Studying galaxy evolution with JWST slitless spectroscopy: forecasting expectations for Roman's HLWAS

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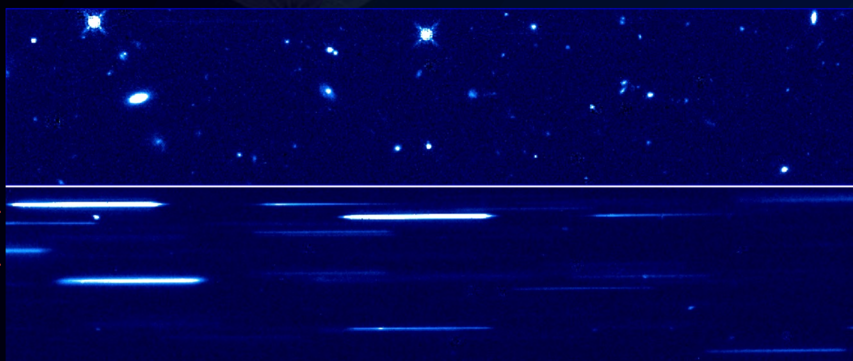
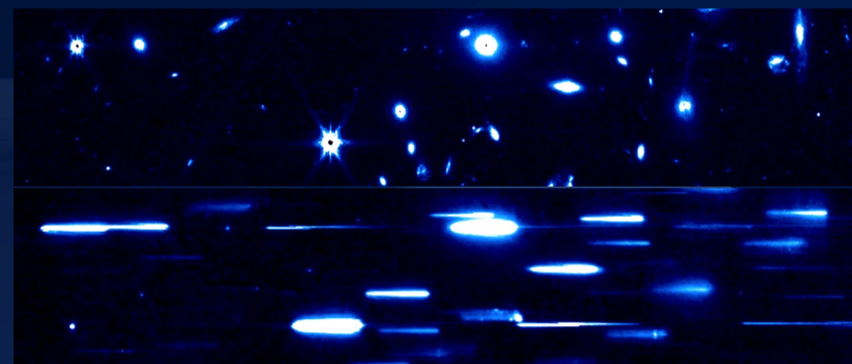
NANCY GRACE ROMAN SPACE TELESCOPE

Slitless Spectroscopy through the past decade



WISPS (HST)



PASSAGE (JWST)

HST (WFC3/IR & ACS) with surveys such as WISPS, 3D-HST, GLASS, AGHAST, FIGS, GRAPES, PEARS

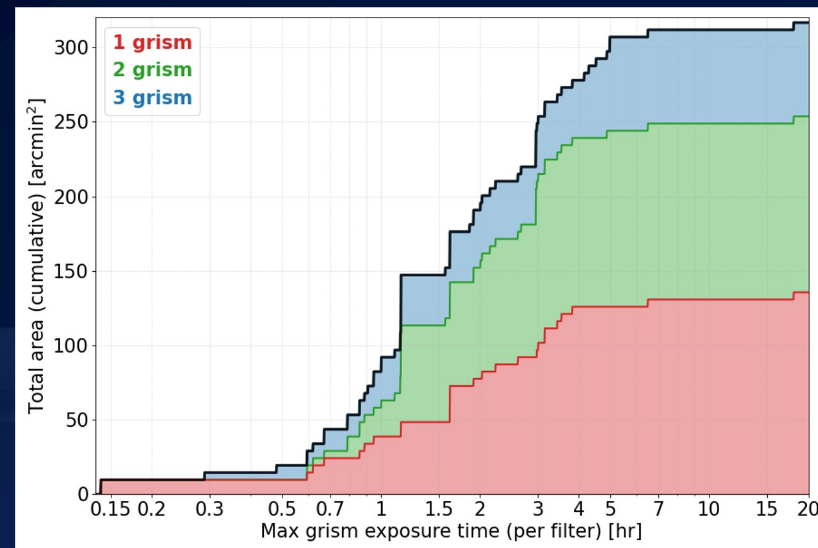
JWST (NIRISS & NIRCam) with surveys such as **PASSAGE**, GLASS, CANUCS, NG-DEEP, COSMOS-3D, EIGER, FRESCO, POPPIES, SAPPHIRES

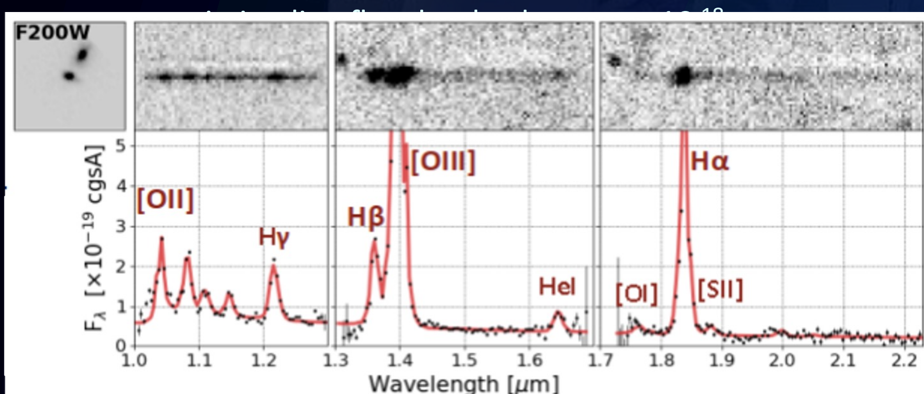
and the now-underway **Euclid** mission

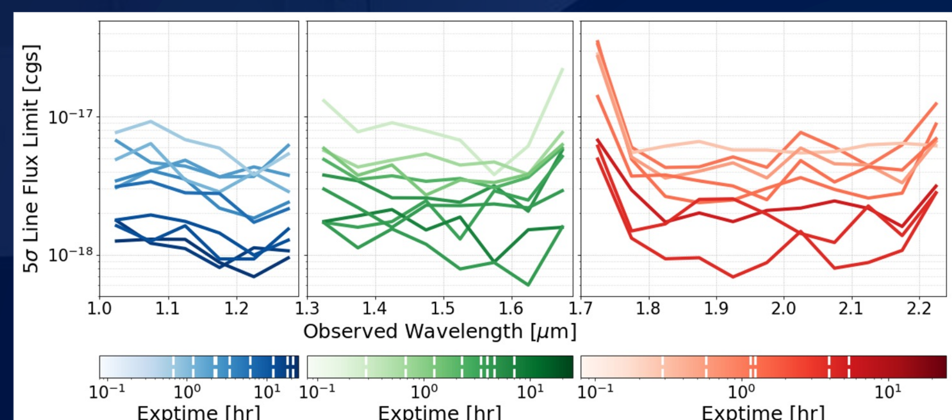
The PASSAGE survey

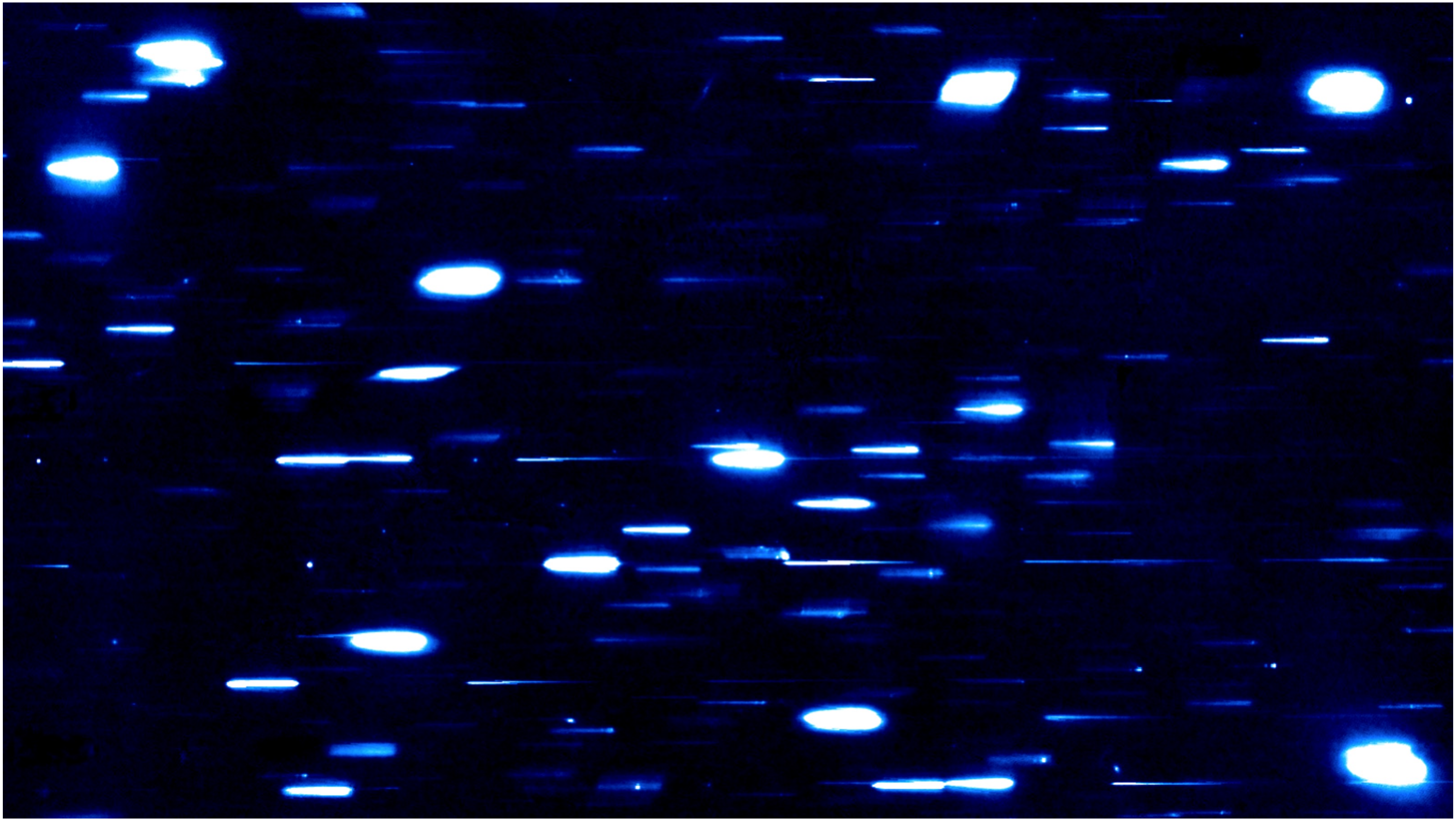
The **P**arallel **A**pplication of **S**litless **S**pectroscopy to **A**nalyze **G**alaxy **E**volution survey (PI: M. Malkan)

- NIRISS grism spectroscopy with upto 3 filters (F115W, F150W, F200W)
- **63** individual fields observed spanning a total of 316.5 arcmin^2 over a total of **383 hrs**
  - exposure times varying from ~1 hr to ~20 hrs per field









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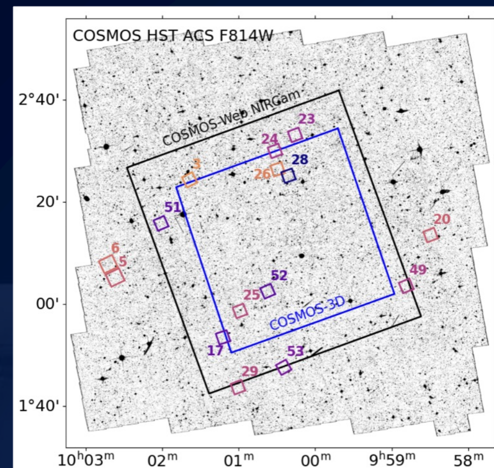
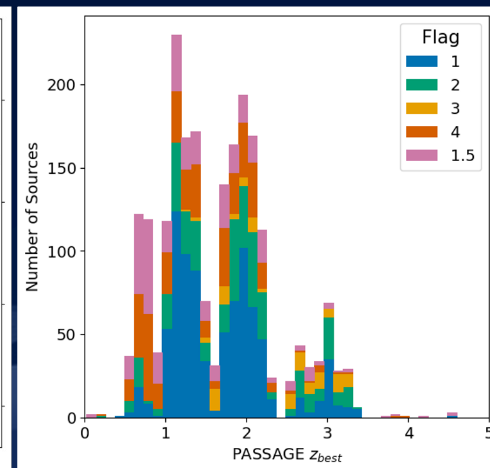
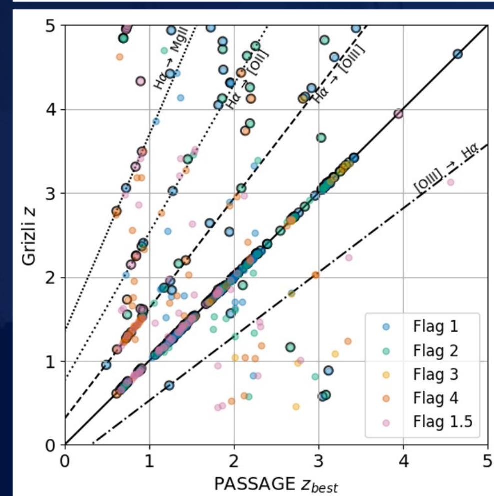
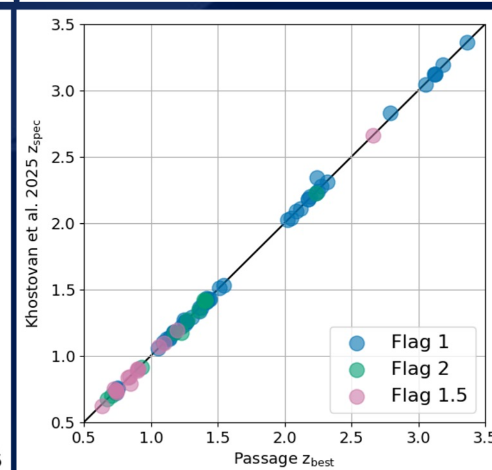
PASSAGE in COSMOS

- Surprisingly (or rather unsurprisingly), a considerable number of PASSAGE fields were in (or near) COSMOS ~15/63 fields
  - **11 fields** in the COSMOS-Web footprint
- Our team *visually inspected* all objects in the 11 fields (within COSMOS-Web footprint) to measure grism-z
  - further leveraged ancillary data to confirm and improve grism-z’s
  - **2183** emission-line sources found over 0.08<z<4.7
- Automated redshift fitting (from grizli) gets a considerable fraction of line misidentifications (~35% overall; ~12% of Flag 1 sources)
- Grism-redshift catalog published in M. Huberty+26 (arXiv:2601.02220)





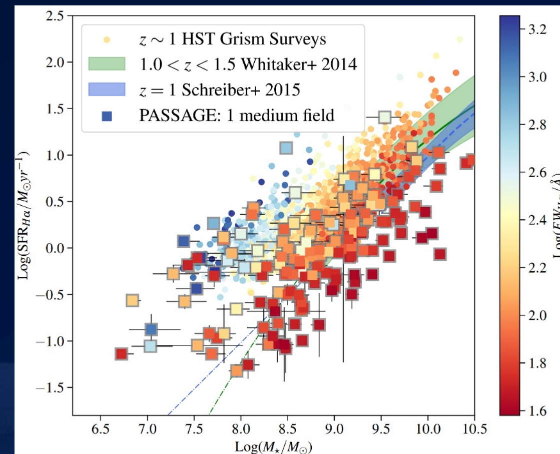




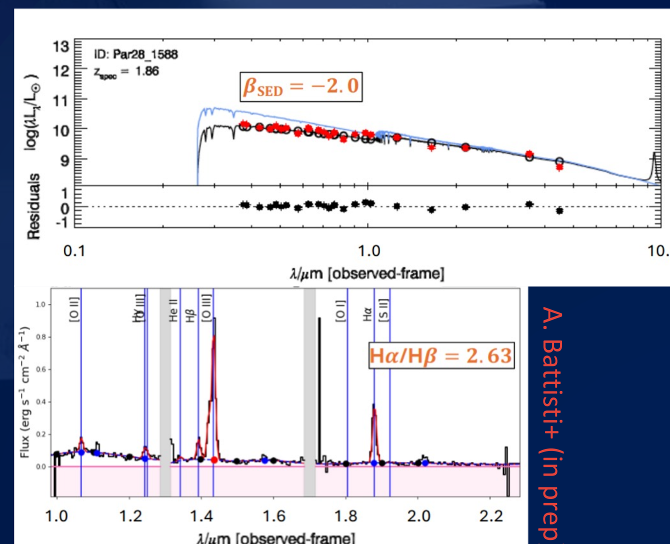
M. Huberty+ (2026)

Galaxy physical properties at Cosmic Noon

- Star-formation in galaxies
  - constrain the SFMS down to ~10^7 $M_\odot$
  - pushing nearly ~1 dex lower than current studies with strong number statistics – 100s of objects added from a single field
- Nebular vs. stellar mass relation
  - nebular dust measured via Balmer decrement
  - constrain the relation down to ~10^7 $M_\odot$
- Nebular vs. Stellar Dust
  - direct comparison between and nebular dust components (from PASSAGE) and the stellar dust component from SED modelling using photometry from ancillary imaging



H. Atek+ (in prep)

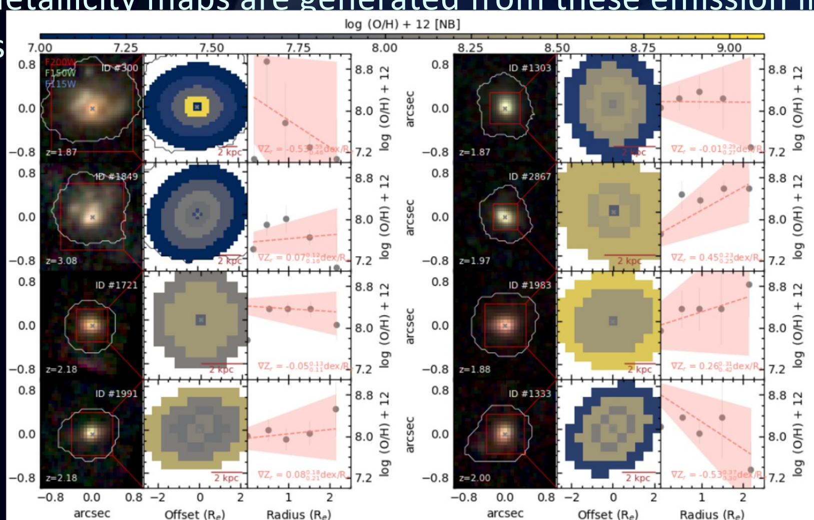


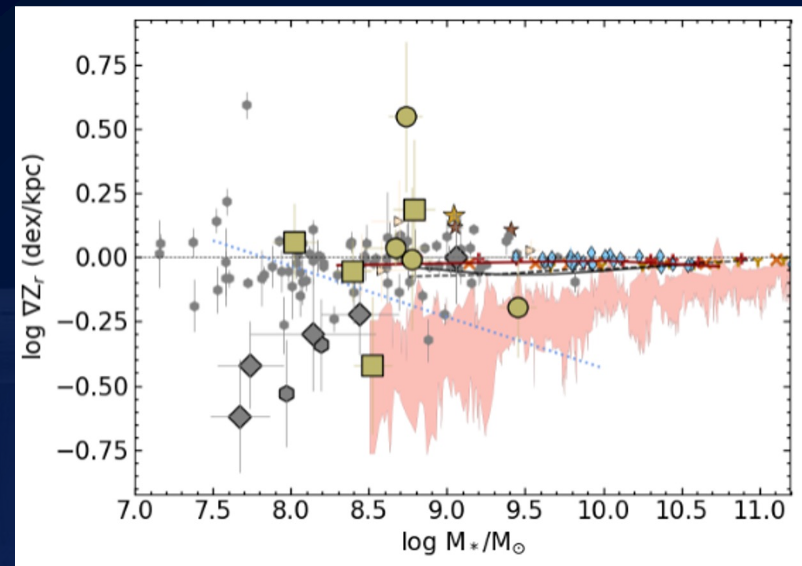
A. Battisti+ (in prep)

Spatially resolved galaxy properties & science

Metallicity gradients in z~2 galaxies

- grism spectra effectively are a spatial map of nebular emission
- metallicity maps are generated from these emission line maps us





A. Acharyya+ (2025)

- gradients in metallicity are generally consistent with flat within errorbars
- no clear trend in the metallicity gradients as a function of stellar mass – contrary to predictions from simulations
- possible hint towards high-z galaxies not having started their accretion-dominated phase yet

Galaxy protoclusters & environmental effects

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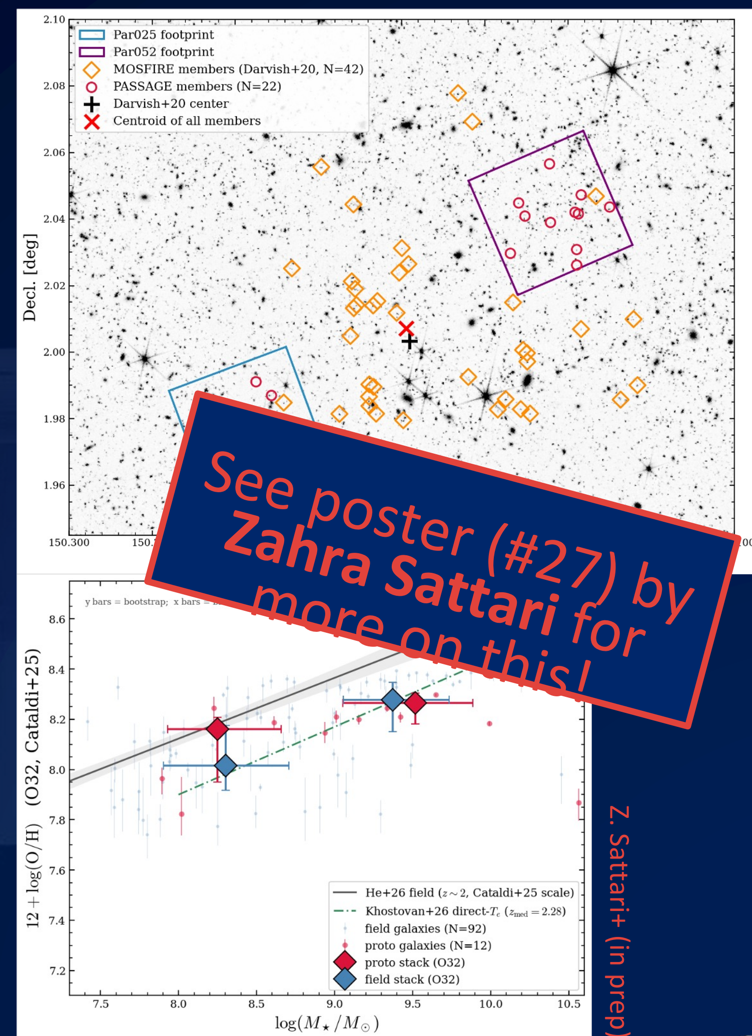
Serendipitously, 2 NIRISS pointings overlapped with a known protocluster CC2.2 (z=2.23) in COSMOS

- confirmed **20** new protocluster members from PASSAGE reaching down ~$10^{7.5} M_{\odot}$ (~1 dex deeper than MOSFIRE)
- measured gas-phase metallicity from the PASSAGE+MOSFIRE data to quantify the difference in metallicity between cluster and field galaxies

Key science drivers:

- how does environment impact the star-formation in cluster galaxies?
- is the chemical evolution influenced by large-scale environment?



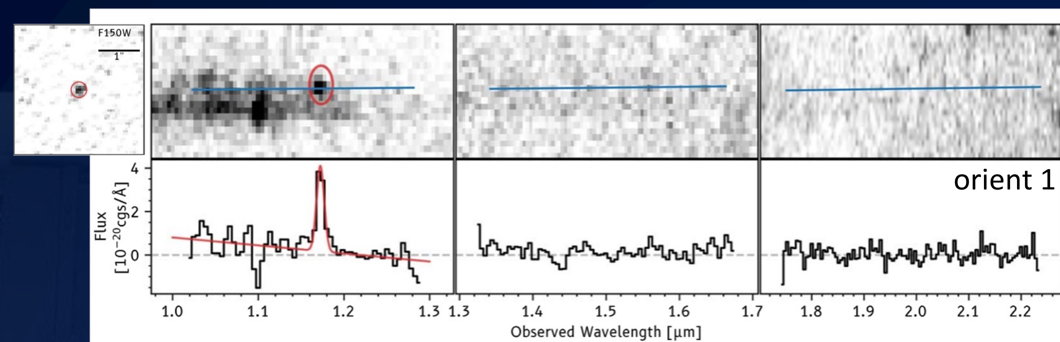
Z. Sattari+ (in prep)

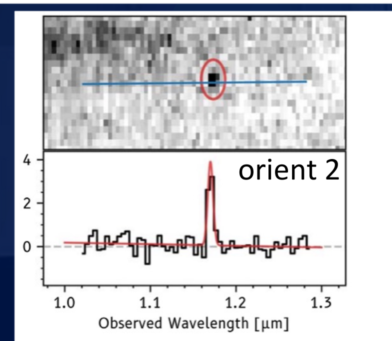
Finding reionizing sources at Cosmic Dawn

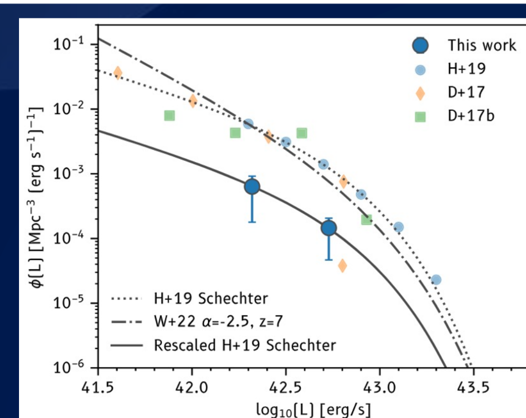
Search for Lyα emitters at z>8 by employing a "blind-search" technique

- look for bright emission lines in the grism images directly
- identify potential sources to associate with the emission line
- use multiple orients to confirm these are real (and not artifacts or other low-z interlopers)

4 LAE candidates found in 4 PASSAGE fields (4 x NIRISS FoV ~ 19 arcmin^2)





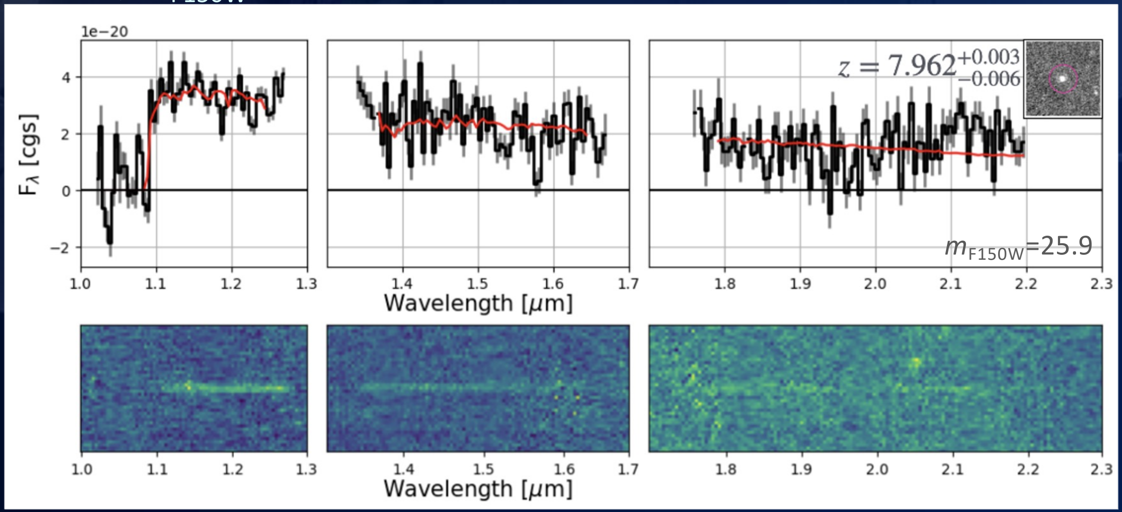


A. Runnholm+ (2025)

Finding reionizing sources at Cosmic Dawn

Searching for Lyman-break galaxies at z~8

- confirm the Lyman continuum break in the grism spectral data
- spectroscopically confirmed 1 out of 7 photo-z selected sources in COSMOS
- remaining are too faint; m_{F150W}>26 AB



Z. Sackih+ (2026)

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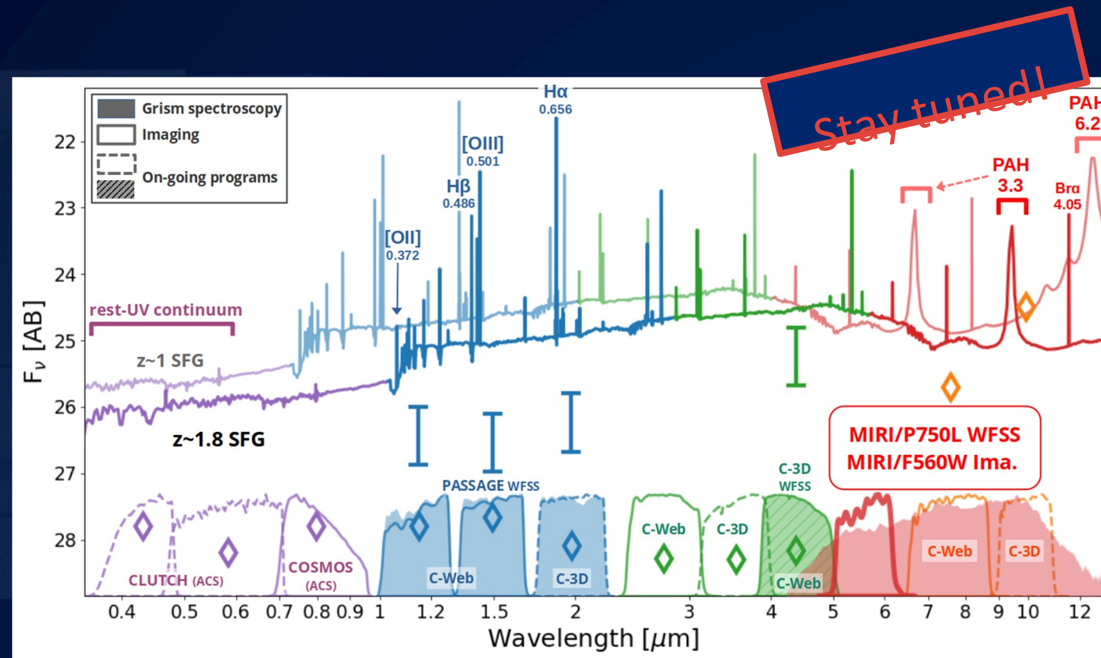
Further into the IR with JWST/MIRI

Recently approved JWST Cy 5 program (PID: 11605; PI: Mehta)

- uses the newly available MIRI WFSS mode
- targets 2 fields from PASSAGE in COSMOS
- UV-to-MIR wavelength coverage with imaging
- near-contiguous wavelength coverage in IR
  - 1–2.3 µm with NIRISS
  - 4–5 µm with NIRCam
  - 5–10 µm with MIRI



Primary science objectives:

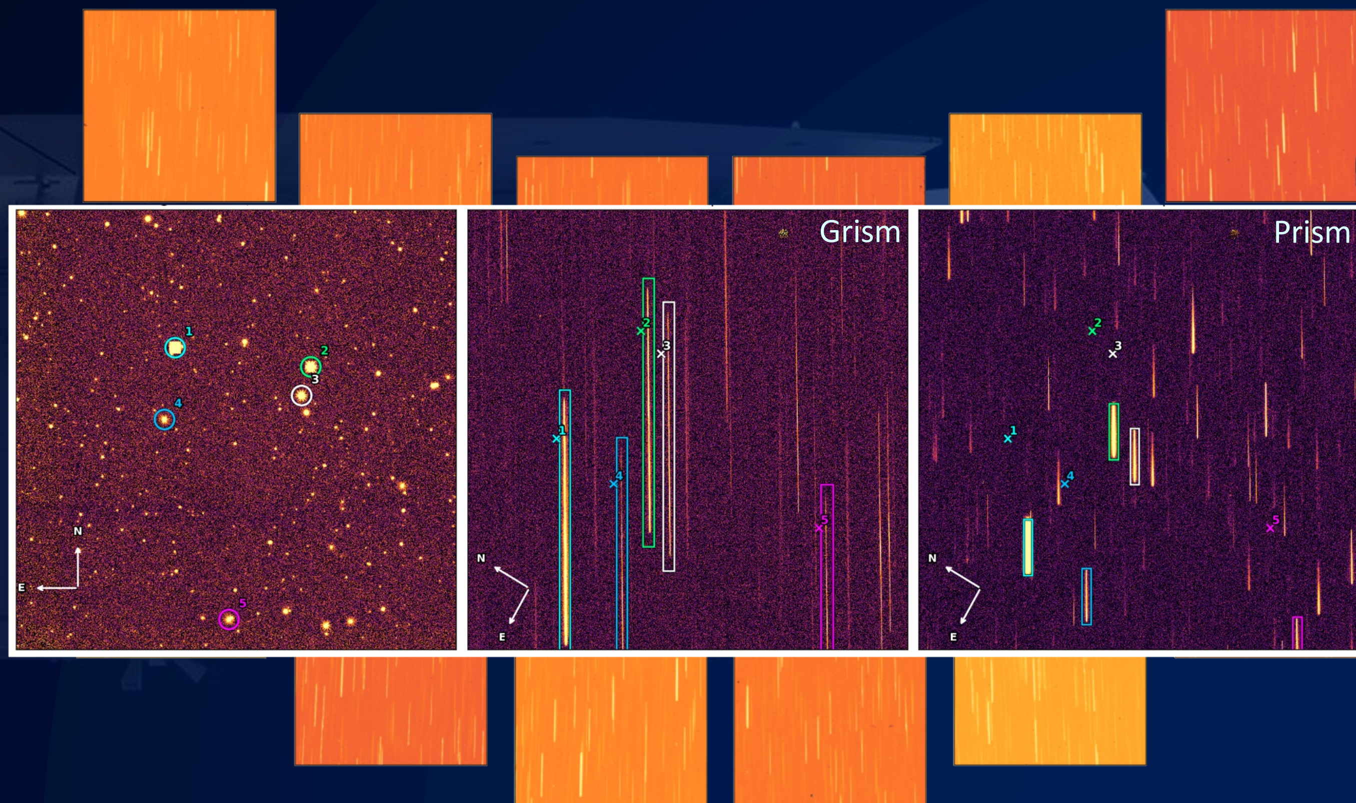
- unbiased search for PAH-3.3 µm emission at z=0.5-2.3
- calibrate PAH-3.3 µm as an SF indicator at cosmic noon

Slitless spectroscopy with Roman

Roman carries two disperser elements – a grism and a prism

The grism is of particular interest for a variety of galaxy evolution science:

- covers 1–1.93 µm
- with a spectral resolution of R∼461 (higher than HST, JWST, and Euclid)
- at Hubble-like resolution of ∼0.1 arcsec

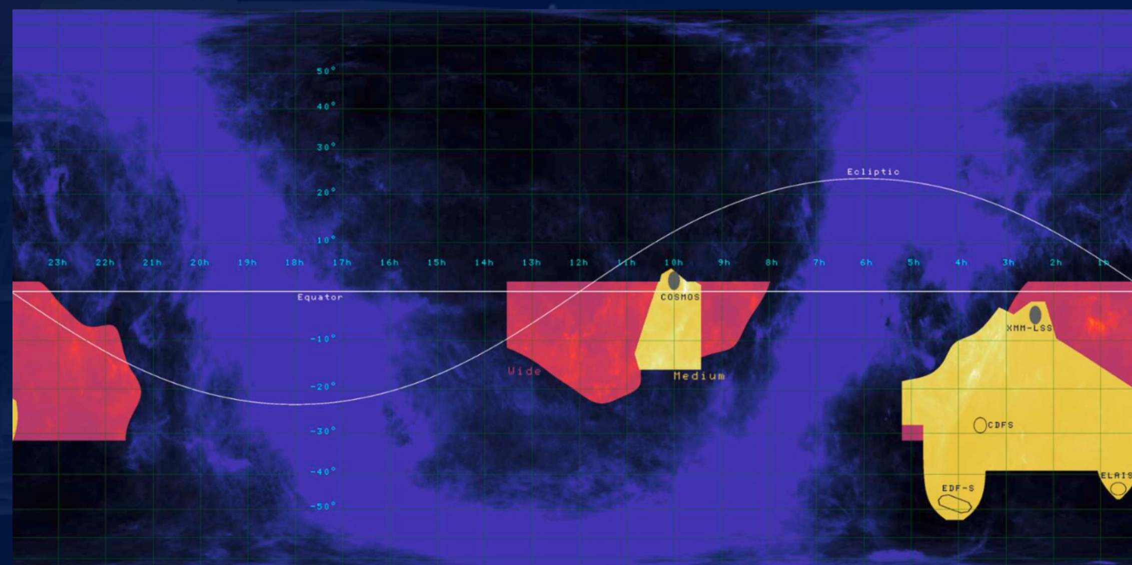


Courtesy: N. Padmanabhan & GRS PIT

Roman's High-Latitude Wide Area Survey (HLWAS)

Key advantages:

- significantly wider area with grism
  - ~2,400 deg^2 (for Medium-tier)
  - ~19.5 deg^2 (for Deep-tier)
- uniform, competitive sensitivity in spectroscopy
  - ~1.5×10^{-16} cgs (for Medium-tier)
  - ~6×10^{-17} cgs (for Deep-tier)
- higher spectral resolution with grism
- complementary imaging in multiple filters (3 for Medium-tier; 7 for Deep-tier)
- multiple roll-angles!



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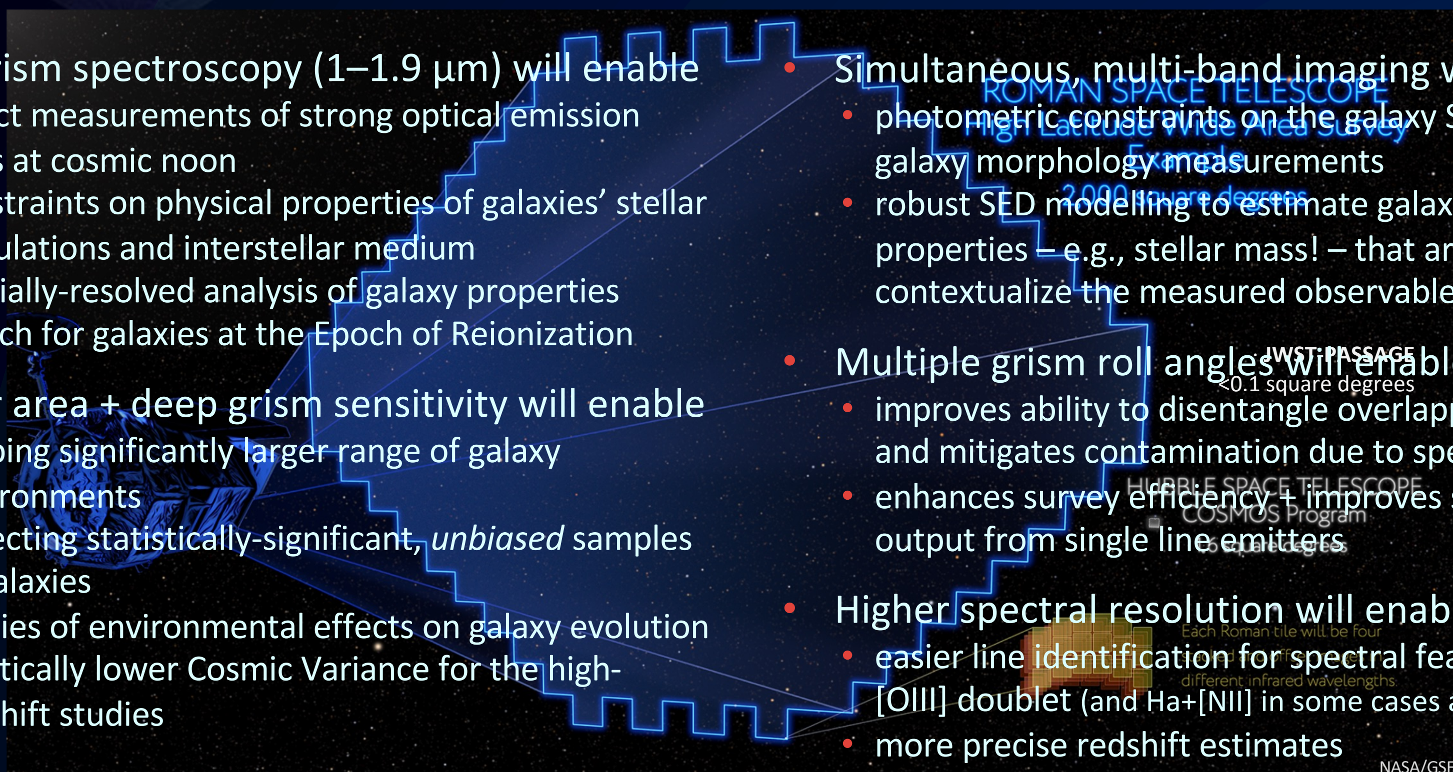
galaxy evolution

Roman HLWAS will deliver transformative science



- NIR grism spectroscopy (1–1.9 μm) will enable
  - direct measurements of strong optical emission lines at cosmic noon
  - constraints on physical properties of galaxies' stellar populations and interstellar medium
  - spatially-resolved analysis of galaxy properties
  - search for galaxies at the Epoch of Reionization
- Wider area + deep grism sensitivity will enable
  - probing significantly larger range of galaxy environments
  - collecting statistically-significant, *unbiased* samples of galaxies
  - studies of environmental effects on galaxy evolution
  - drastically lower Cosmic Variance for the high-redshift studies
- Simultaneous, multi-band imaging will enable
  - photometric constraints on the galaxy SEDs as well as galaxy morphology measurements
  - robust SED modelling to estimate galaxy physical properties – e.g., stellar mass! – that are essential to contextualize the measured observable quantities
- Multiple grism roll angles will enable
  - improves ability to disentangle overlapping spectra and mitigates contamination due to spectral overlap
  - enhances survey efficiency + improves science output from single line emitters
- Higher spectral resolution will enable
  - easier line identification for spectral features such as [OIII] doublet (and Ha+[NII] in some cases at high-z)
  - more precise redshift estimates

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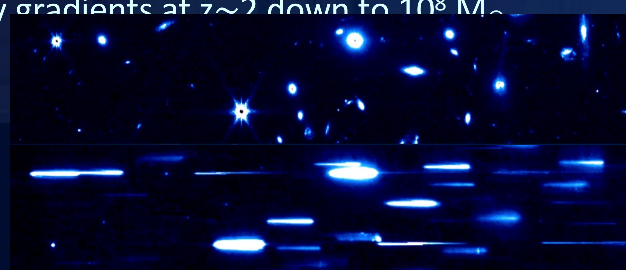
Summary

PASSAGE – a JWST/NIRISS grism program:

- ~383 hrs of data collected over 63 independent fields
- provides a rich NIR spectroscopic dataset
- new grism-redshifts for 1000s of galaxies + line properties
- great synergy with other COSMOS surveys

Key new science results with PASSAGE:

- constraints on galaxy scaling relations at cosmic noon down to ~10^7 $M_\odot$ (SFMS, MZR, nebular vs. stellar dust)
- spatially resolved metallicity gradients at z~2 down to 10^8 $M_\odot$
- new protocluster members discovered + analysis of environmental effects in protoclusters
- 4 LAE candidates found + 1 LBG confirmed at z~8



Roman is here!

- we will be drowning in grism spectroscopy data
- lots of exciting things to discover and new parameter spaces to explore