

REVISITING THE L_X – SFR RELATIONSHIP IN NEARBY GALAXIES

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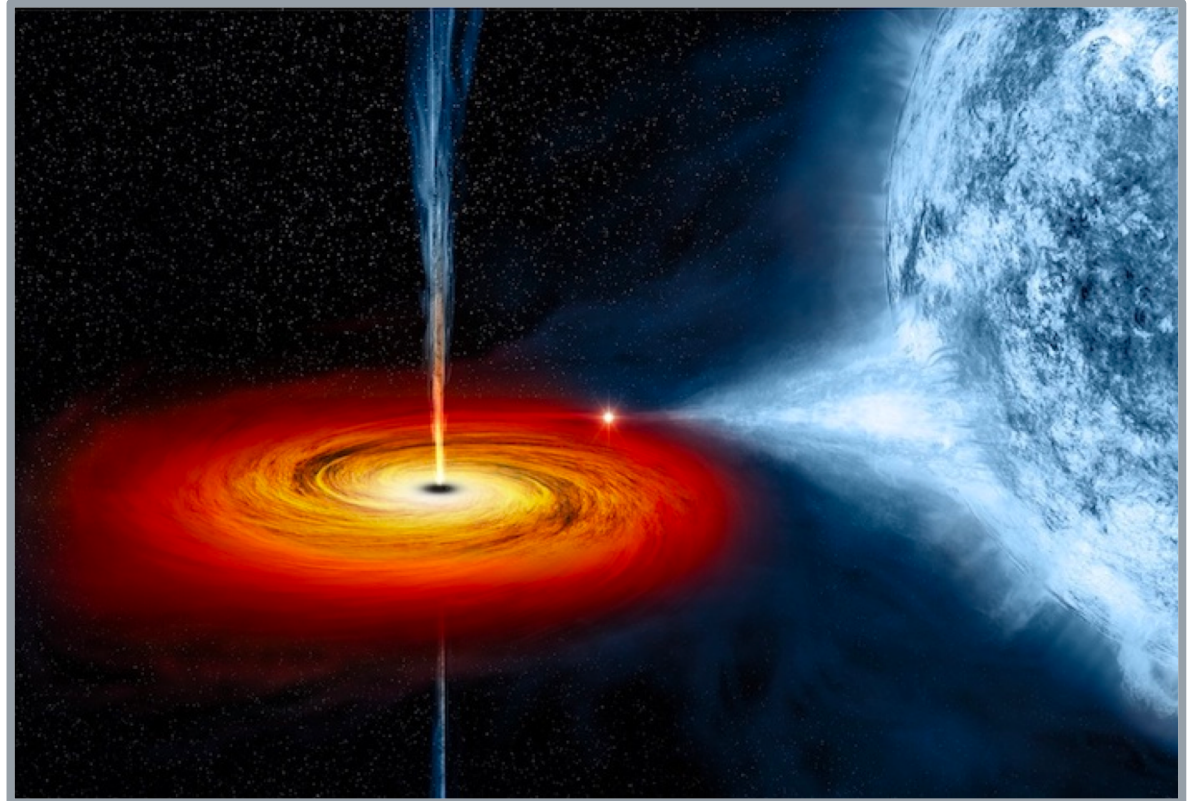
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 @BreXRB



20 Years of *Chandra* Science Symposium
4 December 2019

WHERE THERE IS STAR FORMATION, THERE ARE X-RAY BINARIES

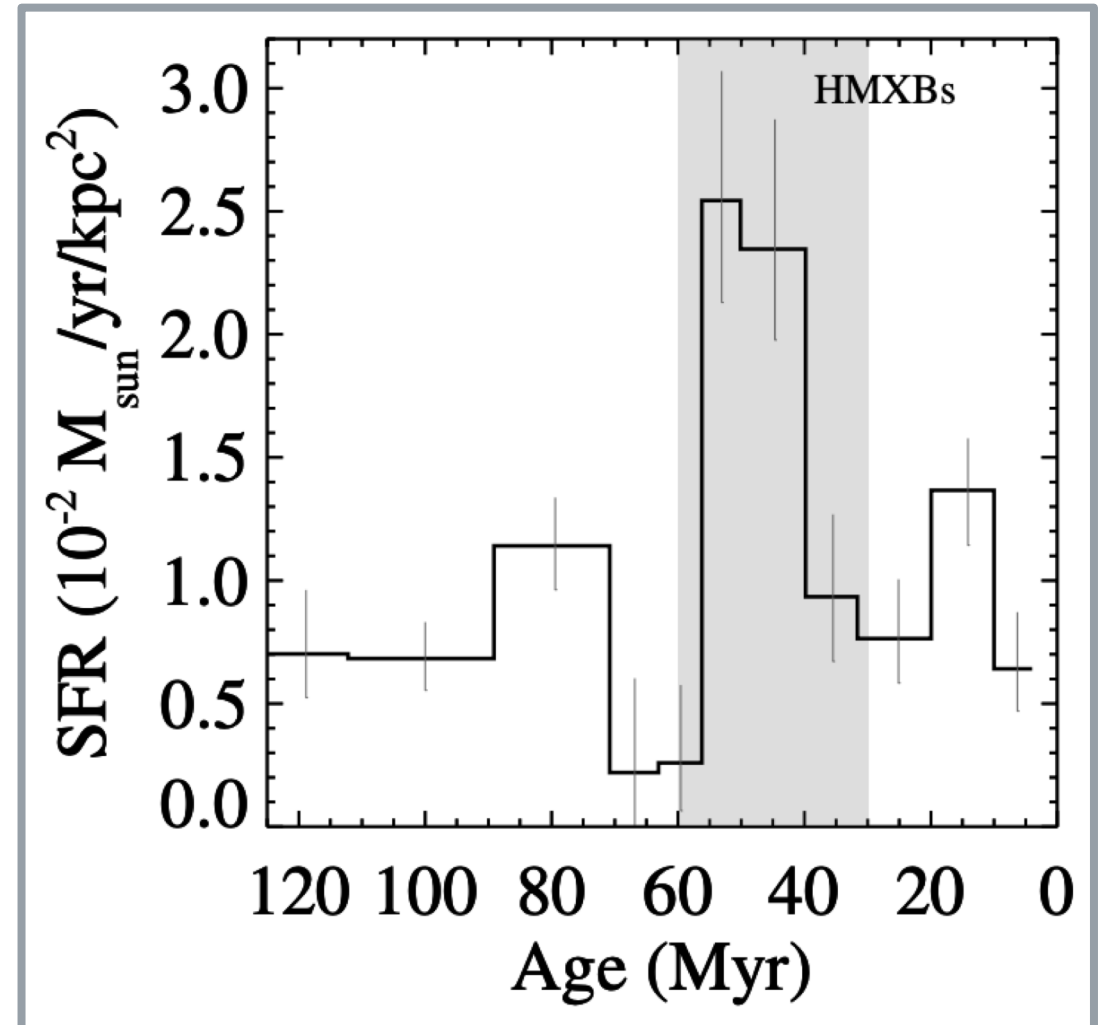


WHERE THERE IS STAR FORMATION, THERE ARE X-RAY BINARIES

HMXBs start forming at after ~ 5 Myr

HMXBs peak at ~ 40 -55 Myr

ULXs ≤ 20 Myr

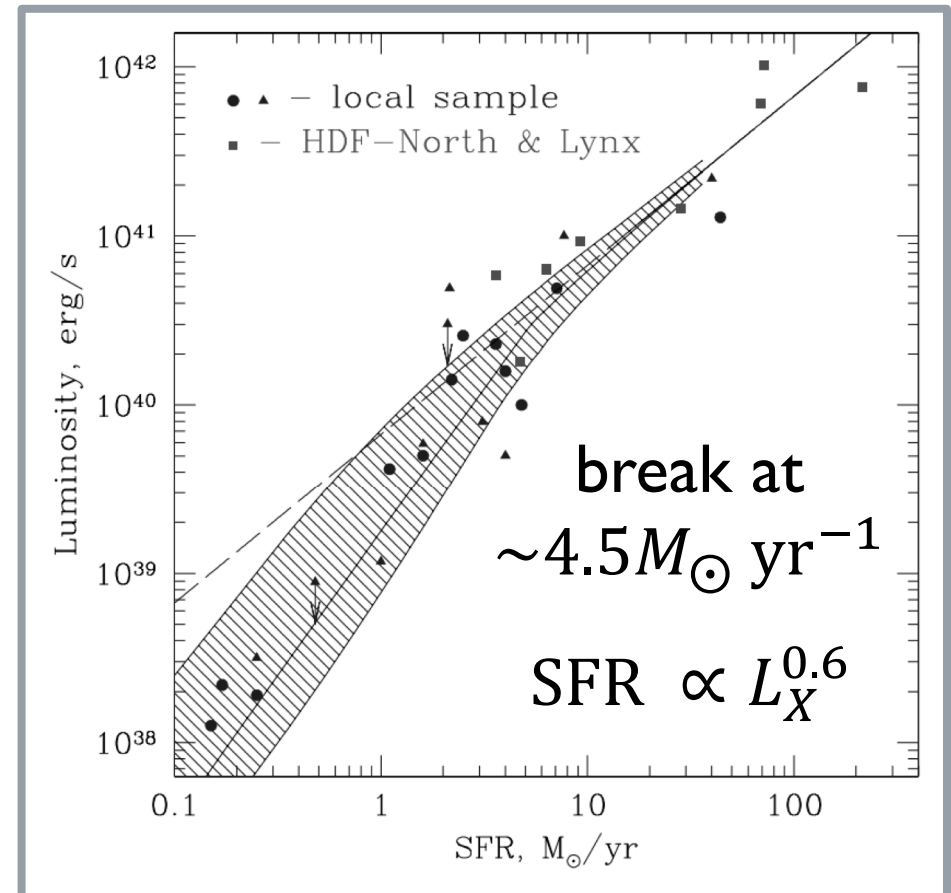
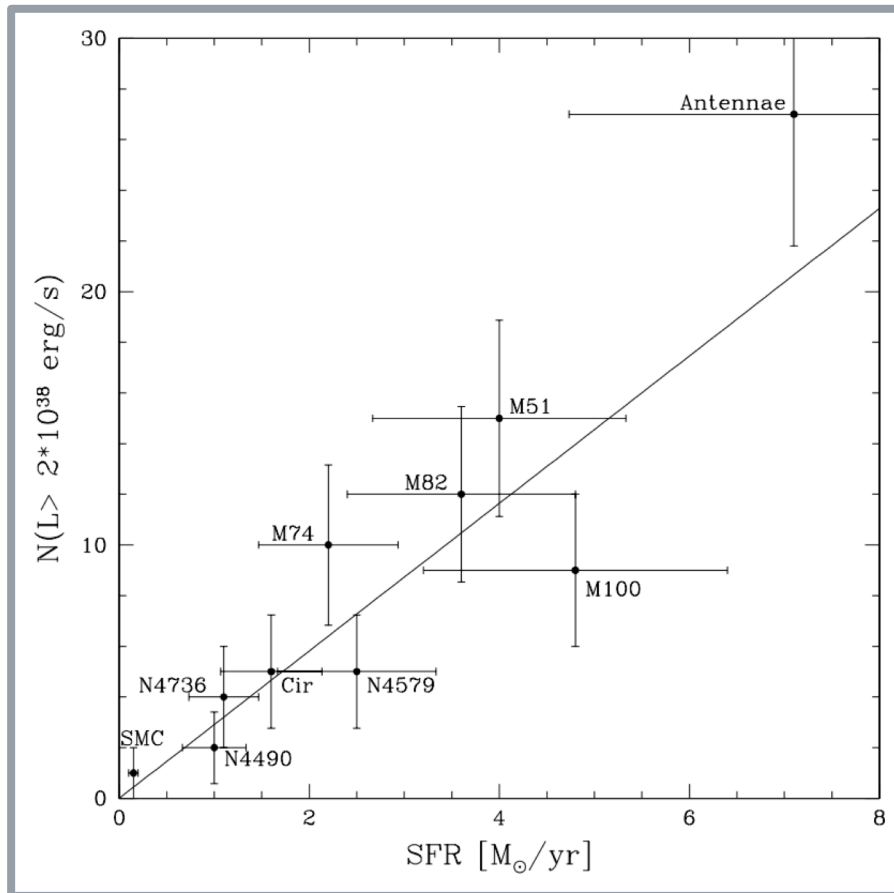


*Linden et al. (2010), Williams et al. (2013), Binder et al. (2016),
Garofali et al. (2018)*

HIGHER SFR = MORE X-RAY BINARIES

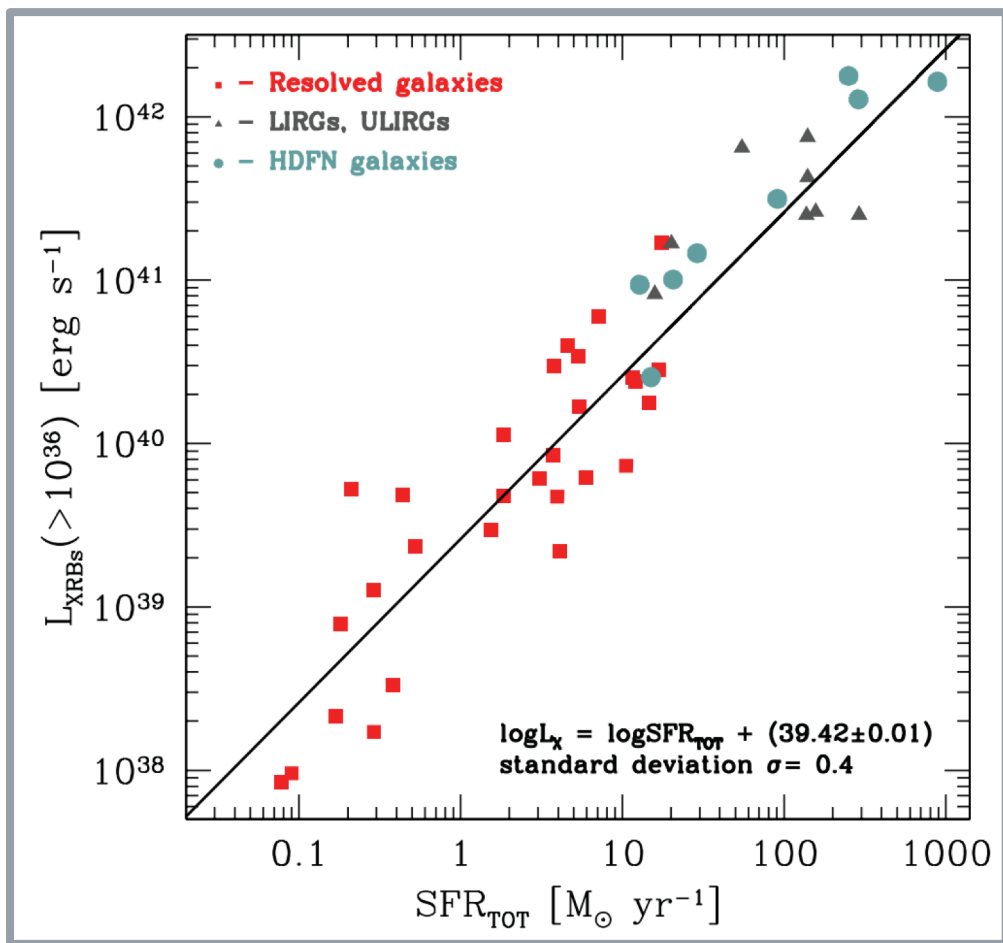
$$N(L > 2 \times 10^{38} \text{ erg s}^{-1}) = 2.9 \text{ SFR } (M_{\odot} \text{ yr}^{-1})$$

$$L = (6.7 \times 10^{39}) \text{ SFR } (M_{\odot} \text{ yr}^{-1}) \text{ erg s}^{-1}$$

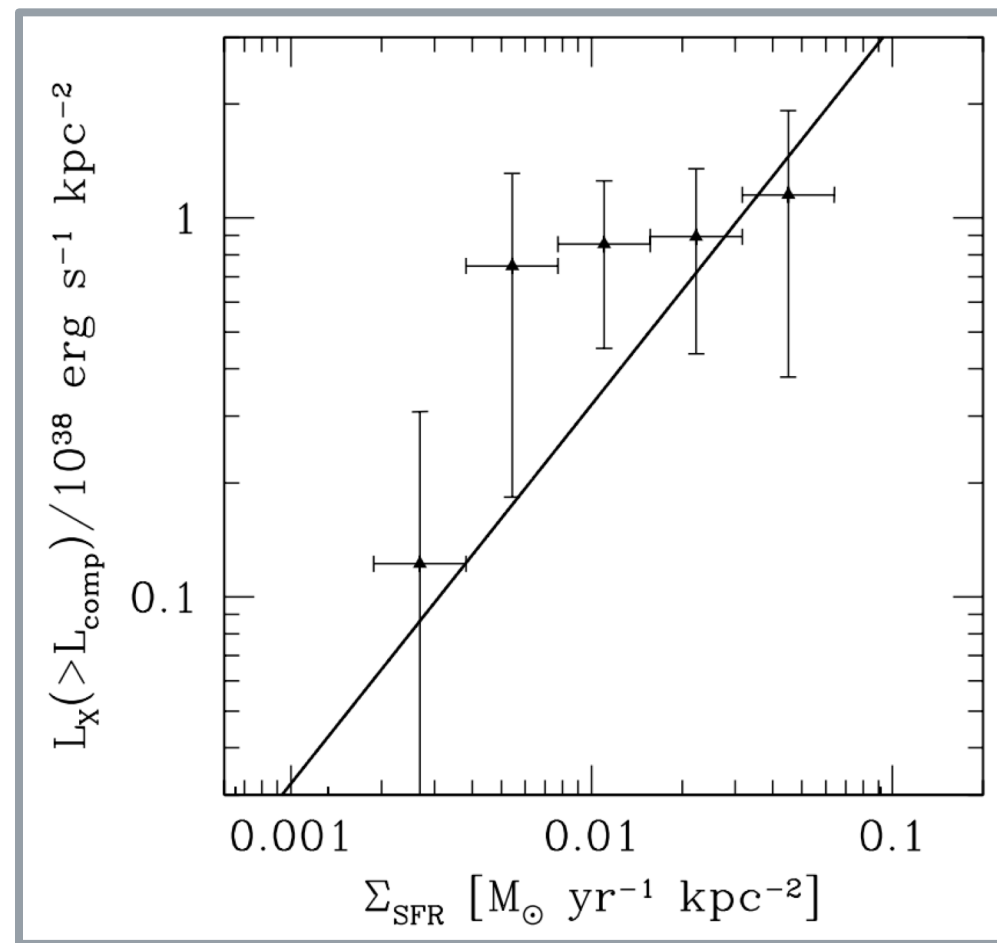


LX-SFR ACROSS DISTANCE SCALES

high-z galaxies



Mineo, Gilfanov & Sunyaev (2012)



local, sub-kpc scales

Mineo et al. (2013)

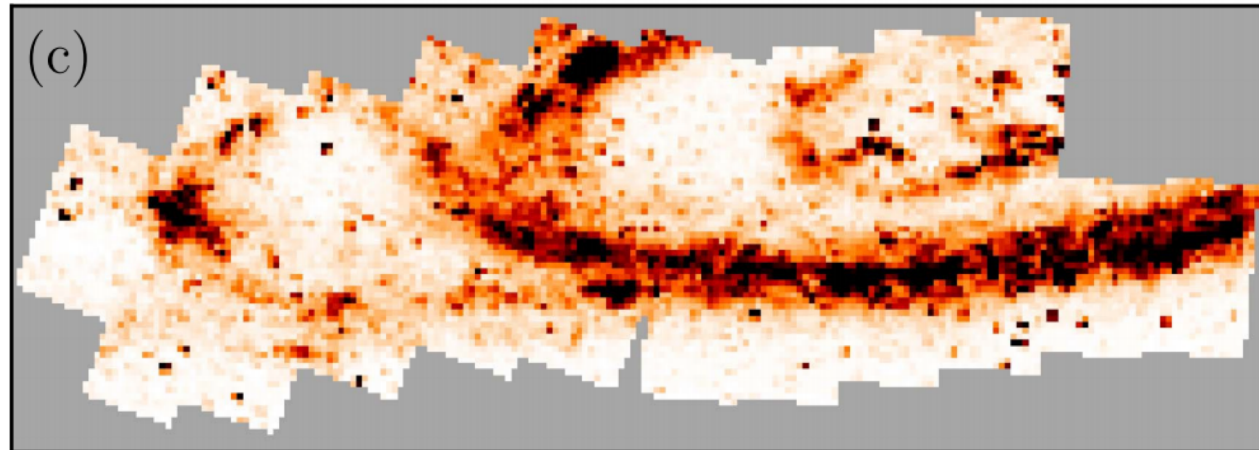
SO, WHAT'S THE PROBLEM?

SFR is typically estimated using FUV + 24 μm tracers

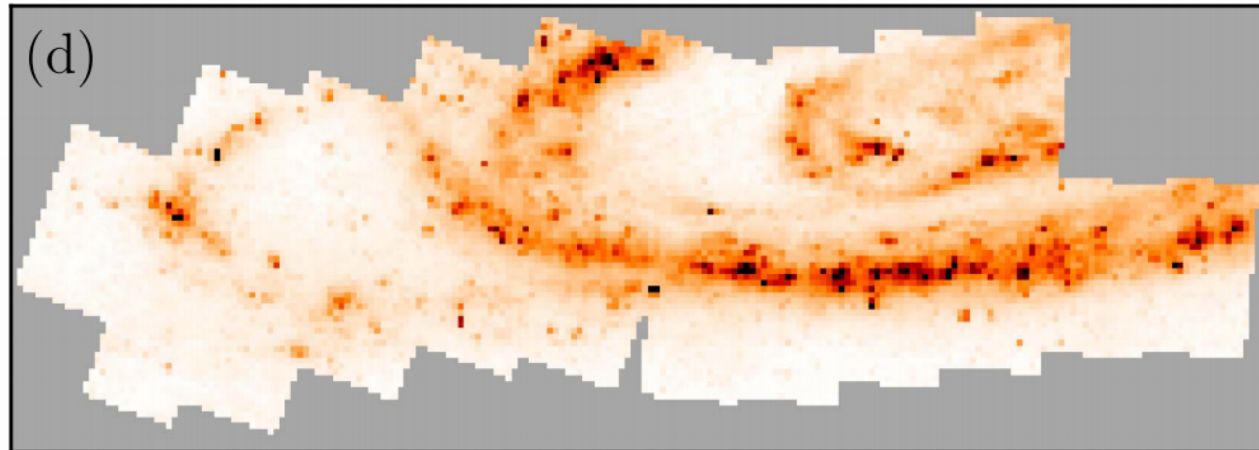
On sub-kpc scales, FUV + 24 μm does not agree with resolved stellar populations

factor of ~5-8x higher

Lewis et al. (2017)



predicted, unreddened



observed

SFR TRACERS & TIMESCALES

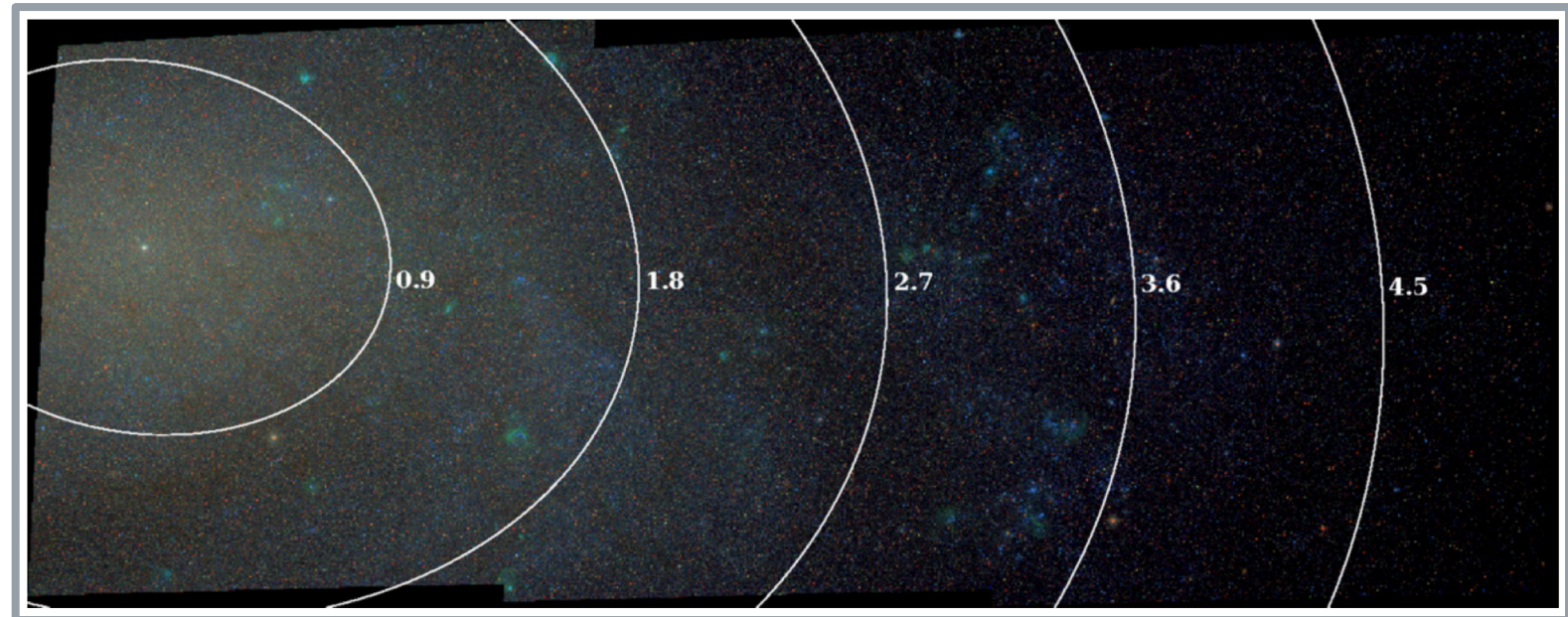
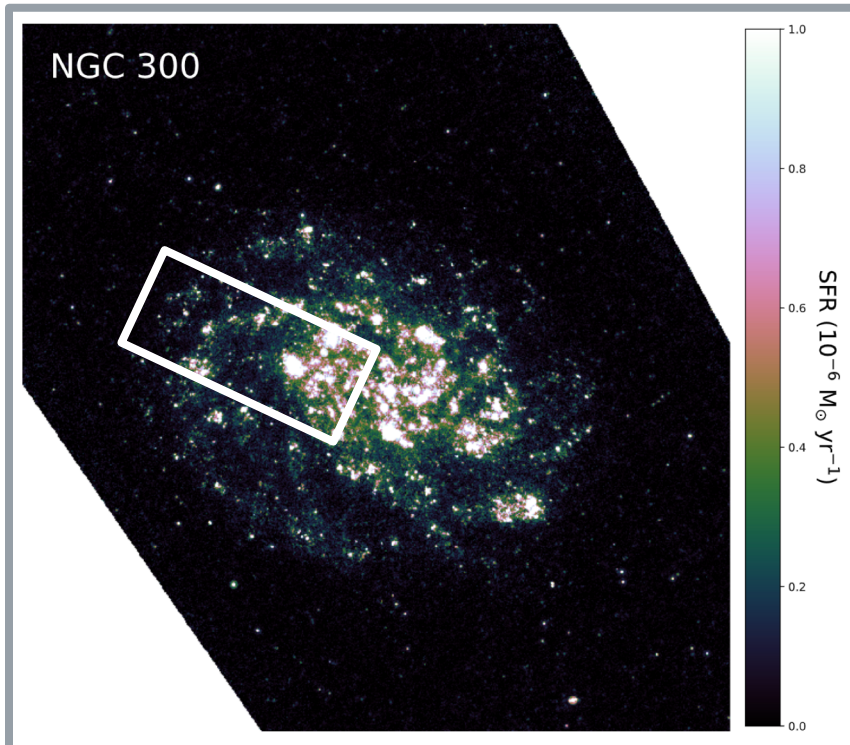
NUV < 300 Myr
FUV < 100 Myr
24 μm < 3 Myr

← HMXBs + LMXBs

← HMXBs

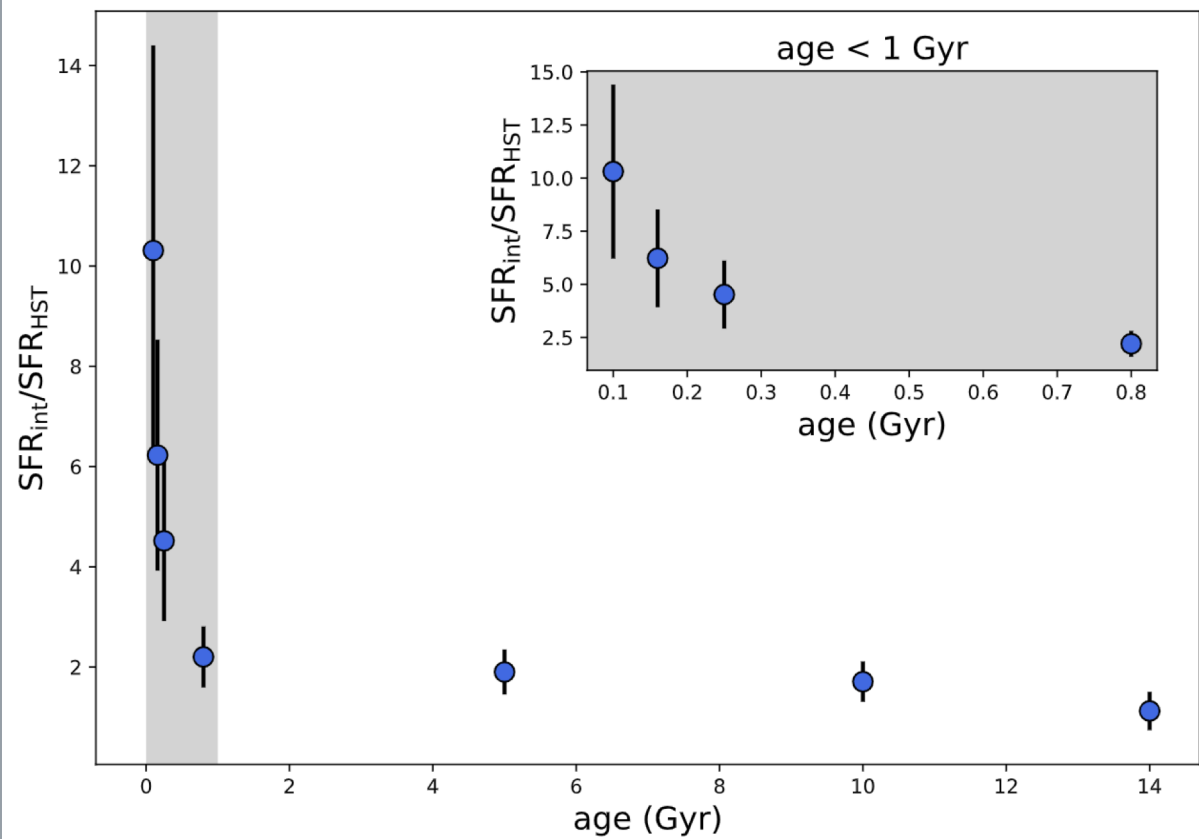
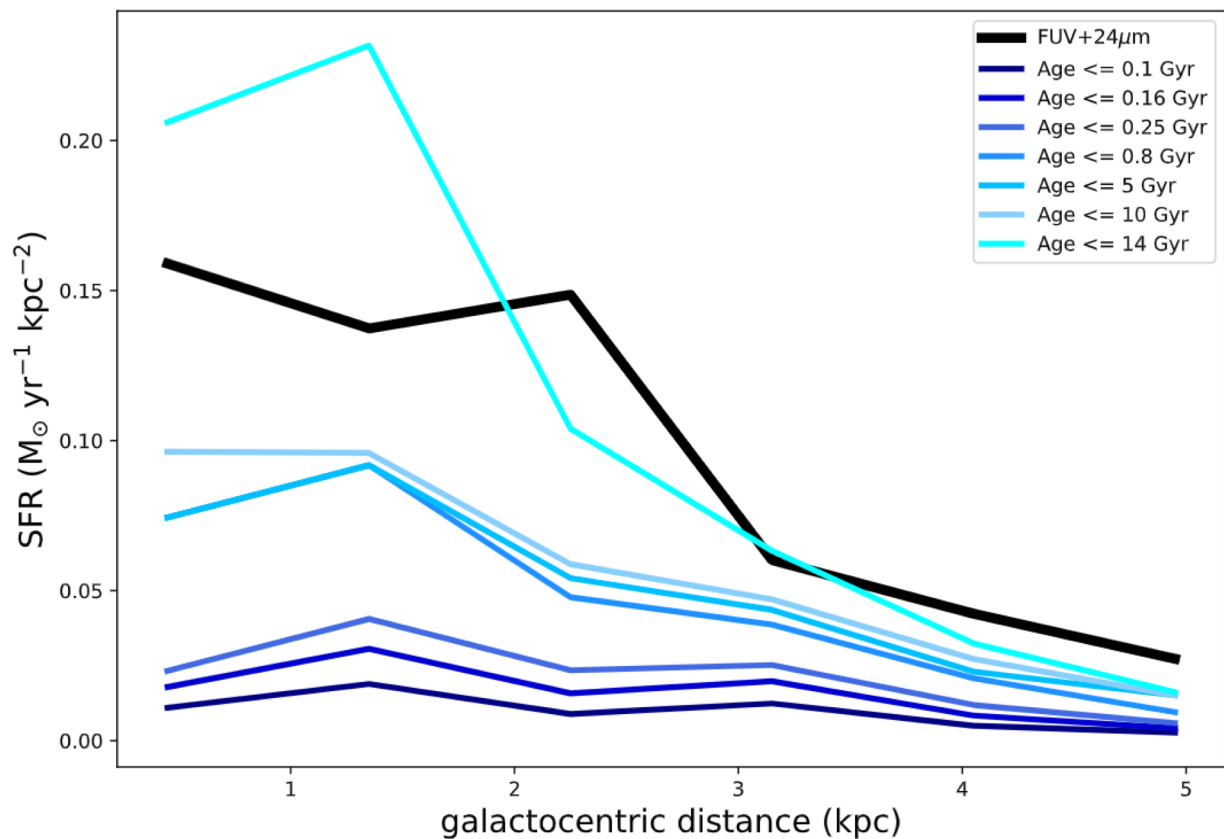
← none (*dust matters! a lot!*)

Do we see the same FUV+ 24 μm vs. Hubble SFH discrepancy in other galaxies?

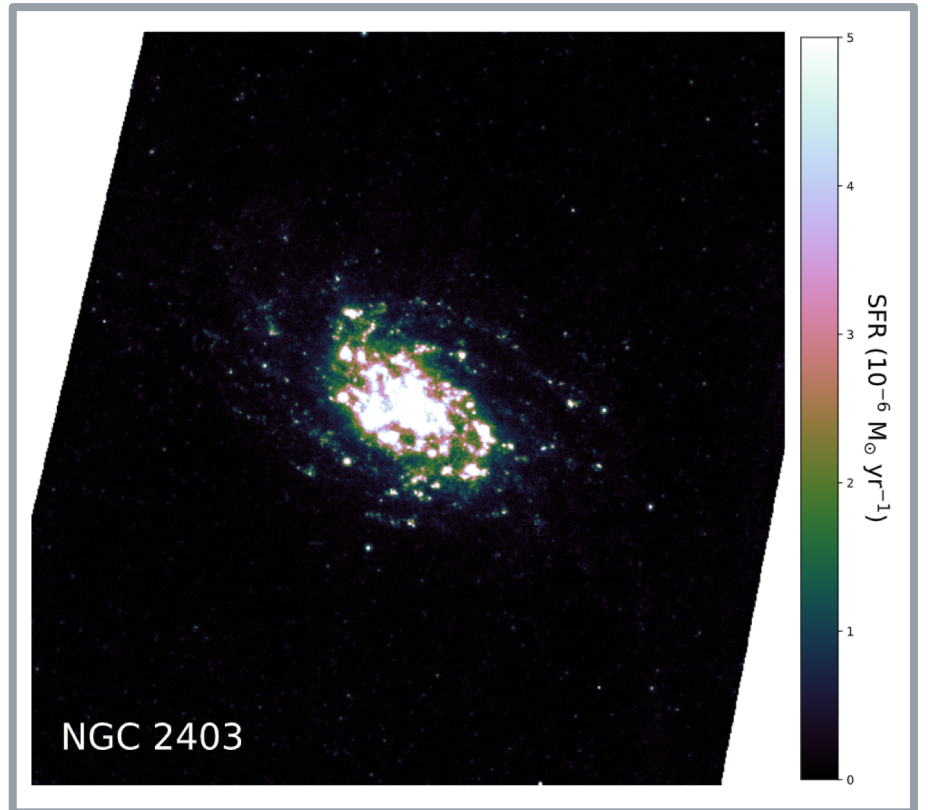
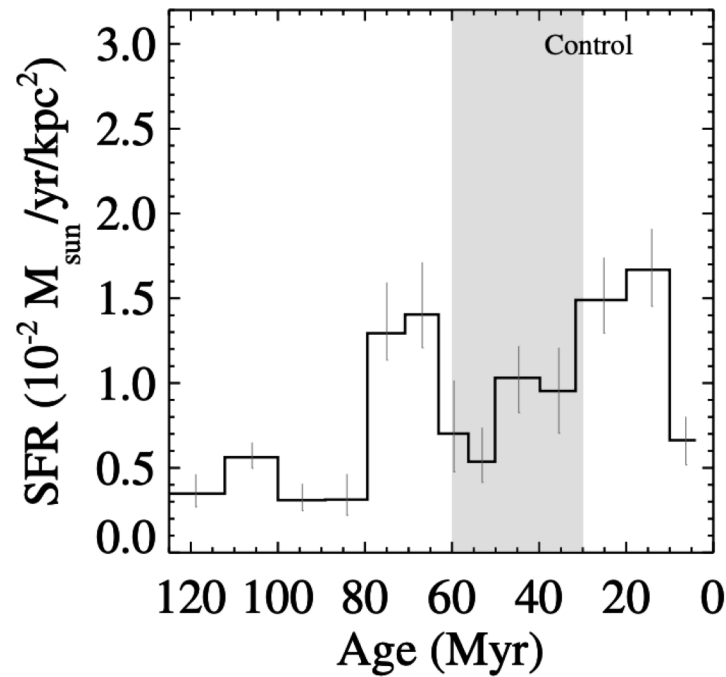
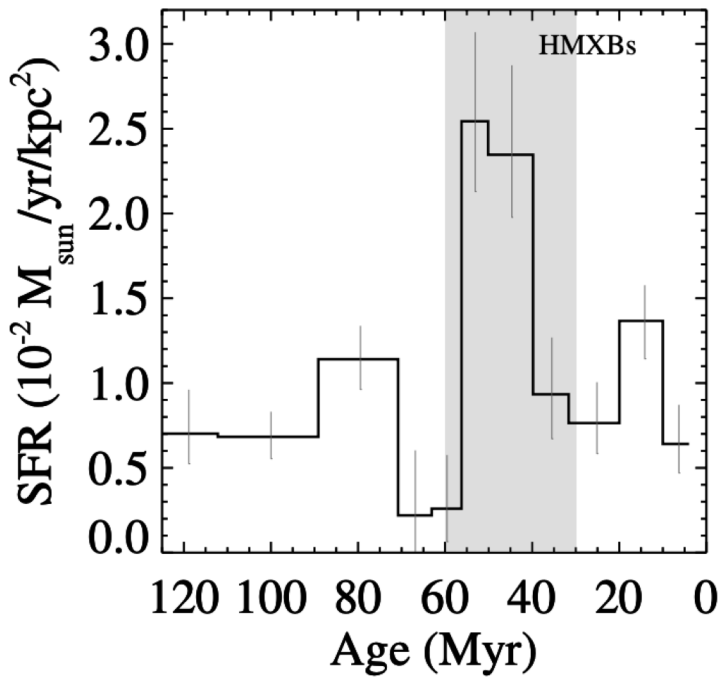


NGC 300

SFR TRACERS & TIMESCALES



SFR ON SUB-KILOPARSEC SCALES



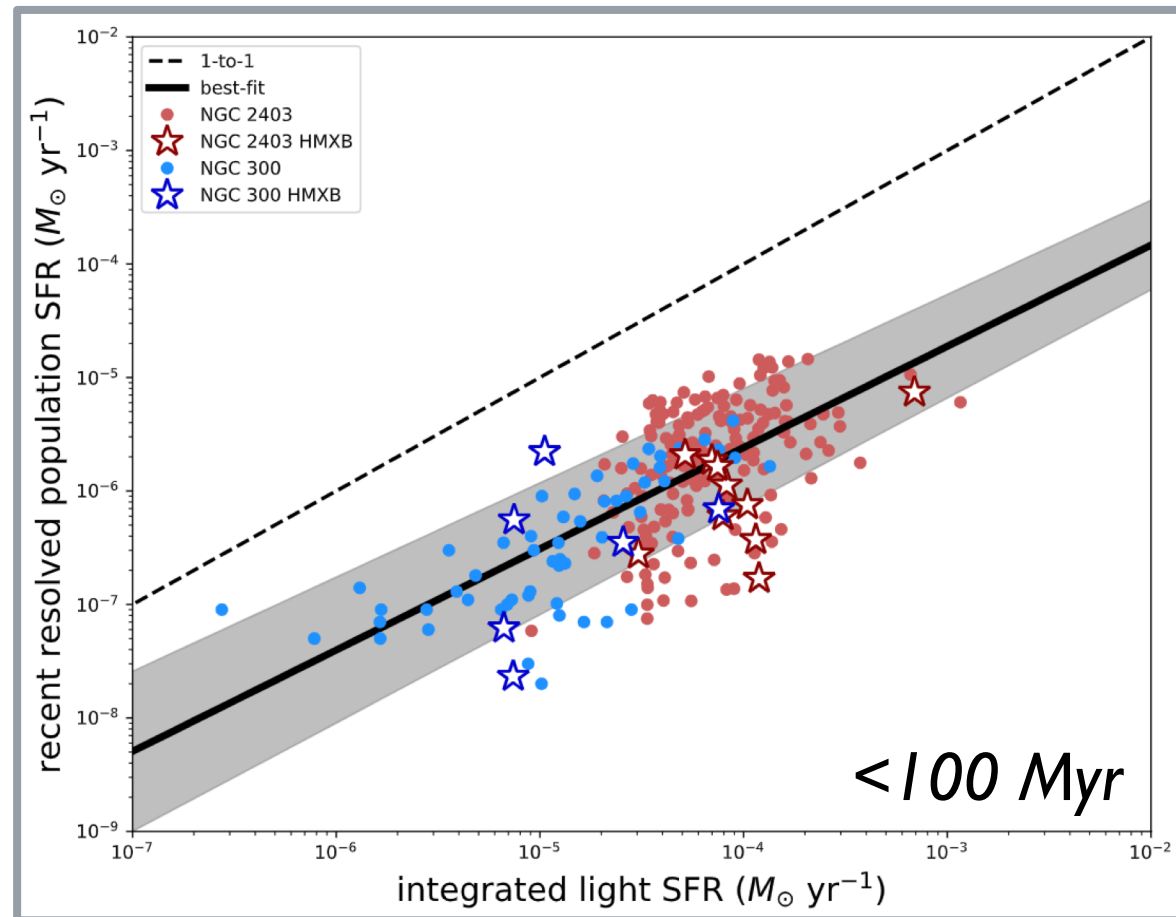
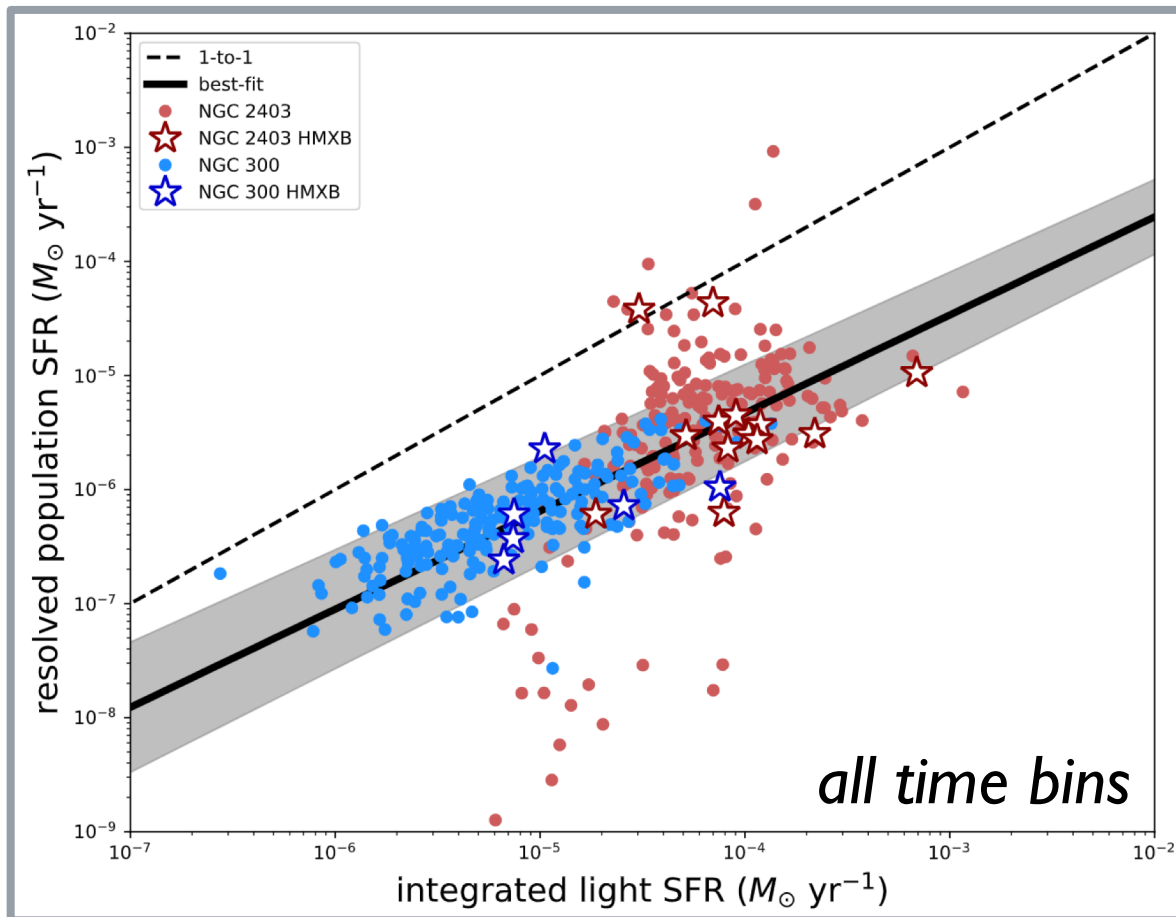
Williams et al. (2013)

Can we calibrate one SFR tracer to the other?
How does this affect the L_X -SFR relationship on sub-kpc scales?

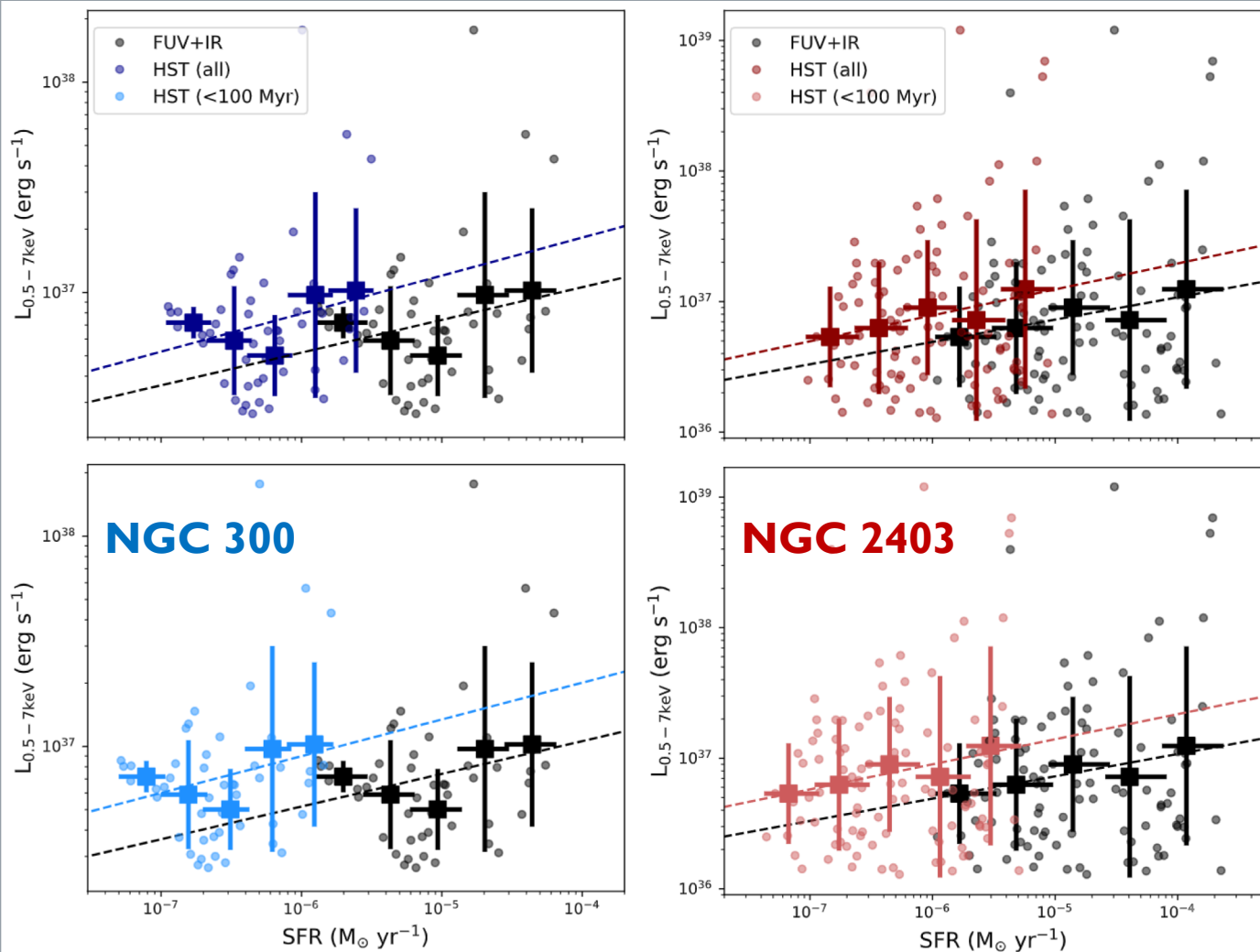
HUBBLE VS. INTEGRATED LIGHT SFR CALIBRATION

$$\log \text{SFR}_{\text{HST}}^{\text{all}} = 0.86 \log \text{SFR}_{\text{int}} - 1.89$$

$$\log \text{SFR}_{\text{HST}}^{100} = 0.89 \log \text{SFR}_{\text{int}} - 2.05$$



THE L_X -SFR RELATIONSHIP



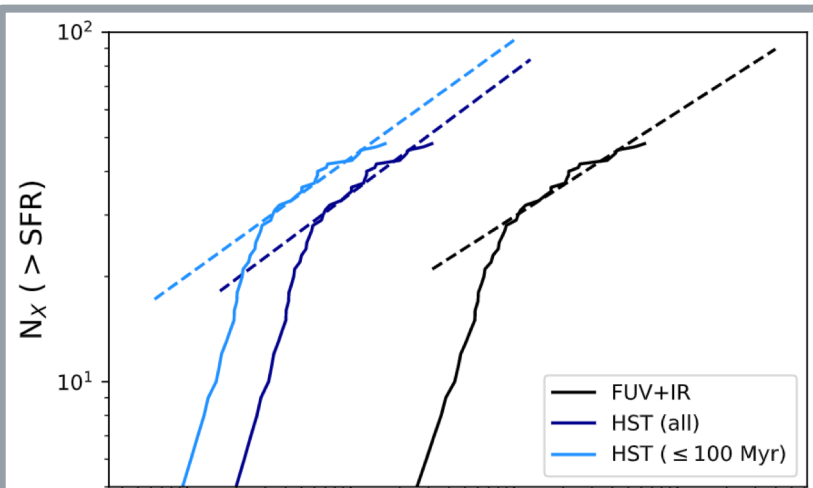
Thanks, Chandra Source Catalog v2.0!

$$\log L_X (\text{erg s}^{-1}) = m \log \text{SFR} + b$$

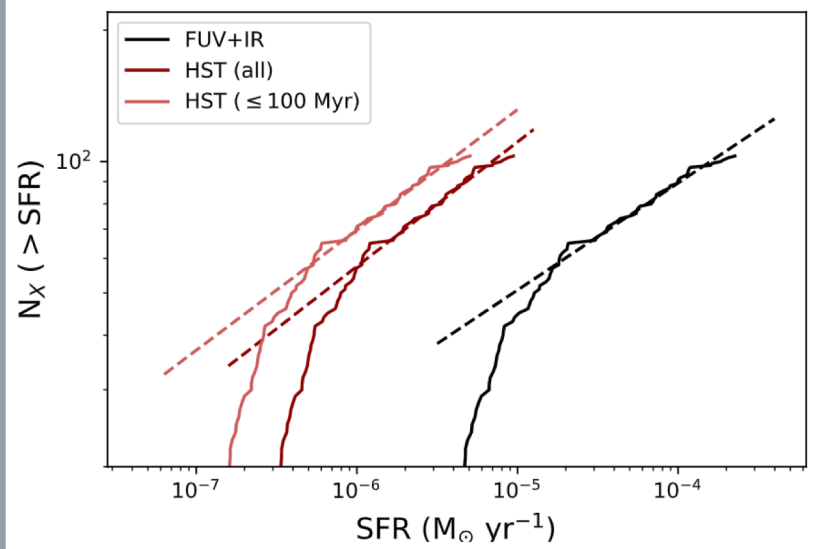
Indicator	m	b
FUV+IR	0.16 ± 0.11	37.65 ± 0.58
	0.17 ± 0.05	37.72 ± 0.26
HST (full SFH)	0.18 ± 0.13	37.98 ± 0.83
	0.20 ± 0.06	38.09 ± 0.38
HST (≤ 100 Myr)	0.17 ± 0.13	38.00 ± 0.84
	0.19 ± 0.06	38.11 ± 0.39

THE N_X -SFR RELATIONSHIP

NGC 300



NGC 2403



$$\log N_X (\text{erg s}^{-1}) = m \log \text{SFR} + b$$

Indicator	m	b
FUV+IR	0.30 ± 0.02	2.97 ± 0.07
	0.25 ± 0.01	2.93 ± 0.02
HST (full SFH)	0.35 ± 0.02	3.63 ± 0.10
	0.29 ± 0.01	3.47 ± 0.03
HST (≤ 100 Myr)	0.34 ± 0.02	3.66 ± 0.10
	0.28 ± 0.01	3.50 ± 0.03

MAIN TAKE-AWAYS... SO FAR

Using HST star formation rates yields **~4x more X-ray binaries** (by number) and **~2x higher X-ray luminosities** at a given SFR compared to FUV+IR

Sub-linear slopes: low-SFR environments are less efficient at forming HMXBs...
but they still form HMXBs

They are forming more HMXBs than expected based on FUV+IR tracers

FUTURE WORK

- More galaxies! Determine sub-kpc SFR calibrations, L_X -SFR and N_X -SFR relationships for ~ 20 additional galaxies < 4 Mpc
- Global L_X -SFR and N_X -SFR relationships in low-SFR galaxies (& down to much lower L_X levels – thanks *Chandra!*)
- K-band magnitudes to get stellar mass & correct for LMXB contribution

