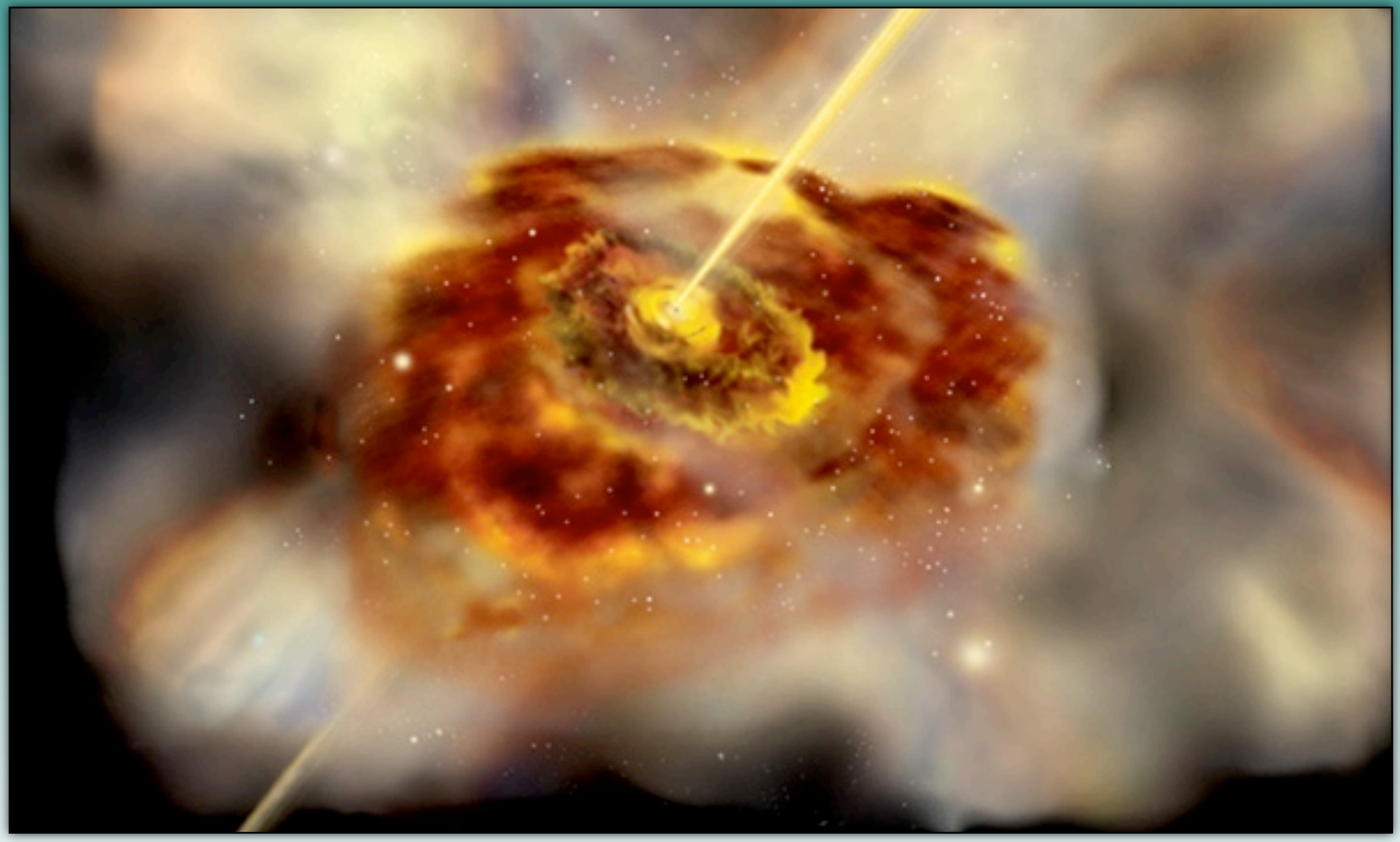
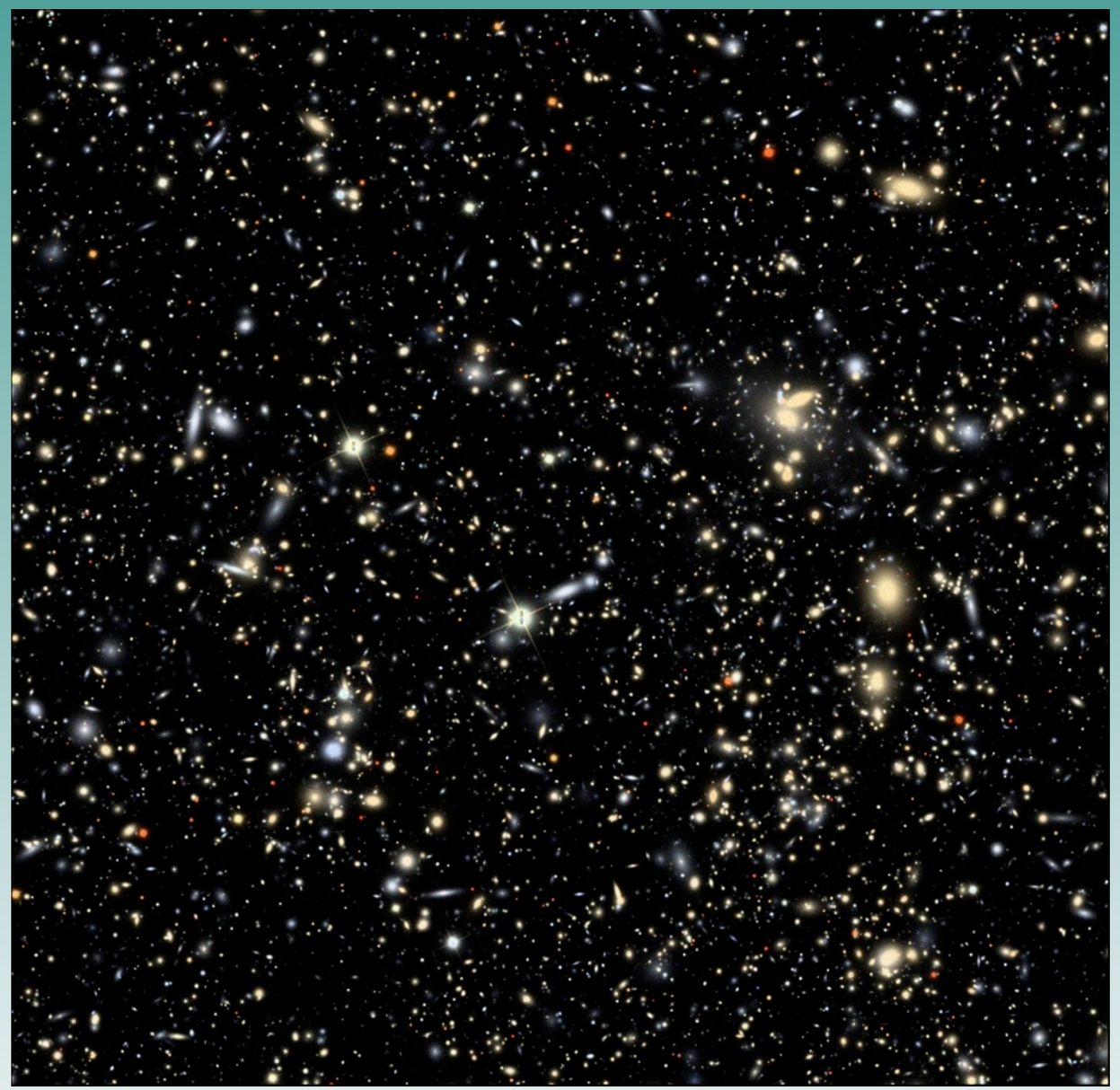
X-ray/IR Stacking Analyses of BPT-comp: AGN Activity Dominates



Laura Trouille, CIERA Postdoctoral Fellow

(Christy Tremonti, Amy Barger, & Ryan Hickox)

The Battle for BPT-Comp



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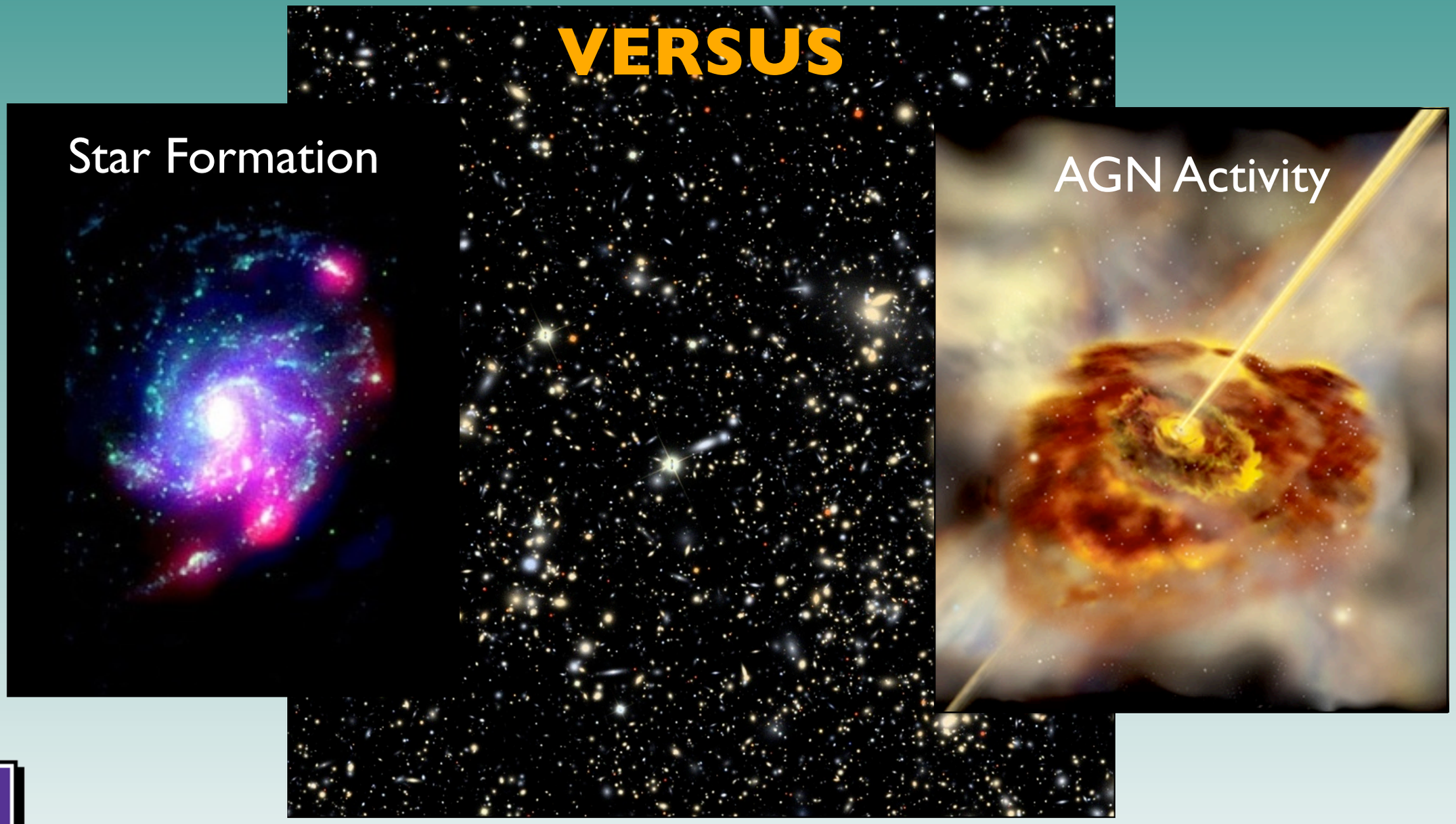

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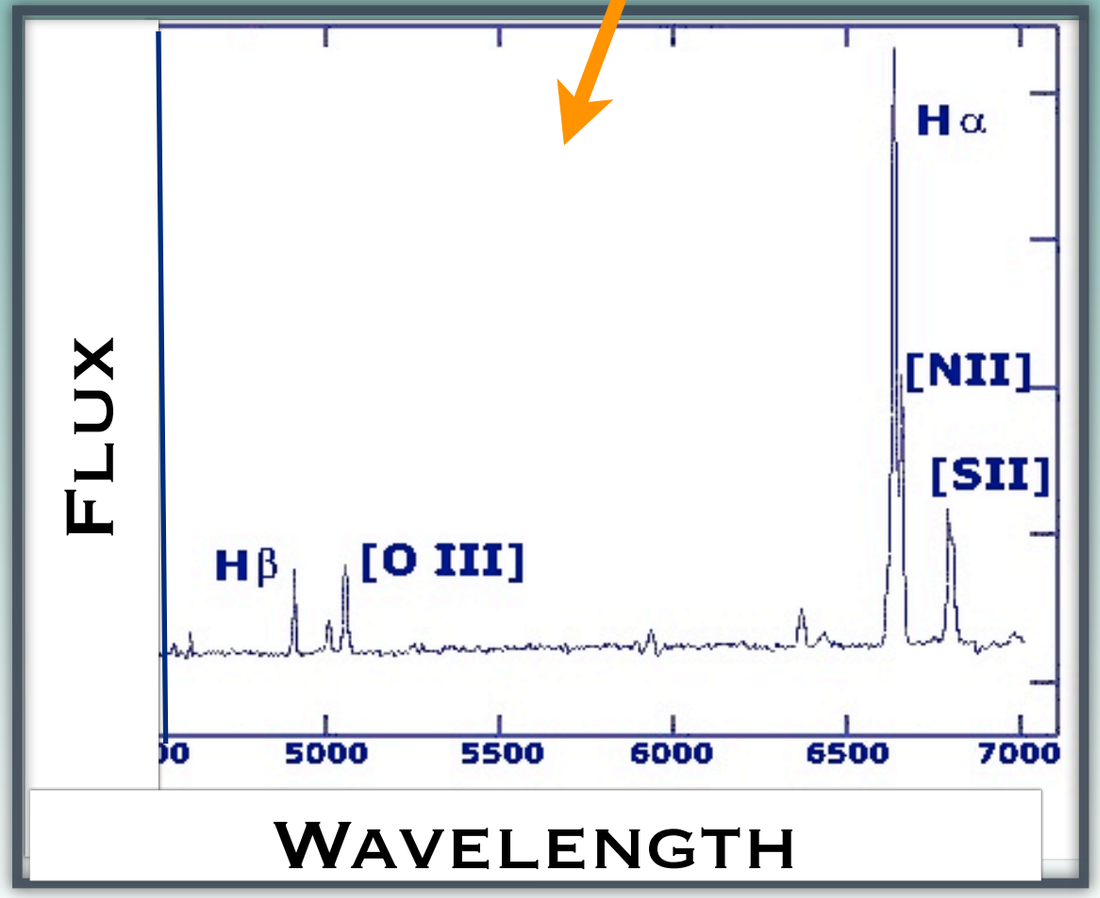
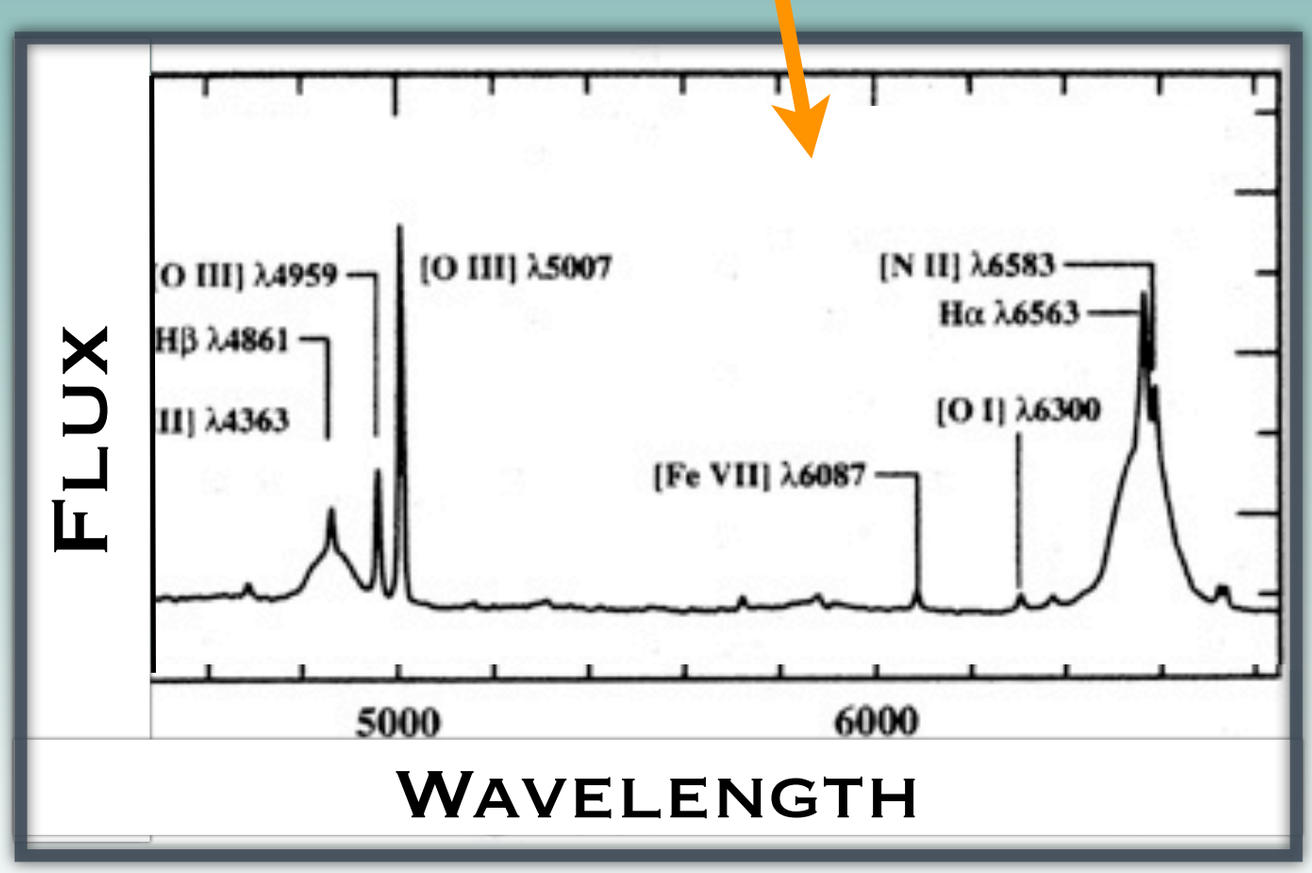
Star Formation

VERSUS

AGN Activity





Star Formation

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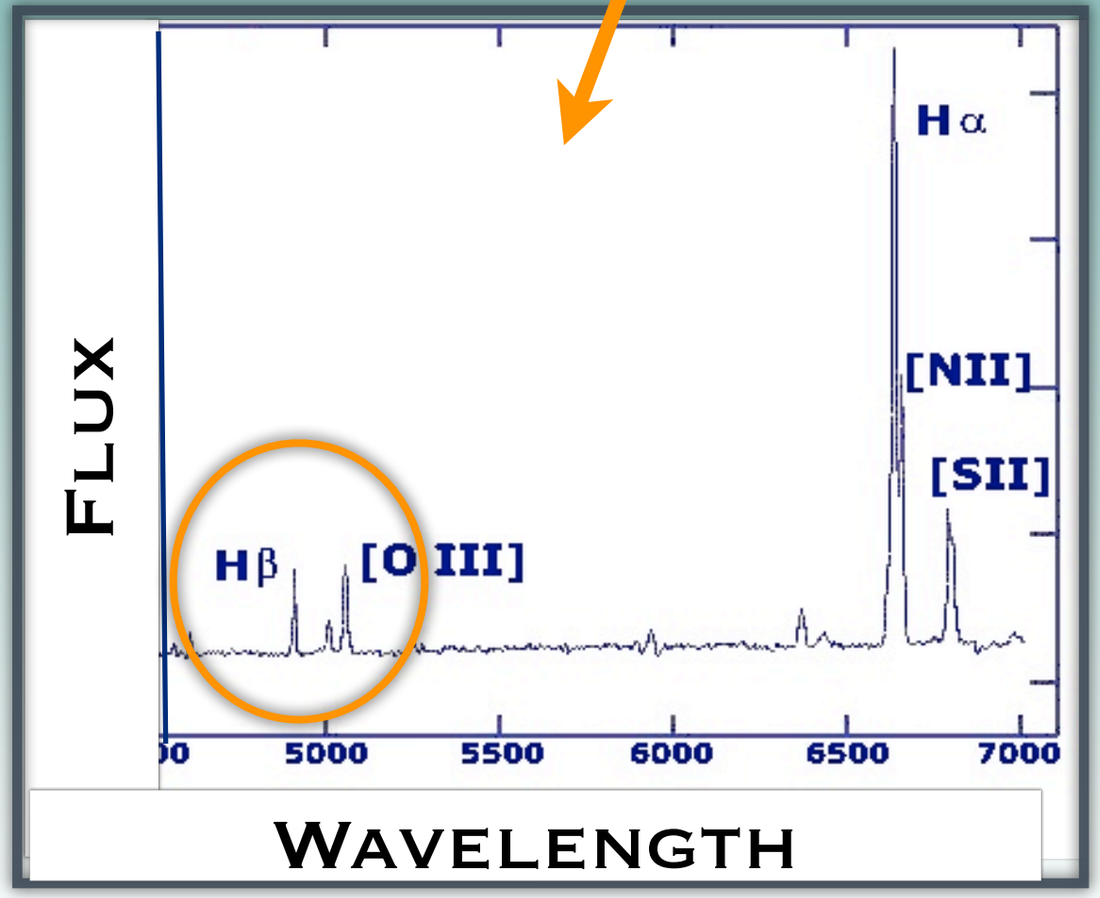
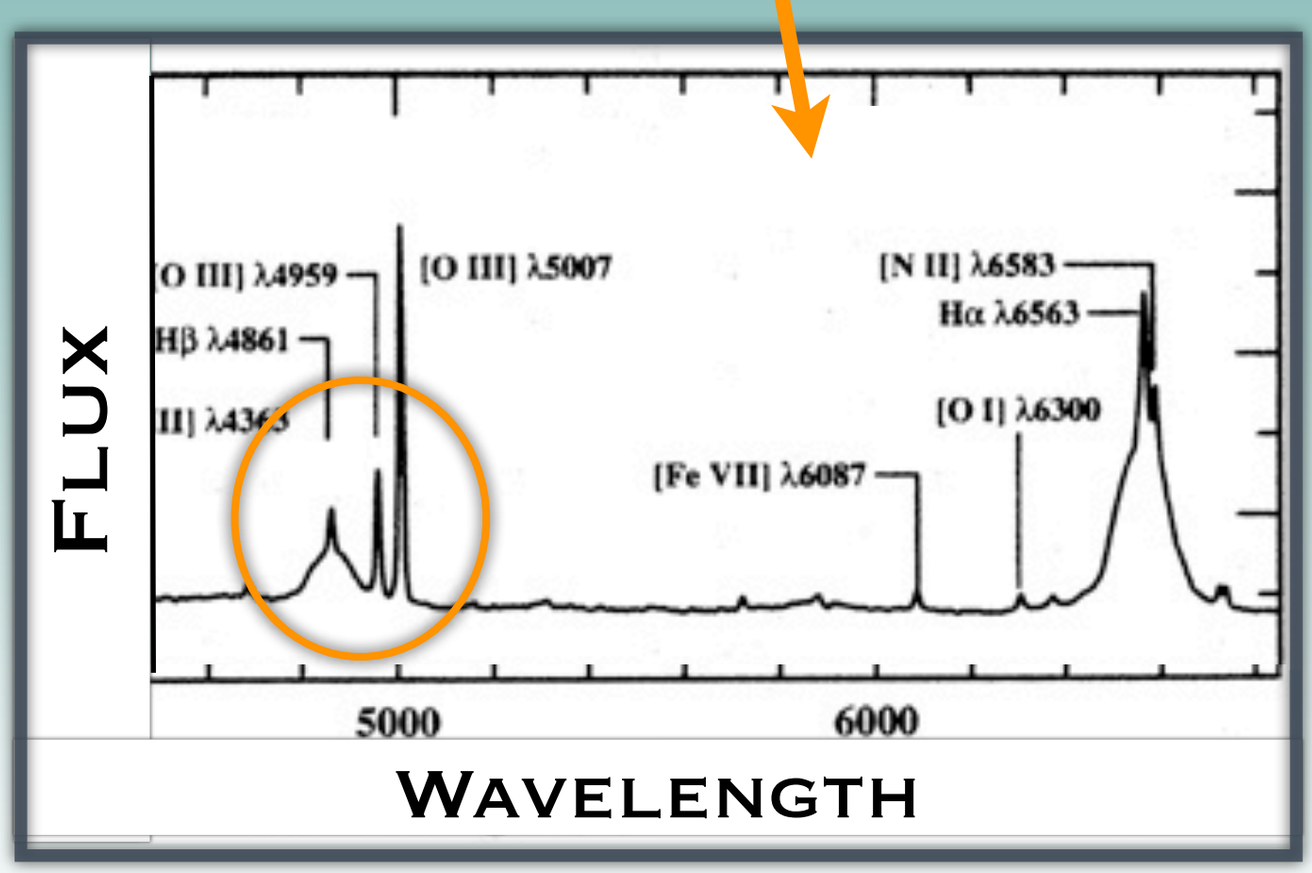
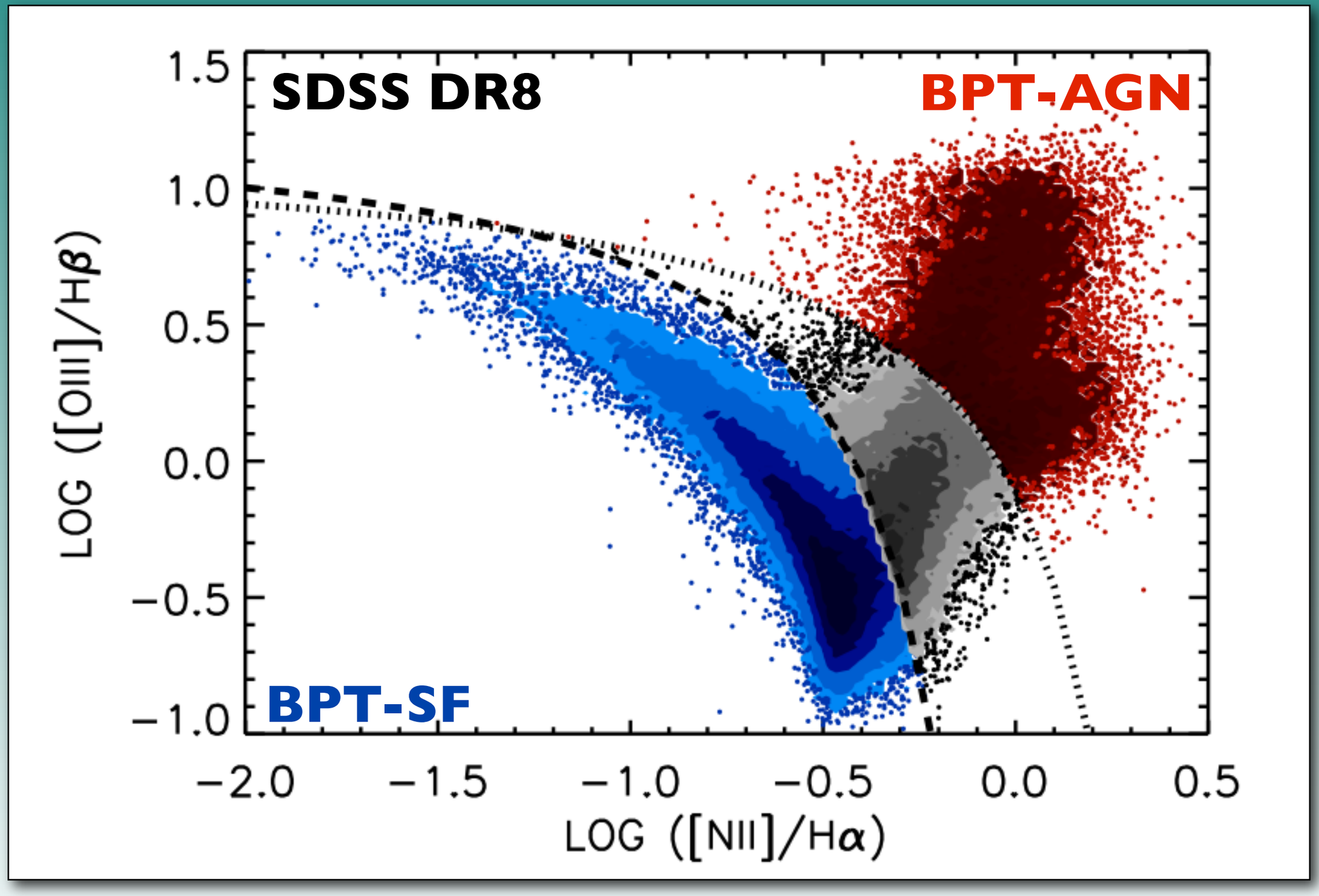
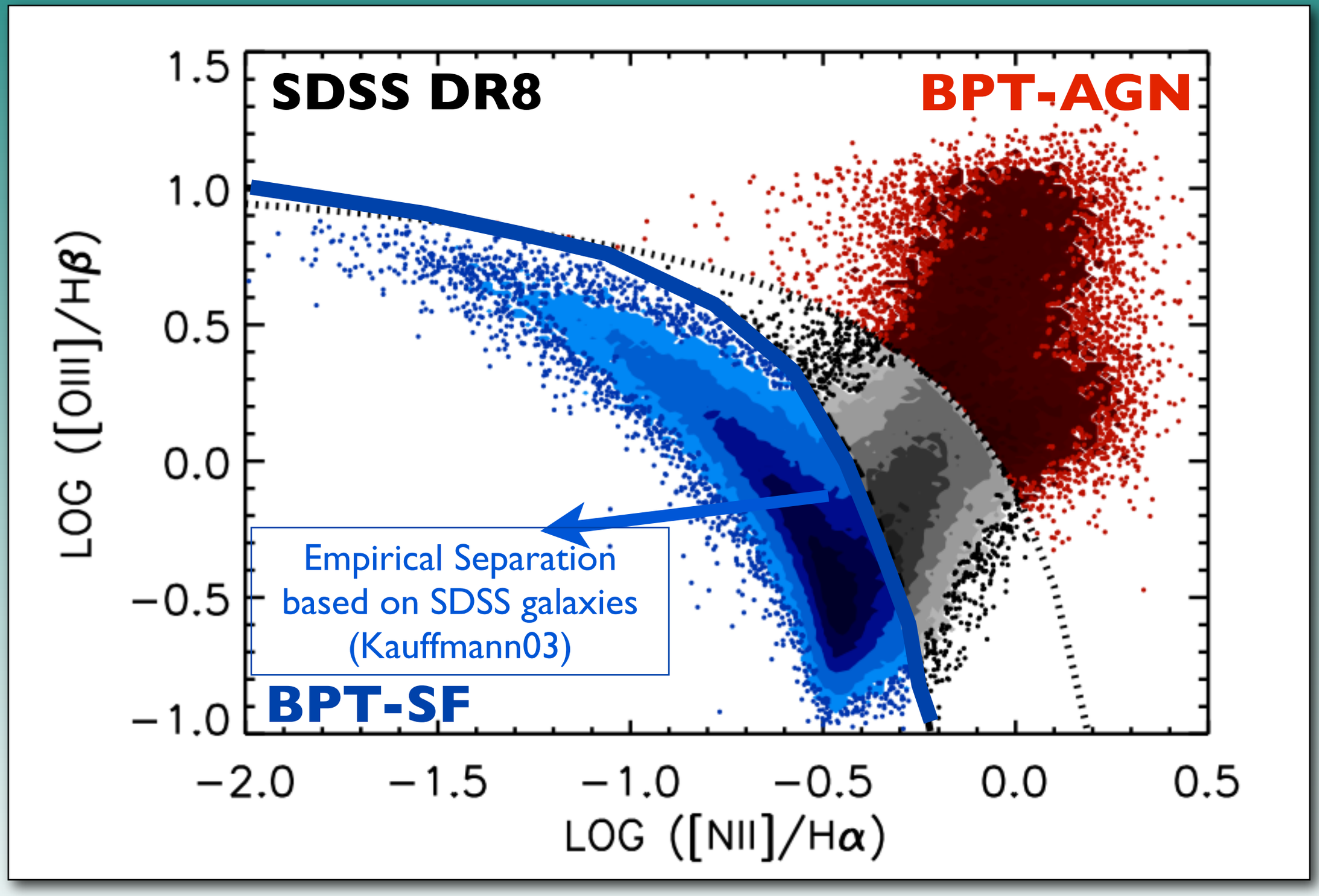




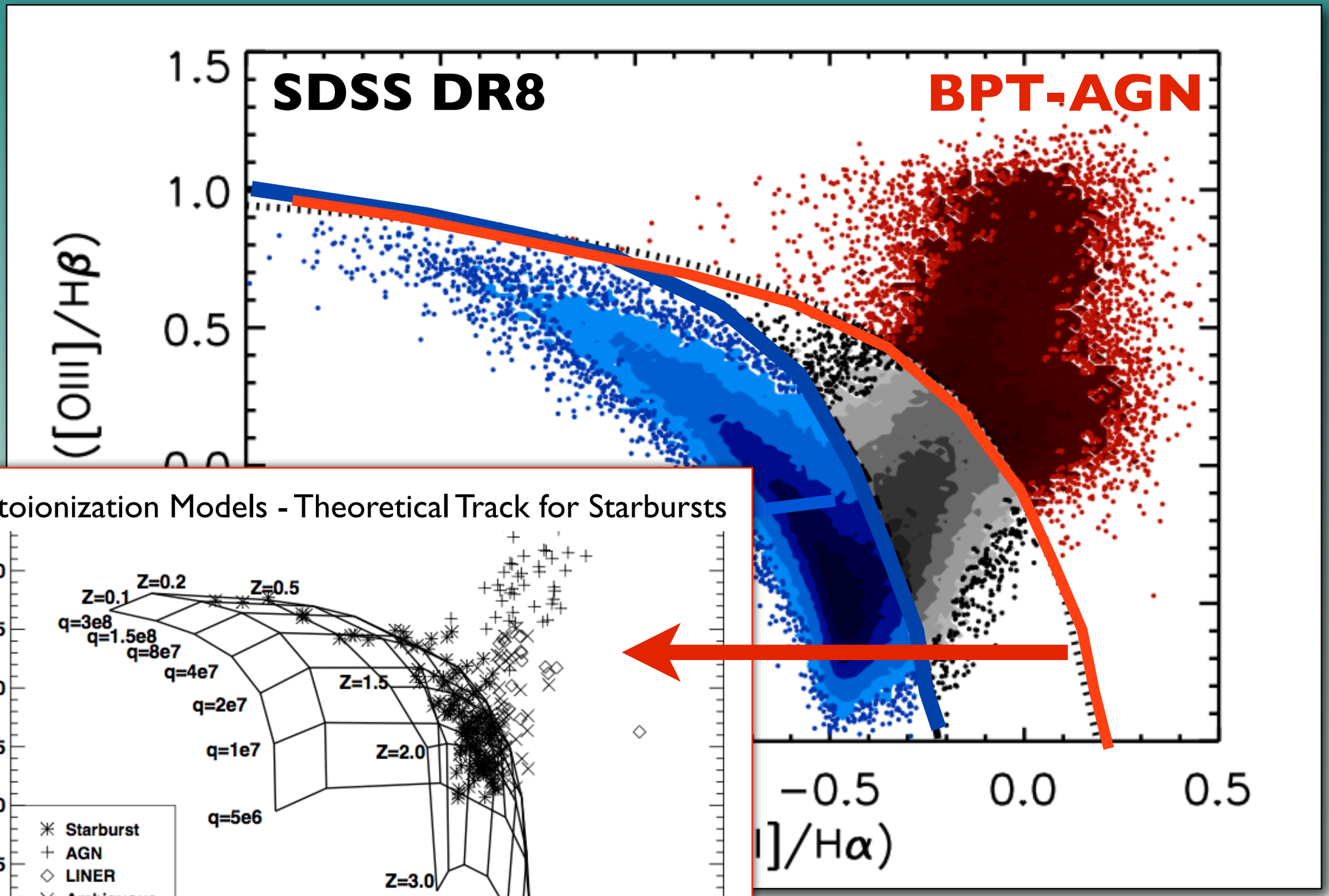
BPT Diagram


SDSS DR8
BPT-AGN
BPT-SF
1.5
1.0
0.5
0.0
−0.5
−1.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5
LOG ([OIII]/Hβ)
LOG ([NII]/Hα)

BPT Diagram


SDSS DR8
BPT-AGN
Empirical Separation
based on SDSS galaxies
(Kauffmann03)
BPT-SF
LOG ([OIII]/Hβ)
LOG ([NII]/Hα)
1.5
1.0
0.5
0.0
−0.5
−1.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5

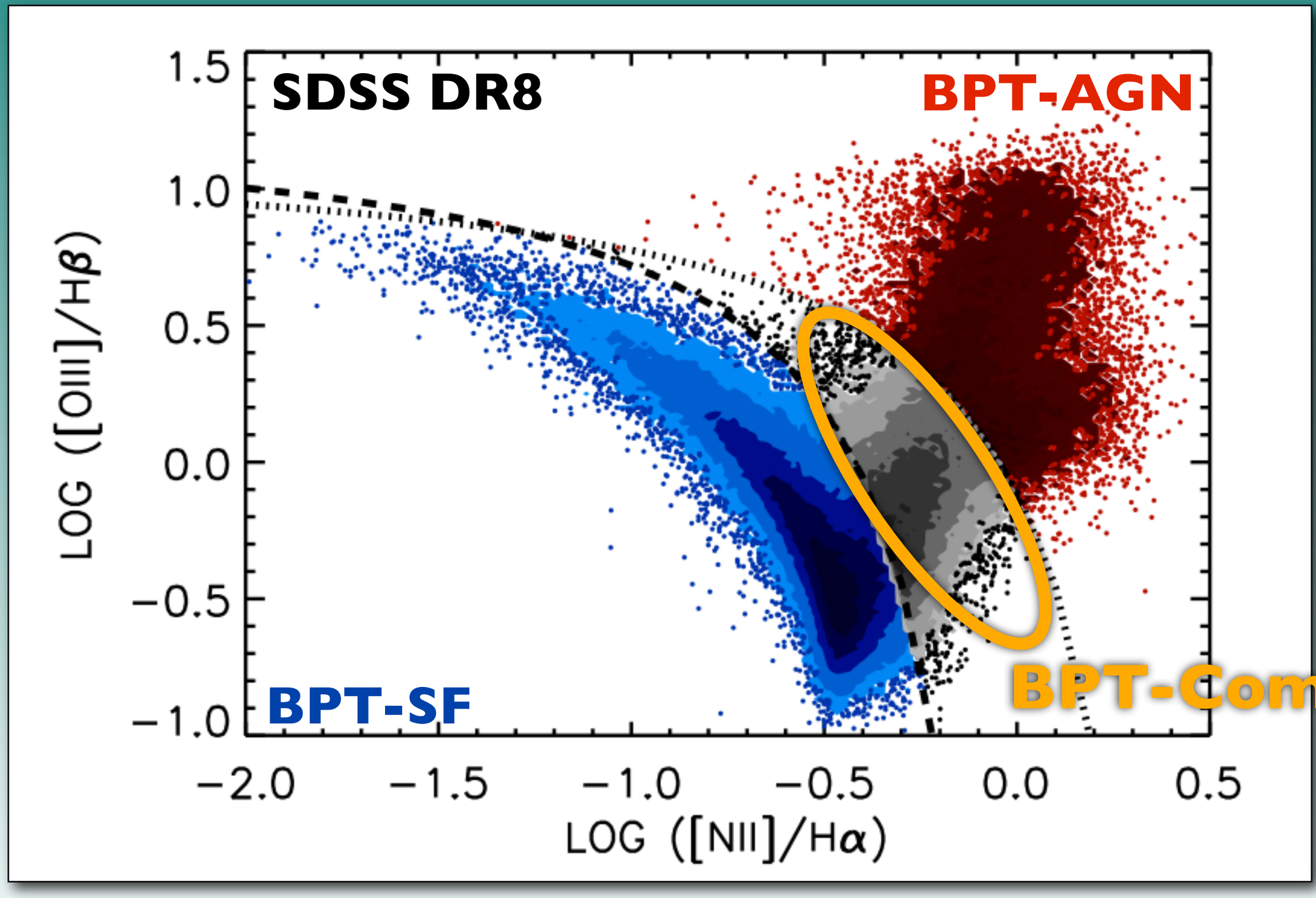
BPT Diagram



Photoionization Models - Theoretical Track for Starbursts

Kewley01

BPT-Comp


SDSS DR8
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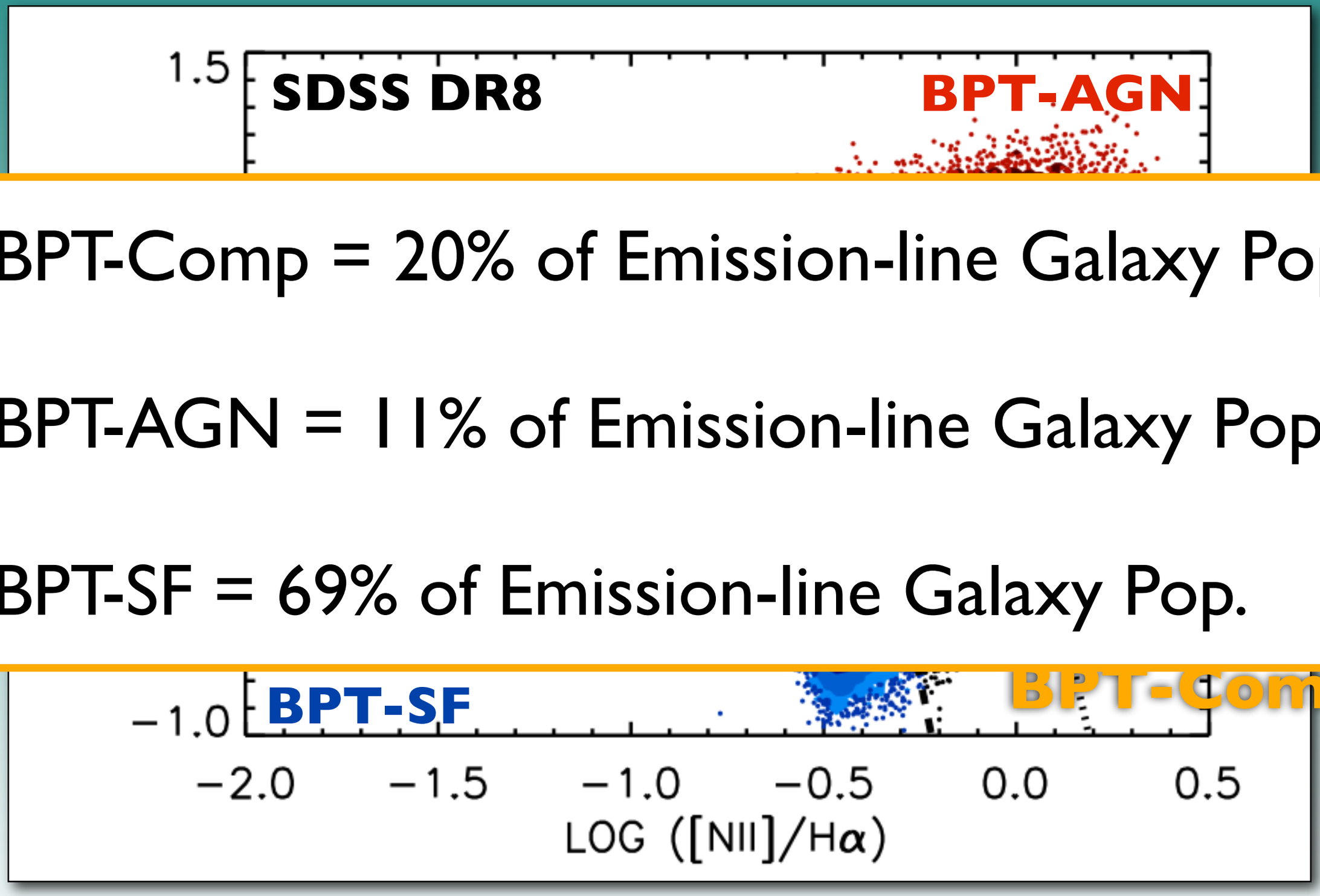
BPT-Comp



- BPT-Comp = 20% of Emission-line Galaxy Pop.
- BPT-AGN = 11% of Emission-line Galaxy Pop.
- BPT-SF = 69% of Emission-line Galaxy Pop.

The Battle for BPT-comp:

And the winner is... AGN!

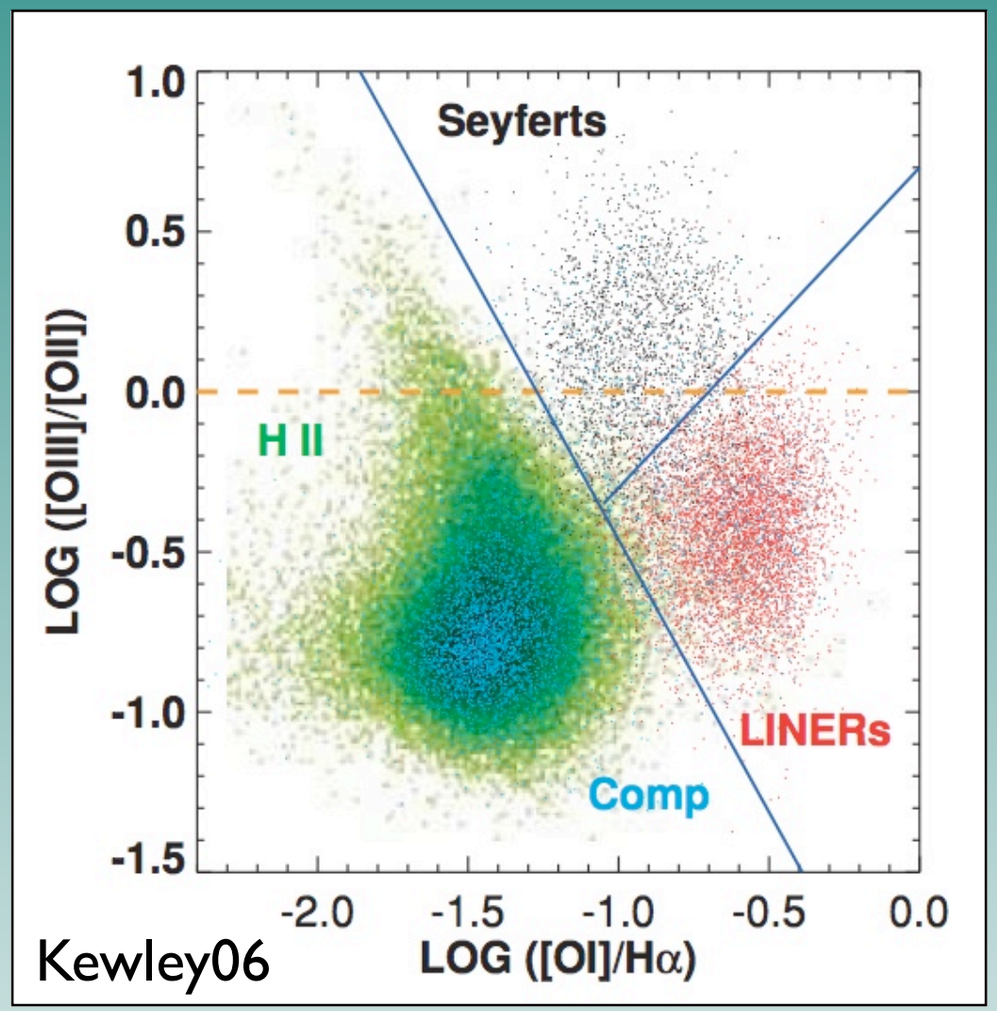
Outline:

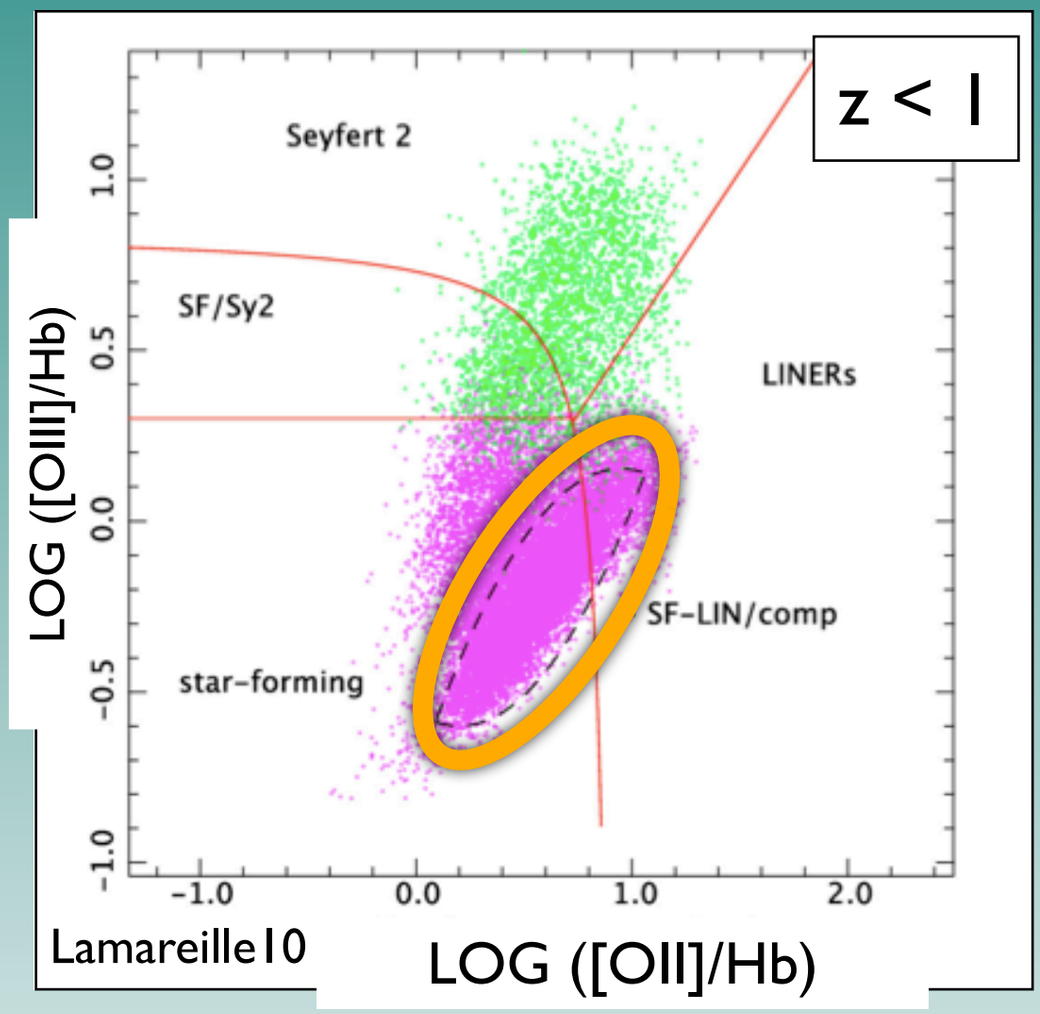
- High versus low ionization line ratios
  The TBT diagnostic ($z \leq 1.4$)
- X-ray Stacking Analysis
- X-ray/IR luminosity ratio

[Trouille, Barger, & Tremonti 2011]

Low Ionization Optical Emission Lines:

Exclude BPT-comp from AGN samples





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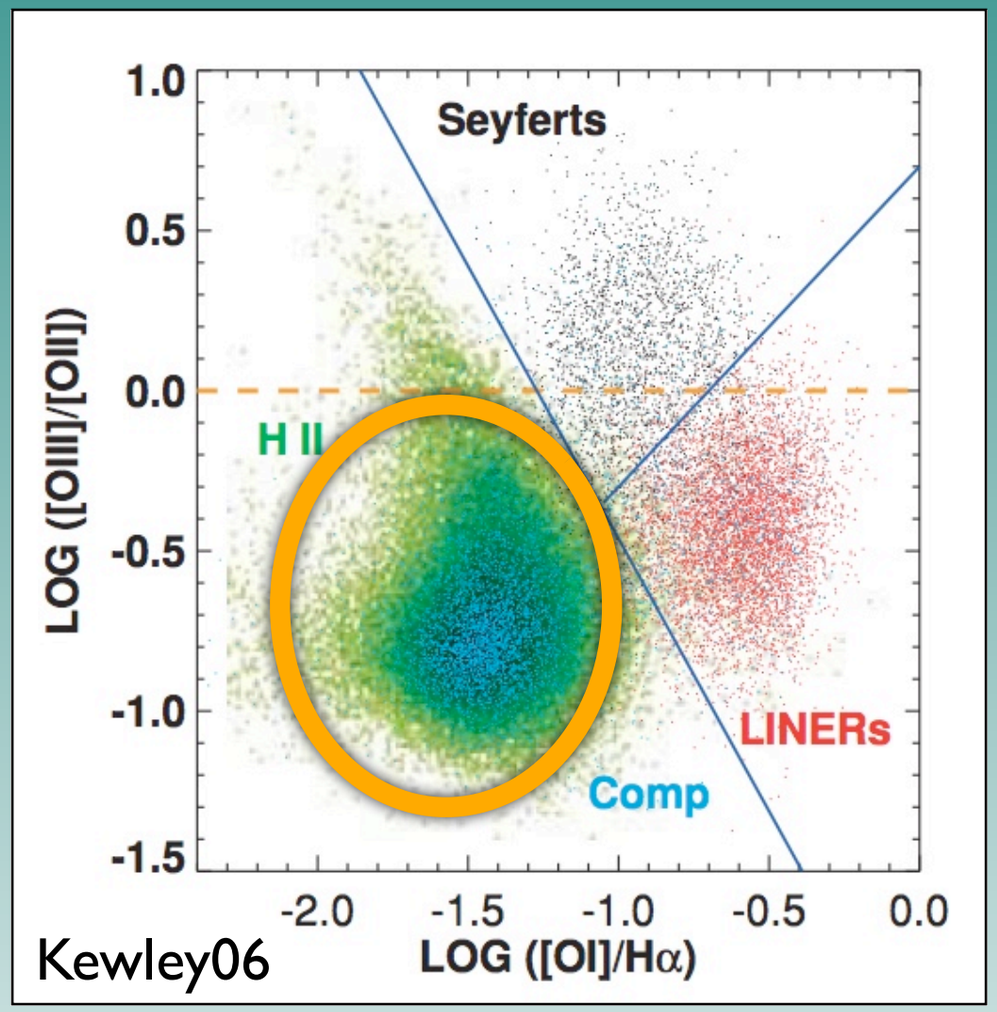

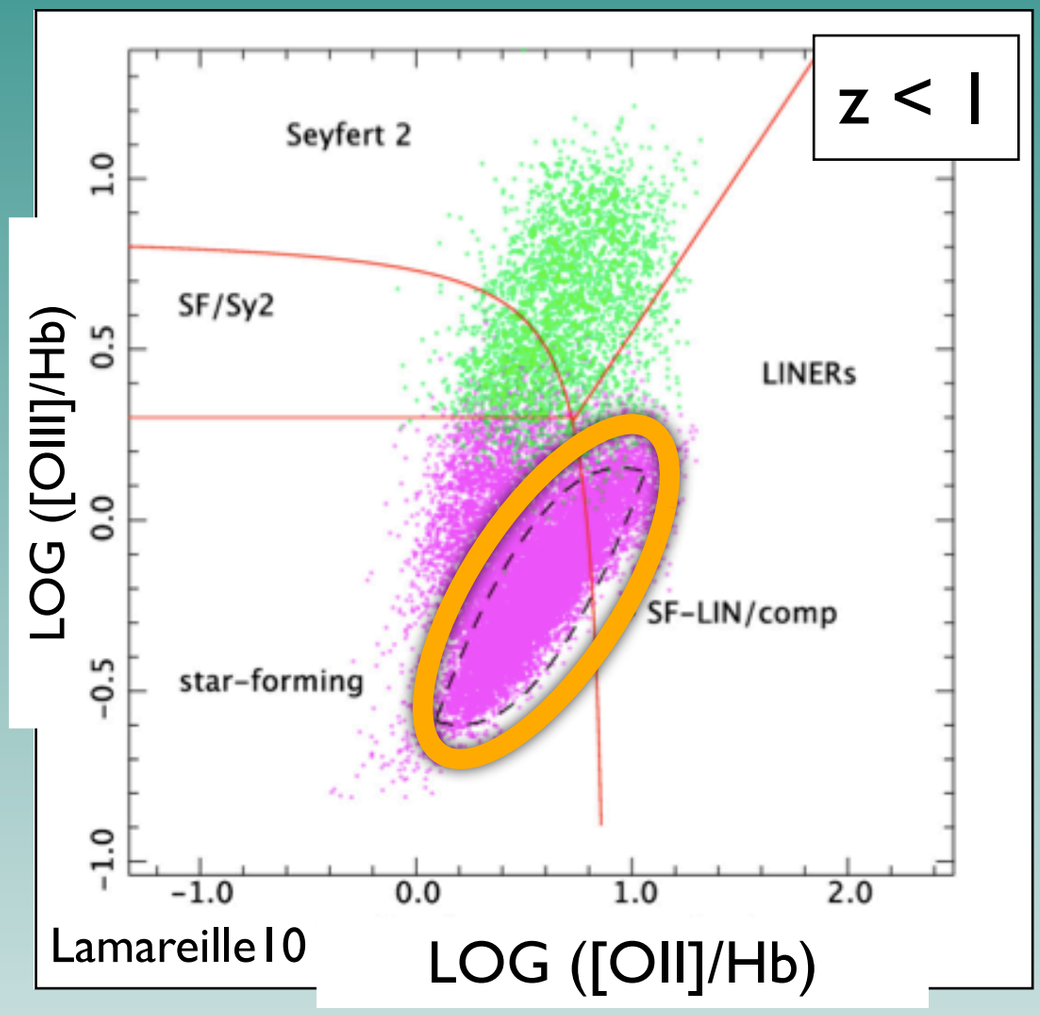

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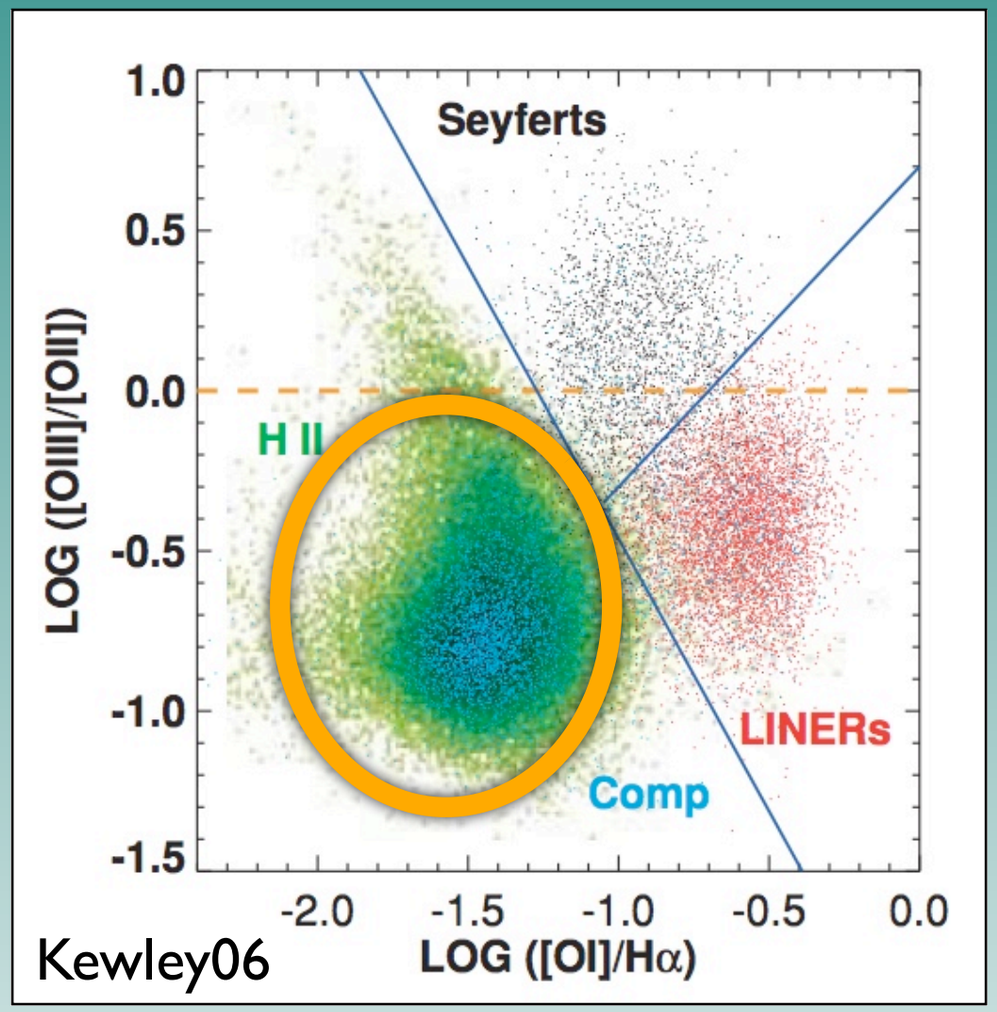
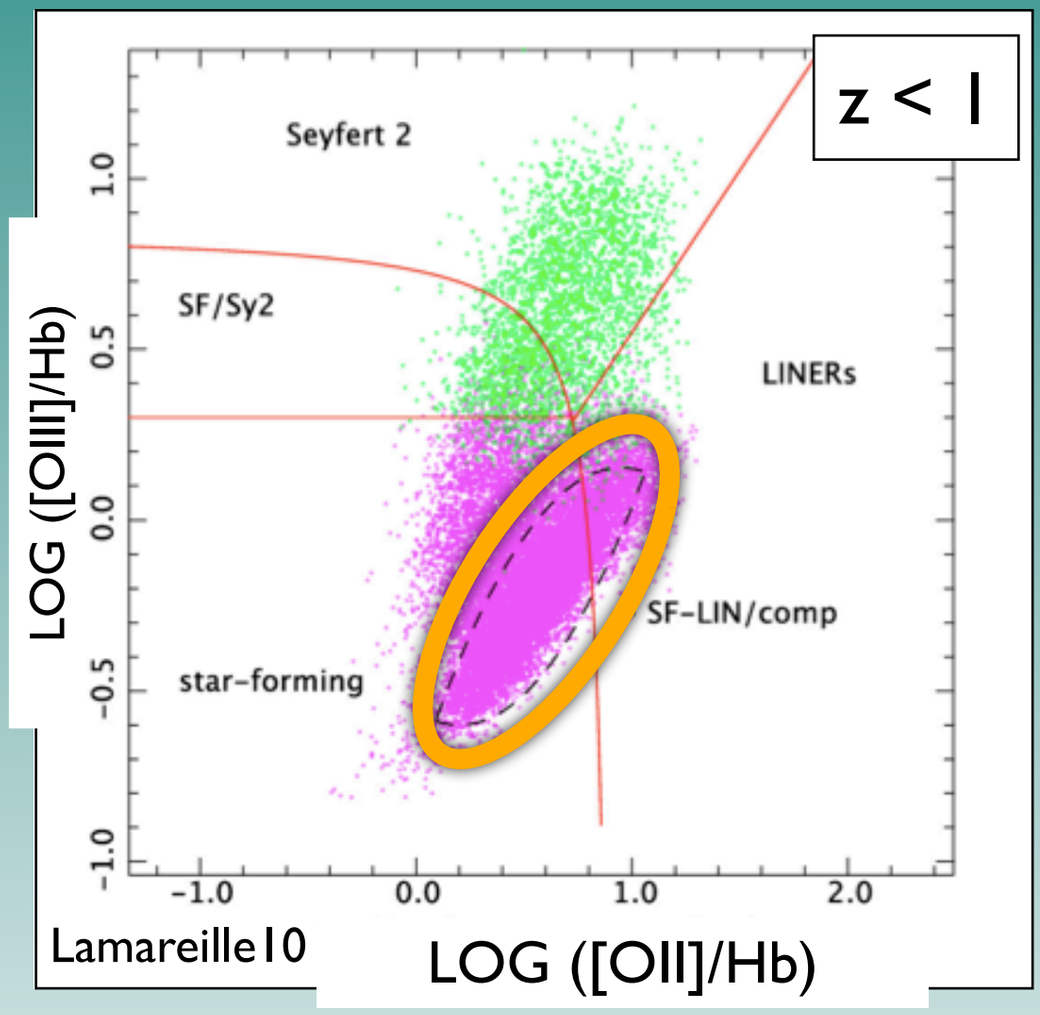
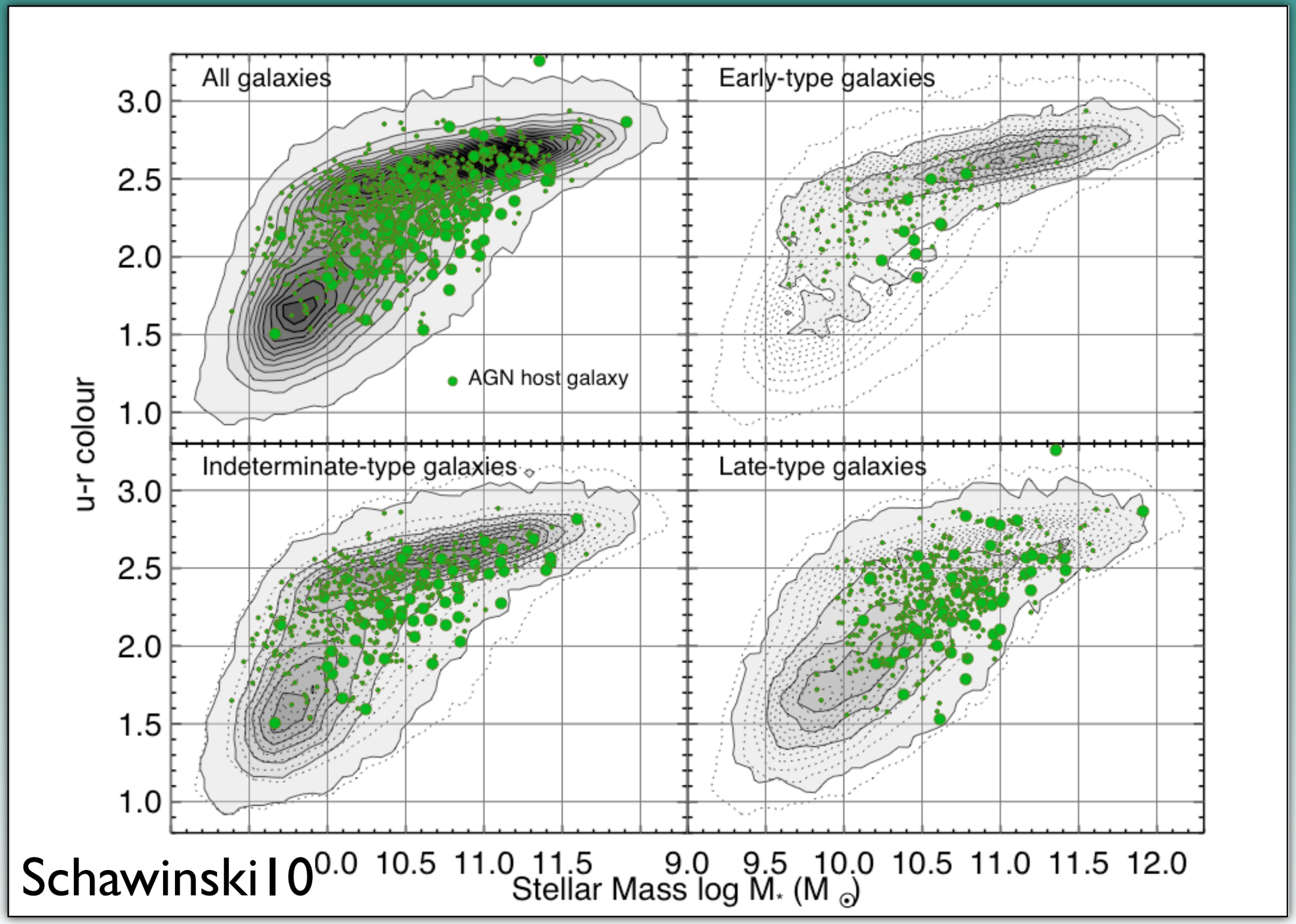




- 90% of BPT-comp lie in Kewley-HII regime
- 83% of BPT-comp lie in Lamareille-SF regime
- Kewley01: < 50% of BPT-comp ionizing flux is due to AGN
- 75% of BPT-comp lie in Yan11 CEx-SF regime

Impact of AGN activity on Galaxy Evolution: Excluded BPT-comp from AGN sample



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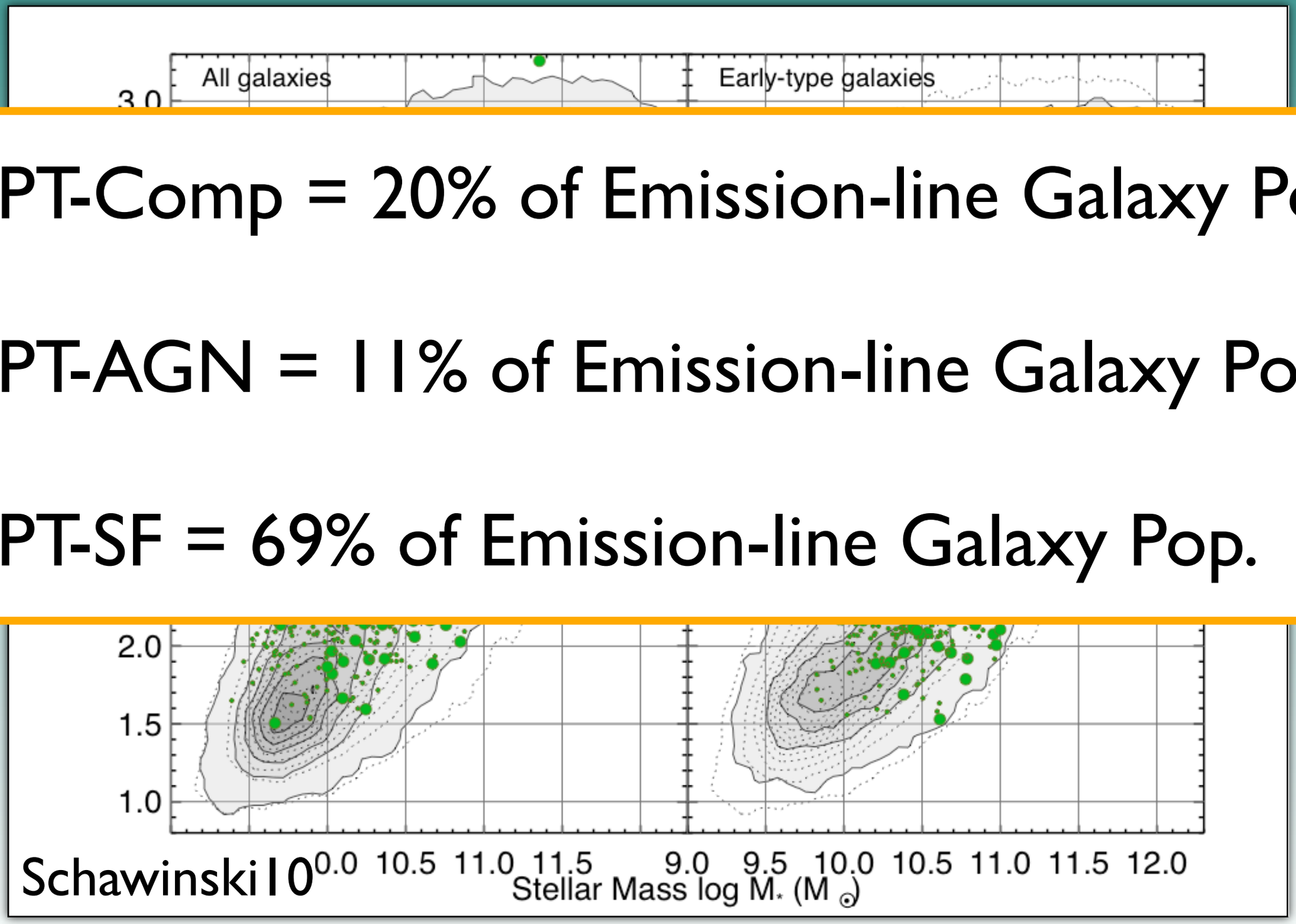

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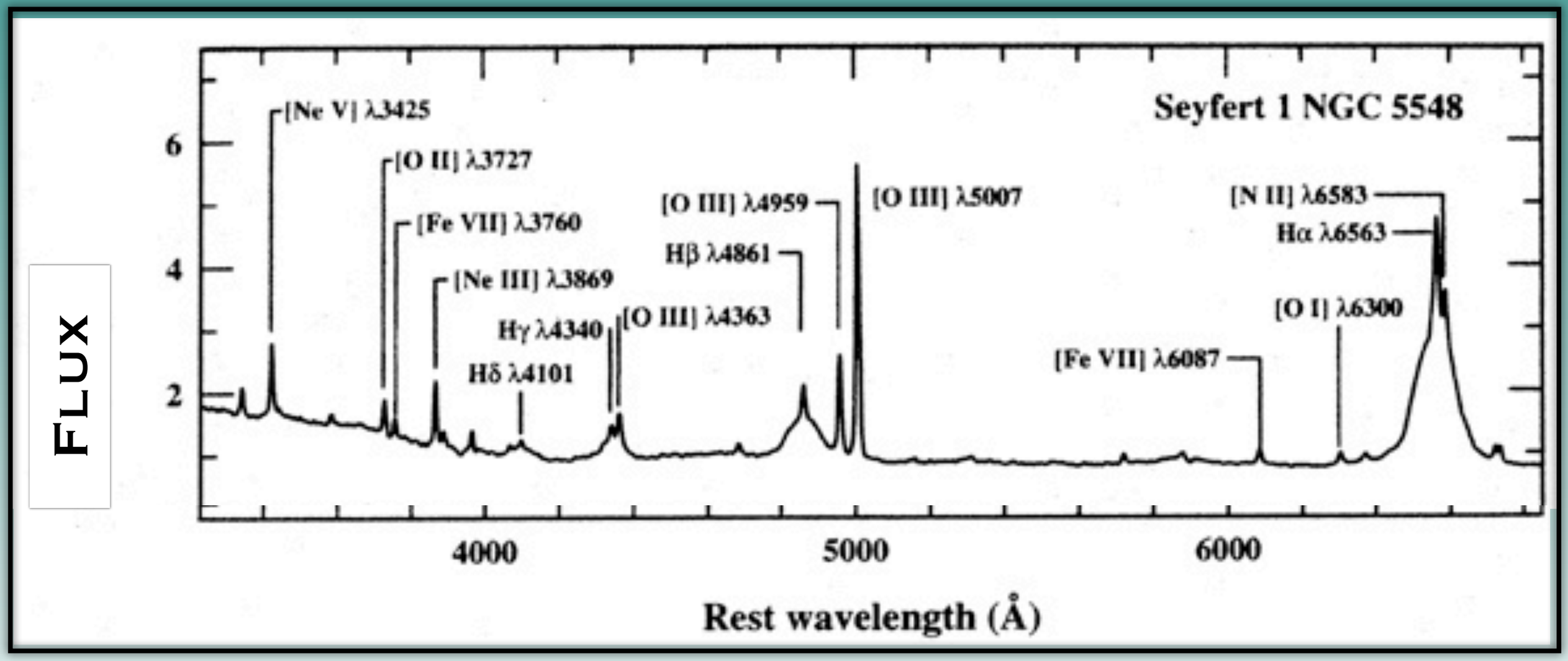
- BPT-AGN = 11% of Emission-line Galaxy Pop.
- BPT-SF = 69% of Emission-line Galaxy Pop.

The TBT Diagnostic (z < 1.4): Blue lines with higher ionization potential



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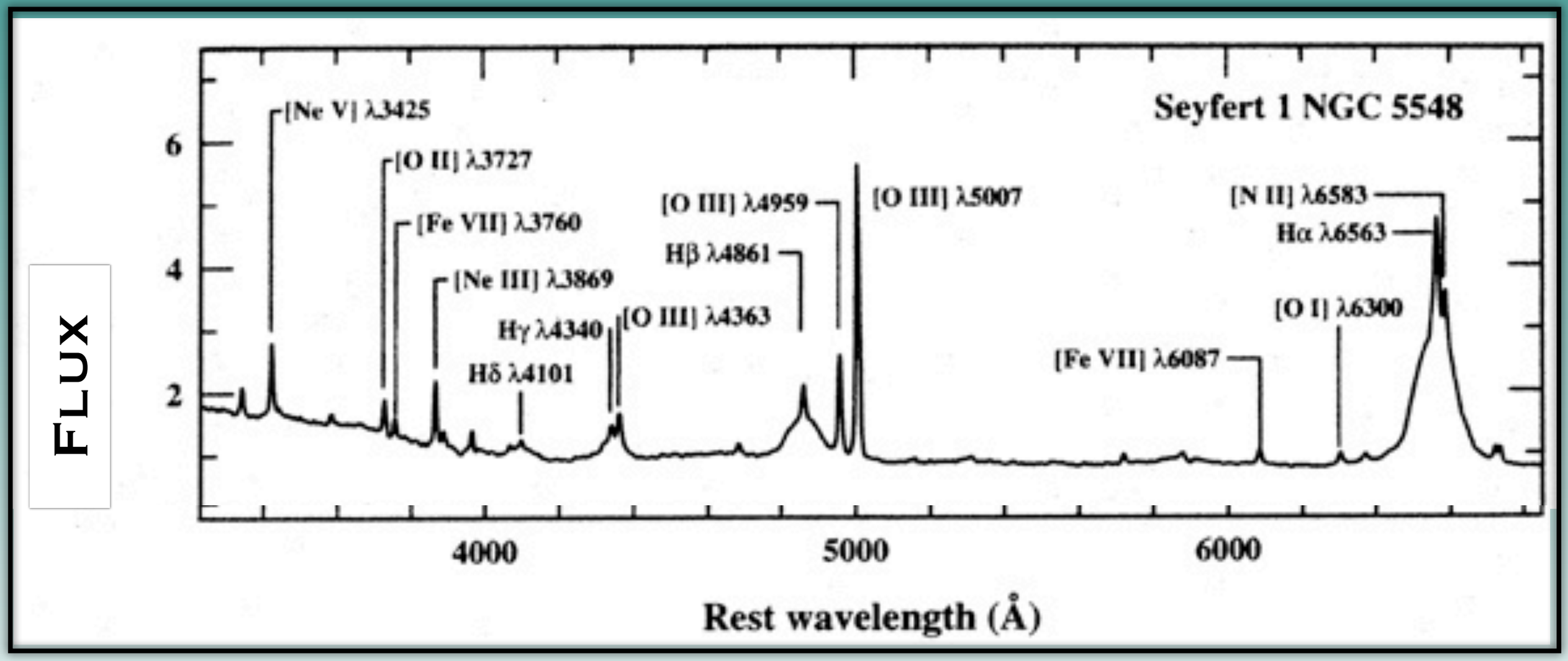
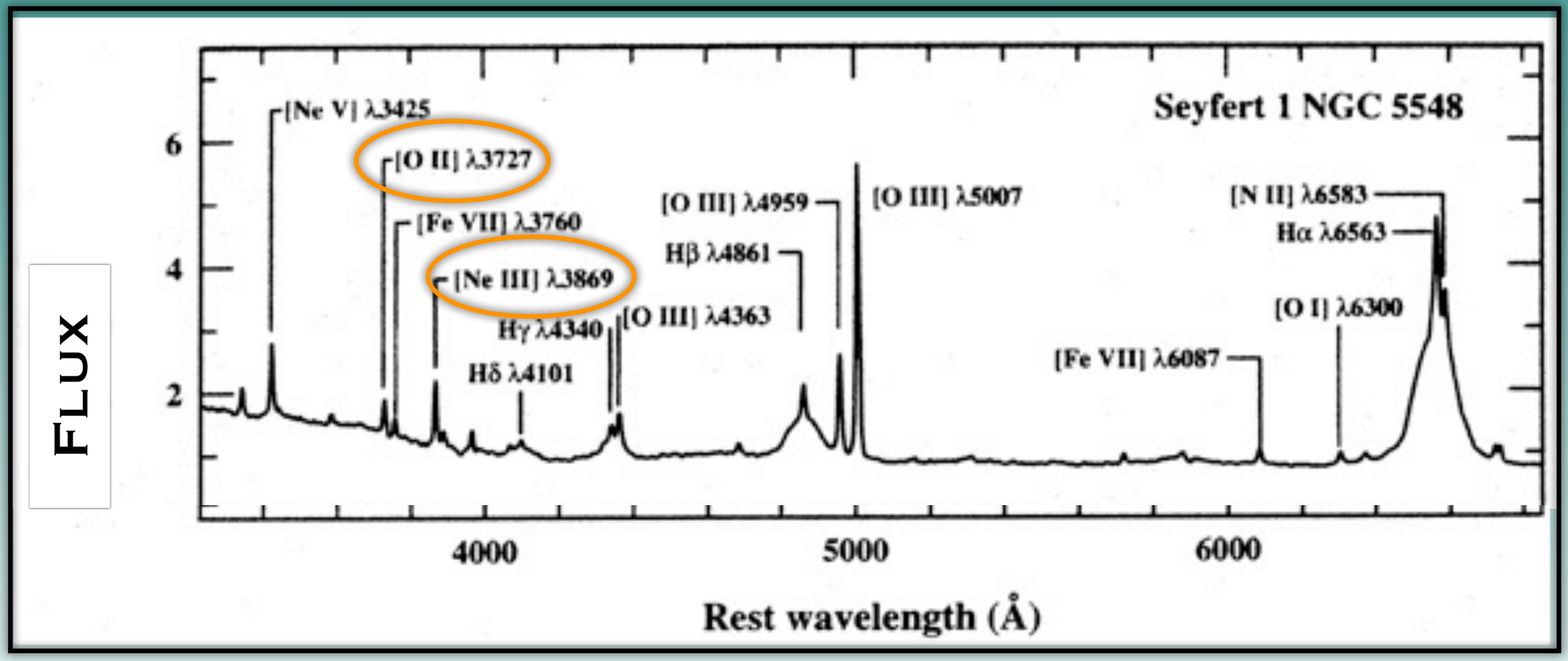


- BPT: $z < 0.5$
- 'Blue': $z < 1$
- CEx: $z < 1$
- MEx: $z < 1$

The TBT Diagnostic (z < 1.4): Blue lines with higher ionization potential



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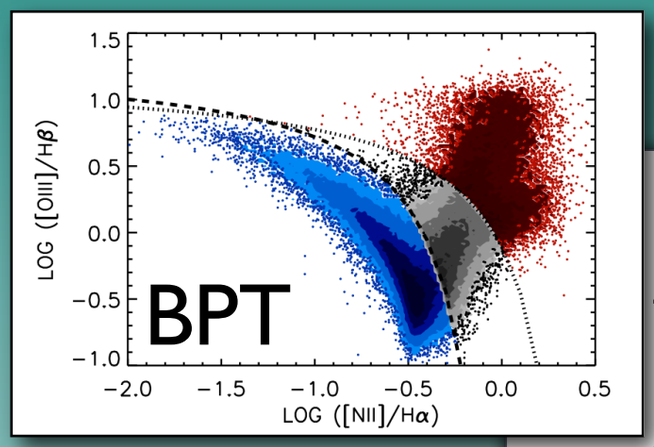
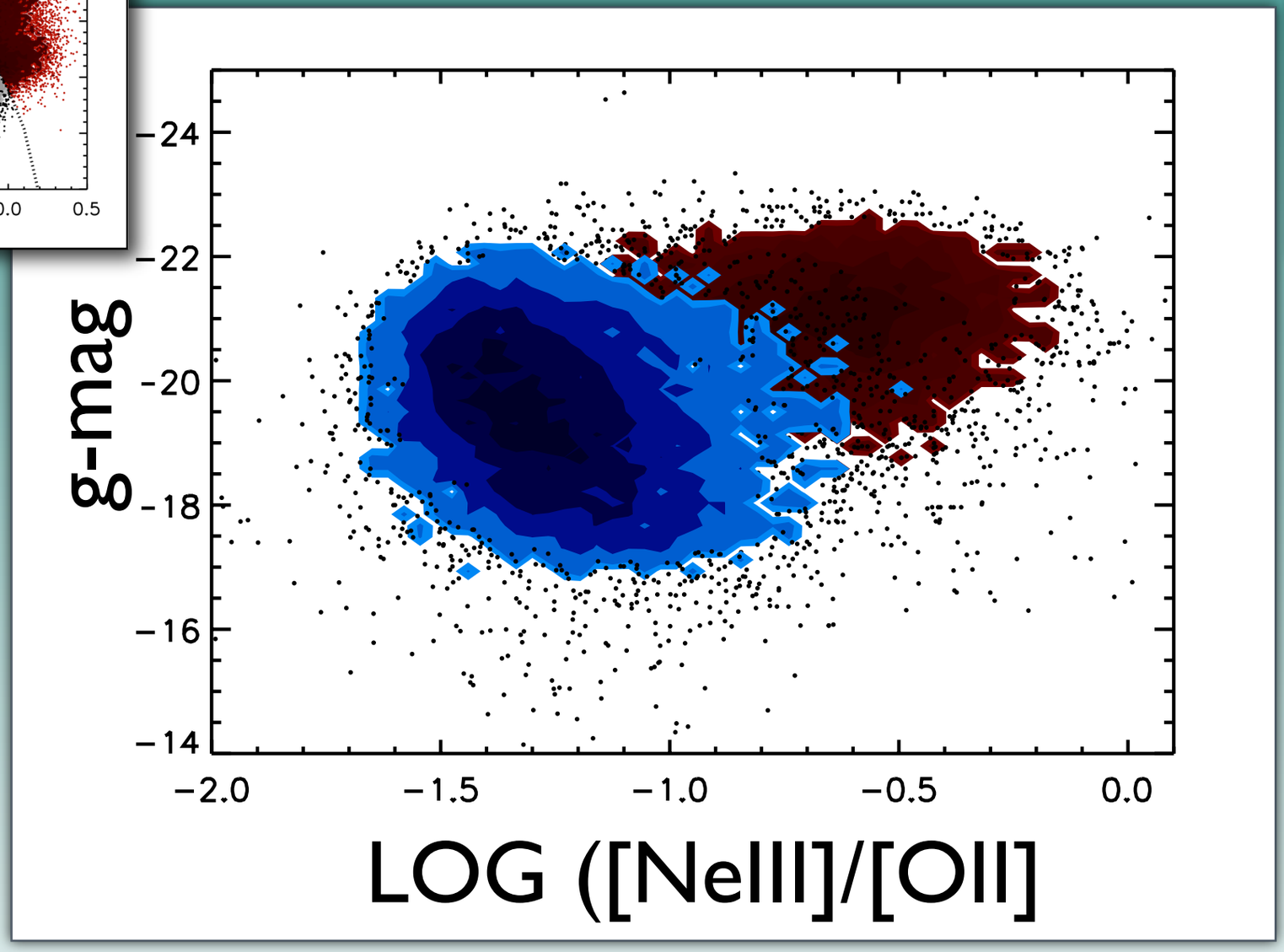
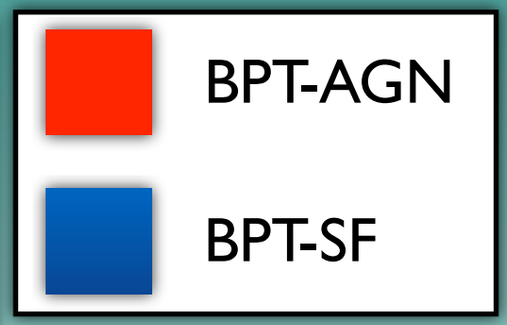
- MEx: z < 1

TBT Diagnostic (z < 1.4)

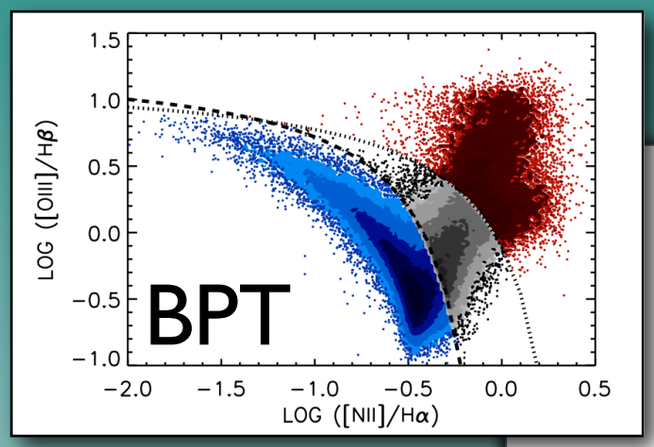


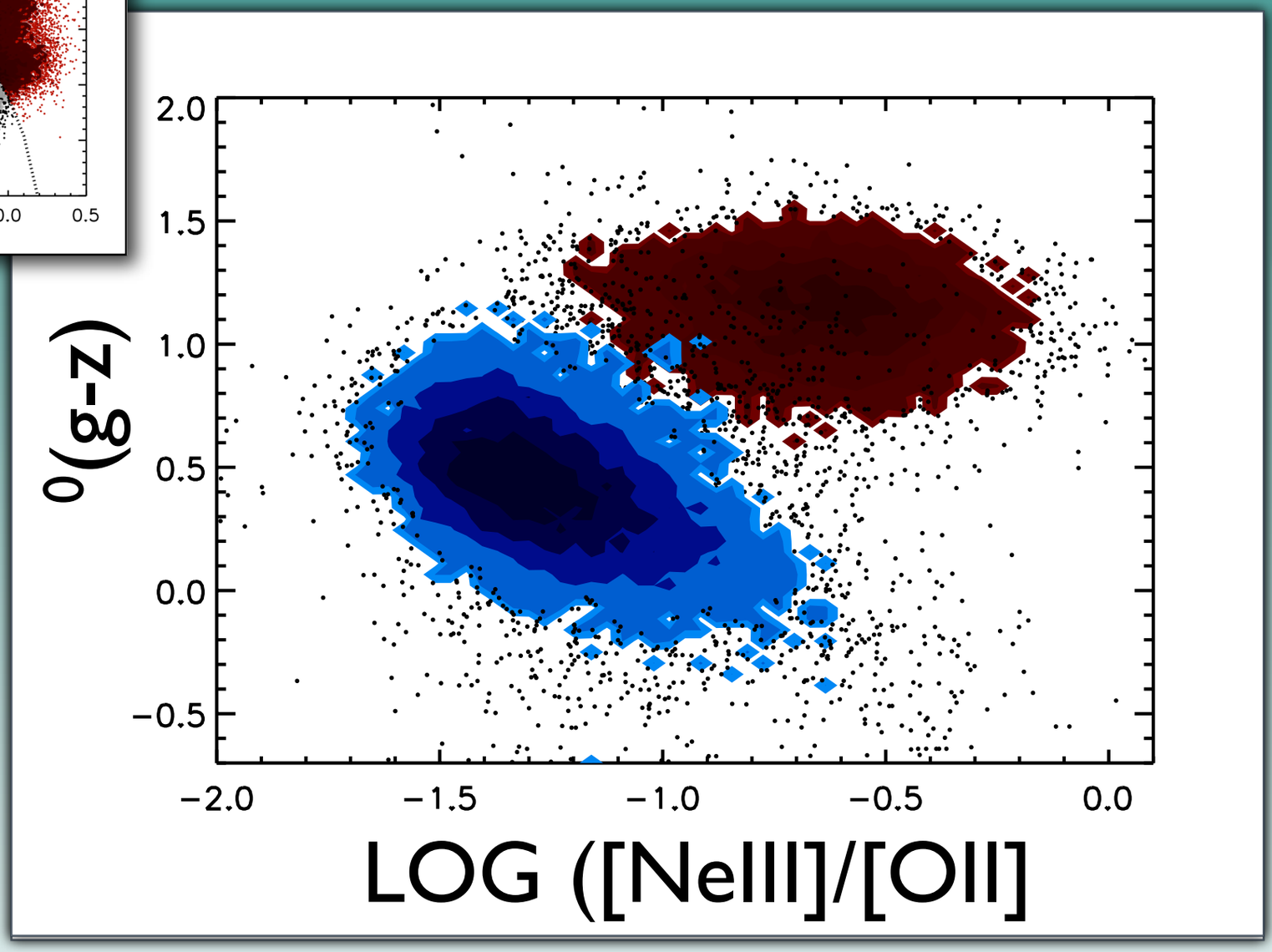


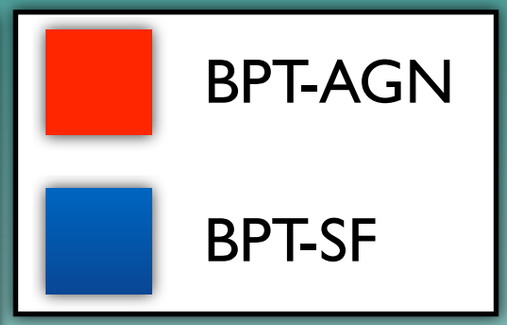


- Problem: Low metallicity BPT-SF have high [NeIII]/[OII]

TBT Diagnostic (z < 1.4)

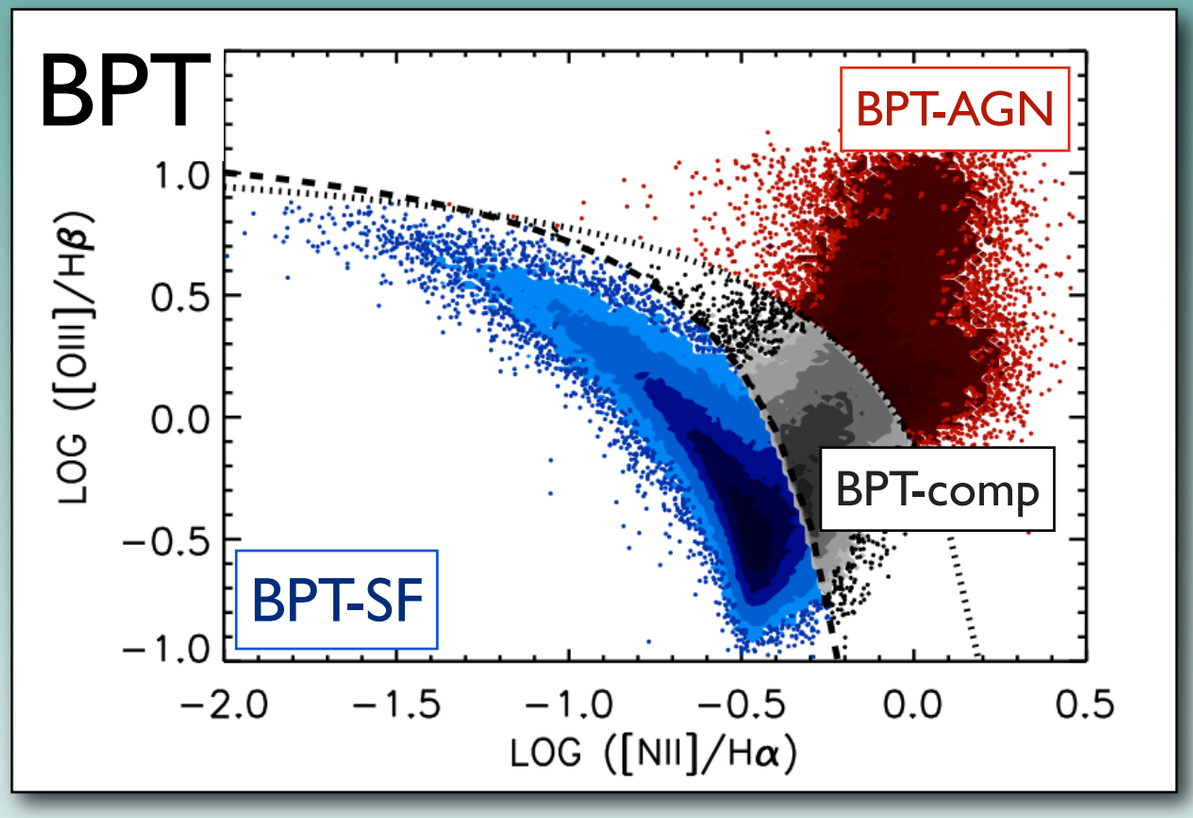


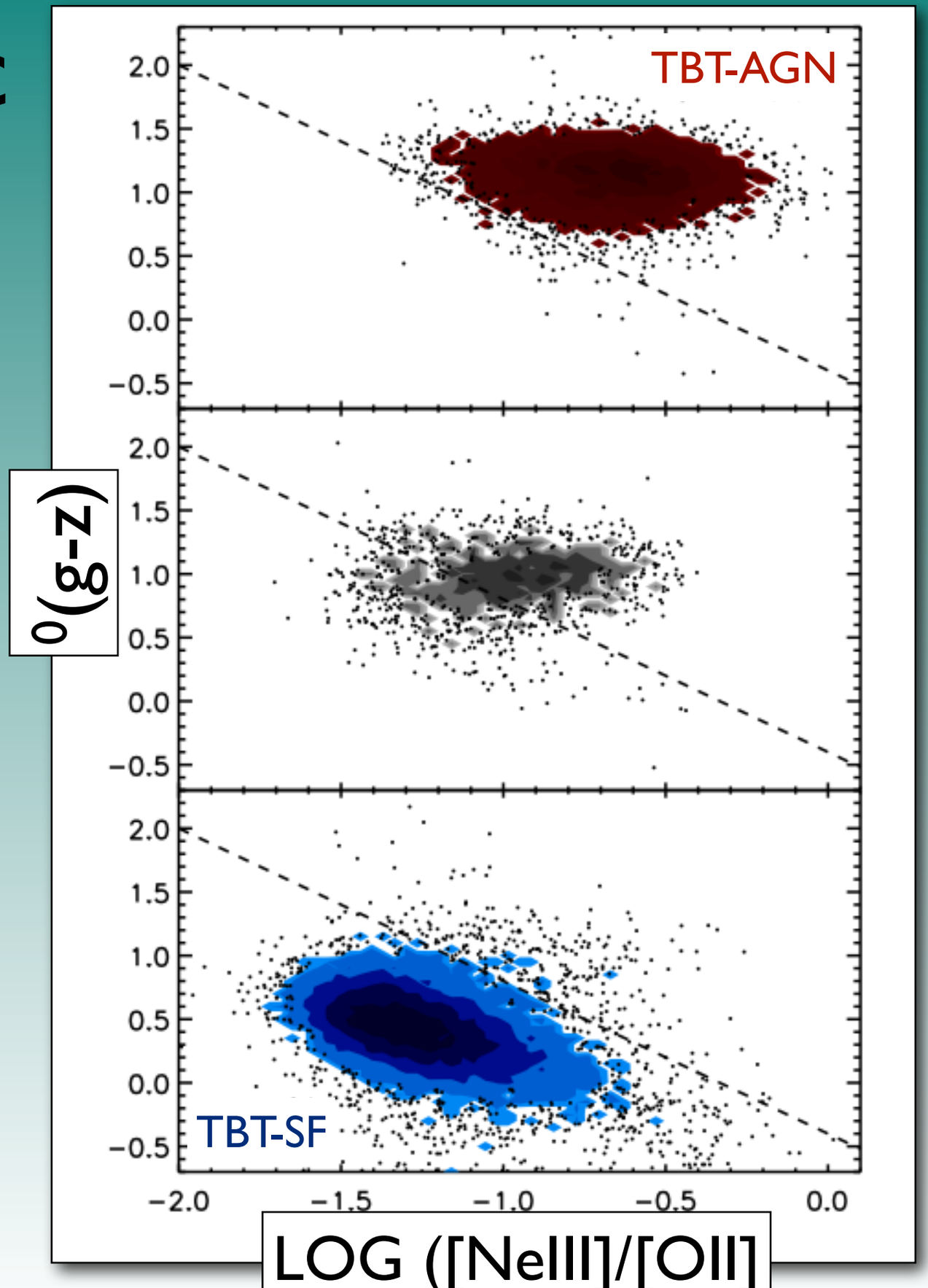




- Problem: Low metallicity BPT-SF have high [NeIII]/[OII]
- Solution: Low-metallicity BPT-SF are bluer (Tremonti04)

The TBT Diagnostic





The TBT Diagnostic

BPT-SF:

- 97% in TBT-SF regime

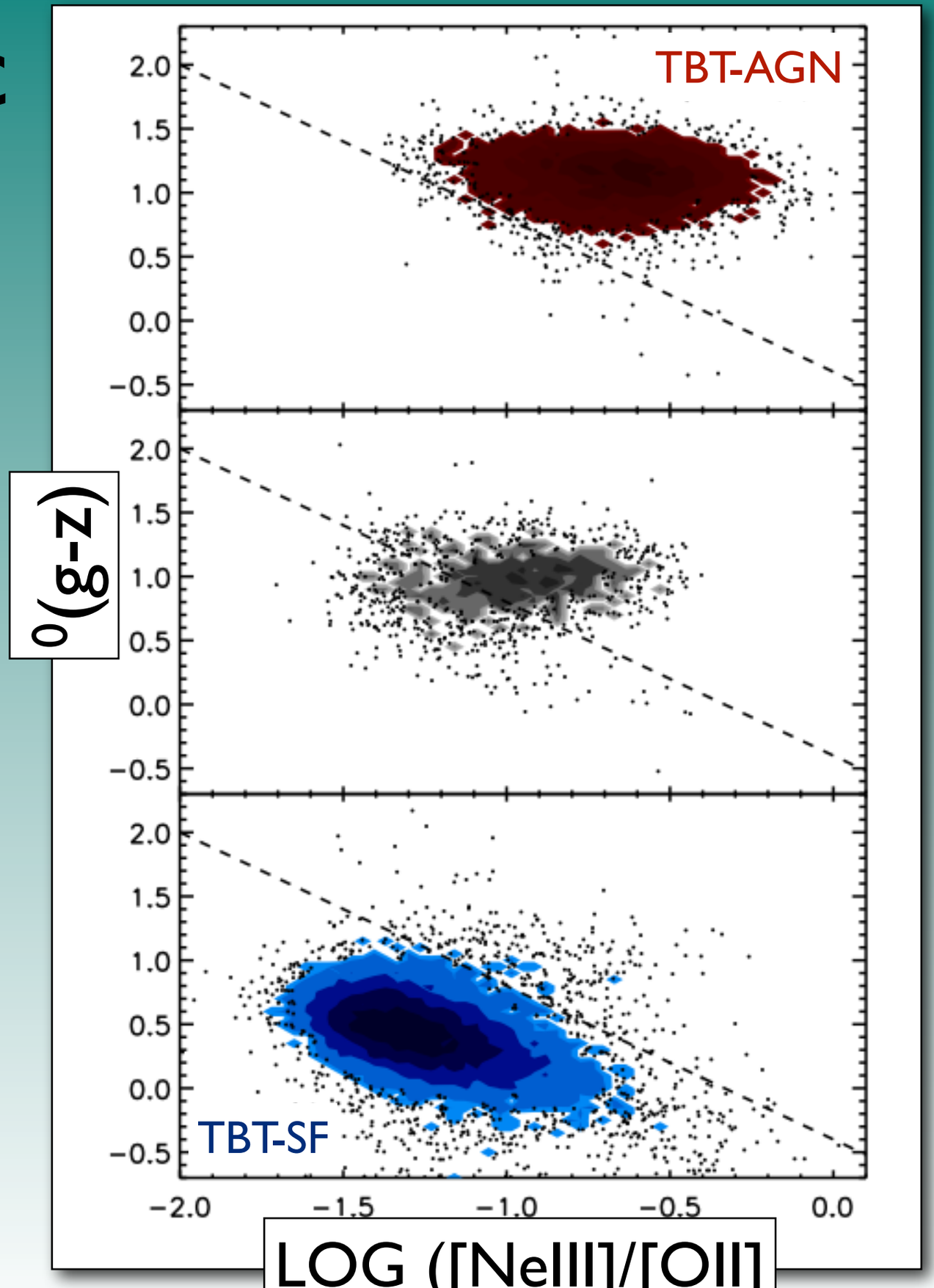
BPT-AGN:

- 99% in TBT-AGN regime

BPT-Comp:

- 69% in TBT-AGN regime

- 1% of sources in TBT-SF are BPT-AGN
- 3% of sources in TBT-AGN are BPT-SF



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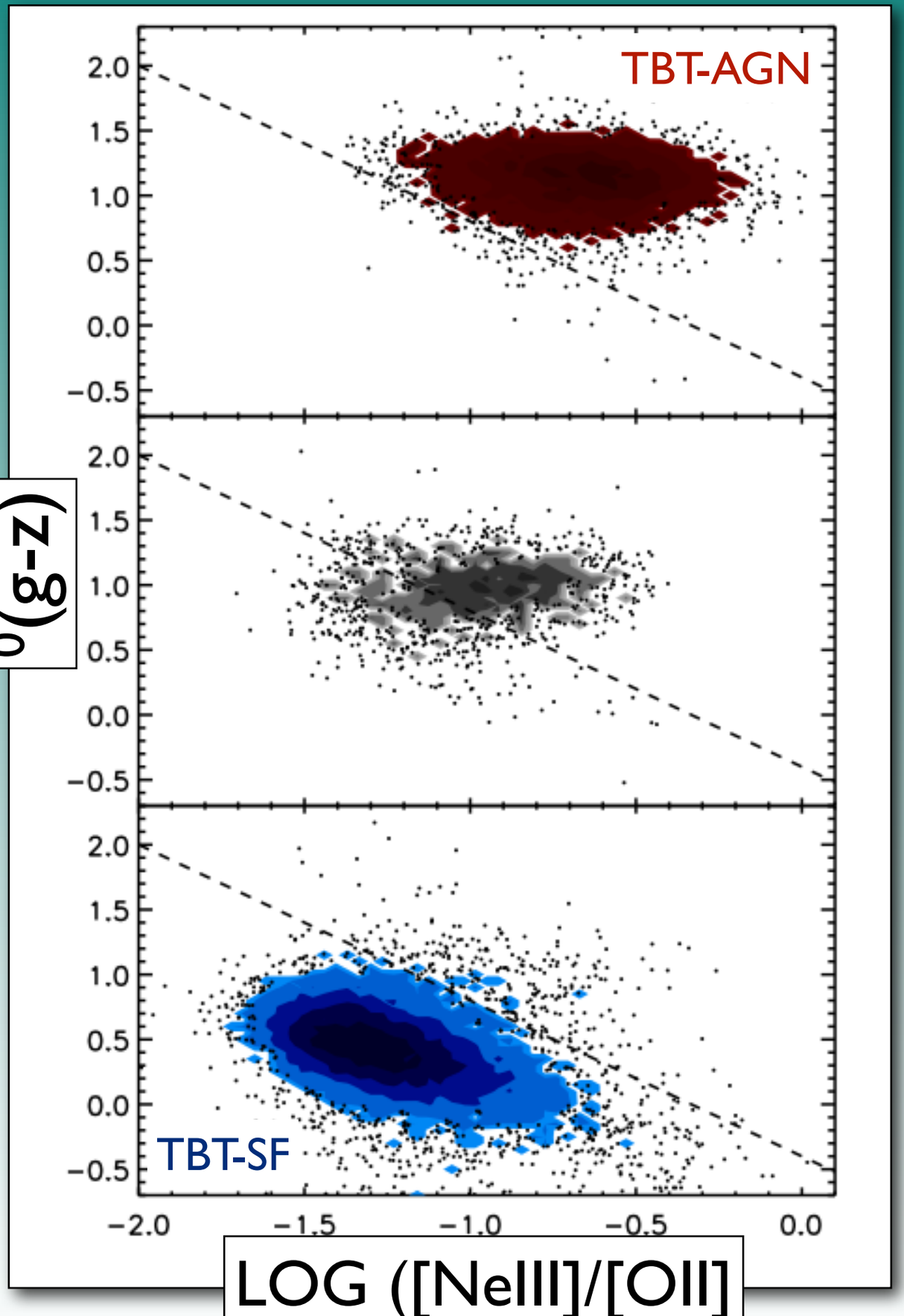
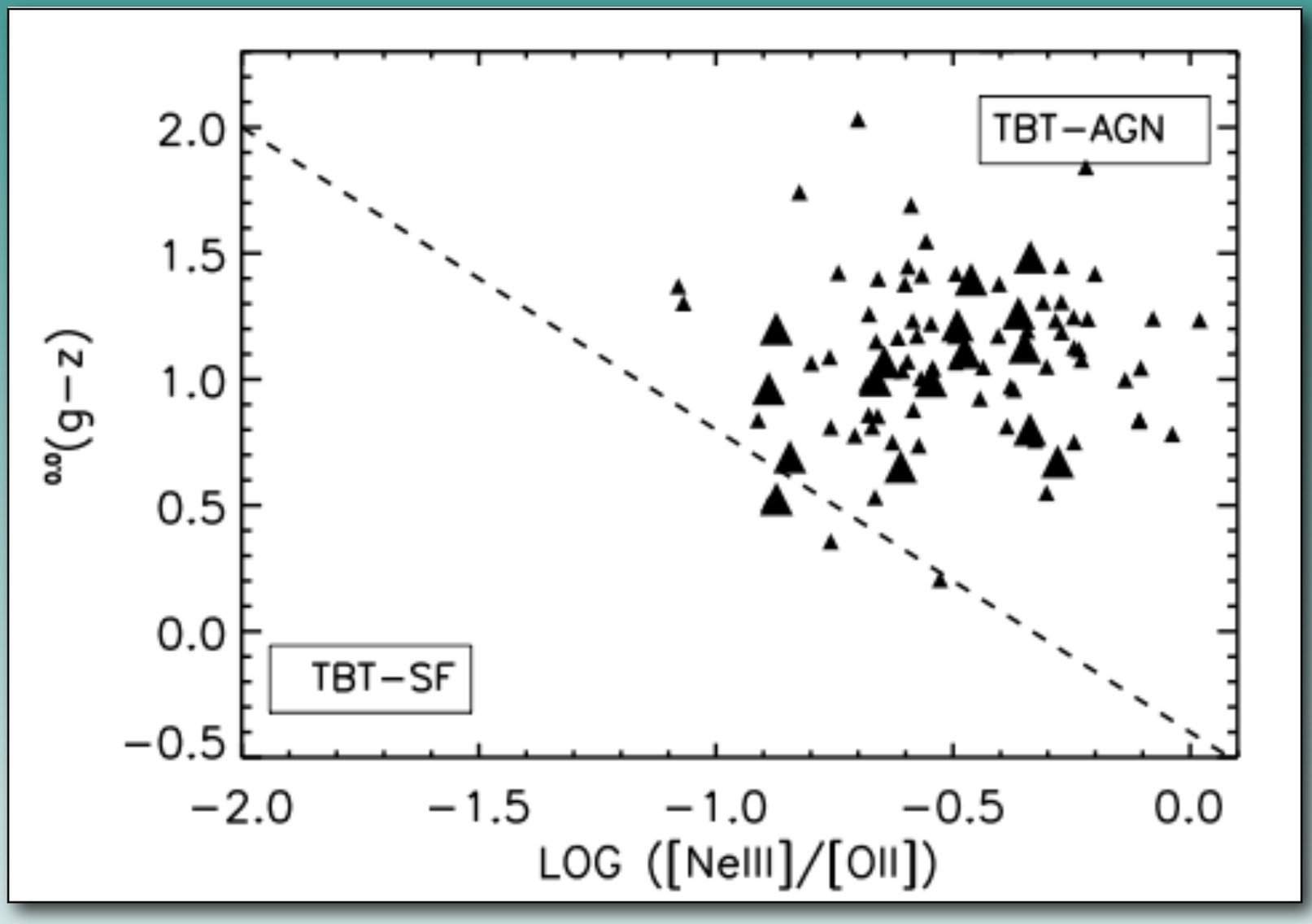


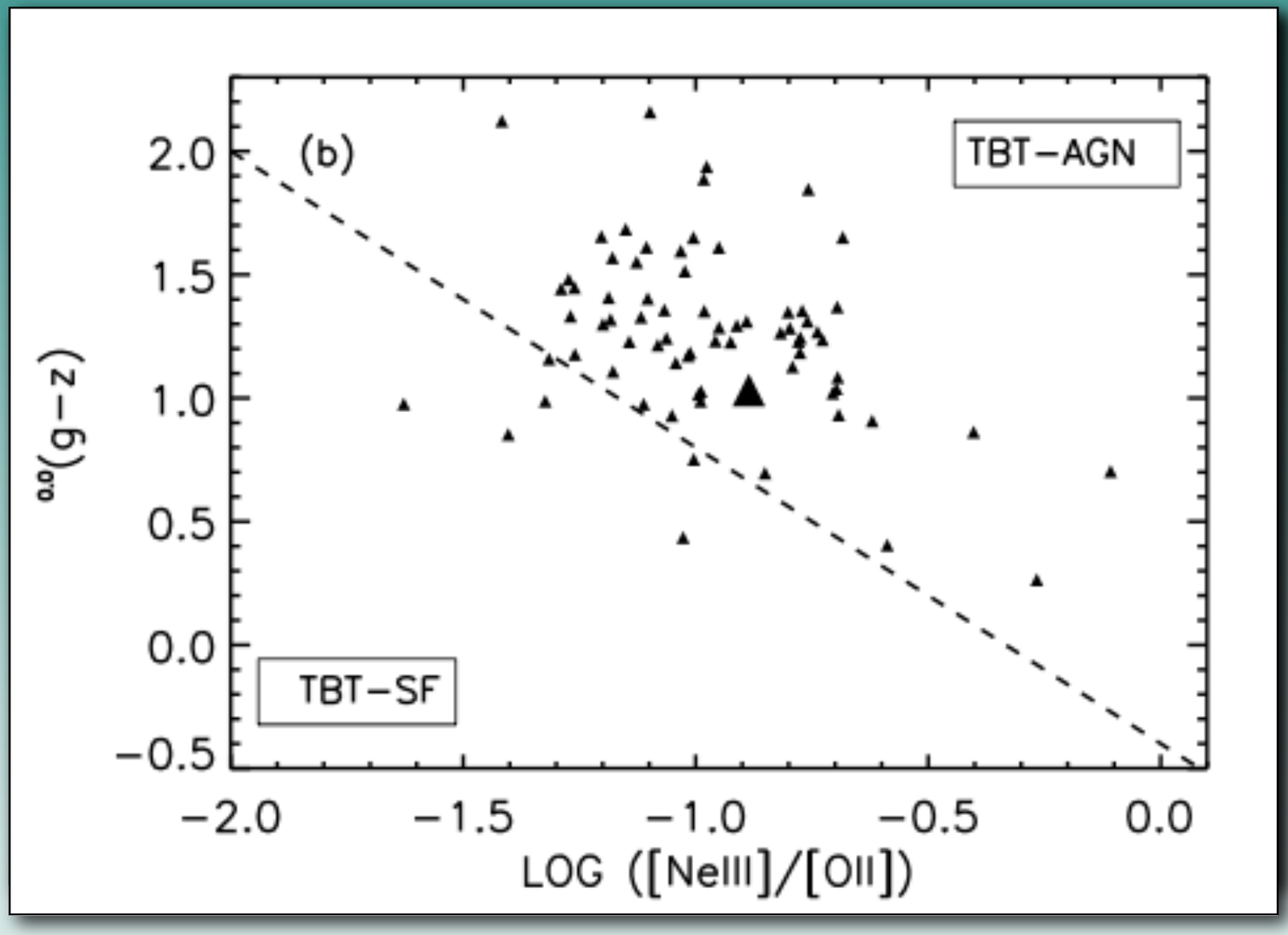
The TBT Diagnostic:
(OPTX X-ray selected sample of AGNs, z<1.4)



- 197 OPTX non-BLAGNs w/ Lx>10^{42} erg/s
- 103 [OII] & [NeIII] SNR>5
- 78 [OII] SNR>5, [NeIII] SNR<5
- 16 [OII] & [NeIII] SNR<5
- 0 [NeIII] SNR>5, [OII] SNR<5

- (a) 97% (100/103) recovery of X-ray selected AGNs

The TBT Diagnostic:
(OPTX X-ray selected sample of AGNs, z<1.4)



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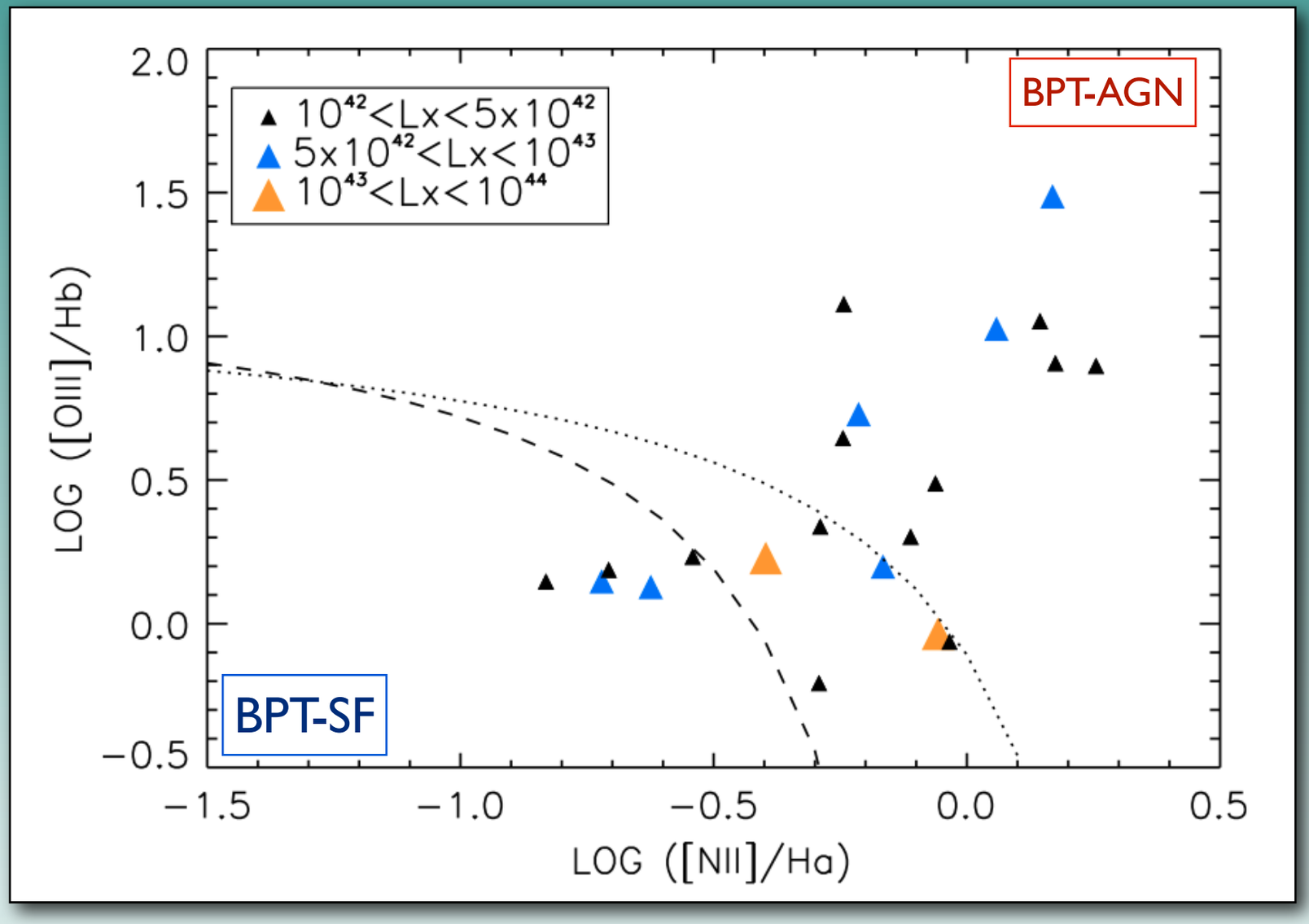
- 78 [OII] SNR>5, [NeIII] SNR<5
- 16 [OII] & [NeIII] SNR<5
- 0 [NeIII] SNR>5, [OII] SNR<5

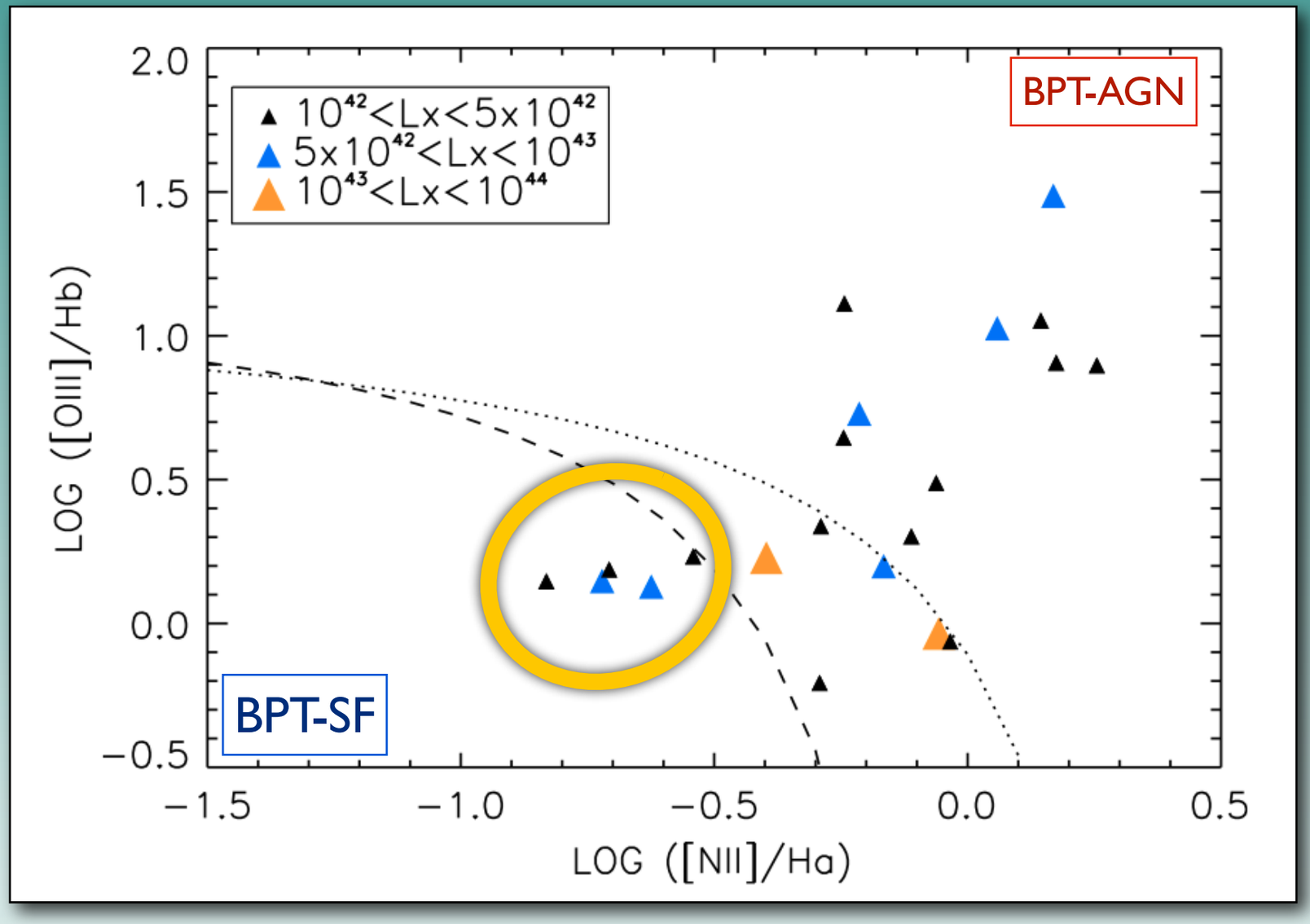
- (a) 97% (100/103) recovery of X-ray selected AGNs
- (b) 92% (72/78) recovery of X-ray selected AGNs

Low ionization emission-line diagnostics: (OPTX X-ray selected sample of AGNs, z < 0.5)



- BPT misidentifies 20% of OPTX X-ray selected AGNs as BPT-SF

Low ionization emission-line diagnostics: (OPTX X-ray selected sample of AGNs, z < 0.5)



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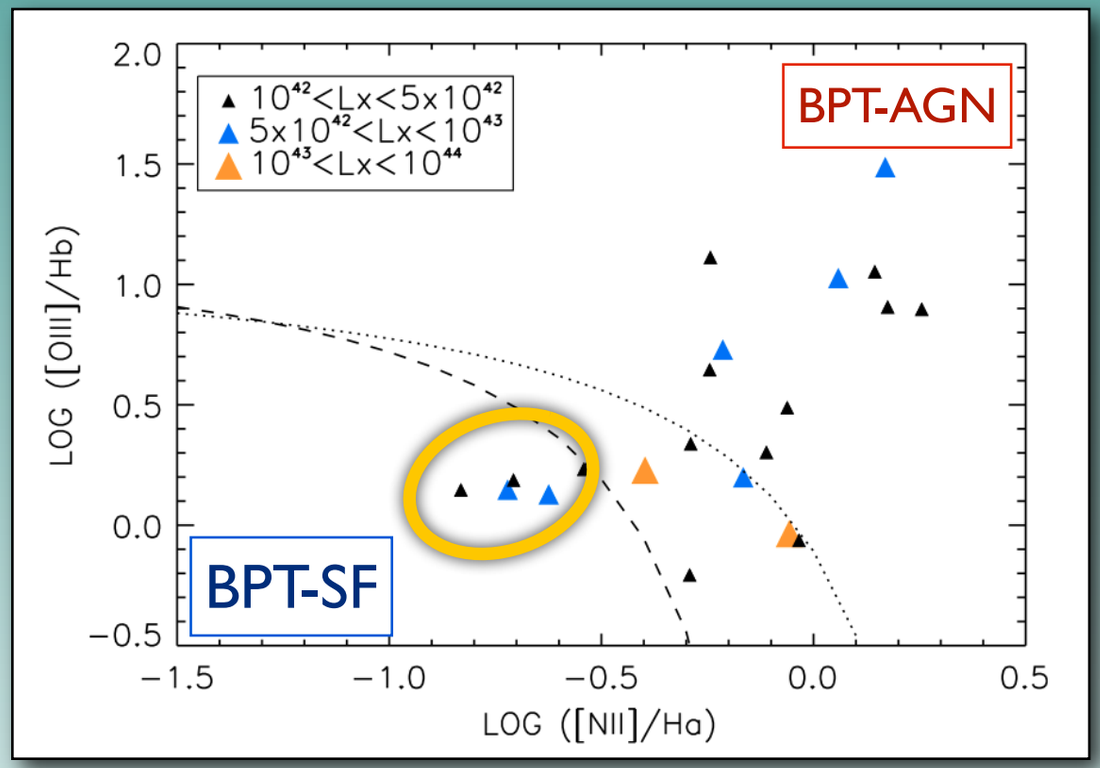
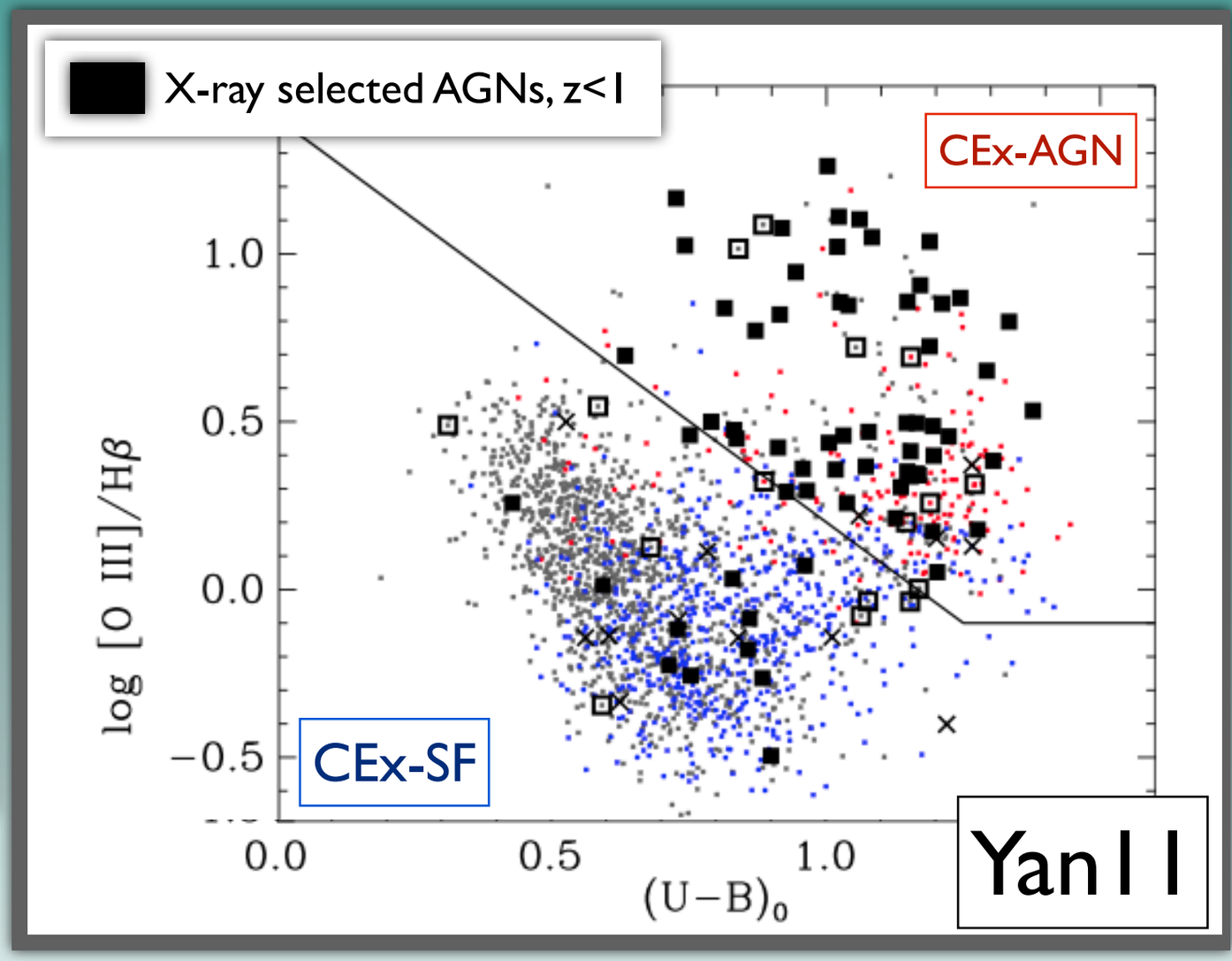
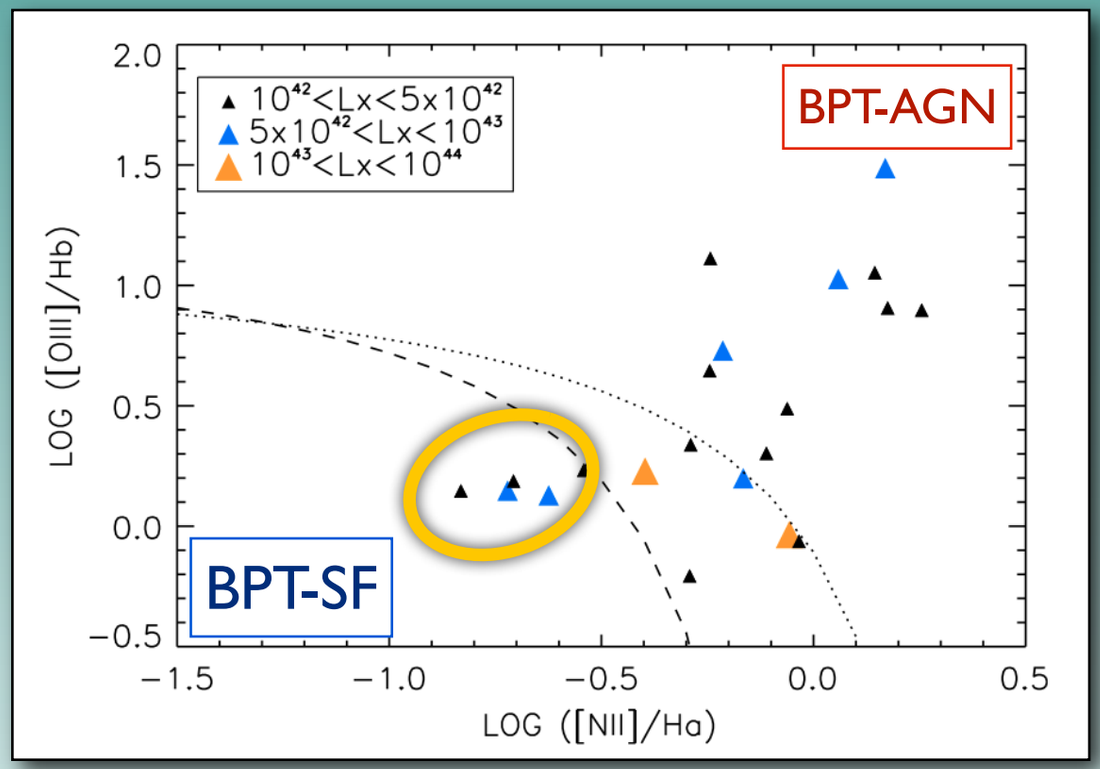
Low ionization emission-line diagnostics: X-ray Selected AGNs

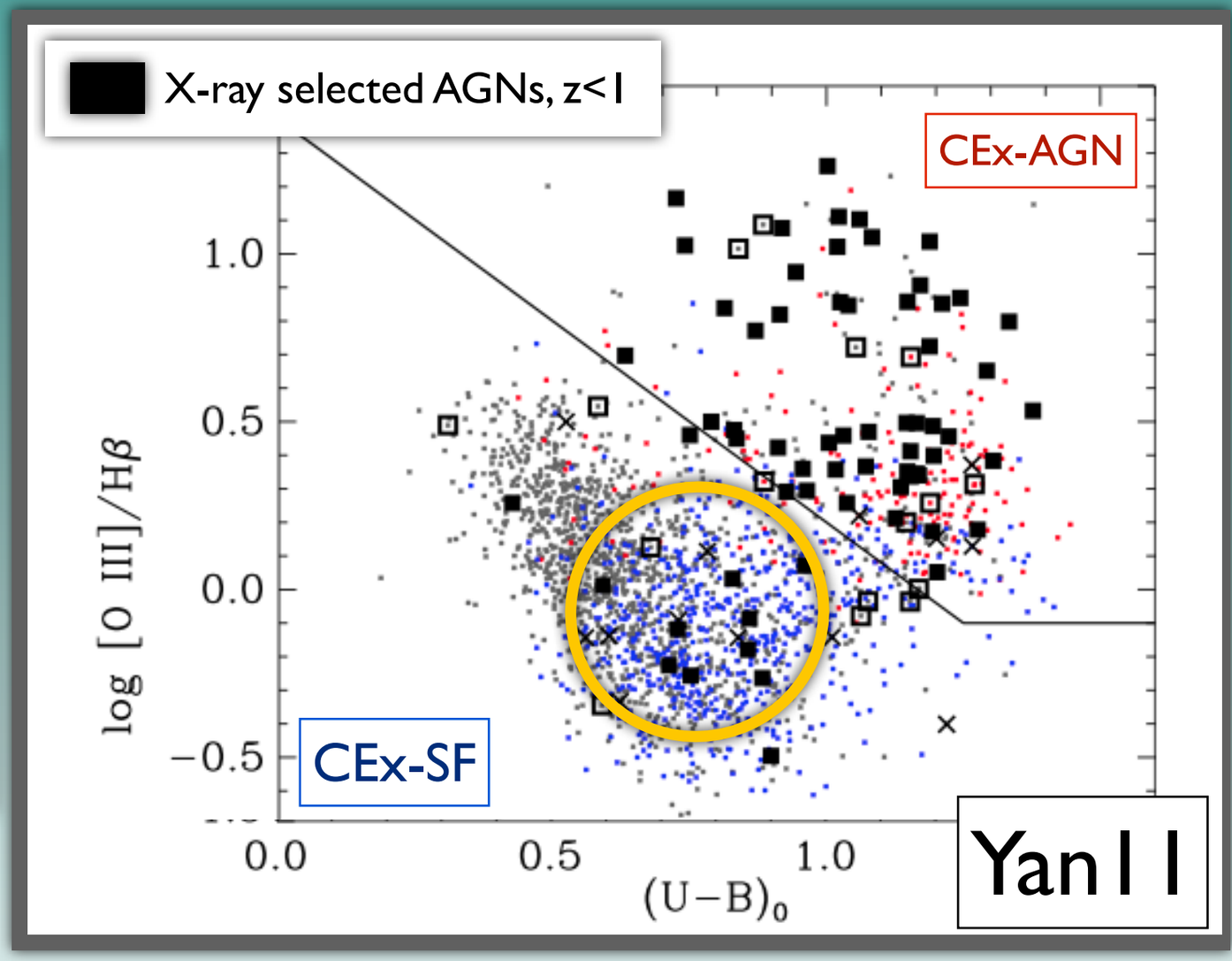




- BPT misidentifies 20% as BPT-SF
- CEx misidentifies 22% as CEx-SF

Low ionization emission-line diagnostics: X-ray Selected AGNs





- BPT misidentifies 20% as BPT-SF
- CEx misidentifies 22% as CEx-SF

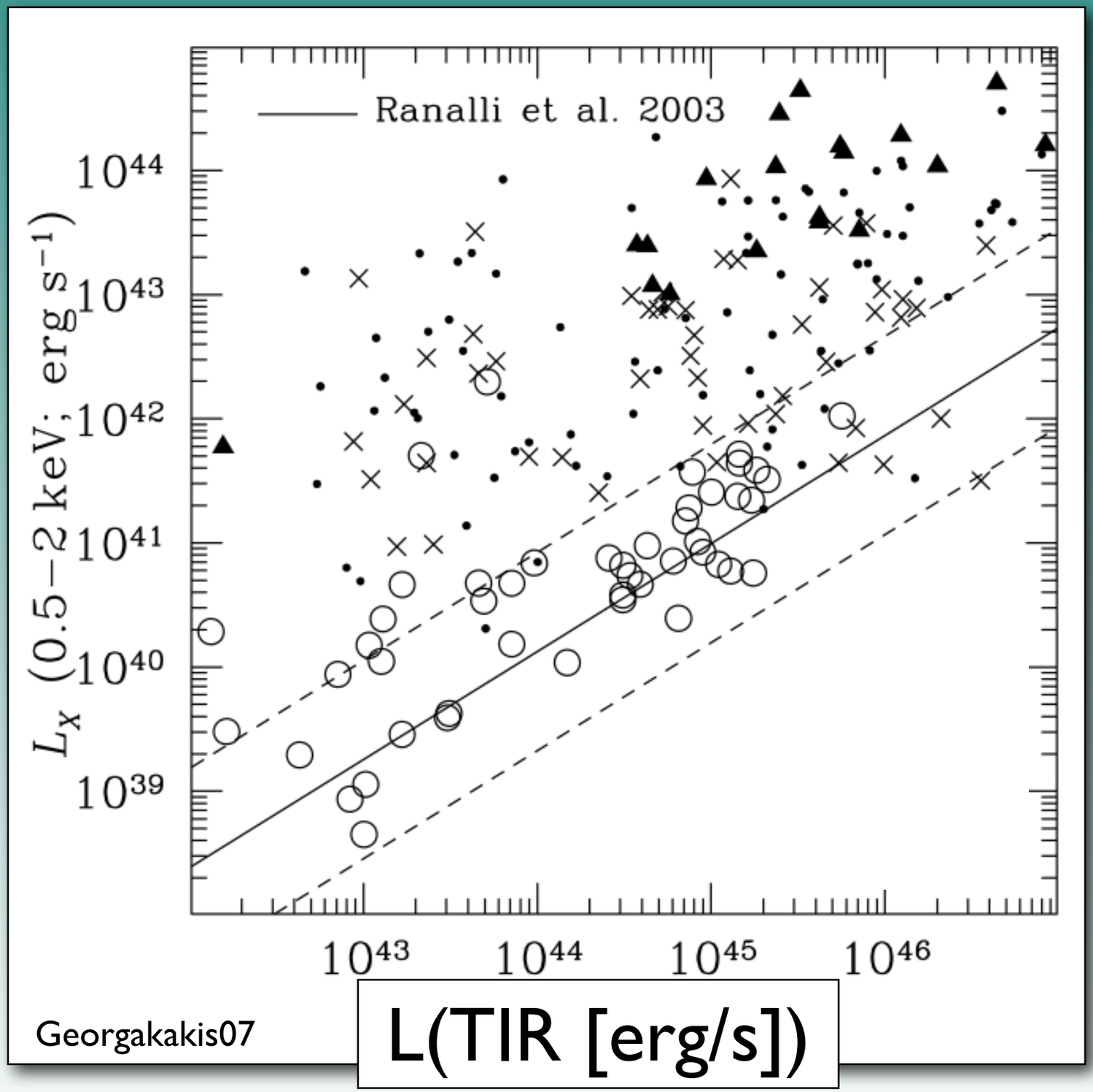
Stacking Analysis: X-ray

X-ray spectral slope, Γ_{eff}, can indicate source type:

- **X-ray Soft: $\Gamma_{eff} > 1.7$**
  - Unobscured AGNs*
  - LMXBs, assoc. with old stellar pops
- **X-ray Hard: $\Gamma_{eff} < 1.4$**
  - Obscured AGNs*
  - HMXBs, assoc. with ongoing SF: $\Gamma_{eff} = 0.5 - 1$

XRB studies: Hornschemeier, Lehmer, et al.; Colbert04; Fabbiano06; Remillard06

Stacking Analysis: IR/X-ray

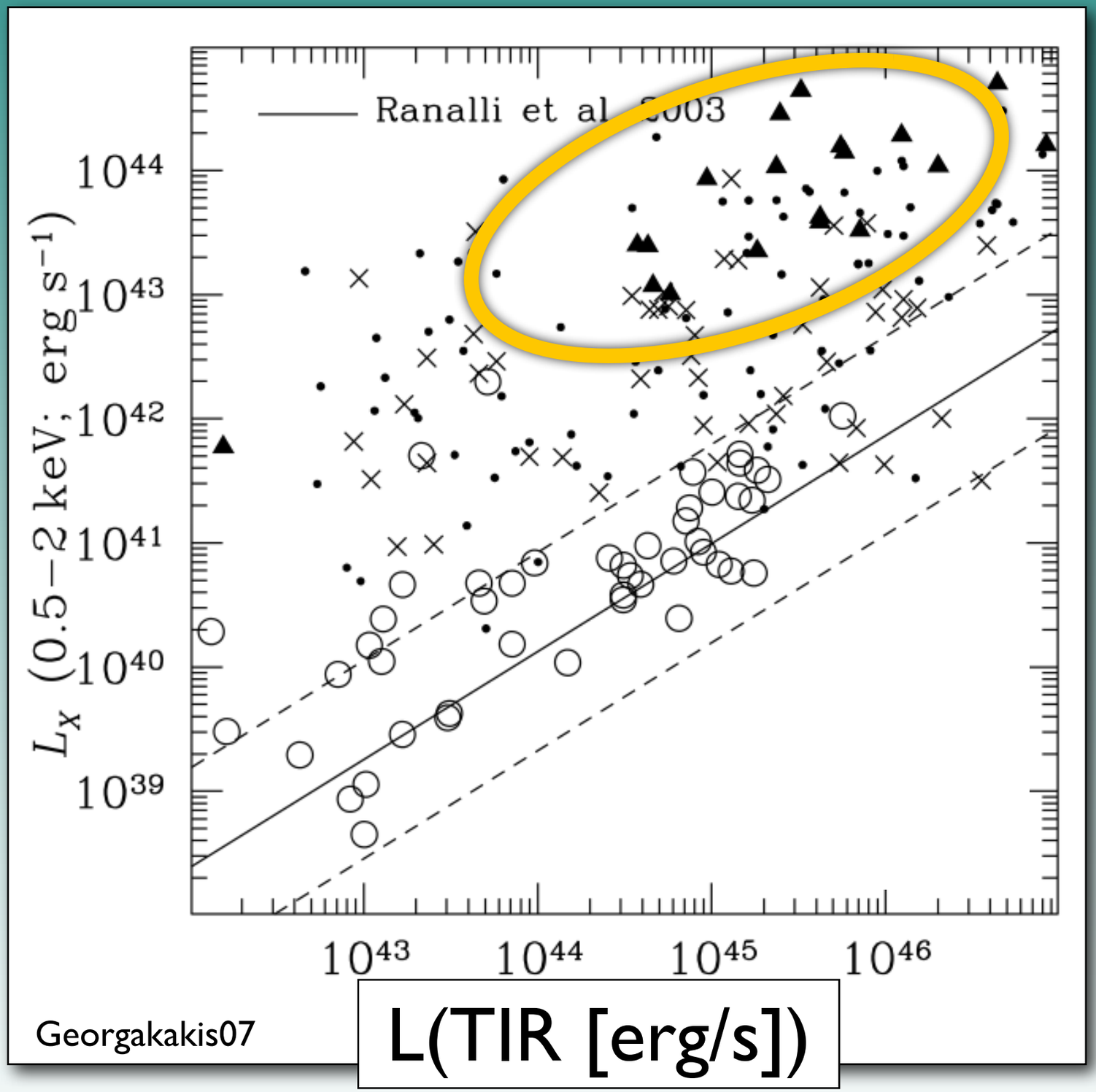


AGN-Type I

AGN-Type II

Star former

Stacking Analysis: IR/X-ray

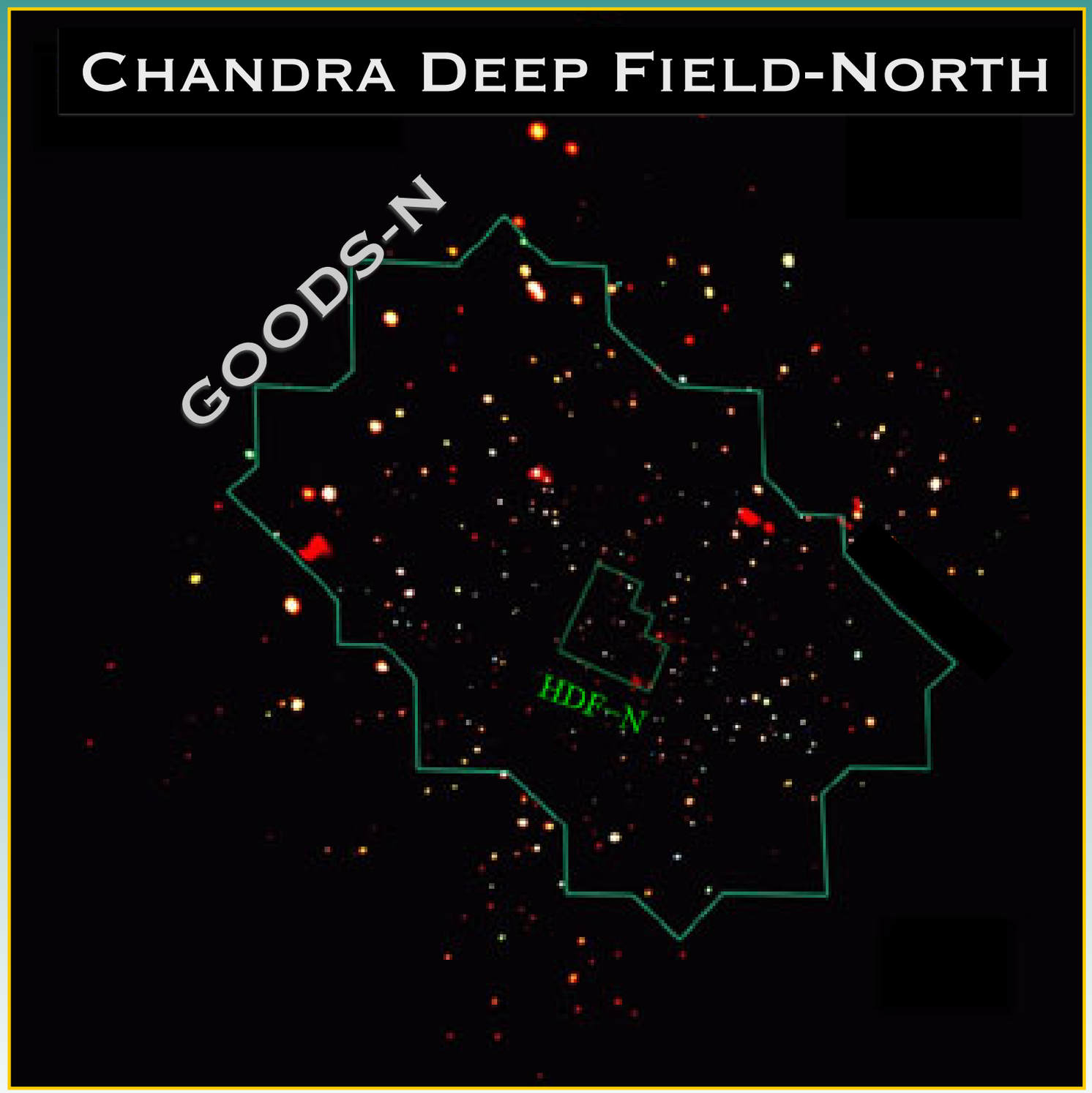


AGN-Type I

AGN-Type II

Star former

GOODS-N/LH Galaxy Sample



- 2710 galaxy spectra, GOODS-N (>90% complete)
- 3082 galaxy spectra, LH fields

X-ray Stacking Results

STACKFAST (Hickox et al.)

SF Categories: X-ray Soft

- TBT-SF: 148 sources, $\Gamma_{eff,} = 1.7^{+0.5}_{-0.4}$ (caveat: 2-8 keV only 2 sigma)
- BPT-SF: 448 sources, $\Gamma_{eff,} = 1.5^{+0.7}_{-0.3}$ (caveat: 2-8 keV only 2 sigma)

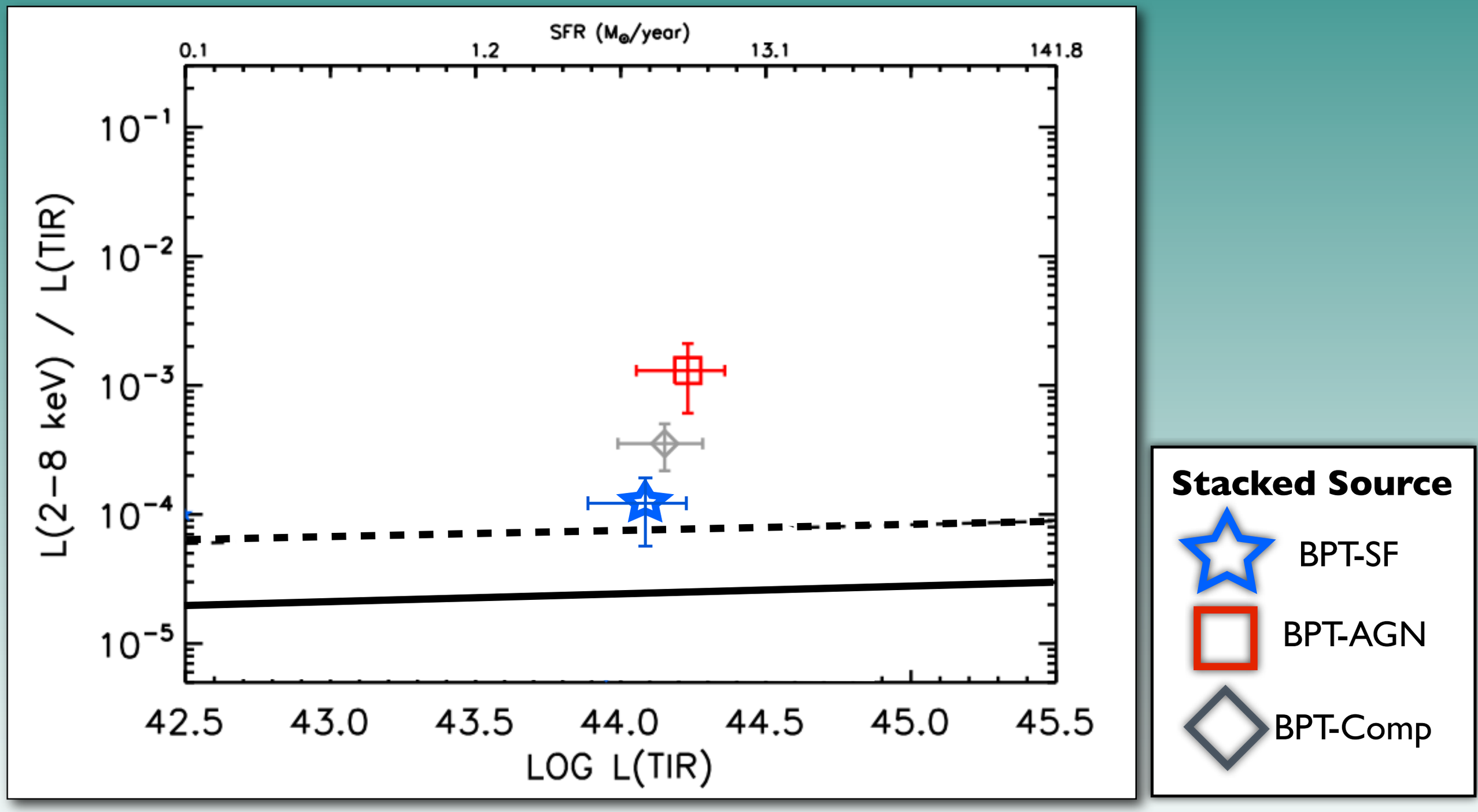
AGN Categories: X-ray Hard

- TBT-AGN: 54 sources, $\Gamma_{eff,} = 1.0^{+0.3}_{-0.3}$ (both bands > 4 sigma detection)
- BPT-AGN: 17 sources, < 2 sigma in both bands

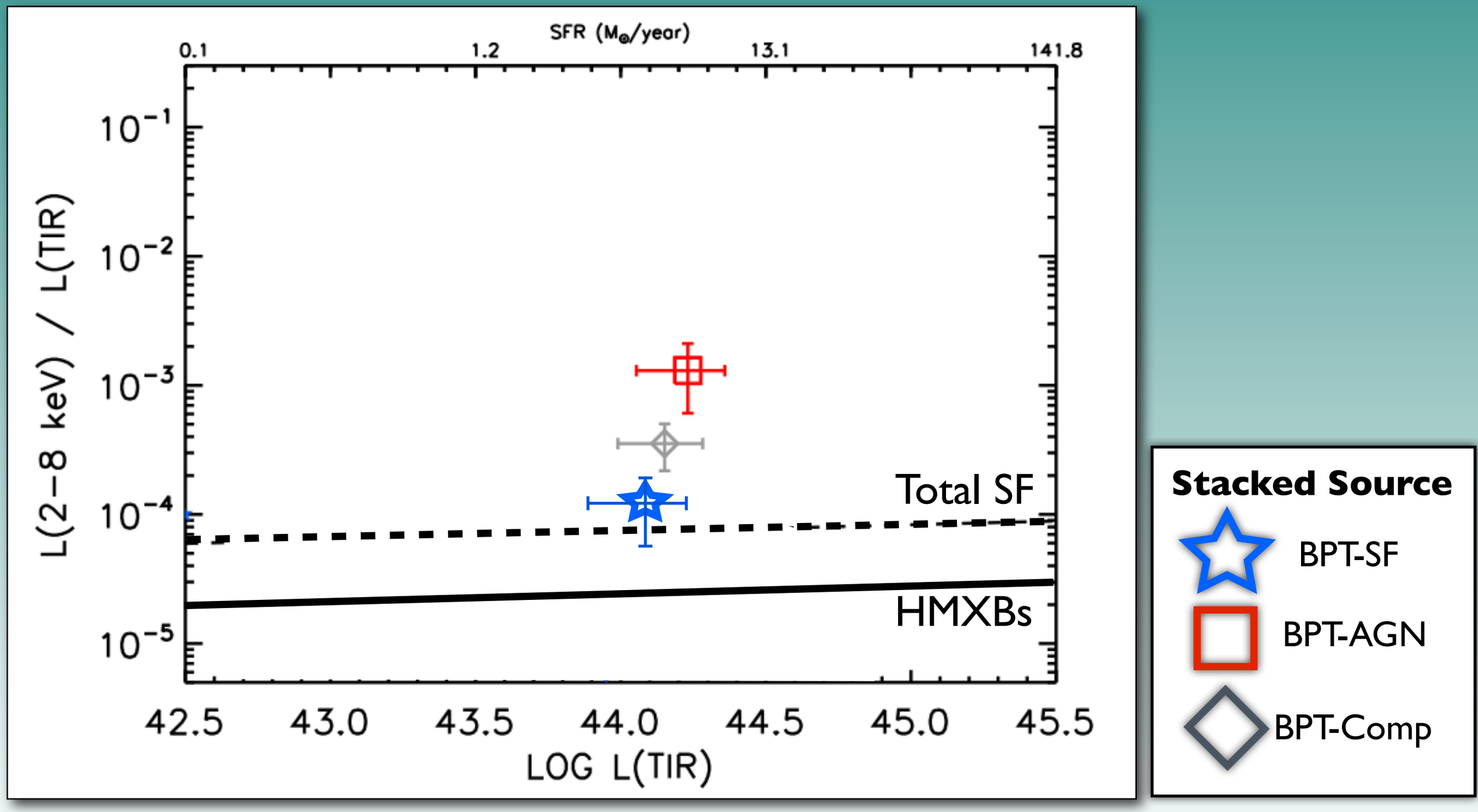
BPT-Comp: X-ray Hard

- 76 sources, $\Gamma_{eff,} = 1.0^{+0.4}_{-0.4}$ (both bands > 4 sigma detection)

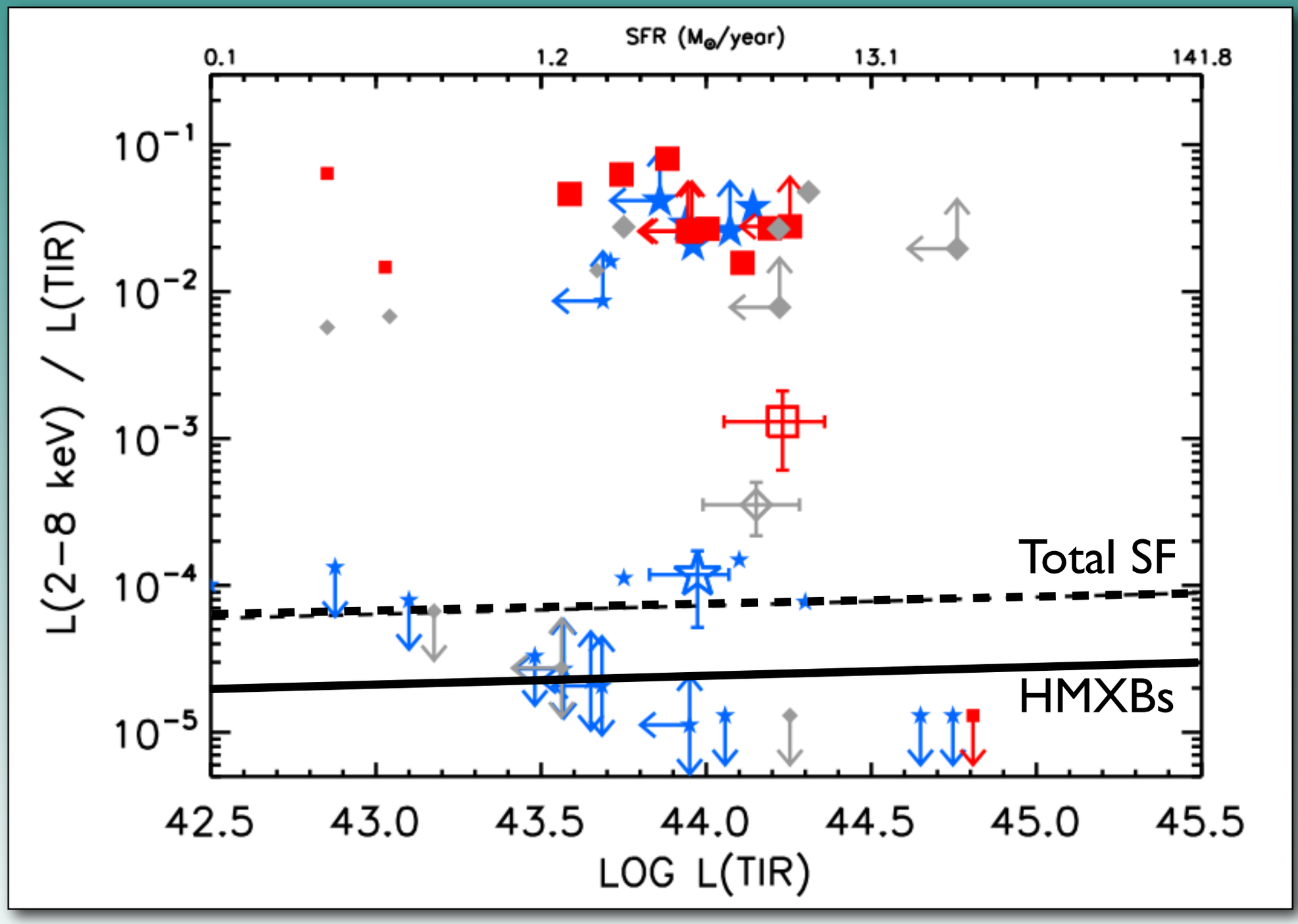
BPT-comp are AGN-dominated



BPT-comp are AGN-dominated



BPT-comp are AGN-dominated



X-ray Detected

BPT-SF

BPT-AGN

BPT-Comp

Stacked Source

BPT-SF

BPT-AGN

BPT-Comp

Conclusion

- **BPT-comp are AGN-dominated**
  - The TBT diagnostic (z<1.4)
  - X-ray Stacking Analysis
  - X-ray/IR luminosity ratio

- **Carefully consider inclusion/exclusion of BPT-comp...**
  - **in star-forming galaxy or AGN samples**
  - **in creating higher-redshift diagnostics**

[Trouille, Barger, & Tremonti 2011, also see Juneau11-MEx Diag.]

A Solid Foundation for Exploring the next Frontiers