Galaxies at cosmic noon: What will SKA1-MID see?

Mark Sargent

with:
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- M. Ghasemi-Nodehi, F. Tabatabaei, E. Murphy, H. Khosroshahi, R. Beswick, A. Bonaldi, E. Schinnerer

INTERNATIONAL SPACE SCIENCE INSTITUTE

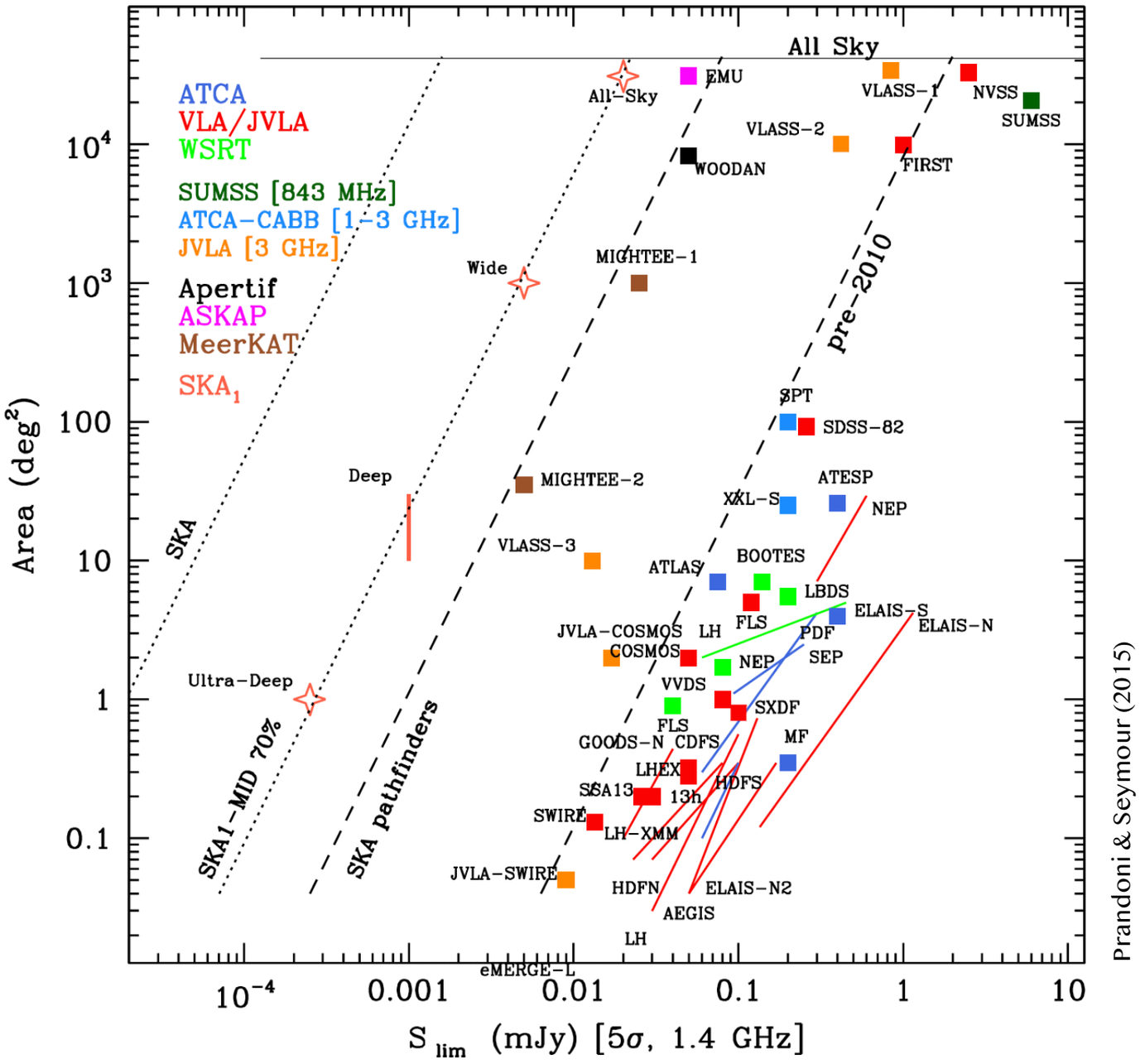
GOODS-N (credit: ESA/Hubble Media)

GALAXY FORMATION IN THE RADIO WINDOW

Area & depth of current and future surveys

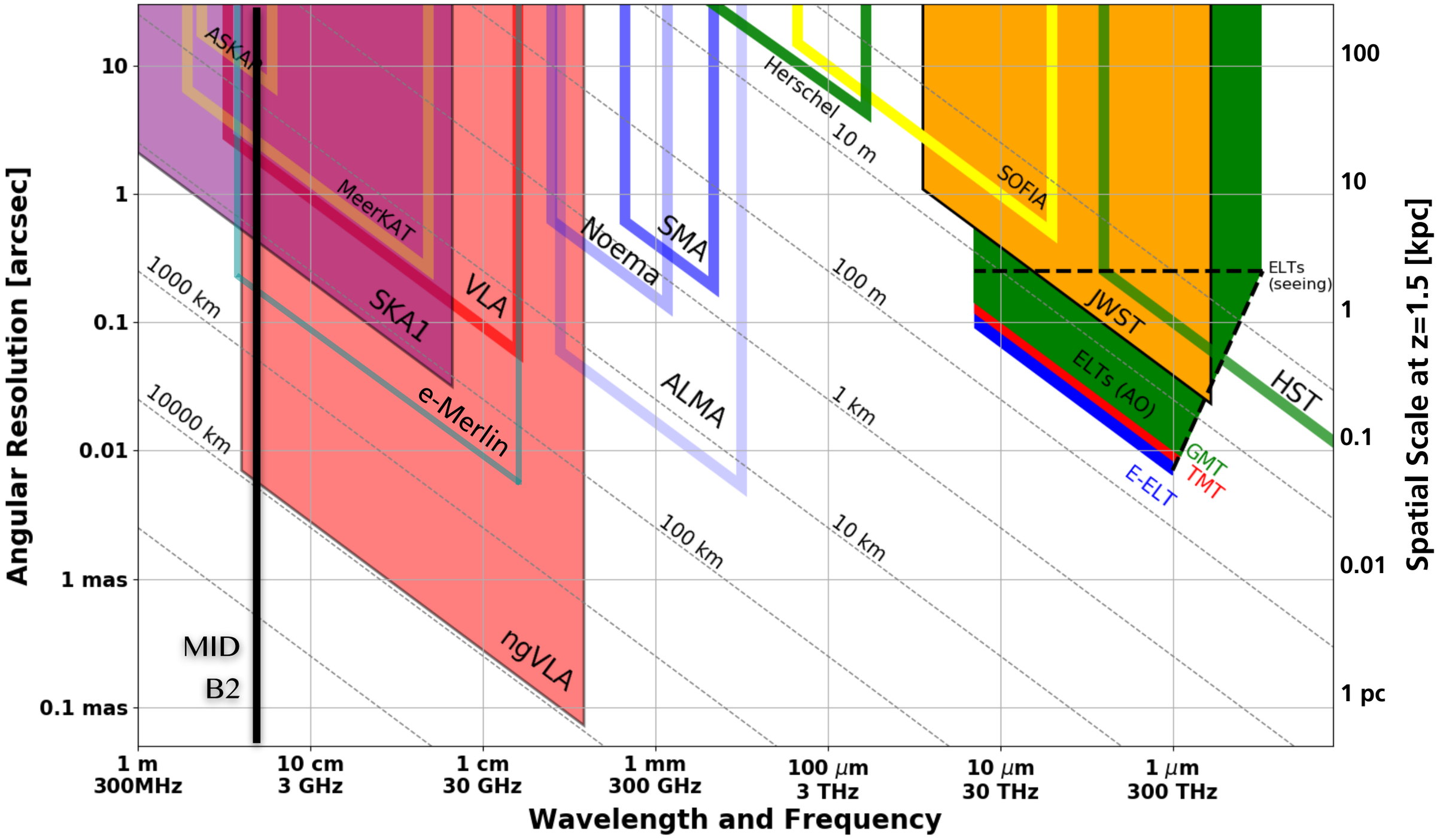
SKA-MID surveys are expected to achieve - at fixed survey area - an almost 100-fold achievement in survey depth compared to “current” surveys.

(Pathfinder surveys with MeerKAT and ASKAP will also provide significantly deeper imaging but at an approx. 10-fold coarser angular resolution.)



GALAXY FORMATION IN THE RADIO WINDOW

Angular & spatial scales probed



Adapted from: Reid et al. (2018)

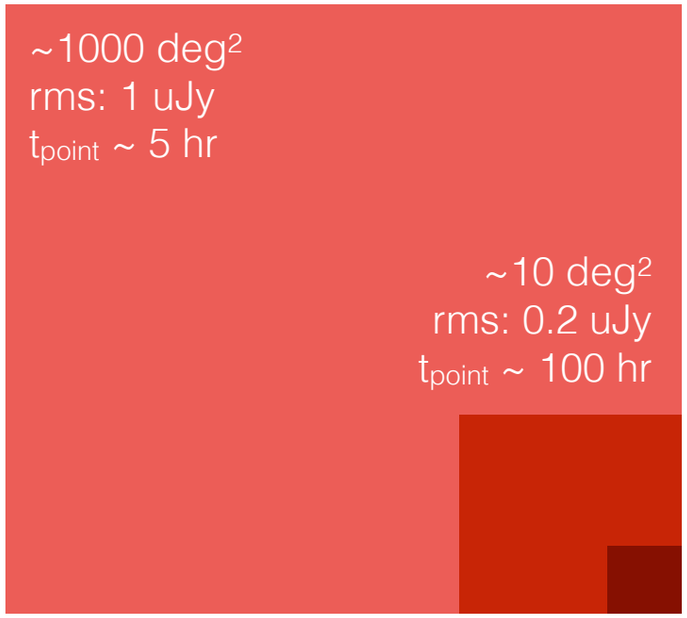
SKA1-MID TIERED CONTINUUM SURVEYS

Tracing the cosmic star-formation history & galaxy-black hole co-evolution

The SKA Extragalactic Continuum Science Working Group (SWG) has defined 2 tiered reference surveys (aka “high priority science objectives” in SKA jargon) for galaxy evolution science:

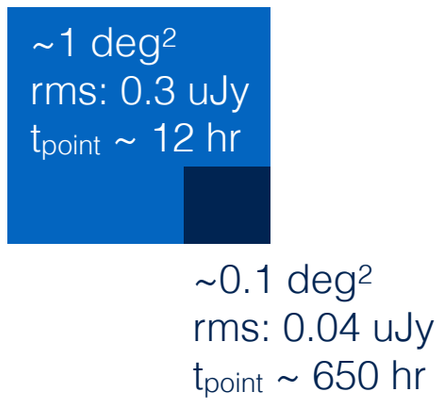
1 SFH - non-thermal processes & AGN/galaxy co-evolution

band 2 (1.4 GHz), ≤0.5” resolution
duration: ~2 years



2 SFH - thermal processes & AGN/galaxy co-evolution

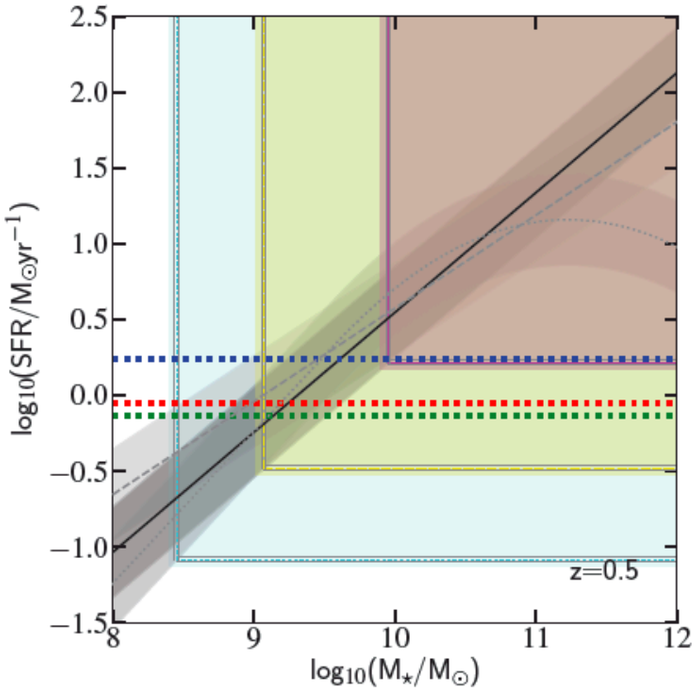
band 5 (~10 GHz), ~0.1” resolution
duration: ~6 months

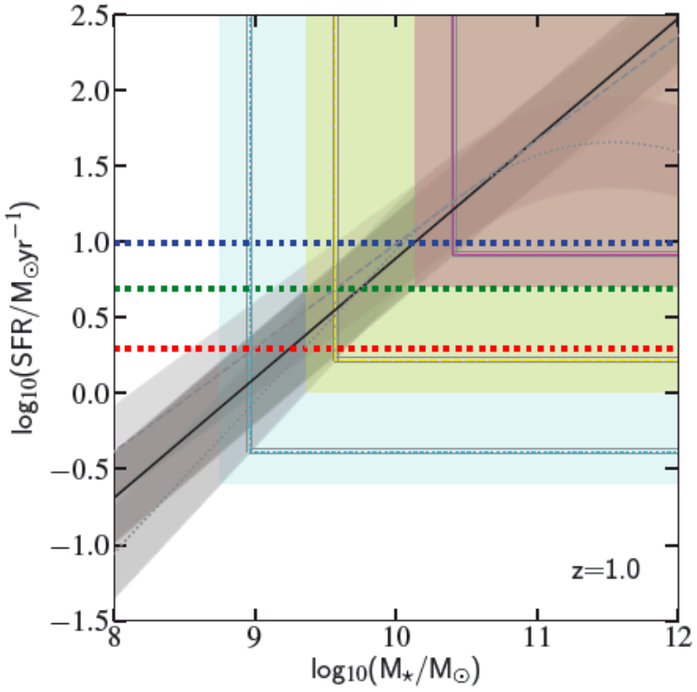


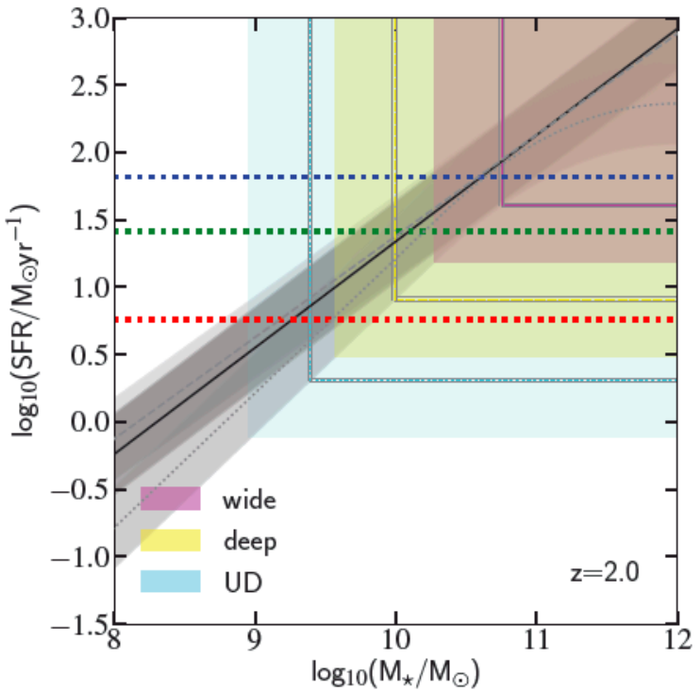
Most data based on: Prandoni & Seymour (2015)

SKA1-MID TIERED CONTINUUM SURVEYS

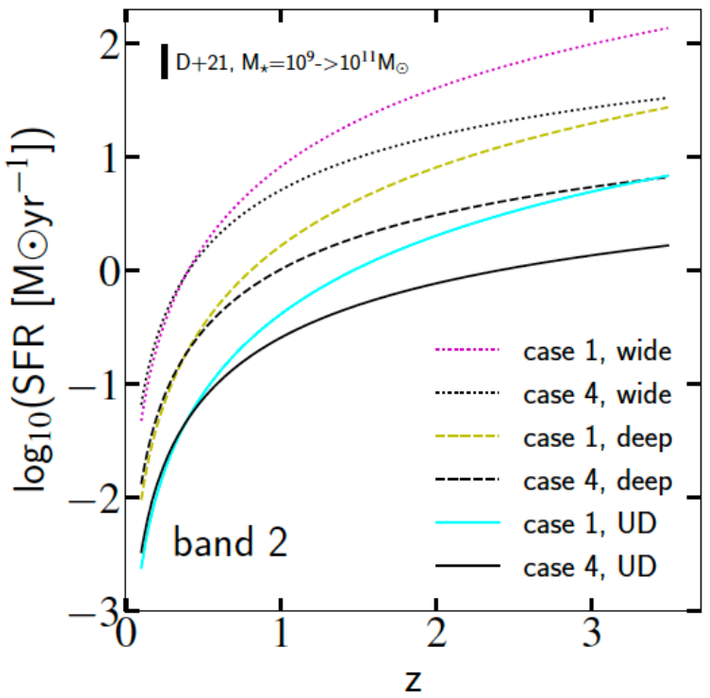
Physical parameter space probed

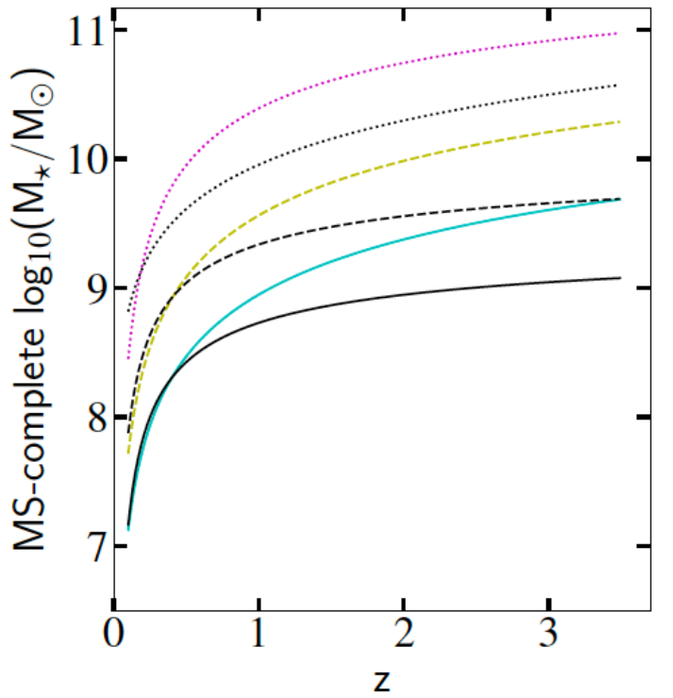






Predicted SFR and stellar mass completeness limits of the band 2 tiered references surveys for galaxy evolution science:





Coogan, Sargent et al. (in prep.)

STAR-FORMING GALAXIES AT COSMIC NOON

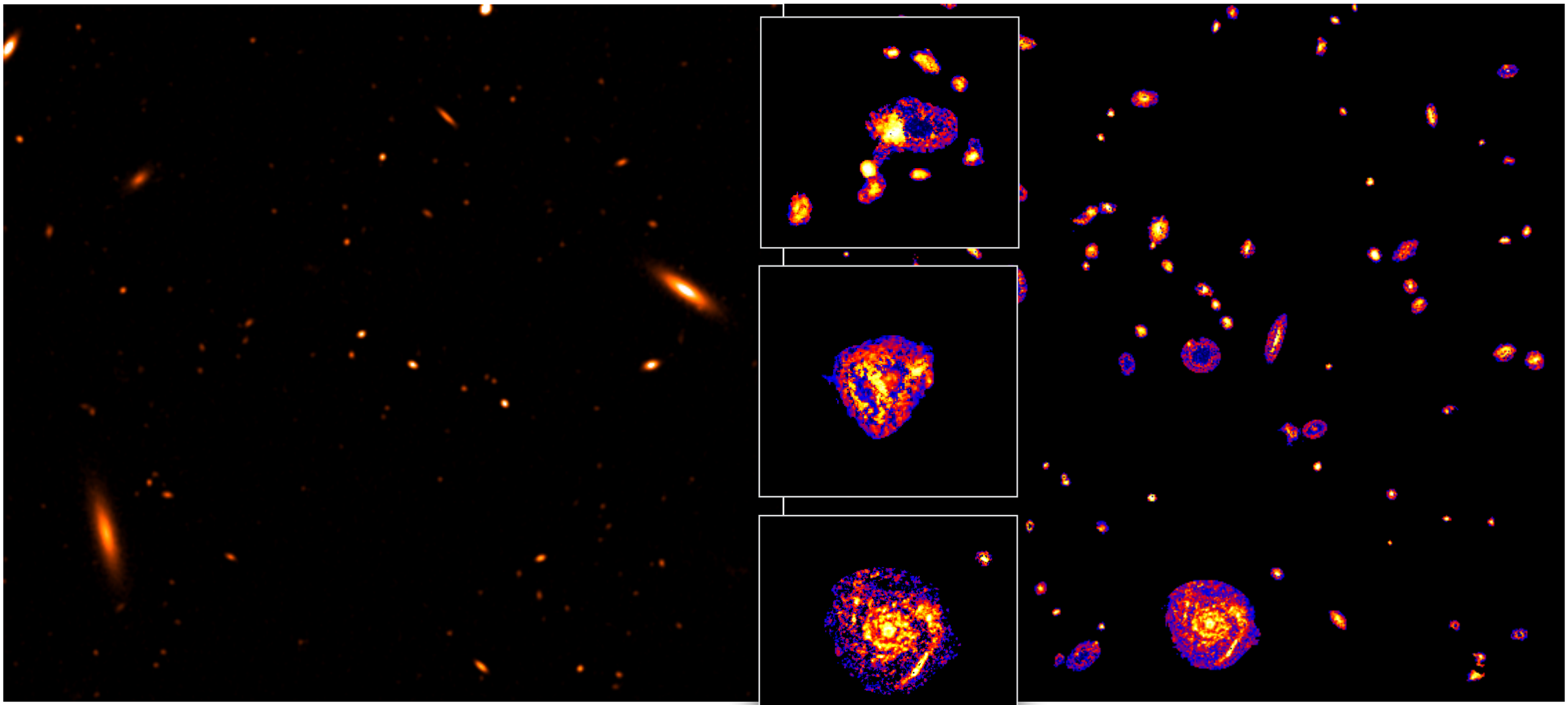
Revisiting SDC1 in GOODS-N

T-RECS/SKA Sci. Data Challenge #1

(Bonaldi et al. 2021)

mock GOODS-N

(Coogan, Sargent et al., in prep.)



STAR-FORMING GALAXIES AT COSMIC NOON

Bulge growth and clumpy star-forming disks

I

SFH - non-thermal processes & AGN/galaxy co-evolution

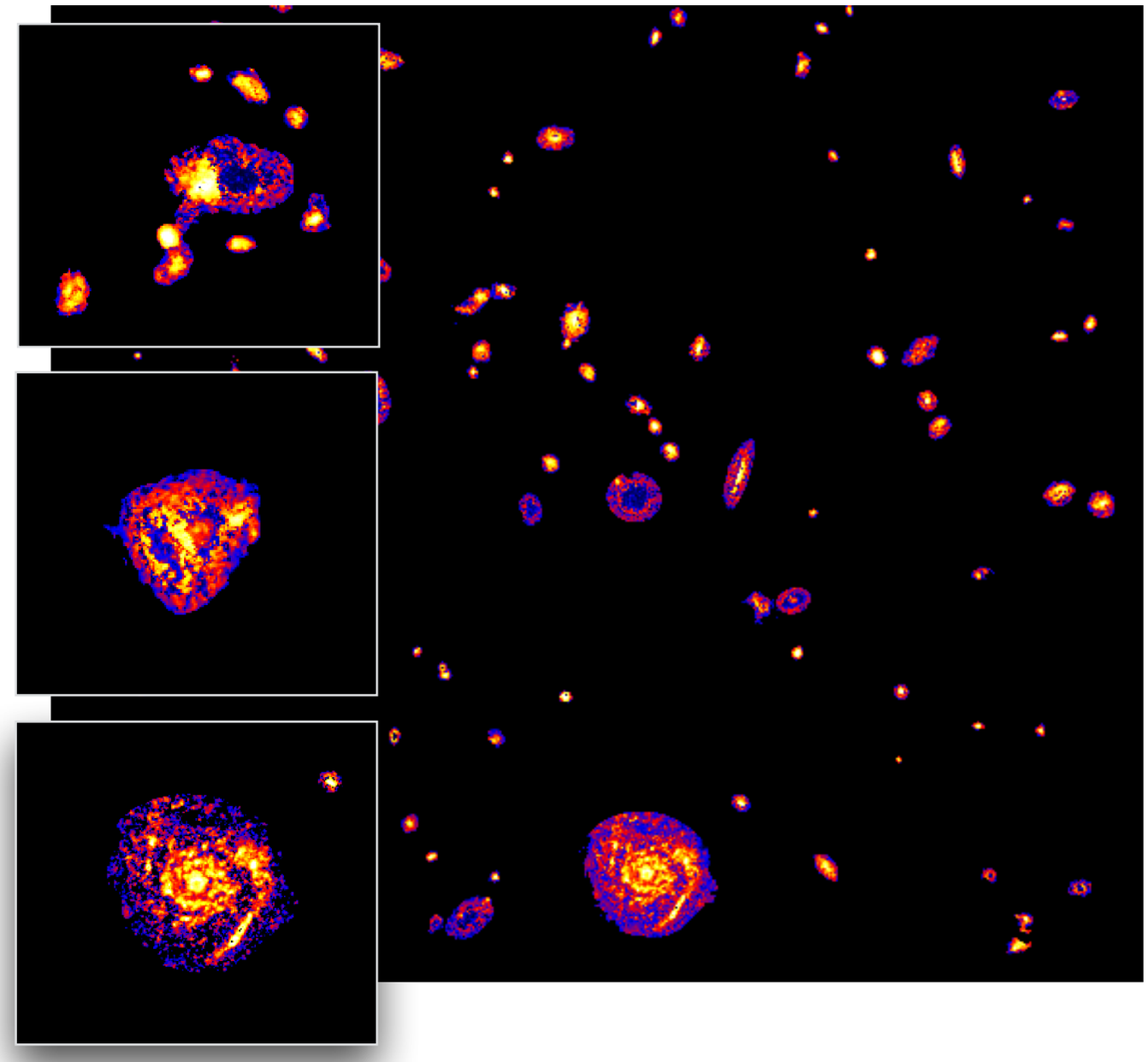
band 2 (1.4 GHz), ≲0.5” resolution
duration: ~2 years

~1000 deg^2
rms: 1 uJy
t_{point} ~ 5 hr

~10 deg^2
rms: 0.2 uJy
t_{point} ~ 100 hr

~1 deg^2
rms: 0.05 uJy
t_{point} ~ 1700 hr

mock GOODS-N
(Coogan, Sargent et al., in prep.)



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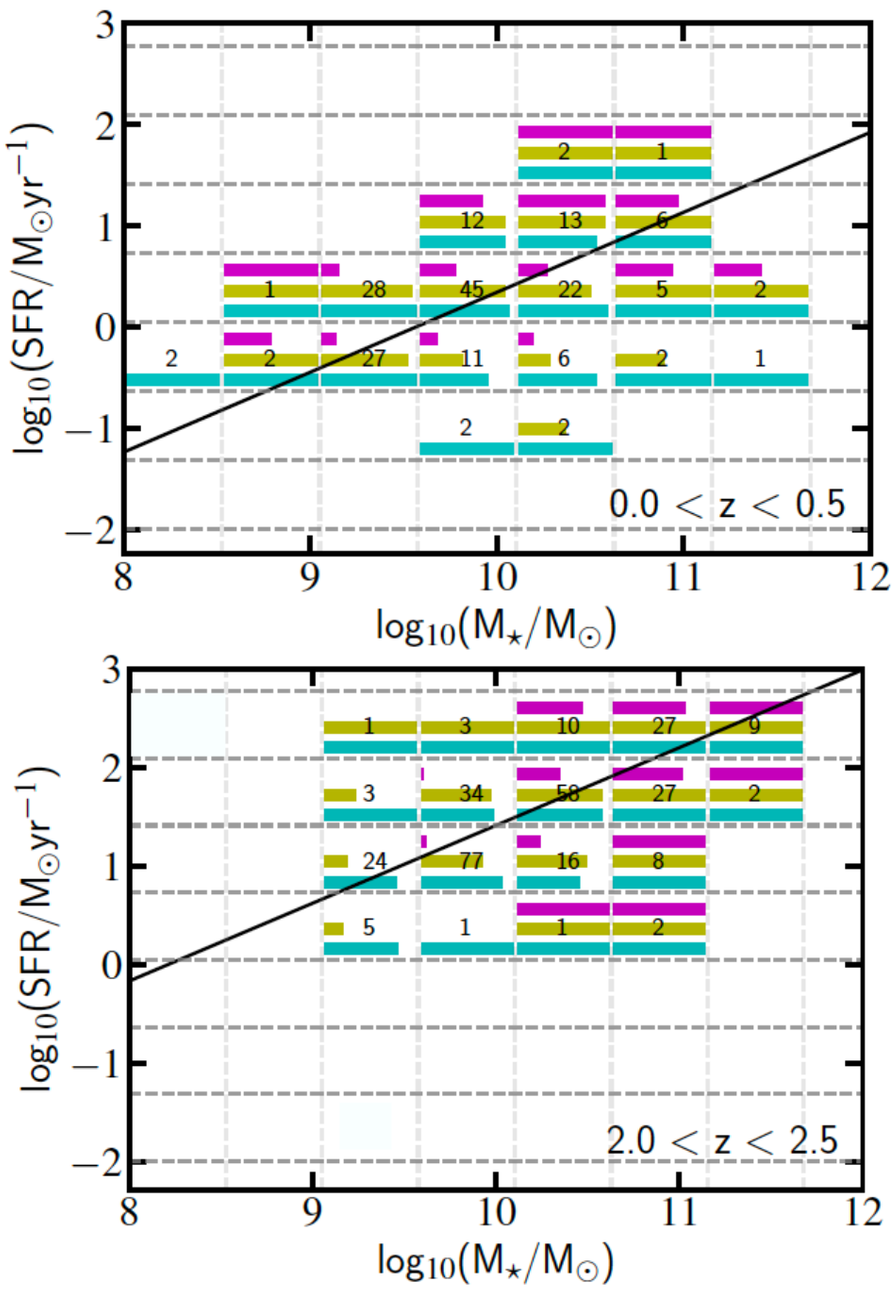
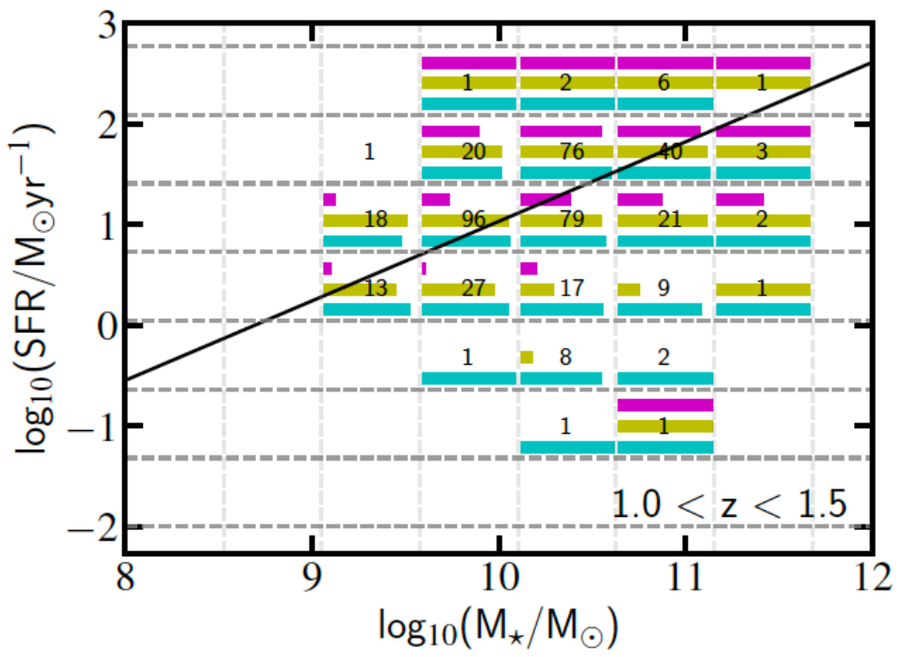
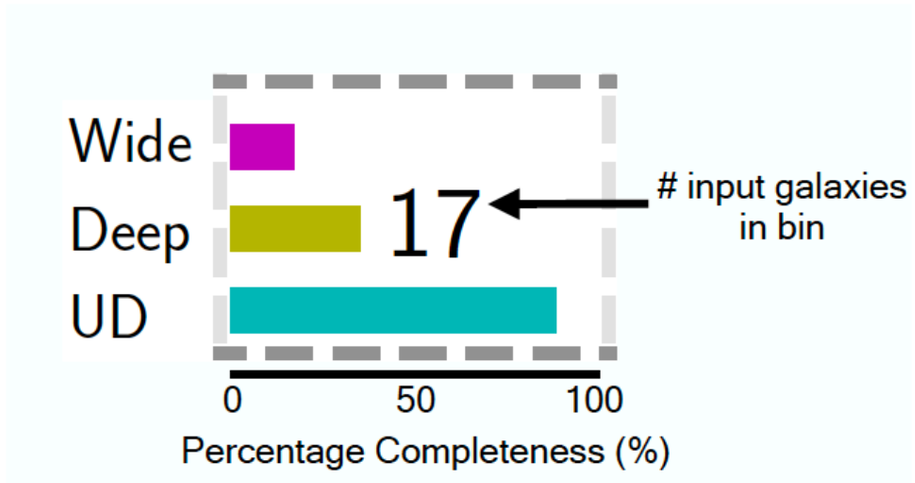






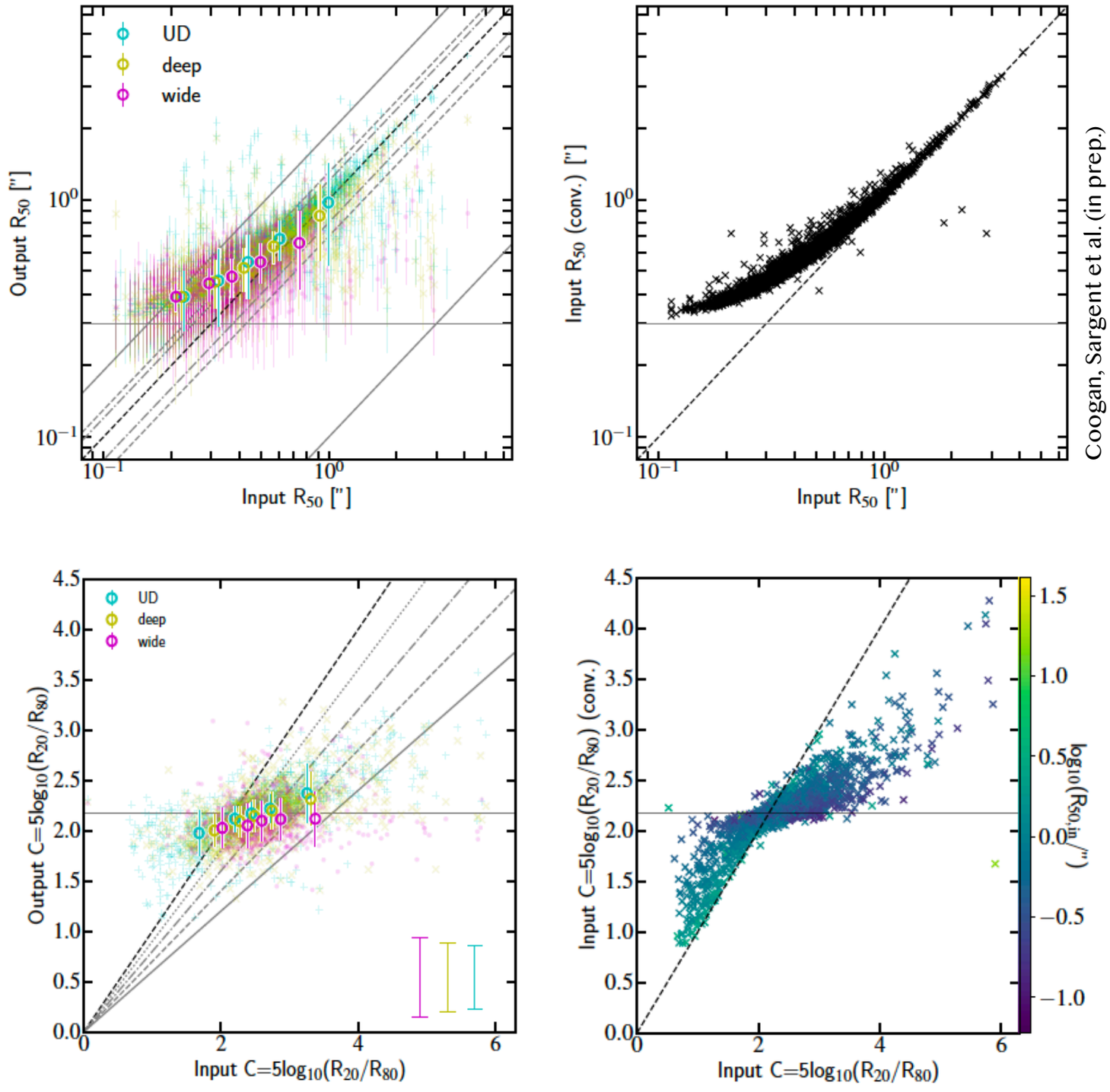
Coogan, Sargent et al. (in prep.)

STAR-FORMING GALAXIES AT COSMIC NOON

Recoverability of spatially resolved morphologies

Large numbers of galaxies at sub-arcsec resolution in band 2 images with SKA1 awaiting morphological classification…

E.g., via CAS parameters as a basis for PCA. How feasible is this?



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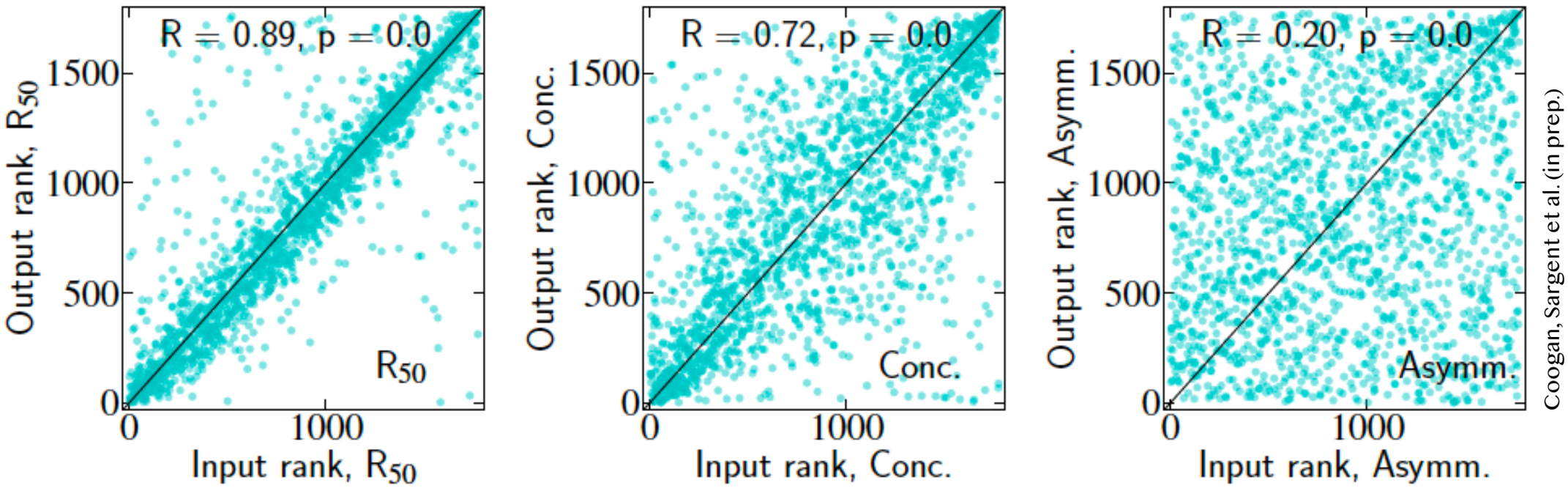


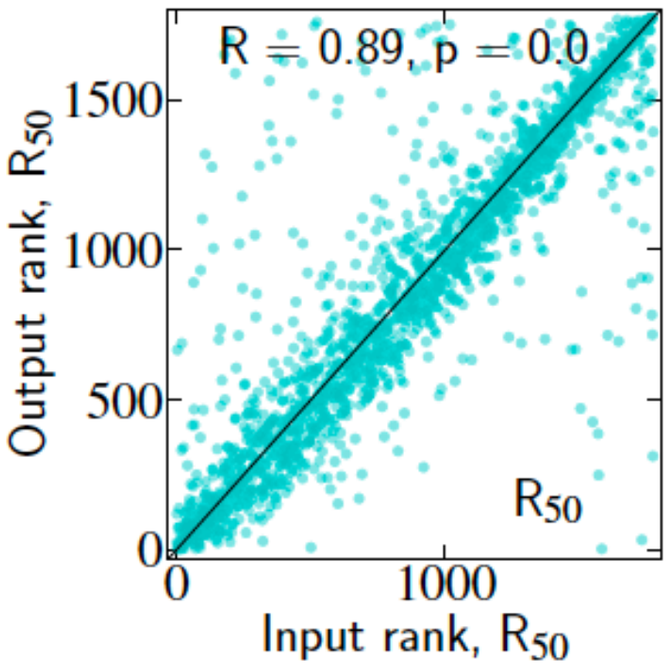
Coogan, Sargent et al. (in prep.)

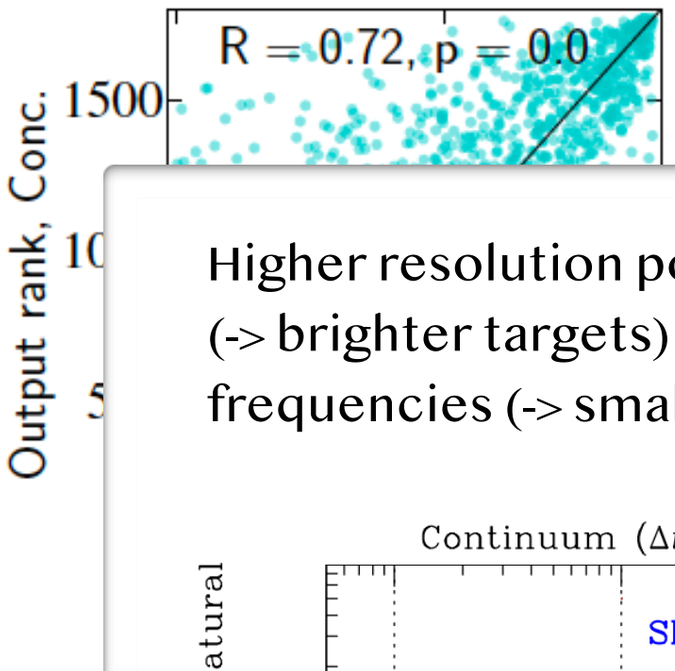
In the parameter space where we are able to rank galaxies in terms of their flux, size and concentration in the "workhorse" SKA1-MID extragalactic continuum surveys we can study the

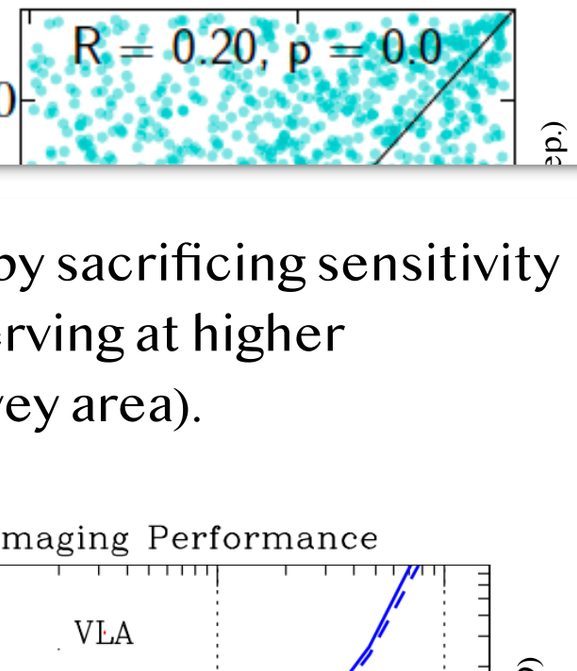
- growth of galaxy disks
- relative importance of centrally concentrated starbursts vs. extended star-formation (also: separation of AGN-related emission and star-formation)
- star-formation distributions of quenching galaxies across different environments

STAR-FORMING GALAXIES AT COSMIC NOON

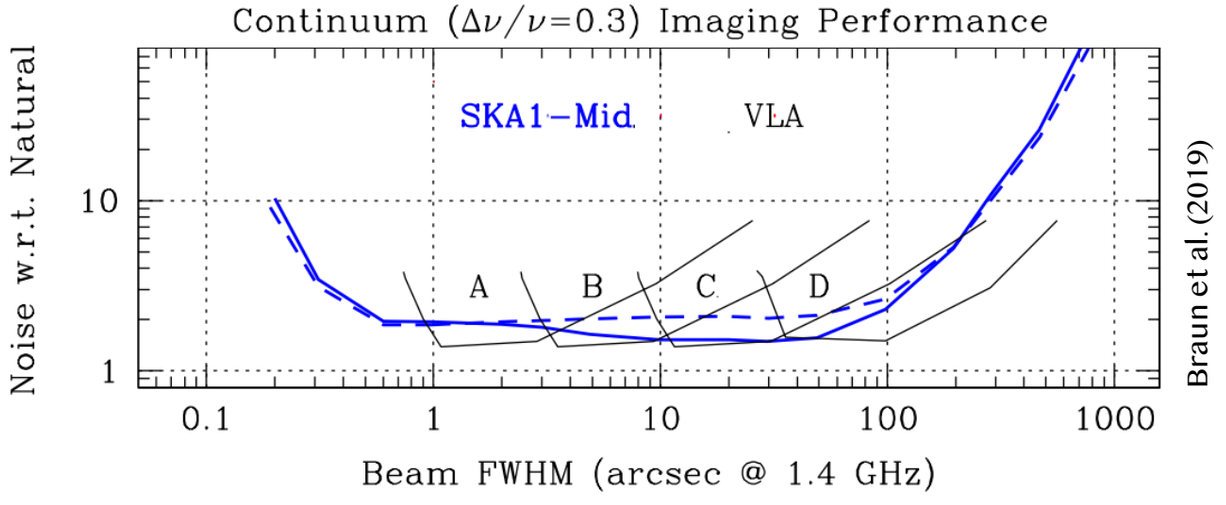
Recoverability of spatially resolved morphologies







Higher resolution possible by sacrificing sensitivity (-> brighter targets) or observing at higher frequencies (-> smaller survey area).



In the parameter space where we a
concentration in the “workhorse” S

- growth of galaxy disks
- relative importance of centrally
  separation of AGN-related emission and star-formation)
- star-formation distributions of quenching galaxies across different environments

STAR-FORMING GALAXIES AT COSMIC NOON

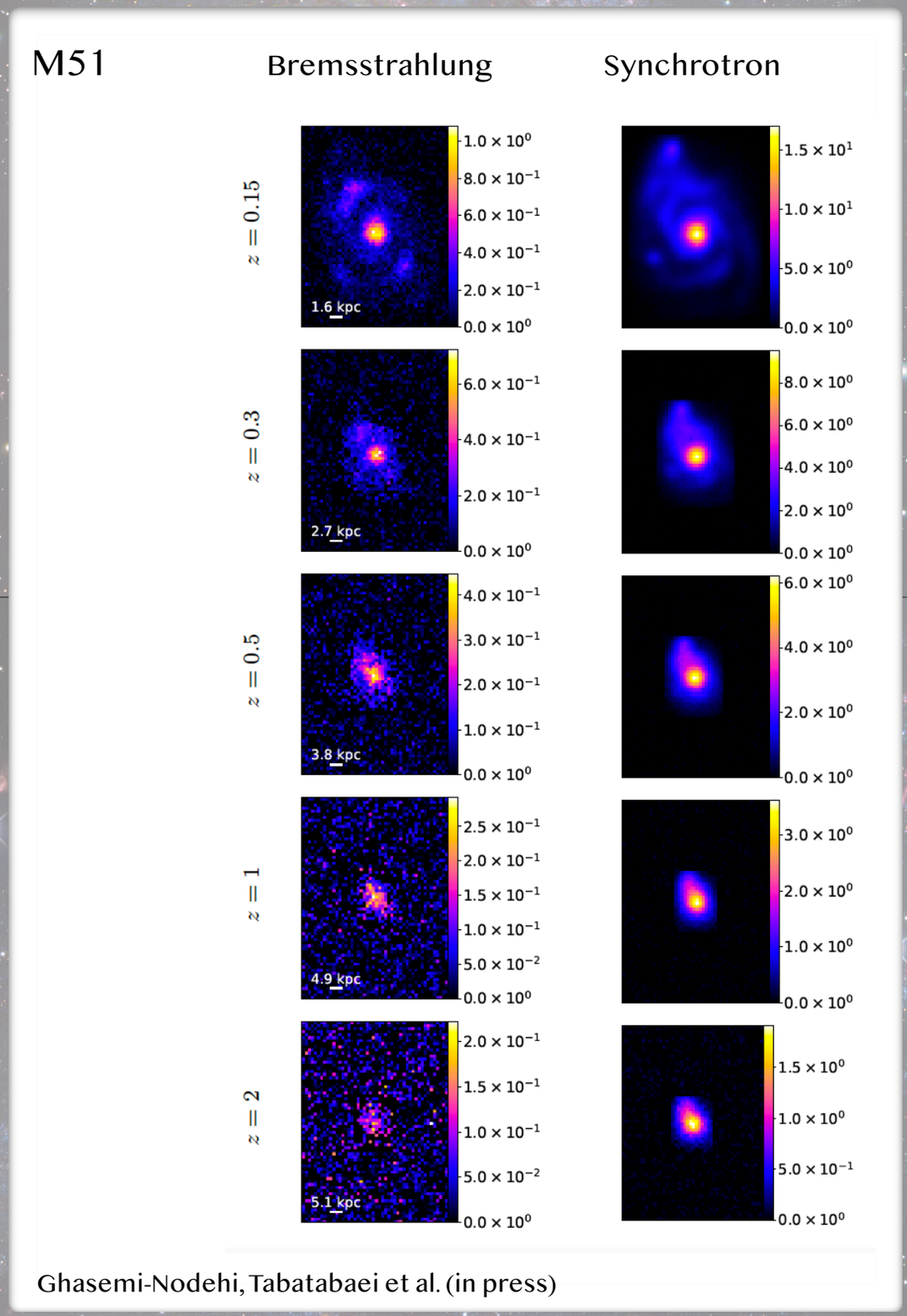
Recoverability of spatially resolved spectral components

M51, NGC6946, M33 (credit: ESA/Hubble Media, APOD)

STAR-FORMING GALAXIES AT COSMIC NOON

Recoverability of spatially resolved spectral components

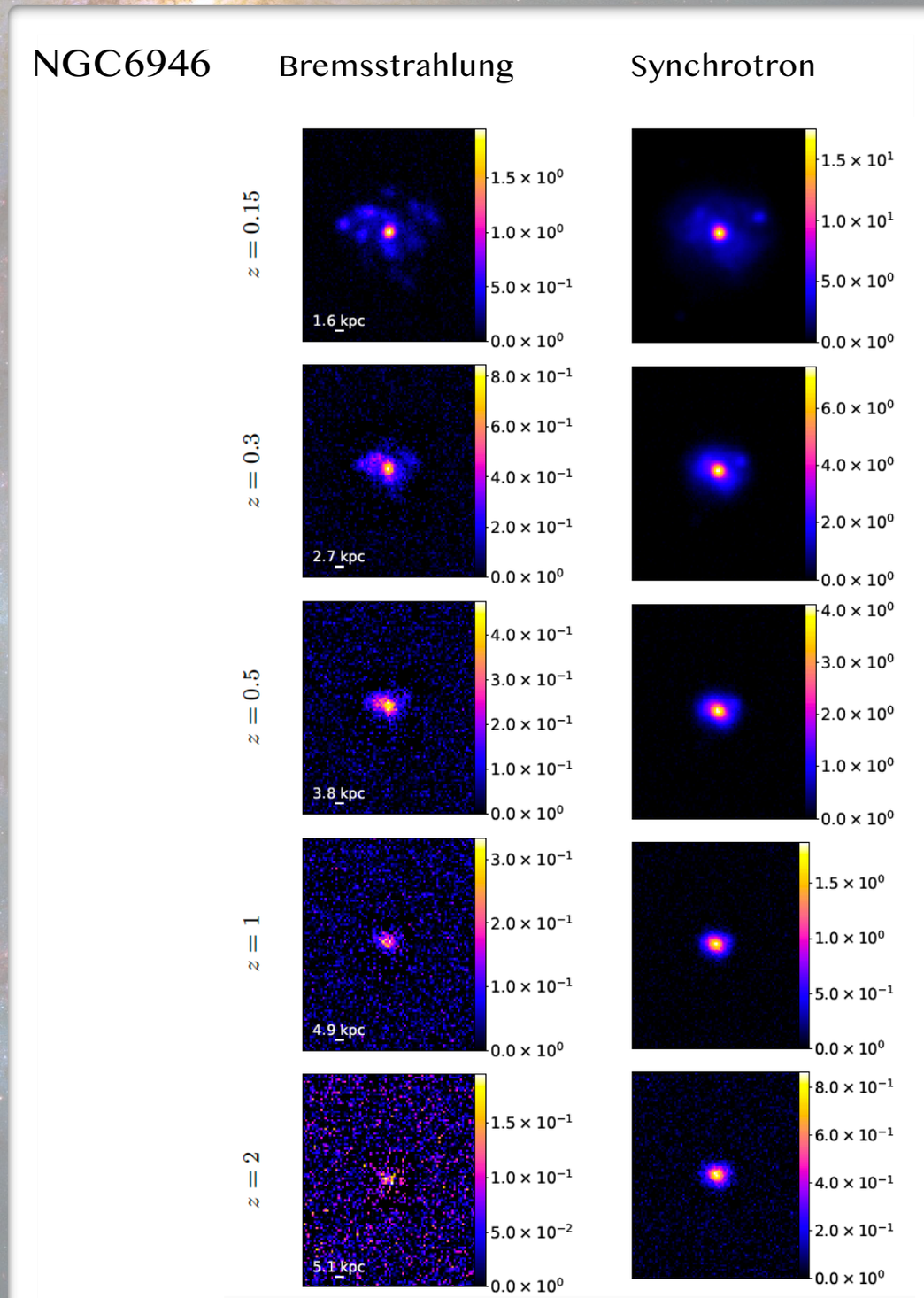
M51, NGC6946, M33 (credit: ESA/Hubble Media, APOD)



Ghasemi-Nodehi, Tabatabaei et al. (in press)

STAR-FORMING GALAXIES AT COSMIC NOON

Recoverability of spatially resolved spectral components



Ghasemi-Nodehi, Tabatabaei et al. (in press)

M51, NG

Summary

1. With SKA1-MID we will for the first time have access to sub-arsec radio morphologies (=dust-unbiased star-formation distributions) of large statistical galaxy samples.
2. Ability to resolve galaxies makes adds complexity to the assessment of survey completeness and recoverability of galaxy properties -> simulations with realistic sources are important!
3. Simulations suggest that for galaxies with Milky Way-like masses (~M* galaxies) it will be possible to study well into the peak epoch of galaxy formation:
   - structural properties providing insight into the star-formation mode of galaxies and their eventual “quenching”
   - balance/distribution of emission mechanisms shaping galaxy radio spectra

THE EXTRAGALACTIC CONTINUUM SWG

- ~130 scientists (15 core group) from 20+ countries (SWG co-chairs: N. Hurley-Walker, M. Sargent)

  Full list: https://astronomers.skatelescope.org/science-working-groups/galaxy-evolution-continuum

- 5 scientific focus groups:

  A. Active Galactic Nuclei and Their Role in Galaxy Evolution (coordinators: I. Prandoni, D. V. Lal)
  B. Star formation history of the Universe (coordinators: M. Jarvis, M. Sargent)
  C. Detailed Astrophysics of Star Formation and Accretion in Local Galaxies (coordinators: A. Alberdi, R. Beswick)
  D. Strong Lensing (coordinator: J. McKean)
  E. ISM & IGM: Structure Formation and Energy Balance (coordinator: F. Tabatabaei)
  F. Galaxy Clusters and Large Scale Structure (coordinator: R. Cassano)