The 2015 outbursts of the black hole transient V404 Cyg

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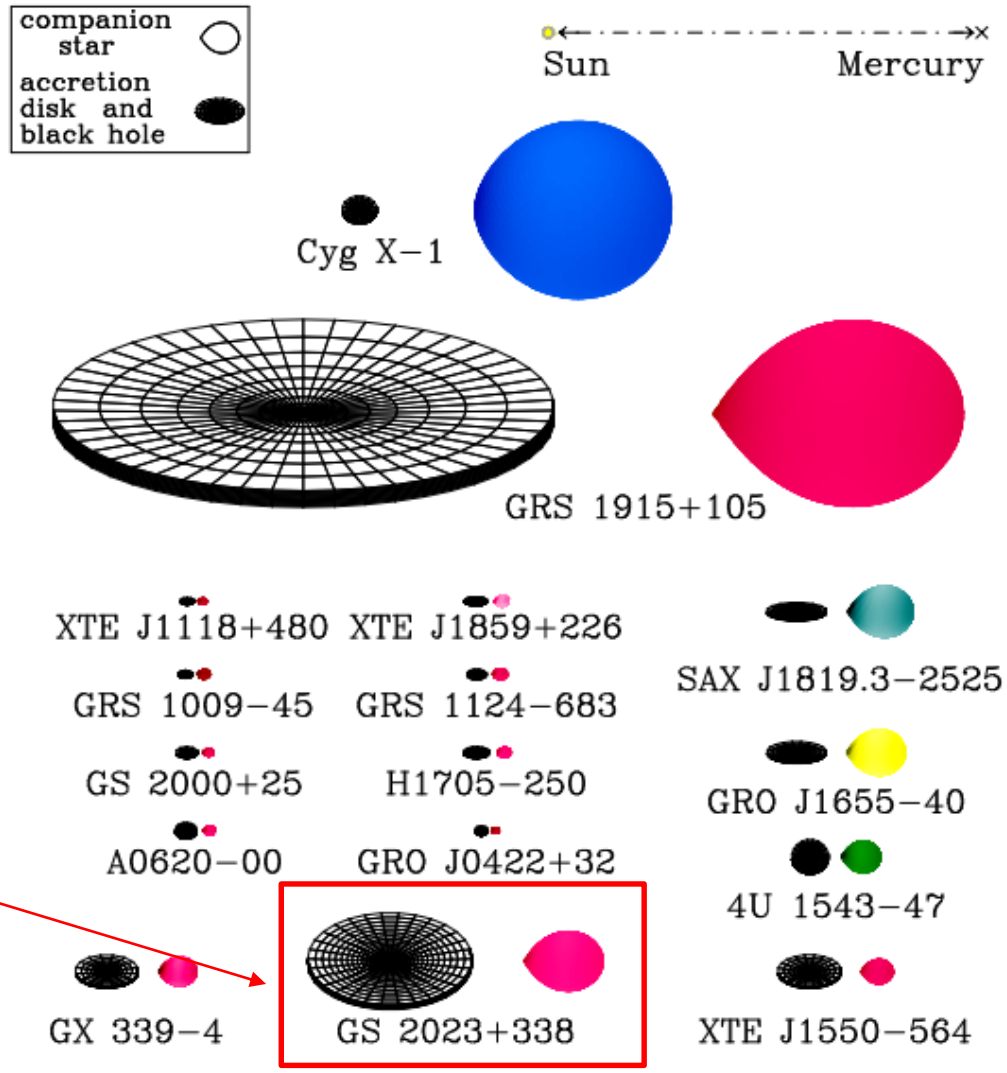
Black hole binaries



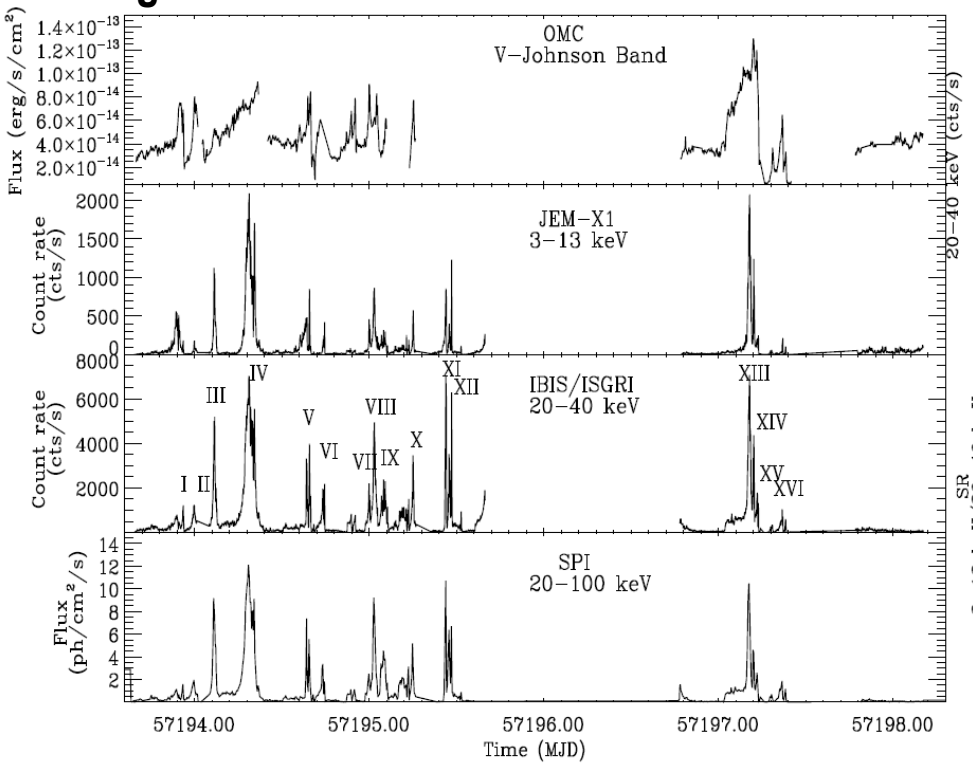
V404 Cyg key parameters & properties

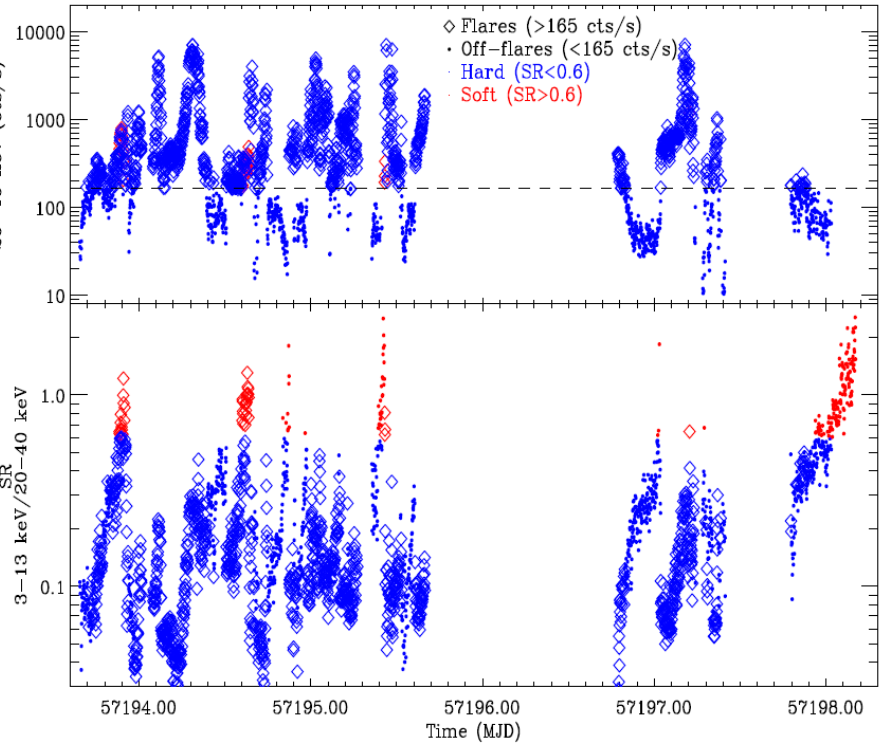
- Discovery in 1938 as an optical nova, before X-ray astronomy era
- Bright X-ray outburst in 1989, with Japanese Ginga X-ray satellite
  - Variable local absorption (Tanaka+89, Oosterbroek+96, Zycki+99)
- **Second and third X-ray outbursts in June & December 2015**
- First ever black hole with dynamically measured mass
  - Mbh = 9.0pm0.6 Msun; at least M>6.08 Msun, (Casares+94); i~67deg
- Accurate distance measurement using radio parallax
  - D = 2.39pm0.14 kpc (Miller-Jones+09)
- X-ray outbursts are extremely bright and short, ~2 weeks
  - Peak X-ray luminosity slightly above Eddington (L~2x10^{39} erg/s)
- Extreme variability during outbursts

INTEGRAL light curves V404 Cyg in June 2015

- Rapid flaring in optical and X-rays:
  - factor 1000 dynamic range; spectral variations (transitions) in less than an hour

Rodriguez+15

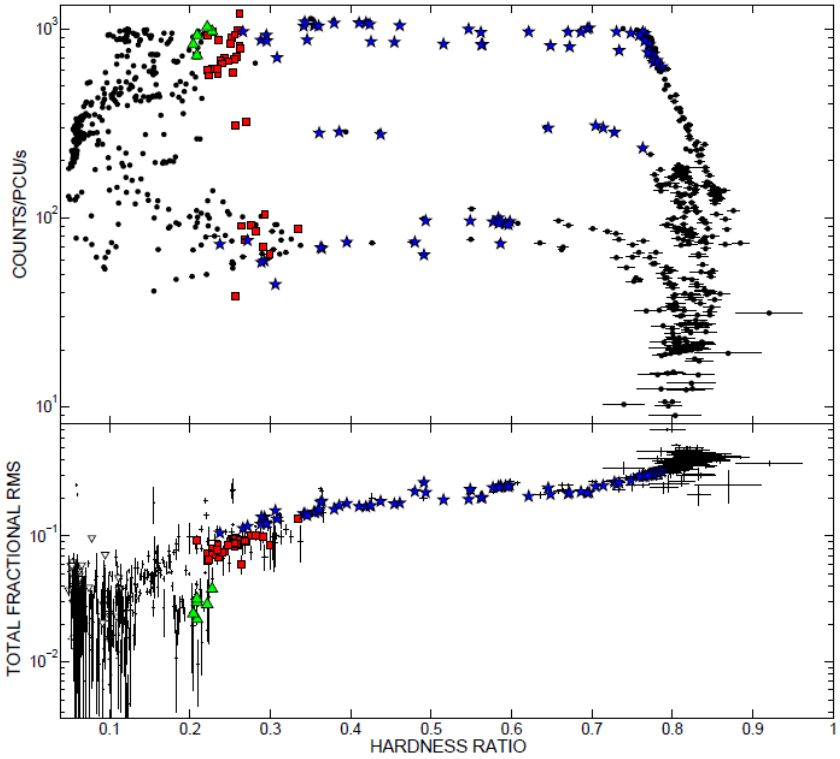




HIDs of GX 339-4 vs. V404 Cyg

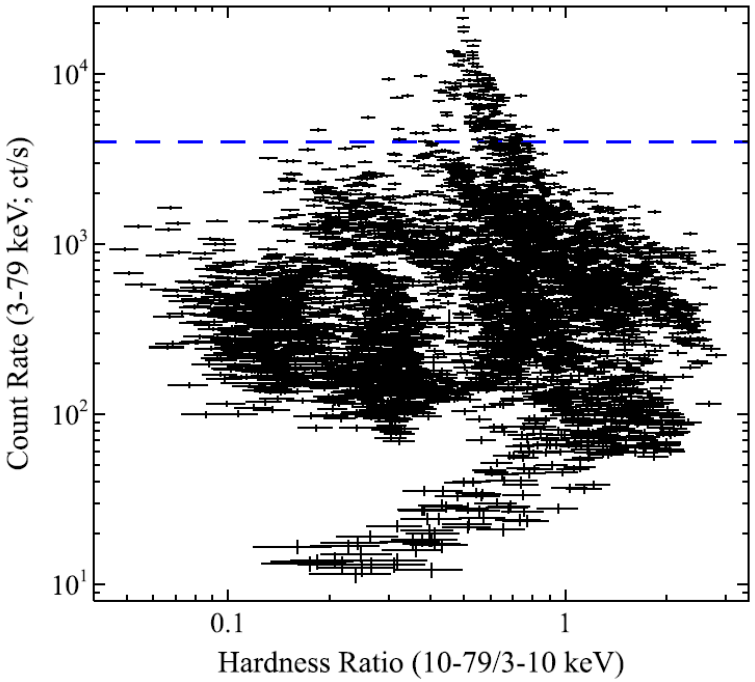
- Outbursts in GX 339-4 are “well behaved”, V404 Cyg is a mess

GX 339-4 (3 outbursts; t~year)



Motta+11

V404 Cyg (half a day)



Walton+17

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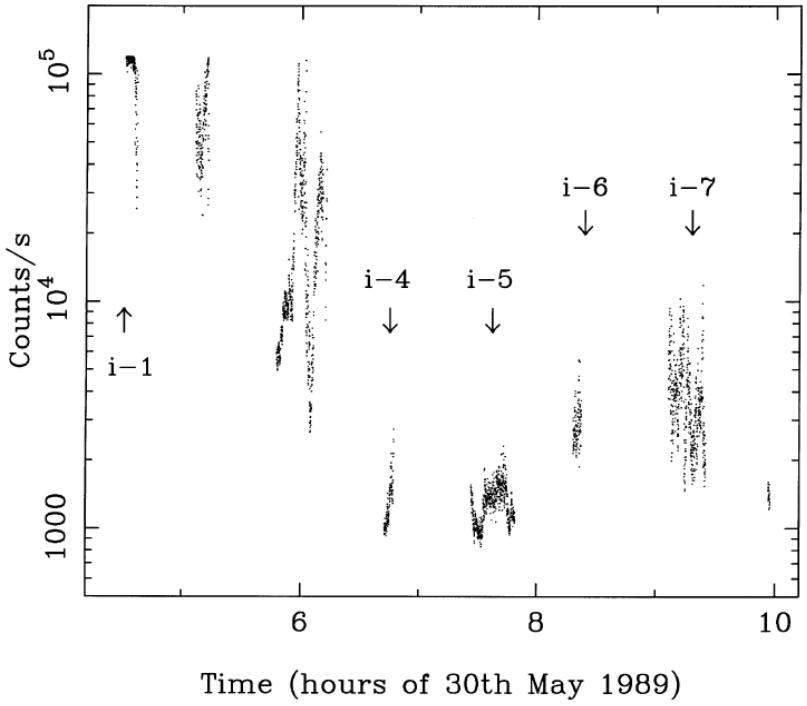
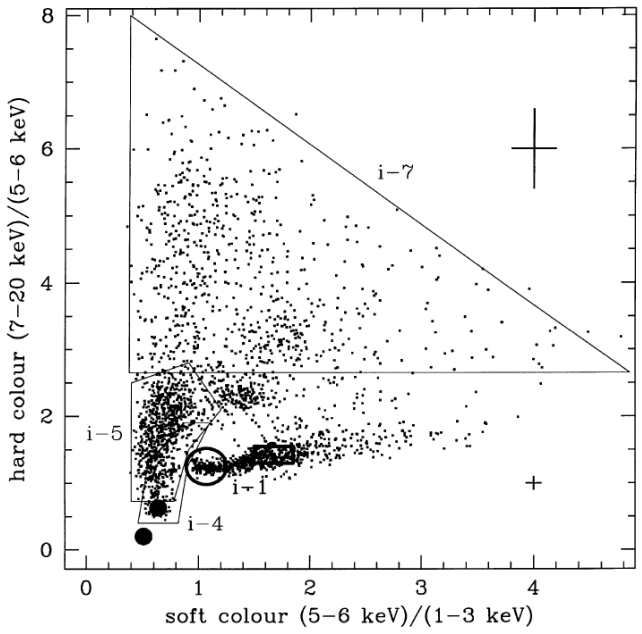
V404 Cyg during the 1989 outburst

- Similar flaring in 1989 as in 2015, variability due to flares and obscuration by Compton-thick, N_H~3x10^{24} cm^{-2} absorber (Zycki+99).



Zycki+99



Color-color diagram

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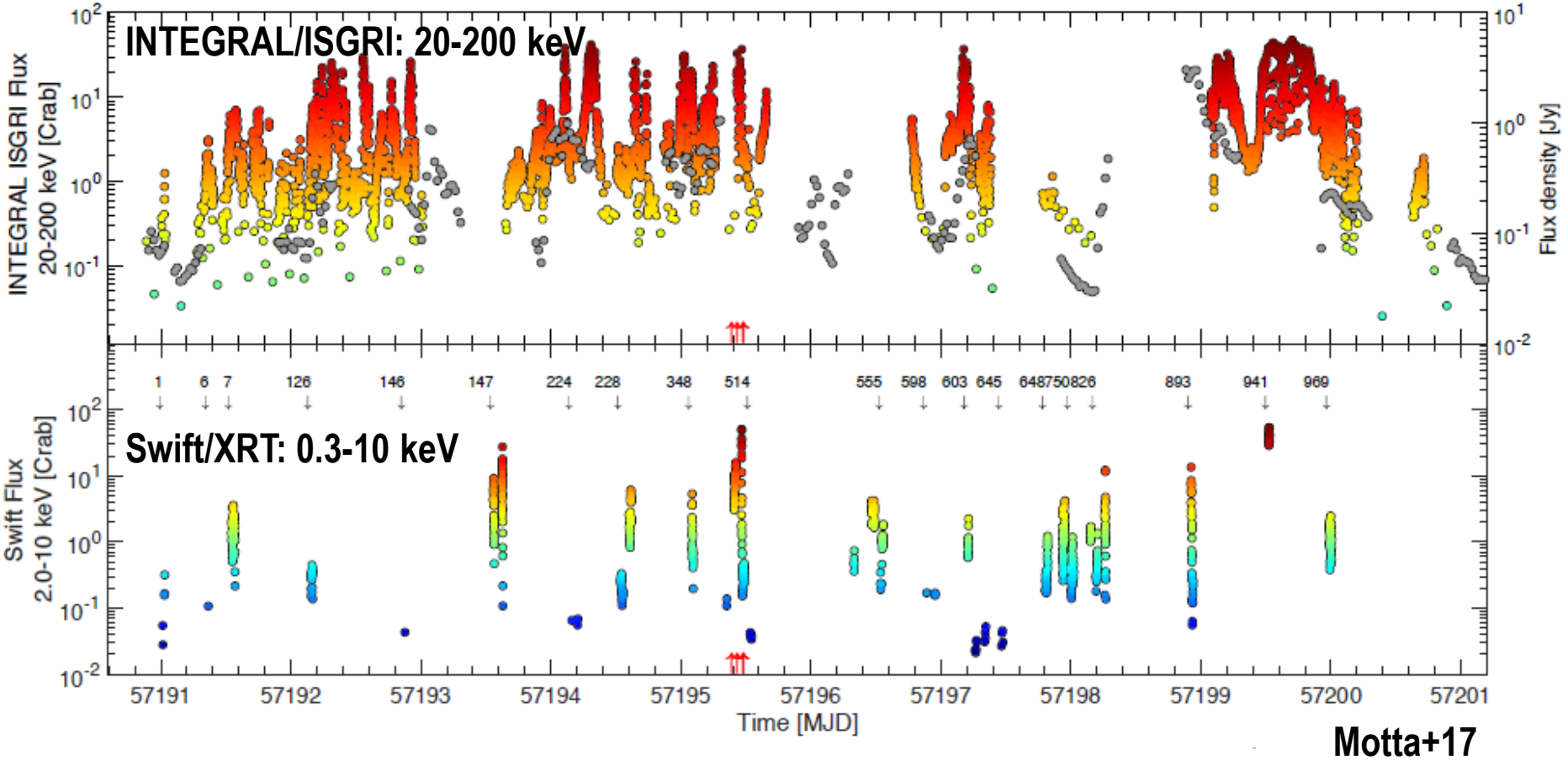
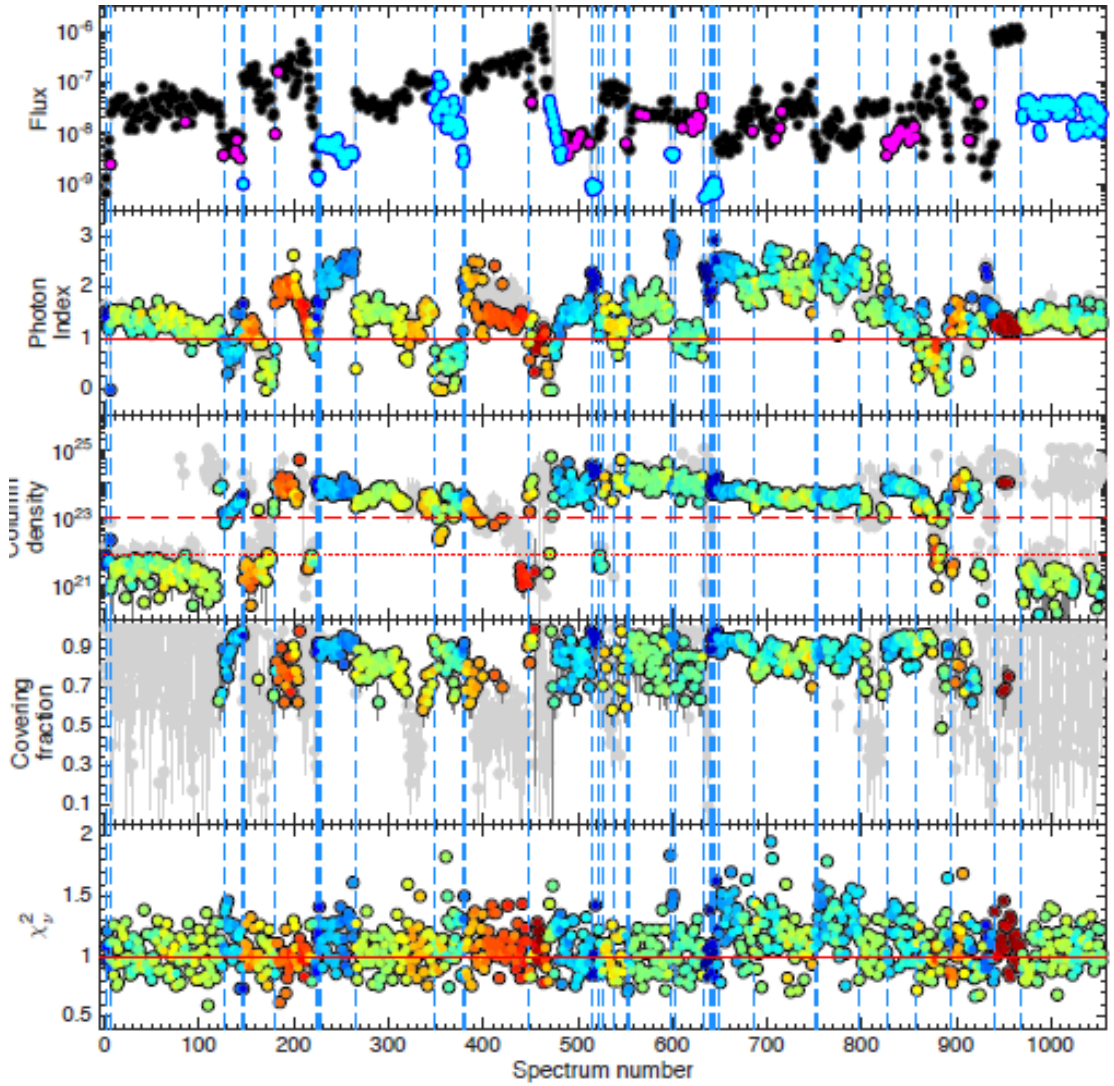
V404 Cyg outburst in June 2015

- State transitions and factor 1000 changes in flux occurred in hours



Soft X-rays affected by local absorption

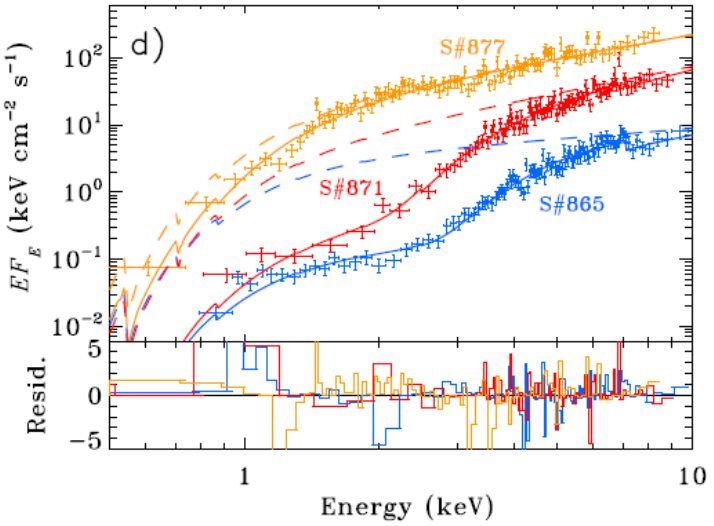


- >1000 Spectra collapsed in X-axis
- Partially covered powerlaw + Fe line(s)
- Photon index varies up and down in minutes (state transitions!)
- Absorption and covering changes in minutes (clumpy wind obscuring the disc)

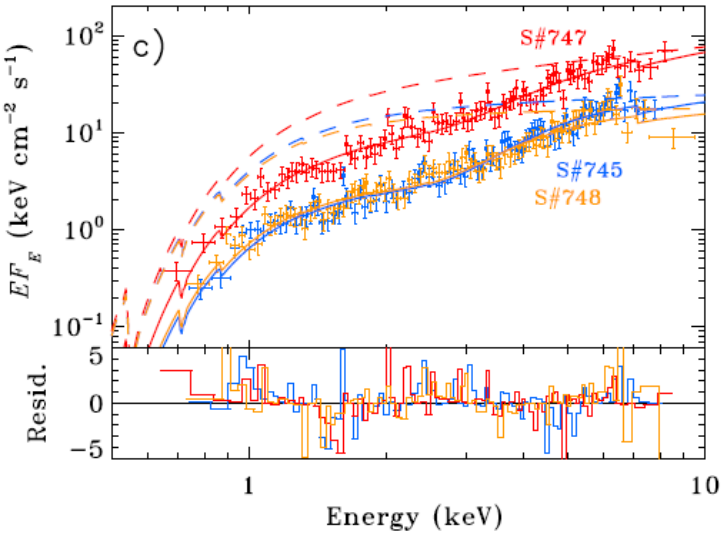
Motta+17

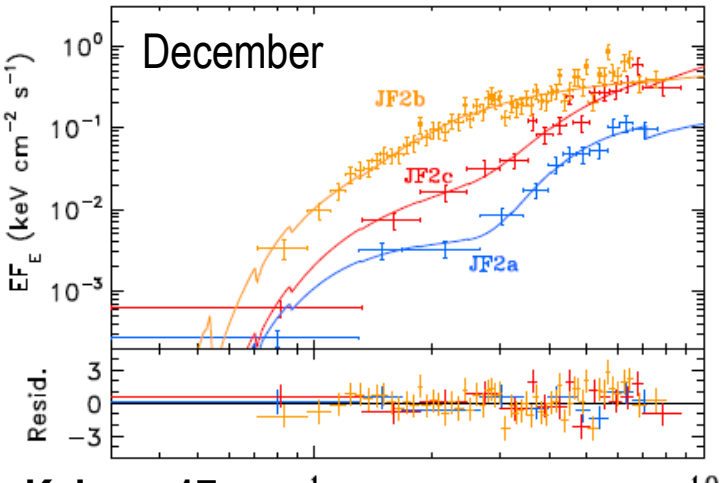
Flares and wind absorption

Changes in photon index, partial covering and column density (336s)



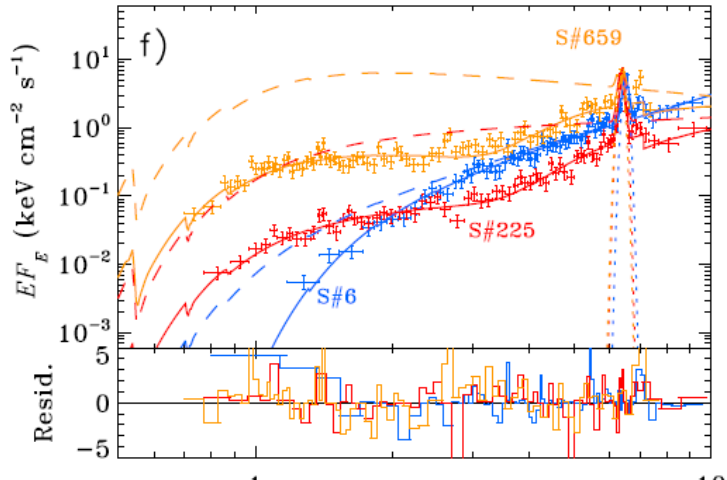
Changes in photon index and partial covering (48s) **Motta+17**





Kajava+17

Examples of spectra showing a narrow line



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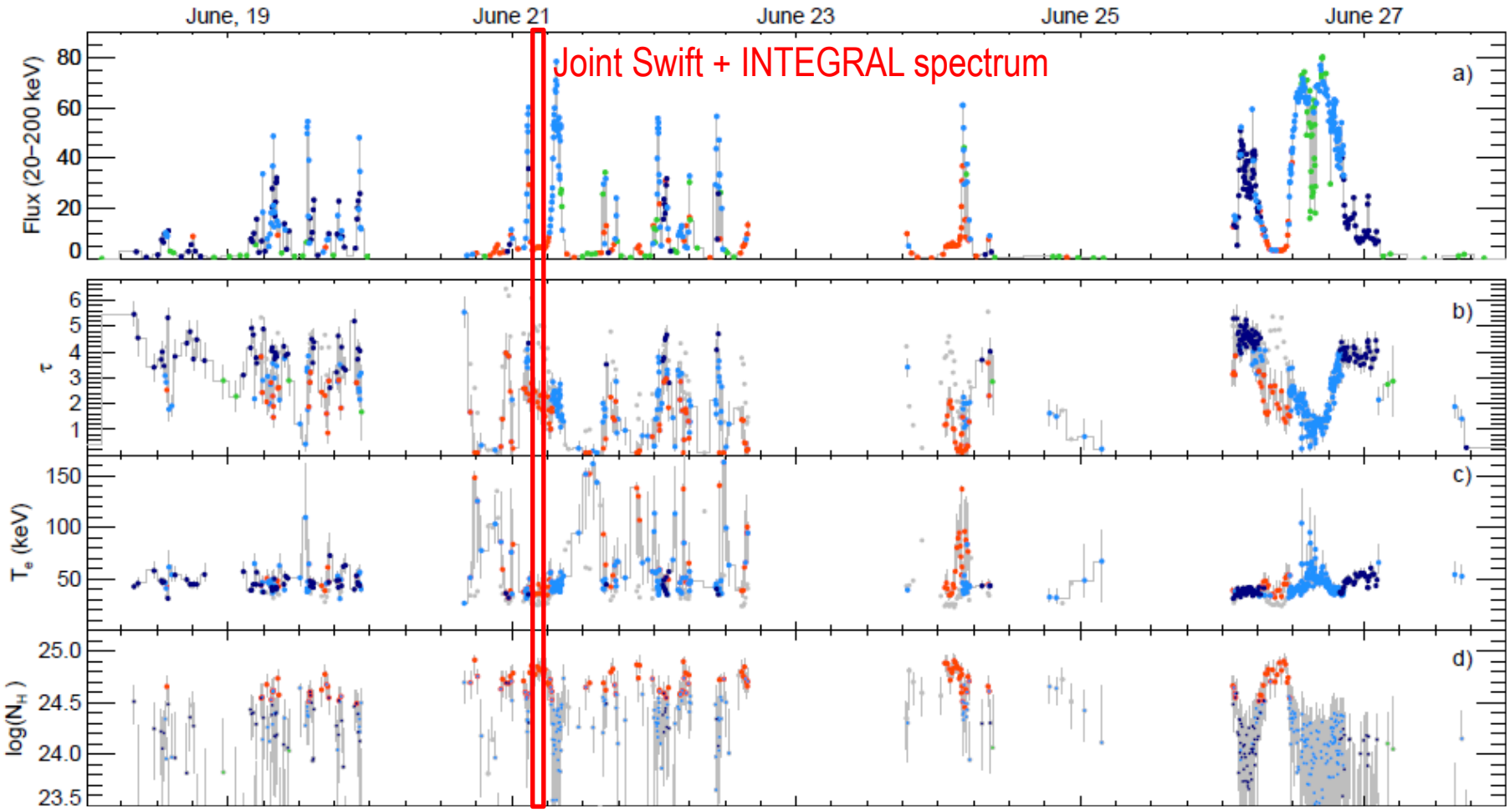
INTEGRAL (>20 keV) sees the absorption too



Sanchez-Fernandez+17

Check out Celias poster!

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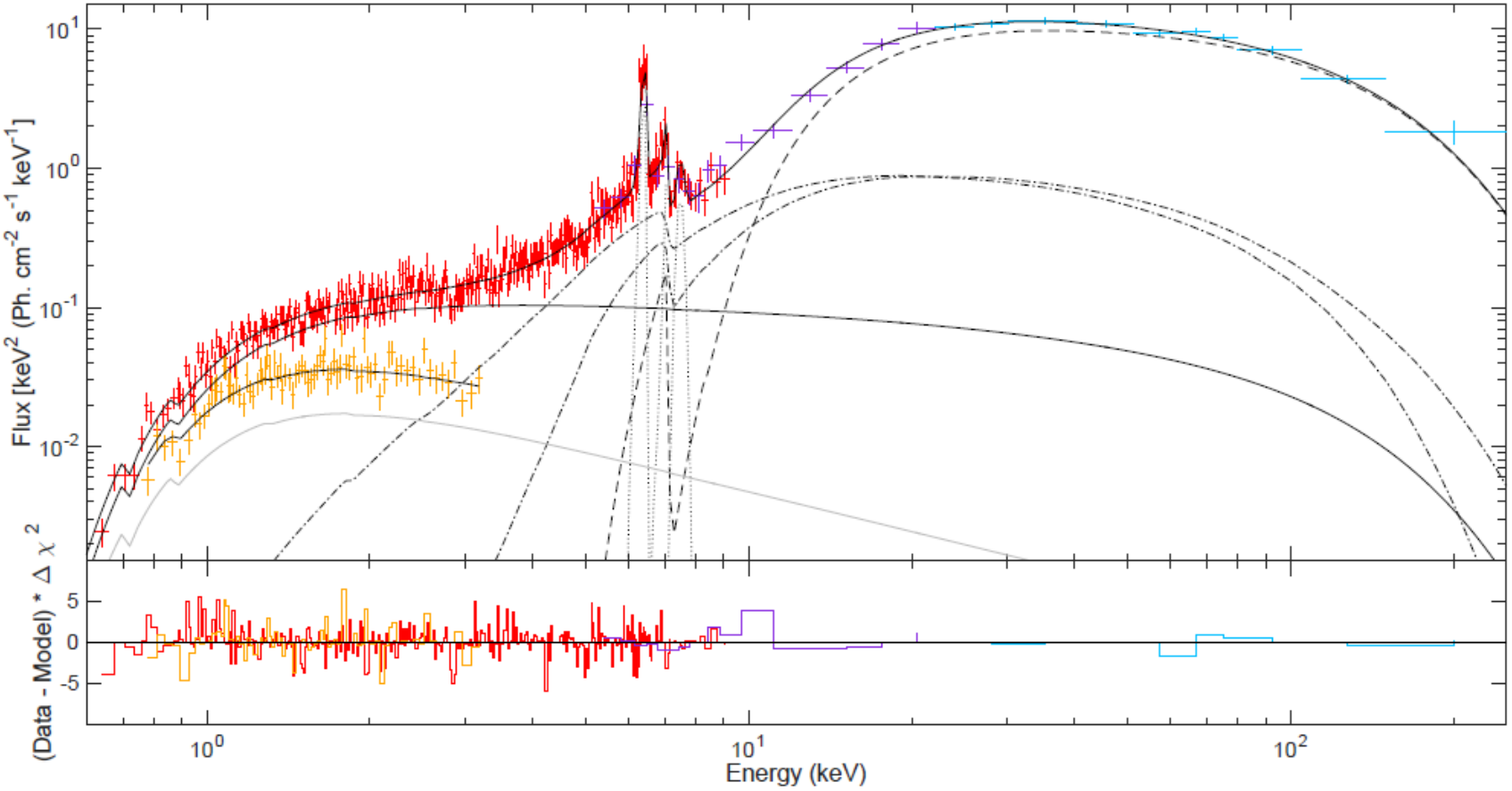
Broad band spectrum ~ Compton-thick AGN

- Absorber has N_H~3x10^{24} cm^{-2}; i.e. “Compton-thick”

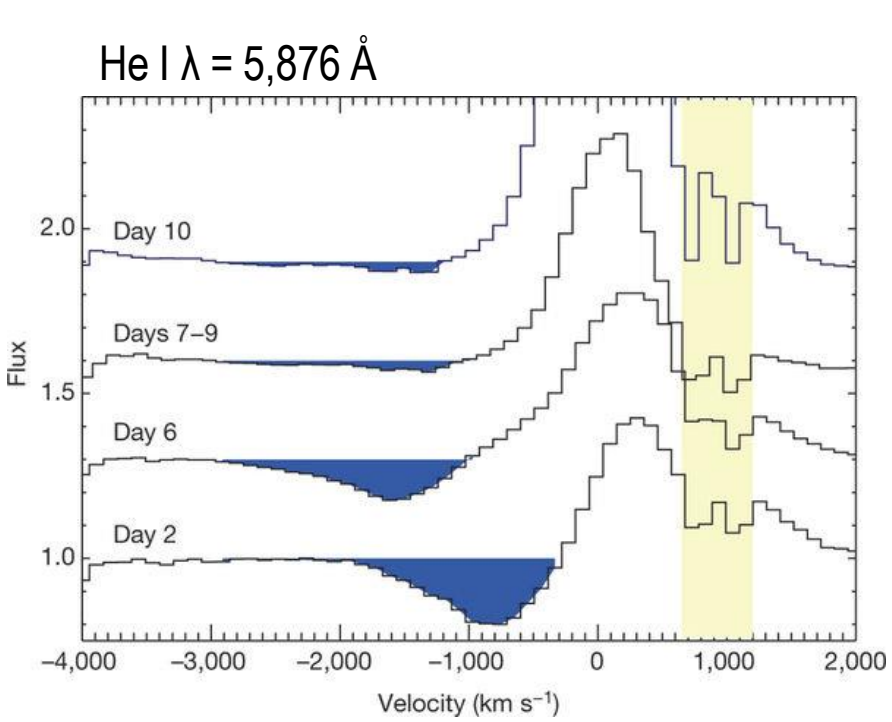
Motta+17



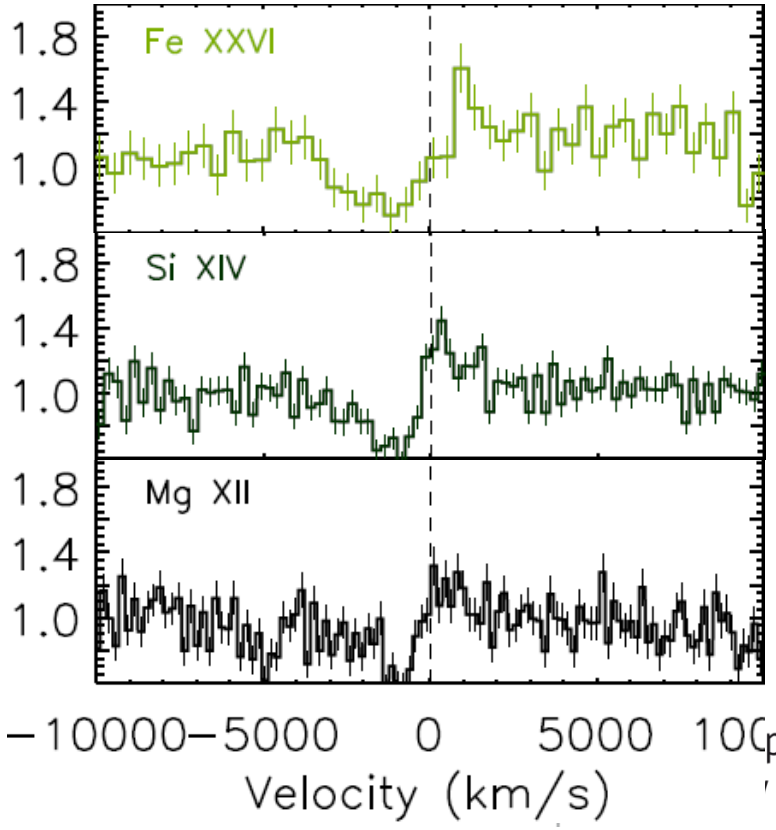
Winds from high-resolution data

- Optical and X-ray lines show P-Cygni profiles (blue line wing in absorption); ~2000 km/s disc wind

King+15

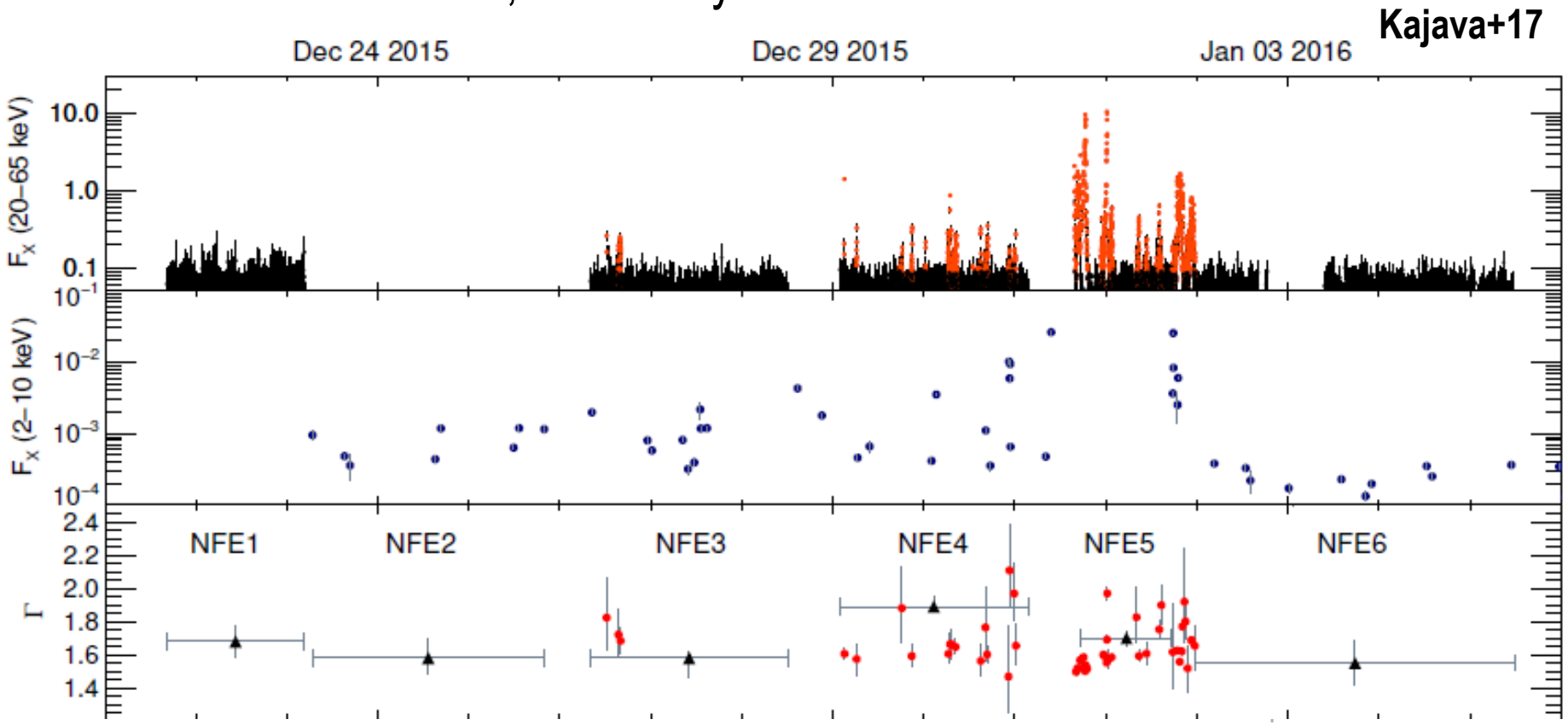


Muñoz-Darias+16



V404 Cyg outburst in December 2015

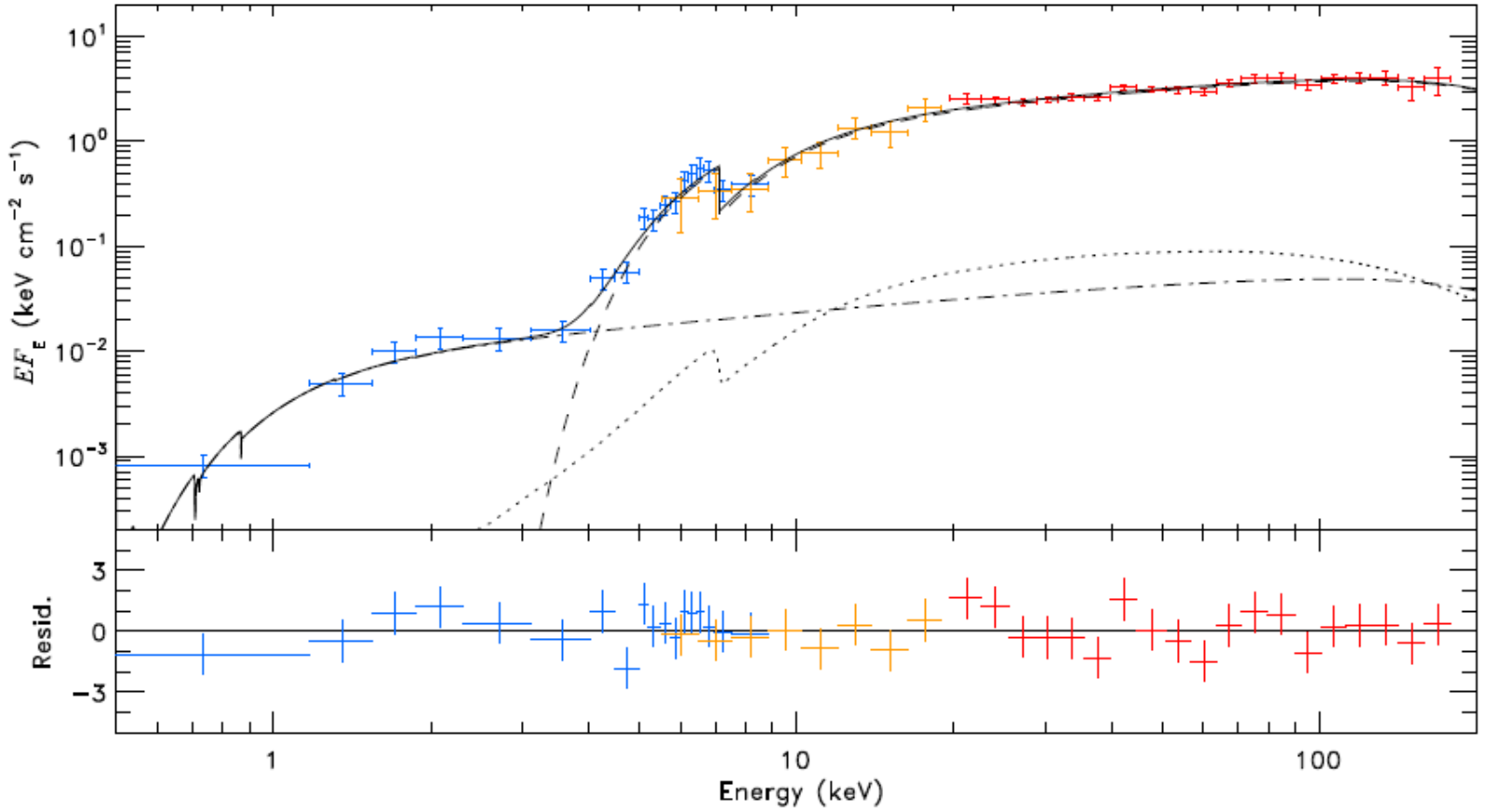
- December outburst was less intense; less flares overall, lower non-flare emission level, and always in “hard state”



Broad band spectrum ~ Compton-thick AGN

- Similar event during December outburst; N_H~1x10^{24} cm^{-2}

Kajava+17



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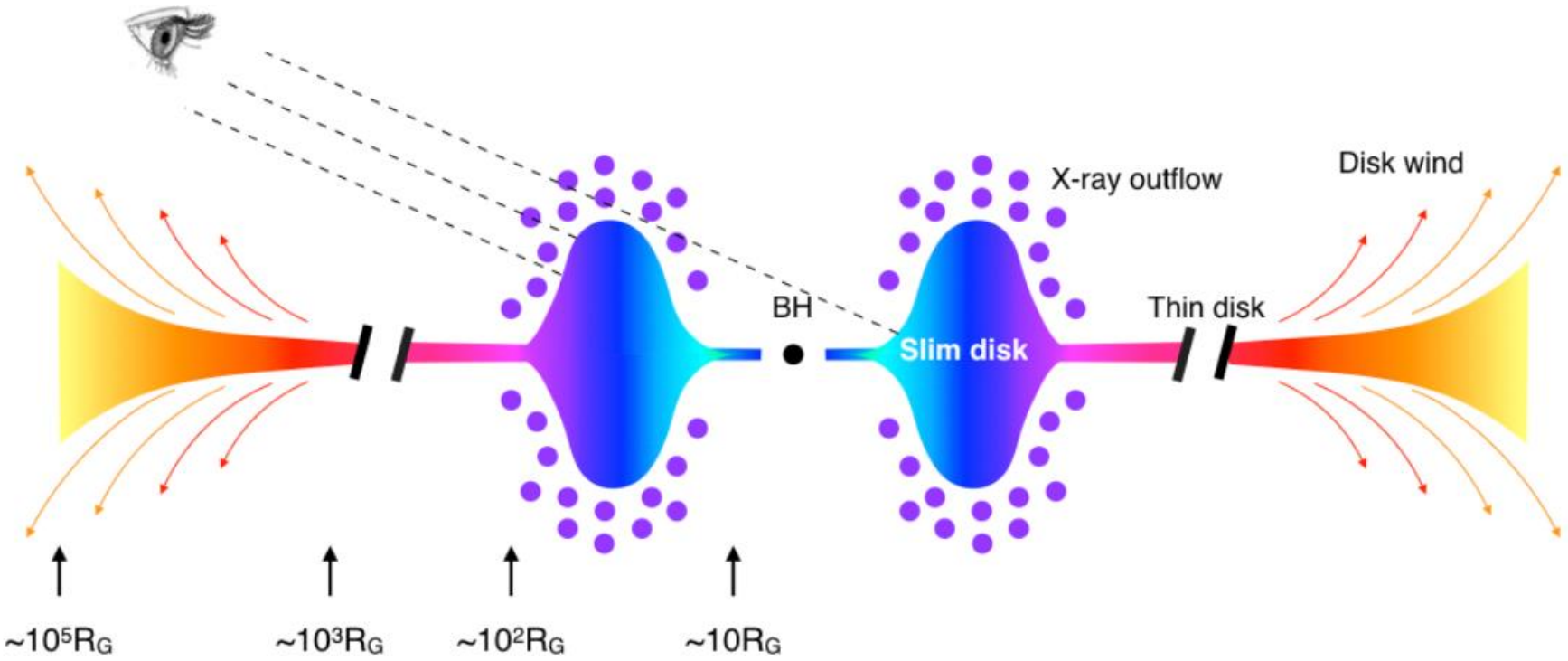
Possible disc geometry (not to scale)

- Inner disc puffs up → disc wind → X-rays obscured → “flares”
  - Similar picture proposed for ULXs (Poutanen+07; Middleton+15)



Conclusions and implications

- V404 Cyg X-ray flaring is generated by two processes:
  - Intrinsic variability by mass accretion rate fluctuations
  - Obscuration of the X-ray source by Compton-thick absorber
    - Observed flux can be orders of magnitude lower than intrinsic flux
- Comparisons between other wavelengths is complicated:
  - While X-rays are obscured, jet emission (radio, submm) may not be as it is likely emitted above the disc midplane
- Many open questions and work remain to be done:
  - Is the same outflow responsible for N_H variations, X-ray and optical P Cyg profiles?
  - What is the link between winds, jet activity and X-ray flares?
  - Study of time scales of state transitions?

Find more from these 4 recent papers

- Motta S., Kajava J. et al., 2017, MNRAS, 471, 1797, ”Swift observations of V404 Cyg during the 2015 outburst: X-ray outflows from super-Eddington accretion”
- Motta S., Kajava J. et al., 2017, MNRAS, 468, 981, ” The black hole binary V404 Cygni: a highly accreting obscured AGN analogue”
- Sánchez-Fernández C., Kajava J. et al., 2017, A&A, 602, 40 ”Hard X-ray variability of V404 Cygni during the 2015 outburst”
- Kajava J. et al. (2017), A&A, submitted, ”The December 2015 re-brightening of V404 Cyg: Variable absorption and outflows from the inner accretion disc”