Bars rejuvenating bulges?
Evidence from stellar population analysis

Coelho & Gadotti
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Do bars impact the evolution of bulges?

NGC1365

- Bars: bring disk gas from within the bar ends to the central parts of the disk, supposedly helping building bulges through star formation episodes

- Evidence of current star-forming activity in the center of barred galaxies from H II regions (e.g. Ho et al. 1997)


M81

Credit: APOD

What about direct evidence of bars building bulges, i.e.

is there any difference between *ages of the stars in bulges* in barred and unbarred galaxies?

Expected from models, but observationally elusive.

Bulges and bars

- We obtained mean stellar ages and metallicities via spectrum fitting for a sample of 575 bulges with spectra available from the SDSS.

- Structural properties from Gadotti (2009)

- 251 barred and 324 unbarred galaxies, 187 type II AGNs

- Galaxies with stellar masses $\geq 10^{10} M_{sun}$, $0.02 \leq z \leq 0.07$, all face-on


0270−51909−095
$\bar{\Delta} = 2.6\%$
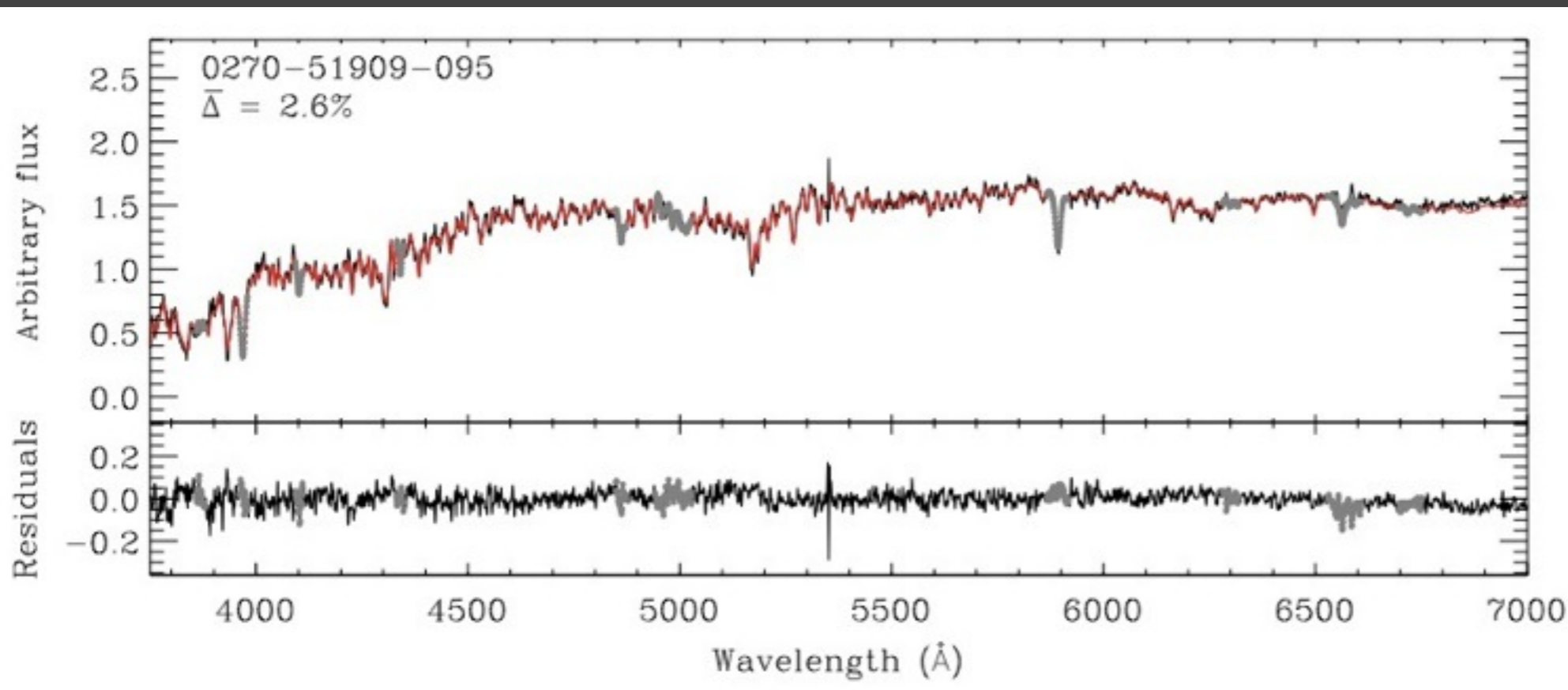
A STARLIGHT fit
(Cid Fernandes et al. '05, models from Vazdekis et al. '10)

Observed spectrum in black and model in red Residuals are shown in the bottom panel.

Normalized distribution of ages and metallicities

- Non-active barred galaxies have larger fraction of younger populations in the bulge.

- KS significance of 99.94%,

- Galaxy mass distributions are the same.
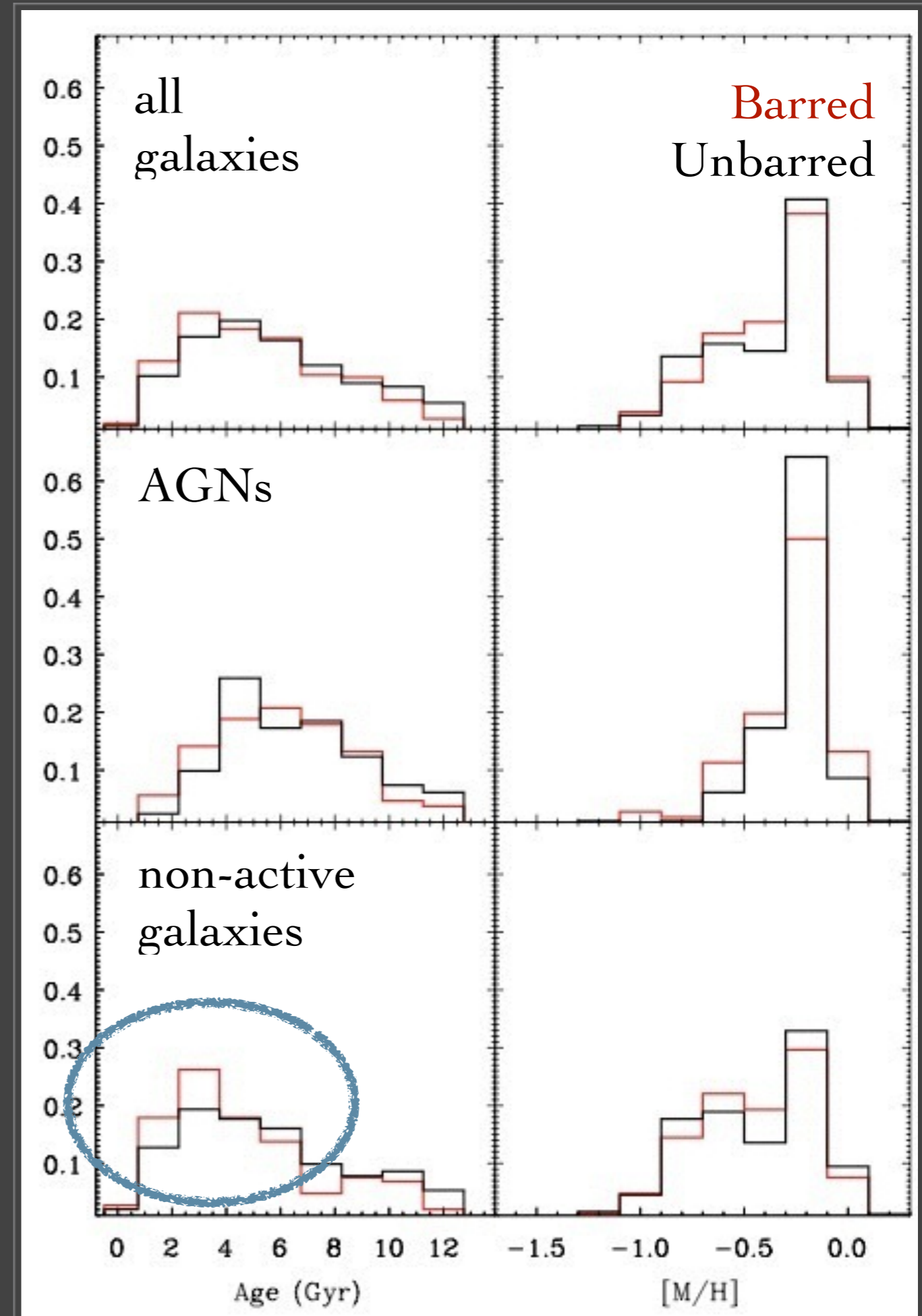
✓ **Galaxy mass distributions** are **similar** in the previous sample, but **bulge mass** distributions **are not**.

✓ Comparing **similar bulge mass** distributions:

   ✓ **lower-mass** interval: $8.30 \leq \log M_{bulge} < 10.10$

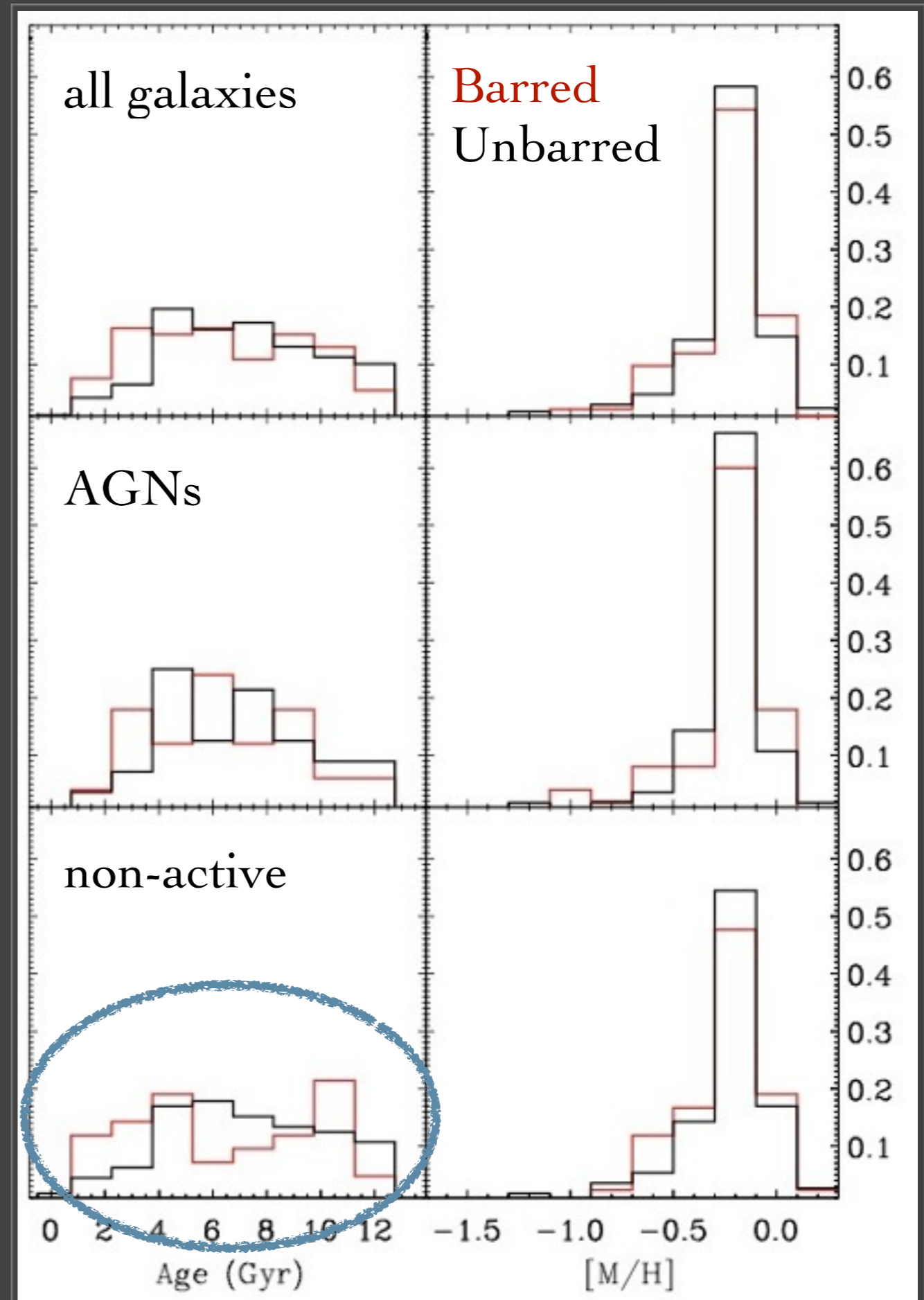   ✓ **higher-mass** interval: $10.10 \leq \log M_{bulge} < 10.85$
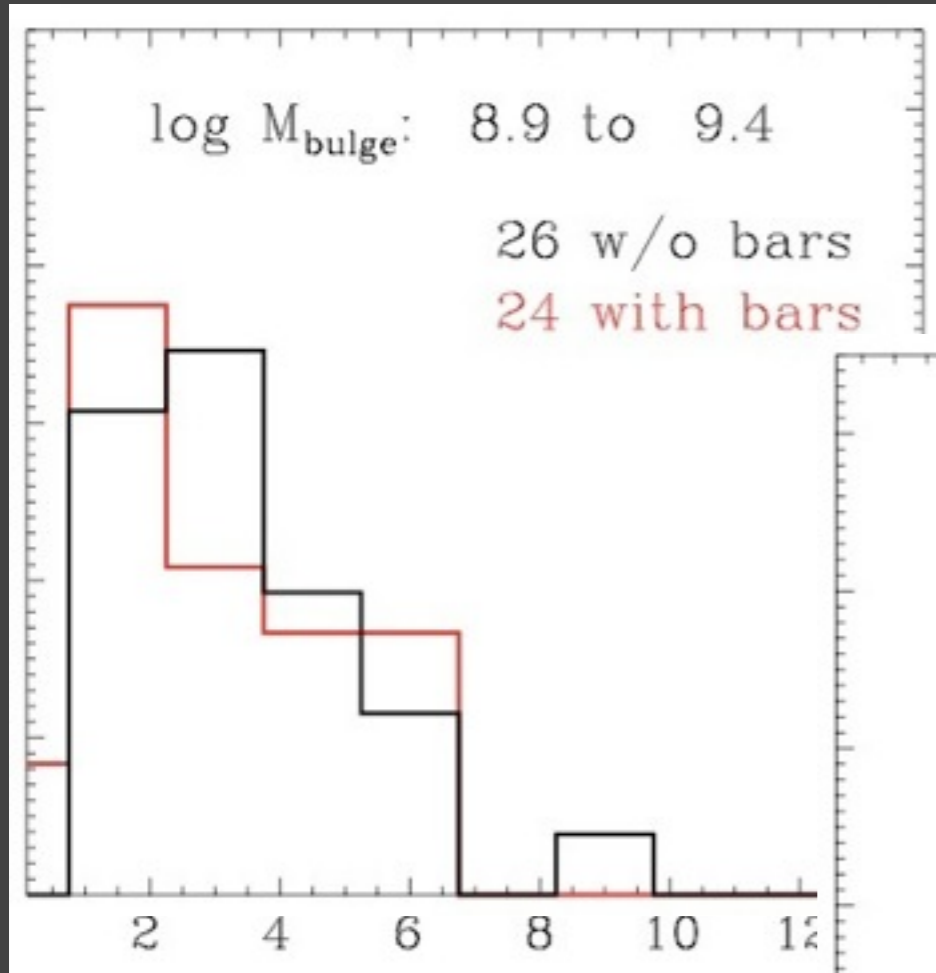
Lower-mass interval

- $8.30 \leq \log M_b < 10.10$

- Difference between **age** distributions **disappears**

- **AGNs** are more **metal-rich**

- **AGNs** are **twice more common** in **barred galaxies** (35%) than in unbarred galaxies (16%)
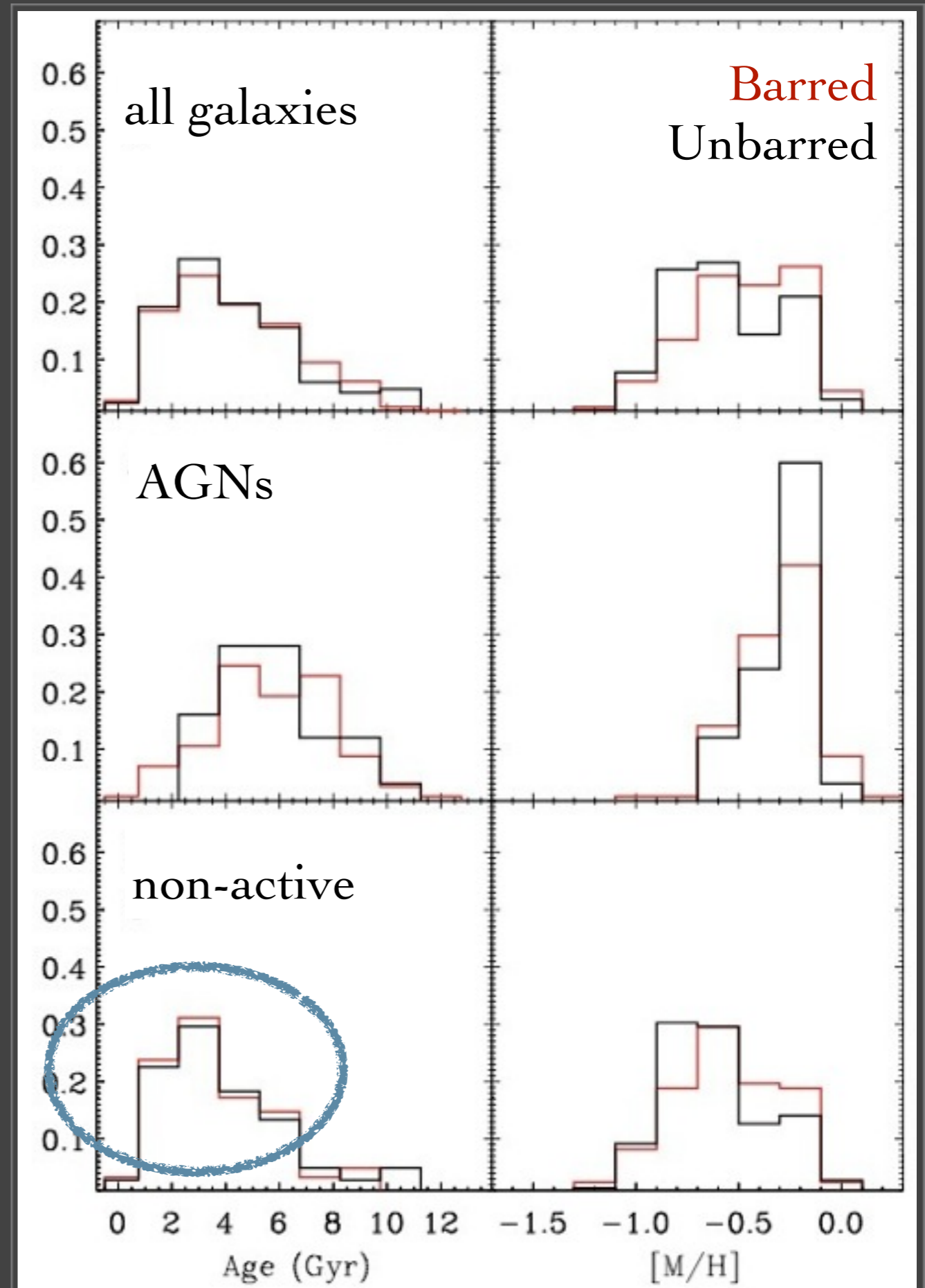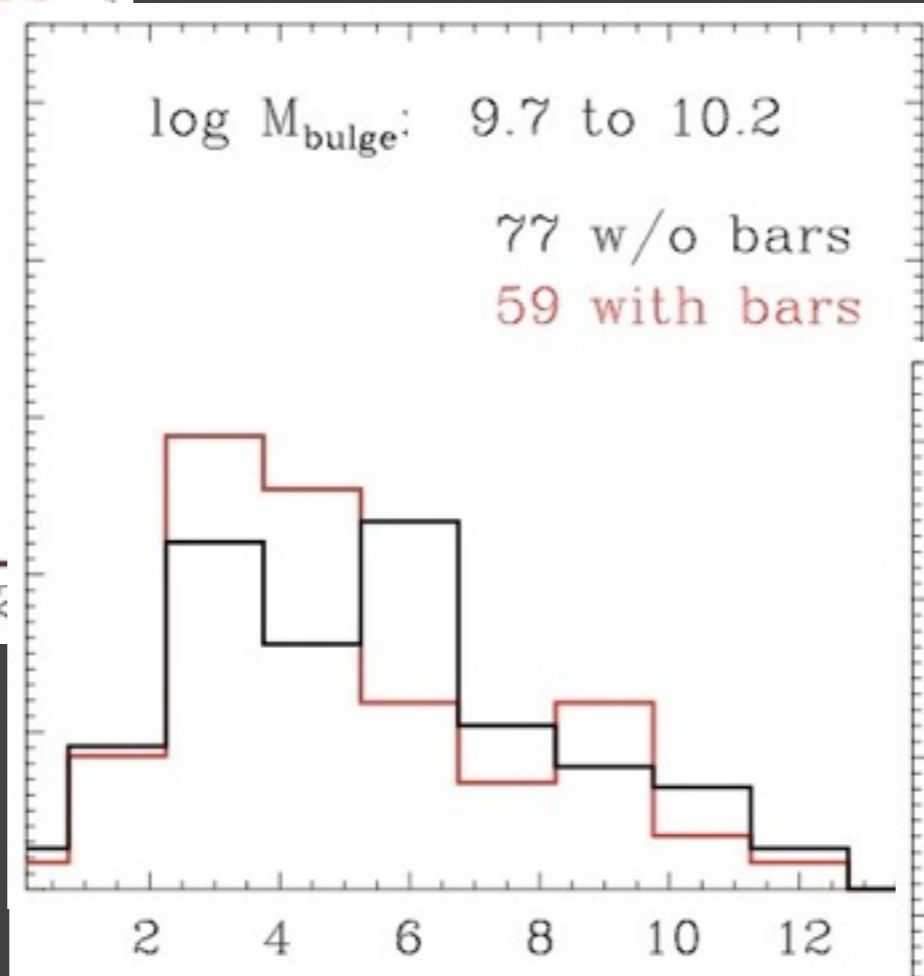
Higher-mass regime

- $10.10 \leq \log M_b < 10.85$

- **Bimodal** age distribution, only in **non-active** galaxies

- Two normal distributions with **mean ages of 4.7 and 10.4 Gyr** (KMM test, confidence level above 4σ).

- AGNs fractions in barred galaxies larger (55%) than in unbarred galaxies (34%)
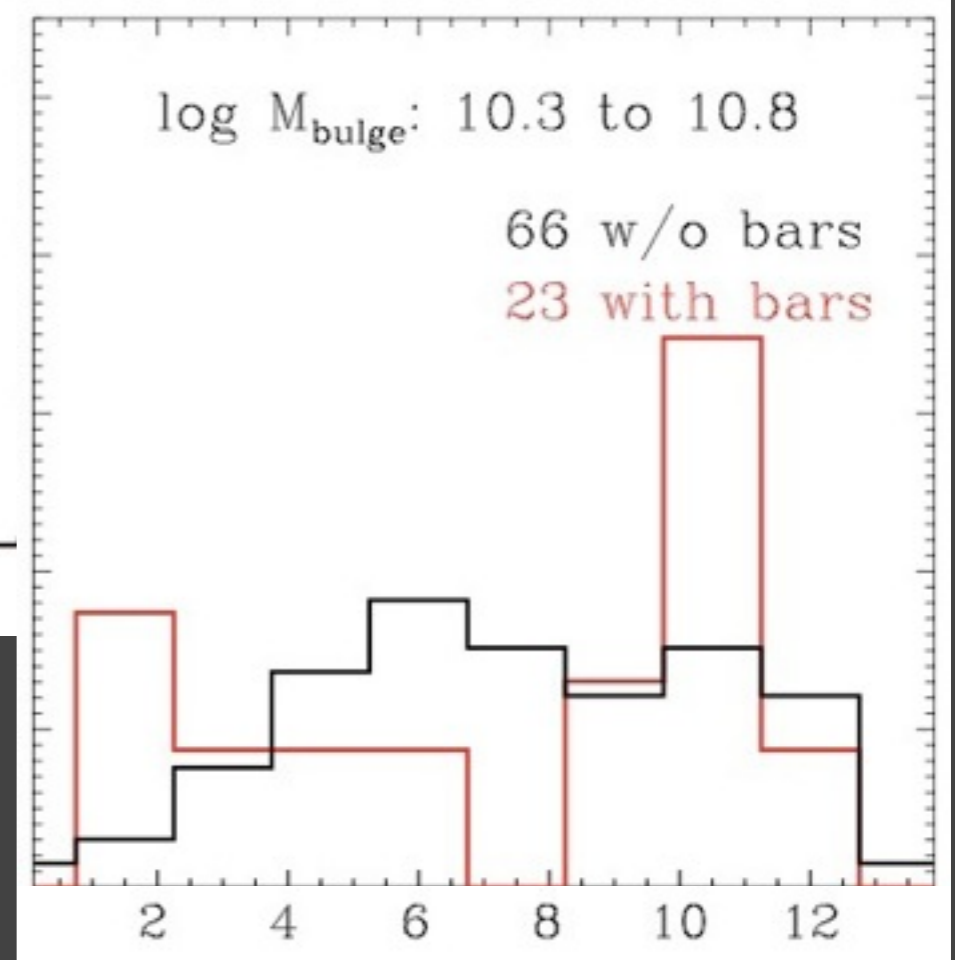
log M$_{bulge}$: 8.9 to 9.4

26 w/o bars
24 with bars

Age (Gyr)

log M$_{bulge}$: 9.7 to 10.2

77 w/o bars
59 with bars

Age (Gyr)

log M$_{bulge}$: 10.3 to 10.8

66 w/o bars
23 with bars

Bulge mass

Bimodal age distribution in
barred galaxies

Characteristic mass:
log M$_{bulge}$ between 9.7 and 10.2

Conclusions

✓ **Barred galaxies show a dichotomy and younger bulge component at 4σ confidence!** This lends support to models in which bars trigger star formation activity in the centers of galaxies.

    ✓ $\log M_{bulge} < 10.1\ M_\odot$: **no difference** in age distribution

    ✓ $\log M_{bulge} > 10.1\ M_\odot$: **bimodal bulge age distribution** (peaks at 4.7 and 10.4Gyr)

✓ AGNs:

    ✓ **no difference** in the age distributions between barred and unbarred galaxies

    ✓ **up to twice as much AGNs are found in barred galaxies** (depending on the mass interval).

Open questions

✓ Why the age distributions between barred and unbarred galaxies are similar

    ✓ in lower-mass non-active bulges?

    ✓ in AGNs? Feedback preventing star formation?

✓ Why bimodal distribution only above a characteristic mass (9.7 < log M_{bulge} < 10.2)? The old peak corresponds to bulges with not enough gas? Classical versus pseudo(disky) bulges?

✓ Then bars are either feeding AGNs or triggering star-formation?