Winds in AGN in a multi-wavelength context

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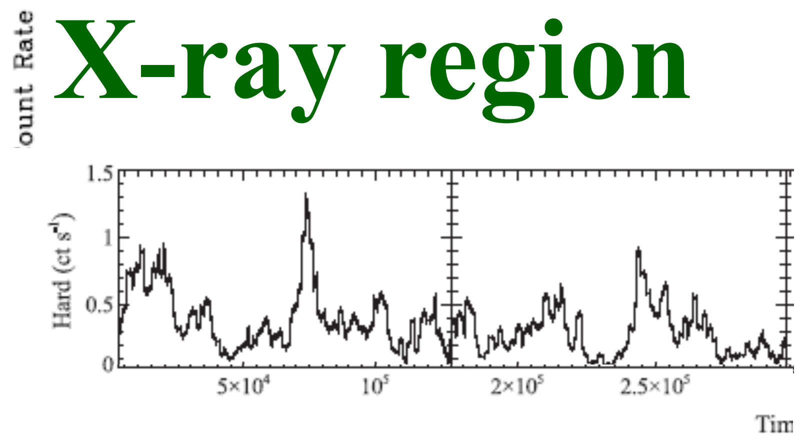
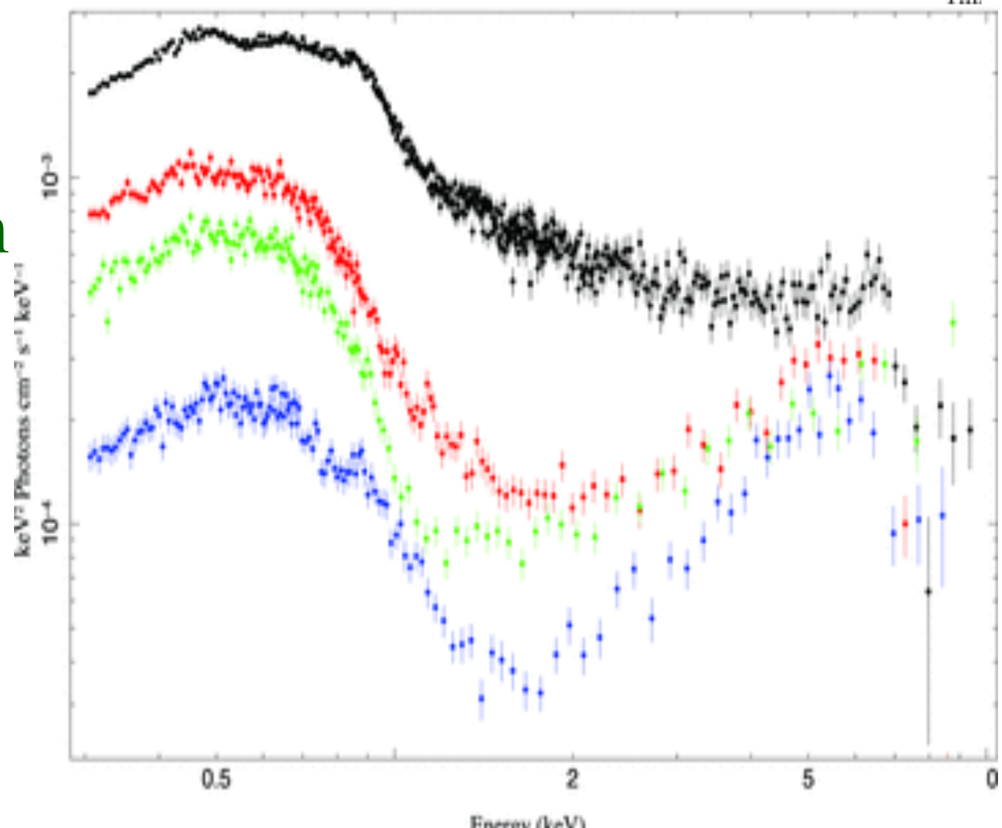
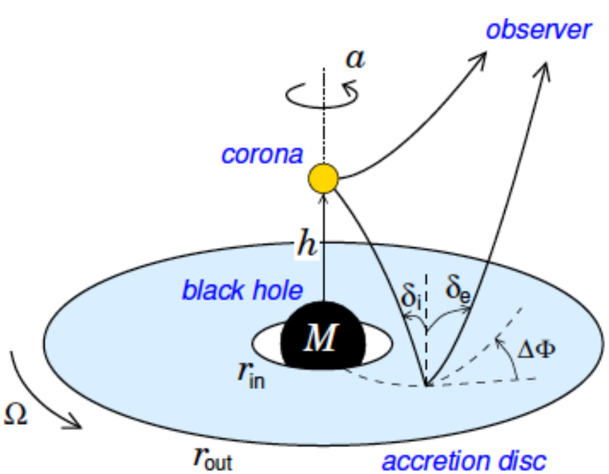
Geometry of the X-ray region

- 'Complex' NLS1 (Gallo 2006) eg 1H0707-495
- Deep dips – hard spectra, large Fe features
- Tiny source <2Rg from high spin BH



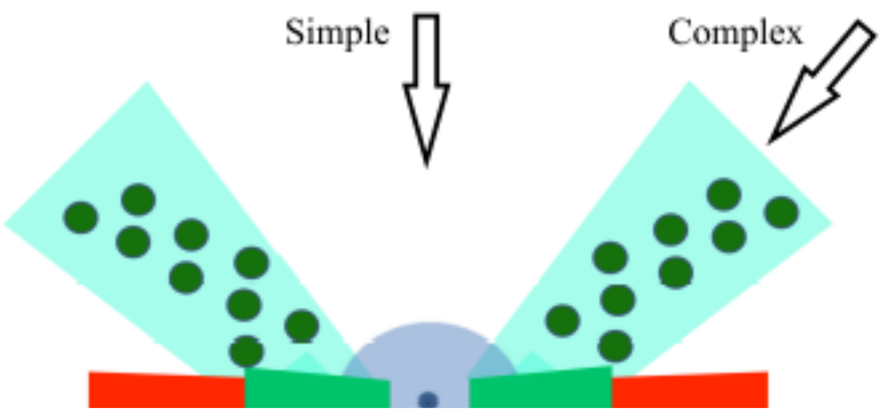


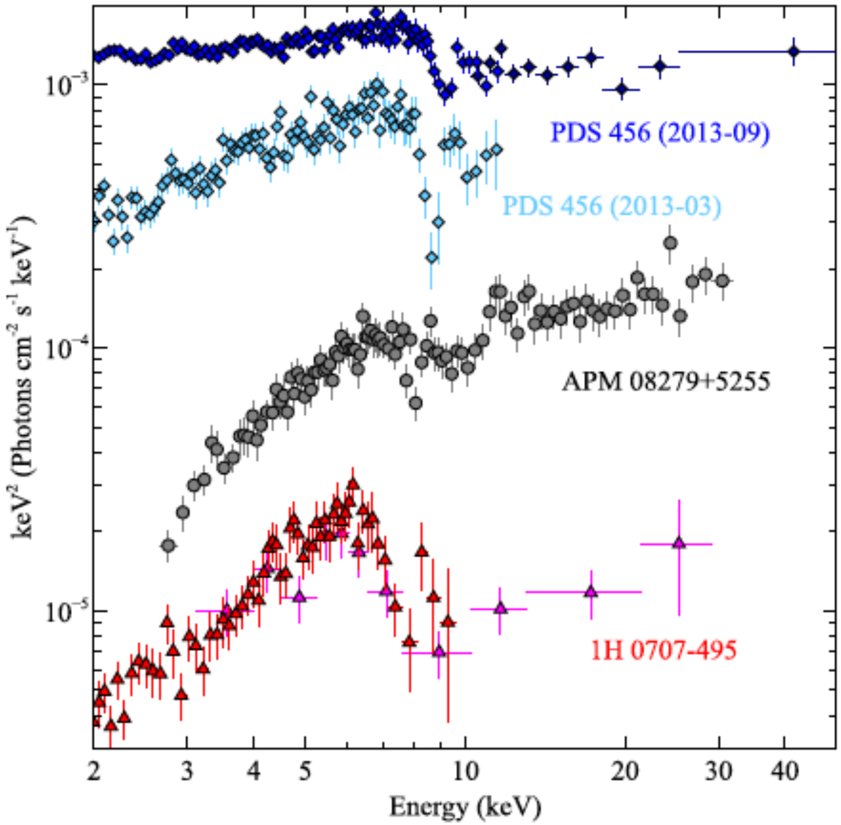


Fabian et al 2009

Or complex wind absorption?

- PDS456 and APM08279 both clear winds –
- Clumpy, complex (high and low ξ together)
- 1H0707 fits as well, 5-10 Rg source

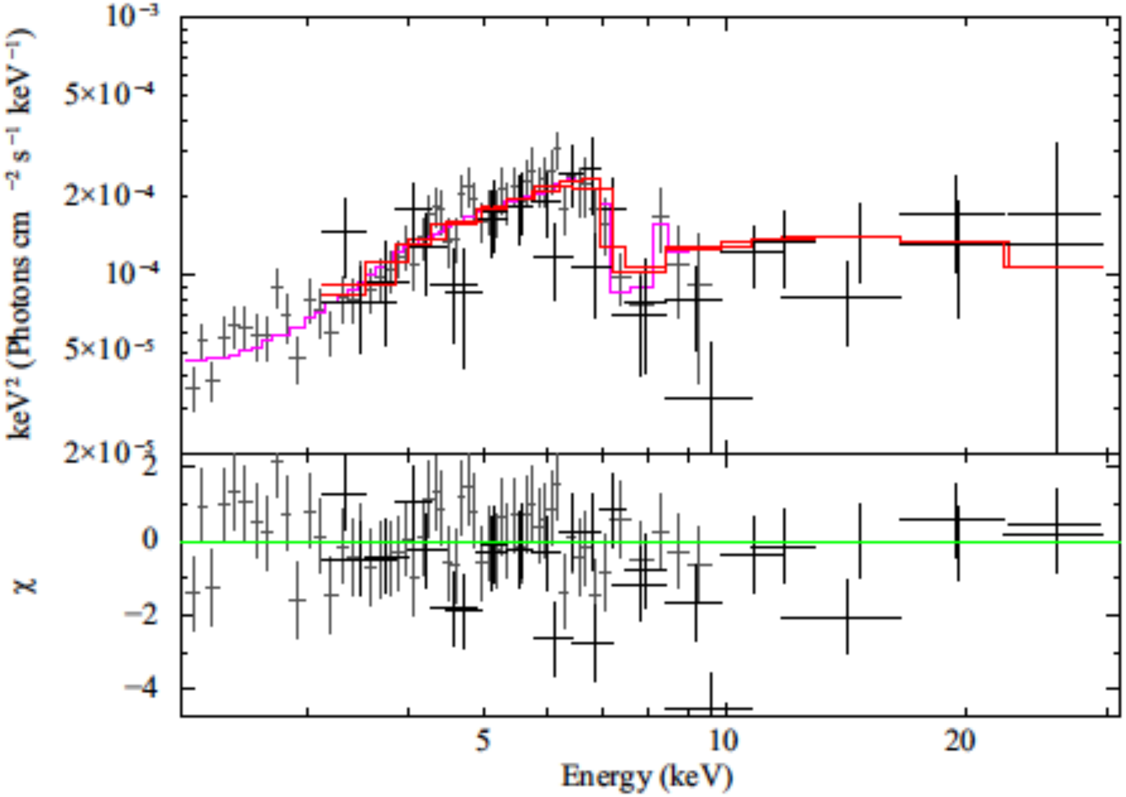




Hagino et al 2016

Complex NLS1 – X-ray view

- Extreme spin with reflection from flat disc
- Or wind absorption with no constraints on spin!! Can probably do lags as well from wind

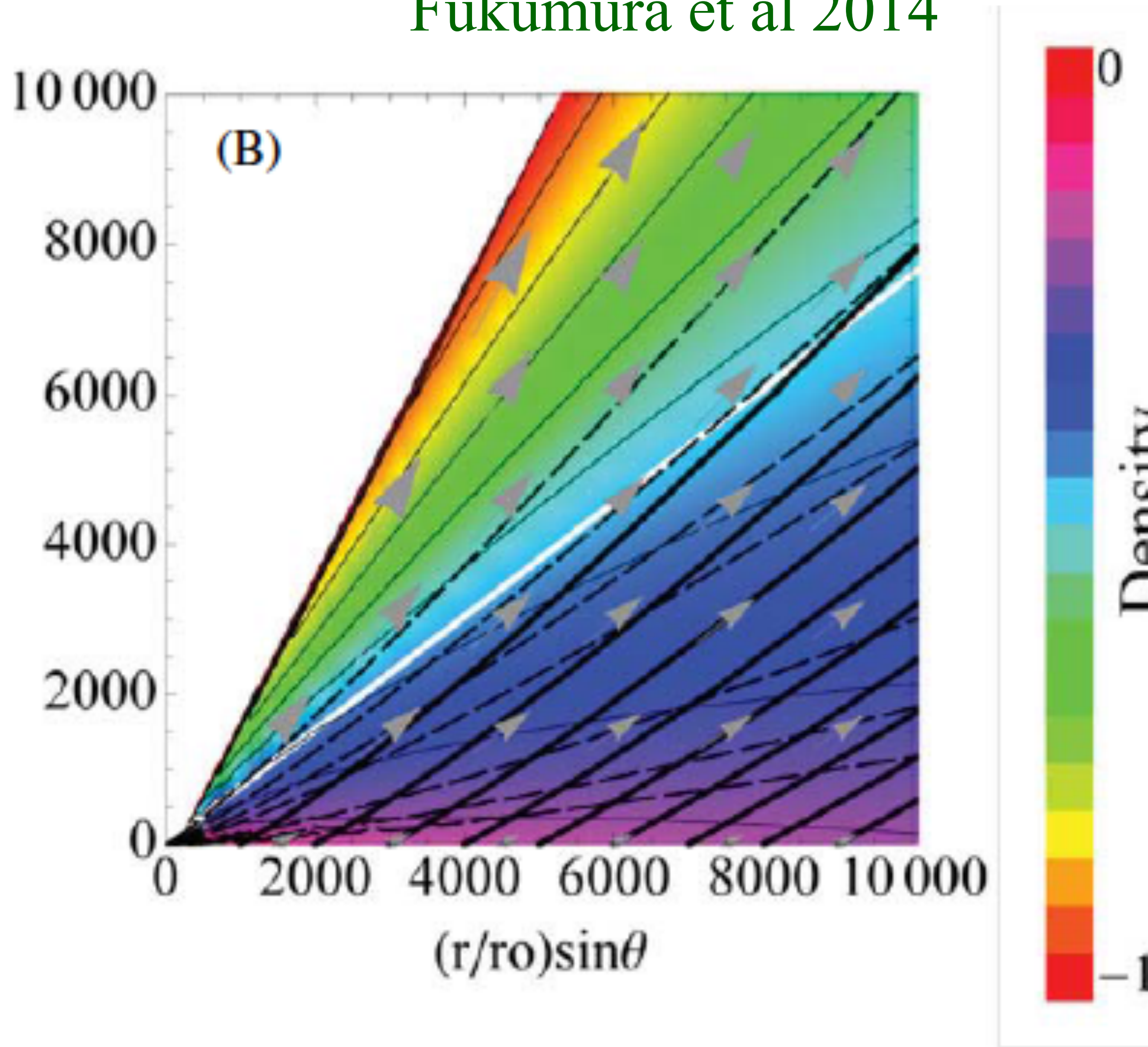


Hagino et al 2016

Magnetically driven Winds

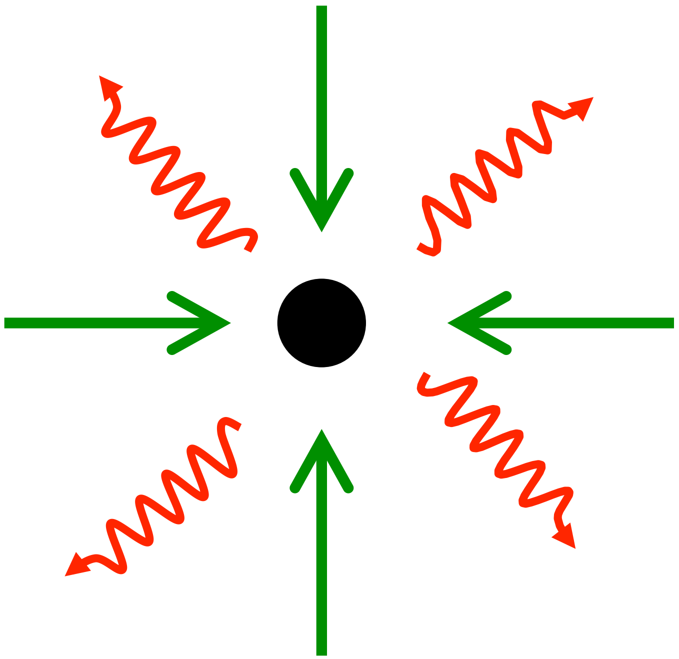
- Unknown!!
- Need specific B field geometry but then can get powerful wind from inner disc
- What about other winds which we can calculate?

Fukumura et al 2014



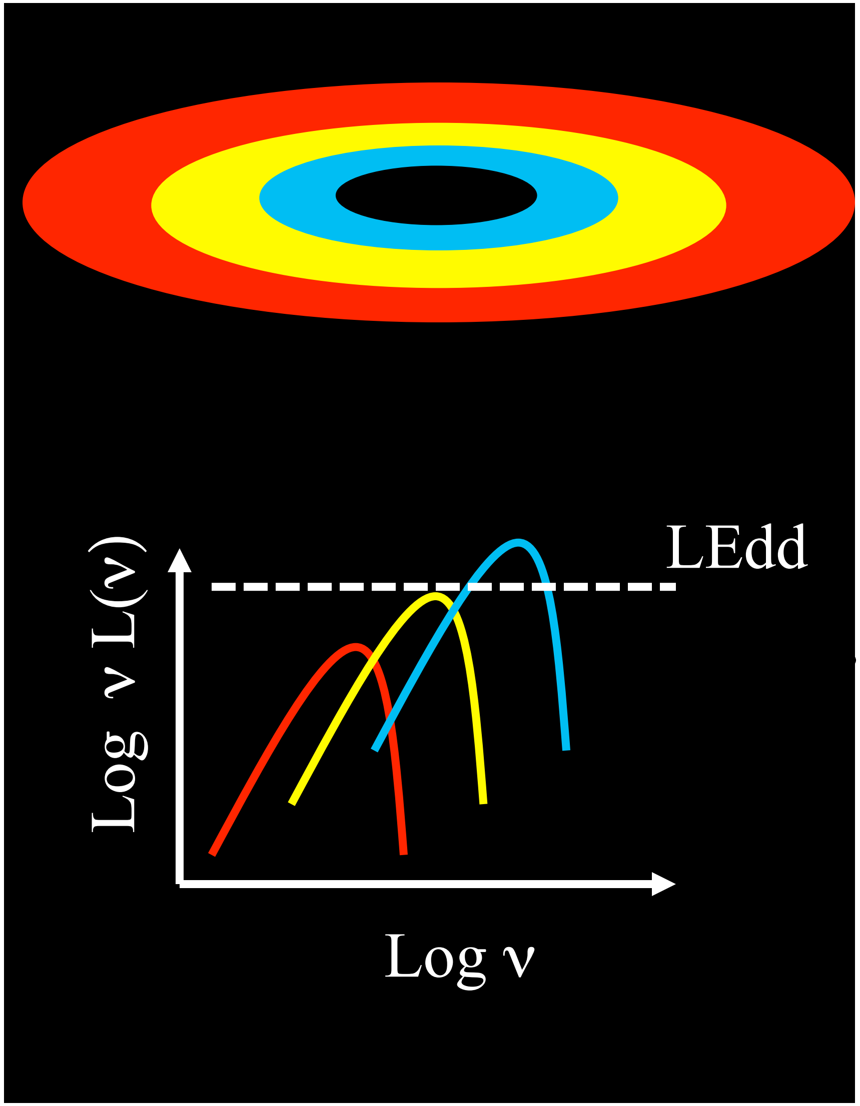
SuperEddington winds

- Eddington limit
- inward gravity balanced by outward radiation pressure on electrons
- $F_{grav} = (1 - L/L_{Edd})\, GM/R^2$
- superEddington flows:
- $L > L_{Edd}$
- But disc geometry?



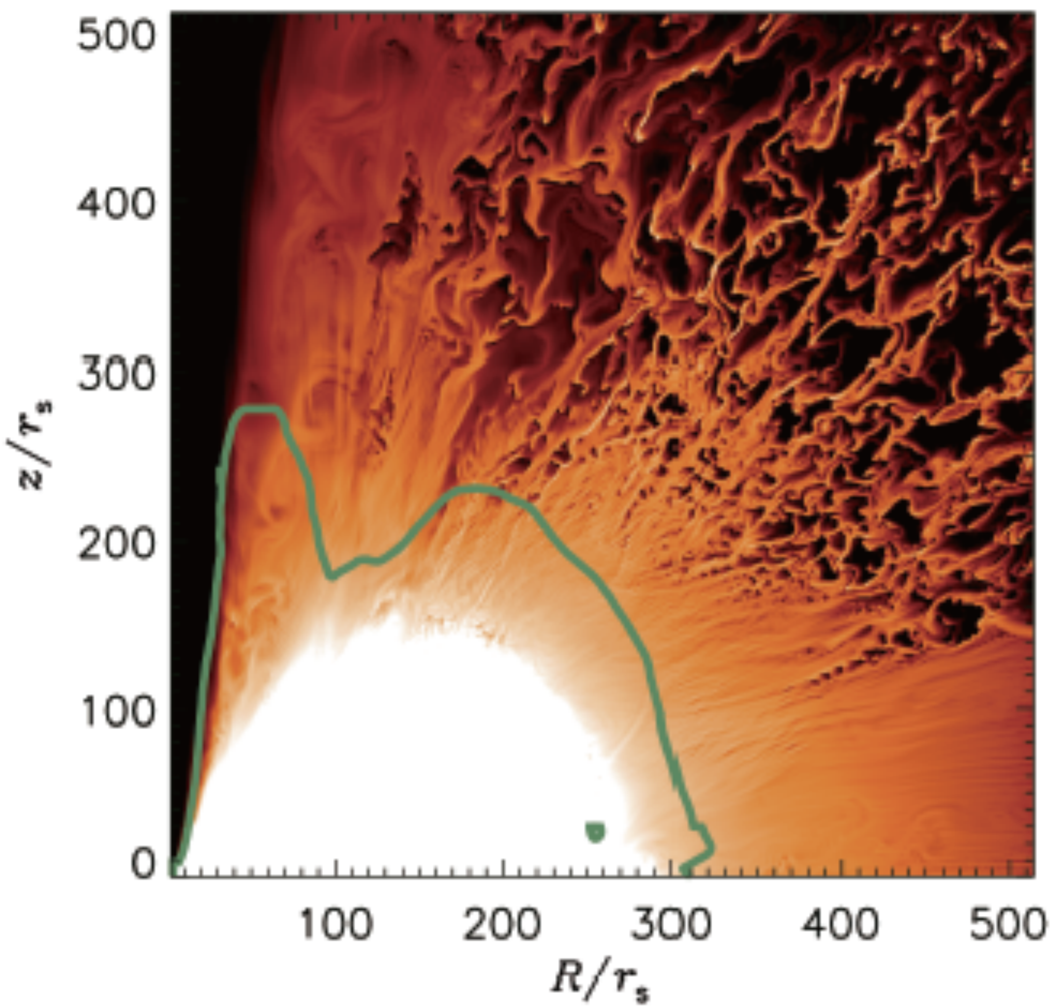
SuperEddington winds

- Ldisc>Ledd means exceeds Eddington limit in inner regions
- Launch wind from inner disc - fast, v~0.3c for launch radius ~20Rg



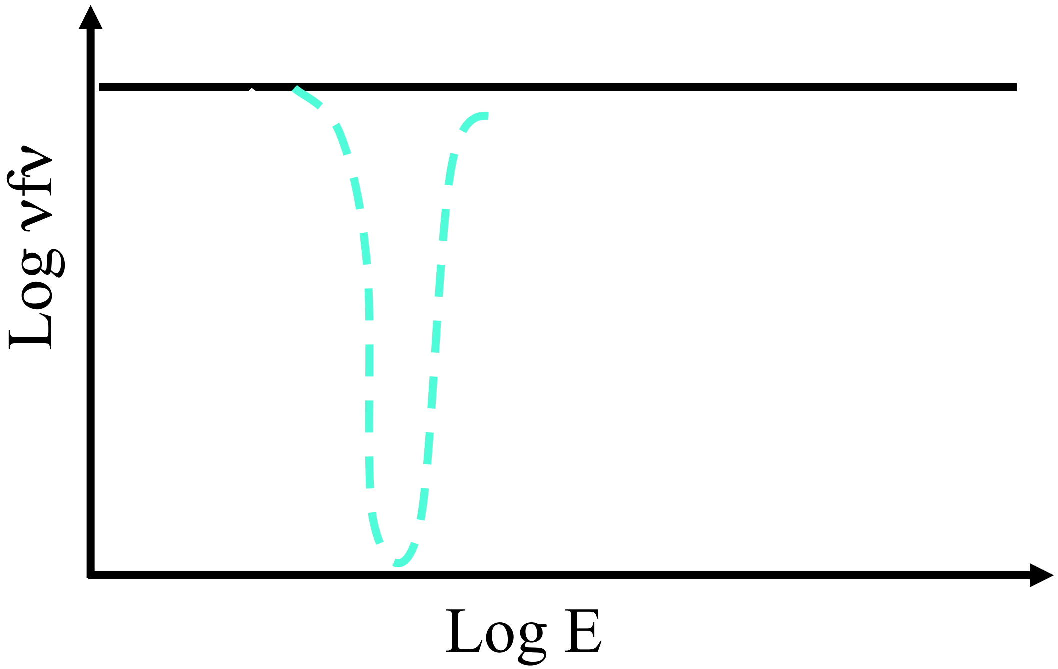
SuperEddington winds

- Powerful $L_{KE} \sim L_{rad}$
- Clumpy, complex
- Takeuchi, Ohsuga, Mineshige (2013)
- Local AGN L<LEdd



UV line driven Winds ?

- Momentum absorbed in line accelerates wind so more momentum absorbed in line
- UV line cross-section much bigger than electron scattering, so wind at $L_{UV} \sim \sigma_{es}/\sigma_{UV}\, L_{edd} << L_{Edd}$



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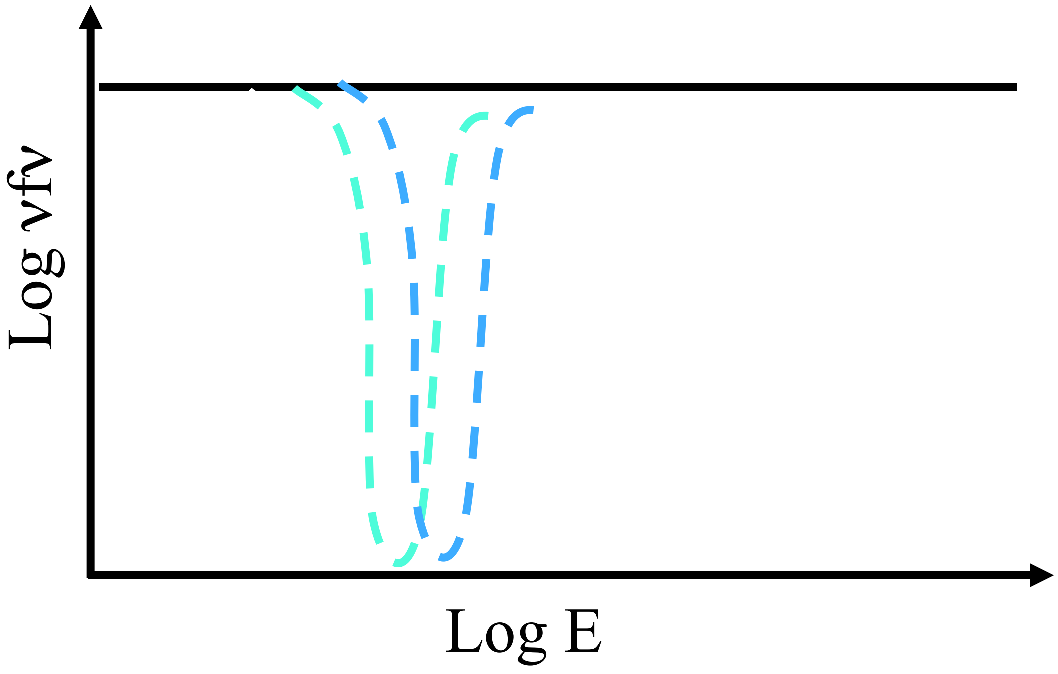

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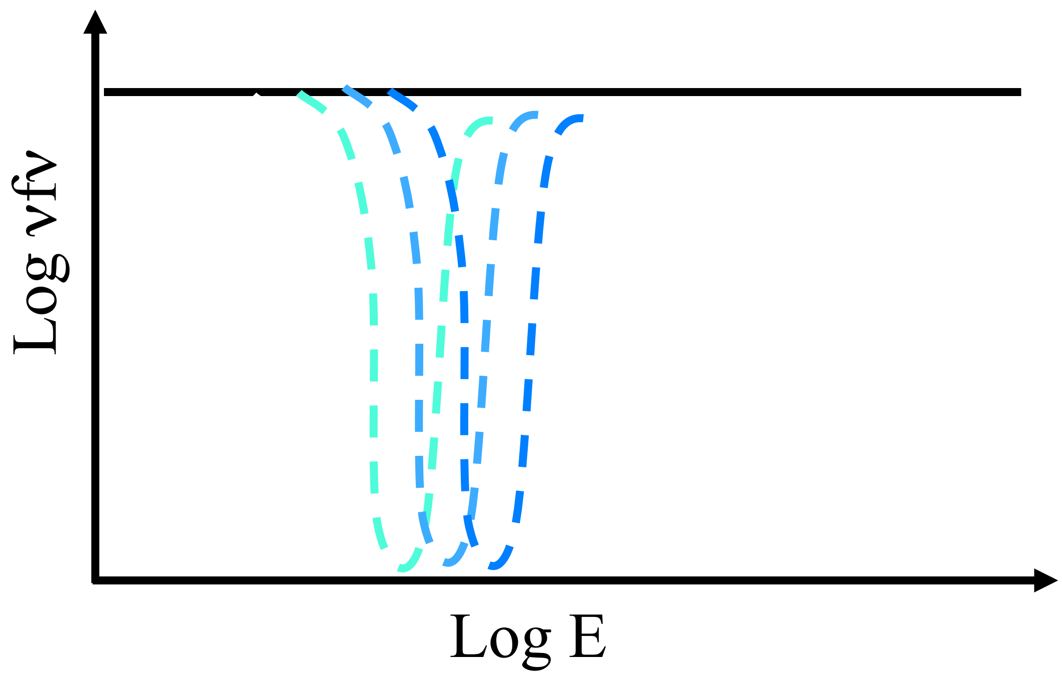

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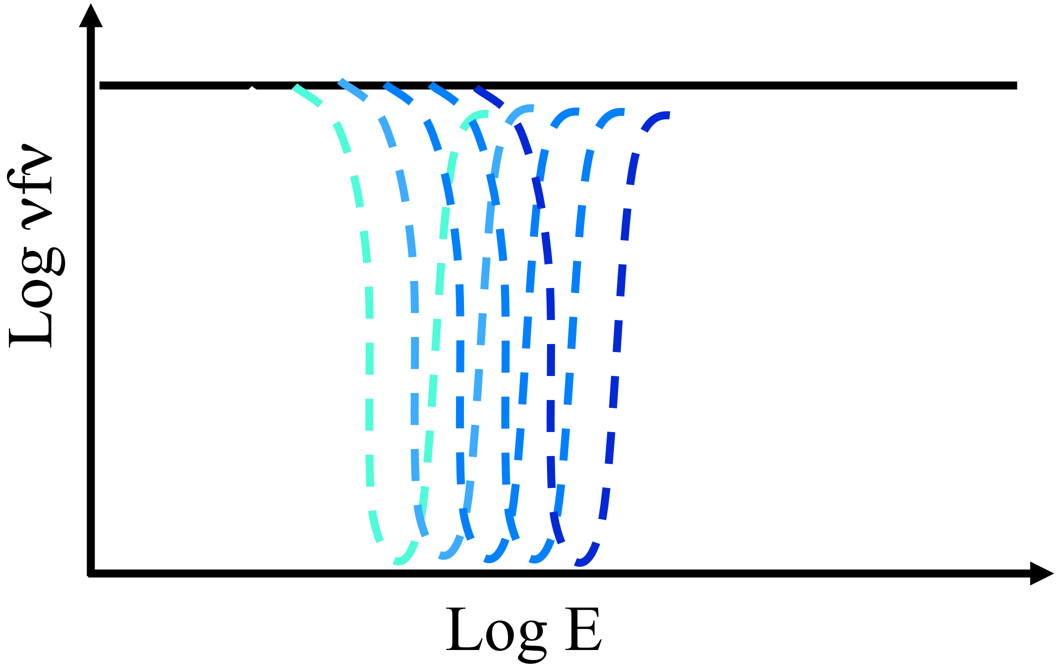
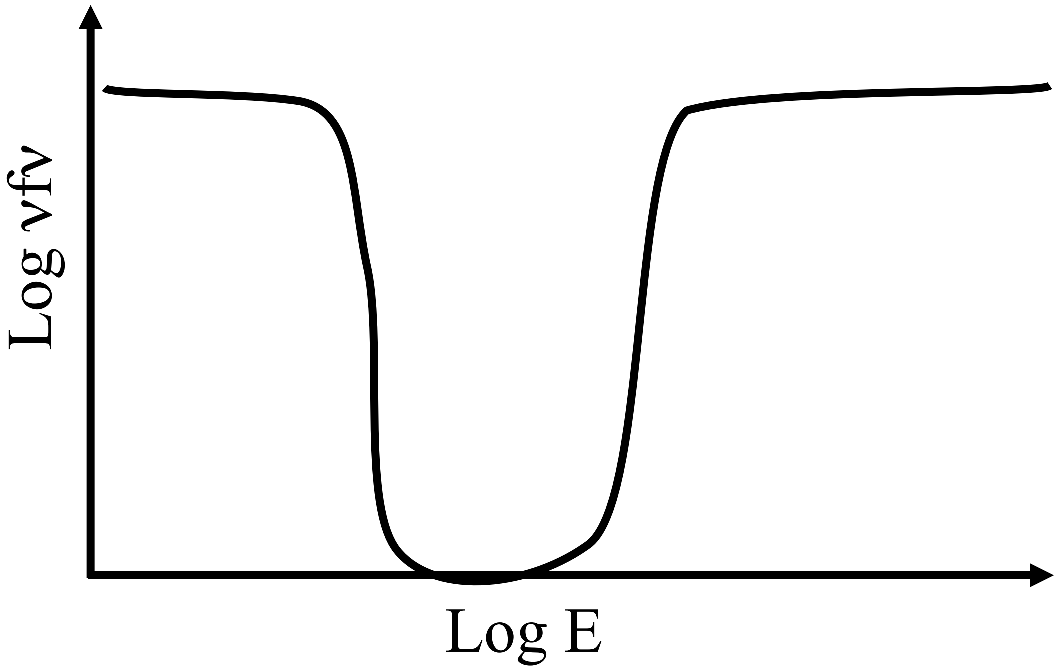


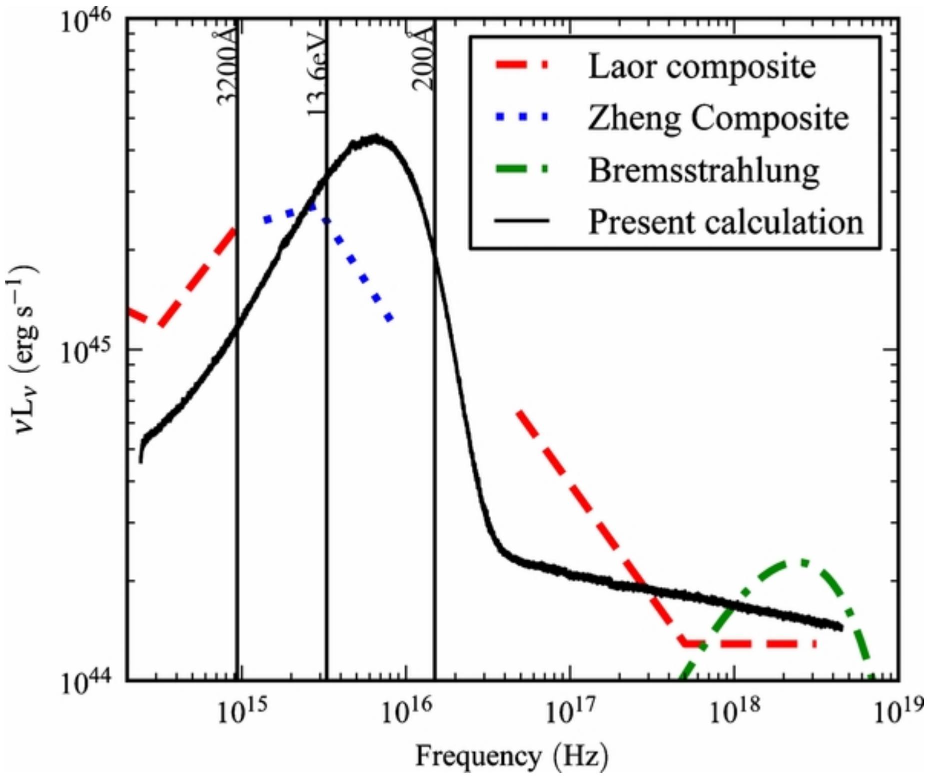
UV line driven Winds ?

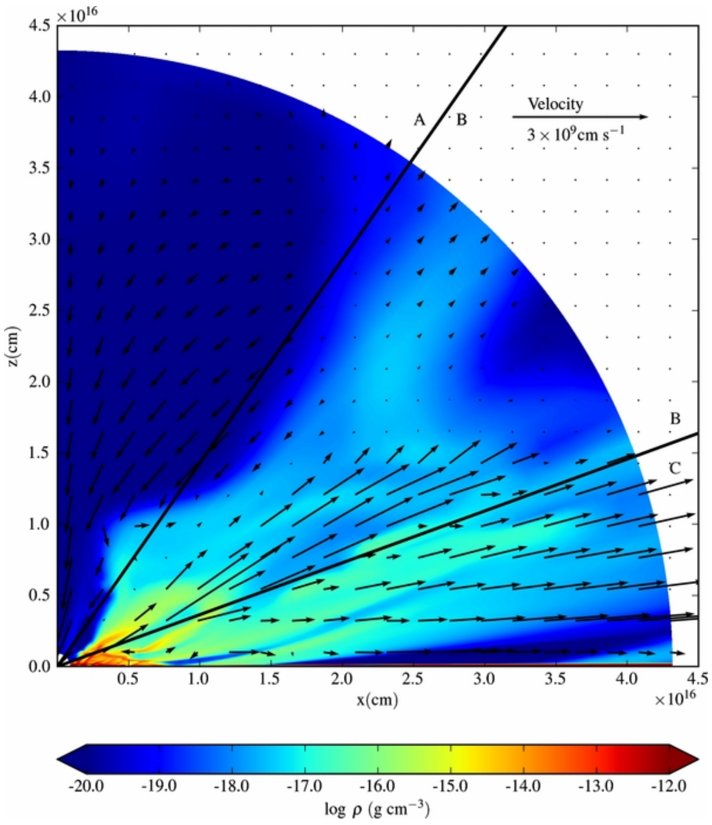
- Strong (but sub LEdd) UV radiation
- Low ionisation state in disc photosphere so abundant ions with UV line transitions – weak FUV/X-ray irradiation!



UV line driven Winds ?

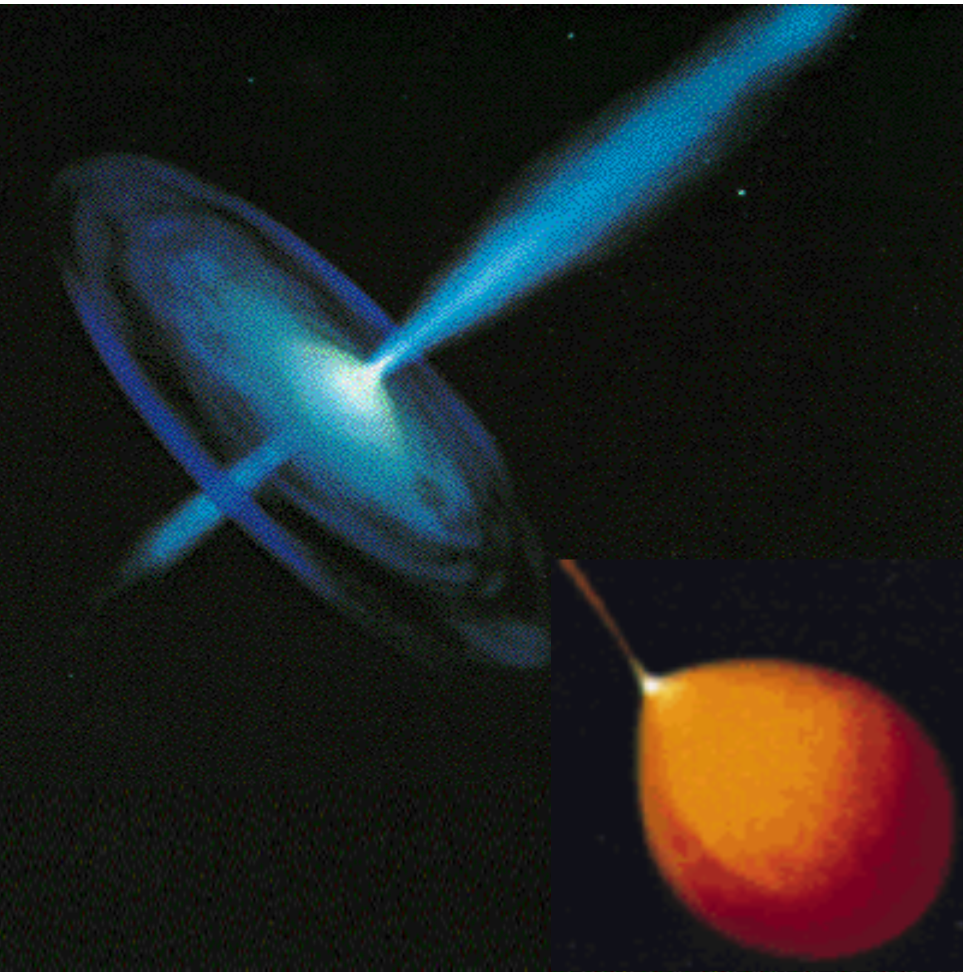
- Clumpy, complex
- 10^8 Msun, L/Ledd = 0.5 BUT wind depends on SED and AGN not pure discs. Proga & Kallman 2004,

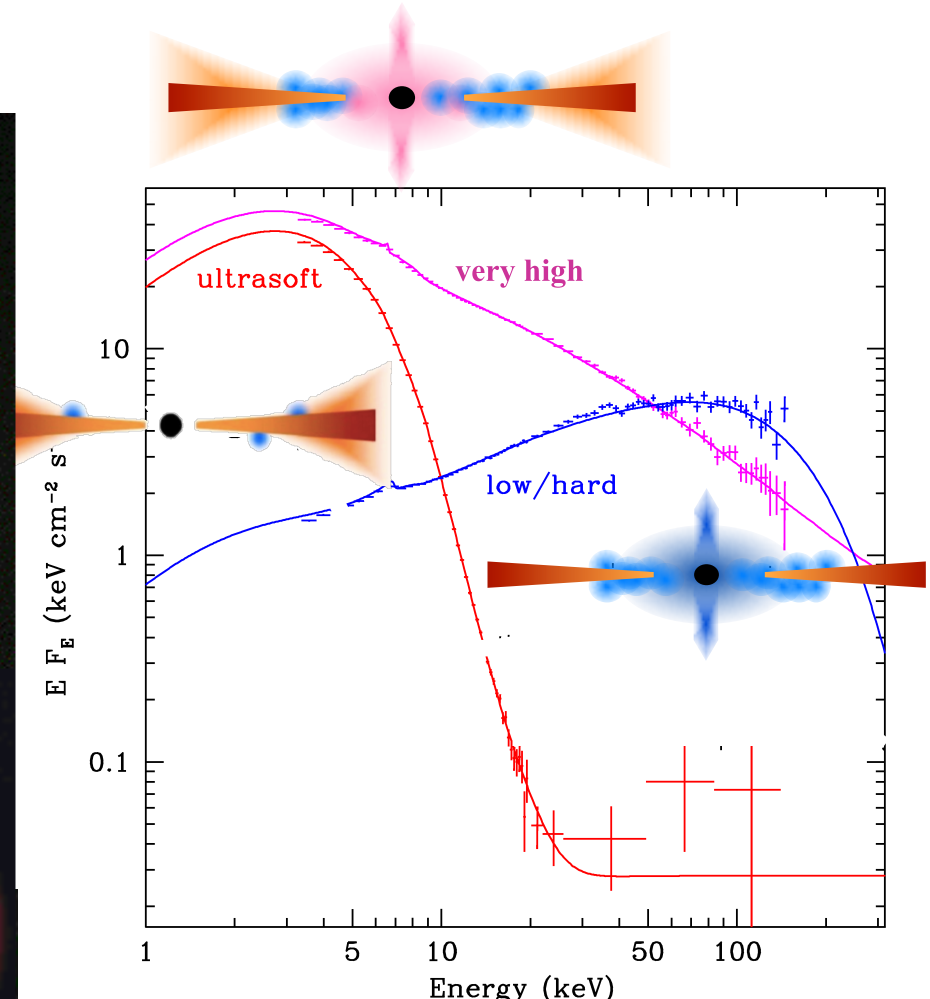




Higginbottom et al 2014

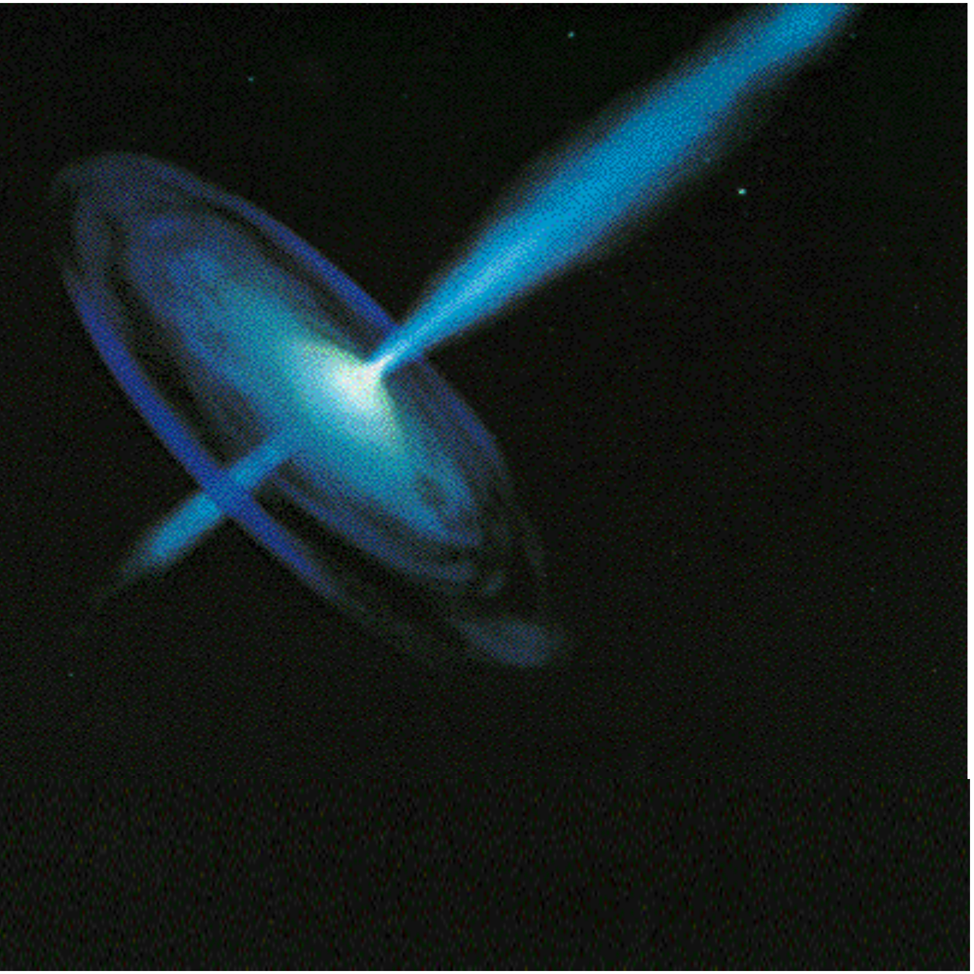
BHB: template for SED L/Ledd?





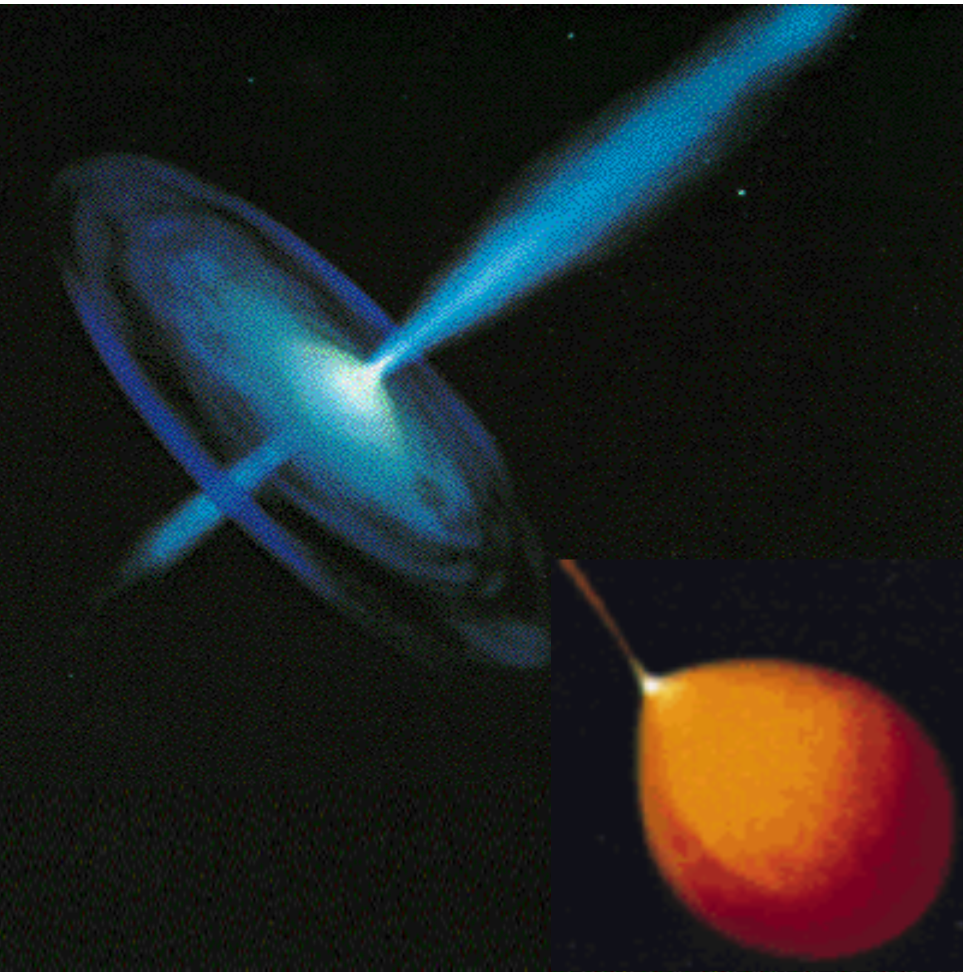
Gierlinski & Done 2003

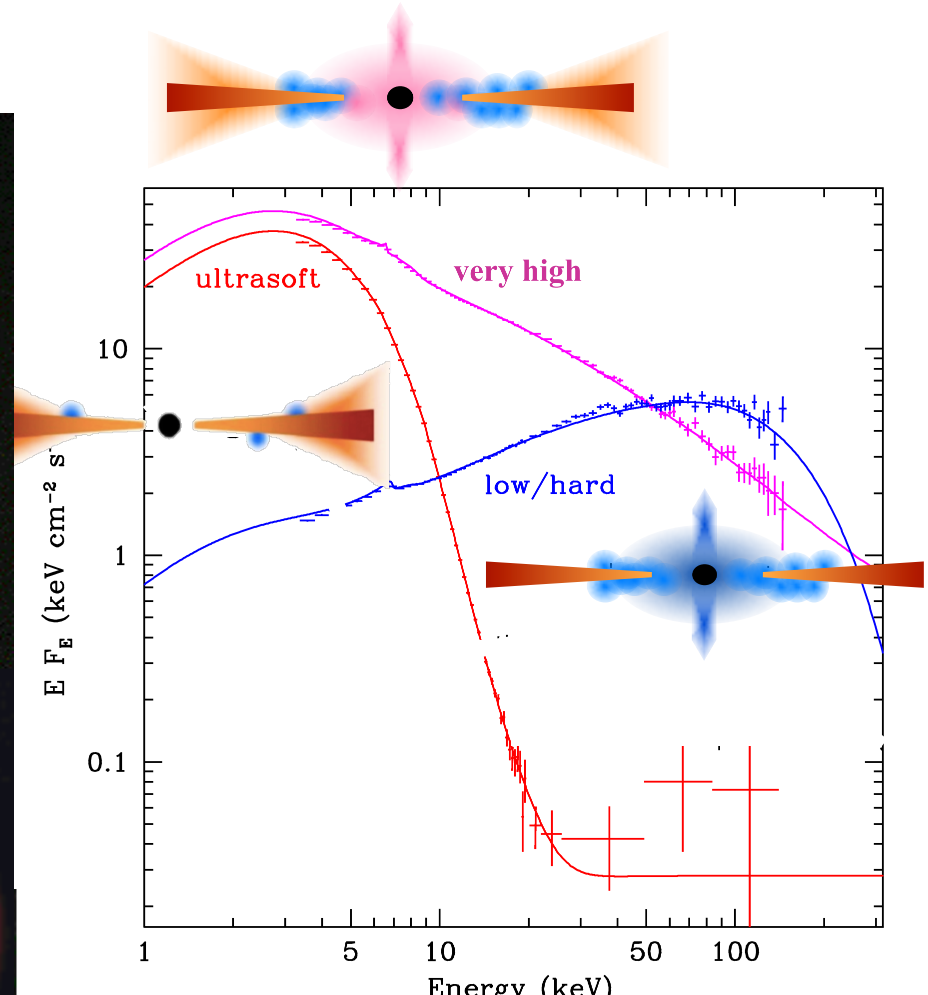
Scaling black hole accretion flow



- Scale up to AGN
- Bigger mass!
- Disc temp lower – peaks in UV (more power, but more area!)
- ATOMIC PHYSICS
- Larger RANGE in mass –from 10^5-10^{10}M
- And maybe bigger range in spin??

BHB: template for SED L/Ledd?

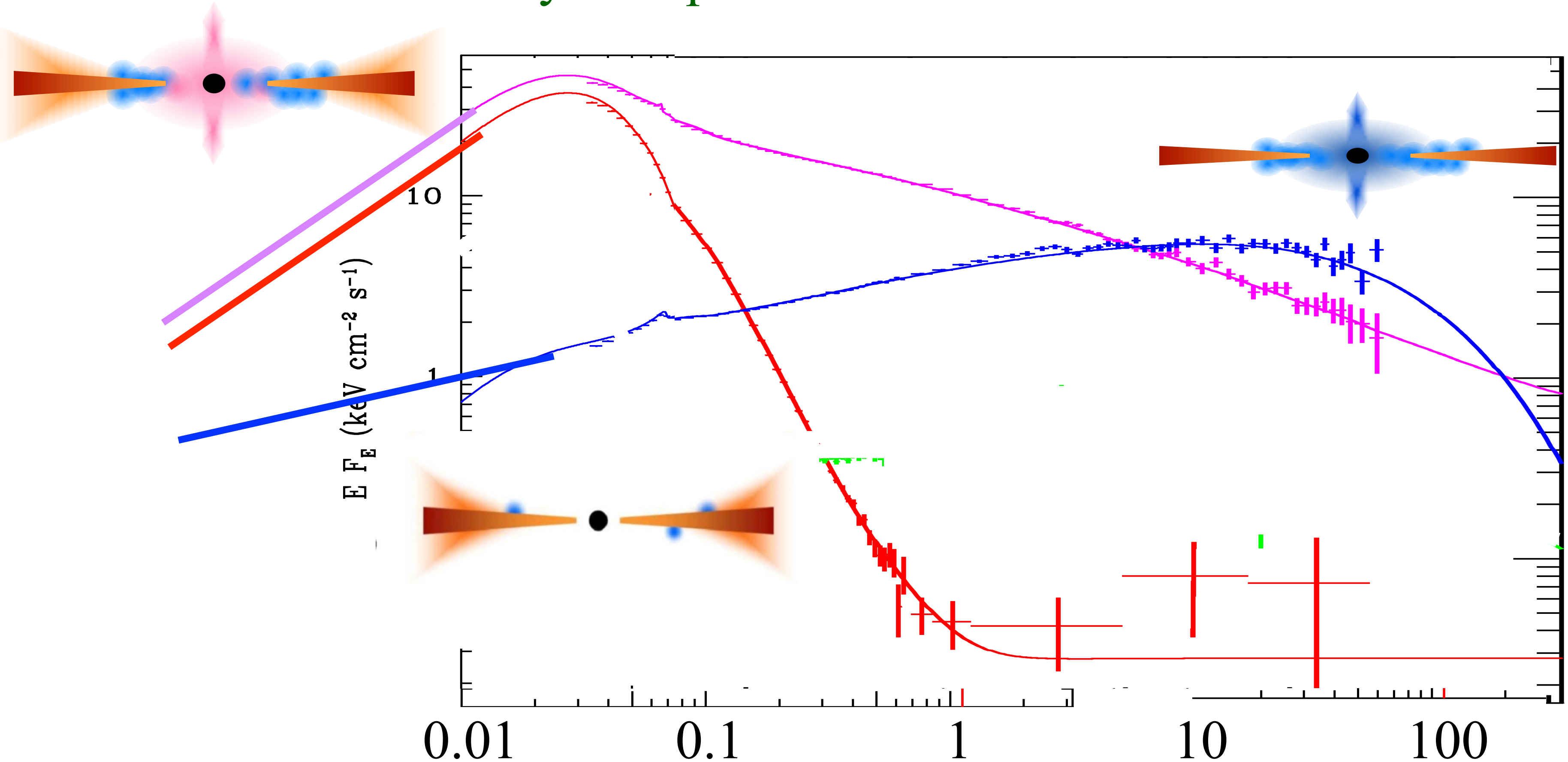




Gierlinski & Done 2003

‘Spectral states in AGN’

Disc BELOW X-ray bandpass. Peaks in UV – ATOMIC PHYSICS



XMM-Newton gives us simultaneous OM data ! Perfect

Interstellar absorption

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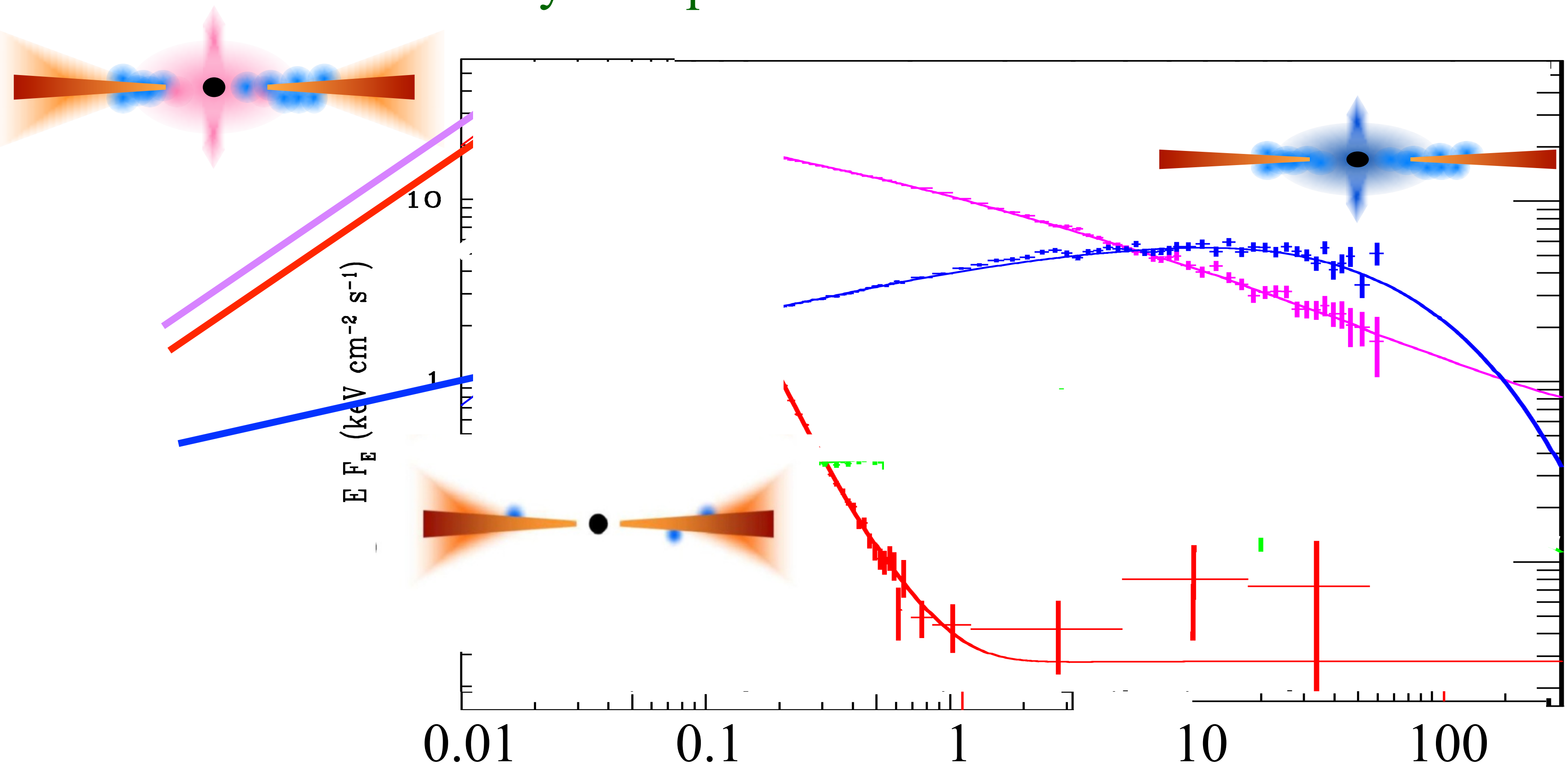
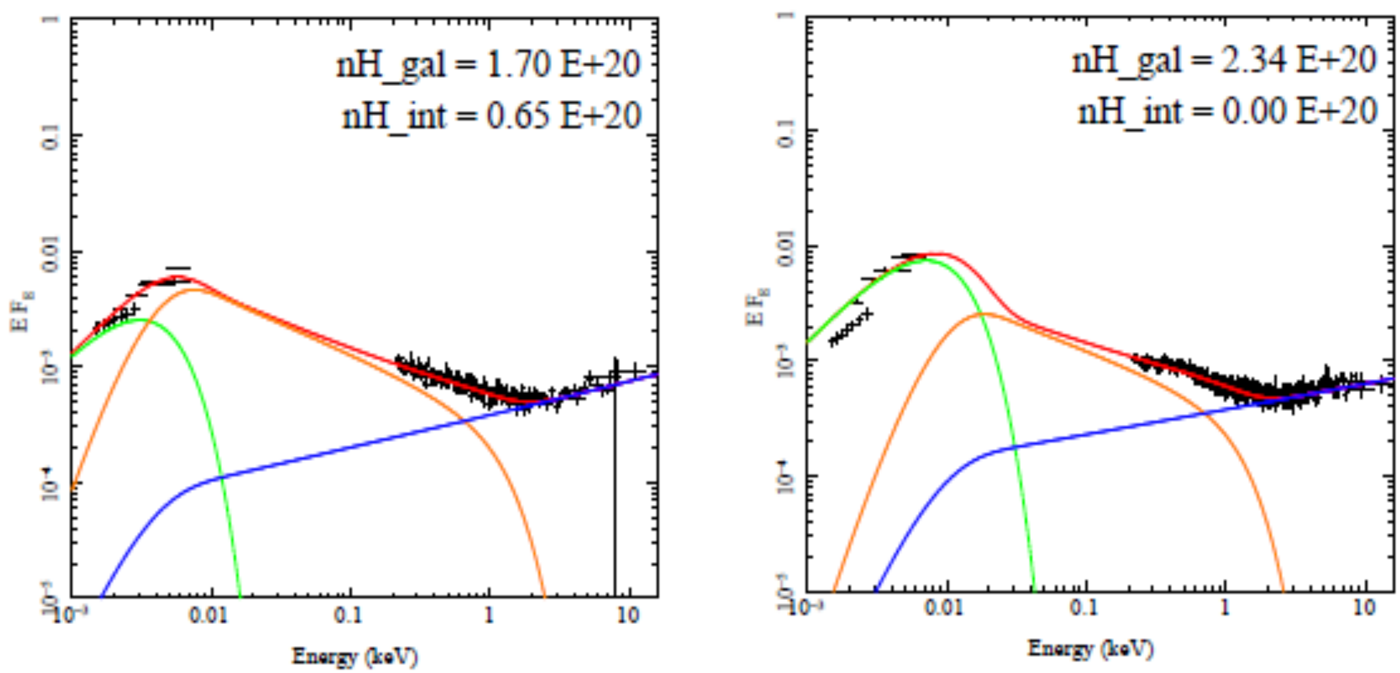


XMM-Newton gives us simultaneous OM data ! Perfect

Typical AGN SED

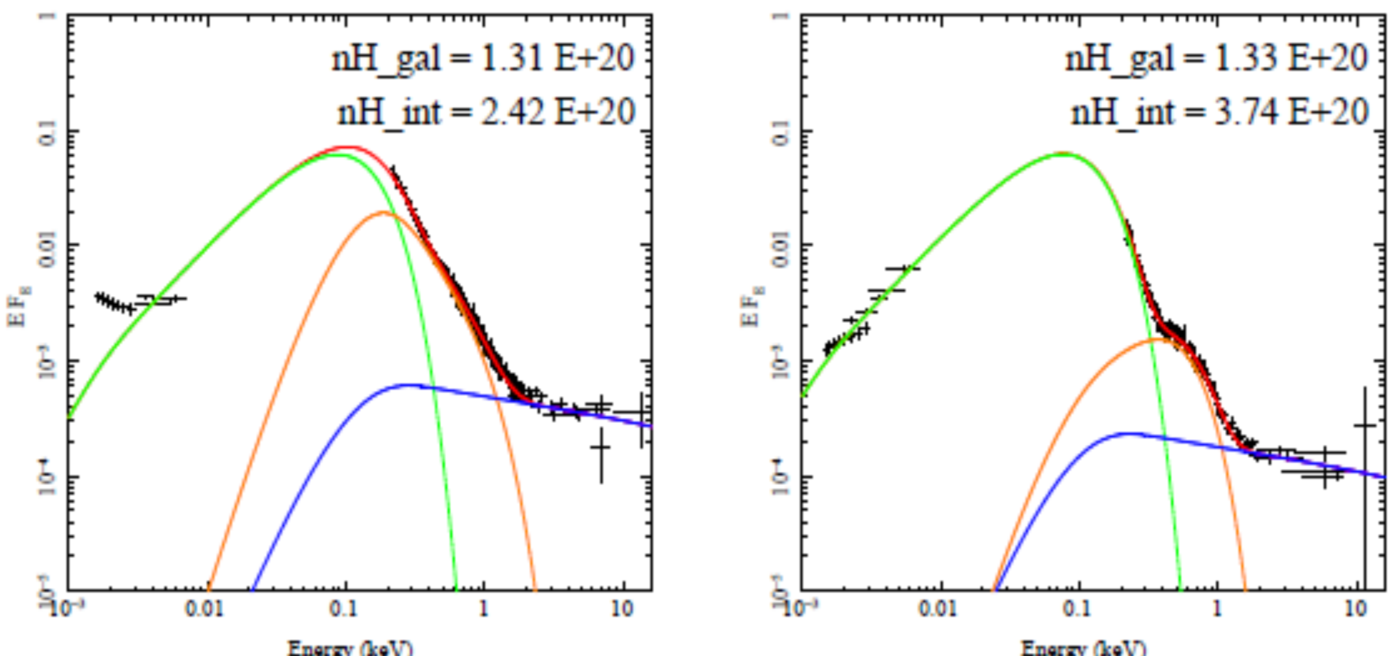
- Most standard BLS1/QSO <M>~10^8, <L/LEdd>~0.1
- Outer disc, strong UV peak from soft X-ray excess
- hard X-ray tail – supresses powerful UV line driving



Jin et al 2012

Very different to NLS1

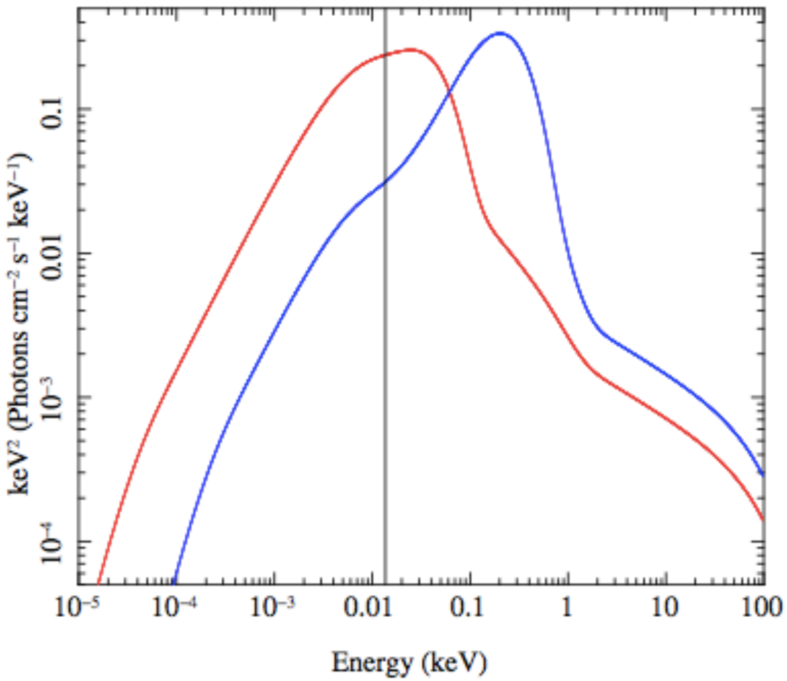
- <M>~10^7, <L/LEdd>~1 NLS1 in local universe
- Disc dominated, small SX, weak X-rays



Jin et al 2012

Mass dependence!!

- NLS1 $M \sim 10^{6-7}$, $L/L_{Edd} \sim 1$ X-ray weak
- But disc peaks in soft X-rays – overionises UV
- $M \sim 10^{9-10}$, $L/L_{Edd} \sim 1$ Disc peaks in UV NOT soft X-rays.
- This really is PERFECT for UV line driving



Hagino et al 2015

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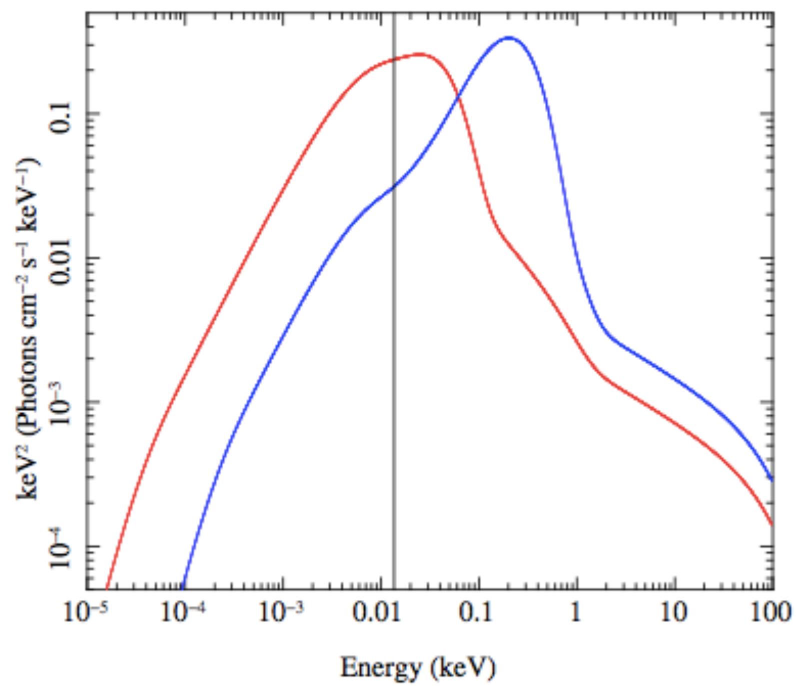
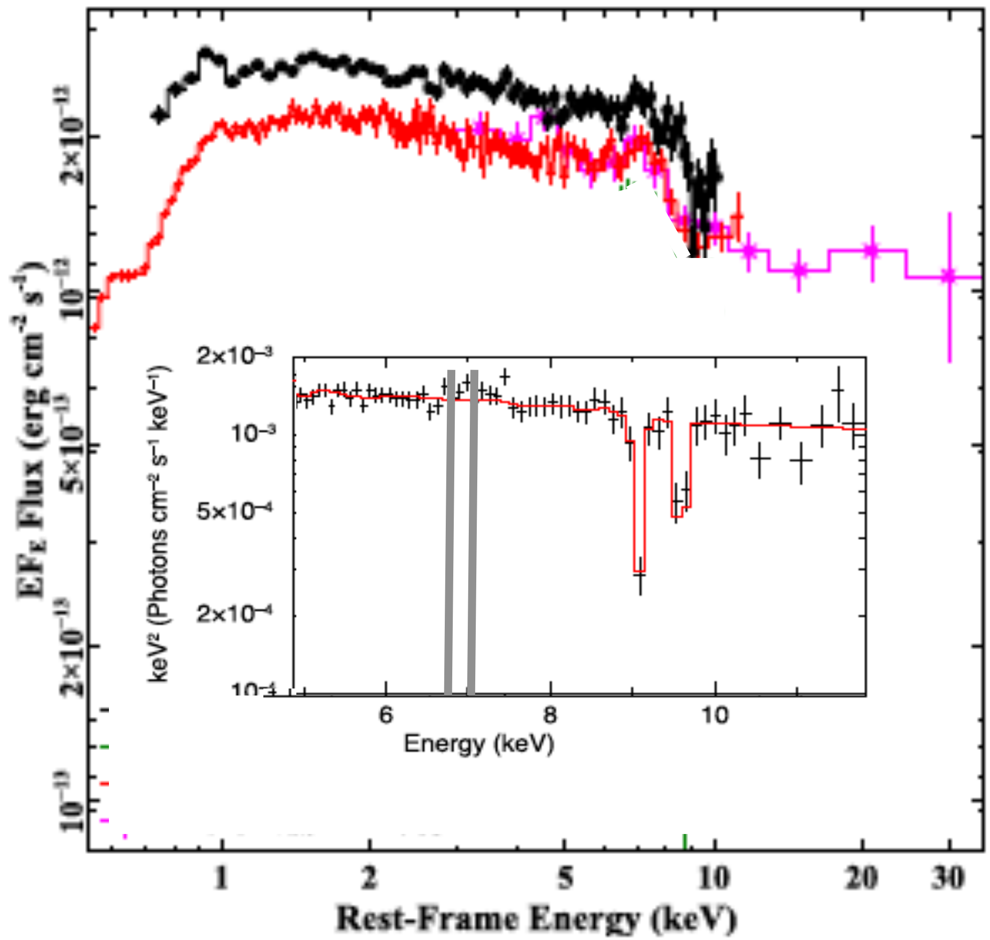
- SED of PDS456
- Biggest local UFO
- SED of APM08279
- Biggest high z UFO



Hagino et al 2015

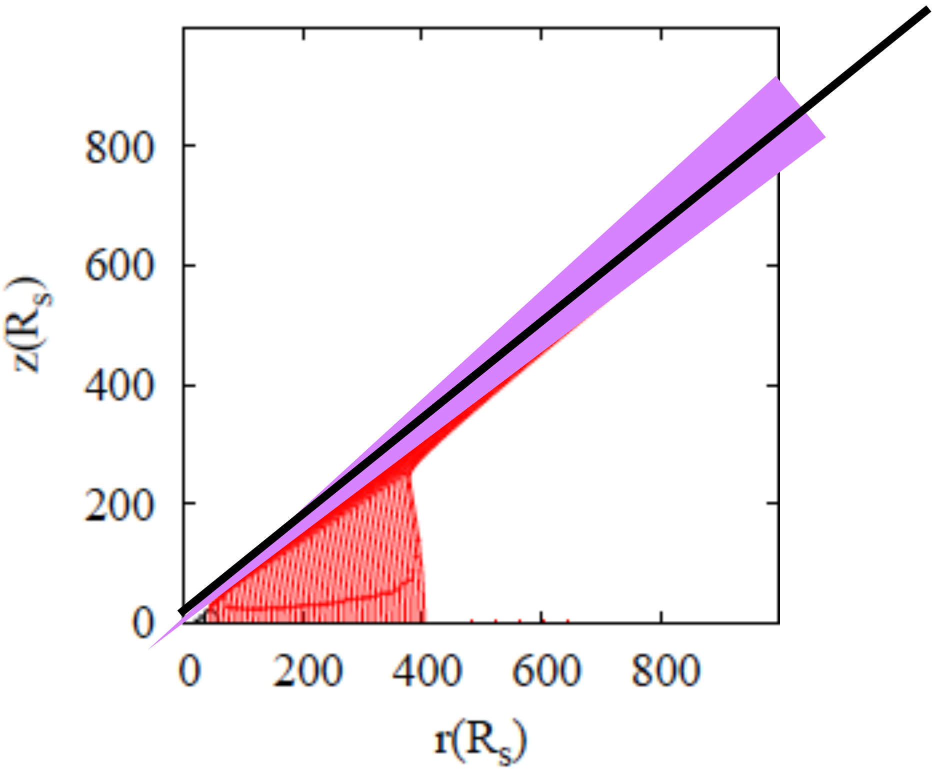
PDS456: UFO as UV line wind?

- High column, v~0.2c
- KE enough to do feedback (Reeves et al 2003)
- high ionisation
- H and He-like Fe only
- so no UV line opacity!
- Reeves et al 2003,2009
  Hagino et al 2015
  Matzeu et al 2017



Launch close to disc, then ionise?

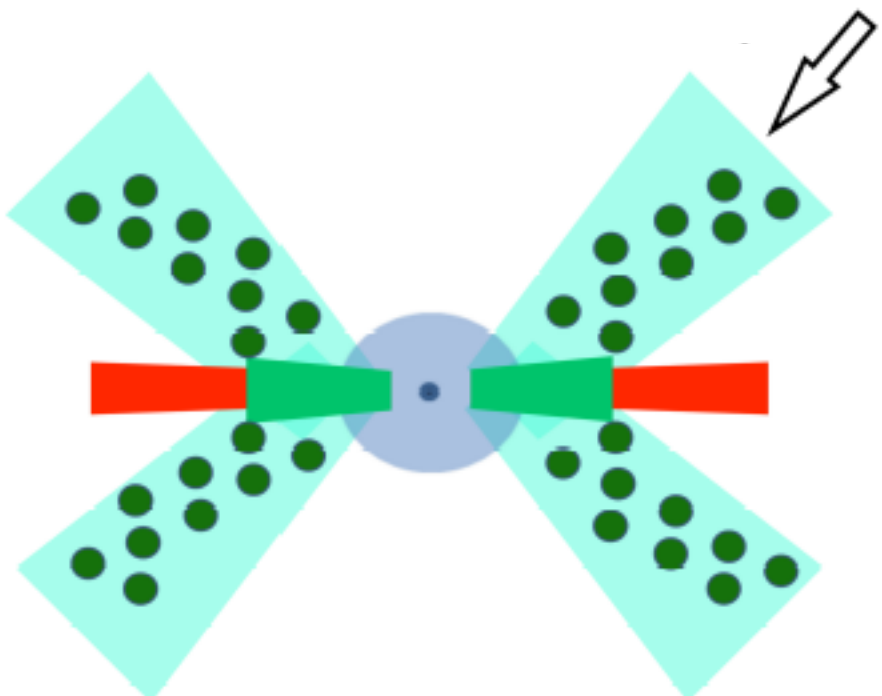
- UV line driving gives fast acceleration close to disc surface
- Material ionised after acceleration, removing UV opacity on line of sight
- Prediction – powerful UV line driven winds in $M \sim 10^9$, L~LEdd
- APM08279
- WISSH QSO Piconcelli



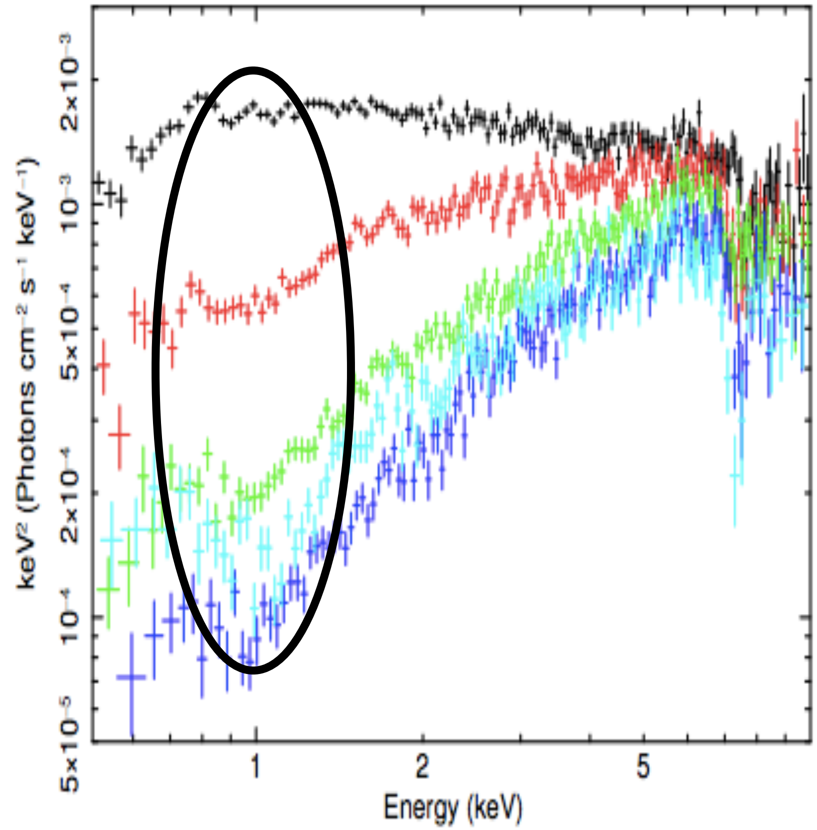
Nomura et al 2014

PDS456: UFO wind is clumpy

- High ionisation lines AND low energy absorption



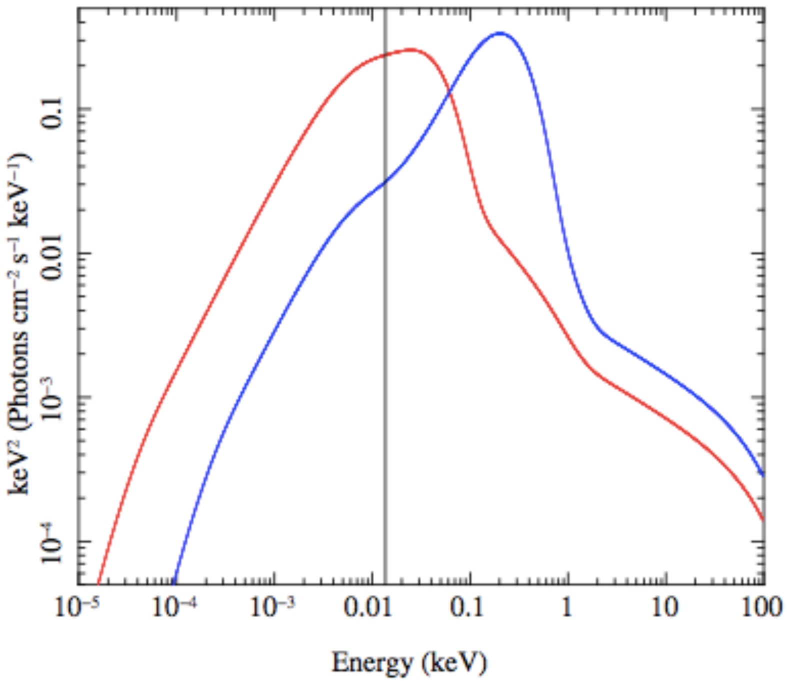
Done & Jin 2016



Reeves et al 2009
Hagino et al 2015
Matzeu et al 2016

Winds from low mass NLS1?

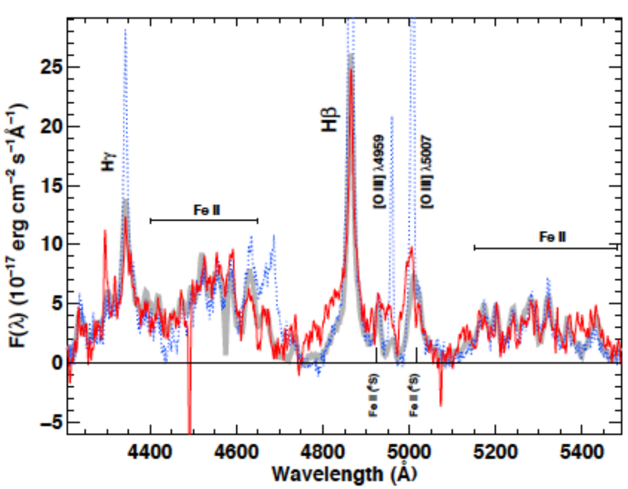
- NLS1 $M \sim 10^{6-7}$, $L/L_{Edd} \sim 1$ X-ray weak
- But disc peaks in soft X-rays – overionises UV
- Need $L \gg L_{Edd}$ for wind in NLS1 $M \sim 10^{6-7}$

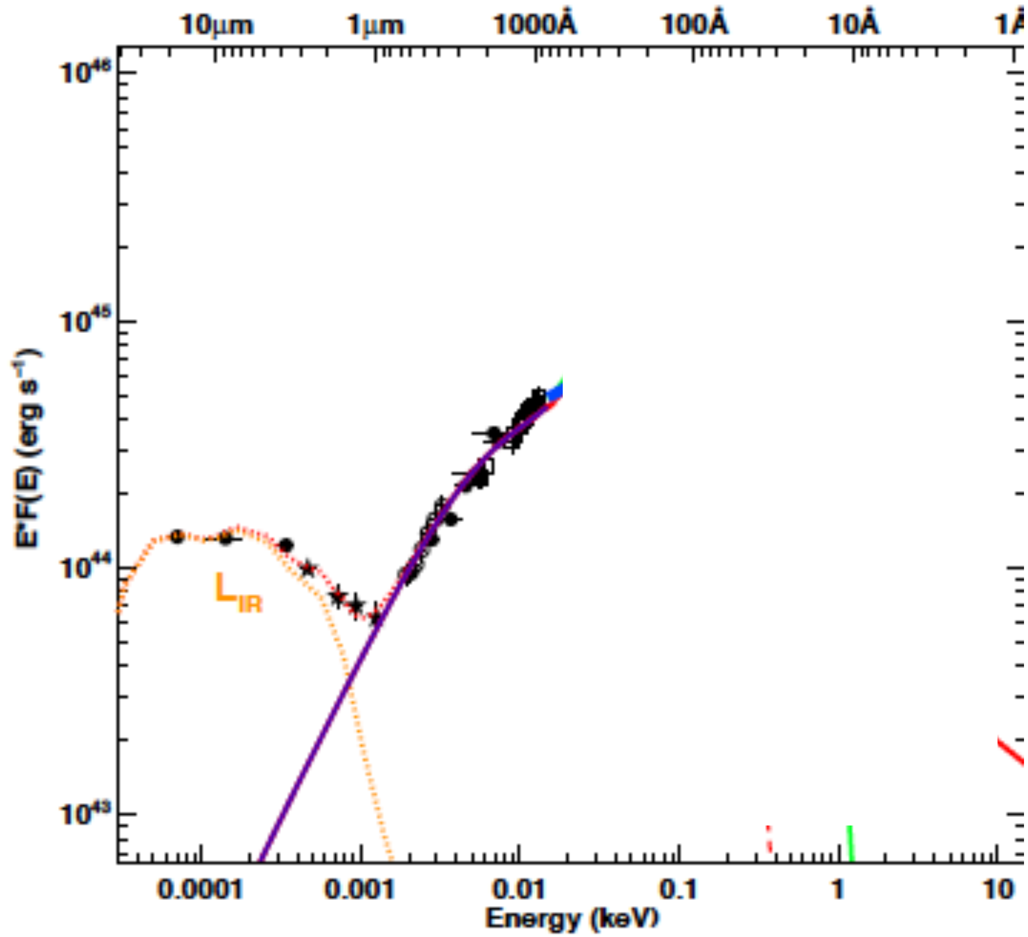


Hagino et al 2015

Extreme NLS1 RX0439

- $M=7x10^6$ Msun
- Mdot though outer disc is 12x Eddington and zero spin
- Lobs=4.6LEdd
- Winds/advection

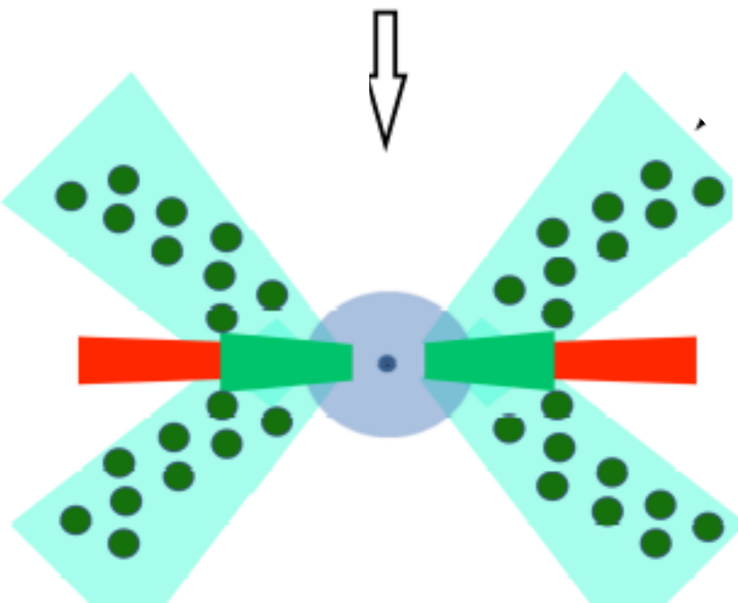


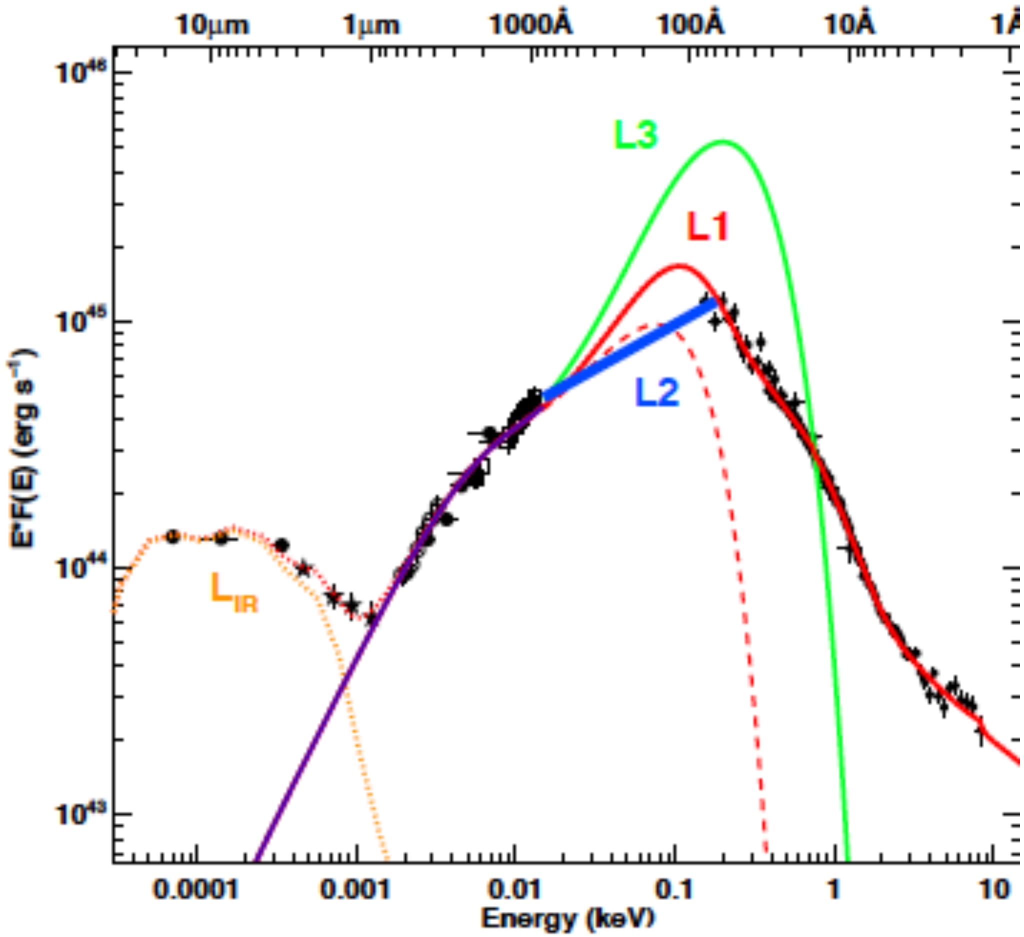


Jin et al 2017

Extreme NLS1 RX0439

- Mdot=12MdotEdd
- Lobs=4.6LEdd wind and/or advection
- No absorption features– face on ??

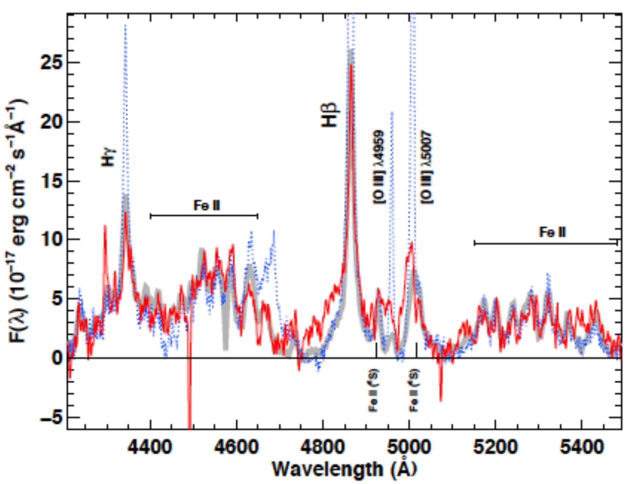


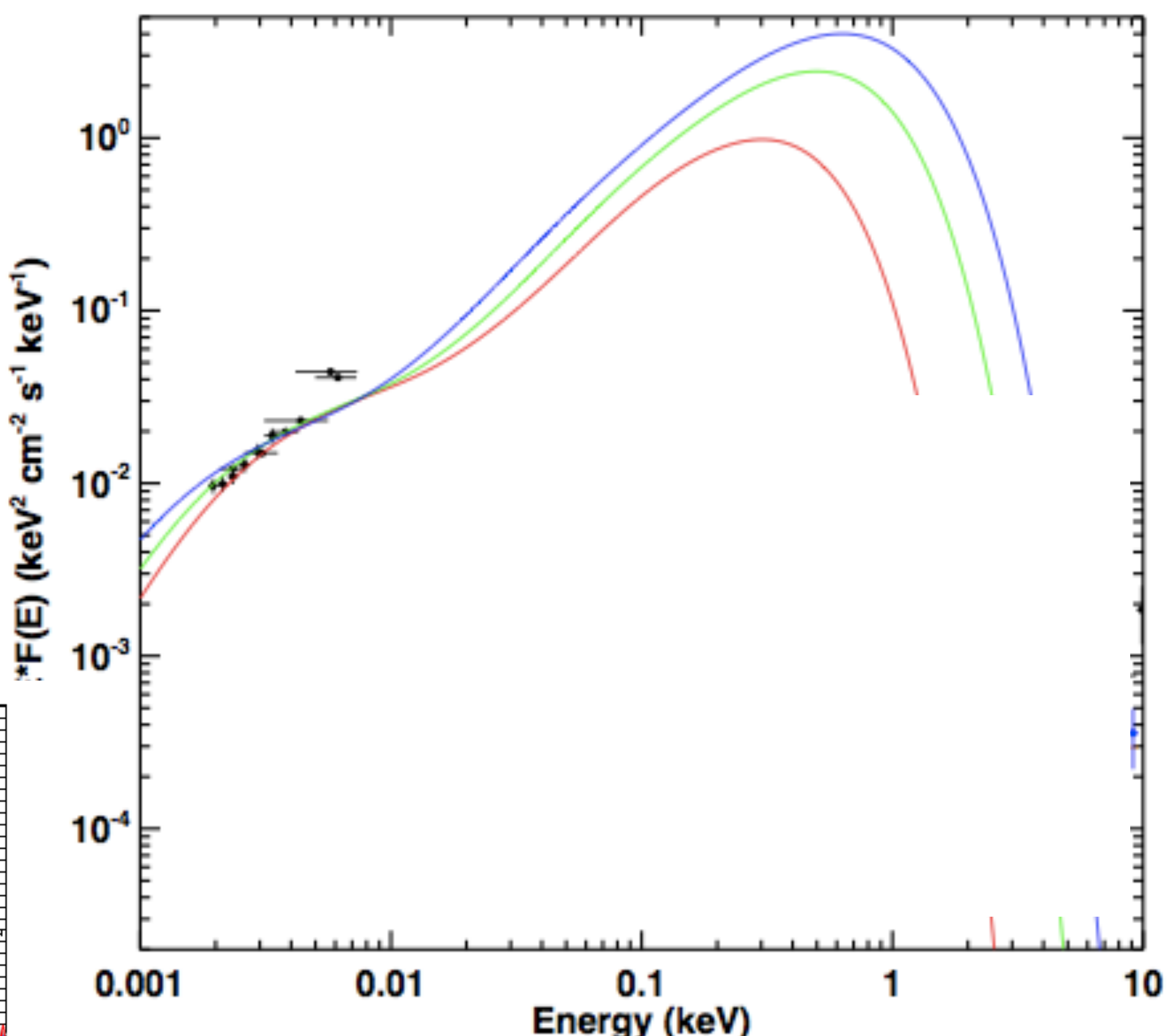


Jin et al 2017

1H0707-495 Extreme NLS1

- 1H0707
- $2\text{-}4\times10^6$
- L/Ledd = 11, 40 70
  (60 degrees)
- superEddington

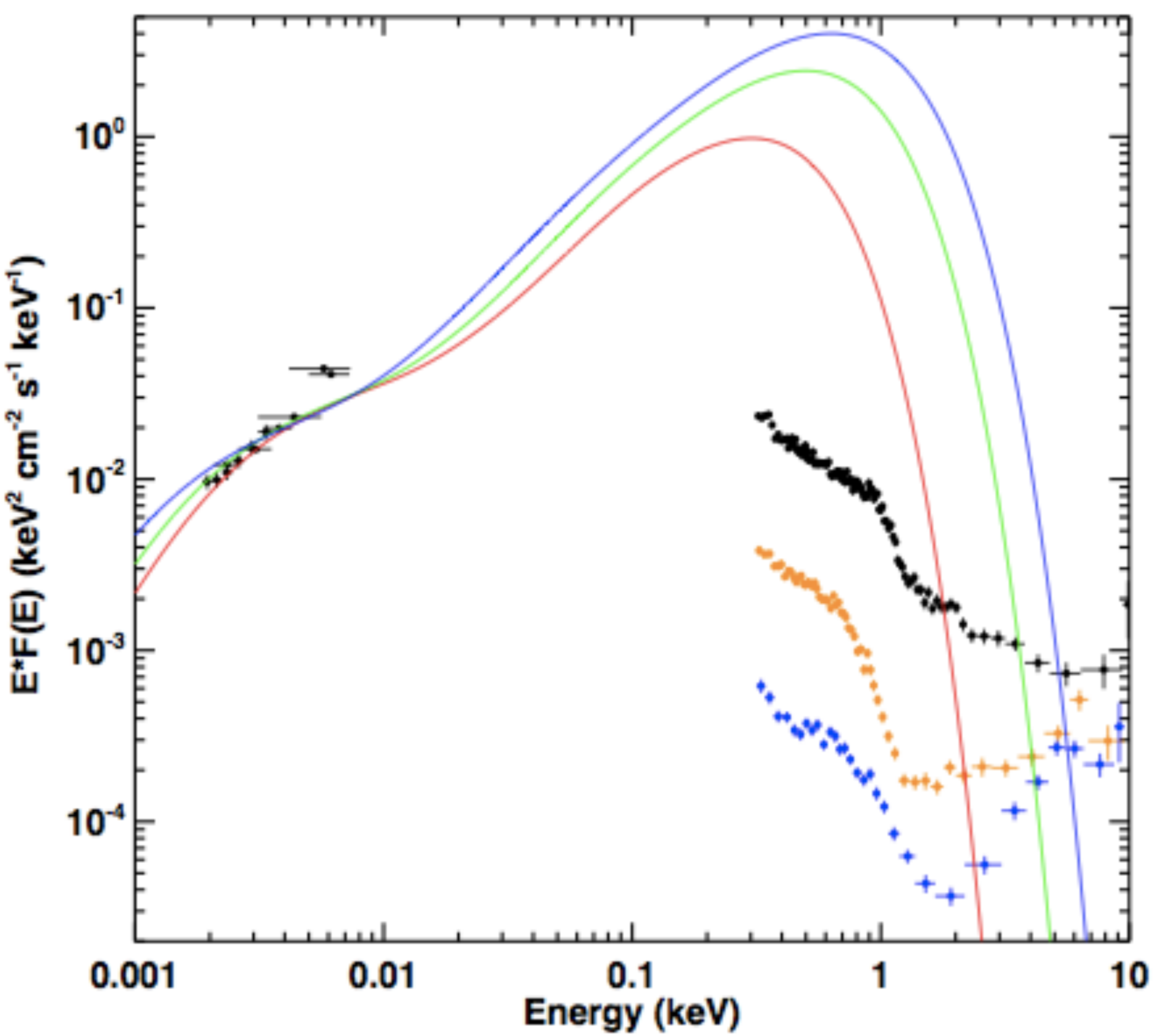




Done & Jin 2016

1H0707-495 Extreme NLS1

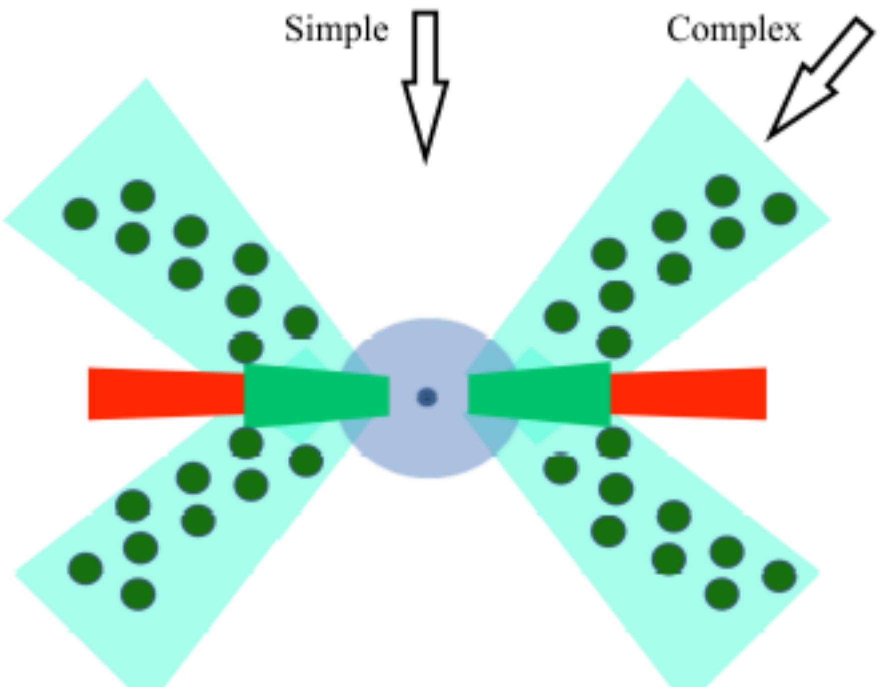
- 1H0707
- $2\text{-}4\times10^6$
- L/Ledd = 11, 40 70
  a=0 0.9 0.998
  60 degrees 4×10^6
- superEddington
- Strong wind, losing energy so not all potential power radiated



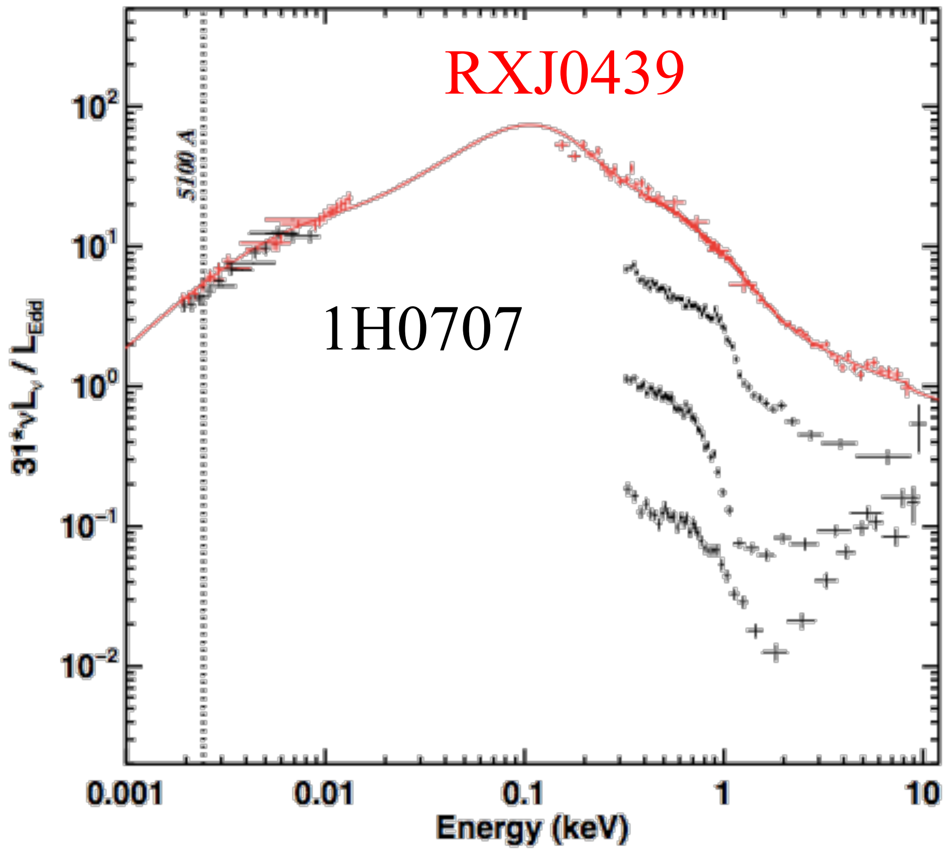
Done & Jin 2016

Extreme NLS1 – simple / complex

- RXJ 0439 'simple' NLS1
- 1H0707 'complex' NLS1 so see wind absorption - UFO?



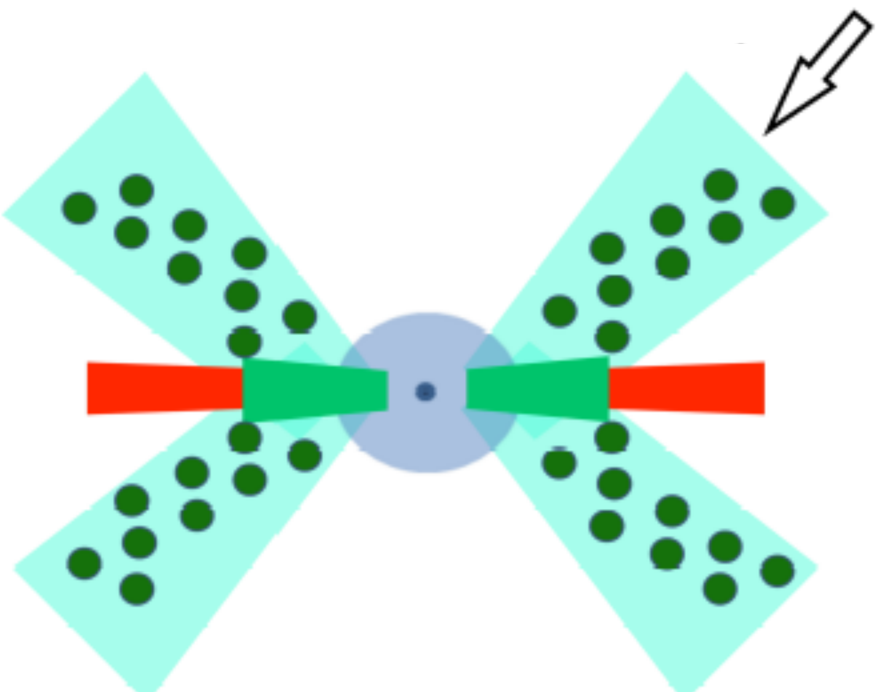
Done & Jin 2016



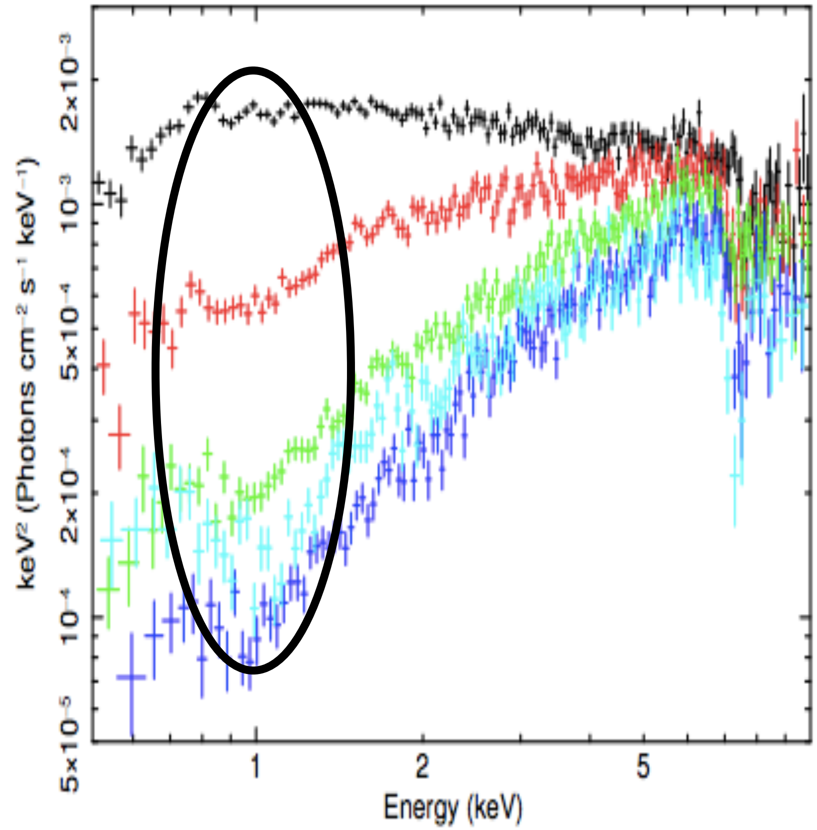
Jin et al 2017

PDS456: UFO wind is clumpy

- High ionisation lines AND low energy absorption

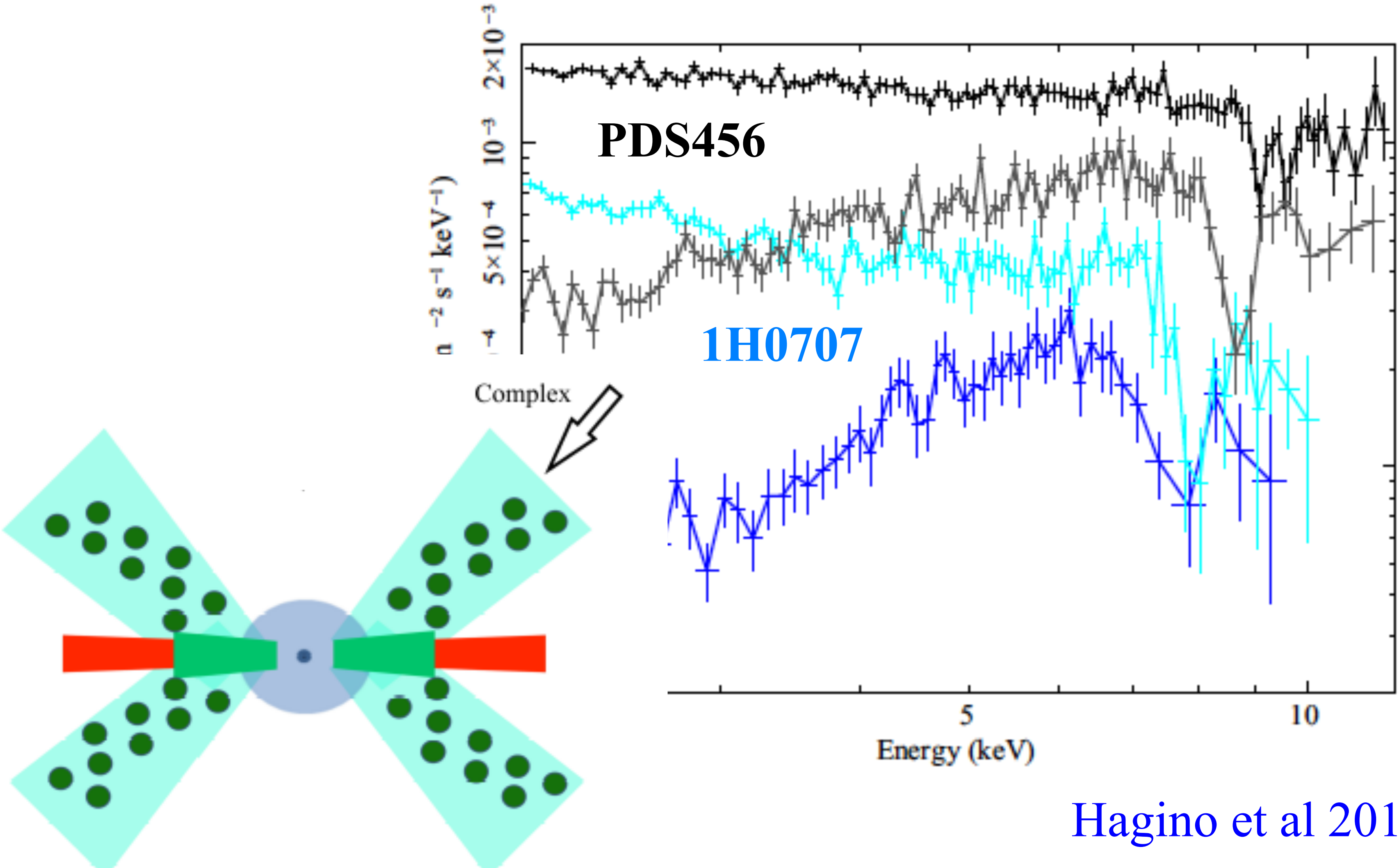


Done & Jin 2016



Reeves et al 2009
Hagino et al 2015
Matzeu et al 2016

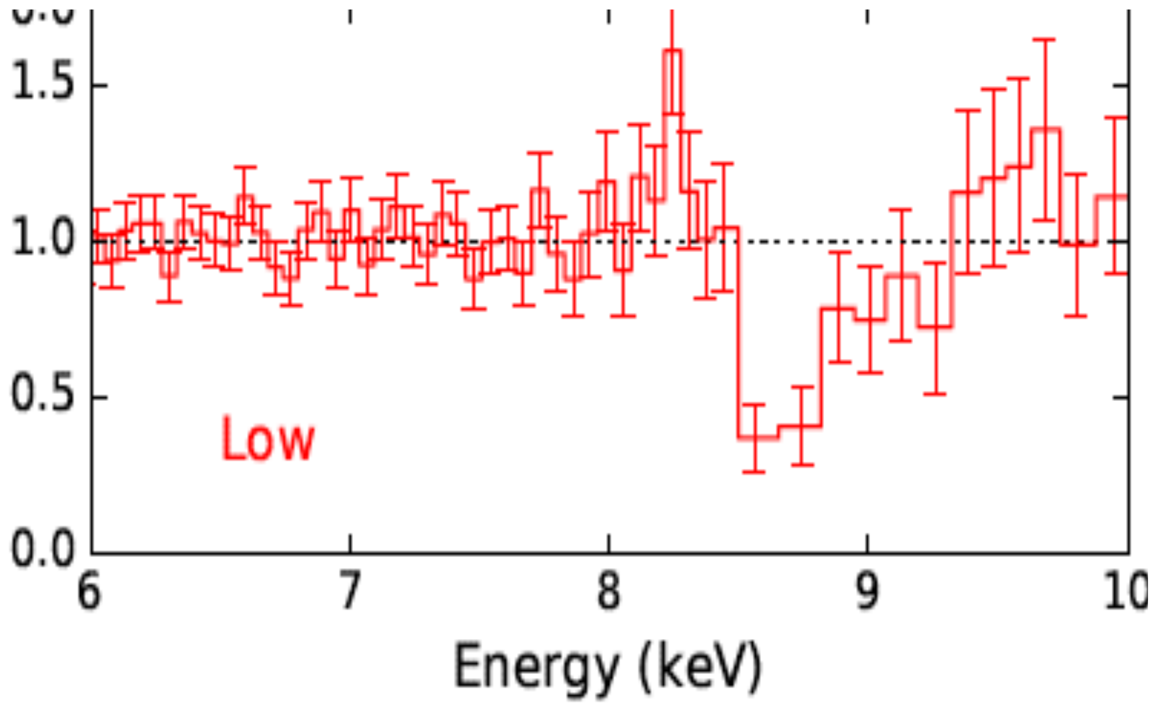
1H0707 shows very similar range of spectral shapes to PDS456



Hagino et al 2017

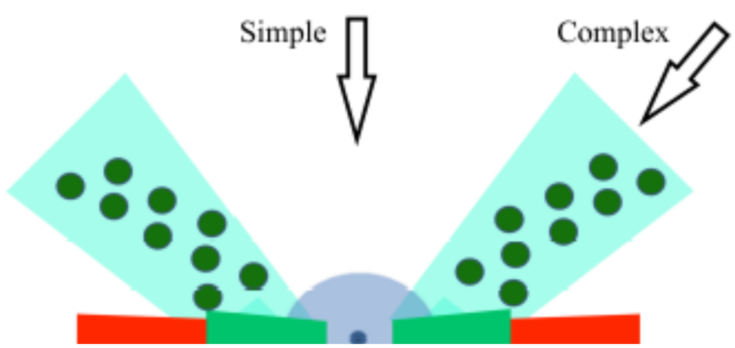
IRAS13224

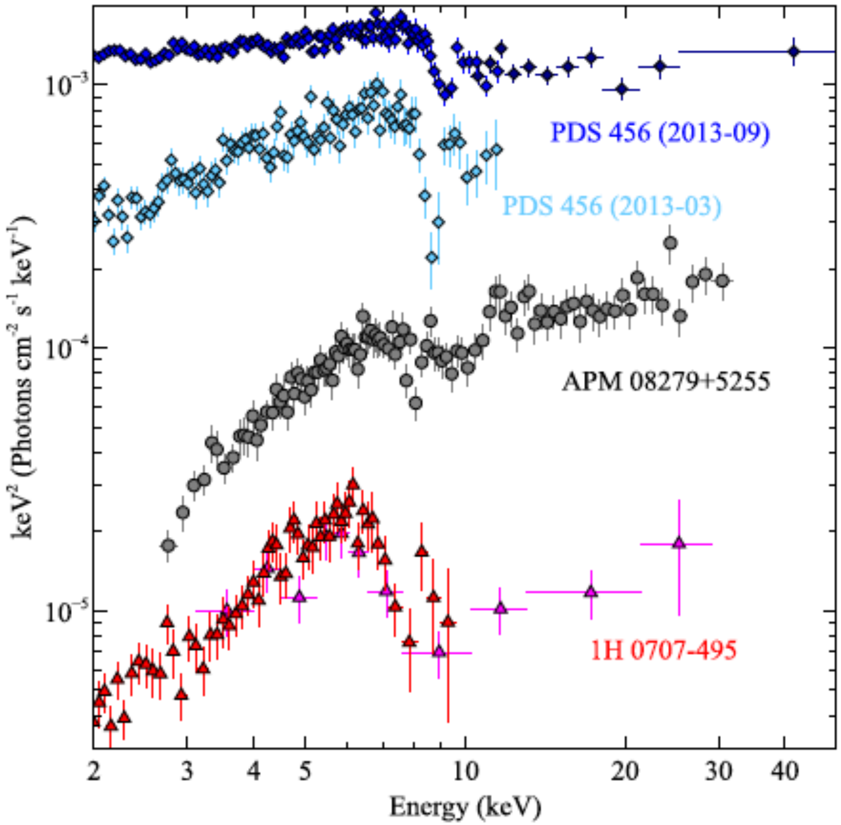
- IRAS13224 Parker et al 2017 – clear UFO!!
- Called ‘twin’ of 1H0707, interpreted as similarly highly relativisitic reflection (Ponti et al 2009) – probably similarly superEddington (Leighly 2004)



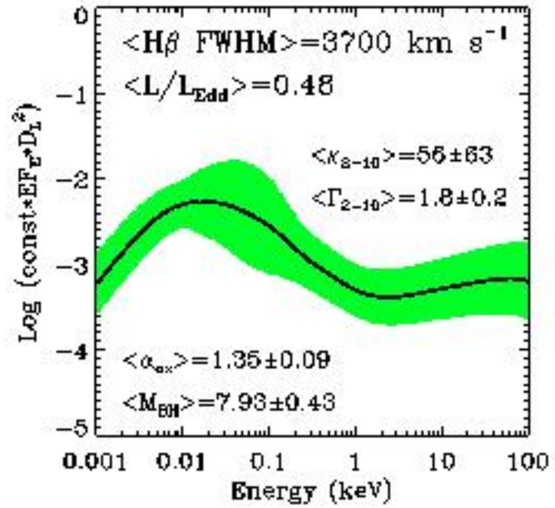
Conclusions – most powerful winds

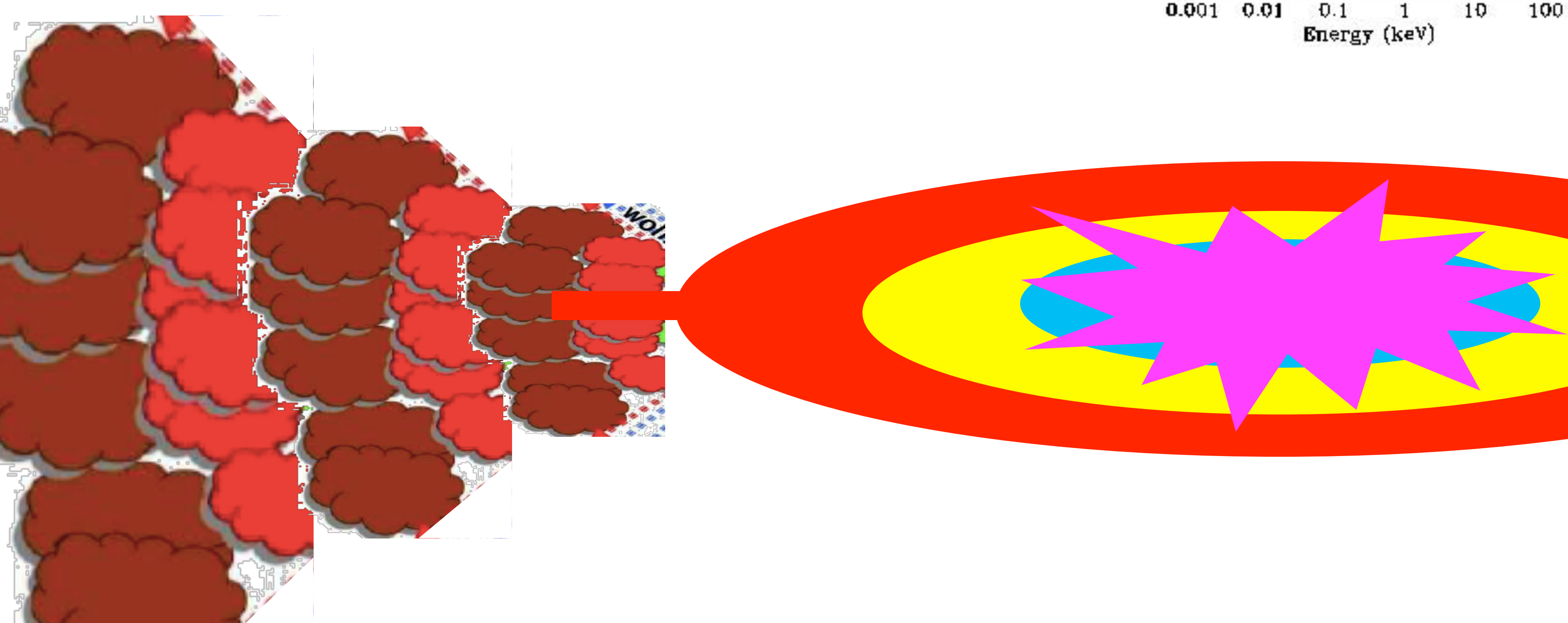
- Quantatative AGN feedback
- SED – L/LEdd and M
- high M, L~LEdd UV bright, X-ray weak, UV driving
- Eddington wind L>LEdd
- Both at z~2-3 QSO epoch
- Clumpy, complex - los





Which wind goes where?
L~0.1LEdd





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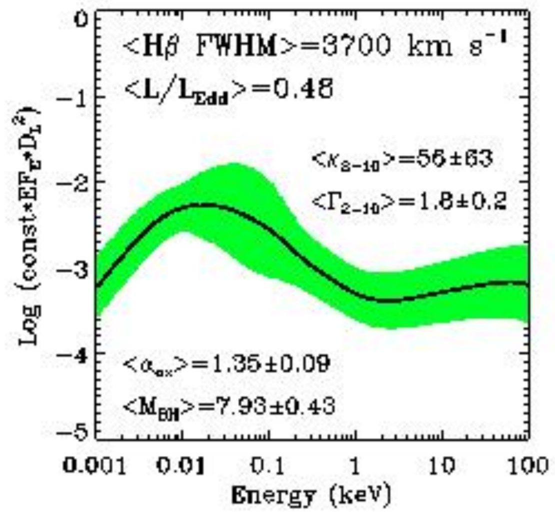
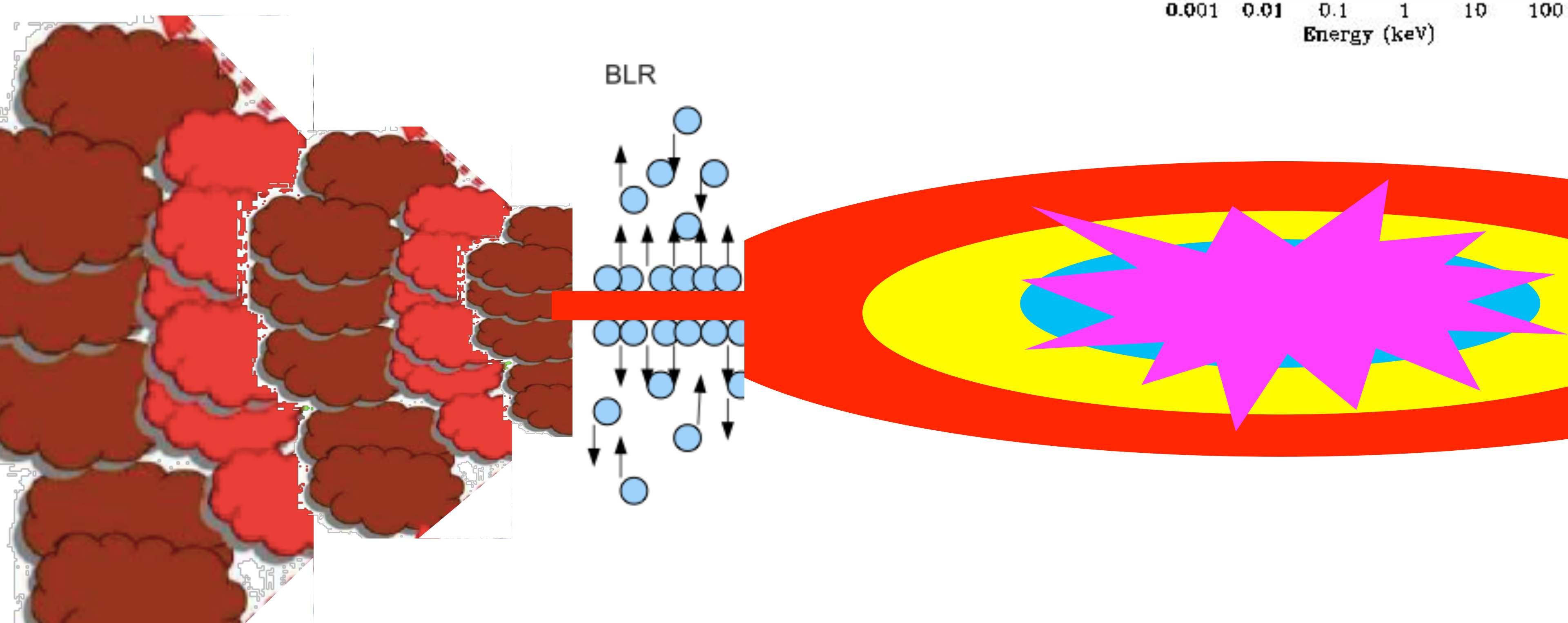
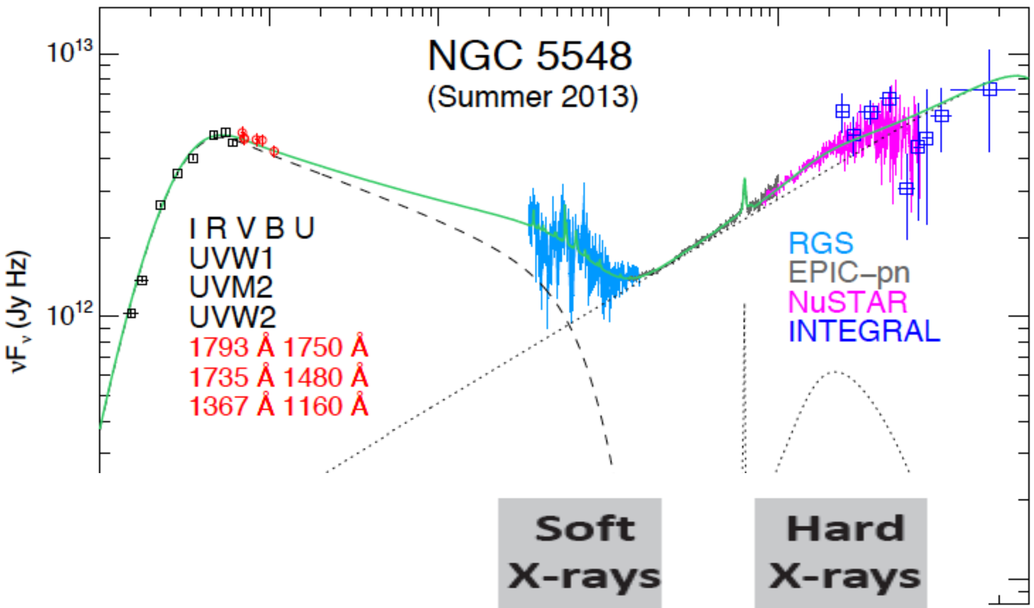
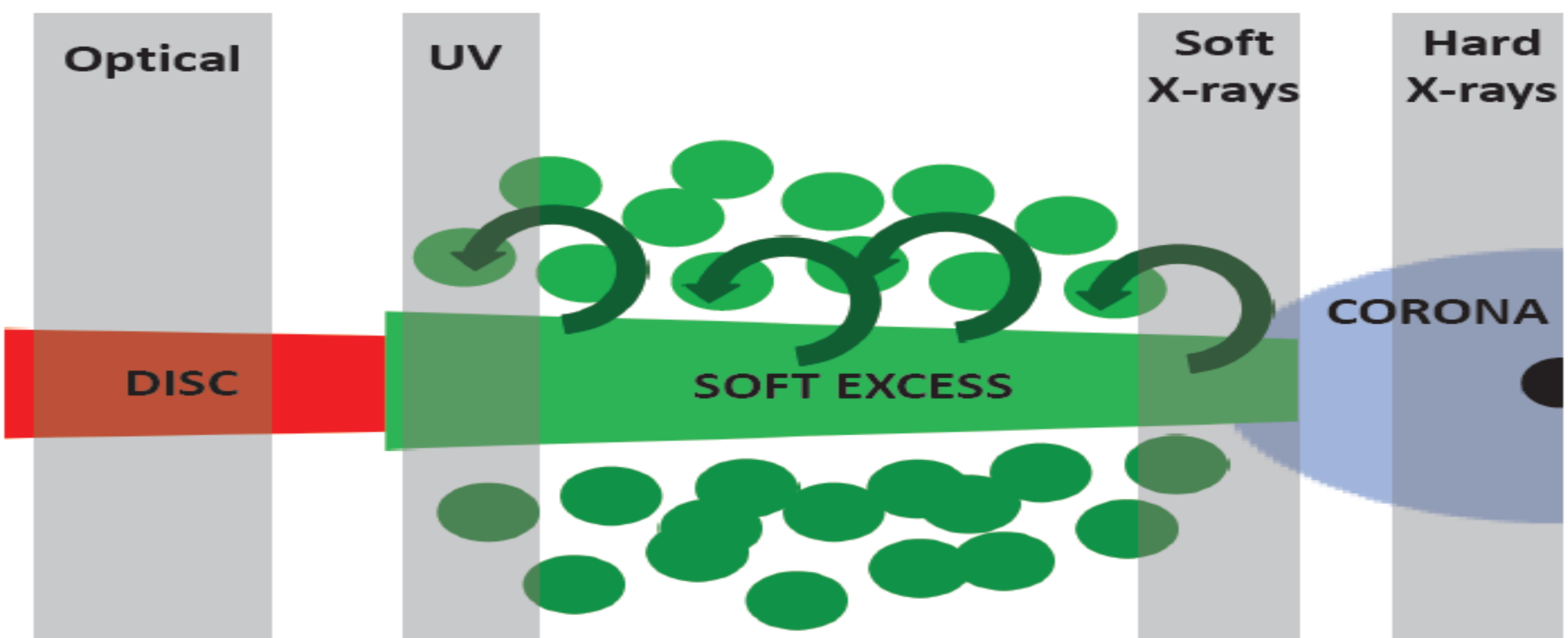




Nature of soft excess region?

- UV disc – UV line driving, overionised by X-rays so falls back down..





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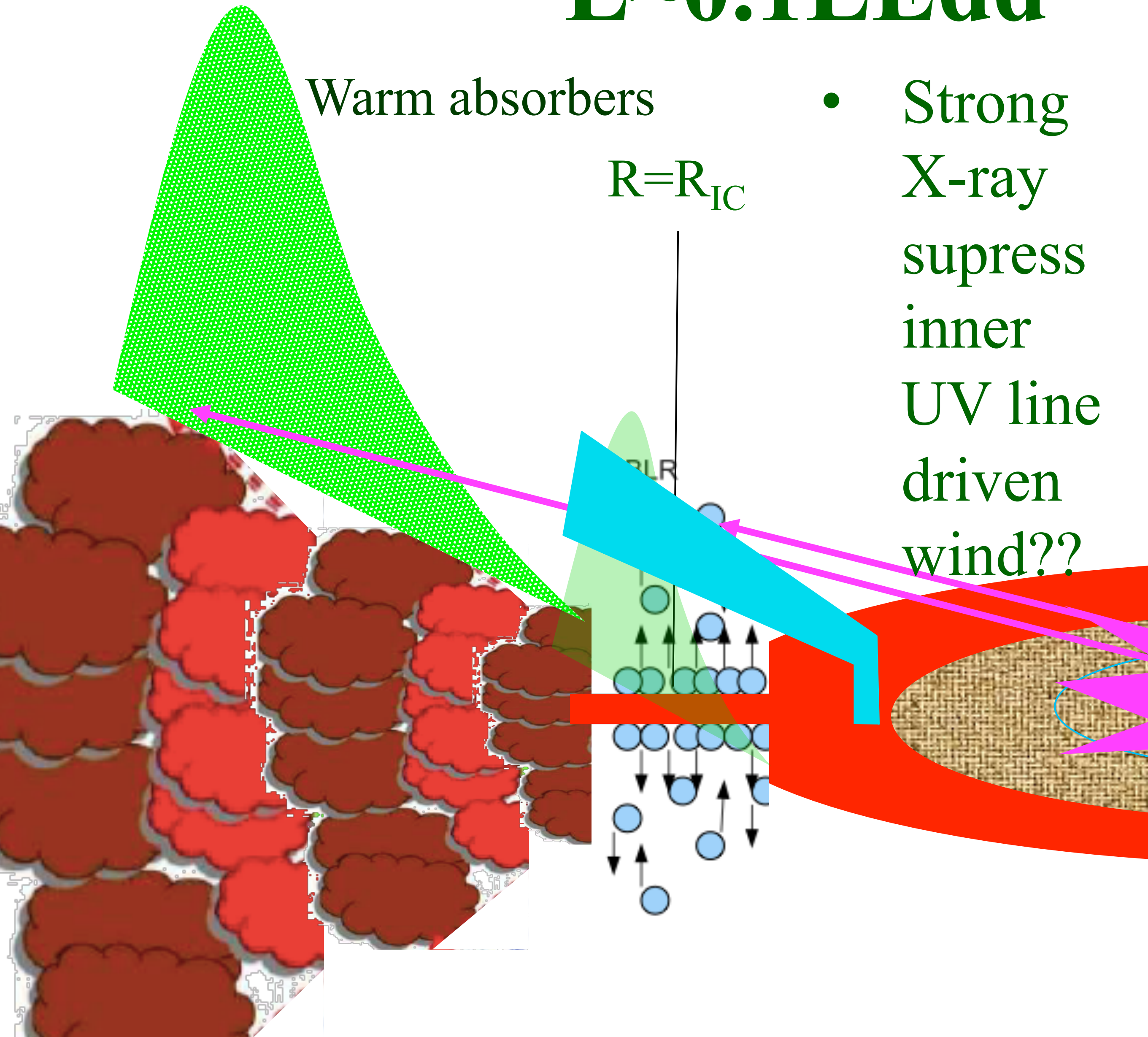
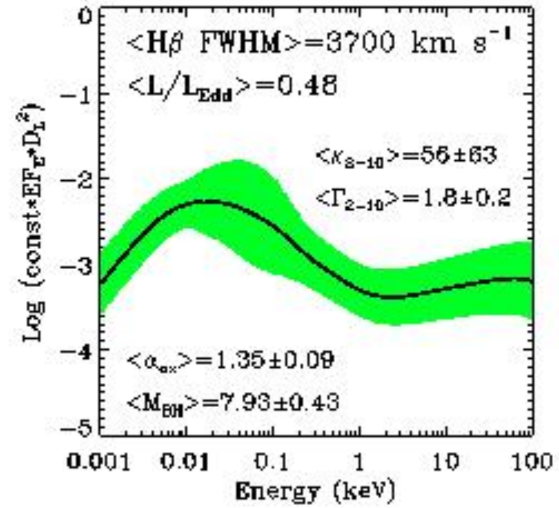
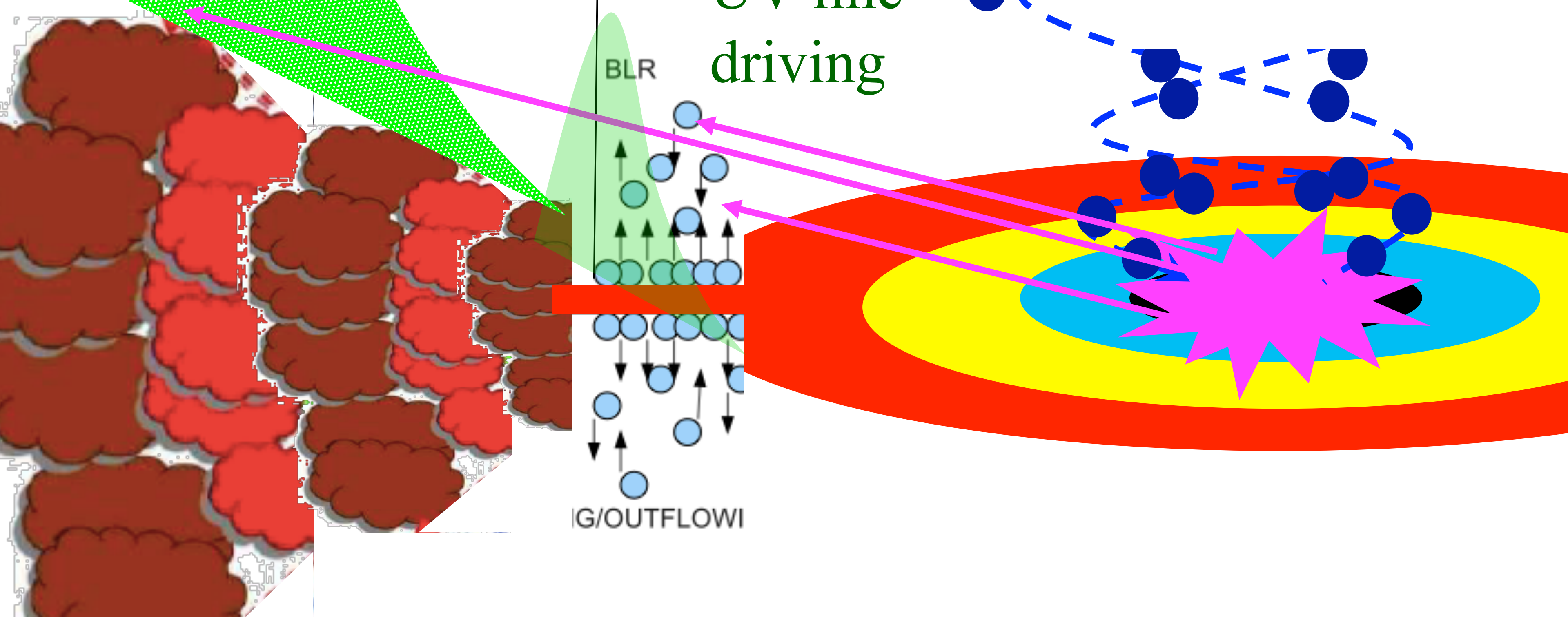


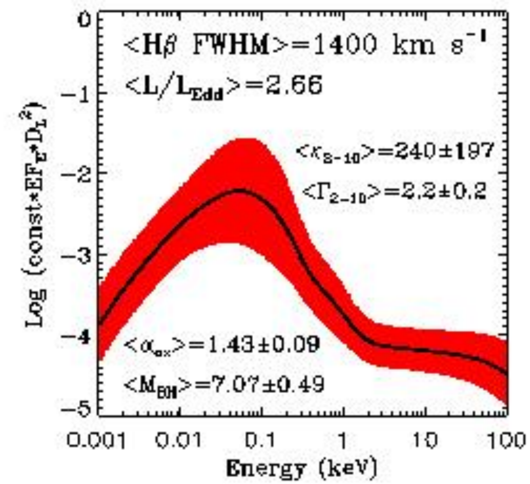
- Strong X-ray supress inner UV line driven wind??



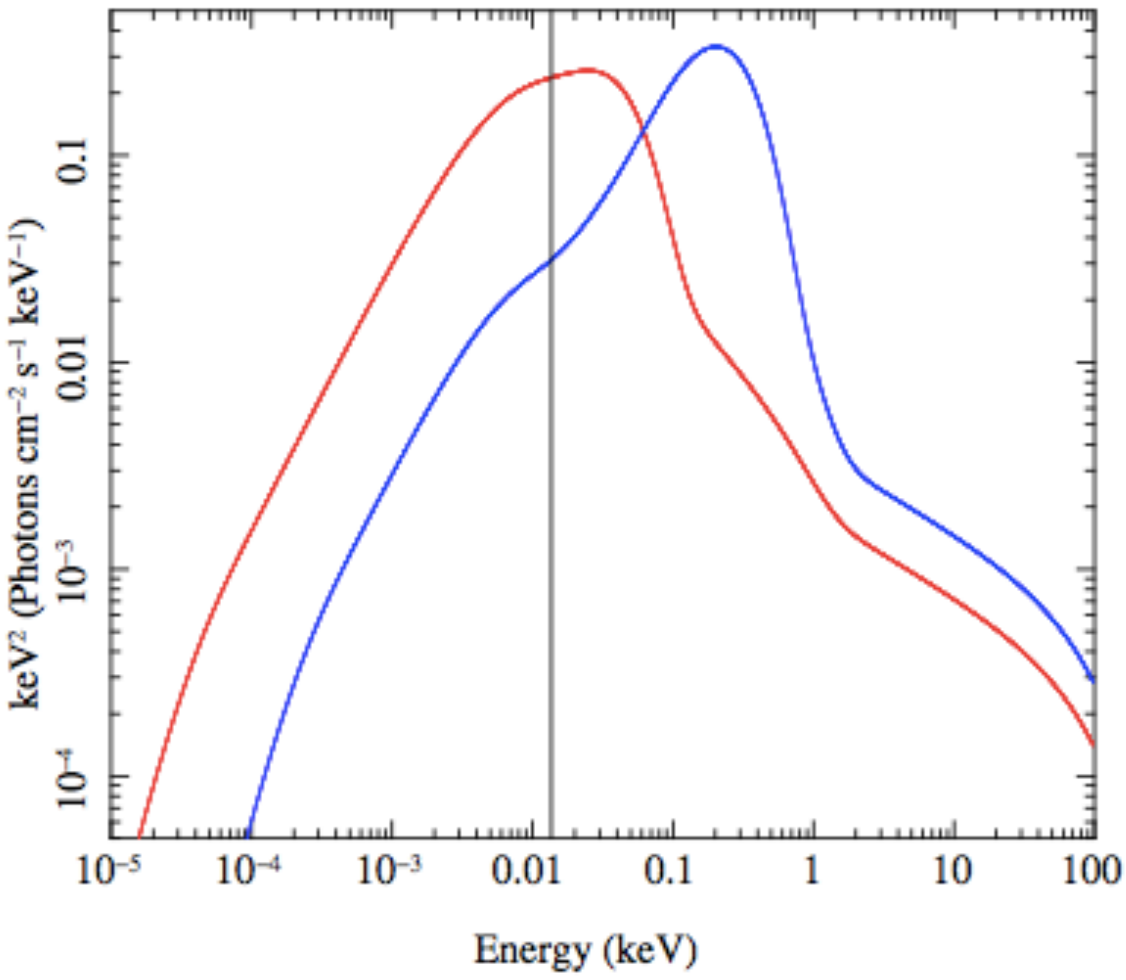
Which wind goes where?
L~LEdd

- Strong FUV from disc peak supresses UV line driving





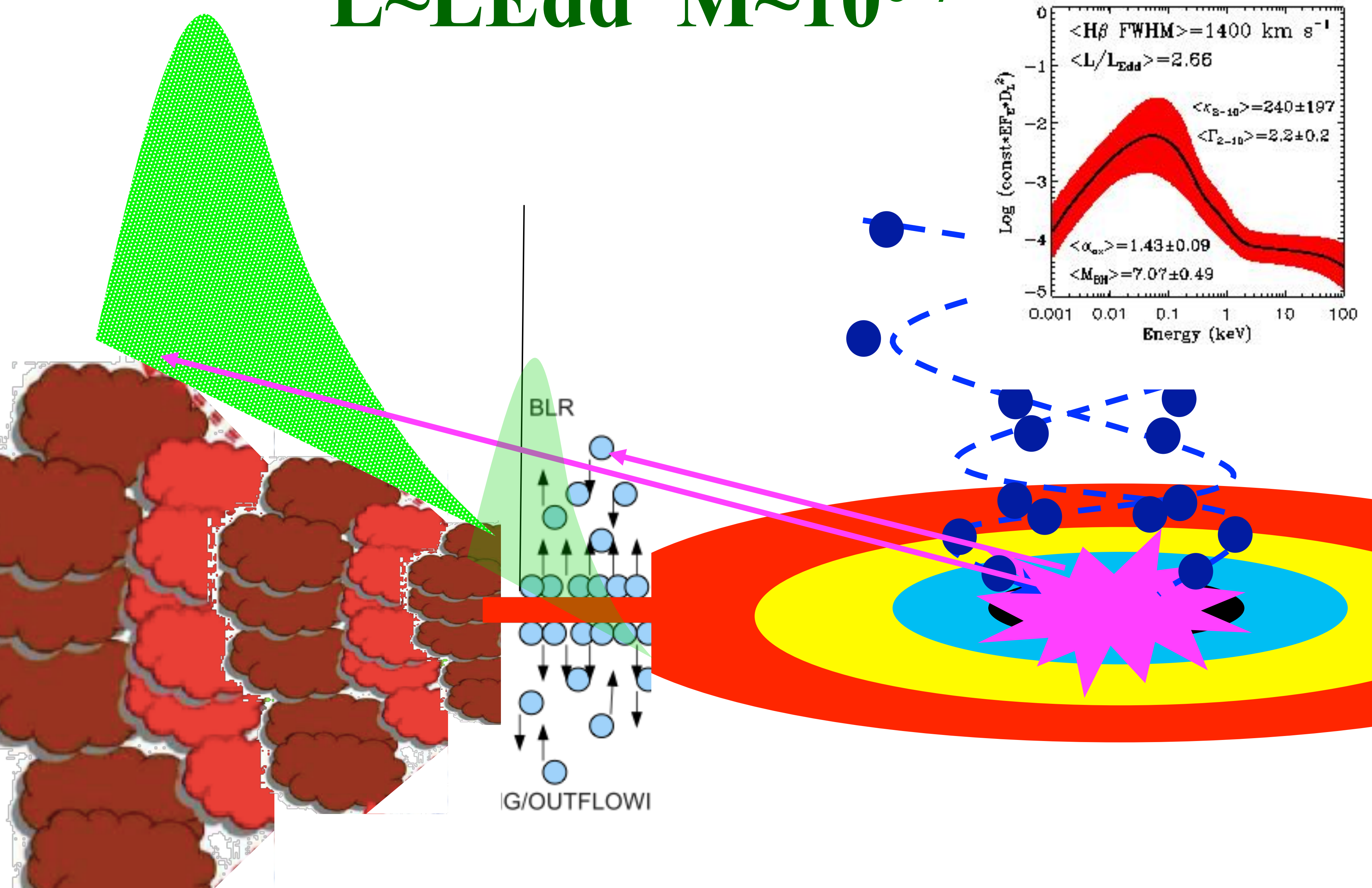
10^6 versus 10^9 M



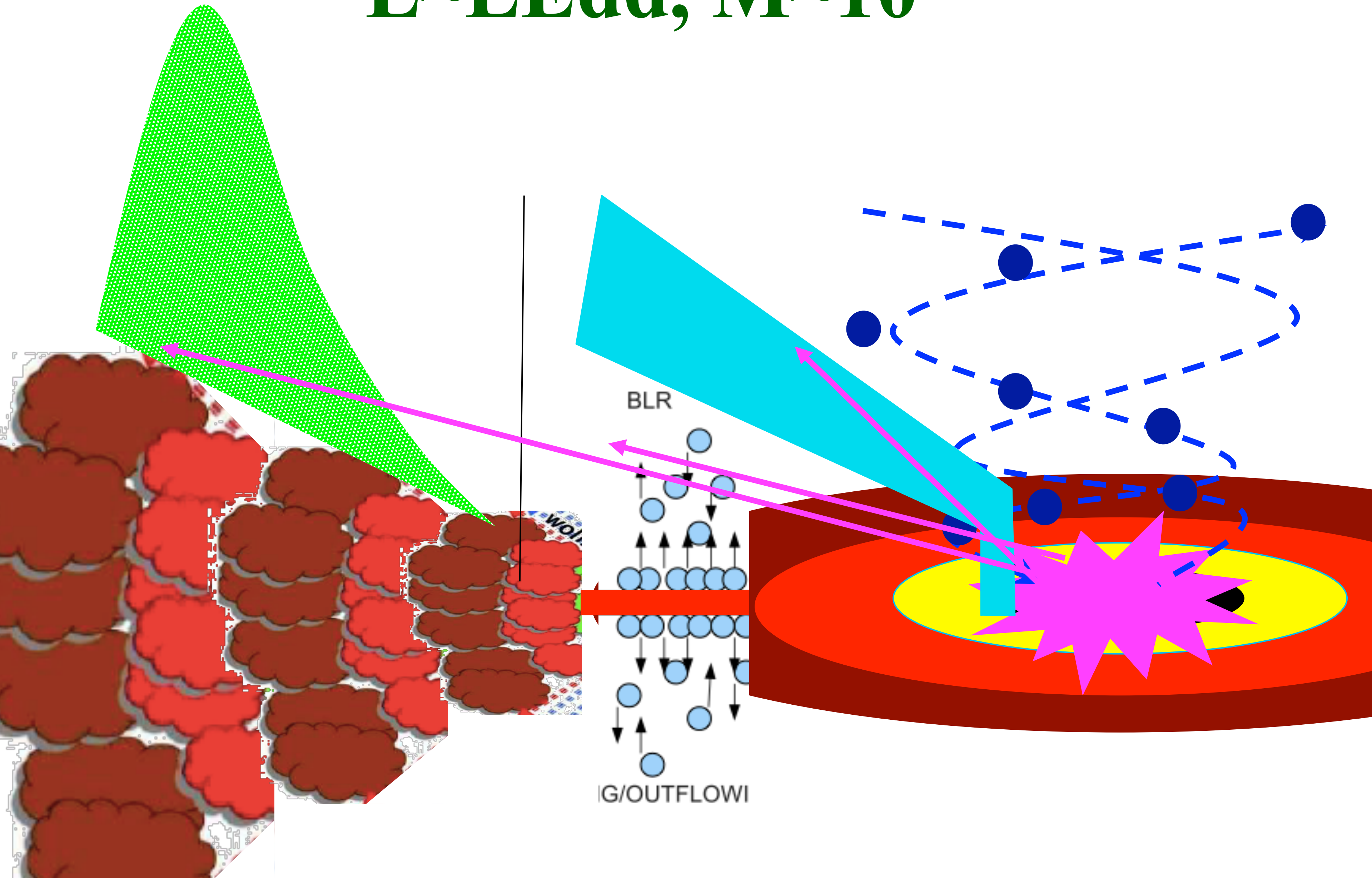
Hagino et al 2014

Which wind goes where?

L~LEdd M~10^6-7



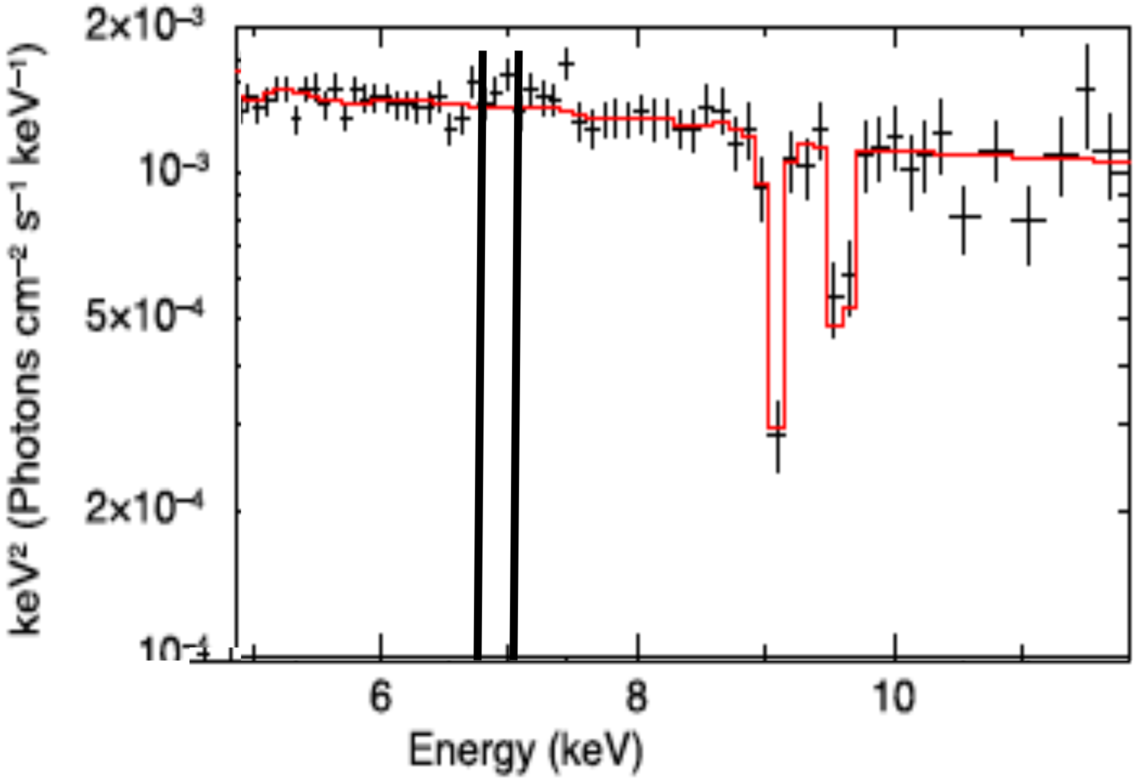
Which wind goes where?
L~LEdd, M~10^{9-10}



Ultra Fast Outflows: UFOs

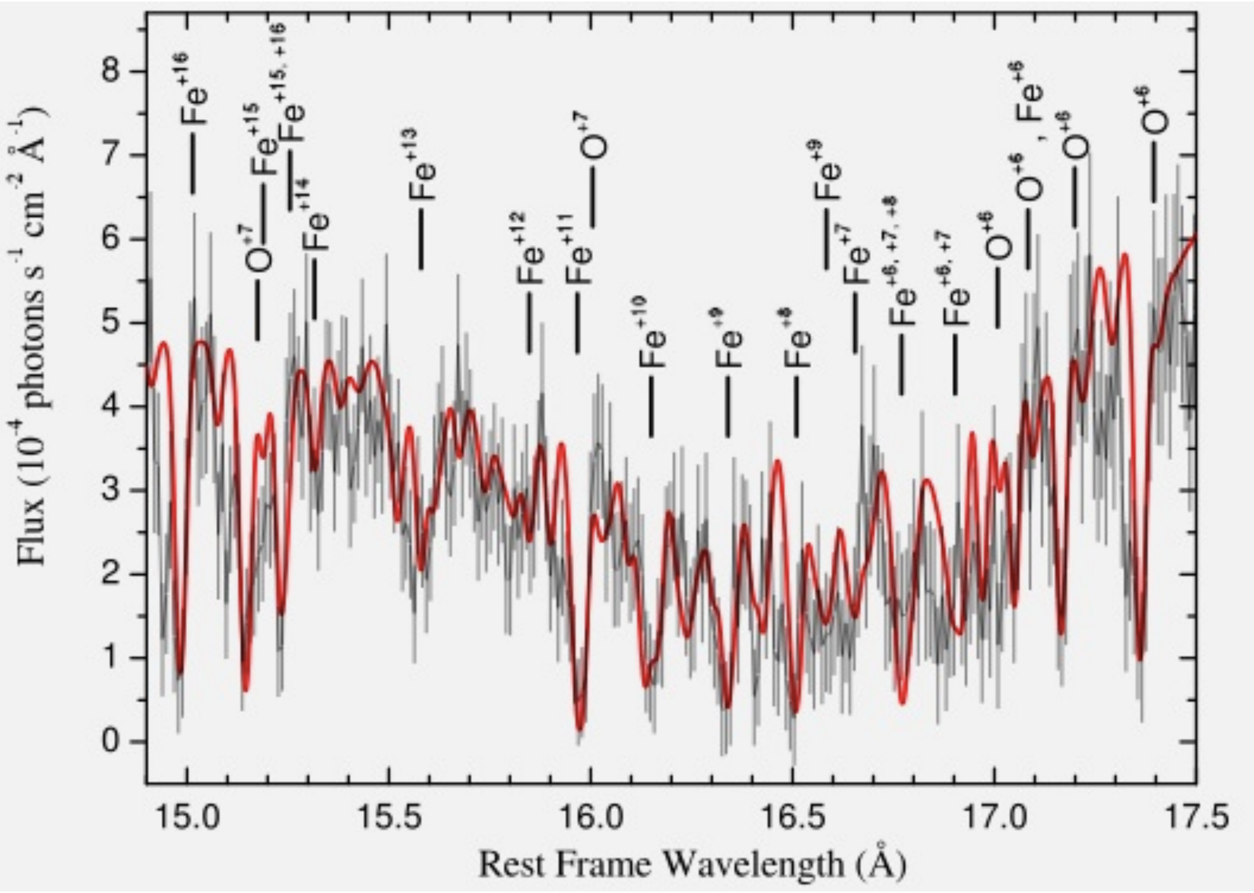
- High column,
- High v~0.2c
- high ionisation
- $\xi = L/nR^2$
- Log ξ = 5

Reeves et al 2003; 2009; Hagino et al 2015; Matzeu et al 2016



X-ray warm absorbers

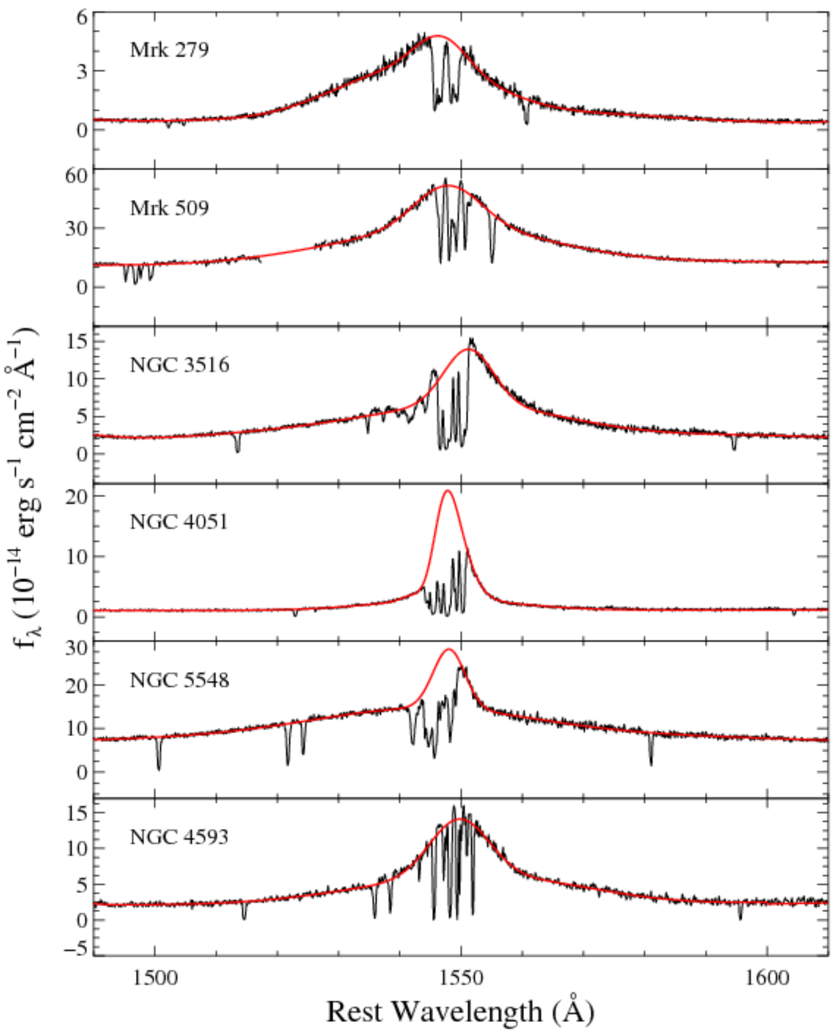
- NGC3783
- Lower column
- Log Nh =20-22
- V~200-1000 km/s
- Log x = 1-3
- Multiphase
- Not much KE
Blustin et al 2005
Mathur et al 1997



Netzer et al 2003
Holczer et al

UV narrow absorption

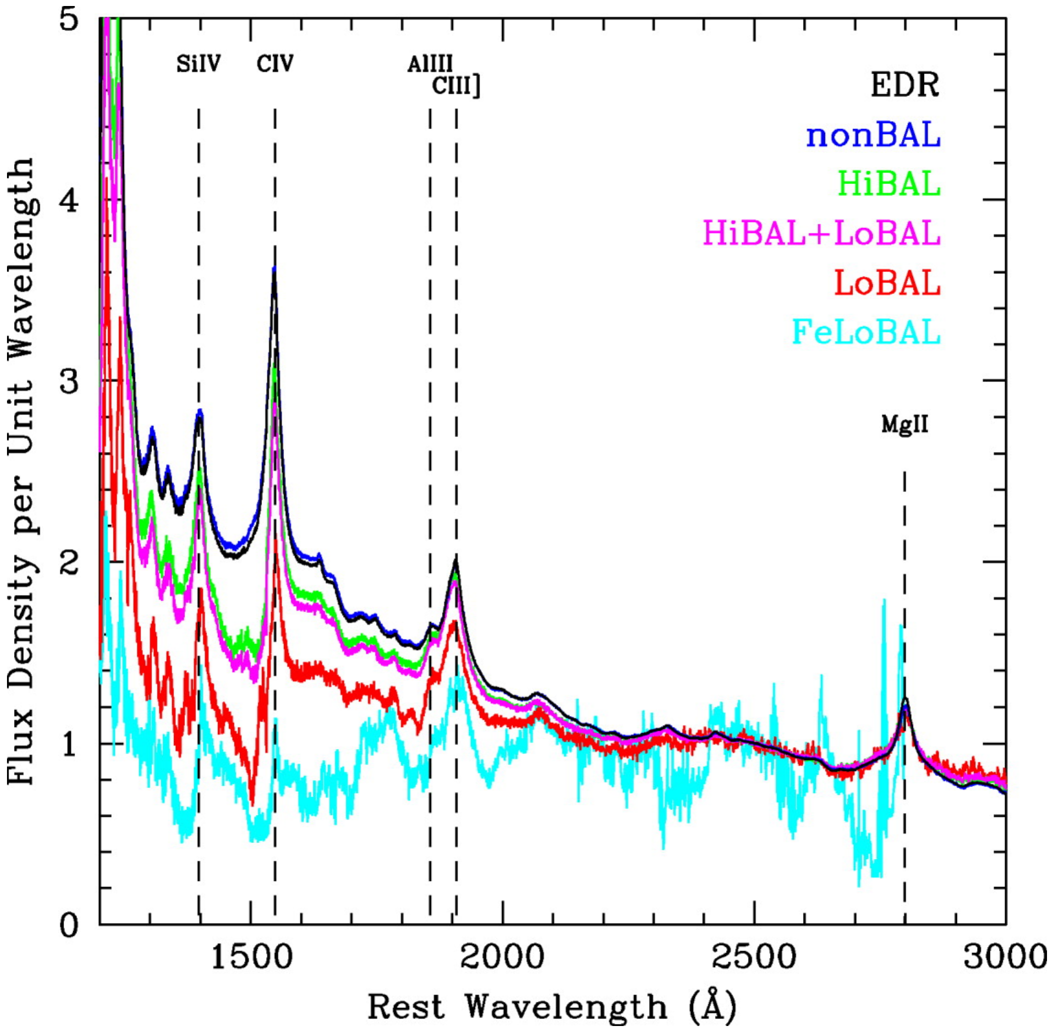
- Lowest ξ X-ray absorbers are ‘high ionisation’ UV
- Mathur et al 1997



Park et al 2013

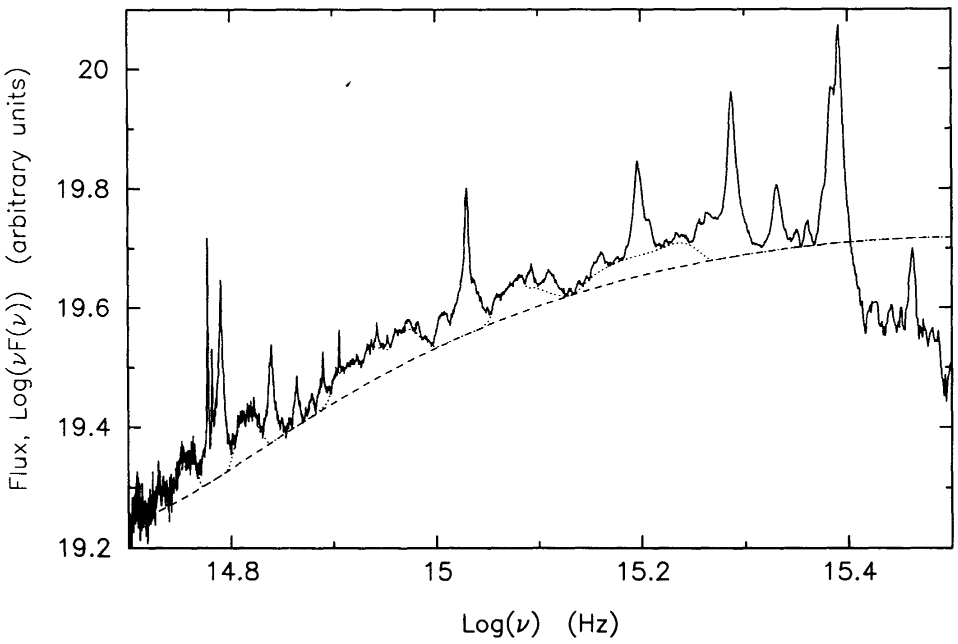
BAL QSOs

- BAL QSOs: v=0-0.15c
- Highish column
- Log Nh=21
- in 10% QSOs



The BLR itself?

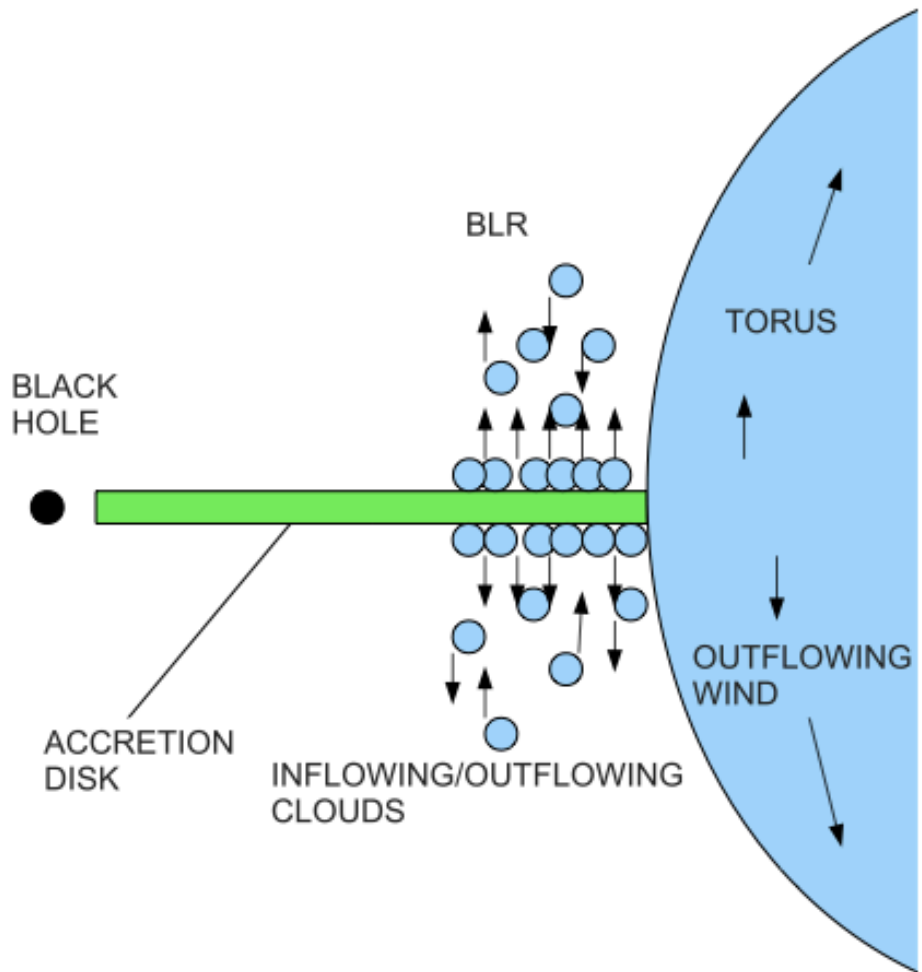
- BLR!!
- Smoothness of profile implies very larger number of 'clouds'
- Lowest L AGN shows can't be bloated stars as these are too large!
- Continuous distribution of material - wind/disc? Chiang & Murray 1995



Francis et al 1997

Dust driven winds ?

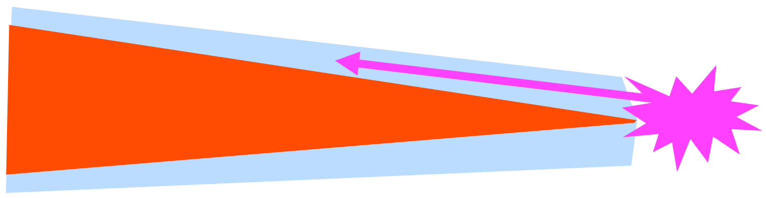
- Ldust/Ledd = $\sigma_{es}/\sigma_{dust}$
- ~ 0.01-0.001 Dust has big cross-section! Fabian et al 2008
- Torus face outflowing?
- BLR dust driven wind Czerny & Hryniewicz 2011
- Hβ radius ≈ 1600K, Galiani & Horne 2013



Czerny & Hryniewicz 2011

Thermally driven Winds

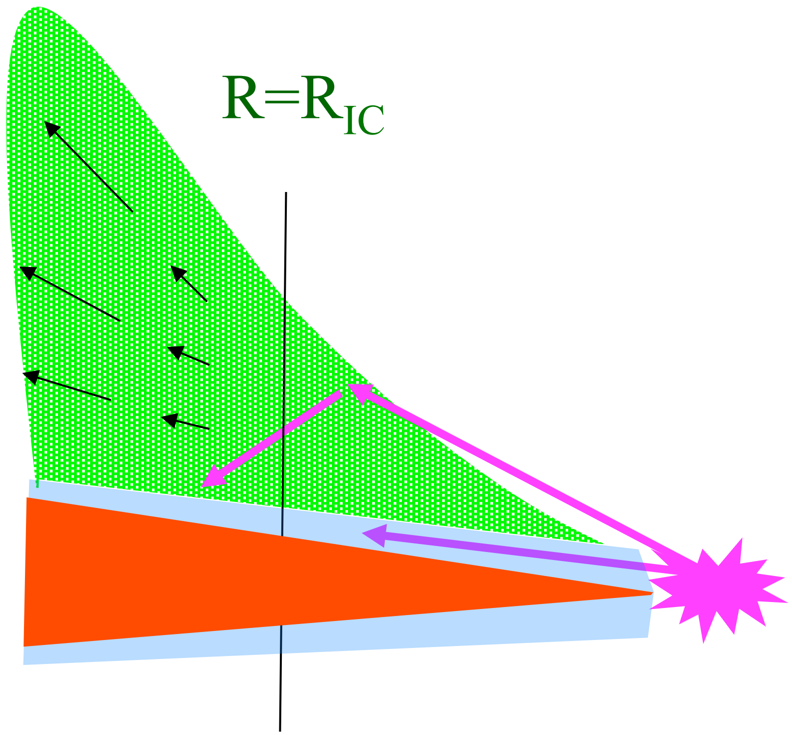
- Direct illumination or scattering from wind…
- X-ray source irradiates top of disc, heating it to Compton temperature
- T_{IC} depends only on spectrum - L_{irr} only controls depth of layer



Begelman McKee Shields 1983

Thermally driven Winds

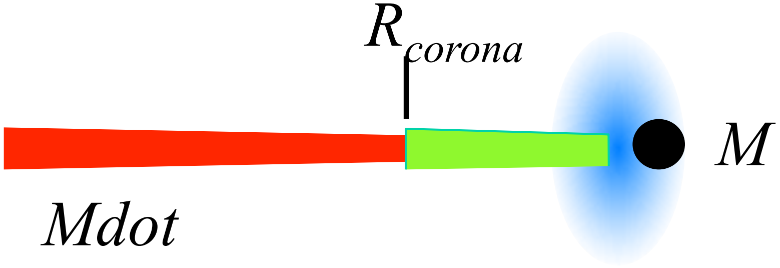
- Direct illumination or scattering from wind…
- X-ray source irradiates top of disc, heating it to Compton temperature
- T_{IC} depends only on spectrum
- $kT_{IC} = GMmp/R_{IC}$
- Thermal wind from large radii – slow
- WA: BLR and torus?? Kriss & Krolik 2001

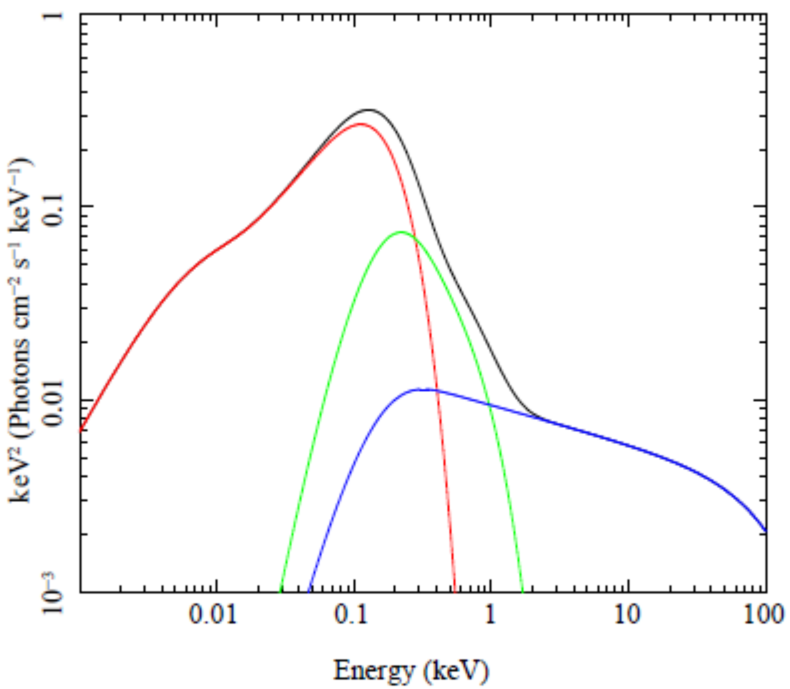


Begelman McKee Shields 1983
Jimenez Garate et al 2002

Models conserving energy!!

- Smaller R_{corona}
- Softer 2-10 keV corona
- Spectra are more disc dominated!
- Weak soft X-ray excess and weak corona
- X-ray bolometric correction CHANGES!!
- Vasudevan & Fabian 2007; 2009

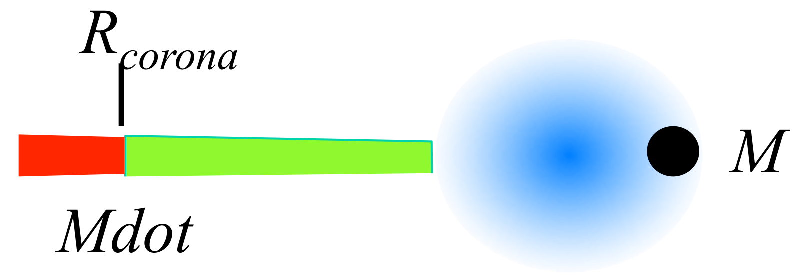


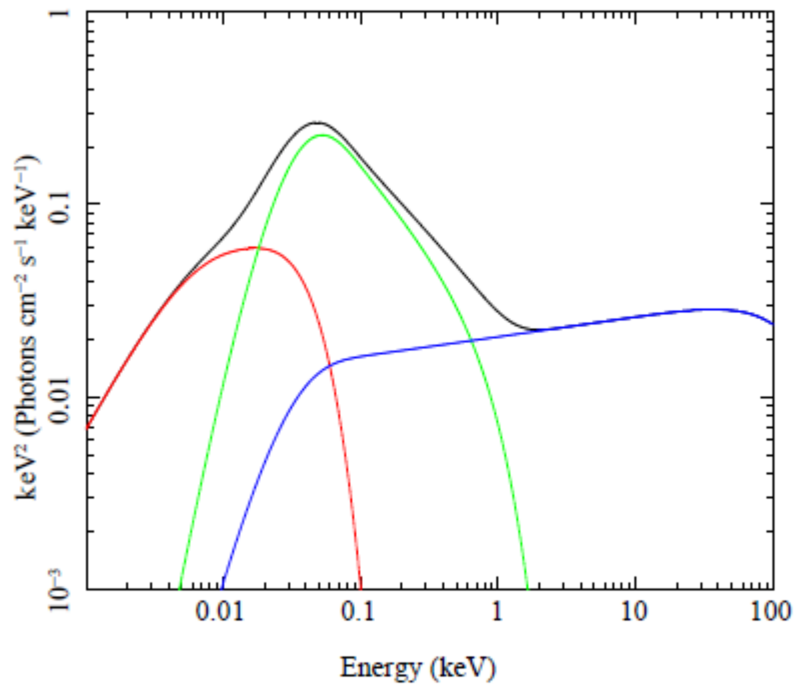


Done et al 2012

Models conserving energy!!

- Outer standard disc down to R_{corona}
- Then luminosity not completely thermalised to make soft X-ray excess ?
- Failed UV line driven wind? And/or H ionisation instability
- Inner corona as in hard state BHB (L/LEdd?)



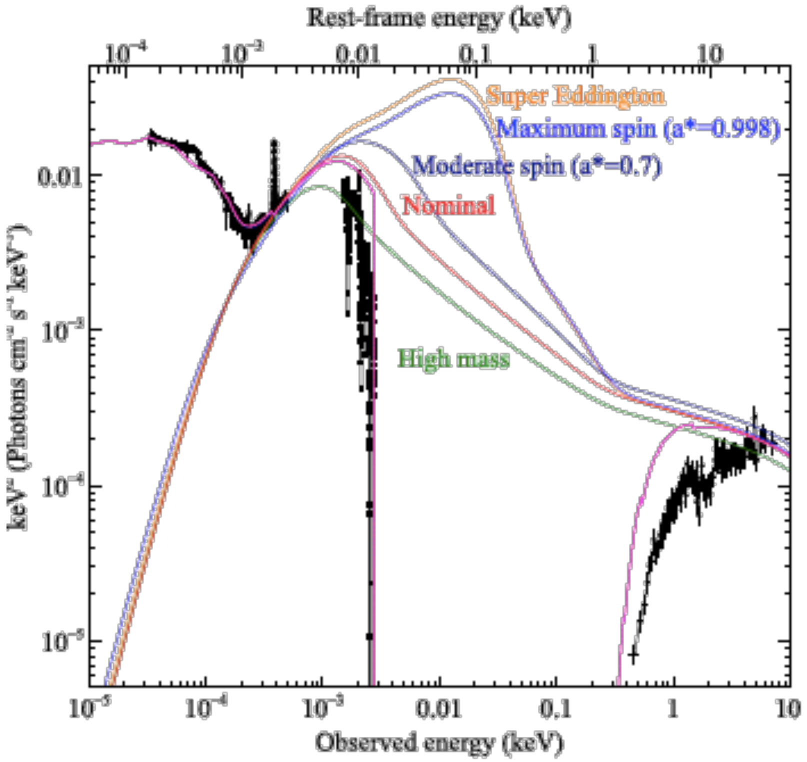


Done et al 2012

Mass dependence!!

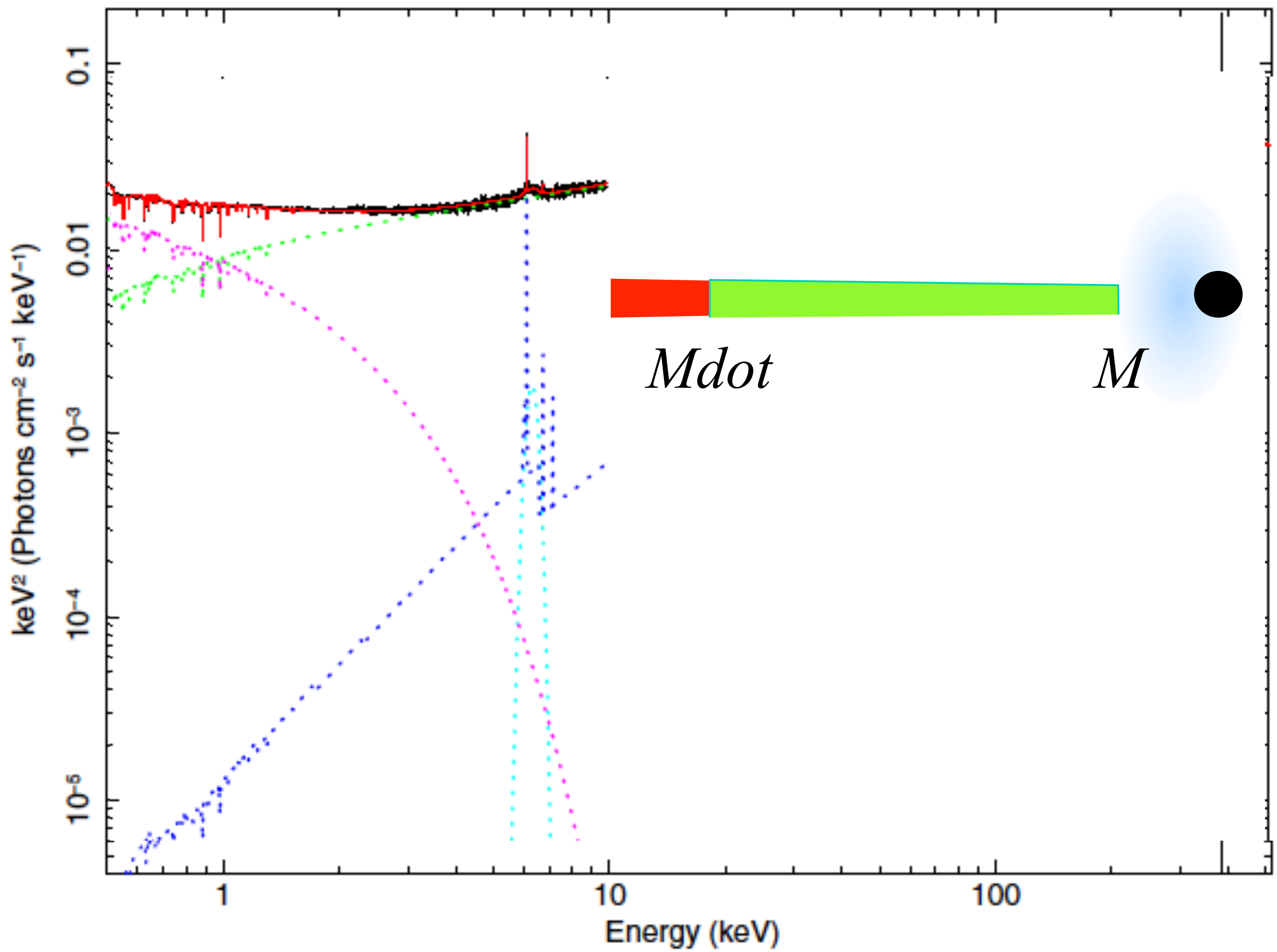
- NLS1 $M \sim 10^{6-7}$, L/LEdd~1 X-ray weak
- But disc peaks in soft X-rays – overionises UV
- $M \sim 10^{9-10}$-, L/LEdd~1 Disc peaks in UV NOT soft X-rays.
- This really is PERFECT for UV line driving

- SED of APM08726
- Biggest high z UFO
- BAL QSO
- $M \sim 10^{10}$ Msun



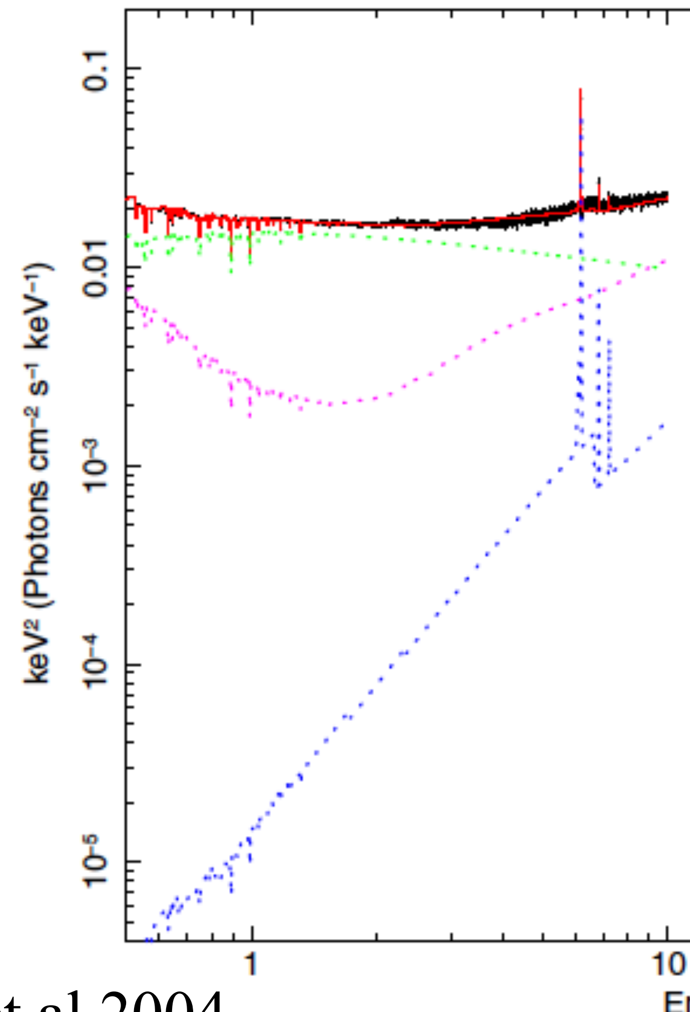
Hagino et al 2017

An additional component?

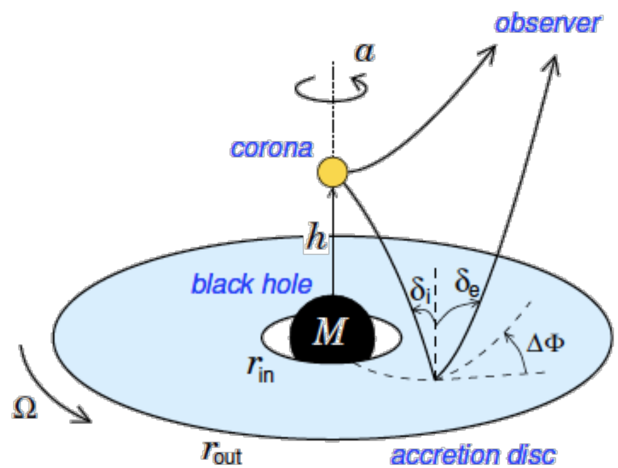


Boissay et al 2014

Reflected/smeared hard X-rays?



Fabian et al 2004
Crummy et al 2006



Boissay et al 2014

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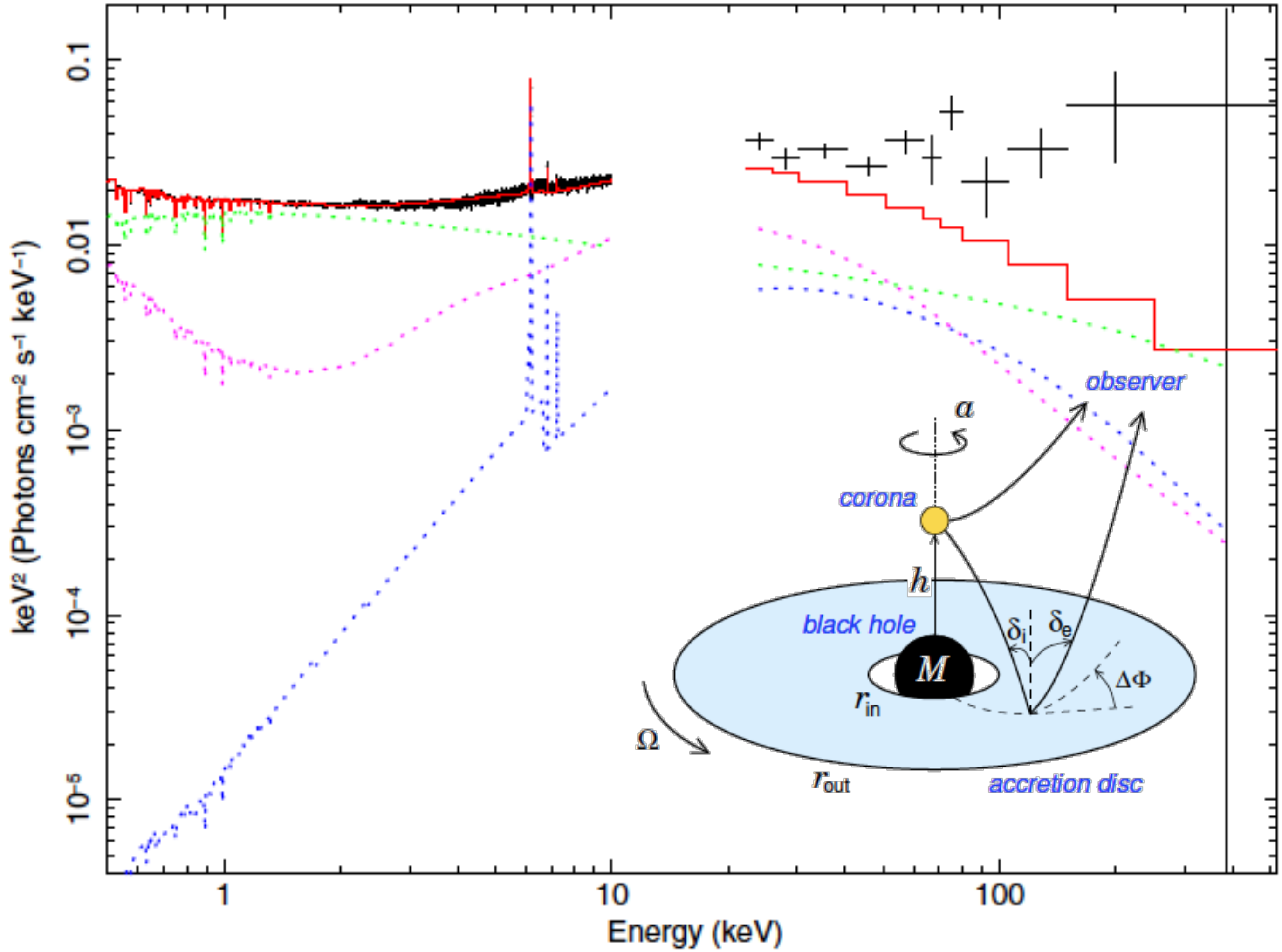
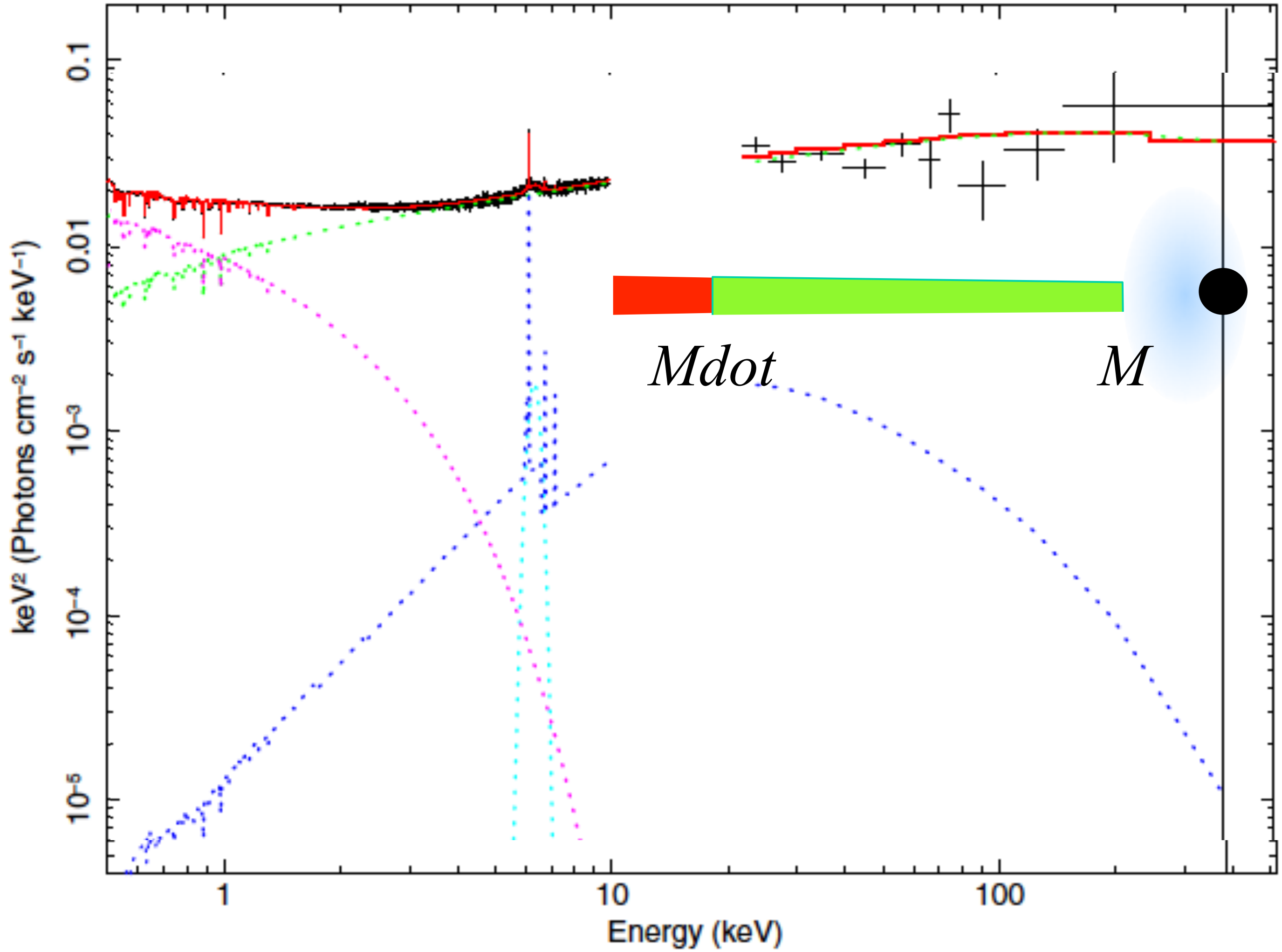
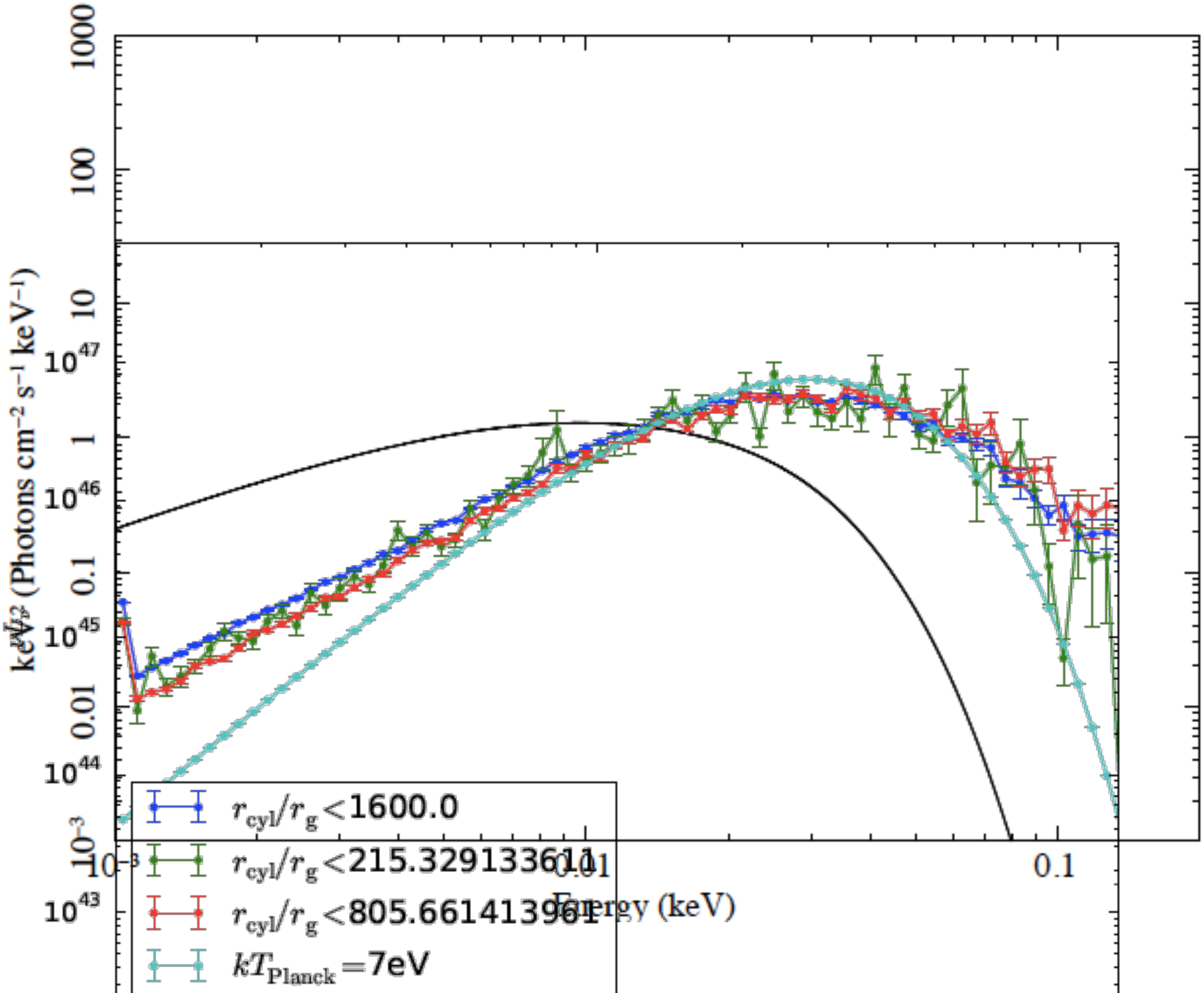


Boissay et al 2014

An additional component?



Boissay et al 2014


1000
100
10
1
0.1
0.01
10^{-3}
10^{47}
10^{46}
10^{45}
10^{44}
10^{43}
10^{-3}
0.01
0.1
Energy (keV)
keV^2 (Photons cm^{-2} s^{-1} keV^{-1})
$r_{\rm cyl}/r_{\rm g}$<1600.0
$r_{\rm cyl}/r_{\rm g}$<215.329133611
$r_{\rm cyl}/r_{\rm g}$<805.661413961
$kT_{\rm Planck}$=7eV