A large spectroscopic survey of the z=1-3 Universe with HST

Gabriel Brammer, Erica Nelson, Mattia Fumagalli, Kaspar Schmidt, Shannon Patel, Ros Skelton, Anna Williams, Elisabete de Cunha, Pieter van Dokkum, Marijn Franx, Hans-Walter Rix, for the 3D-HST team

Surveying the z>1 Universe

- We know vastly more than a few years ago: mass functions, cosmic star formation history, size distributions, etc out to z=4-8
- Keck and HST have not been superseded and have been around for nearly 20 years: what changed?

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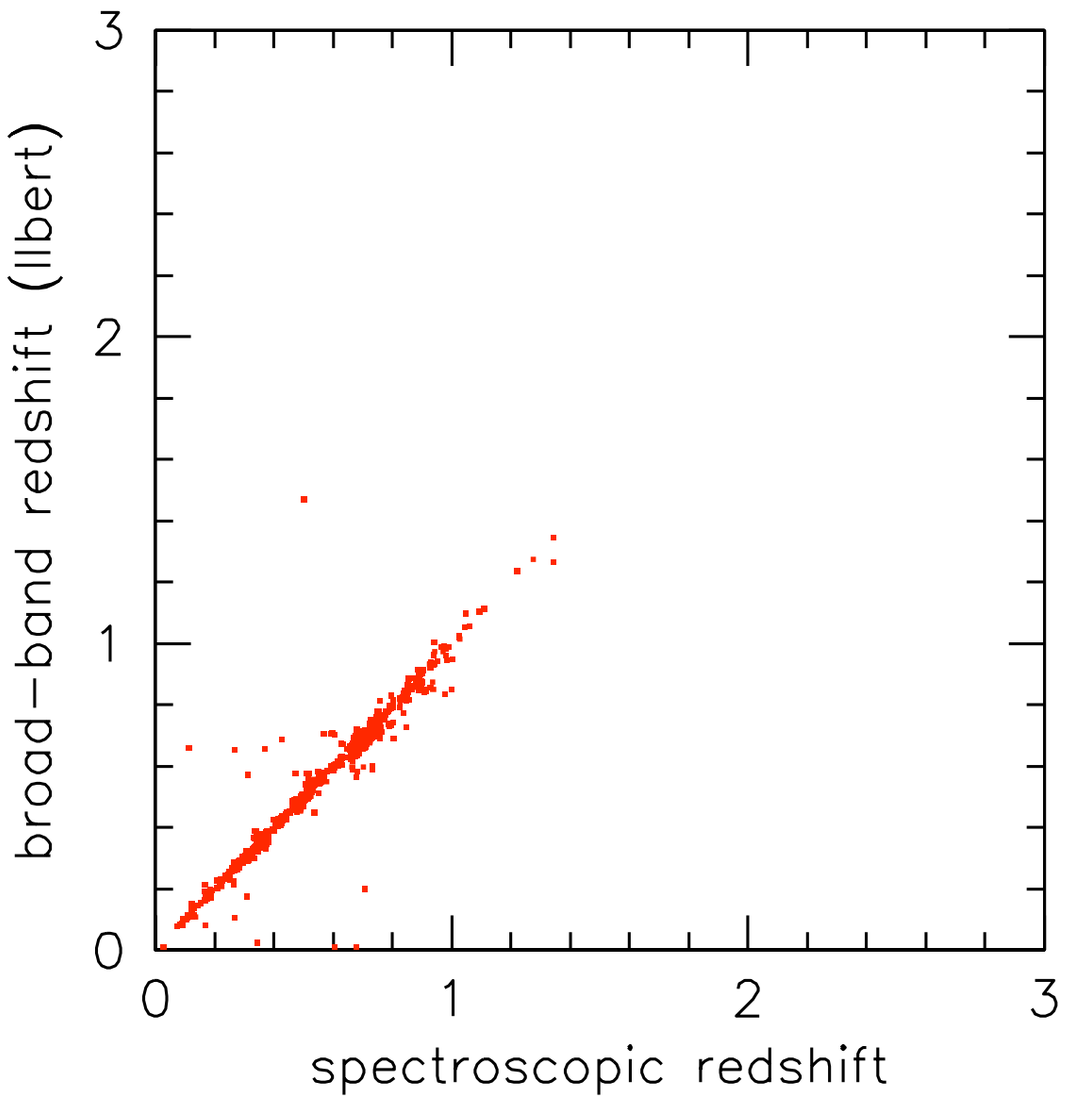
- Keck and HST have not been superseded and have been around for nearly 20 years: what changed?
  - Instrumentation such as SINFONI on VLT: excellent information on relatively small, bright samples

    Forster Schreiber et al 2007-11, Kriek et al 2008-11, etc
  - Photometric redshifts, and stellar population fitting, have gone mainstream: 10s of 1000s of galaxies

    Dickinson et al 2003, vD et al 2006, Ilbert et al 2008, etc etc

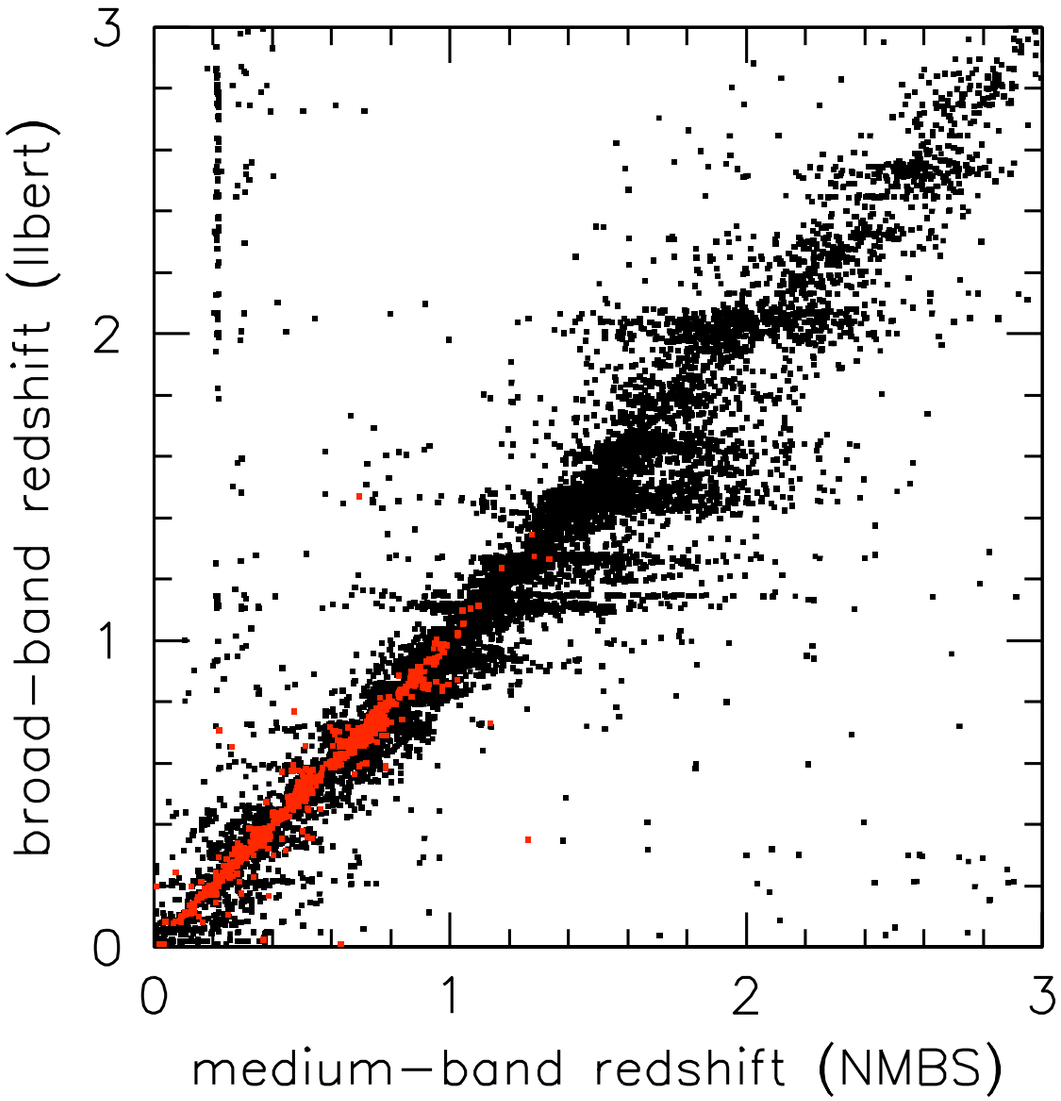
Quality of broad-band redshifts

- Excellent for (optically) bright samples



Quality of broad-band redshifts

- Excellent for (optically) bright samples
- Not so good for K-selected, optically-faint samples



Note: Milky Way would have K~23, R~27 at z=2

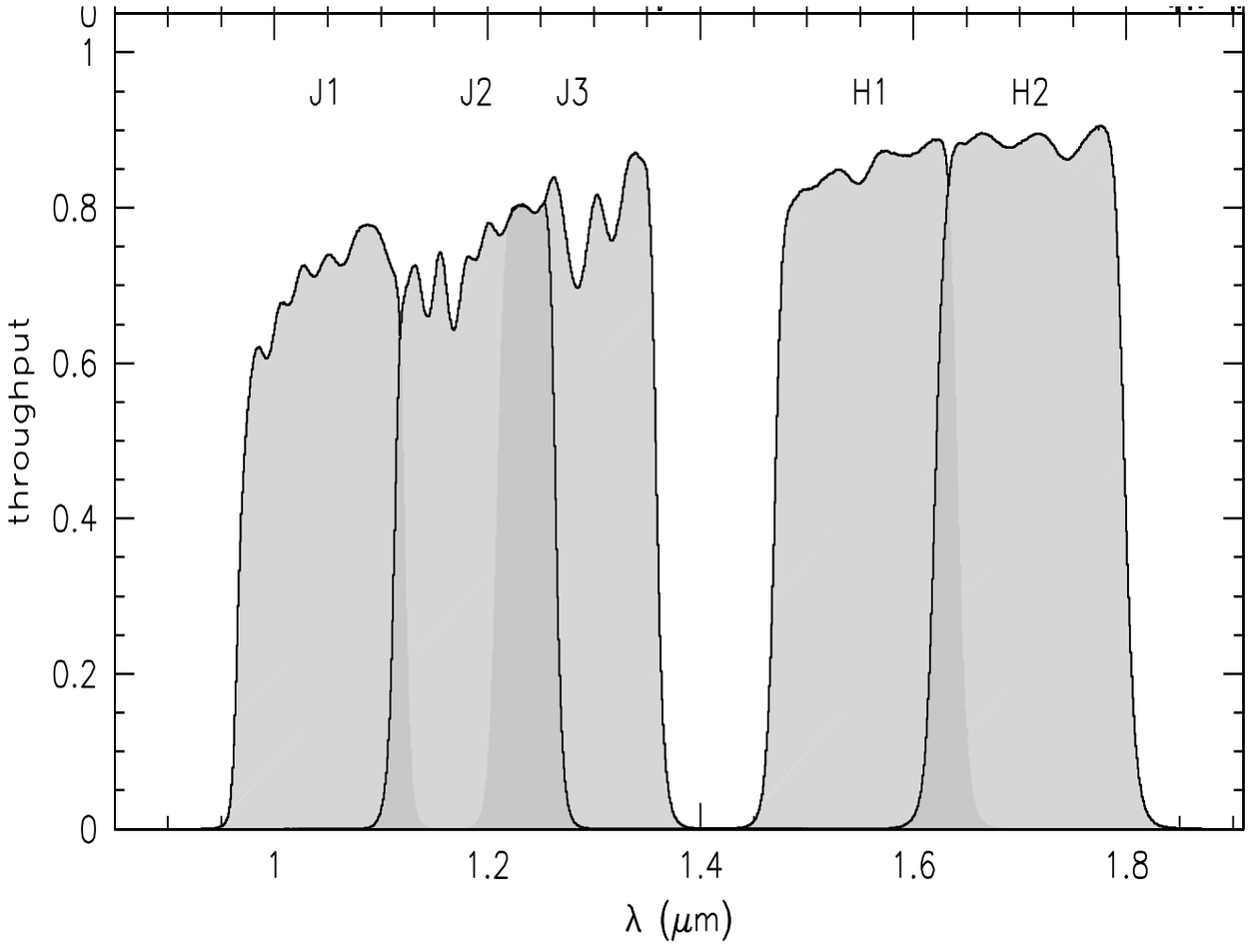
Having your cake ..

- Ideally, combine efficiency and depth of imaging with accuracy of spectroscopy

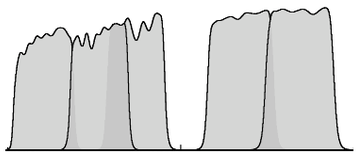
- **NEWFIRM Medium Band Survey** (Whitaker et al 2011): replace J and H band with five medium-band filters

- **3D-HST** (Brammer et al, in prep):
  use grisms on HST to obtain R~100 spectra

NEWFIRM Medium Band Survey



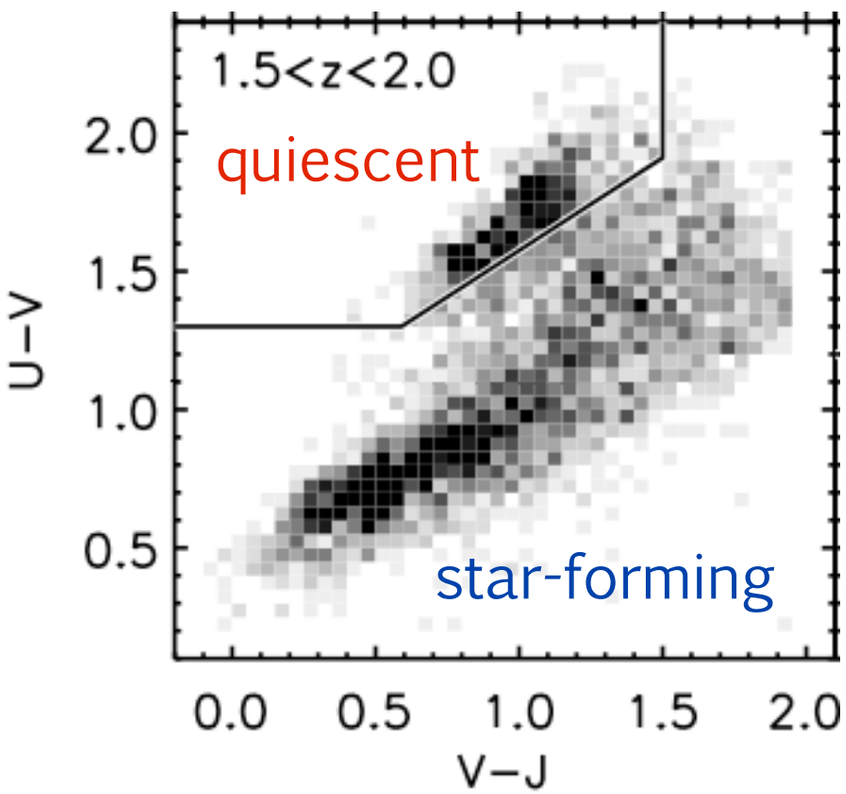
Kate Whitaker+ (2010,11)
Redshifts good to ~2% for ~13,000 galaxies at z>1.5



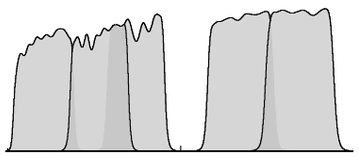
NEWFIRM Medium Band Survey

Whitaker et al 2011

separate star-forming and quiescent galaxies



Whitaker et al 2011



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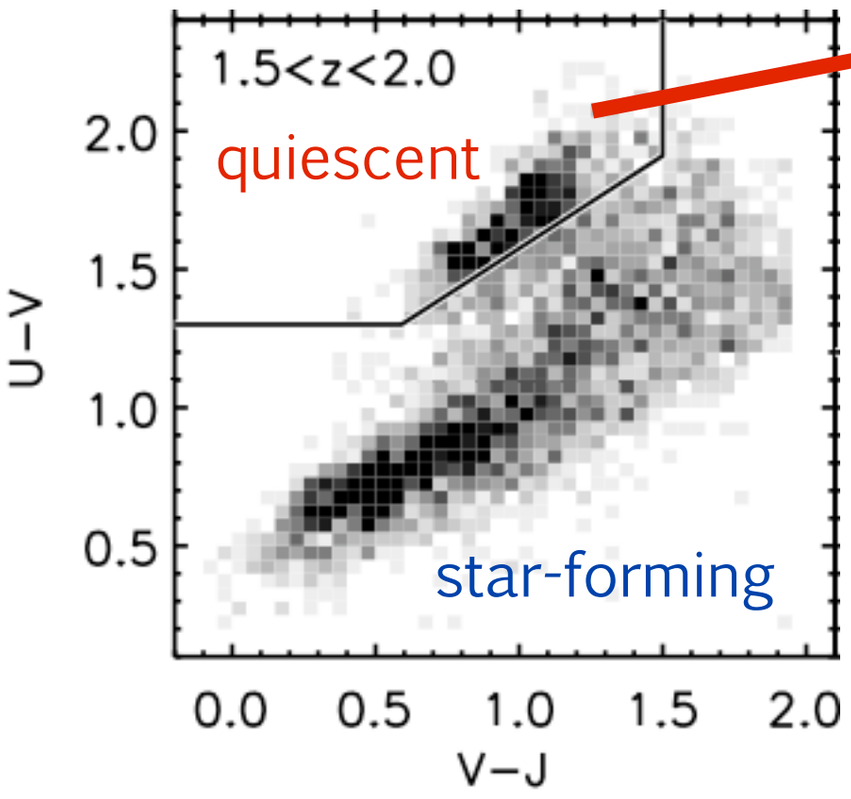
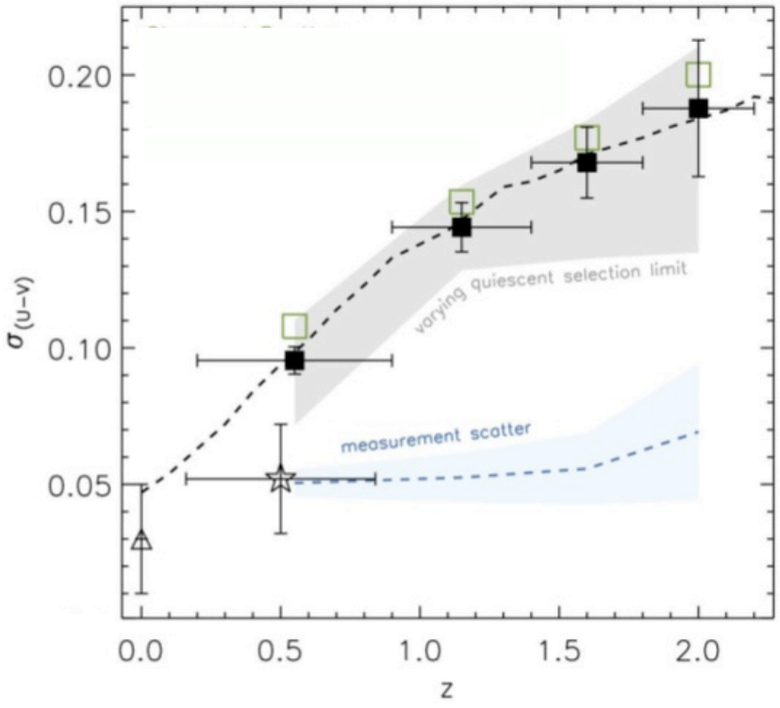
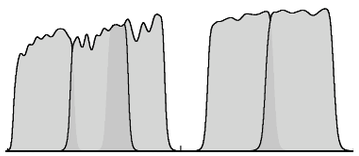


Whitaker et al 2011



age spread of quiescent galaxies

Whitaker et al 2010



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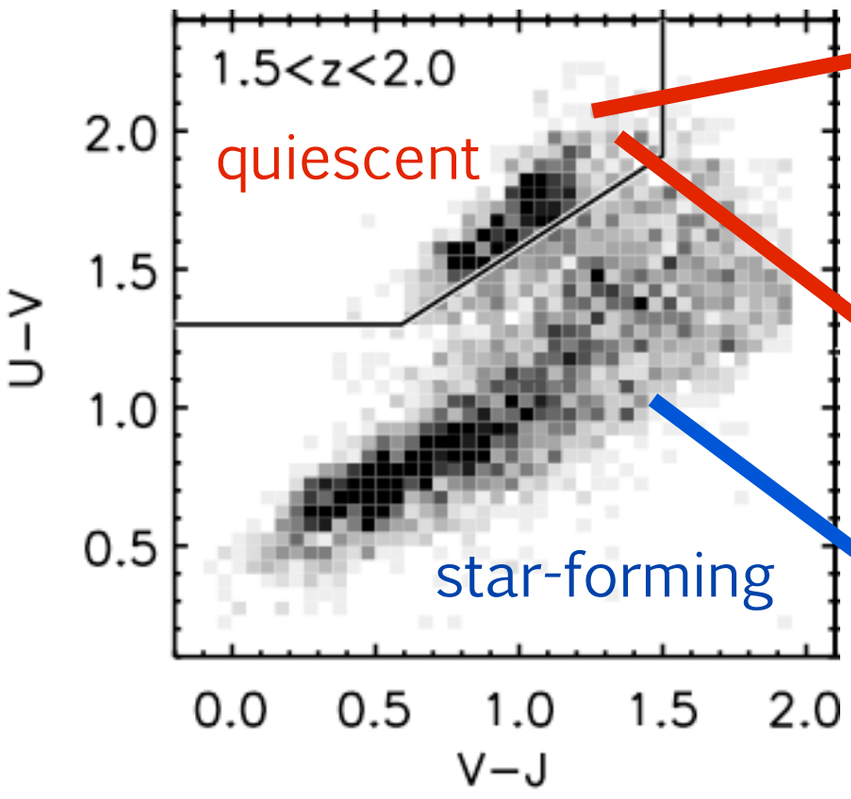
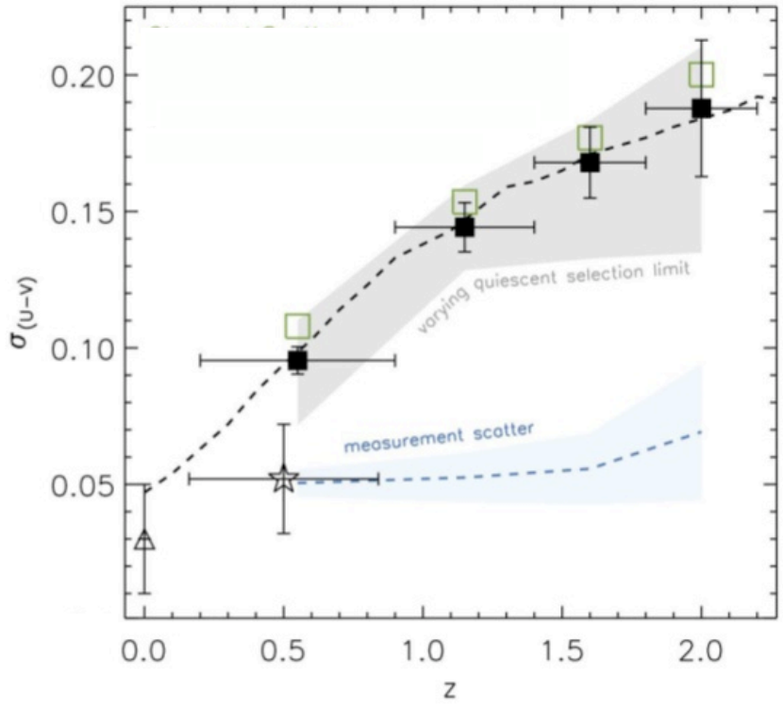


Whitaker et al 2011



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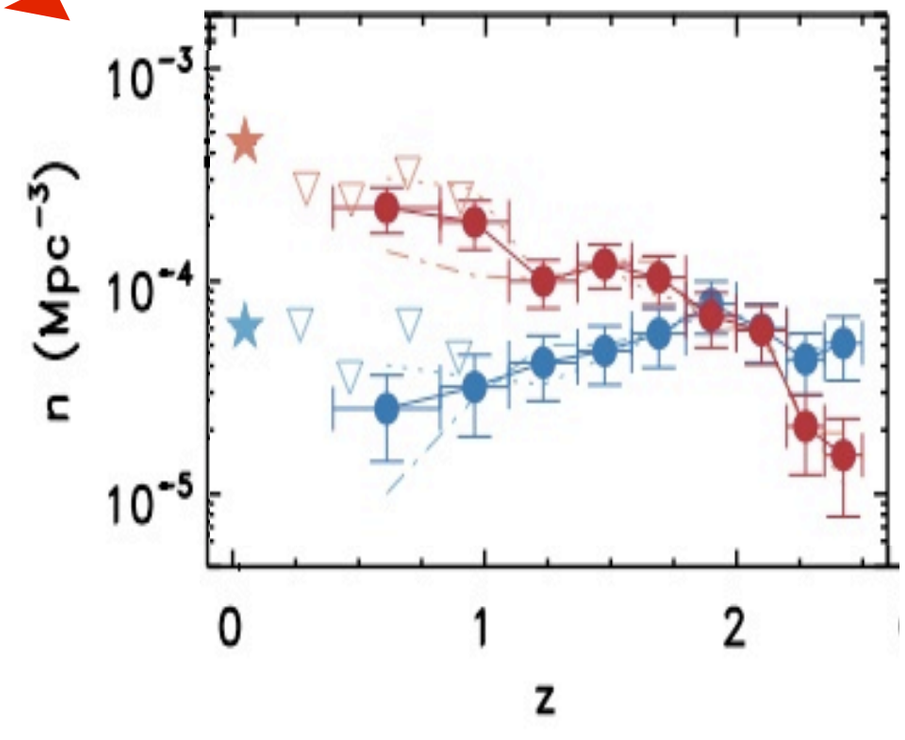
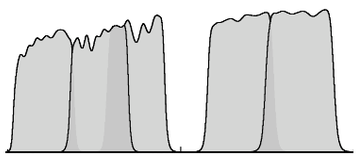


mass and number density evolution

vD et al 2010
Brammer et al 2011



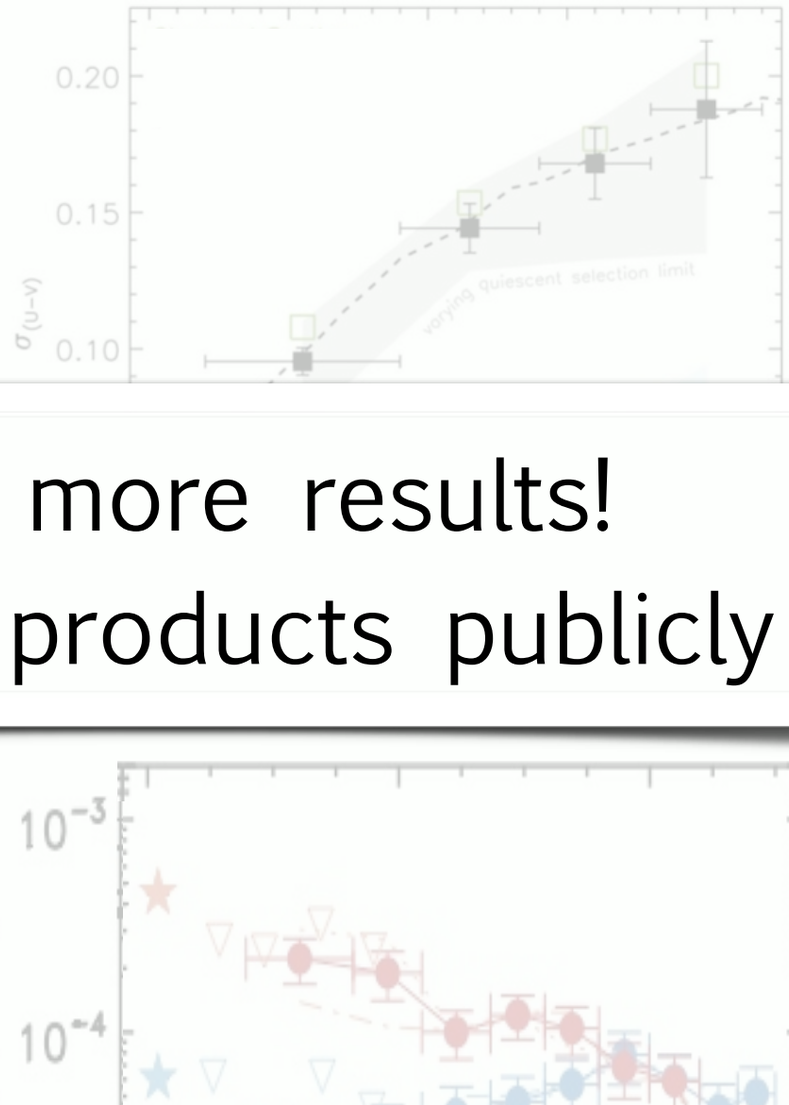
NEWFIRM Medium Band Survey

Whitaker et al 2011

separate star-forming and quiescent galaxies

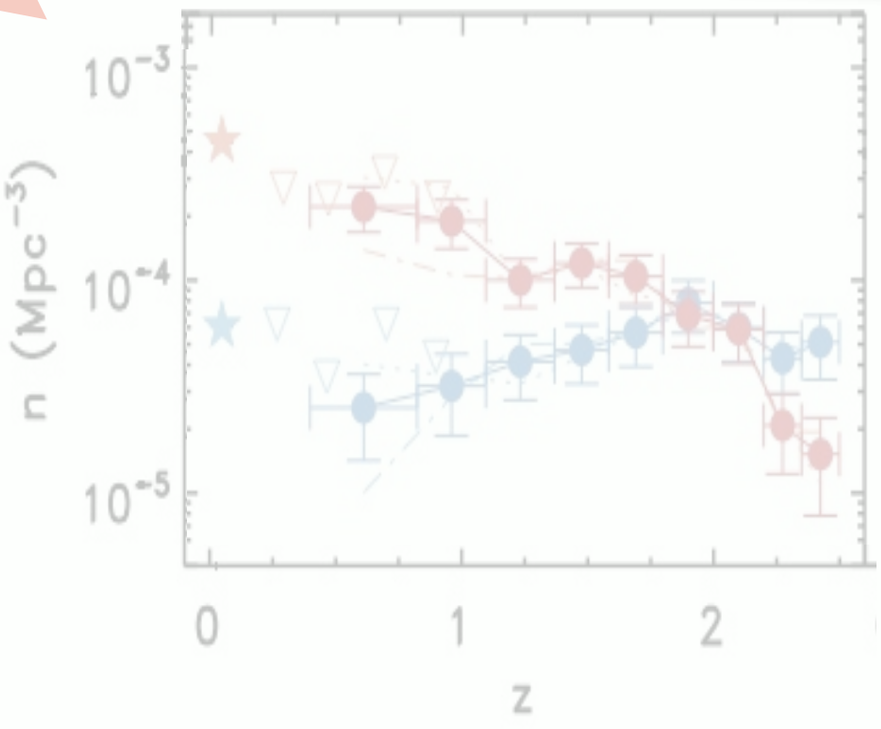
star-forming

Whitaker et al 2011



Many more results!

- all data and data products publicly available -



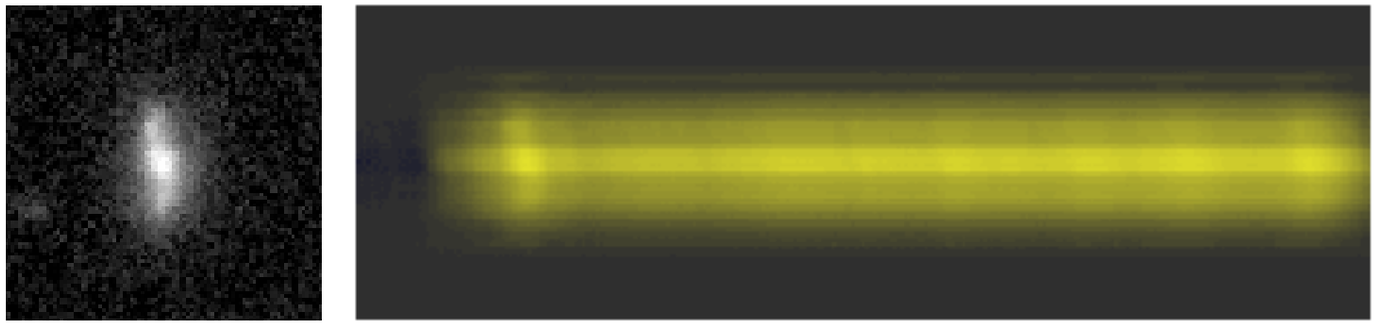
number density evolution

Brammer et al 2011

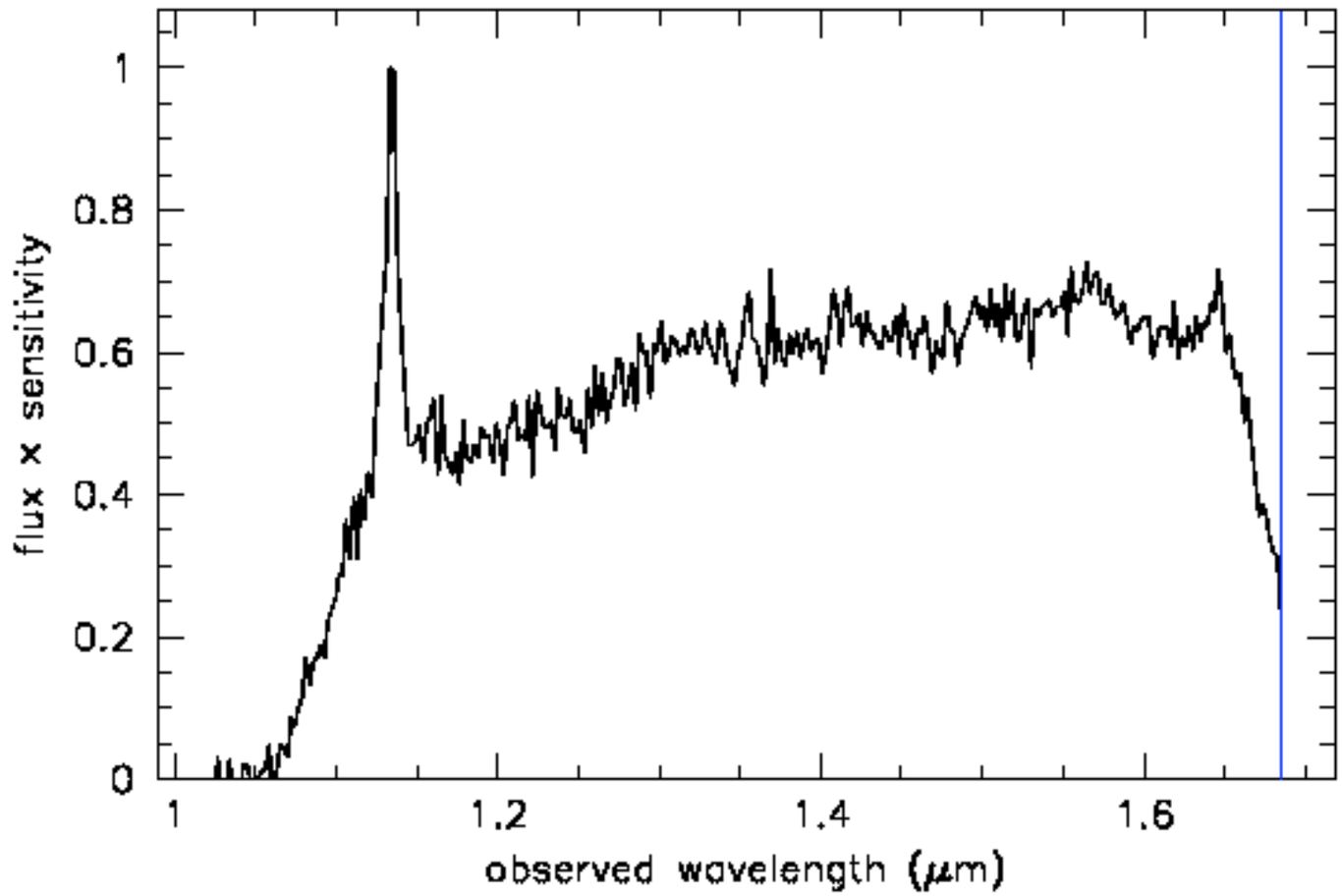
248 orbit Treasury program
2-orbit depth WFC3 + ACS grism
redshifts to ~0.4%

Gabriel Brammer (ESO) et al, 2011

WFC3 G141 grism



Nelson+ 2011
Schmidt+ 2011



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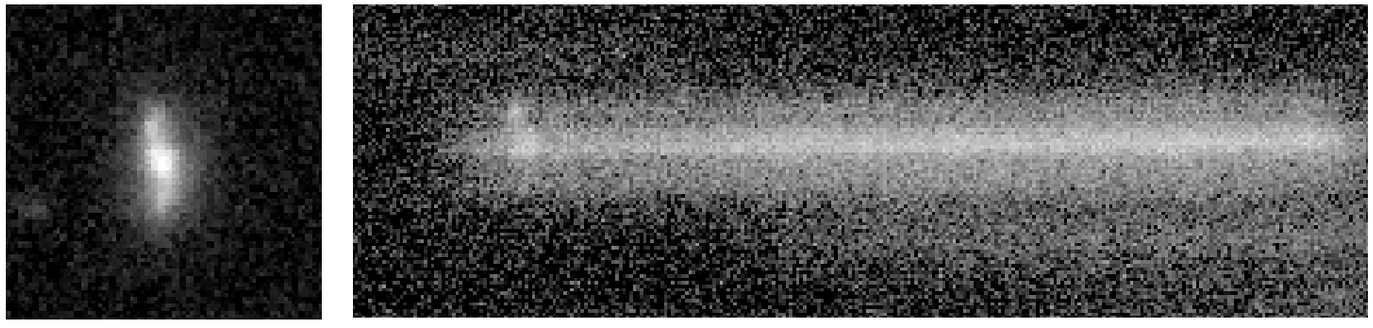
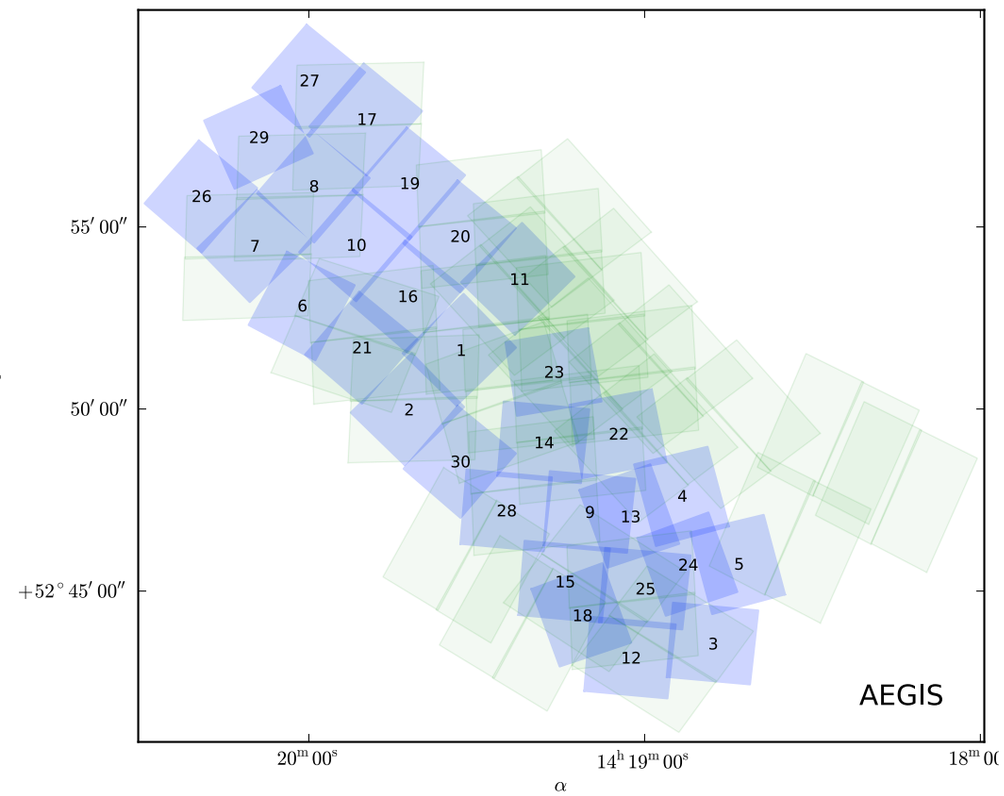
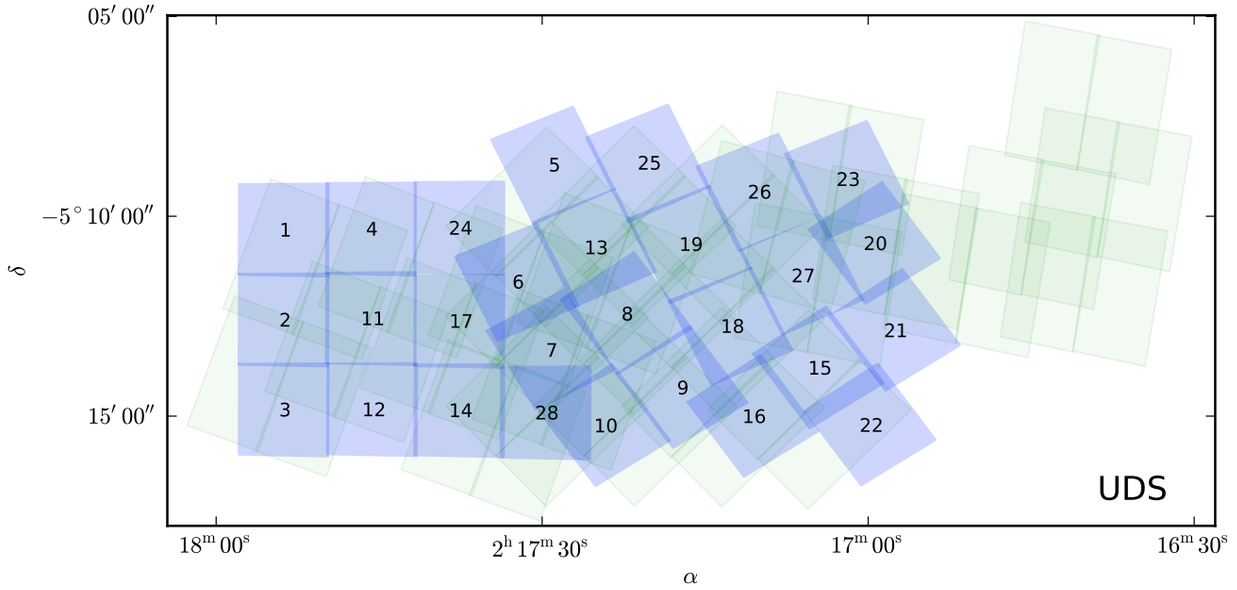
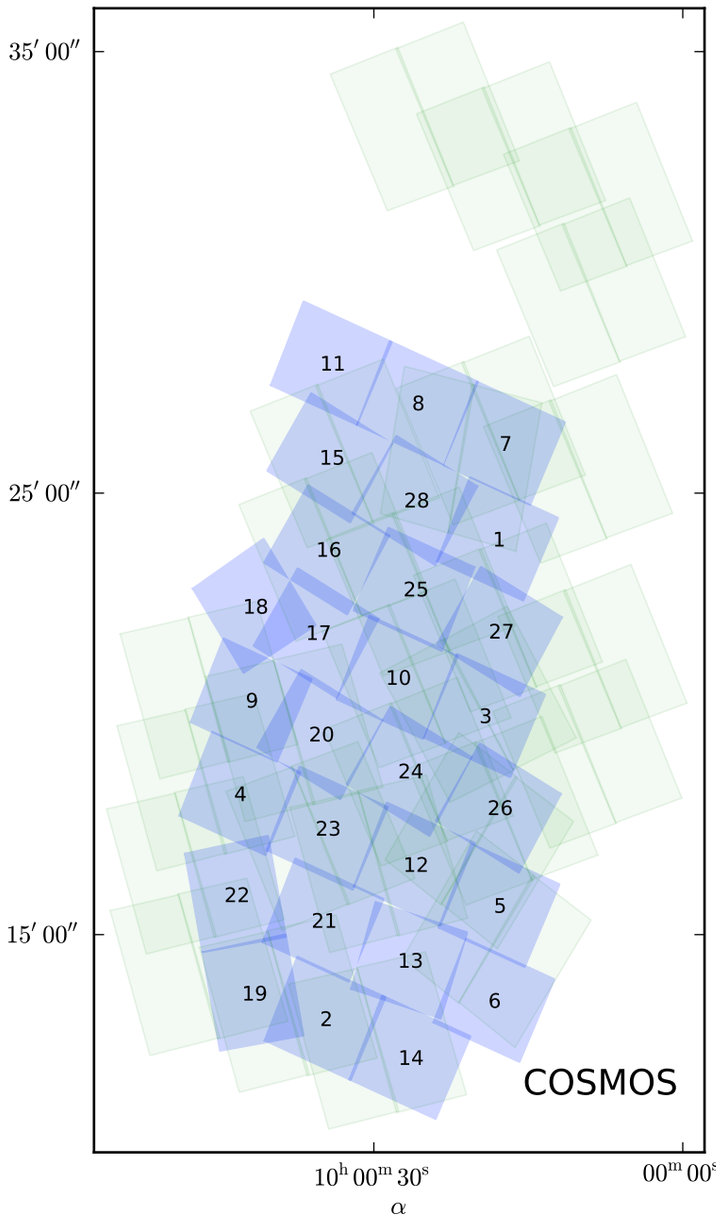


Nelson+ 2011
Schmidt+ 2011

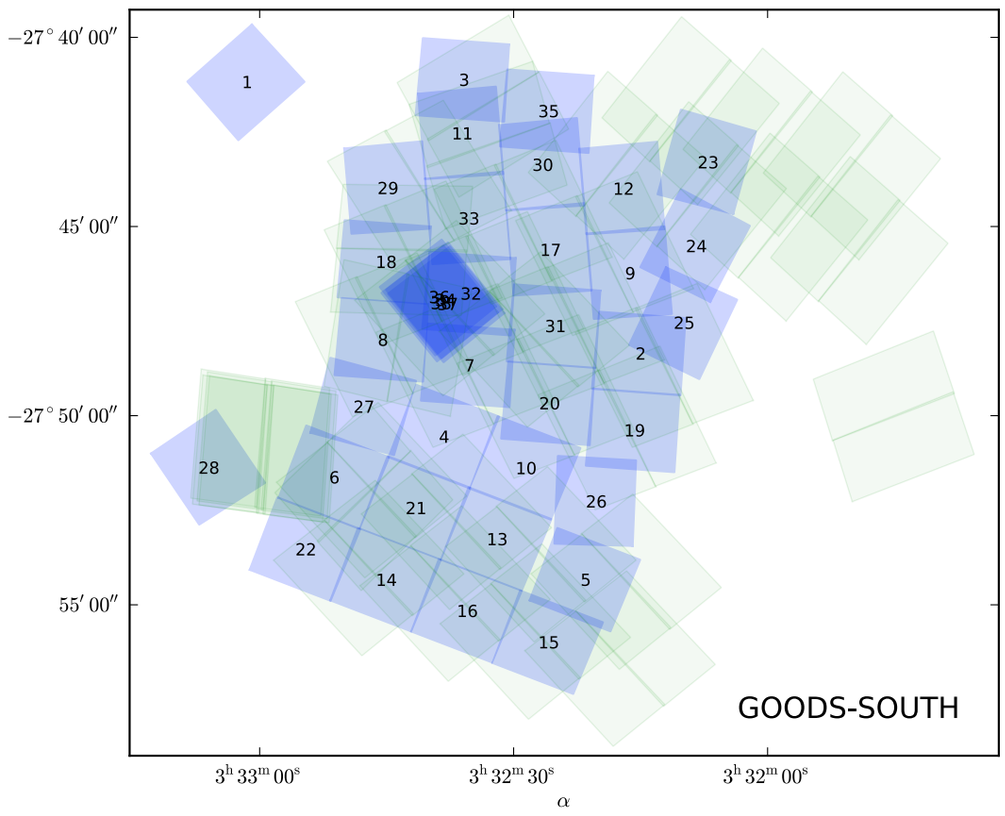
- Provides spectra of all objects in the 2'x2' WFC3 field simultaneously
- R~100, wavelength coverage 1.10 - 1.65 micron
- Redshifts, line diagnostics, and 2D spatial distribution of line emitting gas

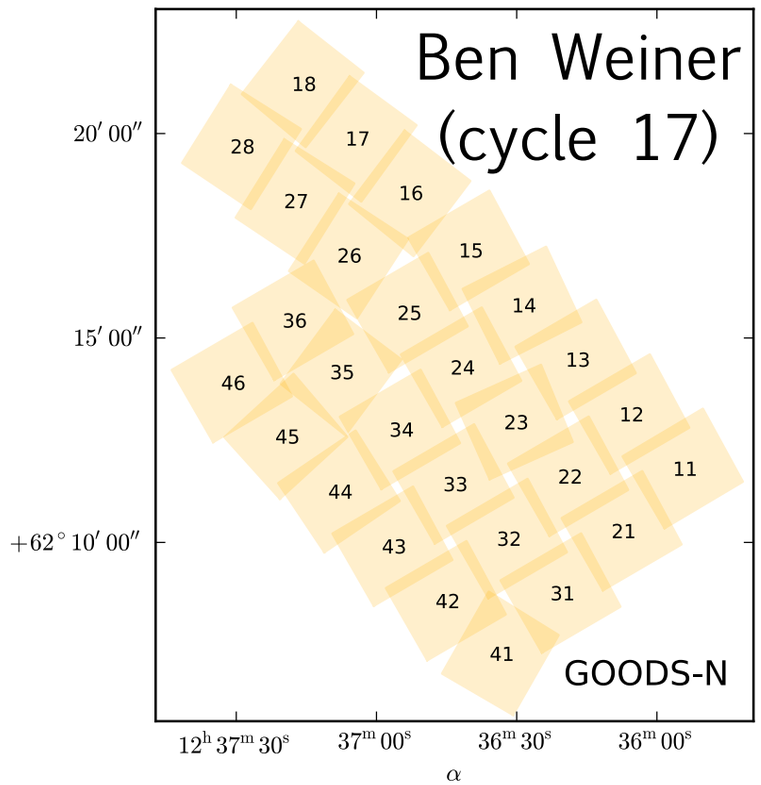




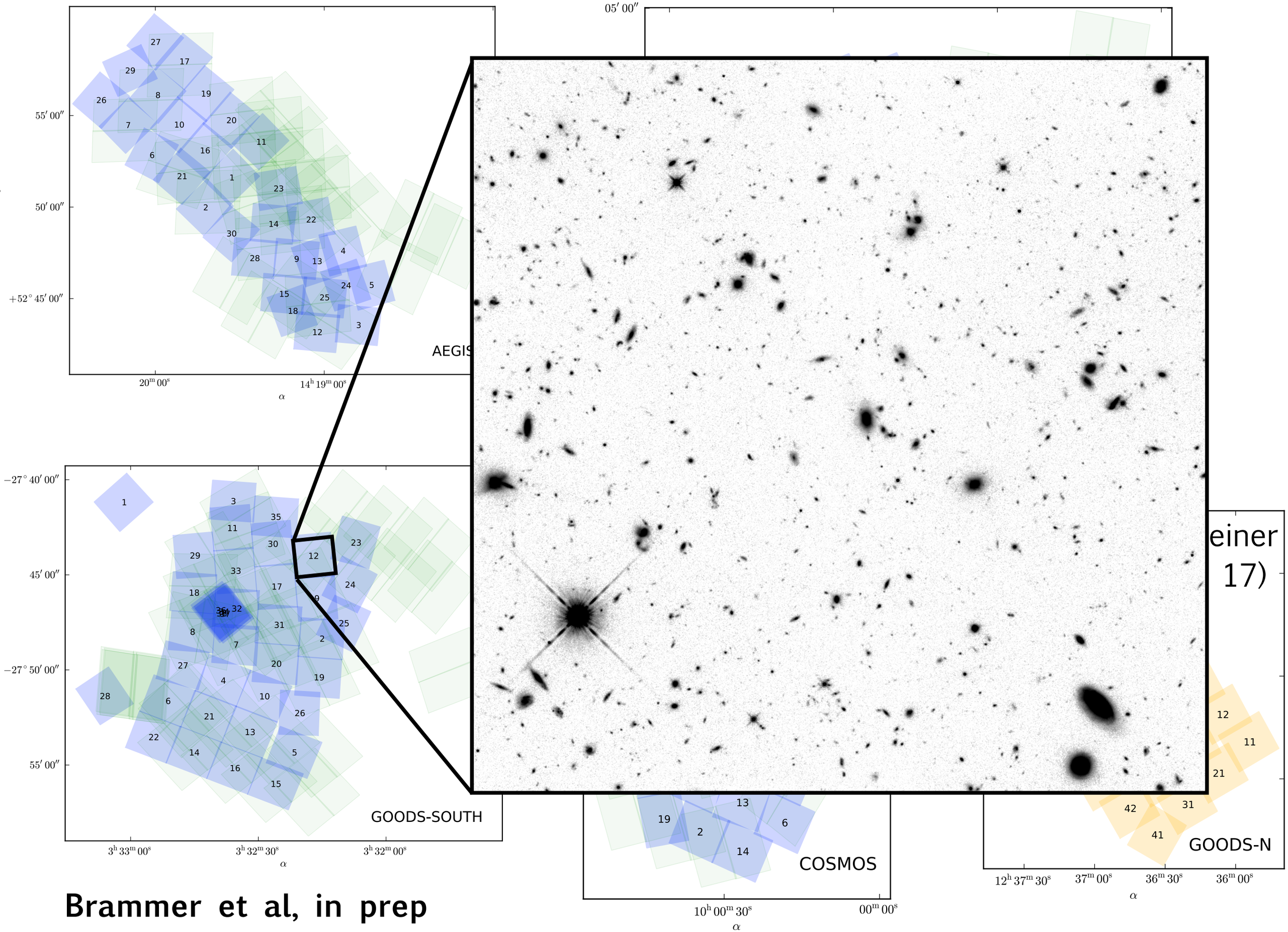


3D-HST fields





Brammer et al, in prep



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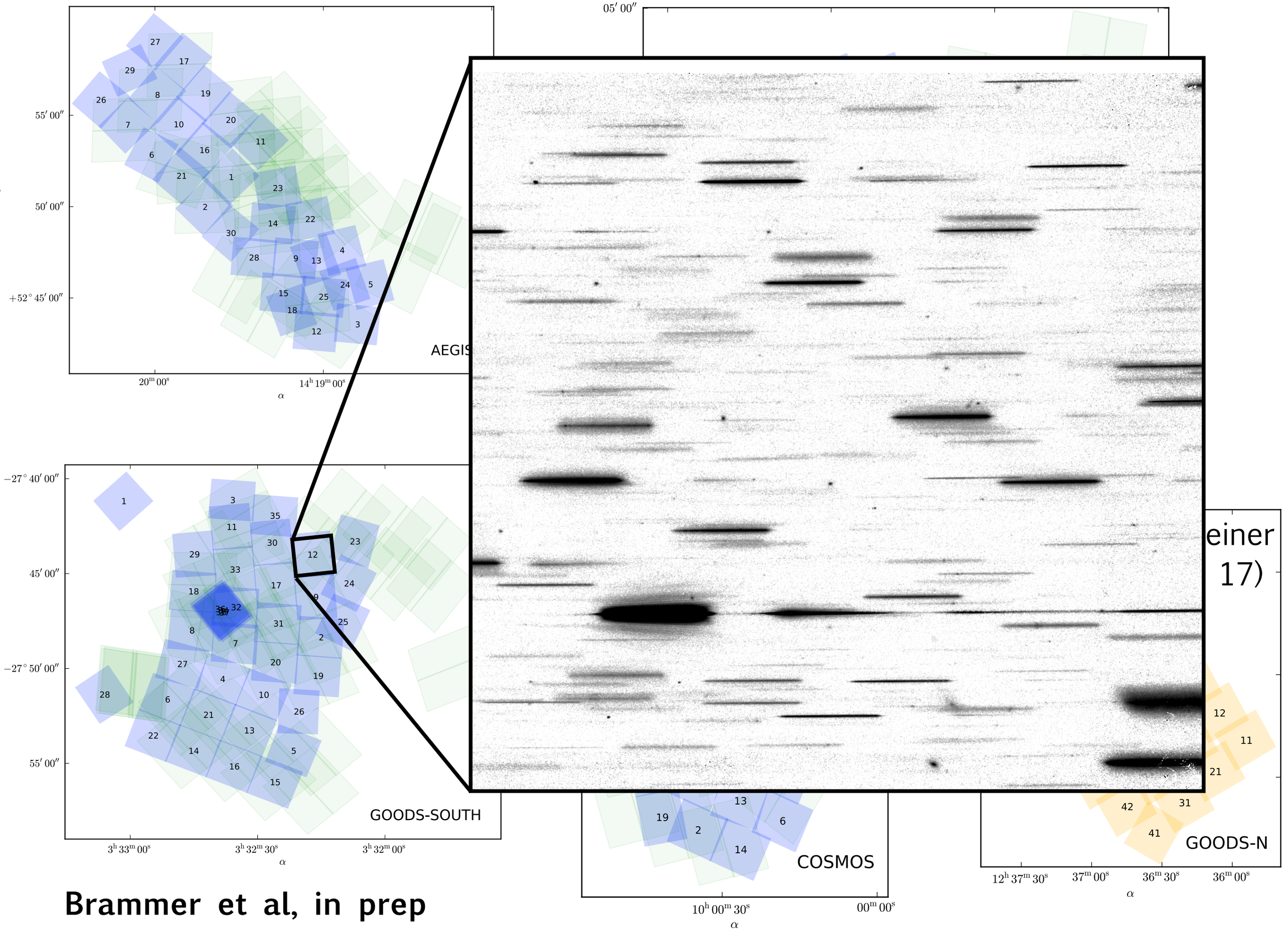

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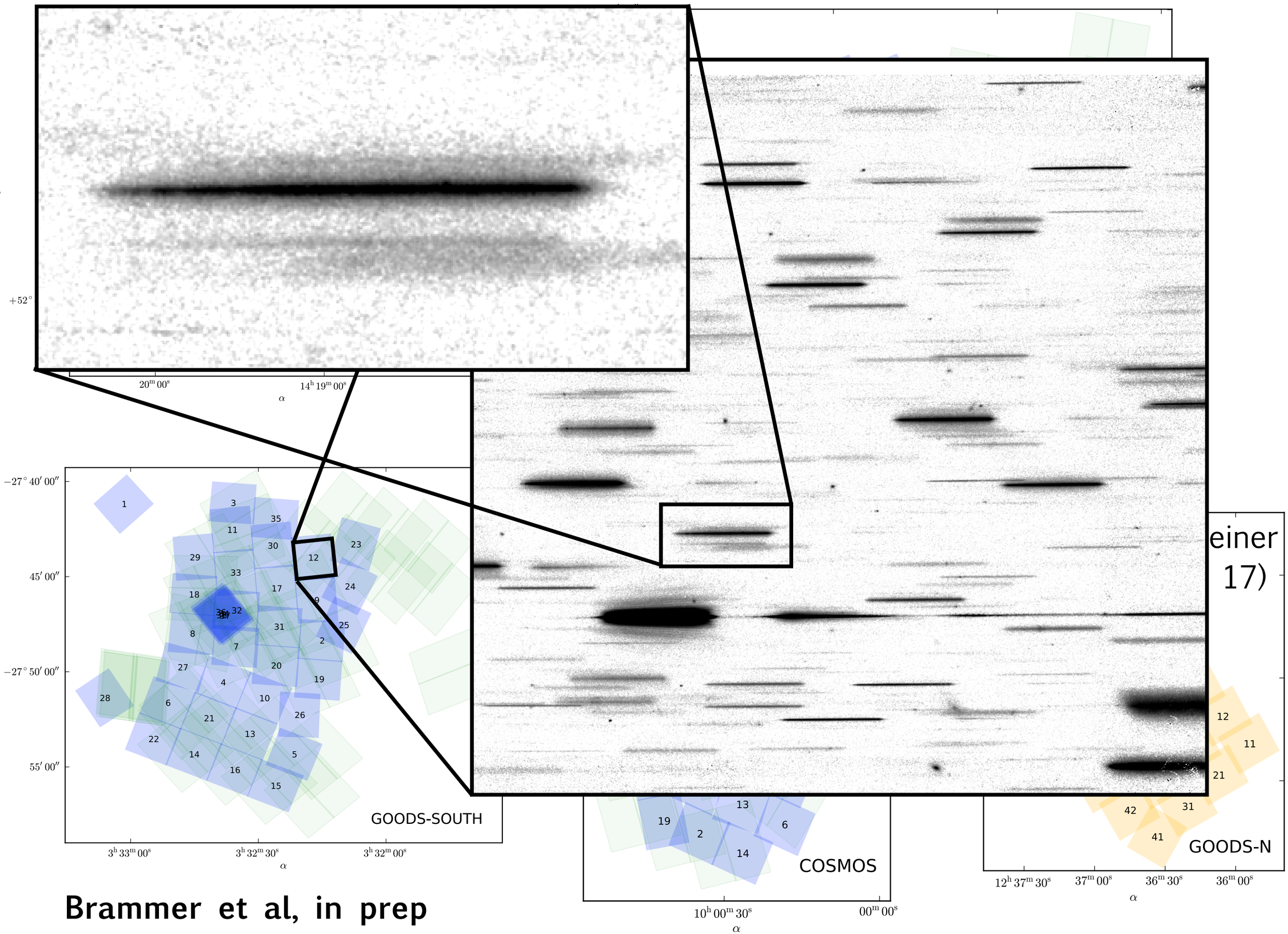
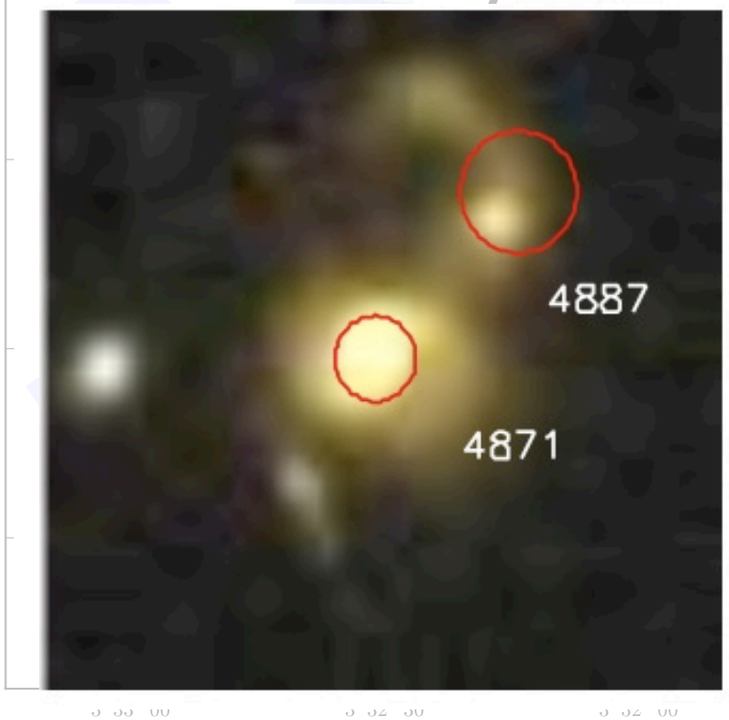
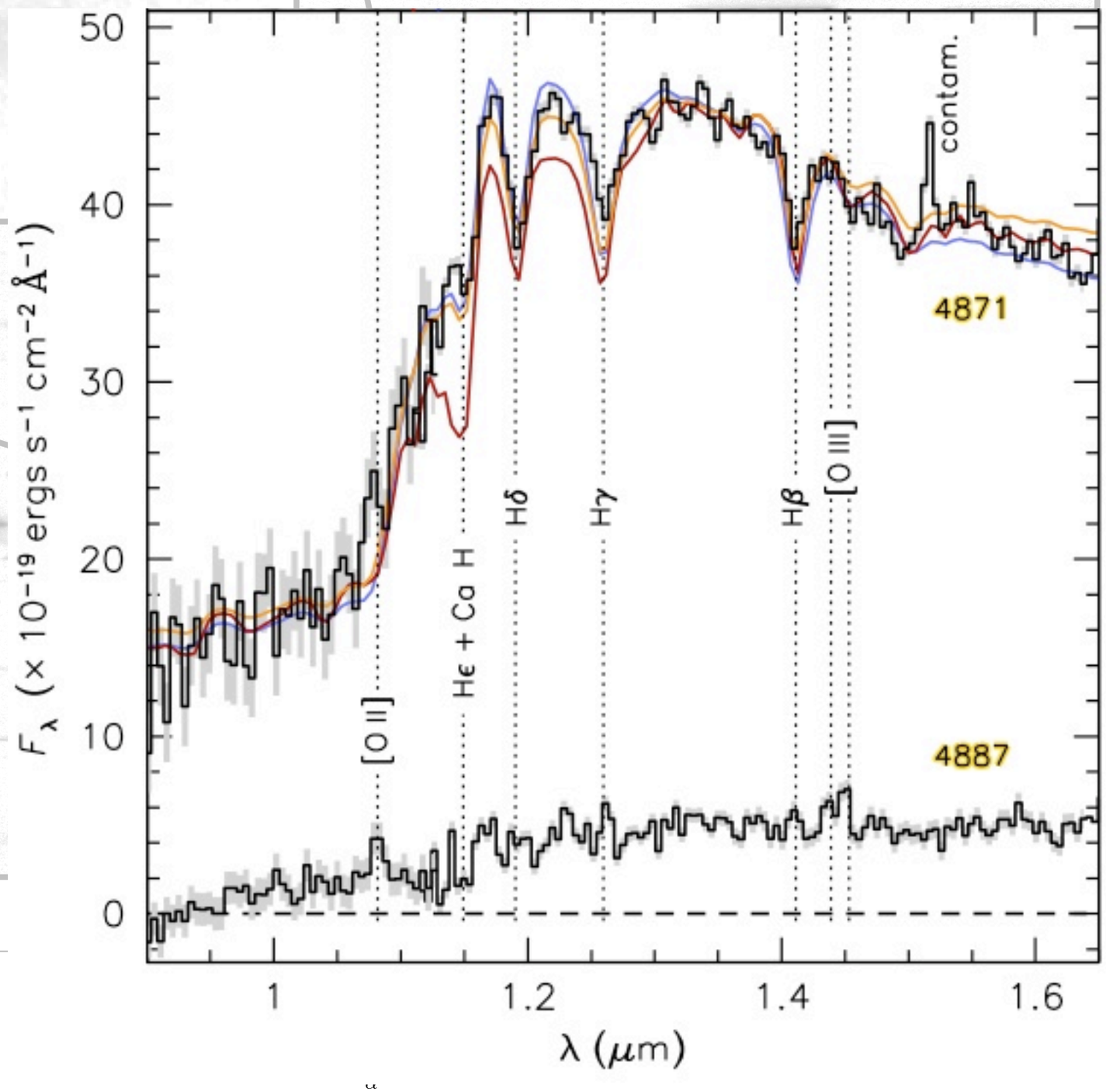


Brammer et al, in prep

vD+Brammer 2010

Growing compact galaxy at z=1.9 !

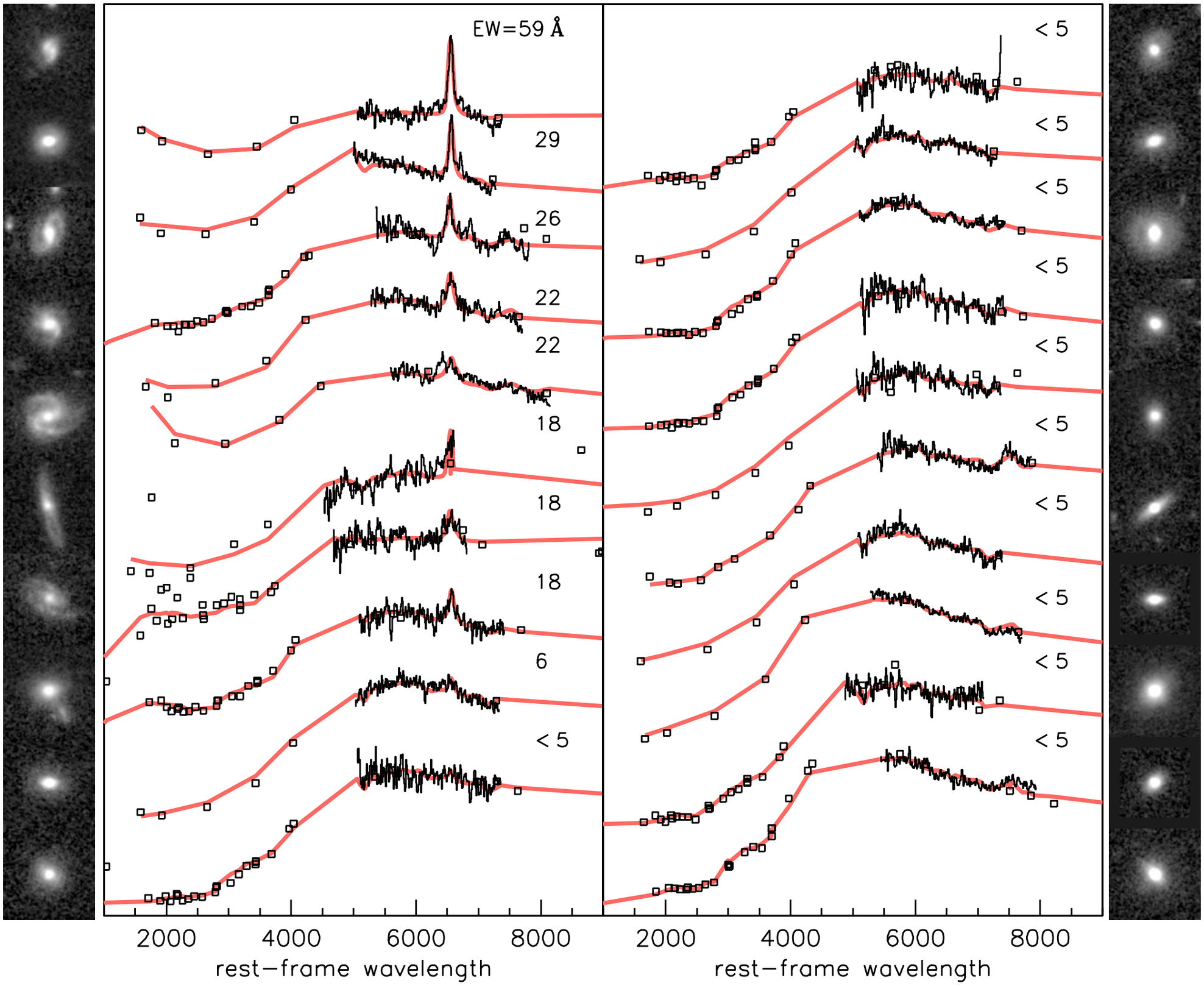




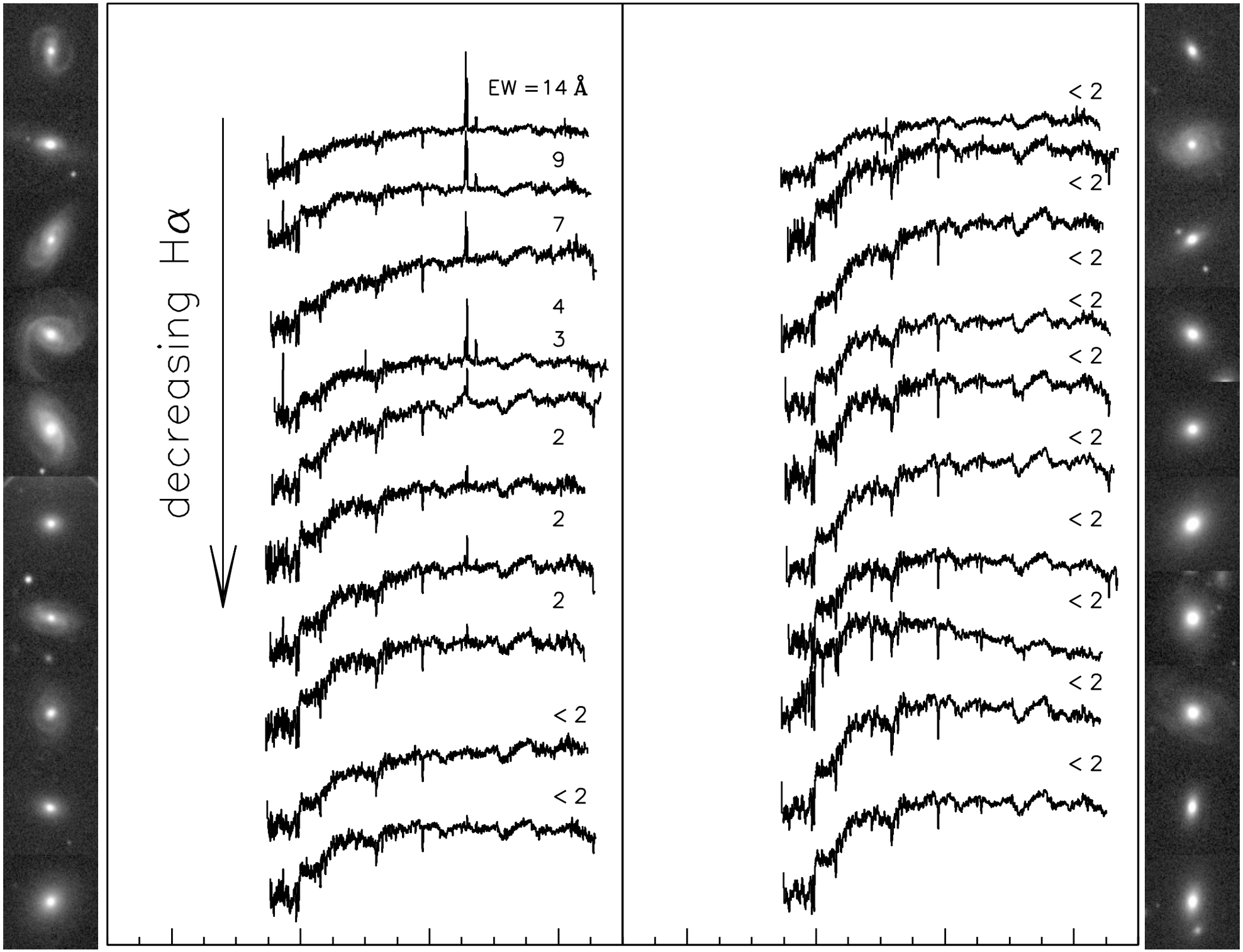
So .. can we now do better?

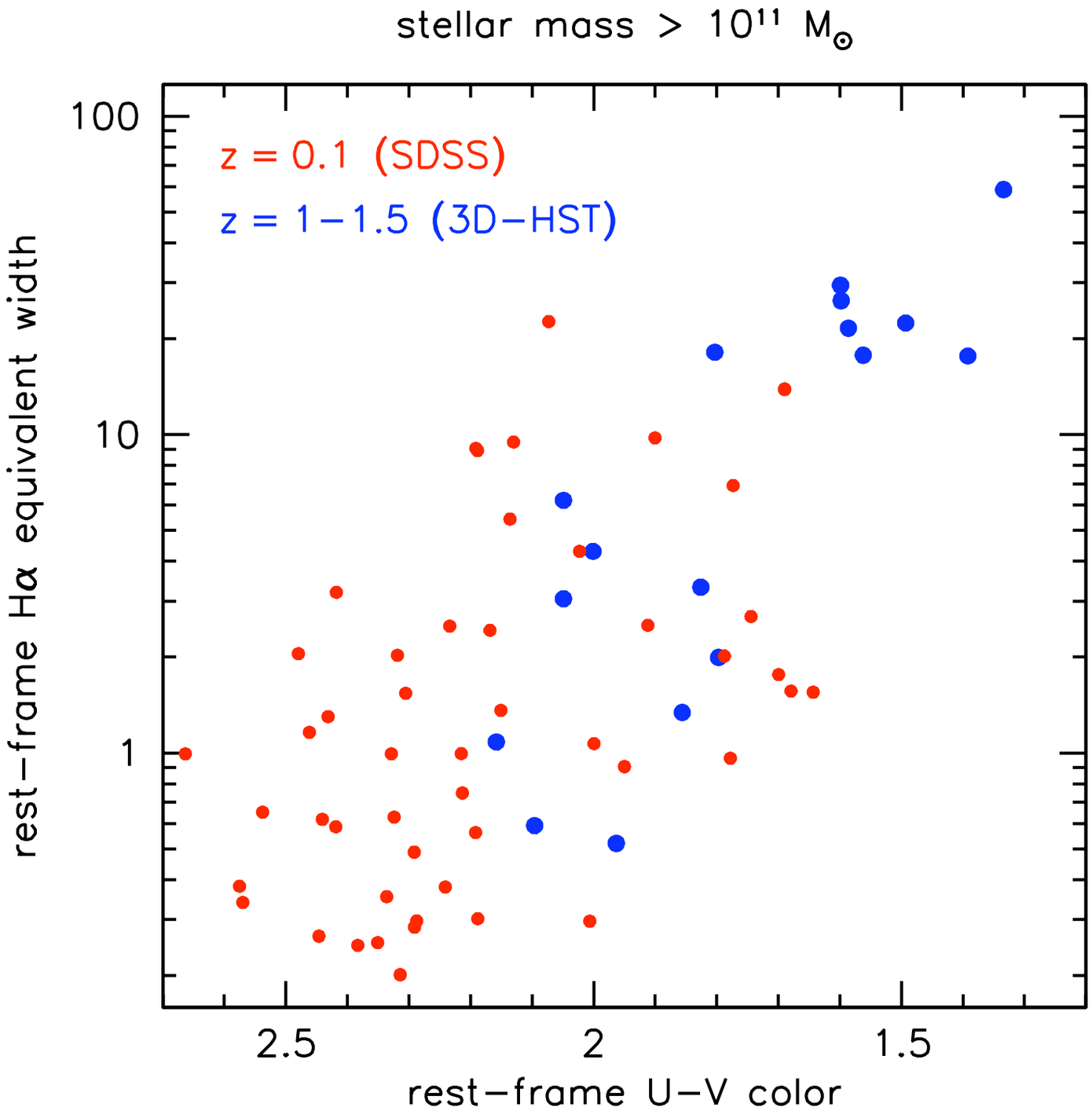
- Complete, mass-limited spectroscopic samples do not exist beyond z~0.8
- From early 3D-HST data, selected $M_{star} > 10^{11}$ M_{sun} galaxies with z=1-1.5

massive galaxies at z=1-1.5, from 3D-HST



massive galaxies at z=0.1, from SDSS

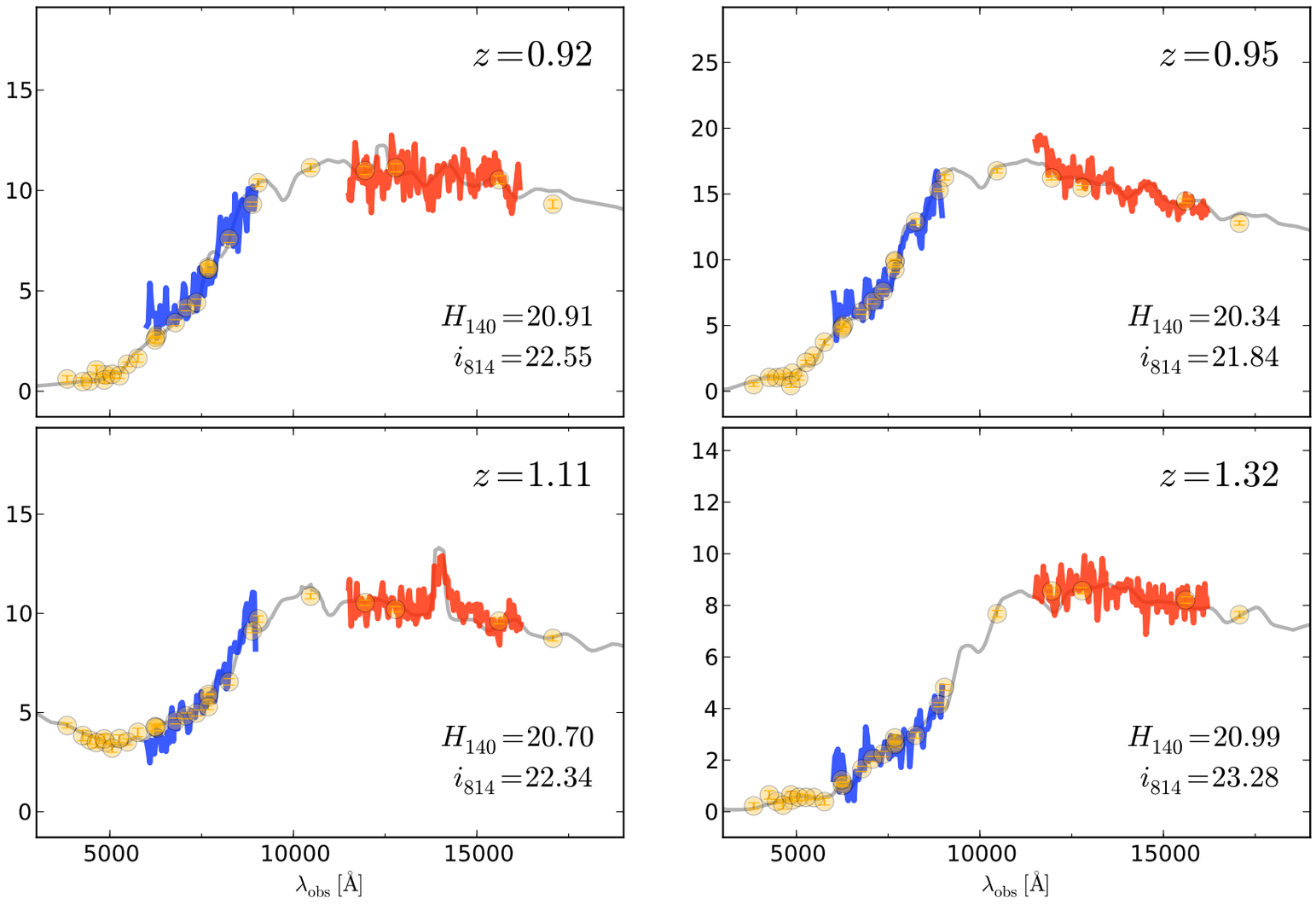




Massive galaxies at z=1-1.5 are bluer and have stronger Hα emission than at z=0

Status / next steps

- About 1/3 of observations obtained; remainder to come over course of next ~12 months
- Optimizing reduction, analysis; adding ACS + WFC3



Brammer et al

spectral resolution

Summary

R~5

- Broad-band photometric redshifts useful for general properties of high redshift galaxies (e.g., mean color)

R~10

- Medium-band filters provide redshifts to ~2%, accurate colors, masses, crude environmental information

R~100

- 3D-HST: redshifts to ~0.4%, line diagnostics, spatially-resolved information for 1000s of galaxies in CANDELS

Meet the students + postdocs !

Gabe Brammer

Kate Whitaker

Kasper Schmidt

Erica Nelson

Shannon Patel

Rachel Bezanson