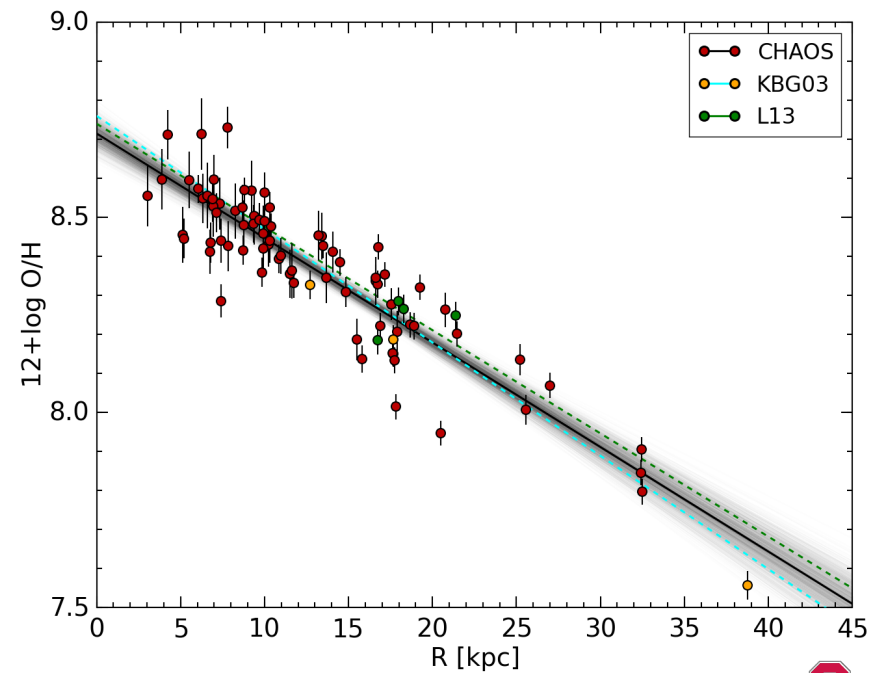


Measuring Gas-Phase Chemical Abundances in Nearby Spirals with CHAOS



Richard Pogge, The Ohio State University
2nd LBT User's Meeting, Firenze, Italy

CHemical Abundances Of SPirals



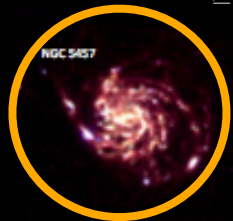
PIs: Evan Skillman (Minnesota) & Rick Pogge (OSU)
Kevin Croxall (OSU & Illumination Works LLC)
Malinda Baer (OSU undergrad)
Danielle Berg (UM & UW-Milwaukee, OSU in 2018)
John Moustakas (Sienna College)



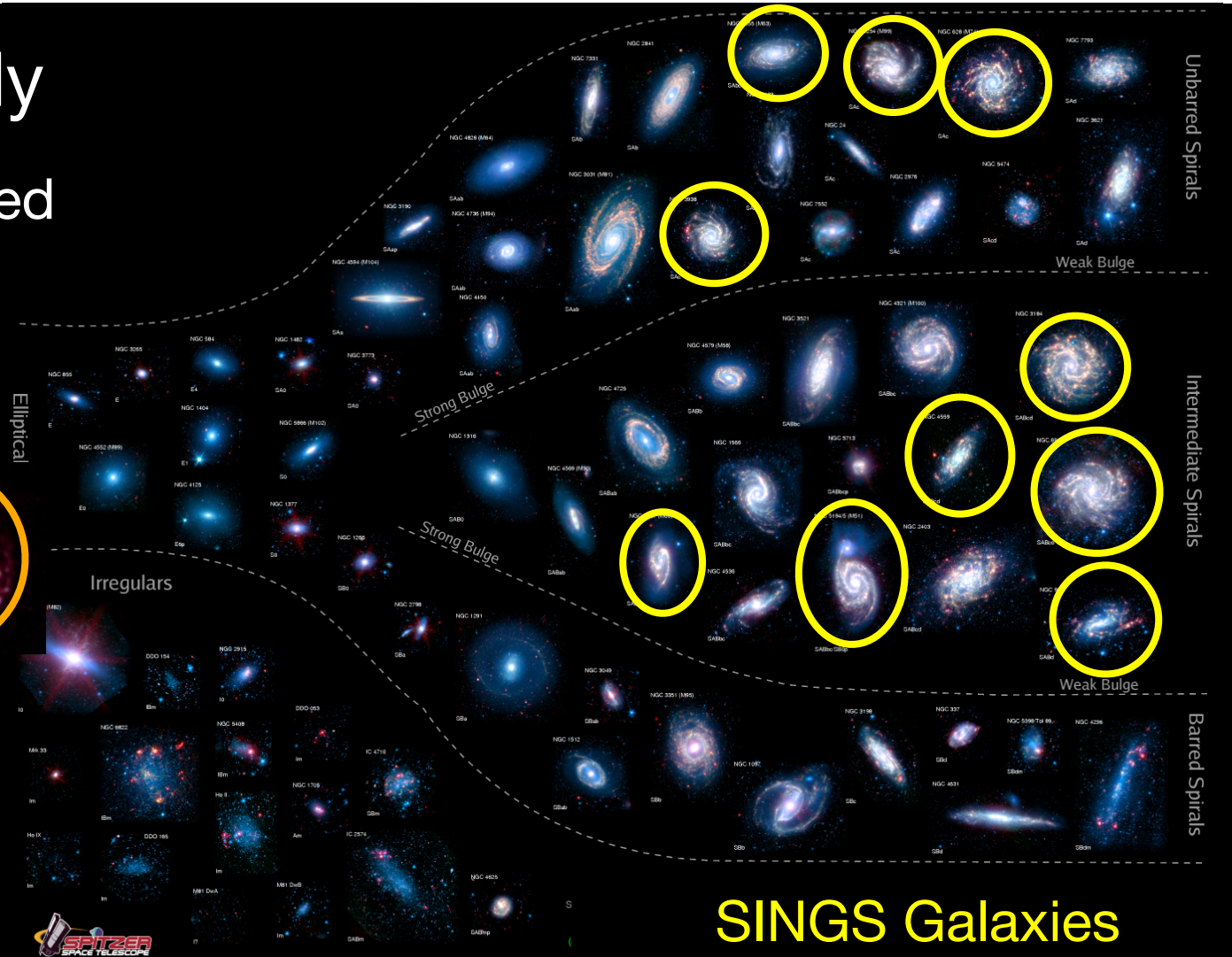
US National Science Foundation
Collaborative Grant AST-1108693

CHAOS Study

Uniformly observed
spectra of ~650
HII regions in 11
spiral galaxies.



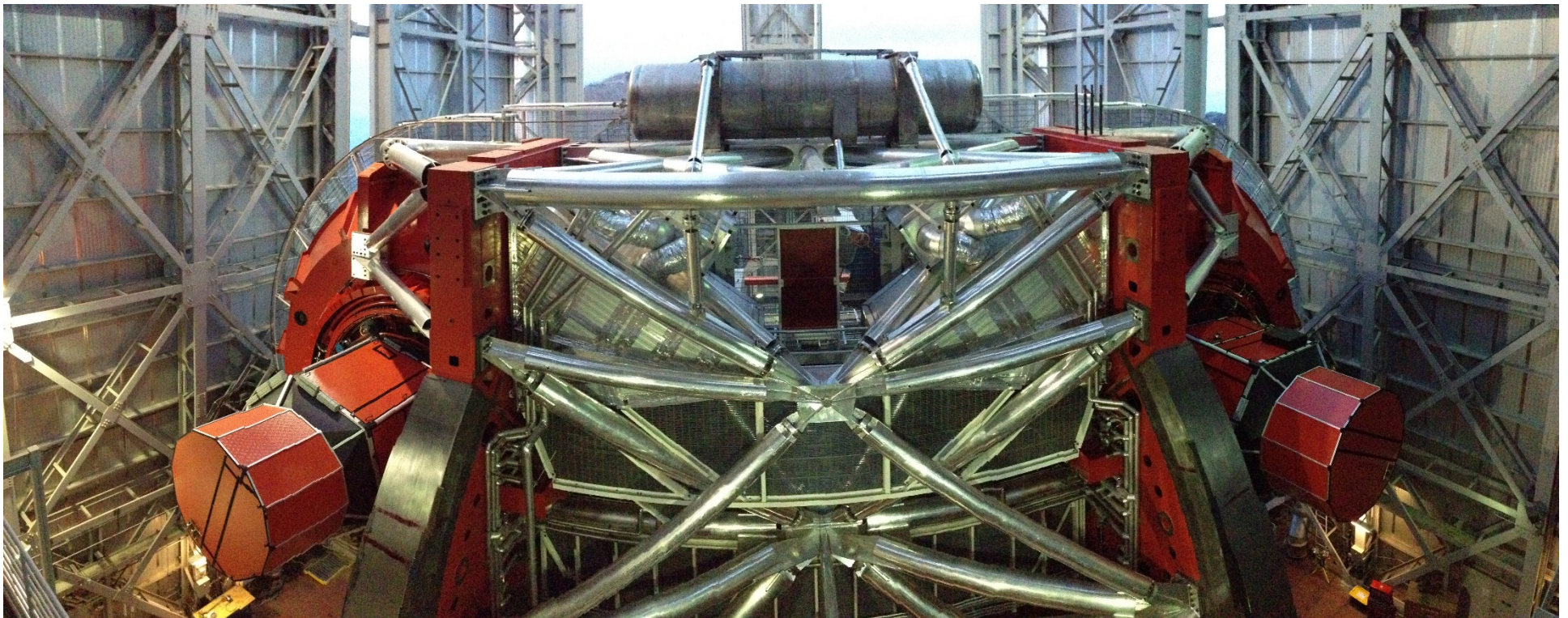
KINGFISH



SINGS Galaxies

Spectra obtained using MODS1 on the LBT in grating mode.

20-30 HII region + sky slits per mask: 1" wide x 10-20" long
2^h total integrations per field (6×20^m)



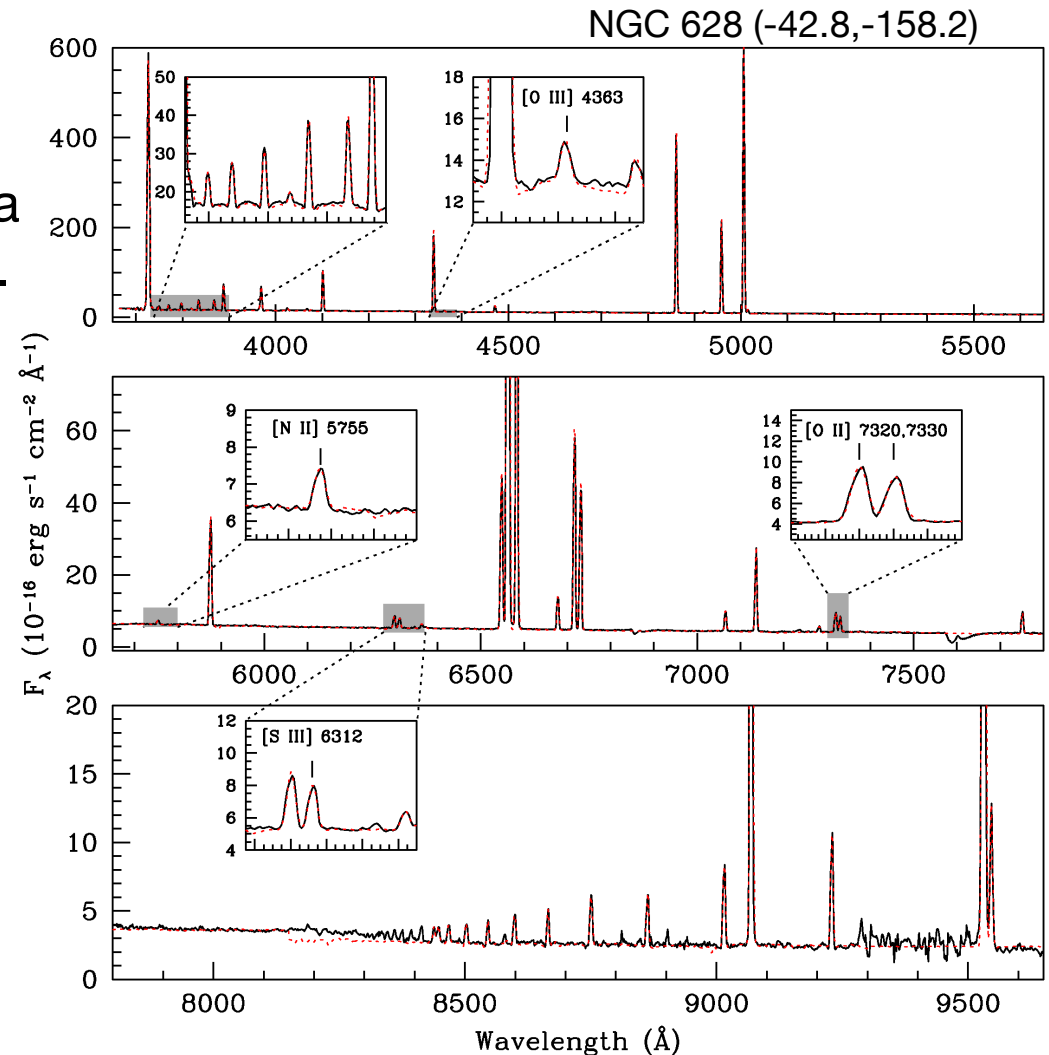
CHAOS Data:

High-quality emission-line spectra of ~650 HII regions in 10 galaxies.

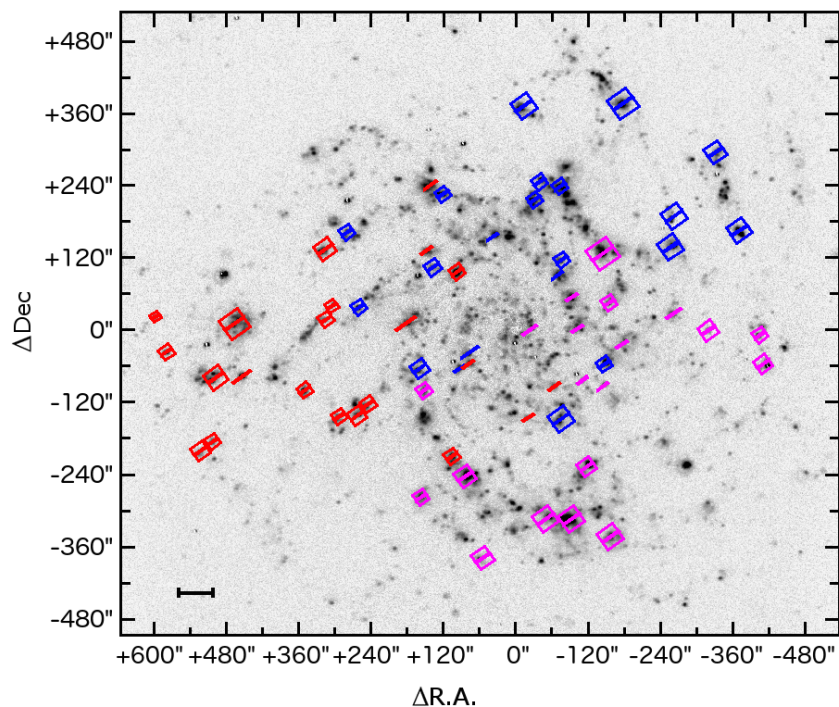
Measure Temperature-sensitive auroral emission lines of O^{++} , N^+ , S^{++} , S^+ , & O^+ in ~400 HII regions

Multi-ion temperature & density measurements for ~300.

Direct gas-phase abundances of O, N, S, Ne, & Ar to <0.1 dex



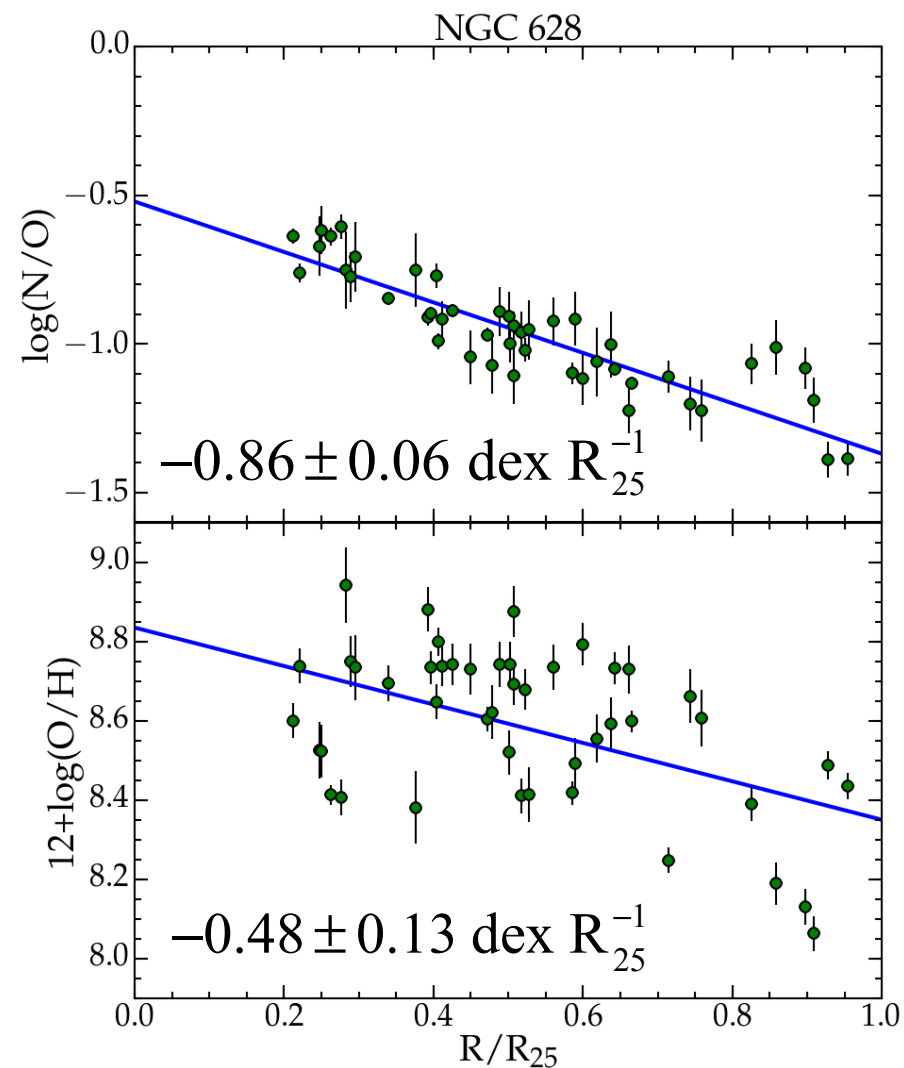
NGC 628 (M74)



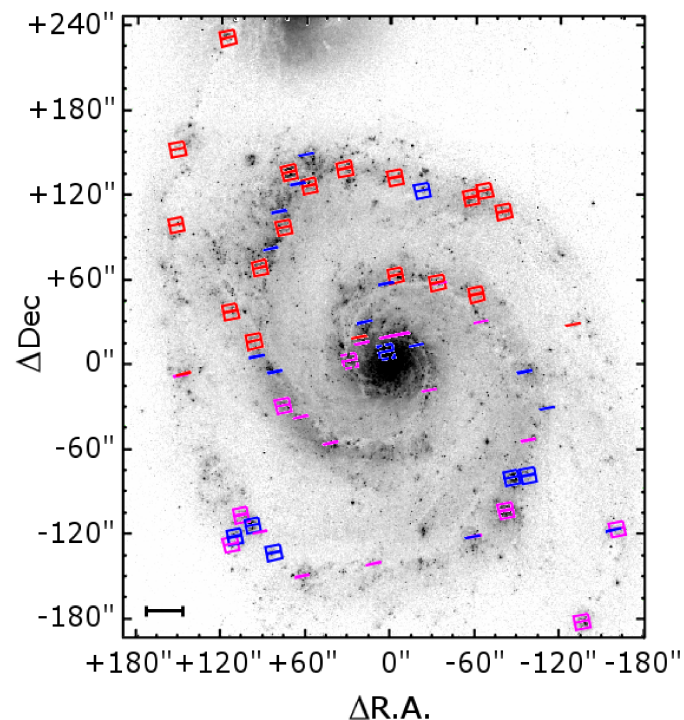
64 HII Regions

46 with one or more auroral lines

Berg et al. 2015, ApJ, 806, 16



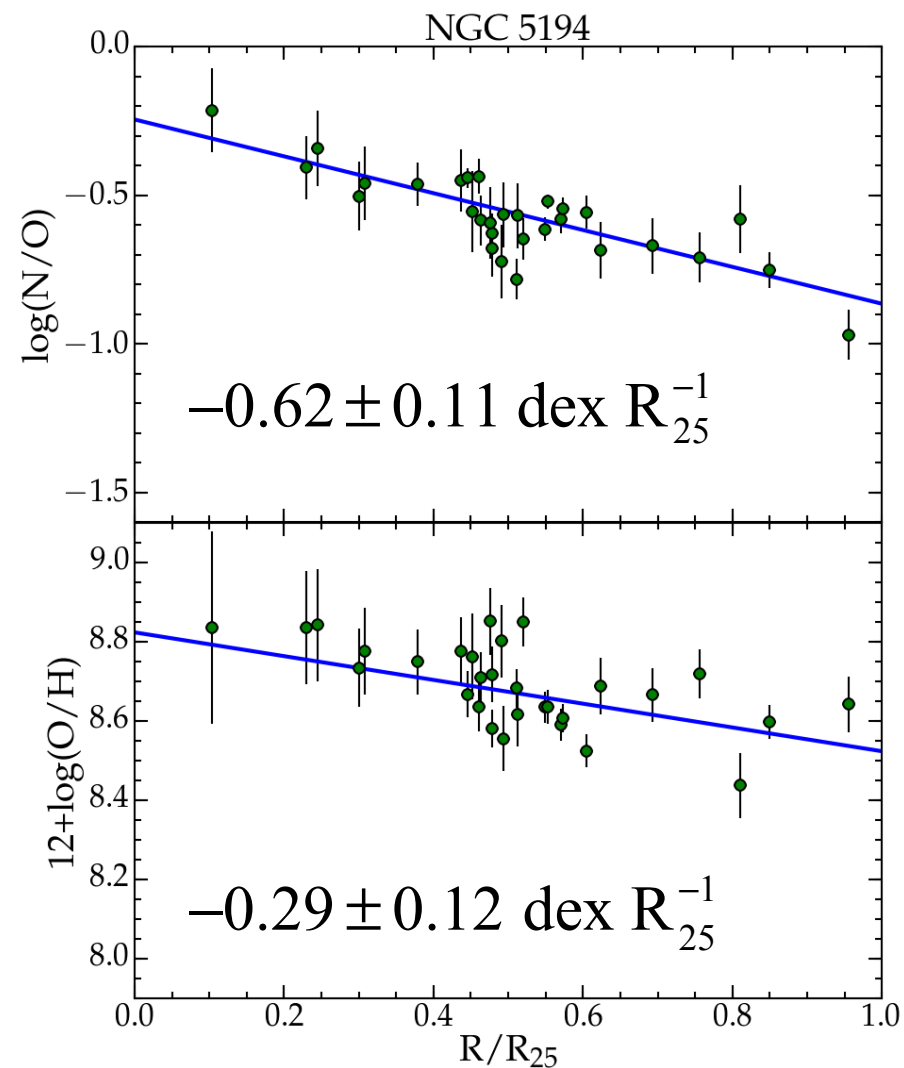
NGC 5194 (M51)



63 H II Regions

30 with one or more auroral lines

Croxall et al. 2015, ApJ, 808, 42



NGC 5457 (M101)

13 pointings:

7 masks

6 long slits

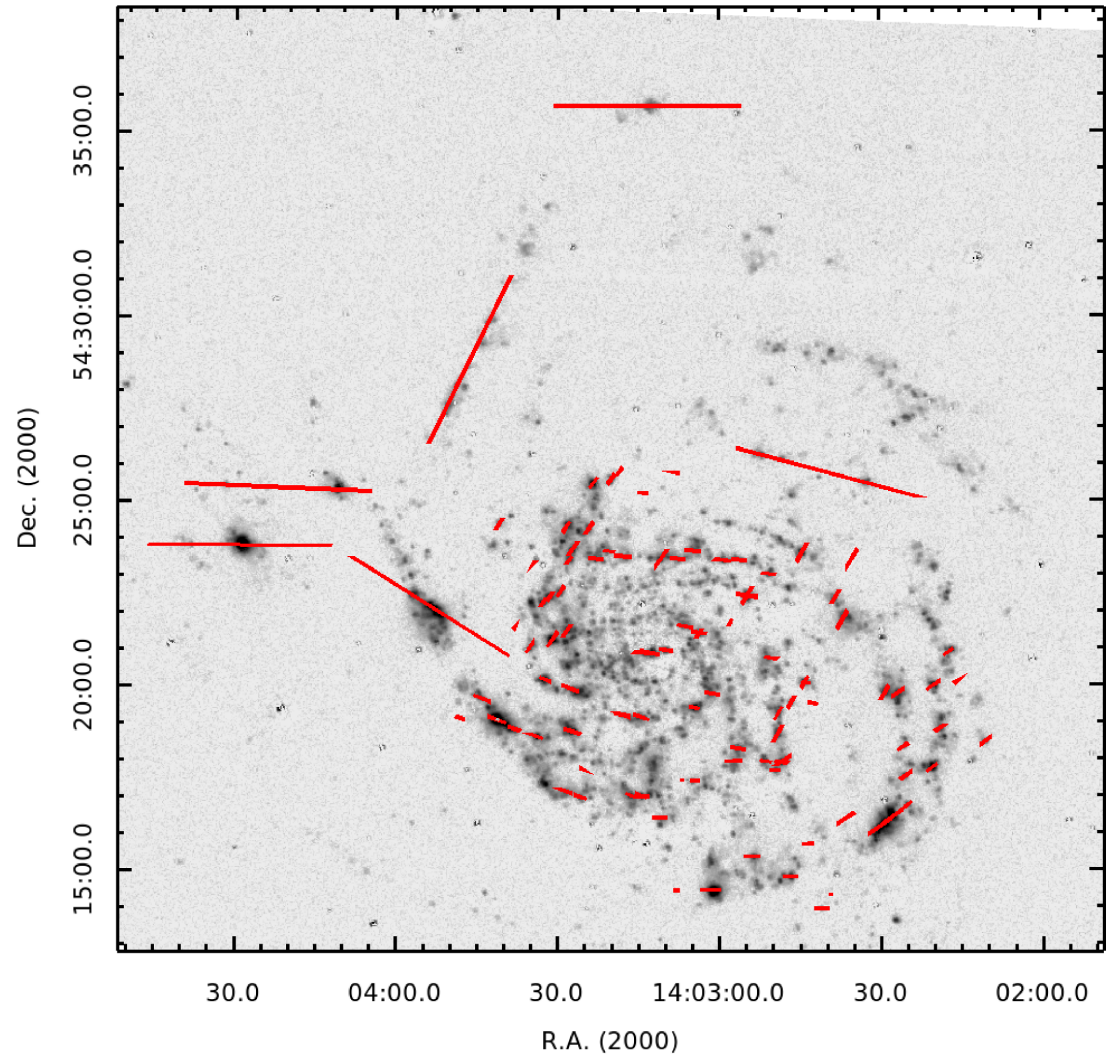
26 h of integration

Yield:

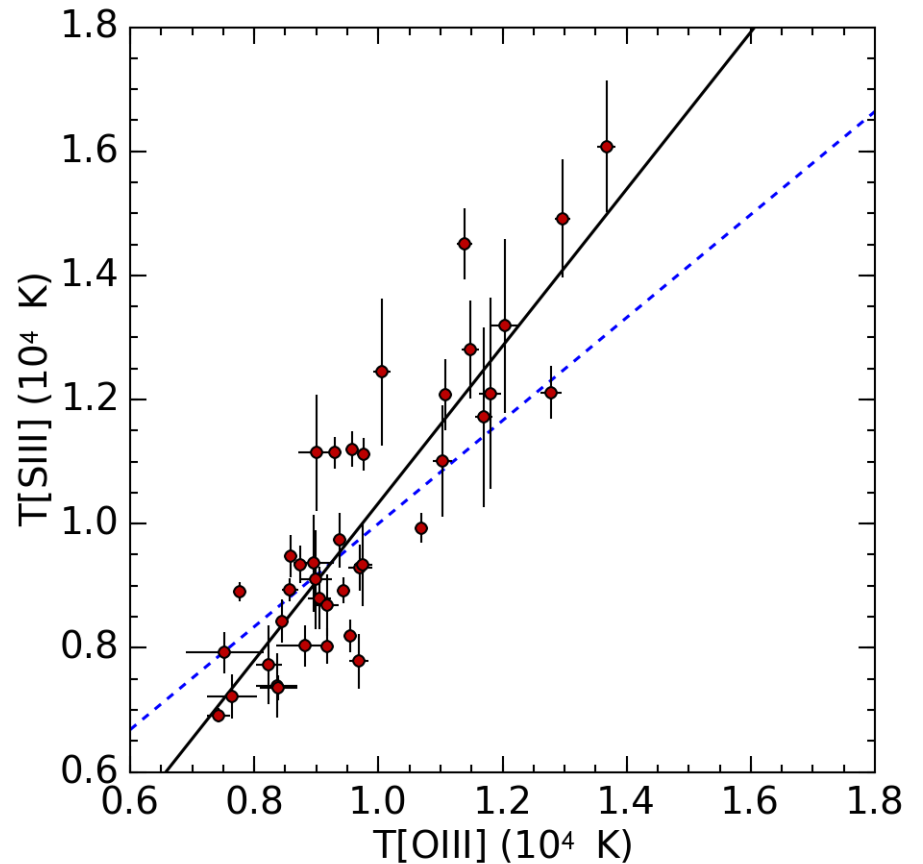
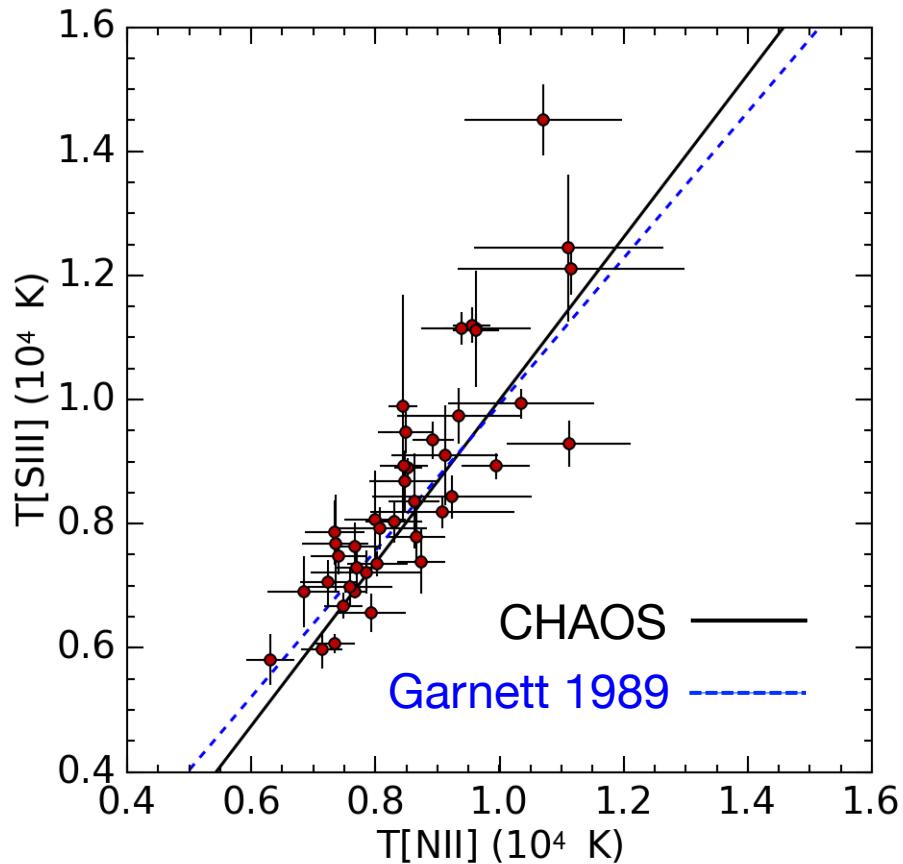
109 HII Regions

84 with one or more
auroral emission lines.

Croxall et al. 2016, ApJ, 830, 4



Recalibration of the standard Temperature-Temperature relations of Garnett (1989) using CHAOS M101 data.

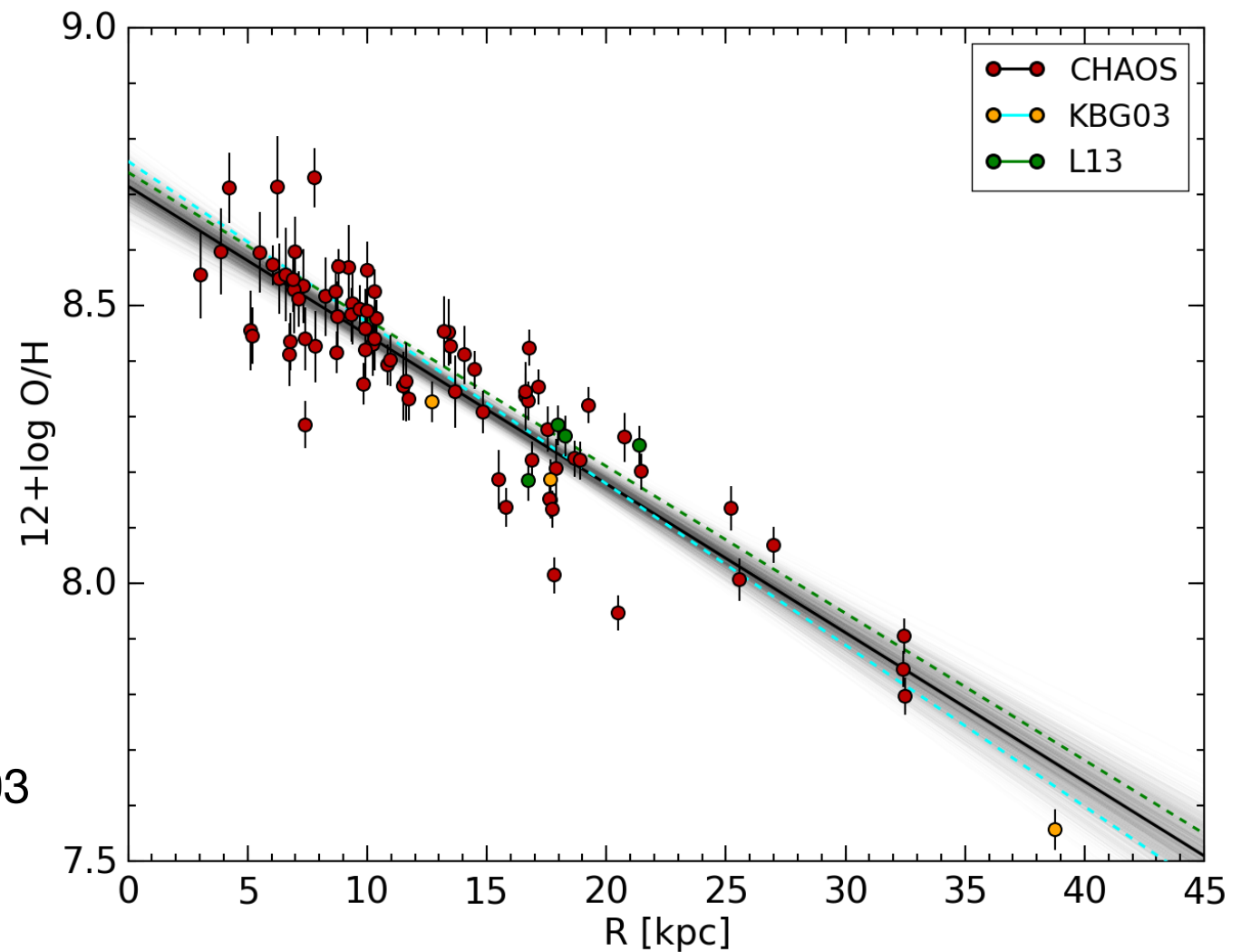


M101 O/H Gradient

$-0.027 \text{ dex kpc}^{-1}$

Internal Dispersion:
 $0.074 \pm 0.009 \text{ dex}$

Consistent with
Kennicutt et al. 2003
Lee et al. 2013

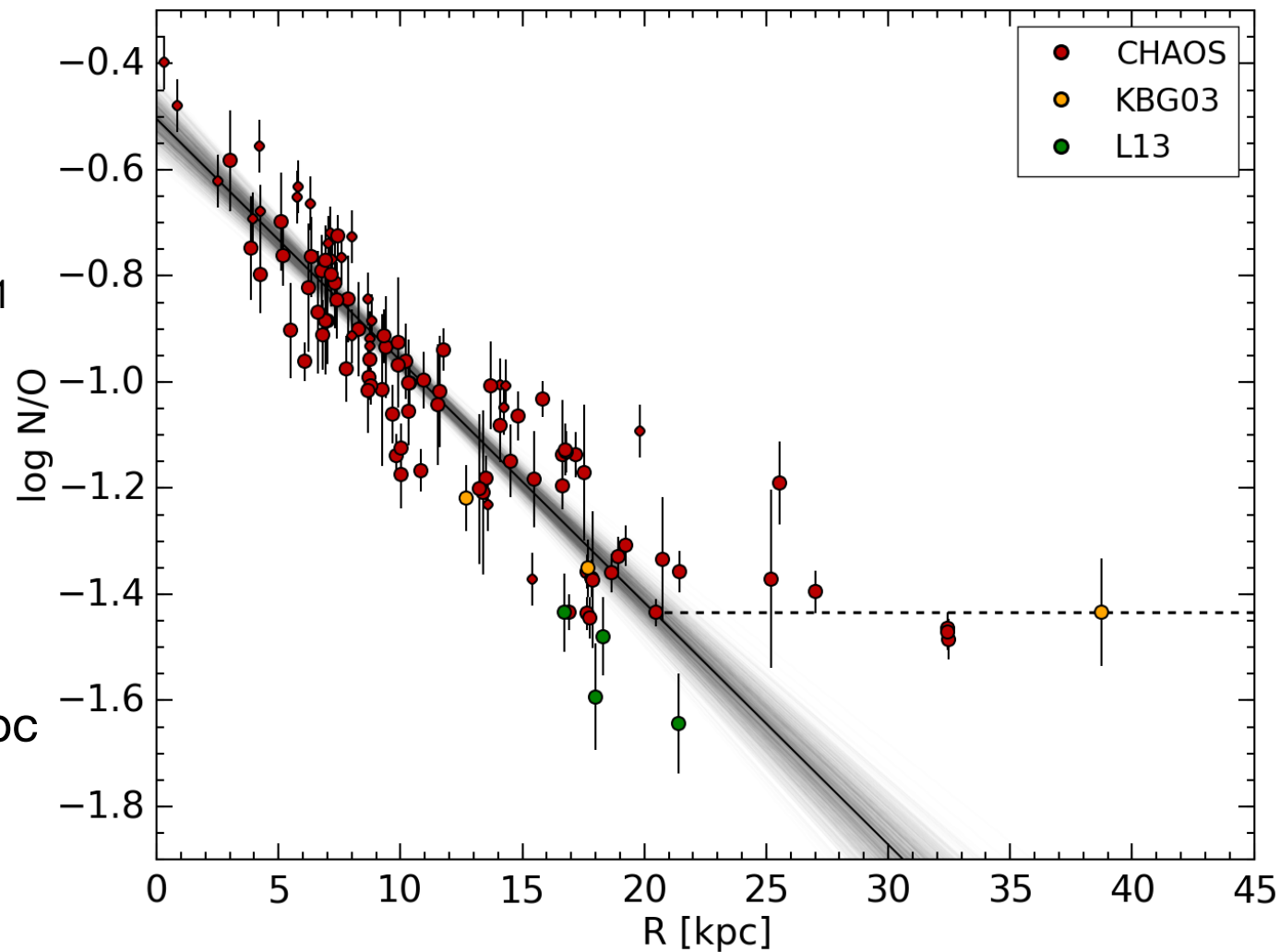


M101 N/O Gradient

$-0.046 \text{ dex kpc}^{-1}$

Internal Dispersion:
 $0.095 \pm 0.009 \text{ dex}$

Flattens for $R > 20 \text{ kpc}$
 $\log \text{N/O} = -1.434$

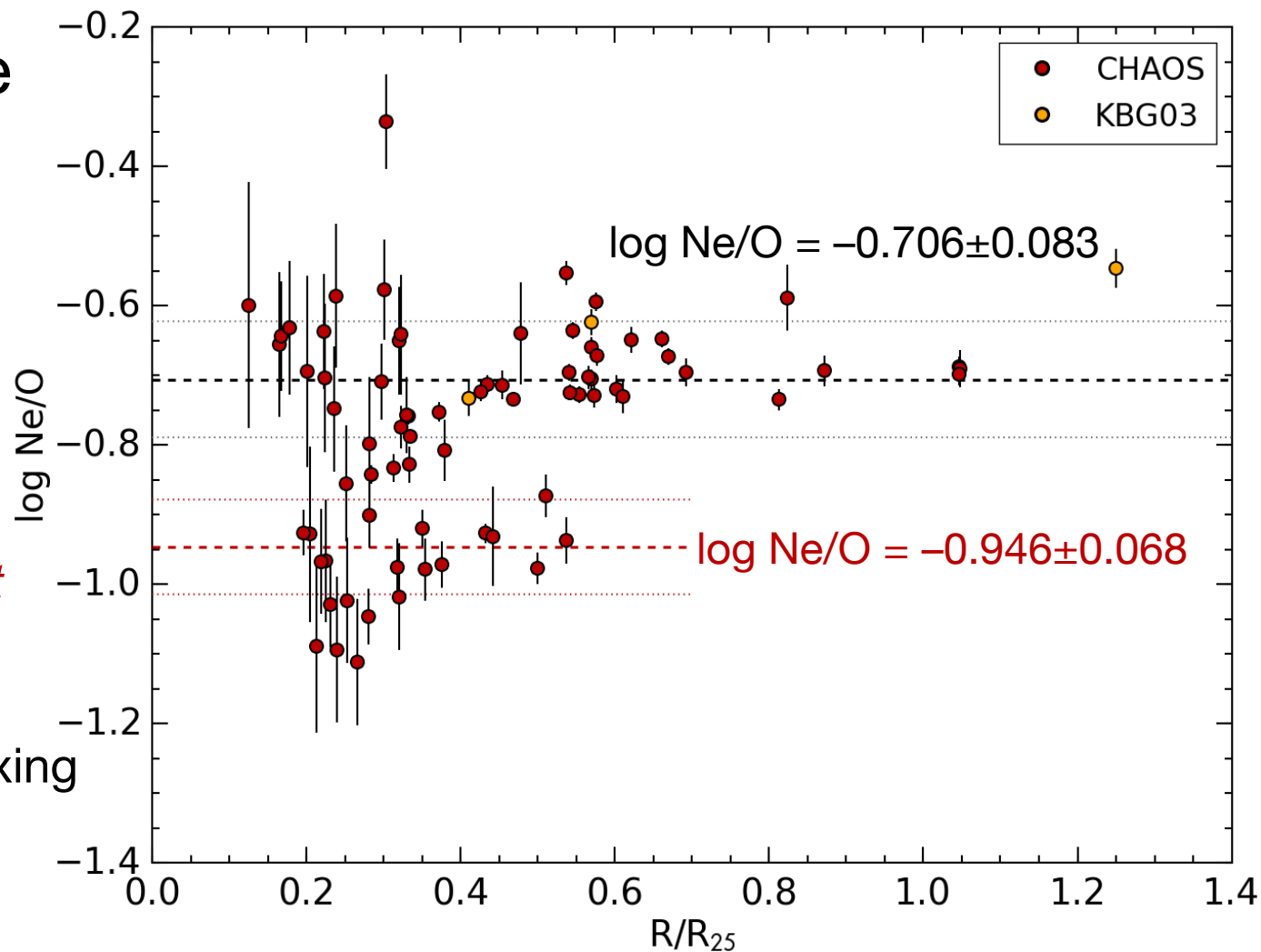


Ne/O is double
valued!

Most is the solar
 $\log \text{Ne/O} \sim -0.7$

Some regions show
 -0.24 dex Ne *deficit*

Inhomogeneous mixing
of SN ejecta?

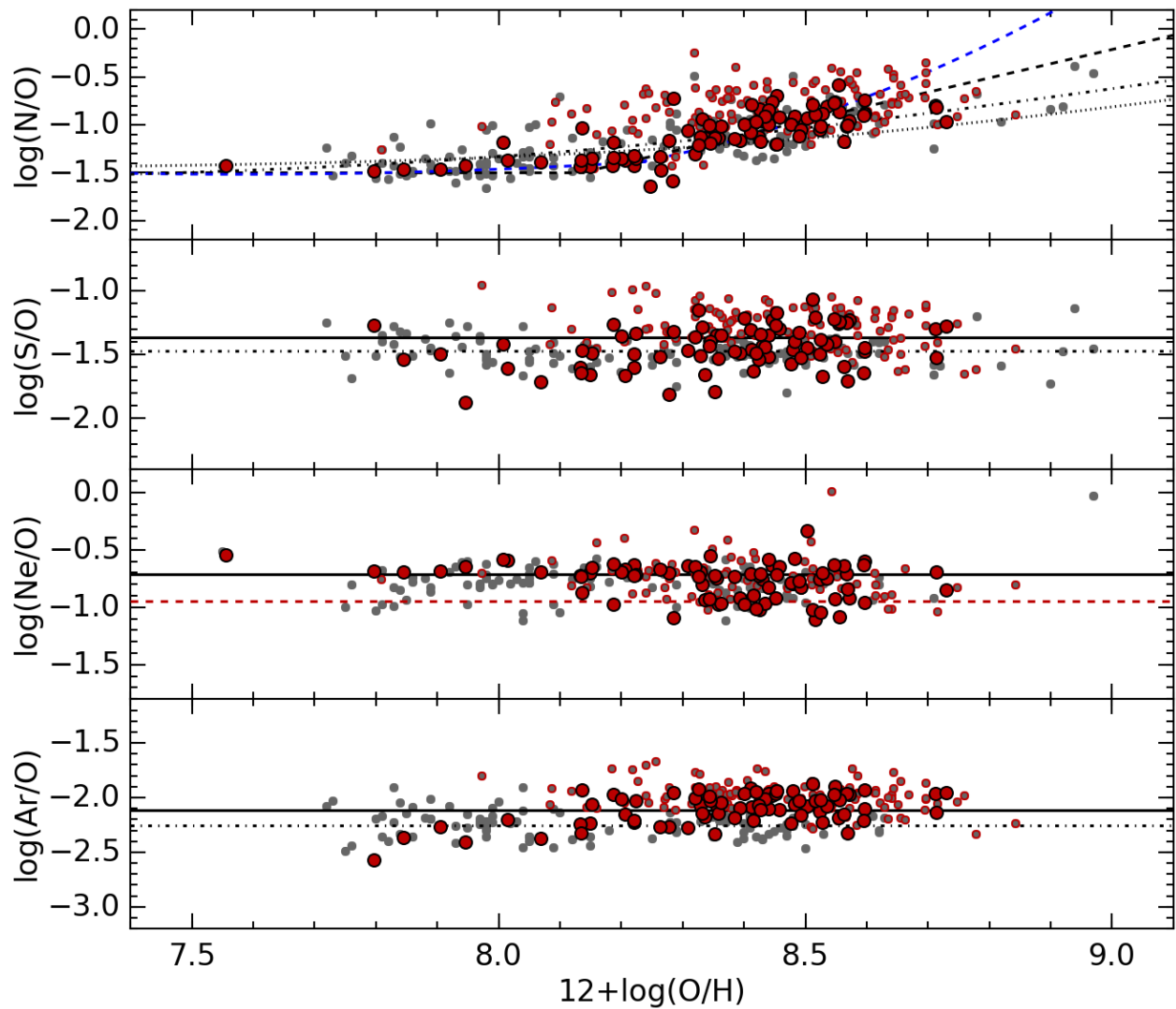


Enrichment Patterns

N/O vs O/H is not a simple “universal” primary/secondary pattern galaxy to galaxy

Ne/O deficit is seen in other galaxies.

S/O & Ar/O follow the expected patterns.



Beyond CHAOS...

Rich MODS1 data for M33 (7 fields) being analyzed.

Detection of faint recombination lines of C, O, and N in M101 & other CHAOS galaxies.

Many faint Helium lines measured, allows analysis of Y/O in external galaxies.

New NSF grant starting in Sept 2017 to extend this work to 2020 (and beyond)