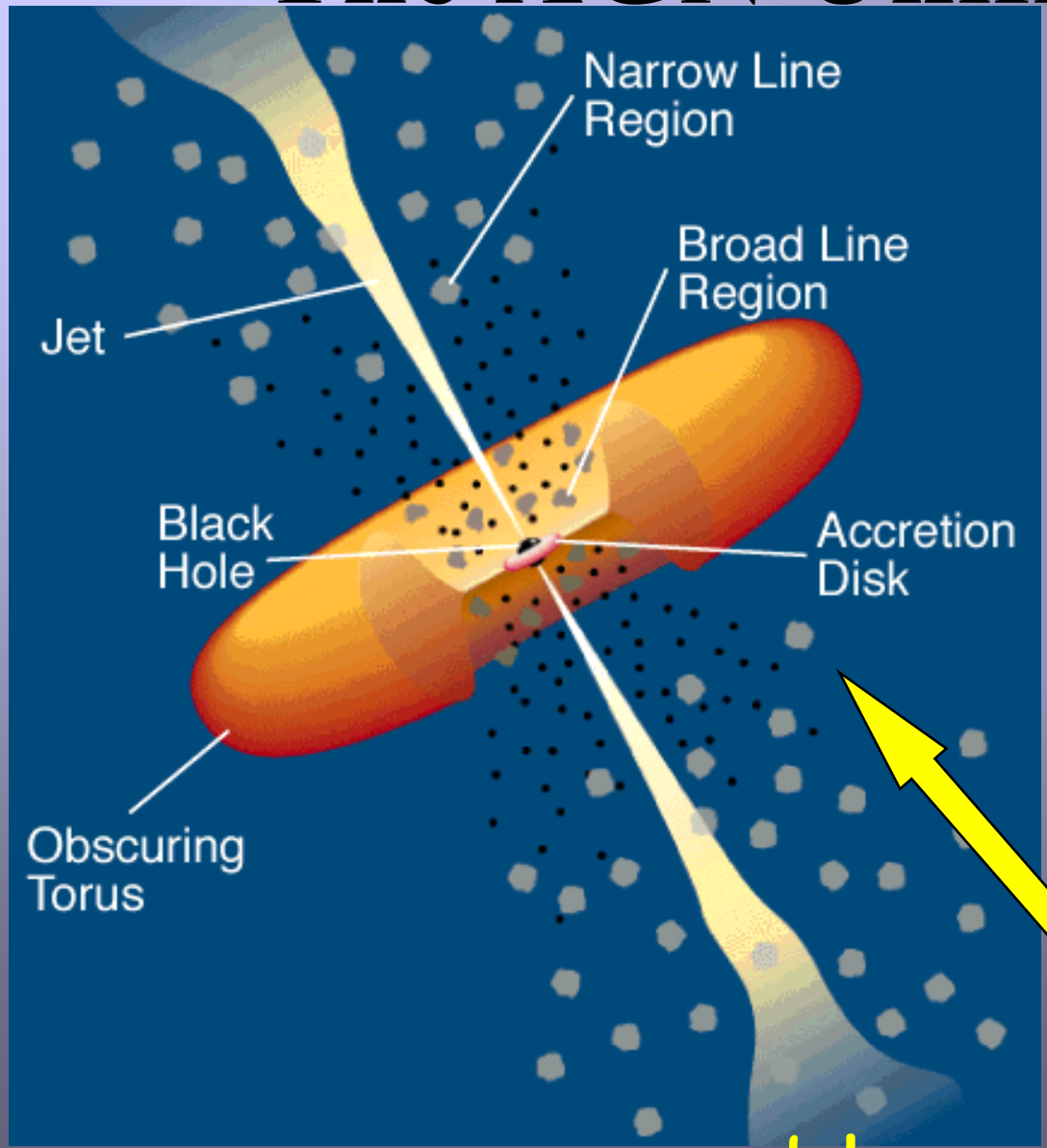
Multiwavelength AGN Number Counts in the GOODS fields

Ezequiel Treister (Yale/U. de Chile)

Meg Urry (Yale)

And the GOODS AGN Team

The AGN Unified Model



broad lines

blazars, Type 1 Sy/QSO

Urry & Padovani, 1995

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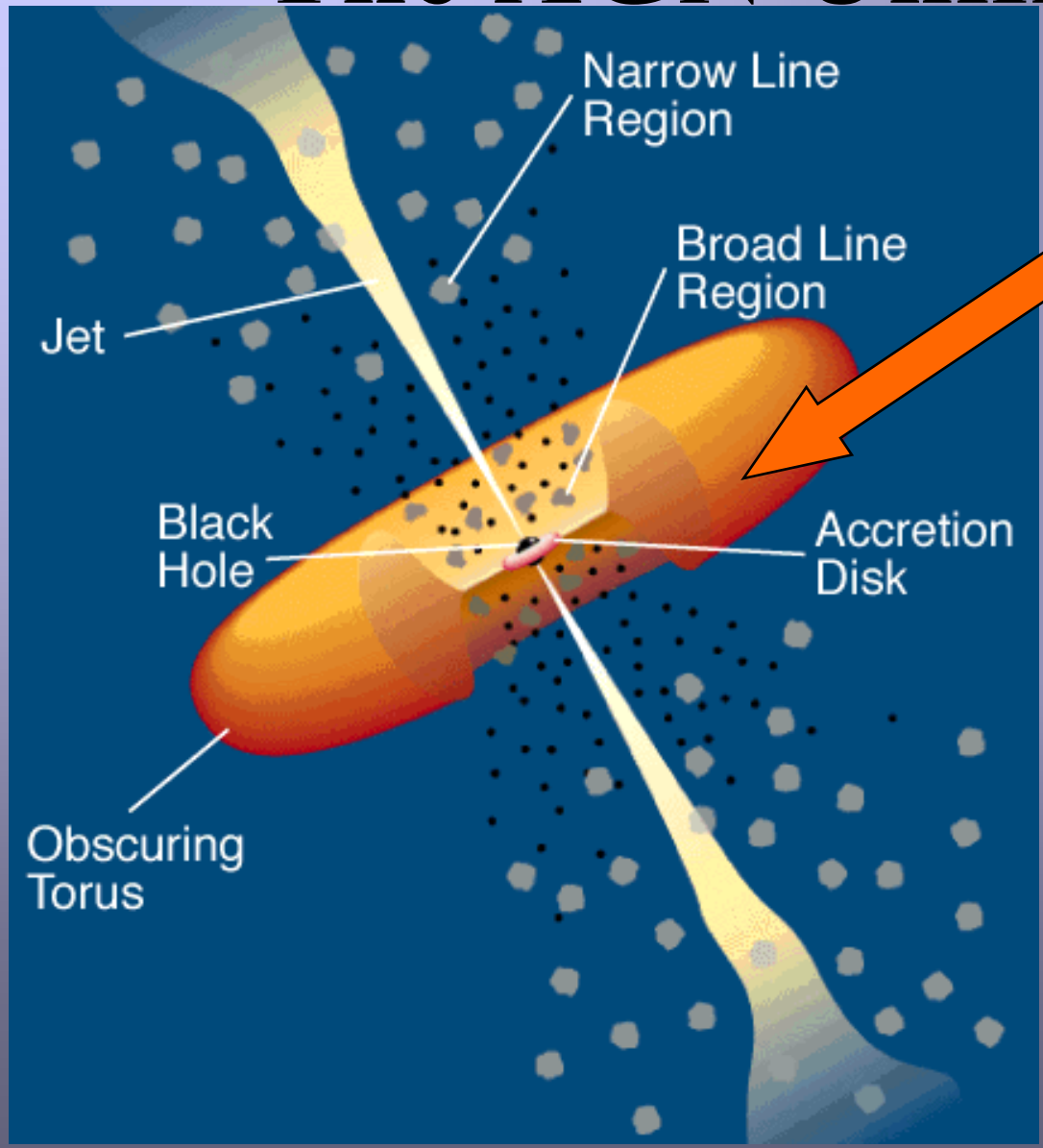
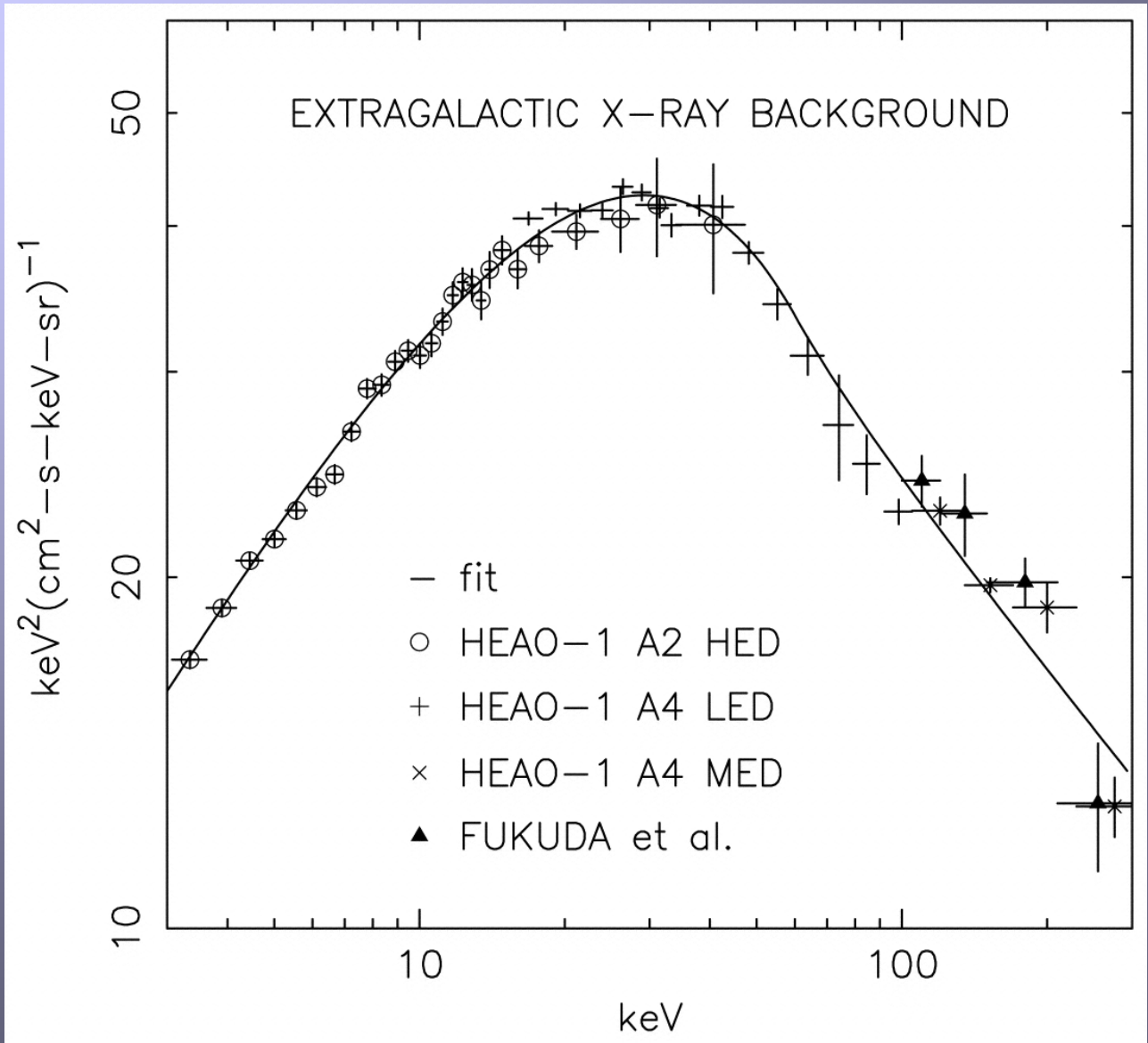


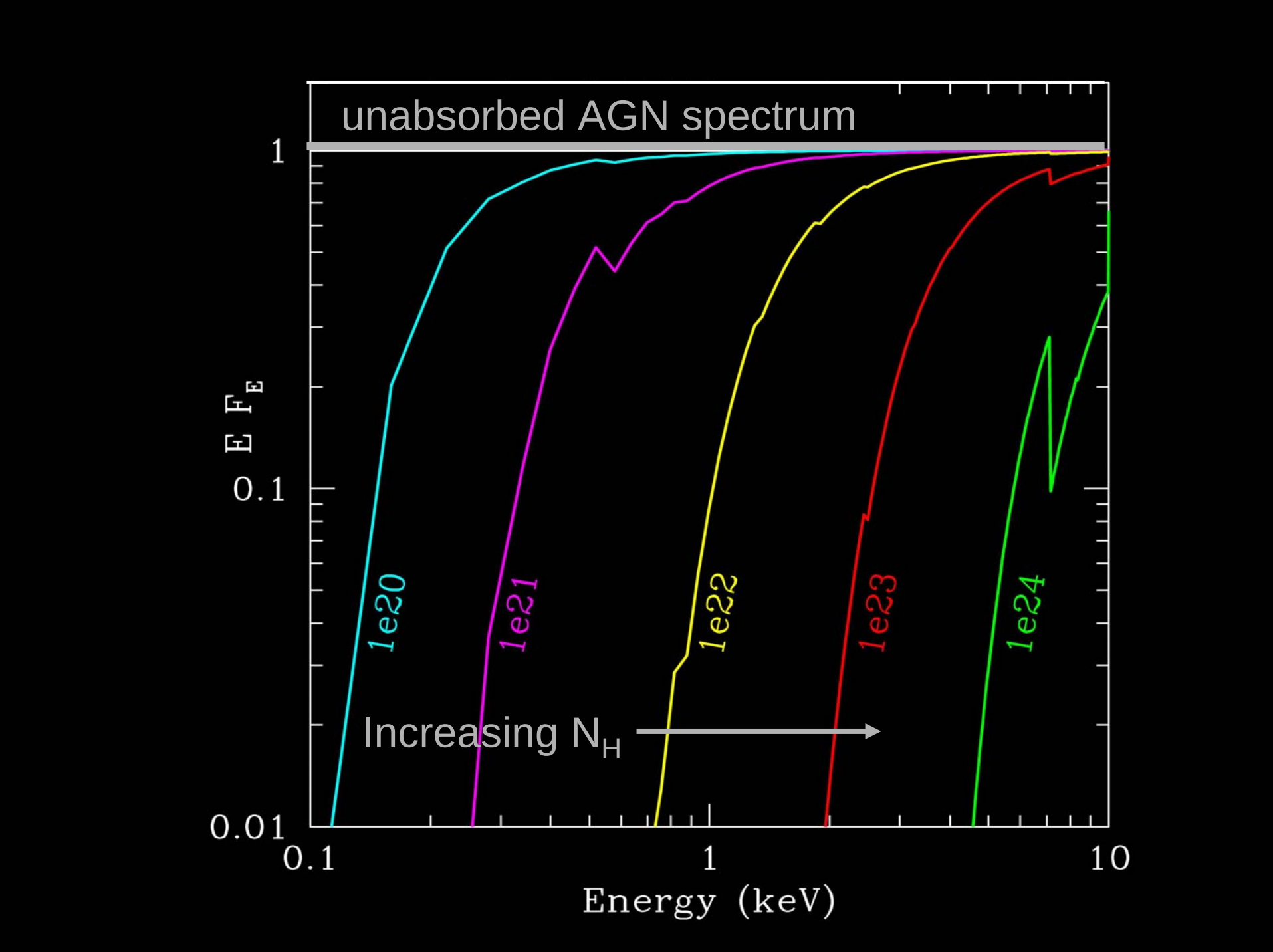
radio galaxies,
Type 2 Sy/QSO
narrow lines

Urry & Padovani, 1995

The X-Ray Background



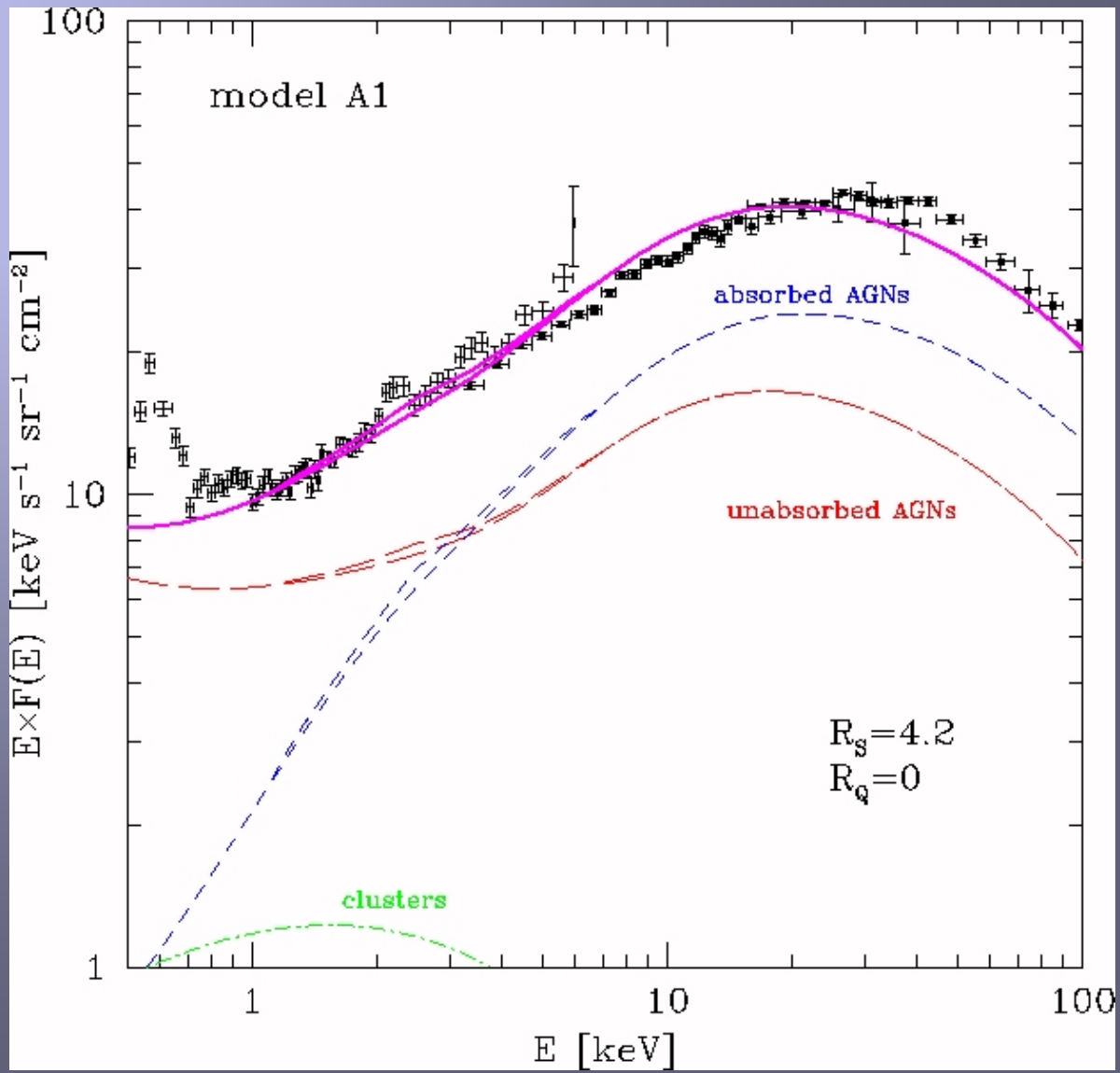
Gruber et al. 1999

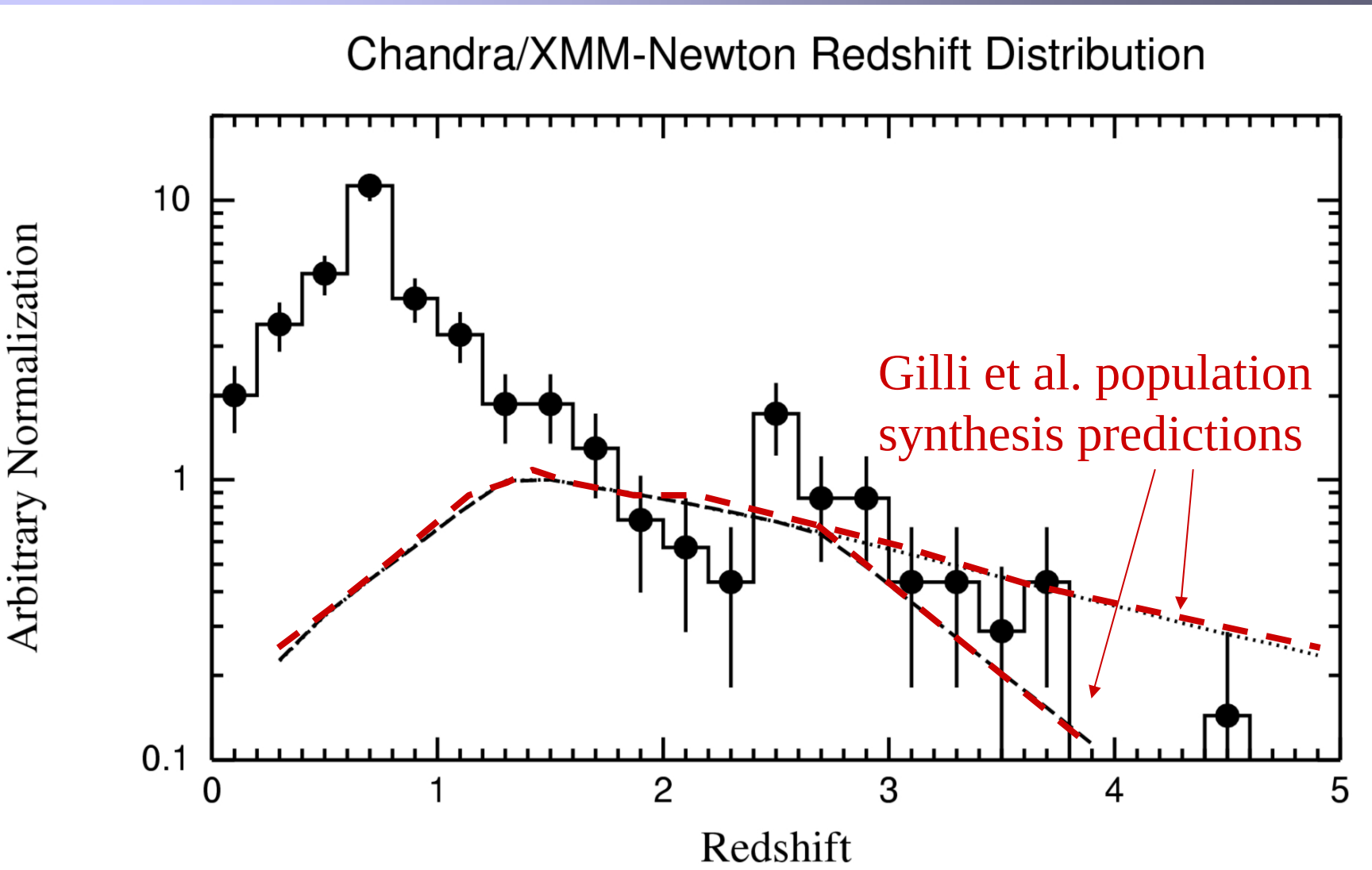

unabsorbed AGN spectrum
1
0.1
0.01
E F_E
1e20
1e21
1e22
1e23
1e24
Increasing N_H
0.1
1
10
Energy (keV)

Population Synthesis Models

Gilli et al. 1999
Gilli et al. 2001

Giacconi et al. 1979
Setti & Woltjer 1989
Madau et al. 1994
Comastri et al. 1995





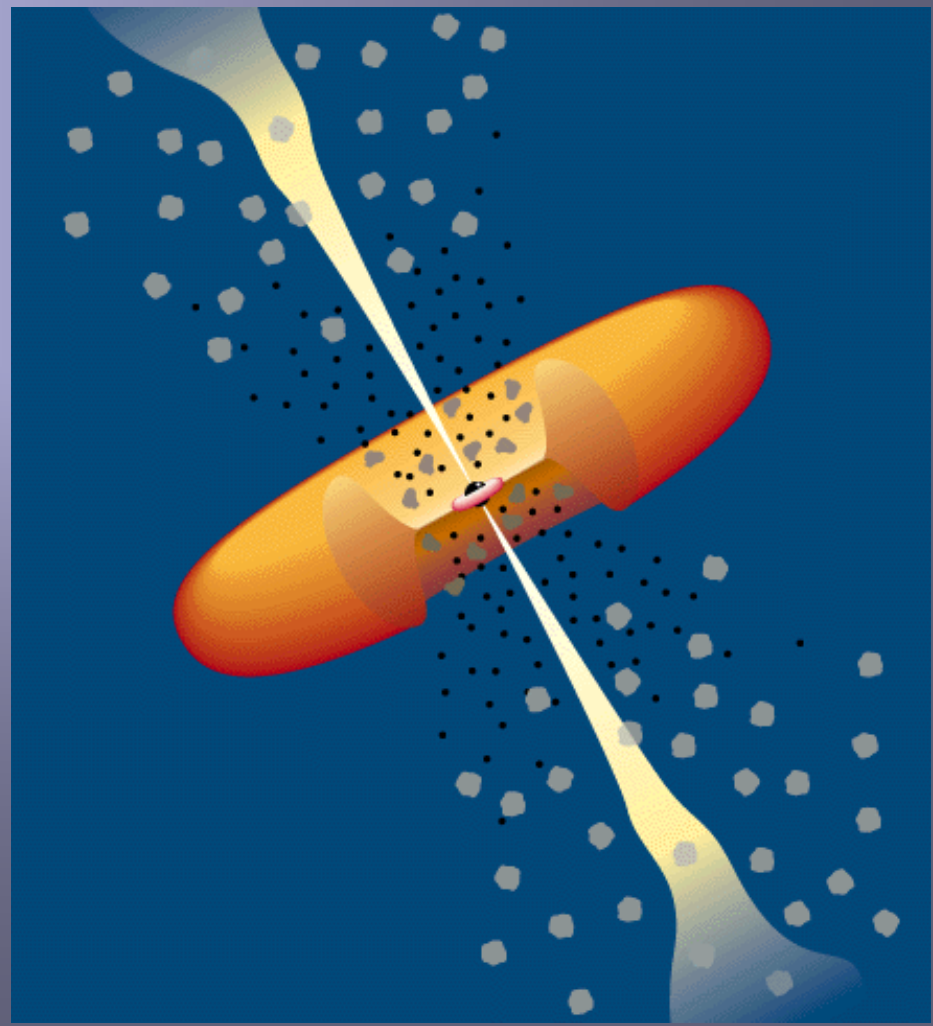
Hasinger 2002

Hidden Population of Obscured AGN at z>1

→ **Not Found in UV/Optical Surveys.**

→ **Multiwavelength Surveys needed:**

- → **Hard X-rays (Chandra)**
- → **Far-IR (Spitzer)**
- → **Optical Spectroscopy (Keck-VLT-Magellan)**



GOODS

designed to find

***obscured AGN** at the quasar epoch, z~2-3*

Chandra Deep Fields, Spitzer Legacy, HST Treasury

(3.5+ Msec) (800 hrs) (600 hrs)

Very deep imaging

~70 times HDF area (0.1 deg^2)

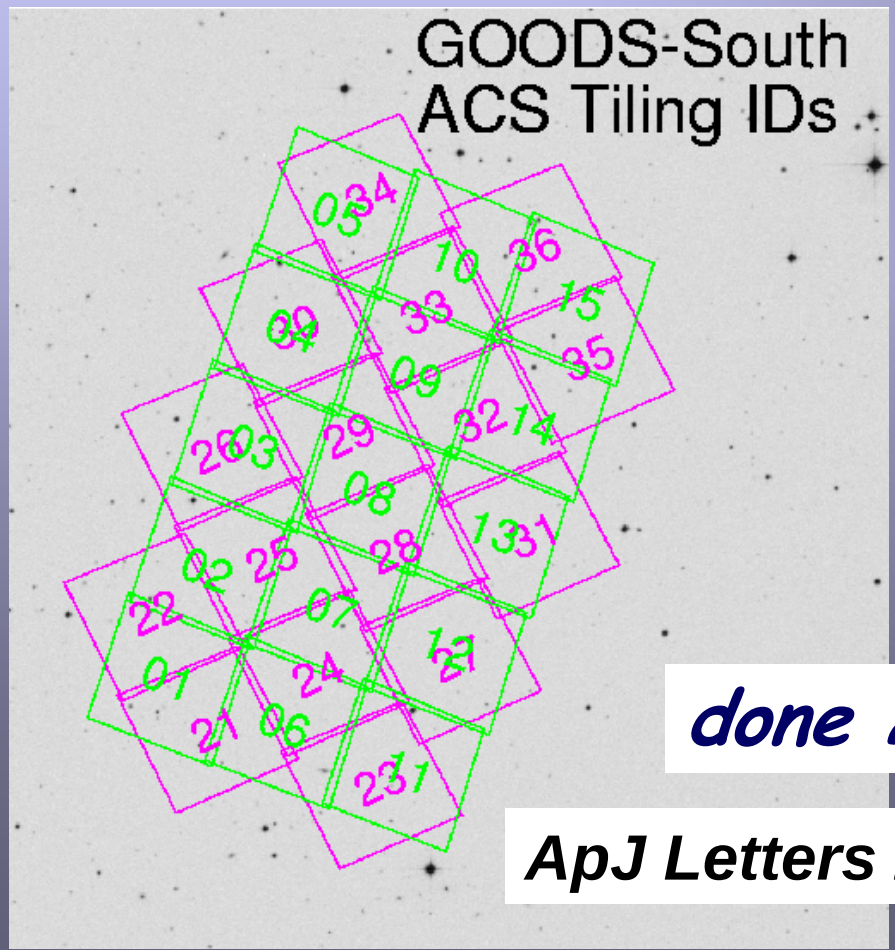
Extensive follow-up spectroscopy (VLT, Gemini, …)

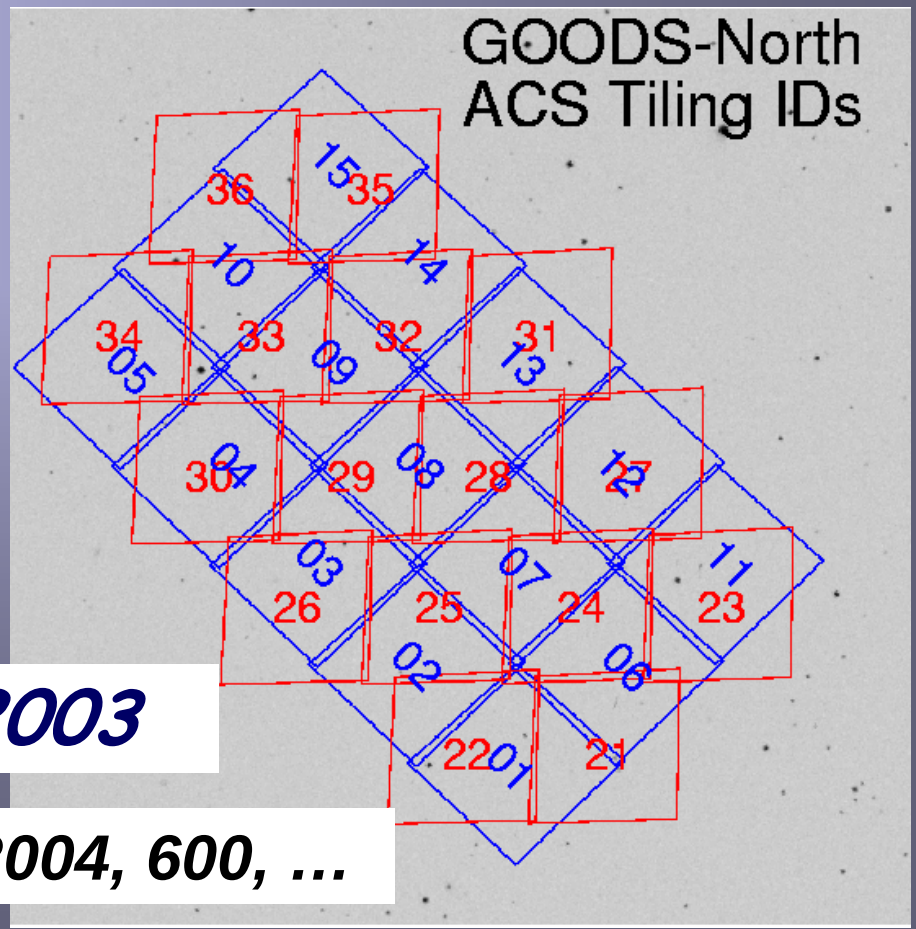
HST ACS fields

5 epochs/field, spaced by 45 days, simultaneous V,i,z bands + B band

CDF-S: Aug '02 – Feb '03

HDF-N: Nov '02 – May '03





done 2003

ApJ Letters 2004, 600, ...

ACS

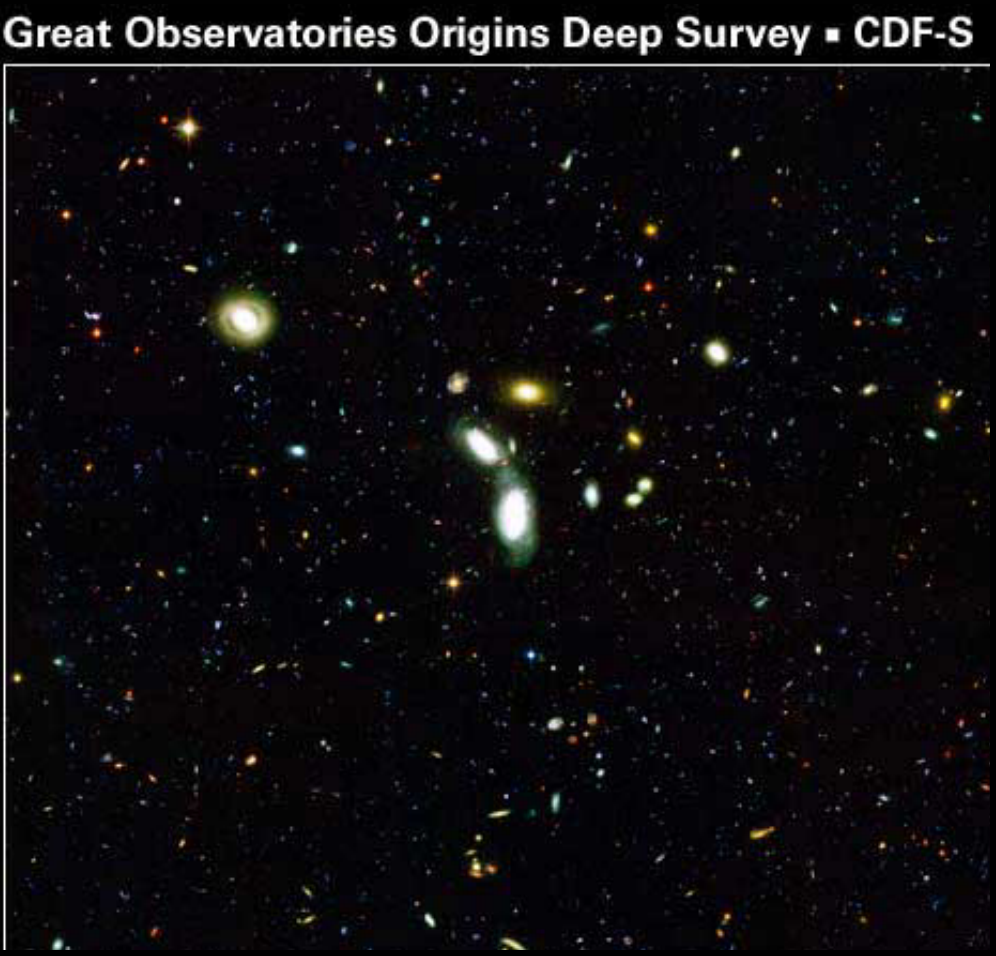
B = 27.2
V = 27.5
i = 26.8
z = 26.7

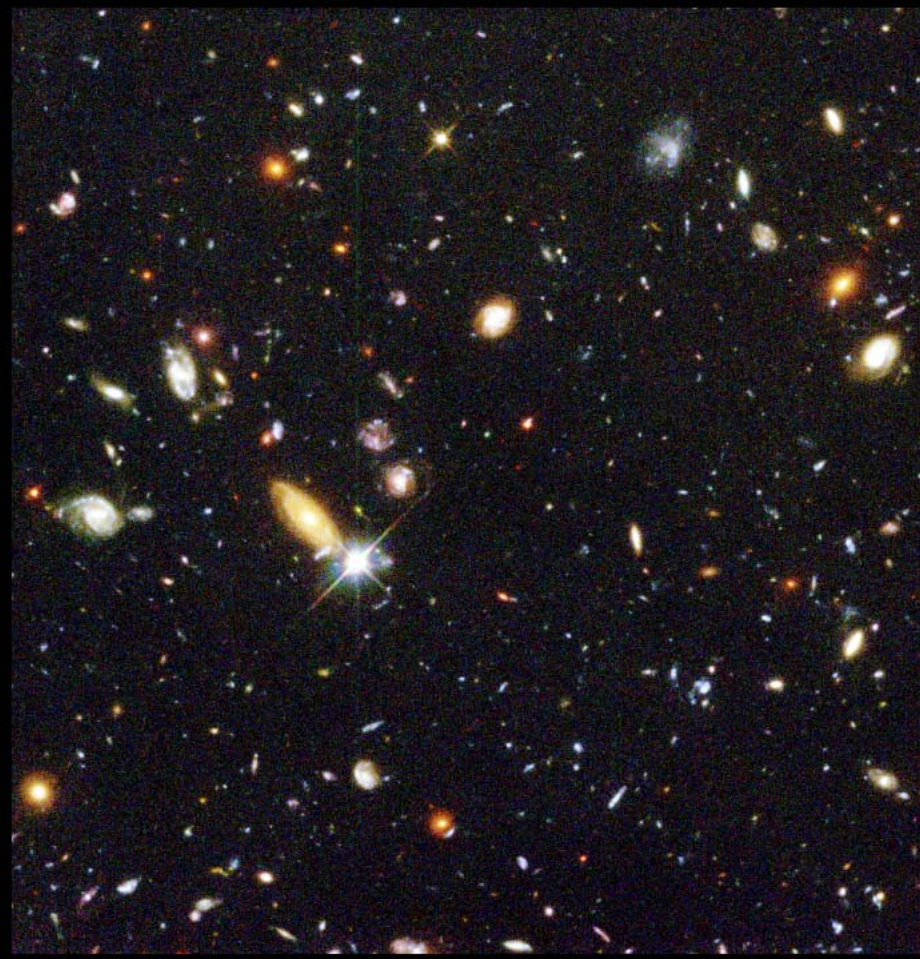
$\Delta m \sim 0.7\text{-}0.8$

AB mag; S/N=10
Diffuse source, 0.5" diameter
Add ~ 0.9 mag for stellar sources

WFPC2

B = 27.9
V = 28.2
I = 27.6





GOODS X-Ray Sources

Chandra Deep Field North:

- ✓ 2 Ms
- ✓ 503 sources
- ✓ 1.4×10^{-16} ergs $cm^{-2}s^{-1}$ (2-8 keV)

Chandra Deep Field South:

- ✓ 1 Ms
- ✓ 326 sources
- ✓ 4.5×10^{-16} ergs $cm^{-2}s^{-1}$ (2-8 keV)

Modeling the AGN Population

- Grid of AGN spectra (L_X,N_H) with
  - SDSS quasar spectrum (normalized to X-ray)
  - dust/gas absorption (optical/UV/soft X-ray)
  - infrared dust emission *Nenkova et al. 2002, Elitzur et al. 2003*
  - L* host galaxy
- Hard X-ray LF & evolution for AGN *Ueda et al. 2004*
- Geometry with obscured AGN = 3 x unobscured, at all z, L
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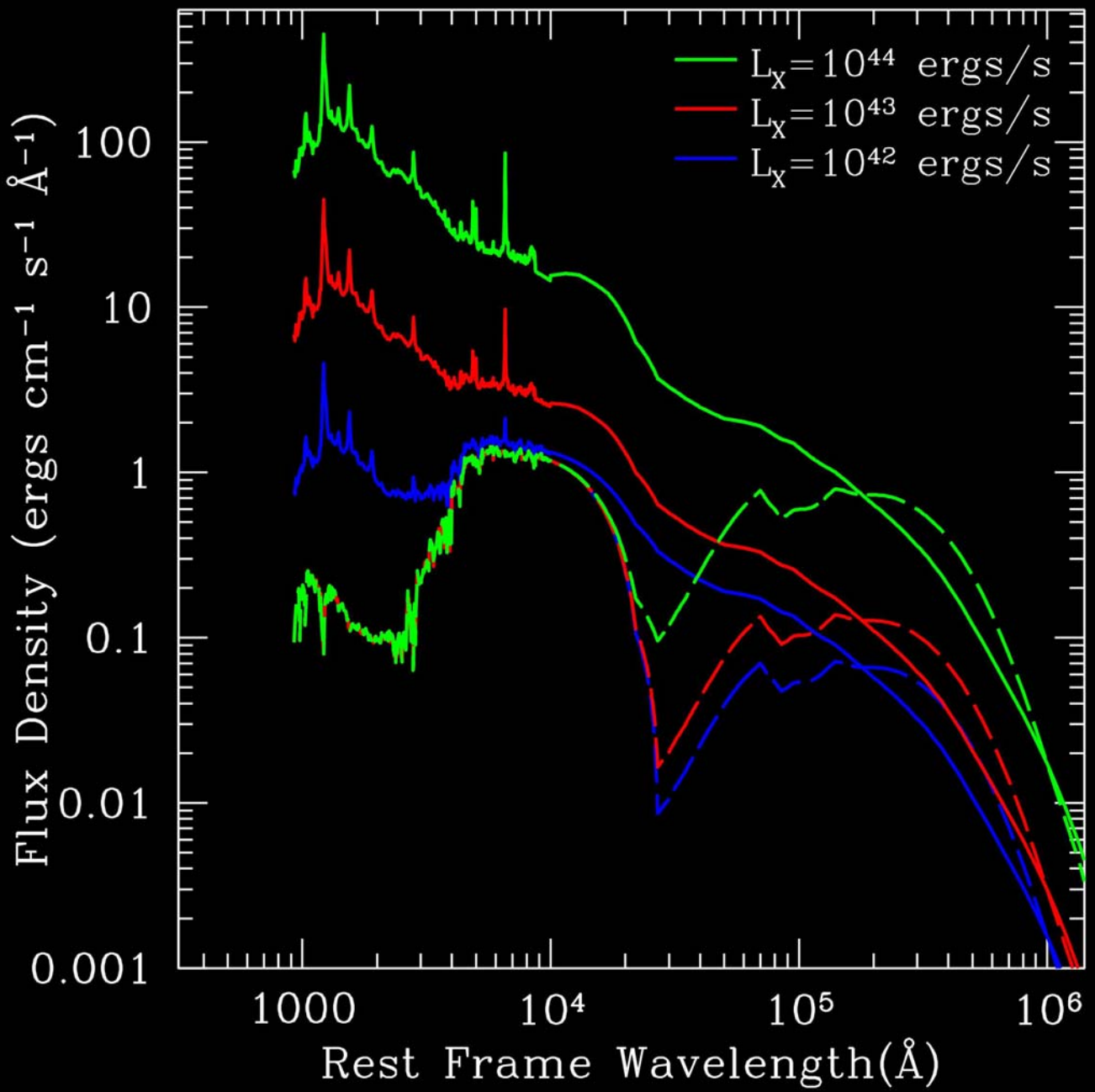
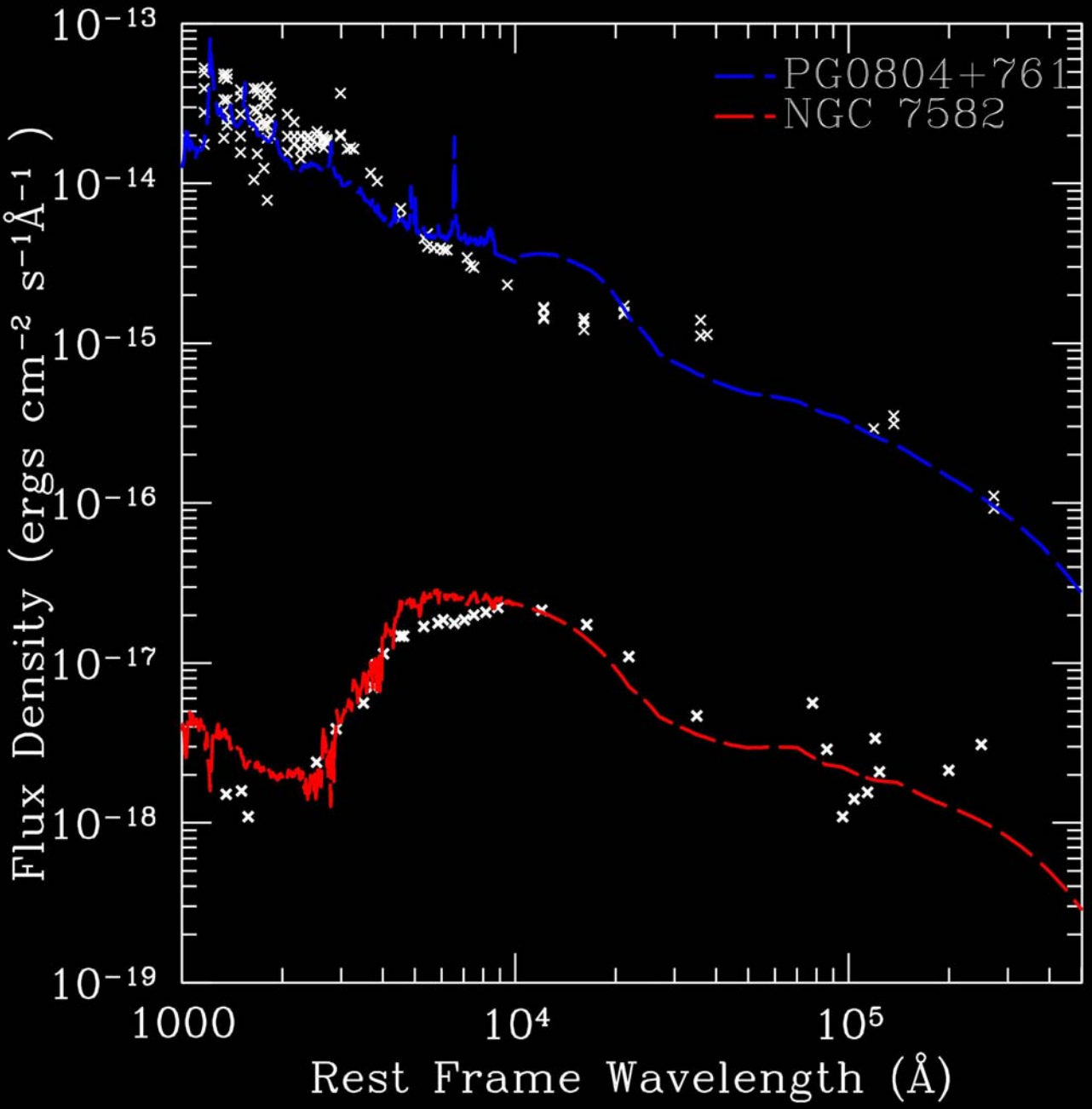


Treister et al. 2004



Treister et al. 2004

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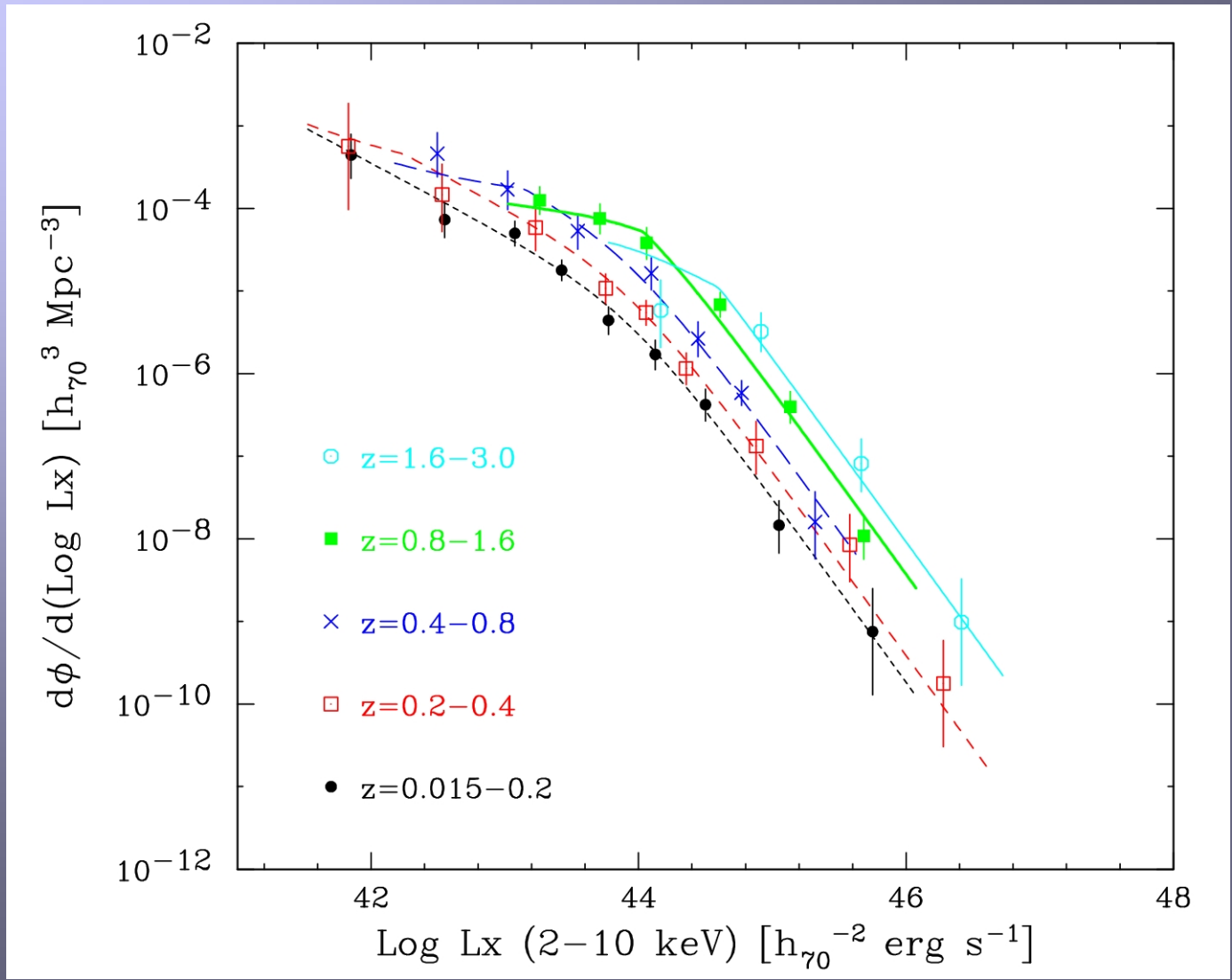
AGN Number Counts Calculation

X-Ray Luminosity Function



Ueda et al, 2003

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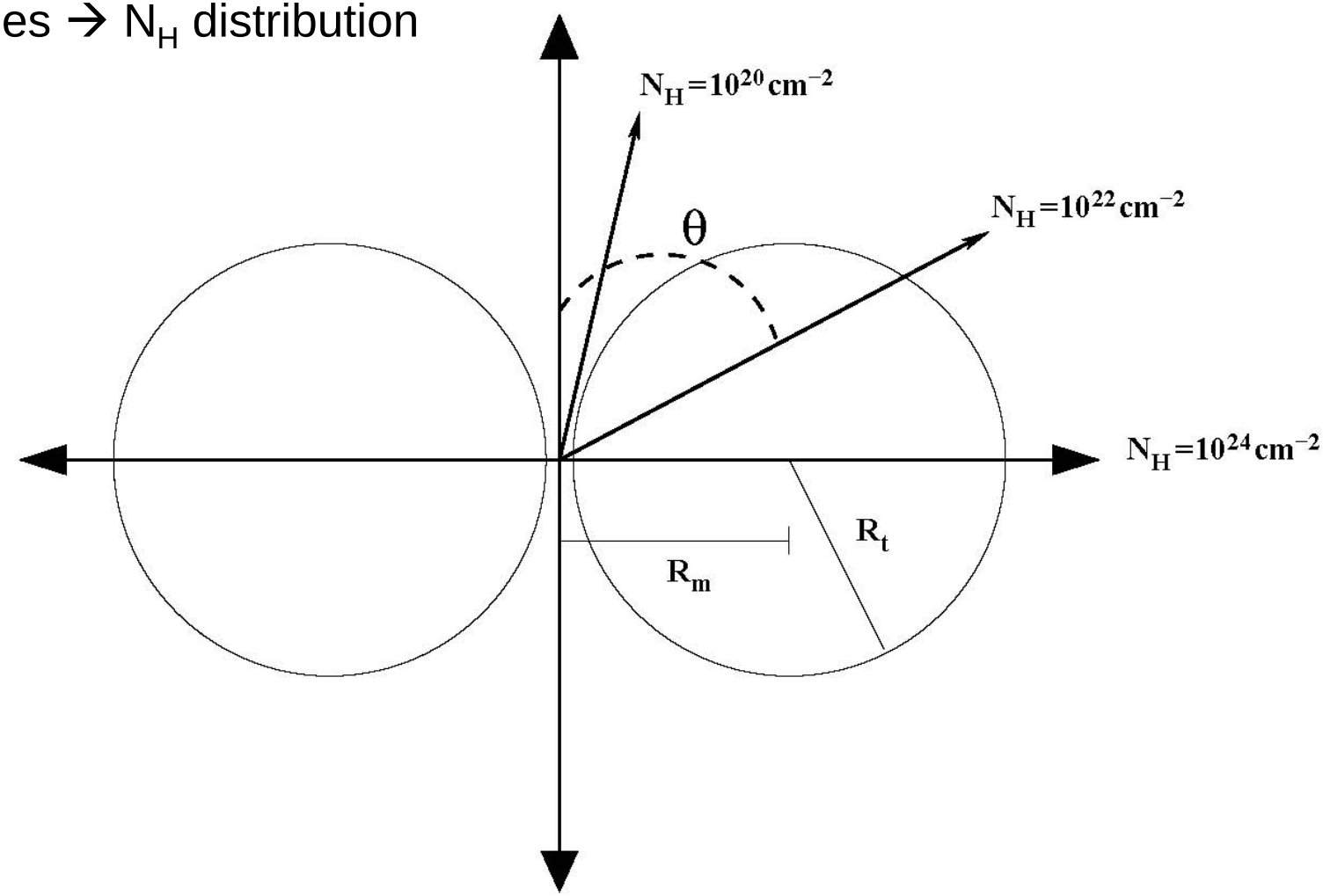
Dust emission models from Nenkova et al. 2002, Elitzur et al. 2003

Simplest dust distribution that satisfies

$N_H = 10^{20} – 10^{24}$ cm^{-2}

3:1 ratio (divide at 10^{22} cm^{-2})

Random angles → N_H distribution



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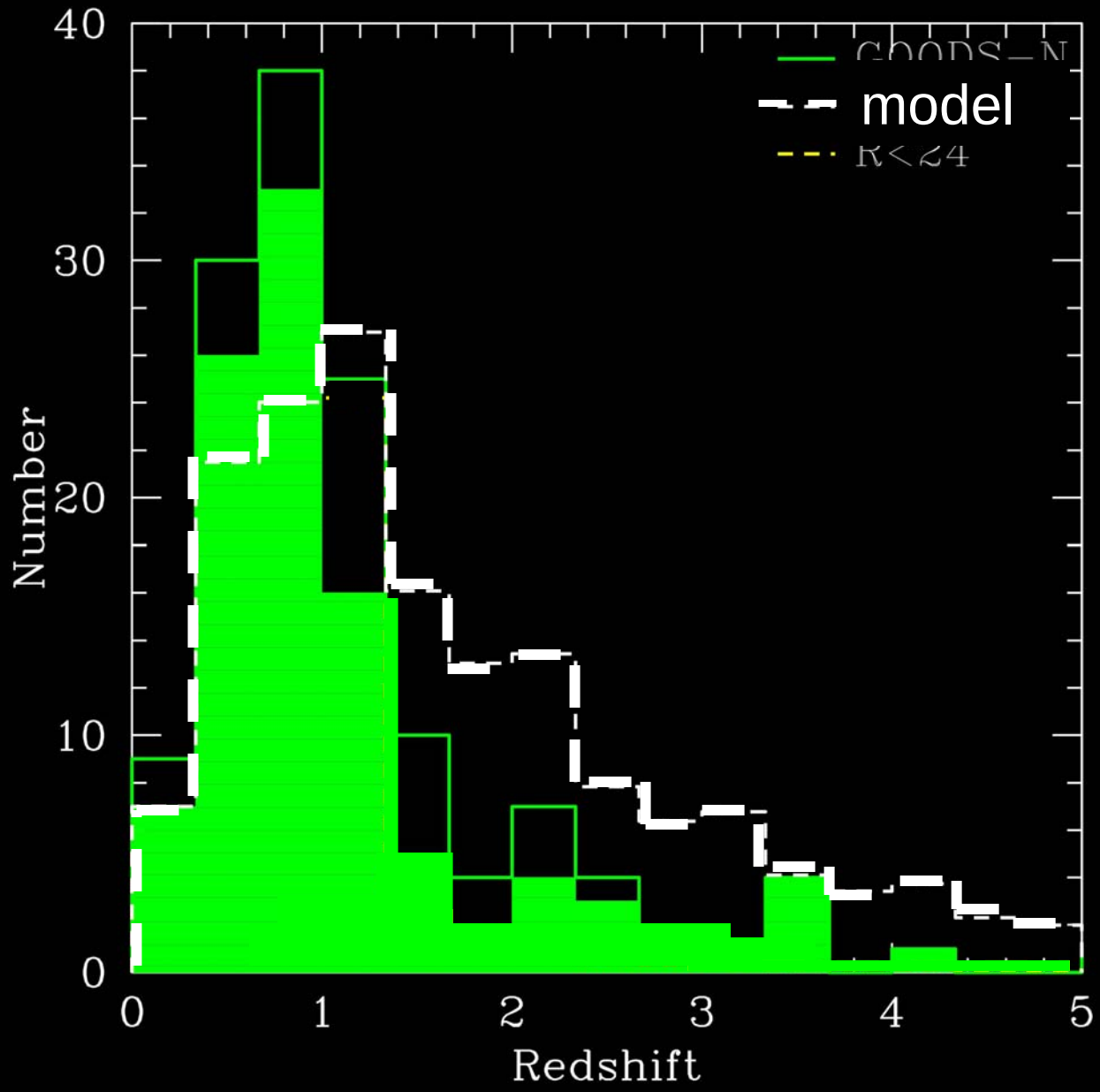
redshifts of Chandra deep X-ray sources

GOODS-N



Barger et al. 2002,3, Hasinger et al. 2002, Szokoly et al. 2004

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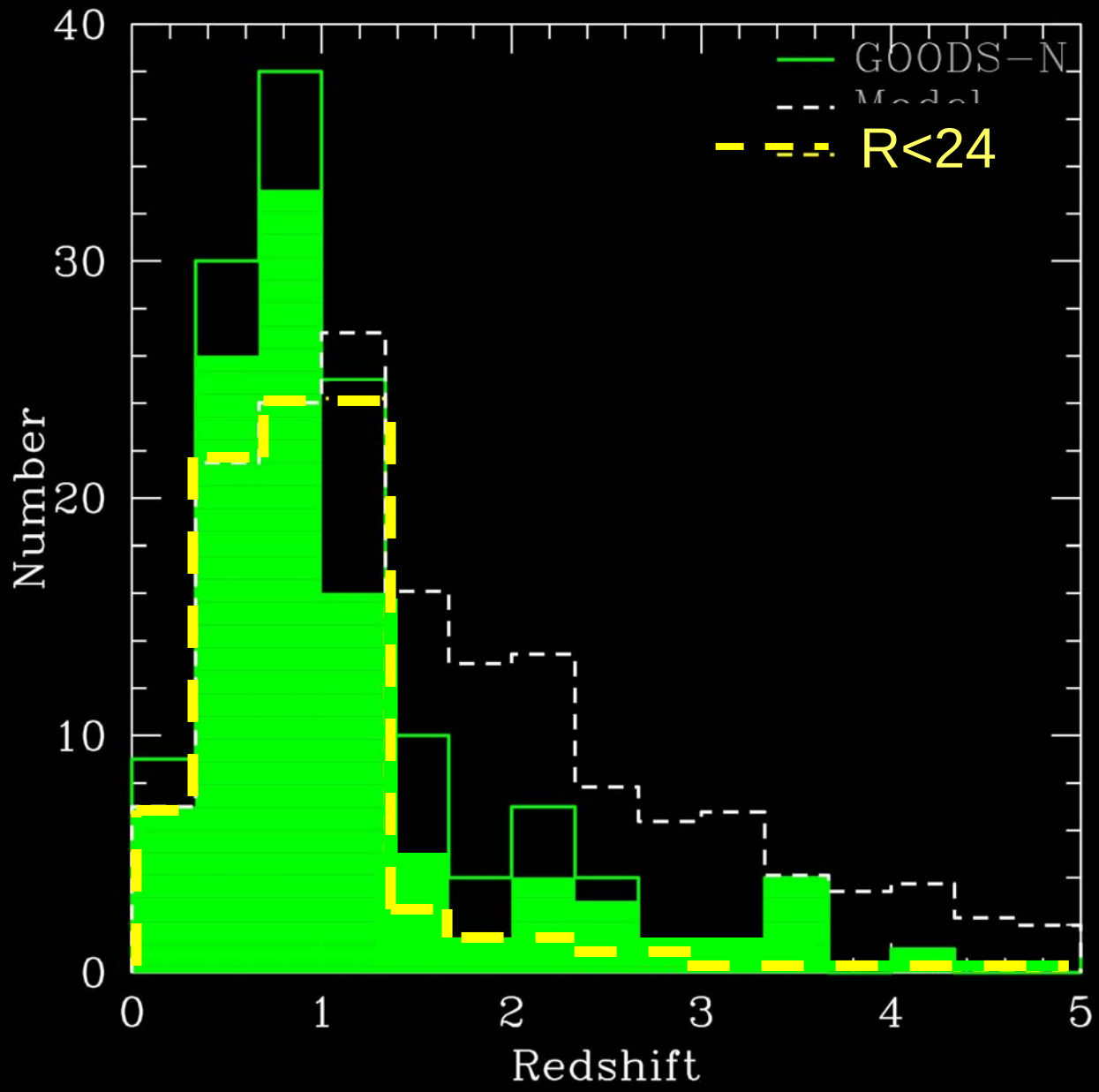

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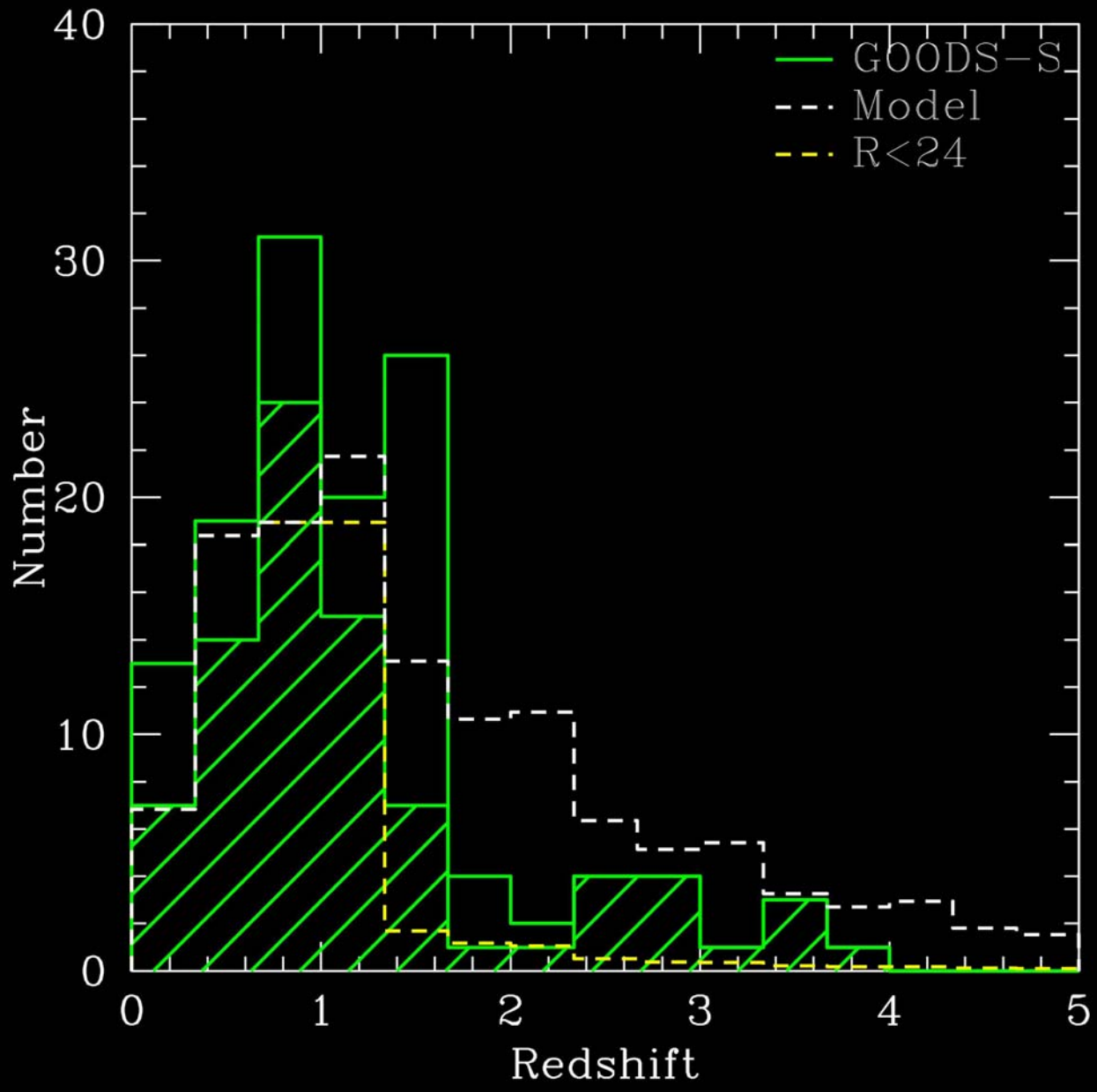
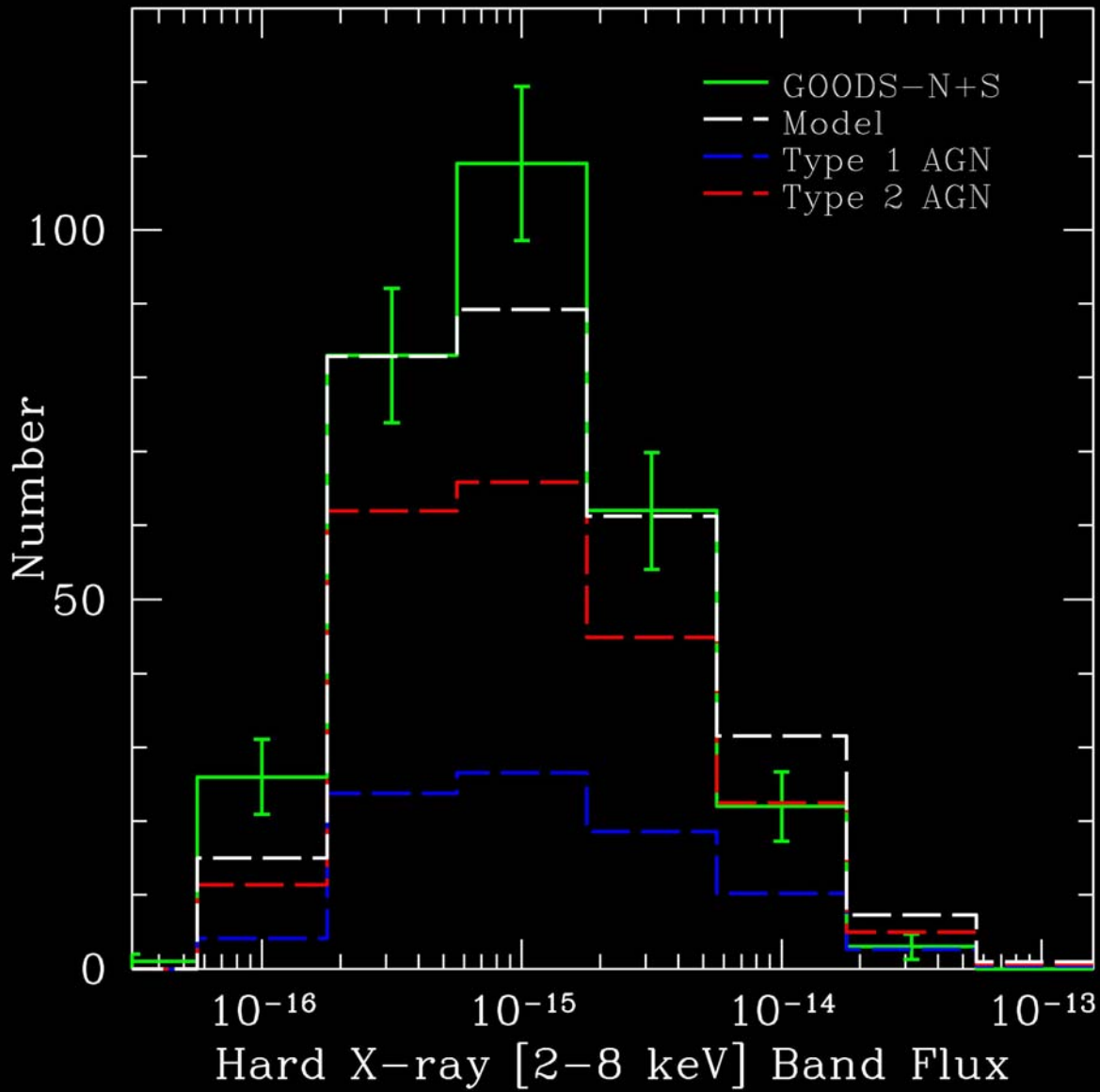
redshifts of Chandra deep X-ray sources

GOODS-S



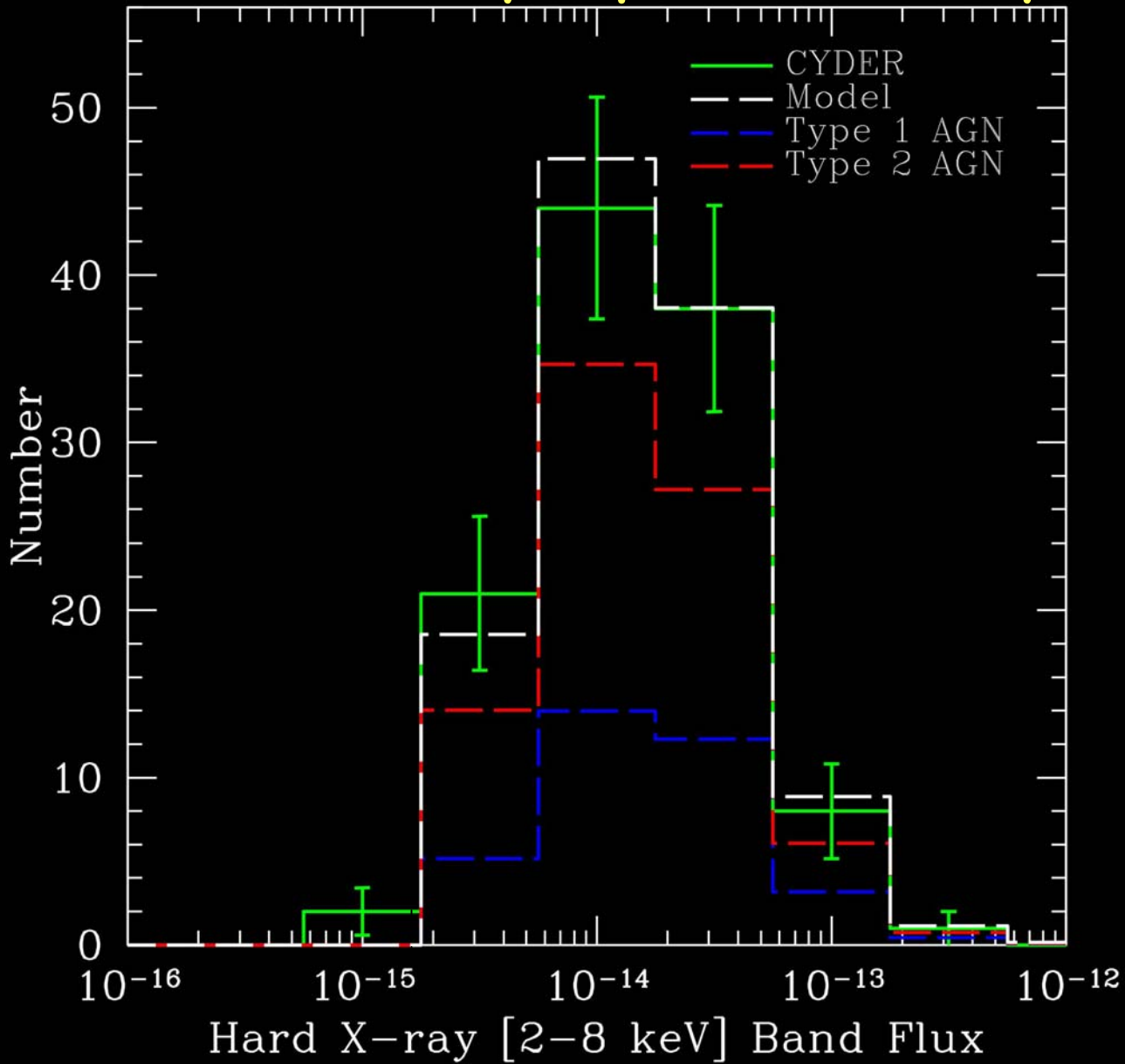
Treister et al. 2004

GOODS N+S Distribution



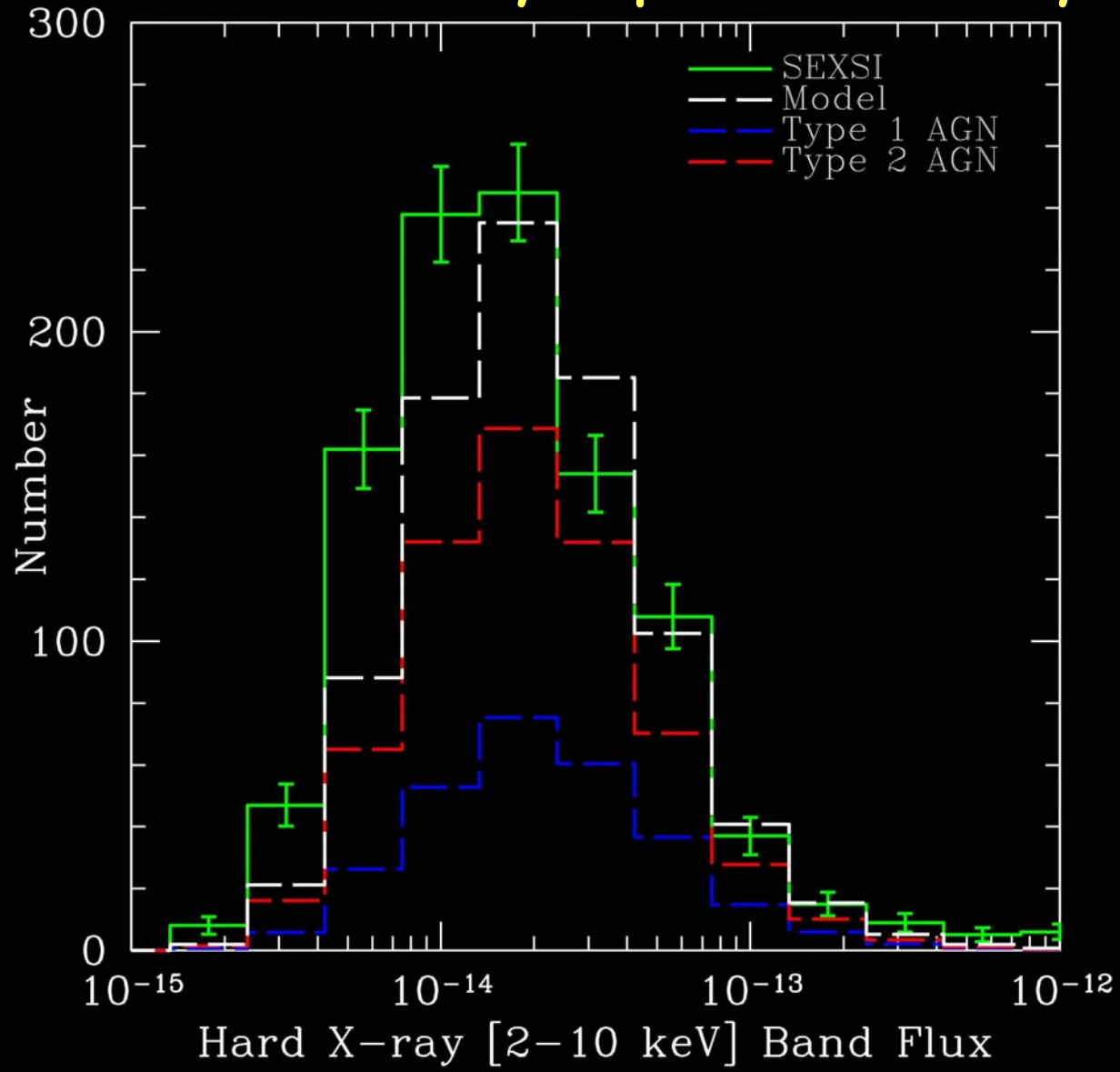
Treister et al, 2004

CYDER X-ray/optical survey



Treister, et al 2004

SEXSI X-ray/optical survey



Harrison, Helfand, et al.

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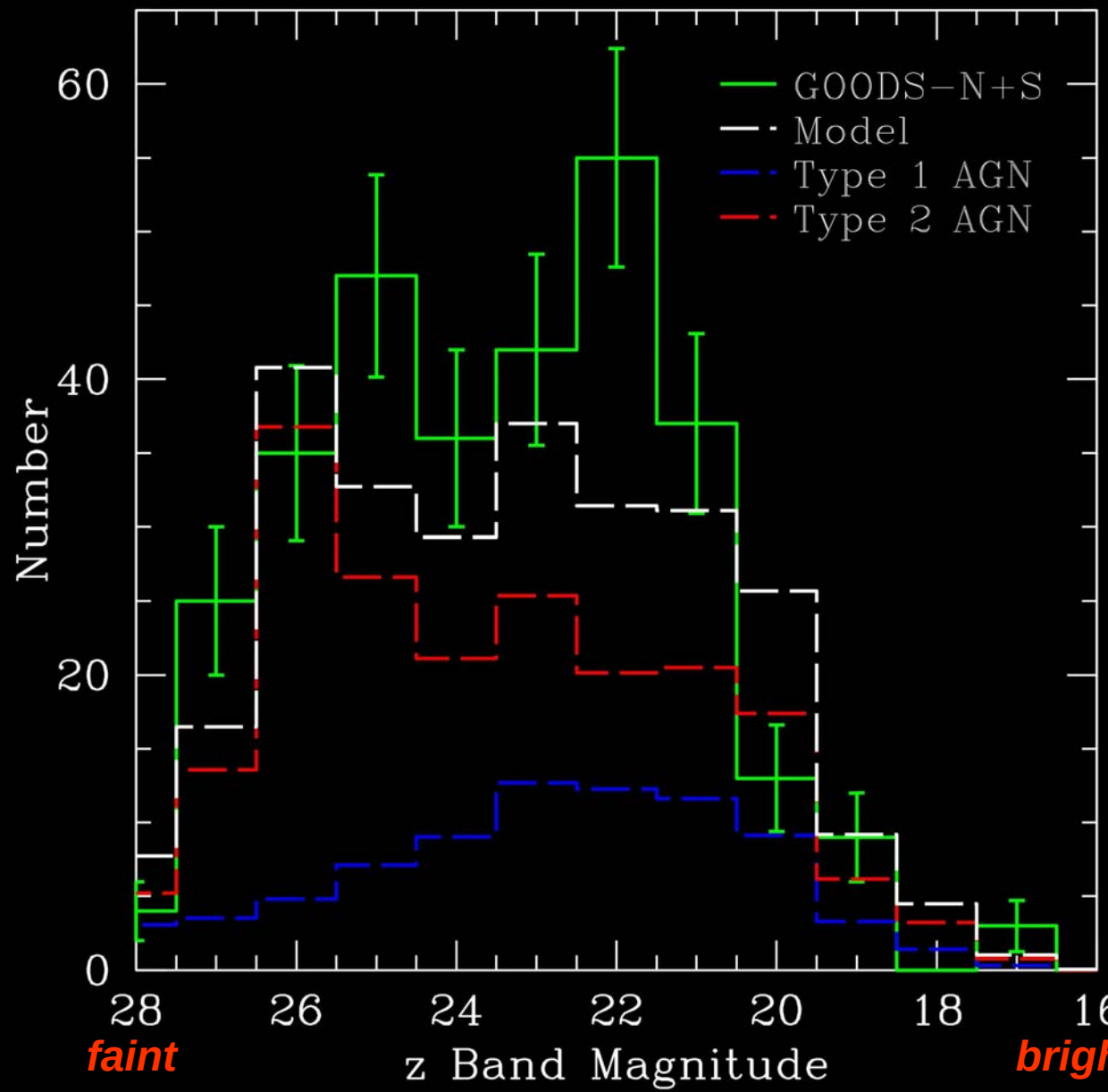

Treister et al. 2004

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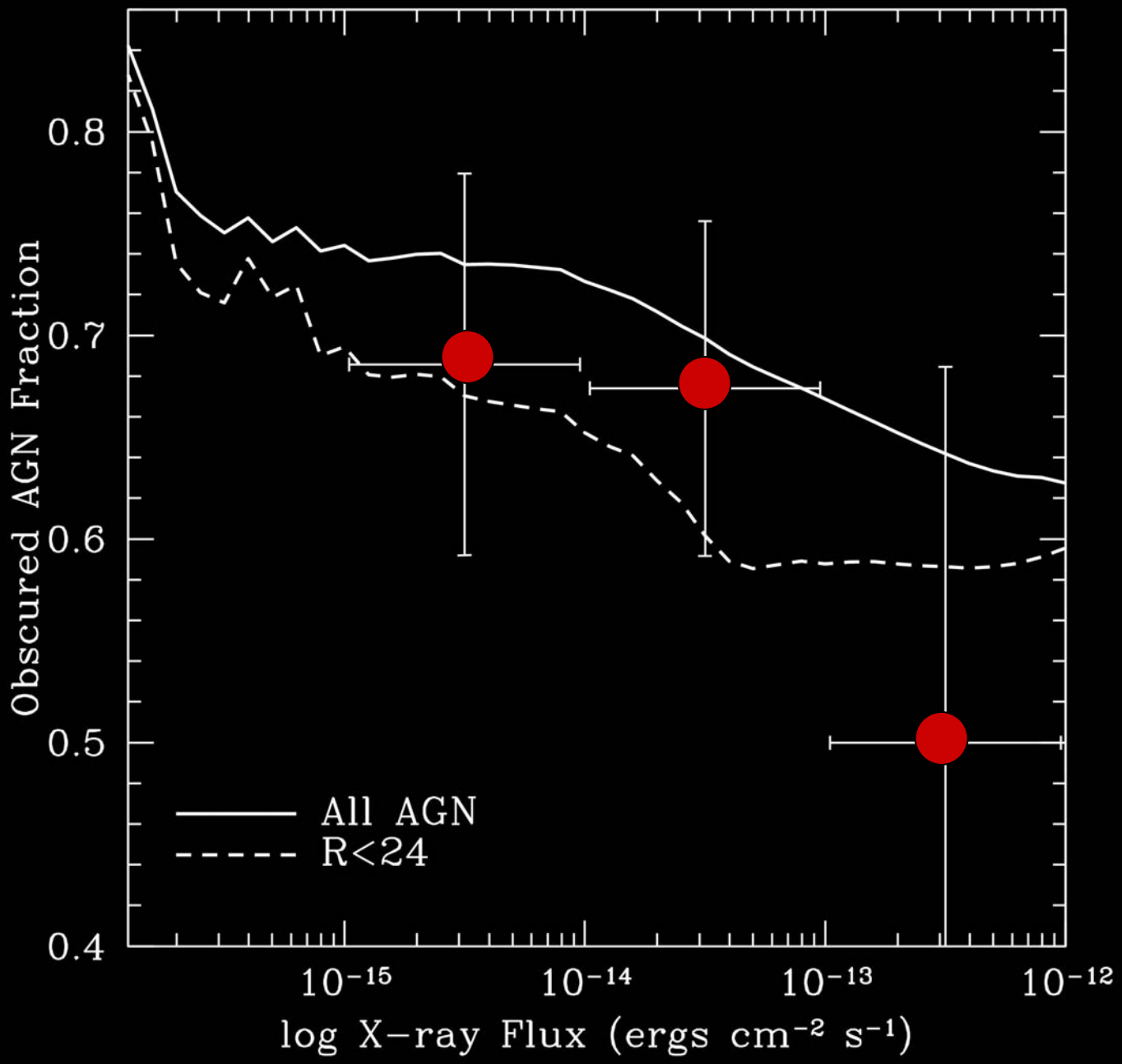
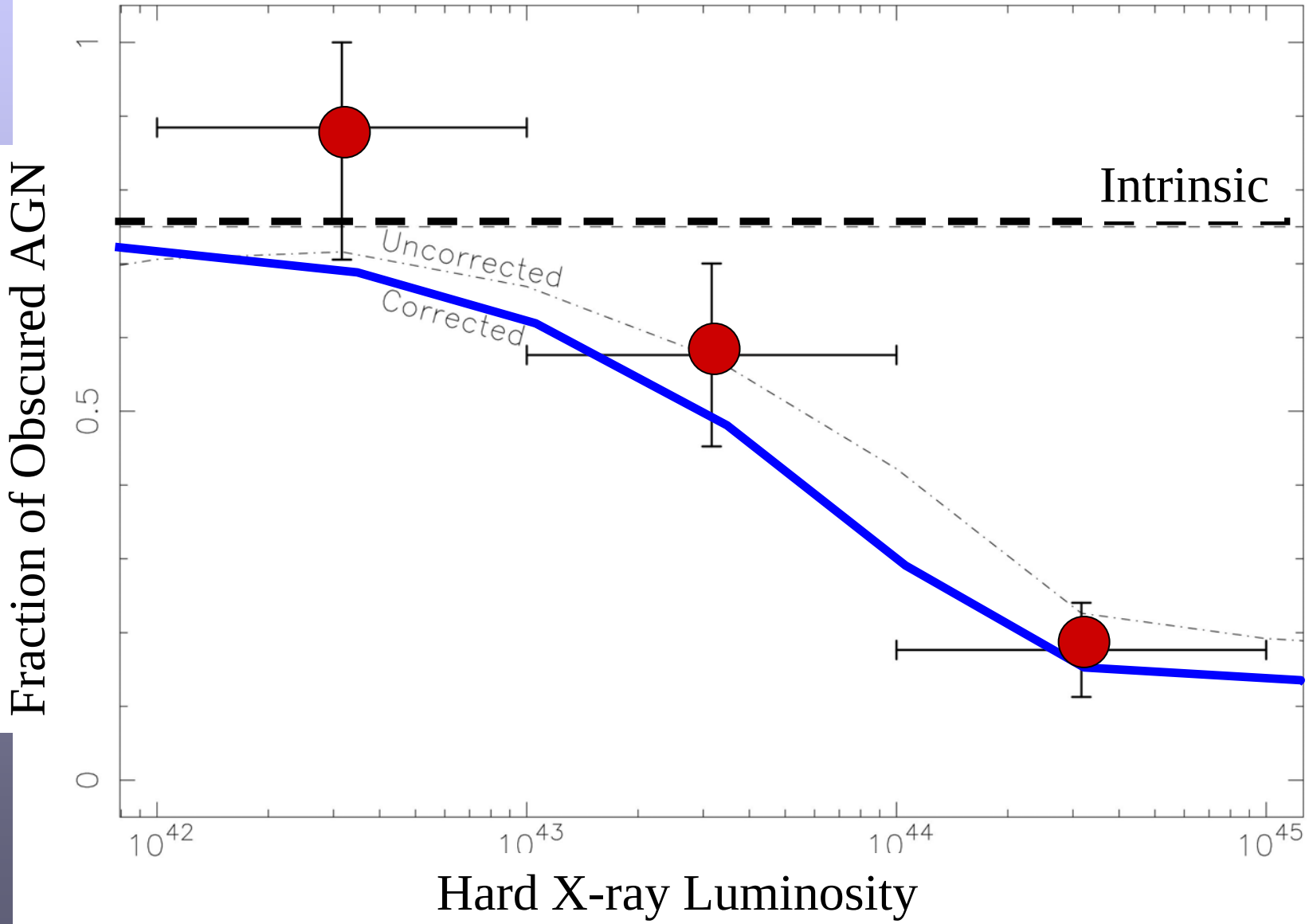
Obscured AGN Fraction vs. Flux



Obscured to Total AGN Ratio



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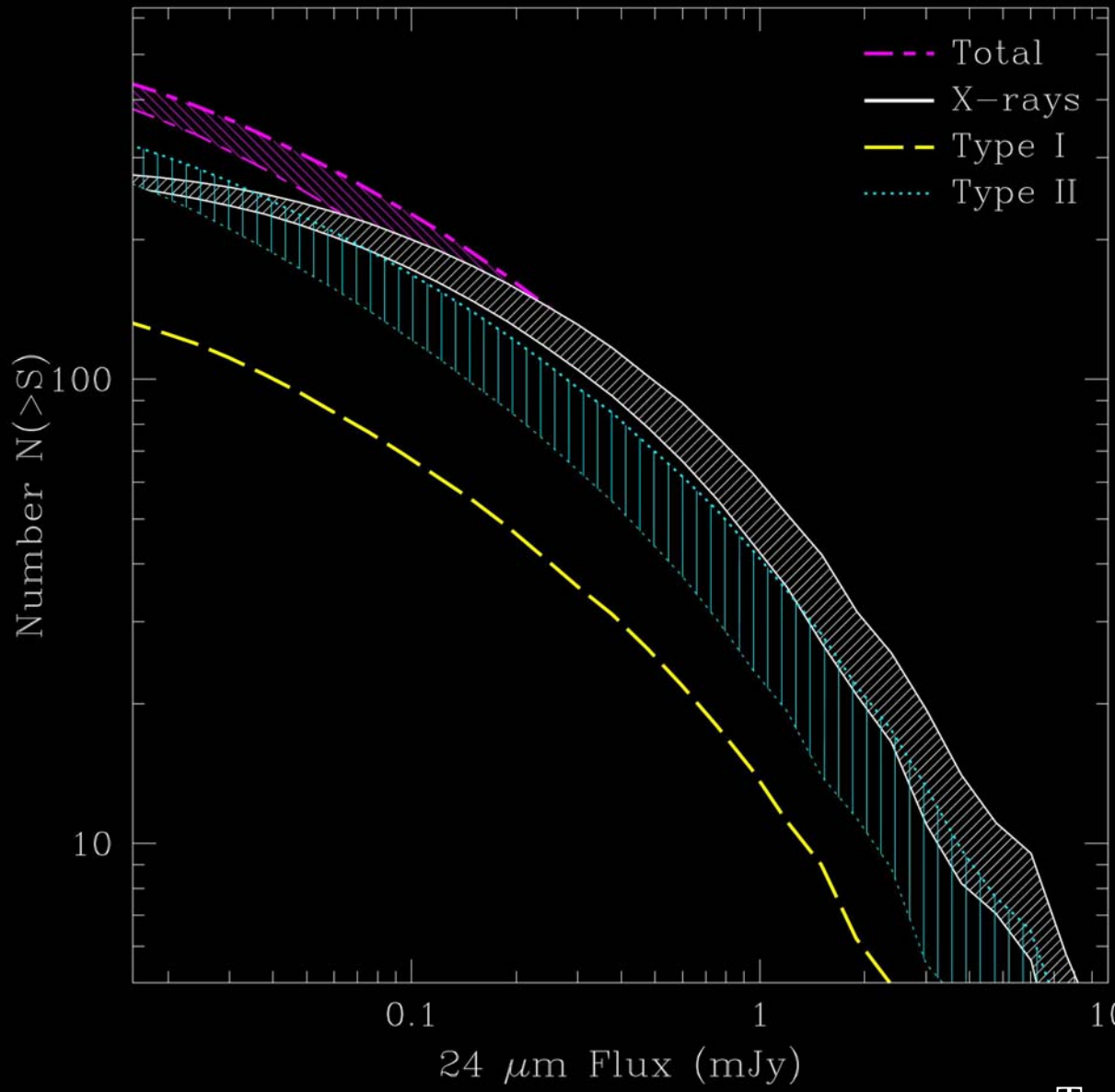
Spitzer Predictions

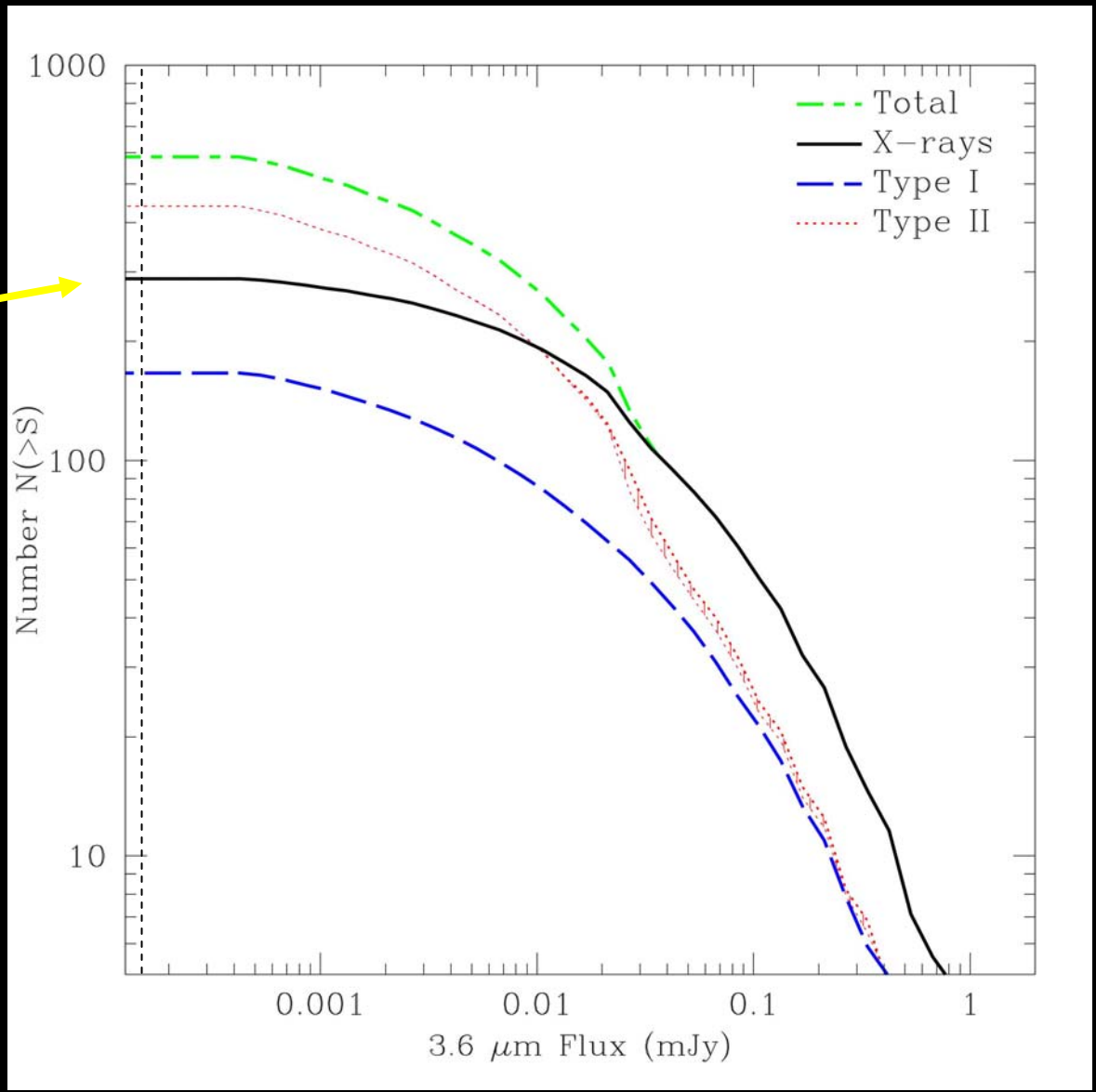


Treister et al, 2004

Predicted Spitzer counts (3.6 μm)

~1/2 AGN missing from deep Chandra samples

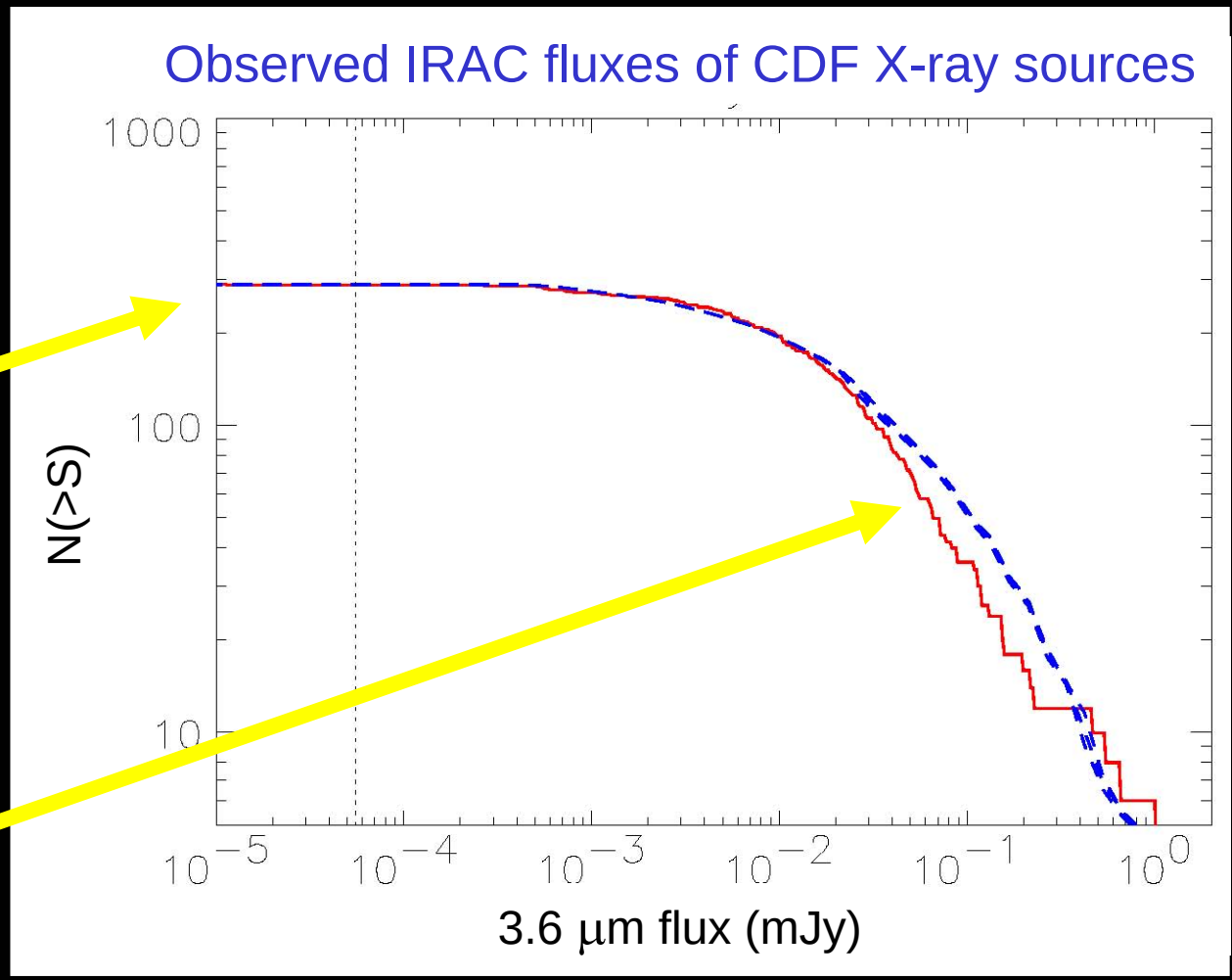
Will be detected with Spitzer IRAC



Spitzer supports model of obscured AGN

Total # infrared sources in GOODS: prediction=observed

Observed distribution of infrared fluxes matches prediction.



Treister, Urry, van Duyne, et al. 2004

Conclusions

- Simple unification model explains:
  - (faint) optical magnitude distribution
  - redshift distribution
- This model is consistent with predictions by XRB population synthesis models:

  - Broader redshift distribution with peak at z~1.3

  - Type 2/Type 1~3
- Observed relation between obscured AGN fraction and X-ray luminosity can be explained as a selection effect
- GOODS Spitzer observations will put strong constrains on these models and the ratio of obscured to unobscured AGN.