ULXs in NGC 2276

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NGC 2276 and NGC2300

Carlos and Crystal Acosta/Adam Block/NOAO/AURA/NSF

Sc at 32.8 Mpc

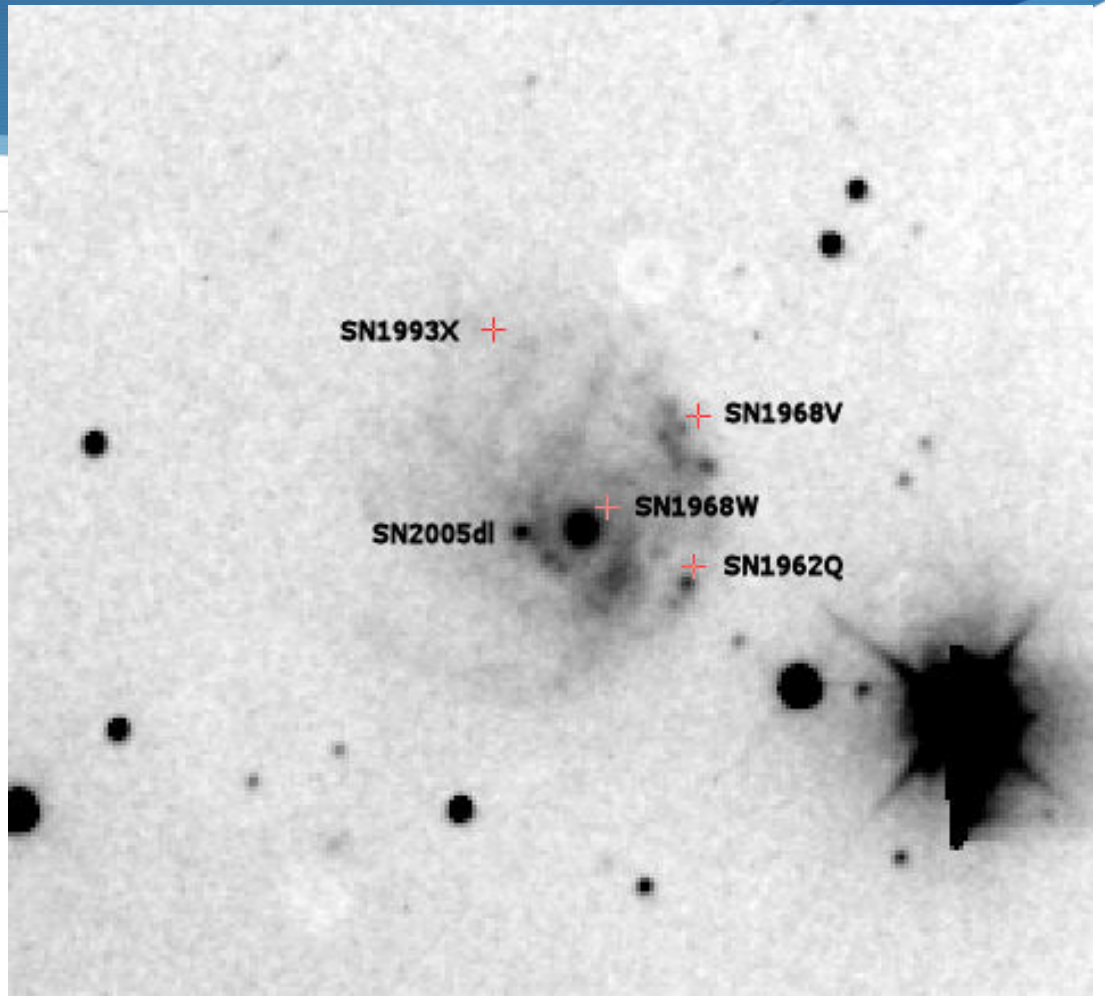
High SFR

SFR=9.5 $M_\odot$/yr
Kennicutt (1983) Hα
SFR=4.3 $M_\odot$/yr
Kennicutt et al. (1994) Hα
SFR=5 $M_\odot$/yr James et al. (2004) Hα

SFR=11 $M_\odot$/yr
Sanders et al. (2003) FIR

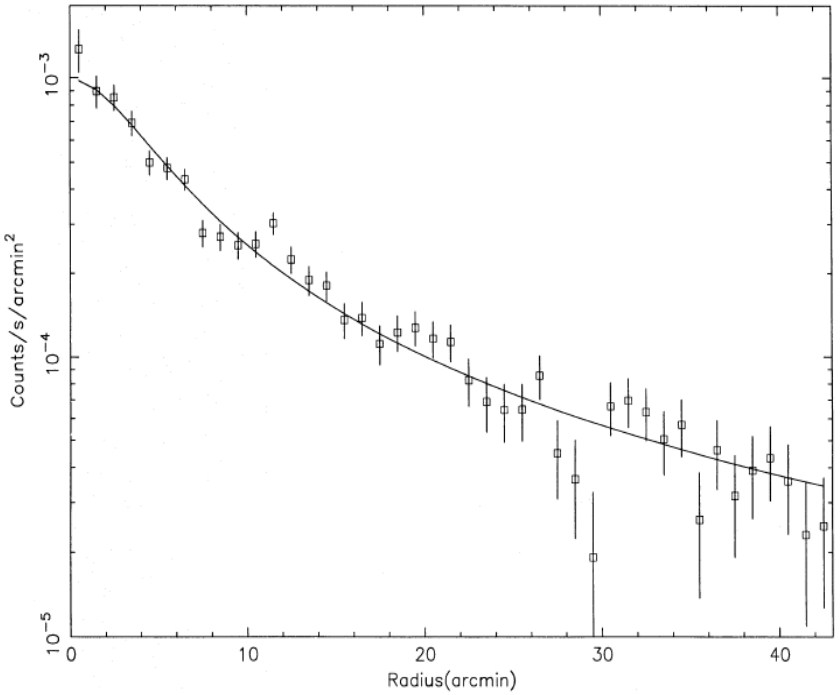
Supernovae in NGC 2276

At least five SN are known in NGC2276, in the last 40 years.



Previous observations: ROSAT

- Mulchaey et al. 1993 ApJL, 404, L9
- Davis et al 1996 ApJ, 450, 601



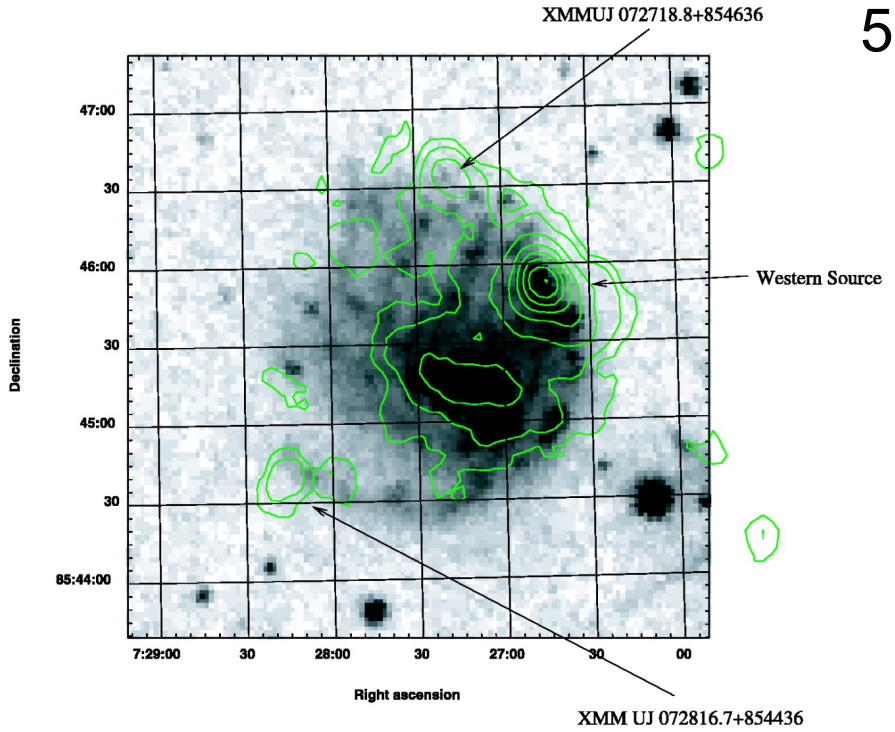
NGC2300 group: first to be detected as extended in X-ray

Surface brightness profile centered on the peak emission, near but not on NGC2300 (about 2'.5 towards NGC2276).

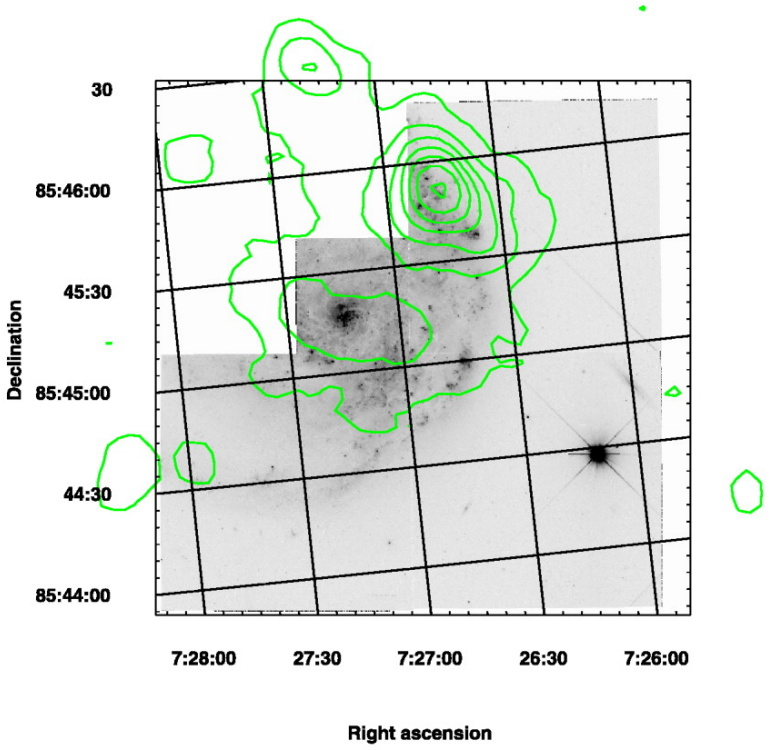
Fit with King model
r_o = 4.28+/- 1 arcmin → ~40 kpc
β = 0.41+/- 0.3
Exent up to 25' at least.

Previous observations: XMM-Newton

- Davis & Mushotzky, 2004 ApJ, 604:653-661



53 ksec; 1 ULX at Lx=1 x 10^{41} cgs



Nucleus non detected: Lx <~ 2 x 10^{39} cgs
Variable?

Prediction on ULX content

By using Z=0.22 $Z_{\odot}$ (Kennicutt 1992) and SFR=5-10 $M_{\odot}$ (~from Hα and FIR) Mapelli et al predict a large number of BH and an expectation value for the number of ULX of ~5-10.

Mapelli et al. 2010 MNRAS in press, arXiv:1005.3548.
(See also Michela Mapelli and Emanuele Ripamonti talks tomorrow)

To compare with 1 found!!

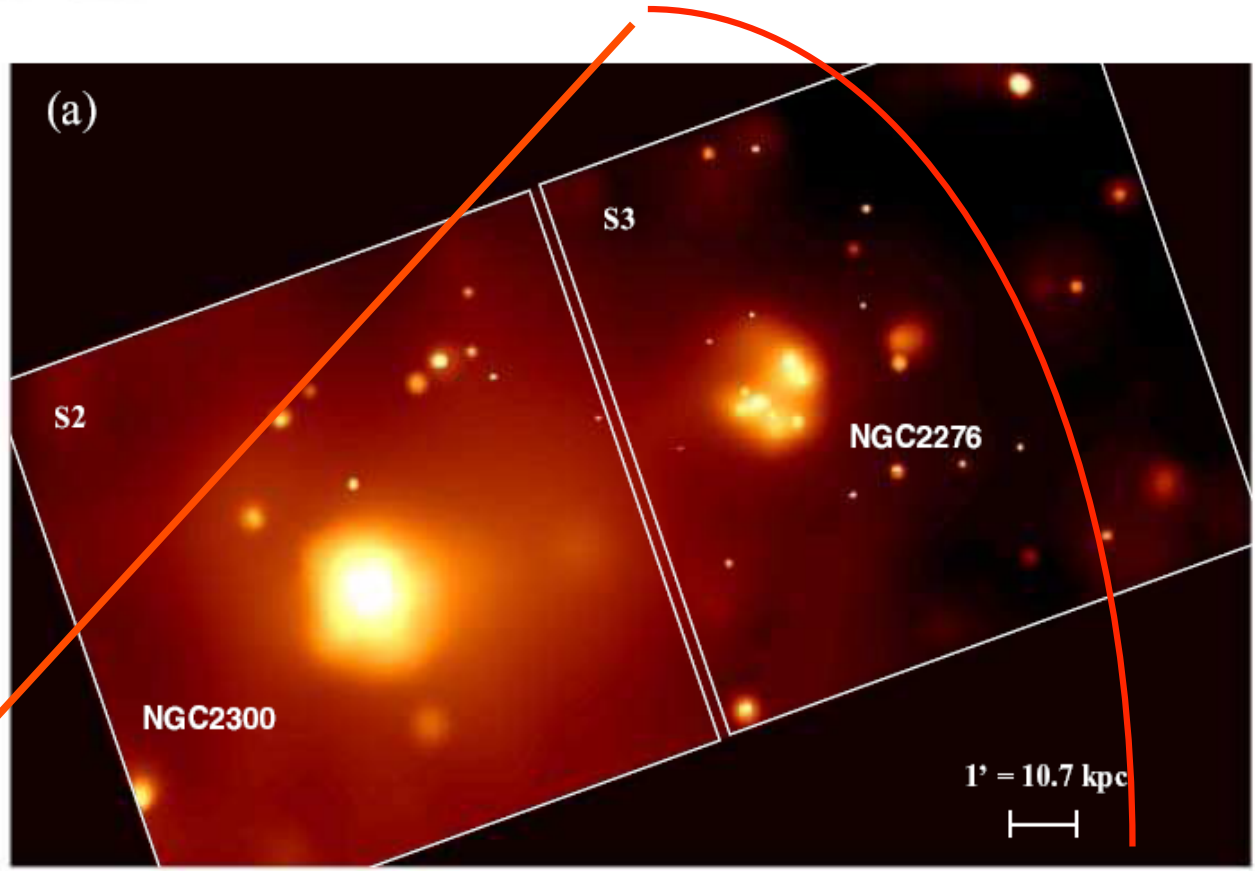
New data: CHANDRA

Rasmussen, Ponman, Mulchaey, 2006,
MNRAS 370, 435

Observed 23 June 2004 for 45.8 ks

Gas at kT~0.3 -0.5 keV

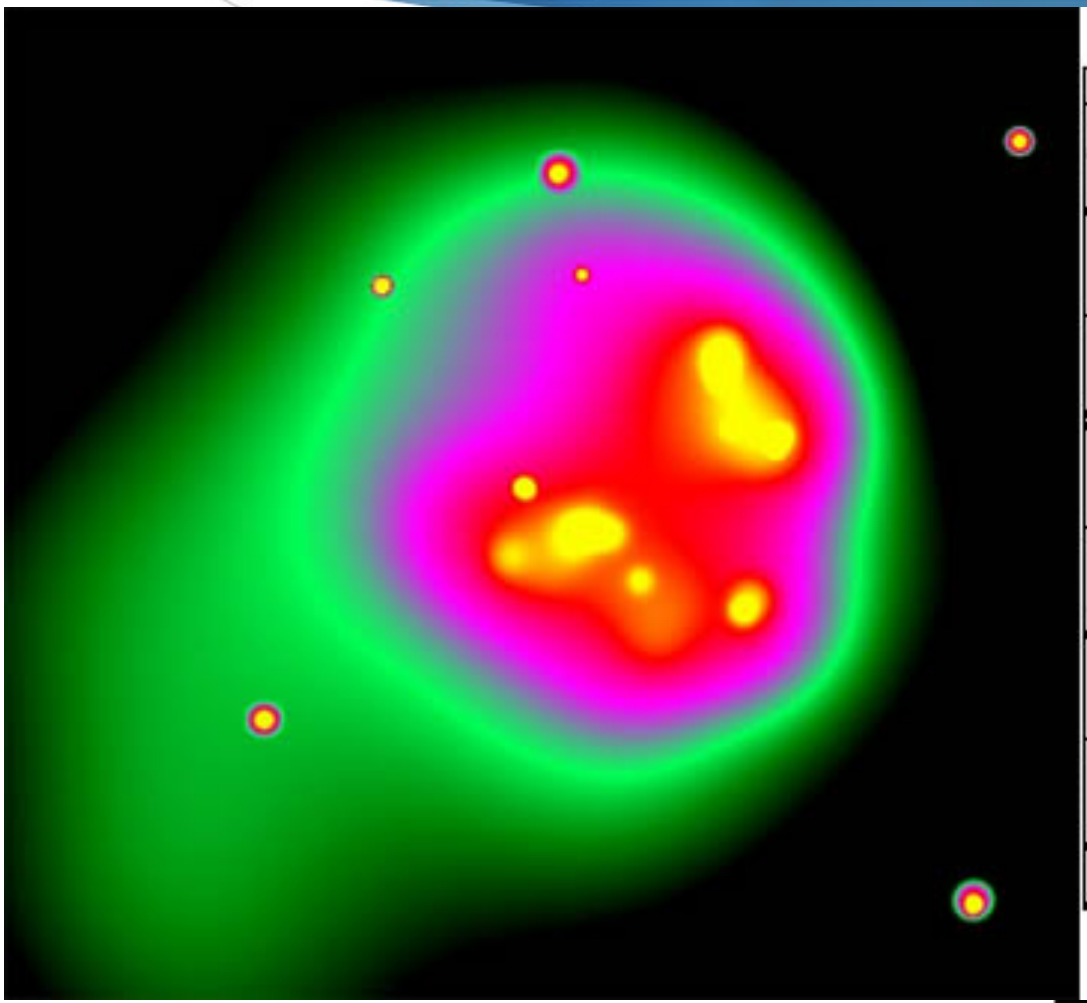
Lx = 1.9 x 10^{40} cgs



This indicates about 1/3 of the group gas extension detected by ROSAT and confirmed by Chandra

kT ~ 0.8 keV

HI tail



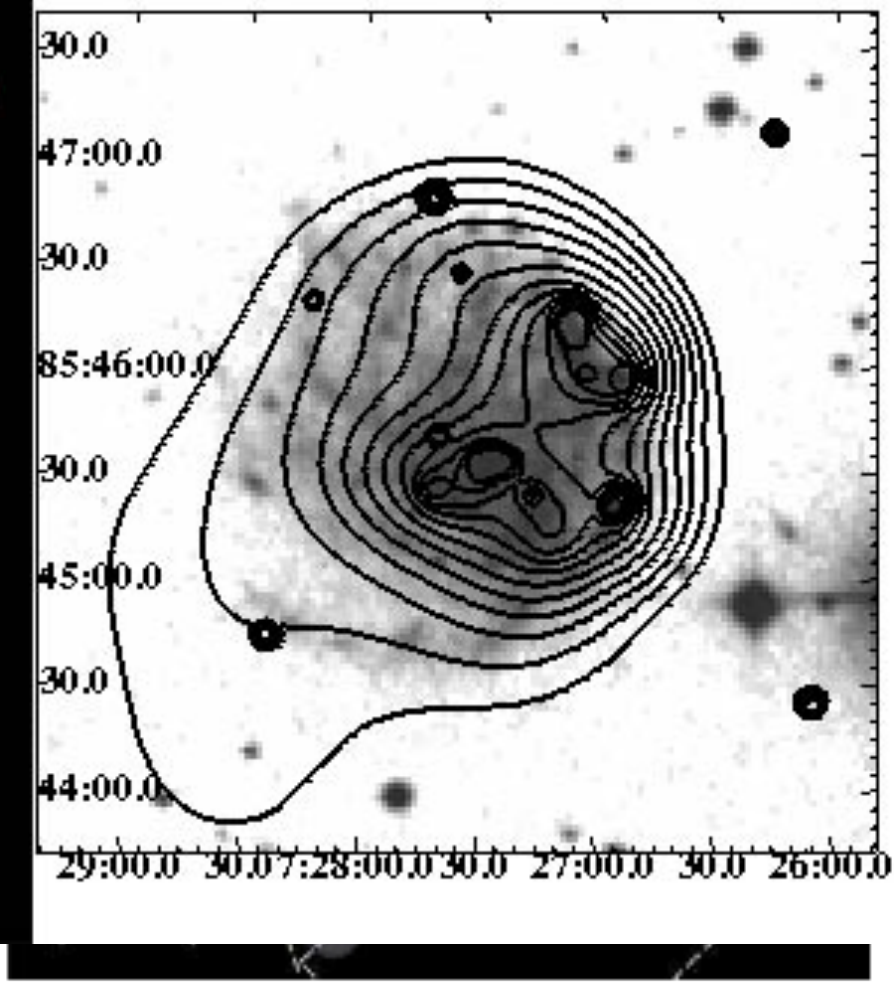
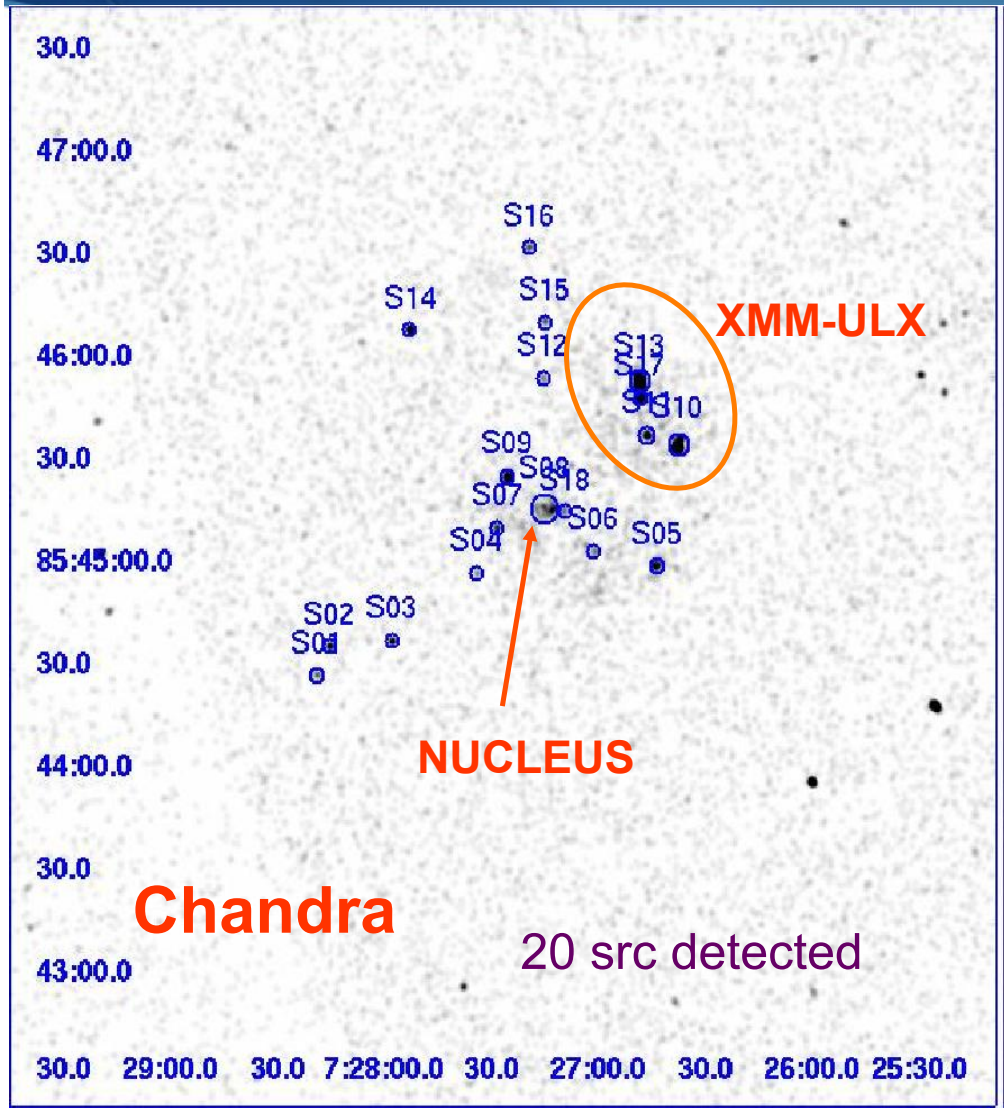
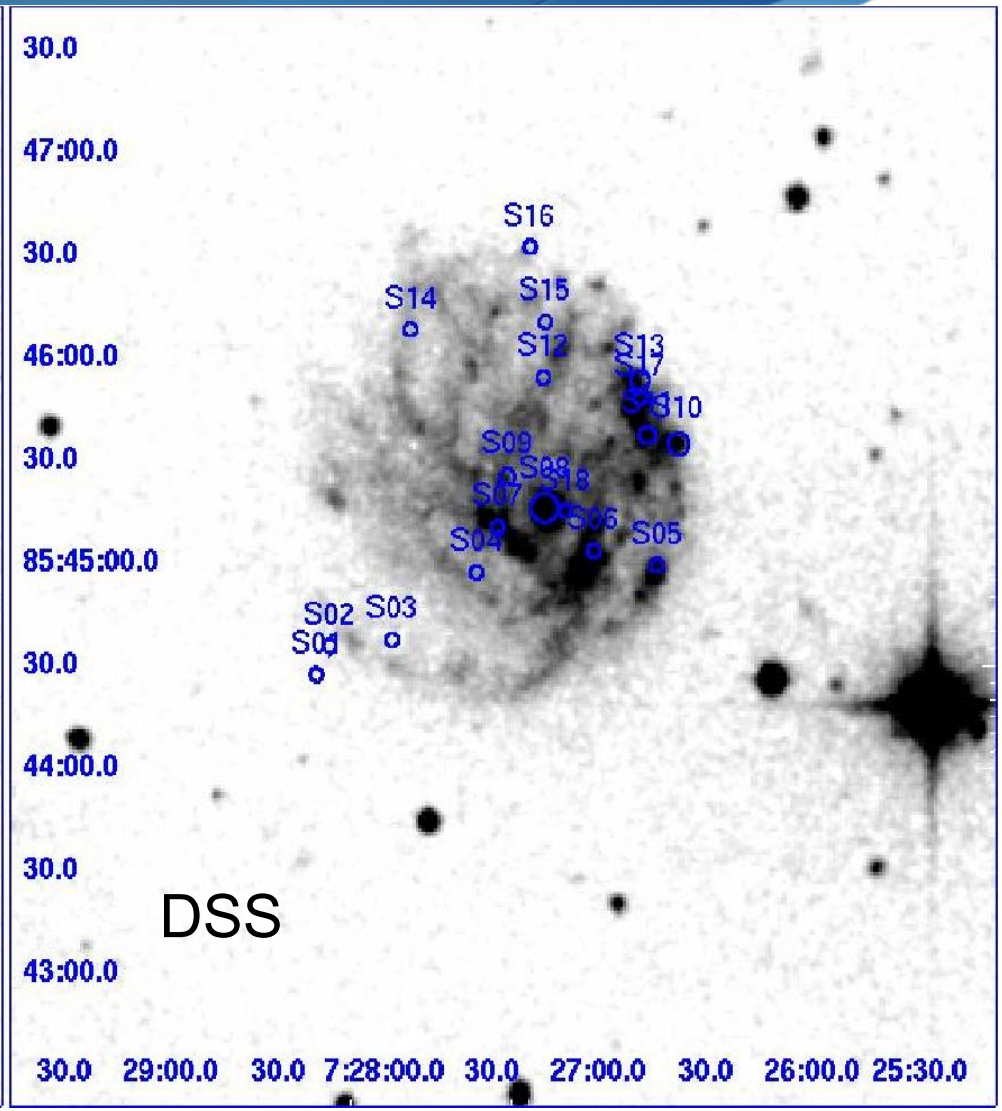


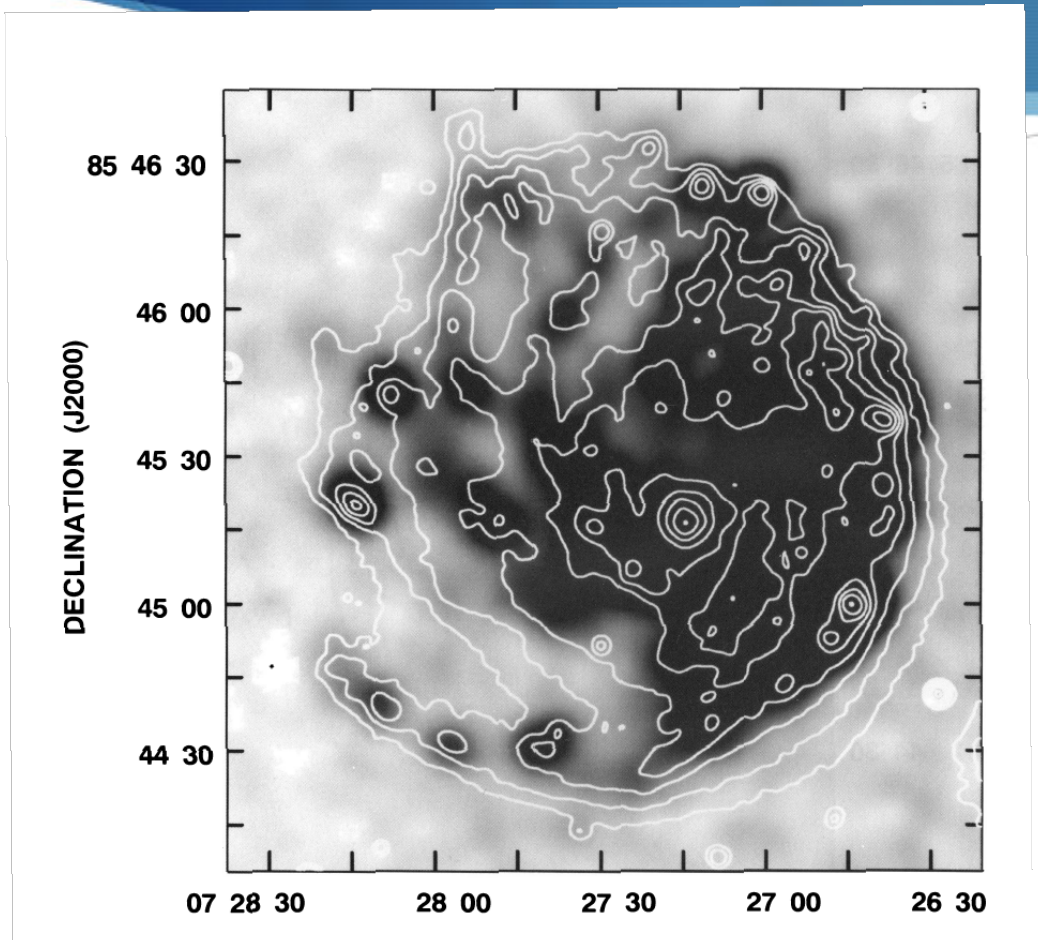
Figure 5. As Fig. 1, but for a 7 × 7-arcmin^2 region around NGC 2276 and

Chandra point sources





Hα images



Gruendl et al 1993, ApJL, 413, L81

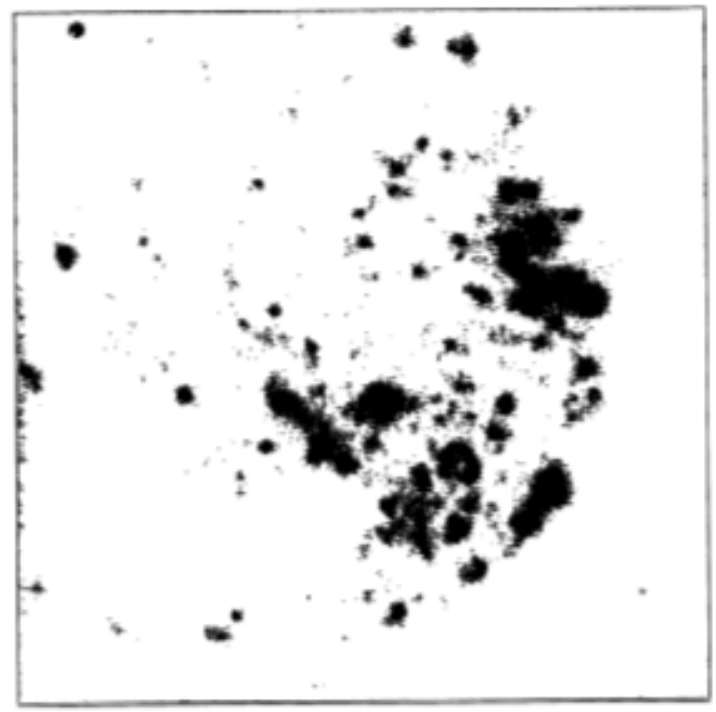


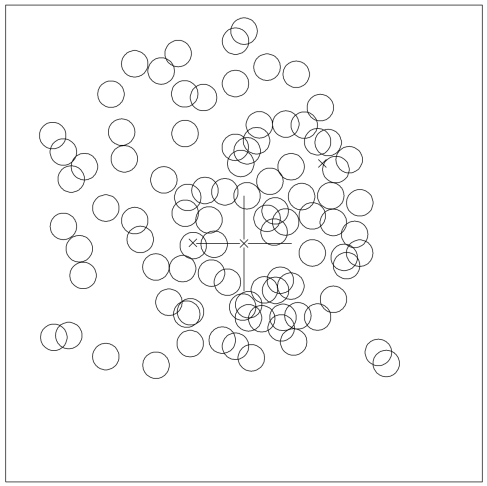
FIG. 4. The Hα image of NGC 2276. North is up and east is to the left. The FOV is 2′ across.

Davis et al 1997, AJ, 114, 613

HII regions

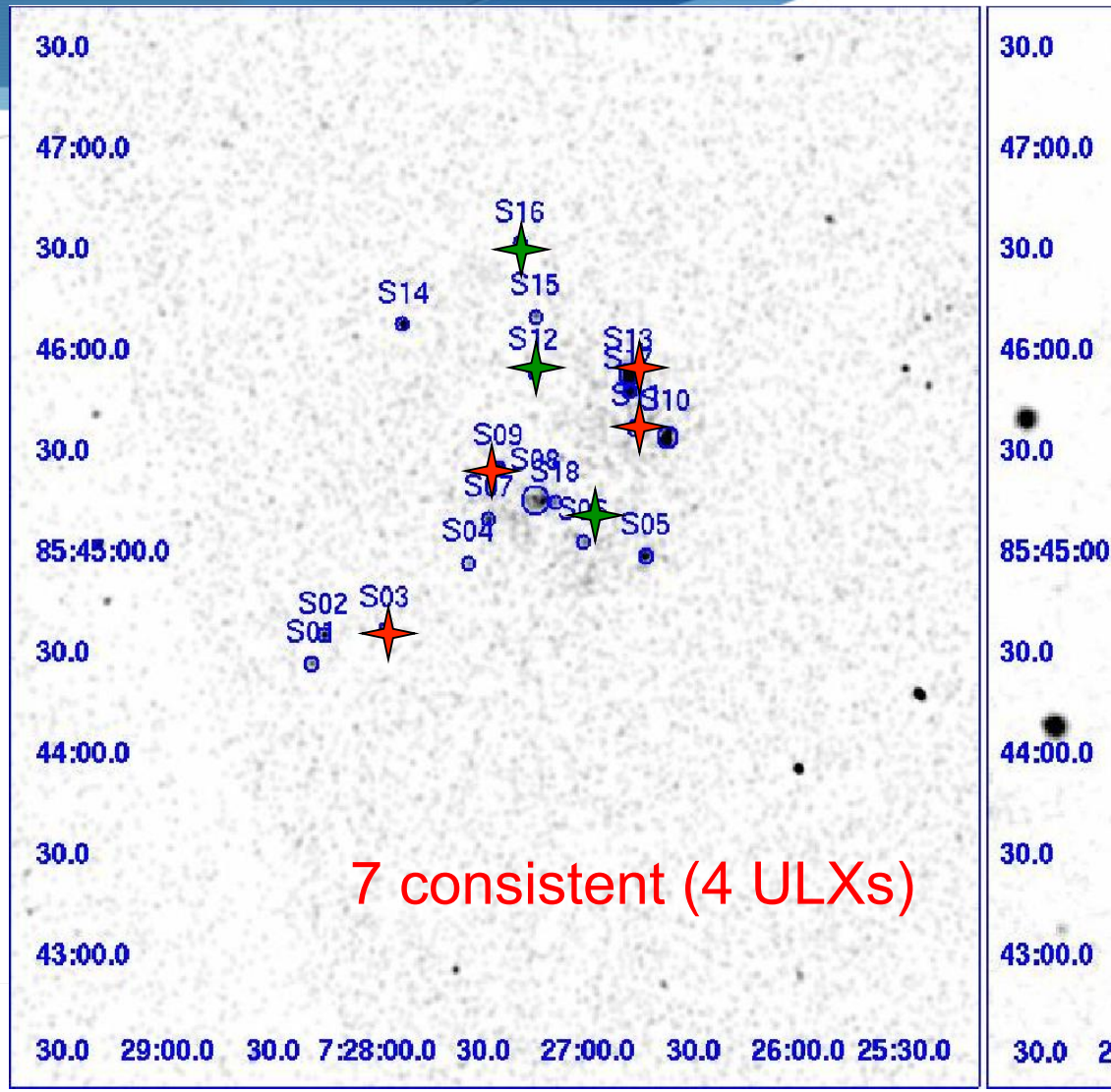
Hodge & Kennicut 1983, AJ, 88, 296
Davis et al. 1997, AJ, 114, 613

72+13 HII region identified



OBJECT NAME = NGC 2276
B1950: 07 10 23.83 +85 50 54.0 SCALE= 1.500"/mm:1950

The HII regions and the Hα map trace the arm shape: recent star formation.

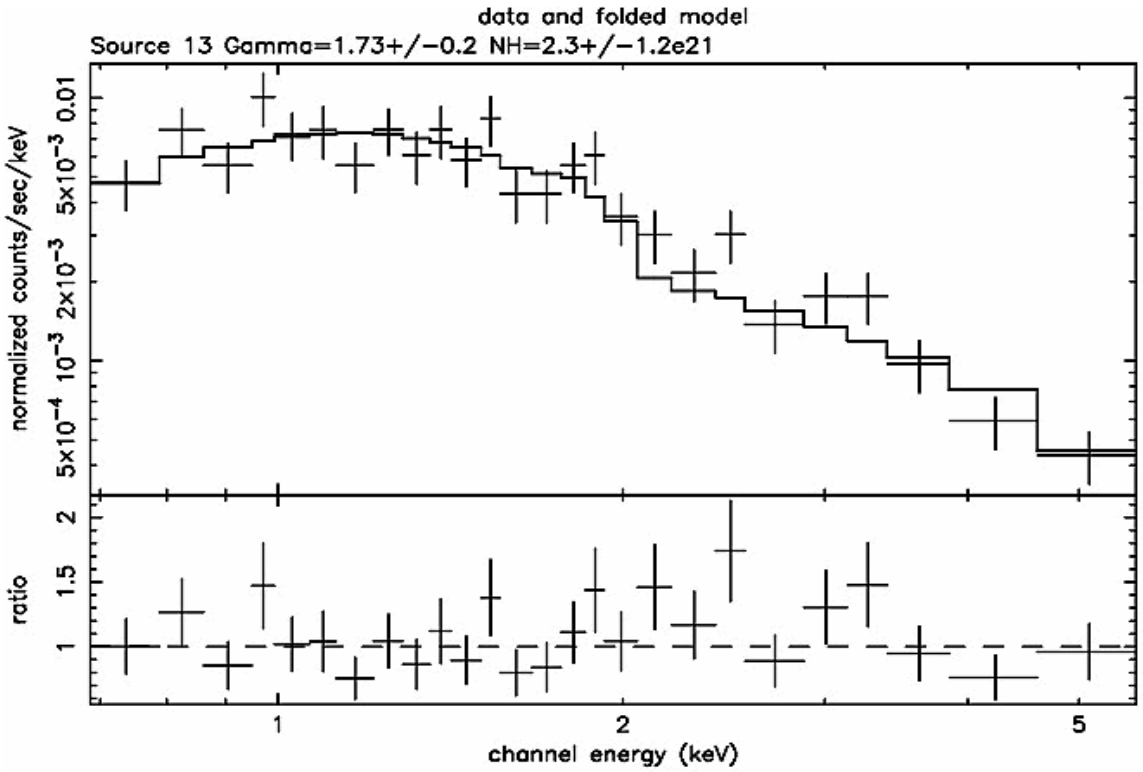


Spectra for the brightest sources

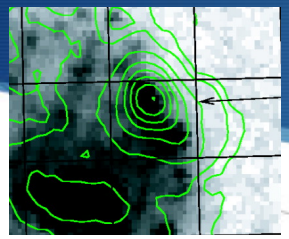
A total of 19 sources are detected, from a few counts up to ~400.

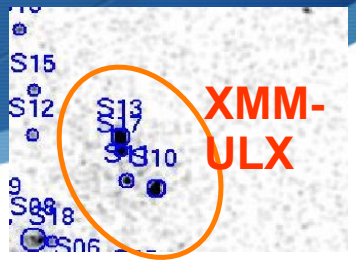
Fit for the brightest sources are consistent with an absorbed power law. N_H ~ 1-3 x 10^{21} cm^{-2}

Γ ~1.6– 1.8



What about the XMM-Newton ULX?





- The source is resolved in 6 sources, of luminosities ranging from a few 10^{38} to almost 10^{40} cgs.
- Sum of all point sources: L_X(2-10keV) = 2 x 10^{40} cgs to compare with : L_X(2-10keV) = 3.8 x 10^{40} cgs in XMM-Newton – L_X(0.5-10keV) = 1.1 x 10^{41} cgs rescaled to 32.8 Mpc and (2-10 keV).
- About 30% of the flux might be in diffuse emission
- Possible variability of at least the brightest ULXs

XLF + contamination

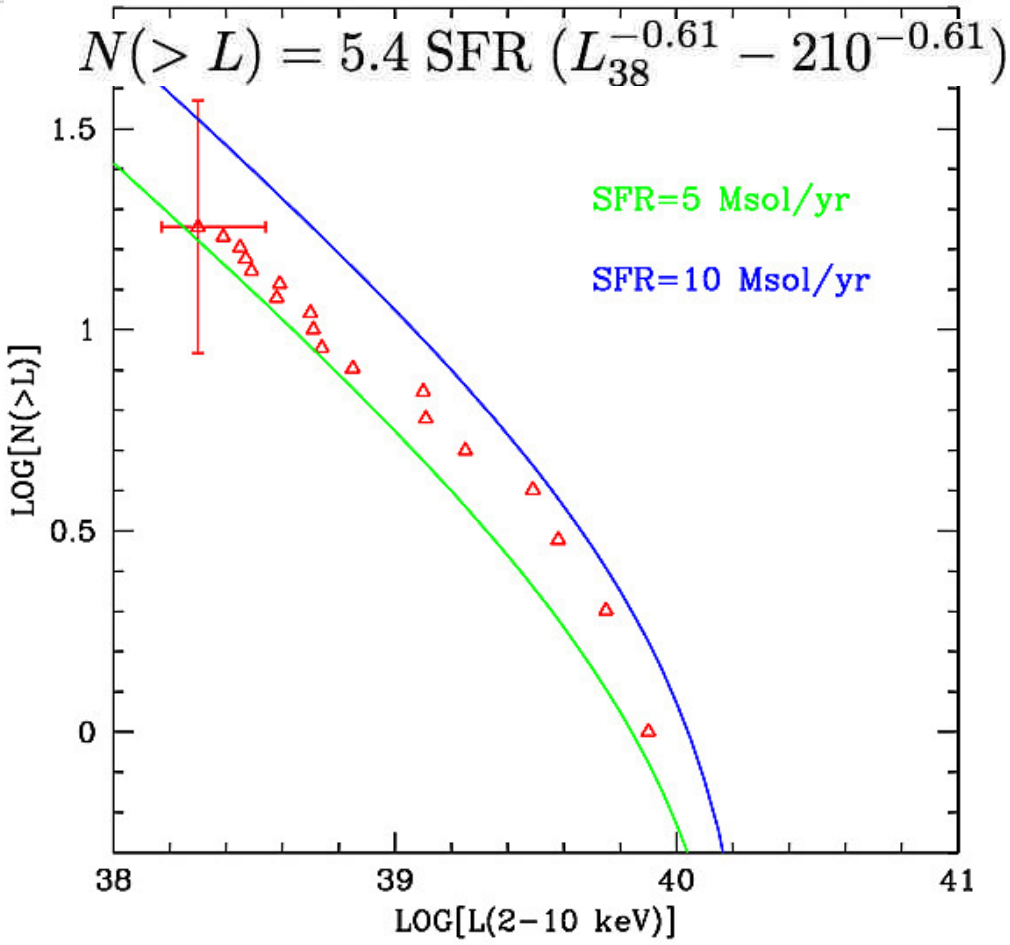
From Hasinger et al. 1993 logN-logS only ~ 1.4 src are spurious – 7 src > 10^{39} cgs

XLF compared with Grimm et al 2003 HMXB formula

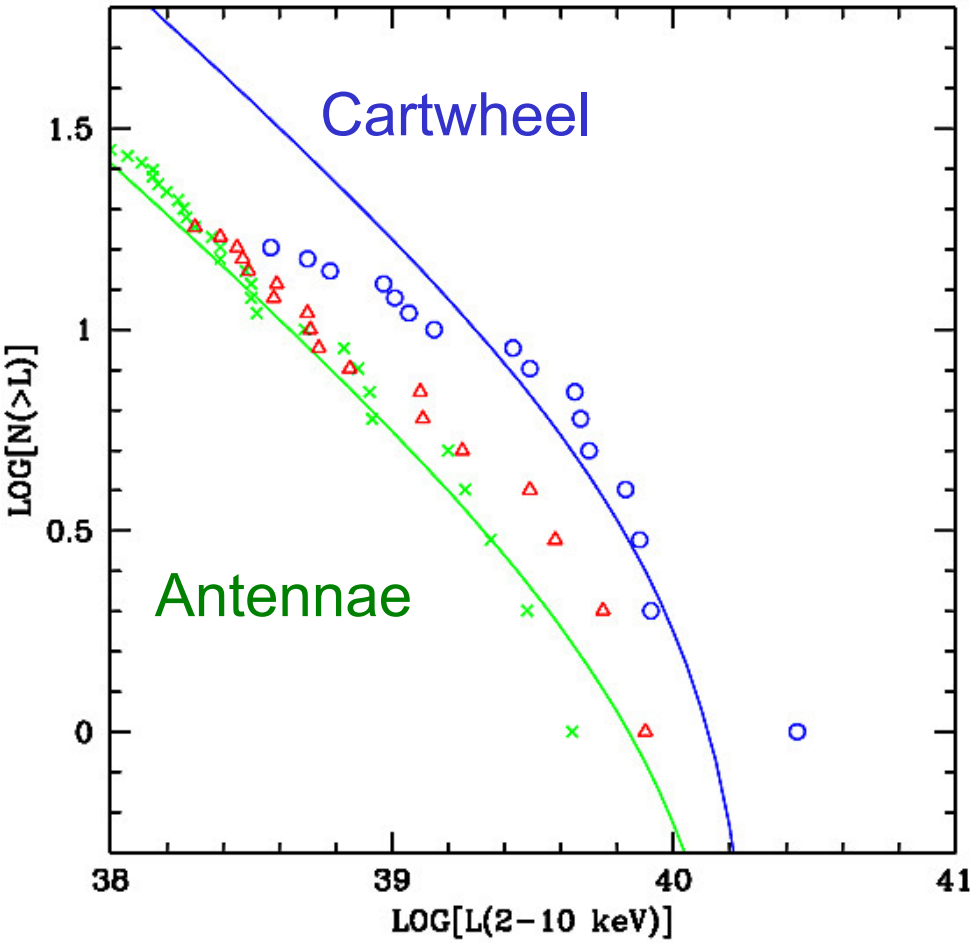
Comparing also the number of ULX and their L_X we find SFR = $5.5 M_\odot$/yr or $5 M_\odot$/yr

$$N(L > 2 \times 10^{38}\ \mathrm{erg\ s^{-1}}) = (2.9 \pm 0.23)\,\mathrm{SFR}\ (\mathrm{M_\odot\ yr^{-1}}),$$

$$\mathrm{SFR}\ (\mathrm{M_\odot\ yr^{-1}}) = \frac{L_{2-10\mathrm{keV}}}{6.7 \times 10^{39}\ \mathrm{erg\ s}},$$



Comparison with other galaxies



The two curves are 5 and 15 $M_{\odot}$/yr respectively

XLF not corrected for possibile confusion both in Cartwheel and NGC2276

I will *NOT draw* any conclusion about ULX being HMXB or not

Variability should be studied at high Lx.

Conclusion

- NGC2276 has a high SFR; high Hα luminosity; many ULXs (even if not at Lx ~ 10^{41} cgs) consistent with predictions
- It is embedded in group gas
- It interacts with NGC2300: tidal + ram pressure? SN winds?
- Is the interaction that drives the SF and the high number of ULX? (Encounter 400 Myr ago? Davis et al 1997)
- ULX are possibly located near HII regions (and also SN?)