Accretion and feedback from stellar-mass black holes at (near-)Eddington rates

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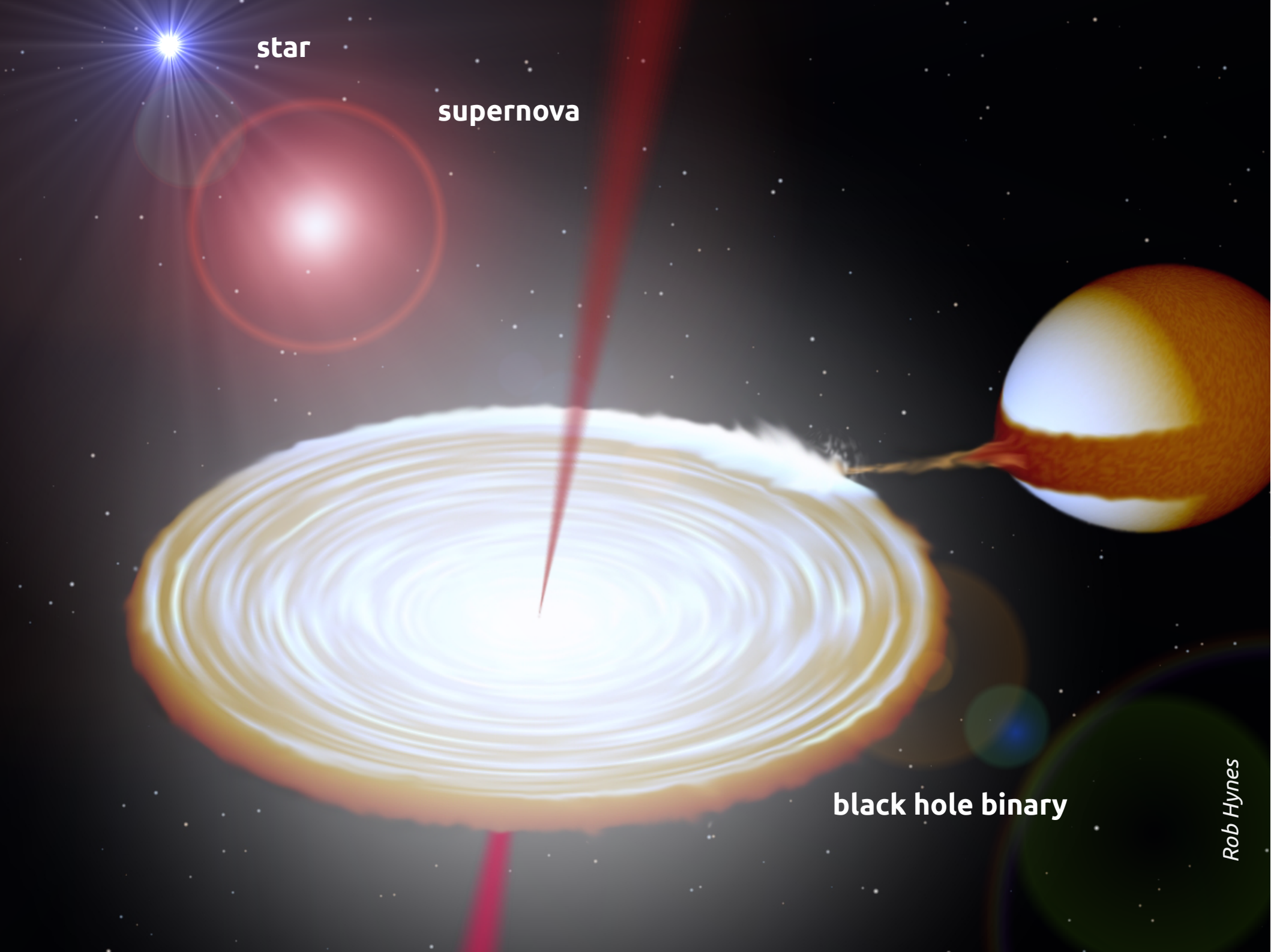
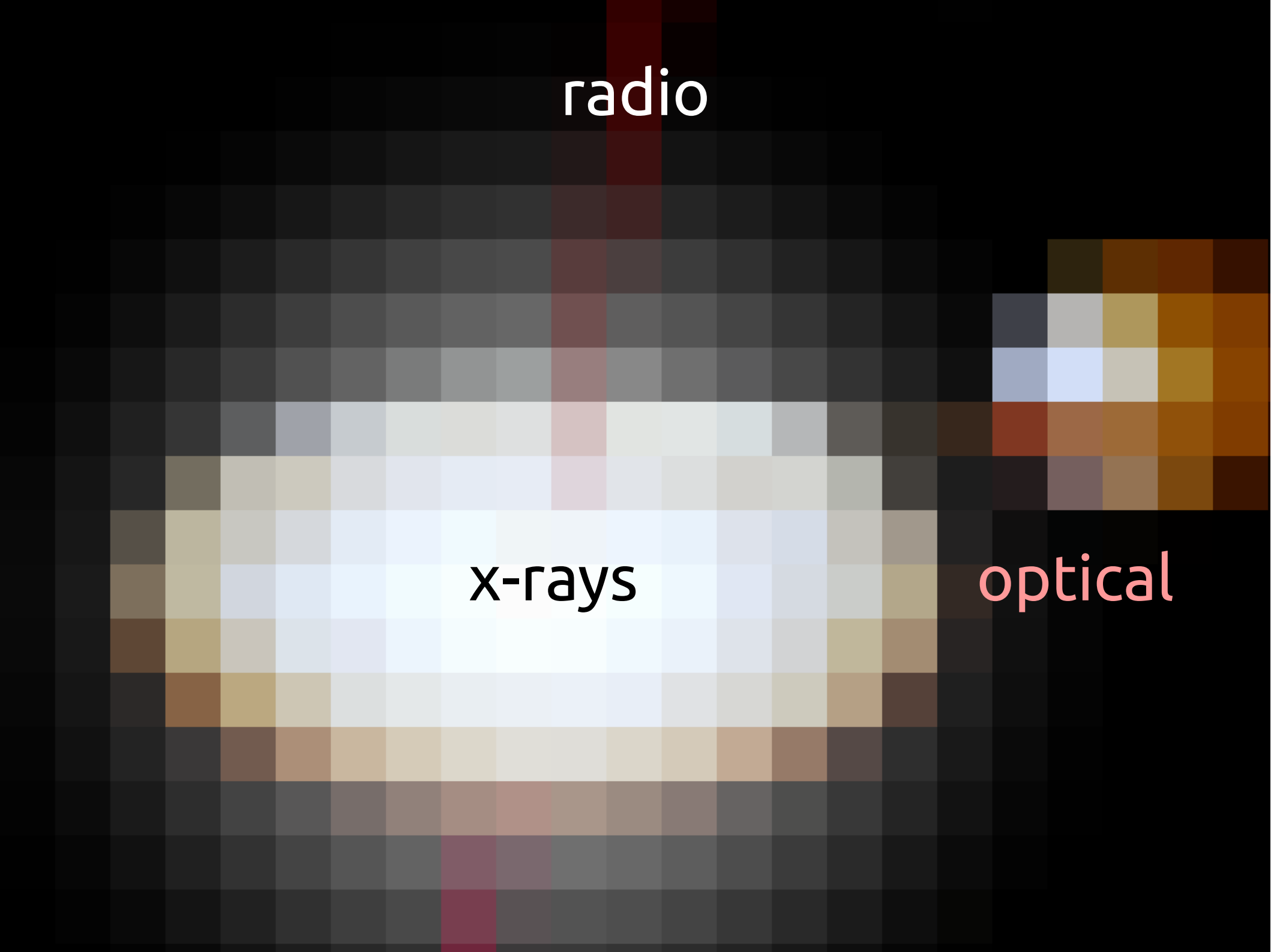
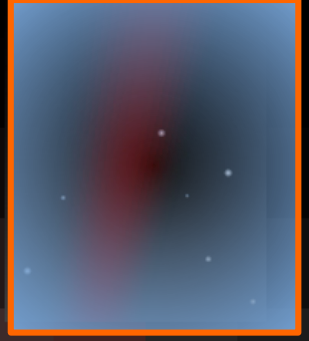

star
supernova
black hole binary
Rob Hynes


radio
x-rays
optical

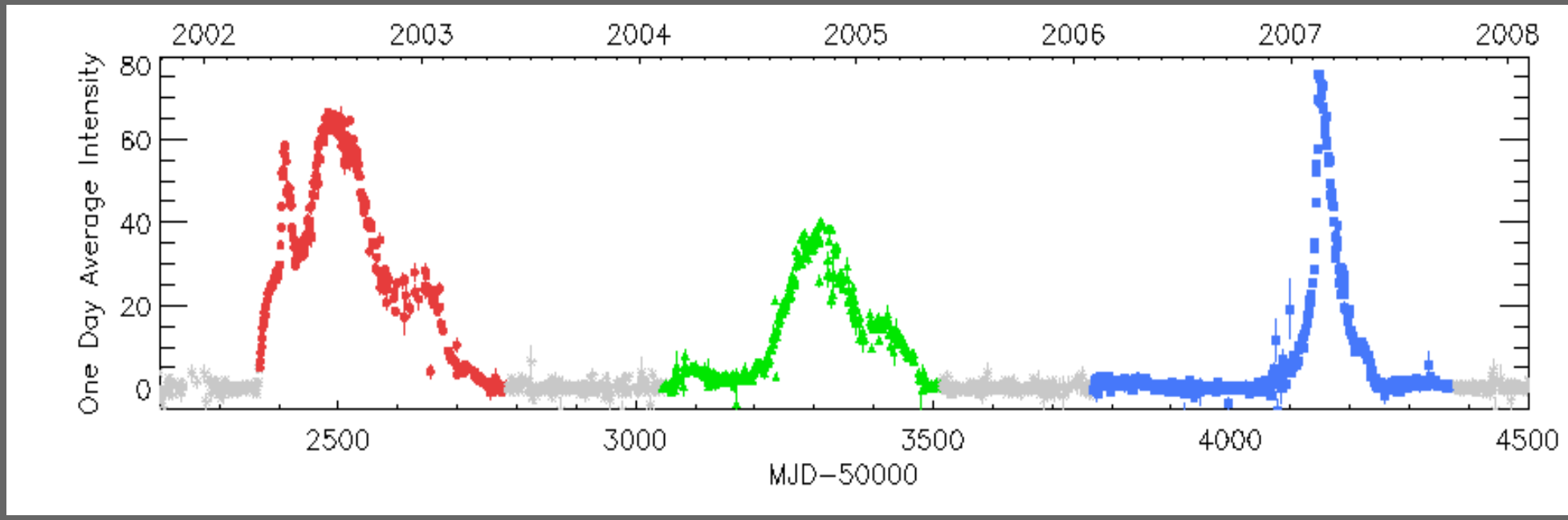
radio



optical

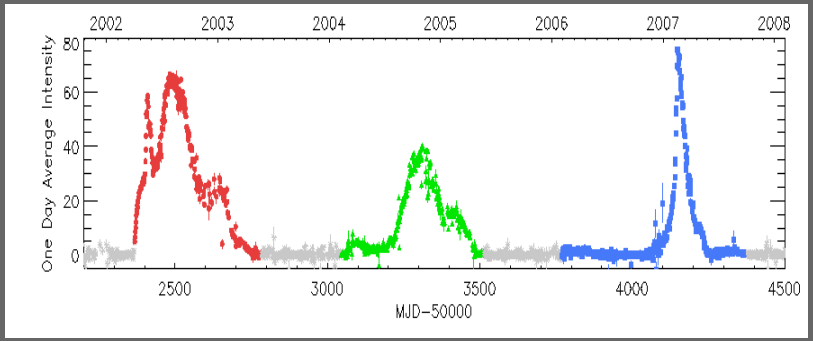
x-rays

Outbursts: increased accretion



Plant, Fender et al. (2014)

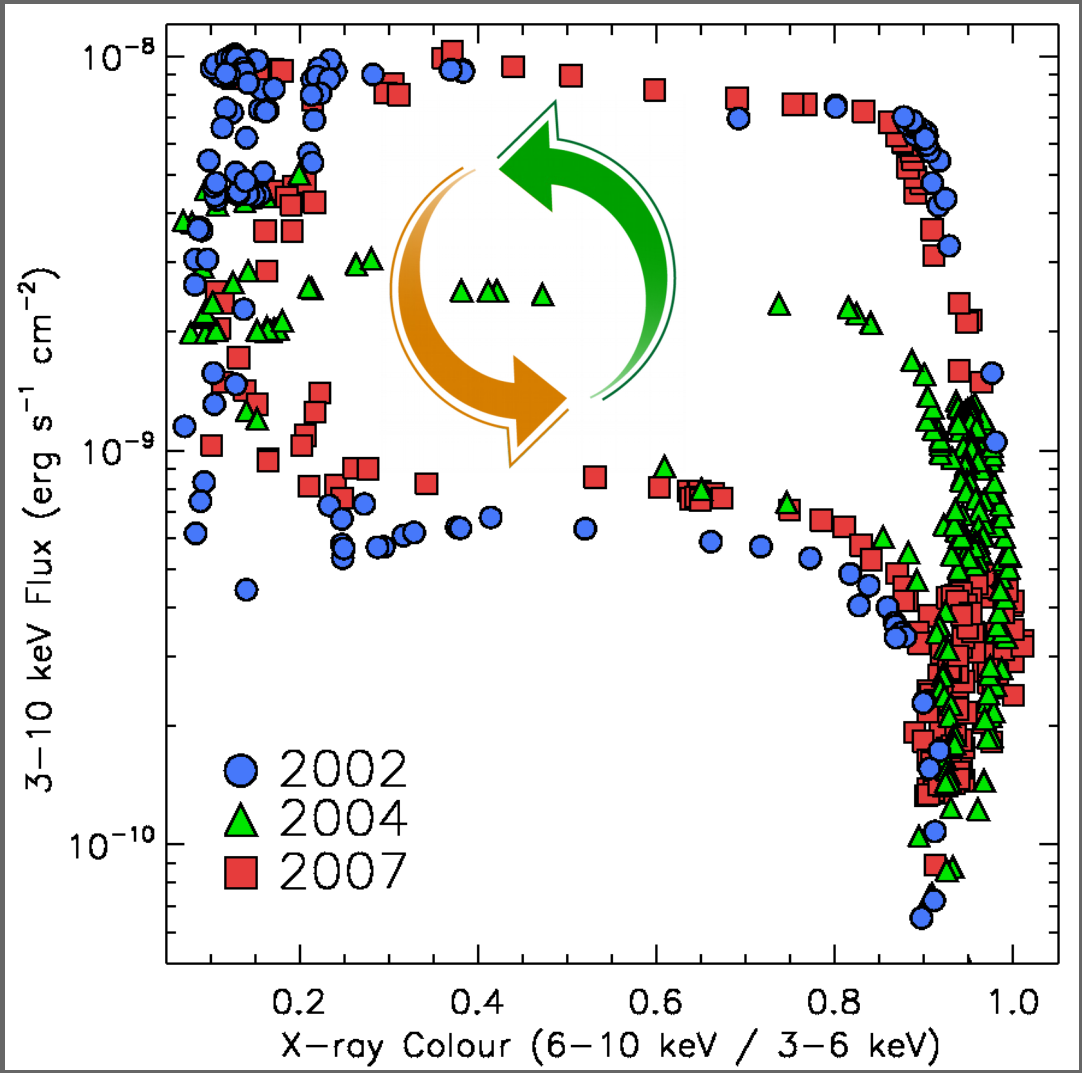
changing spectra



Hardness-Intensity Diagram

changing temperature / optical depth / emission mechanism

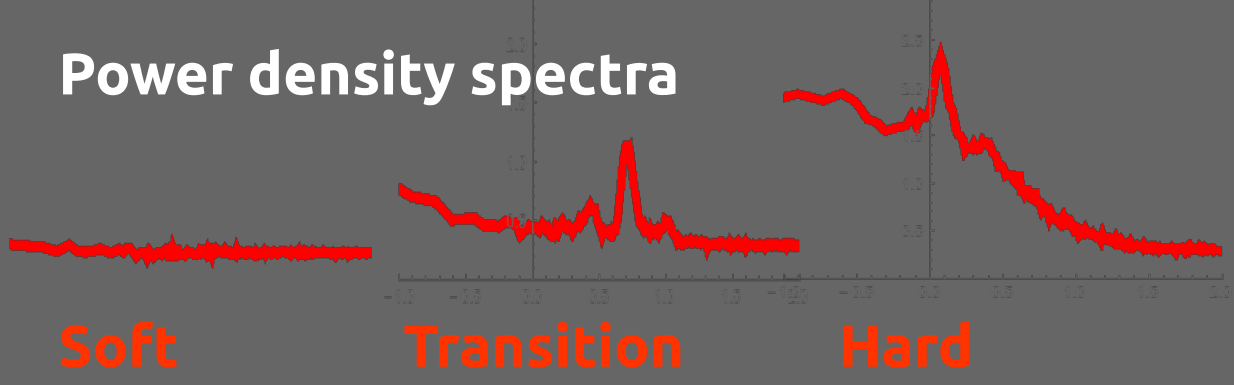
Soft/Red Hard/Blue

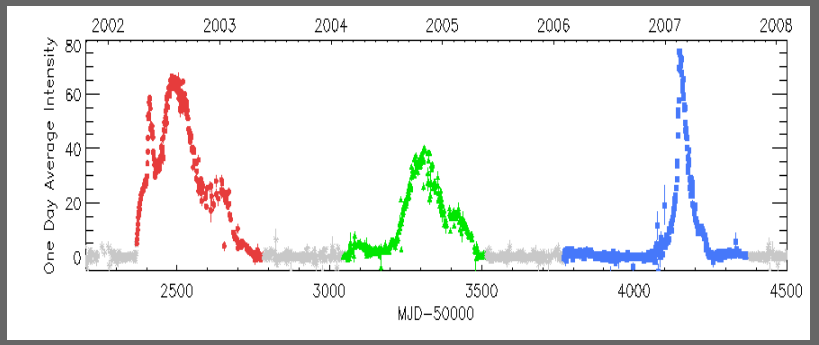


Plant, Fender et al. (2014)

(e.g. Homan et al. 2001, Fender, Homan & Belloni 2009, Dunn et al. 2011)

changing variability

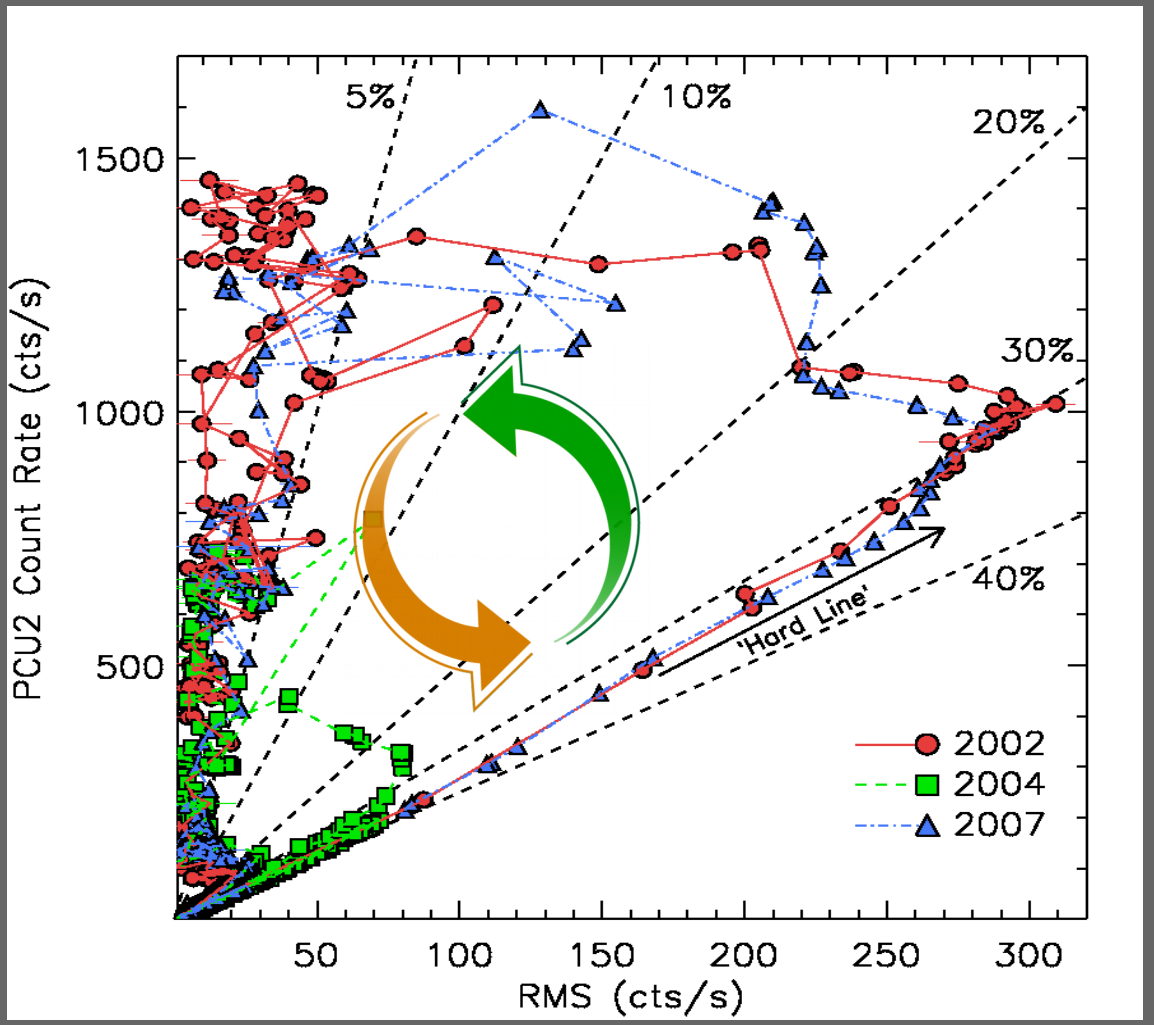




RMS-Intensity Diagram

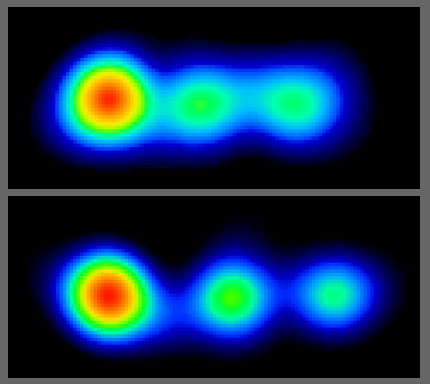
hard states are much more variable

Transition states are associated with a characteristic variability timescale (QPO)

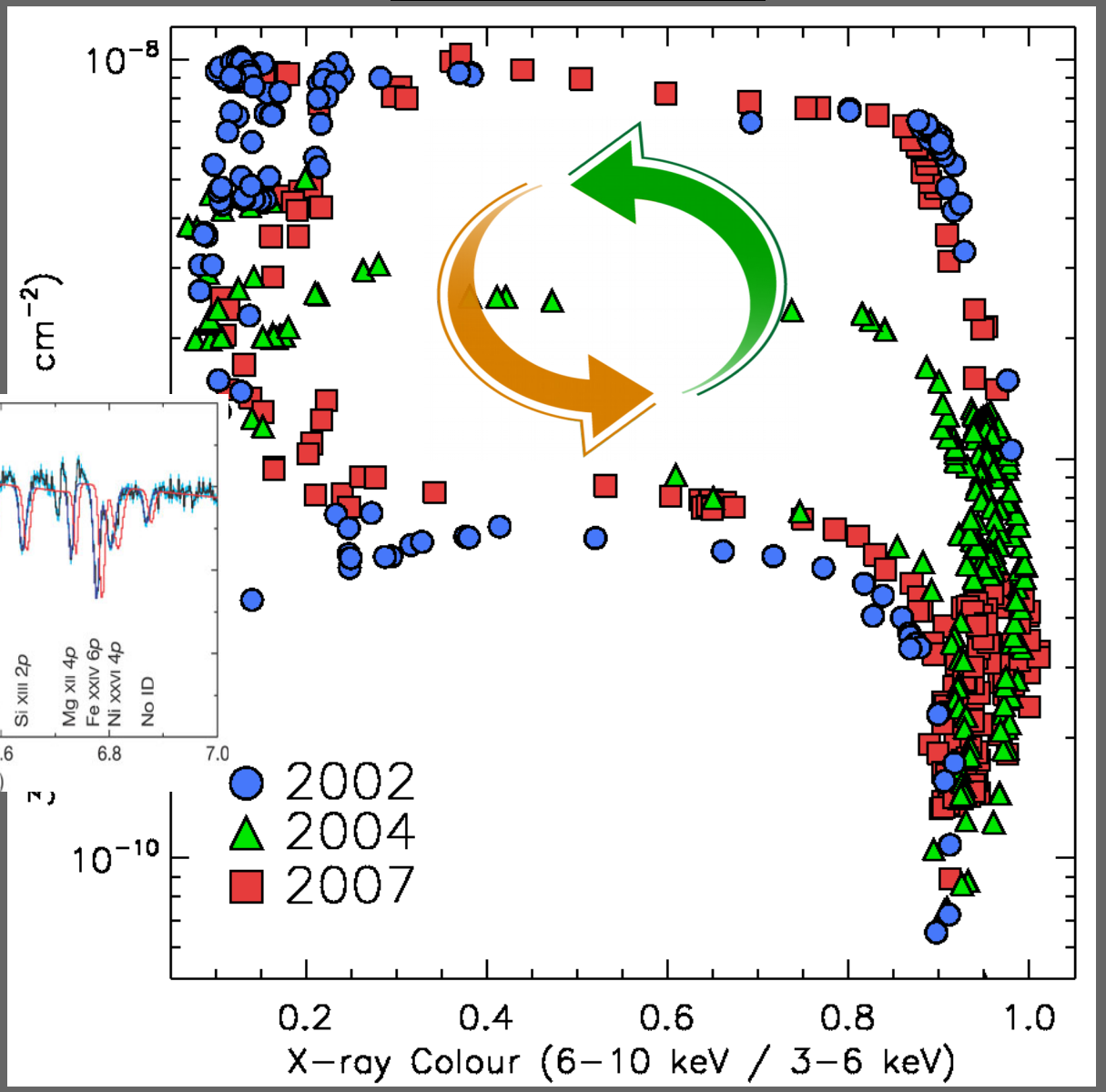


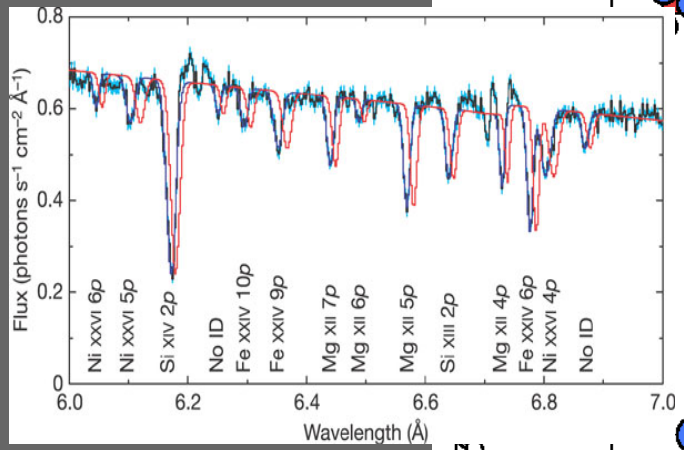
Plant, Fender et al. (2014)
Munoz-Darias, Belloni & Motta (2011)

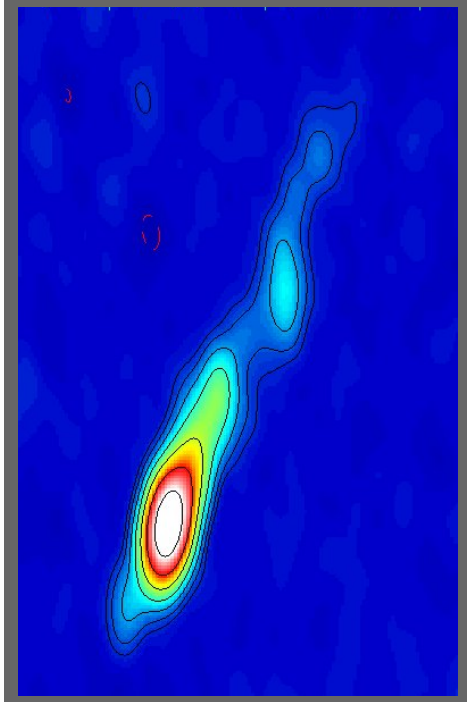
Diminishing of jet activity and appearance of strong accretion disc wind



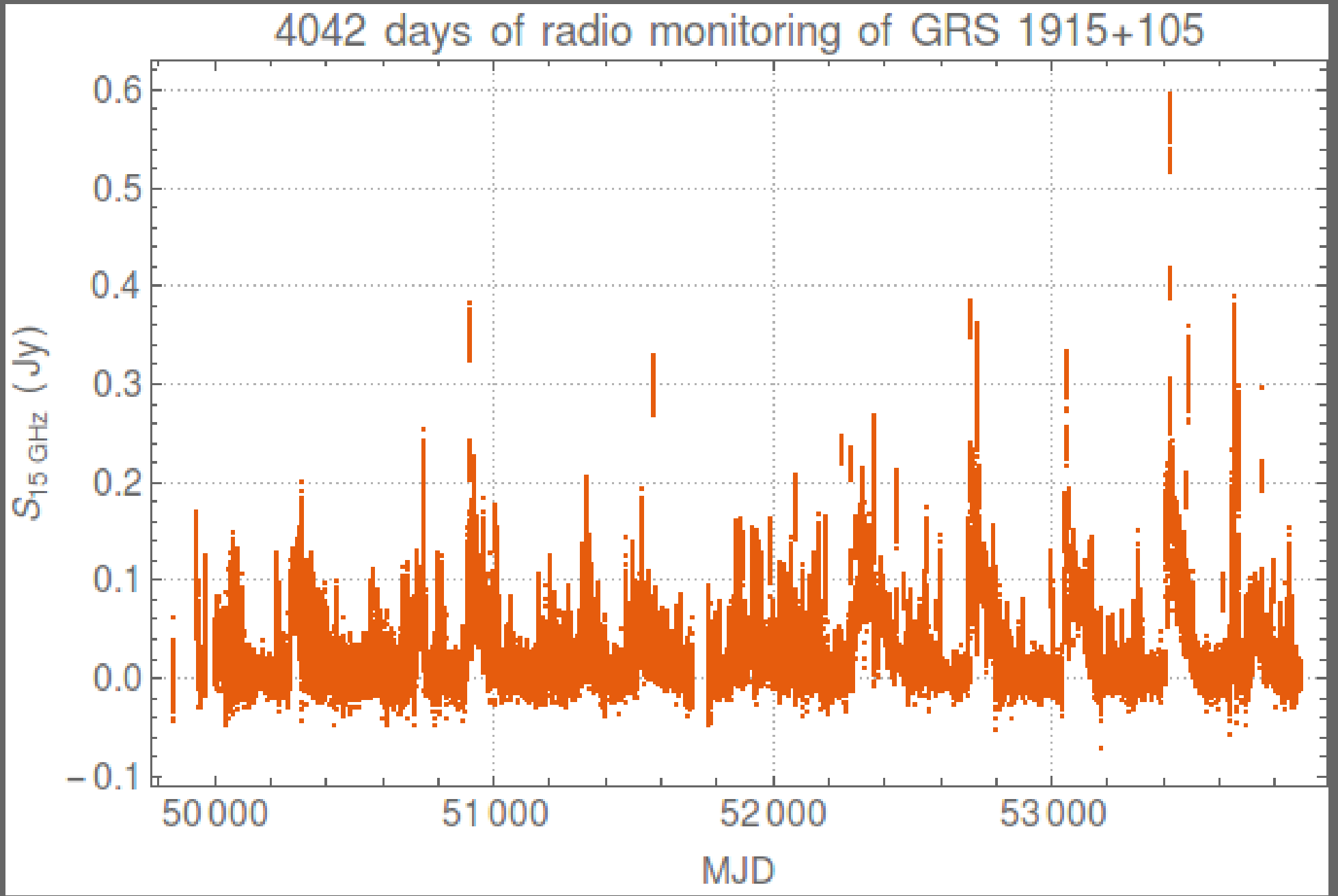
Evolution of jet from ~steady and compact to bright resolved ejections







GRS 1915+105: two decades of state transitions and relativistic jets at ~Eddington

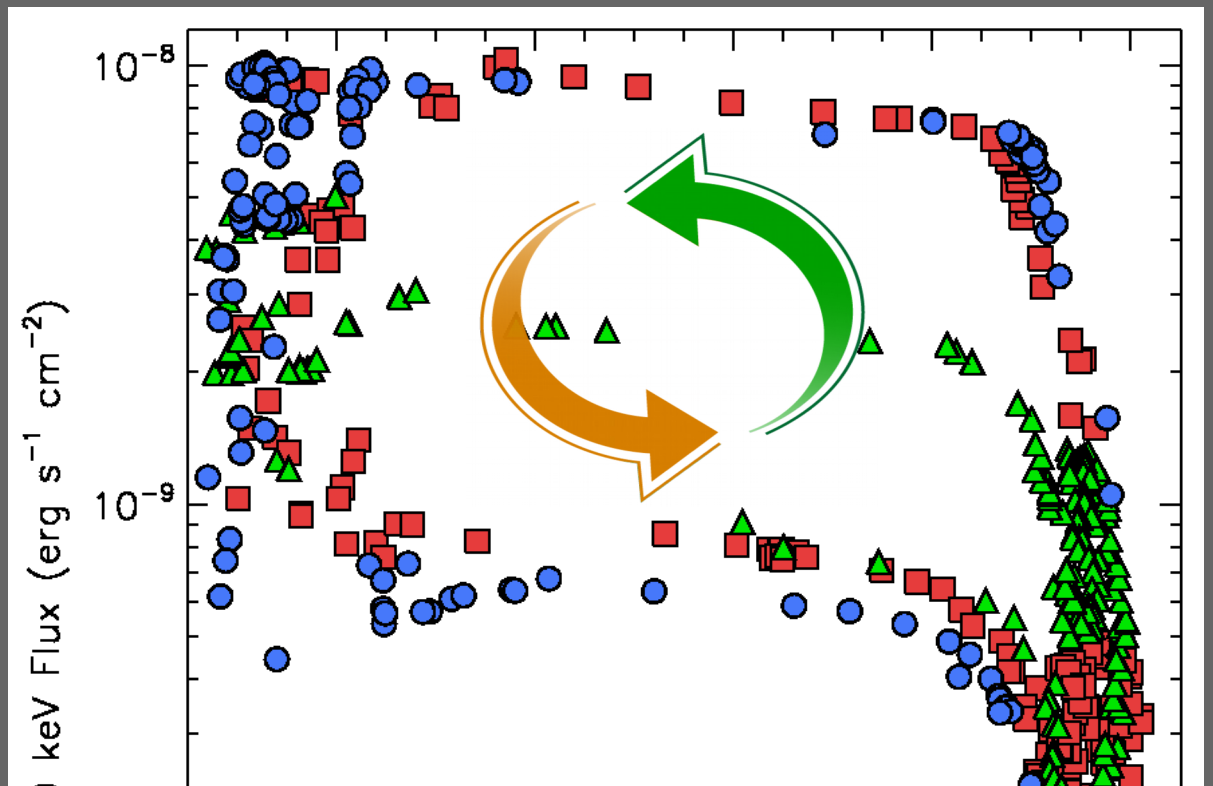


High accretion rates – sometime ≥ Eddington are associated with:

– Rapid state changes, connecting accretion, wind and jet

– Sometimes: ultrarelativistic flow

– Sometimes: strong local absorption (cause and effect)



Ultrarelativistic beams:

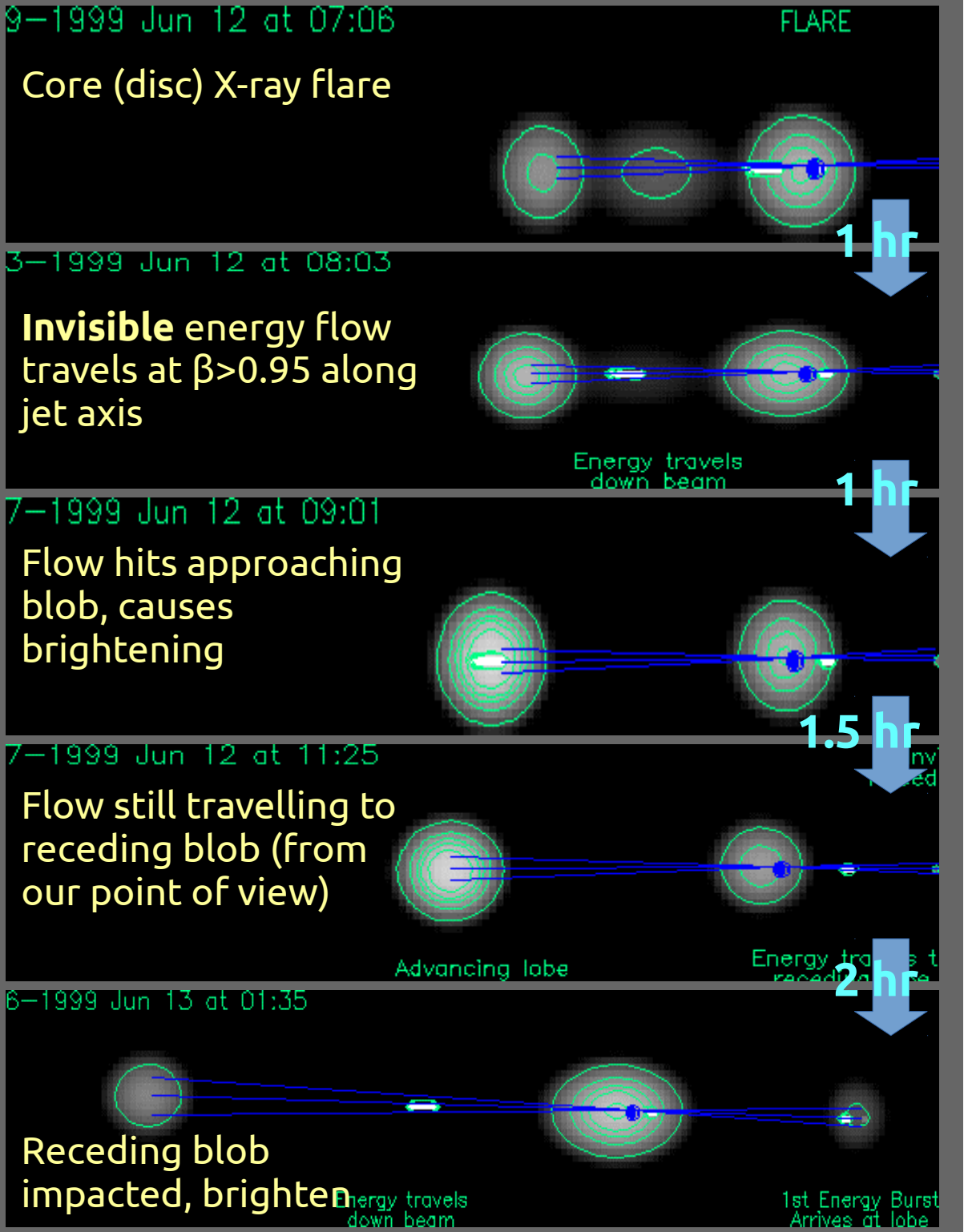
Unique to very high accretion rates? (and NS-only?)

Very clear evidence in Sco X-1 with slow blobs at β~0.3 and faster invisible flow at β>0.95

Evidence also in

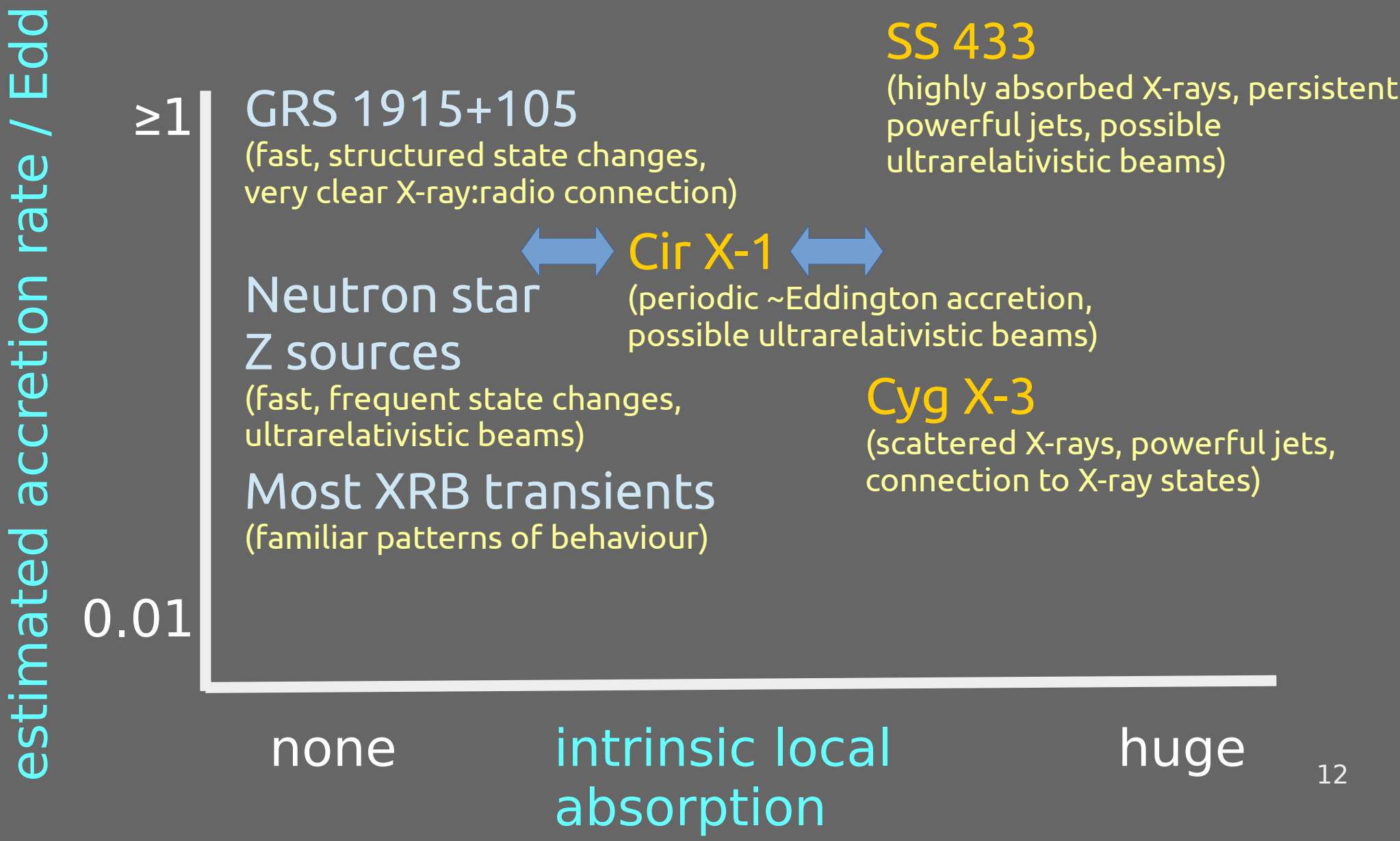
Cir X-1 (NS)
SS 433 (who knows?)

Fomalont et al. (2001)
Fender et al. (2004)
Migliari et al. (2005)



Naked vs veiled:

Type I / II Eddington accretion in X-ray binaries



At 15-06-15 18:28:07 (Monday) an alert of type:
'Swift BAT GRB - initial position'
was received. Details are as follows:
ID: SWIFT_643949
Inferred name: GRB 150615
Co-ords: FK5Coordinates: 20:24:04.90 +33:50:59.28 J2000.0
(Decimal: 306.0204, 33.8498)
Trigger time: 15-06-15 18:31:38 (Monday)

==========
Actions taken:
==========
Observation requested from AMI.
AMI request notified to VOEvent network.

==========
Site reports:
==========
AMI observatory:
LST: 12:03:29.301799
Target is sometimes visible.
Currently visible? False
Rise time: 15-06-15 20:03:57 (Monday)
Transit time: 15-06-16 02:47:20 (Tuesday)
Set time: 15-06-16 09:30:43 (Tuesday)
Transit alt-az position: HorizontalCoordinates:
az=179.595453,alt=71.633651

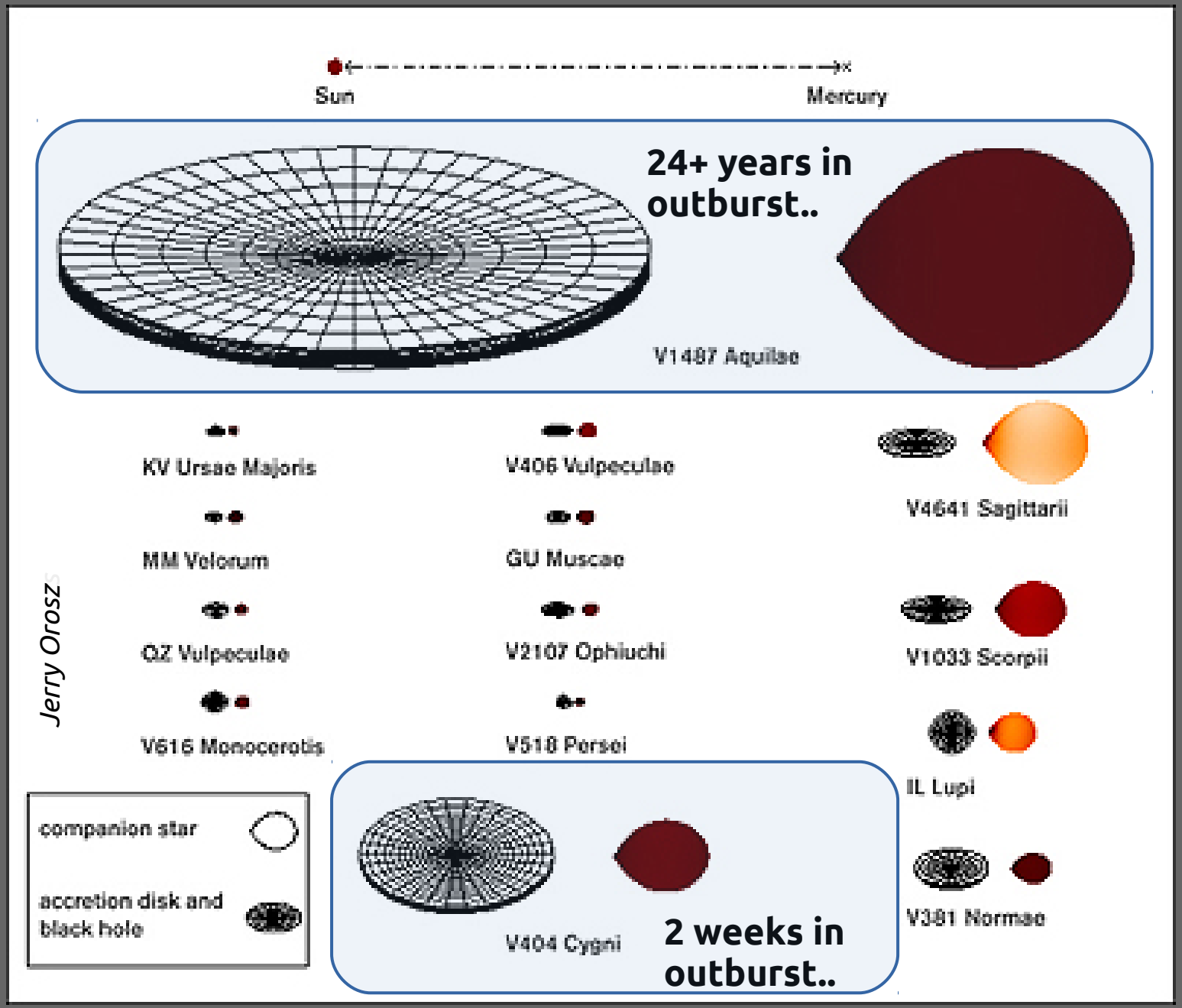
four π sky

V404 Cyg

"Target is sometimes visible"

Trigger time: 18:31:38
Rise time: 20:03:57

V404 Cyg in context



V404 Cyg is the second-largest black hole binary system (accretion disc) known

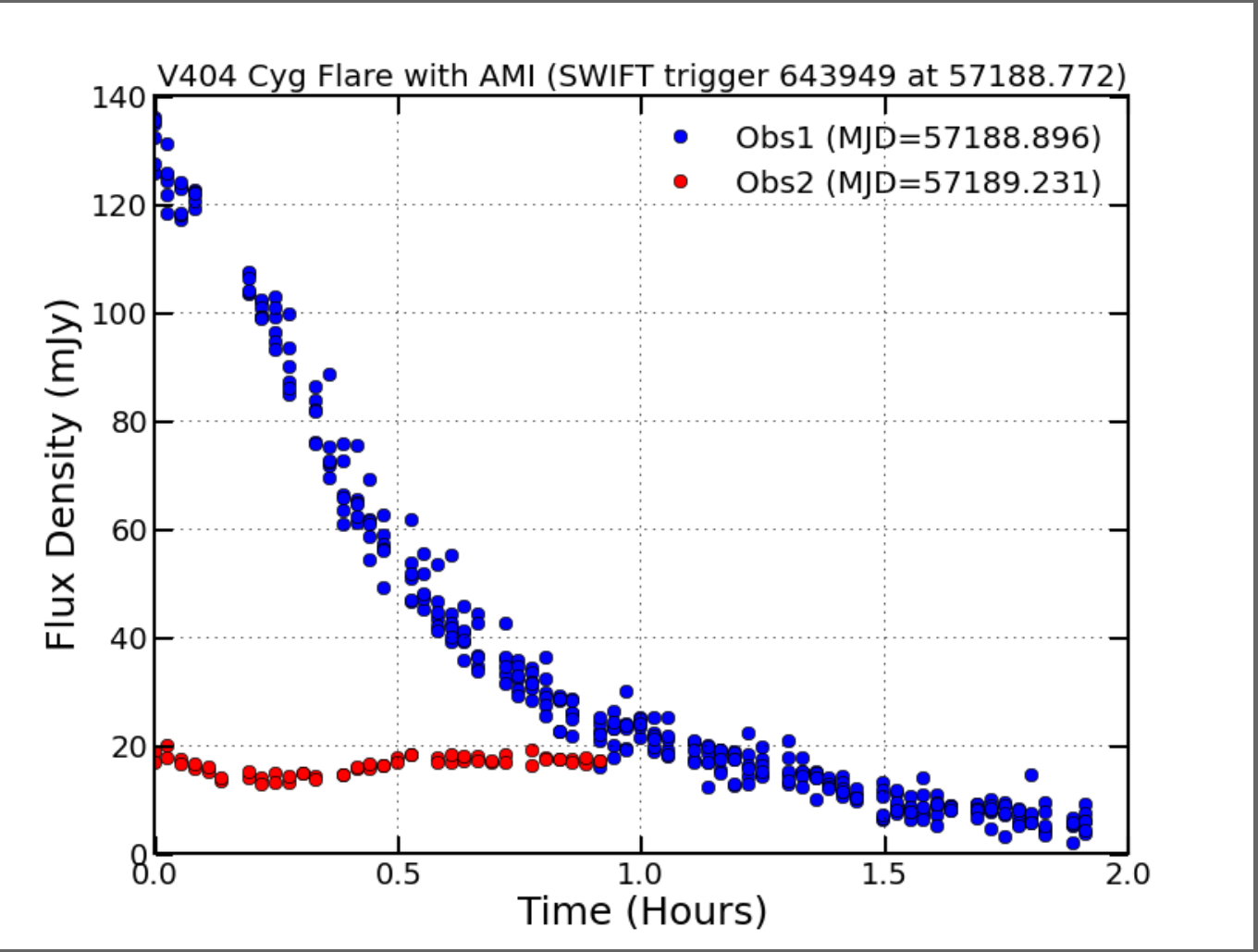
Last outburst in 1989

Dynamically confirmed black hole

Radio parallax distance

Casares et al. (1992)
Miller-Jones et al. (2009)

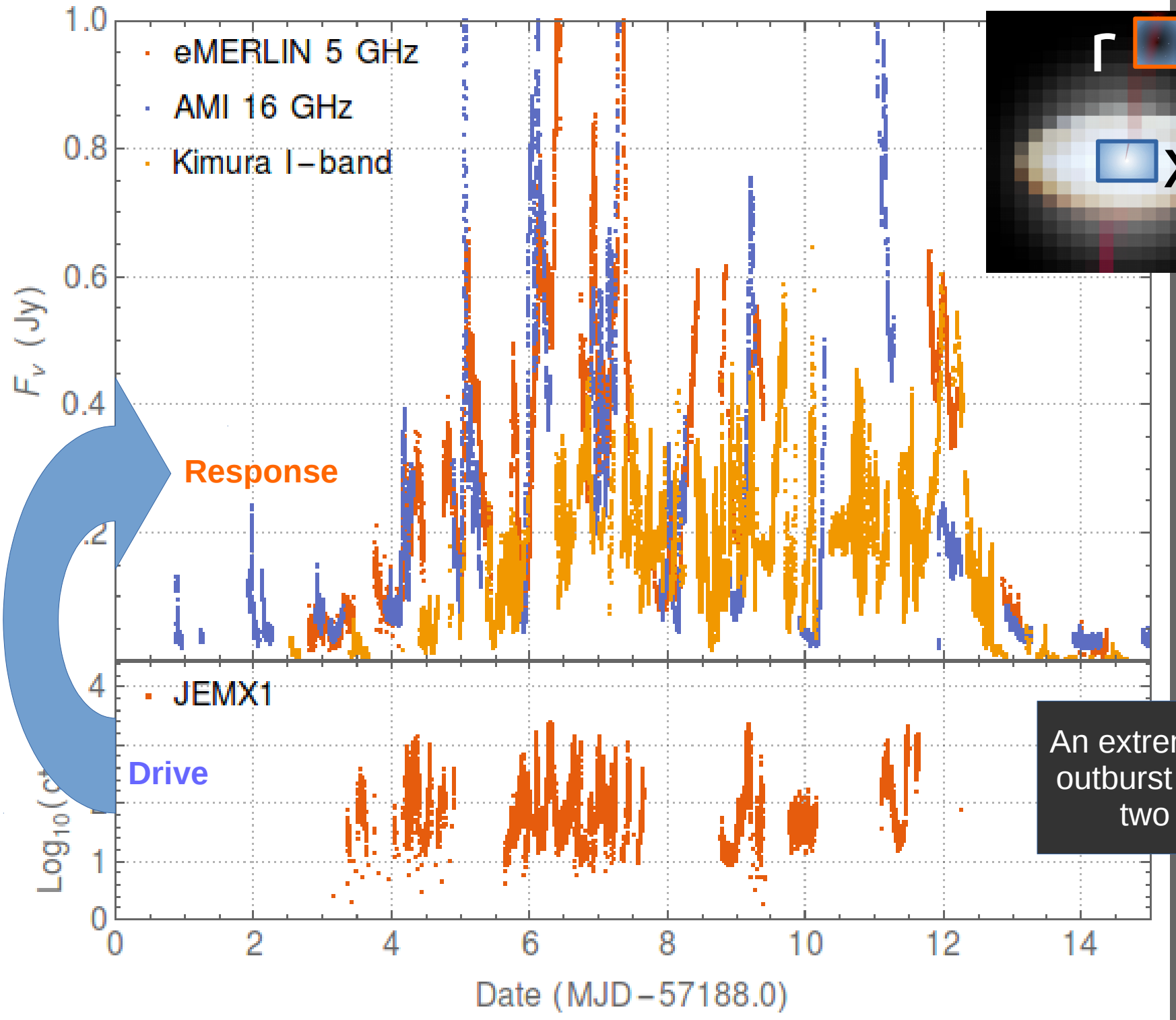
V404: the first day



First day: Radio flare already declining from >100 mJy two hr after burst

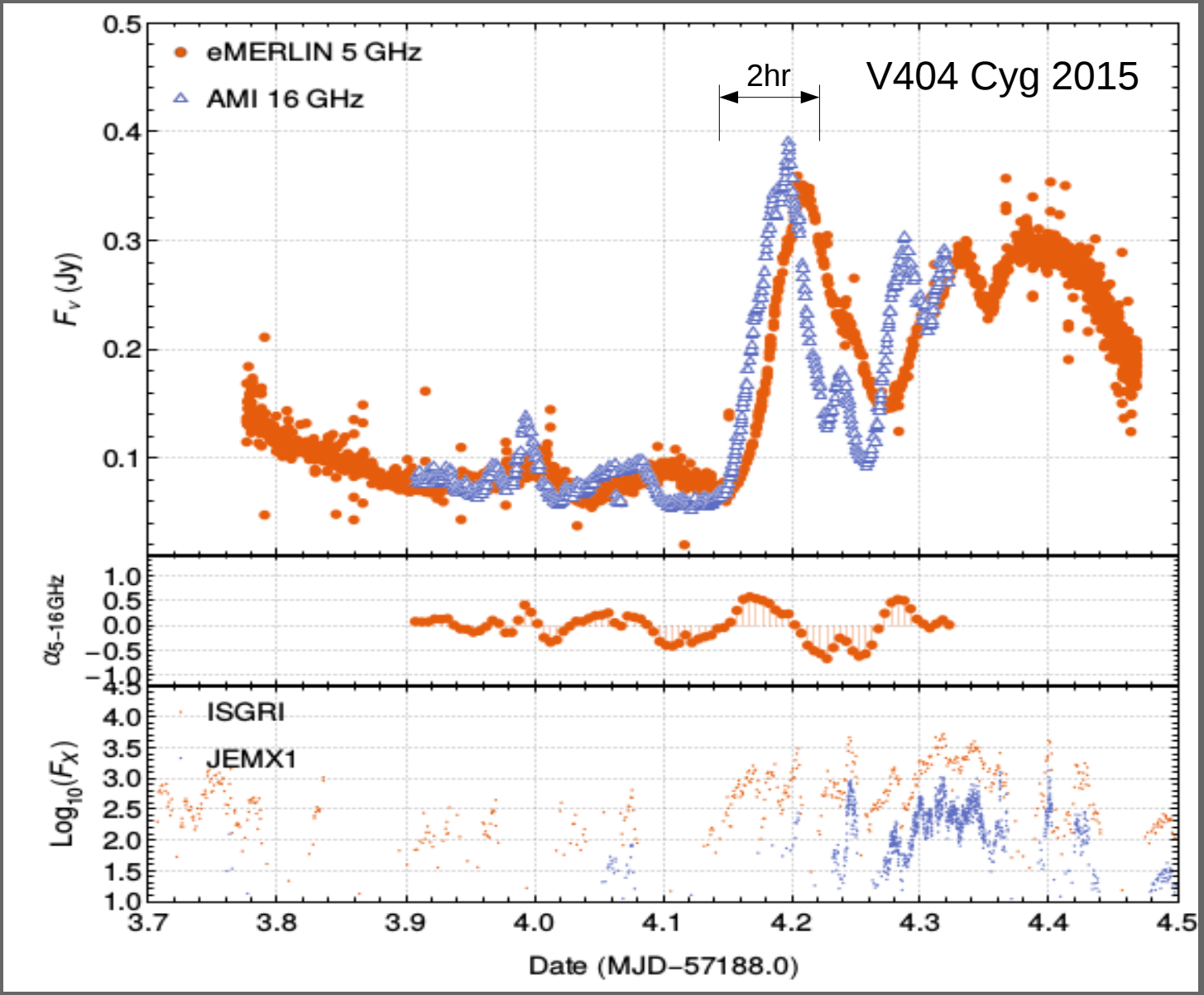
Second day: slow variations at ~50 x quiescent level (0.1 mJy)

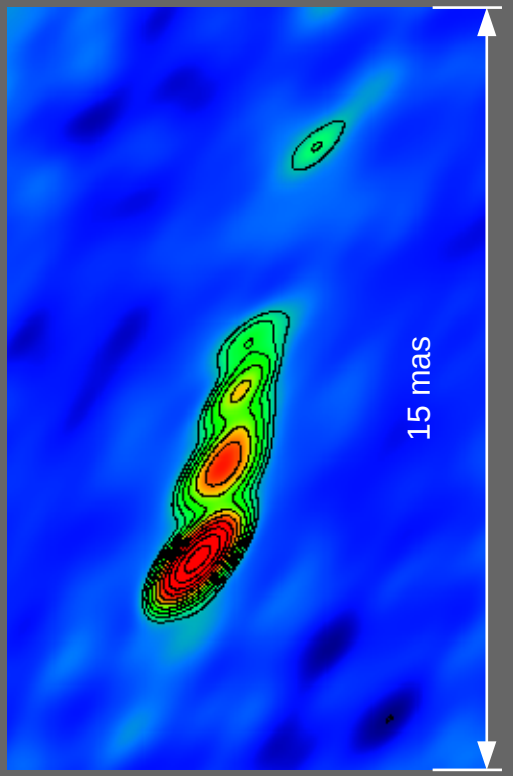
Analysis by Kunal Mooley (Oxford) / Fender et al. (*in prep*)



An extremely violent outburst lasting just two weeks

Radio flares resolved into relativistic ejections

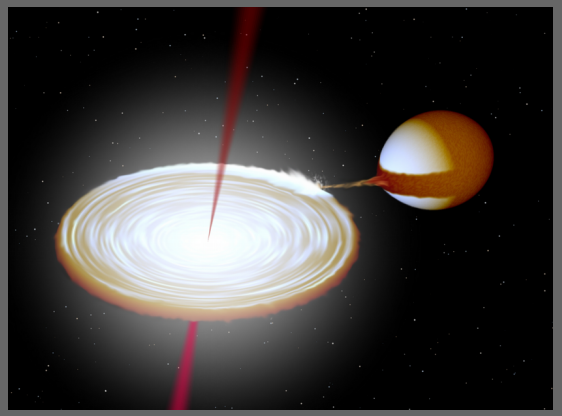


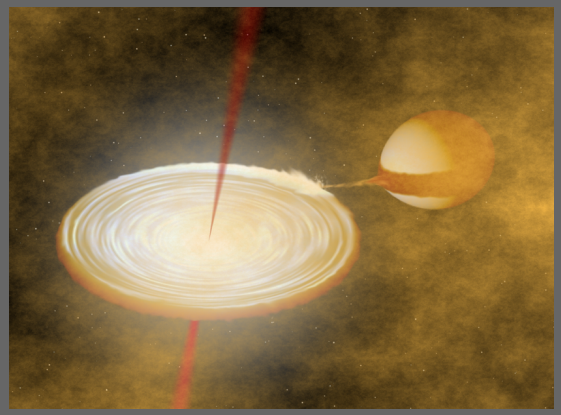


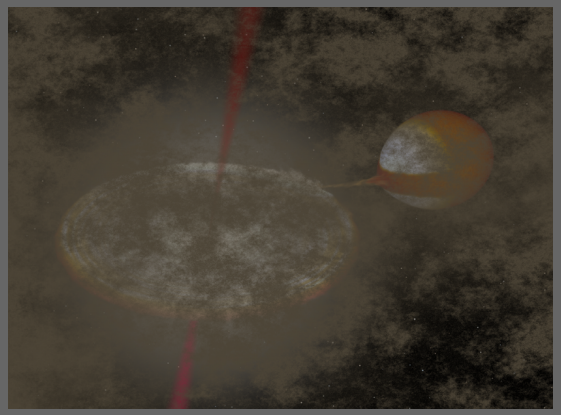
Black hole jet formation resolved temporally and spatially on time scales of min / hr

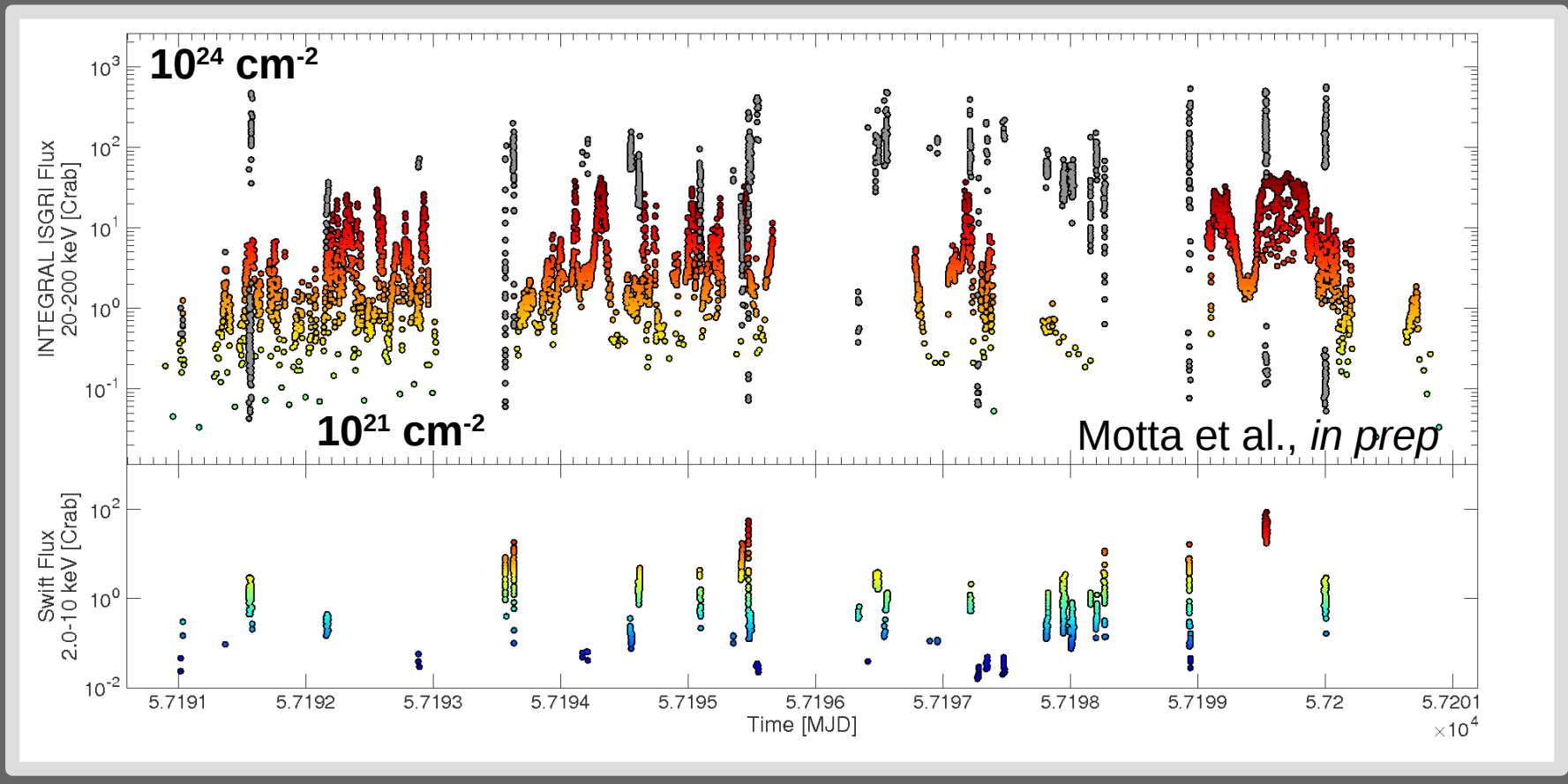
Fender et al. / Miller-Jones et al. (*in prep*)

Highly variable absorption, N_H varying by factor >1000

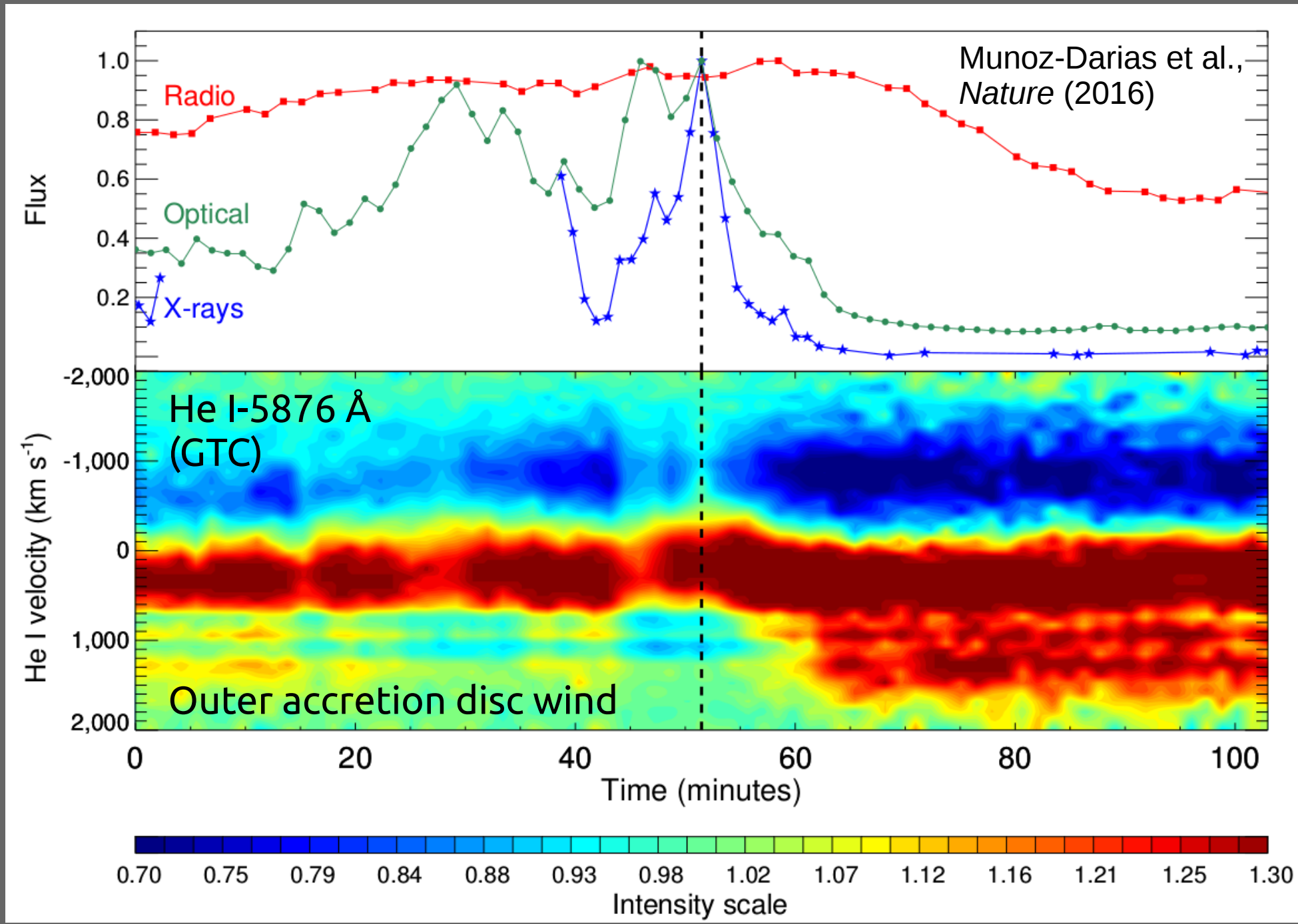




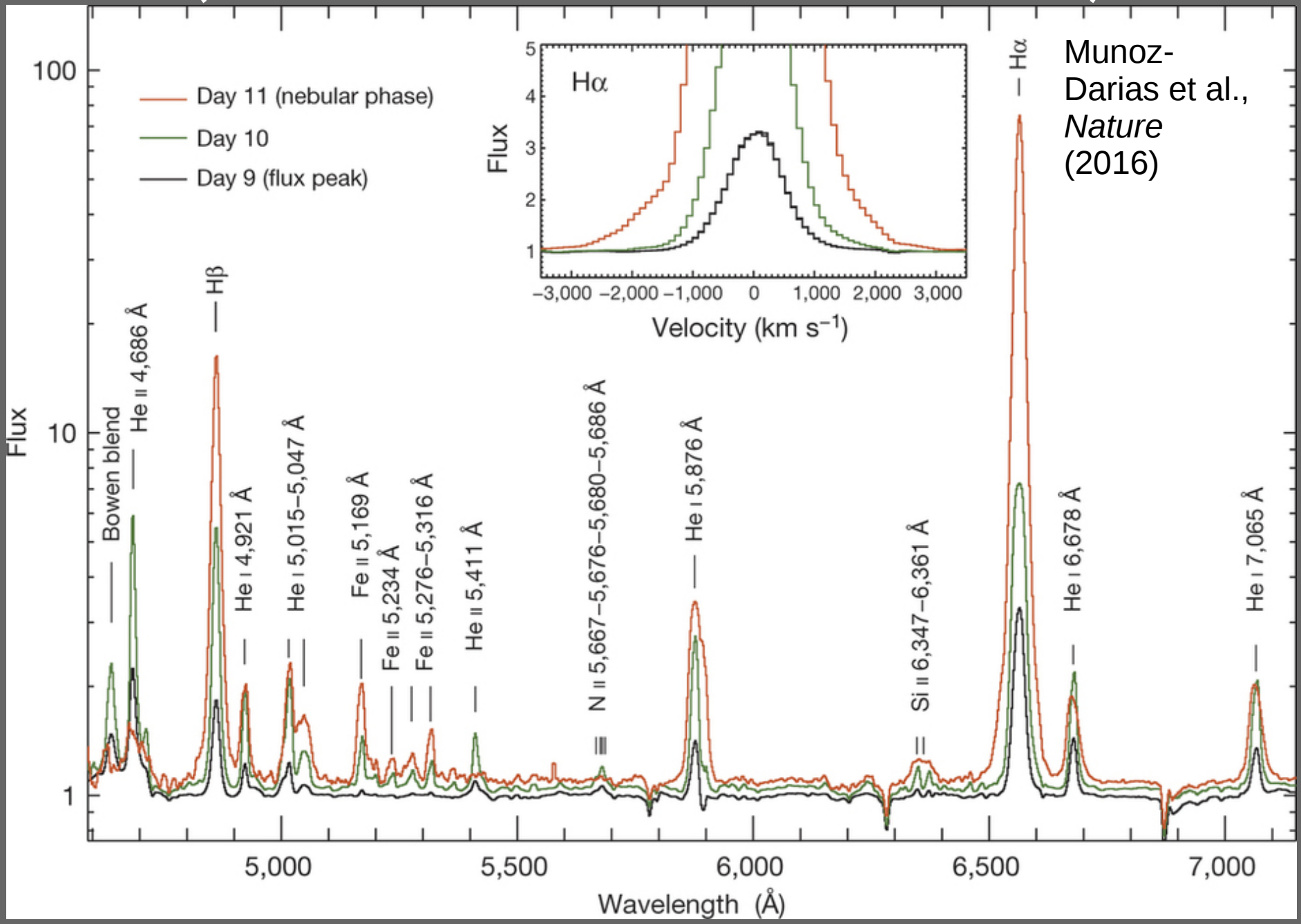




Strong, neutral, accretion disc wind

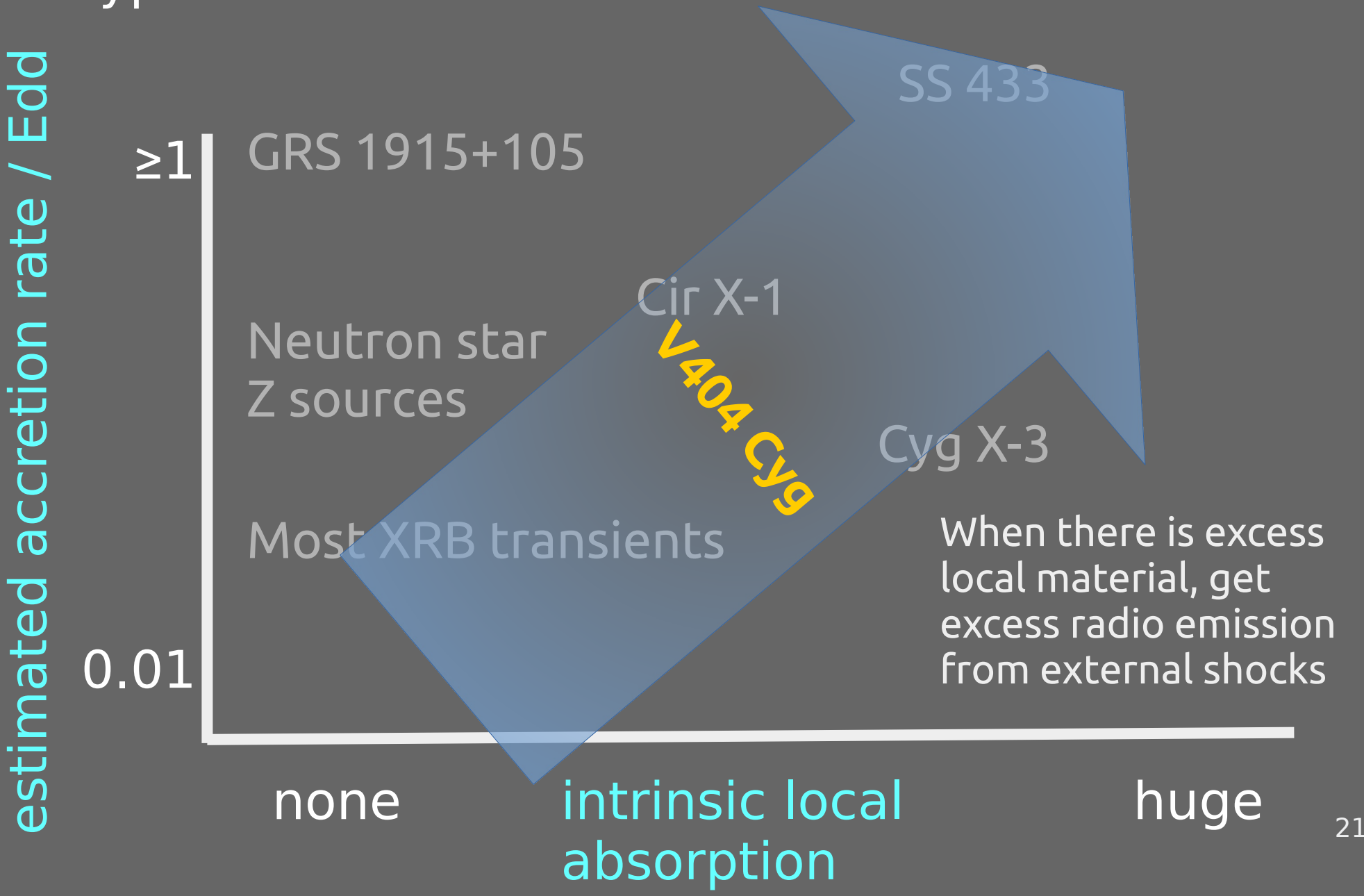


Massive nebular phase after outburst
(0.1-100% of total estimated disc mass)



V404 Cyg:

type I ↔ II from its own accretion disc wind



Conclusions

- We have established a clear phenomenology connecting accretion to feedback in stellar mass black holes and neutron stars
- At the highest accretion rates:
  - rapid state transitions are very common → frequent powerful jet activity
  - Ultrarelativistic beams are observed co-existing with slower-moving ejecta (the hidden secrets of SS433?)
  - Very high accretion rates are often – **but not always** – shrouded, sometimes by mass transfer, sometimes by accretion disc wind


Fin.