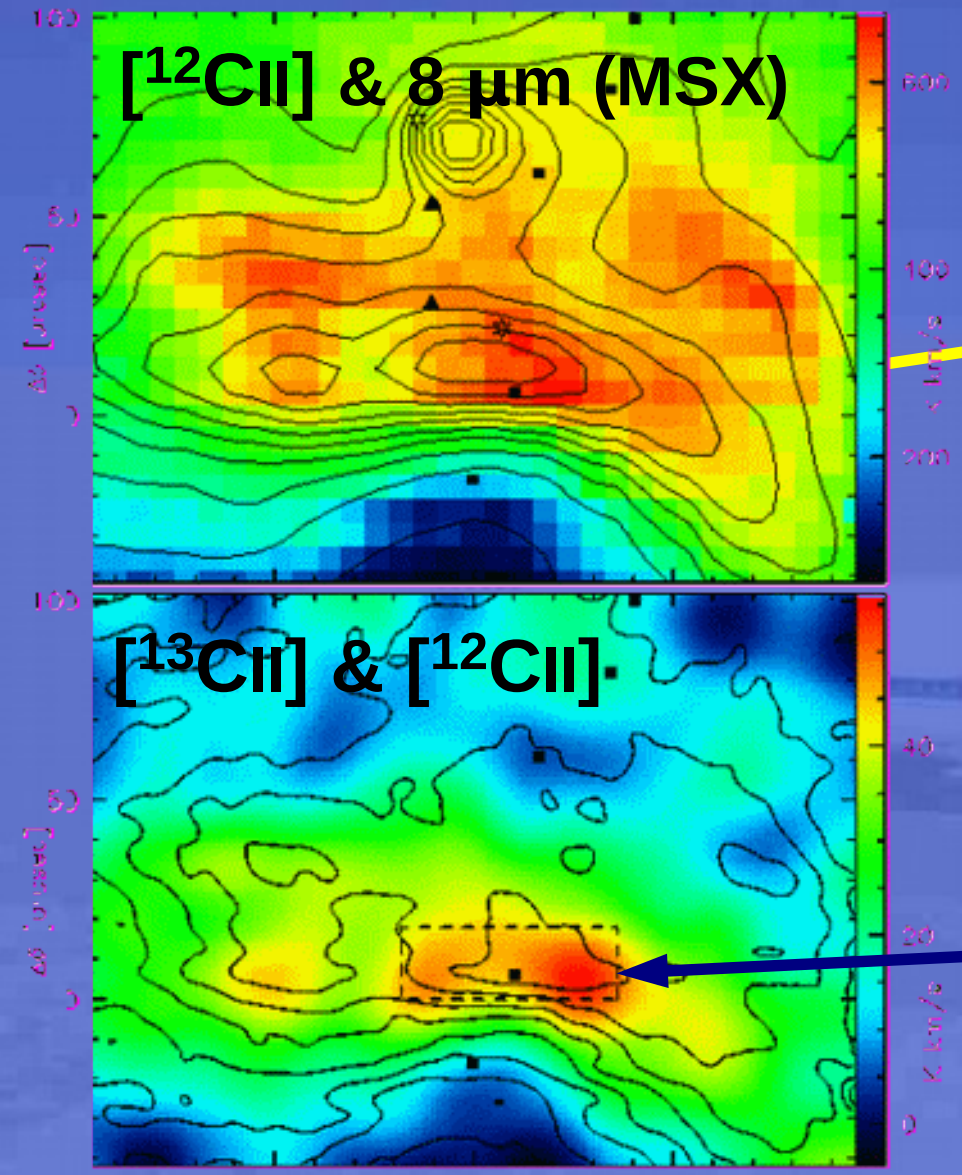
Fine Structure Lines toward NGC 2024

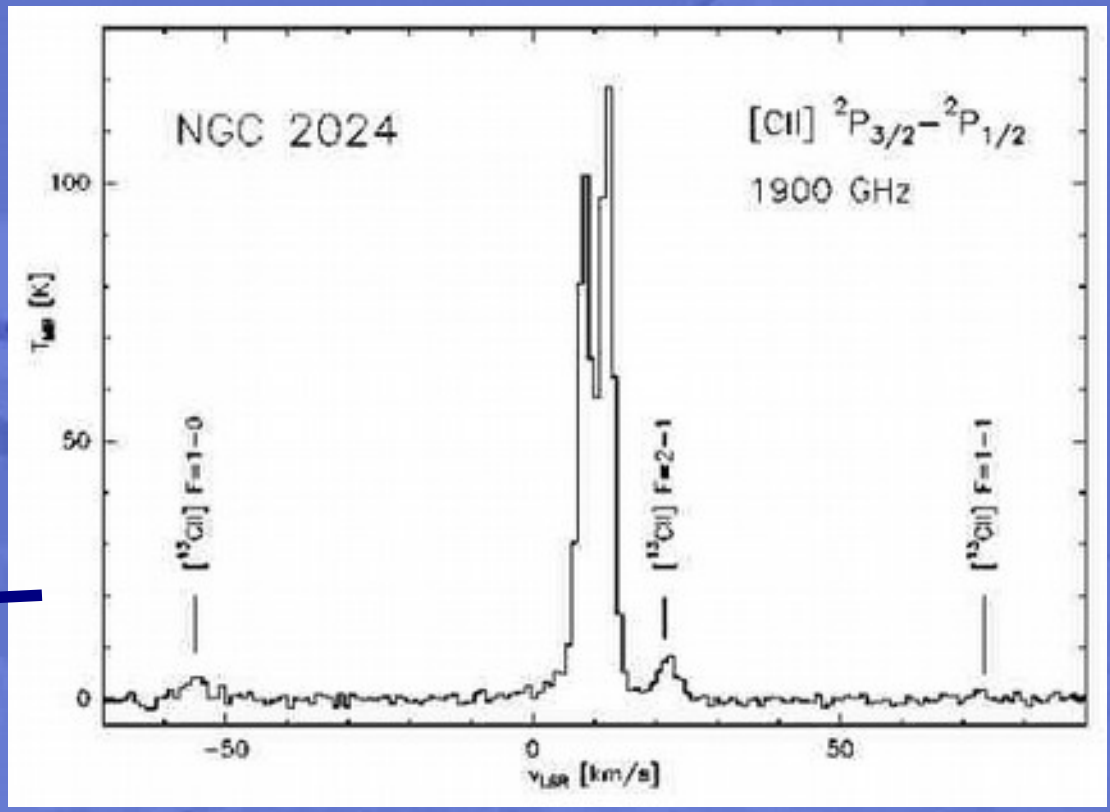
U.U. Graf

R. Simon, J. Stutzki, R. Güsten et al.

Strong [^{12}CII] & [^{13}CII] emission

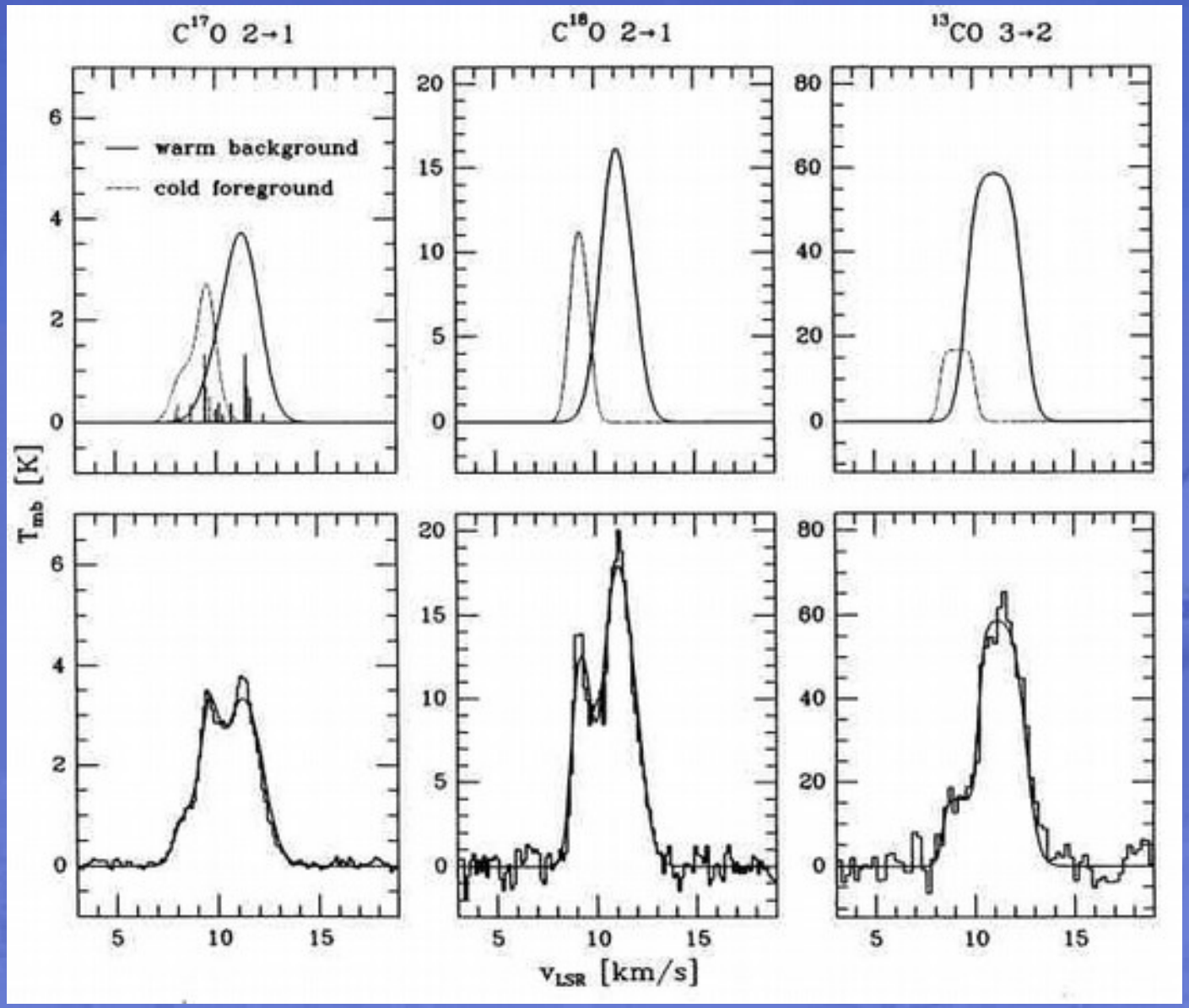


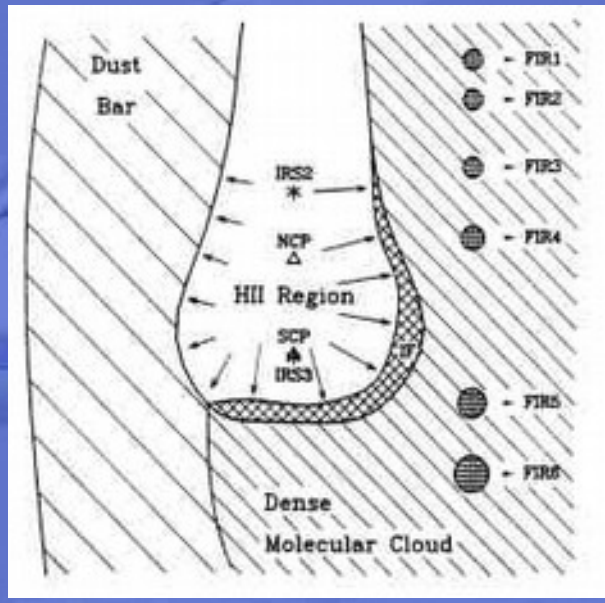
[^{12}CII] and [^{13}CII] mapped in Early Science



Graf et al. 2012

Standard source model: 2 emission components

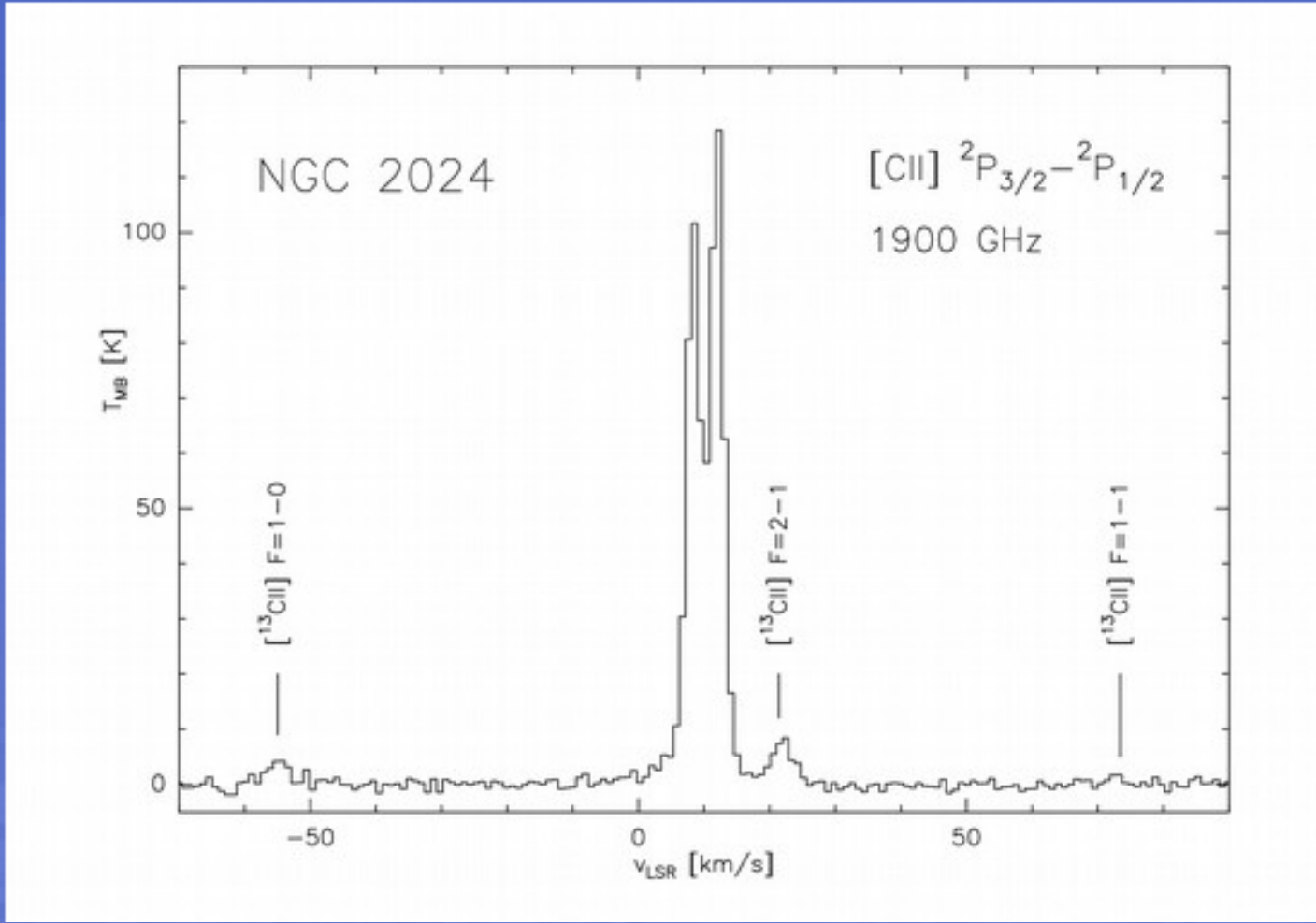




cold fore-ground @9 km/s

warm back-ground @11 km/s

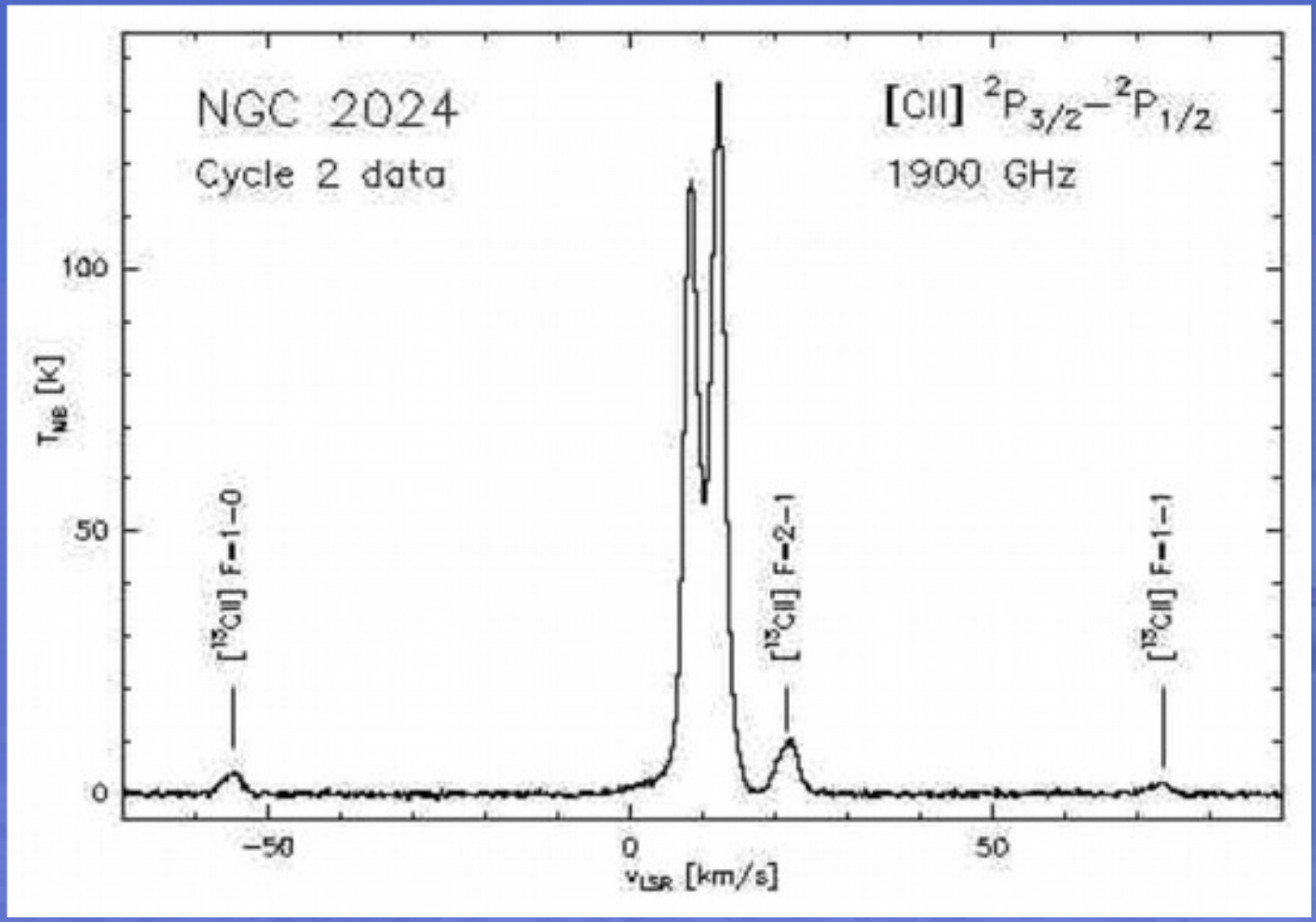
[CII]: self-absorbed emission



Revisited in January 2015:

- **1.5' x 1' maps in**
  - **[OI]**
  - **[^{12}CII], [^{13}CII]**
- **3' x 2' maps in**
  - **[^{12}CII], [^{13}CII]**
  - **^{12}CO 13→12**
  - **^{13}CO 13→12**

[CII]: self-absorbed emission



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Two step line modelling: 1: [^{13}CII] - HFS - fit

Fit optically thin [^{13}CII] HFS components with [^{12}CII] blanked.

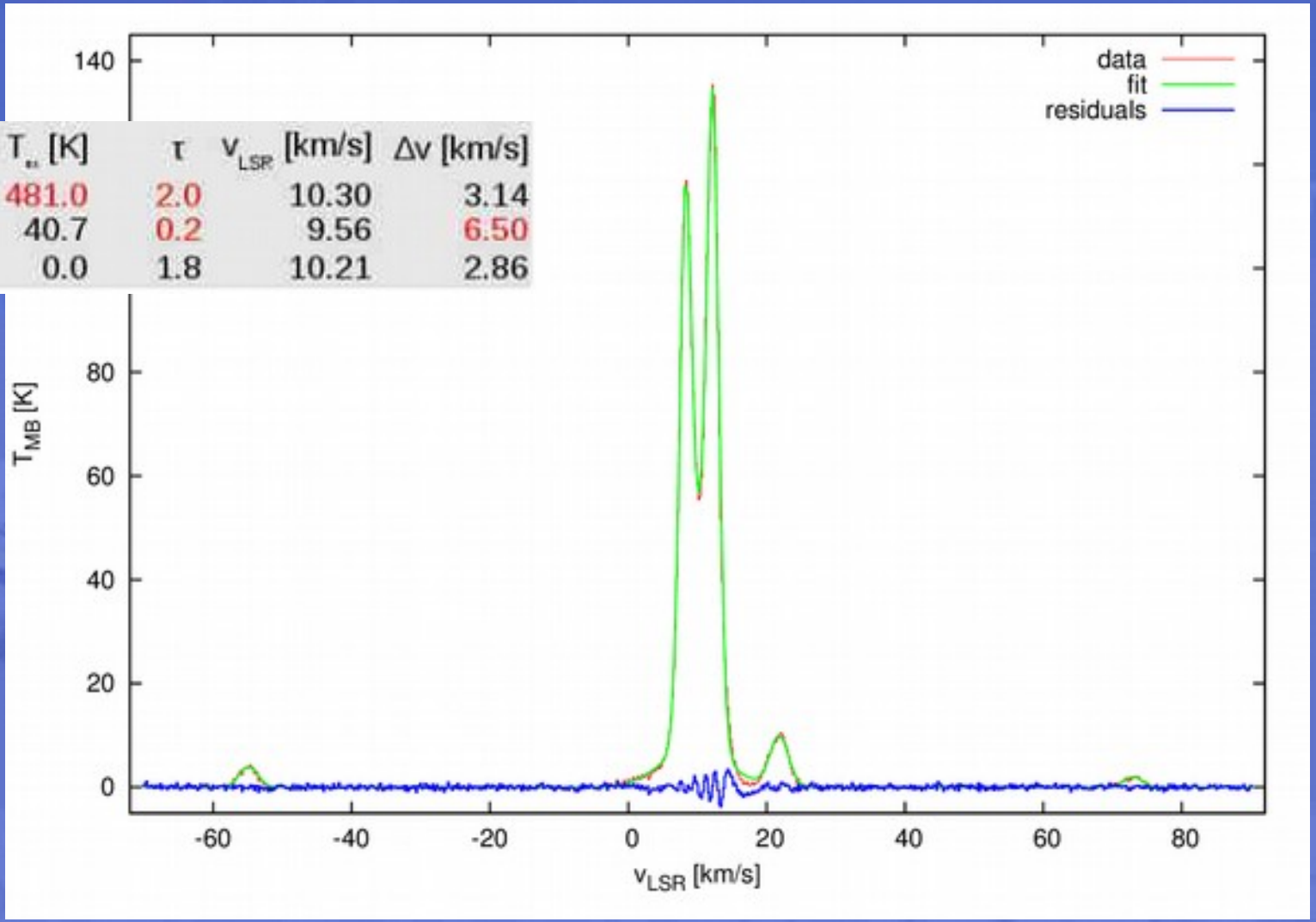
Yields

- **T_{ex} x τ([^{12}CII]) = 962 K**

Two step line modelling: 2: 3-component full line fit

Component	T_{mb} [K]	τ	v_{LSR} [km/s]	Δv [km/s]
Background	481.0	2.0	10.30	3.14
broad emission	40.7	0.2	9.56	6.50
Foreground	0.0	1.8	10.21	2.86

Fixed values in RED



$N_{BG}(^{12}C^{+}) > 10^{19}$ cm^{-2}

$N_{FG}(^{12}C^{+}) > 10^{18}$ cm^{-2}

Note: Rest frequencies of HFS-components revised

[OI] 63 μm map

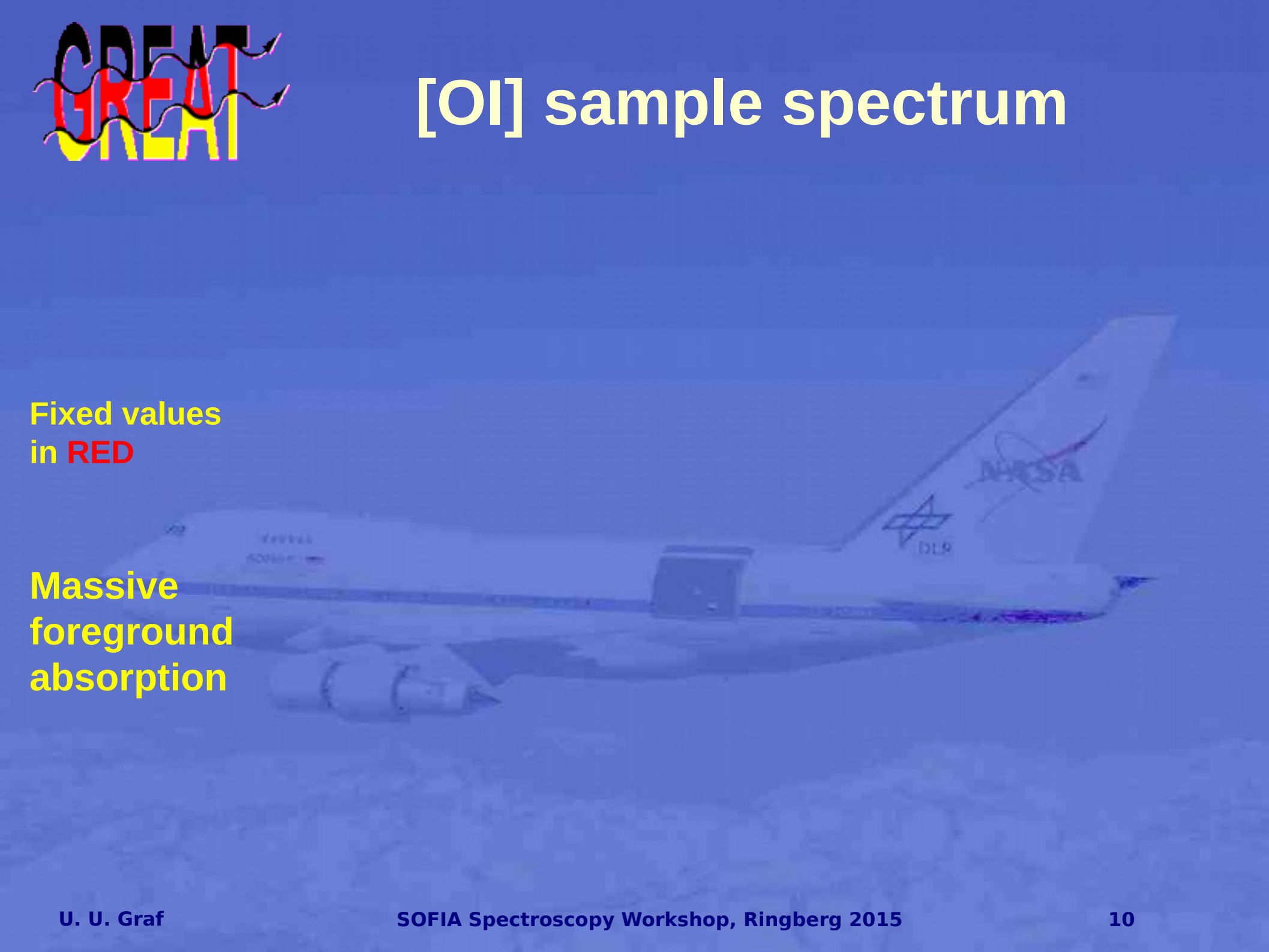
[OI] integrated intensity overlayed on [^{13}CII] map

Peaks just north of ionization front - as expected, but...

[OI] channel maps

essentially NO emission between 9 km/s and 11 km/s!

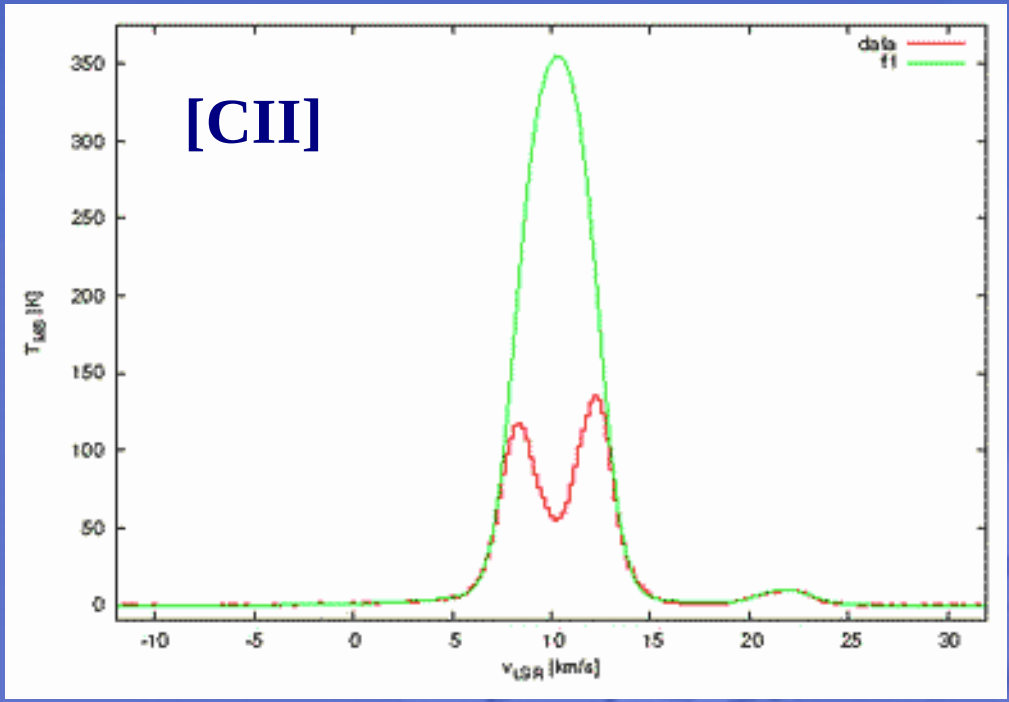
[OI] sample spectrum



Fixed values in RED

Massive foreground absorption

Foreground absorption artificially removed

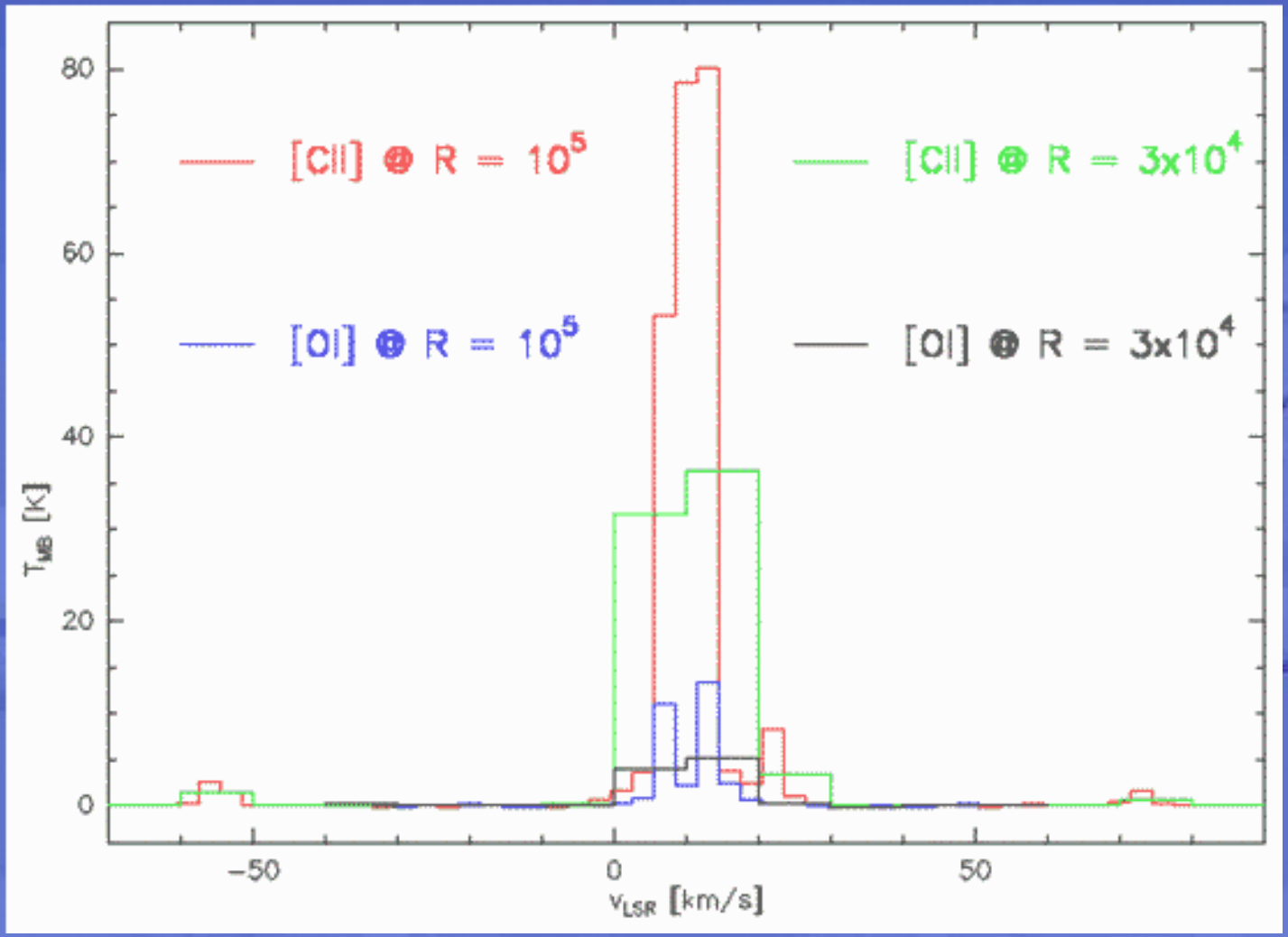


[OI]

>60% of [CII] emission is obscured by foreground

~85% of [OI] emission is obscured by foreground

Resolving power matters!



[CII] self-absorption disappears at R < 100000
[OI] self-absorption disappears at R < 30000

^{13}CO 13→12 on [^{13}CII]

Summary

- High resolution spectroscopy reveals strong foreground absorption in [OI] and [CII]:
  - ~85% of background [OI] emission obscured
  - >60% of background [CII] emission obscured
- Consistent with FG hydrogen column density of 10^{22} cm^{-2}
- Background [OI] / [CII] intensity ratio ~ 5 indicates substantial density and radiation field
- Fine structure emission peaks just north (or wraps around) dense condensation (seen in ^{13}CO 13→12)

Finally: High spectral resolution is crucial for accurate line intensities and to disentangle line of sight source structure