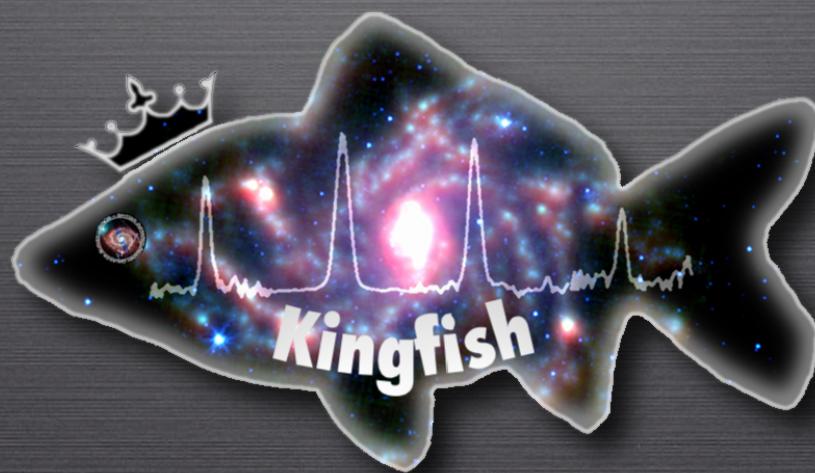


GAS PHYSICS REVEALED BY SPECTRAL MAPPING OF NEARBY GALAXIES



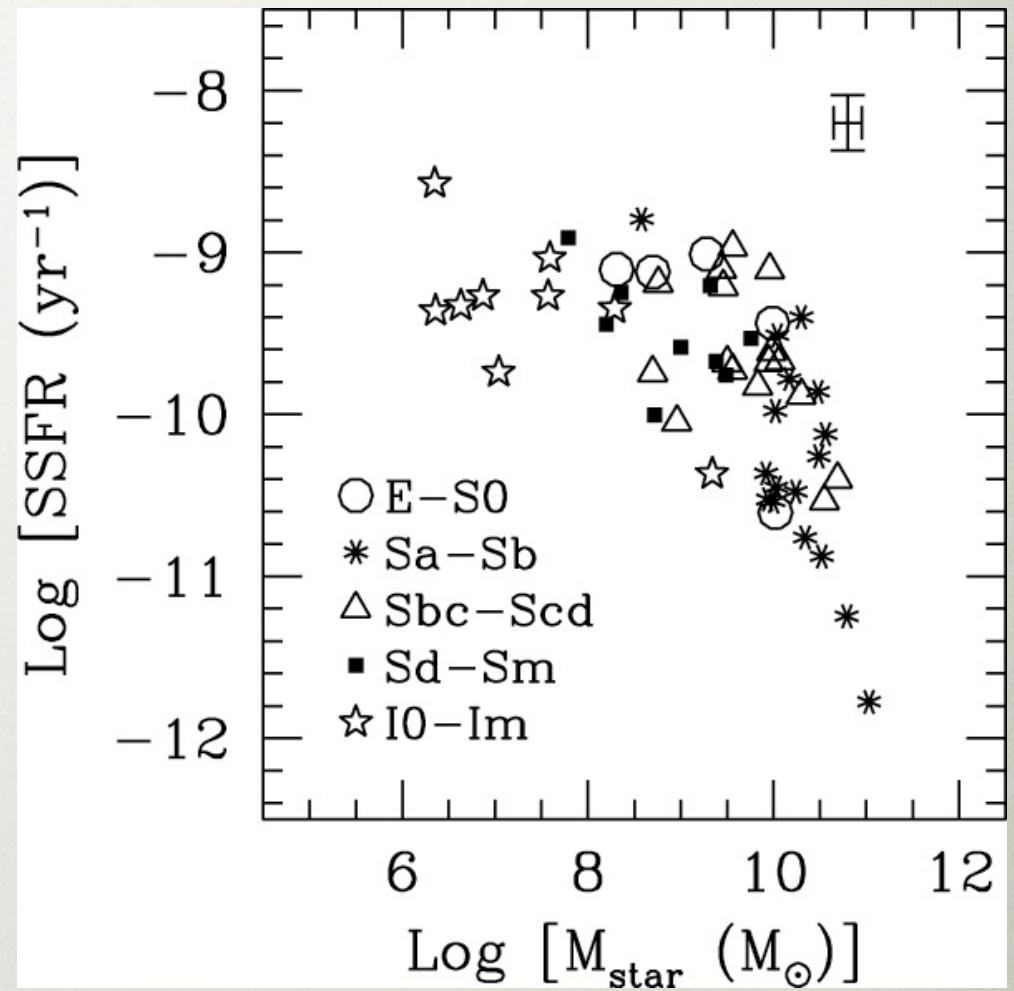
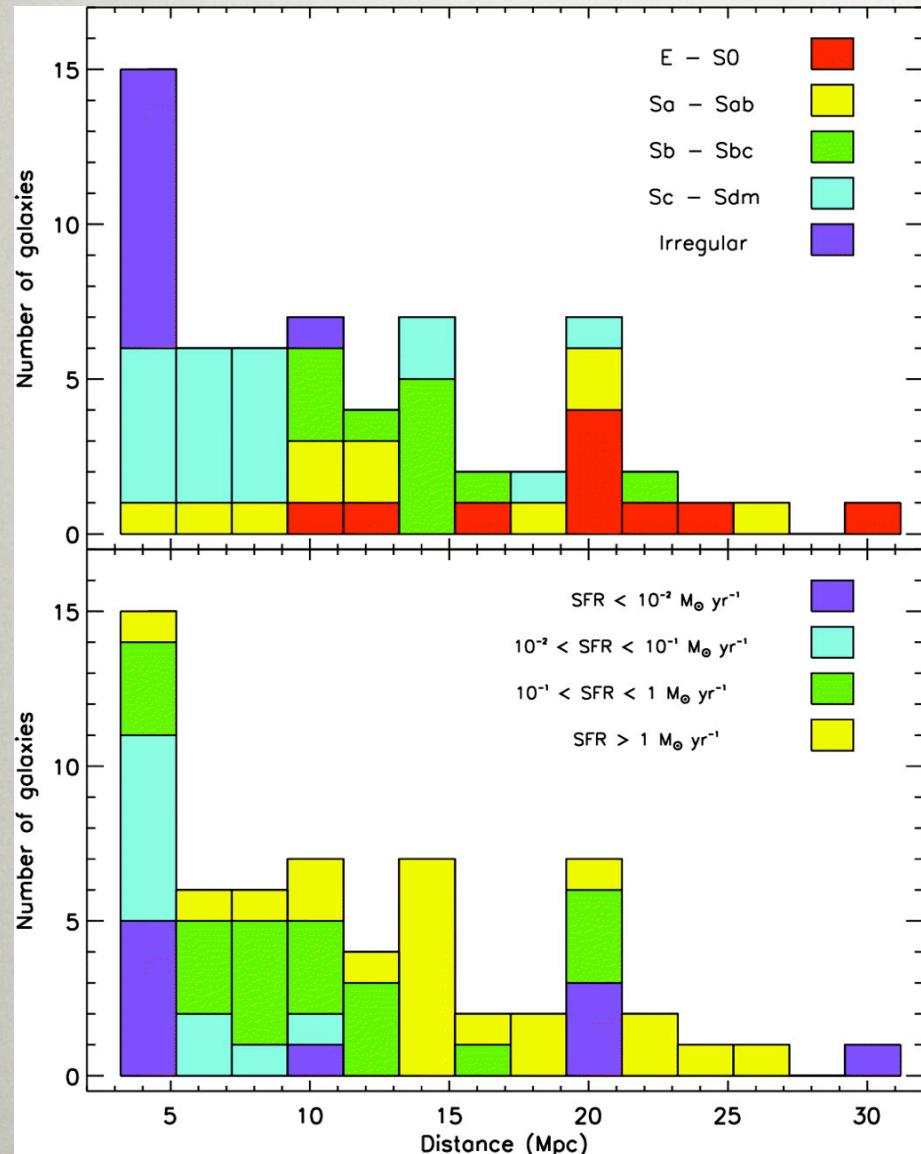
KEVIN V. CROXALL
THE OHIO STATE UNIVERSITY
& THE KINGFISH TEAM

COLLABORATORS:

- **Rob Kennicutt**
- Daniela Calzetti
- Gonzalo Aniano
- Phil Appleton
- Lee Armus
- Pedro Beirao
- **Alberto Bolatto**
- Bernhard Brandl
- Alison Crocker
- **Daniel Dale**
- Jennifer Donavan Meyer
- Bruce Draine
- Charles Engelbracht
- Maud Galametz
- Karl Gordon
- David Green
- **Brent Groves**
- Caina Hao
- George Helou
- Rodrigo Herrera Camus
- Joannah Hinz
- Leslie Hunt
- Ben Johnson
- Jin Koda
- Oliver Krause
- Kathryn Kreckel
- Adam Leroy
- Yiming Li
- Eric Pellegrini
- Sharon Meidt
- Edward Montiel
- Eric Murphy
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- Helene Roussel
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- Sundar Srinivasan
- Laurent Vigroux
- Fabian Walter
- Bradley Warren
- Christine Wilson
- Mark Wolfire
- Stefano Zibetti



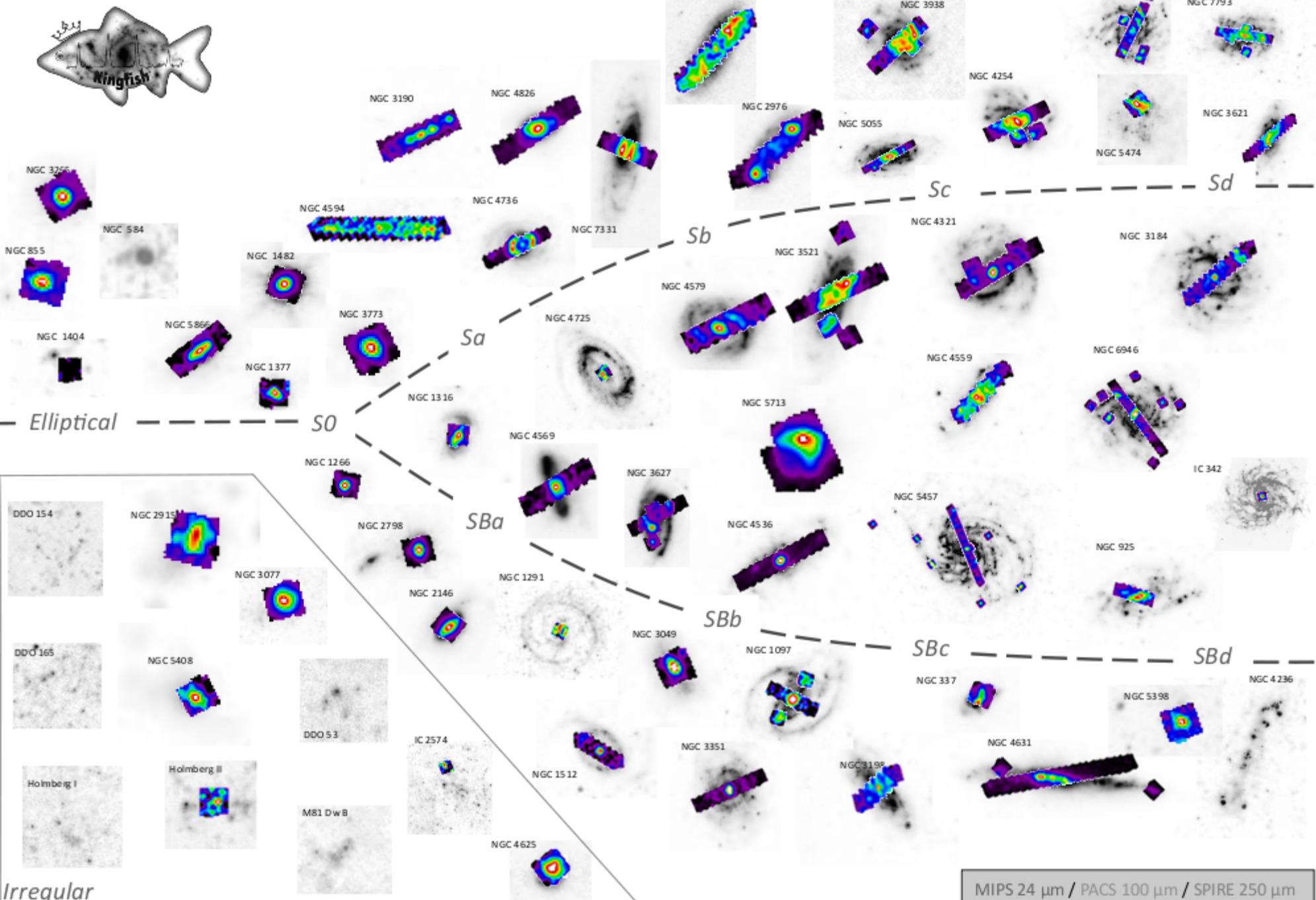
KEY INSIGHTS ON NEARBY GALAXIES: A FAR-INFRARED SURVEY WITH HERSCHEL



Kingfish (Key Insights on Nearby Galaxies: a Far-Infrared Survey with Herschel)



Kingfish (Key Insights on Nearby Galaxies: a Far-Infrared Survey with Herschel)



MIPS 24 μm / PACS 100 μm / SPIRE 250 μm

KINGFISH SPECTRAL RELEASE

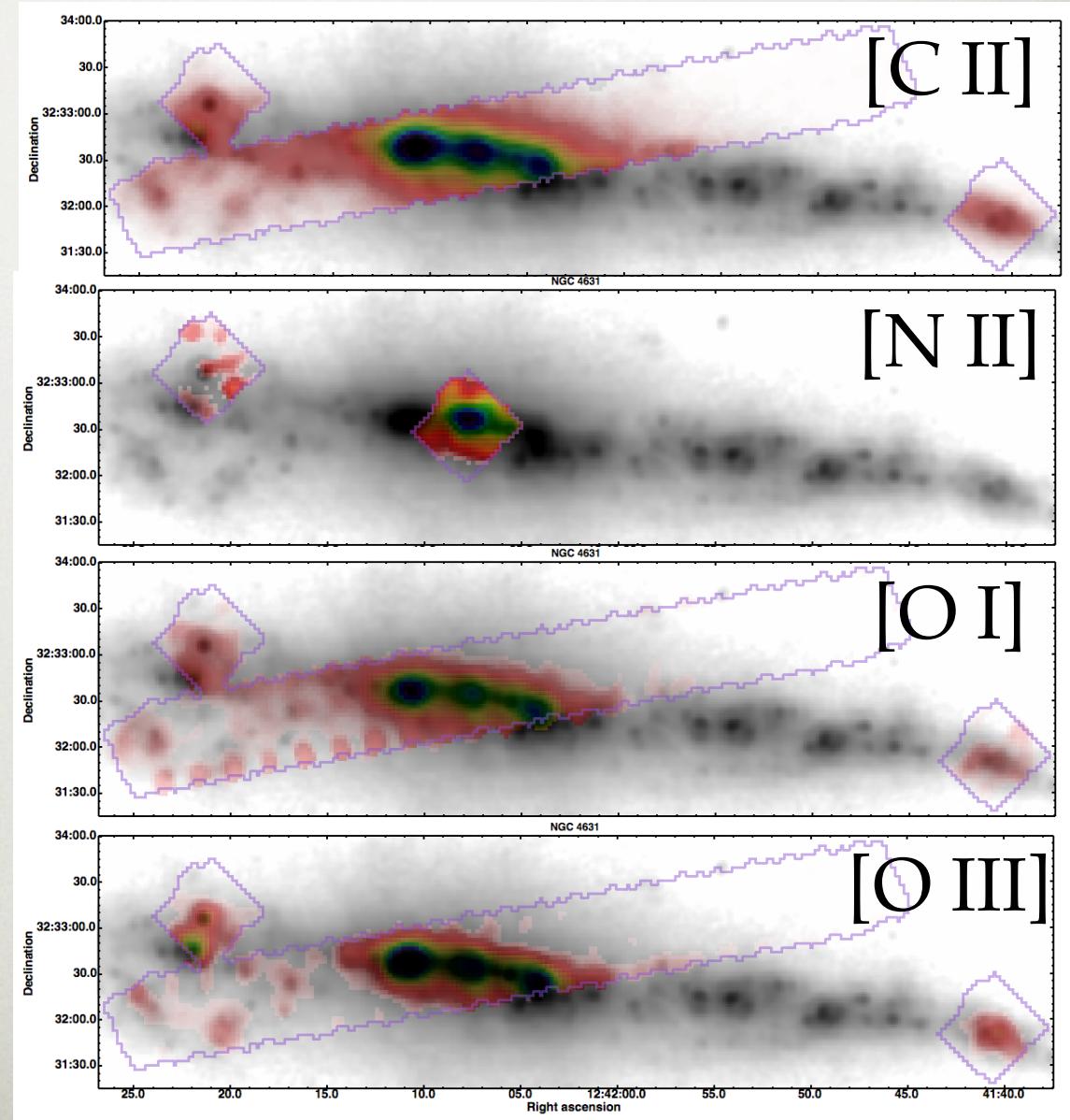
386.2 Hours of PACS Line Spectroscopy in mapping mode

16% of the 2,340 Hours for KPOT for Nearby Galaxies

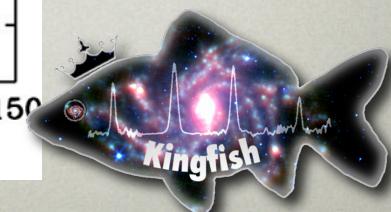
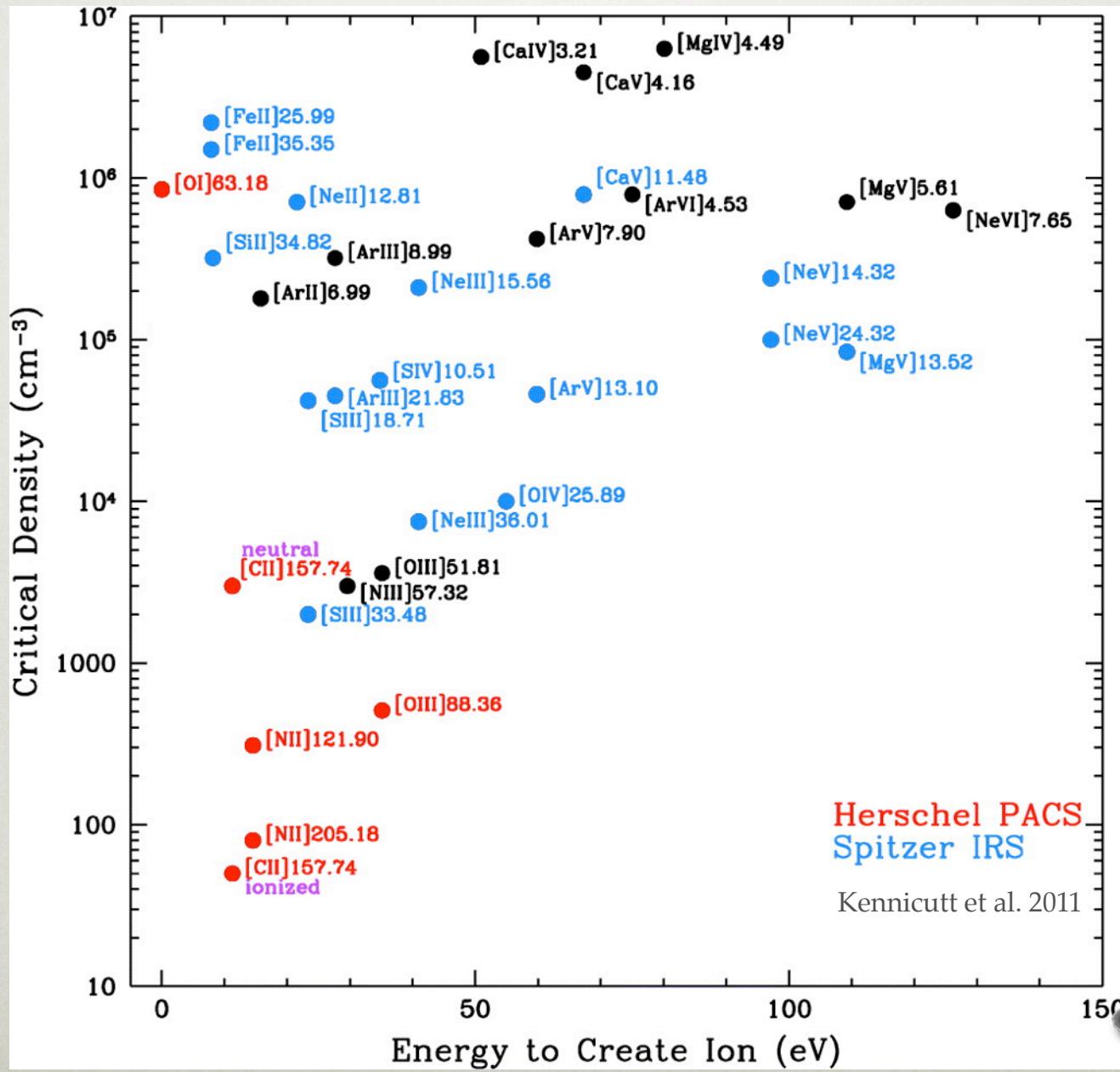
Majority of Un-chopped Mapping data

Moment-0 maps and spectral cubes soon to be released

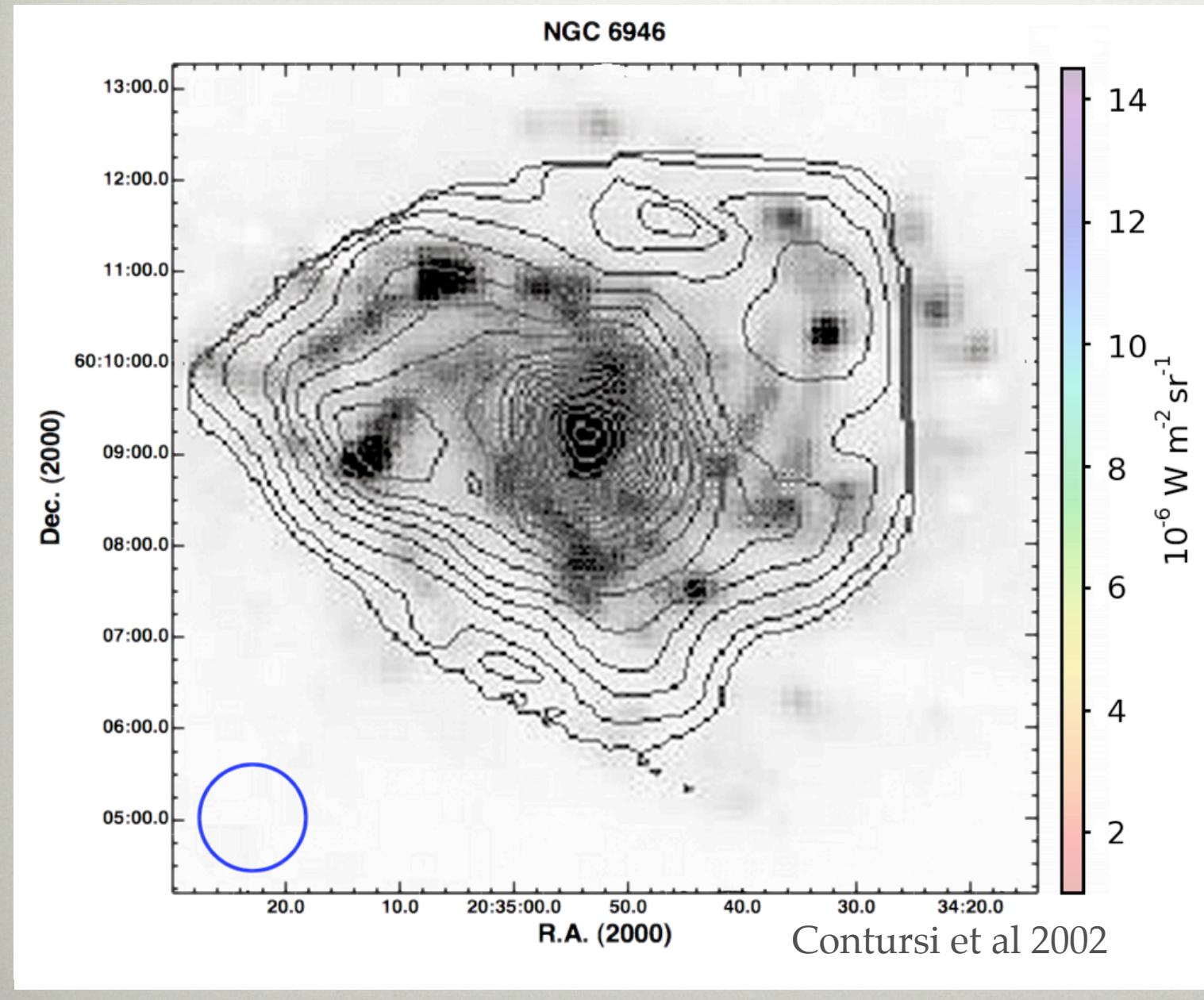
NGC 4631



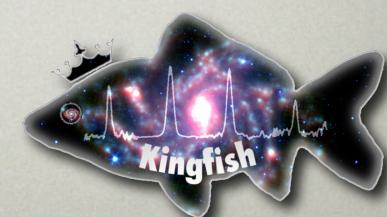
A ROADMAP OF IR LINES



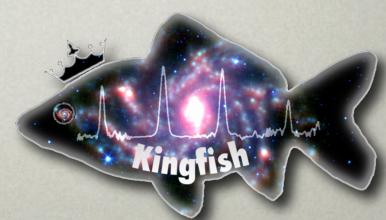
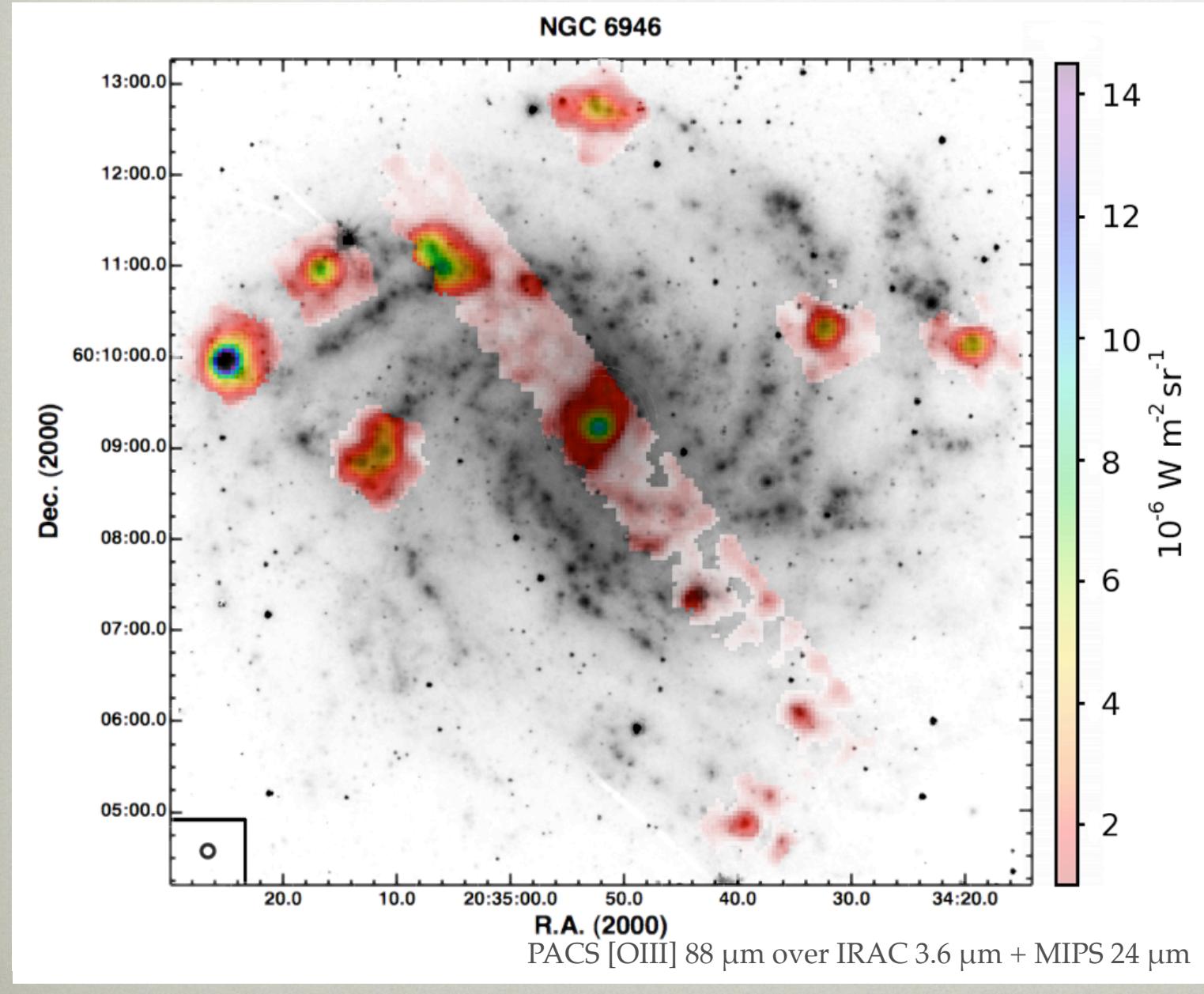
RESOLUTION: ISO VS HERSCHEL



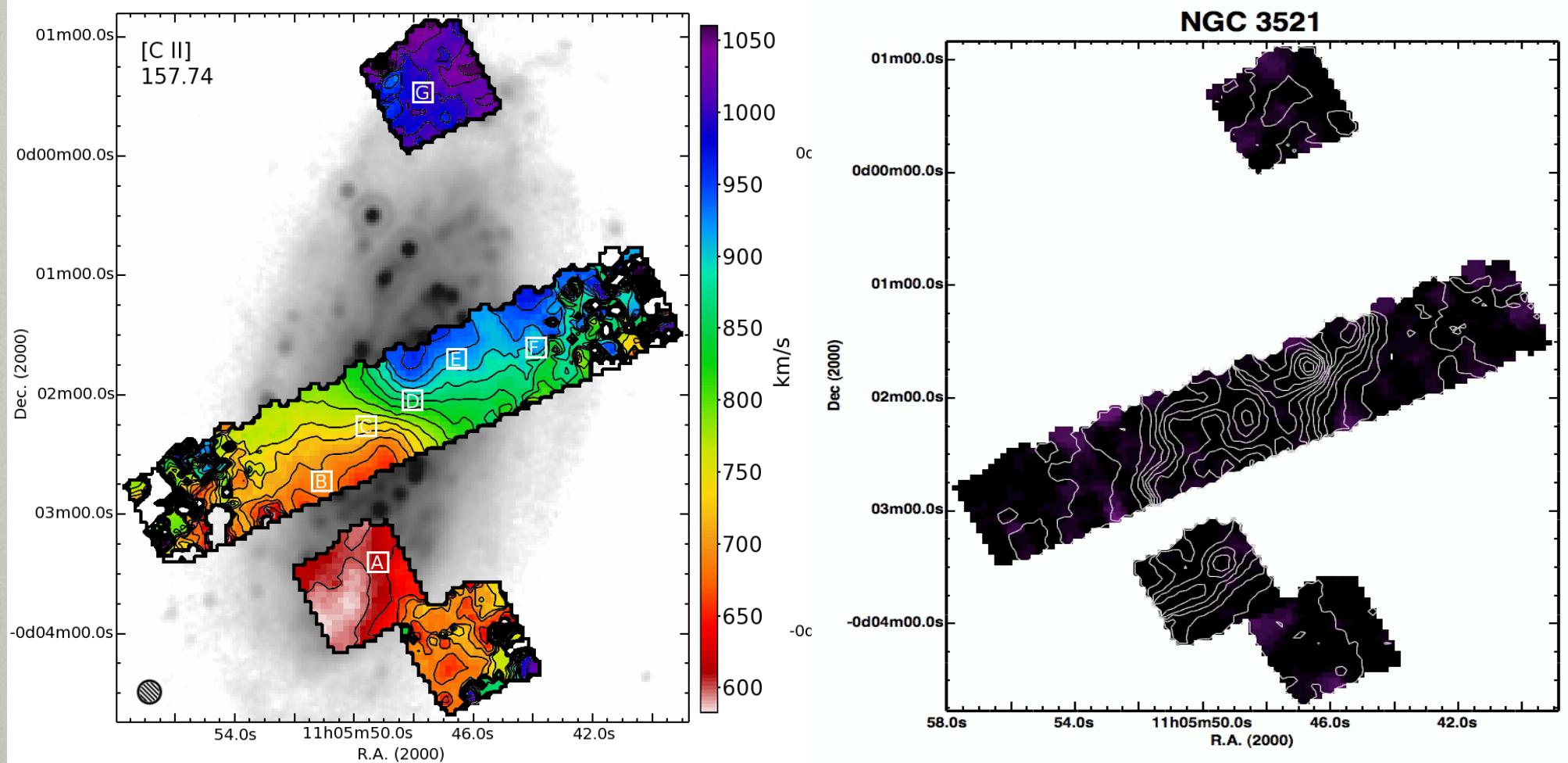
- ISO
70'' beam
- PACS
8'' beam



RESOLUTION: ISO VS HERSCHEL



MORE THAN JUST FLUX



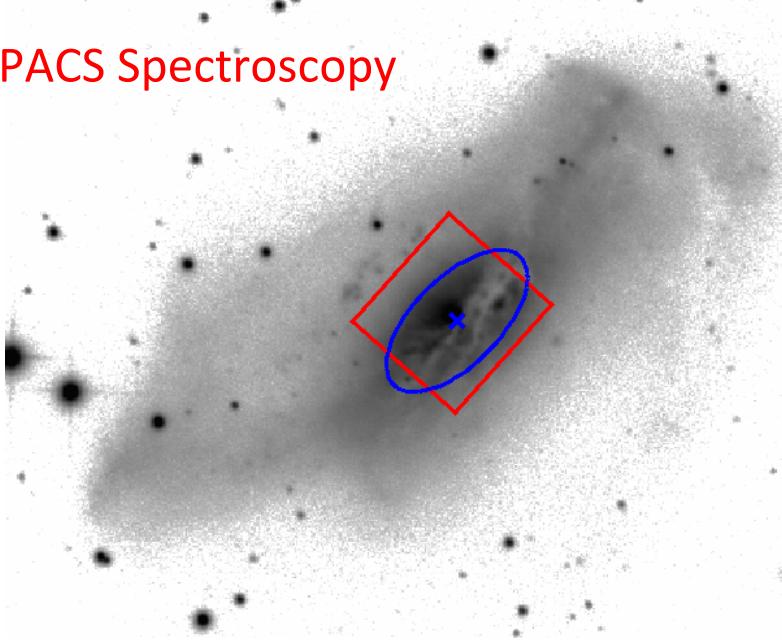
Kennicutt et al. 2011

A far-IR view of the starburst driven superwind in NGC 2146

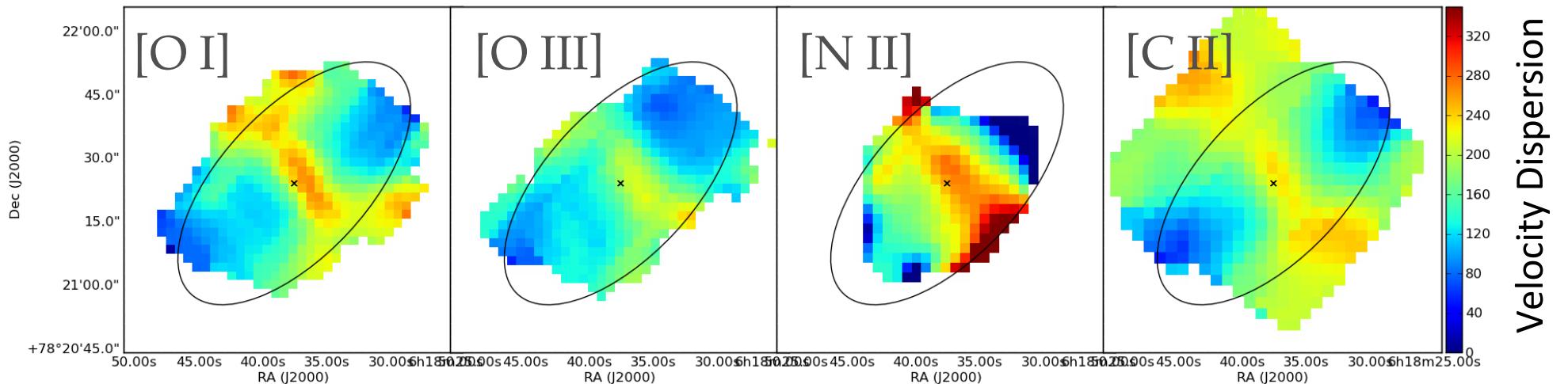
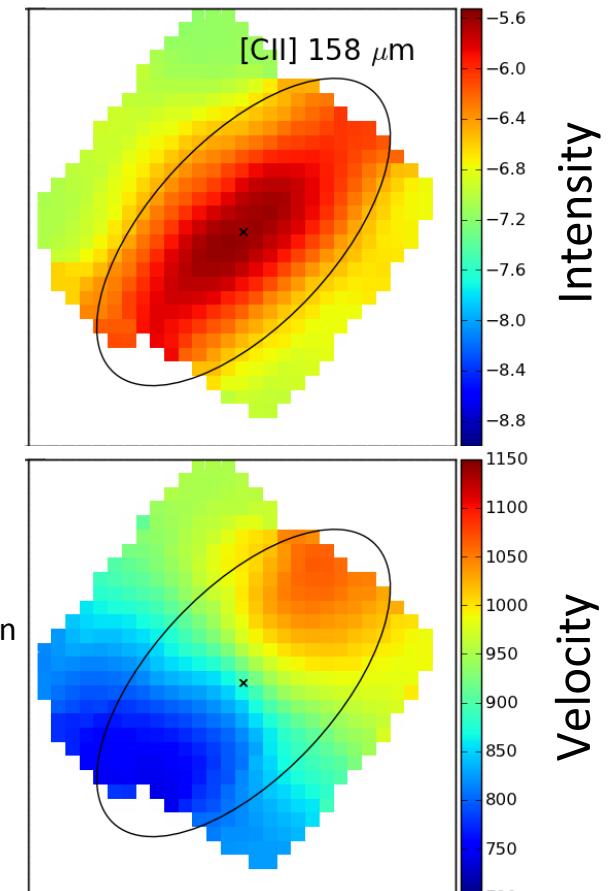


Kreckel et al., in prep

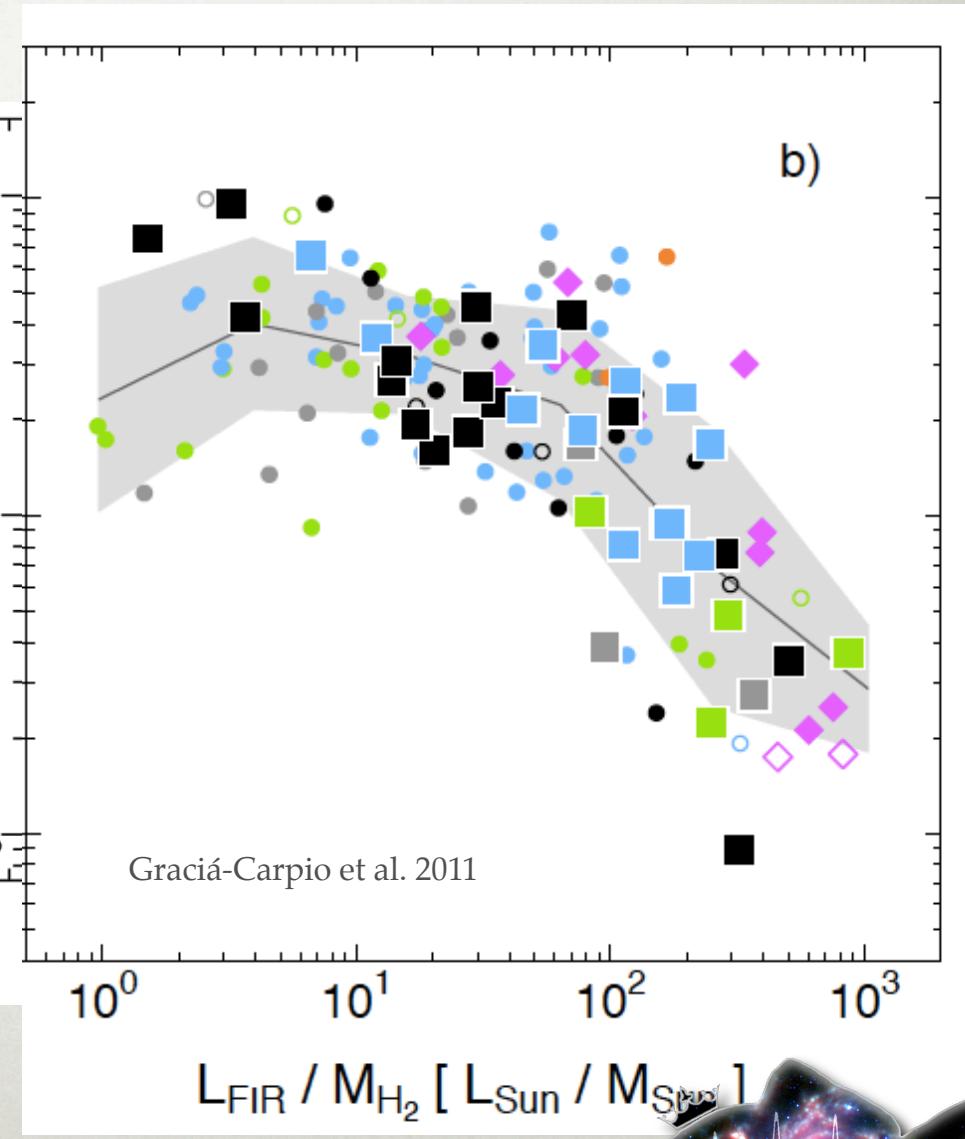
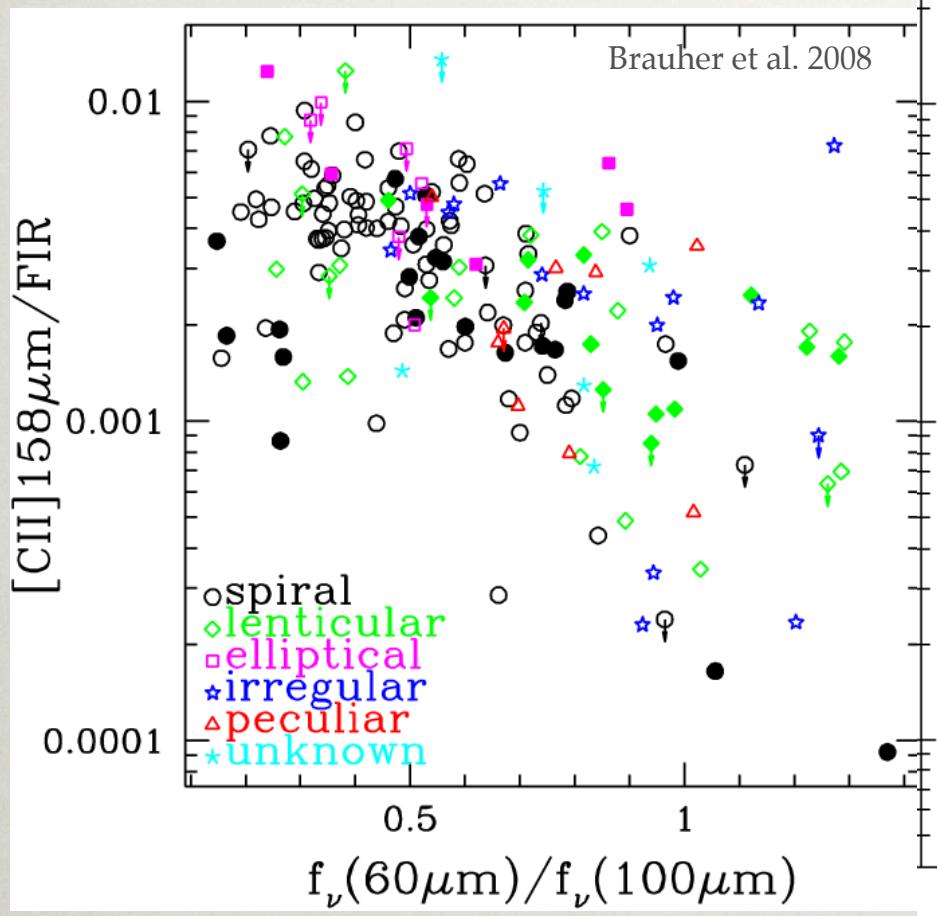
PACS Spectroscopy



LIRG, $L_{\text{IR}} = 1.2 \times 10^{11} L_{\text{sun}}$
SFR = $7.9 M_{\text{sun}}/\text{year}$
 $M_* = 2 \times 10^{10} M_{\text{sun}}$
No AGN



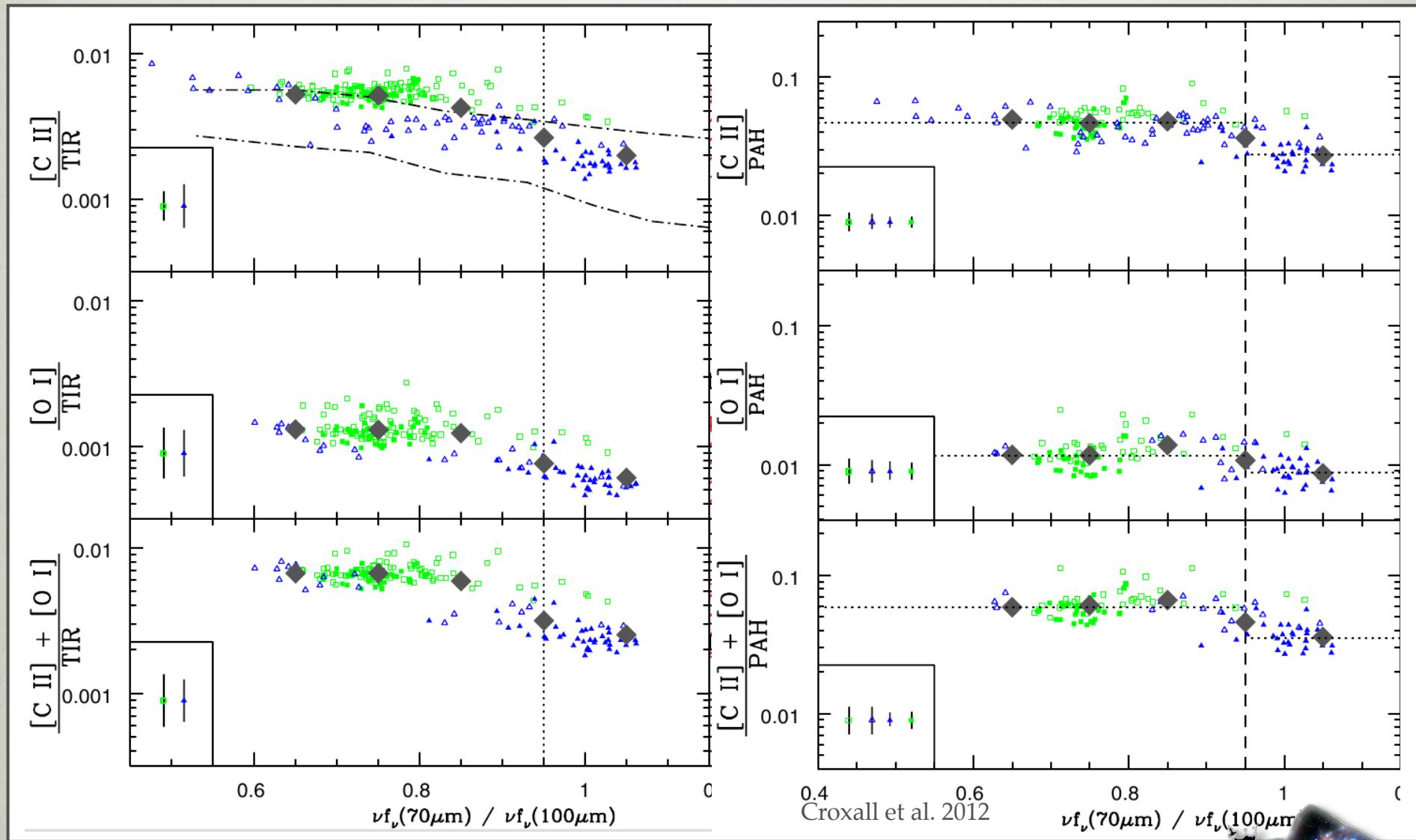
THE C+ LINE DEFICIT



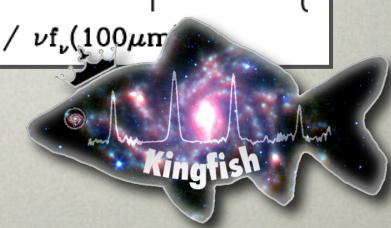
$L_{\text{FIR}} / M_{\text{H}_2} [L_{\text{Sun}} / M_{\text{Solar}}]$



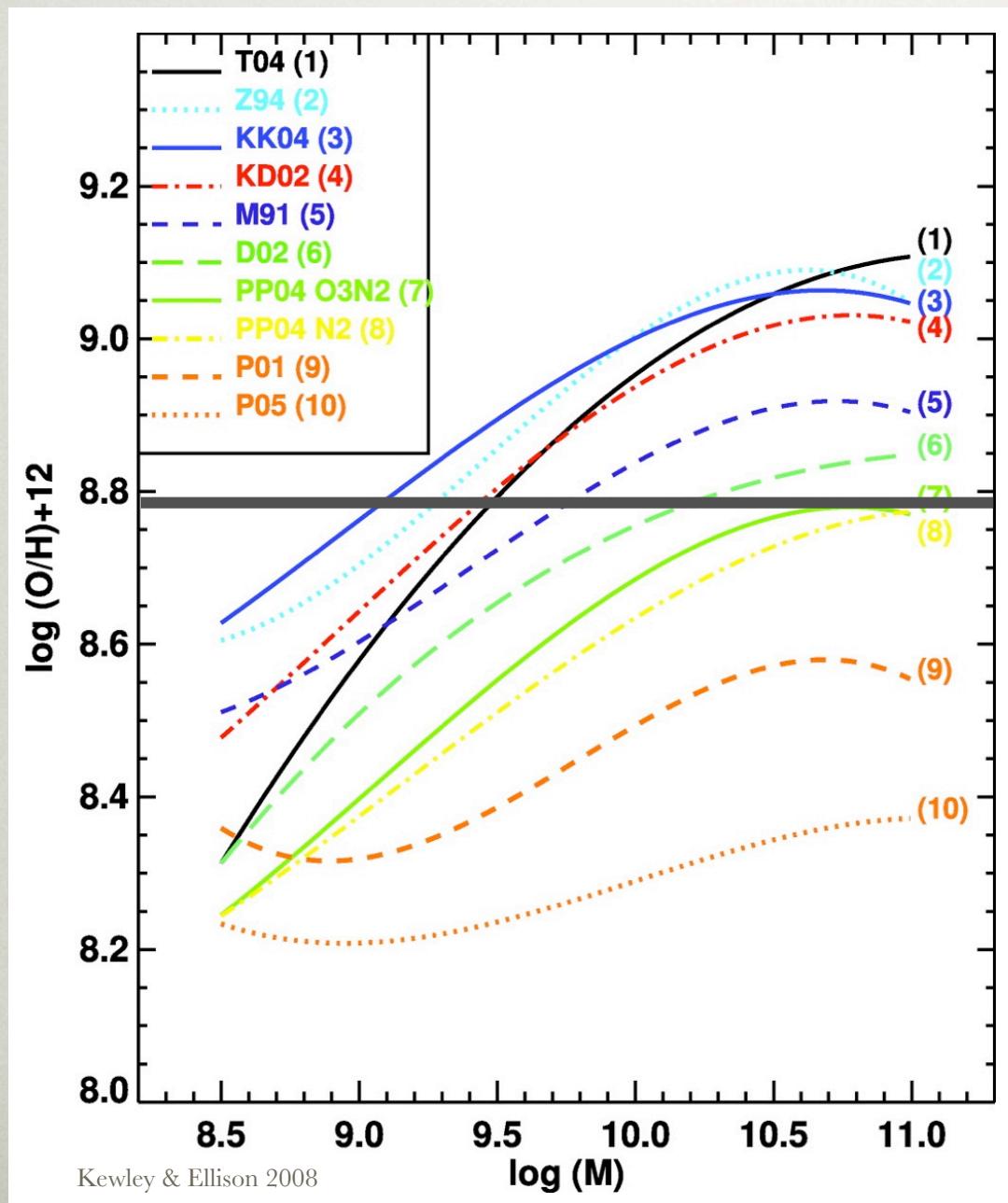
THE C+ LINE DEFICIT



Croxall et al. 2012



IS THE UNIVERSE SUB- OR SUPER- SOLAR?



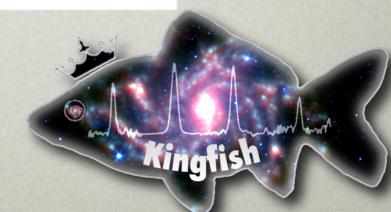
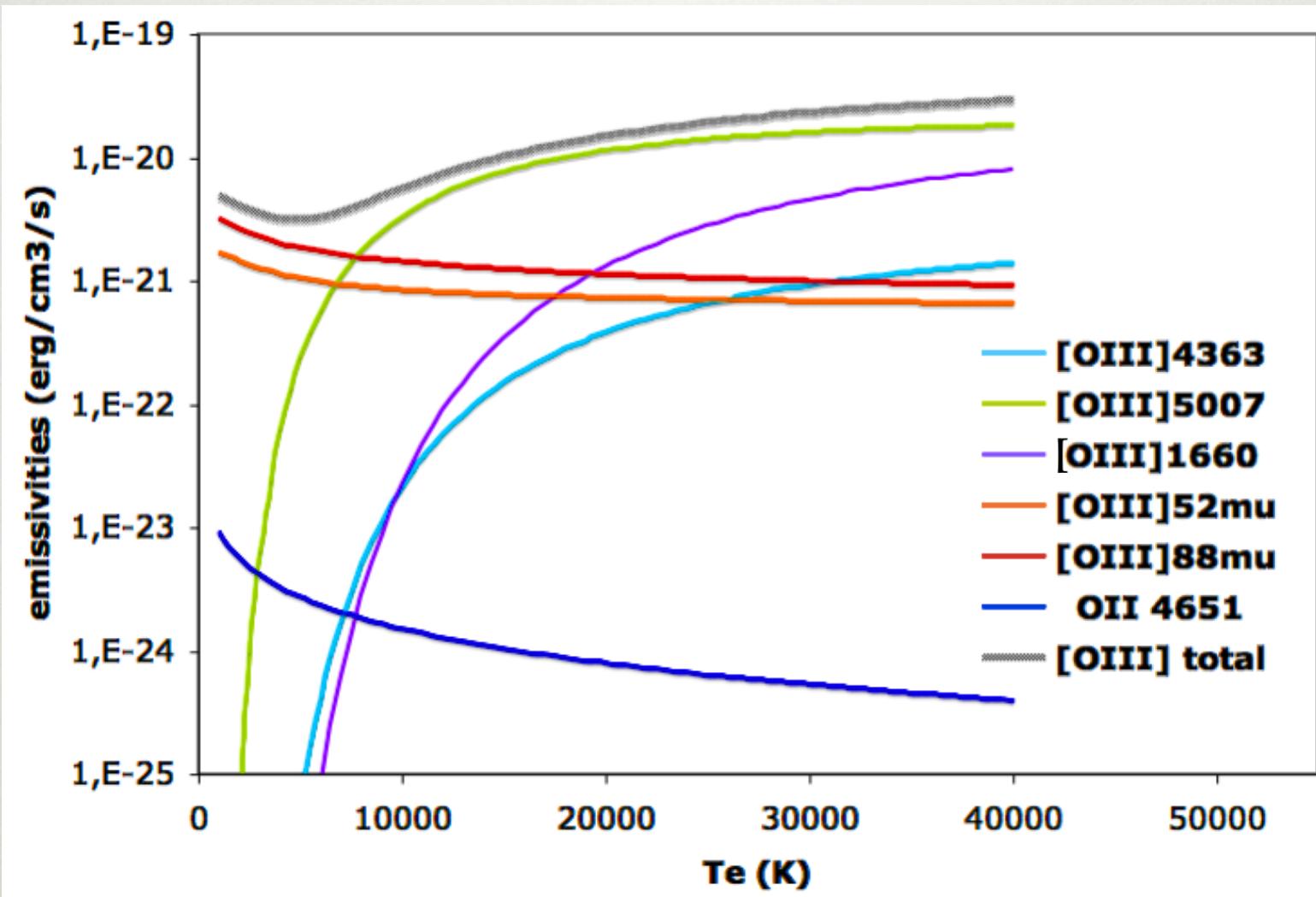
} - Photoionization
models

Solar Ayres

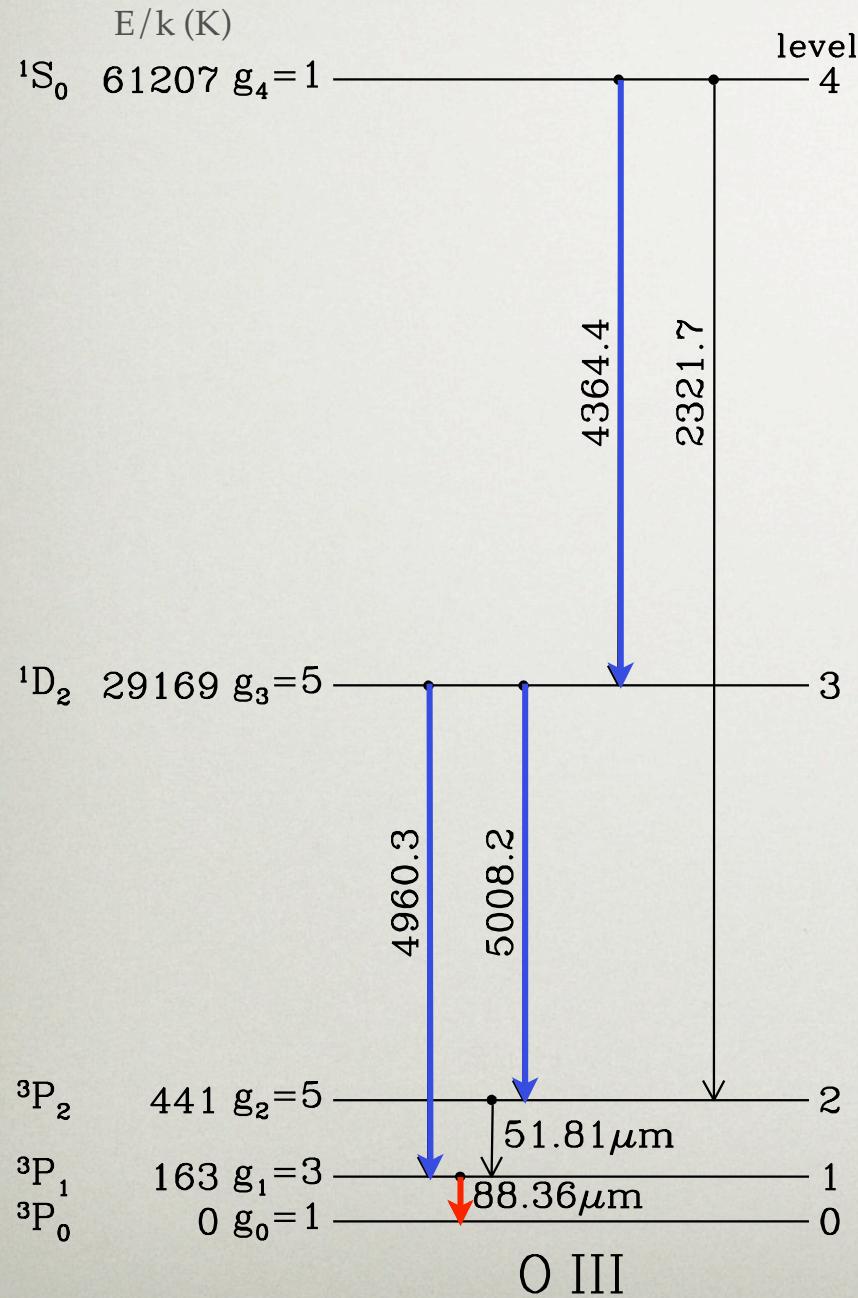
} - Empirical
Solutions



TEMPERATURE DEPENDENCIES

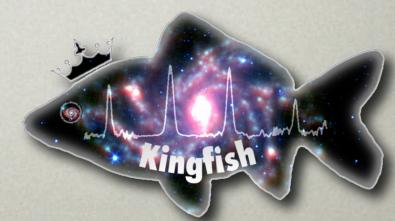


YOU ALWAYS GET [OIII] 88 μ M

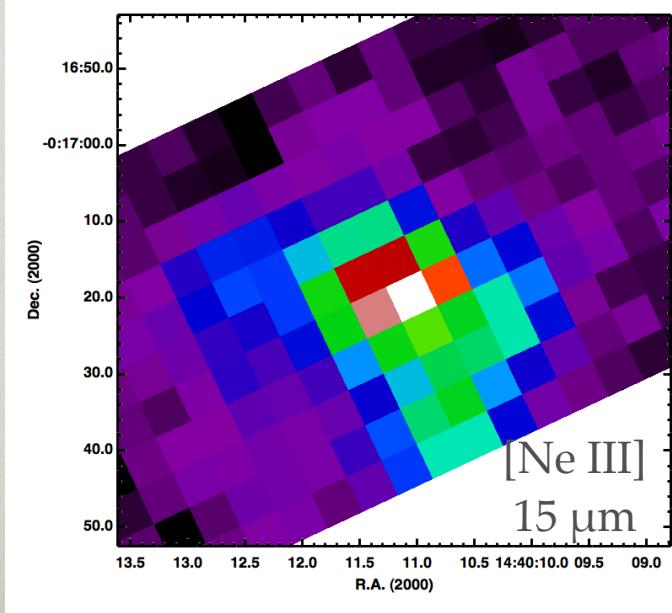
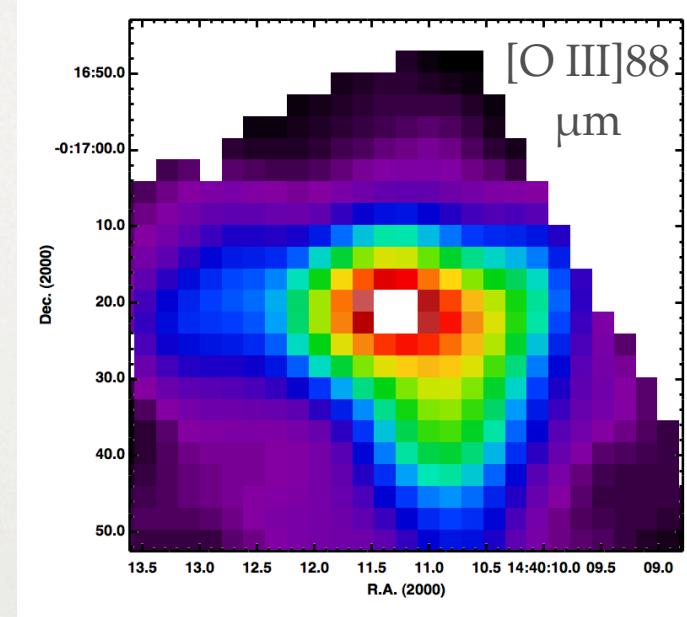
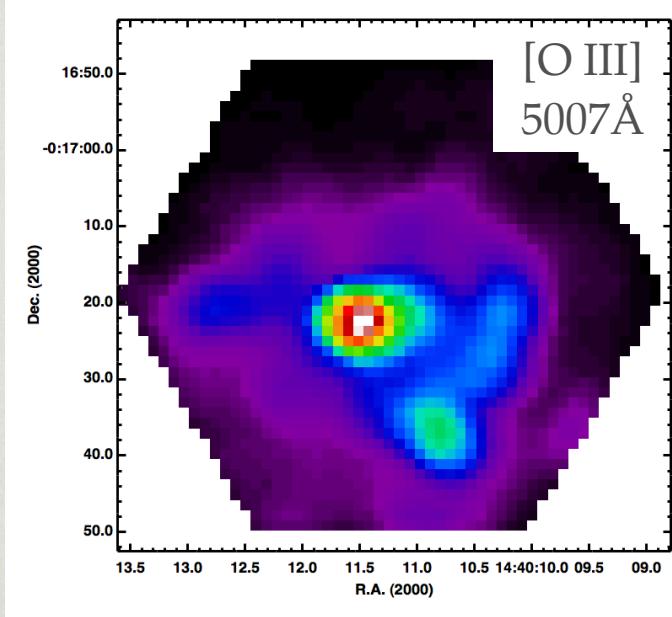


- Temperature Sensitivities
- Dust Obscuration

- Density Dependencies
- Spatial Resolution
- Ionization Correction Factors



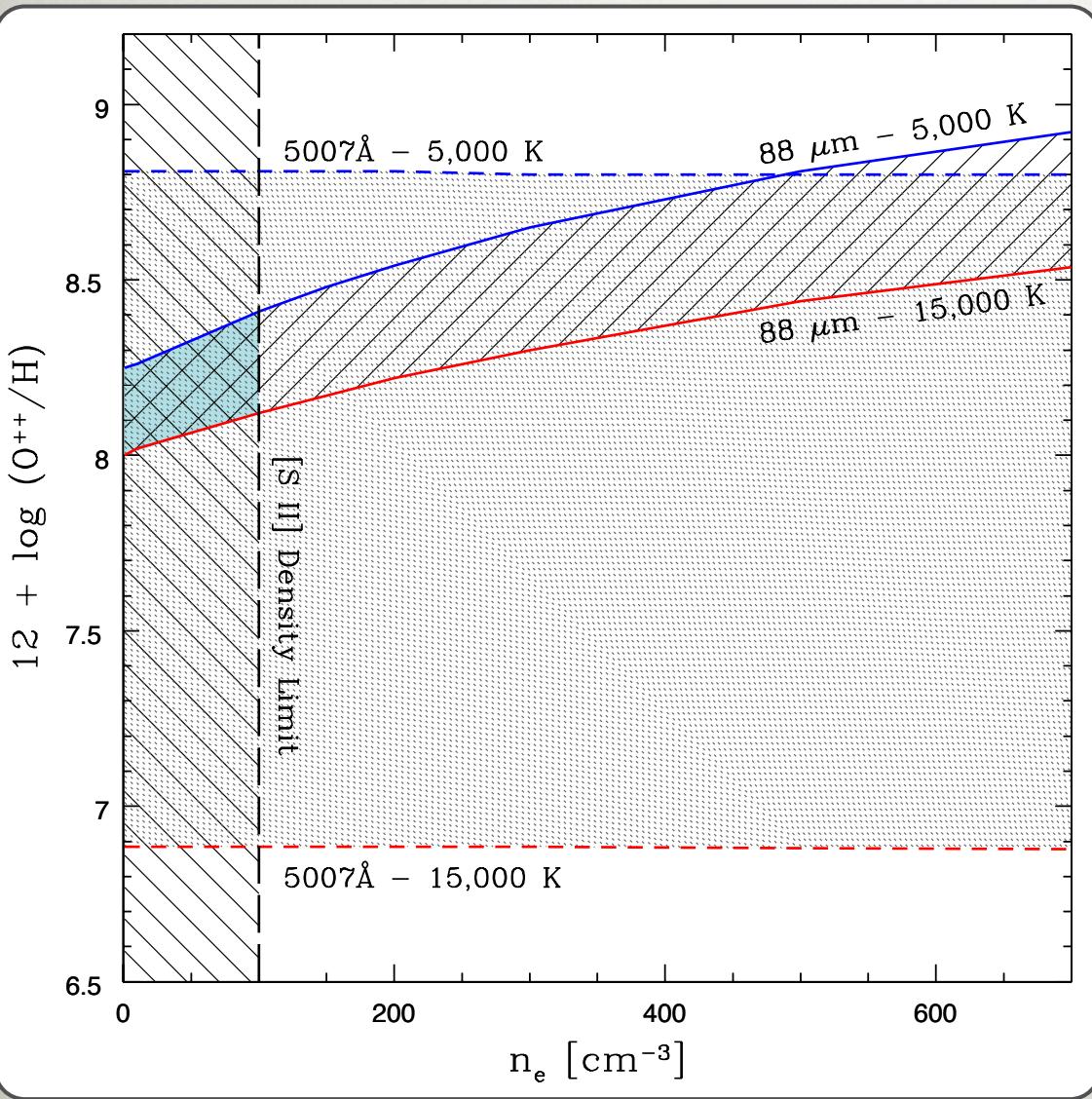
WE MUST MATCH APERTURES



- SINGS IRS spectra
- PPAK Maps
- SINGS drift scan spectra

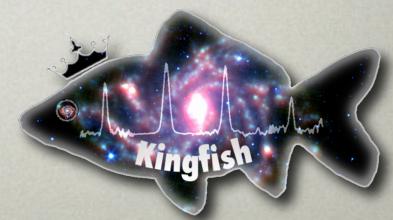


TEMPERATURE DEPENDENCIES OF O⁺⁺



Using the FIR data can place stronger constraints on the abundance of (O⁺⁺ / H)

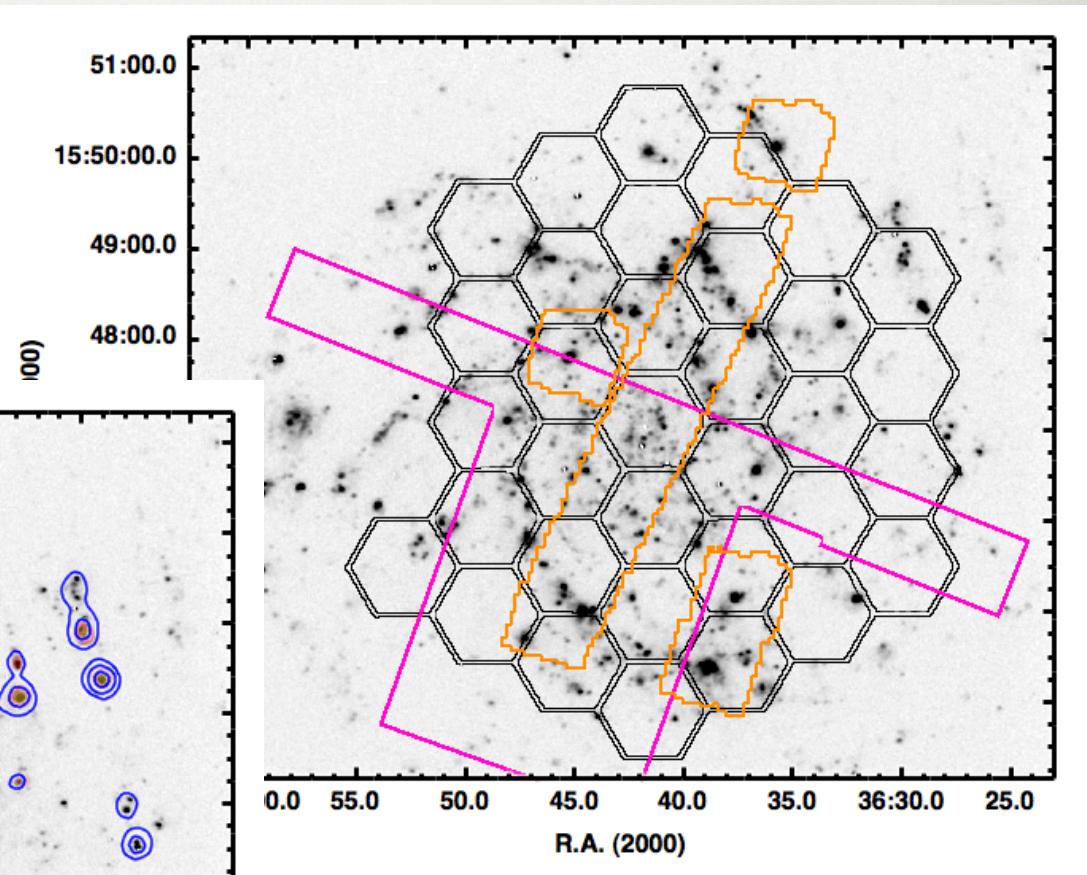
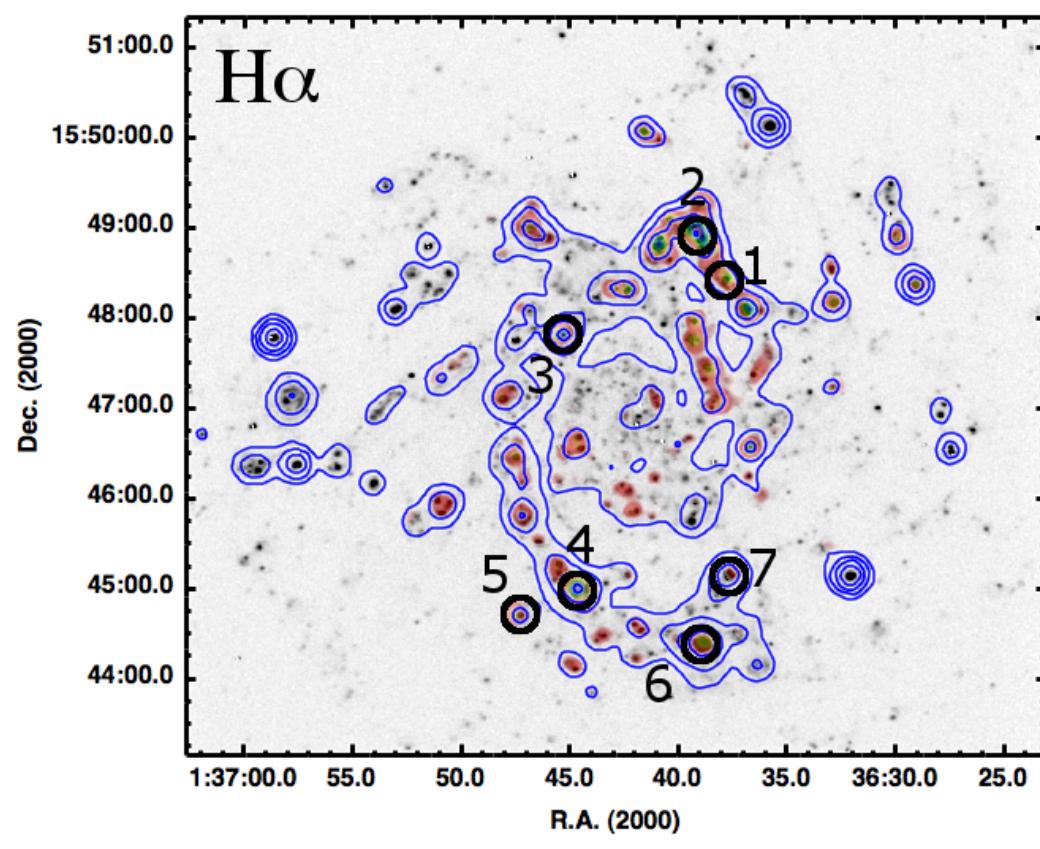
Constraints on density further limit the uncertainty



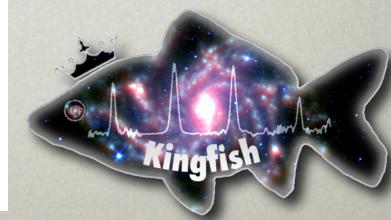
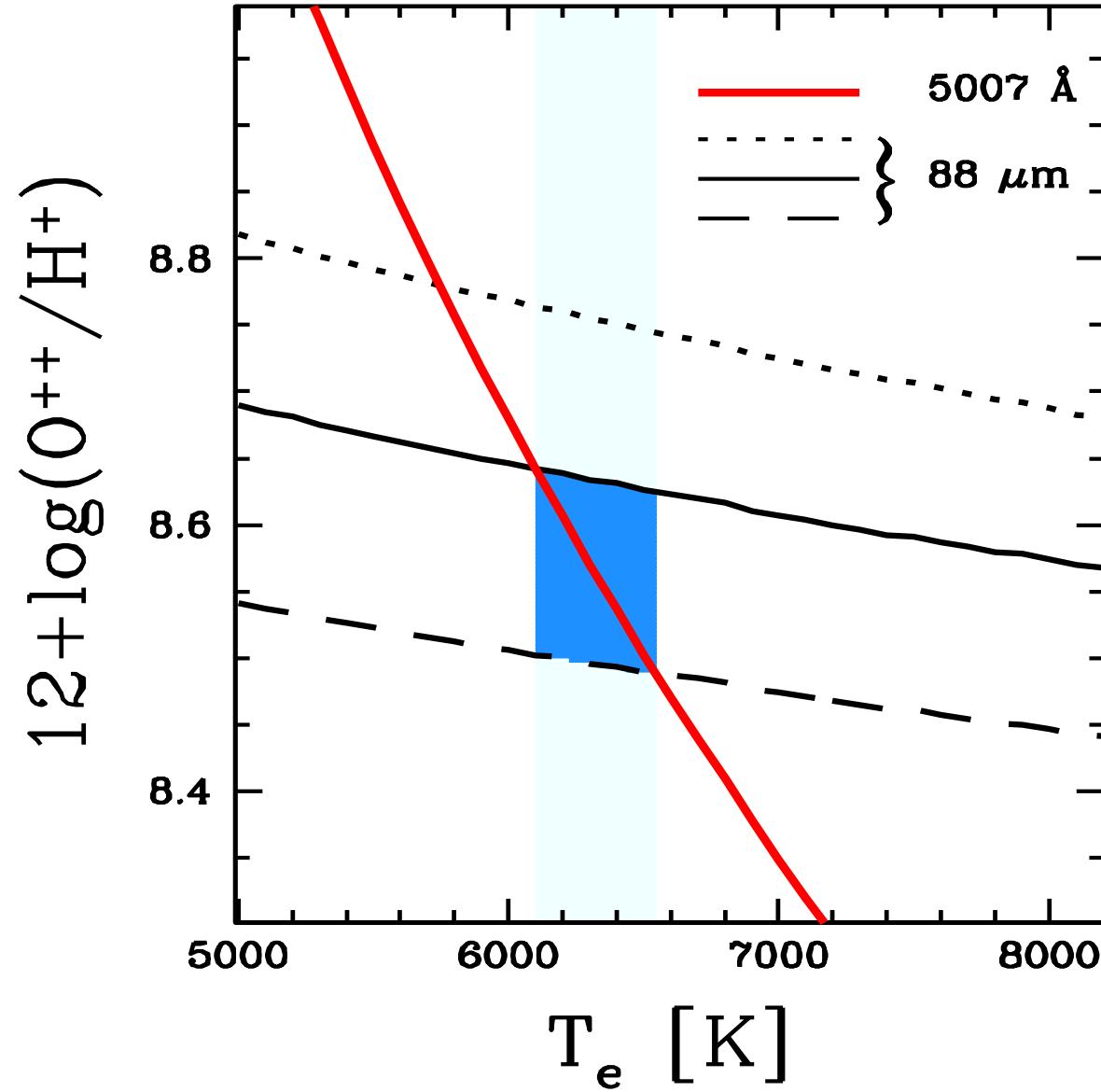
NGC 628

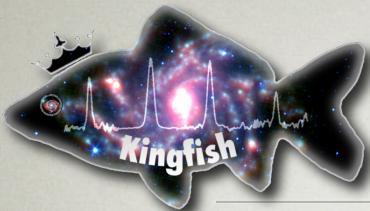
KK04 SINGS : 9.02 ± 0.01

PT05 SINGS : 8.35 ± 0.01



OPTICAL & FIR ORIGINATE FROM THE SAME IONS





NGC 628

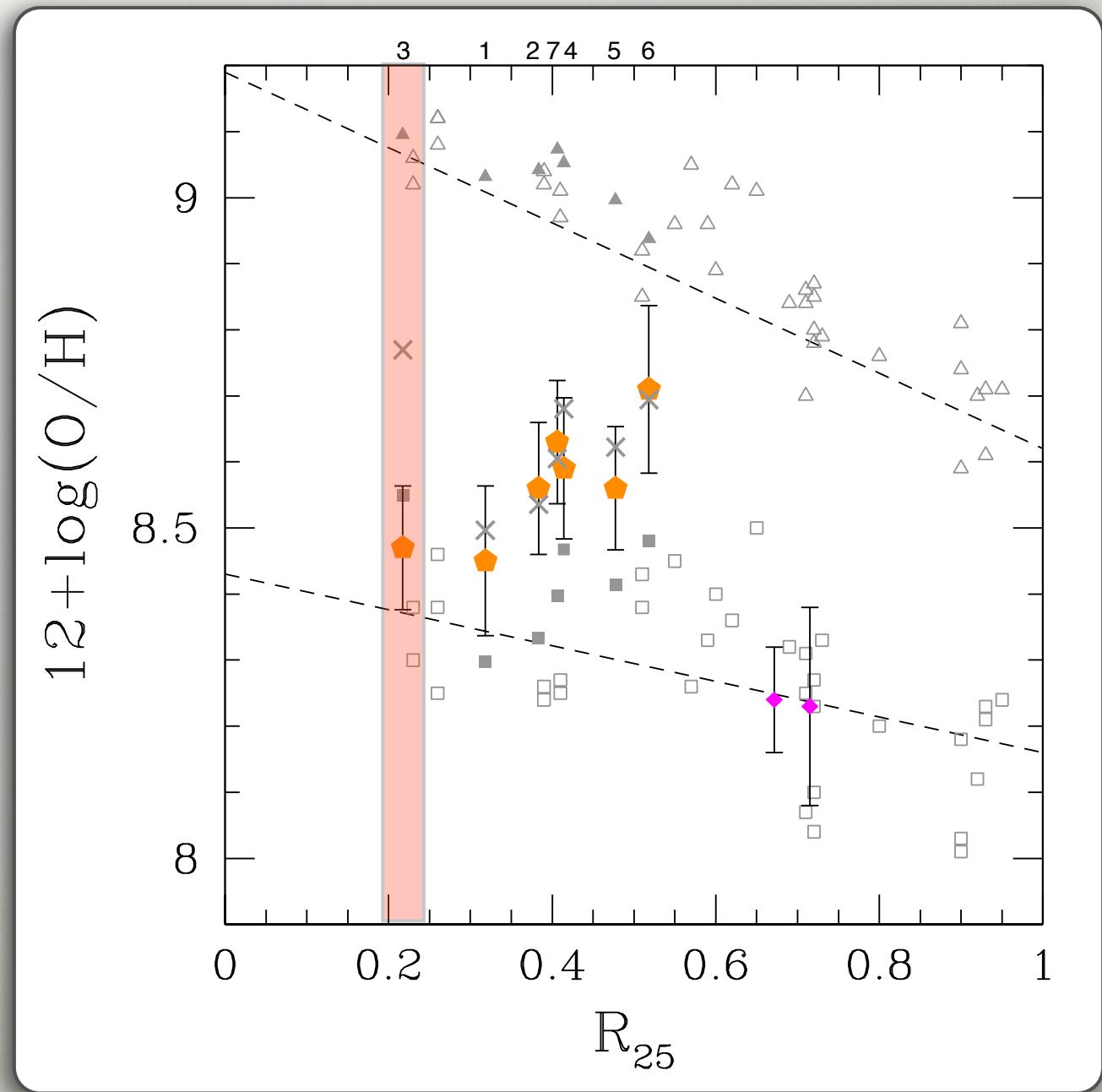
pentagon FIR + Opt

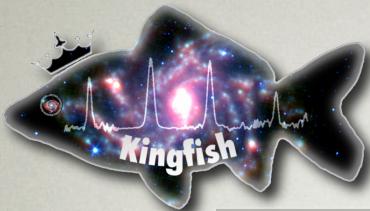
cross PG12 (Fluct)

triangle KK04 (MOD)

square PT05 (Emp)

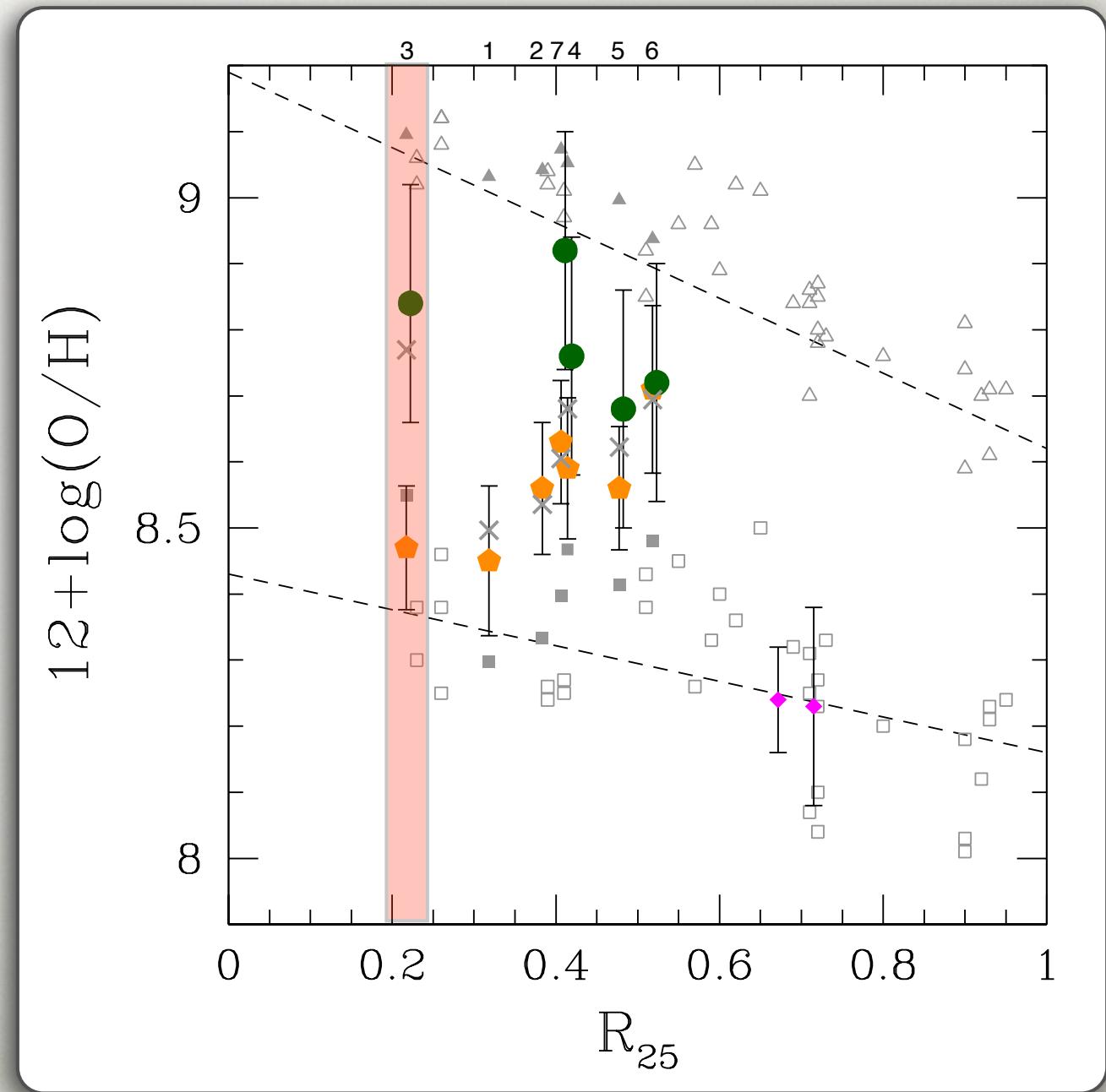
diamond $\lambda 4363$ (Dir)





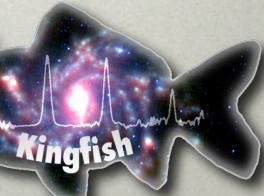
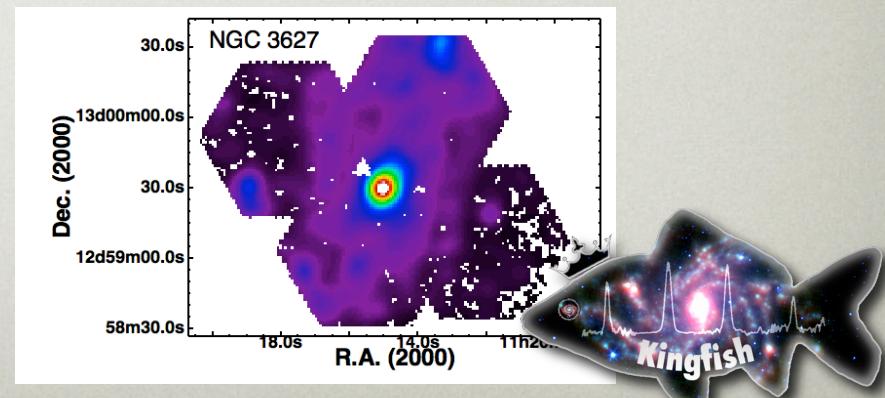
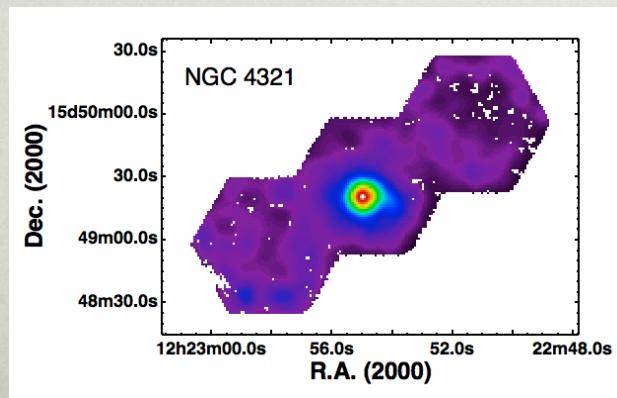
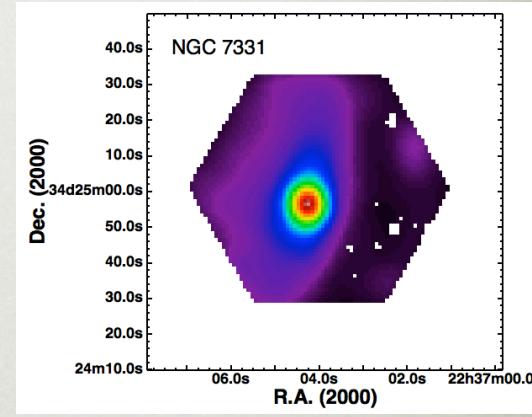
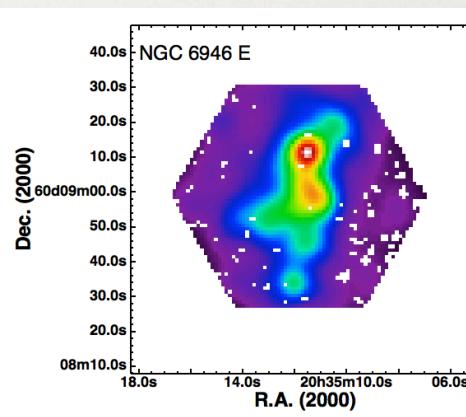
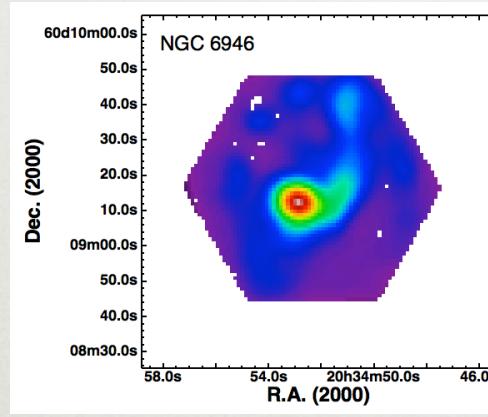
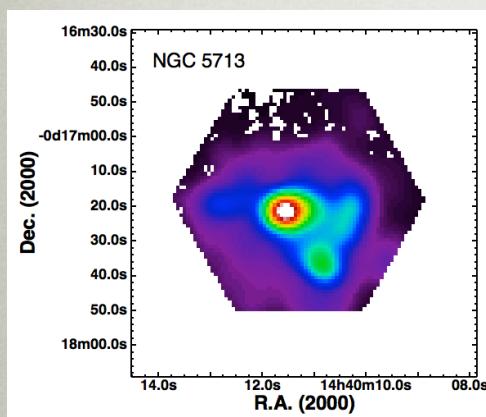
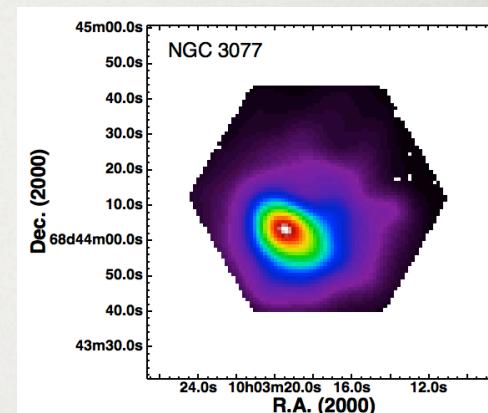
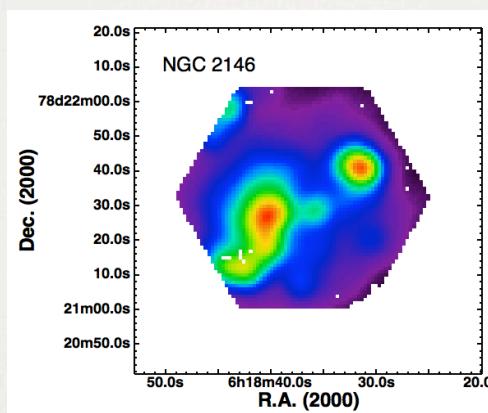
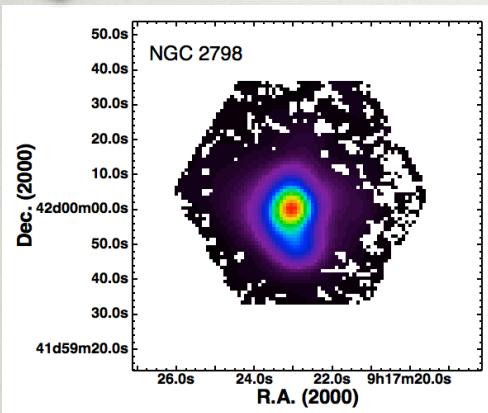
NGC 628

- FIR + Opt
- MIR + MOD
- PG12 (Fluct)
- KK04 (MOD)
- PT05 (Emp)
- $\lambda 4363$ (Dir)





FUTURE PLANS:



IN CONCLUSION:

- **KINGFISH** is permitting the study of spatially resolved line emission in nearby galaxies thanks to Herschel/PACS.
- We can study numerous aspects of **gas physics**: dynamics, star-formation, gas cooling, etc.
- Far-IR [O III] observations from Herschel are **insensitive** to the **temperature**, enabling a FIR calibration of O/H.

