

Mislav Baloković
(Harvard-Smithsonian CfA)

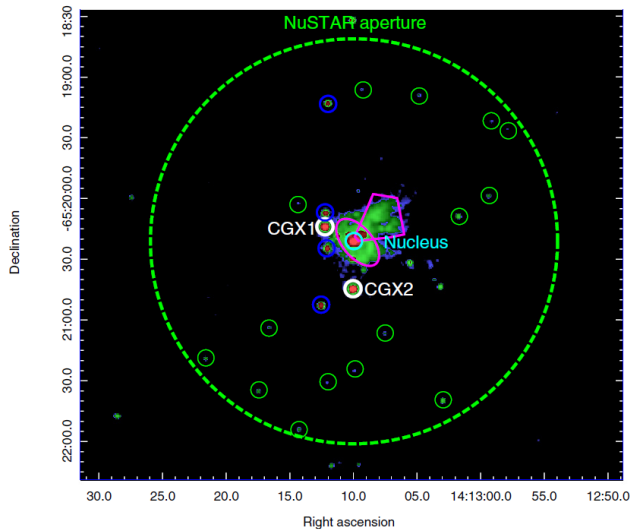
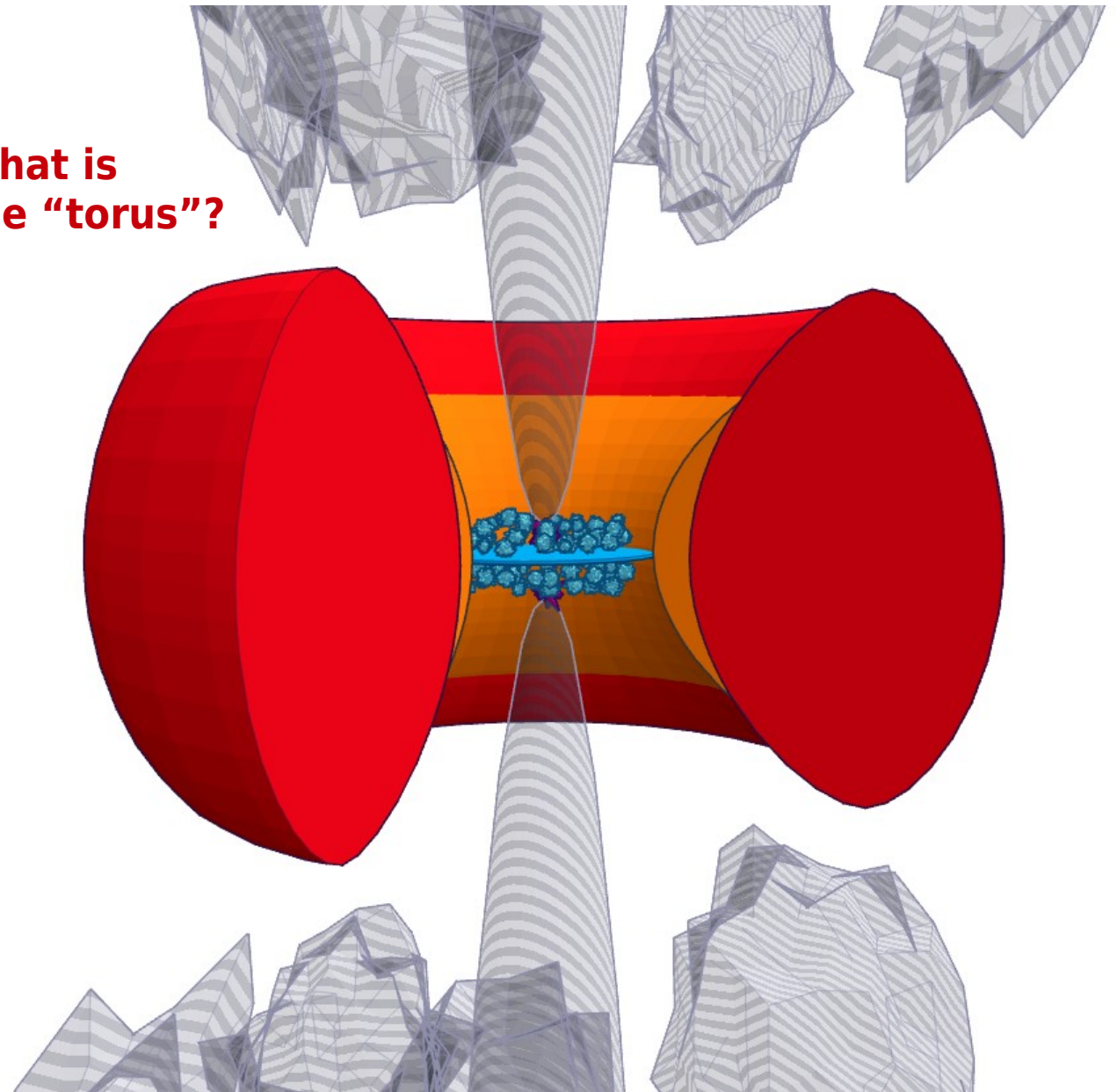
Local Obscured AGN with STROBE-X (& NuSTAR)

STROBE-X Science Definition Meeting, Lubbock, TX, September 2017

SIMPLIFIED AGN STRUCTURE

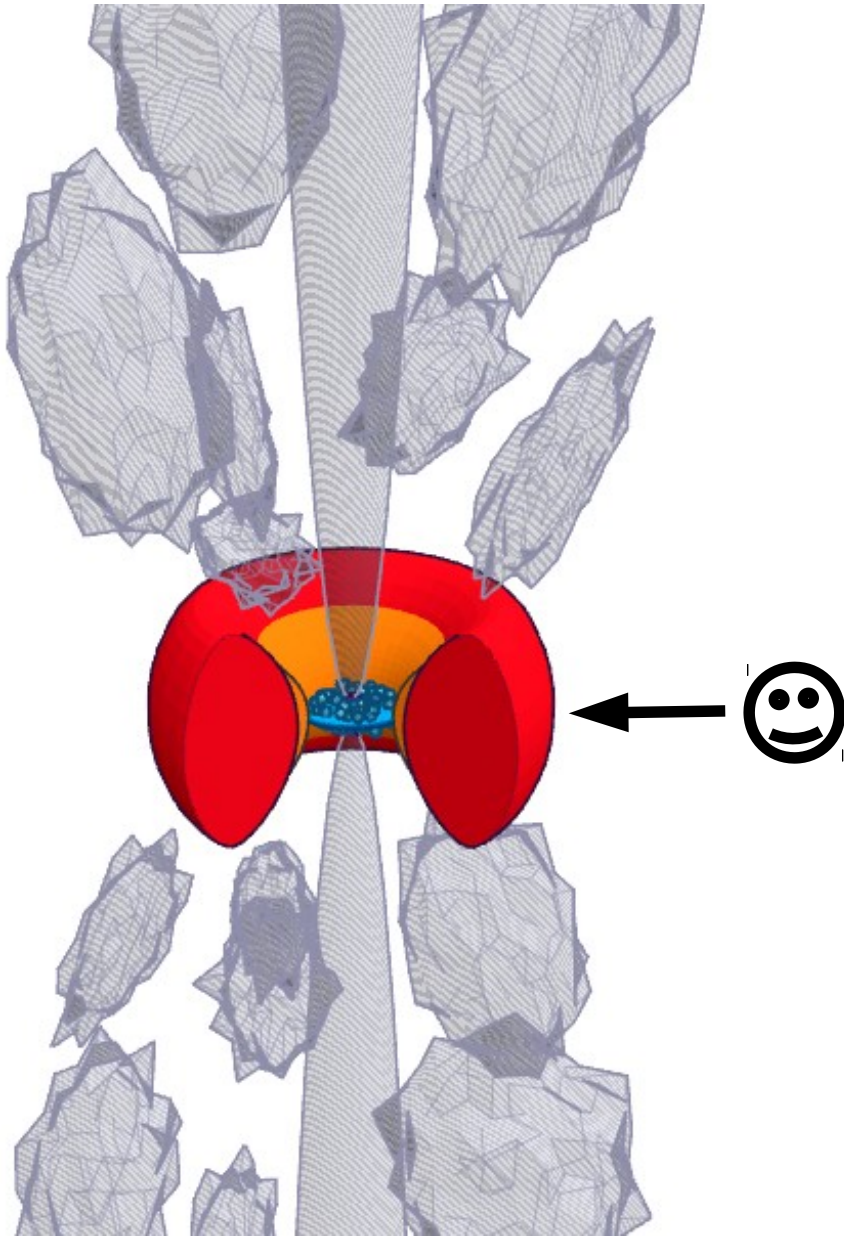


What is
the “torus”?

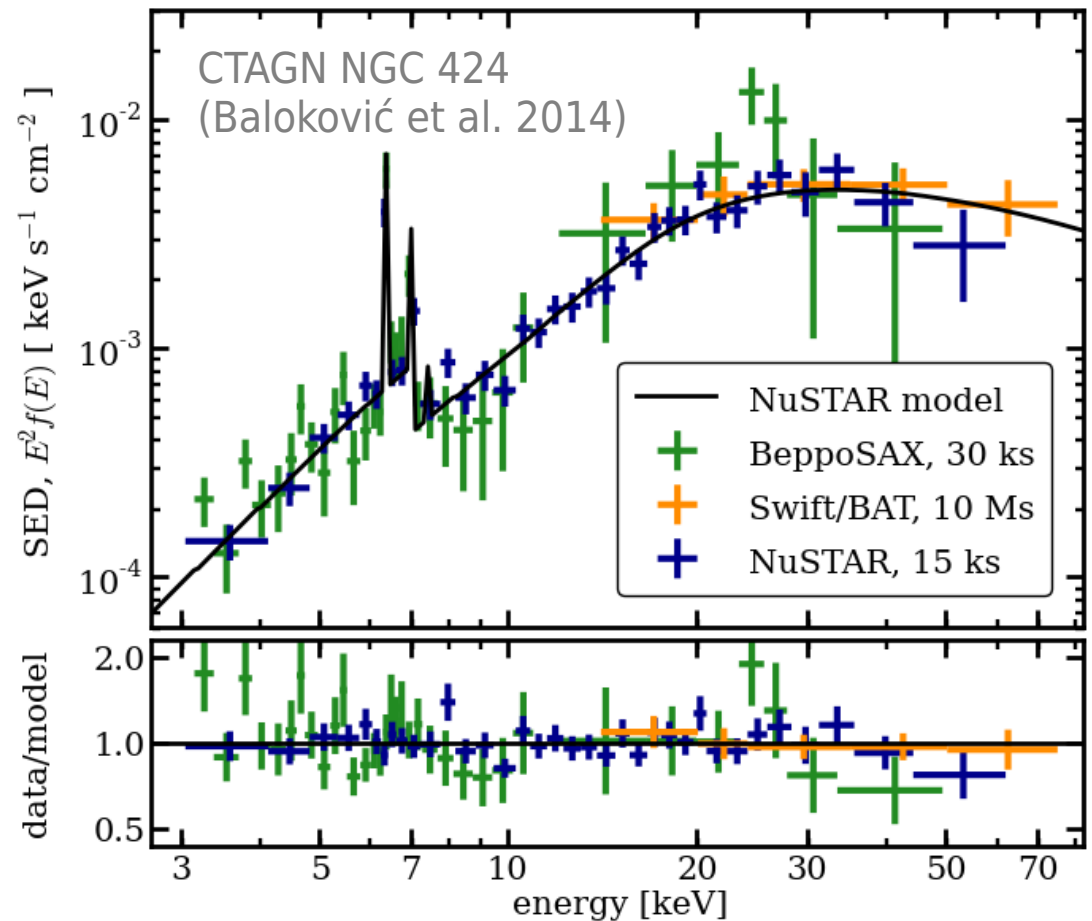


Circinus Galaxy
(Arevalo et al. 2014)

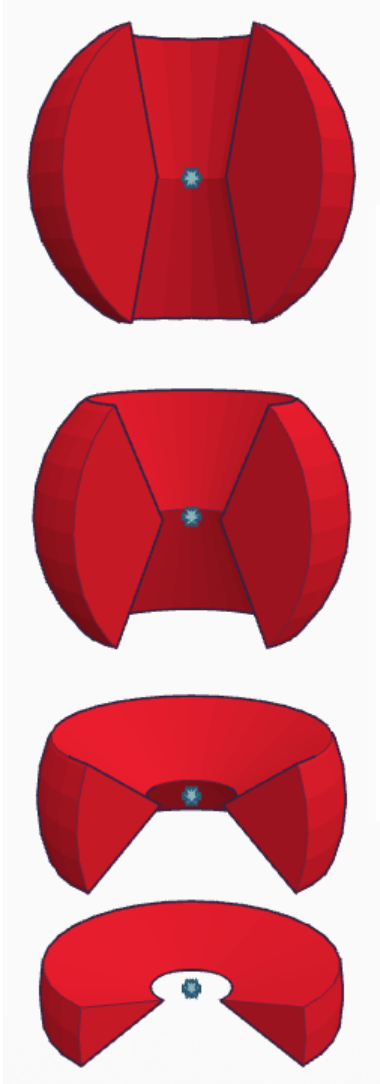
HARD X-RAY BAND FEATURES



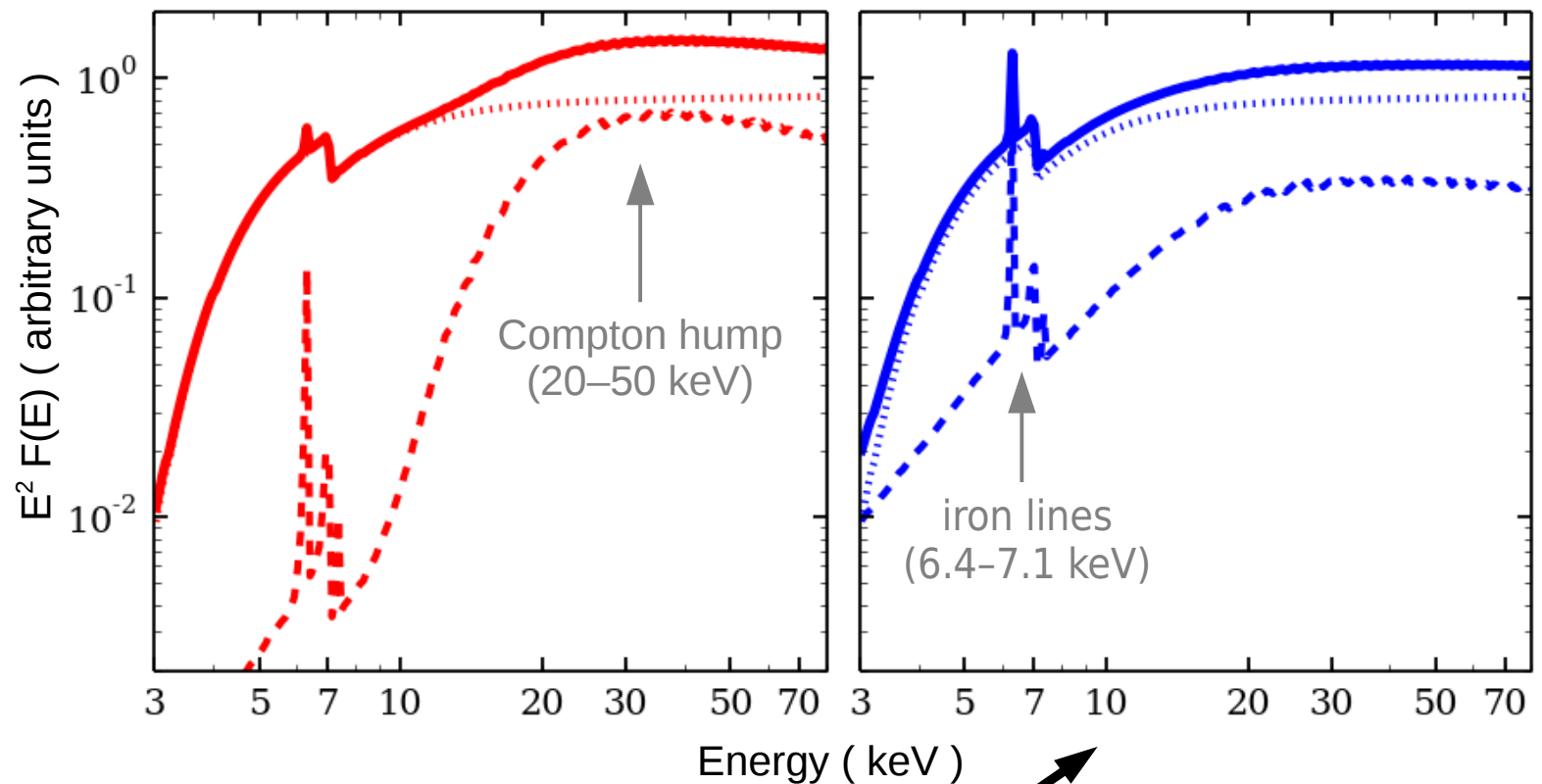
Reprocessed spectra contain information about the black hole environment.



KEY TORUS PARAMETERS

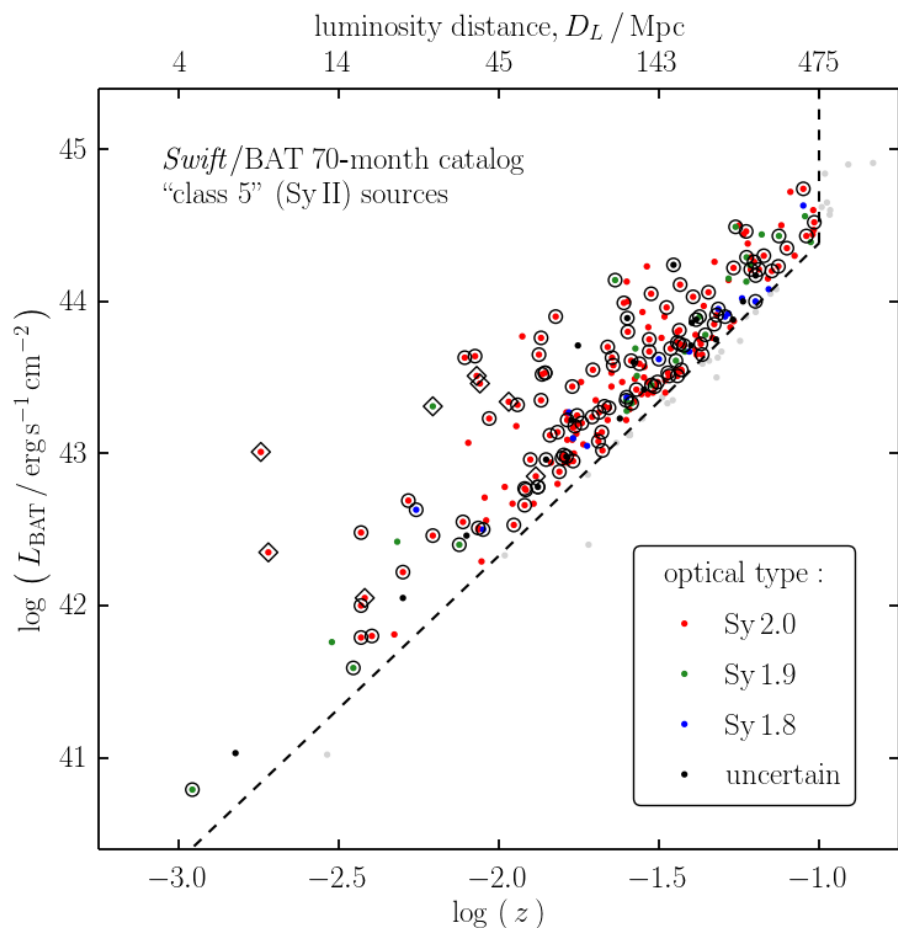


**sphere-like torus
(covering factor 90%)**

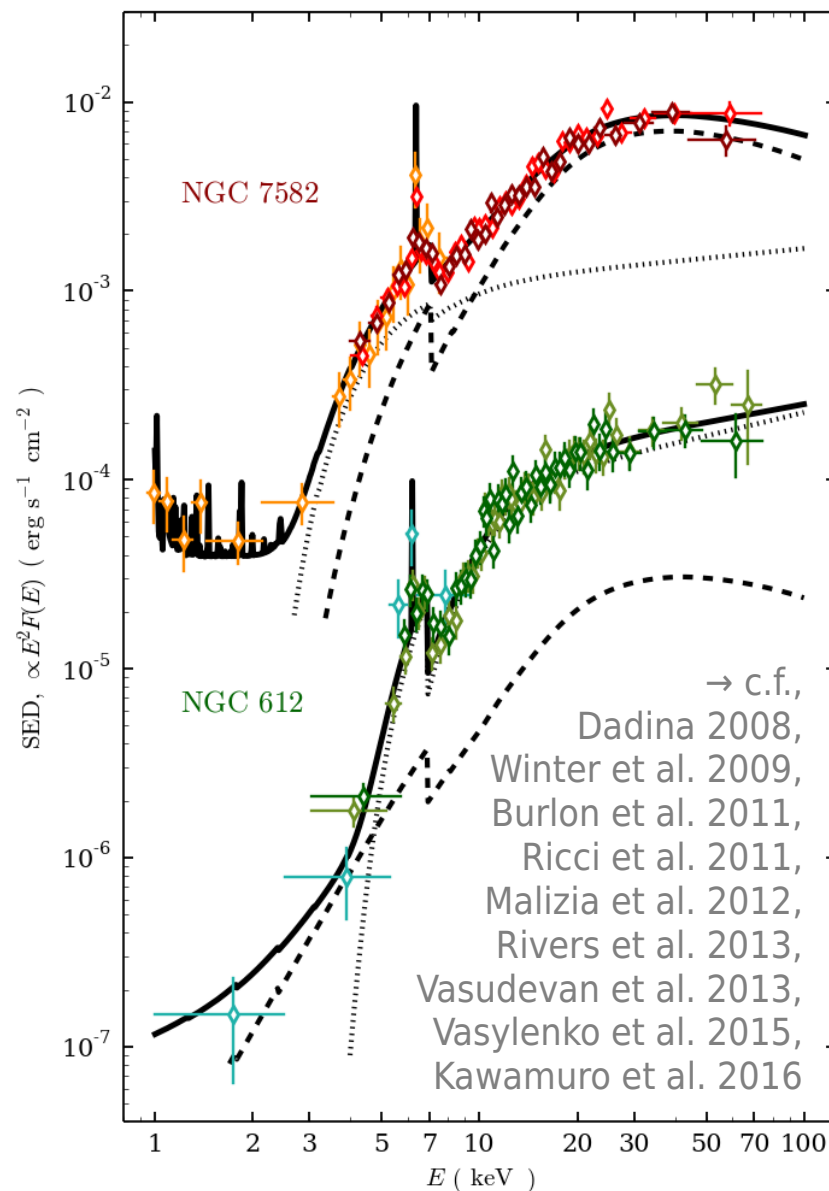


**disk-like torus
(covering factor 10%)**

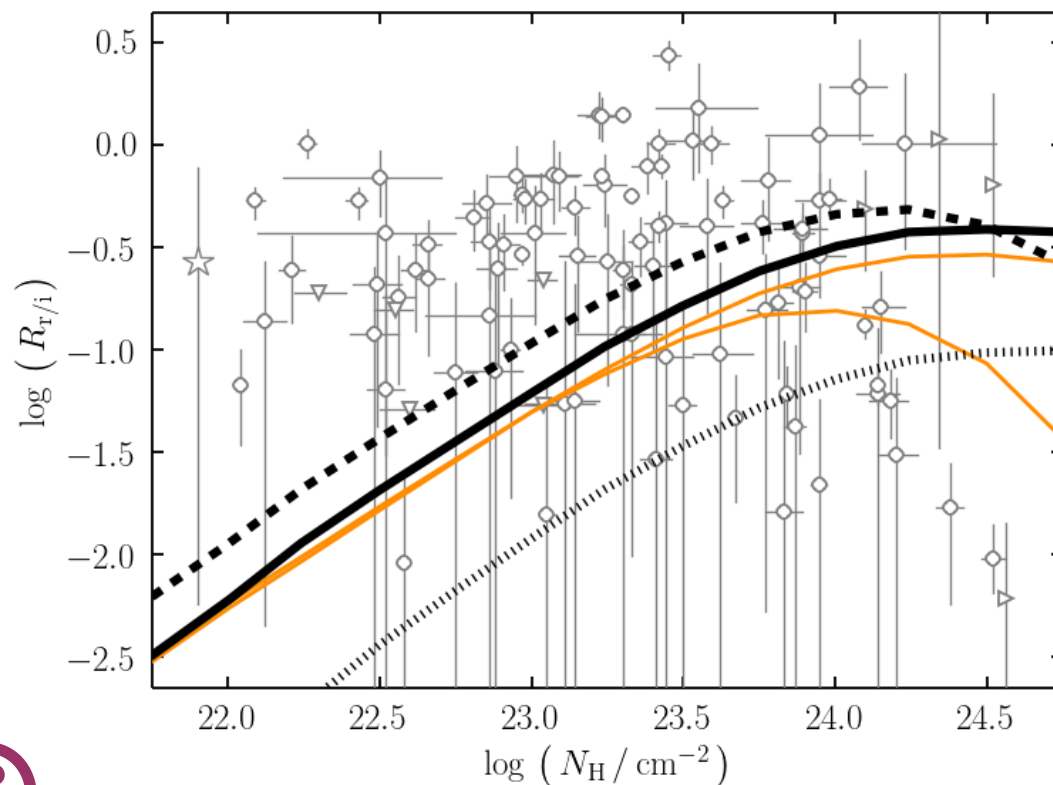
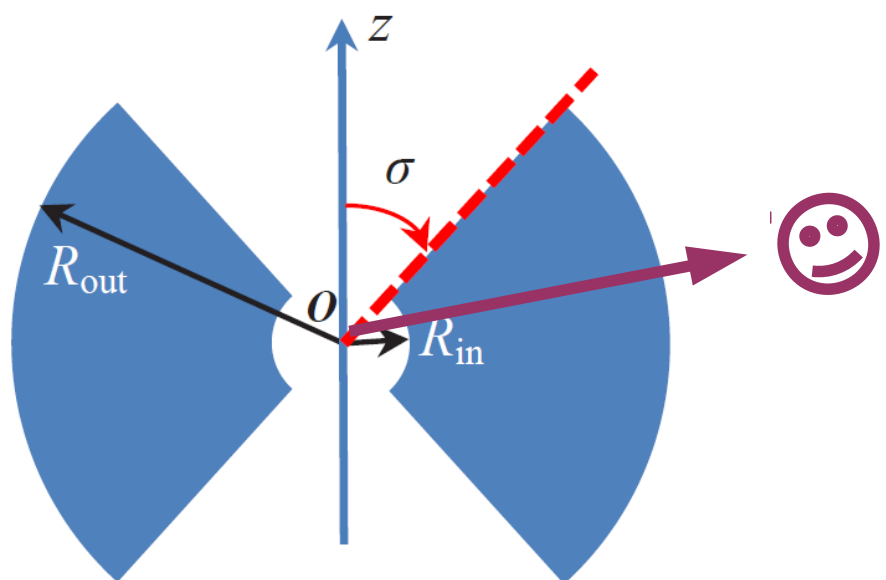
LARGE SAMPLE: *SWIFT*/BAT AGN



Sample: 125 Seyfert 2 nuclei from the *Swift*/BAT 70-month catalog ($\frac{1}{2}$ of the total), observed with *NuSTAR* and *Swift*/XRT.



- Murphy & Yaqoob 2009
- Ikeda et al. 2009
- Brightman & Nandra 2011
- Liu & Li 2014
- Furui et al. 2016



N_{H} in the line of sight IS NOT the same as the average N_{H} of the torus \rightarrow there are two different values to measure.

2 BEYOND THE DONUT

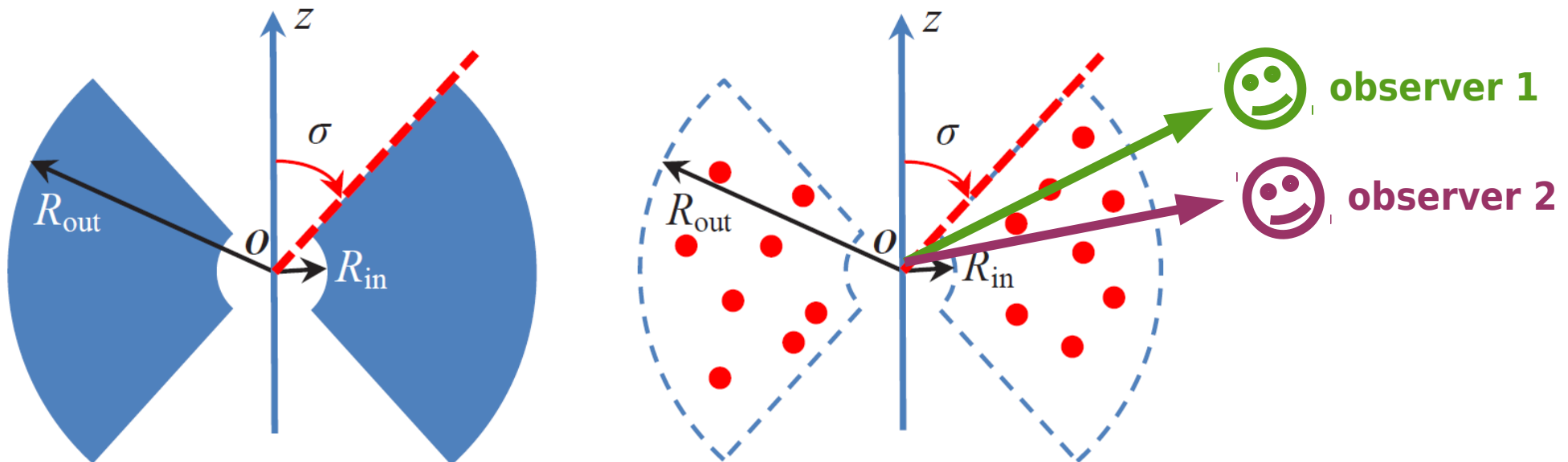
**Complex, clumpy torus!
(with no suitable spectral model yet)**

Extended on >10 pc scale, e.g.:

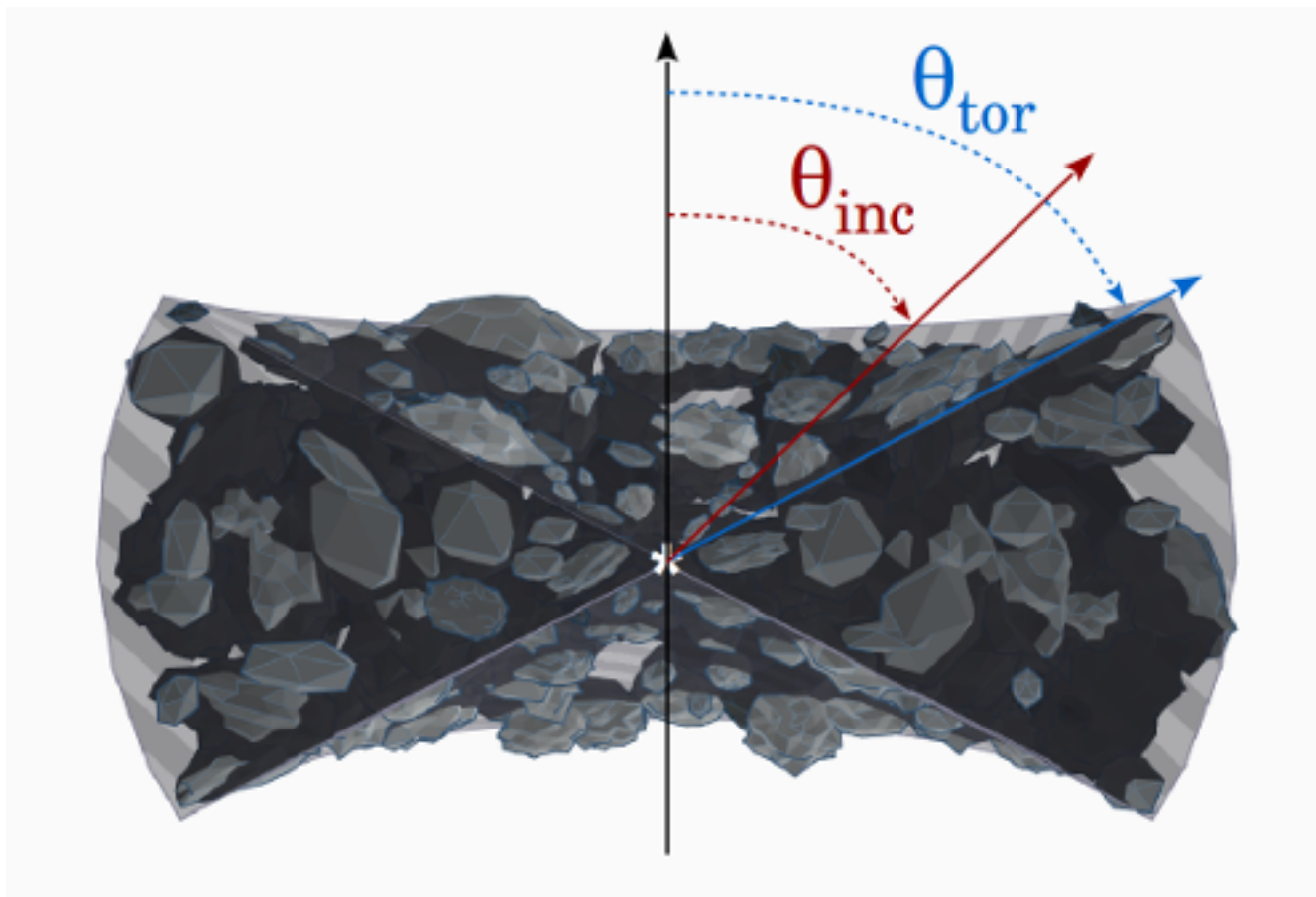
Marinucci et al. 2012; Bauer, M.B. et al. 2015

Clouds passing through the line of sight, e.g.:

Markowitz et al. 2014; Rivers, M.B., et al. 2015



3 NEW MODEL: borus02

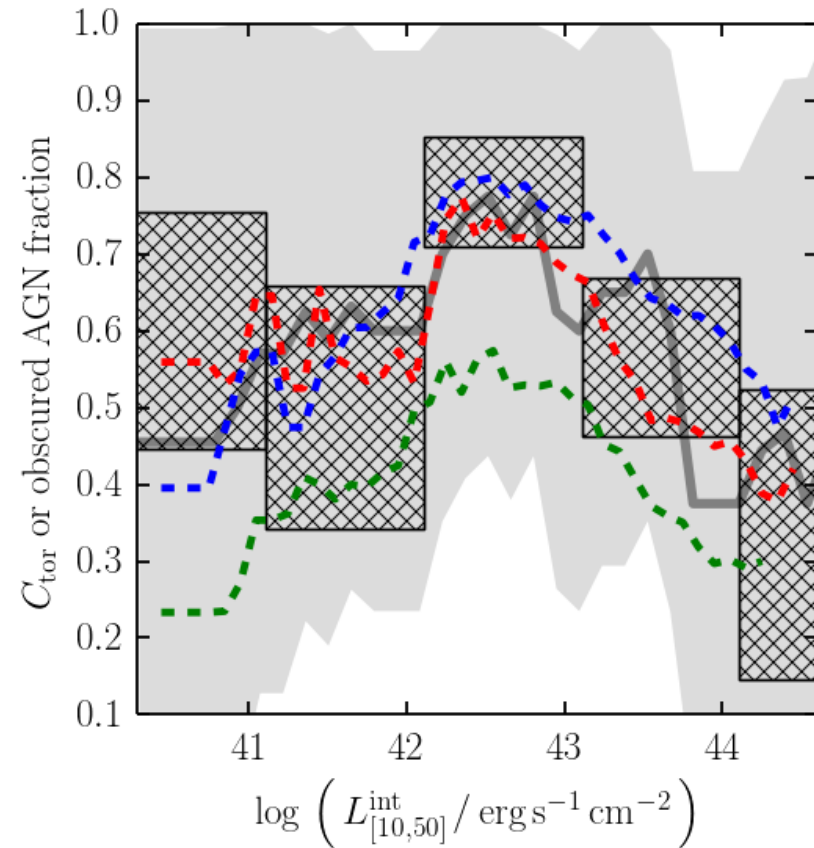
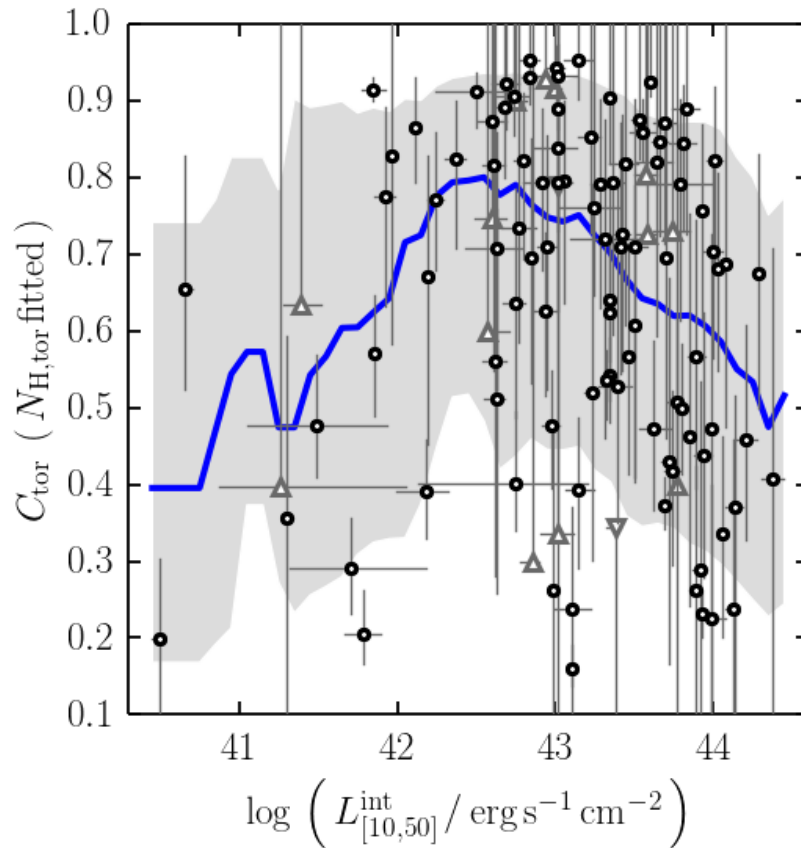


Baloković et al. 2017 (submitted)

Xspec table model available: <http://www.astro.caltech.edu/~mislavb/download>

POPULATION CONSTRAINTS

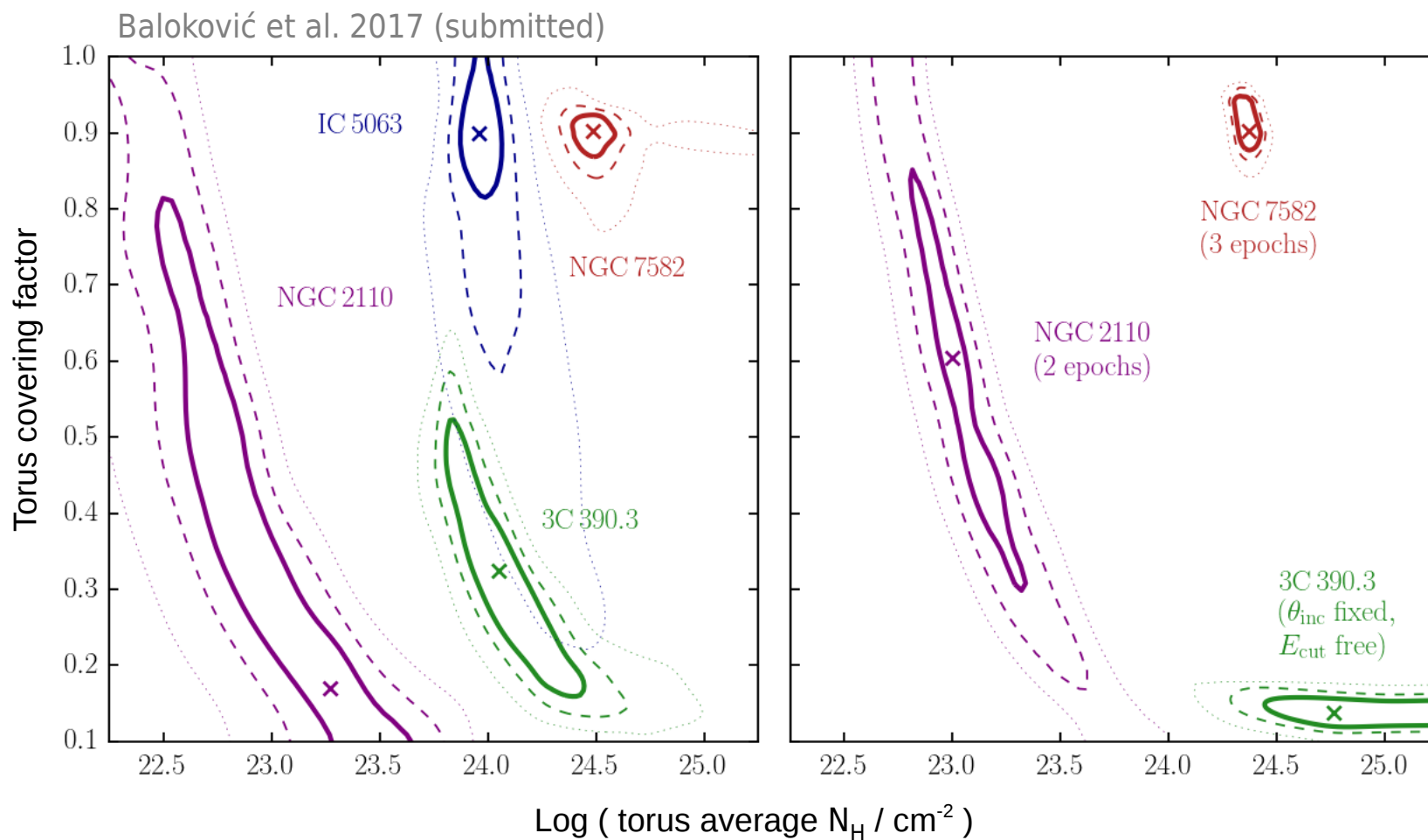
Torus covering factor is a function of luminosity: declines in both extremes.



GREY (RIGHT PANEL): obscured AGN fraction from Brightman & Nandra (2011) and Vasudevan et al. (2013)

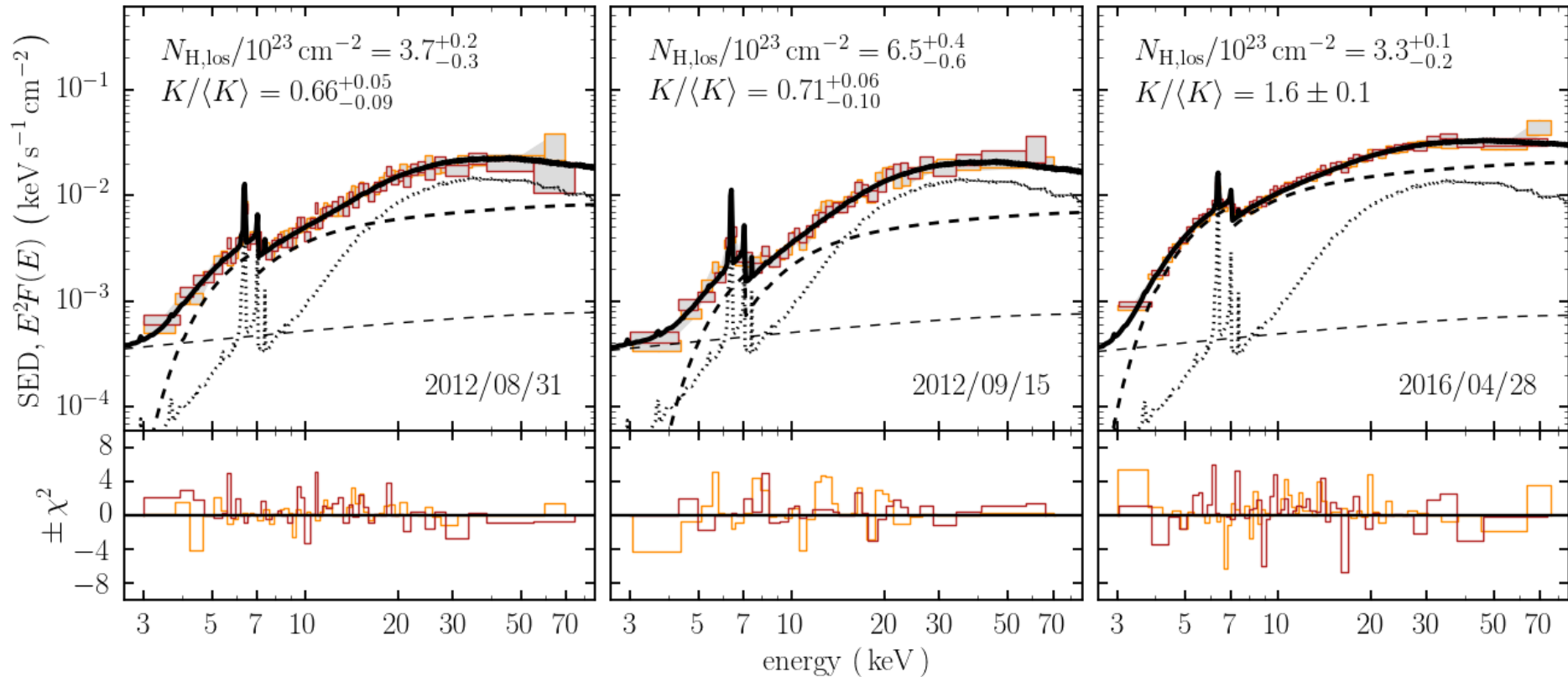
INDIVIDUAL AGN CONSTRAINTS

Spectra alone give (degenerate) constraints on the main torus parameters.

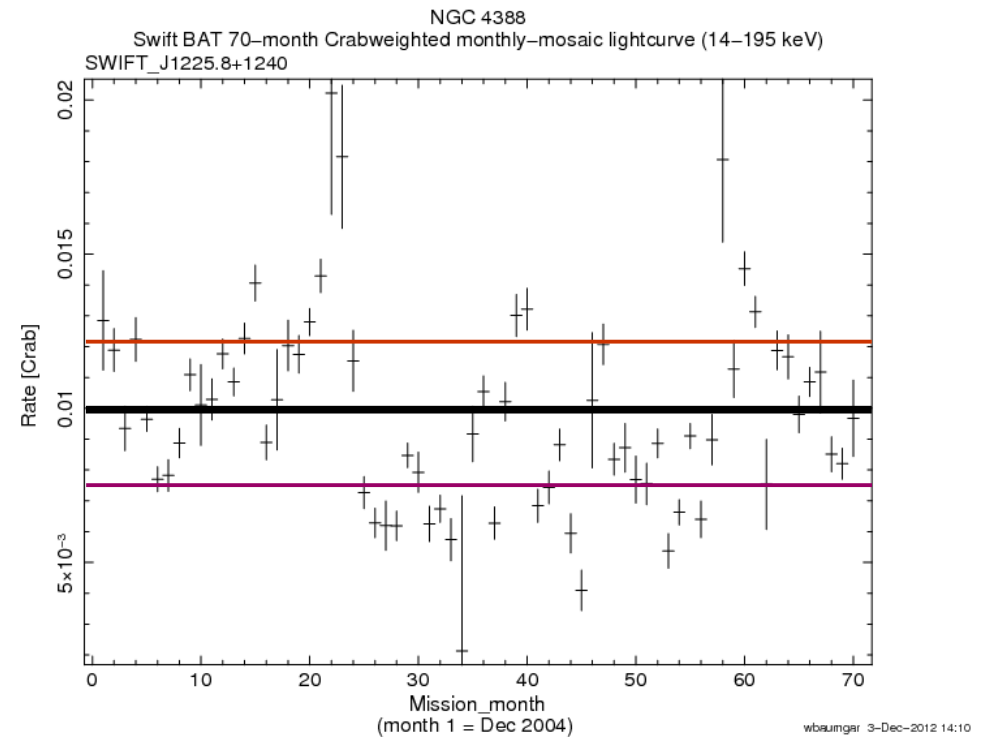
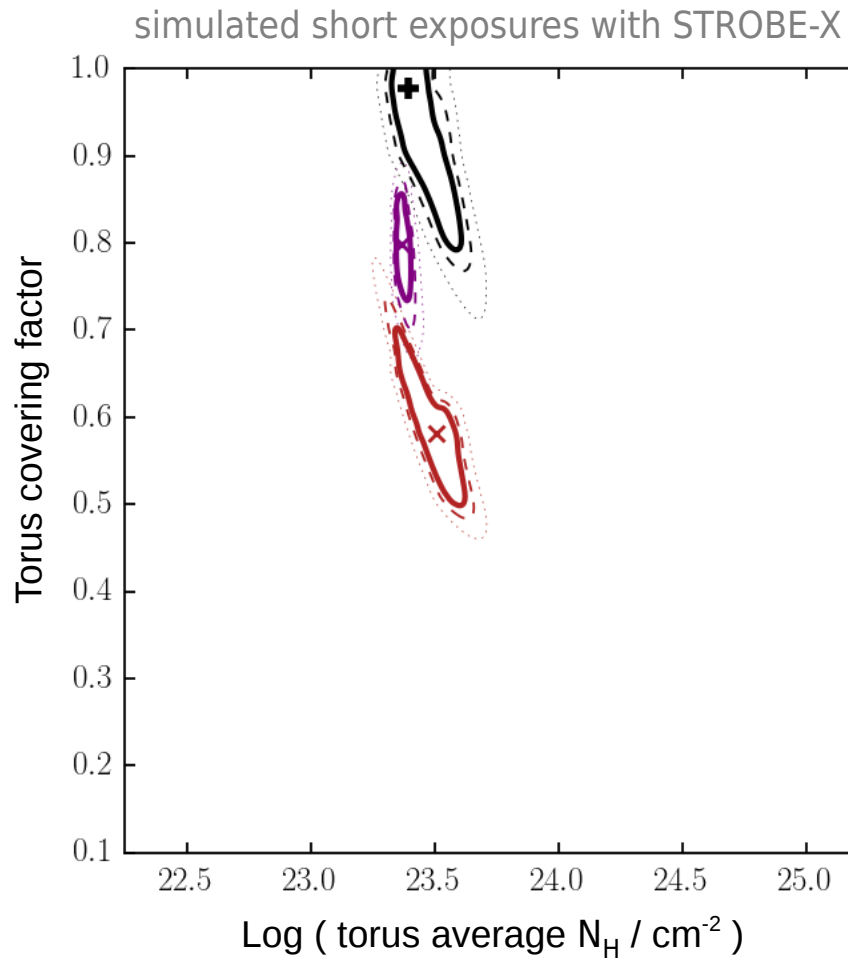


BEWARE OF SINGLE EPOCHS

Baloković et al. 2017 (submitted)



BEWARE OF SINGLE EPOCHS



STAGED APPROACH

- main torus parameters from single epoch snapshots
- main torus parameters from multi-epoch snapshots
 - significantly **reduced systematics**
 - sampling of obscuration variability → **cloud statistics**
 - sampling of continuum shape variability (photon index, **coronal cutoff**)
- **detailed torus parameters** from a long-term baseline model
(assuming, to first order, that the torus does not reverberate)
- reverberation off the torus in narrow Fe line and the Compton hump
(assuming, in the second order, that the torus does reverberate)
 - gives the measurements a **physical scale and interpretation**

SURVEY REQUIREMENTS

- focus on bright targets: ~30 brightest obscured AGN across the sky
- *many* short epochs (just enough for spectral decomposition): 1-10 ks
 - Shortest exposure limit?
 - Fast target switching?
 - Only half of the sky available at any time?
 - Long baseline is essential.
- **priority is LAD sensitivity; energy resolution second (narrow Fe line)**
 - Both depend on orbit (SAA)?
 - High-energy end of the bandpass?
 - XRCA important for broadband coverage, but not critical.
 - WFM could provide smooth lightcurves as additional constraints.

SUMMARY

- “torus” = interface between inner accretion flow and the galaxy
- key X-ray signatures: fluorescent lines & Compton hump
- requires multi-epoch broadband snapshots
- STROBE-X could provide:
 - 1) basic torus parameters from spectroscopy
 - 2) obscuring cloud statistics from monitoring
 - 3) physical scale from reverberation

