Top: the MeerKAT Telescope
Bottom: region of the Euclid Deep Field South observed with MeerKAT

SKA (precursors) and Euclid Team up:

Exploring the galaxy - halo connection at cosmic noon and beyond

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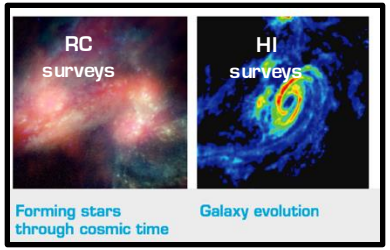
Sintra, 21-25 October 2024

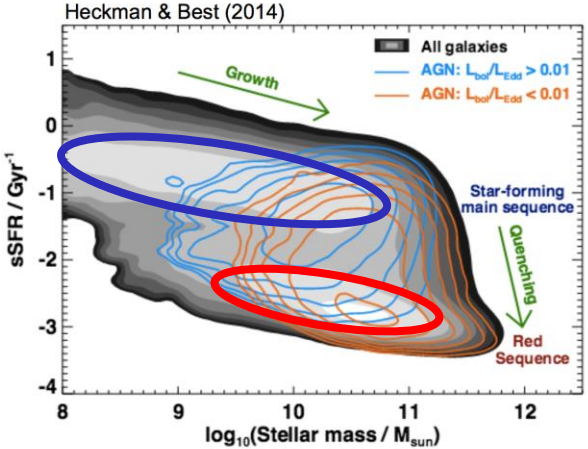
Disclaimer:
Euclid images and details presented in this presentation are all publicly available

A Radio Window on Galaxy Evolution

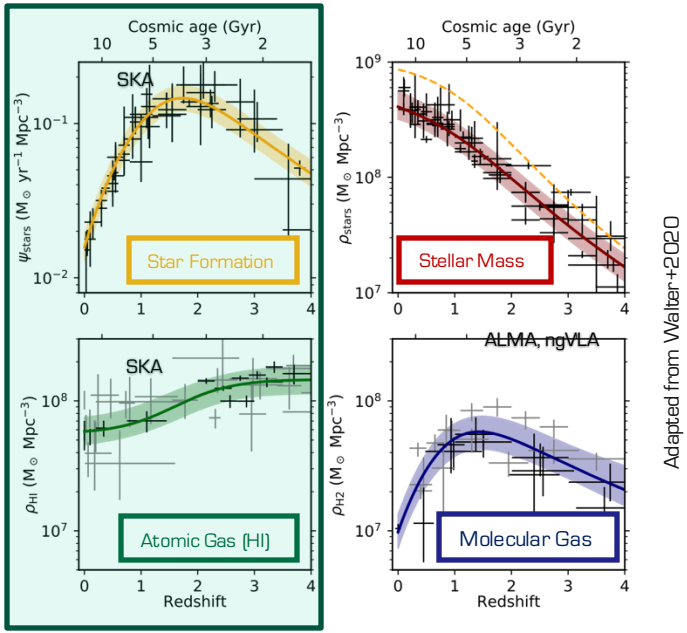


Radio surveys:

1) unique role in probing jetted AGN populations
2) unbiased view of SFG and AGN populations (no dust extinction/gas obscuration effects)
3) unique role in probing HI properties of galaxies and AGN



BUT... Sensitivity matters!

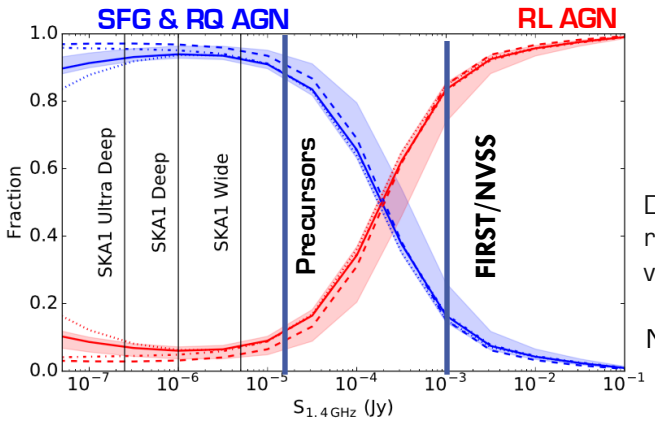


Adapted from Walter+2020

The promise of new generation radio surveys

A radio window on galaxy formation and evolution:

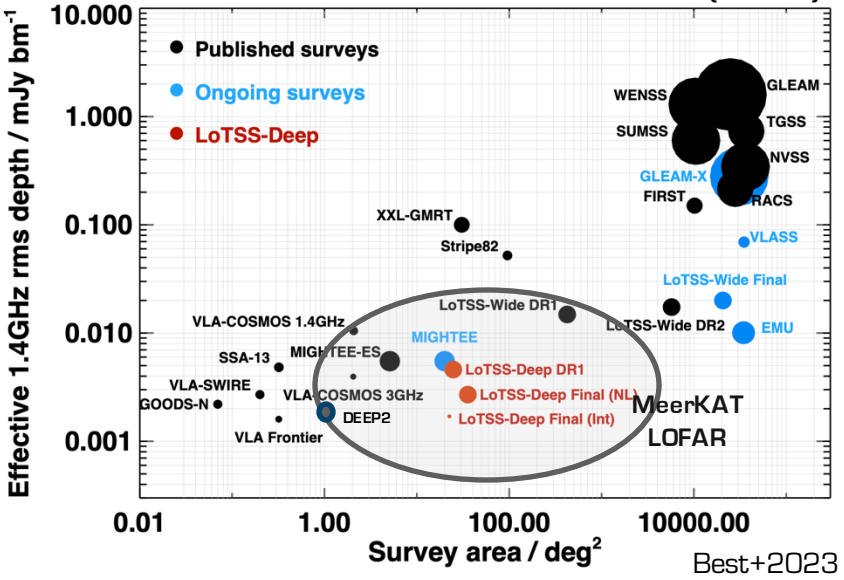
- Jetted AGN populations
- Complete (unbiased) view of SFG and AGN down to RQ regime to cosmic noon and beyond



Distribution of radio sources vs flux density

Novak+2018

(α=-0.7)



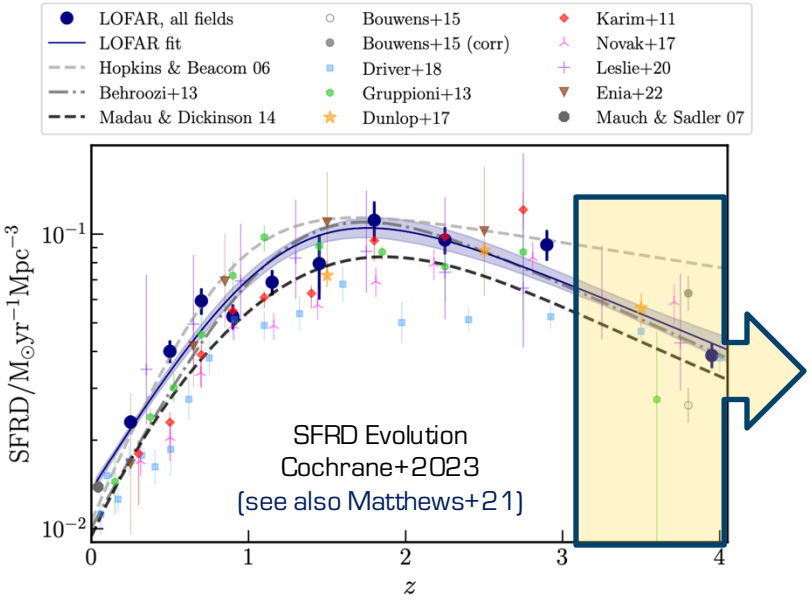
Best+2023

MIGHTEE (Jarvis+17; Heywood+22)
LoTSS-Deep DR1 (Tasse+2021; Sabater+2021]
DEEP2 (Mauch+2020; Matthews+2021)

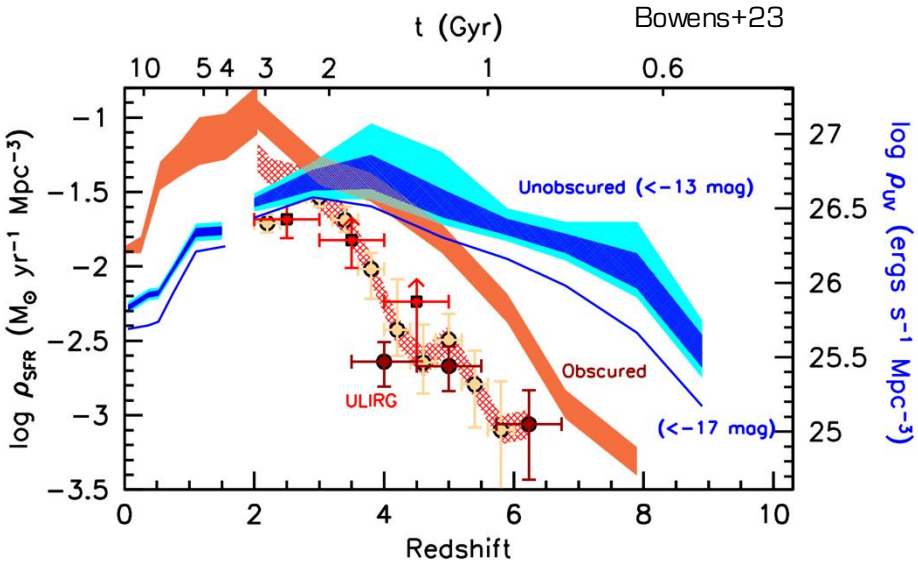
Role of obscured SF in SFRD

LoTSS Deep DR1

- novel observational constraints on radio SFRD
- NB: 10x statistics with respect to COSMOS (2 deg^2)



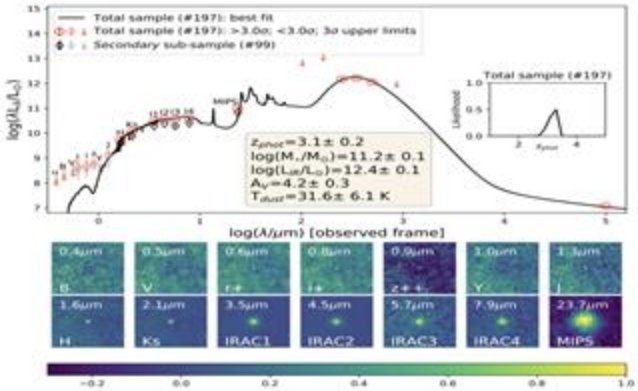
Higher SFRD between z~0 and z~3 than at shorter λ



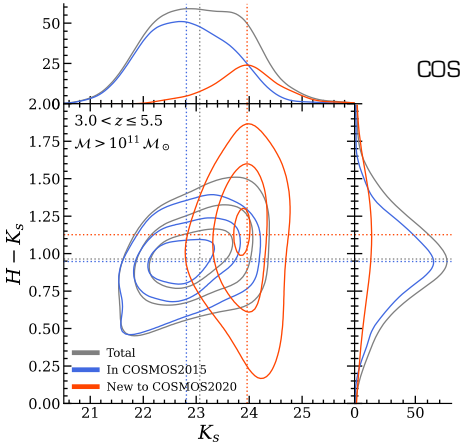
Obscured SF at z>3

NIR-faint / dark dusty massive galaxies at high redshift (deep NIR / JWST + Spitzer)

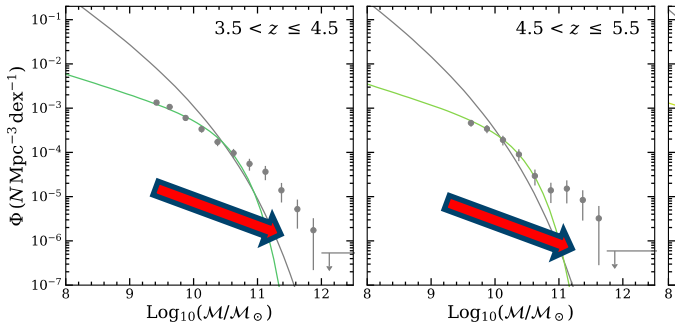
- How important are optically dark / NIR faint galaxies for SFRD at z >3 ?
- Are dusty SFGs at z >3, progenitors of massive local early type galaxies ?
- Are they preferentially living in dense environments?



Talia+2021
Enia+22



COSMOS - Weaver+2023



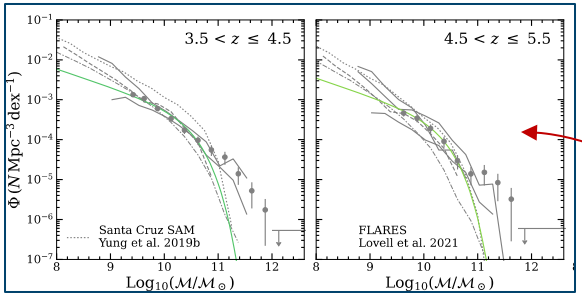
Modeling obscured SF

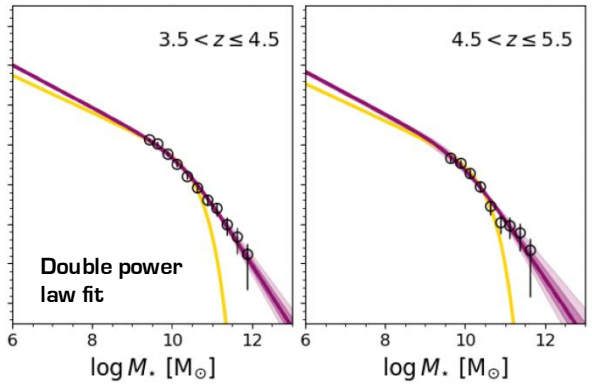
Giulietti+
to be subm.

Novel semi-empirical model for SFGs

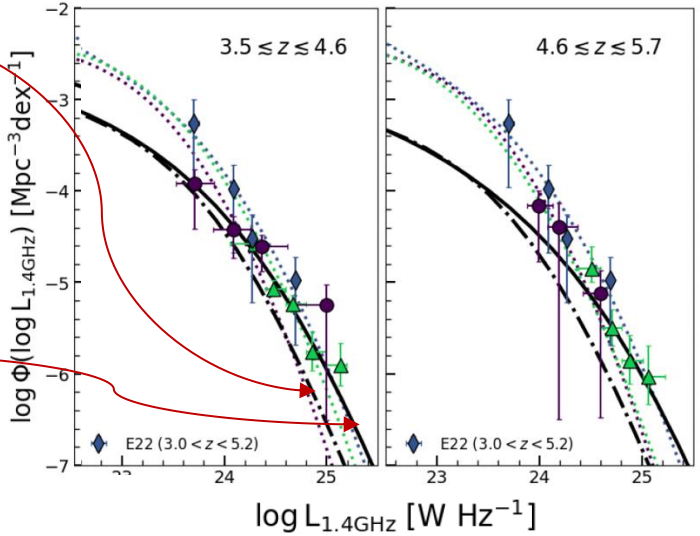
- NIR redshift-dependent galaxy stellar mass functions (Weaver+23; this work)
- galaxy main sequence (Popesso+23)
- SFR-radio lum. Relations (McCheyne+21; Delvecchio+21)

Double Schechter function – Weaver+23





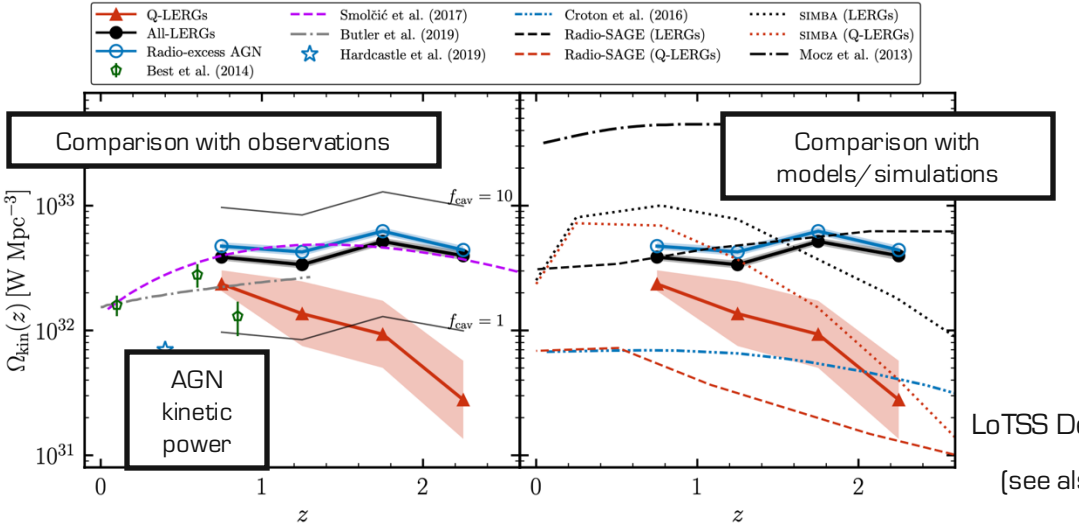
Comparison with Cochrane+23 RLFs

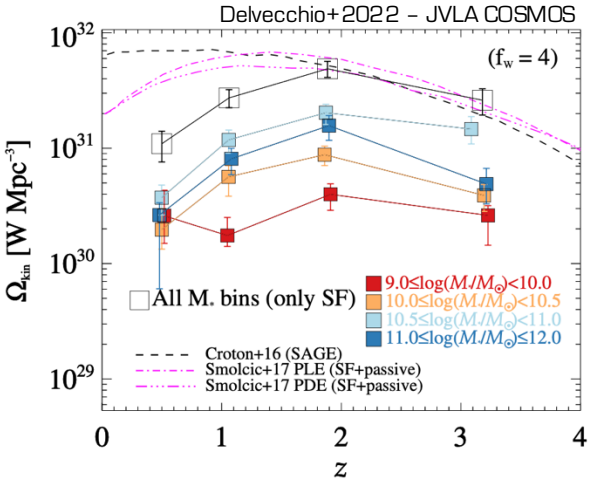


Role of Jetted AGN in galaxy evolution

- Kinetic power density remains flat to $z>3$ over a range of masses
- SFG become the main radio AGN hosts at $z>1$
- first constraints to simulations

- Is jet-induced feedback relevant also at high-z and low stellar/halo mass?





LoTSS Deep - Kondapally+2023

(see also Slaus+2024)

The added value of Euclid

Euclid launched 2022: wide survey (≳ 14k deg^2) + three deep fields → 1 mag deeper

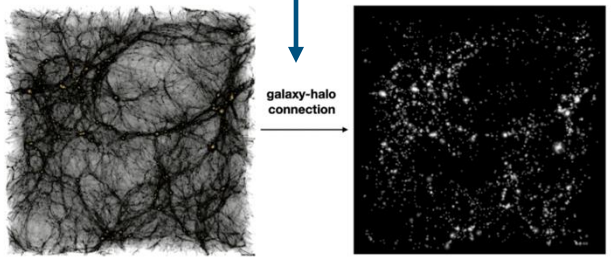
- **Multi-band Photometry:** IYJH + ugriz from ground-based telescopes
- **Multiple observations** (medium/deep fields)

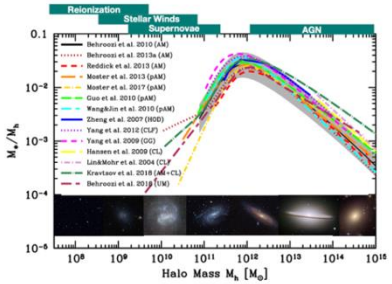
→ **source ids, SED fitting → photo-z, host galaxy properties, …**
→ **variability → AGN duty cycles**

- **VIS near-HST quality** (0.2" PSF): **Weak lensing**
- **Slitless Spectroscopy:** optimized for Hα line over 1<z<2 range
  - Hα line over 0.4<z<1.82
  - Multiple em. Lines over 0.89<z<2.69
  - SFR (Hα), metallicity (Oxygen lines, blue grism)
  - resolved spectra
  - line ratios (0.89<z<2.69)→ AGN id. and classification
  - access to Lyα line at z>6 → probe EoR

→ DM halo properties
→ reconstruction of LSS at cosmic noon

Wider cosmological context





Wechsler & Tinker 2018

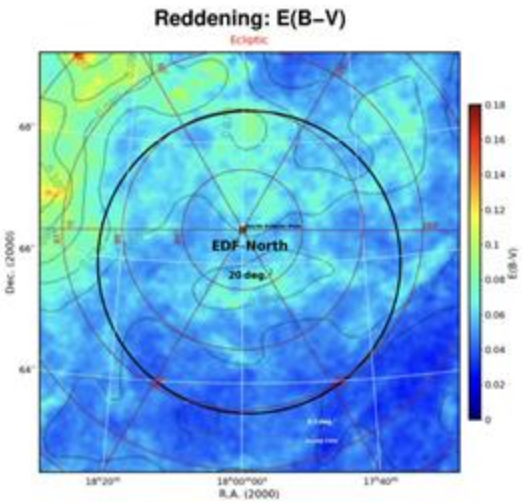
Euclid Deep Fields (EDF)

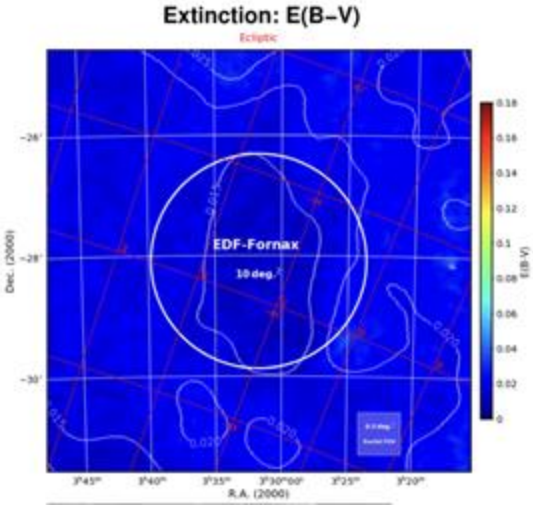
Euclid will complement the wide survey ($\gtrsim$ 14k deg^2) with three dark fields visited multiple times over 6 years 2023-2029 (calibration purposes) → 1 mag deeper than wide survey

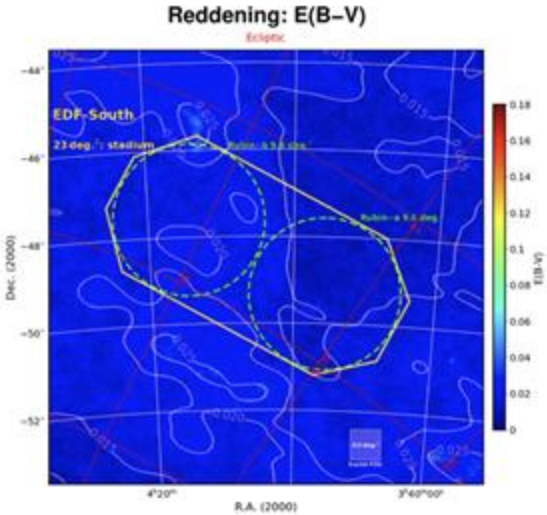
- ❏ EDF North (RA 18h; Dec. +66°; NEP): 20 deg^2 (40 visits)
- ❏ EDF Fornax (RA 3.5h; Dec. -28°; E-CDFS): 10 deg^2 (52 visits))
- ❏ EDF South (RA 4h; Dec. -48.4°): 23 deg^2 (45 visits)

} **53 deg^2**

credits: ESA/Euclid Consortium

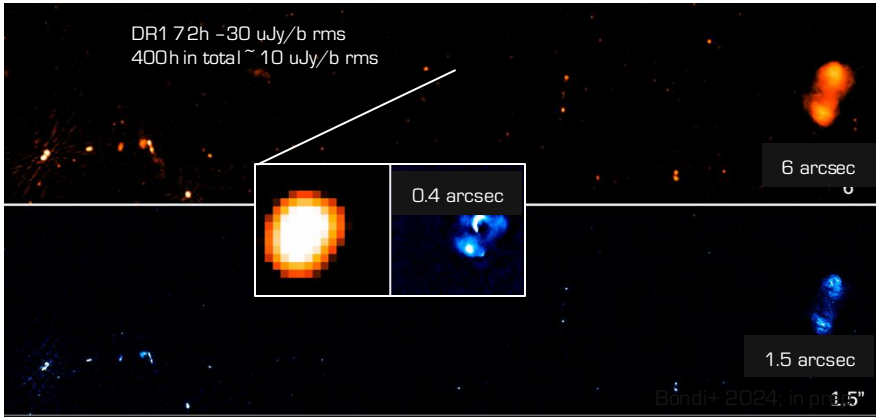


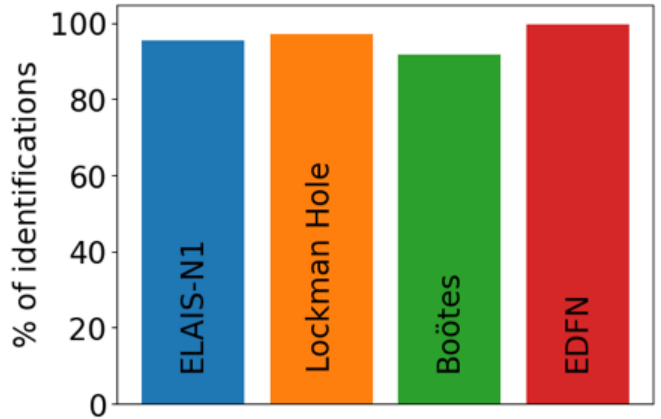




EDF-North @ LOFAR

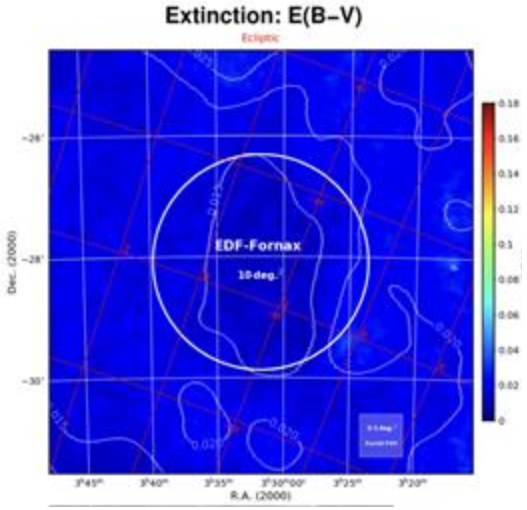
- **EDF North** – observed by LOFAR: LoTSS-Deep (400h in total)
- **10 deg2** (Bondi+ 2024) – DR1 70h
- **Int. baselines** (Bondi+in prep.) → down to 0.3" resolution (Euclid match)
- **Optical identifications and photo-z** (Bisigello+ in prep.)

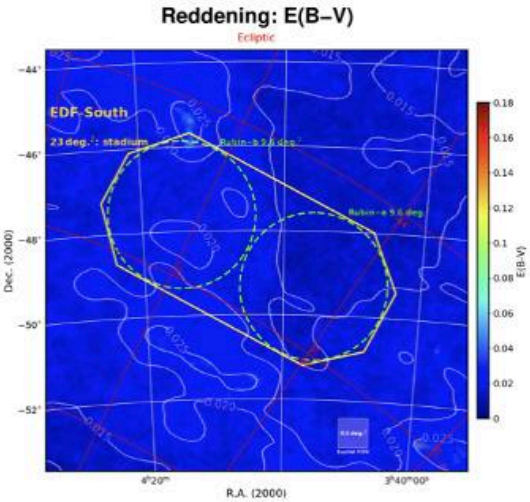




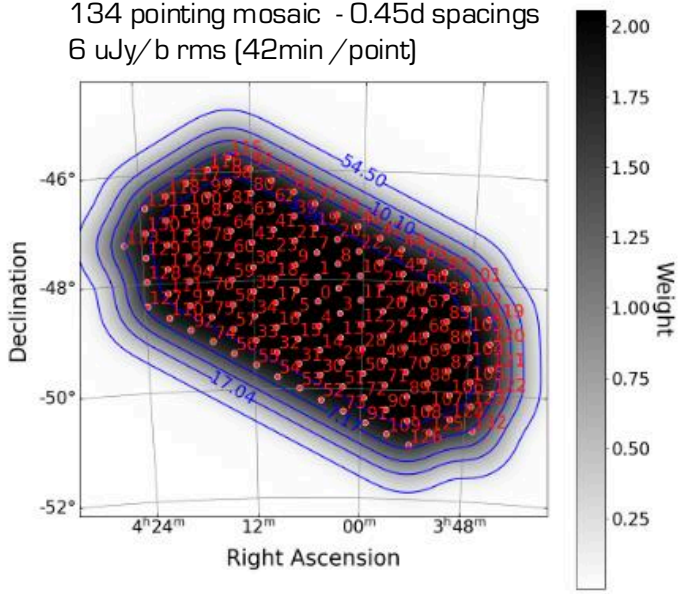
Euclid Deep Fields @ MeerKAT

- **EDF-Fornax** – observed by MeerKAT: MIGHTEE L-band (Jarvis+2017) – **8 deg2** / LADUMA U-Band (Blyth+ 2016) – **4 deg2**
- **EDF-South** – observed by MeerKAT: PI project (Prandoni+ in prep.) – **23 deg2 [118h allocated for a pilot survey]**





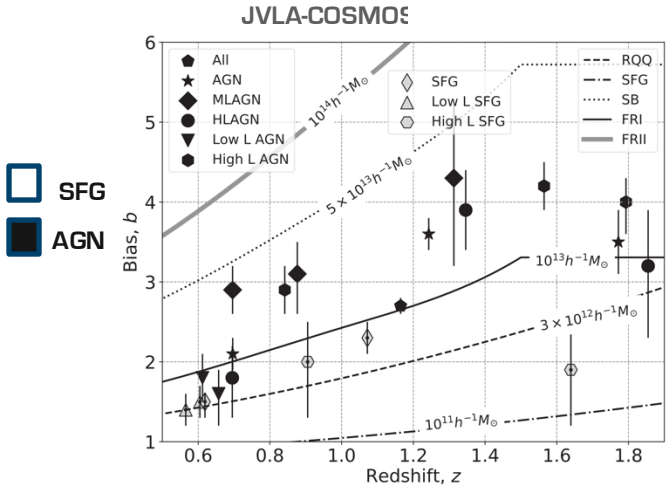
134 pointing mosaic - 0.45d spacings
6 uJy/b rms (42min /point)



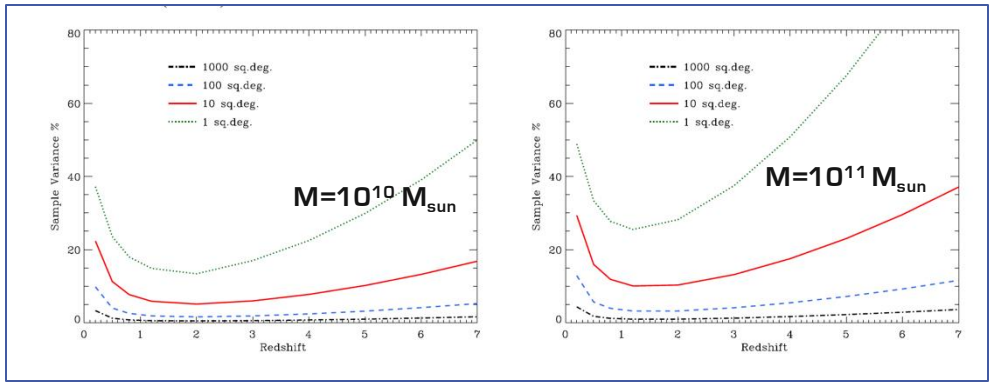
Added Value of EDF-South

- **Largest (23 deg^2) and only one fully surveyed at radio band**
  - ➢ doubles Euclid/Radio Joint Deep coverage (EDFN~10 deg^2; EDFF~8.3 deg^2
  - ➢ essential for multi-parameter characterization (mass, SFR, dust, AGN type, halo mass…) at cosmic noon
  - ➢ Rare/high-z populations (sample variance)

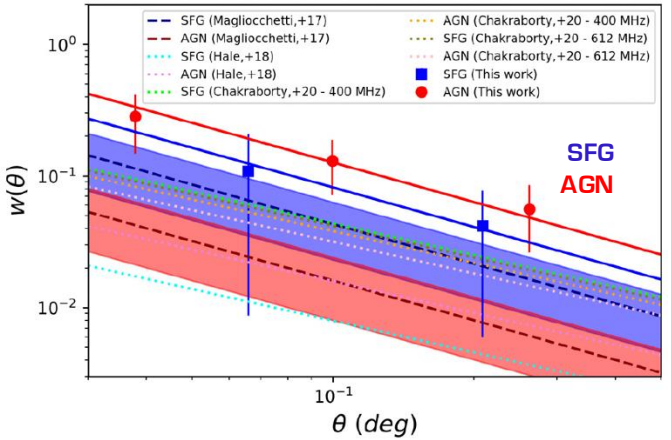
- **Large connected area: EDFS ~ 95 x 210 Mpc comoving at z=1.75**
  - ➢ trace LSS and clustering properties of selected populations at different redshifts



Jarvis+2015

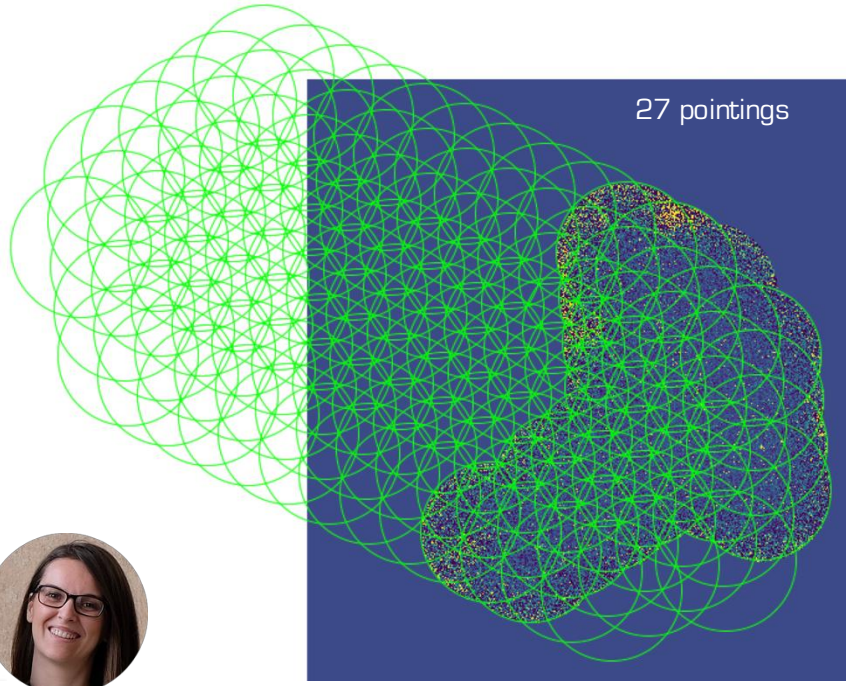


LH –inner 1.4 deg^2) - Bonato+2021



EDF-South @ MeerKAT

- **EDF South** – observed by MeerKAT: PI project (Prandoni+ in prep.) – **23 deg2 [118h allocated for a pilot survey]**



Brienza+ in prep.

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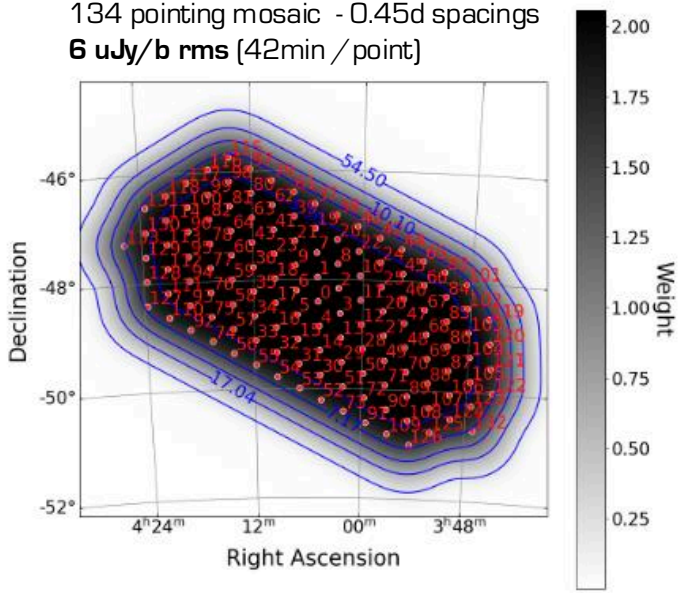

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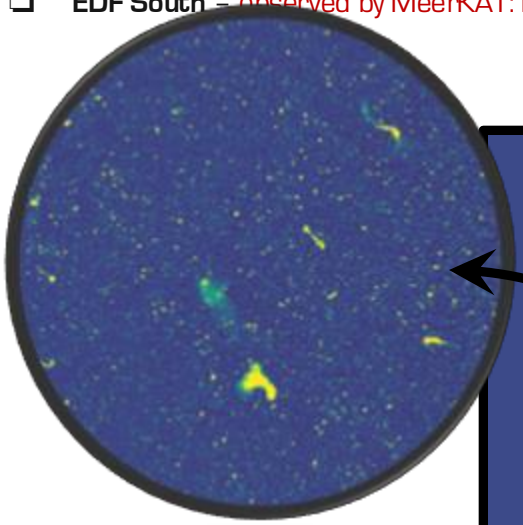
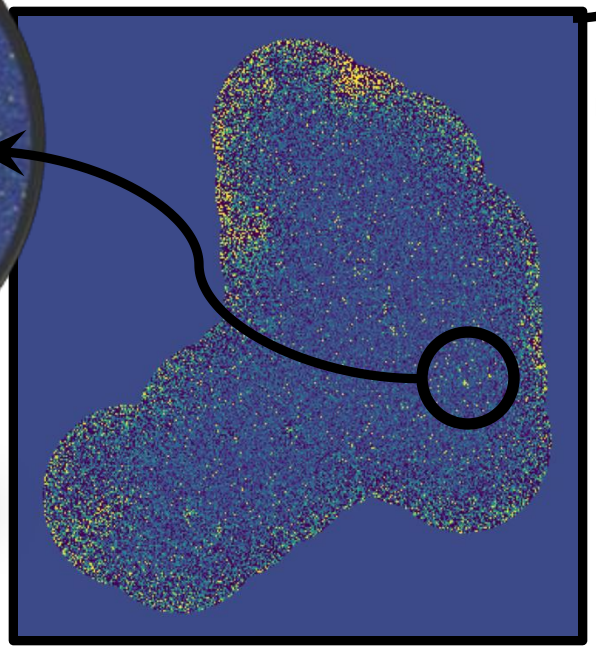
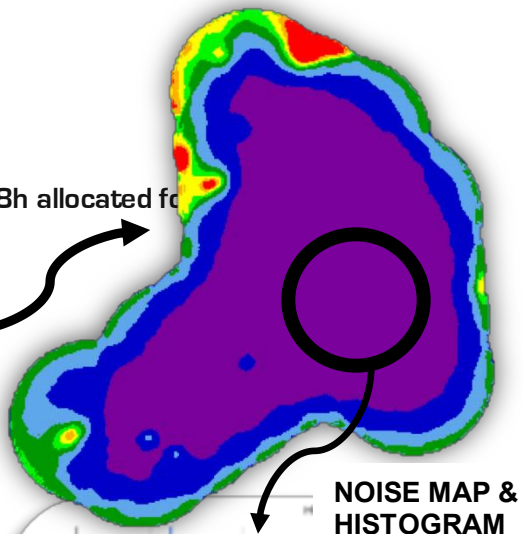
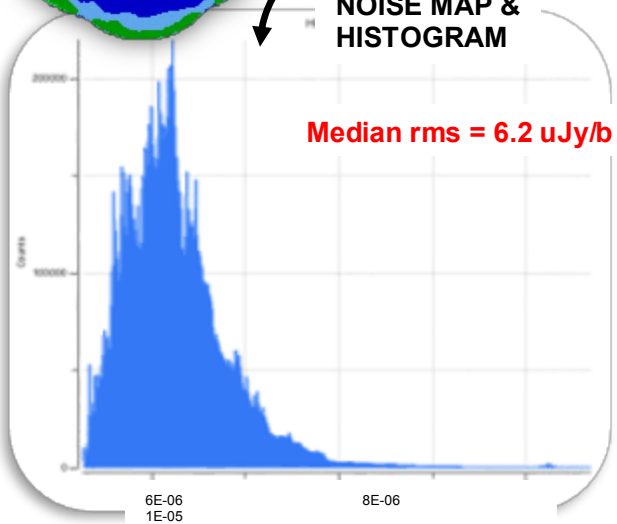






Brienza+ in prep.



Take-home messages

- Deep radio fields unique for galaxy evolution studies:
  - unbiased SFRs & census of dusty galaxies at z>3
  - Role of jet-mode AGN feedback at high-z
  - HI role in galaxy assembly and in fueling/feedback AGN cycle

- Euclid Deep Fields unique for studying link between galaxies/AGN and underlying DM distribution, up to the rarest populations/extreme environments
  - Spectroscopy for 0.4<z<2.7, optimized for 0.9<z<1.8 → accurate gal. redshifts & **LSS at cosmic noon**
  - Near-HST VIS imaging (0.2" PSF) + WL + photo-z provide **Dark Matter halo properties** vs z
  - Near-HST VIS imaging + slitless spectroscopy → **resolved 3D studies z~1**

- Ongoing & planned radio surveys of EDFs with LOFAR/LOFAR 2.0 and Mk/Mk+
  - Stay tuned!