The Contemporary Universe in the WFIRST Era

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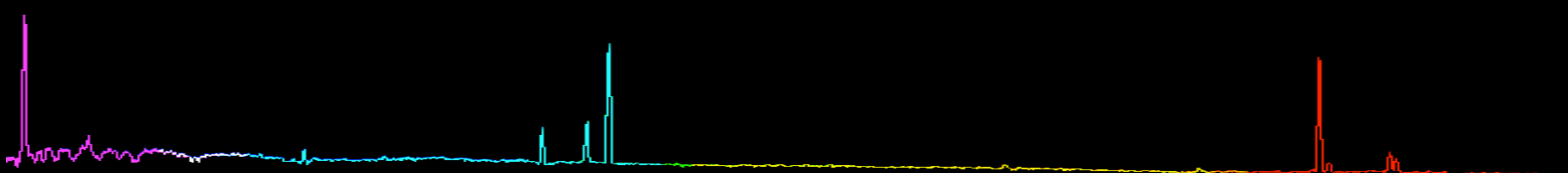
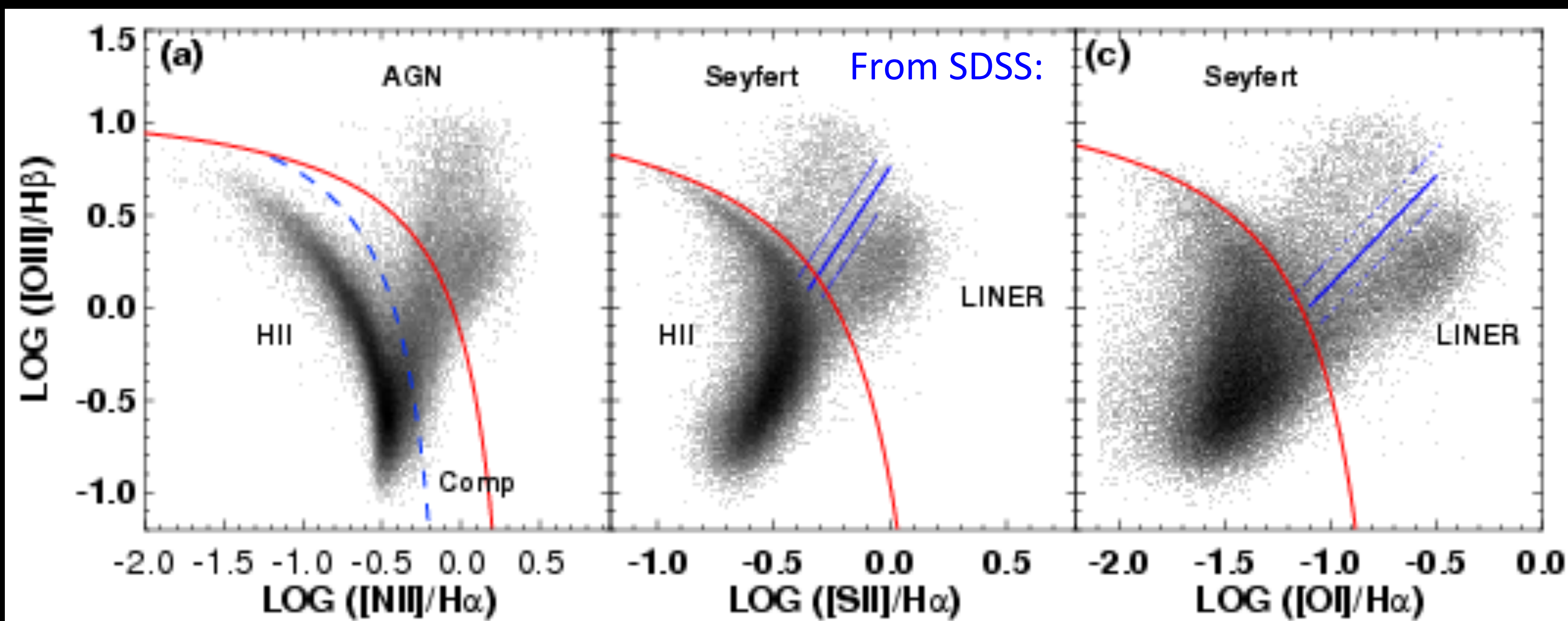
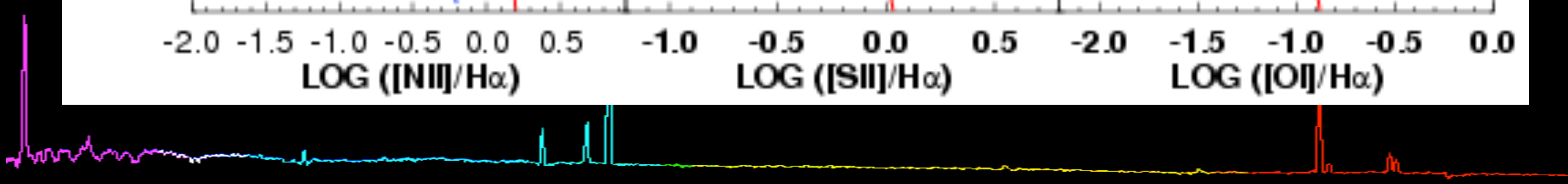


Deep Guest Observer Surveys

Key spectroscopic window: 1.8<z<2

- allows [OIII]/Hβ and [NII]/Hα

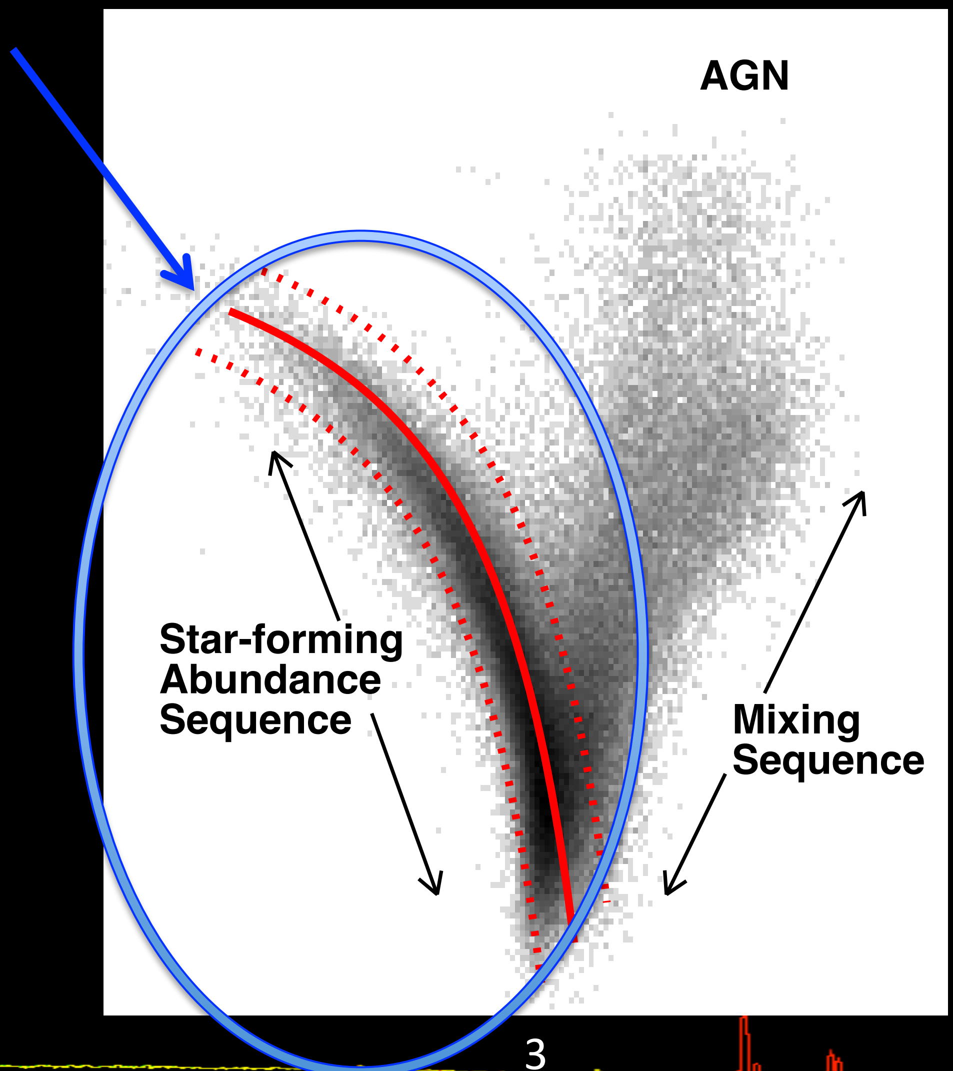




Star-forming Abundance Sequence

Sensitive to:

- Metallicity (Z)
- Ionization parameter (q)
- Electron density (n_e)
- Hardness of EUV radiation field

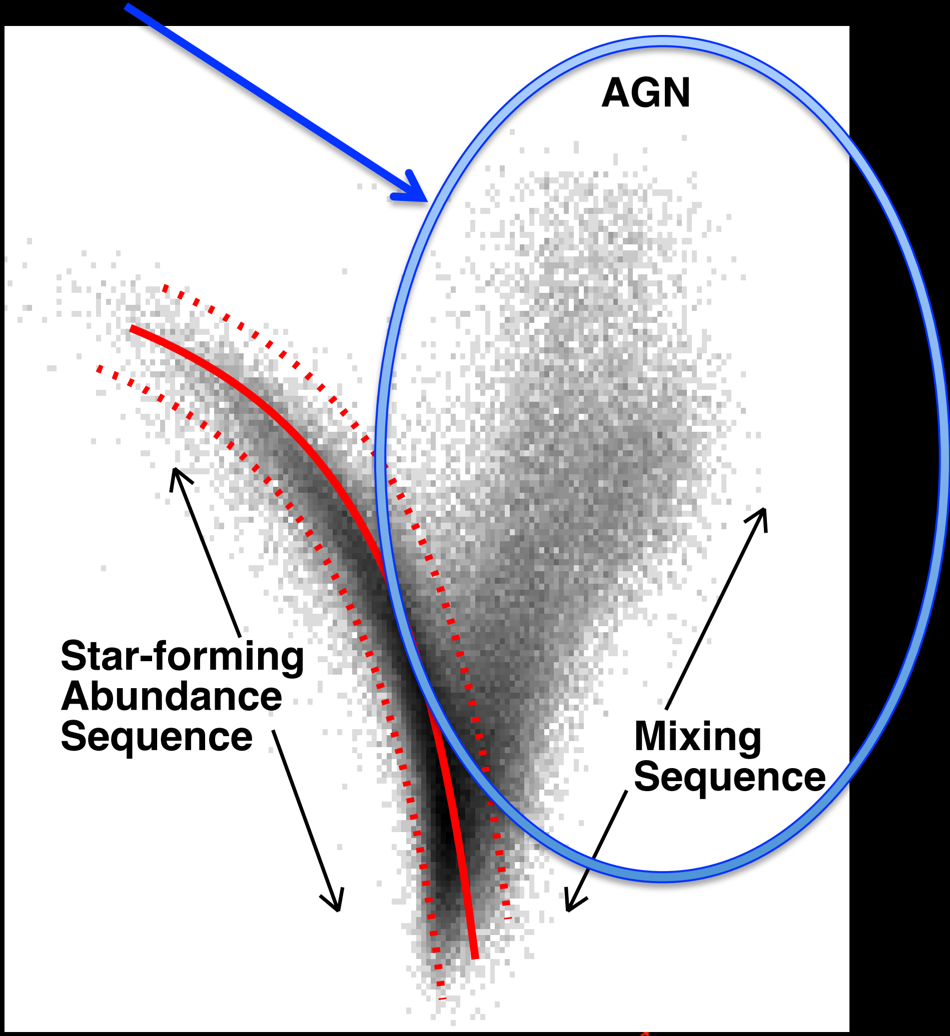


AGN Mixing Sequence

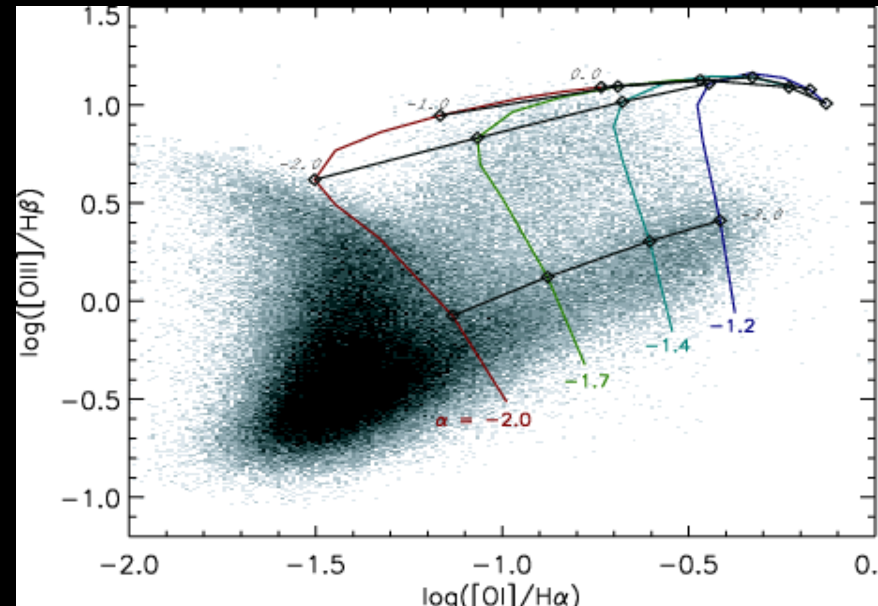
Shape and position from:

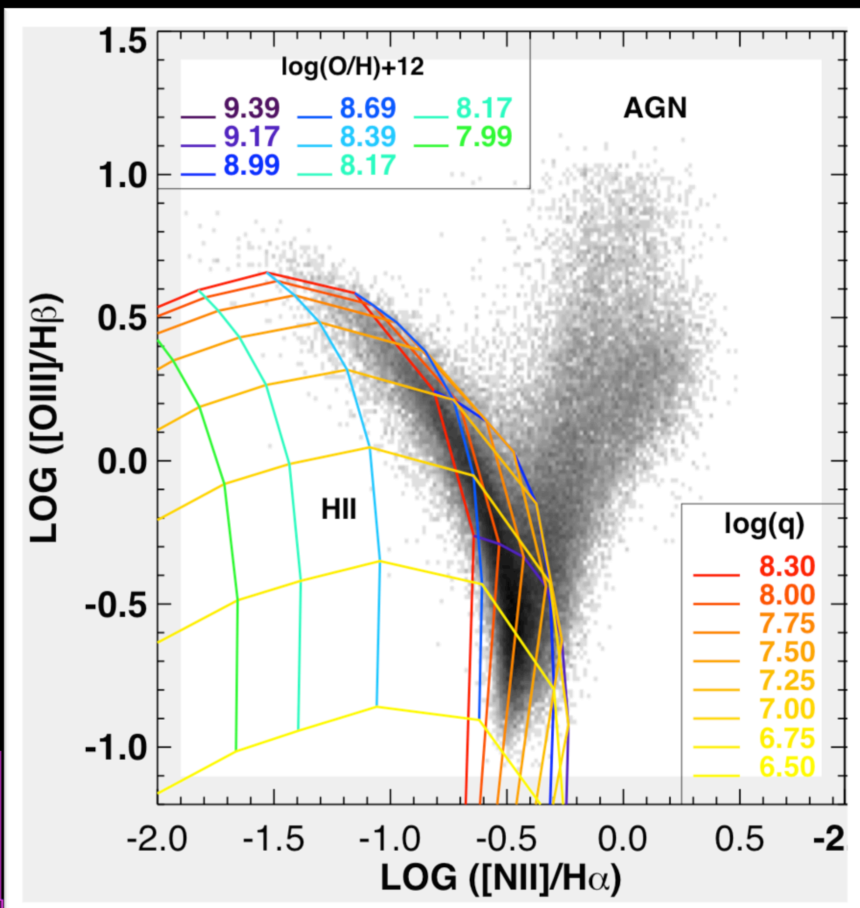
- Metallicity (Z)
- Ionization parameter (q)
- Power-law index (α)

  (EUV hardness)



AGN contribution to emission-lines





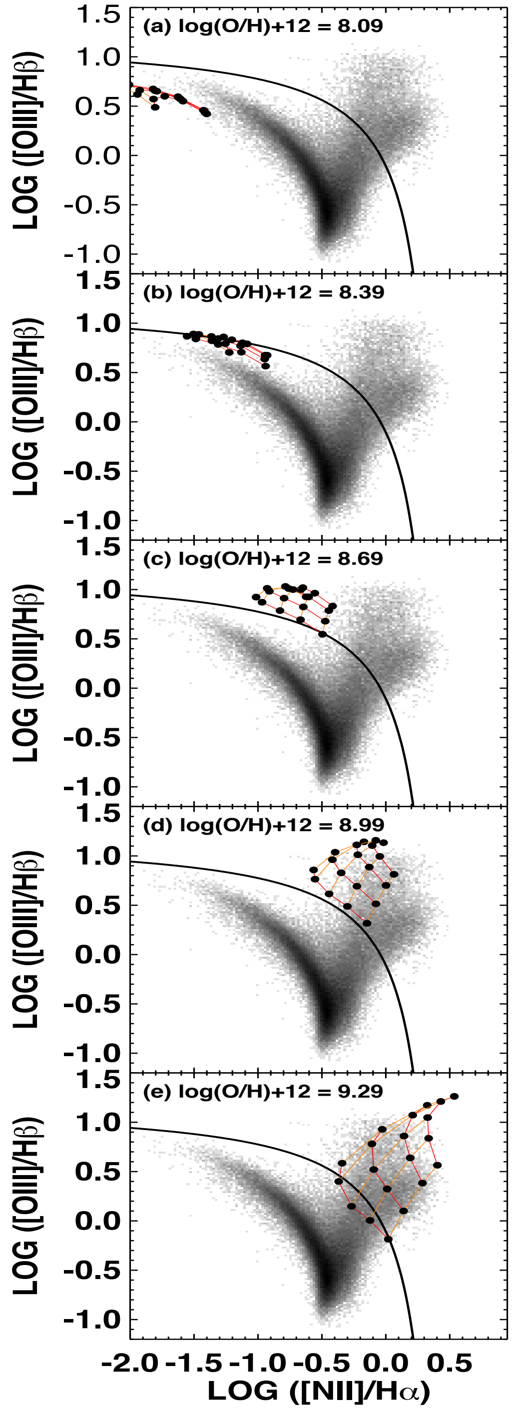
AGN & starburst photoionization models

Need to constrain metallicity, ionization parameter & α

Photoionization Models

AGN position & metallicity

Kewley et al. 2013a, ApJ, 774, 110



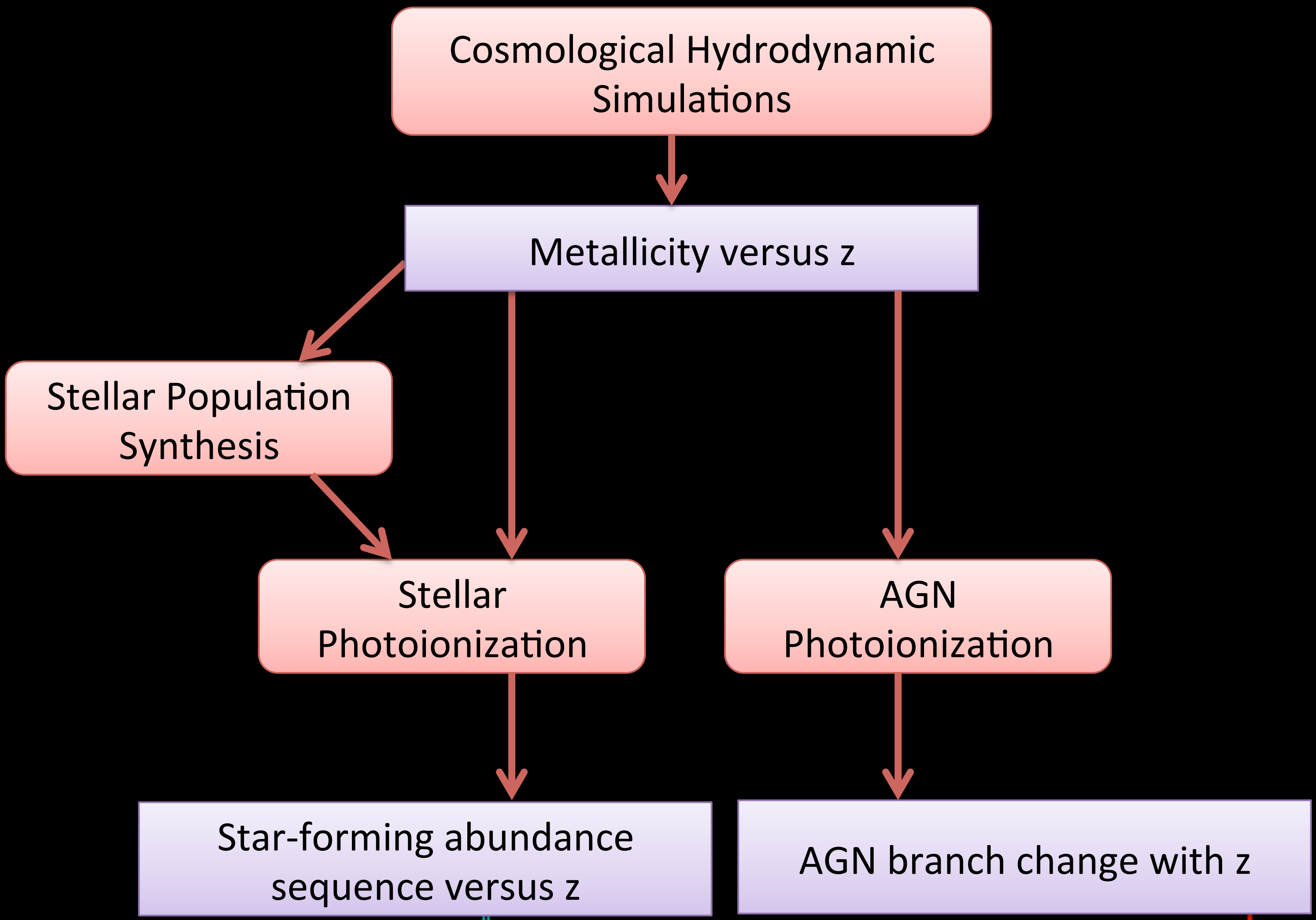
Low Metallicity

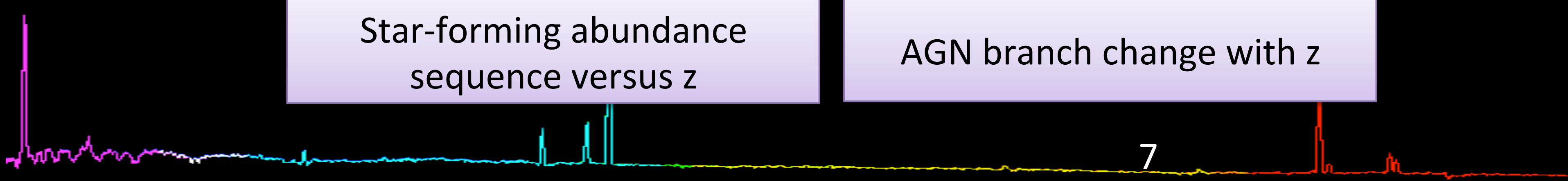
AGN locus depends on metallicity

High Metallicity

Theoretical predictions

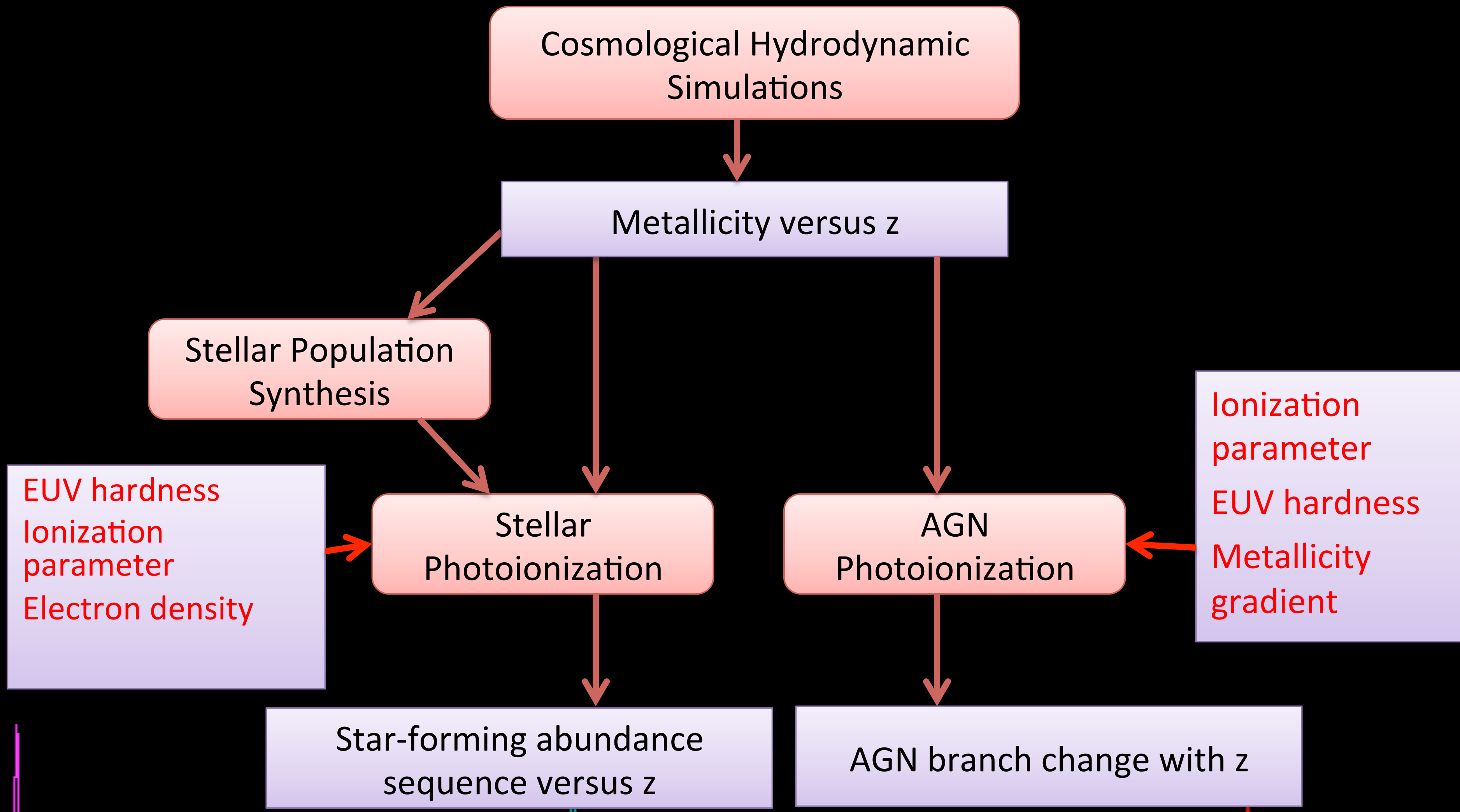
Cosmic evolution of star-forming and active galaxy spectra





Theoretical predictions

Cosmic evolution of star-forming and active galaxy spectra



Two sets of extreme scenarios

Star-forming galaxies at z~3:

ISM conditions (q, n_e) and/or EUV hardness

- → Same as local ("normal")
- or
- → More extreme than local (x10)

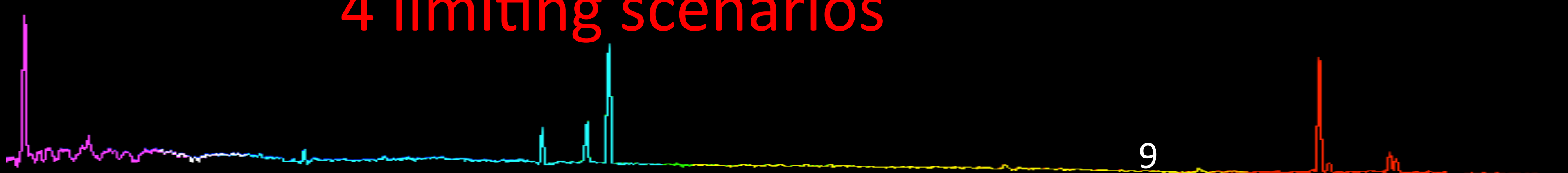
AGN at z~3: (assume full range of q & α)

NLR Metallicity

- → already fully enriched – "metal-rich"
- or
- → similar to surrounding star-forming gas "metal-poor"

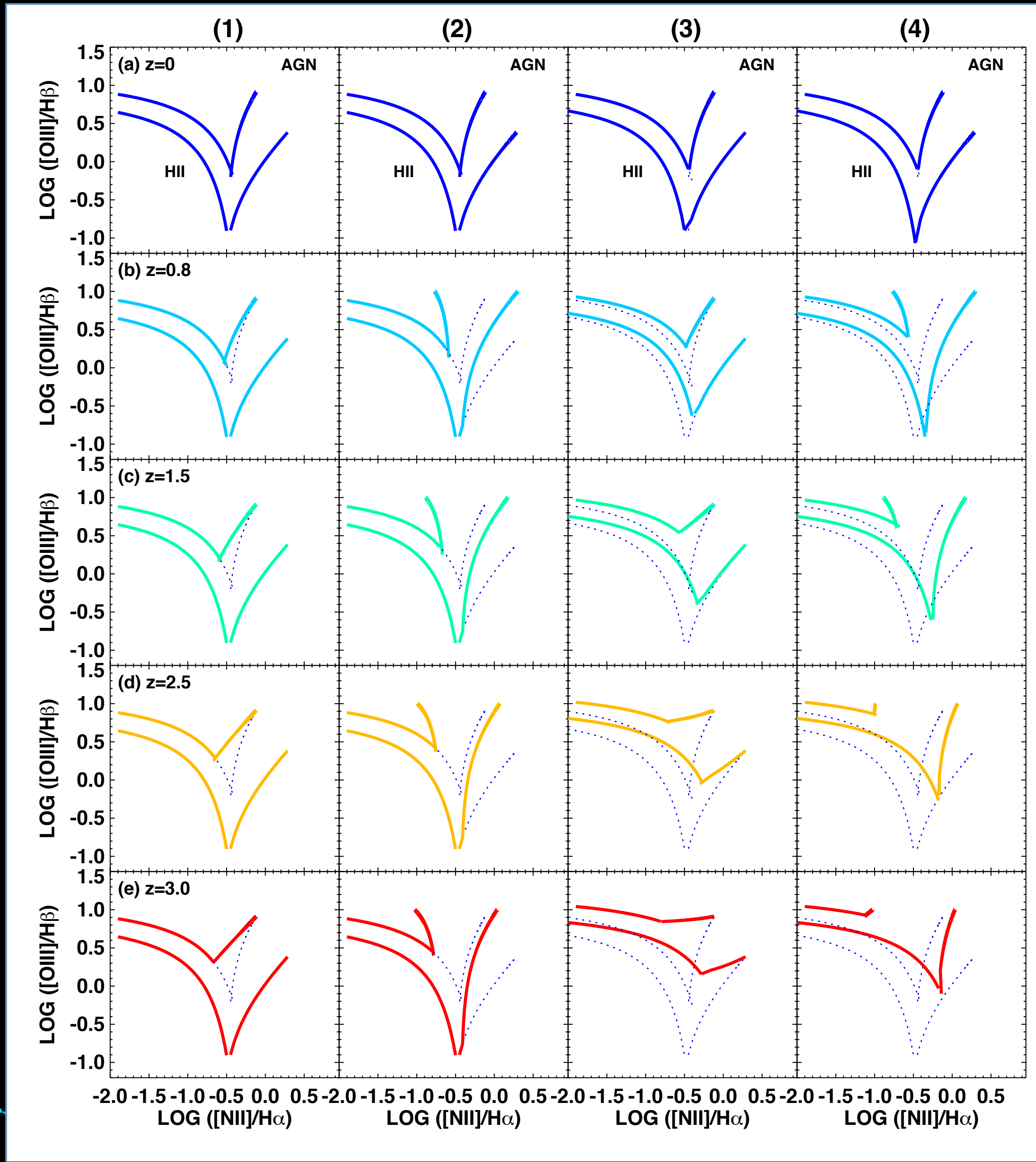
⇓

4 limiting scenarios



The Cosmic BPT Diagram

Kewley+13a, ApJ, 774, 110



z=0

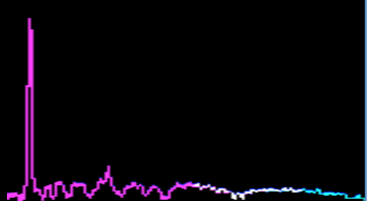
z=0.8

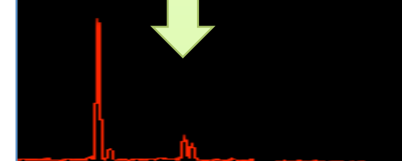
z=1.5

z=2.5

z=3.0

redshift





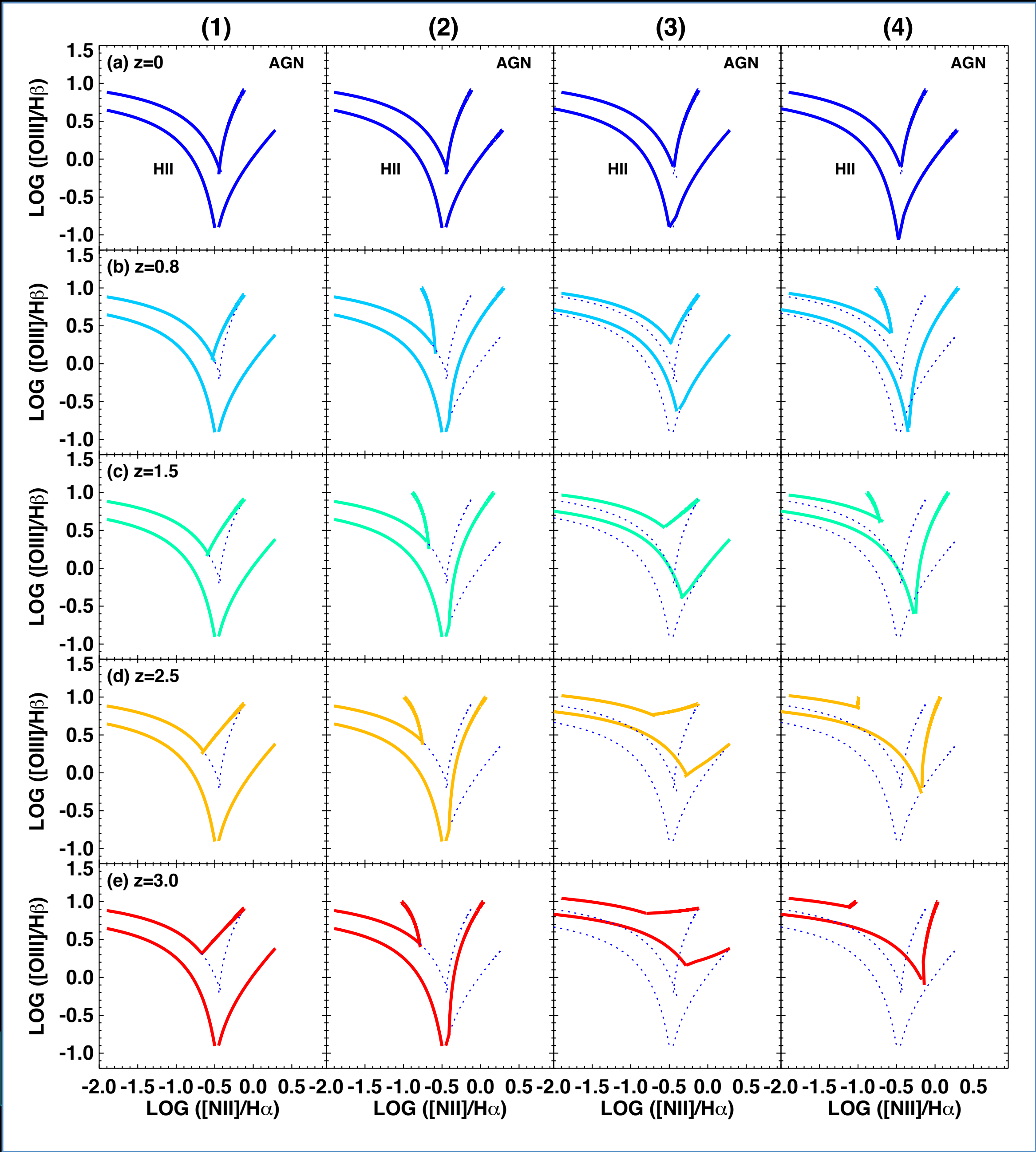
The Cosmic BPT Diagram

Key Take Home Points:

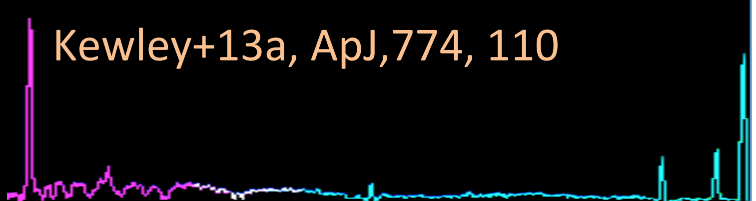
1. Testing ISM conditions/EUV hardness: z>1.5 ideal

2. Local classification schemes won't work at z>1.5 if ISM conditions extreme.

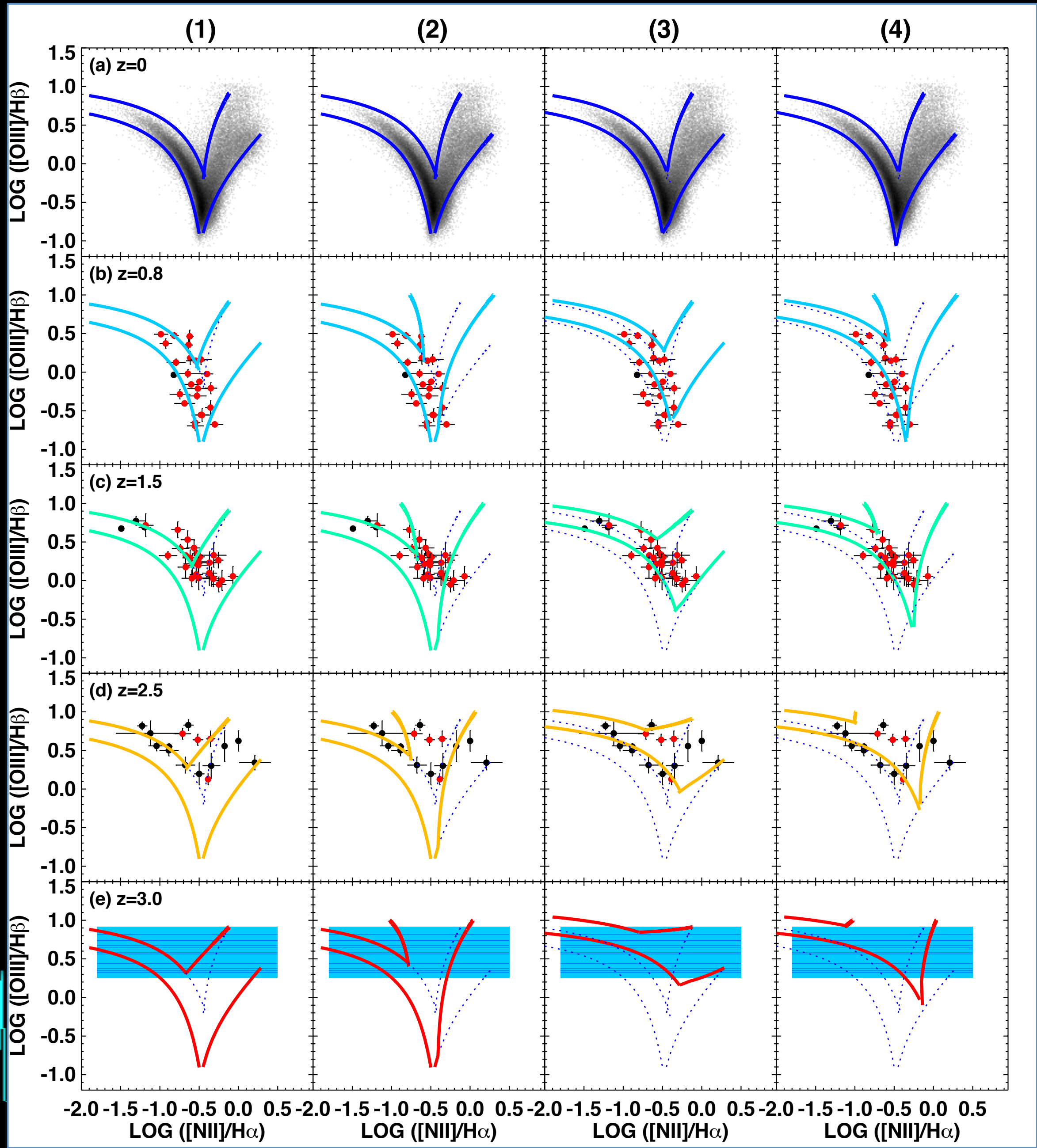
3. AGN mixing sequence very sensitive to metallicity gradient (1.5 ≤ z ≤ 2.5 ideal)



Kewley+13a, ApJ,774, 110



The BPT Diagram with redshift



Where do the data lie?

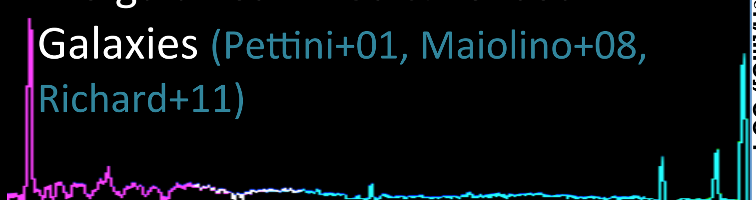
(Kewley+13b, ApJL, 774, 10)

z~0.8: zCOSMOS
(NIR data: Maier+13)

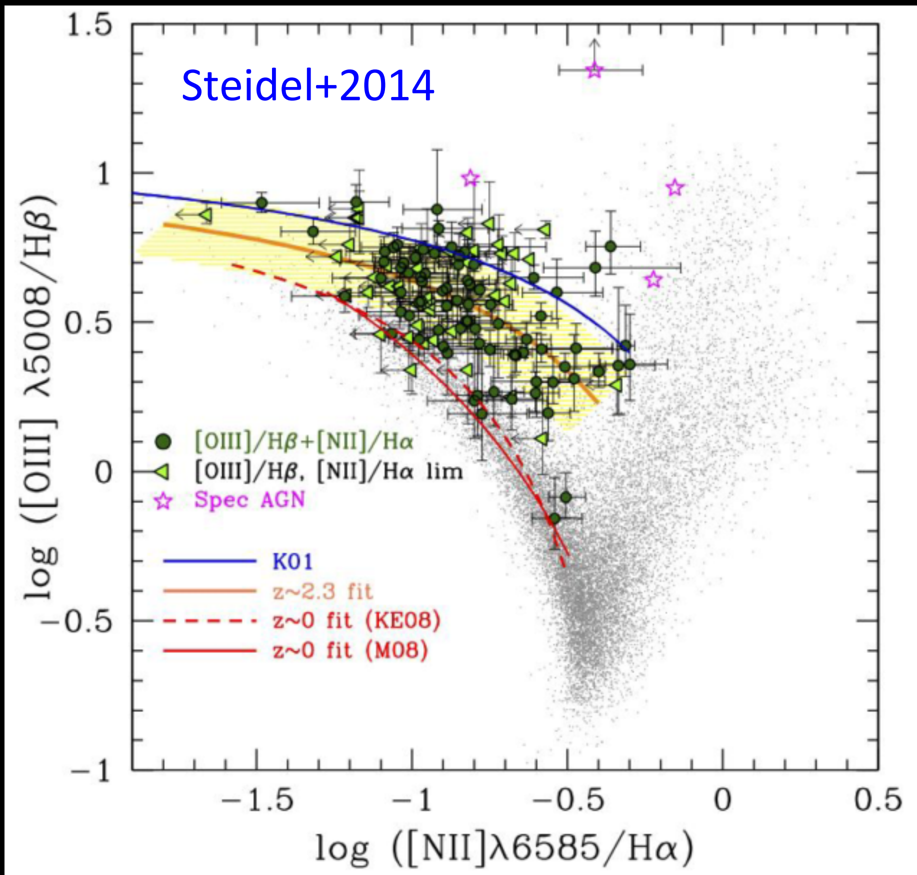
z~1.5: Subaru-XMM Deep Survey and the UKIDSS Ultra Deep Survey
(NIR data: Yabe+12,13)

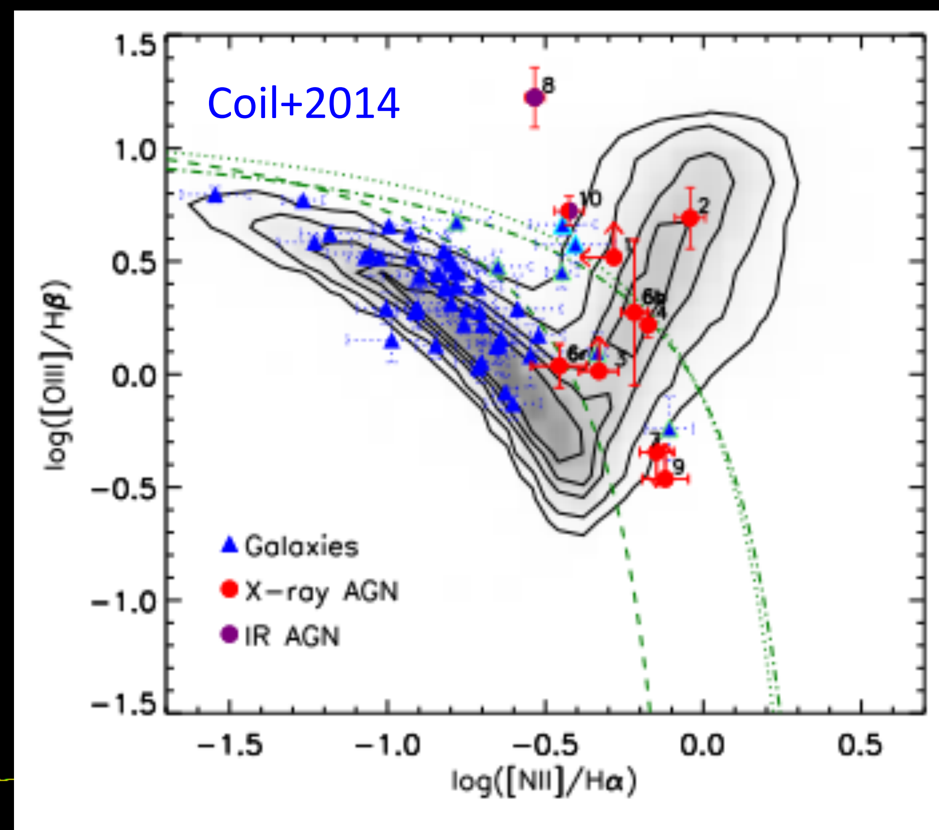
z~2.5: Lensed galaxies + BzKs
(Richard+11, Jones+13, Yuan+13)

z=3 galaxies: LBGs & Lensed Galaxies (Pettini+01, Maiolino+08, Richard+11)



Hot off the press:



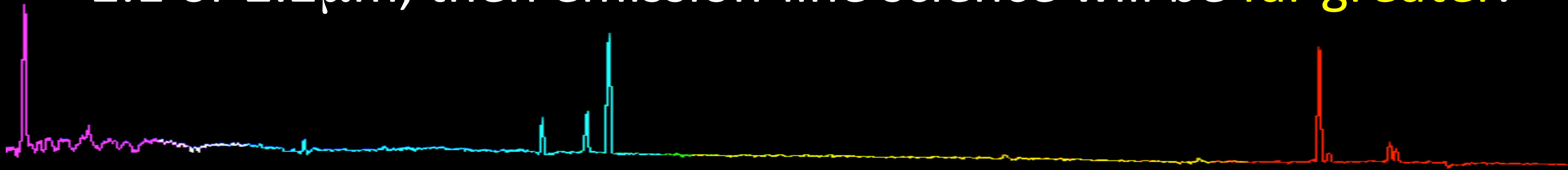


Causes of a BPT offset

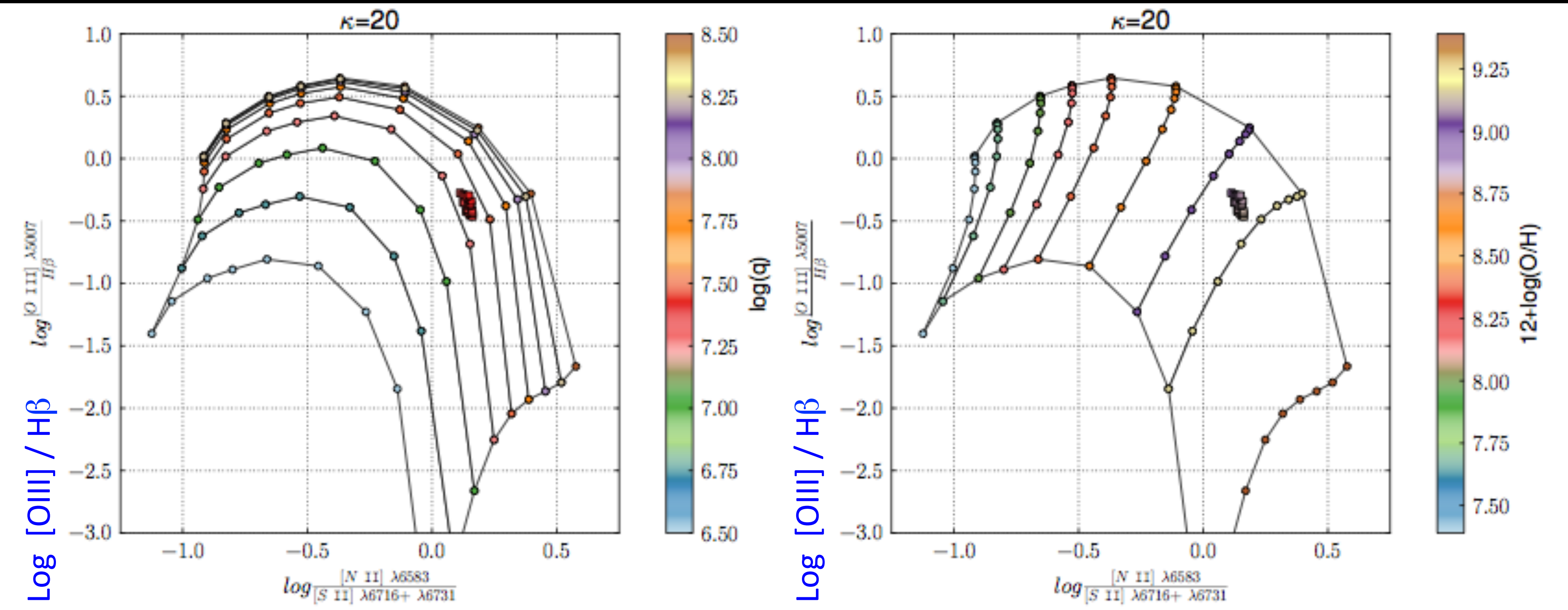
- Hard ionizing radiation field
- Higher ISM pressure
- Higher ionization parameter
- Shocks
- AGN contribution

....need [SII] (at least)!

WFIRST can obtain [SII] and other lines only for 1.8<z<1.85 If the grism could be extended > 1.95μm to 2.1 or 2.2μm, then emission-line science will be far greater.



Ionization parameter



Log [NII] / [SII]

Log [NII] / [SII]

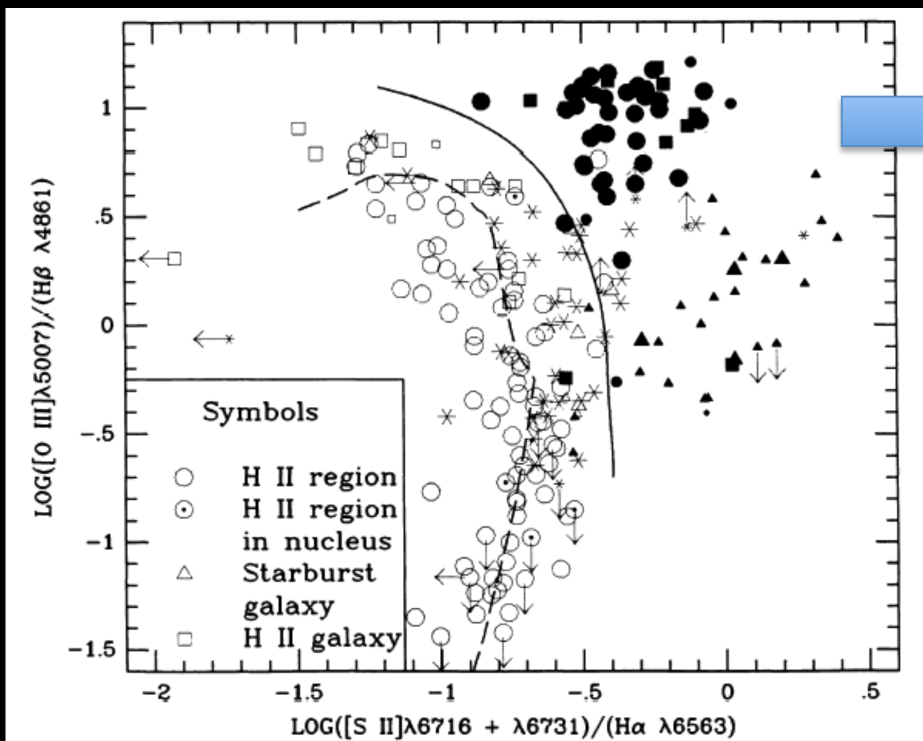
Kewley, Leslie et al. (2014, in prep)

What will WFIRST do that we can't already do with MOSFIRE =>TMTs?

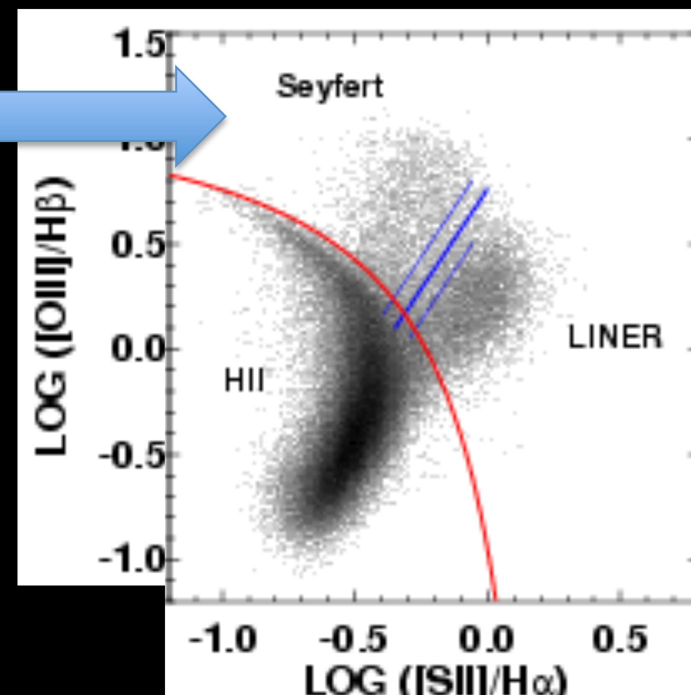
We are in a similar situation for z=2

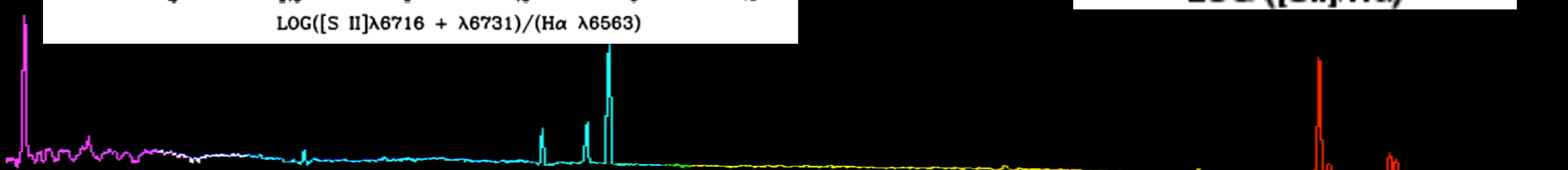
as we were at z=0, pre-SDSS.

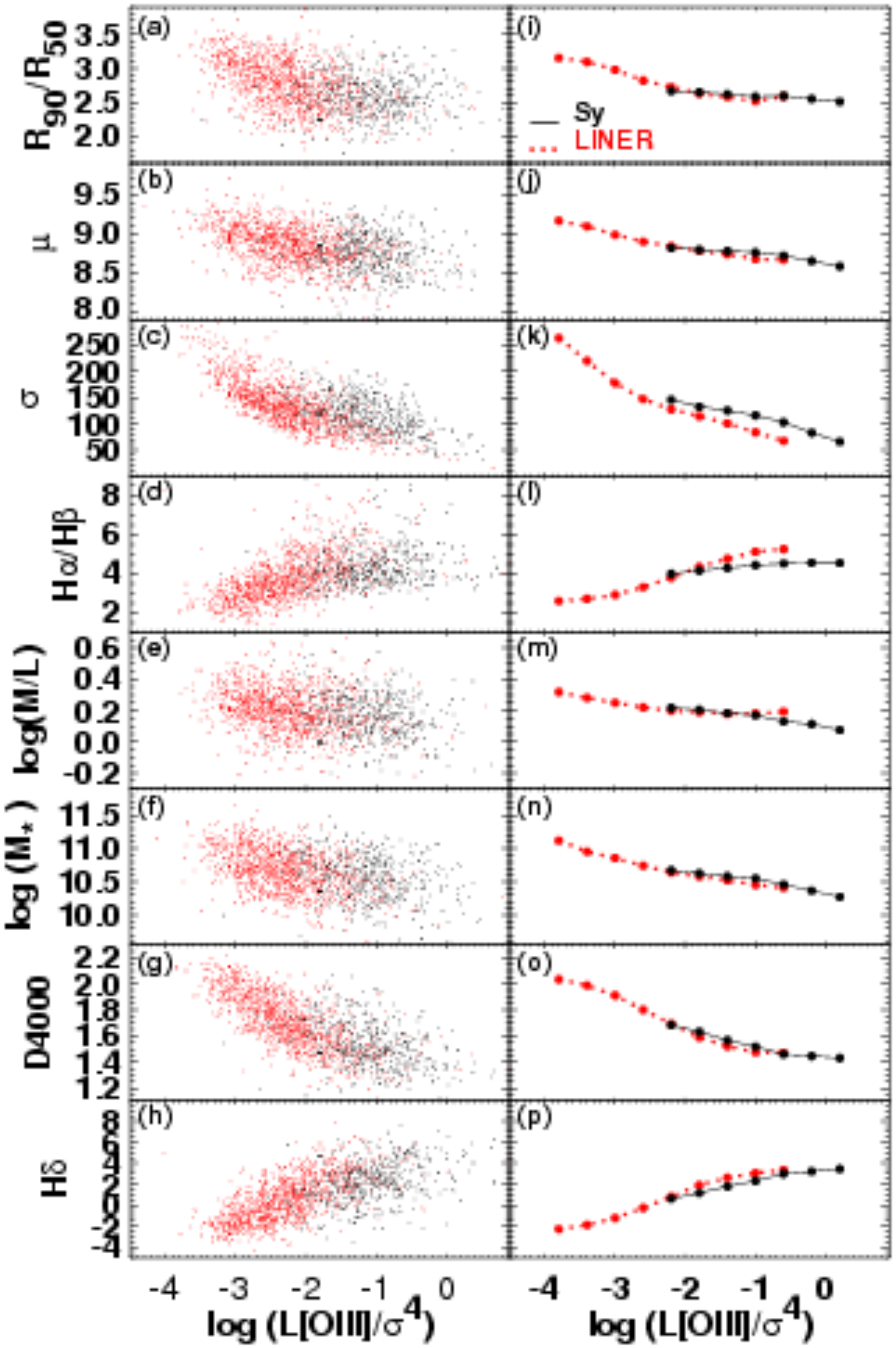
Veilleux & Osterbrock (1987)   200-400 galaxies



SDSS   85,000 galaxies







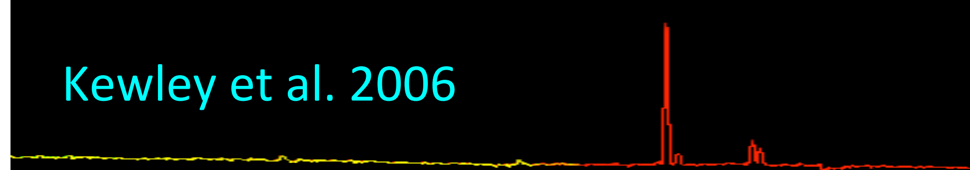
SDSS: The Nature of nuclear LINERS

At constant accretion rate L/L_{EDD}, differences between LINER and Sy disappear!

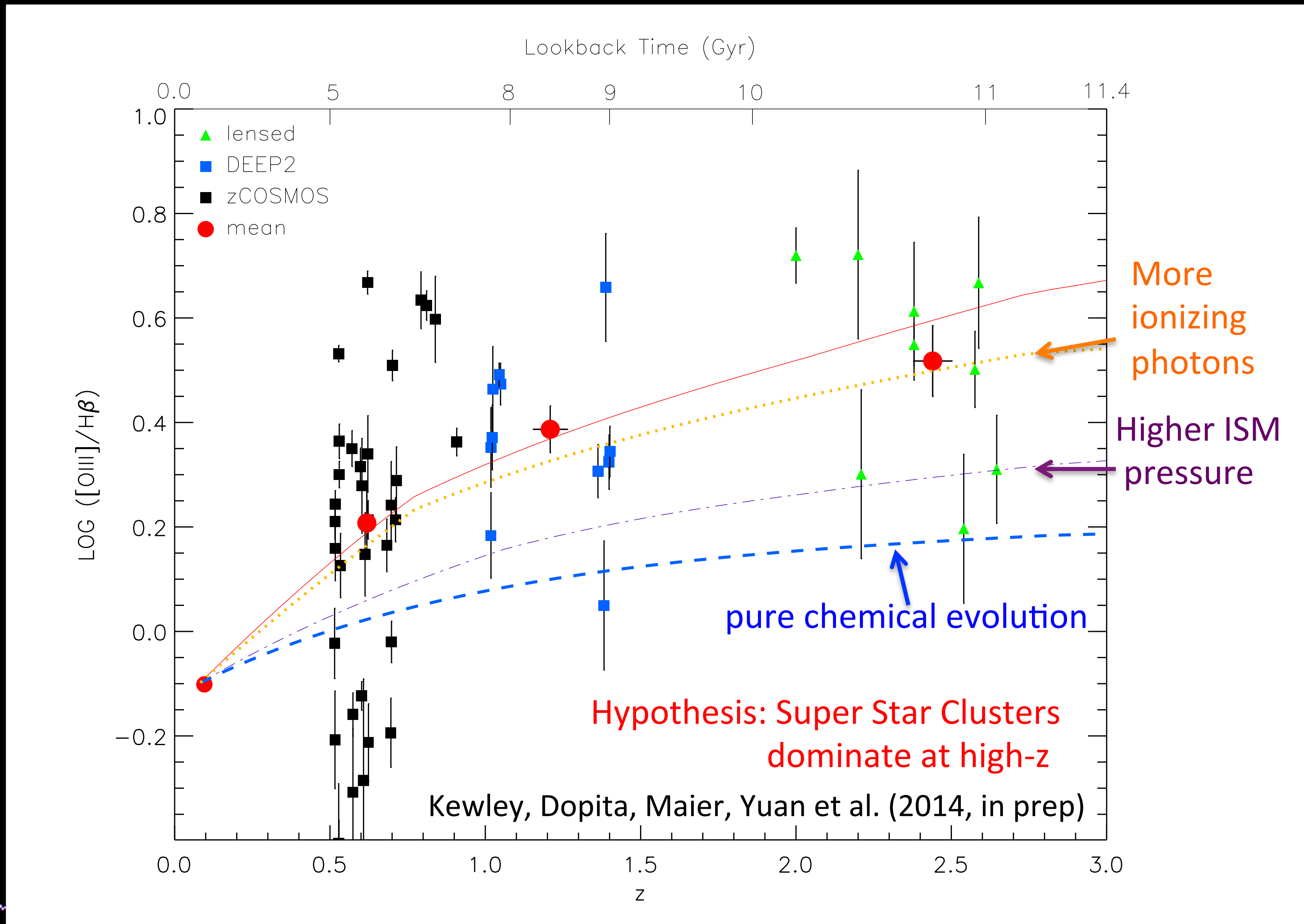
red = LINER

black = Sy

Kewley et al. 2006



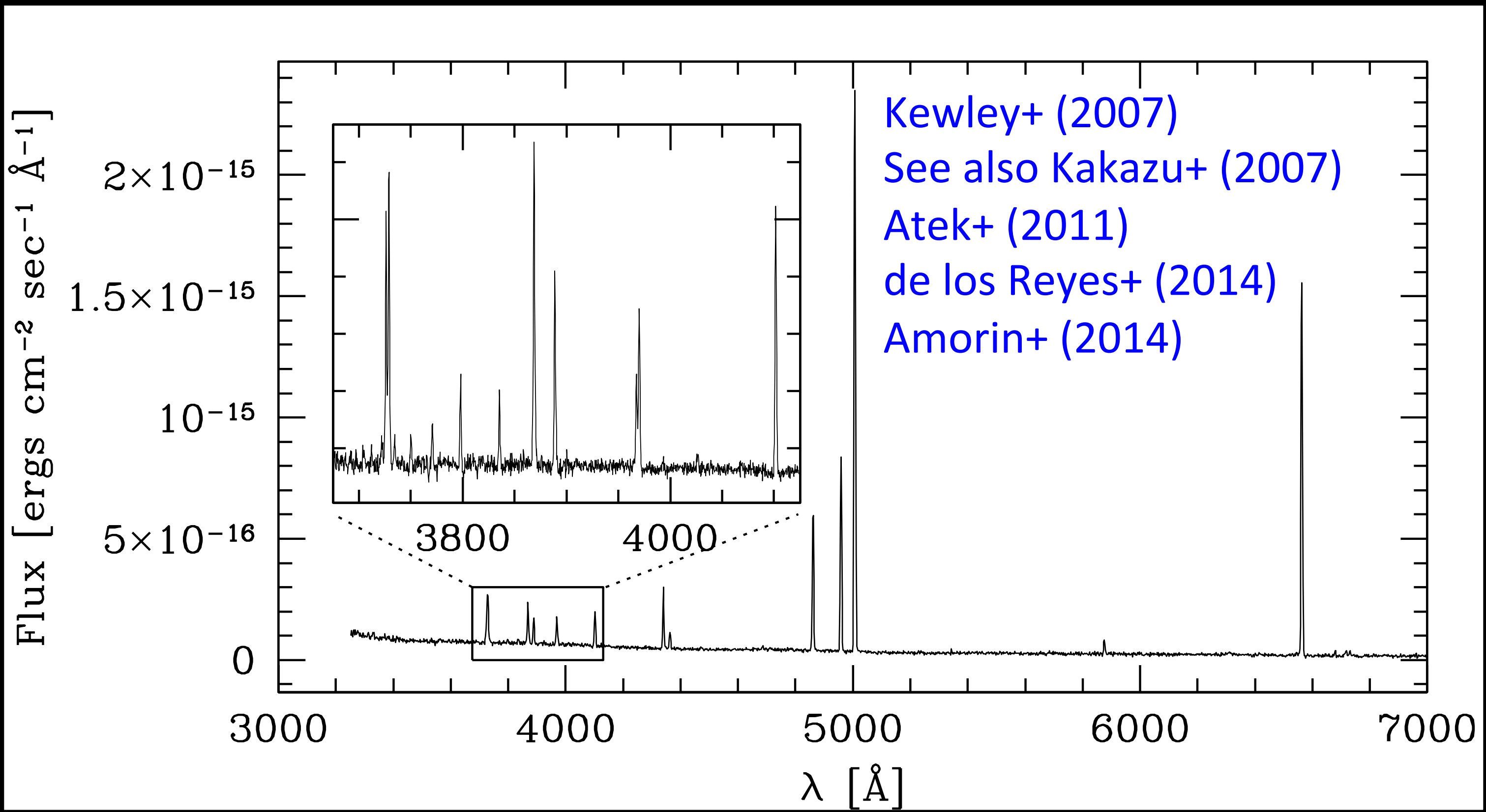
Change in ISM conditions with redshift

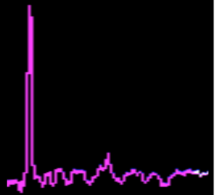


WFIRST high latitude survey (HLS)

- 20 million Hα emitters 1<z<2
- 2 million [OII] emitters z>2

What are Hα and [OII] emitters?





WFIRST high latitude survey (HLS)

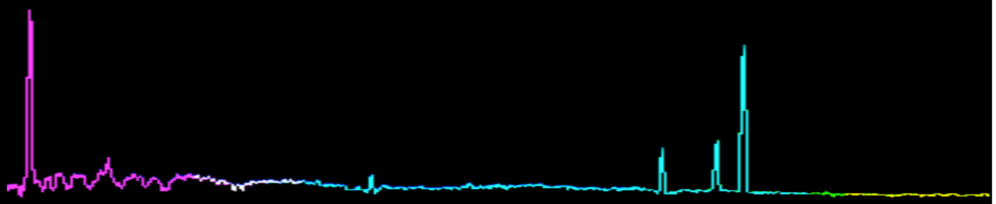
- 20 million Hα emitters 1<z<2
- 2 million [OII] emitters z>2

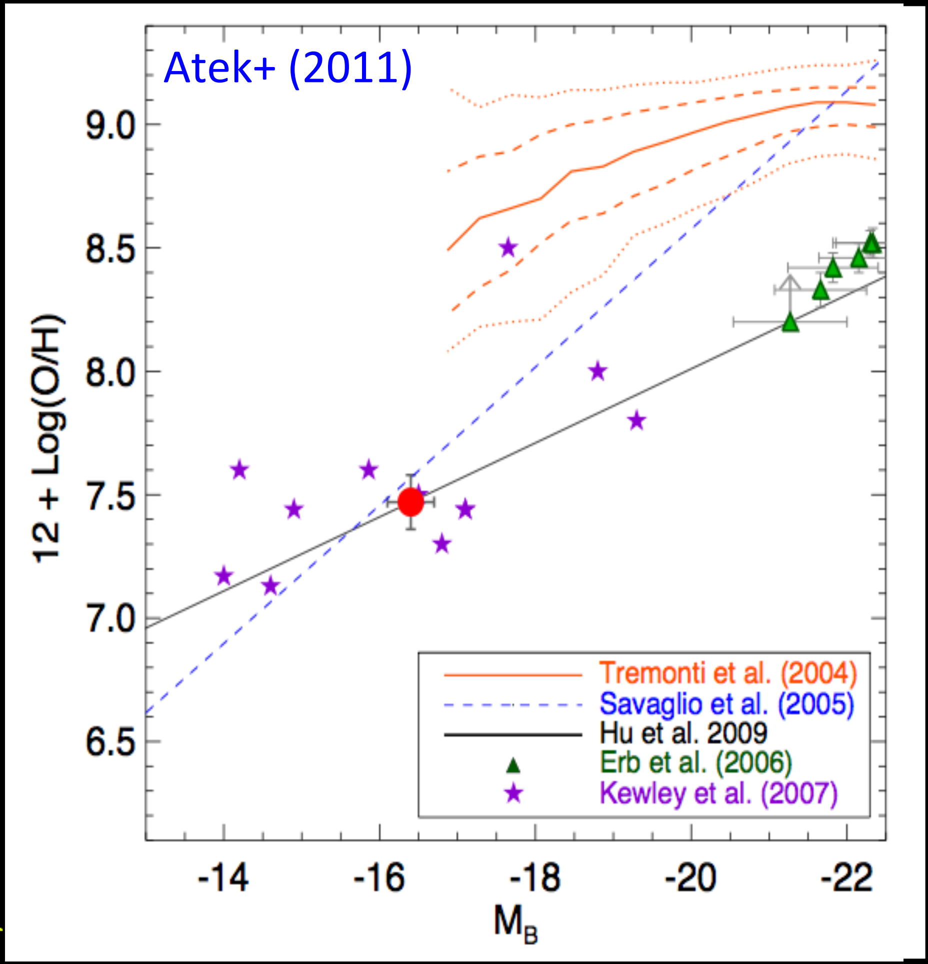
What are these emitters?

Low metallicity

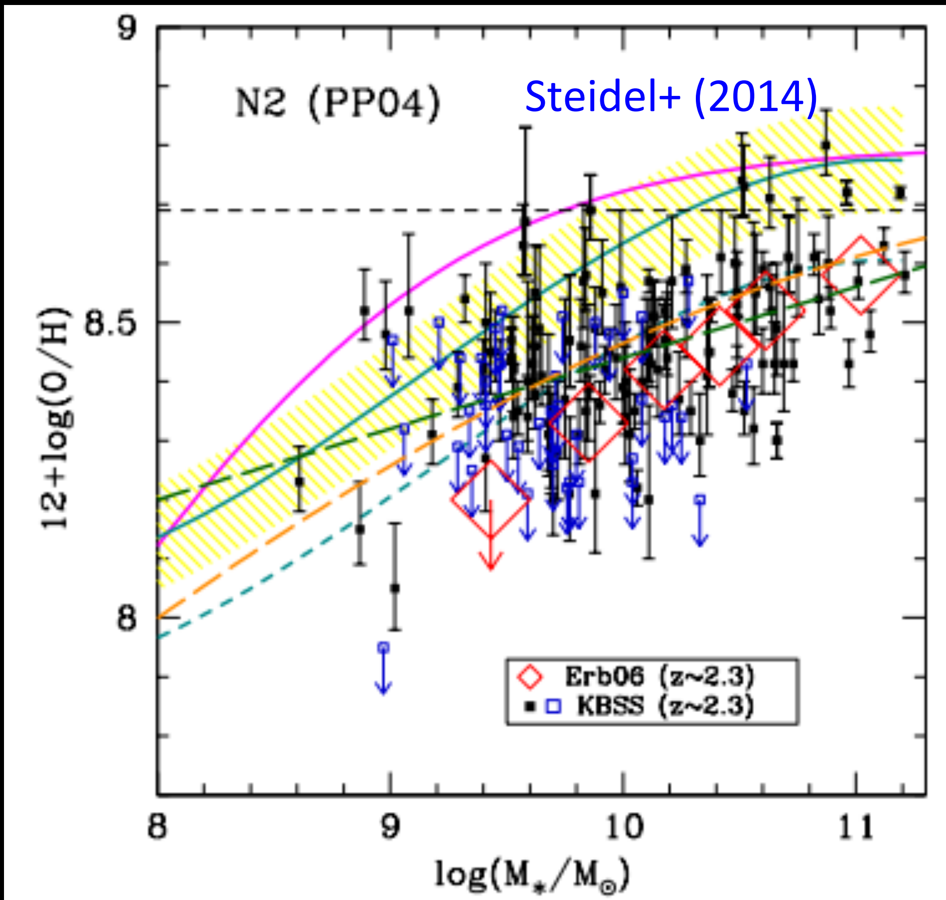
High ionization parameter

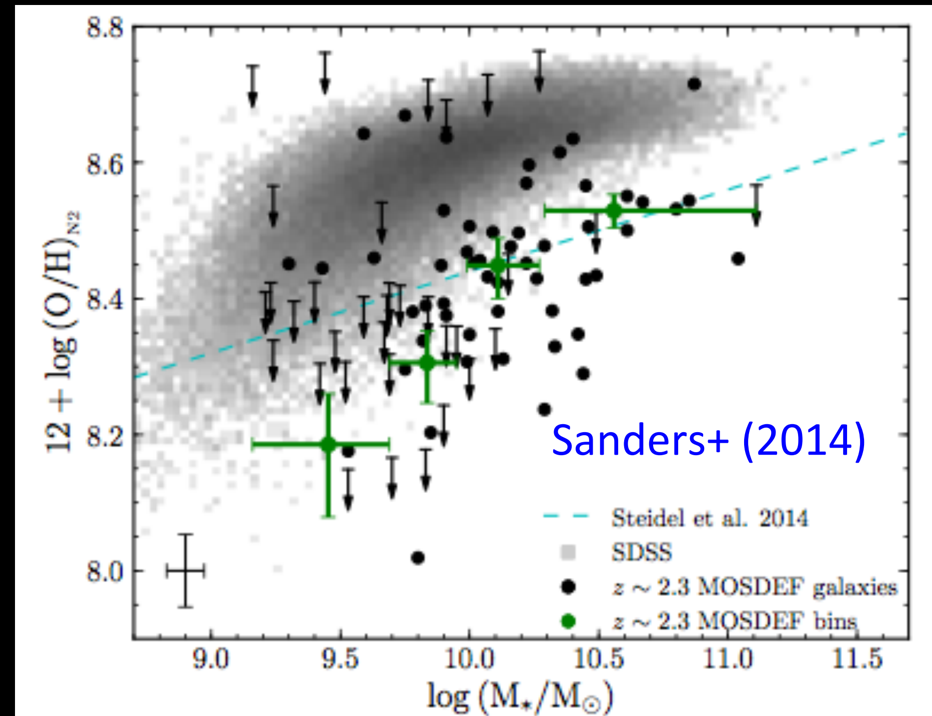
High sSFR

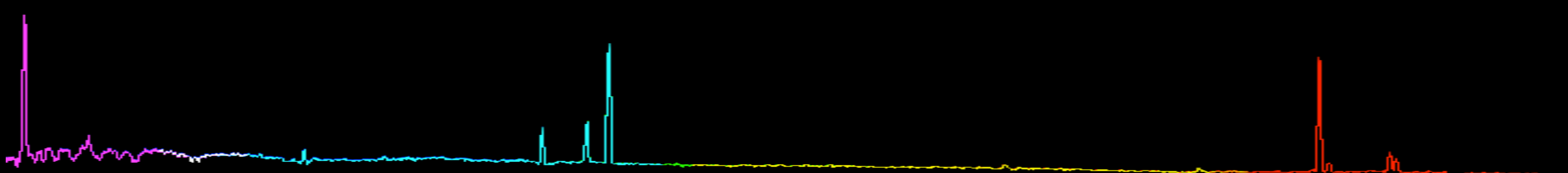




Contribution to metal budget?







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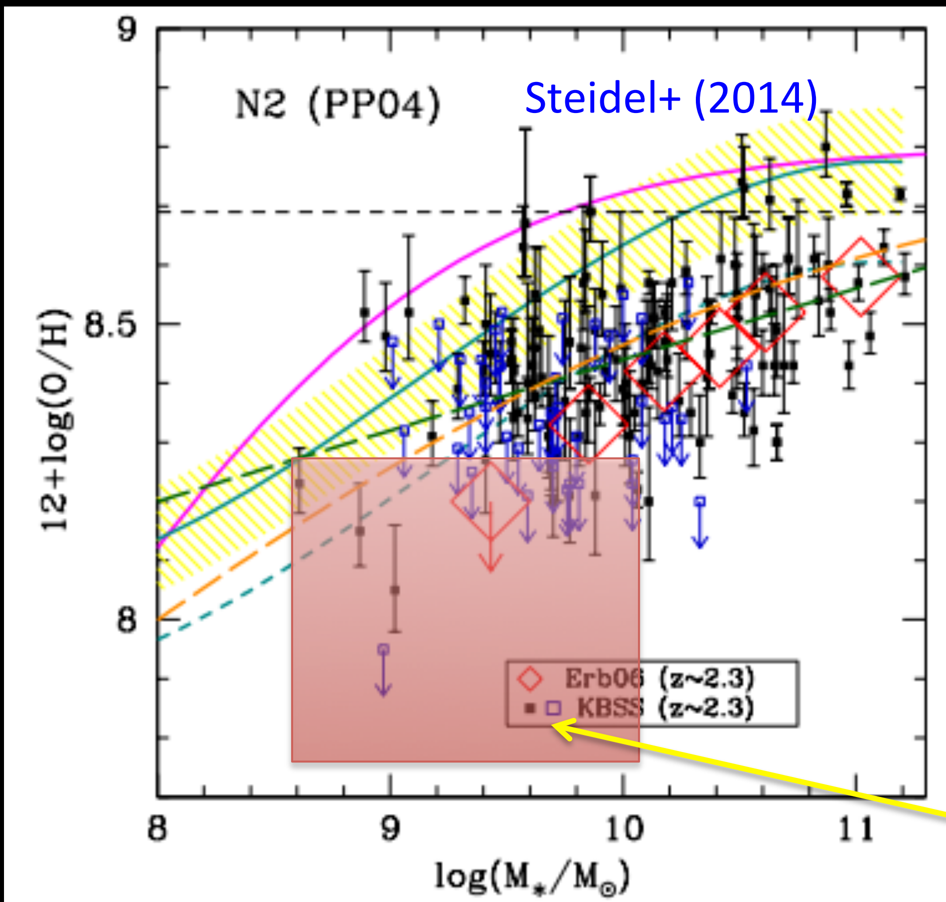
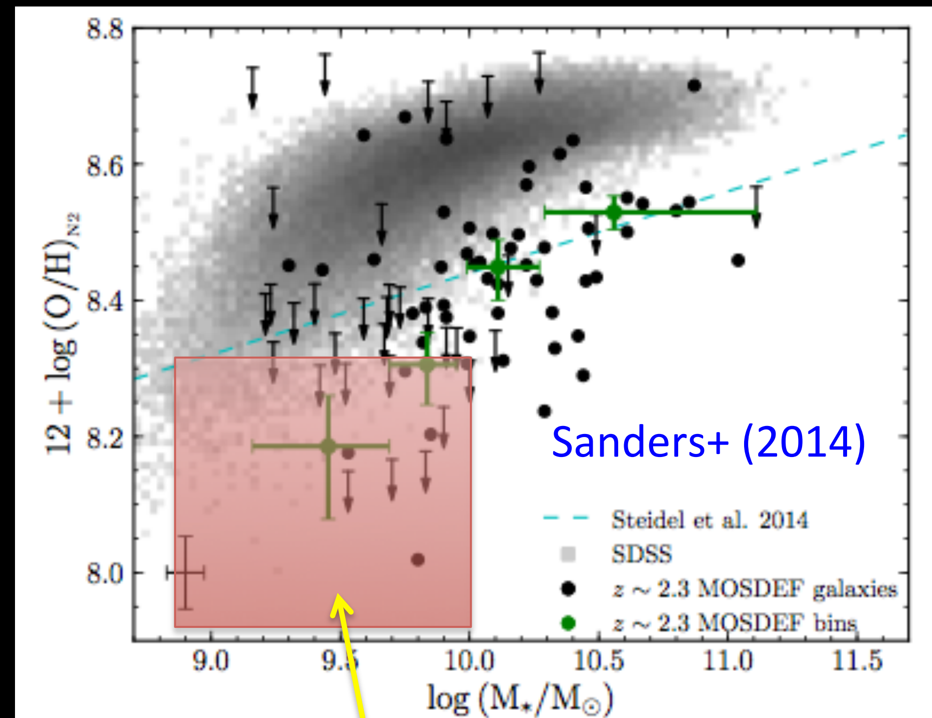
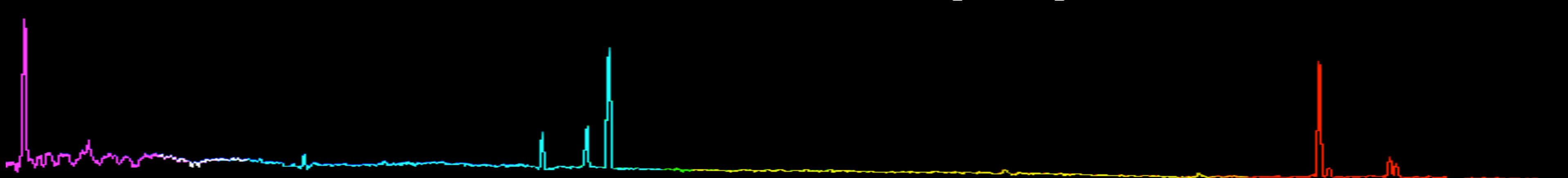




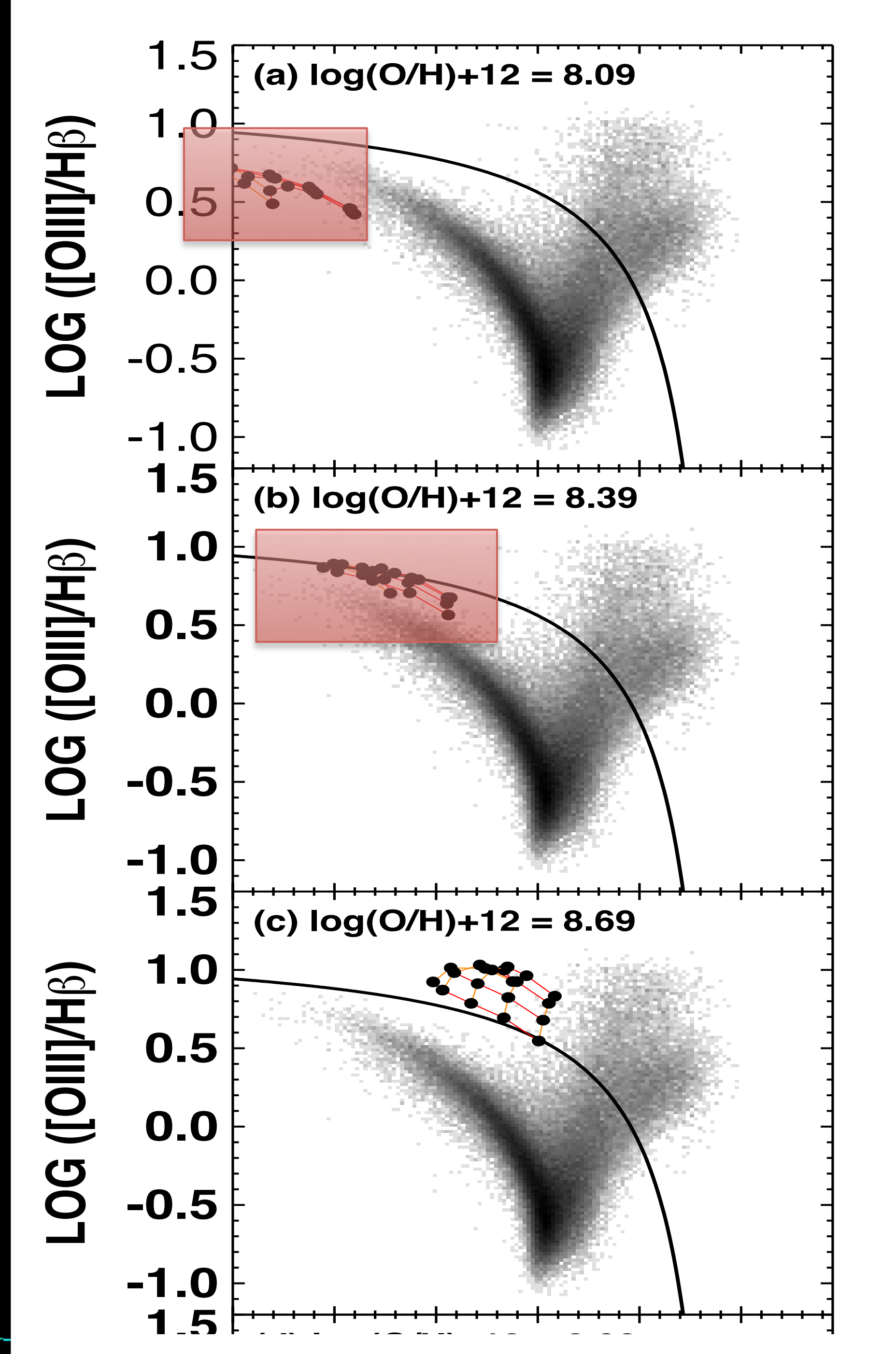
[OIII] and Hα emitters



Low Luminosity AGN

Low luminosity AGN in Low metallicity, dwarf galaxies - rare

But WFIRST will have the Numbers to find them.



Kewley et al. 2013a, ApJ, 774, 110

Summary: WFIRST

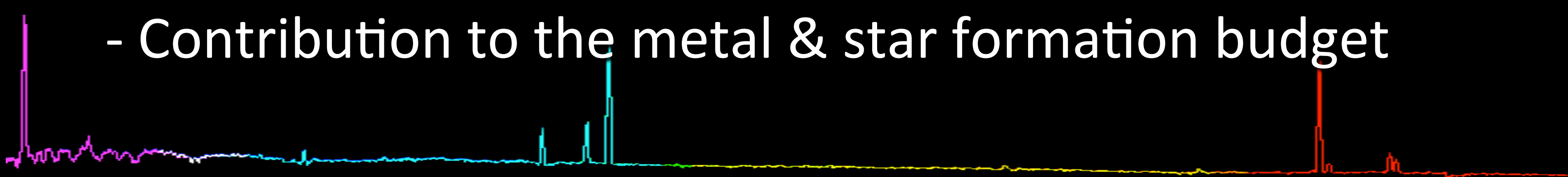
- Open up z=2 line ratio space to extremely large samples.

  (Yes, it really is Sloan in Space)

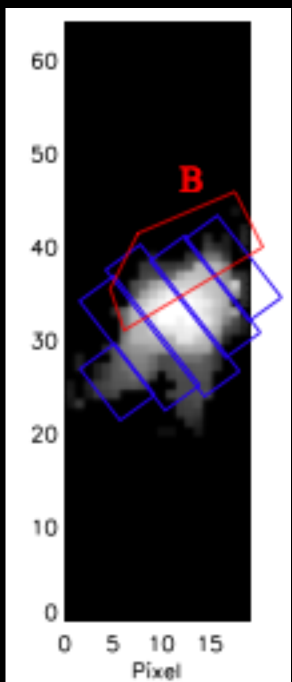
  - star-forming sequence changes
  - ionization parameter, ISM pressure changes
  - Seyfert vs LINER changes
  - Shocks (Appleton's talk earlier)

- Low metallicity galaxies

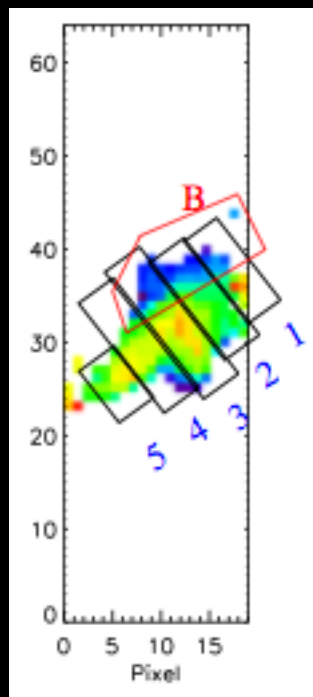
  - Extending the MZ relation down in stellar mass
  - Contribution to the metal & star formation budget



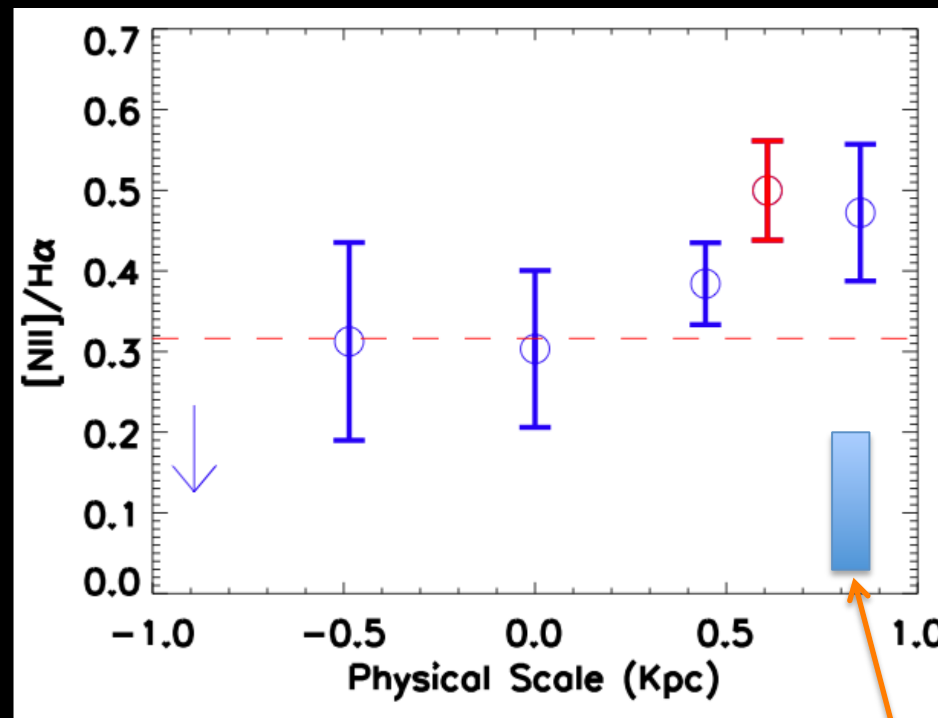
Shocks at z=1



Hα



velocity



Line ratios

Our high-z starbursts

Yuan, Kewley et al. (2012, ApJ, 759, 66)