

Status Report of “Extended Wide Imaging with Subaru HSC of the Euclid Sky (WISHES+)”

Subaru Intensive Program S24B-S27A

Ken Osato (Chiba U) on behalf of WISHES+ team

2026/06/18; Subaru Users Meeting FY2026

1. WISHES+ Science with Euclid

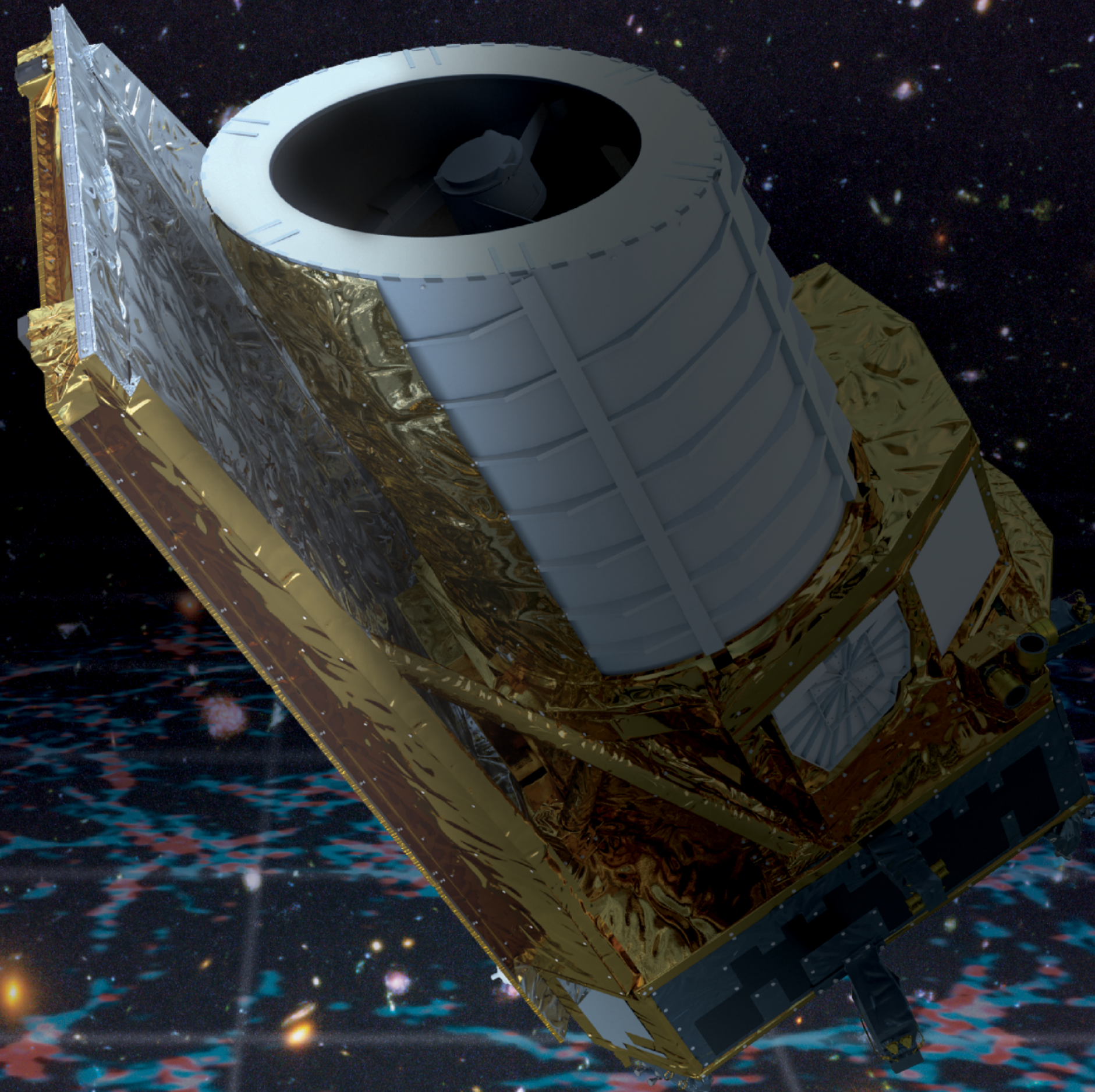
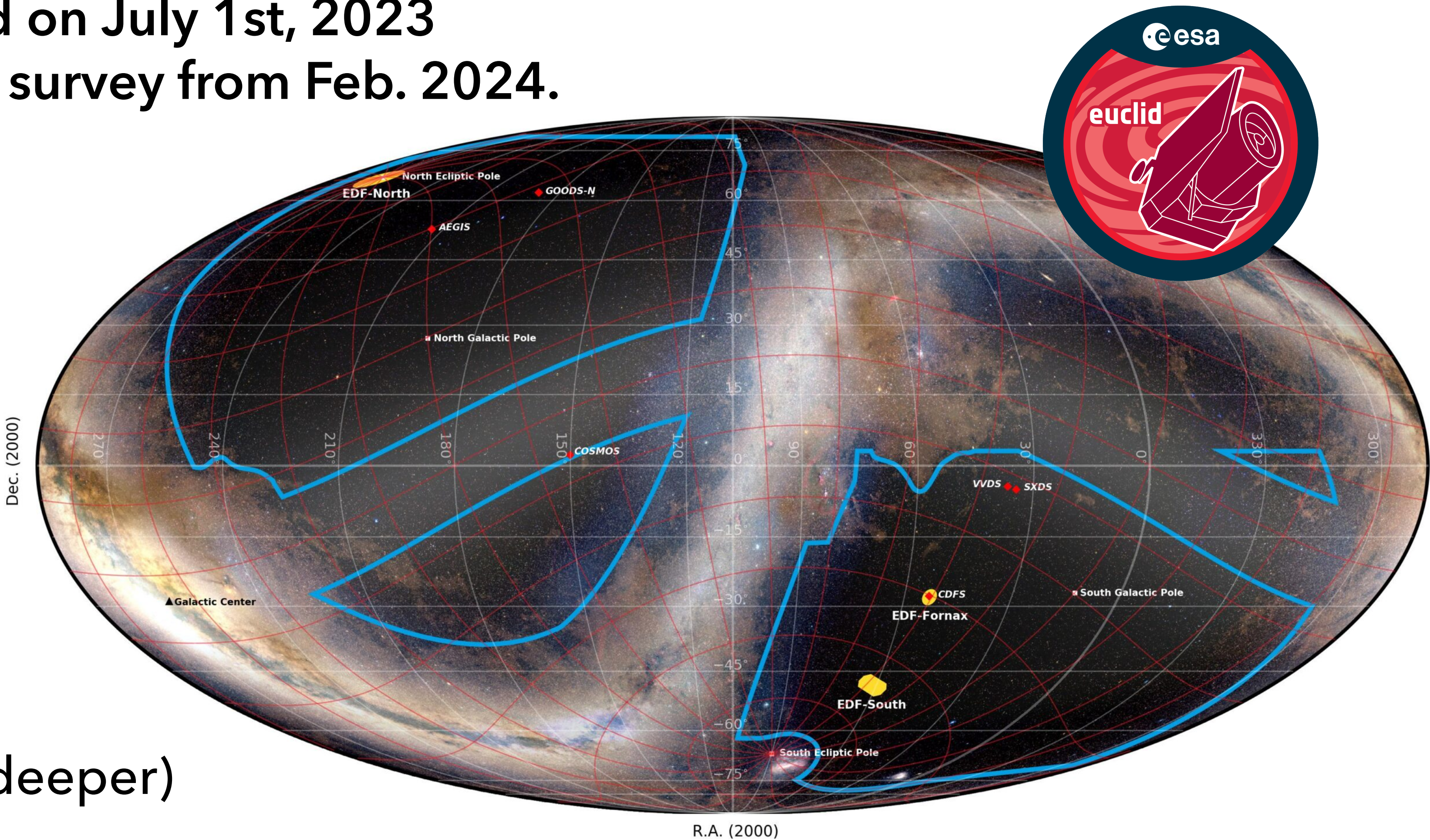


Image credit: ESA

Euclid Survey

◆Euclid satellite was launched on July 1st, 2023
and began 6-year wide field survey from Feb. 2024.

- **Wide Imaging Survey**
(14,000 deg², VIS+NIR)
Core science: *Weak lensing*
- **Wide Spec. Survey**
(14,000 deg², grism)
Core science: *Galaxy clustering*
- **Deep Survey**
(3 patches, 53 deg², 2 mag deeper)



The 15,000 deg.² Euclid Wide Survey, the 53 deg.² Euclid Deep Survey, and the 6 deep auxiliary fields (6.5 deg.²) [Mollweide Celestial]

- Euclid Wide Survey region of interest : 16 Kdeg.² compliant with a 15 Kdeg.² survey
- Euclid Deep Fields : North=20 deg.², Fornax=10 deg.², South=23 deg.²
- Euclid deep auxiliary fields (GOODSN=0.5, AEGIS=1, COSMOS=2, VVDS=0.5, SXDX=2, CDFS=0.5 deg.²)

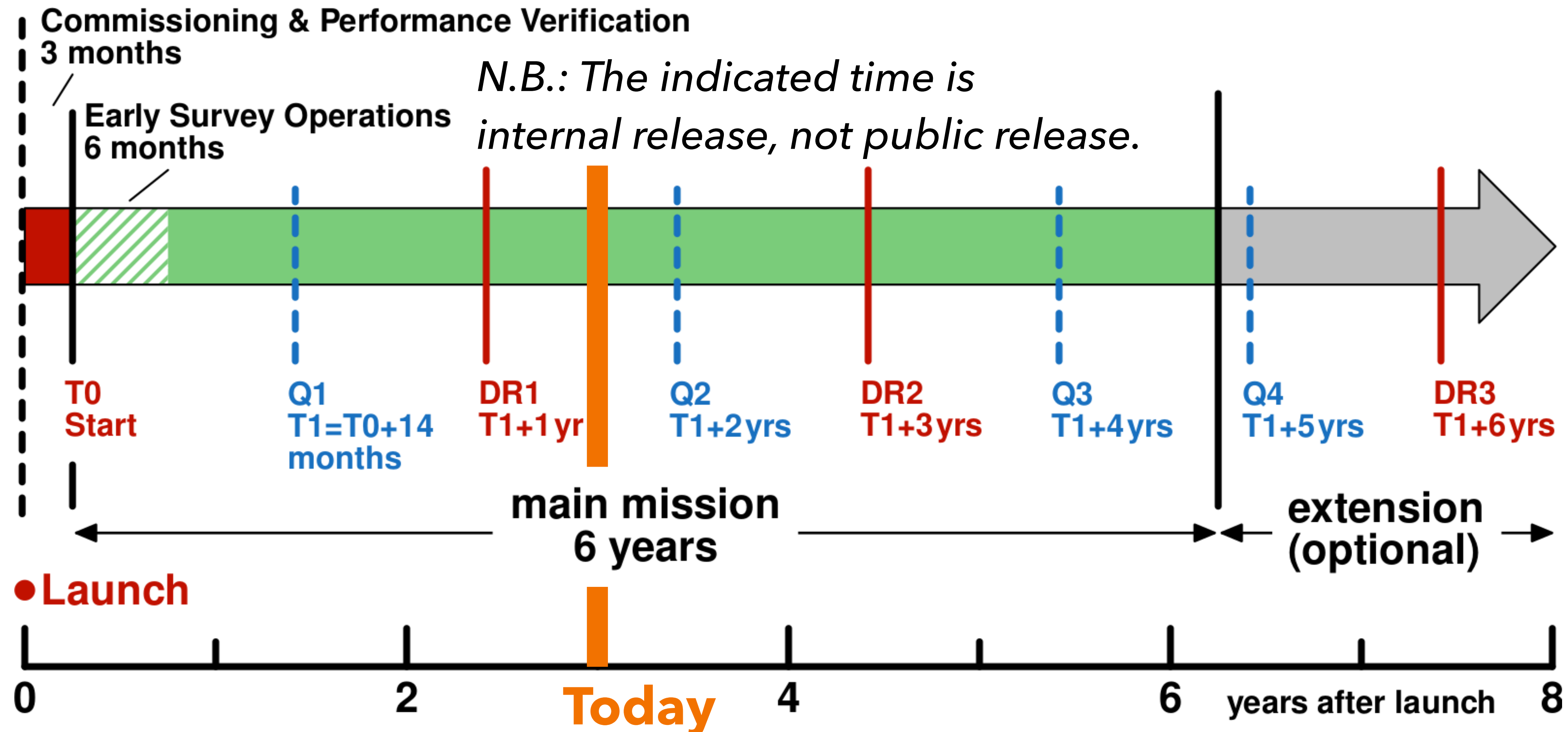
Euclid Deep Field South



Image credit: ESA

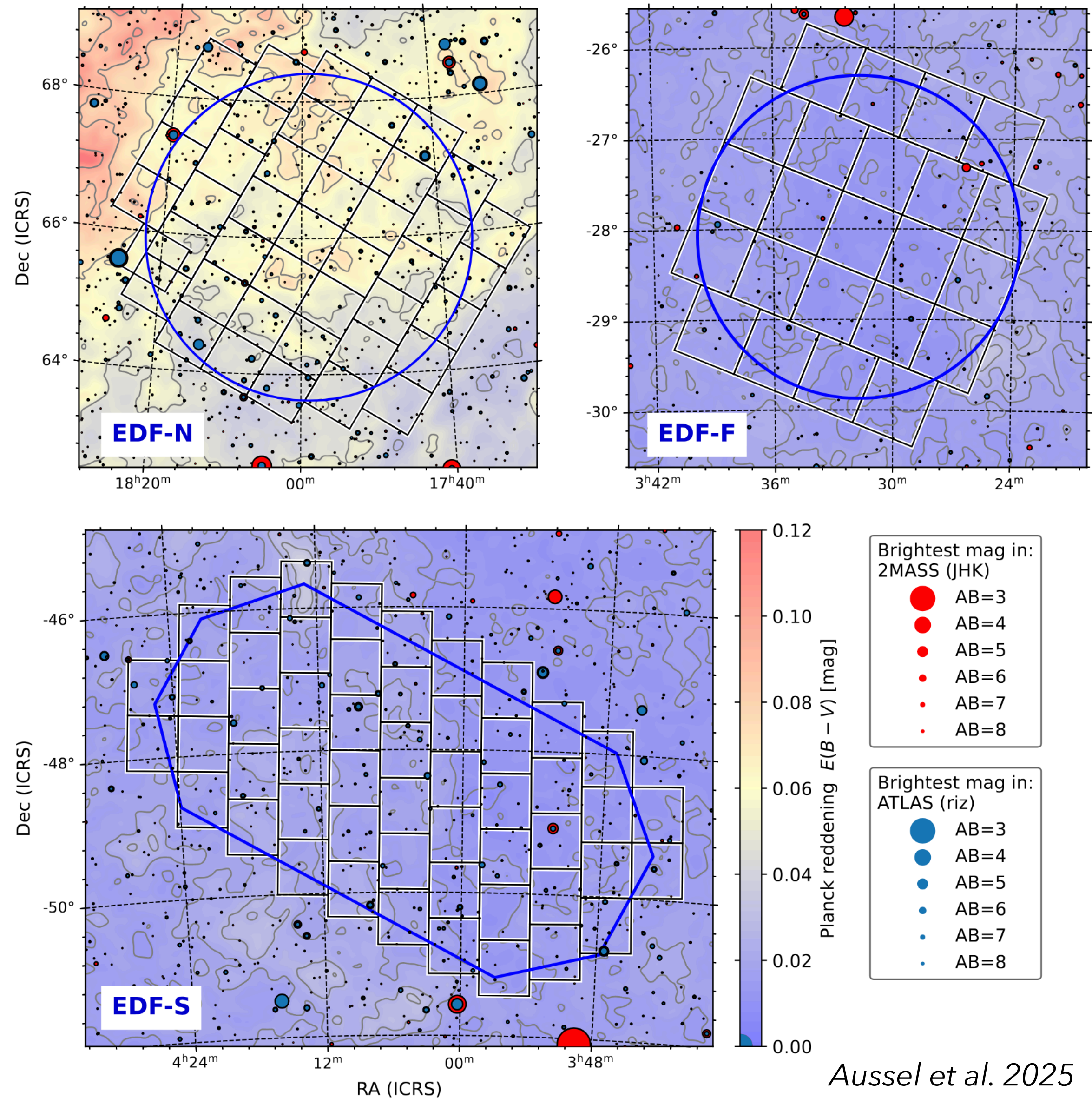
Timeline of Data Release

- Public data release of Q1 (Quick release; 63.1 deg²): Mar 2025
- Public data release of DR1 (~1,900 deg²): Nov. 2026 (1st), mid-2027 (2nd)
 - DR1 includes Euclid Medium Deep survey which overlaps HSC-SSP.



Euclid Q1 Data Release

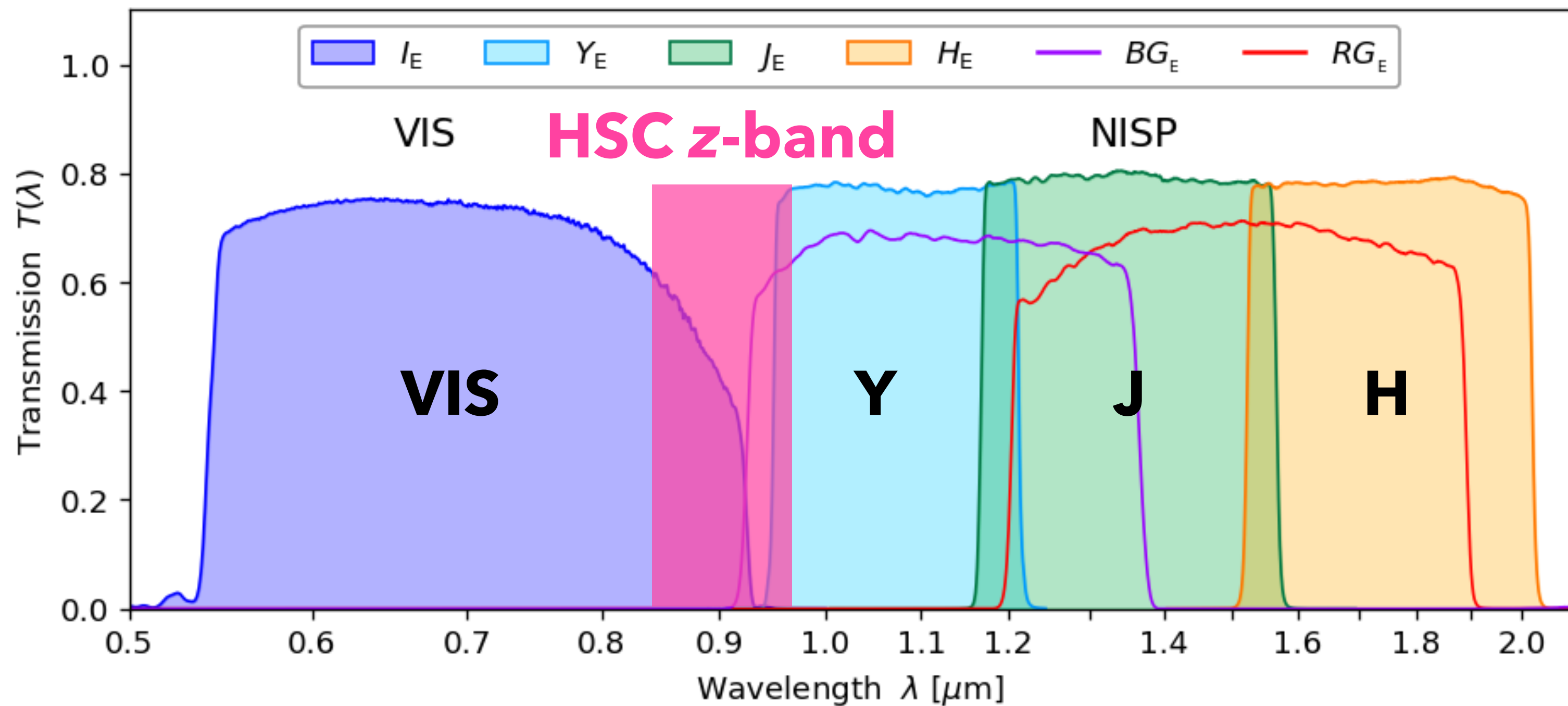
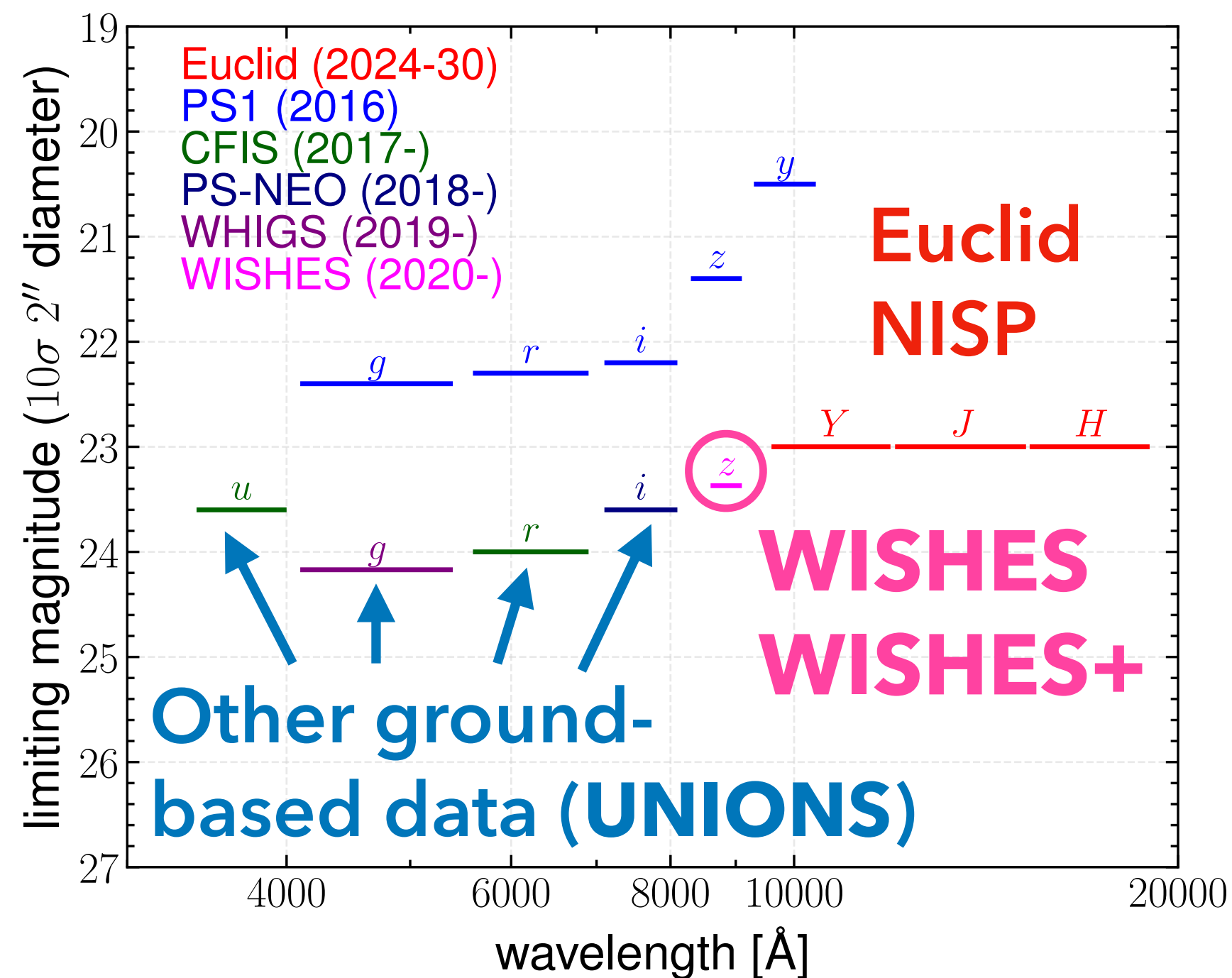
- **Q1 Data Release happened on March 19, 2025**
 - **Single visit (equivalent to Wide layer)**
 - Total area: 63.1 deg²
 - 23 deg² of the EDF South
 - 10 deg² of EDF Fornax
 - 20 deg² of the EDF North
 - **Data product**
 - VIS and NISP image and 2d spectra frames
 - Merged mosaics
 - Ground-based images in g, r, i, z
 - NISP 1d spectra and redshift catalogues
 - Catalogues based on VIS
 - Masks



Aussel et al. 2025

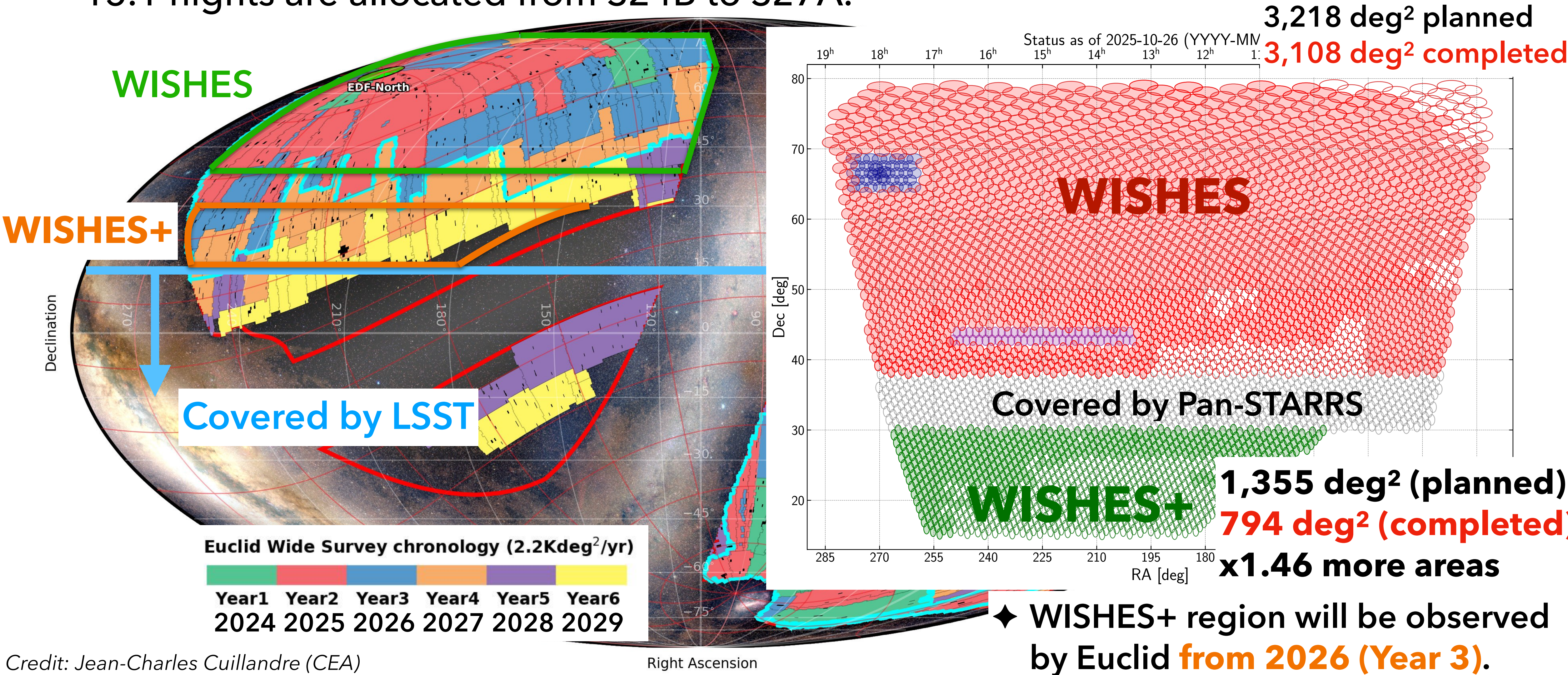
WISHES and WISHES+: z-band Survey for Euclid

- ◆ Wide Imaging with Subaru HSC of the Euclid Sky (WISHES): S20B-S24A (PI: M. Oguri)
 - Provide HSC z-band imaging data covering the northern footprint of Euclid Survey
 - (i) improve photo-z of source galaxies for **cosmic shear science**
 - (ii) search for rare objects such as **high-z quasars**
- ➡ The regions at $+15 \text{ deg} < \text{Dec.} < +30 \text{ deg}$ will not be observed by LSST nor WISHES.
WISHES+ will cover the missing sky and open up a synergy with ALMA.



Survey Footprints of Euclid and WISHES/WISHES+

- ◆ Extended Wide Imaging with Subaru HSC of the Euclid Sky (WISHES+; PI: K. Osato)
15.1 nights are allocated from S24B to S27A.



Credit: Jean-Charles Cuillandre (CEA)

Current Observing Status of WISHES/WISHES+

- WISHES

Planned area (w/ PS1): **3,218 deg²**

Planned area (w/o PS1): **4,400 deg²**

Observed area: **3,108 deg²**

Completion rate:

70.6% (w/o PS1), **96.6%** (w/ PS1)

Completing WISHES (PI: M. Oguri)
is ongoing in S26A.

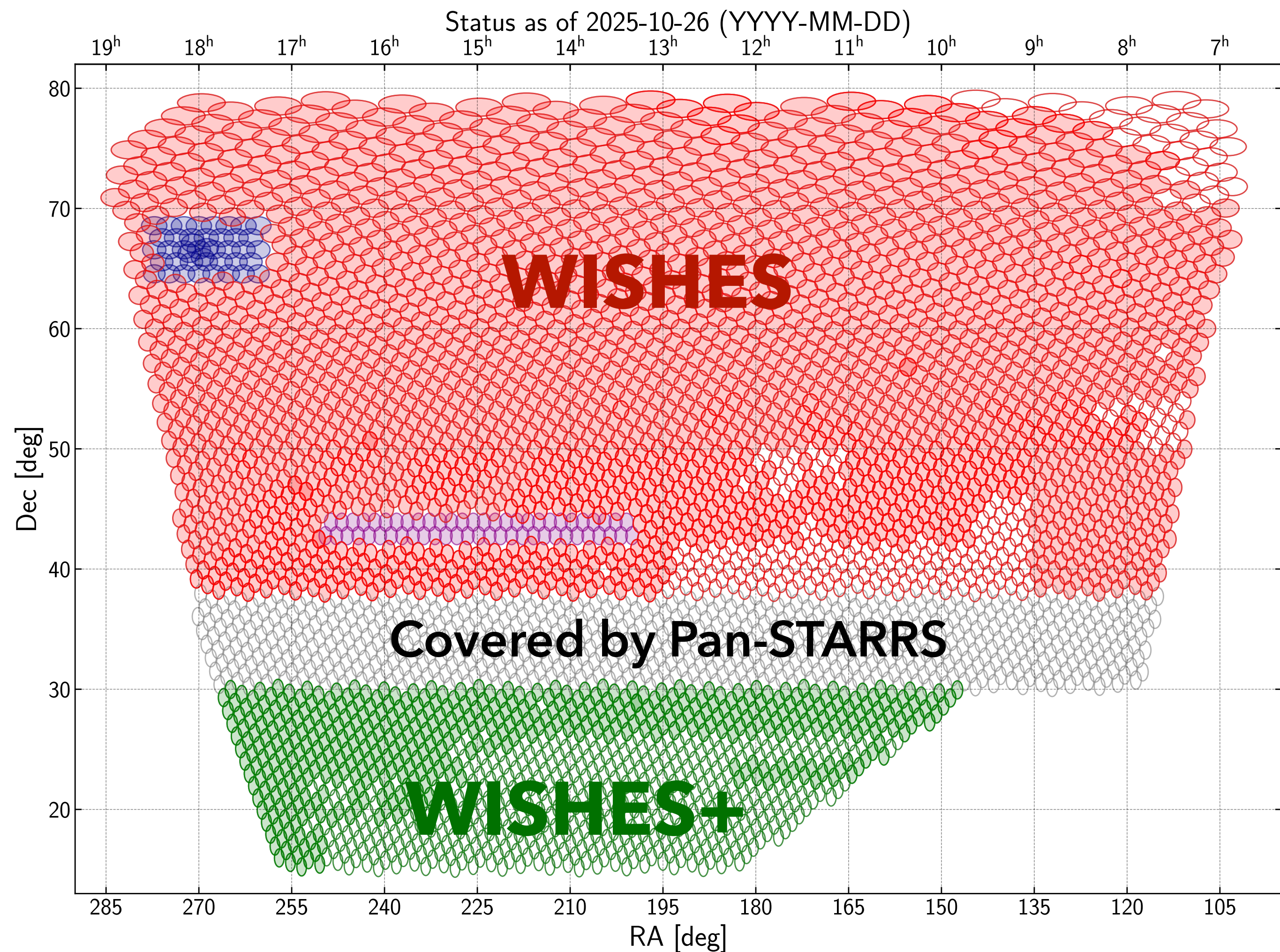
- WISHES+

Planned area: **1,355 deg²**

Observed area (as of today): **794 deg²**

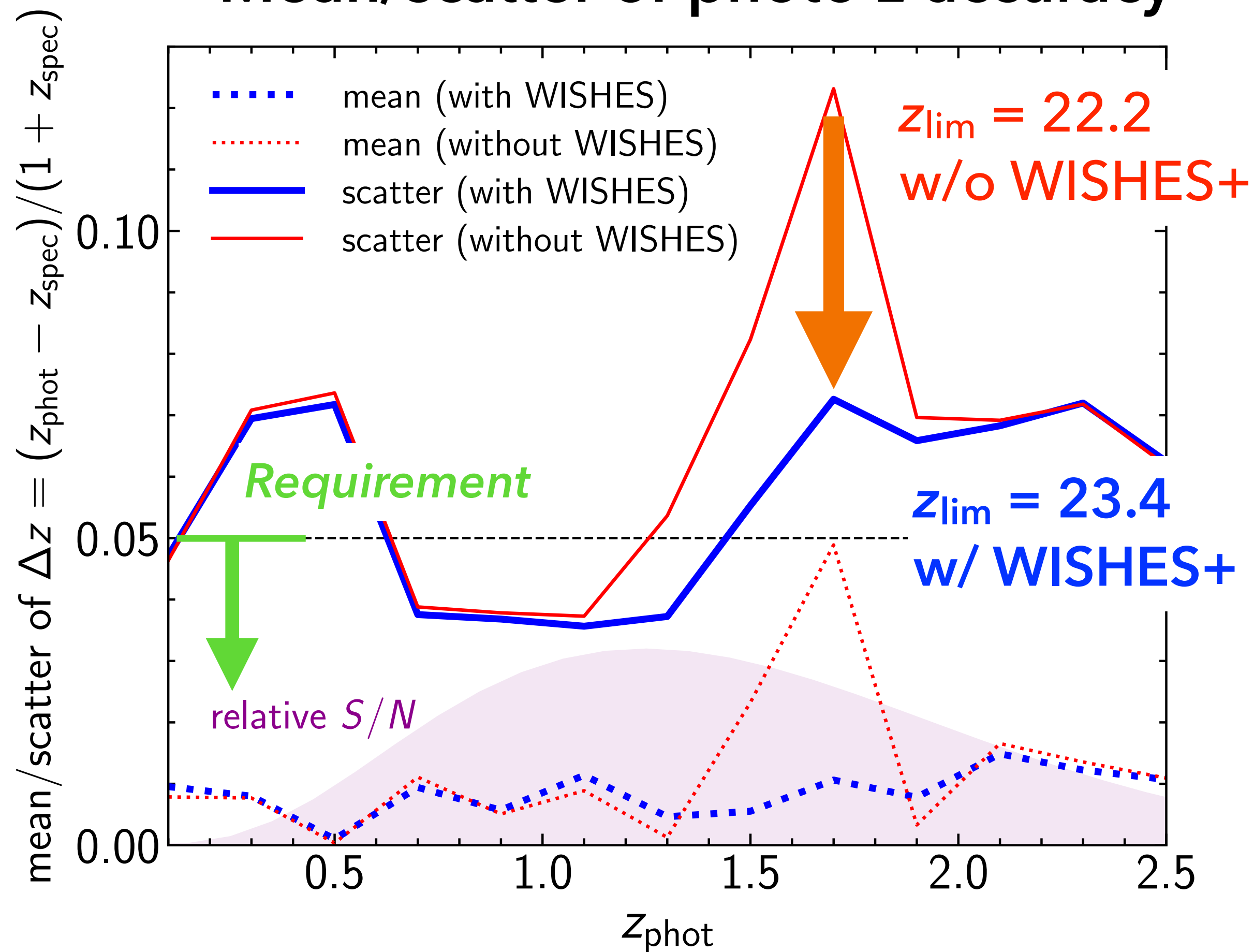
Completion rate: **58.6%**

N.B.: WISHES+ region is more visible
in spring semester. We will request more
nights should be allocated
in spring semesters.

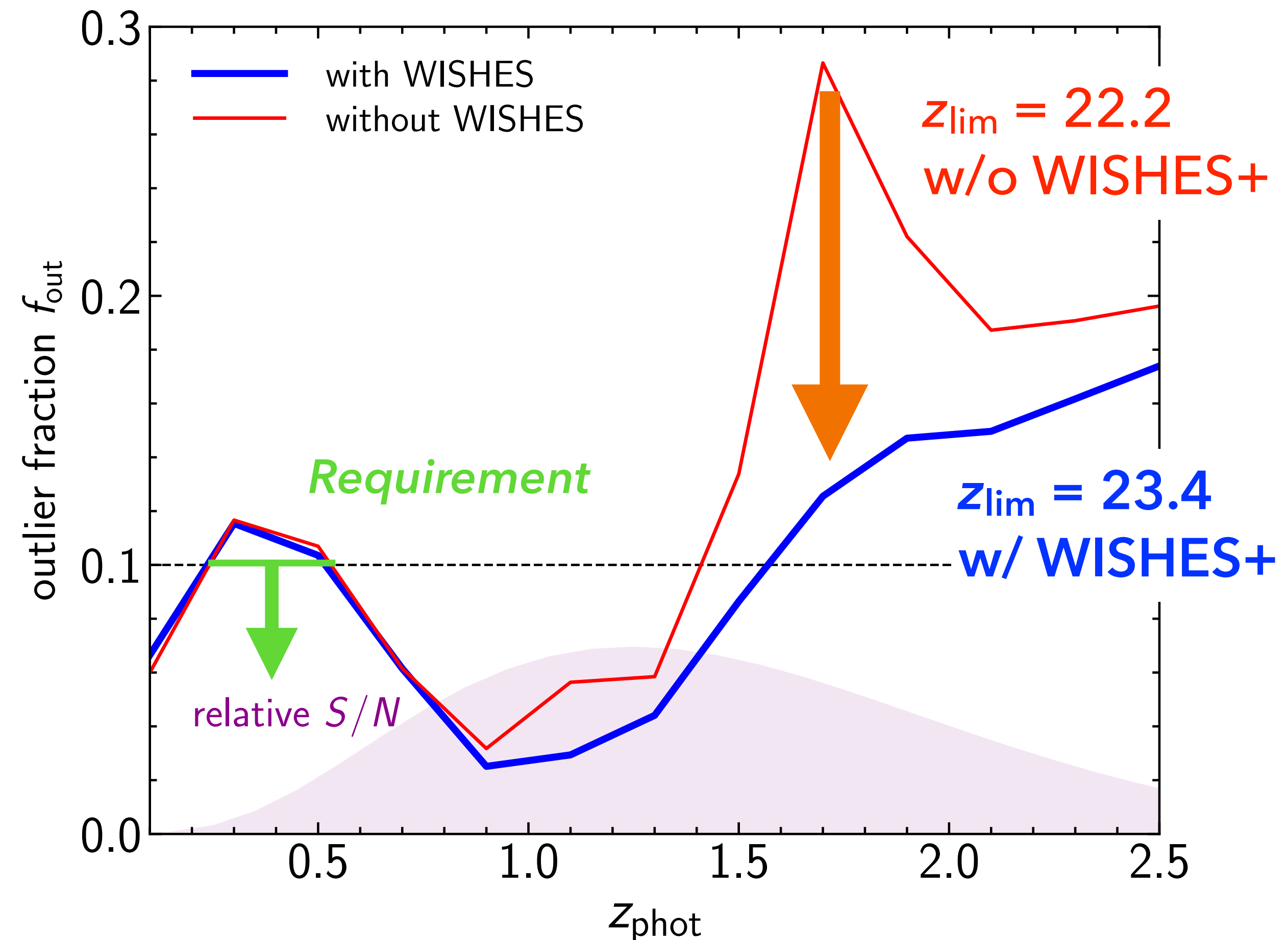


Improving Photo-z for Cosmic Shear Cosmology

• Mean/scatter of photo-z accuracy



• Outlier fraction



◆ **Blue lines:** Only z-band depth changed with depth of other bands (VIS+ugri+YJH) kept.
➡ **Without WISHES+, constraints on cosmo. params. would be degraded!**

2. WISHES+ Science with UNIONS



The Ultraviolet Near Infrared Optical Northern Survey is a collaboration of 4 scientific projects:

Hawaiian
Islands



Pan-STARRS
2 x 1.8m



CFHT
3.6m



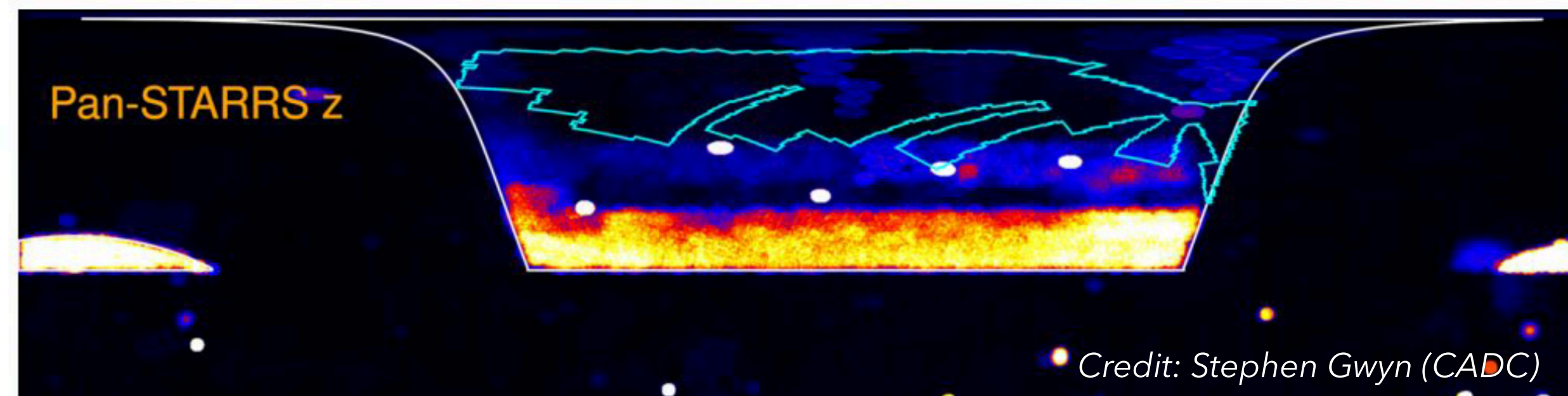
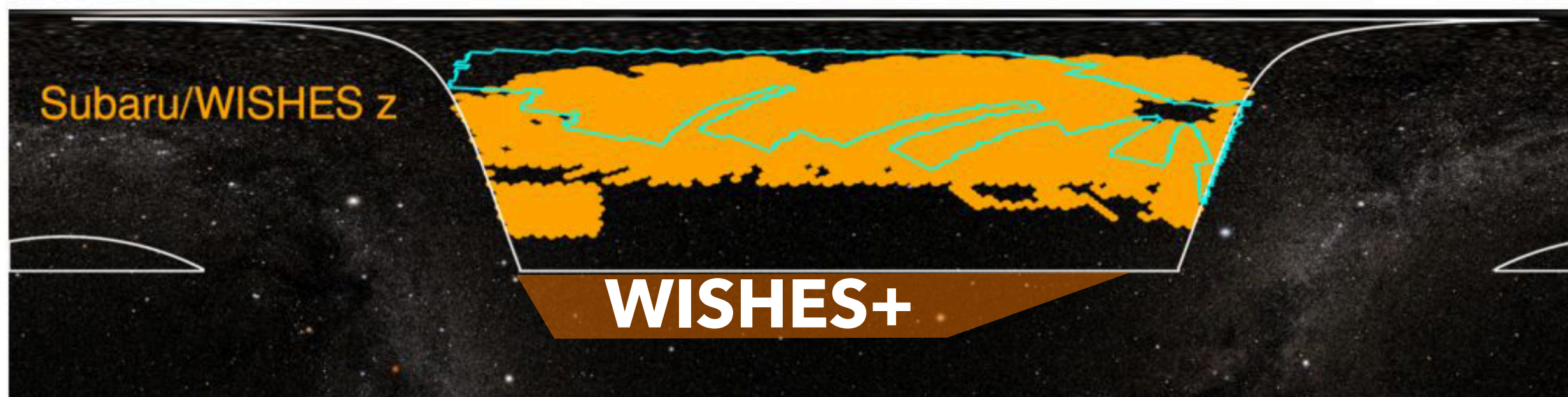
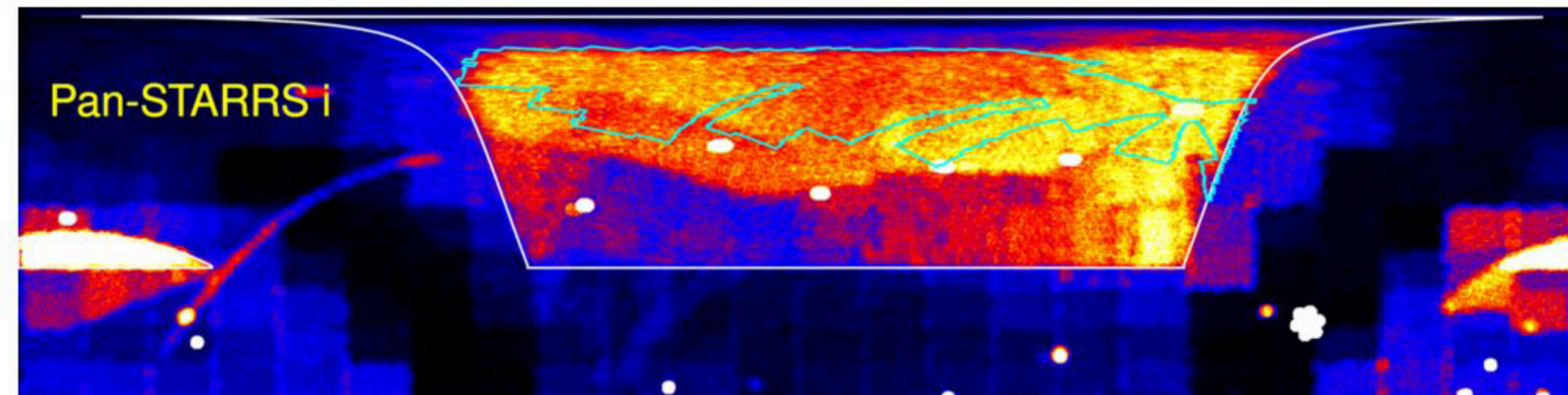
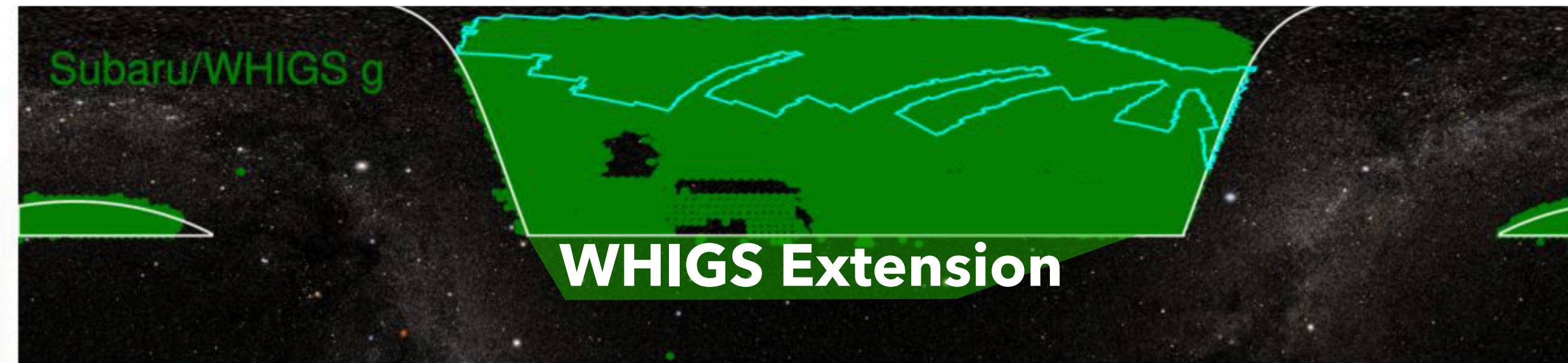
Subaru
Telescope
8.2m



UNIONS

Hawaiian Alliance of ground-based telescopes:

CFHT/CFIS(++) (u, r), **Subaru/WISHES(+)** (z), Subaru/WHIGS (Extension) (g), Pan-STARRS (i, z)

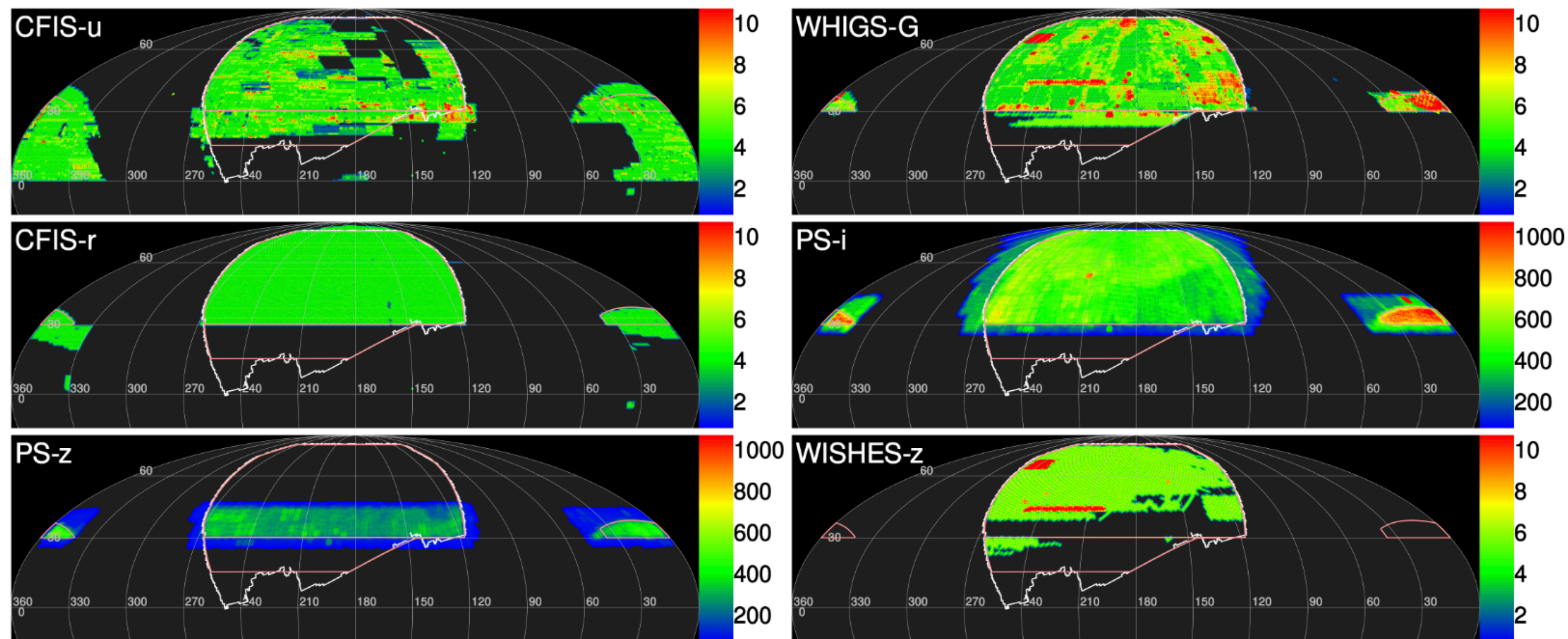


Credit: Stephen Gwyn (CADC)

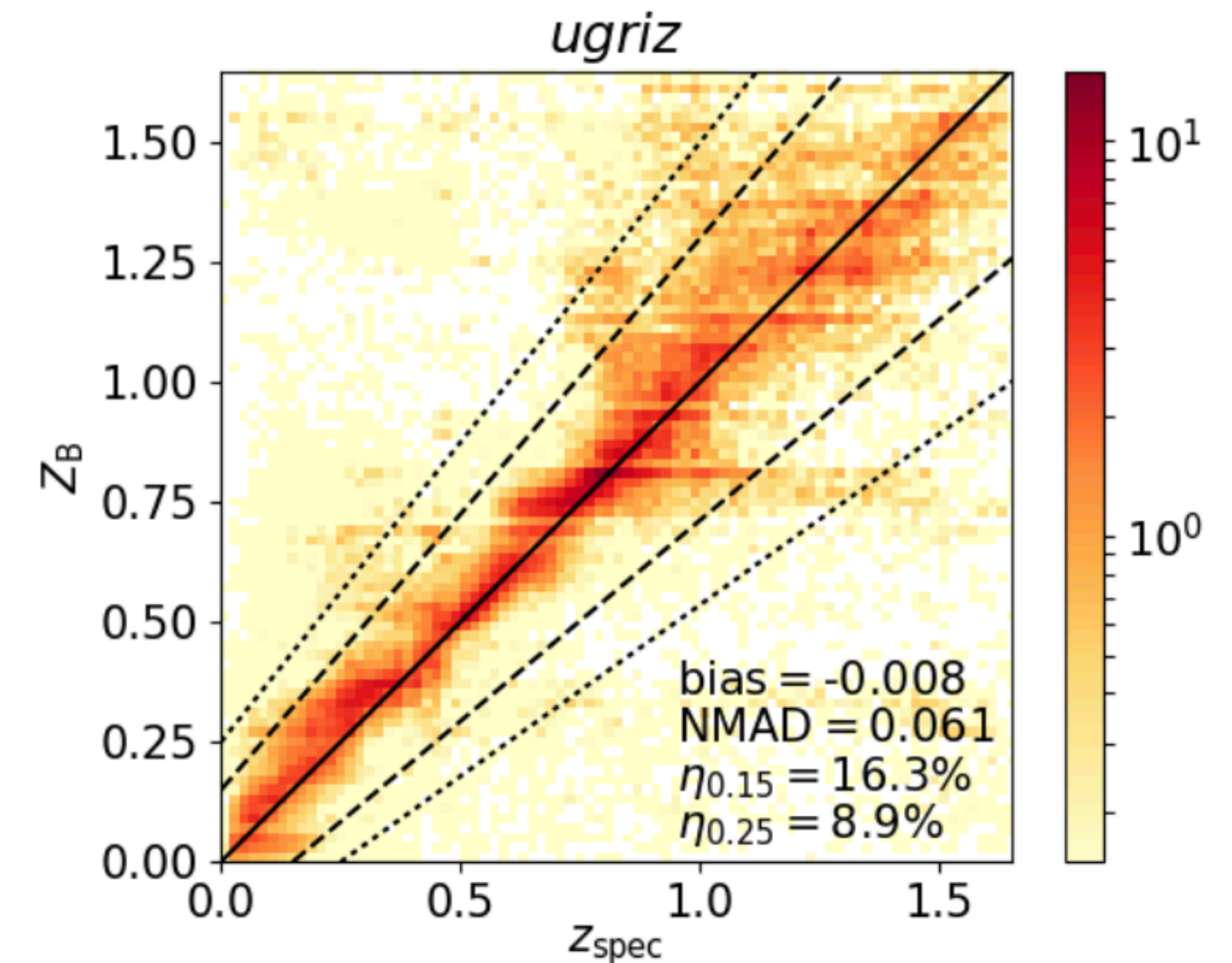
UNIONS Overview Paper

◆ UNIONS Overview Paper (Gwyn et al., 2025; 2503.13783) has been published in AJ!

- Coverage of each survey



- Photo-z accuracy



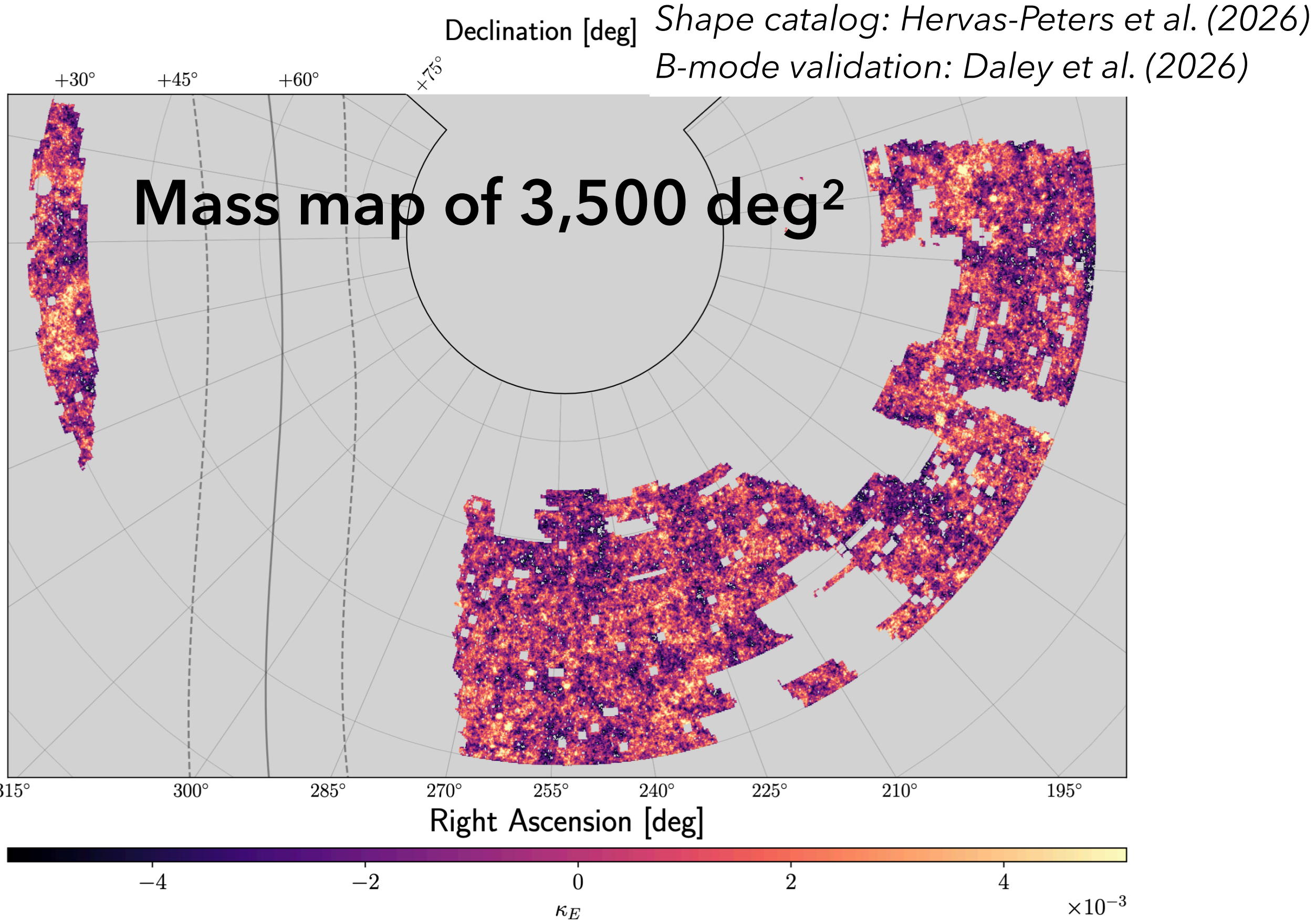
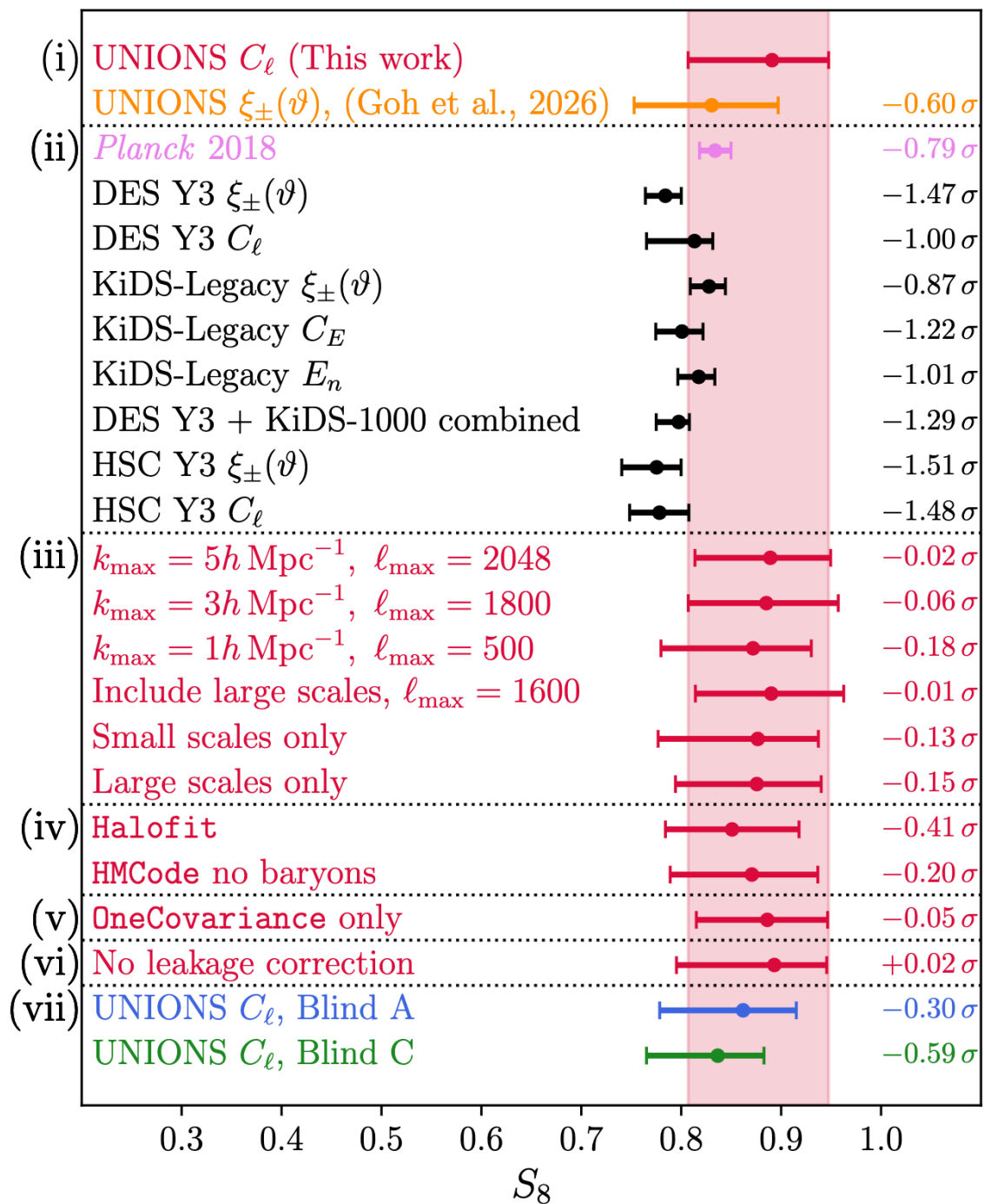
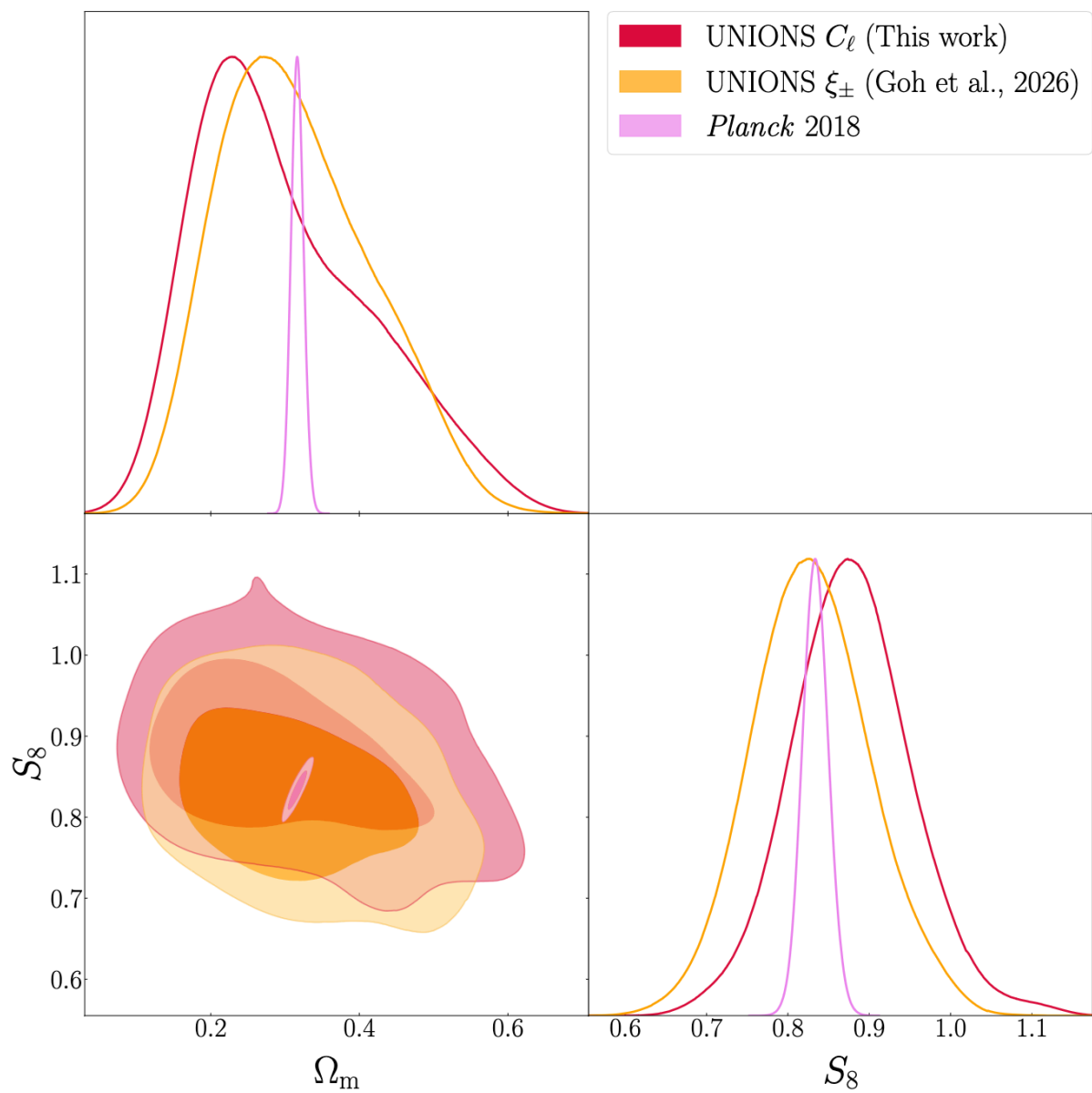
UNION-3500 Weak Lensing

◆ Stand-alone weak lensing measurements with UNIONS data

• Cosmology constraints

Fourier space: Guerrini et al. (2026)

Config. space: Goh et al. (2026)



Survey	Area [deg ²]	n_{eff} [arcmin ⁻²]	σ_{ϵ} (weighted)	PSF FWHM [arcsec]
KiDS-Legacy	1,347	8.94	0.29	0.7 (r)
DES-Y3	4,143	5.59	0.261	0.98 (r) – 0.85 (z)
DES-Y6	4,422	8.22	0.29	0.95 (r) – 0.83 (z)
HSC-Y3	433	22.9	0.236	0.59 (i)
DECADE	8,768	4.49	0.258	1.08 (r) – 0.95 (z)
UNIONS-v0	1,700	6.8	0.35 (raw)	0.65 (r)
UNIONS-3500	3,648	4.96	0.27	0.71 (r)

Summary

- **WISHES+** is the deep z-band survey for Euclid and stand-alone science. In combination with WISHES, the total survey area reaches **4,550 deg²**. Its legacy value is high; the data can be used for many years in various fields.
- WISHES+ observations are going well; the current observed area is 794 deg² and the completion rate is 58.6%. The rest will be completed by the end of S27A.
- We are working with other UNIONS surveys (CFIS, WHIGS, and Pan-STARRS). The synthetic multi-band catalogues have legacy values. The data have already led to several publications and more to come in near future.

Appendix

UNIONS Results

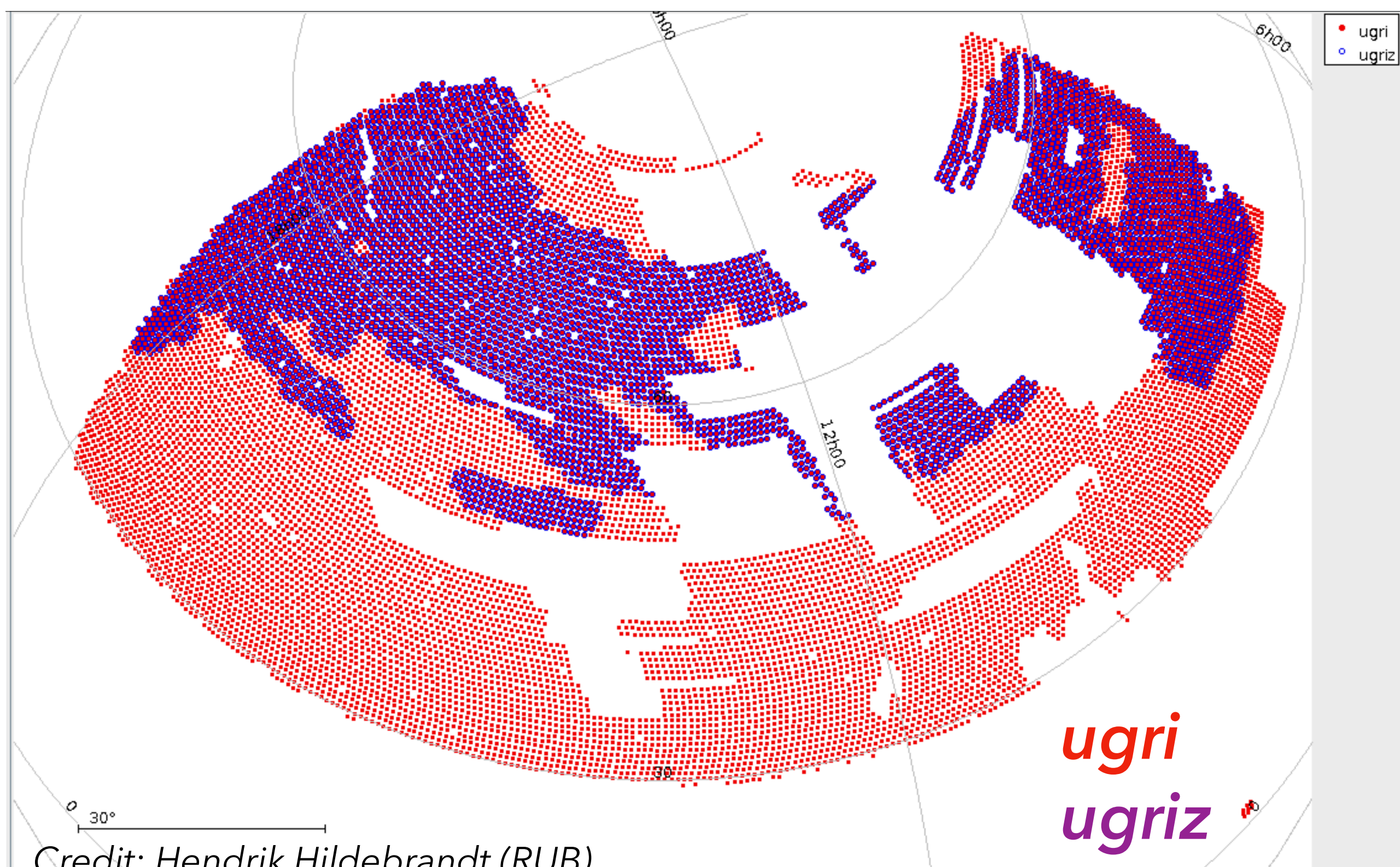
◆ Stand-alone science projects with UNIONS data

- **UNIONS Grand Unified Catalog**

- ➡ Deep multi-band catalog

Current area: $>3,000 \text{ deg}^2$ (*ugri*)

$>1,200 \text{ deg}^2$ (*ugriz*)



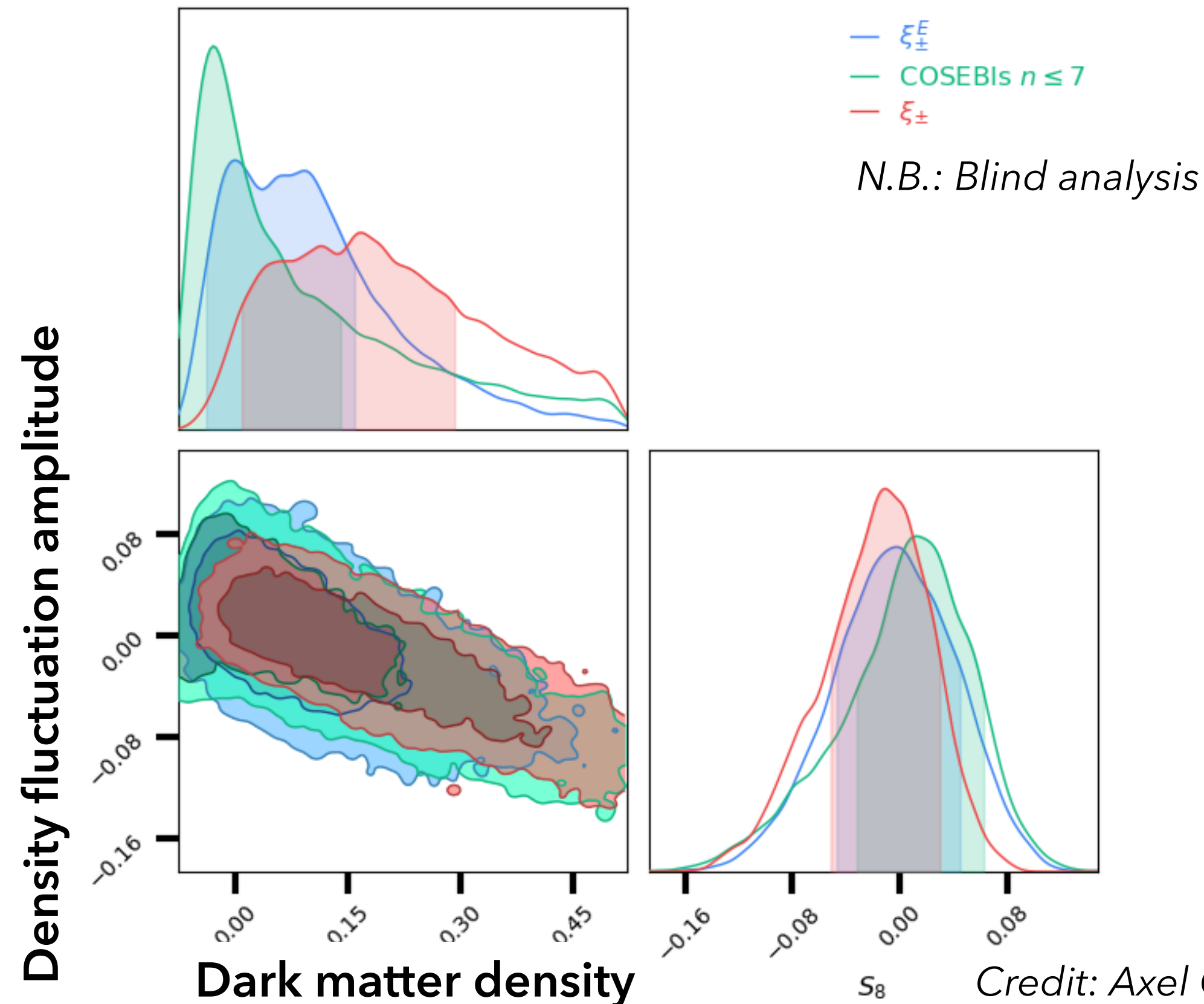
Credit: Hendrik Hildebrandt (RUB)

- **UNIONS WL**

- ➡ Precursor of Euclid WL

Current area: $1,440 \text{ deg}^2$

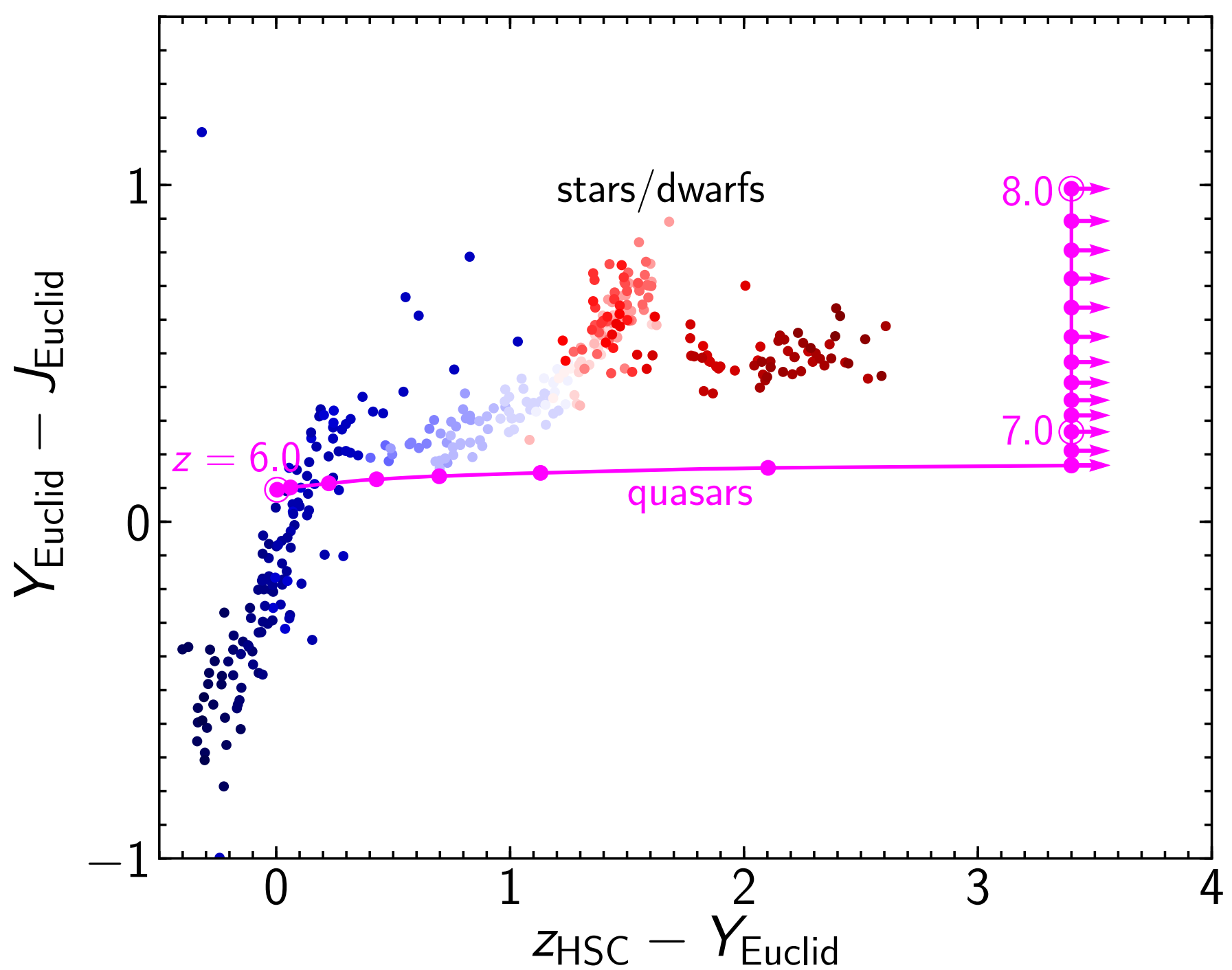
Source density: $6.73 \text{ gals/arcmin}^2$



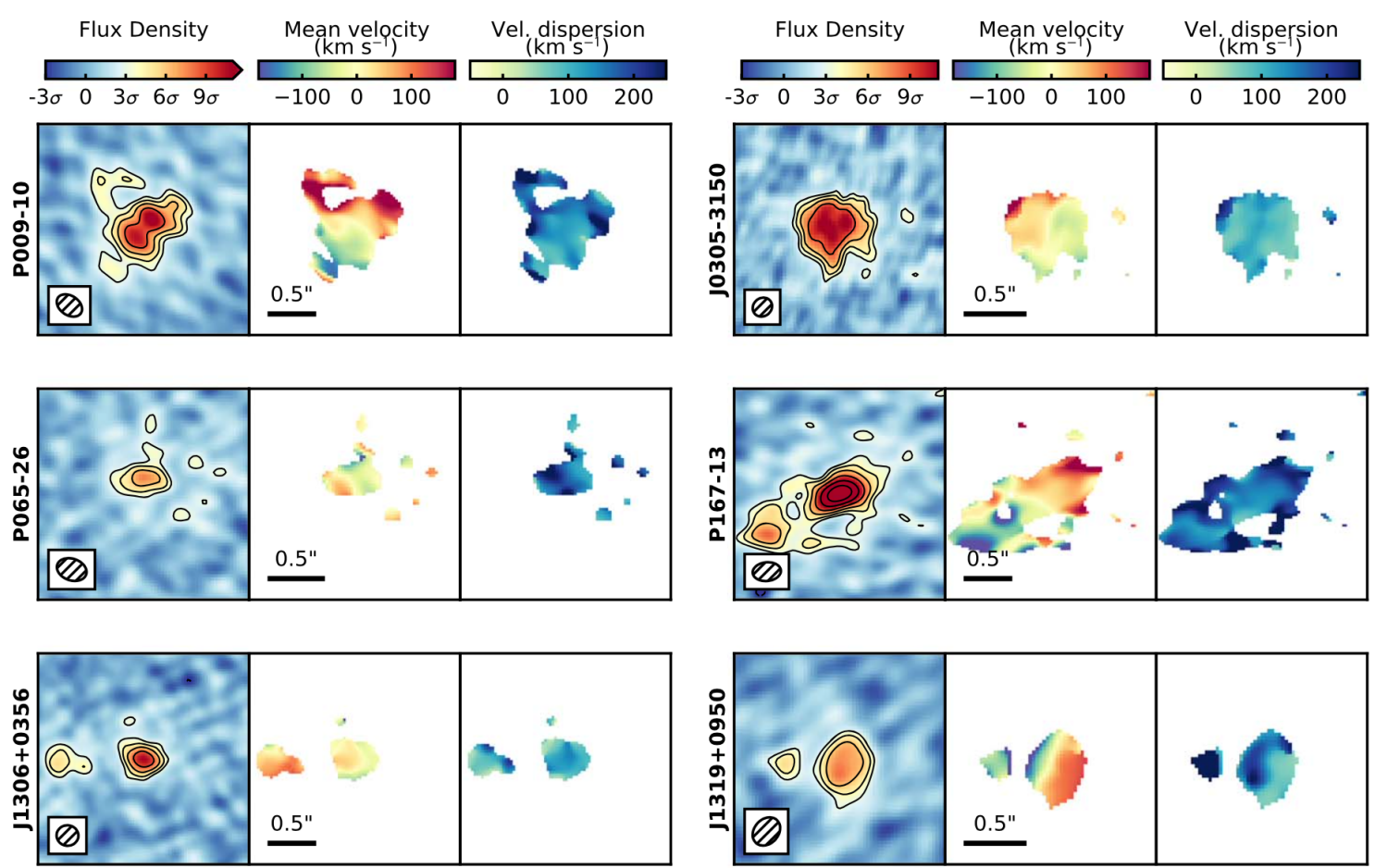
Credit: Axel Guinot (CMU)

Search for High- z Quasars

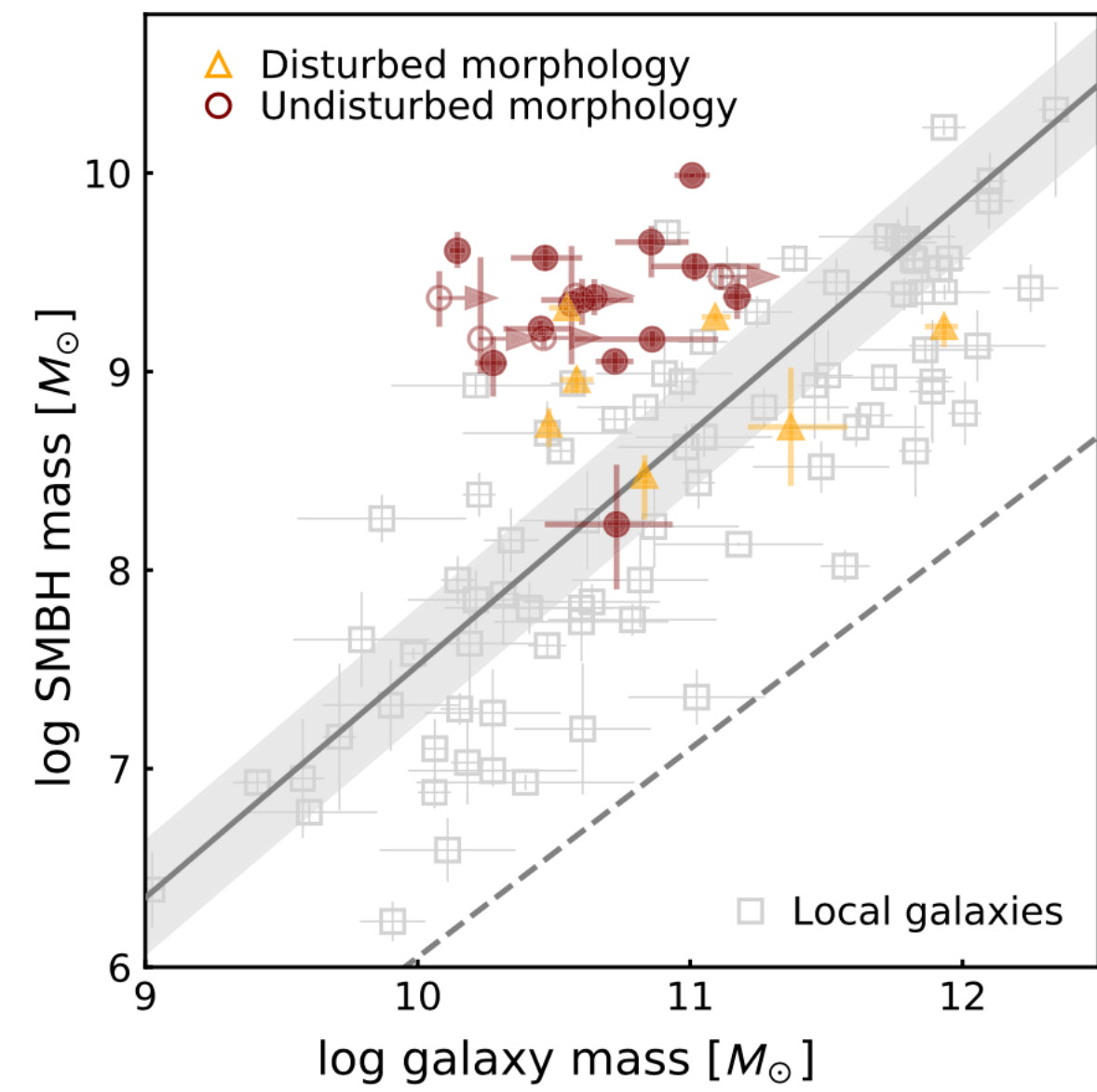
- ◆ Deep z -band images are very important for efficient quasar search from Euclid.
- ◆ WISHES + WISHES+ provide ~ 20 quasars at $7 < z < 7.5$, ~ 15 quasars at $7.54 < z$ (these numbers are limited by z -band depth!)
- ◆ We will start selections with the first UNIONS Grand Unified Catalog ($z_{\text{WISHES}} - y_{\text{PS1}}$), later replaced with Euclid Y .



- ◆ ALMA Host galaxy studies are only possible in the WISHES+ area.

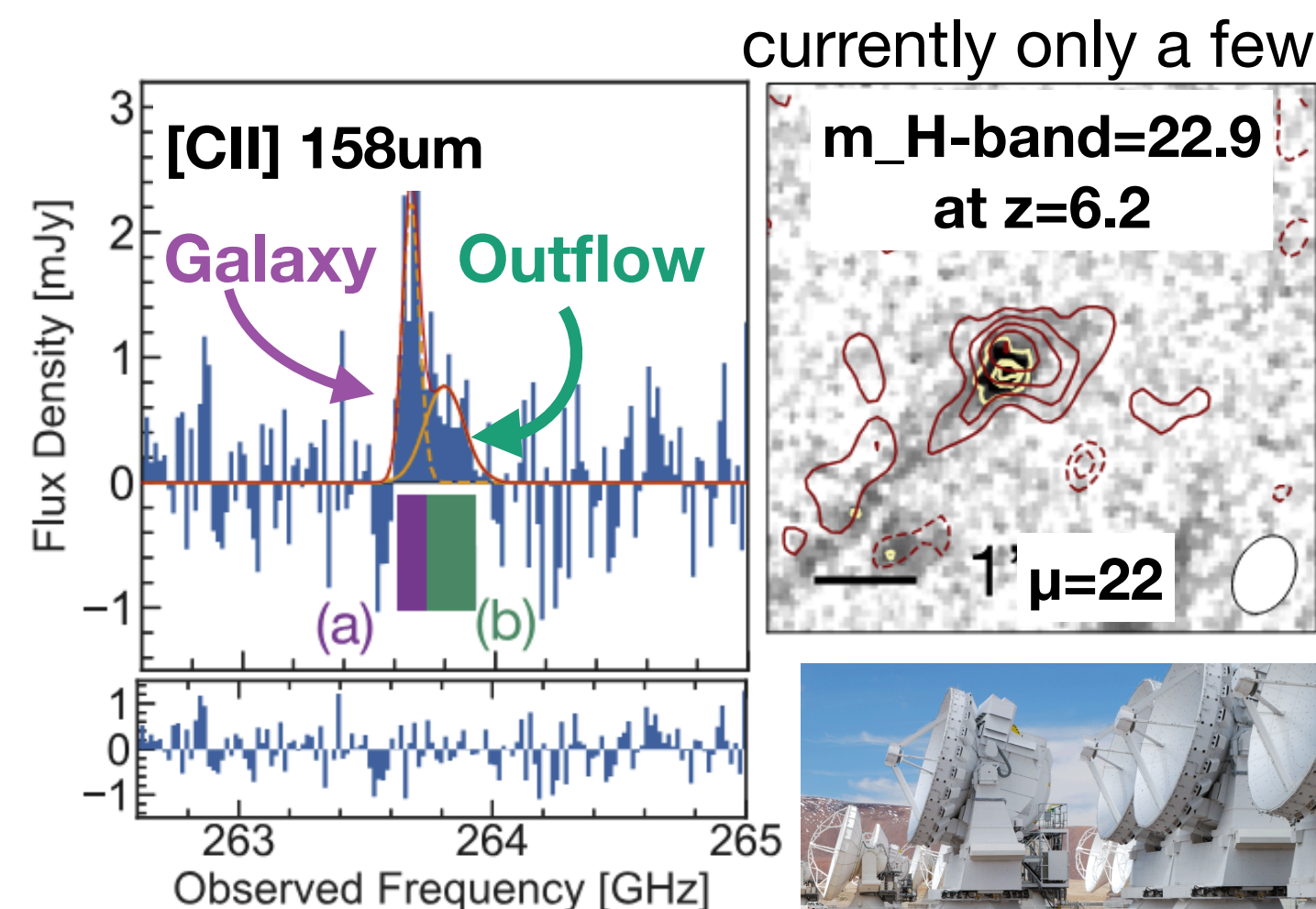
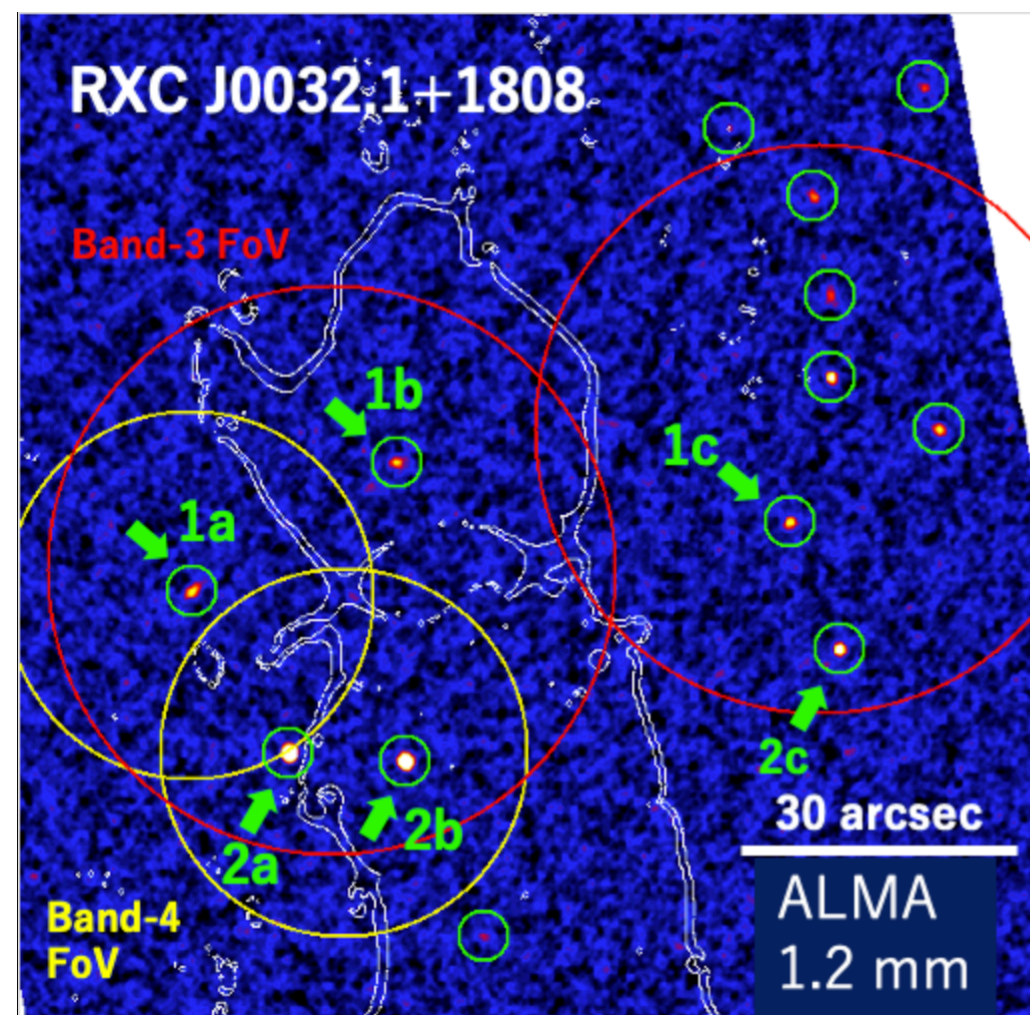


Neeleman et al. 2021



Multi-Wavelength Synergy with ALMA and TMT

- ◆ WISHES+ unlocks synergy with ALMA and future large telescope in northern sky.
- Searches of :
 - Massive high-redshift galaxies ($\sim a \text{ few } \times 10,000$)
 - Highly lensed galaxies ($\sim 16,000$ clusters expected in WISHES+ area)
- ◆ Euclid + WISHES/WISHES+ will provide unique opportunity to study high- z galaxies in great details.



Representative Inputs
for the future telescopes,
such as TMT

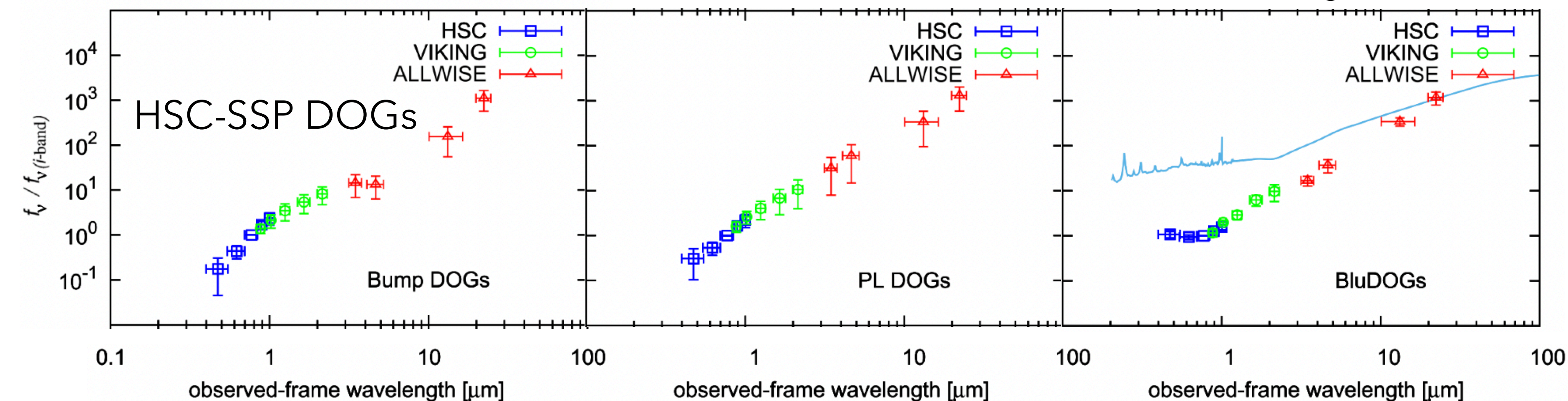


(Left) ALMA survey of lensing cluster (Right): Emission observation of lensed galaxies

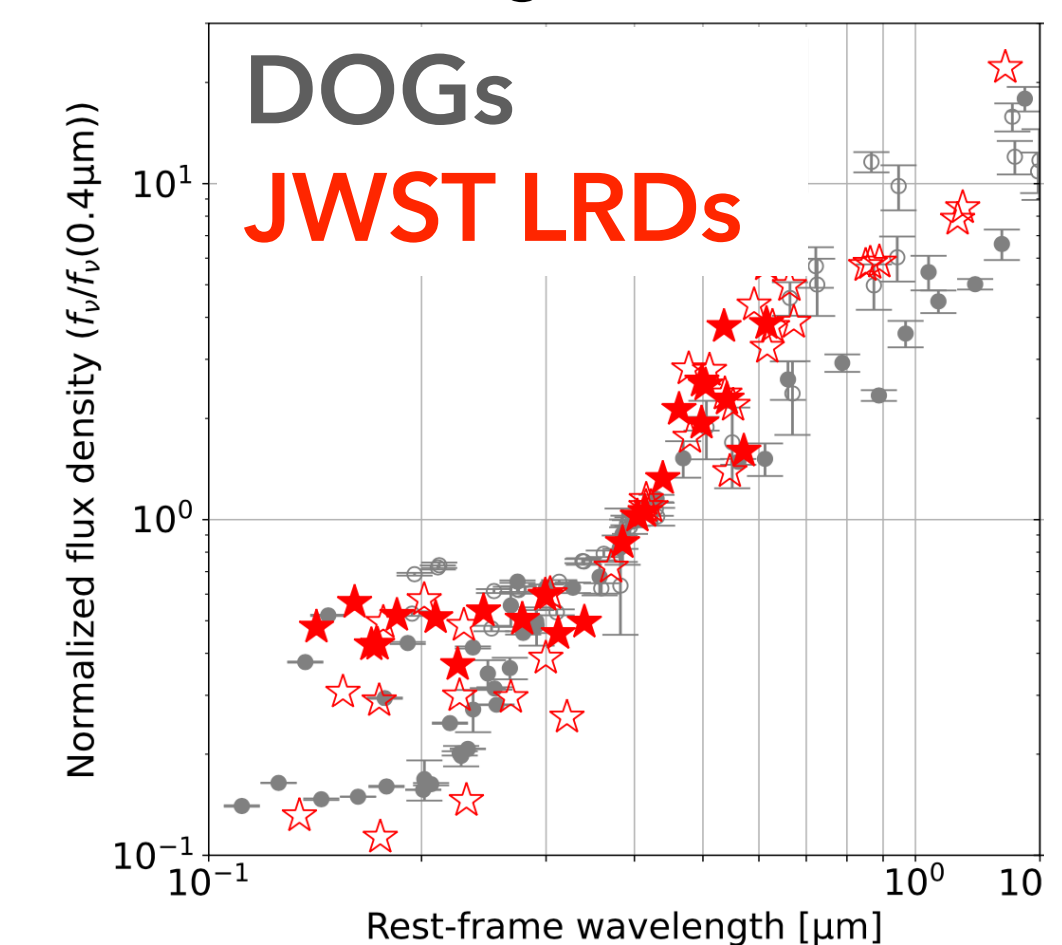
Ongoing WISHES surveys of rare AGN

- ◆ **Dust Obscured Galaxies (DOGs):** an AGN pop. between dusty starburst and quasar
 - 3,700 DOGs selected from the current UNIONS catalog of 800 deg² (w/o WISHES-z; Yoshida, Nagao et al. in prep.)
 - DOGs could be lower-z counterparts of JWST “Little Red Dot (LRD)” AGN
- ◆ WISHES+ characterizes the sub-population at different evolution stages
 - Deep NIR catalog available in WISHES+ area
- ◆ **Radio galaxy search (u/g/r/i-dropout)** also ongoing (Ide, Nagao et al. in prep.)

Noboriguchi et al. 2019



Noboriguchi et al. 2023



Details of Observations

- Observation conditions:
seeing $< 1.0''$, transparency > 0.7 , gray,
 > 30 deg from moon
- Following HSC Wide observing strategy,
3 dithers for each pointing, 80 sec exposure for each
Effective area of a pointing: 1.46 deg^2
- 105.5 hours (~ 15 nights with weather factor)
in HSC Queue mode (assuming 10 hours = 1 night, weather factor = 0.7)
- WISHES pointings are given higher priority.

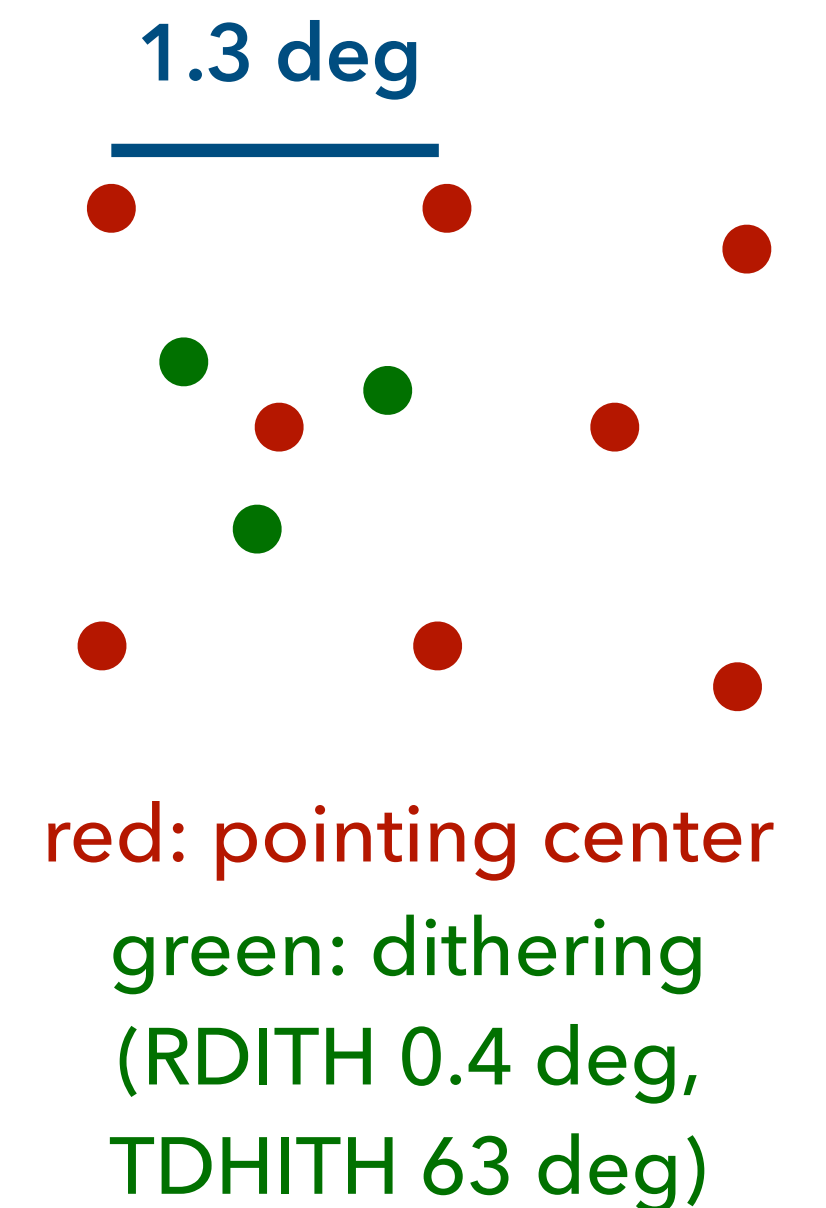
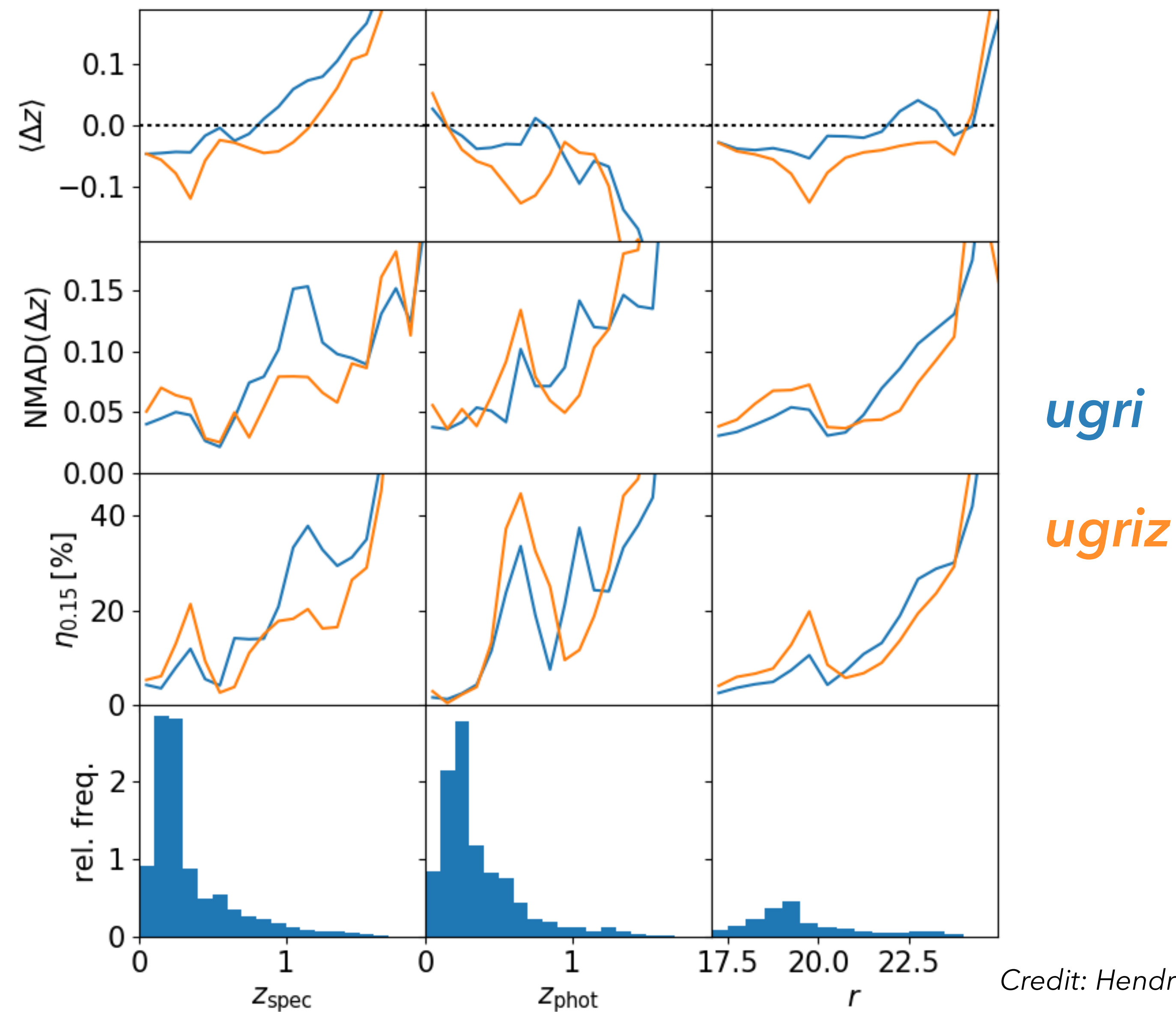
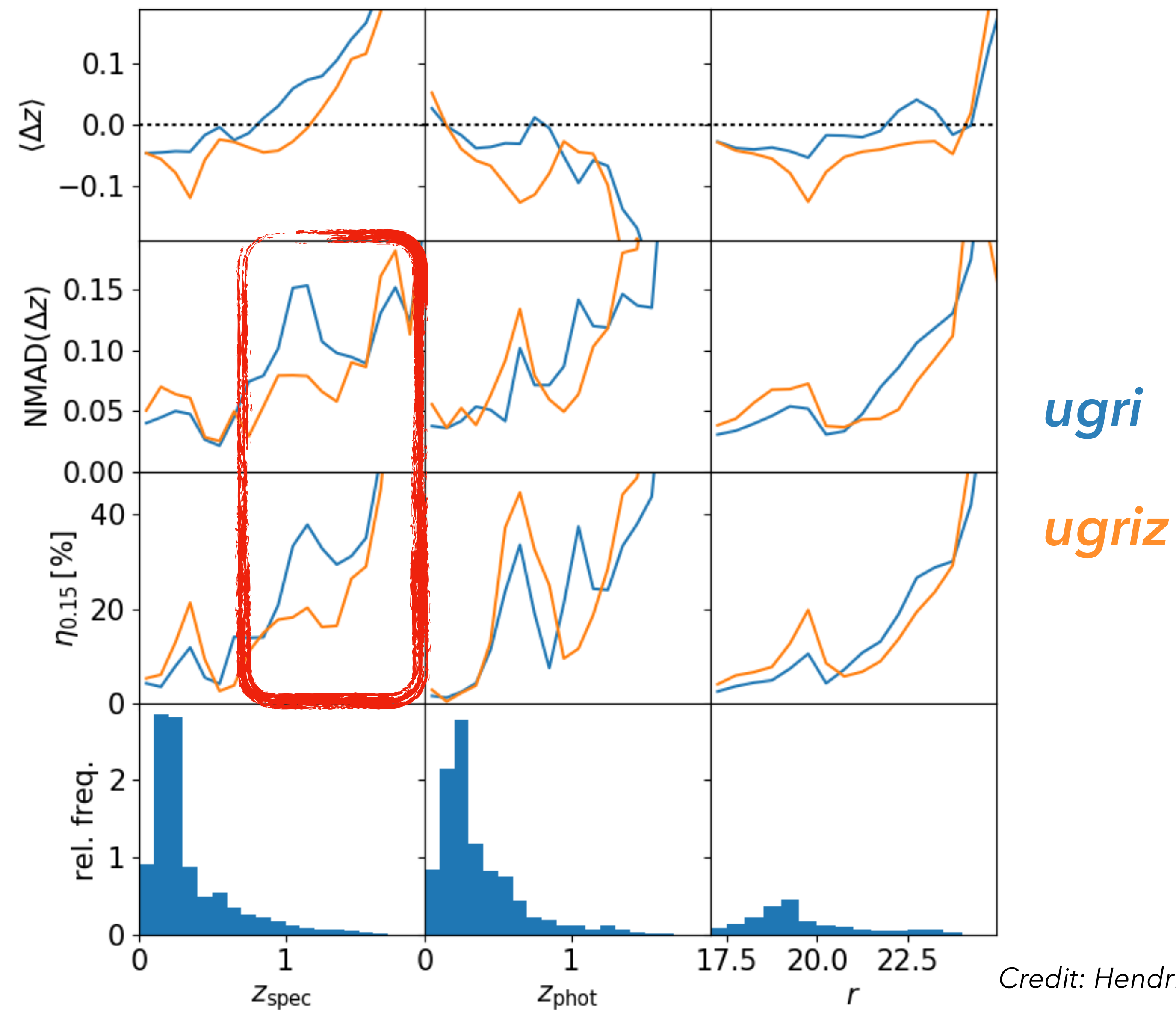


Photo-z in UNIONS Grand Unified Catalog



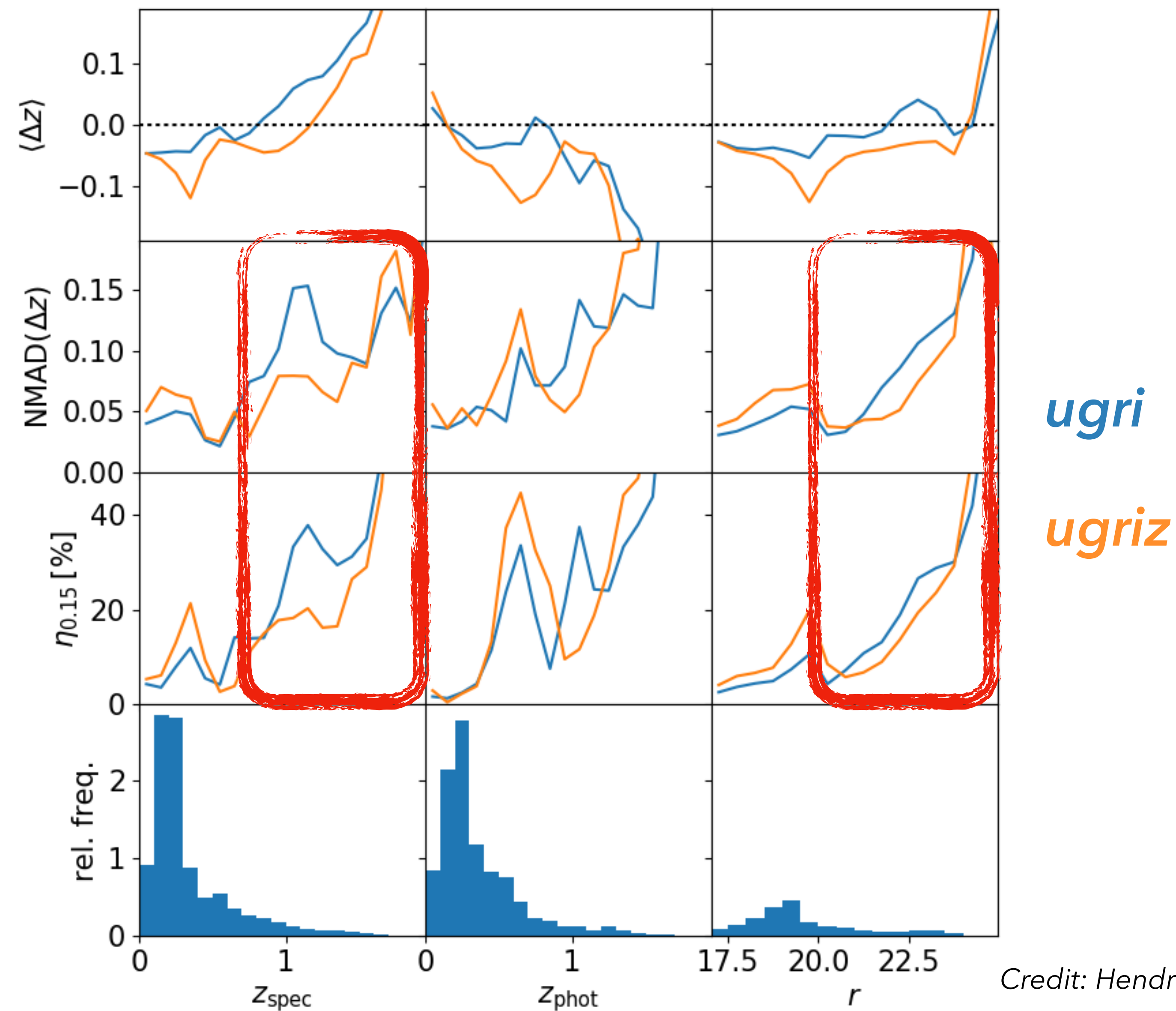
Credit: Hendrik Hildebrandt (RUB)

Photo-z in UNIONS Grand Unified Catalog



Credit: Hendrik Hildebrandt (RUB)

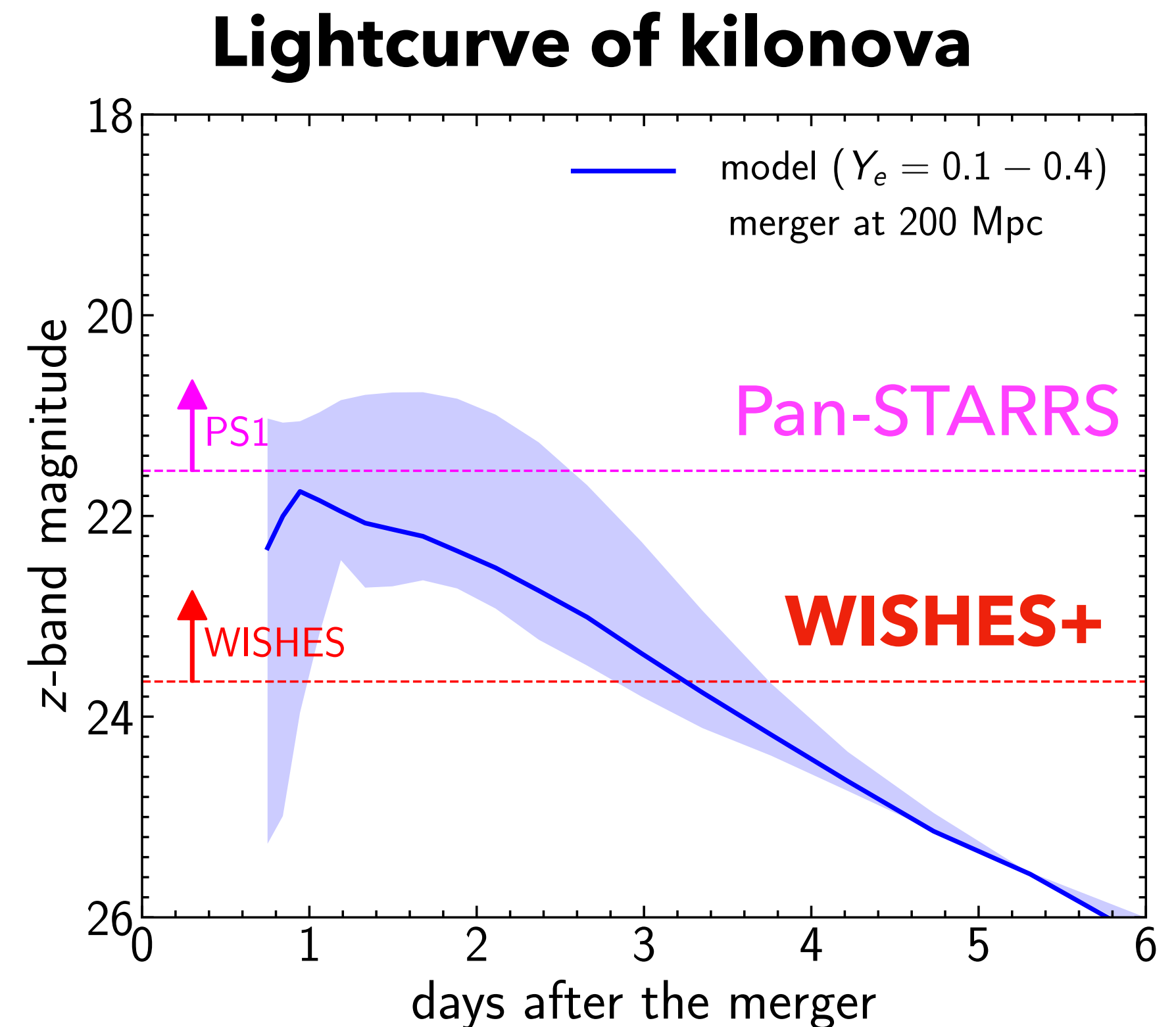
Photo-z in UNIONS Grand Unified Catalog



Credit: Hendrik Hildebrandt (RUB)

Other Science Cases

- Optical counterpart of GW sources
Identification of neutron star mergers is important for studies on origins of *r*-process elements.
➔ **Deep reference image is critical.**
- Probing MW structures
The tidal stream of the last major merger of MW (Gaia-Sausage-Enceladus) is expected to lie within WISHES+ footprint.
➔ **Understanding the kinematics and chemistry of MW**
- Finding strong lenses, cluster sample up to $z = 1, \dots$



Euclid Wide Survey

- ◆ The survey observation started on Feb. 2024 and is ongoing.
The first image of mosaic (132 deg², ~1% of the full area) was released on Nov. 2024.

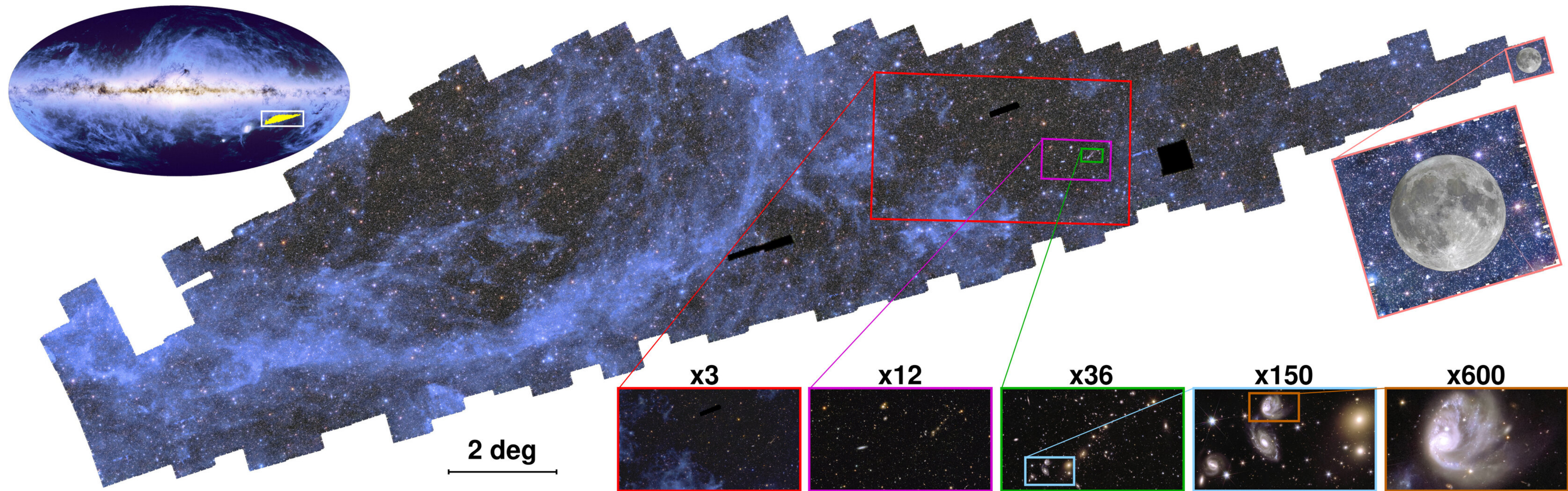


Image credit: ESA

Euclid DR1 Coverage

◆ DR1 (blue footprint) spans 1900 deg² (500 deg² in North, and 1400 deg² in South)

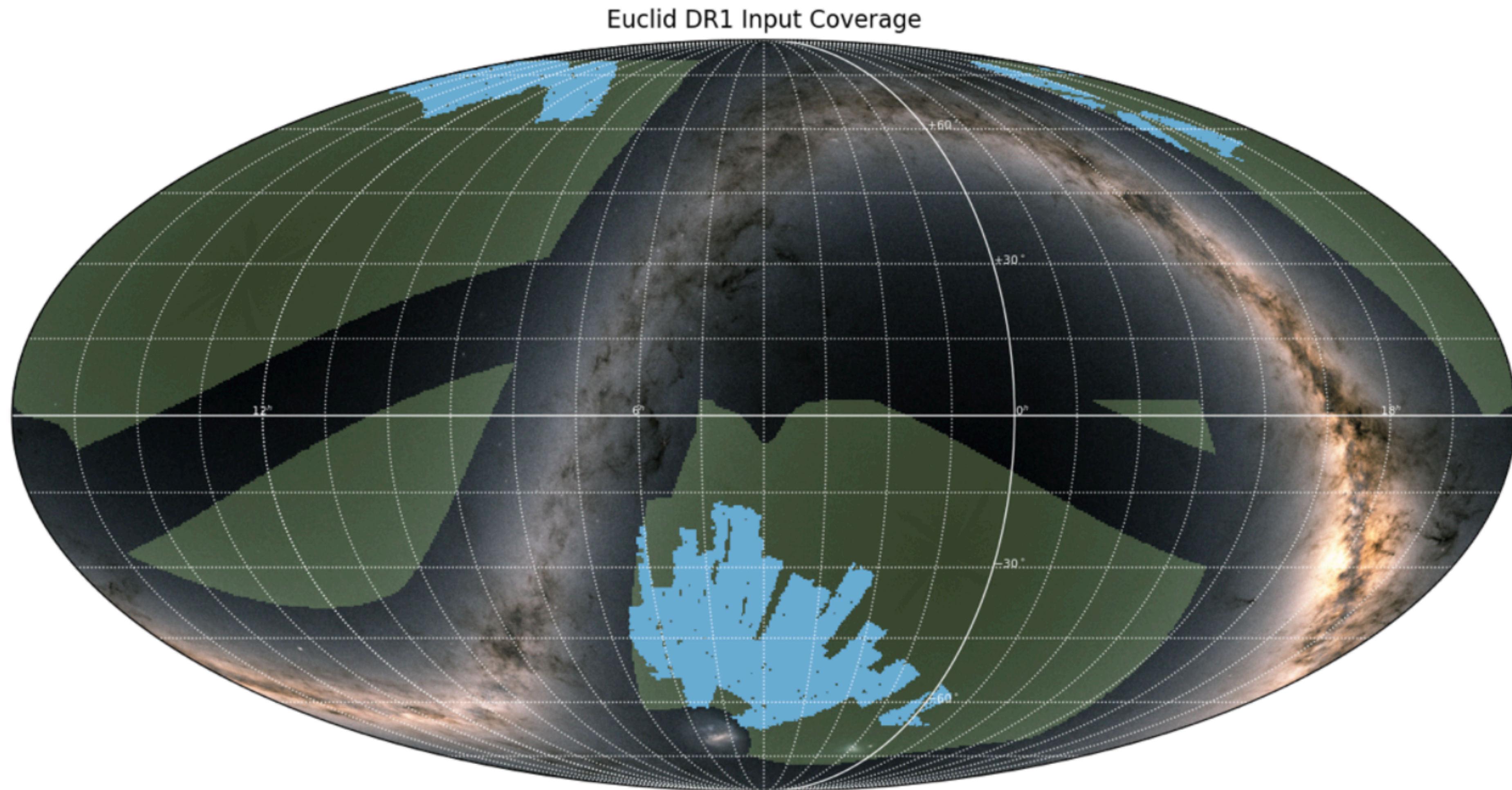


Image credit: ESA