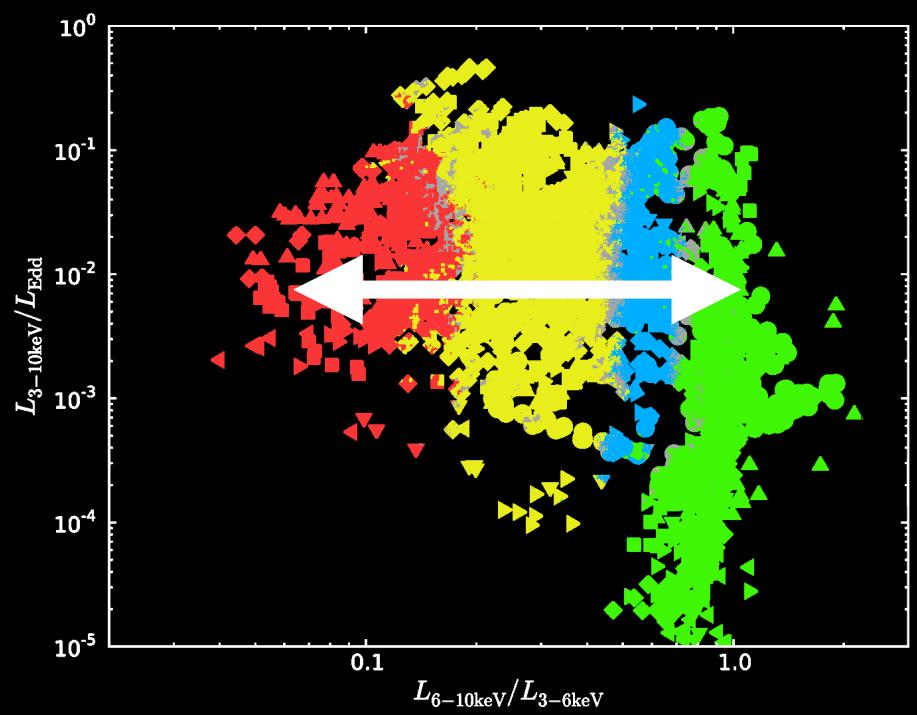
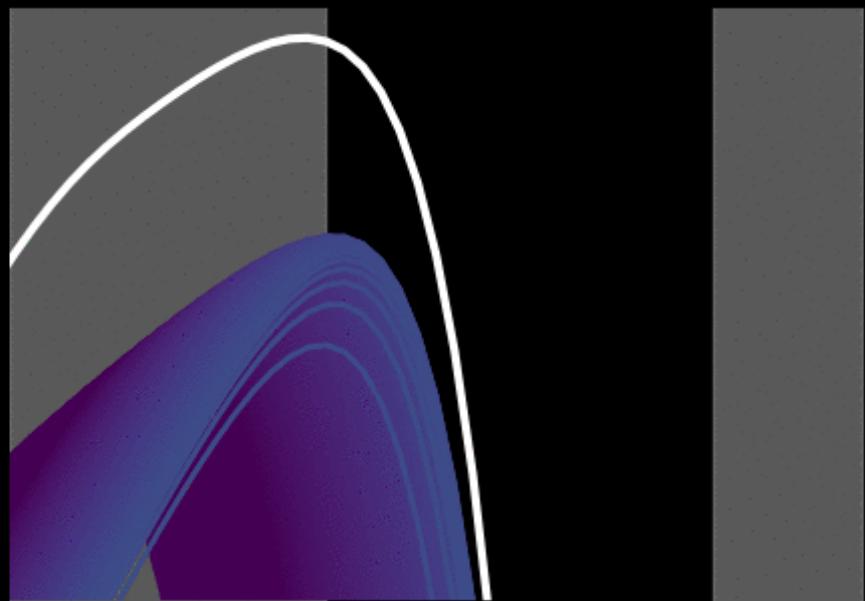
(e.g. Fender et al. 2004, 2009, Gandhi et al. 2010, Dunn et al. 2010, Zhang S.-N. 2013, Corbel et al. 2013)



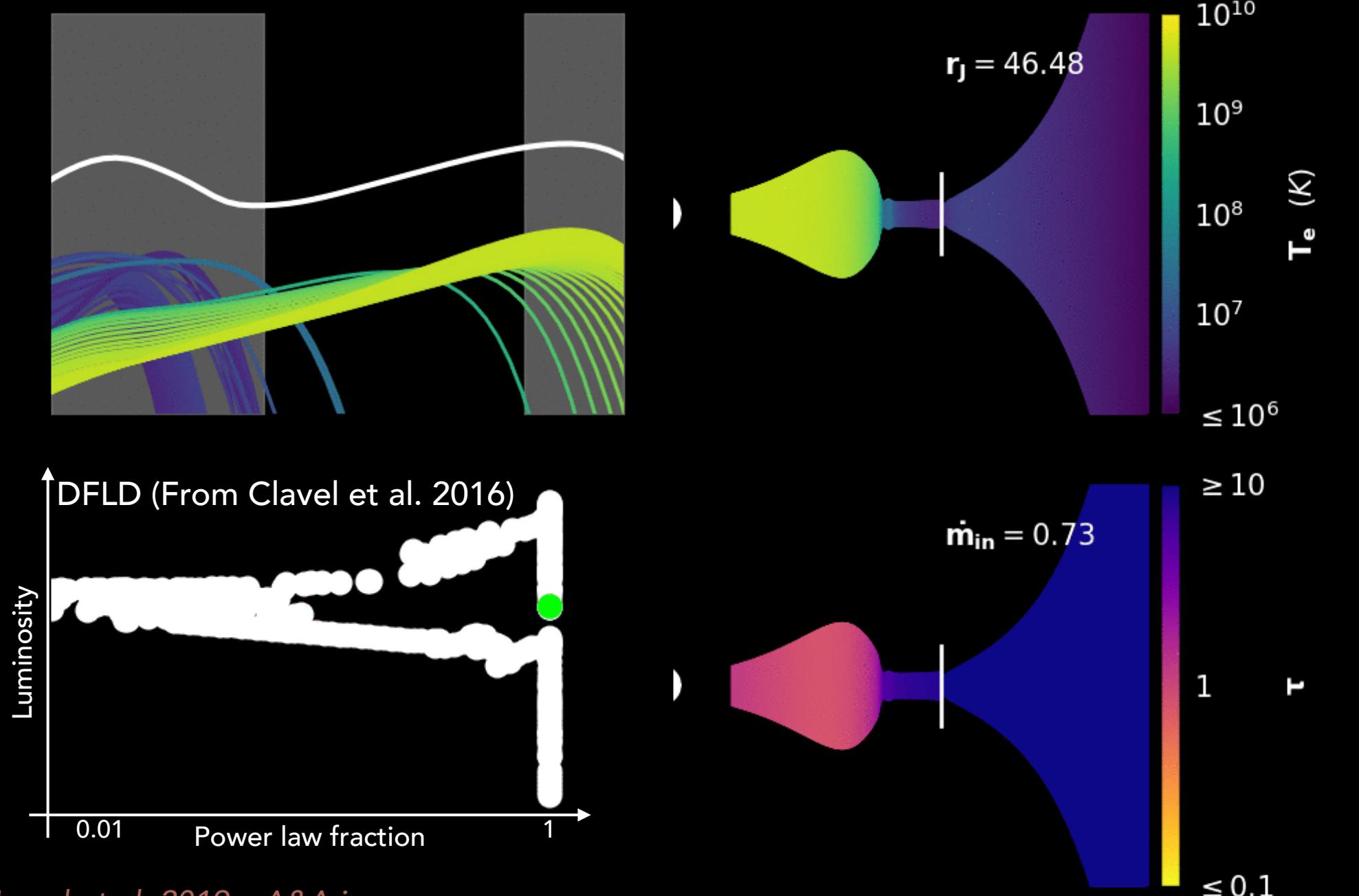
Reaching high luminosity hard states



From soft to hard states!

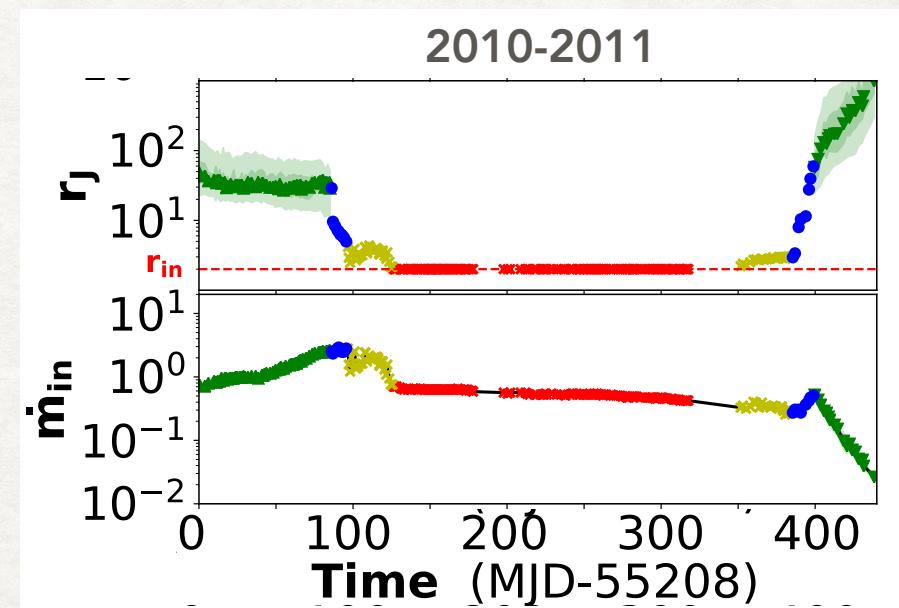
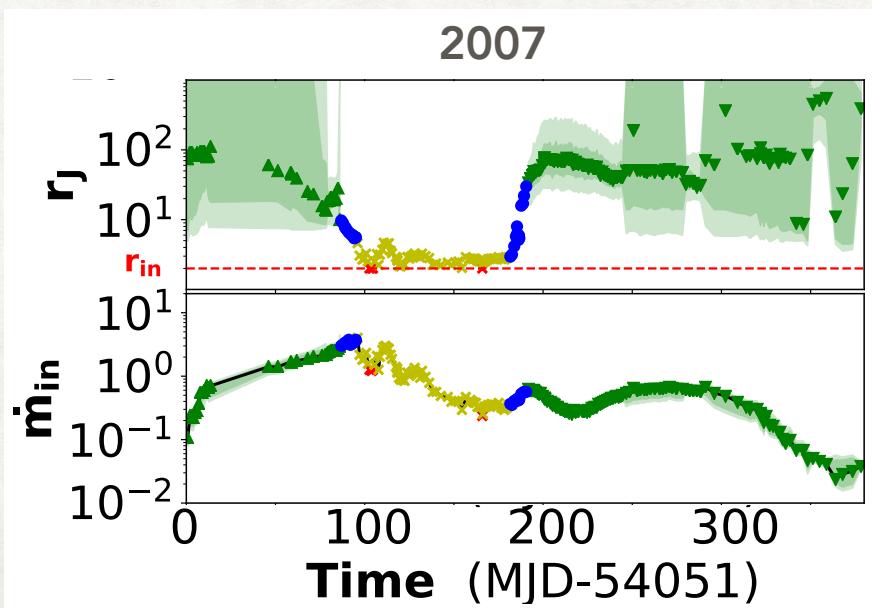
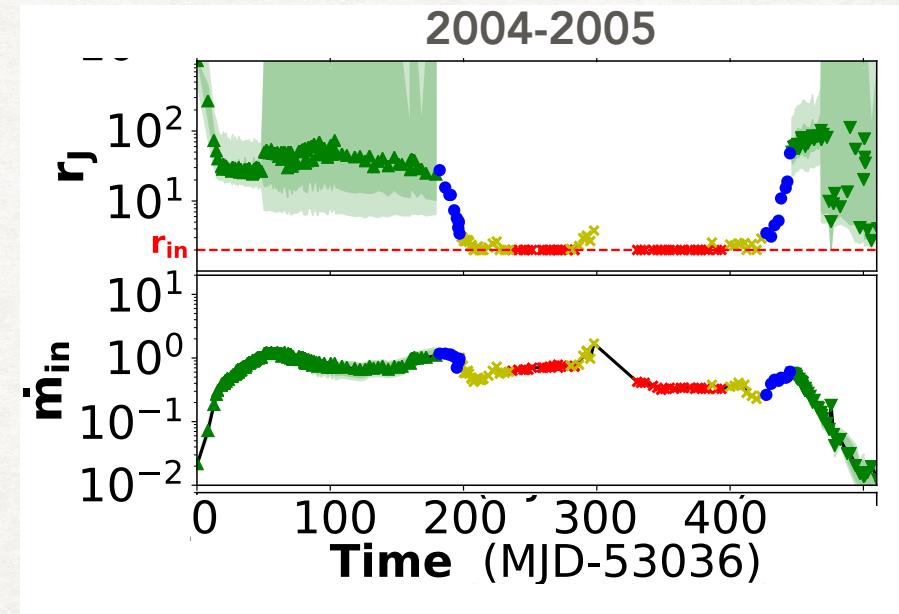
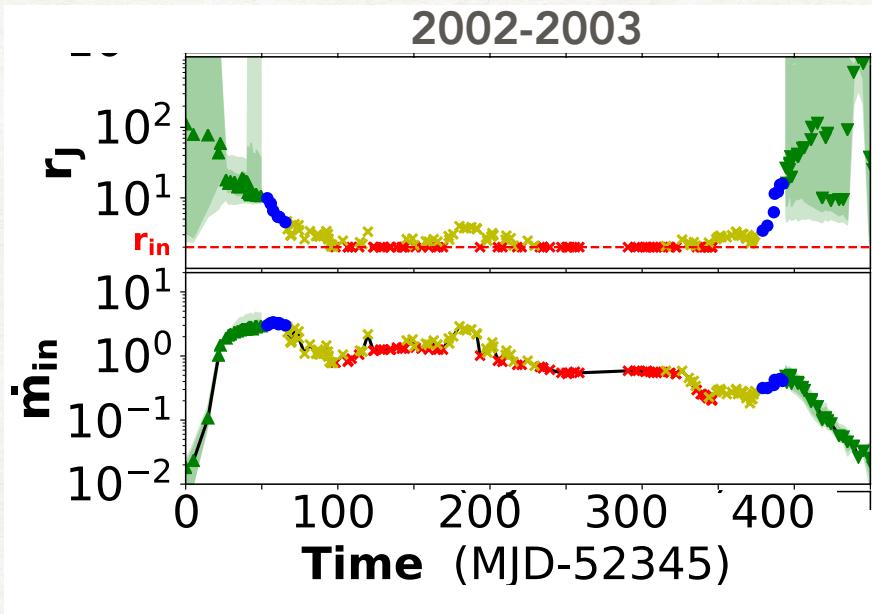


Replication of GX339-4 behavior in 2010-2011



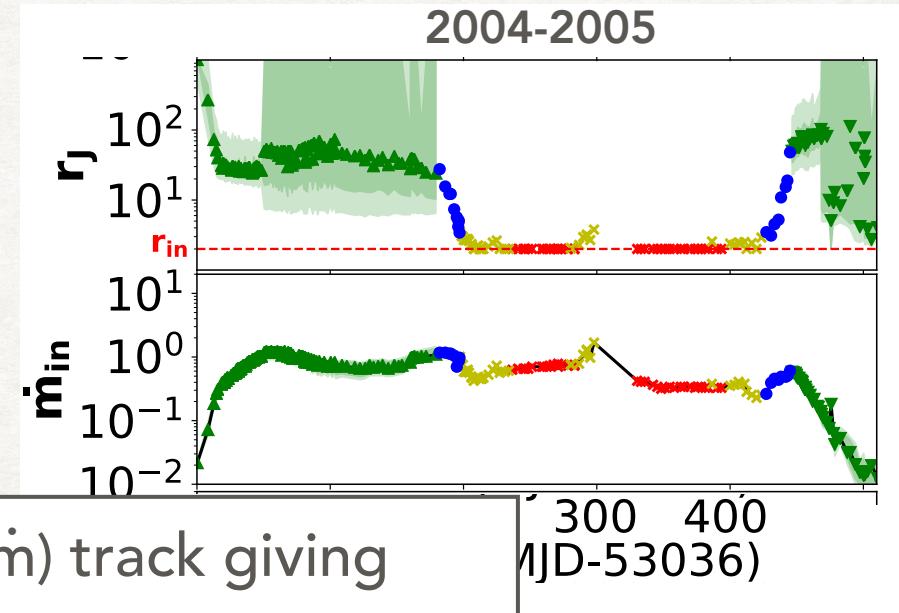
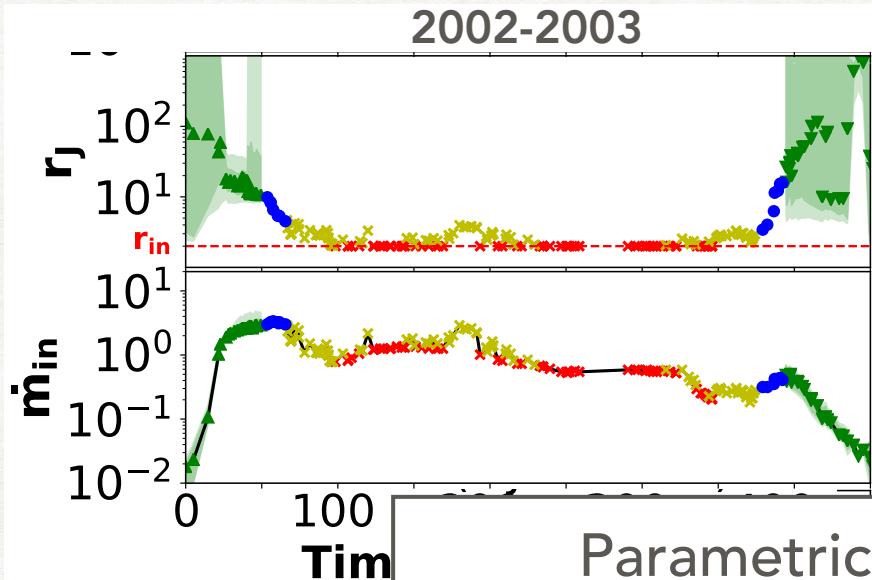
GX339-4: 15 years of RXTE

Marcel et al. 2019b

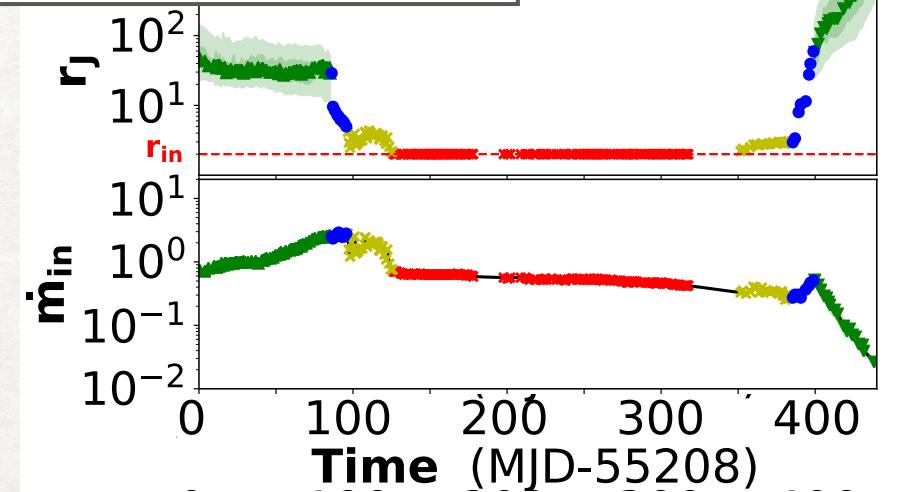
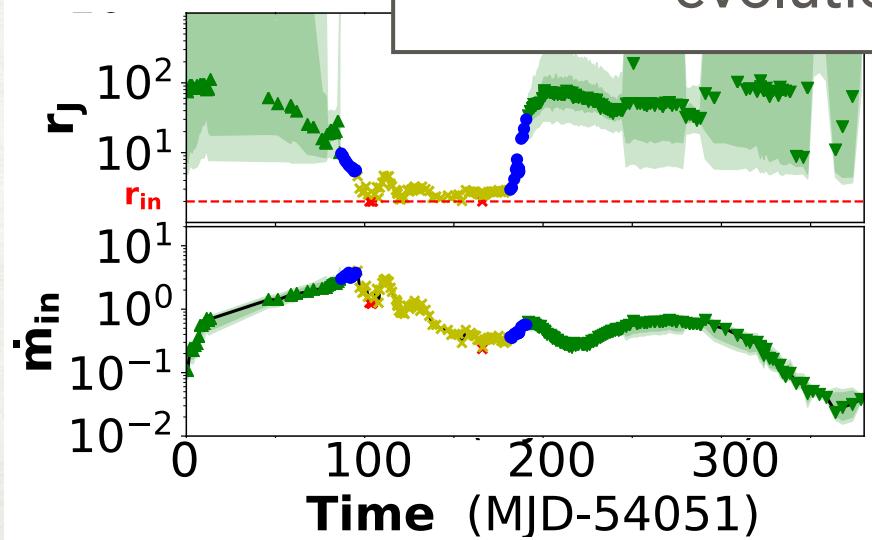


GX339-4: 15 years of RXTE

Marcel et al. 2019b

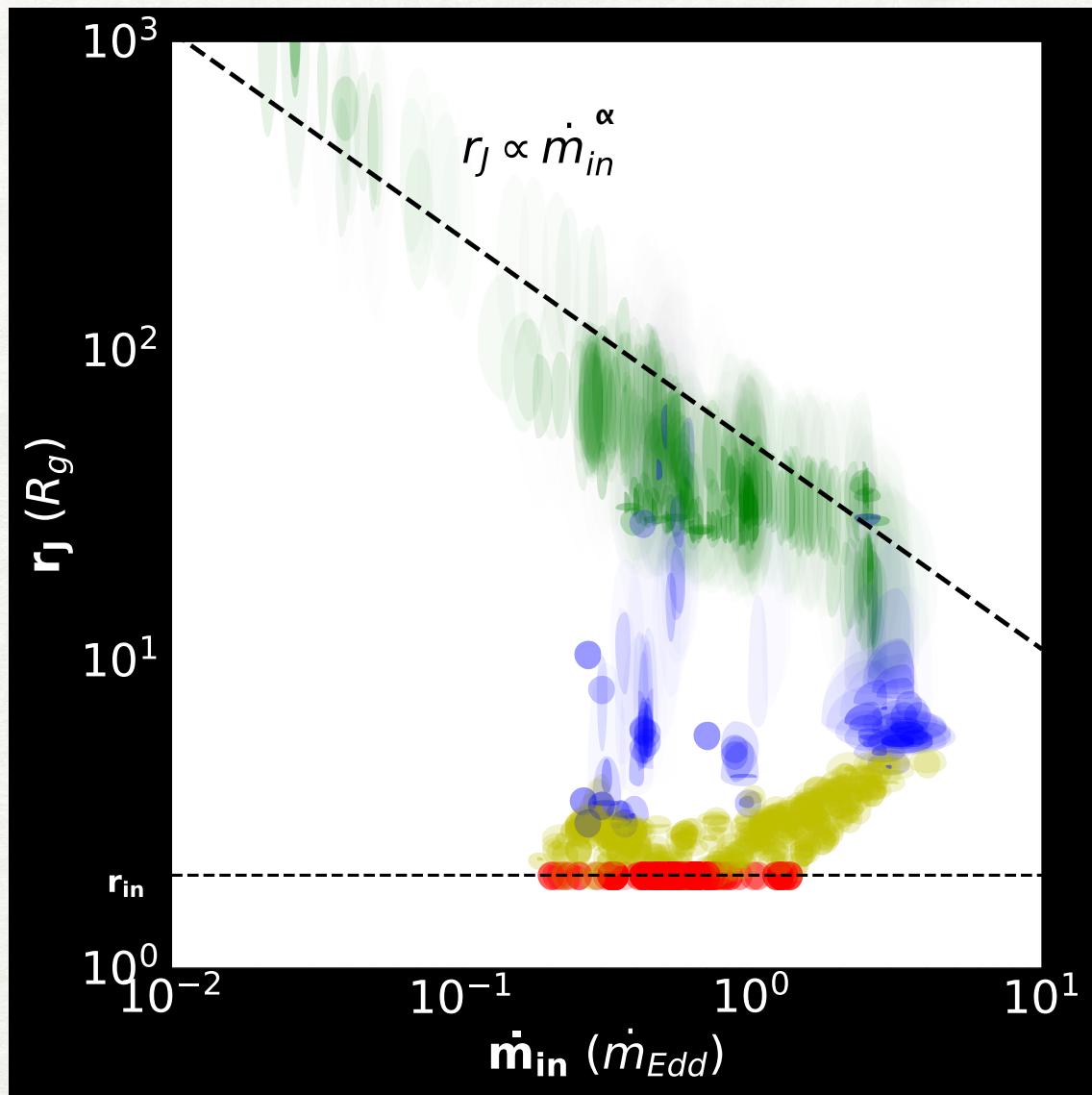


Parametric $r_J(\dot{m})$ track giving
dynamical constraints on the
evolution of GX339-4



GX339-4: 15 years of RXTE

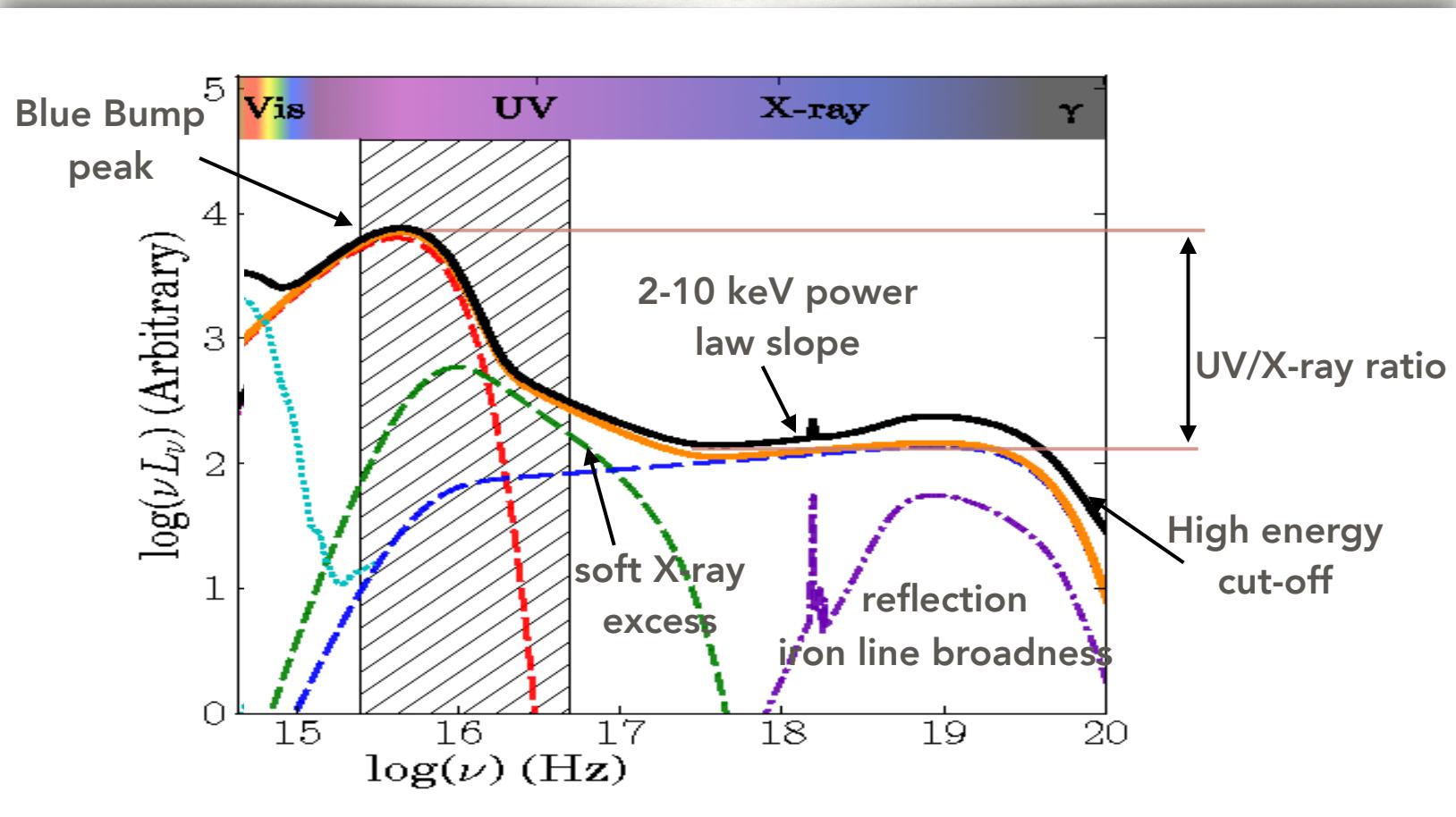
Marcel et al. 2019b



Next Steps: Direct Fits

- JED and SAD tables for XSPEC and ISIS
- Coherent Reflection tables (using reflionx or xillver)
- Application to other X-ray binaries
- Application to AGNs

Application to AGNs



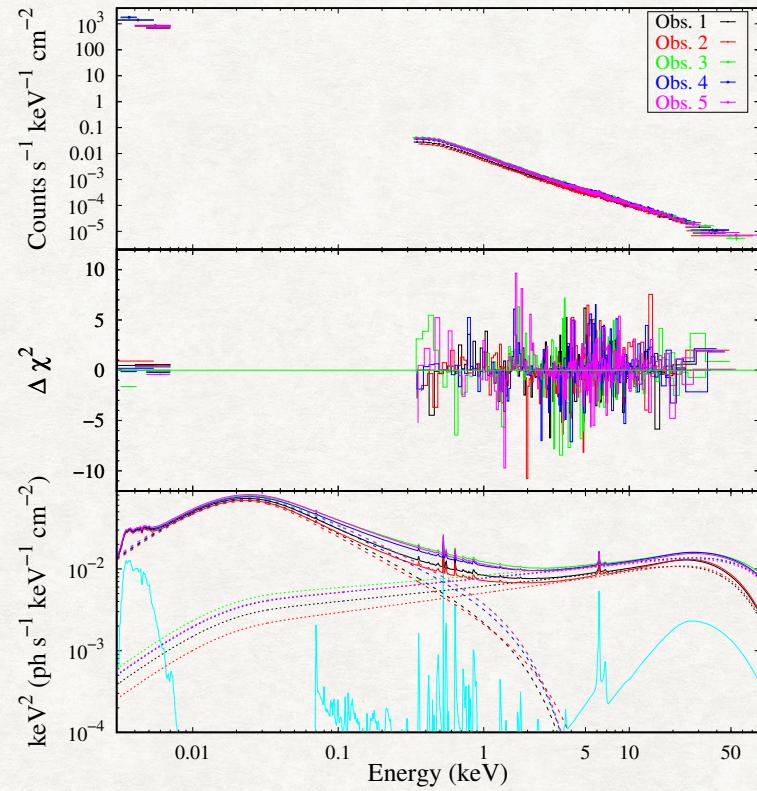
- Data from UV to hard X-rays
- Soft X-ray excess: warm comptonisation of the SAD (*simpl* model of XSPEC)

Model parameters: R_{in} , R_j , M_{BH} , M_{in} , R_{out}

The Case of the Seyfert HE 1143-1810

Ursini et al. (2019) submitted

- Hosting a supermassive black hole with $M_{\text{BH}} \sim 5 \times 10^7 M_{\text{sun}}$
- Luminosity estimated $> L_{\text{Edd}}$
- Blue bump, soft X-ray excess, high energy cut-off, no broad iron line
- Radio-quiet but shows an unresolved radio emission consistent with L_x - L_{radio} fundamental plane of black hole activity



	all obs.	obs. 1	obs. 2	obs. 3	obs. 4	obs. 5
$M_{\text{BH}} (10^7 M_{\odot})$	3.71 ± 0.07					
Γ_s		2.55 ± 0.02	2.58 ± 0.02	2.40 ± 0.0	2.44 ± 0.02	2.40 ± 0.02
$E_s (\text{keV})$		1.33 ± 0.13	$1.44^{+0.18}_{-0.15}$	1.18 ± 0.07	1.19 ± 0.09	1.11 ± 0.06
$r_J (R_{\text{G}})$		17.9 ± 0.5	18.8 ± 0.6	19.3 ± 0.4	19.7 ± 0.4	18.9 ± 0.4
$\dot{m} (L_{\text{Edd}}/c^2)$		0.79 ± 0.02	0.734 ± 0.014	0.92 ± 0.02	0.89 ± 0.02	0.89 ± 0.02
χ^2/dof	2050/2001					

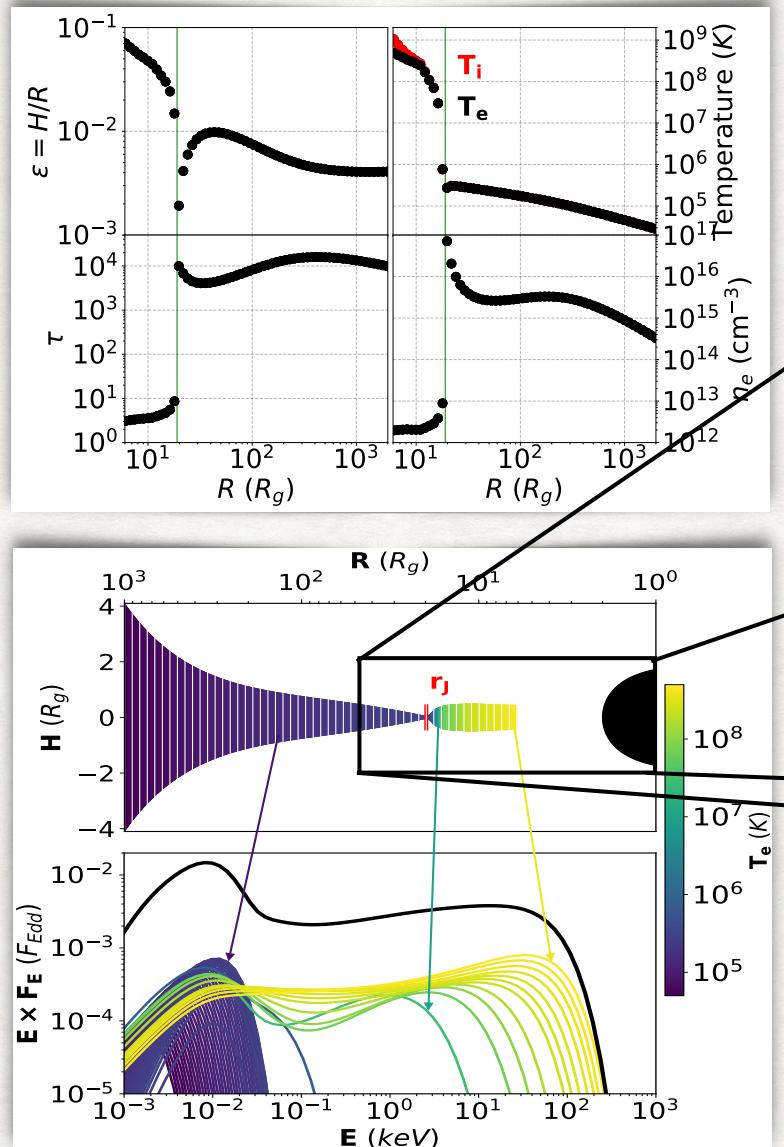
$$\frac{M_{\text{BH}}}{M_{\odot}} \simeq 4 \times 10^7$$

$$\langle R_j \rangle \simeq 20 R_g$$

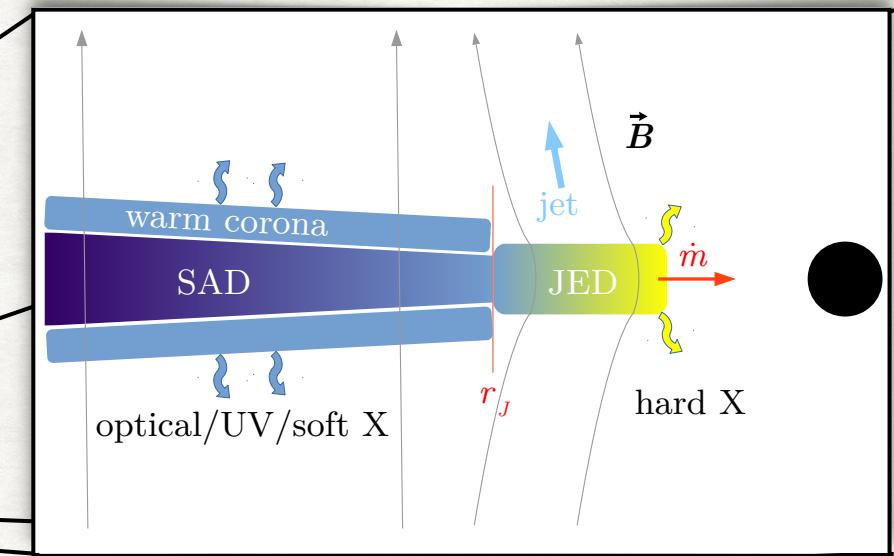
$$\langle \dot{M} \rangle \simeq 0.8 \dot{M}_{\text{Edd}}$$

The Case of the Seyfert HE 1143-1810

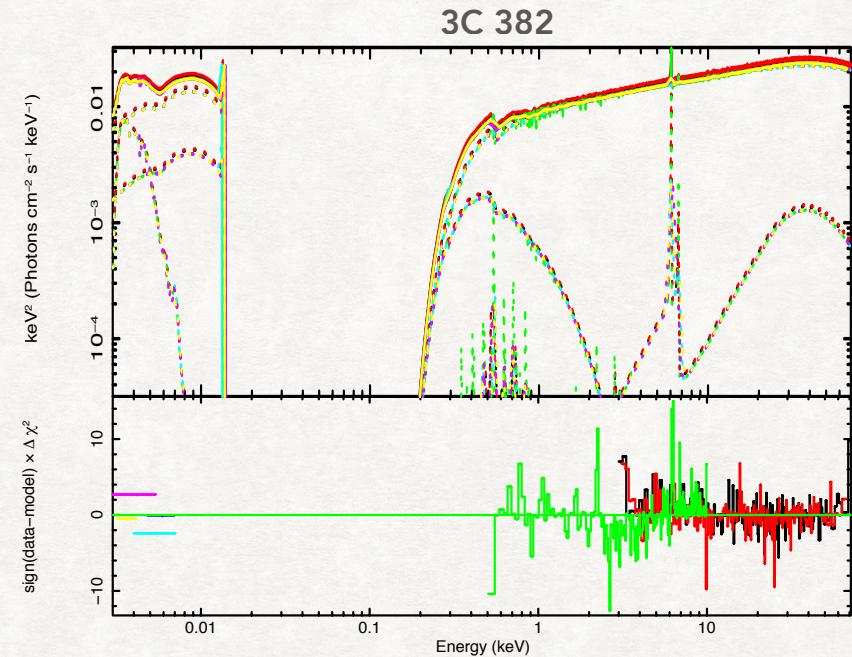
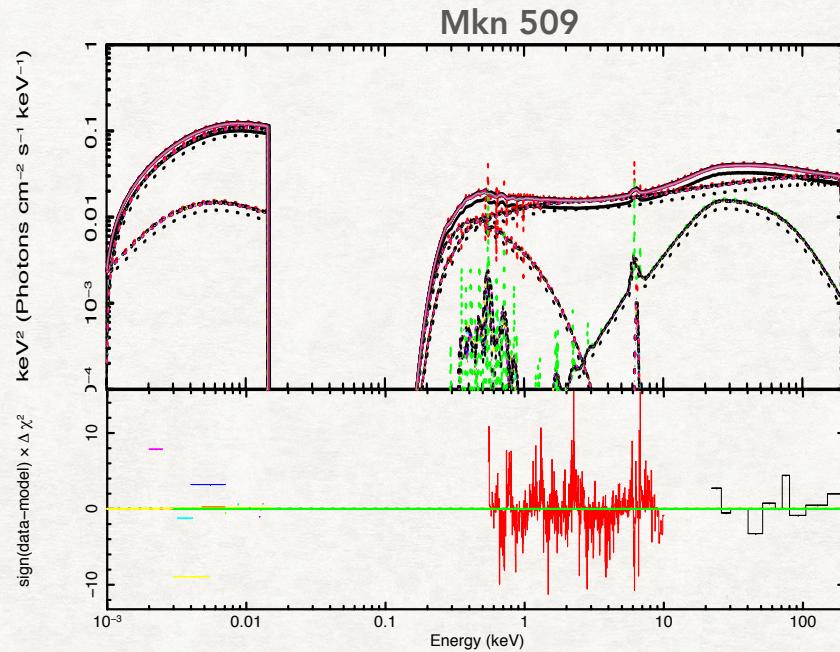
Ursini et al. (2019) submitted



The inner region of an AGN?

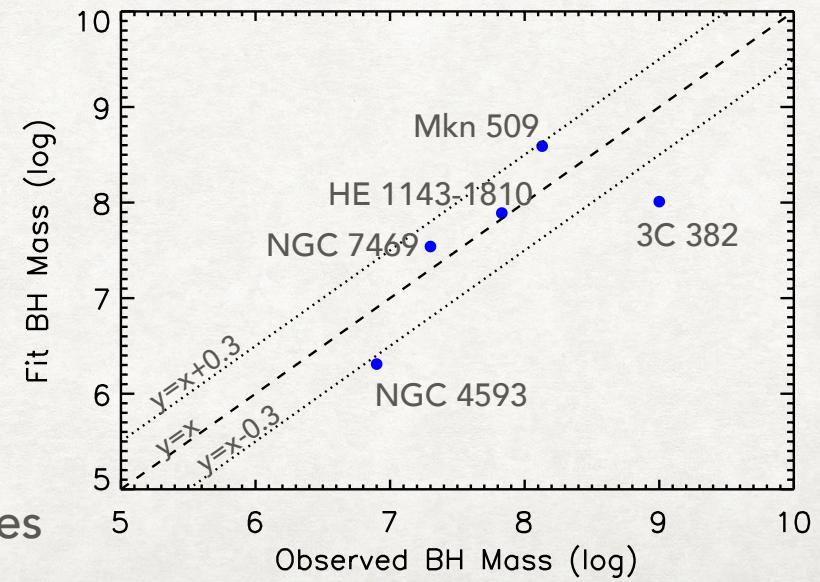


Other AGNs



Source	R_j/R_g	\dot{M}/\dot{M}_{Edd}	$\log M_{BH}$	R_{in}/R_g
HE 1143	$23.77^{+0.32}_{-0.38}$	0.70 ± 0.02	7.89 ± 0.03	6.00 ± 0.09
Mrk 509	$13.68^{+0.11}_{-0.08}$	0.32 ± 0.01	$8.59^{+0.01}_{-0.02}$	2.20 ± 0.04
3C382	$14.91^{+0.21}_{-0.41}$	$1.12^{+0.04}_{-0.06}$	8.01 ± 0.01	$1.79^{+0.06}_{-0.10}$
NGC 4593	$26.51^{+0.42}_{-0.96}$	1.09 ± 0.06	$6.31^{+0.04}_{-0.03}$	$5.98^{+0.36}_{-4.44}$
NGC 7469	$14.33^{+0.10}_{-0.01}$	0.41 ± 0.01	7.54 ± 0.01	$3.30^{+0.05}_{-0.06}$

BH masses in agreement with published ones



Conclusion

- JEDoSAD model for compact objects (Ferreira et al. 2006, Marcel et al., 2018a, b)
- Reproduced the different outbursts of GX 339-4 observed by RXTE (Marcel et al., 2019a, b)
- Built XSPEC/ISIS table model with reflection (xillver & reflionx).
Already applied to:
 - MAXI J1535-571 (Marcel, Neilsen et al., in prep)
 - H1743-322 & GX339-4 (Barnier, Petrucci et al., in prep.)
 - GRS1739-278 (Petrucci et al.),
 - AGN HE1143-1810 (Ursini et al. 2019, subm.)
 - Sample of AGNs (Barnier et al., in prep)
 - ...

THANKS!