Mildly obscured active galaxies and the diffuse X-ray background

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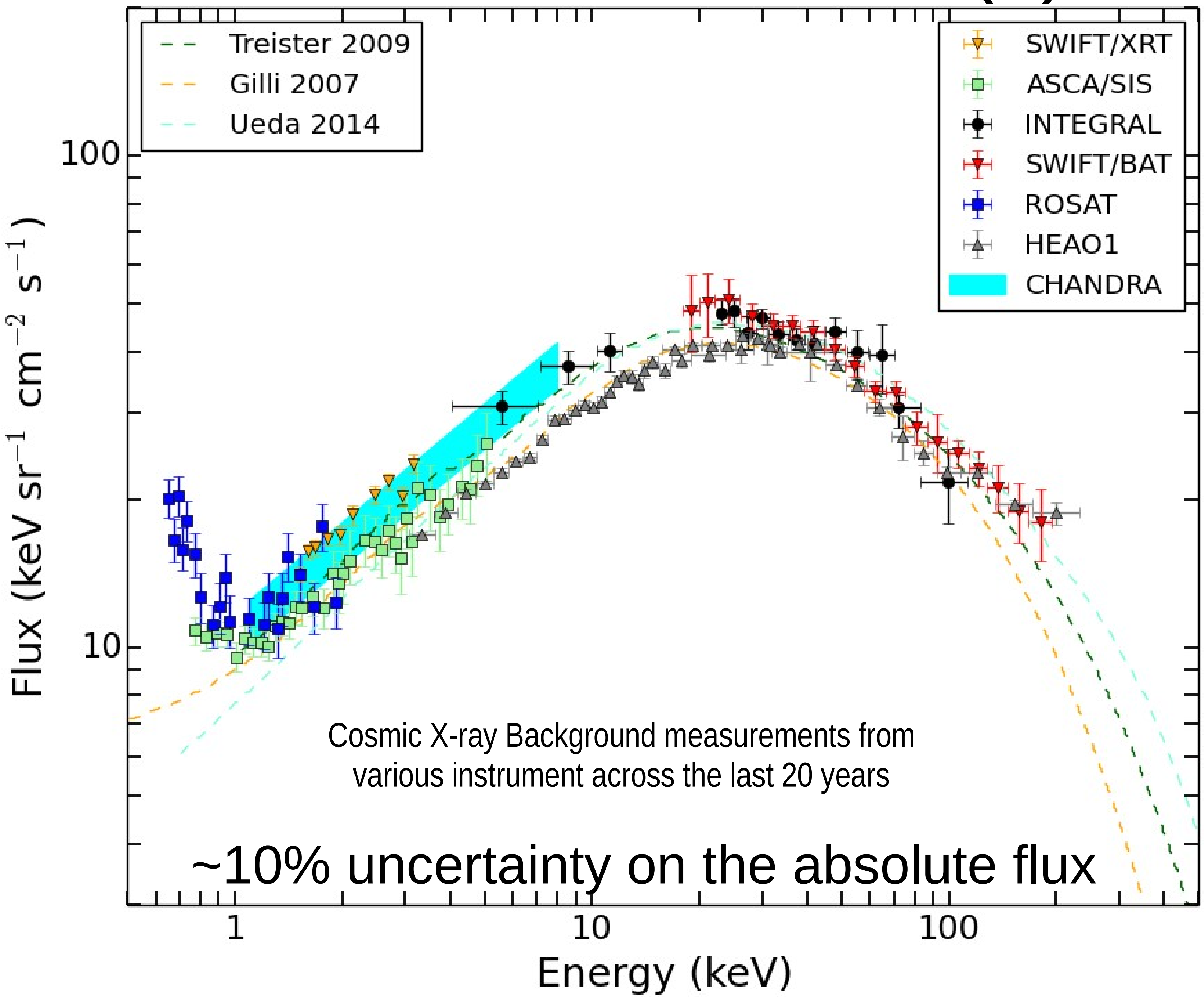
ISDC

Outline

- Review of the Cosmic X-ray Background and the limits of our knowledge.
- Stacking ~10^9s of Swift/BAT data for different AGN classes.
- Implication on the Compton Thick AGN population.

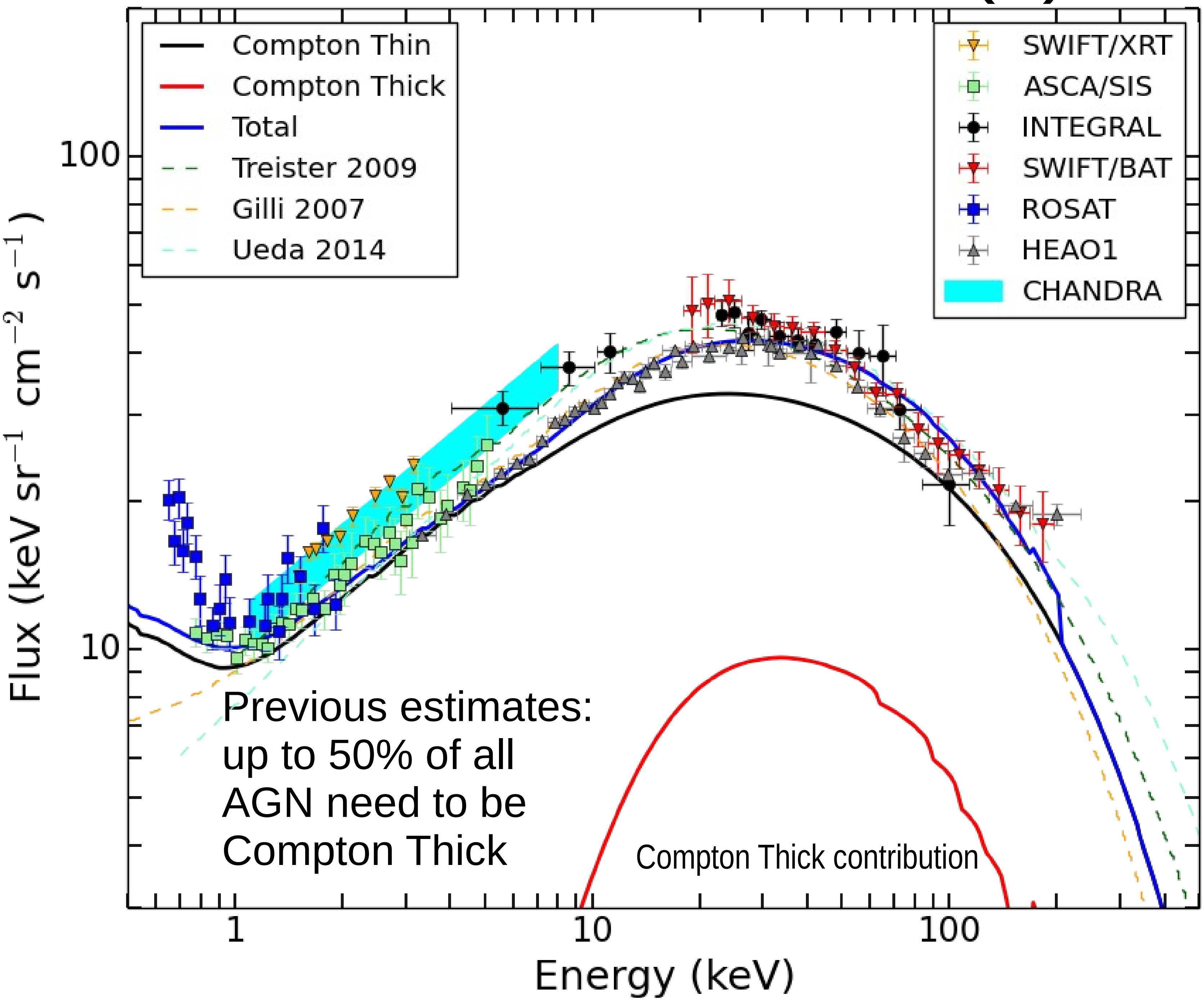
Introduction: the CXB (1)



Cosmic X-ray Background measurements from various instrument across the last 20 years

~10% uncertainty on the absolute flux

Introduction: the CXB (2)



The CXB synthesis (1)

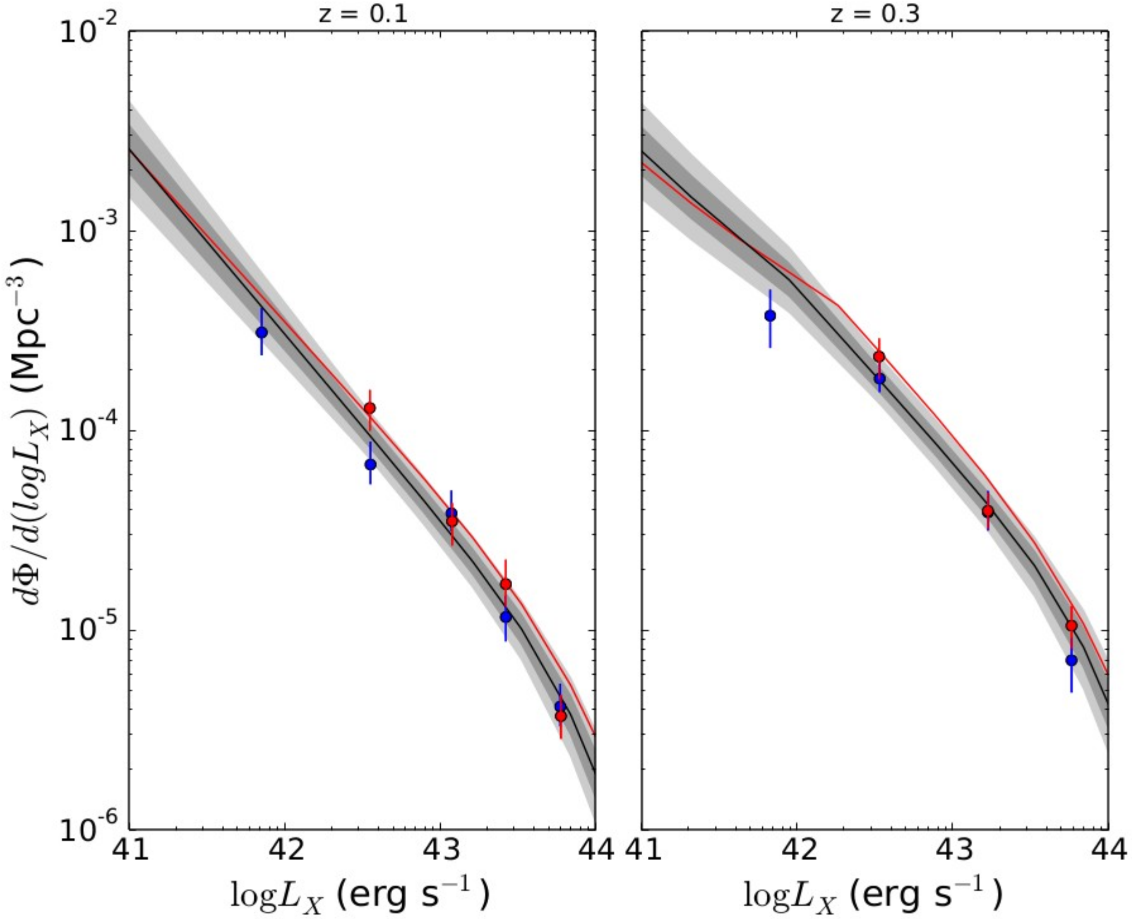
Necessary ingredients:

- X-rays Luminosity Function (XLF).
- N_H distribution.
- Spectral templates of AGN classes.

Ueda et al 2014: hard band (2–10 keV), 4039 AGNs.

Absolute normalization:

- 10% 1σ uncertainties on best fit parameters
- 15% Ueda 2014 vs Ueda 2003



The CXB synthesis (2)

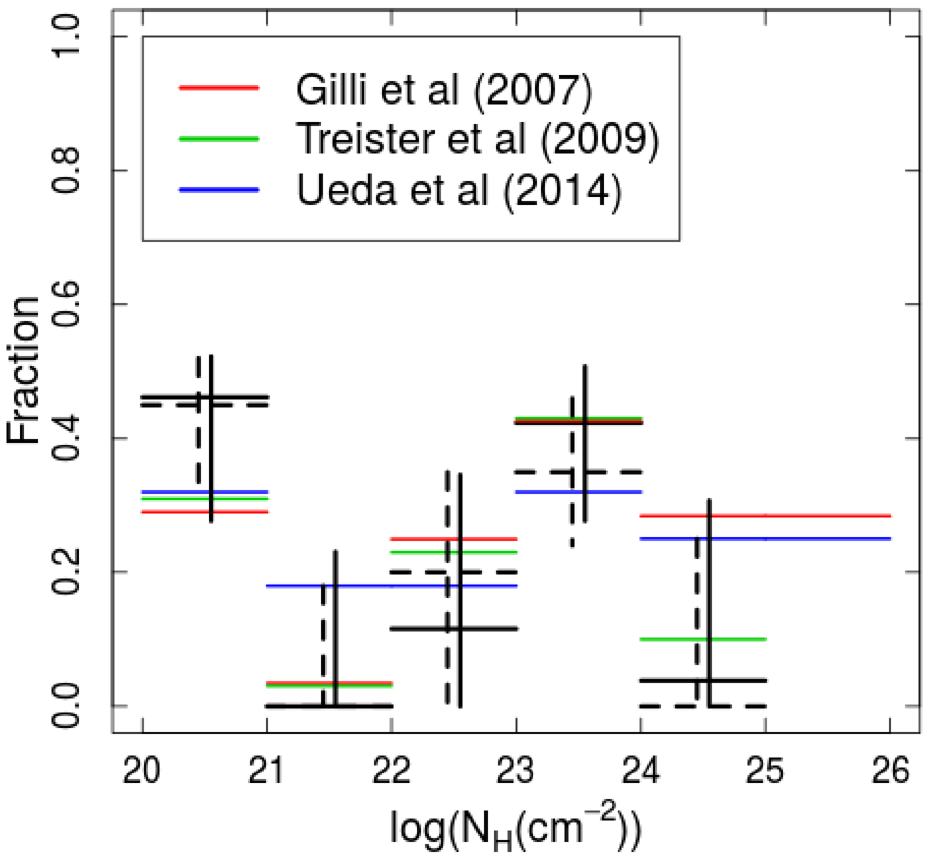
Necessary ingredients:

- X-rays Luminosity Function (XLF).
- N_H distribution.
- Spectral templates of AGN classes.

AGN distribution as a function of the absorption (N_H).

Still 11% of mildly obscured AGN ($23 < \log N_H < 24$) escape detection.

We fit the N_H distribution



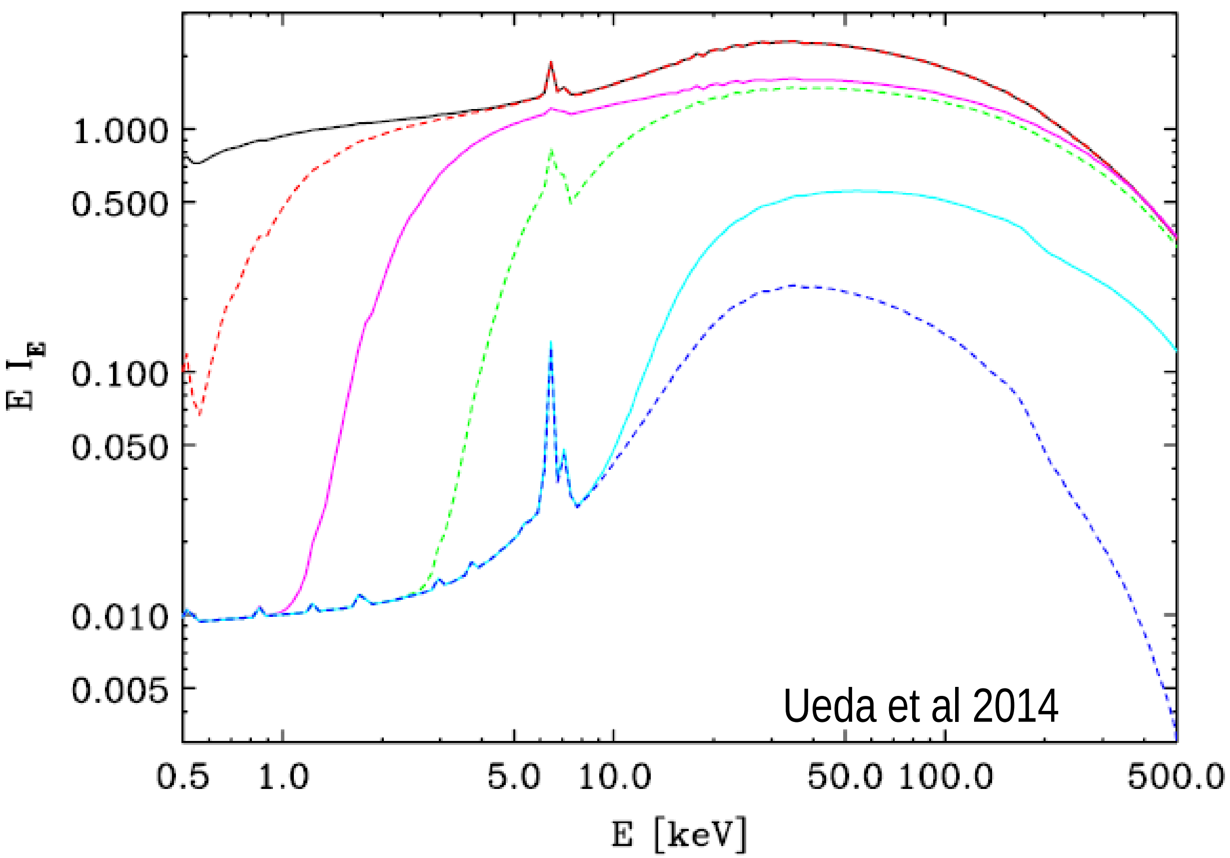
The CXB synthesis (3)

Necessary ingredients:

- X-rays Luminosity Function (XLF).
- N_H distribution.
- Spectral templates of AGN classes.

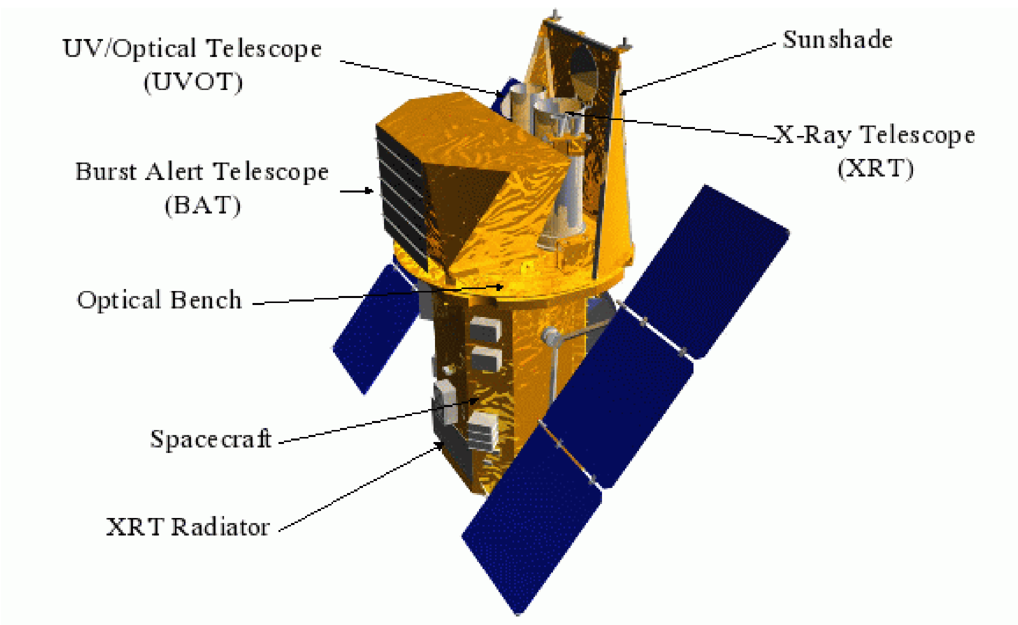
Assumption for numerical models:

- Intrinsic continuum.
- Torus geometry.

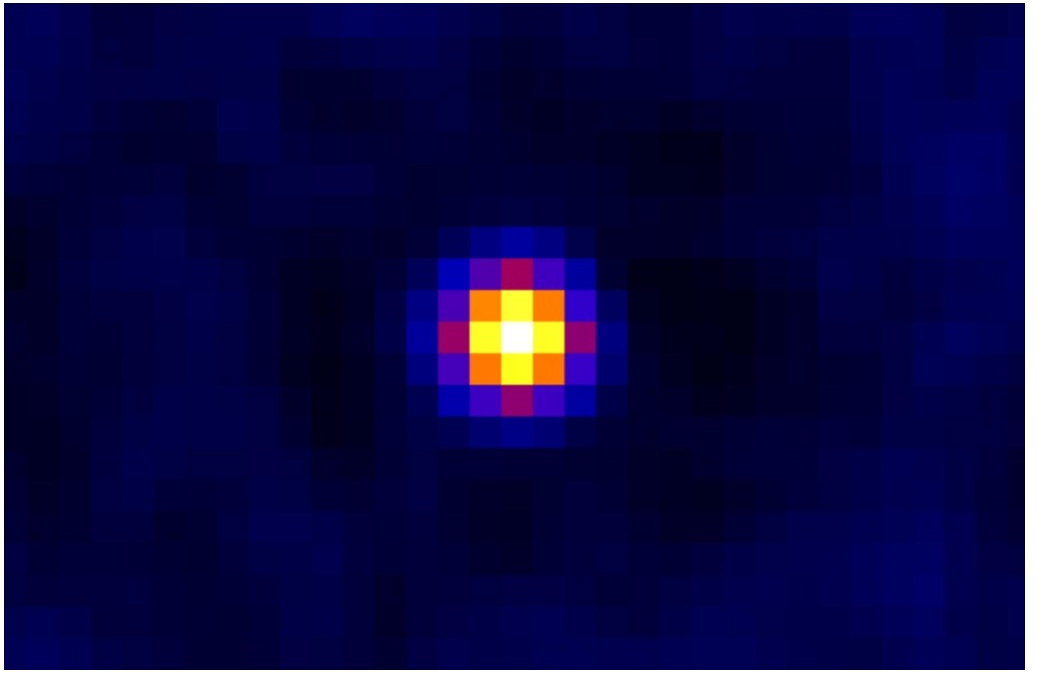


This work

- Use BAT data to constrain the spectral properties.
- Swift / BAT (14 – 195 keV) average spectra of Seyfert Galaxies are obtained with the stacking procedure.



Swift/BAT Payload



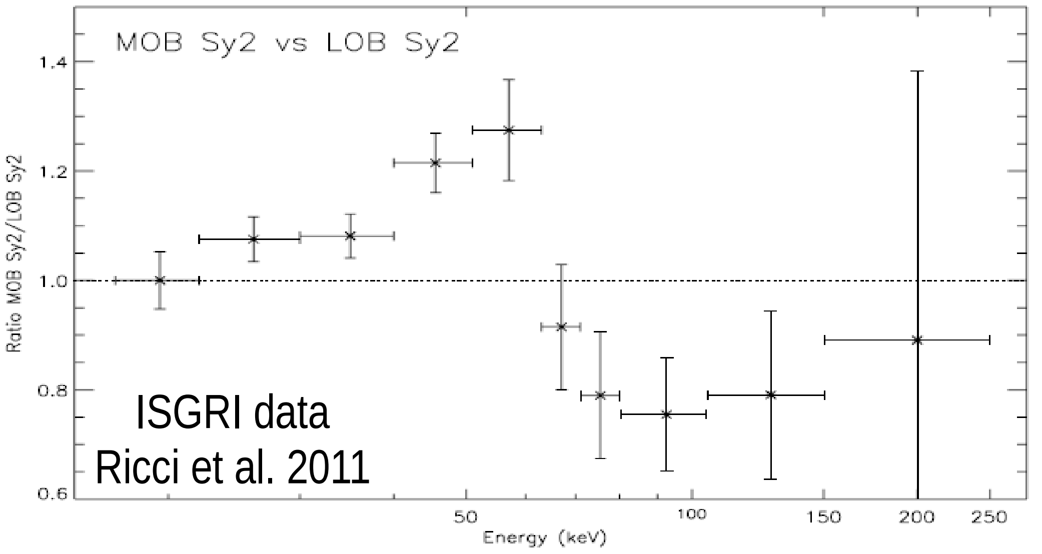
~0.6 Gs (~20 years) of exposure with Swift/BAT

The sample and average spectra

165 Seyfert galaxies (> 5σ) (Ricci et al 2011).

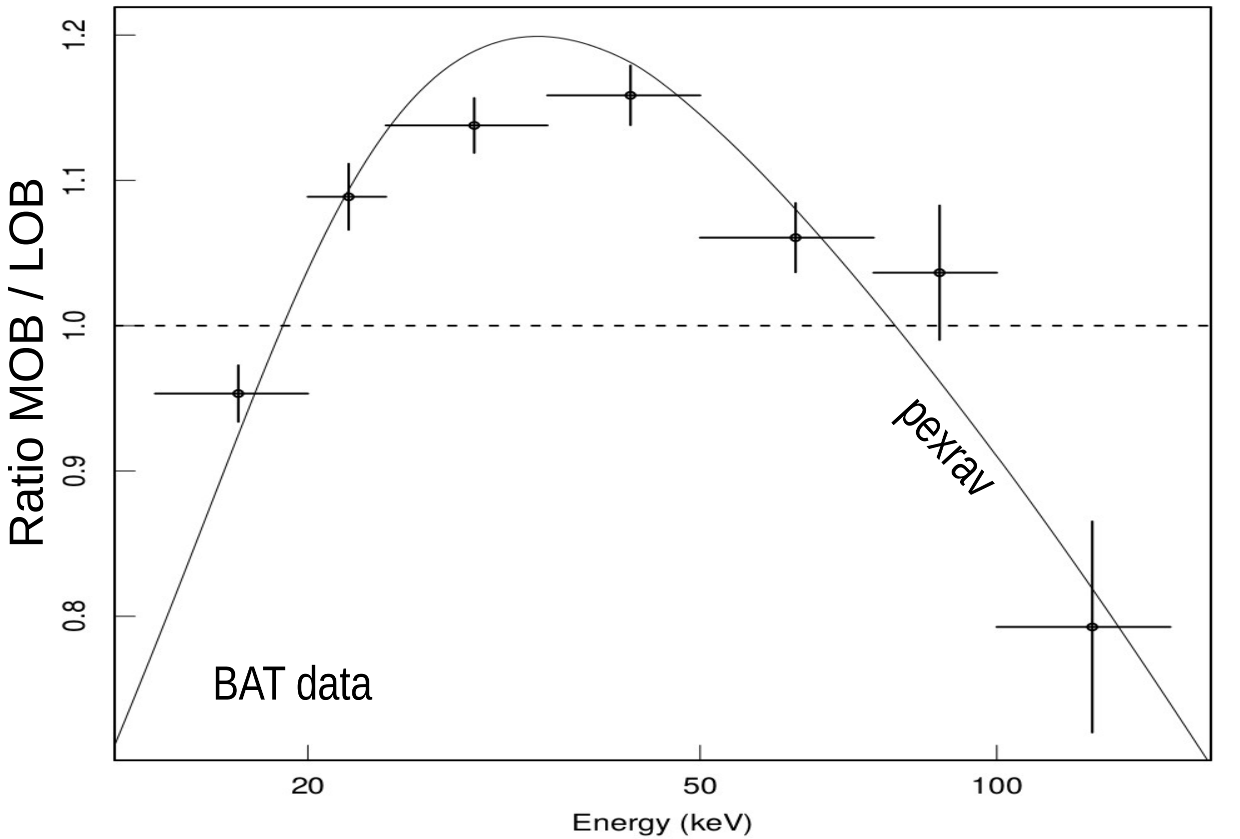
ISGRI data: ~ 2 10^7s

BAT data: ~ 5 10^8s

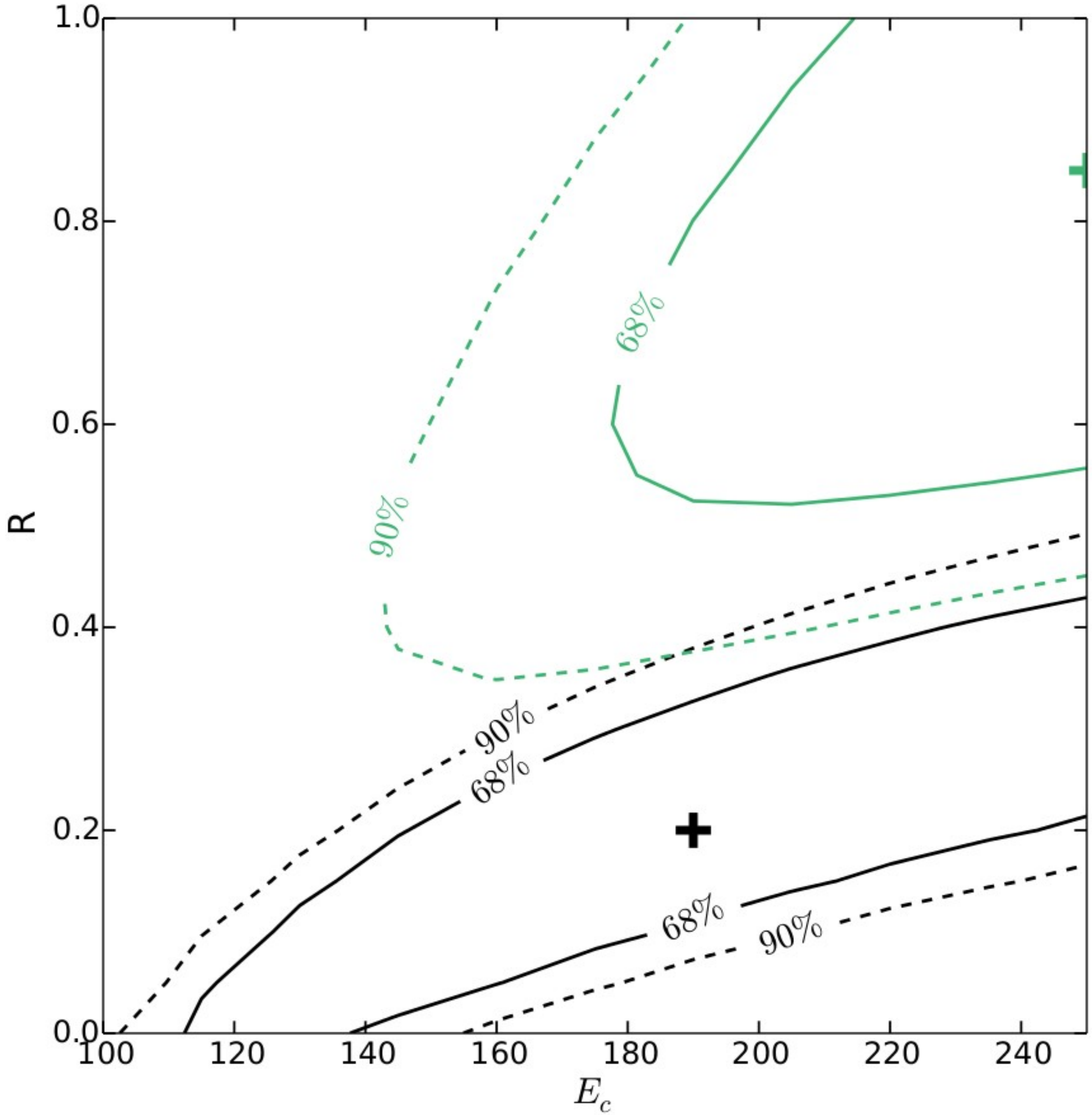


MOB: 23 < $\log N_H$ < 24

LOB: $\log N_H$ < 23



The reflection component



BAT energy band: 14 – 195 keV

with pexrav model:

20 < $\log N_H$ < 22
23 < $\log N_H$ < 24

Limited energy bandpass of BAT.

But it does not matter much for the CXB synthesis.

The BAT spectral templates

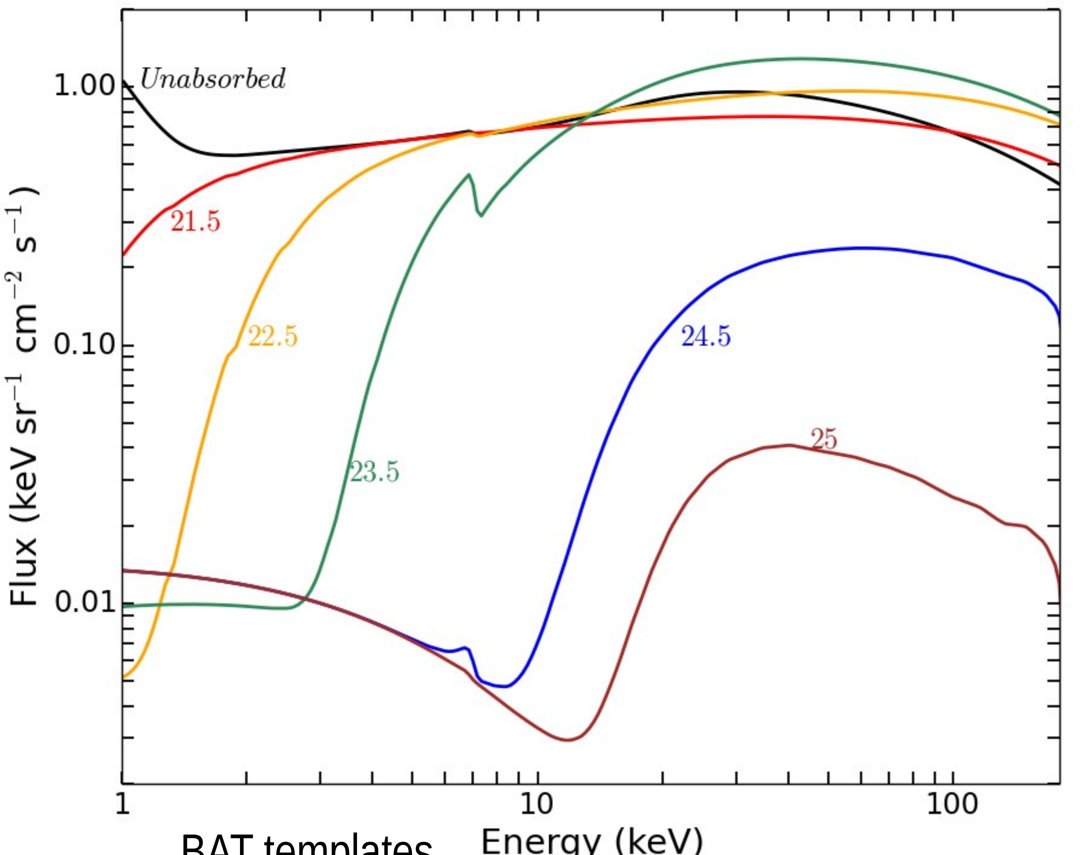
Necessary ingredients:

- X-rays Luminosity Function (XLF).
- N_H distribution.
- Spectral templates of AGN classes.

Spectral templates derived by stacked BAT spectra.

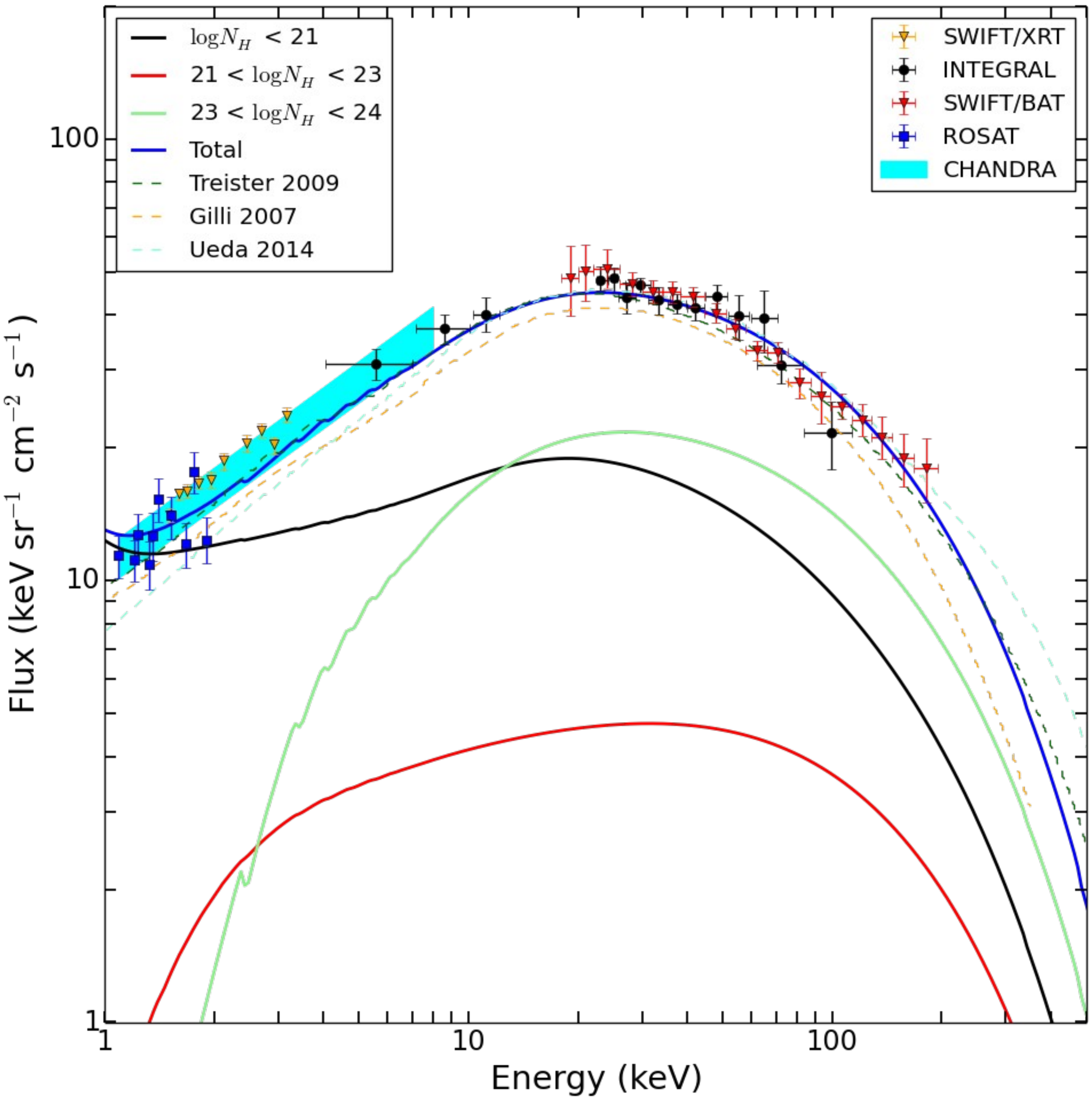
E_c fixed at 200 keV.

Compton thick templates derived with MYTORUS model (Yaqoob 2012).



BAT templates

The CXB spectrum



- N_H fit performed on ROSAT, Swift/XRT, Swift/BAT, INTEGRAL.
- Scaling factor on the absolute normalization.
- Mildly obscured sources contribute massively to the CXB.

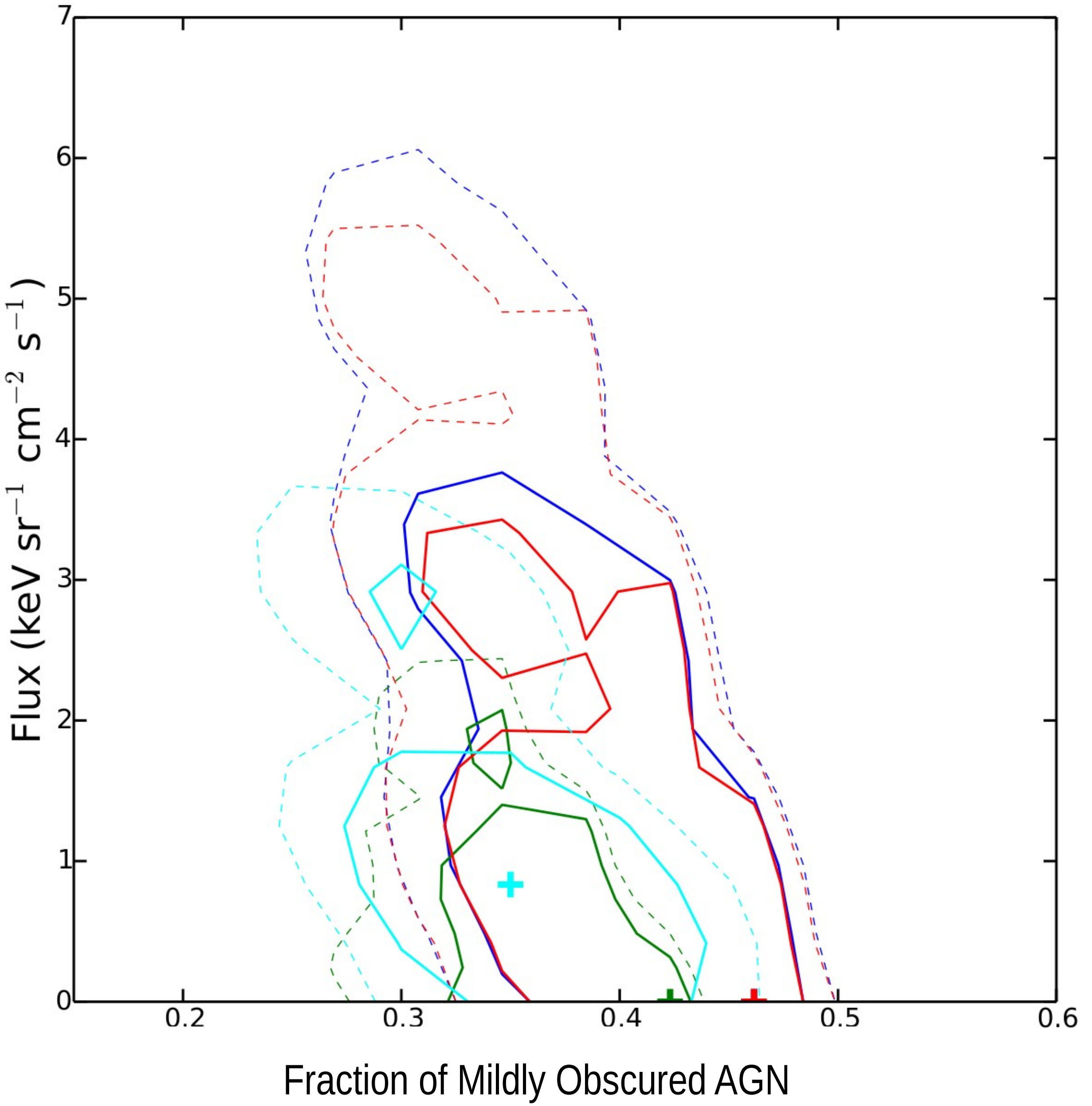
CXB best fit: scaling factor = 1.3 with Ueda 2014 XLF

CXB Flux from CTK sources (1)

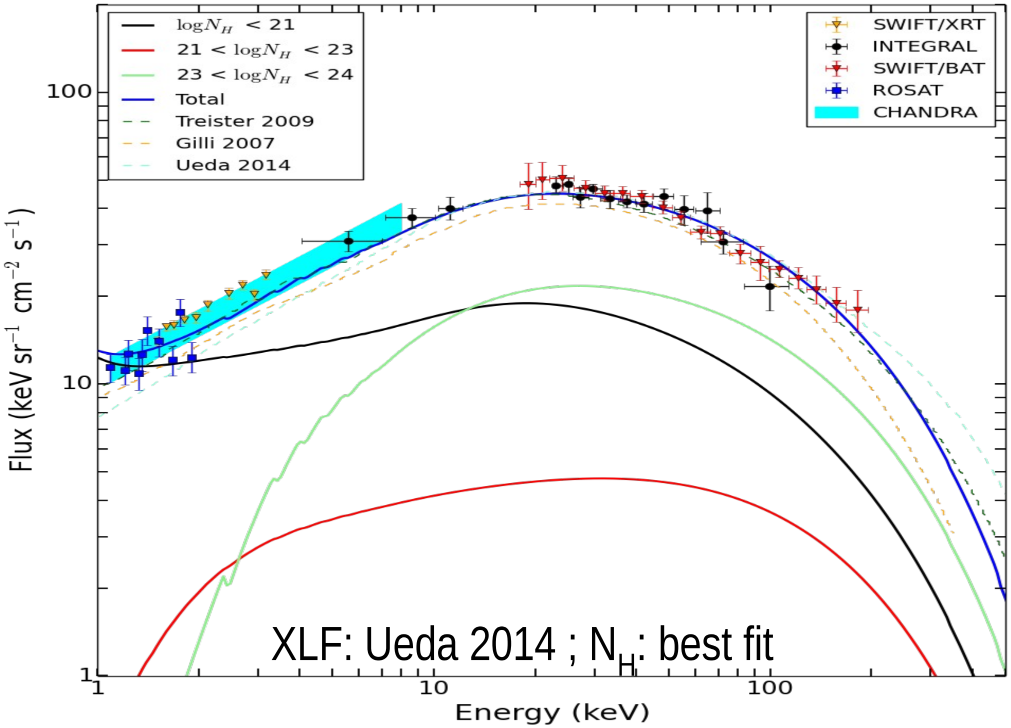
Contour plot for various combinations of ingredients.

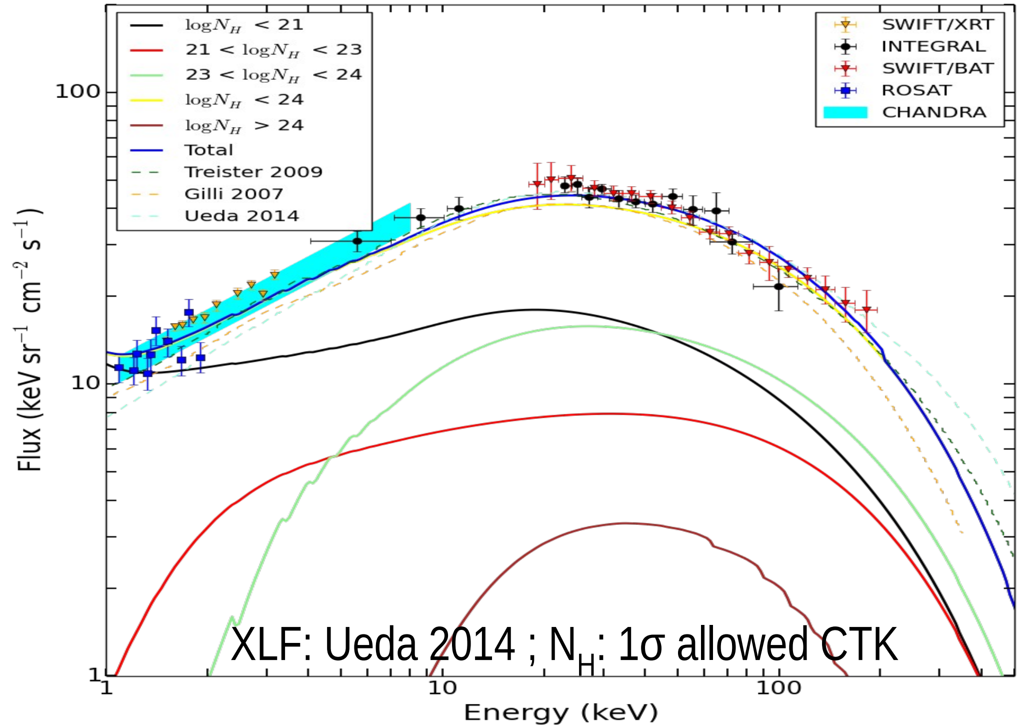
F_{CTK} (30 keV) < 4 keV sr^{-1} cm^{-2} s^{-1} (at 1σ)

A huge CTK population is not needed.



CXB Flux from CTK sources (2)





Previous XLF and N_H distr. + BAT templates: fit not good.

A good fit can be achieved only fitting the N_H distribution to the data.

Sp. T.	XLF	N_H distr	χ^2_{red}	CT Flux
G07	H05	G07		10
T09	U03	T09		4
U14	U14	U14		9
BAT	H05	G07	2.0	1.5±0.5
BAT	U03	T09	2.1	< 1
BAT	U14	U14	1.7	11.5±0.5
BAT	U03	fitted	1.1	< 2
BAT	U14	fitted	1.0	< 4

Conclusion

- We confirm the hint found by Ricci et al 2011: Mildly obscured Seyferts show more reflection than Lightly obscured.
- We reproduce the CXB spectrum using spectral templates derived from BAT stacking. CXB is dominated by AGN at $z < 1.3$: if the average spectra are representative up to $z = 1.3$, CTK fraction is less than 20%. It is compatible with the observation at low redshift.
- The large reflection found in Mildly obscured Seyferts is in contrast with the obscuring torus model, and points towards a clumpy obscuring material. This is in line with the recent modelling of the infrared spectra of AGNs (works of Ramos Almeida, Elitzur, Nankova).