9th FERO Meeting – Heraklion, 23-25 May 2018

NGC 1068 – A deep view into the Compton-thick absorbing medium

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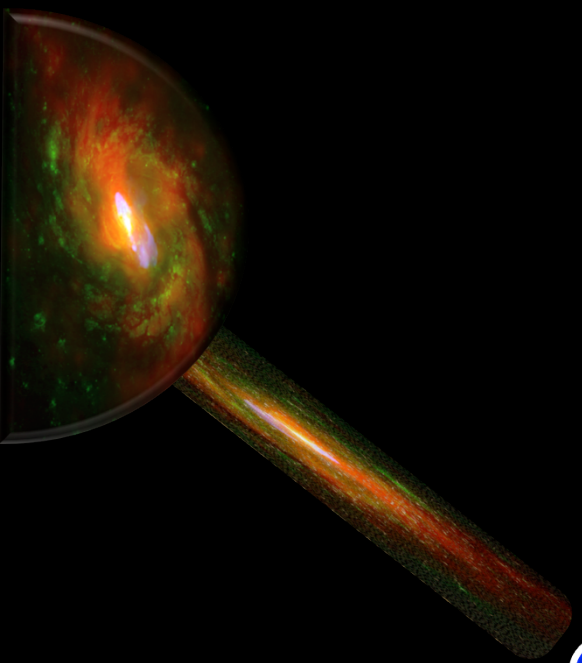
ROMA TRE
UNIVERSITÀ DEGLI STUDI

Outline



- *The circumnuclear region of NGC 1068*
- *The 2017-2018 NuSTAR monitoring*
- *Preliminary results*

- *What's next?*

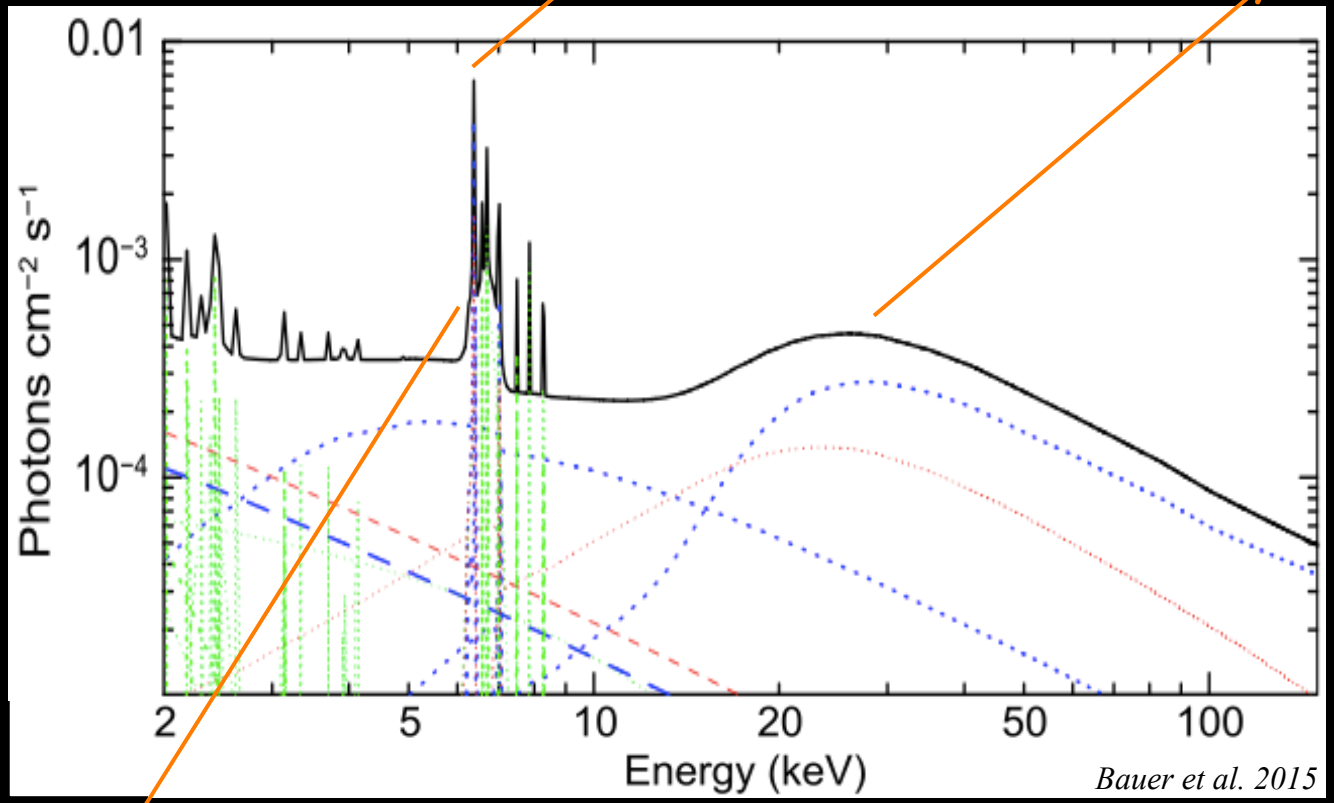
Unveiling the nucleus of NGC 1068

Bauer et al. (2015)

The broadband cold reflected emission of NGC 1068 is due to multiple reflectors with three distinct column densities.

$N_{H,2} = (1.5 \pm 0.1) \times 10^{23}$ cm^{-2}

$N_{H,1} \sim 10^{25}$ cm^{-2}



$N_{H,3} \sim (4\text{-}10) \times 10^{24}$ cm^{-2}

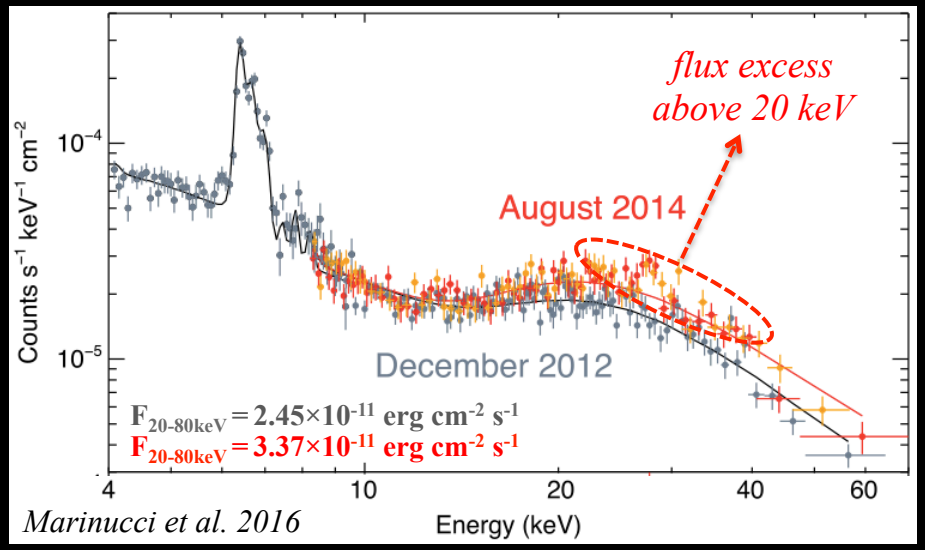
Almost 30% of the neutral Fe Kα line flux arises from regions outside the central 140 pc and is clearly extended.

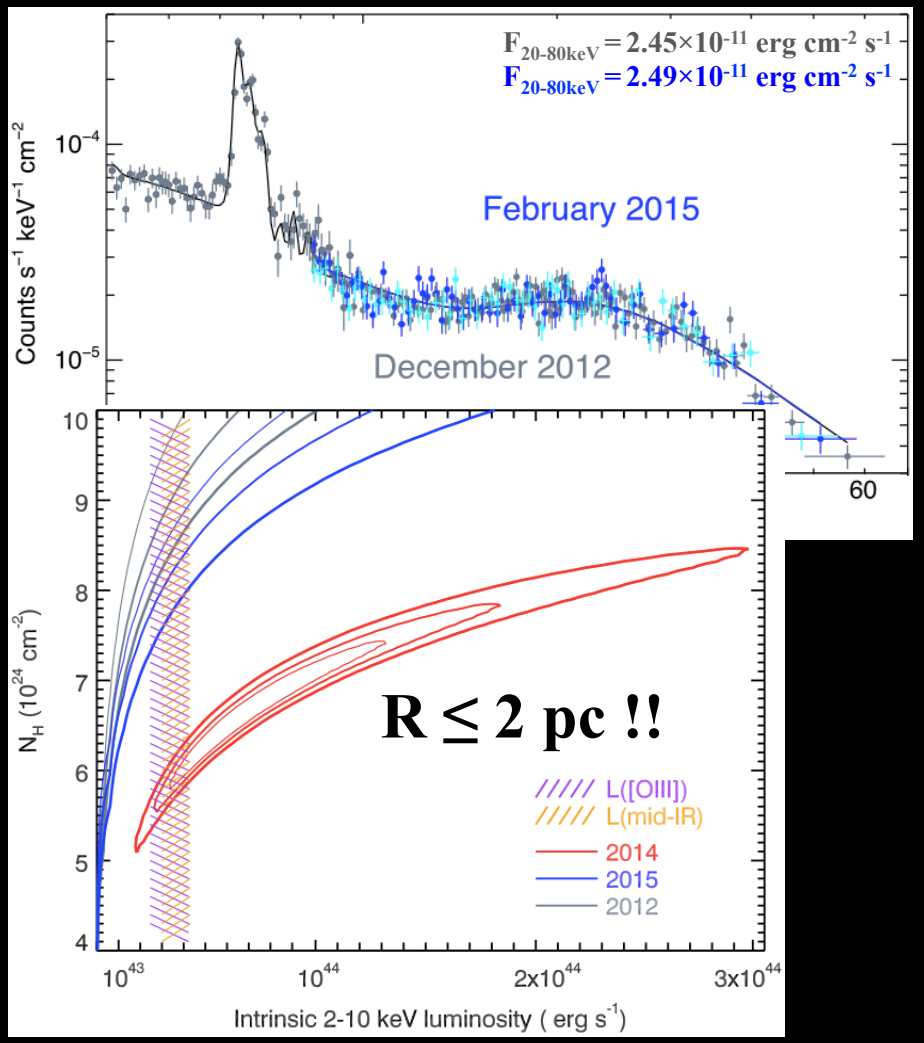
Monitoring 2017-2018 – rationale

NuSTAR observation

Dec 2012 → Bauer et al. 2015

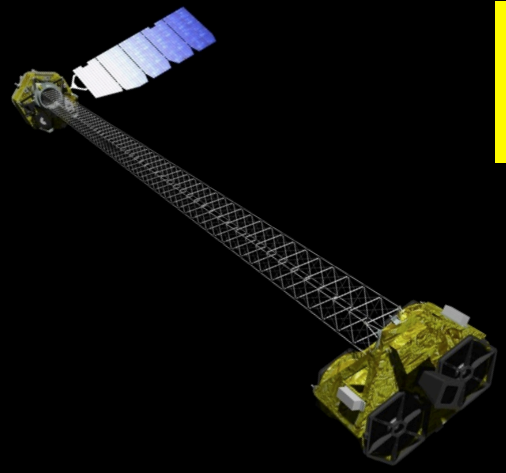
Aug 2014
Feb 2015 } joint XMM-Newton





Compton-thick unveiling event
($\Delta N_H \geq 2.5\times10^{24}$ cm^{-2})

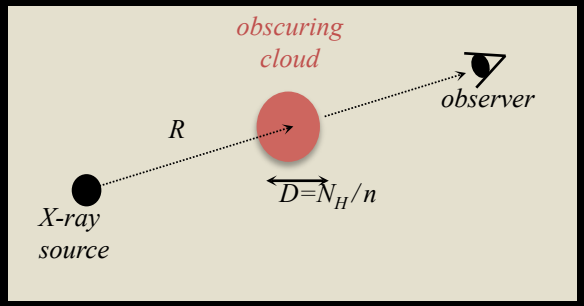
Monitoring 2017-2018 – aim and method

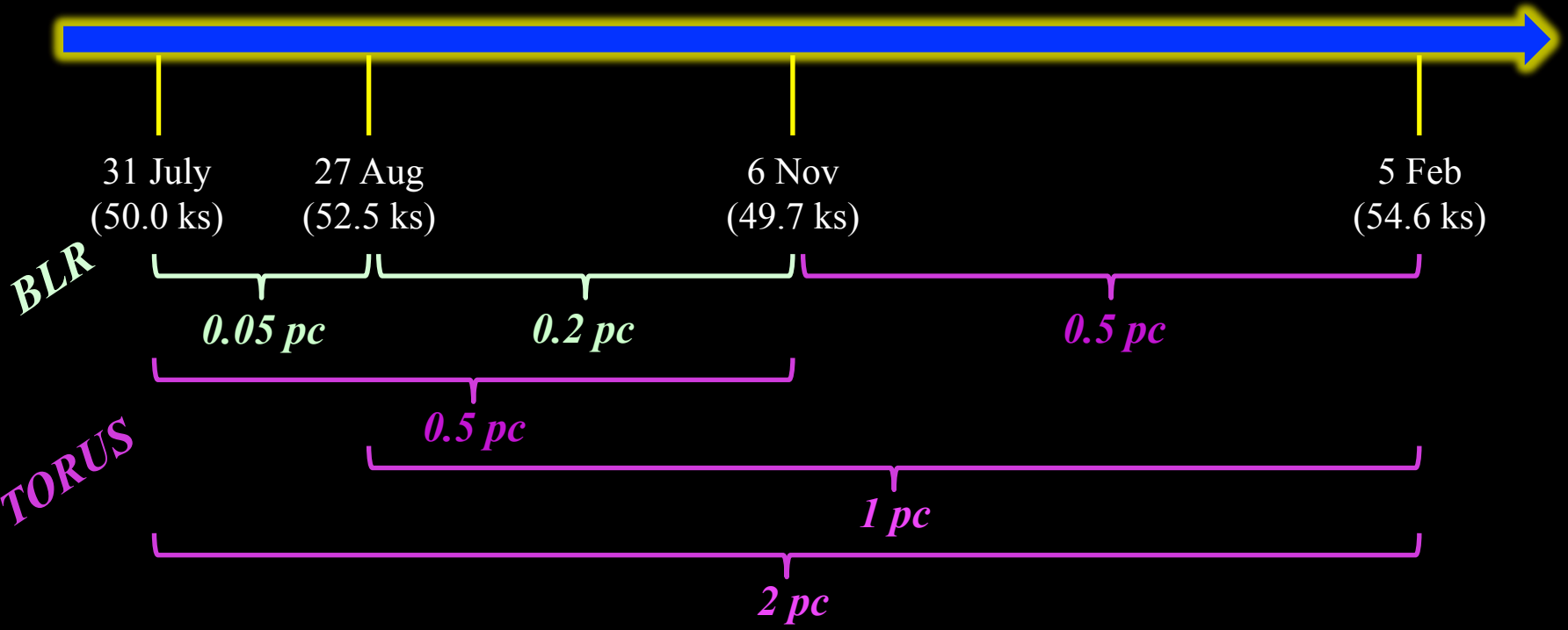


Aim: *to give tighter constraints on the location of the absorbing circumnuclear material*

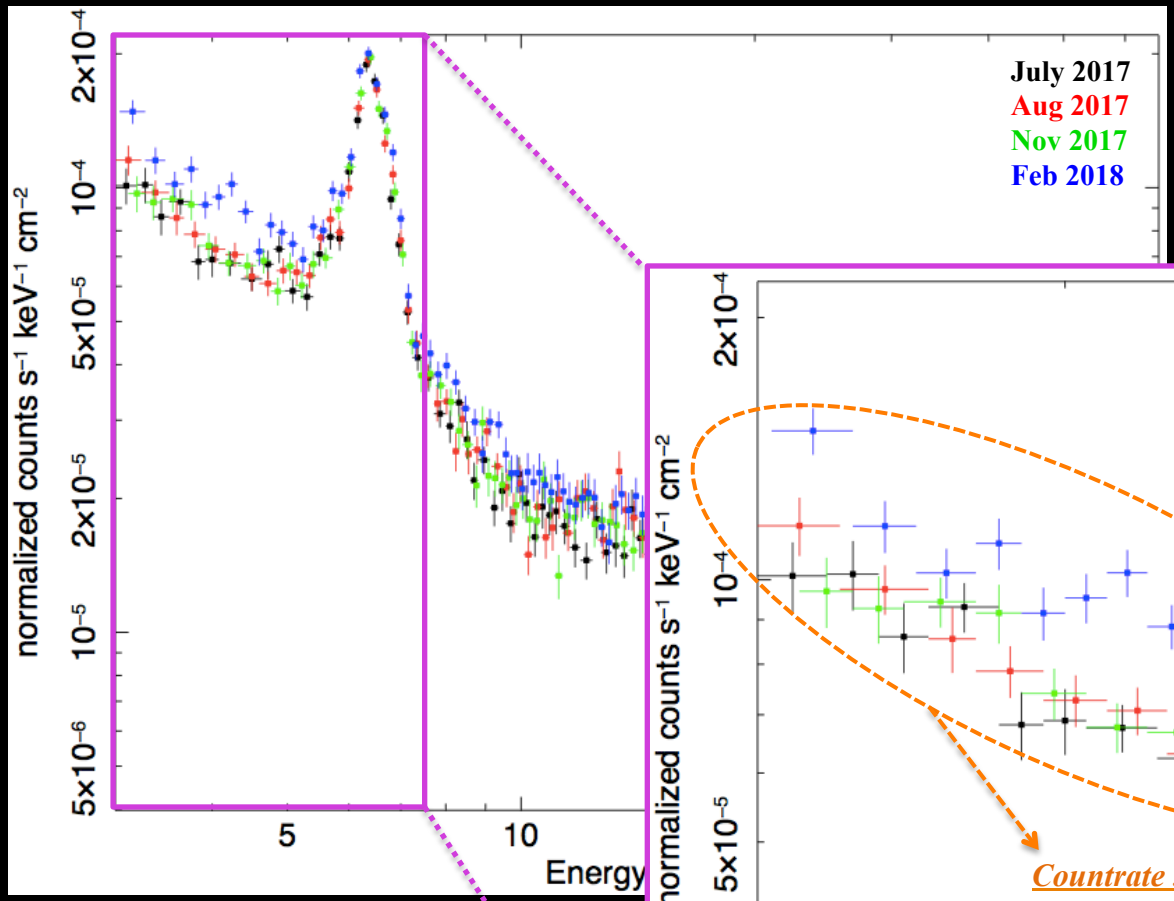
$$R = \frac{G M_{BH} t^2 n^2}{N_H^2}$$

$M_{BH} \sim 10^7\ M_\odot$
$n \sim 10^{10}\ cm^{-3}$
$N_H \sim 2.5 \times 10^{24}\ cm^{-2}$
$t \sim$ 1-6 months

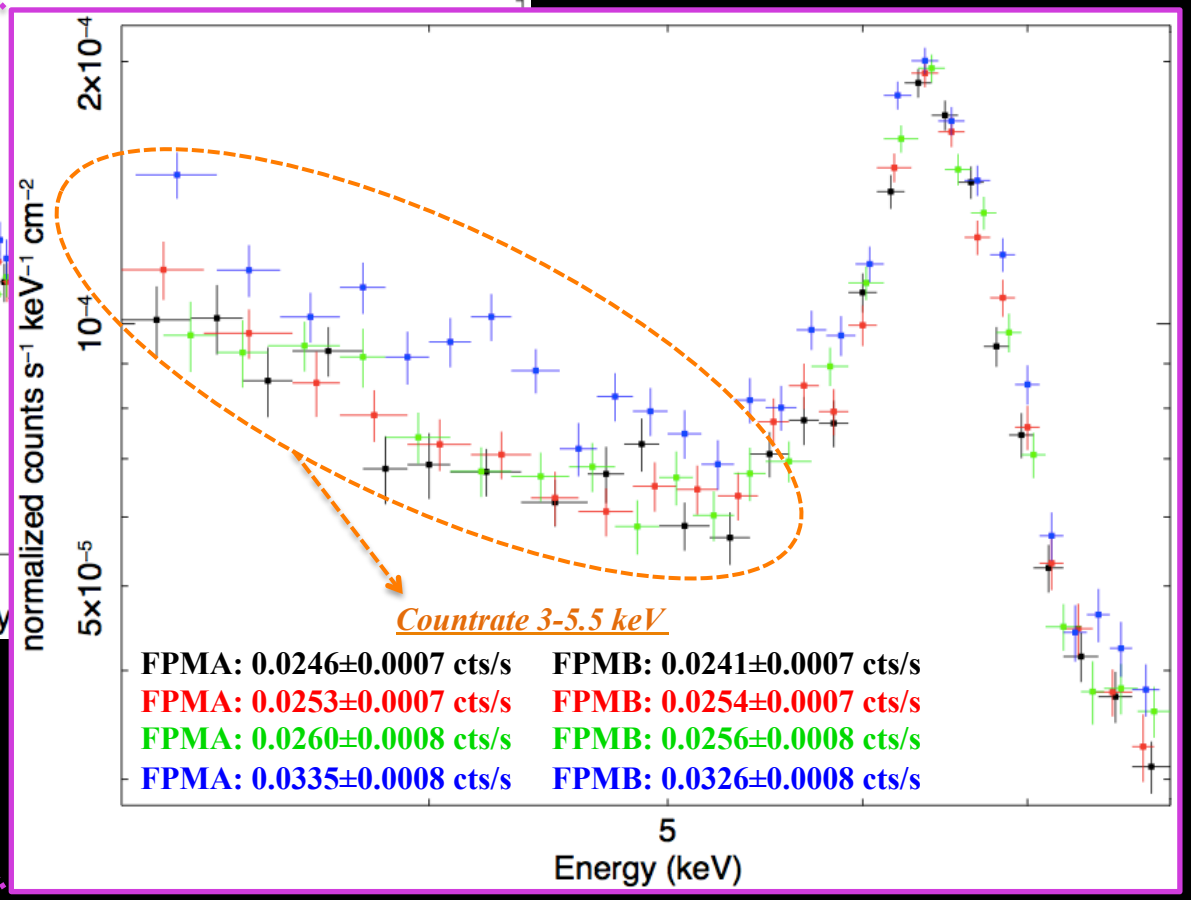




The 2017-2018 monitoring spectra – soft X band

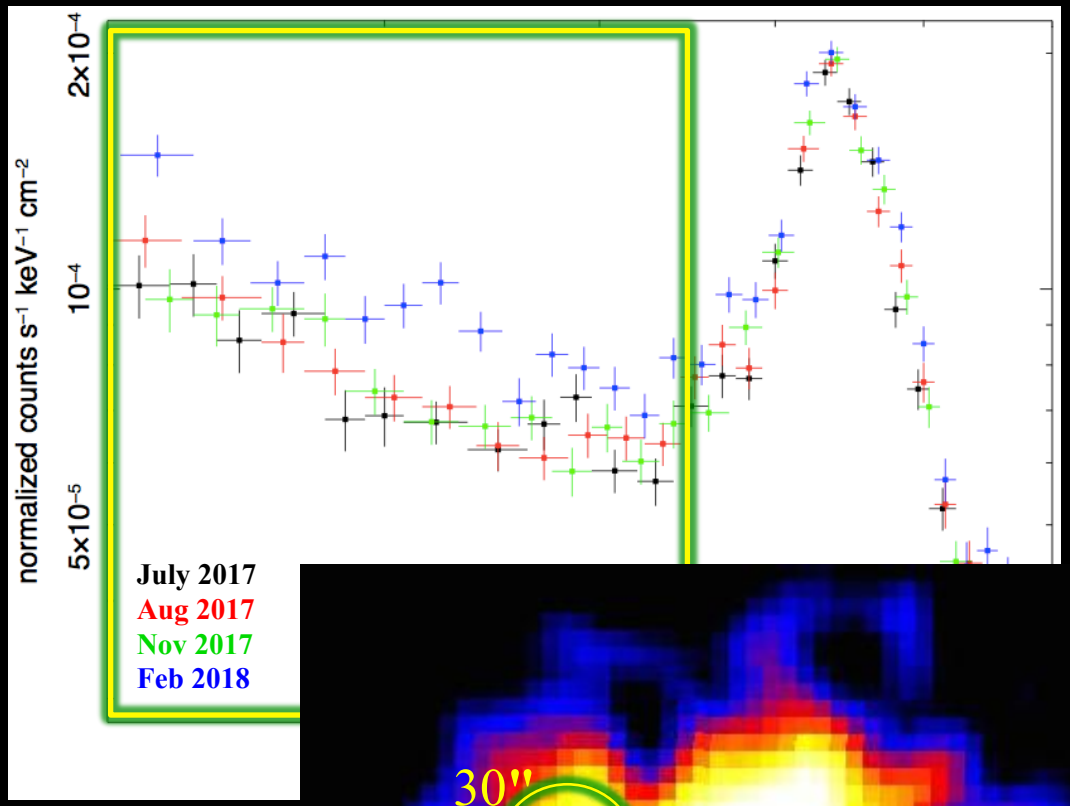


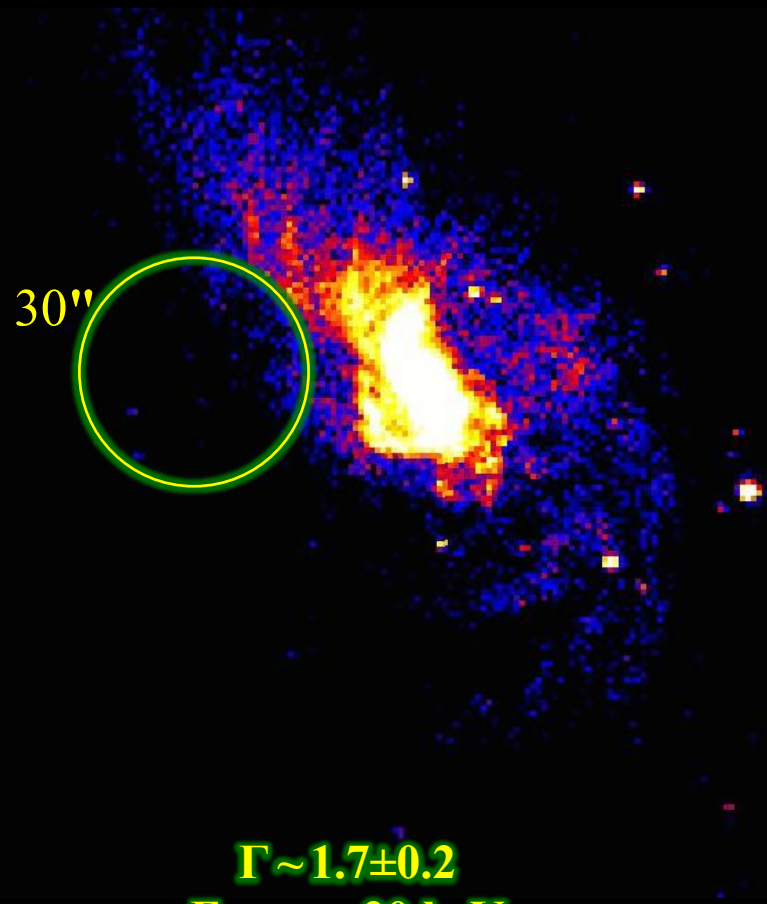
a. No evidence of Fe lines variation

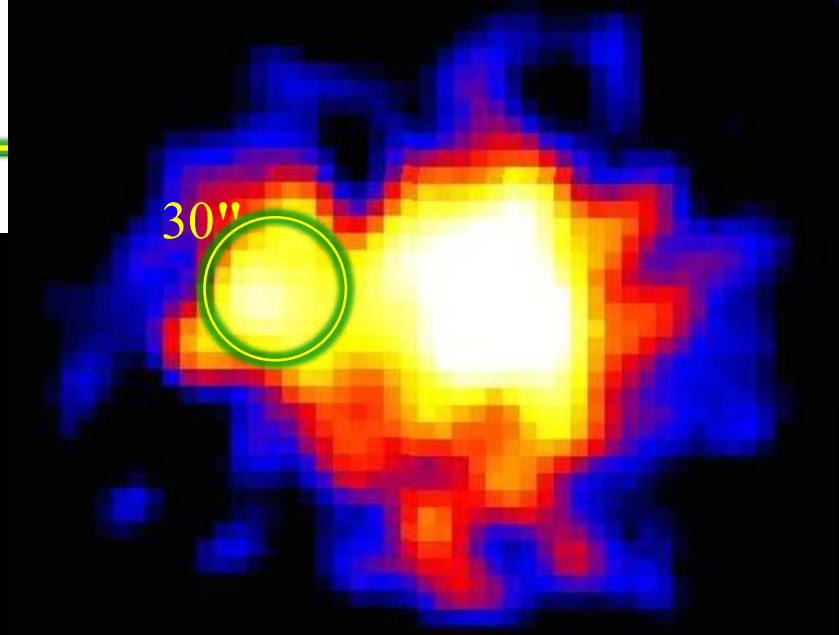


b. $F_{3\text{-}5.5keV}$ increases by ~35% in Feb 2018

A new object in NGC 1068?







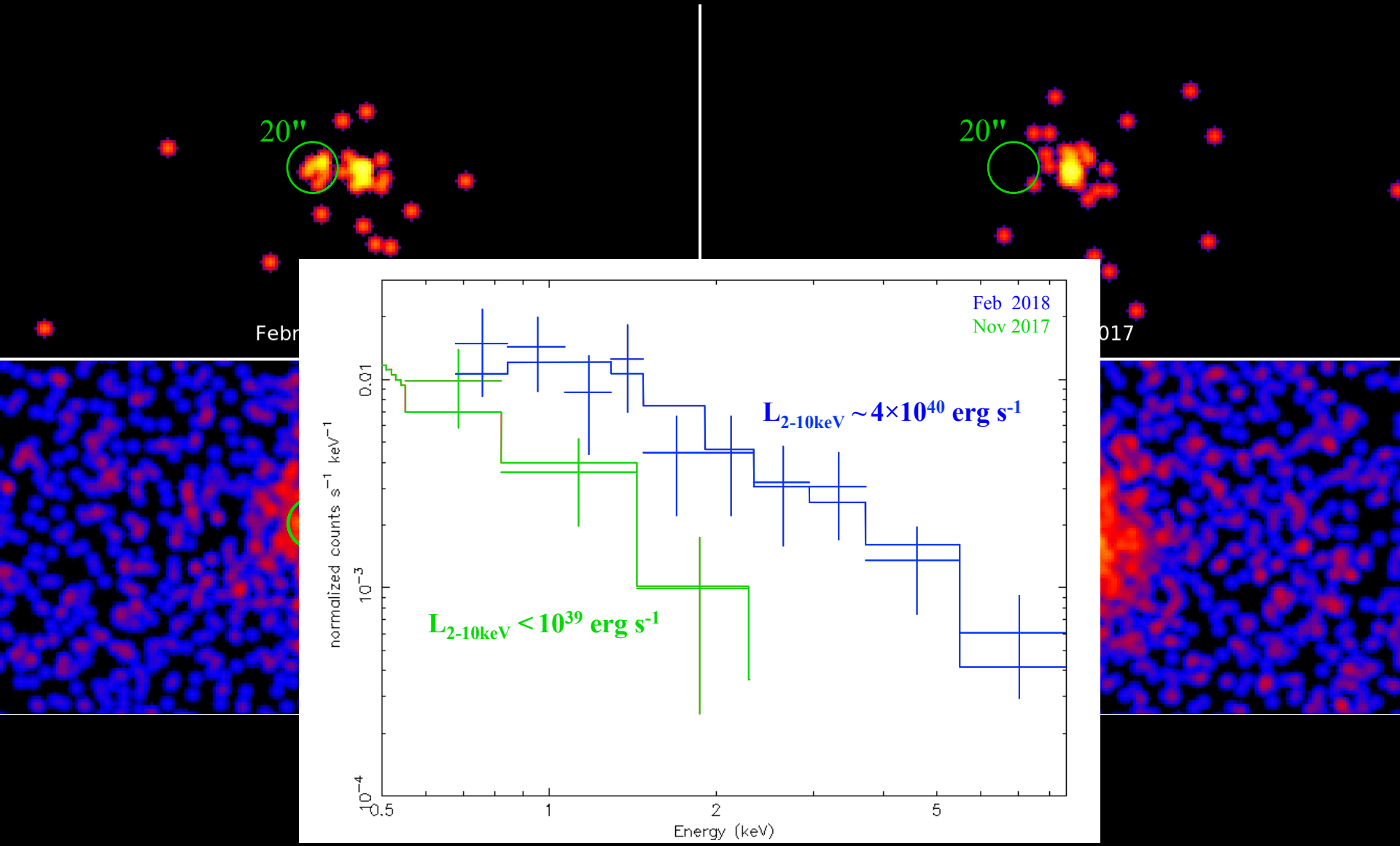
$\Gamma \sim 1.7 \pm 0.2$

$E_{cut\text{-}off} \sim 20$ keV

$L_{2\text{-}10keV} \sim 4 \times 10^{40}$ erg s^{-1}

A new object in NGC 1068?

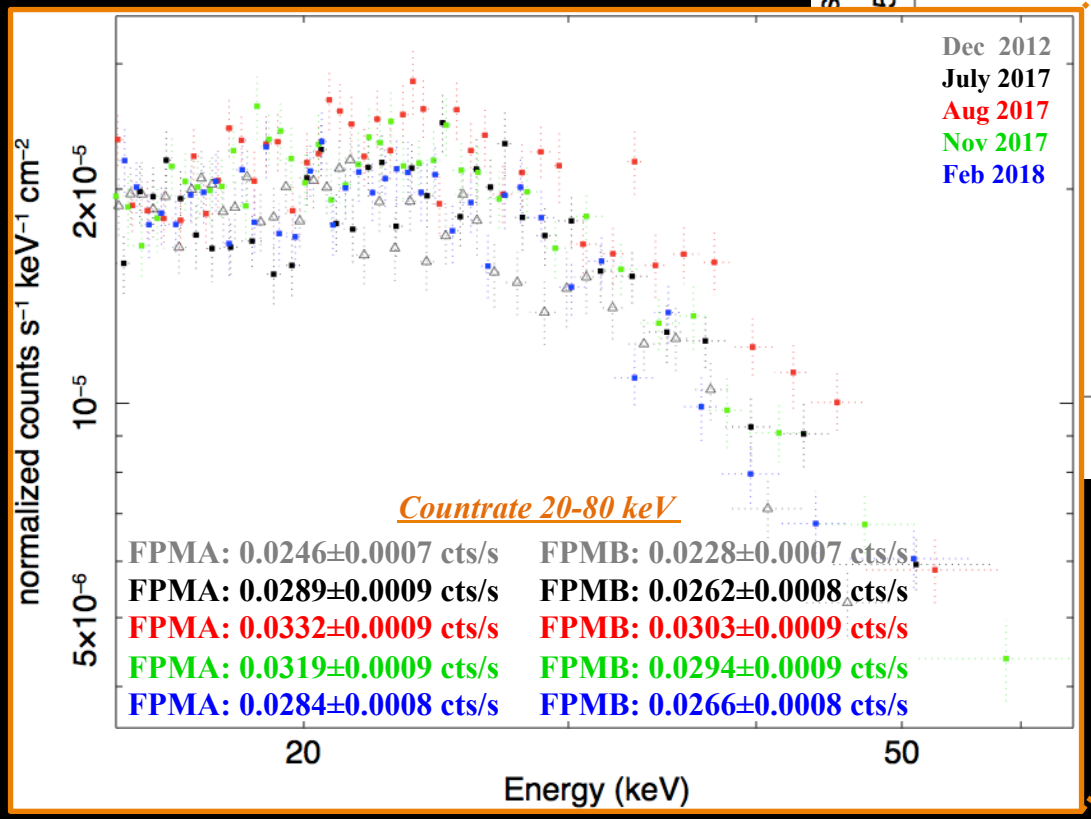
✧ *Simultaneous Swift data in the 3-5.5 keV band*

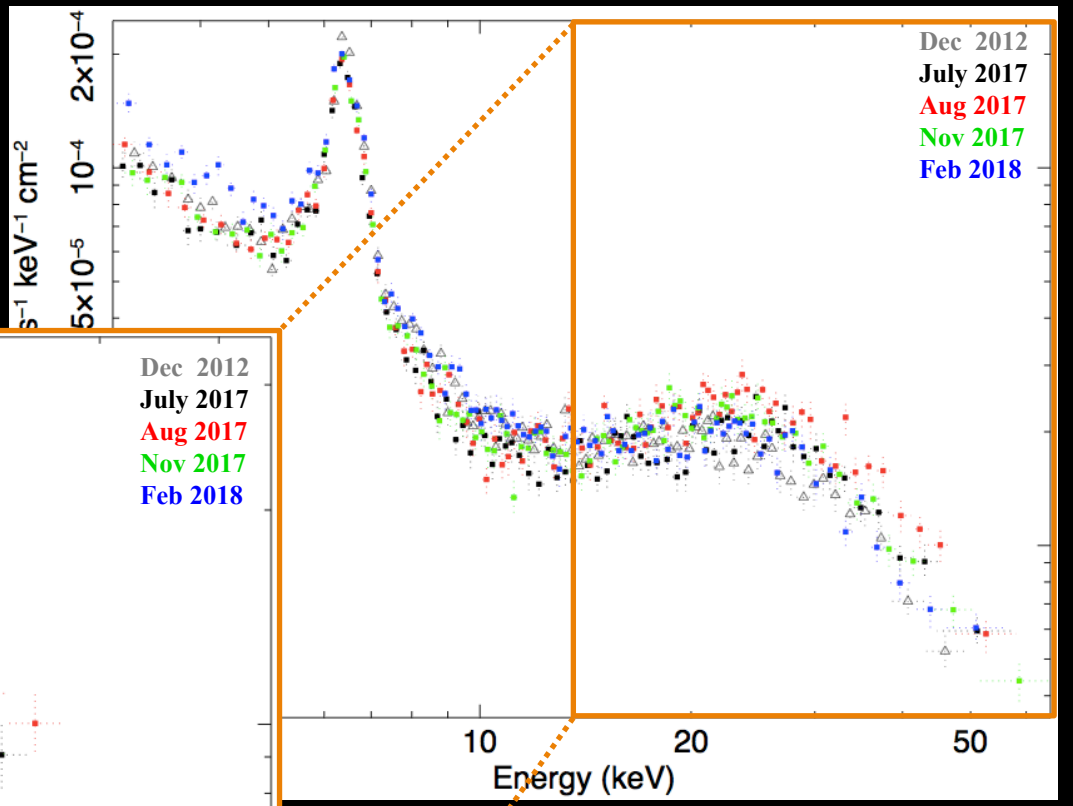


The 2017-2018 monitoring spectra – hard X band

✧ *Comparison between Dec 2012 low state and the monitoring spectra*

Aug 2017: high state
Feb 2018: low state
Jul&Nov 2017: to be explored!

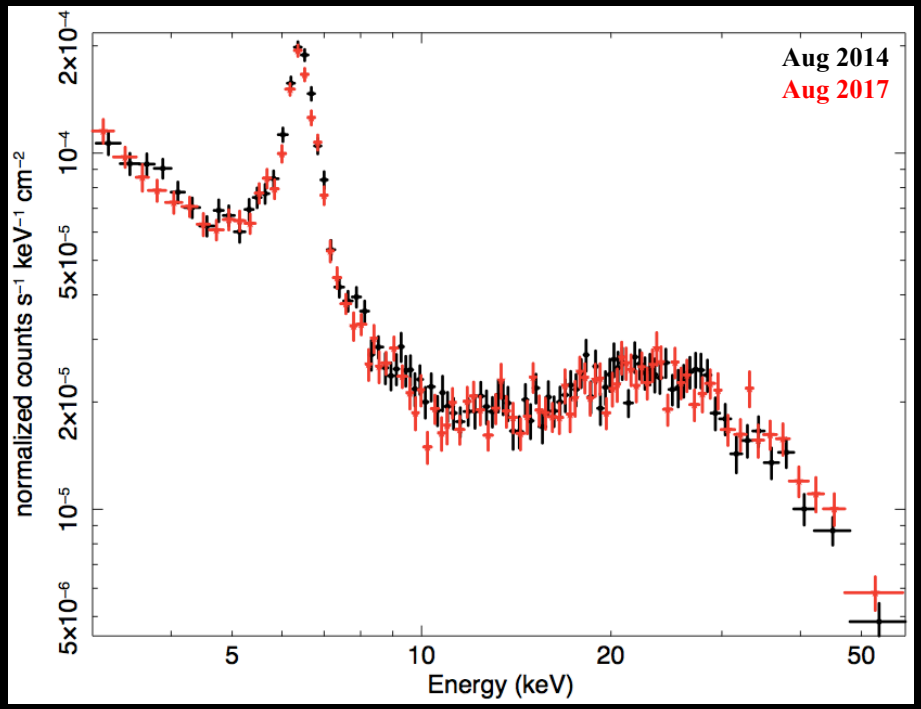


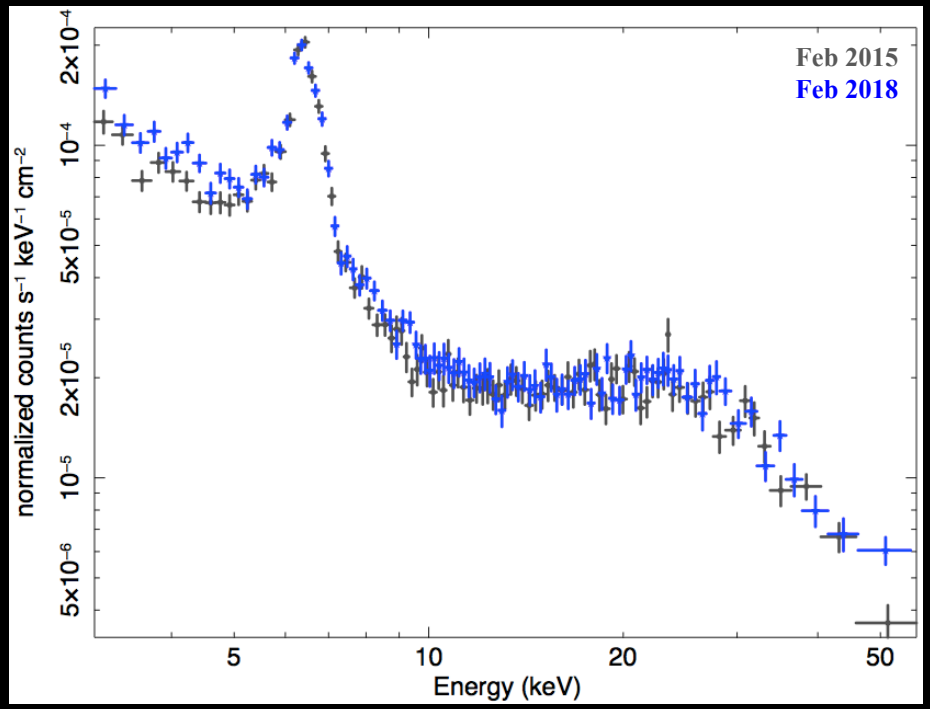


Aug 2014:
FPMA: 0.0329±0.0009 cts/s
FPMB: 0.0315±0.0009 cts/s

2014-2015 vs. 2017-2018

NGC 1068 during this monitoring shows a behaviour similar to that observed three years ago

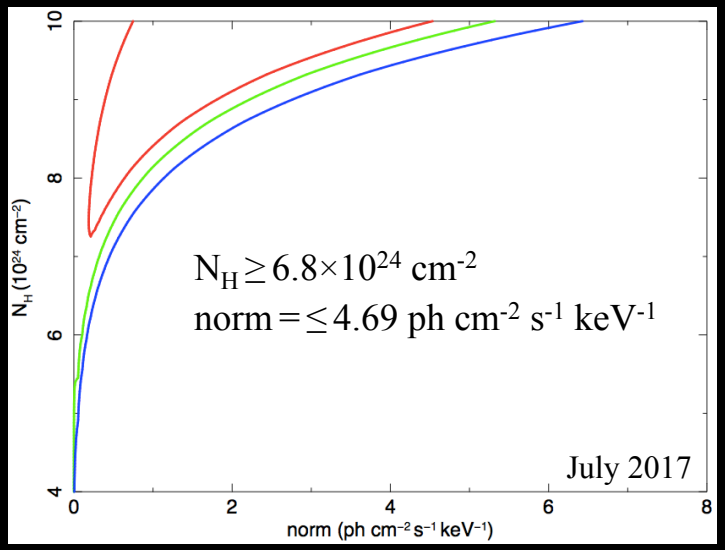


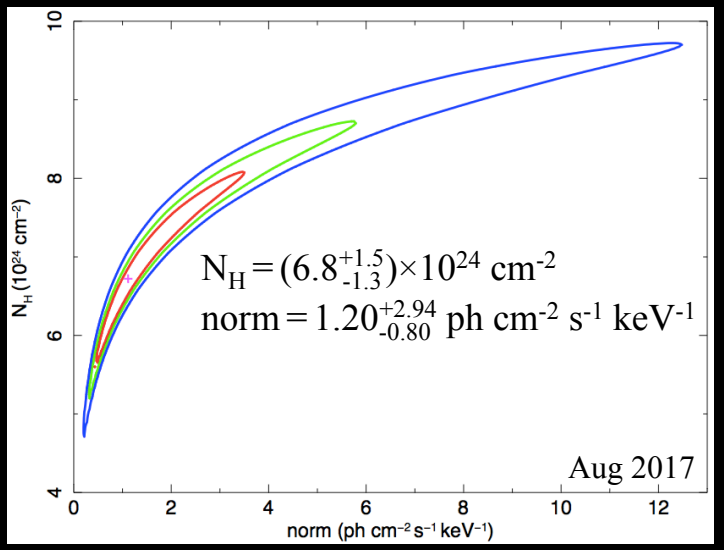


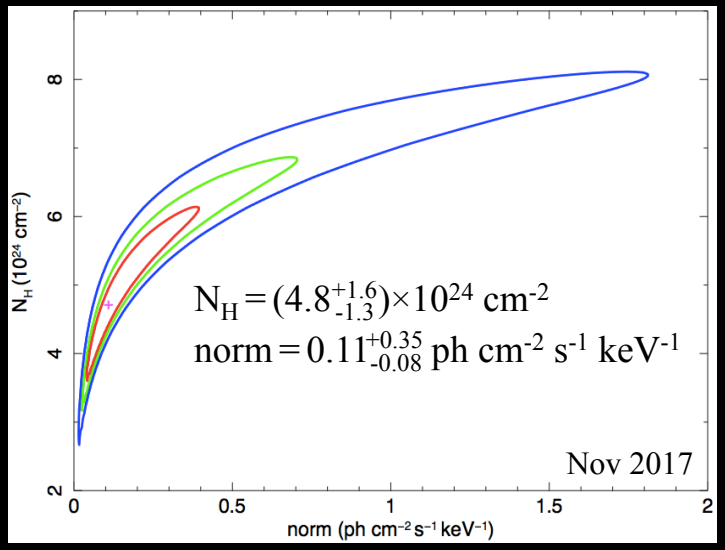
But we have two more observations available,
one of which is between these two…

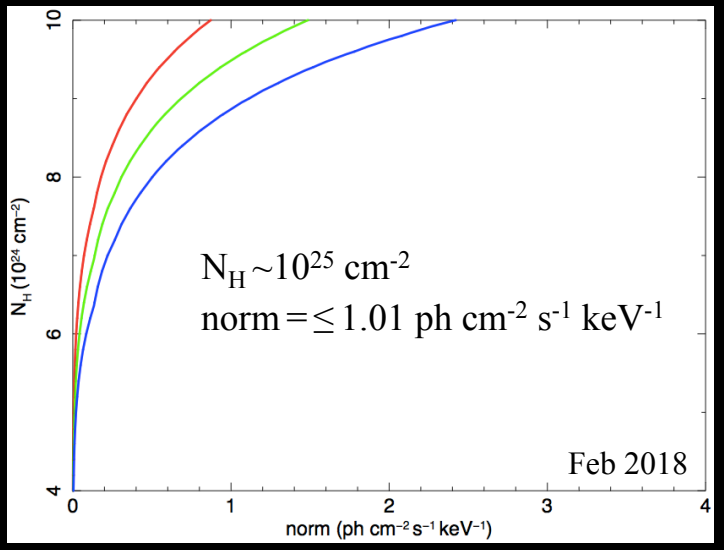
Monitoring 2017-2018 – preliminary results

We adopt the Bauer +15 model leaving only the N_H and flux of the primary component free to vary.



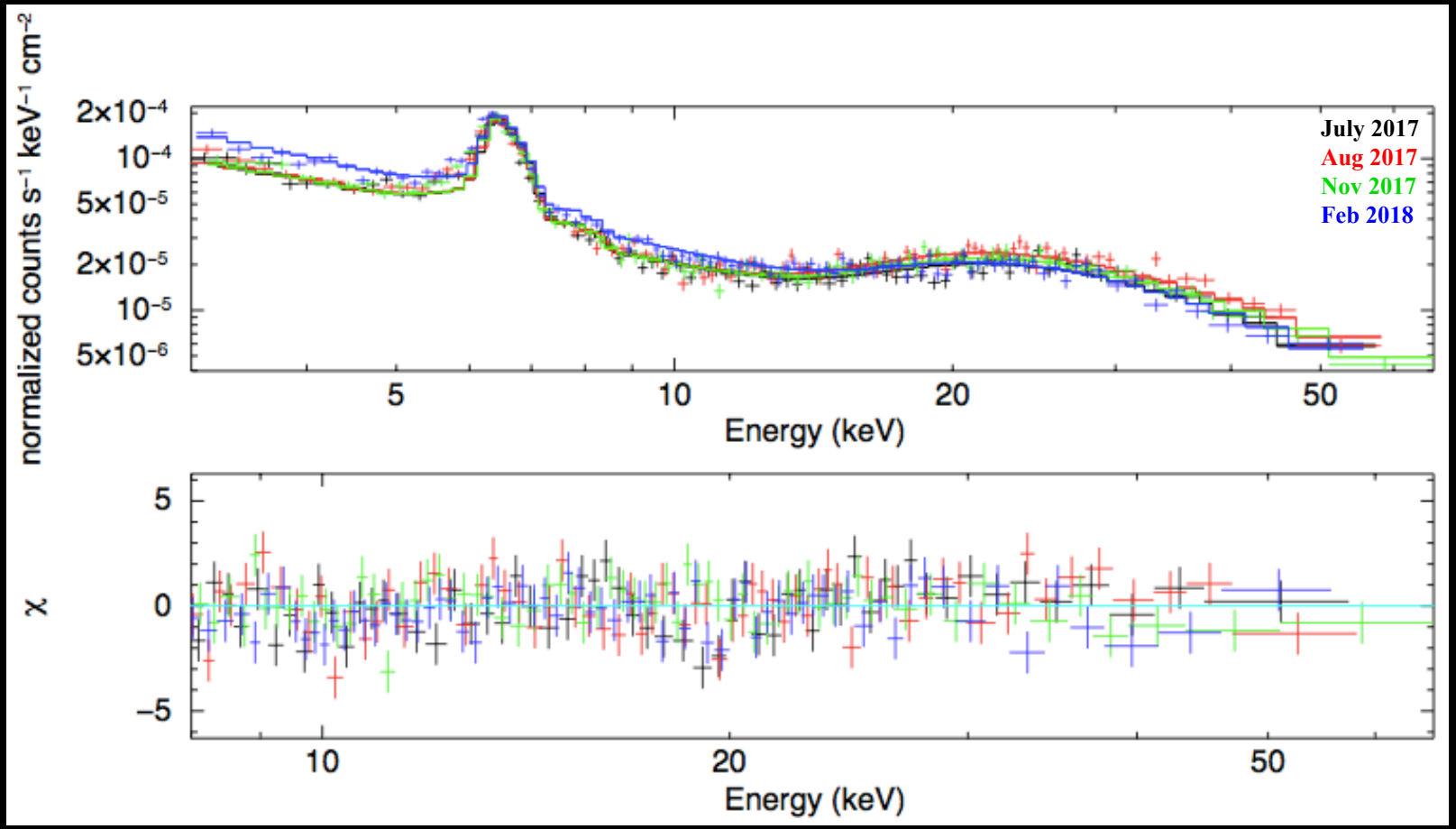






Monitoring 2017-2018 – preliminary results

To break the N_H-norm degeneracy, we assume that the intrinsic X-ray luminosity of the source is the same during the whole monitoring…



We obtain an intrinsic X-ray luminosity of ~3.4×10^{43} erg/s, fully consistent with those inferred using other proxies (e.g. mid-IR and [OIII]).

Monitoring 2017-2018 – preliminary results

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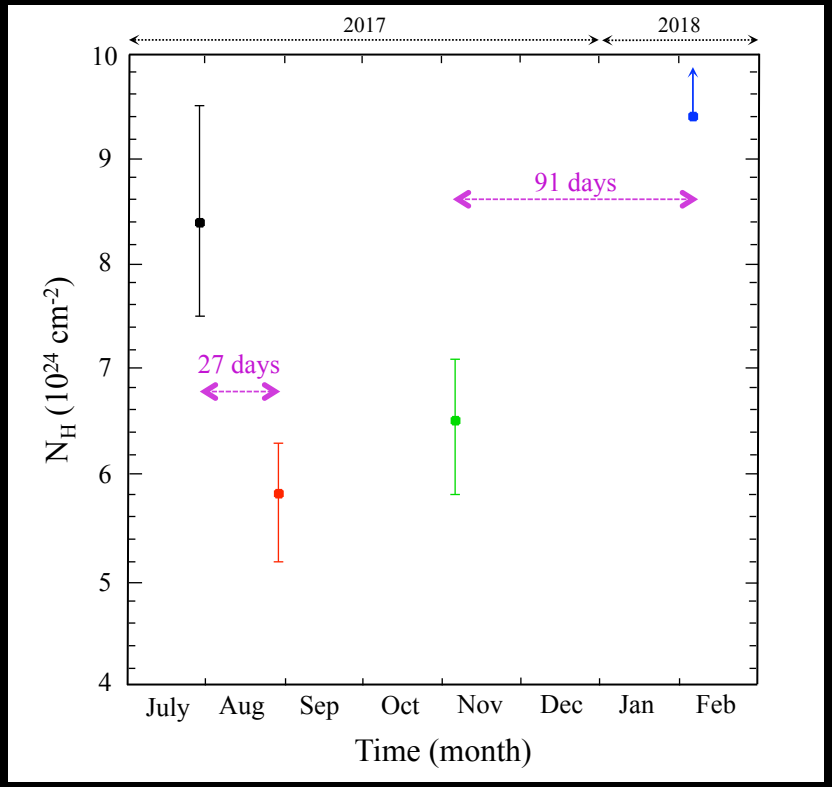


We observe N_H variability on time-scales of ~1 month.

$10^7\ M_\odot$ $\quad$ $10^{10}\ cm^{-3}$

$$R = \frac{G M_{BH} t^2 n^2}{N_H^2} = 1.334 \times 10^{53} \frac{t^2}{N_H^2}\ cm$$

OBS1 – OBS2

$\Delta N_H = (2.6^{+1.7}_{-1.4}) \times 10^{24}$ cm^{-2}

$R = 0.03^{+0.13}_{-0.02}\ M_7\, n_{10}^2\ pc$

OBS3 – OBS4

$\Delta N_H \geq (2.9^{+0.7}_{-0.6}) \times 10^{24}$ cm^{-2}

$R \leq 0.32^{+0.19}_{-0.11}\ M_7\, n_{10}^2\ pc$

Conclusions and future perspectives

Summary and conclusions

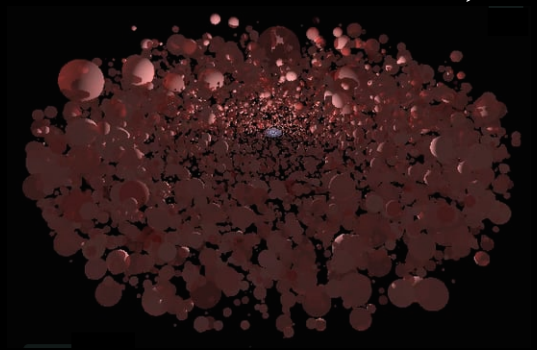
- Analysis of the latest NuSTAR monitoring of NGC 1068, composed of four observations of ~50 ks each and probing time-scales from 1 to 6 months.

- A brand new flaring ULX reaching a luminosity of $\sim 4\times10^{40}$ erg/s in three months;
- Two unveiling events at 1-sigma due to CT material within ~0.5 pc.

What's next?

- Further observations and analysis to characterize the new ULX;

- To use clumpy torus models, e.g. *ctorus* (Liu et al. 2014) or the *unified CLUMPY AGN torus model* (Buchner et al. 2017);



- To infer the number of clouds needed to obtain the observed X-ray variability.

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Thank you for your attention!

Any questions?
Just ask!