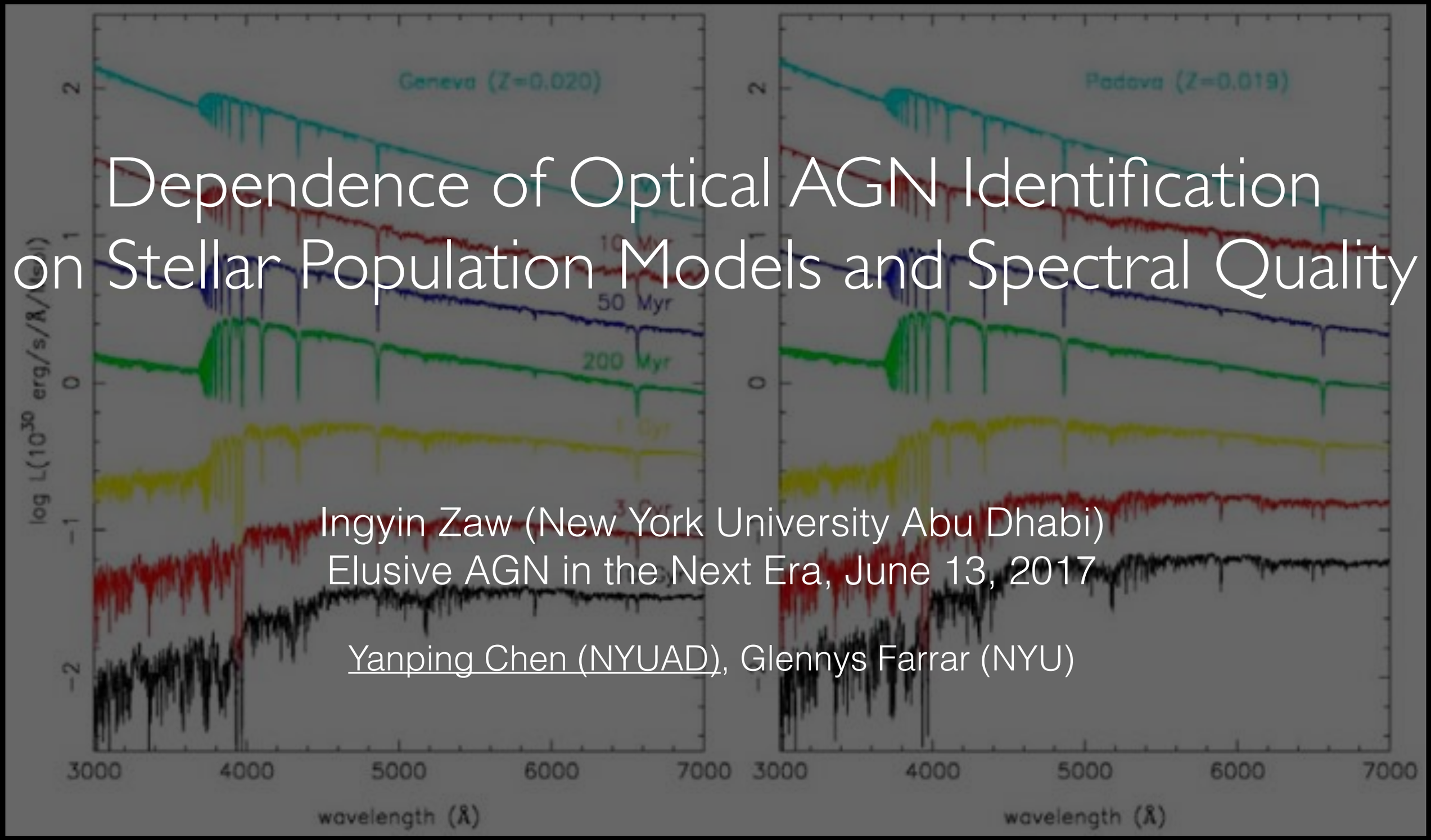


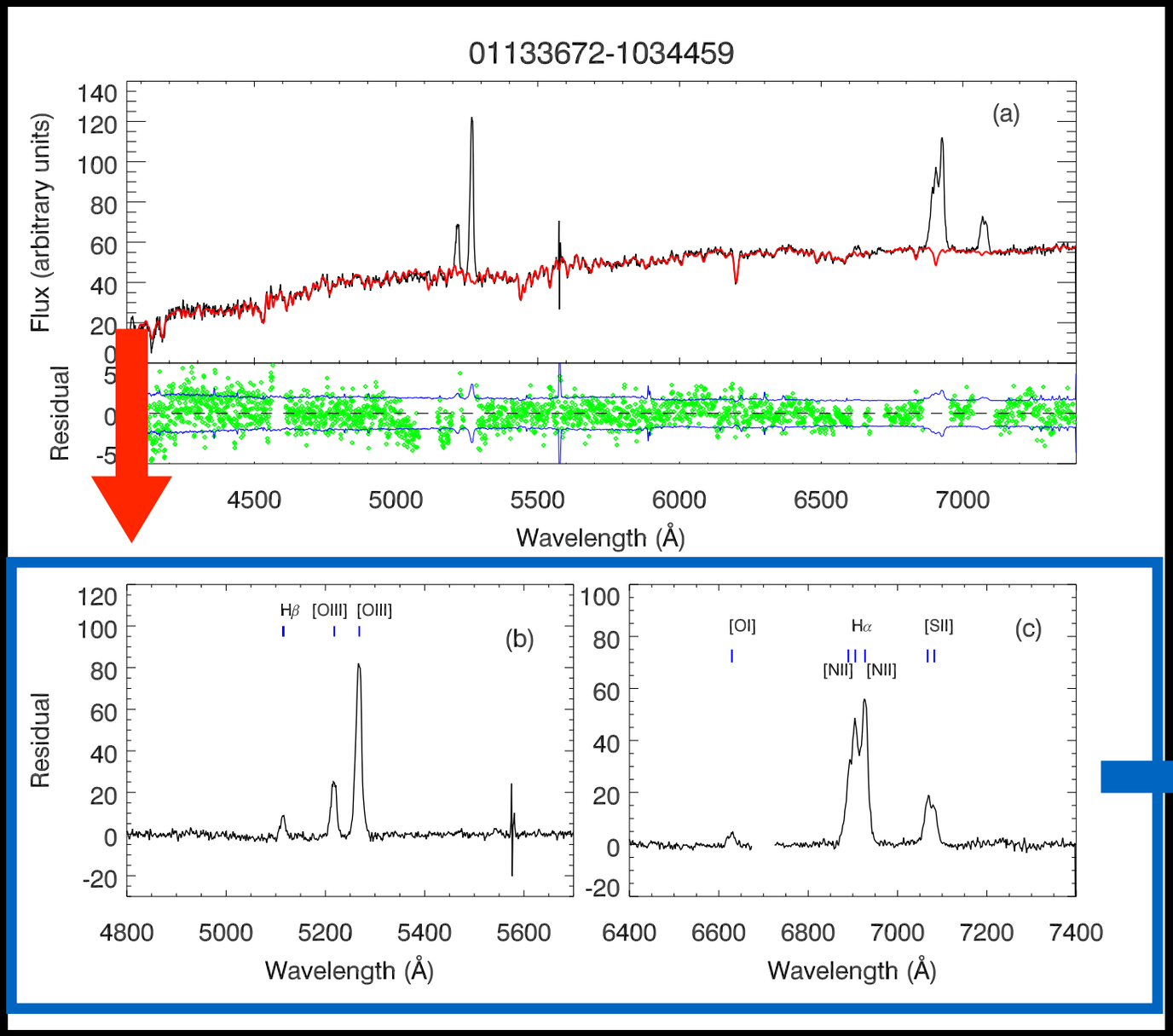
Dependence of Optical AGN Identification on Stellar Population Models and Spectral Quality

Ingyin Zaw (New York University Abu Dhabi)

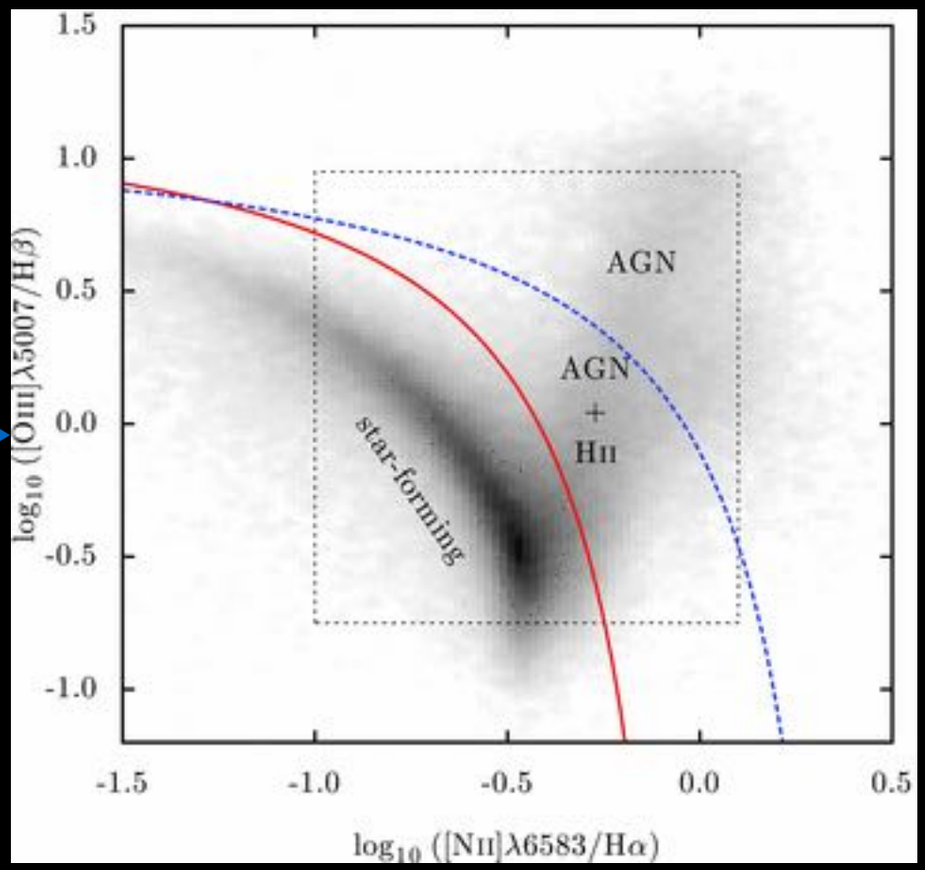
Elusive AGN in the Next Era, June 13, 2017

Yanping Chen (NYUAD), Glennys Farrar (NYU)

Optical AGN Identification (Narrow Line AGNs)

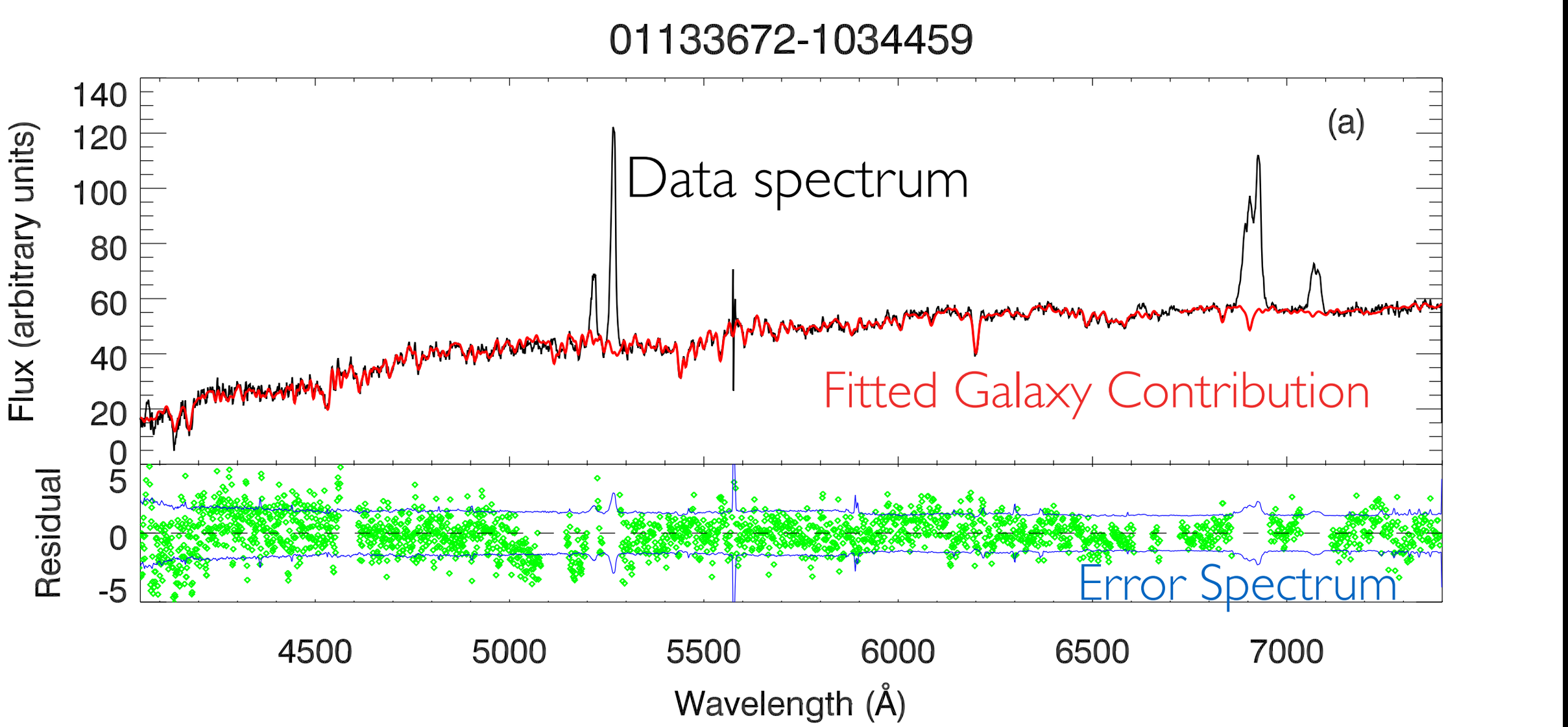


Zaw, Chen, & Farrar, in prep



Dobos et al. (2012)

- Pros: Well defined and reliable
- Cons: Can miss obscured and low luminosity AGN, sensitivity to host galaxy subtraction



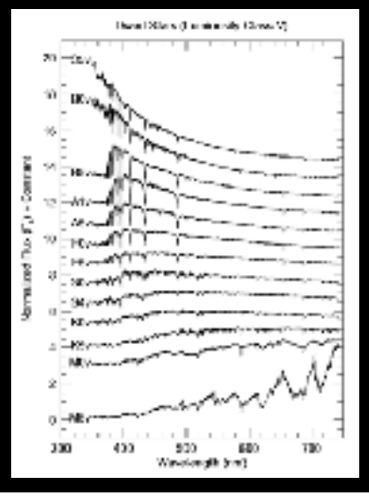
Zaw, Chen, & Farrar, in prep

- Fitted Galaxy Contribution: Linear combination of single stellar population (SSP) templates
- Data/Error: Spectral signal-to-noise

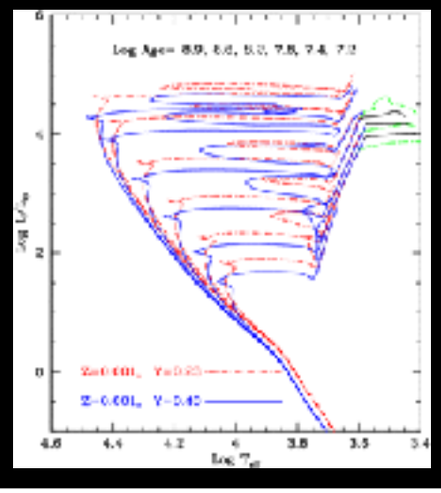
Single Stellar Population (SSP) Models

Inputs

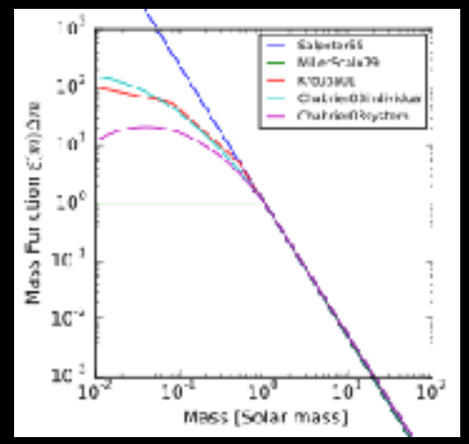
Stellar Library
Spectra of stars
Data and/or Theory



Isochrone
Evolutionary model
Age and metallicity

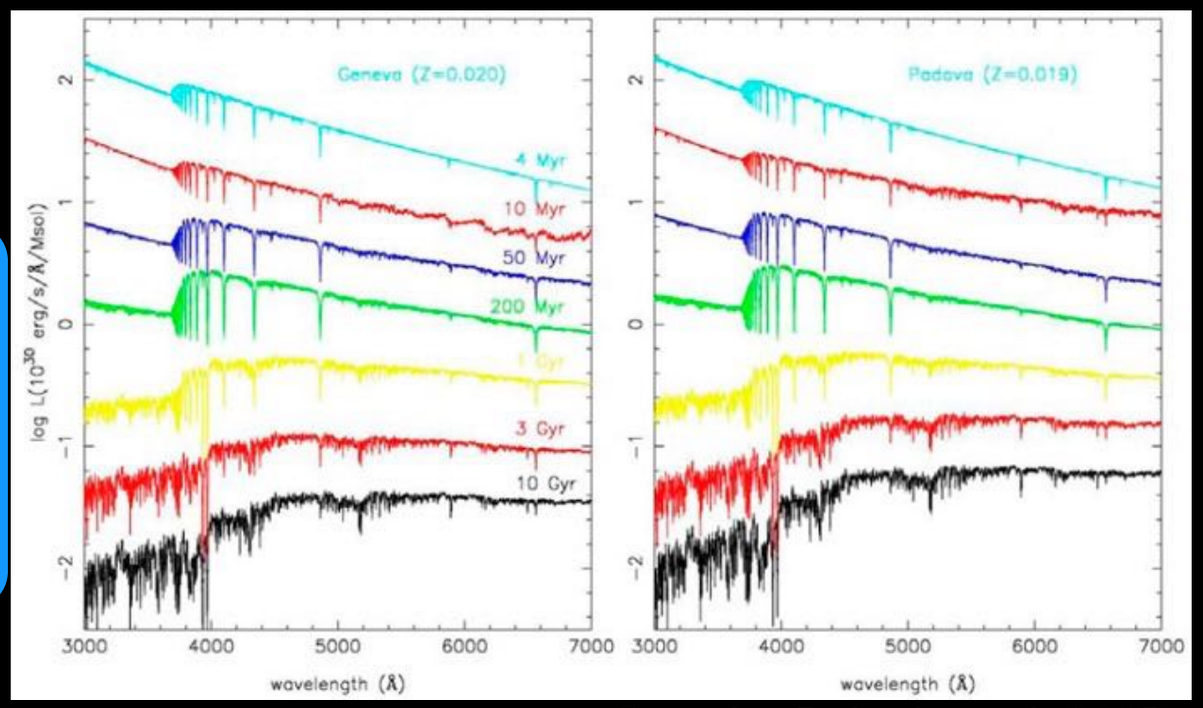


Initial Mass Function
Empirical function



Output

Single Stellar Population Models
Spectra of stellar populations
Empirical, theoretical, or mixed
Age, Metallicity, Wavelength range



Gonzalez-Delgado et al. (2005)

Stellar Population Models

- **MILES:** 3500-7500Å, 63Myr-18Gyr, Z=0.0001-0.03, purely empirical library
- MIUSCAT: 3500-9469Å, extended MILES models, purely empirical stellar libraries
- Maraston05: 0.3-2.5μm, 3Myr-15Gyr, Z=0.0001-0.04, mixed libraries
- Maraston11: 1000-25000Å, various metallicity depends on input stellar library, empirical libraries
- PEGASE-HR: 4000-6800Å, higher resolution of PEGASE, purely empirical library

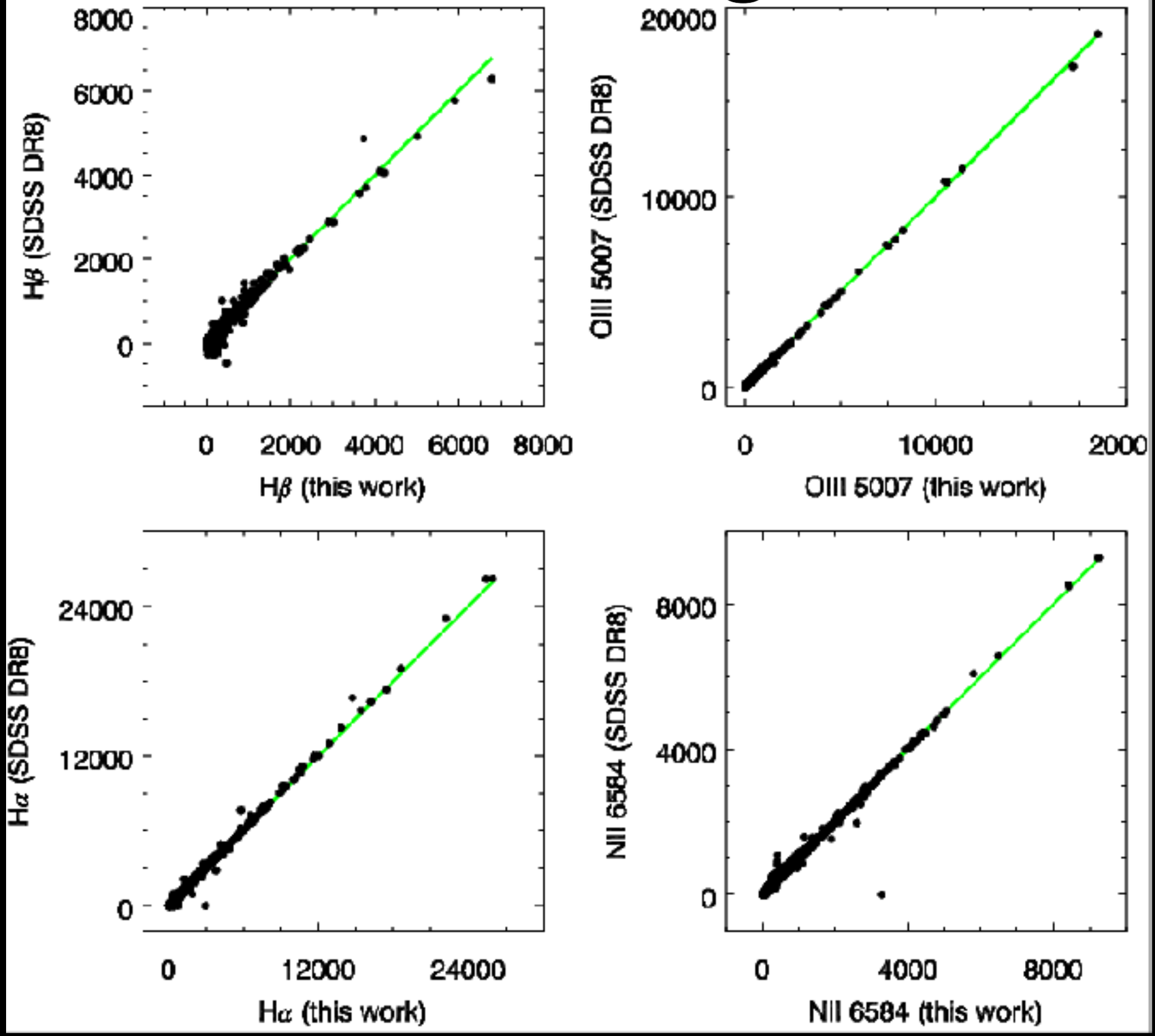
- **BC03:** 91Å-160μm, 0.1Myr-20Gyr,Z=0.0001-0.05, mixed stellar library (empirical + theoretical)
- FSPS (Conroy09,10): 91Å-160μm, 3Myr-15Gyr, Z=0.0001-0.03, mixed stellar library (empirical + theoretical)

- Starburst99: 91Å-160μm, 1Myr-1Gyr, Z=0.001-0.04, purely theoretical stellar library
- PEGASE: 220Å-5μm, 1Myr-20Gyr, Z=0.0004-0.05, purely theoretical stellar library
- **González Delgado et al. 2005**: 3000-7000Å, 4Myr-17Gyr, Z=0.004-0.019, purely theoretical stellar library

Analysis

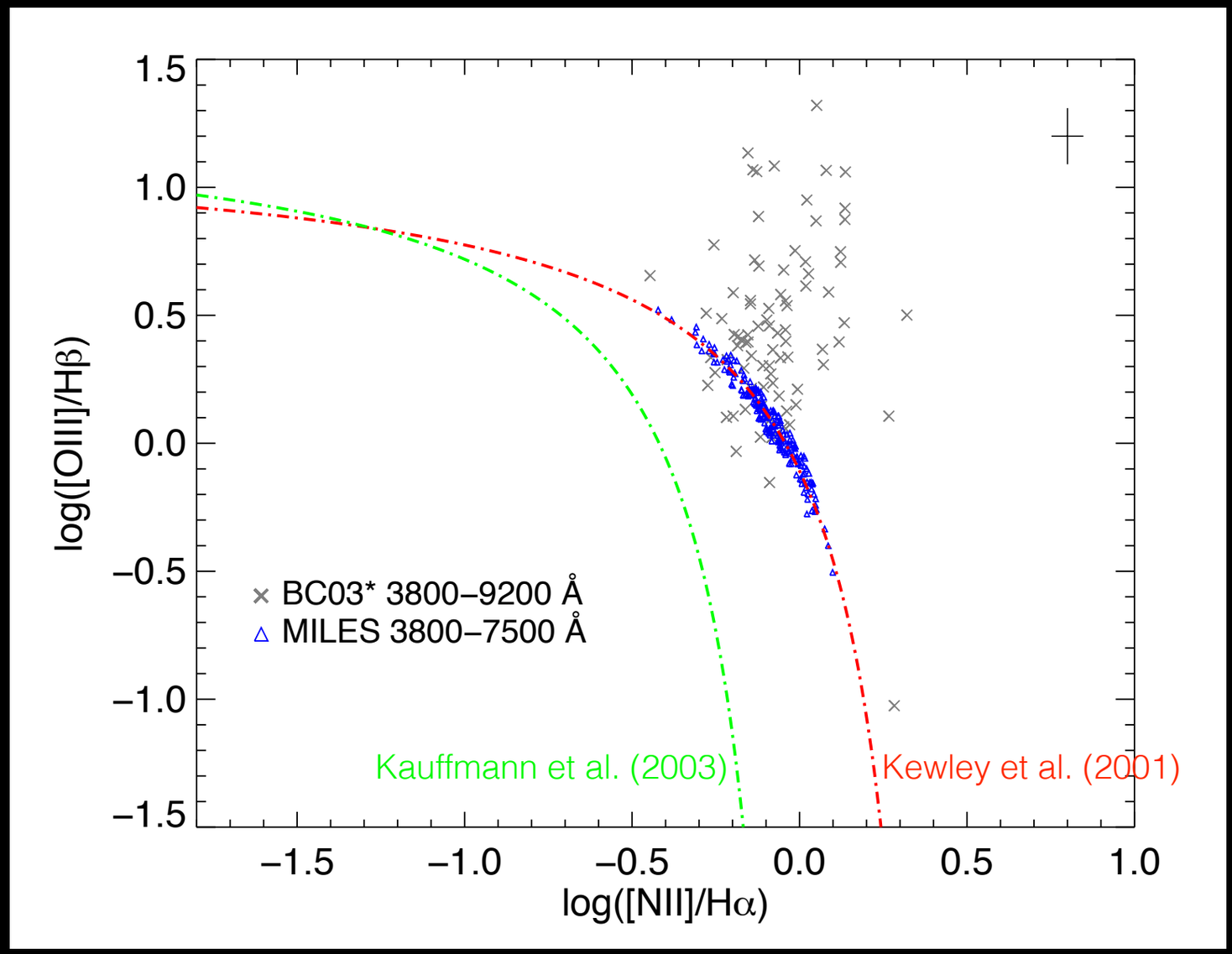
- Spectral Sample (from 2MASS Redshift Survey)
  - SDSS spectra: good S/N, flux calibrated, 7069 galaxies
  - 6dF, FAST, CTIO: worse S/N, not flux calibrated, 19478 galaxies
  - Nearby: Out to z ~ 0.08
- Template Fitting
  - Main SSP templates from Vazdekis et al. (2010), MILES
  - Test with young templates from Gonzalez-Delgado et al. (2005), G05
  - Require reduced χ^2 (SSP fit) $\leq$ 2.5, S/N $\geq$ 2.0 for all 4 lines
- Comparisons with SDSS published fluxes
  - From MPA-JHU (DR8) using Bruzual & Charlot (2003), BC03
  - From Portsmouth (Thomas et al. 2013) using Maraston et al. (2011), M11

Fluxes Agree



Zaw, Chen, & Farrar, in prep

Systematic Shift in Line Ratios



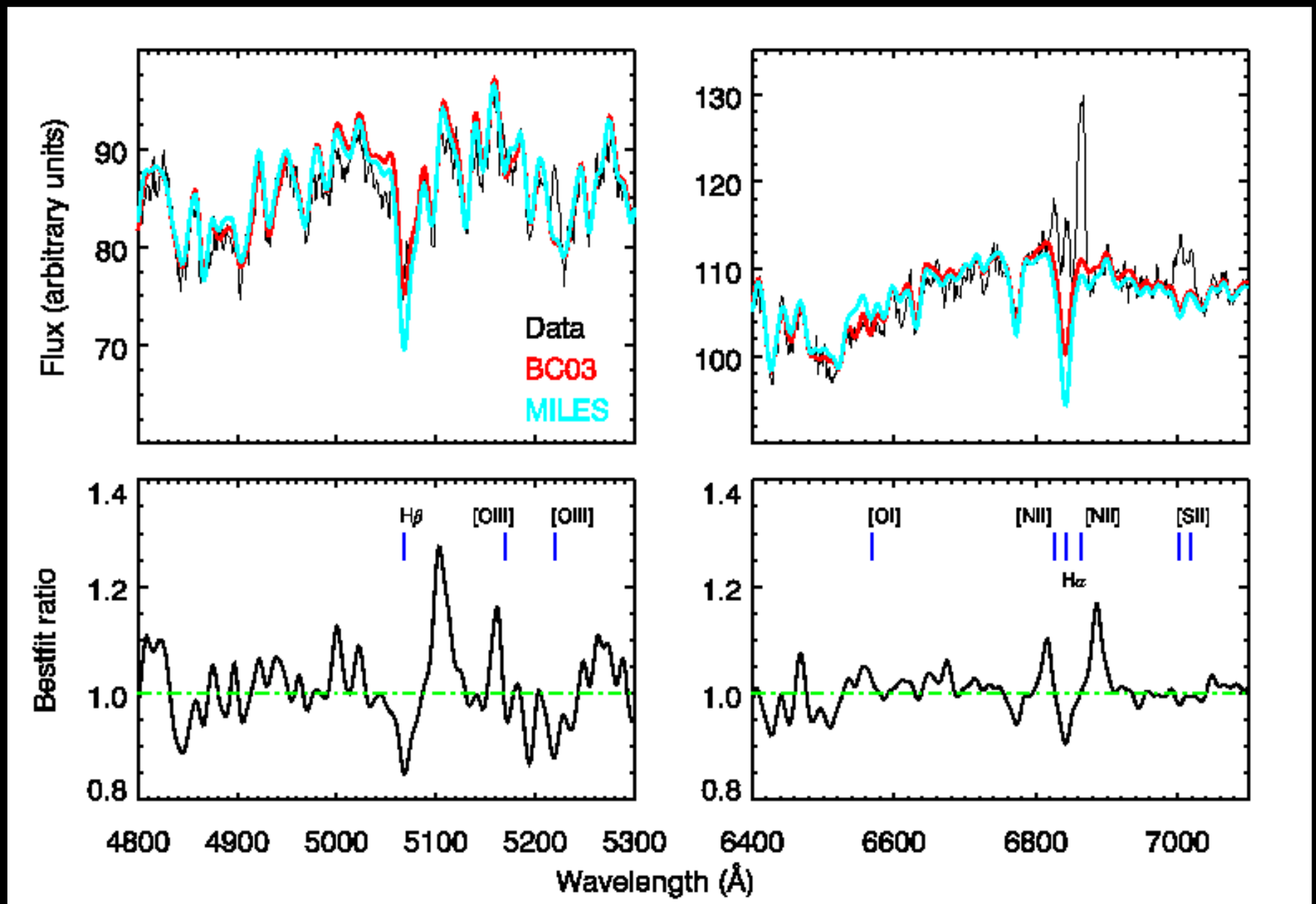
Zaw, Chen, & Farrar, in prep

- Checked galaxies on the Kewley et al. (2001) boundary
- Less dependent on contribution from SF to emission lines

Tracking down the differences

Hβ Region

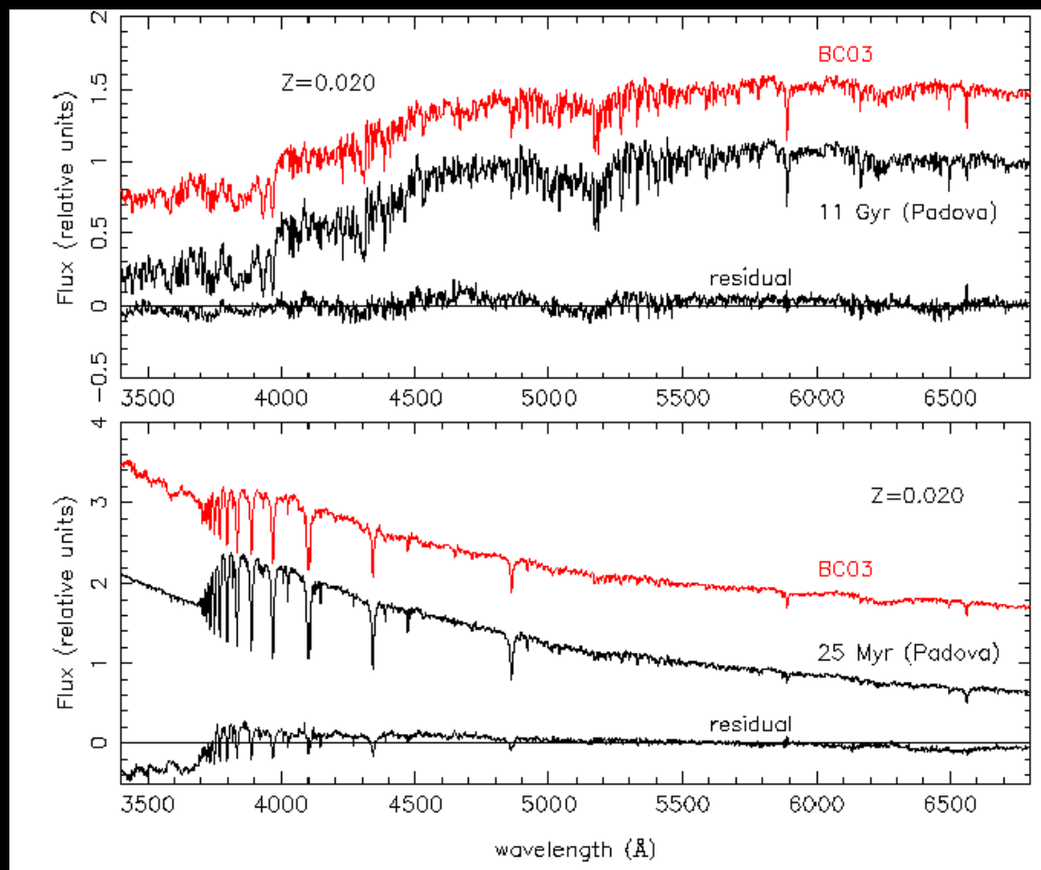
Hα Region

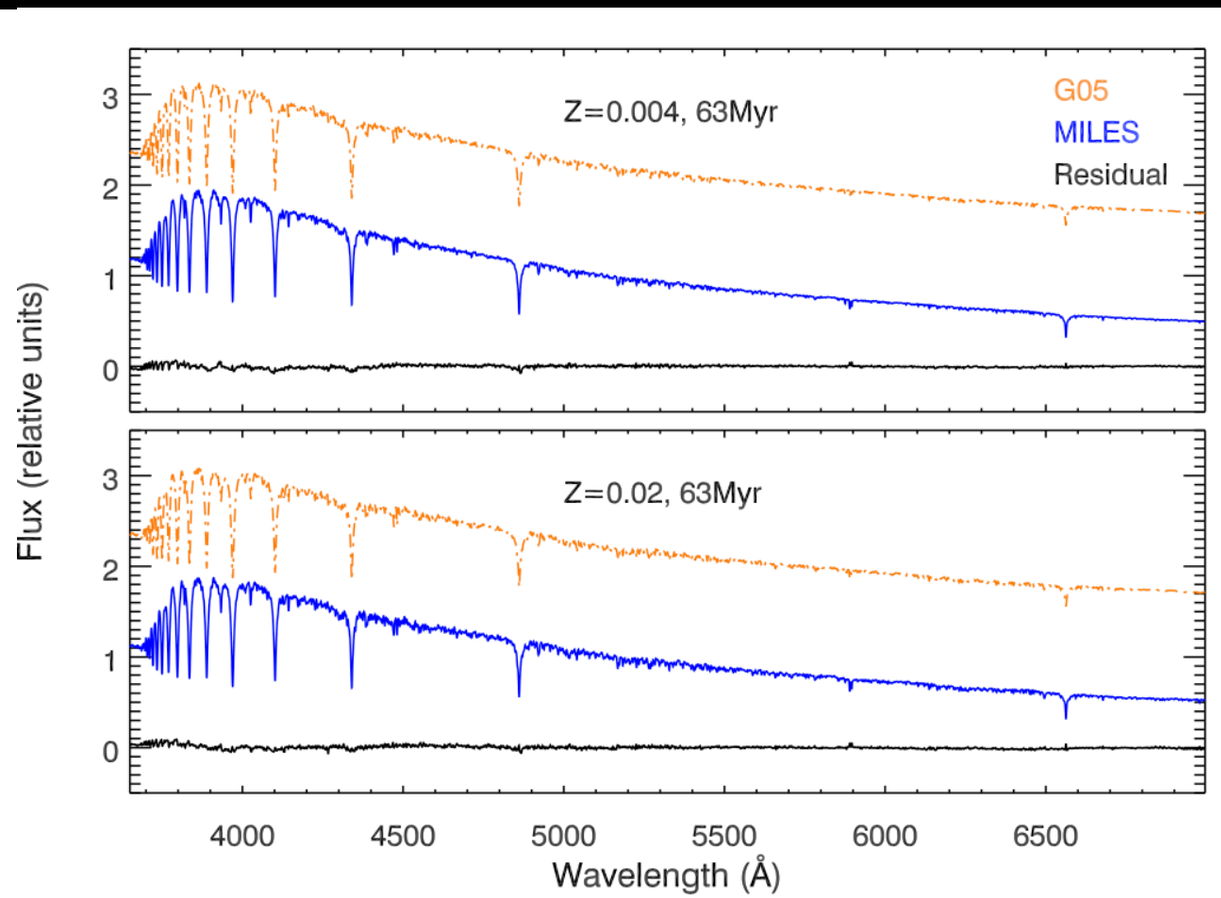


Ratio of best fits:
BC03/MILES

Chen, Zaw, & Farrar, in prep

Underlying Cause

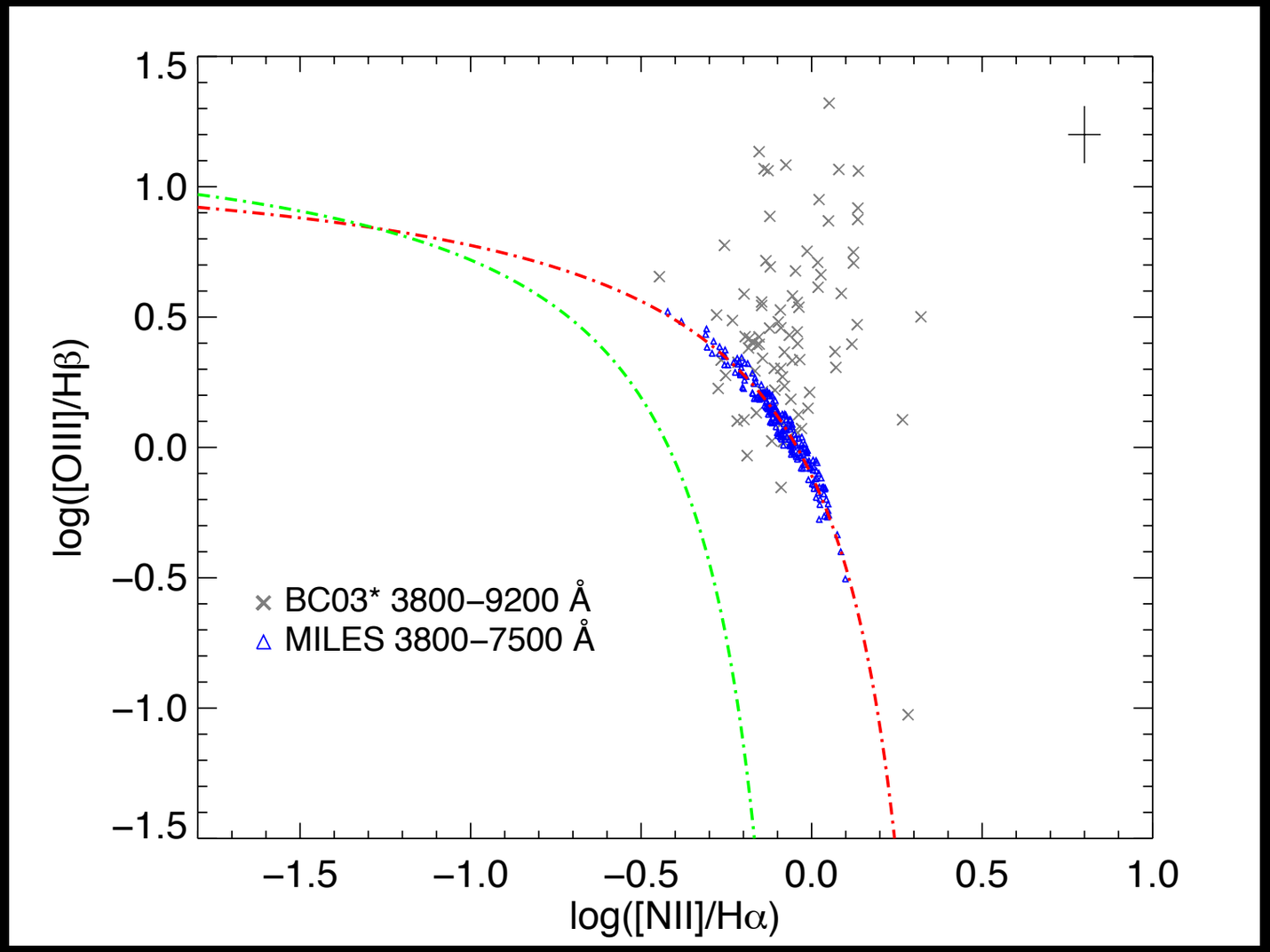




Chen, Zaw, & Farrar, in prep

- Comparison with theoretical SSPs
- BC03 based on a smaller, less well calibrated stellar library. Corrected colors but not lines for younger populations.

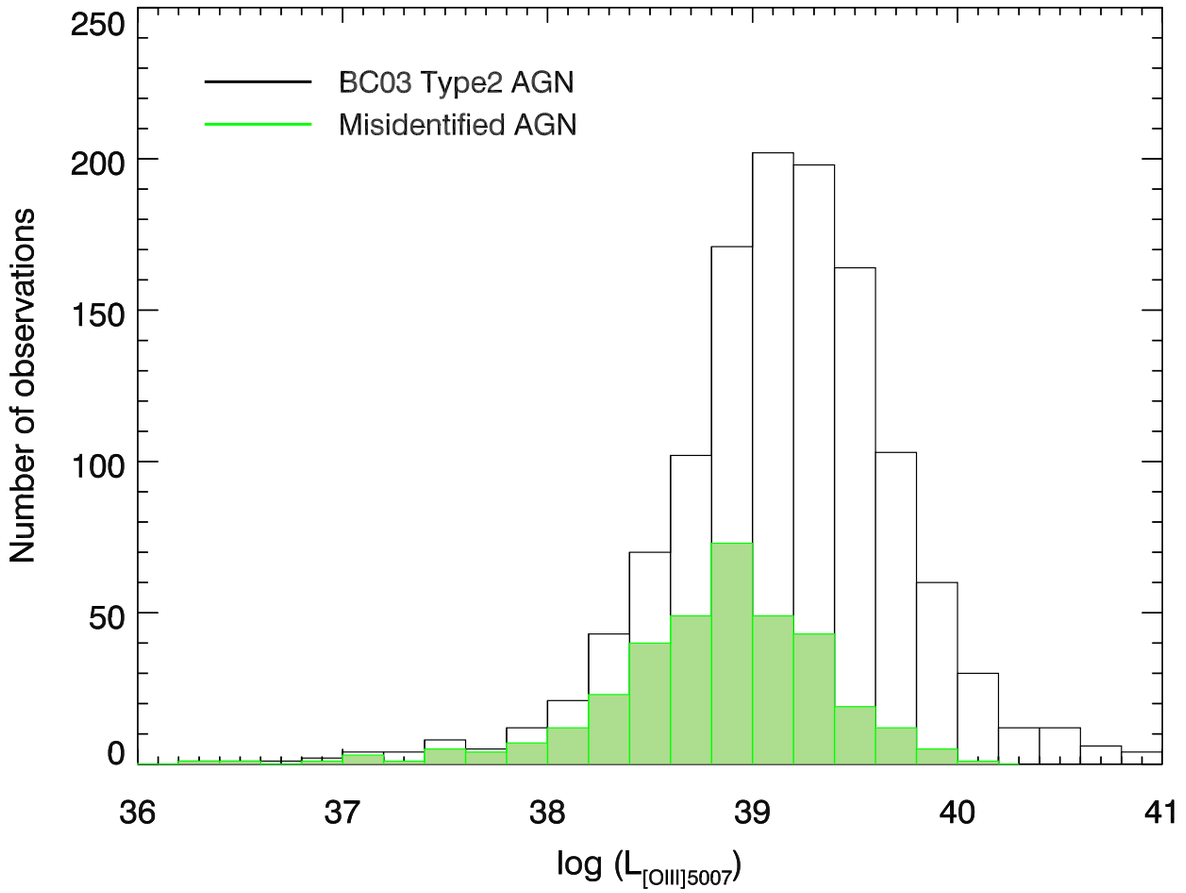
Systematic Shift in Line Ratios

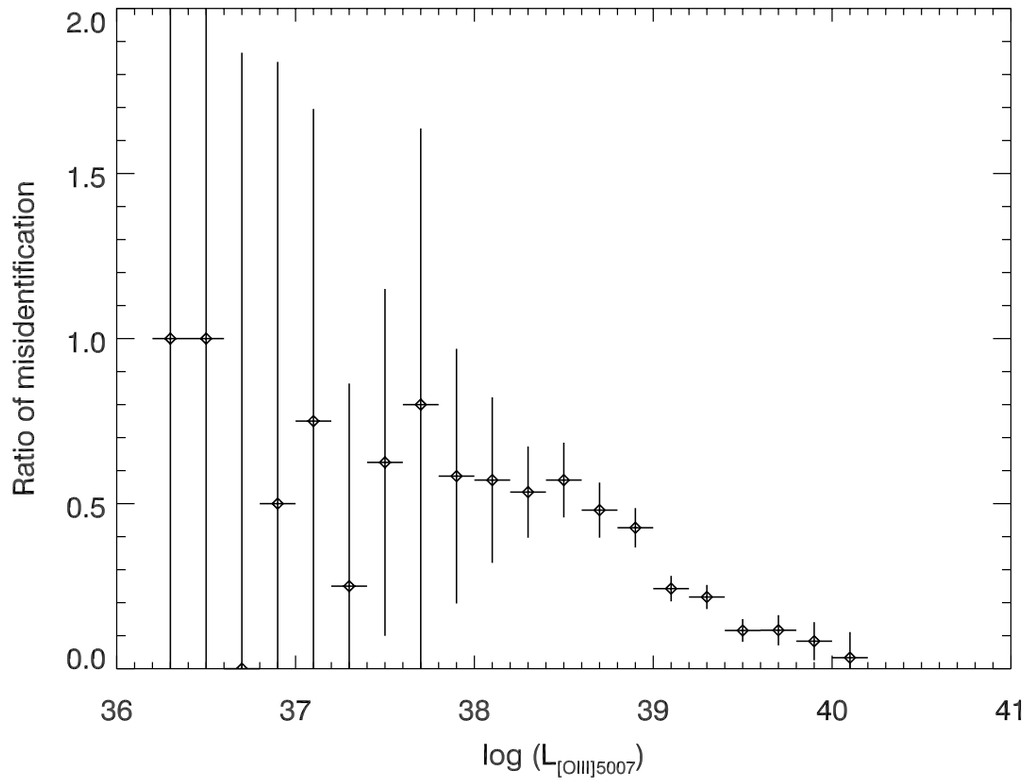


Zaw, Chen, & Farrar, in prep

- BC03 has shallower Hα and Hβ absorption
- Consequently underestimates Hα and Hβ emission
- Systematically shifts line ratios up and to right in the BPT diagram

Discrepancies in Identification

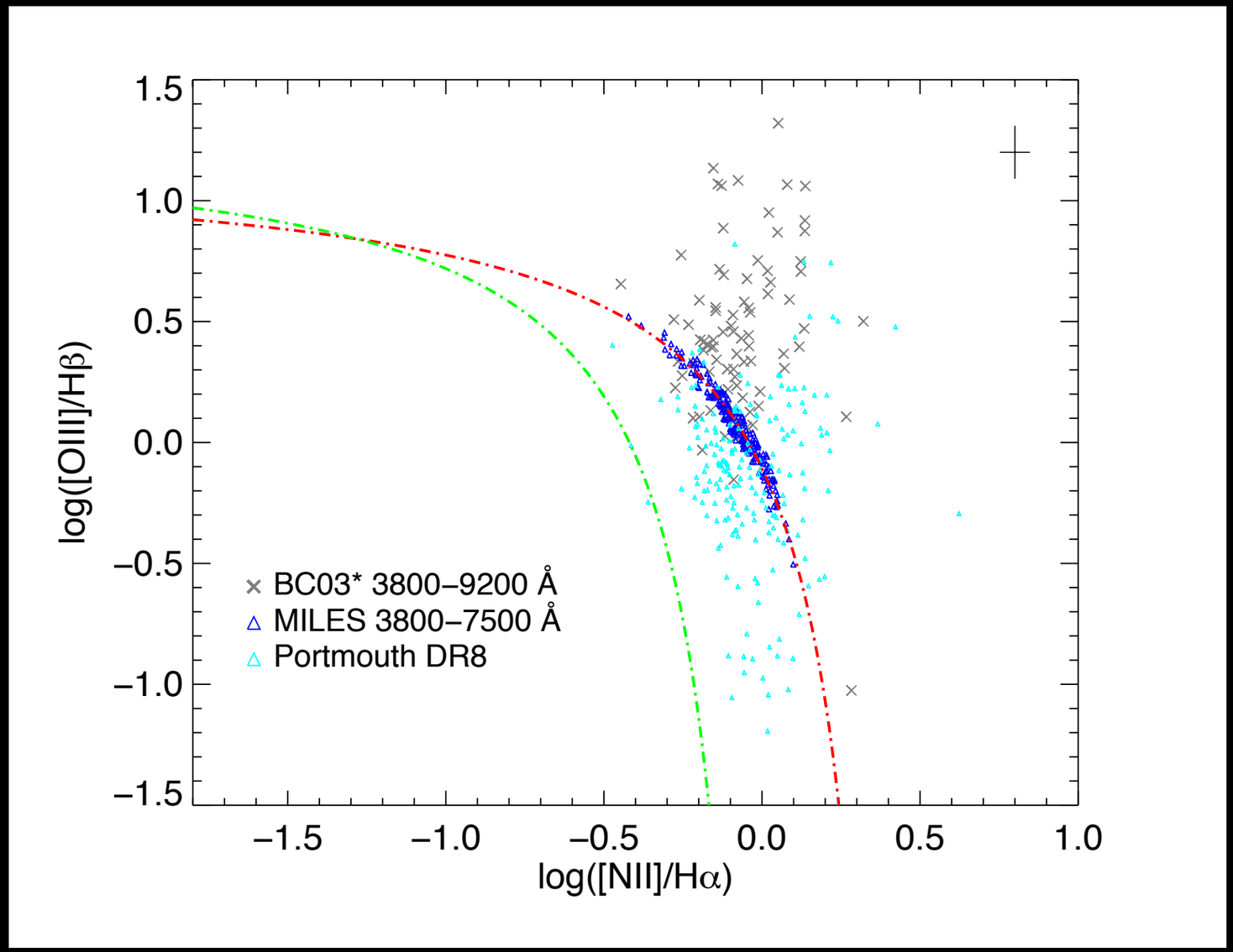




- Full sample (BC03 vs. MILES)
- BC03 AGNs which fall below the Kewley et al. (2001) line with MILES
- Discrepancy large at lower luminosity

Chen, Zaw, & Farrar, in prep

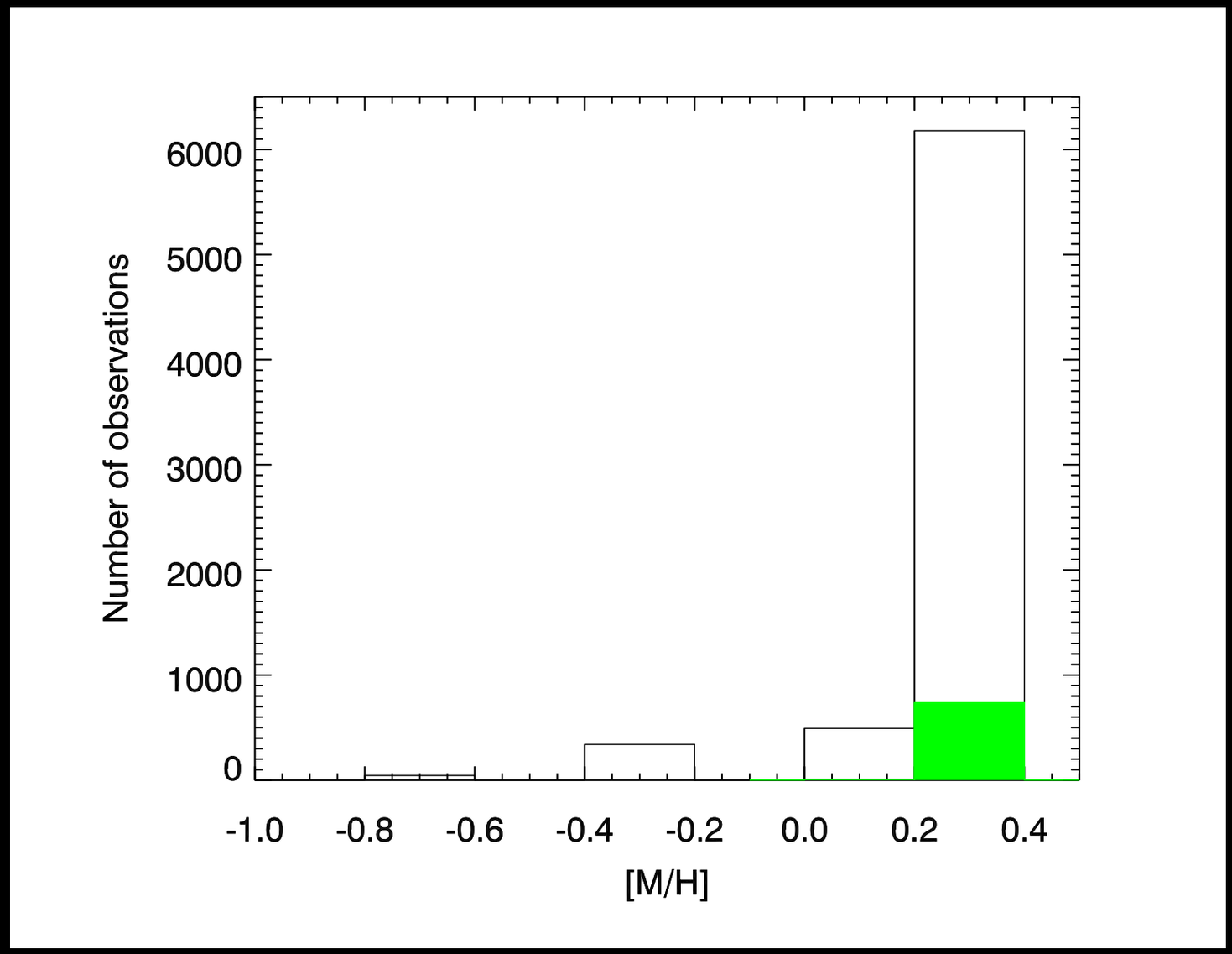
New SDSS Line Fluxes



Zaw, Chen, & Farrar, in prep

- Lines have been refit with Maraston et al. (2011) models (Portsmouth, Thomas et al. 2013)
- Maraston models also based on the MILES stellar library
- Systematic shift downwards

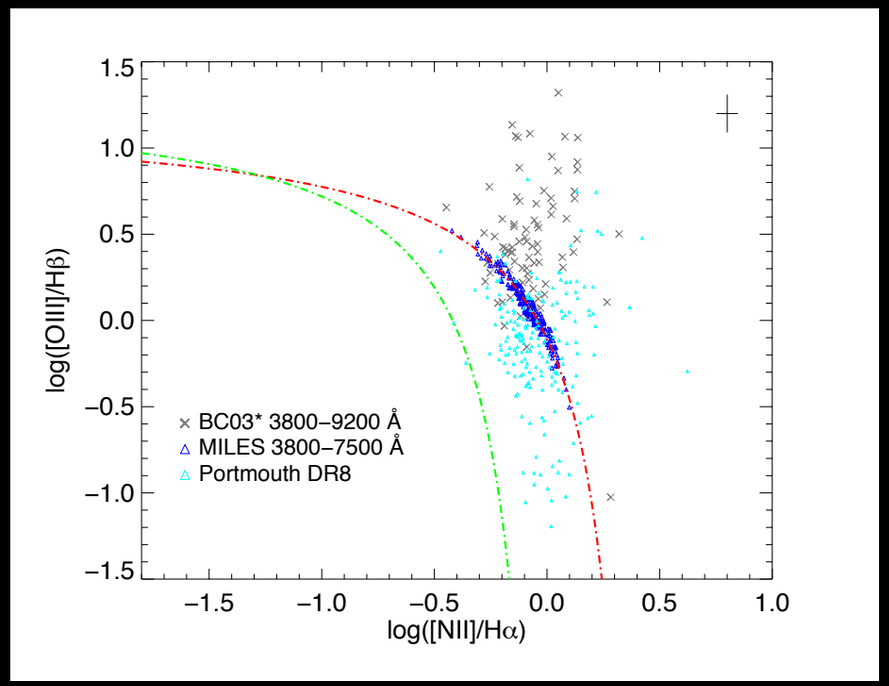
Metallicity Leading to Discrepancy?



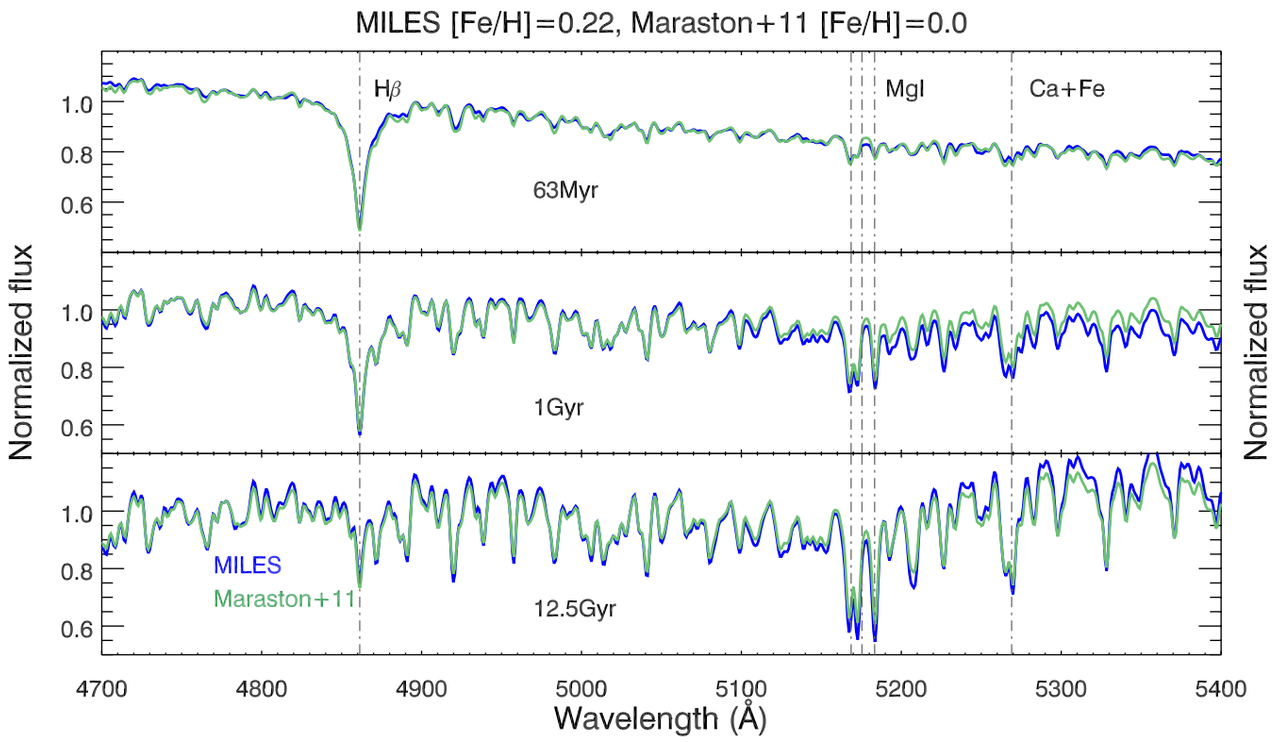
Chen, Zaw, & Farrar, in prep

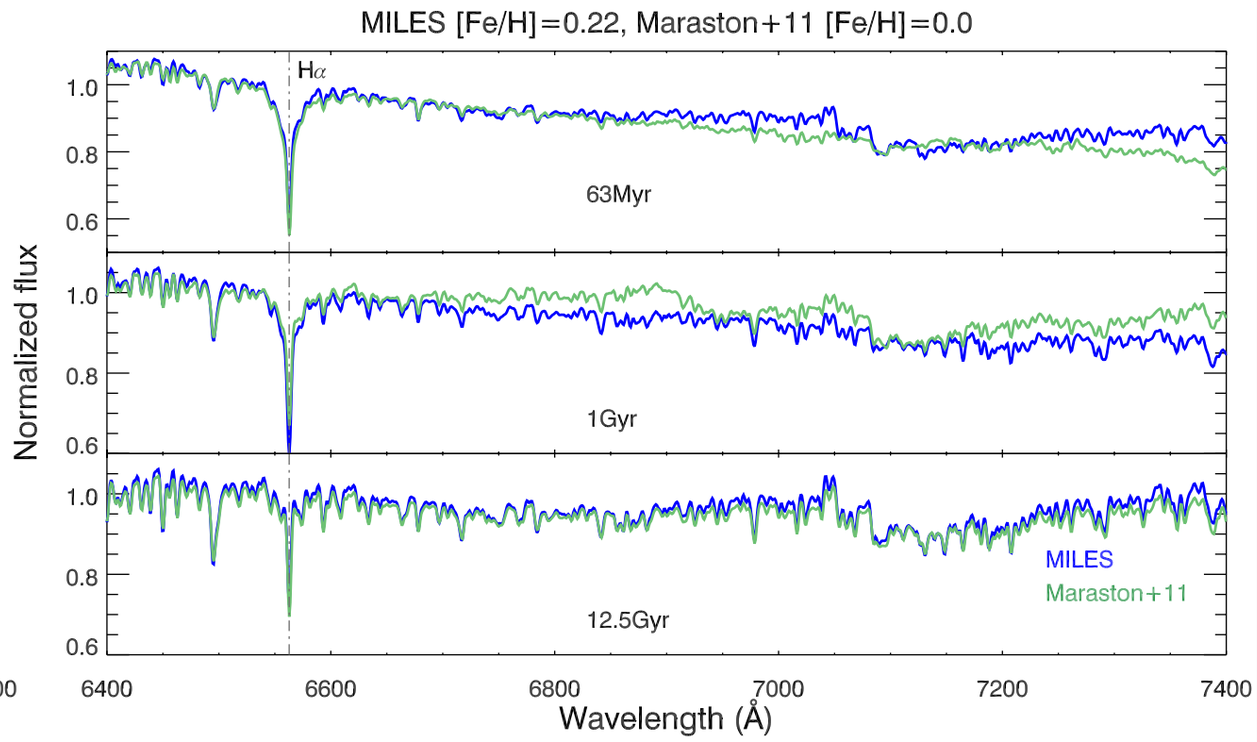
- Portsmouth fits (Thomas et al. 2013) use only solar metallicity templates
- Our fits favor higher metallicity templates

Metallicity and Lines



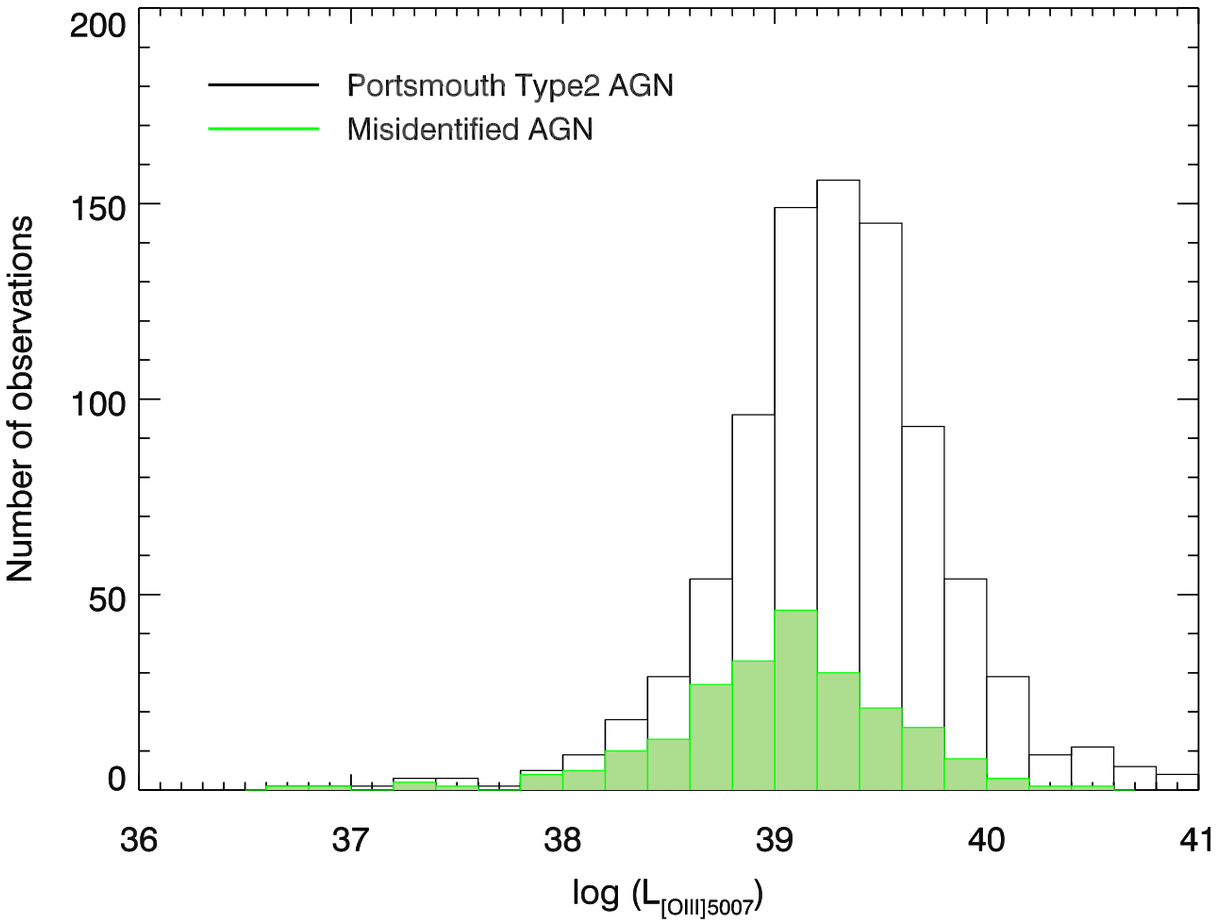
Zaw, Chen, & Farrar, in prep

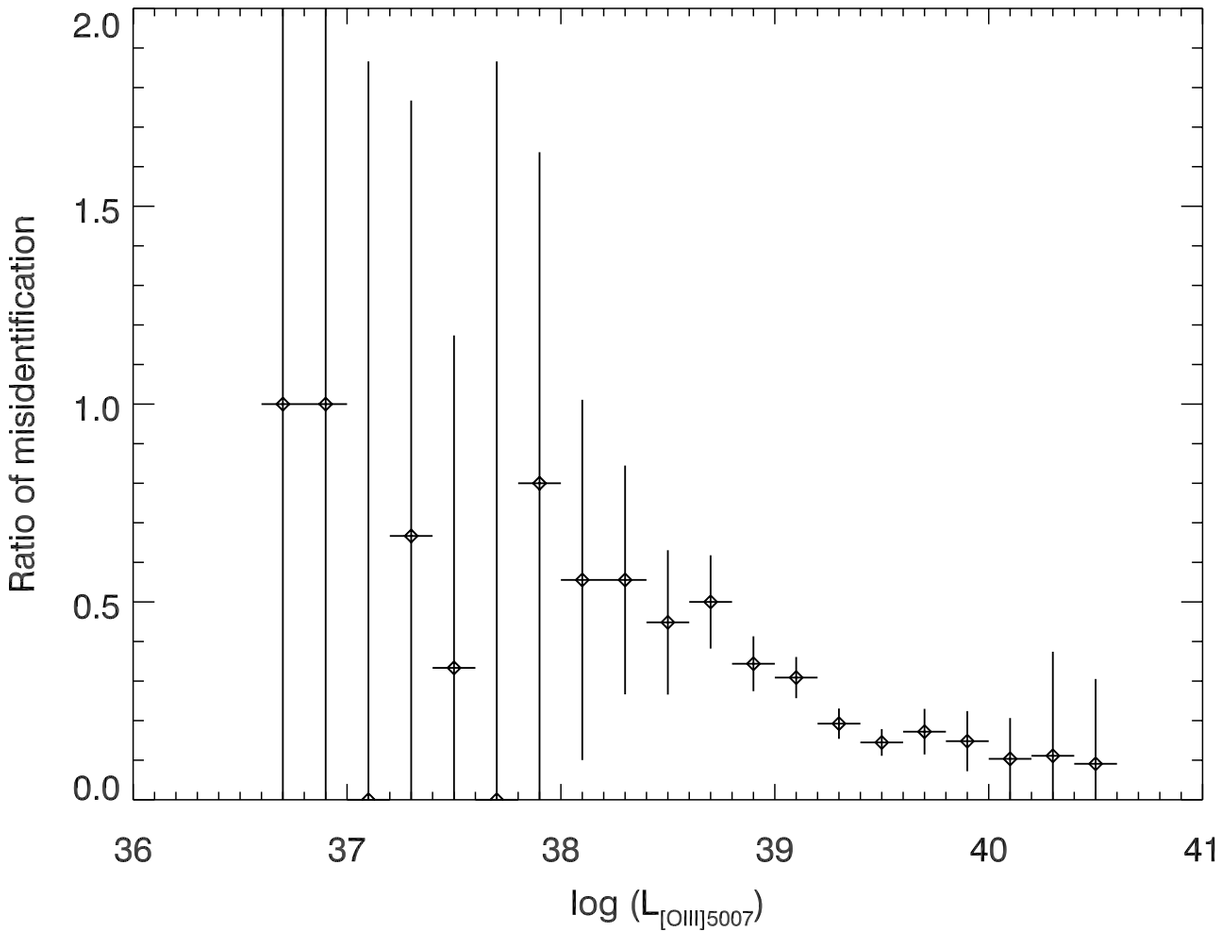




Chen, Zaw, & Farrar, in prep

Discrepancies in Identification



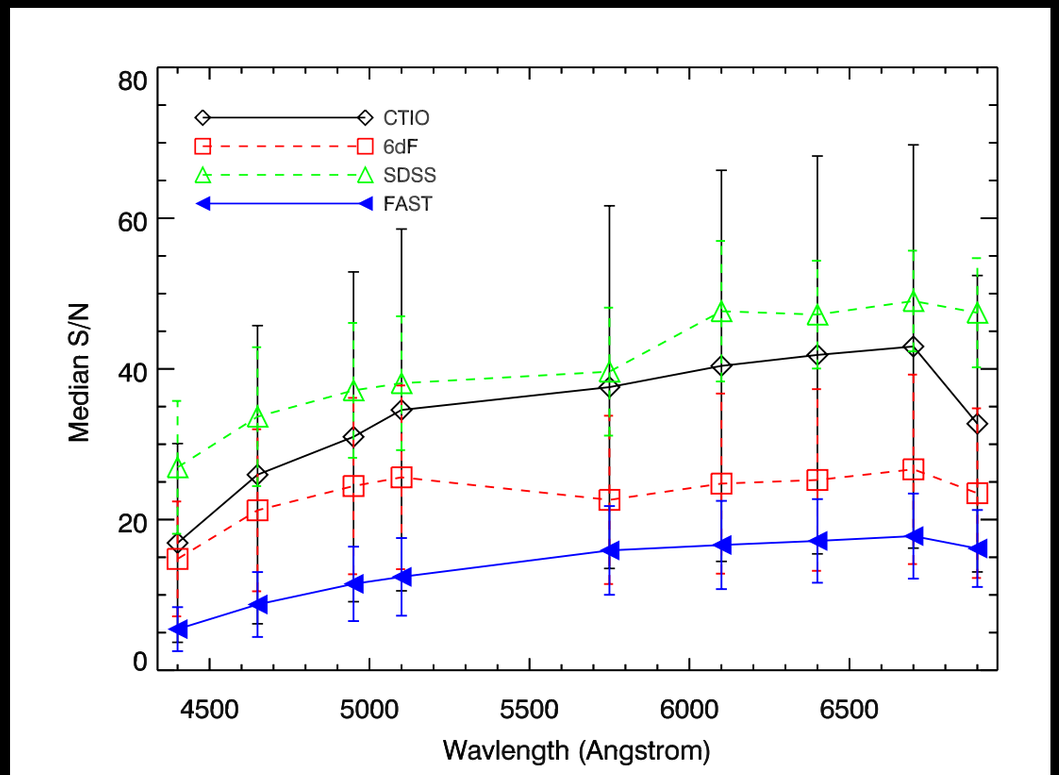


Chen, Zaw, & Farrar, in prep

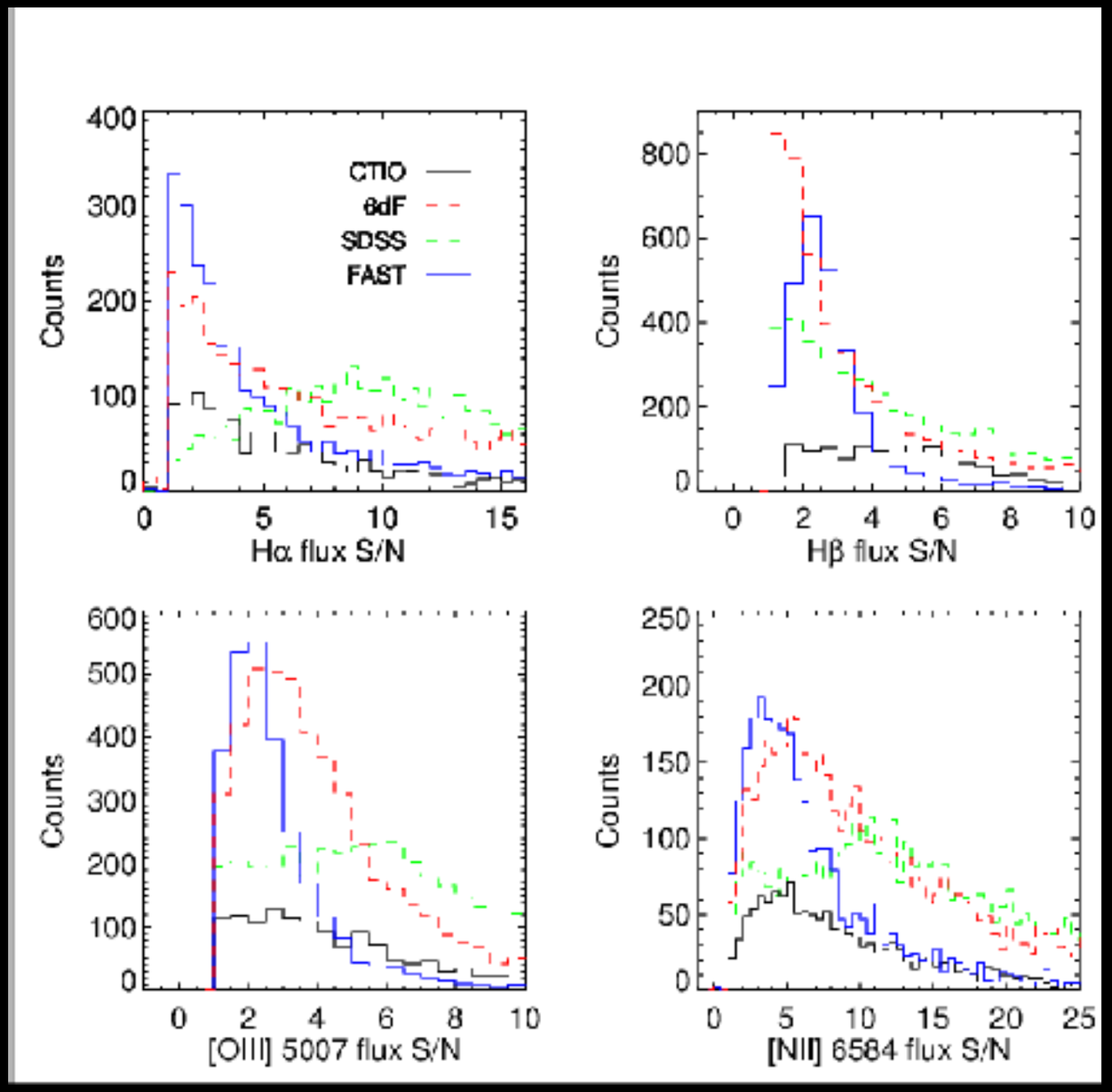
- Full sample (M11 vs. MILES)
- MILES AGNs which fall below the Kewley et al. (2001) line with M11
- Discrepancy large at lower luminosity

Effects of Spectral S/N

S/N in Continuum Regions



S/N of Lines



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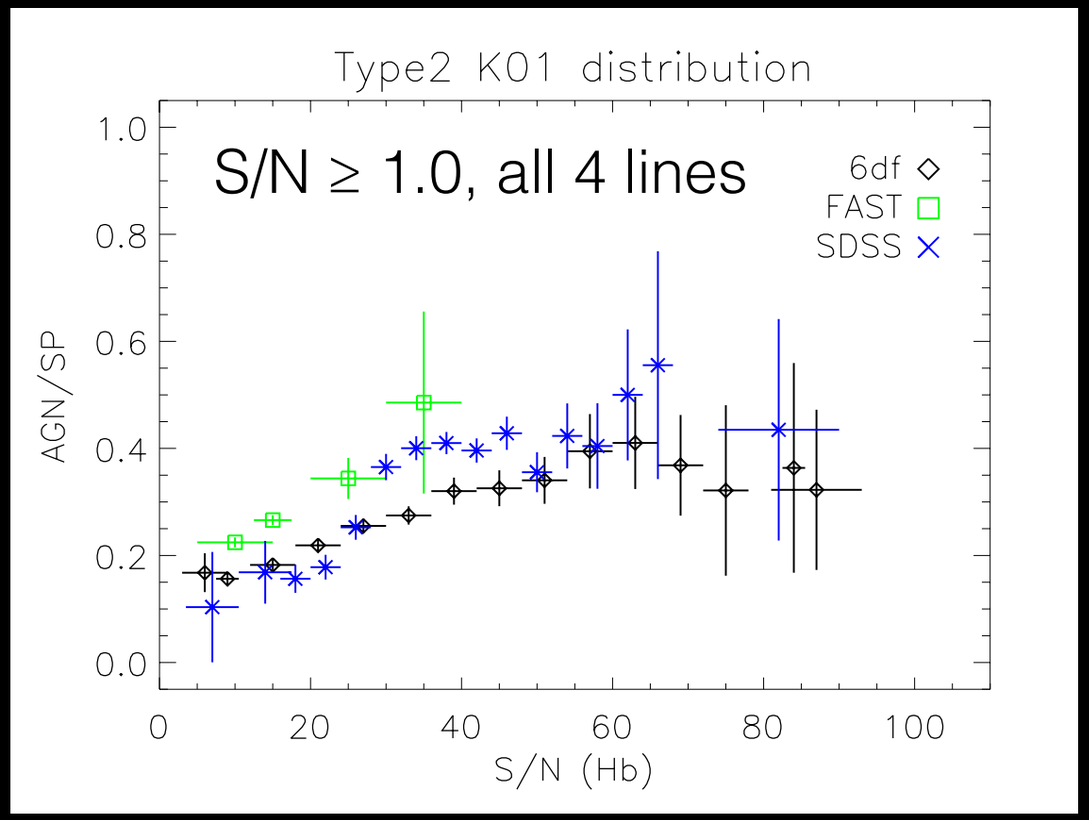
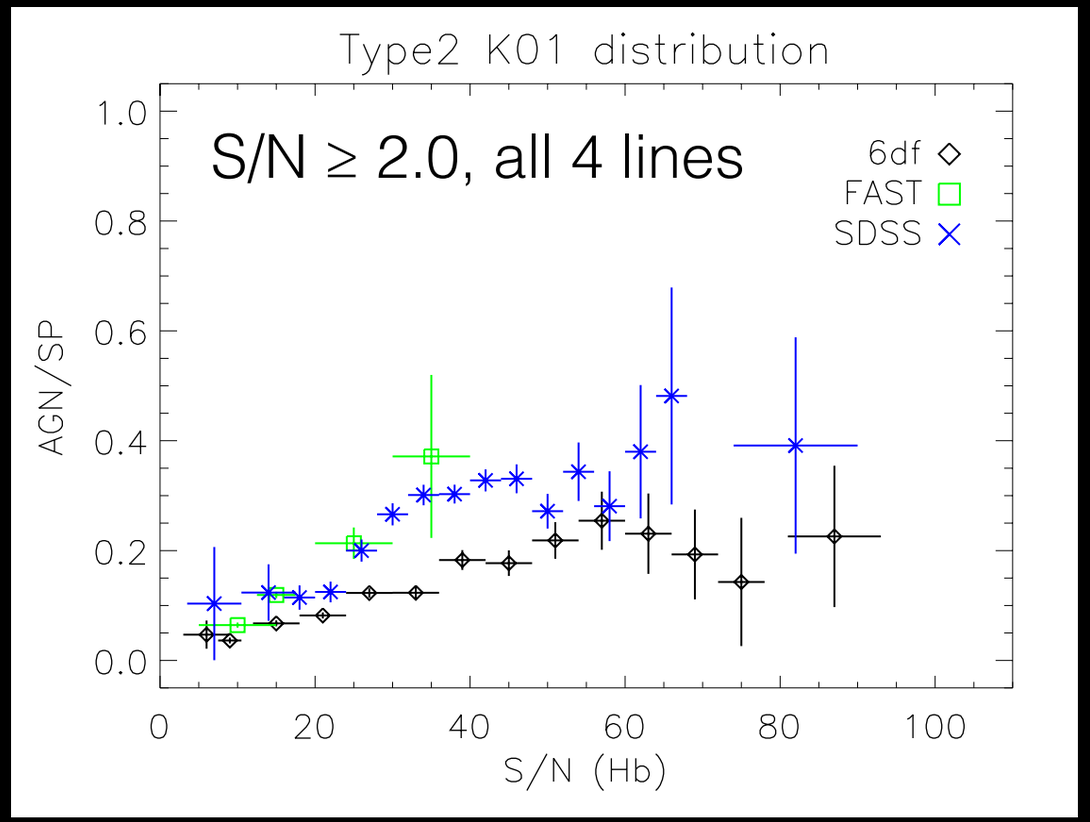
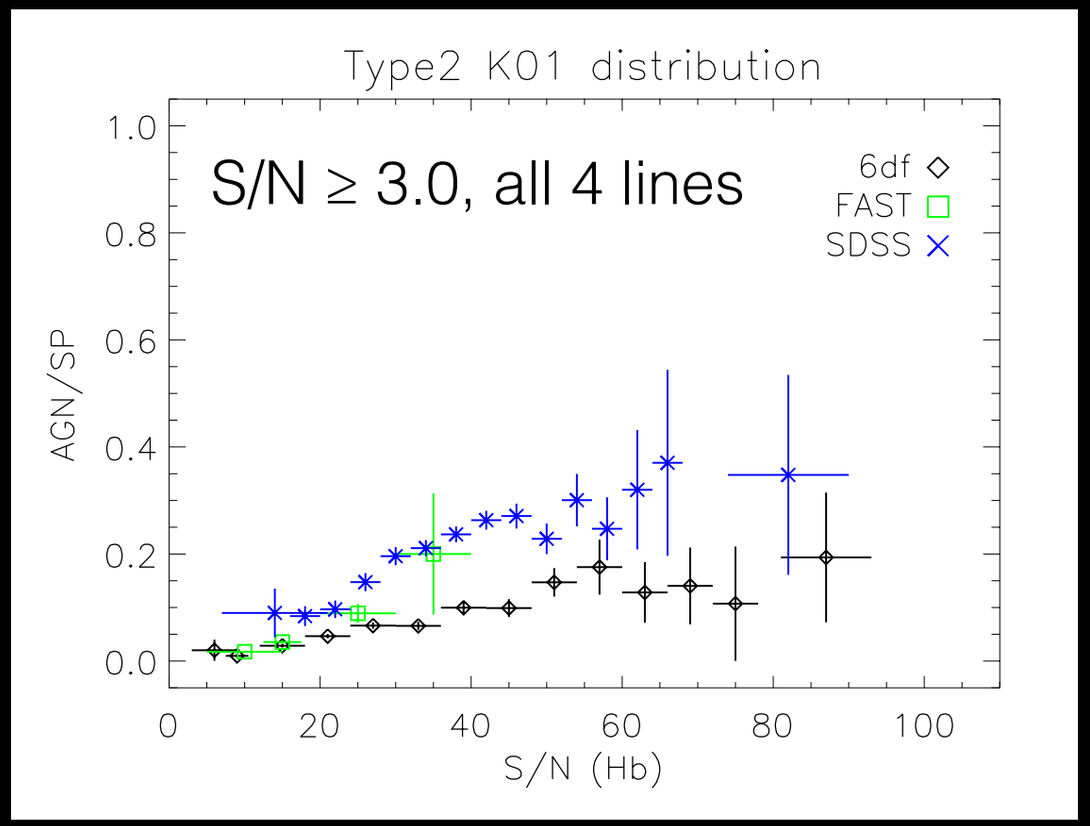
- Important for combining or comparing different samples





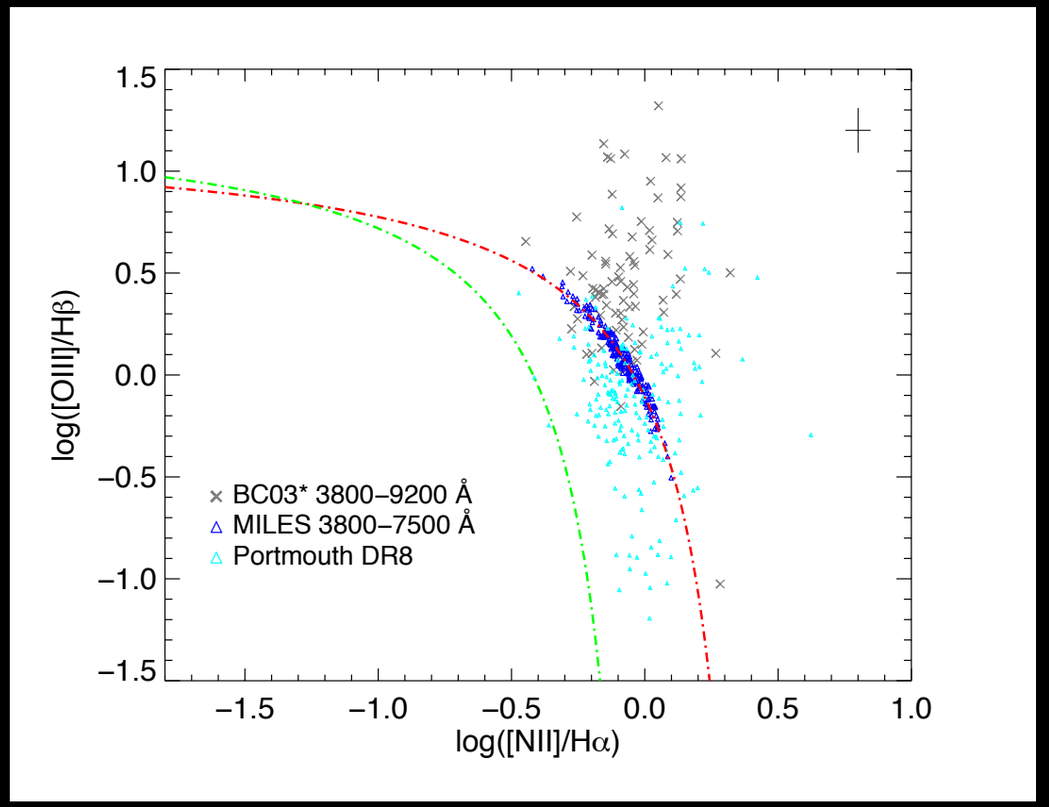
- Effects of S/N for continuum and lines
  - Flattens out at high S/N(continuum)
  - S/N (line) requirement separates samples

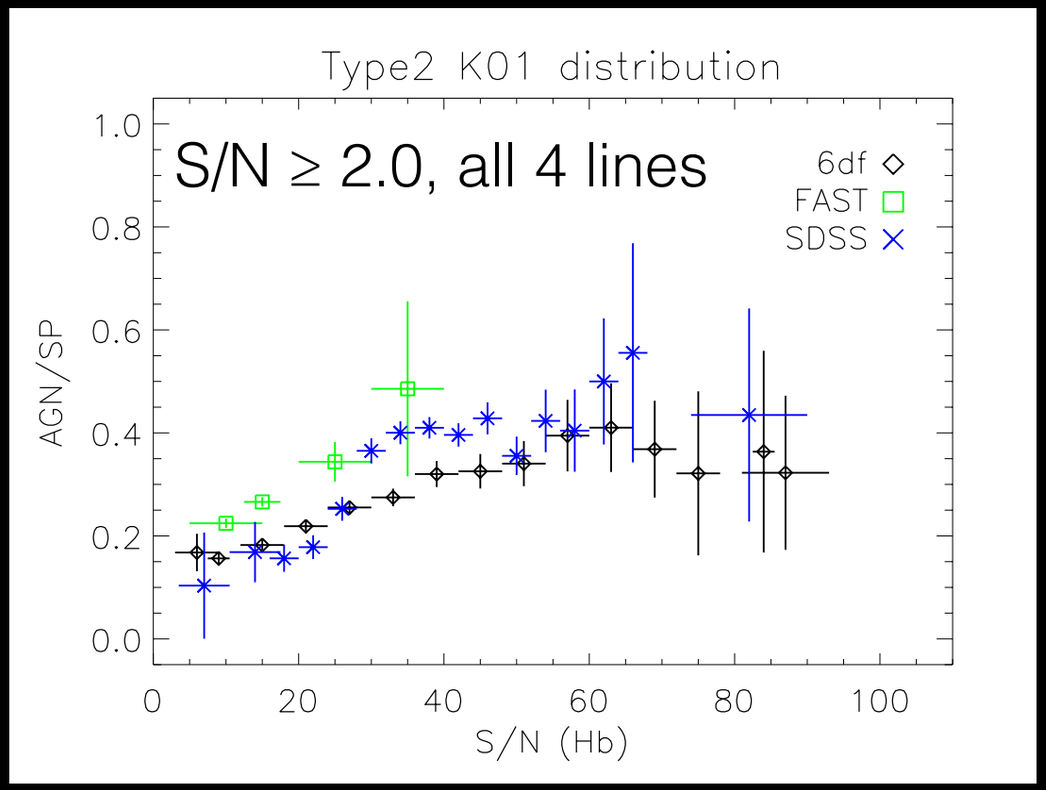


Zaw, Chen, & Farrar, in prep

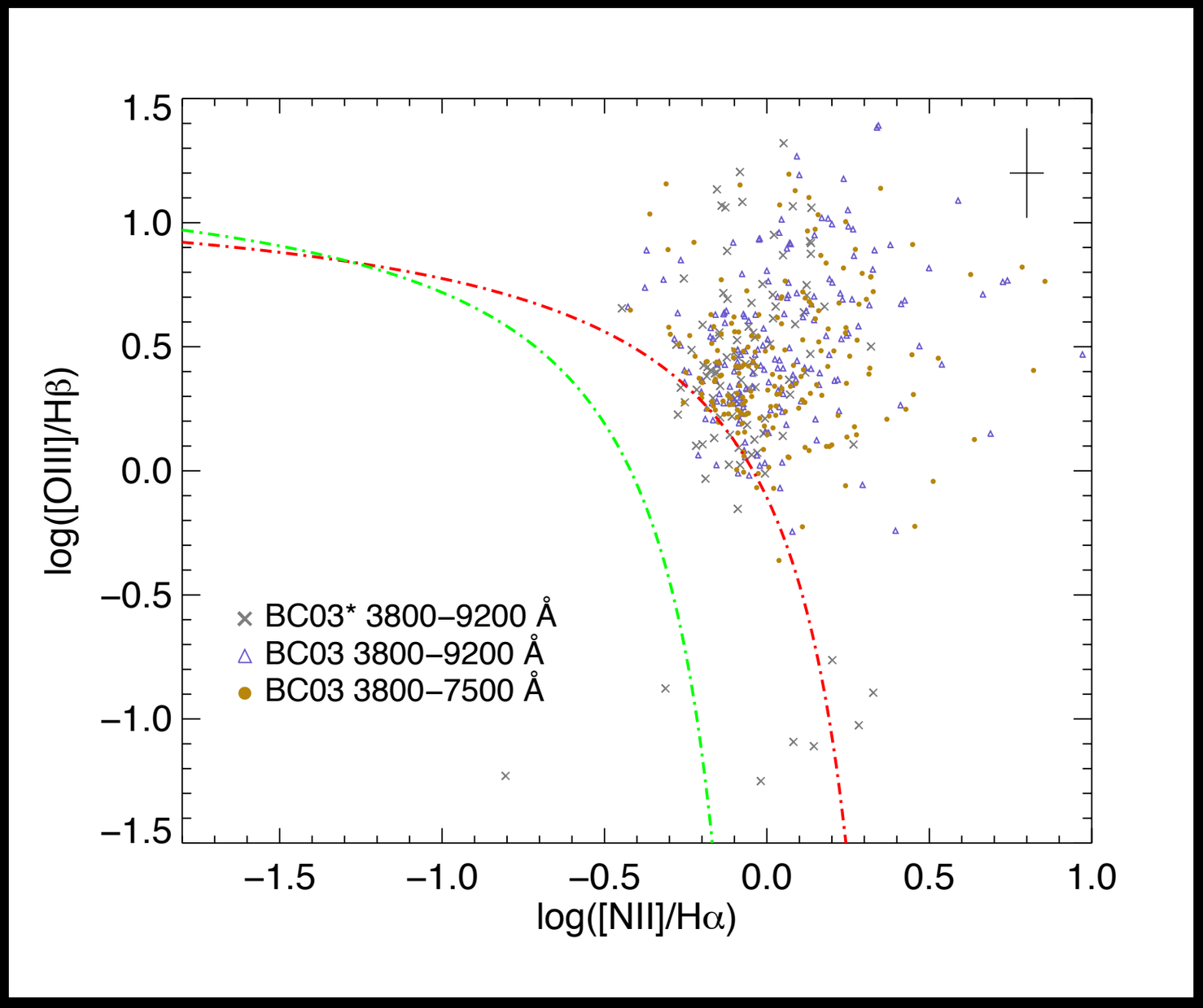
Conclusions

- Have to subtract the host galaxy contribution to isolate emission lines for AGN ID
- Different stellar population models give systematic differences in line ratios
  - Effect more pronounced at lower [OIII] luminosities
- Signal-to-noise of spectra affect fraction identified as AGNs
  - Flattens out at high continuum S/N

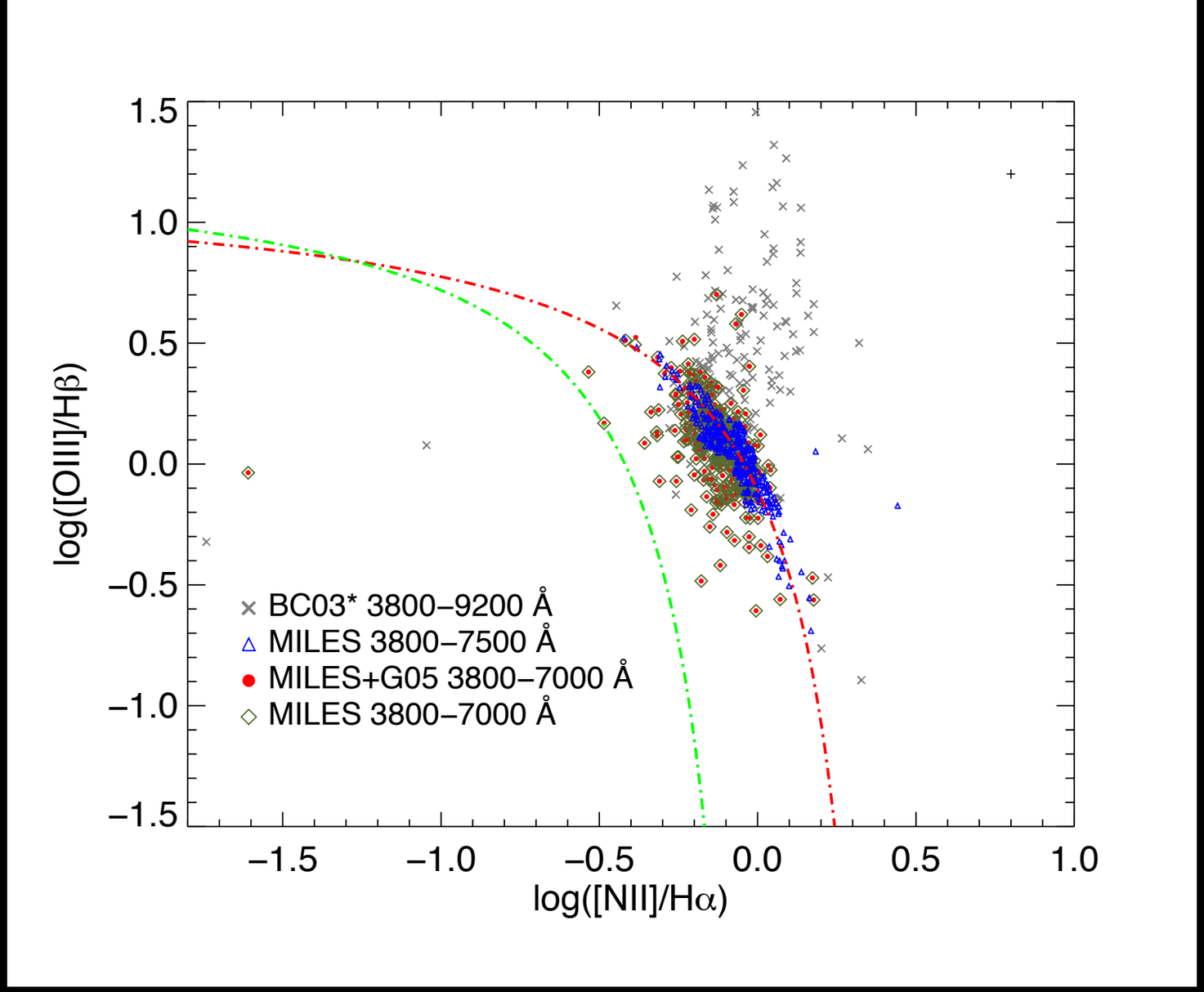




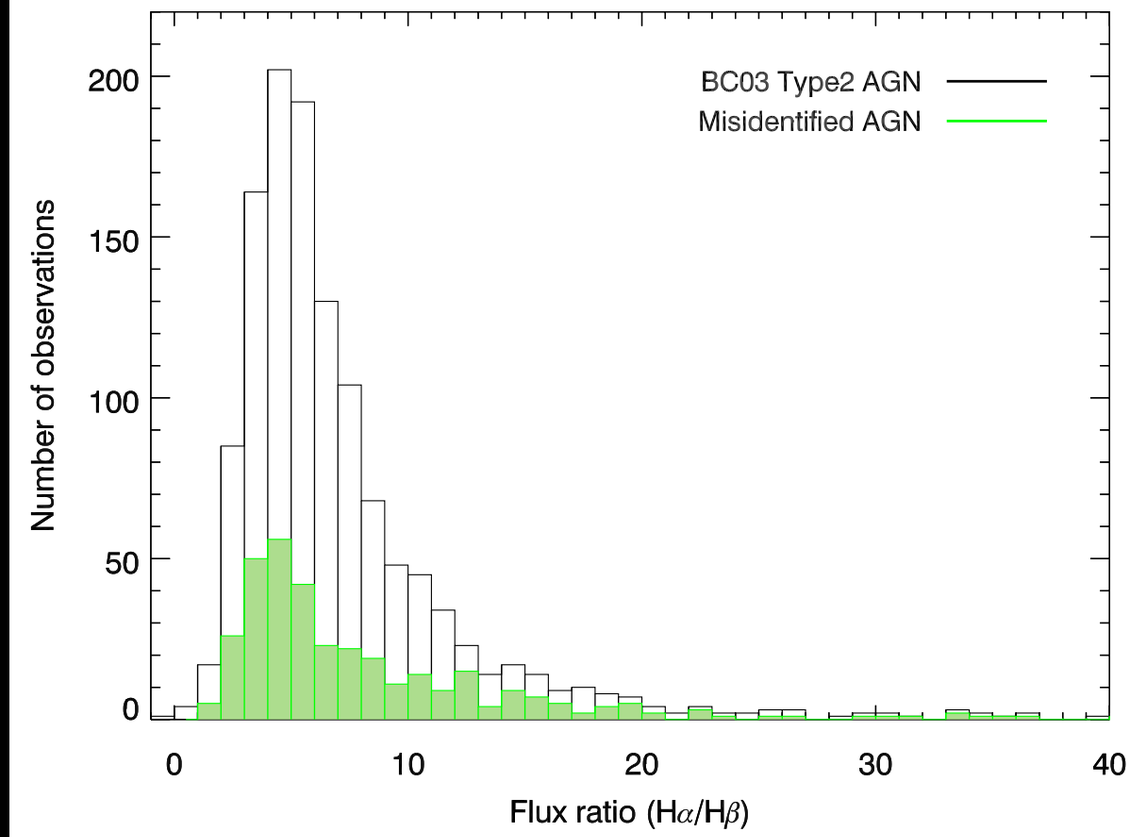
Backup Slides

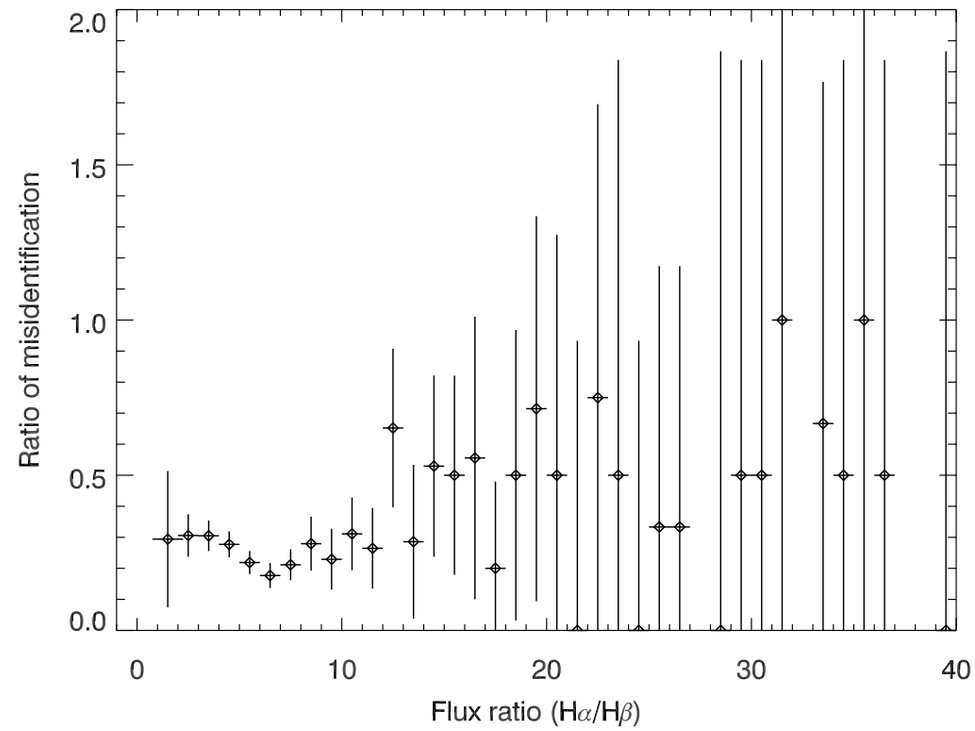


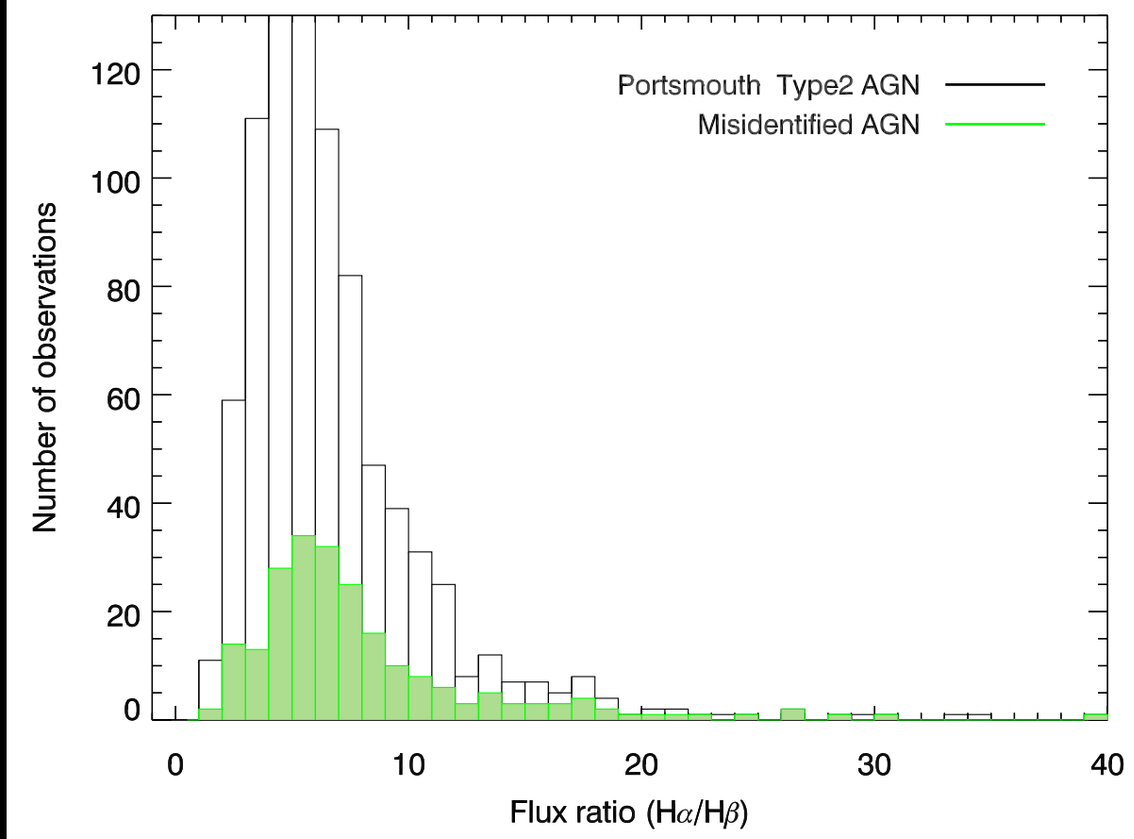
- No major systematic shifts due to differences in fitting methods

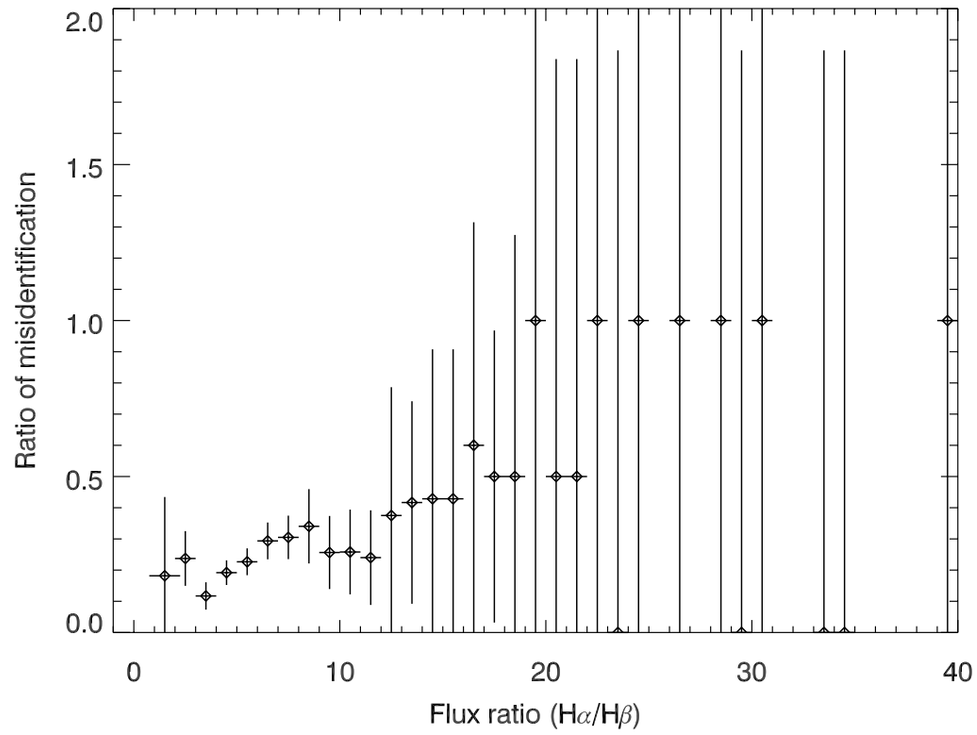


- No major contributions from populations younger than MILES templates
- Wavelength range has a small systematic effect


BC03 Type2 AGN
Misidentified AGN
Number of observations
Flux ratio (Hα/Hβ)
0
50
100
150
200
0
10
20
30
40


Ratio of misidentification
Flux ratio (Hα/Hβ)
0.0
0.5
1.0
1.5
2.0
0
10
20
30
40


Portsmouth Type2 AGN
Misidentified AGN
Number of observations
Flux ratio (Hα/Hβ)
0
20
40
60
80
100
120
0
10
20
30
40


Ratio of misidentification
Flux ratio (Hα/Hβ)
0.0
0.5
1.0
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40