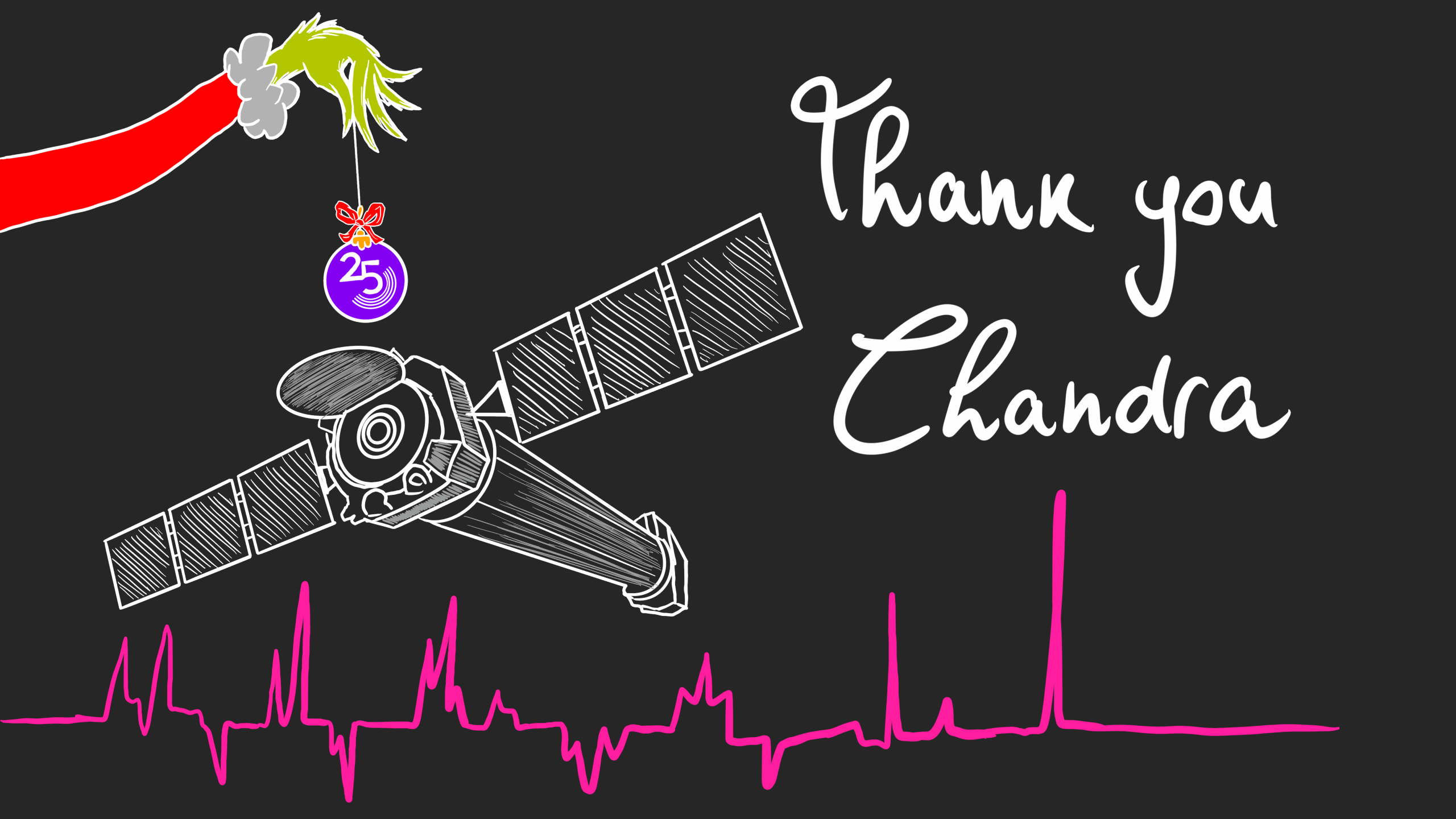
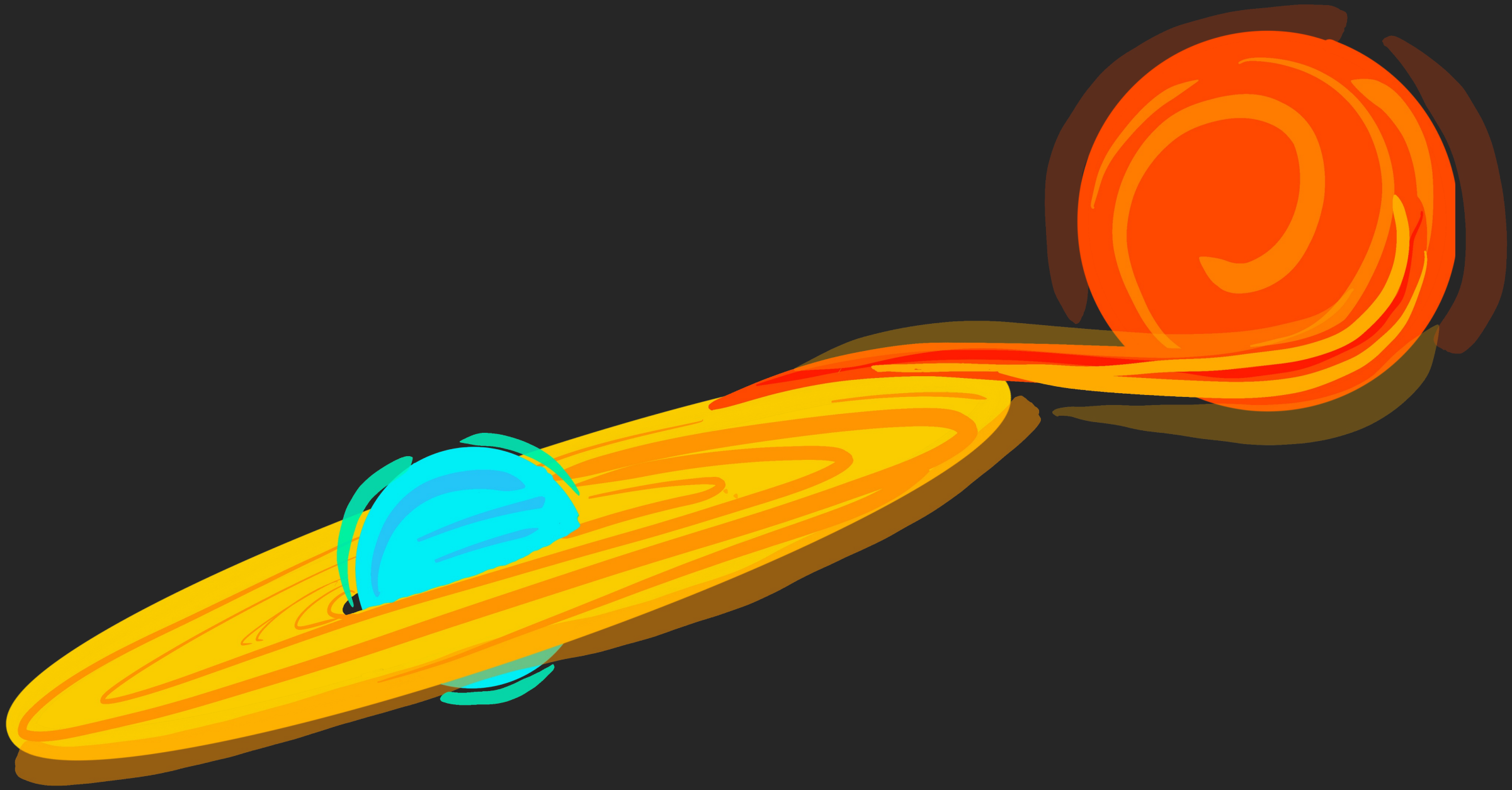
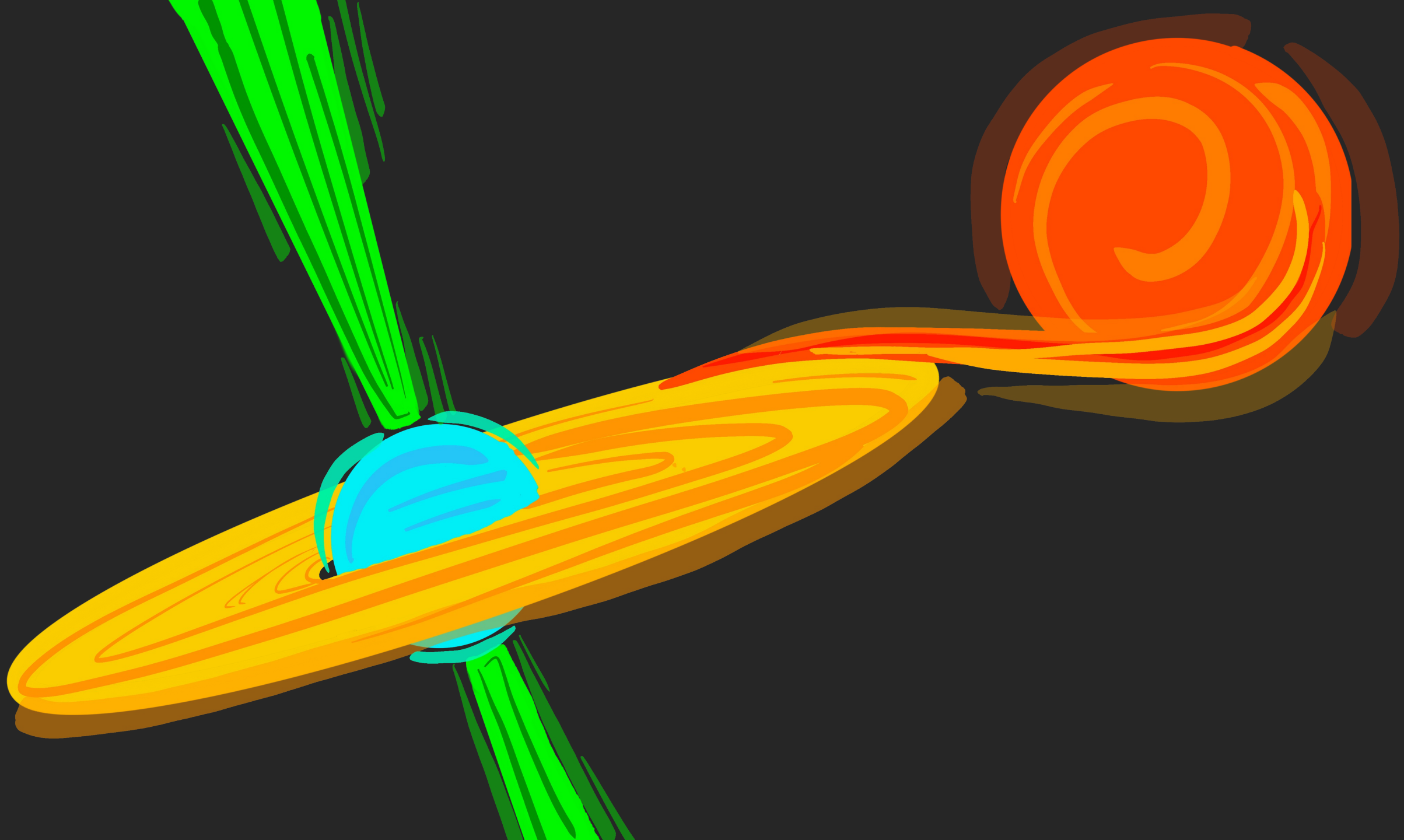
Chandra25 Symposium – December 5, 2024

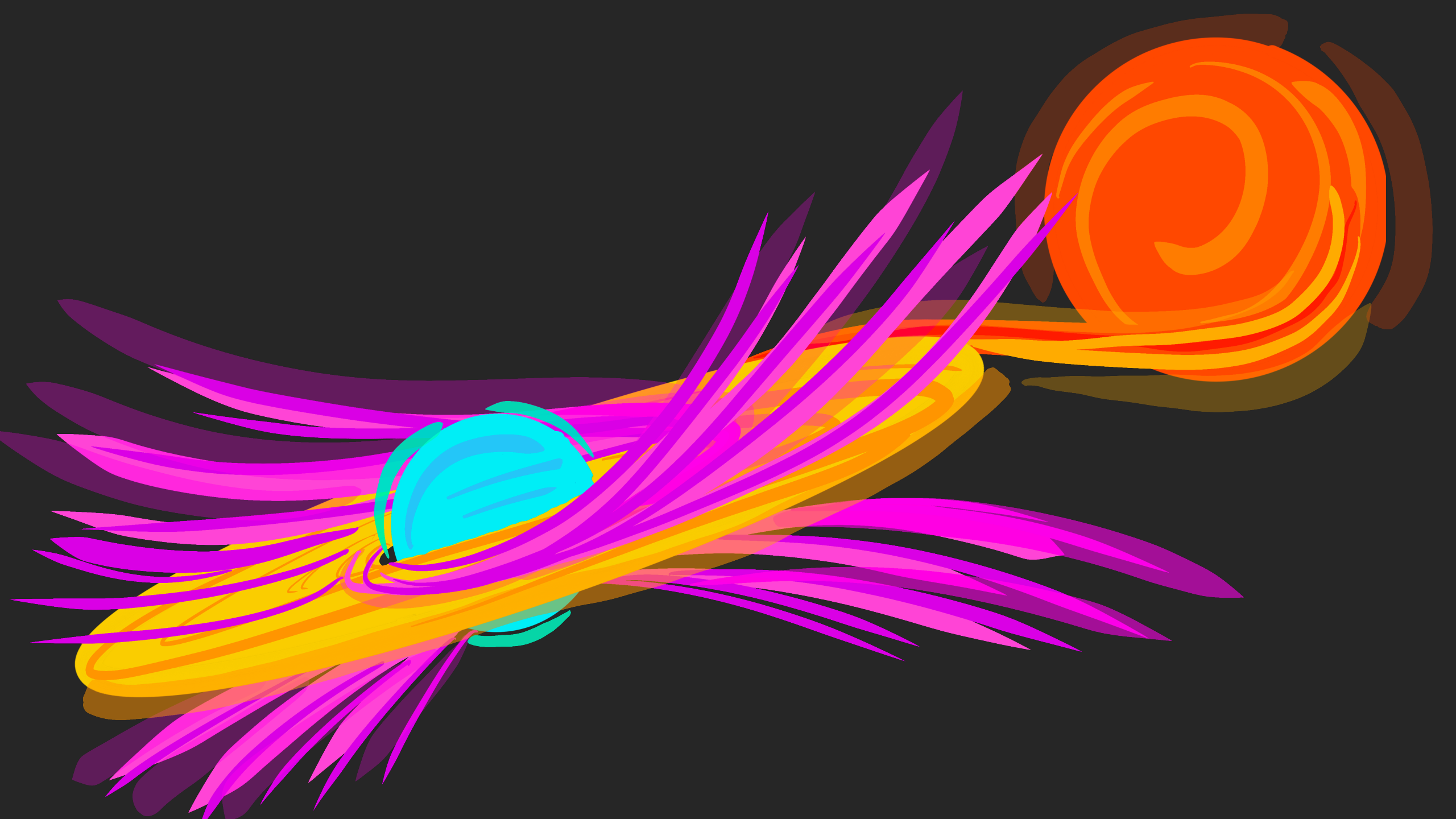
THE INTERPLAY BETWEEN ACCRETION DISK WIND AND JET IN GX 13+1

Daniele Rogantini
Jeroen Homan, Rich Plotkin
Joey Neilsen, James Miller-Jones, Maureen van de Berg,
Rob Fender, Norbert Schulz, Deepto Chakrabarty


Thank you
Chandra
25







DO JETS AND WINDS COEXIST IN LOW MASS X-RAY BINARIES?

Why do we care about it?

- Understand the launching mechanism of the two different outflow
- Strong constrains on the outflow inflow coupling

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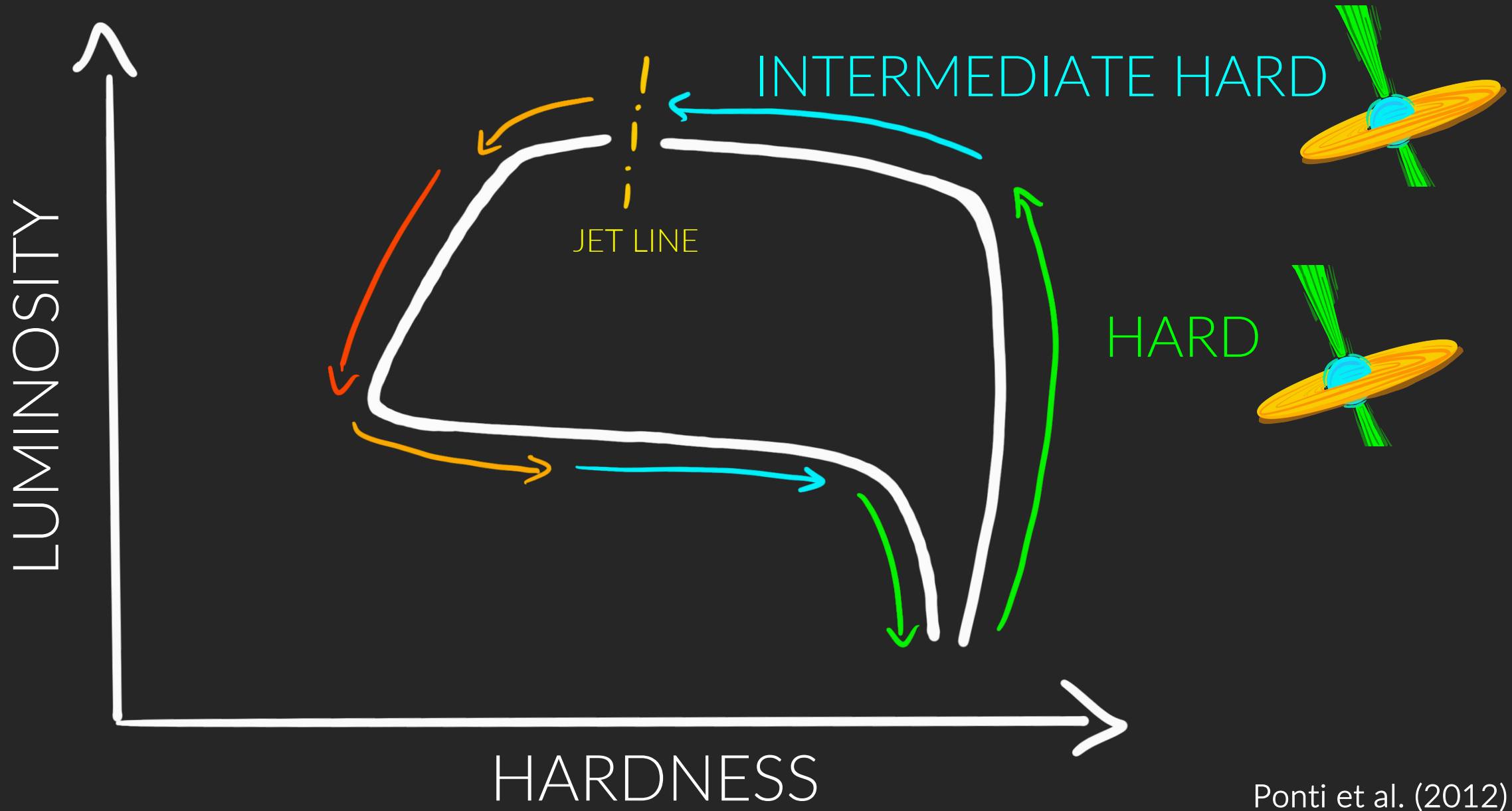
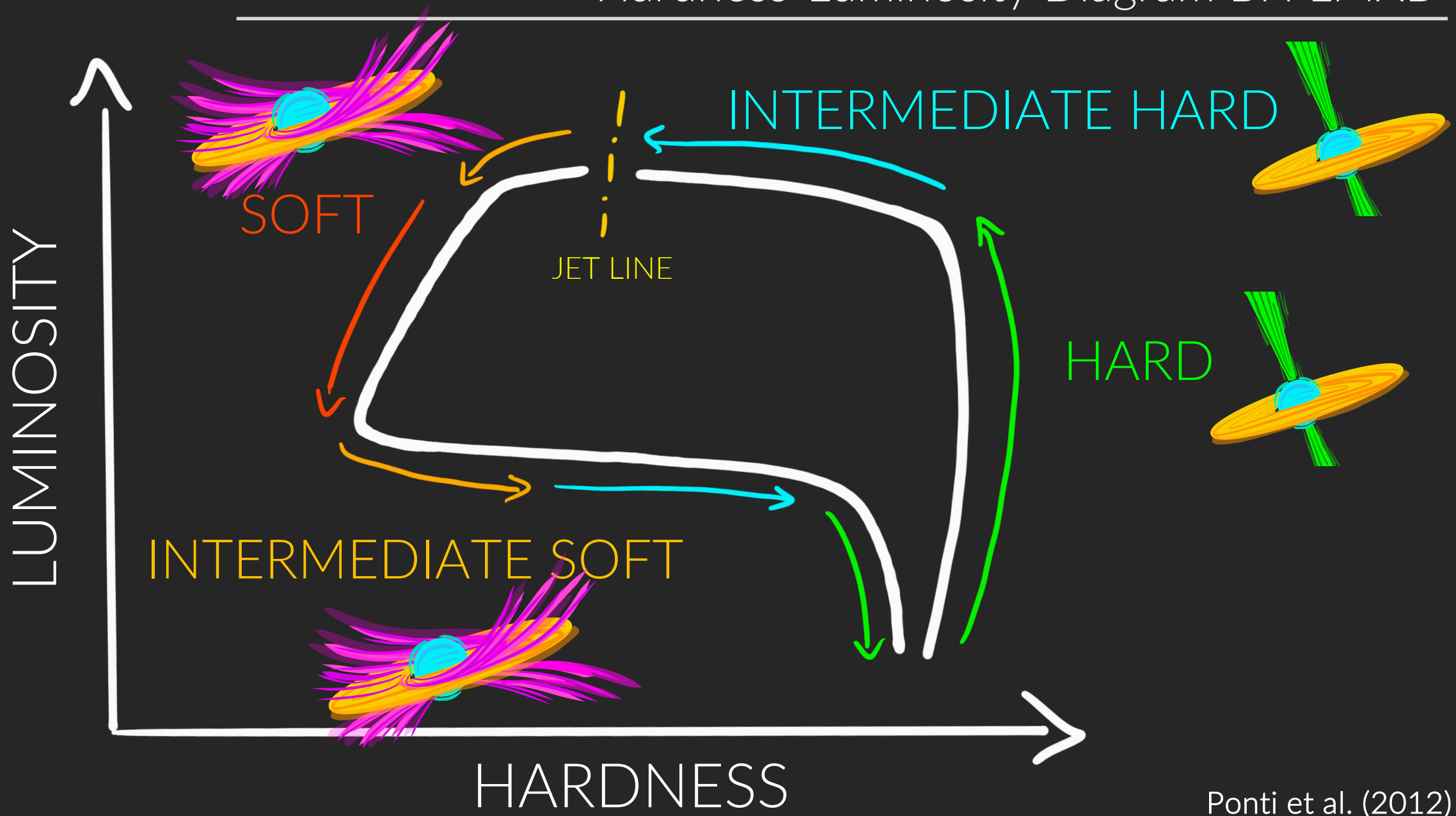
LET'S START WITH THE STELLAR BLACK HOLES

Hardness-Luminosity Diagram BH LMXB



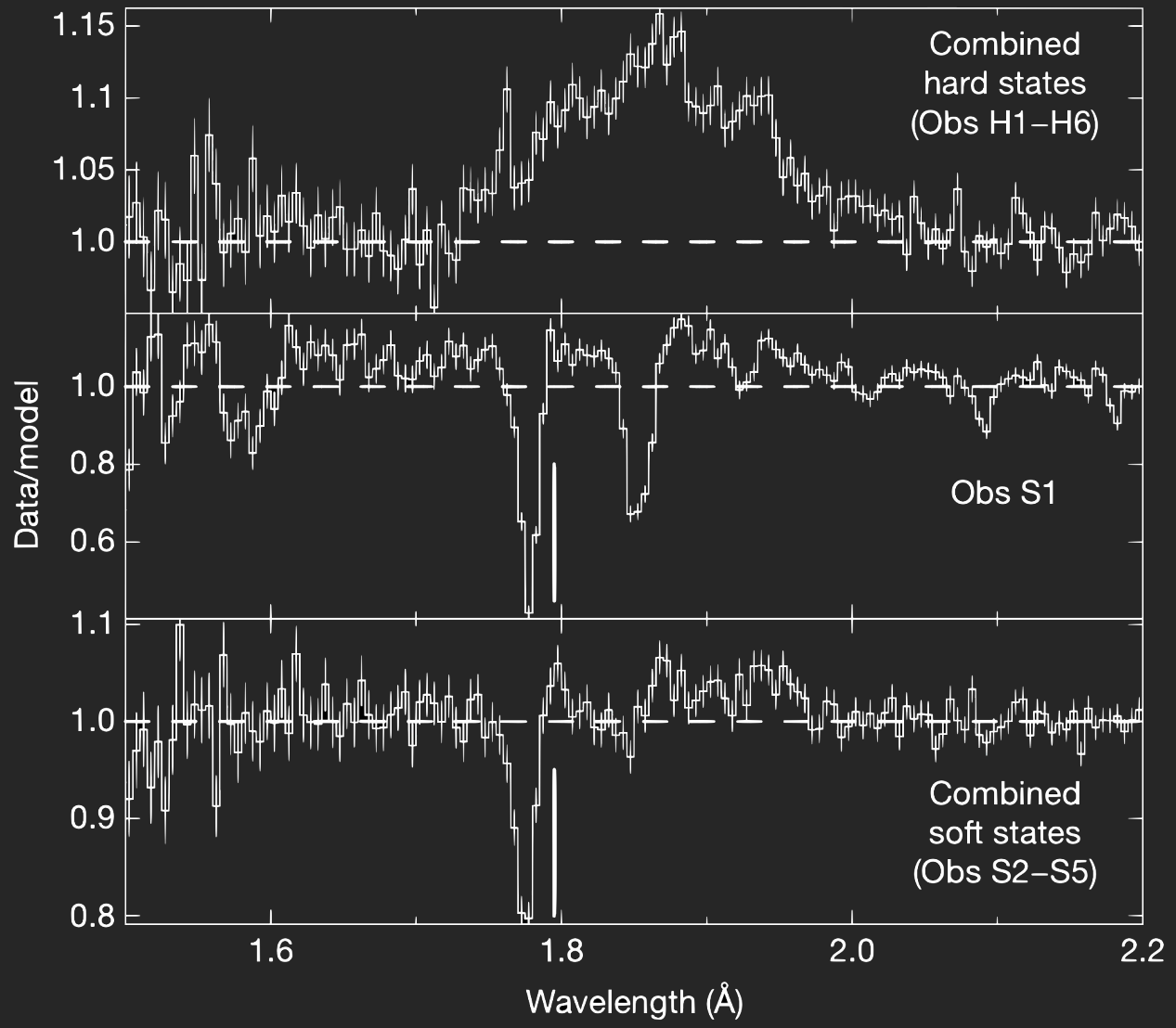
Ponti et al. (2012)

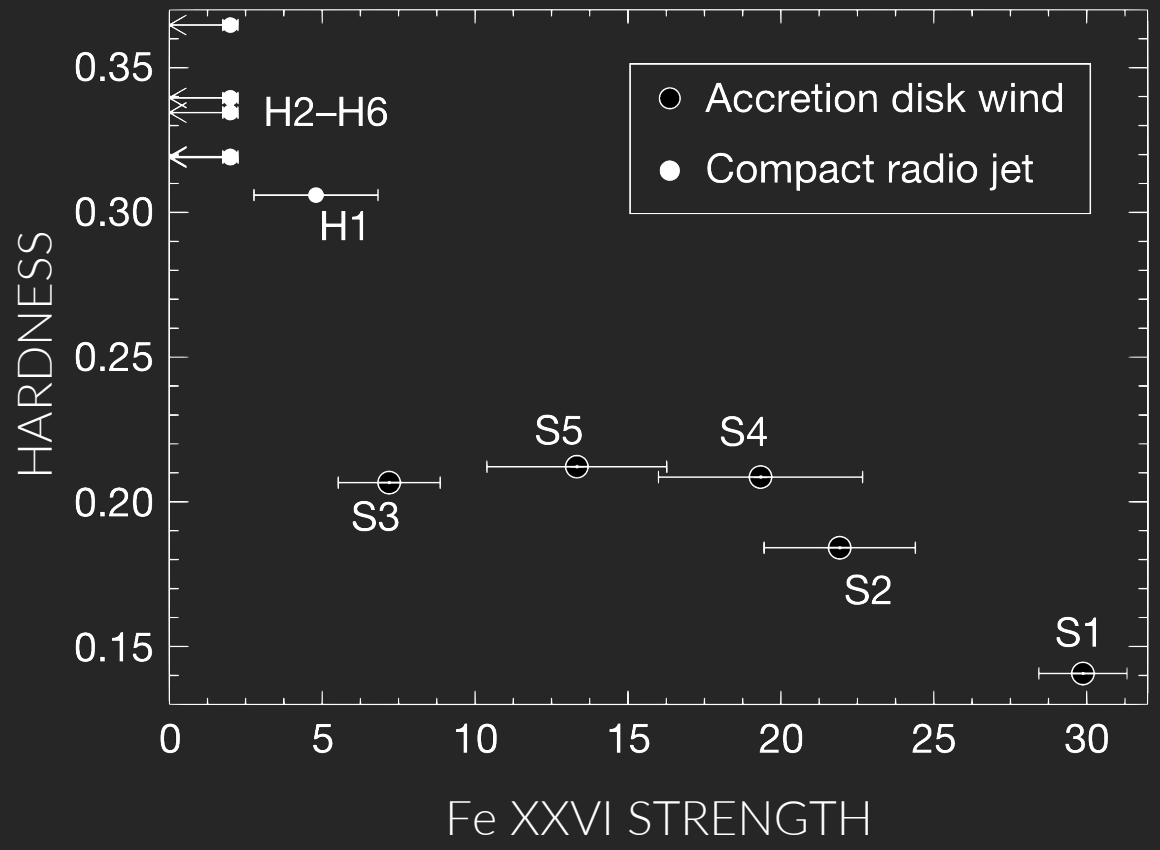
Hardness-Luminosity Diagram BH LMXB



Ponti et al. (2012)

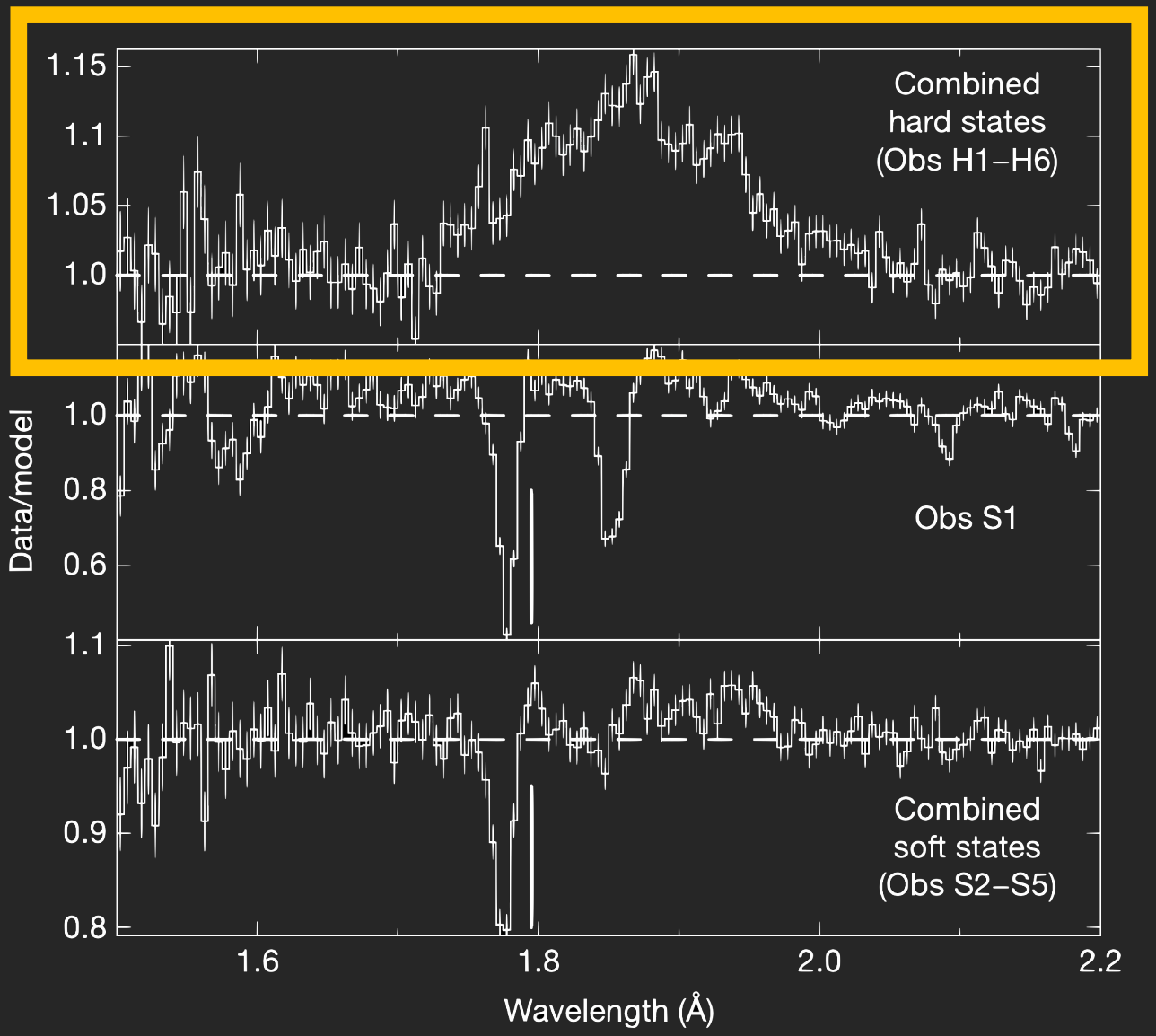
JET & WIND in GRS 1915



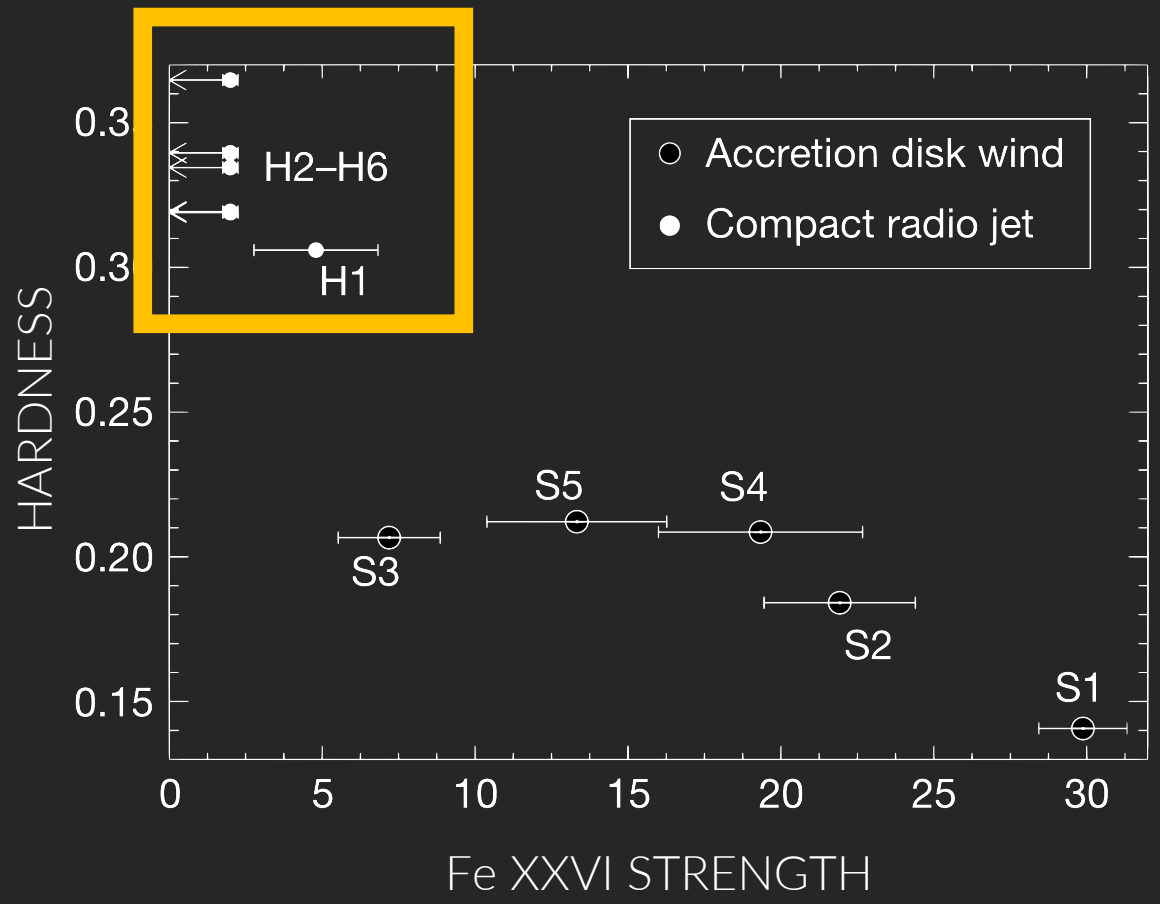


Neilsen & Lee (2009)

JET & WIND in GRS 1915



HARD STATE



Neilsen & Lee (2009)

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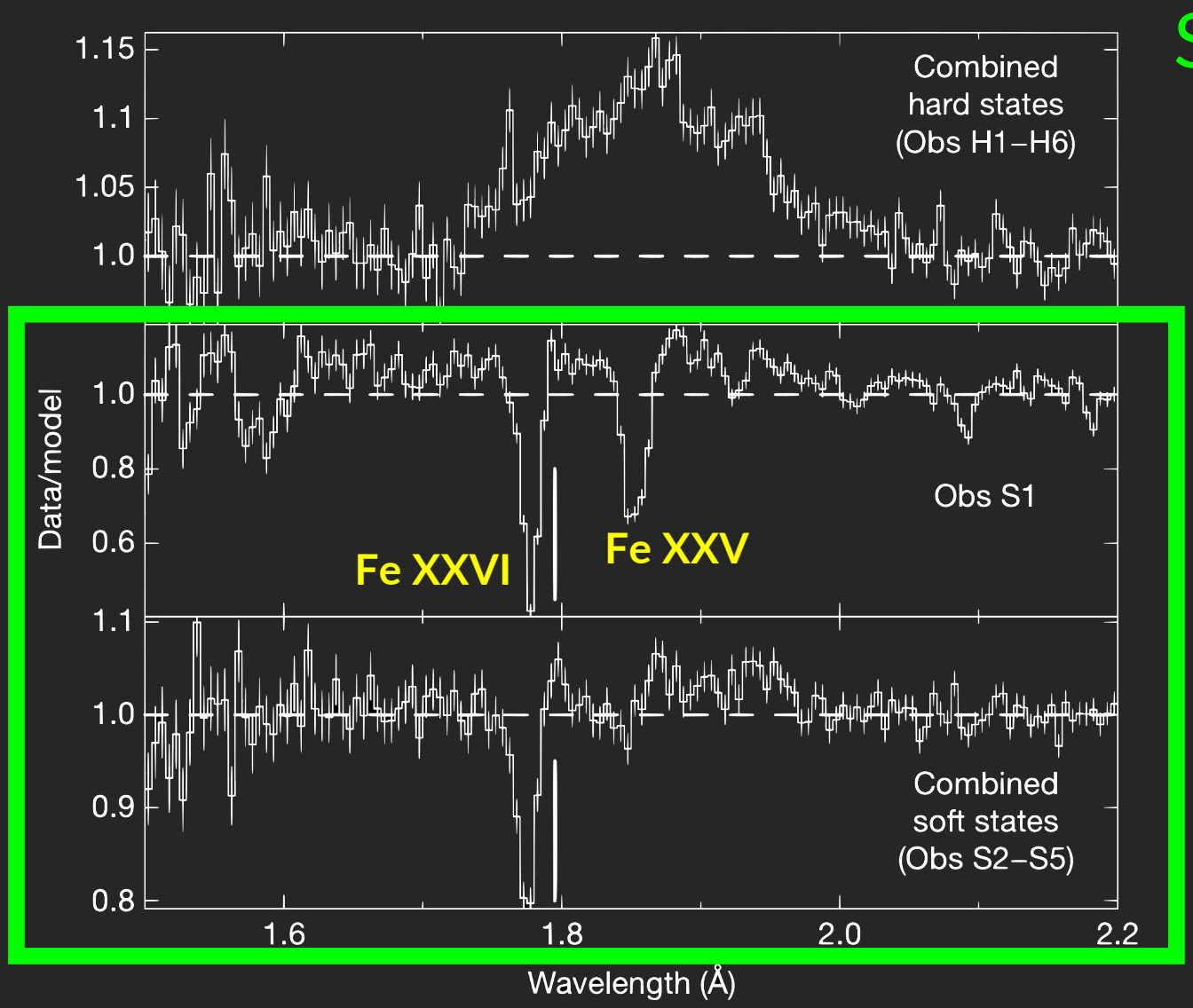
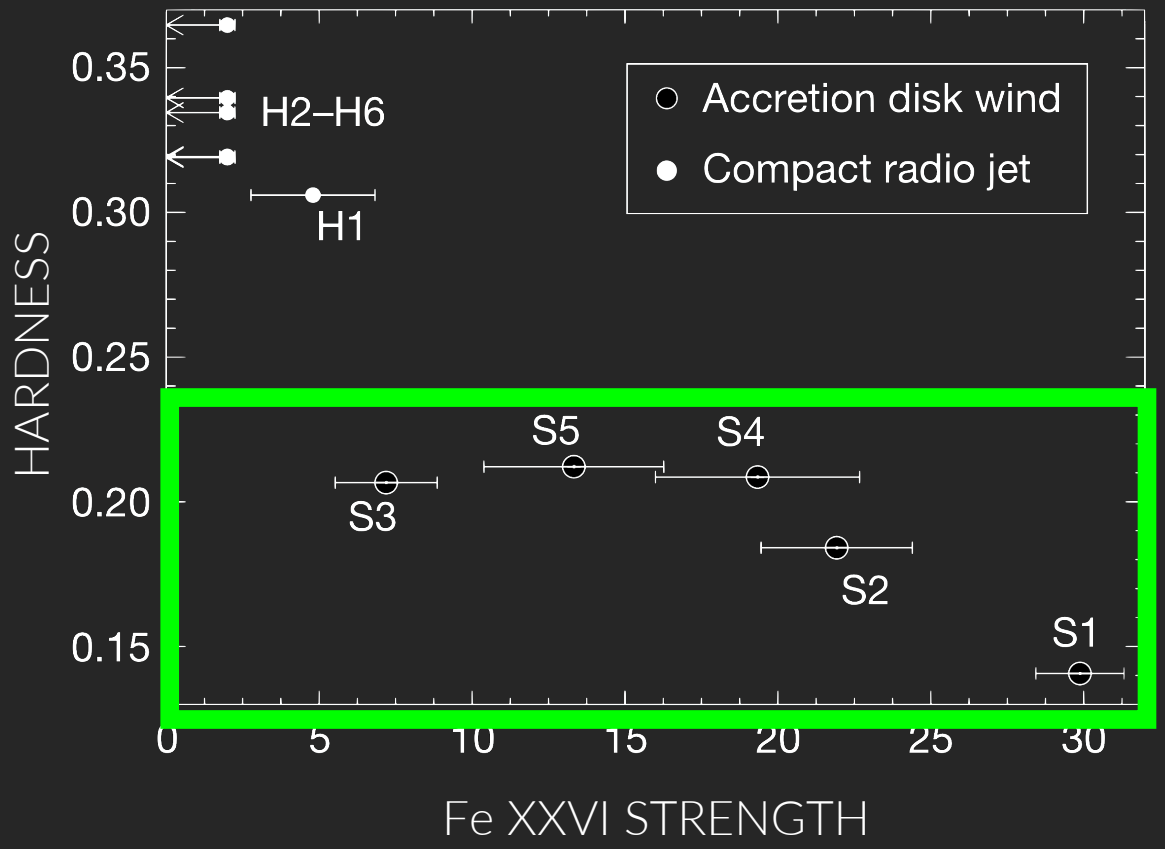
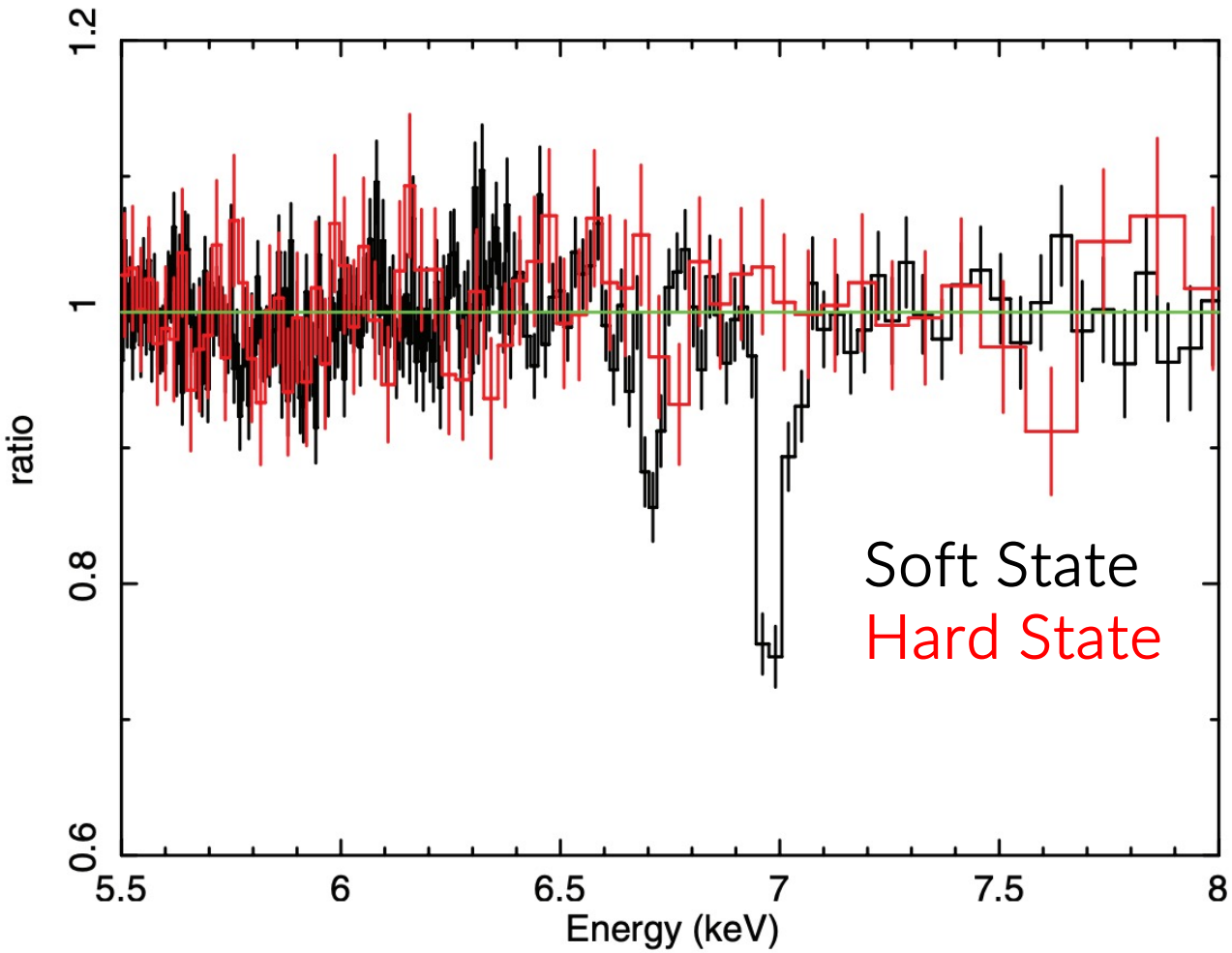
SOFT STATE





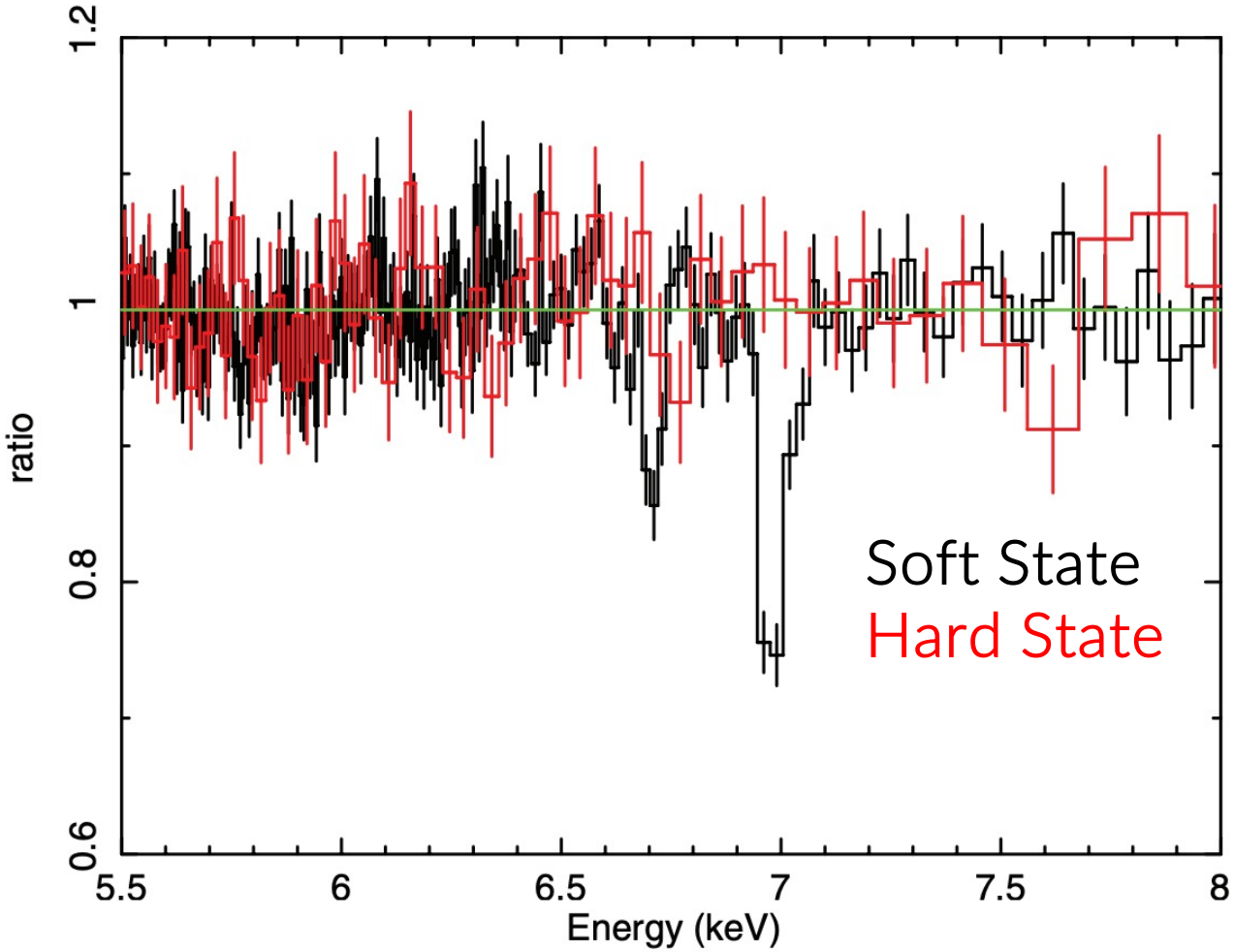
Neilsen & Lee (2009)

JET & WIND in H 1743-322



Miller et al. (2012)

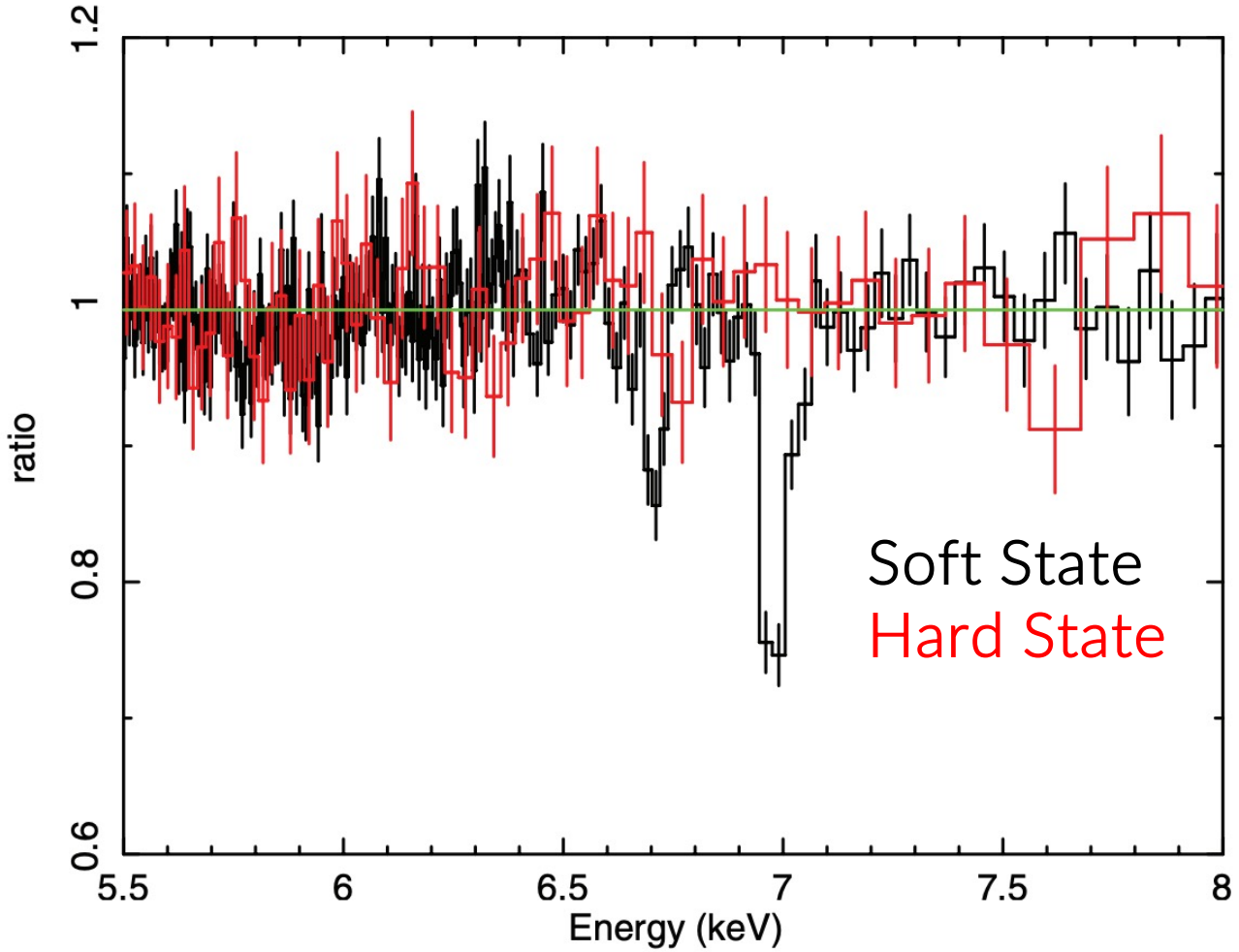
JET & WIND in H1743-322

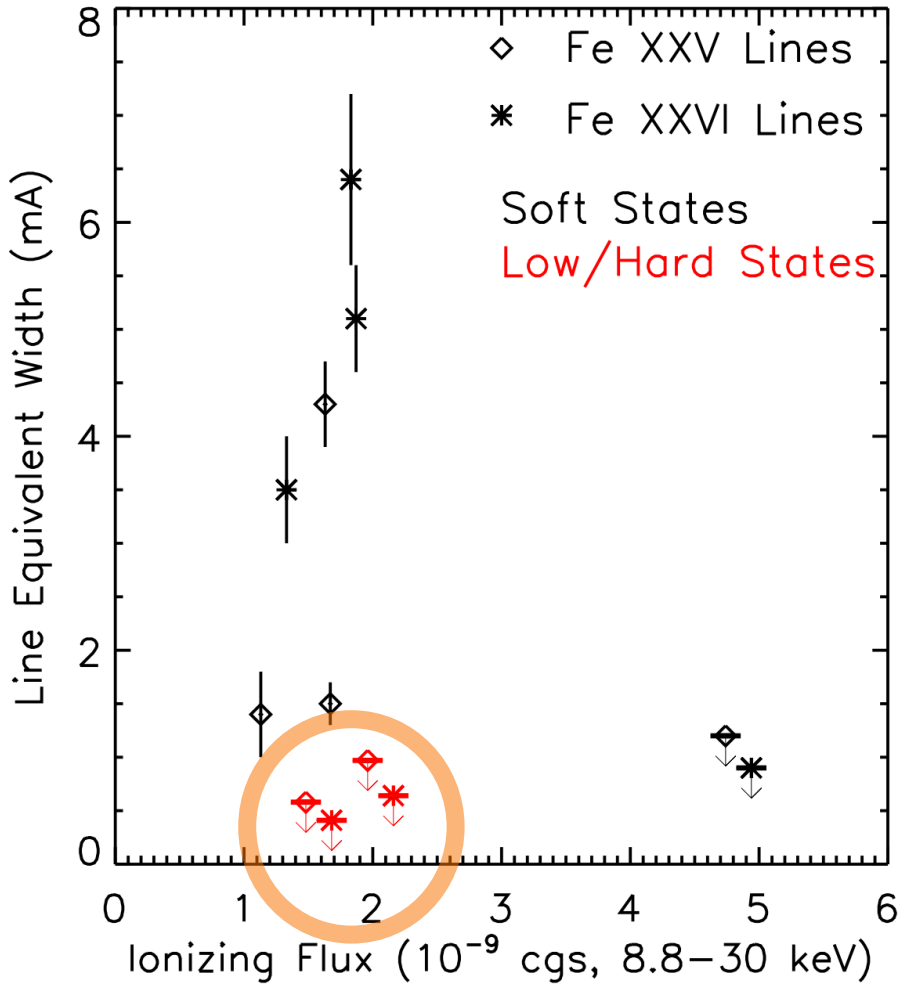


Can the Hard State SED overionize the wind making it undetectable?

Miller et al. (2012)

JET & WIND IN H 1743-322





Miller et al. (2012)

JET AND WIND IN BH LMXBs

WIND AND JET ARE RELATED BUT ANTI-CORRELATED

Strong wind features appear in the soft state when the jet is absent, and they disappear during hard states where the jet is ubiquitous detected.

ENERGY REDISTRIBUTION BETWEEN WIND AND JETS

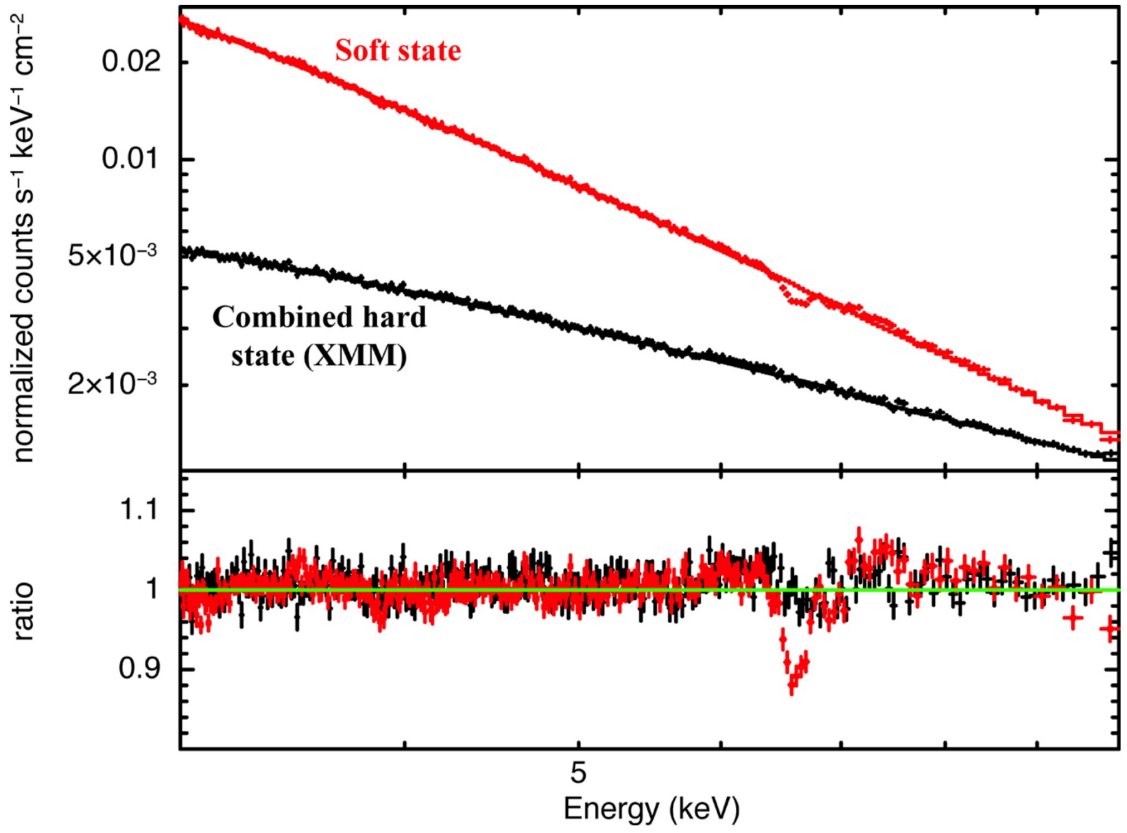
Wind drives approximately the same mass loss as the radio jet, suggesting that the X-ray binary is able to maintain a rough equilibrium between mass accretion and outflow, independent of its spectral state and the outflow mechanism.

WIND GEOMETRY VARIATIONS

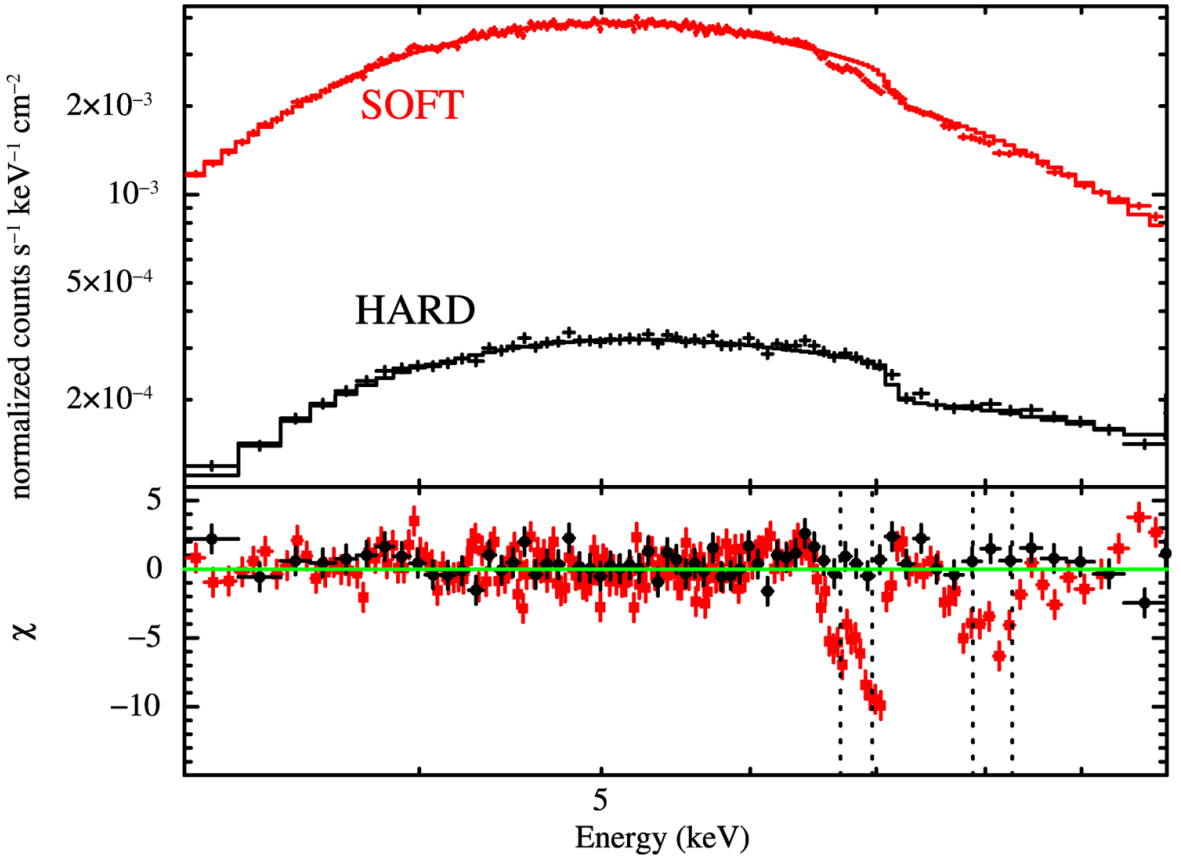
Changes in the ionization cannot explain the wind variability in all binaries. The non-detection of wind requires a change in the wind geometry (i.e. covering fraction, density, depth)

WHAT ABOUT NEUTRON STAR LOW-MASS X-RAY BINARIES?

EXO 0748-676



AX J1745.6-2901

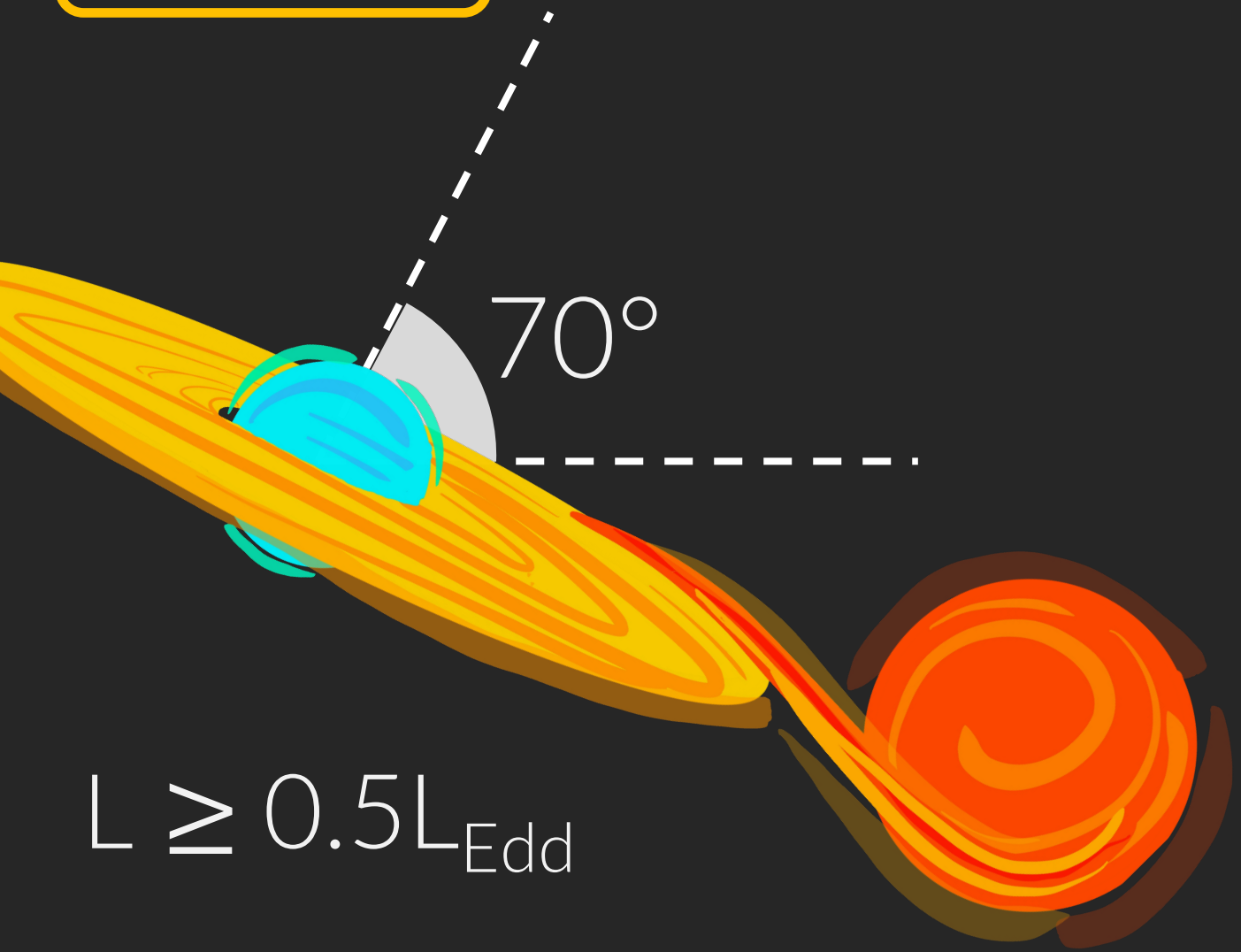


Ponti et al. (2014, 2015)

Do NS X-ray binaries accreting at high Eddington fractions ($L>0.3\ L_{edd}$) behave the same?

NEUTRON STAR LMXB GX 13+1

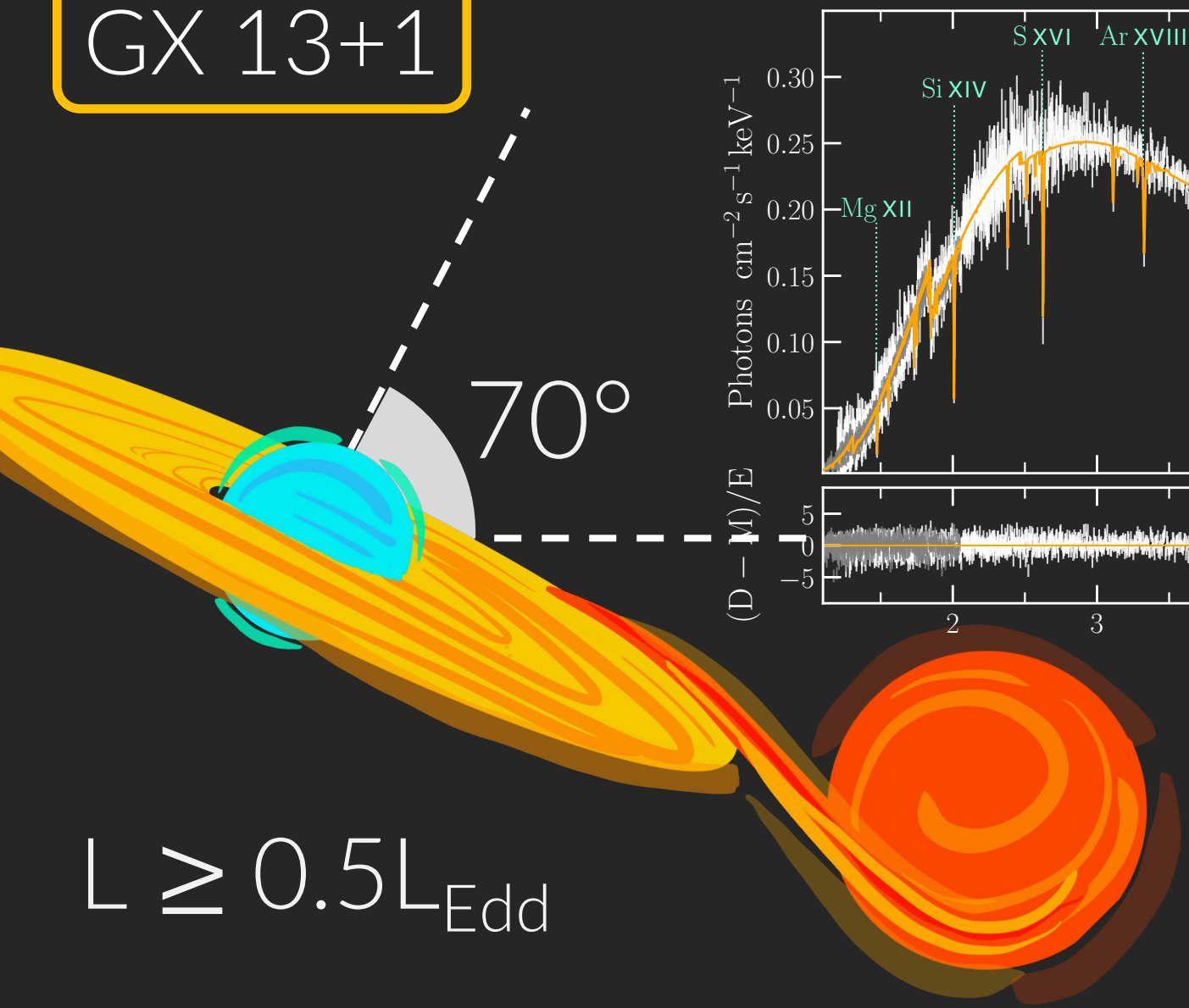
GX 13+1

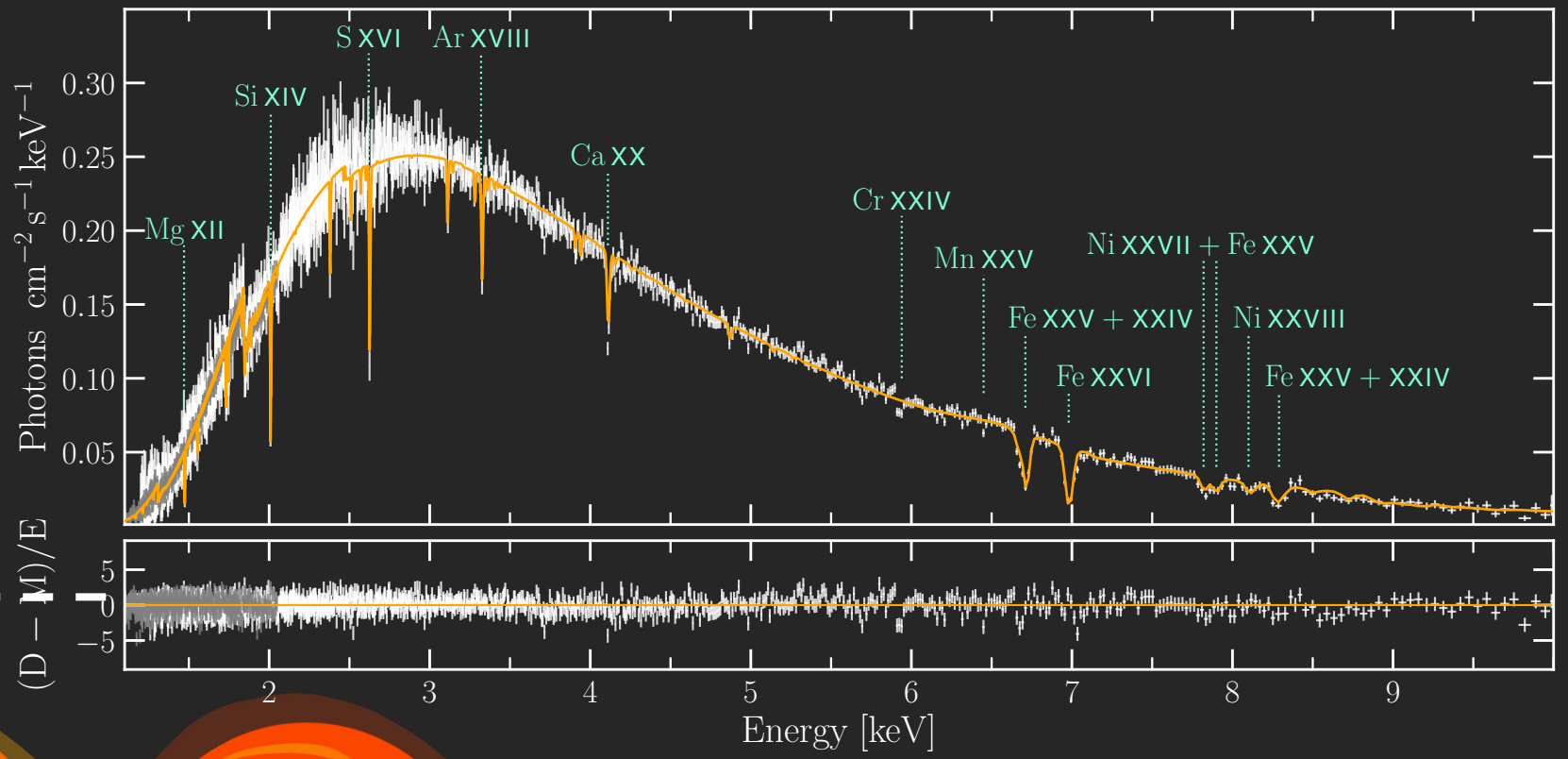


$L \geq 0.5 L_{Edd}$

NEUTRON STAR LMXB GX 13+1

GX 13+1





$L \geq 0.5 L_{Edd}$

Allen et al. (2018)

GX 13+1 IN Z STATE

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From past Chandra/HETG and VLA observations

HORIZONTAL BRANCH
WINDS ➔ YES
JET ➔ STRONG

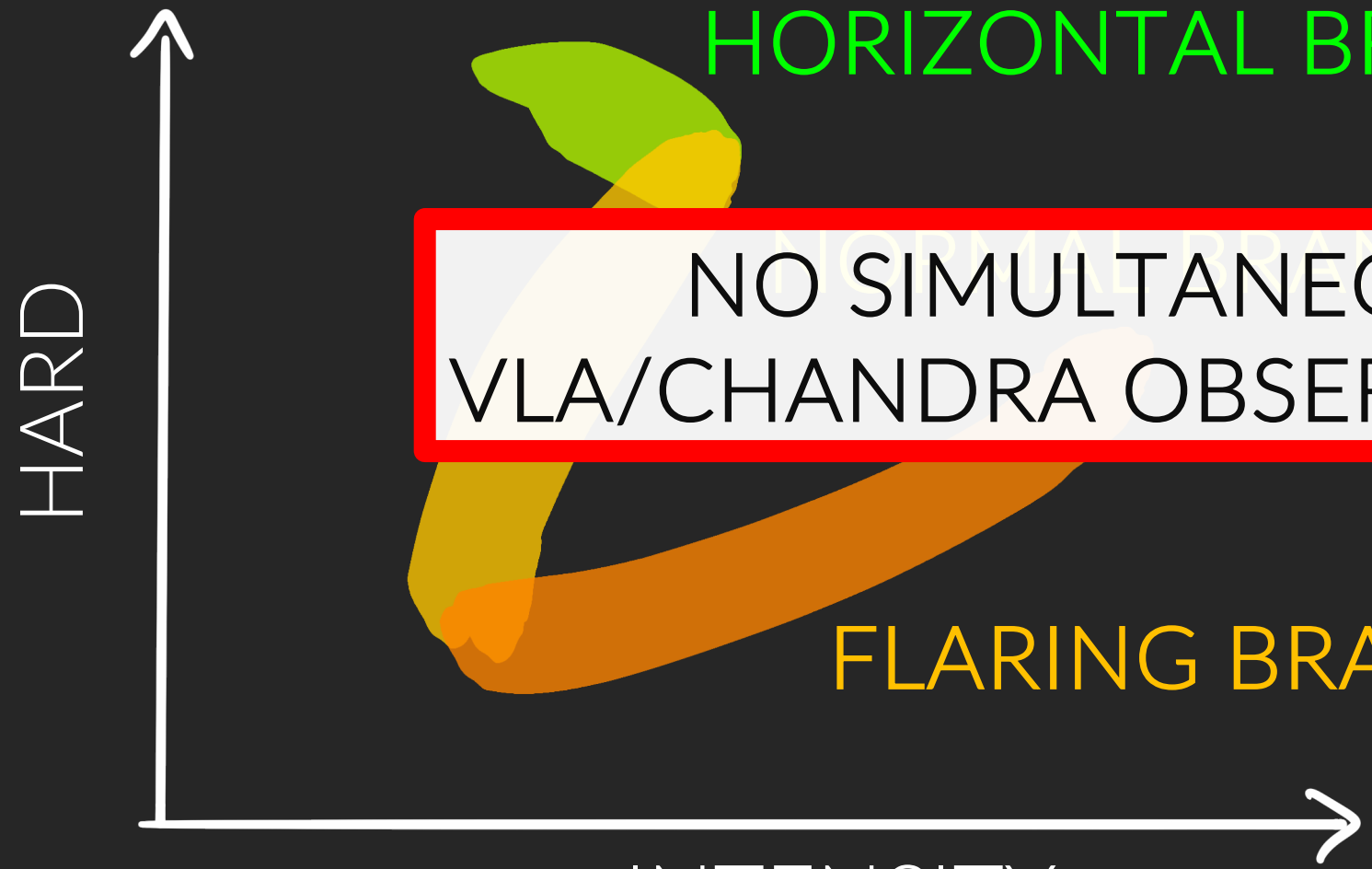
NORMAL BRANCH
WINDS ➔ YES
JET ➔ STRONG

FLARING BRANCH
WINDS ➔ ???
JET ➔ WEAK/NO

Ferland et al. (2015), Homan et al. (2016)

GX 13+1 IN Z STATE

From past Chandra/HETG and VLA observations



HORIZONTAL BRANCH

WINDS ➔ YES
JET ➔ STRONG

NORMAL BRANCH

WINDS ➔ YES
JET ➔ STRONG

NO SIMULTANEOUS
VLA/CHANDRA OBSERVATIONS

FLARING BRANCH

WINDS ➔ ???
JET ➔ WEAK/NO

Ferland et al. (2015), Homan et al. (2016)

Simultaneous Multiwavelength Campaign

CHANDRA/HETG

detect and study the X-ray winds through photoionization absorption lines

NICER

determine the state of the accreting neutron star

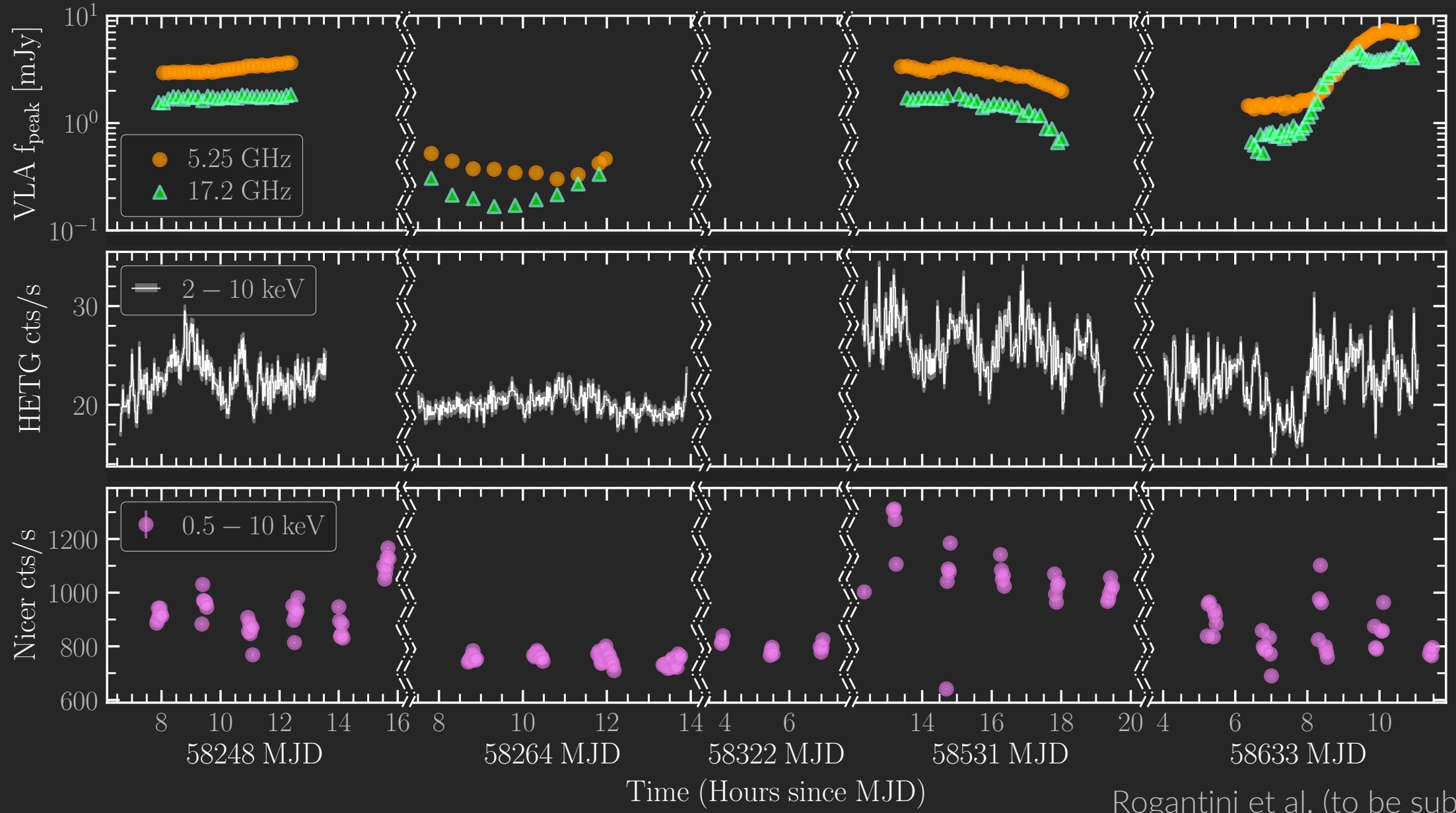
Jansky Very Large Array (VLA)

measure the radio emission from the jet

TO STUDY THE COUPLING BETWEEN WIND, ACCRETION STATE, AND JET

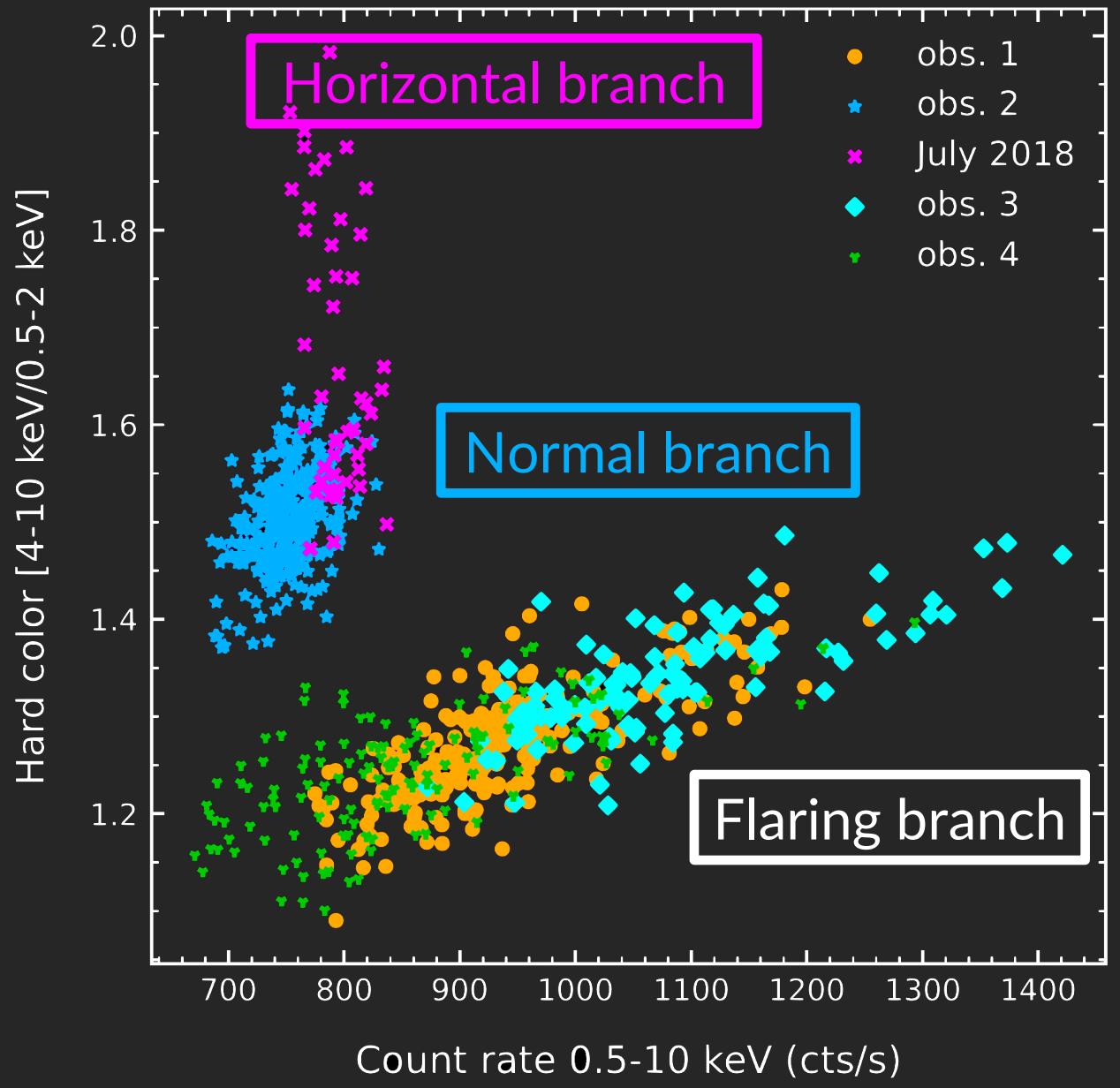
PI: Jeroen Homan

Simultaneous Multiwavelength Campaign

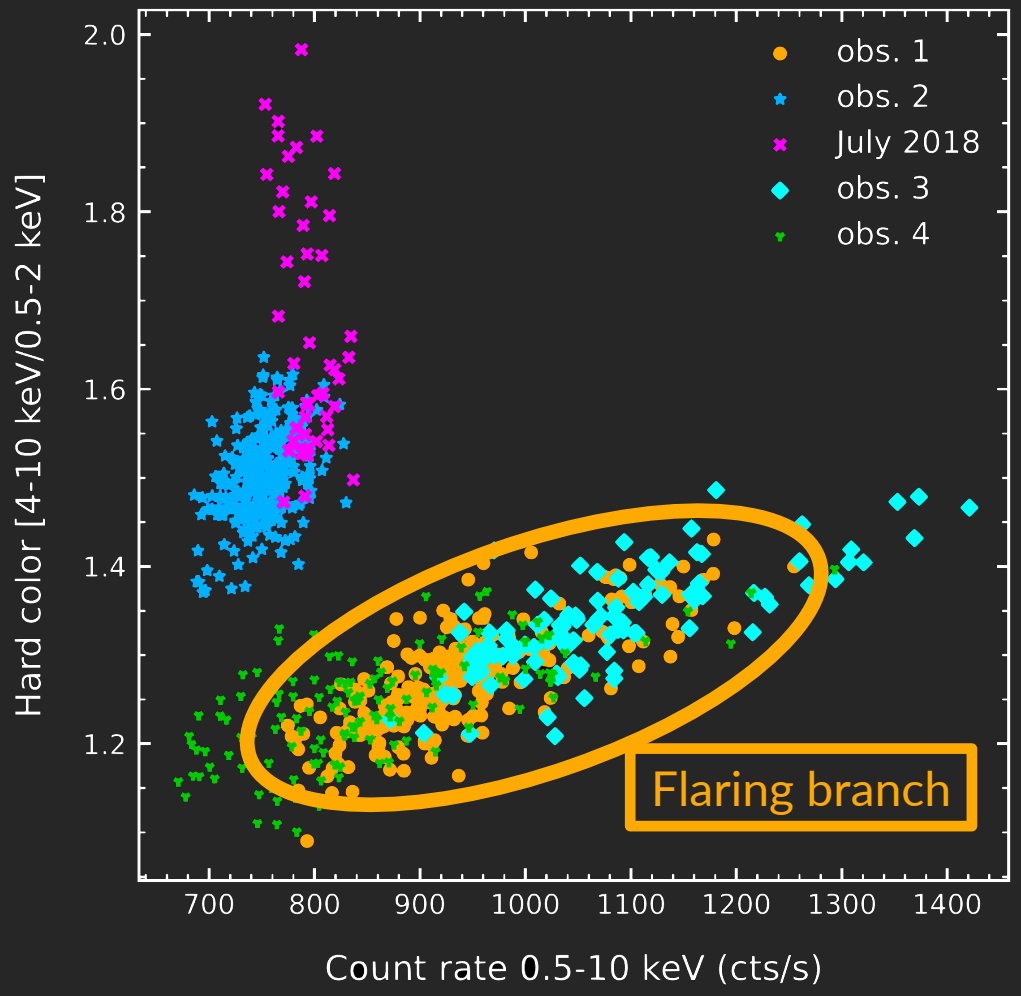


Rogantini et al. (to be submitted)

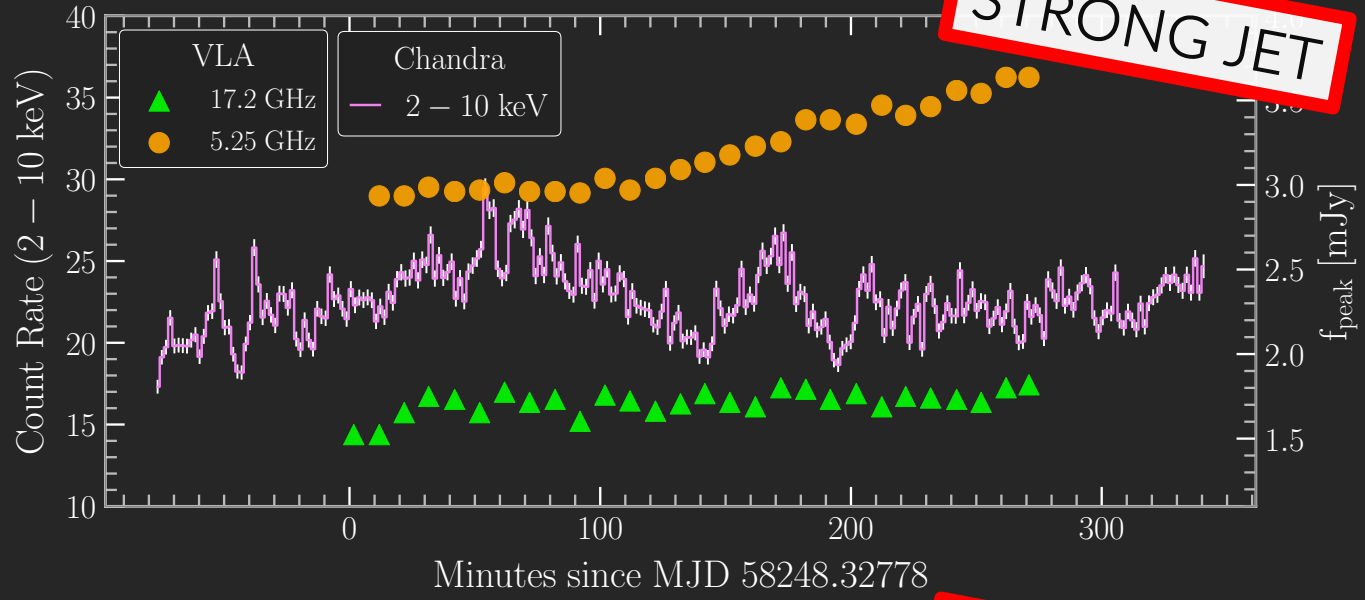
Chandra/VLA/Nicer



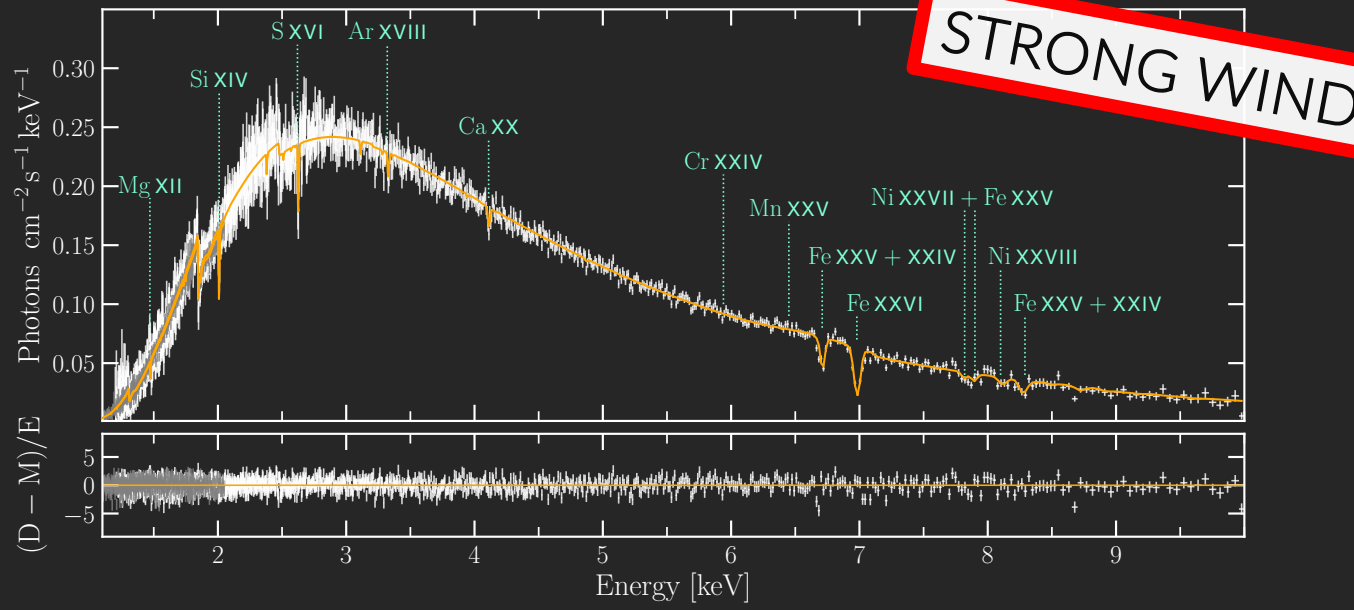
Chandra/VLA/Nicer (Epoch 1)



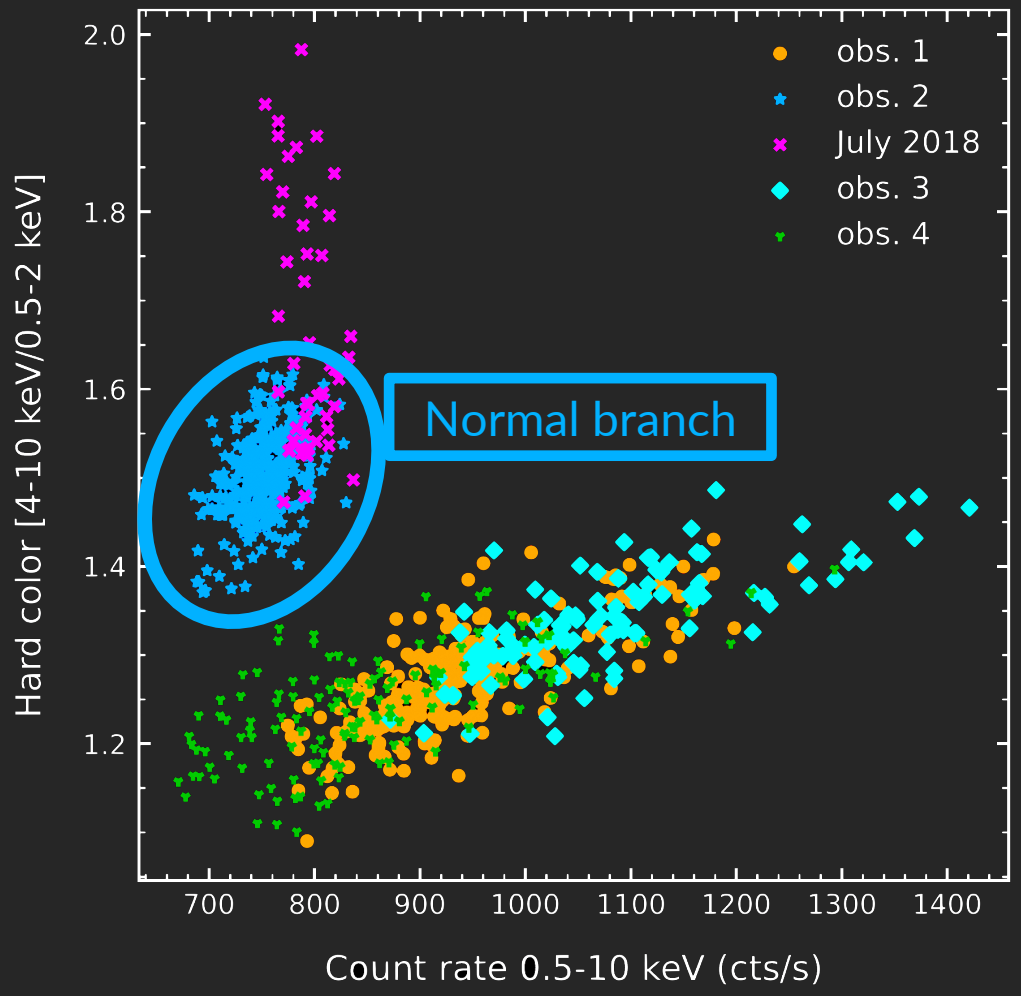
STRONG JET



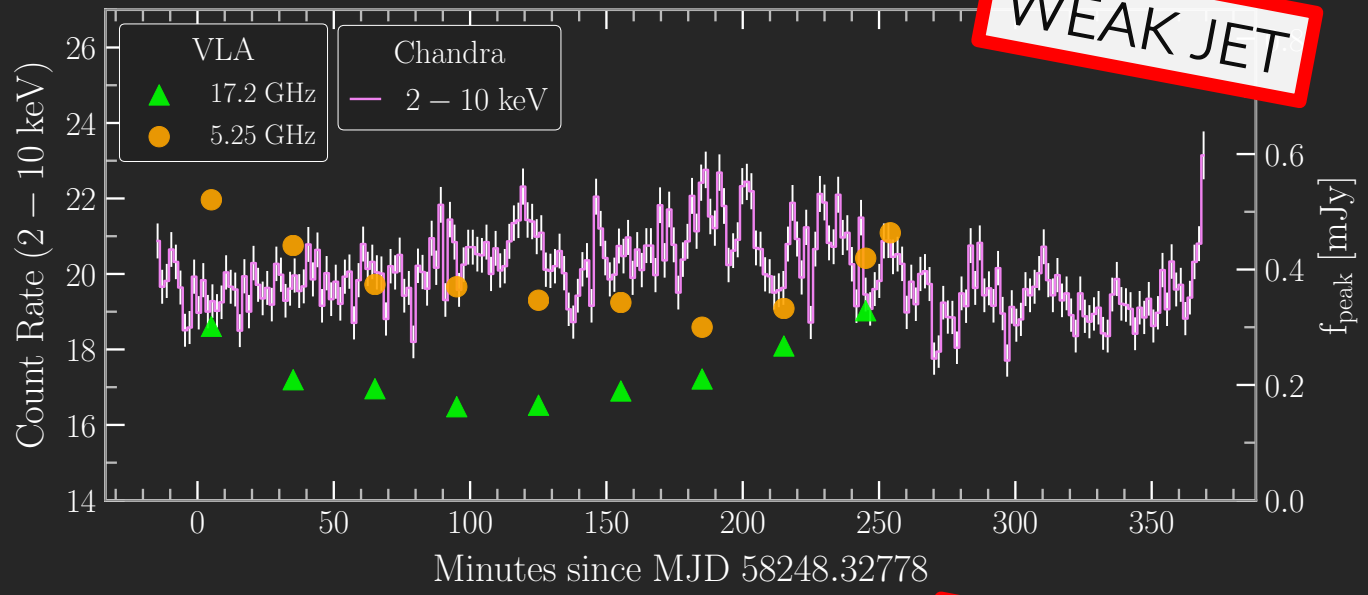
STRONG WIND



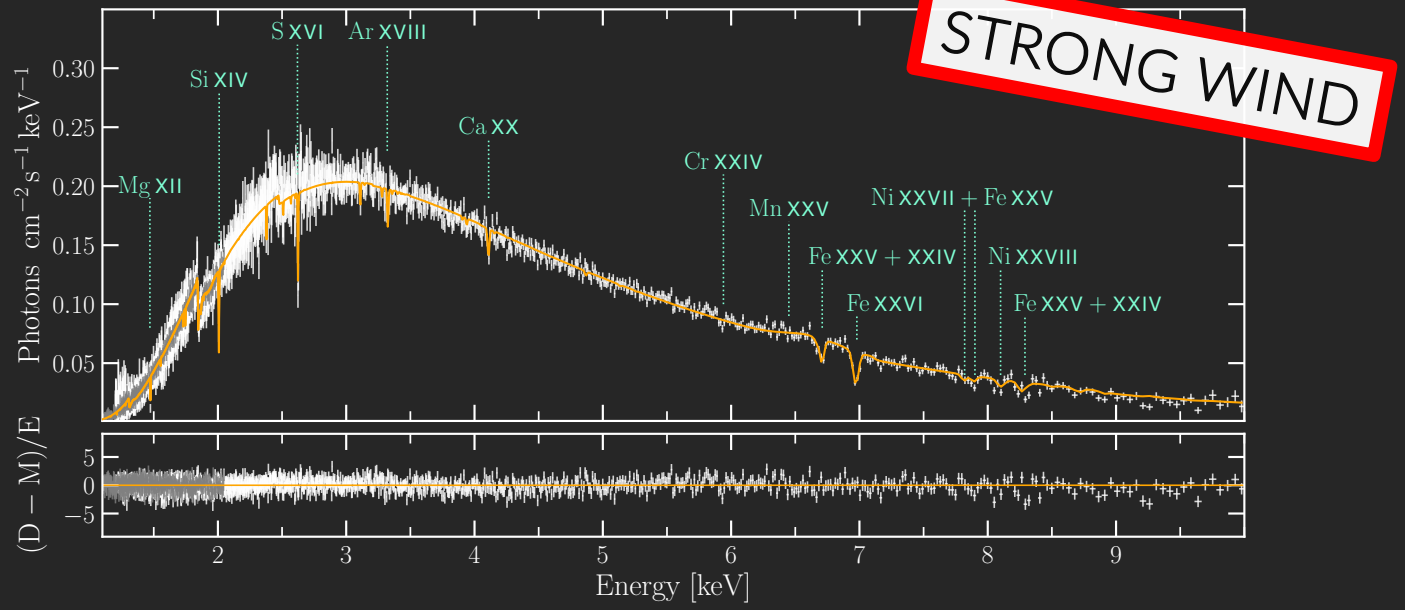
Chandra/VLA/Nicer (Epoch 2)



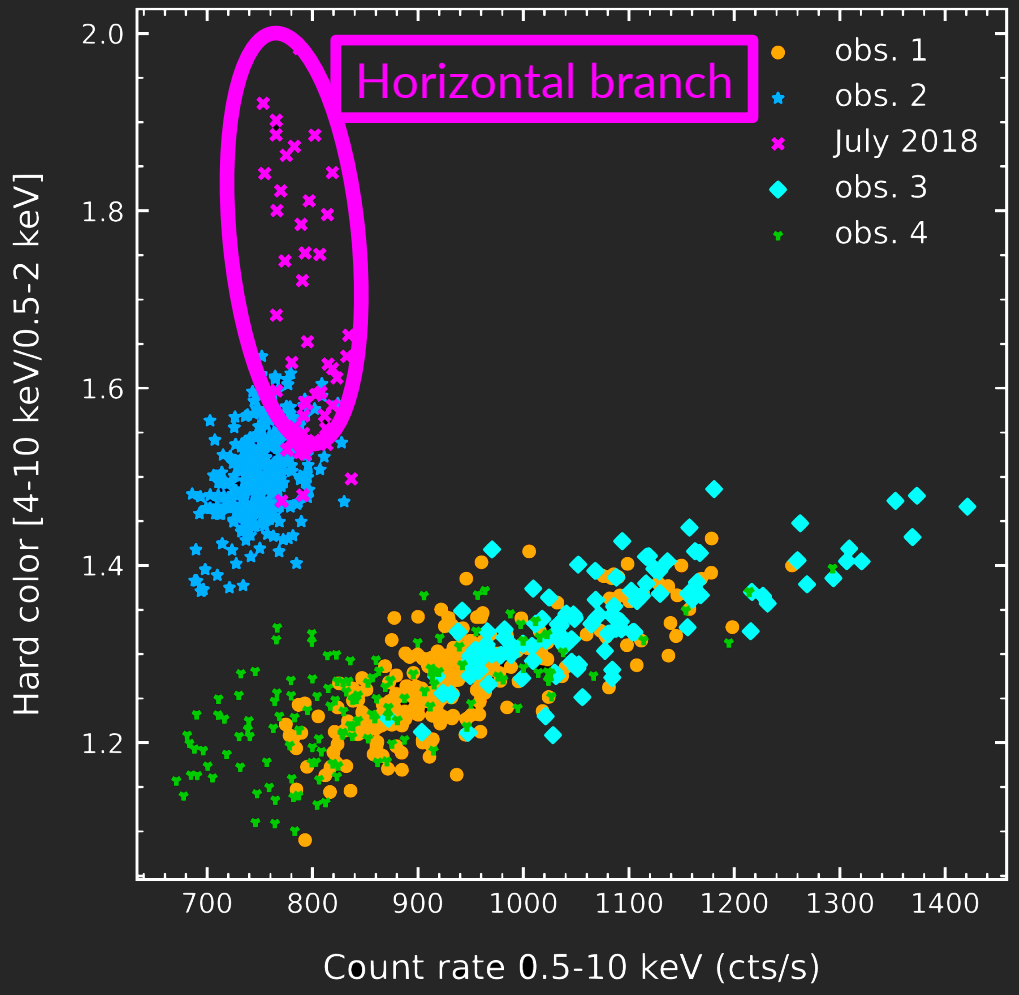
WEAK JET

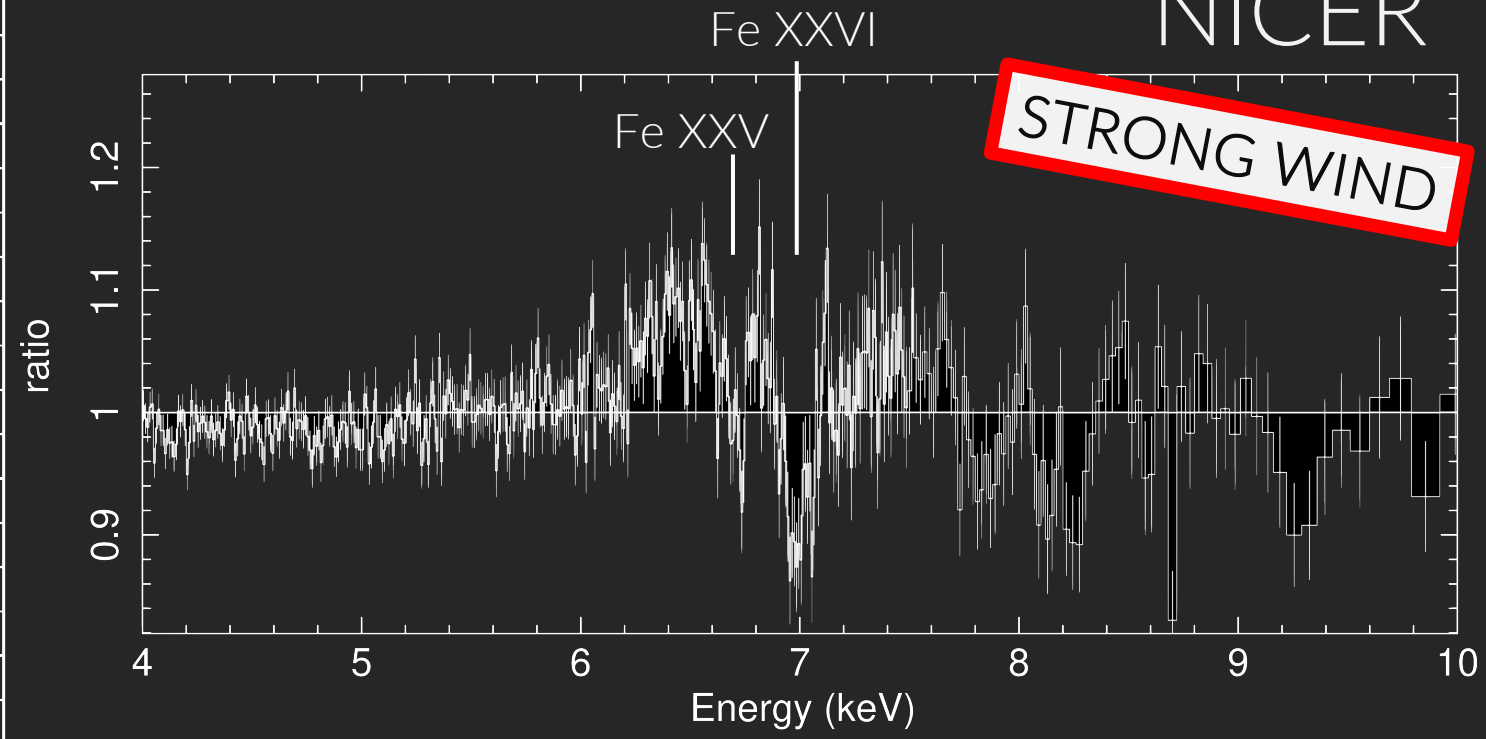


STRONG WIND

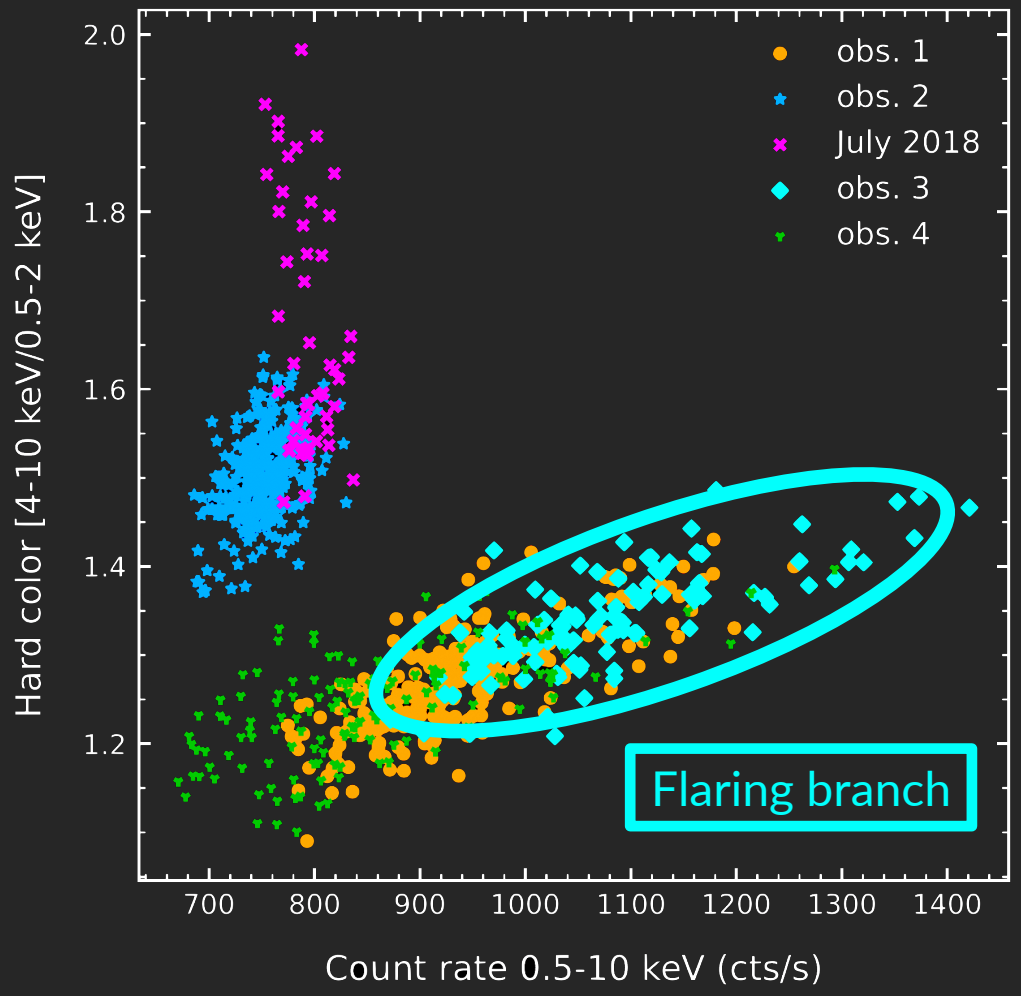


Chandra/VLA/Nicer (Epoch 3)

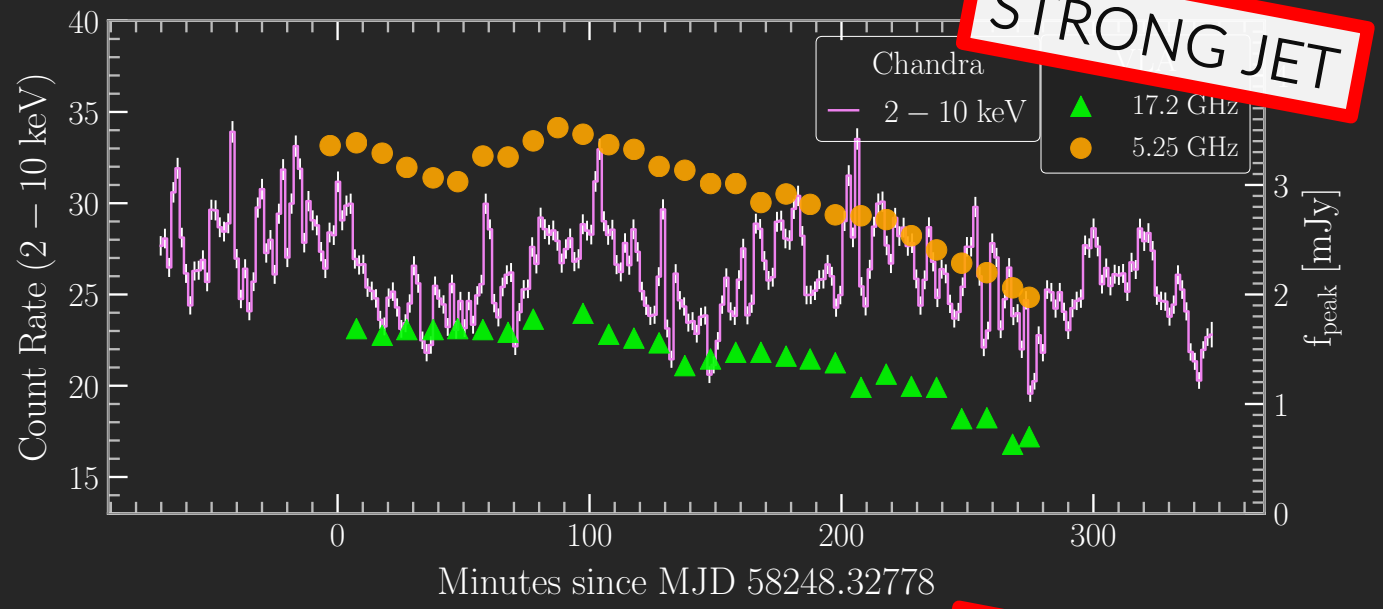




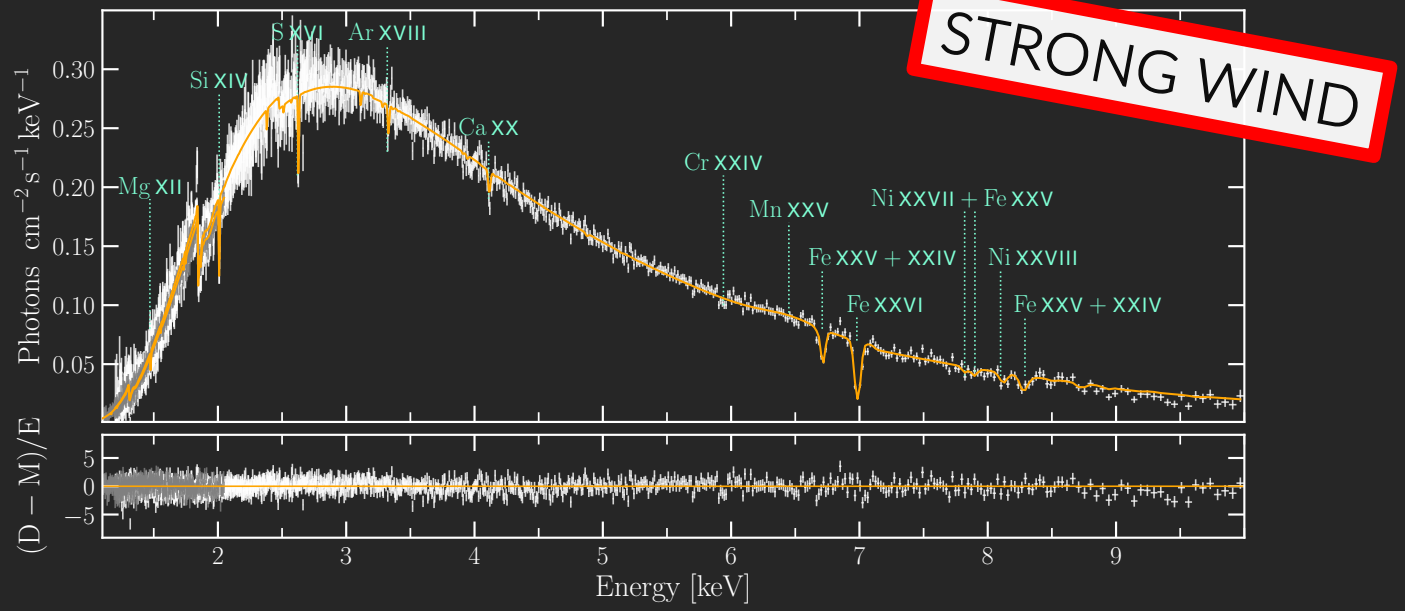
Chandra/VLA/Nicer (Epoch 4)



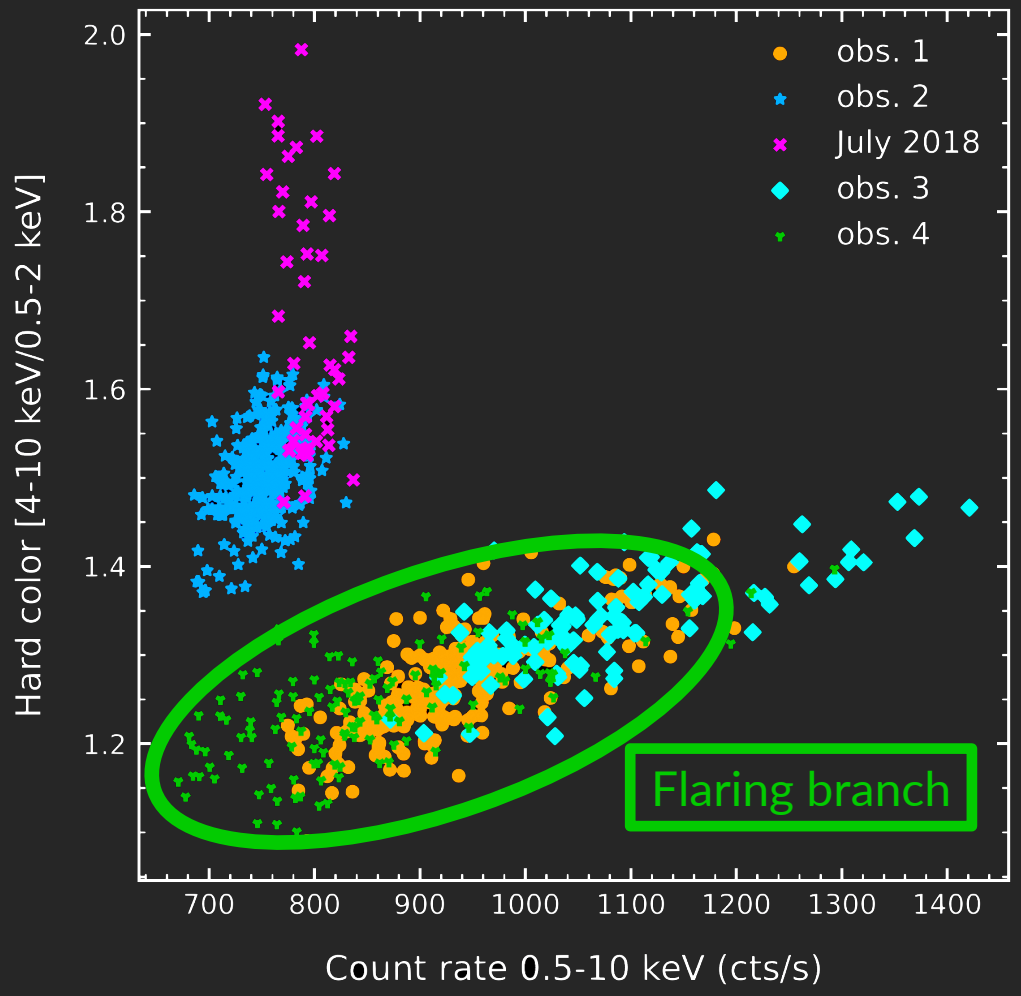
STRONG JET



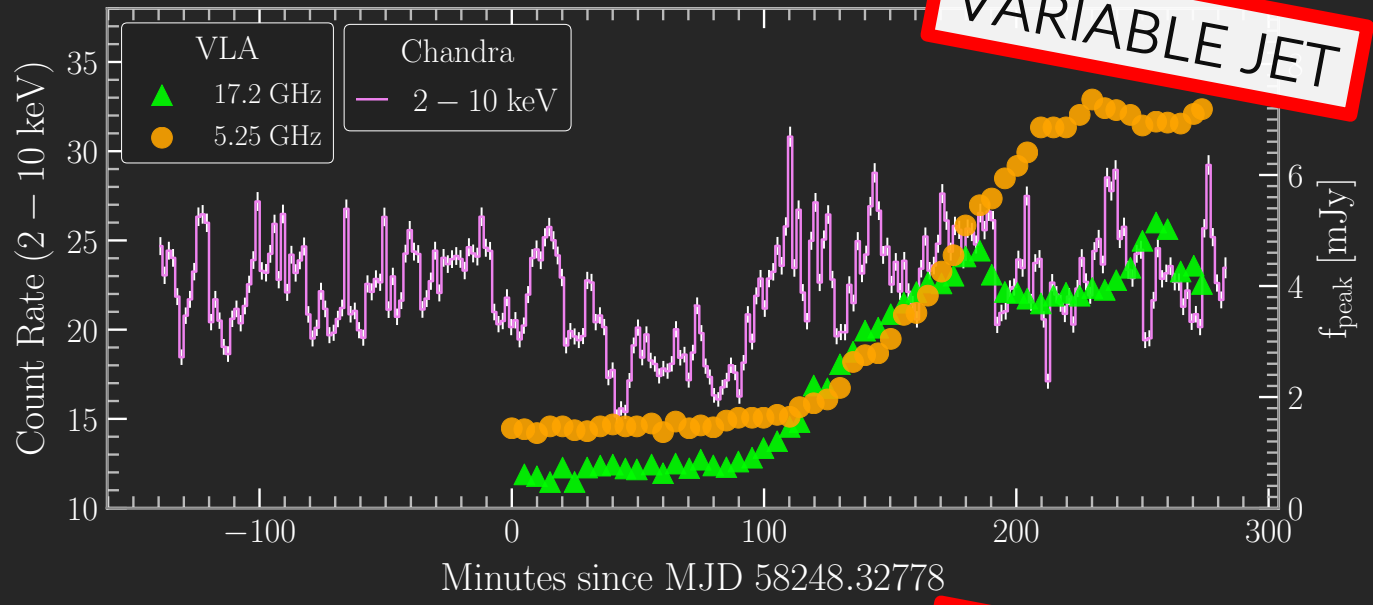
STRONG WIND



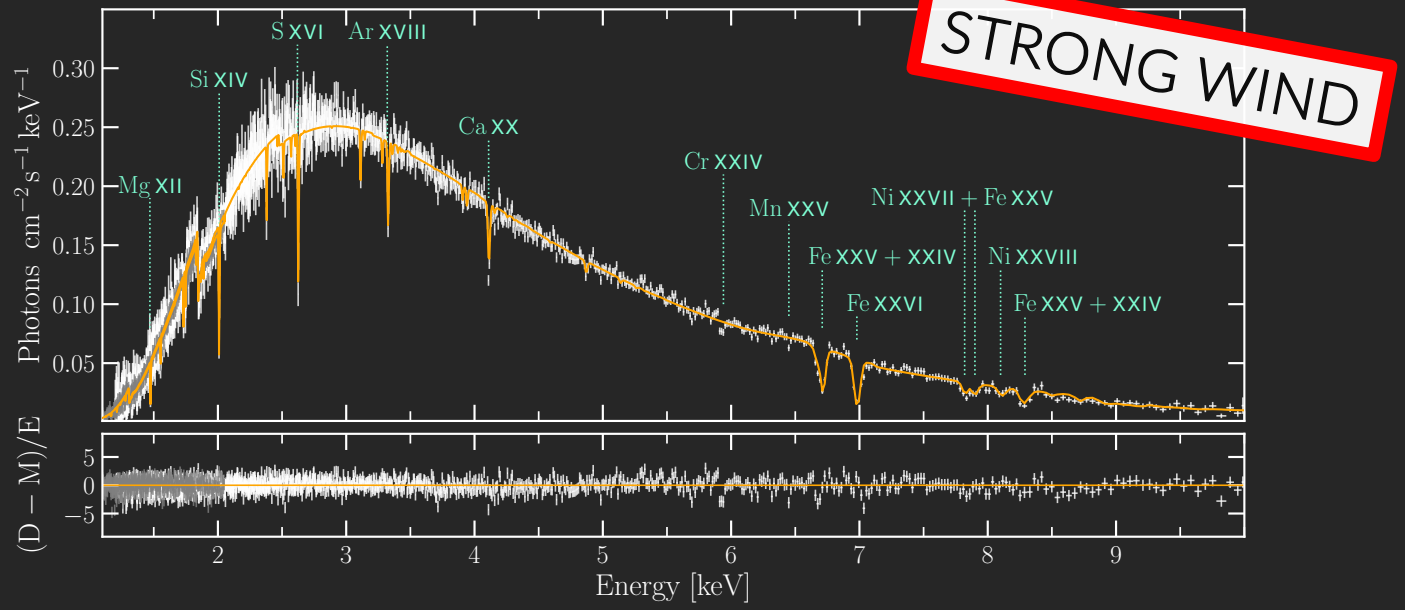
Chandra/VLA/Nicer (Epoch 5)



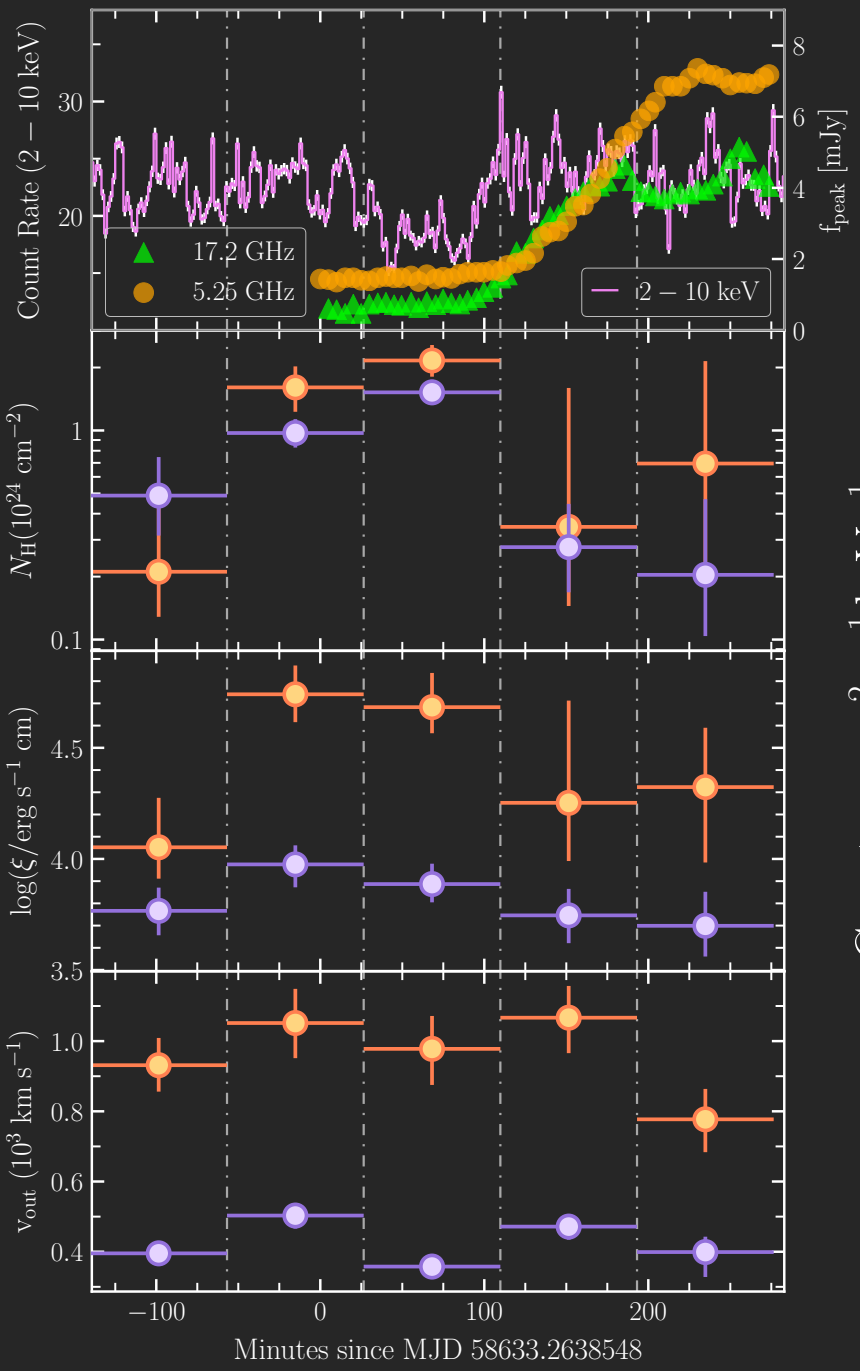
VARIABLE JET

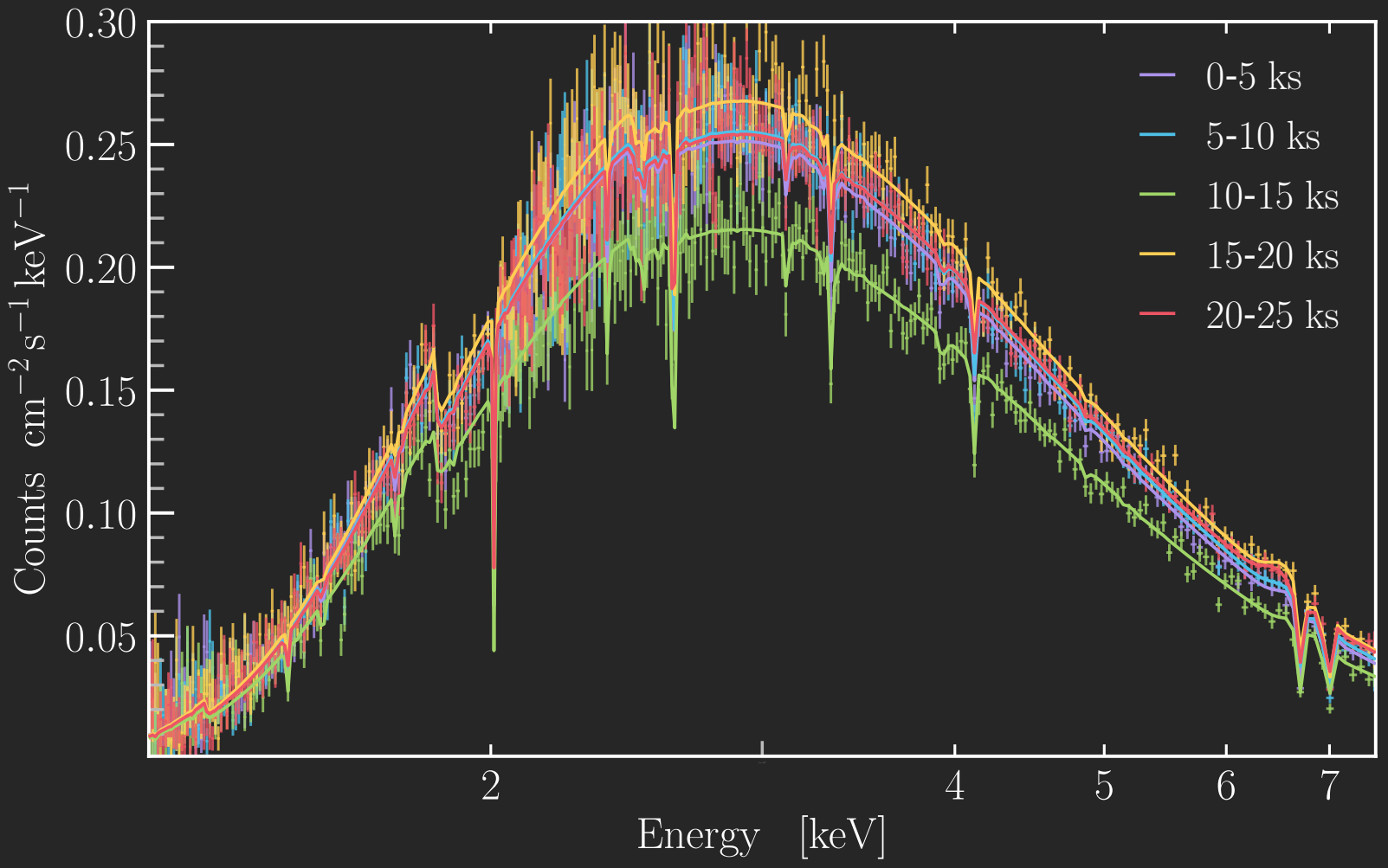


STRONG WIND

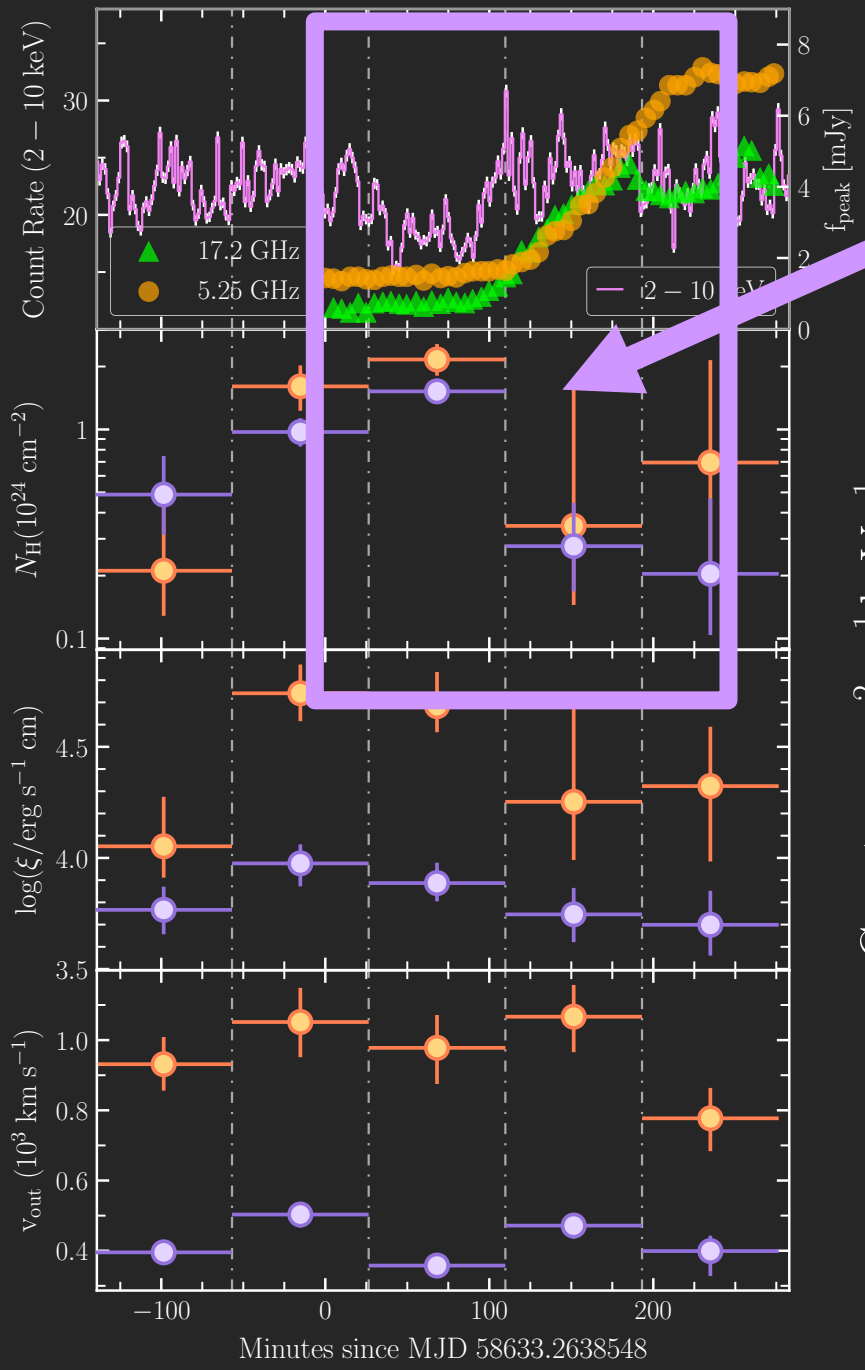


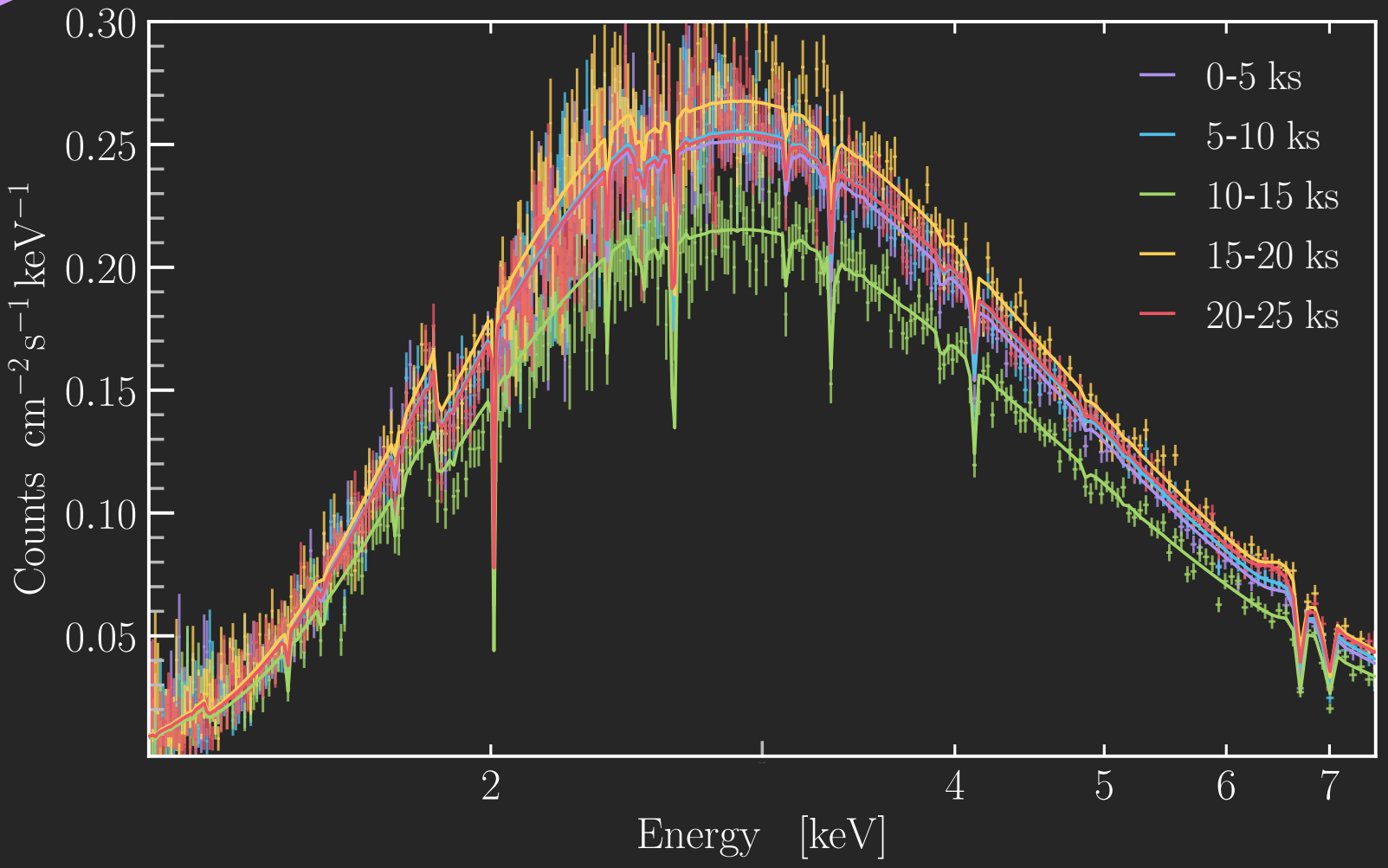
TIME RESOLVED SPECTROSCOPY- EPOCH 5



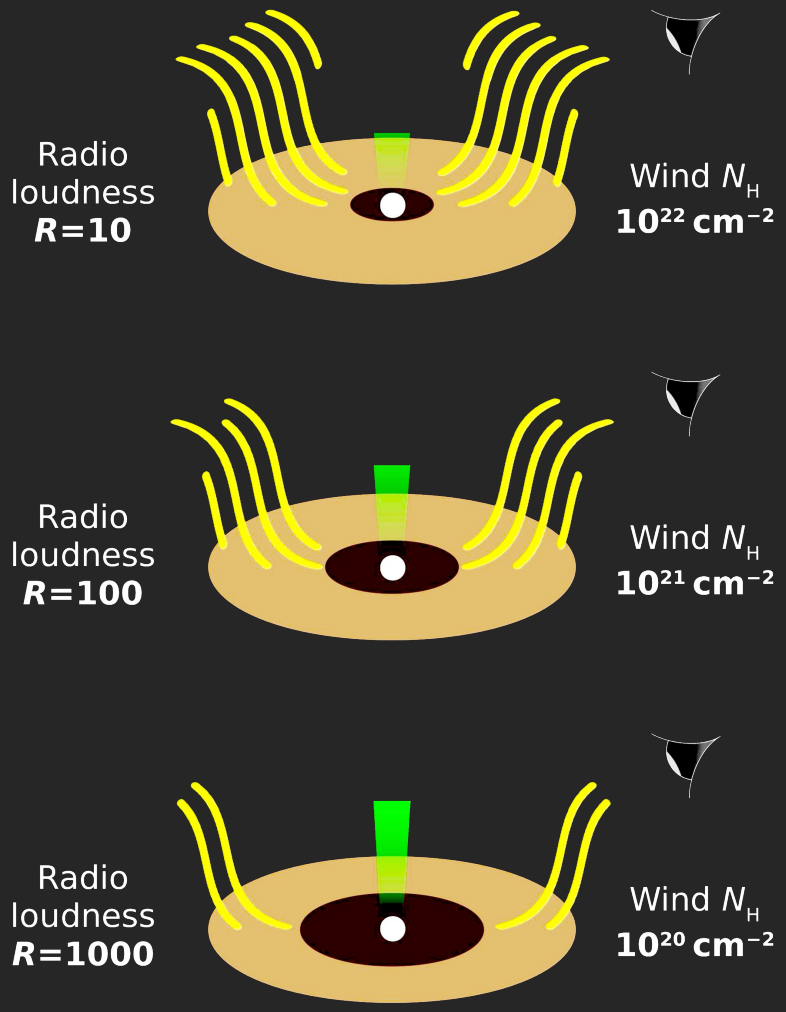


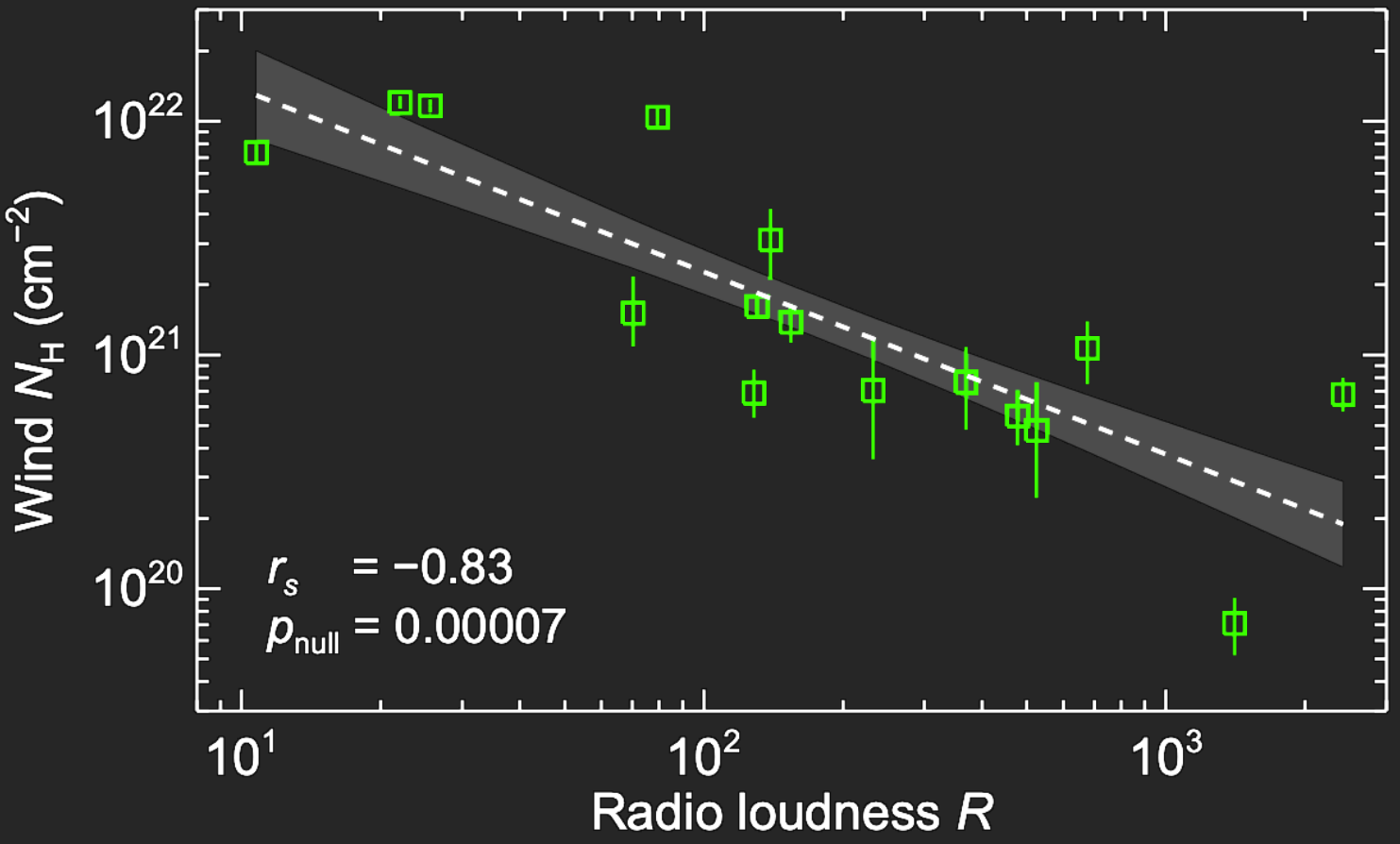
TIME RESOLVED SPECTROSCOPY- EPOCH 5





WIND AND JET IN AGN

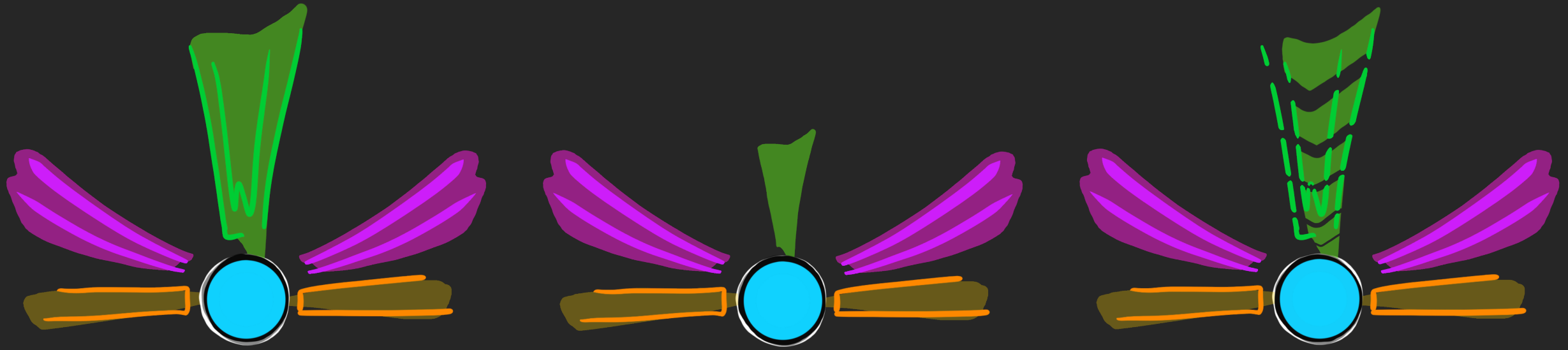




Mehdipour & Costantini (2019)

Also observed in some broad absorption line quasars (e.g. Reynolds+2017)

INTERPLAY OF JET AND WIND IN GX 13+1



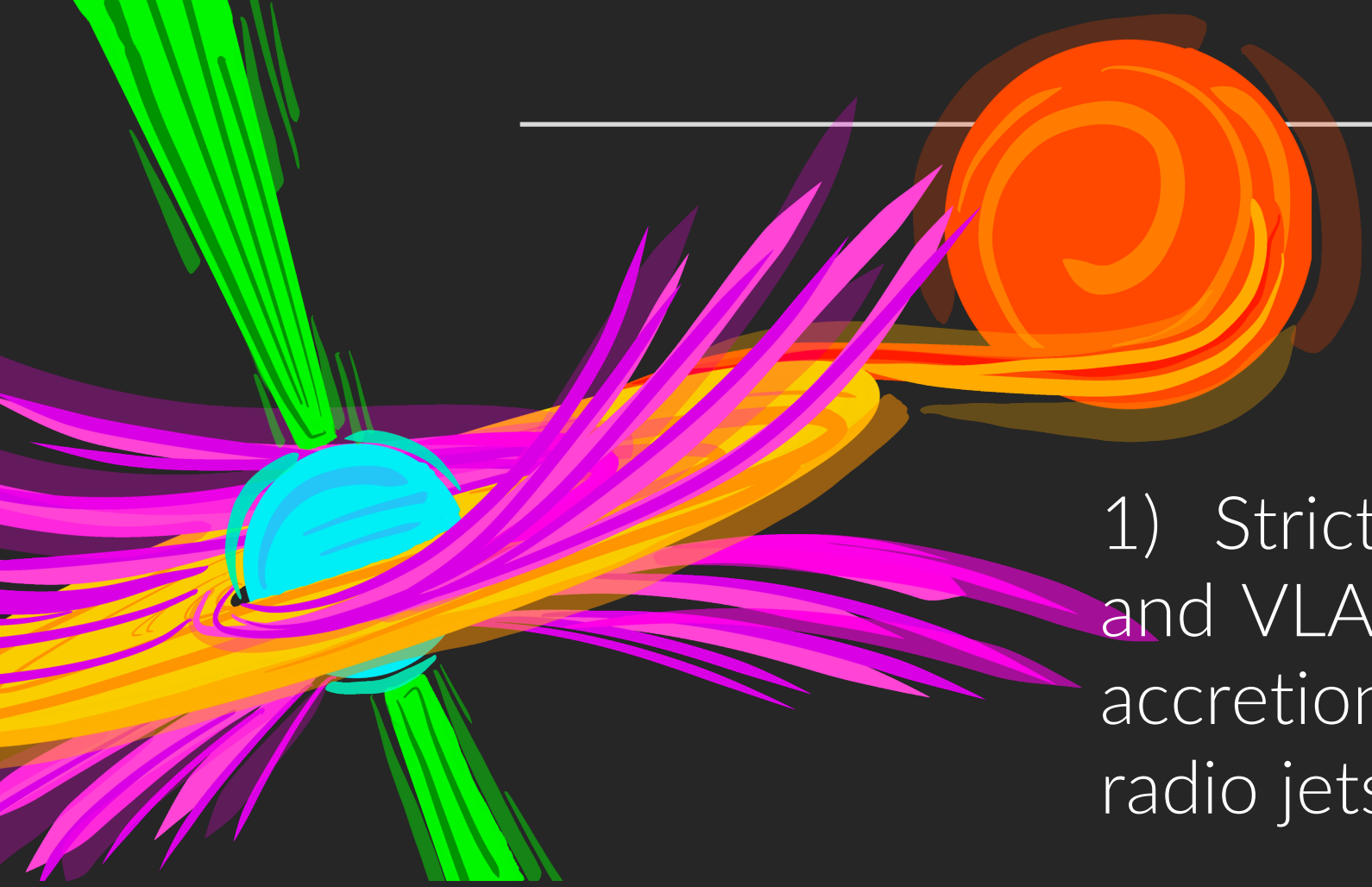
GX 13+1 appears to have a persistent disk wind (two components, with outflow velocity between 400-1200 km/s) and a variable radio jet

Wind and jet outflows do not show a strong correlation

The launching mechanisms of wind and jet are likely not related. They seem to NOT compete for the same mass or energy reservoir.

Rogantini et al. (to be submitted)

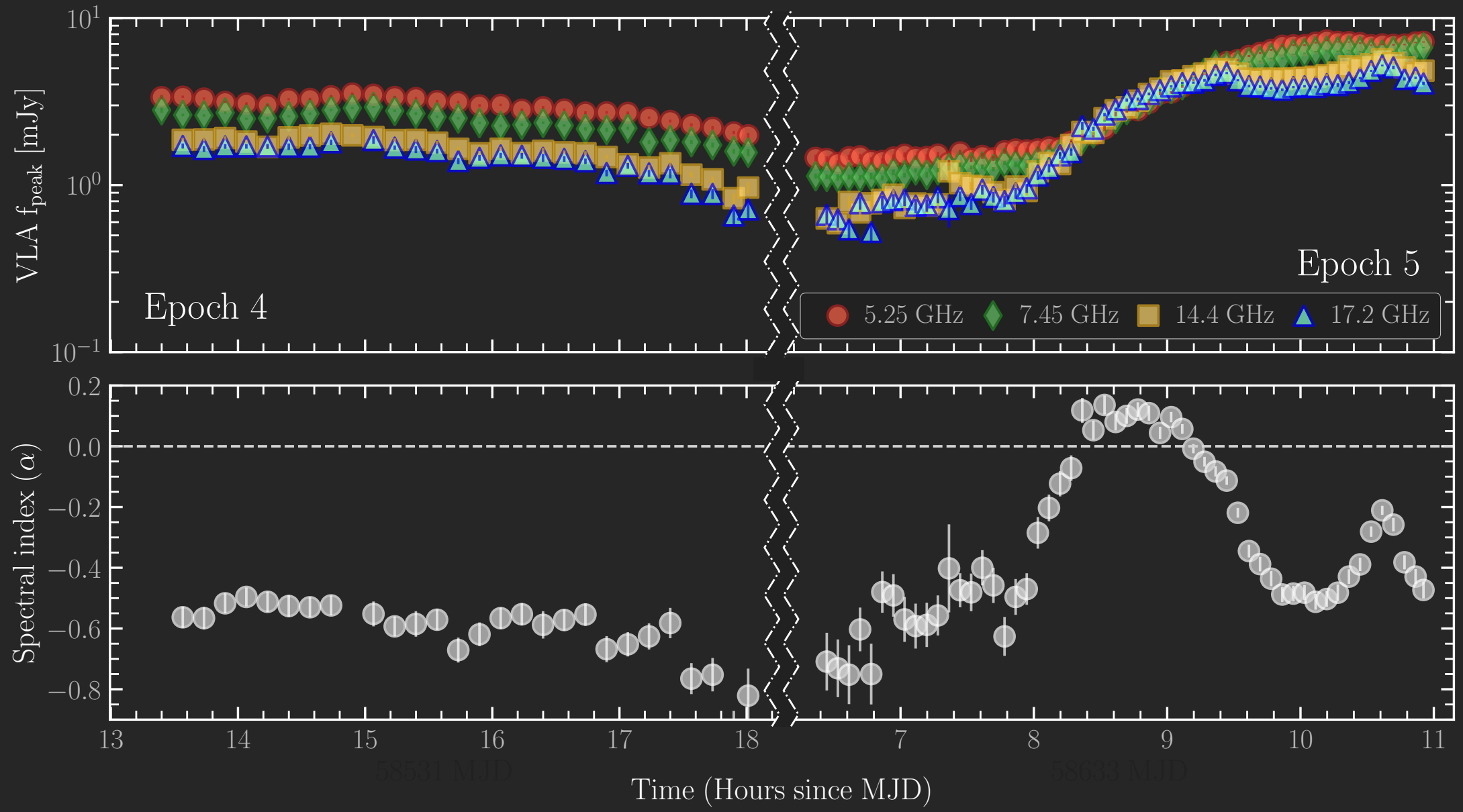
CONCLUSION



1) Strictly simultaneous Chandra and VLA observations reveal that accretion disk X-ray winds and radio jets co-exist in GX 13+1.

2) The contrasting variability between the wind and radio jets suggests that these outflows likely originate from distinct mechanisms and do not share a common launching process

JET VARIABILITY



HIGH-EDDINGTON LMXBs

NS X-ray Binaries

GX 340+00

Presence of disc winds and jets (Migliari & Fender 2006, Miller+2016)

Cir X-1

Winds along the whole Z track (Schulz & Brandt 2002) and variable radio emission (e.g. Soleri et al. 2009)

Sco X-1

Radio core “always” detected (Pandey+2005) and presence infrared outflow Bandyopadhyay+(1999)

BH X-ray Binary

GRS 1915+105

A single observation with both radio emission (high state) and winds (Lee+2002, Neilsen & Lee 2009)

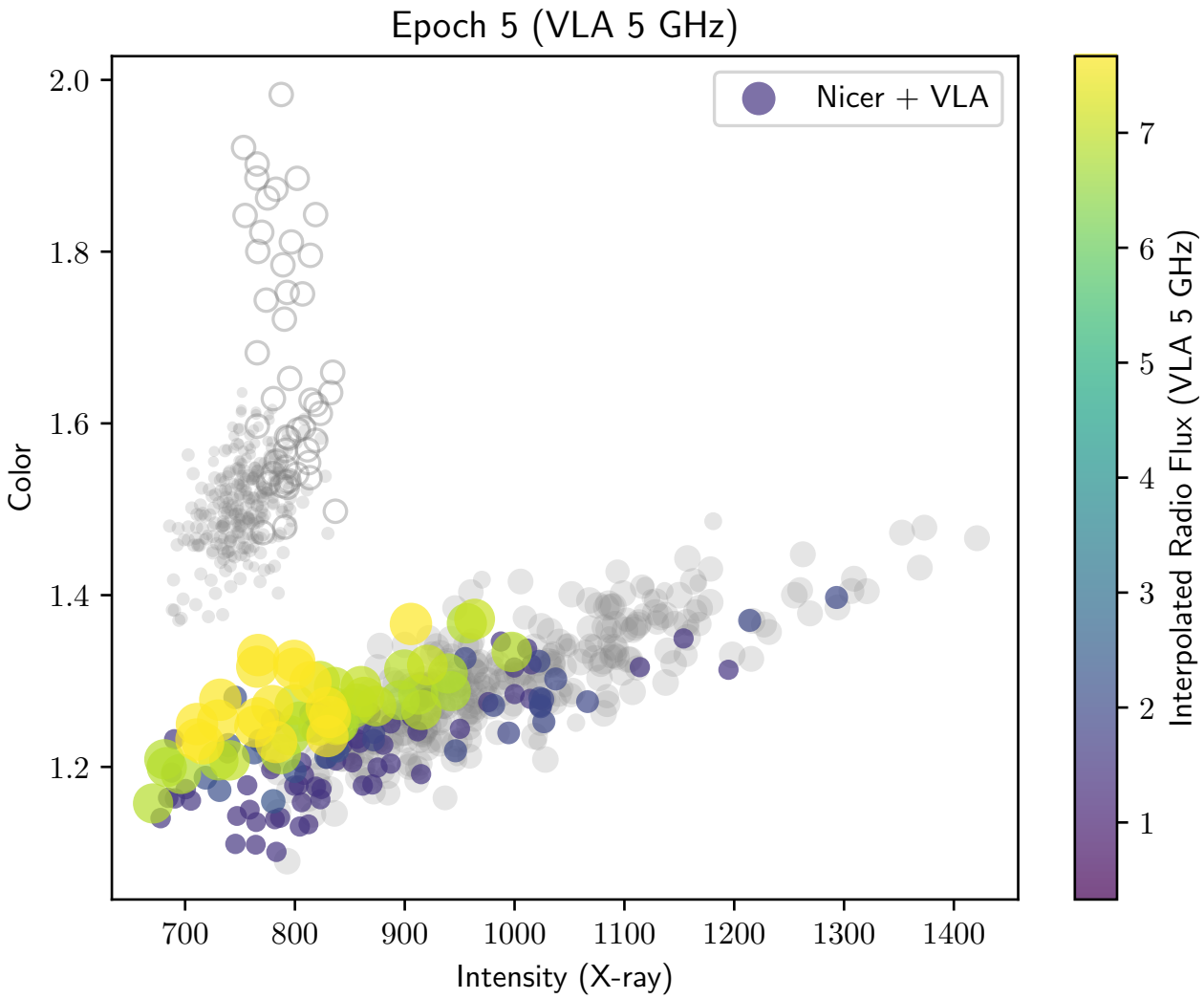
V404 Cyg

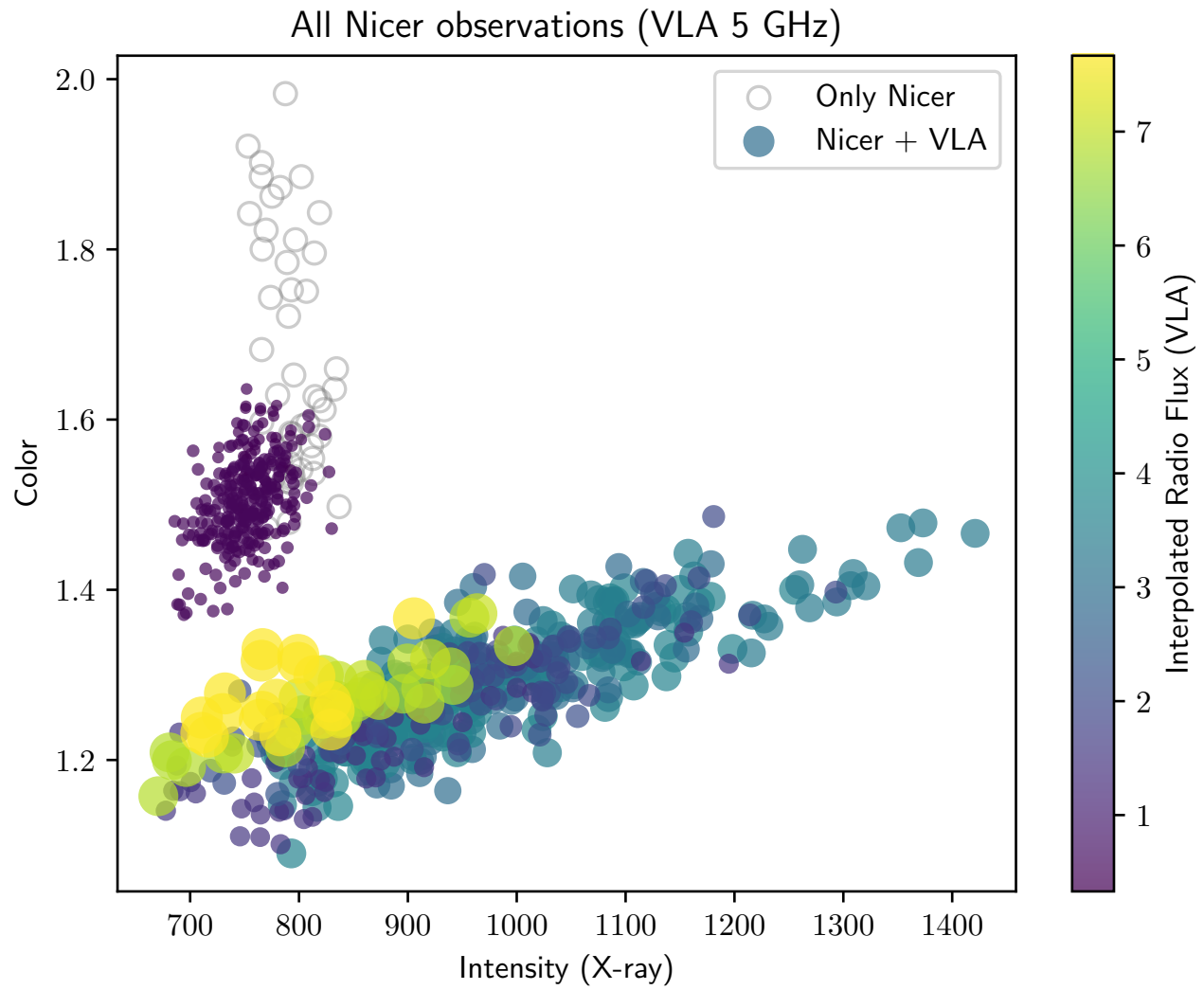
Detection of simultaneous optical/X-ray wind (King+2015, Munos-Darias+2016) and radio emission from a jet during the outburst of 2015

4U 1630-47

Detection of X-ray winds and radio emission during a soft-state (Neilsen+2014). Radio emission probably from jet-ISM interaction.

HID vs VLA 5 GHz





HID vs VLA 17 GHz