X-ray emission from Ultraviolet-Luminous Galaxies and Lyman Break Galaxies

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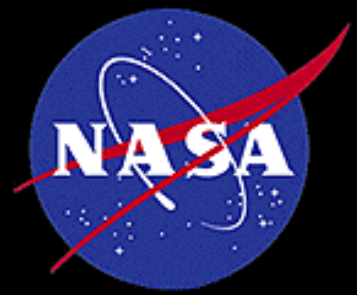

X-UVLG Collaborators

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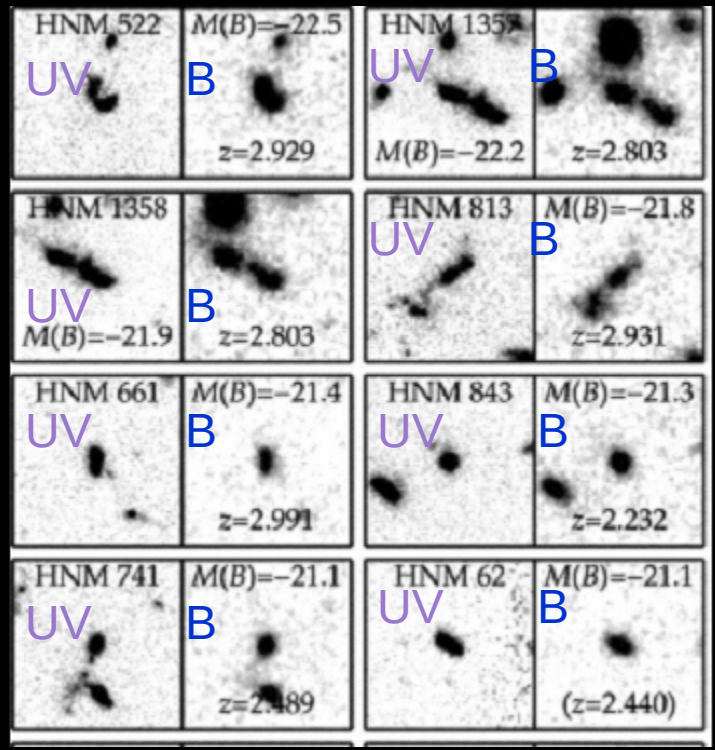
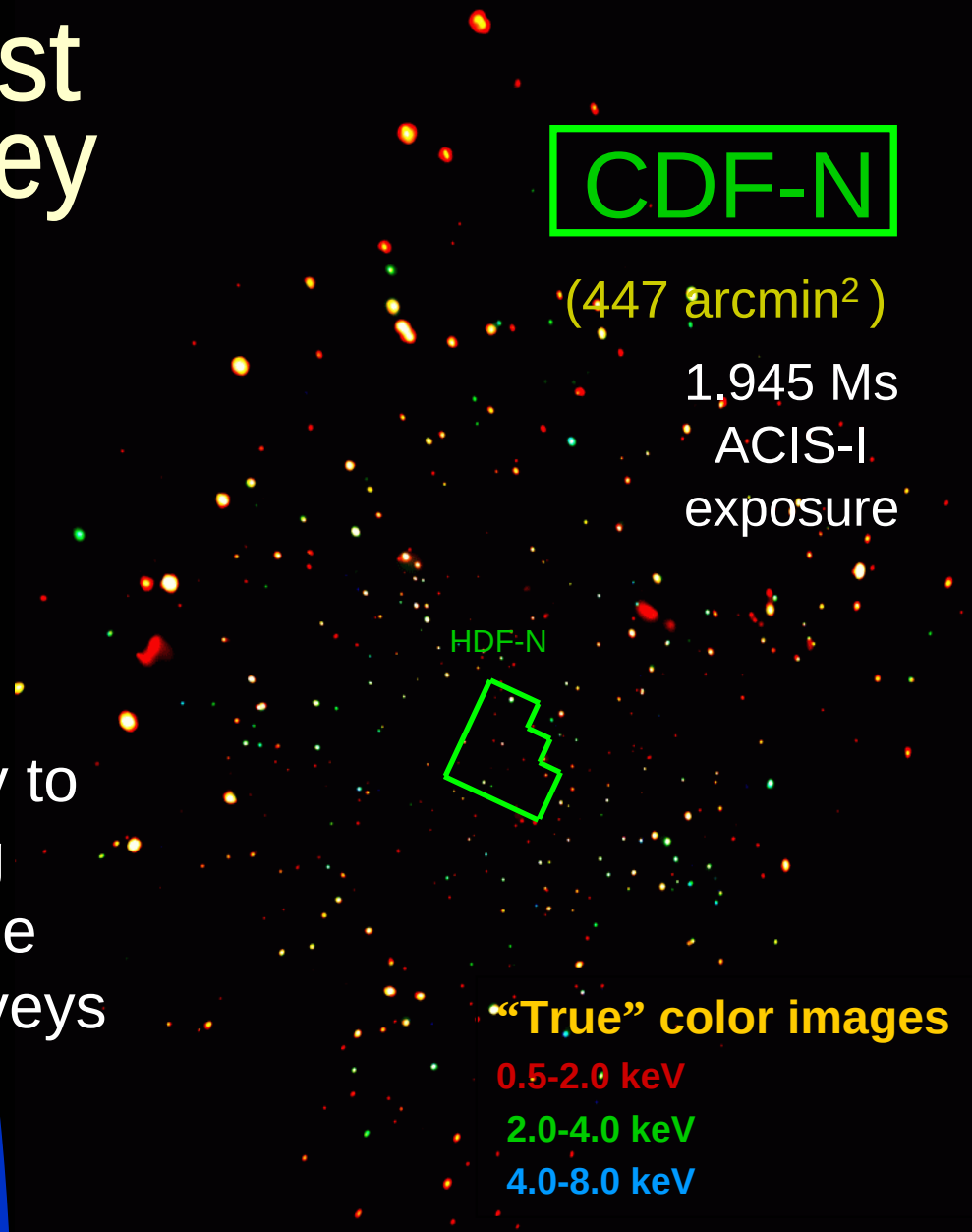
Lyman Break Galaxies

- UV luminous galaxies selected from $2 < z < 6$ (e.g., Steidel & Hamilton 1993; Bouwens et al. 2006)
- Likely precursors to massive elliptical galaxies of today (e.g., Adelberger et al. 2005)
- Sizes are typically 1-5 kpc (0.1”-0.3”) and surface brightnesses are very high (dominated by a few UV-luminous knots; e.g., Papovich et al. 2005)
- Relatively dust-free compared to local starbursts



Hubble images of Lyman Break Galaxies Papovich et al. 2005

The deepest X-ray survey (CDF-N)

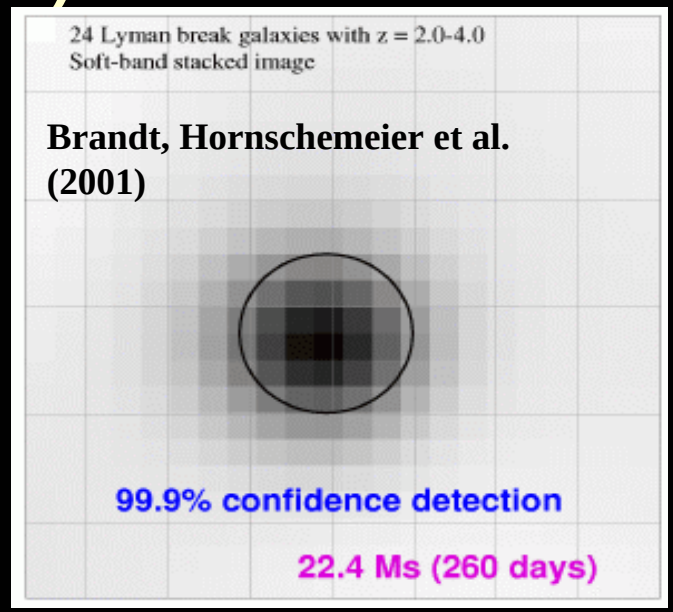


At $z >> 1$, X-ray sources are AGN

Lack the sensitivity to detect star-forming galaxies in even the *deepest* X-ray surveys at $z >> 1$

X-ray Emission from Starbursts (Lyman Break Galaxies) at z~3

- Stacking analysis:
  $<L_X> \approx 1\text{-}3 \times 10^{41}$ erg s^{-1} (2-8 keV; Brandt, Hornschemeier et al. 2001; Nandra et al. 2002; Lehmer et al. 2005)
- Independent verification of UV methodology for measuring extinction at high z (Seibert, Meurer & Heckman 2001)
- Recently has been extended to even higher redshift (z~4) by Lehmer et al. (2005)



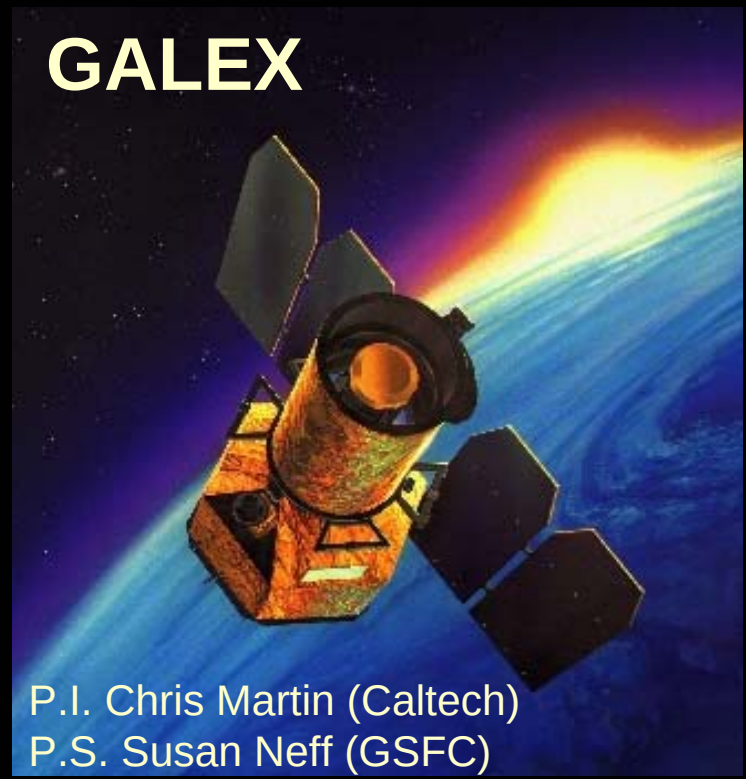
X-rays provide one of few direct cross-checks to UV-derived SFRs at z≥3

Chandra and XMM-Newton studies of UV-luminous galaxies

Prospect of Lyman Break galaxies at $z \leq 0.3$
(Heckman et al. 2005)
$f_x \sim 10^{-15}$ erg cm^{-2} s^{-1} (0.5-2 keV)

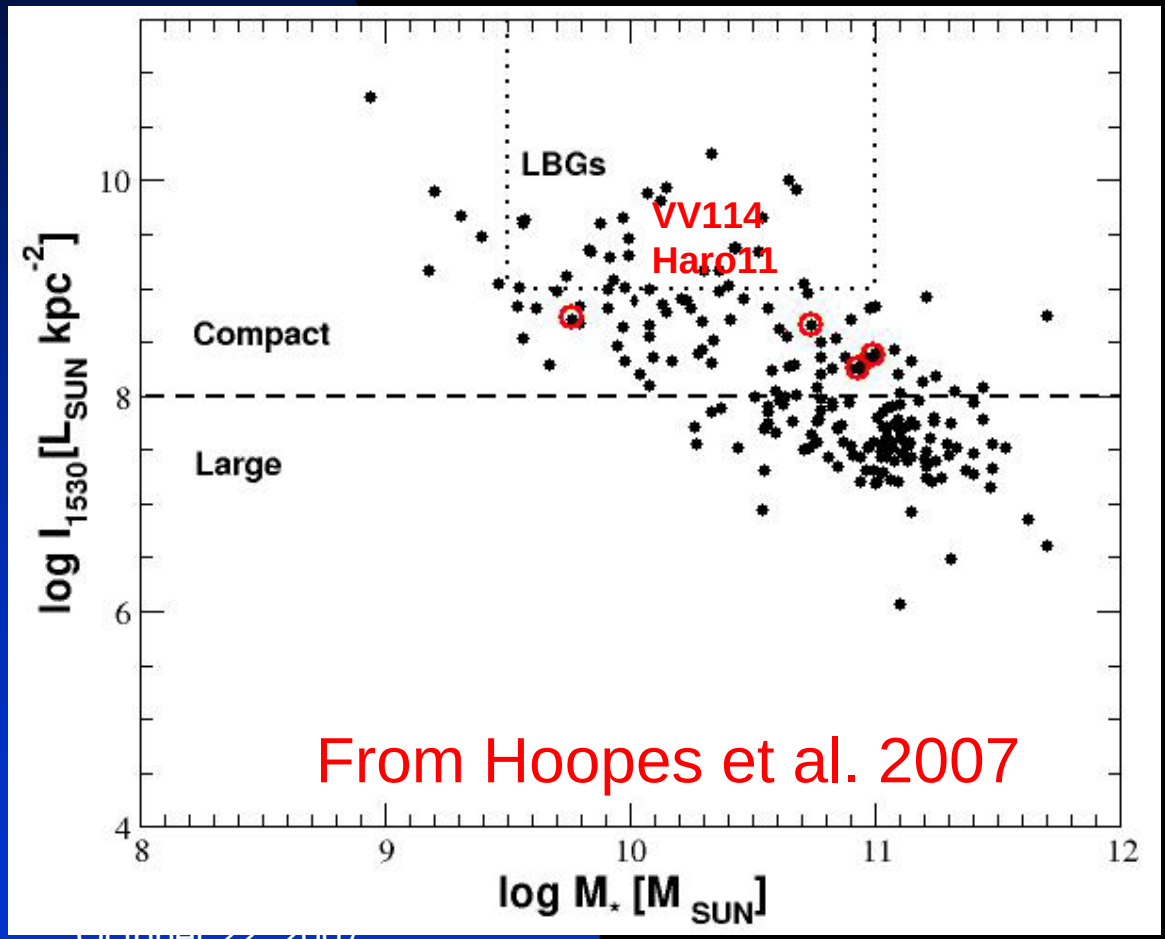
XMM/Chandra exposures (per object):

- 20-50 ks exposures



LBG analogs: *compact* UVLGs

TWO CLASSES OF UVLGs

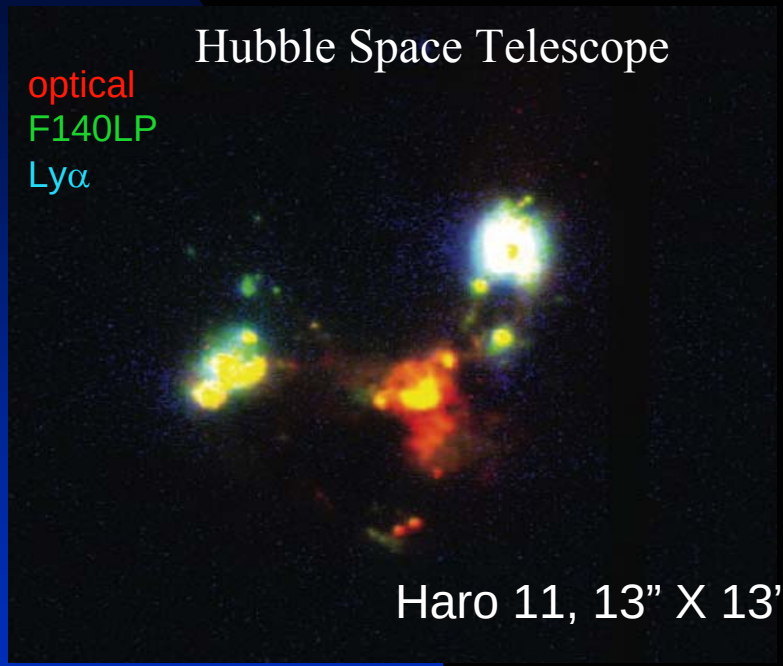


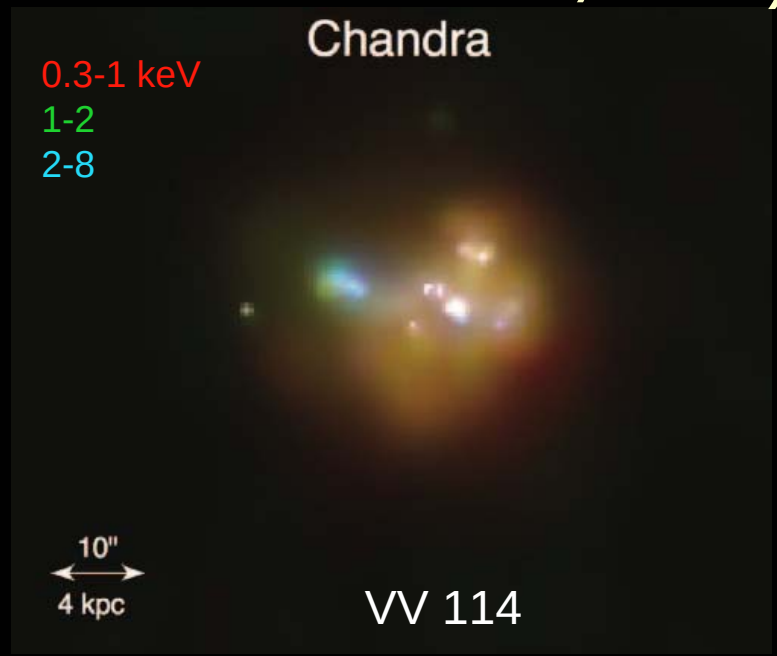
COMPACT UVLGs:

- Very compact, HST imaging shows 1”-3” extent (Overzier et al. 2007)
- Very low dust content based on radio/FIR observations (Basu-Zych et al. 2007)
- Fun reading: Scarpa et al. 2007

Nearest UVLGs (z~0.02)

(Grimes et al. 2006; 2007)



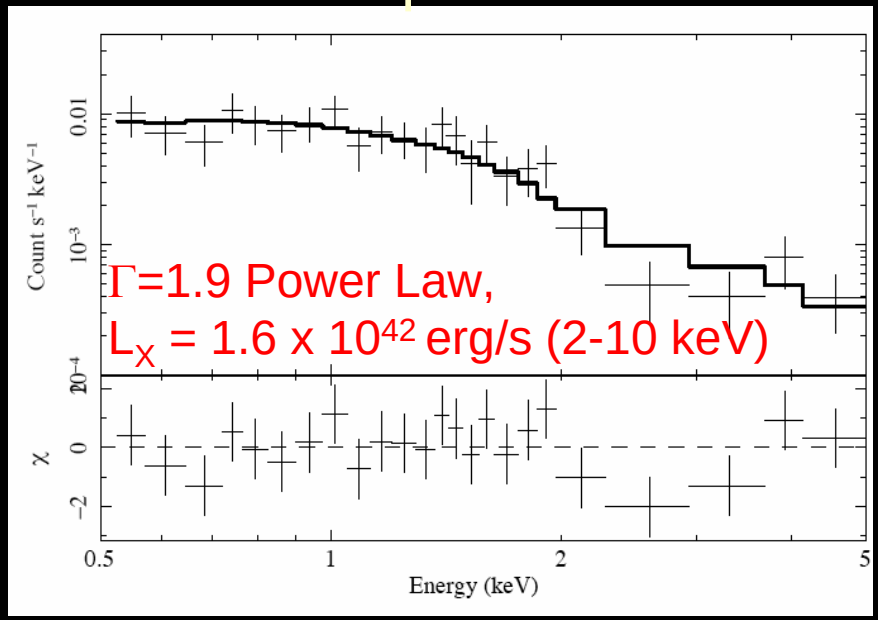


X-ray emission is well-resolved: 2-10 keV band clearly dominated by accreting binary population

XMM Study of UVLGs (Hornschemeier et al. 2008)

SDSS IMAGES

XMM MOS Spectrum - UVLG02



L_X comparable to most X-ray luminous starburst In the local Universe, NGC 3256 (Moran et al. 1999)

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

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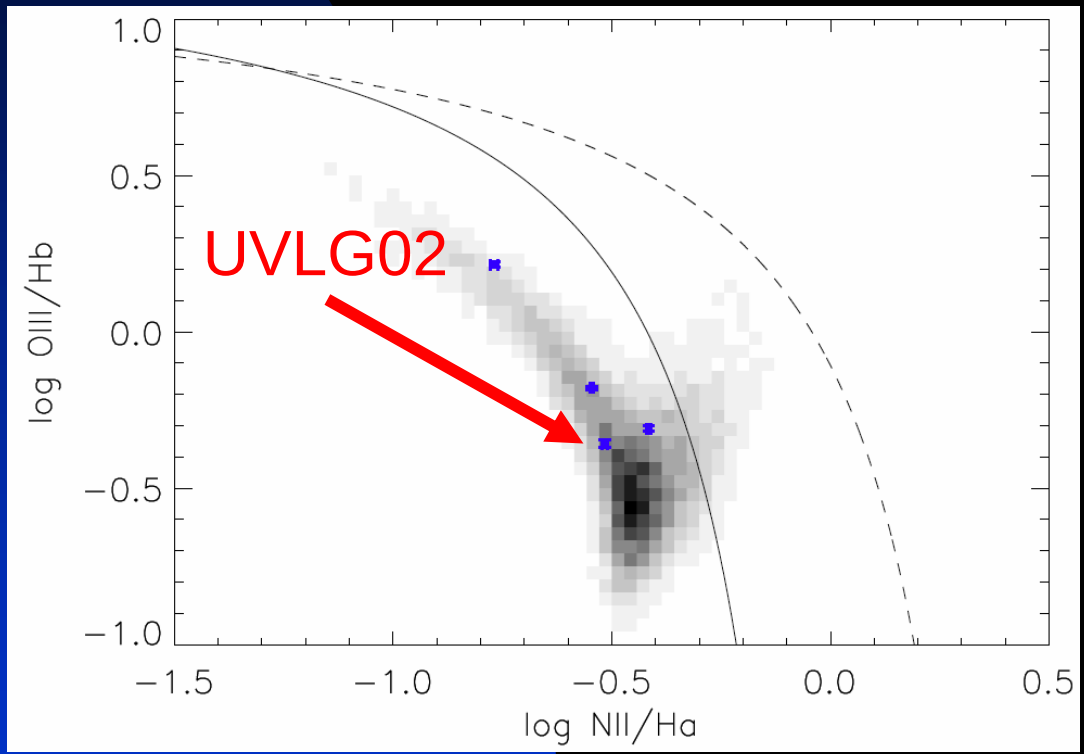
XMM images of UVLG03 & UVLG04 (VERY FAINT)

UVLG02 : really a starburst?

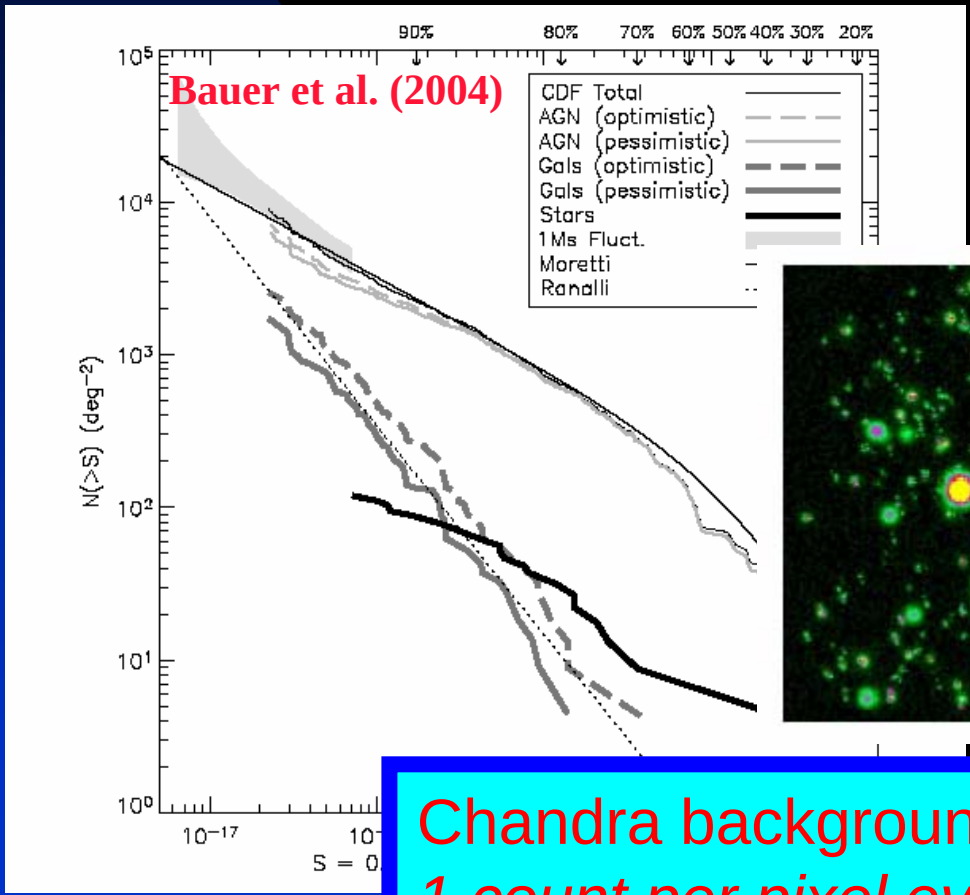


- The answer appears to be yes!
- Squarely in starburst region of three starburst/AGN diagnostics plots (see Kewley et al. 2006):
  - [OIII]/Hβ vs NII/Hα (classical BPT)
  - [OIII]/Hβ vs. [OI]/Hα
  - [OIII] /Hβ vs. [SII]/Hα
- EXCESSIVE X-ray emission (factor of 2-3) given SFR

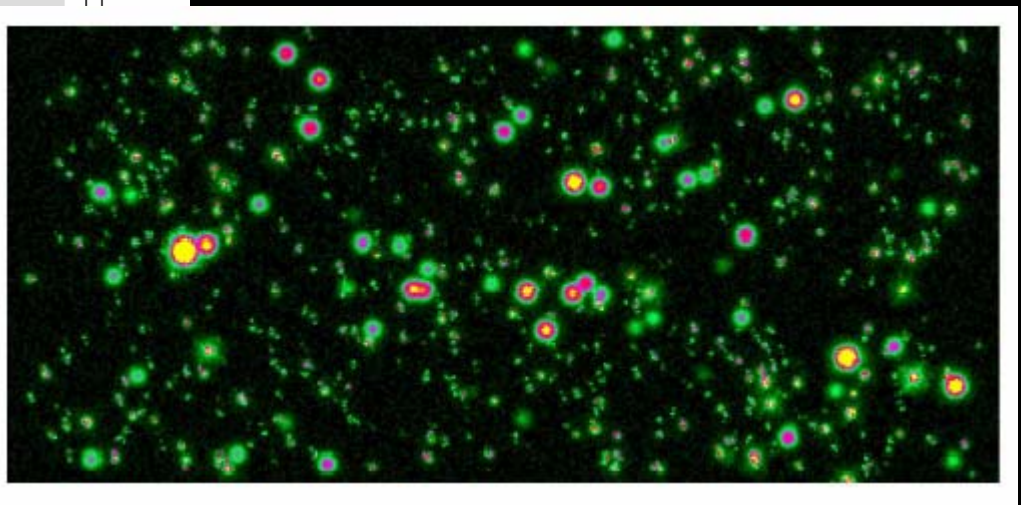
What is the nature of the most vigorous starbursts in the Universe?

- Expanding the sample:
  - Median UVLG redshift is z~0.2
  - 50-100 ks required for *detection* of many of these by Chandra and XMM-Newton
  - Wide-field surveys (square degrees) at ~< 10^{-15} erg cm^{-2} s^{-1} needed
- Constellation-X will detect these sources in much shorter exposures

Going deeper now to detect more galaxies: an important input to future X-ray missions



Ultra-deep X-ray survey ($\leq 10^{-18}$ erg cm^{-2} s^{-1})



Chandra background is less than
1 count per pixel every ten days
We can go deeper (>5 Ms) now.