

# Herschel Spectroscopy of Early Type Galaxies

Ryen Lapham and Lisa Young



OB



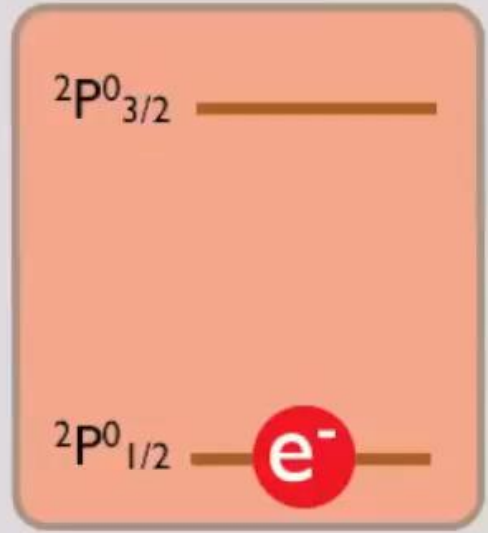
Gas



small dust grain  
or PAH



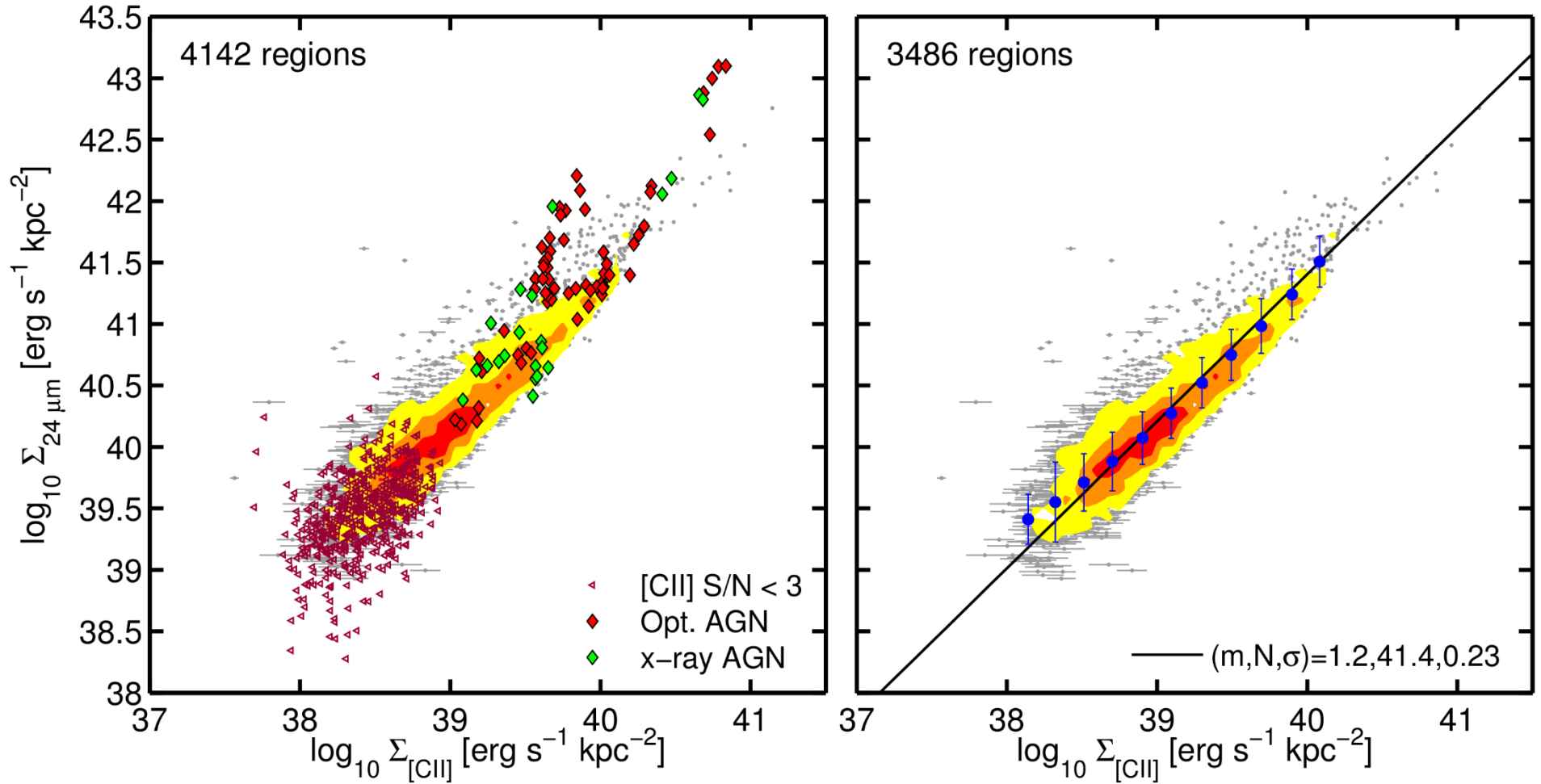
C<sup>+</sup>



# Emission Lines

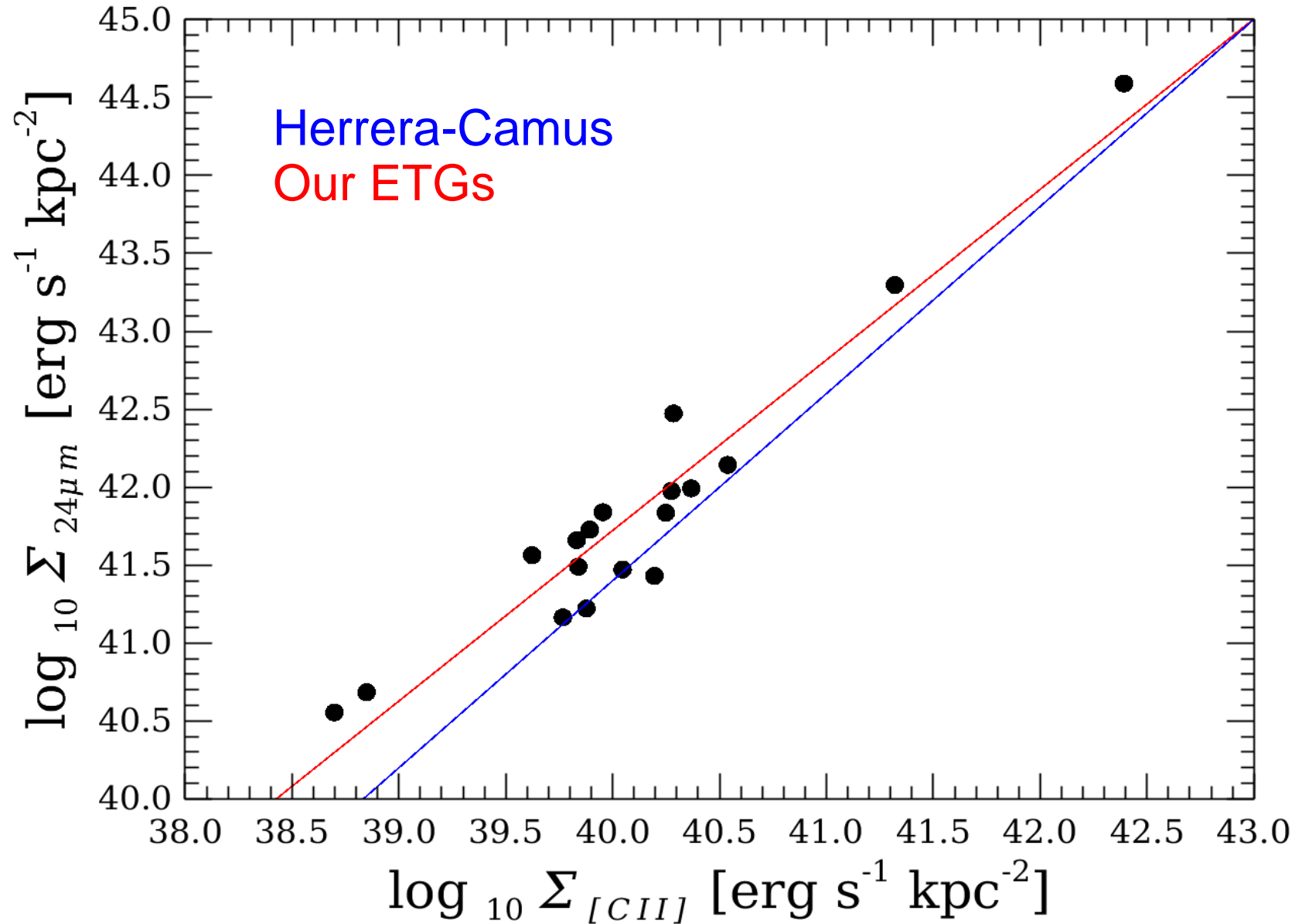
- [CII] 158 micron
  - Ionization potential 11.3 eV
- [OI] 63 micron
  - Ionization potential 13.6 eV
- [NII] 122 micron
  - Ionization potential 14.5 eV
- Sample of nearby E and S0 galaxies with prominent dust features, bright in CO and FIR

# [CII] and Star Formation

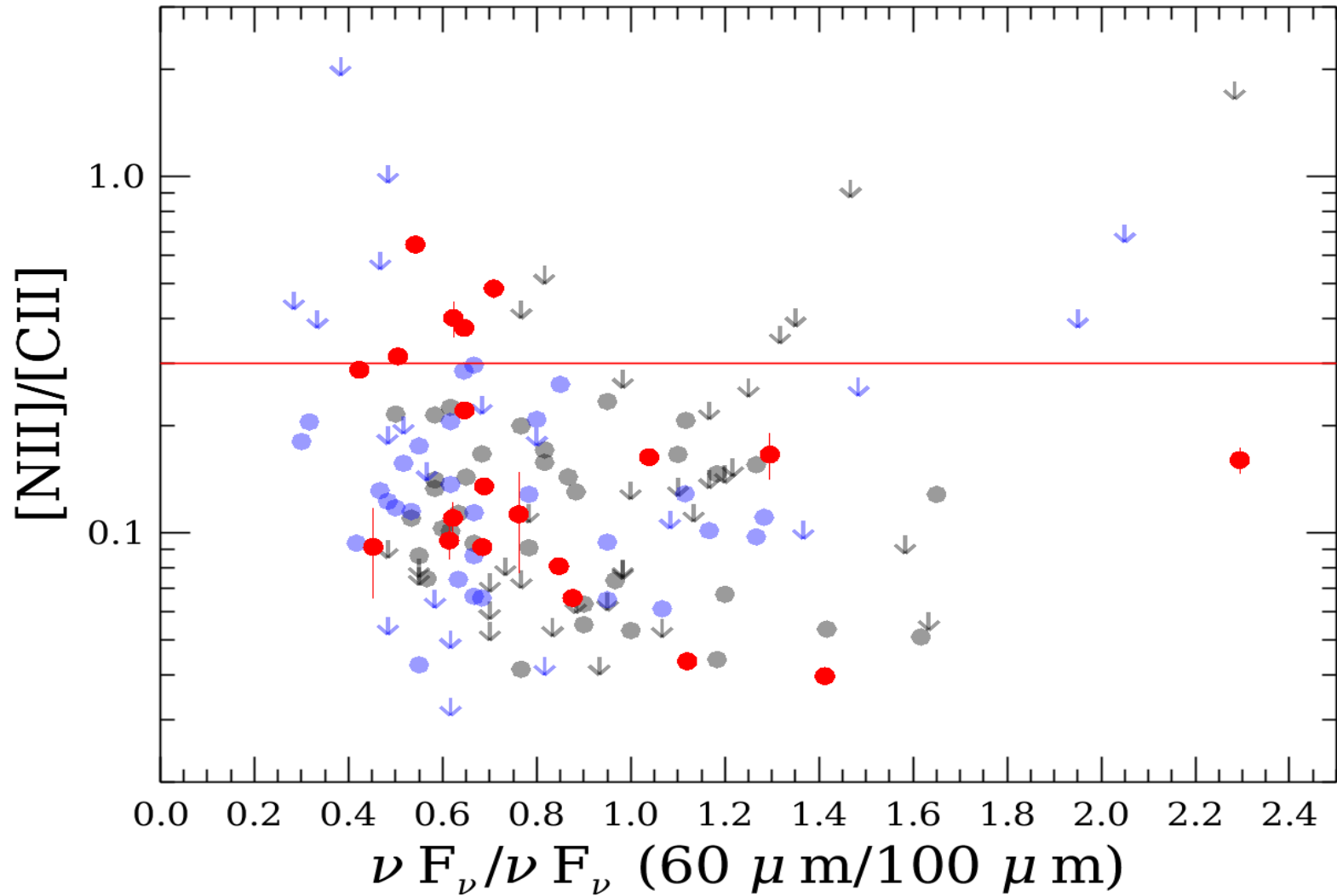


**Herrera-Camus et al. (2015)**

# [CII] and Star Formation

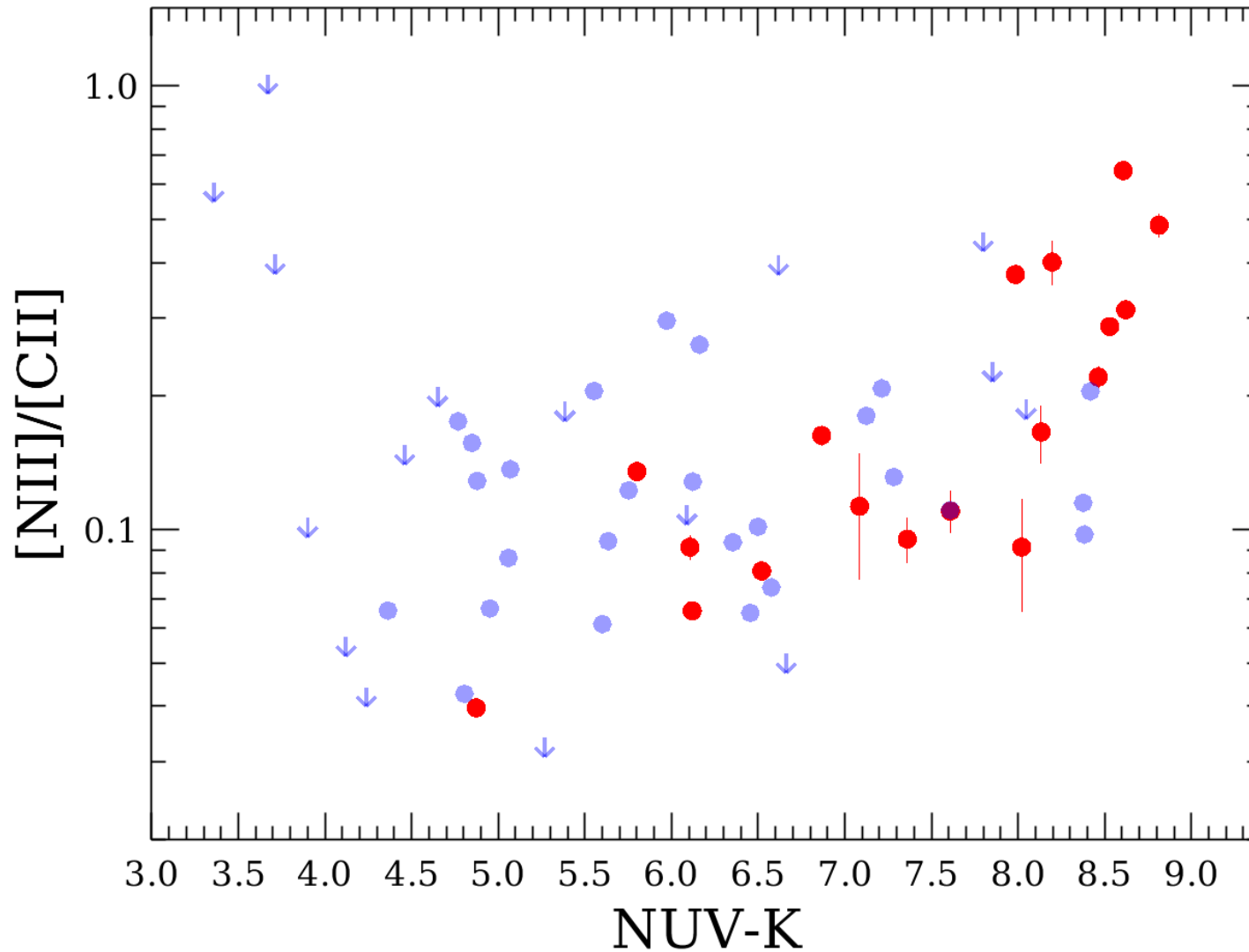


# High [NII]/[CII] Ratios



**Our ETGs** **KINGFISH (spirals)** Brauhar, Dale, and Helou (2008)

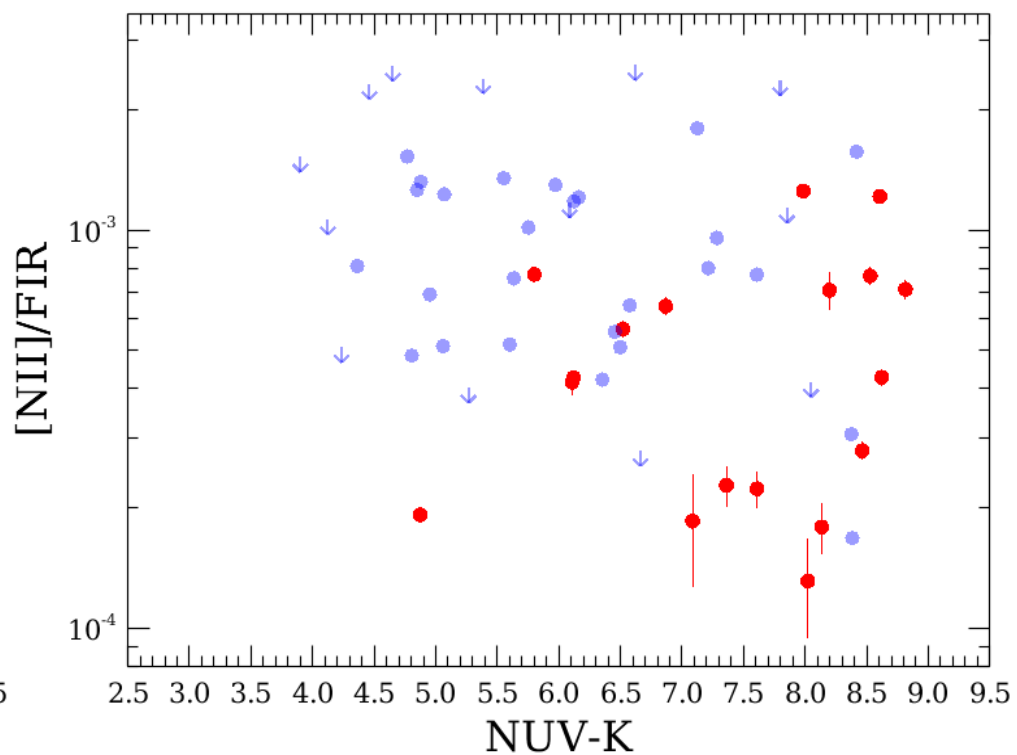
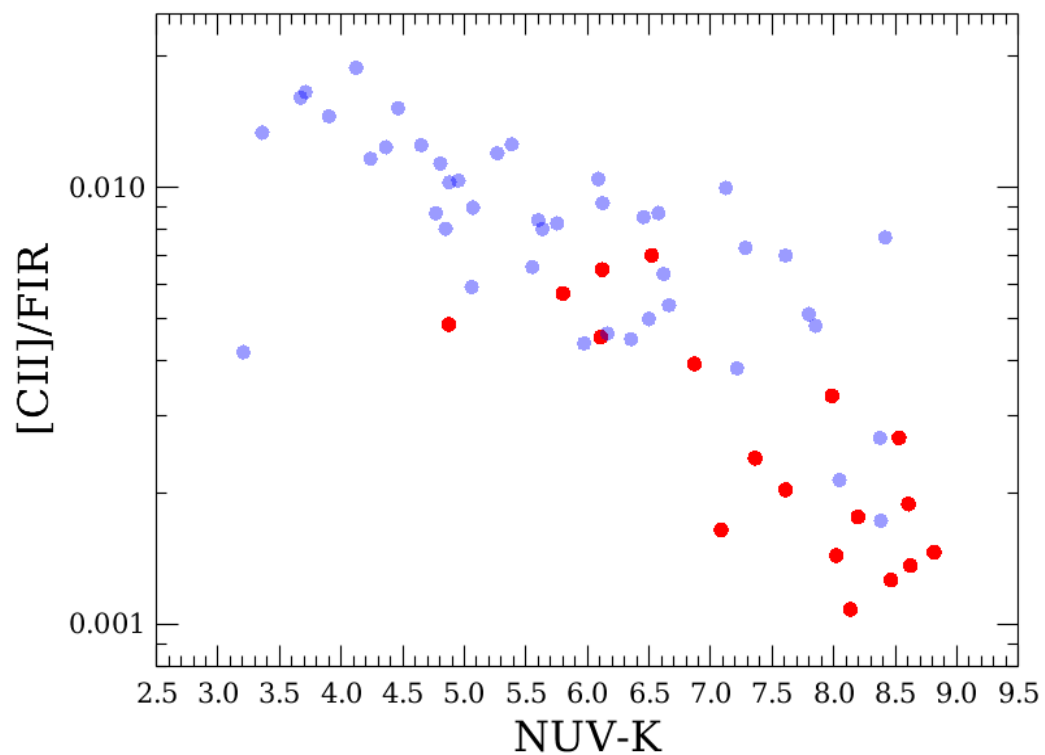
# UV-Optical Colors



**Our ETGs**

**KINGFISH (spirals)**

# UV-Optical Colors

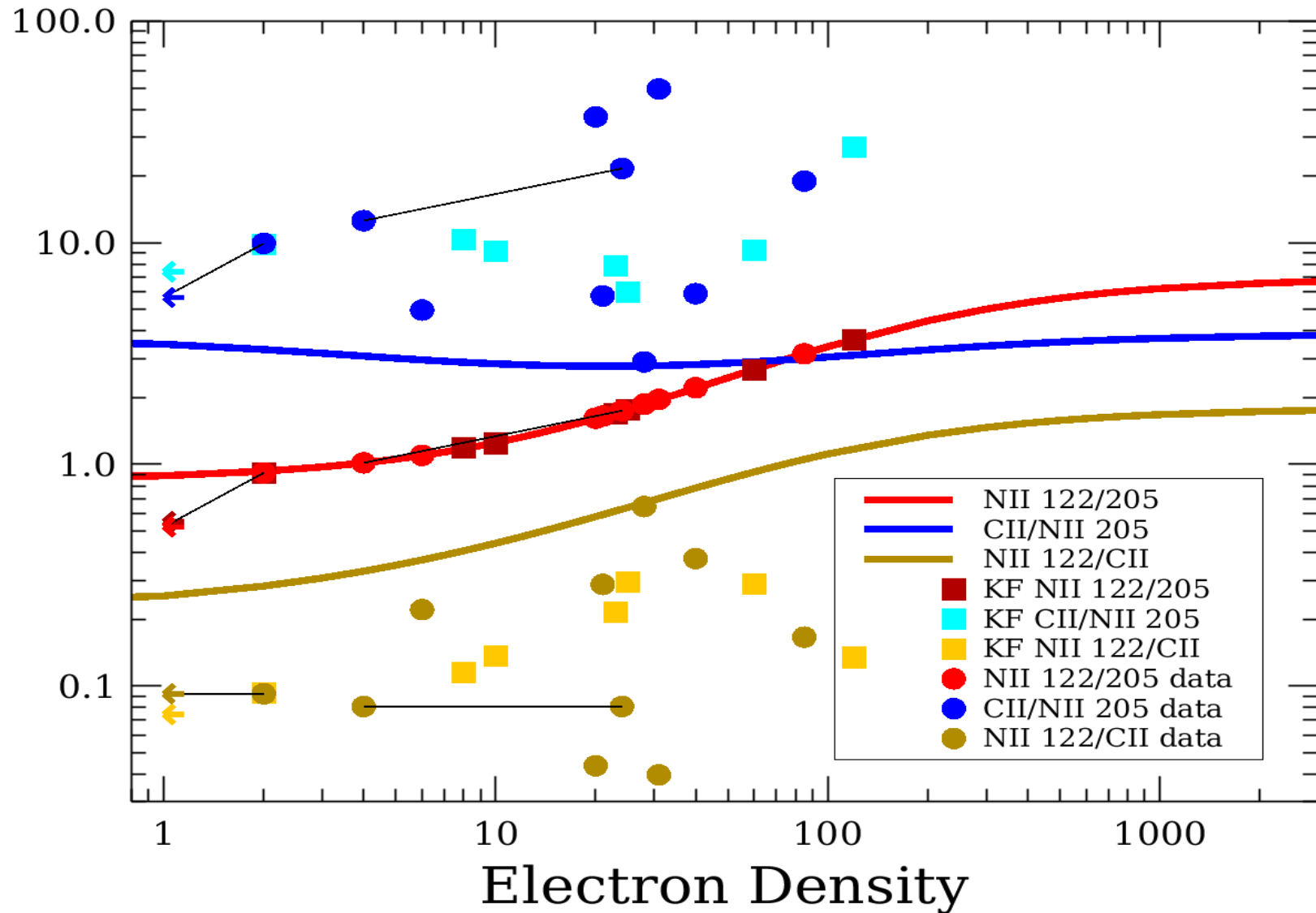


**Our ETGs**

**KINGFISH (spirals)**



# Separating [CII] Components



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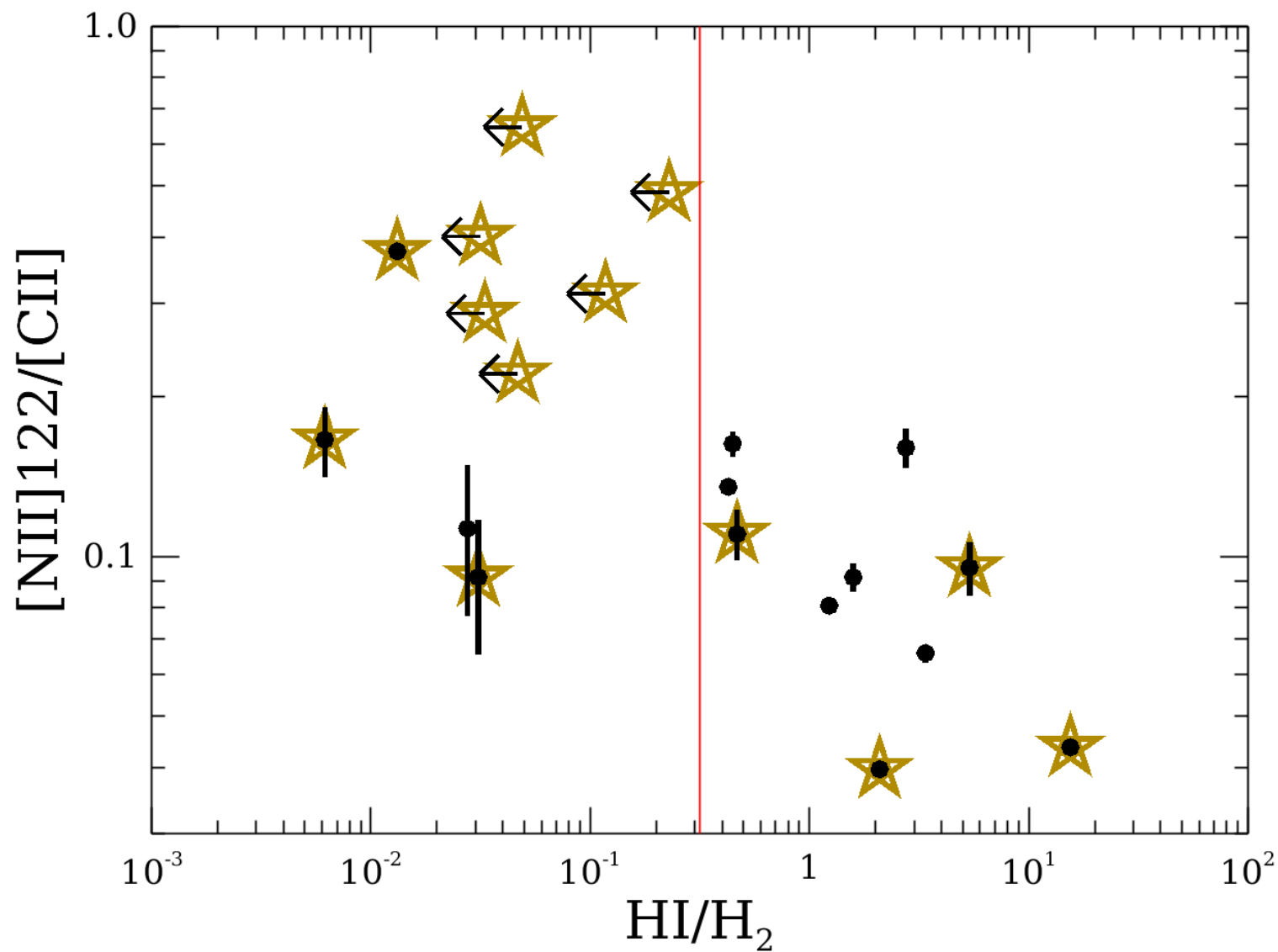
**Table 3**  
Separating [C II] Emission Components

Galaxy	$\frac{[NII]_{122}}{[NII]_{205}}$	$\frac{[NII]_{122}}{[NII]_{205}} \sigma$	e <sup>-</sup>	$\frac{[CII]}{[NII]_{205}}$	PDR%
NGC 1222	1.96	0.084	31	2.79	94.4
NGC 1266	3.15	0.56	85	3.00	84.2
NGC 2764	1.75	0.067	24	2.77	87.2
NGC 3665	1.65	0.086	21	2.77	51.8
NGC 4459	1.10	0.066	6	2.96	40.4
NGC 4526	1.87	0.021	28	2.78	4.1
NGC 4710	2.22	0.019	40	2.82	52.2
NGC 5866	0.915	0.26	2	3.30	66.8
NGC 7465	1.62	0.13	20	2.77	92.5
NGC 2764*	1.02	0.038	4	3.08	75.5
NGC 5866*	0.522	0.15	< 1	3.78	33.1
IC0342	2.66	0.23	60	2.90	68.5
NGC1097	1.76	0.06	25	2.78	53.7
NGC2146	3.63	0.33	120	3.10	88.5
NGC3521	0.55	0.15	< 1	3.78	48.9
NGC3627	1.24	0.22	10	2.84	68.9
NGC4826	1.69	0.20	23	2.77	64.8
NGC5713	0.91	0.19	2	3.30	66.4
NGC6946	1.18	0.16	8	2.89	72.0

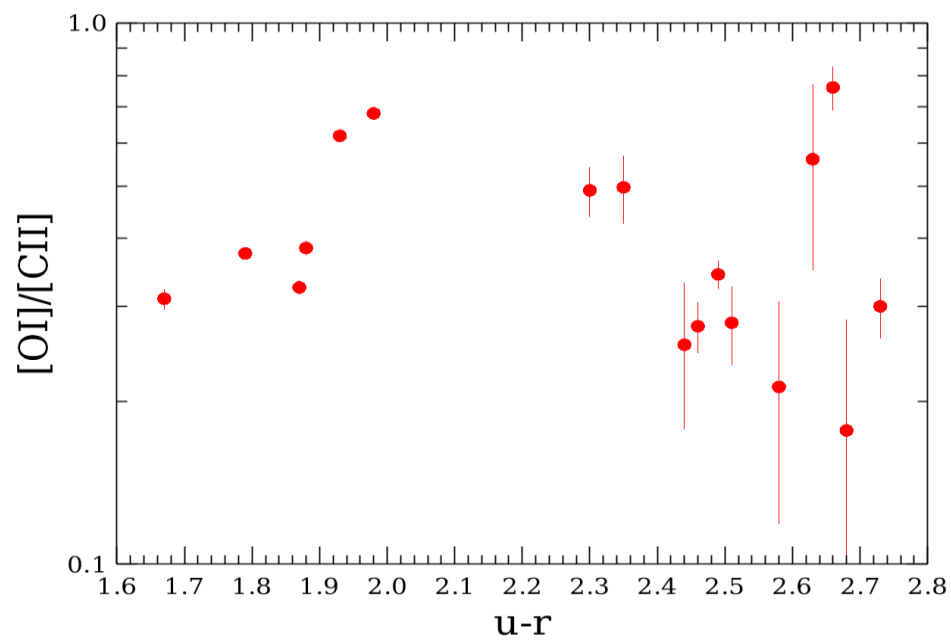
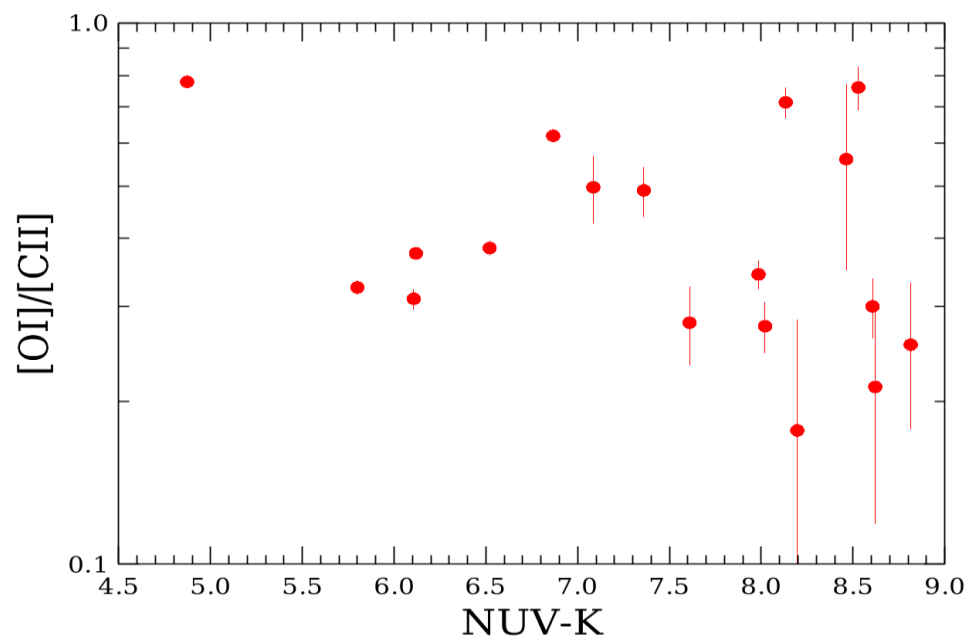
# Recap

- [CII] is a reliable star formation tracer in all galaxy morphologies and could be useful for high  $z$  observations
- Some ETGs have unusual [NII] 122/[CII] ratios
  - [NII] may be more sensitive to Lyman continuum fields
  - [CII] may be more sensitive to the general ISRF
  - [CII] deficit in galaxies with redder stellar populations
- The amount [CII] from ionized gas is often much greater than models predict

# [NII]/[CII] vs HI/H<sub>2</sub>



# [OI]/[CII]



# [OI]/FIR

