Beyond the Lockman Hole: spectroscopy of the absorbed Universe

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XMM Next Decade

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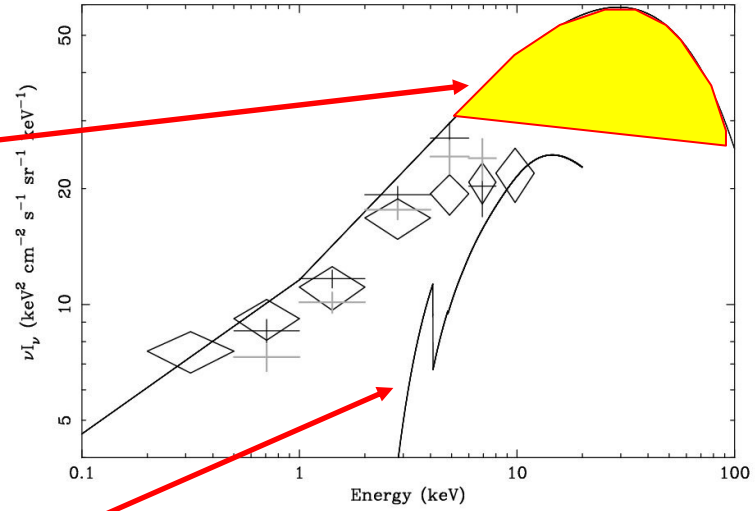
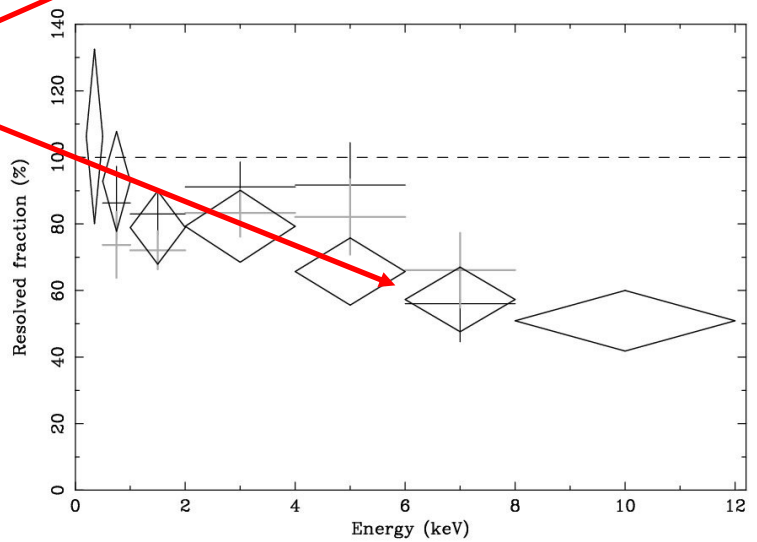
What is there beyond the Lockman Hole? (Why bother?)

- Bolometric intensity of XRB still unresolved:
  - Need >30 keV
  - Until then, XMM best chance >5keV
- XRB resolved fraction 6-8 keV ~60% (Worsley+05):
  - Rest compatible with obscured AGN ($\log N_{\rm H}$~23-24) @z~1
- Unified XRB models predict absorbed AGN fraction ~3/4 (Gilli+07), but up to now ~1/2





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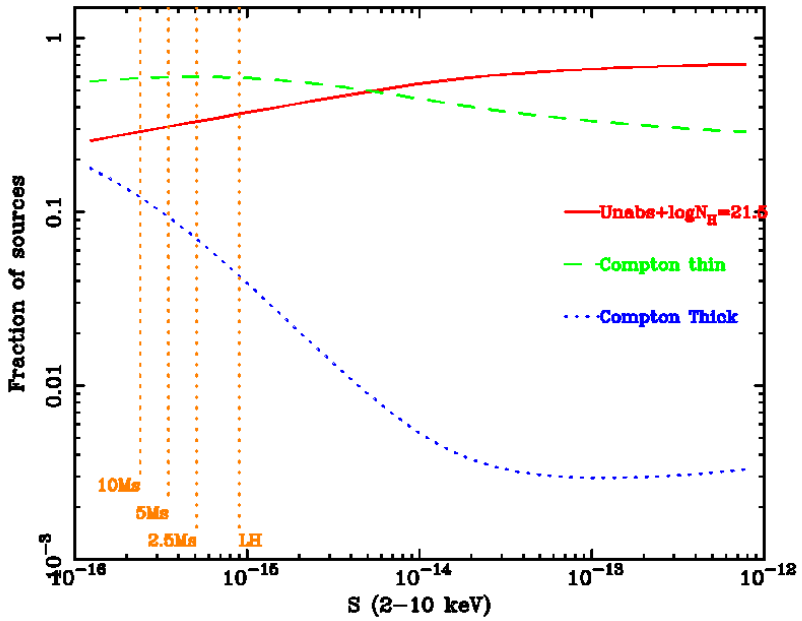

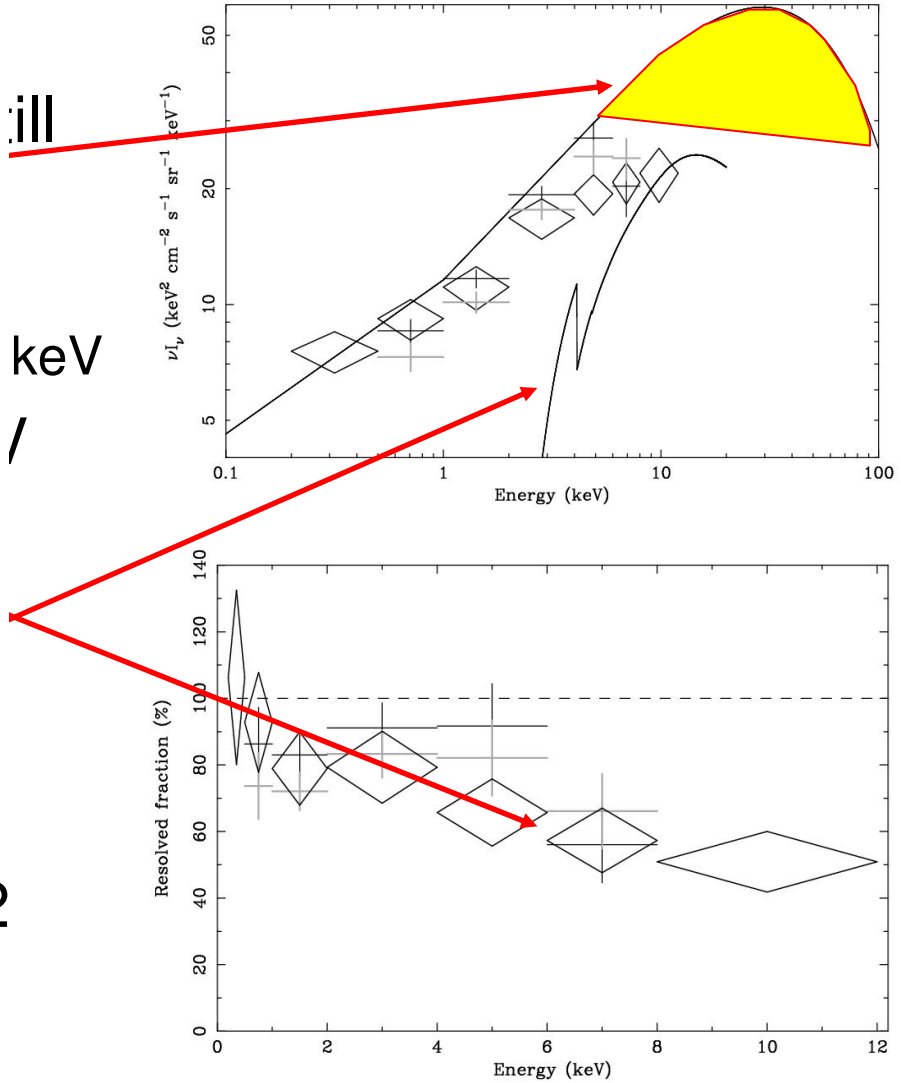

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Source confusion

- Source confusion occurs when two or more sources fall in a single resolution element of the detector
- Effects:
  - Flux amplification
  - Spectral distortion (flatter spectra)

  } strong effect on the $\log N$-$\log S$ determination
- Effective limit to source detection:
  - It can be reached before expected from counting statistics
  - LH could have already reached the confusion limit in the soft band, and hard band not far off

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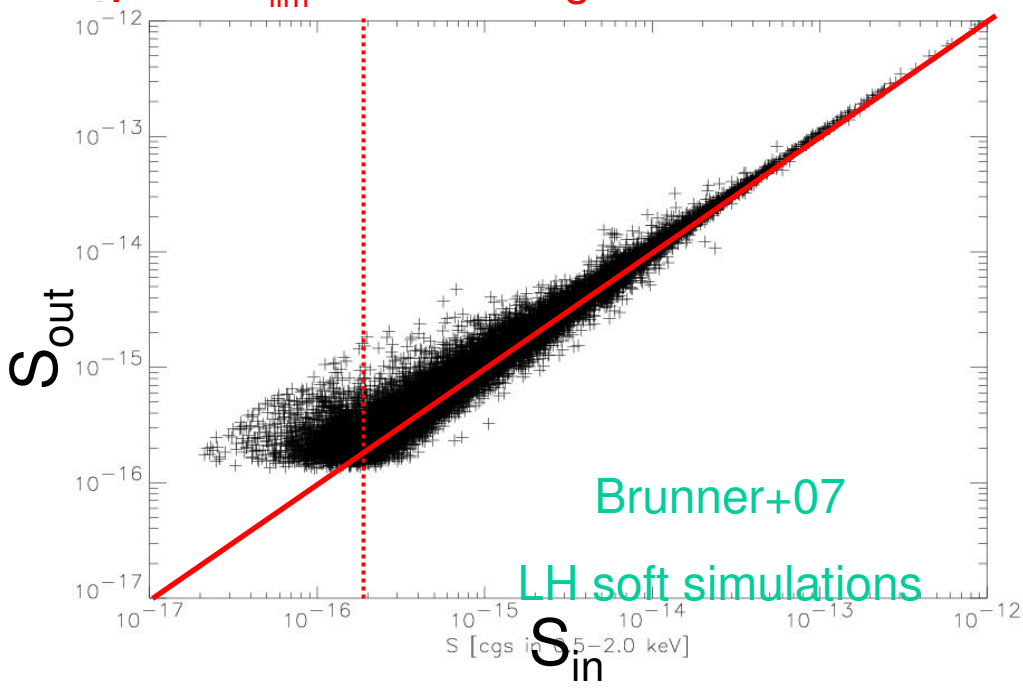
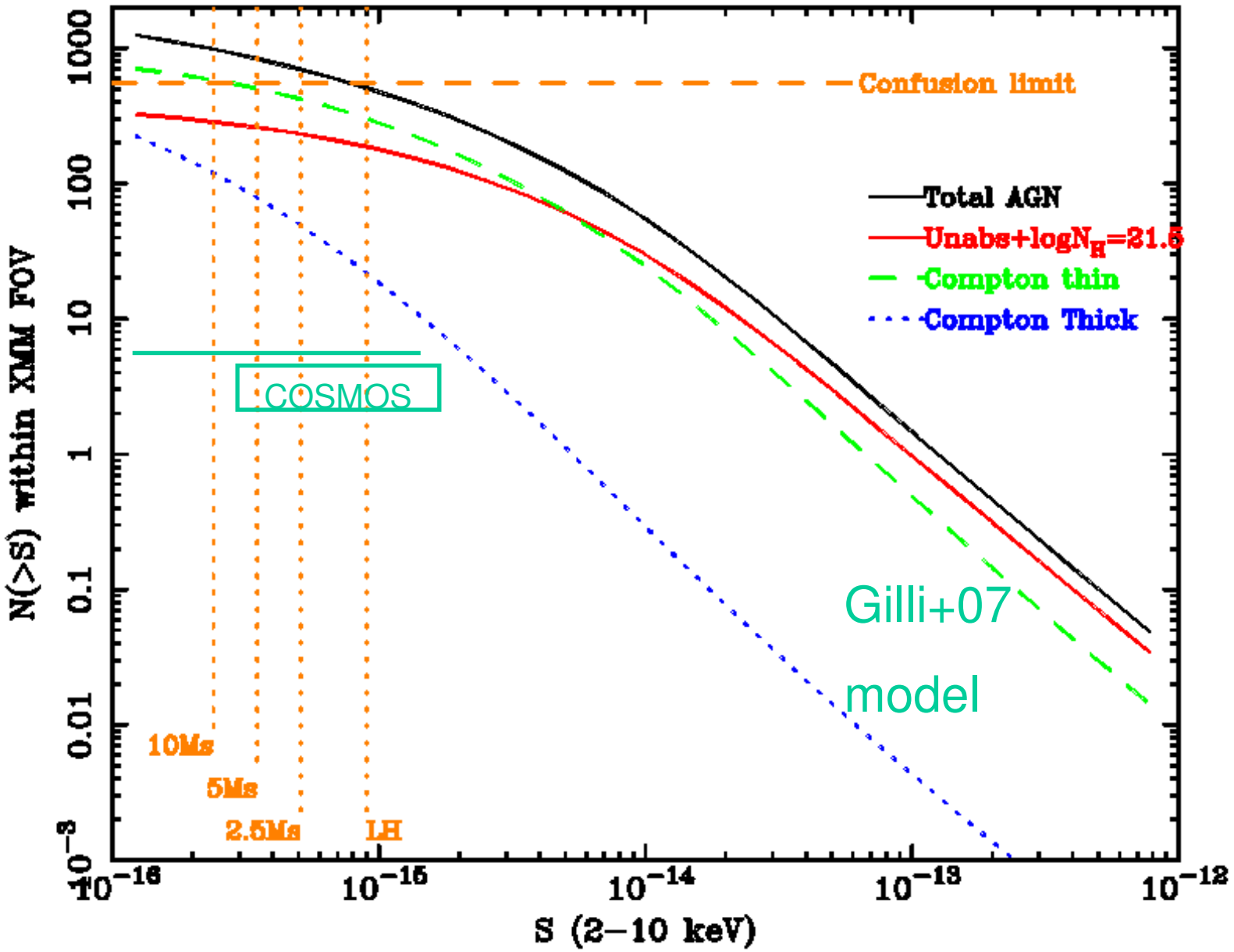
$S_{lim}=1.9\times10^{-16}$ cgs



How deep can XMM-Newton go?

- Let's assume that the angular density of the soft band sources in the LH is the confusion limit
- Using deep $\log N$-$\log S$ (Brunner+07,Carrera+07):
  - found the 2-10 keV (hard), 5-10 keV (ultra-hard) fluxes necessary to reach that density
    - hard: 6.0×10^{-16} cgs (LH 9.0×10^{-16} cgs)
    - ultra-hard: 3.9×10^{-16} cgs (LH 1.8×10^{-15} cgs)
- Using the LH hard and ultra-hard backgrounds:
  - Estimated the exposure times needed to detect absorbed AGN for Γ=2, z=1 and a number of $\log N_H$ values
    - Ultra-hard more sensitive to AGN with $\log N_{\rm H}$>24

Source counts (2-10 keV)



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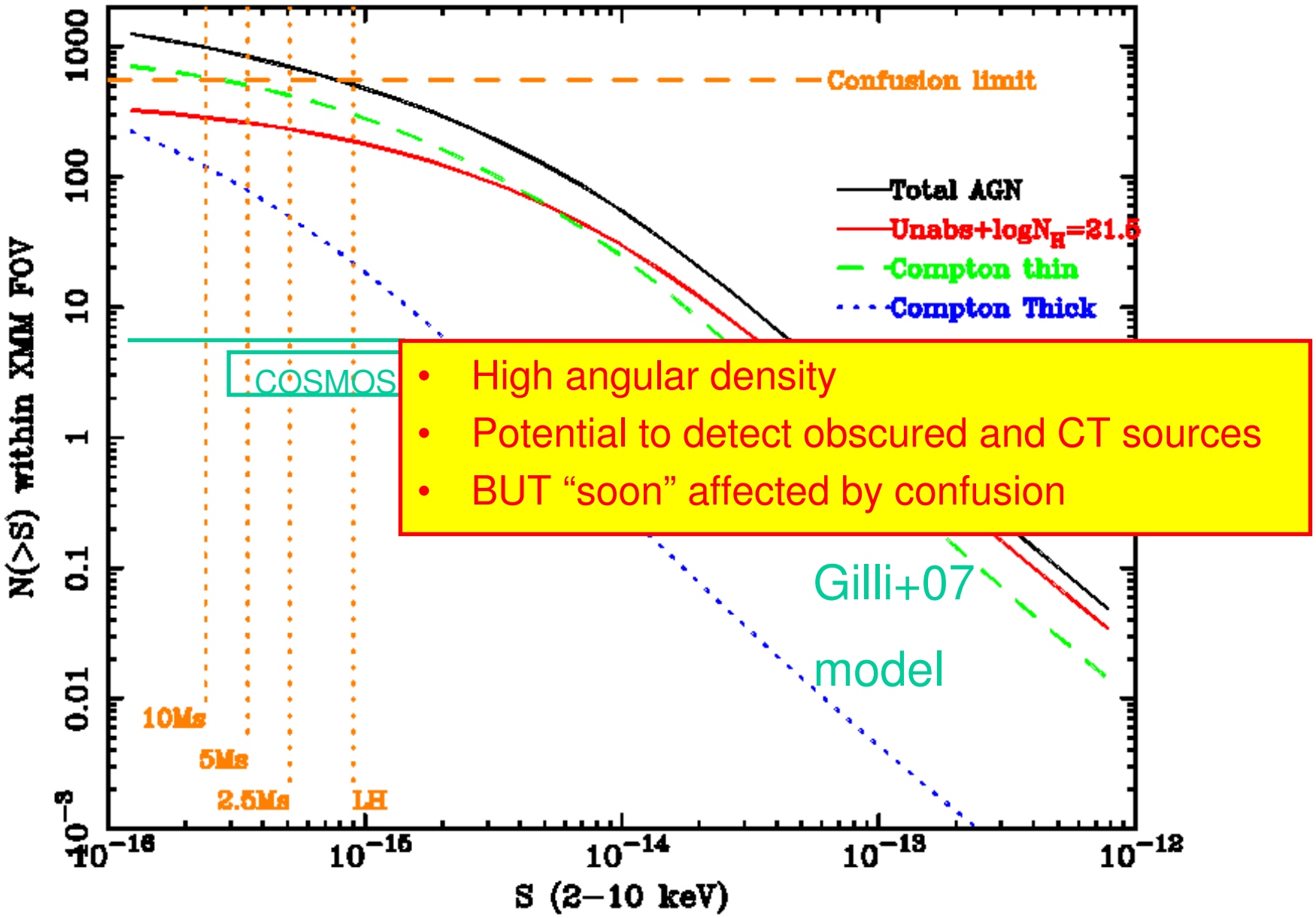
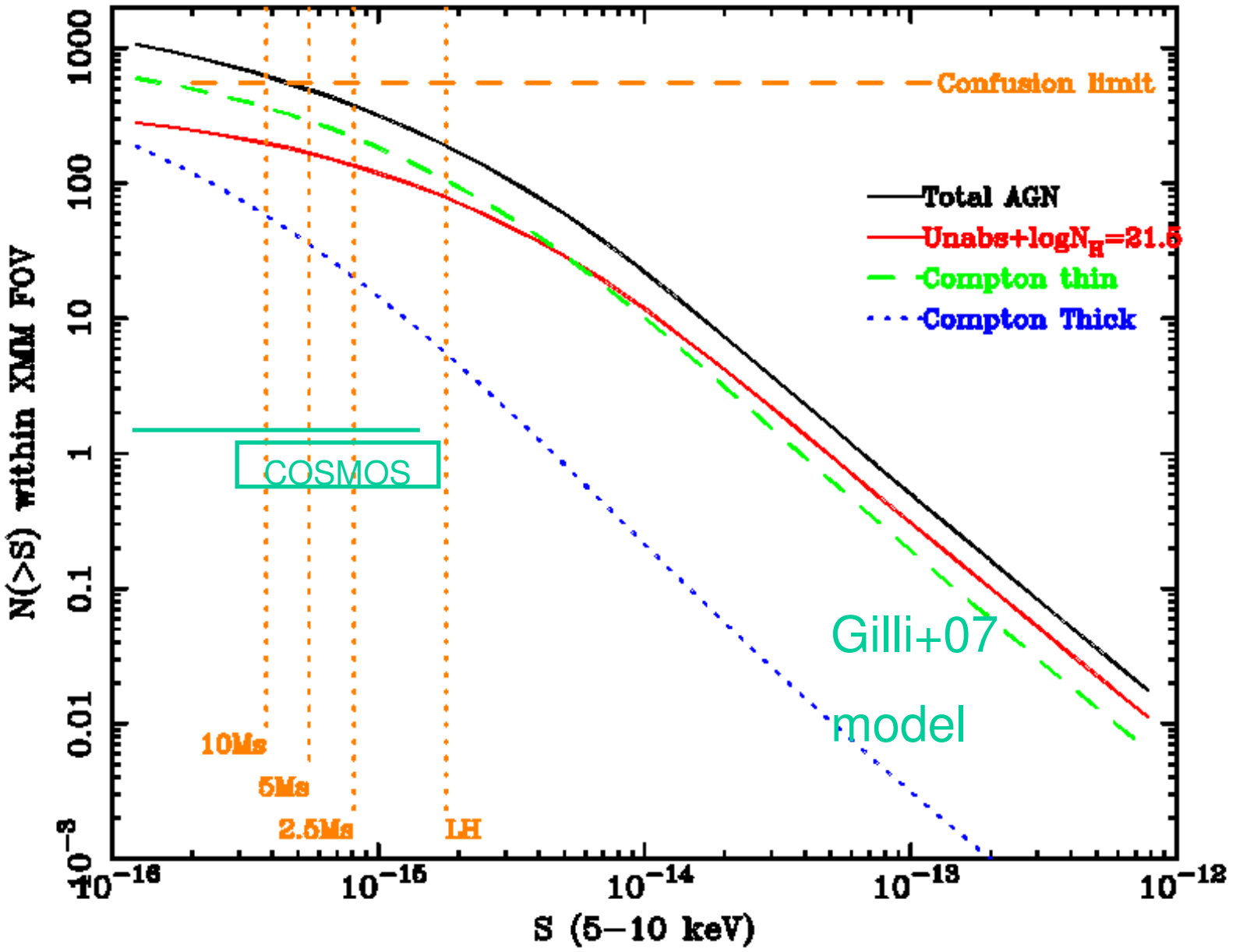


- High angular density
- Potential to detect obscured and CT sources
- BUT “soon” affected by confusion

Source counts (5-10 keV)



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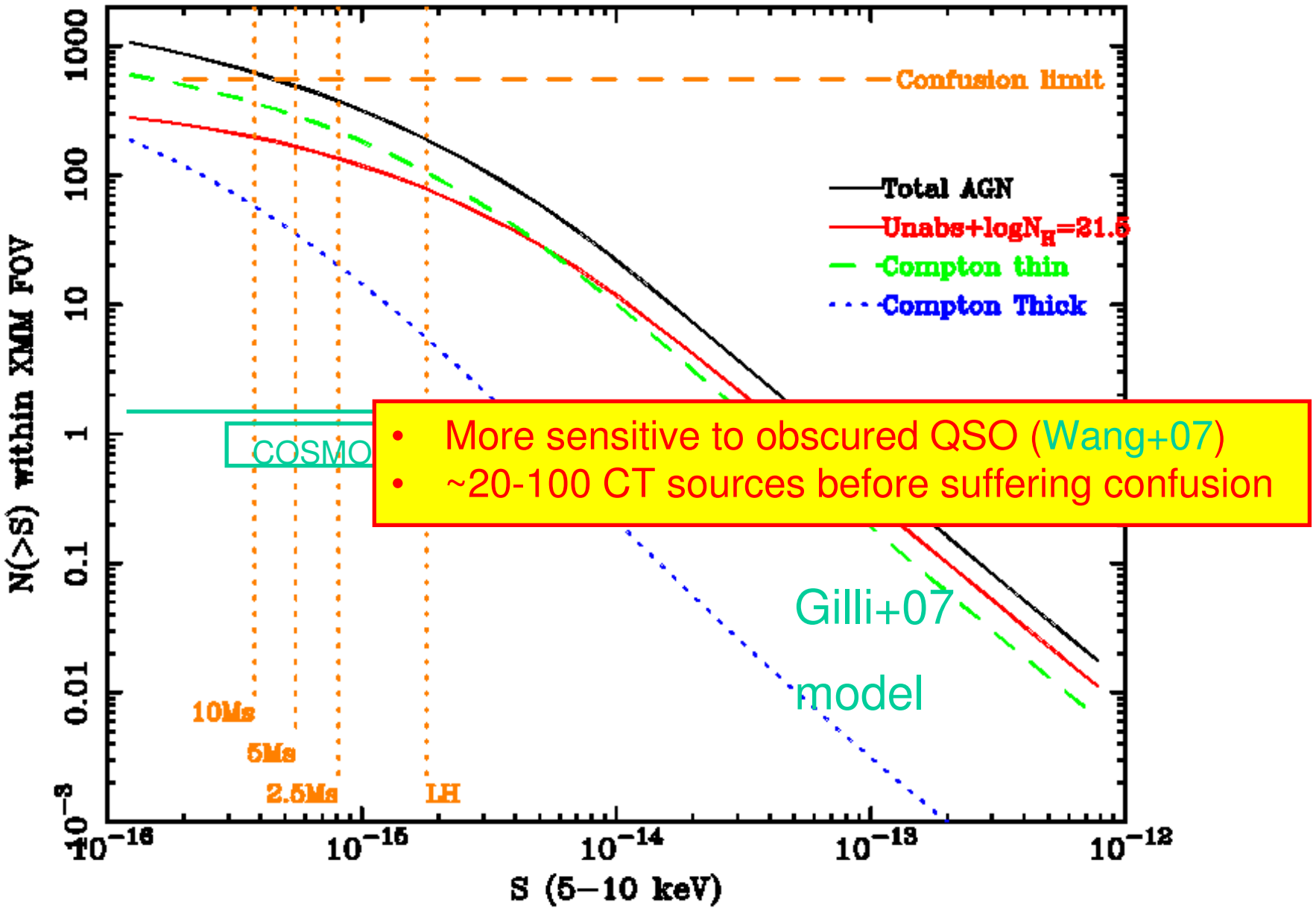
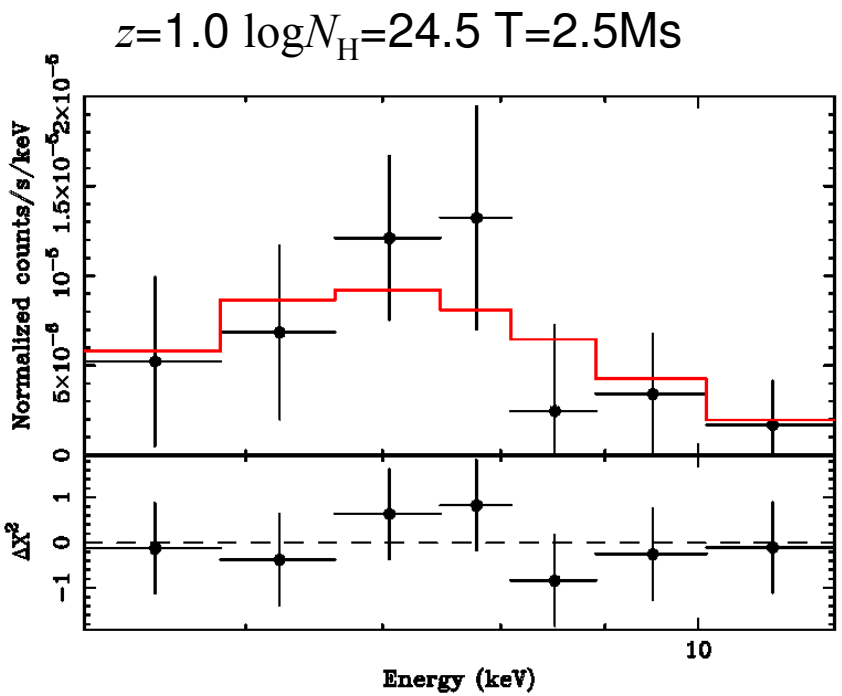


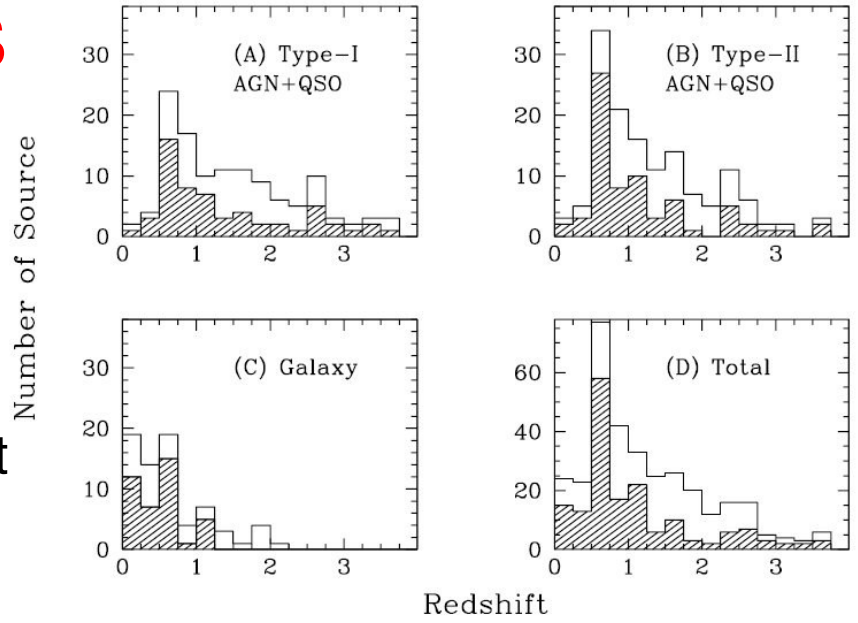
- More sensitive to obscured QSO (Wang+07)
- ~20-100 CT sources before suffering confusion

X-ray spectra

- Simulations of CT sources at detection limit:
  - LH bgd
  - absorbed p.l.: Γ=2
  - T=2.5, 5, 10Ms
- Fitting only 5-12 keV
- $\log N_{\rm H}$=24.5:
  - very flat spectral fit
  - $N_{\rm H}$ free not always improves fit



Identification of the optical counterparts



- "Normal" galaxies at z~1: I~23.7
  - Spectroscopic redshifts very difficult
- Zheng+04, CDF-S:
  - 10 bands: NUV-NIR
  - Photometric redshifts for $S_{2\text{-}10keV} \leq 5 \times 10^{-16}$cgs (~5Ms XMM det. limit)
- Identification possible, but need deep multi-λ coverage
  - Longer exposure on present deep field (LH,ECDFS...) with existing data
  - Use of new facilities (GTC/OSIRIS-EMIR)...

Conclusions

- Source confusion sets effective detection limit:
  - The Lockman Hole close to confusion limit in soft band
  - Confusion reached in 2-10 keV in~2Ms
  - Unreachable in 5-10 keV in foreseeable future
- A single very deep pointing in 5-10 keV could uncover the Compton Thick population of AGN:
  - ~20 in 2.5Ms
  - ~40 in 5 Ms
  - ~60 in 10Ms
- Hundreds of Compton thin AGN
- X-ray spectroscopy feasible even down to detection limit
- Identification through photometric redshifts