Lyα Tomography in *Euclid* Deep Field North with ʻŌnohiʻula PFS

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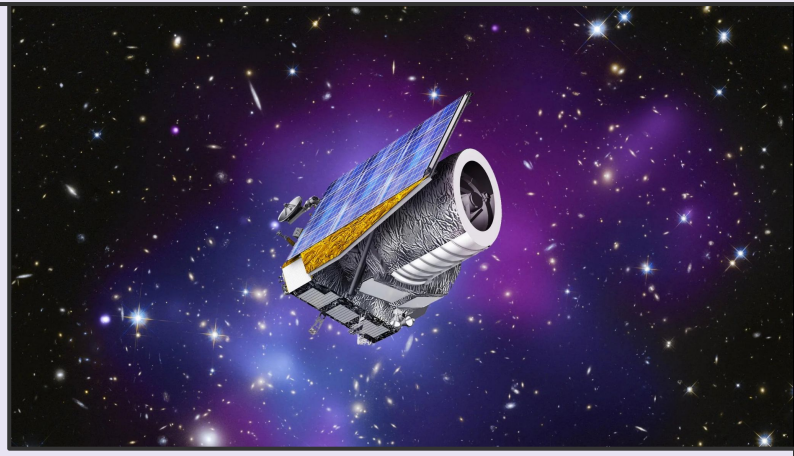
Subaru Users Meeting 2026

Euclid Space Telescope

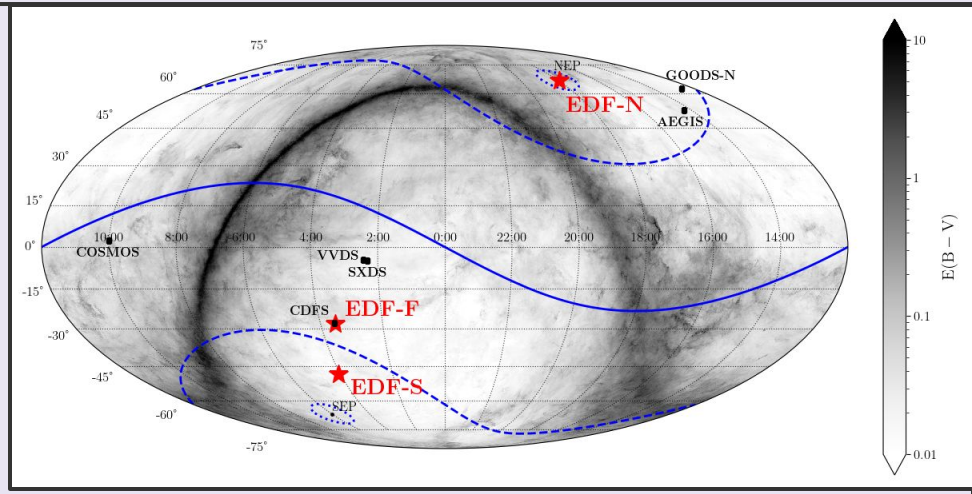
- ★ Launched July 2023!
- ★ VIS/NIR photometry & spectroscopy
  - Wide: ~14000 deg^2, $m_{AB} < 24.5$
  - Deep: 53 deg^2, $m_{AB} < 26.5$
- ★ Main goal: constrain dark matter/energy with 3x2pt ($z < 2$)
  - Weak lensing, galaxy clustering
- ★ DR1 public release: 11/2026, mid-2027

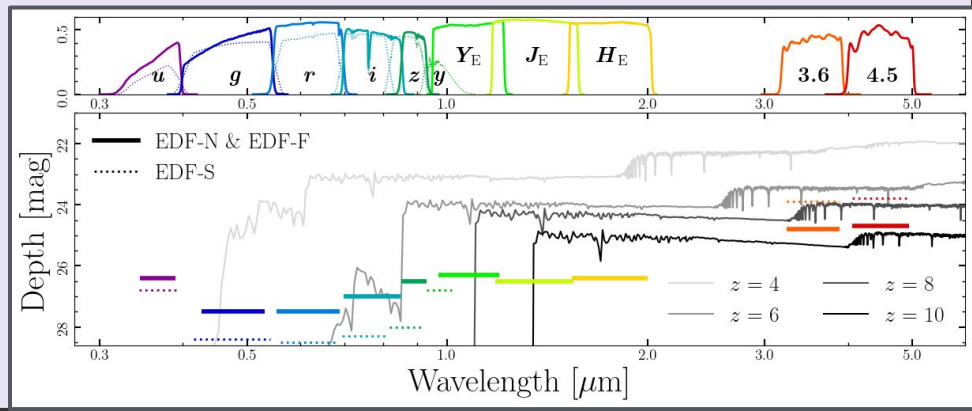


ESA, Euclid Consortium

The Hawaii Two-0 (H20) Survey

- ★ CFHT *u* + HSC *griz* + IRAC Ch1/2 imaging in EDF-N + EDF-F
  - m_{AB} < 26.5 over 30 deg^2
- ★ PL catalog: ~20 deg^2, >4 million galaxies, **public** (EC+Zalesky et al., 2025)
- ★ DAWN survey: all EDFs, EAFs
  - Out to z ~ 10!



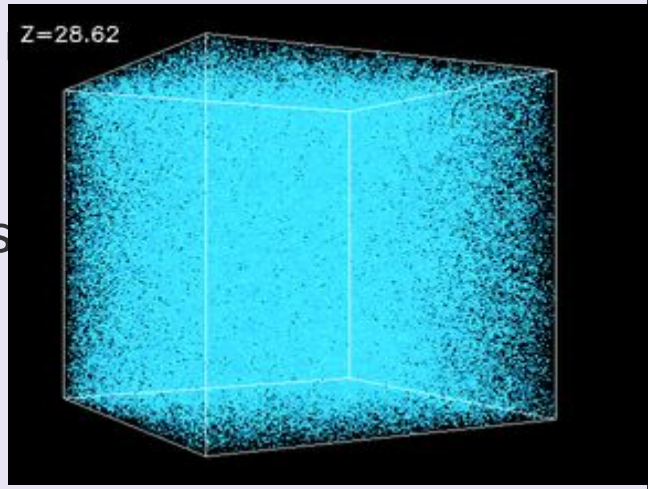


Euclid Consortium + McPartland et al., 2025

Mapping Large Scale Structure

★ How do galaxy properties evolve as a functio of environment at $z > 2$?

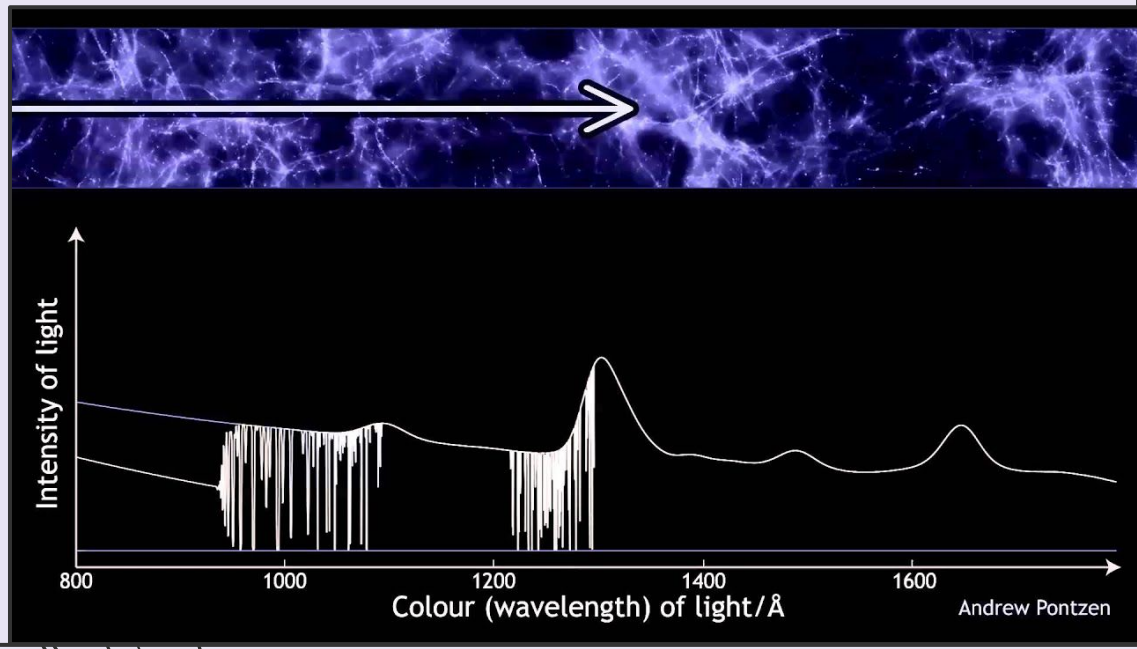
- Need a large sample of structures (nodes filaments, sheets, voids)
- Observed galaxy distribution is a biased tracer of underlying matter distribution
- On large scales (>100 cMpc), HI traces DM distribution



Simulation by National Center for Supercomputer Applications by Andrey Kravtsov (The University of Chicago) and Anatoly Klypin (New Mexico State University)

Lyα Tomography

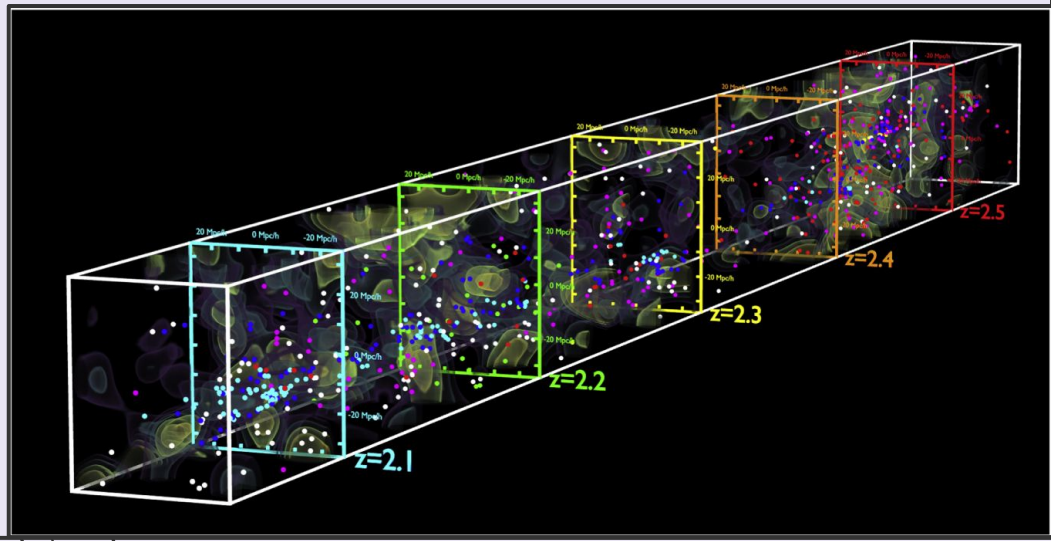
- ★ Use Lyα forest to reconstruct matter distribution via the IGM
  - Lyman continuum absorbed by HI
- ★ Successful with quasars (BOSS, DESI)
  - Limited by spatial sampling ($< 100/\mathrm{deg}^2$)



Lyα Tomography

- ★ Use galaxies instead of quasars to increase spatial sampling
- ★ Main parameter: ***n***, number of sightlines (galaxies)
  - Sets map resolution ~ $\boldsymbol{n}^{-1/2}$
- ★

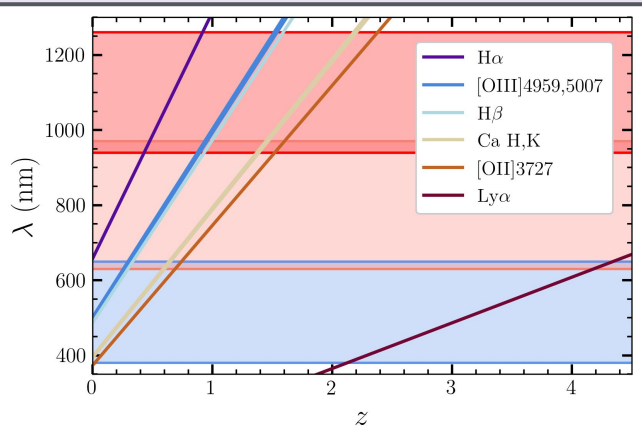
CLAMATO	LATIS
~0.2 deg^2	~1.7 deg^2
~2 h^{-1} cMpc	~3 h^{-1} cMpc
$2.05 < z < 2.55$	$2.2 < z < 2.8$

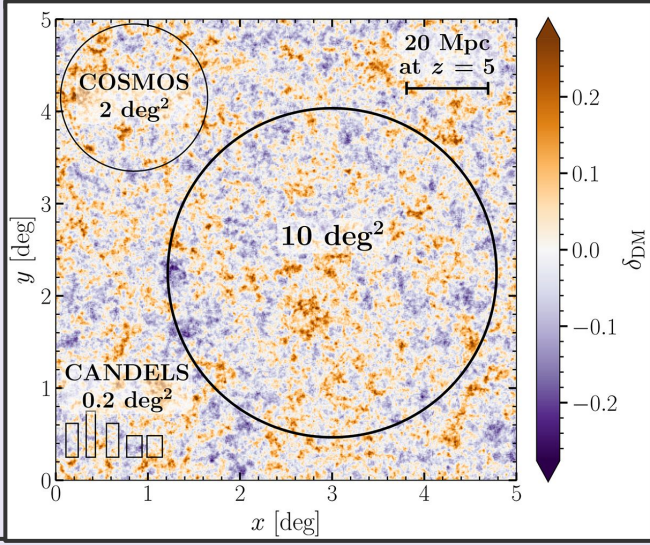


CLAMATO, Horowitz+2022

Lyα Tomography with PFS

- ★ PFS: great for Lyα tomography!
  - High target density (~1400/deg^2)
- ★ H20: great for selecting LBG targets!
  - EDF-N: central 10 deg^2 complete to full depth (*ugriz* + Ch1/2)
  - Sample diverse environments
    - Rare high/low density peaks





Euclid Consortium + McPartland et al., 2025

Lyα Tomography with PFS

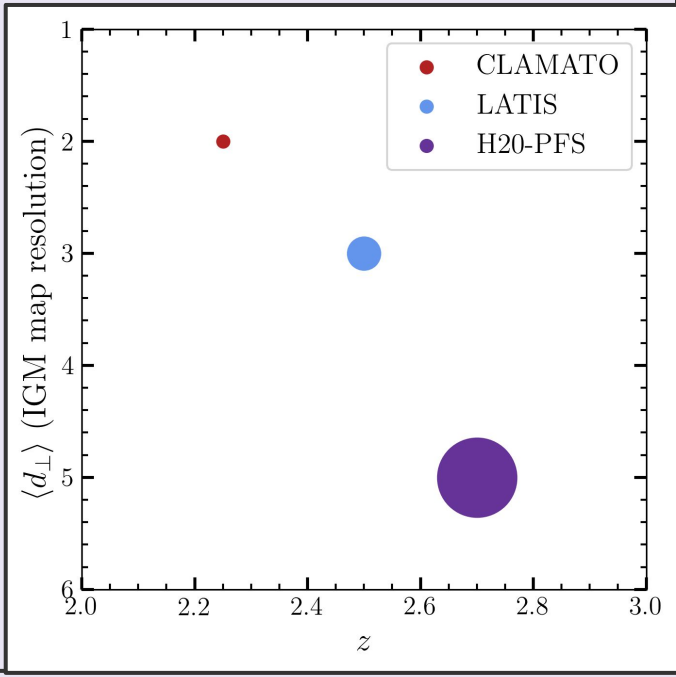
$g - r < 1.2$

$u - g < 0.98$

$u - g > 1.99\ (g - r) + 0.88$

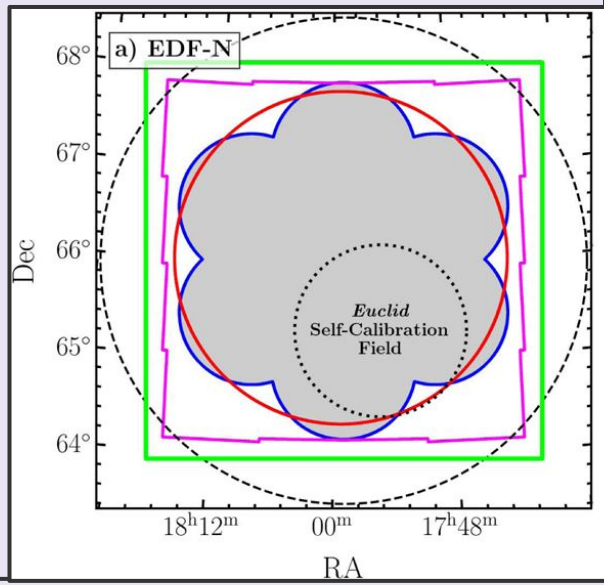
- ★ Target LBGs in EDF-N central 10 deg^2
  - *u*-band dropouts:
    - $z \sim 2.5 - 3.5,\ 23 < m_r < 24.5$
  - $2.5 < z_{\rm phot} < 3.5,\ 23 < m_r < 24.5$
  - In H20-PL catalog:
    - ~1,000/deg^2
    - -> IGM map resolution

      ~5 h^{-1} cMpc, $2.2 < z < 3.2$



Observing Plan

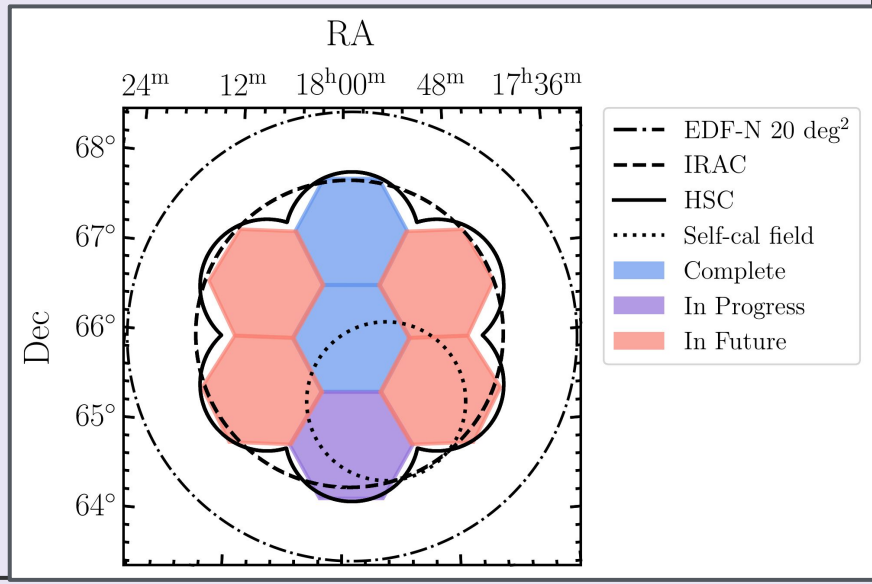
- ★ Targets: 7 pointings
  - LBGs (~1000/deg^2)
    - Goal: 8hrs exposure time (SNR/pix ~2)
  - Fill extra fibers with photo-*z* sources
    - $z < 1$, massive galaxies, strong lenses



Euclid Collaboration + Zalesky et al., 2025

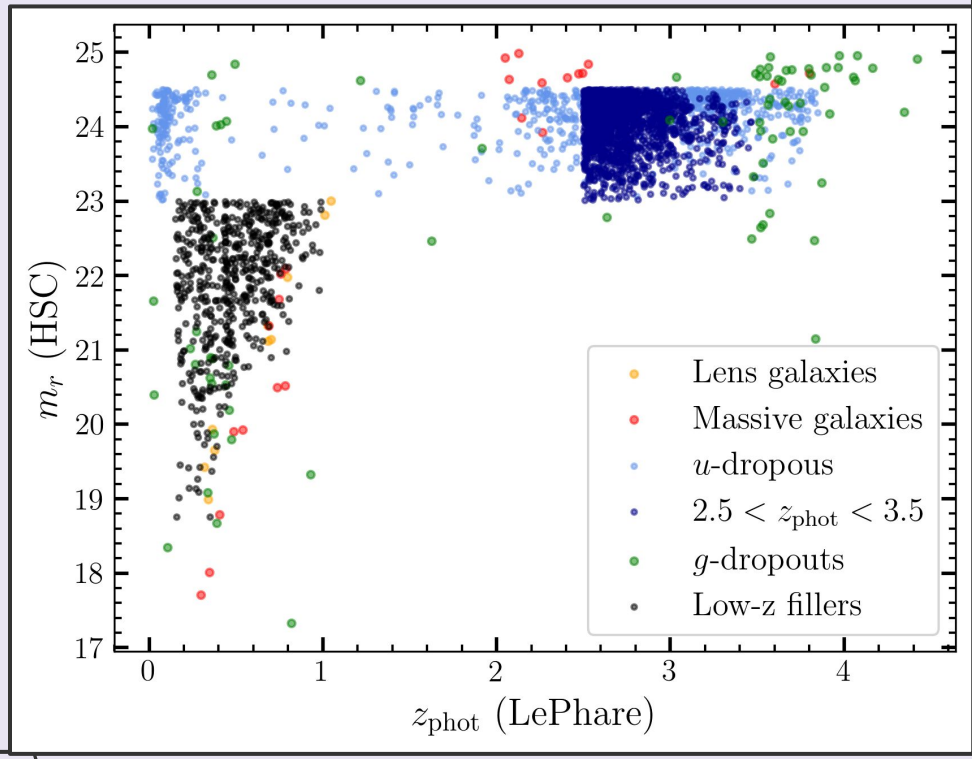
Observations

- ★ S25A: 2.5N classical (5/23, 6/20-22)
  - 5hr on center, 6.5hr on top pointing (3hr bad weather)
  - Lost ~0.5N to weather
- ★ S26A: 2N classical (5/17-20)
  - 3-3.5hr on 3 pointings
  - Lost 0.5N to weather
- ★ S26B: 1.5N queue
  - August, lower pointing



S25A Observations

- ★ Targets: S25A_April2026
  - Strong lenses: 12
  - Massive galaxies: 23
  - *u*-dropouts: 663
  - $2.5 < z_{phot} < 3.5$: 1884
  - *g*-dropouts: 76
  - $0.1 < z_{phot} < 1$: 535



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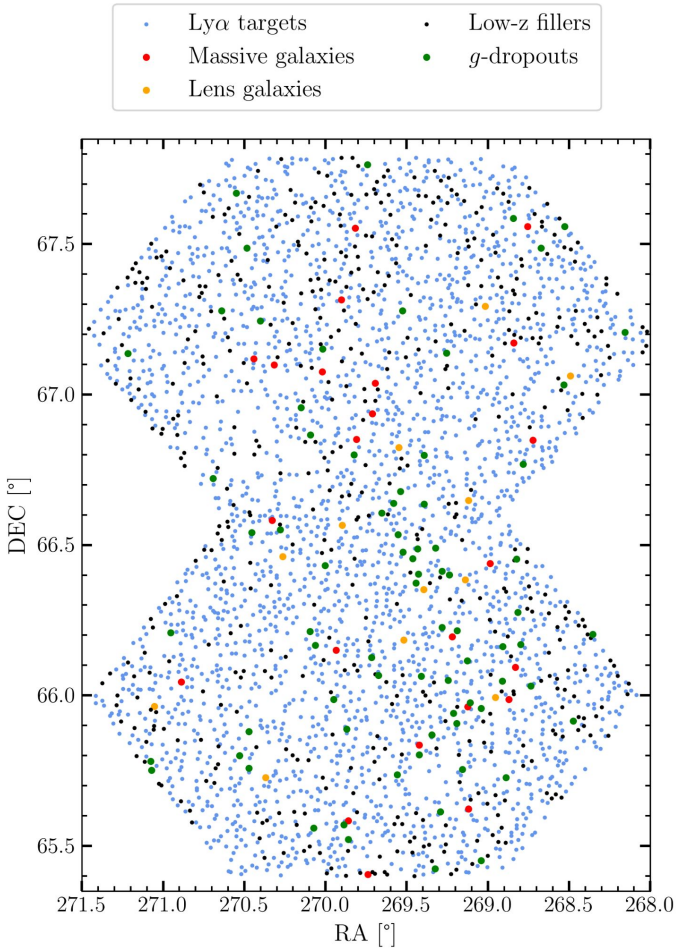
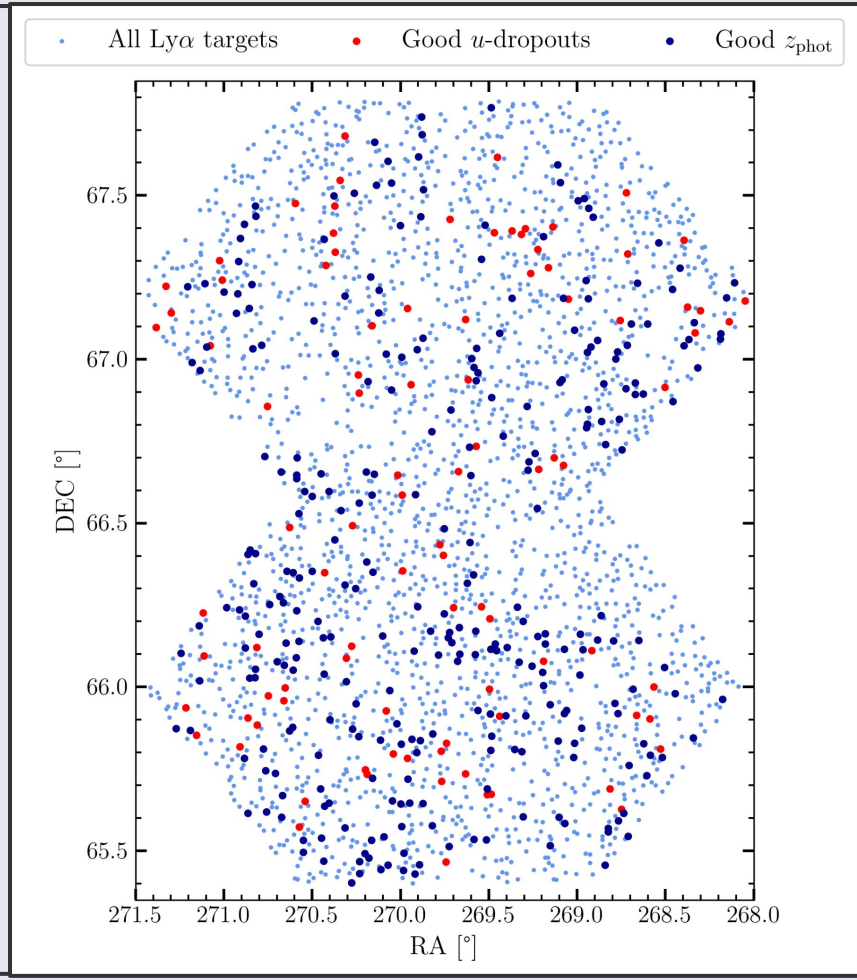


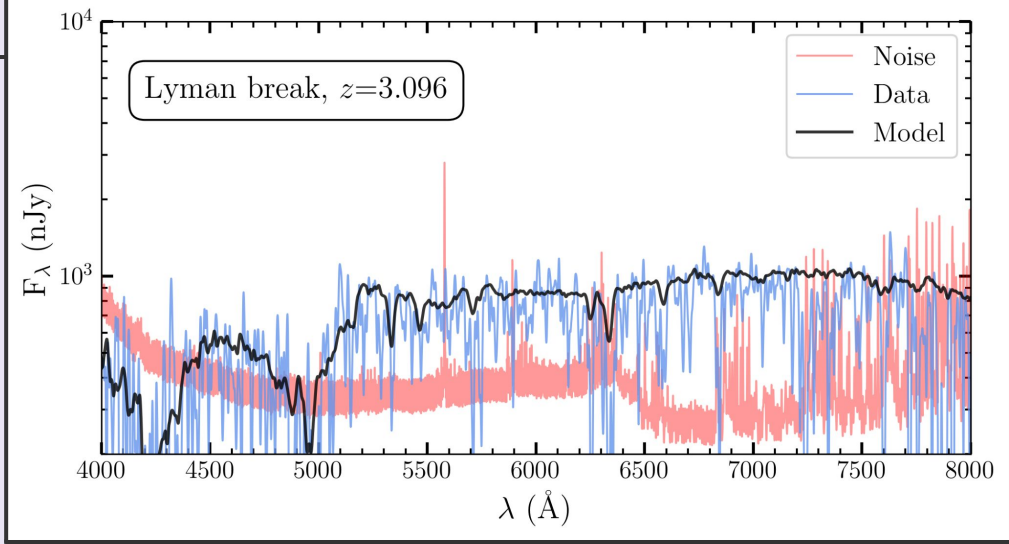
Preliminary Results

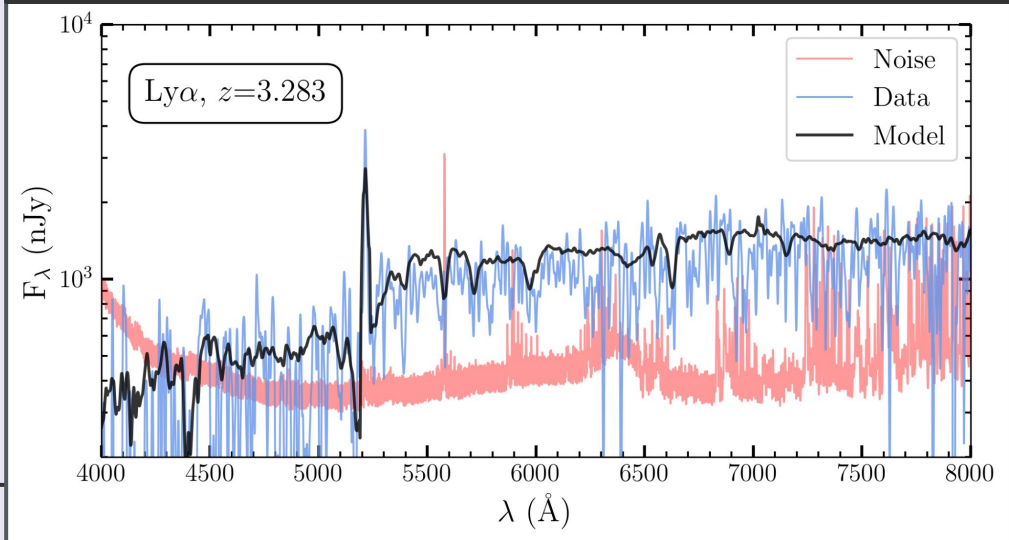
- ★ Bright LAEs/LBGs confirmed in < 6hrs!
  - $r < 24$
  - u-dropouts: 95
  - $2.5 < z_{phot} < 3.5$: 298



Preliminary Results

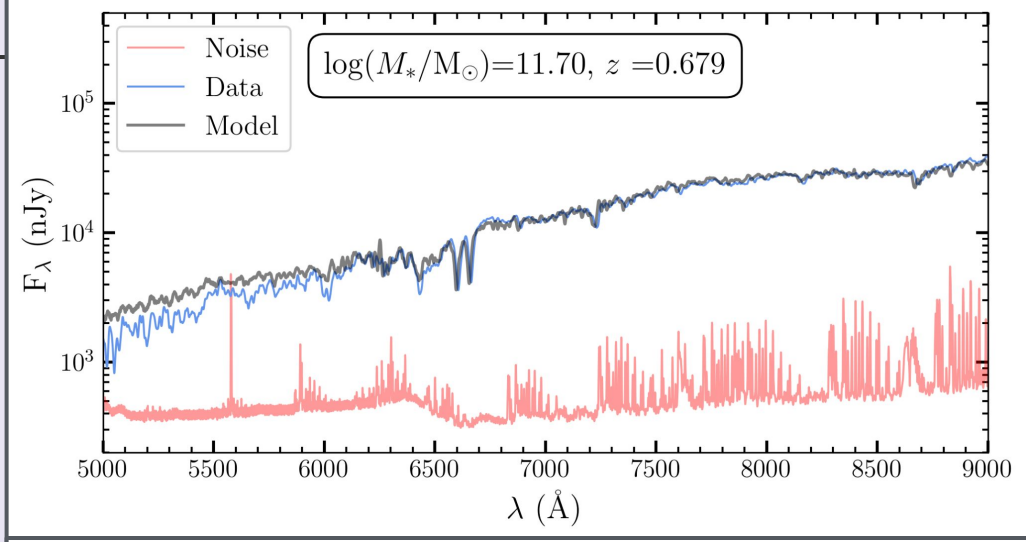
- ★ Example LBG, LAE
  - Only 5hr exposure
  - More data on the way!

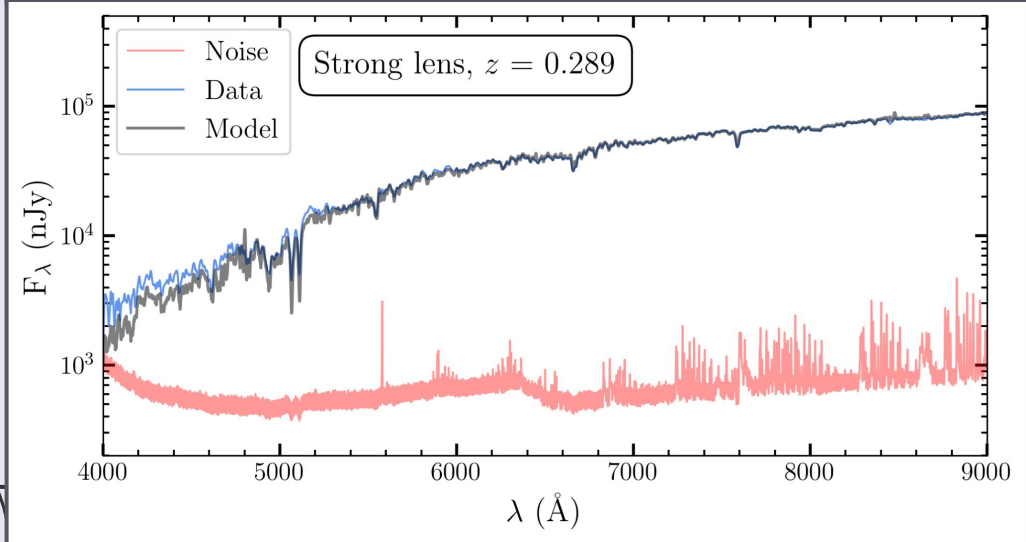




Preliminary Results

- ★ Additional targets:
  - 11 massive galaxies
    - $\log(M_*/M_\odot) > 11$
  - 12 strong lenses
    - From *Euclid* SWG
  - 535 $z < 1$ galaxies
- ★ All useful for *Euclid* team!

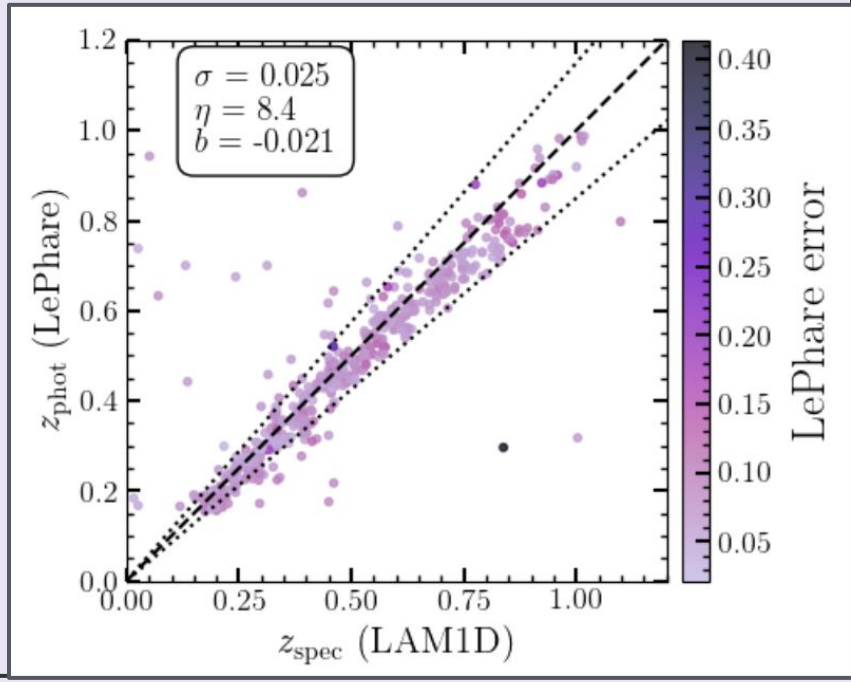




LAM1D Redshifts

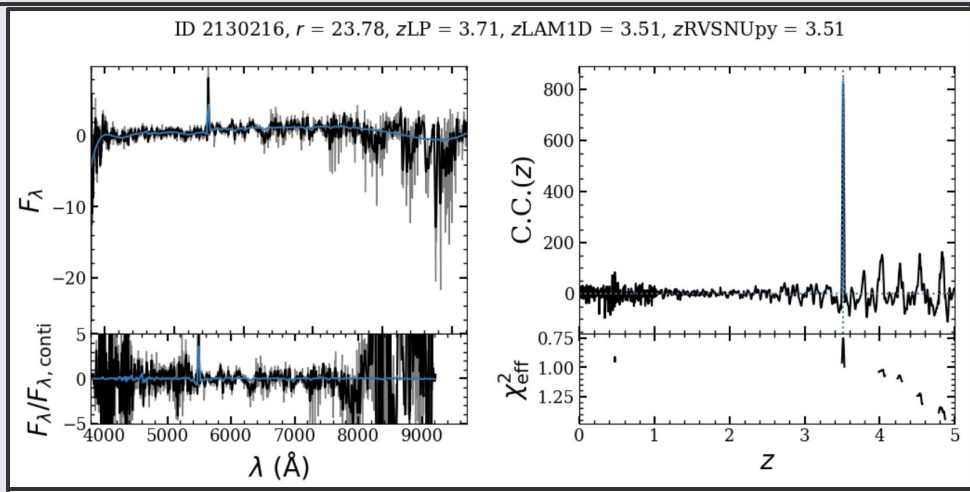
★ Great agreement with LePhare photo-*z* < 1 !

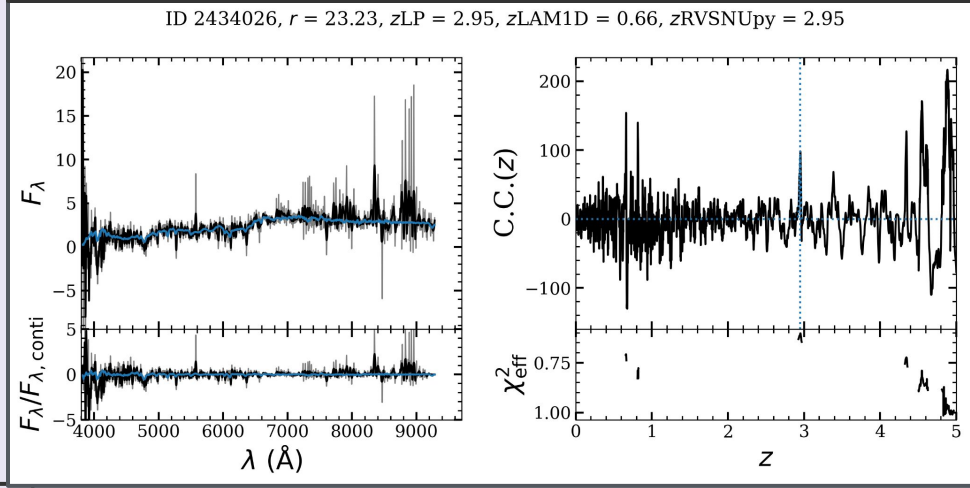
- σ similar to COSMOS2020
- Will help calibrate H20/*Euclid* photometric redshifts



RVSNUpy Redshifts

- ★ RVSNUpy: template cross-correlation (Kim+2025)
  - Goal: optimize for $z > 2$ galaxies
  - Templates: DEEP2 (Newman+2013)
  - Fit Lyα, Lyman break
  - Require visual inspection
    - Finn's GUI!

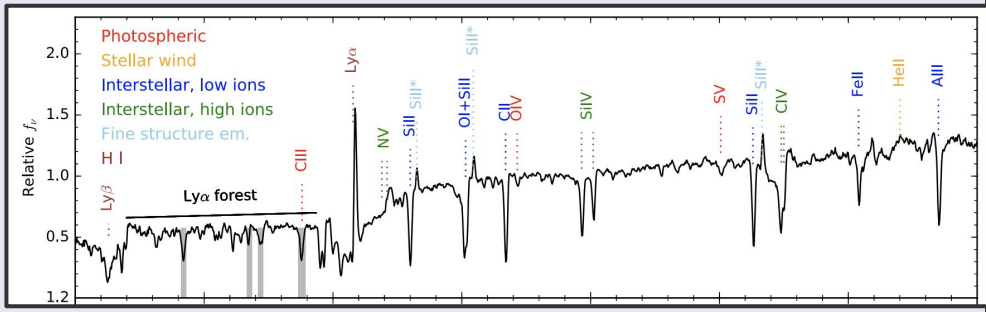


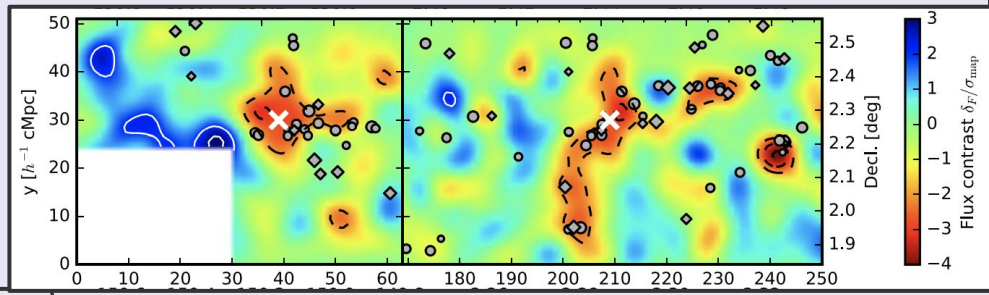


Tomographic Analysis

★ Once target depth is reached:

- Fit template to LBG spectra to extract Lyα forest flux
- Create tomographic maps
- Identify structures
- Analyze galaxy properties in different environments





LATIS, Newman+2020

Summary

For more information on our catalogs, check out the DAWN survey website!

- ★ Lyα tomography observations have begun
  - Bright LAEs/LBGs confirmed
  - Successful fillers useful for *Euclid* Consortium
  - Tomographic analysis coming soon
- ★ ありがとう to the whole PFS team!
  - SAs/OAs, data reduction pipeline, science platform, instrumentation...
- ★ Happy to collaborate on tomography, fillers!

Observing from IfA Mānoa :)

Calibrating Photo-*z*'s

- ★ EAZY & LePhare struggle with Lyman break galaxies...
  - Best-fit SEDs are degenerate
  - CFHT *u*-band + *Euclid YJH* help
- ★ Large sample of $0.1 < z < 3.5$ spectroscopic redshifts in EDF-N essential for H20/*Euclid* photo-*z* calibration