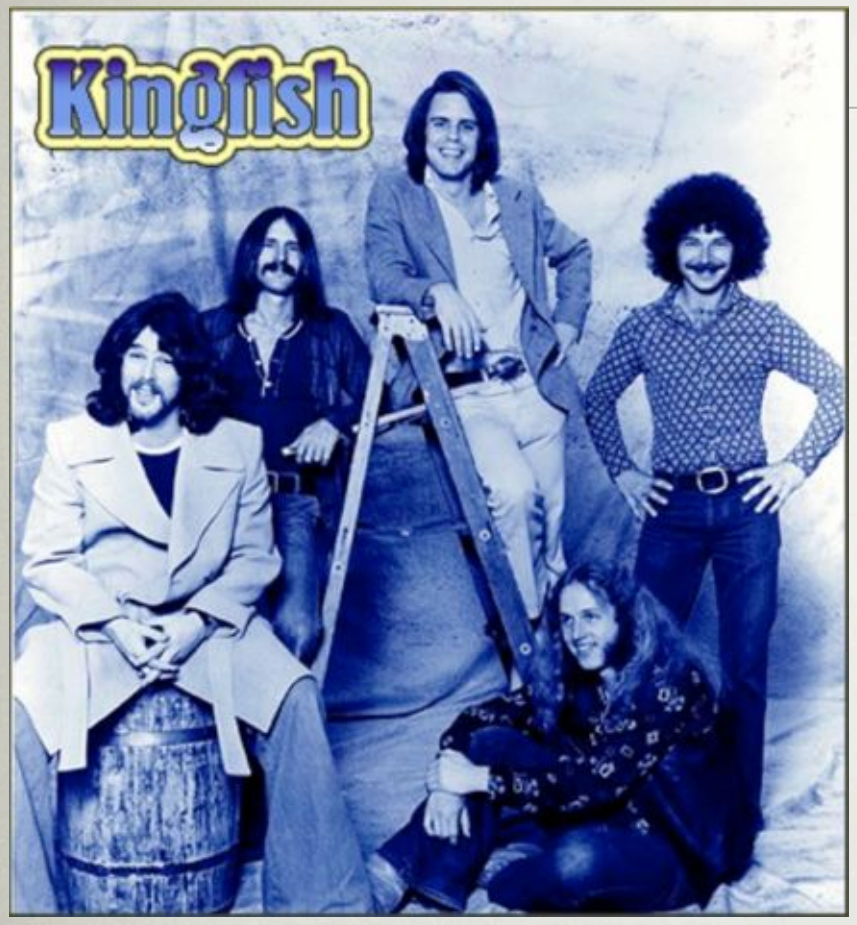
Oxygen In The Far-IR

Mapping Nearby Galaxies with Herschel

Kevin Croxall

and the KINGFISH Team



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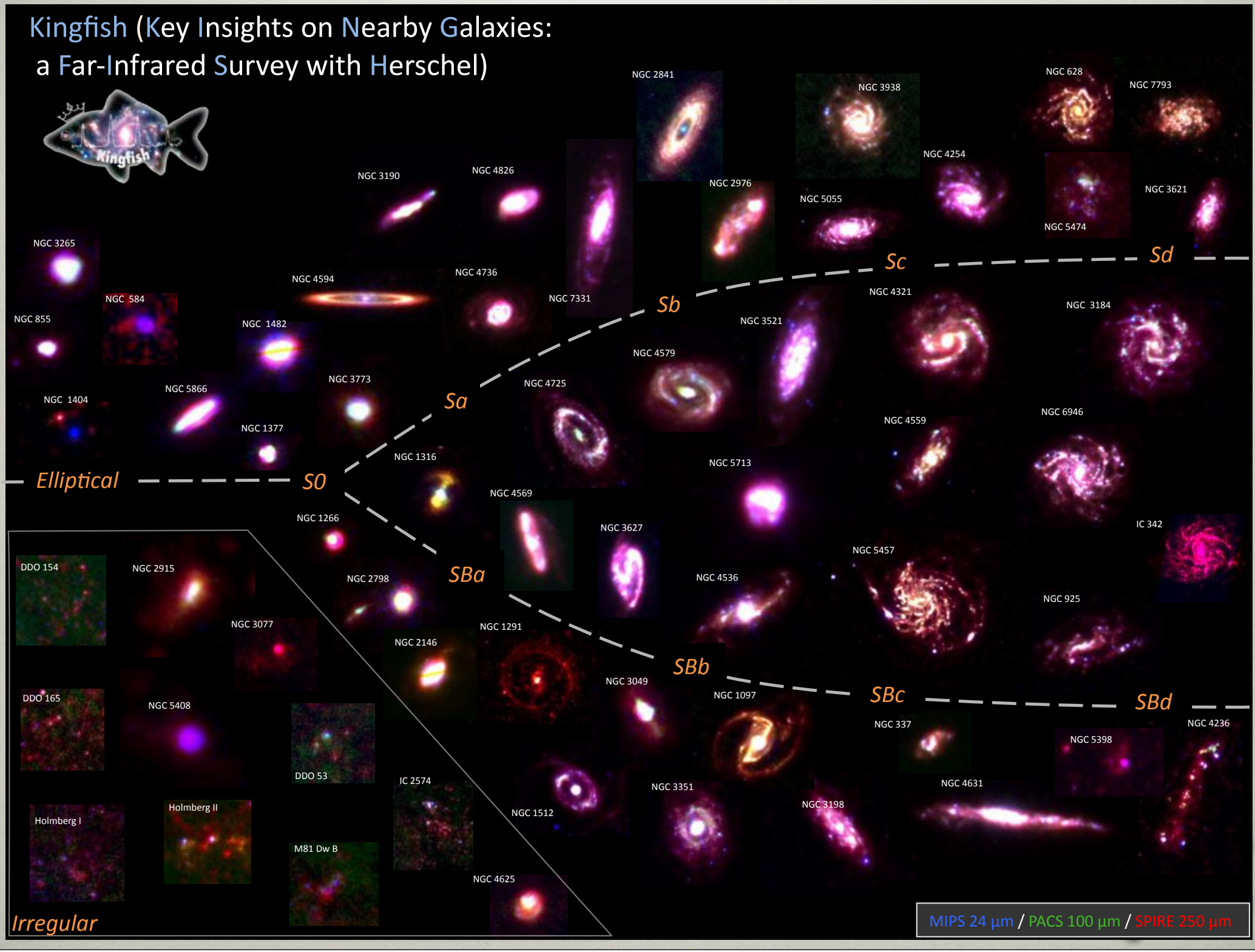
- Laurent Vigroux
- Fabian Walter
- Bradley Warren
- Christine Wilson
- Mark Wolfire
- Stefano Zibetti

Key Insights on Nearby Galaxies: a Far-Infrared Survey With Herschel

- Star-Formation Rate Tracers
- Star-Formation (schmidt) law(s)
- Gas+Dust: Coupled Energy Budget of heating and cooling (SF & weak AGN)
- ISM Conditions, Radio/IR correlation
- (Temperature insensitive) Abundances
- Dust mass budget (cold dust distribution?)
- Resolving out the Radio-IR correlation


Kingfish (Key Insights on Nearby Galaxies:
a Far-Infrared Survey with Herschel)
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NGC 2841
NGC 3938
NGC 628
NGC 7793
NGC 4254
NGC 3190
NGC 4826
NGC 2976
NGC 5055
NGC 5474
NGC 3621
NGC 3265
Sc
Sd
NGC 4594
NGC 4736
NGC 7331
Sb
NGC 4321
NGC 584
NGC 855
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NGC 3521
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S0
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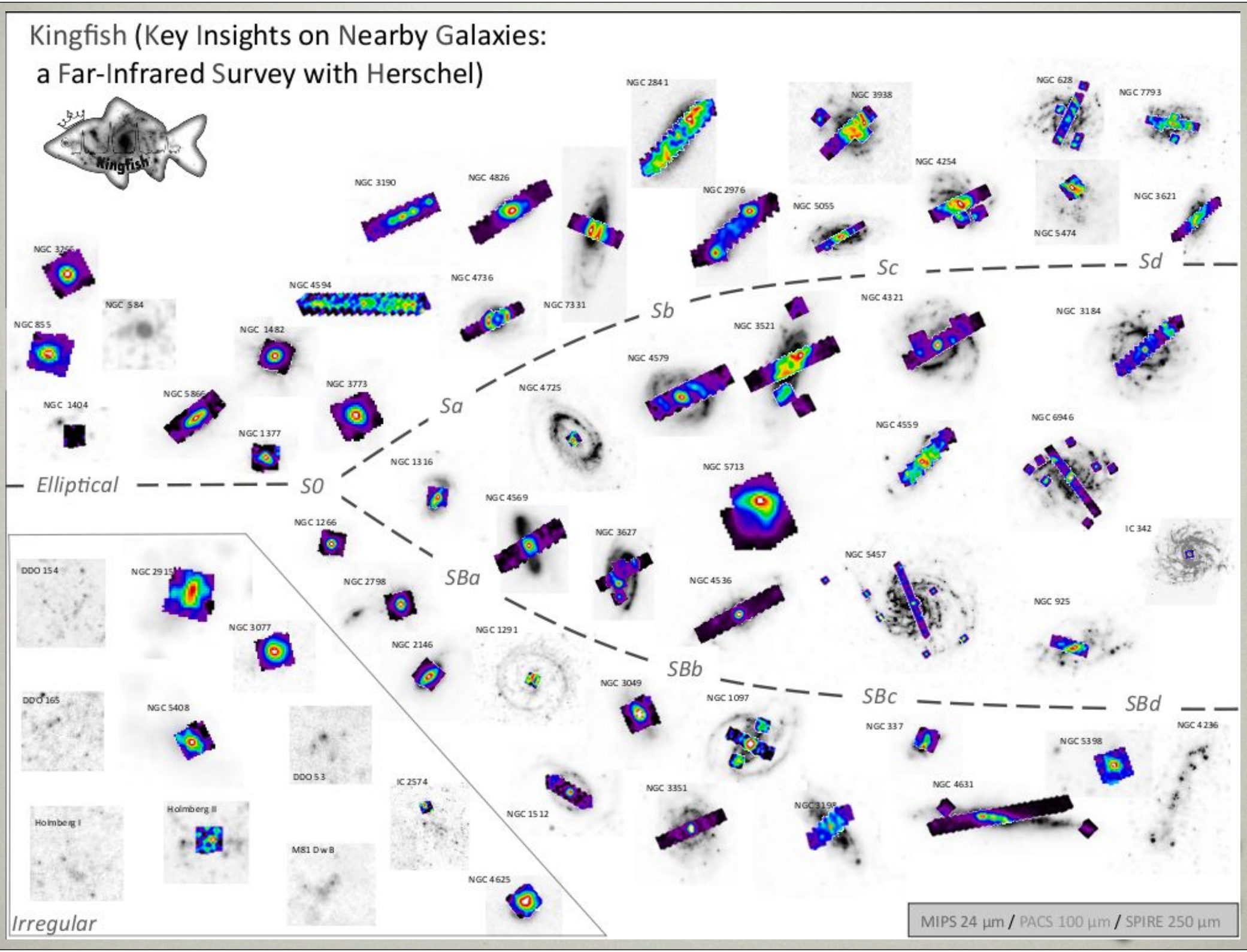
DDO 165
NGC 5408
NGC 1097
NGC 337
NGC 4236
NGC 5398
DDO 53
IC 2574
NGC 3351
NGC 4631
NGC 1512
NGC 3198
Holmberg I
Holmberg II
M81 Dw B
NGC 4625
Irregular
MIPS 24 μm / PACS 100 μm / SPIRE 250 μm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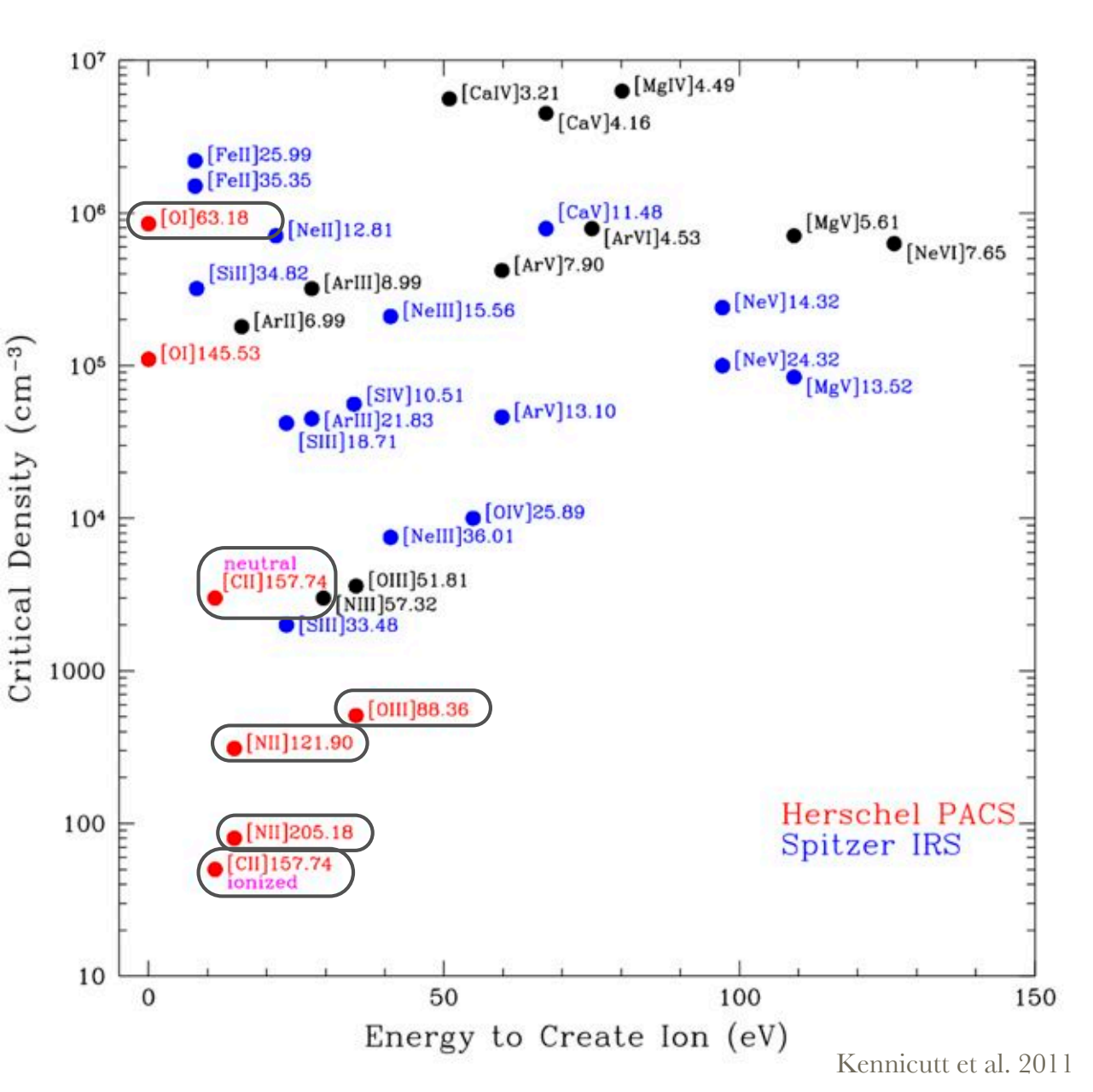
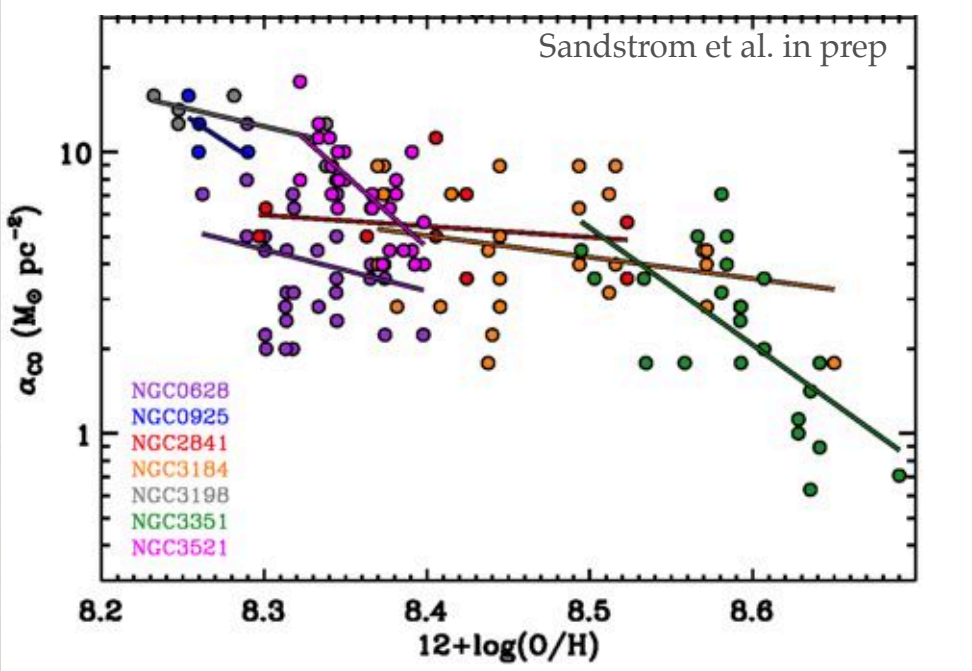
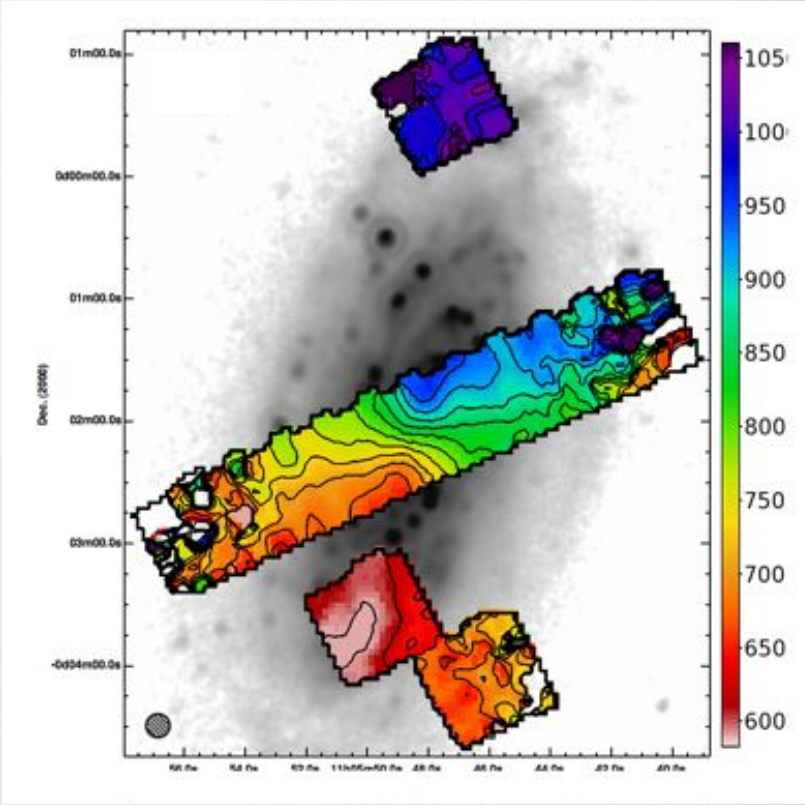
A Sampling of Lines

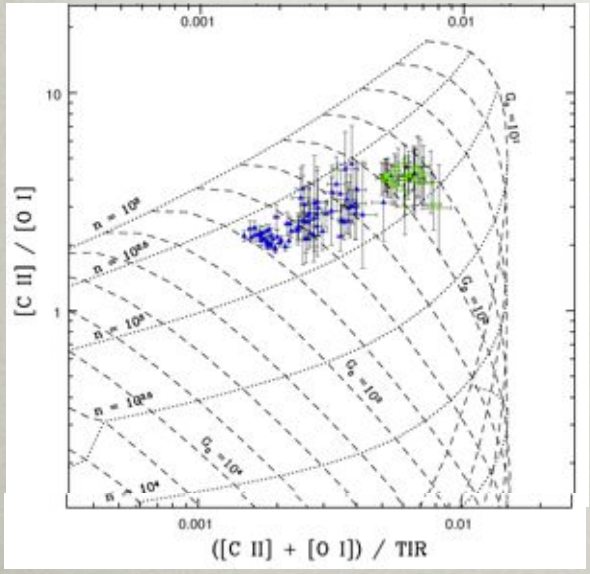


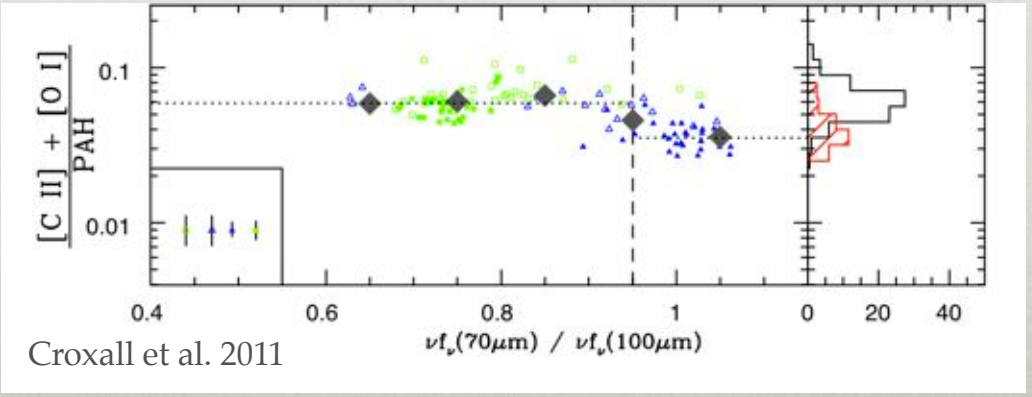
Kennicutt et al. 2011

Investigating Dust Properties





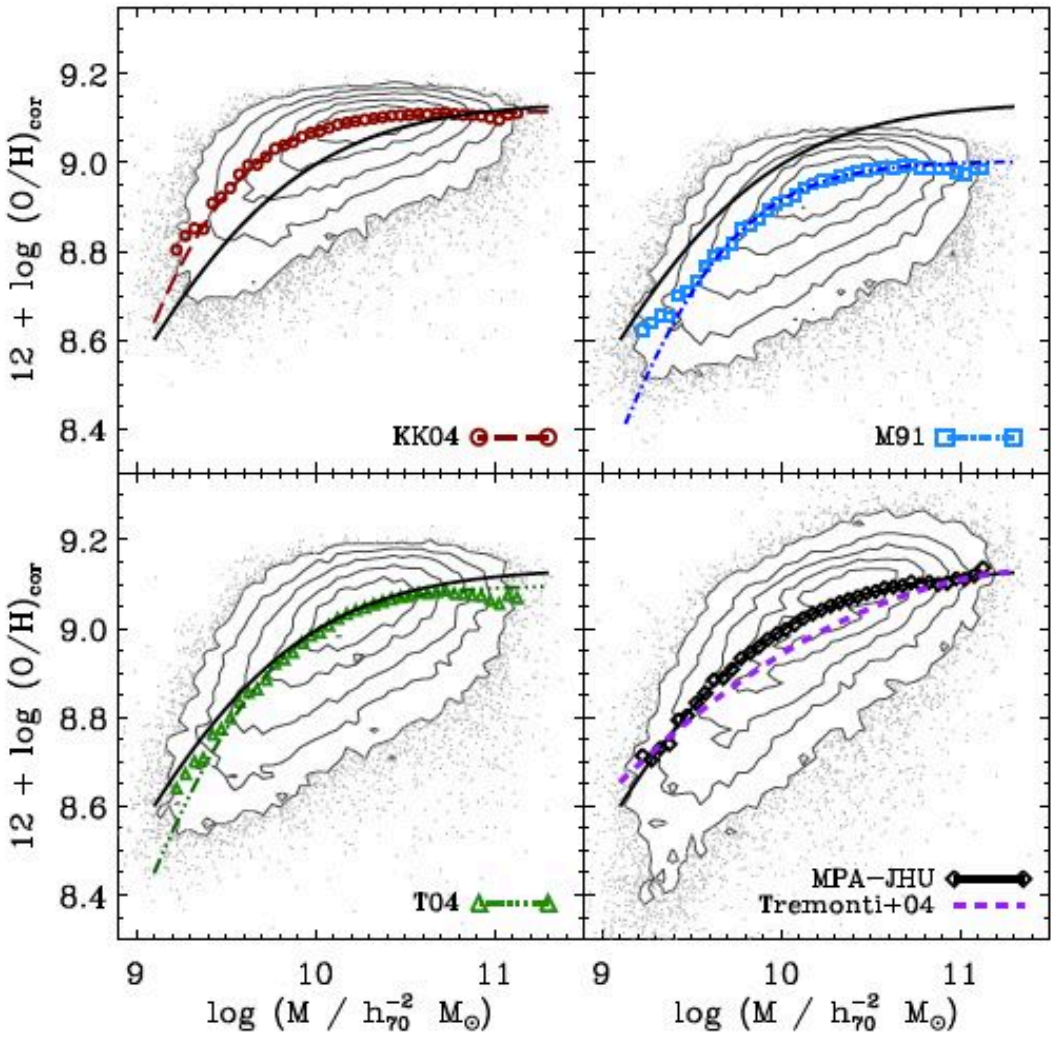


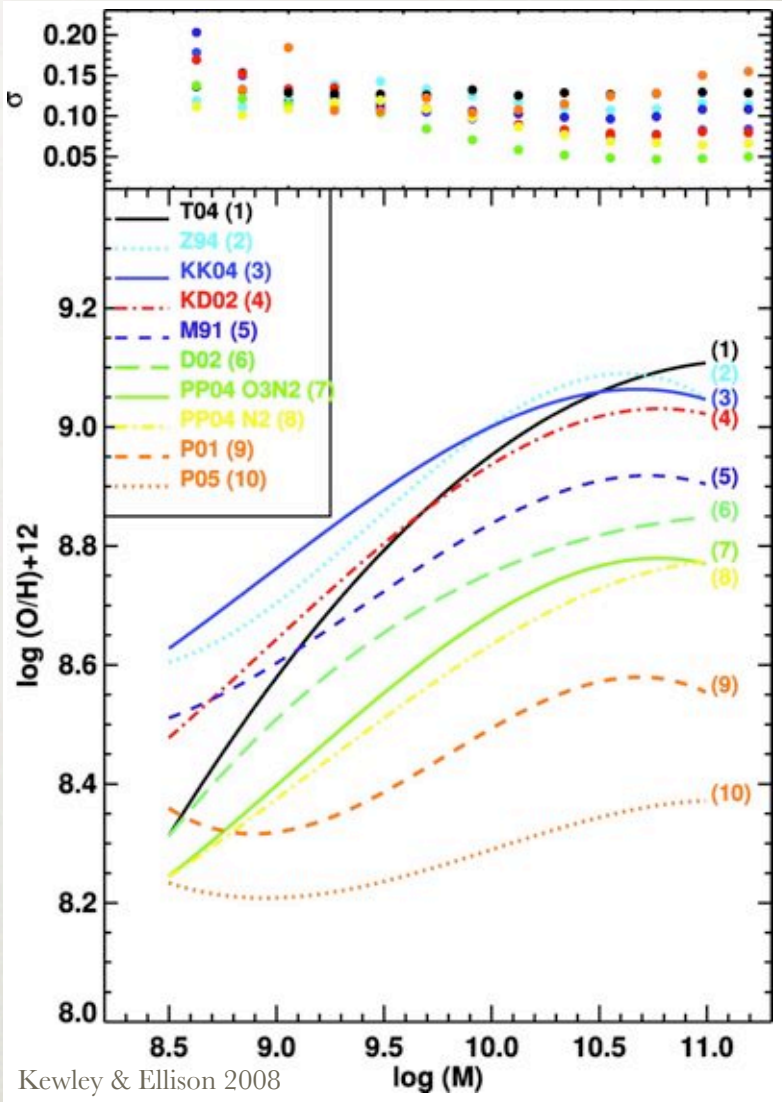


Croxall et al. 2011

Dex is a logarithmic Unit

Moustakas et al. 2012

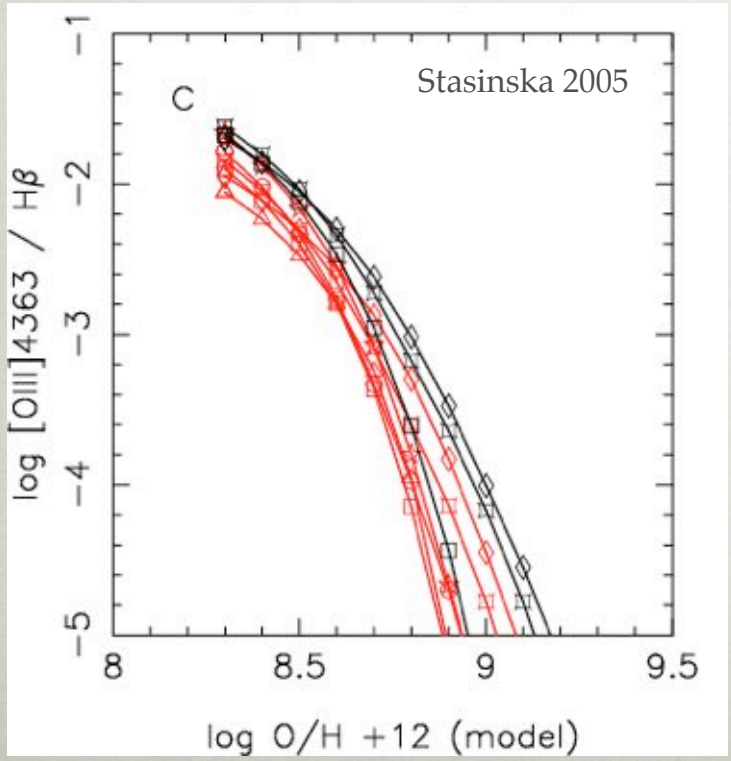


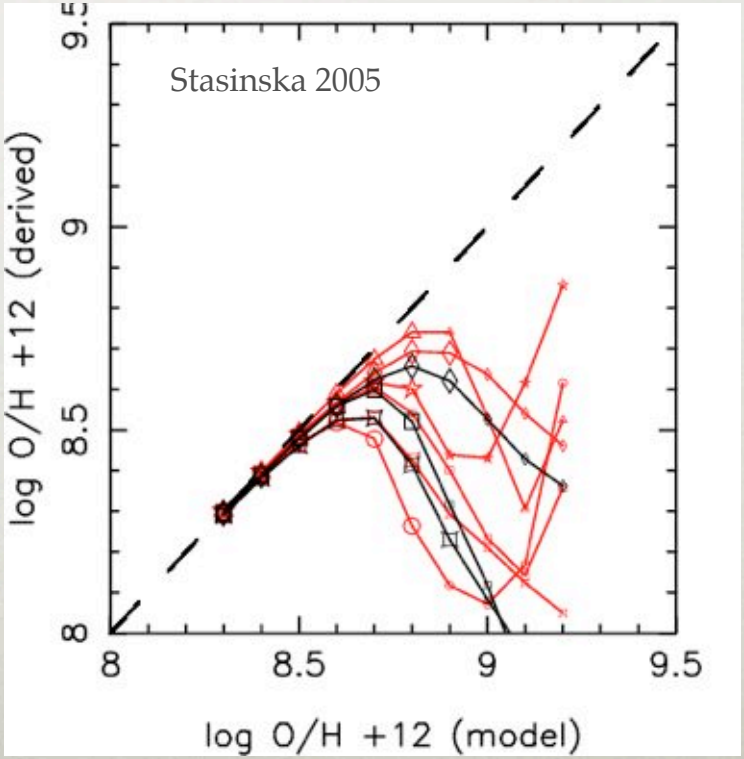


Kewley & Ellison 2008

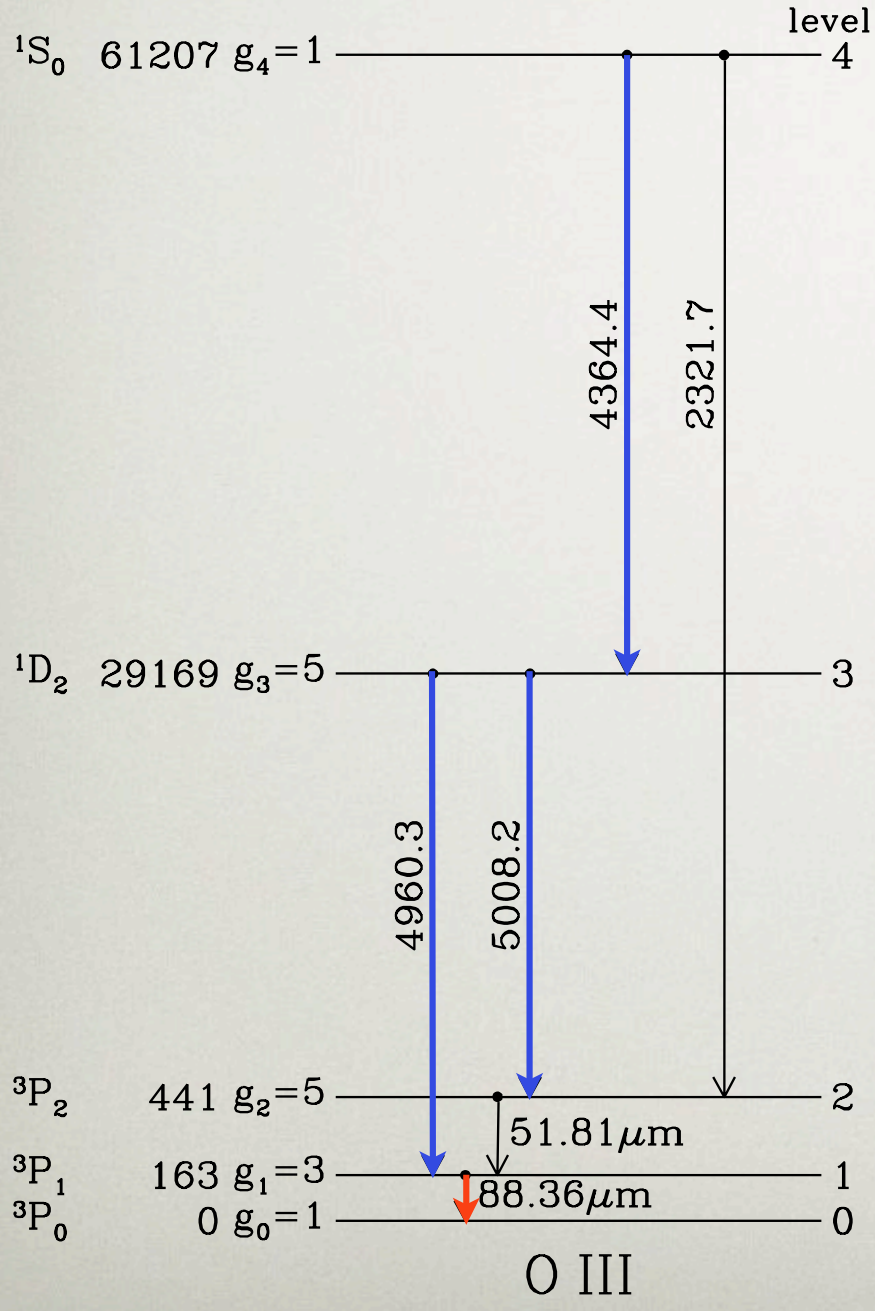
The Temperature of an HII Region

- At high O/H we lose ability to detect the temperature sensitive [O III] 4363 line.
- Different spectral lines yield different temperatures.
- Temperatures are not uniform within an HII region.



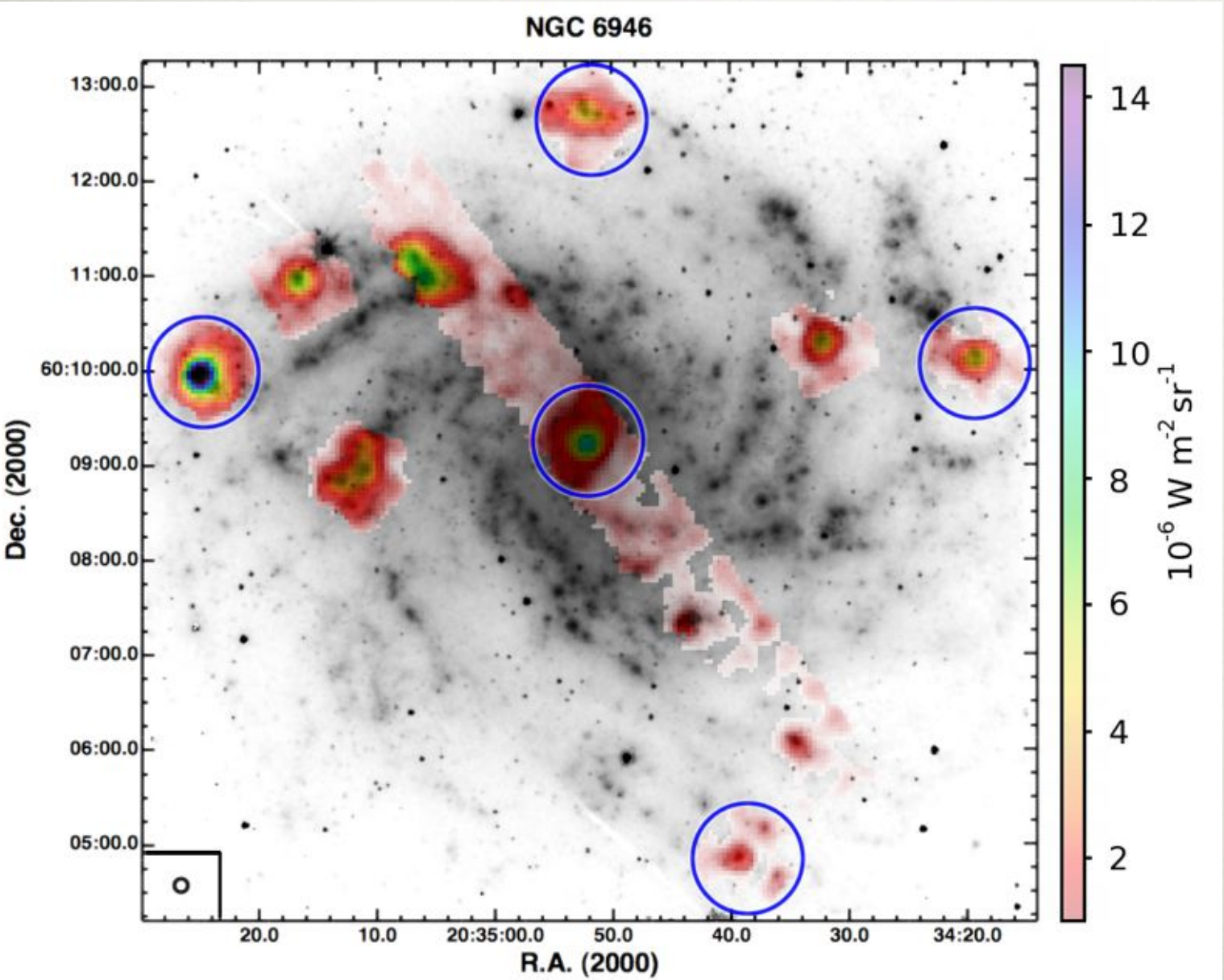


You Always Get [OIII] 88μm



- Temperature Sensitivities
- Density Dependencies
- Ionization Correction Factors
- Dust Obscuration

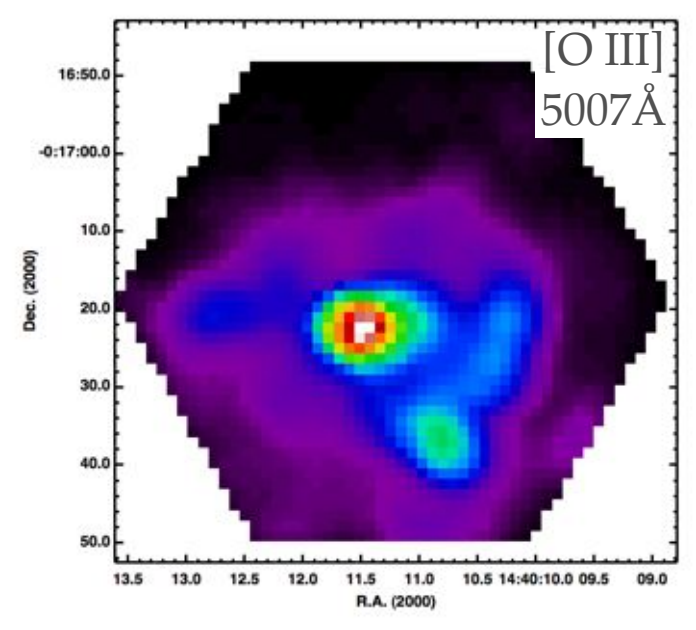
Resolution: ISO Vs Herschel

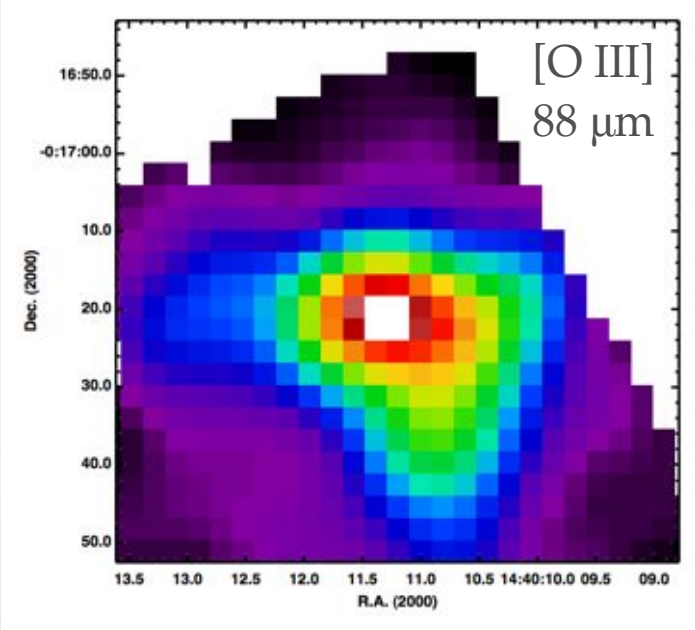


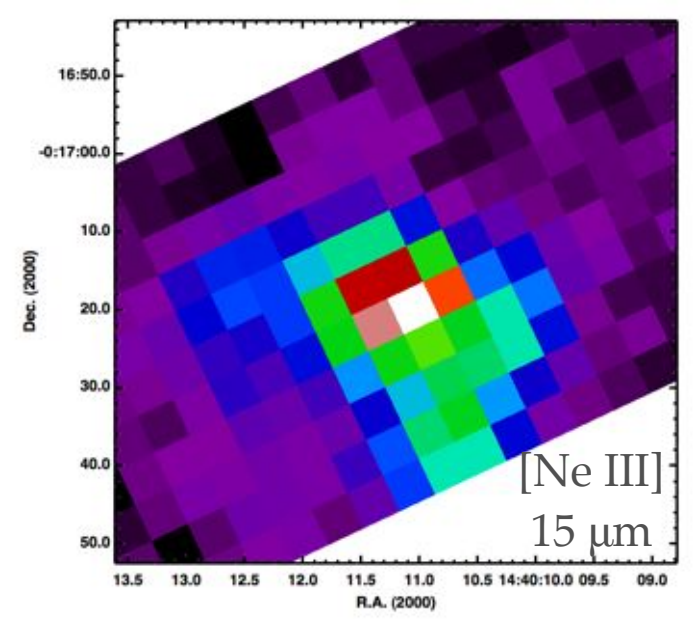
PACS [OIII] 88 μm over IRAC 3.6 μm + MIPS 24 μm

- ISO
  - 70″ beam
- PACS
  - 8″ beam

We must Match Apertures



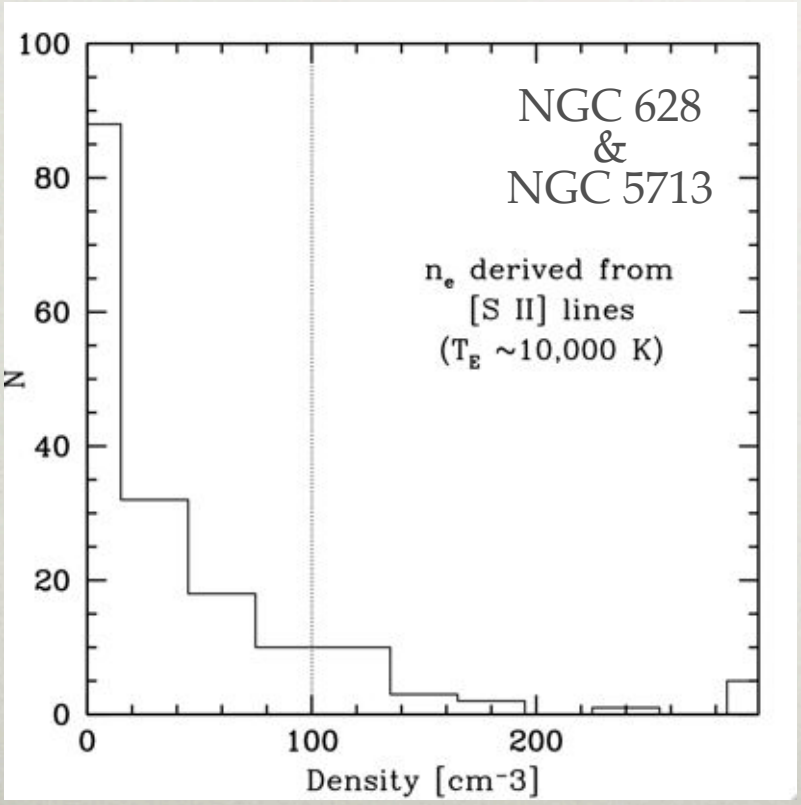


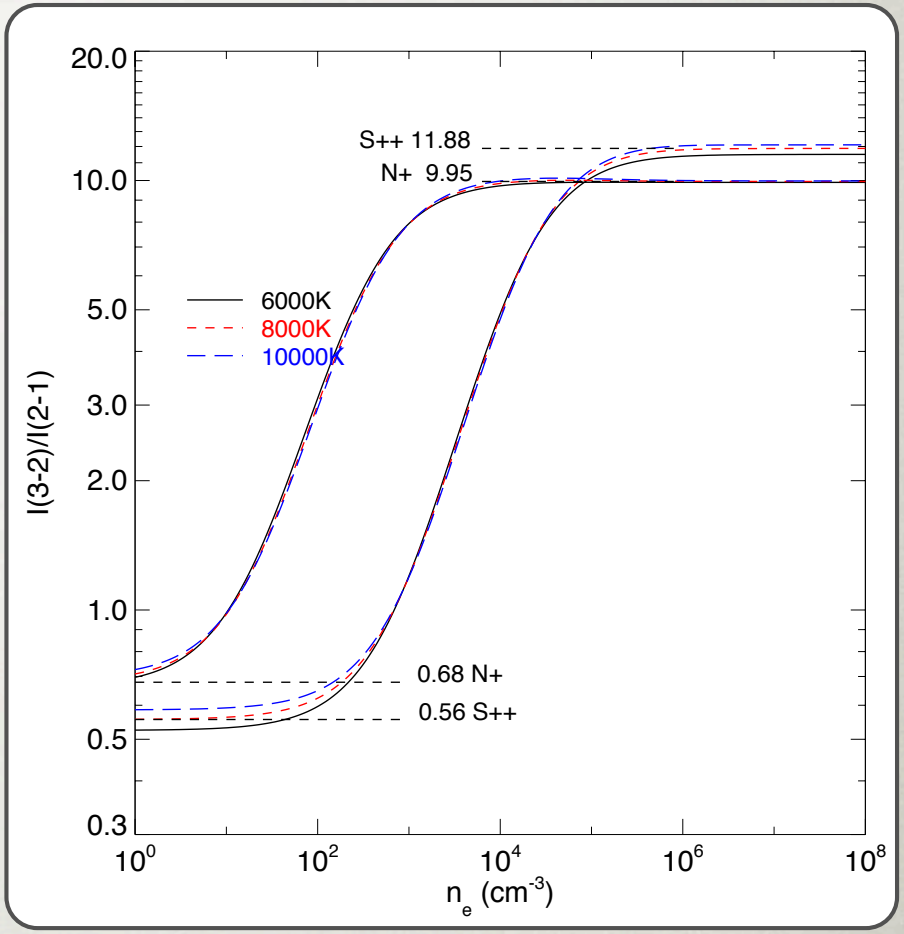


- Combine optical, mid-IR, and far-IR
- SINGS IRS spectra
- Long and Short slit spectra from the literature
- SINGS drift scan spectra

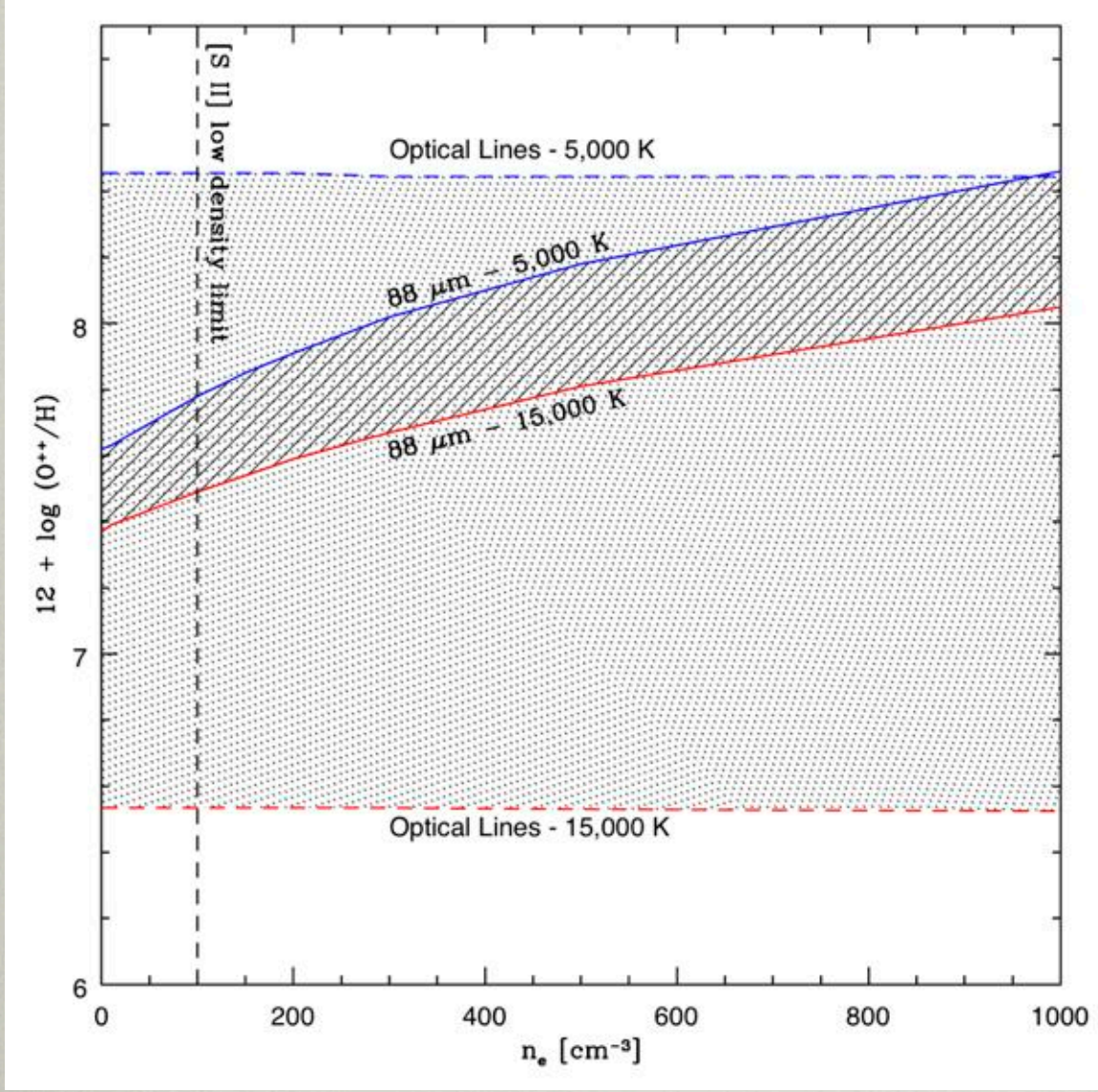
Density Diagnostics

- [S III] 18/33 μm
- [S II] 6717/6733 Å
- [N II] 121/205 μm
- [O III] 88/52 μm





Comparing the IR and Optical

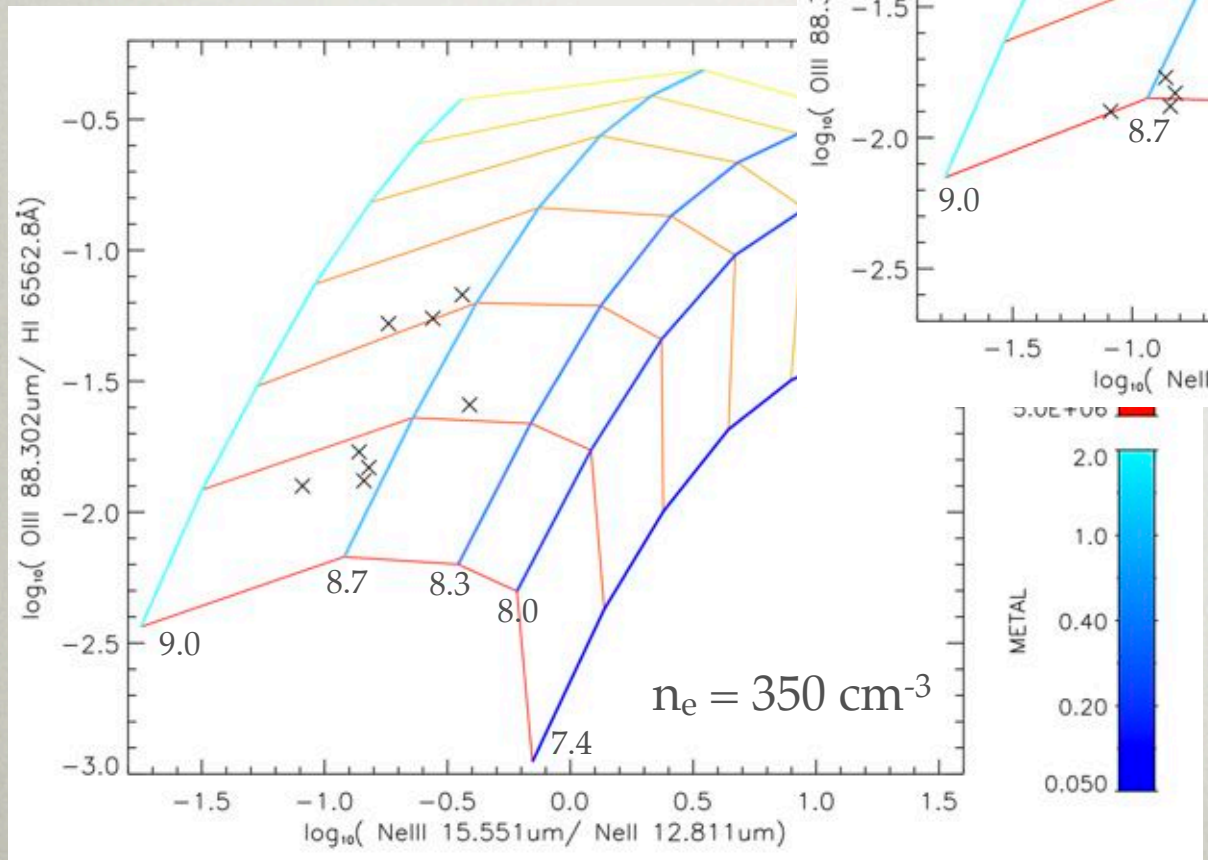


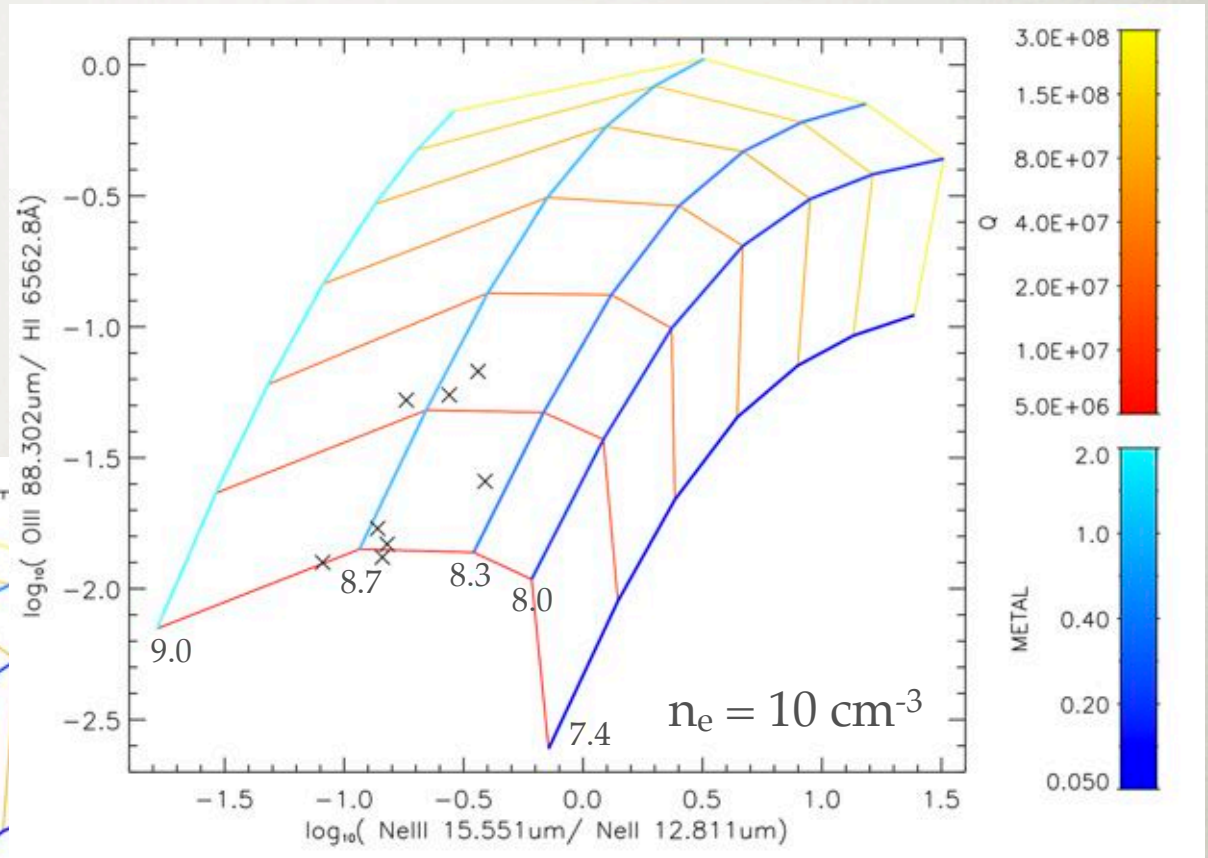
- We can limit the parameter space for the abundance of (O++ / H)
- Constraints on density further limit uncertainty
- We can use the 88 μm line to constrain the temperature

Preliminary Results - NGC 628

NGC 628

- $KK04_{SINGS}$: 9.02 ± 0.01
- $PT05_{SINGS}$: 8.35 ± 0.01
- IR : ~8.7





Mappings III Models

Summary

- High quality [O I] 63μm & [O III] 88μm maps have been obtained as part of KINGFISH (as well as [CII] and [NII]).
- [O III] emission in the Far-Infrared is significantly less sensitive to temperature.
- Plan: calibrate the nebular abundance scale independent of the temperature structure of HII regions.