Changing look microquasars

Teo Muñoz Darias

RyC advanced Fellow @ IAC-Tenerife

Investigación Programa Ramón y Cajal

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Why QSO variability lovers (might want to) care about STELLAR-MASS Black Holes

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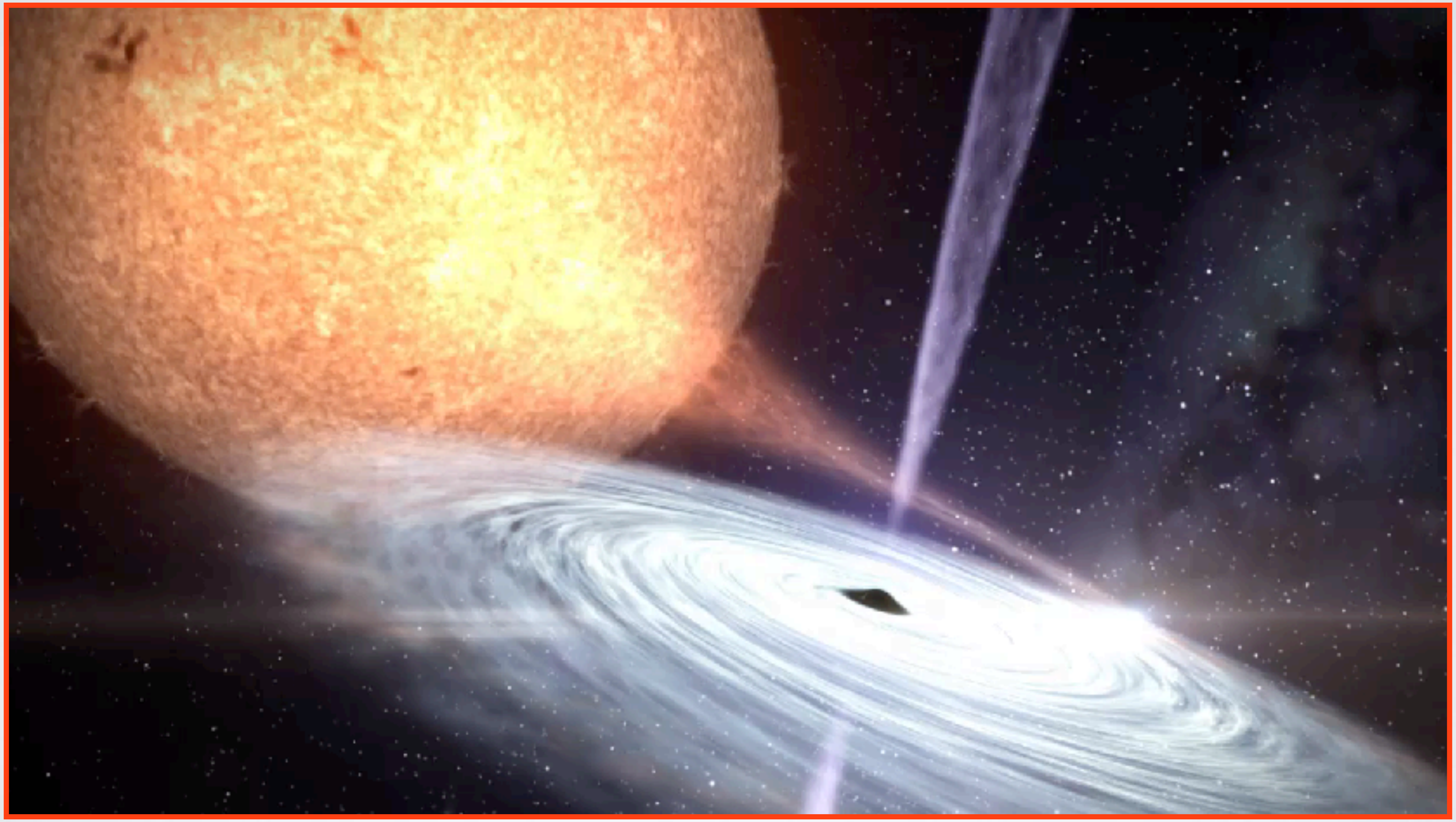
(Low-Mass) X-ray Binaries

Low-mass star transferring matter onto **B**lack **H**ole

via an **accretion disc**



Credit: G. Perez (IAC)

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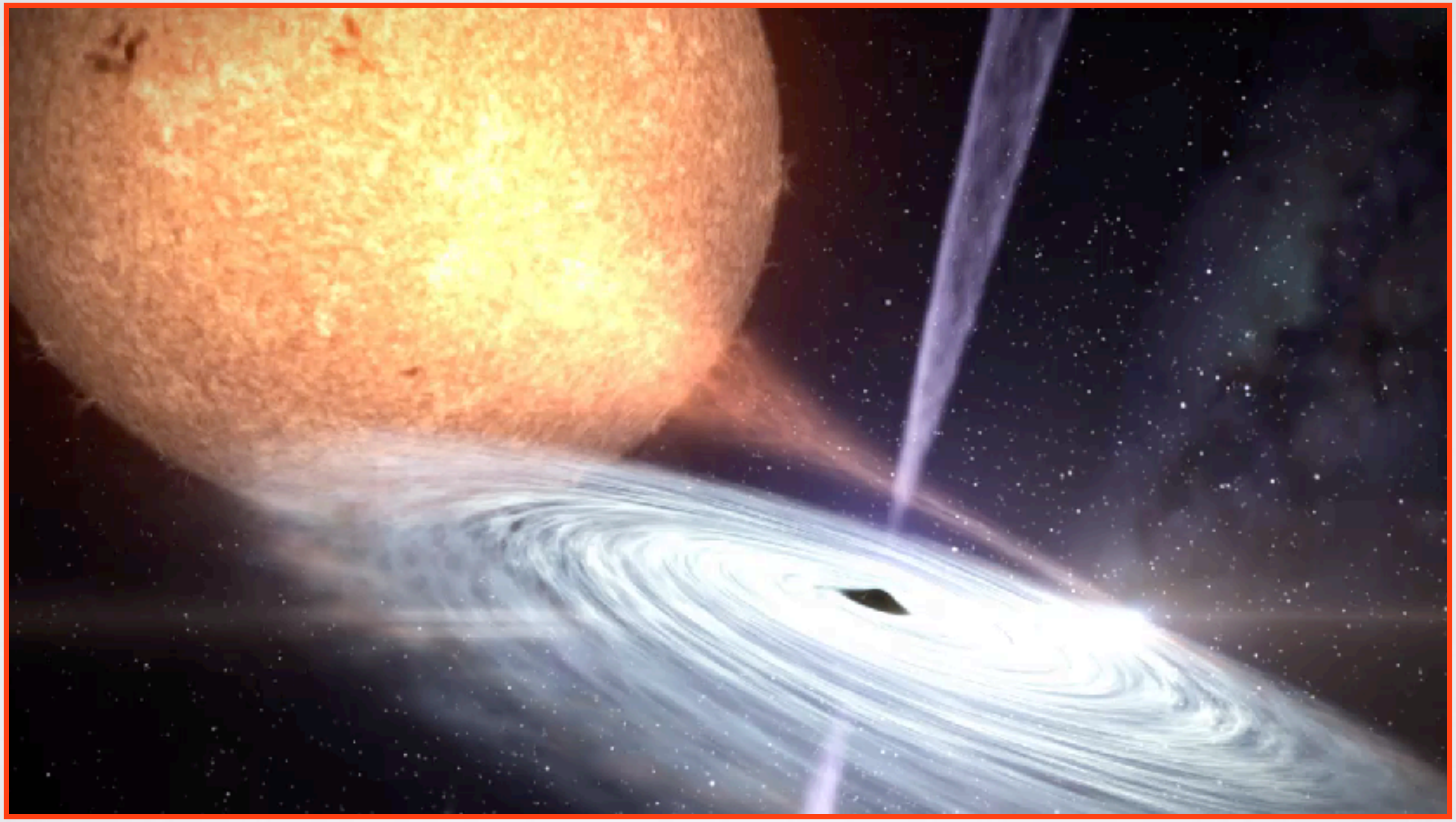

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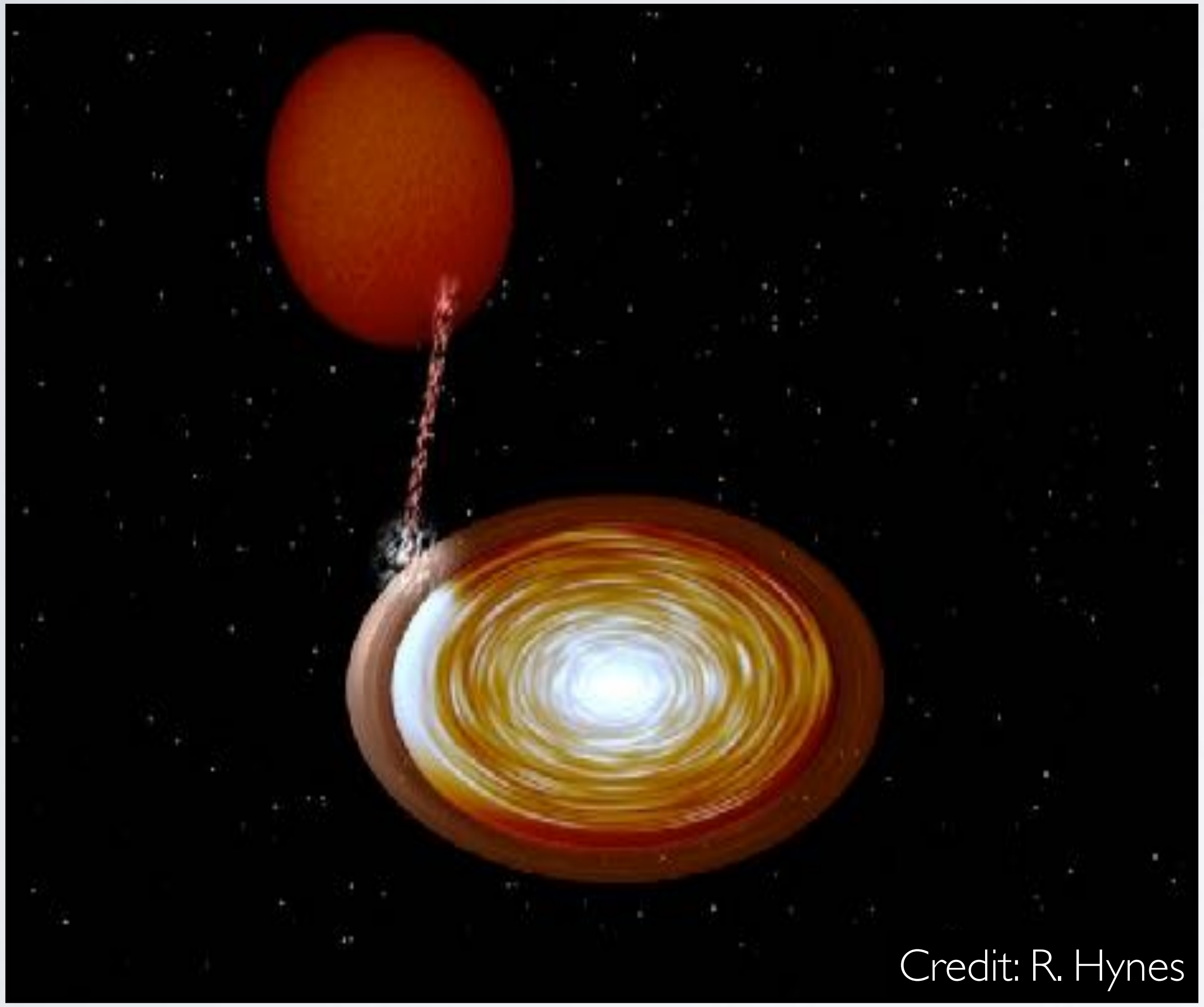
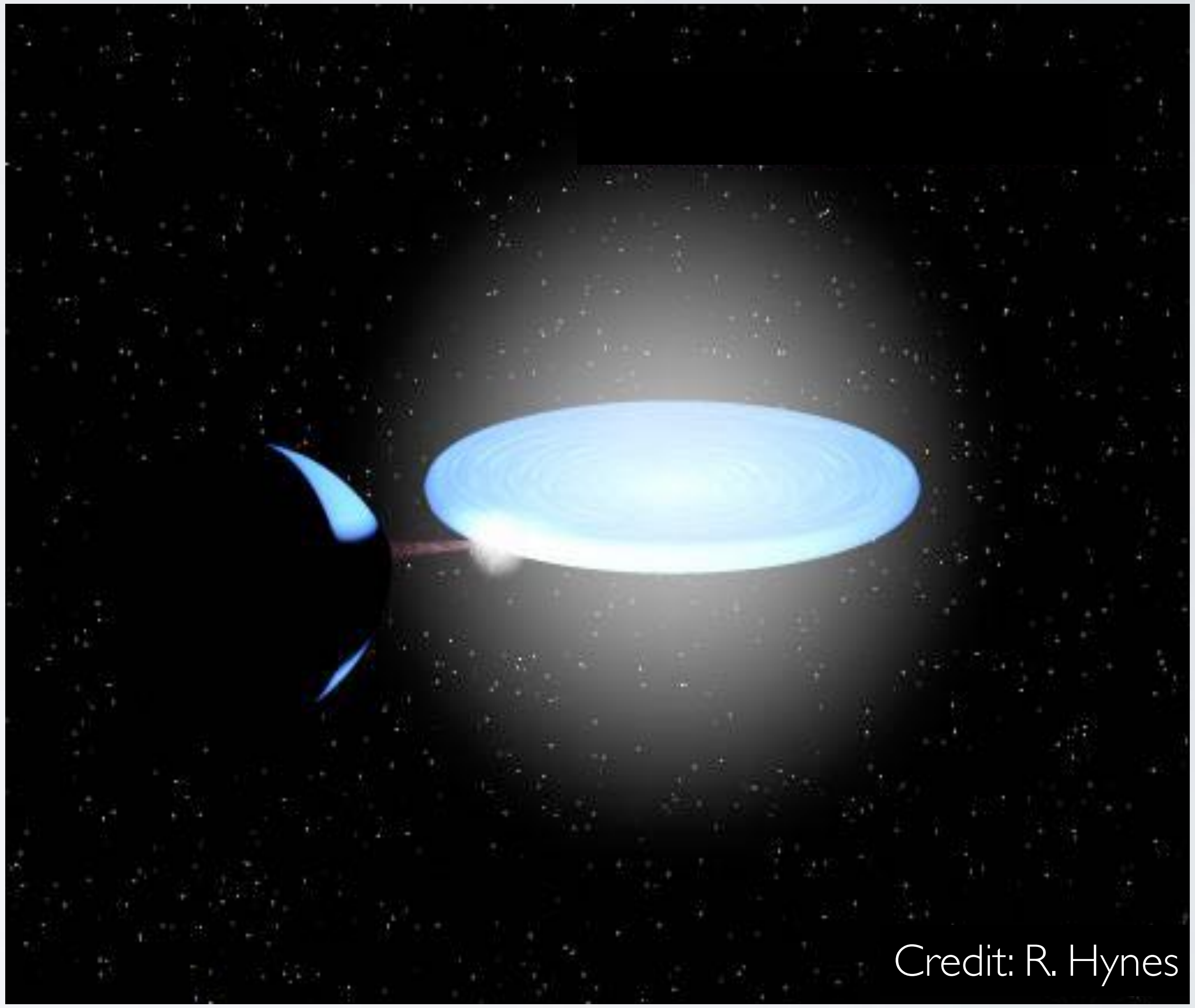
BLACK HOLES are TRANSIENT

Quiescence / Outburst

see e.g. Casares & Jonker 2014

see e.g. Fender & Muñoz-Darias 2016





Dynamical BH masses

Accretion Processes
General Relativity

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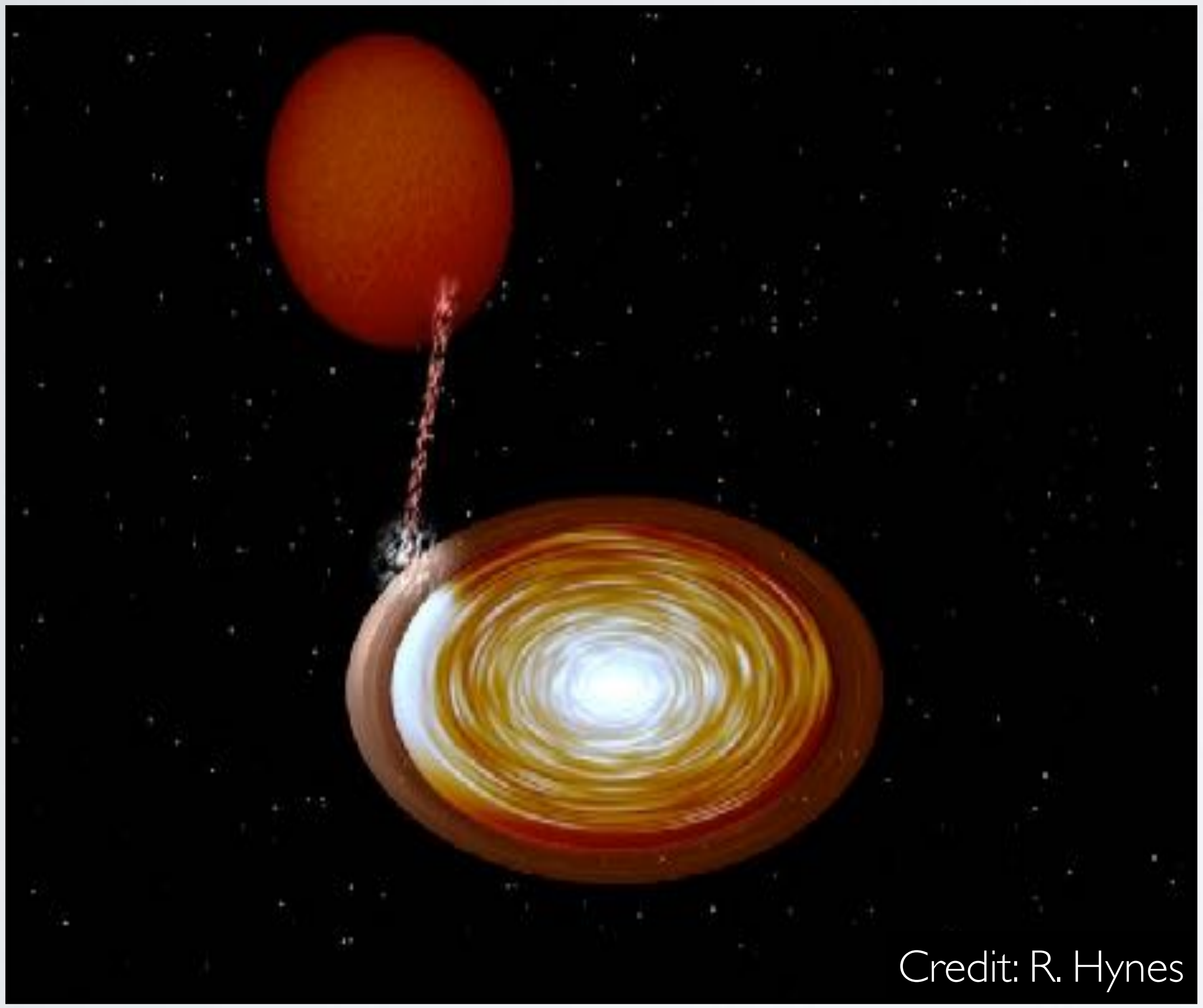

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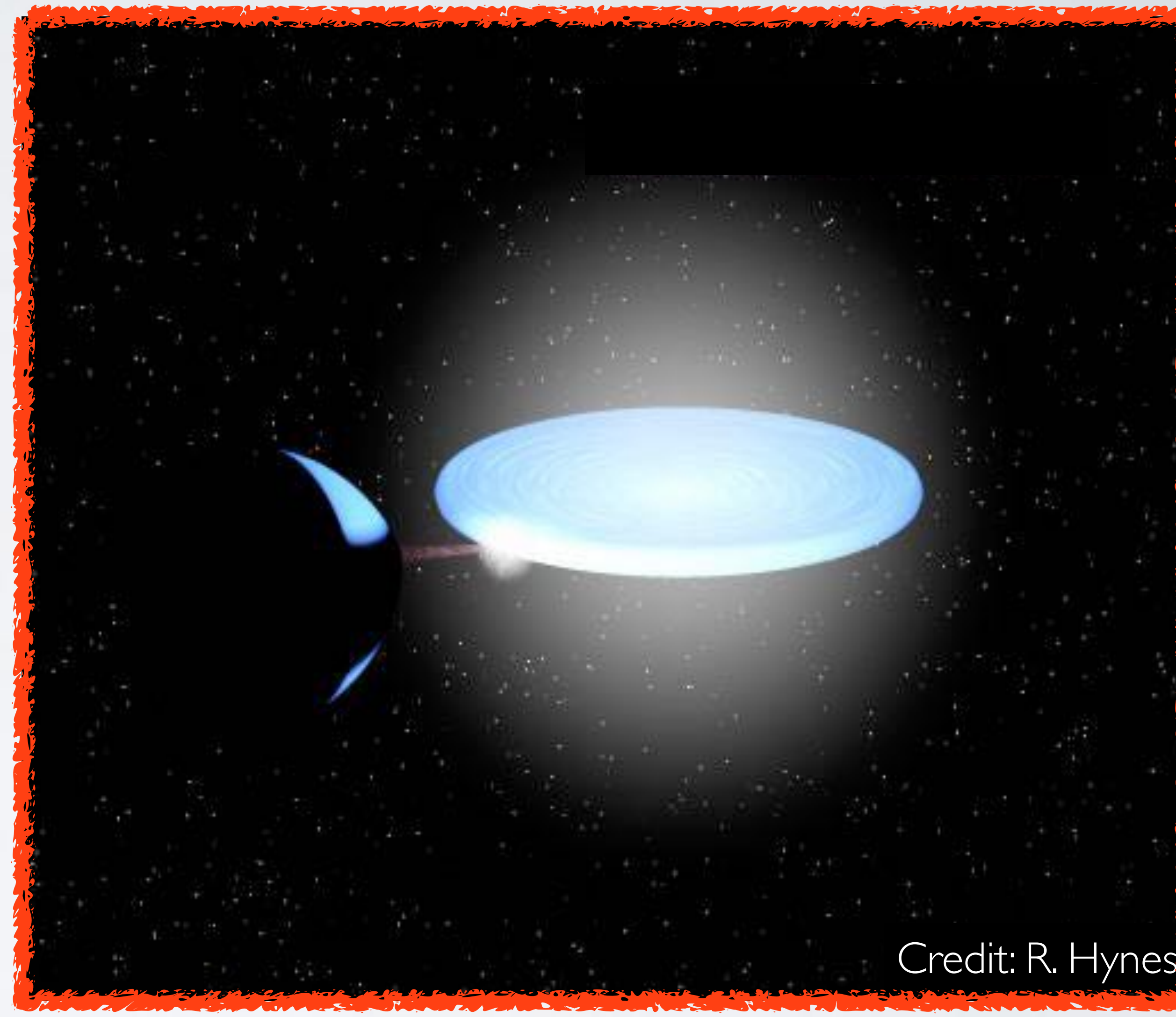

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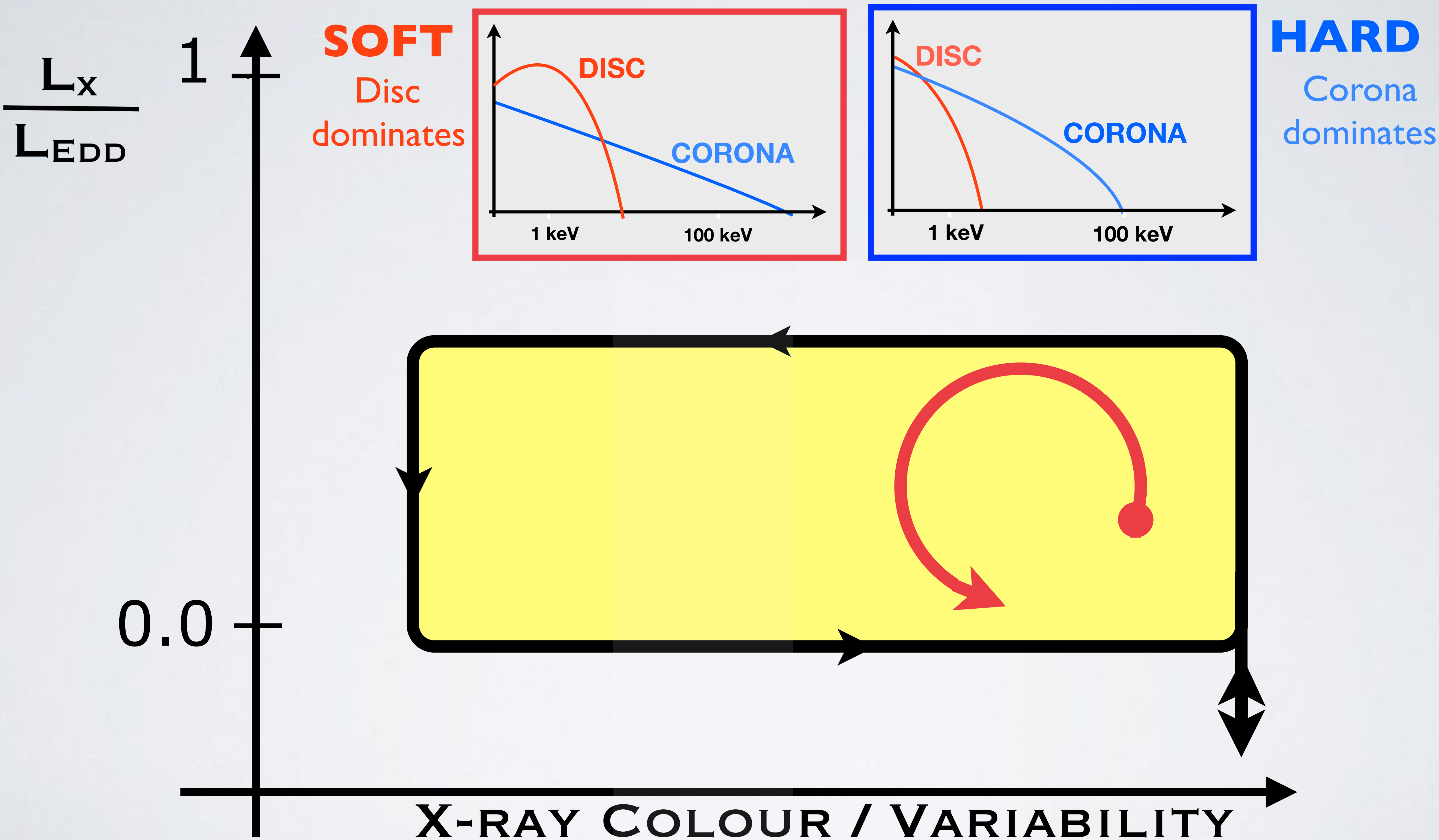
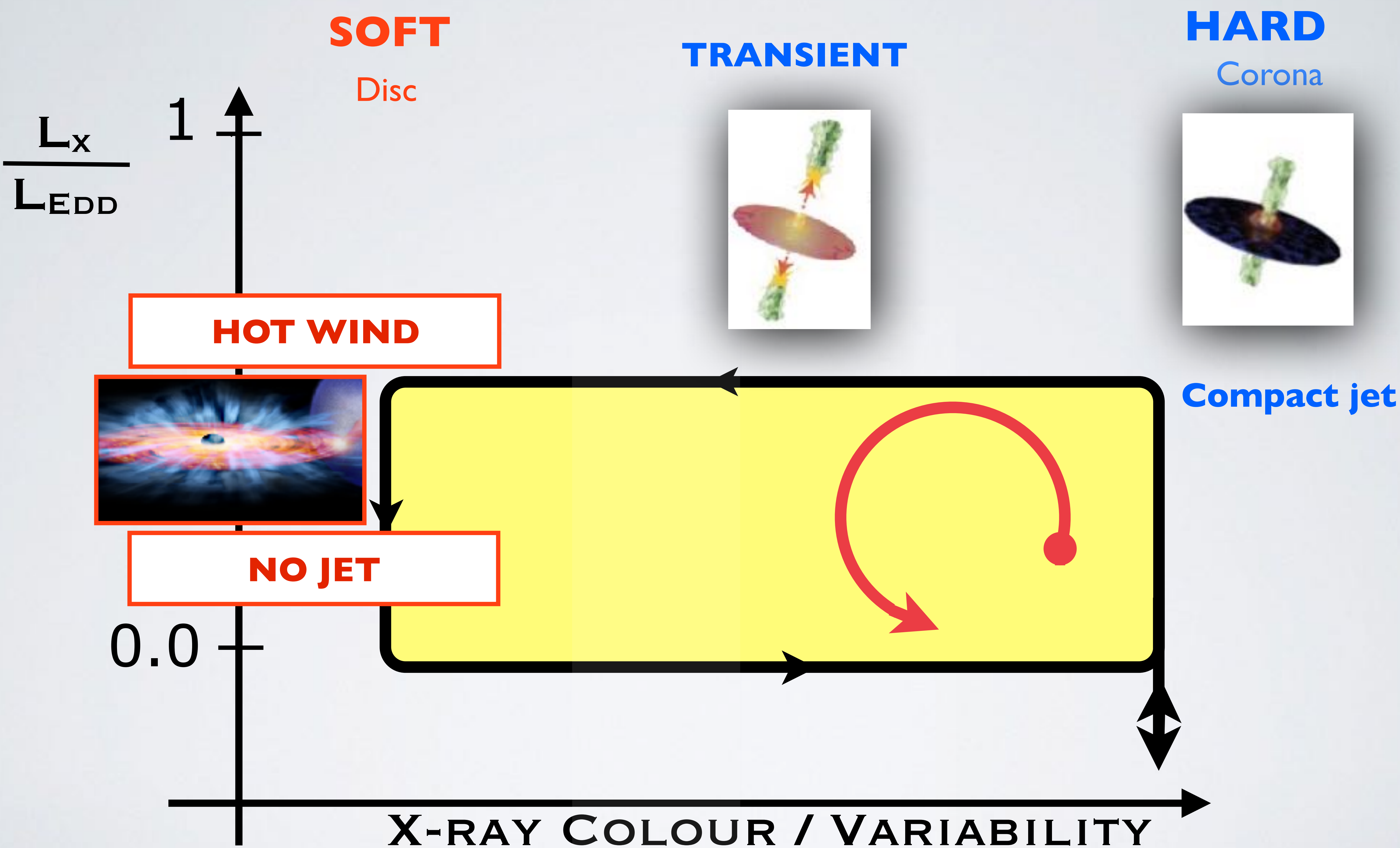
ACCRETION STATES



e.g. Remillard & McClintock 2006 / Belloni et al. 2011

ACCRETION/OUTFLOW PROPERTIES



This was the picture in 2015 (e.g. Fender & Muñoz-Darias 2016)

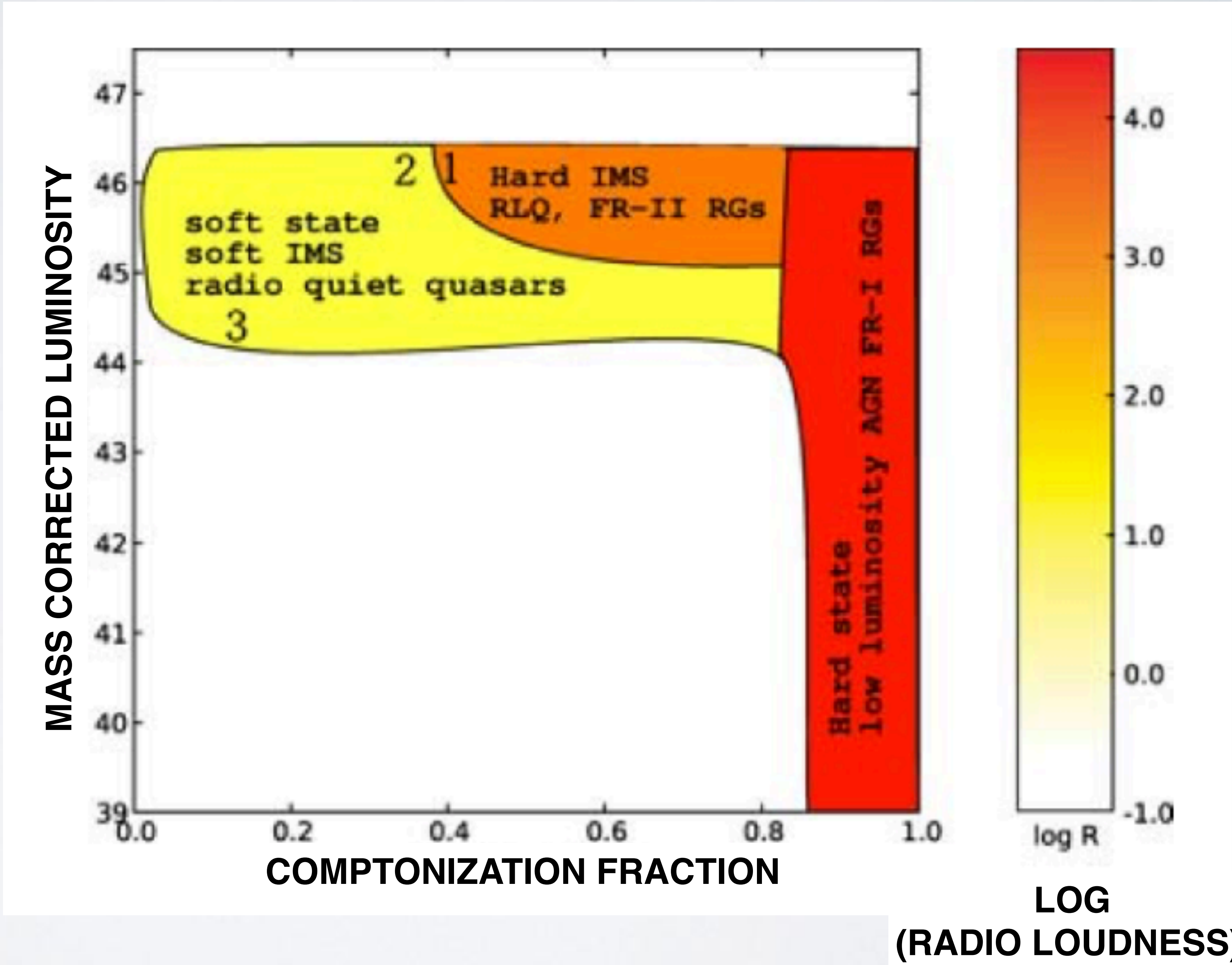
ACCRETION STATES IN AGN ?

Koerding, Jester and Fender 2006

SAMPLE OF DIFFERENT AGN (Type I)

- Radio Luminosity
- Optical —> Disc Luminosity
- X-rays —> Comptonization Component

Mass and K-correction



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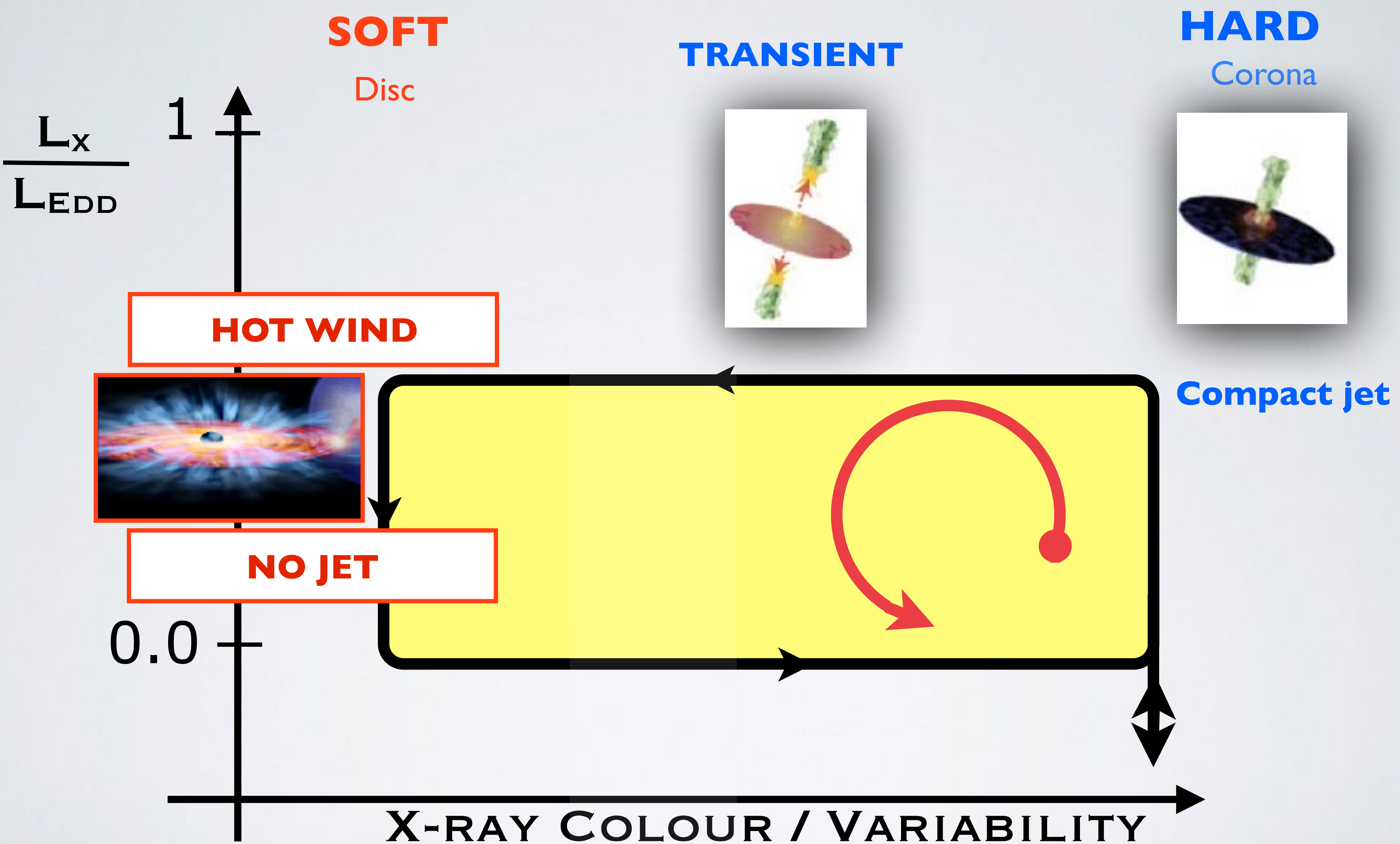

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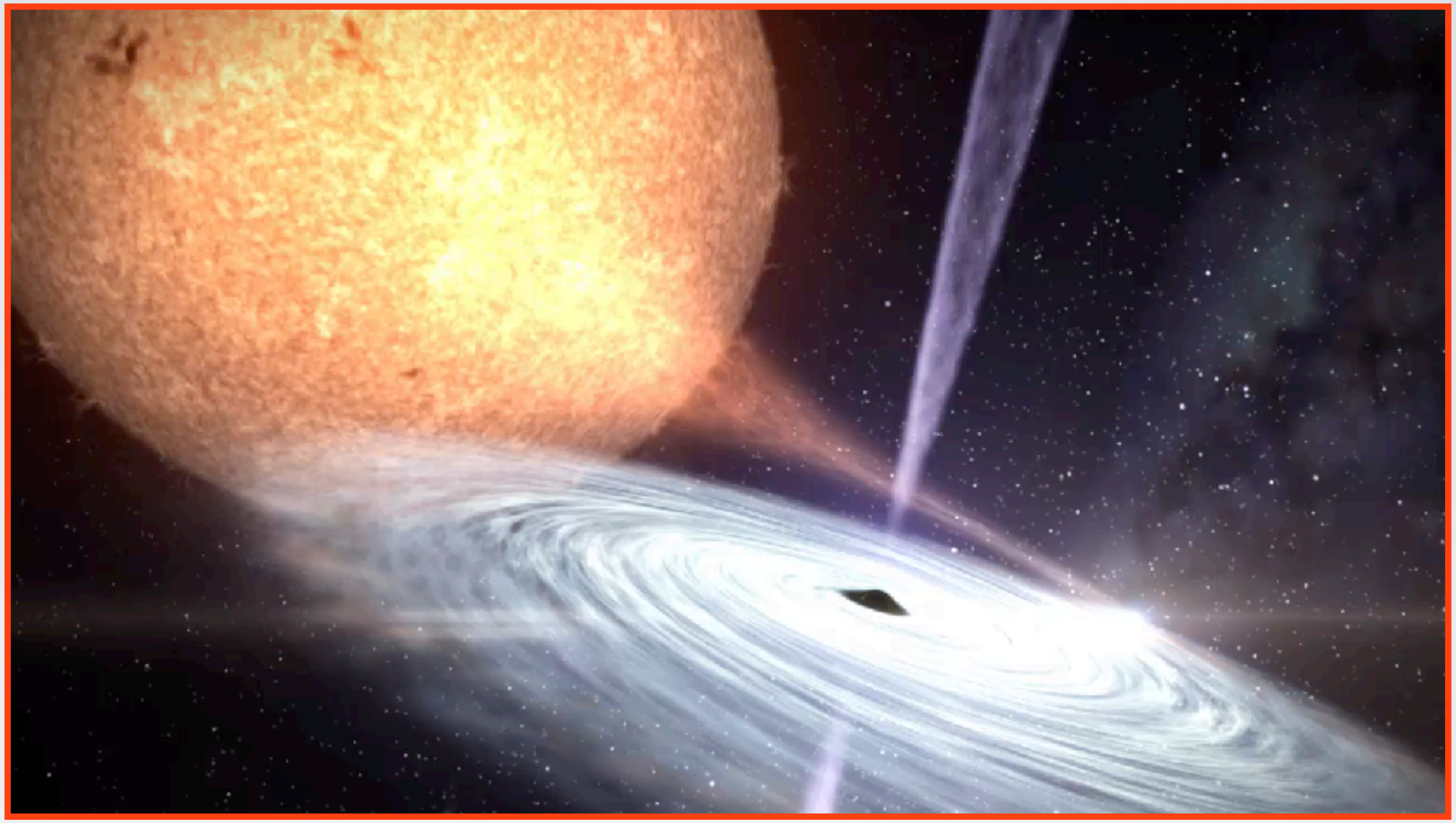
V404 Cygni: a nearby and powerful BH transient



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, Nature; 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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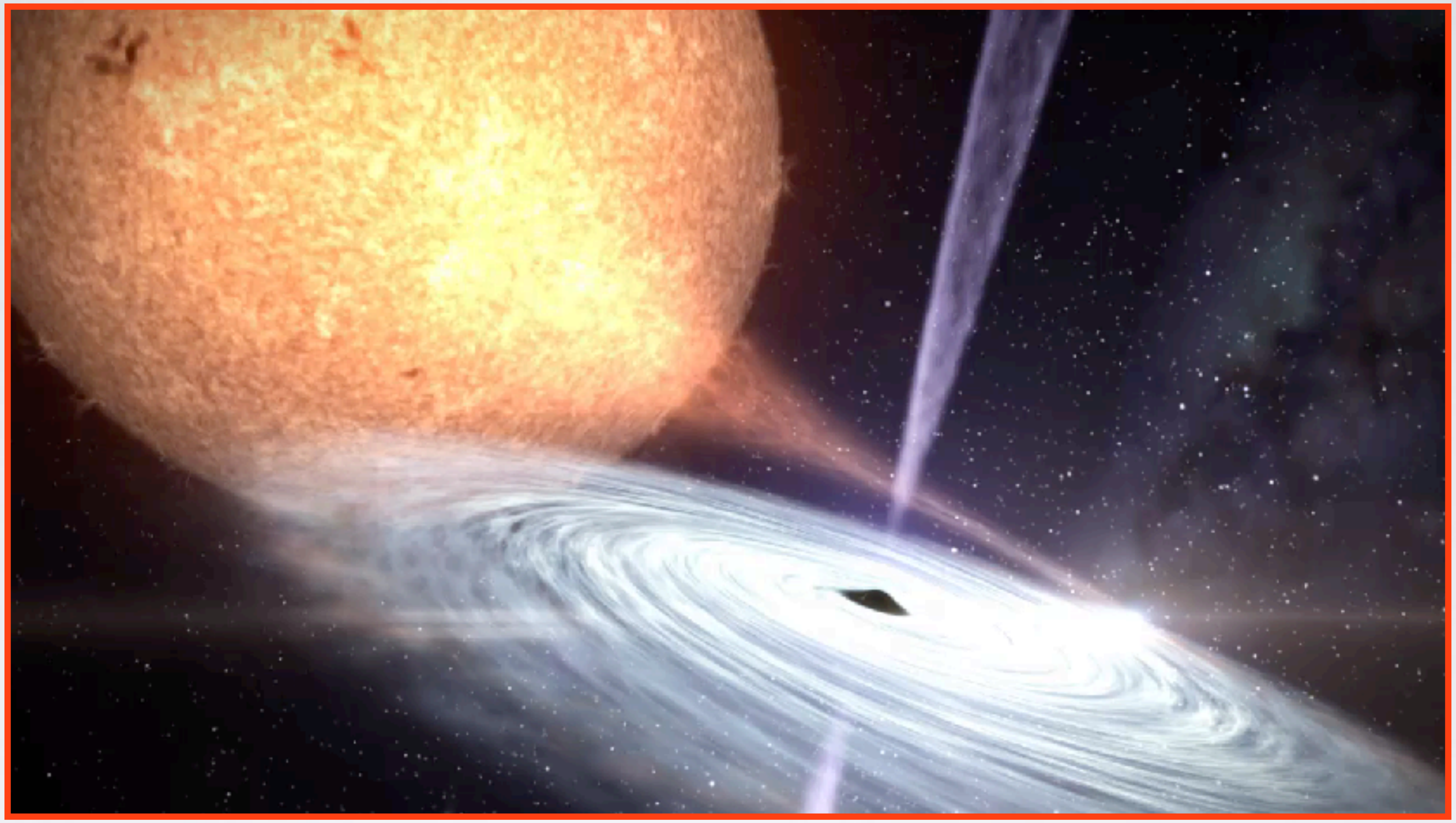

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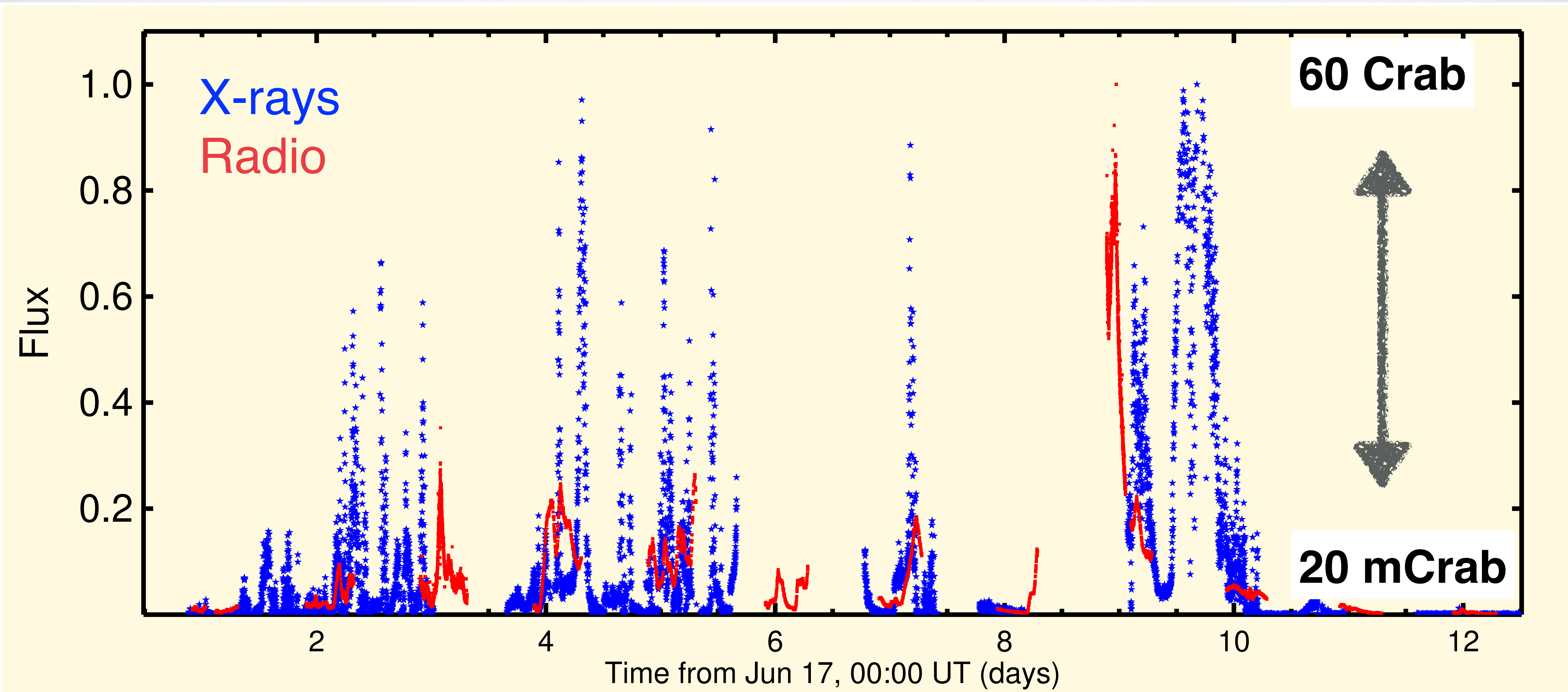

X-rays (20-200 keV): Superb INTEGRAL coverage

Rodriguez et al. 2015; Roques et al. 2015; Muñoz-Darias et al. 2016; Motta et al. 2017

Radio (16 GHz): AMI (Cambridge, UK)

Muñoz-Darias et al. 2016; Motta et al. 2017; Fender et al. in prep.

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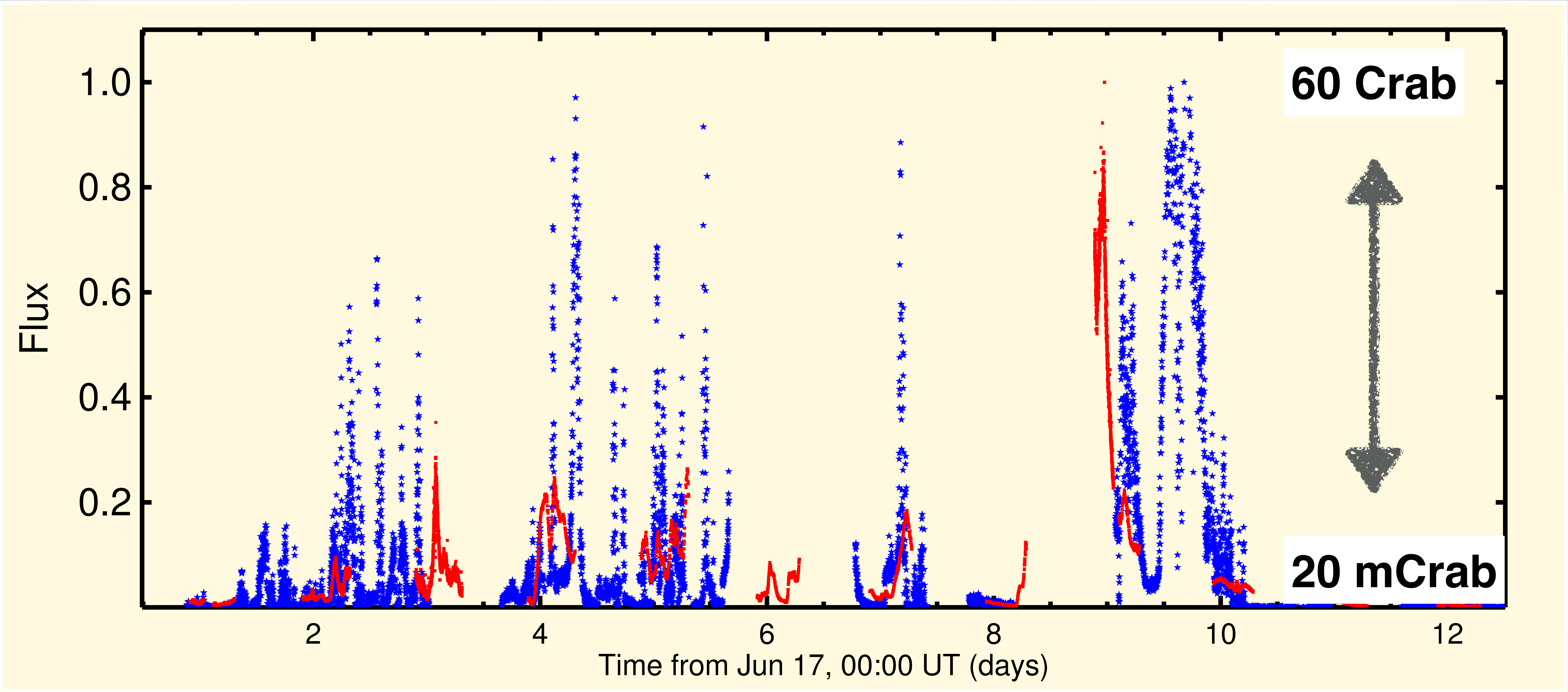
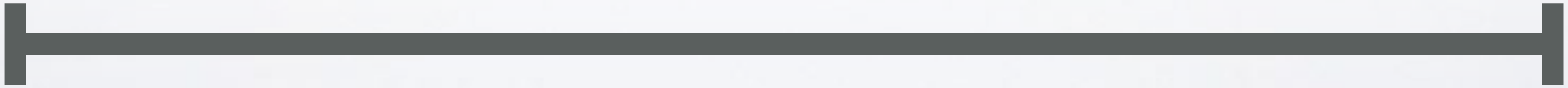


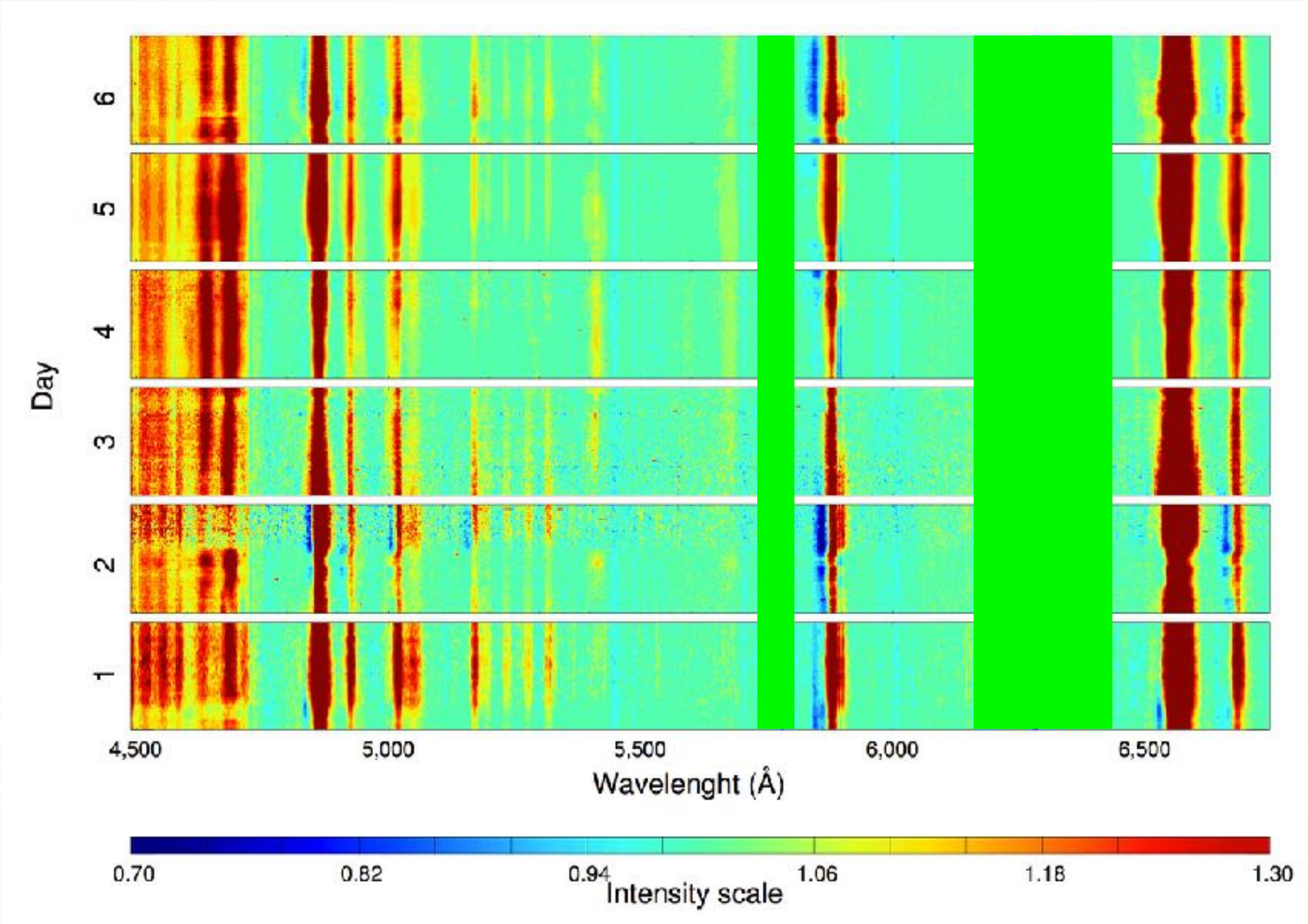


10 + 5 days

BUT VERY SHORT…

Optical Accretion disc wind from V404 Cyg

P-CYG PROFILES IN 12 EMISSION LINES



Muñoz-Darias et al. 2016, Nature

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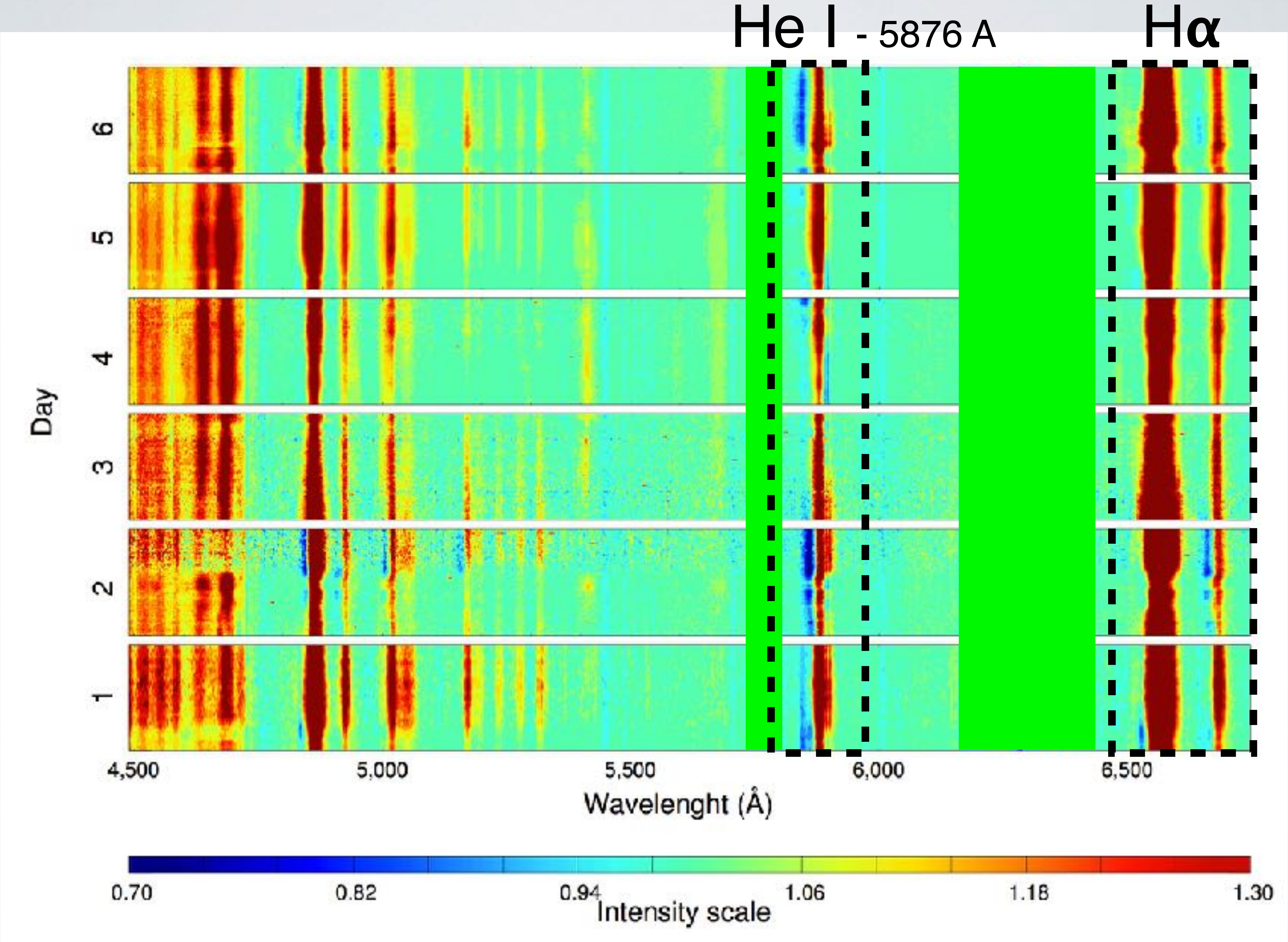

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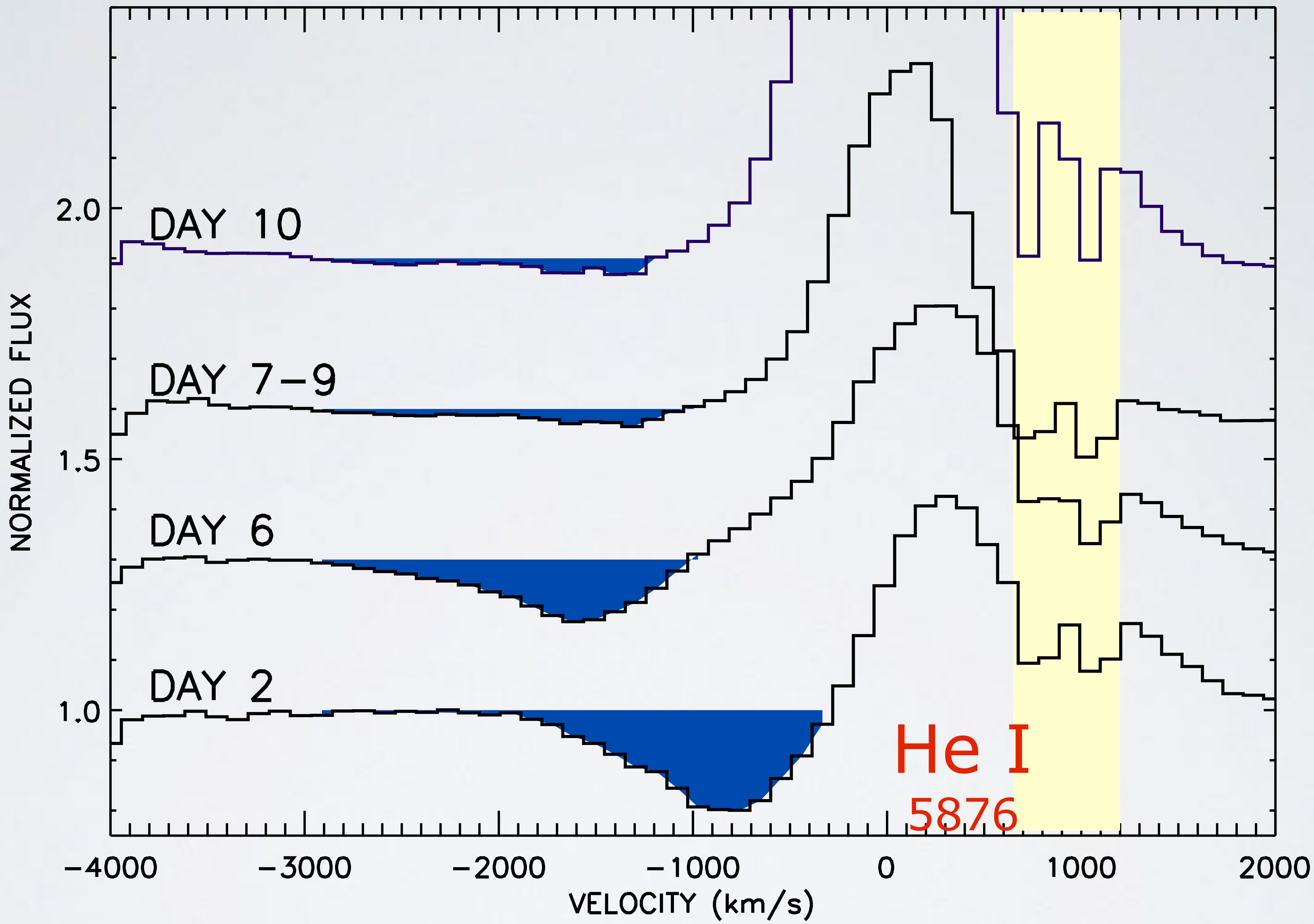


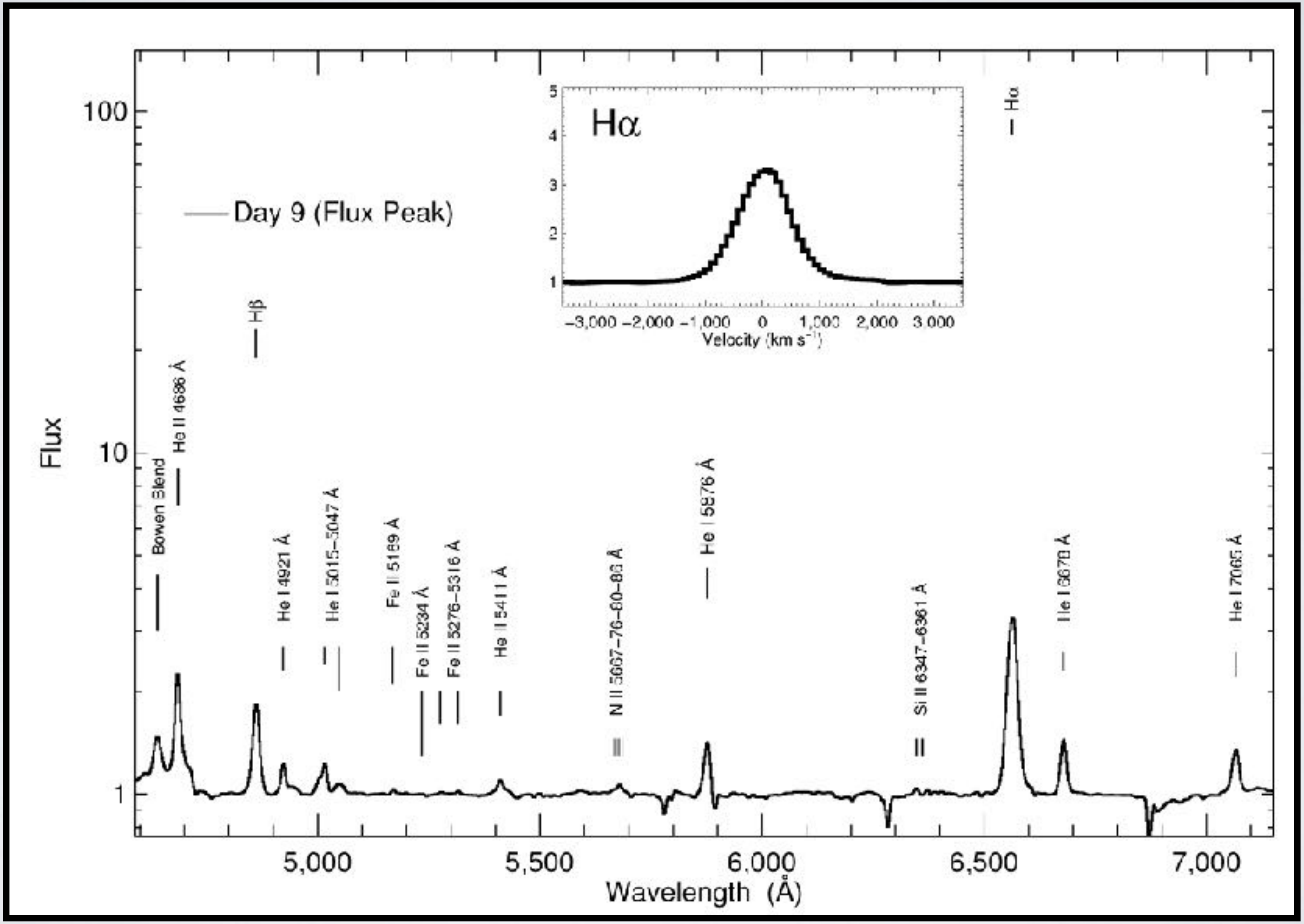
High-velocity, optical wind simultaneous with the radio jet

Strong flaring activity and high intrinsic extinction Motta et al. 2017

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

NEBULAR PHASE

Muñoz-Darias et al. 2016, (see also Rahoui et al. 2016 and Mata-Sanchez et al. 2018)



Optically thick to optically thin transition

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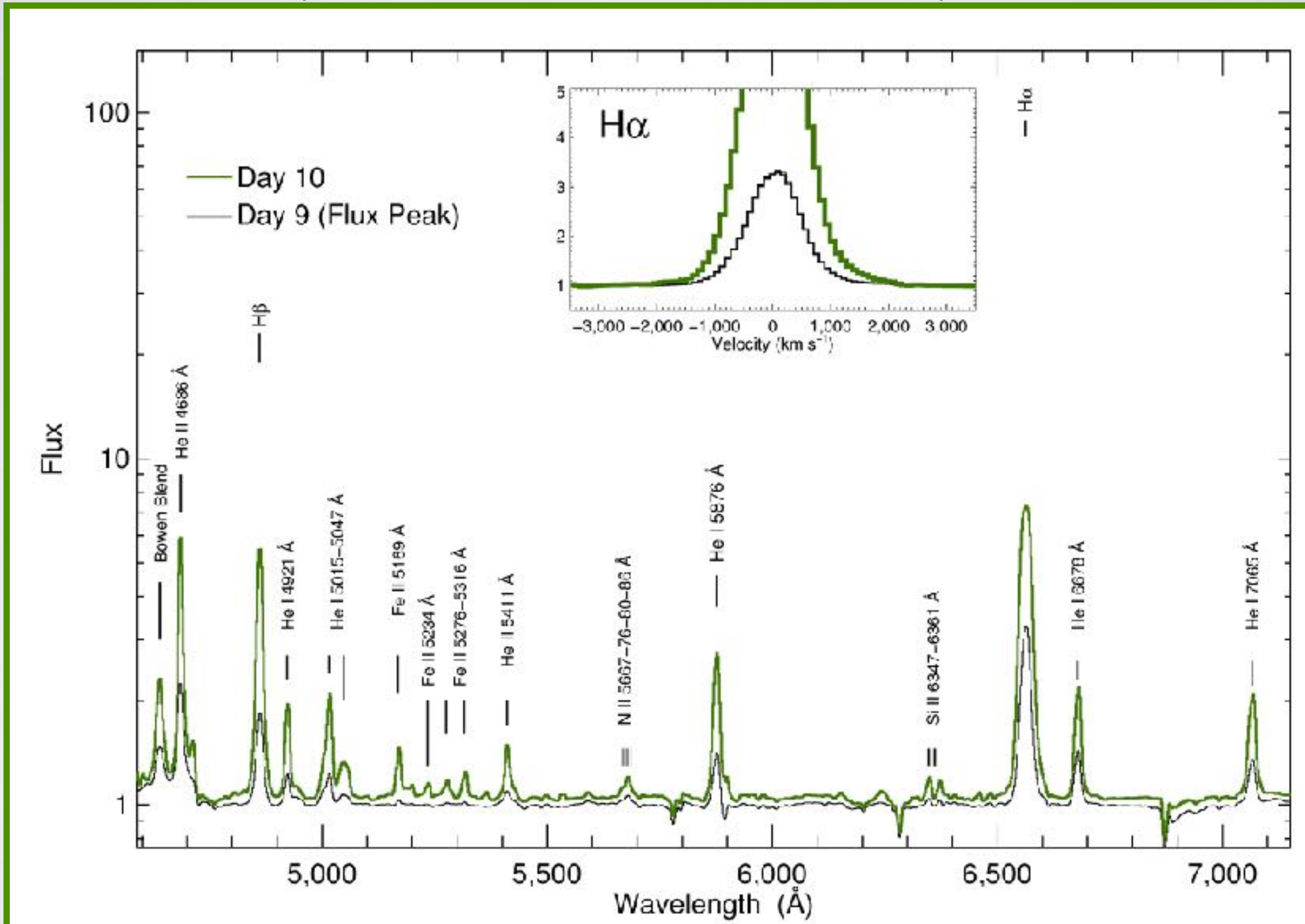

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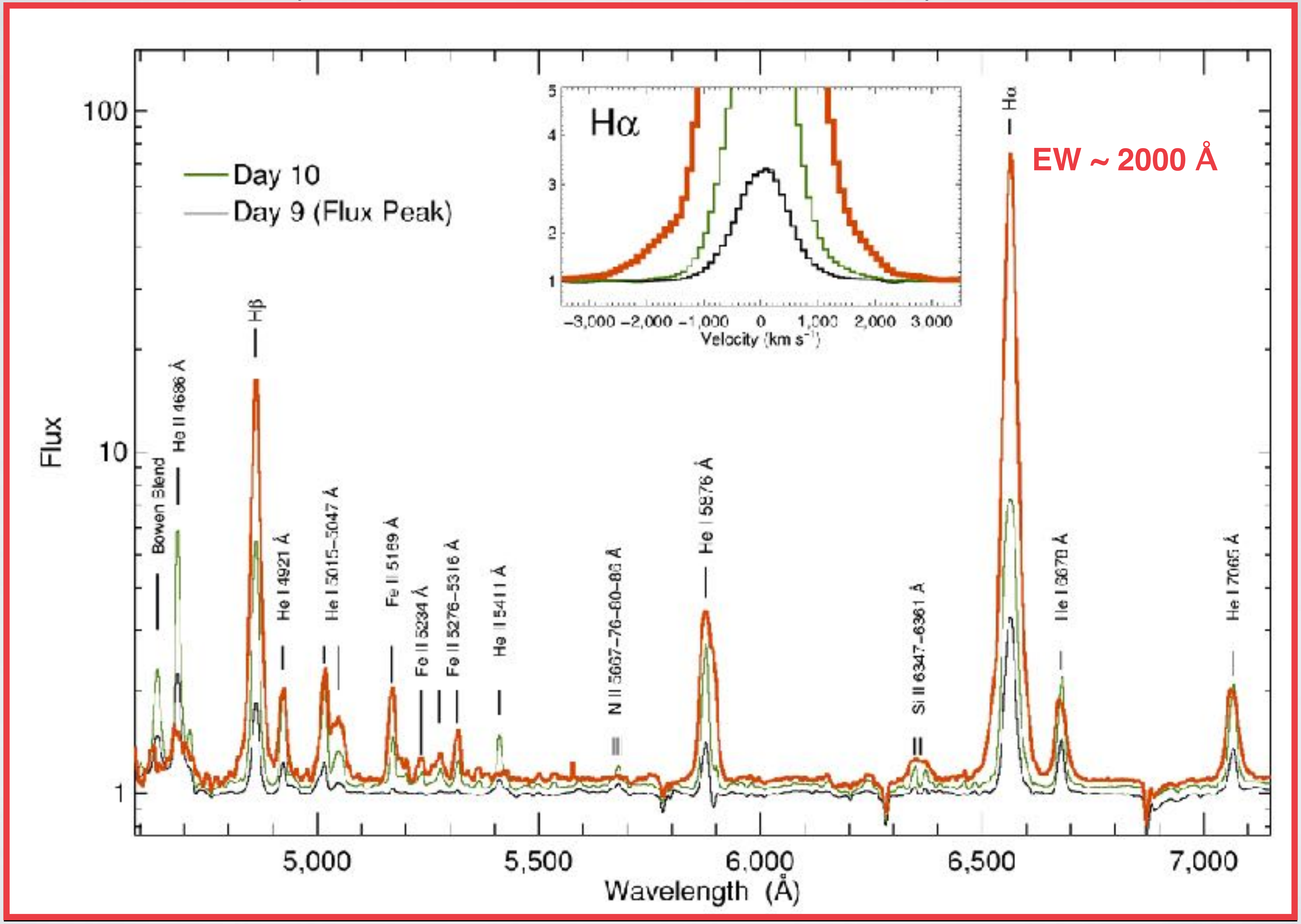

Optically thick to optically thin transition

Mass Balance (King, Kolb, Burderi 1996)

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

- Ejected Mass: >> 0.001 $\mathbf{M_{disc}}$
  $\sim$0.1 $\mathbf{M_{disc}}$ Casares et al. 2019
- Accreted Mass: ~ 0.001 $\mathbf{M_{disc}}$
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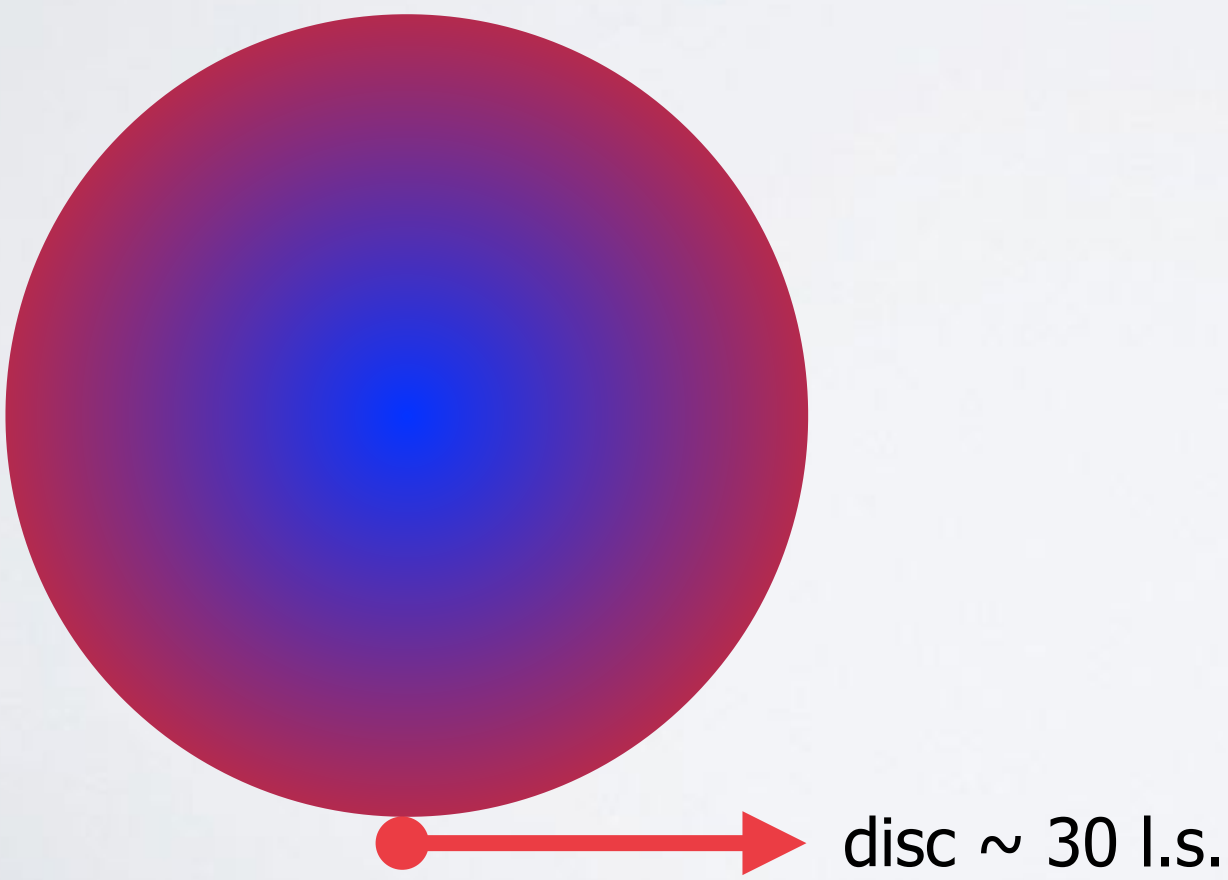

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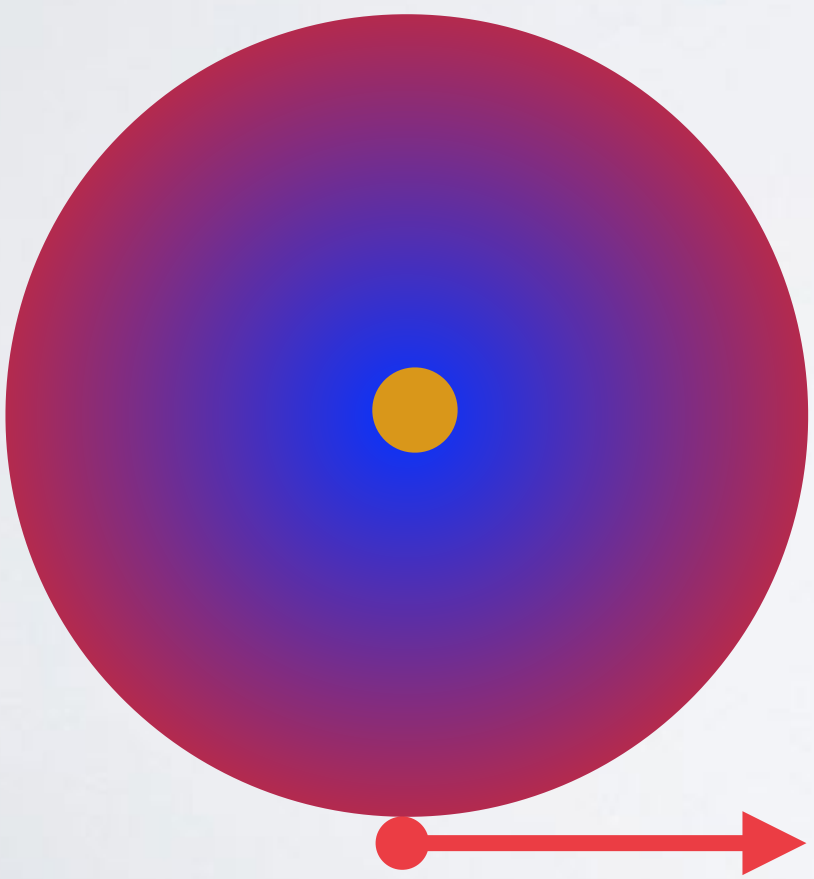
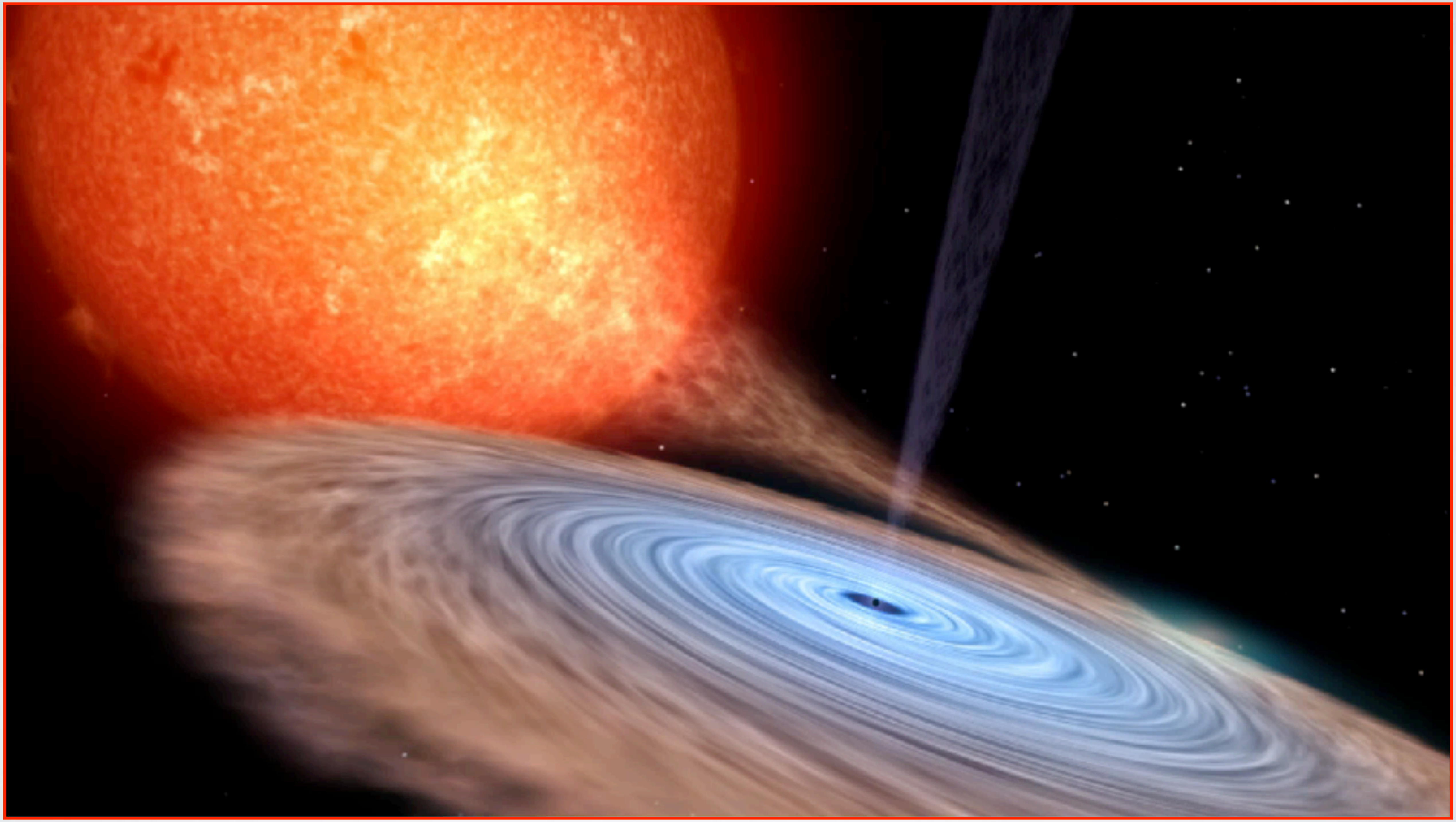


disc ~ 30 l.s.

Innermost 3 l.s. (Consistent with thermal wind launching radius)

The wind is regulating the outburst! (?)



Credit. G. Perez (IAC)

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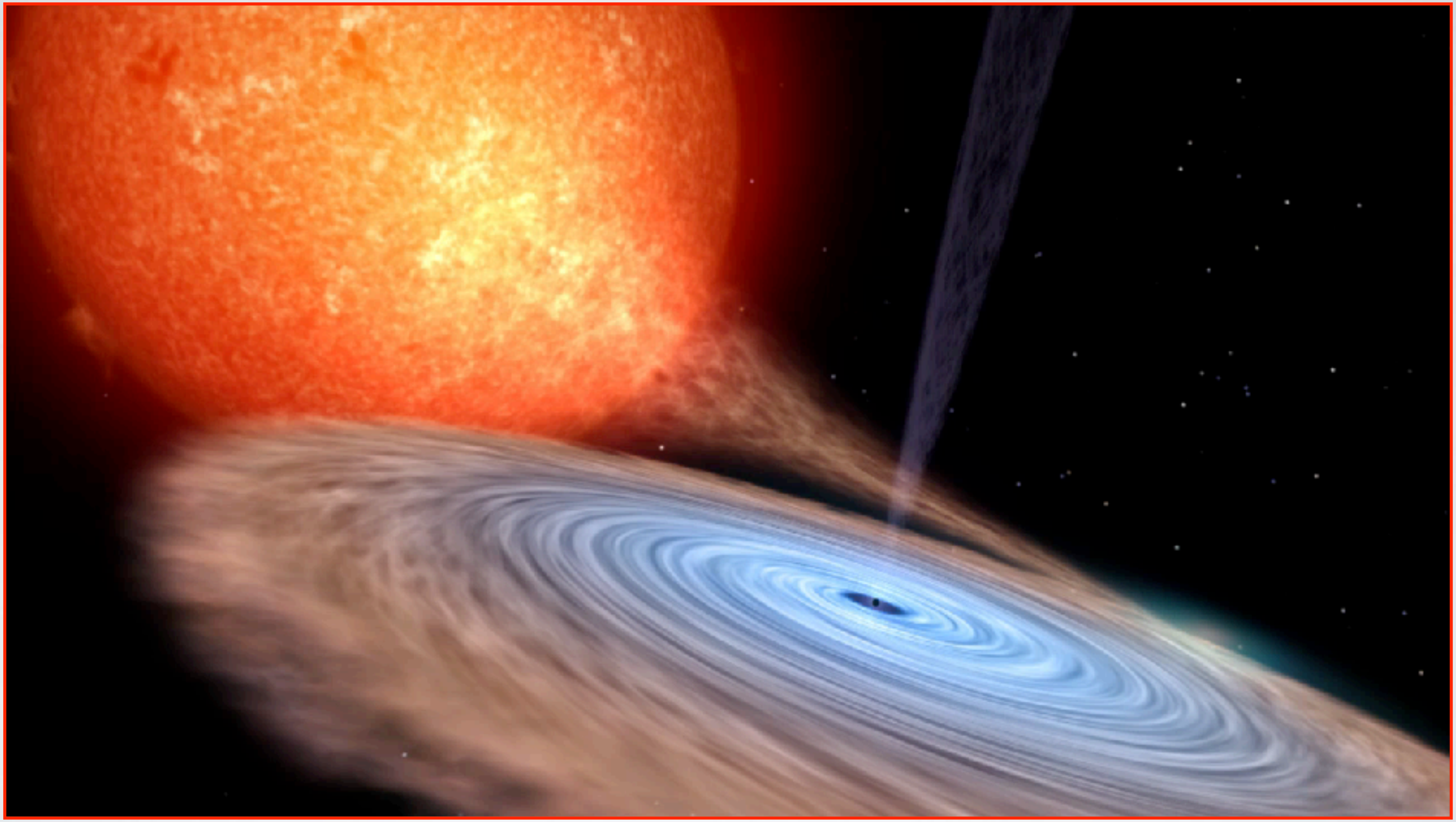

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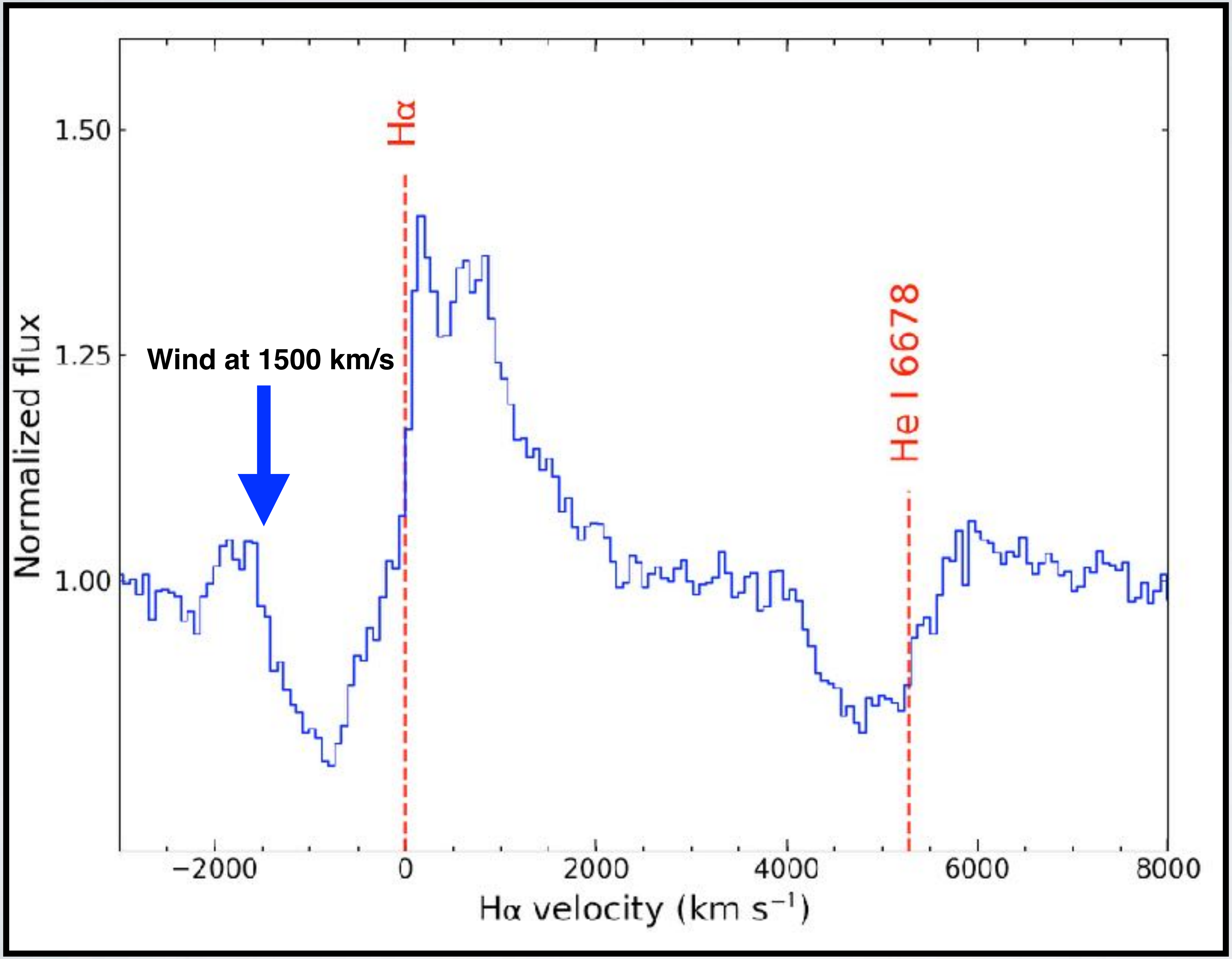
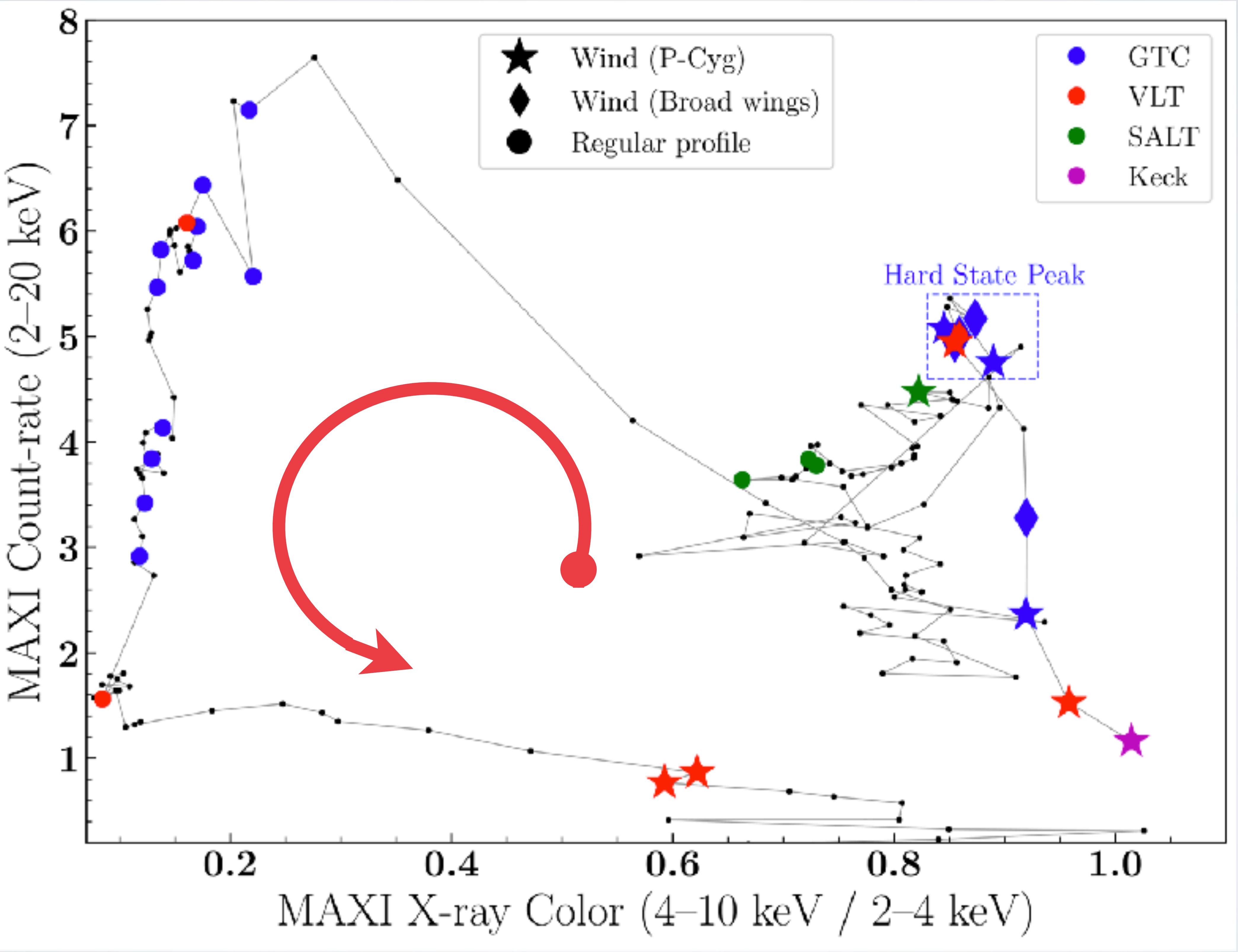
Conspicuous optical winds in other BHs transients

Muñoz-Darias, Torres & Garcia, 2018, MNRAS



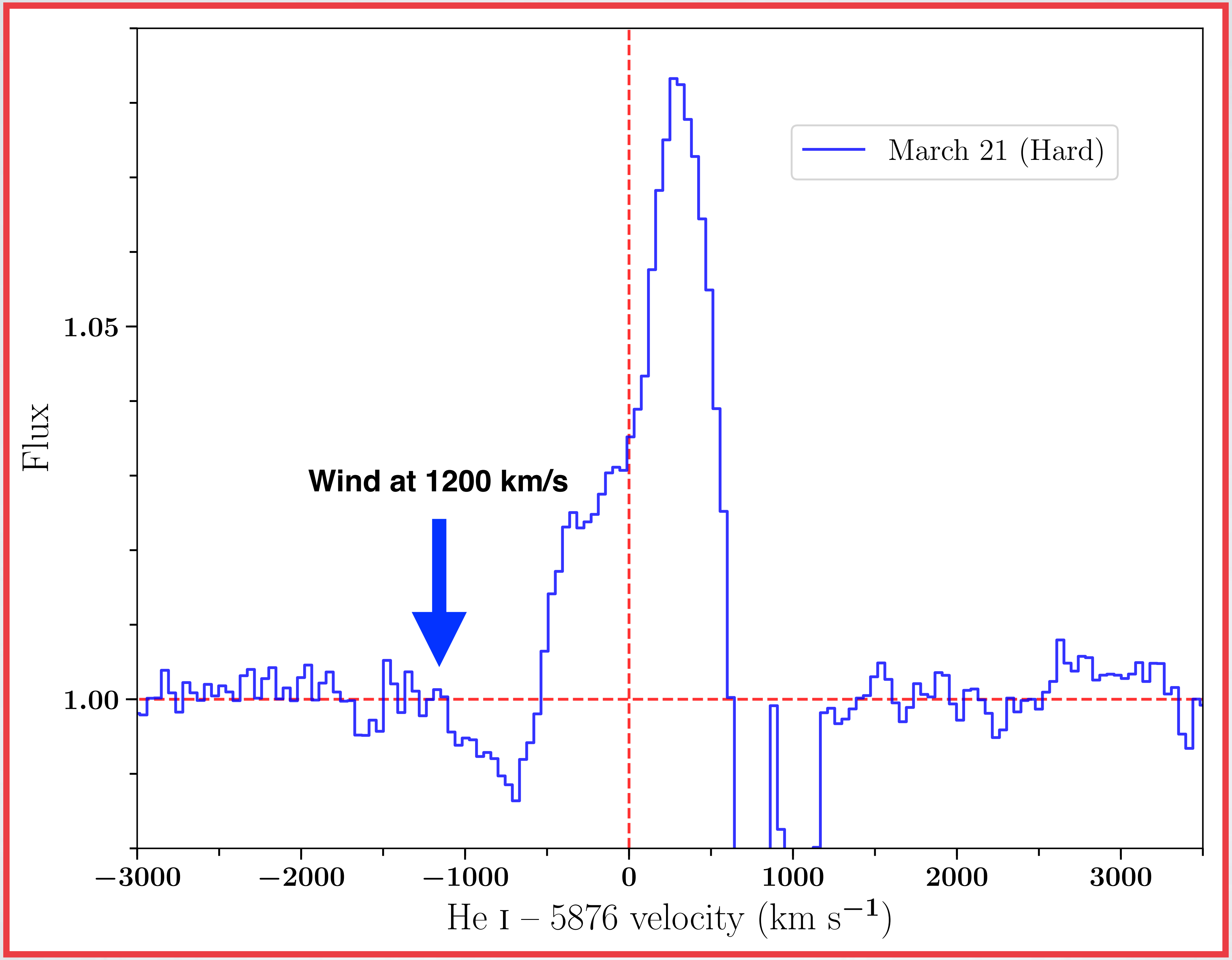
MAXI J1820+070: optical wind during a regular outburst

Muñoz-Darias et al. 2019 ApJ Lett.



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

MAXI J1820+070: weak features from a state-dependent cold wind



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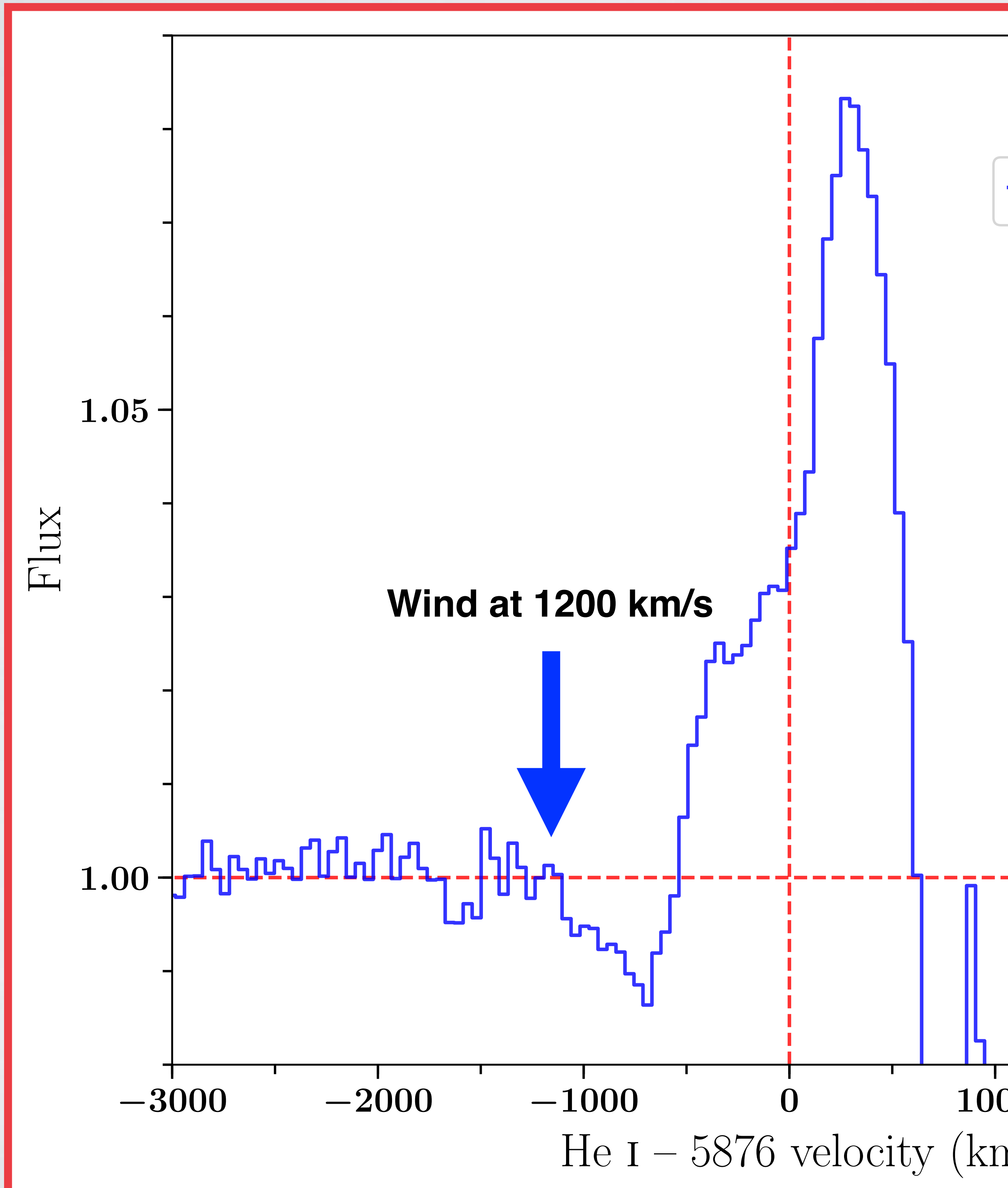

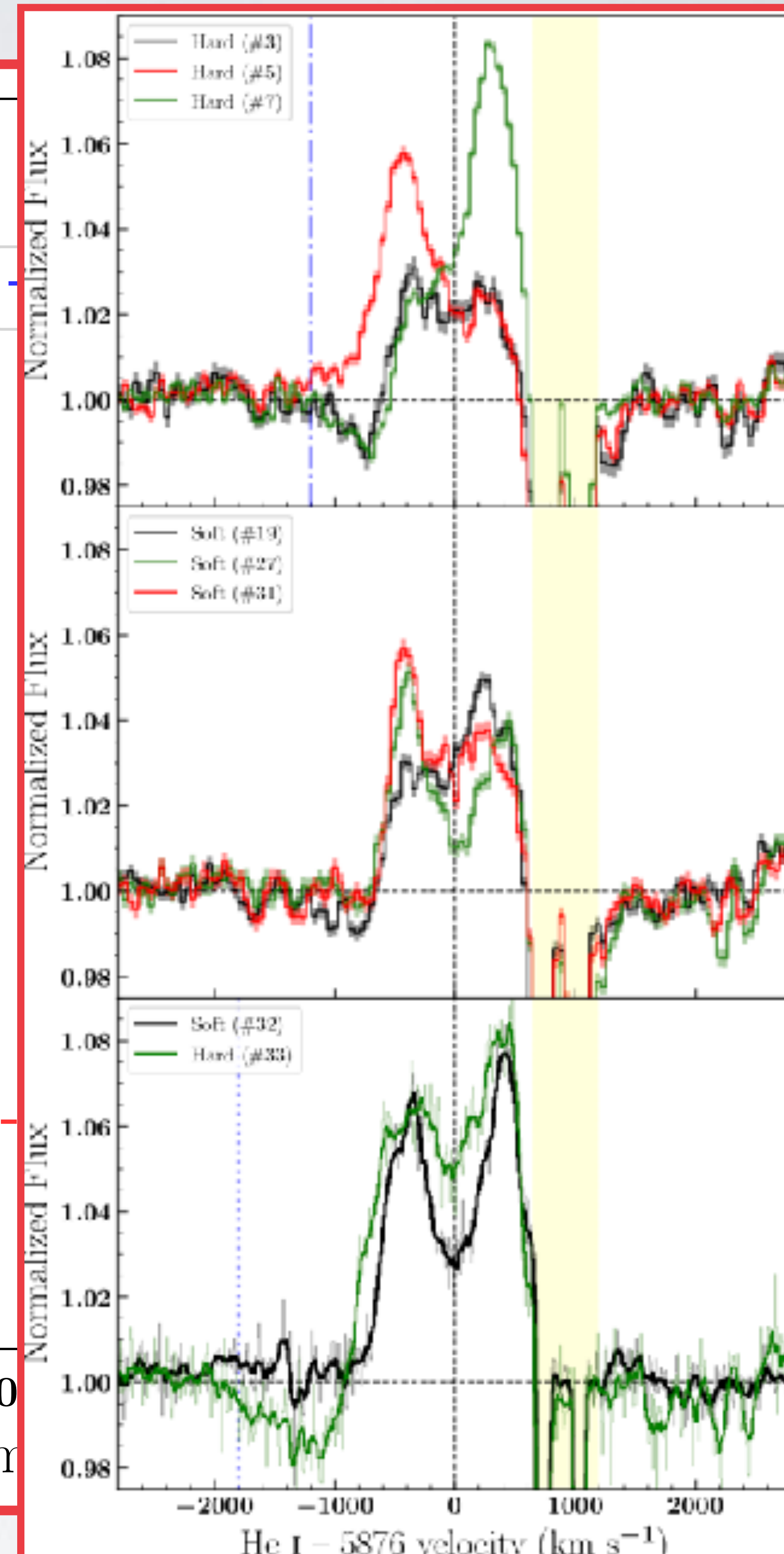

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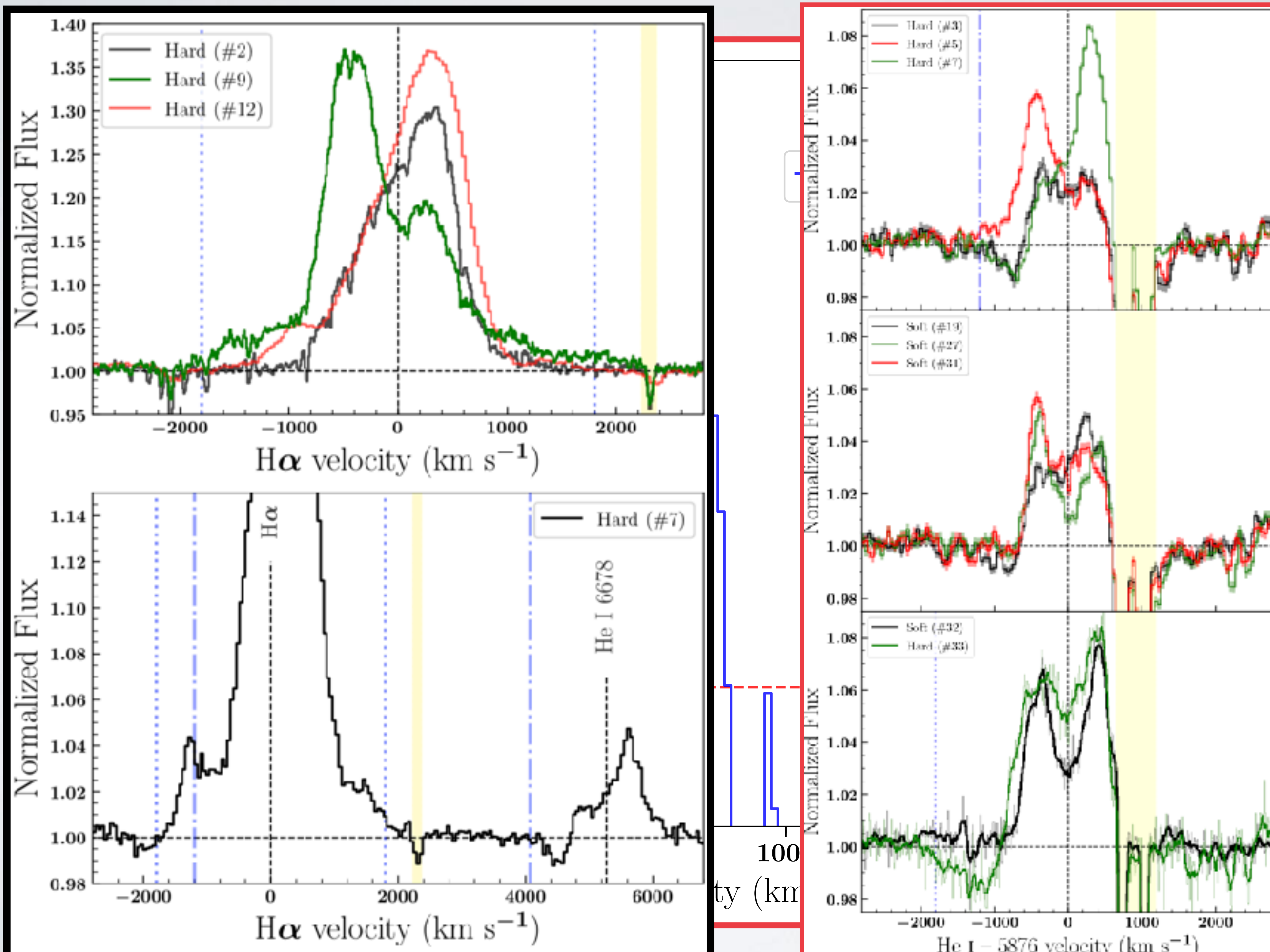
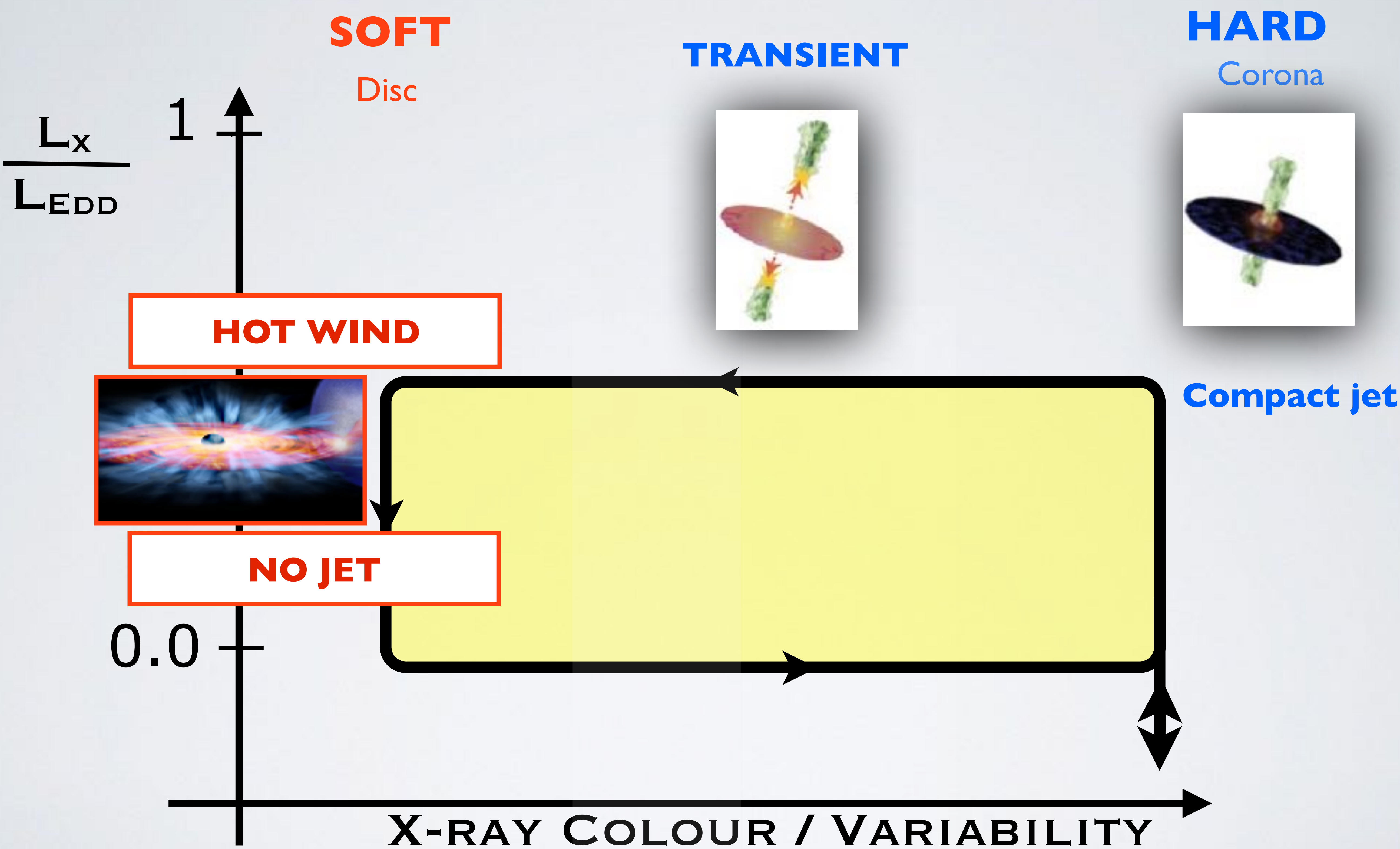


ACCRETION/OUTFLOW COUPLING



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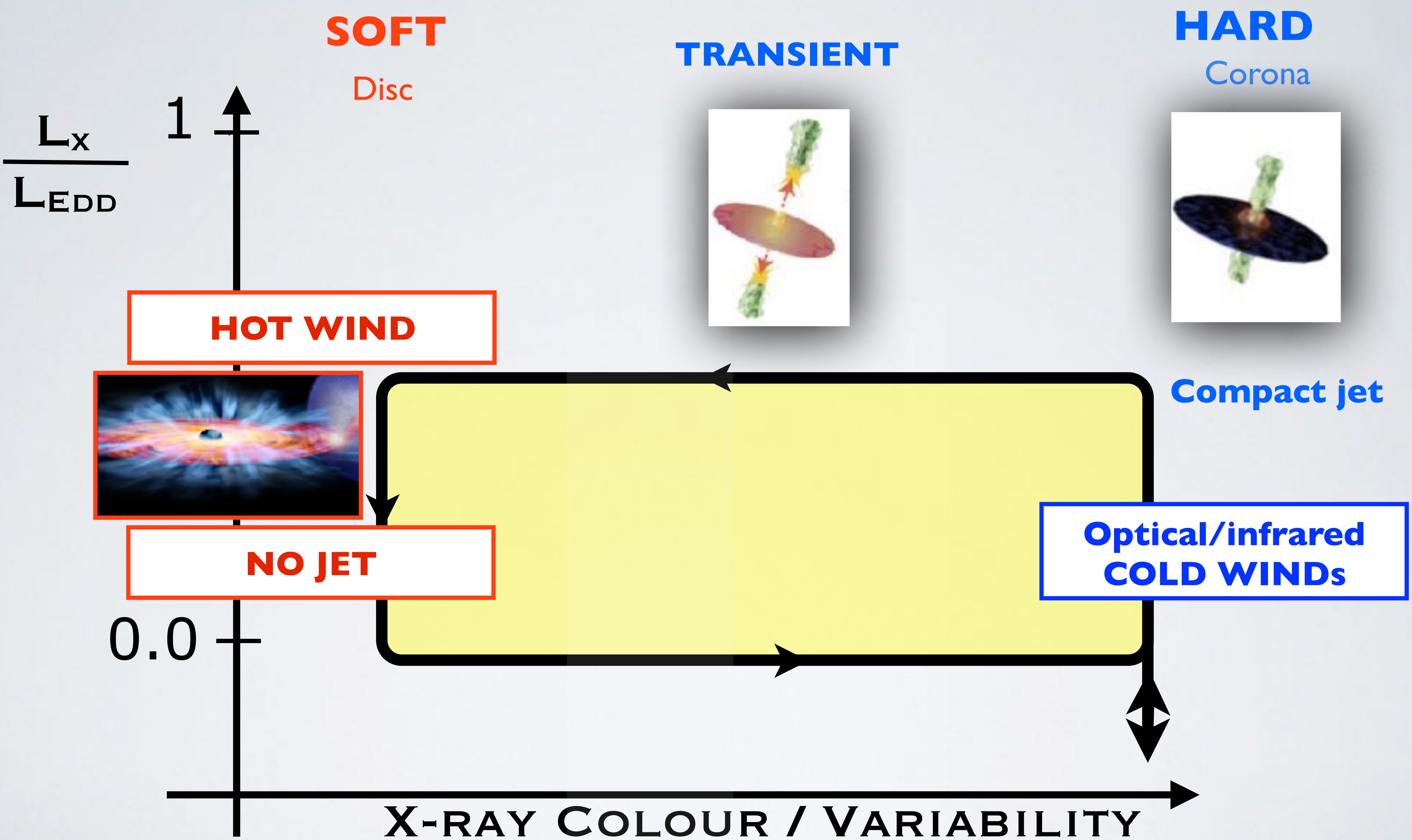
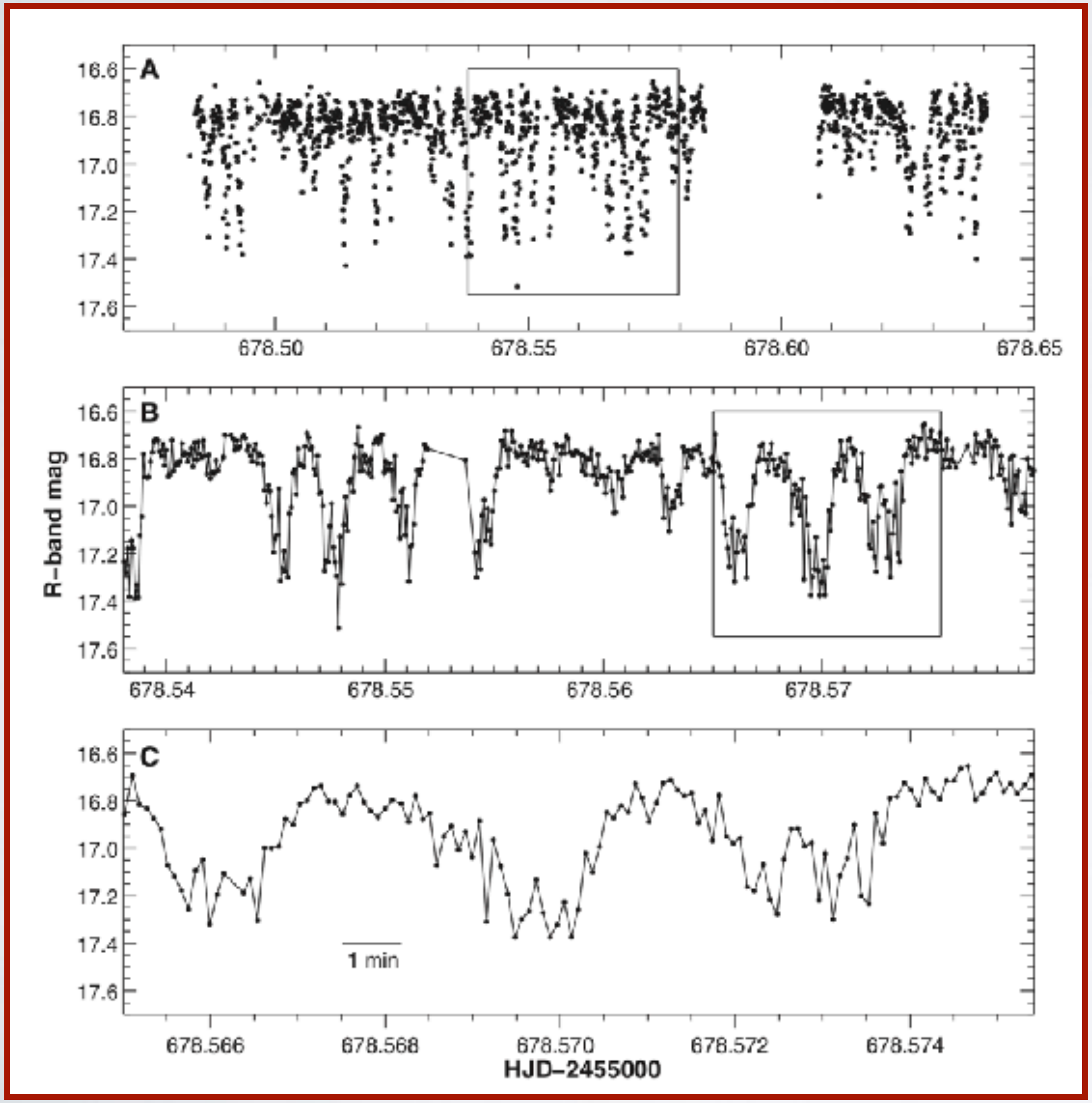


Swift J1357.2-0933: the changing look micro-quasar

Optical dipper seen at very high inclination (Corral Santana et al. 2013, **Science**)



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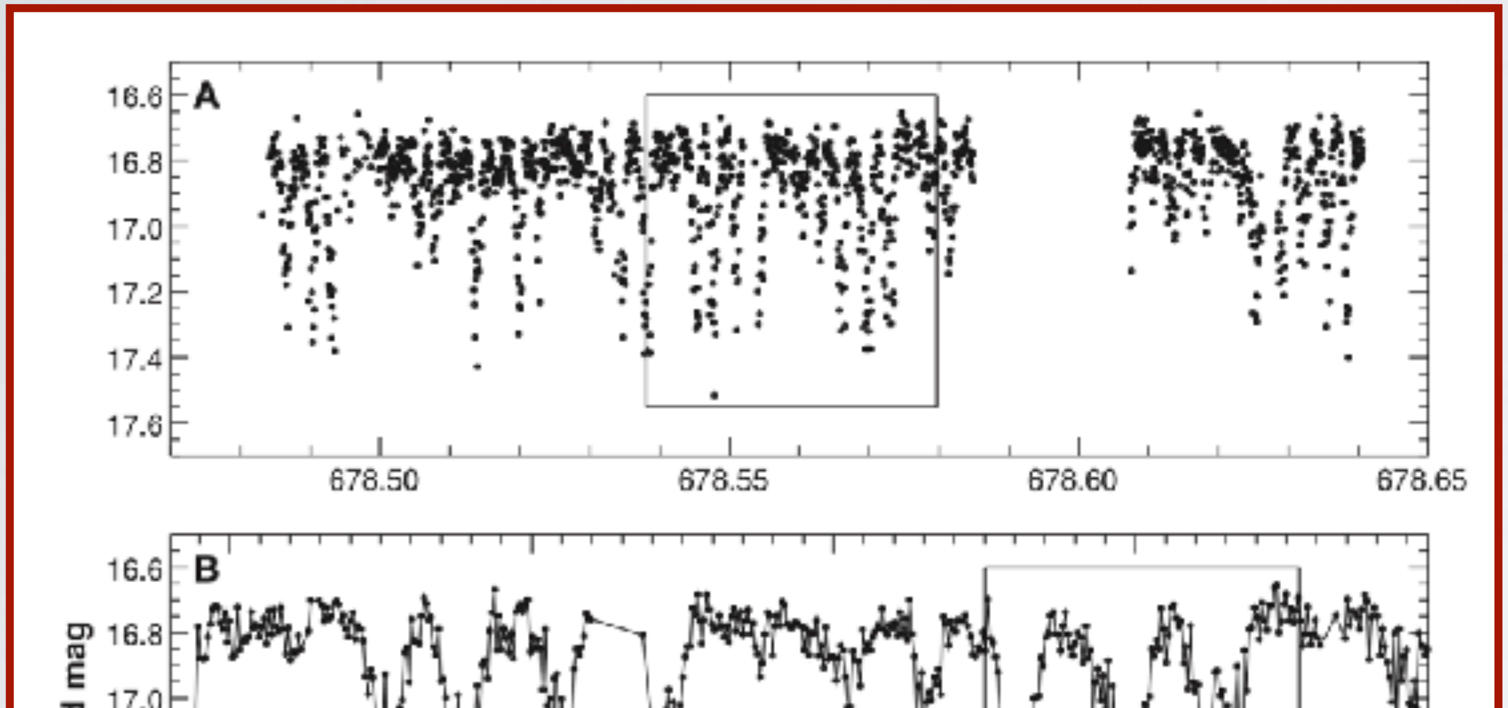

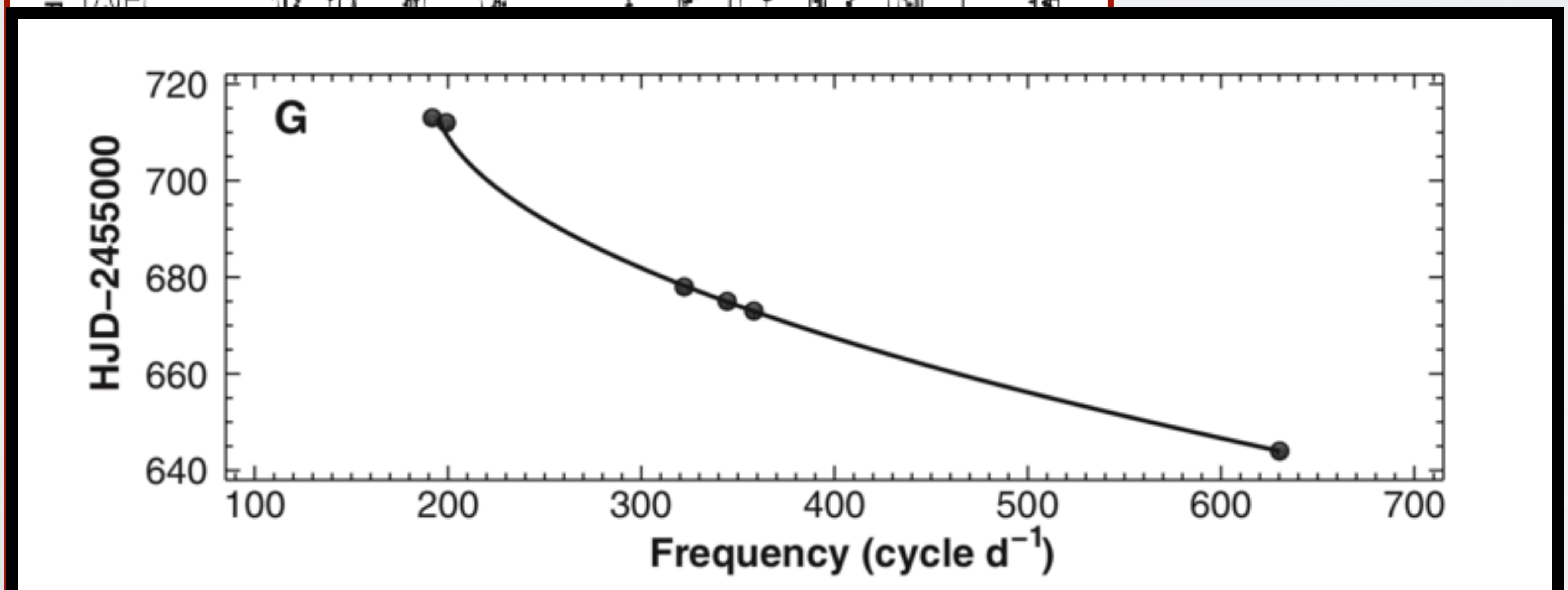

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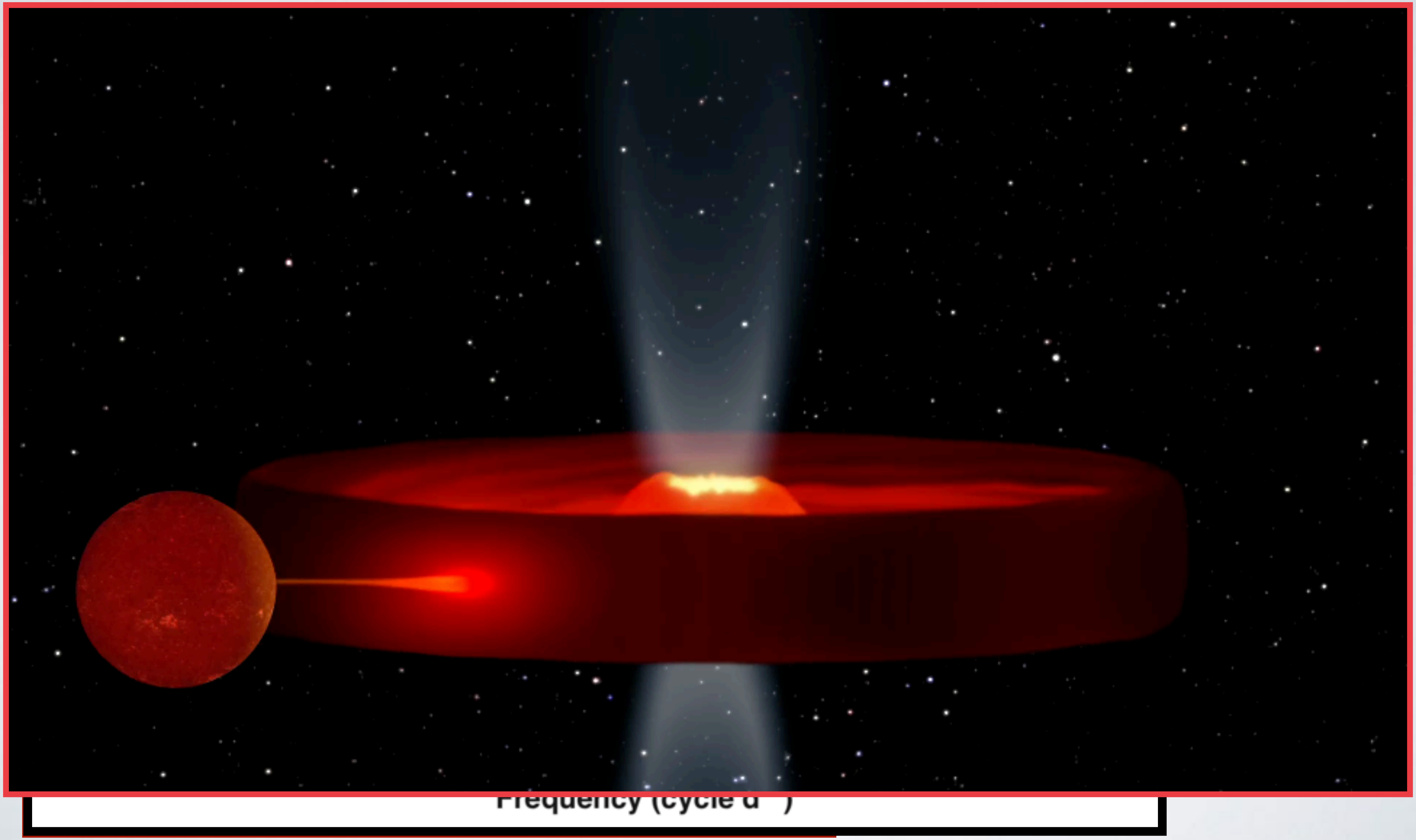

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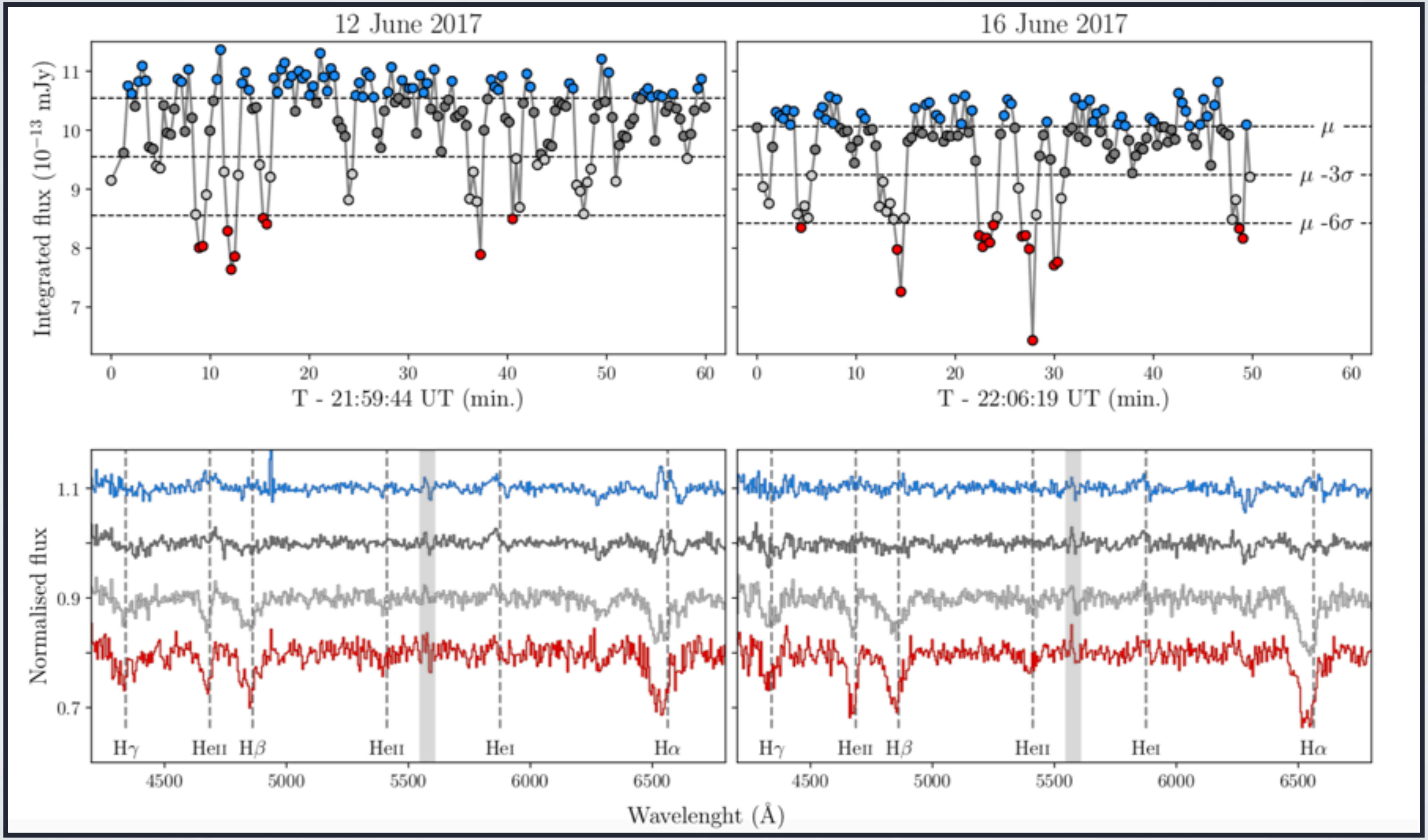
Black Hole transient optical dipper seen at high inclination (Corral Santana et al. 2013)



Dip-resolved spectroscopy Jiménez-Ibarra, TMD et al. 2019, MNRAS

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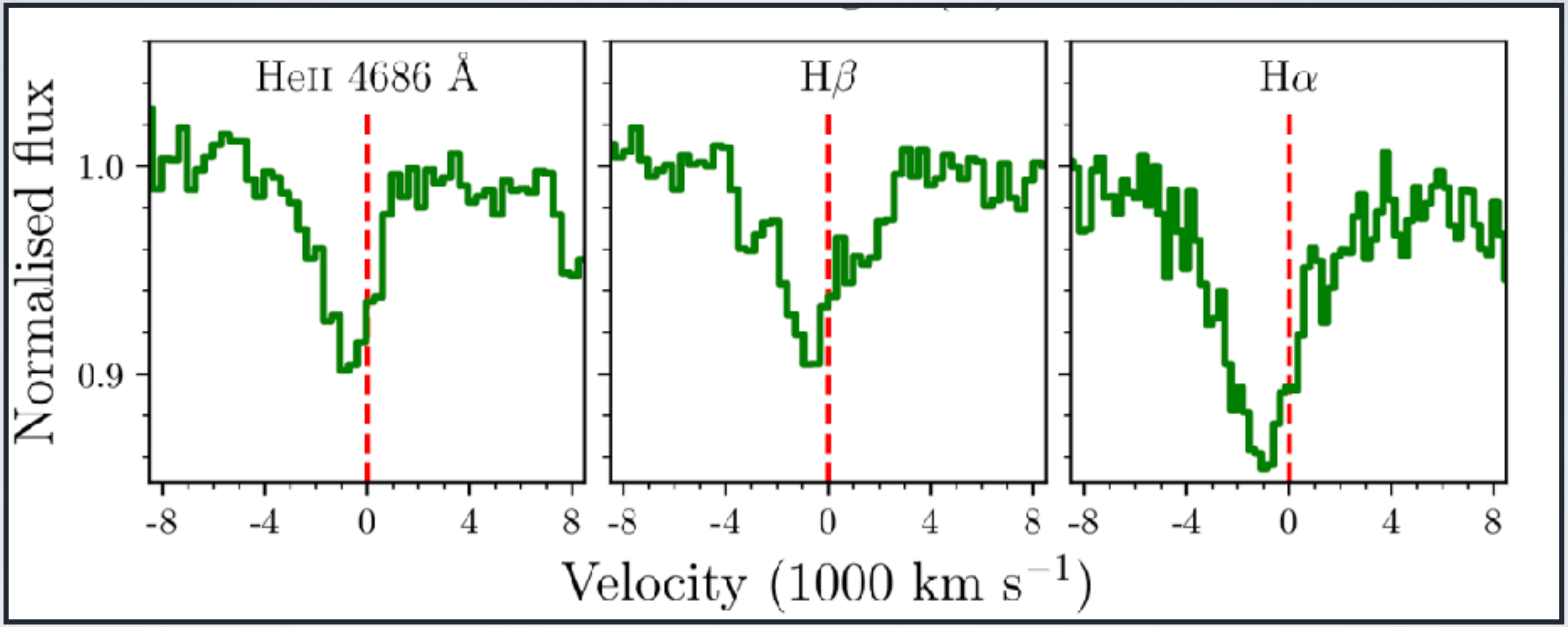

Equatorial outflow: Blue-shifted absorptions a 0.01c (blue-edge)

Launching radius (scape velocity) consistent with dip recurrence period

Outflowing structure at ~ 10^5 km (7000 Rg)

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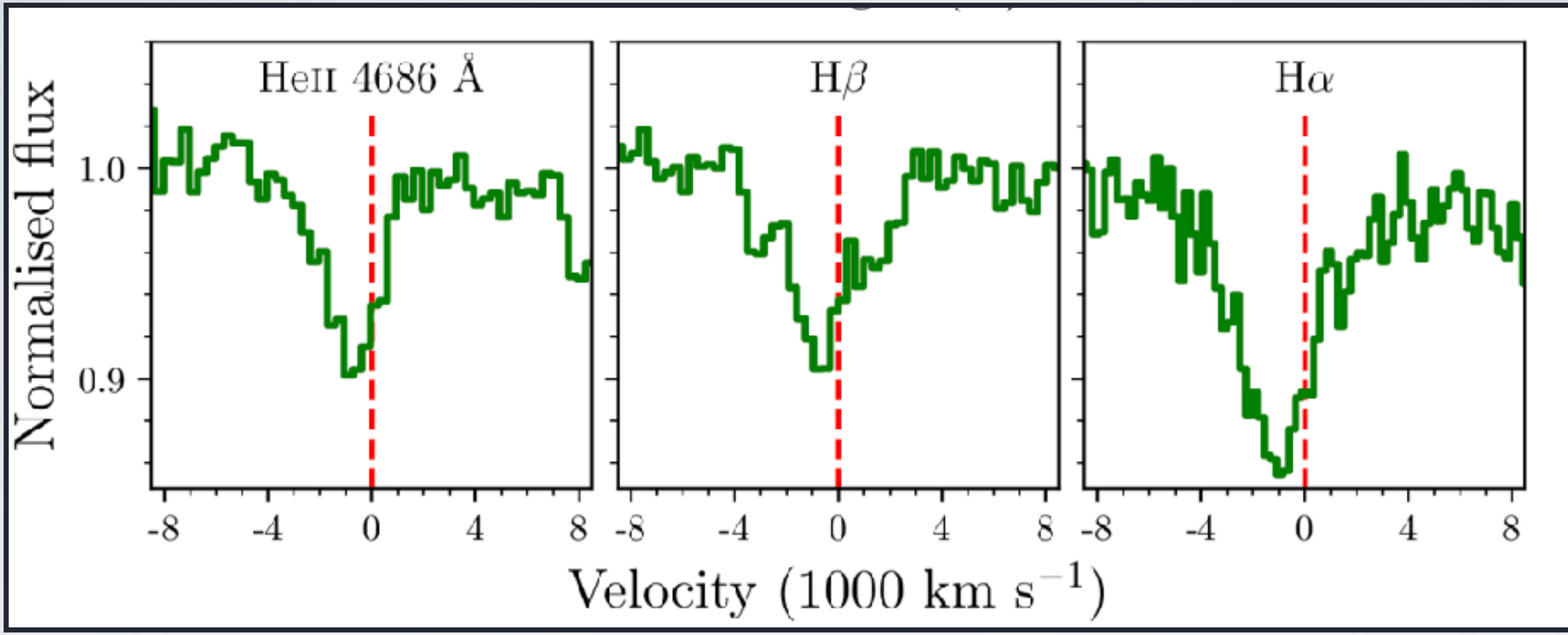

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Blue-shifted absorptions observed later in the outburst and modelled by dense and hot outflow component (Charles et al. 2019, MNRAS)

Stellar-mass Black Holes allow us to:

- To study accreting BHs on human beings time scales and cleaner environments
- To establish an “Accretion-Ejection” scheme (which may be present in AGN to some extent)

Strong emission/absorption line variability

- In most cases linked to outflows. They do impact on accretion
- Obscuration effects (might be also related to outflows).