

PDR study of 30 Doradus

PACS spectroscopy and SPIRE FTS

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SOFIA Workshop - 18/03/2015

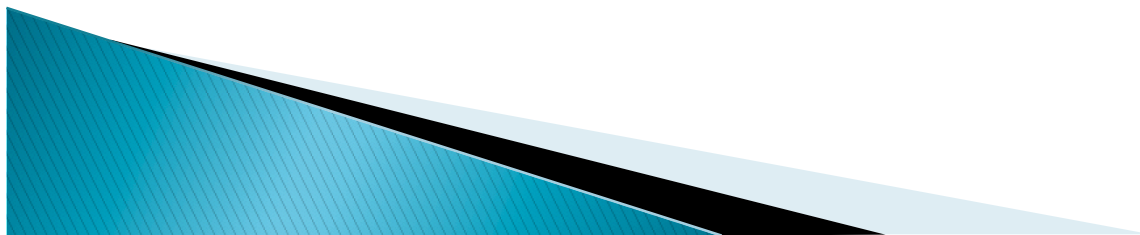
Introduction

Low metallicity galaxies, chemically young, are good laboratories to understand better the evolution of galaxies.

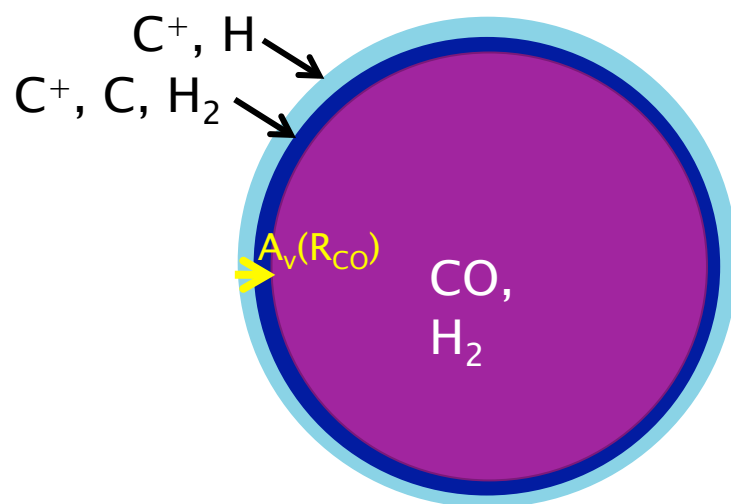
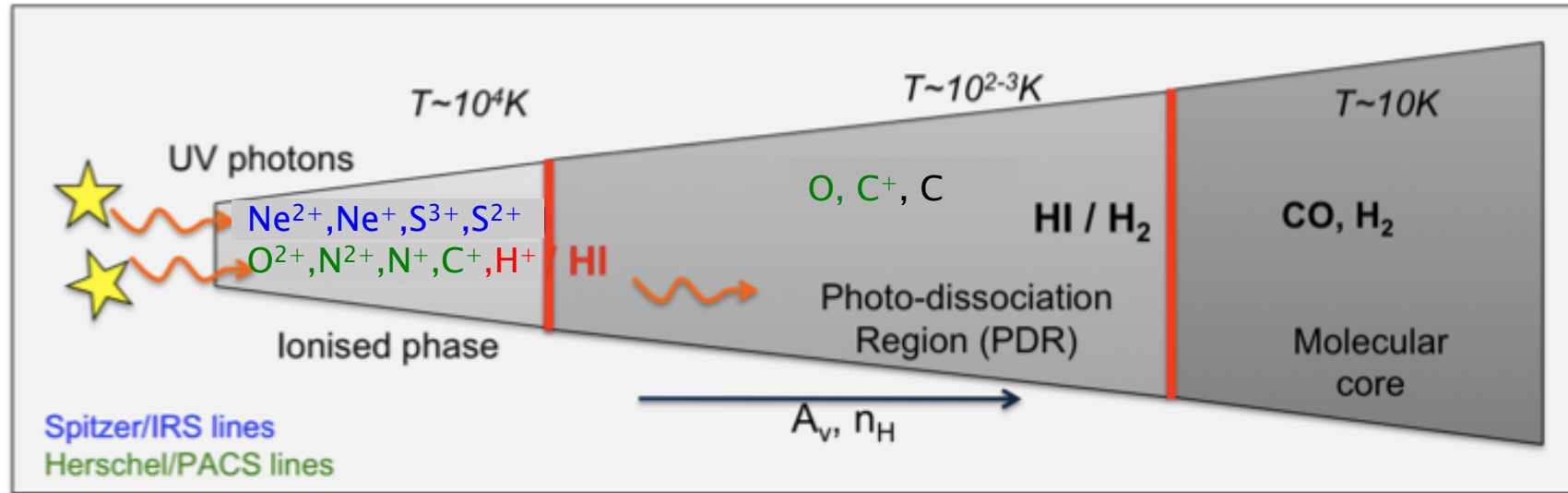
In some dwarf galaxies at low metallicity, we measure an important star formation rate but we hardly detect CO.

- ▶ What are the effects of metallicity, locally and globally in galaxies ?
- ▶ What is the structure of the interstellar medium in low metallicity environments ?
- ▶ How does star formation interact with the surrounding low metallicity PDR/molecular gas ?

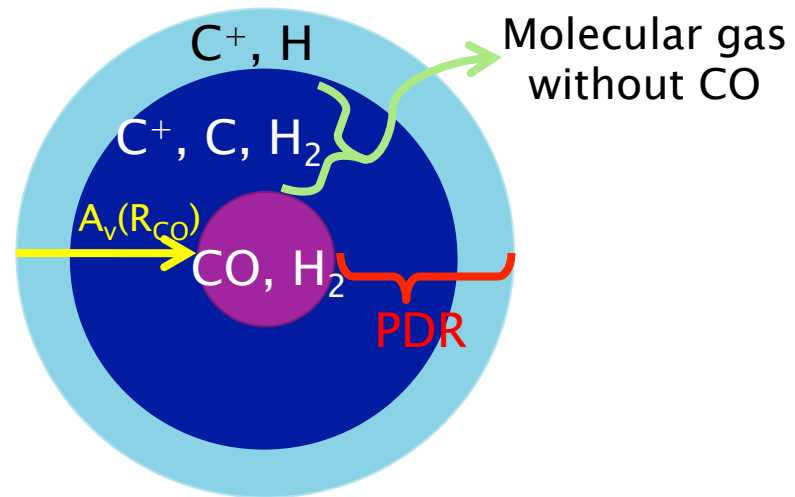
- ▶ Zooming in 8 star-forming regions in the LMC and the SMC (*PACS GT + Hony OT2*)
- ▶ PACS spectroscopy + SPIRE FTS + Spitzer/IRS + dust... -> develop PDR modeling tools for the Magellanic clouds
- ▶ Start with 30 Doradus as first test bed



Structure of the interstellar medium at low metallicity



Solar metallicity



Low metallicity

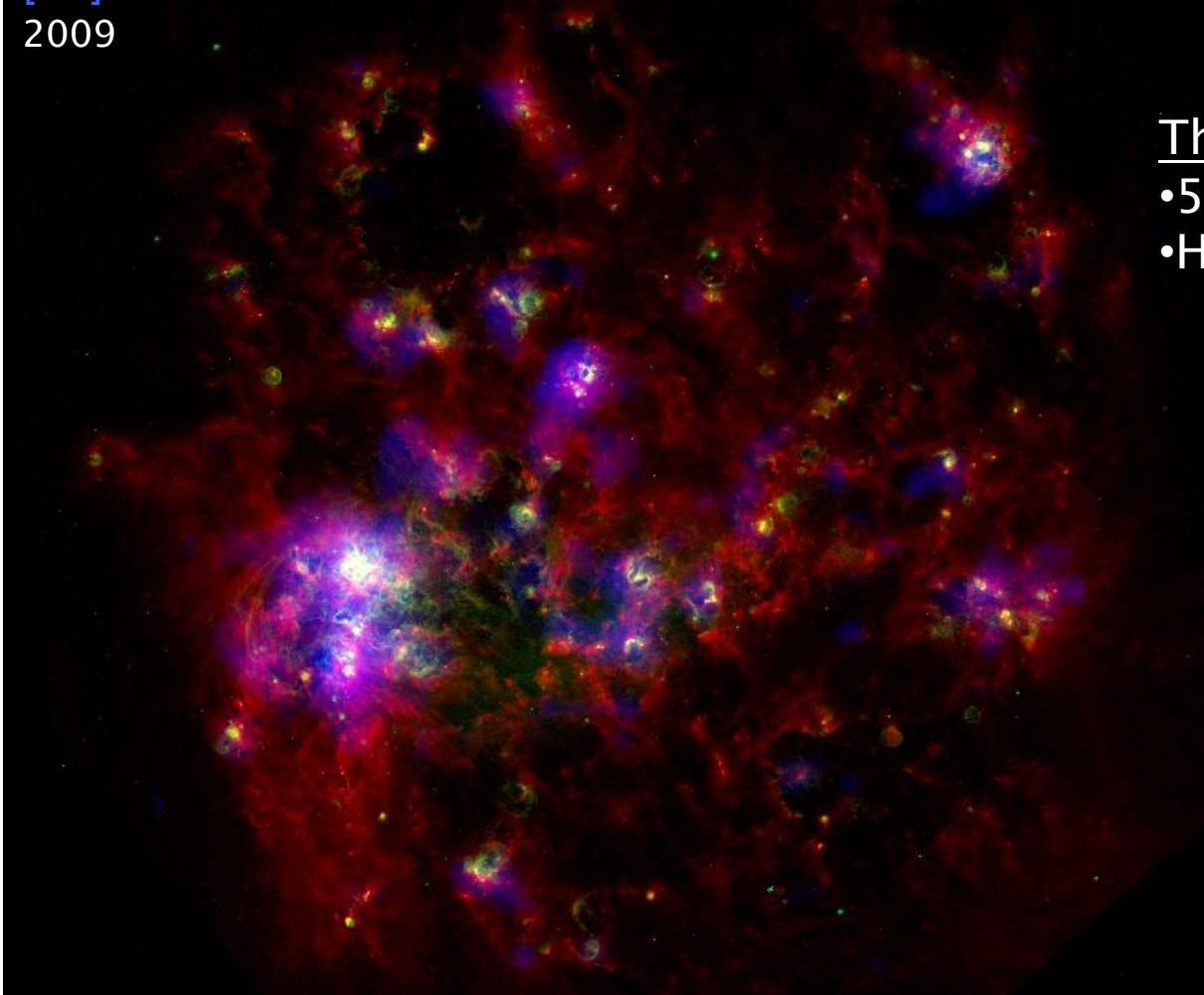
160 μ m HERITAGE Meixner+ 2010

H α MCELS Smith+

[CII] BICE Mochizuki+ 1994. Rubin+
2009

The Large Magellanic Cloud :

- 50 kpc
- Half solar metallicity



160 μ m HERITAGE Meixner+ 2010
H α MCELS Smith+
[CII] BICE Mochizuki+ 1994. Rubin+
2009

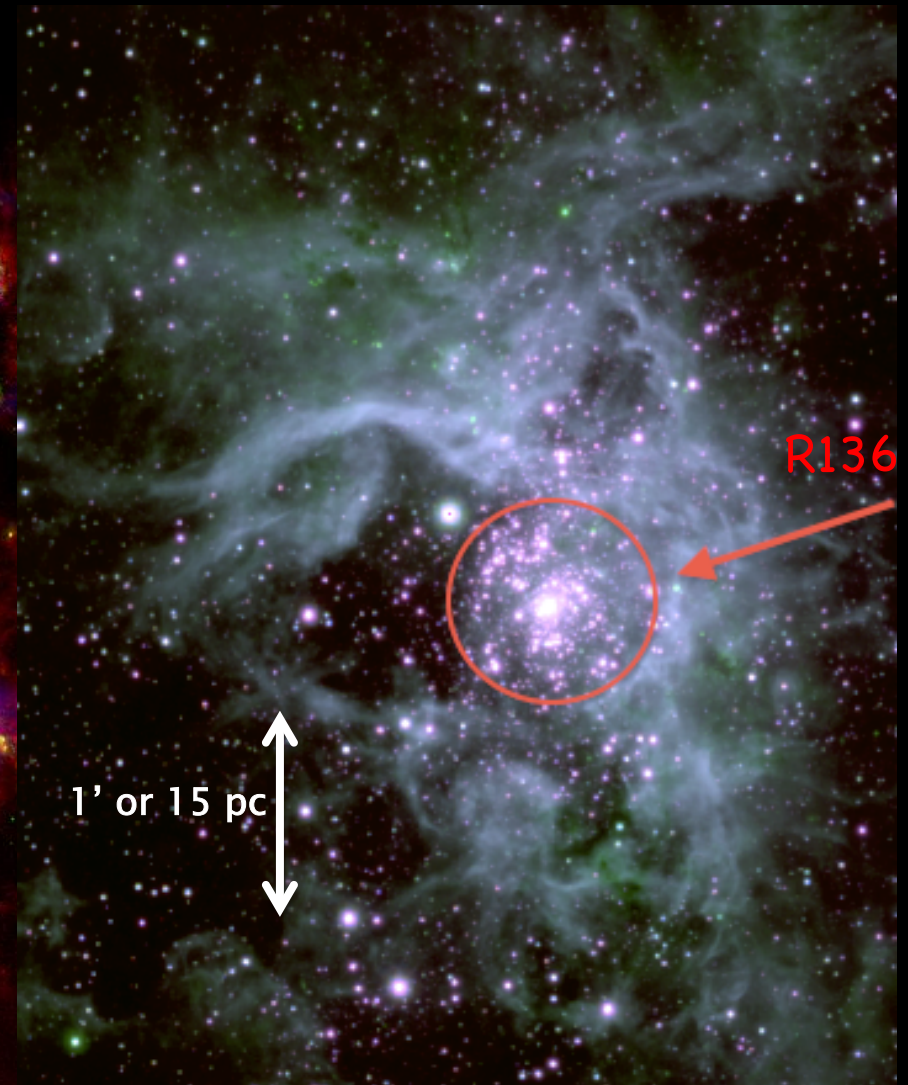
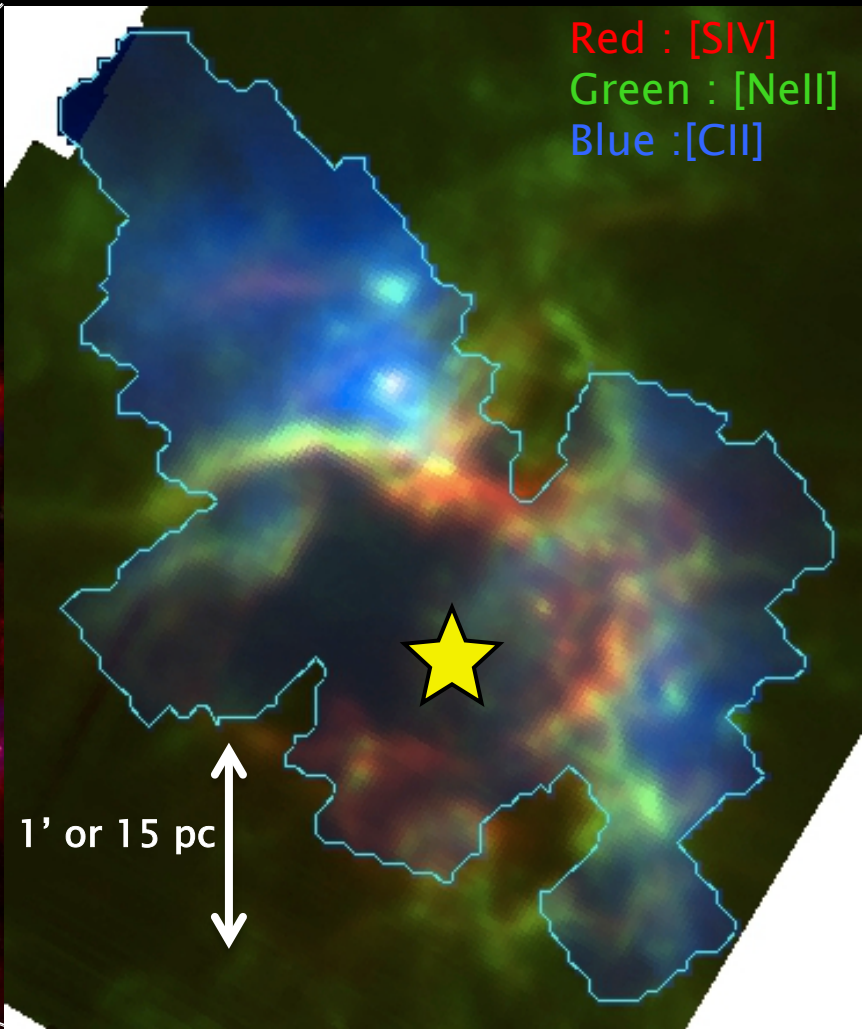


Image : Vista

160 μ m HERITAGE Meixner+ 2010
H α MCELS Smith+
[CII] BICE Mochizuki+ 1994. Rubin+
2009

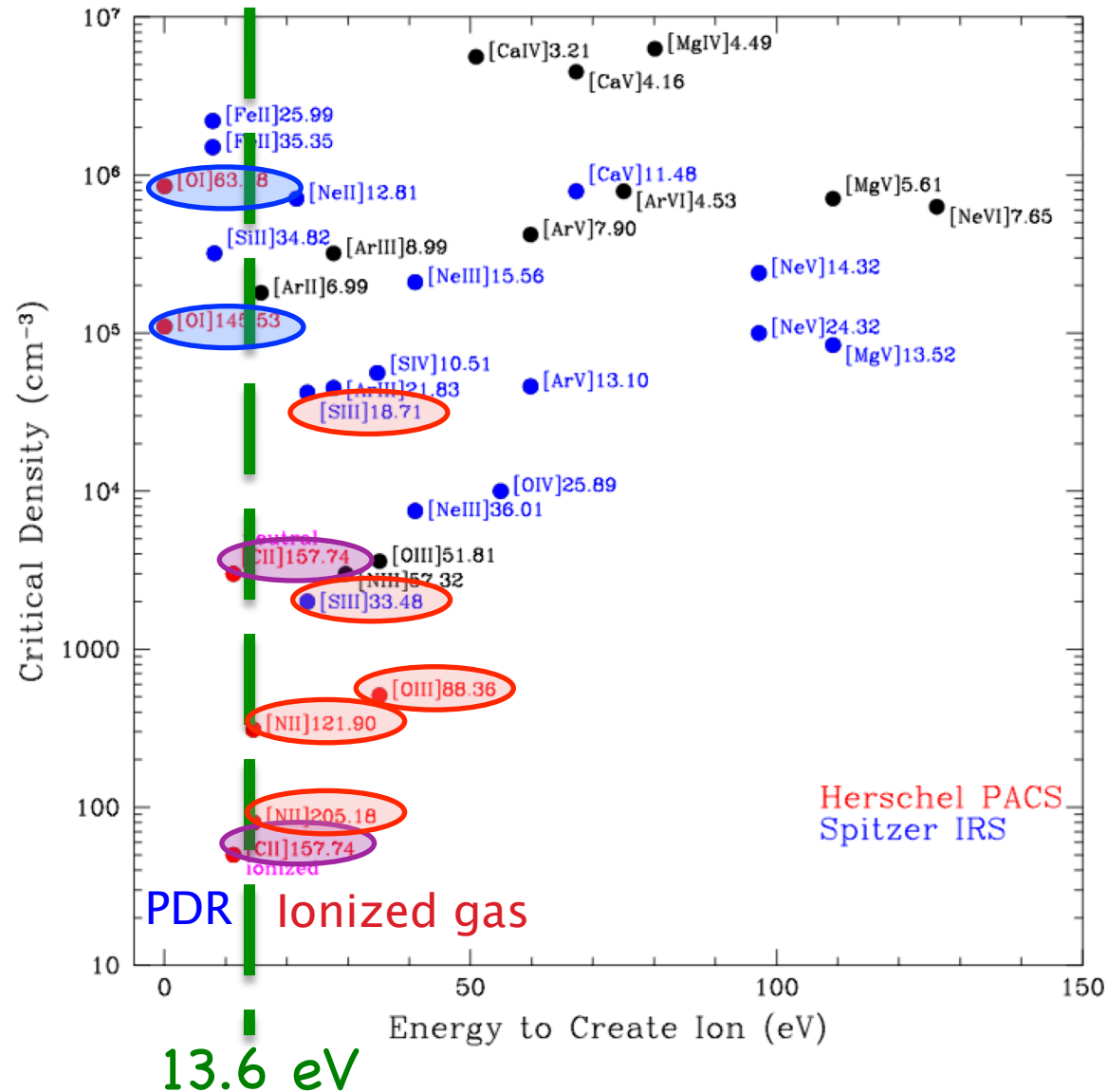
Red : [SIV]
Green : [NeII]
Blue : [CII]



Tracing PDRs

»» The origin of C⁺

Diagnostic of various phases in the ISM



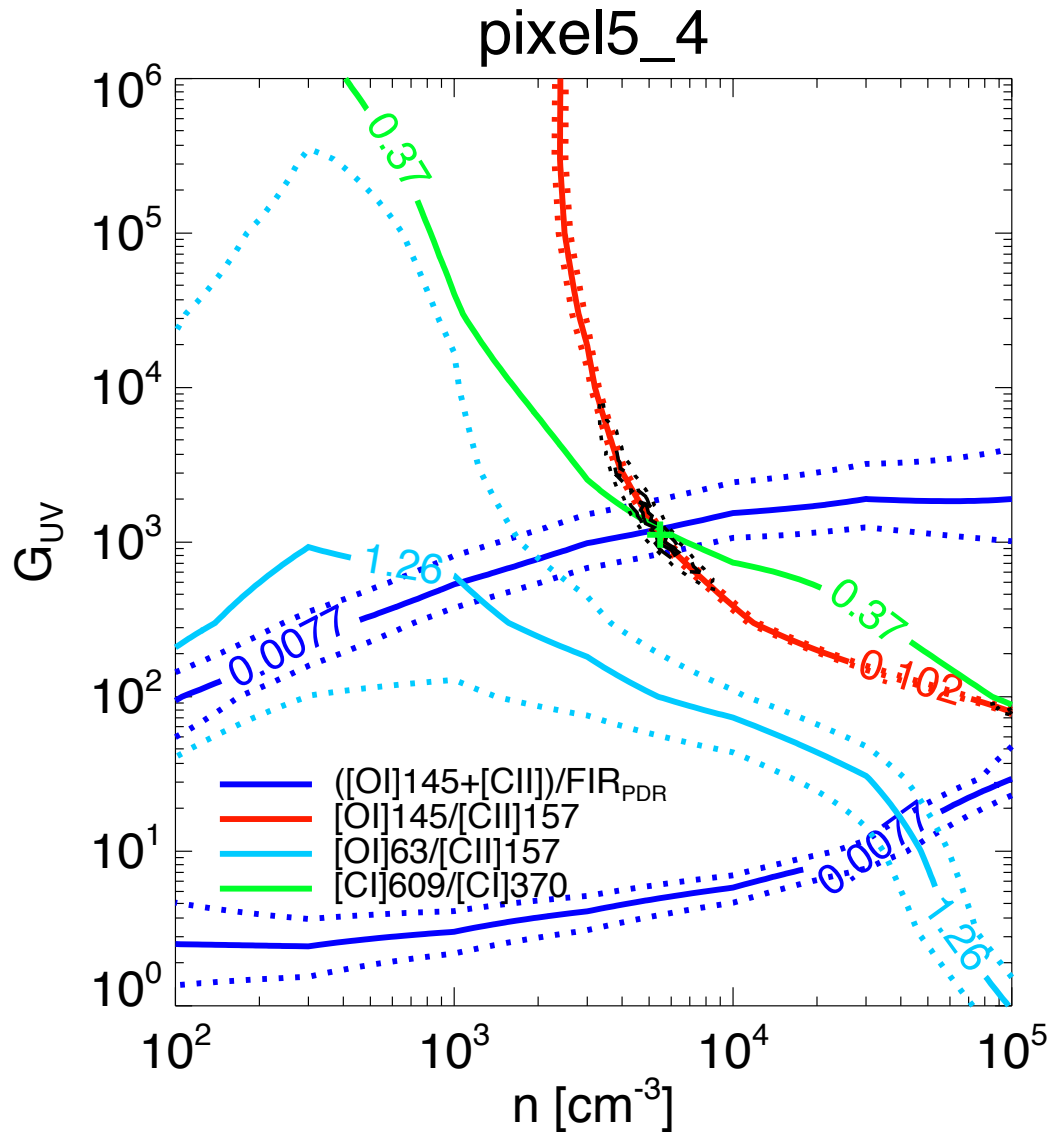
Physical conditions in the ISM of 30 Dor

» PDR modeling

PDR modeling

The Meudon PDR code (Le Petit+ 2006)

(adapted by Benjamin Godard)



Two parameters:

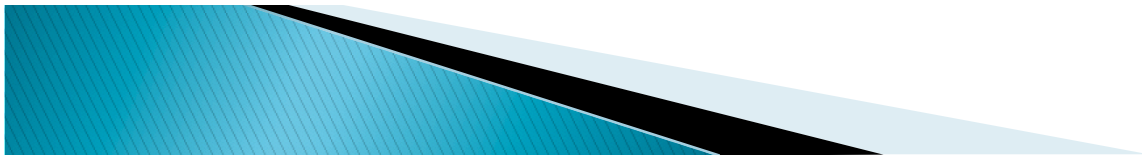
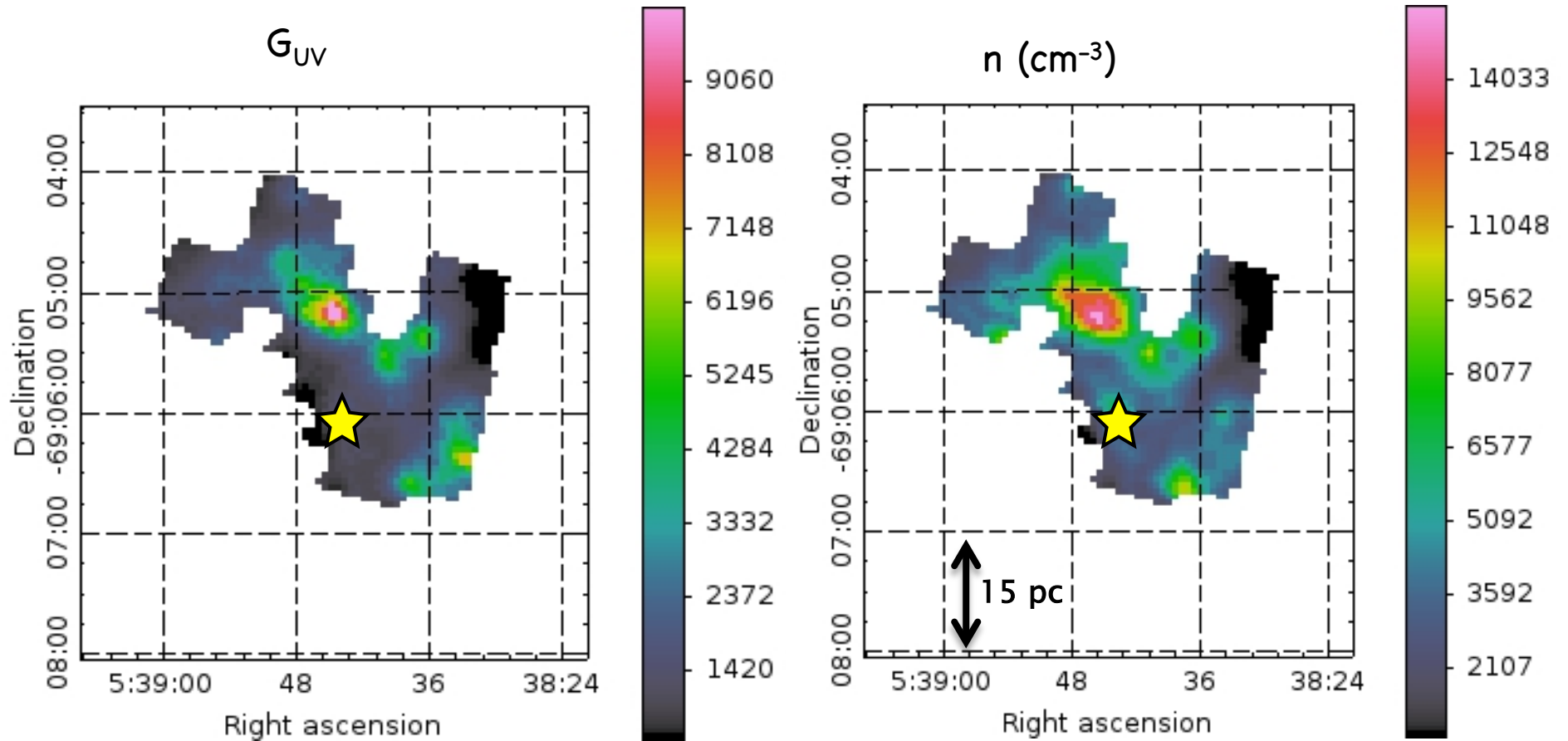
- G_{UV} : intensity of the *incident* radiation field (in units of the Habing field : $1.2e-4 \text{ erg/cm}^2/\text{s}/\text{sr}$)
- n : density of the cloud (in cm^{-3})

Model characteristics:

- Parallel slab geometry
- Abundances measured in 30Dor
- $A_{v,\text{total}}=3$
- Constant density

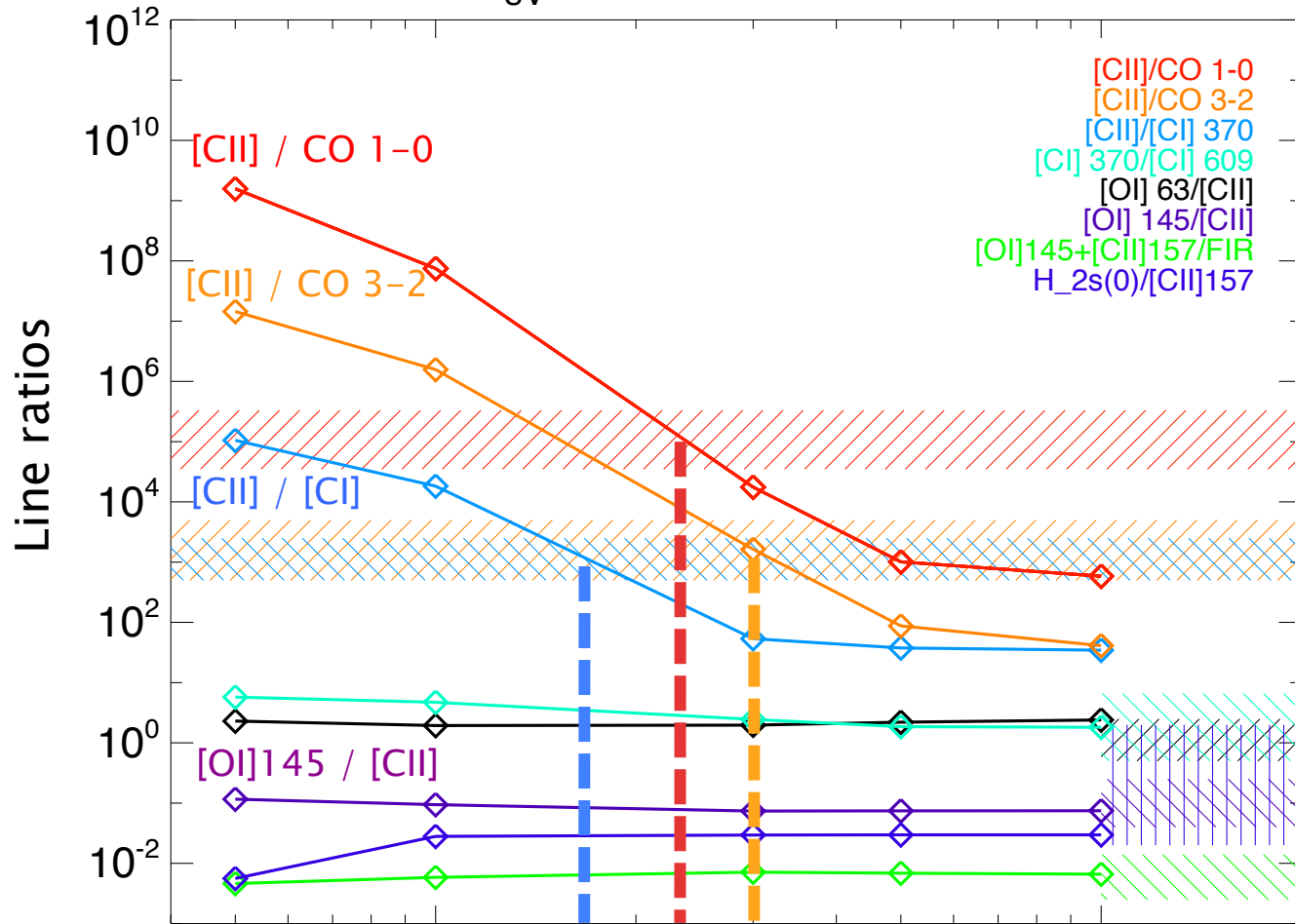
➤ Maps of n and G_{UV} from the observations

Results for G_{UV} and n



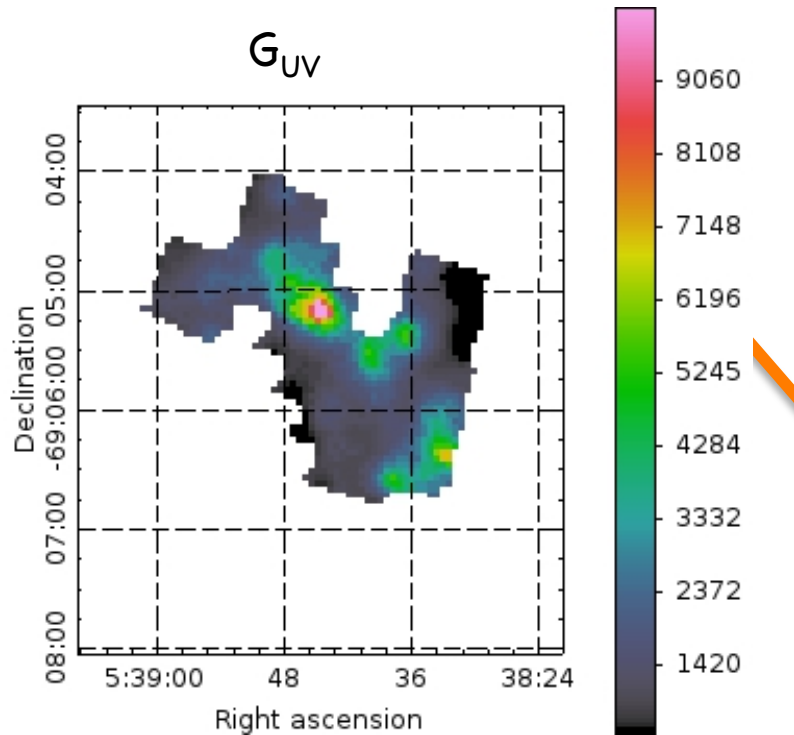
Total Av of the cloud

$G_{UV} = 1000$, $n = 3000 \text{ cm}^{-3}$

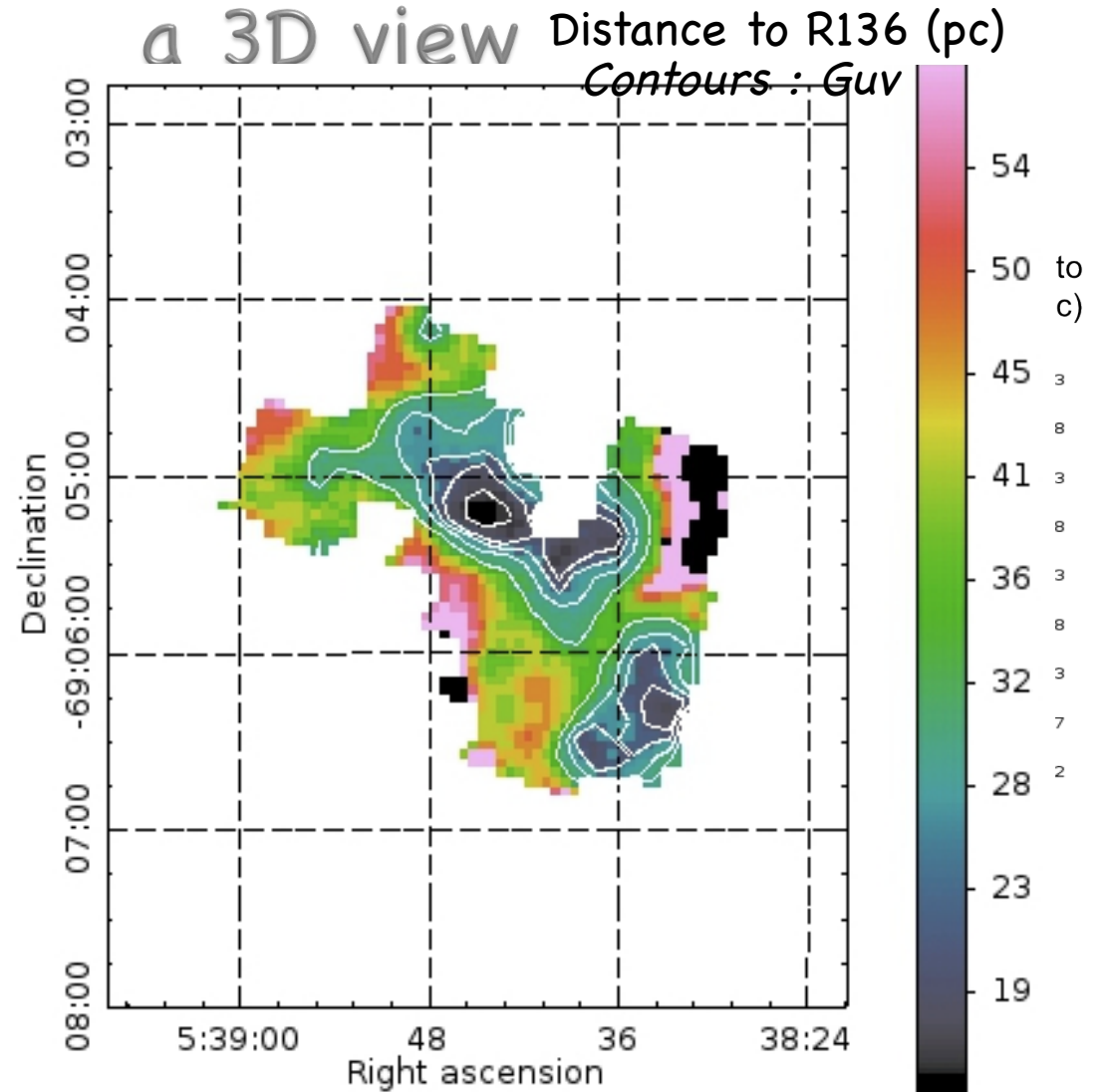


Three dimensional view of 30Dor

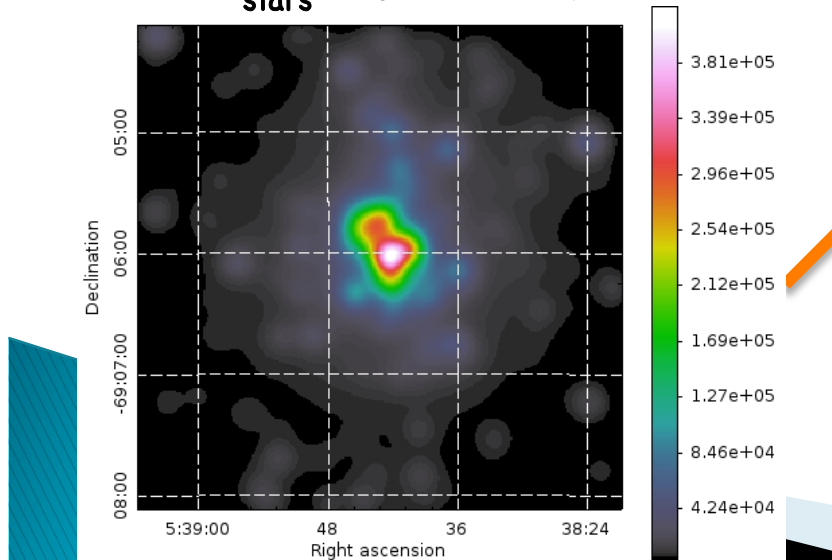
» Structure and geometry



Physical distance between stars and clouds : a 3D view



Emitted G_{stars} from the cluster

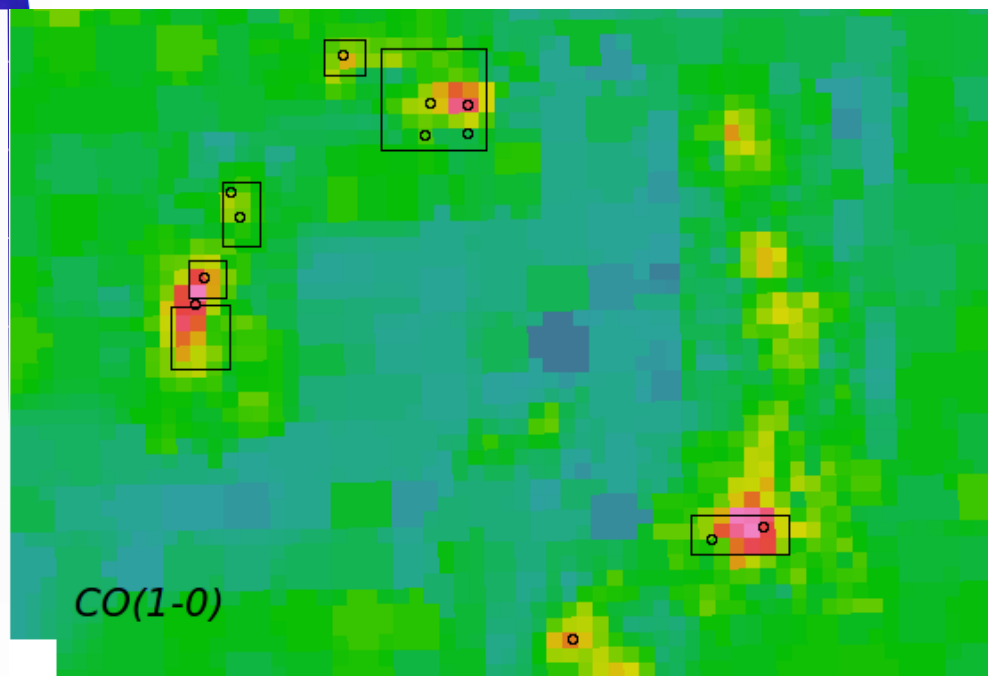
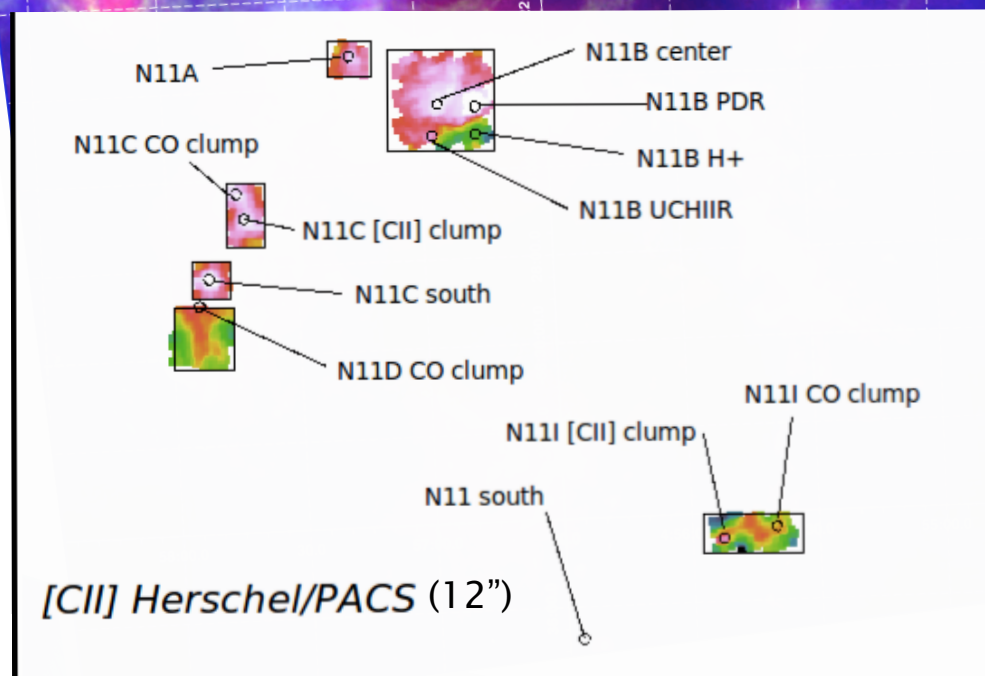
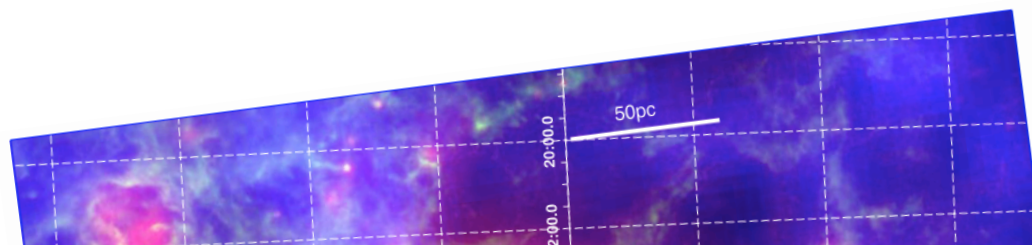


Analysis of [CII] spectral profile in LMC-N11 with SOFIA/GREAT

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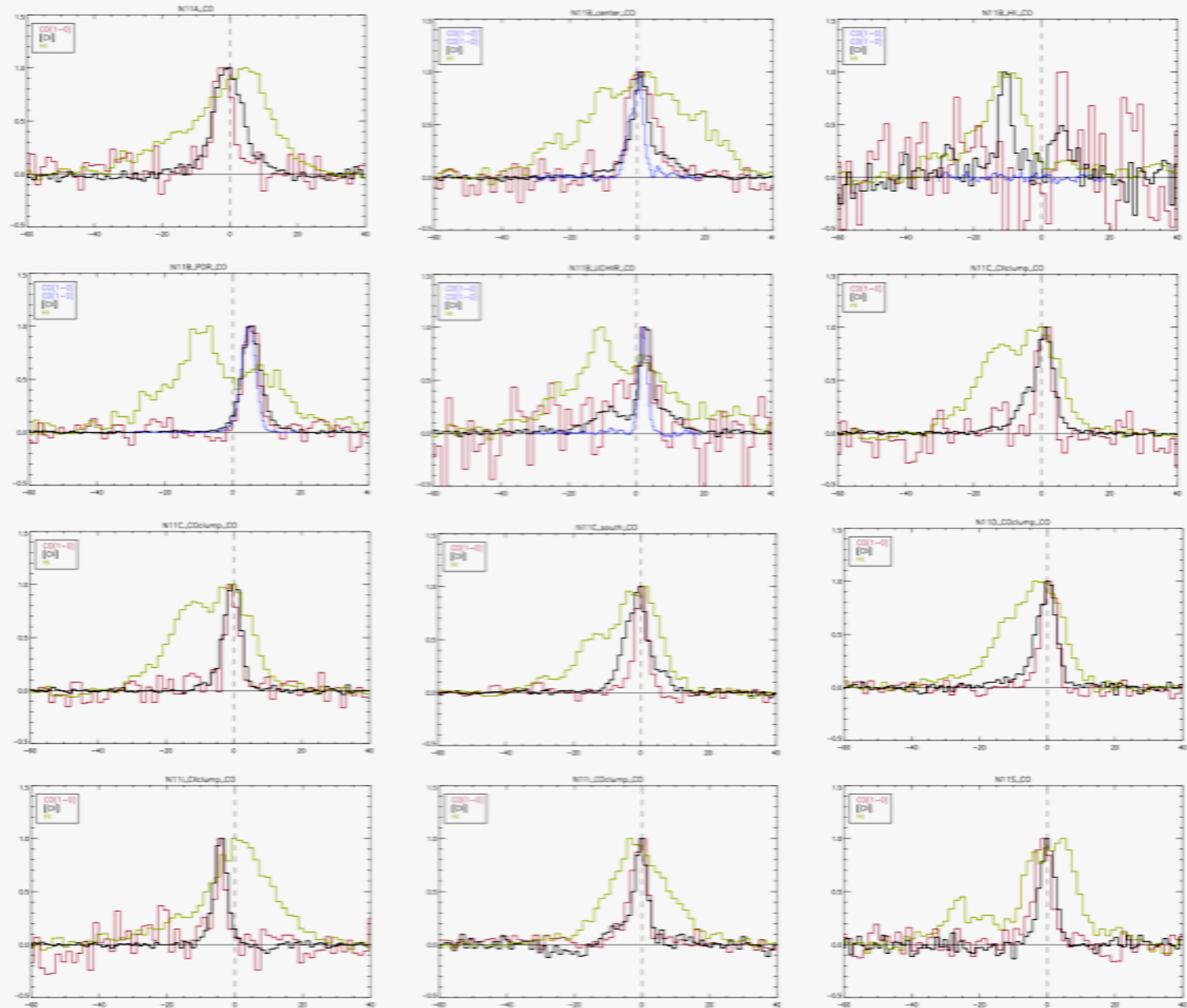
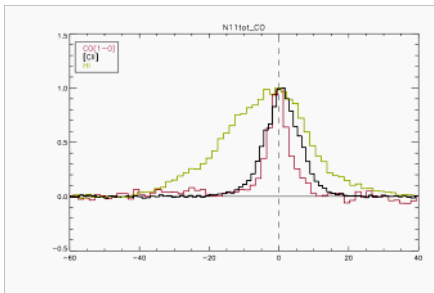
GREAT: German REceiver for Astronomy at Terahertz Frequencies



Comparison [CII]-CO-HI

[CII] GREAT
HI (ATCA+Parkes,
Kim+ 2003)
CO MOPRA
CO ALMA

Sum of all profiles

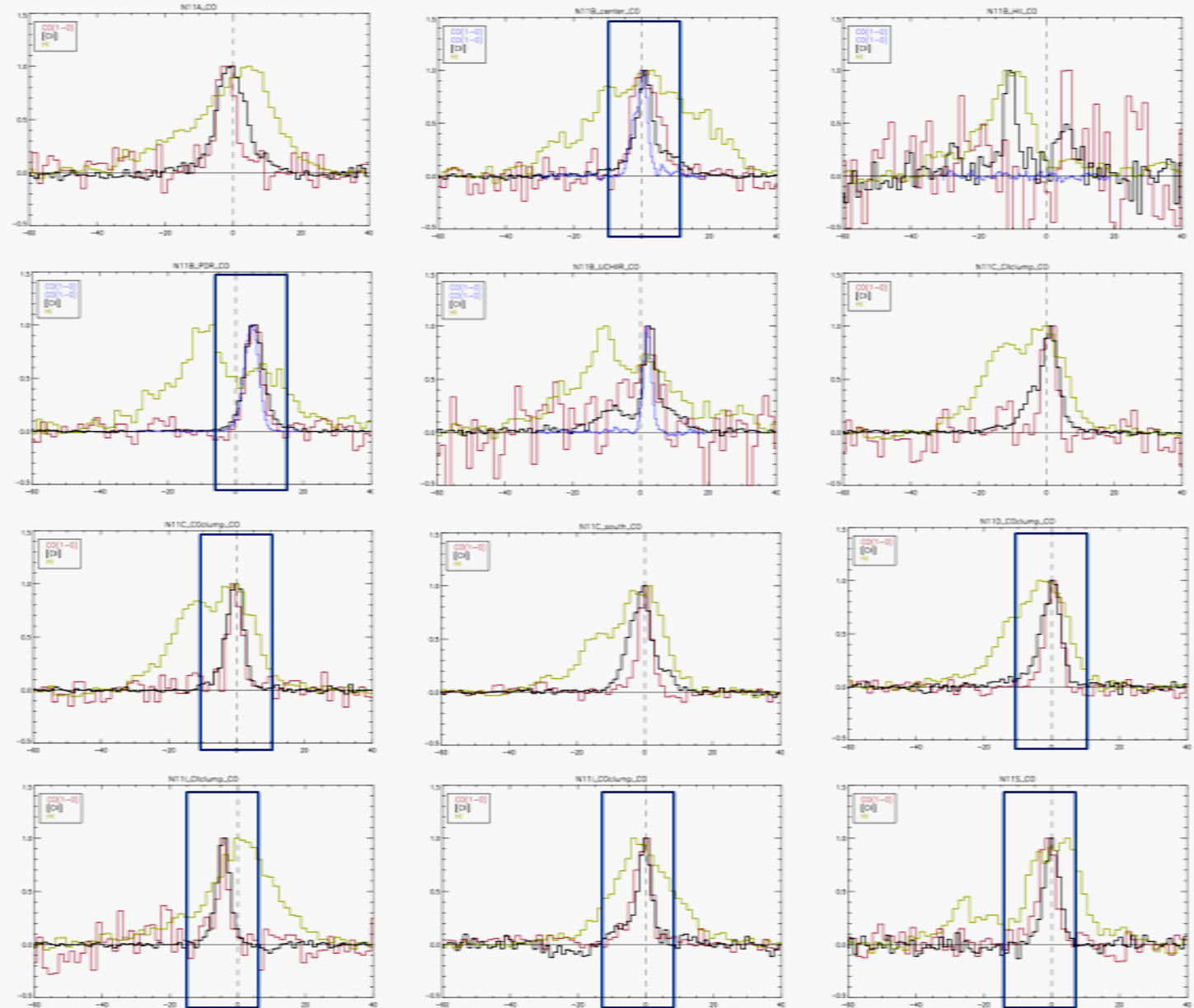
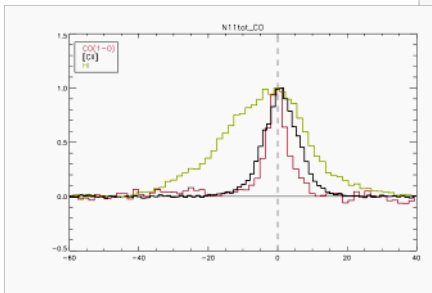


(Normalized profiles)

[CII] similar to CO

[CII] GREAT
HI (ATCA+Parkes)
CO MOPRA
CO ALMA

Sum of all profiles

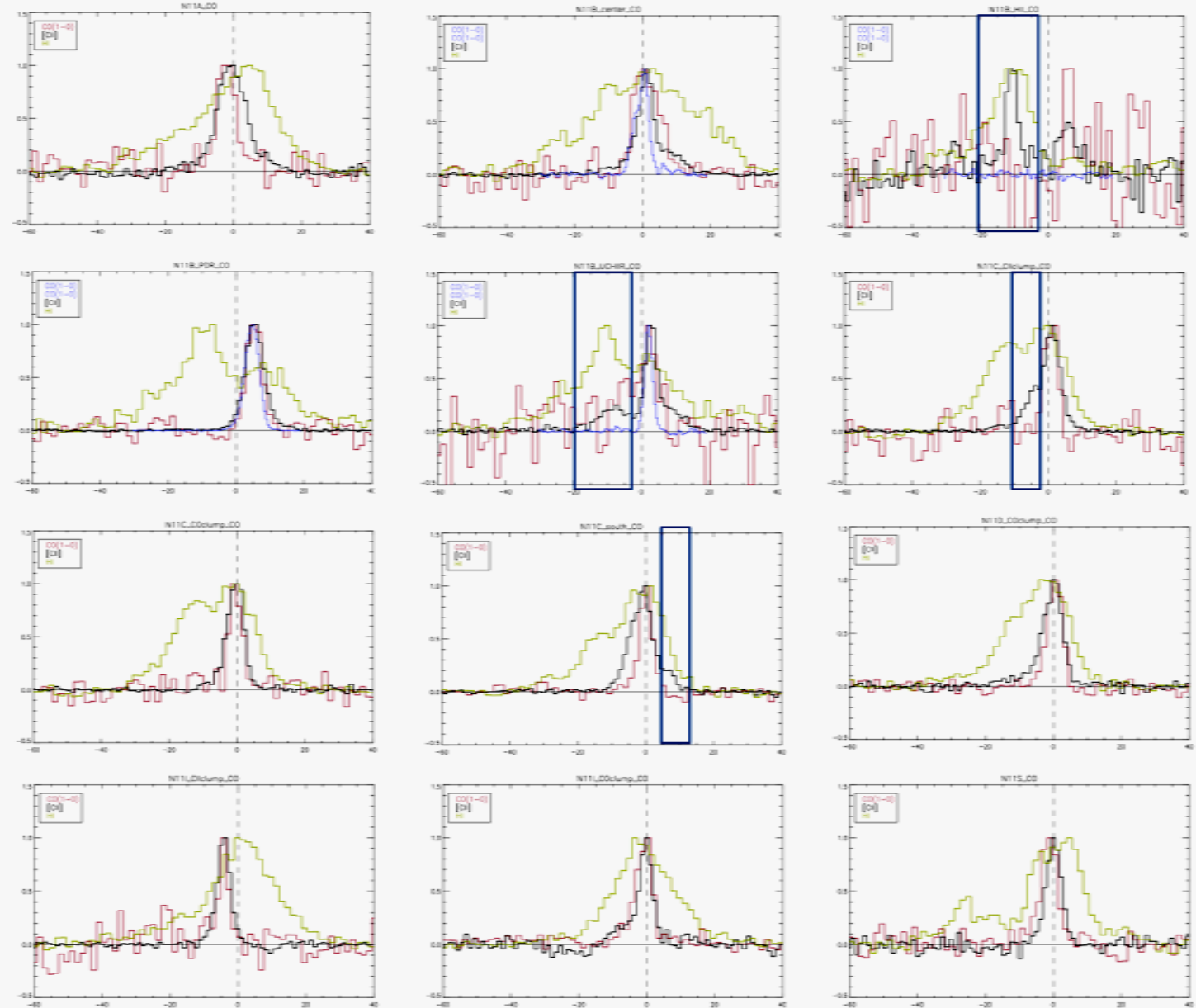
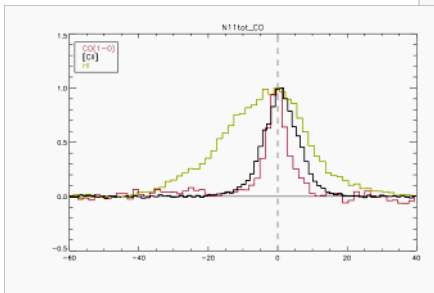


(Normalized profiles)

[CII] components not associated with CO

[CII] GREAT
HI (ATCA+Parkes)
CO MOPRA
CO ALMA

Sum of all profiles

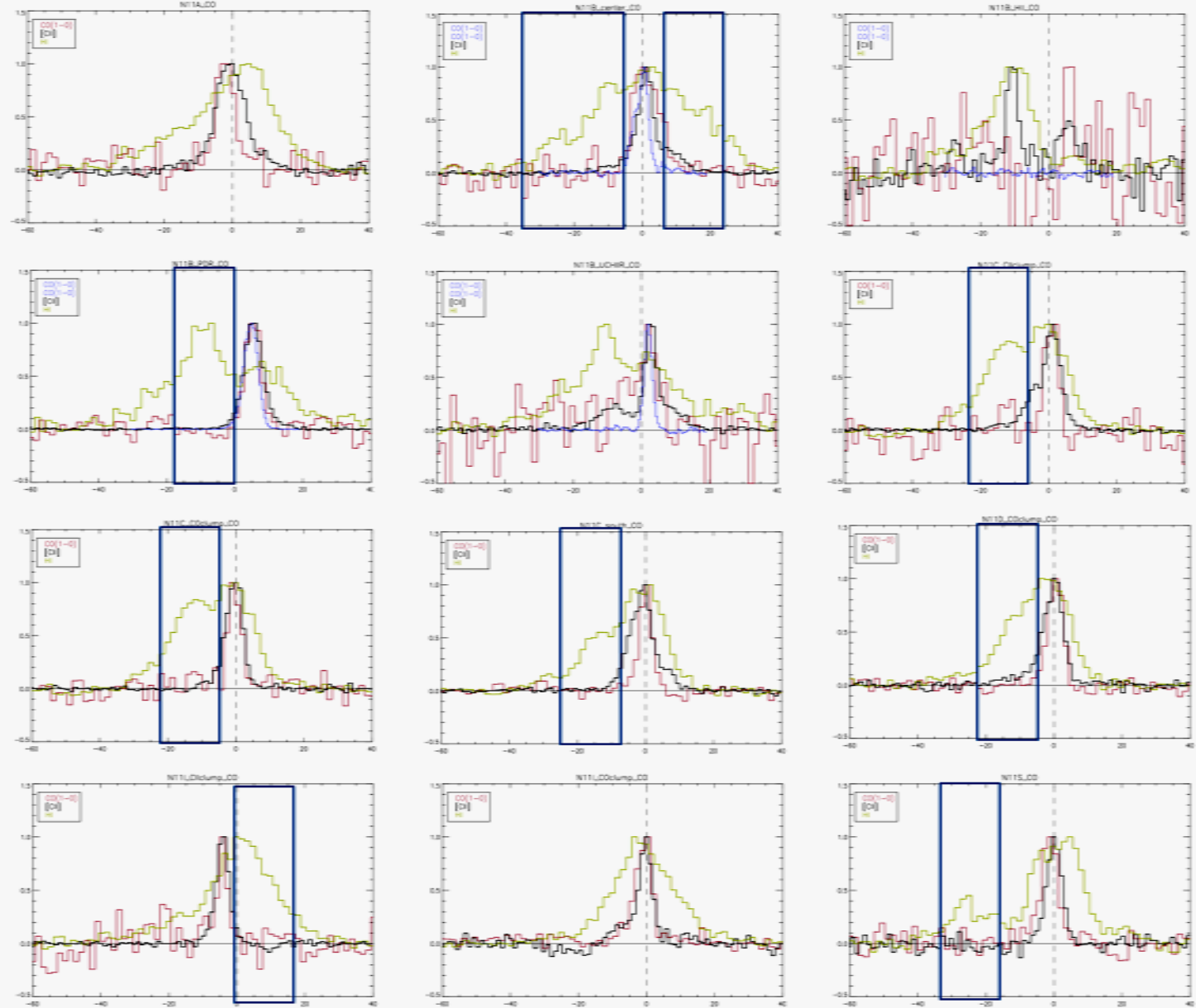
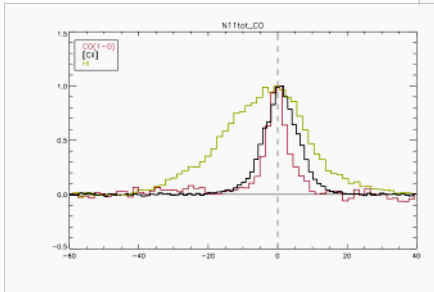


(Normalized profiles)

HI components not associated with CO or [CII]

[CII] GREAT
HI (ATCA+Parkes)
CO MOPRA
CO ALMA

Sum of all profiles



(Normalized profiles)

What the GREAT data tells us so far:

- Preliminary results ! Clouds properties are still analyzed.
 - Most of [CII] (>50%) is dynamically associated with CO toward [CII] and CO clumps. Other regions seem H⁰-dominated ($f([\text{CII}]-\text{CO}) \sim 35\% - 100\%$). Ionized gas contribution seems negligible but ionized gas dynamics still missing
 - Fraction [CII] associated with CO in extended [CII] regions (that may dominate the global [CII] emission) unknown

 - **New observations with upGREAT to be planned**
 - Full map of N11 in [CII] and [OI] 63um
 - Focus on extended [CII] emission and HI knots
 - ([NII] seems hopeless)

 - **New observations with FORCAST to be planned**
 - Measure PAH bands
 - Study the efficiency of the photoelectric effect.

 - More analysis coming out of the comparison of the ALMA data and the SOFIA data
- 