

Turning the radio dial on star formation in dwarf galaxies

A multi-wavelength view of star formation from the 144 MHz sky to the optical spectrum.

Pascal Venedey
Astronomical Institute, Ruhr University Bochum



Dwarf galaxies

Dwarf galaxies

- the most numerous galaxies in the Universe

Dwarf galaxies

- the most numerous galaxies in the Universe

MILKY-WAY-LIKE

STELLAR MASS

$$10^{10} - 10^{12} M_{\odot}$$

TYPICAL SFR

$$1 - 3 M_{\odot}/\text{yr}$$

DWARFS

STELLAR MASS

$$10^5 - 10^9 M_{\odot}$$

TYPICAL SFR

$$10^{-3} - 10^0 M_{\odot}/\text{yr}$$

Dwarf galaxies

- the most numerous galaxies in the Universe

MILKY-WAY-LIKE

STELLAR MASS

$$10^{10} - 10^{12} M_{\odot}$$

TYPICAL SFR

$$1 - 3 M_{\odot}/\text{yr}$$

DWARFS

STELLAR MASS

$$10^5 - 10^9 M_{\odot}$$

TYPICAL SFR

$$10^{-3} - 10^0 M_{\odot}/\text{yr}$$

→ Dwarfs are $\sim 3-5$ orders of magnitude less massive and form stars at comparably lower rates

When a dwarf galaxy *ceases* the star formation,
what happens next? Can the galaxy start again?

Transition-type dwarfs

Transition-type dwarfs

MIXED MORPHOLOGY

- objects between dwarf irregular and dwarf elliptical galaxies

Transition-type dwarfs

MIXED MORPHOLOGY

- objects between dwarf irregular and dwarf elliptical galaxies
- some retain HI but are optically quiescent, others show young stars in regular old bodies

Transition-type dwarfs

MIXED MORPHOLOGY

- objects between dwarf irregular and dwarf elliptical galaxies
- some retain HI but are optically quiescent, others show young stars in regular old bodies

MIXED STAR FORMATION

- some have a high star formation rate, others show no star formation

The sample

The sample

Targets 19 Nearby dwarf galaxies, $D < \sim 170$ Mpc

The sample

Targets 19 Nearby dwarf galaxies, $D < \sim 170$ Mpc

Selection $-19 < M_B < -14.5$

The sample

Targets 19 Nearby dwarf galaxies, $D < \sim 170$ Mpc

Selection $-19 < M_B < -14.5$

Optical SDSS and DESI spectra

The sample

Targets 19 Nearby dwarf galaxies, $D < \sim 170$ Mpc

Selection $-19 < M_B < -14.5$

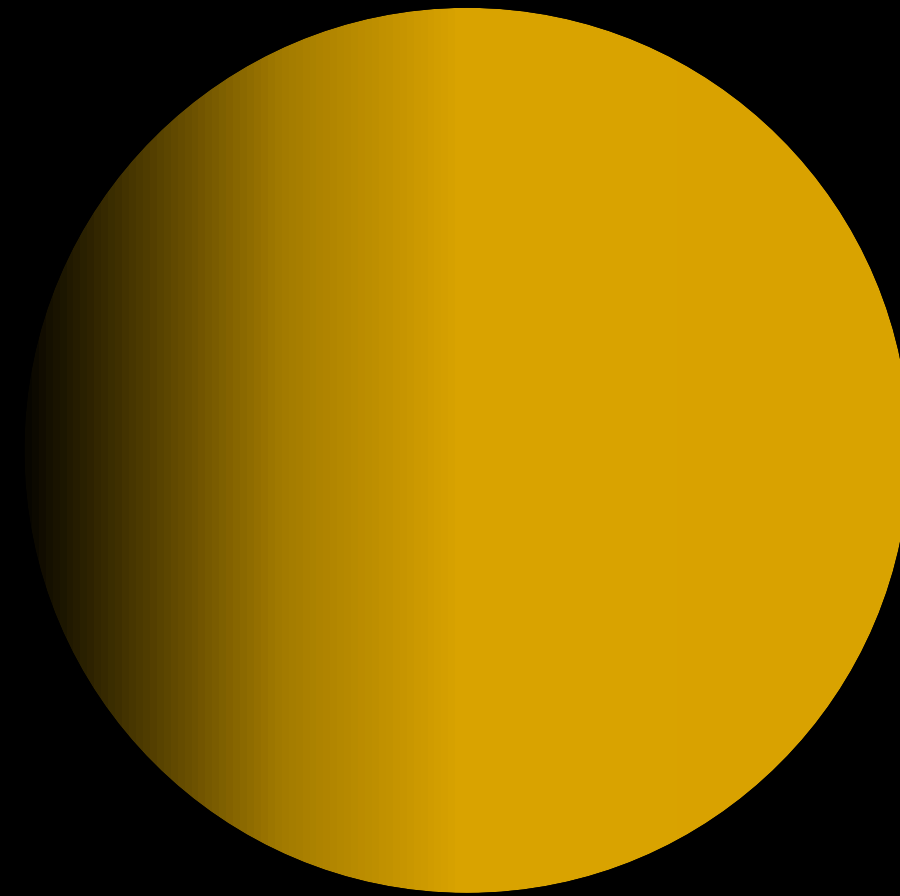
Optical SDSS and DESI spectra

Radio LOFAR LoTSS 144 MHz

Each wavelength tells a *different* part of the story

Each wavelength tells a *different* part of the story

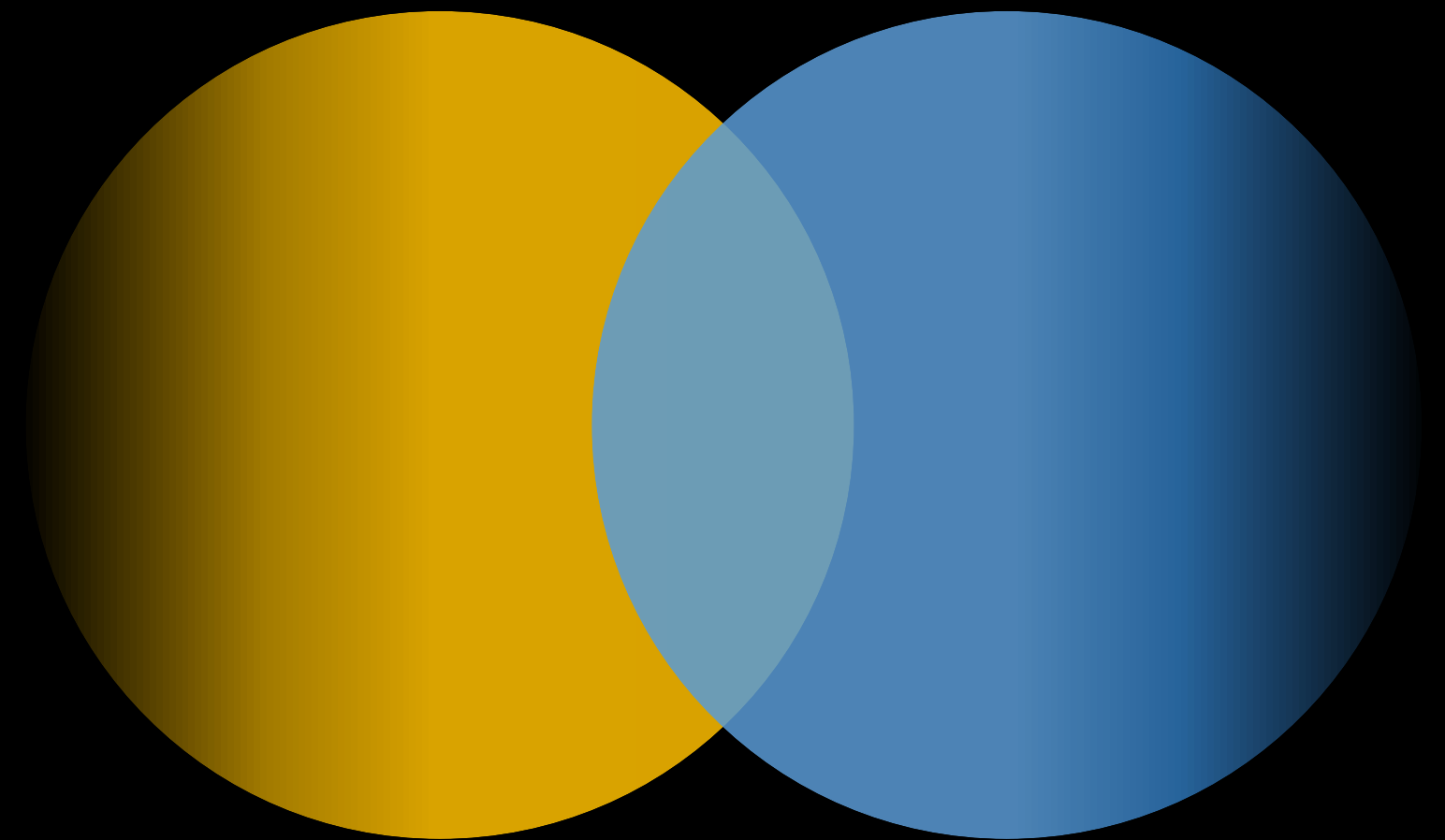
- **optical** spectra shows young stellar radiation



OPTICAL · STARS

Each wavelength tells a *different* part of the story

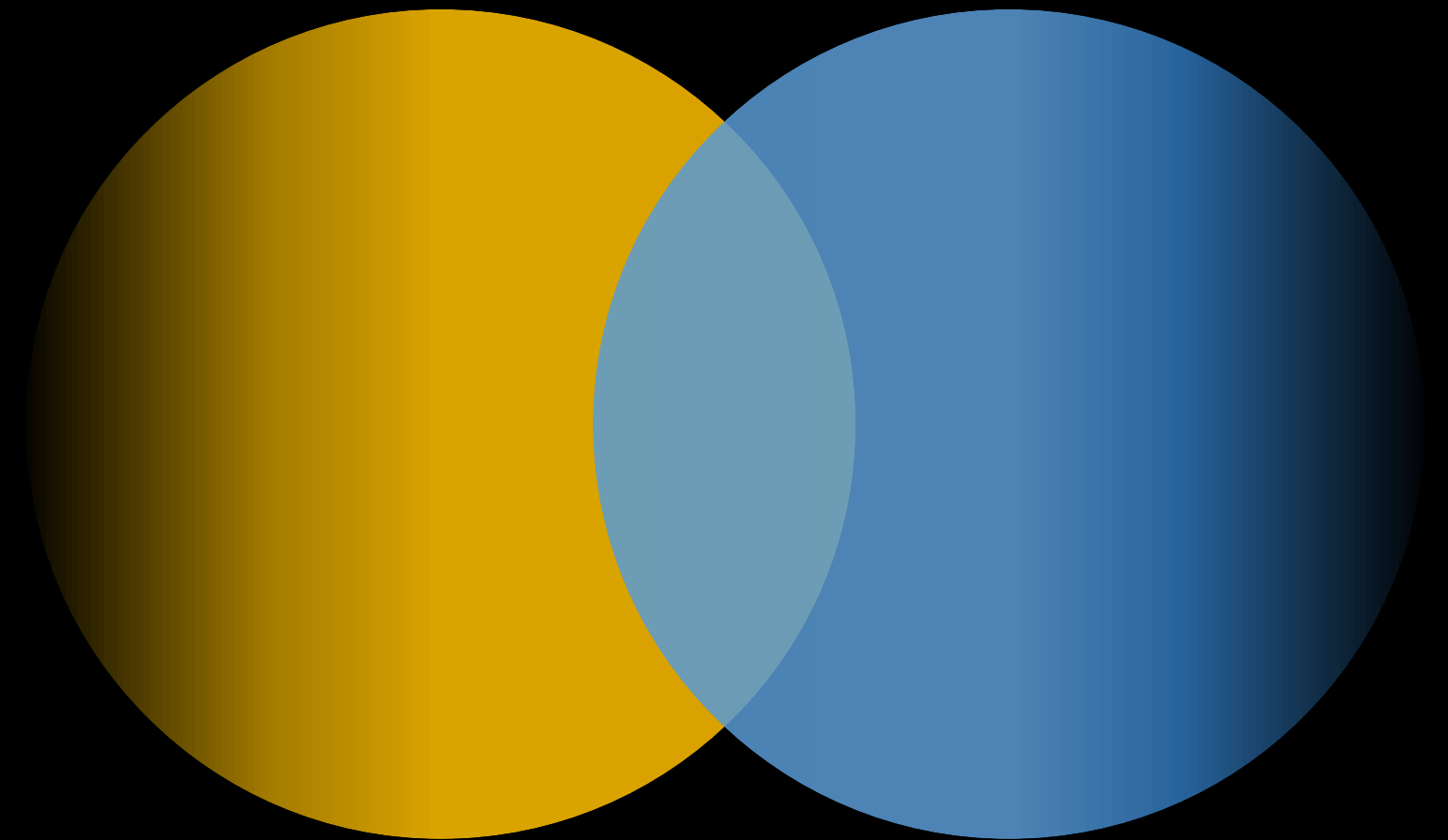
- **optical** spectra shows young stellar radiation
- **radio** is sensitive for the last ~ 100 Myr



OPTICAL · STARS RADIO · SUPERNOVAE

Each wavelength tells a *different* part of the story

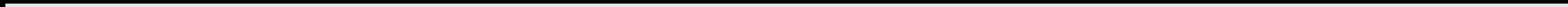
- **optical** spectra shows young stellar radiation
- **radio** is sensitive for the last ~ 100 Myr
- combination gives a more complete picture



OPTICAL · STARS RADIO · SUPERNOVAE

Each tracer reads a different clock

Each tracer reads a different clock



Each tracer reads a different clock



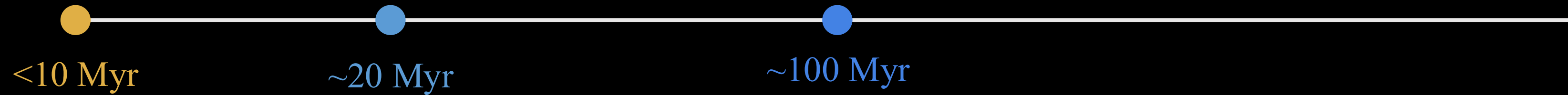
Each tracer reads a different clock

H α · massive stars

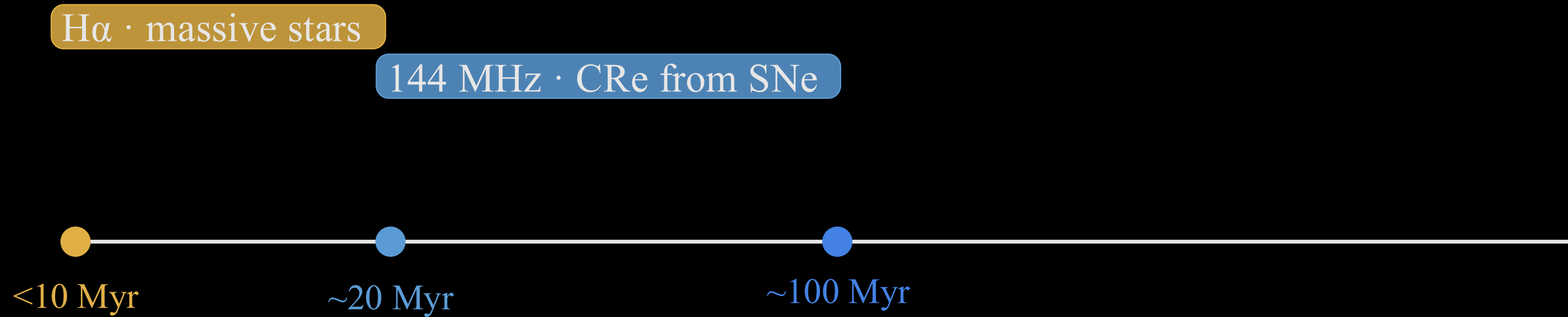


Each tracer reads a different clock

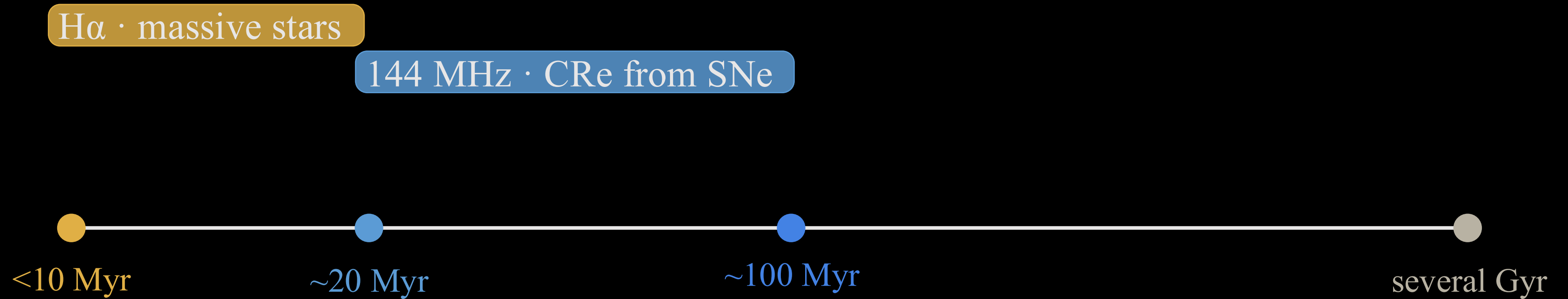
H α · massive stars



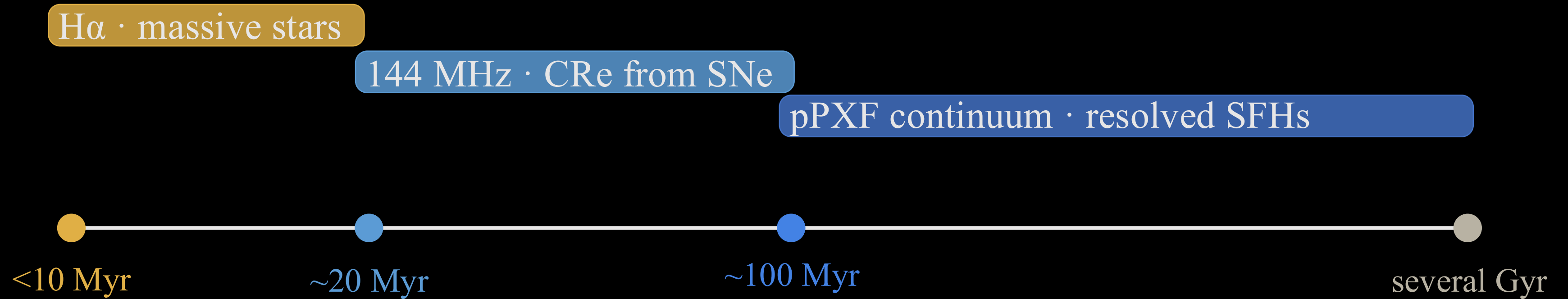
Each tracer reads a different clock



Each tracer reads a different clock



Each tracer reads a different clock



Optical spectra with *pPXF*

Optical spectra with *pPXF*

- full-spectrum fitting with libraries of single-stellar-population templates

Optical spectra with *pPXF*

- full-spectrum fitting with libraries of single-stellar-population templates

Templates	16 metallicities
	220 ages

Optical spectra with *pPXF*

- full-spectrum fitting with libraries of single-stellar-population templates

Templates 16 metallicities

220 ages

Wavelength 3000–9400 Å rest-frame

Optical spectra with *pPXF*

- full-spectrum fitting with libraries of single-stellar-population templates

Templates 16 metallicities

220 ages

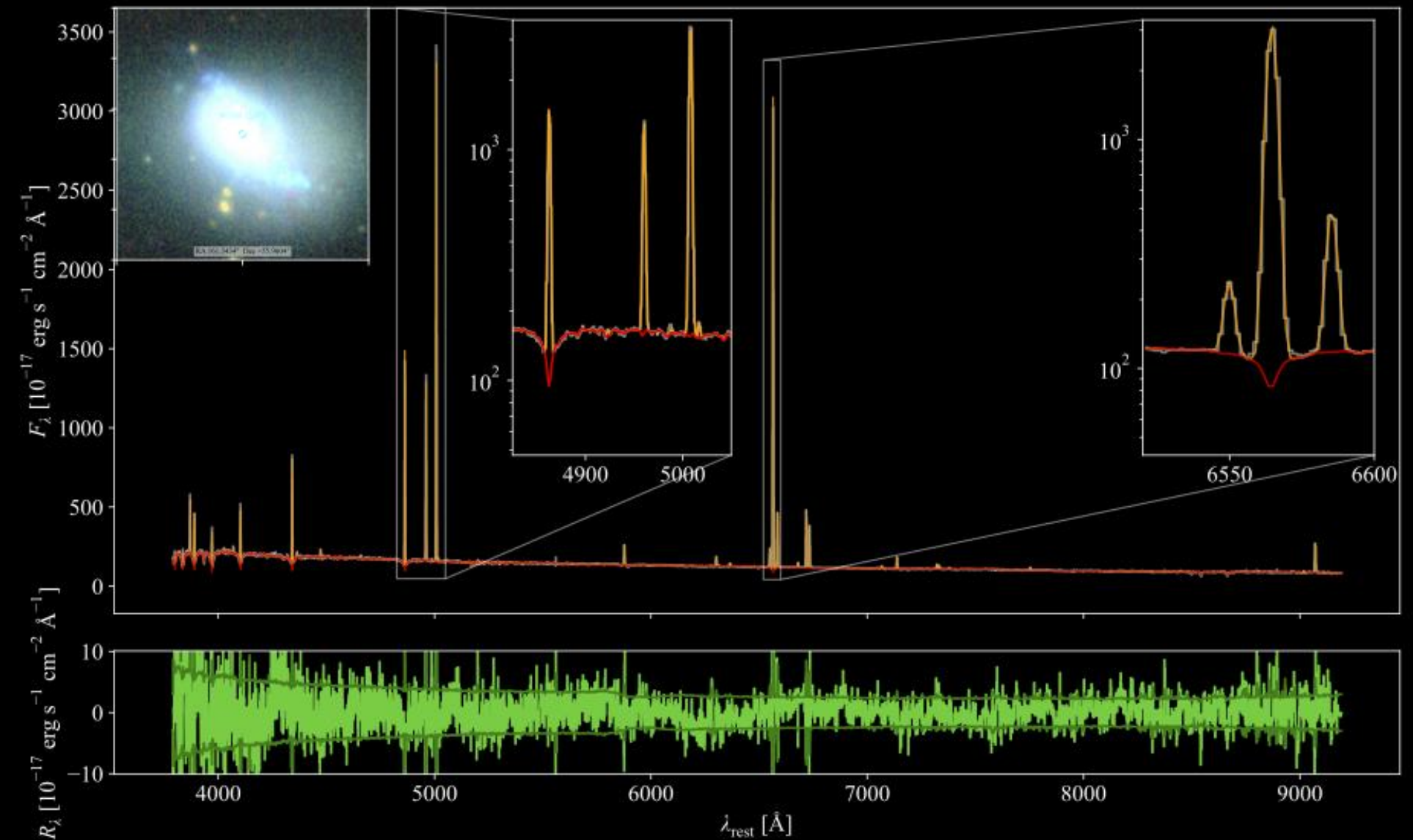
Wavelength 3000–9400 Å rest-frame

Output SFR, SFH, electron density
and temperature and more

Optical spectra with *pPXF*

- full-spectrum fitting with libraries of single-stellar-population templates

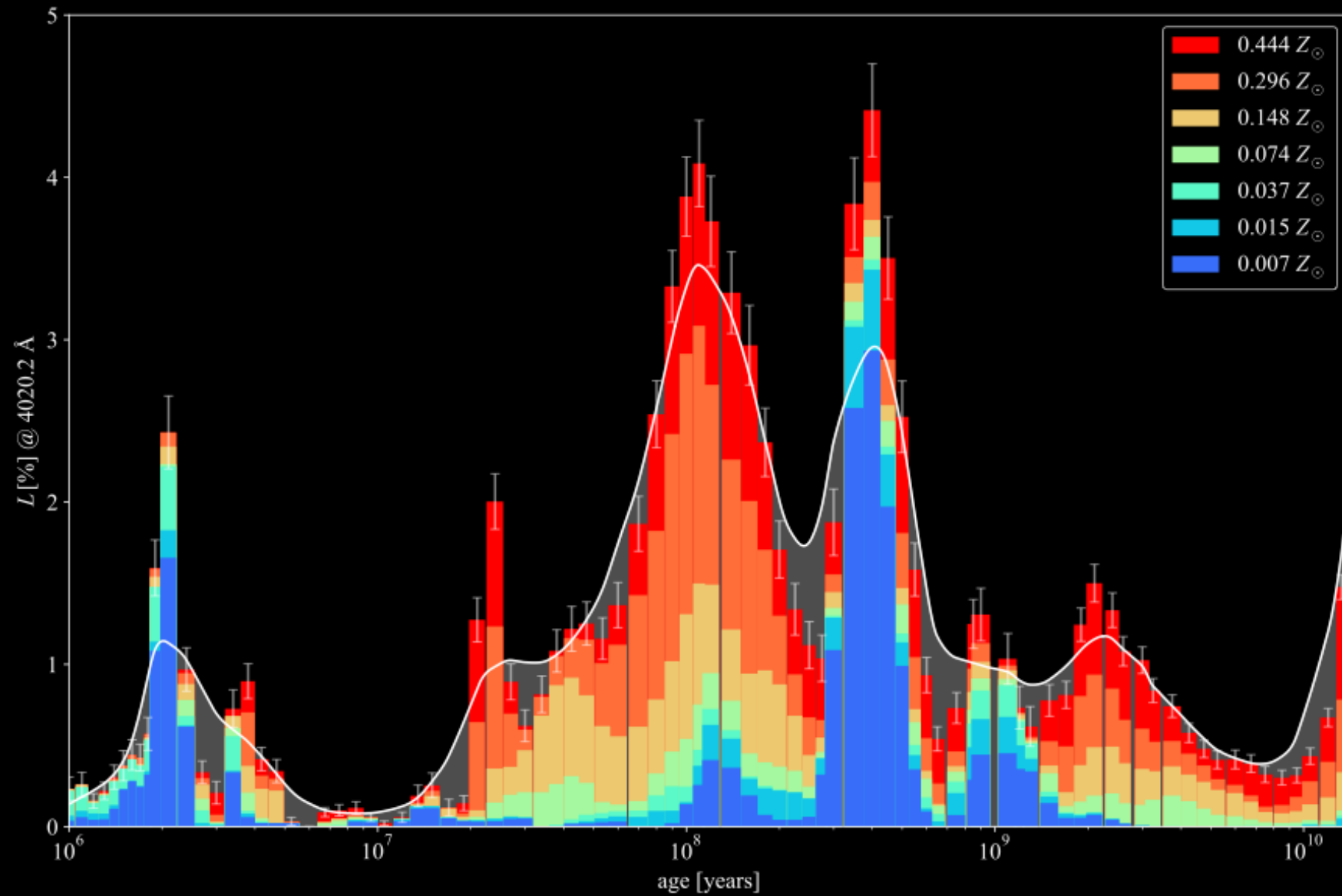
Templates	16 metallicities 220 ages
Wavelength	3000–9400 Å rest-frame
Output	SFR, SFH, electron density and temperature and more



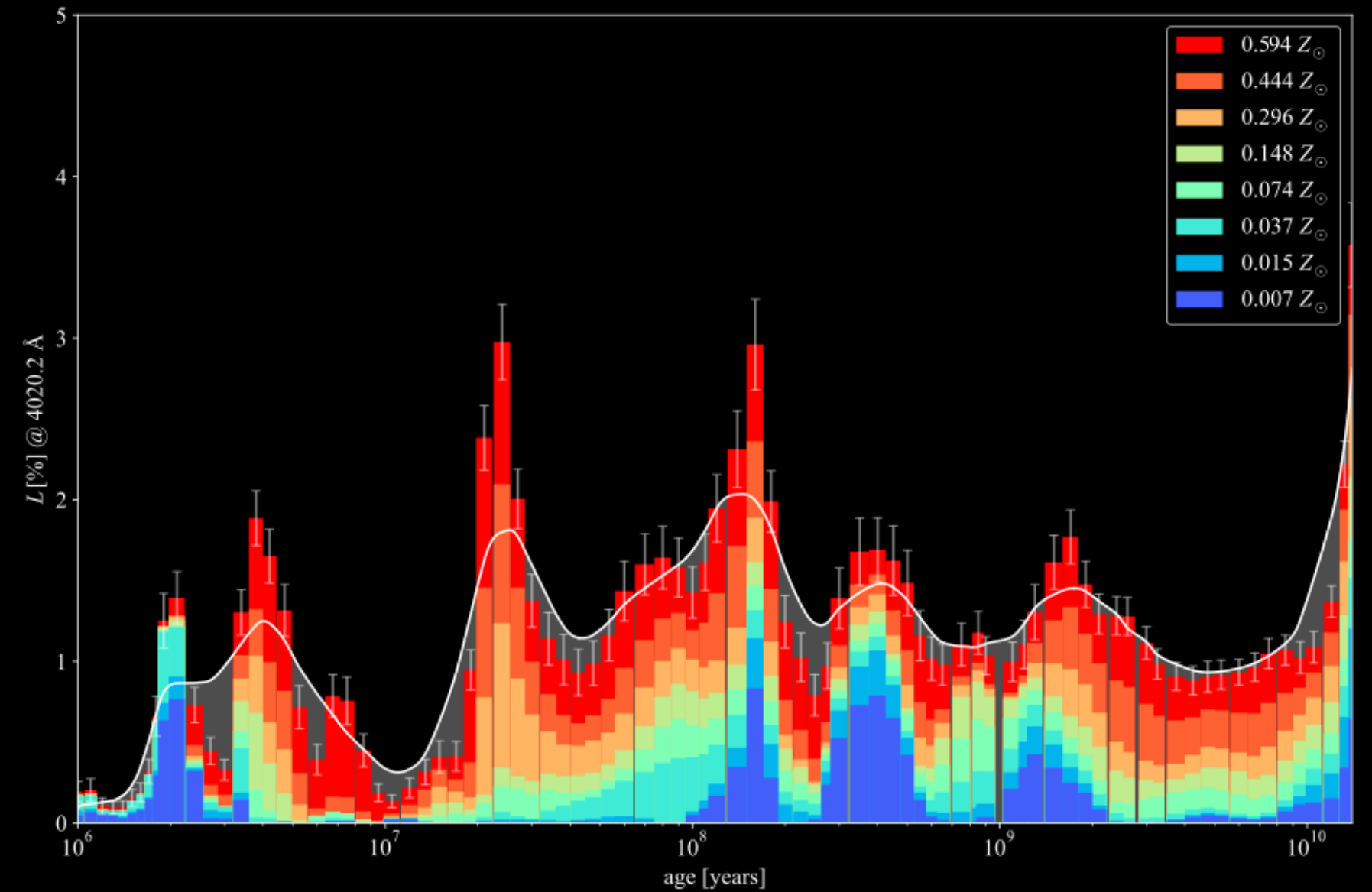
Recovered *star formation histories*

Recovered *star formation histories*

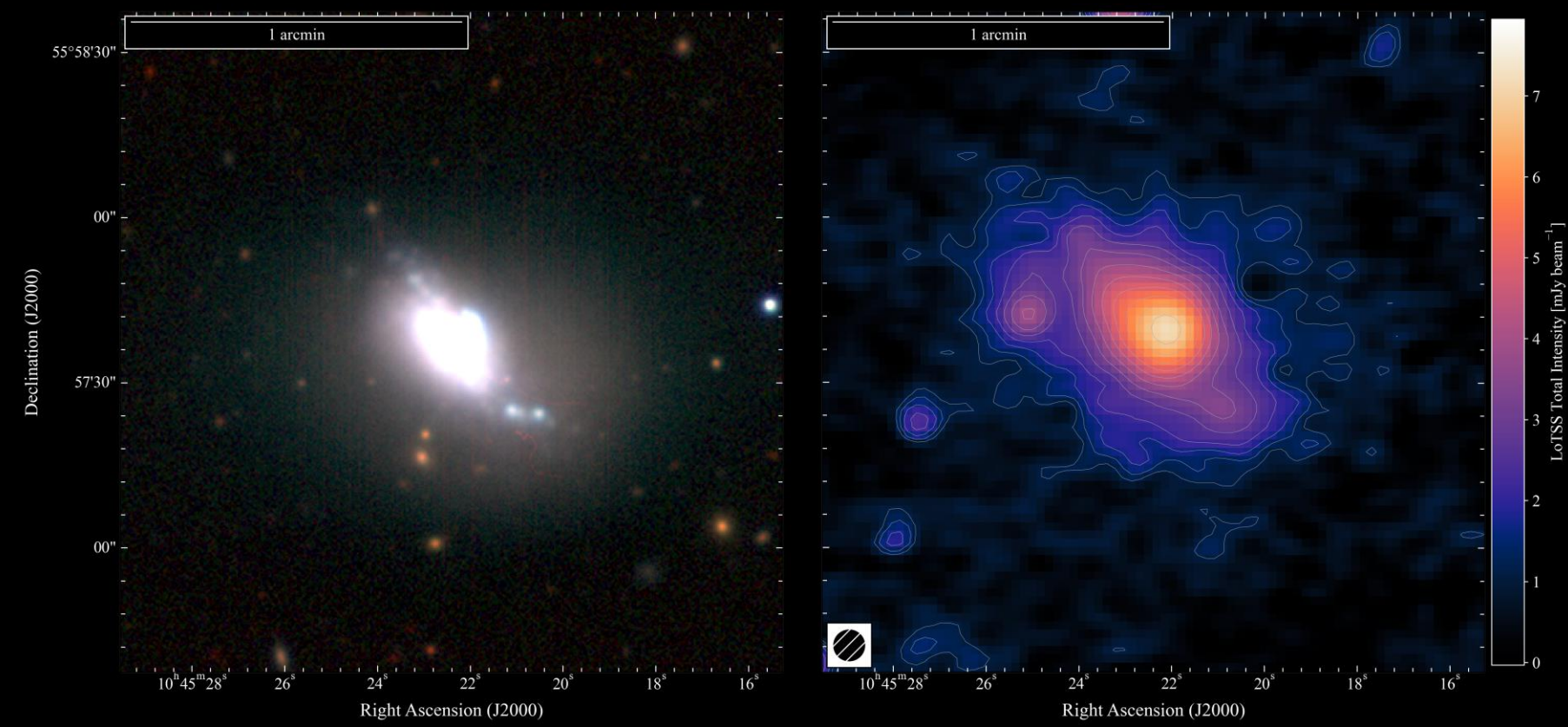
NGC 3353



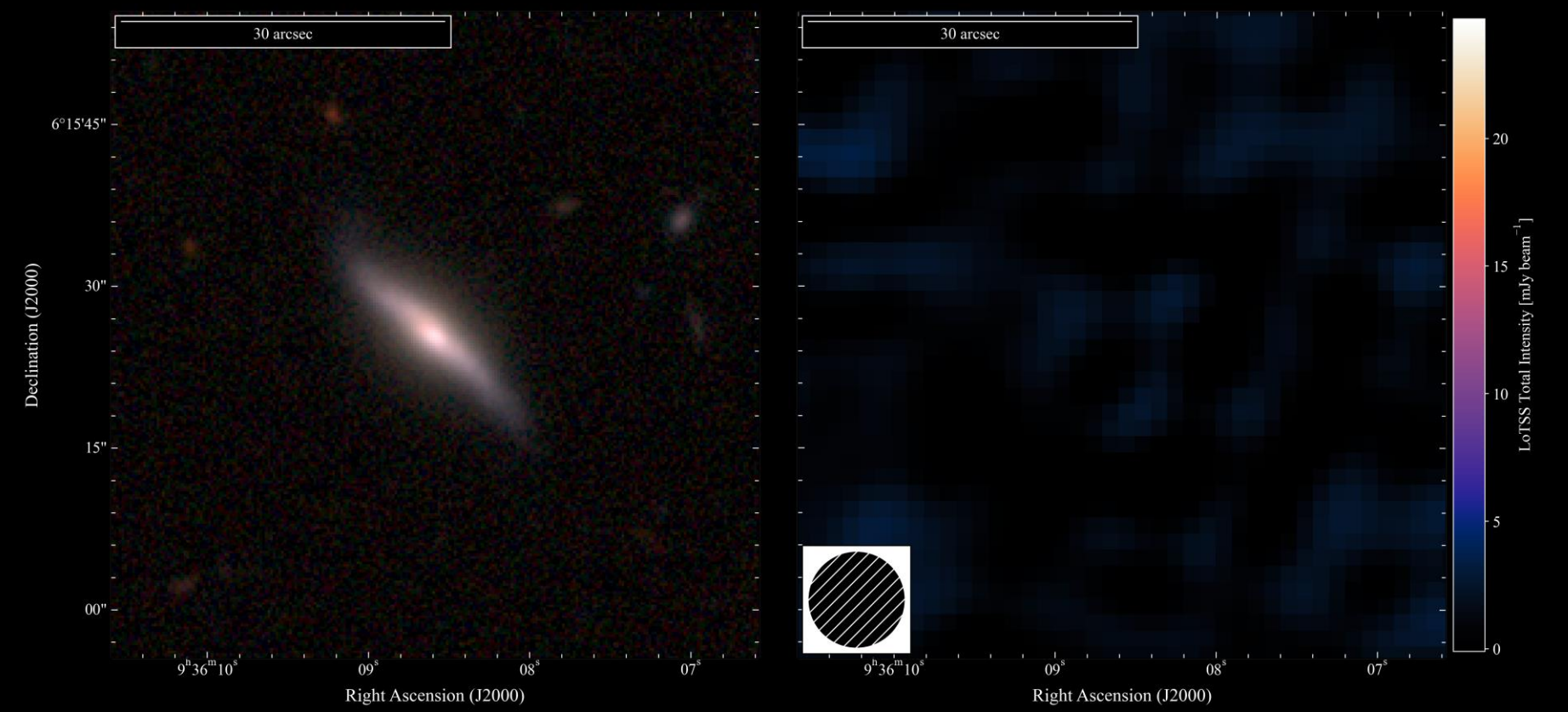
SDSS J0936



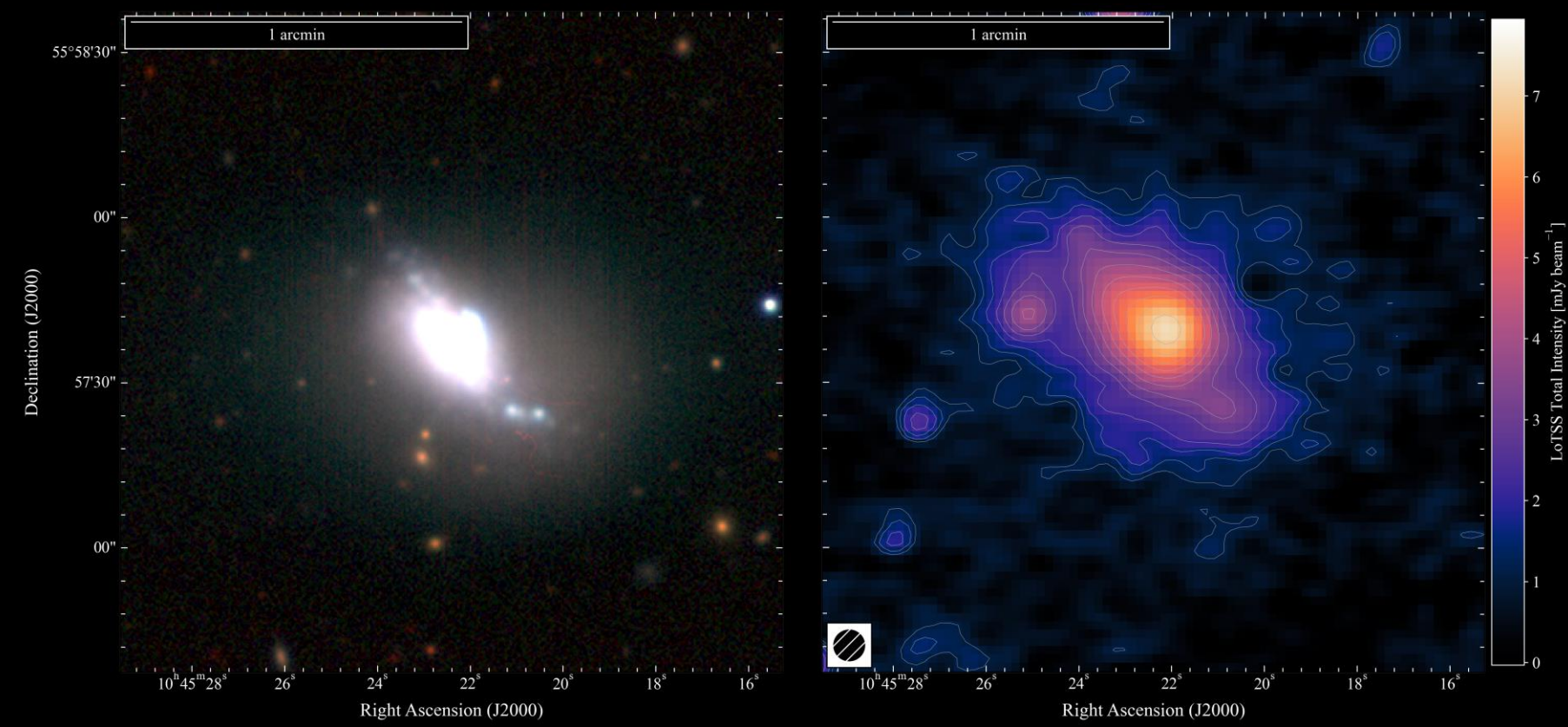
NGC 3353



SDSS J0936

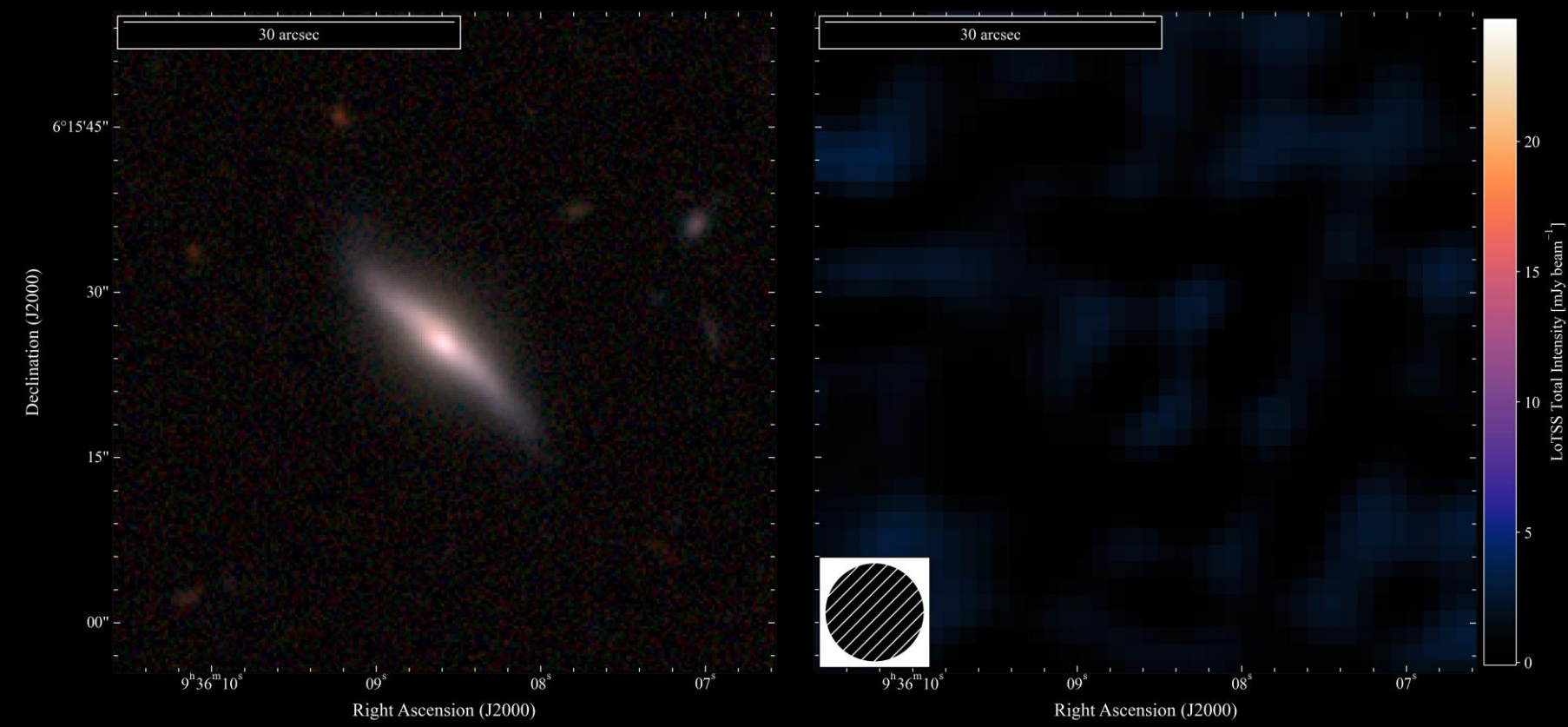


NGC 3353



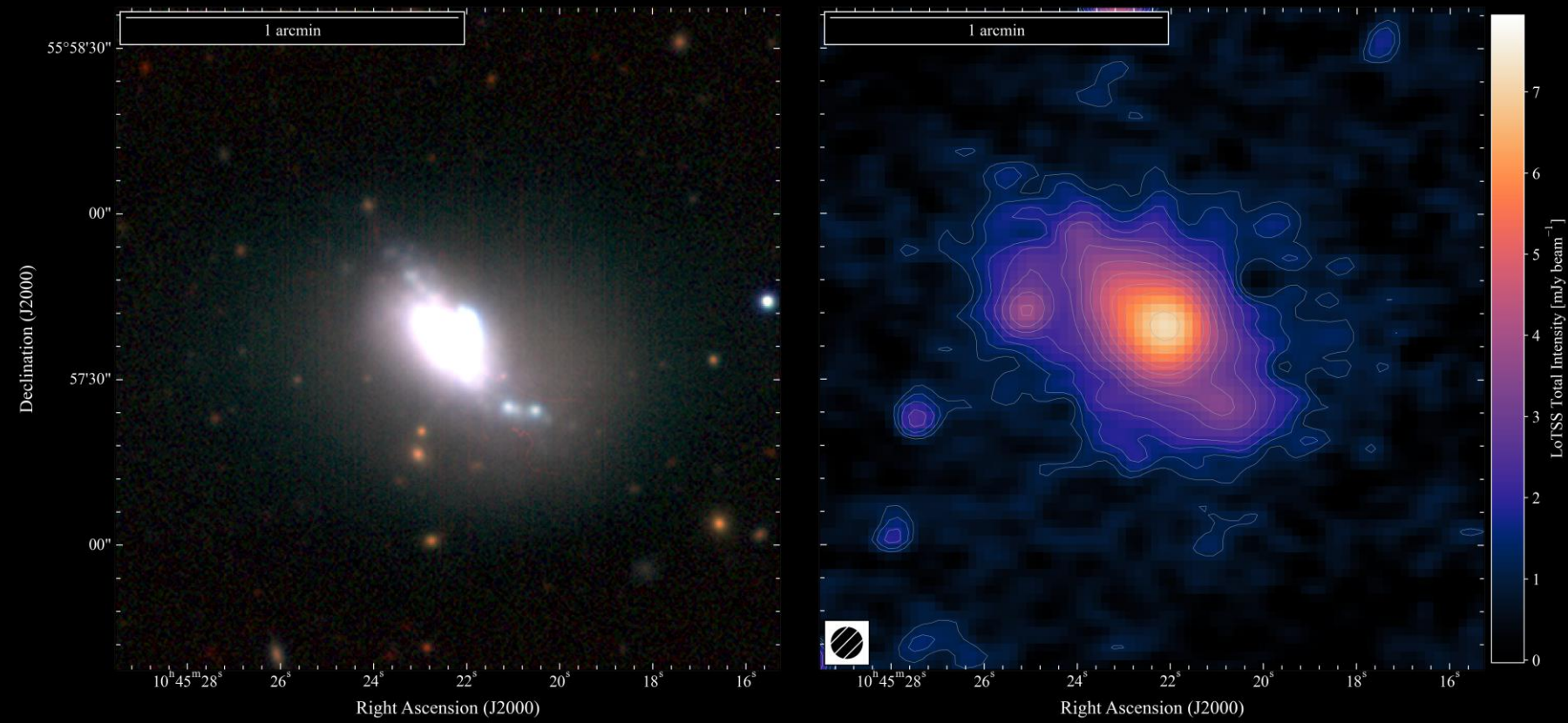
SFR(<100 Myr) 0.013 M_⊙/yr

SDSS J0936



SFR(<100 Myr) 0.009 M_⊙/yr

NGC 3353



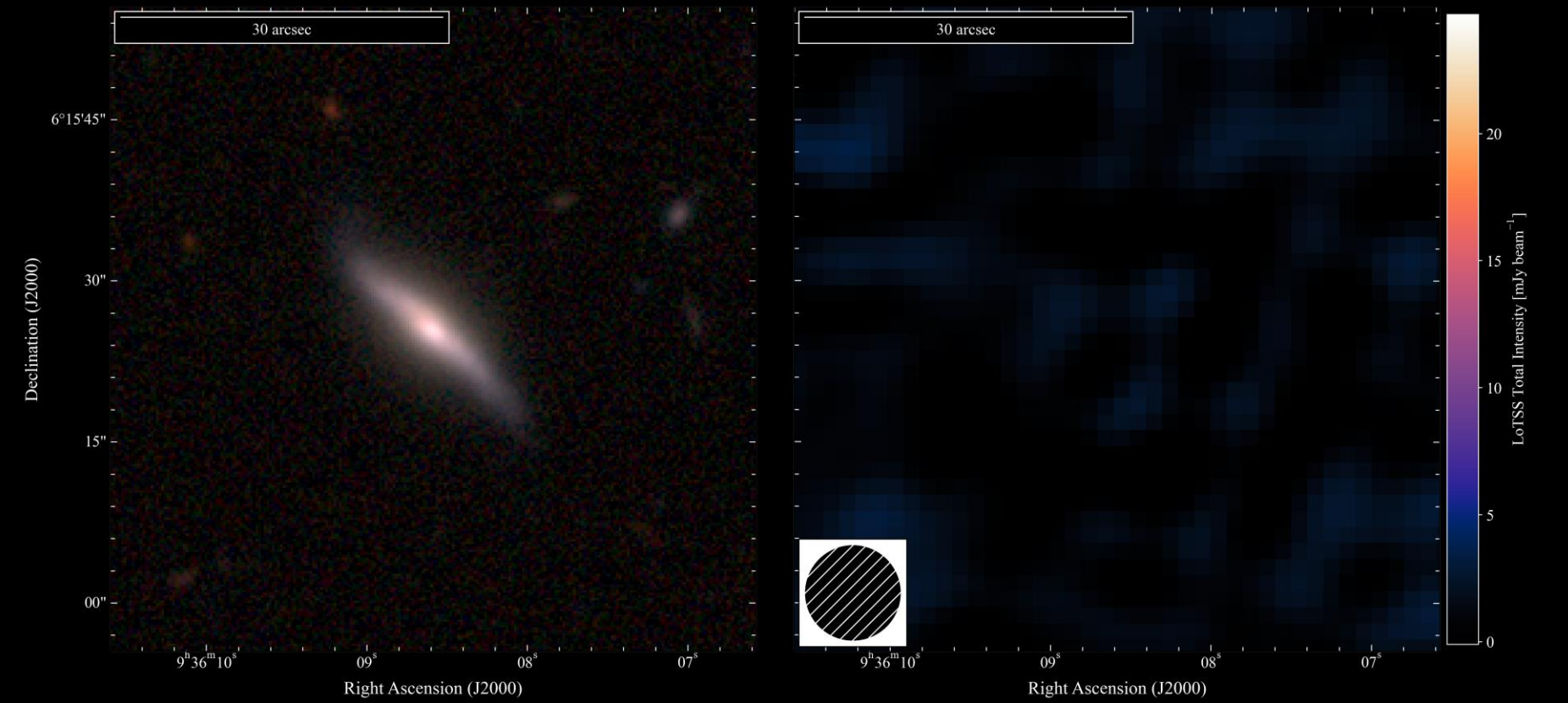
SFR(<100 Myr)

0.013 M_☉/yr

SFR(H α)

0.0109 M_☉/yr

SDSS J0936



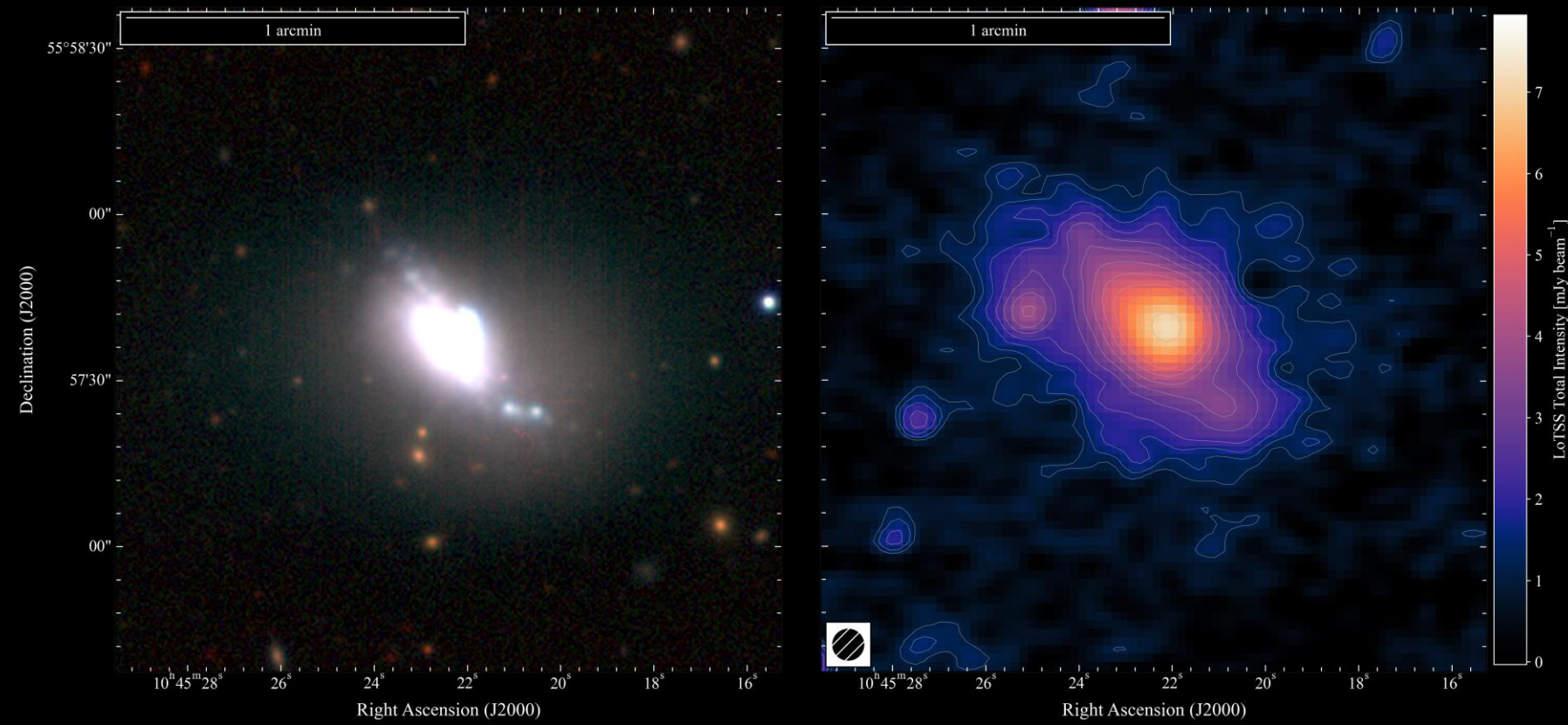
SFR(<100 Myr)

0.009 M_☉/yr

SFR(H α)

0.0023 M_☉/yr

NGC 3353

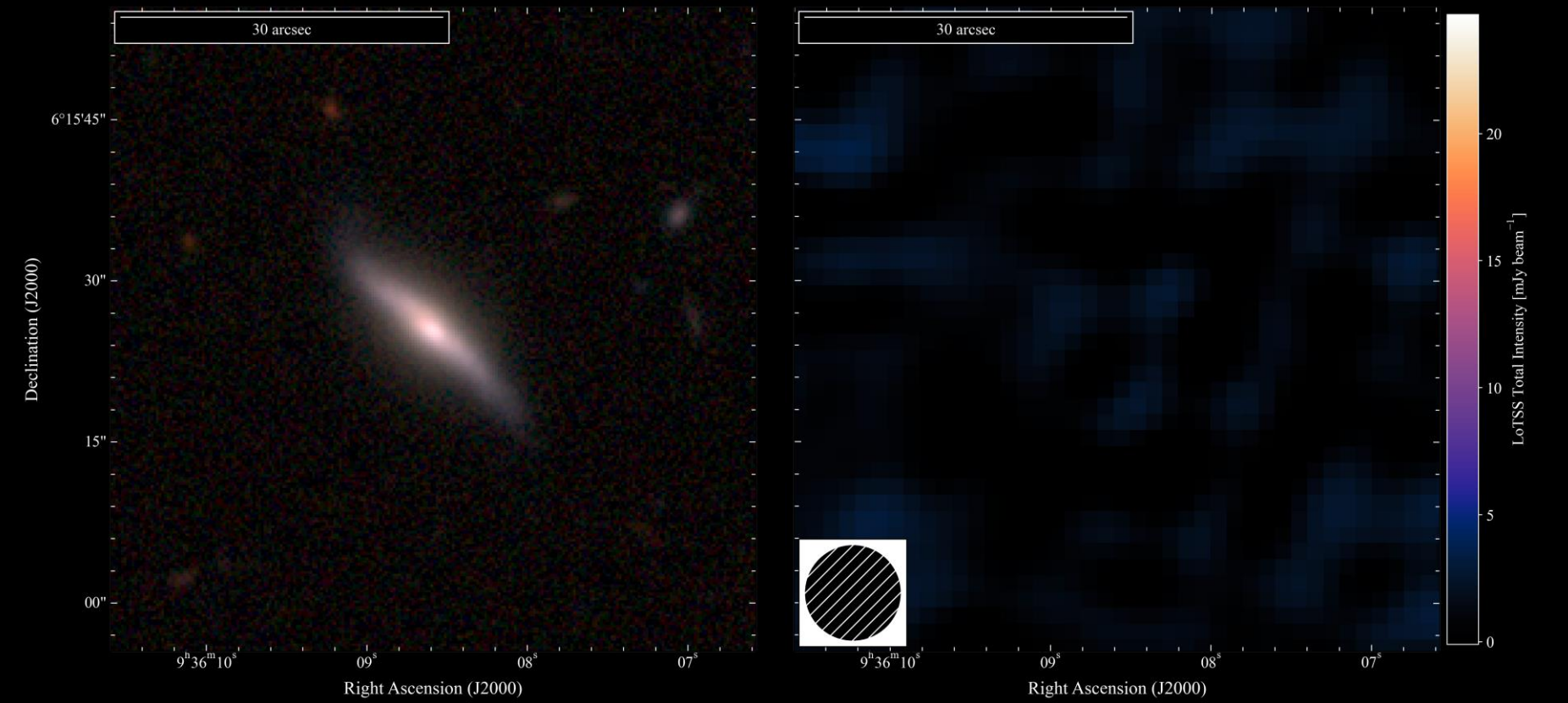


SFR(<100 Myr) 0.013 M_☉/yr

SFR(H α) 0.0109 M_☉/yr

SFR(radio) 0.079 M_☉/yr

SDSS J0936



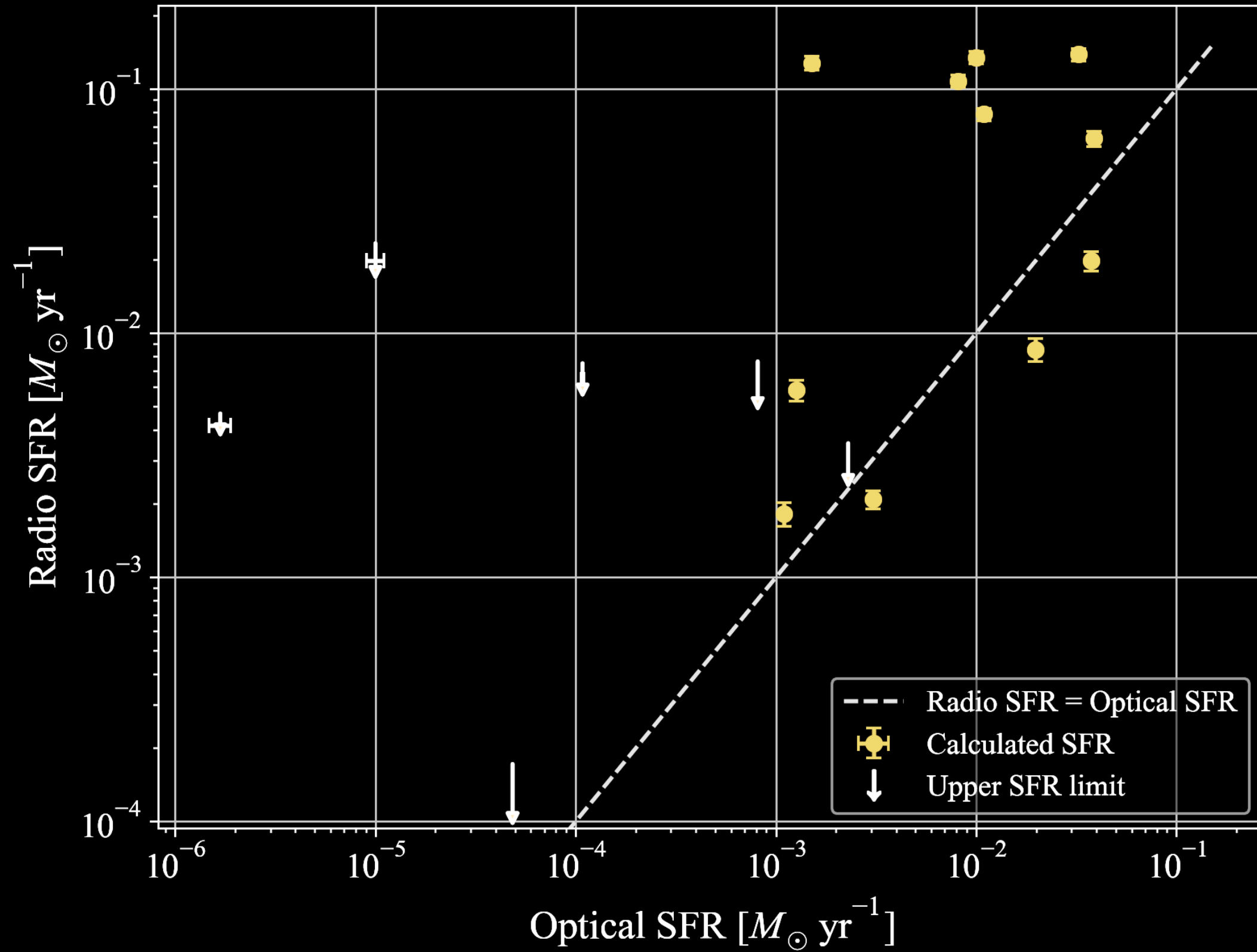
SFR(<100 Myr) 0.009 M_☉/yr

SFR(H α) 0.0023 M_☉/yr

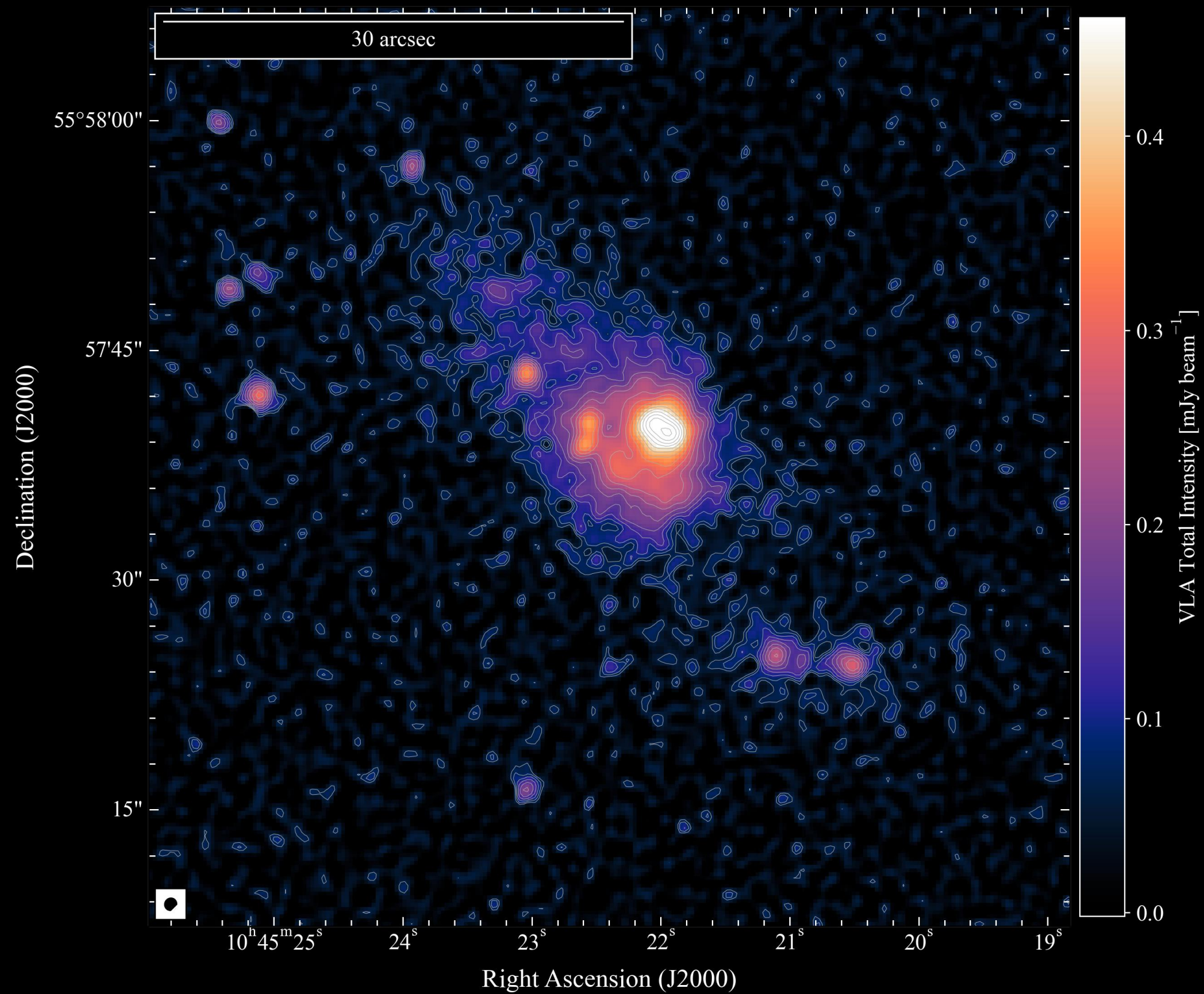
SFR(radio) < 0.0029 M_☉/yr

Galaxies with *similar* star formation histories show very *different* radio detections.

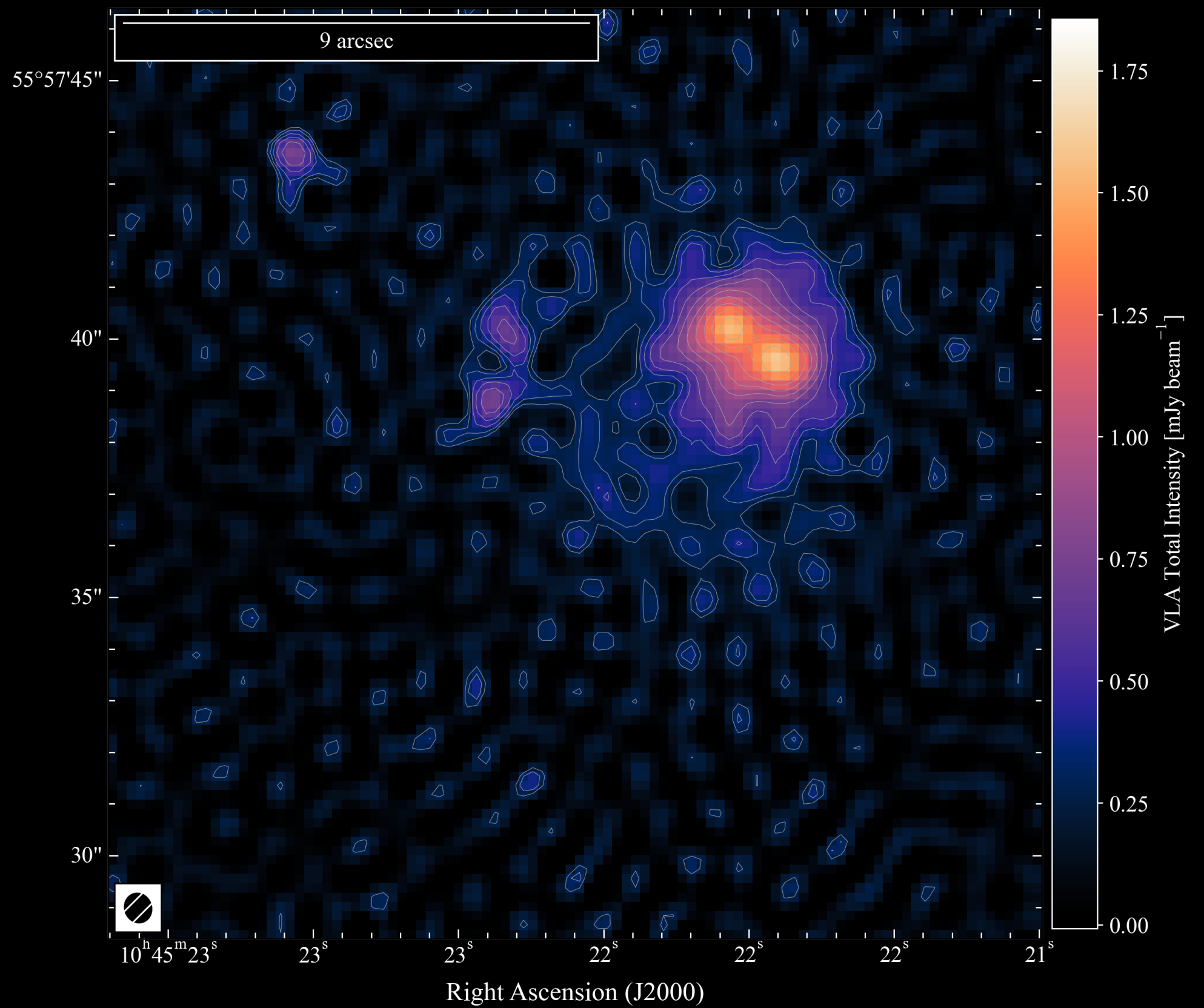
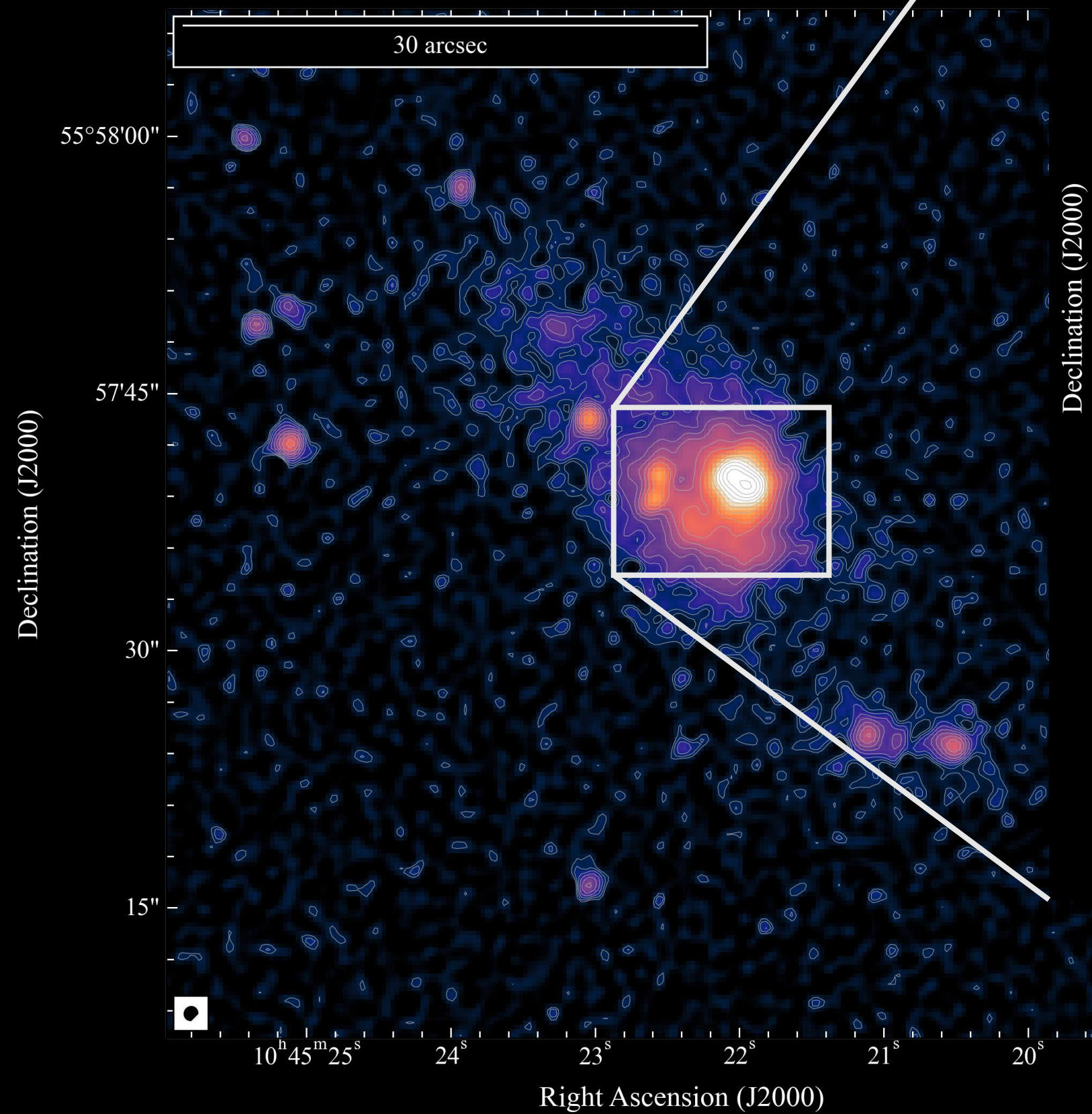
Calculated SFRs



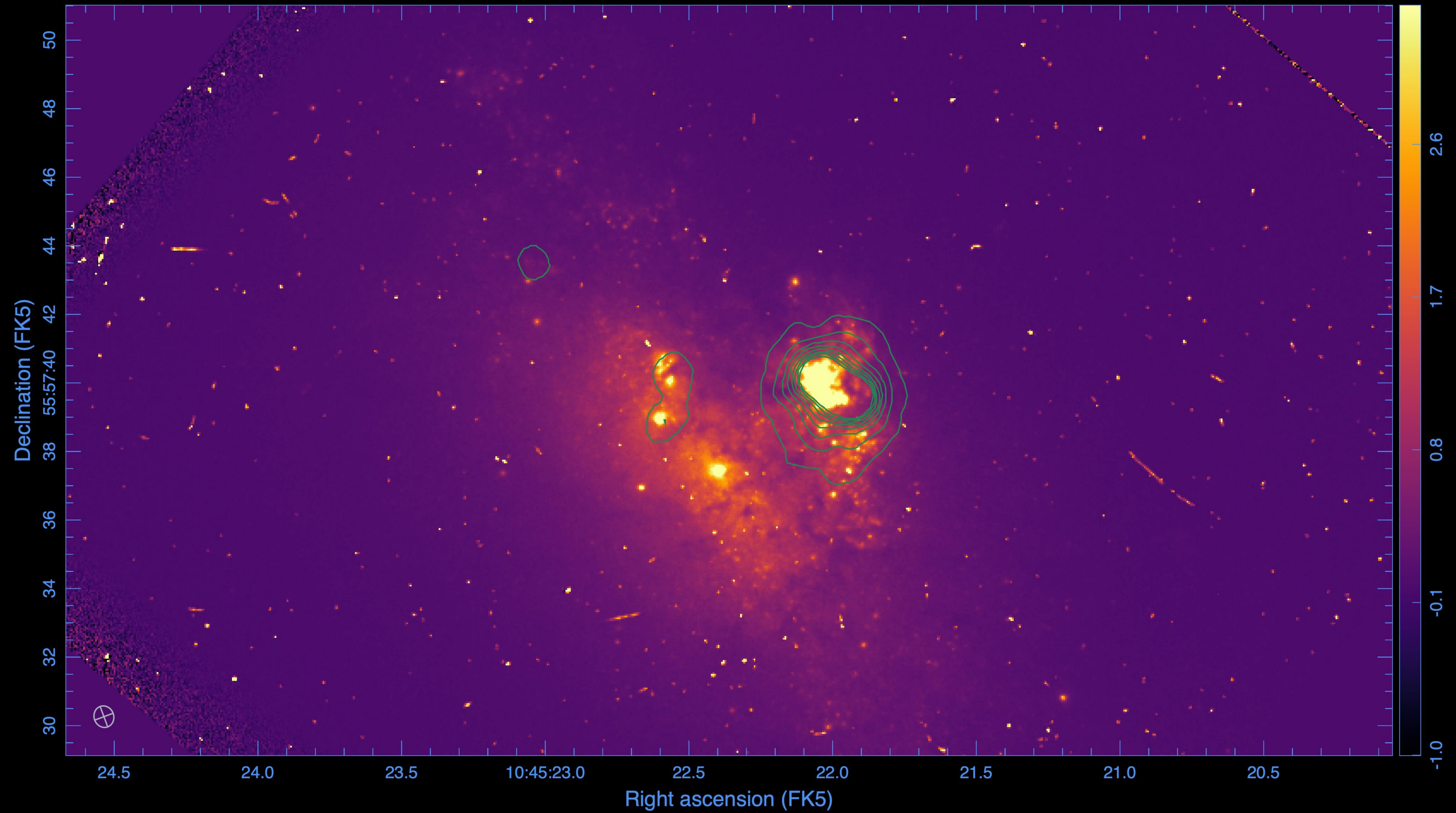
Follow-up observation



Follow-up observation

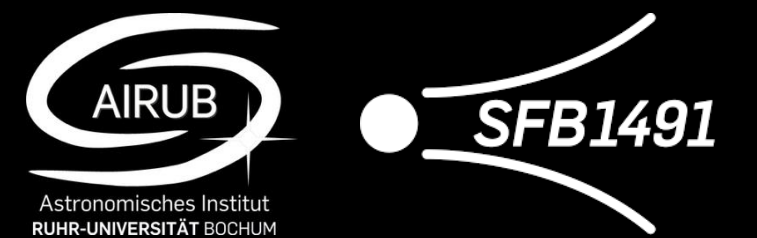


Follow-up observation



Takeaways

Pascal Vennedey
AIRUB · vennedey@astro.rub.de



Takeaways

- Transition-type dwarfs represent intermediate state between *starburst* and *quiescent*

Takeaways

- Transition-type dwarfs represent intermediate state between *starburst* and *quiescent*
- pPXF constrains star formation histories via optical spectra SSP fitting

Takeaways

- Transition-type dwarfs represent intermediate state between *starburst* and *quiescent*
- pPXF constrains star formation histories via optical spectra SSP fitting
- similar SFHs show systematically *different* LOFAR flux densities

Takeaways

- Transition-type dwarfs represent intermediate state between *starburst* and *quiescent*
- pPXF constrains star formation histories via optical spectra SSP fitting
- similar SFHs show systematically *different* LOFAR flux densities
- SFR diverges between *optical* and *radio*

Takeaways

- Transition-type dwarfs represent intermediate state between *starburst* and *quiescent*
- pPXF constrains star formation histories via optical spectra SSP fitting
- similar SFHs show systematically *different* LOFAR flux densities
- SFR diverges between *optical* and *radio*
- VLA follow-up constrains the radio spectral index and morphology