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The curious new state of Swift J1753.5-0127

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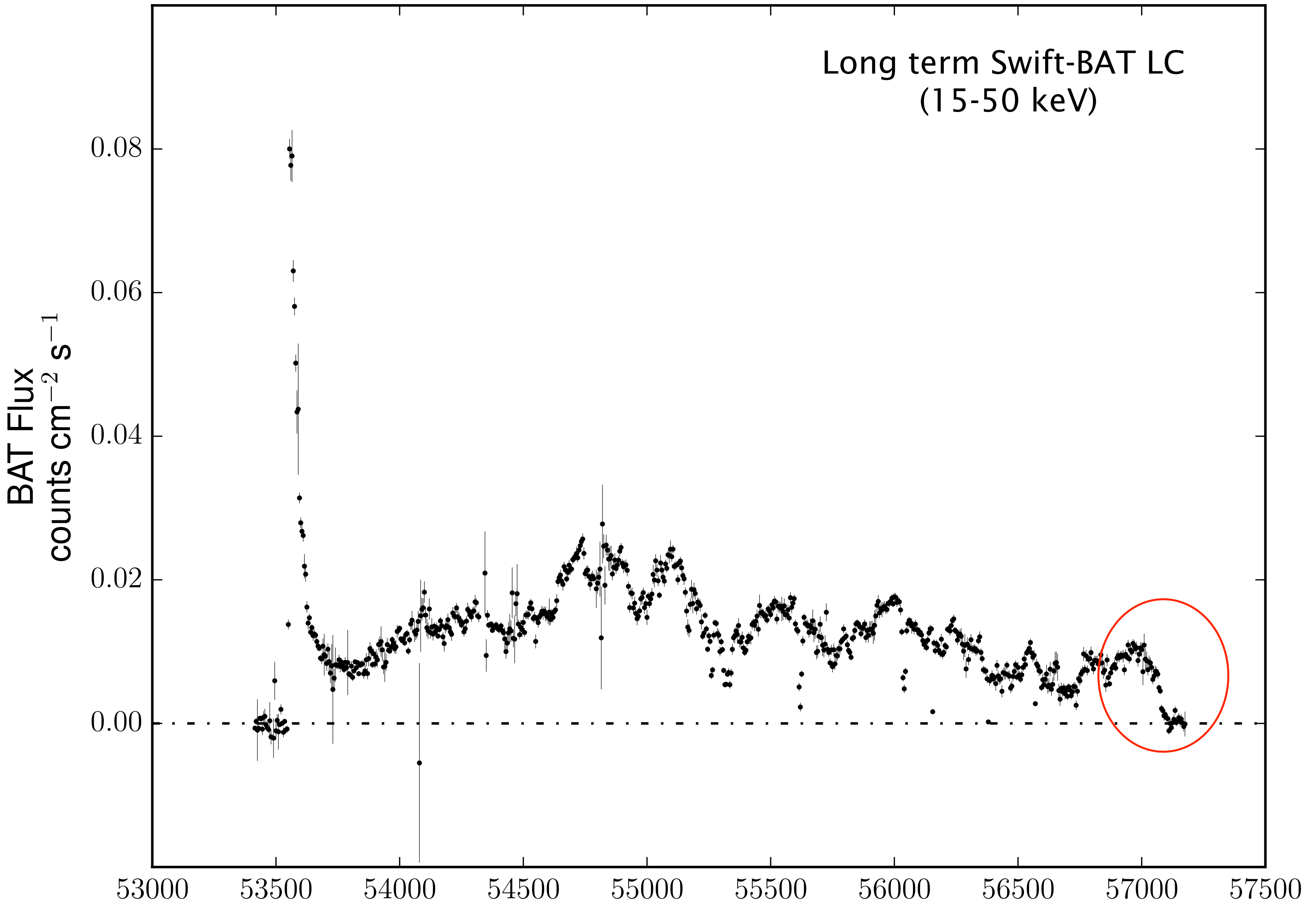
Background

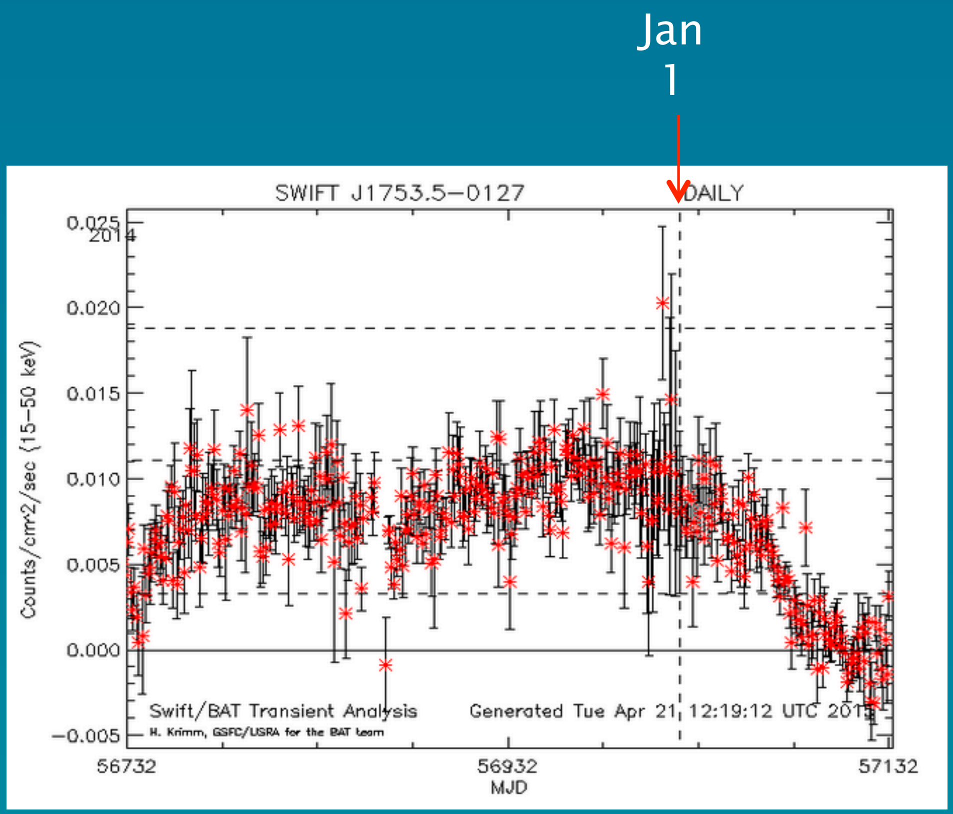
- Discovered in 2005 (Palmer+05) as a transient, however it has still not returned to quiescence >10 years later!
- Source has never entered the soft state, however it has experienced at least 4 short term spectral softenings (Yoshikawa+15) – ‘failed’ state- transitions (Soleri+13).
- BHC with one of the shortest orbital periods (3.24h; Zurita+08), but recent observations suggest it may be even shorter (Neustroev+14).

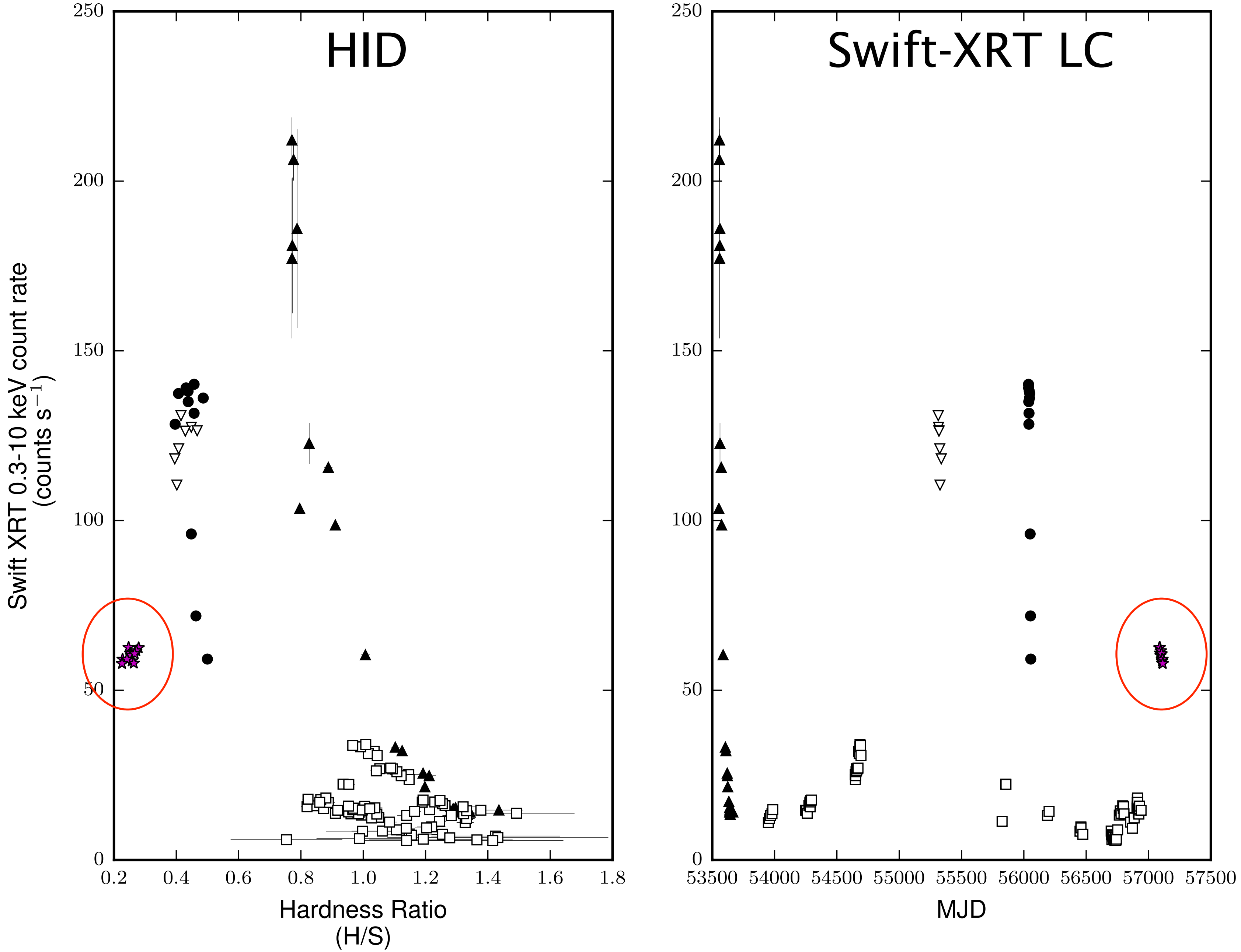


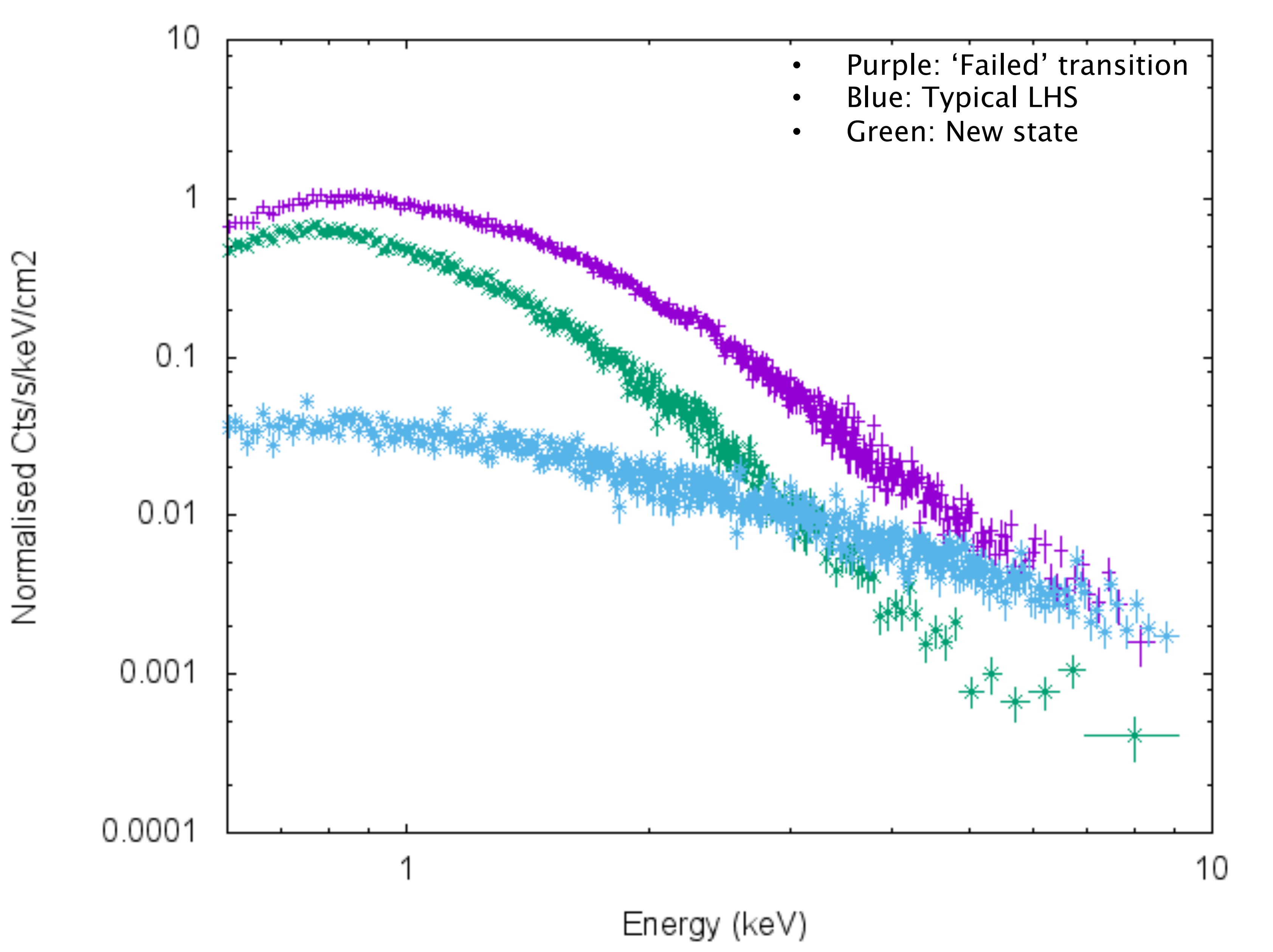
Long term Swift-BAT LC
(15-50 keV)
BAT Flux
counts cm^{-2} s^{-1}
0.08
0.06
0.04
0.02
0.00
53000
53500
54000
54500
55000
55500
56000
56500
57000
57500

Recent developments

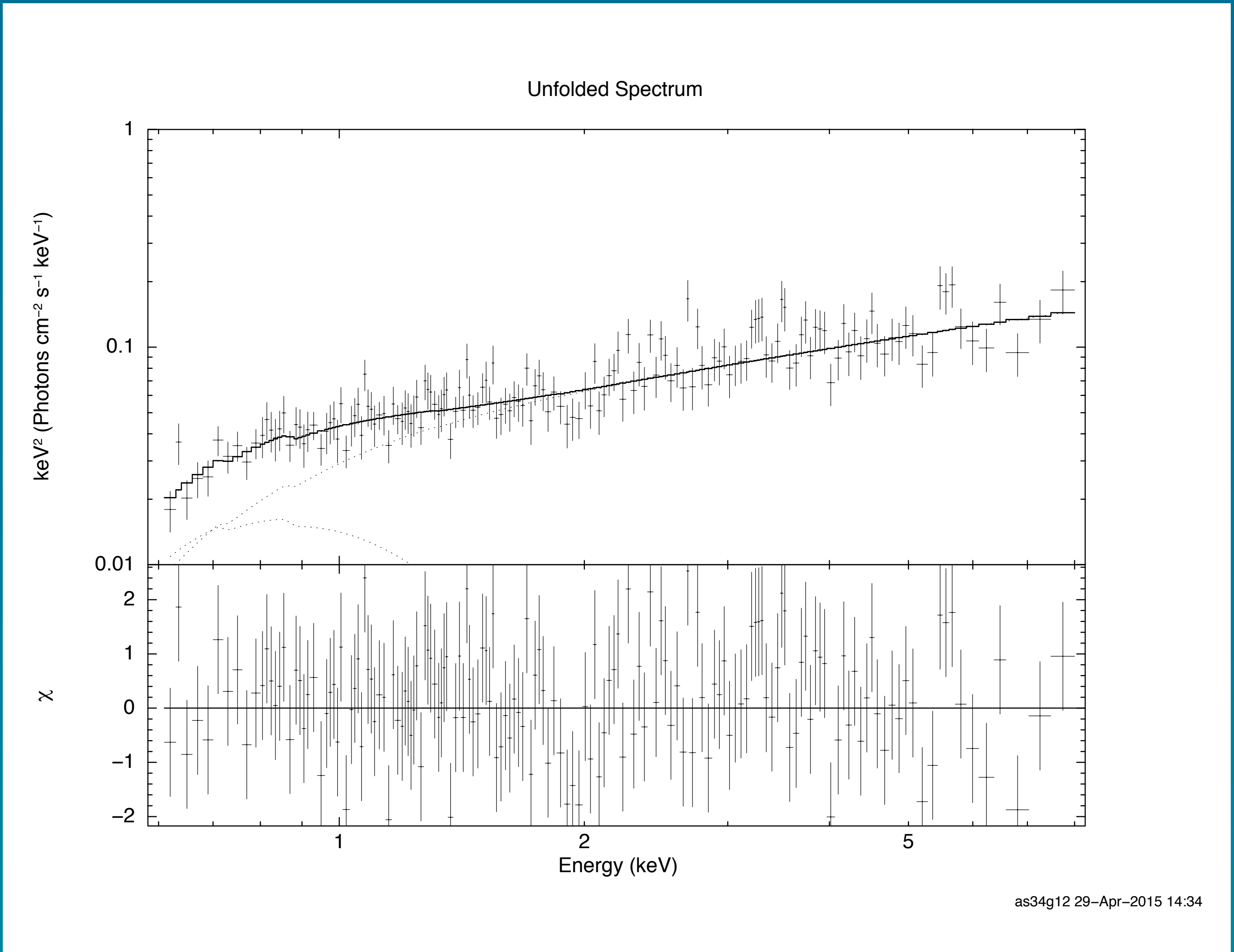
- Significant decrease in hard X-ray flux (Swift-BAT). Count rate in Swift-XRT had increased dramatically.
- Swift observations revealed softest spectrum seen in J1753, well constrained by diskbb +pow (Tin=0.36 keV, Γ=4.1!).
- Comparisons with previous observations in LHS and during failed transition imply a first time transition to the soft state.



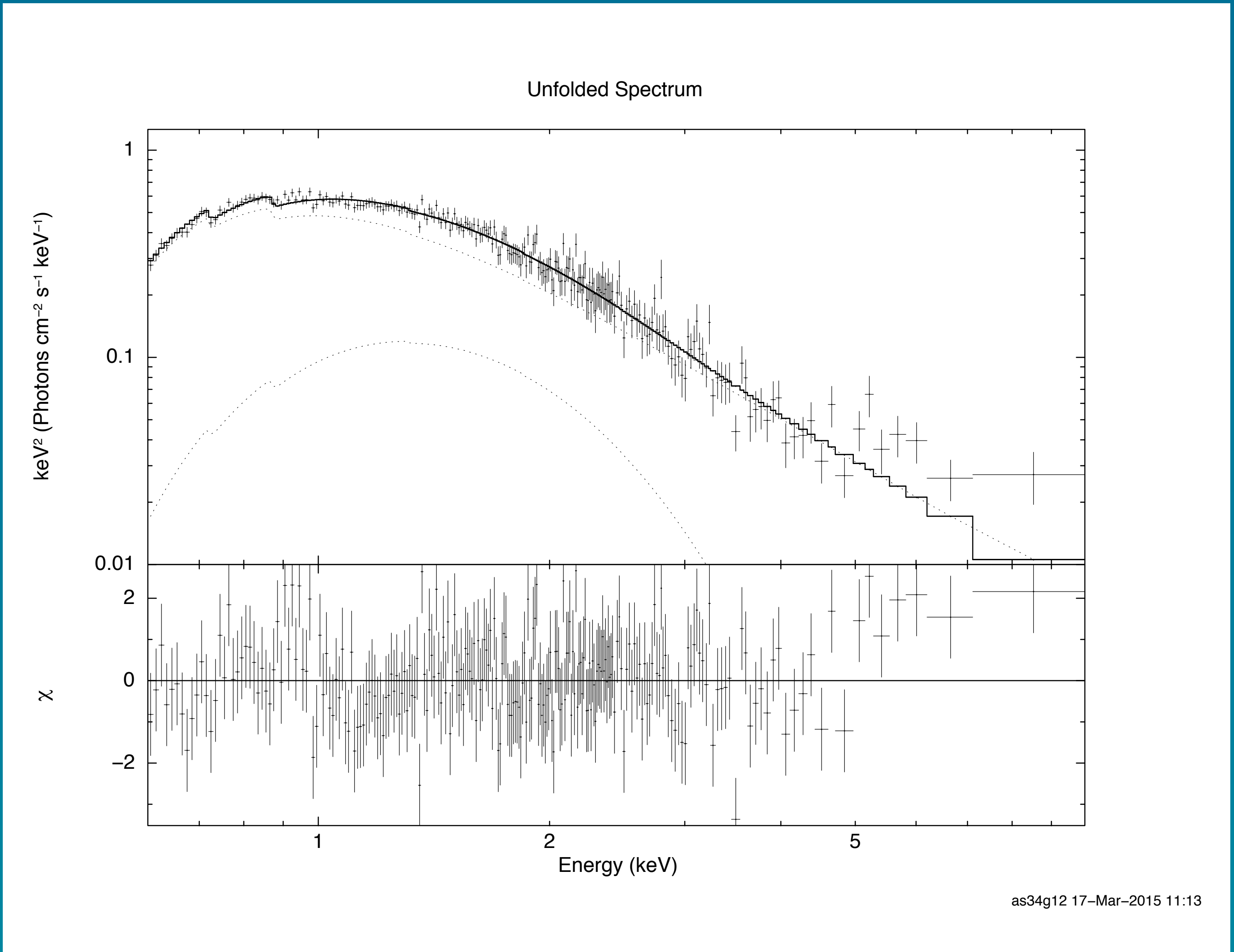

HID
Swift-XRT LC
Swift XRT 0.3-10 keV count rate
(counts s^{-1})
Hardness Ratio
(H/S)
MJD
250
200
150
100
50
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
53500
54000
54500
55000
55500
56000
56500
57000
57500



Purple: 'Failed' transition
Blue: Typical LHS
Green: New state
Normalised Cts/s/keV/cm2
Energy (keV)
10
1
0.1
0.01
0.001
0.0001
1
10



- Jun 2013 (Typical LHS)
- Tbabs*(diskbb+pow) -> χ^2/dof = 1.02
- Flux (0.6-10keV) = 3.65E-10 cgs
- Flux (2-10keV) = 2.79E-10 cgs

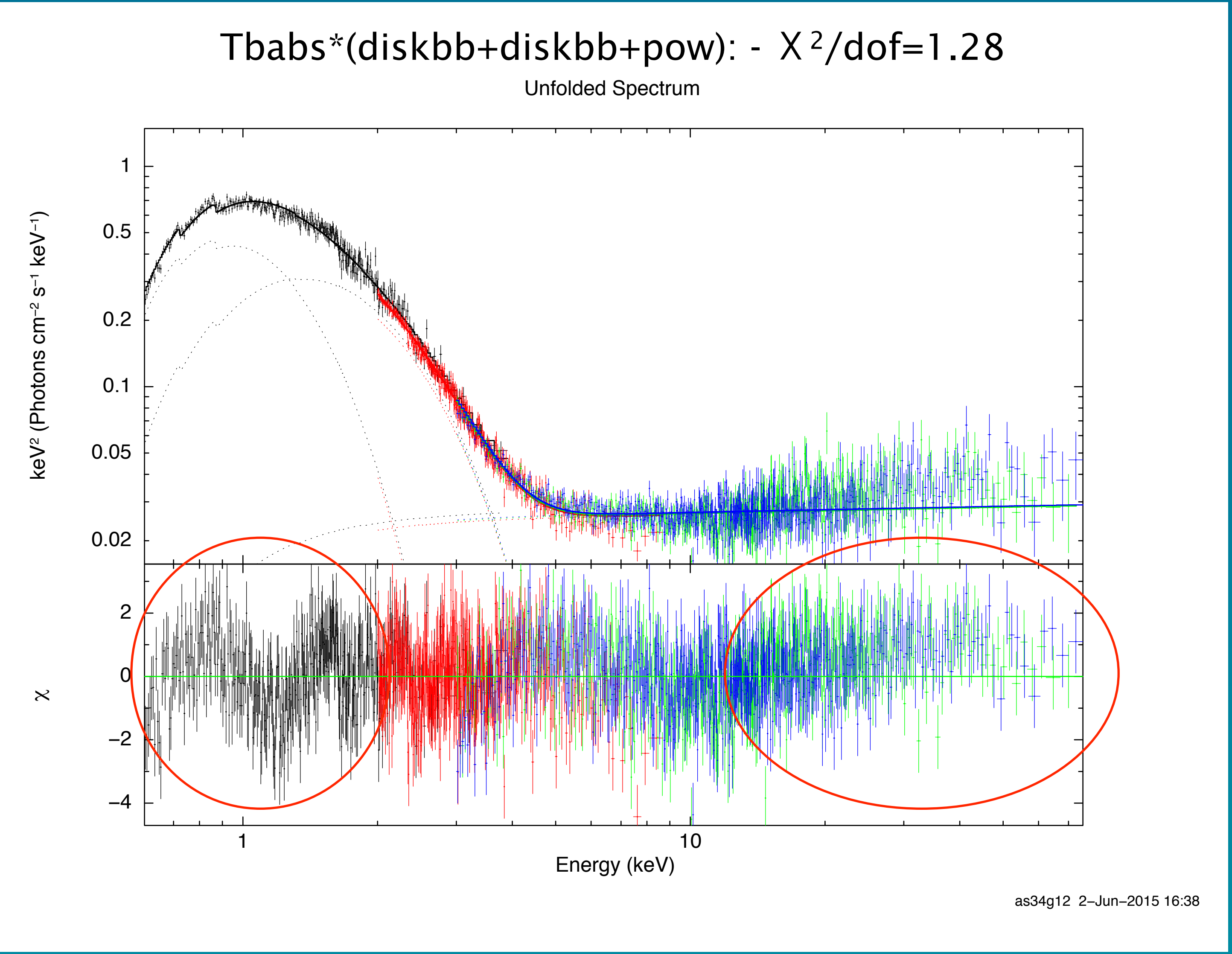


- 11 Mar 2015 (First Swift spectrum in new state)
  - Tbabs*(diskbb+pow) -> χ^2/dof = 1.05
  - Flux (0.6-10keV) = 1.1E-9 cgs
  - Flux (2-10keV) = 1.85E-10 cgs
  - Excess >5 keV

XMM + NuSTAR

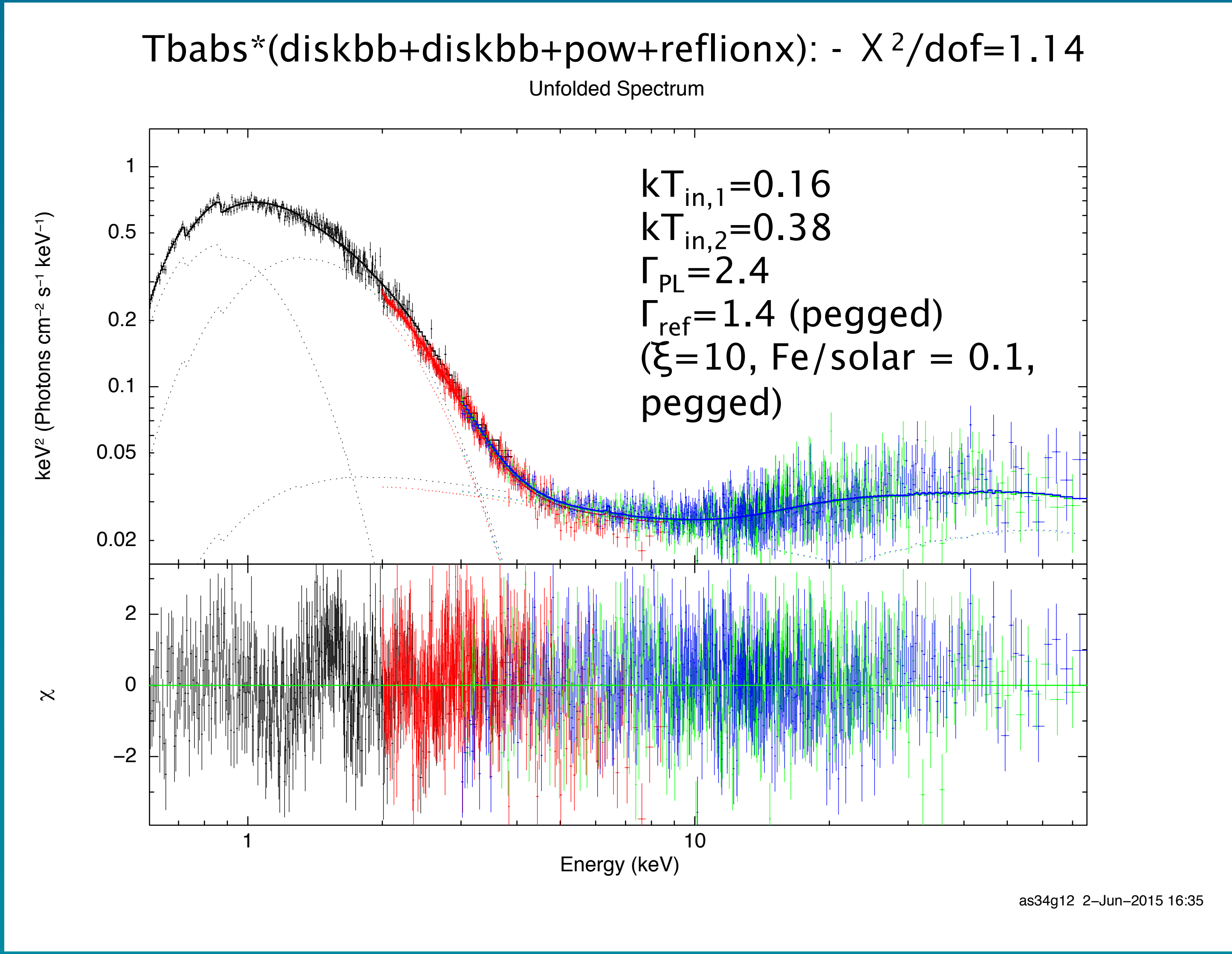
- 40 ks XMM DDT (30ks Timing Mode; 10ks Burst Mode) + 30ks NuSTAR DDT granted and performed 2015 Mar 19
- Spectrum shows that the hard component has decayed significantly, whilst the soft component has increased. $F_{PL,unabs}$(2-10keV) ~ 7E-11, compared with LHS $F_{PL,unabs}$(2-10keV) ~ 2.5E-10 (Tomsick+15; submitted - which was already in one of the lowest hard states recorded).
- Fitting of entire spectrum is not trivial – XMM timing mode data appears to be poor below ~2 keV. Burst mode data aiding fitting.
- A number of models have been attempted, none have been perfect.

Fits



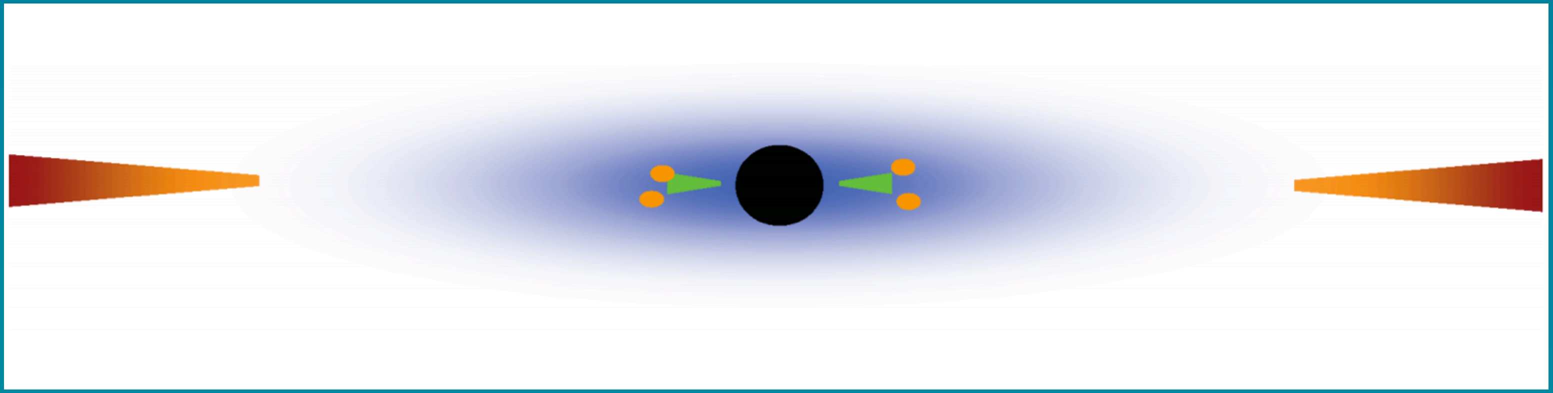
Tbabs*(diskbb+diskbb+pow): - Χ 2/dof=1.28
Unfolded Spectrum
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
1
0.5
0.2
0.1
0.05
0.02
χ
2
0
−2
−4
1
10
Energy (keV)
as34g12 2−Jun−2015 16:38

Fits


Tbabs*(diskbb+diskbb+pow+reflionx): - Χ 2/dof=1.14
Unfolded Spectrum
kT in,1=0.16
kT in,2=0.38
Γ PL=2.4
Γ ref=1.4 (pegged)
(ξ=10, Fe/solar = 0.1,
pegged)
keV2 (Photons cm−2 s−1 keV−1)
1
0.5
0.2
0.1
0.05
0.02
χ
2
0
−2
1
10
Energy (keV)
as34g12 2−Jun−2015 16:35

An extra soft component?

- The need for an additional soft component to constrain the X-ray spectrum is not new (see e.g. Wilkinson & Uttley 12; Chiang+10). The need for the additional component is amplified by the new accretion state of J1753.
- Supports the idea of two accretion discs (Chiang+10; Tomsick+15). An inner, residual accretion disc as well as the strongly truncated disk at a larger radius.



Chiang+10

Reflection

- Low reflection covering fraction ($\Omega/2\pi \sim 0.15$) – in agreement with previous measurements (Tomsick+15).
- Low ionization ($\xi < 10$) – cool accretion disk, reflection component from outer disk?
- High ionization solution also potentially viable - reflection component from inner disk?
- Two power law indices – reflector sees a different continuum (See e.g. Fuerst+15, submitted).

Future

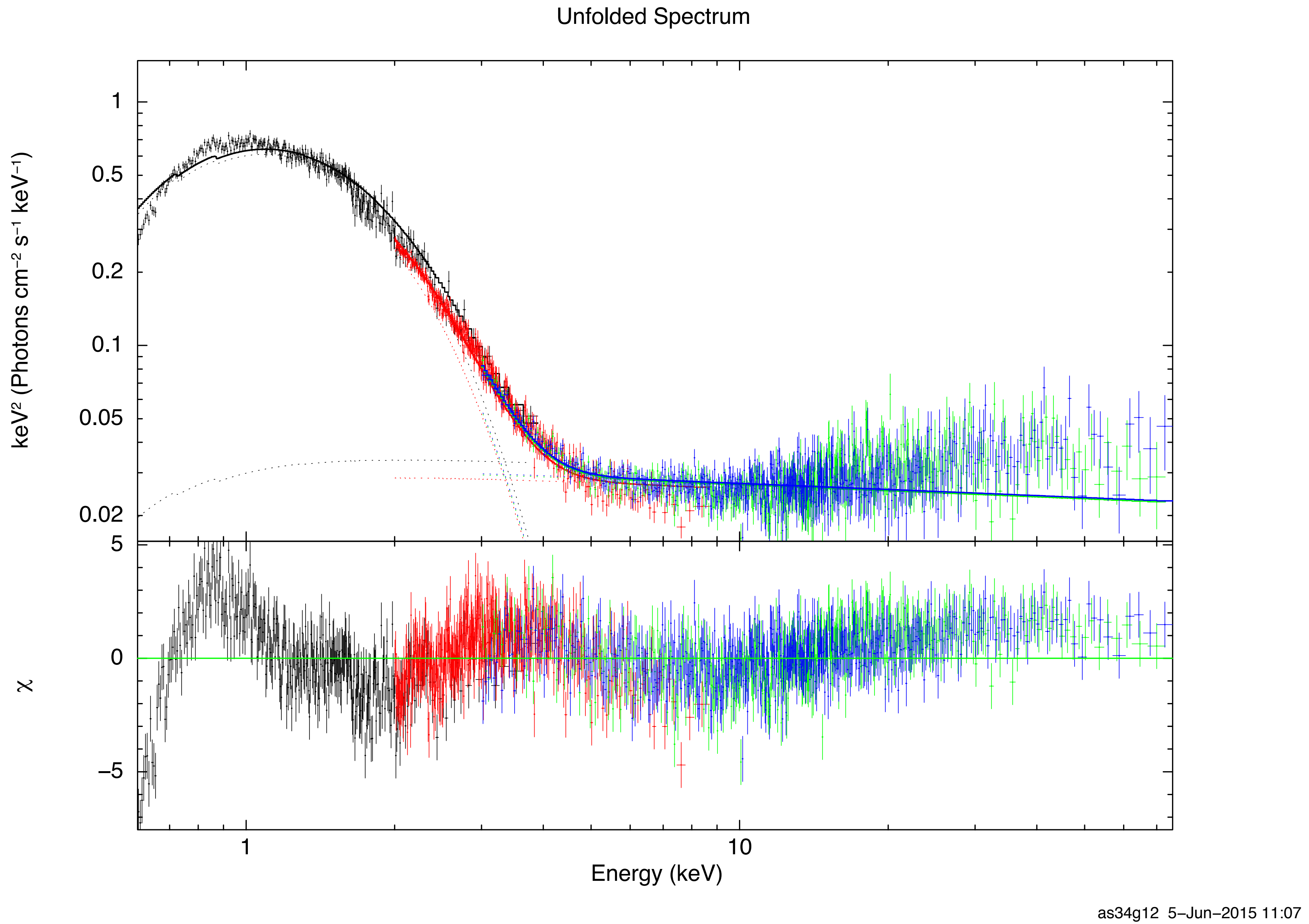
- Huge multi-wavelength observing campaign (Radio – X-ray).
- Timing – fast photometry (SALT), XMM timing mode, future observations w/ ULTRACAM (simultaneous Swift).
- Winds in the new state? XMM-RGS data could reveal evidence of outflows.
- JVLA DDT observation in soft state – strong upper limit on radio flux in soft state.

Conclusions

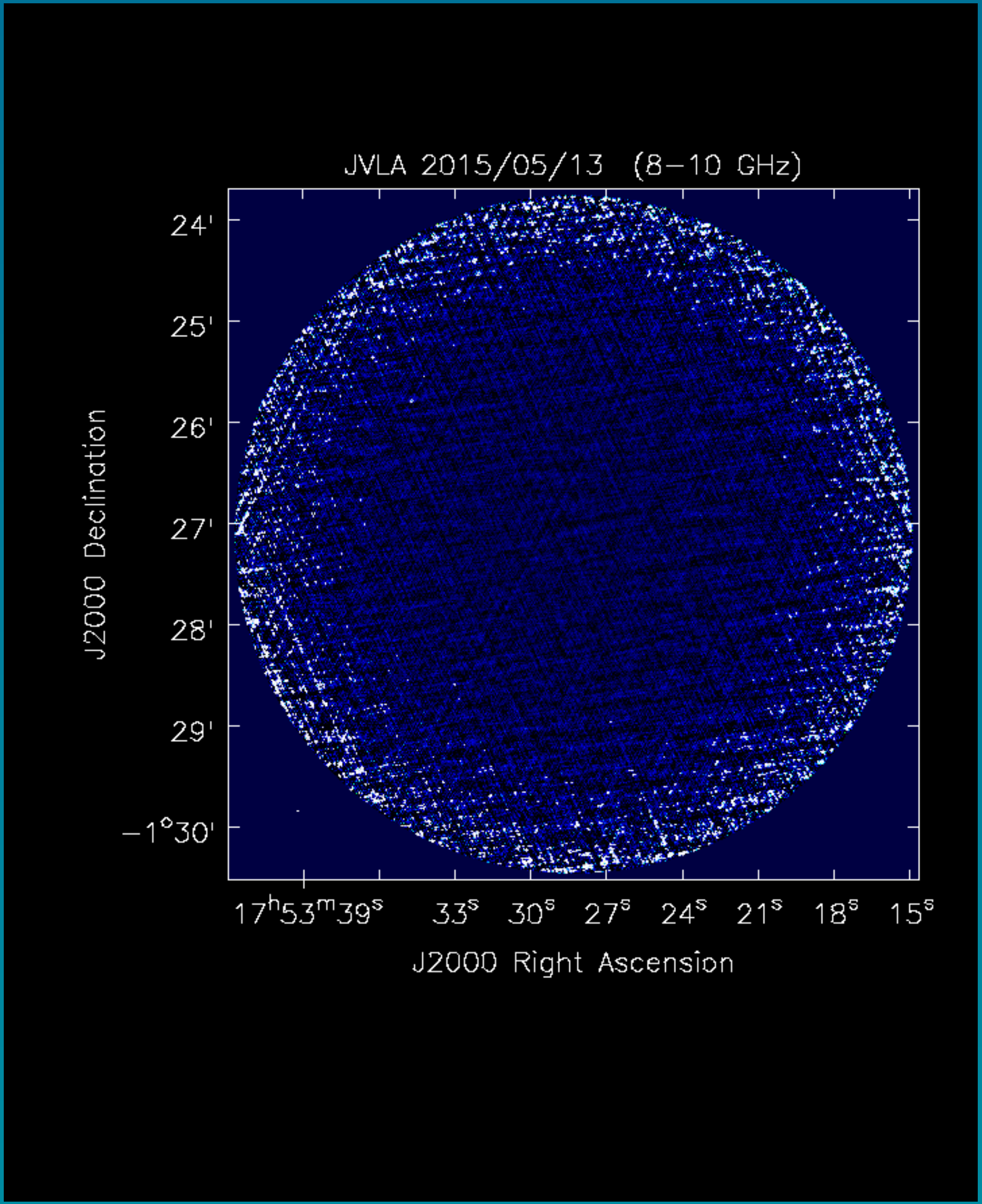
- J1753 entered a new low-luminosity soft state in March 2015
- Joint XMM-NuSTAR observation revealed extremely soft spectrum, well constrained by two diskbbs + powerlaw + reflection component
- Evidence for two accretion disks – inner, hotter disk plus truncated outer disk.
- Radially extended corona with a non-uniform temperature profile?
- Huge multi-wavelength observing campaign – this is a work in progress!

Supplementary Material

- One diskbb spectrum
- Radio image



Unfolded Spectrum
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
1
0.5
0.2
0.1
0.05
0.02
5
0
−5
χ
1
10
Energy (keV)
as34g12 5−Jun−2015 11:07



JVLA image

8uJy upper limit

Simultaneous Swift shows source in even lower luminosity soft state (HR=0.2, flux=21ct/s)

Rushton et al. in prep.