Far-infrared Emission Lines in Galaxies:

The SHINING Contribution to the Understanding of General Trends

Javier Graciá-Carpio (MPE)

on behalf of the SHINING team:

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E. González-Alfonso, A. Sternberg, A. Verma, N. Christopher, R. Genzel, R. Davies,
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Eckhard Sturm et al.

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- Fine structure lines

- Molecular lines

- High-J CO lines

- Full PACS SEDs

- Resolved spatial information

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Far-infrared fine structure lines:

- PDR lines: [C II] 158μm, [O I] 145μm, [O I] 63μm

- HII lines: [N II] 122μm, [O III] 88μm, [N III] 57μm, [O III] 52μm

Sample:

- 9 local starbursts (M 82, NGC 253, M 83, ...)

- 18 Seyfert galaxies (NGC 1068, Cen A, Circinus, ...)

- 28 LIRGs and ULIRGs (NGC 4418, Arp 220, Mrk 231, ...)

- 5 high-z star forming galaxies (MIPS J142824.0, ...)

- 4 high-z AGNs (IRAS F10214, Cloverleaf, ...)

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The [CII] line deficit
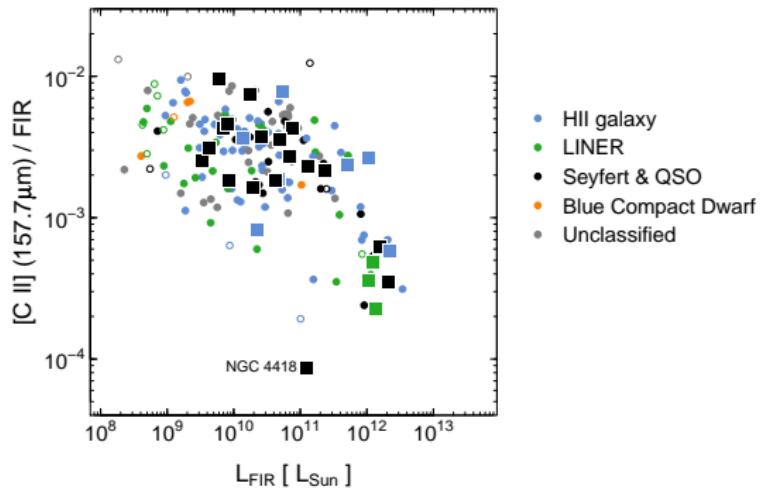
[Graciá-Carpio et al. 2010, submitted]
[Brauher et al. 2008, ApJS 178: 280]
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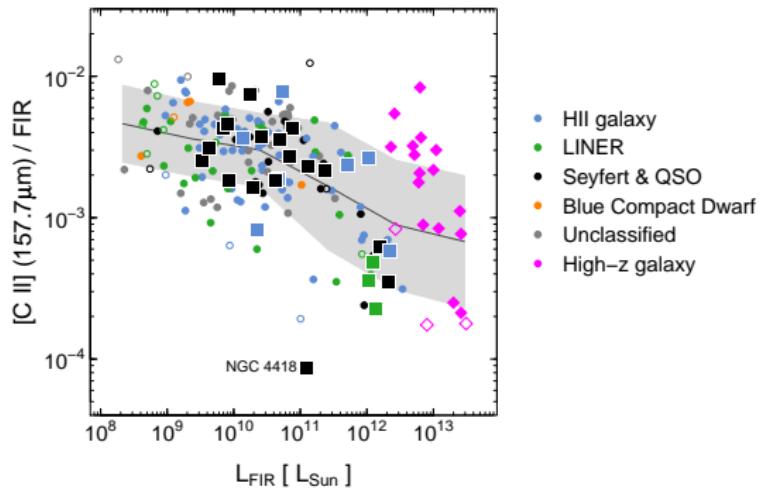
- HII galaxy
- LINER
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- Blue Compact Dwarf
- Unclassified
- High–z galaxy

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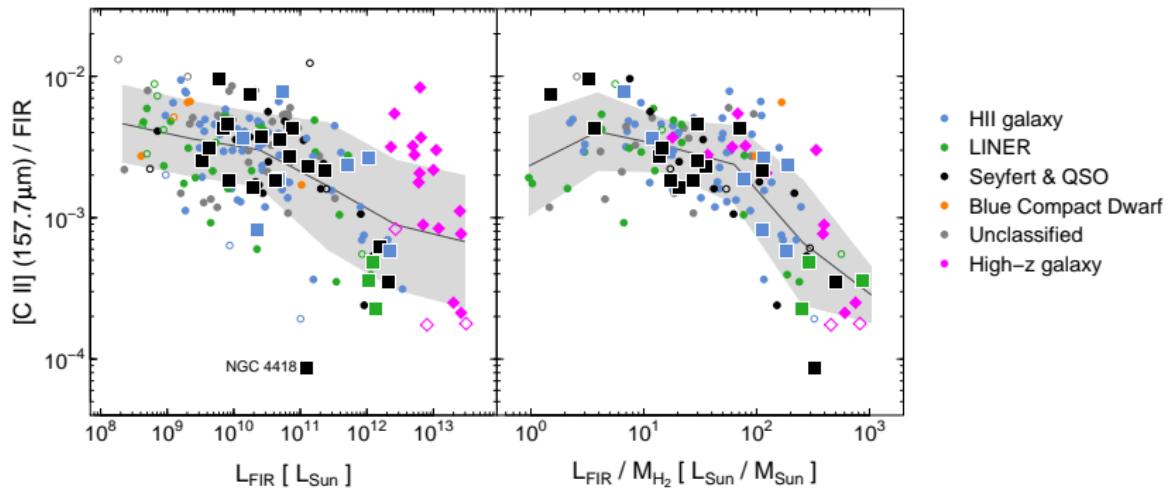
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A general far-infrared line deficit
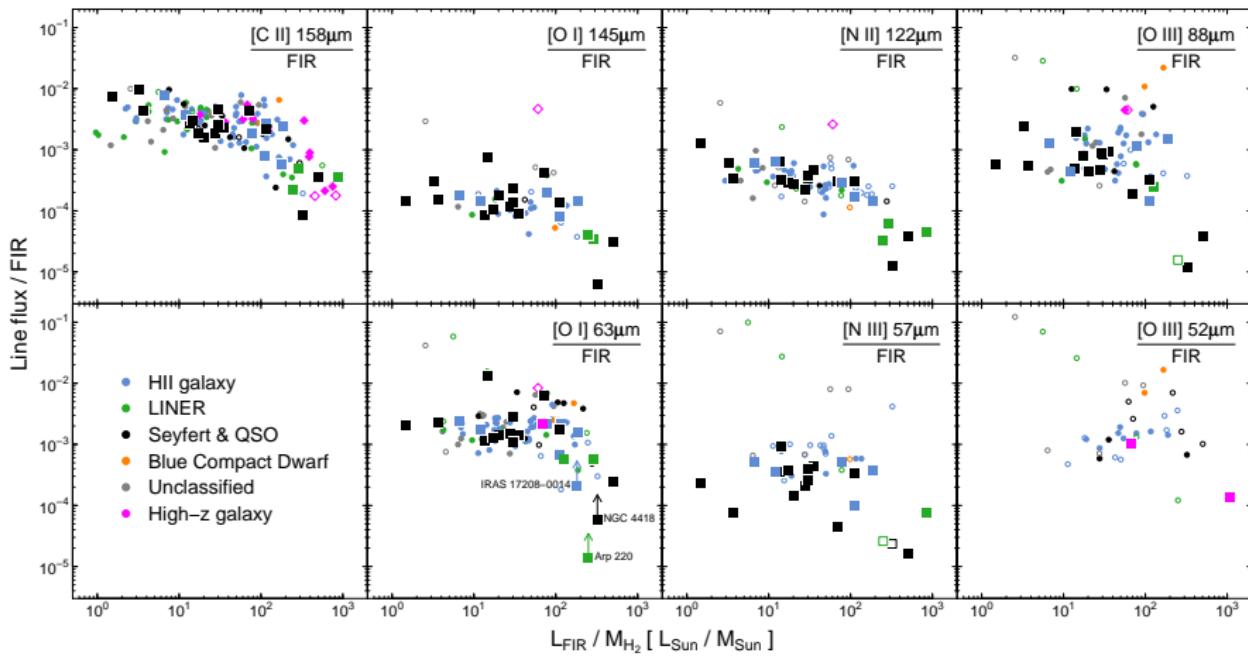
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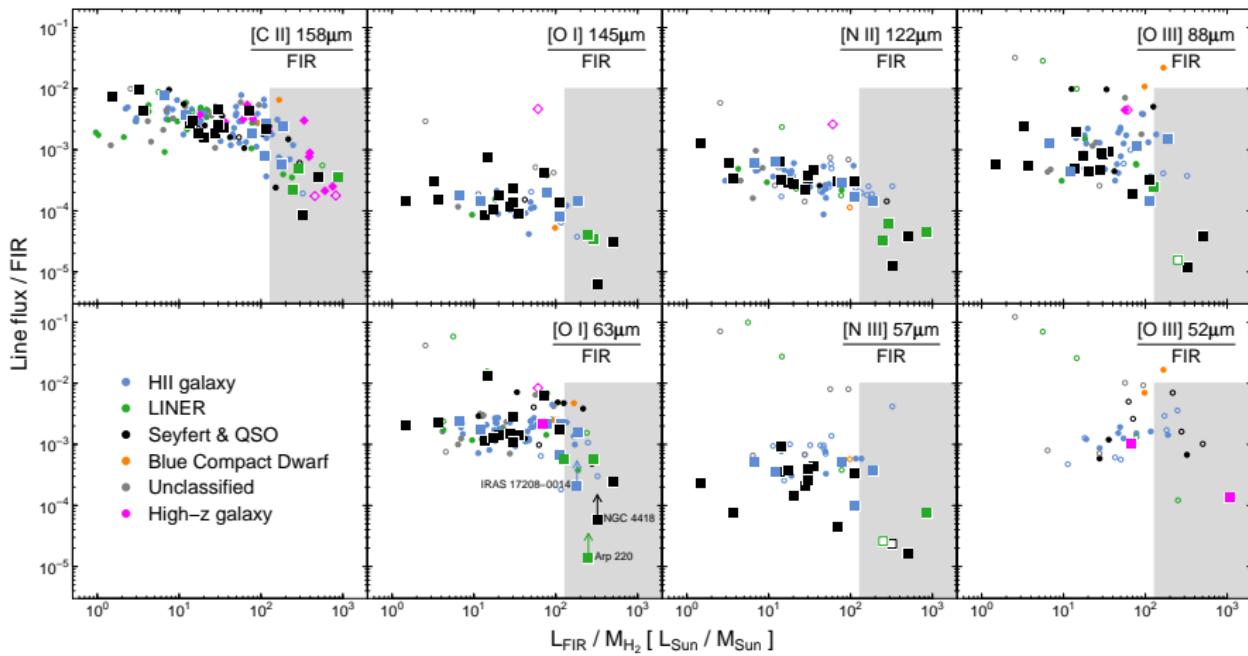
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Two modes of star formation
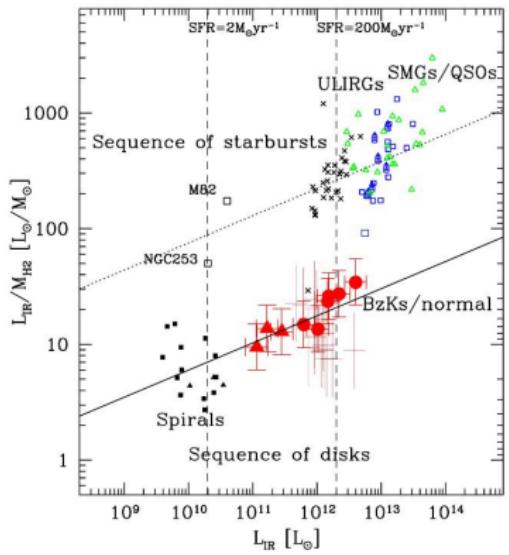
[Genzel et al. 2010, MNRAS 407: 2091]

[Daddi et al. 2010, ApJ 714: L118]
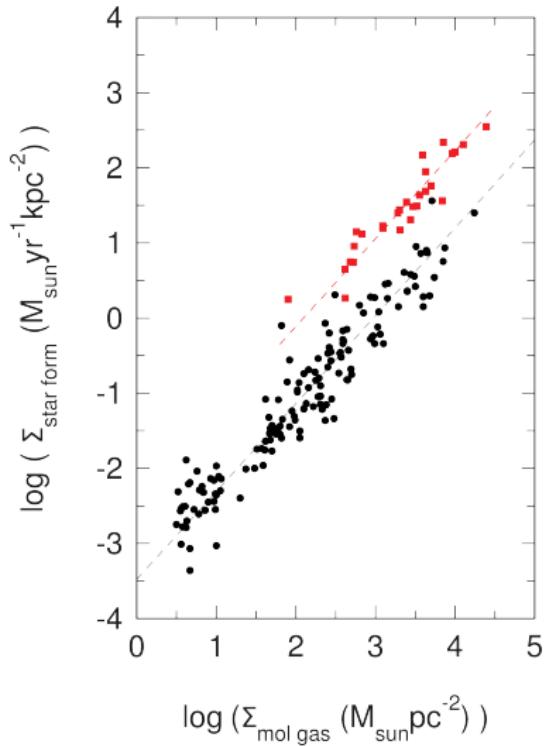
Line emission vs. $L_{\mathrm{FIR}}/M_{\mathrm{H}_2}$
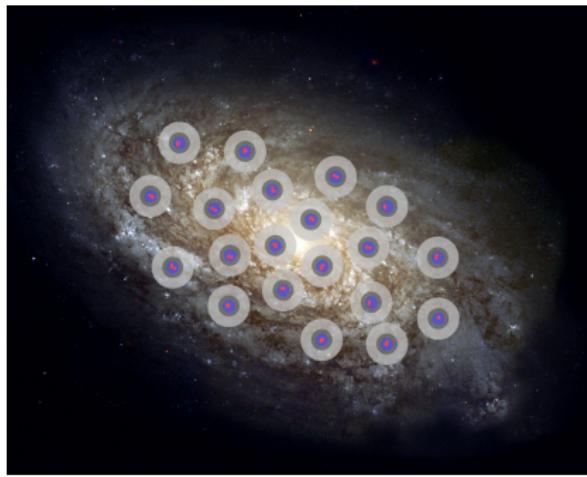
$$L_{\mathrm{FIR}}/M_{\mathrm{H}_2} \simeq 1\text{--}100\,L_{\odot}\,M_{\odot}^{-1}$$

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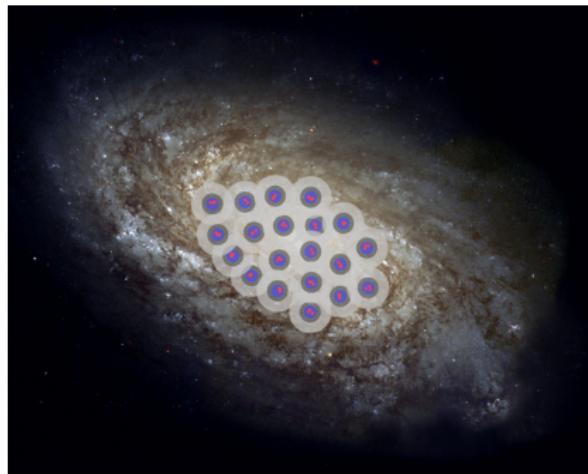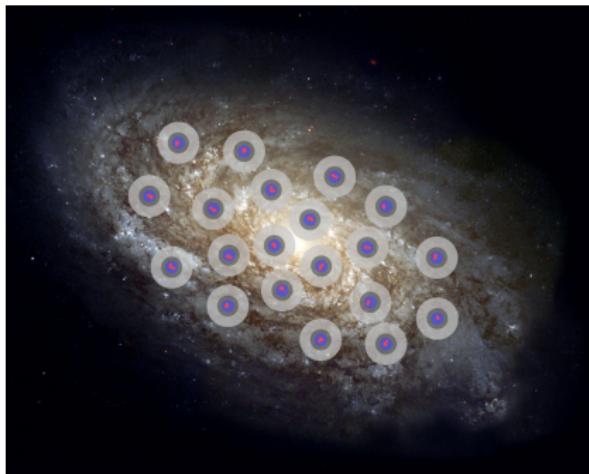
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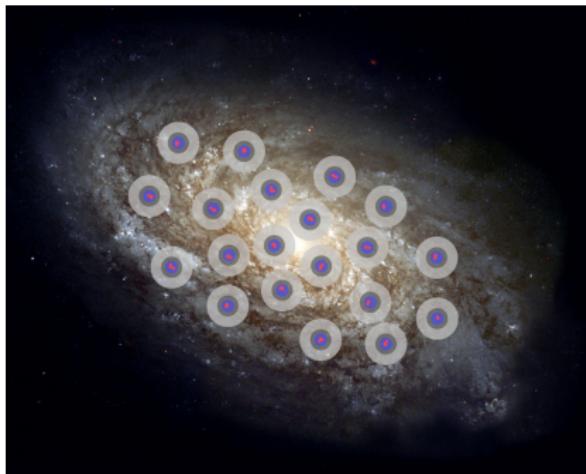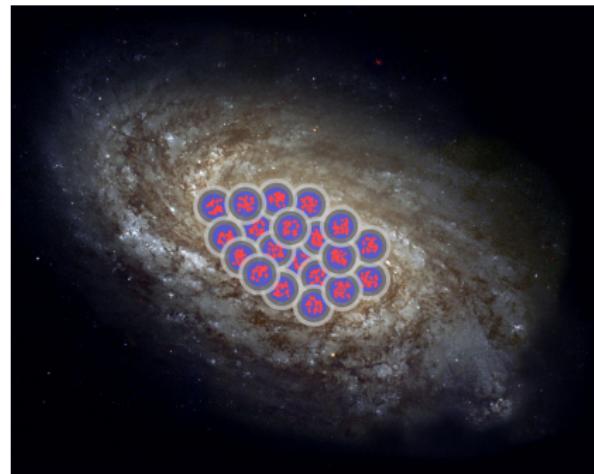
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$L_{\mathrm{FIR}}/M_{\mathrm{H}_2} \simeq 100\text{--}1000\,L_\odot\,M_\odot{}^{-1}$

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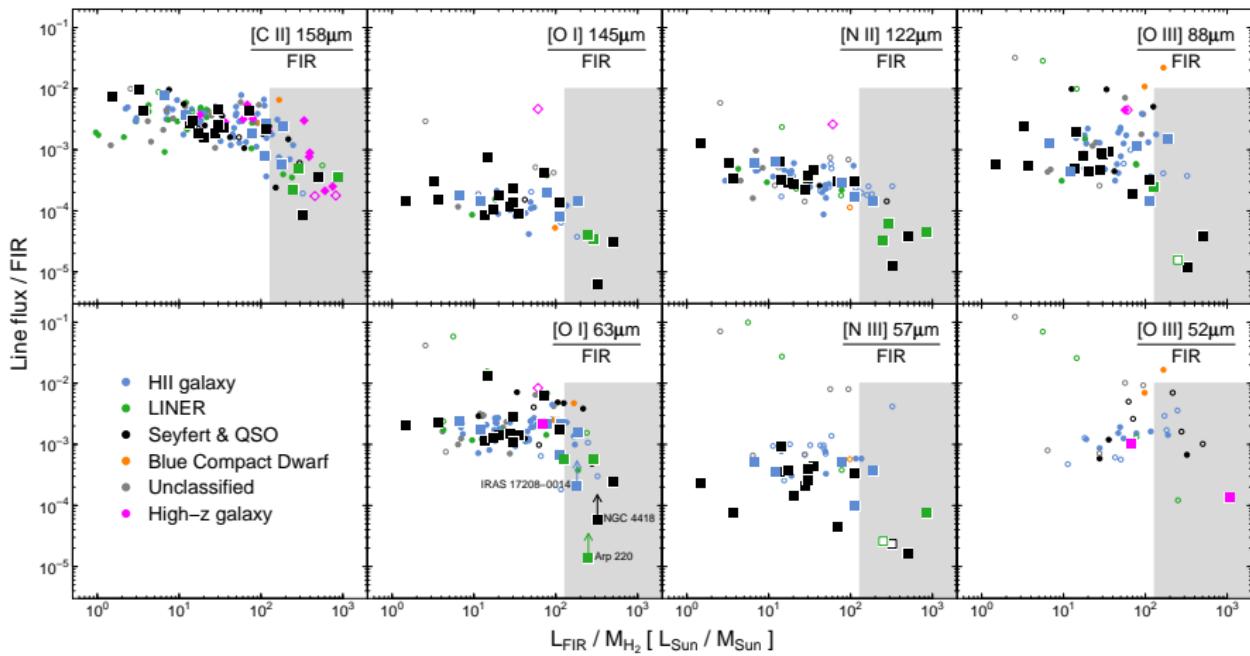
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Cloudy models
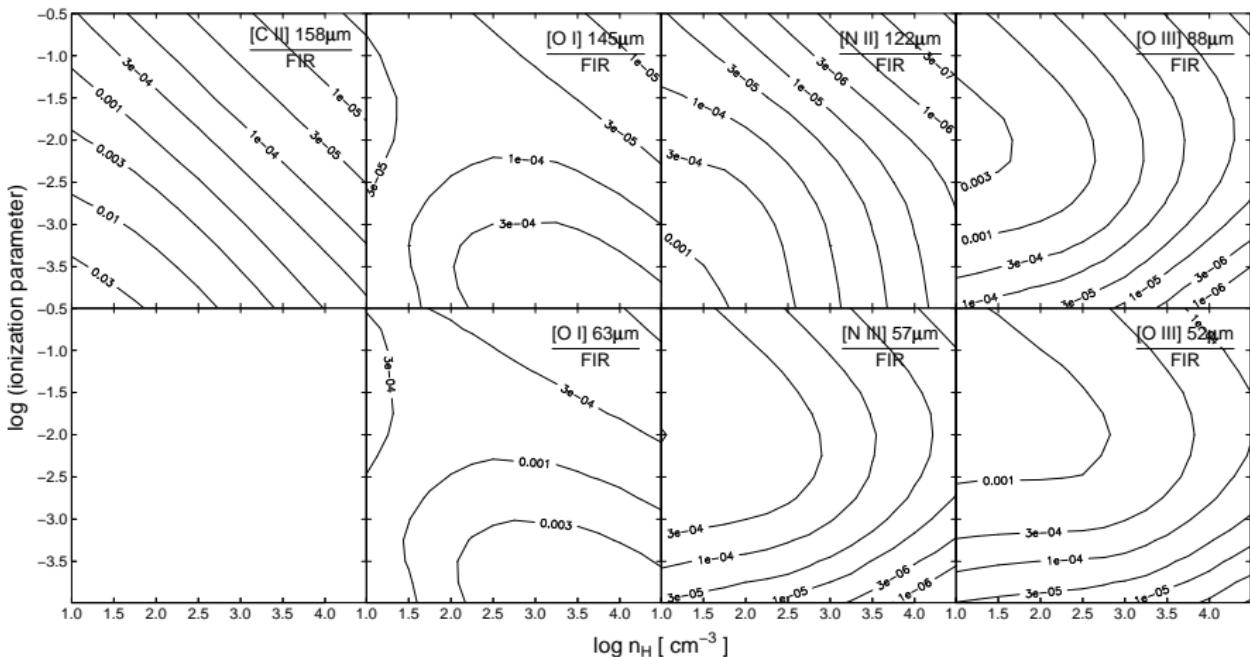
$T_* = 36000 \, \text{K}, A_V = 100 \, \text{mag}$
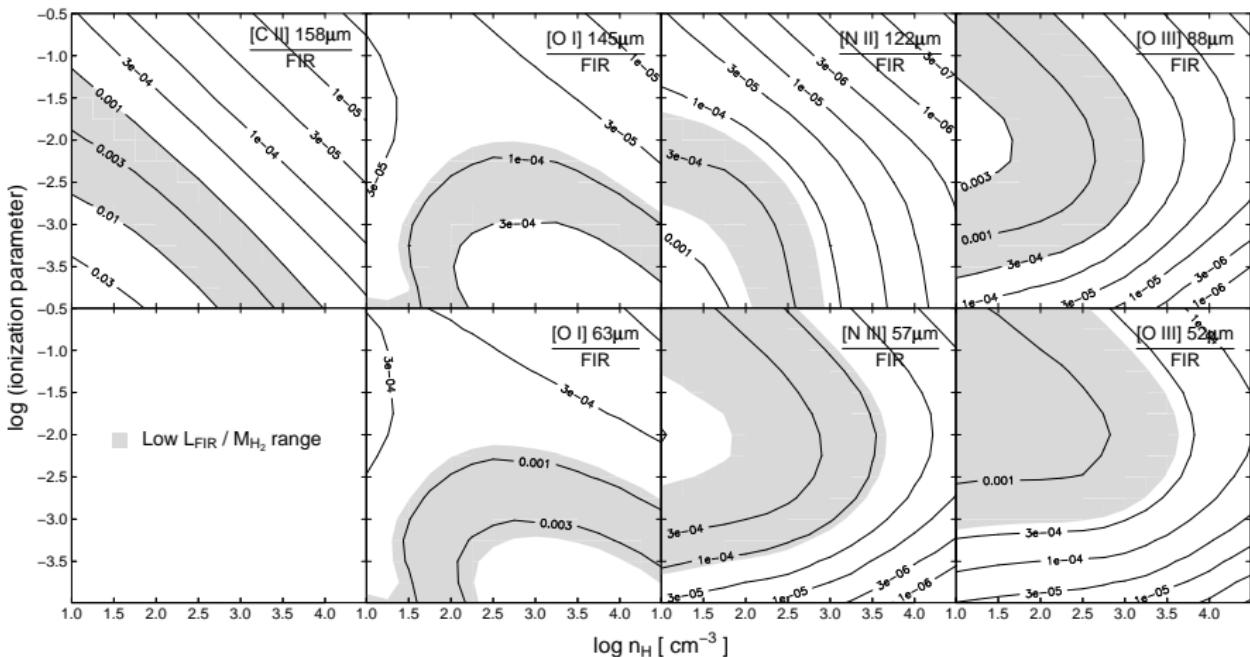
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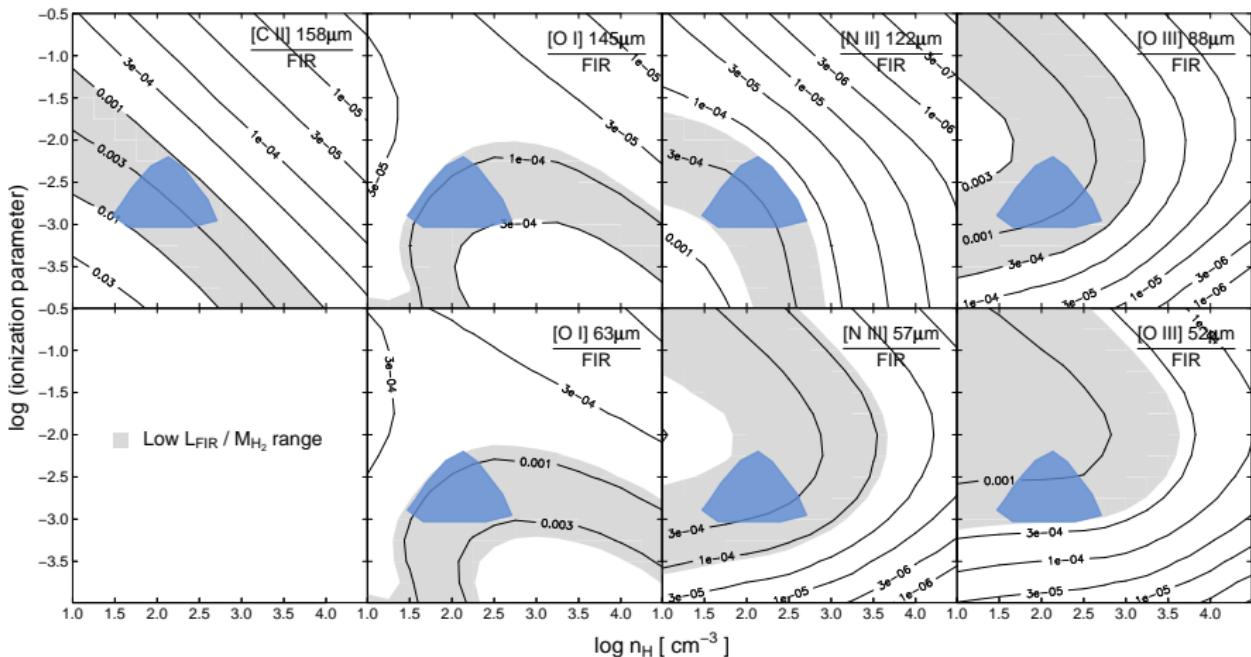
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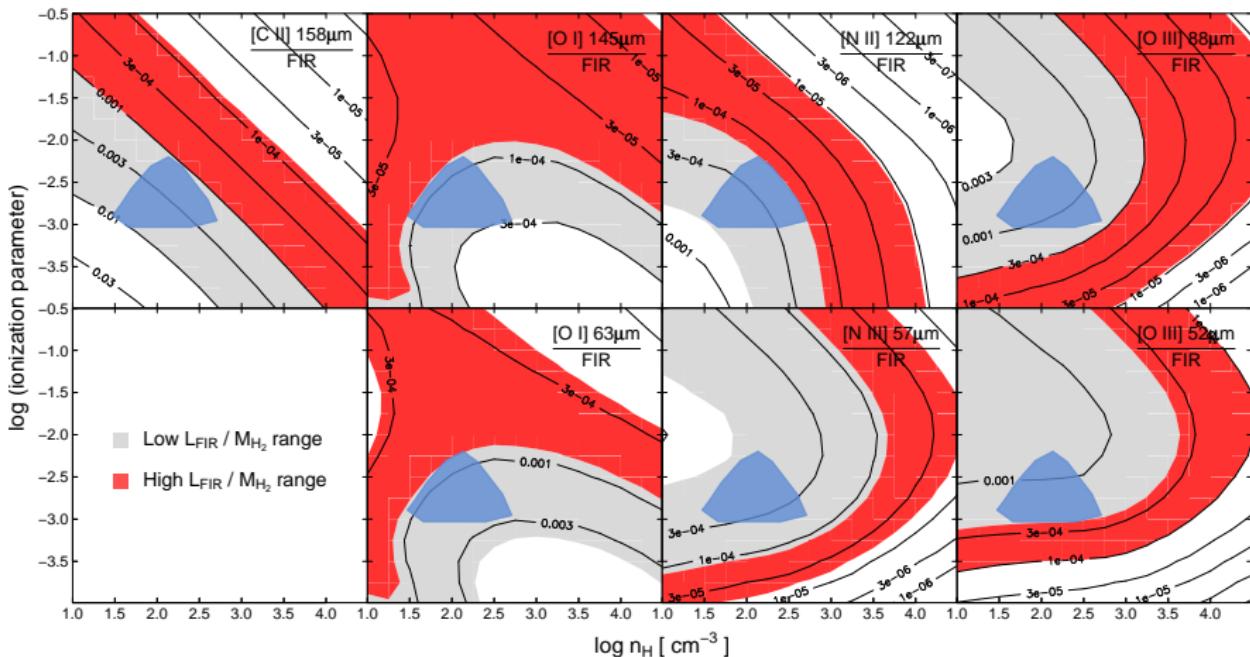
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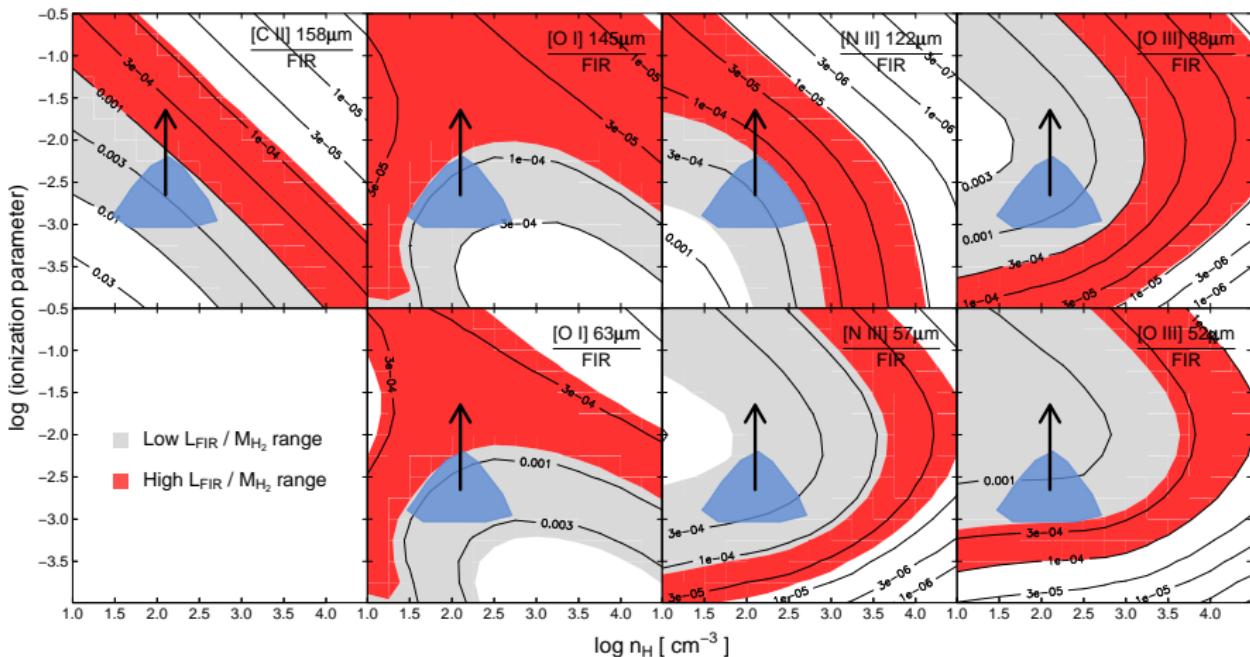
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Spatially resolved information
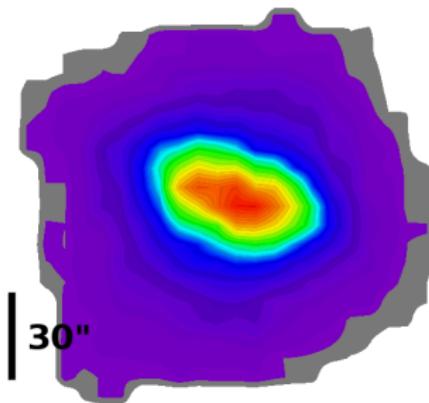
M 82   [C II] 158μm

30"

[Contursi et al. 2010, in preparation]

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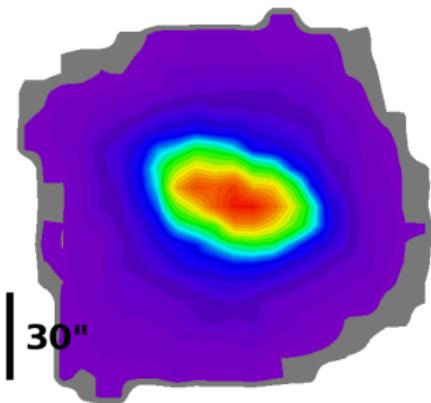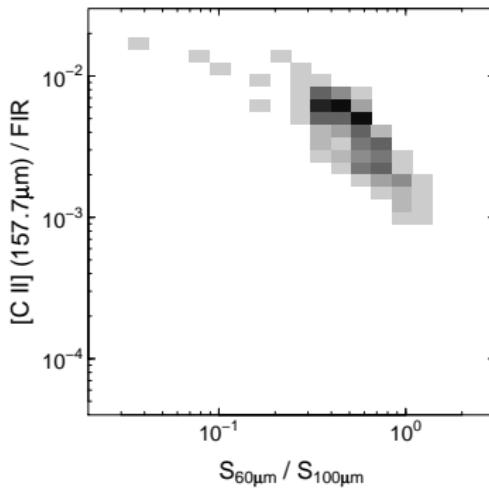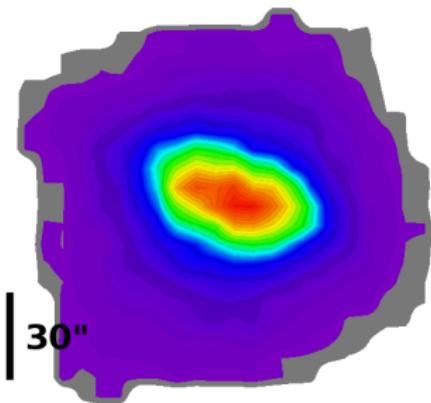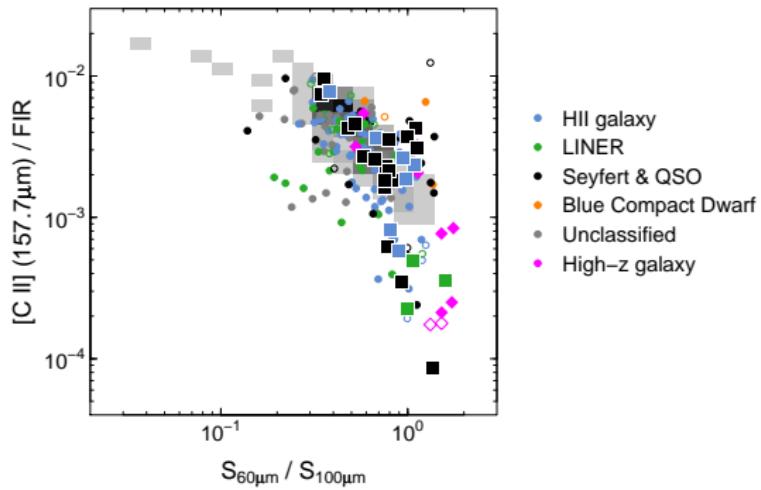
Conclusions

- $L_{\mathrm{FIR}}/M_{\mathrm{H_2}}$ is a good proxy for the relative brightness of the far-infrared fine structure lines.

- We find line deficits in all the fine structure lines, regardless of their origin in the ionized or neutral phase of the ISM.

- The $L_{\mathrm{FIR}}/M_{\mathrm{H_2}}$ threshold is similar to the limit that separates between the two modes of star formation recently found in galaxies.

- High ionization parameters can explain the line deficits in the [C II], [O I] and [N II] lines. Further modeling is needed to explain the [N III] and [O III] lines.

- More to come!