A deep NuSTAR view of the buried AGN in NGC 1068

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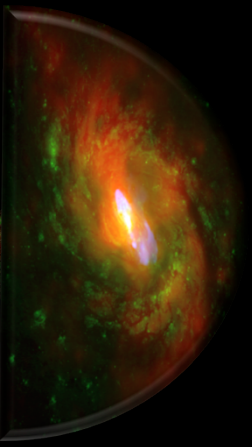
Outline



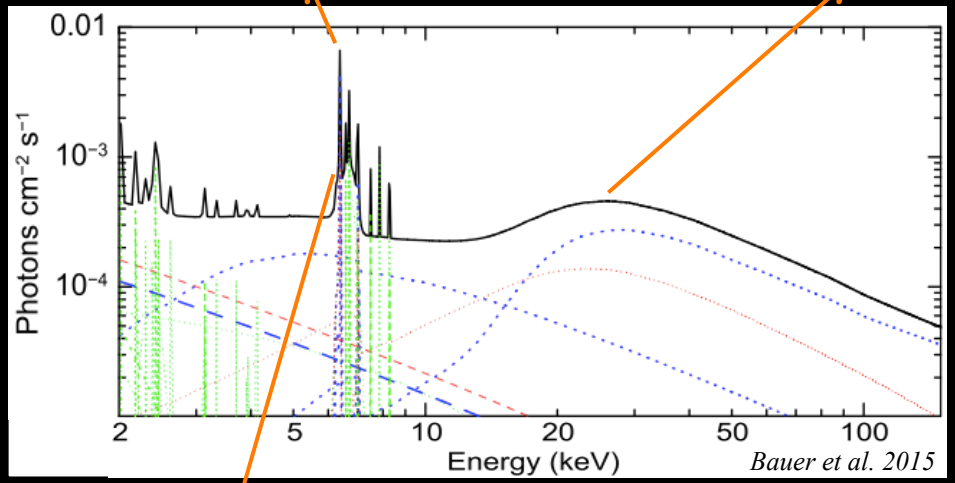
- *What do we already know about NGC 1068?*
- *The 2017-2018 NuSTAR monitoring*
- *Results*
- *Summary and conclusions*

Unveiling the nucleus of NGC 1068

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

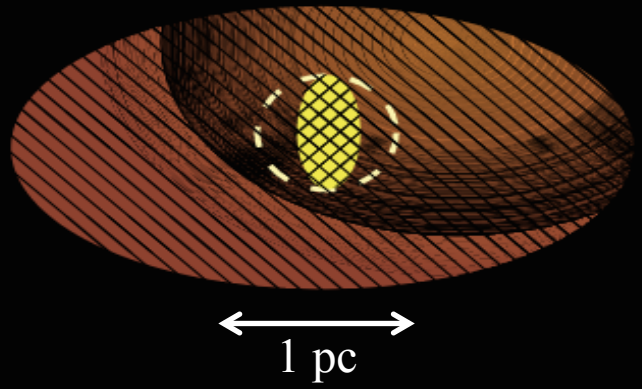
$N_{H,2} = (1.4 \pm 0.1) \times 10^{23}$ cm^{-2}

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



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

Jaffe et al. 2004



Torus consistent with a two-component dust distribution:

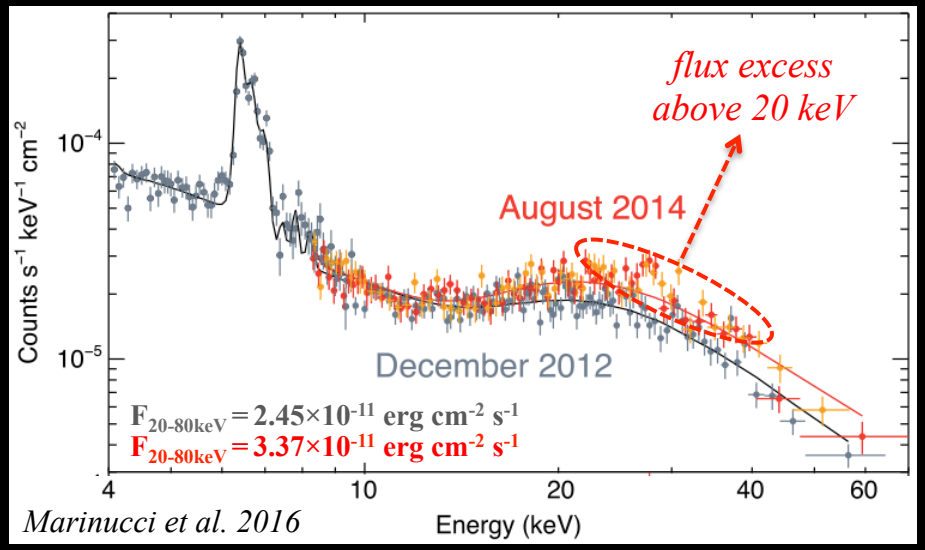
- an inner (0.7±0.2 pc) hot (T > 800 K) component;
- a more extended (~3-4 pc) colder component (T~320 K).

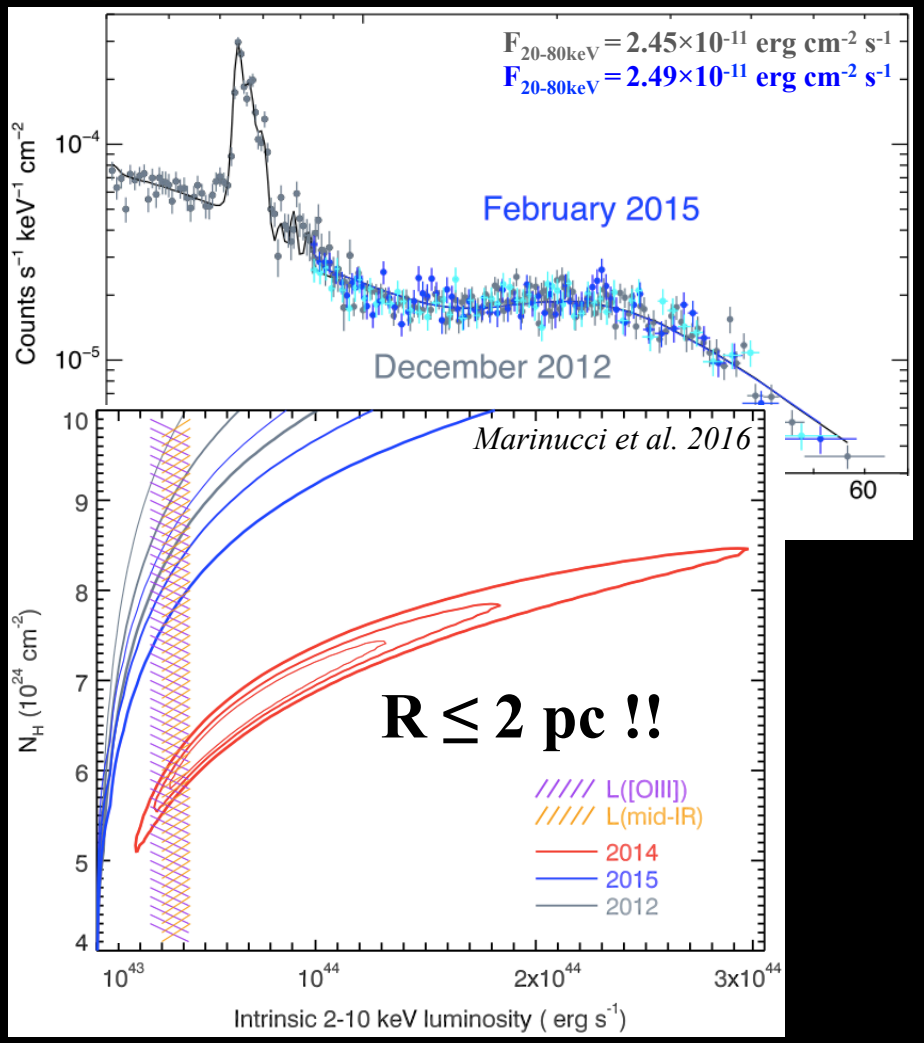
Monitoring 2017-2018 – rationale

NuSTAR observation

Dec 2012 → Bauer et al. 2015

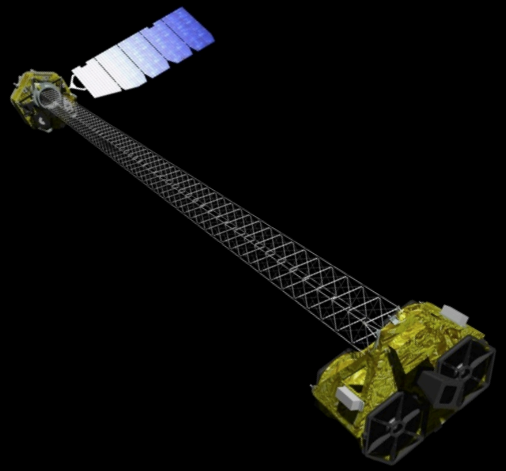
Aug 2014, **Feb 2015** } joint XMM-Newton



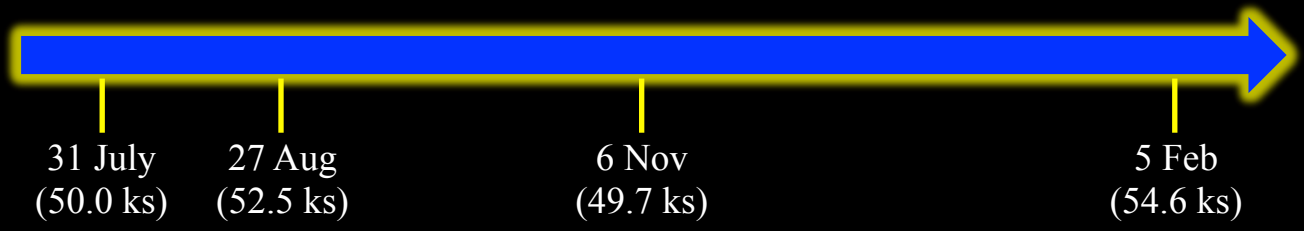


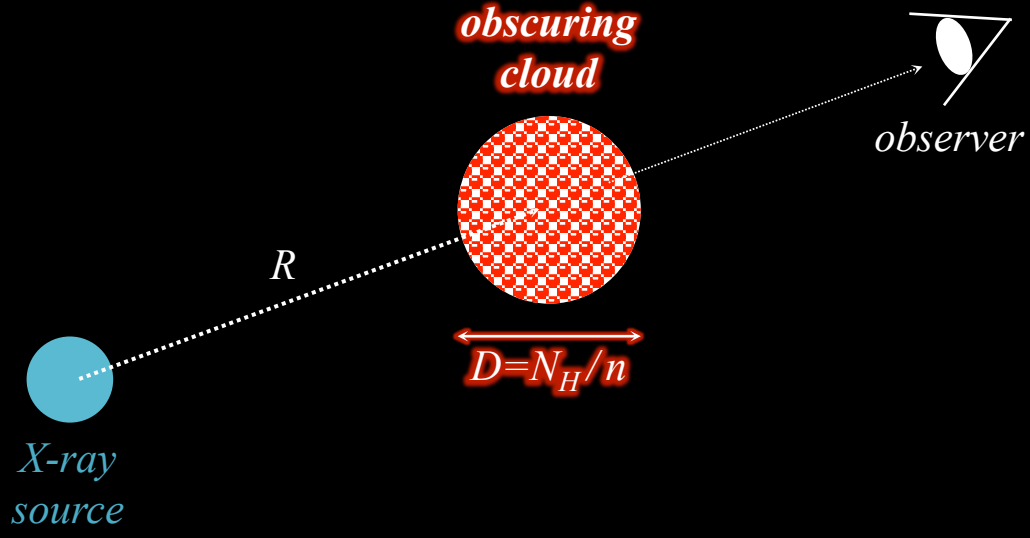
Compton-thick unveiling event
($\Delta N_H \geq 2.5\times10^{24}$ cm^{-2})

Monitoring 2017-2018 – aim and method



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



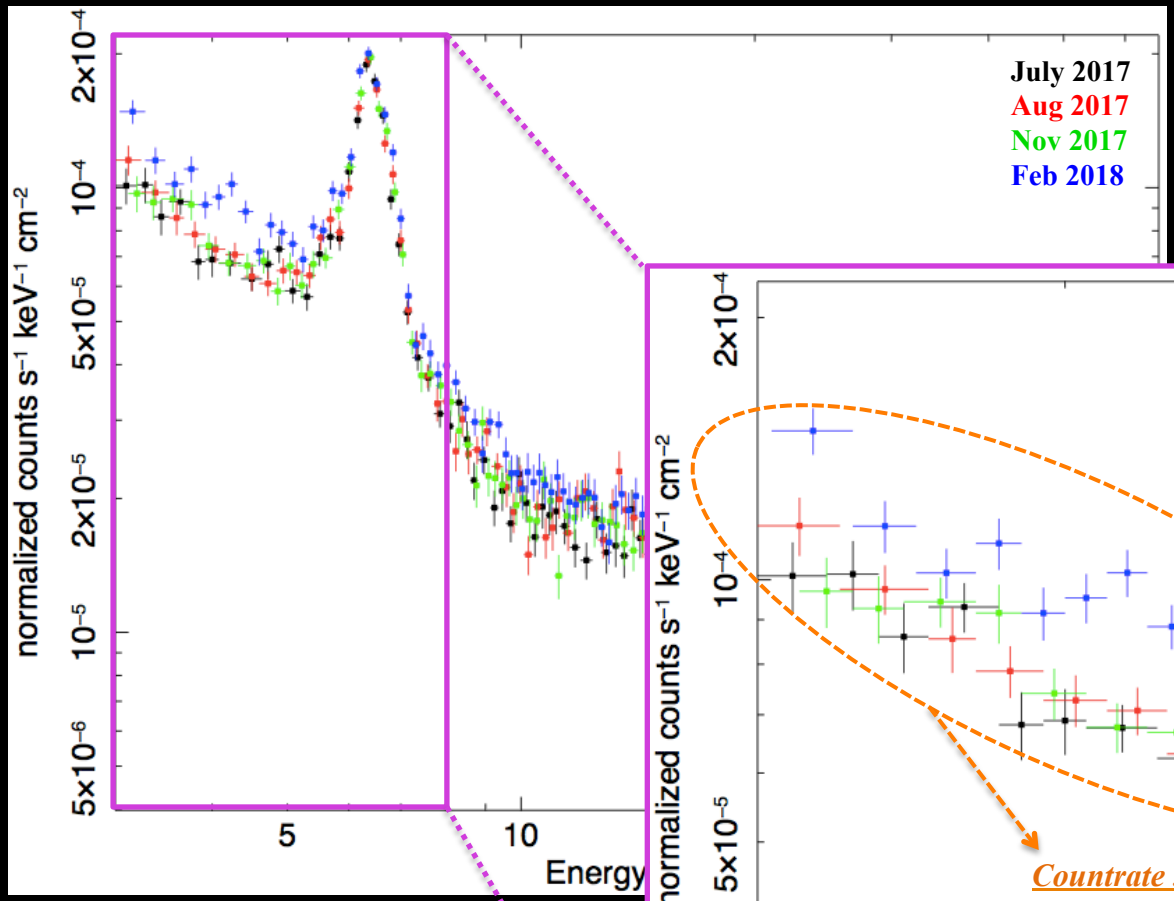


$$R = \frac{G M_{BH} t^2 n^2}{N_H^2}$$

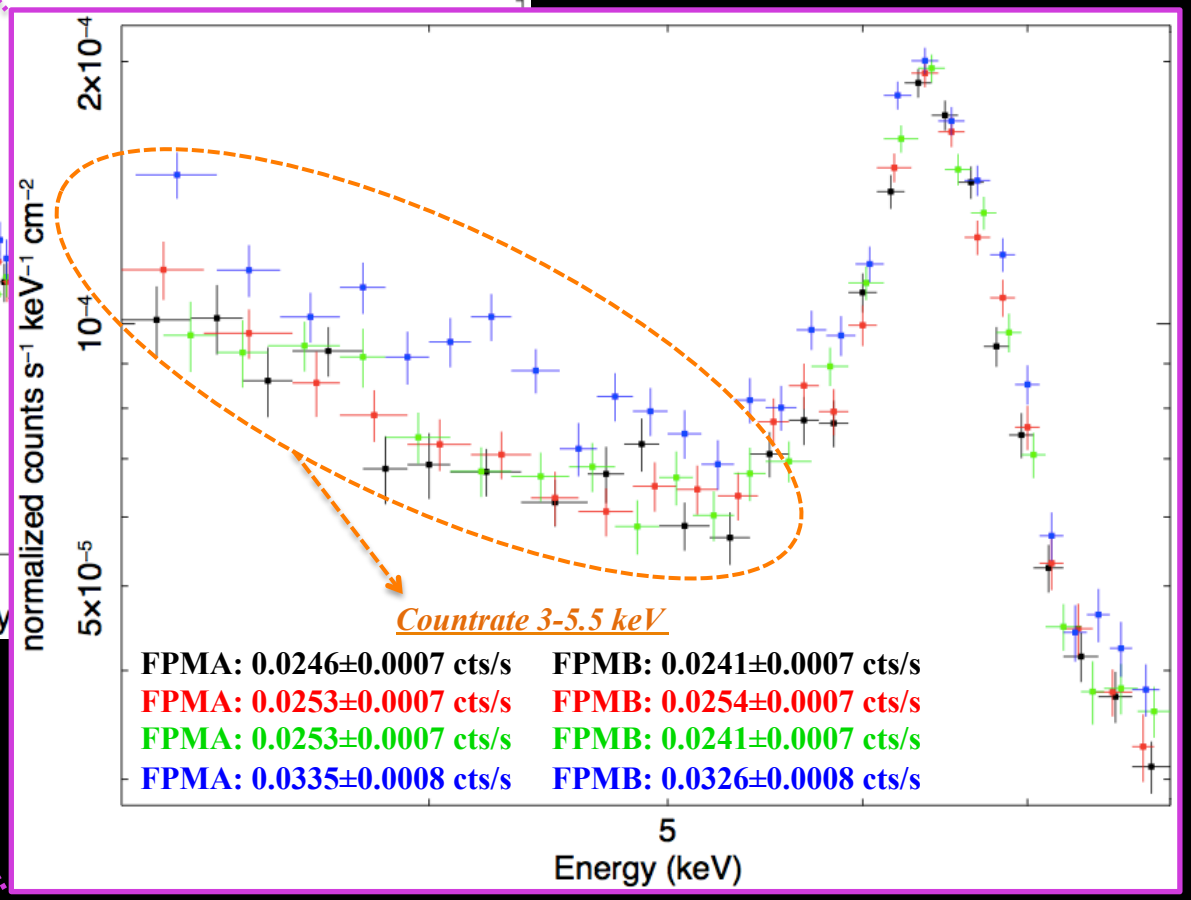
$M_{BH} \sim 10^7\ M_\odot$
$n \sim 10^{10}\ cm^{-3}$
$N_H \sim 2.5 \times 10^{24}\ cm^{-2}$
$t \sim$ *1-6 months*

R ~ 0.05-2 pc

The 2017-2018 monitoring spectra – soft X band

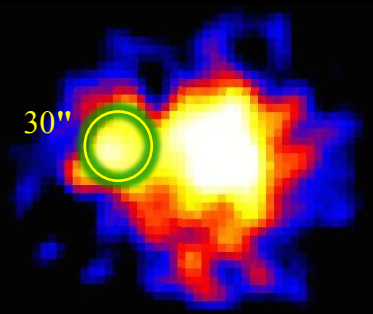


a. No evidence of Fe lines variation



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

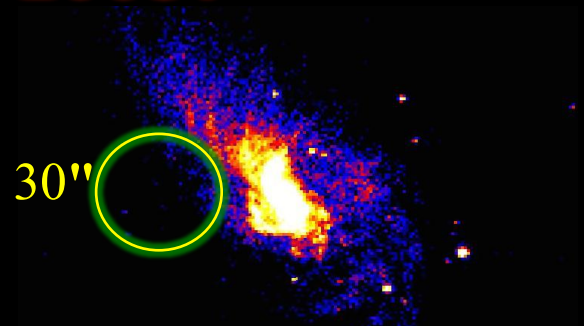
A new object in NGC 1068?



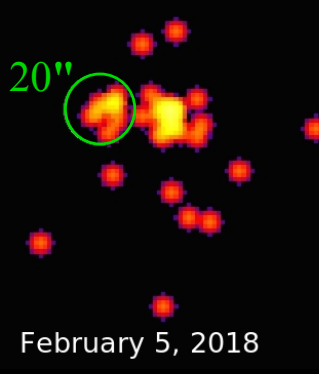
$\Gamma \sim 1.7 \pm 0.2$

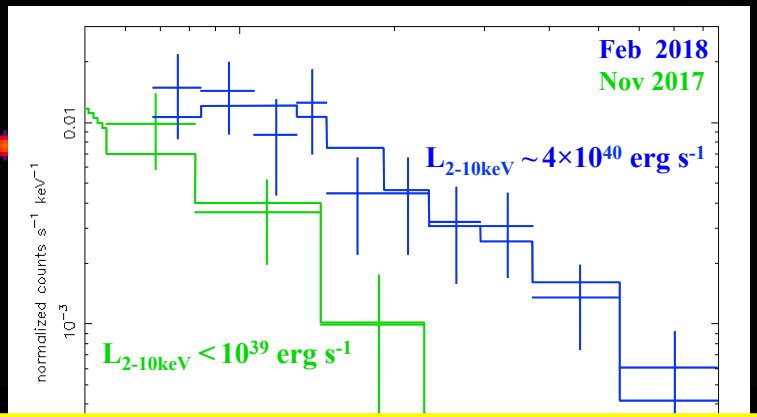
$E_{cut\text{-}off} \sim 20$ keV

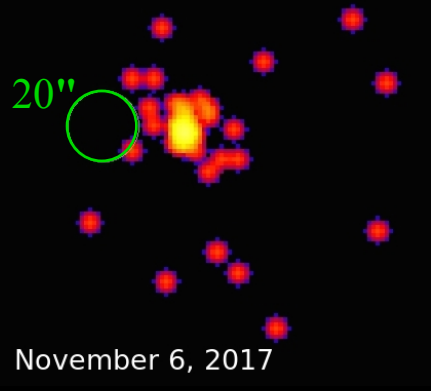
$L_{2\text{-}10keV} \sim 4 \times 10^{40}$ erg s^{-1}

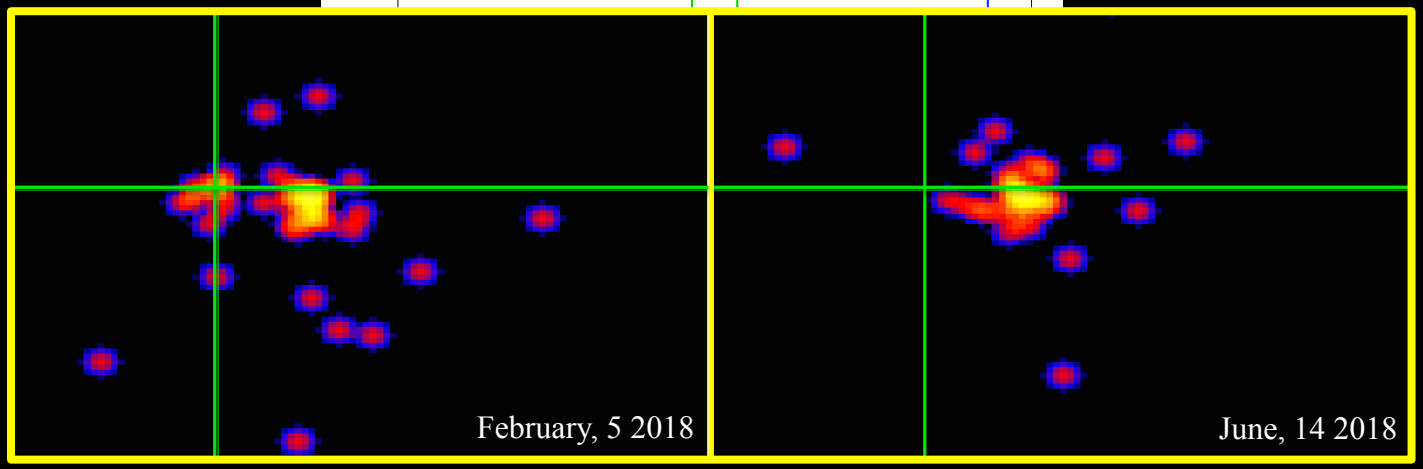


✧ *Simultaneous Swift data in the 3-5.5 keV band*



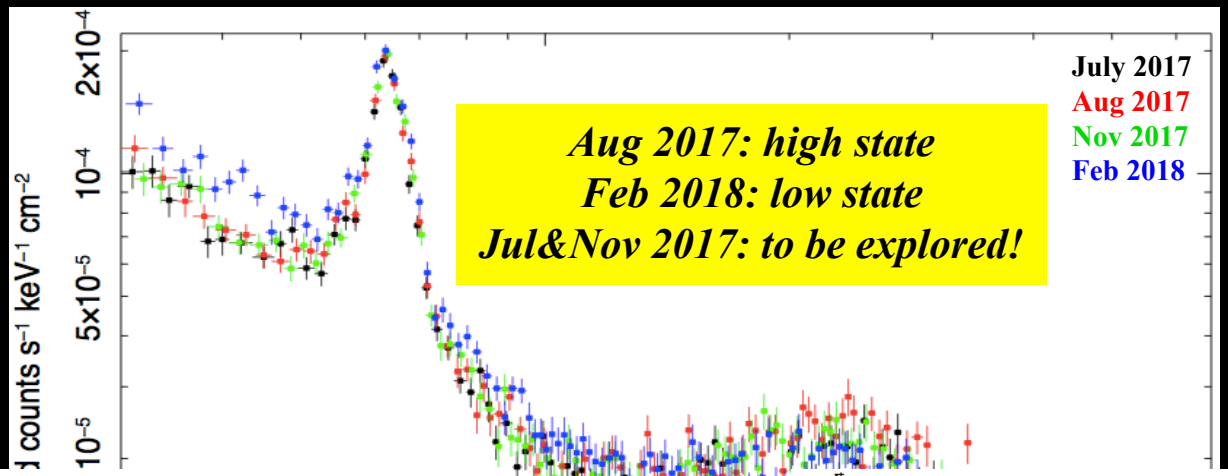


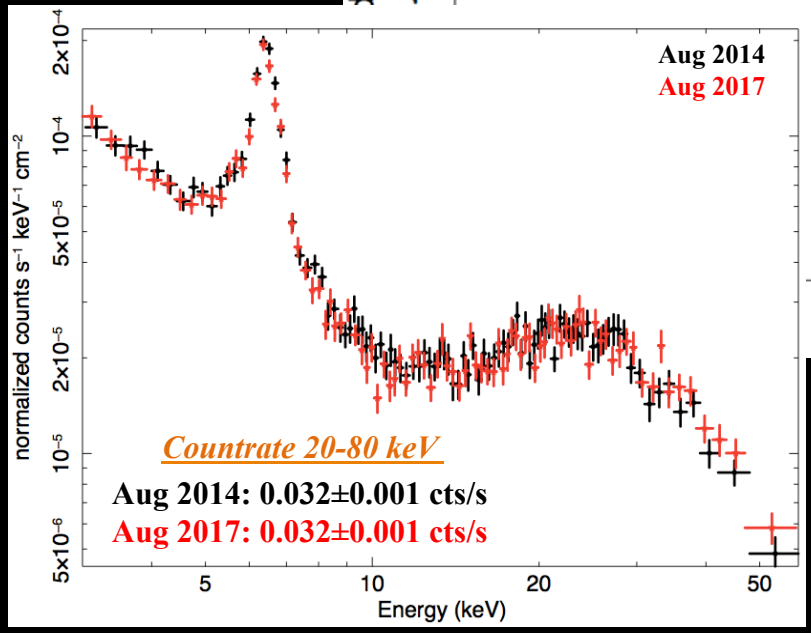


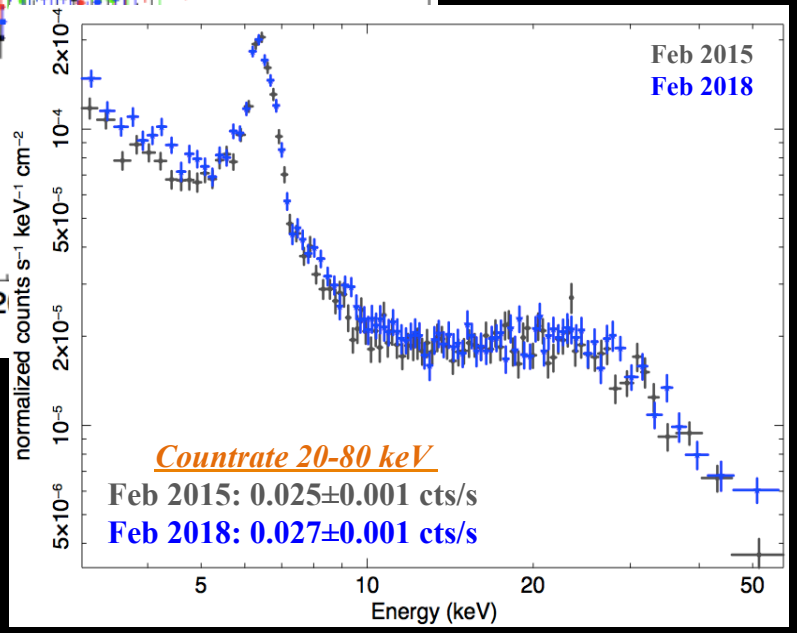


2014-2015 vs. 2017-2018

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



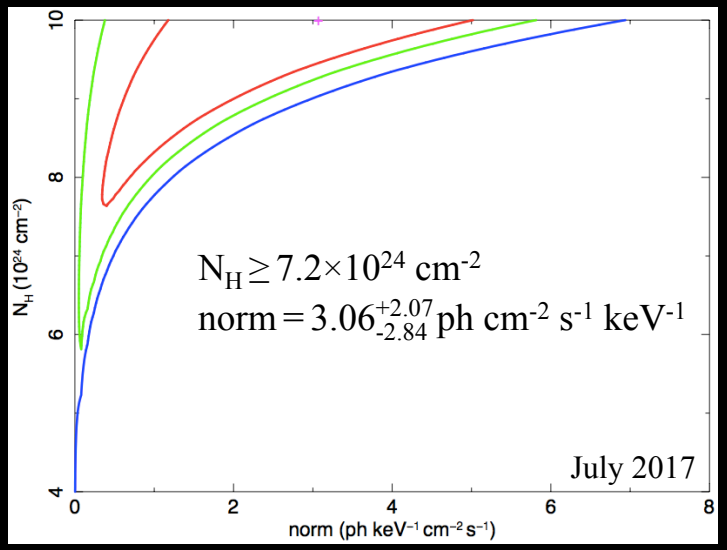


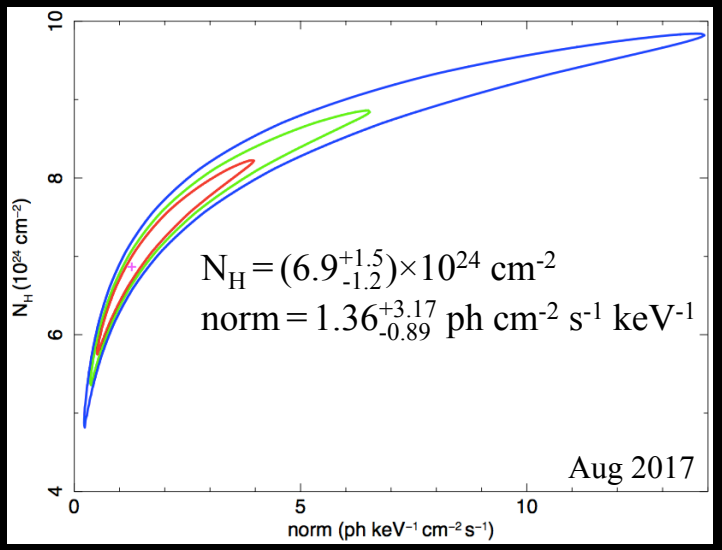


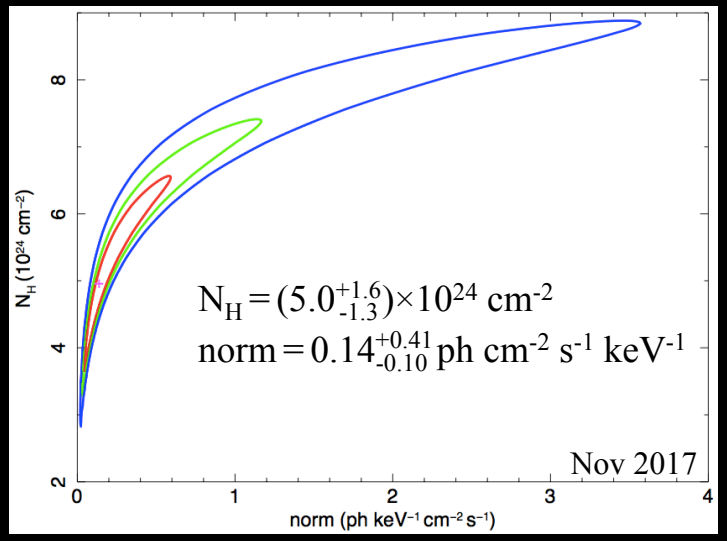
But now, we have one more observation between these two…

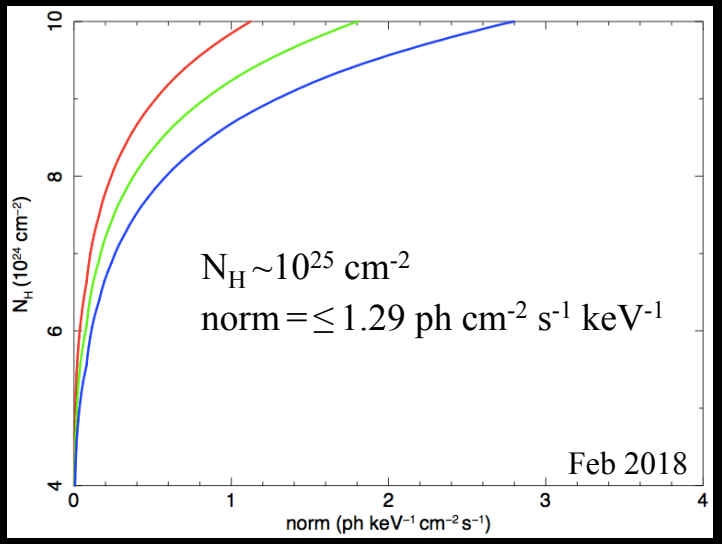
Monitoring 2017-2018 – results

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



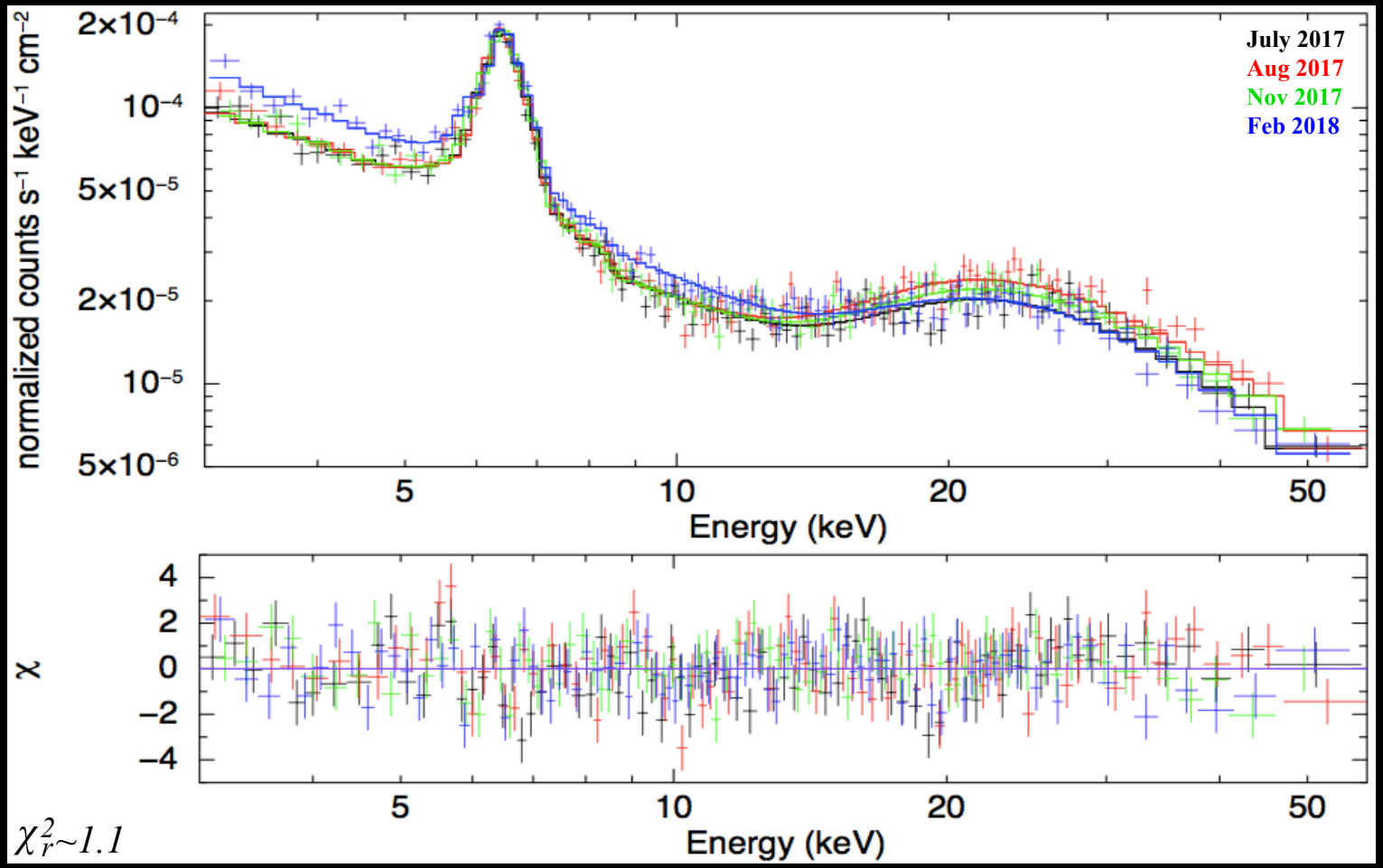






Monitoring 2017-2018 – results

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



We obtain an intrinsic X-ray luminosity consistent within the errors with those inferred using other proxies (e.g. mid-IR and [OIII]).

Monitoring 2017-2018 – results

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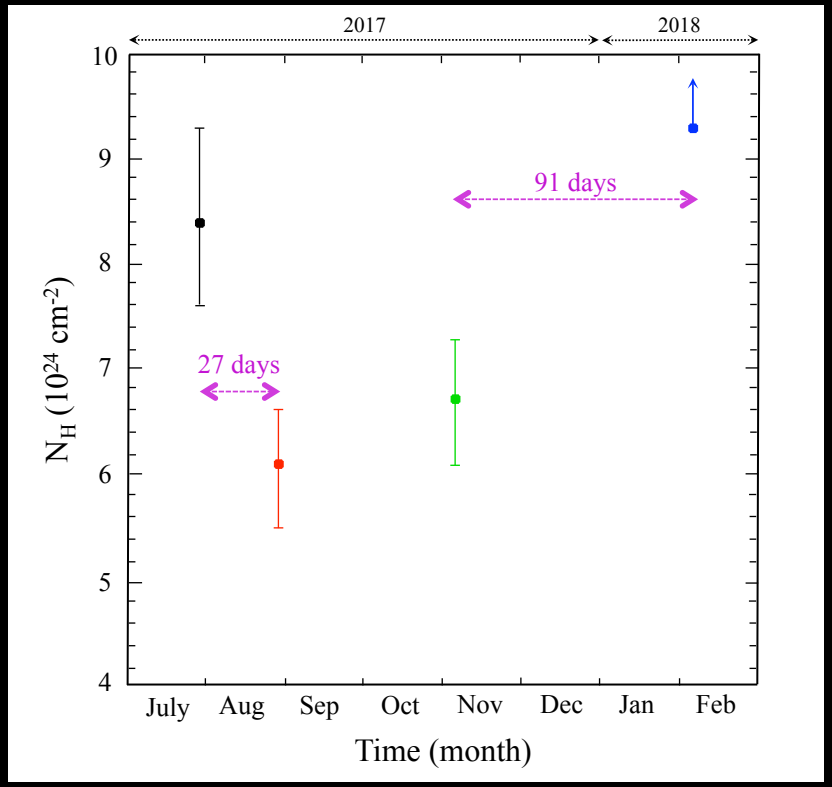

$10^7\ M_\odot$ $10^{10}\ cm^{-3}$

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

OBS1 – OBS2

$\Delta N_H = (2.3 \pm 1.0) \times 10^{24}$ cm^{-2}

$R = (0.04^{+0.18}_{-0.02}) M_7 n_{10}^2\ pc$

OBS3 – OBS4

$\Delta N_H \geq (2.6 \pm 0.6) \times 10^{24}$ cm^{-2}

$R \leq (0.40 \pm 0.26) M_7 n_{10}^2\ pc$

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

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.

① A brand new flaring ULX reaching a luminosity of $\sim 4\times10^{40}$ erg/s in three months and disappearing in the following four months;

② Two unveiling events due to Compton-thick material located in the innermost part of the torus or even more inside.


Thank you for your attention!
Any questions?
Just ask!