

The current state of disk wind observations in galactic Black Hole LMXBs through X-ray absorption lines

<https://arxiv.org/abs/2308.00691>

The current context

The current context

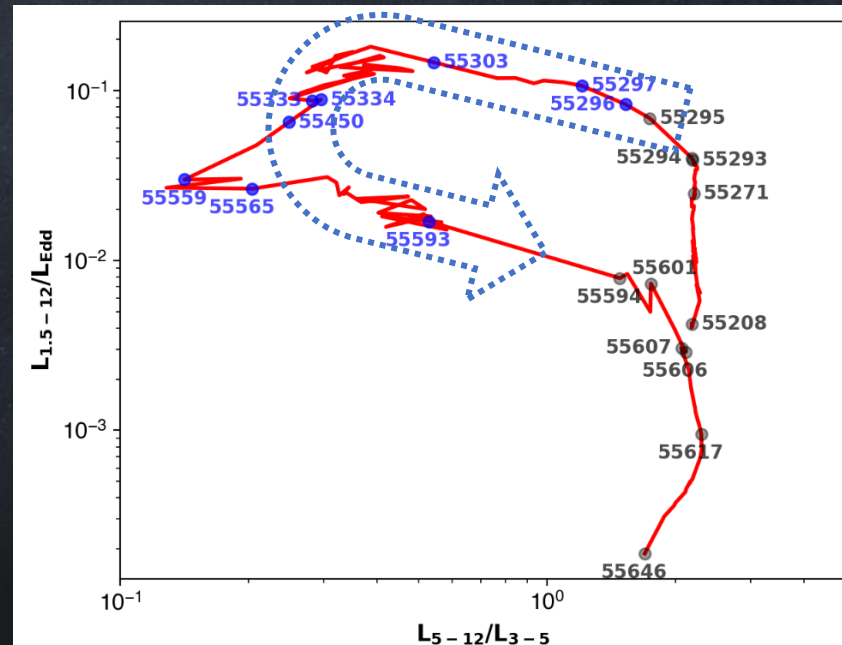
- Accretion in Black Hole X-ray Binaries

□ Low-Mass X-ray Binaries

- Accretion through Roche-Lobe overflow → Accretion disk

Switch between two standard states

Soft State



Hard State

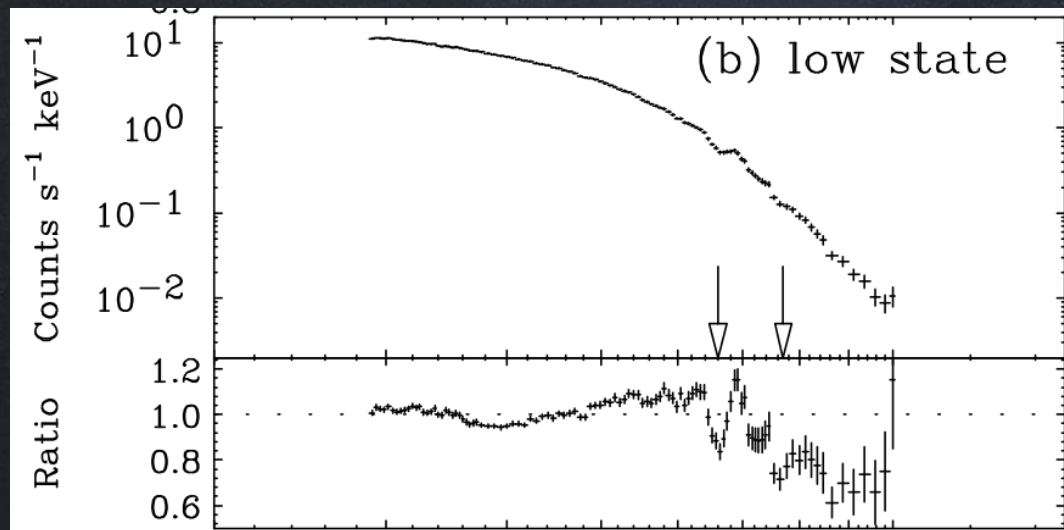
The current context

- Wind detection in Black Hole X-ray Binaries

□ First detections of blueshifted narrow absorption lines before 2000

(Ueda et al. 1998, Kotani et al. 2000)

- material + low speed = not jet



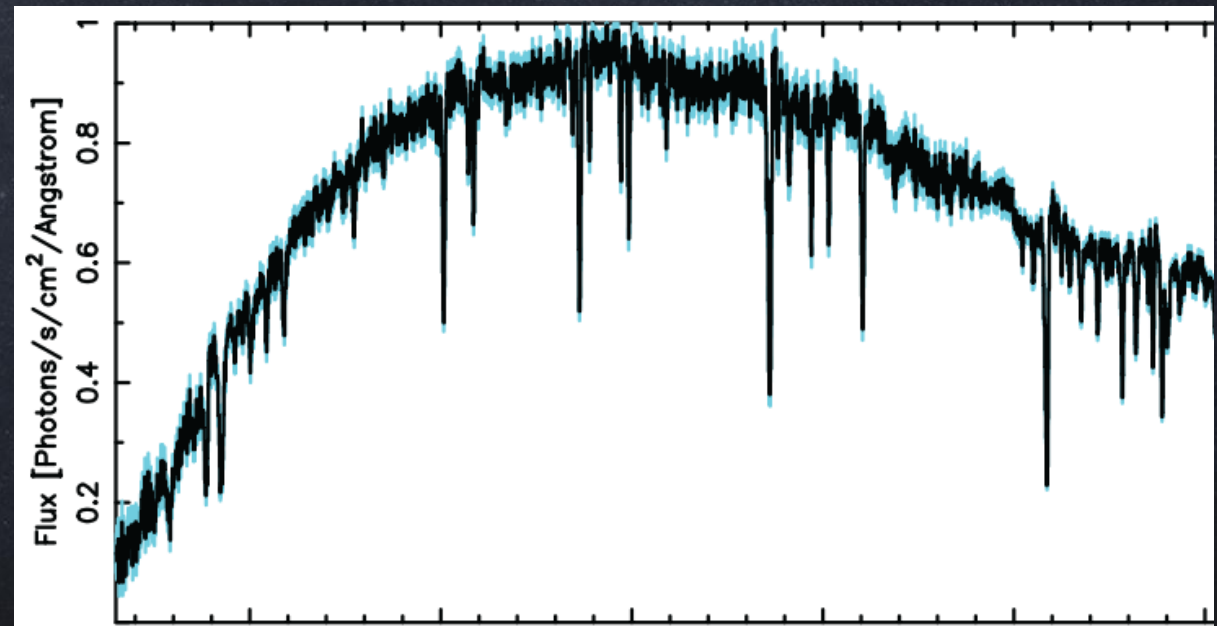
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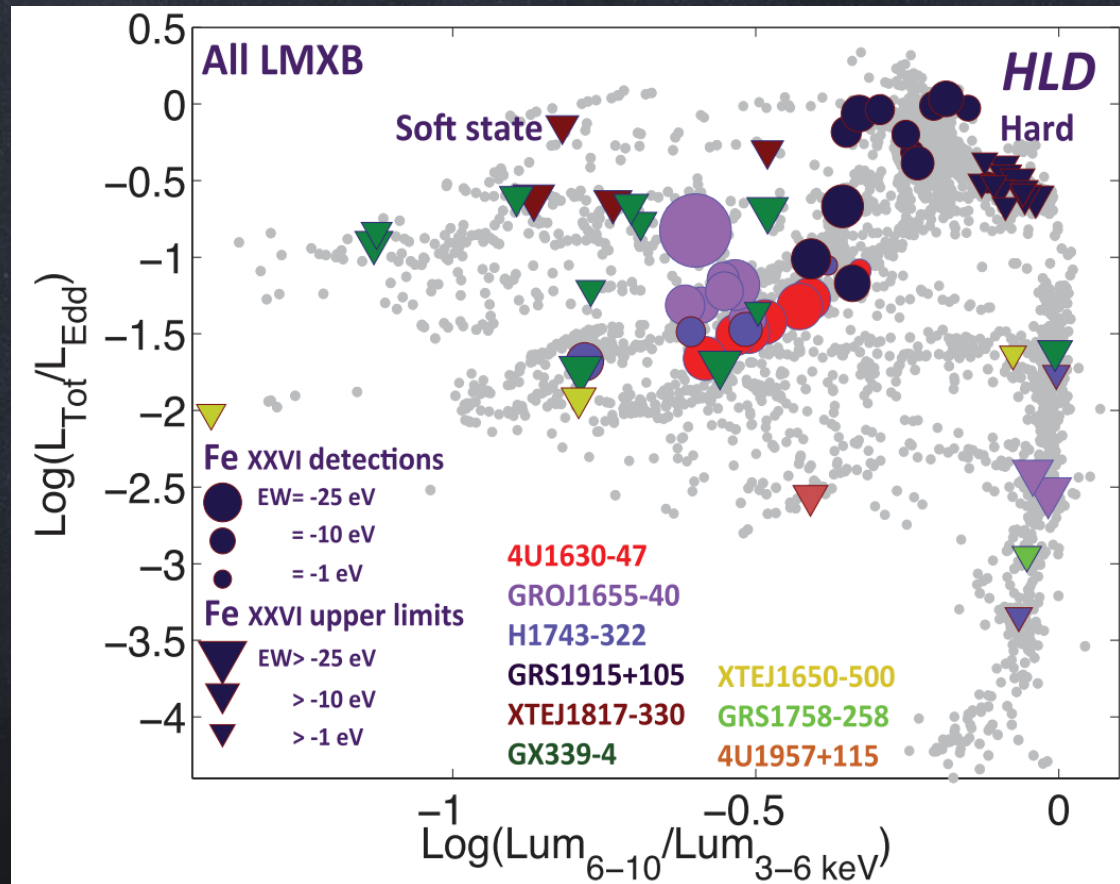
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The current context

- Wind detection in Black Hole X-ray Binaries

□ First global analysis by Ponti et al. in 2012

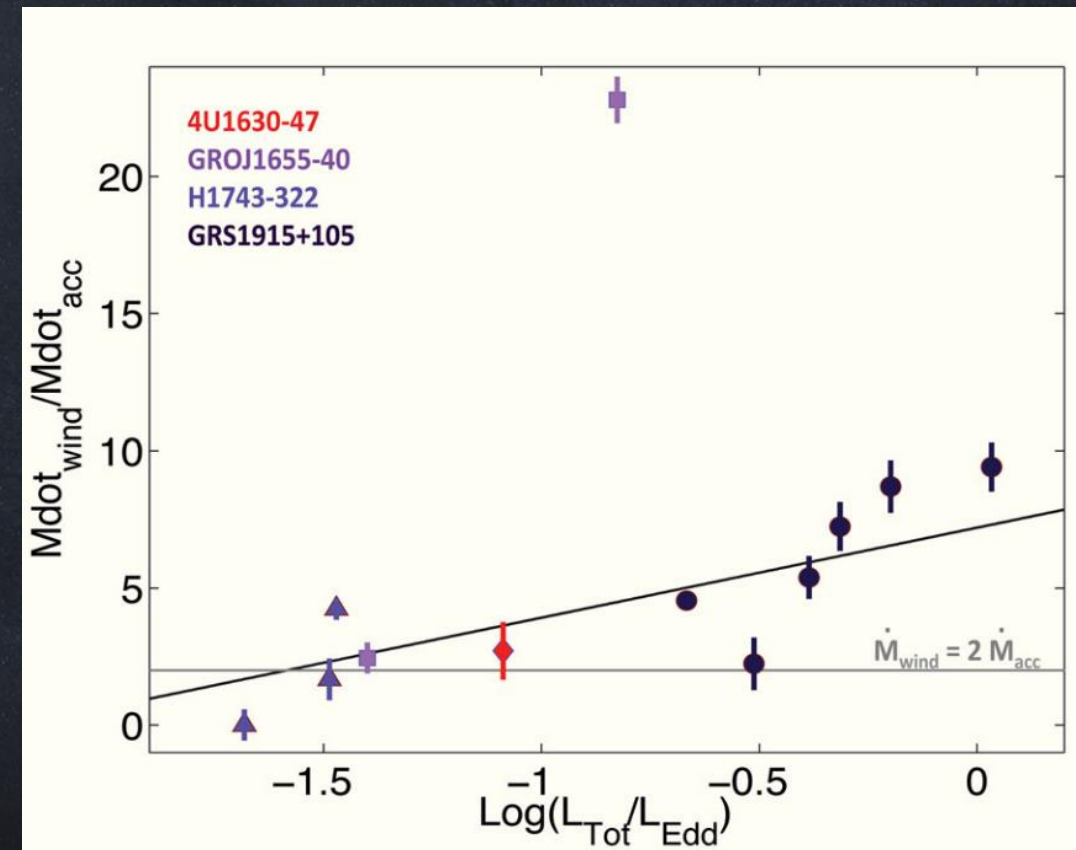
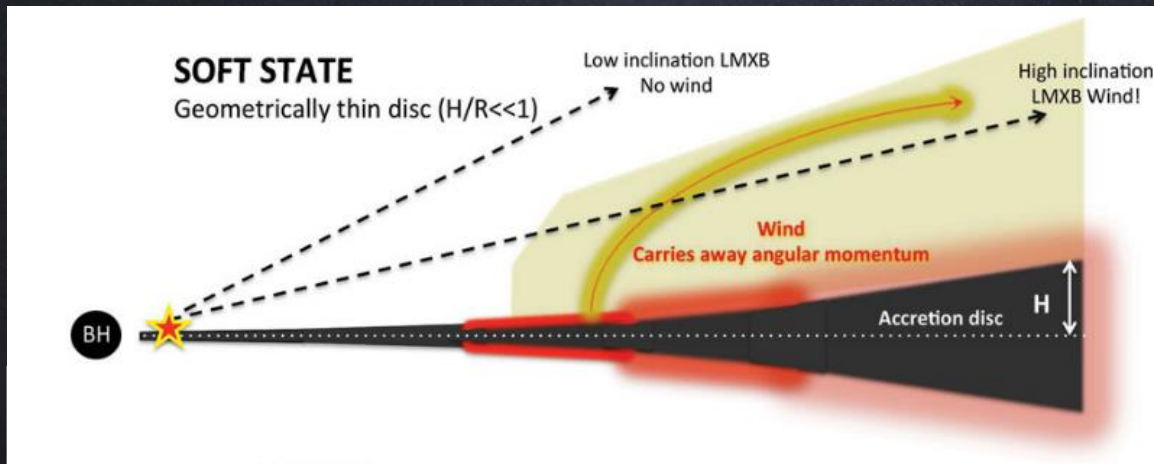


The current context

- Wind detection in Black Hole X-ray Binaries

□ First global analysis by Ponti et al. in 2012

□ Winds → soft state
→ high inclination



The current context

- Wind detection in Black Hole X-ray Binaries

The picture is much more complex now:

- Explain more exotic detections ?
- Thermal and/or MHD driving to launch the gas ?
- Build a coherent picture combining all wavelengths ?

Methodology

Methodology

- Main elements

□ Sample of sources

- All the BHLMBX candidates from BlackCAT[1] + WATCHDOG[2]
68 sources + 13 more

□ Available spectra where we can detect lines of $EW < 75\text{eV}$

- For XMM EPIC PN exposures -> 137 "good" spectra
- For *Chandra* HETG exposures -> 102 "good" spectra
- 42 sources have at least one 'high-quality' spectrum

□ A line detection procedure

Methodology

- Line detection

☐ Methodology

Data reduction



Continuum Fit



Blind Line Search

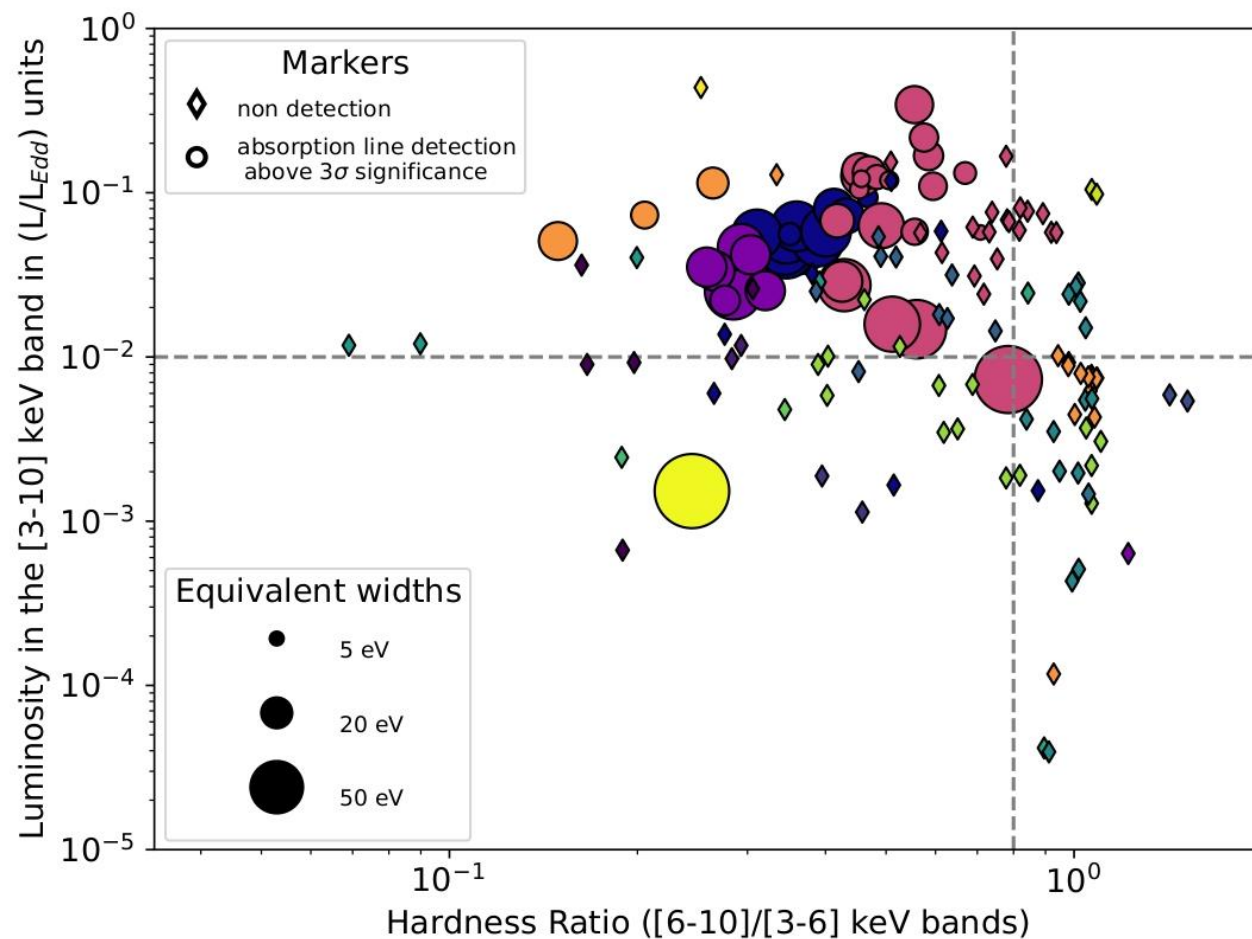


Line fit / Upper limit computation

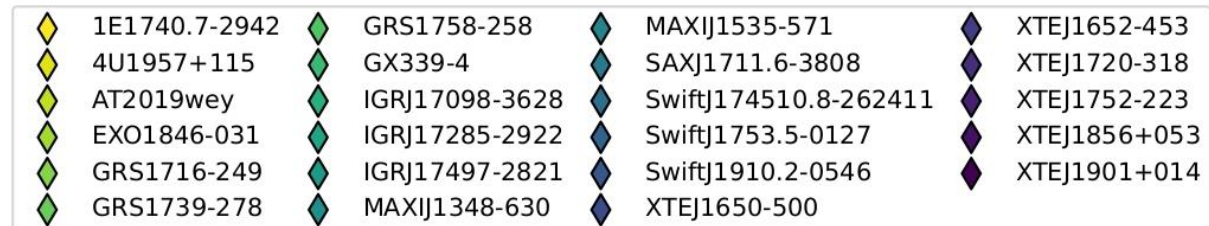
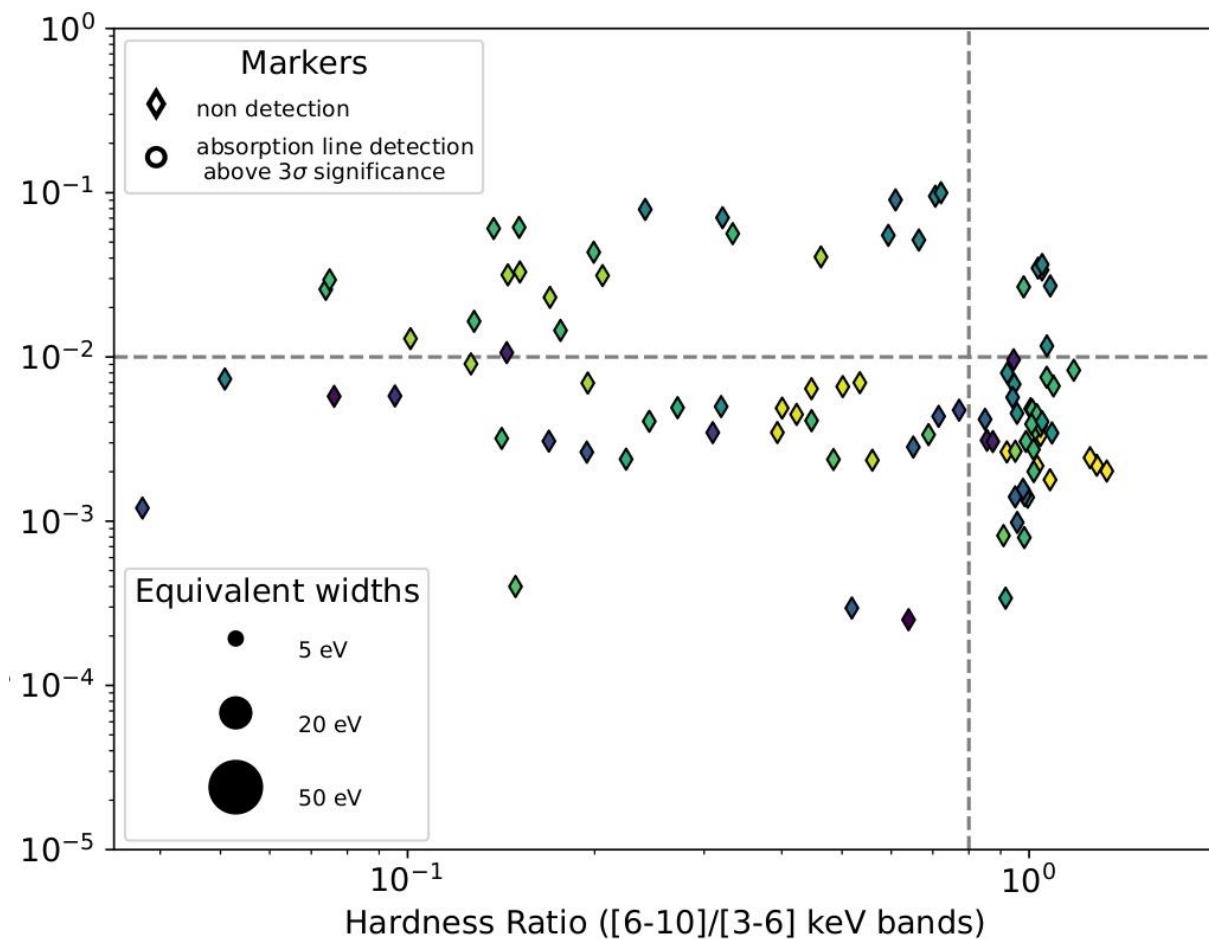
- ☐ Line significance assessment

Results

Global HLD behavior

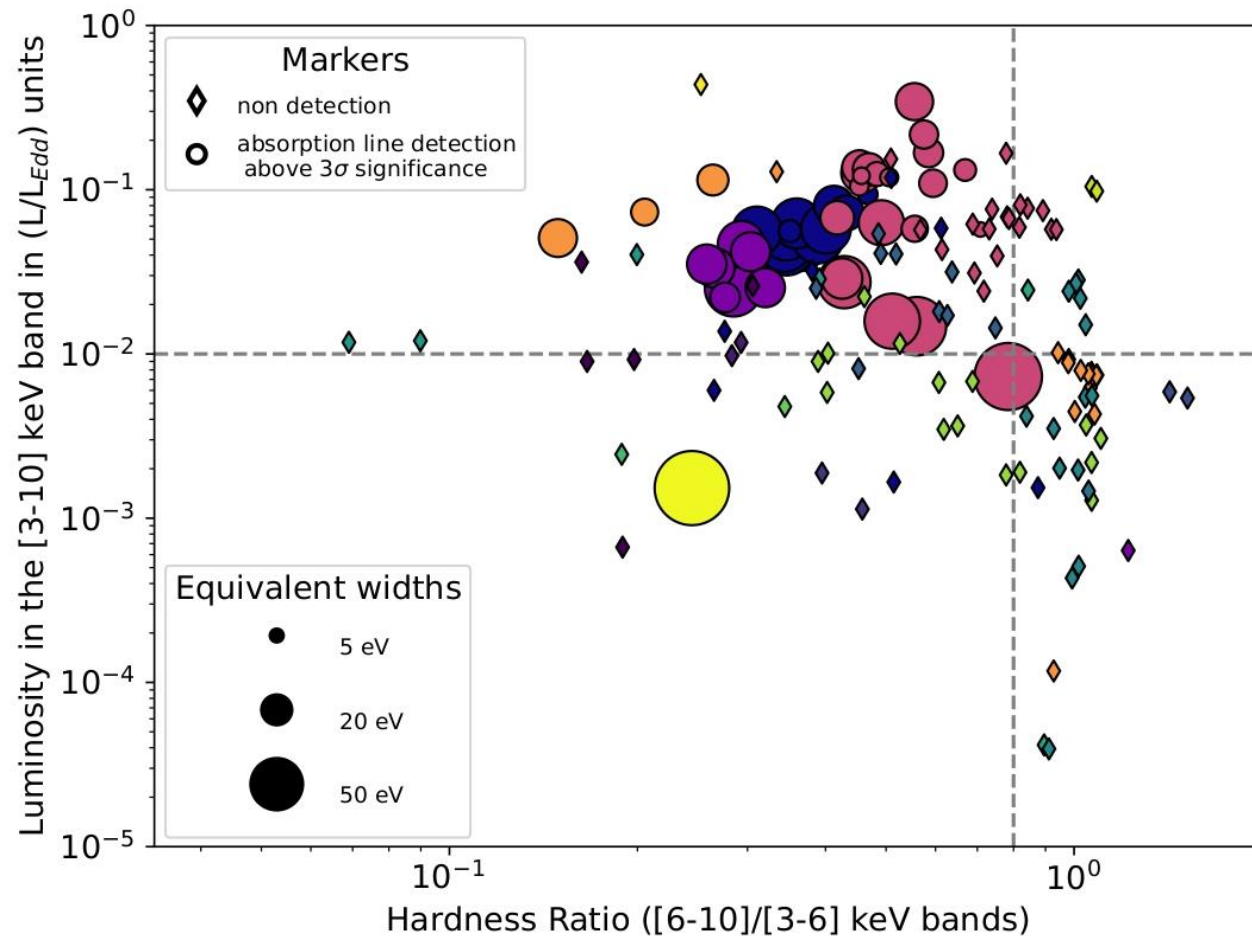


High inclination & dippers



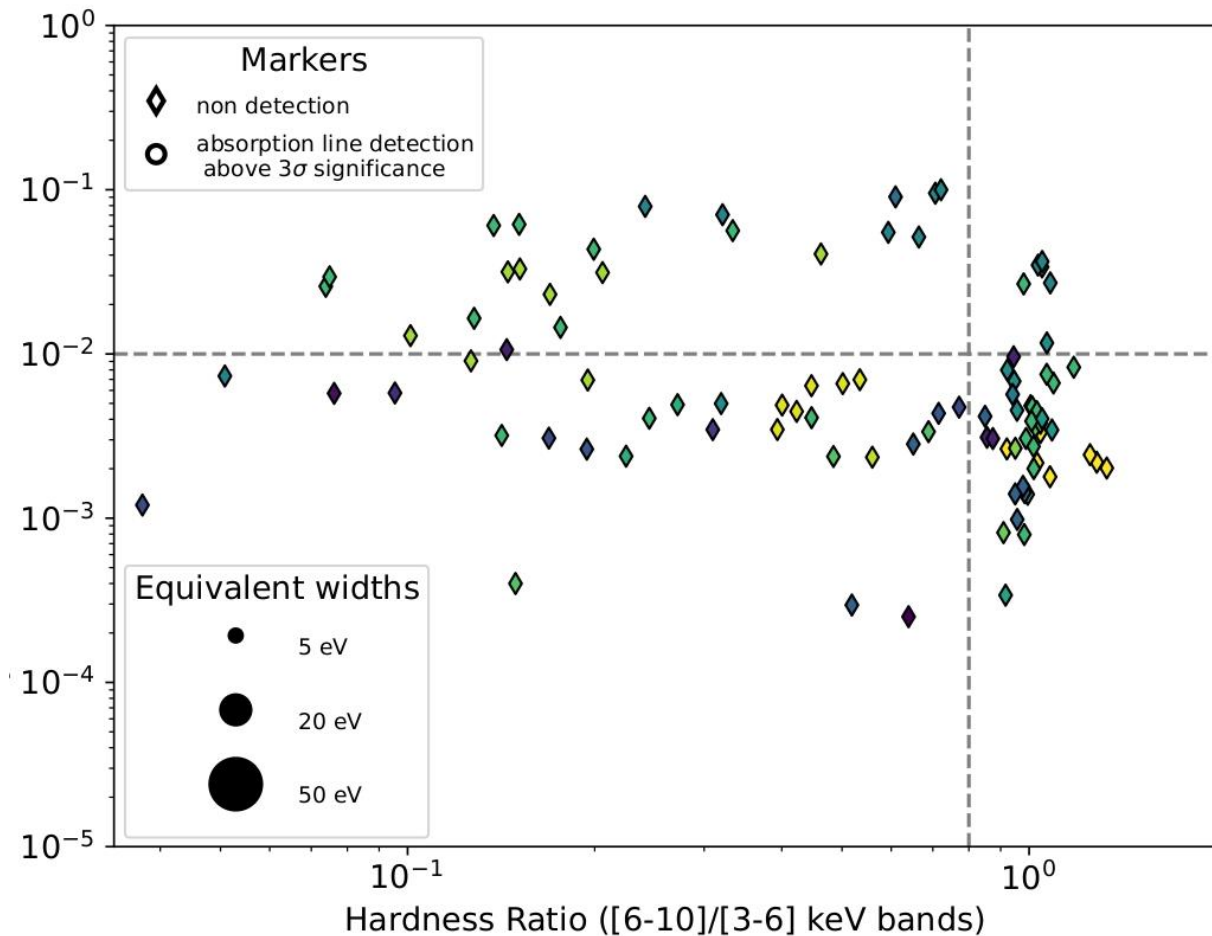
- No detection above HR=0.8
- No standard detection below $L_x/L_{Edd}=0.01$

- No detection at low inclination



High inclination & dippers

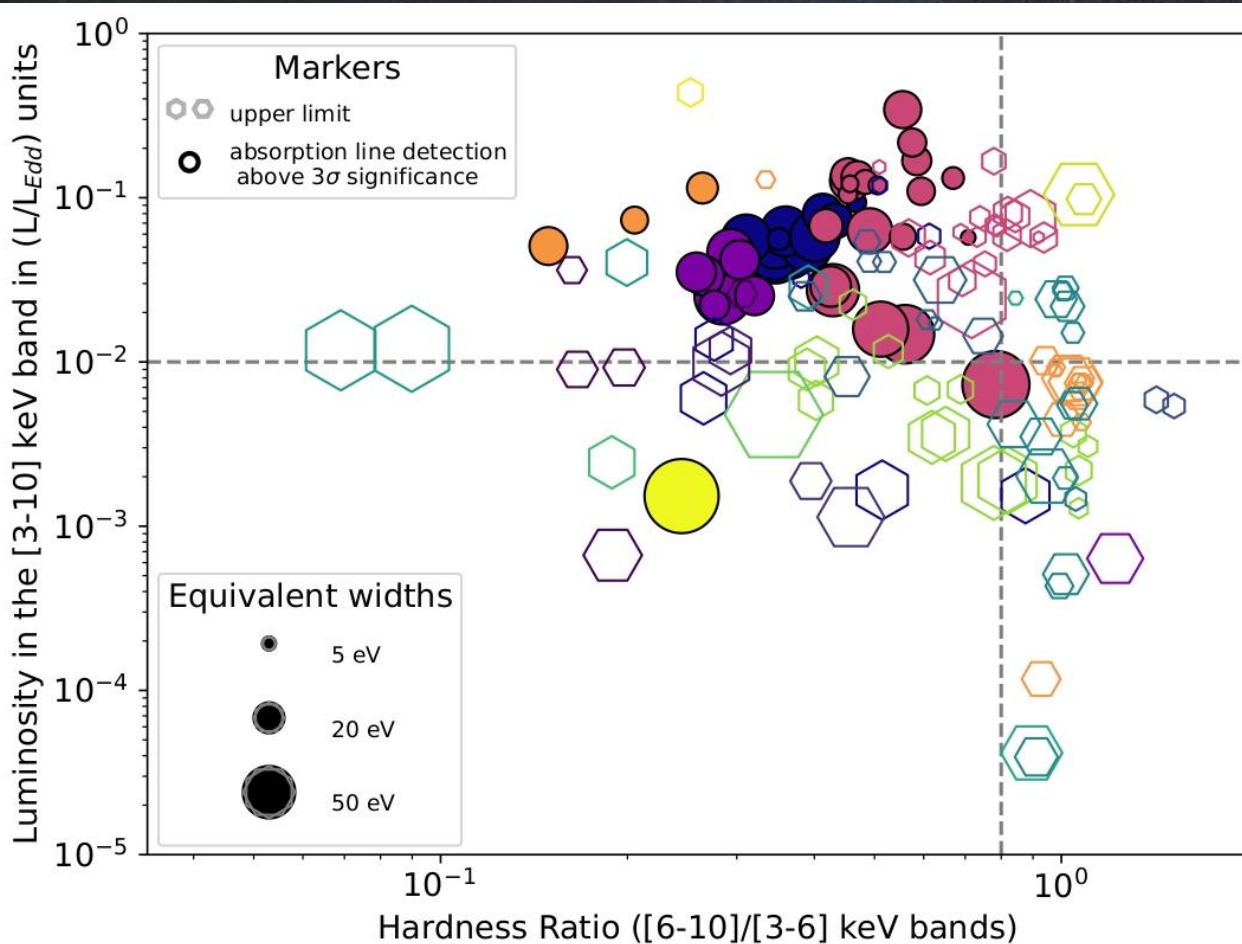
4U1630-47	4U1543-475	MAXIJ1659-152	V404Cyg
GROJ1655-40	GS1354-64	MAXIJ1803-298	V4641Sgr
GRS1915+105	IGRJ17091-3624	MAXIJ1820+070	XTEJ1550-564
H1743-322	MAXIJ0637-430	SwiftJ1357.2-0933	XTEJ1817-330
IGRJ17451-3022	MAXIJ1305-704	SwiftJ1658.2-4242	



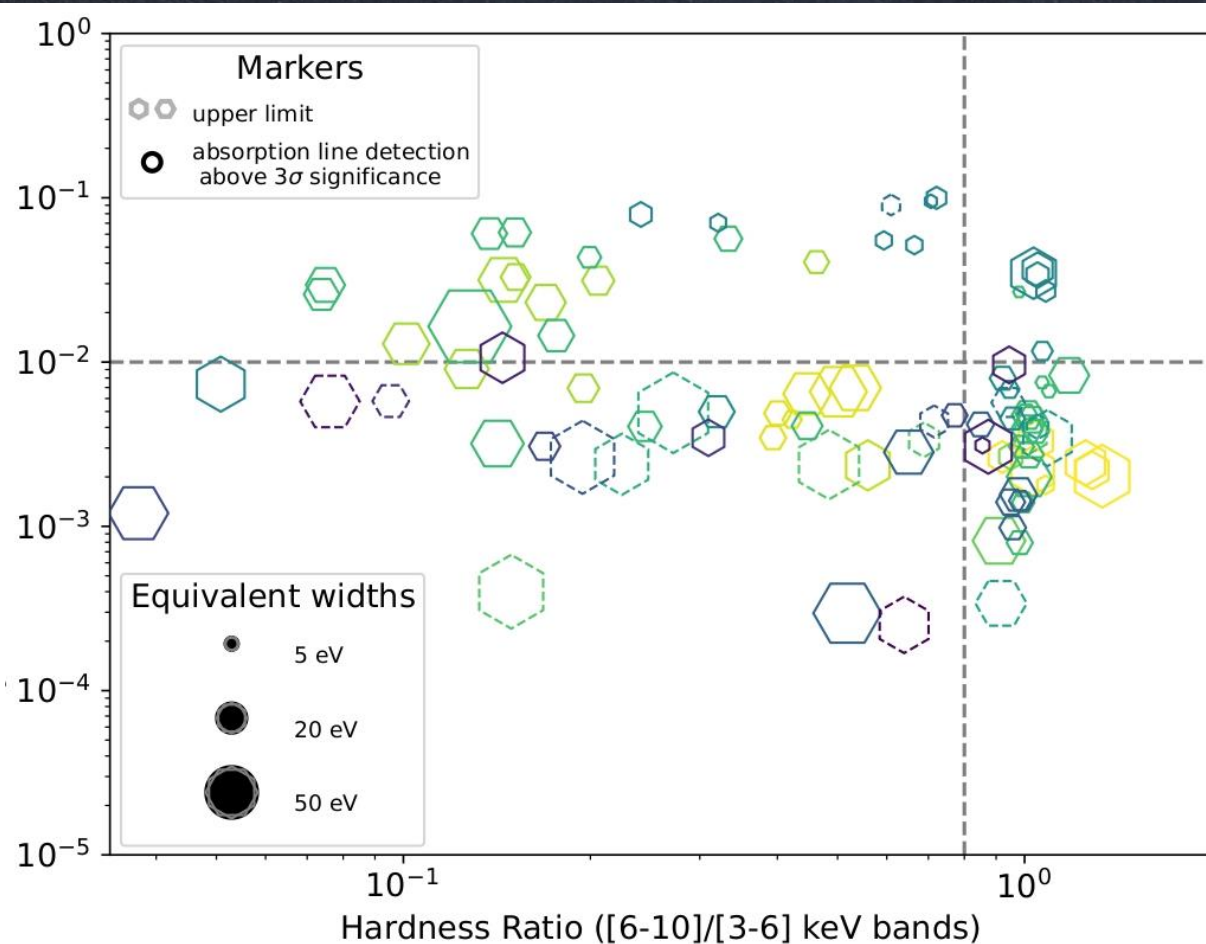
1E1740.7-2942	GRS1758-258	MAXIJ1535-571	XTEJ1652-453
4U1957+115	GX339-4	SAXJ1711.6-3808	XTEJ1720-318
AT2019wey	IGRJ17098-3628	SwiftJ174510.8-262411	XTEJ1752-223
EXO1846-031	IGRJ17285-2922	SwiftJ1753.5-0127	XTEJ1856+053
GRS1716-249	IGRJ17497-2821	SwiftJ1910.2-0546	XTEJ1901+014
GRS1739-278	MAXIJ1348-630	XTEJ1650-500	

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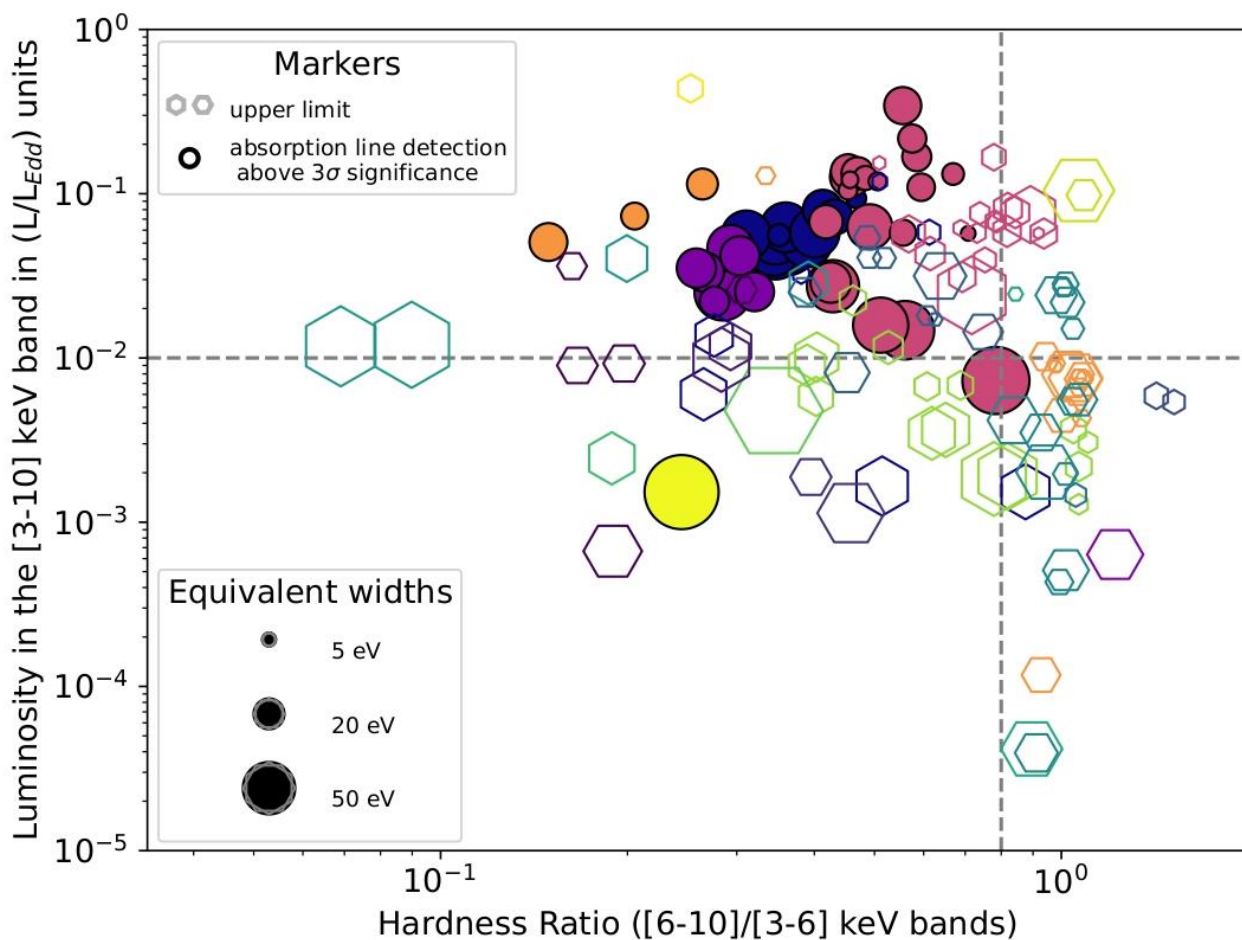
- No detection at low inclination



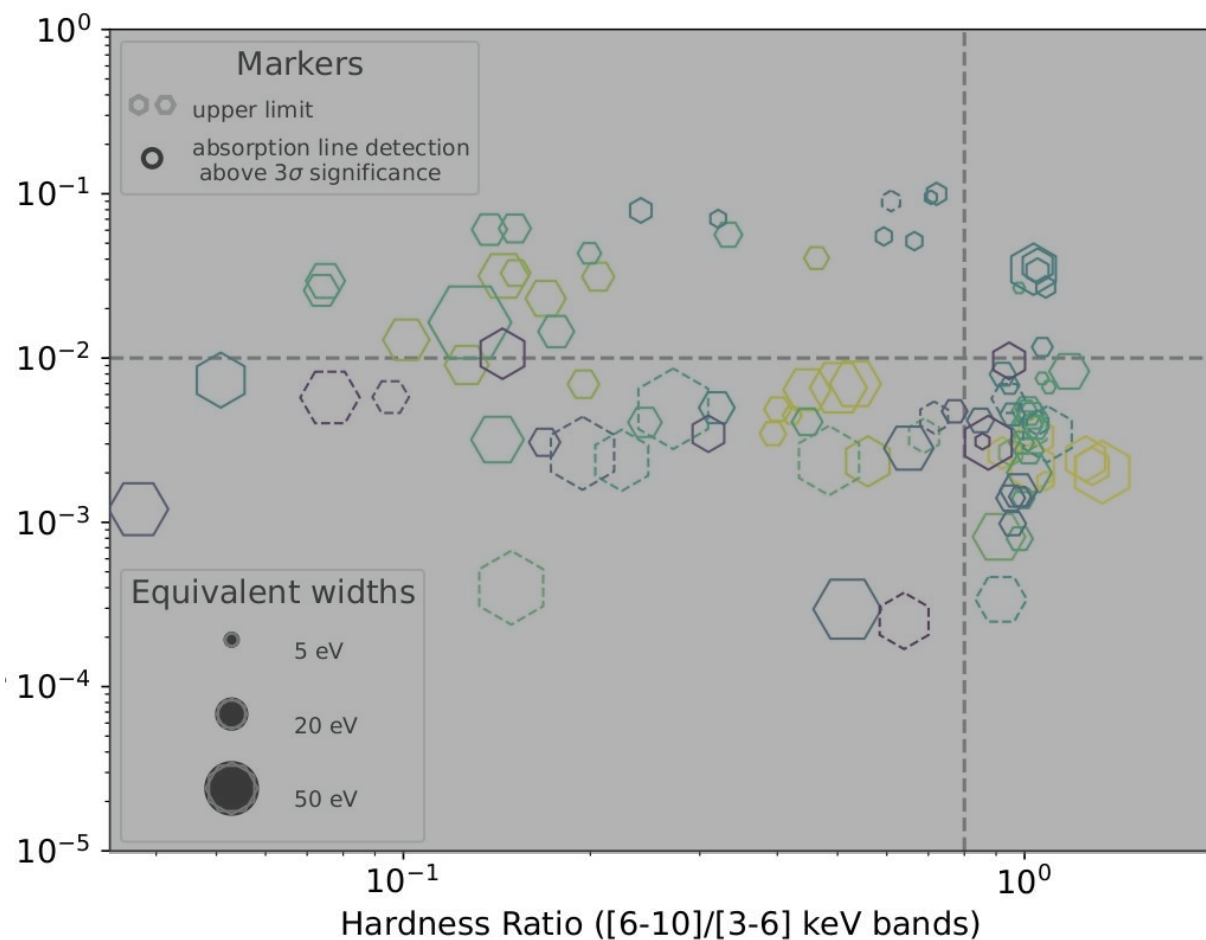
High inclination & dippers



■ No detection at low inclination ?

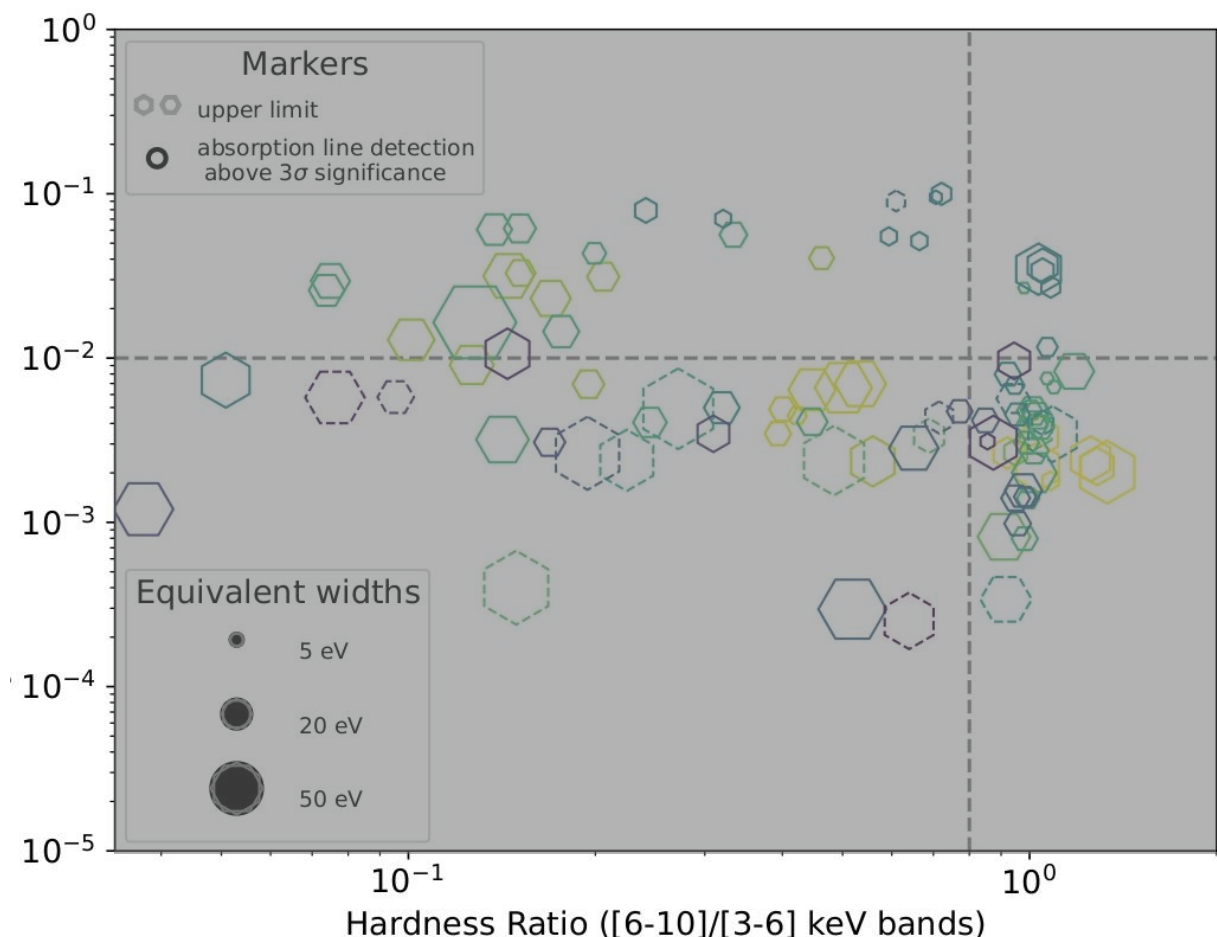
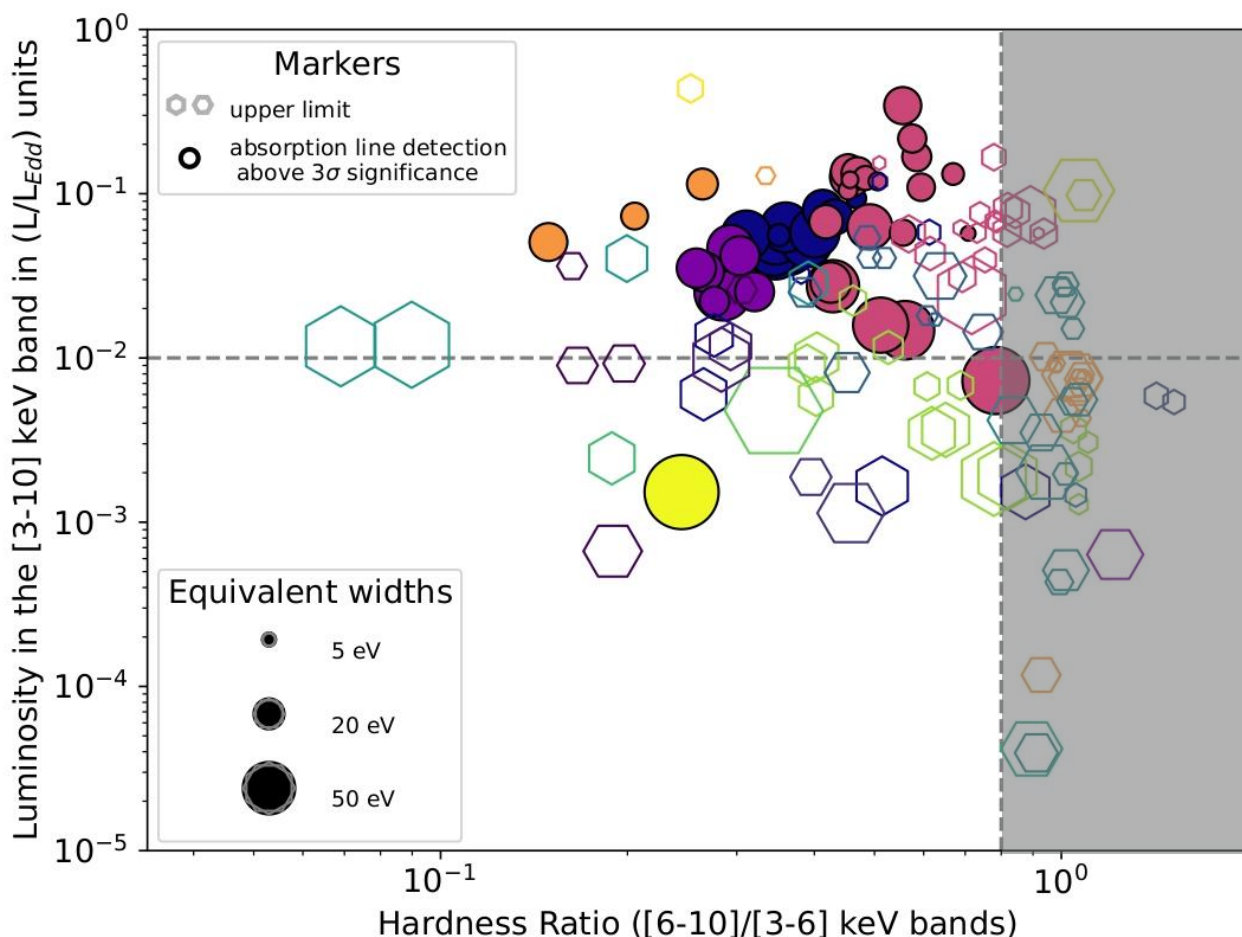


High inclination & dippers



■ No detection above HR=0.8 ?

■ No detection at low inclination ? ✓



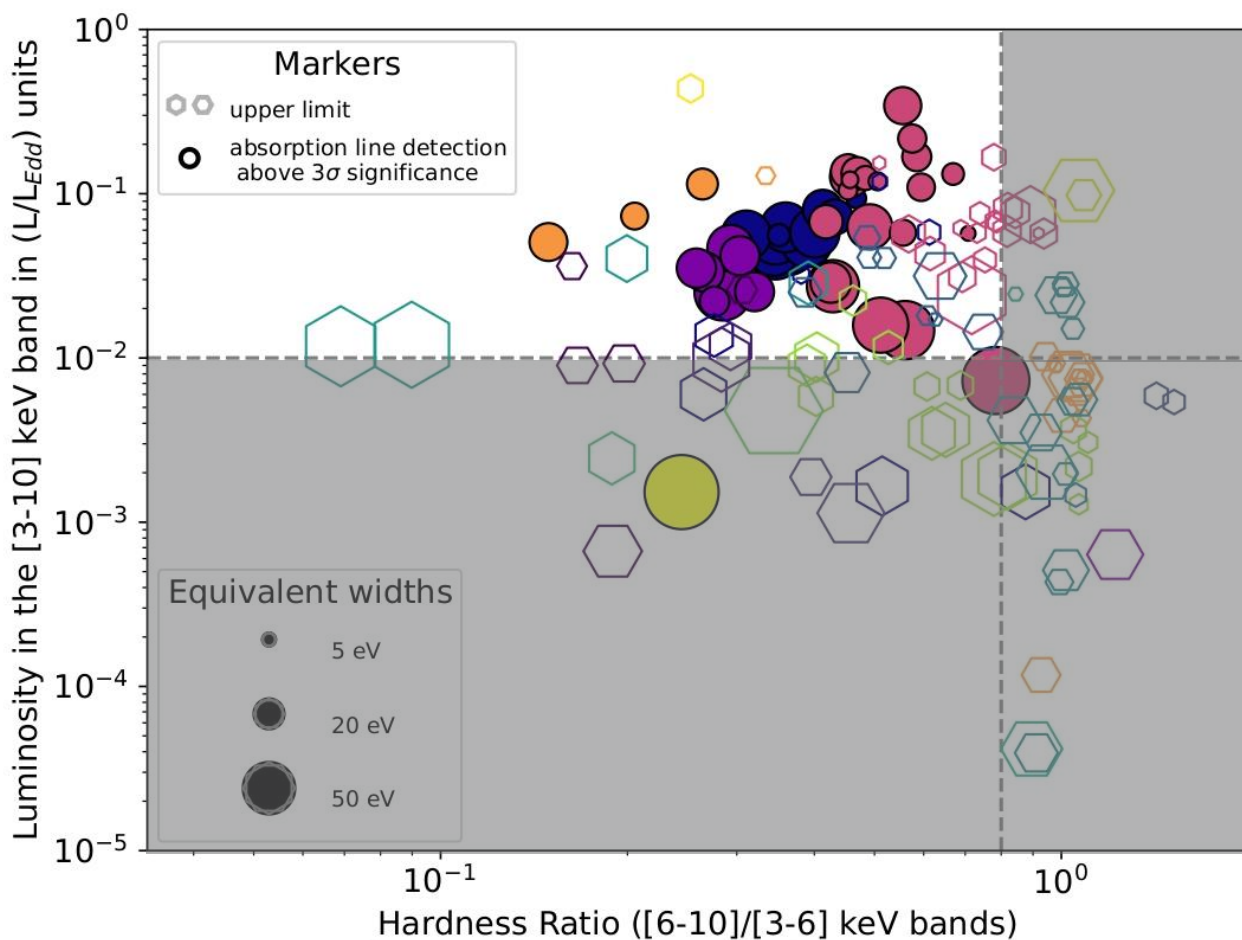
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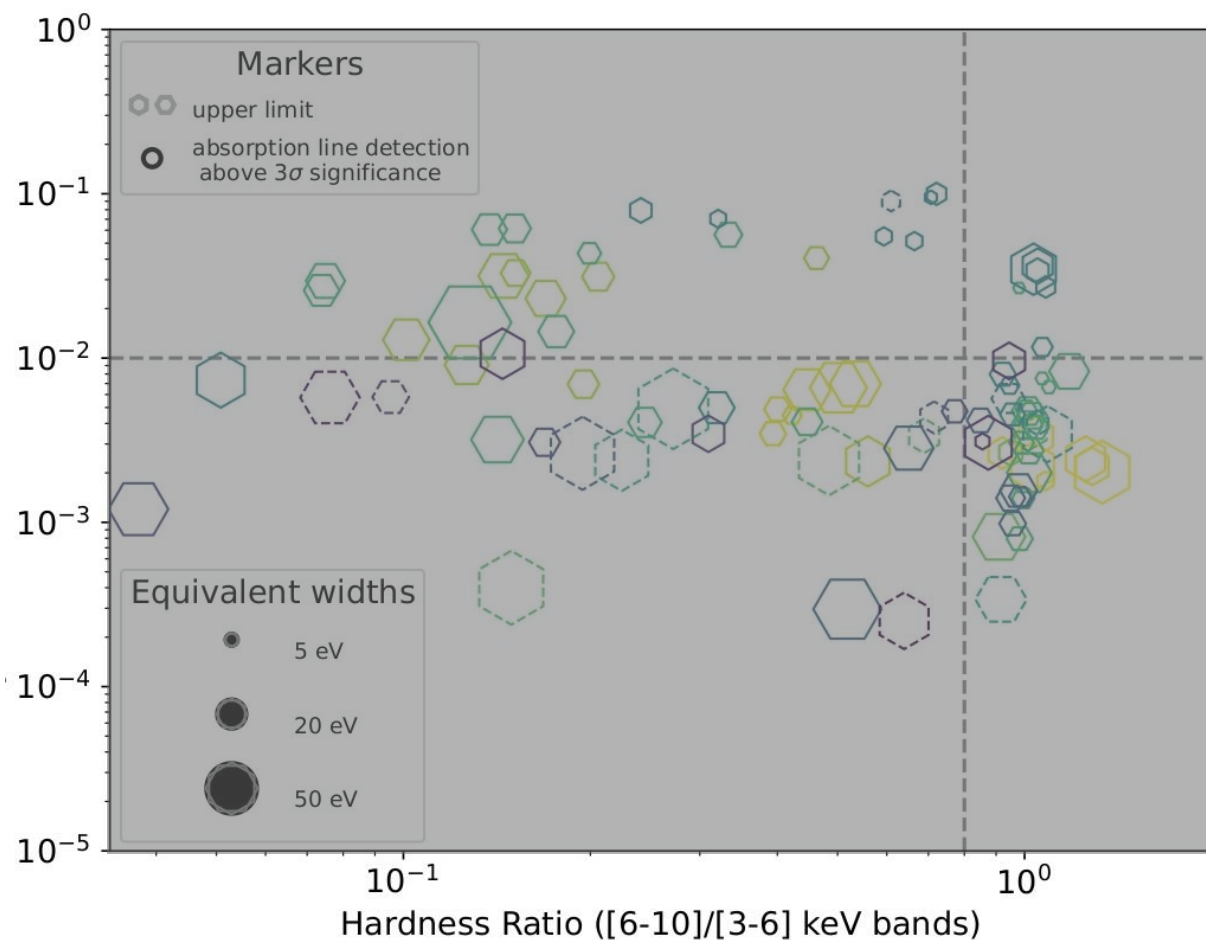
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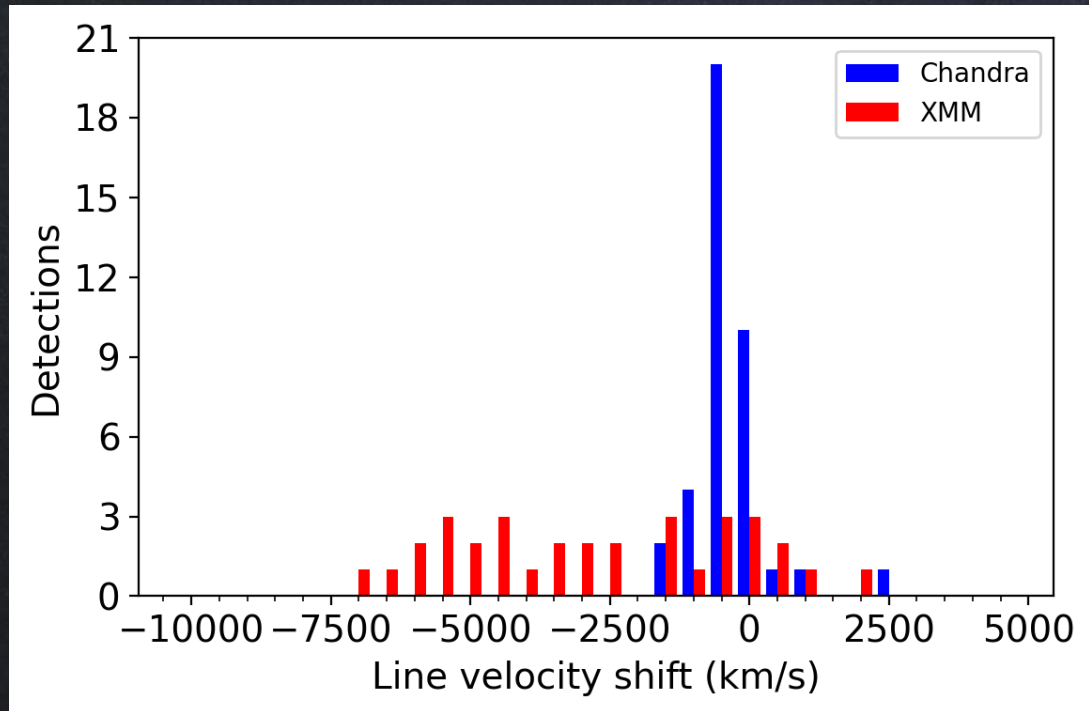


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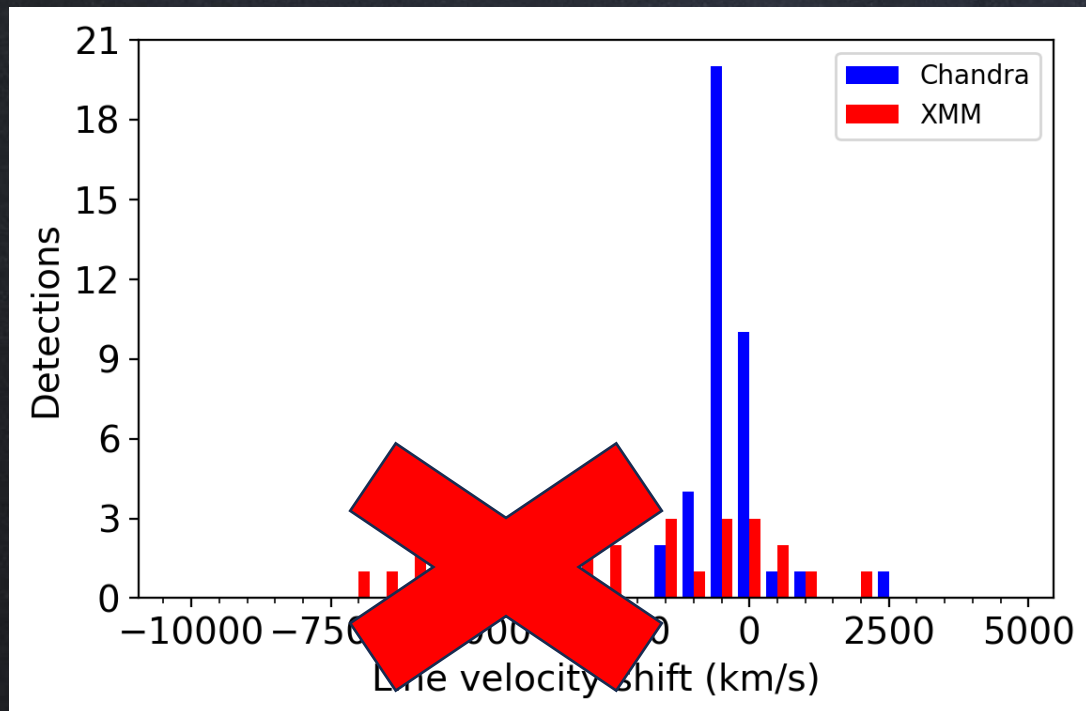
Results

- Distributions of line parameters



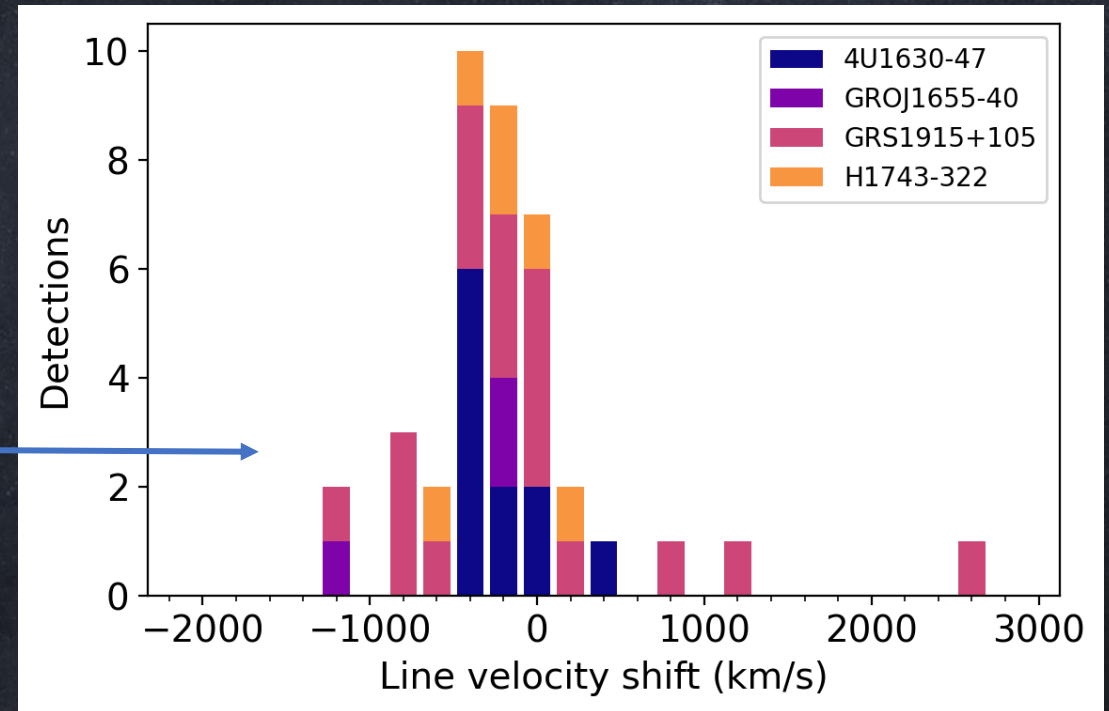
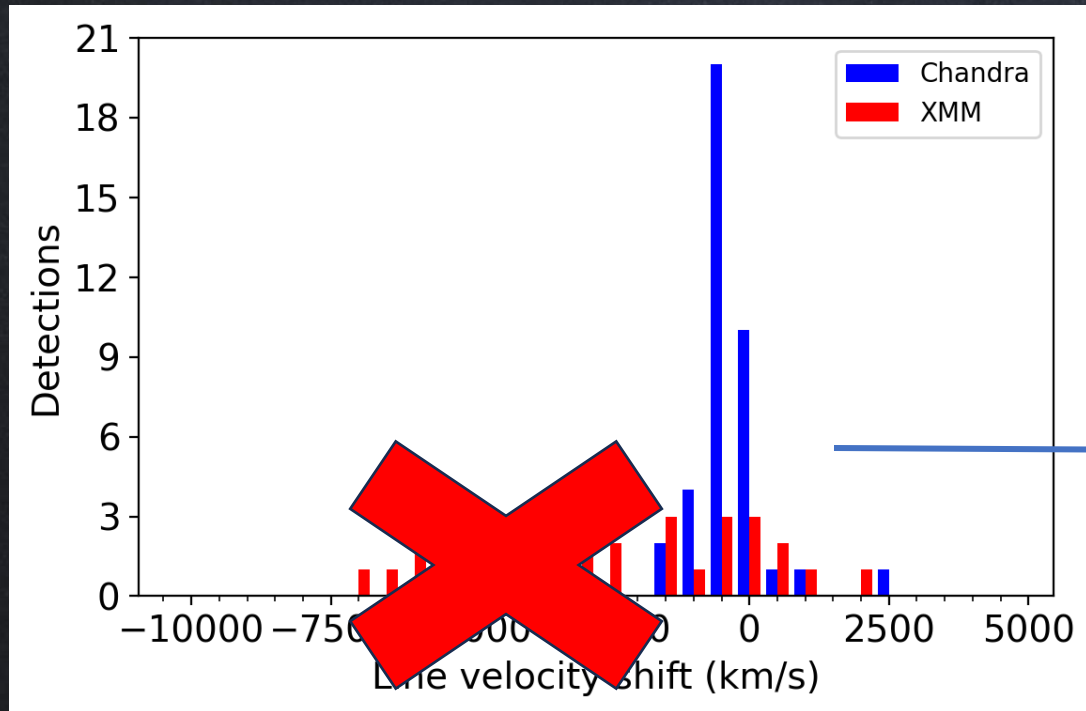
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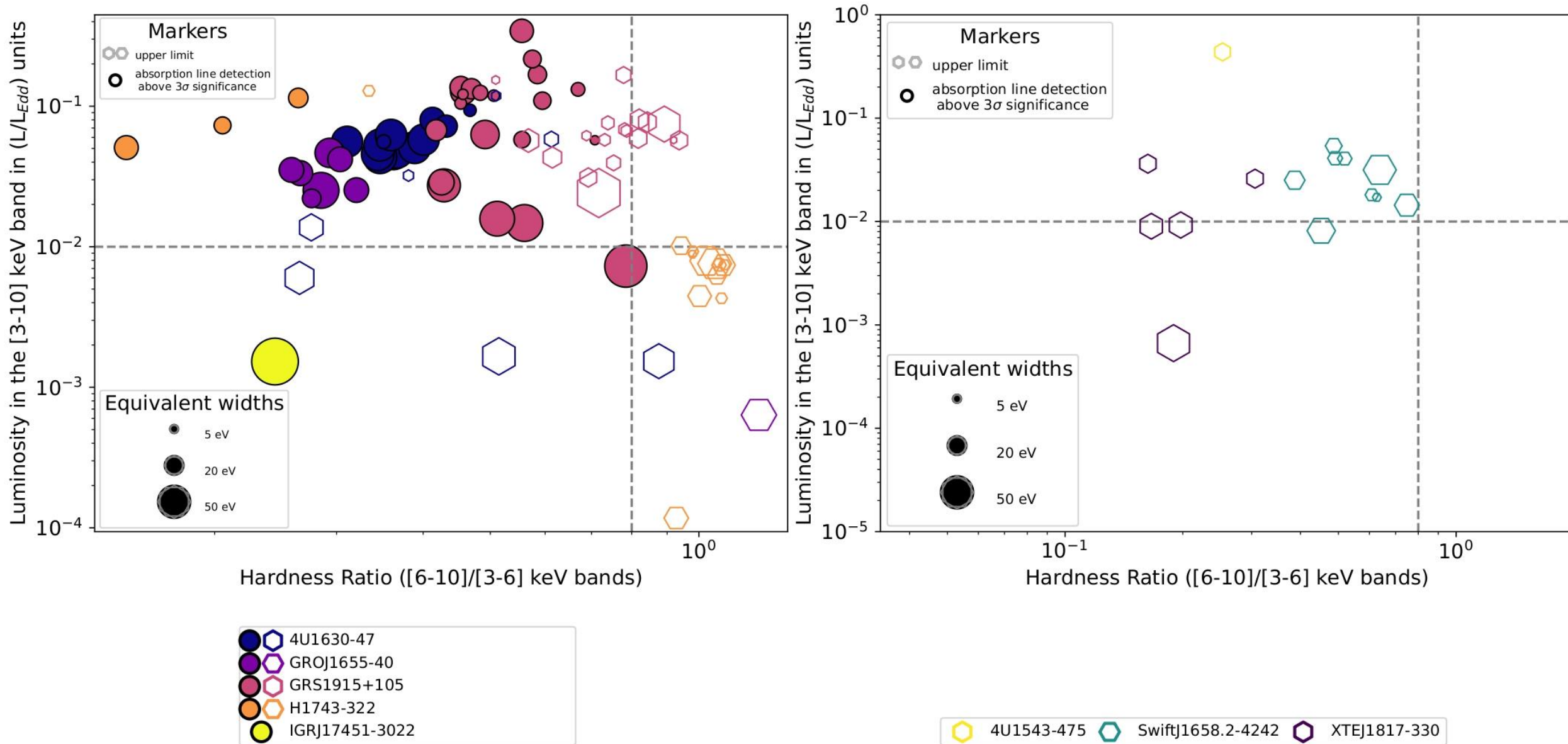
- Distributions of line parameters



$$\mu = -200 \pm 60 \text{ km/s}$$

$$\sigma = 360 \text{ km/s}$$

▪ Non detections in the favorable zone



Comparisons & Conclusion

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- The bigger picture

□ Current Sample

- 5 sources with detections, all dippers
- Almost all soft states
- Blueshifts of few 100km/s

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□ Literature in the X-rays

- Few other sources with detections, **almost all high inclination**
- Multiple detections in the hard state BUT **vast majority embedded in strong reflection components**
- Mostly **low blueshifts** except for **secondary components** and when **mixed with reflection**

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□ Literature in Visible & Infrared

- Other sources, **almost all high inclination**
- **Visible only in hard state, IR everywhere**
- **Higher blueshifts** (few 1000km/s)

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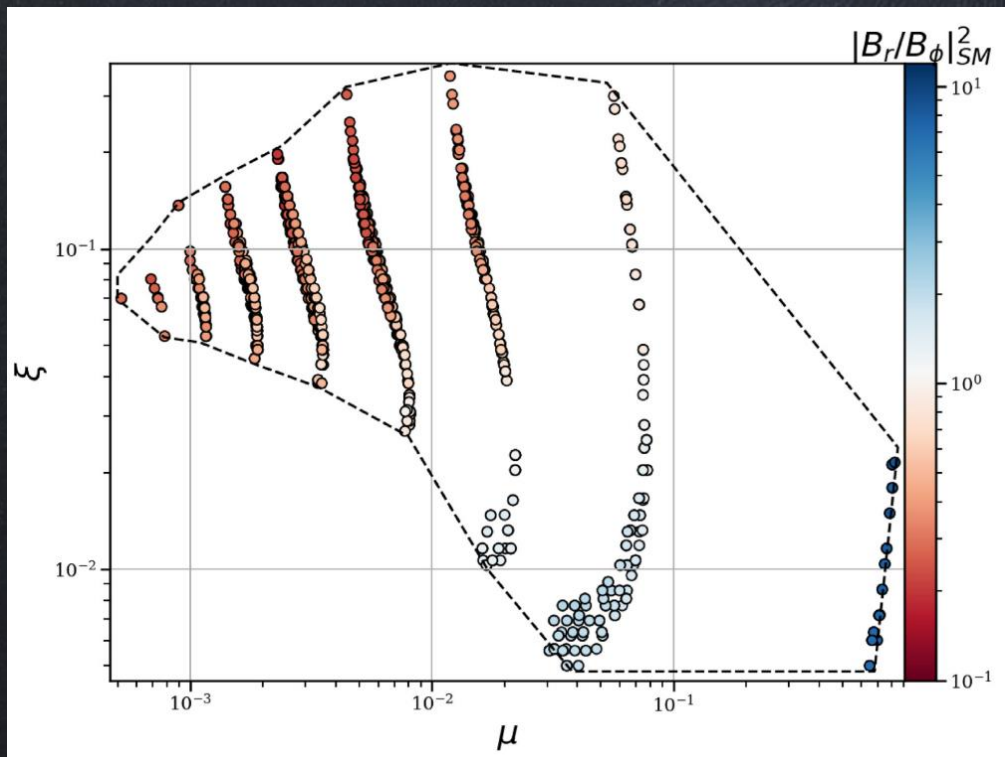
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Comparisons & Conclusion

Current work

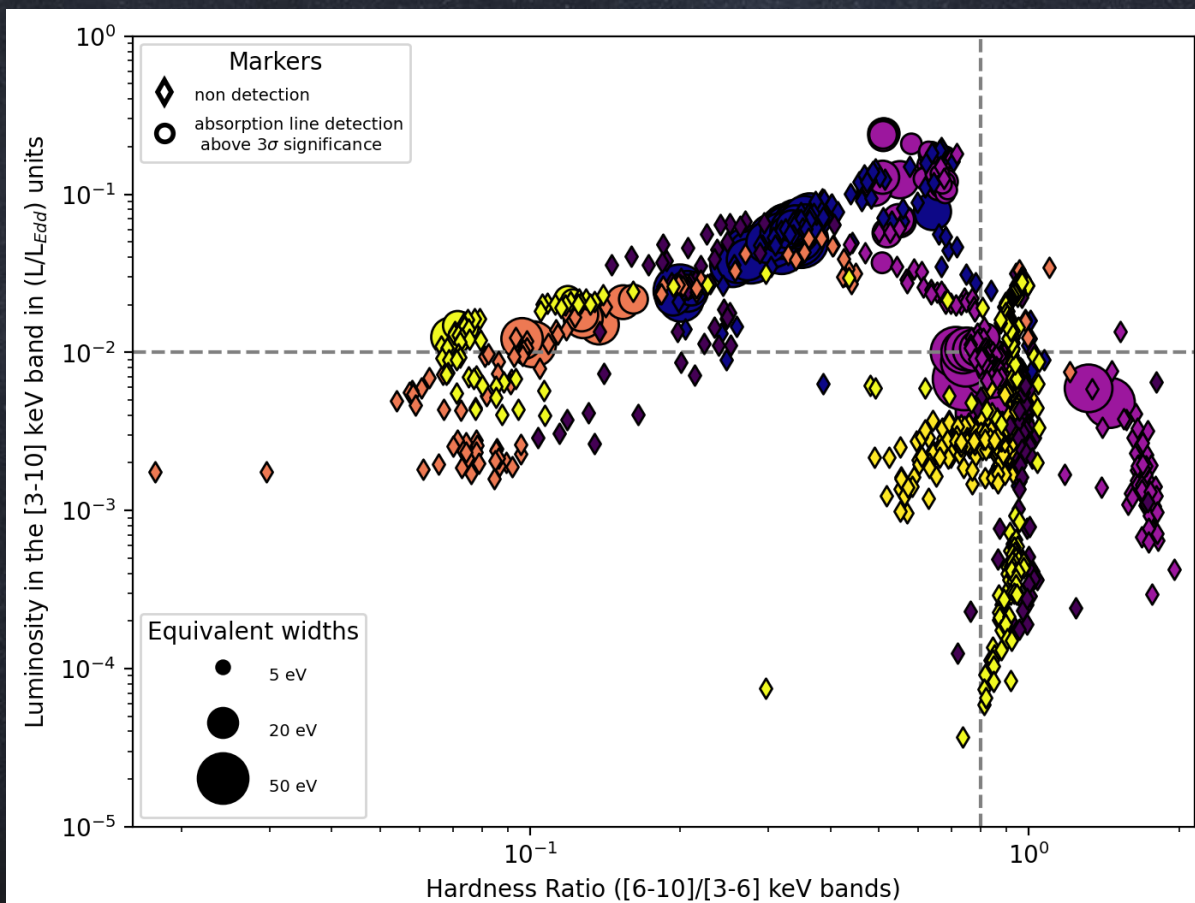
Self similar modeling



VS

- high resolution detections
- high resolution non-detections
- evolutions during single outbursts

NICER archive



Thanks for your attention !

Bonus

<https://visual-line.streamlit.app/>

Sample selection

Telescopes

XMM x Chandra x

Display options:

- All Objects
- Multiple Objects
- Single Object

Absorption lines restriction

Inclination

Restrict time interval

Detection significance threshold

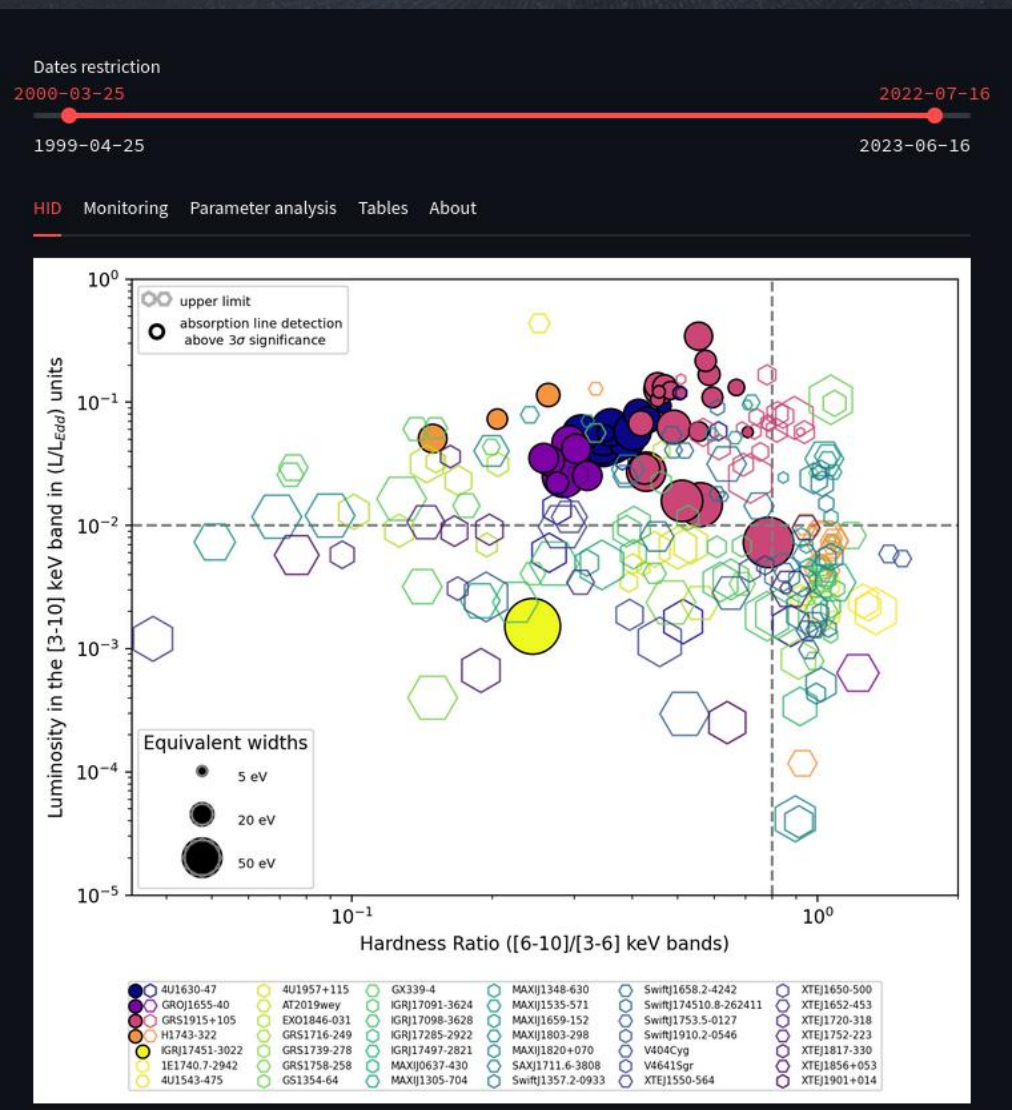
0.900 0.997 1.000

HID options

Show detections below significance threshold

HID colormap

- Source
- Velocity shift
- Delta C
- EW ratio
- Inclination
- Time



Bonus

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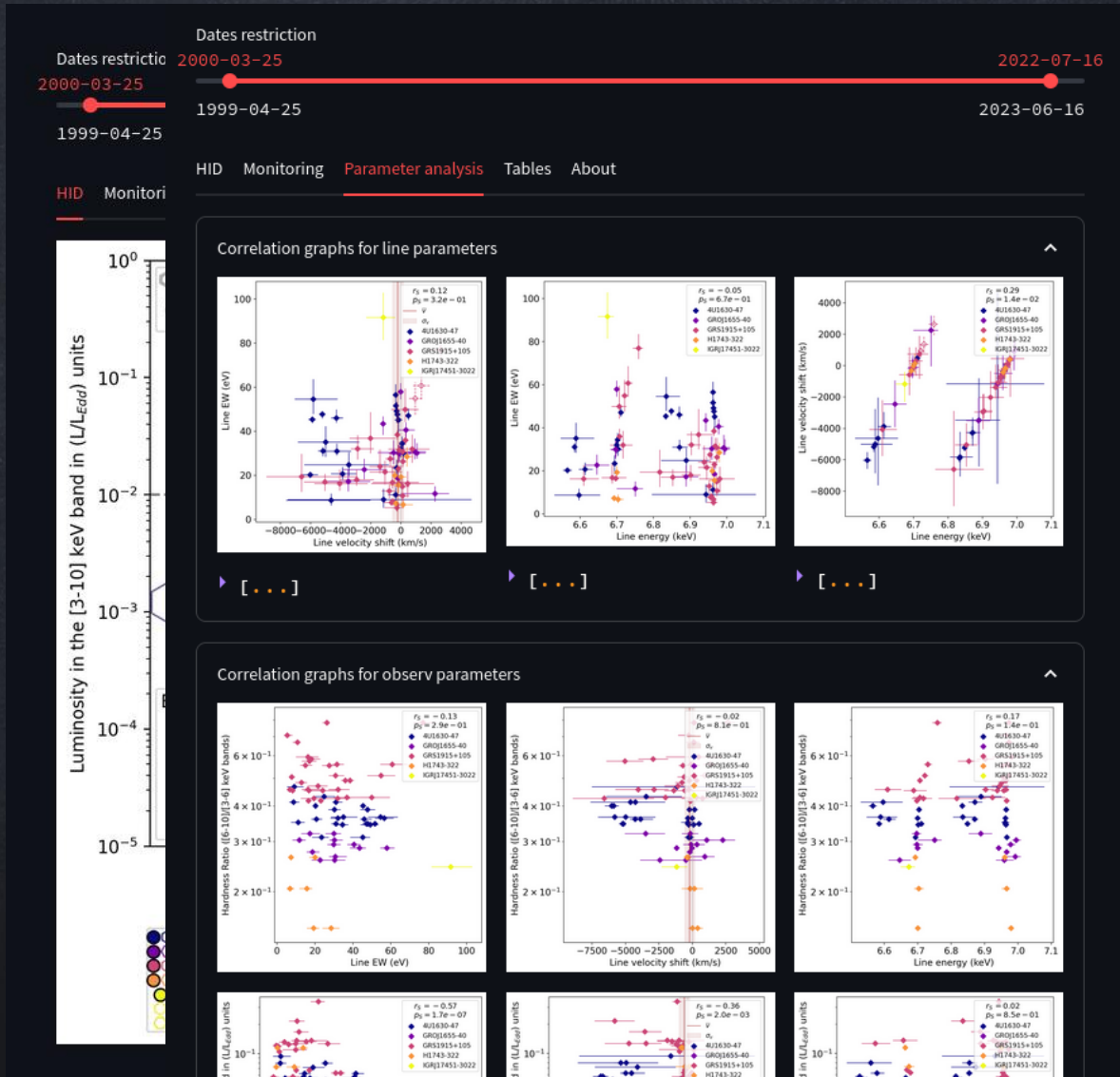
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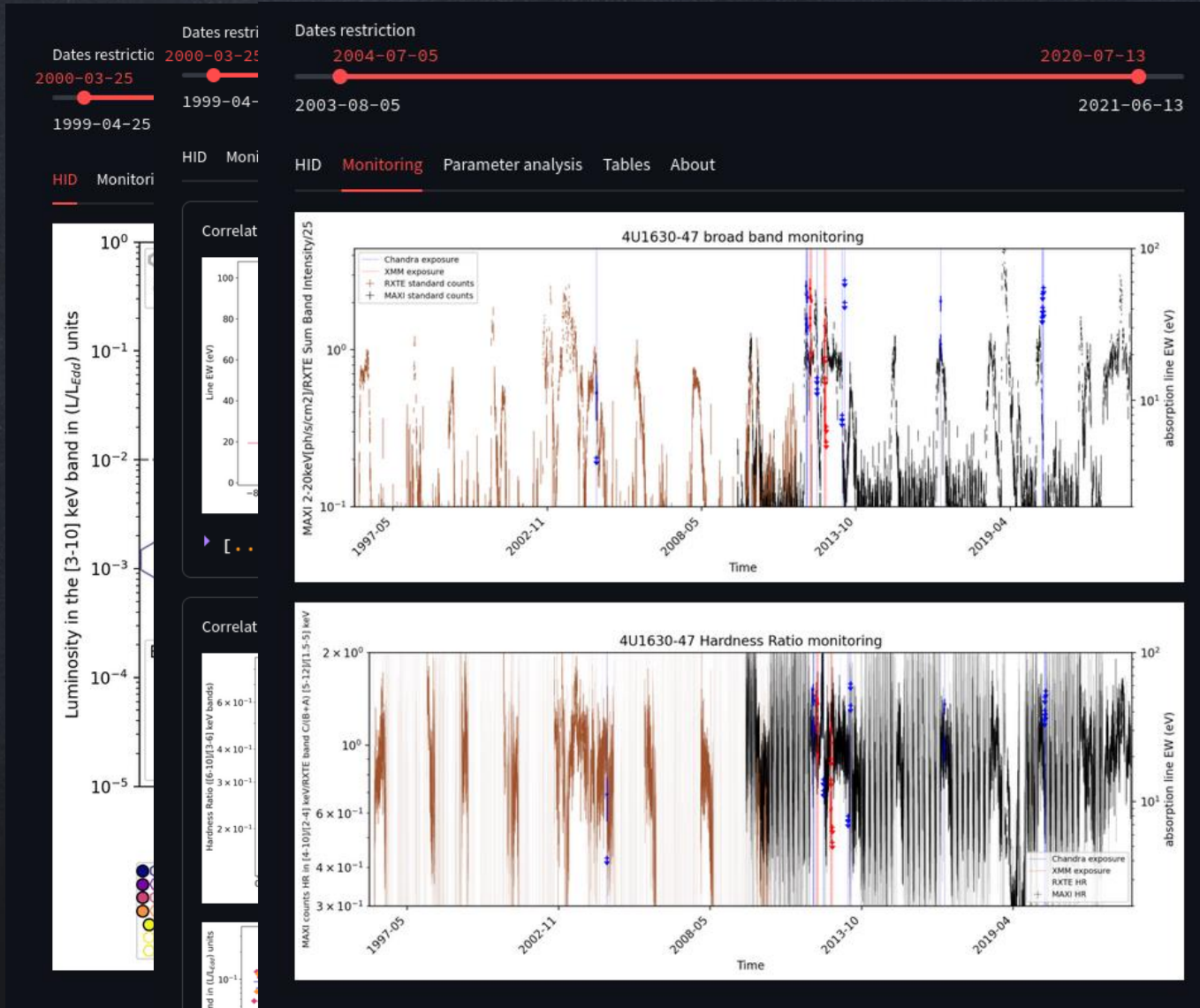
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HID colormap

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- EW ratio
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- Time

Dates restriction

2000-03-25 2000-03-25 1999-04-25

Dates restricti

2004- 1999-04- 2003-08-

Dates restric

2004- 2003-08-

Dates restriction

2004-07-05 2003-08-05 2020-07-13 2021-06-13

HID Moni

HID Monit

HID Monitoring Parameter analysis Tables About

Source parameters

Observation parameters

Line parameters

Source	obsid	date	line	EW	EW	EW	blueshift	blueshift
				⚠ main	⚠ err-	⚠ err+	⚠ main	⚠ err-
4U1630-47	13714	2004-08-04T13:25:37	FeKa25abs	0	0	0	None	None
4U1630-47	13714	2004-08-04T13:25:37	FeKa26abs	11.2135	3.842	3.3277	-346.5681	506.962
4U1630-47	13715	2012-01-17T04:24:48	FeKa25abs	32.0083	3.9126	3.6482	-12.4028	140.714
4U1630-47	13715	2012-01-17T04:24:48	FeKa26abs	56.5761	5.0119	4.8488	-340.8134	142.71
4U1630-47	13716	2012-01-20T23:44:57	FeKa25abs	34.4904	4.6703	3.1515	84.0207	147.153
4U1630-47	13716	2012-01-20T23:44:57	FeKa26abs	49.178	5.1341	4.1755	-278.63	140.704
4U1630-47	13717	2012-01-26T13:01:41	FeKa25abs	47.159	2.0524	3.2722	483.414	215.419
4U1630-47	13717	2012-01-26T13:01:41	FeKa26abs	51.6373	2.9434	1.3012	-336.7929	93.2334
4U1630-47	14441	2012-01-30T08:49:46	FeKa25abs	30.201	3.1937	3.3852	152.8765	266.286

Download as CSV

Luminosity in the [3-10] keV band in (L/L_{Edd}) units

Correlat

Line EW (eV)

MAXI 2-20keV(ph/s/cm²/RXTE Sum Band Intensity/25

1997-08

Correlat

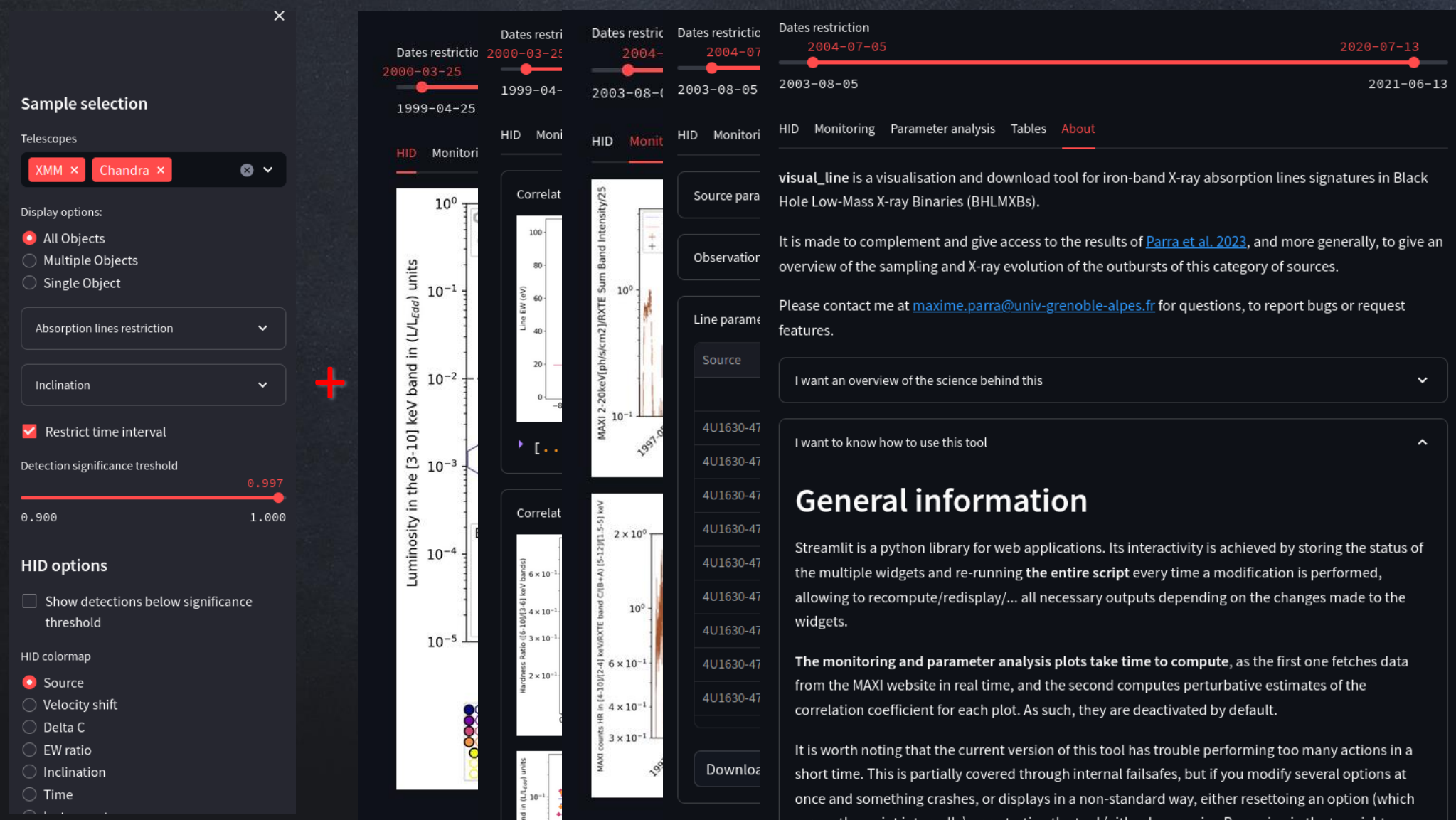
Hardness Ratio (6-10/[3-4] keV bands)

MAXI counts_HR in [4-10]/[2-4] keV/RXTE band C(B+A) (5-12)/[1.5-5] keV

1997-08

Bonus

<https://visual-line.streamlit.app/>



The screenshot shows the 'visual_line' web application interface. On the left, there is a sidebar with 'Sample selection' containing 'Telescopes' (XMM, Chandra) and 'Display options' (All Objects, Multiple Objects, Single Object). Below this are 'Absorption lines restriction', 'Inclination', and 'Restrict time interval' (checked). A 'Detection significance threshold' slider is set to 0.997. The 'HID options' section includes 'Show detections below significance threshold' (unchecked) and 'HID colormap' (Source selected). The main area features a 'Dates restriction' timeline from 1999-04-25 to 2021-06-13. Below the timeline are tabs for 'HID Monitoring', 'Parameter analysis', 'Tables', and 'About'. The 'HID Monitoring' tab is active, displaying a grid of plots: a large plot of 'Luminosity in the [3-10] keV band in (L/L_{Edd}) units' on a log scale, and smaller plots for 'Correlat' and 'MAXI 2-20keV(ph/cm²/RXTE Sum Band Intensity/25'. A 'Source para' table lists source IDs like 4U1630-47. A 'Download' button is visible at the bottom.

visual_line is a visualisation and download tool for iron-band X-ray absorption lines signatures in Black Hole Low-Mass X-ray Binaries (BHLMXBs).

It is made to complement and give access to the results of [Parra et al. 2023](#), and more generally, to give an overview of the sampling and X-ray evolution of the outbursts of this category of sources.

Please contact me at maxime.parra@univ-grenoble-alpes.fr for questions, to report bugs or request features.

I want an overview of the science behind this

I want to know how to use this tool

General information

Streamlit is a python library for web applications. Its interactivity is achieved by storing the status of the multiple widgets and re-running the entire script every time a modification is performed, allowing to recompute/redisplay/... all necessary outputs depending on the changes made to the widgets.

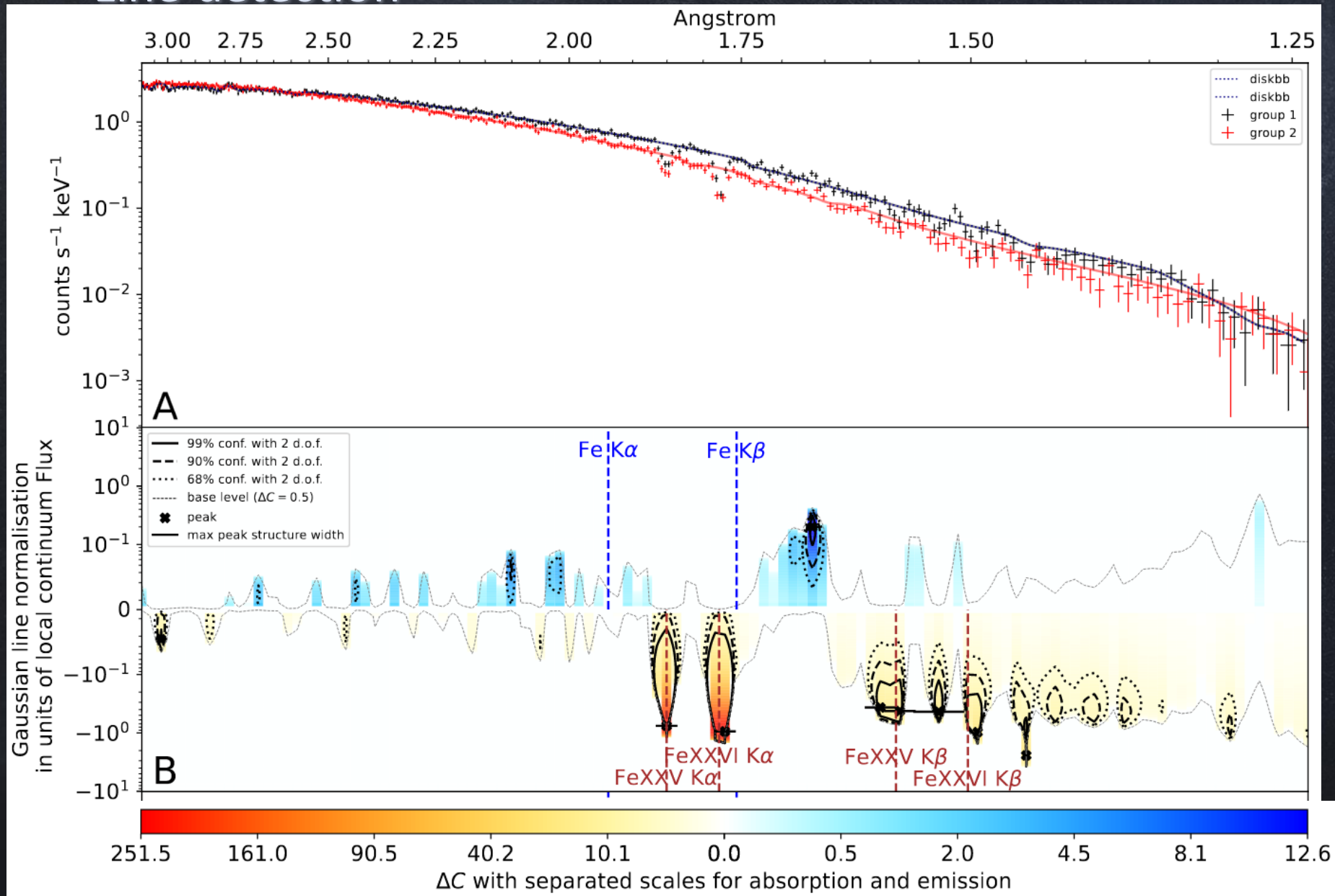
The monitoring and parameter analysis plots take time to compute, as the first one fetches data from the MAXI website in real time, and the second computes perturbative estimates of the correlation coefficient for each plot. As such, they are deactivated by default.

It is worth noting that the current version of this tool has trouble performing too many actions in a short time. This is partially covered through internal failsafes, but if you modify several options at once and something crashes, or displays in a non-standard way, either resetting an option (which

Appendices

Methodology

Line detection



The current context

- Winds detection in Black Hole X-ray Binaries

The picture is much more complex now:

□ What about intermediate states ?

- Due time for a new global analysis of the observations

□ Thermal and/or MHD driving to launch the material ?

- Difficult to assess with current observations
(Díaz-Trigo & Boirin 2016, Tetarenko et al. 2018,...)

□ Impact of the spectral shape on the thermal stability

- The wind could be a permanent component
(Sánchez-Sierras & Muñoz-Darias 2020)

The current context

- Modeling and stability of absorption lines

The picture is much more complex now

□ What about intermediate states ?

- Many observations but unclear global behavior



□ Thermal and/or MHD driving[5][6] to launch the material ?

- $T_{wind} \ll T_{acc}$



□ The spectral shape affects the thermal stability and ξ

- Wind always here[7] but only detectable in the right conditions ?

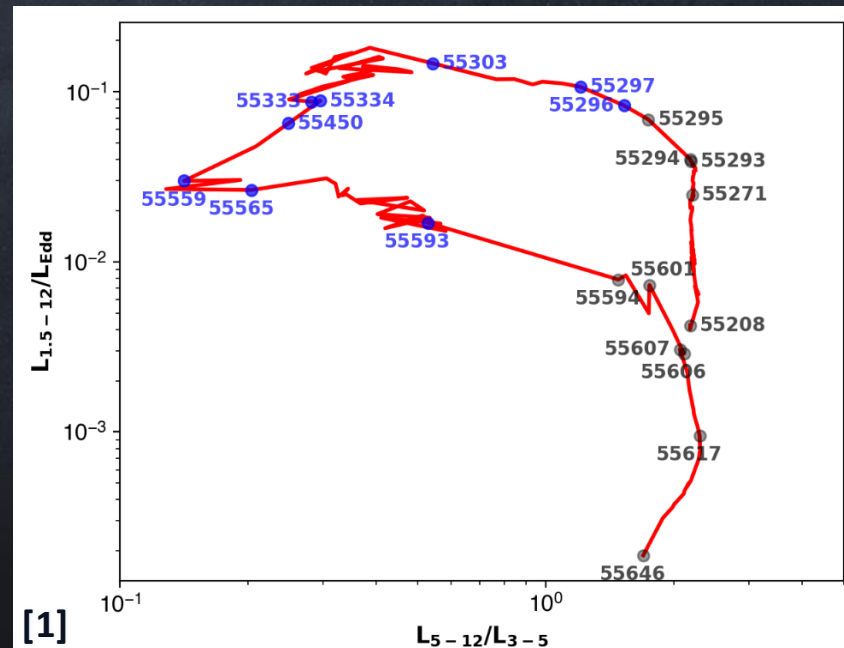
The current context

- Modeling and stability of absorption lines

□ The wind thermal stability curves can be computed

- Very sensitive to the SED → requires broad band data that doesn't exist

□ With a bit of physically motivated [8] extrapolation... [9]



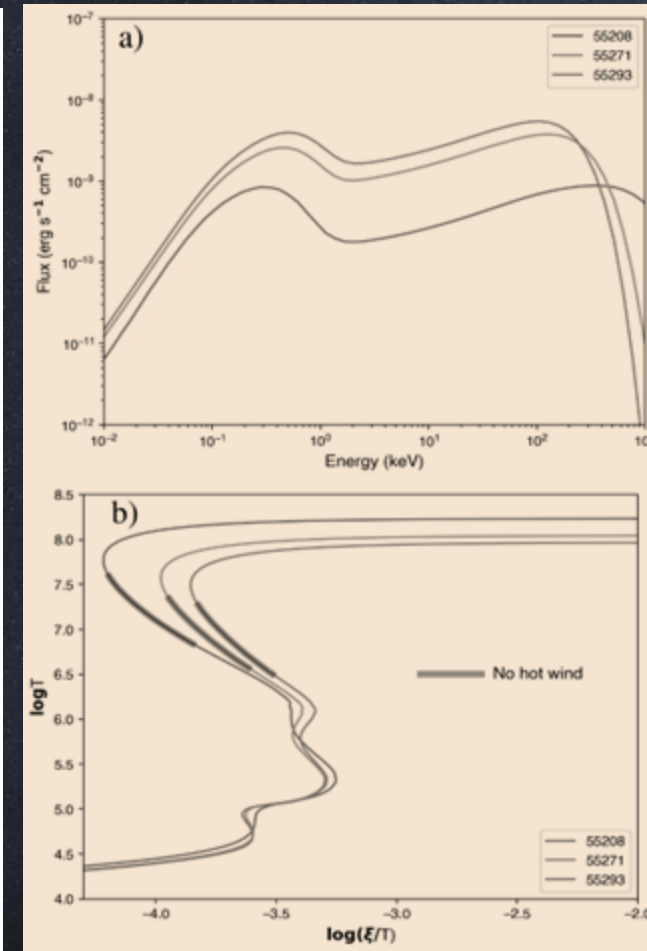
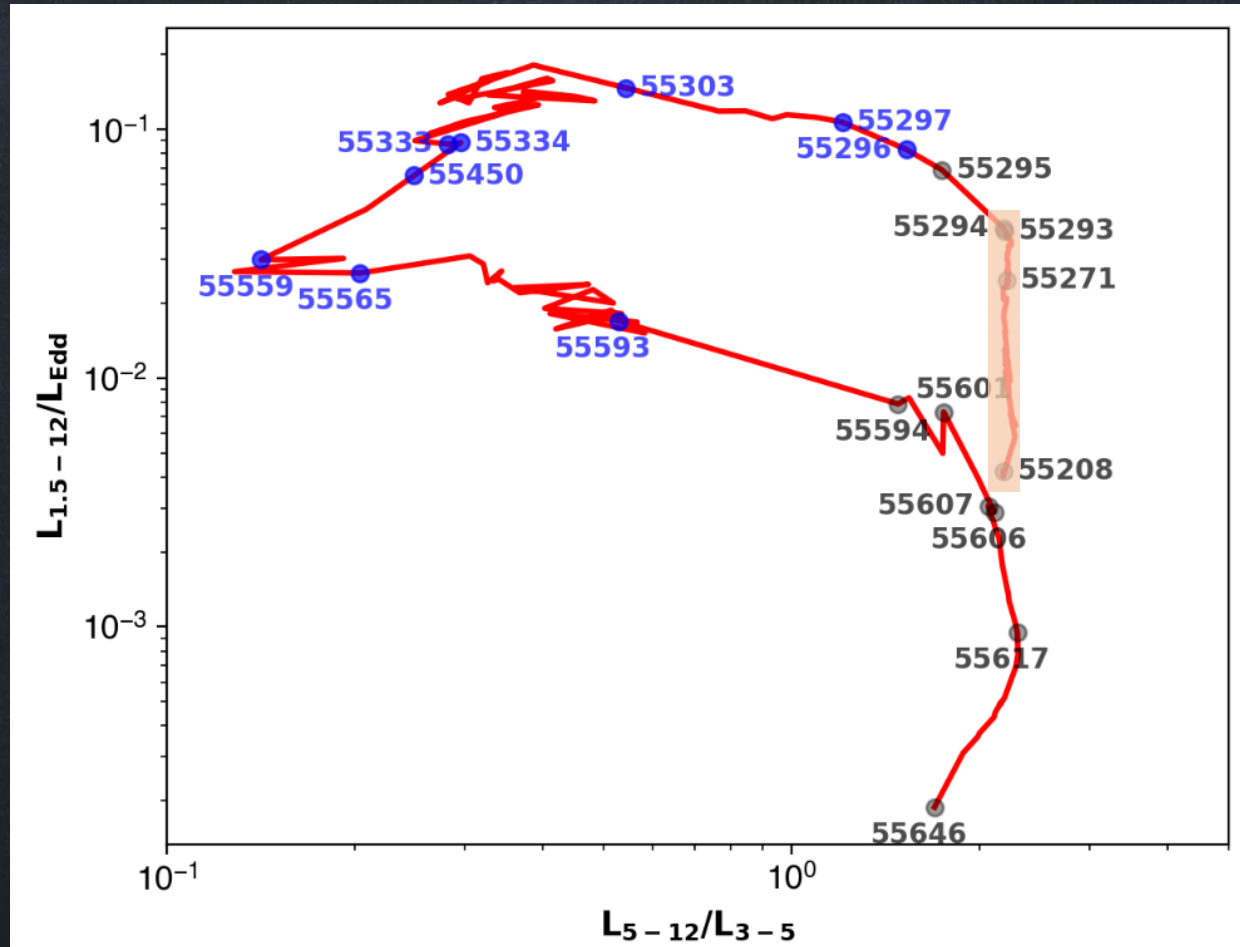
[8] Marcel et al. 2018

[9] Marcel et al. 2019

[1] Petrucci et al. 2021

The current context

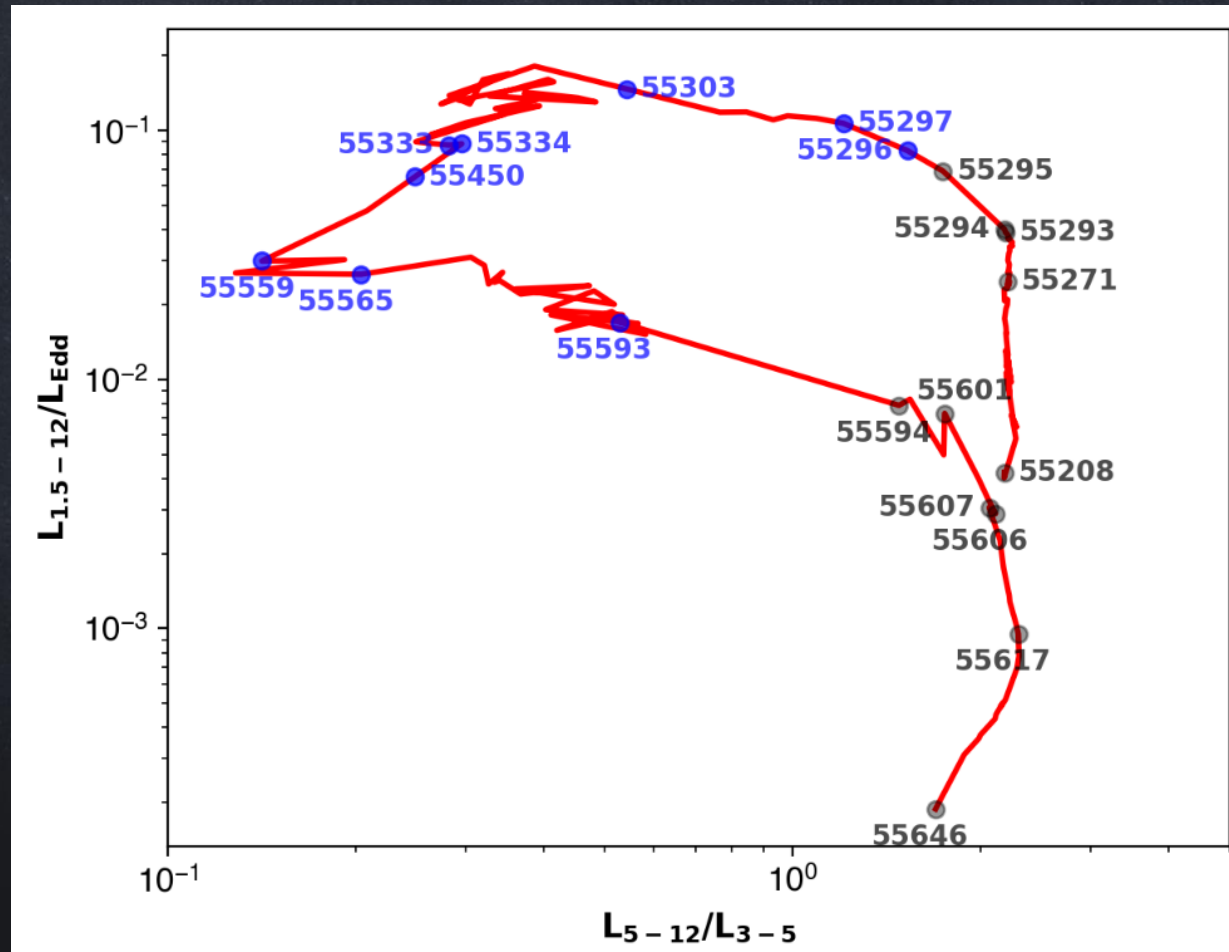
- Modeling and stability of absorption lines

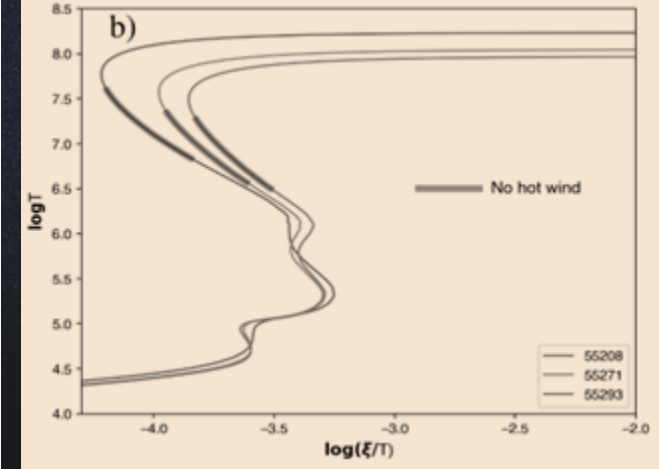
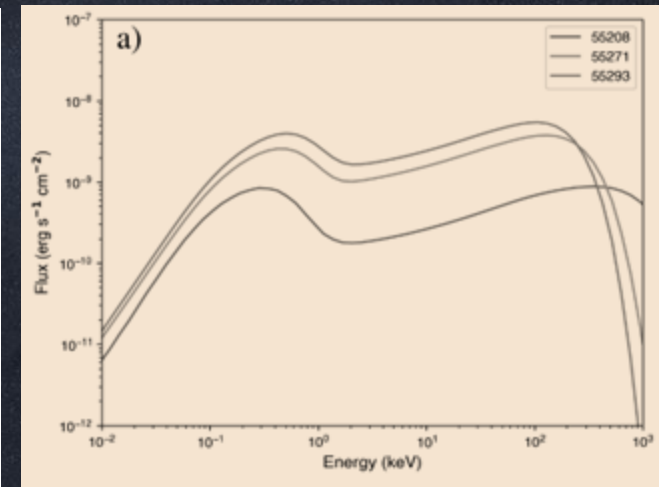
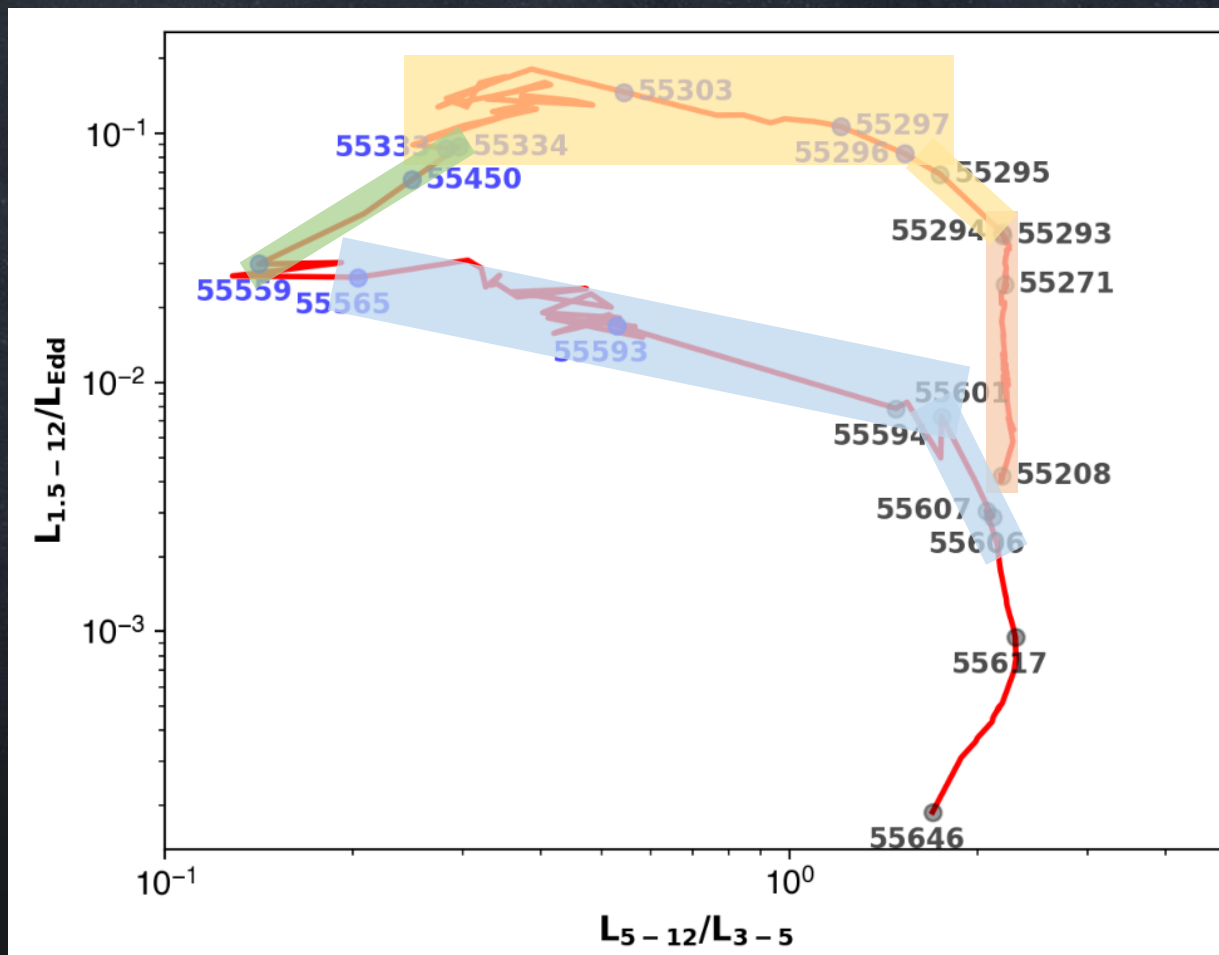
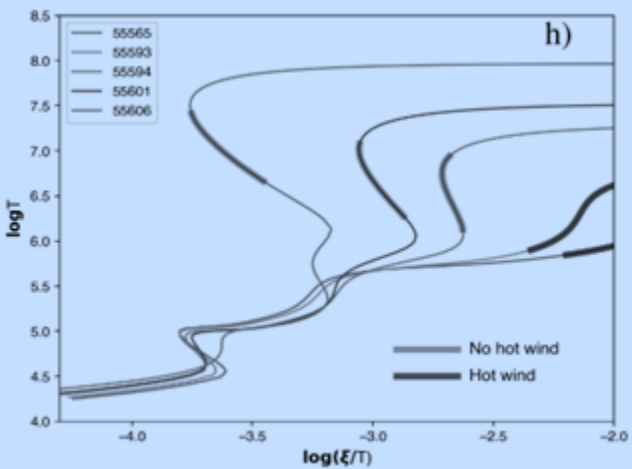
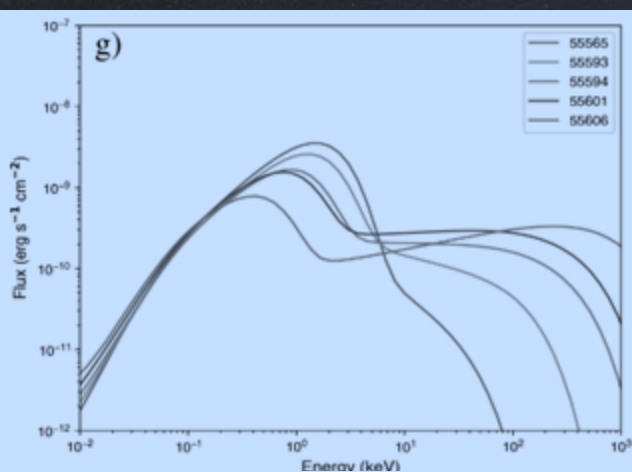
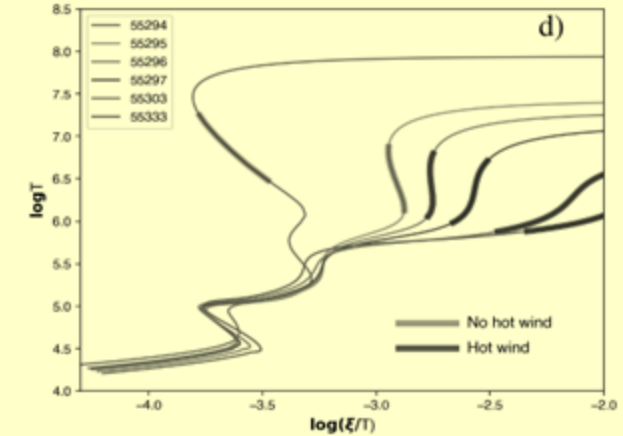
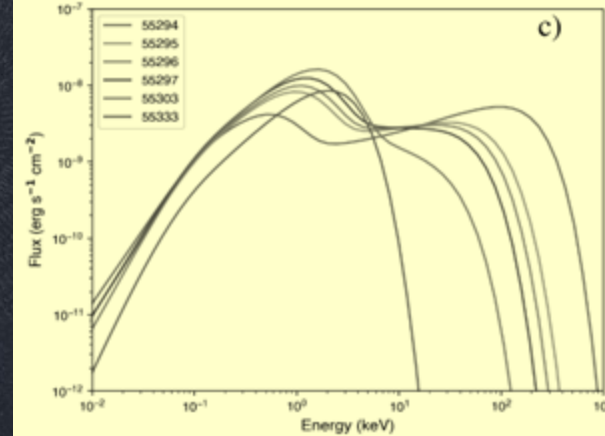
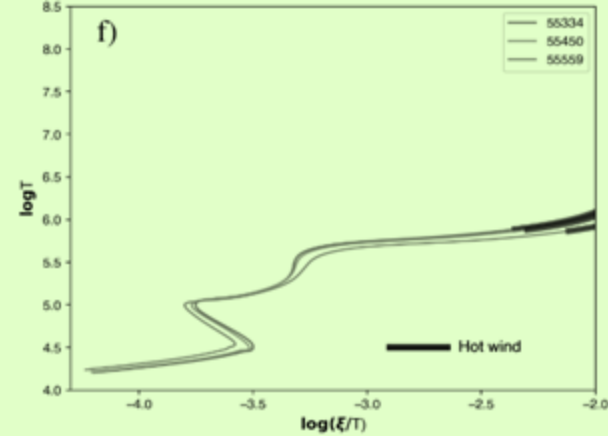
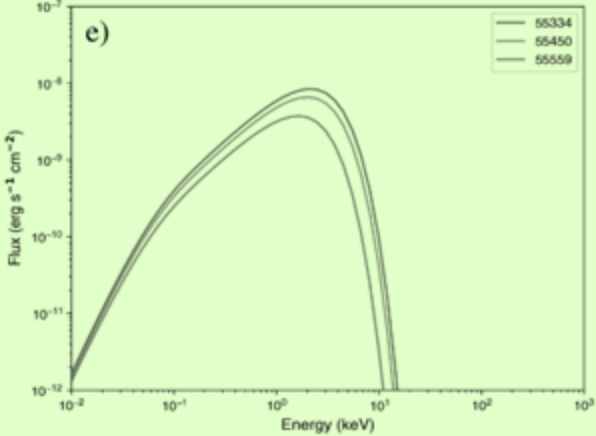


□ Now to be compared with observations for objects with detections

The current context

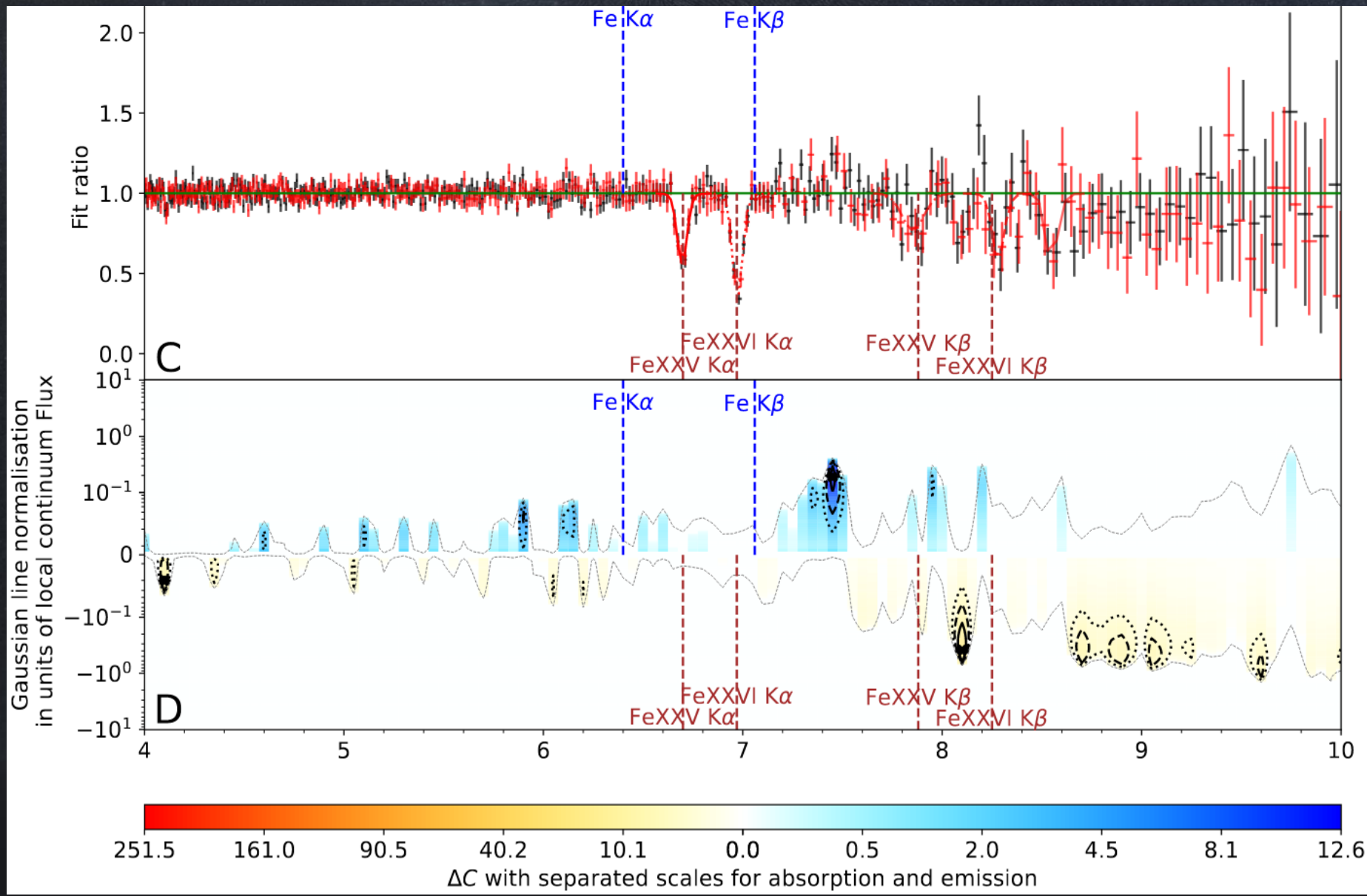
- Modeling and stability of absorption lines





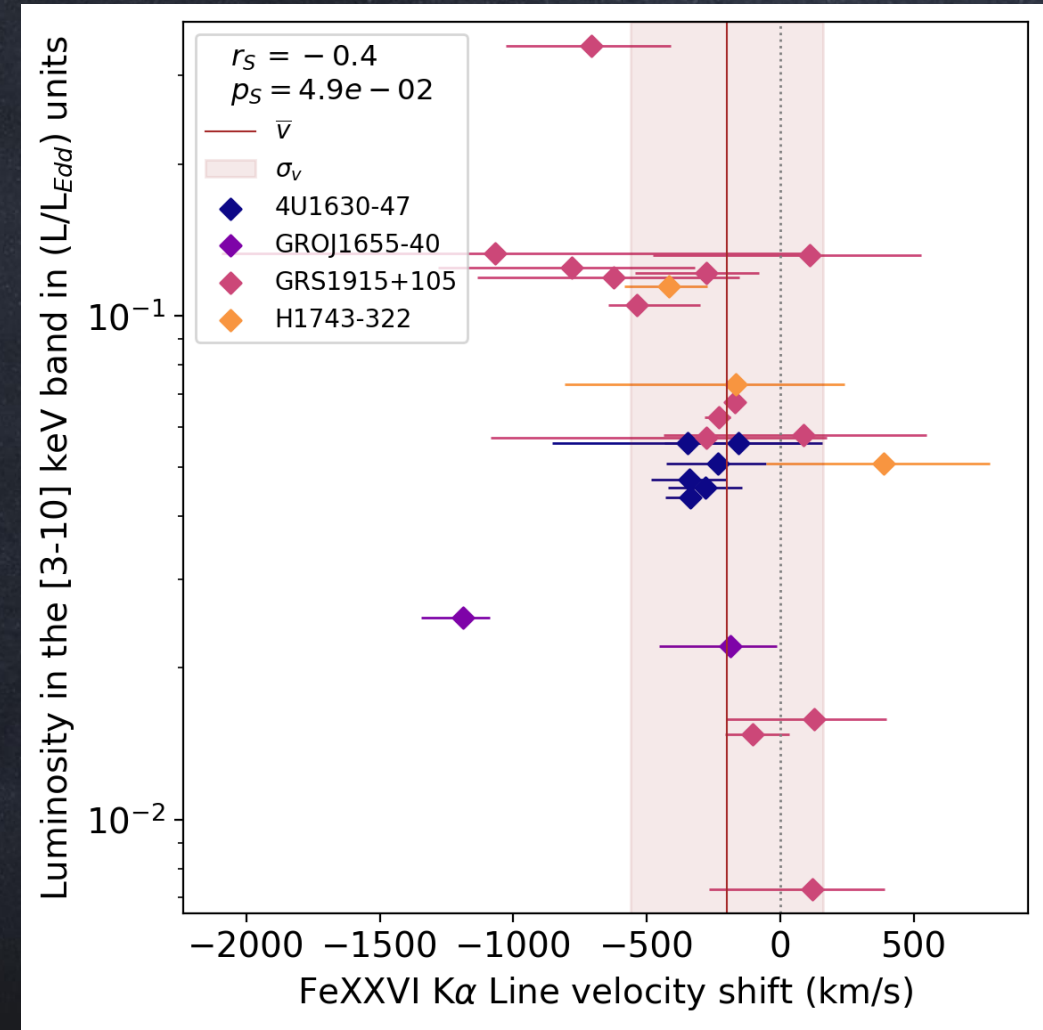
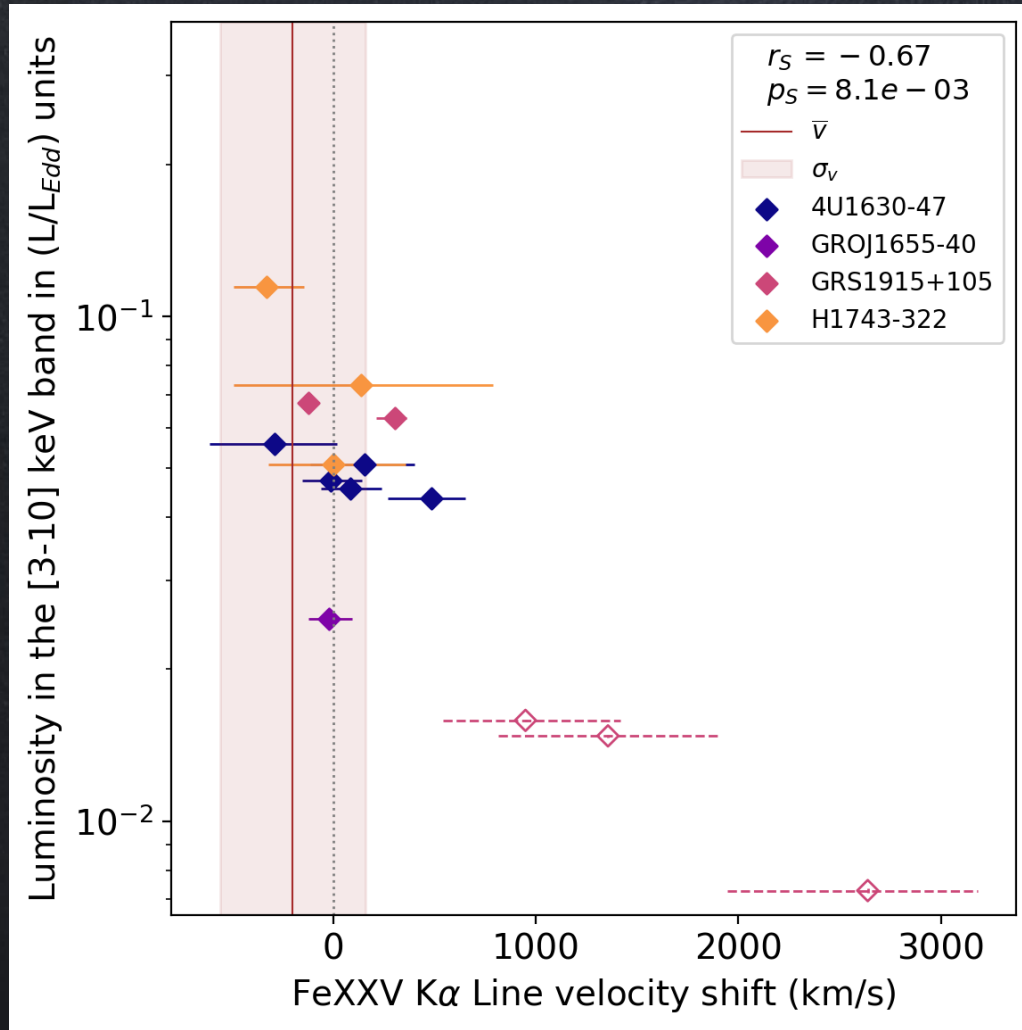
Methodology

Line detection



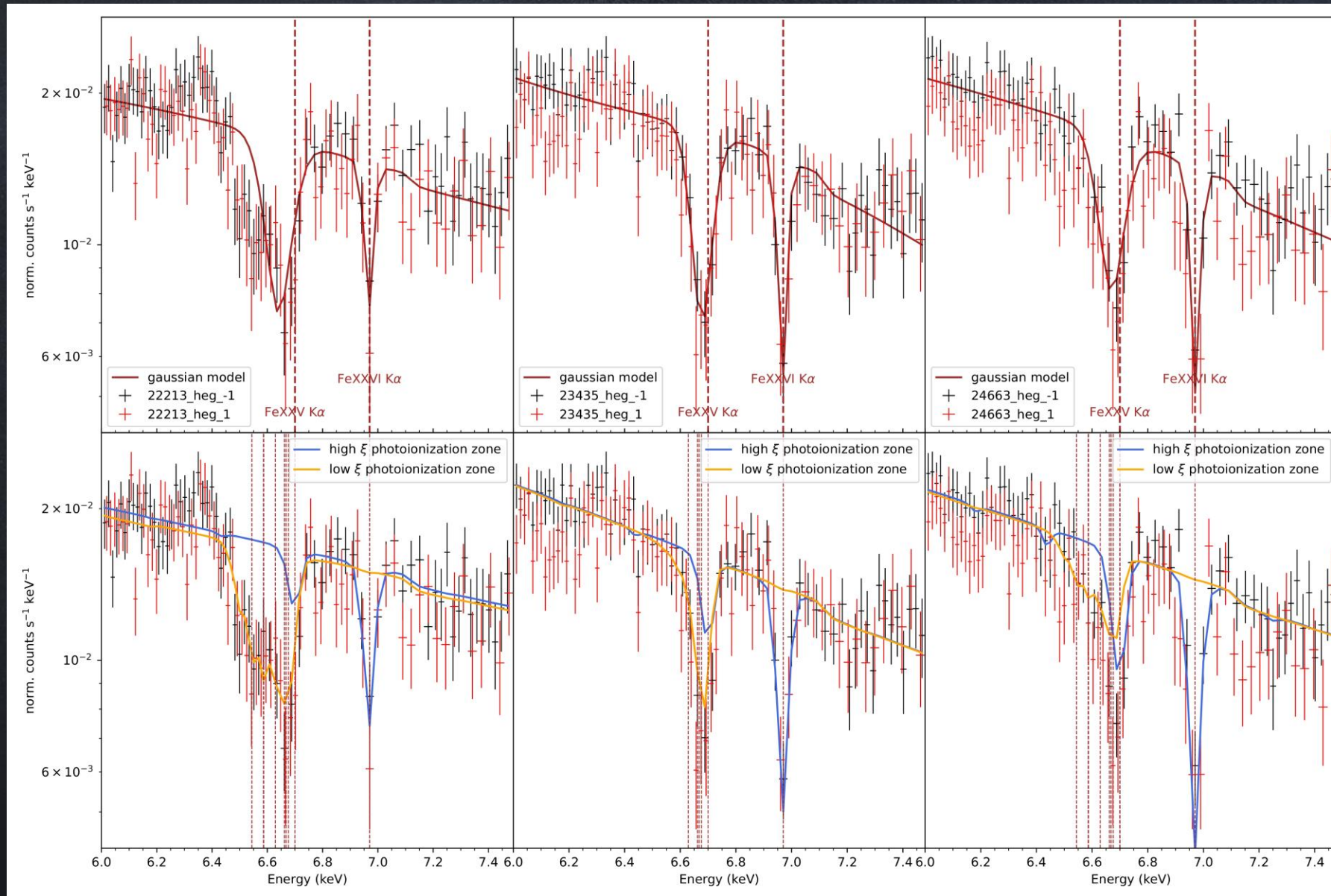
Results

■ Distributions



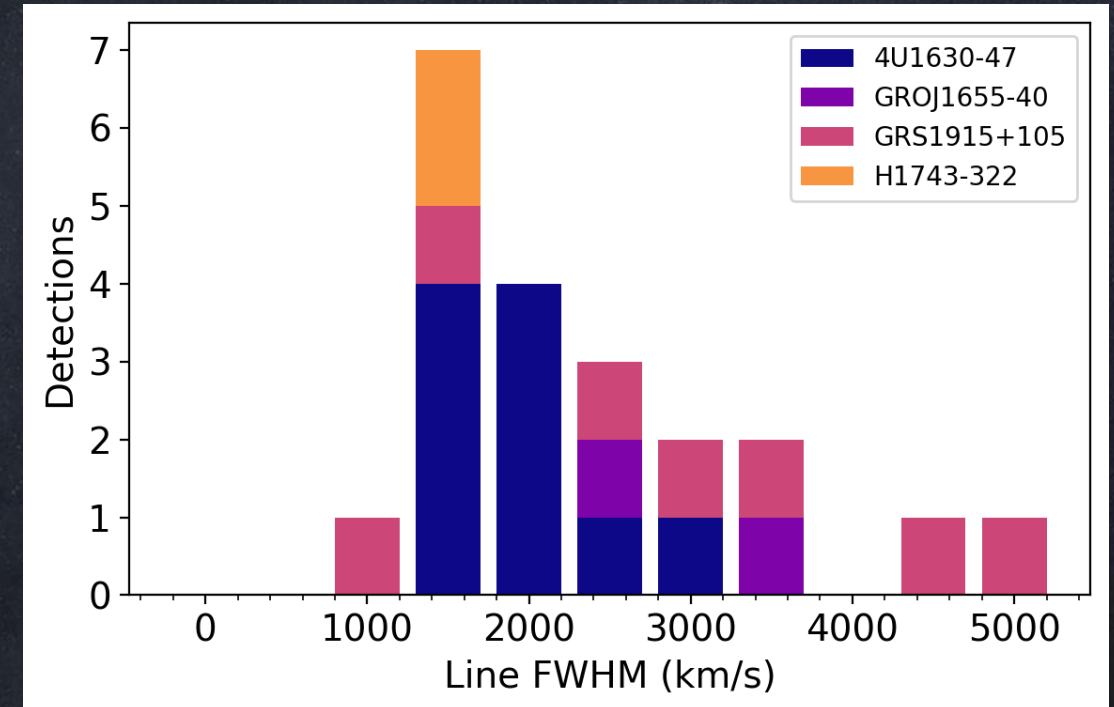
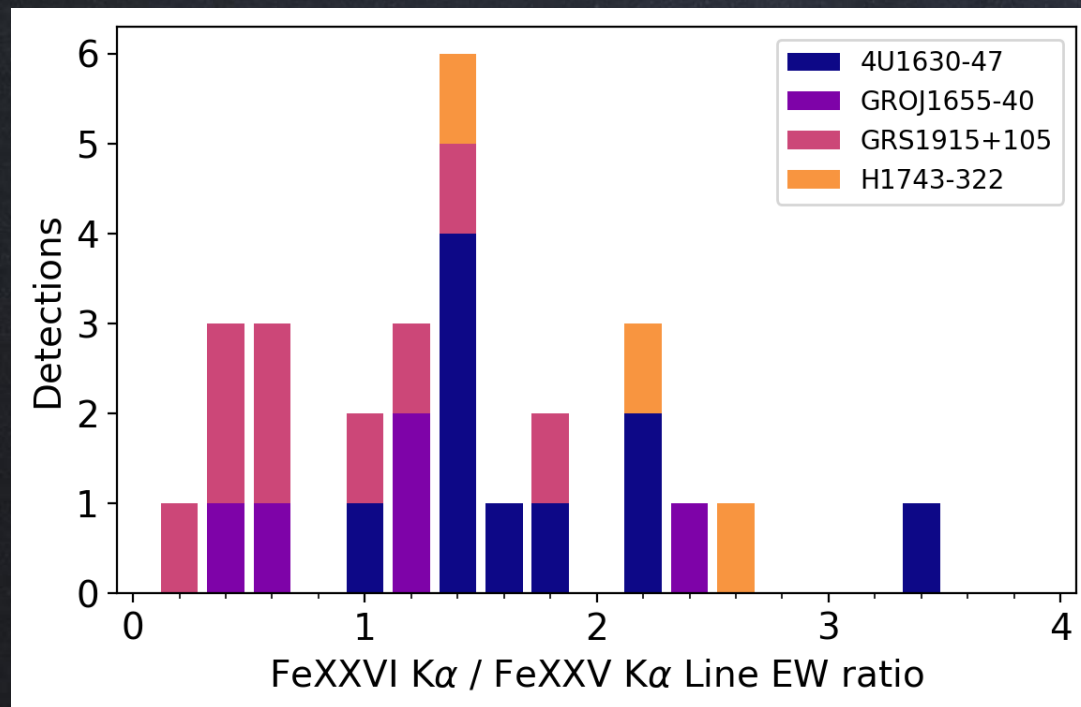
Results

■ Distributions



Results

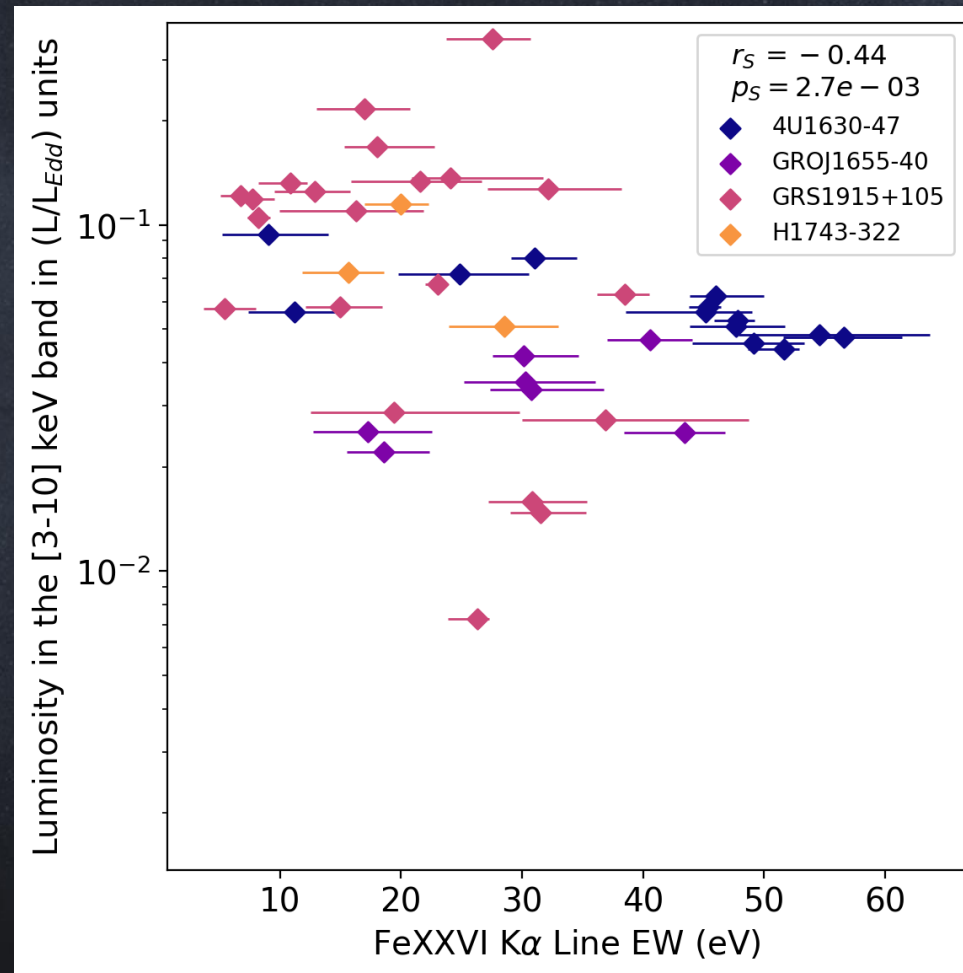
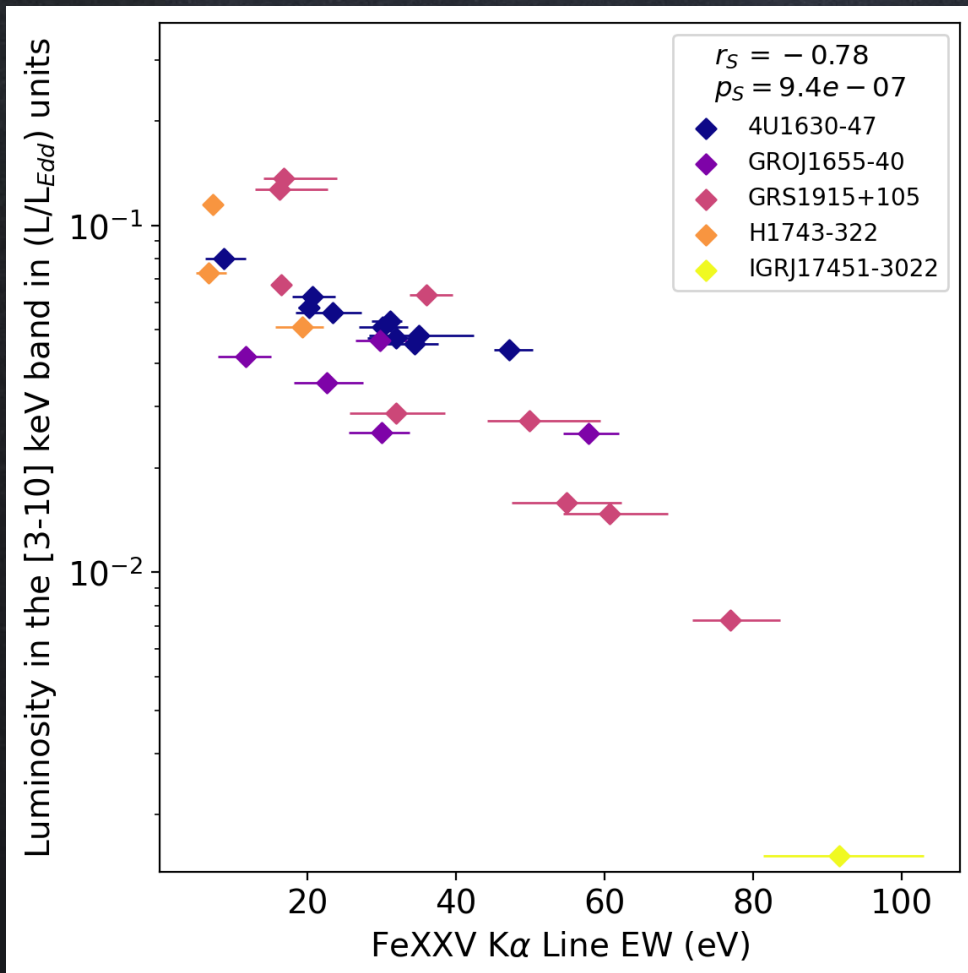
- Distributions of line parameters



Results

- Comparing line behaviors

The FeKa25 EW correlates significantly with luminosity

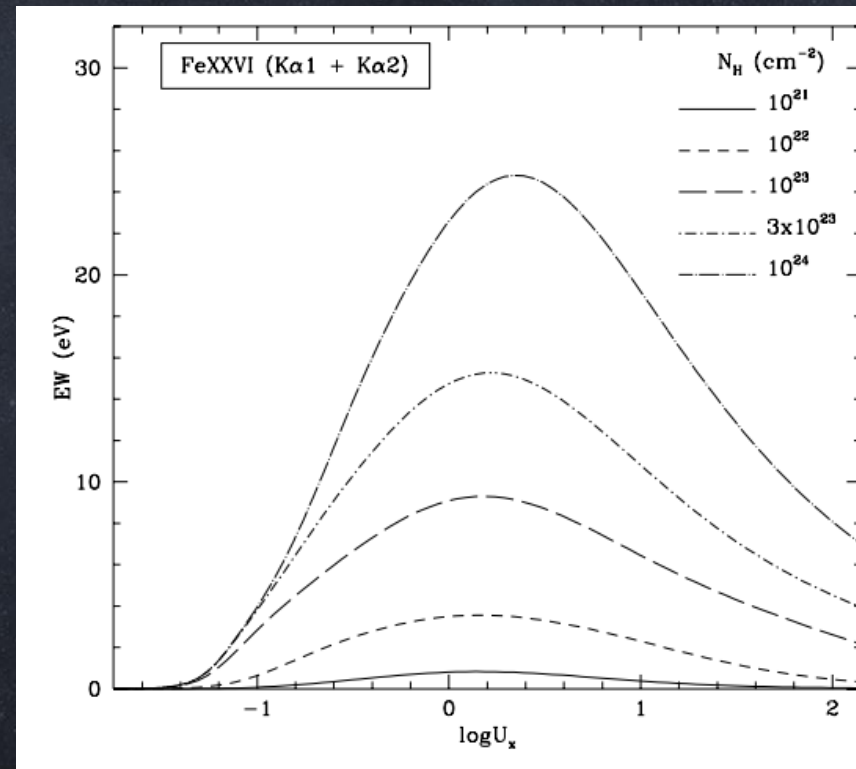
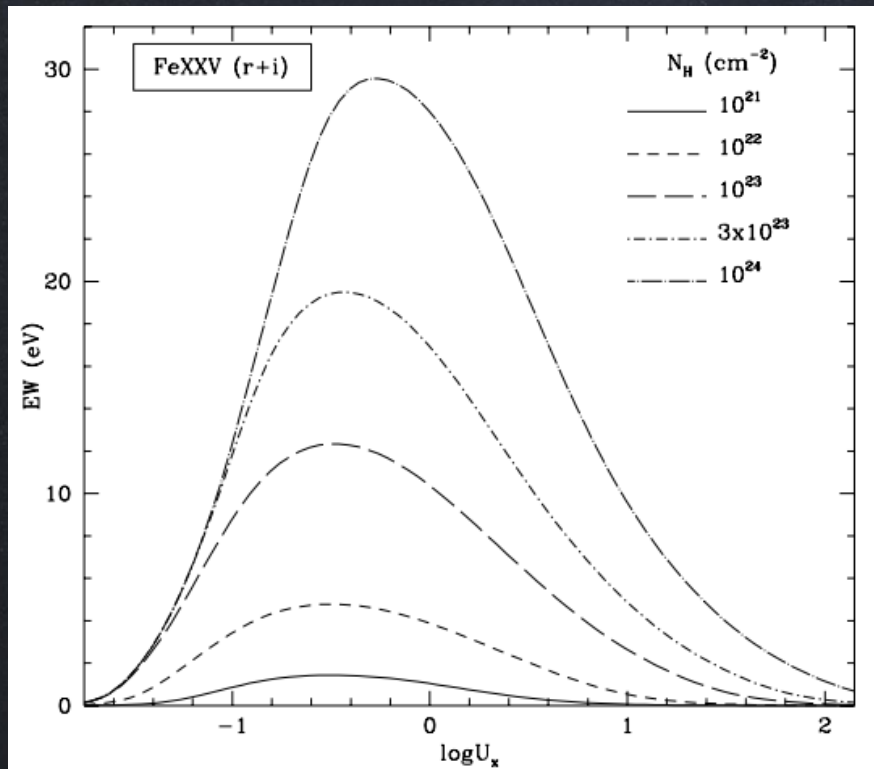


FeKa26 EW behaves completely differently

Results

- Parameter distribution and correlation

This can be explained if the range of ionisation parameter we probe has two different behaviors for FeKa26/FeKa25.

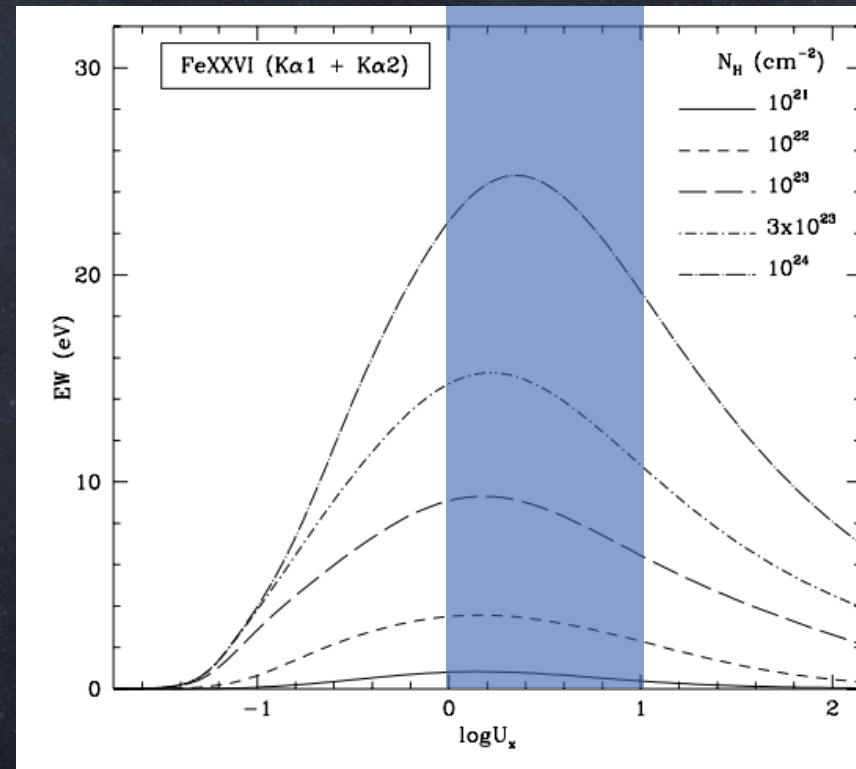
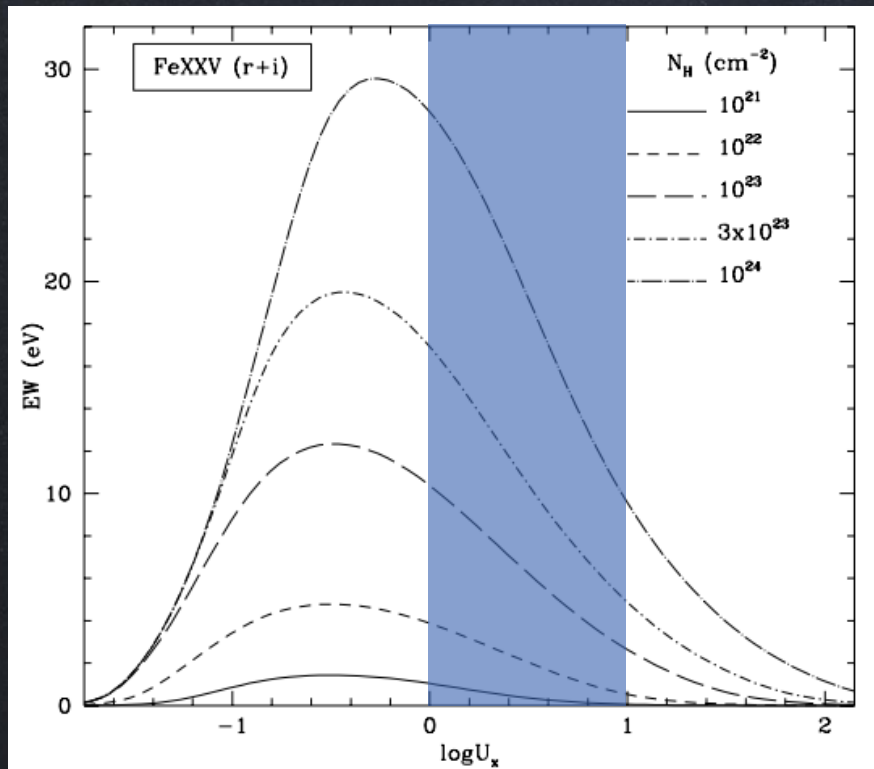


Example of the effect of U_x (modified ionisation parameter) on the line EW for a single spectral shape in AGNs [13]

Results

- Parameter distribution and correlation

This can be explained if the range of ionisation parameter we probe has two different behaviors for FeKa26/FeKa25.

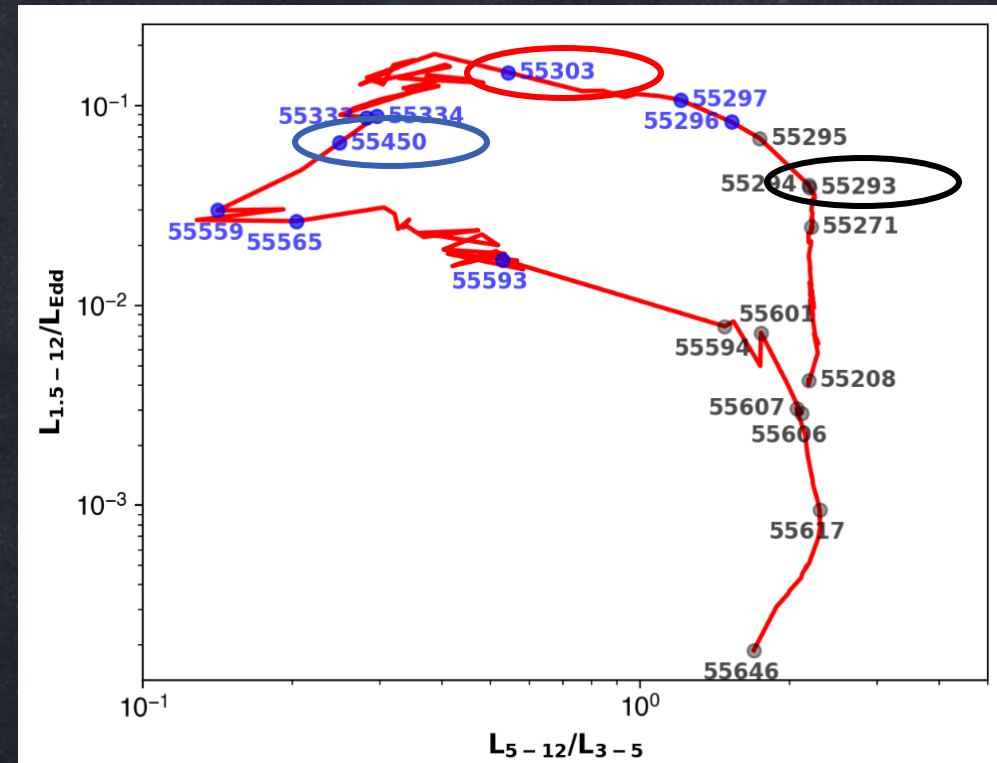
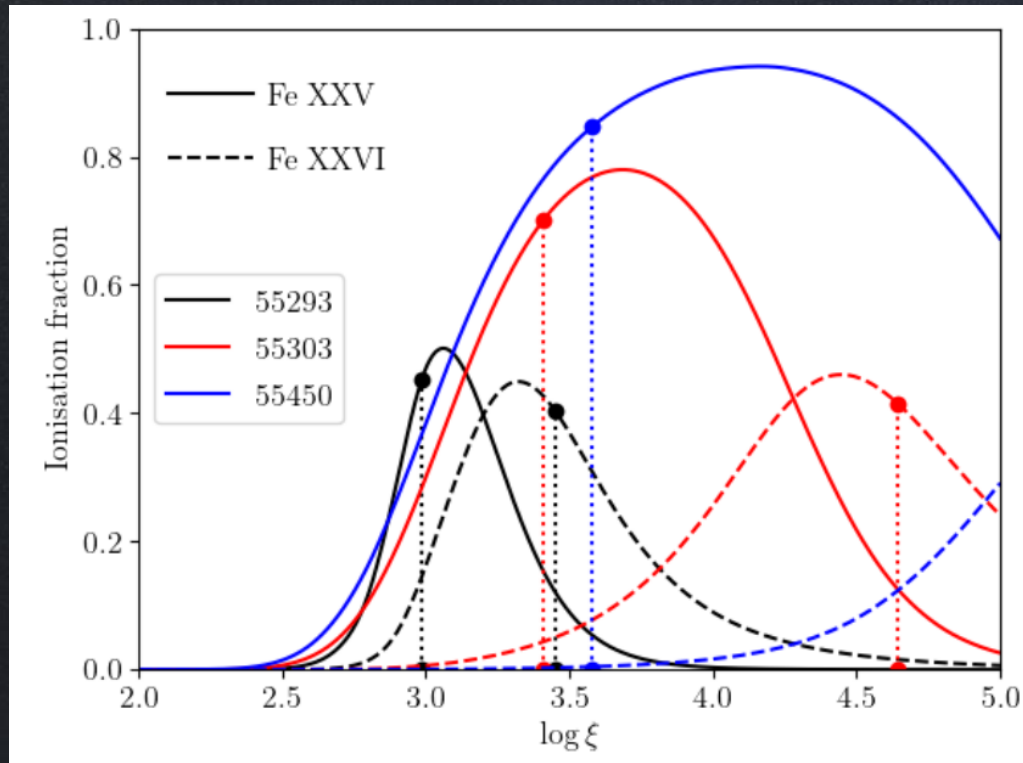


Example of the effect of U_x (modified ionisation parameter) on the line EW for a single spectral shape in AGNs [13]

Results

- Parameter distribution and correlation

This can be amplified by the changes in spectral state (even in the soft state) of BHLMBs

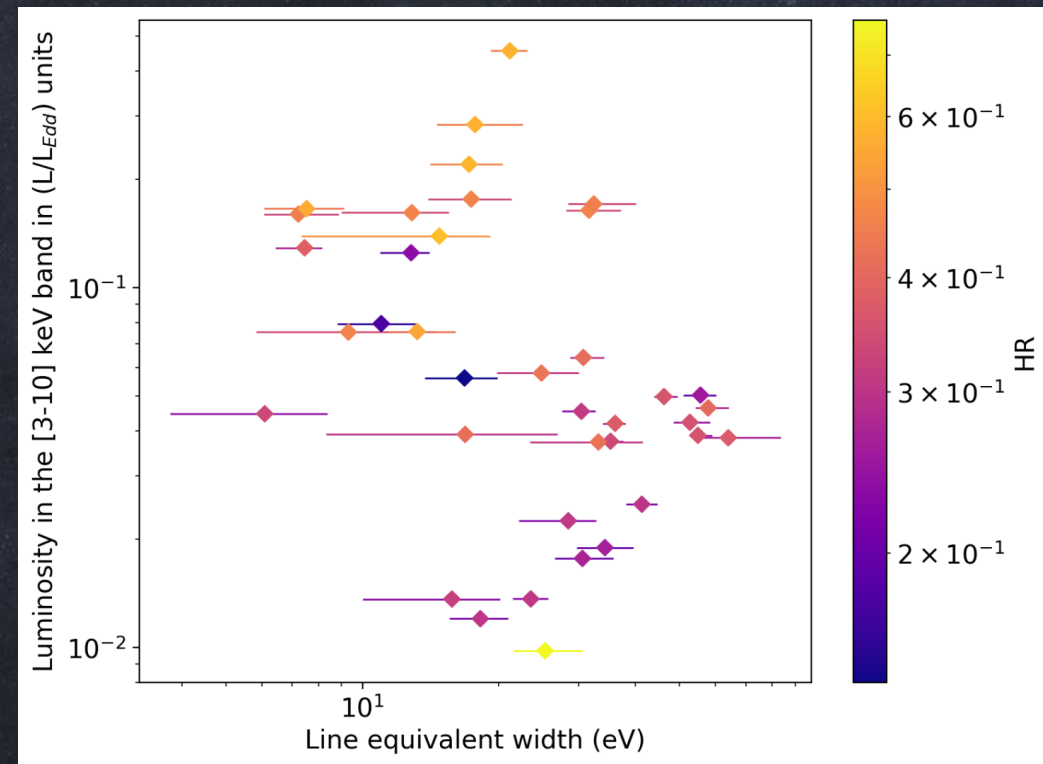
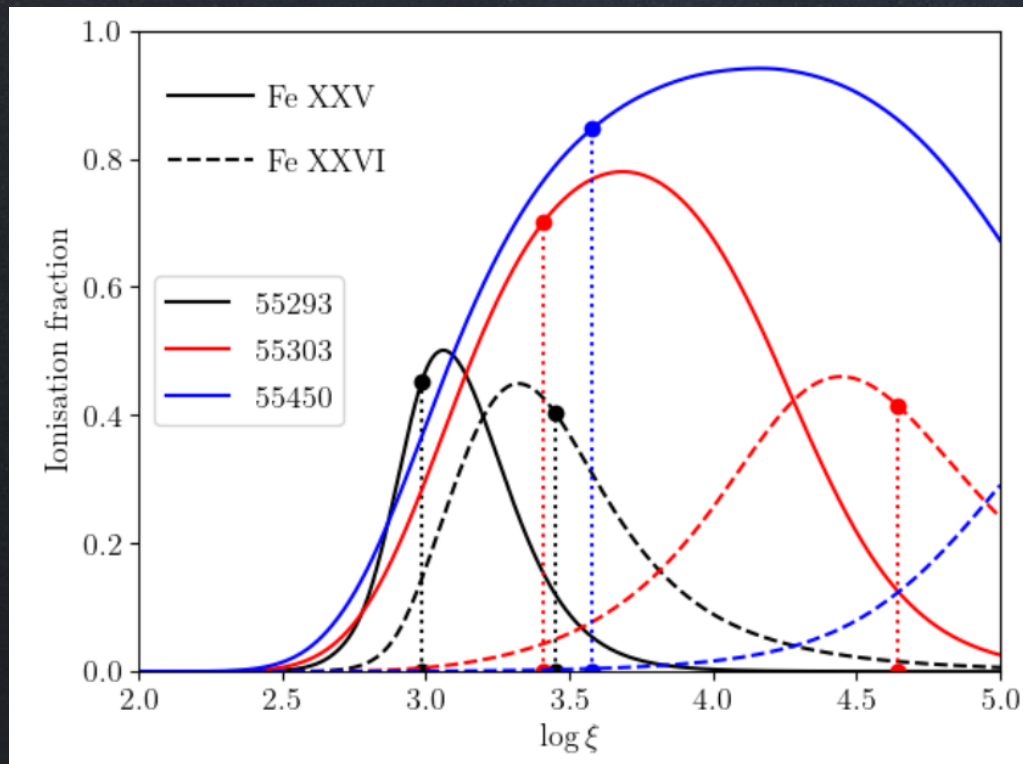


Effect of different SEDs on the ionic fractions of Fe XXVI and Fe XXV in GX339-4 from [1]

Results

- Parameter distribution and correlation

This can be amplified by the changes in spectral state (even in the soft state) of BHLMXBs



FeKa26 Scatter color-coded with the HR ratio

Comparisons & Conclusion

■ The bigger picture

Source	accretion states with absorption lines reported		
	this work	other works	
		iron band	iron band
4U 1543-47	X	soft (1)	X
4U 1630-47	soft	soft (2)	soft ^X (3)
EXO 1846-031	X	hard (4)	X
GRO J1655-40	soft	soft (5)	soft ^X (6)
GRS 1716-249	X	X	hard ^V (7)
GRS 1758-258	X	hard (8)	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ (9) , θ (10) , κ (11) , λ (12) , hard: χ (13) , obscured* (15)	soft ^X : ϕ (14)
GX 339-4	X	X	soft ^V (16) , hard ^V (16)
H 1743-322	soft	soft (17)	X
IGR J17091-3624	X	soft (18) , hard (19) †	hard ^X (20)
IGR J17451-3022	soft	soft (21)	soft ^X (21)
MAXI J1305-704	X	soft (22) , (23) , hard (23)	soft ^X (22) , (23) , hard ^X (23)
MAXI J1348-630	X	soft (24) , hard (24)	hard ^X (25) , soft ^{IR} (26) , hard ^{V,IR} (26)
MAXI J1803-298	X	soft (27) , (28)	hard ^V (29)
MAXI J1820+070	X	soft (30)	soft ^{IR} (31) , hard ^{V,IR} (31)
Swift J1357.2-0933	X	X	hard ^V (32) , (33)
Swift J1658.2-4242	X	hard (34)	X
V404 Cyg	X	hard (35)	obscured*: hard ^X (36) , hard ^V (37)
V4641 Sgr	X	X	obscured*: hard ^V (38)
XTE J1652-453	X	hard † (39)	X

Comparisons & Conclusion

■ The bigger picture

Source	accretion states with absorption lines reported		
	this work	other works	
	iron band	iron band	other energies
4U 1543-47	X	soft (1)	X
4U 1630-47	soft	soft (2)	soft ^X (3)
EXO 1846-031	X	hard (4)	X
GRO J1655-40	soft	soft (5)	soft ^X (6)
GRS 1716-249	X	X	hard ^V (7)
GRS 1758-258	X	hard (8)	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ (9), θ (10), κ (11), λ (12), hard: χ (13), obscured* (15)	soft ^X : ϕ (14) IR?
GX 339-4	X	X	soft ^V (16), hard ^V (16)
H 1743-322	soft	soft (17)	X
IGR J17091-3624	X	soft (18), hard (19) †	hard ^X (20)
IGR J17451-3022	soft	soft (21)	soft ^X (21)
MAXI J1305-704	X	soft (22), (23), hard (23)	soft ^X (22), (23), hard ^X (23)
MAXI J1348-630	X	soft (24), hard (24)	hard ^X (25), soft ^{IR} (26), hard ^{V,IR} (26)
MAXI J1803-298	X	soft (27), (28)	hard ^V (29)
MAXI J1820+070	X	soft (30)	soft ^{IR} (31), hard ^{V,IR} (31)
Swift J1357.2-0933	X	X	hard ^V (32), (33)
Swift J1658.2-4242	X	hard (34)	X
V404 Cyg	X	hard (35)	obscured*: hard ^X (36), hard ^V (37)
V4641 Sgr	X	X	obscured* hard ^V (38)
XTE J1652-453	X	hard † (39)	X

Comparisons & Conclusion

■ The bigger picture

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4U 1630-47	soft	soft (2)	soft ^X (3)
EXO 1846-031	X	hard (4)	X
GRO J1655-40	soft	soft (5)	soft ^X (6)
GRS 1716-249	X	X	hard ^V (7)
GRS 1758-258	X	hard (8)	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ (9), θ (10), κ (11), λ (12), hard: χ (13), obscured* (15)	soft ^X : ϕ (14) IR?
GX 339-4	X	X	soft ^V (16), hard ^V (16)
H 1743-322	soft	soft (17)	X
IGR J17091-3624	X	soft (18), hard (19) †	hard ^X (20)
IGR J17451-3022	soft	soft (21)	soft ^X (21)
MAXI J1305-704	X	soft (22), (23), hard (23)	soft ^X (22), (23), hard ^X (23)
MAXI J1348-630	X	soft (24), hard (24)	hard ^X (25), soft ^{IR} (26), hard ^{V,IR} (26)
MAXI J1803-298	X	soft (27), (28)	hard ^V (29)
MAXI J1820+070	X	soft (30)	soft ^{IR} (31), hard ^{V,IR} (31)
Swift J1357.2-0933	X	X	hard ^V (32), (33)
Swift J1658.2-4242	X	hard (34)	X
V404 Cyg	X	hard (35)	obscured*: hard ^X (36), hard ^V (37)
V4641 Sgr	X	X	obscured* hard ^V (38)
XTE J1652-453	X	hard † (39)	X

Dipper

Dynamical
high
inclinationNo conclusive
info

Comparisons & Conclusion

■ The bigger picture

Source	accretion states with absorption lines reported		
	this work	other works	
		iron band	iron band
4U 1543-47	X	soft₍₁₎	X
4U 1630-47	soft	soft ₍₂₎	soft ^X ₍₃₎
EXO 1846-031	X	hard₍₄₎	X
GRO J1655-40	soft	soft ₍₅₎	soft ^X ₍₆₎
GRS 1716-249	X	X	hard ^V ₍₇₎
GRS 1758-258	X	hard₍₈₎	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ ₍₉₎ , θ ₍₁₀₎ , κ ₍₁₁₎ , λ ₍₁₂₎ , hard: χ ₍₁₃₎ , obscured* ₍₁₅₎	soft ^X : ϕ ₍₁₄₎ IR?
GX 339-4	X	X	soft ^V ₍₁₆₎ , hard ^V ₍₁₆₎
H 1743-322	soft	soft ₍₁₇₎	X
IGR J17091-3624	X	soft ₍₁₈₎ , hard₍₁₉₎ *	hard ^X ₍₂₀₎
IGR J17451-3022	soft	soft ₍₂₁₎	soft ^X ₍₂₁₎
MAXI J1305-704	X	soft₍₂₂₎ , hard₍₂₃₎	soft ^X ₍₂₂₎ , ₍₂₃₎ , hard ^X ₍₂₃₎
MAXI J1348-630	X	soft₍₂₄₎ , hard₍₂₄₎	hard ^X ₍₂₅₎ , soft ^{IR} ₍₂₆₎ , hard ^{V,IR} ₍₂₆₎
MAXI J1803-298	X	soft ₍₂₇₎ , ₍₂₈₎	hard ^V ₍₂₉₎
MAXI J1820+070	X	soft₍₃₀₎	soft ^{IR} ₍₃₁₎ , hard ^{V,IR} ₍₃₁₎
Swift J1357.2-0933	X	X	hard ^V ₍₃₂₎ , ₍₃₃₎
Swift J1658.2-4242	X	hard₍₃₄₎	X
V404 Cyg	X	hard ₍₃₅₎	obscured*: hard ^X ₍₃₆₎ , hard ^V ₍₃₇₎
V4641 Sgr	X	X	obscured* hard ^V ₍₃₈₎
XTE J1652-453	X	hard₍₃₉₎ *	X

Dipper

Dynamical
high
inclinationNo conclusive
info

Comparisons & Conclusion

- The bigger picture

Source	accretion states with absorption lines reported		
	this work	other works	
		iron band	iron band
4U 1543-47	X	soft ₍₁₎	X
4U 1630-47	soft	soft ₍₂₎	soft ^X ₍₃₎
EXO 1846-031	X	hard ₍₄₎	X
GRO J1655-40	soft	soft ₍₅₎	soft ^X ₍₆₎
GRS 1716-249	X	X	hard ^V ₍₇₎
GRS 1758-258	X	hard ₍₈₎	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ ₍₉₎ , θ ₍₁₀₎ , κ ₍₁₁₎ , λ ₍₁₂₎ , hard: χ ₍₁₃₎ , obscured* ₍₁₅₎	soft ^X : ϕ ₍₁₄₎ IR?
GX 339-4	X	X	soft ^V ₍₁₆₎ , hard ^V ₍₁₆₎
H 1743-322	soft	soft ₍₁₇₎	X
IGR J17091-3624	X	soft ₍₁₈₎ , hard ₍₁₉₎ ⁺	hard ^X ₍₂₀₎
IGR J17451-3022	soft	soft ₍₂₁₎	soft ^X ₍₂₁₎
MAXI J1305-704	X	soft ₍₂₂₎ , hard ₍₂₃₎	soft ^X ₍₂₂₎ , hard ₍₂₃₎ , hard ^X ₍₂₃₎
MAXI J1348-630	X	soft ₍₂₄₎ , hard ₍₂₄₎	hard ^X ₍₂₅₎ , soft ^{IR} ₍₂₆₎ , hard ^{V,IR} ₍₂₆₎
MAXI J1803-298	X	soft ₍₂₇₎ , hard ₍₂₈₎	hard ^V ₍₂₉₎
MAXI J1820+070	X	soft ₍₃₀₎	soft ^{IR} ₍₃₁₎ , hard ^{V,IR} ₍₃₁₎
Swift J1357.2-0933	X	X	hard ^V ₍₃₂₎ , hard ₍₃₃₎
Swift J1658.2-4242	X	hard ₍₃₄₎	X
V404 Cyg	X	hard ₍₃₅₎	obscured*: hard ^X ₍₃₆₎ , hard ^V ₍₃₇₎
V4641 Sgr	X	X	obscured* hard ^V ₍₃₈₎
XTE J1652-453	X	hard ₍₃₉₎	X

ongoing

missing?

Dipper

Dynamical high inclination

No conclusive info

Comparisons & Conclusion

- The bigger picture

Source	accretion states with absorption lines reported		
	this work	other works	
		iron band	iron band
4U 1543-47	X	soft ₍₁₎	X
4U 1630-47	soft	soft ₍₂₎	soft ^X ₍₃₎
EXO 1846-031	X	hard ₍₄₎	X
GRO J1655-40	soft	soft ₍₅₎	soft ^X ₍₆₎
GRS 1716-249	X	X	hard ^V ₍₇₎
GRS 1758-258	X	hard ₍₈₎	X
GRS 1915+105	soft,hard	soft: $\phi, \gamma, \rho, \beta$ ₍₉₎ , θ ₍₁₀₎ , κ ₍₁₁₎ , λ ₍₁₂₎ , hard: χ ₍₁₃₎ , obscured* ₍₁₅₎	soft ^X : ϕ ₍₁₄₎ IR?
GX 339-4	X	X	soft ^V ₍₁₆₎ , hard ^V ₍₁₆₎
H 1743-322	soft	soft ₍₁₇₎	X
IGR J17091-3624	X	soft ₍₁₈₎ , hard ₍₁₉₎	hard ^X ₍₂₀₎
IGR J17451-3022	soft	soft ₍₂₁₎	soft ^X ₍₂₁₎
MAXI J1305-704	X	soft ₍₂₂₎ , hard ₍₂₃₎	soft ^X ₍₂₂₎ , hard ₍₂₃₎ , hard ^X ₍₂₃₎
MAXI J1348-630	X	soft ₍₂₄₎ , hard ₍₂₄₎	hard ^X ₍₂₅₎ , soft ^{IR} ₍₂₆₎ , hard ^{V,IR} ₍₂₆₎
MAXI J1803-298	X	soft ₍₂₇₎ , hard ₍₂₈₎	hard ^V ₍₂₉₎
MAXI J1820+070	X	soft ₍₃₀₎	soft ^{IR} ₍₃₁₎ , hard ^{V,IR} ₍₃₁₎
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Swift J1658.2-4242	X	hard ₍₃₄₎	X
V404 Cyg	X	hard ₍₃₅₎	obscured*: hard ^X ₍₃₆₎ , hard ^V ₍₃₇₎
V4641 Sgr	X	X	obscured* hard ^V ₍₃₈₎
XTE J1652-453	X	hard ₍₃₉₎	X

ongoing

compatibility

missing?

Dipper

Dynamical high inclination

No conclusive info