Towards an informed quest for quasar accretion disc winds

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Supermassive Black Holes: Environment and Evolution

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SMBH winds and galaxy evolution

The Kipling rule:

I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.

Just So Stories, Rudyard Kipling (1902)

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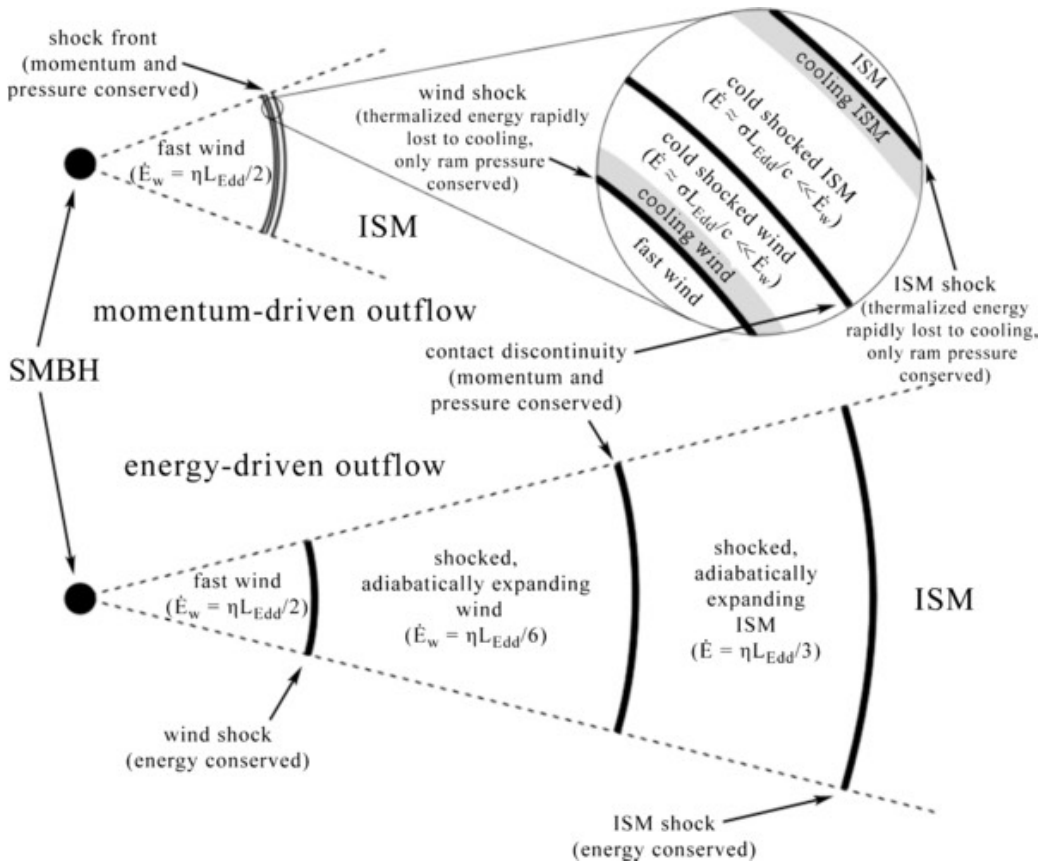
What and **Why**:

Several problems in structure formation and evolution models: galaxy/SMBH scaling relations, galaxy mass and luminosity function, cosmic downsizing, cooling flow problem, …

Where and **Who**:

The energy released by SMBH growth at accretion-disc scales can heavily affect the surrounding environment out to the edge of a galaxy and beyond (i.e. AGN feedback)

Our (limited) view of ultra-fast winds



How?

Ultra-fast *winds* are expected to shock against the ISM of the host galaxy, entraining the swept-up gas in large-scale, massive *outflows*.

e.g. *Zubovas & King (2012)*
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… and many others

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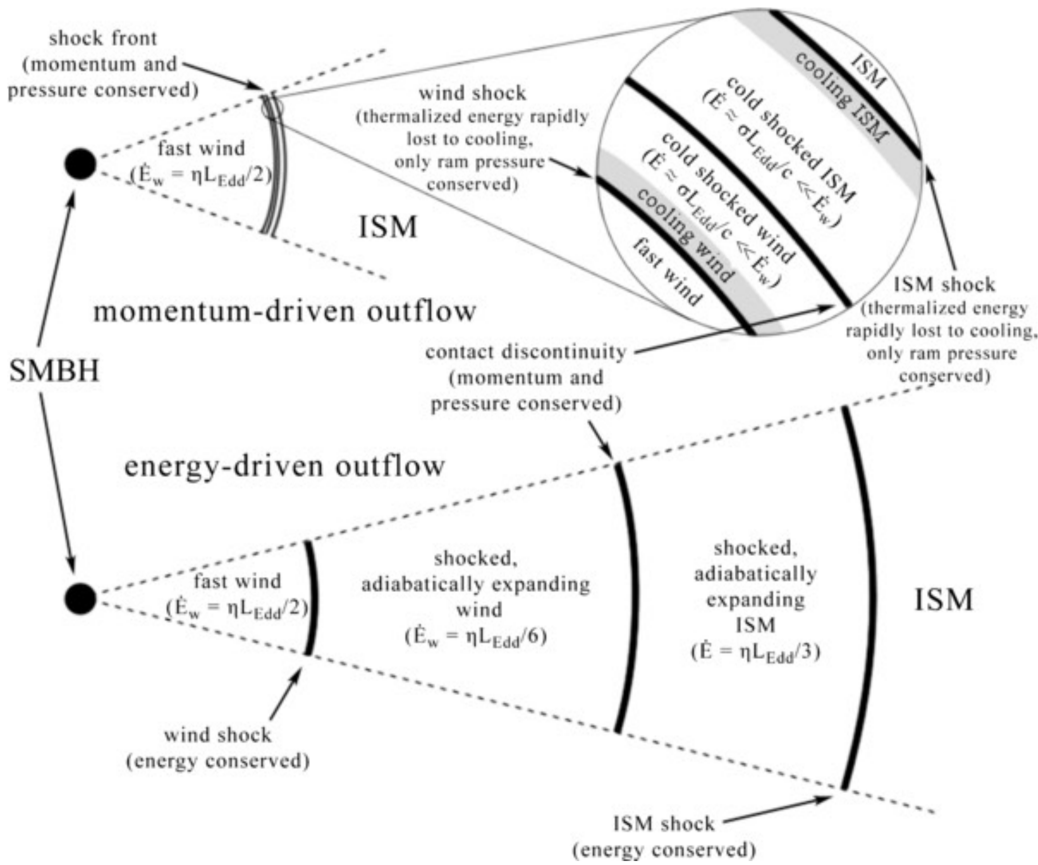

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When? → determine the amount of energy injected into the host

The fraction of AGN with at least one blueshifted Fe-K feature is about 40%

- 100% duty cycle and 40% covering factor?
- 40% duty cycle and 100% covering factor?
- any other combination of the two?

e.g. *Tombesi et al. (2010)*
Gofford et al. (2013)

Why the quest for winds must be informed

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… at least one, and at least ***once*** → wind incidence is possibly lower

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e.g. *Nardini & Zubovas (2018)*

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The discovery of ultra-fast X-ray winds still relies on blind searches over highly inhomogeneous samples (many Seyferts, some PG quasars, a few lensed high-*z* objects) or follow-ups of otherwise peculiar sources

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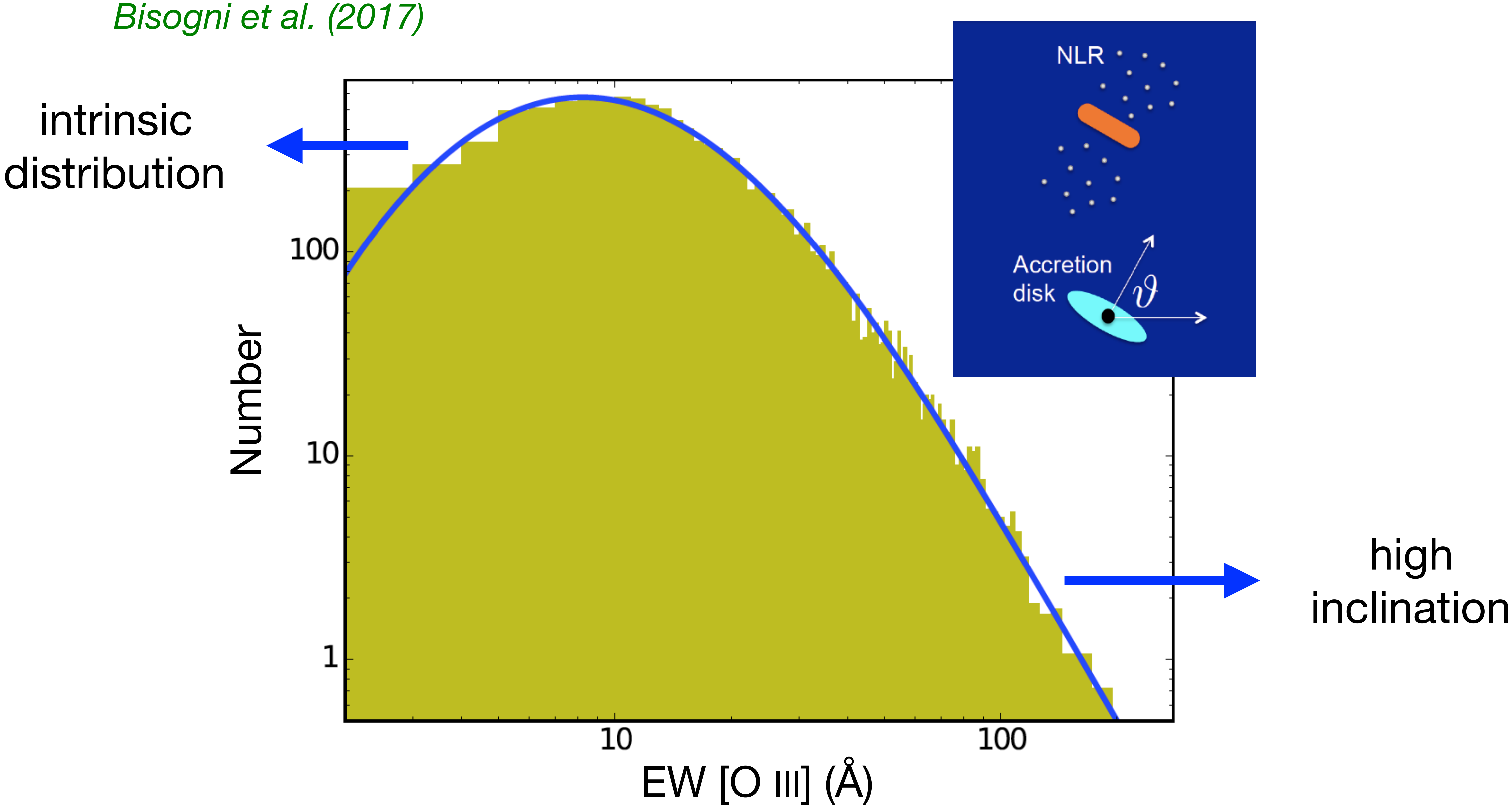
★ Identify any distinctive multi-wavelength signature of the *X-ray blow-out phase* for an indirect characterization of X-ray winds

A tailored selection method

Parent sample: 12,300 SDSS DR7 sources from 5th quasar catalogue

Bisogni et al. (2017)



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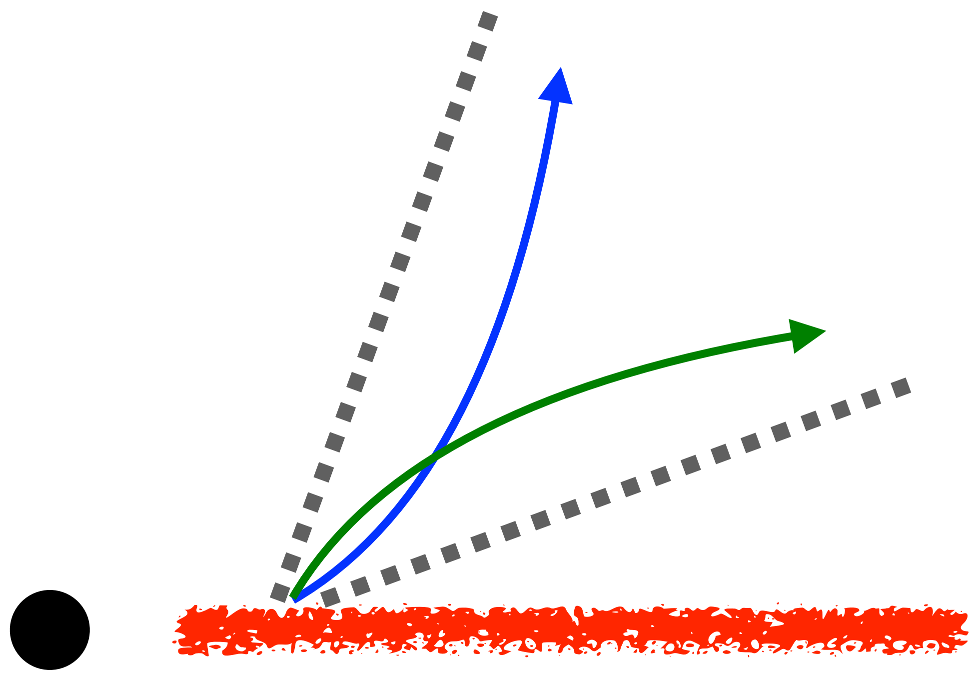

e.g. *Giustini & Proga (2012)*

Large opening angle:

- PG 1211+143 *Pounds & Reeves (2009)*
- PDS 456 *Nardini et al. (2015)*
- PID 352 *Vignali et al. (2015)*

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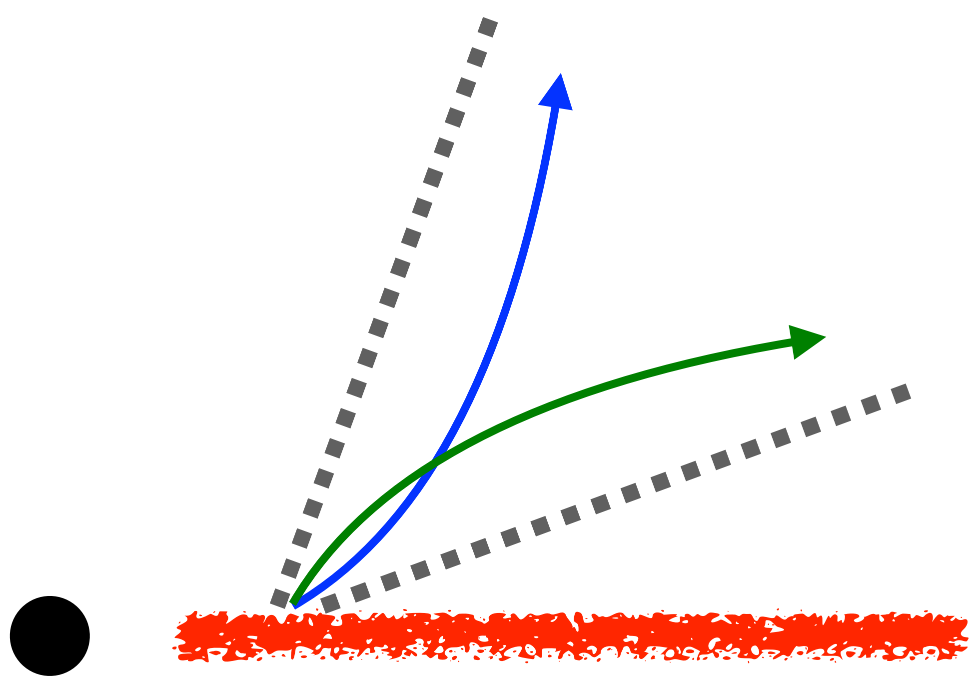

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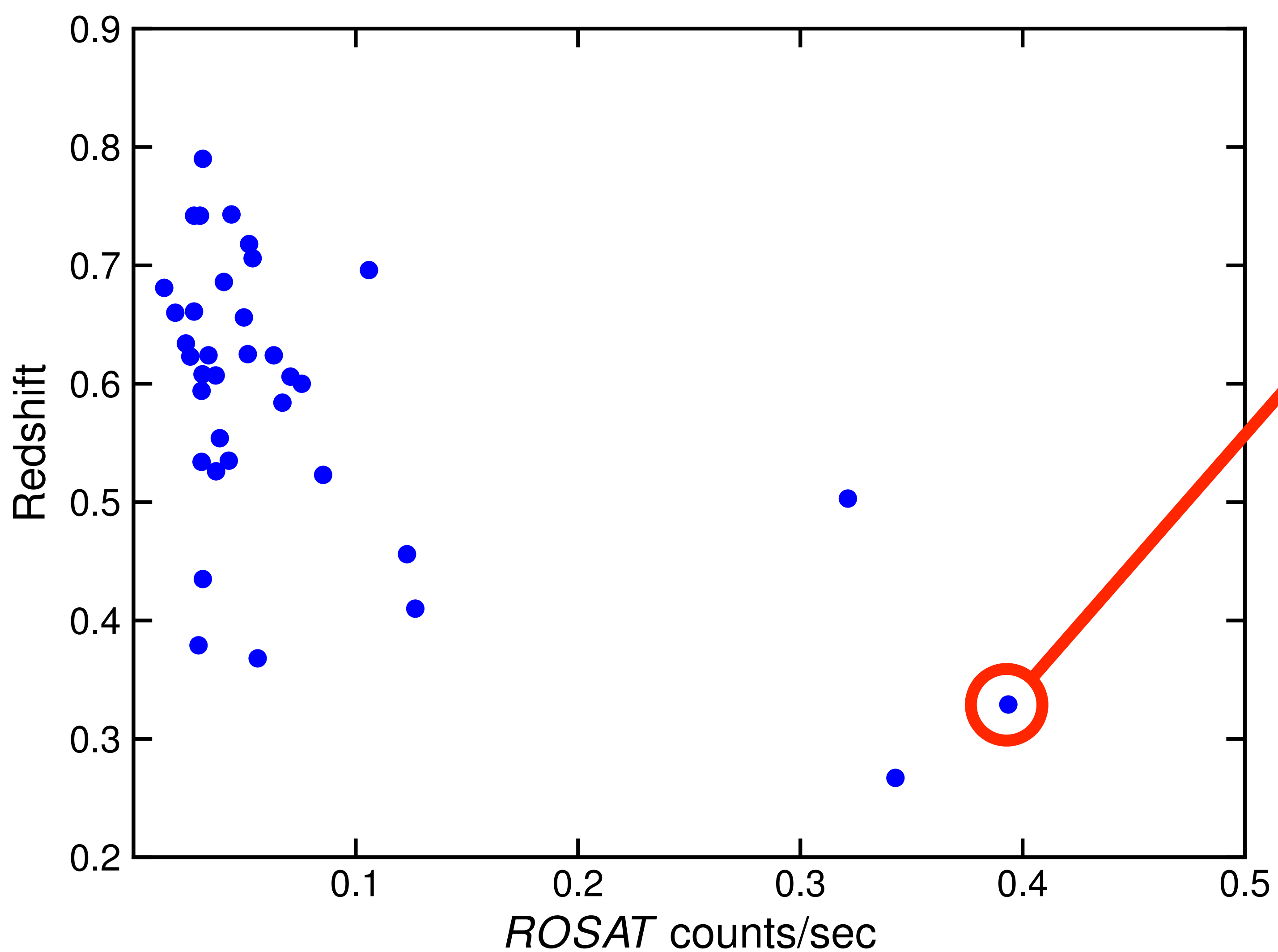
- High luminosity: $L_{bol} > 10^{46}$ erg/s (proxy of high accretion rate)

Persistent nature:

- APM 08279+5255 *Saez & Chartas (2011)*
- PDS 456 *Matzeu et al. (2017)*

A tailored selection method

- 1,091 objects with EW [O III] < 6 Å (most likely to be face-on)
- High luminosity: $L_{bol} > 10^{46}$ erg/s (proxy of high accretion rate)
- Radio-quiet and detected by *ROSAT* (36 objects)



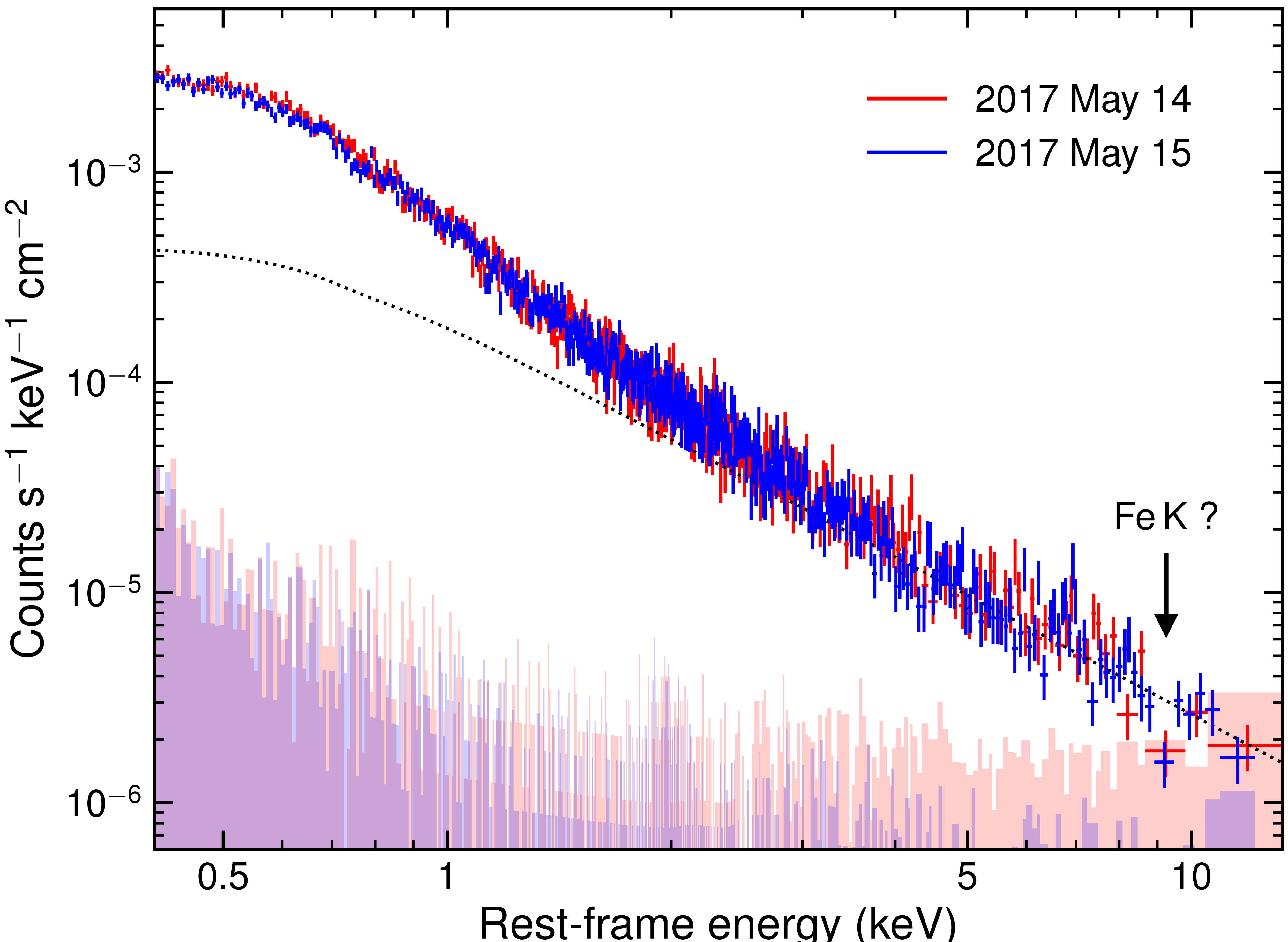
Ton 28

$z = 0.329$

$\log L_{bol} = 46.4$

Optimal target to reveal an ultra-fast X-ray wind

XMM-Newton observation(s) of Ton 28



Nardini et al. (2019)

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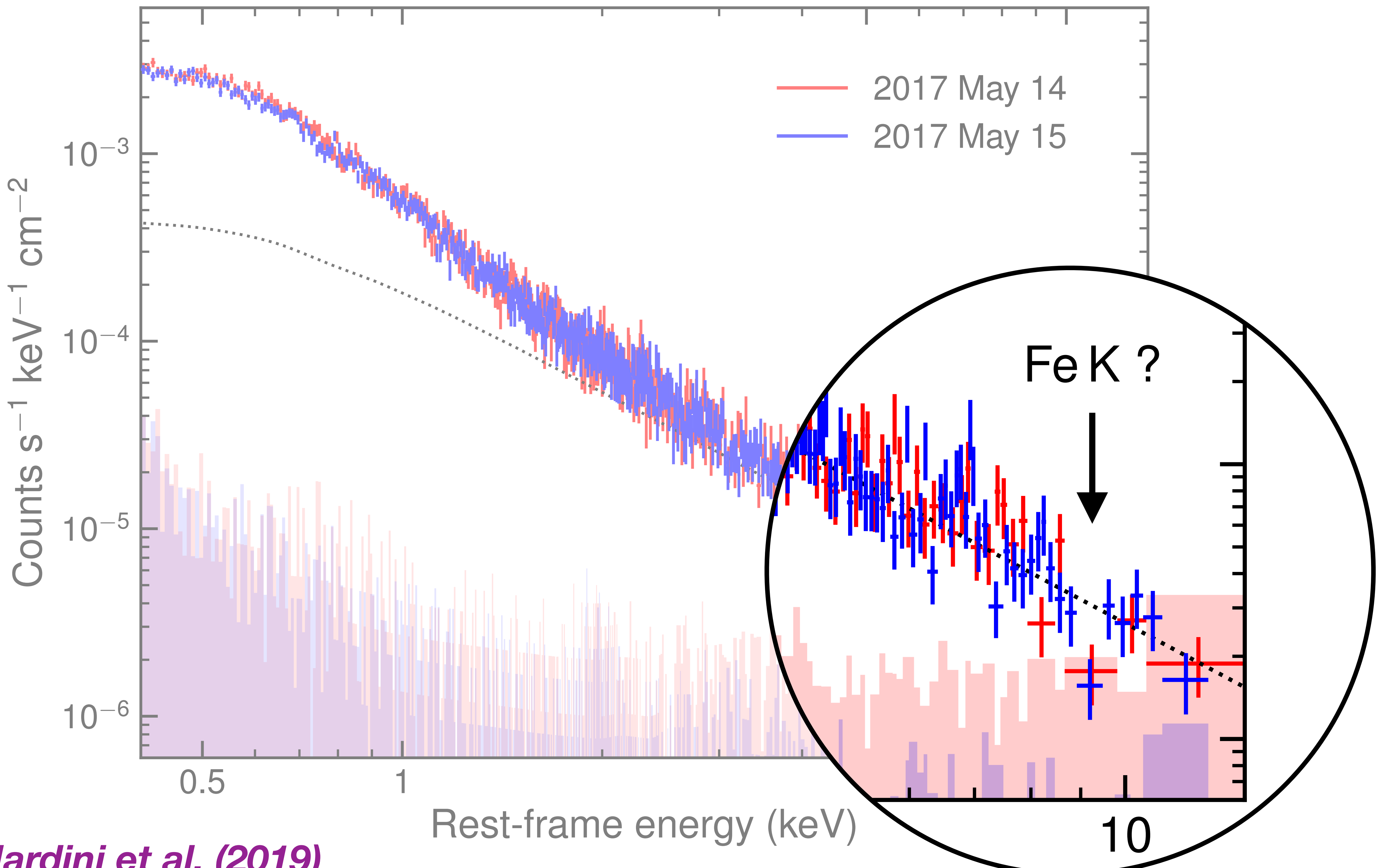

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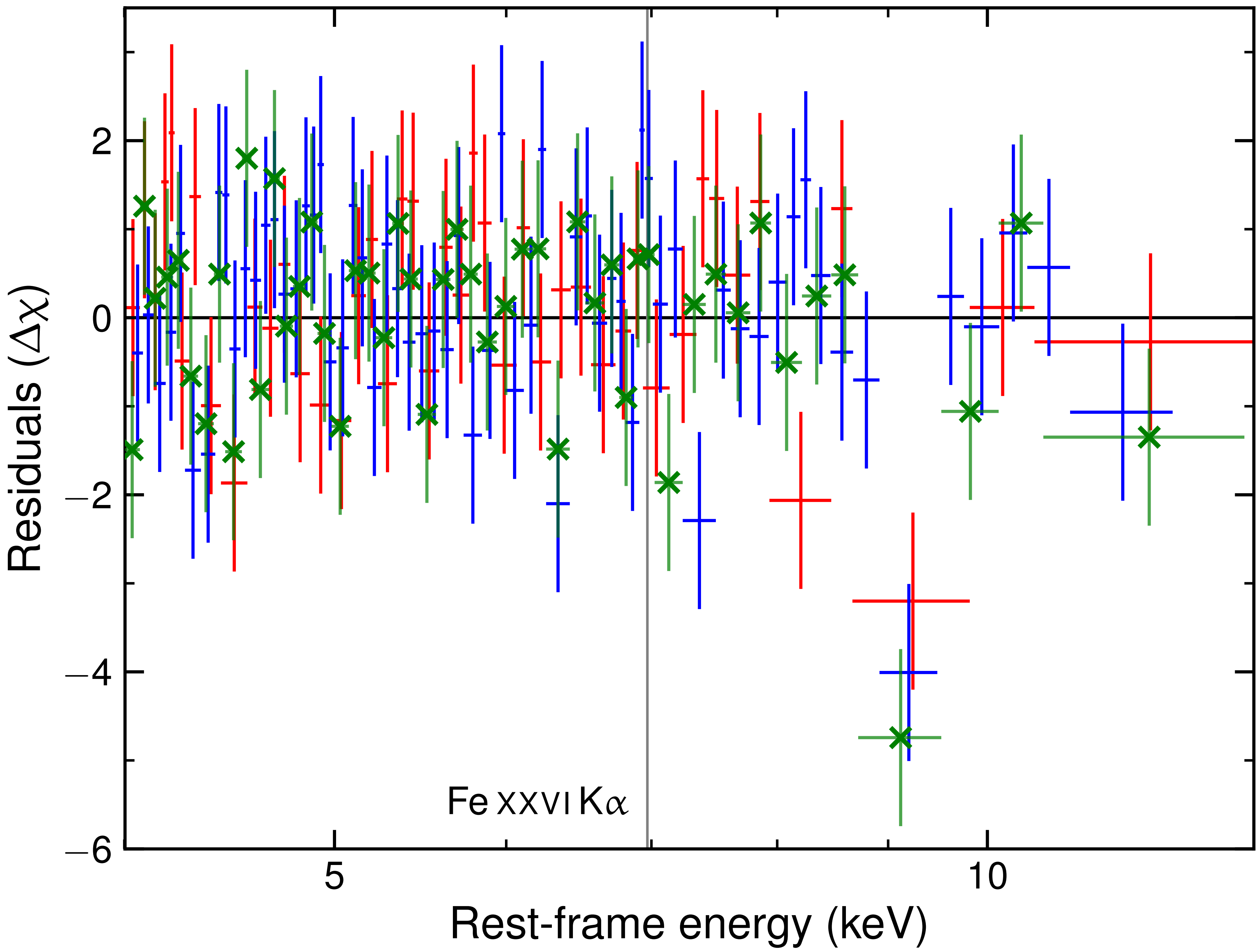
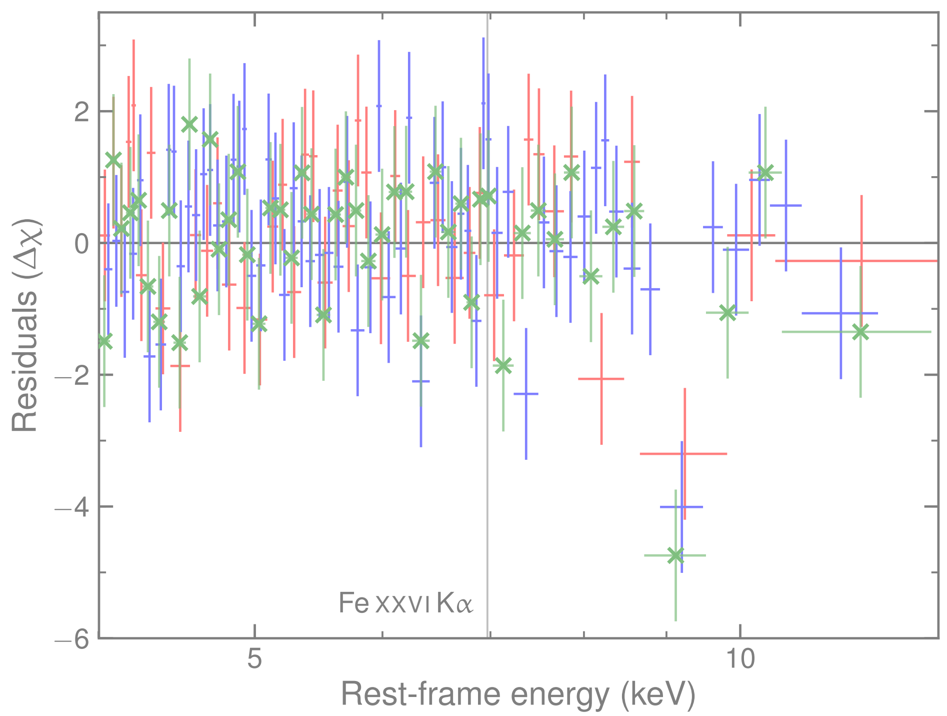
Wind significance and physical properties



Wind significance and physical properties

	Obs. 1	Obs. 2	Tied
E_{abs} (keV)	6.97(f)	6.97(f)	6.97(f)
v_{out}/c	$0.29^{+0.03}_{-0.06}$	$0.25^{+0.04}_{-0.01}$	$0.25^{+0.04}_{-0.01}$
F (10^{-13} c.g.s.)	3.7	3.6	3.7
χ^2/ν	44.0/38	63.3/58	111.6/102
$\Delta\chi^2$	−7.6	−12.9	−19.5
F-test prob.	0.9514	0.9954	0.9997



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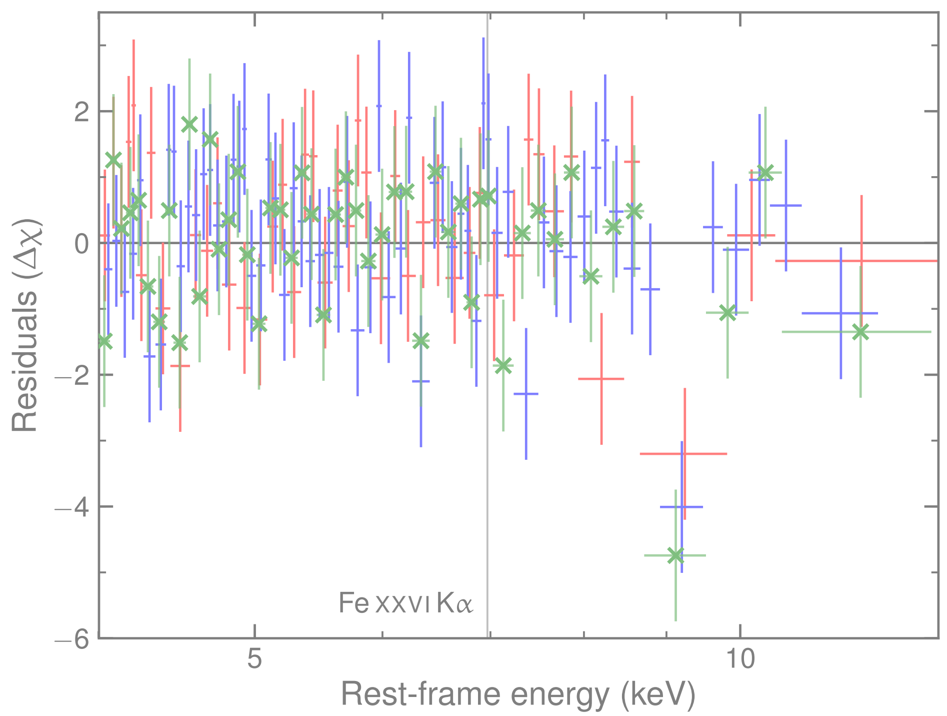
0.9991 according to MC simulations



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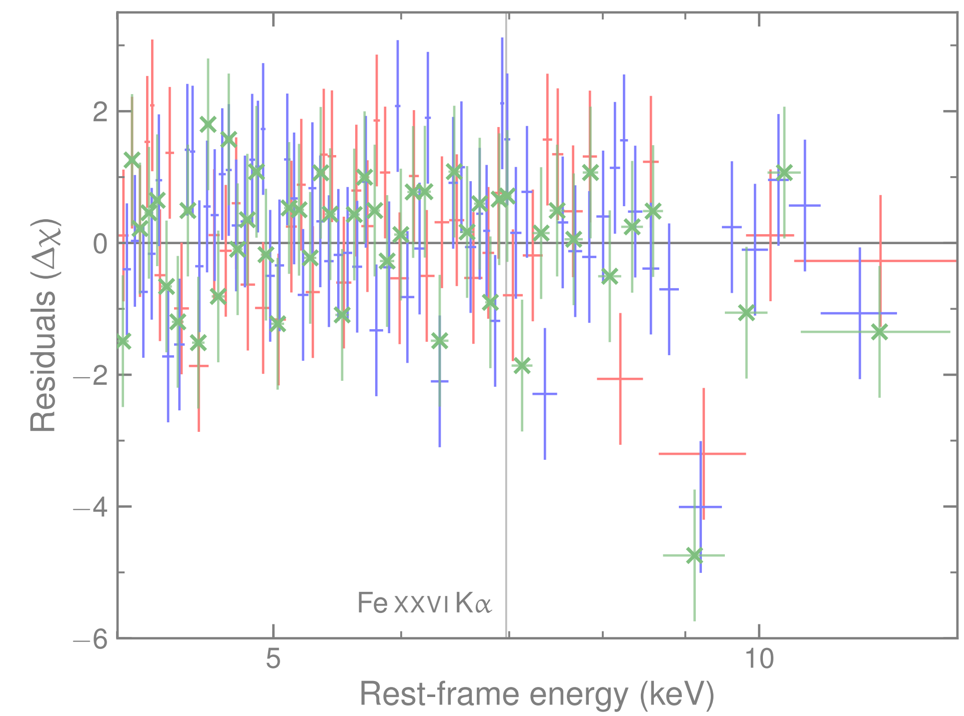
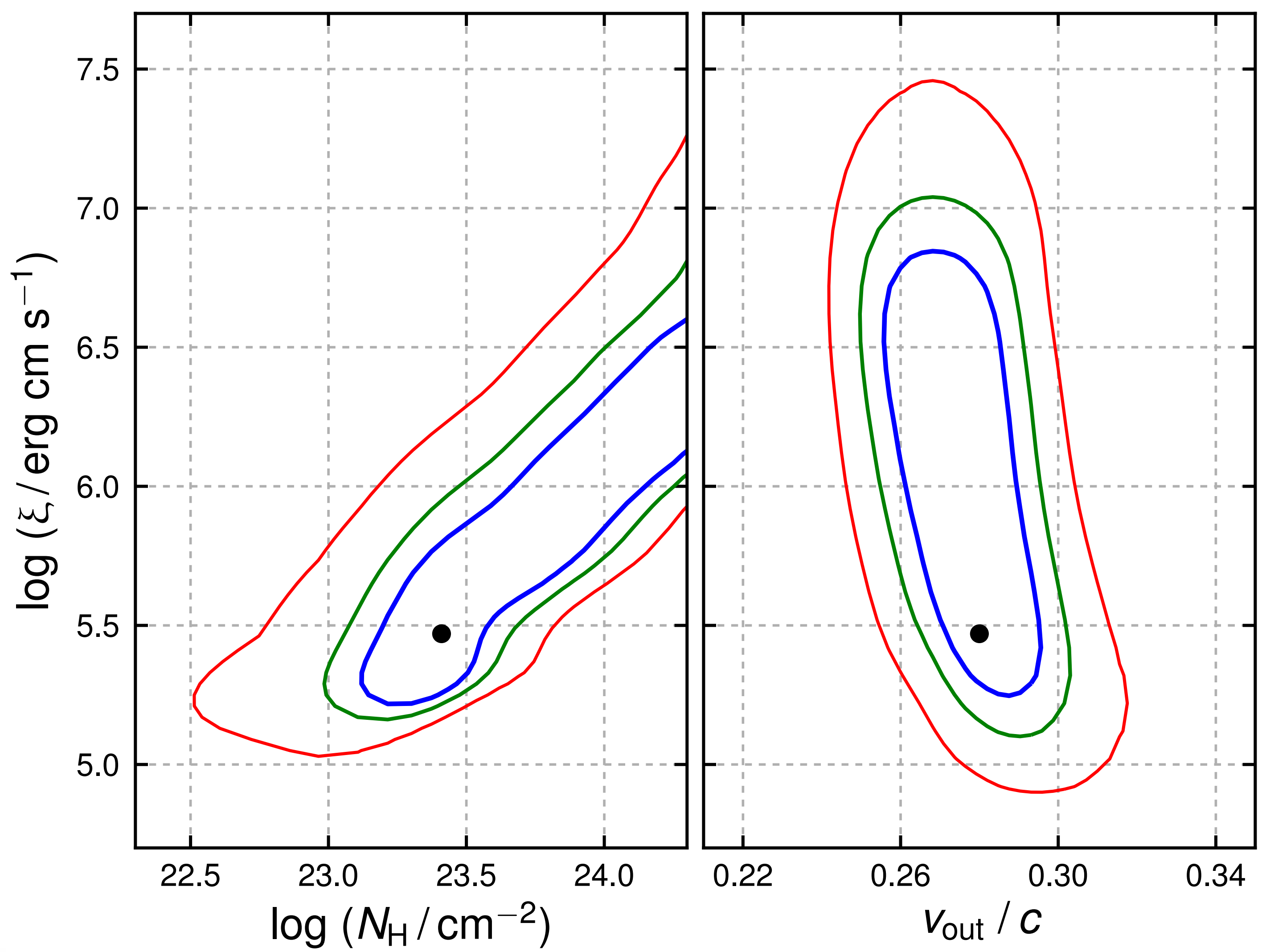


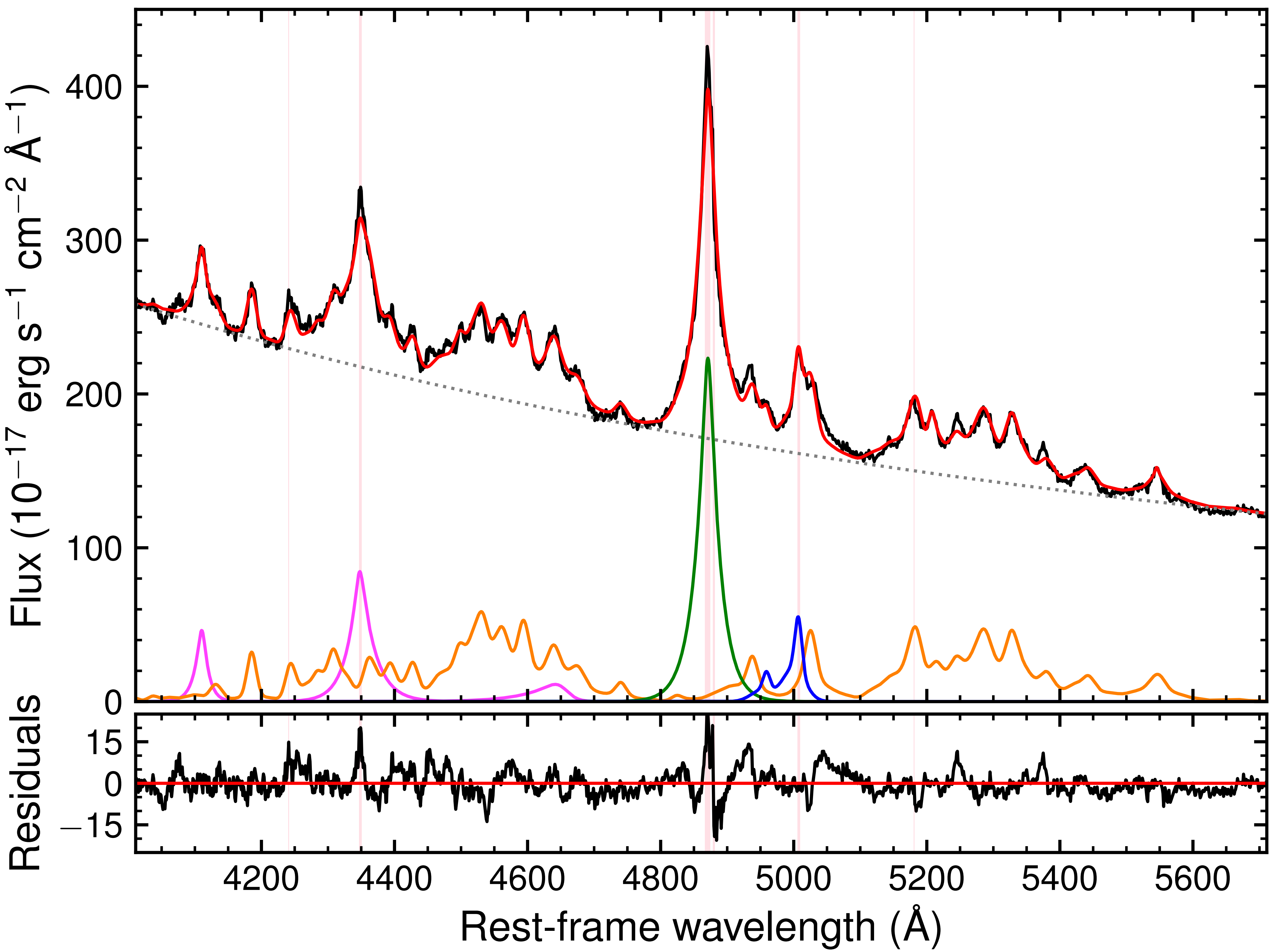


Very large uncertainty on wind energetics (N_H, R, Ω)

↓

Best guess under most conservative assumptions:
$dE_{kin}/dt = 0.01\ L_{bol}$

A closer look at Ton 28



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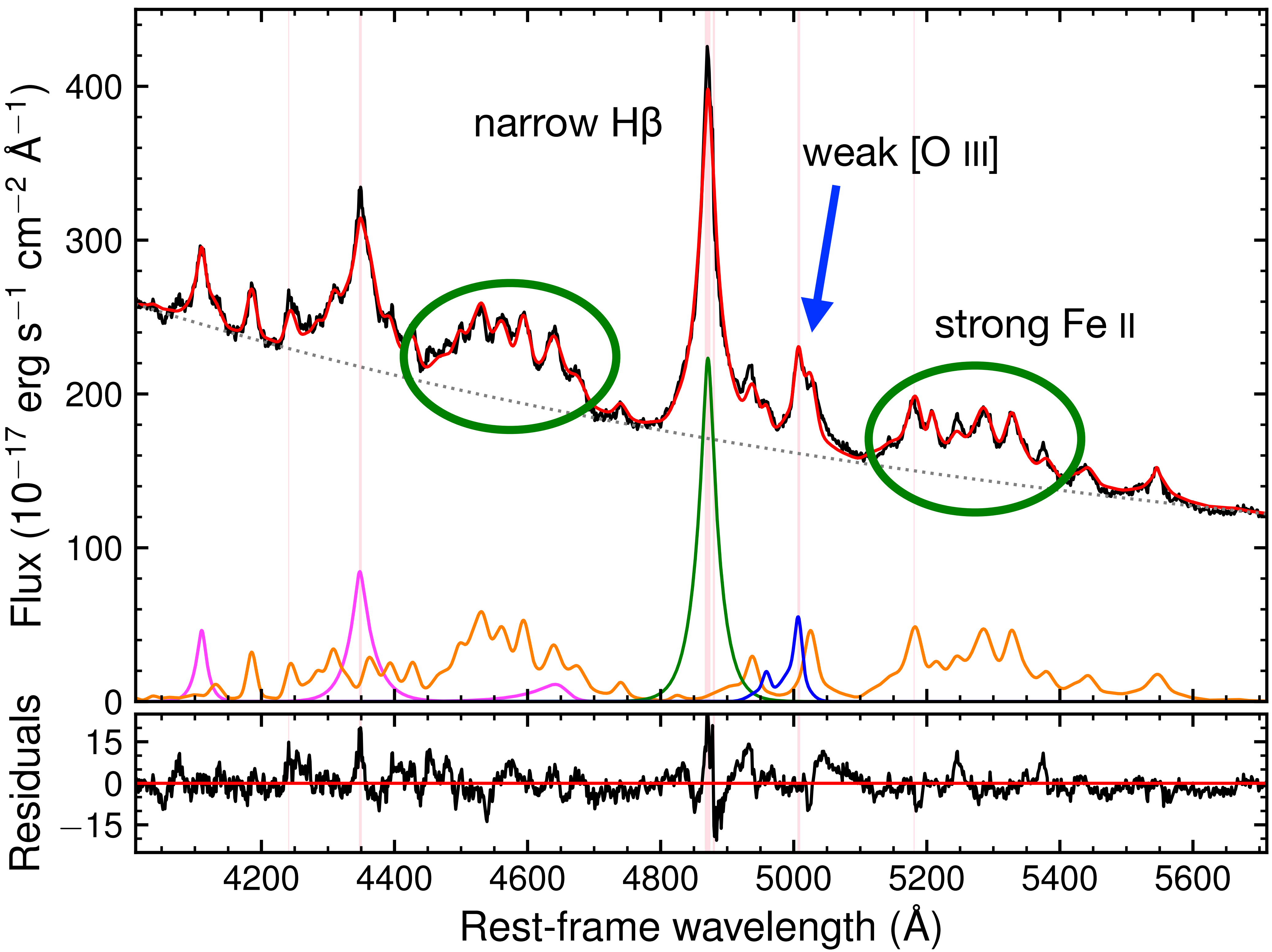
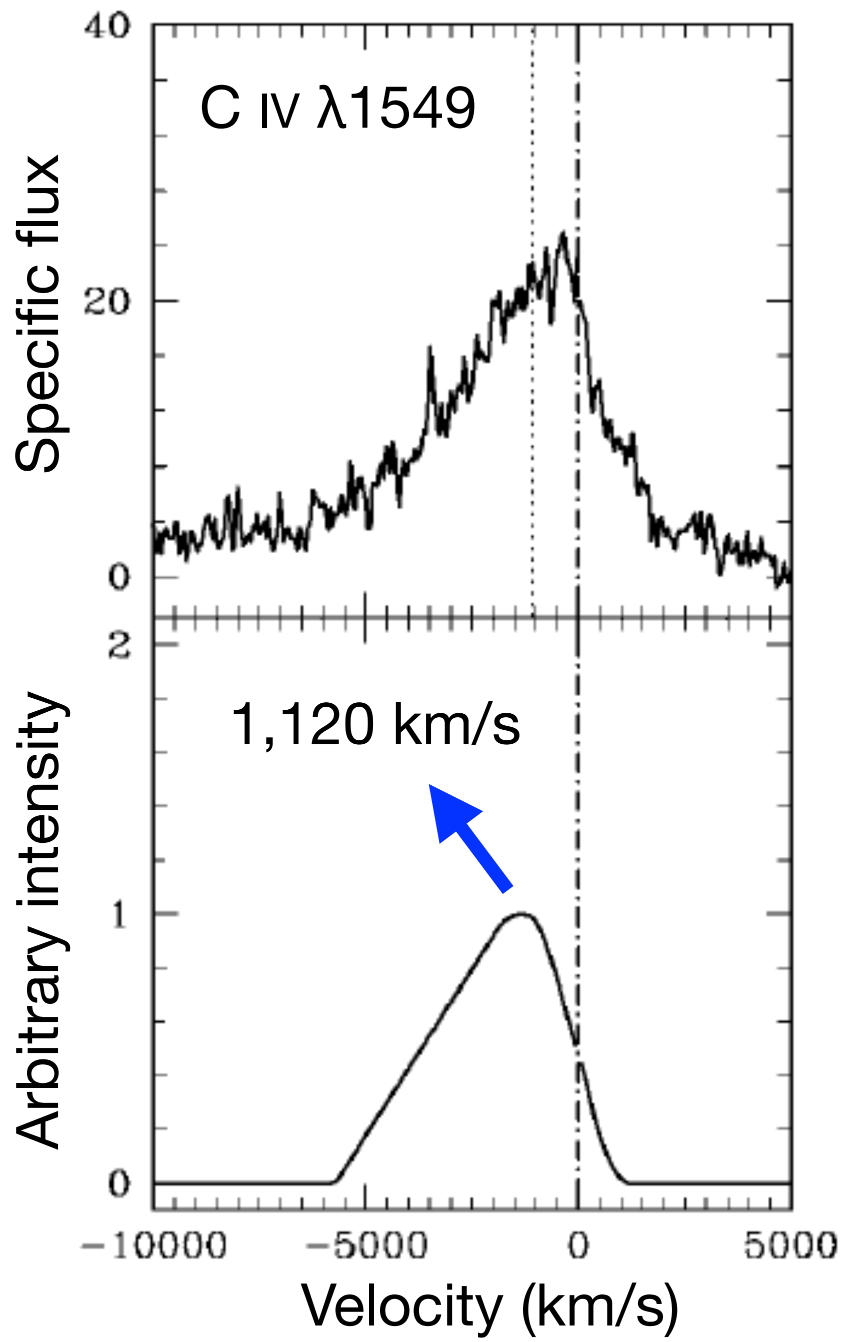
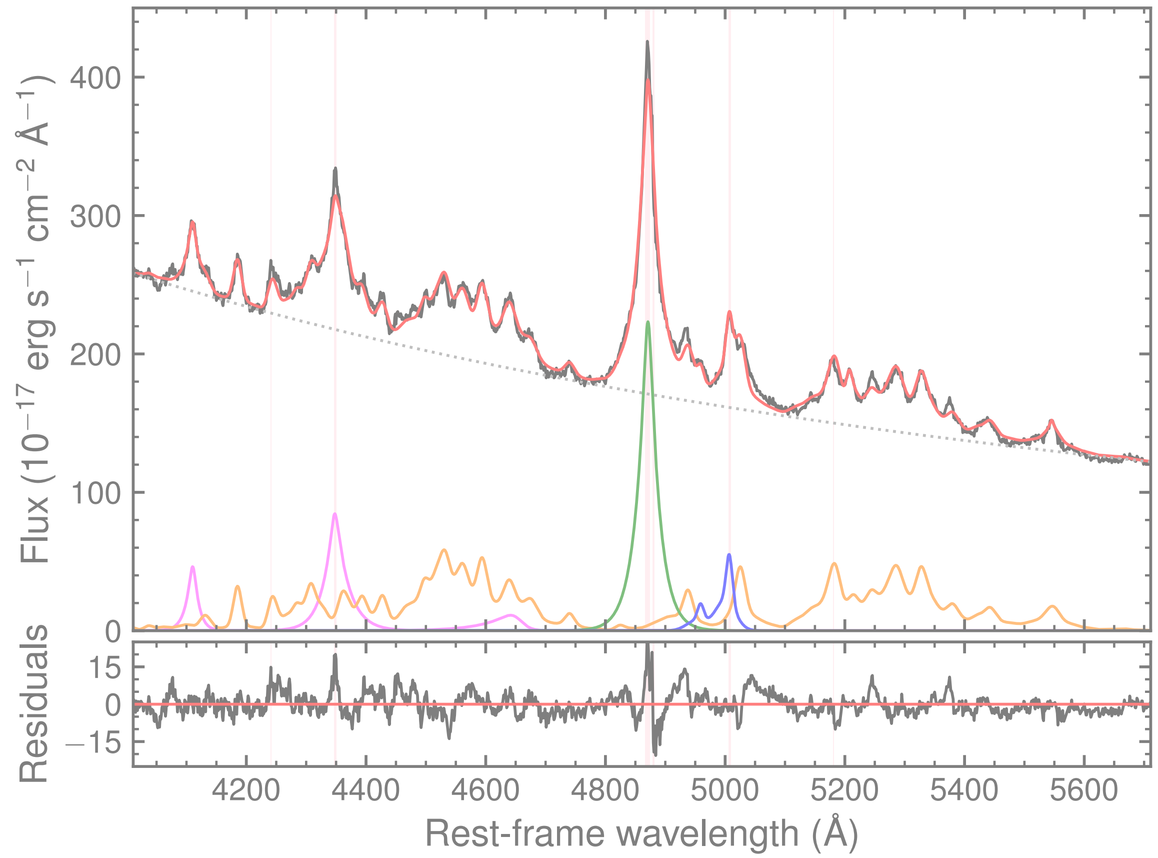


Possible relation with Eigenvector 1



Zamanov et al. (2002)



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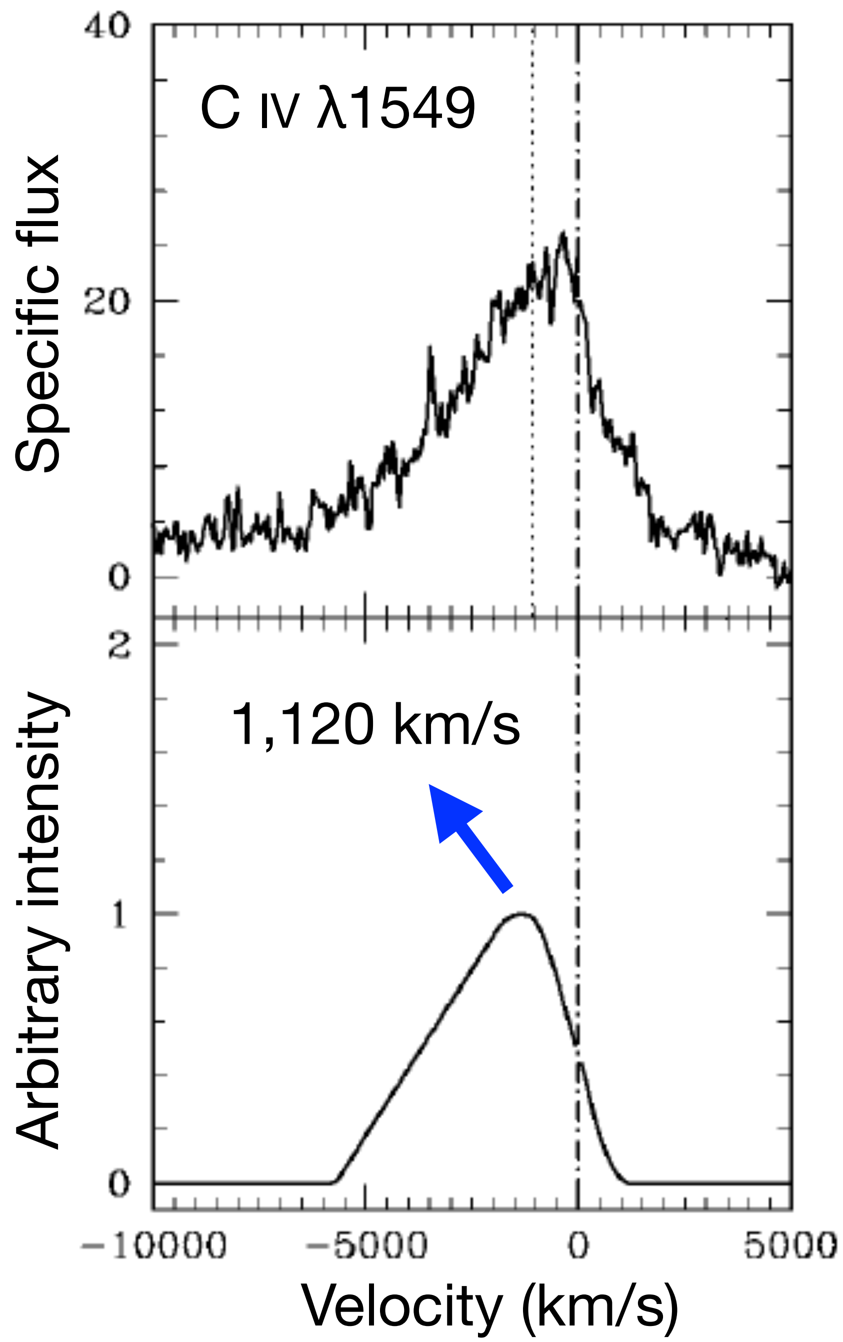

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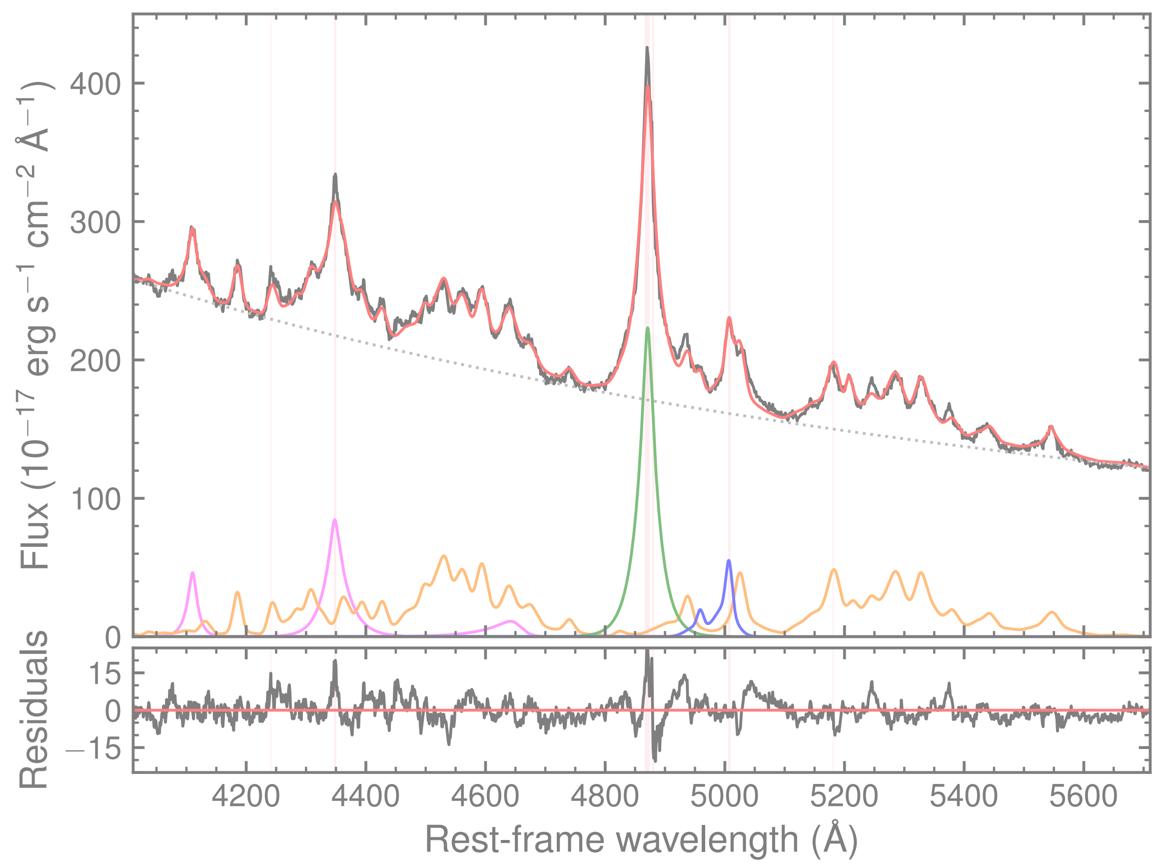

Also [O III] has a blue component outflowing at 680 km/s, interpreted as part of the same wide-angle outflow seen almost face-on

In terms of the Eigenvector 1 formalism, Ton 28 is a *blue outlier* among extreme population A objects (e.g. I Zw 1)

Summary and next steps

- Ton 28 was specifically selected as an ideal target to reveal an ongoing ultra-fast X-ray wind: and the wind is there!
- Detailed multi-wavelength study of Ton 28 to piece together the different wind/outflow signatures at different scales
- X-ray focus on similar objects to investigate the relation with Eigenvector 1 and refine our selection criteria
- The use of multi-wavelength tracers to probe ultra-fast accretion disc winds is compelling in the absence of X-ray spectra with high S/N (i.e. high-*z* quasars before *Athena*)

Nardini, Lusso & Bisogni (2019), MNRAS 482, L134