NIRSpec Galaxy Assembly

Oct 13 2015

M Franx & NIRSPEC Science Team

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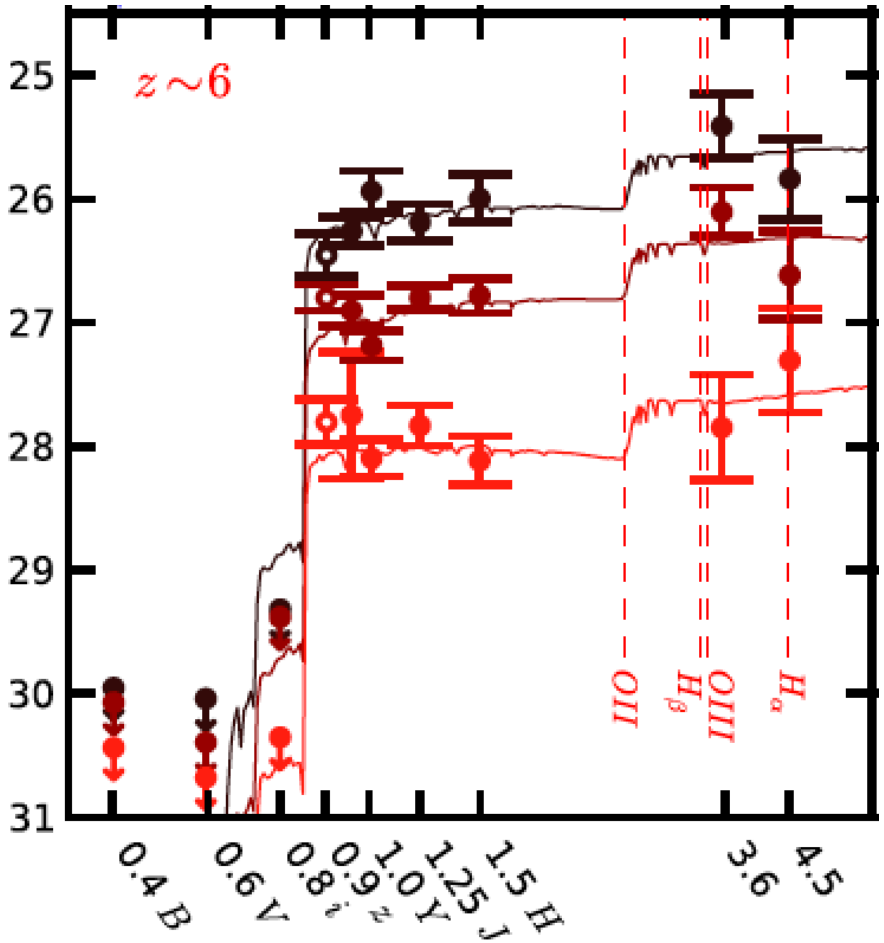
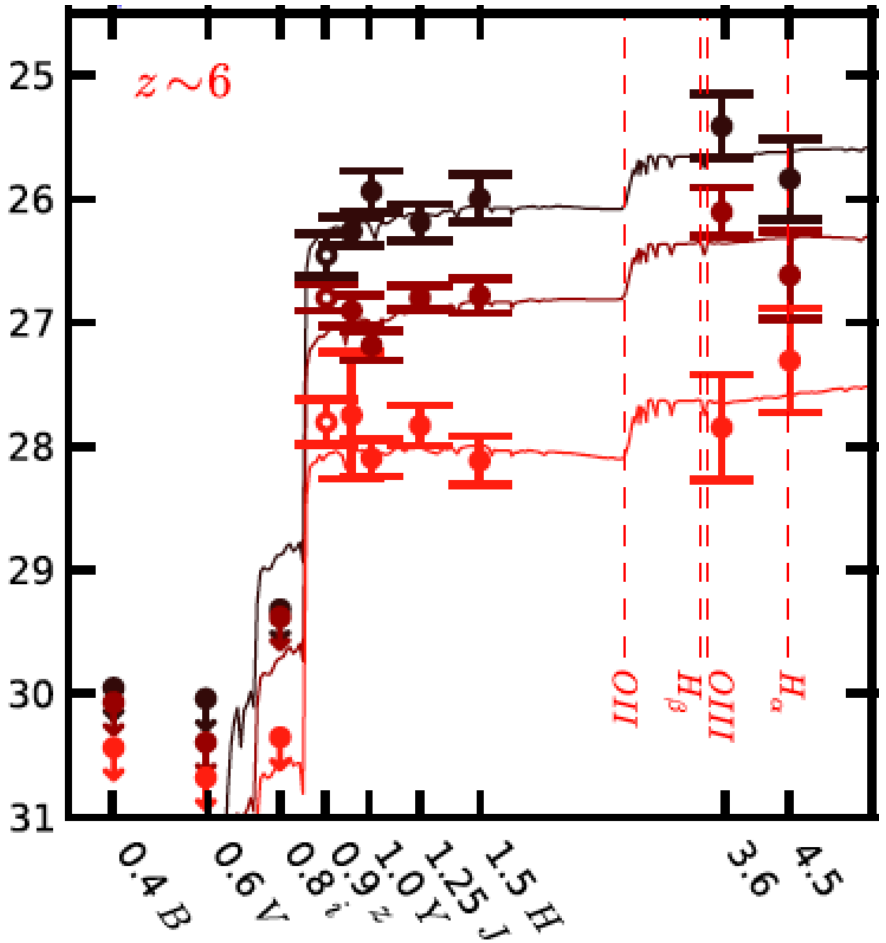
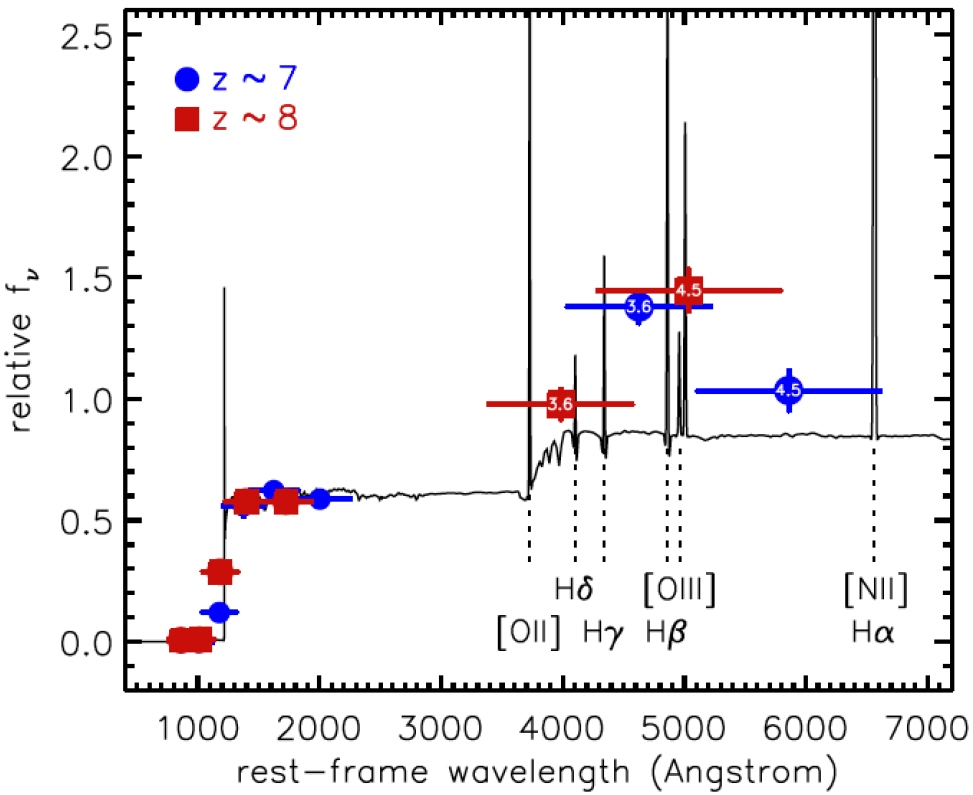
in collaboration with the NIRCAM team (see presentation by Marcia Rieke)



Eyles et al, Gonzalez et al., Stark et al.

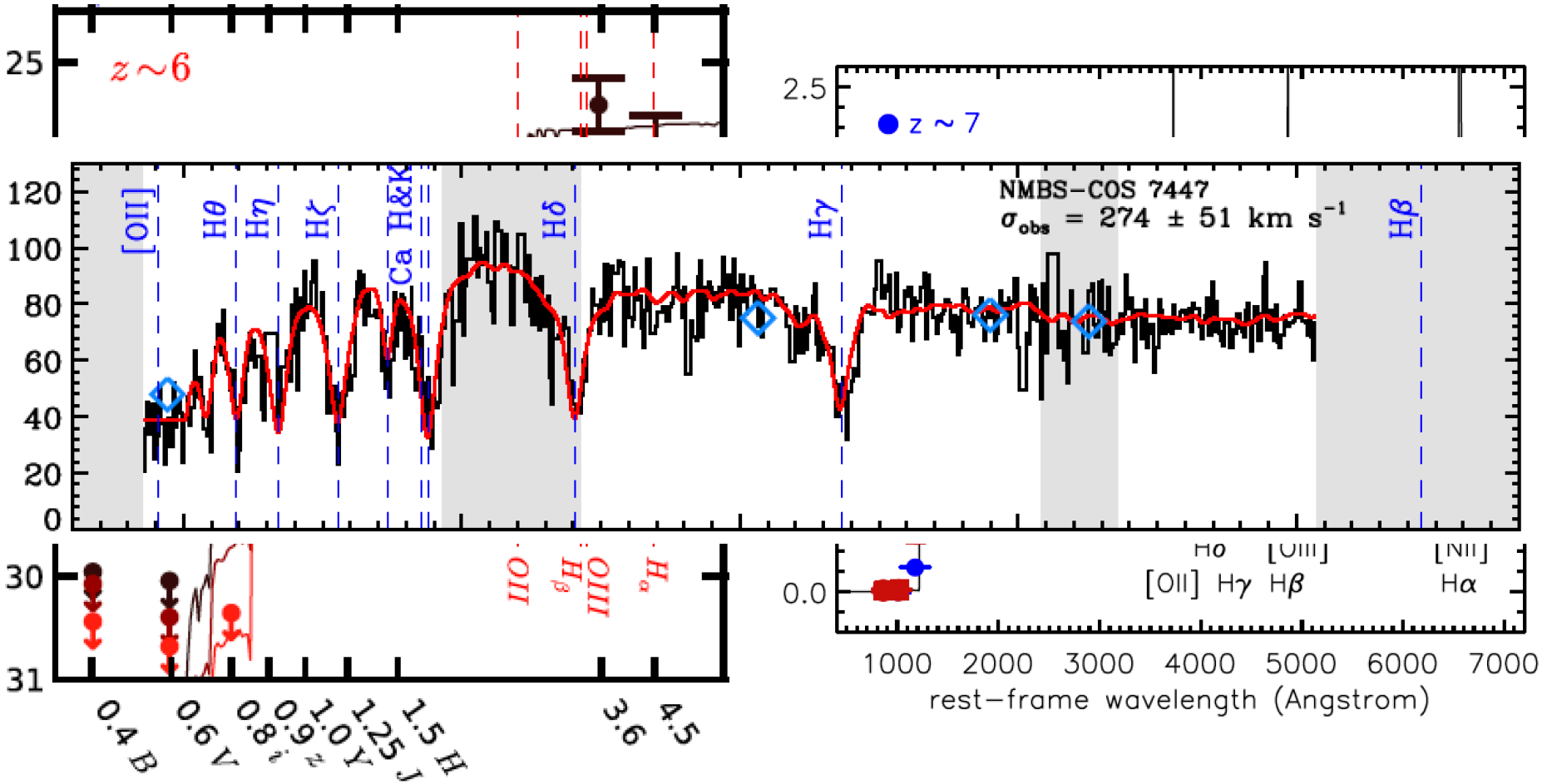
Spectra are needed to derive stellar continuum, emission lines, etc.





Labbe et al 2013, Schaerer&deBarros 2009,

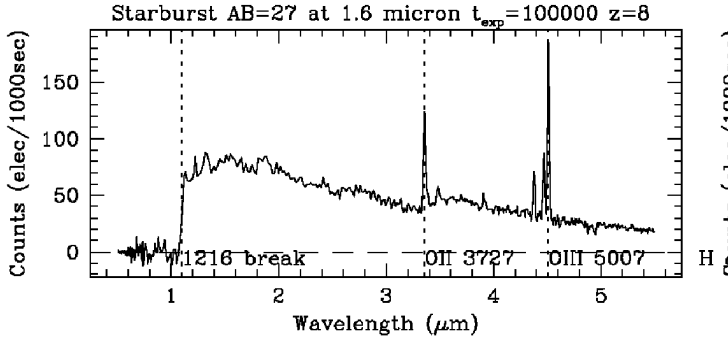
We need SPECTRA !

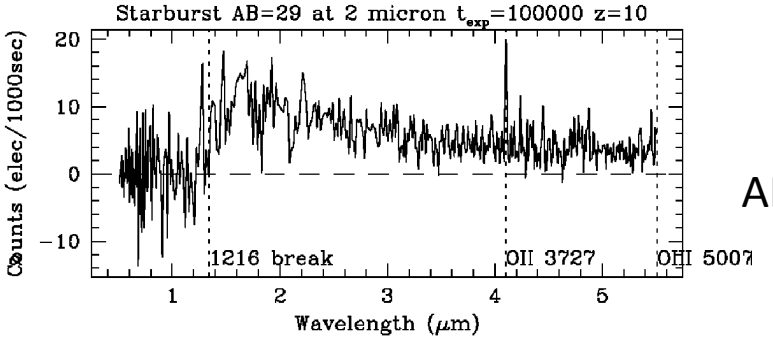


Groundbased Near-IR AB=20-21 ! (van de Sande2013, Belli et al 2014, 2015)

What NIRSPEC can do !

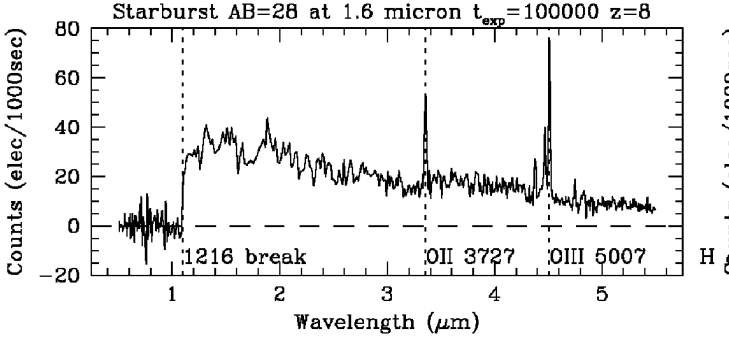
AB=27

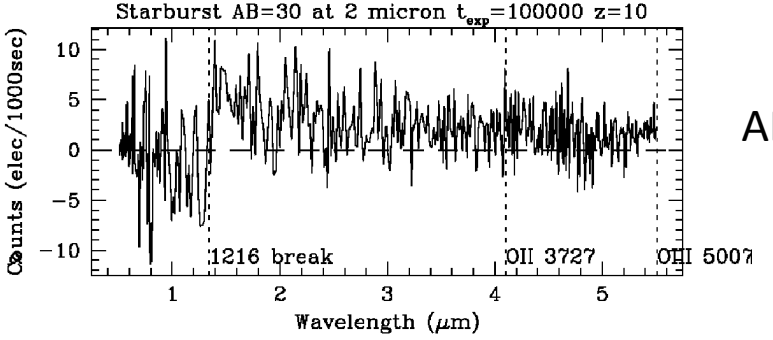




AB=29

AB=28





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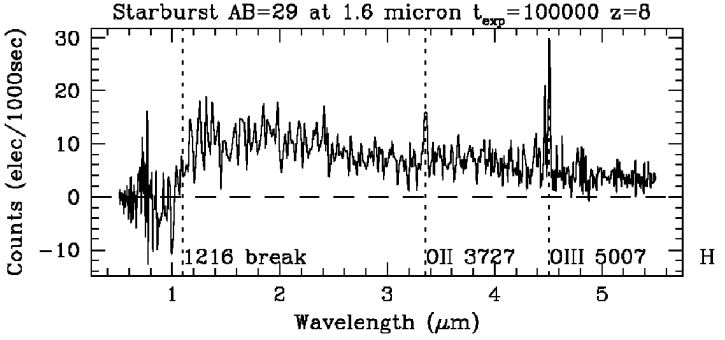
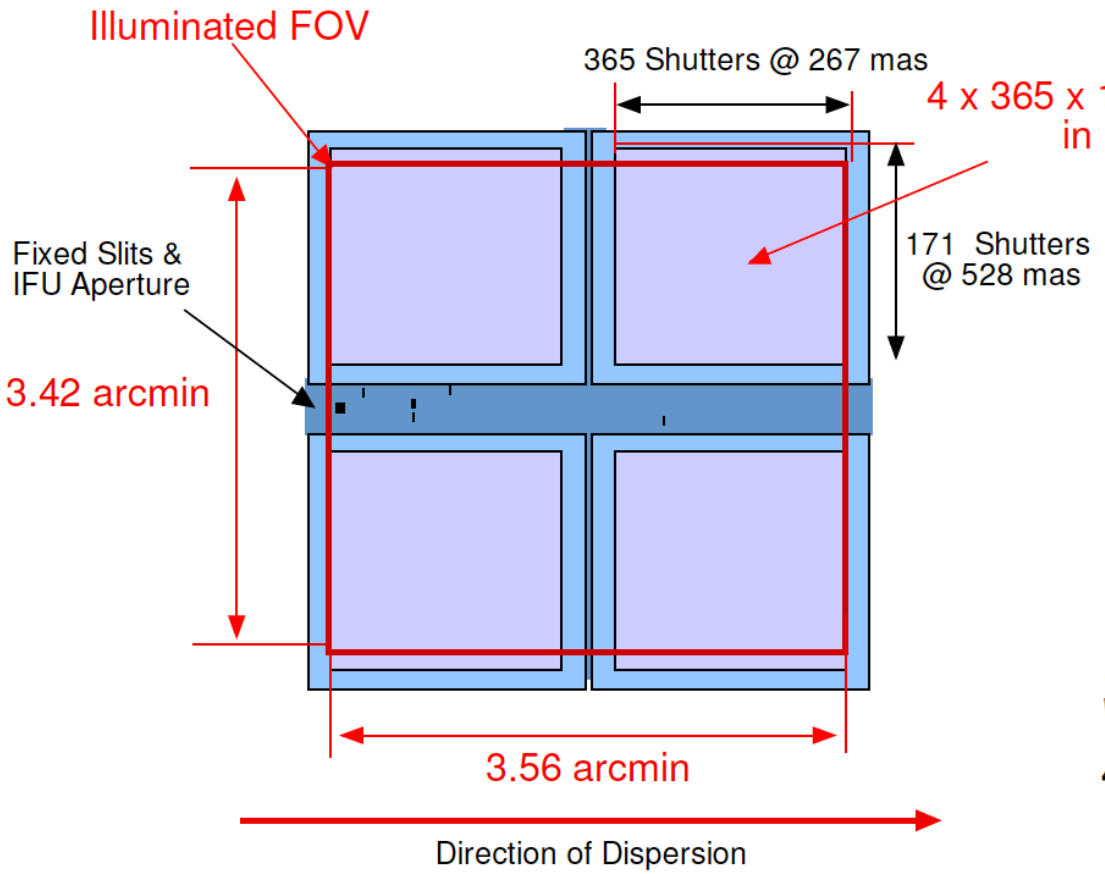
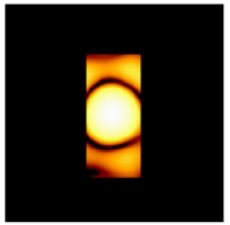


Derive redshifts, stellar masses, stellar ages, gas ionization and metallicities, star formation rates, kinematics, pop III stars, Ly-α LF to z=10, etc.

NIRSpec Multi Slit Capabilities

Micro Shutter Array





Single 200 mas x
450 mas slits

9 Square Arcmin of MSA Area

James Webb Space Telescope

Overall NIRSpec GTO Galaxy Assembly Plan

- a MSA wedding cake survey at R=100 and R=1000

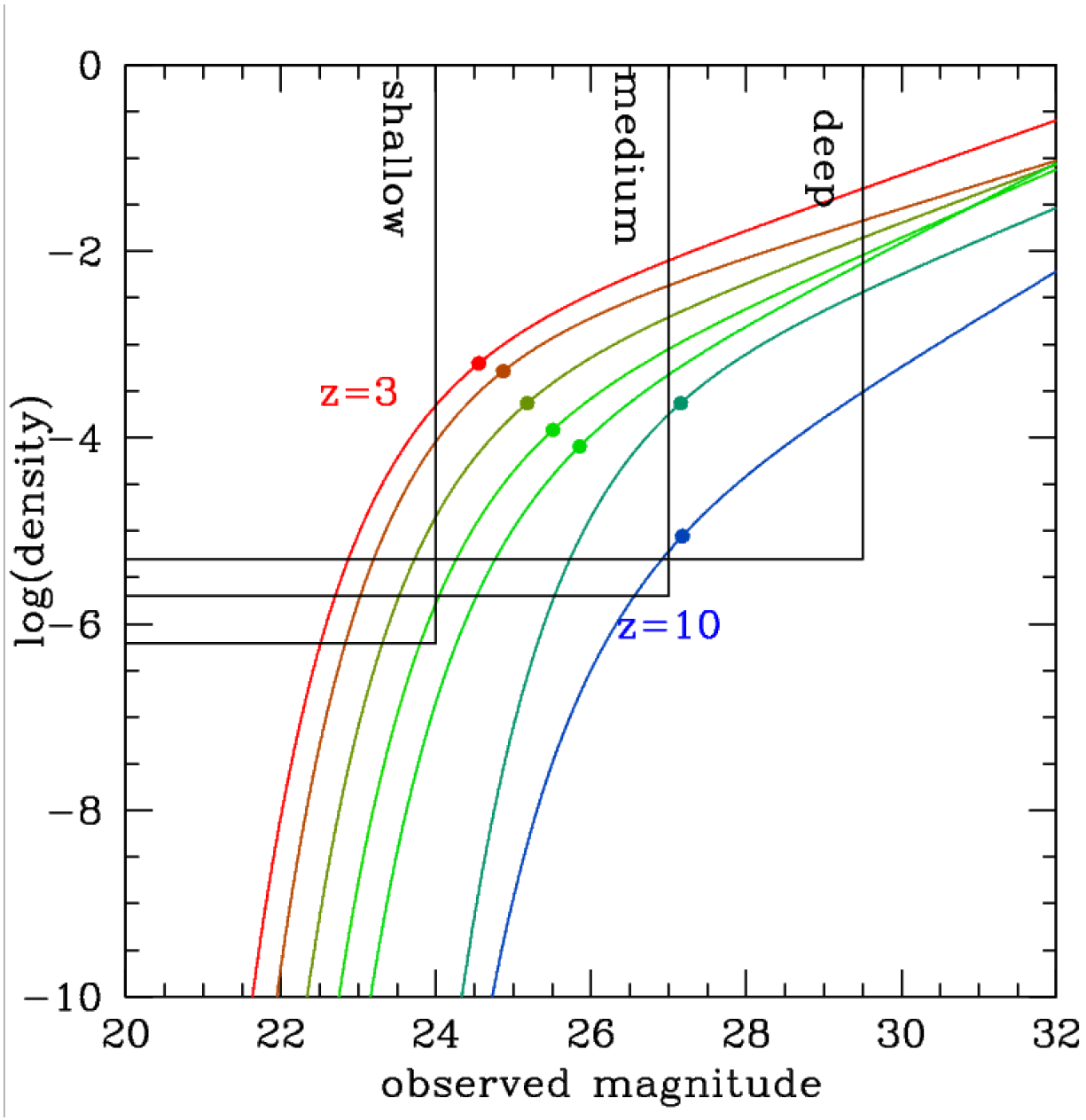
1) Deep, 20-30 sq arcmin, 1-5 μm, 40-45% of the time, AB≤29-30, 2<z<14, with NIRCAM team
2) Medium, 100 sq arcmin, 1-5μm, 40-45% of the time, AB≤27-28, 2<z<14 , with NIRCAM team
3) Shallow, 400 sq arcmin, 2-5μm, 10-20% of the time, AB≤25-26, 7000+ spectra, 2<z<4 (4<z<14)

≈500 hours

Fields: HST, NIRCAM deep and medium fields

4) R=3000 IFU spectroscopy of extended objects

≈300 hours


shallow
medium
deep
z=3
z=10
log(density)
observed magnitude
0
−2
−4
−6
−8
−10
20
22
24
26
28
30
32

Immediate results

- up to 300 spectra to AB=29.5, z=10 and beyond
- up to 1500 spectra to AB= 27, z=6 and beyond

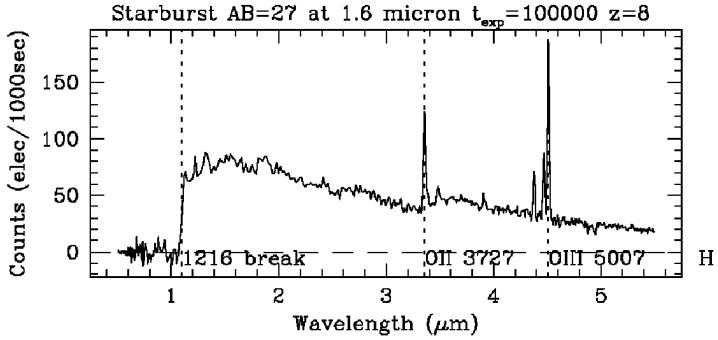
Extensive characterization of the field population to $L_*/10$ at the highest redshifts

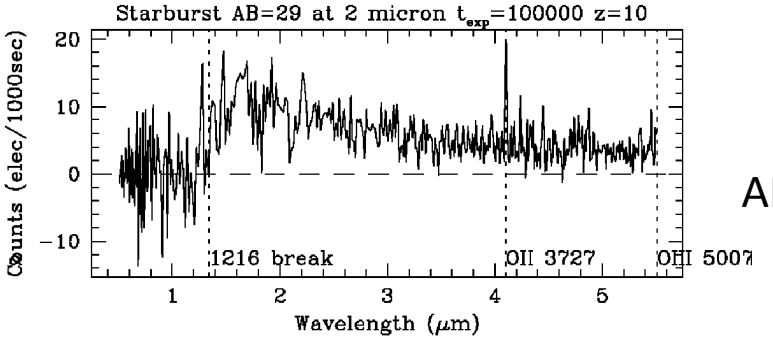
Overall Goals

- Obtain accurate spectroscopy from z=15 to z=2 – the era of first light to the peak in SFR, AGN growth, and the onset of the red sequence
- Go > 5 magnitudes fainter at 1-5 μm than possible now – sample an entirely new domain.
- Science questions (see the beautiful presentations at this meeting)
  - what are the earliest galaxies/stellar populations (pop 3, etc) ?
  - what caused reionization, what is escape fraction ?
  - what are the stellar masses, metallicities, SFRs, ages, etc ?
  - How do star formation rates and stellar masses evolve ?
  - how do galaxies assemble ?
  - how is star formation regulated ?
  - how does AGN growth relate to galaxy growth ?
  - what is the role of environment ?
  - what is the relation between galaxies and their halos ?
  - what feedback processes can we observe ?

NIRSpec Simulations

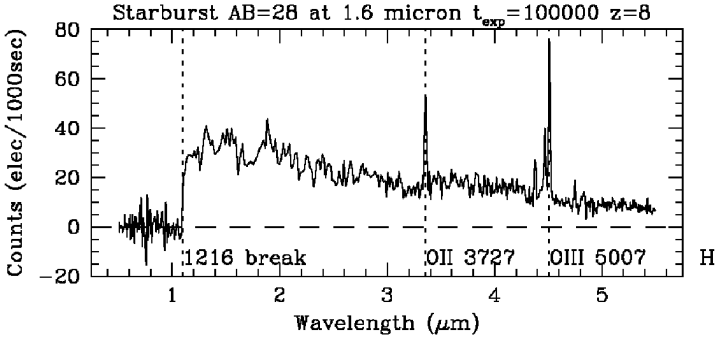
AB=27

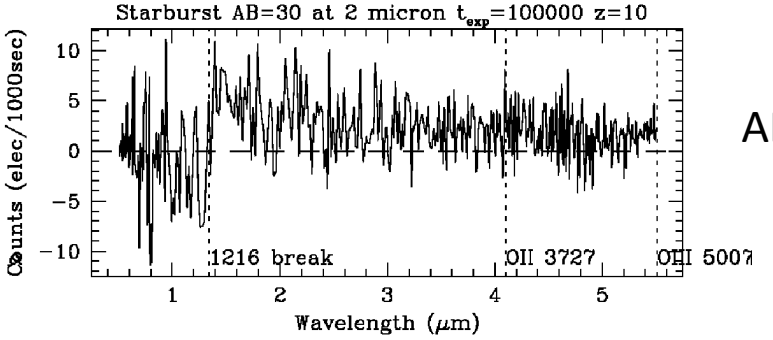




AB=29

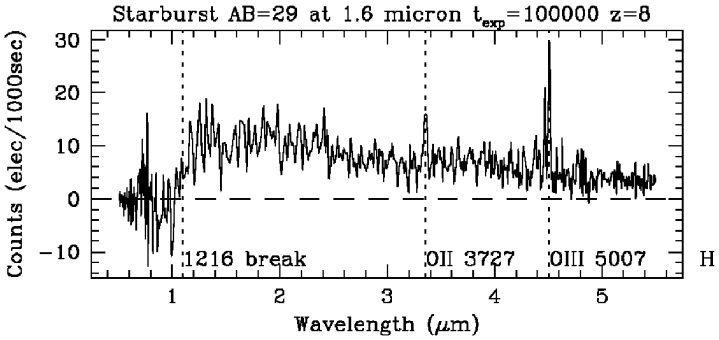
AB=28





AB=30

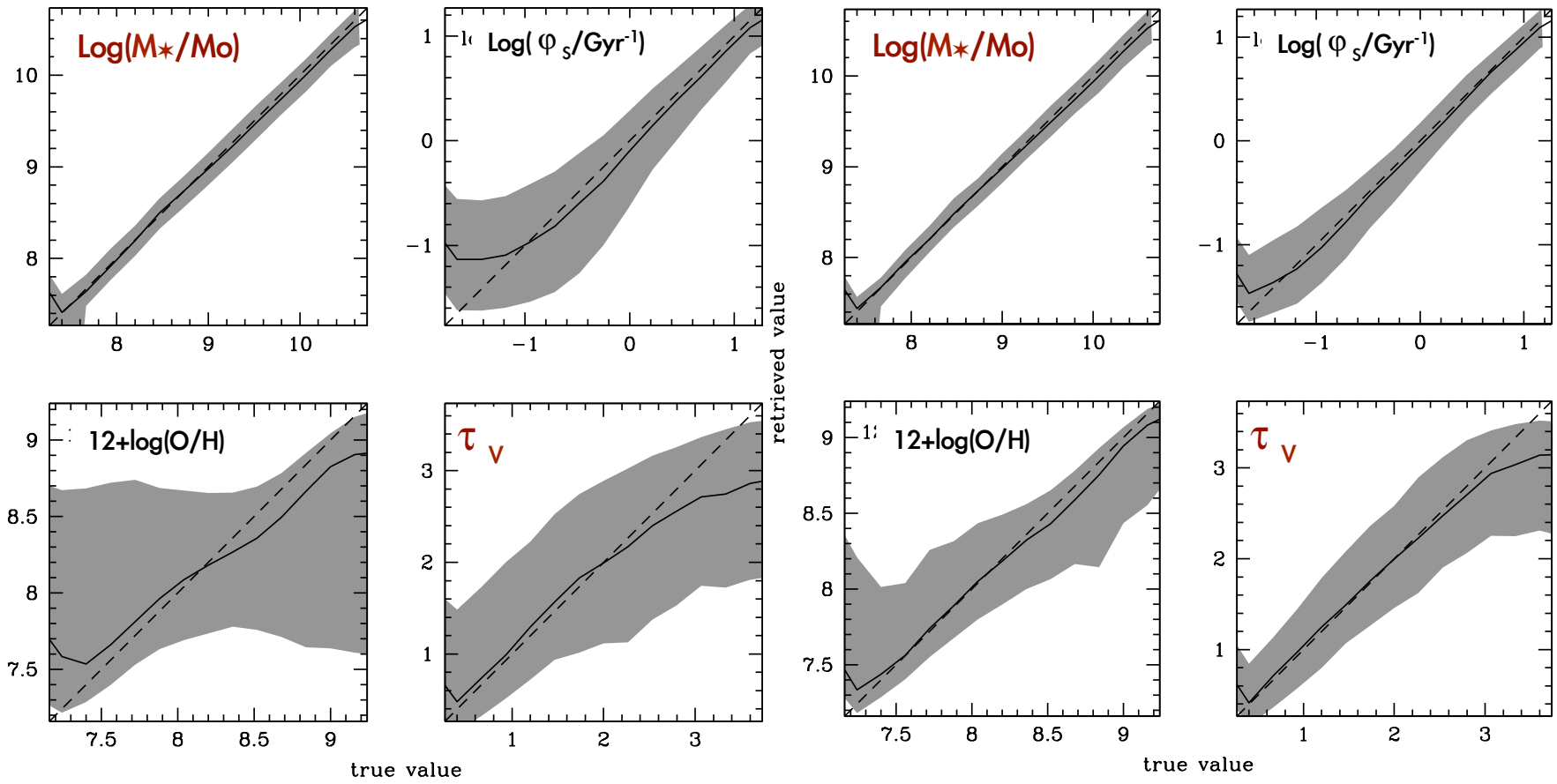
AB=29



Derive redshifts, stellar masses, stellar ages, gas ionization and metallicities, star formation rates, kinematics, pop III stars, Ly-α LF to z=10, etc.

Retrievability of galaxy physical parameters

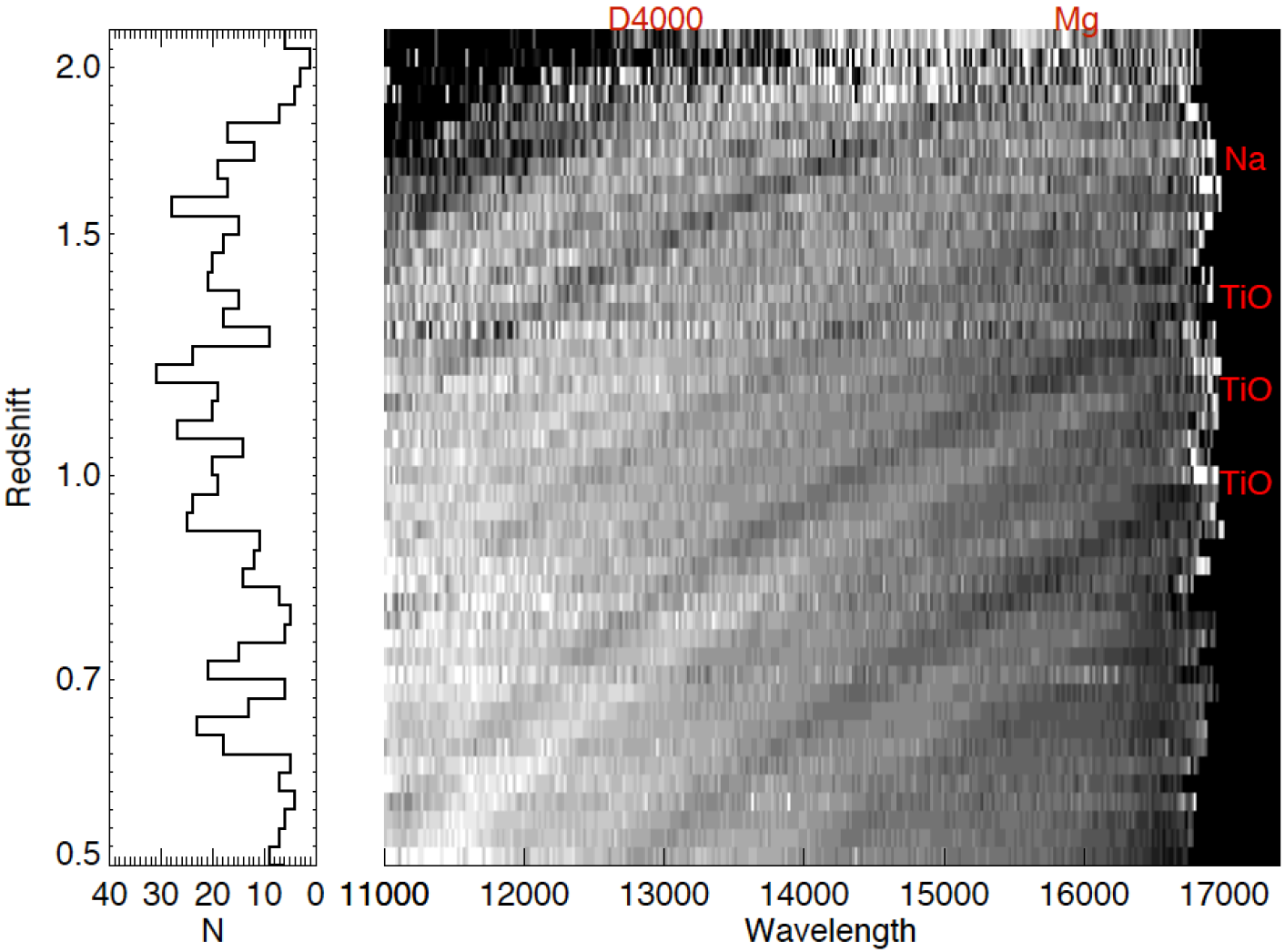
Global results for 10,000 pseudo-observed galaxies (wide range of true parameters)



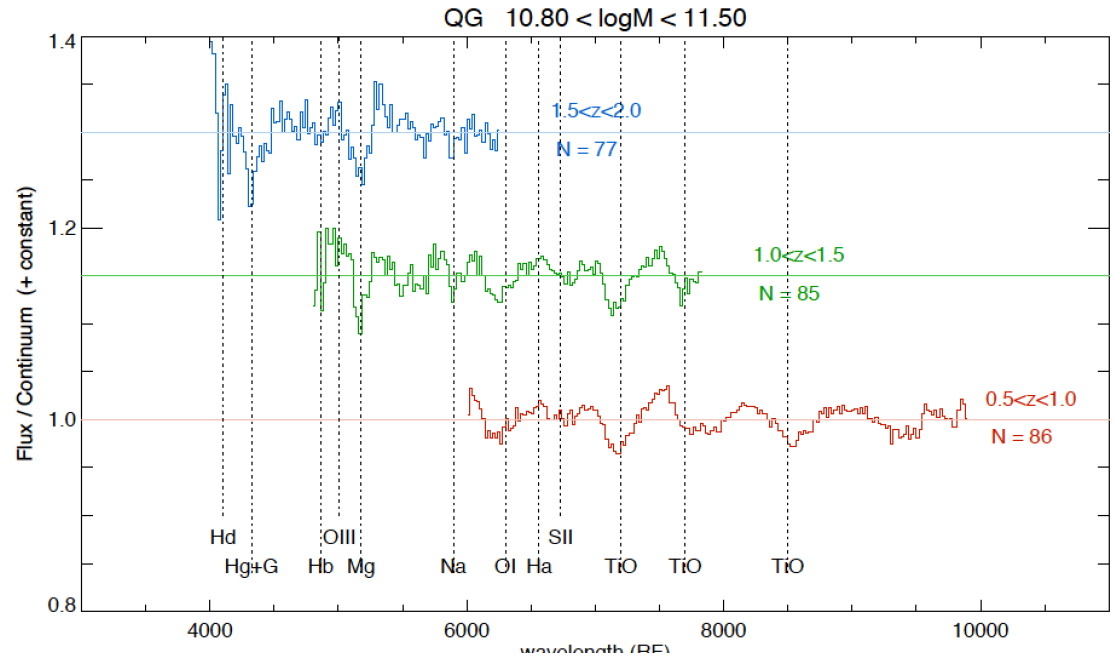
See also presentation by Chevallard

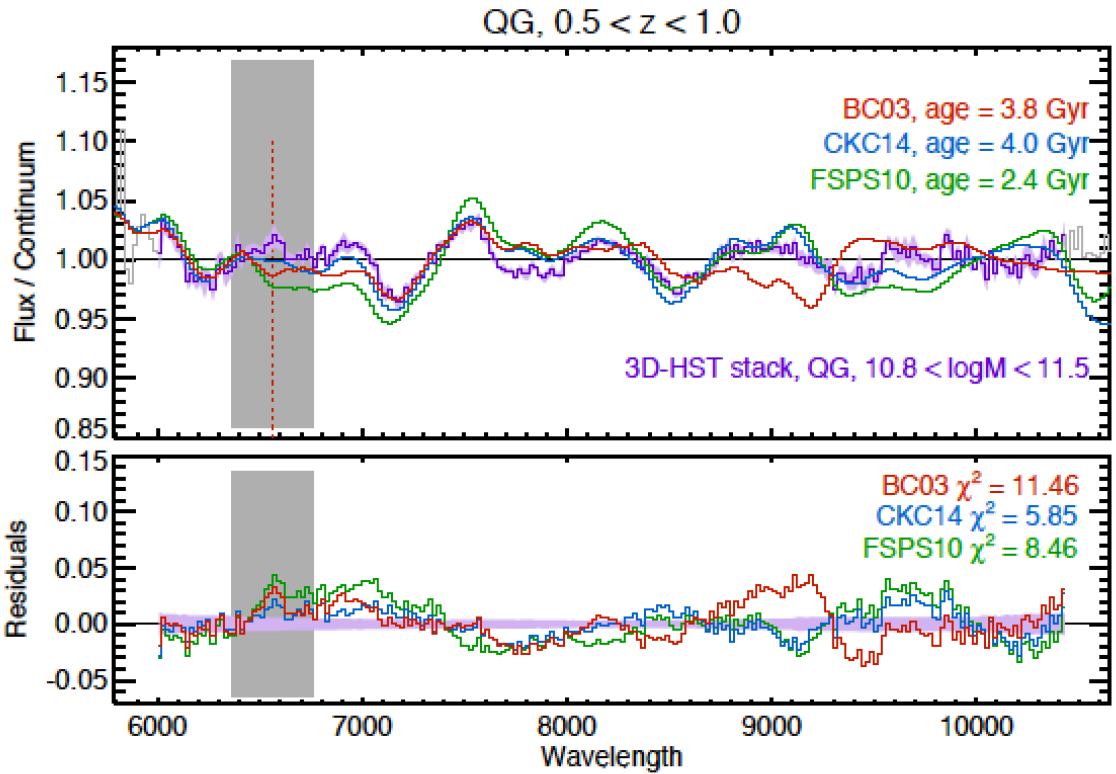
(Pacifici et al. 2012)

A cautionary tale – 3D-HST spectra



Brammer et al 2012,
Momcheva et al 2015,
Fumagalli et al 2015


QG 10.80 < logM < 11.50
Flux / Continuum (+ constant)
1.5<z<2.0
N = 77
1.0<z<1.5
N = 85
0.5<z<1.0
N = 86
Hd
Hg+G
Hb
OIII
Mg
Na
OI
Ha
SII
TiO
TiO
TiO
1.4
1.2
1.0
0.8
4000
6000
8000
10000


QG, 0.5 < z < 1.0
Flux / Continuum
BC03, age = 3.8 Gyr
CKC14, age = 4.0 Gyr
FSPS10, age = 2.4 Gyr
3D-HST stack, QG, 10.8 < logM < 11.5
Residuals
BC03 χ² = 11.46
CKC14 χ² = 5.85
FSPS10 χ² = 8.46
Wavelength
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.15
0.10
0.05
0.00
-0.05
6000
7000
8000
9000
10000

One Key Result

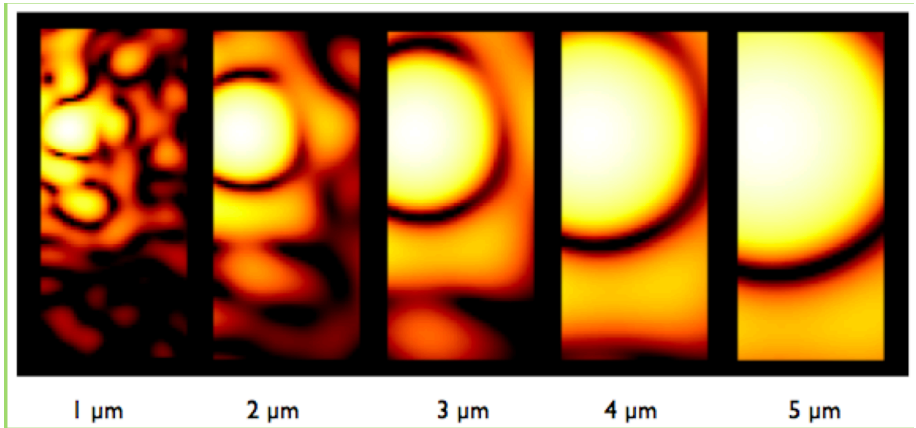
Census of the universe to z=14

- Select galaxies in the red (4.4μ) -
  - rest frame optical to z=9 - get dusty, "old", or low star formation galaxies to z=9
- Consistent stellar masses and ages

  (get rid of those emission lines !)
- Consistent star formation rates from Balmer lines
- Evidence for Pop III or AGN, or other "special effects" ?

Don’t get euphoric yet

- Spectra undersampled at 0.1 arcsec pixel scale
- PSF varies significantly from 0.6 to 5 µm
- Galaxies are extended – (large) slit losses as function of wavelength and difficulty in modeling
- Multiwavelength NIRCAM imaging is almost a “must” to allow modeling

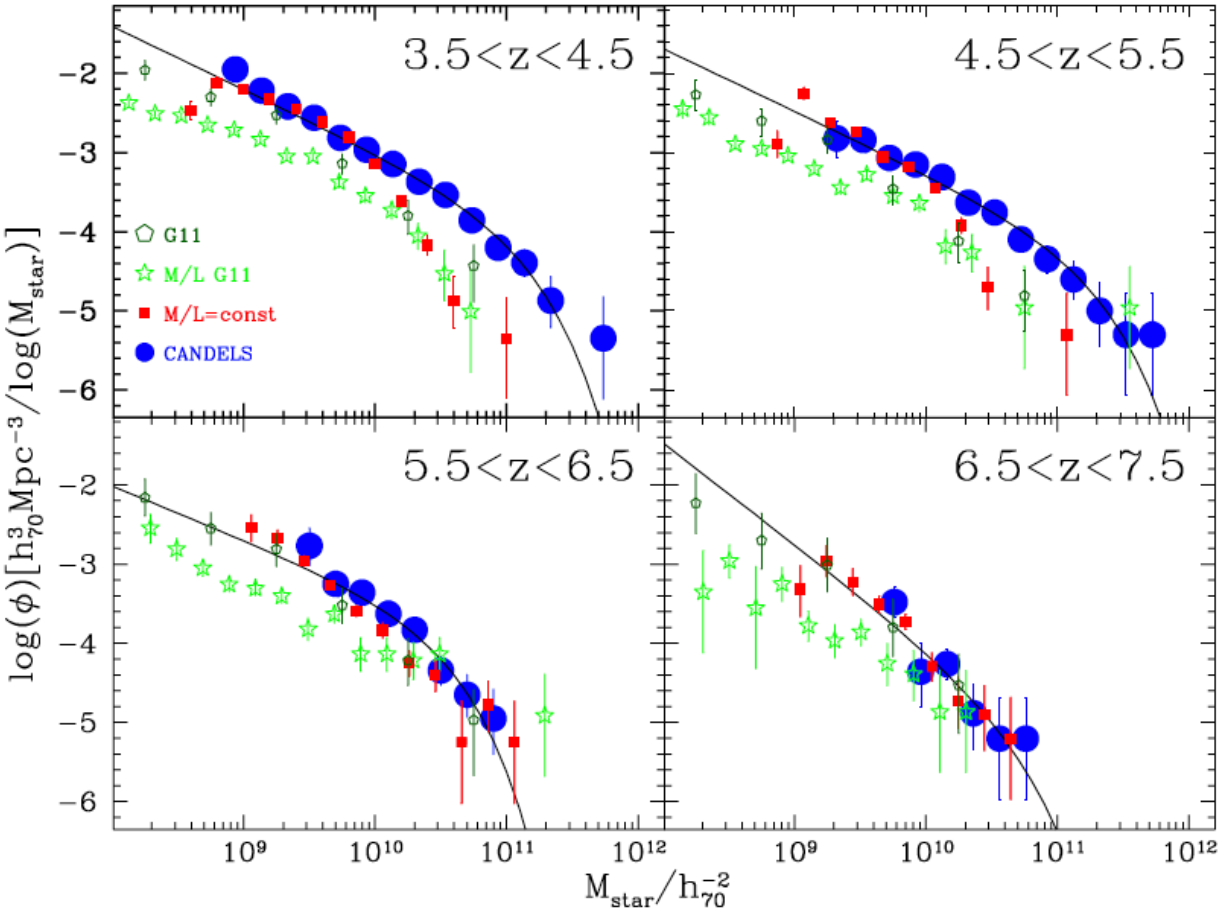


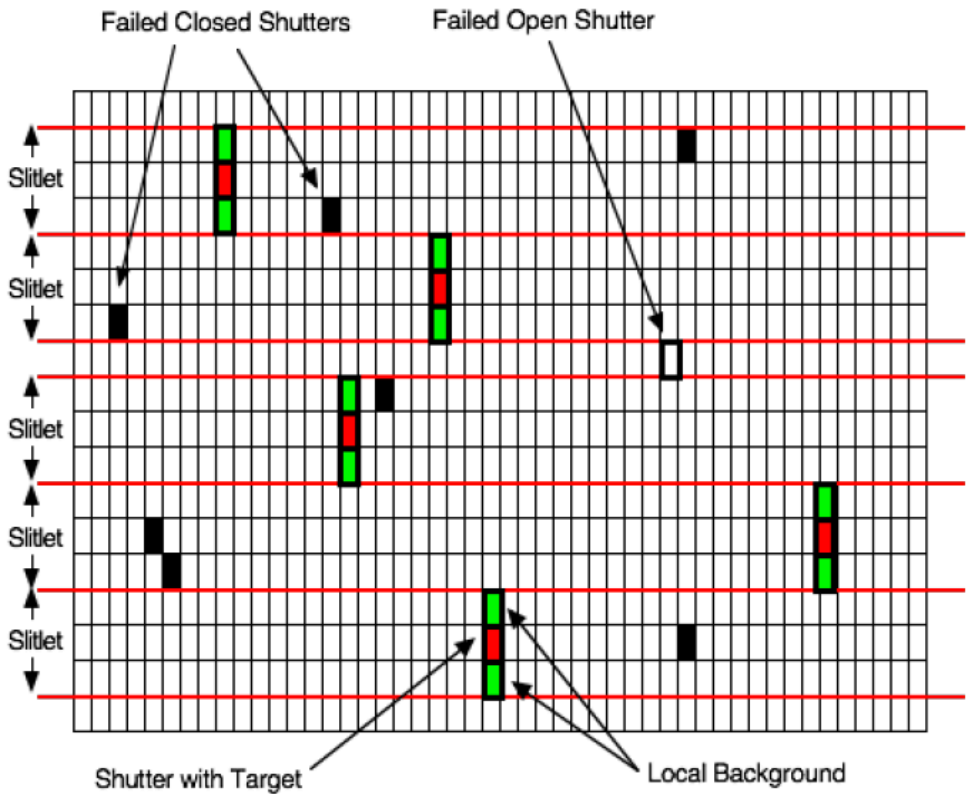
Conclusion

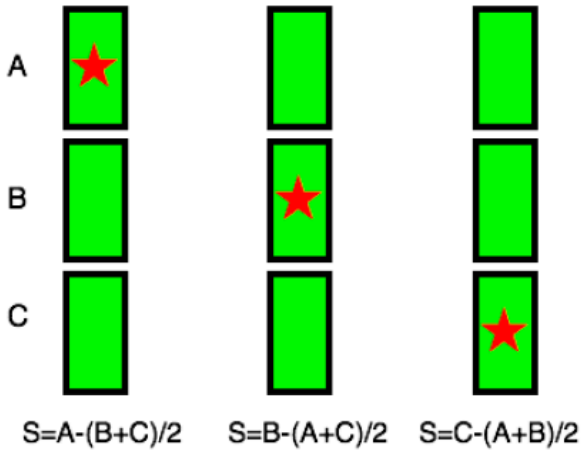
- NIRSpec will produce thousands of spectra from low redshift to the highest redshifts
- NIRSpec an push to the limits of imaging
- NIRSpec will vastly extend our characterization of the high redshift universe and produce consistent estimates of key properties of galaxies

end

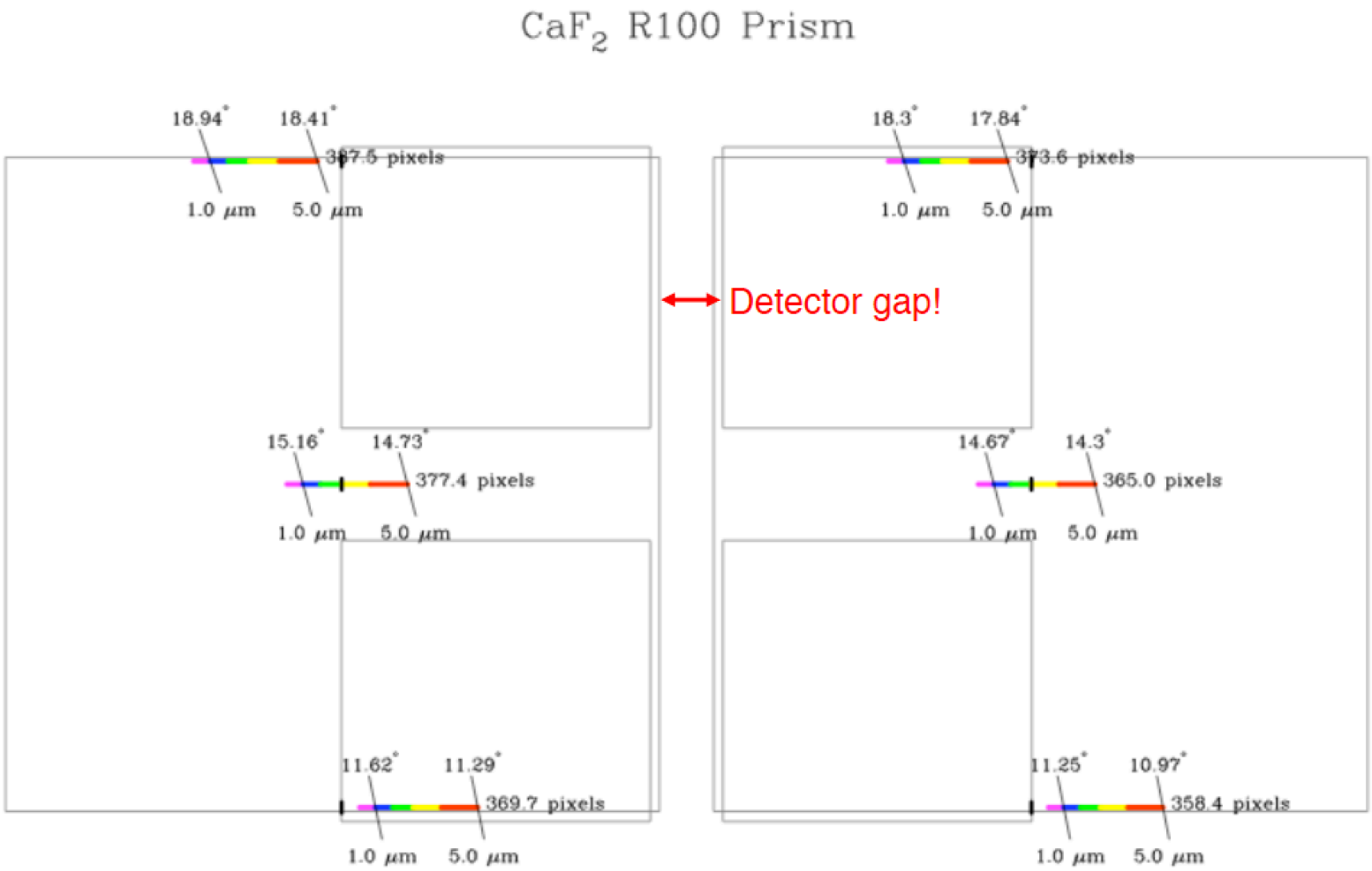
An example


3.5<z<4.5
4.5<z<5.5
5.5<z<6.5
6.5<z<7.5
G11
M/L G11
M/L=const
CANDELS
log(Φ)[h70^3 Mpc^-3/log(Mstar)]
Mstar/h70^-2
−2
−3
−4
−5
−6
10^9
10^10
10^11
10^12


Failed Closed Shutters
Failed Open Shutter
Slitlet
Slitlet
Slitlet
Slitlet
Slitlet
Shutter with Target
Local Background

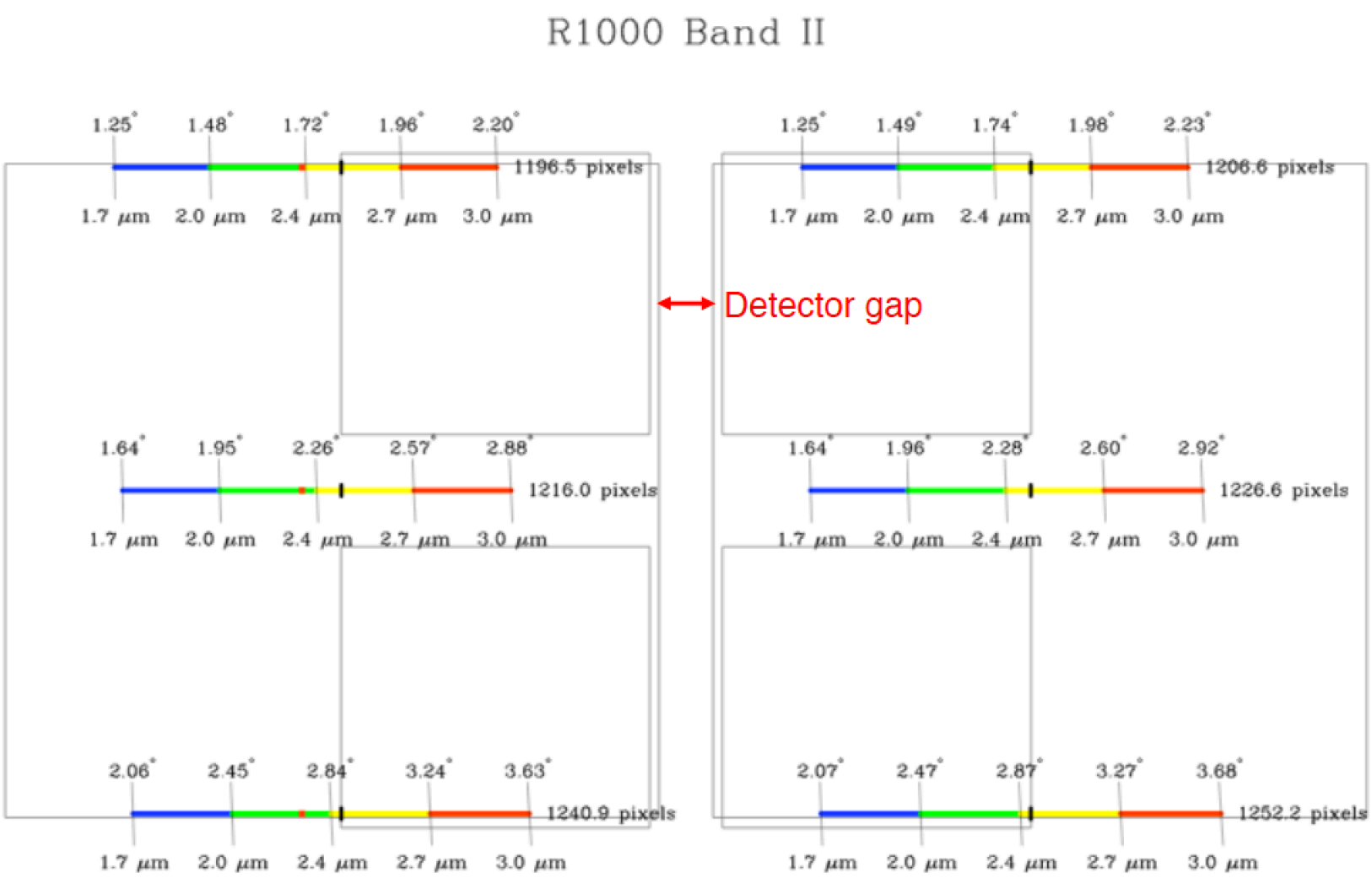

A
B
C
S=A-(B+C)/2
S=B-(A+C)/2
S=C-(A+B)/2

Location of Spectra



James Webb Space Telescope

Location of Spectra



James Webb Space Telescope