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@Winchester, UK

The Origin of UFOs in AGN

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Outline

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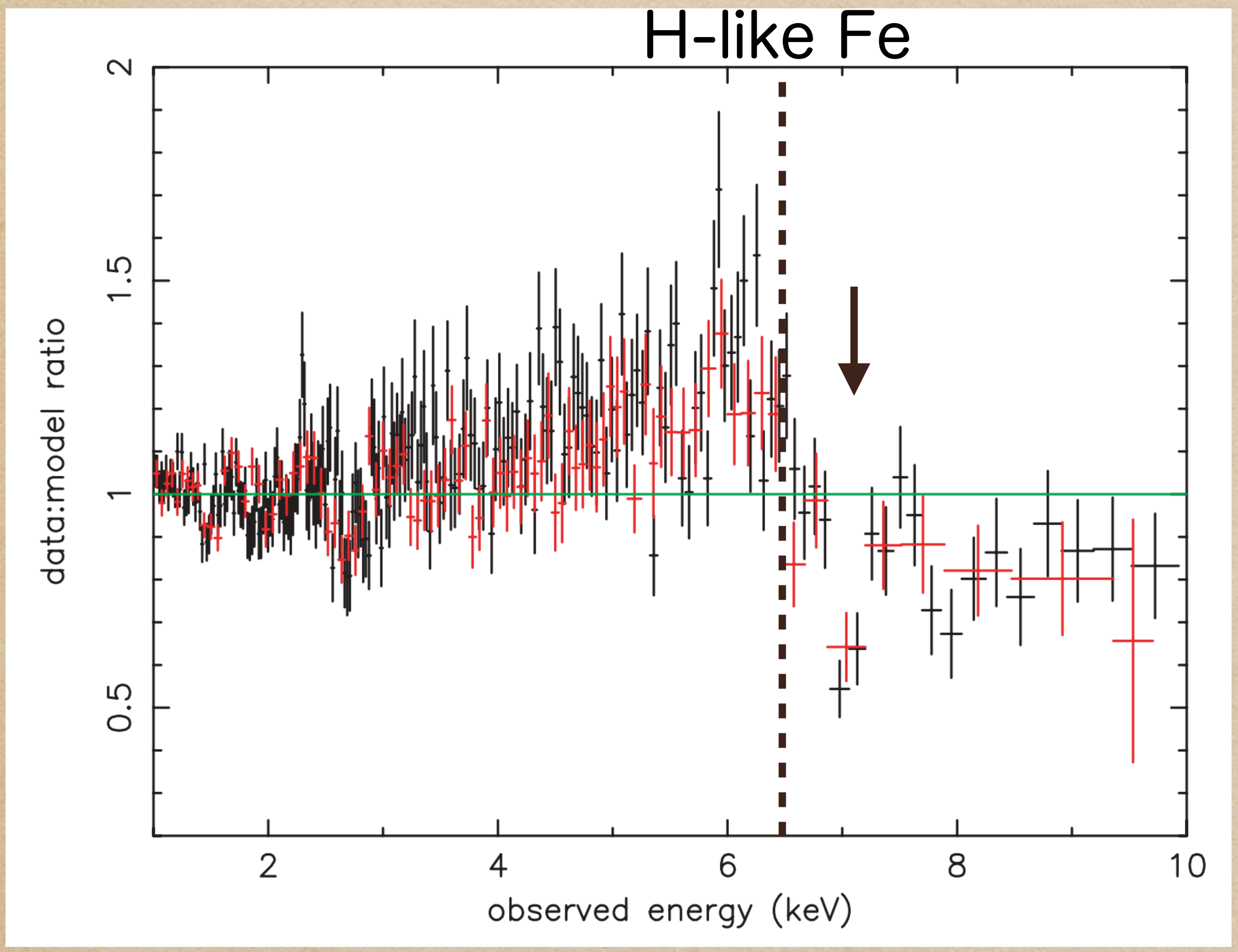
UltraFast Outflow(UFO)

PG 1211+143



(Pounds+03)

Blueshifted absorption lines

v= 0.1c - 0.3c

H-like or He-like Fe ion

Seen in many AGNs

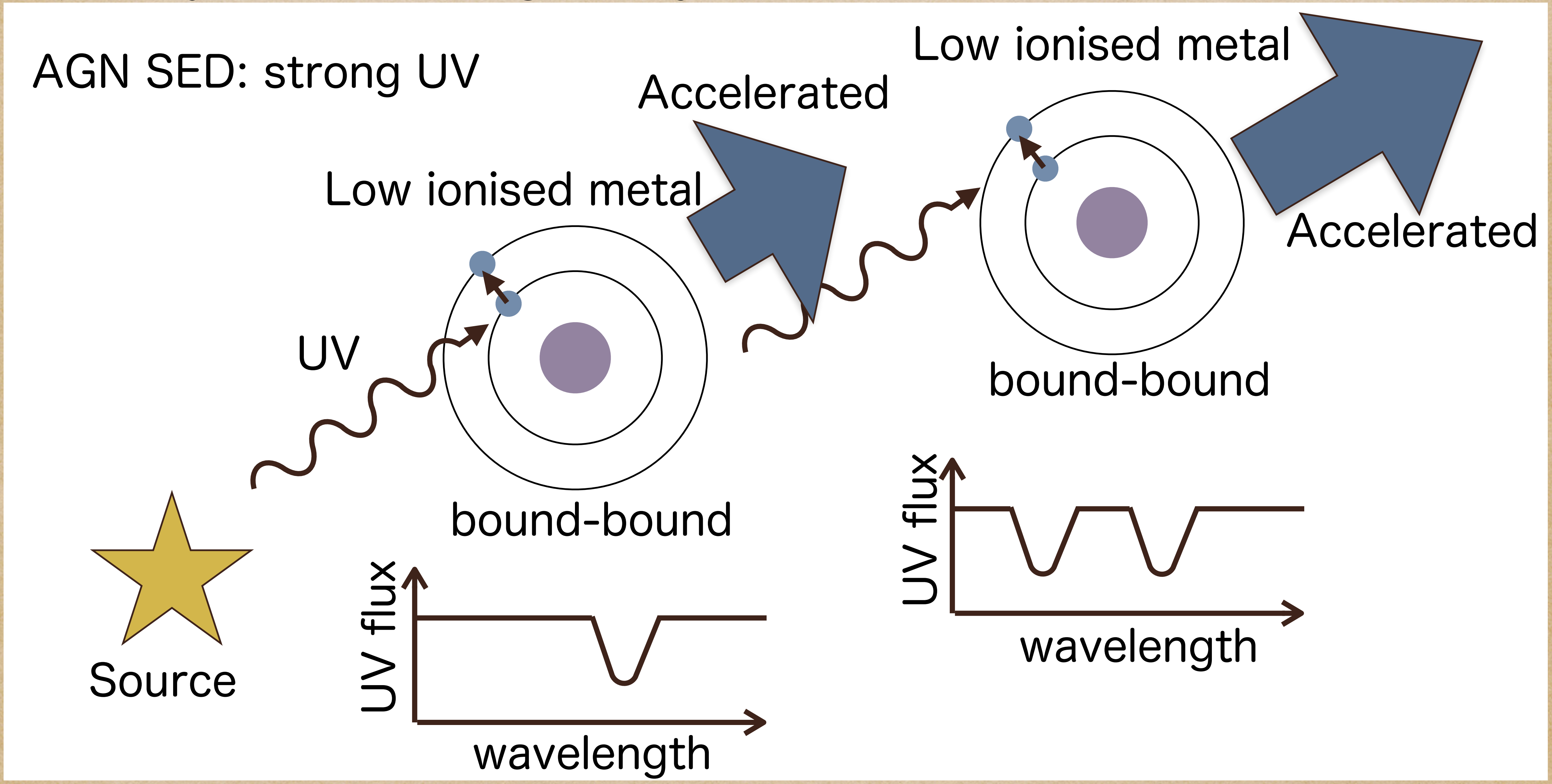
(e.g. Tombesi+11)

Carry a lot of kinetic energy from AGN to host galaxy

UV line driven disc wind

(e.g. Proga+00)

Especially for sub-Eddington objects



Can be accelerated even in the lower stream

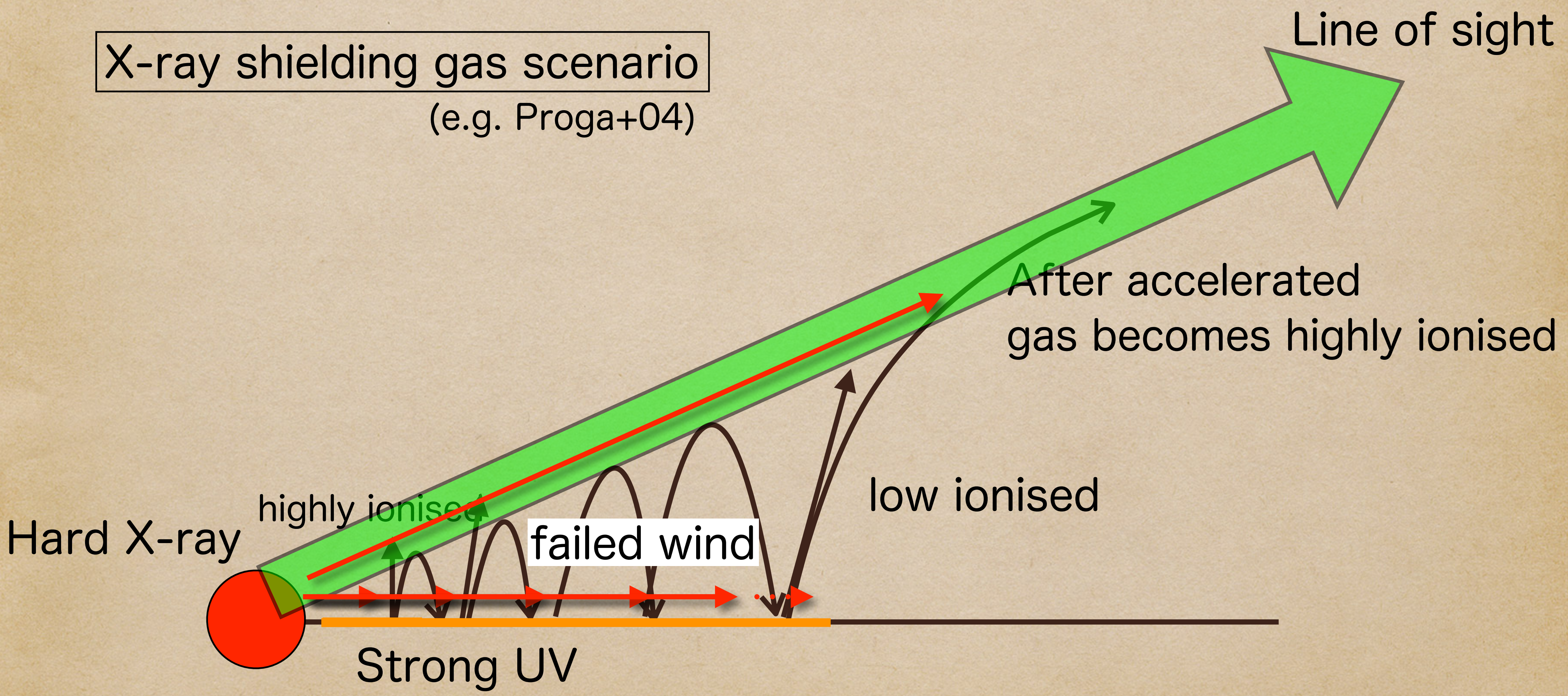
Problem of UV line driven disc wind

UV line driven disc wind: require low ionised metal

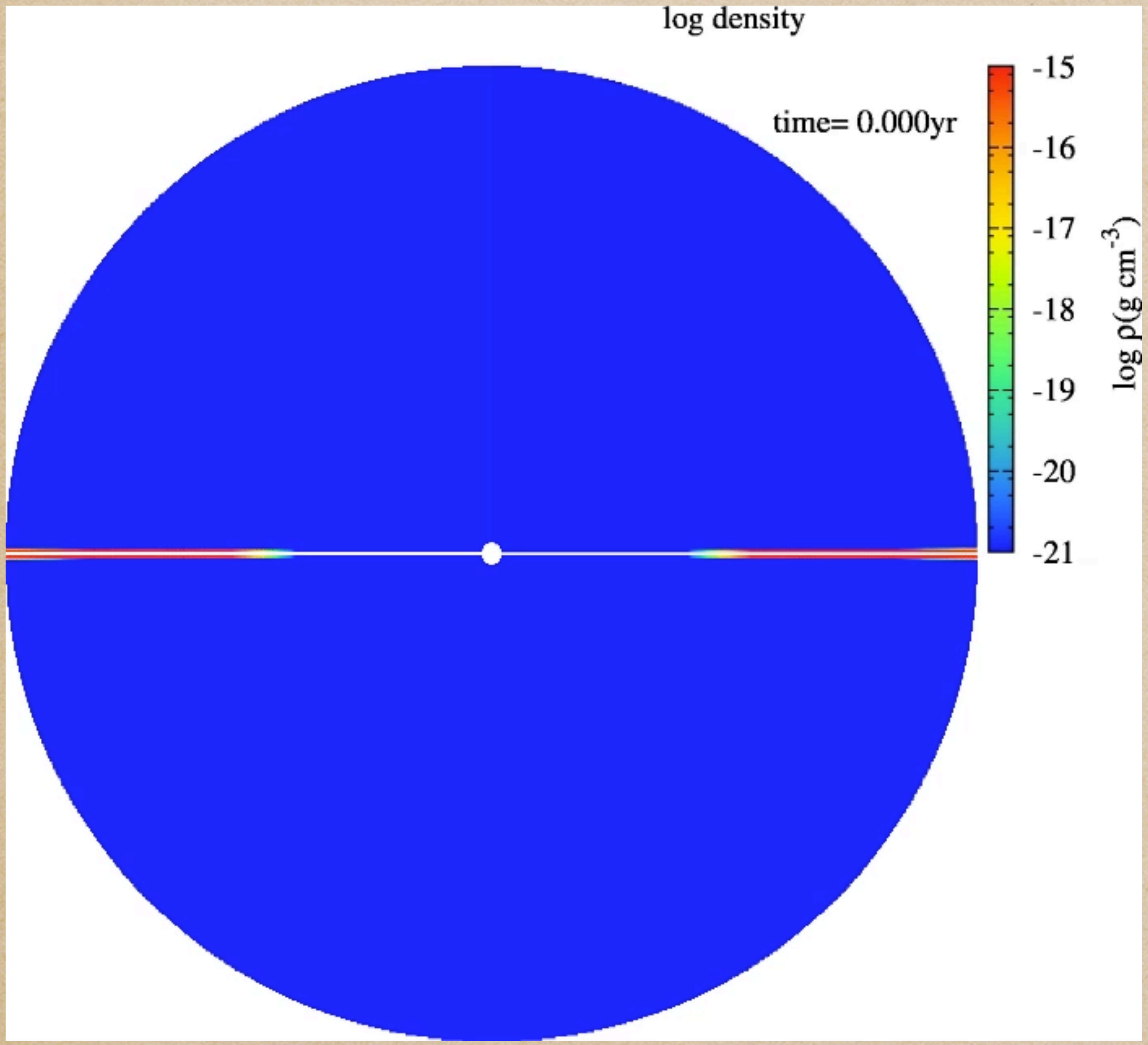
Observation: require highly ionised metal

X-ray shielding gas scenario

(e.g. Proga+04)



Motivation



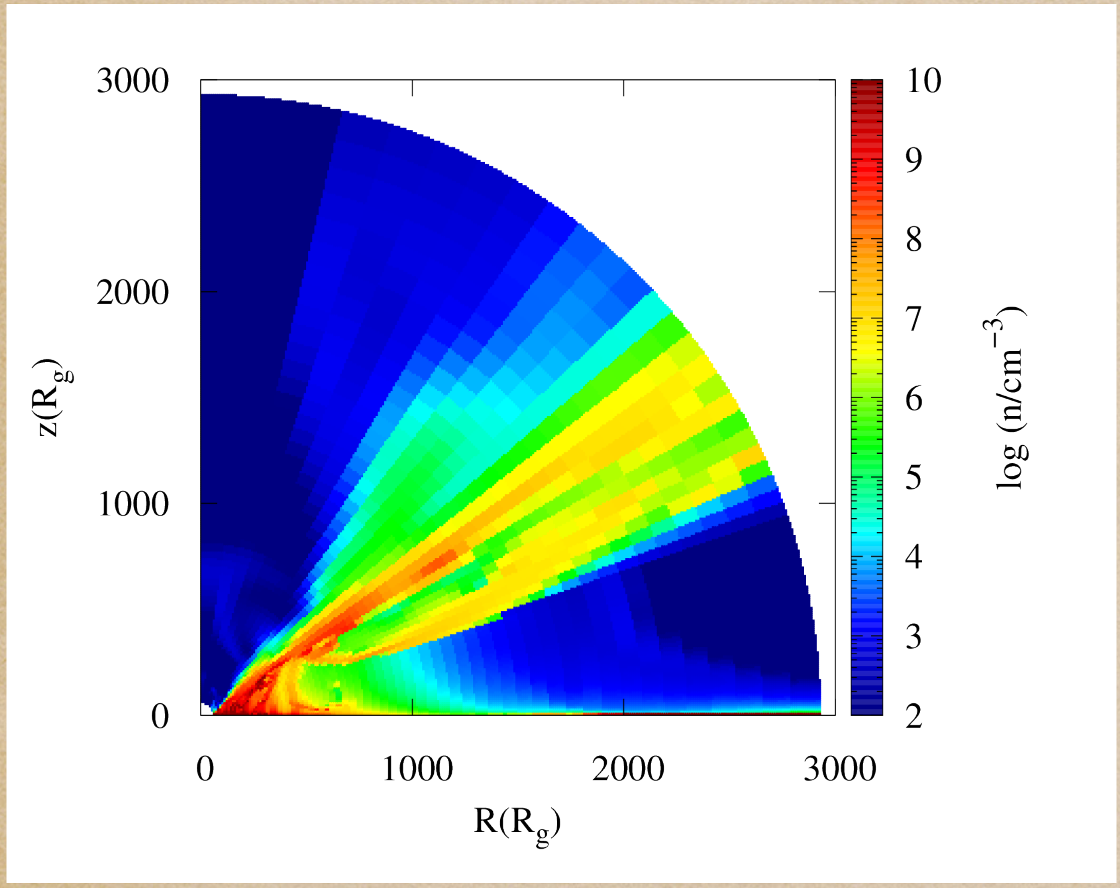
By M. Nomura

Study whether the UV line driven wind can explain UFOs

Calculate model spectra based on radiative hydrodynamics simulation of UV line driven disc wind
-> Apply to the observations

Simulation setup

Radiation hydrodynamics simulation



(Nomura+19, arXiv:1811.01966)

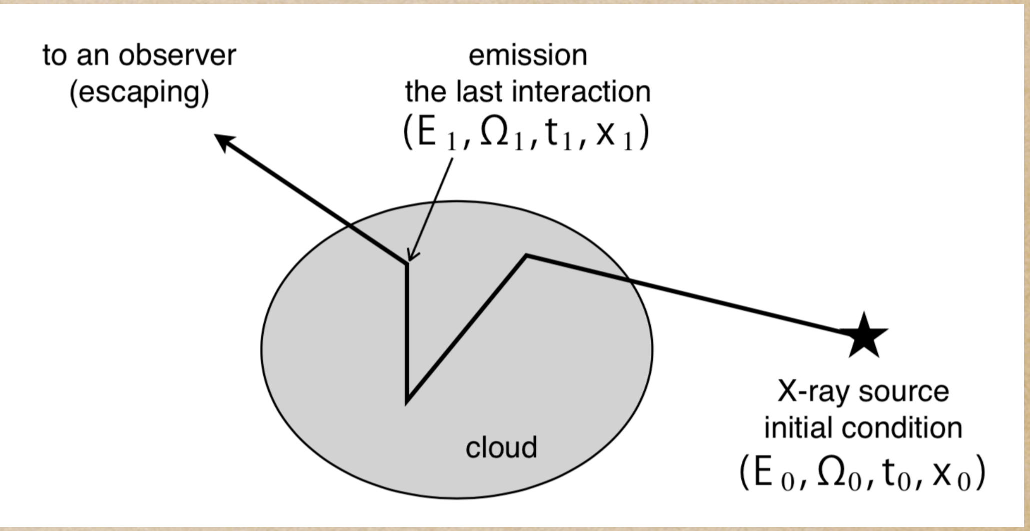
$\dot{M}_{acc}=0.9\dot{M}_{Edd}$

$\dot{M}_{wind}=0.63\dot{M}_{Edd}$

$L_{wind}=0.18L_{Edd}$

Monte Carlo simulation

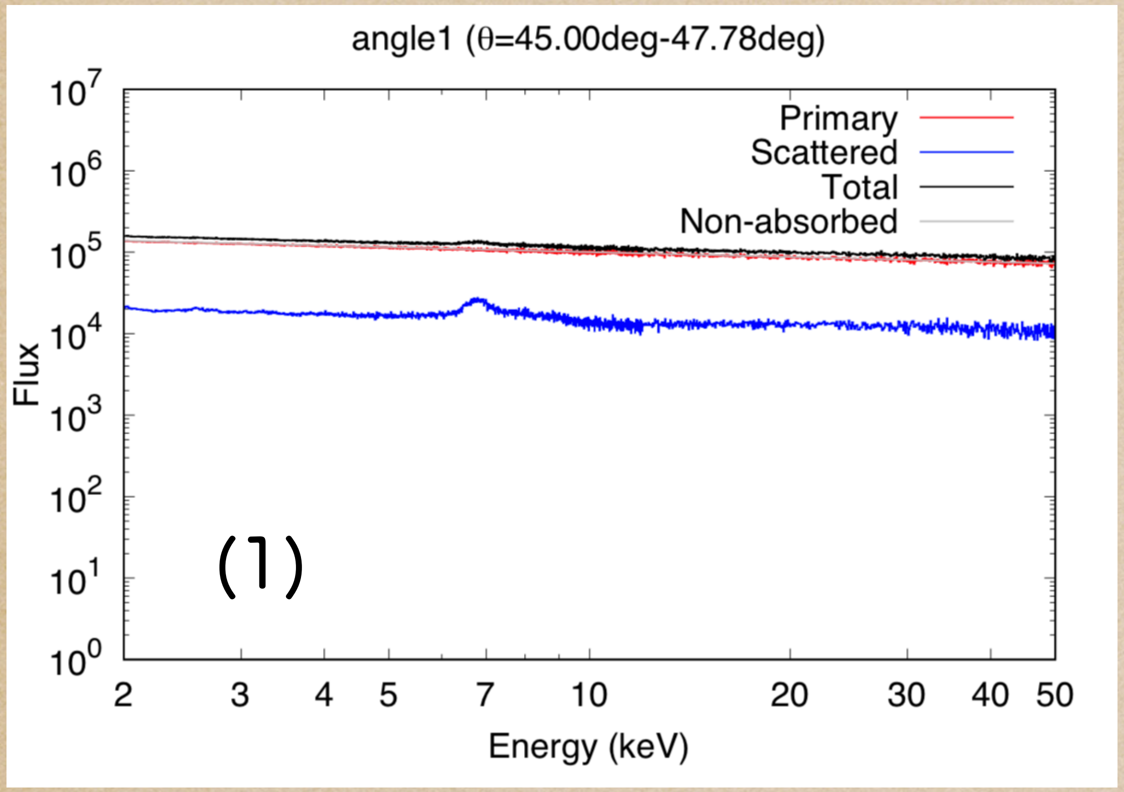
"MONACO" (Odaka+11)

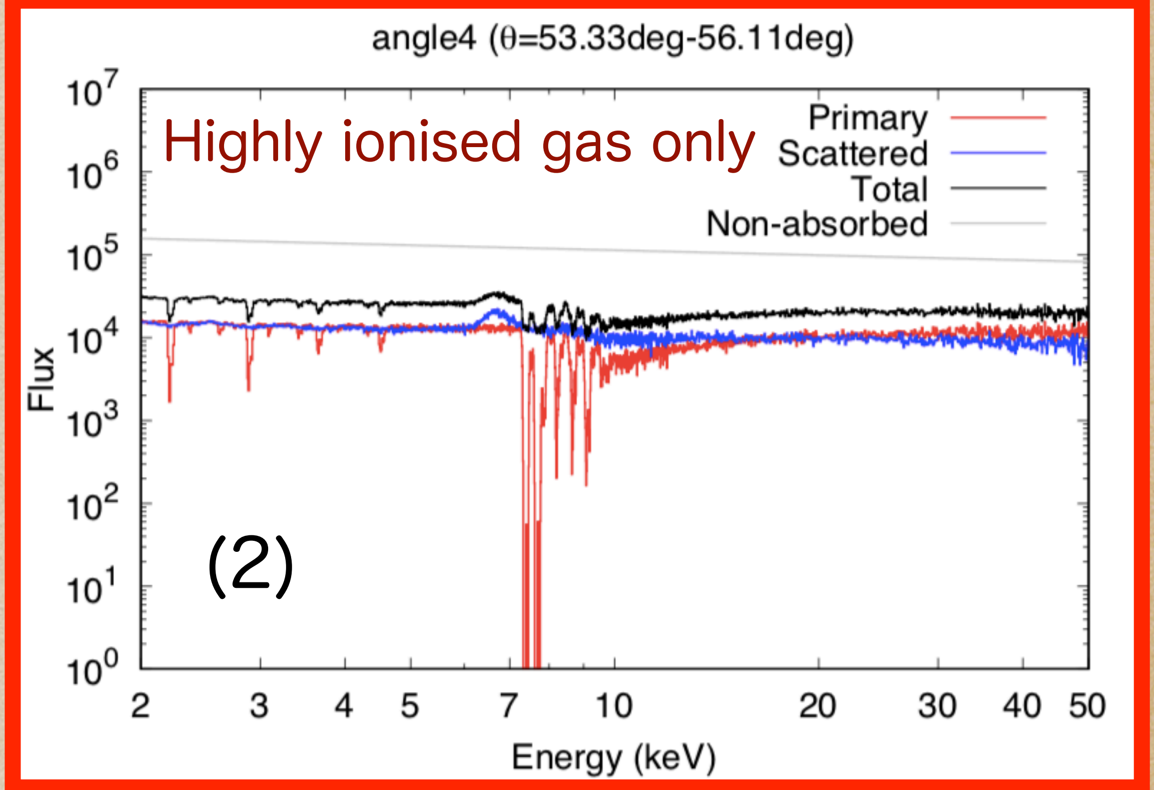


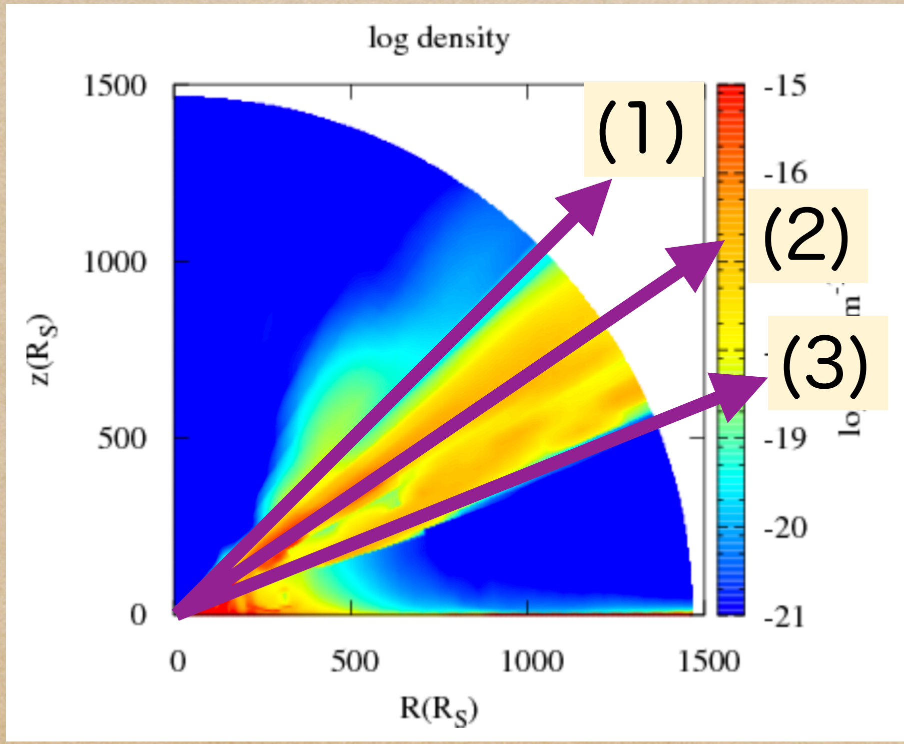
Assuming

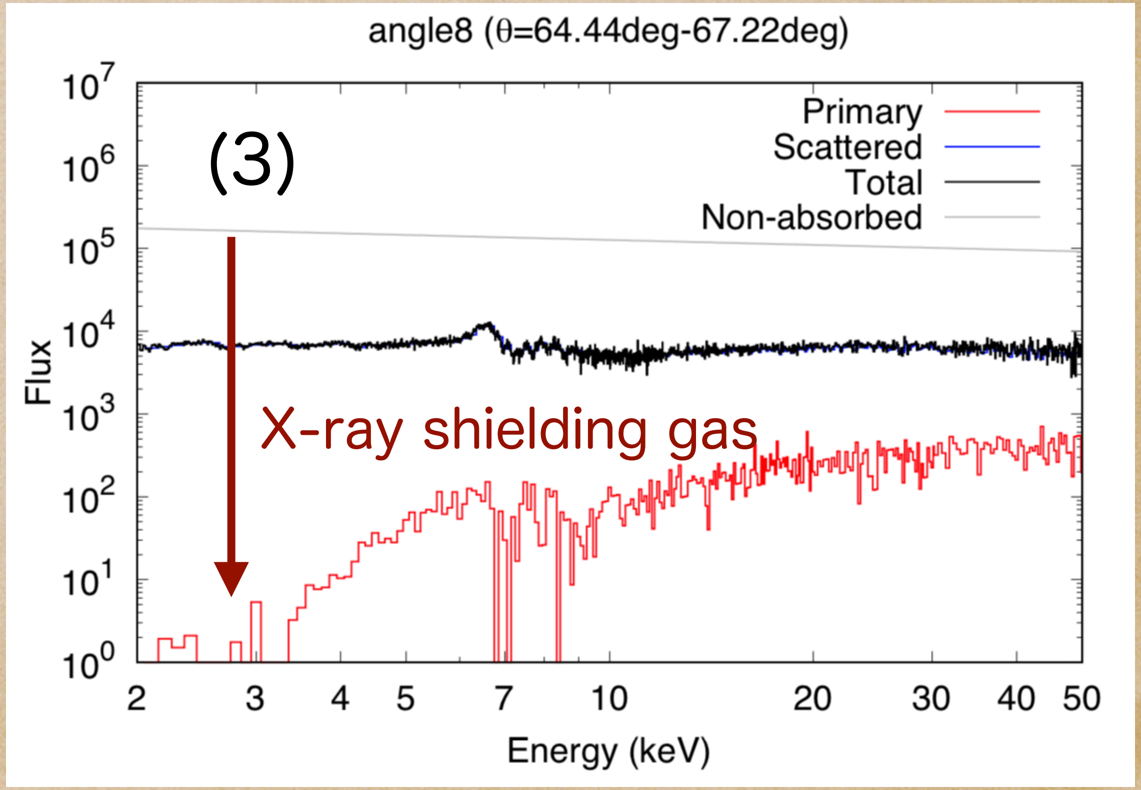
- axisymmetric
- Input: power-law with $\Gamma=2.2$

Model spectra



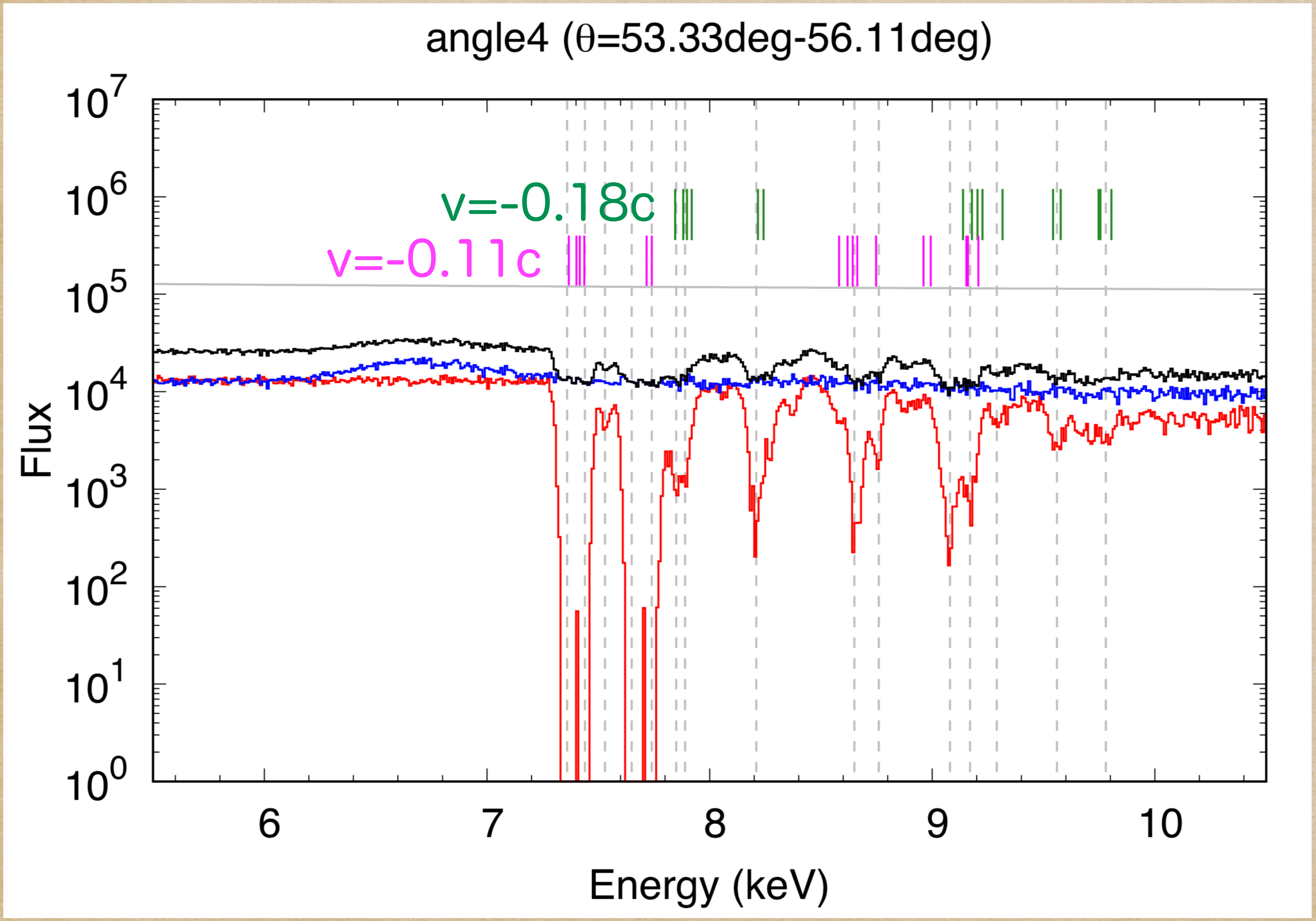






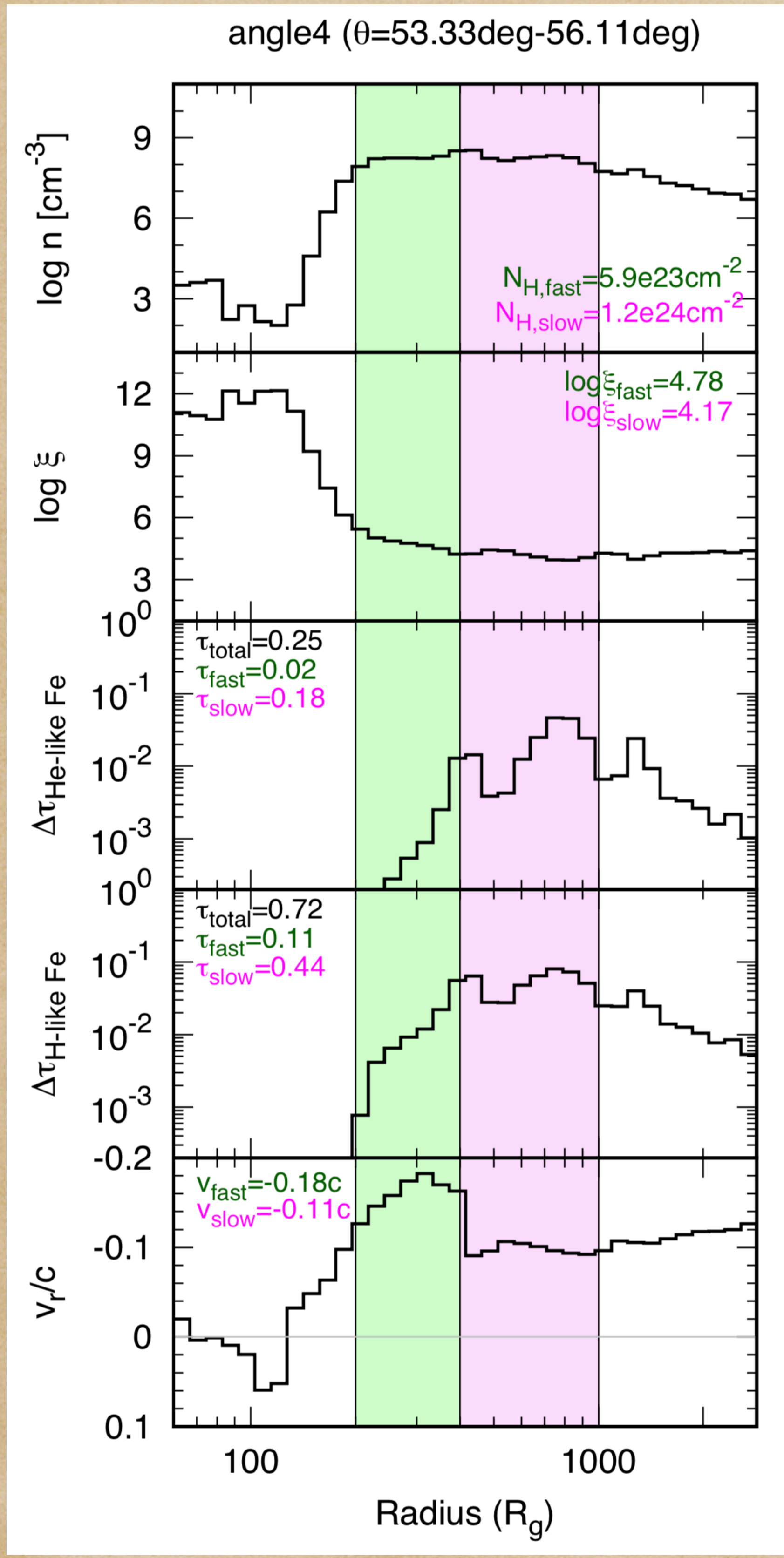
3. Results

UFO absorption features

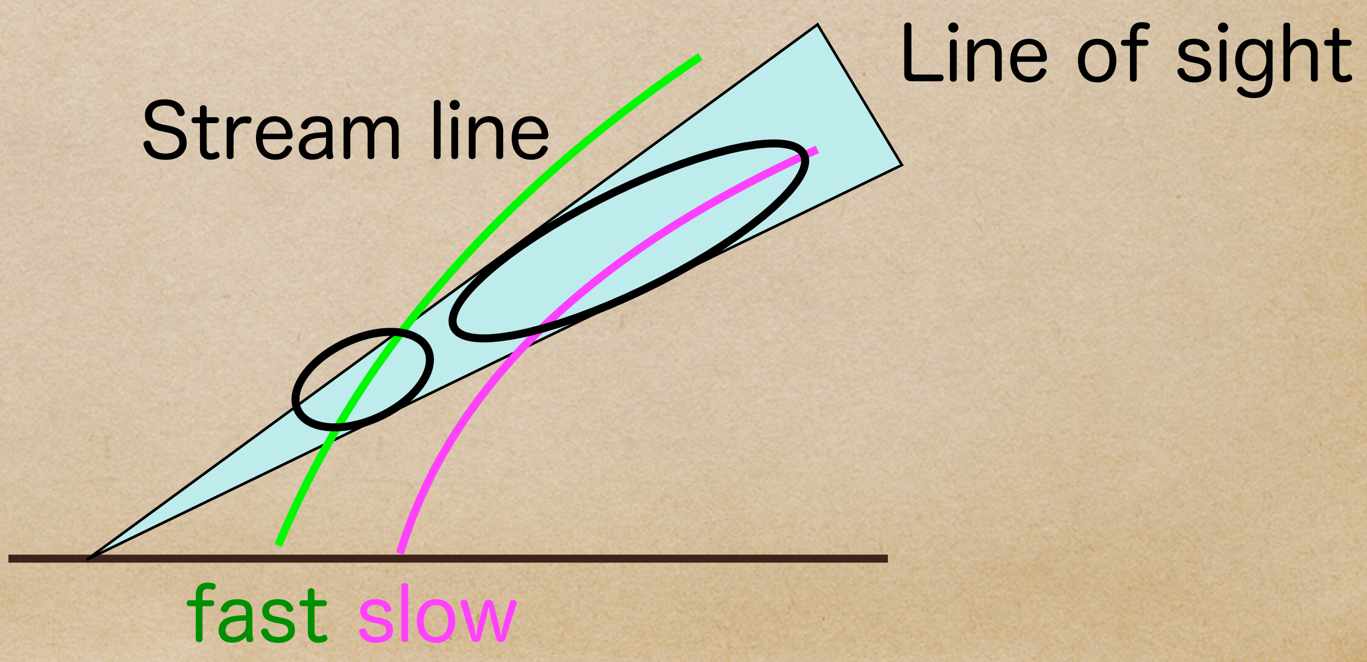


Species	Line	Energy (keV)
Fe XXV	He α (f)	6.637
	He α ($i2$)	6.668
	He α ($i1$)	6.682
	He α (r)	6.700
Fe XXVI	Ly α_2	6.952
	Ly α_1	6.973
Ni XXVII	He α (f)	7.731
	He α ($i2$)	7.765
	He α ($i1$)	7.786
	He α (r)	7.805
Fe XXV	He β (r)	7.881
Ni XXVIII	Ly α_2	8.073
	Ly α_1	8.102
Fe XXVI	Ly β_2	8.246
	Ly β_1	8.253
Fe XXV	He γ (r)	8.295

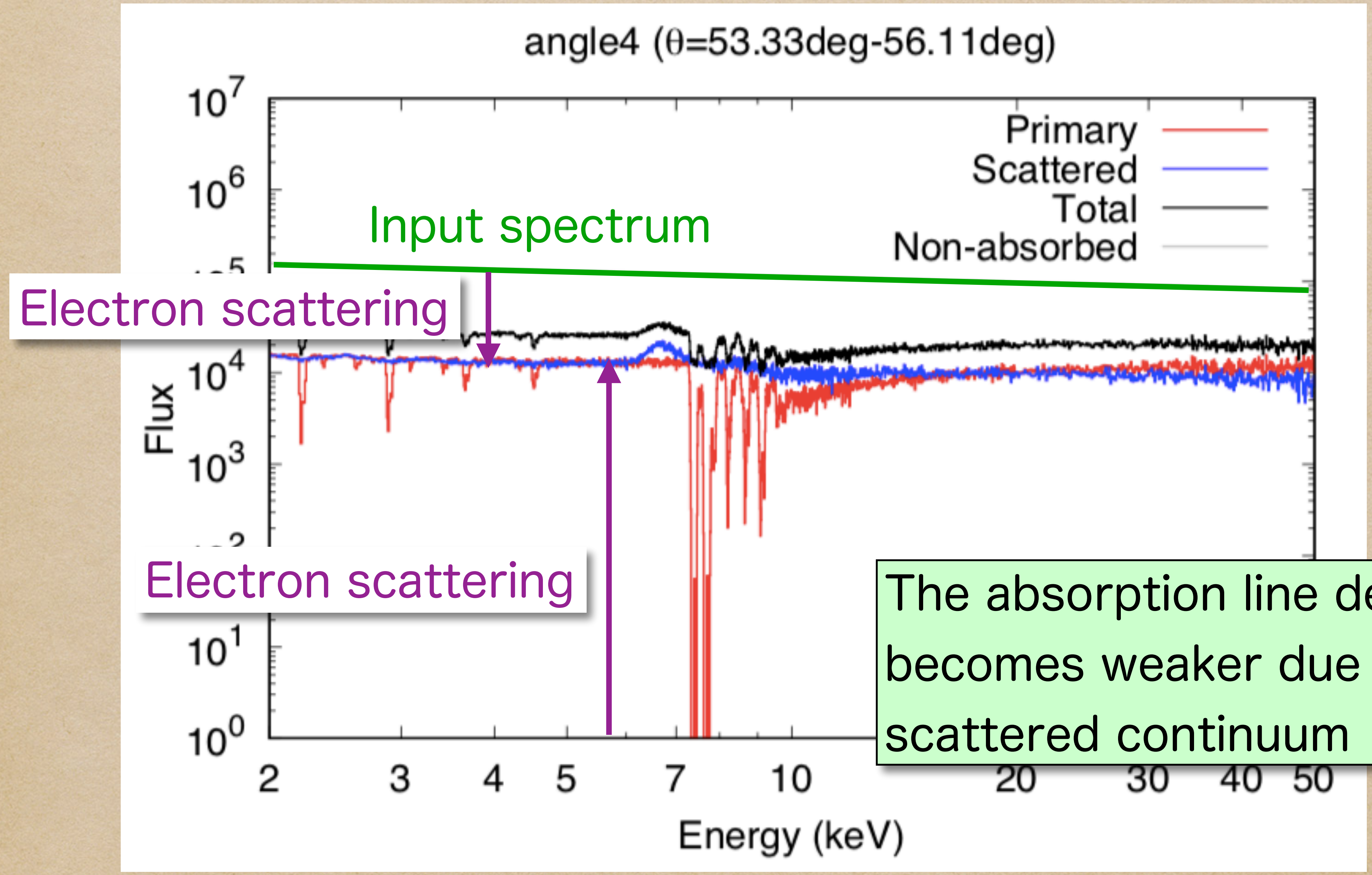
Wind properties



	Fast	Slow
N_H [cm^{-2}]	5.9E+23	1.2E+24
logxi	4.78	4.17
velocity	-0.18c	-0.11c
Radius	200-400R_g	400-1000R_g

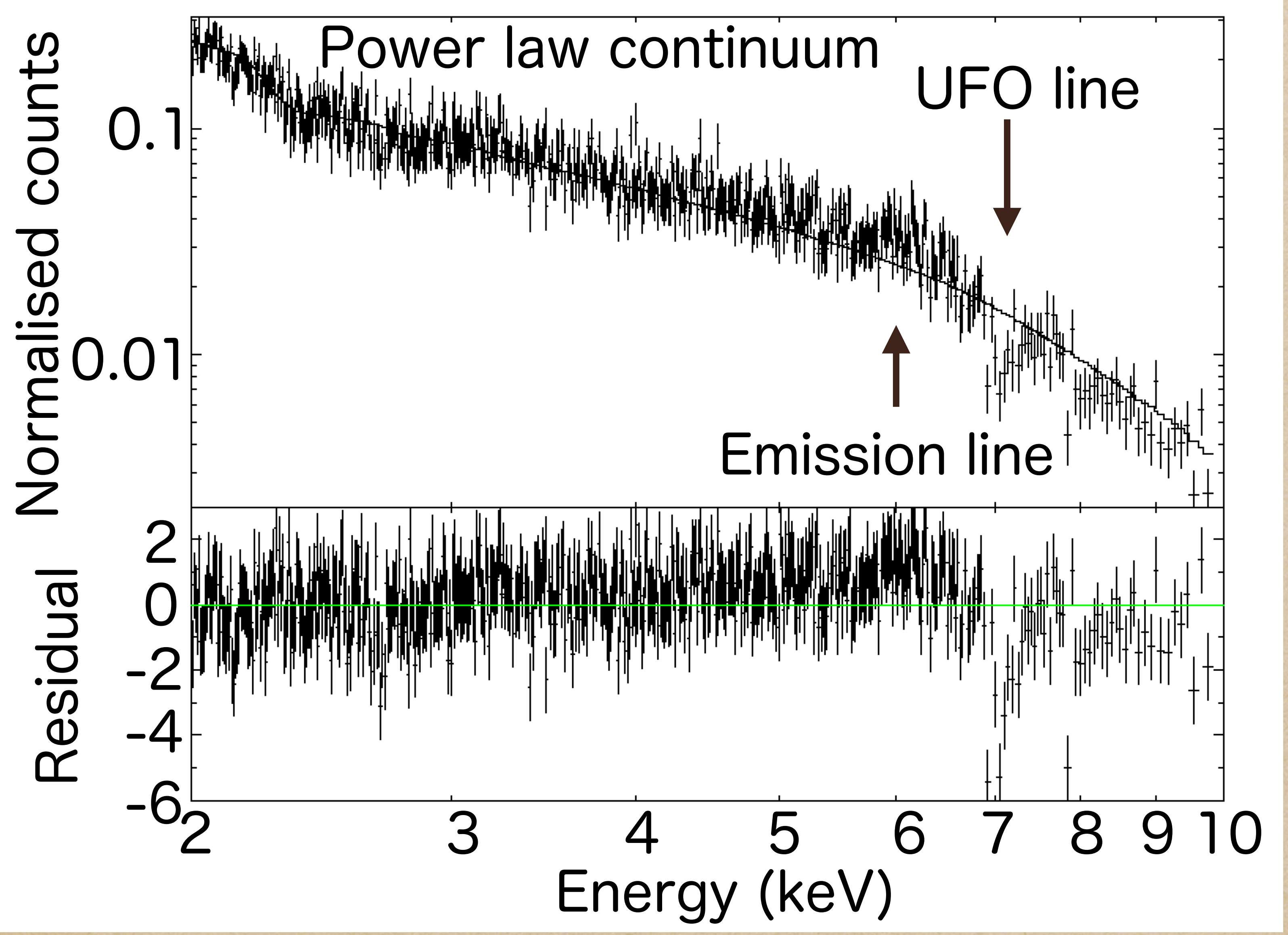


Scattering



The absorption line depth becomes weaker due to scattered continuum

PG 1211+143



XMM-Newton/EPIC-pn

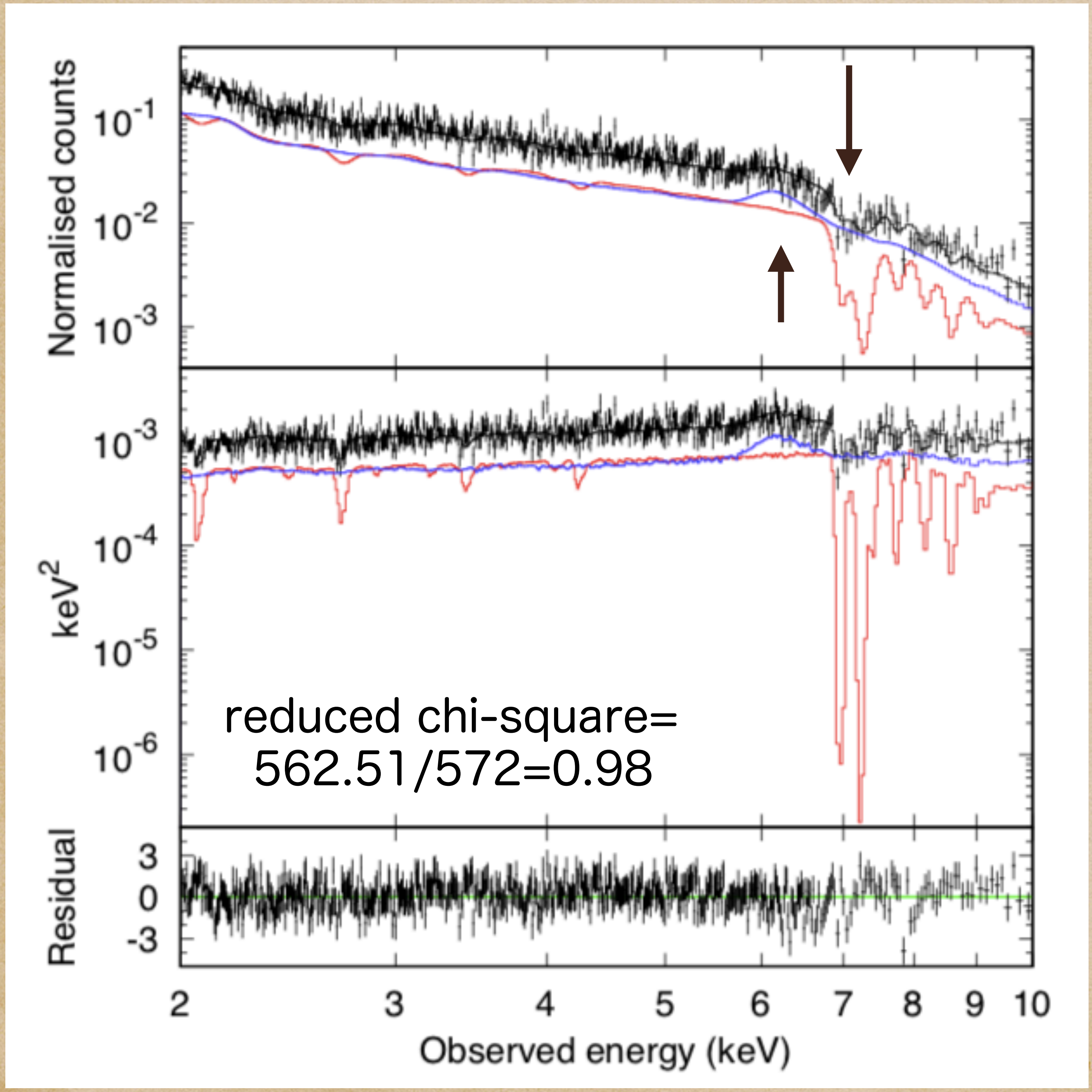
ID=0112610101

Exp. time=49ks

L_{bol}/L_{Edd} ~ 0.9

4. Discussion

PG 1211+143



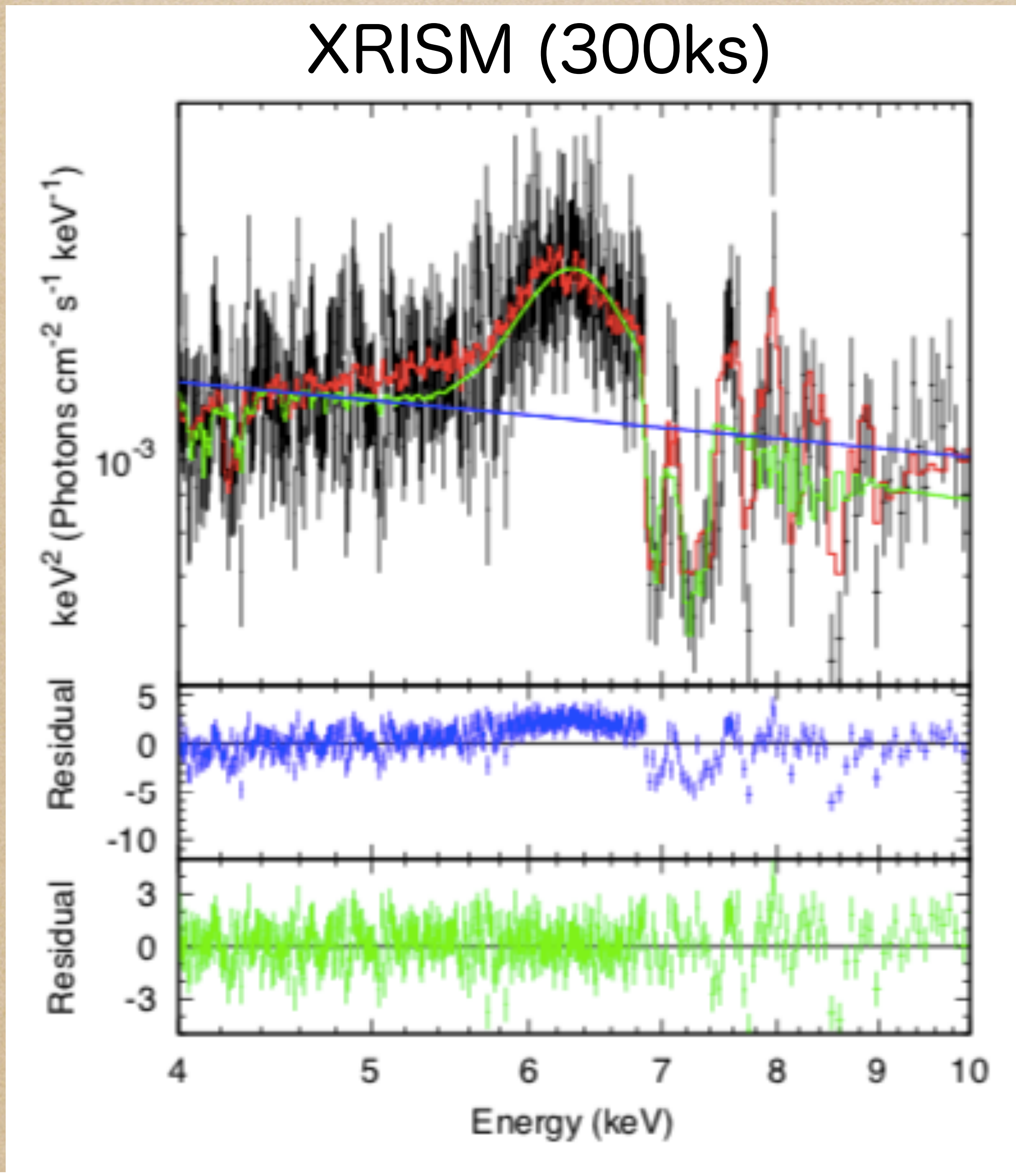
Free parameters:
Power-law index &
total normalisation

Can explain the emission/absorption lines

— Primary
— Scattered

XRISM si

$\dot{M}_{wind}$ and L_w are underestimated by more than one magnitude



— This work — Power law continuu

— XSTAR table model + positive Gaussian

	Fitting	Answer
	Fast	Fast
N_H [cm^{-2}]	1.0E+23	5.9E+23
logxi	3.05	4.78
Velocity	-0.17c	-0.18c
Radius	$60R_g$	$200\text{-}400R_g$
$\dot{M}_{wind}$	1.8×10^{-2}	(6.3×10^{-1})
L_w	4.6×10^{-3}	(1.8×10^{-1})
	Slow	Slow
N_H [cm^{-2}]	1.0E+23	1.2E+24
logxi	2.92	4.17
Velocity	-0.14c	-0.11c
Radius	$100R_g$	$400\text{-}1000R_g$
$\dot{M}_{wind}$	2.3×10^{-2}	(6.3×10^{-1})
L_w	3.7×10^{-3}	(1.8×10^{-1})

4. Discussion

Mass loss rate estimation

Total mass loss rate is

$$\dot{M}_{\rm wind} = \Omega b r^2 \; 1.2 m_{\rm p} n(r) \; v_{\rm w} \,. \quad (1)$$

If we assume that

$$N_{\rm H} = \int n(r) dr \sim b n(r) r,$$

b=filling factor

Eq. (1) becomes

$$\dot{M}_{\rm wind} \sim \Omega m_{\rm p} v_{\rm w} N_{\rm H} r$$ (Gofford+13)

- Scattering continuum contamination
  -> N_H is underestimated
- "wind velocity = escape velocity"
  -> r is underestimated

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Take home message

- <u>The UV line driven disc wind</u> can make the UFO features.
  - Lines of sight which only passes through highly ionised gas exist.
  - Multi-velocity components will be made by a "single" disc wind.
- (Traditional) spectral fitting may underestimate the UFO mass loss rate and kinetic power.
  - We may get wrong N_H and r.
- <u>We are looking forward to observing PG 1211+143 with XRISM.</u>