Density maps of Orion using PPAK data

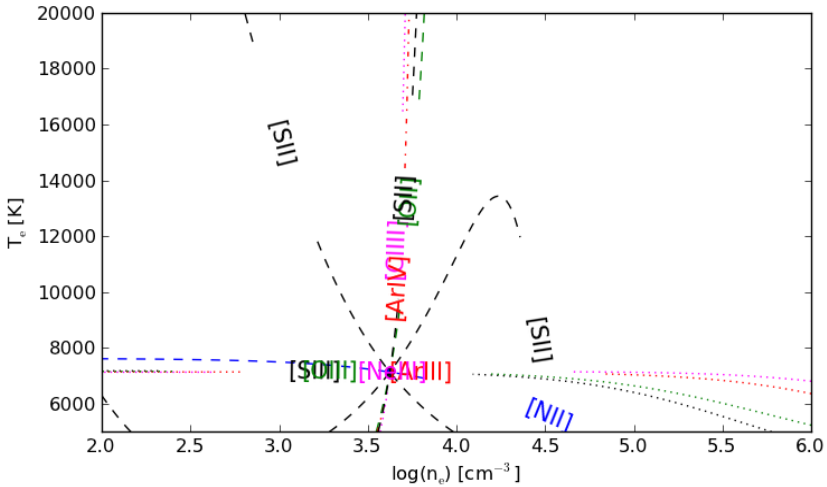
Orion as an atomic physics lab.

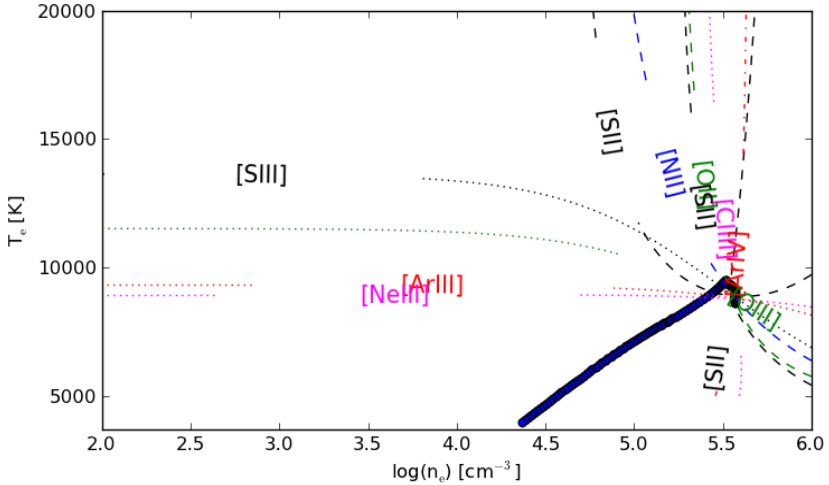
C. Morisset, IA-UNAM
Mexico
in collaboration with Manu, César, Adal, Valentina, Jorge

Determining Te and Ne

- Te is obviously very important to determine abundances. Needs to be corrected from attenuation.
- Ne is also quite important, especially when multi-density medium is suspected. No problem with attenuation.

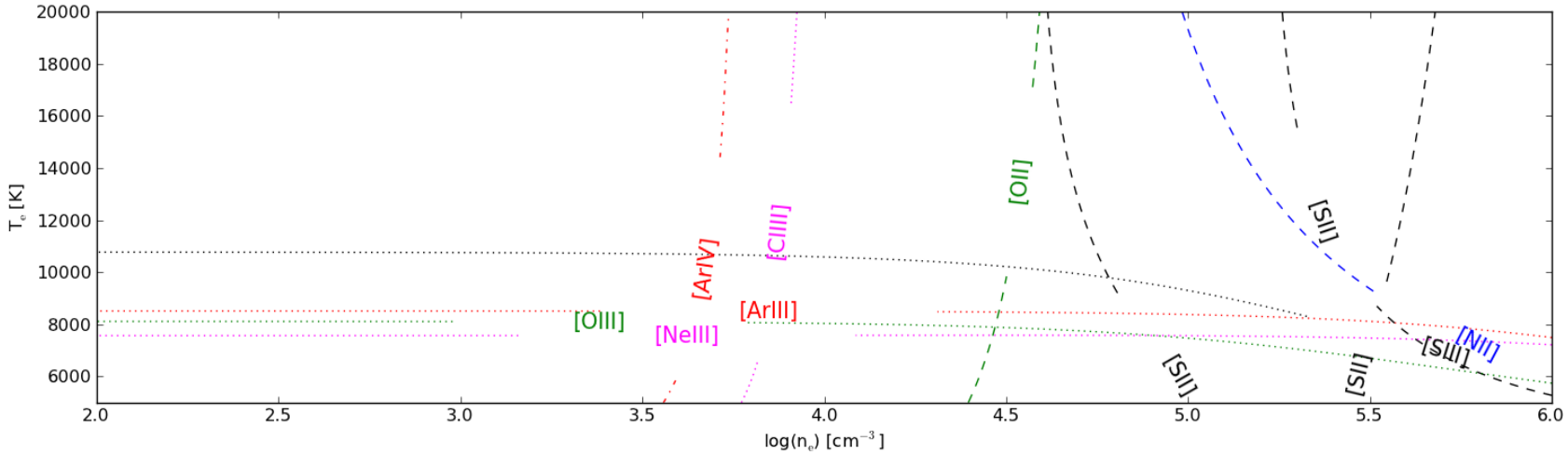
2-densities (model)





2-densities (model)

When the 2 regions are mixed on the line of sight, all the available density and temperature diagnostics are needed to understand and describe the diagnostic diagrams.



Observations

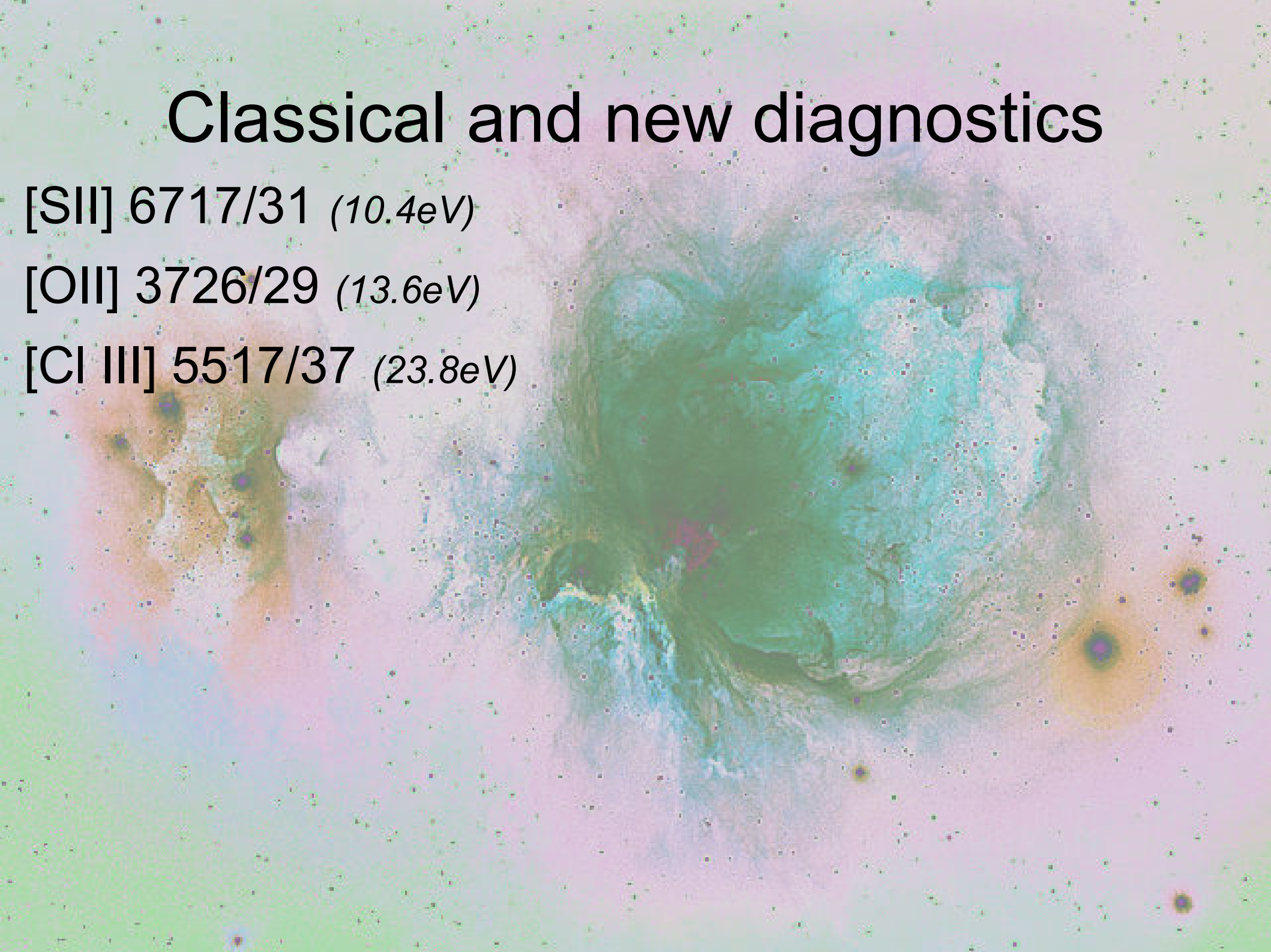
- PMAS-PPak observations, see Manu's talk.
- 3 spectral ranges
- ~331 x 16 fibers.
- Problems with cross calibration and reddening correction.
- Te hard to obtain, but Ne OK.

Classical and new diagnostics

[SII] 6717/31 *(10.4eV)*

[OII] 3726/29 *(13.6eV)*

[Cl III] 5517/37 *(23.8eV)*



Classical and new diagnostics

[SII] 6717/31 *(10.4eV)*

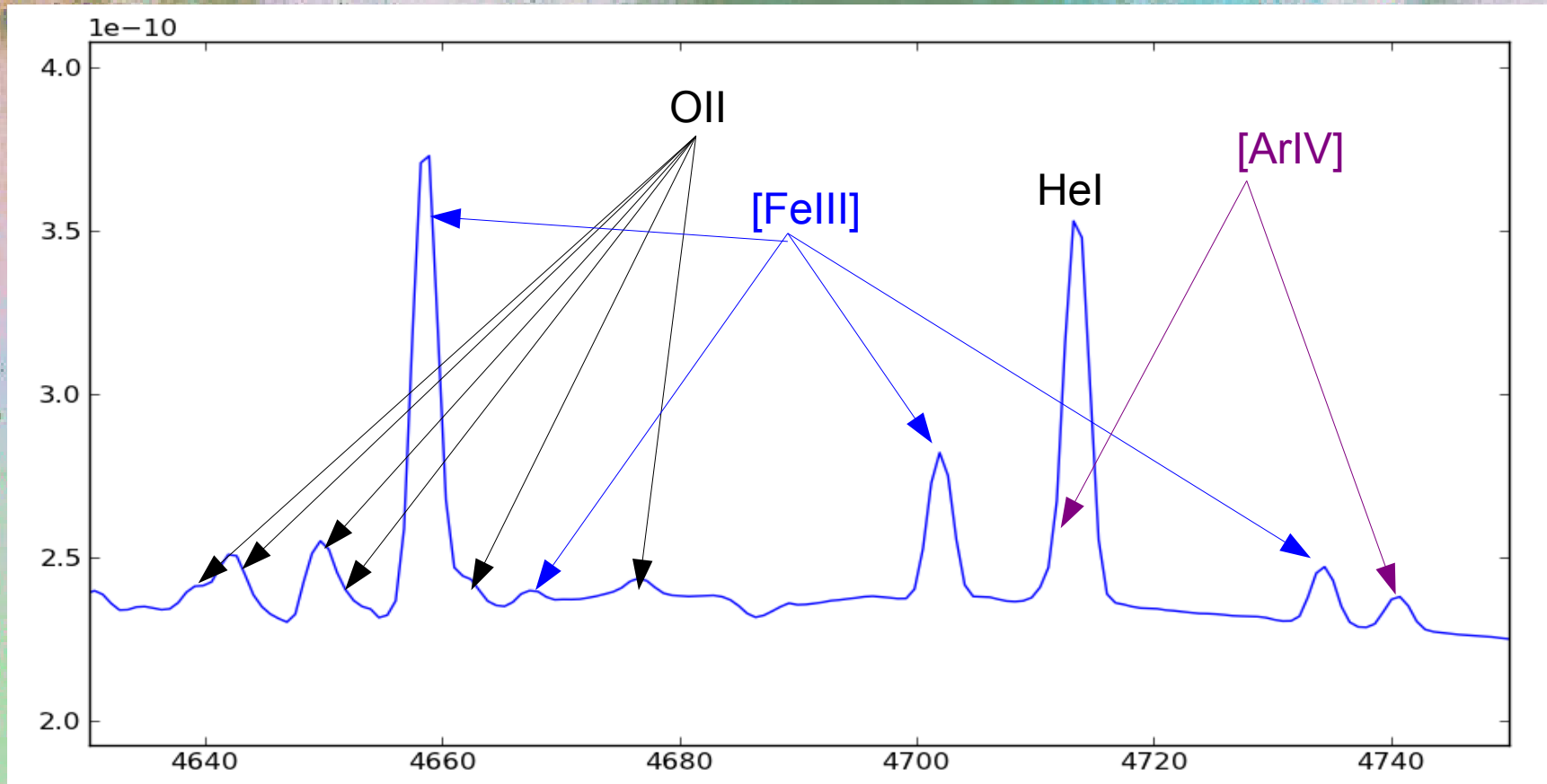
[OII] 3726/29 *(13.6eV)*

[Cl III] 5517/37 *(23.8eV)*

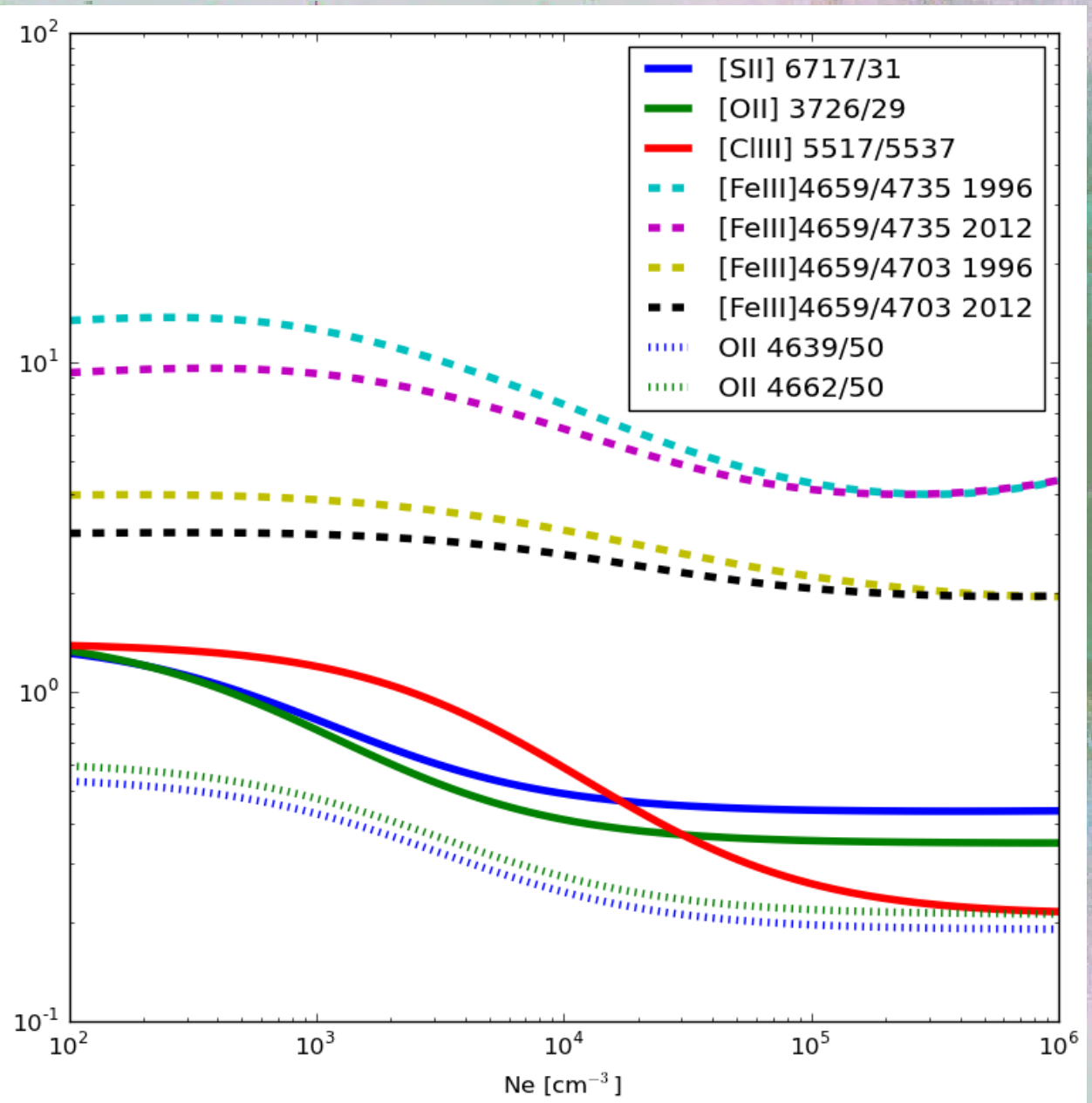
and

[FeIII] *(16.2eV)*

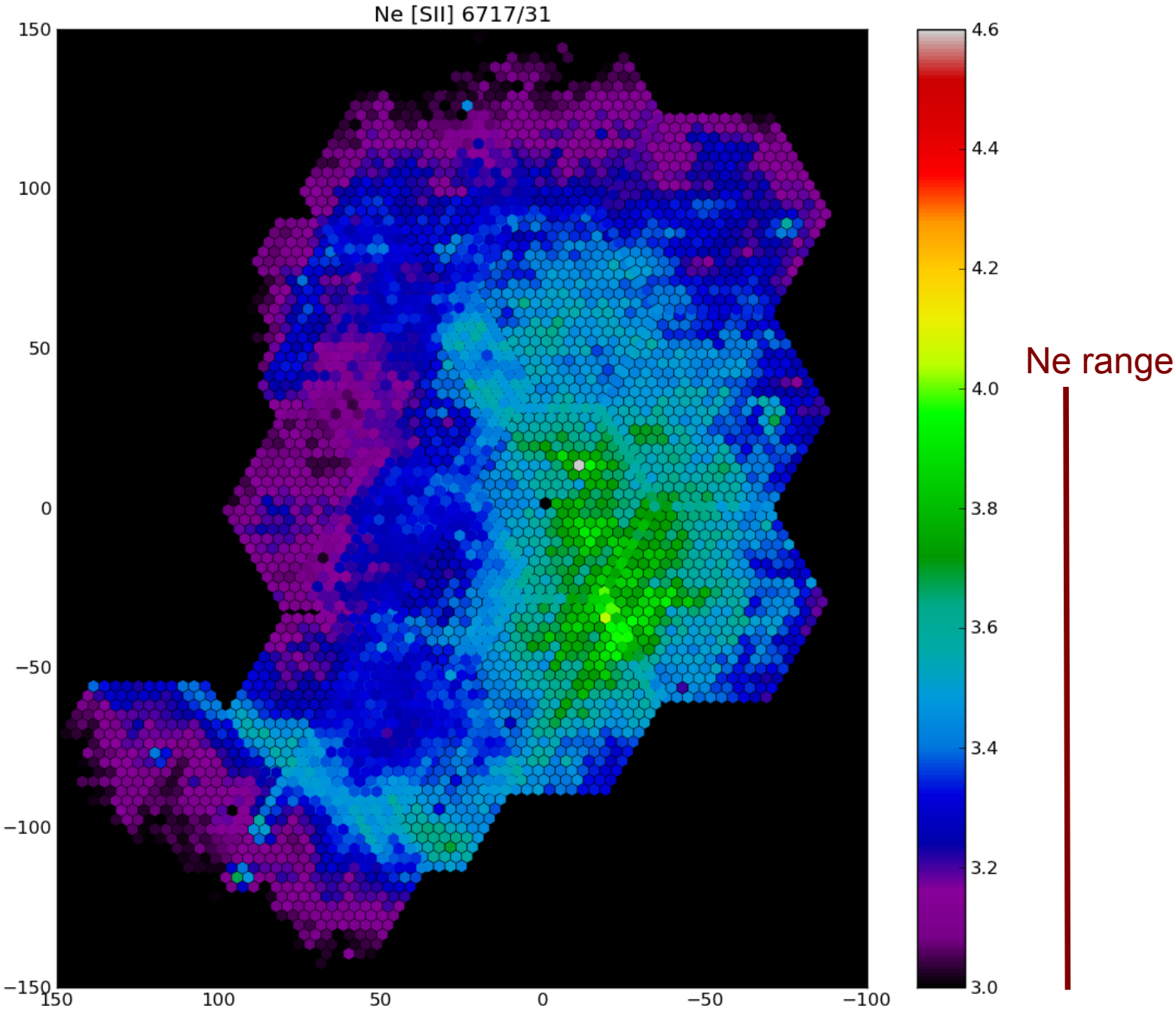
OII *(35.1eV)*

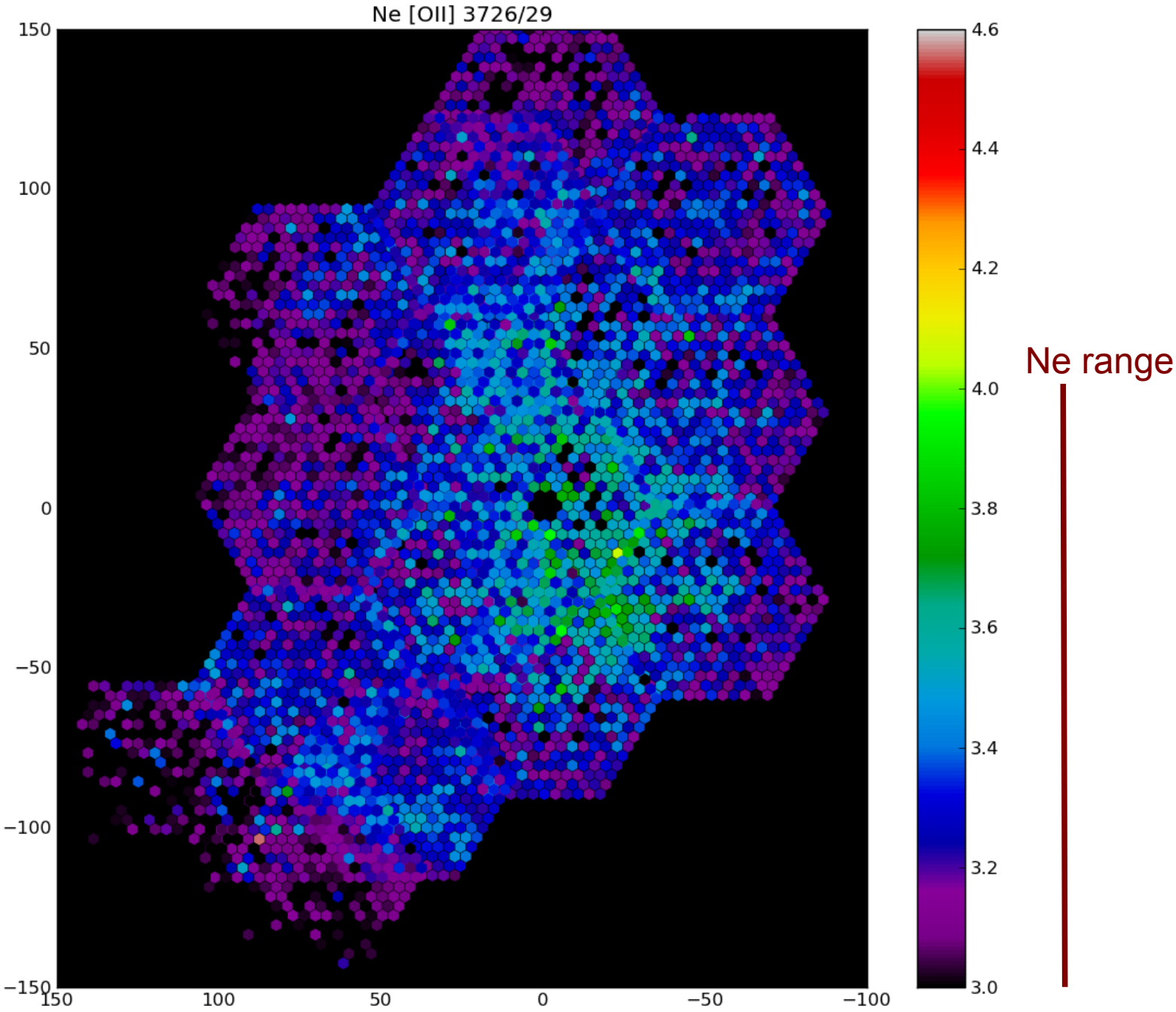


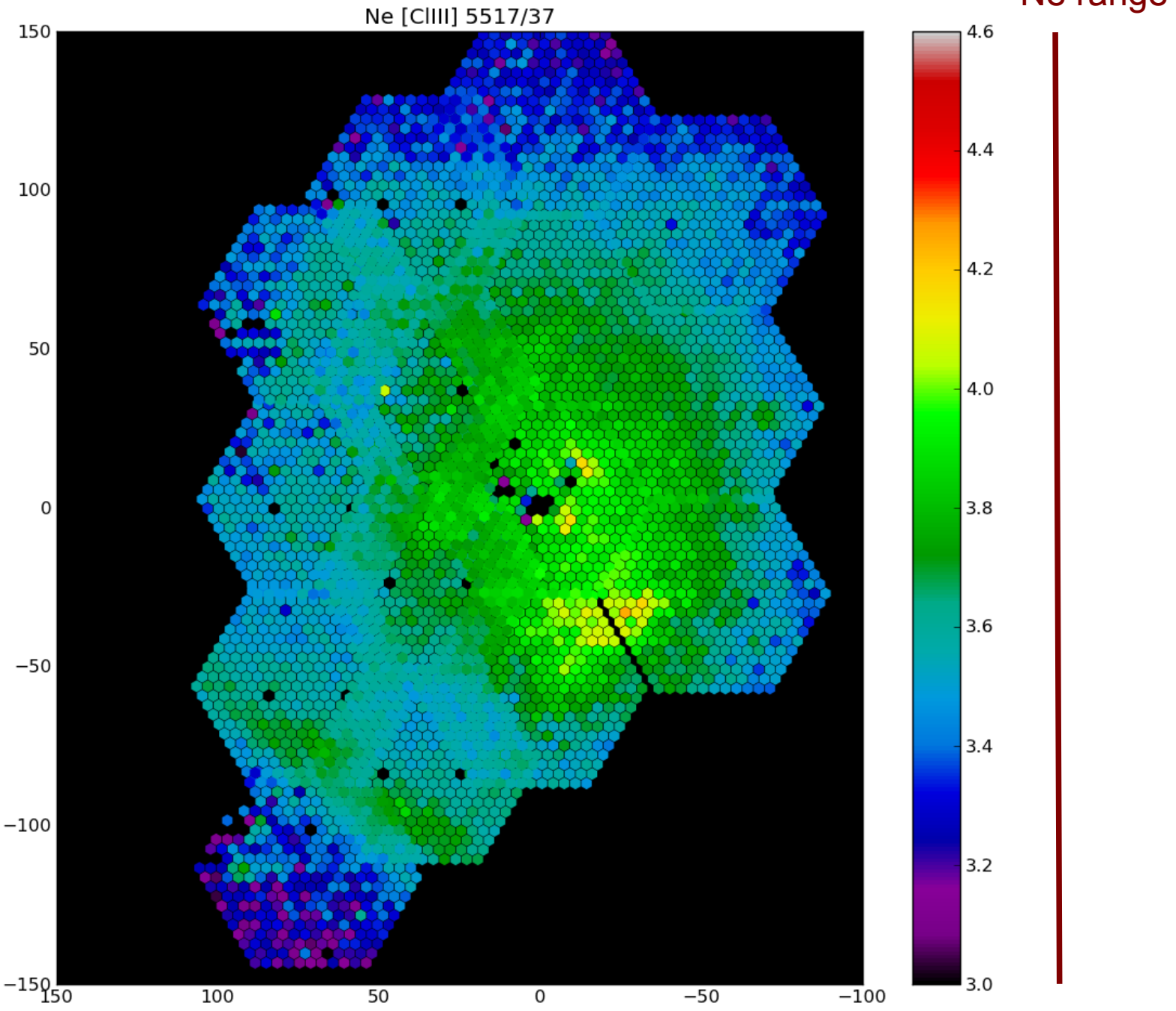
Critical densities



- [ClIII] describes gas at higher density.
- OII diagnostic maps densities between [SII]-[OII] and [ClIII].
- [FeIII] have small sensitivities (even less with the 2012 data) and is mapping high density gas.

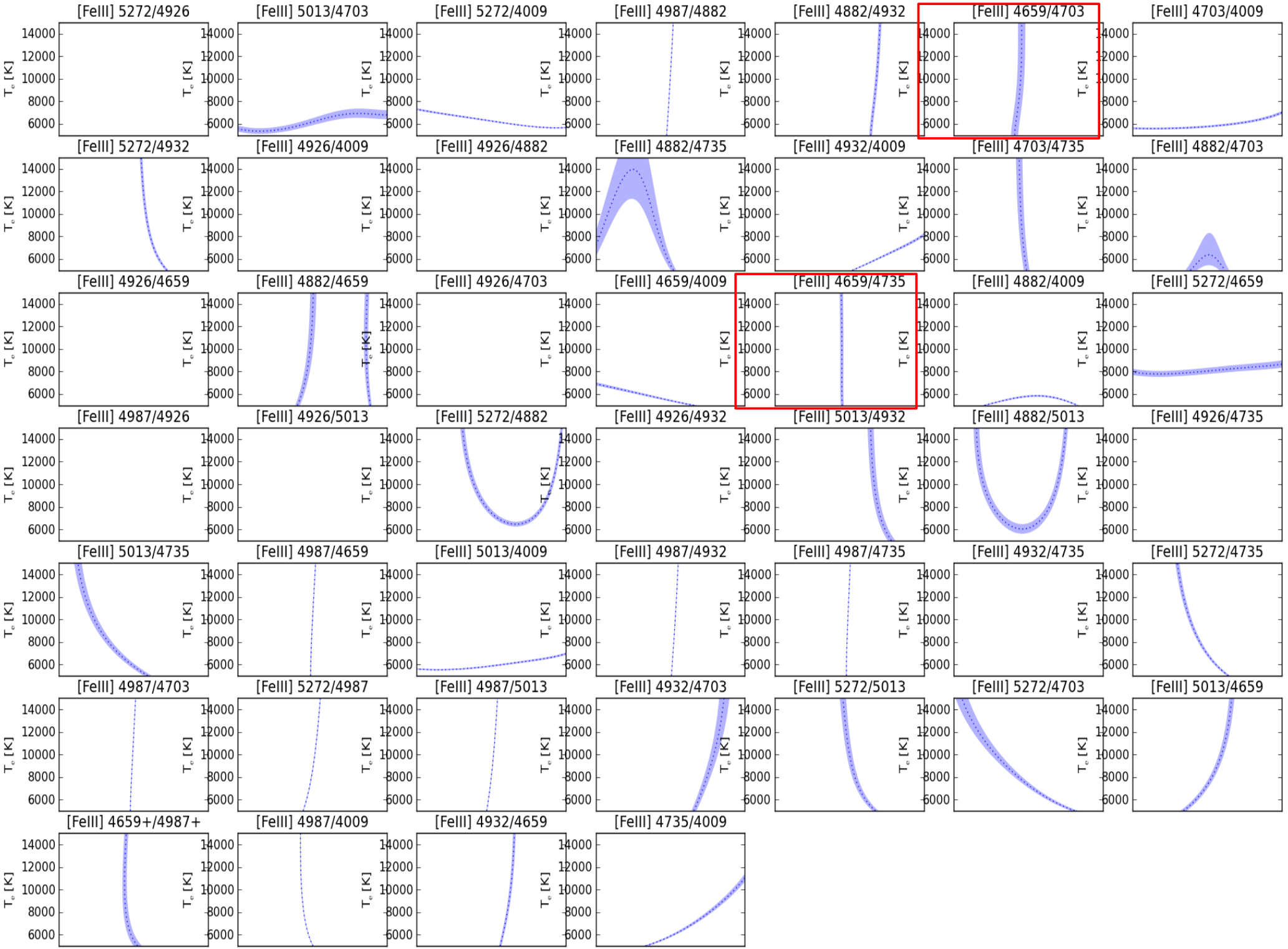

Ne [SII] 6717/31
150
100
50
0
−50
−100
−150
150
100
50
0
−50
−100
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
Ne range


Ne [OII] 3726/29
150
100
50
0
−50
−100
−150
150
100
50
0
−50
−100
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
Ne range

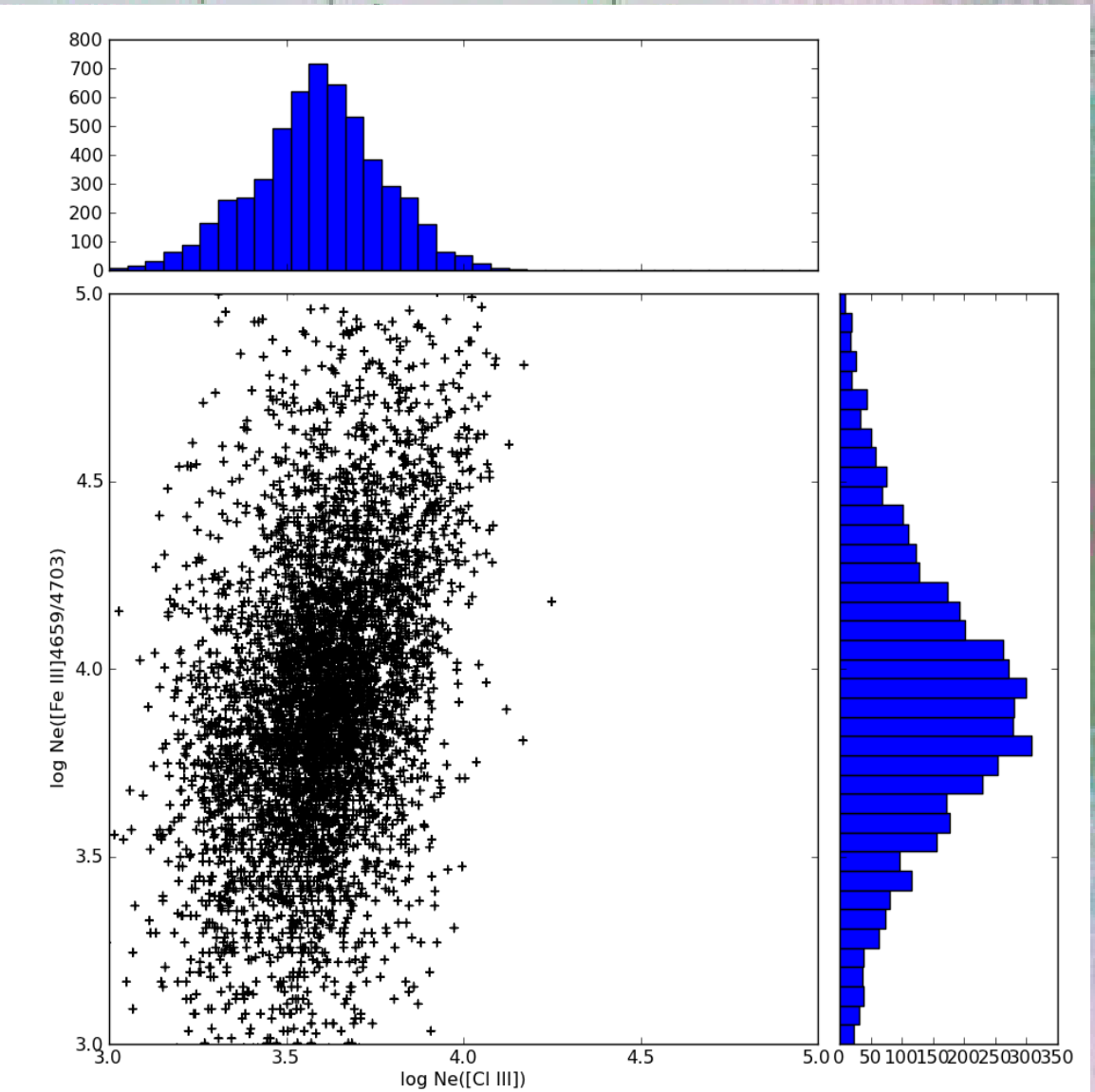

Ne [ClIII] 5517/37
150
100
50
0
−50
−100
−150
150
100
50
0
−50
−100
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
Ne range

[FeIII]

- A lot of lines, actually 34 levels atom.
- PyNeb (Luridiana, Morisset, Shaw) is used.
- Some line ratios can be used to determine electron density or temperature.

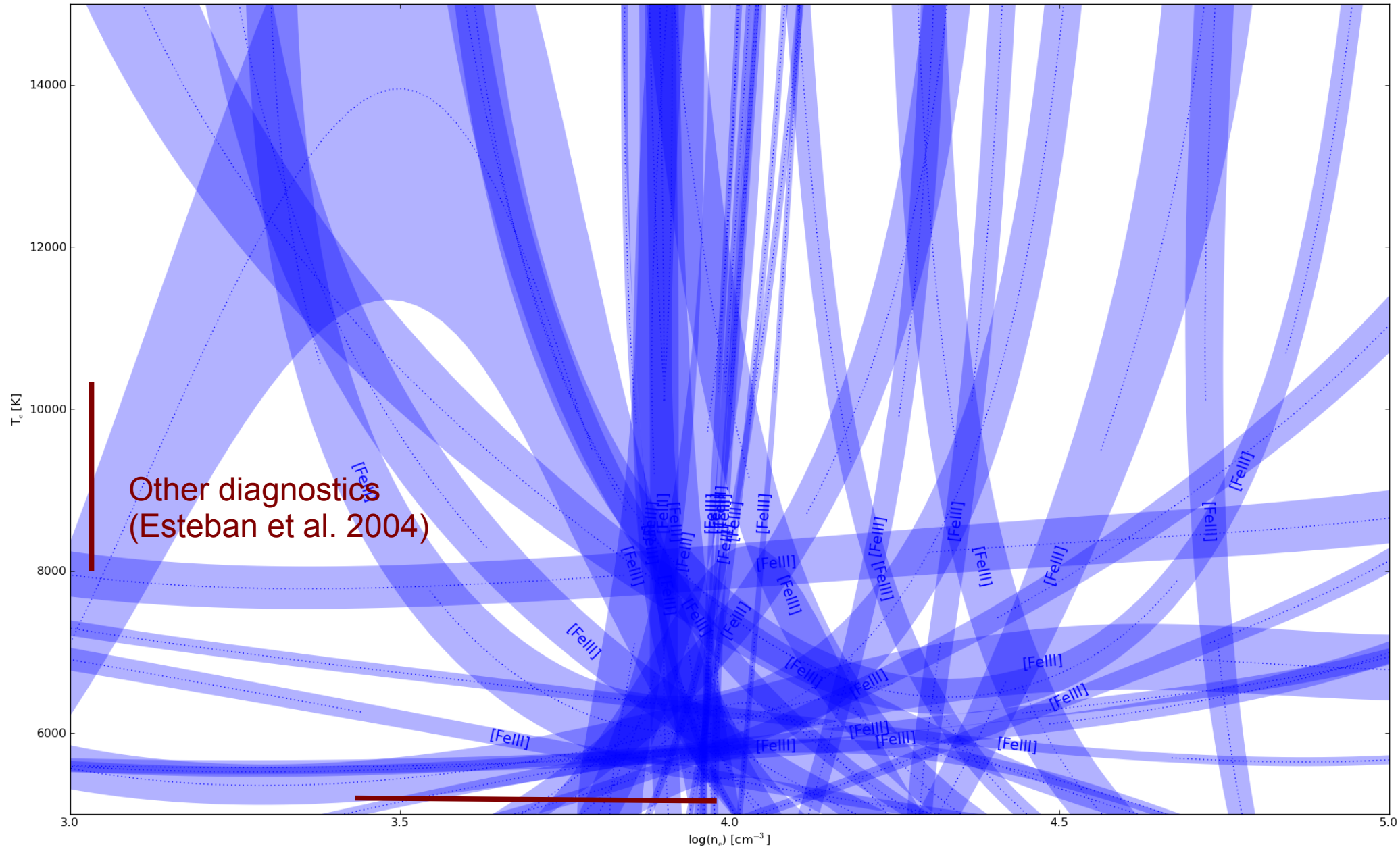

[FeIII] 5272/4926
[FeIII] 5013/4703
[FeIII] 5272/4009
[FeIII] 4987/4882
[FeIII] 4882/4932
[FeIII] 4659/4703
[FeIII] 4703/4009
[FeIII] 5272/4932
[FeIII] 4926/4009
[FeIII] 4926/4882
[FeIII] 4882/4735
[FeIII] 4932/4009
[FeIII] 4703/4735
[FeIII] 4882/4703
[FeIII] 4926/4659
[FeIII] 4882/4659
[FeIII] 4926/4703
[FeIII] 4659/4009
[FeIII] 4659/4735
[FeIII] 4882/4009
[FeIII] 5272/4659
[FeIII] 4987/4926
[FeIII] 4926/5013
[FeIII] 5272/4882
[FeIII] 4926/4932
[FeIII] 5013/4932
[FeIII] 4882/5013
[FeIII] 4926/4735
[FeIII] 5013/4735
[FeIII] 4987/4659
[FeIII] 5013/4009
[FeIII] 4987/4932
[FeIII] 4987/4735
[FeIII] 4932/4735
[FeIII] 5272/4735
[FeIII] 4987/4703
[FeIII] 5272/4987
[FeIII] 4987/5013
[FeIII] 4932/4703
[FeIII] 5272/5013
[FeIII] 5272/4703
[FeIII] 5013/4659
[FeIII] 4659+/4987+
[FeIII] 4987/4009
[FeIII] 4932/4659
[FeIII] 4735/4009
T$_e$ [K]
14000
12000
10000
8000
6000

[FeIII] goes to higer densities

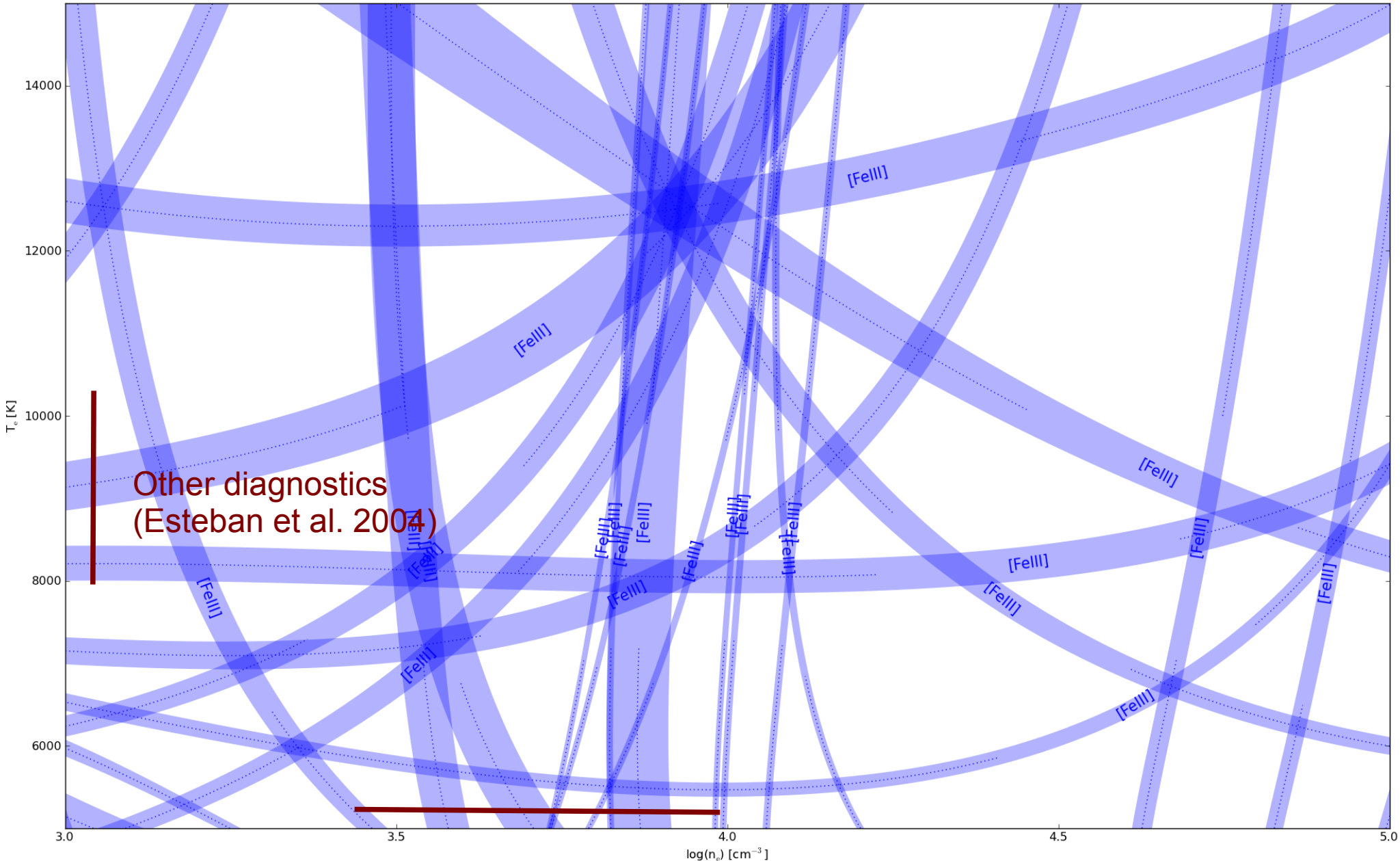


- Some correlation between the two densities can be seen.

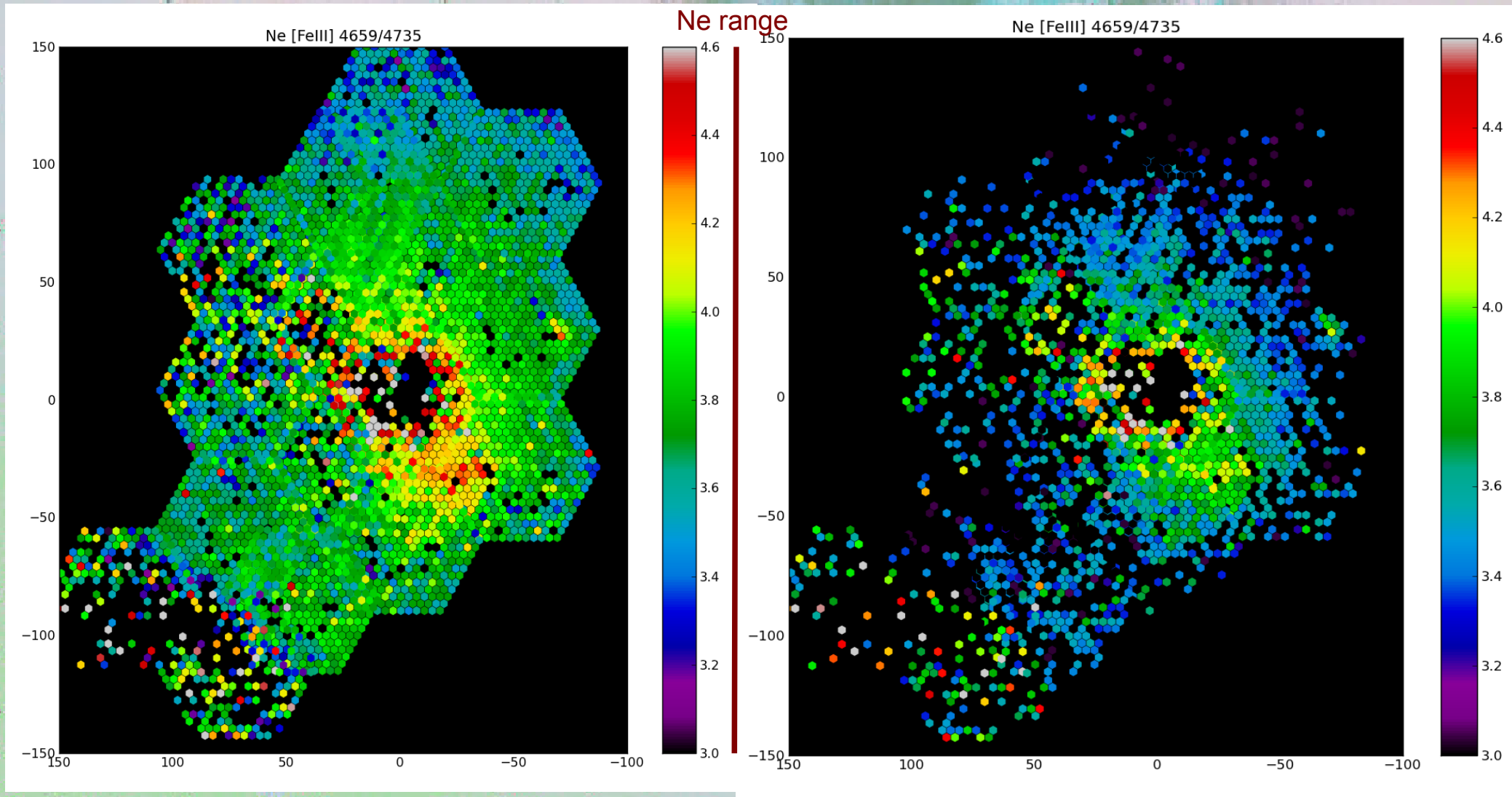
Old atomic data (Quinet 1996)



New atomic data (Bautista et al. 2010)



[FeIII] : comparing 1996 and 2010

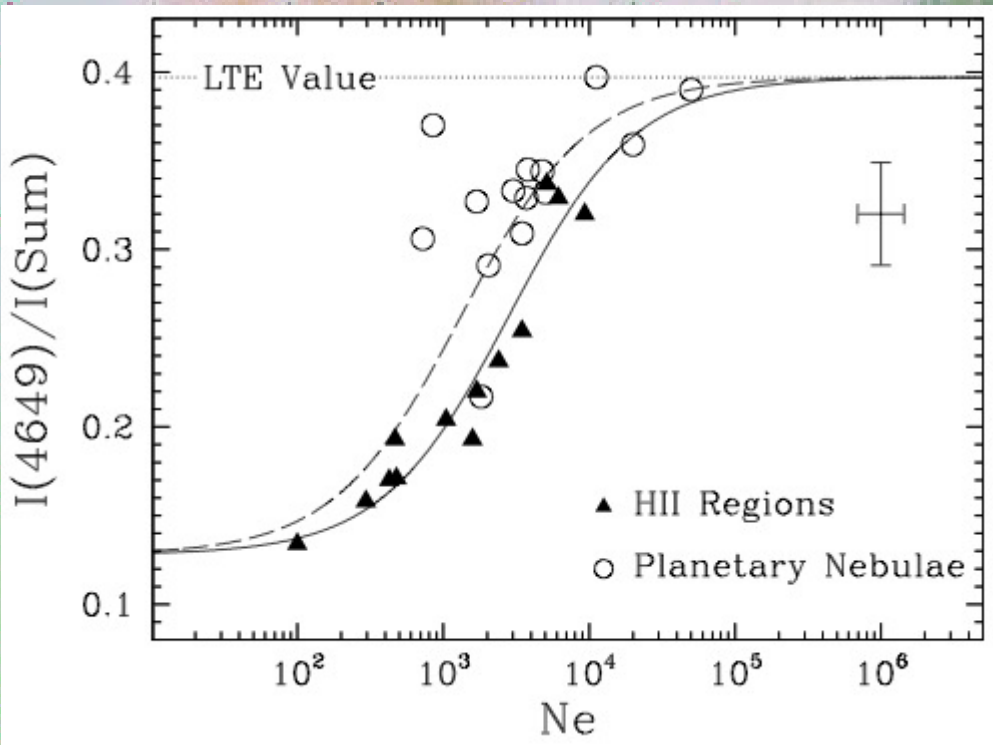


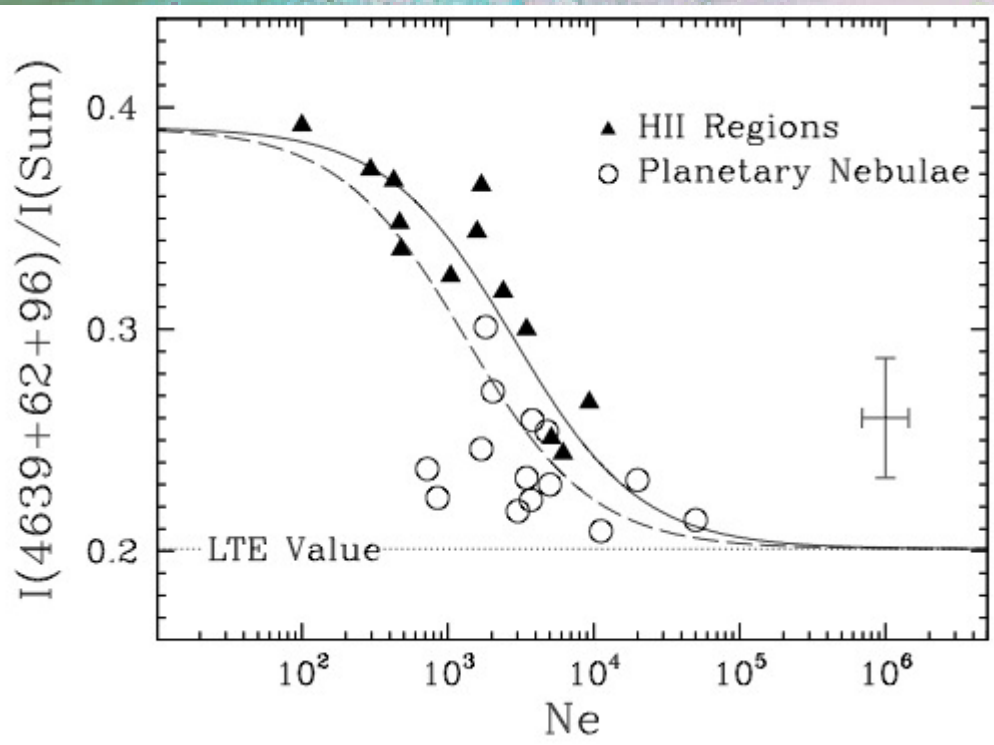
Exploring new phases with OII lines

Log Ne\IP	10.4	13.6	16.2	23.8	35.1	*40.9*
2	S+	O+			O++	
3	S+	O+	Fe++	Cl++	O++	*Ar*+++
4	S+	O+	Fe++	Cl++	O++	*Ar*+++
5			Fe++	Cl++		*Ar*+++

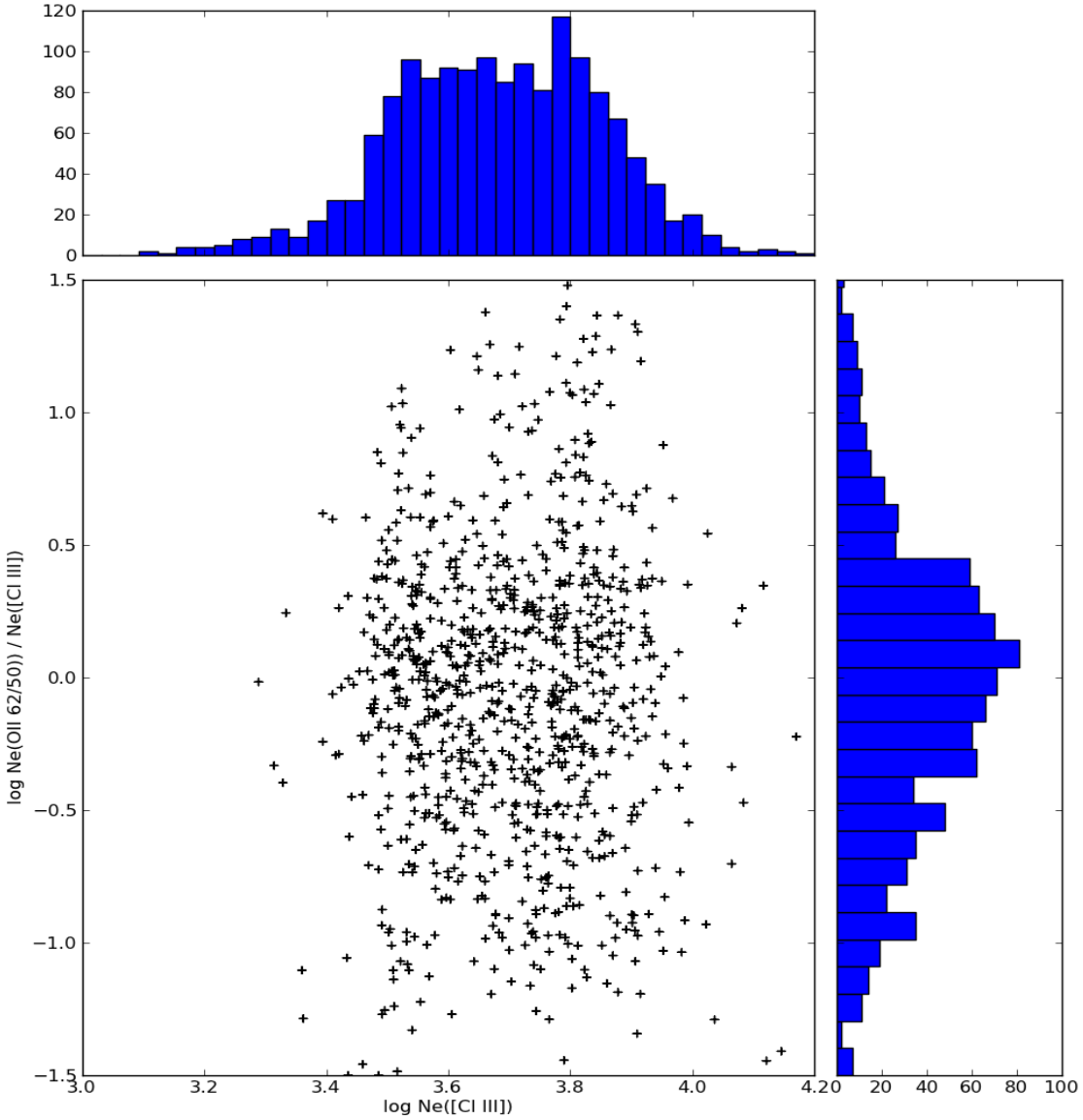
OII as density diagnostic

A. Peimbert and M. Peimbert. Oxygen Recombination Line Abundances in Gaseous Nebulae. In S. Torres-Peimbert & G. MacAlpine, editor, *Revista Mexicana de Astronomia y Astrofisica Conference Series*, volume 23 of *Revista Mexicana de Astronomia y Astrofisica, vol. 27*, pages 9–14, Oct. 2005.



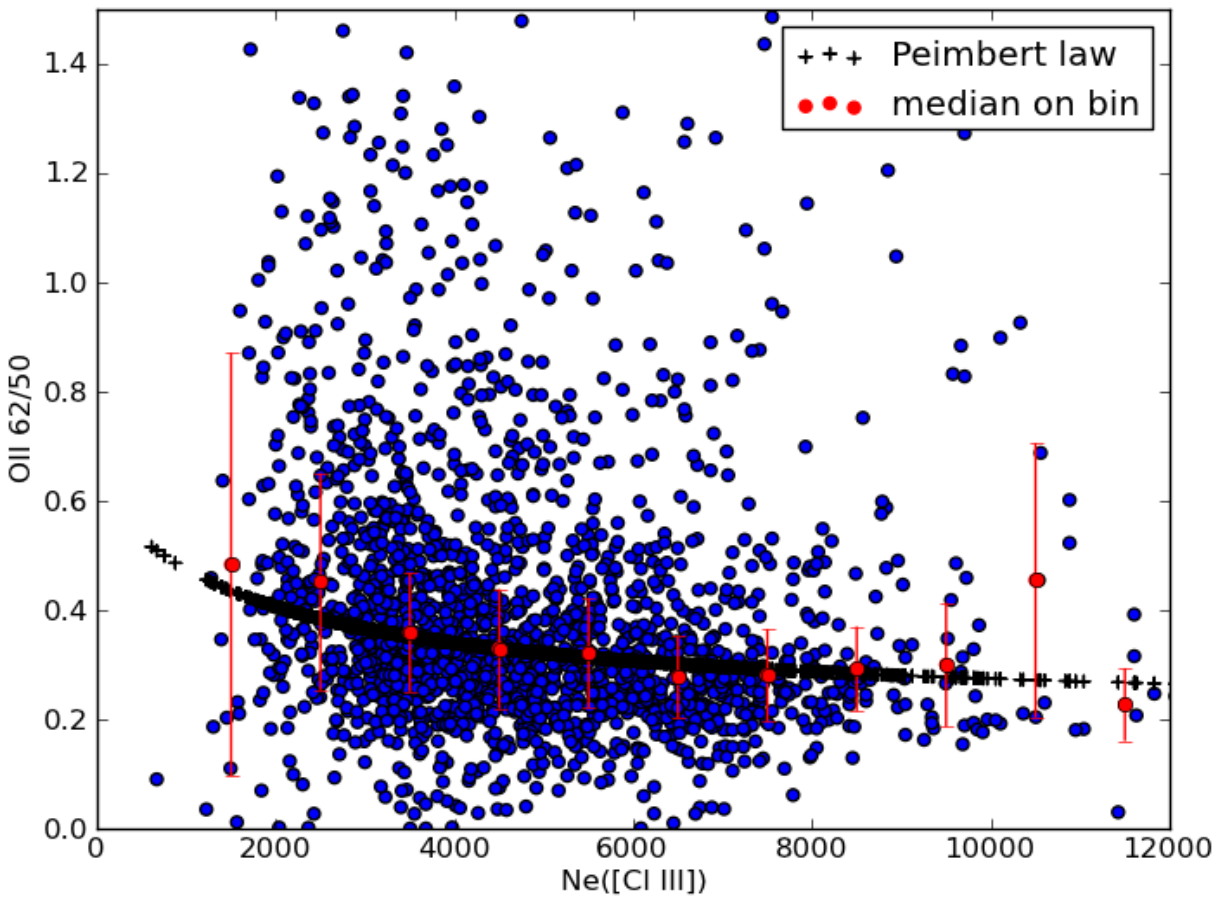


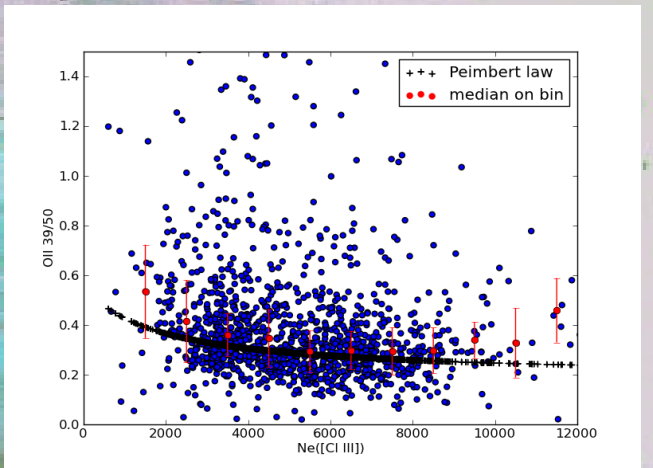
Comparing OII and [Cl III] densities

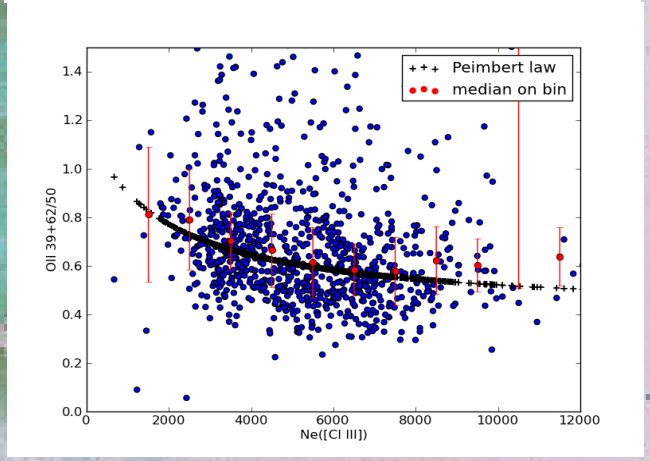


- Nothing obvious in the correlation between Ne(ClIII) and Ne(OII).

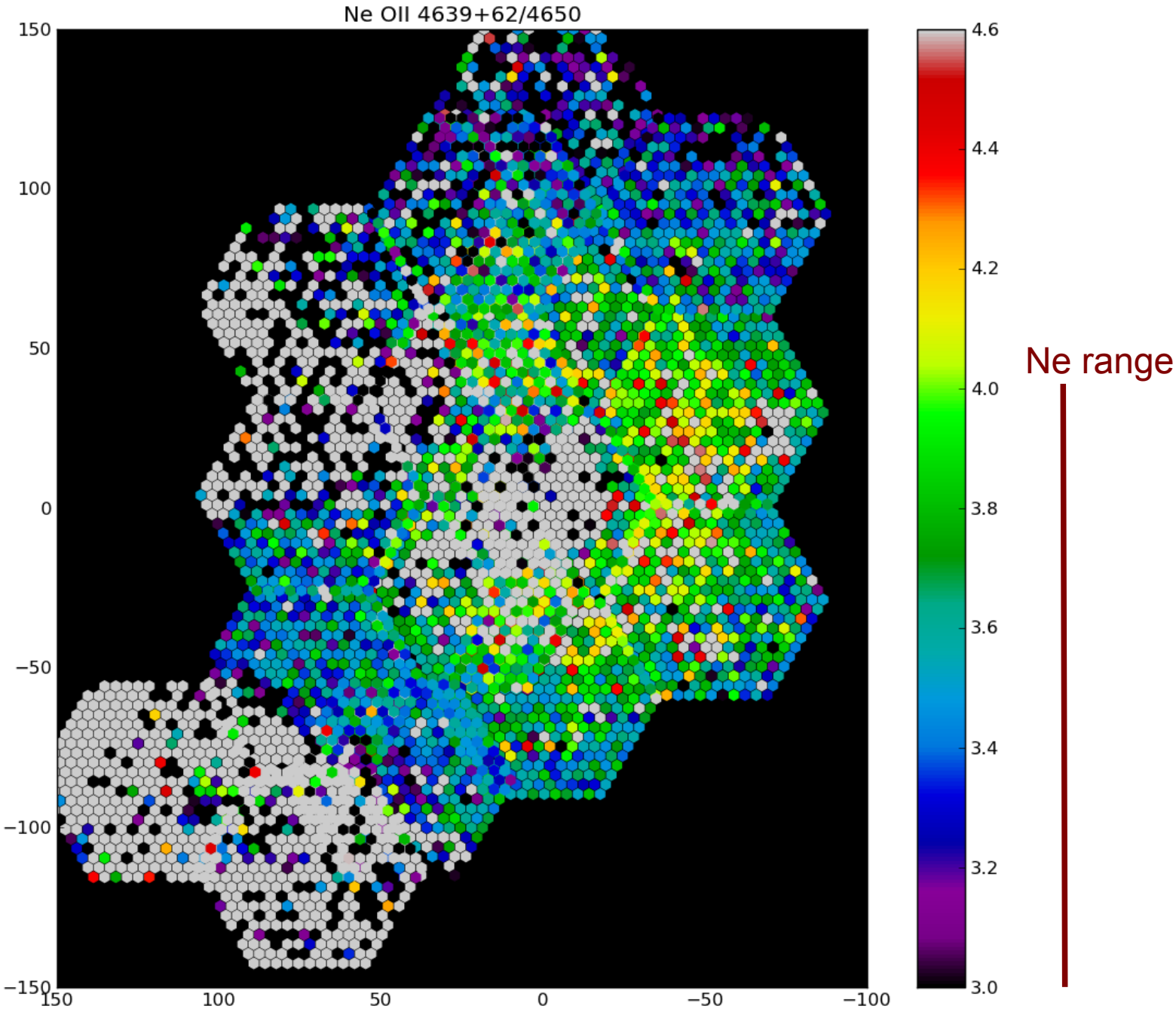
Comparing OII and [Cl III] densities







The scatter is quite big, but the Peimbert's law is reproduced when considering median values in density bins.


Ne OII 4639+62/4650
150
100
50
0
−50
−100
−150
150
100
50
0
−50
−100
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
Ne range

Conclusions

- Orion observed with IFUs is a very usefull lab to test atomic physics.
- [FeIII] maps low ionization - high density medium, but new data may need to be revised.
- OII relative intensities in a multiplet can be used as density diagnostics following Peimbert's paper, but scatter needs to be understood.