HST Infrared Grism Surveys in the CANDELS Fields

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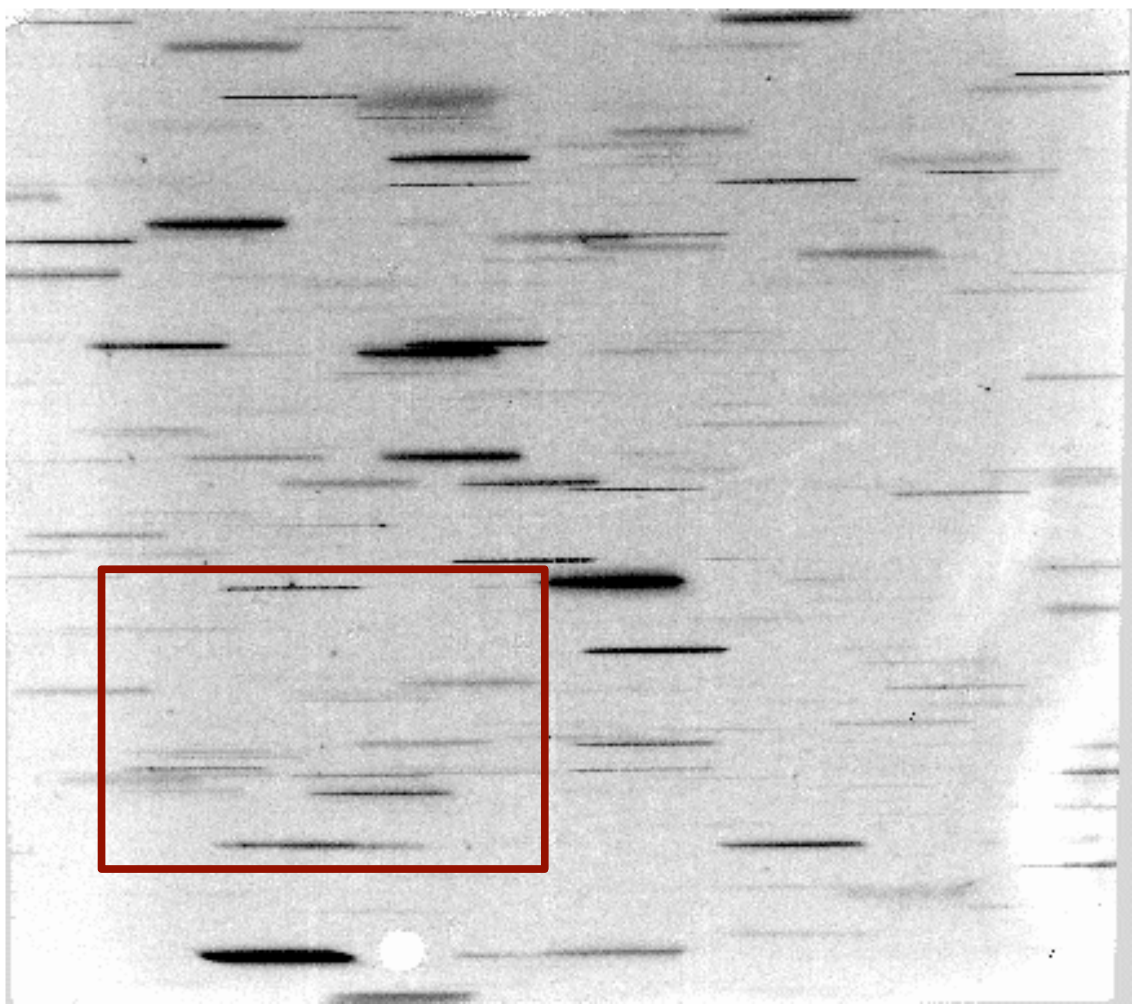
CANDELS
Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey

ARIZONA

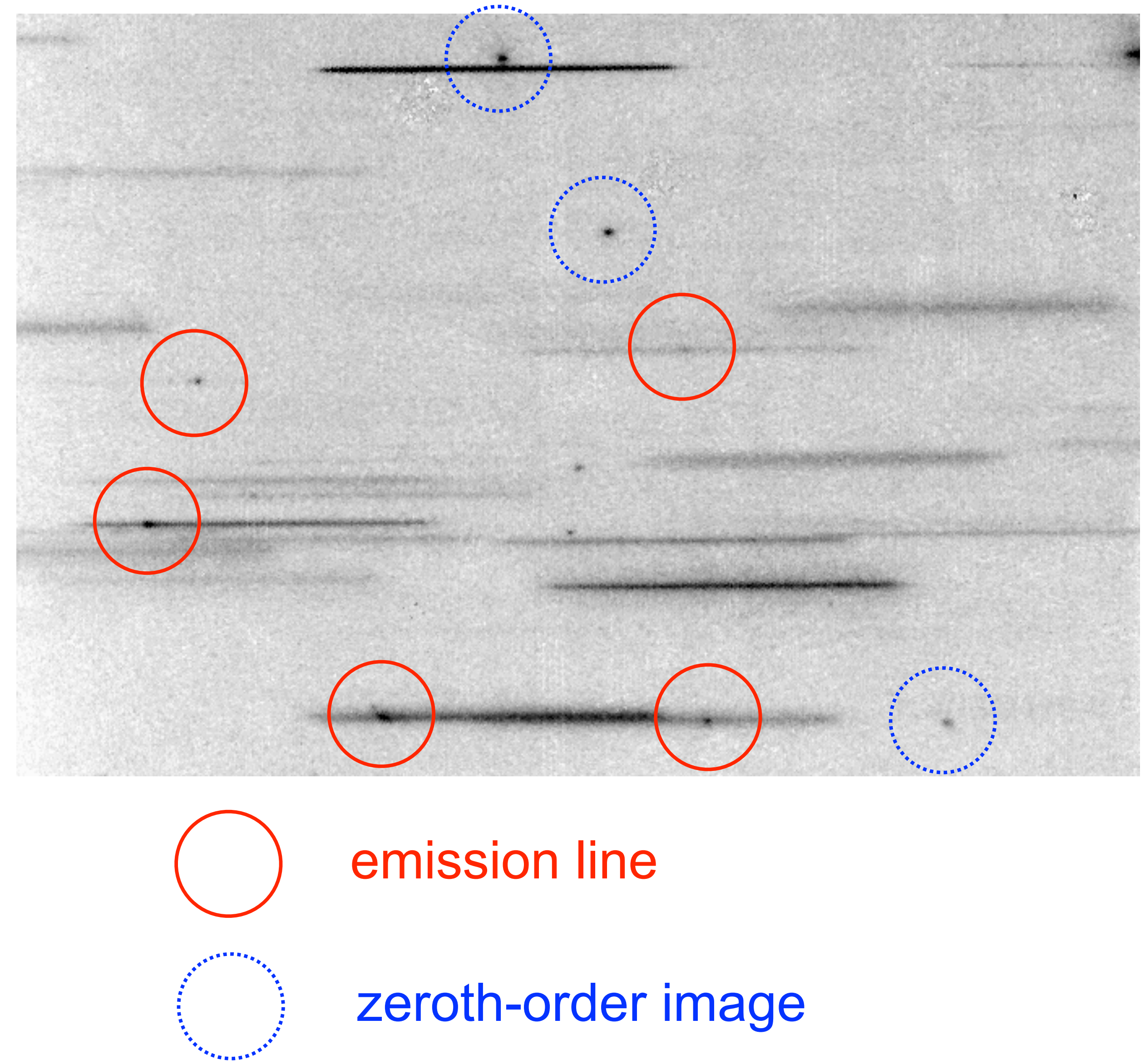
HST's WFC3/G141 measures Hα emission at 0.7<z<1.5, [O III] at 1.2<z<2.3, and bluer lines at higher z



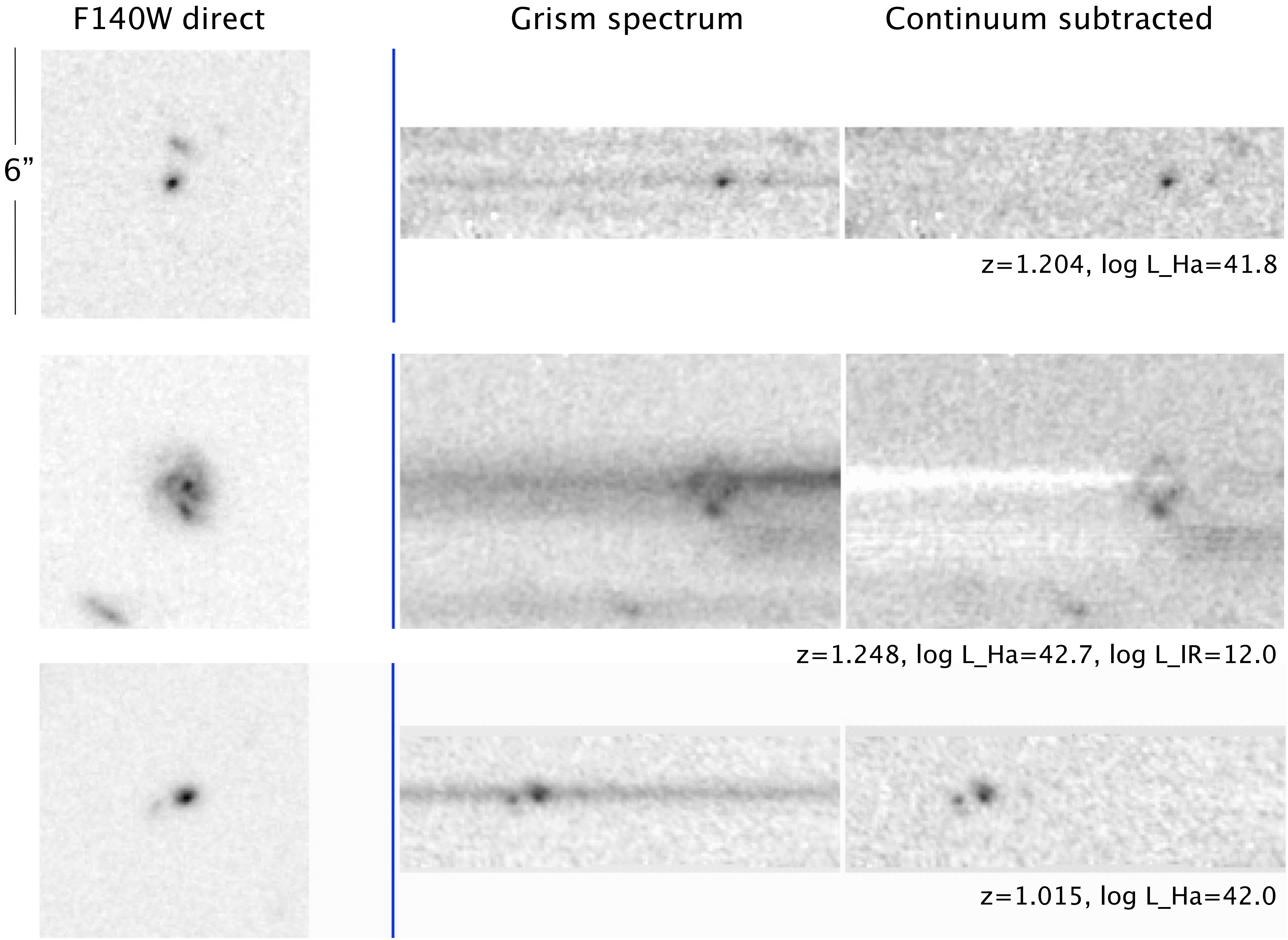
CANDELS takes deep WFC3-IR grism data in single pointings to follow up high-z supernovae.

Wider IR grism field surveys cover CANDELS fields less deeply: 56 orbits covering 3/4 of GOODS-N field (PI Ben Weiner) and the 4 other CANDELS treasury HST IR imaging fields (3D-HST, PI Pieter van Dokkum) ~260 orbits total.

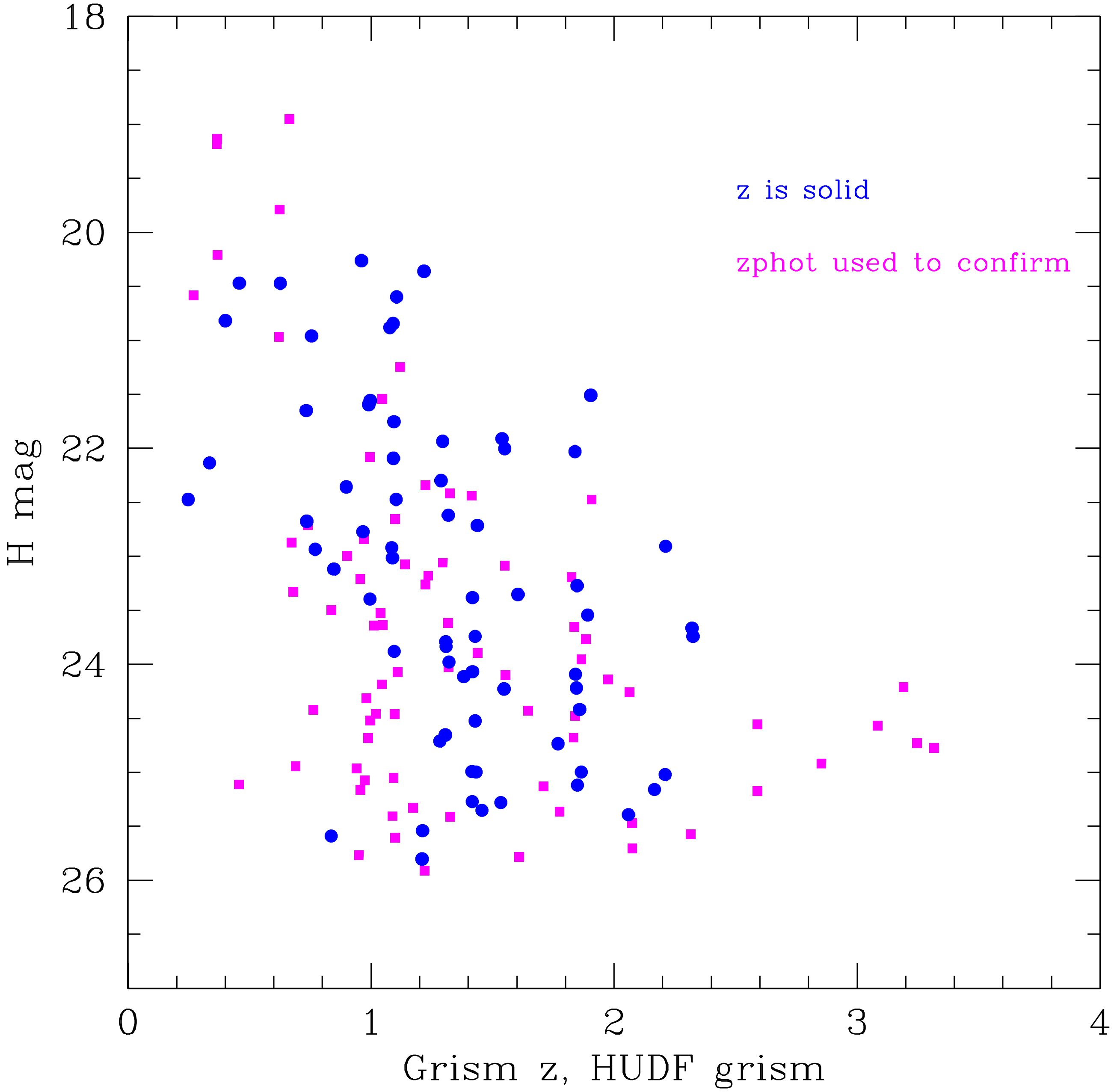
Also a large parallel program, WISP (PI Malkan)

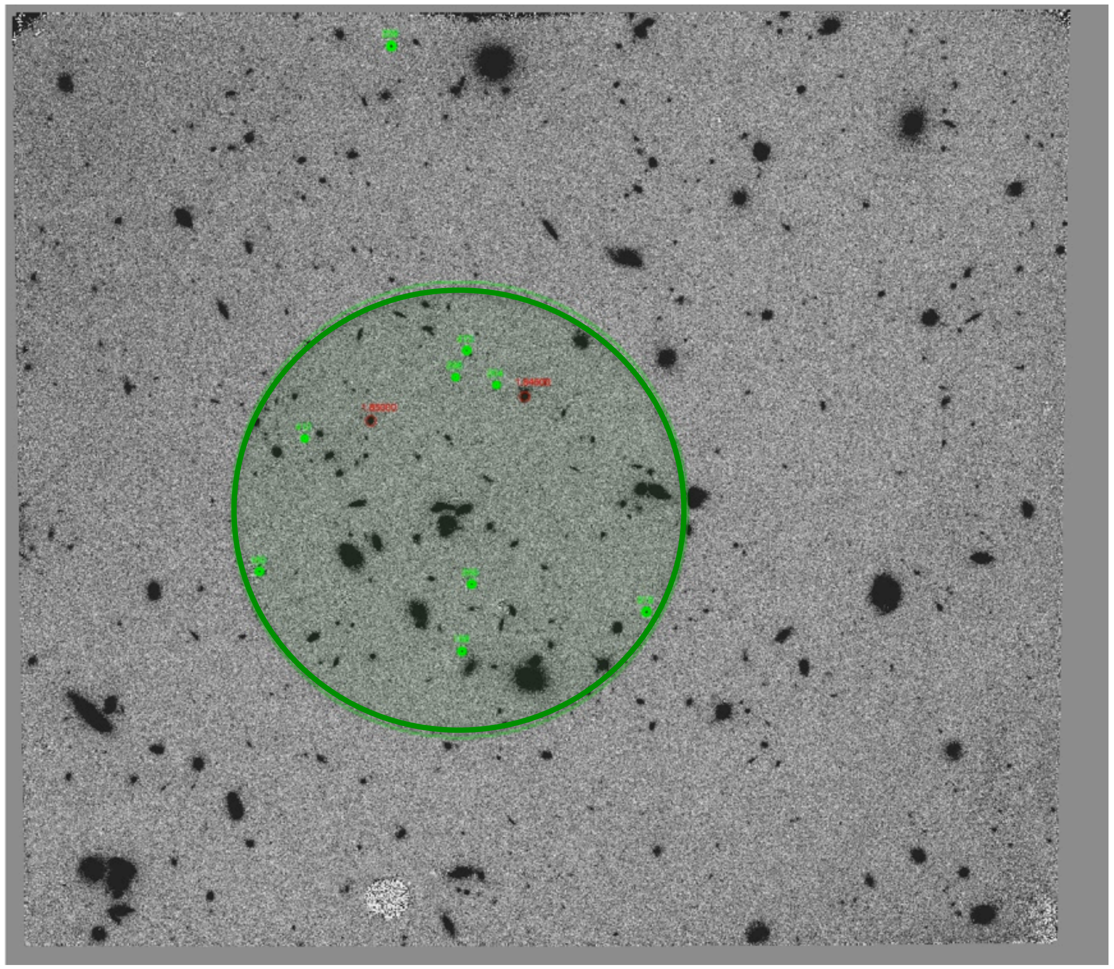


WFC3/G141 spectra: 2.1' field, slitless, 1.1-1.65 microns, R~50-100.
Low background and high spatial resolution make IR slitless practical. Very sensitive, good flux calibration, high multiplex advantage allows blind redshift surveys. Datasets are complex: low R, overlapping spectra.


F140W direct
Grism spectrum
Continuum subtracted
6"
z=1.204, log L_Ha=41.8
z=1.248, log L_Ha=42.7, log L_IR=12.0
z=1.015, log L_Ha=42.0

CANDELS: deep IR grism data goes very faint

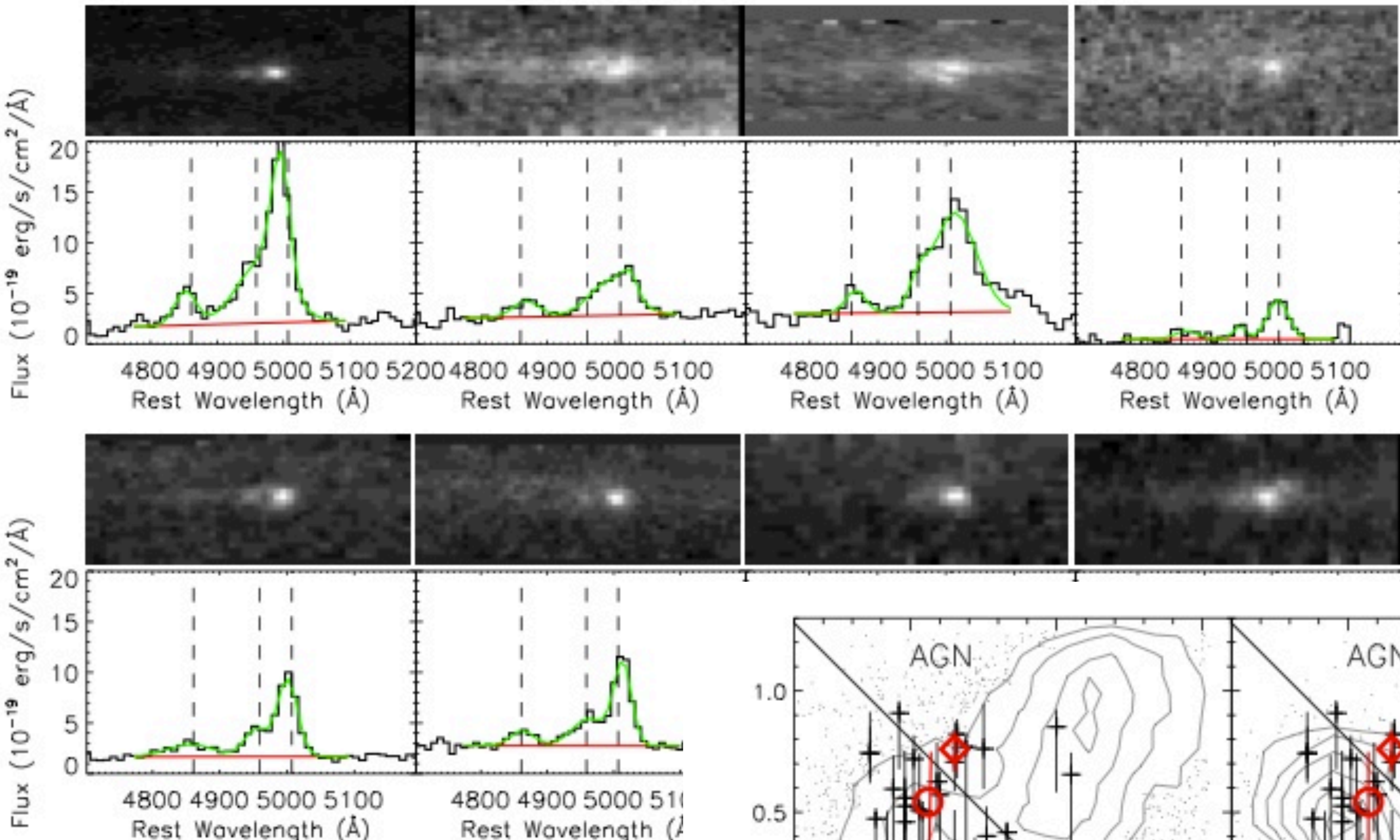




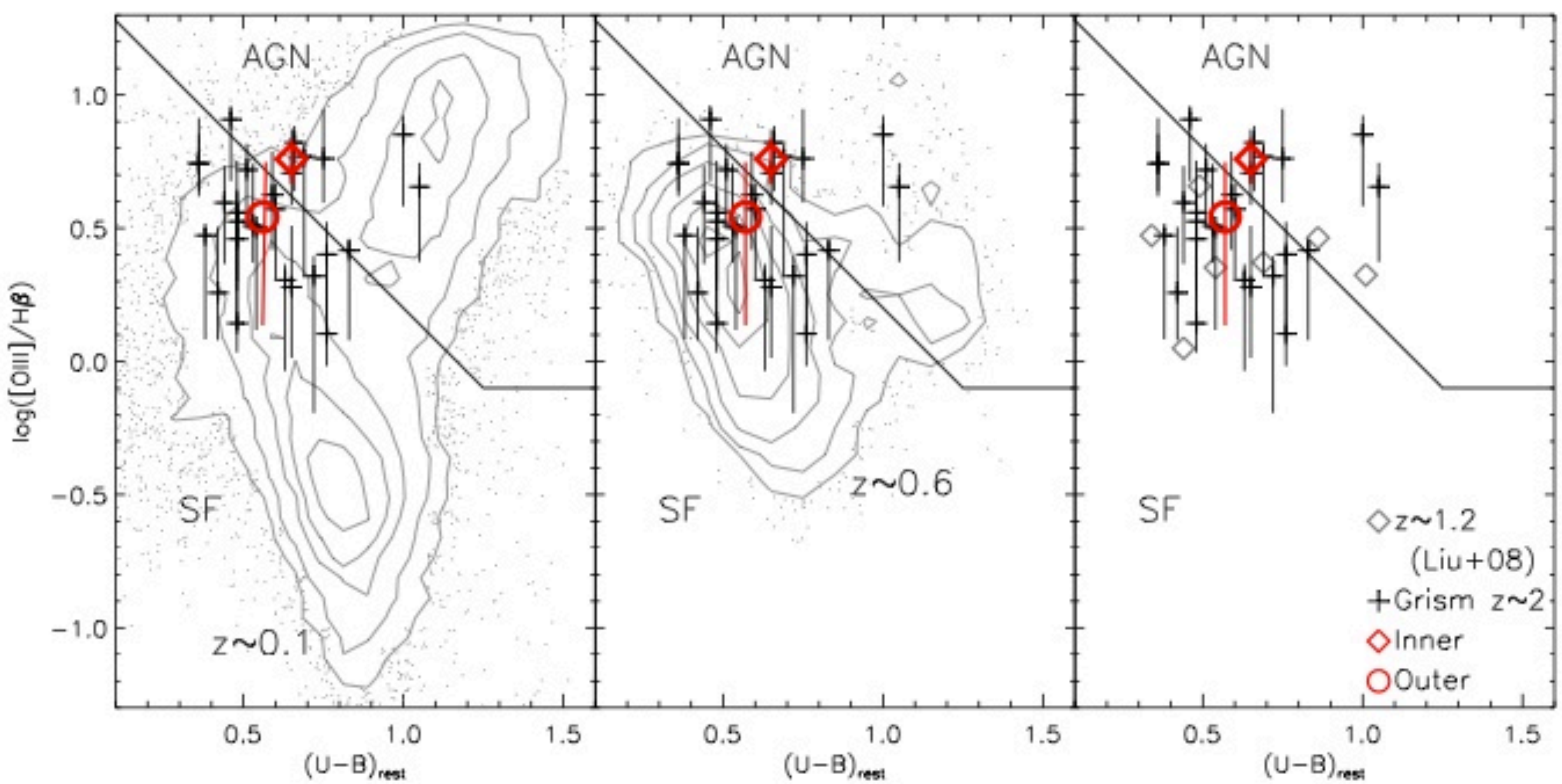
Redshifts from 8 orbit pointing in HUDF as part of CANDELS supernova followup H-alpha at 0.7<z<1.5, [O III to z=2.3, [O II] to z=3.4, photo-z used to confirm line IDs. Yields redshifts to H_{AB} = 26!

Redshift peak at z=1.86:
10 galaxies within 500 kpc ->
overdense region
(Claudia Scarlata, Steven Finkelstein)

[O III]/Hb ratios at z=1.4-2.2 in GOODS-S: low-metallicity galaxies, AGN



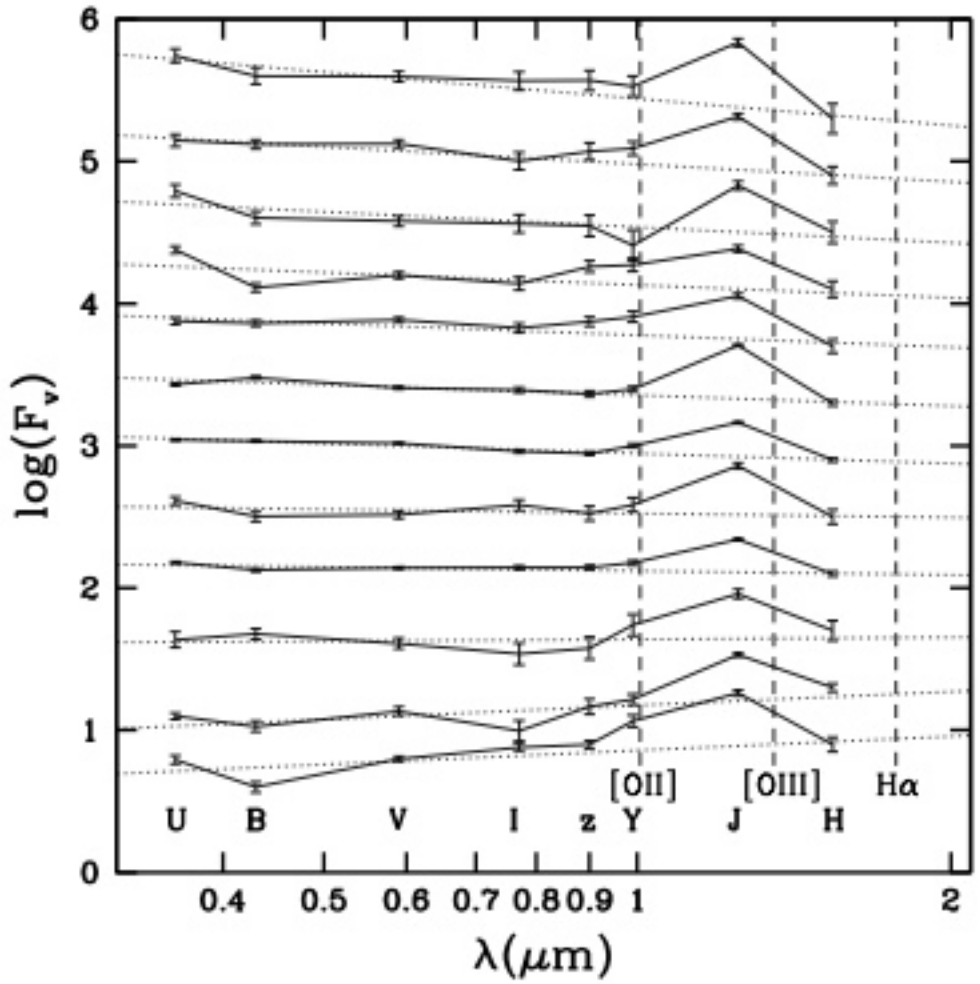
Jonathan Trump et al, 2011 ApJ



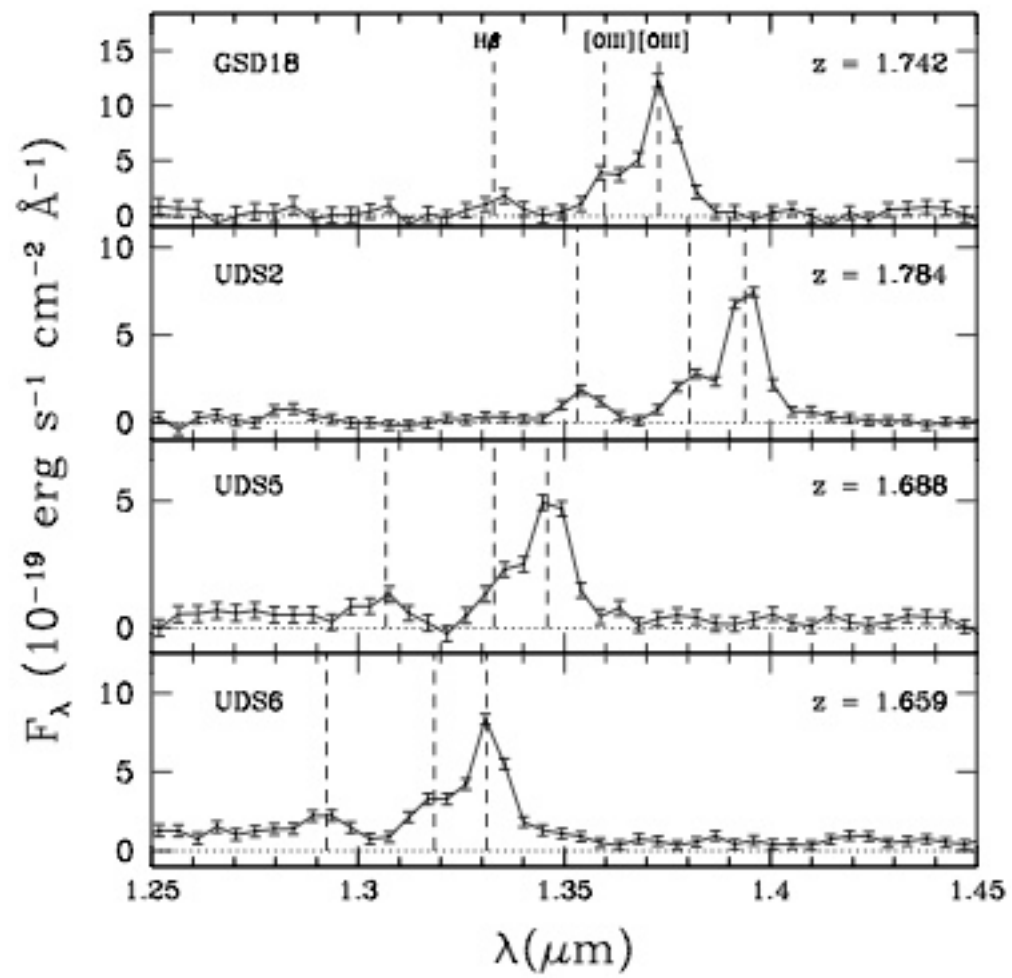
Higher [O III]/Hb ratios than at same color or stellar mass locally.
HST spatial resolution: stacked [O III] is more centrally concentrated than Hbeta (weak AGN?)

J-band excess color-selected galaxies:
extremely strong [O III] emitters, low-mass and starbursting

Arjen van der Wel et al, 2011 ApJ

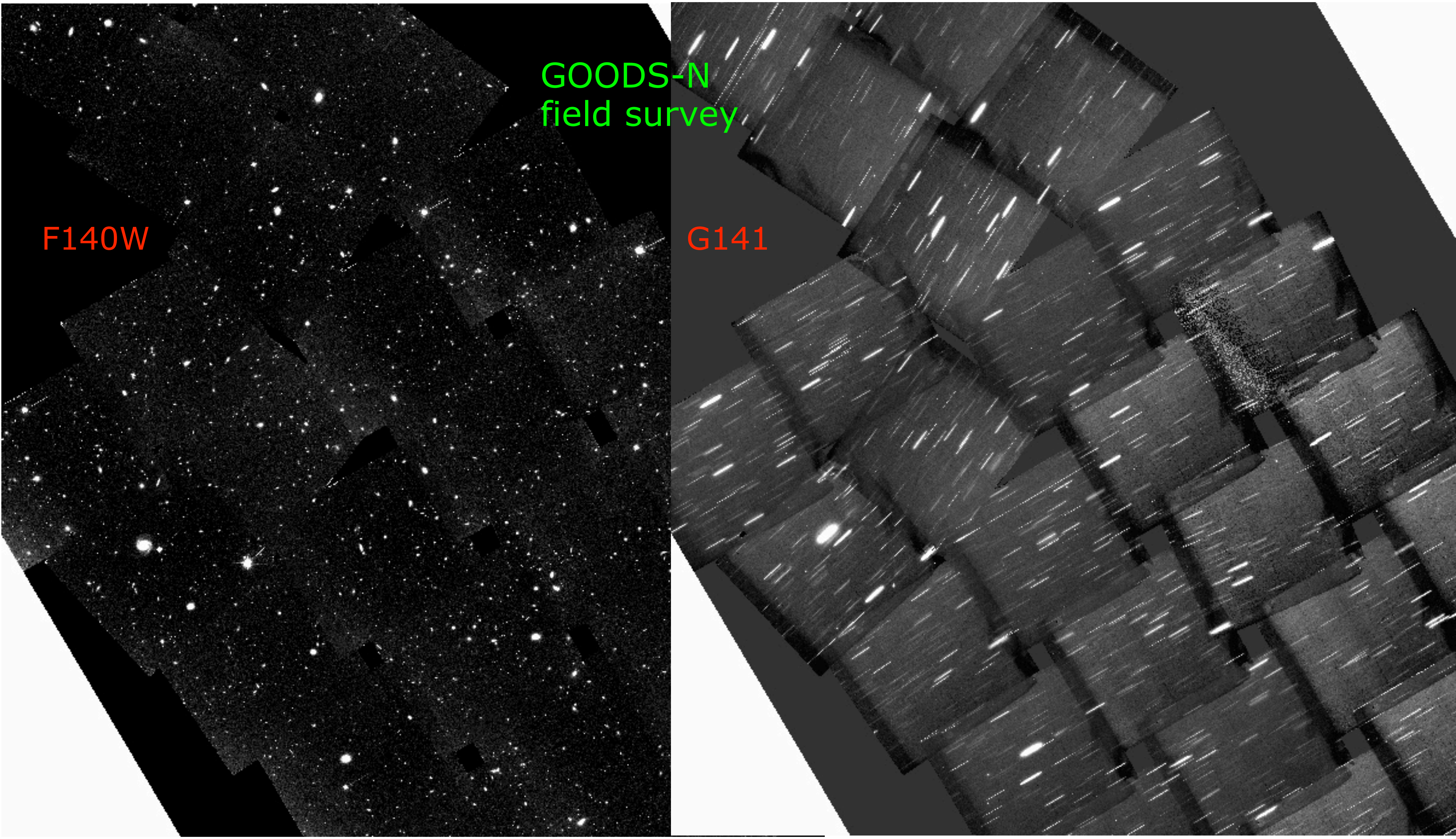


Selected as color outliers in I-J vs J-H.



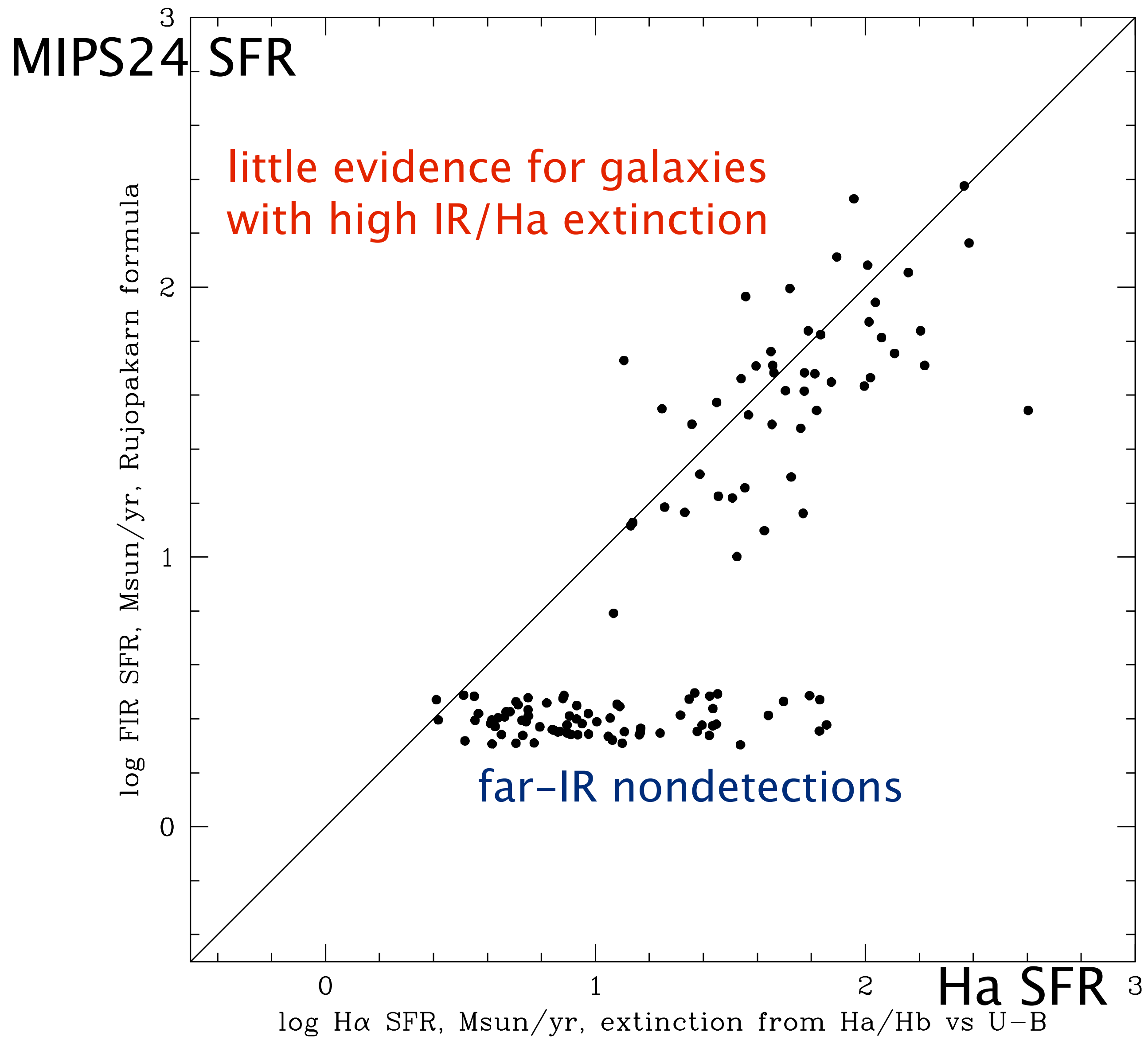
Grism spectra from ERS and CANDELS confirm J-band excess is due to [O III] at z~1.7, with EWs ~500-1000 A. ~100x more abundant than local (Cardamone+ 2009); see also Atek+ 2010.

The area*speed of HST's WFC3-IR enables slitless IR surveys that yield spectra for large numbers of faint objects. This allows spectroscopic redshift surveys at low spectral, high spatial resolution (in GOODS-N led by BJW; 3D-HST led by P. van Dokkum). Proposed dark energy missions use this to cover very large areas.

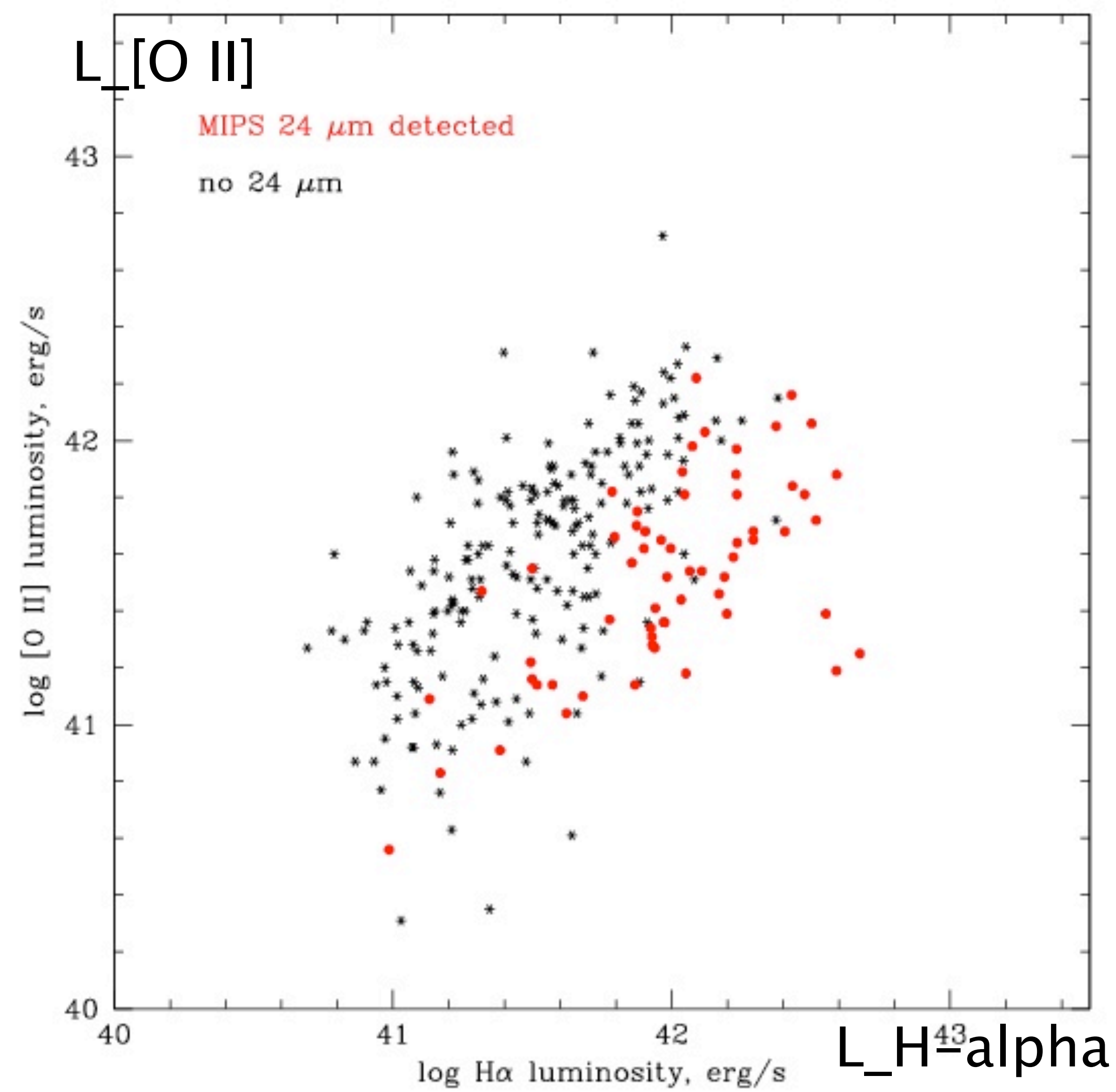


Comparing SFR indicators with a Hα survey in GOODS-N

Hα is sensitive, independent of metallicity, and less affected by extinction than [O II] or UV. But redshifted into the near-IR, it is hard to observe and flux-calibrate from the ground.

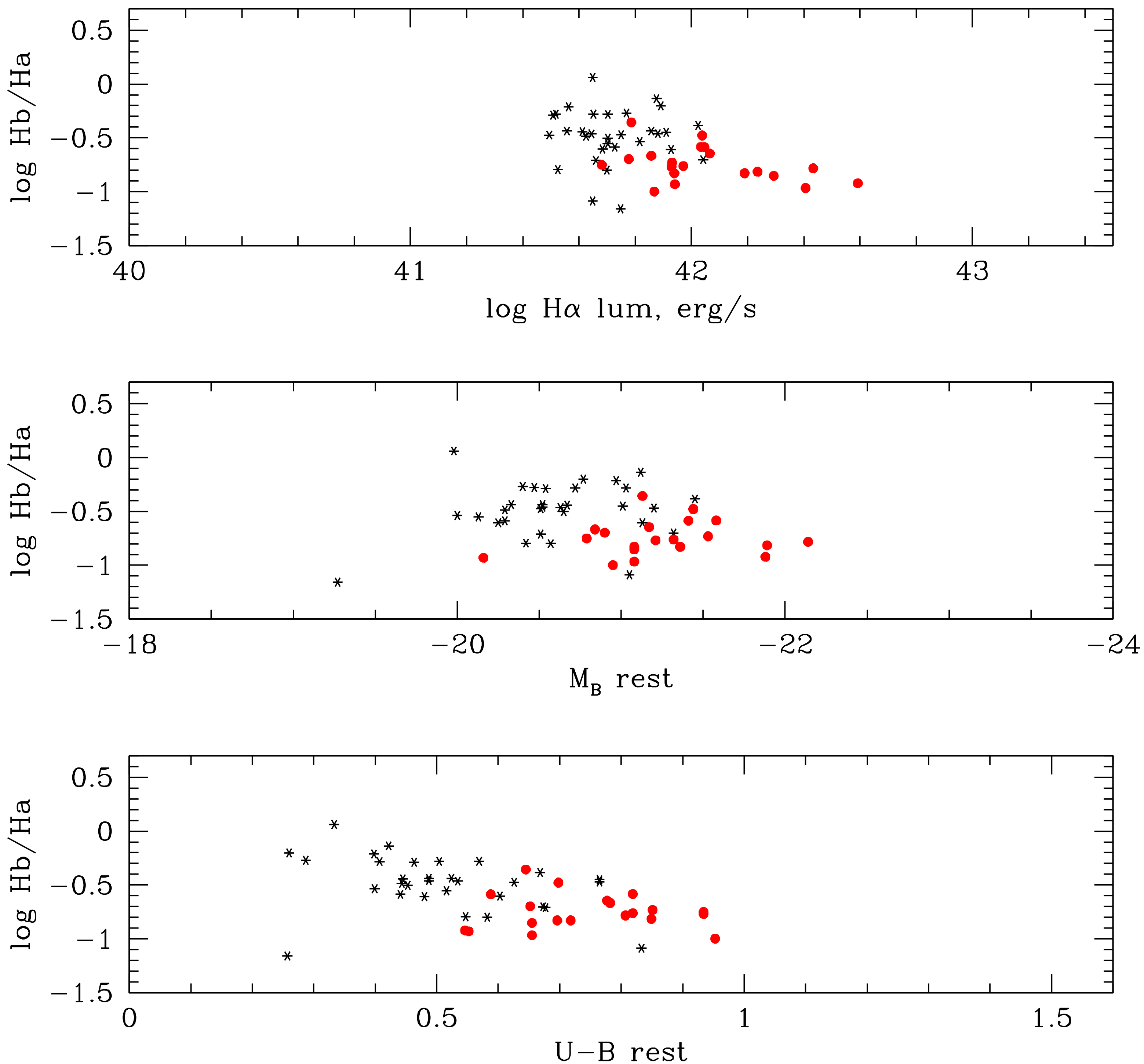


GOODS-N: SFRs from grism Hα and MIPS 24 um agree roughly when both are detected (Hα extinction correction from average Balmer decrement). The far-IR is less sensitive (and lower spatial resolution, 6")



Large scatter between L_Hα and L_[O II] 3727 without extinction corrections. MIPS-detected galaxies and high [O II] galaxies are offset – metallicity and extinction effects.

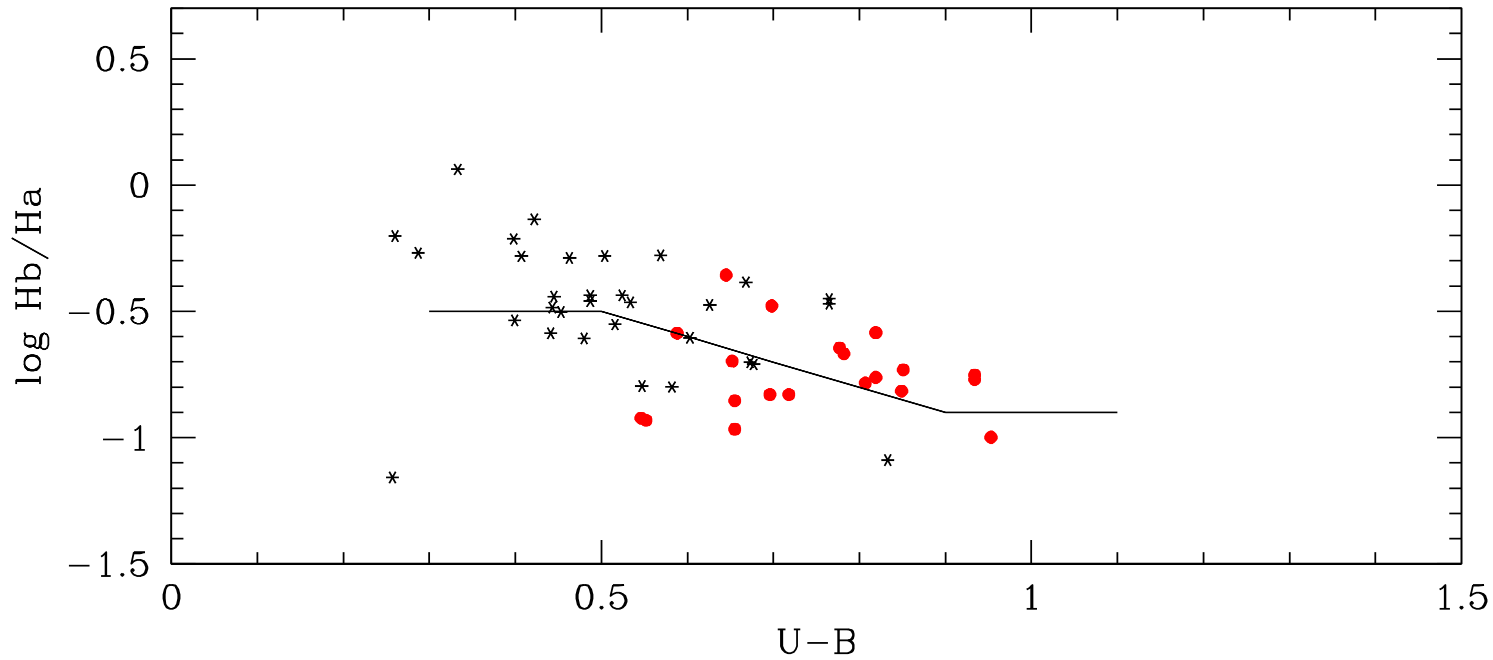
Measuring nebular extinction



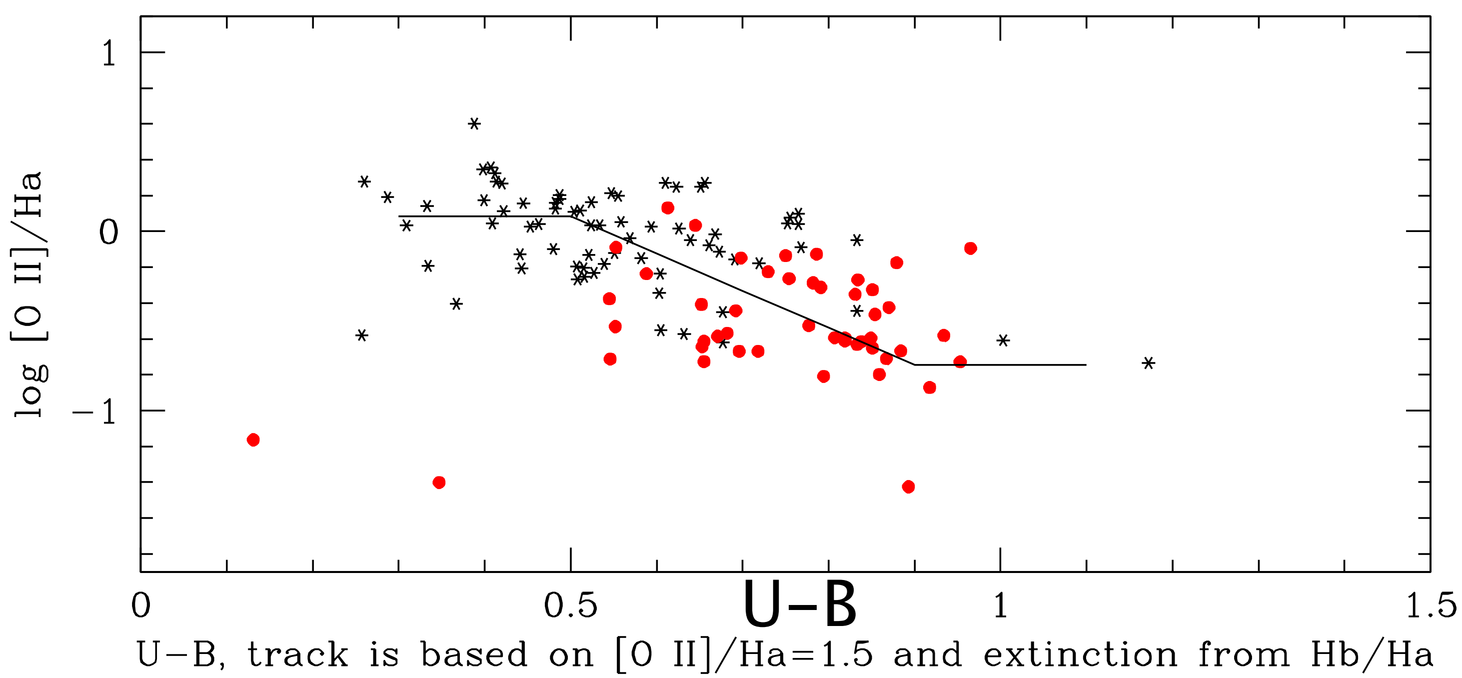
Combining our Hα luminosities from WFC3-IR grism with Hβ from Keck/DEIMOS TKRS survey spectra, we can measure the Balmer decrement at z~1. Nebular extinction correlates fairly well with rest color U-B (also correlated with stellar mass in this sample).

Extinction predicts line ratio variations

log Hβ/Hα



log [O II]/Hα



A rough model of the mean nebular extinction at z~1: varies from A_V = 0.3 to 3 mag.
This extinction could explain most of the observed variation in [O II]/Hα;
a high intrinsic [O II]/Hα is required and some of the variation is likely due to mass-metallicity relation as well.

Summary: WFC3-IR grism spectra in CANDELS fields

Slitless IR spectroscopy at high spatial, low spectral resolution, high multiplex advantage, complex datasets, very sensitive. Allows redshift surveys in IR to 1.6 microns, without color or magnitude pre-selection.

Accurate fluxing, no slit losses, good for emission line fluxes, yields size information. Absorption lines have to be fairly strong to be detected.

Low-metallicity galaxies: high [O III]/Hbeta ratios, possible centrally concentrated [O III] due to obscured/weak AGN (J. Trump).

Color excesses due to high [O III] in low mass starbursts, ~100x more common than locally (A. van der Wel)

Deep grism pointings yield many redshifts in high-value areas of sky, e.g. HUDF: about 30 spectro-z per arcmin^2

Wide grism surveys (BJW and 3D-HST) cover most of CANDELS area:
Hβ/Hα measures extinction variation with color or stellar mass
Hα and far-IR SFRs compare well after extinction correction.
[O II]/Hα has strong systematic due to extinction, and large scatter.