Accretion disc winds from LMXBs

Investigación
Programa
Ramón y Cajal

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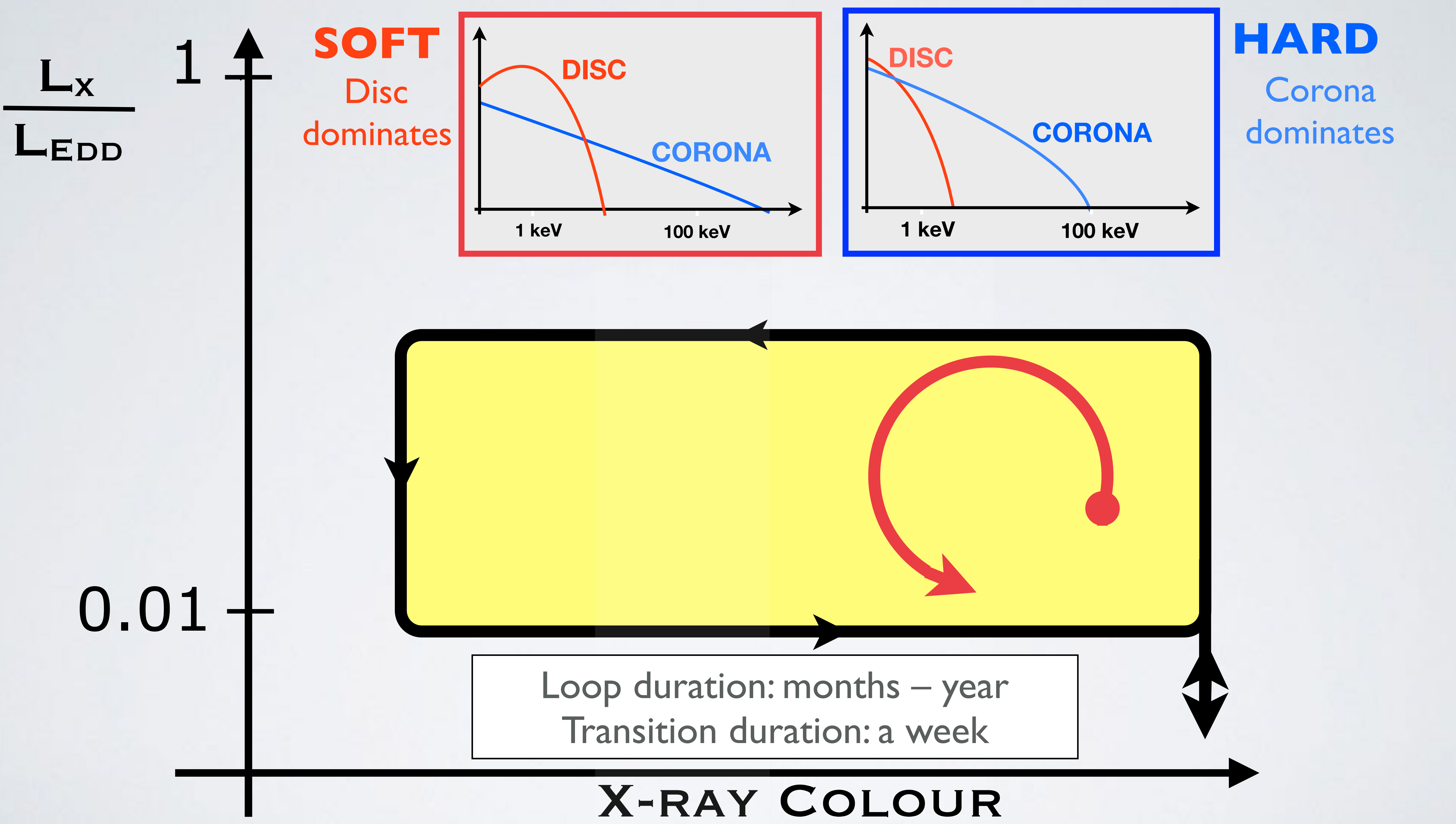
INSTITUTO DE ASTROFÍSICA DE CANARIAS (IAC)

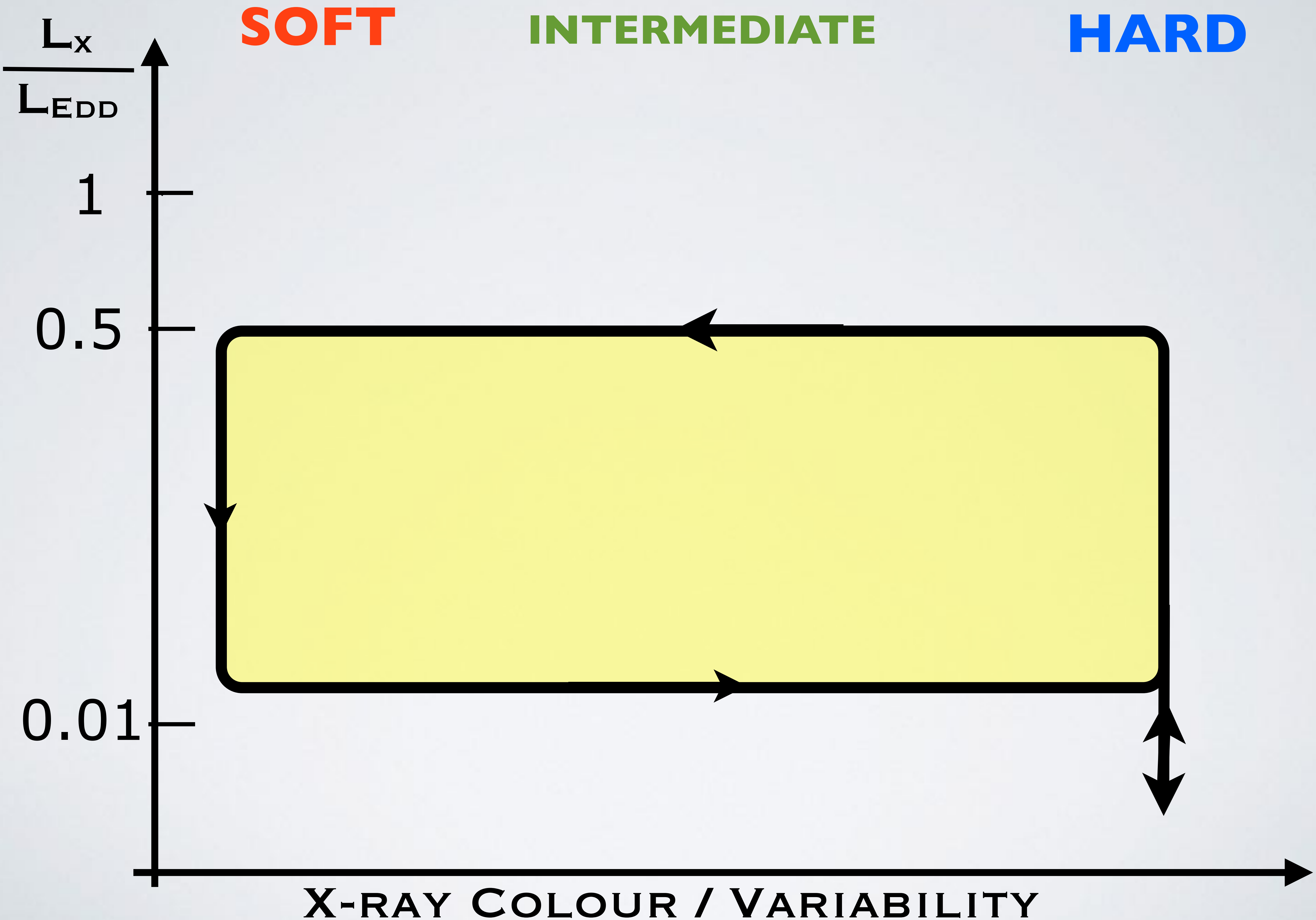
Acciones de dinamización
Proyectos Europa
Excelencia

Accretion States



Fender et al. 2004 / Remillard & McClintock (2006) / Done et al. 2007 / Belloni (2010) / …

Accretion-Outflow states



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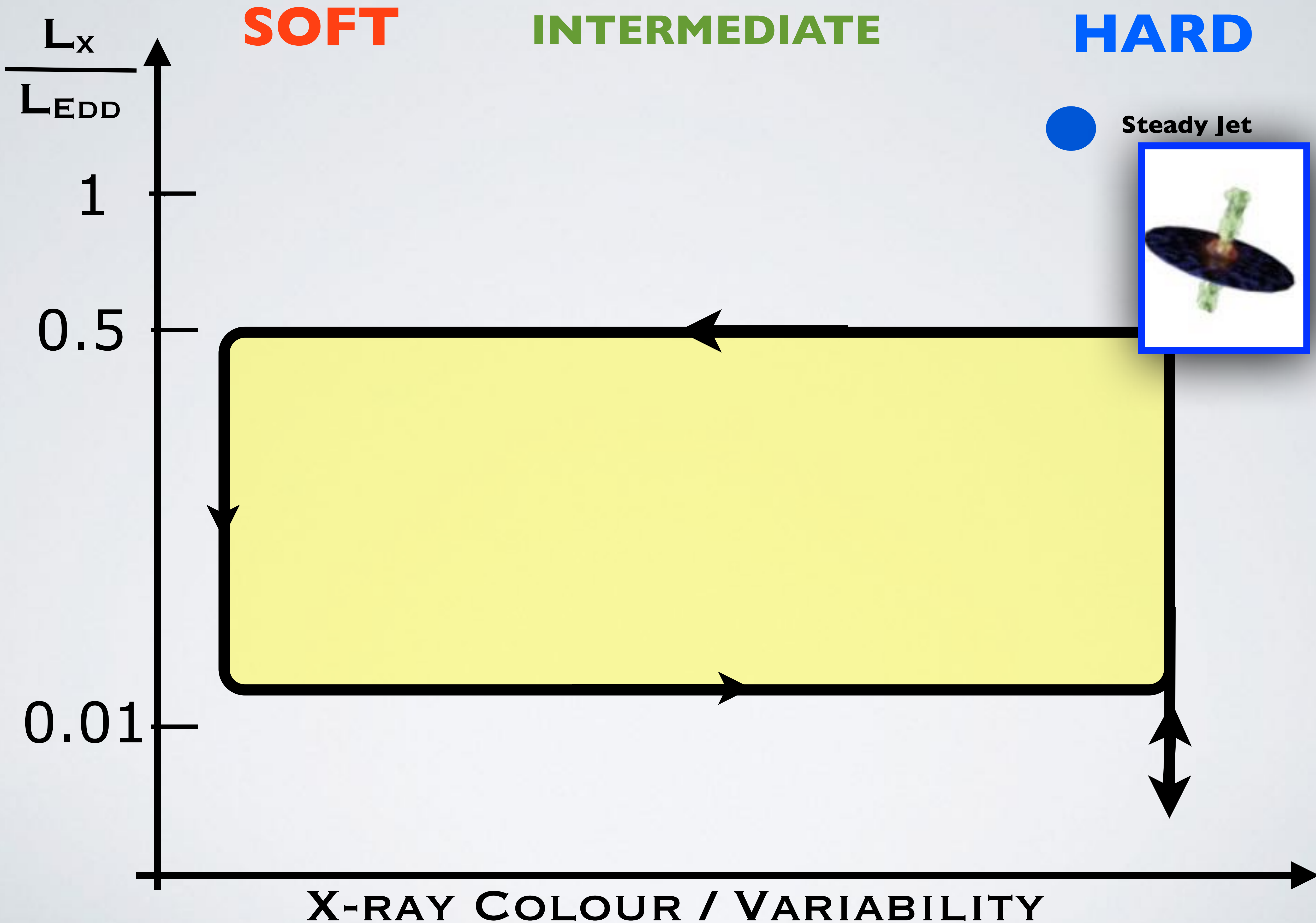

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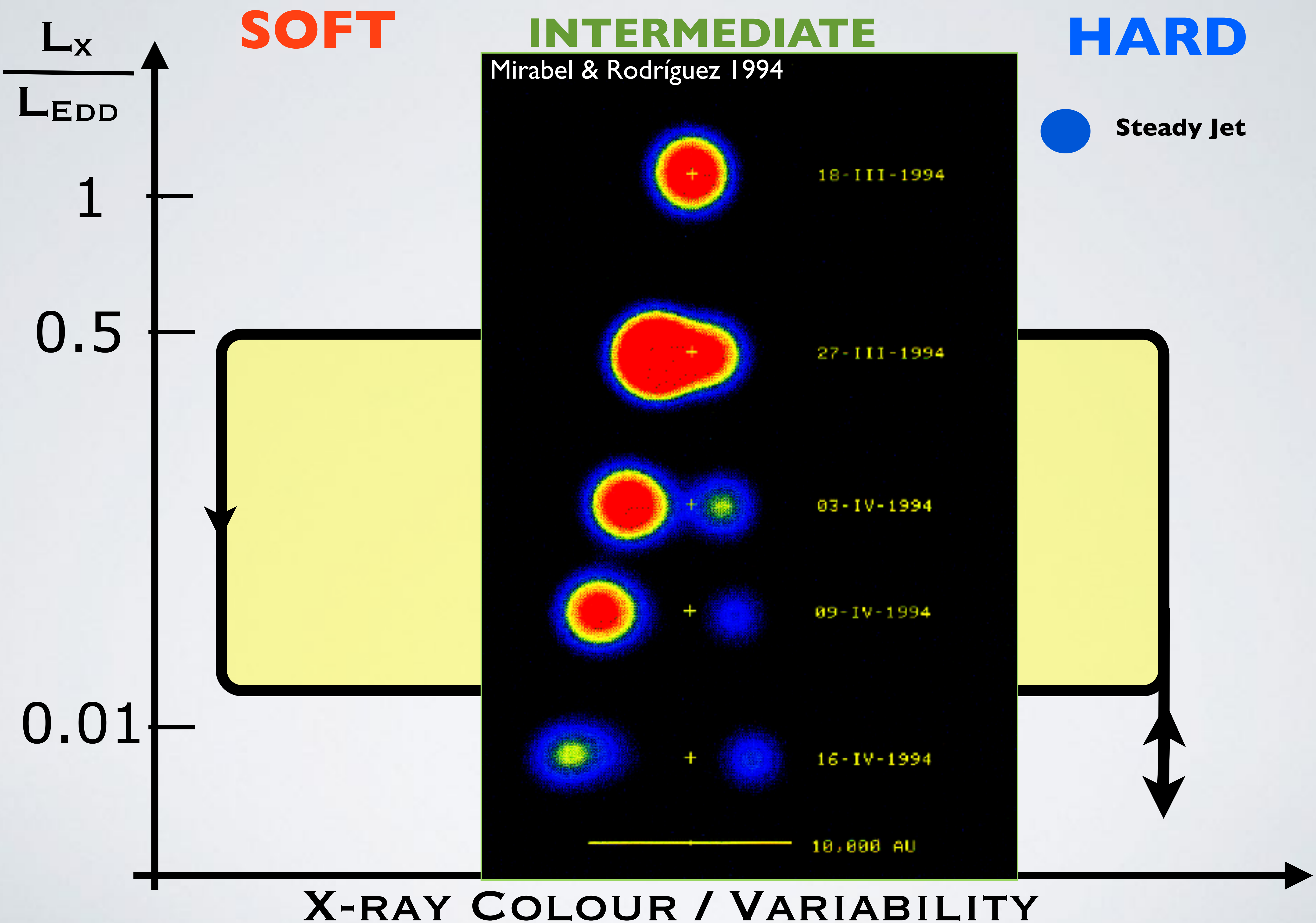

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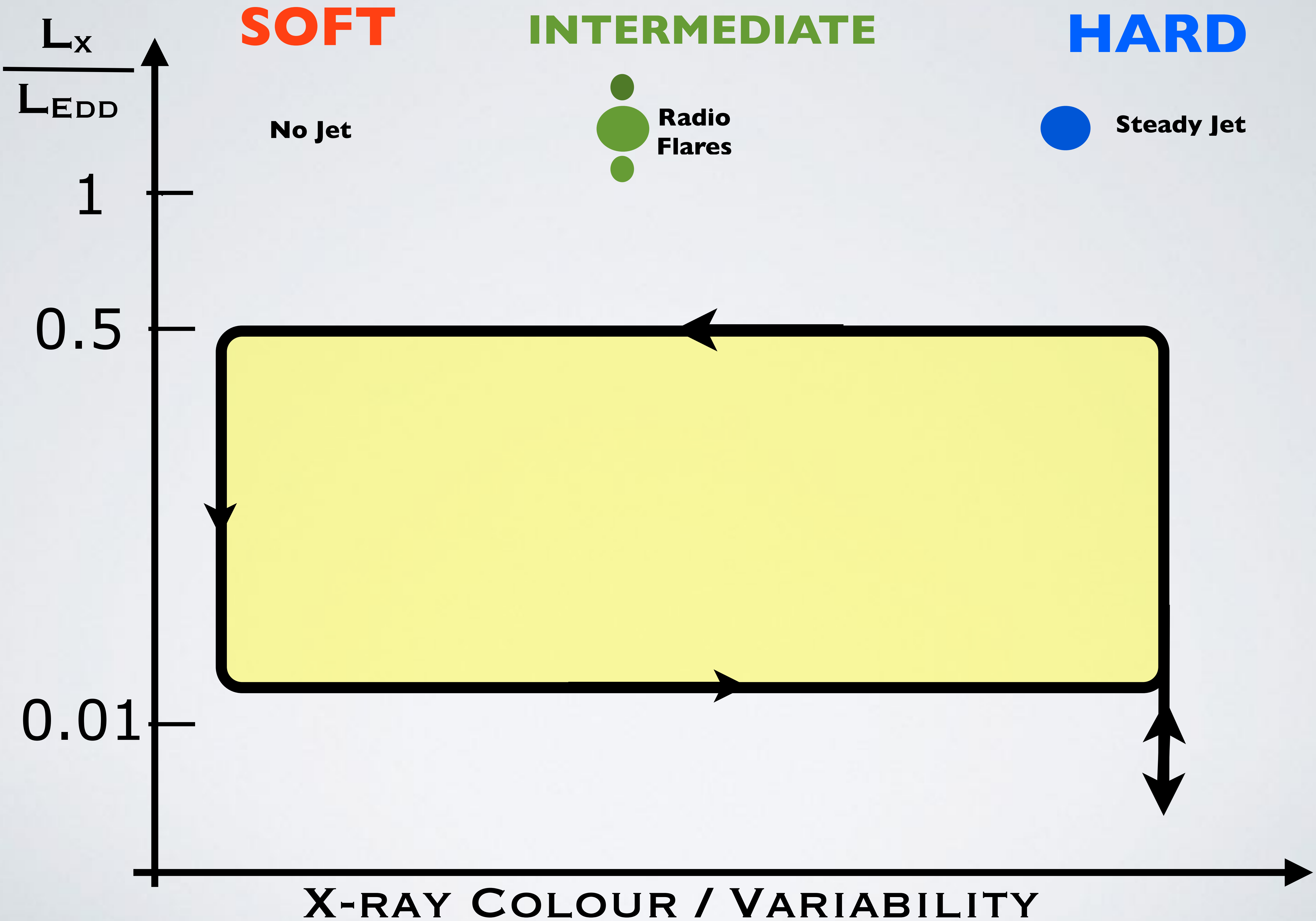

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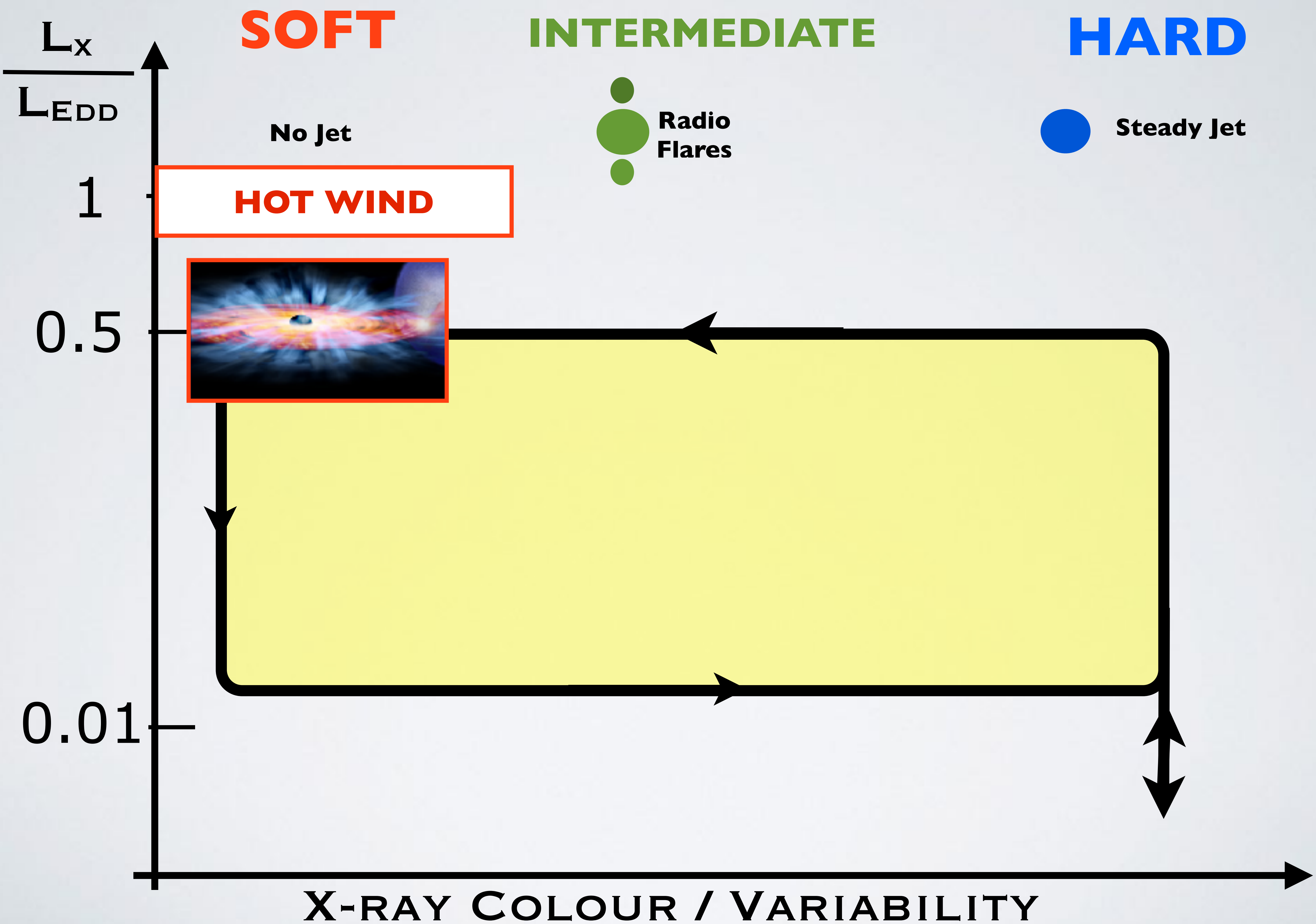
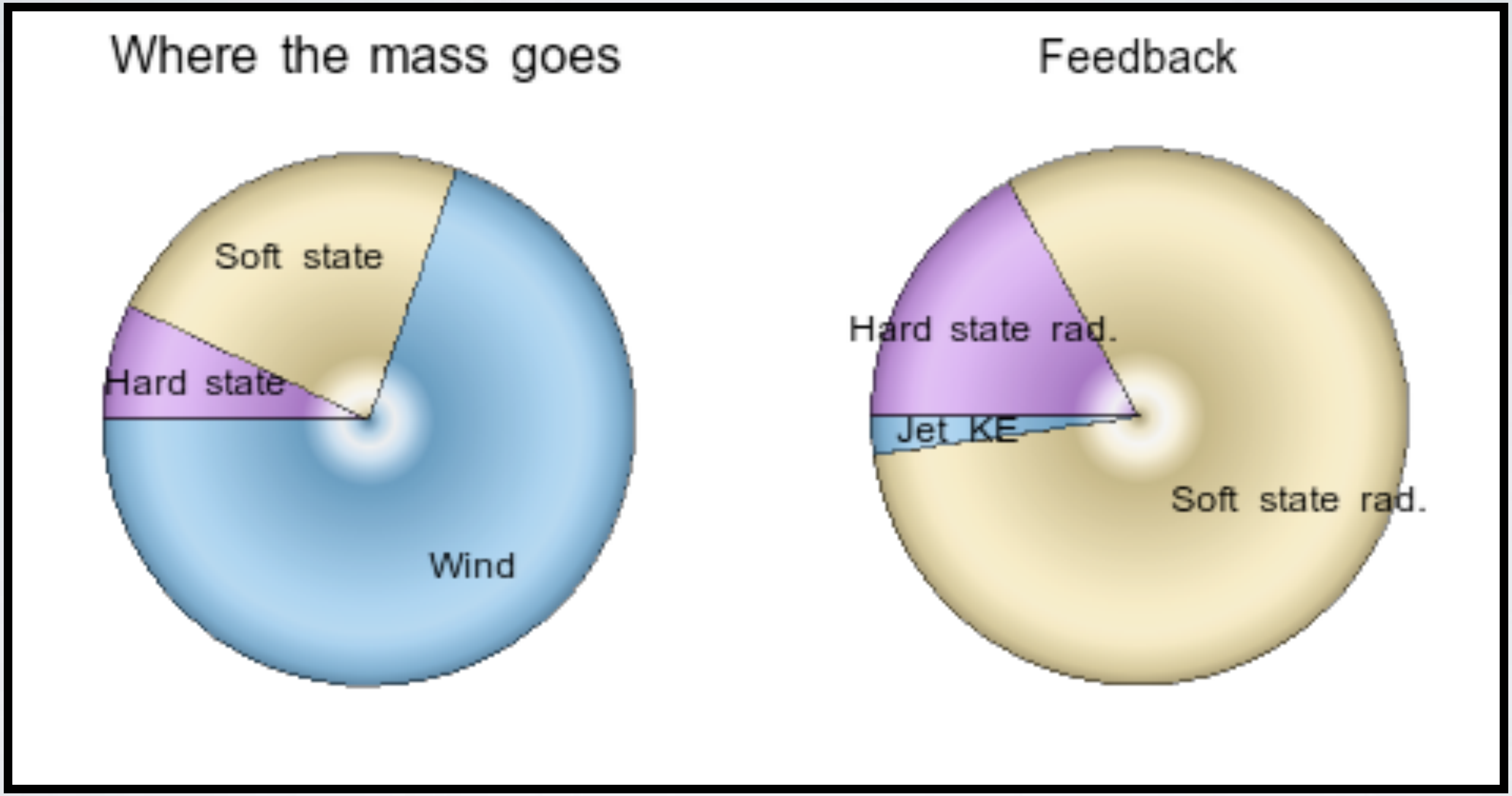


Why outflows are important?



Fender & Muñoz-Darias 2016

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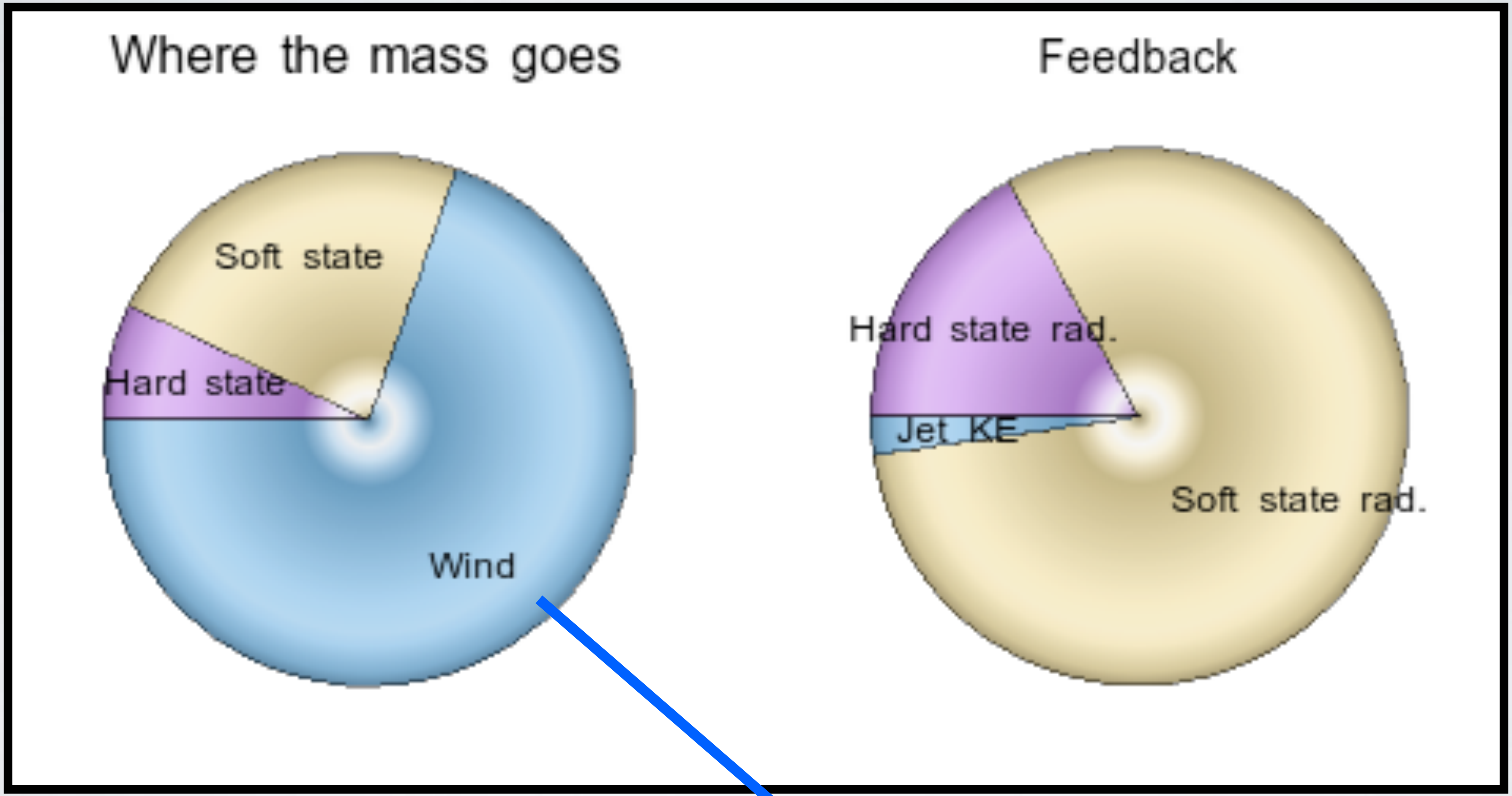
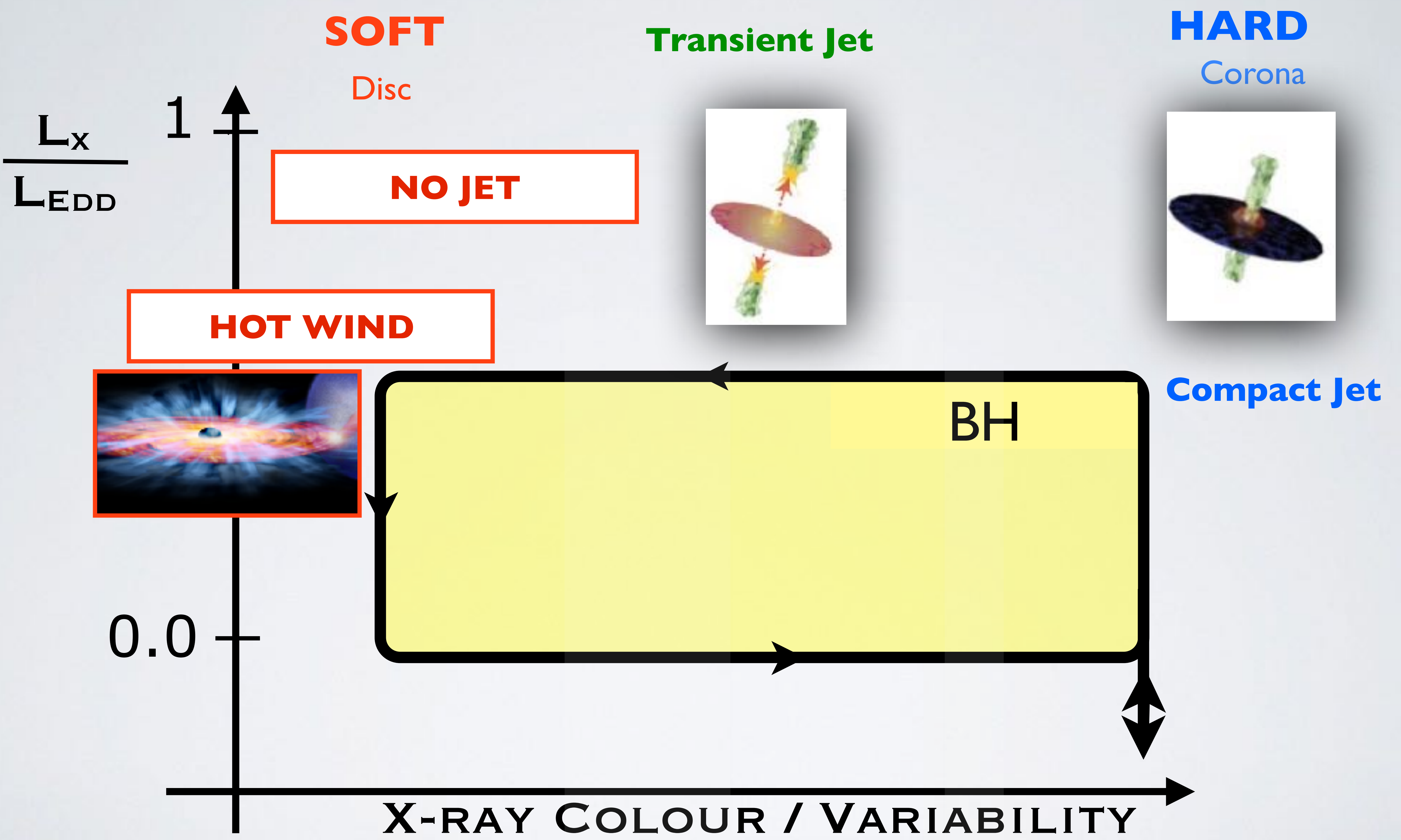


Fender & Muñoz-Darias 2016

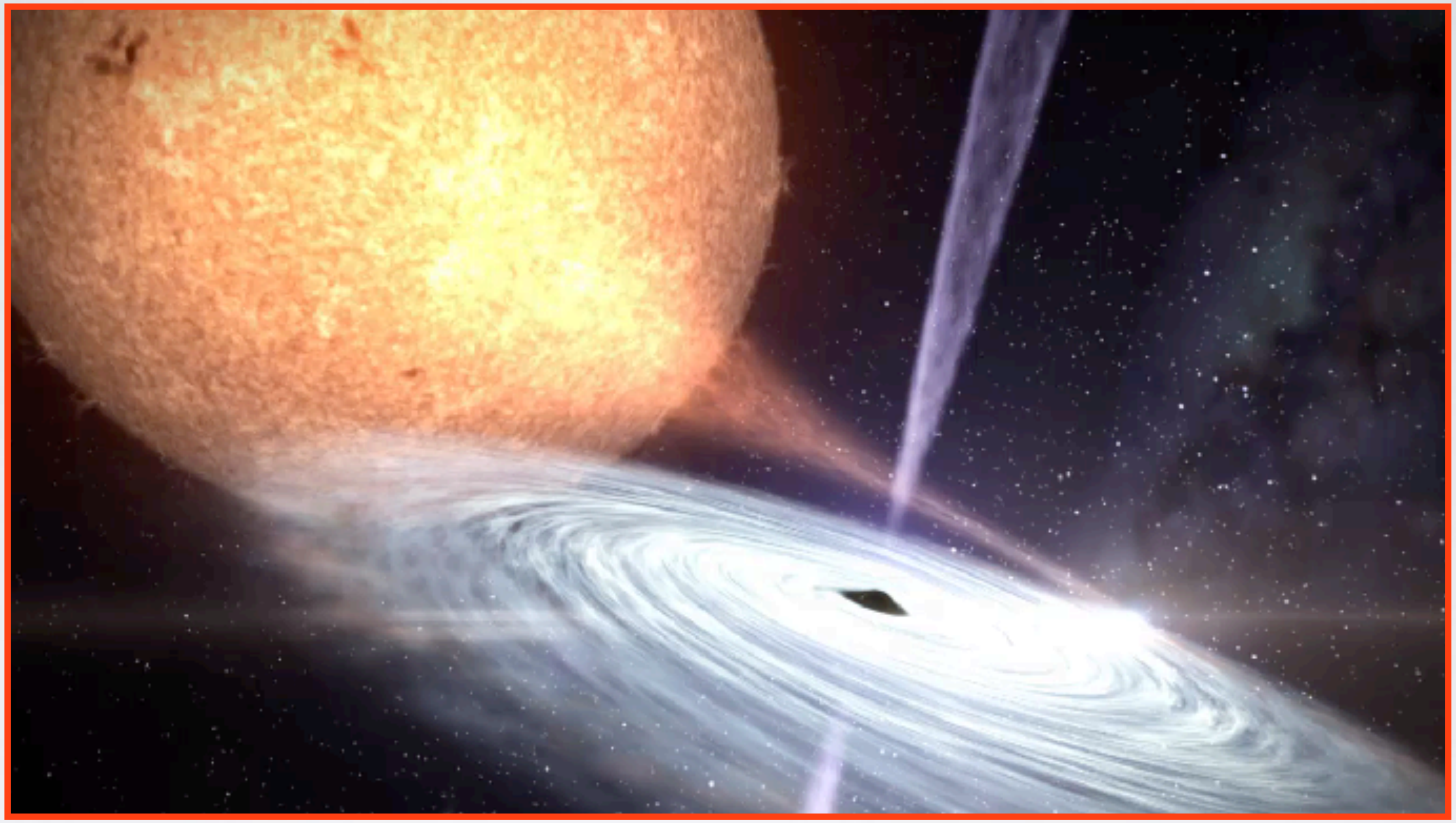
Winds might be fundamental in the outburst evolution

Accretion/Outflow states in Black Holes



Fender & Muñoz-Darias 2016 for a review

V404 Cygni: a nearby and powerful BH transient



V404 Cyg is a ~10 $M_\odot$ is black-Hole in a 6.5 day orbital period at 2.4 kpc

(Casares, Charles & Naylor 1992; Miller-Jones et al. 2009)

★Very large accretion disc with R_{out} ~ 30 light seconds (9 x 10^6 km)

★In quiescence since 1989….back in outburst in June 2015

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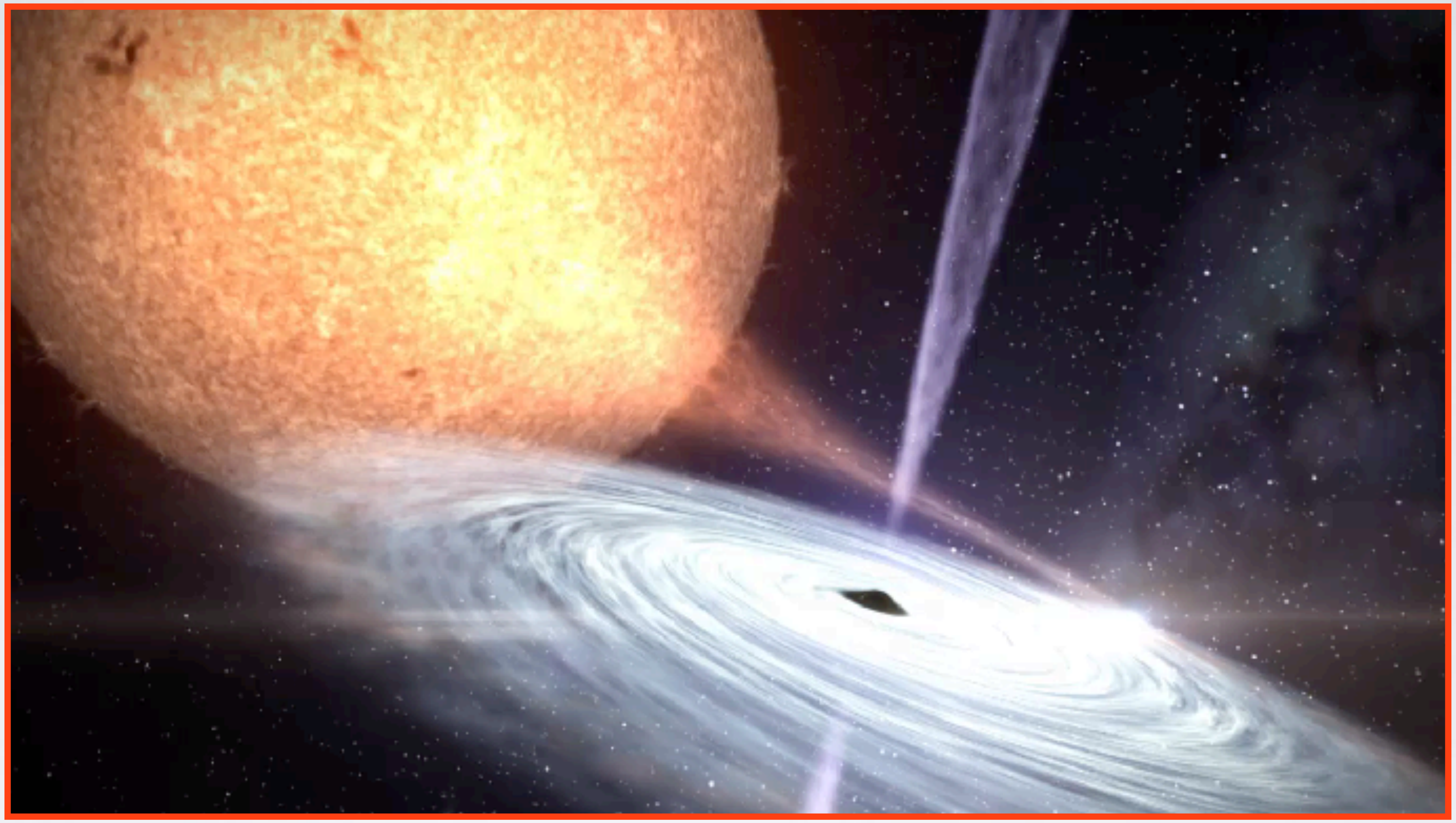

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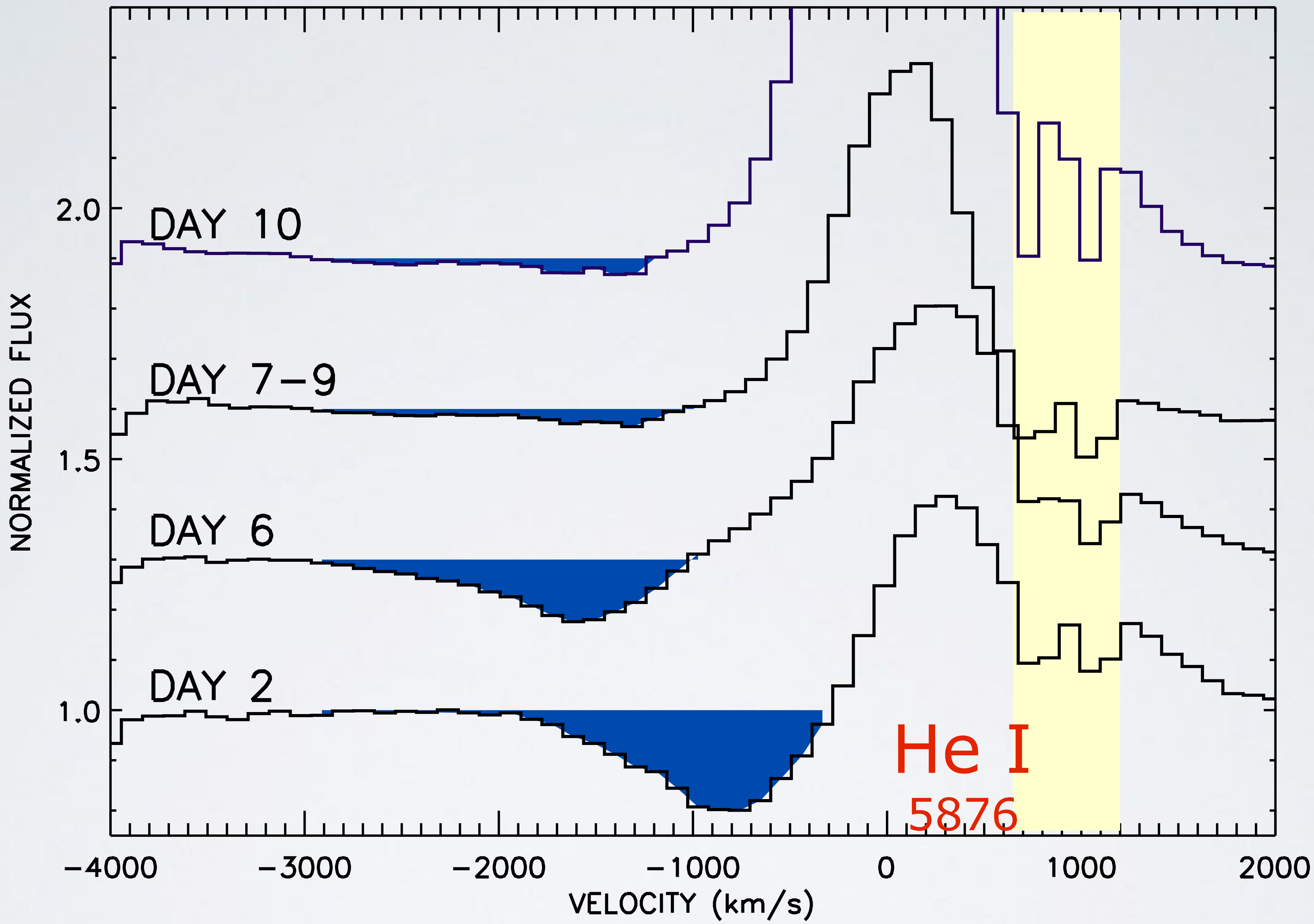
P-Cyg Profiles in 12 emission lines

Muñoz-Darias et al. 2016, Nature

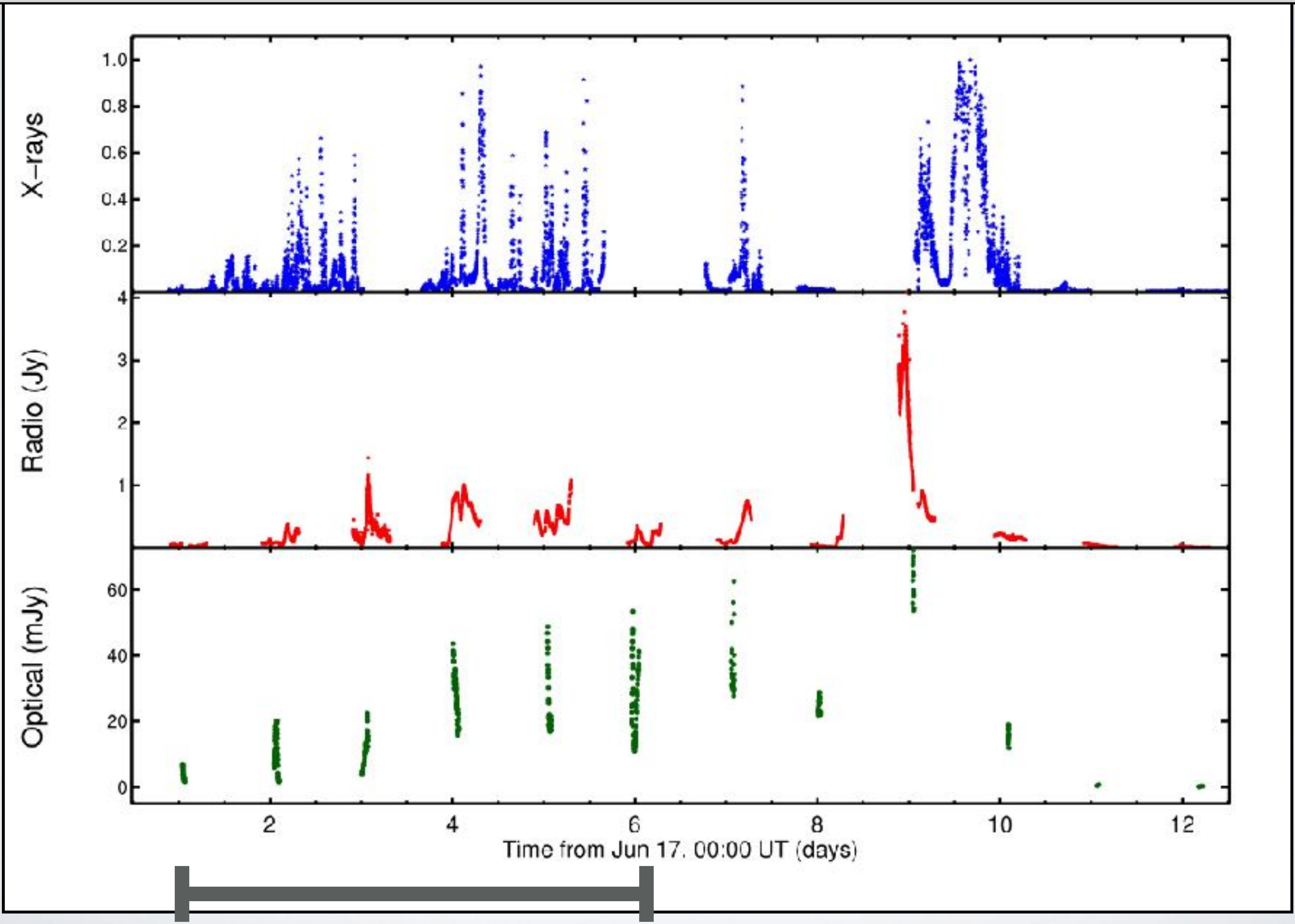


High-velocity, optical wind from the outer disc

Simultaneous with the radio jet

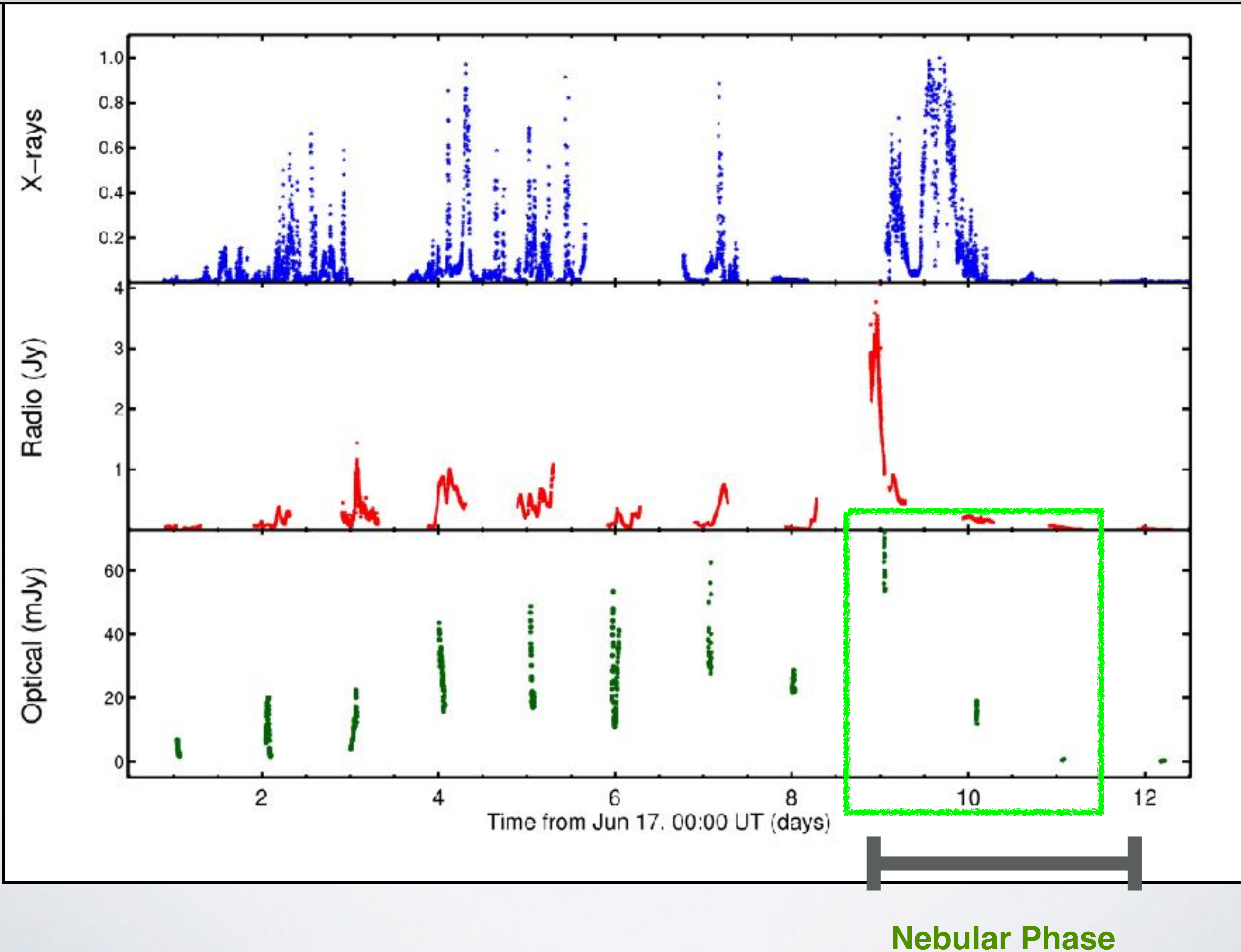
X-ray wind detected by Chandra **King et al. 2015**

V404 Cygni: 2015 Outburst



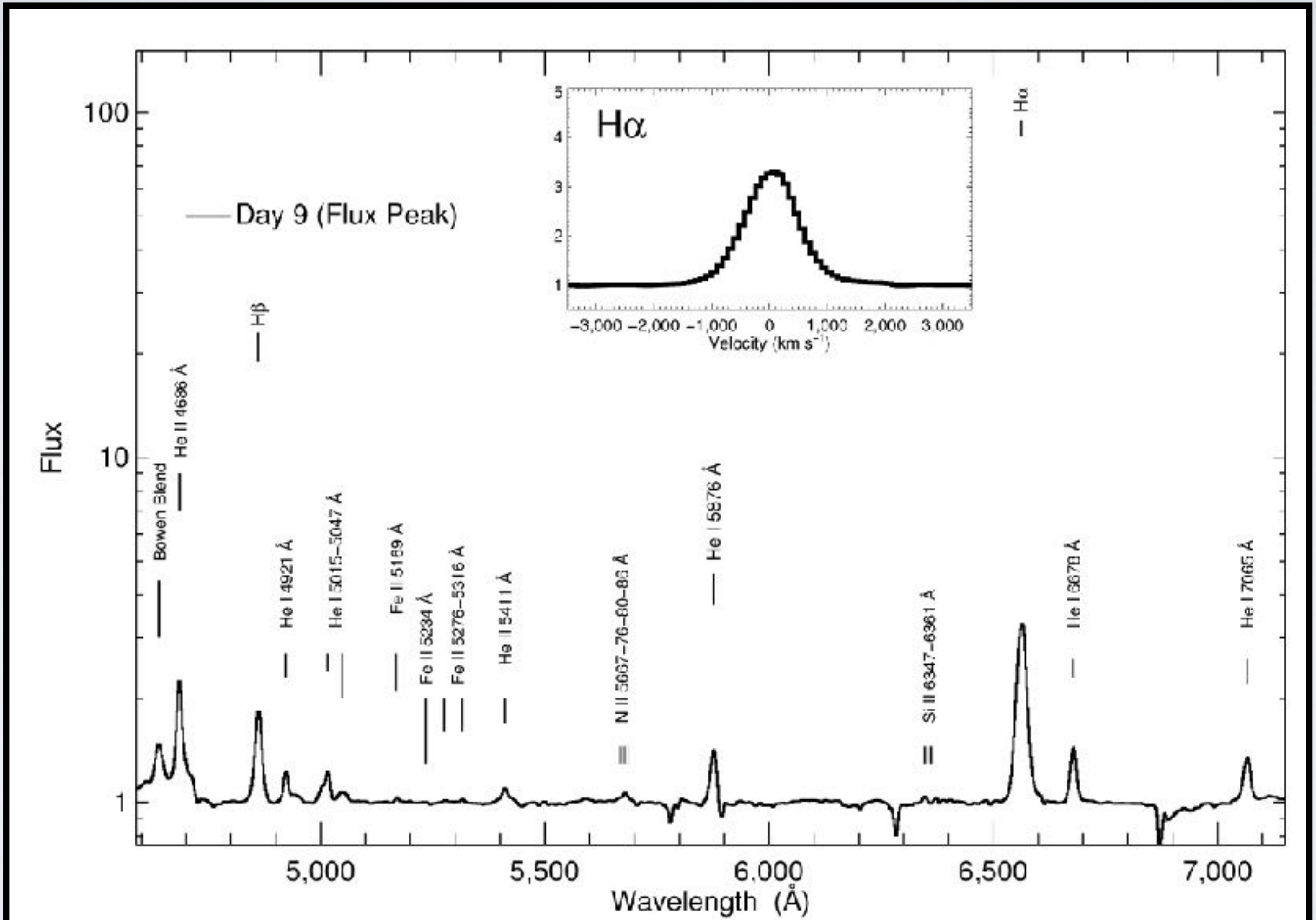
Low Ionisation: P-Cyg Profiles

V404 Cygni: 2015 Outburst



Nebular Phase

Muñoz-Darias et al. 2016, 2017 & Mata Sánchez et al. 2018 & Casares et al. 2019



Optically thick to optically thin transition

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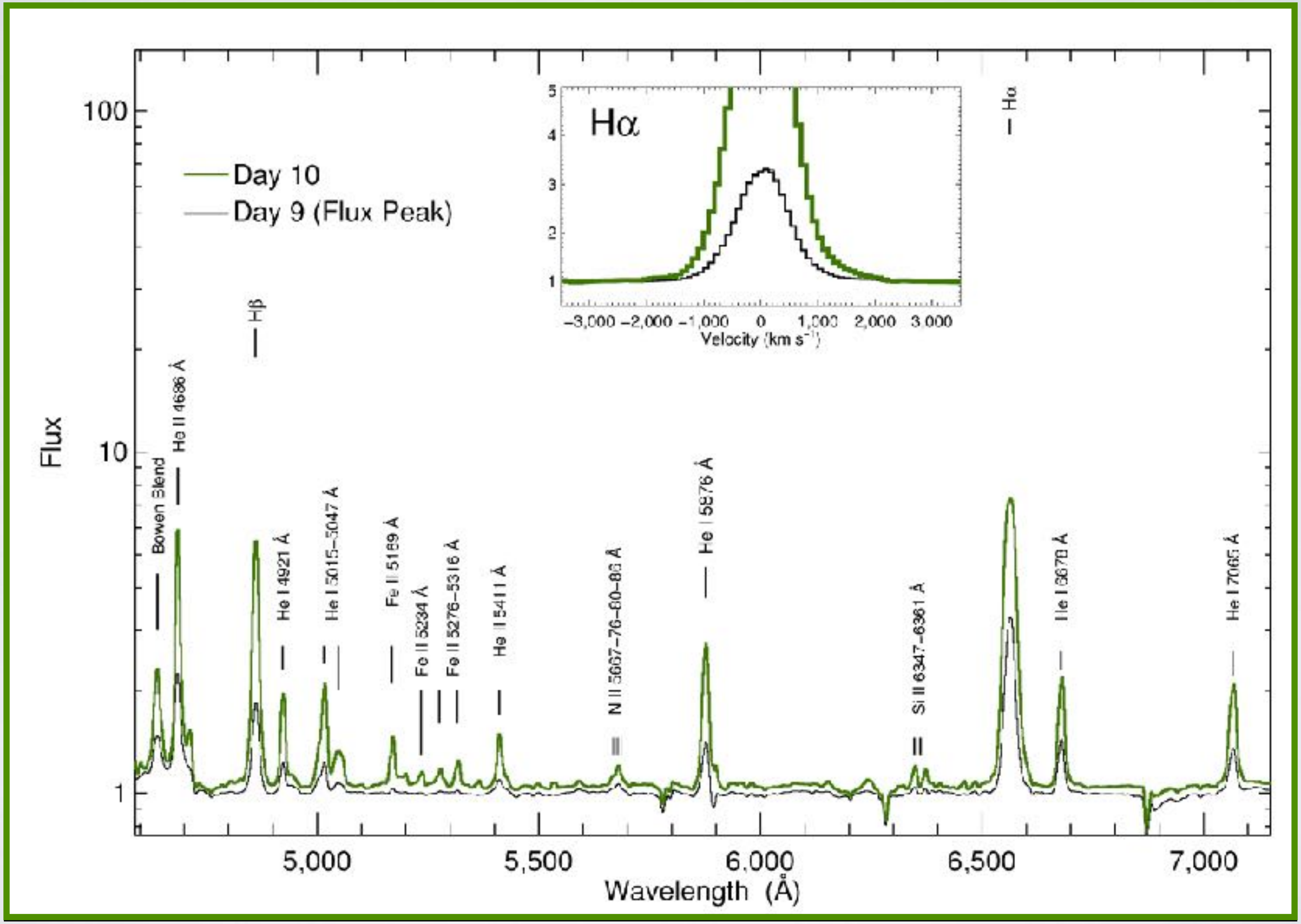

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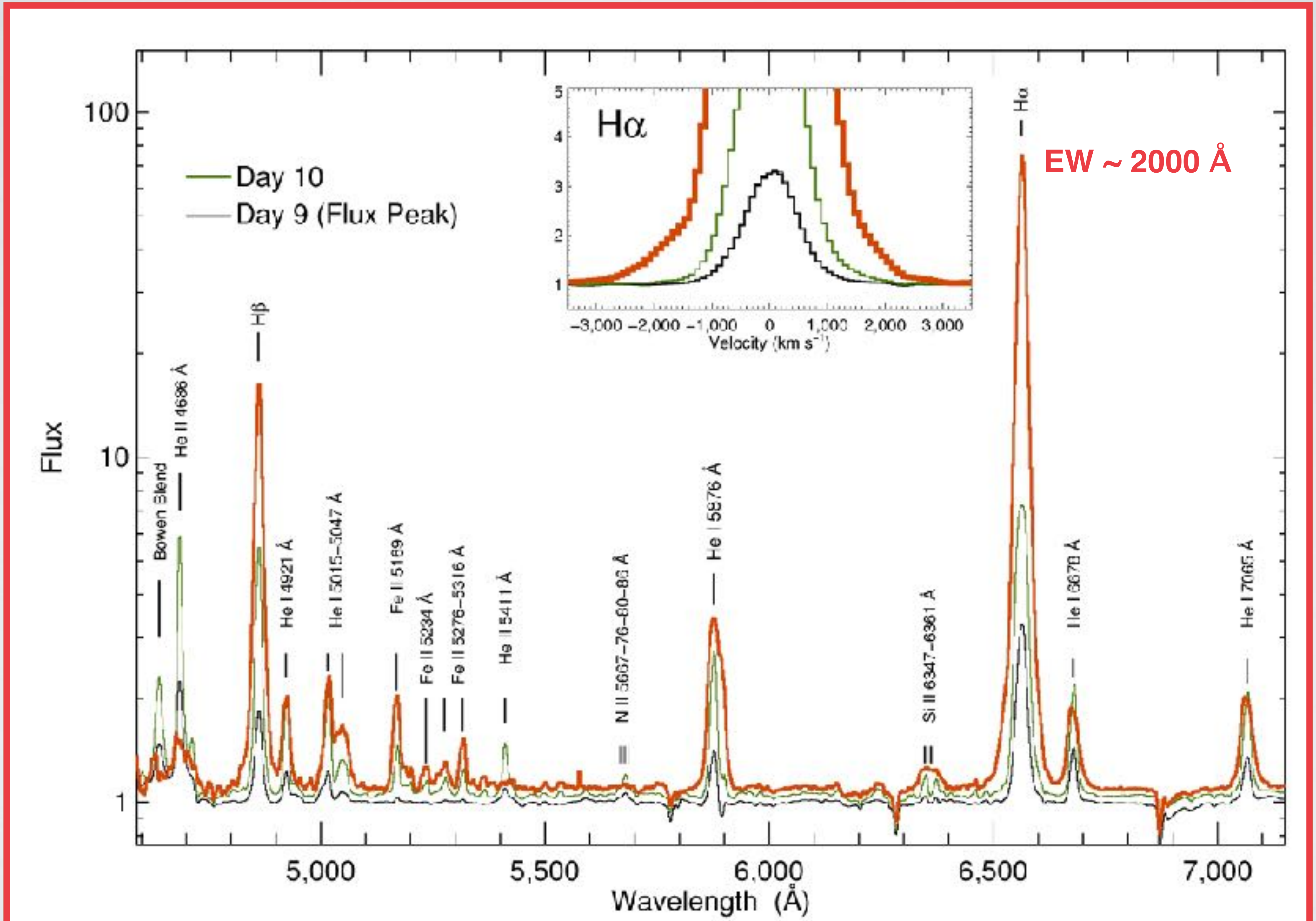

Optically thick to optically thin transition

Mass Balance

Disc contains: $\mathbf{M_{disc}} \sim 10^{-5} - 10^{-6}\ M_\odot$

- Ejected Mass: >> 0.001 $\mathbf{M_{disc}}$
- Accreted Mass: ~ 0.001 $\mathbf{M_{disc}}$
- Transferred Mass (quiescence): ~ 0.001 $\mathbf{M_{disc}}$

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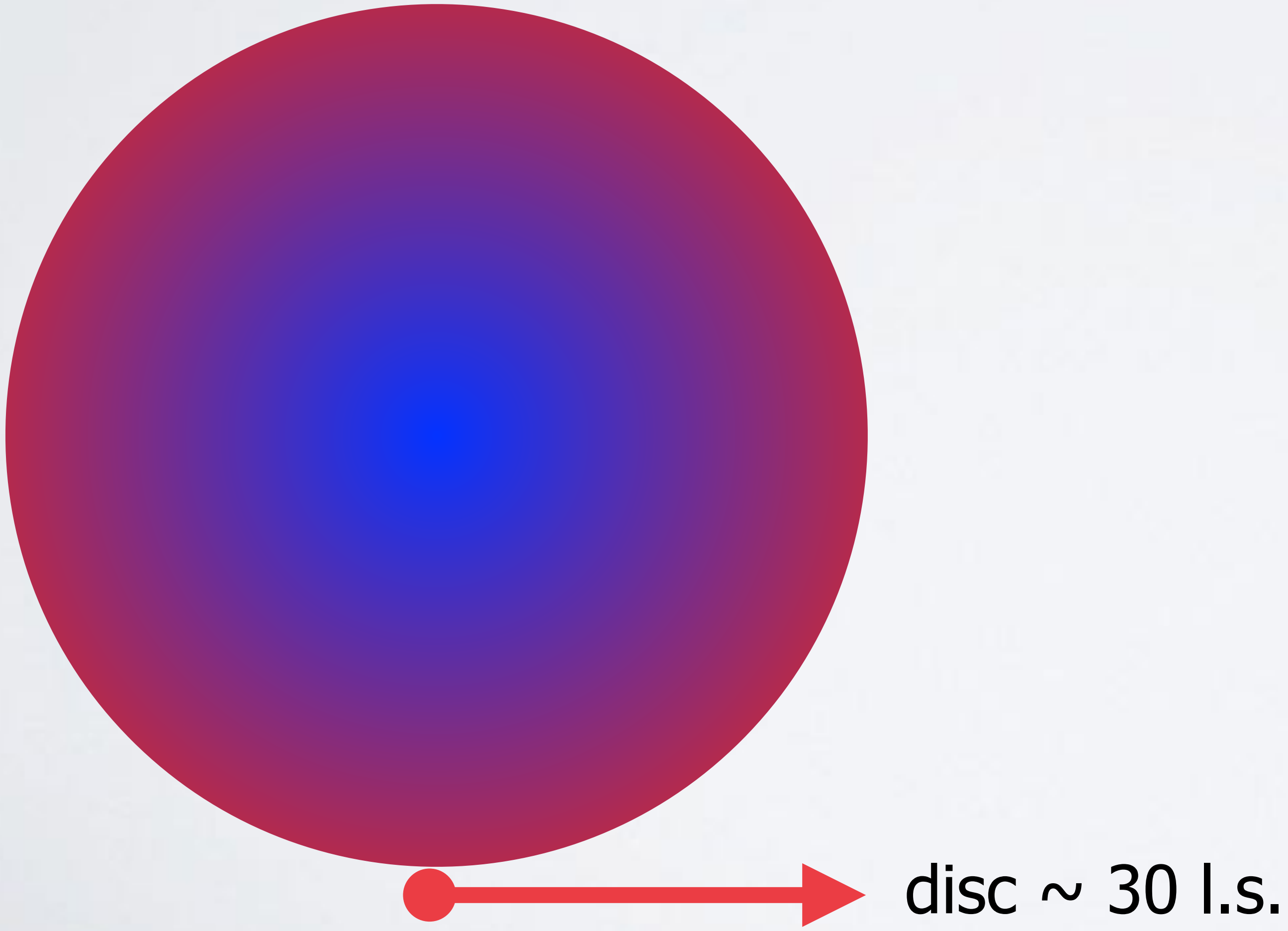

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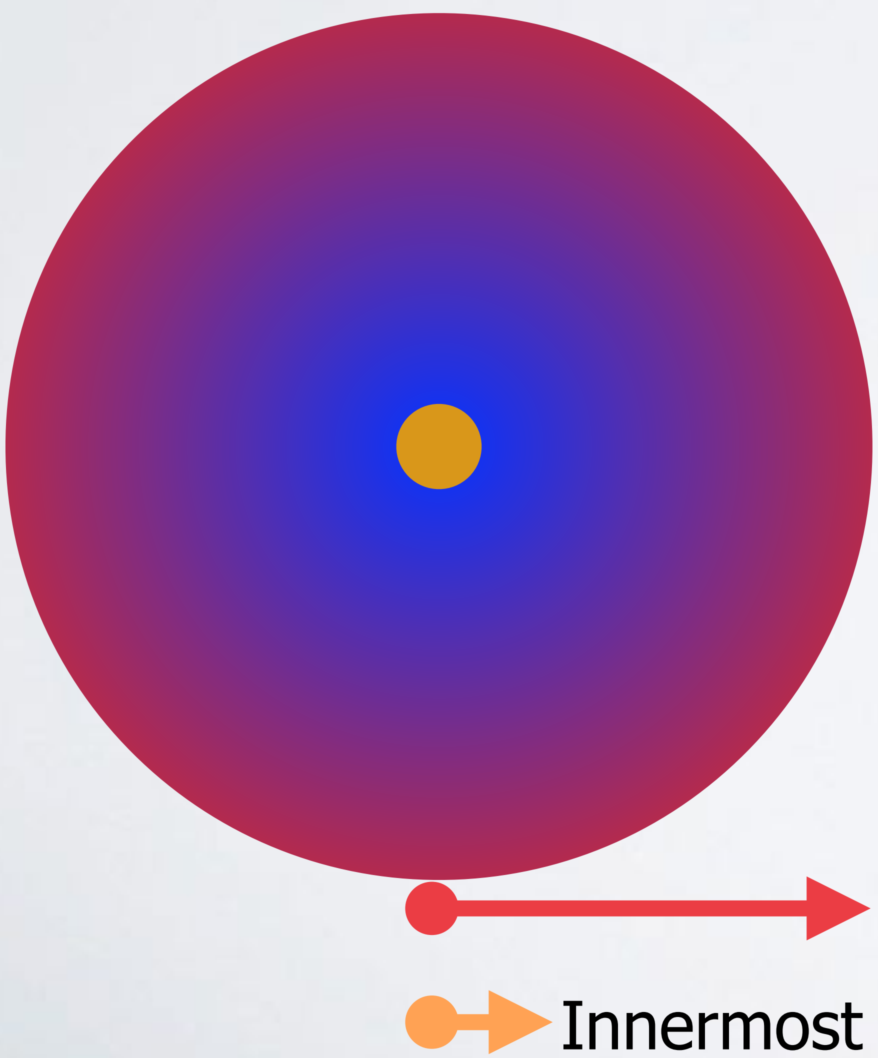
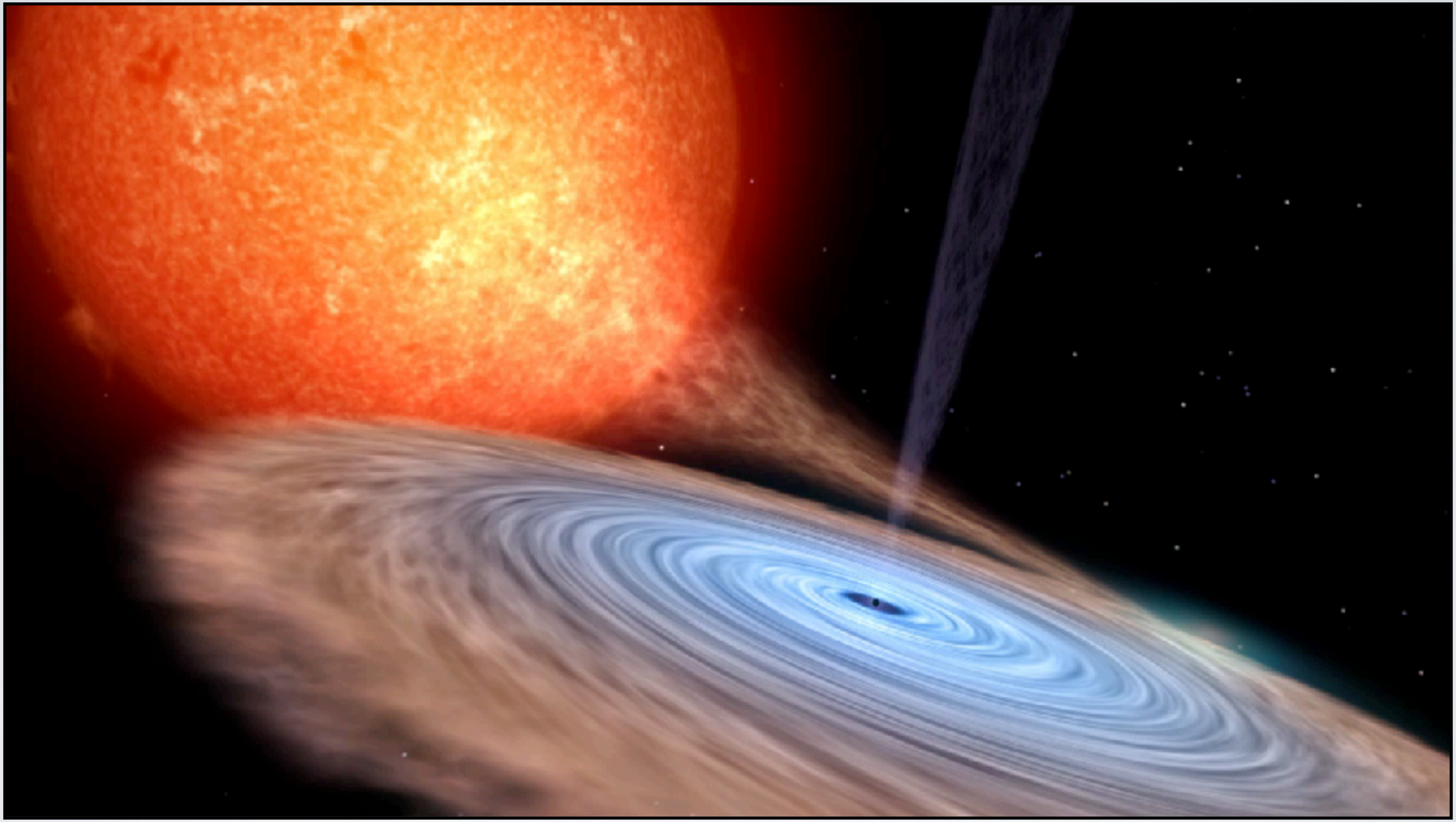


The wind is regulating the outburst!



Credit. G. Perez (IAC)

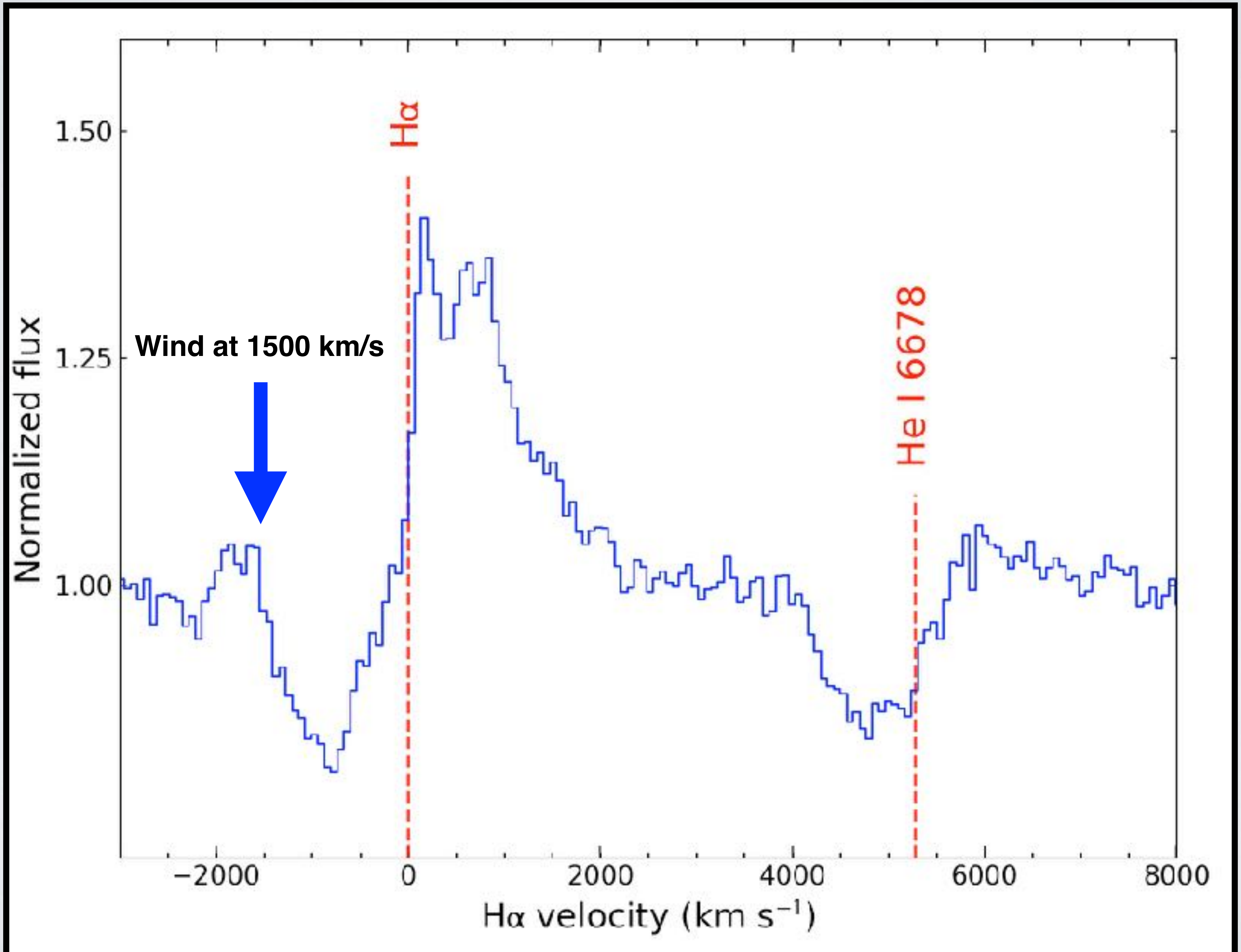
Outflow signatures in **8 transient X-ray binaries** (mostly BHs) …and counting

LMXB	Object	i (°)	P (h)	Wind features	Vel. (km s^{-1})[a]
GX13+1	NS	60–80	589	P-Cygni	~2400
V404 Cyg	BH	60–70	155.3	P-Cygni Broad wings	1500–3000 ~3000
V4641 Sgr	BH	60–70	67.6	P-Cygni Broad wings	900–1600 ~3000
Swift J1357.2-0933	BH	$\gtrsim$80	2.8	P-Cygni	1600–4000
MAXI J1820+070	BH	67–81	16.4	P-Cygni Broad wings Blue-shifted abs.[b]	1200–1800 ~1800 1200–1800
Swift J1858.6-0814	NS	Dipping/eclipsing	21.8	P-Cygni	1700–2400
GRS1716-249	BH	?	?	P-Cygni Flat-top, asymmetries	~2000 -
MAXI J1803–298	BH	Dipping	7–8	P-Cygni	~1250
MAXI J1348–630	**BH**	**Mid-to-low**	**?**	**Broad wings** **Blue-shifted abs.** **Flat-top, asymmetries**	**1500–1700** **500–900** **-**

Adapted from Panizo-Espinar et al. 2022

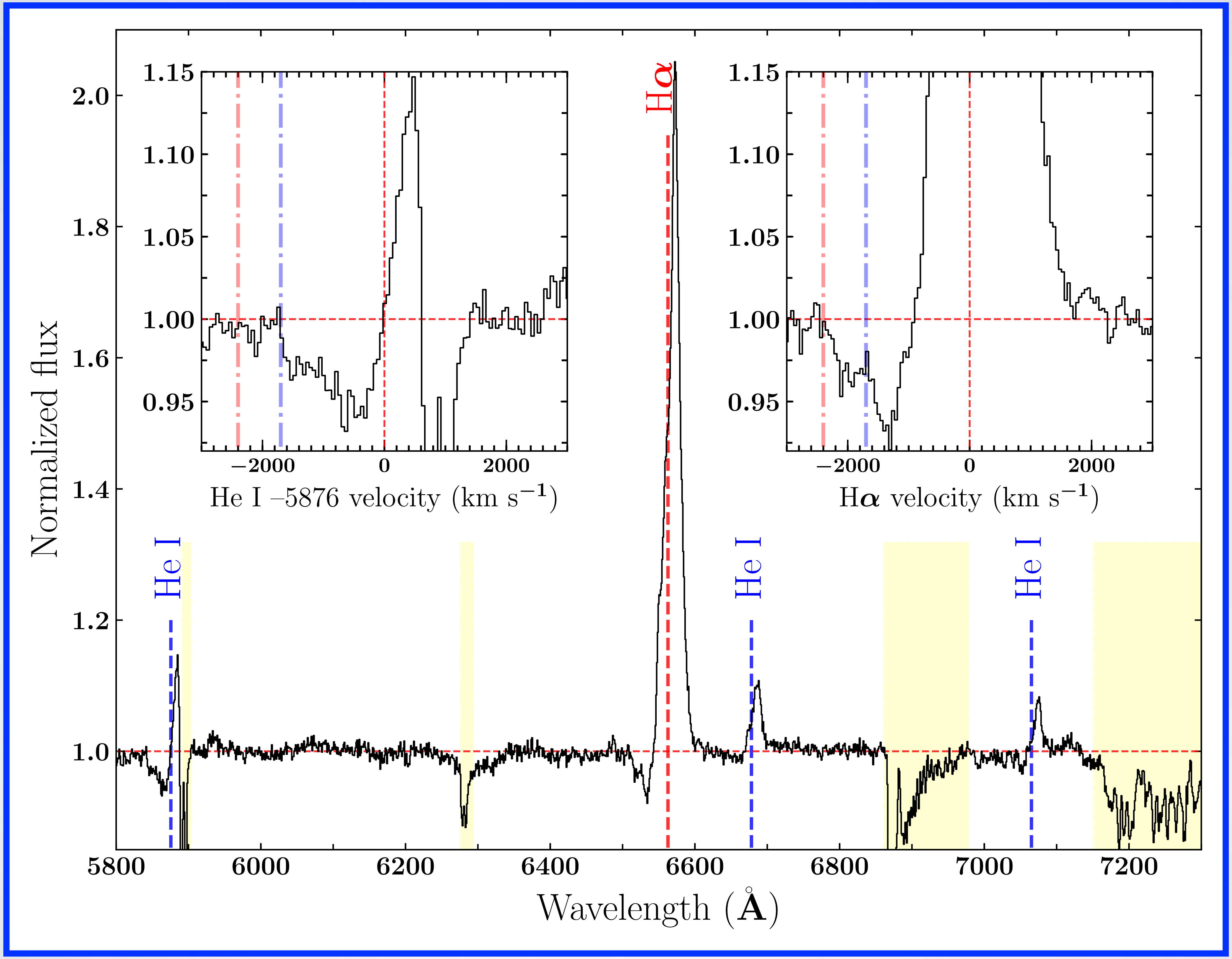
The **strong optical wind** of the black hole transient V4641 Sgr

Muñoz-Darias, Torres & Garcia, 2018, MNRAS



Swift J1858.6-0814: **wind in a neutron star transient**

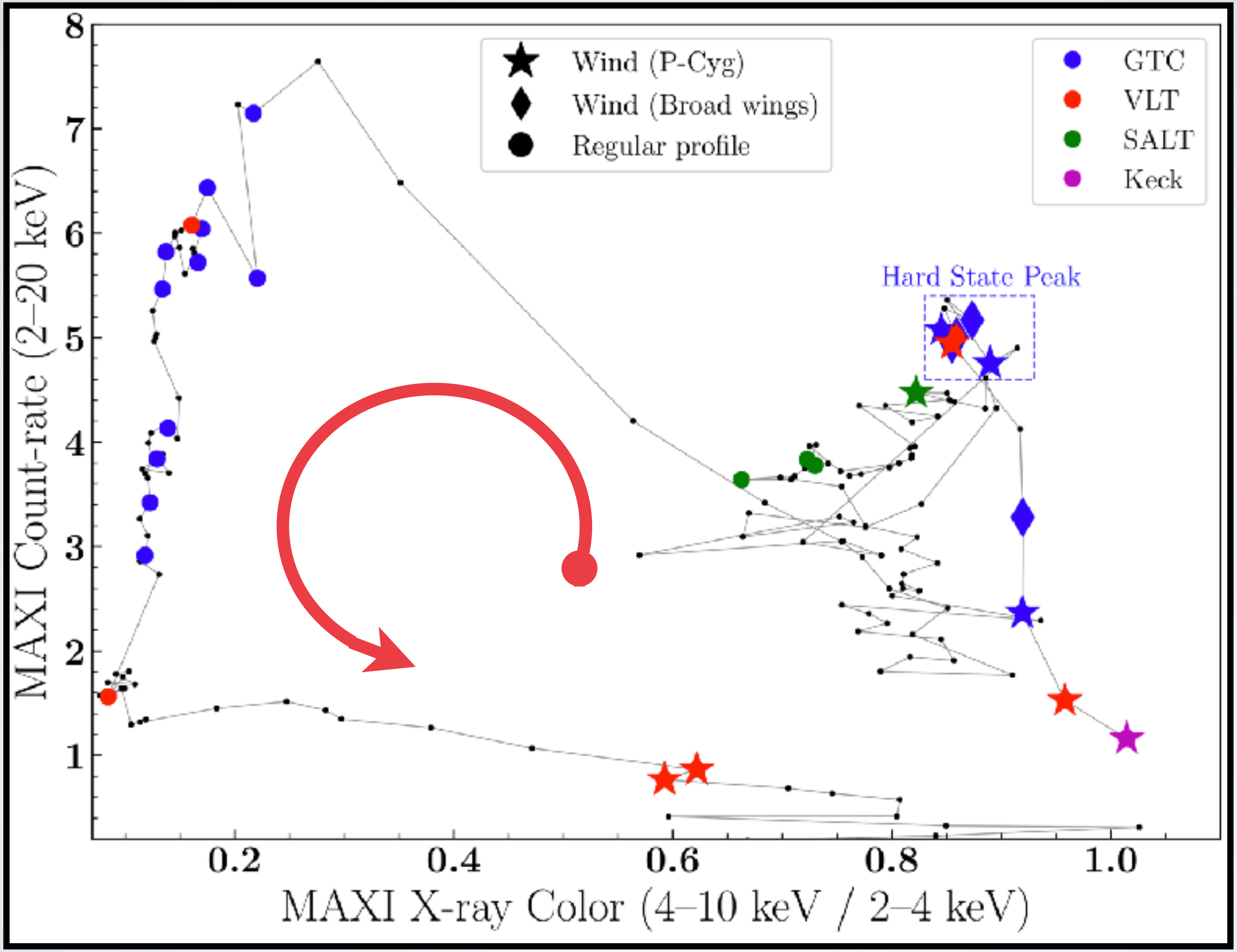
Muñoz-Darias et al. 2020, ApJ Lett



Simultaneous with UV wind (Castro Segura et al. 2022, Nature)

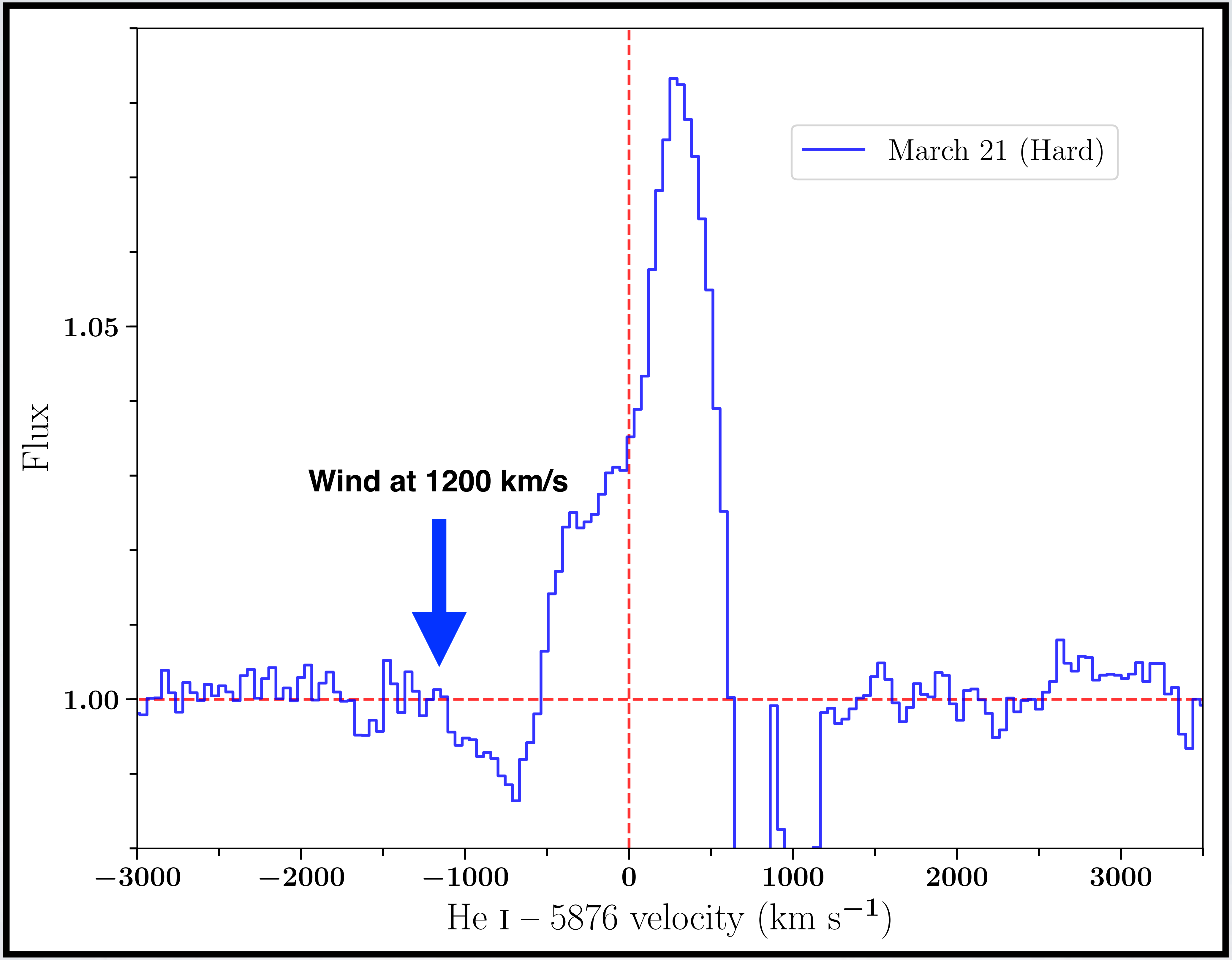
MAXI J1820+070: 37 epochs of high S/N spectroscopy

Muñoz-Darias et al. 2019 ApJ Lett.

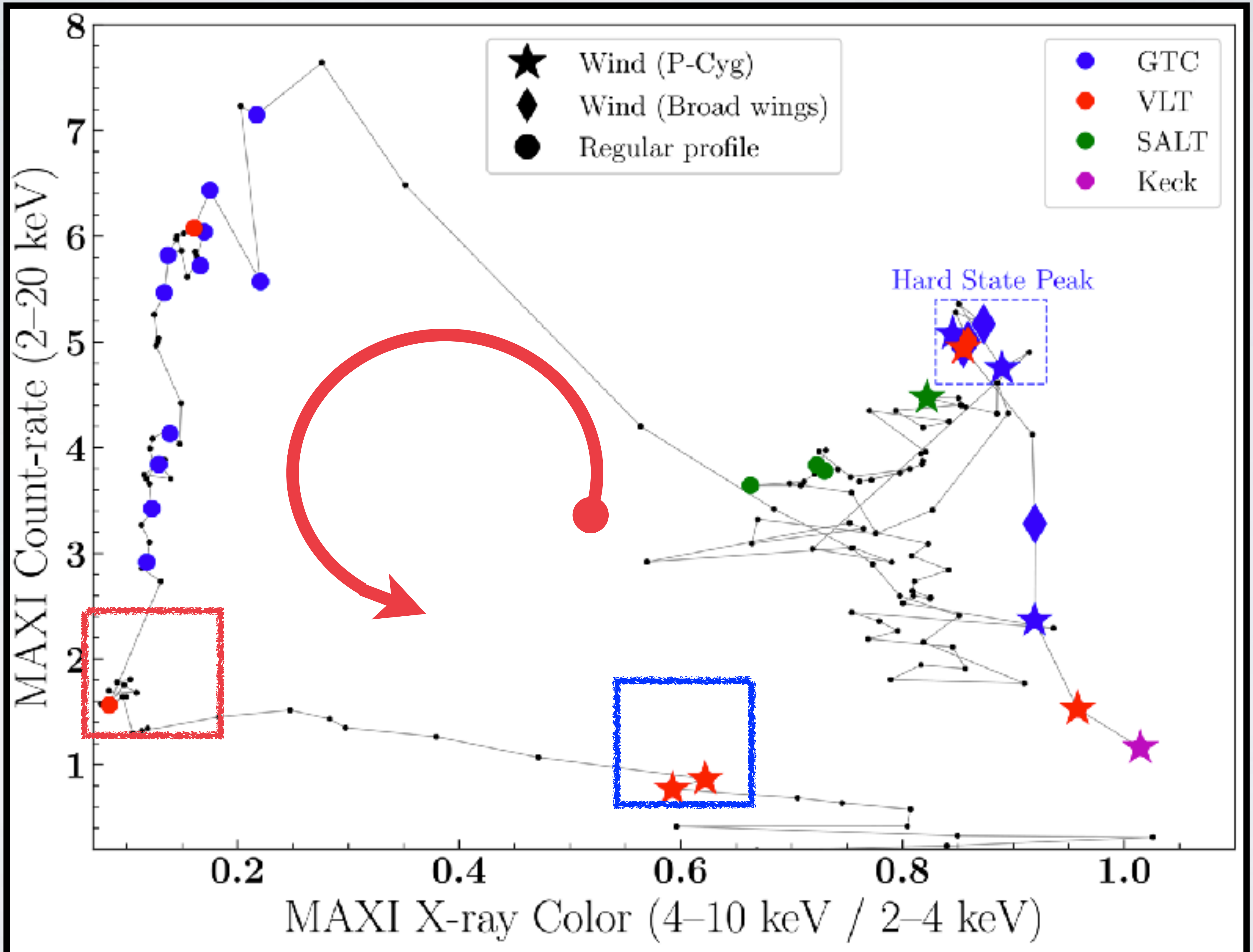


See **Shidatsu et al. 2018, 2019** for the outburst evolution

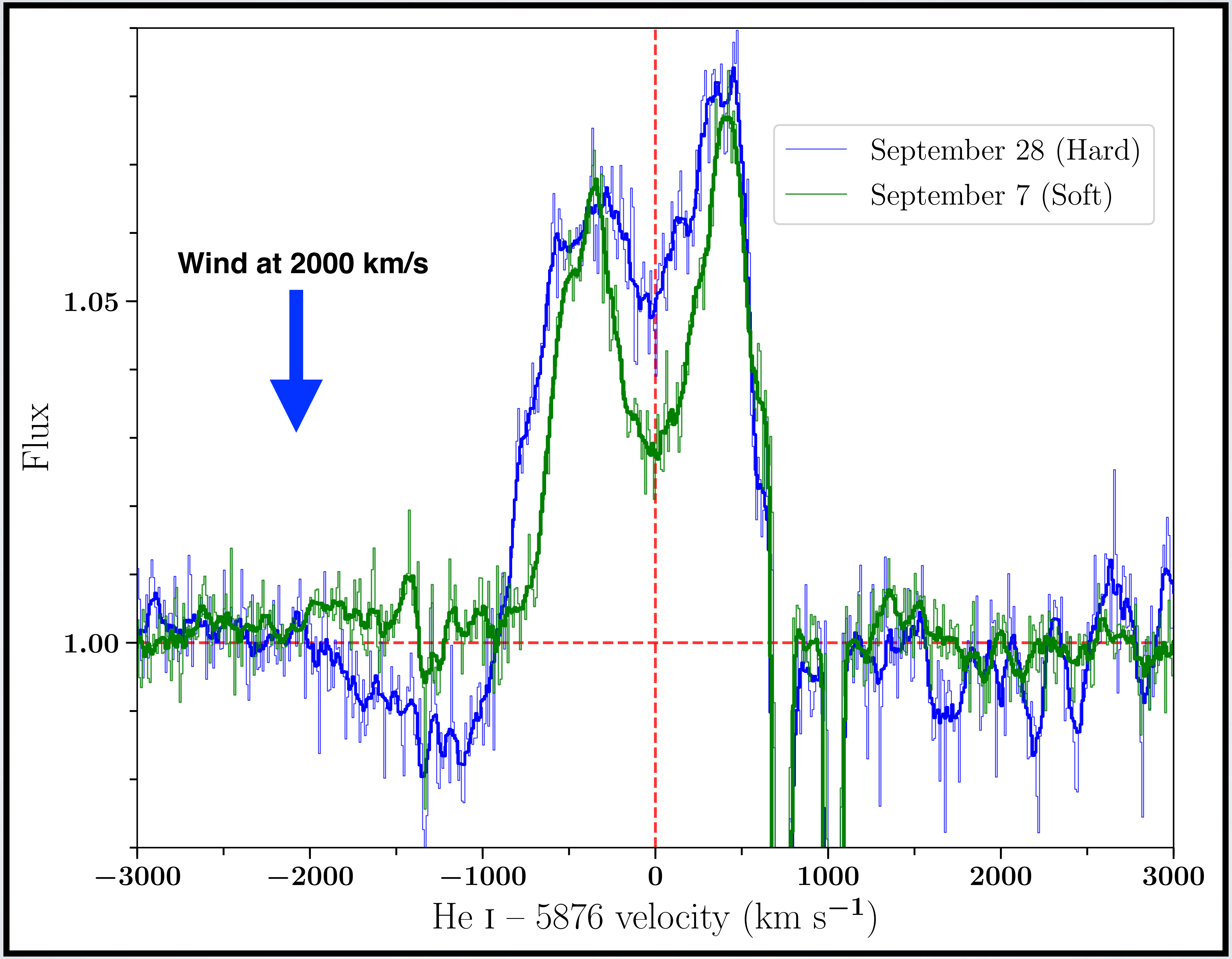
MAXI J1820+070: Optical **Hard State Wind**



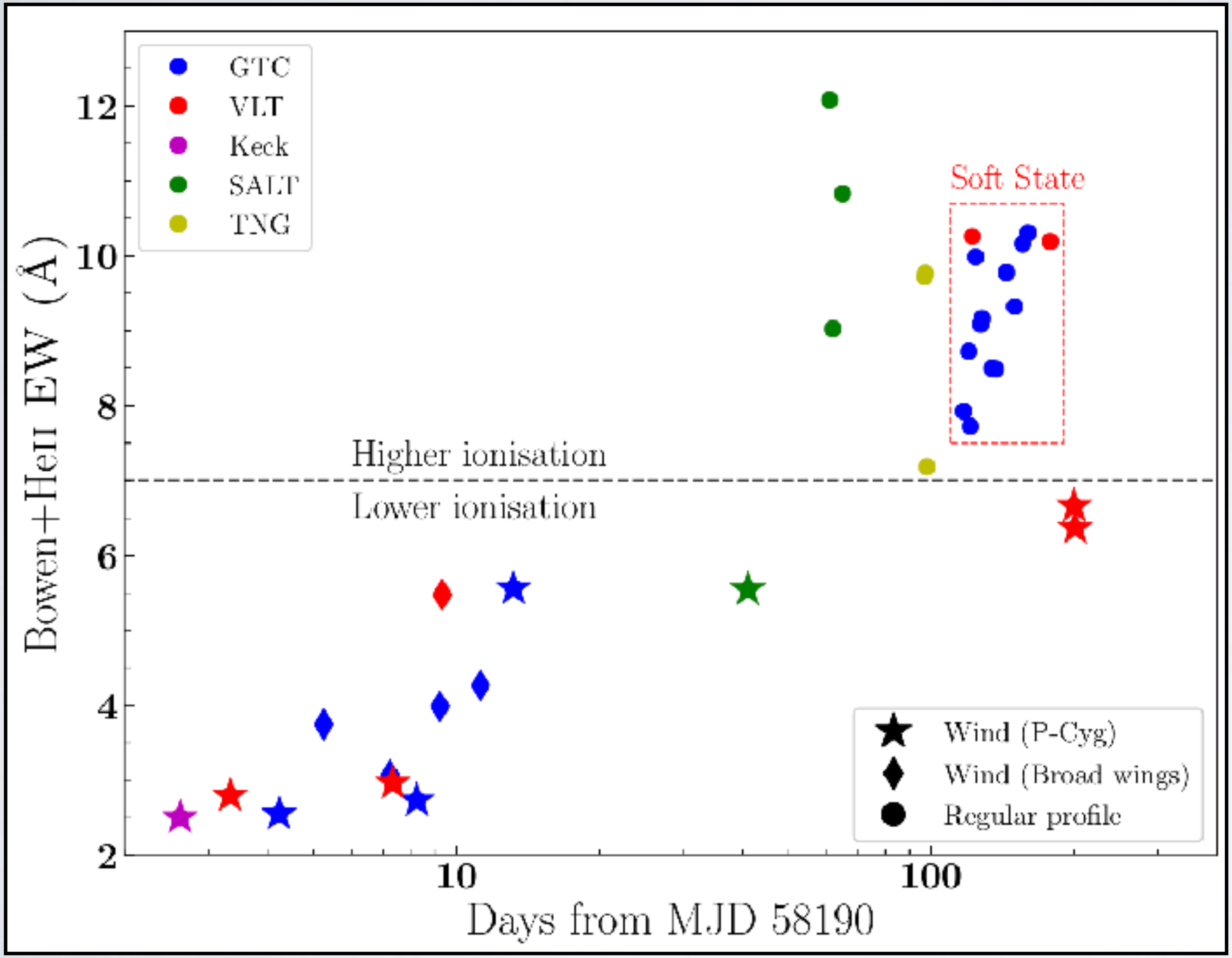
Wind reappeared over the **soft to hard transition**



Soft-to-hard transition: **the wind is back!**



Ionisation effects playing a role?



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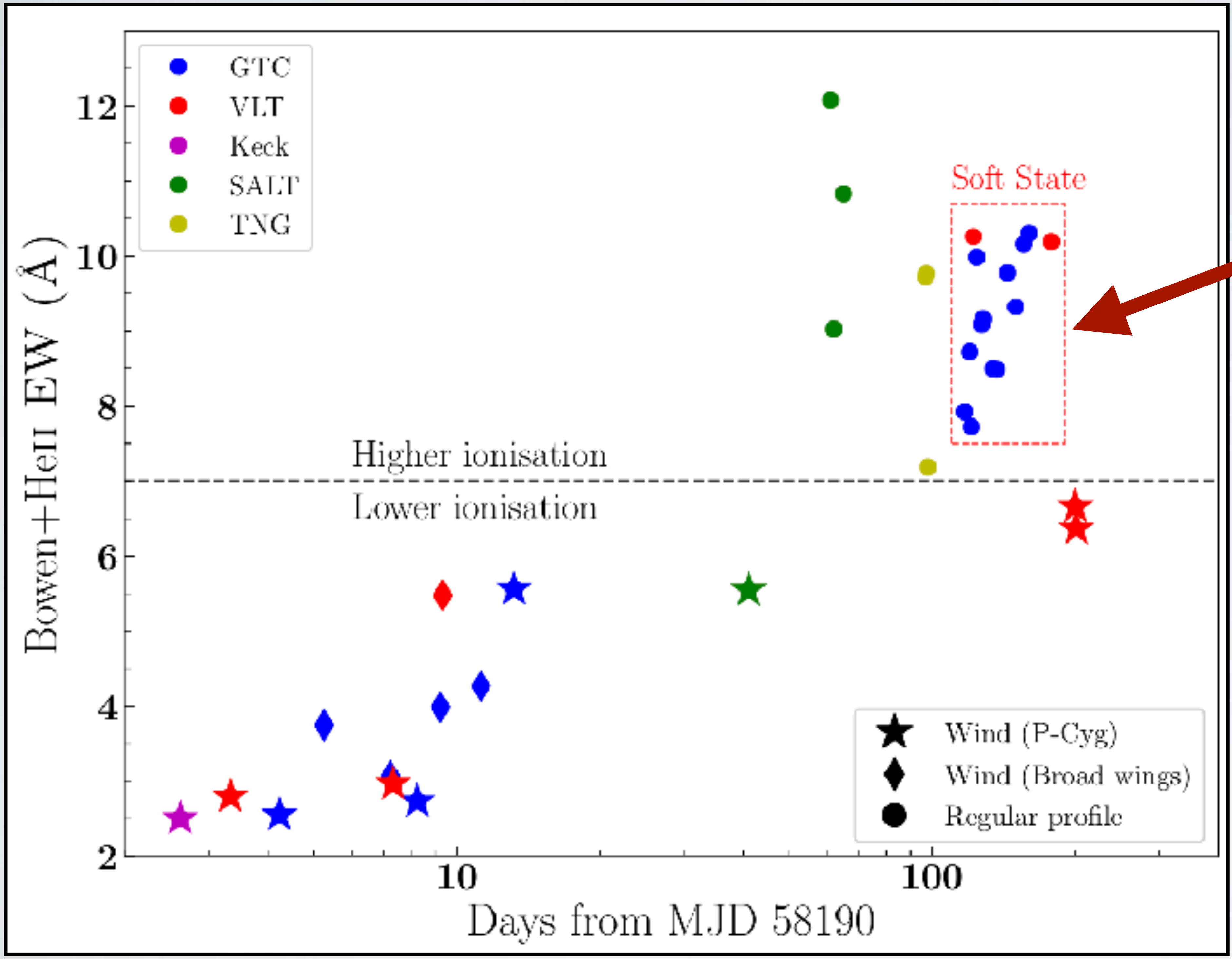

Wind signatures still detected in the near-infrared
Sanchez-Sierras & TMD 2020

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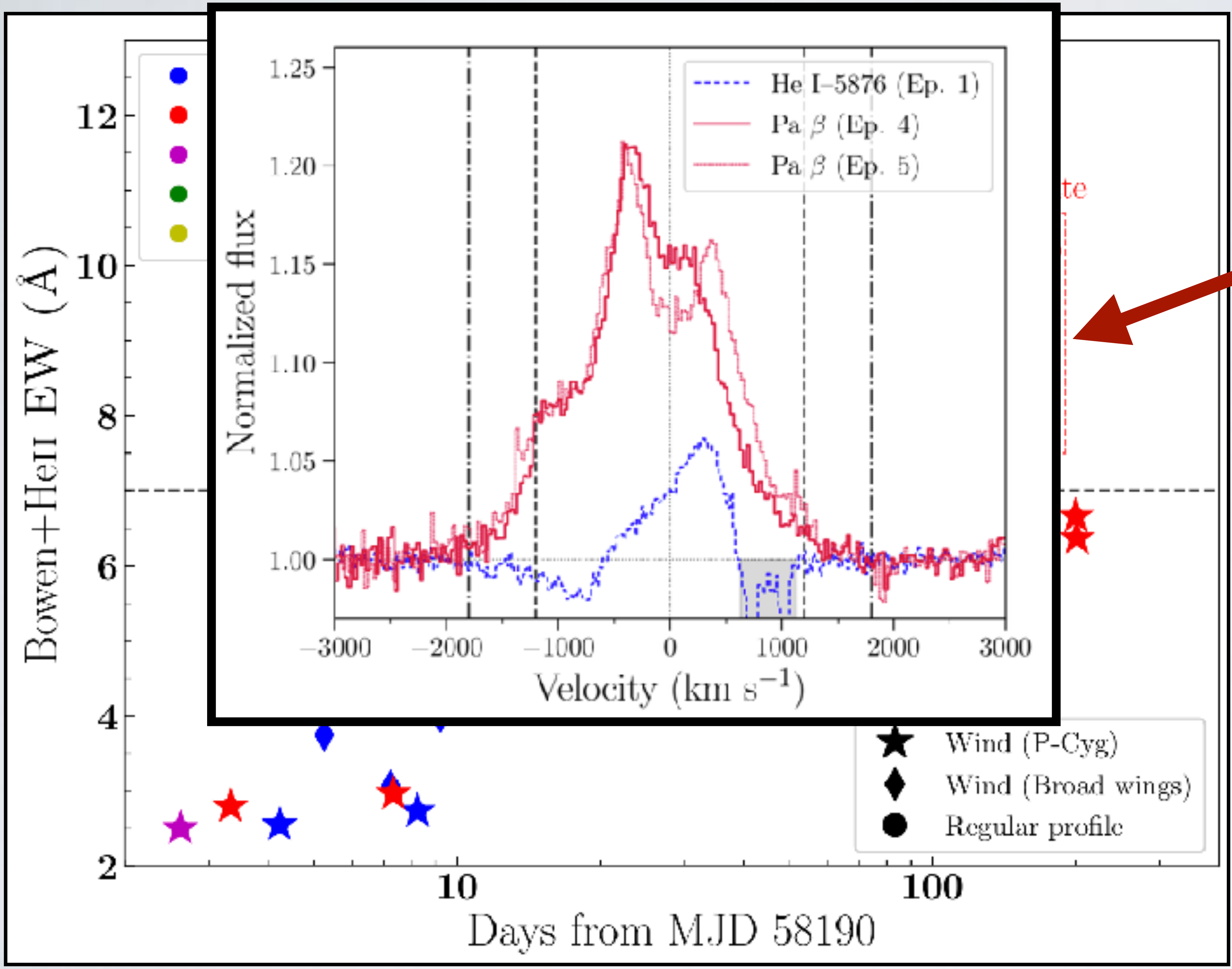

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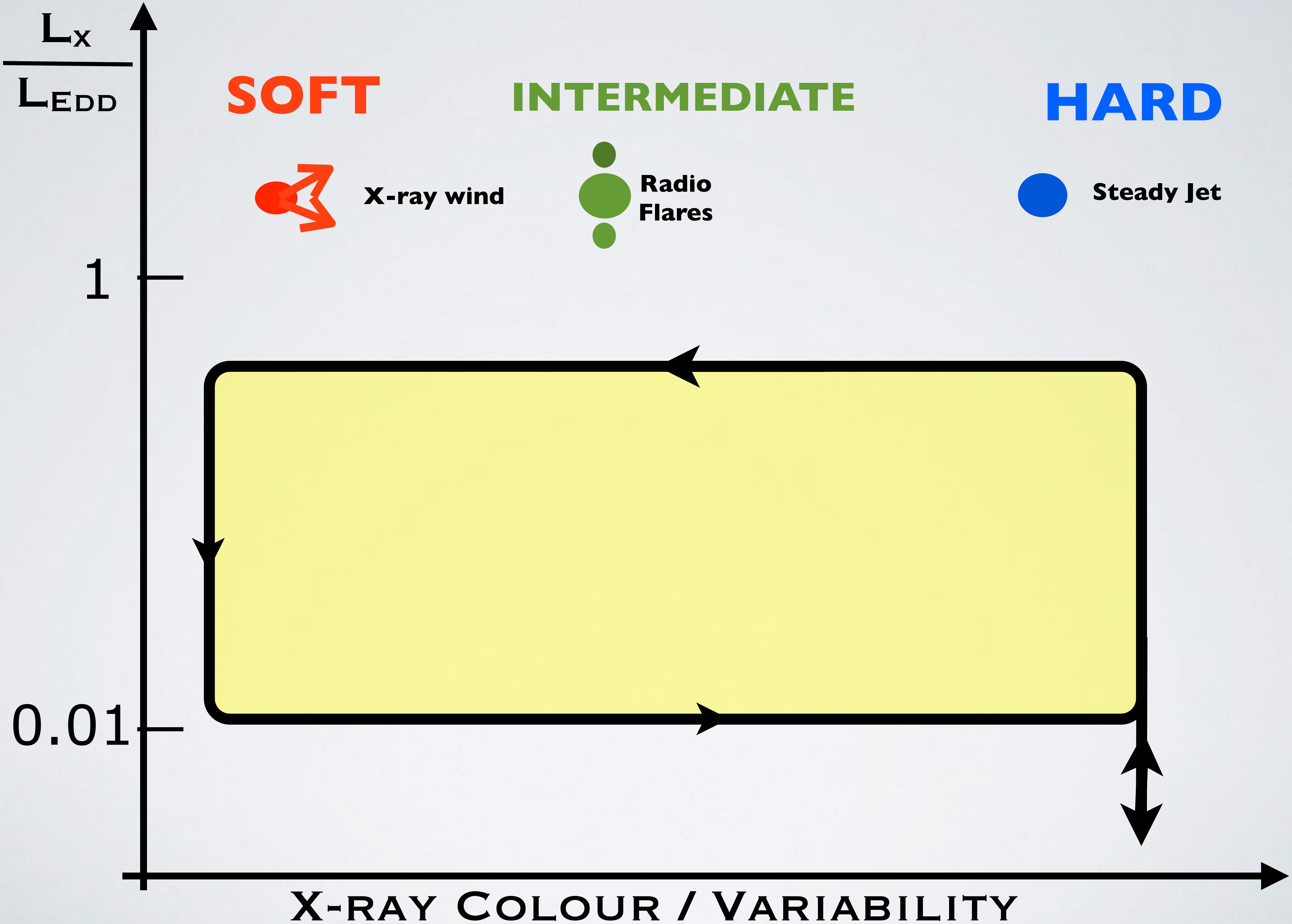
Accretion/Outflow states in Black holes



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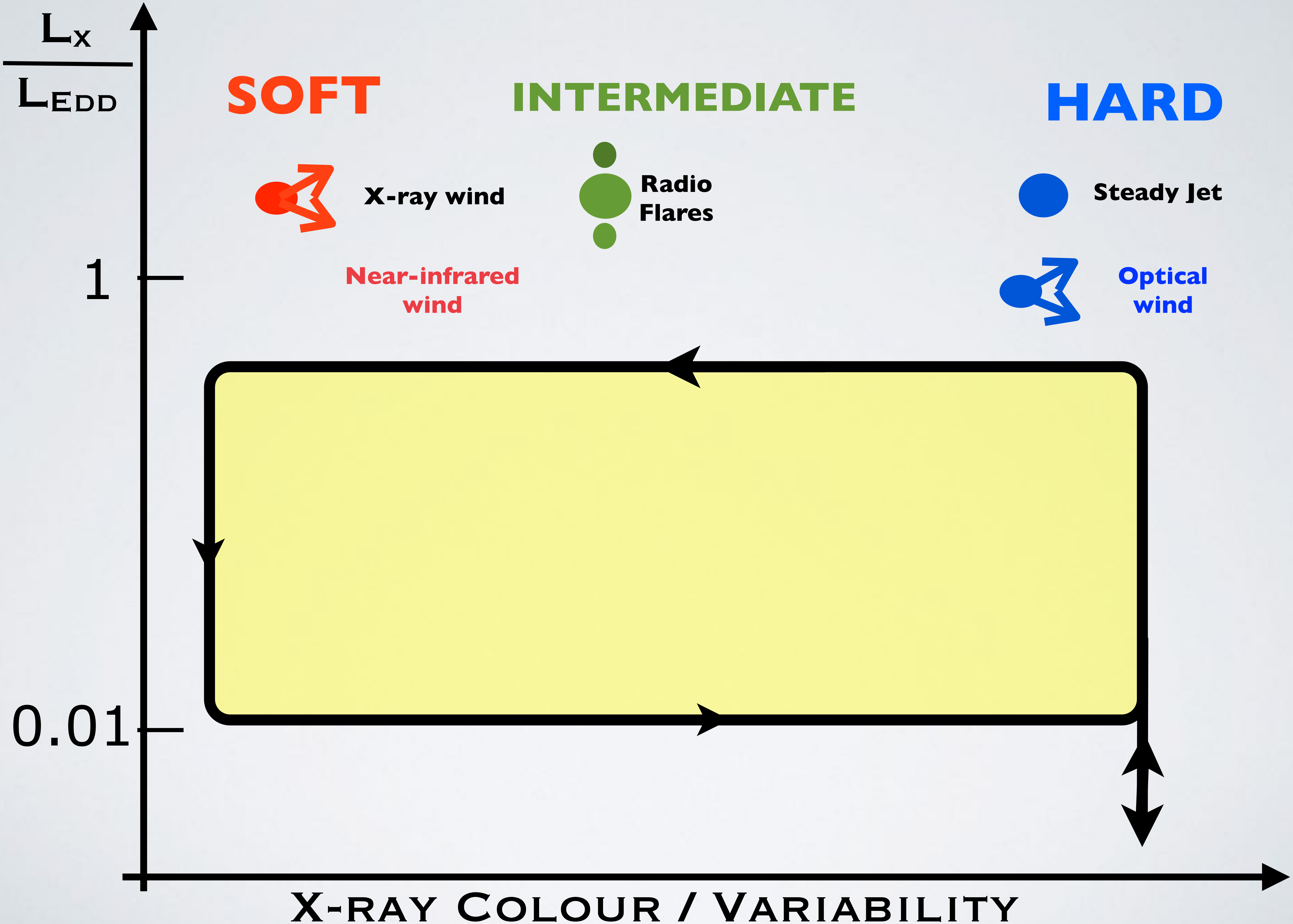


Global properties and Summary

- ★ Optical winds (P-Cyg profiles) detected in (at least) 8 BH and NS transients [500 — 3000 km/s; P-Cyg blue edge]

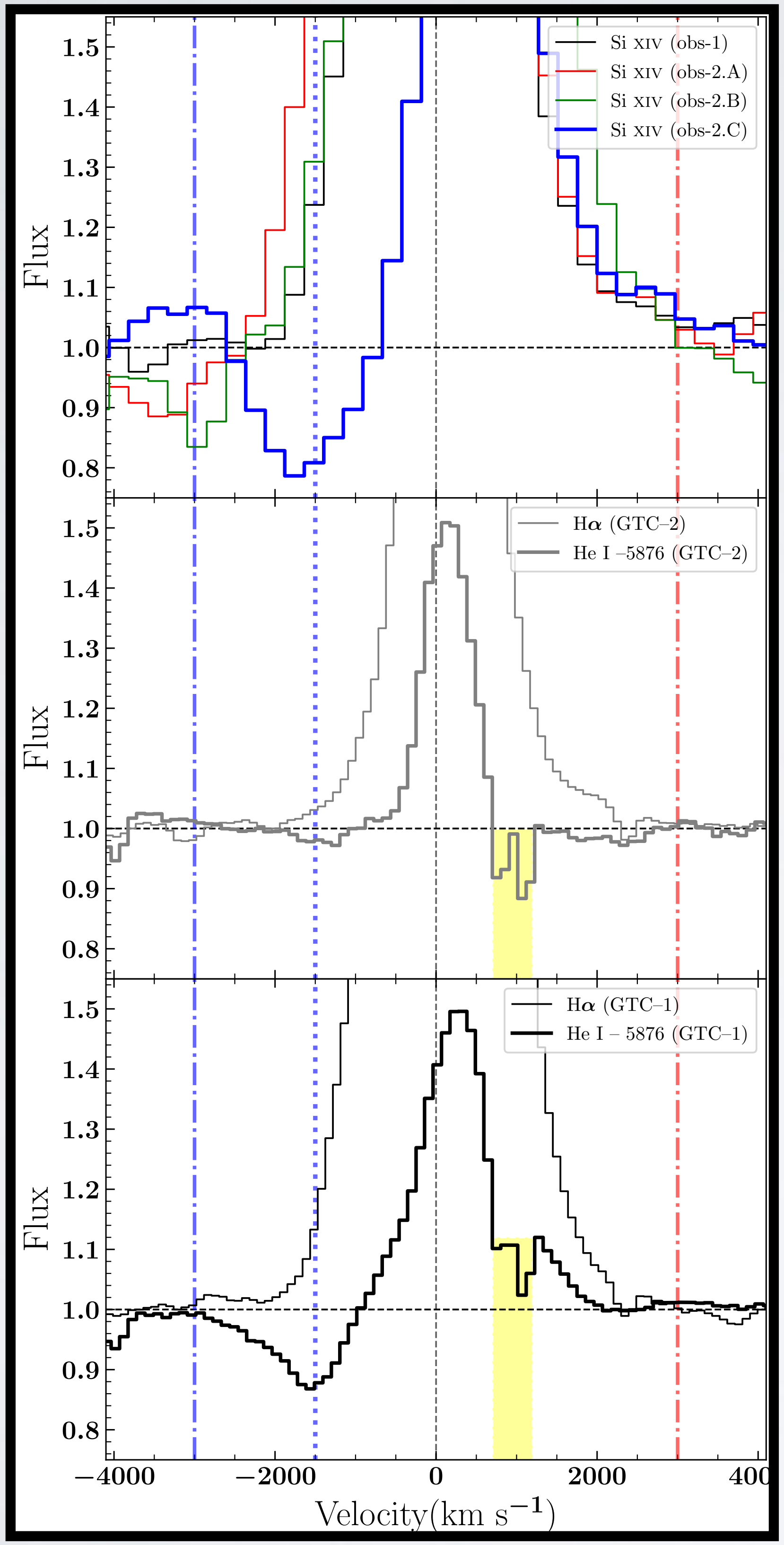
- ★ Optical winds are detected in the hard state (/intermediate). Simultaneous with the Jet. Wind visibility likely affected by ionisation issues. NIR signatures in the soft state.

- ★ More dramatic cases associated with strong flaring activity and intrinsic X-ray absorption.

- ★ Wind terminal velocity: 500 — 3000 km/s (P-Cyg blue edge)

- ★ Wind launching mechanism?
- ★ Relation with the X-ray wind?

V404 Cygni: Optical and X-ray wind



Muñoz-Darias & Ponti 2022

- Kinematic properties of the X-ray and Optical winds are very similar
- Optical and X-ray P-Cyg profiles observed close in time at very different luminosities

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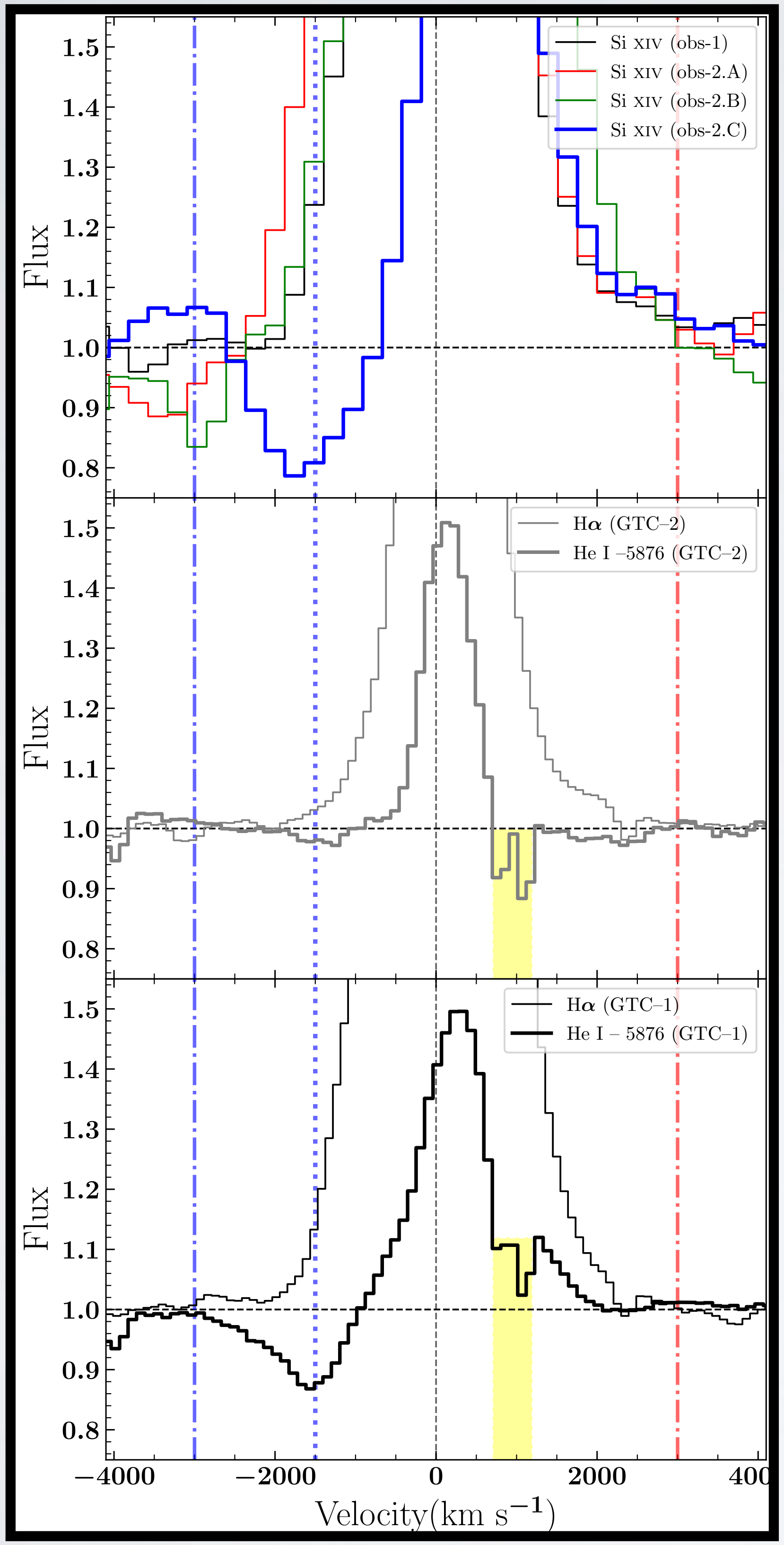

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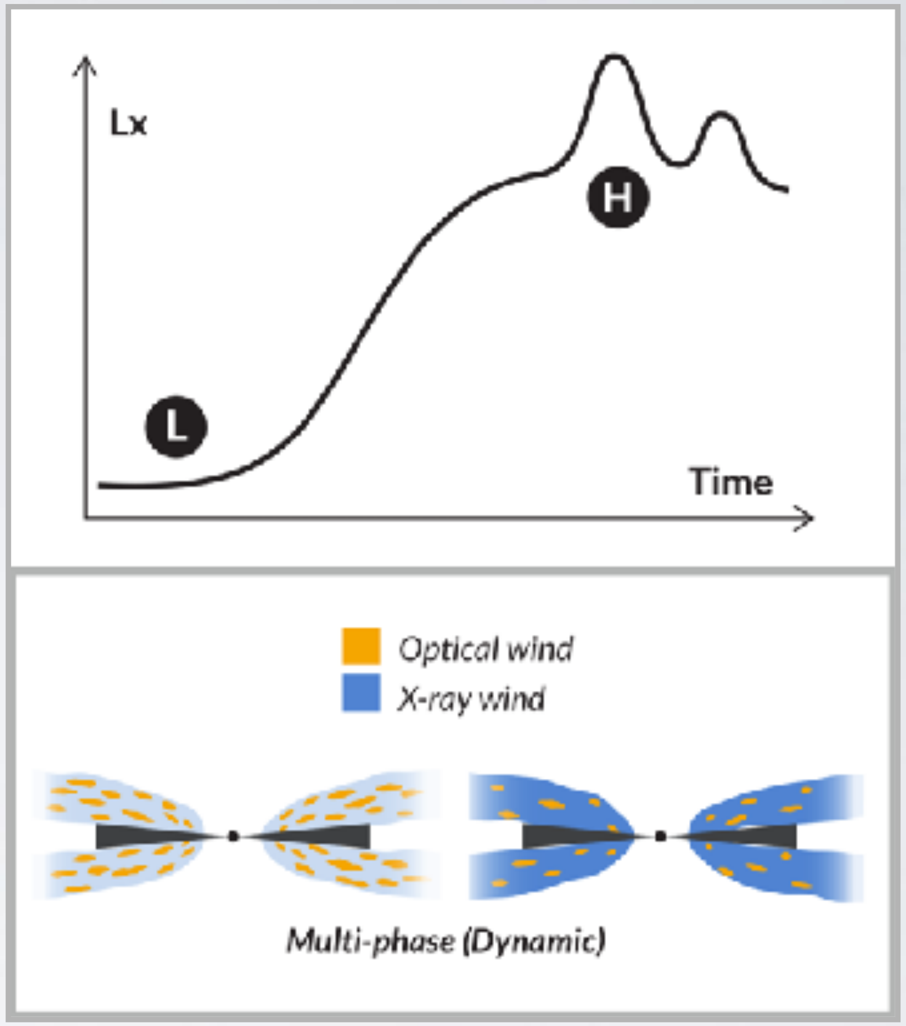

Multi-phase winds is a viable solution

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