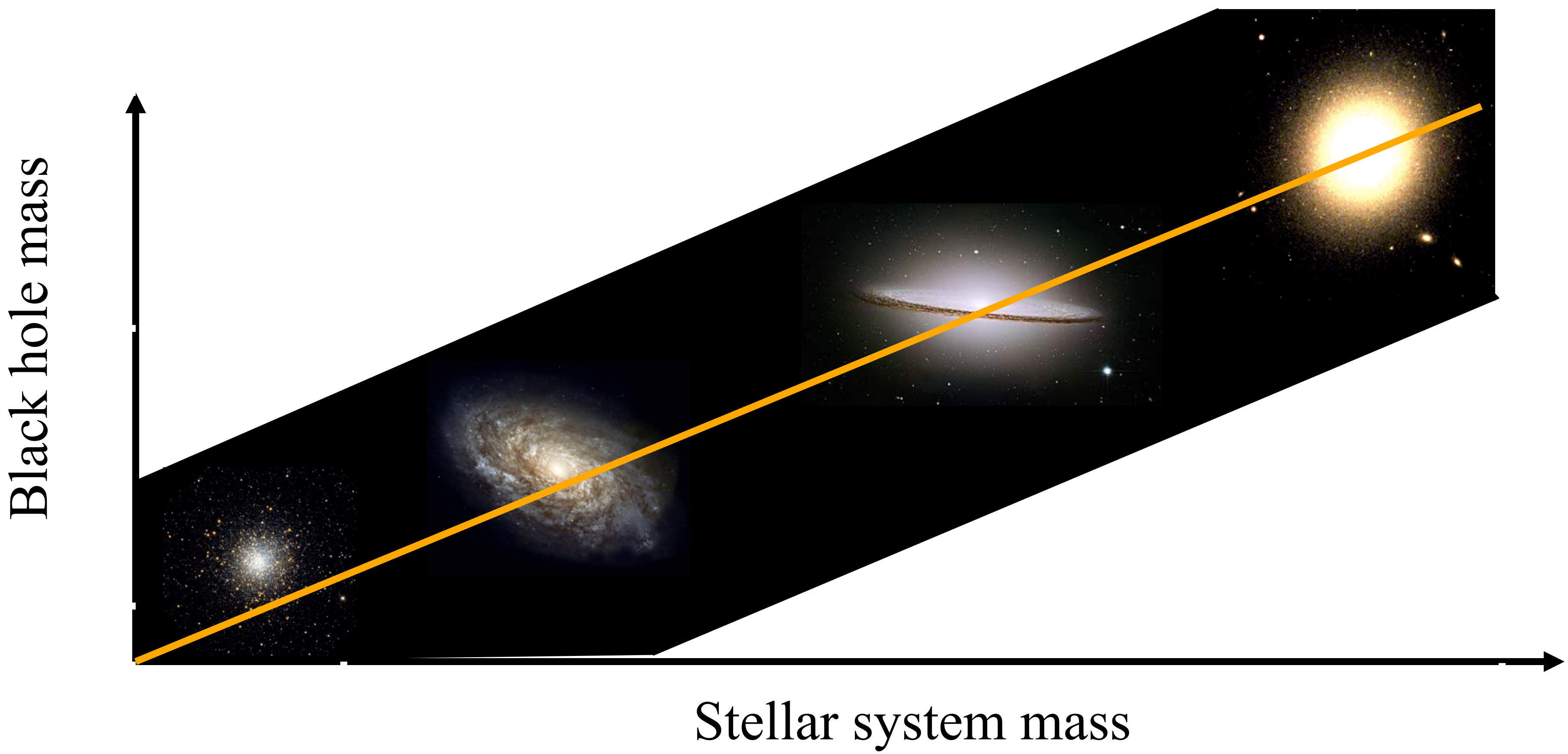
X-rays from AGN in a multi-wavelength context

Chris Done, University of Durham
Martin Ward, Chichuan Jin, Kouchi Hagino

σ

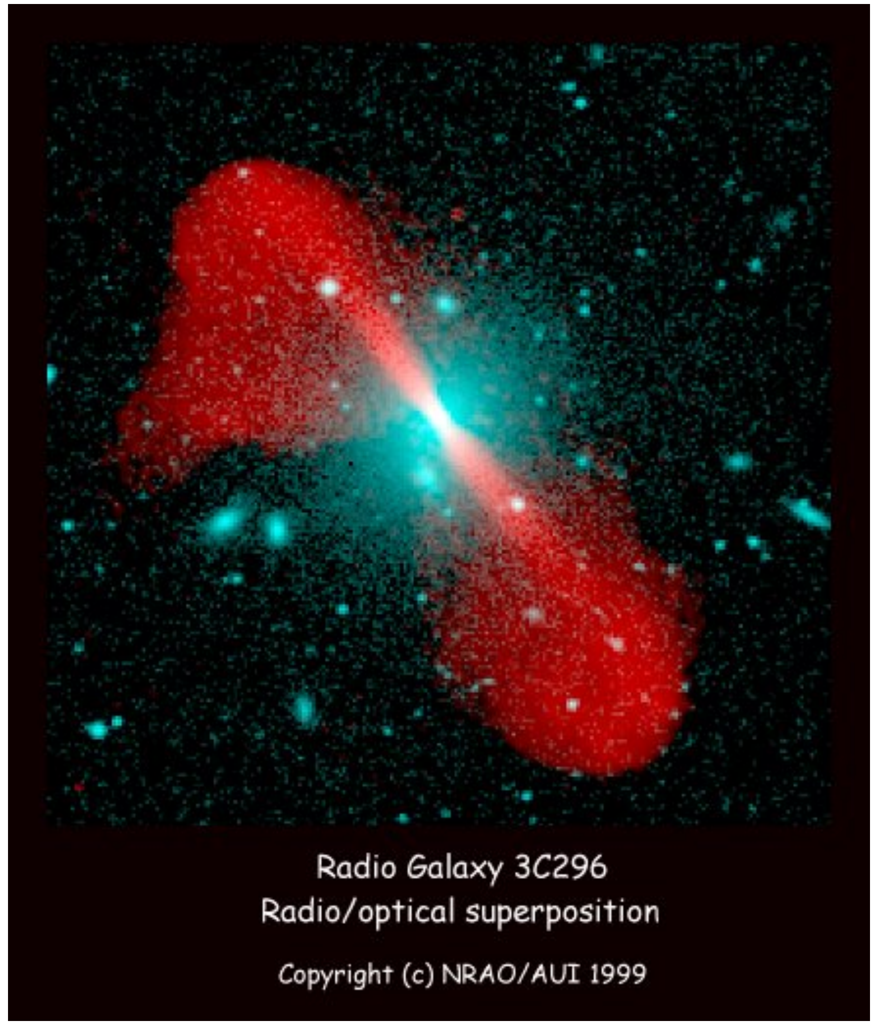
AGN feedback: M-σ relation

- Connecting star-formation powered growth of a galaxy with accretion powered growth of central BH
- Quantatative! M, Mdot, a…



Quasar mode (winds) feedback

- Obvious energy transport from large scale radio jets
- Too good! Dumps energy in halo rather than bulge…



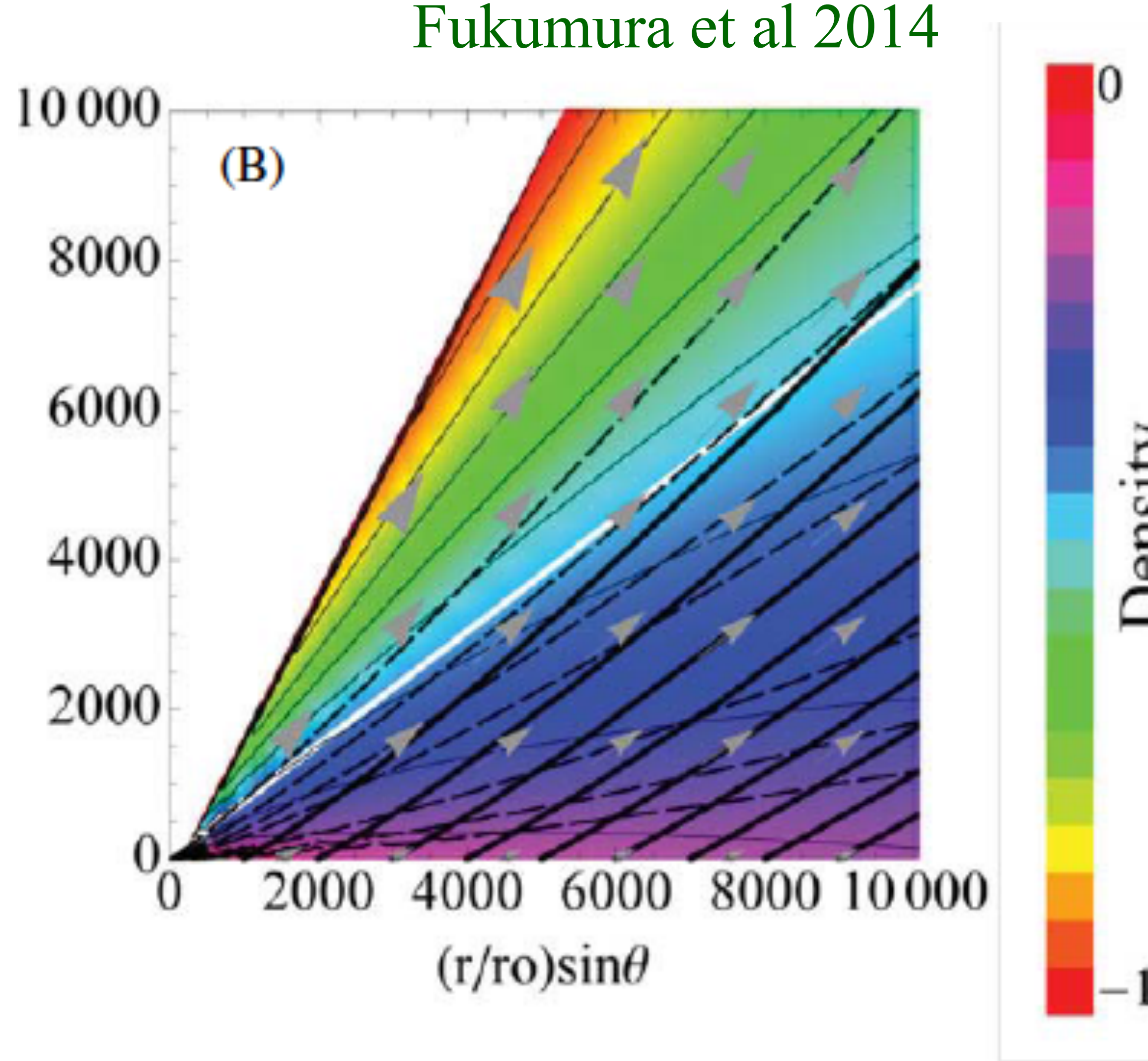
Quasar mode (winds) feedback

- Winds better dissipating energy in bulge to set M-σ relation (King 2008)
- Wind power set by M Mdot, spin
- …Or B fields??
- All winds have typical $v_\infty \sim v_{esc} = c\,(2R_g/R_{launch})^{1/2}$
- Fast (powerful) winds from close in

Magnetically driven Winds

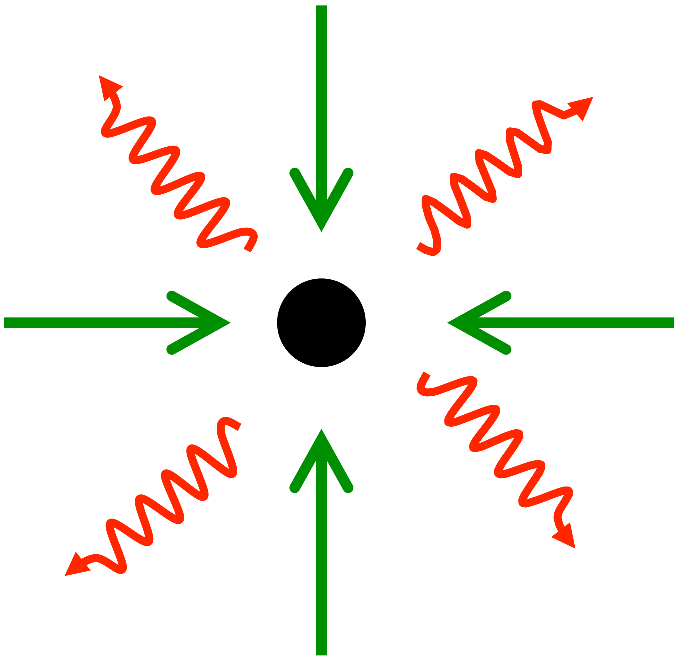
- Unknown!!
- Need specific B field geometry but then can get powerful wind from inner disc
- What about other winds which we can calculate?

Fukumura et al 2014



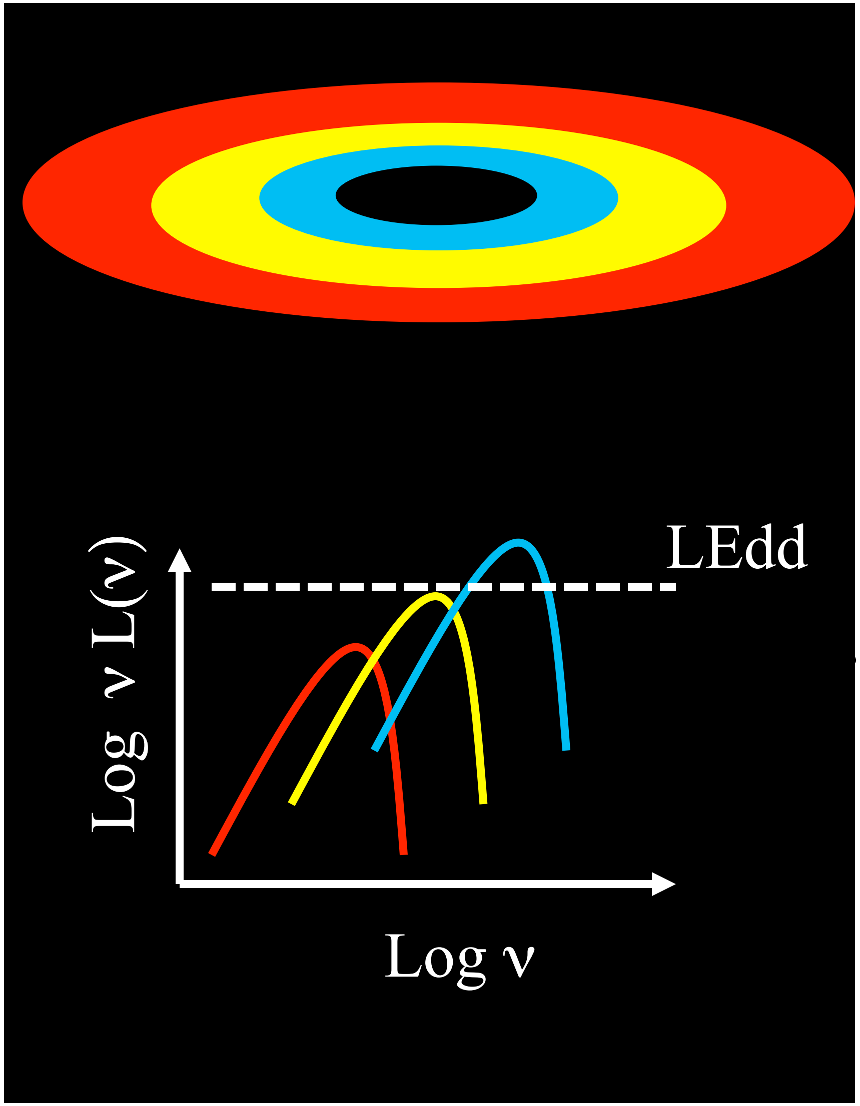
SuperEddington winds

- 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?



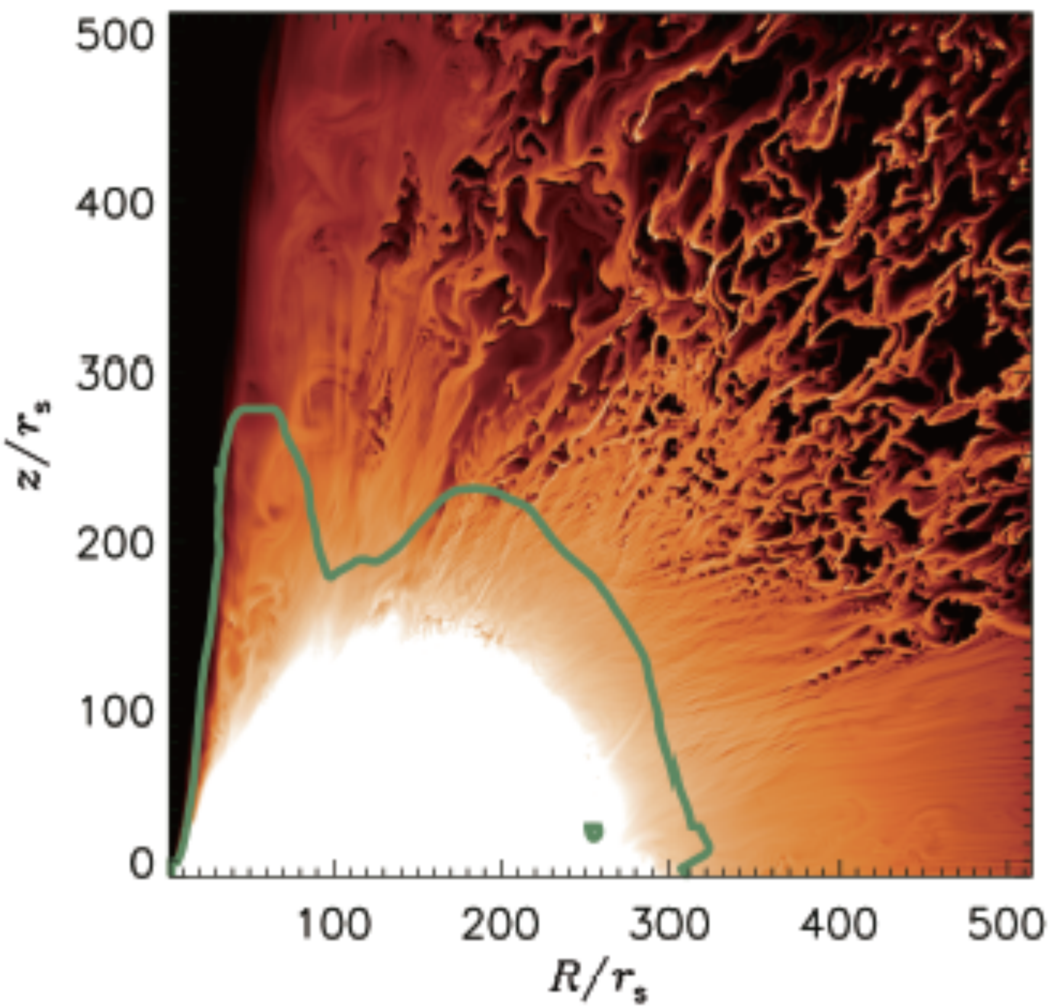
SuperEddington winds

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



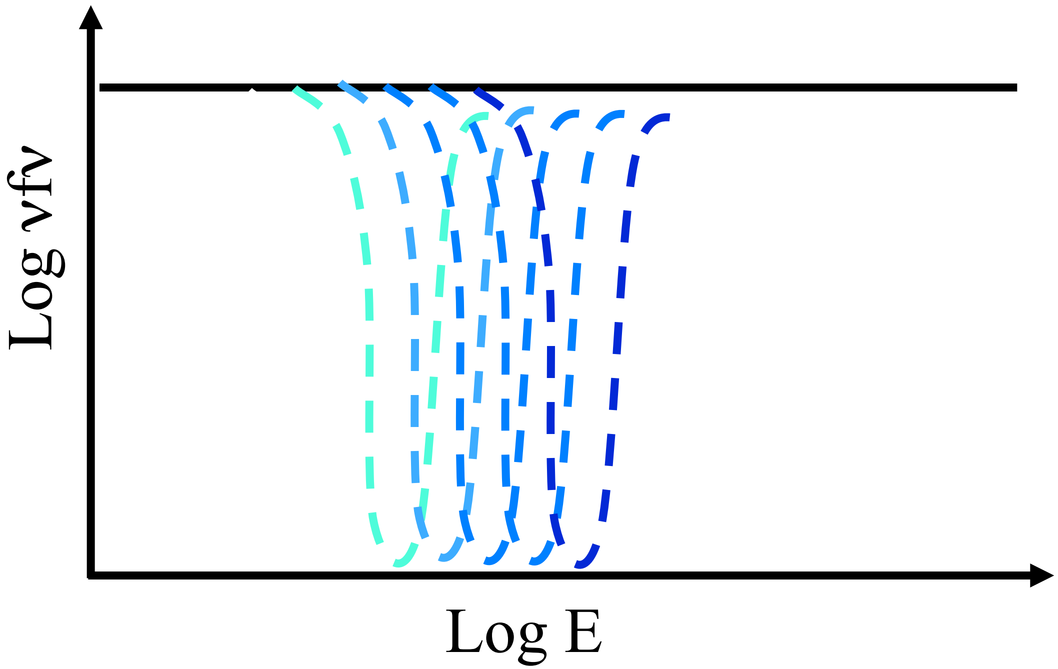
SuperEddington winds

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



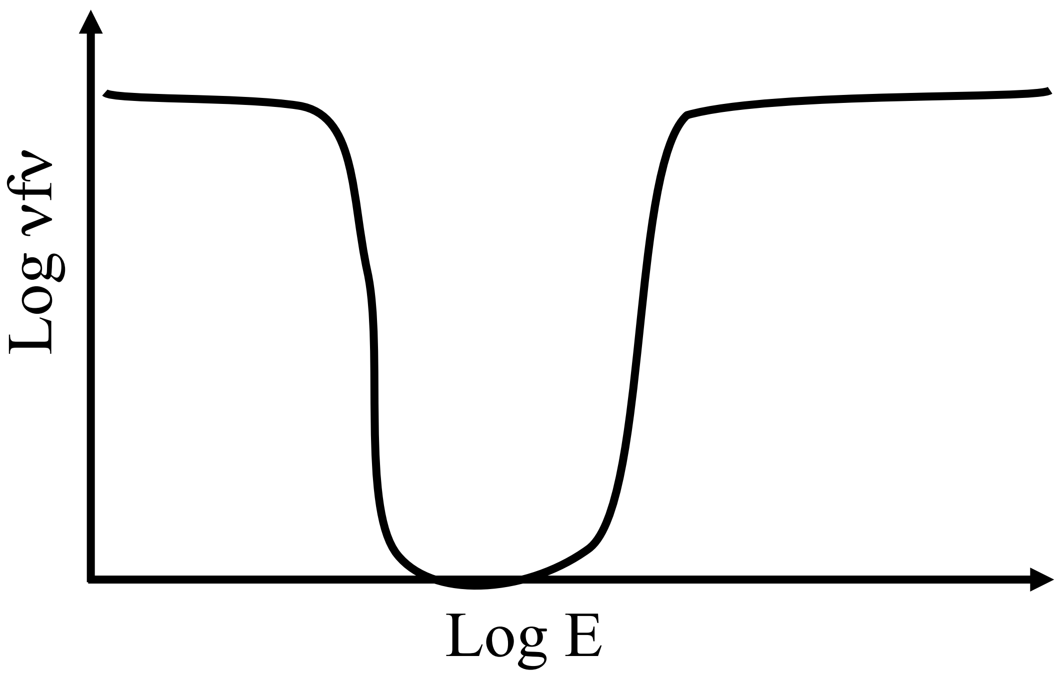
UV line driven Winds ?

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



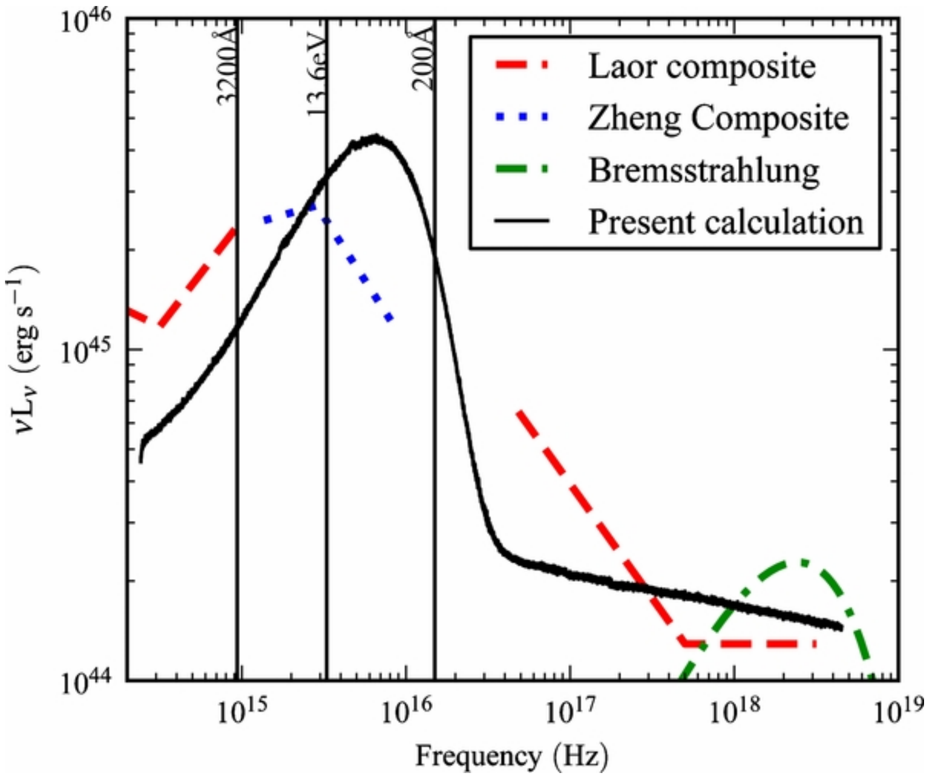
UV line driven Winds ?

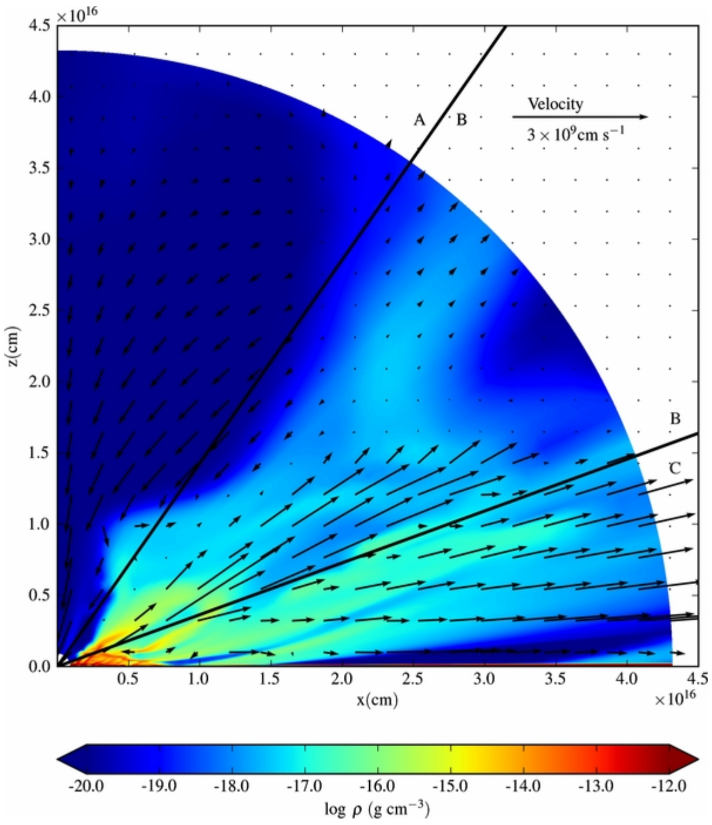
- Strong (but sub LEdd) UV radiation
- Low ionisation state in disc photosphere so abundant ions with UV line transitions – weak FUV/X-ray irradiation!



UV line driven Winds ?

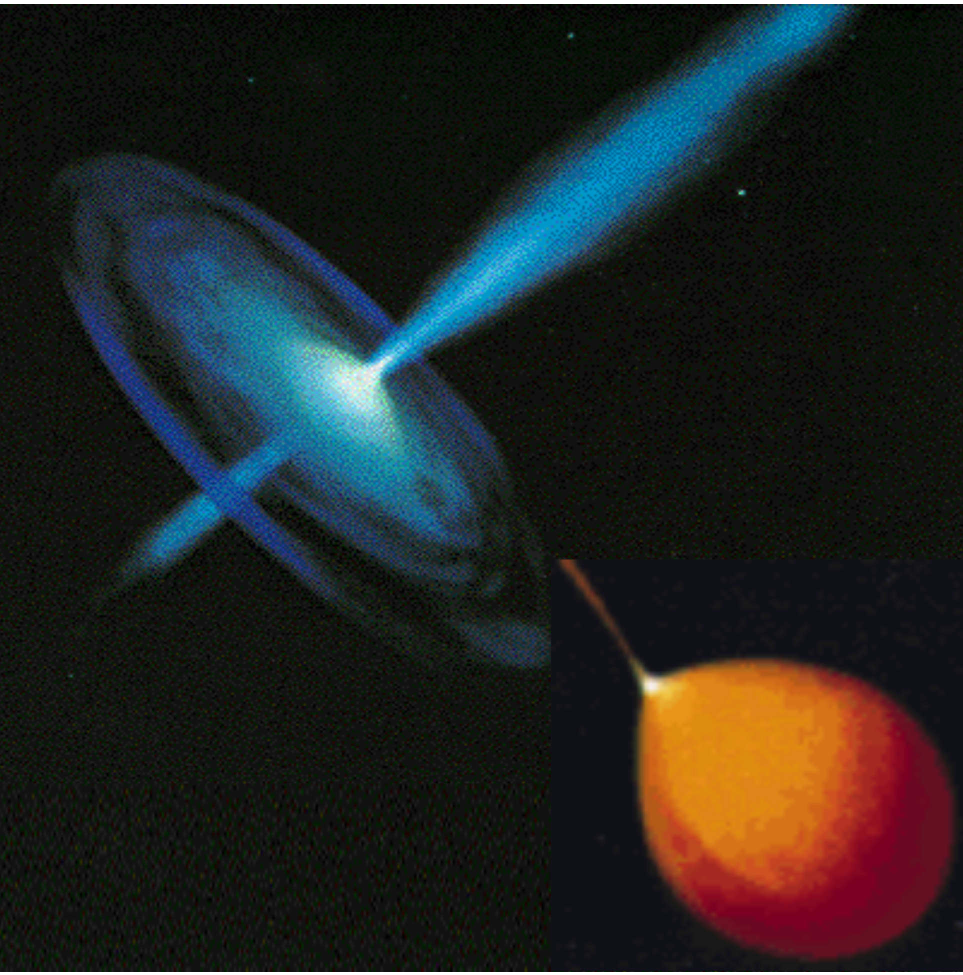
- Clumpy, complex
- 10^8 Msun, L/Ledd = 0.5 BUT wind depends on SED and AGN not pure discs. Proga & Kallman 2004,

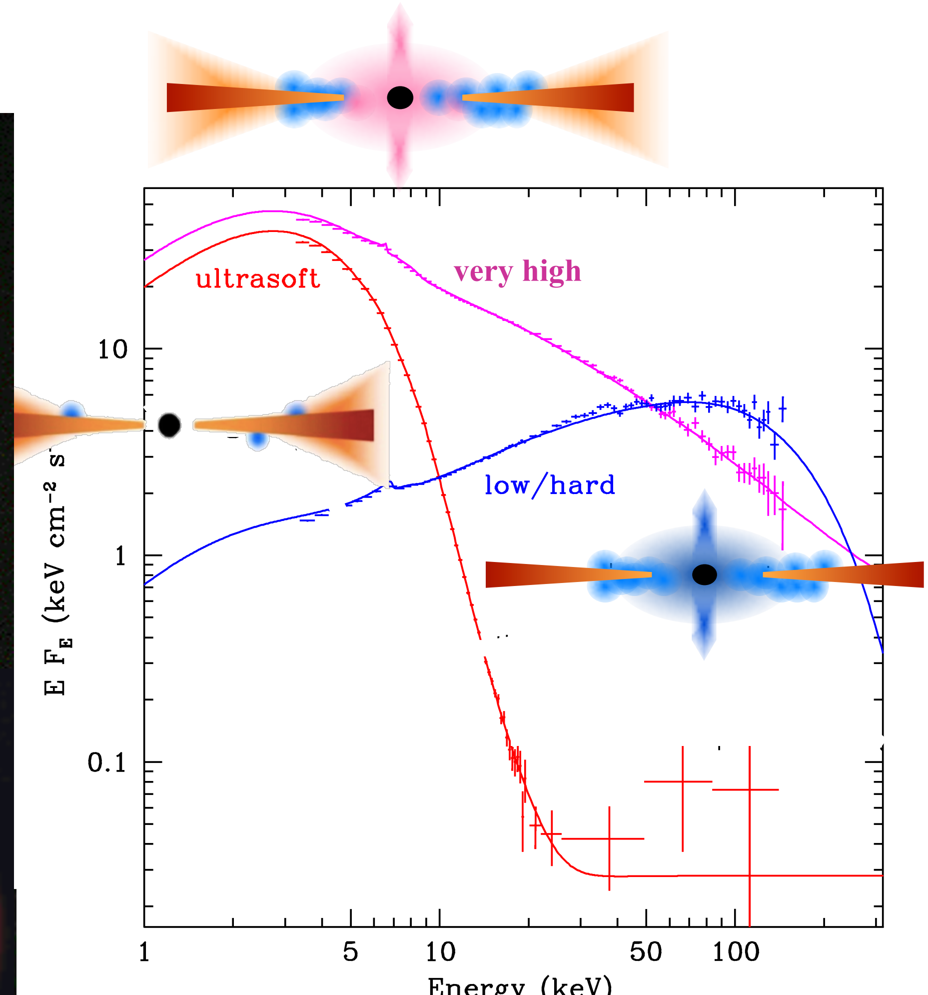




Higginbottom et al 2014

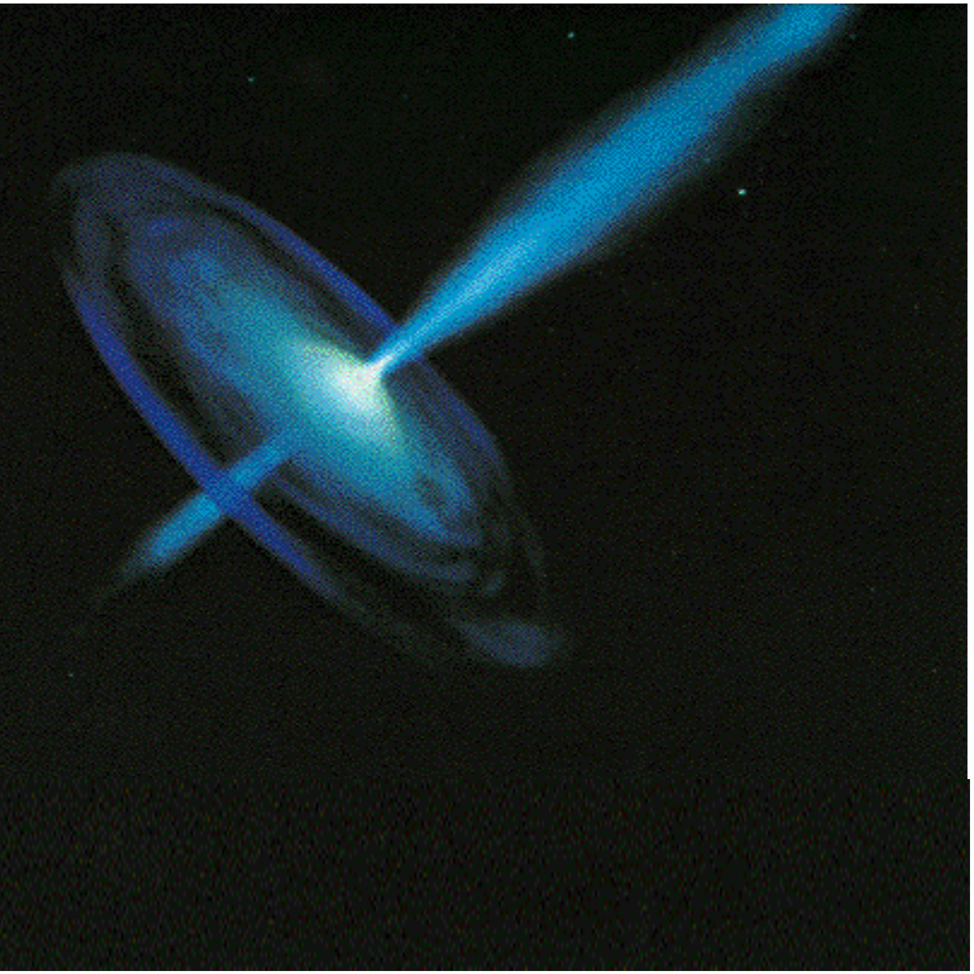
BHB: template for SED L/Ledd?





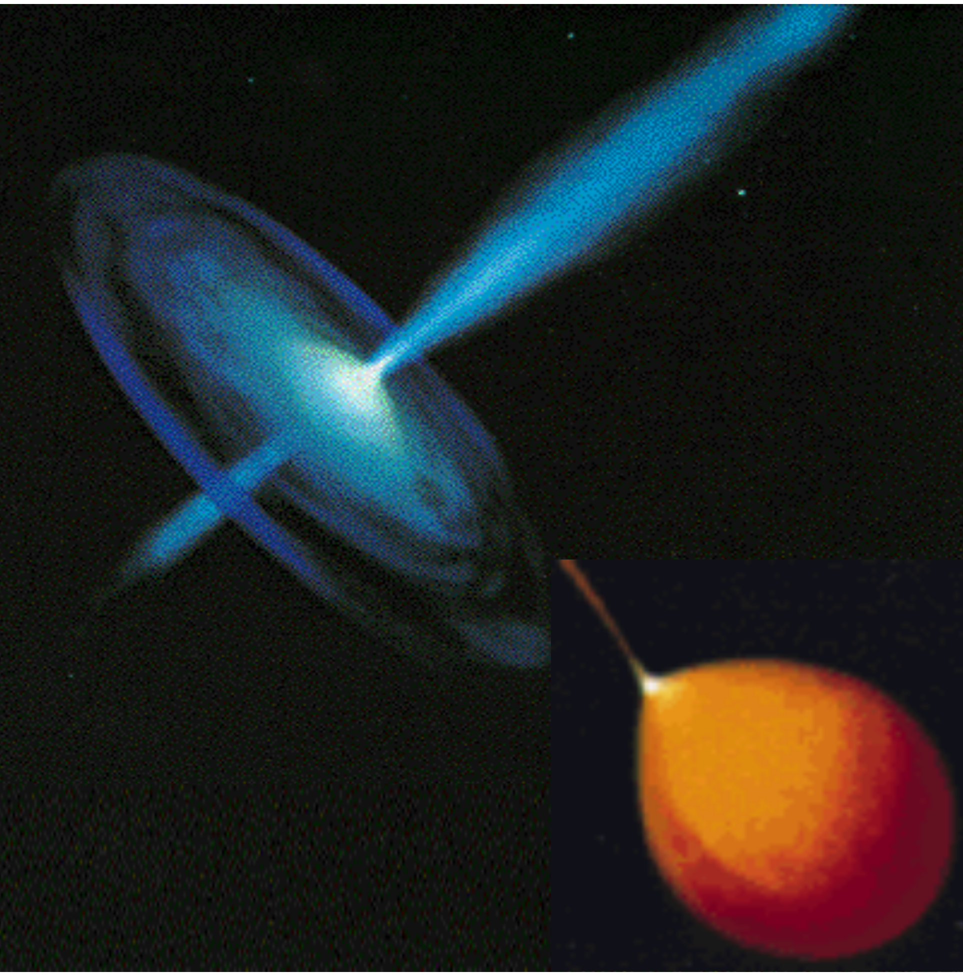
Gierlinski & Done 2003

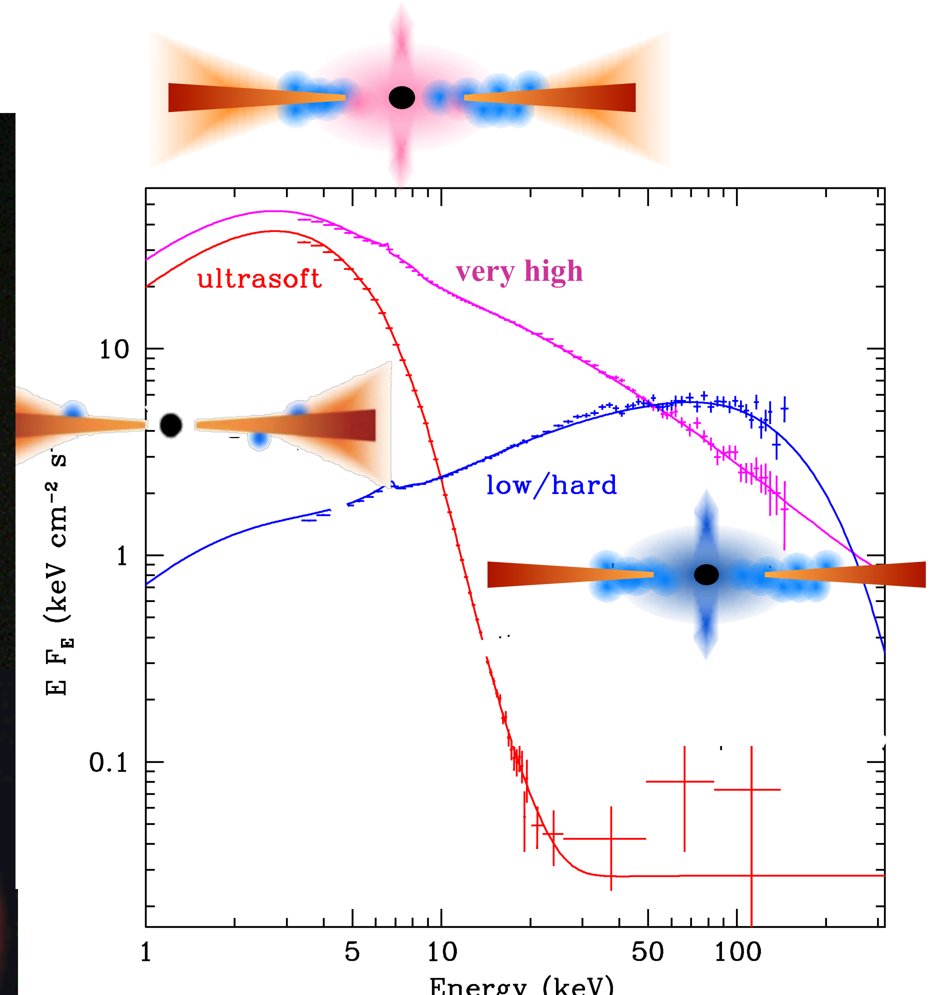
Scaling black hole accretion flow



- 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?

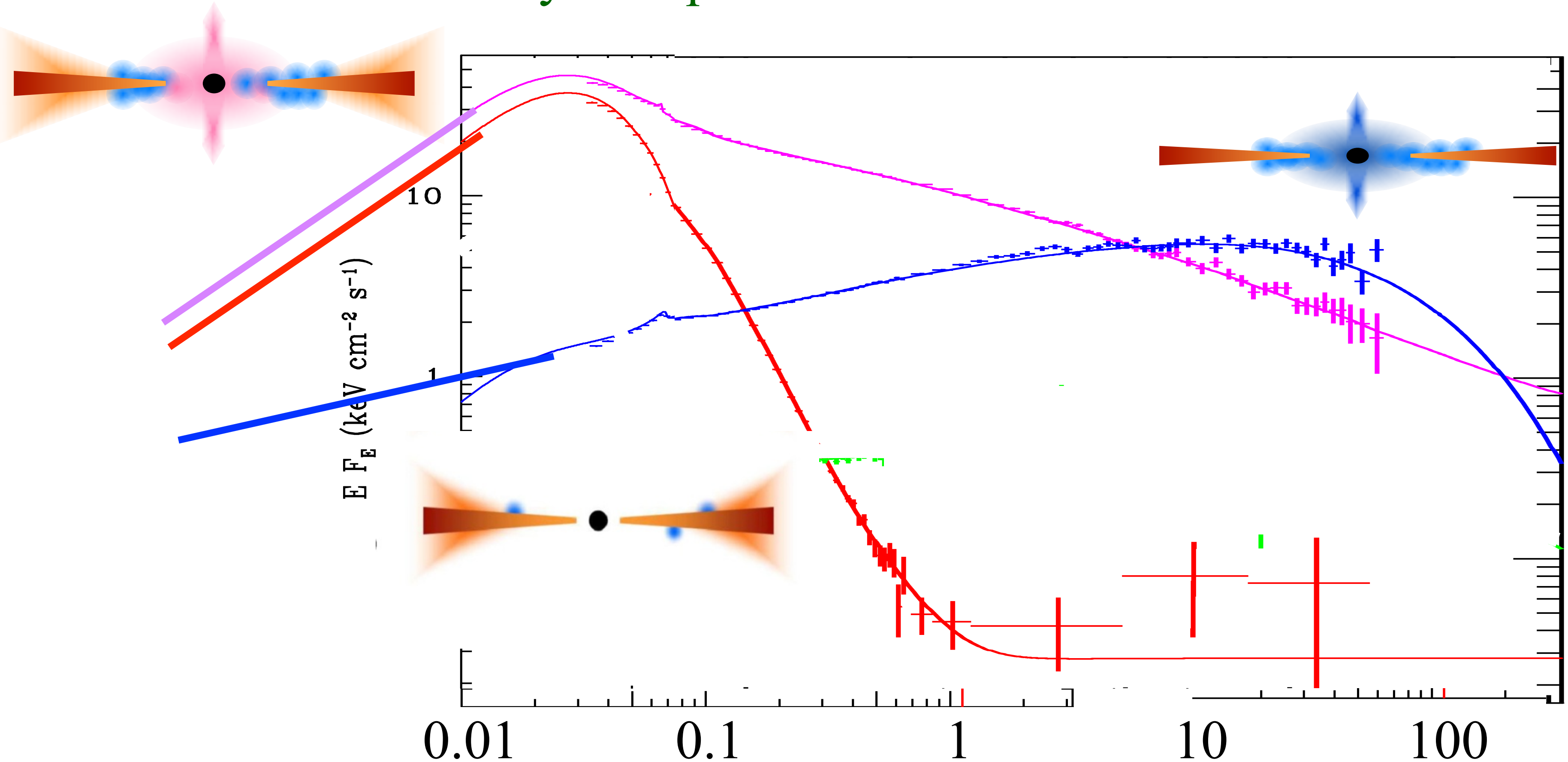




Gierlinski & Done 2003

‘Spectral states in AGN’

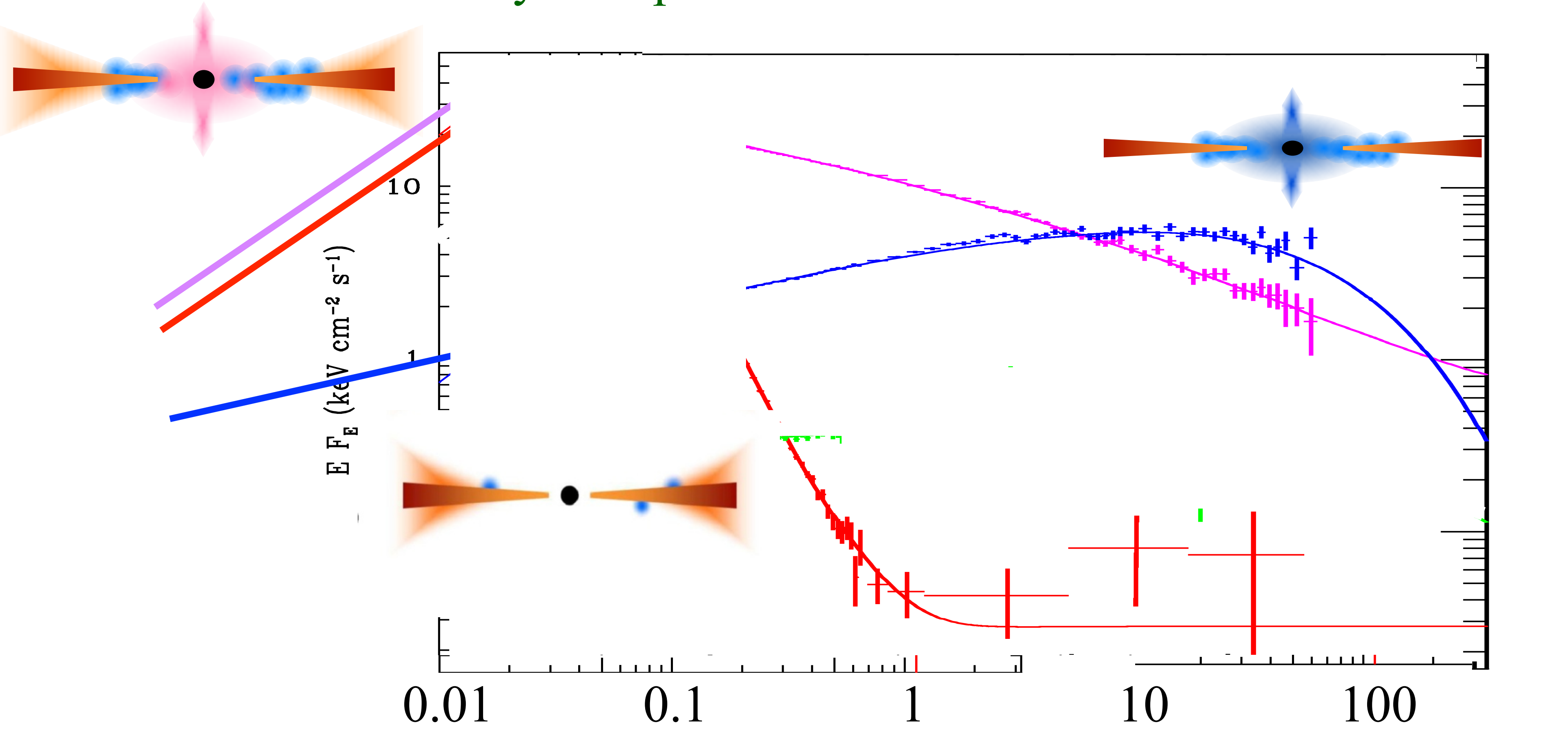
Disc BELOW X-ray bandpass. Peaks in UV – ATOMIC PHYSICS



XMM-Newton gives us simultaneous OM data ! Perfect

Interstellar absorption

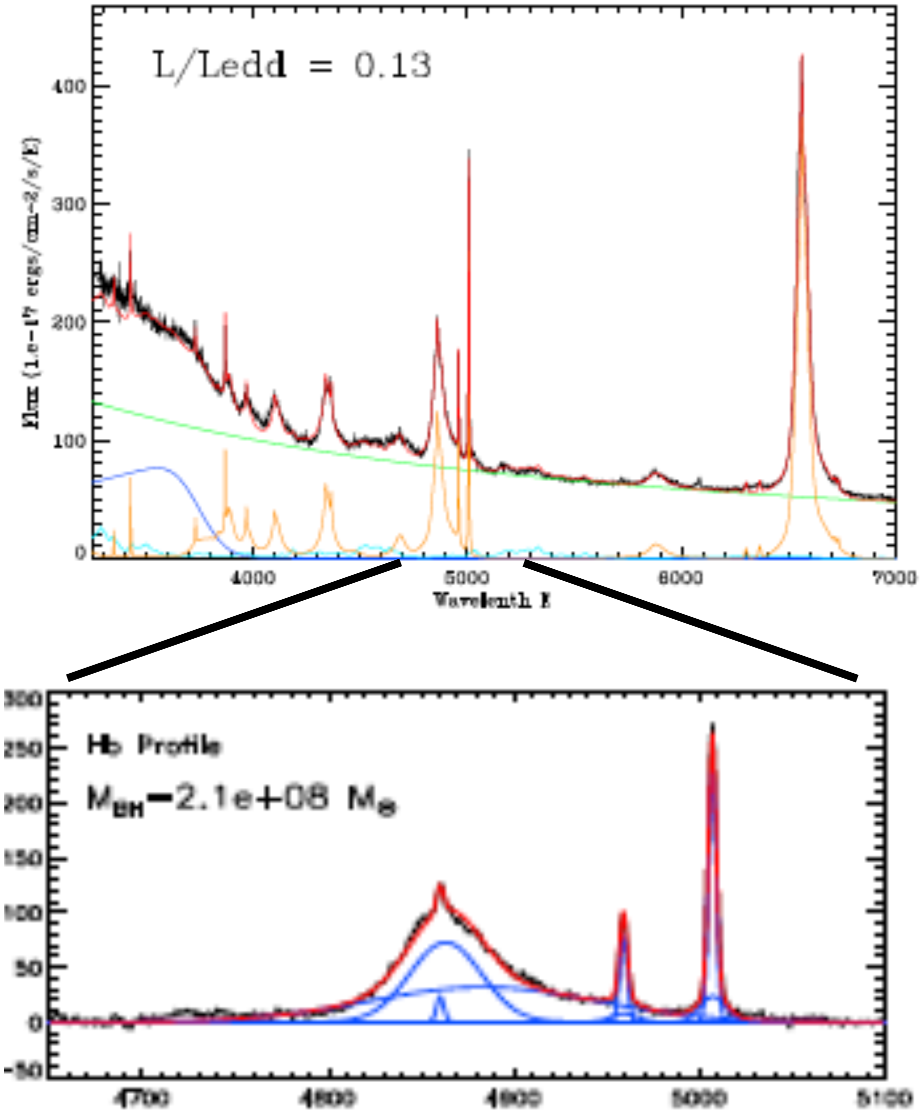
Disc BELOW X-ray bandpass. Peaks in UV – ATOMIC PHYSICS



XMM-Newton gives us simultaneous OM data ! Perfect

AGN L/LEdd ? SMBH Mass

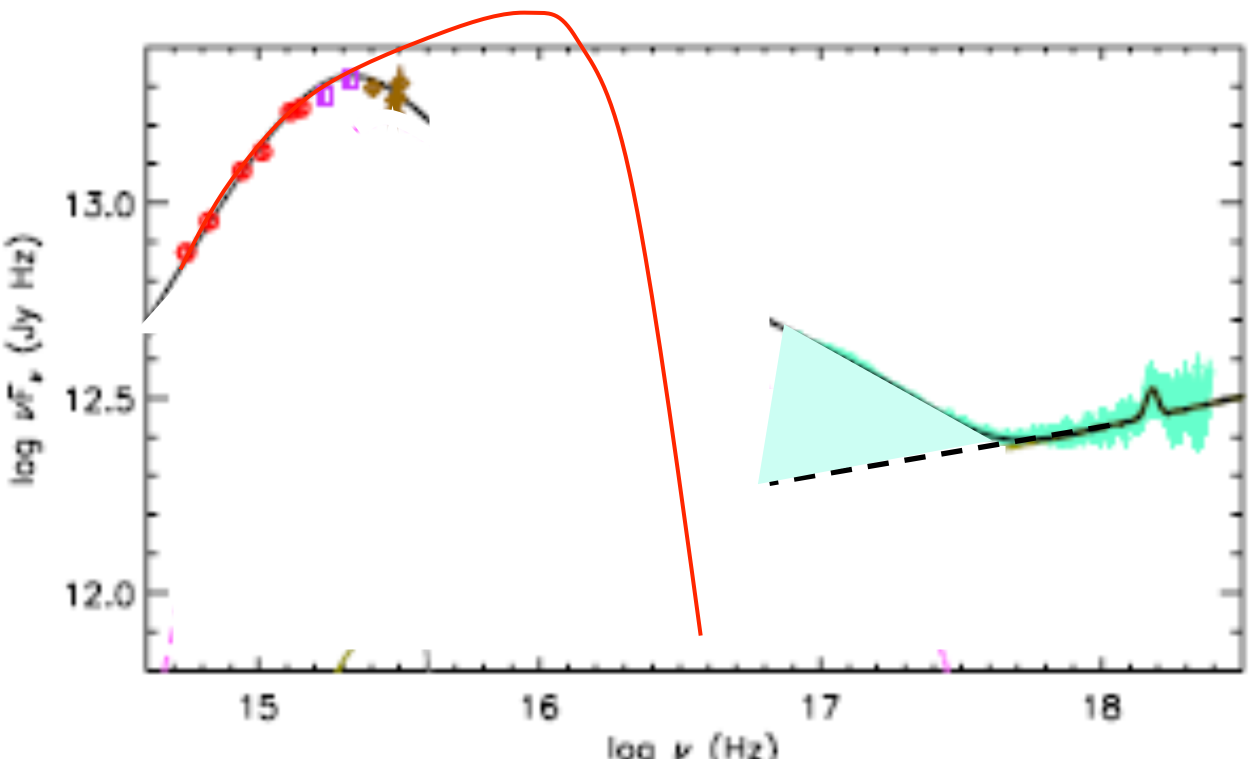
- Scaling relations for M_{BH} in terms of Hβ FWHM and Fopt
- Based on BLR reverberation campaigns
- PG1048+342 SDSS Jin et al 2012 TYPICAL QSO



Full multi-wavelength spectrum

- De-absorb from galactic and intrinsic
- Model across unobservable 0.01-0.2 keV bandpass
- Lbol - know M so know LEdd so get Lbol/LEdd

- Mkn509
- 10^8Msun
- 0.1LEdd
- Not disc!
- Soft X-ray XS



Medhipour et al 2011

Full multi-wavelength spectrum

- De-absorb from galactic and intrinsic
- Model across unobservable 0.0136-0.2 keV bandpass
- Lbol - know M so know LEdd so get Lbol/LEdd

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- 0.1LEdd
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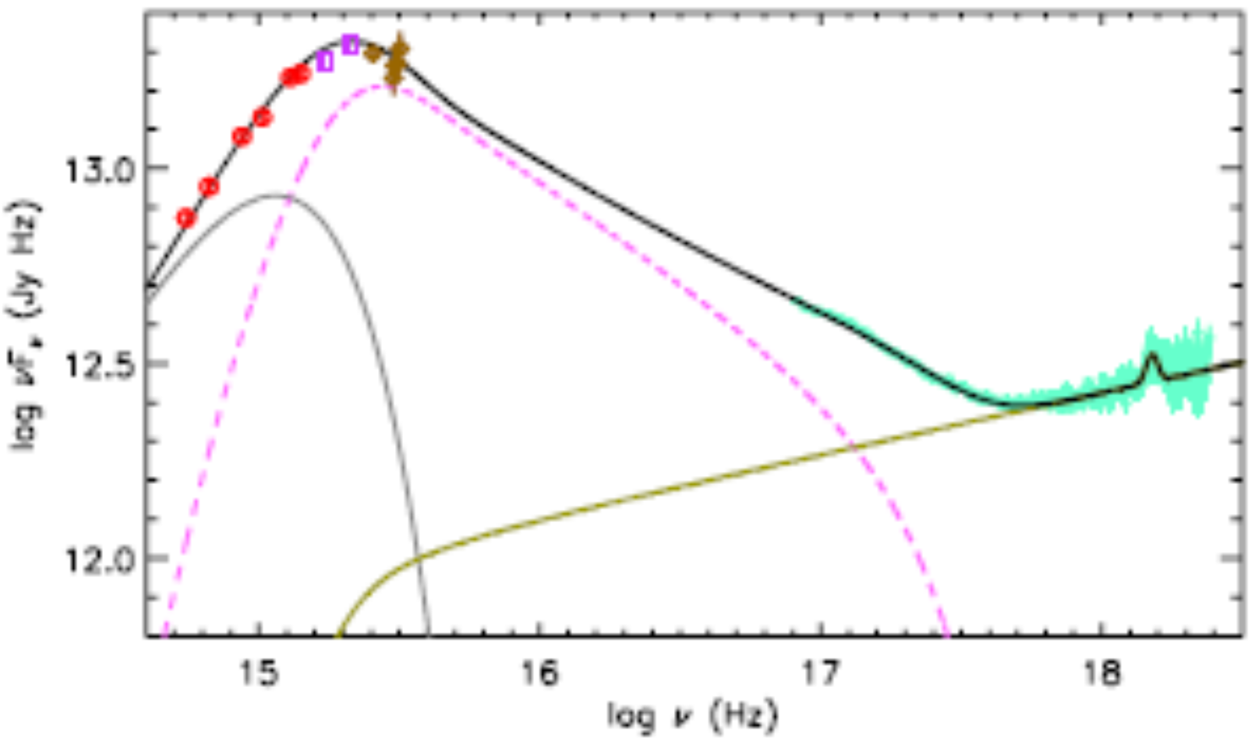
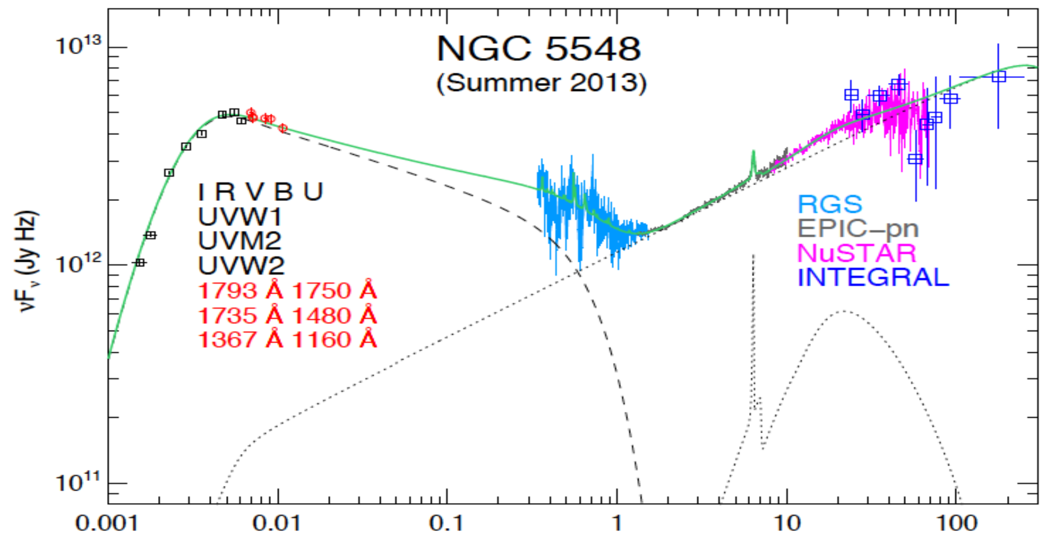
- Soft X-ray XS



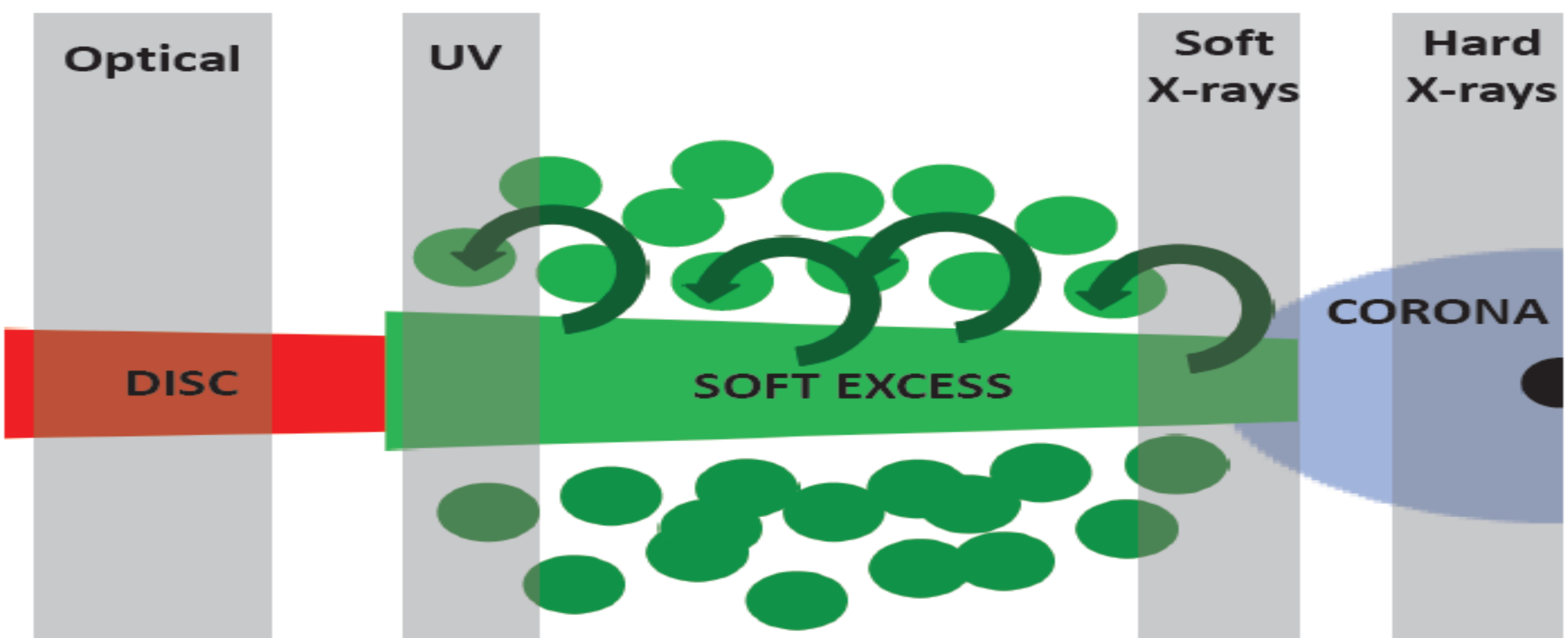
Medhipour et al 2011

Nature of soft excess region?

- Why??
- UV bright region of disc
- Failed wind??



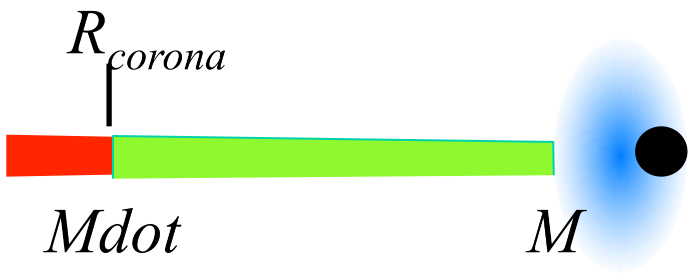
Mehdipour et al 2015

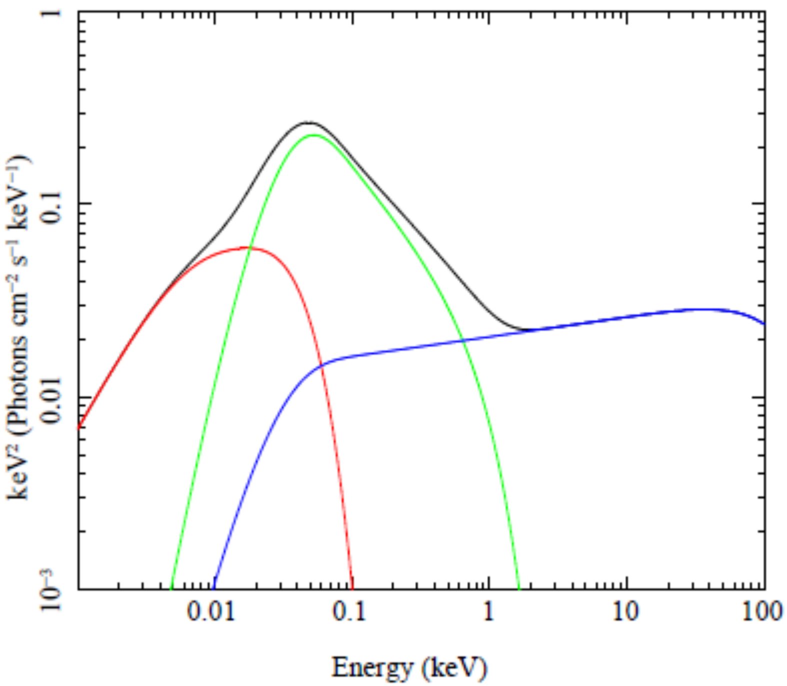


Gardner & Done 2017

Optxagnf: conserving energy

- Outer standard disc – gives Mdot - to R_{corona}
- Then luminosity not completely thermalised to make soft X-ray excess ?
- Inner corona as in hard state BHB (L/LEdd?)

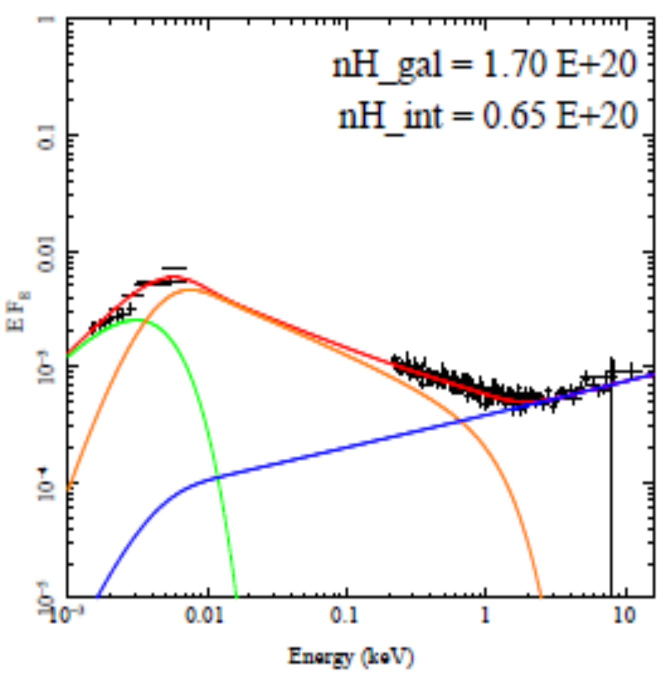


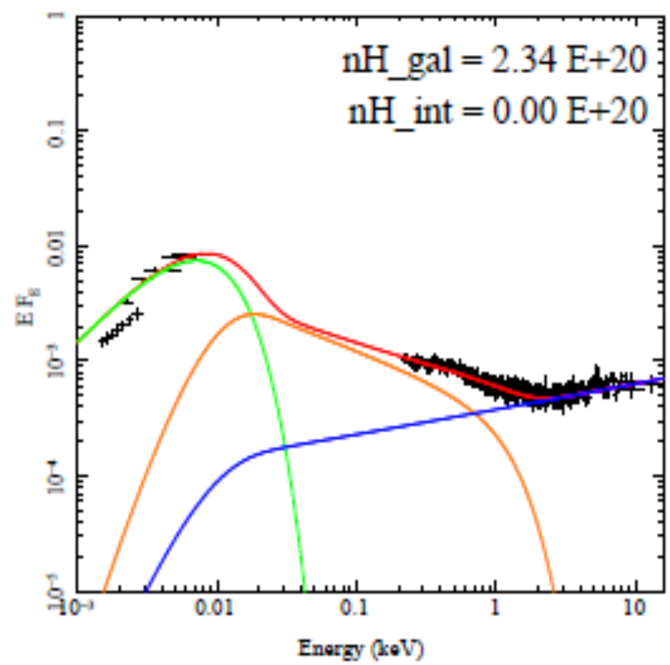


Done et al 2012

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

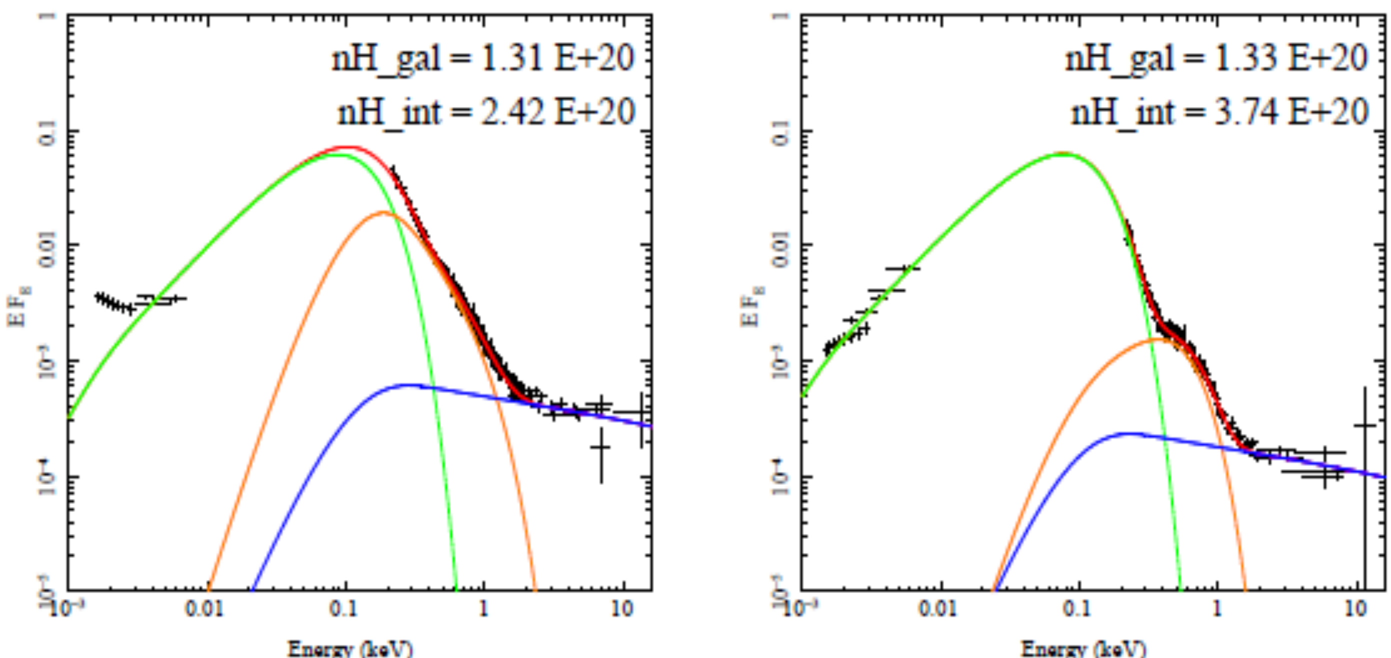




Jin et al 2012

Very different to NLS1

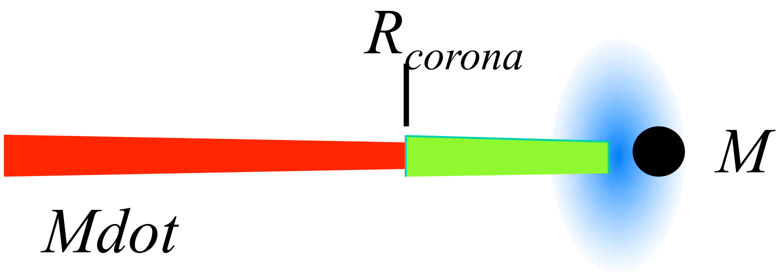
- <M>~10^7, <L/LEdd>~1 NLS1 in local universe
- Disc dominated, small SX, weak X-rays

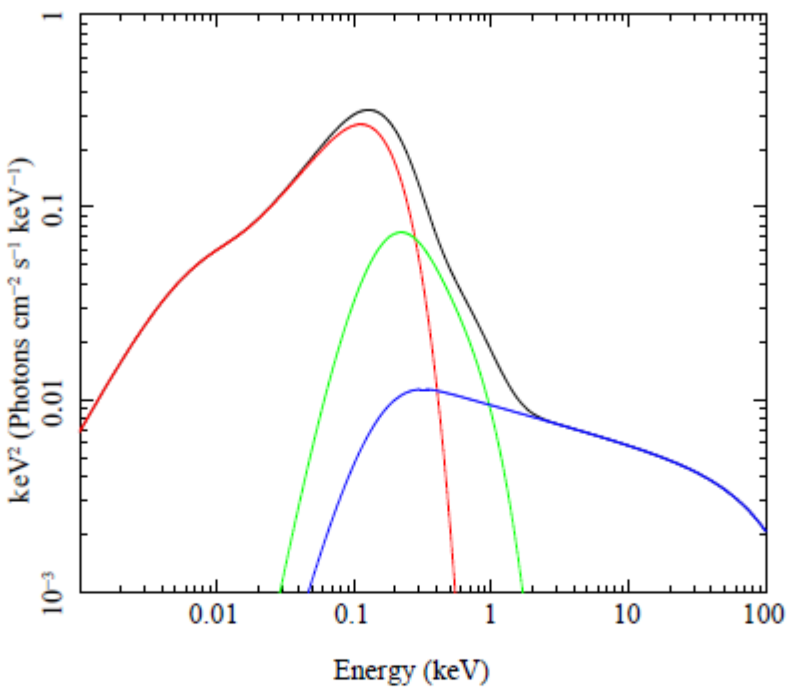


Jin et al 2012

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

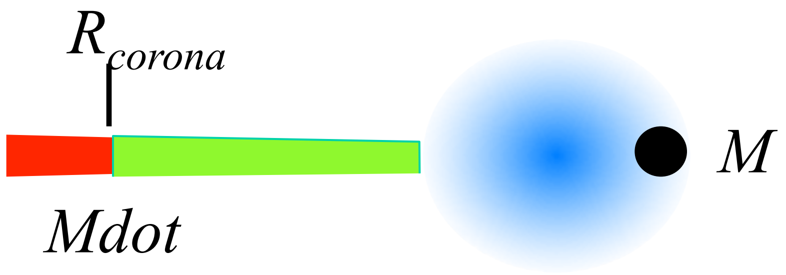


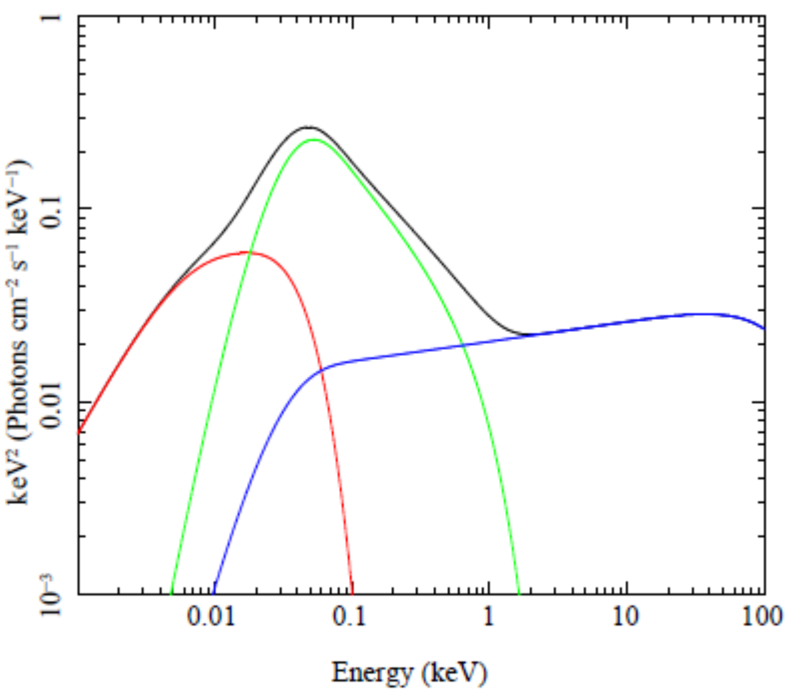


Done et al 2012

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?)

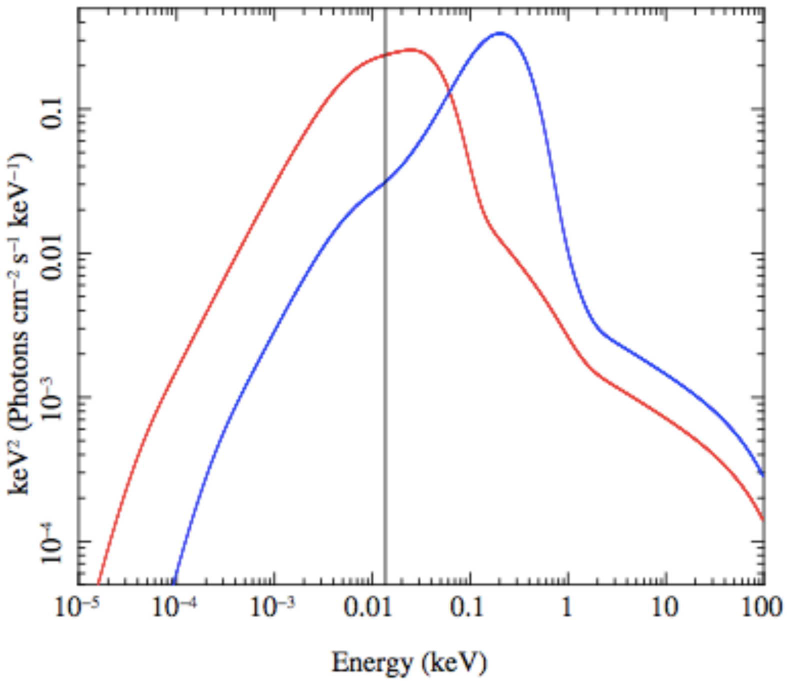




Done et al 2012

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



Hagino et al 2015

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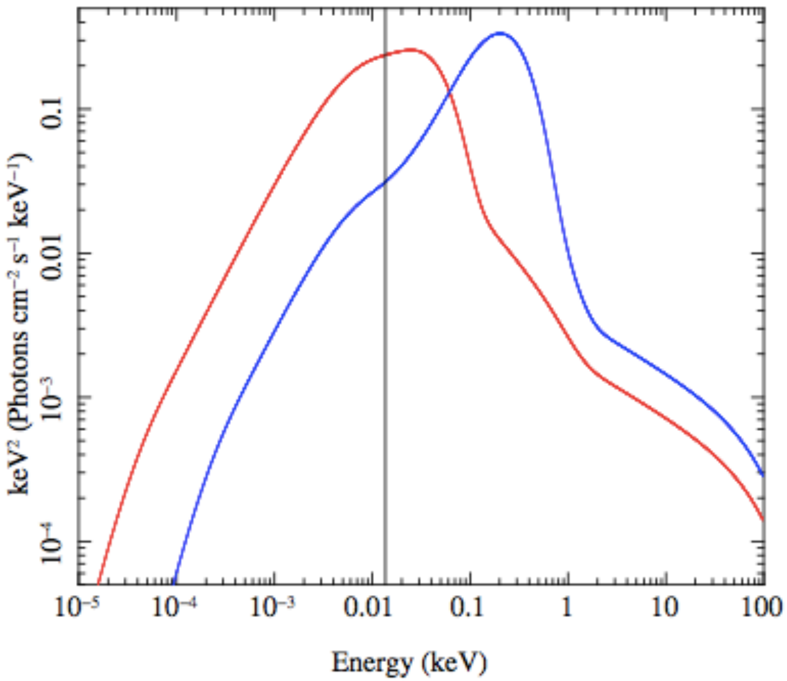
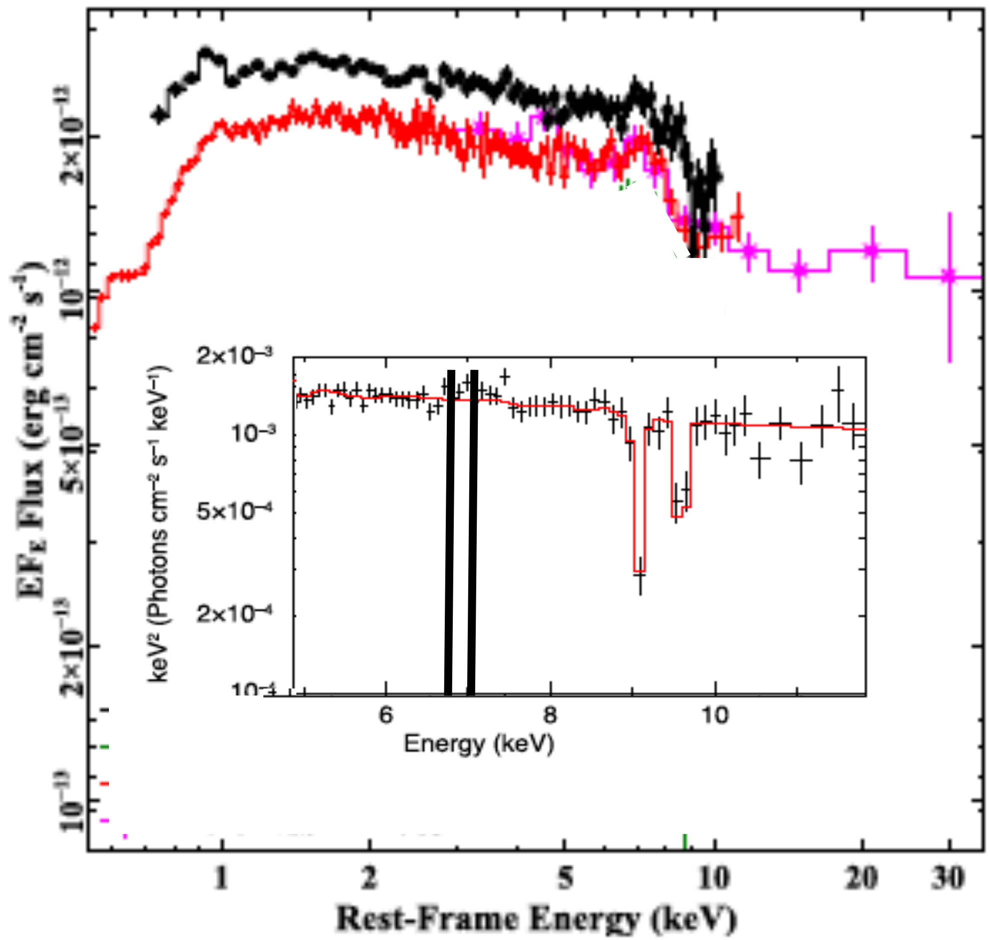
- SED of PDS456
- Biggest local UFO



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



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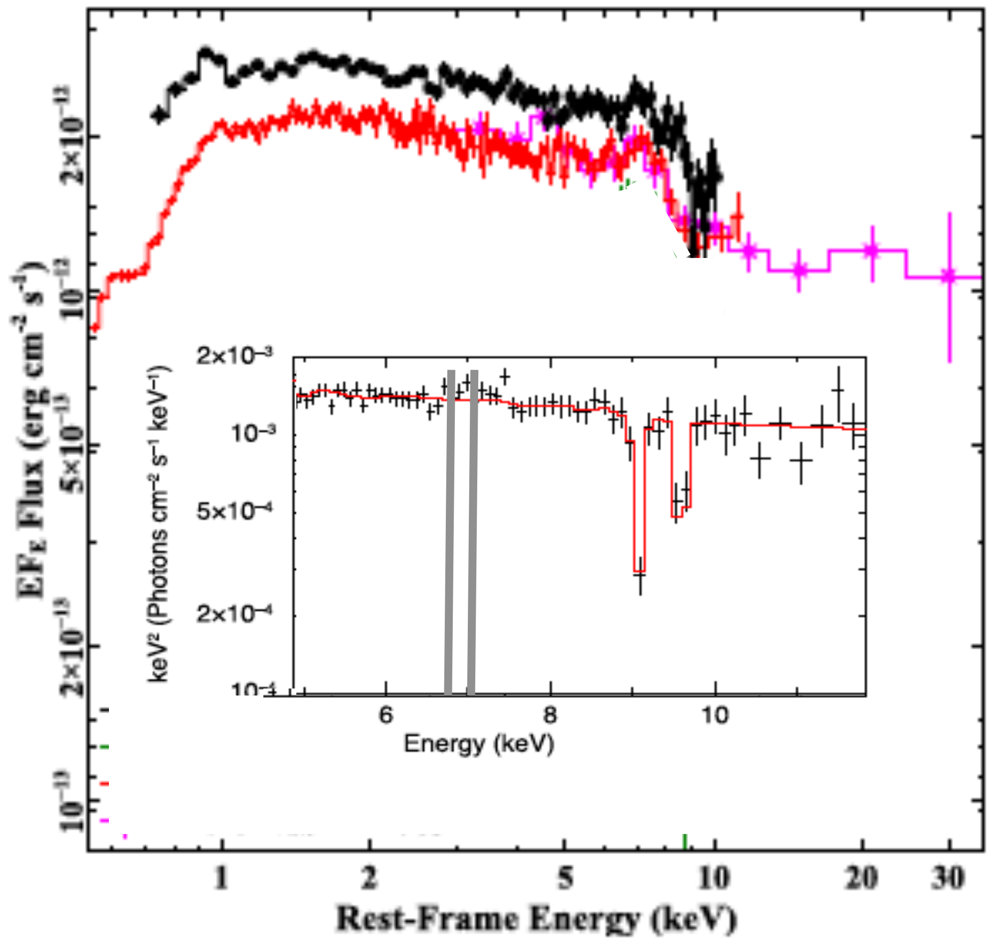
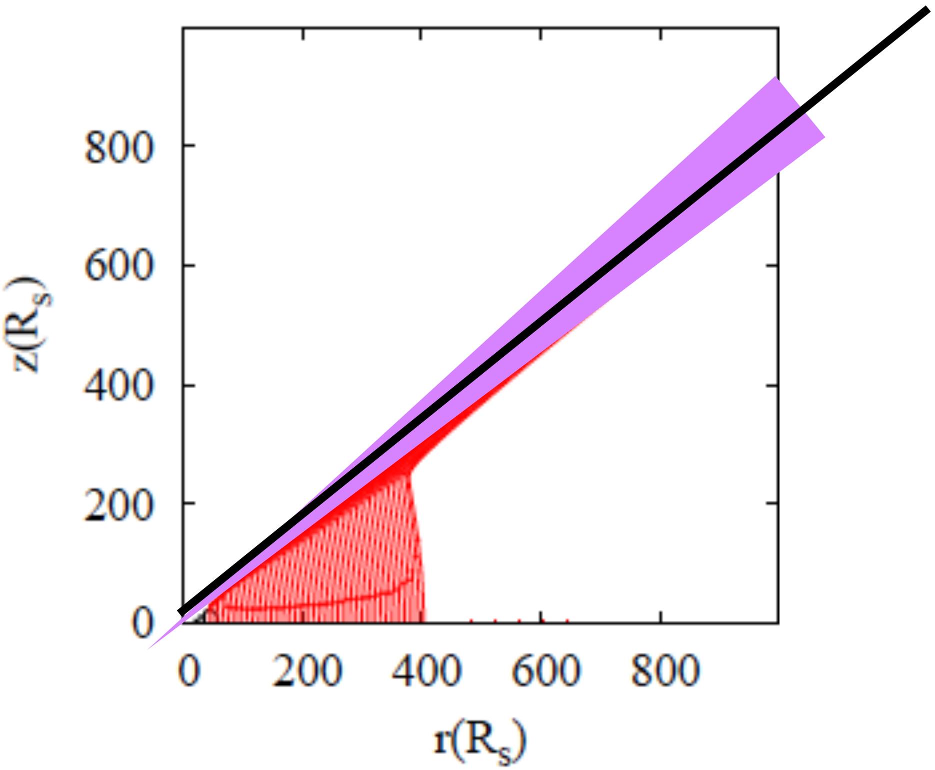


Launch close to disc, then ionise?

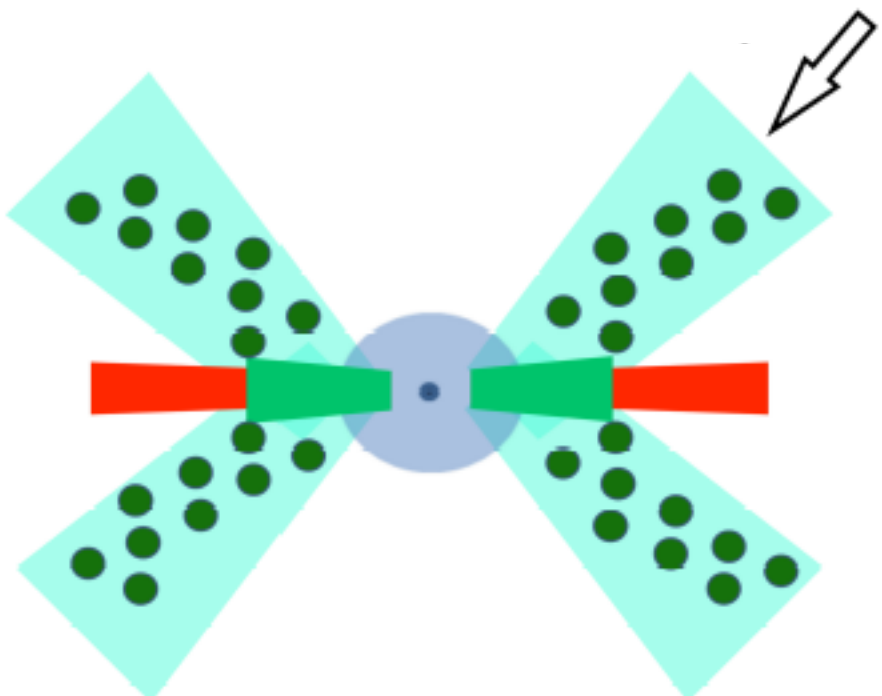
- UV line driving gives fast acceleration close to disc surface
- Material ionised after acceleration, removing UV opacity on line of sight
- Prediction – powerful UV line driven winds in $M \sim 10^9$, L~LEdd
- APM08279 – Hagino talk!
- WISSH QSO Piconcelli



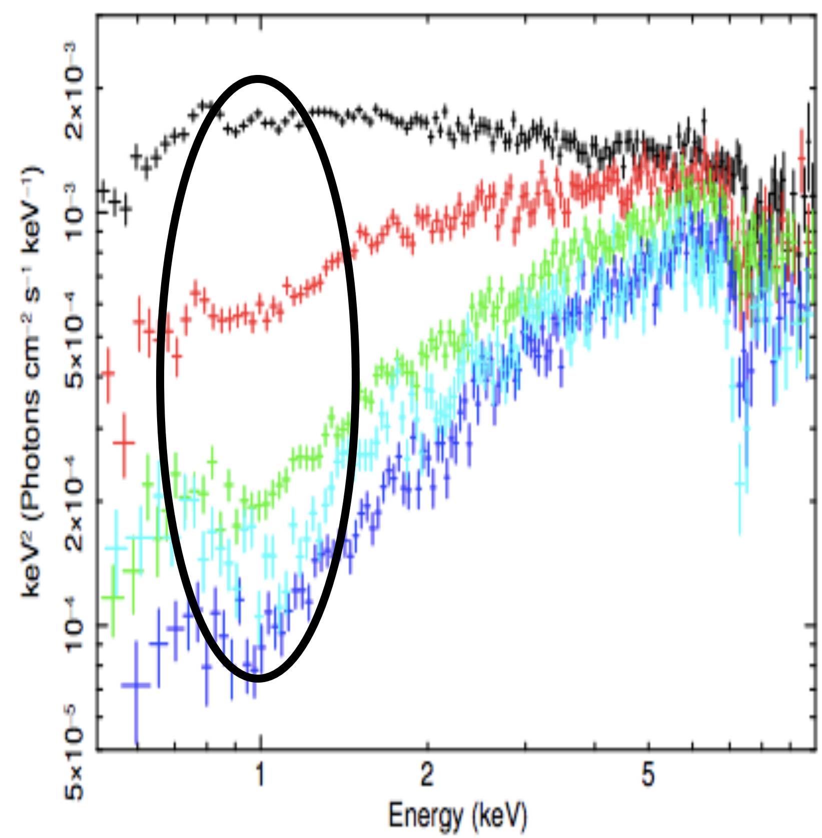
Nomura et al 2014

PDS456: UFO wind is clumpy

- High ionisation lines AND low energy absorption



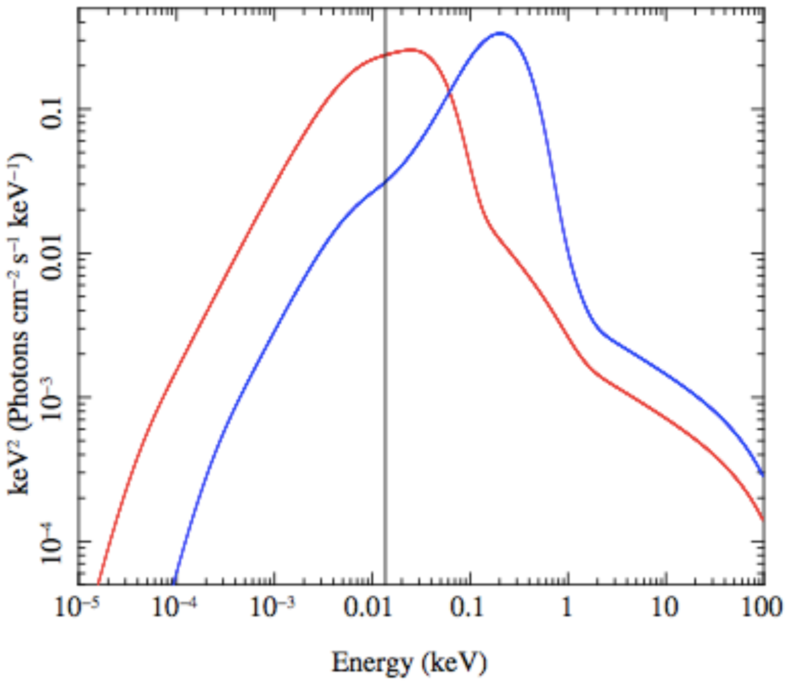
Done & Jin 2016



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

Winds from low mass NLS1?

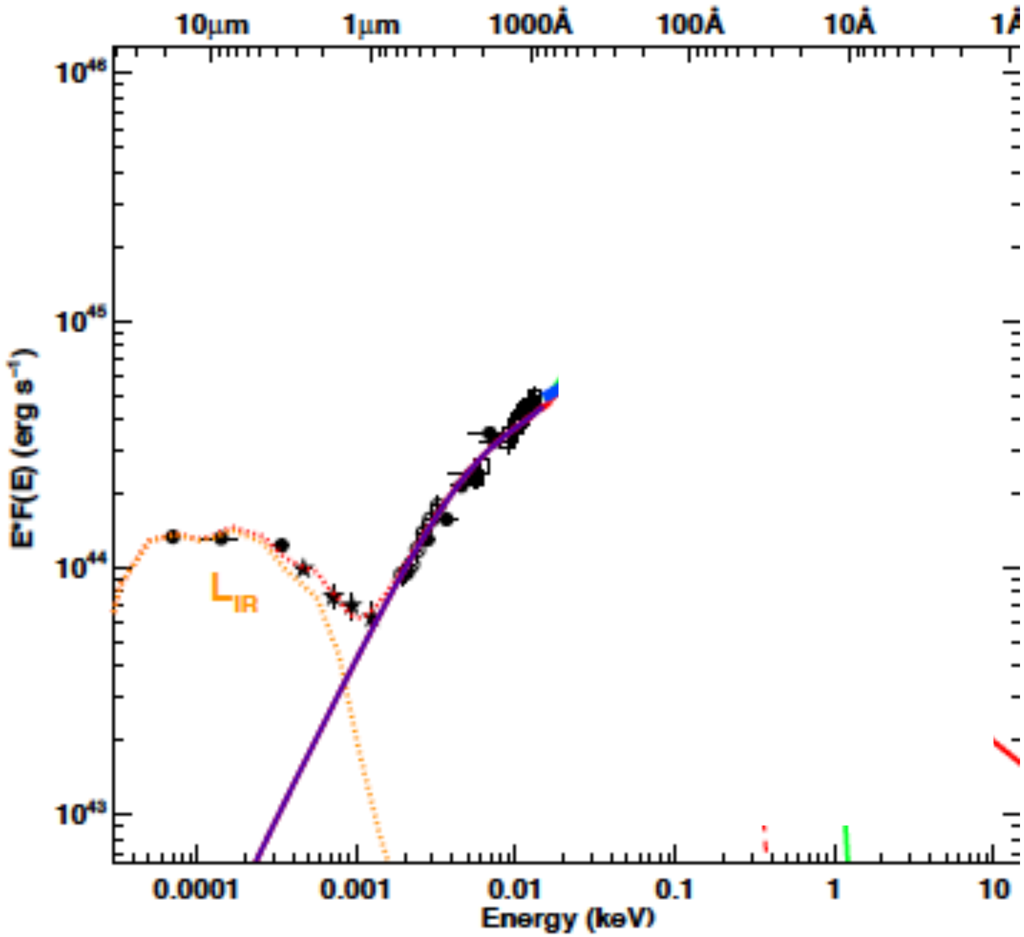
- NLS1 $M \sim 10^{6-7}$, L/LEdd~1 X-ray weak
- But disc peaks in soft X-rays – overionises UV
- Need L>>LEdd for wind in NLS1 $M \sim 10^{6-7}$



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
- See Jin talk



Jin et al 2017

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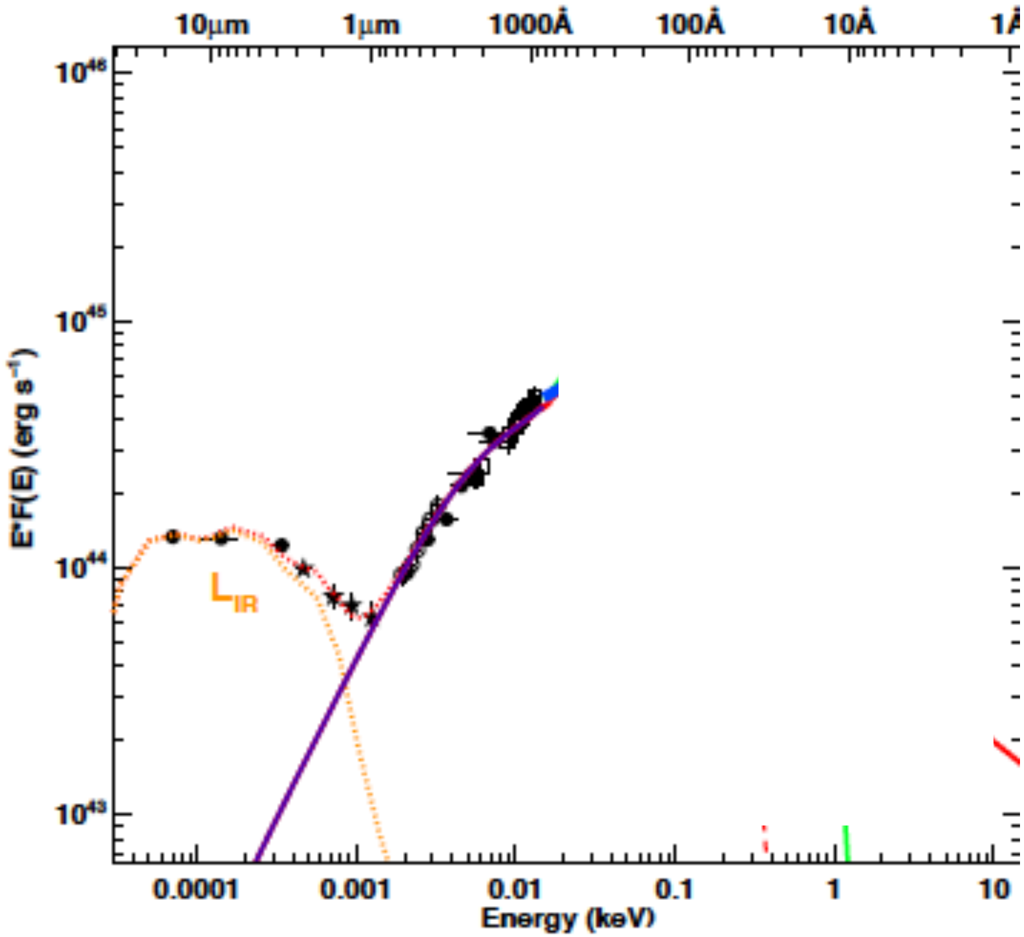
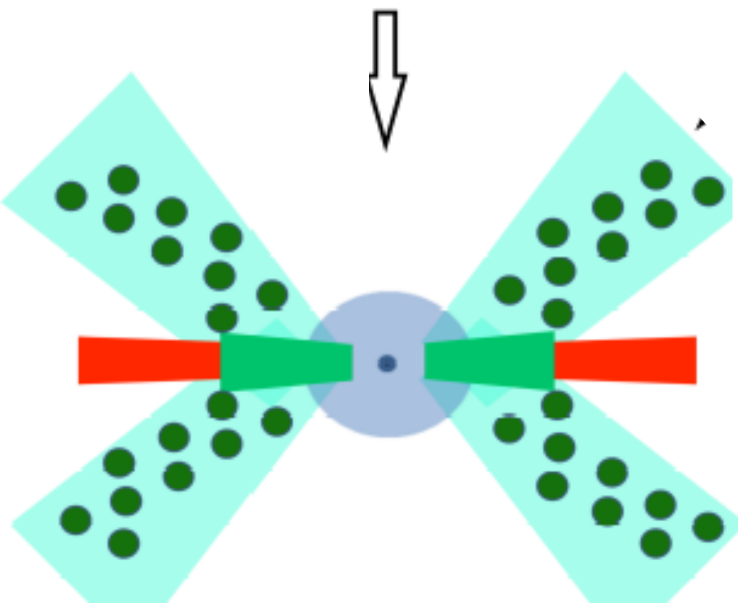
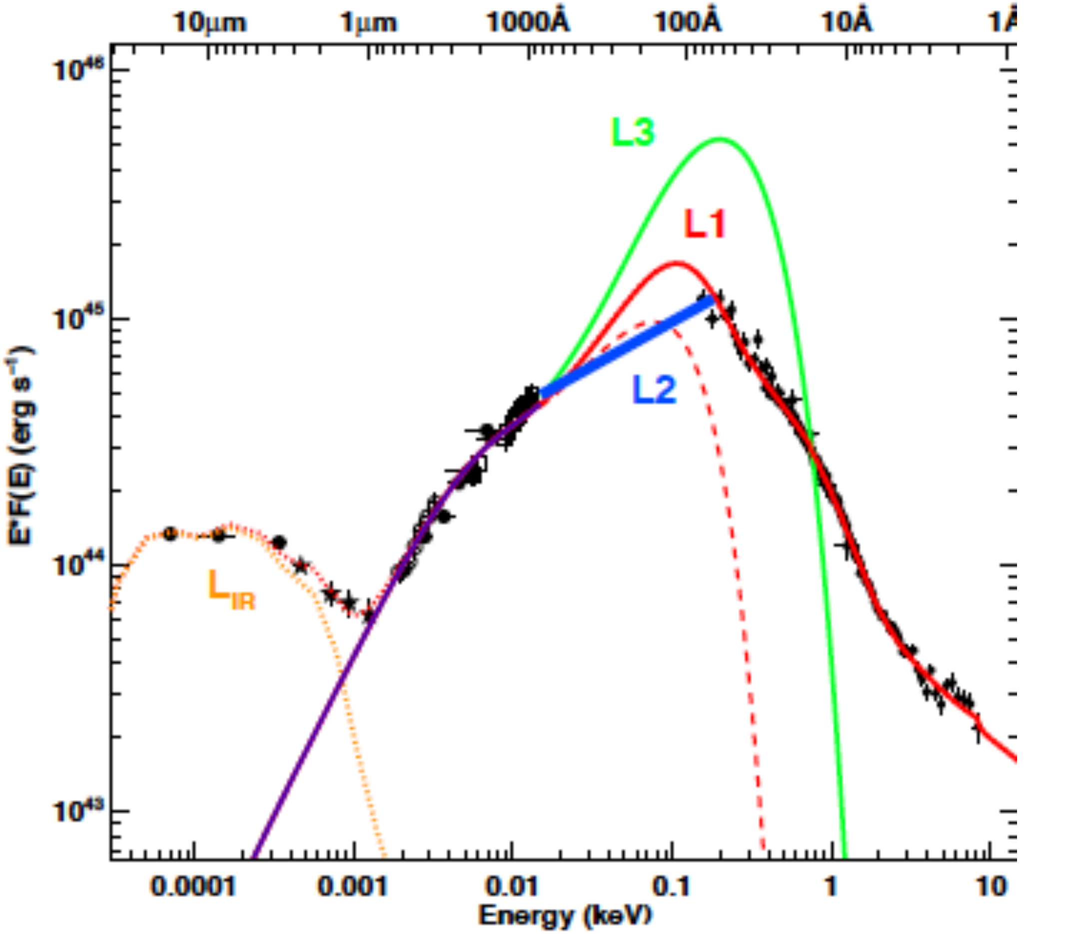


Jin et al 2017

Extreme NLS1 RX0439

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

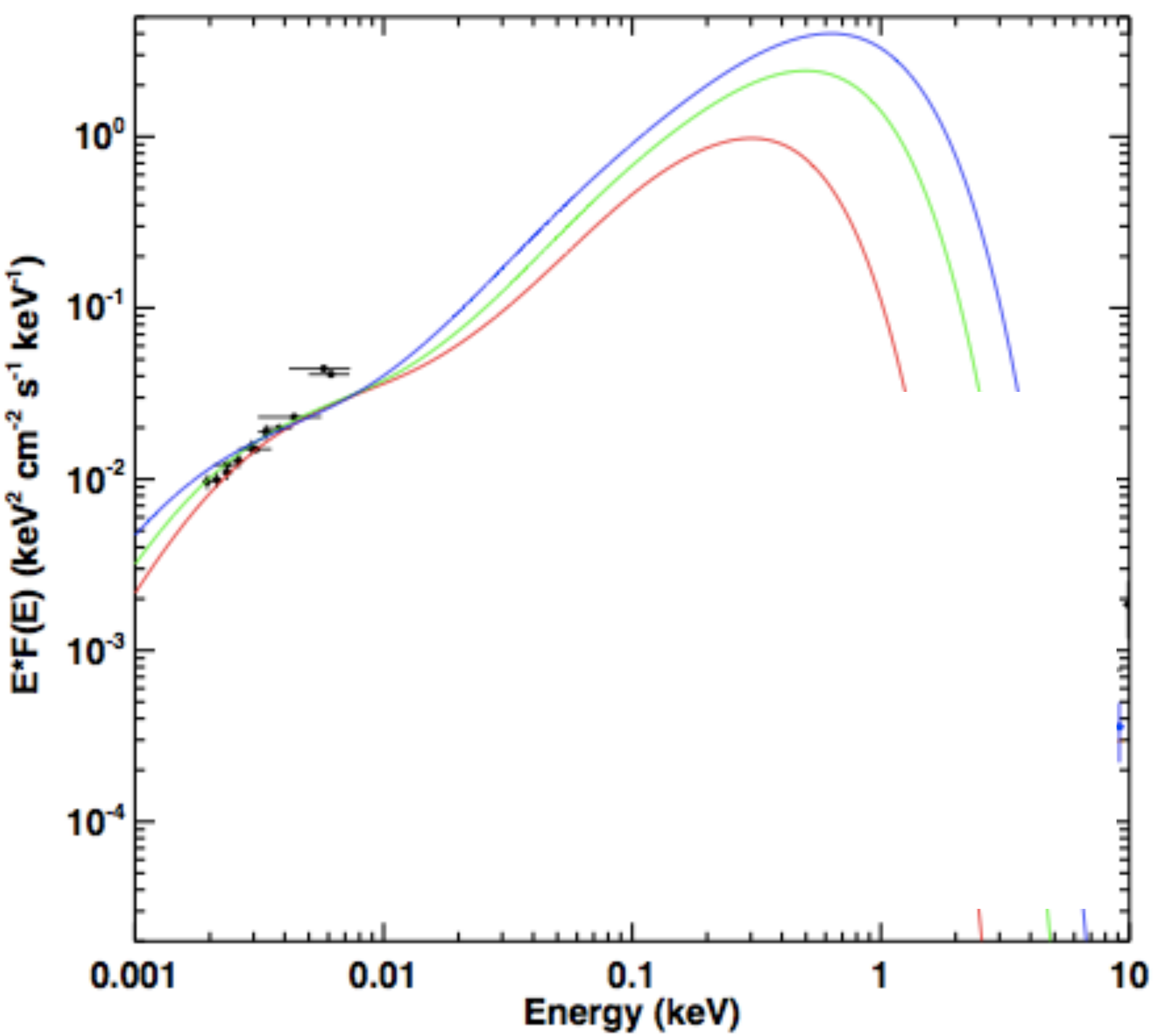




Jin et al 2017

1H0707-495 Extreme NLS1

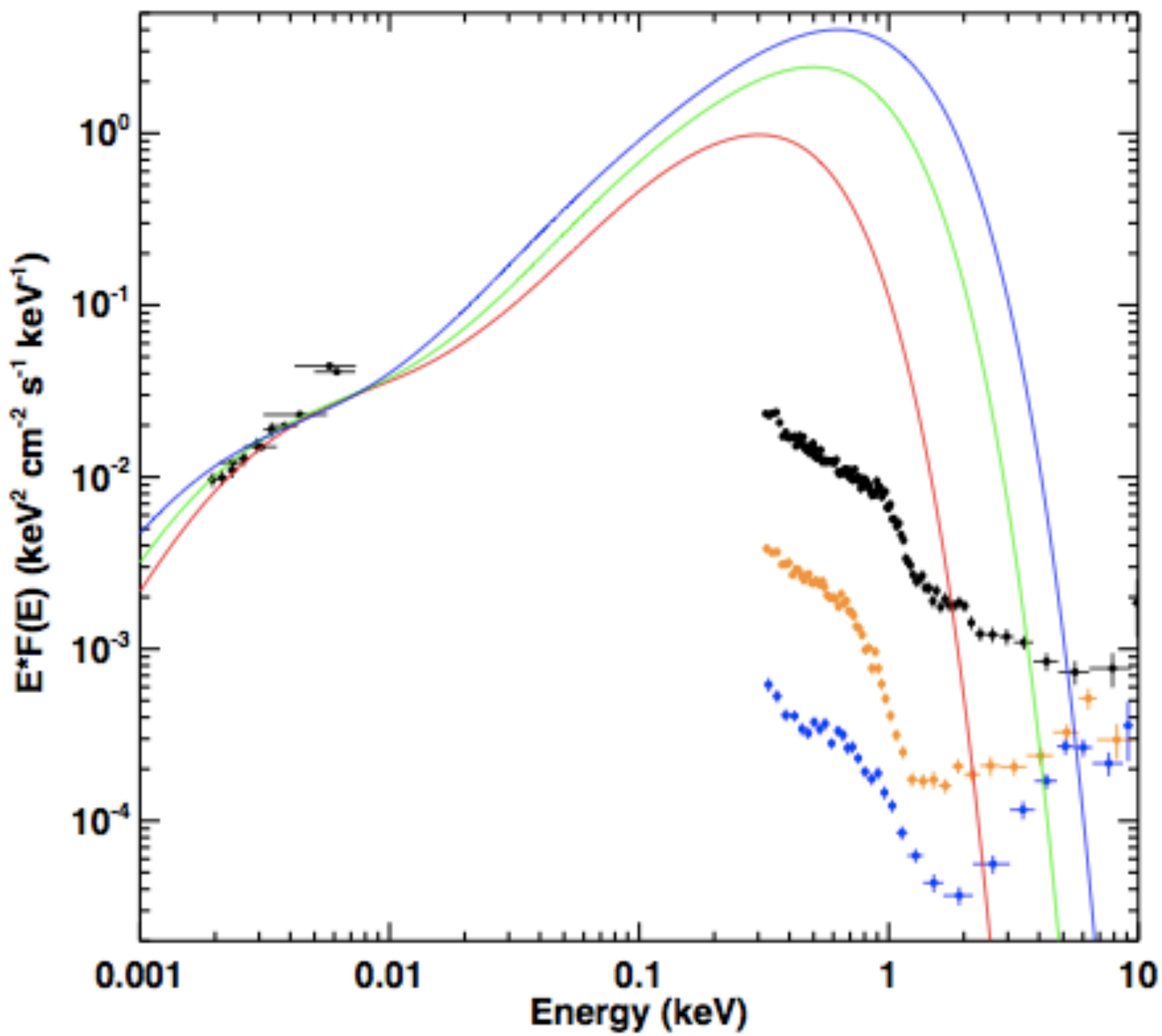
- 1H0707
- 2-4x10^6
- L/Ledd = 11, 40 70
  (60 degrees)
- superEddington



Done & Jin 2016

1H0707-495 Extreme NLS1

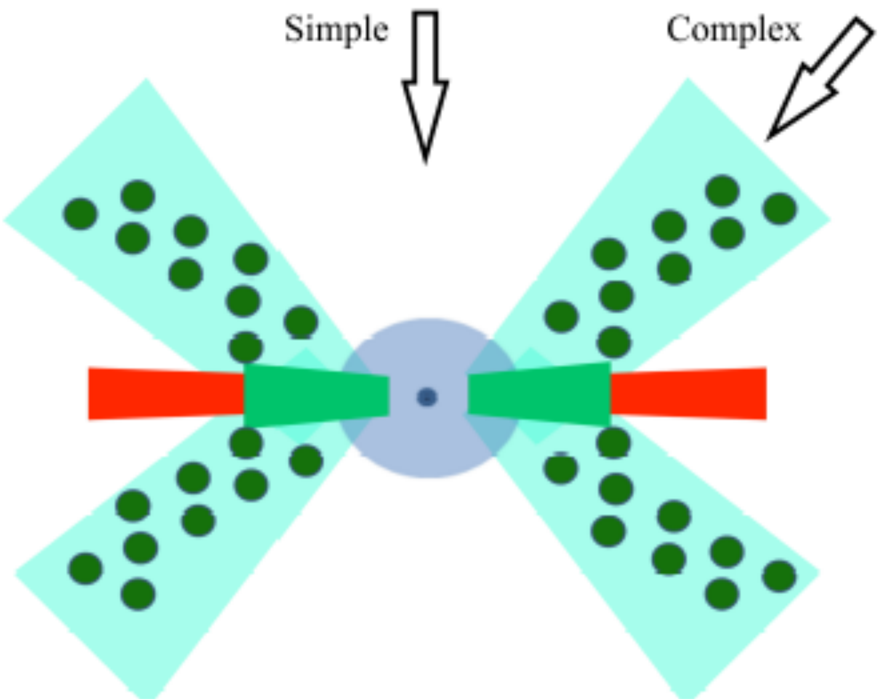
- 1H0707
- 2-4x10^6
- L/Ledd = 11, 40 70
  a=0 0.9 0.998
  60 degrees 4x10^6
- superEddington
- Strong wind, losing energy so not all potential power radiated



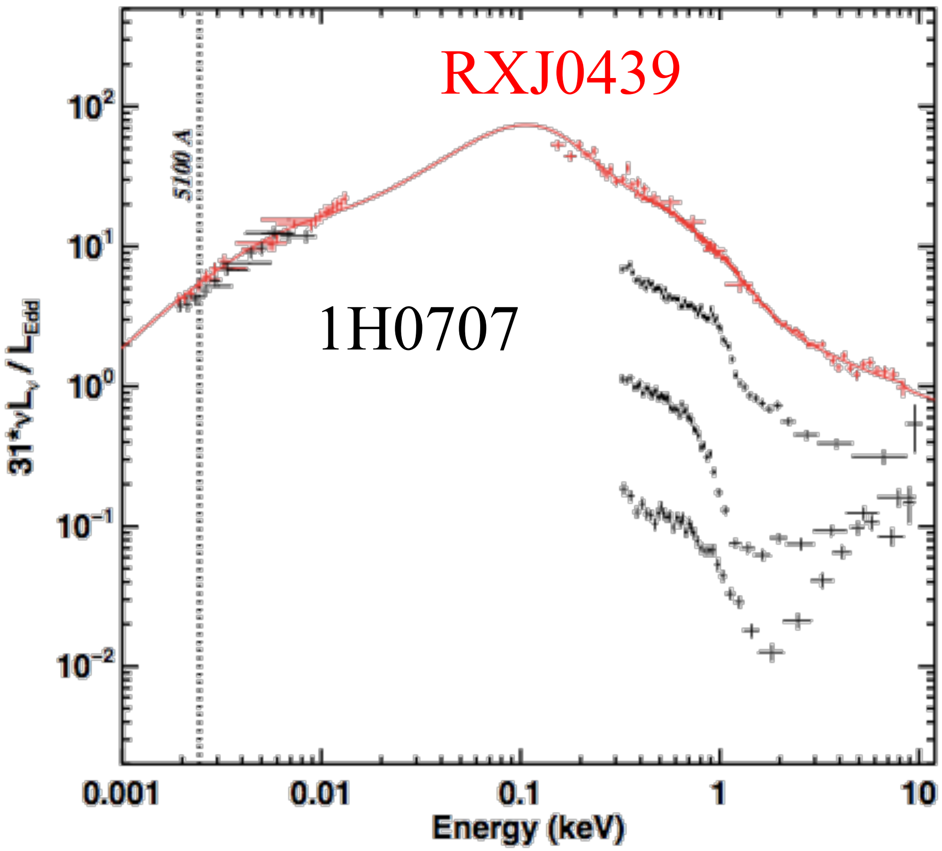
Done & Jin 2016

Extreme NLS1 – simple / complex

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



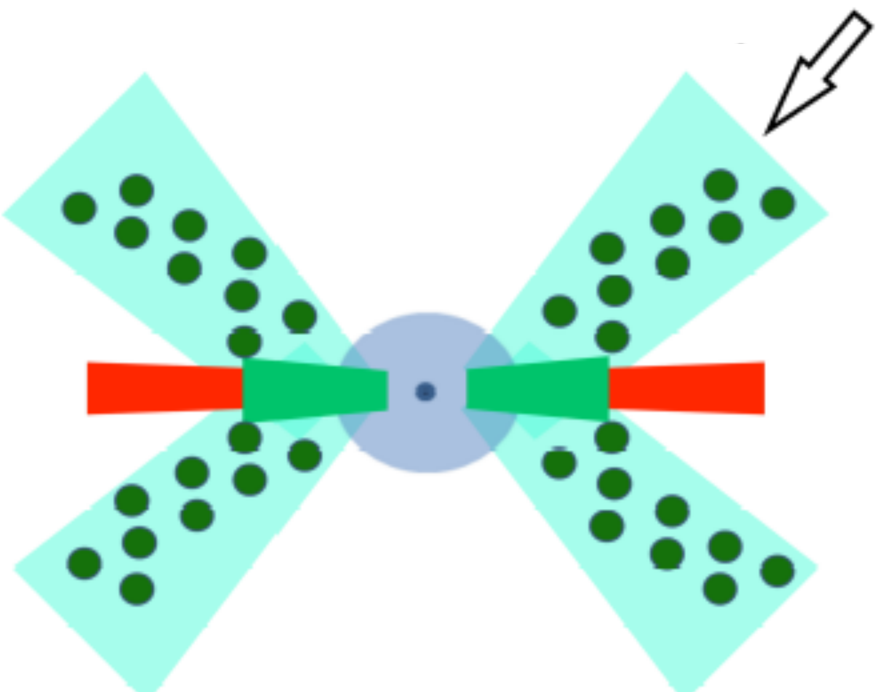
Done & Jin 2016



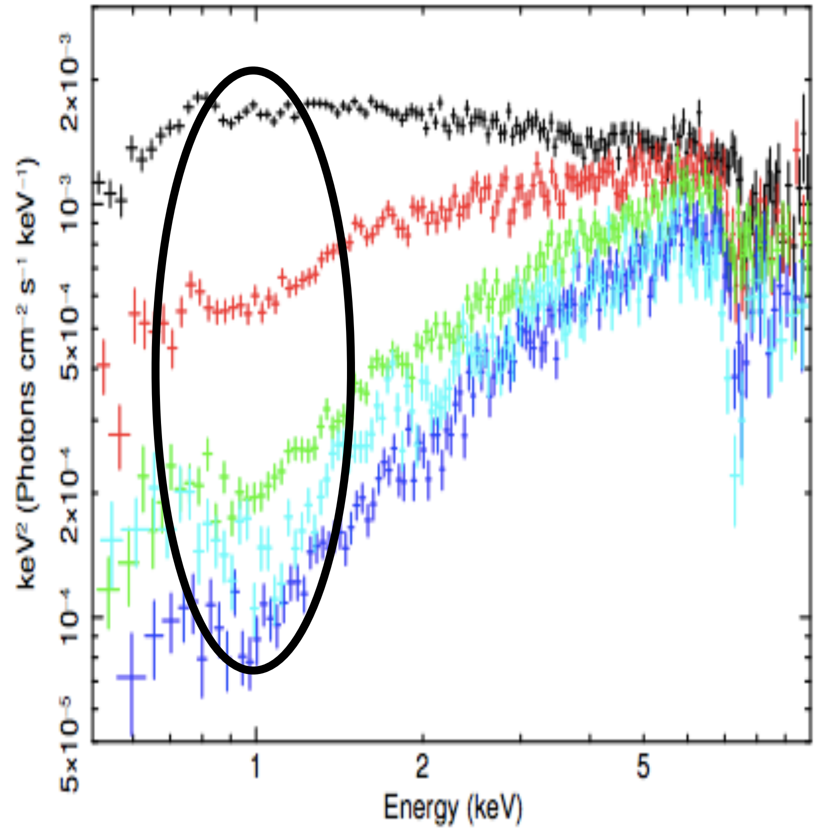
Jin et al 2017

PDS456: UFO wind is clumpy

- High ionisation lines AND low energy absorption

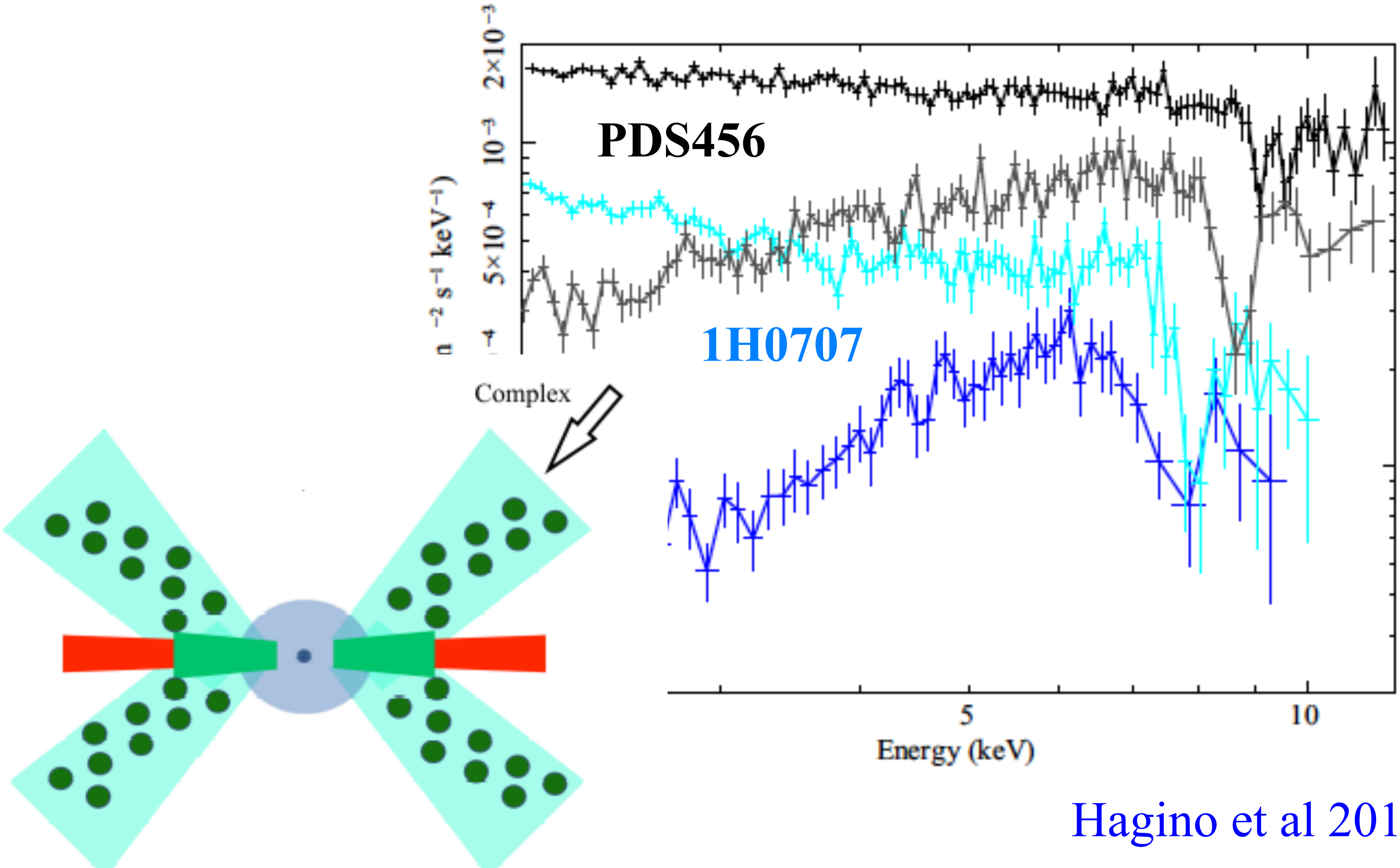


Done & Jin 2016



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

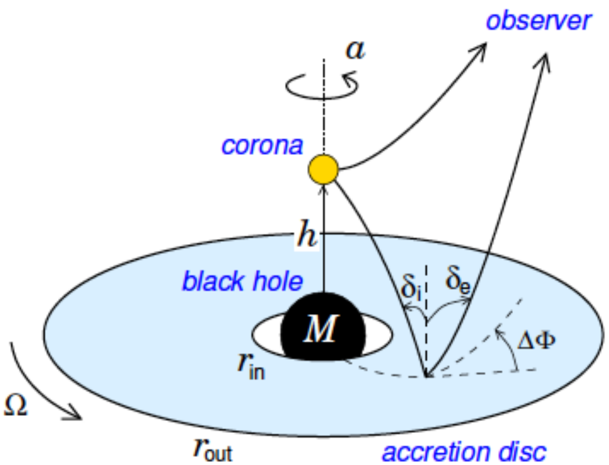
1H0707 shows very similar range of spectral shapes to PDS456

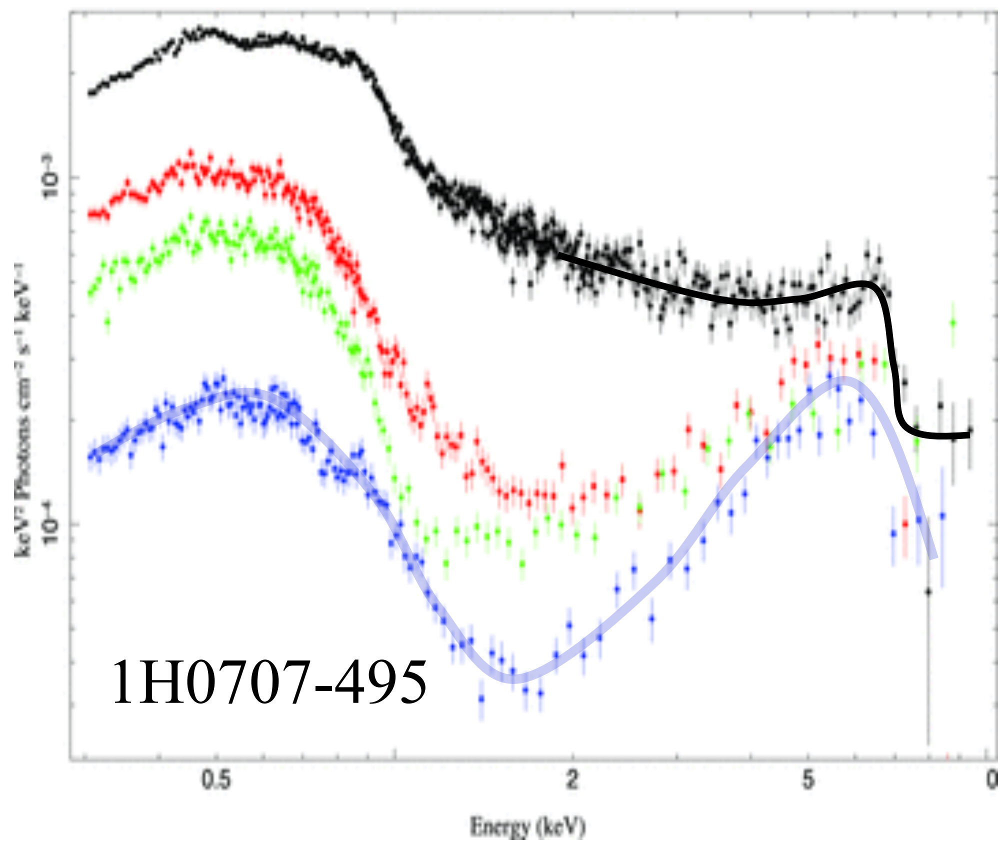


Hagino et al 2017

Complex NLS1 – X-ray view

- ‘Complex’ NLS1 (Gallo 2006) eg 1H0707-495
- Deep dips – hard spectra, large Fe features
- Extreme spin!!

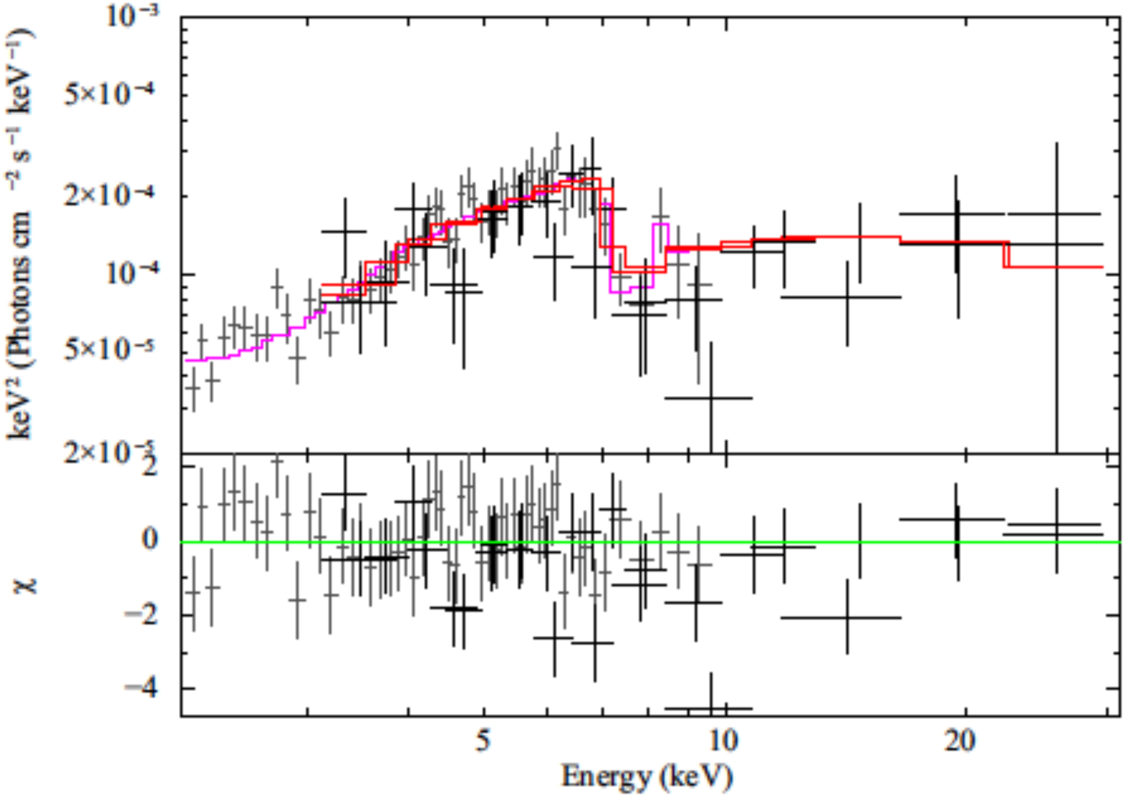




Fabian et al 2009

Complex NLS1 – X-ray view

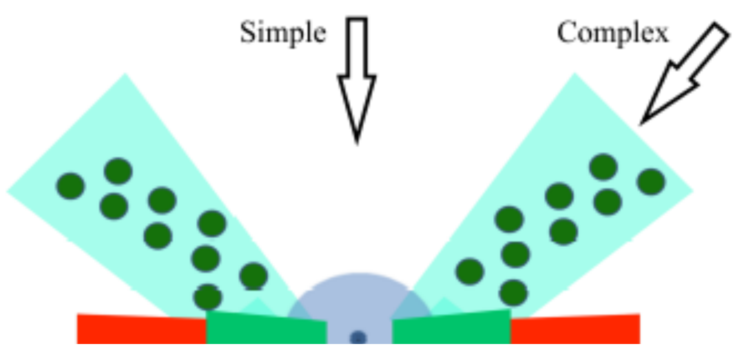
- Extreme spin with reflection from flat disc
- Or superEddington wind absorption with no constraints on spin!!

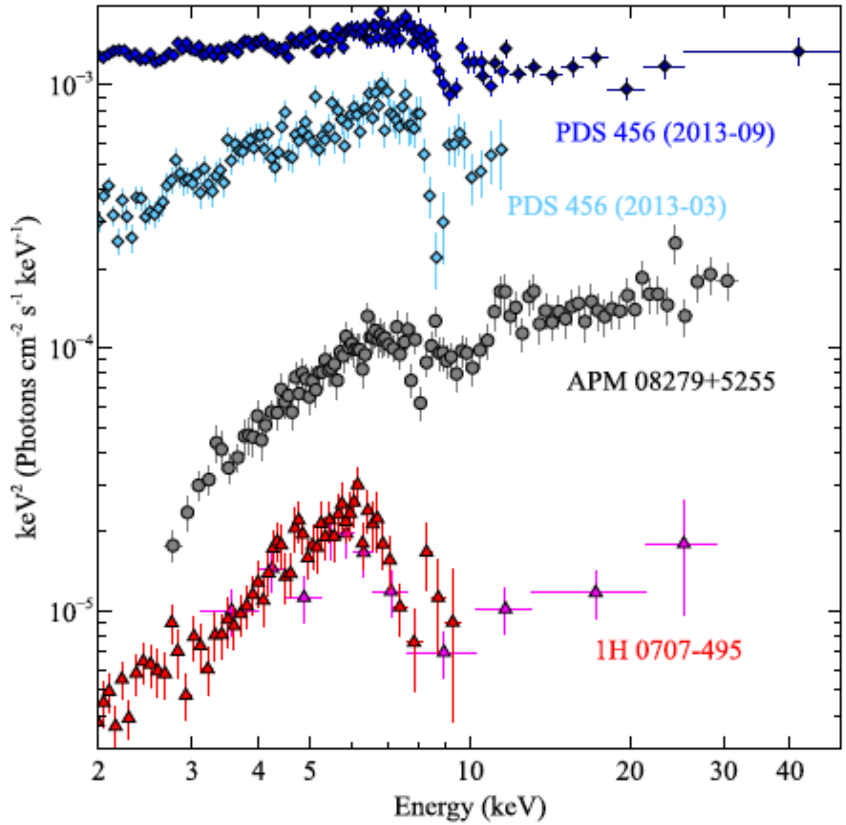


Hagino et al 2016

Conclusions – most powerful winds

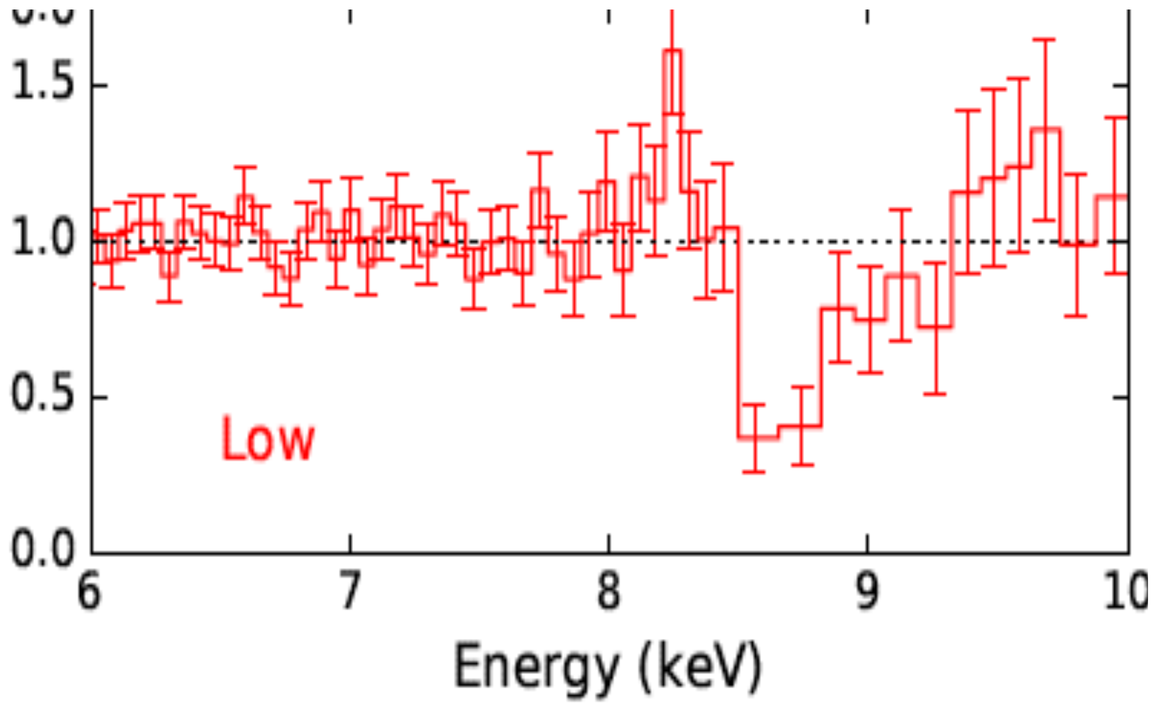
- Quantatative AGN feedback
- SED – L/LEdd and M
- high M, L~LEdd UV bright, X-ray weak, UV driving
- Eddington wind L>LEdd
- Both at z~2-3 QSO epoch
- Clumpy, complex - los



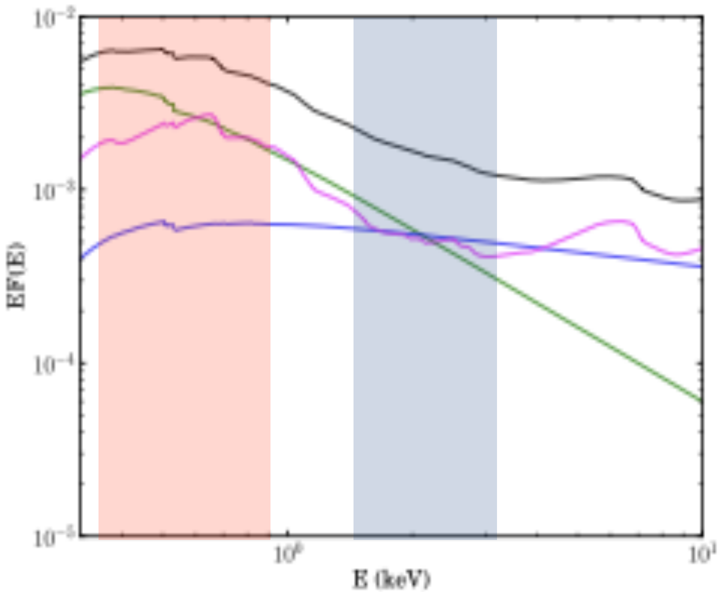


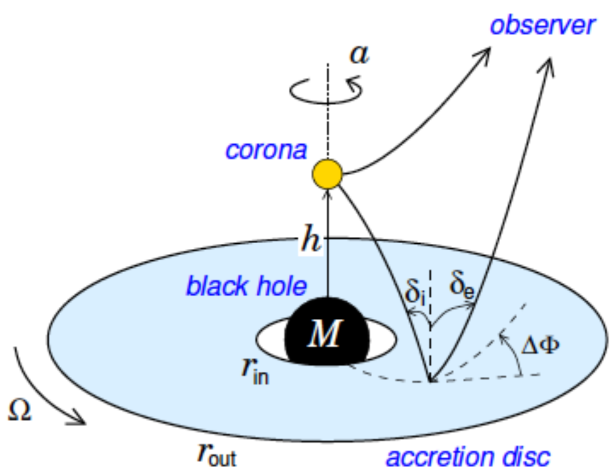
IRAS13224

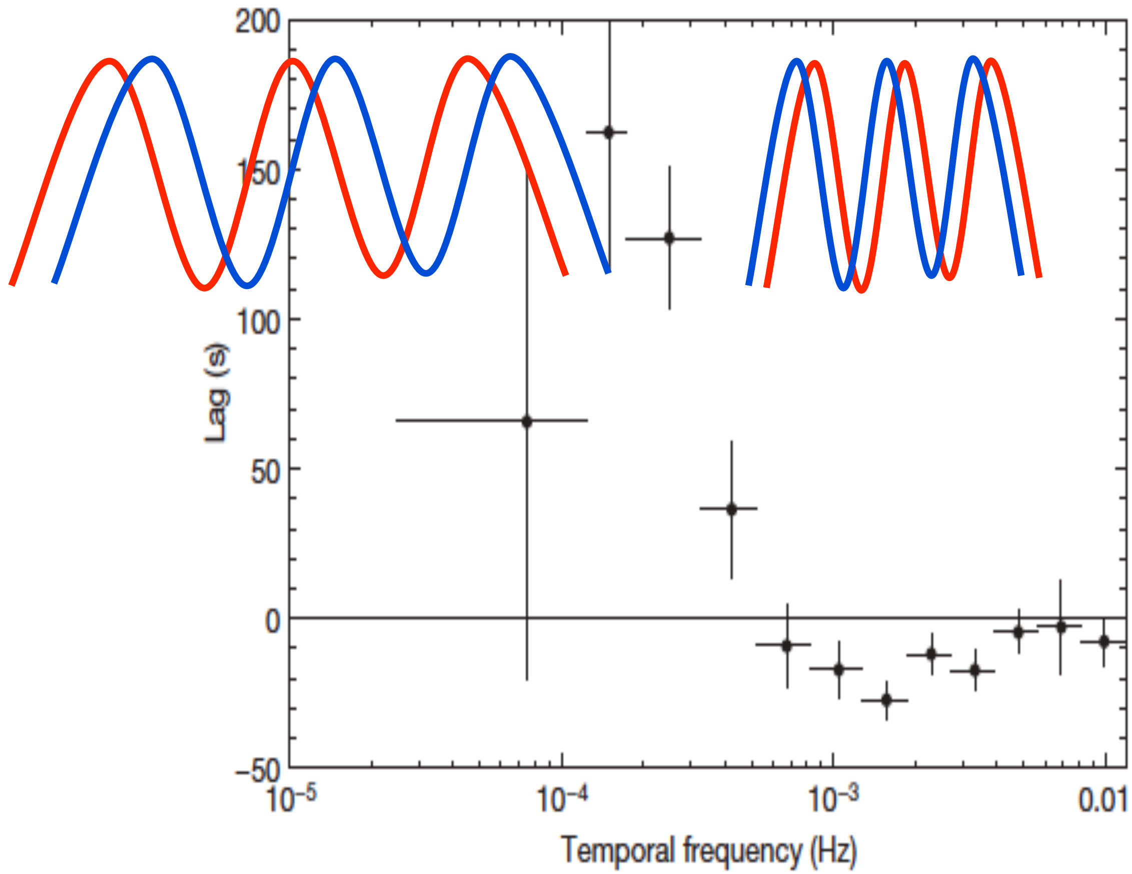
- IRAS13224 Parker et al 2017
- Called 'twin' of 1H0707 (Ponti et al 2009) – probably similarly superEddington (Leighly 2004)



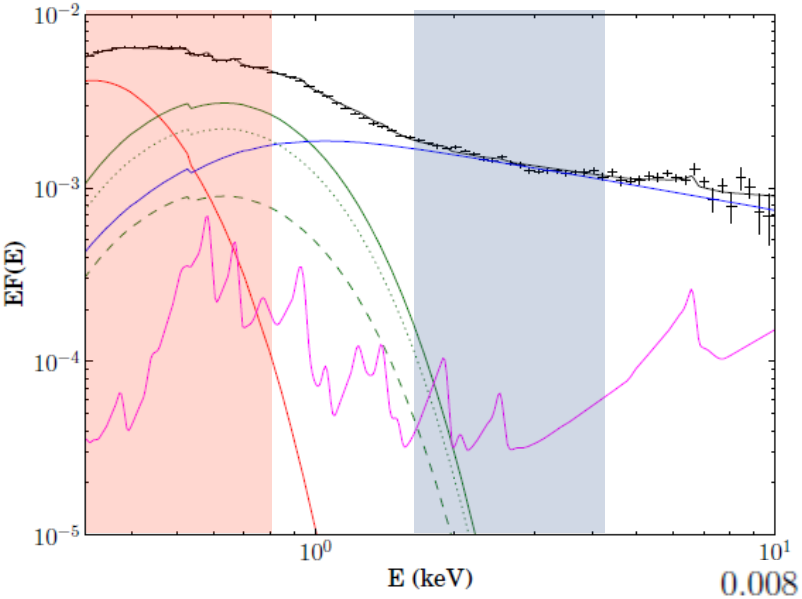
Lags in simple and complex NLS1

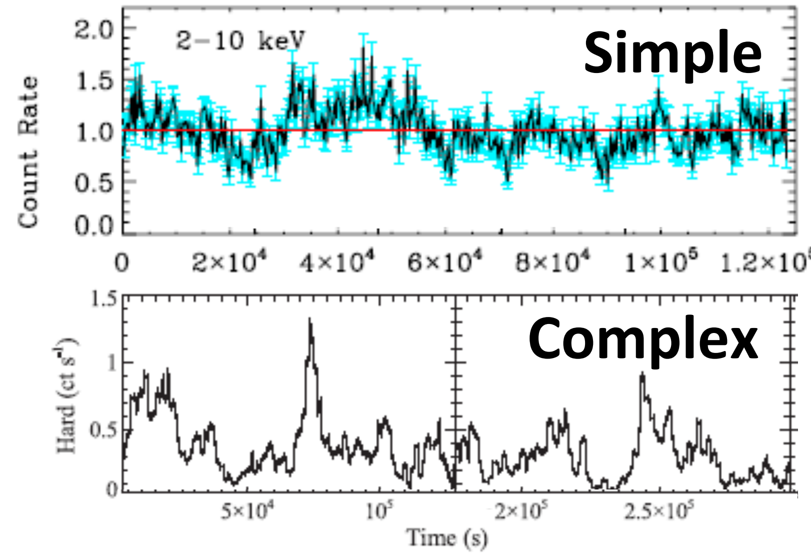


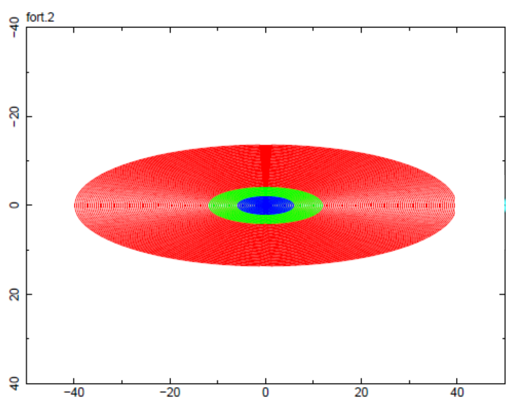


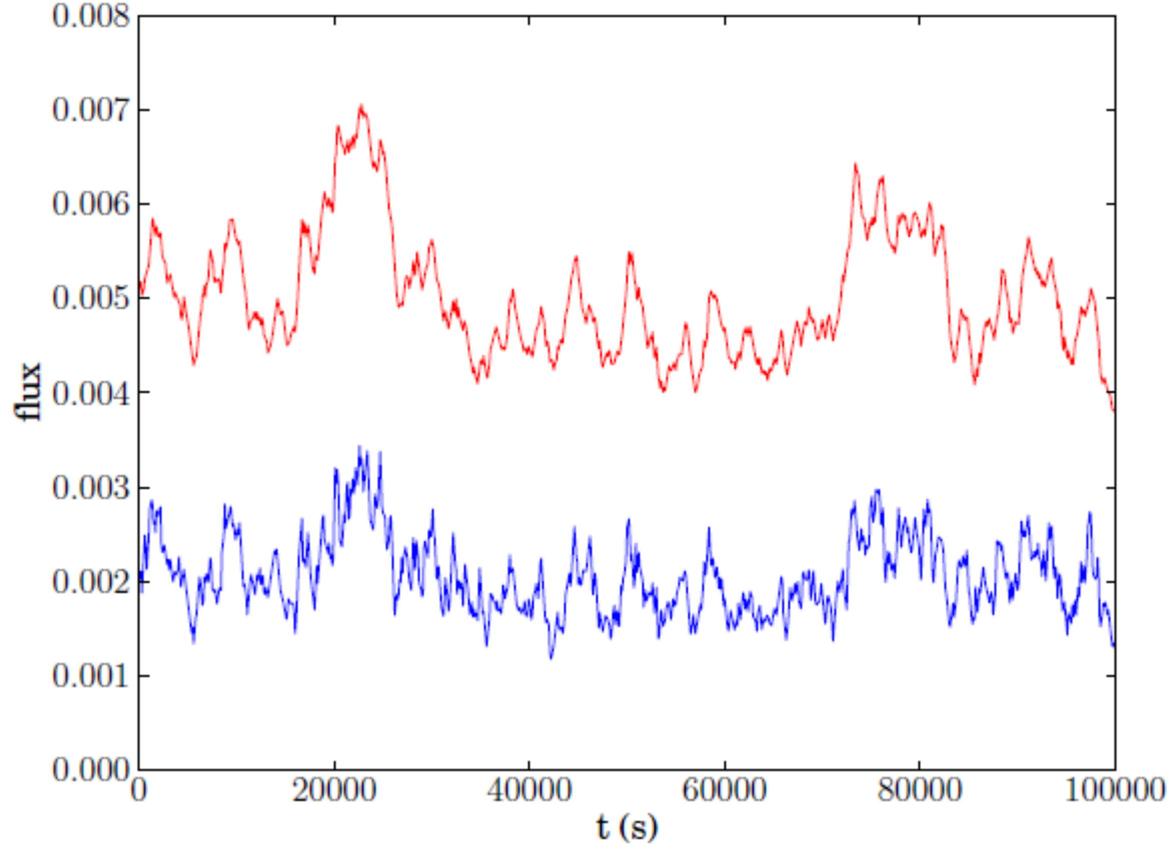


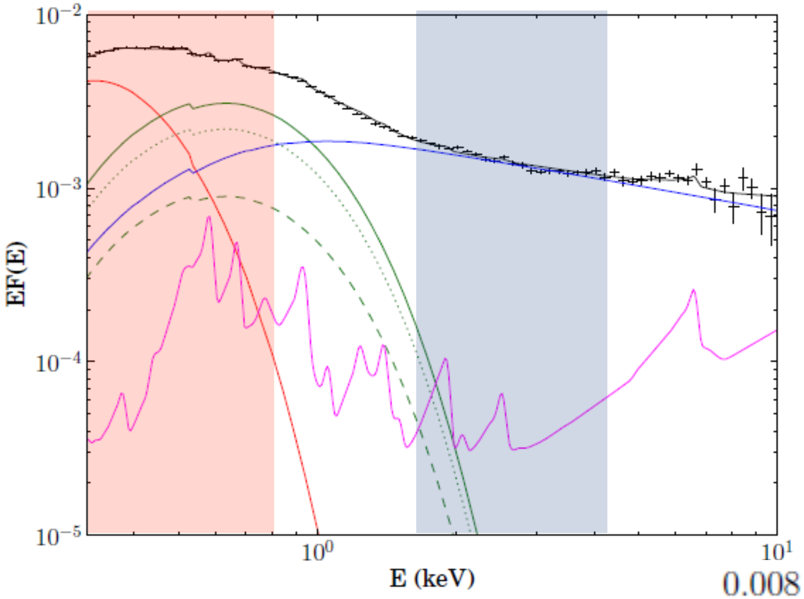
Fabian et al 2009


EF(E)
E (keV)

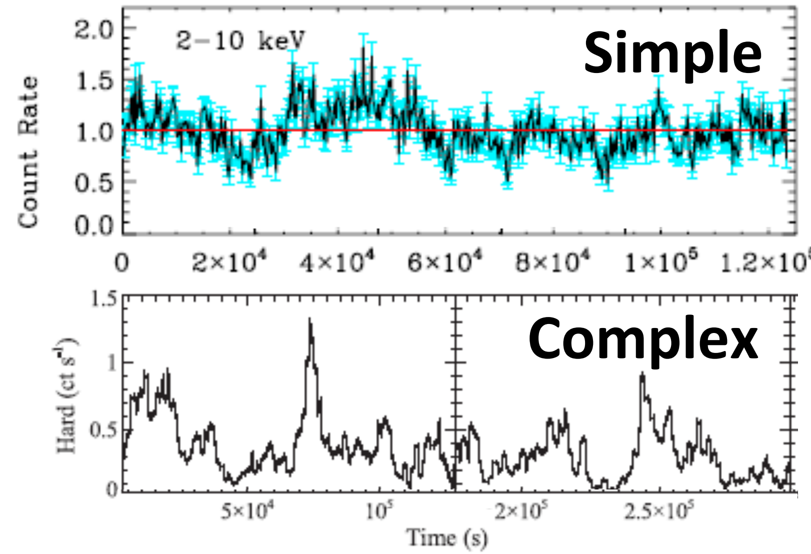

Simple
2−10 keV
Count Rate
Complex
Hard (ct s^{-1})
Time (s)


fort.2

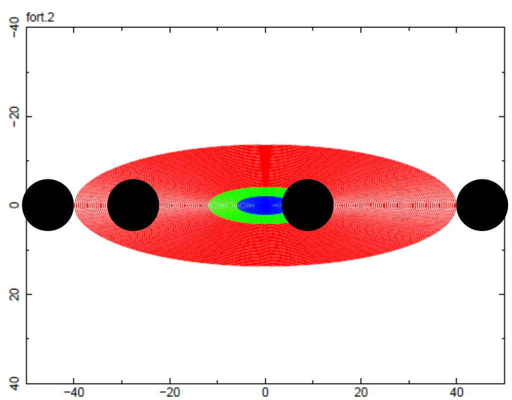

flux
t (s)



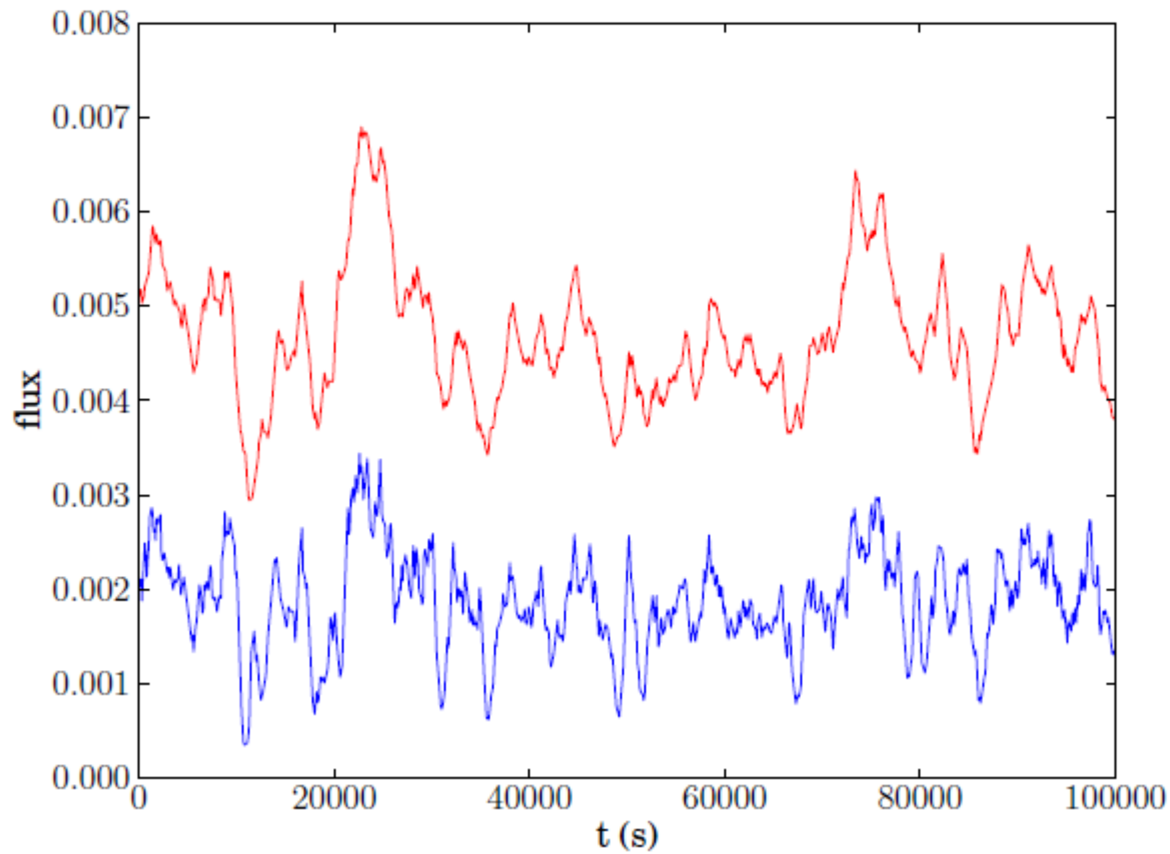
EF(E)
E (keV)



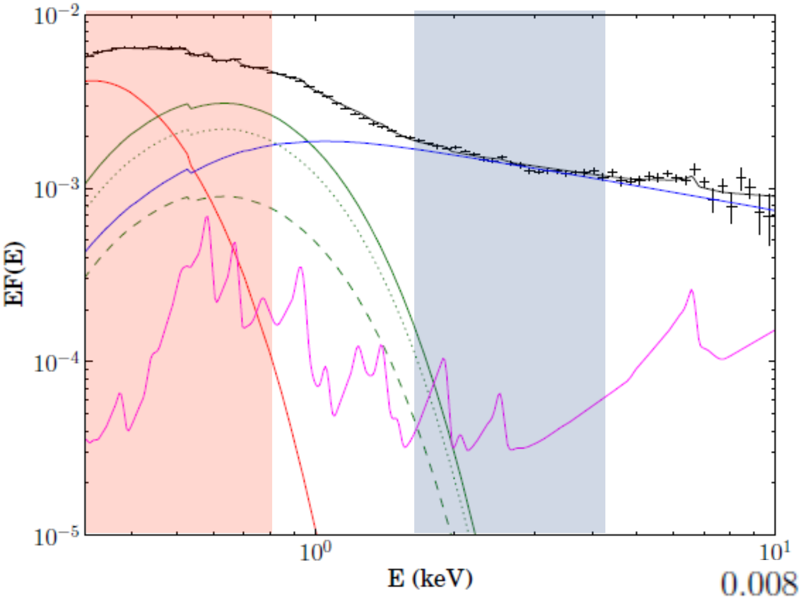
Simple
2–10 keV
Count Rate
Complex
Hard (ct s⁻¹)
Time (s)

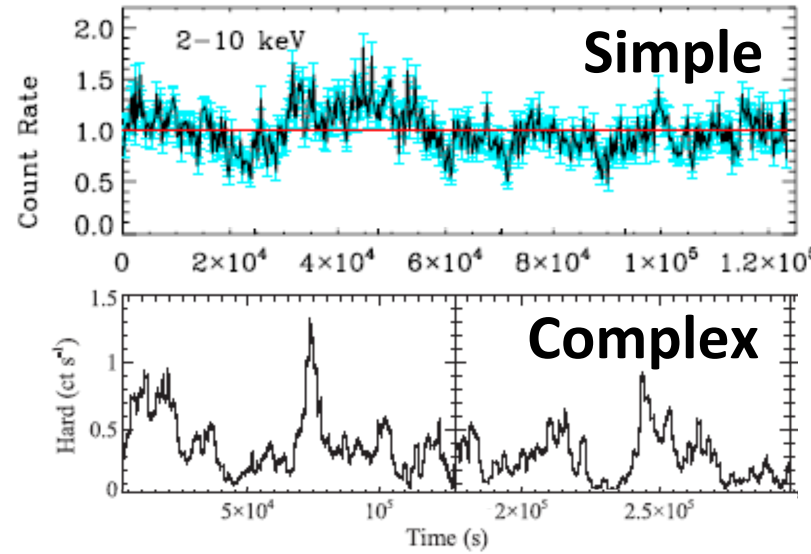


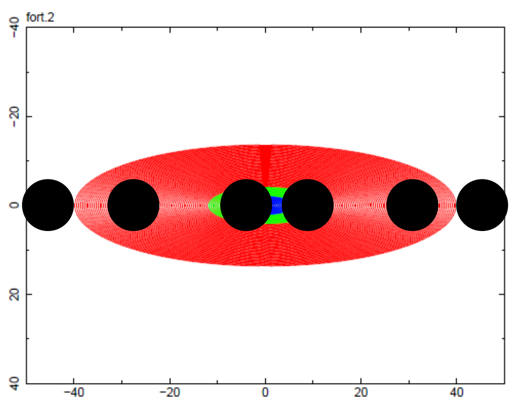
fort.2

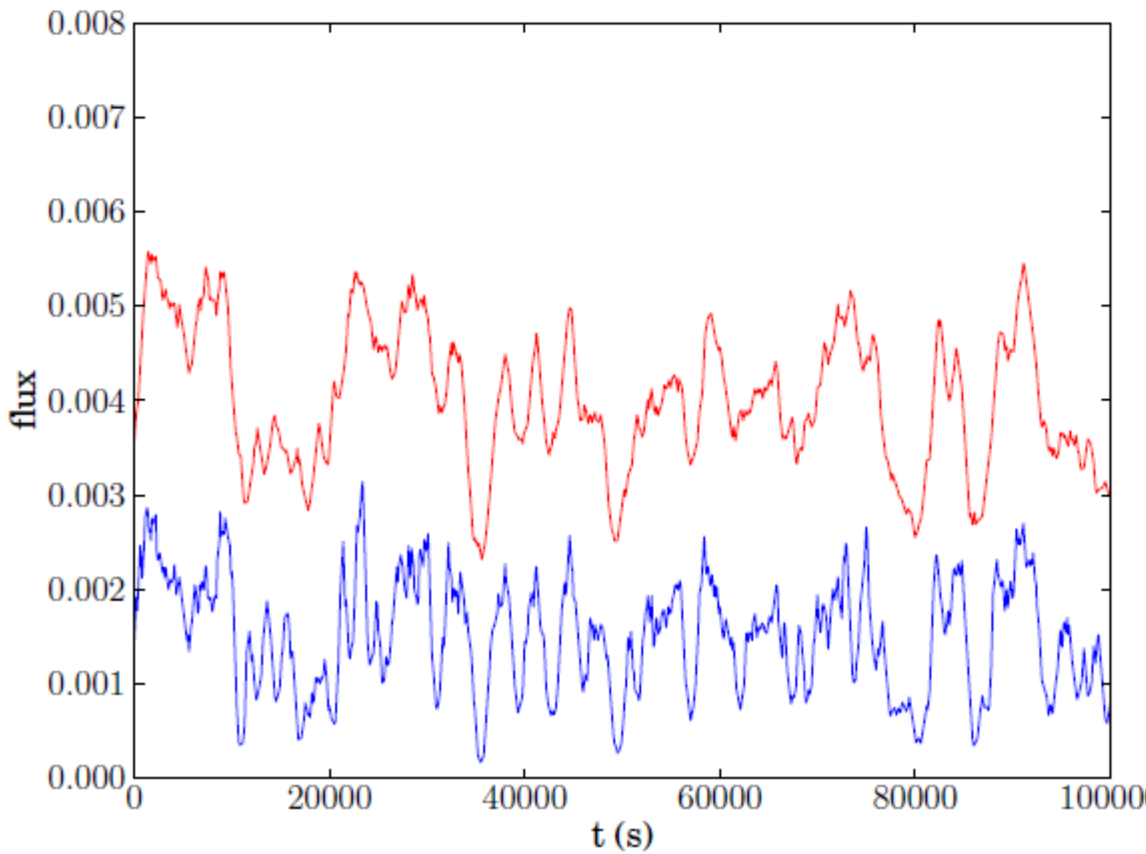


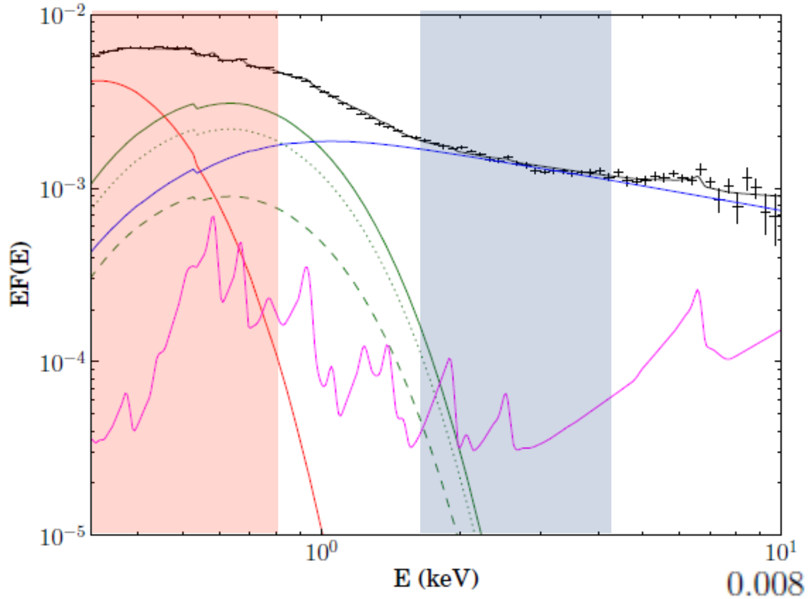
flux
t (s)

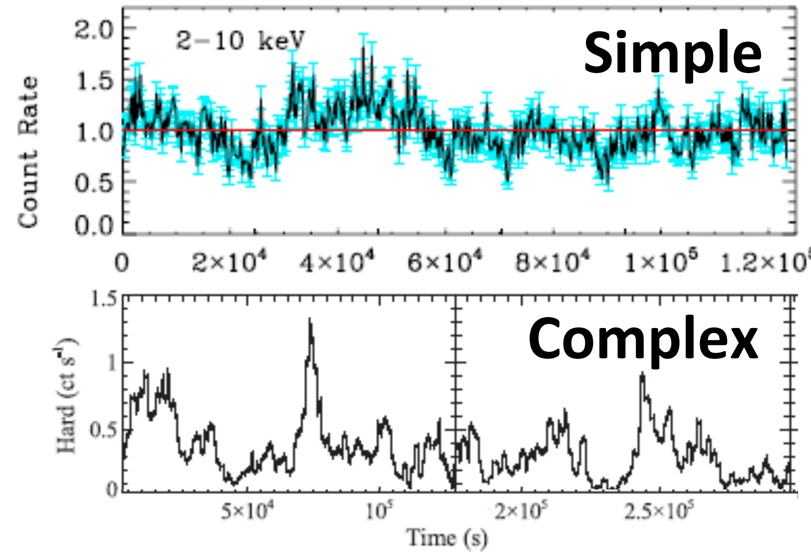

EF(E)
E (keV)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{0}
10^{1}

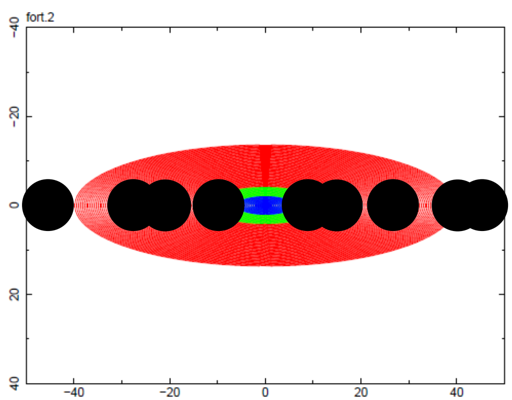

Simple
2−10 keV
Count Rate
Complex
Hard (ct s^{-1})
Time (s)

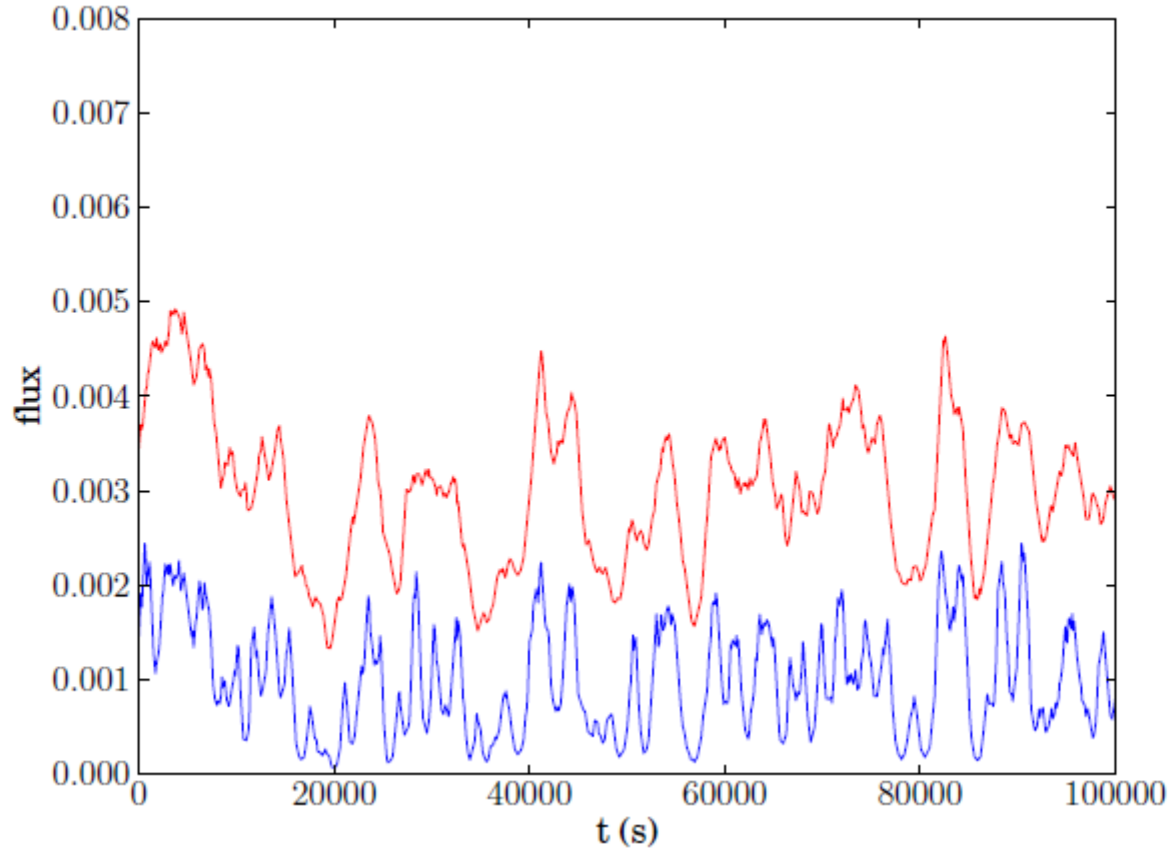

fort.2

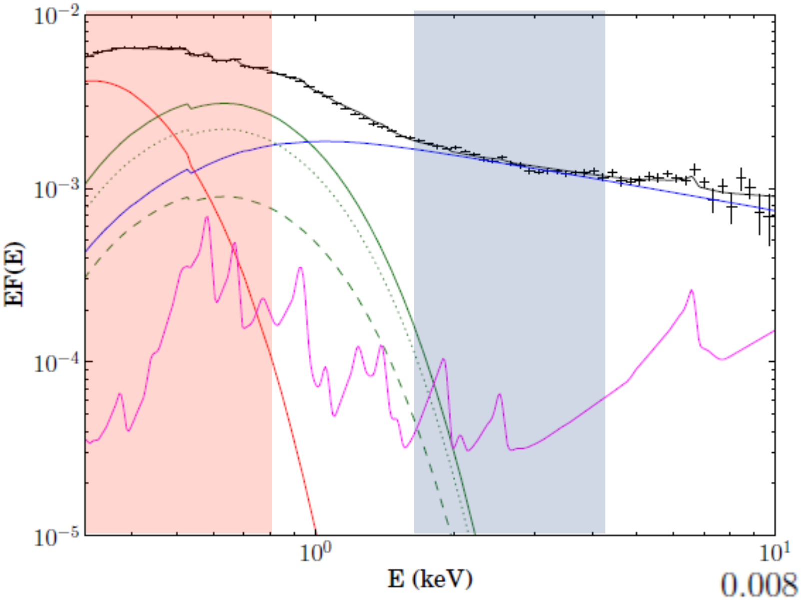

flux
t (s)

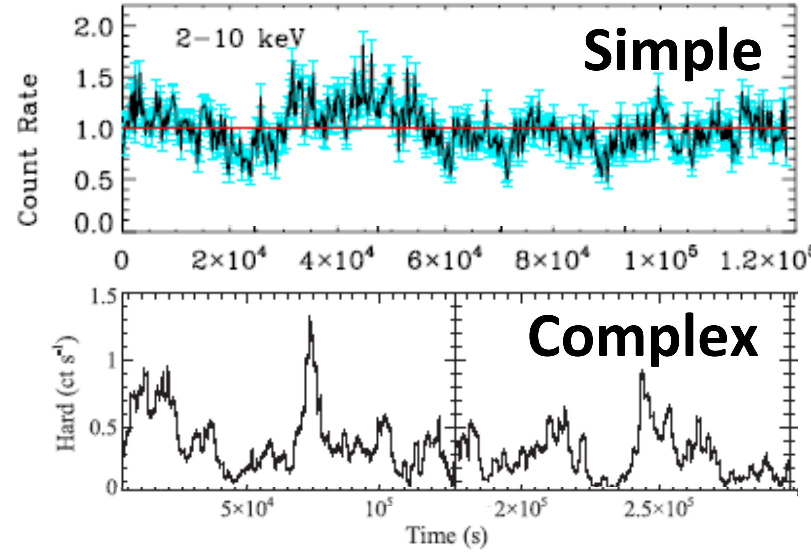

EF(E)
E (keV)

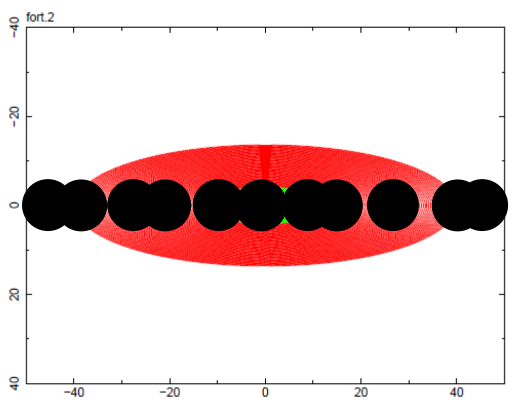

2–10 keV
Simple
Count Rate
Complex
Hard (ct s⁻¹)
Time (s)

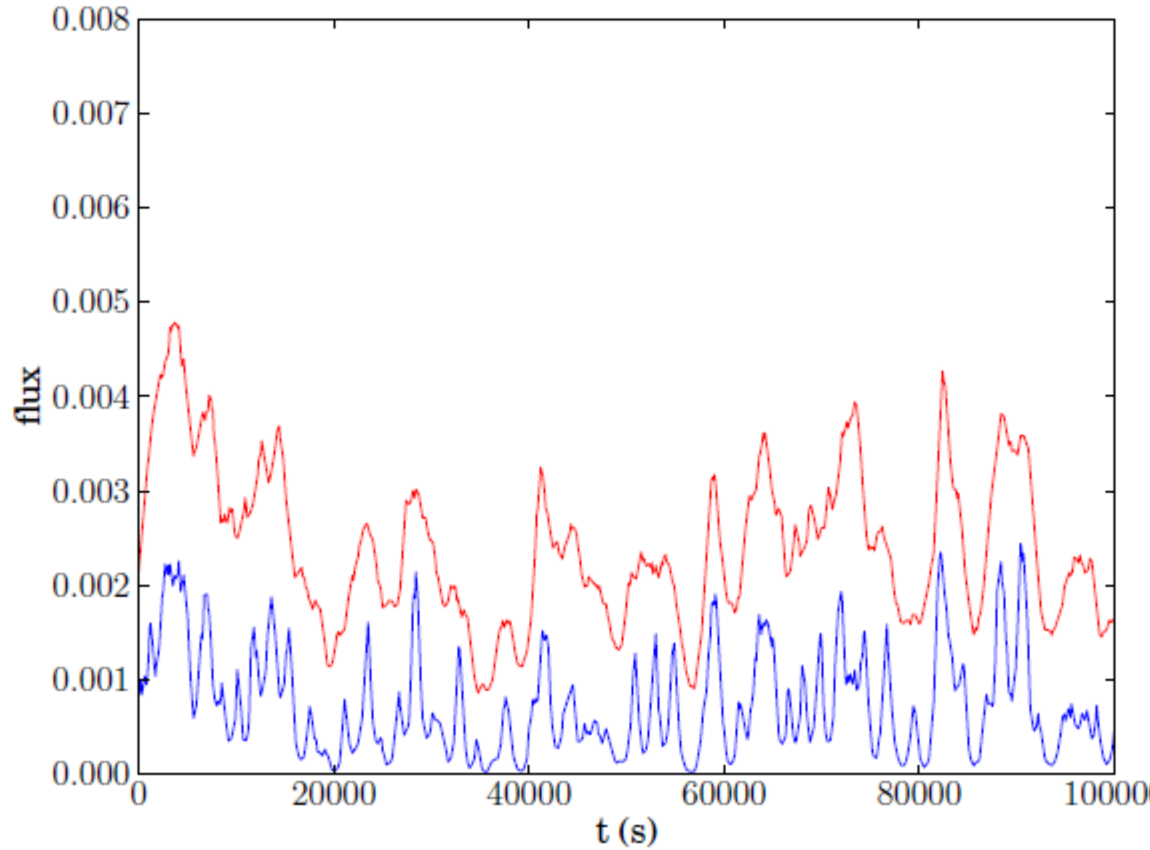

fort.2


flux
t (s)

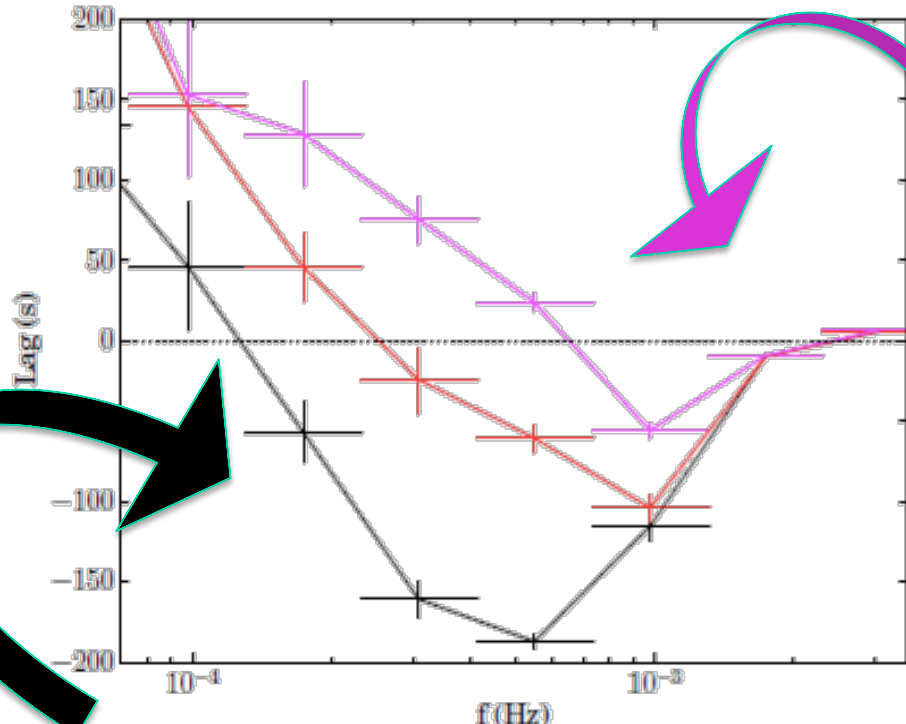

EF(E)
E (keV)


Simple
2–10 keV
Count Rate
Complex
Hard (ct s^{-1})
Time (s)


fort.2


flux
t (s)

Effect of occultations on lag-frequency

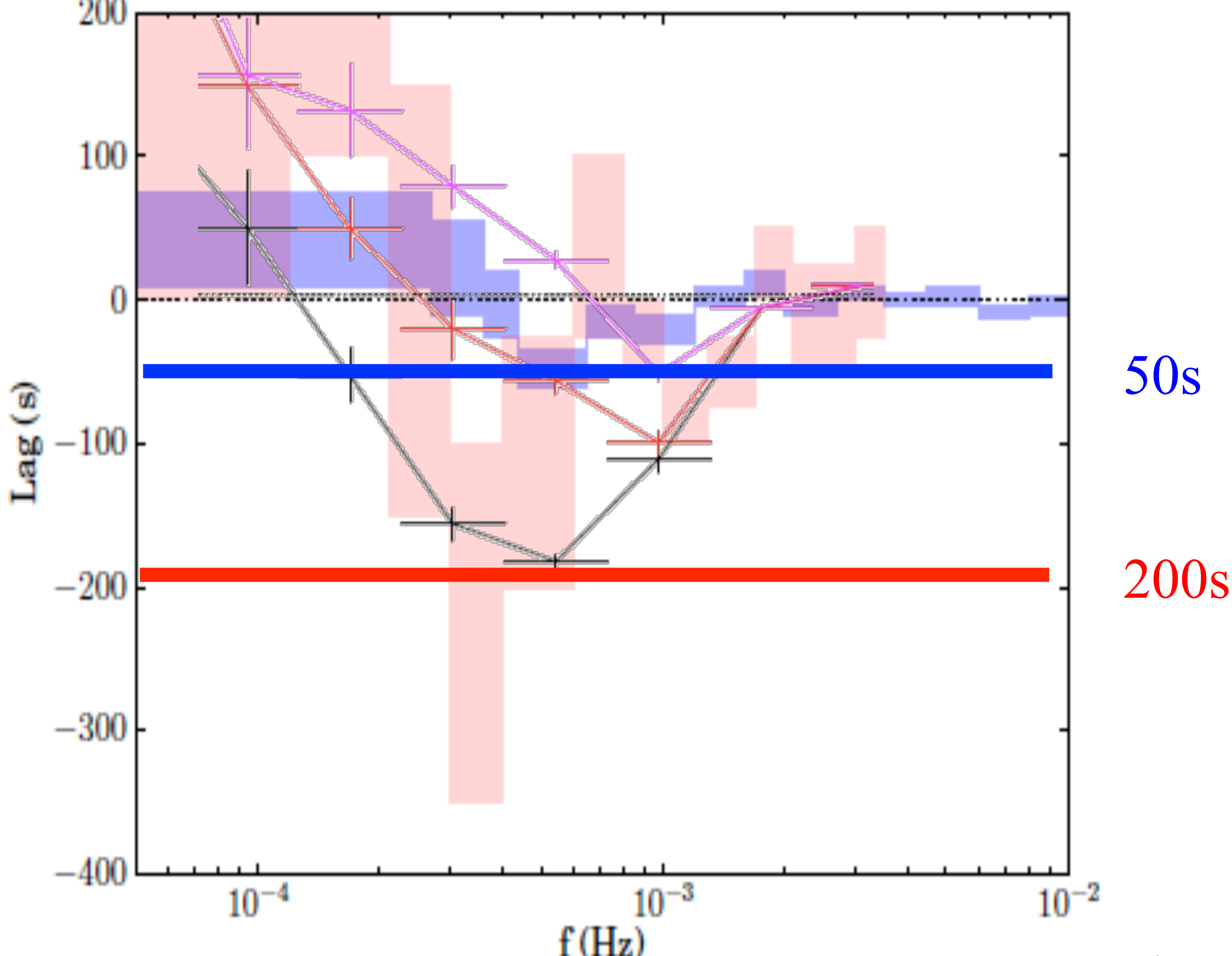


Increasing frequency of occultations gives shorter –ve lag at higher frequency

Simple NLS1 model of propagating fluctuations

Gardner & Done 2014c

Effect of occultations on lag-frequency and Simple and Complex NLS1



Gardner & Done 2014c