



20 years of disk winds in 4U 1630-47

M. Parra, S. Bianchi, P.-O. Petrucci, T. Bouchet, M. Shidatsu, F. Capitanio, M. Dovciak,
T. Russell, F. Carotenuto

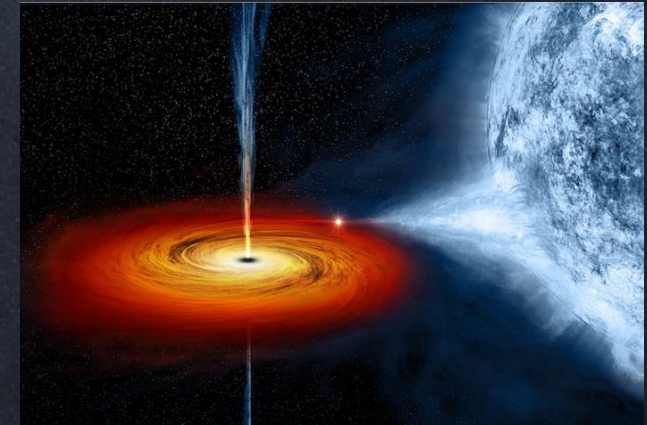
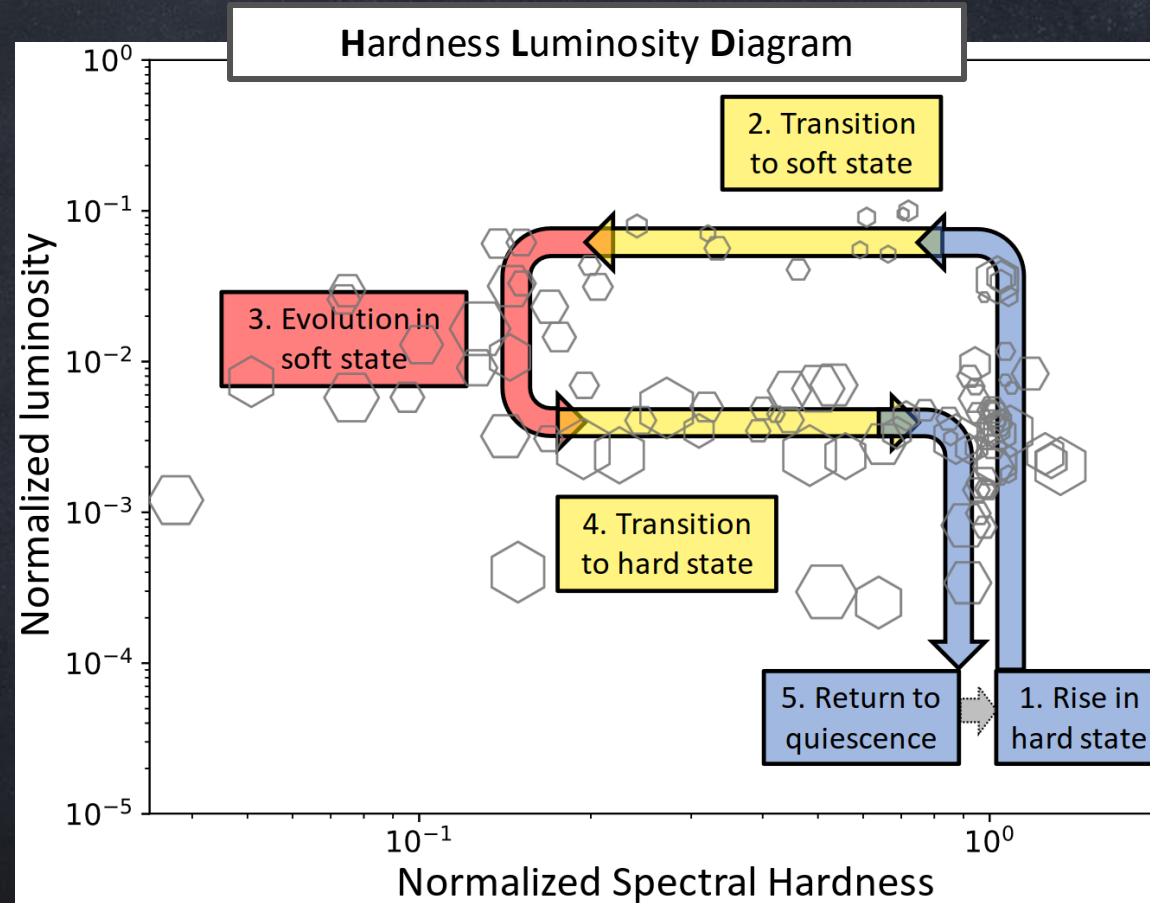
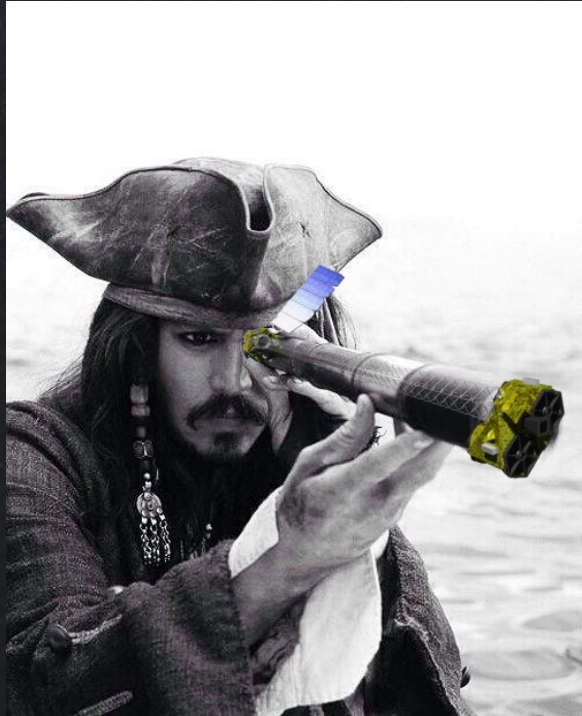
Paper 1...should have been submitted already

12-12-2024

20 years of winds in 4U 1630-47

- The context

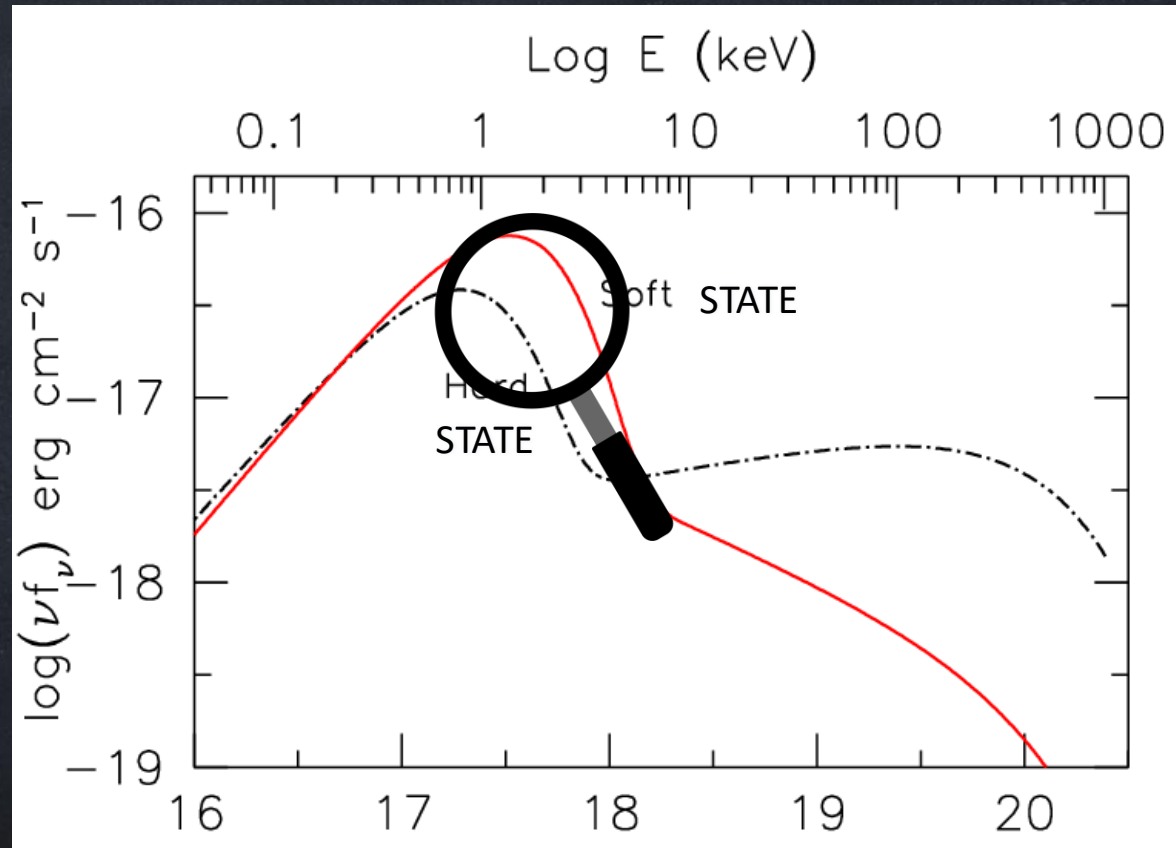
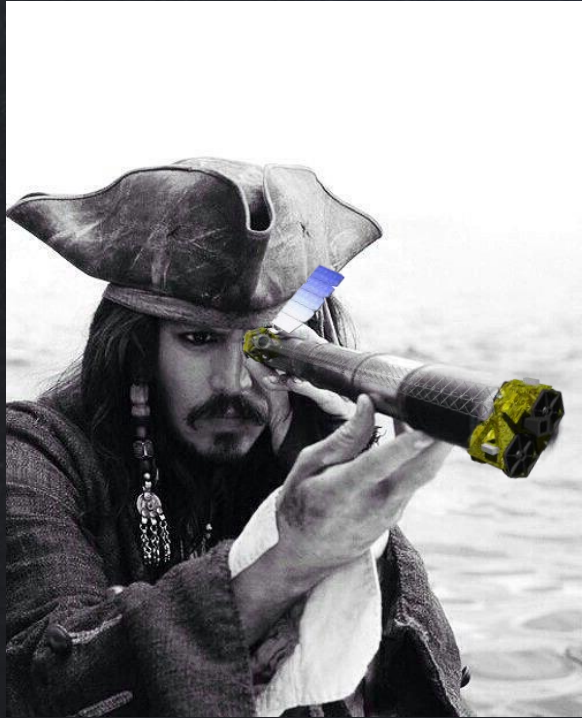
□ What do we see **during an outburst** ?



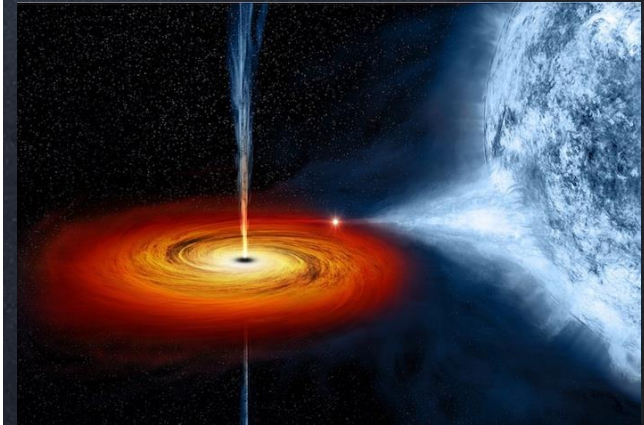
20 years of winds in 4U 1630-47

- The context

□ What do we see **during an outburst** ?



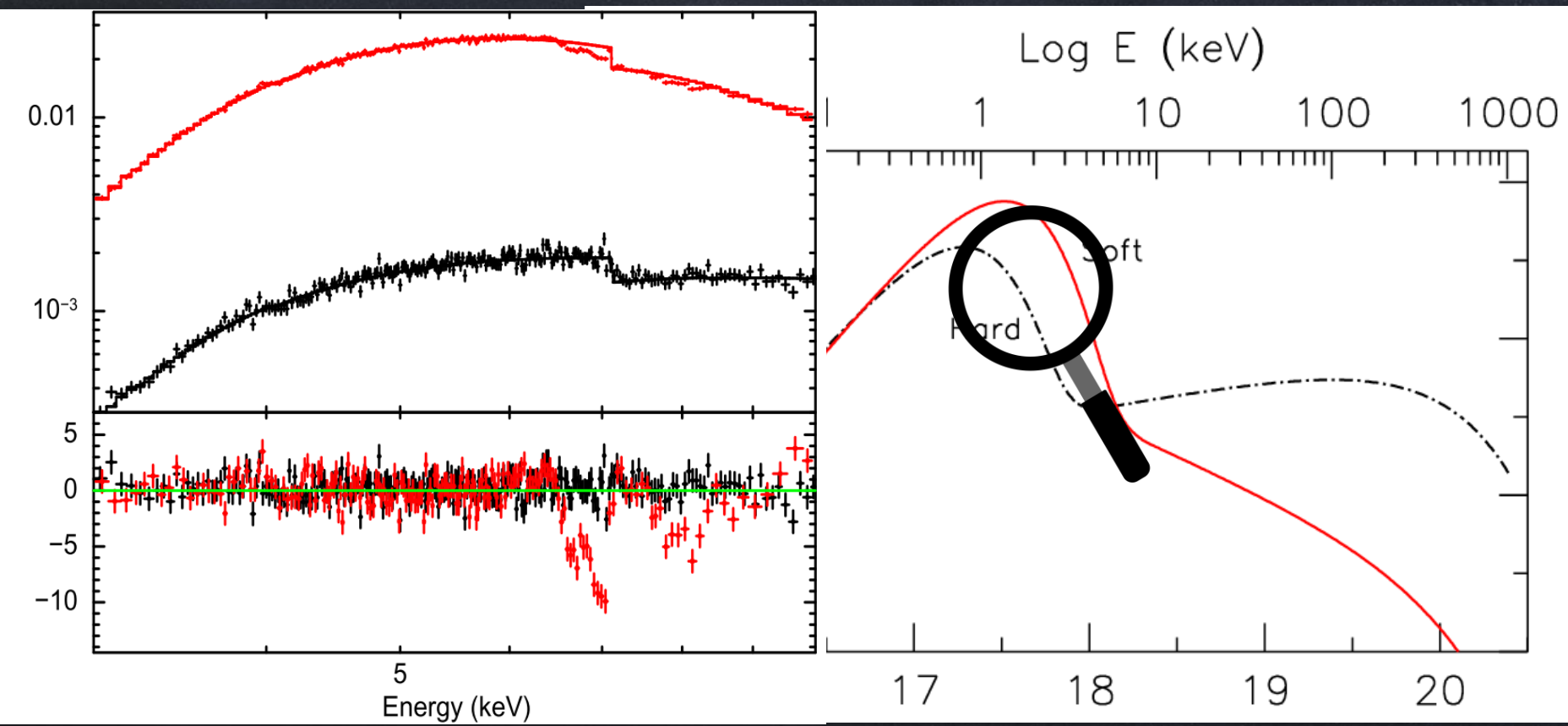
Chakravorty 2016



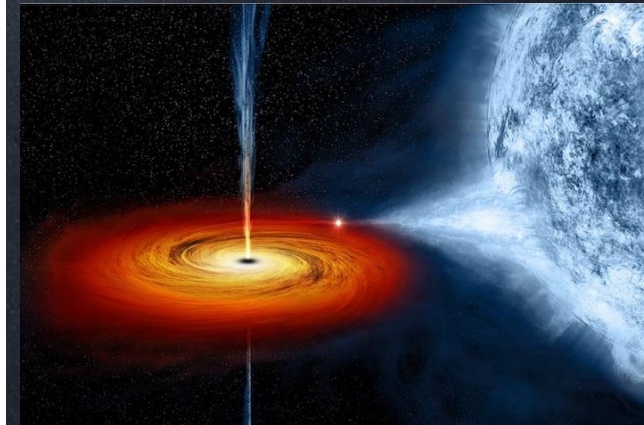
20 years of winds in 4U 1630-47

- The context

□ What do we see **during an outburst** ?

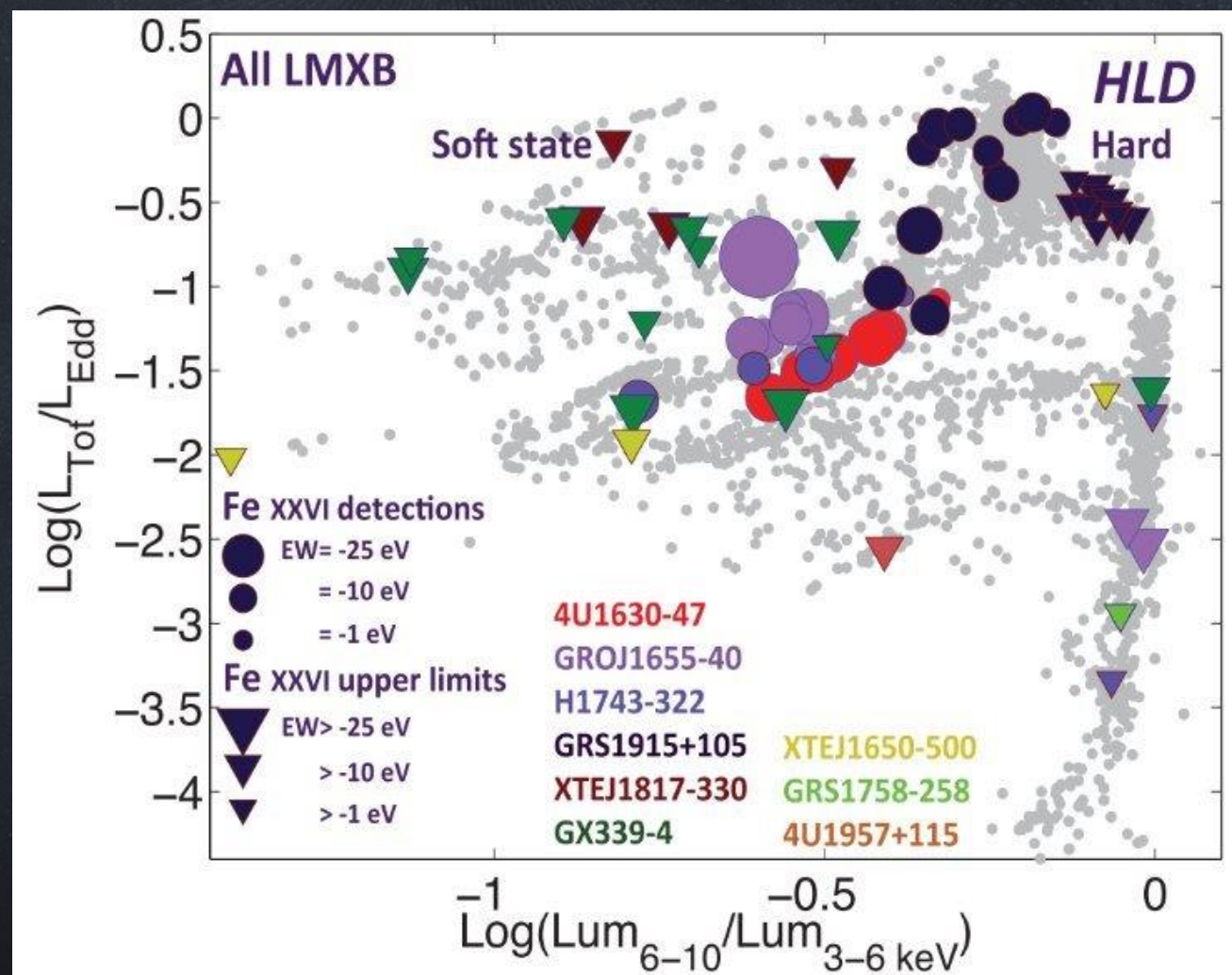


Ponti et al. 2015



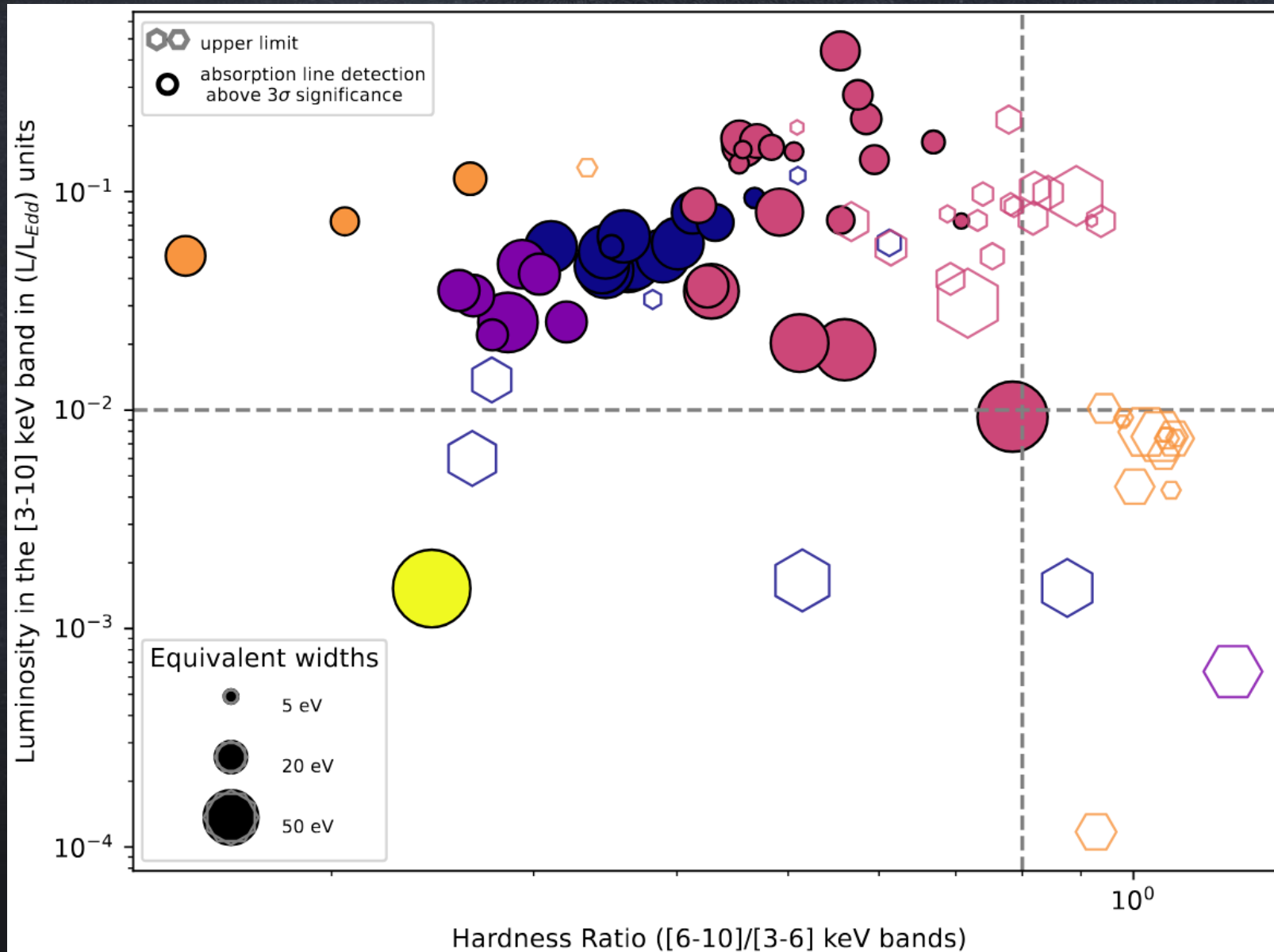
20 years of winds in 4U 1630-47

- The issue of sampling



20 years of winds in 4U 1630-47

- The issue of sampling



20 years of winds in 4U 1630-47

- The source

- BHLMXB, high-inclination (winds, dips) but no eclipses

- Considered one of the "archetypal" wind-emitting BHXRBS

20 years of winds in 4U 1630-47

- The source

□ BHLMXB, high-inclination (winds, dips) but no eclipses

□ Considered one of the "archetypal" wind-emitting BHXRBS

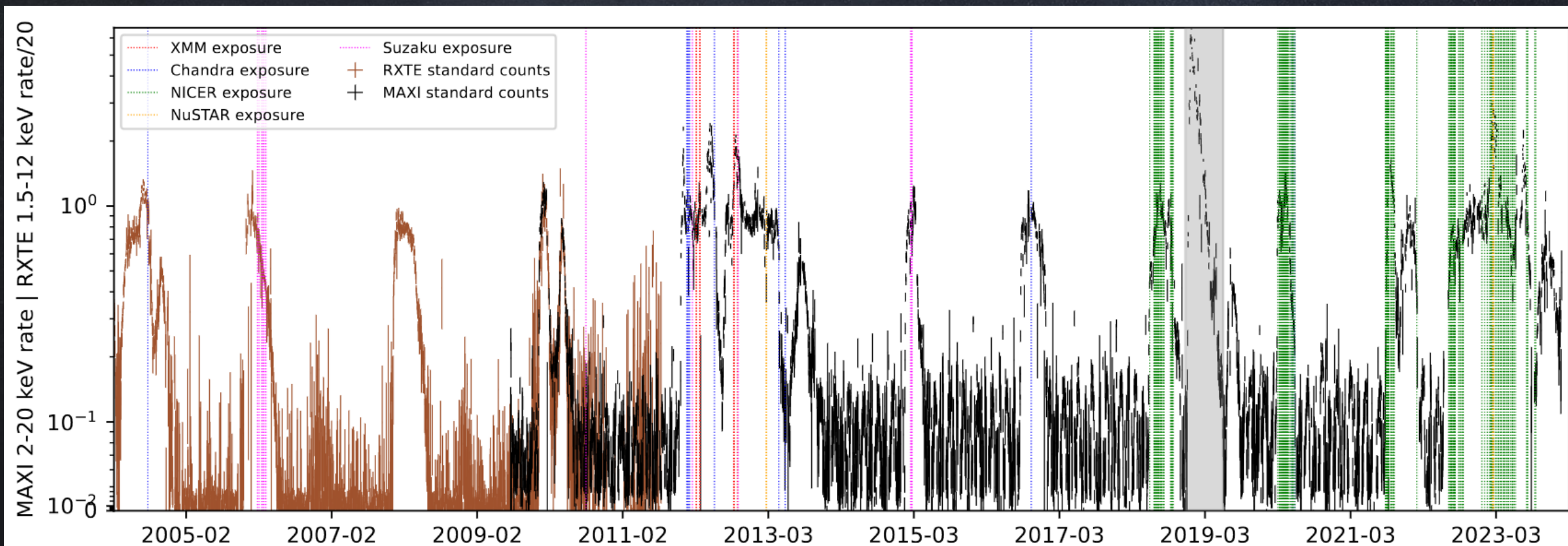
BUT

Really not your average BHXRBS source:

- 2+ types of outburst (normal $\sim 1/y$, "super" $\sim 1/10y$)
- rarely ever in pure hard states
- does soft-only and hard/SPL-only outbursts
- can stay soft down to $<10^{-4}$ L_{Edd}
- can either start outbursts in soft or go from quiescence to low-soft in $<$ few weeks
- ...

20 years of winds in 4U 1630-47

- The source
- 2+ types of outburst (normal, "super") with $\sim 1/y$ and $\sim 1/10y$ recurrence



20 years of winds in 4U 1630-47

■ The data

What has been analyzed ?

Outburst period	Outburst type	Daily Epochs				
		Chandra	NICER	NuSTAR	Suzaku	XMM
2002-2004	super (triple)	1	0	0	0	0
2006	standard	0	0	0	6	0
2010	standard (double)	0	0	0	1	0
2012-2013	super (triple)	7	0	2	2	8
2015	standard	0	0	2*	3	0
2016-2017	standard	1	0	0	0	0
2018	standard	0	33	0	0	0
2020	standard	3	39	0	0	0
2021-2022	standard (double)	0	29	0	0	0
2022-2024 †	super (double)	0	~100	7*	0	0
Total		12	172	11	11	8

Diaz Trigo et al. 2013

Hori et al. 2018

King et al. 2012

Trueba et al. 2019

Gatuzz et al. 2019

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- The data

Why not look at everything at once

and look at the high-energies

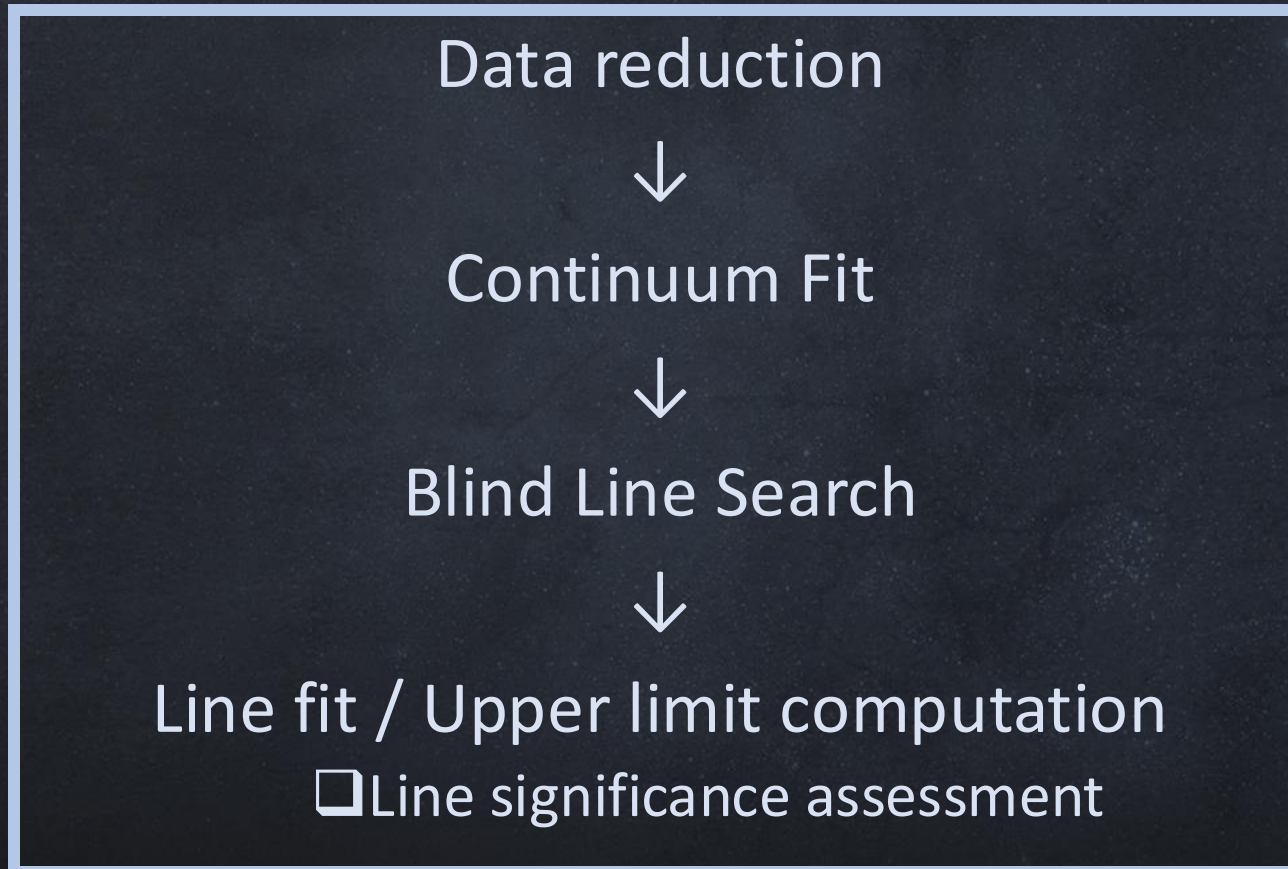
Outburst period	Outburst type	Daily Epochs					High-E additional coverage	
		Chandra	NICER	NuSTAR	Suzaku	XMM	Swift-BAT	INTEGRAL
2002-2004	super (triple)	1	0	0	0	0	0	1
2006	standard	0	0	0	6	0	/	/
2010	standard (double)	0	0	0	1	0	/	/
2012-2013	super (triple)	7	0	2	2	8	15	/
2015	standard	0	0	2*	3	0	1	/
2016-2017	standard	1	0	0	0	0	1	/
2018	standard	0	33	0	0	0	32	0
2020	standard	3	39	0	0	0	42	/
2021-2022	standard (double)	0	29	0	0	0	29	/
2022-2024 †	super (double)	0	~100	7*	0	0	61	1
Total		12	172	11	11	8	180	2

LET'S DO IT THEN!

20 years of winds in 4U 1630-47

- The pipeline

□ Procedure

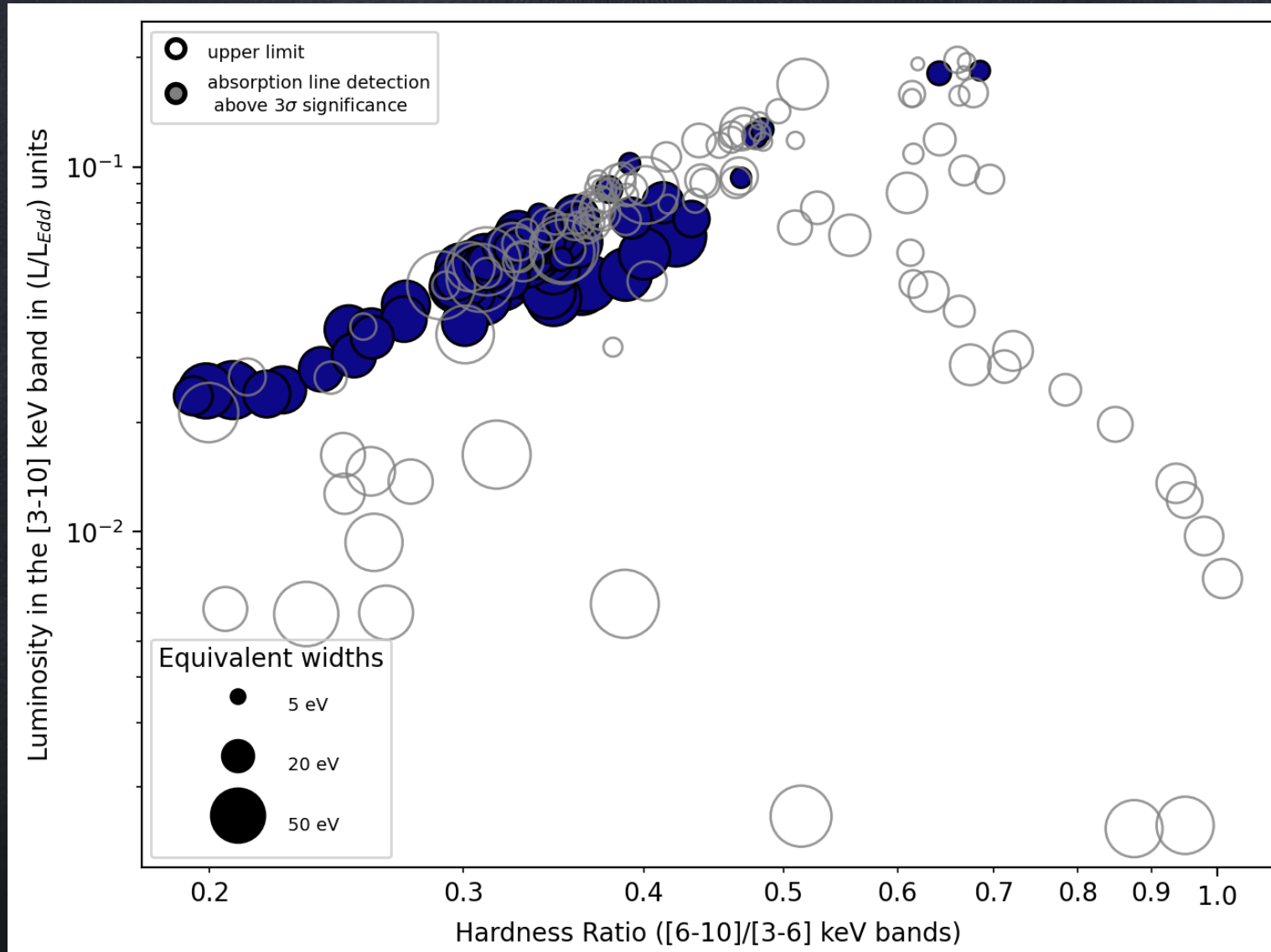


Everything (and more)
accessible online
with an interactive website:
[https://visual-
line.streamlit.app/](https://visual-line.streamlit.app/)

fully automatized

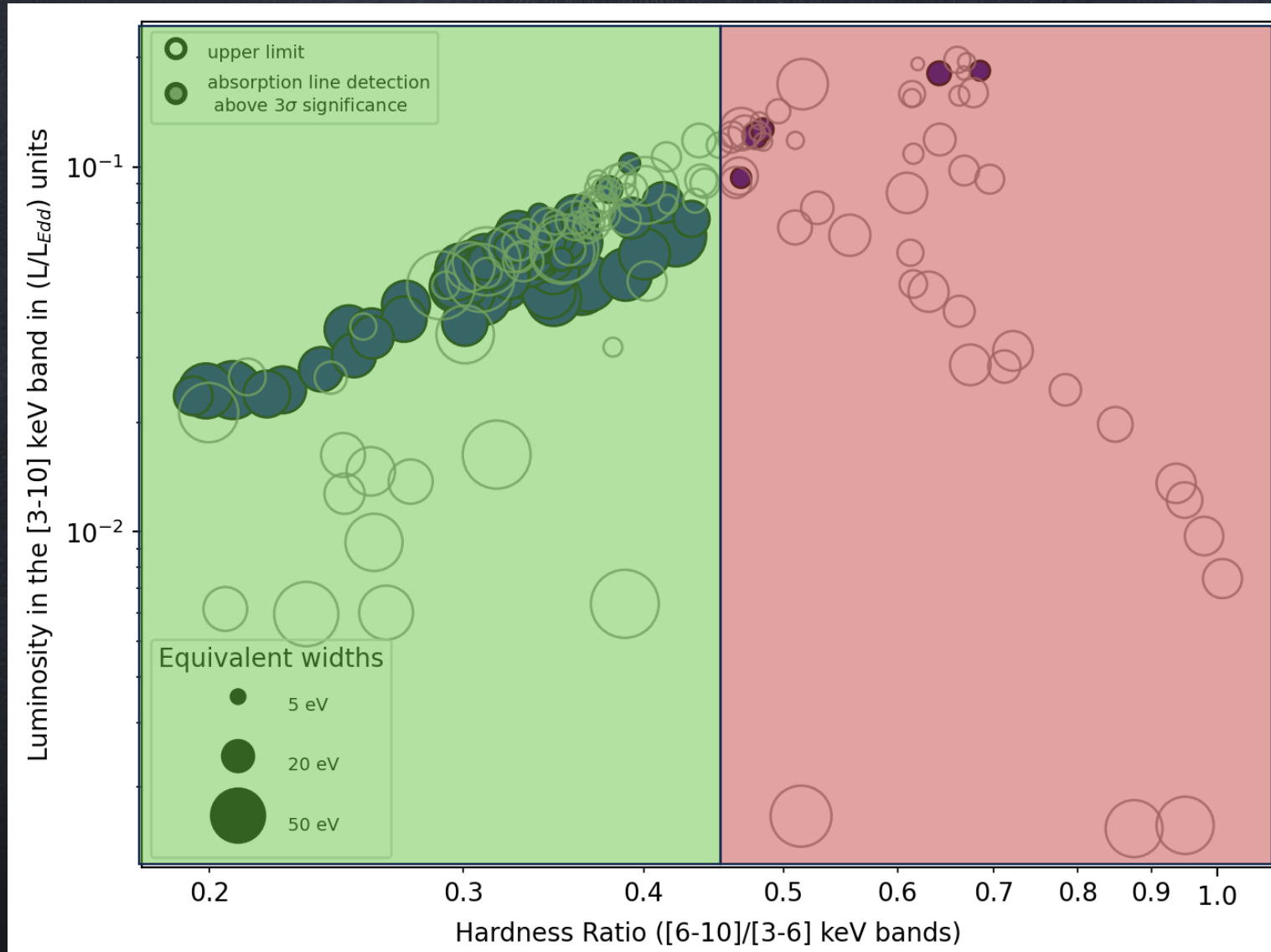
20 years of winds in 4U 1630-47

■ Hardness Luminosity Diagrams



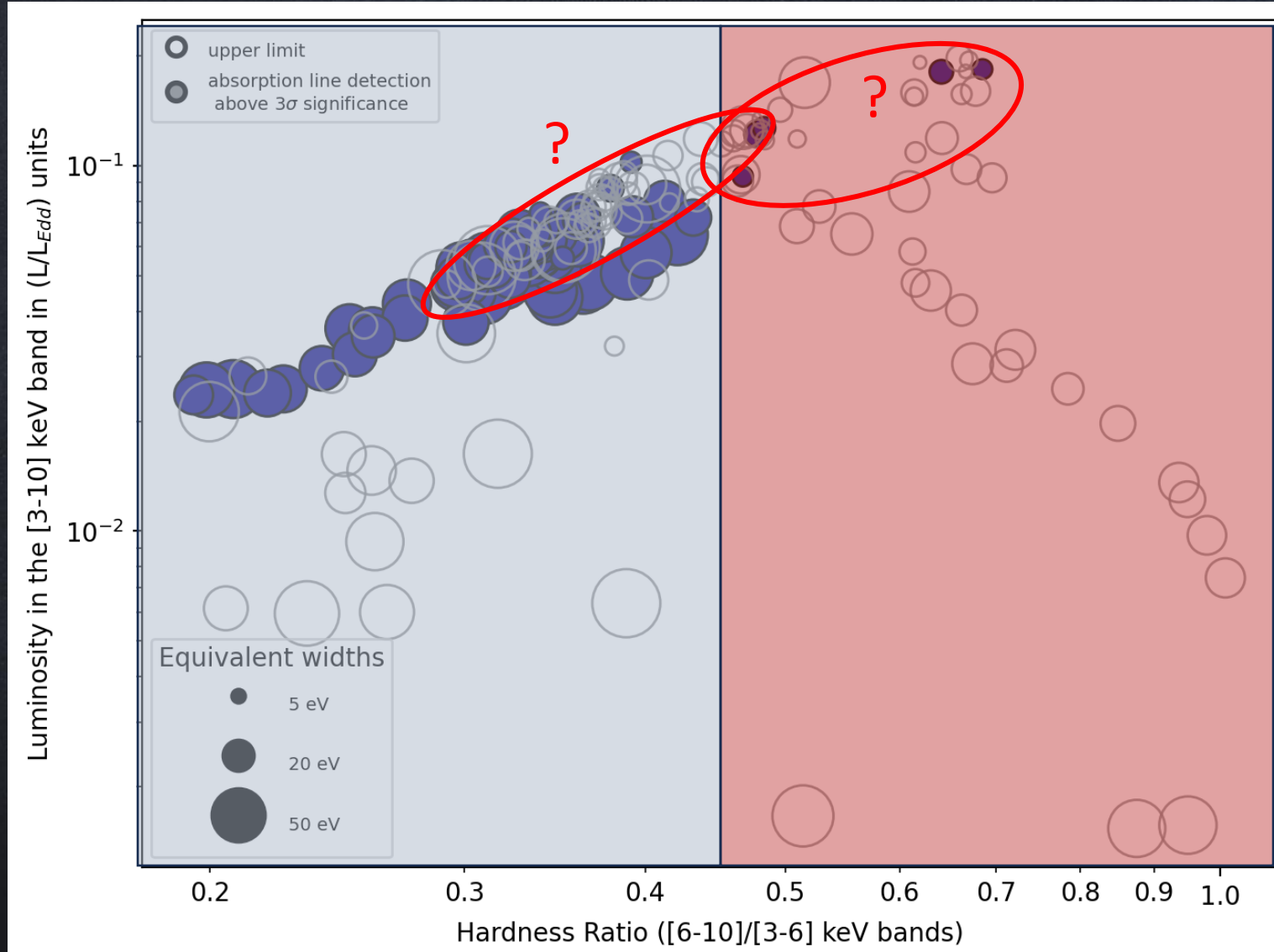
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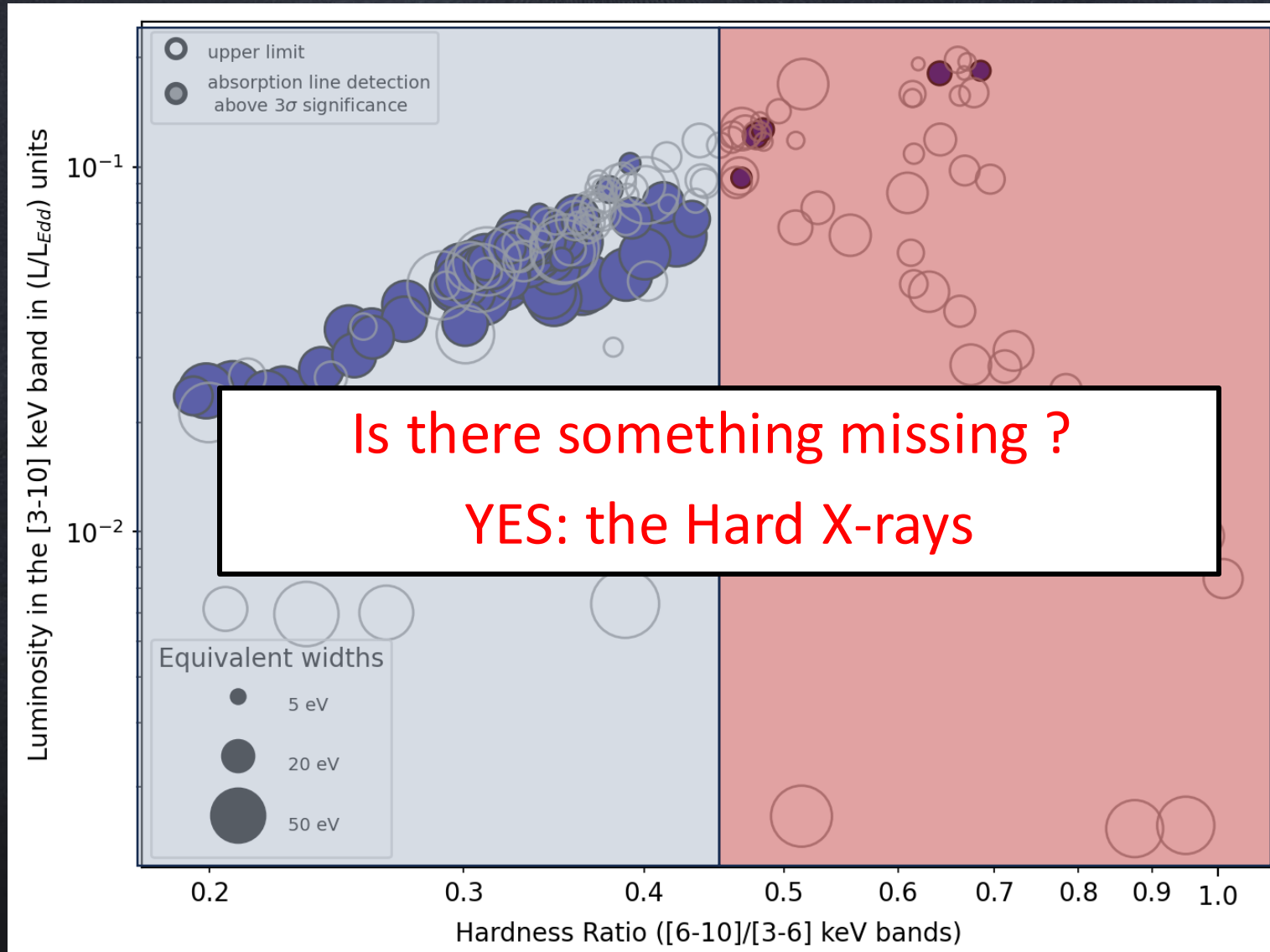
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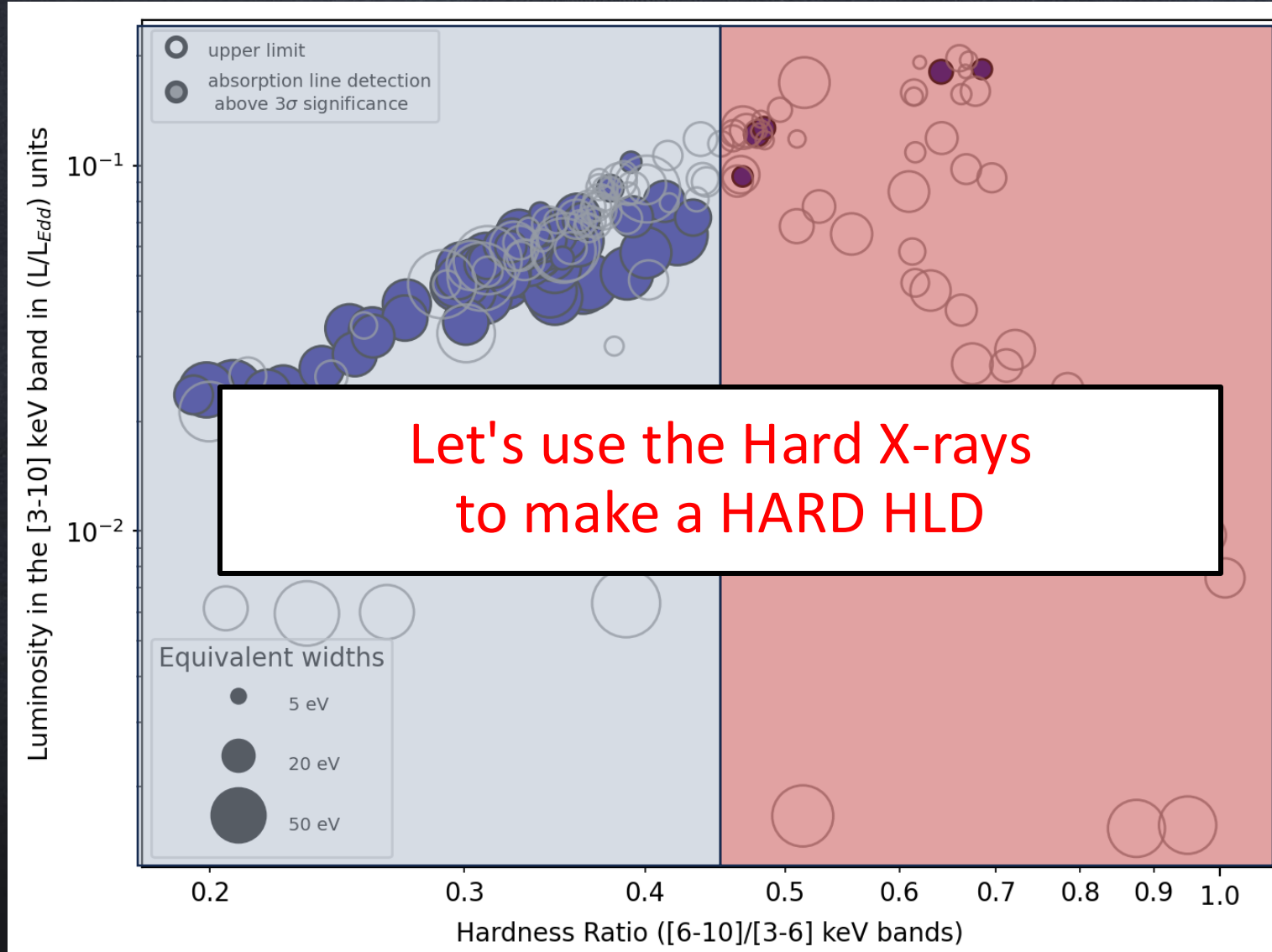
20 years of winds in 4U 1630-47

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Hardness Luminosity Diagrams

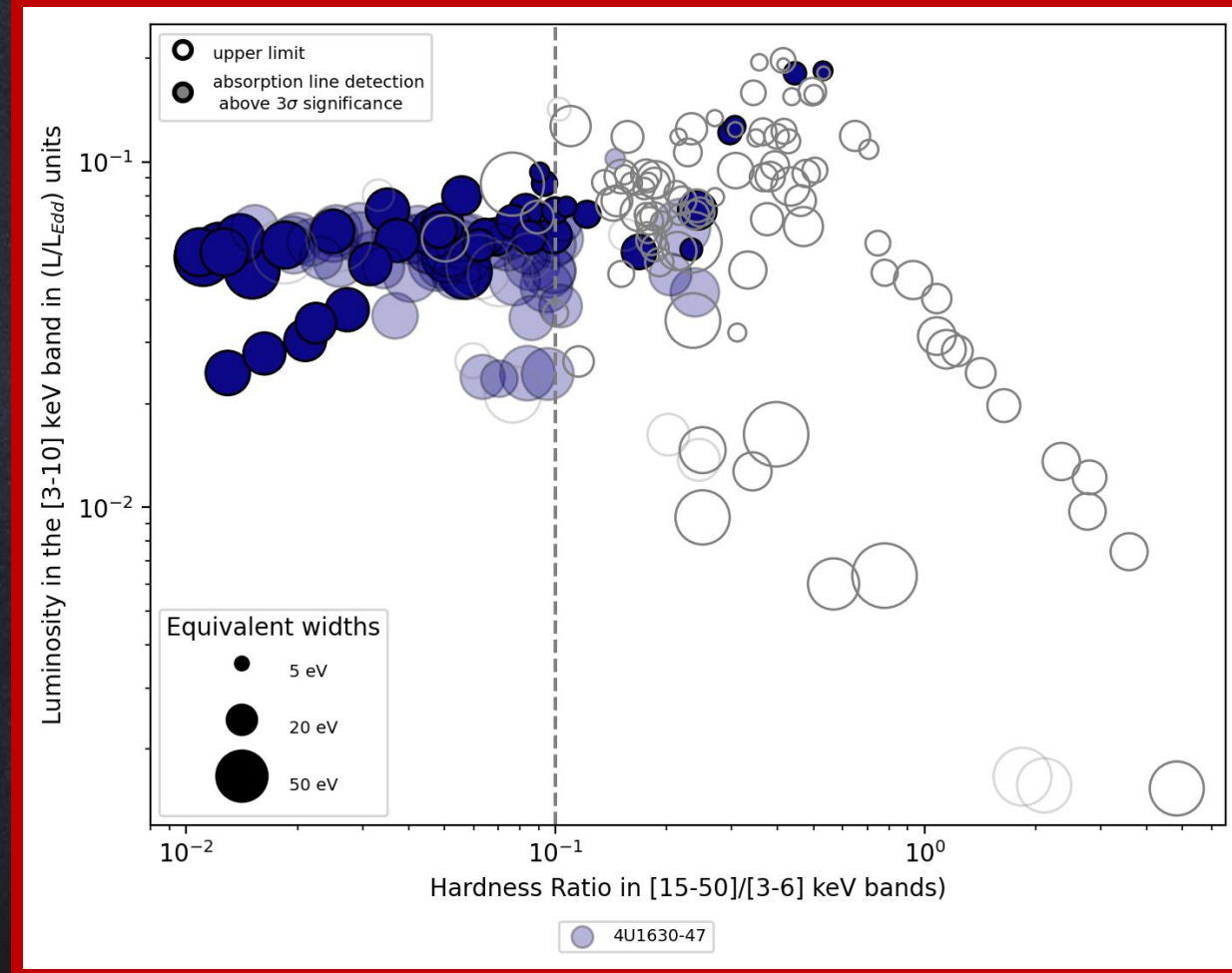
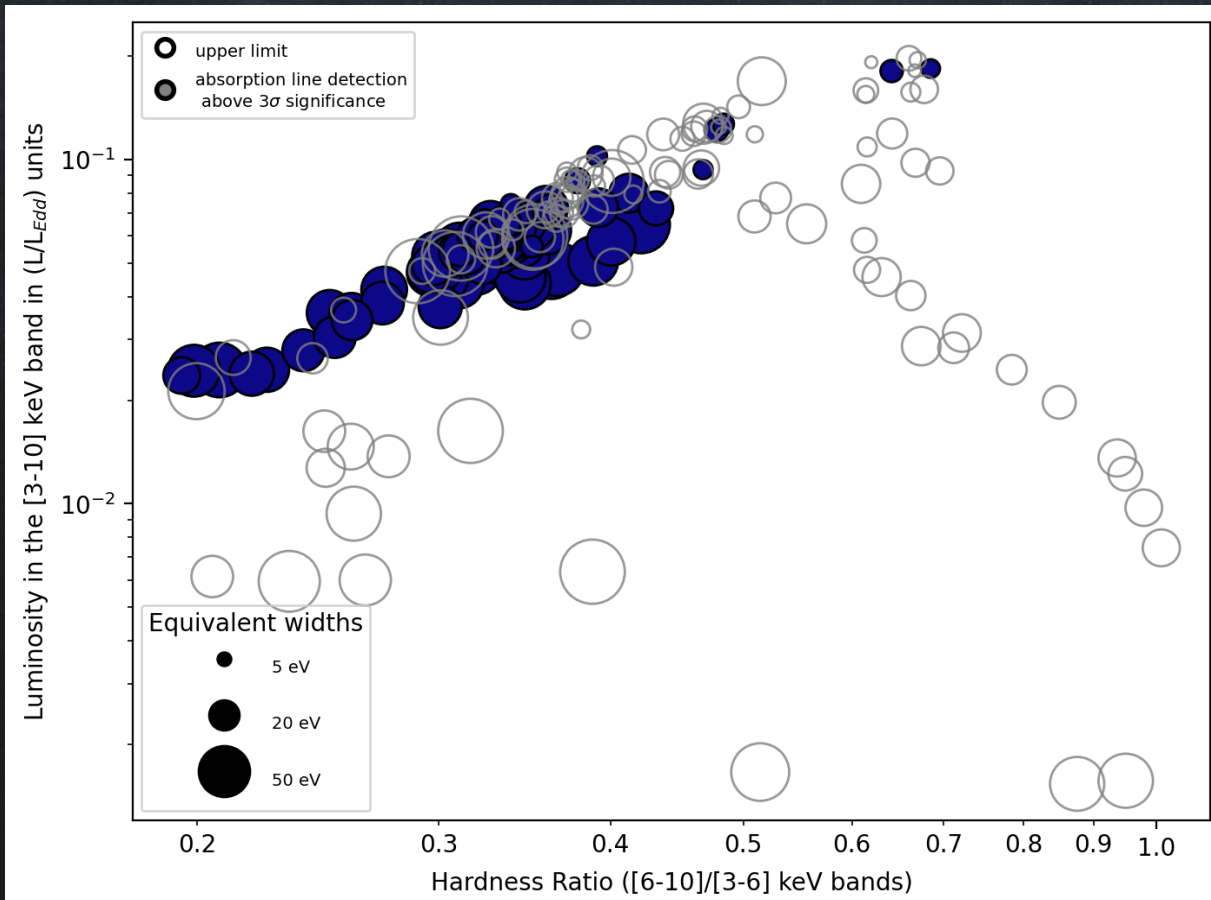


High-E additional coverage

Swift-BAT	INTEGRAL
0	1
/	/
/	/
15	/
1	/
1	/
32	0
42	/
29	/
61	1
180	2

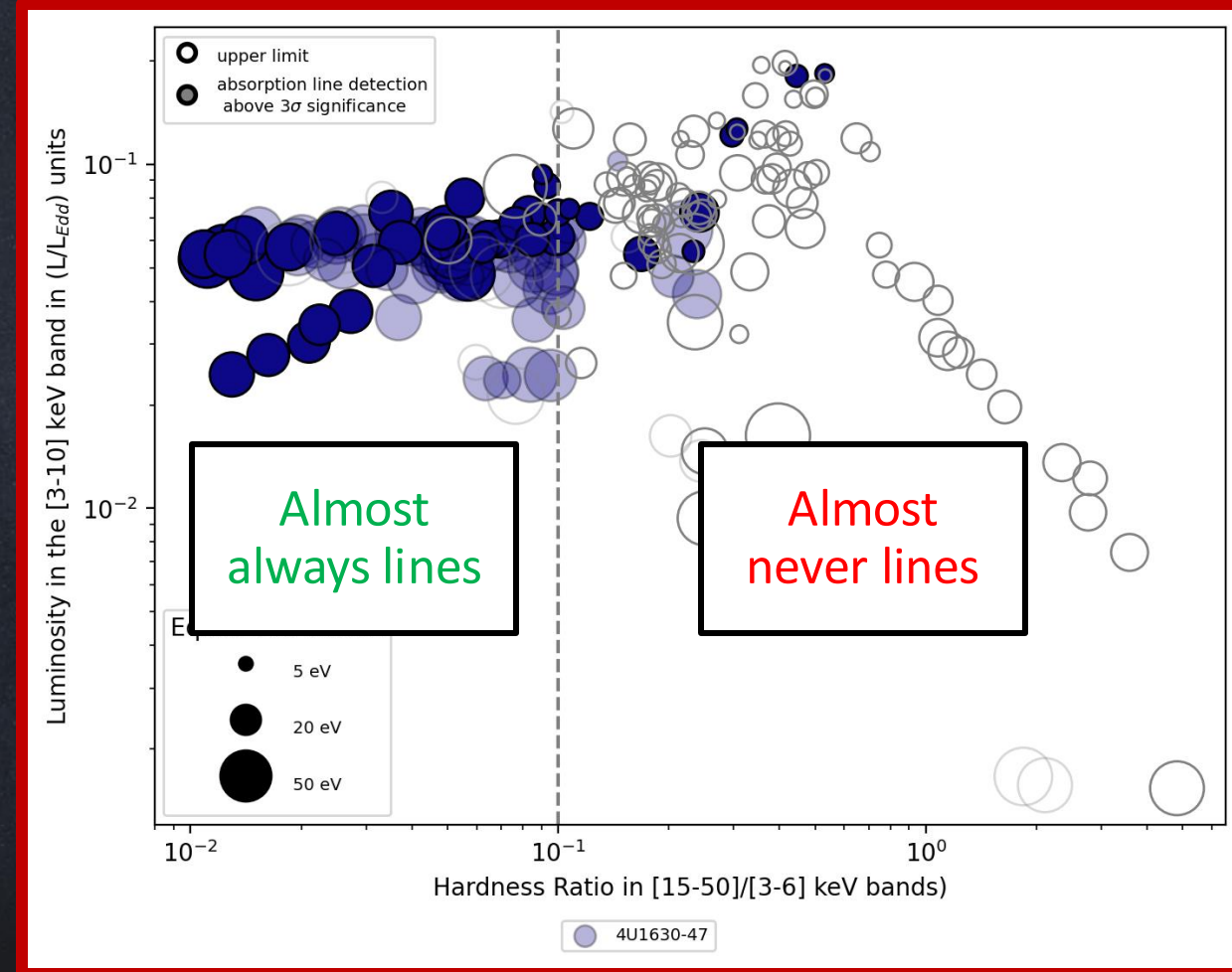
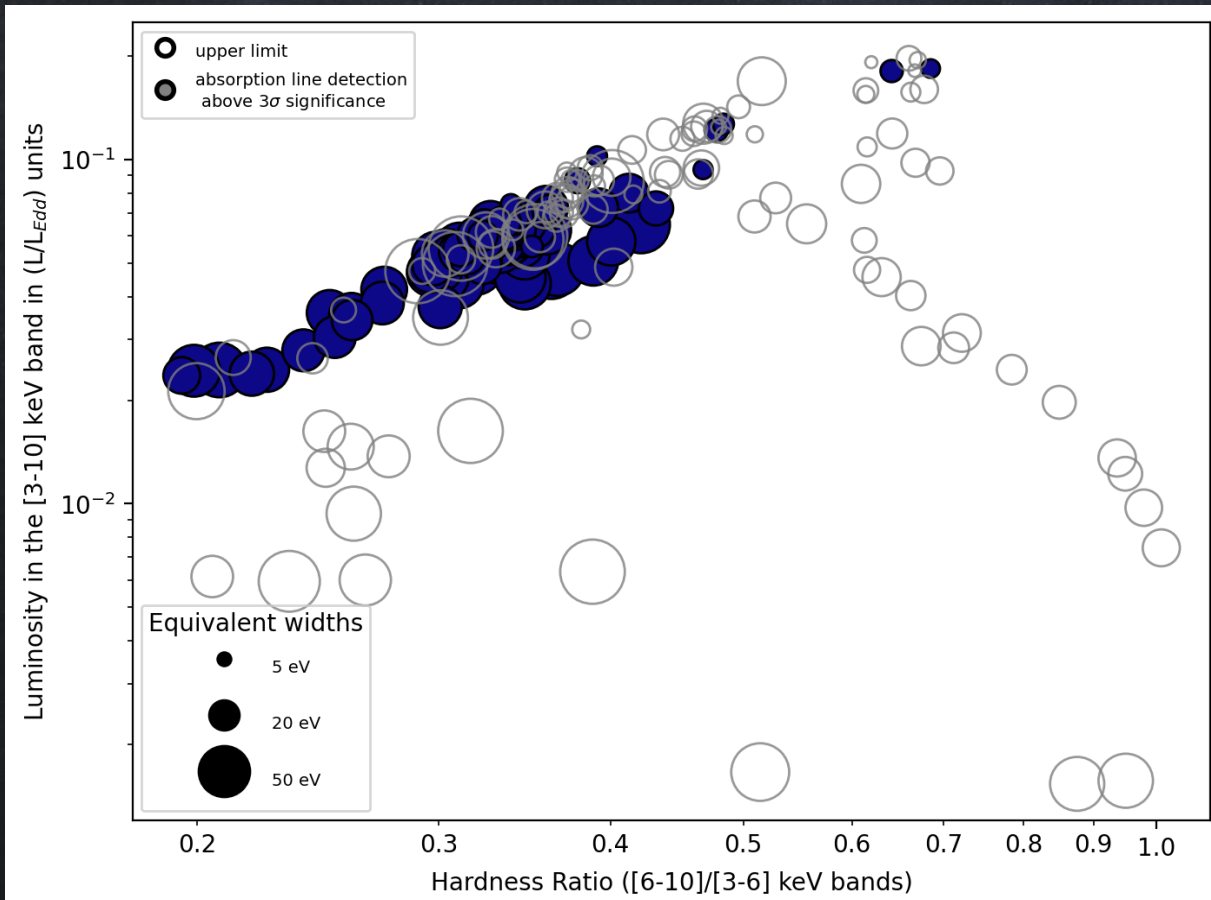
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Hardness Luminosity Diagrams



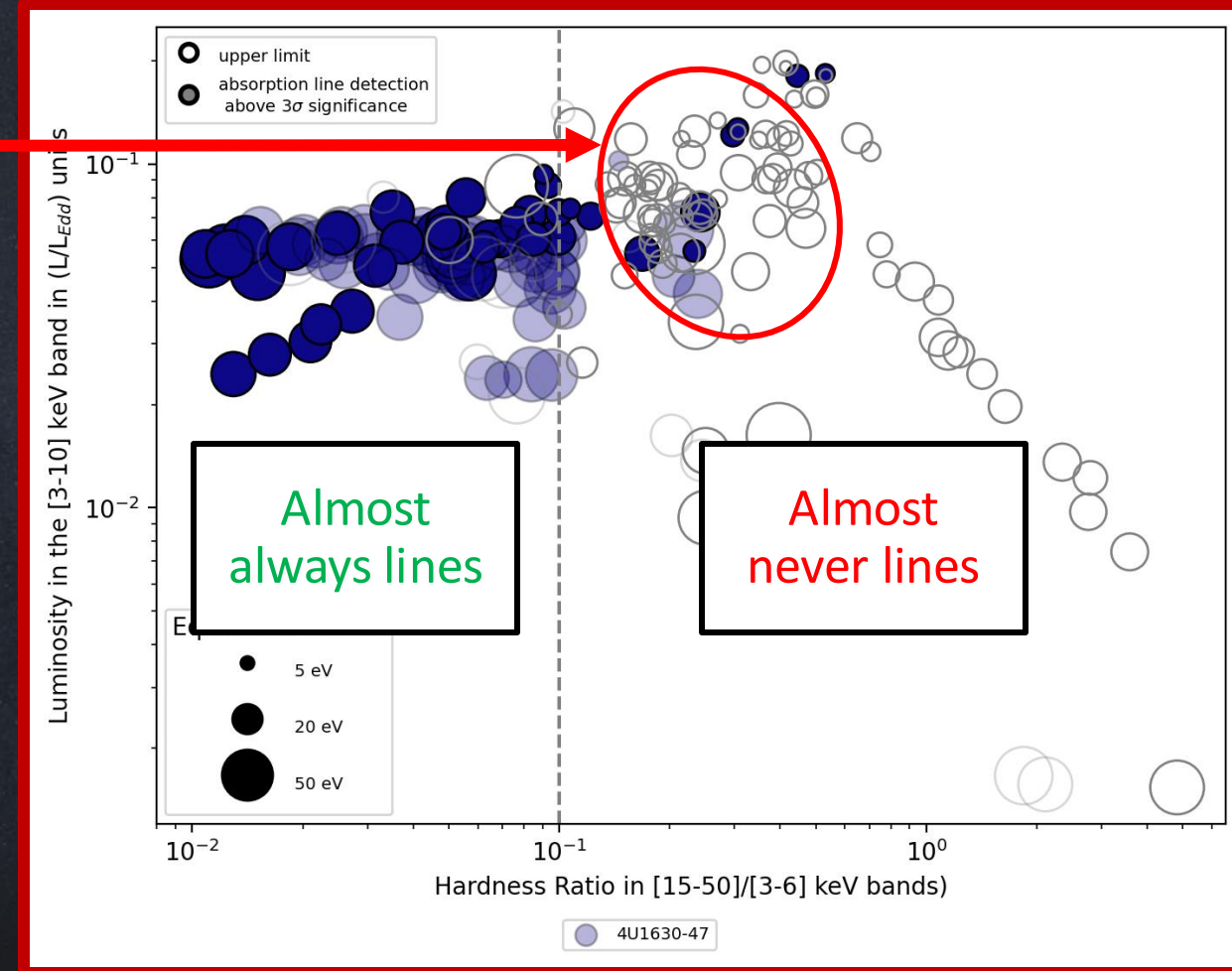
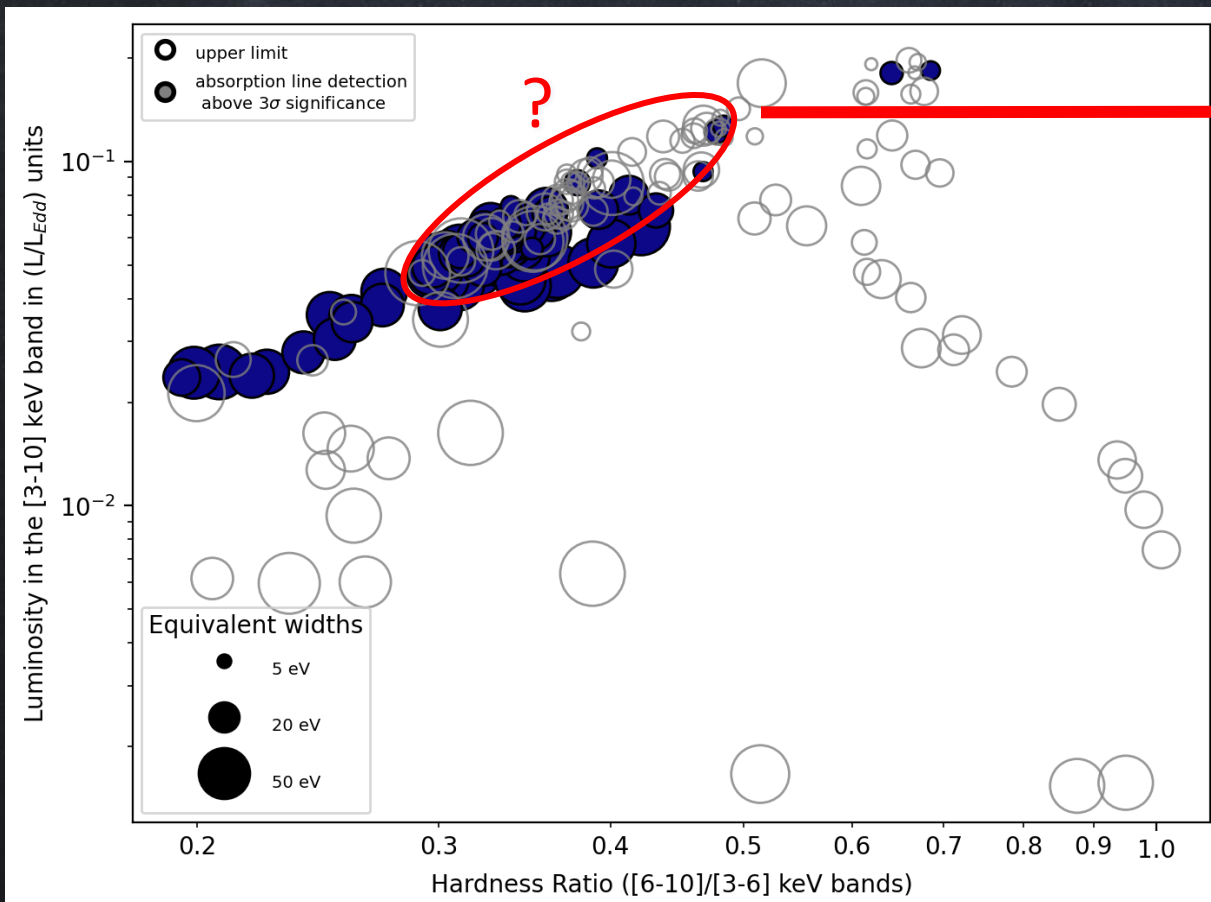
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Hardness Luminosity Diagrams



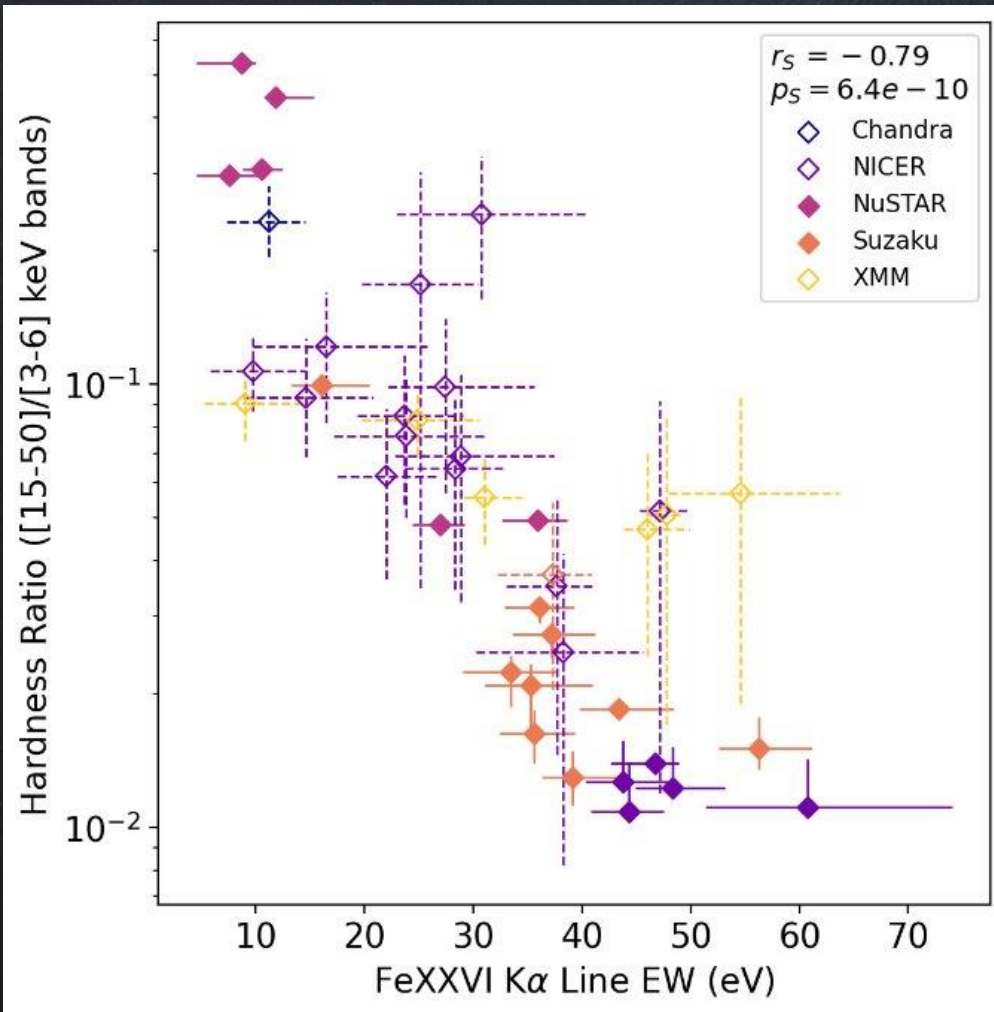
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Hardness Luminosity Diagrams

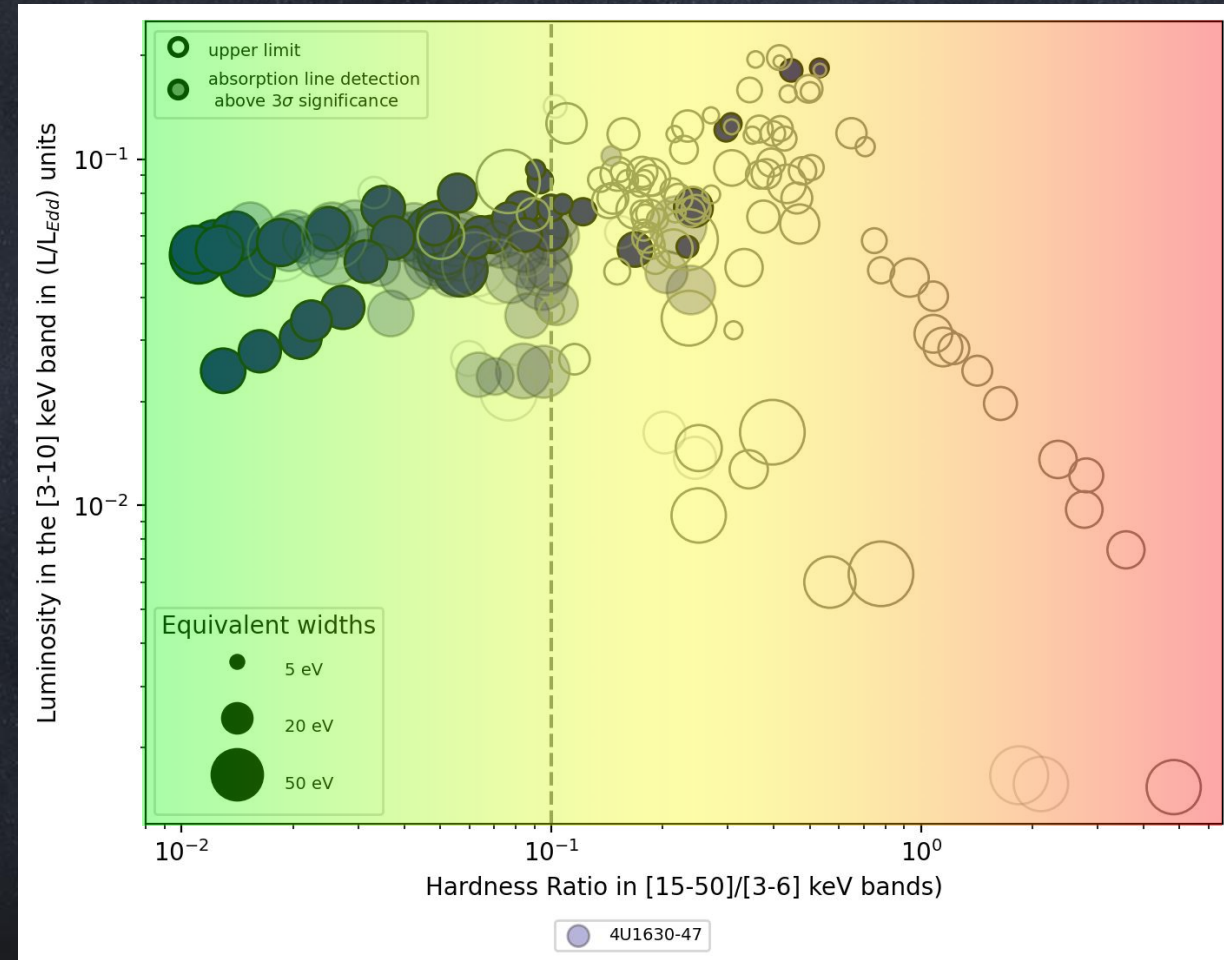


20 years of winds in 4U 1630-47

Hardness Luminosity Diagrams



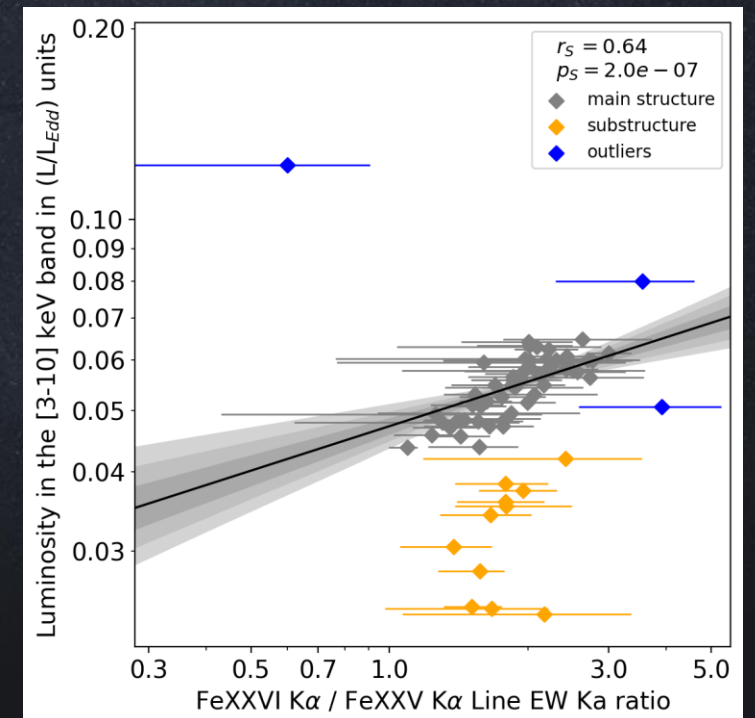
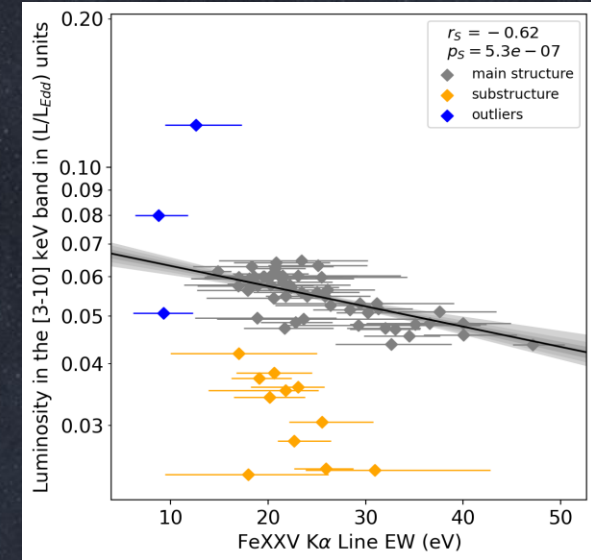
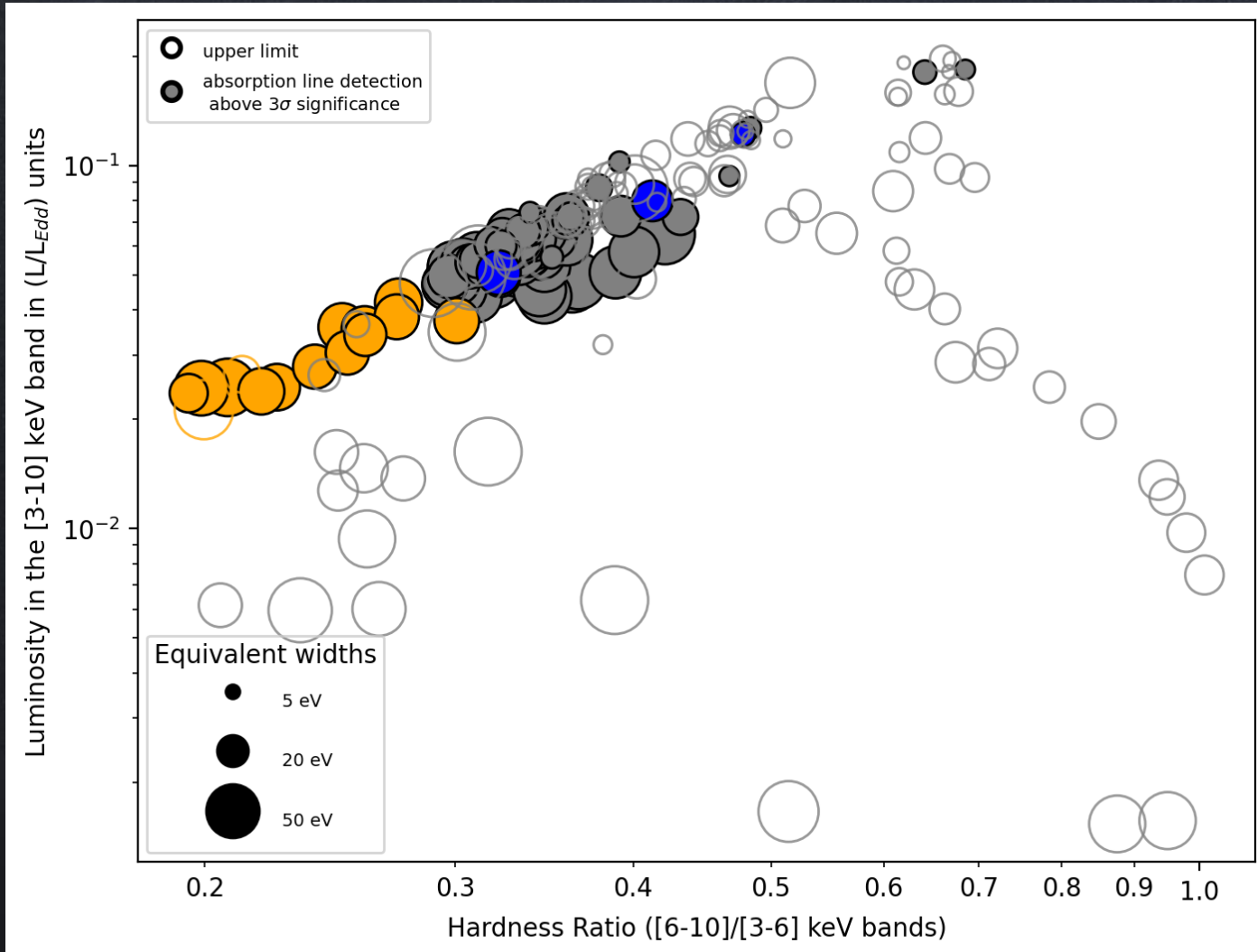
EW decreases



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- Hardness Luminosity Diagrams

Outliers & substructure ?



Alright then, but what does it mean ?

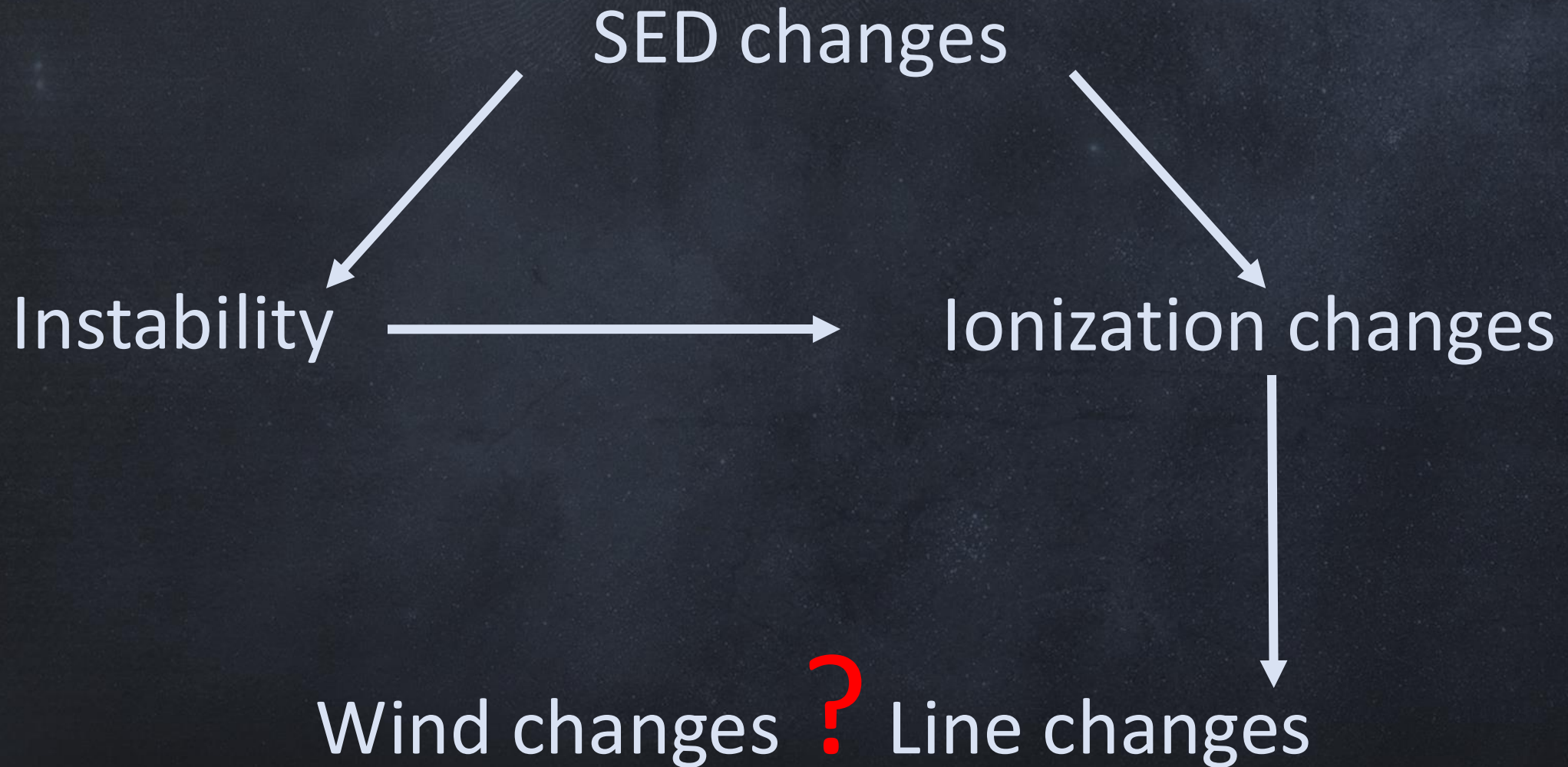
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- Wind evolution ?

Wind changes ? Line changes

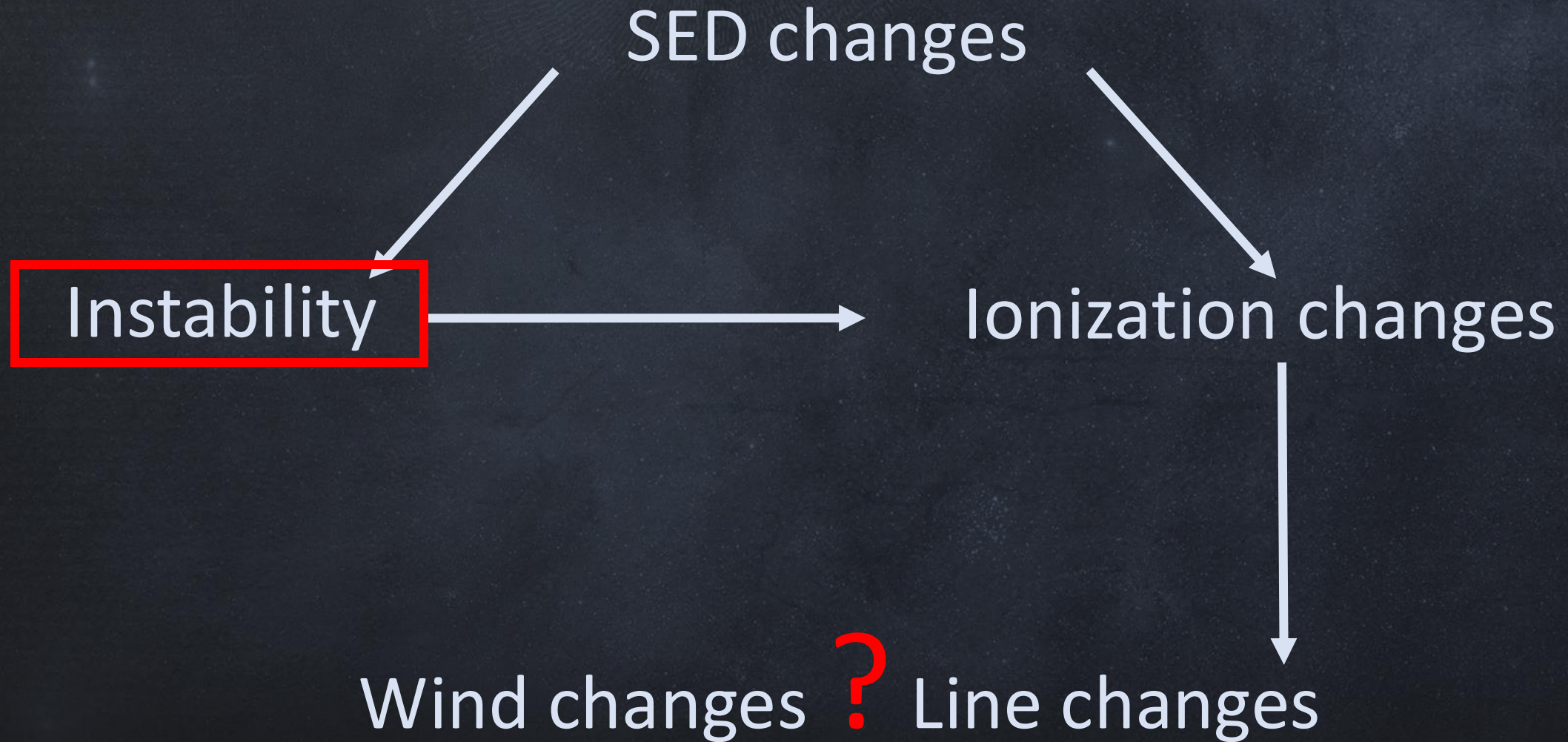
20 years of winds in 4U 1630-47

- Wind evolution ?



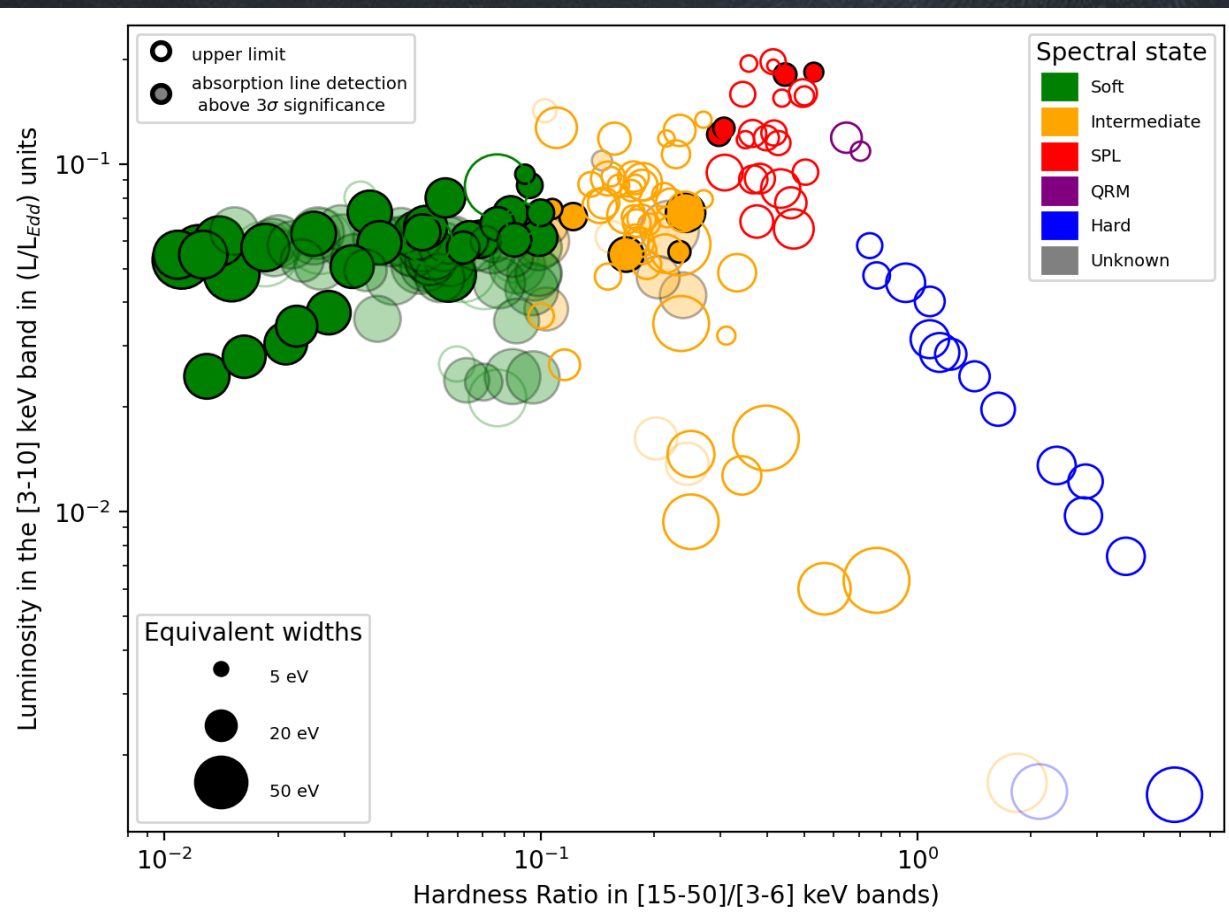
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- Wind evolution ?



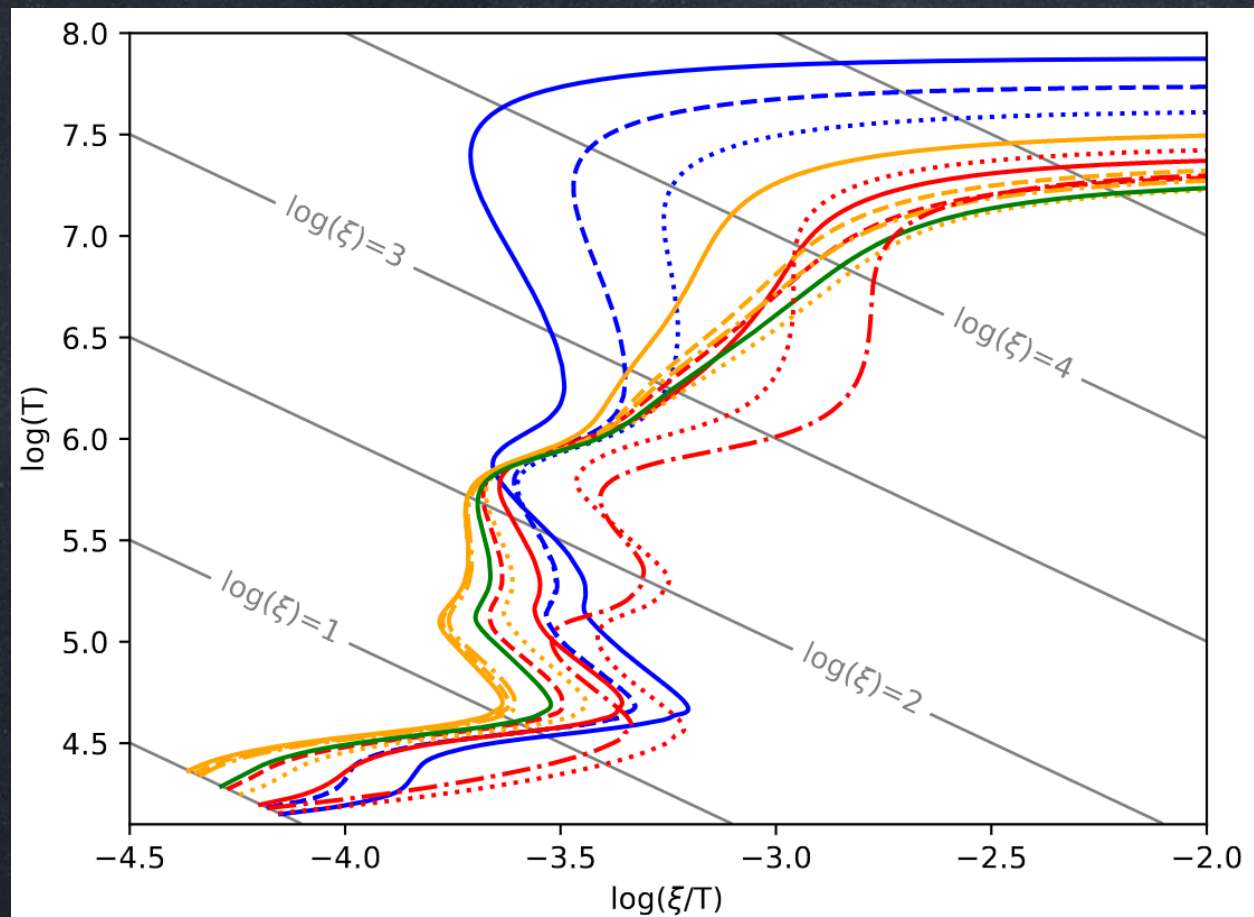
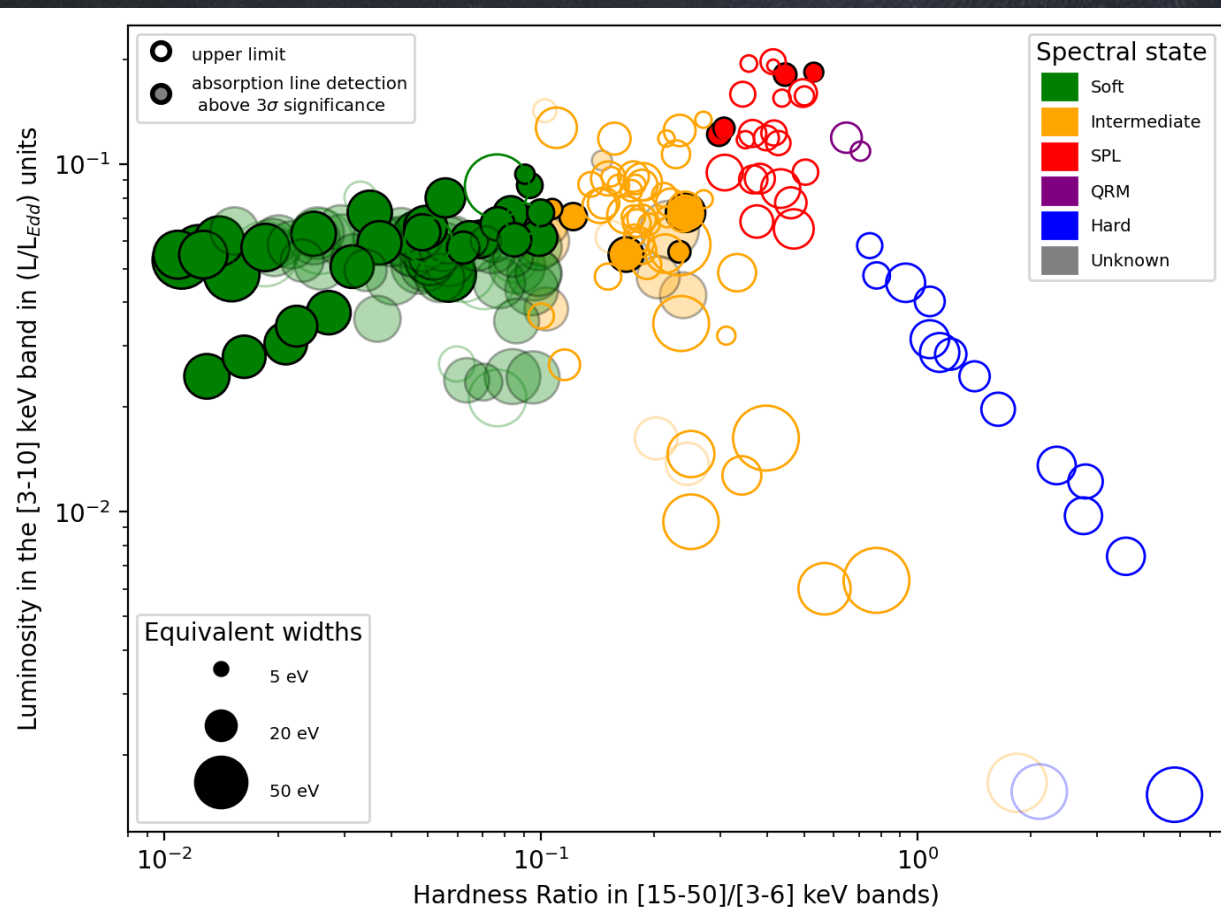
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■ Wind evolution ?



20 years of winds in 4U 1630-47

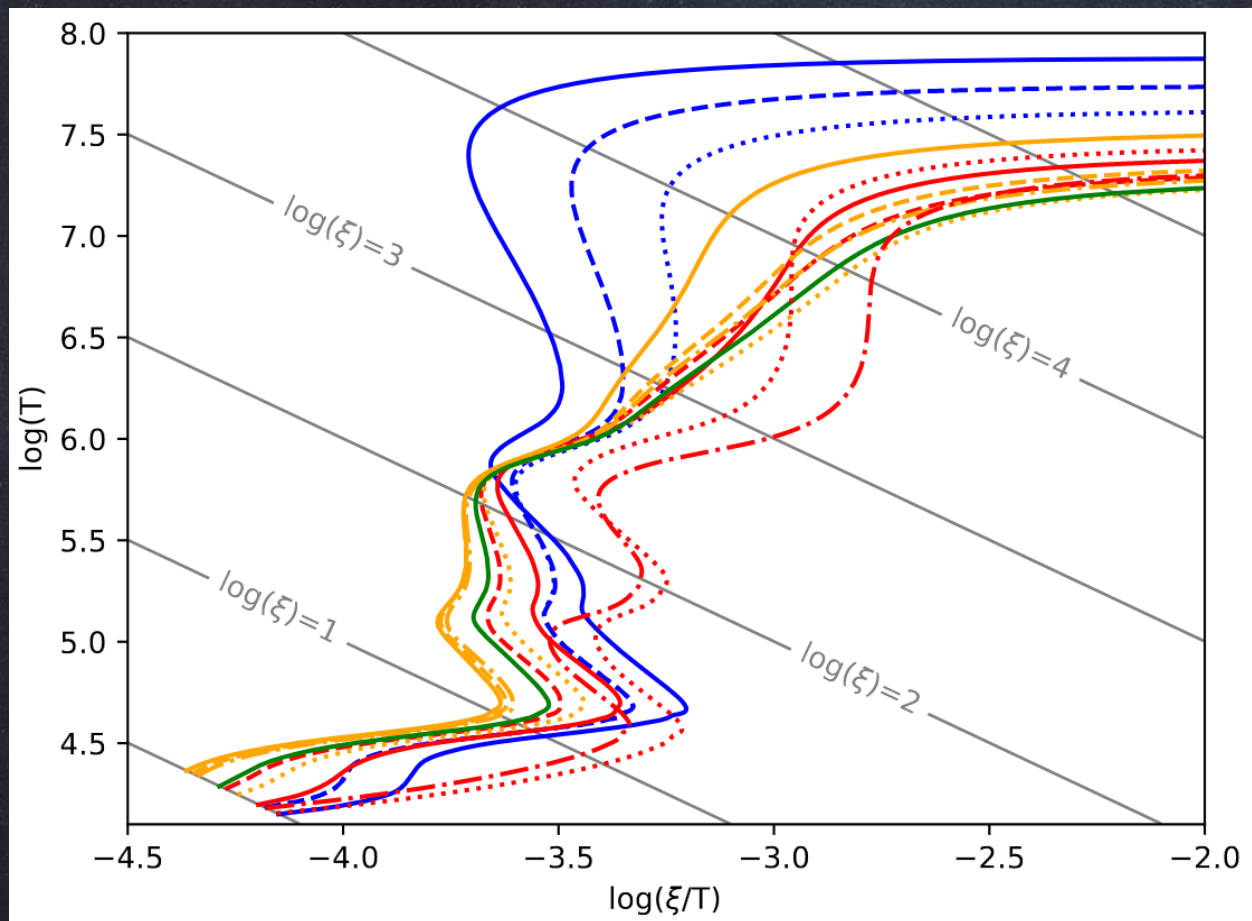
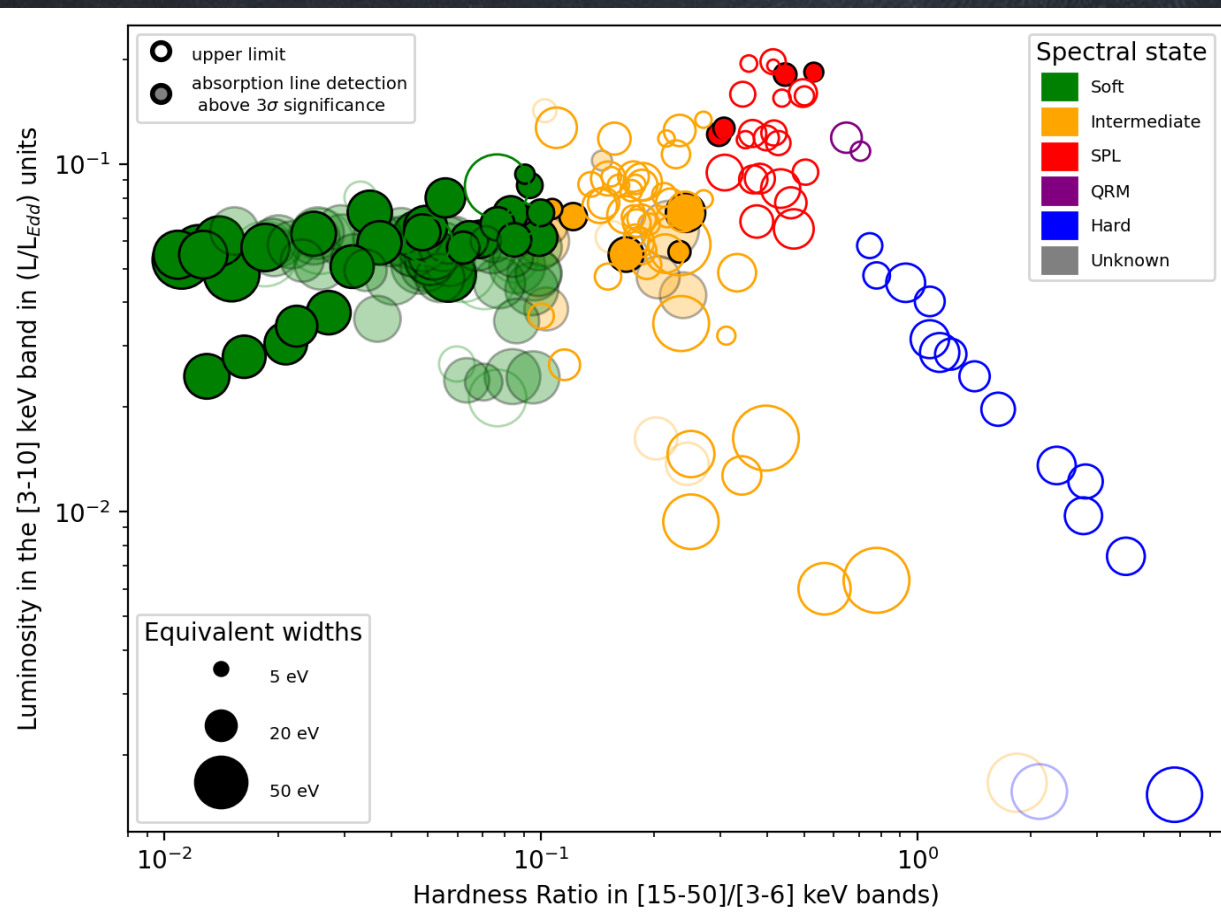
Wind evolution ?



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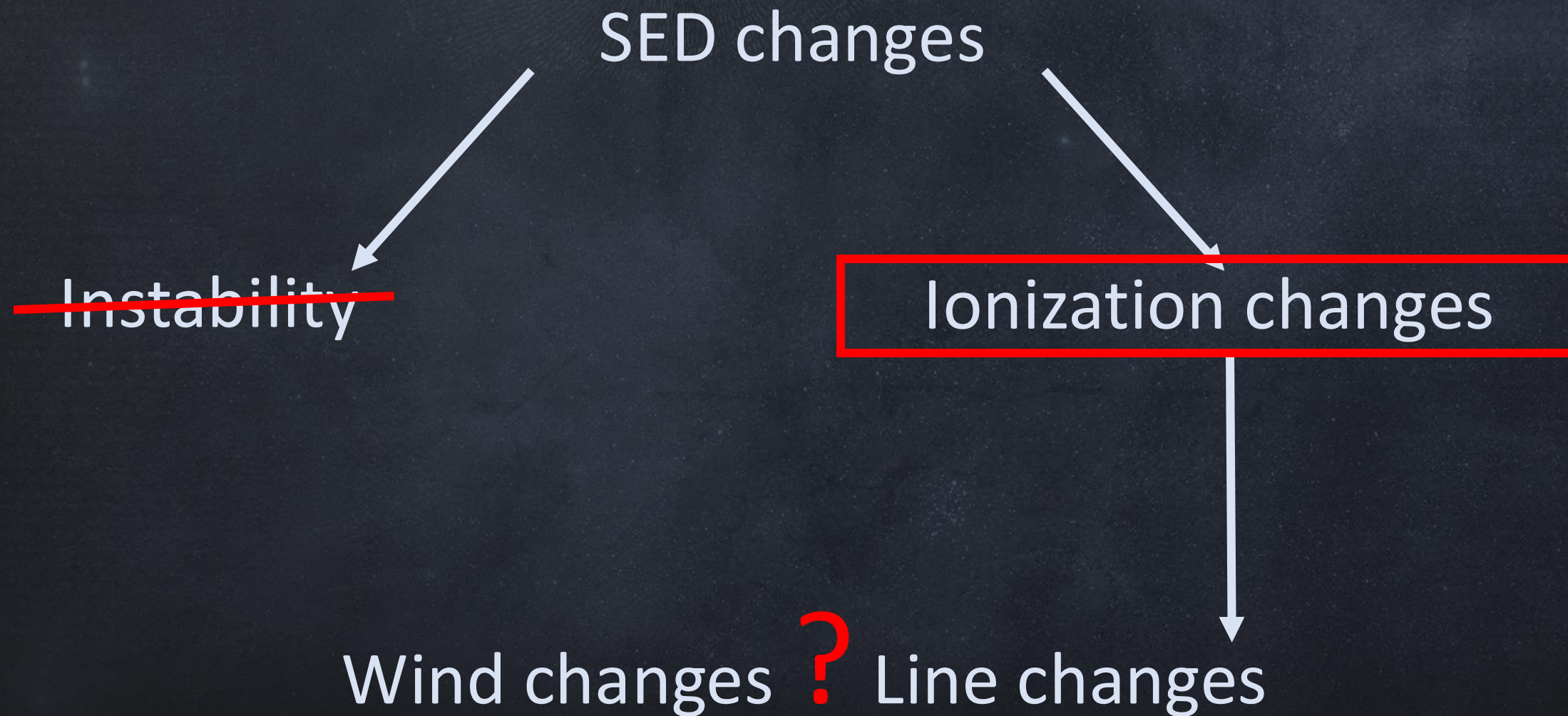
- Wind evolution ?

Not the culprit



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- Wind evolution ?

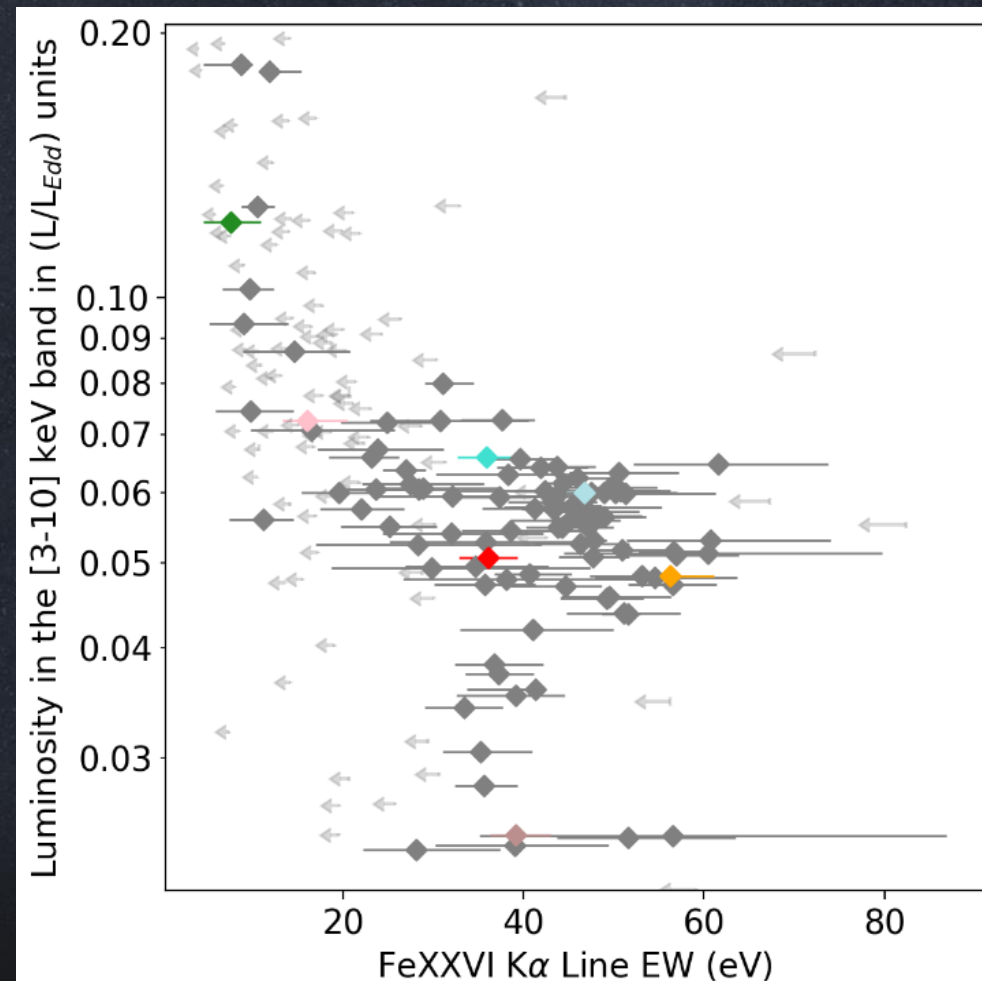
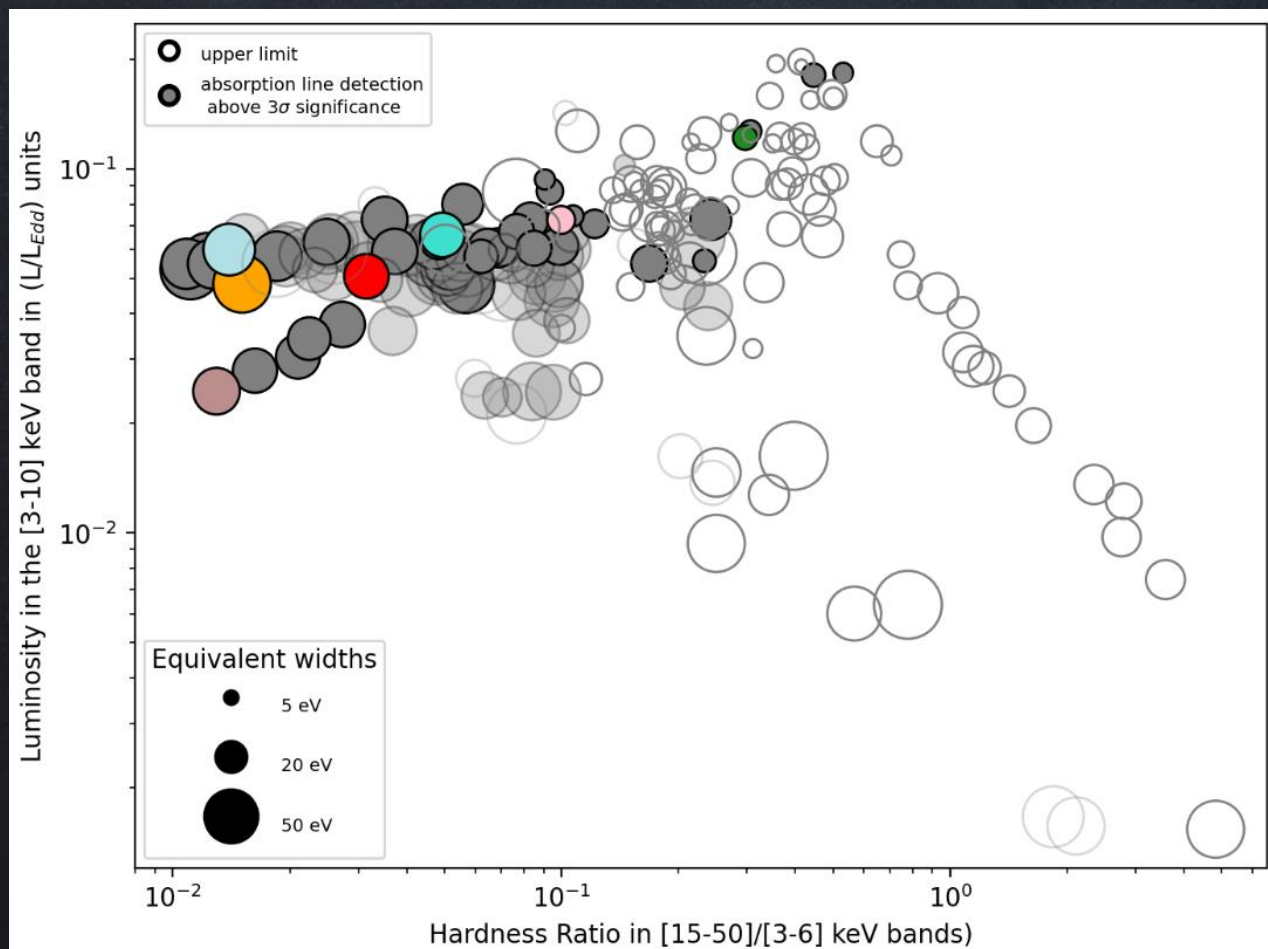


20 years of winds in 4U 1630-47

- Wind evolution ?

□ Select observations across the HLD and line parameters

(highlighted with colors)

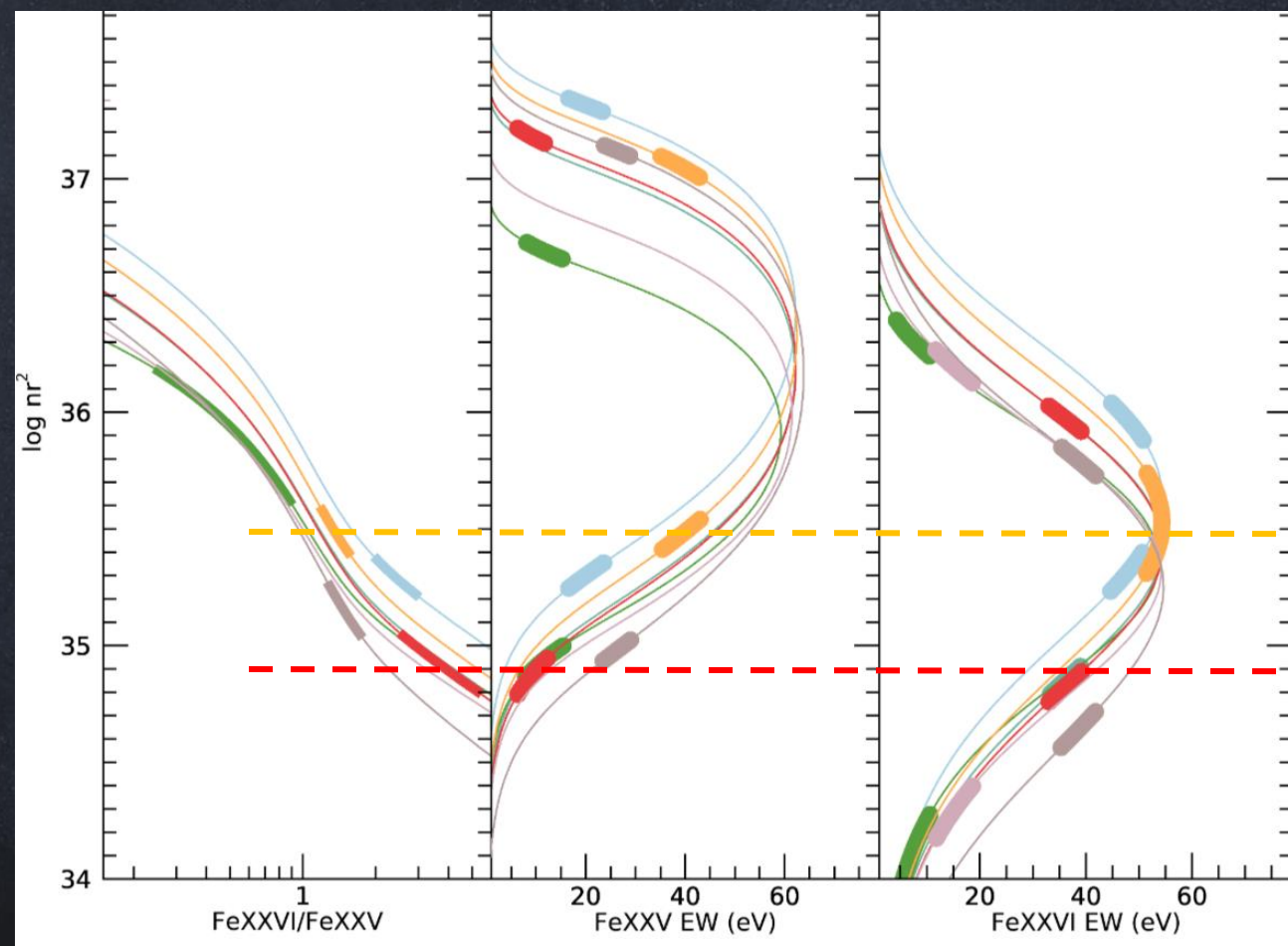
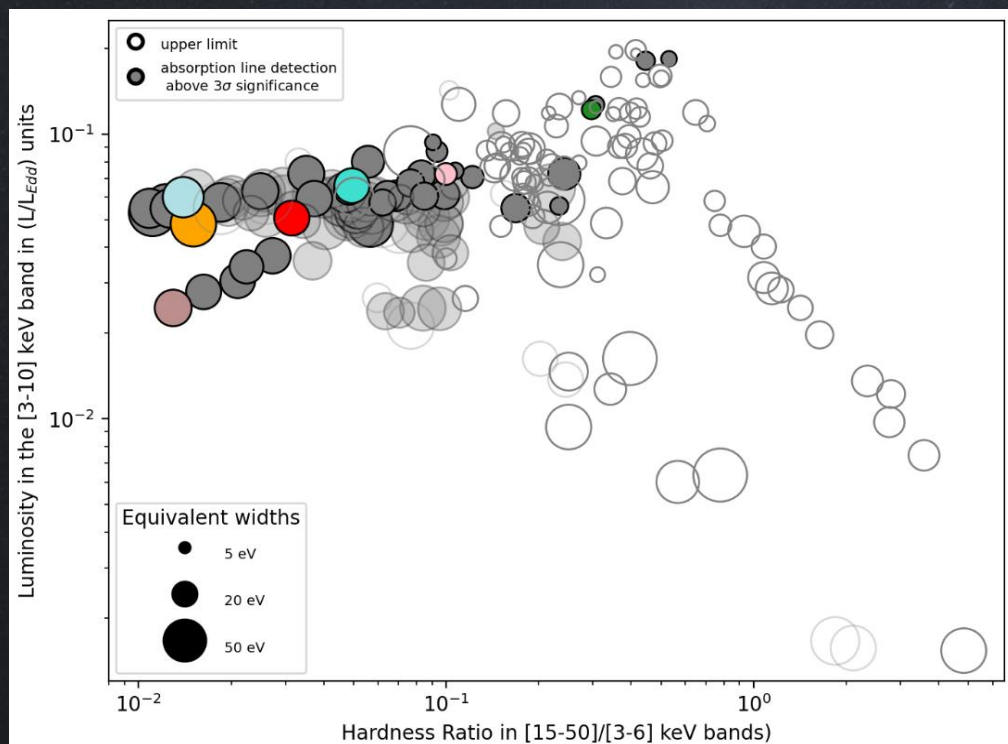


20 years of winds in 4U 1630-47

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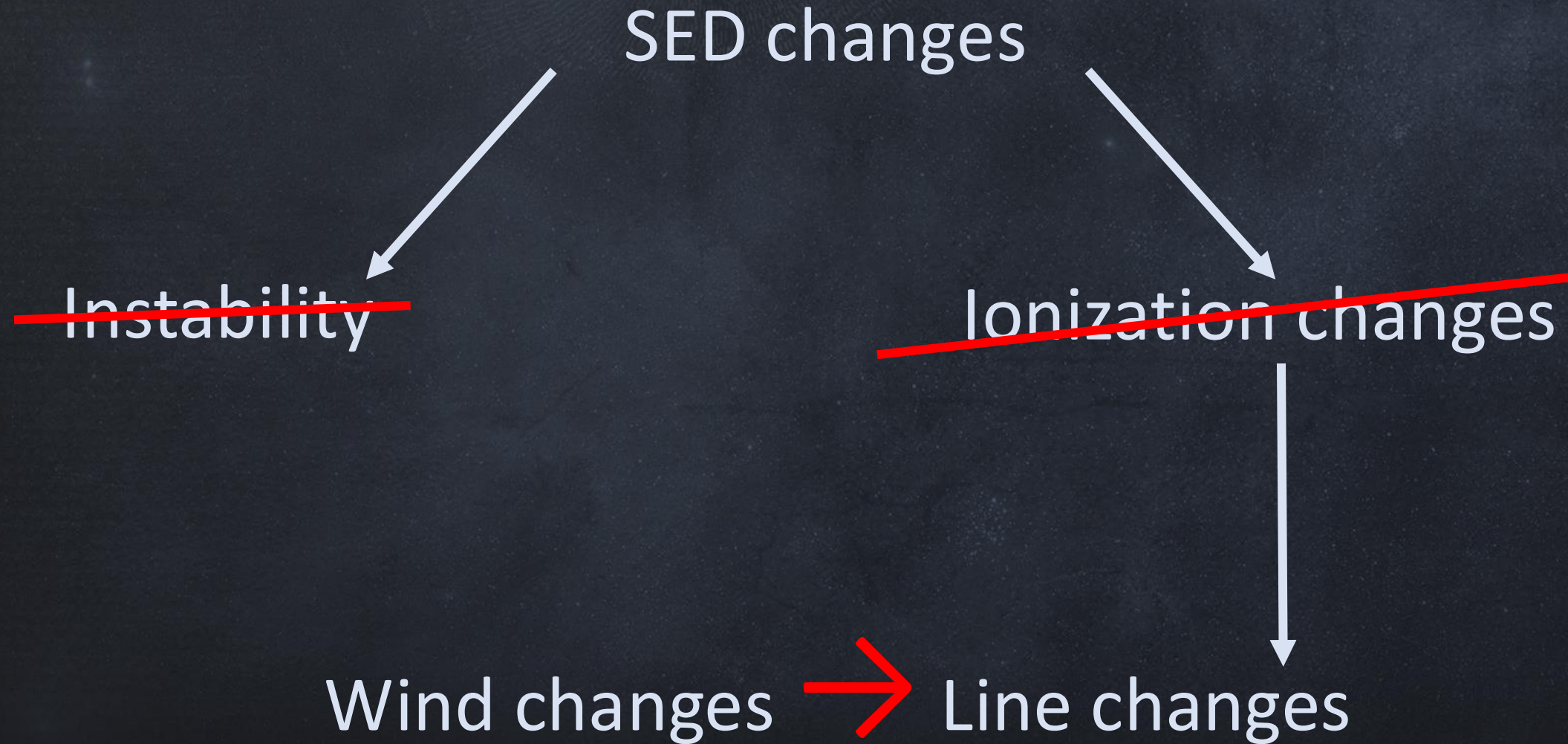
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20 years of winds in 4U 1630-47

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20 years of winds in 4U 1630-47

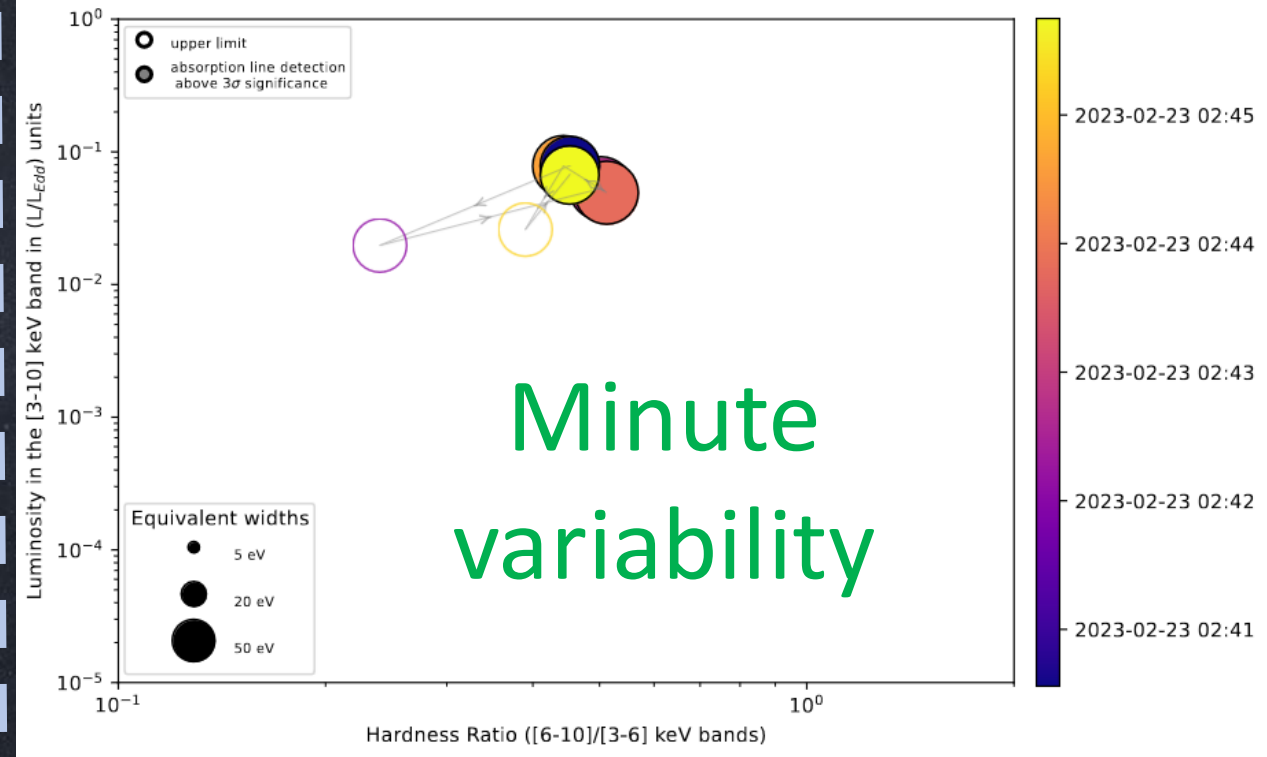
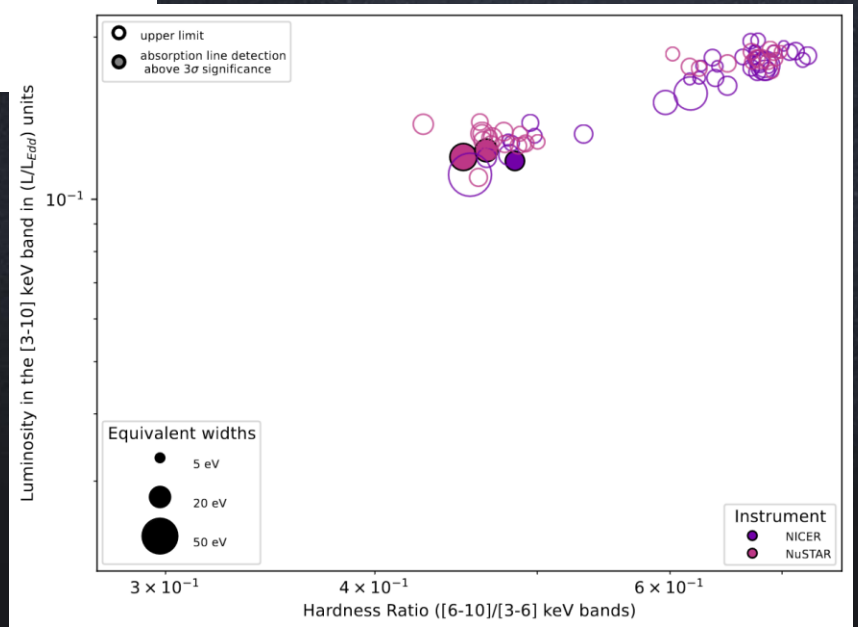
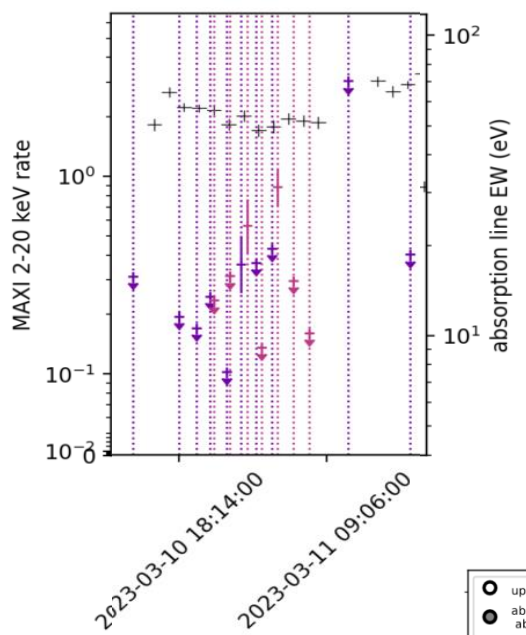
- Summary

- ❑ The high energies work much better to distinguish the evolution of the lines
- ❑ The absorption lines disappear **before** the hard state
- ❑ **Not** due to the gas becoming unstable:
 - Thermally stable in the HARD state
- ❑ Not **only** because of the SED: the wind must evolve along the outburst
 - No notable change between outbursts, only within the outburst pattern itself

20 years of winds in 4U 1630-47

- Time-resolved analysis

Hour variability



Minute variability

20 years of winds in 4U 1630-47

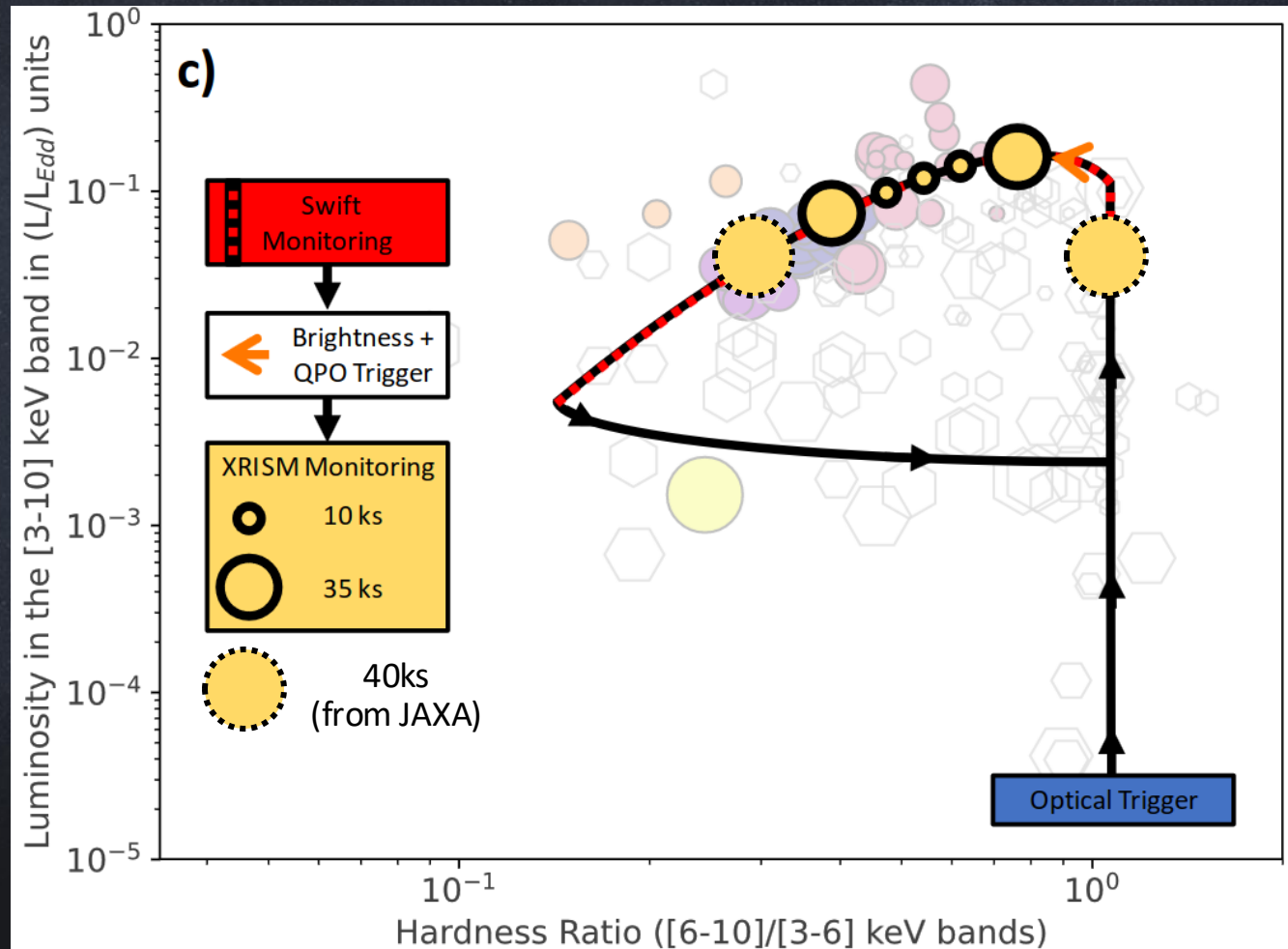
- The next step
- Higher resolution observations with the new generation of instruments, to better constrain the wind properties

180ks XRISM Program (ESA + JAXA)

Accepted in Cycle 1

4U 1630-47 Observation
Performed in the PV Phase

V4641 Sgr DDT (as Co-I)
Performed 3 days ago
but very faint

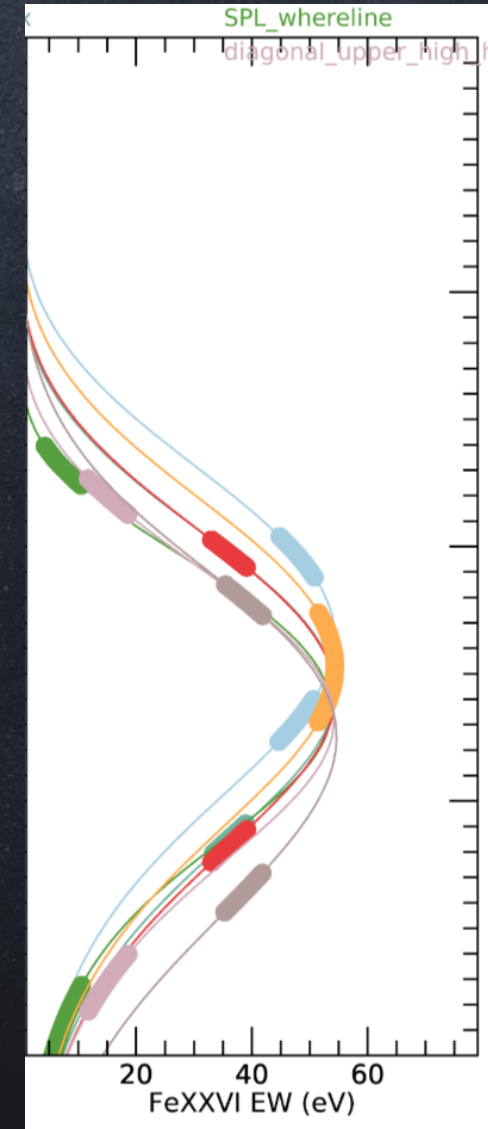


Appendices

20 years of winds in 4U 1630-47

- Wind evolution ?

Wind parameter:
 $nR^2=L/\xi$
 from CLOUDY



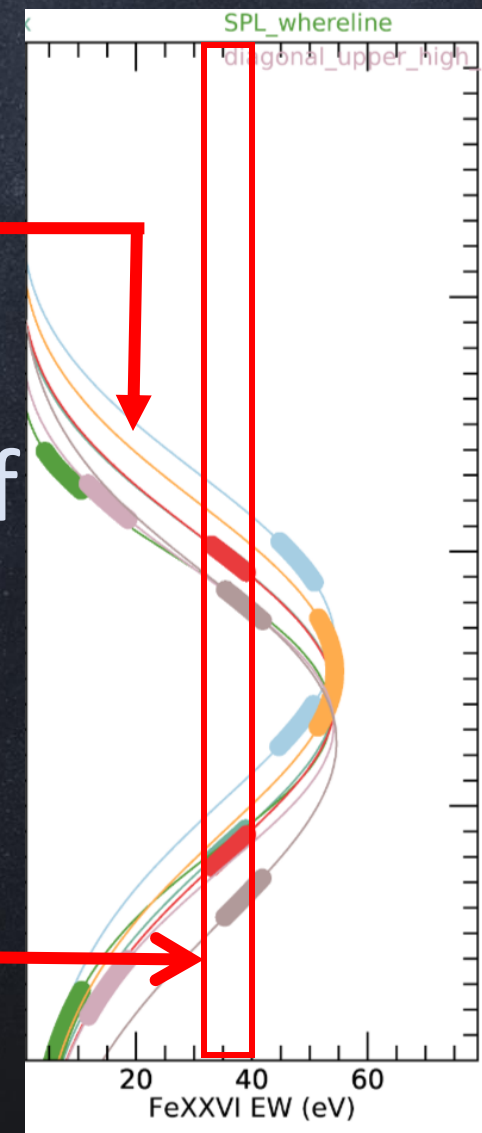
20 years of winds in 4U 1630-47

- Wind evolution ?

Wind parameter:
 $nR^2=L/\xi$
 from CLOUDY

Curves of
 growth from SEDs of
 each observation

Detection

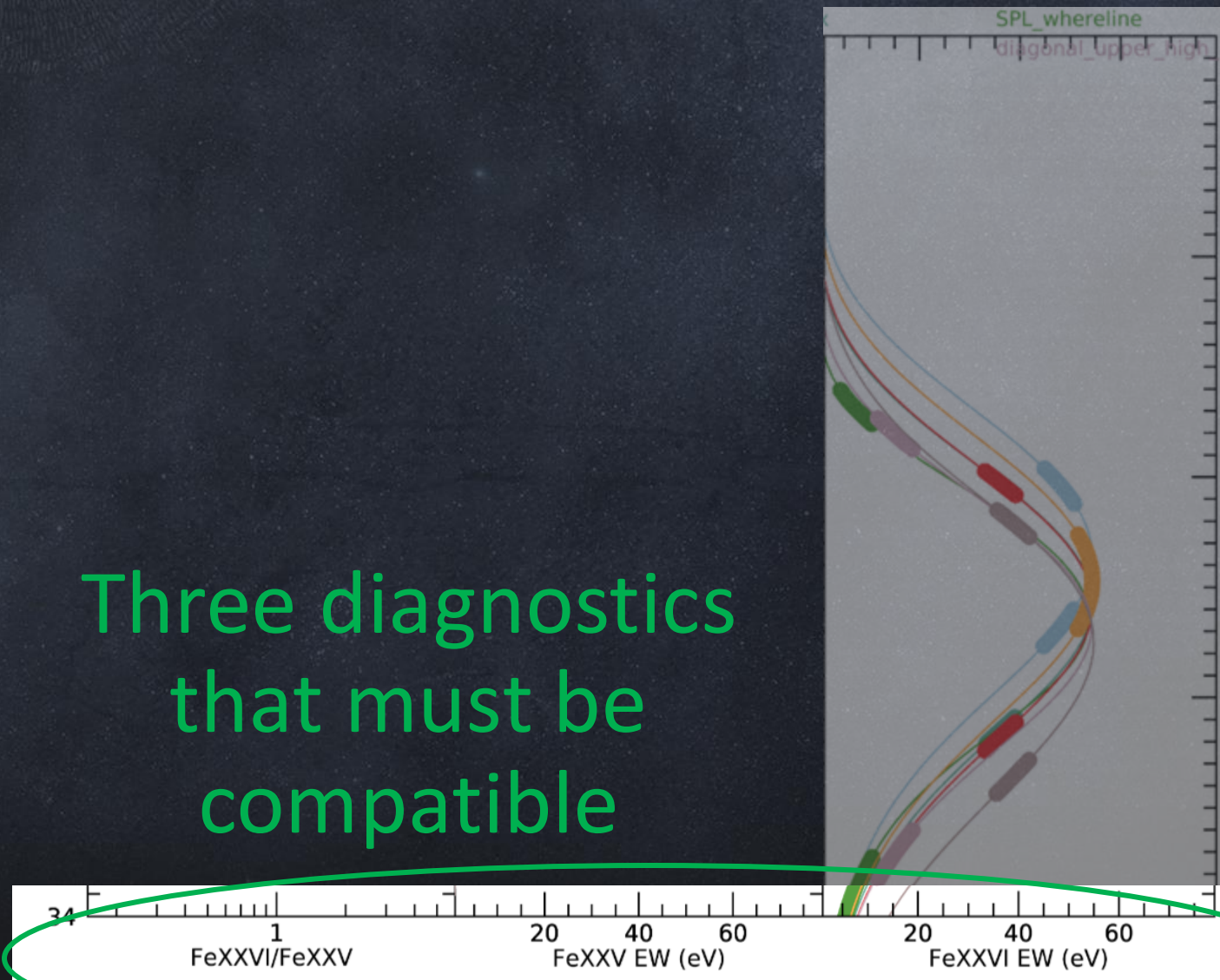


20 years of winds in 4U 1630-47

- Wind evolution ?

Wind parameter:
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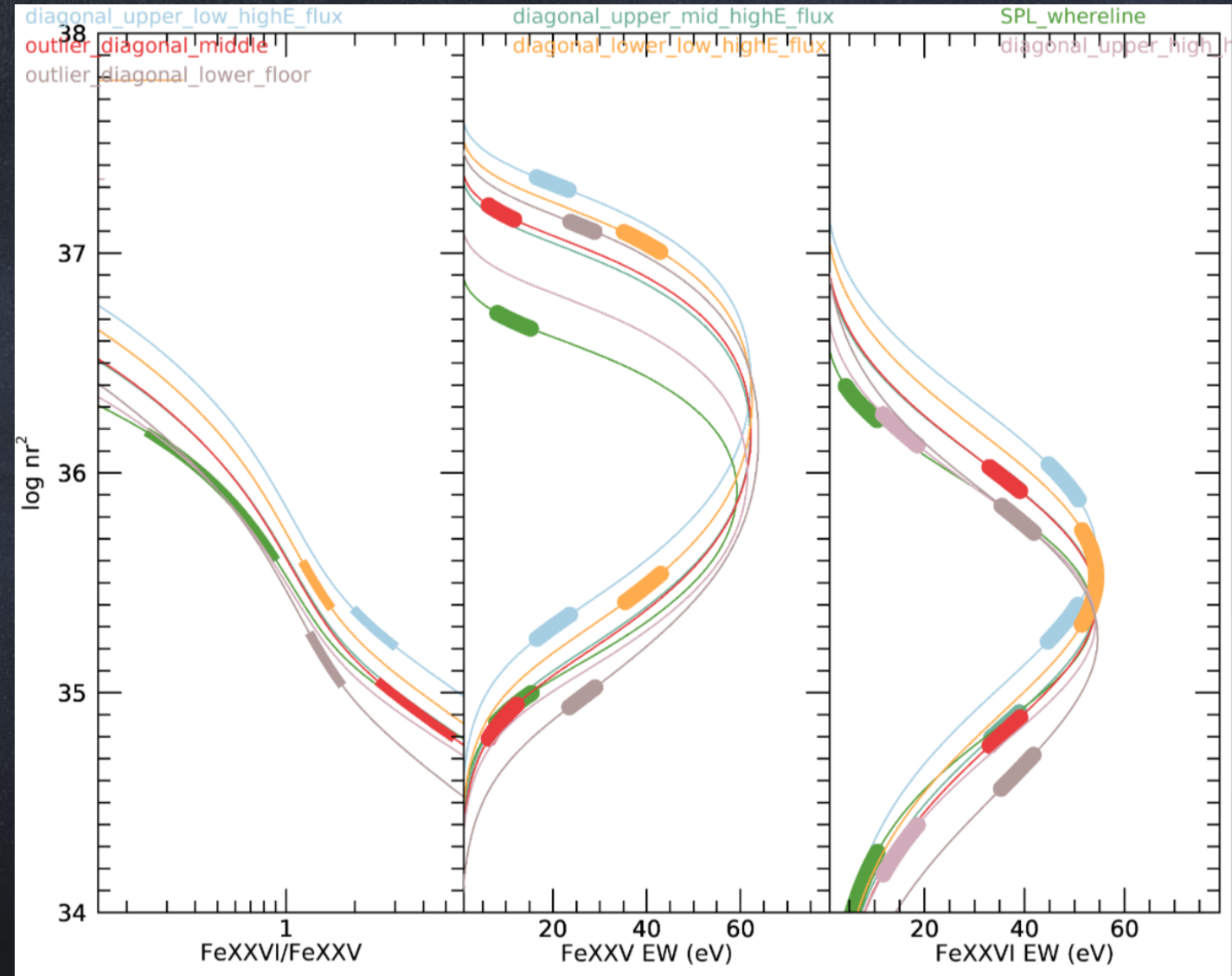
Three diagnostics
 that must be
 compatible



20 years of winds in 4U 1630-47

- Wind evolution ?

Wind parameter:
 $nR^2 = L/\xi$
 from CLOUDY

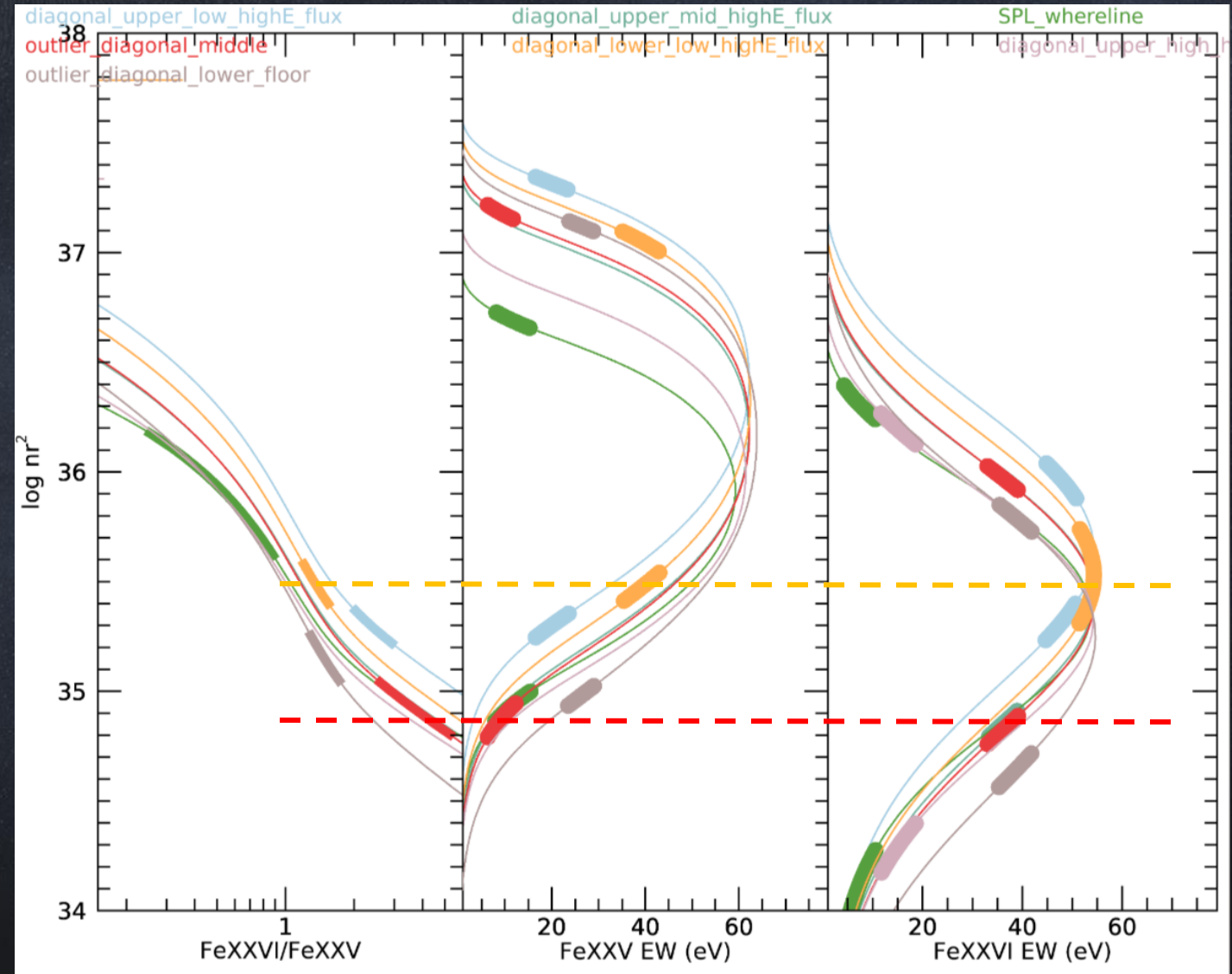


20 years of winds in 4U 1630-47

- Wind evolution ?

Wind changing ?

Wind changing



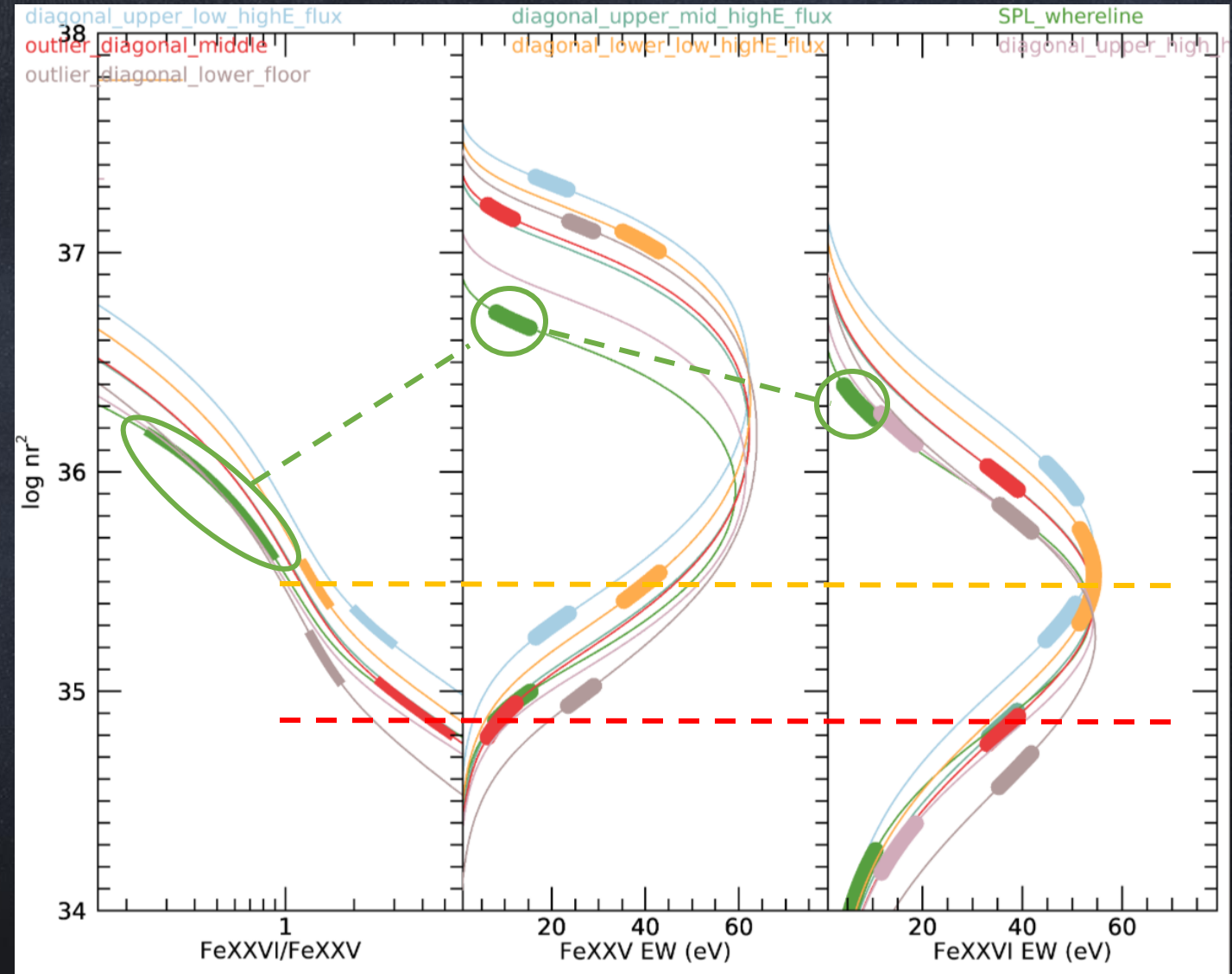
20 years of winds in 4U 1630-47

- Wind evolution ?

Wind changing ?

+
Complex
structure

Wind changing



20 years of winds in 4U 1630-47

- Wind evolution ?

Wind changing

+

Complex
structure

Only after testing with
other N_H
and turbulences

Wind changing

