Correlation of ULXs candidates with metalicity of their host galaxies within 40 Mpc

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Outline

- ULXs definition
- Sample selection
- Correlation between ULXs and the host galaxies
- Conclusion

Ultraluminous X-ray Sources

- off-nuclear point-sources with X-ray luminosities $L_X > 10^{39}$ erg s^{-1} in the ~ 0.5-10 keV band, brighter than the traditional limit for stellar mass black holes X-ray binaries in our galaxy

- What makes a ULX?

$$L \approx \frac{1{,}3 \times 10^{38}}{b} \dot{m} \left(\frac{M}{M_{\odot}}\right) erg\ s^{-1}$$

→ black hole
→ massive, young star companion

⇒

Environment:
host morphology, SFR, metallicity, interactions

Selection of ULXs sample

Liu (2011)

- High Spatial Resolution
- Can resolve sources in crowded area

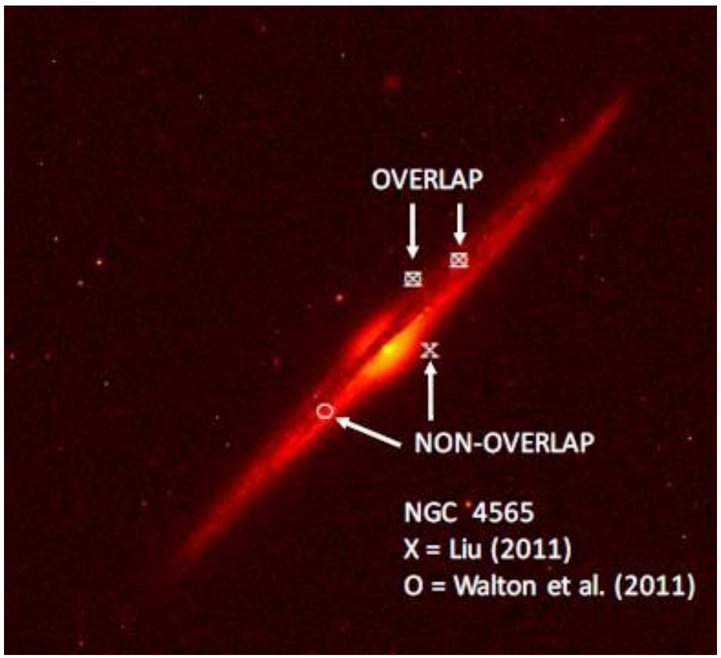
Walton (2011)

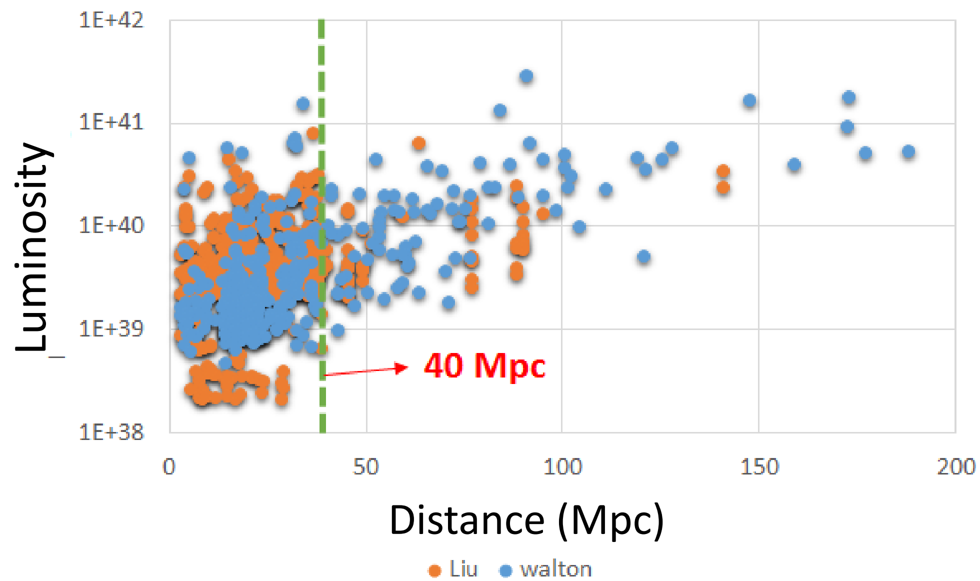
- High Sensitivity
- Can detect dim source better

Source catalog	ACIS Chandra (2007 Dec 14)	2XMM-DR1
Source position uncertainty (arcsec)	< 1	< 2.4
ULXs outside R_{25}	Yes	No
ULXs luminosity (erg/s)	> 2×10^{39}	> 10^{39}
Energy range (keV)	0.3 – 8	0.2 – 12

Selection of ULXs sample

- ObsId with maximum luminosity
- galaxies within 40 Mpc.





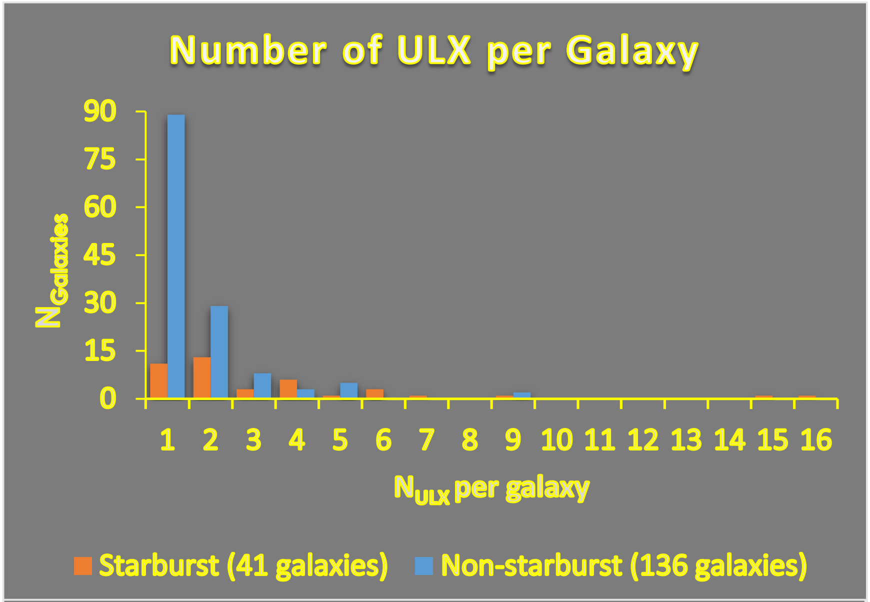
- Deprojected radius (inclination & position angle corrected, data from Hyperleda) → r_{true}/R_{25}

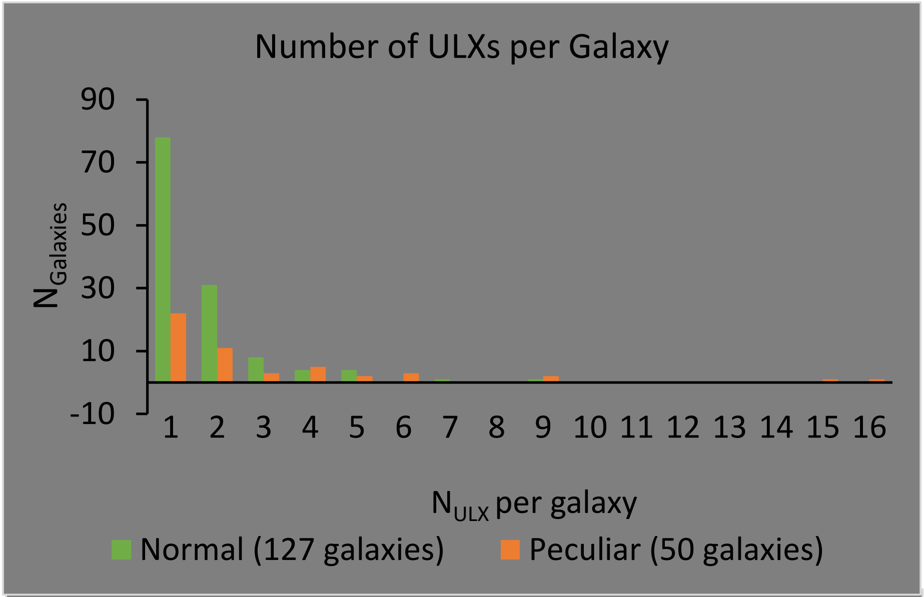
ULXs sample

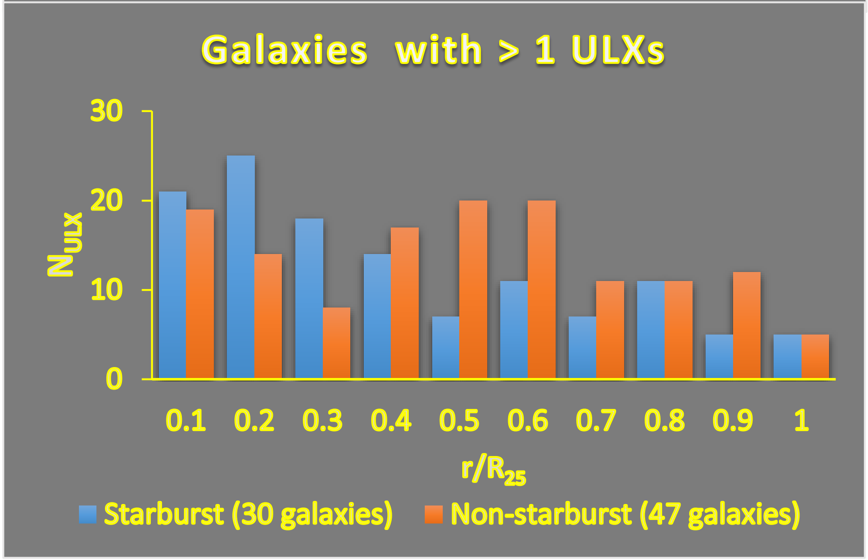
- Focus on $r_{true}/R_{25} < 1$: 366 ULXs (45 overlap) in 177 galaxies (35 overlap), 23% starbursts

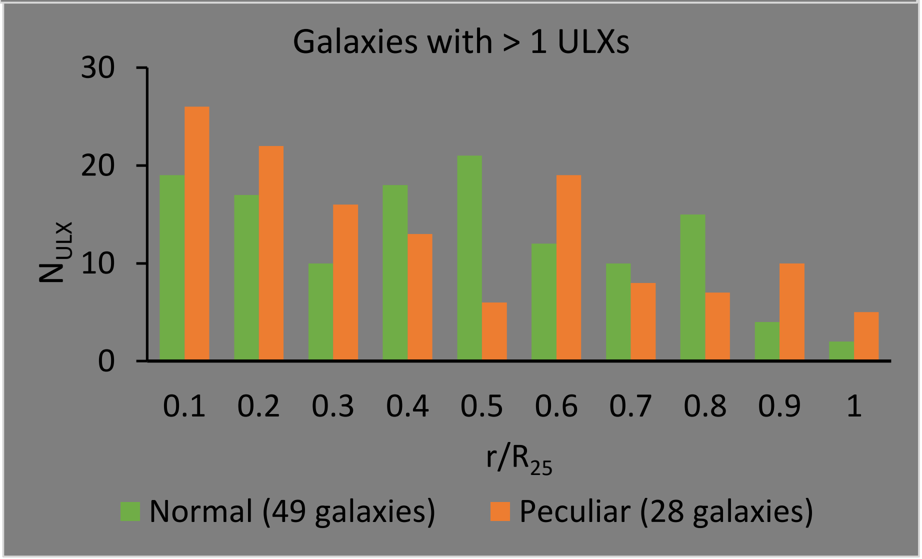
Sampel ($r < R_{25}$)	N(host galaxies)	N(ULXs)
Total	177	366
Overlap	35	45
Normal	127	216
Peculiar	50	150
Spiral	125	274
Elips	29	59
Lenticular	15	20
Irregular	8	13
Starburst	41	140

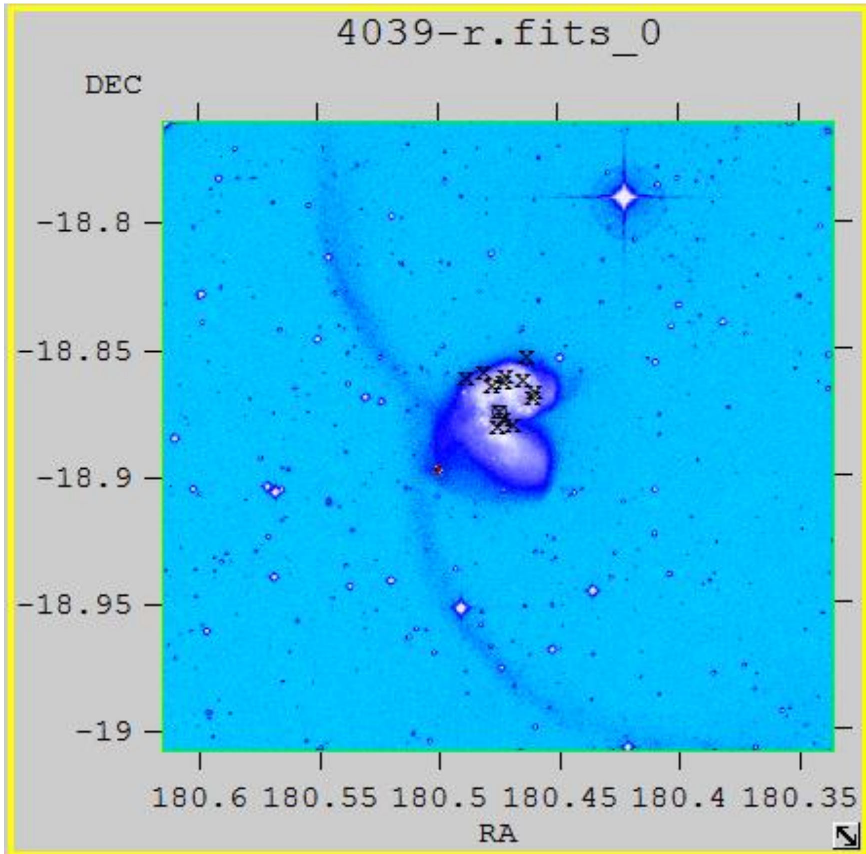
- Most of galaxies host 1 ULX
- ULXs are enhanced in starbursts & peculiars





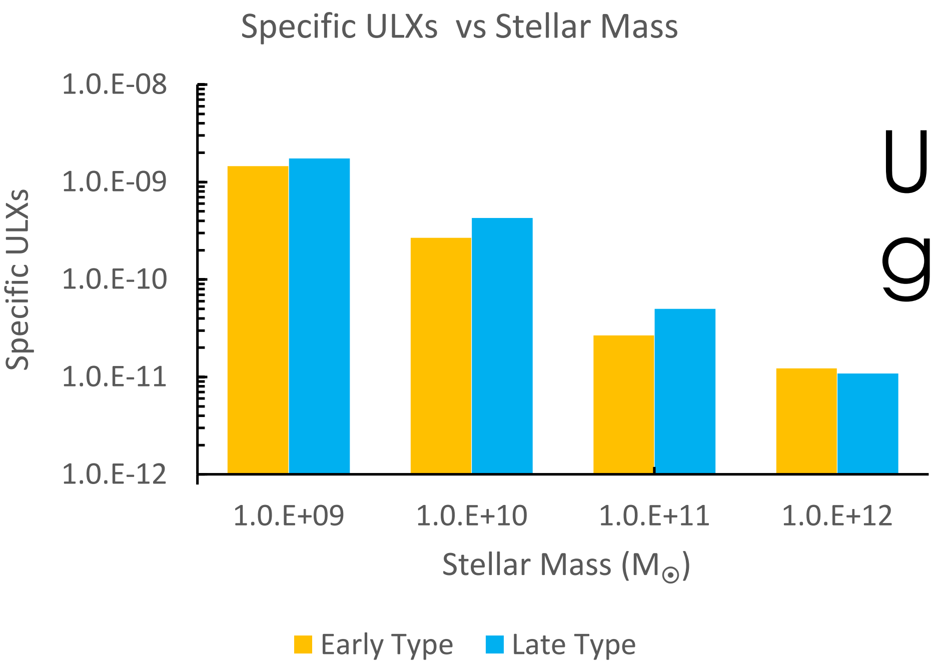






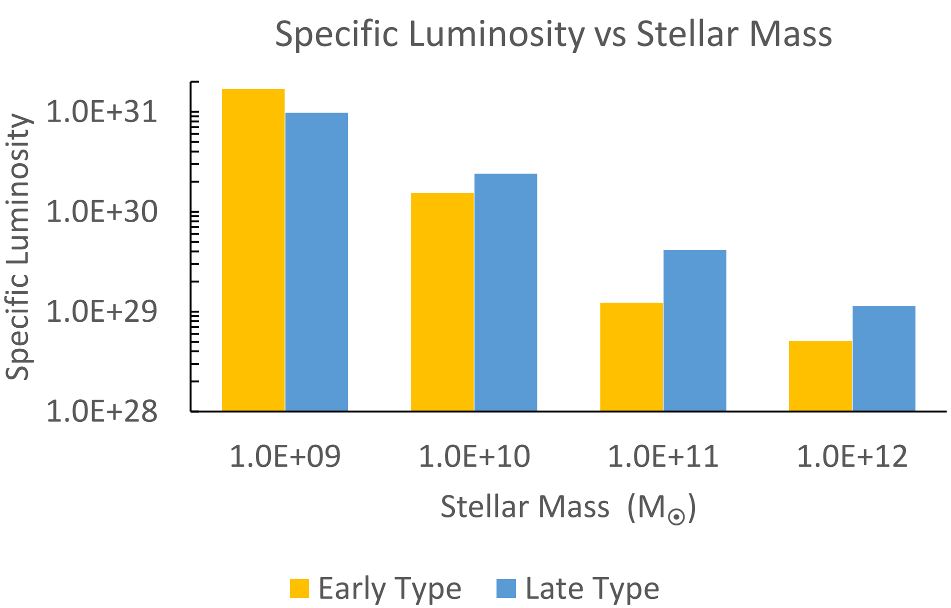
Sample type	ULXs average number
Normal	1.70
Peculiar	3.00
Spiral	2.19
Irregular	1.63
Ellips	2.03
Lenticular	1.33
Early Type	1.80
Late Type	2.16
Starburst	3.41
Non-starburst	1.66

ULXs prefer dwarf galaxies



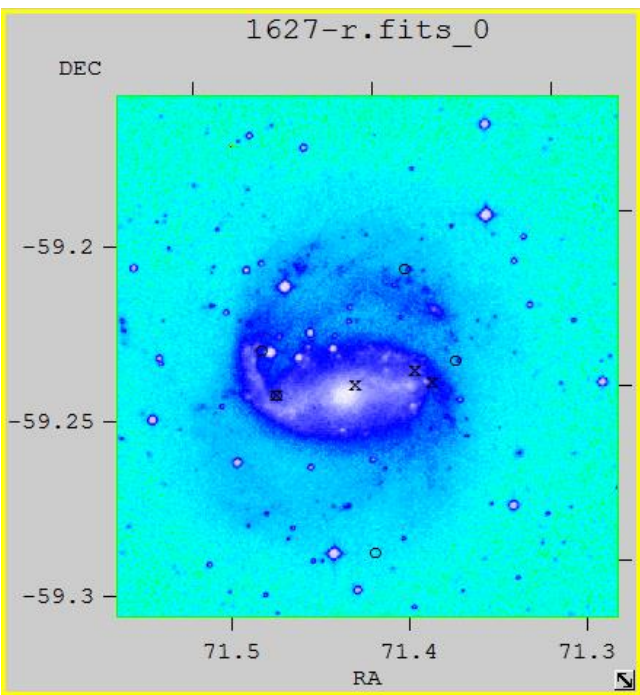
$$log_{10}\left(\frac{M}{L}\right) = a_B + \left(b_B * (B - V)\right)$$

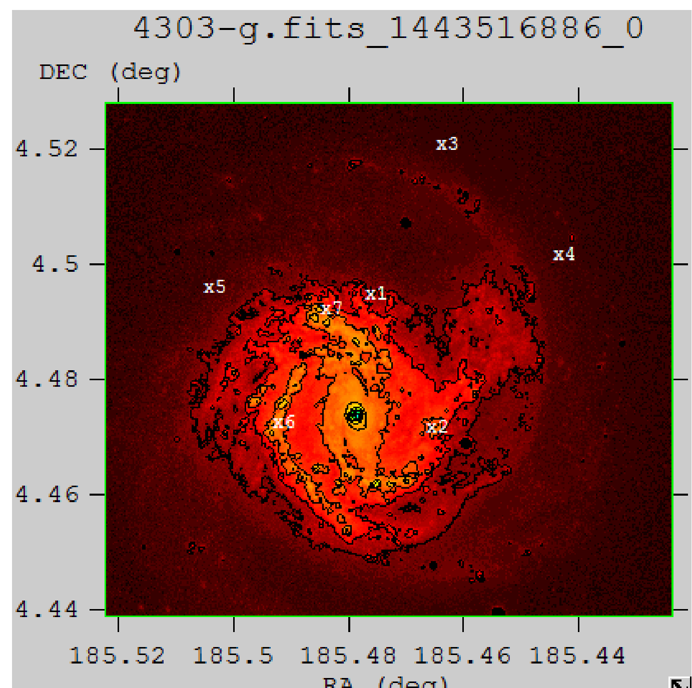
Bell et al. (2003)



Has something to do with metallicity and Star Formation Rate (SFR)…

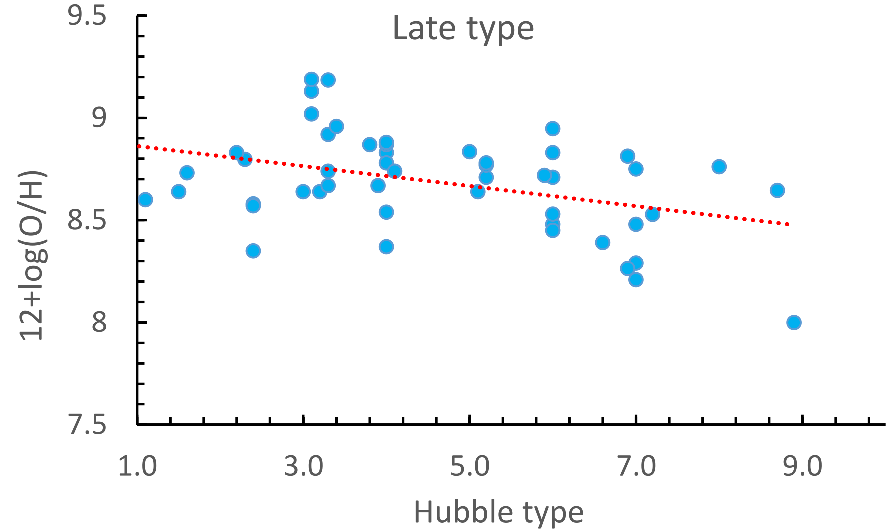
- Massive stars (>30 $M_\odot$) might lose >50% mass by winds (Vink 2001) $\dot{M} \propto Z^{\alpha}$, $\alpha \sim 0.5 - 0.9$
  → Black holes are easier to form at lower metallicity
- Higher SFR → massive young star companions as mass reservoir for accretion

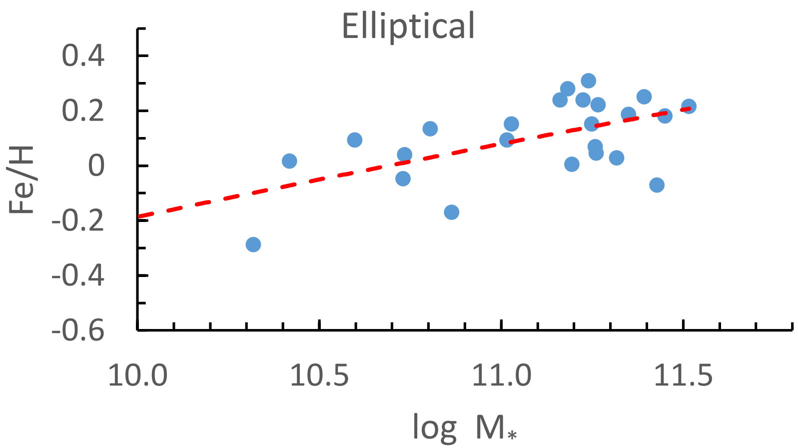


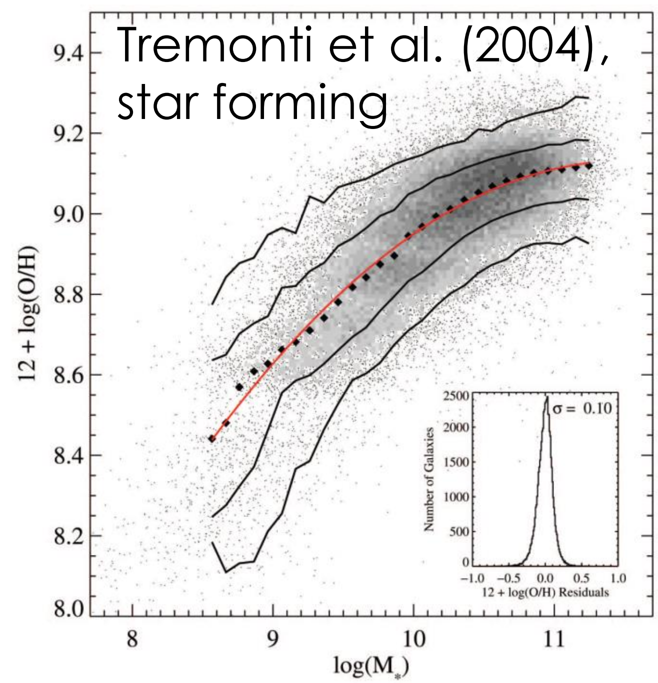


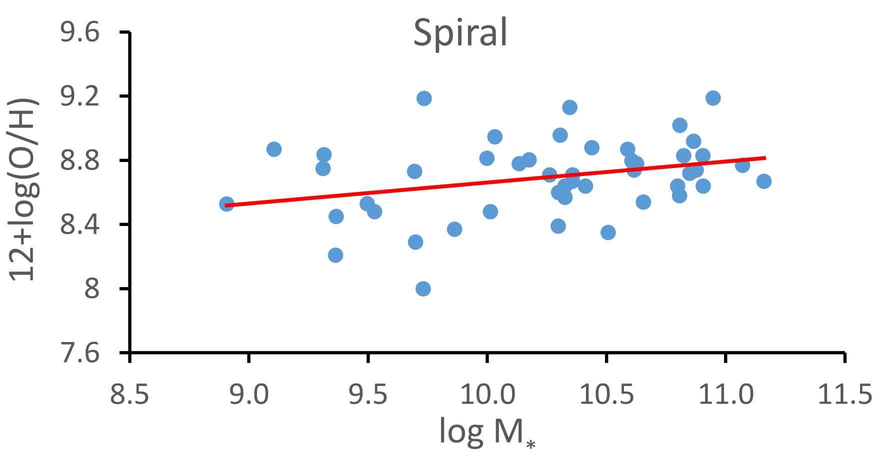
Metallicity

Early type: from *line-strength index* $Mg2$ (catalog Govlev & Prugniel (1998)
Late type: Pilyugin (2014), Denicolo (2002)



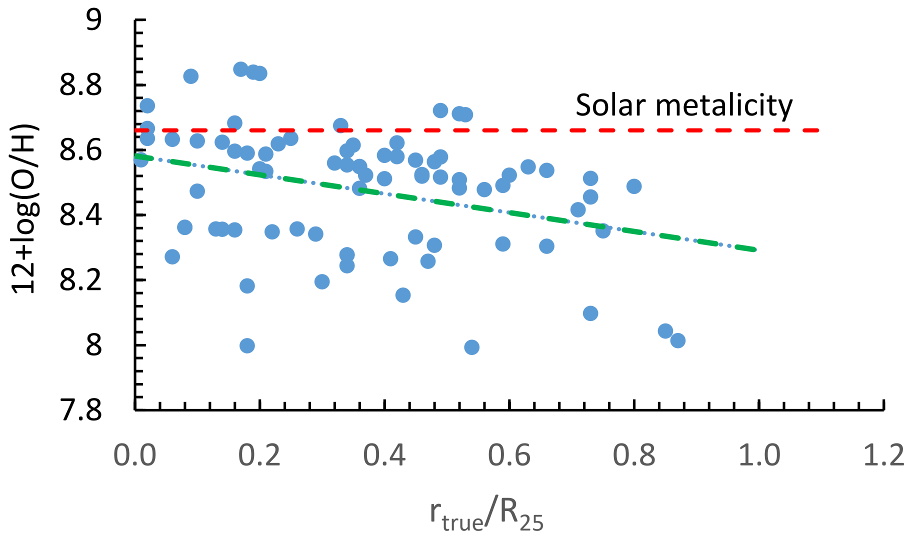






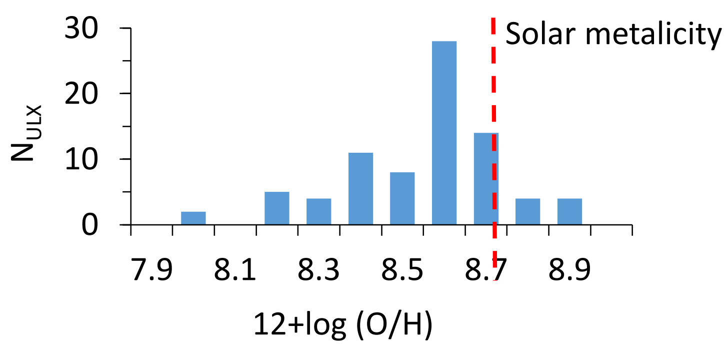
Radial metallicity:

$$12 + \log(O/H) = 12 + \log(O/H)_0 + C_{O/H} \times (R/R_{25})$$

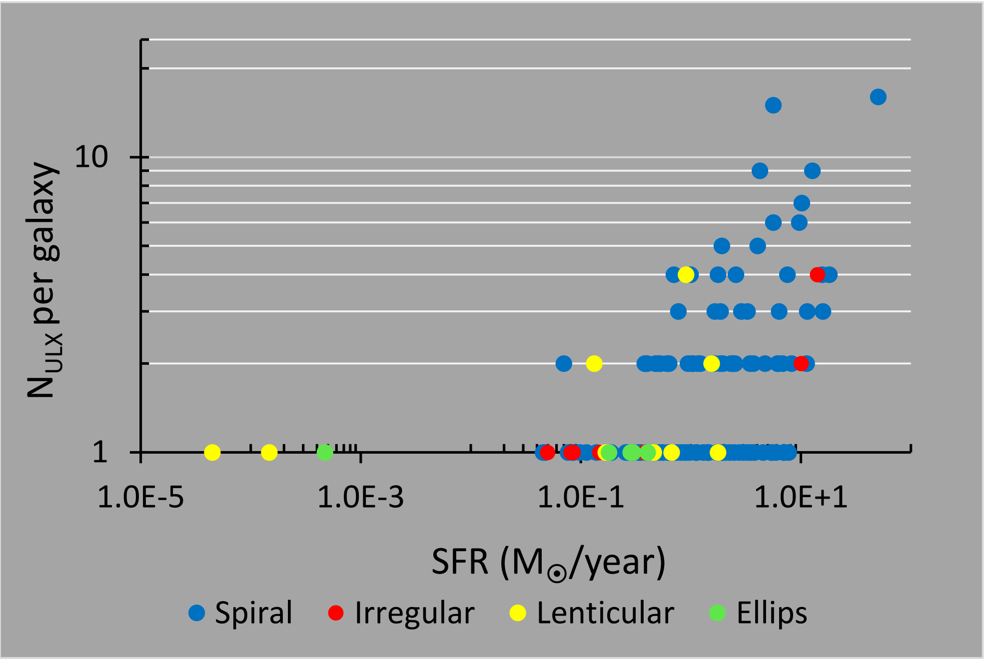


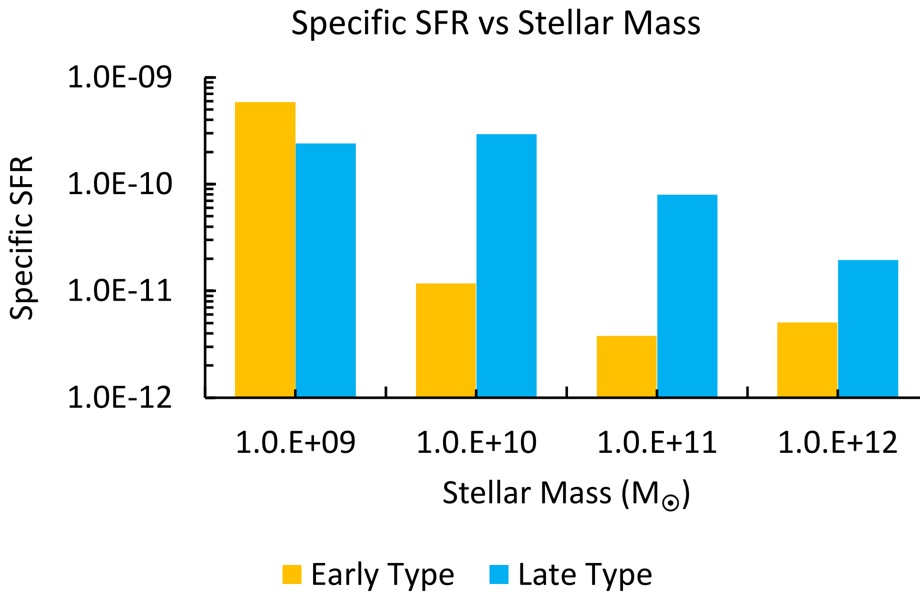
$C_{O/H}$: metalicity gradient (Pilyugin 2014)

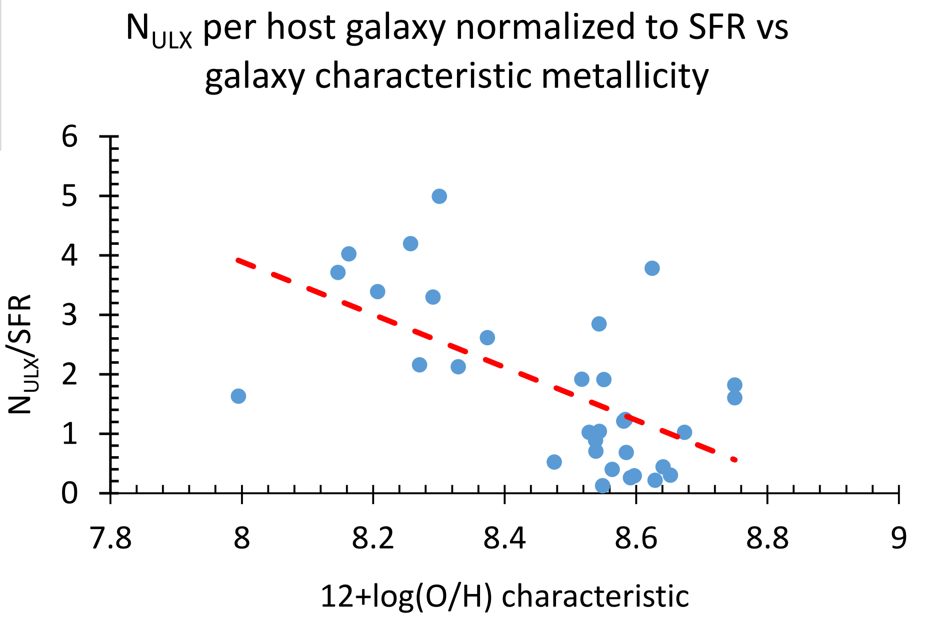
N$_{ULX}$ vs metallicity at the position of ULXs



Star Forming Rate







SFR(Hα) for normal galaxies.
SFR(TIR) for starbursts,
correction for AGN (Mullaney (2011) method)

Conclusion

- Most ULX-host galaxies harbor only one ULX
- ULXs prefer lower mass galaxies
- The friendly environment for the formation of ULXs would be those with low metallicity and high SFR → less massive galaxies
- Star bursts and interactions enhance ULXs formation, but are not necessary conditions for the formation