THE FORMATION OF THE O I 135.56 NM AND THE C I 135.58 NM LINES AND THEIR POTENTIAL DIAGNOSTICS

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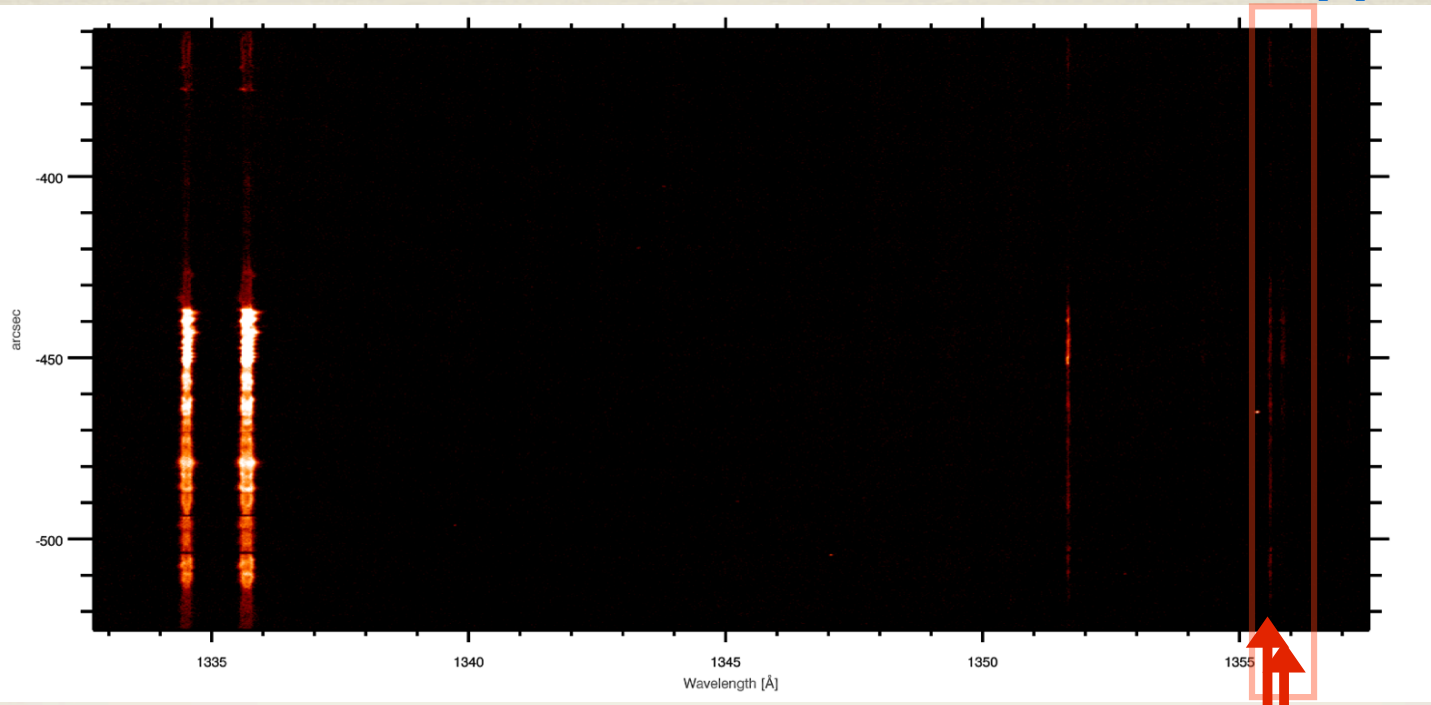
SEVENTH FRAMEWORK PROGRAMME

The O I and the C I lines in IRIS

[IRIS mission/instrument paper]

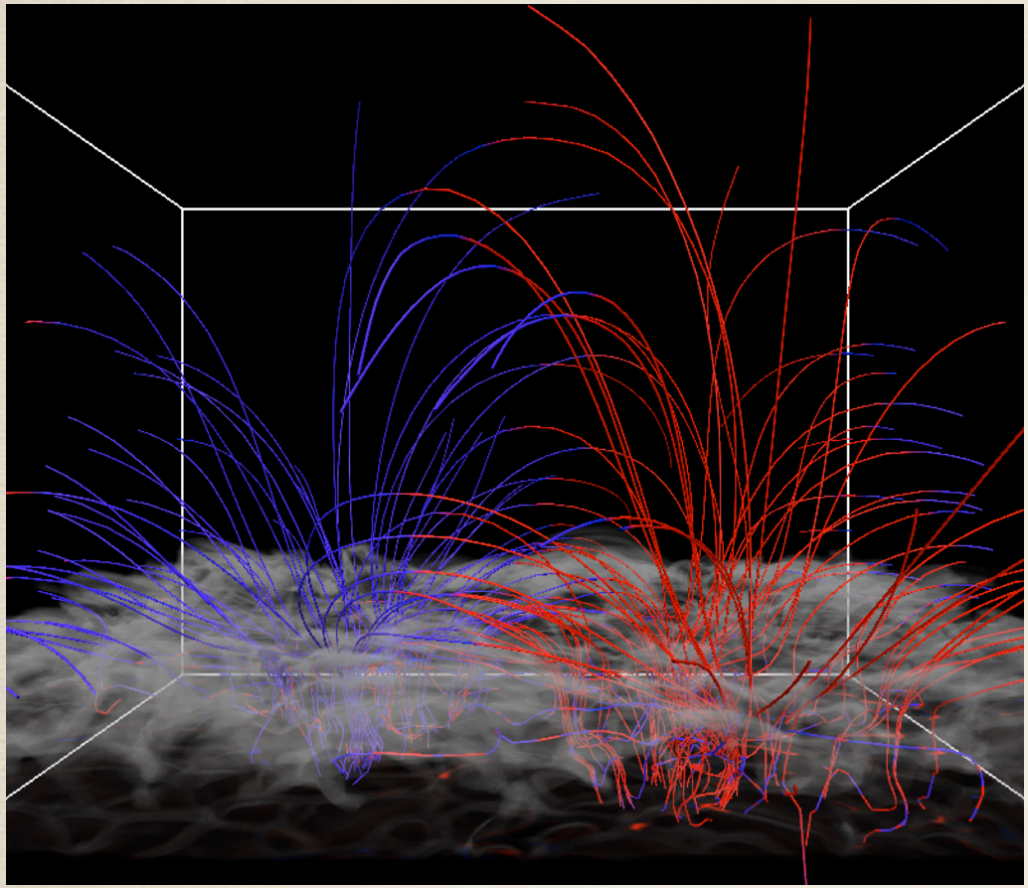


O I 135.56 nm

C I 135.58 nm

- Neutral lines
- Forms at mid-chromosphere [1-2Mm]
- 4000-8000 k [O I 5500k , C I 6000k]
- Relatively weak

Method



- FALC chromosphere model
- 24 Mm x 24 Mm x 17 Mm 3D-RMHD Bifrost snapshot [Gudiksen,B. V., Carlsson, M., Hansteen, V. H., et al. 2011,A & A, 517,A49]
- RH 1.5 d NLTE/PRD radiative transfer [Uitenbroek, H. and Pereira, T. M. D.]

STUDY BASED ON STEADY ATMOSPHERE

SEVENTH FRAMEWORK PROGRAMME

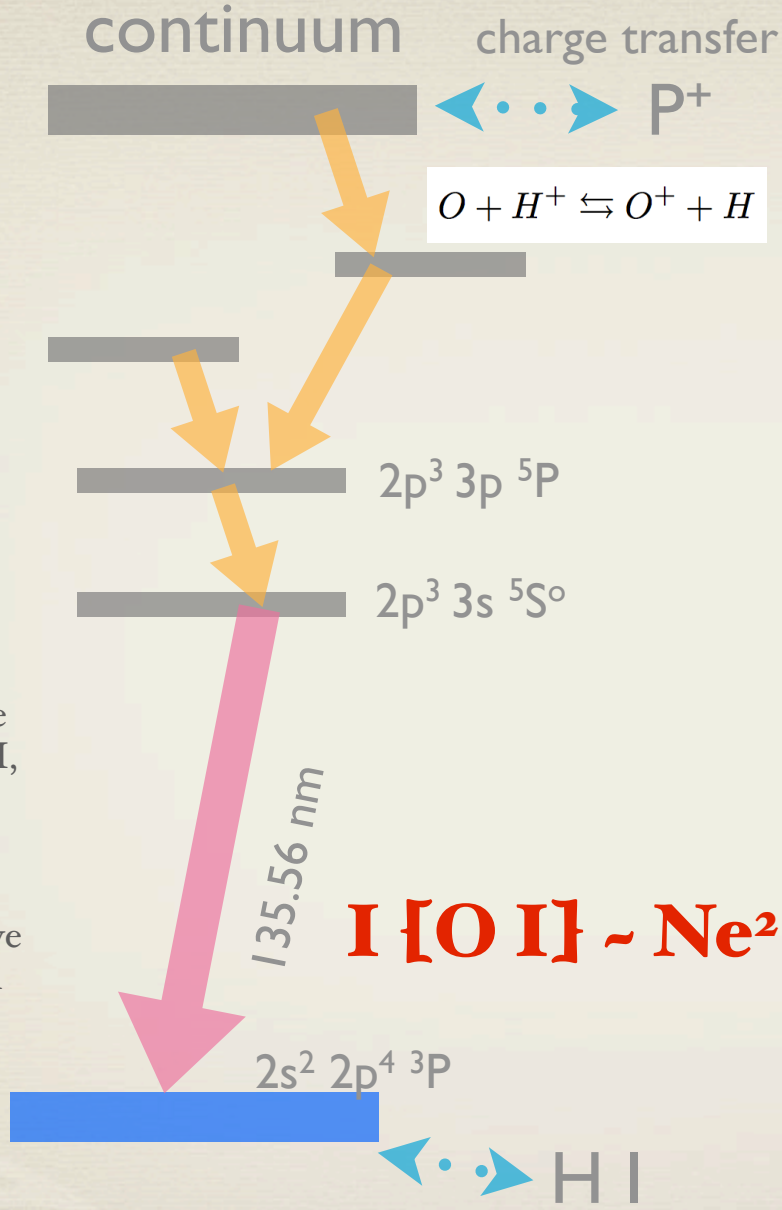
Basic formation of the O I line and the C I line

Radiative cascade

Our transition

Photo excitation

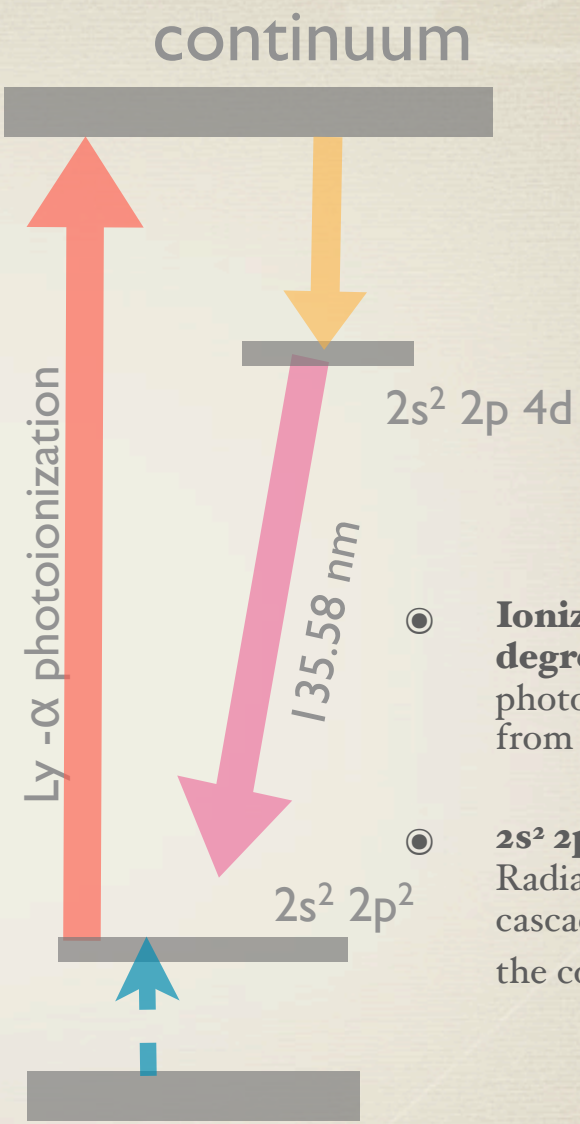
Collision



- **Ionization degree**: charge transfer with H, set by proton number
- **3s $^5S^o$**: Radiative cascading from the continuum

I [O I] ~ Ne²

Carlsson & Judge ,1992



- **Ionization degree**: photoionization from $2s^2\ 2p^2\ {}^1D$
- **$2s^2\ 2p\ 4d\ {}^1F^o$**: Radiative cascading from the continuum

I [C I] ~Ly-α* Ne

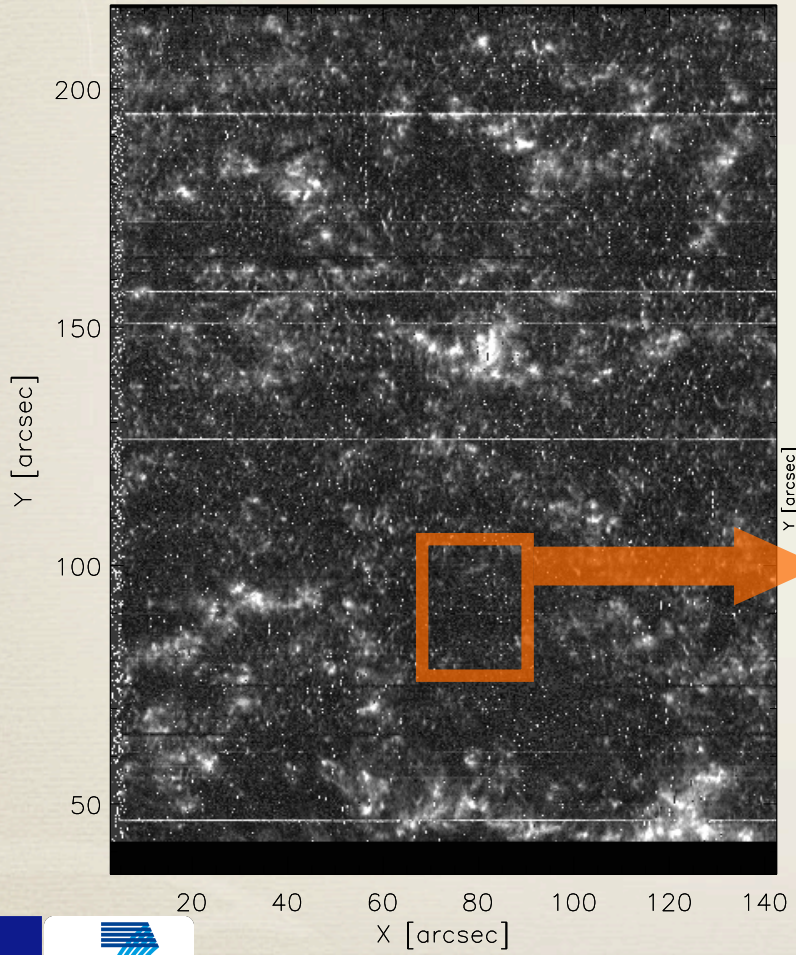
Current work

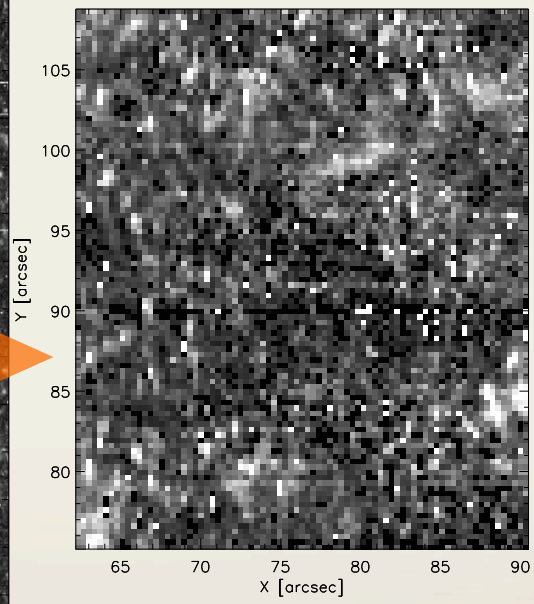
MORE REALISTIC STUDY: DYNAMIC ATMOSPHERE

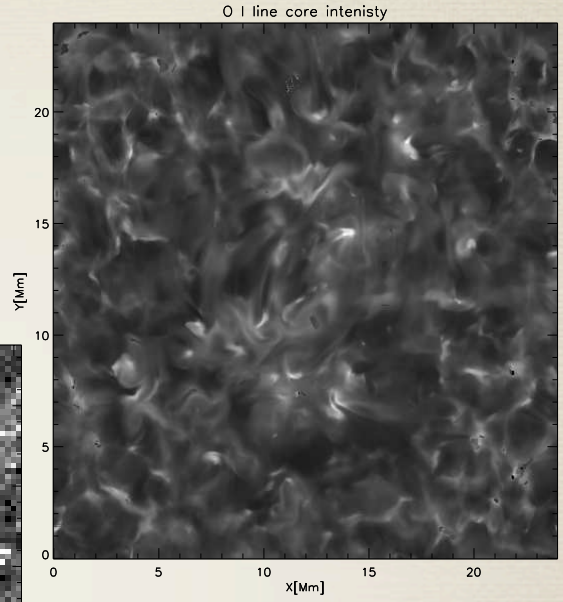
SEVENTH FRAMEWORK PROGRAMME

Simulation v.s. Real sun

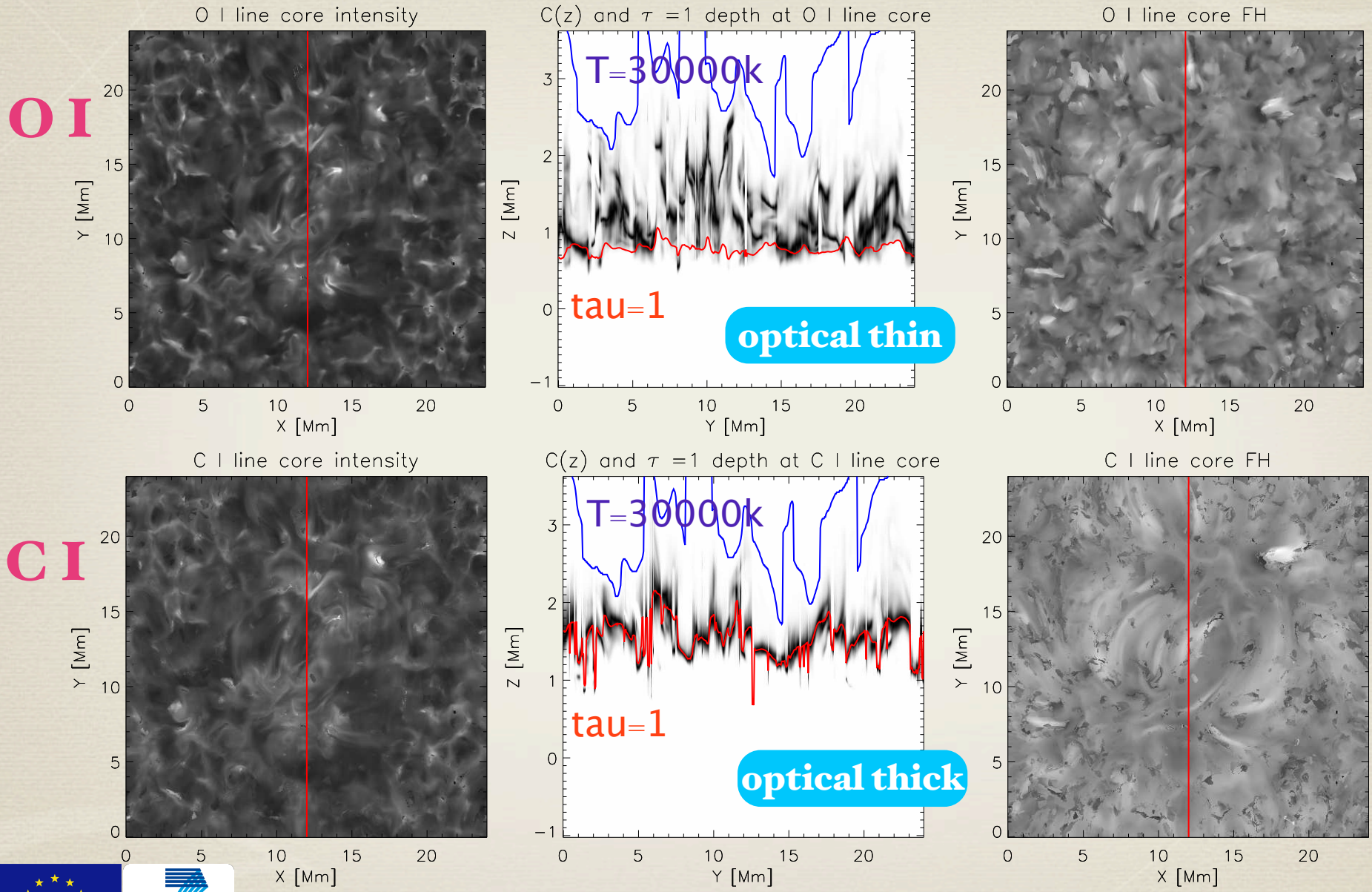
March 05th, 2014 11: 09 51 quiet sun 30 s exp.







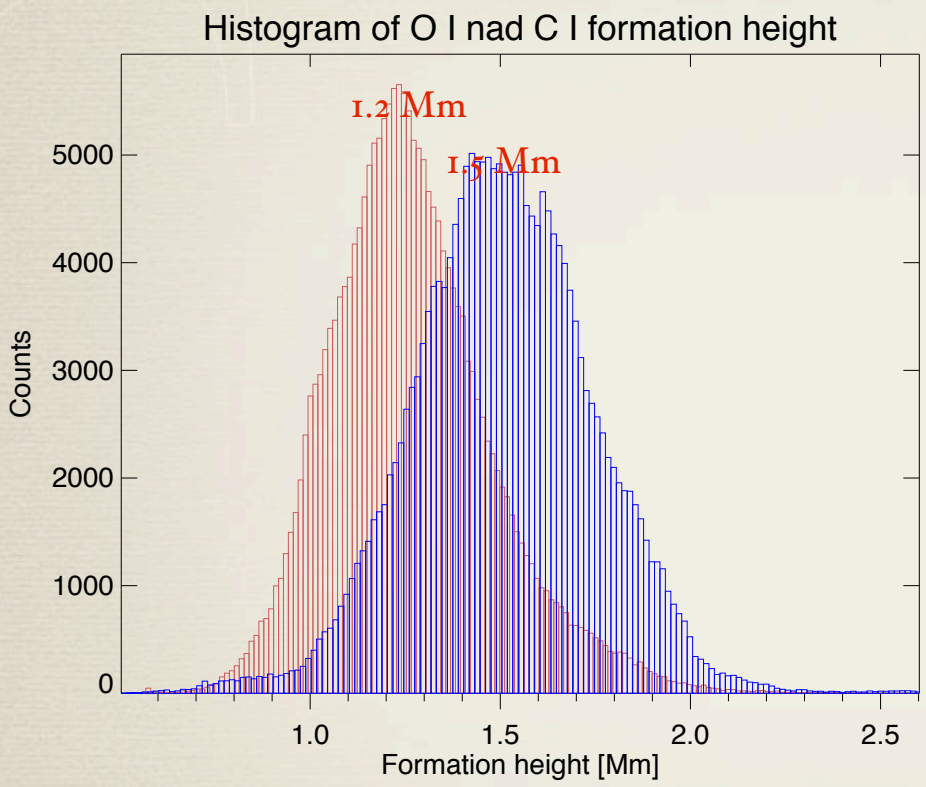
The Intensity, the contribution function and the formation height

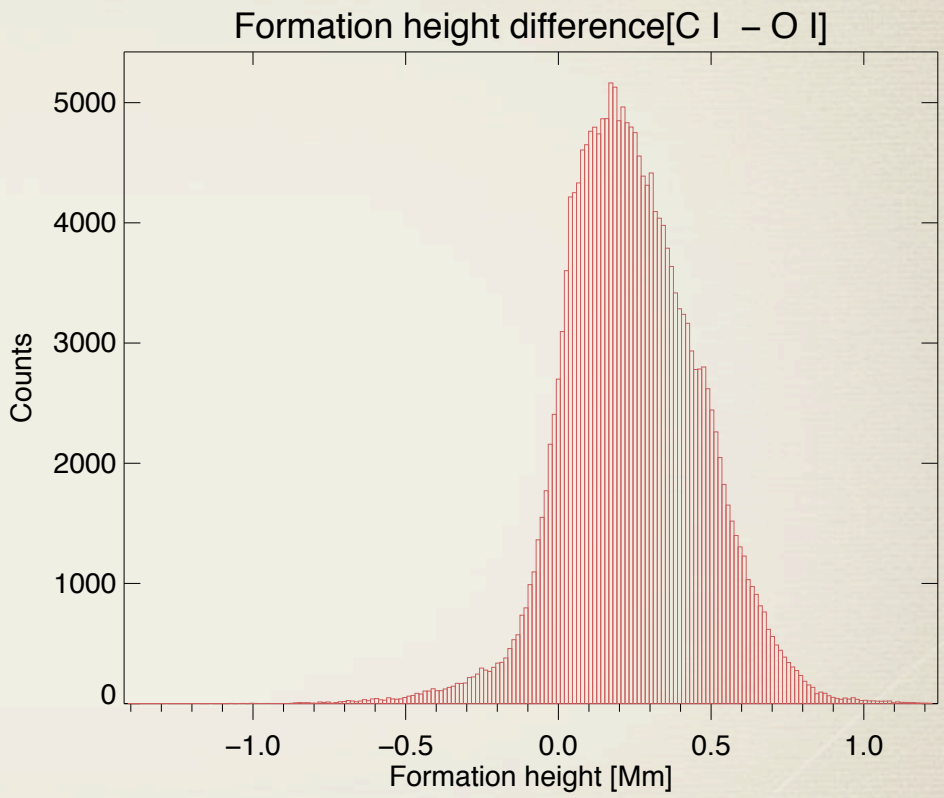


$$I(\nu) = \int_{-\infty}^{z_0} C(\nu, z))dz$$

$$C(\nu, z) = S(\nu, z)e^{-\tau(\nu,z)}\chi(\nu, z)$$

The formation height and the formation height difference





POTENTIAL DIAGNOSTICS

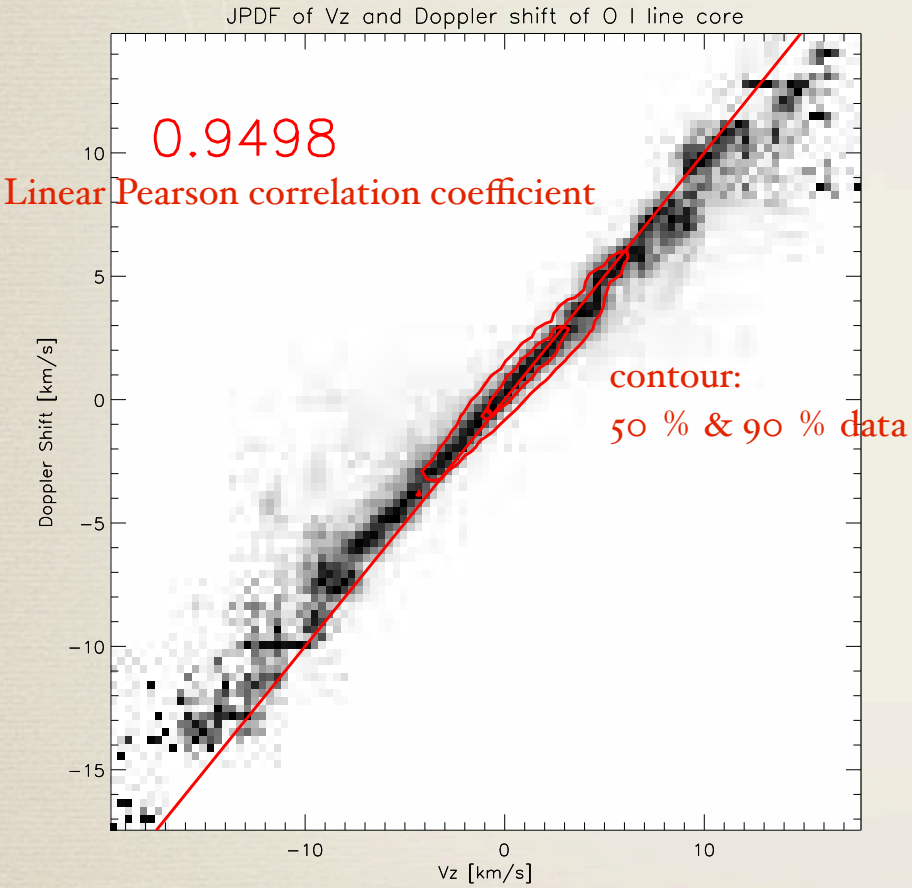
- Link between plasma condition and observables
- Contribution function weighted average

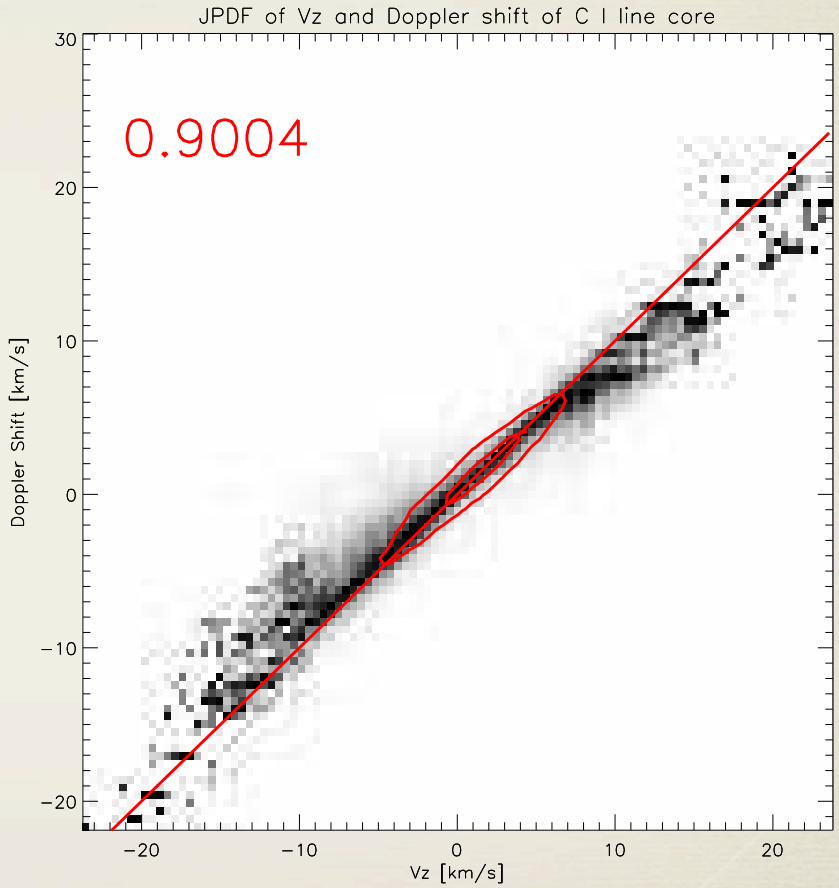
$$V_{fh} = \int_{-\infty}^{\infty} C(z) * V(z) dz$$

SEVENTH FRAMEWORK PROGRAMME

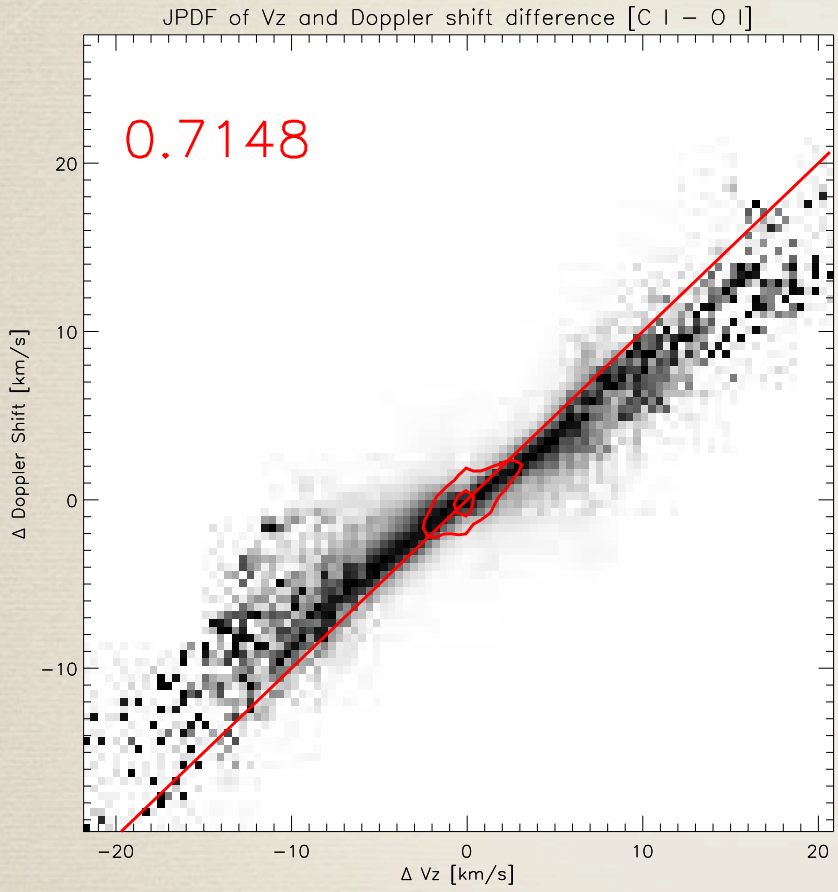
Velocity diagnostics

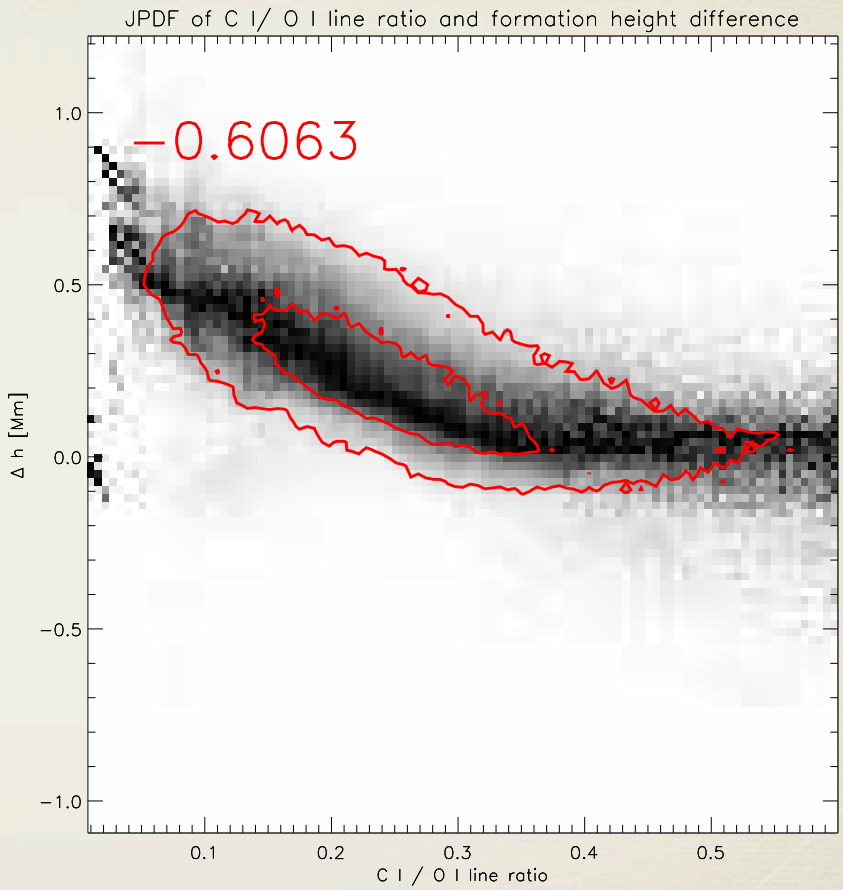
Joint probability density function





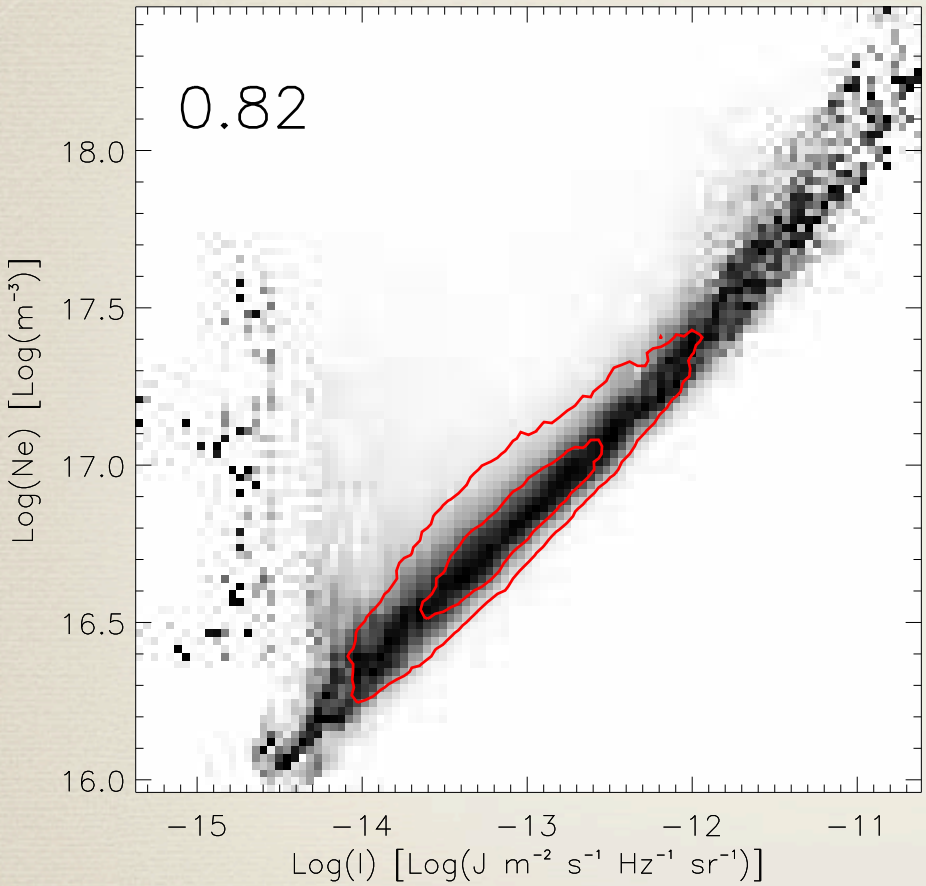
Velocity gradient diagnostics



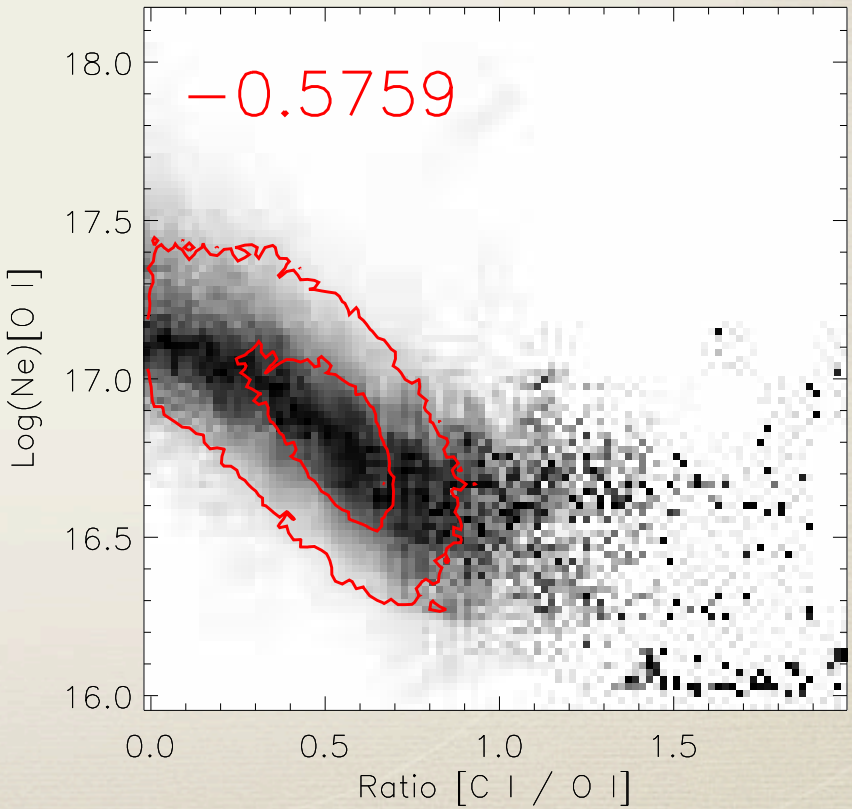


Velocity gradient $\stackrel{\text{def}}{=} \Delta V/\Delta h$

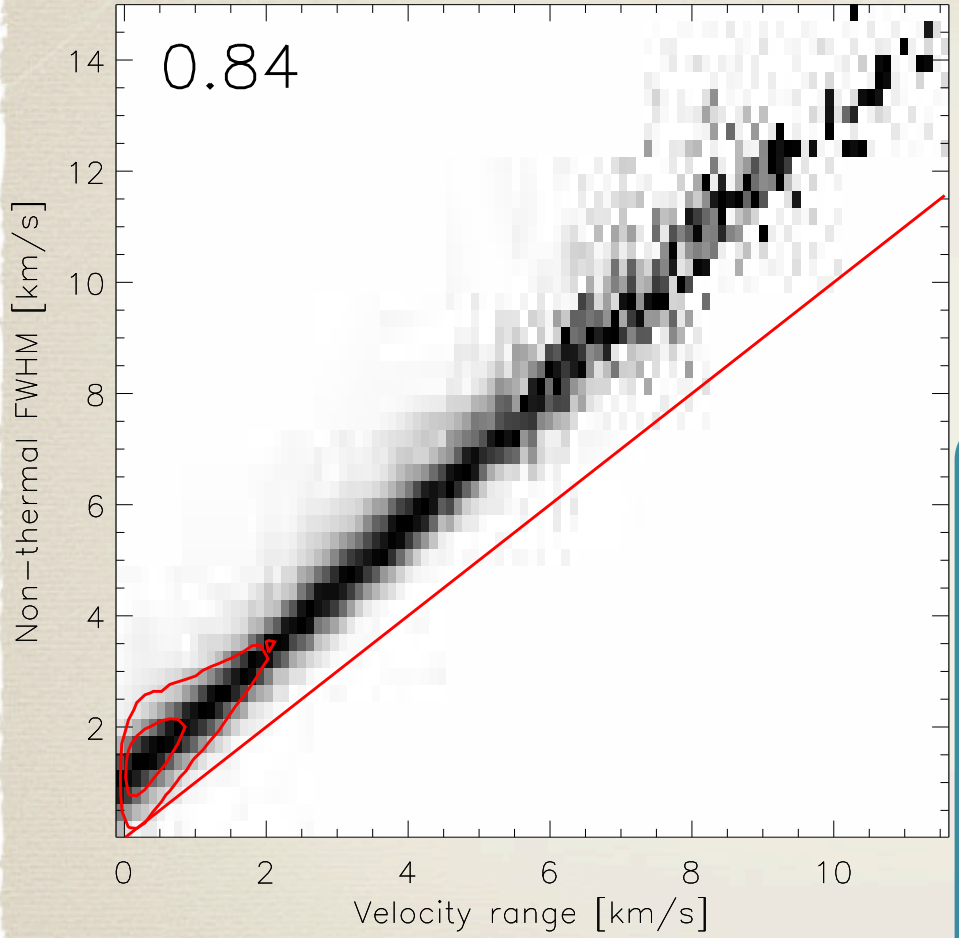
Electron density diagnostics



I {O I} ~ Ne²
I {C I} ~Ly-α* Ne
Ratio{CI /O I} ~ Ly-α/Ne



Velocity profile diagnostic

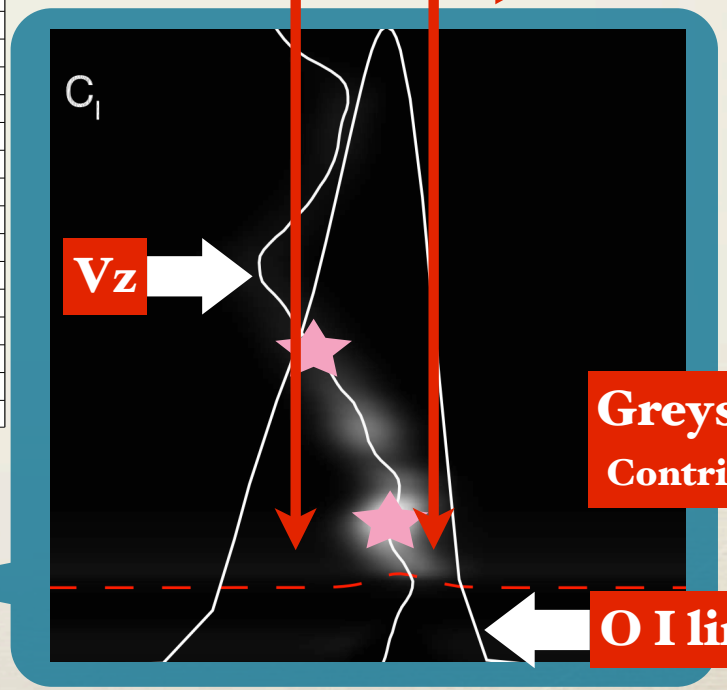


$$V_{th} = \sqrt{2k_bT/m},$$

$$V_{nth} = \sqrt{FWHM^2/4\ln(2) - {V_{th}}^2}$$

Frequency range of FWHM

Velocity range



Greyscale:
Contribution function

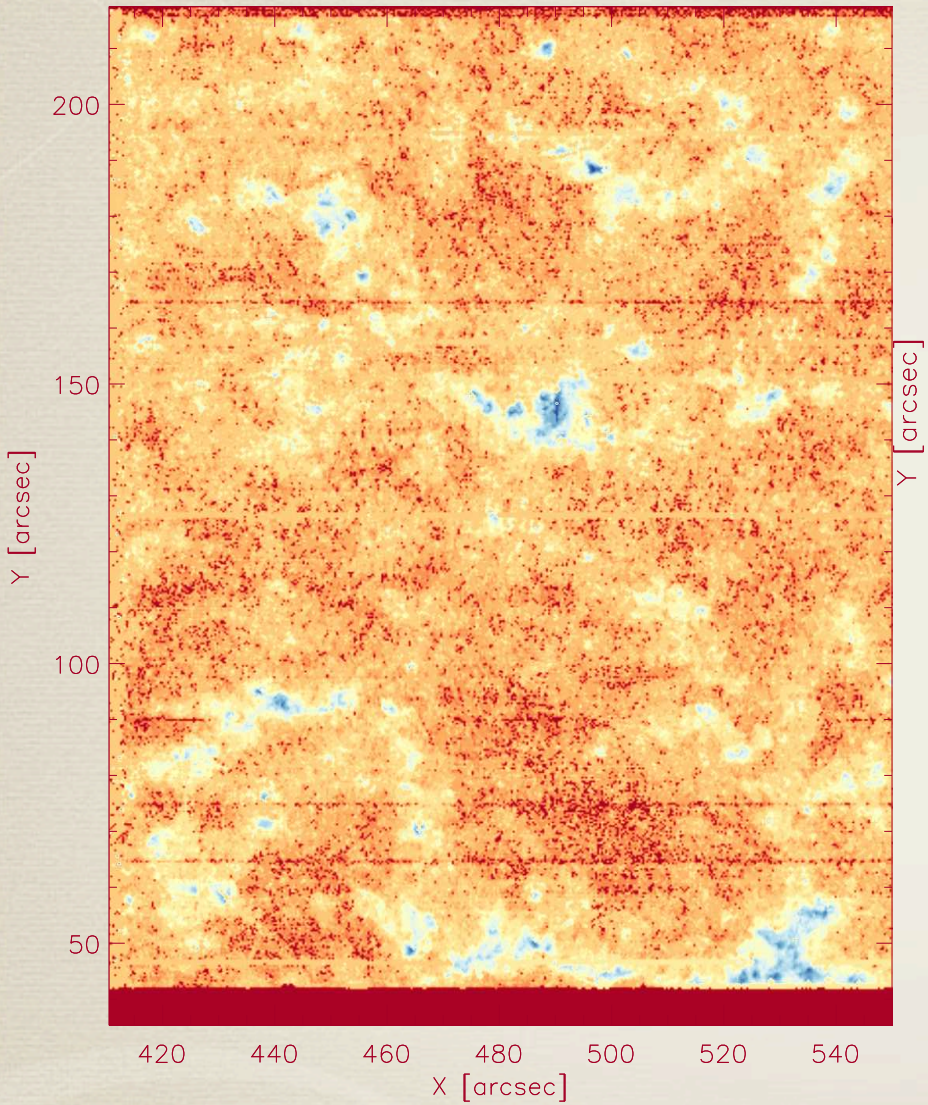
O I line profile

- Provide the upper bound of non-thermal broadening

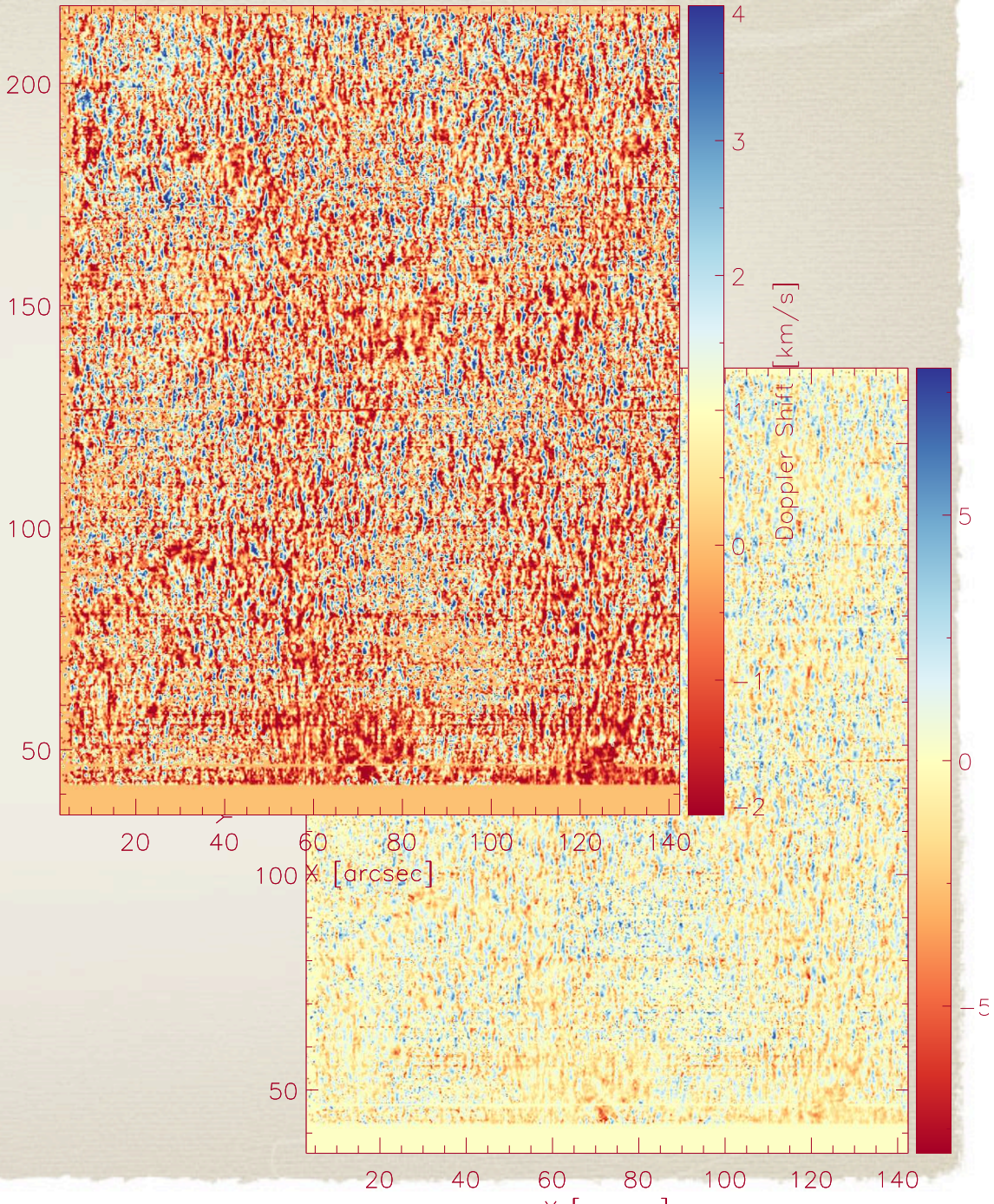
APPLICATION I. QUIET SUN

SEVENTH FRAMEWORK PROGRAMME

SQRT(O I line intensity) ~ Ne



O I Doppler Shift [saturated]

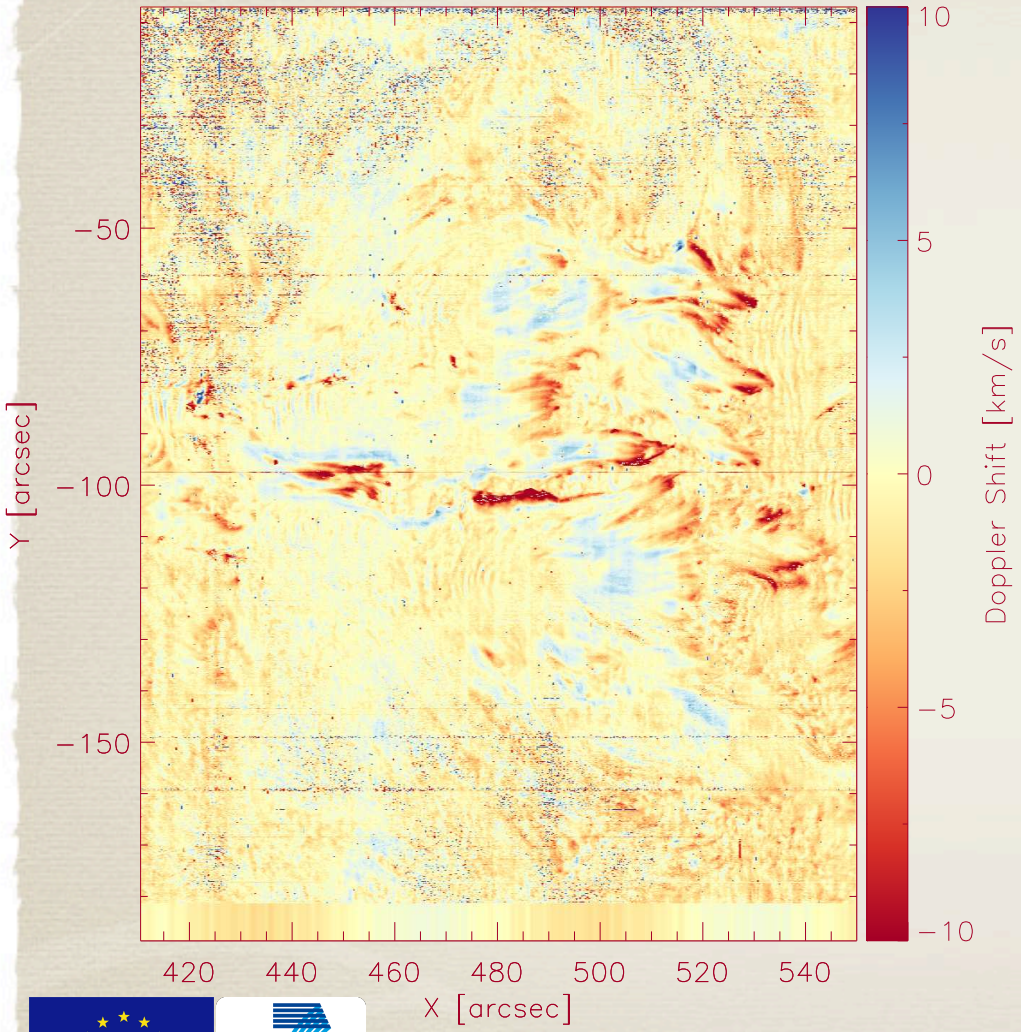


APPLICATION
II. ACTIVE REGION

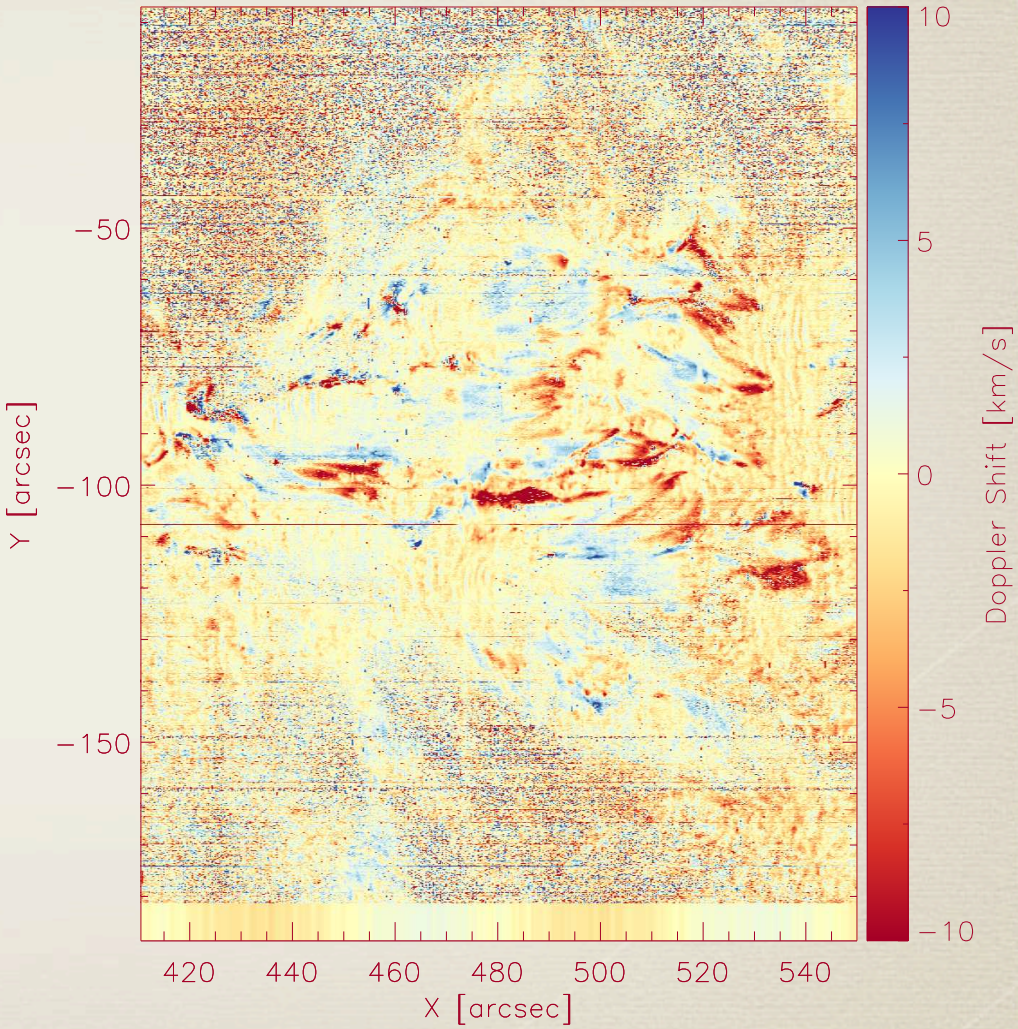
SEVENTH FRAMEWORK PROGRAMME

IRIS Feb. 14th, 2014 11:49 30s exp. [Active region]

Doppler shift [O I]

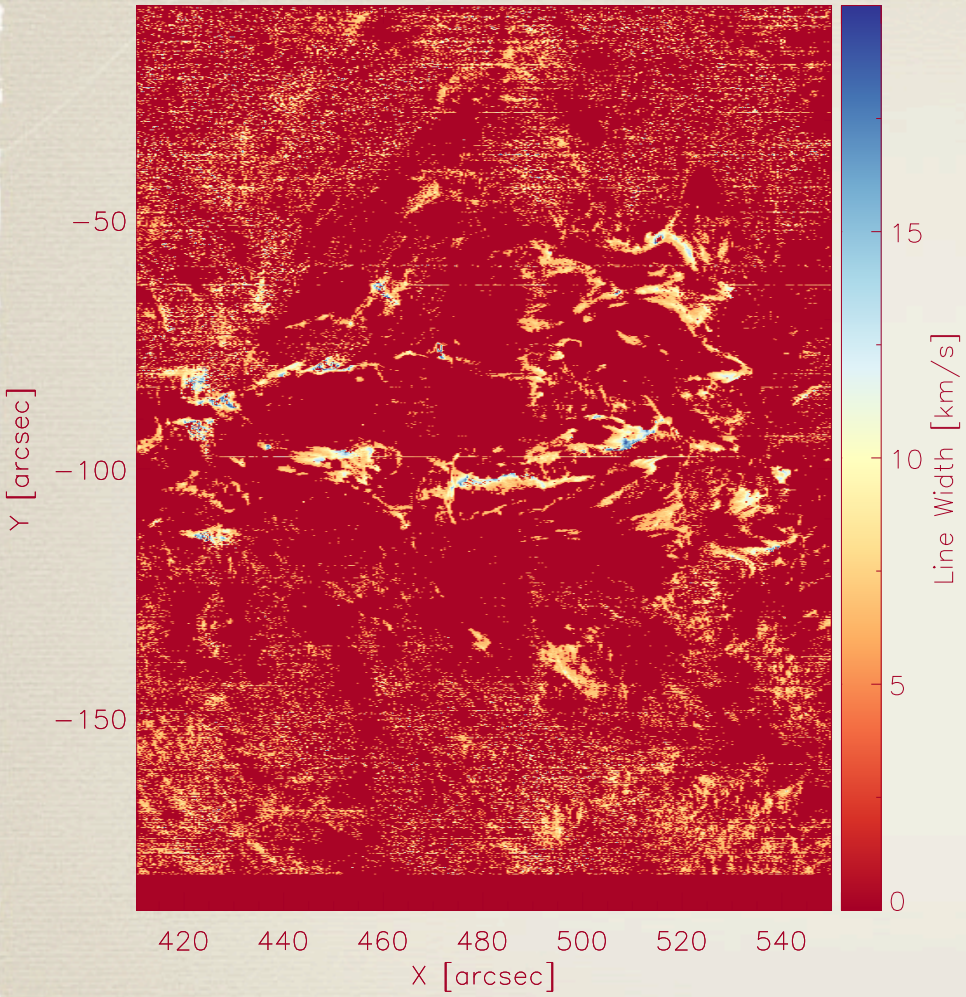


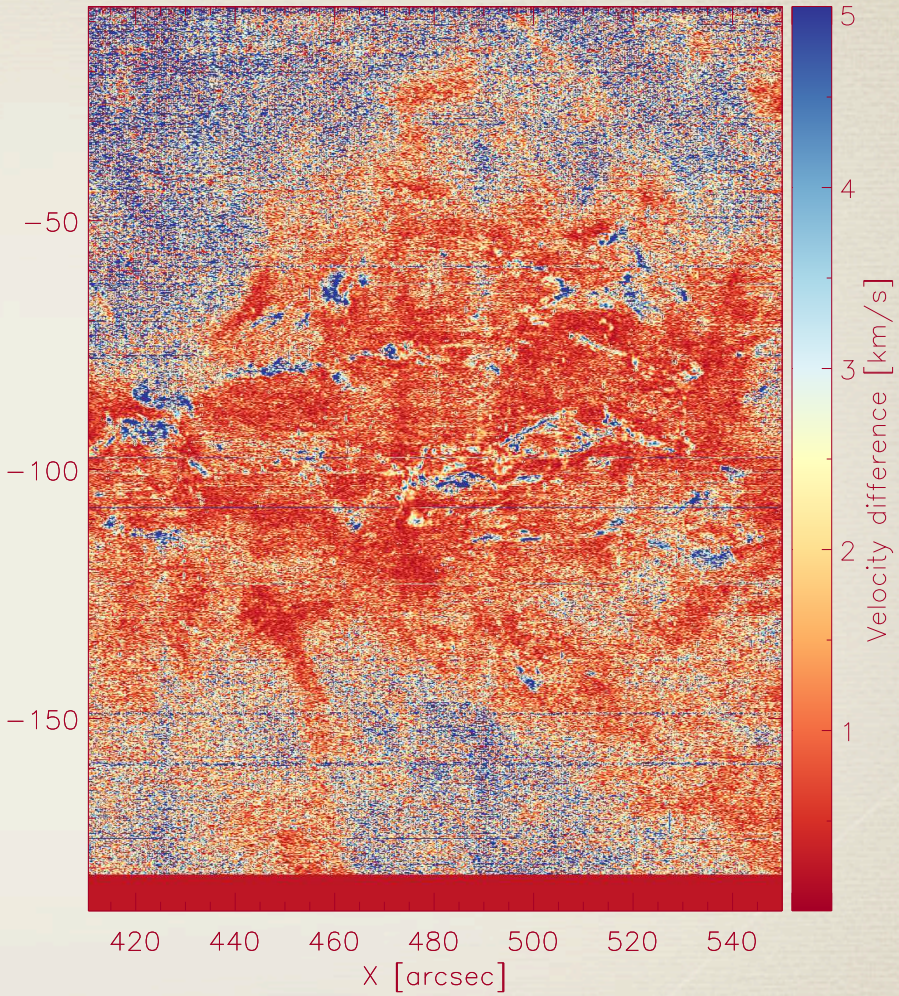
Doppler shift [C I]



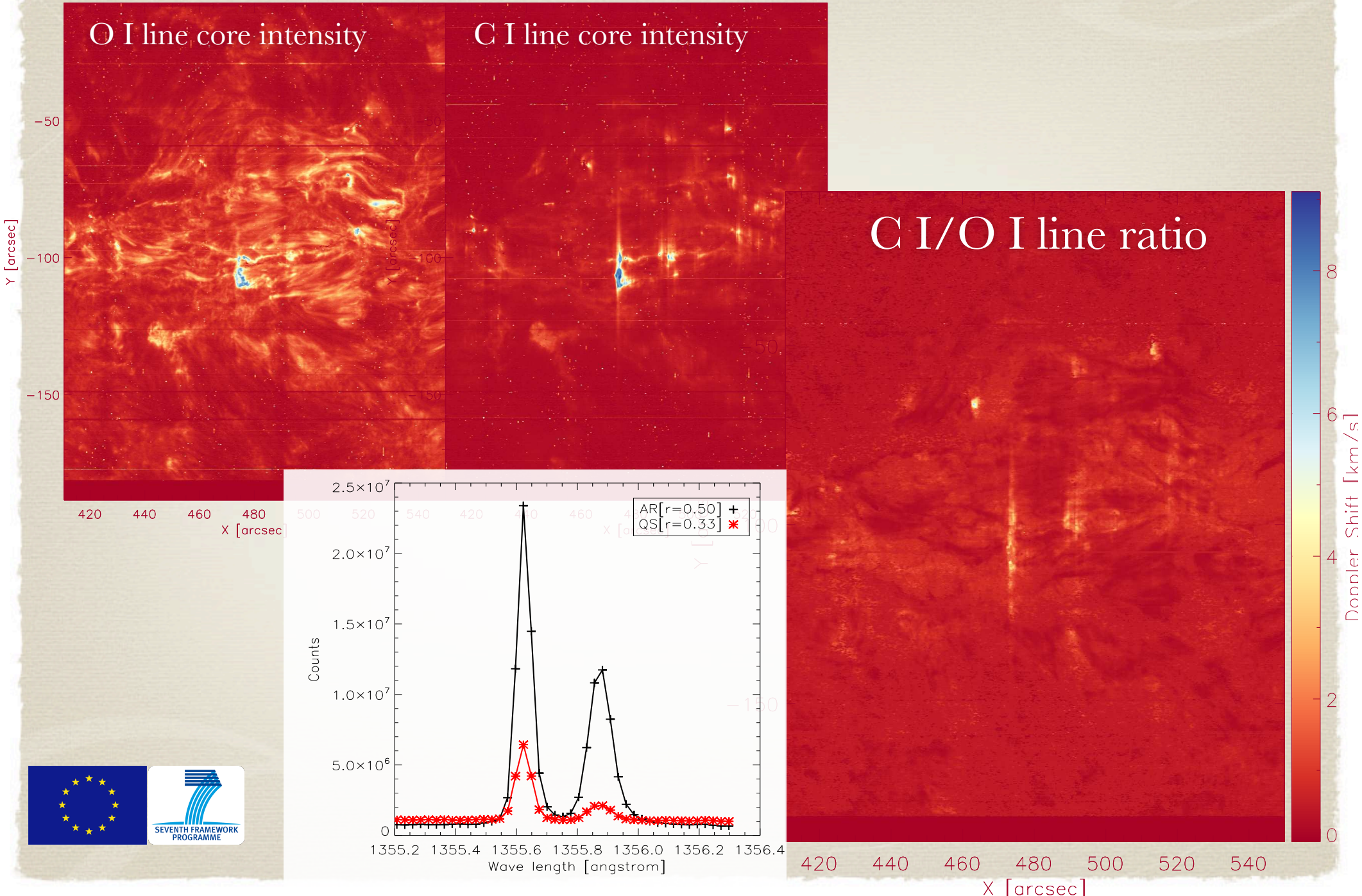
SEVENTH FRAMEWORK PROGRAMME

O I line width v.s. velocity difference [C I - O I]

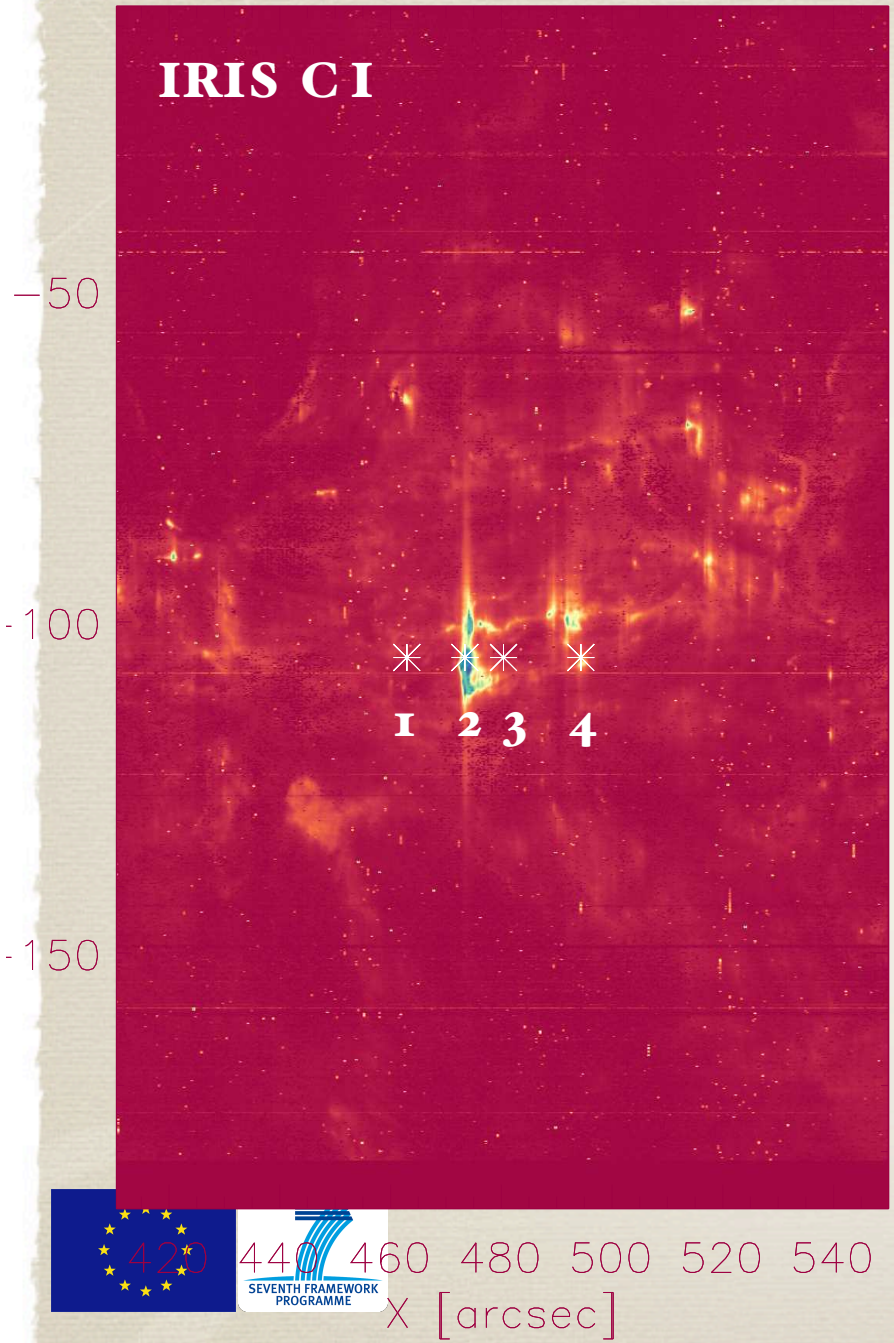


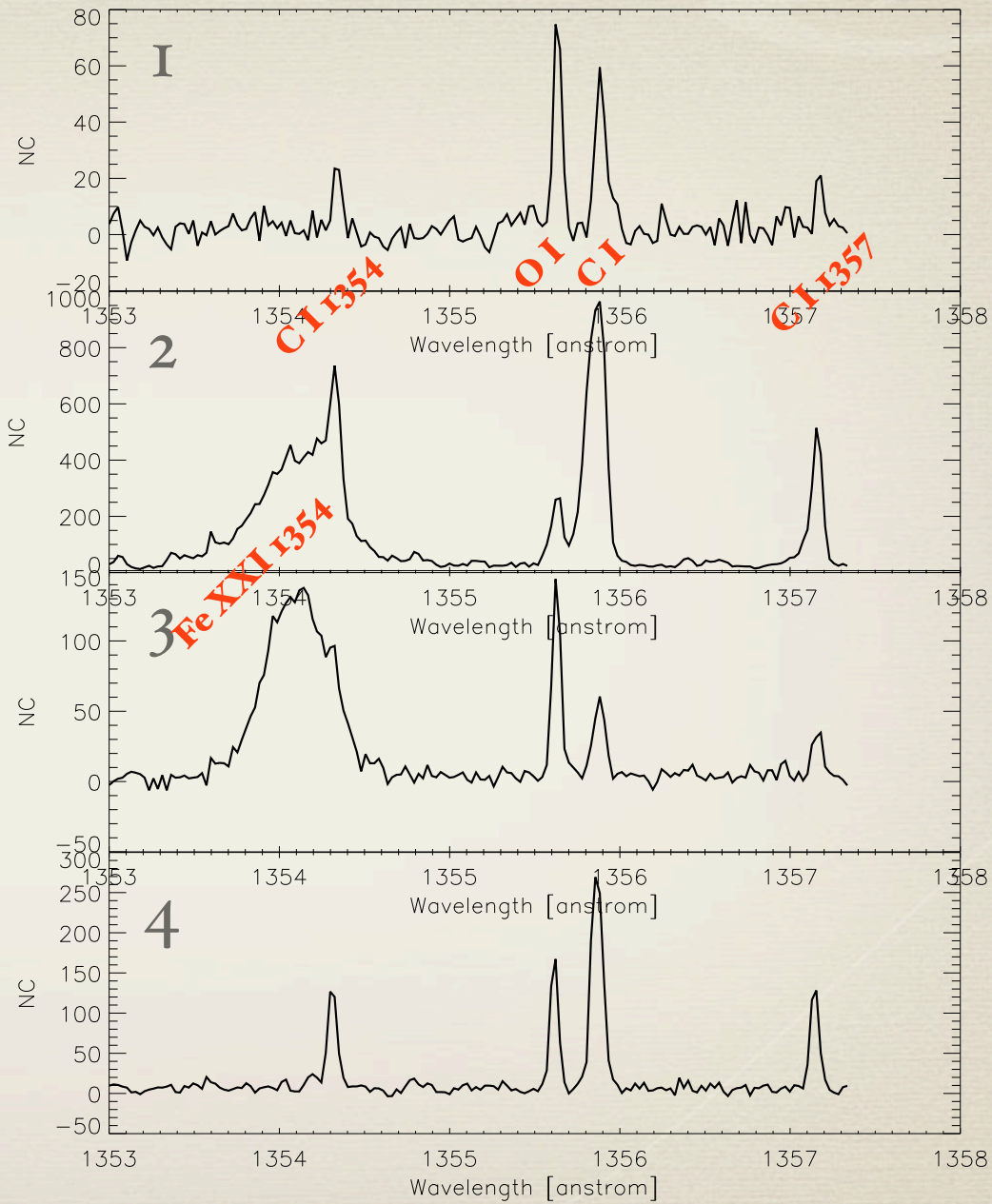


The O I and C I line intensity and their line ratio



Ratio change at flaring active region





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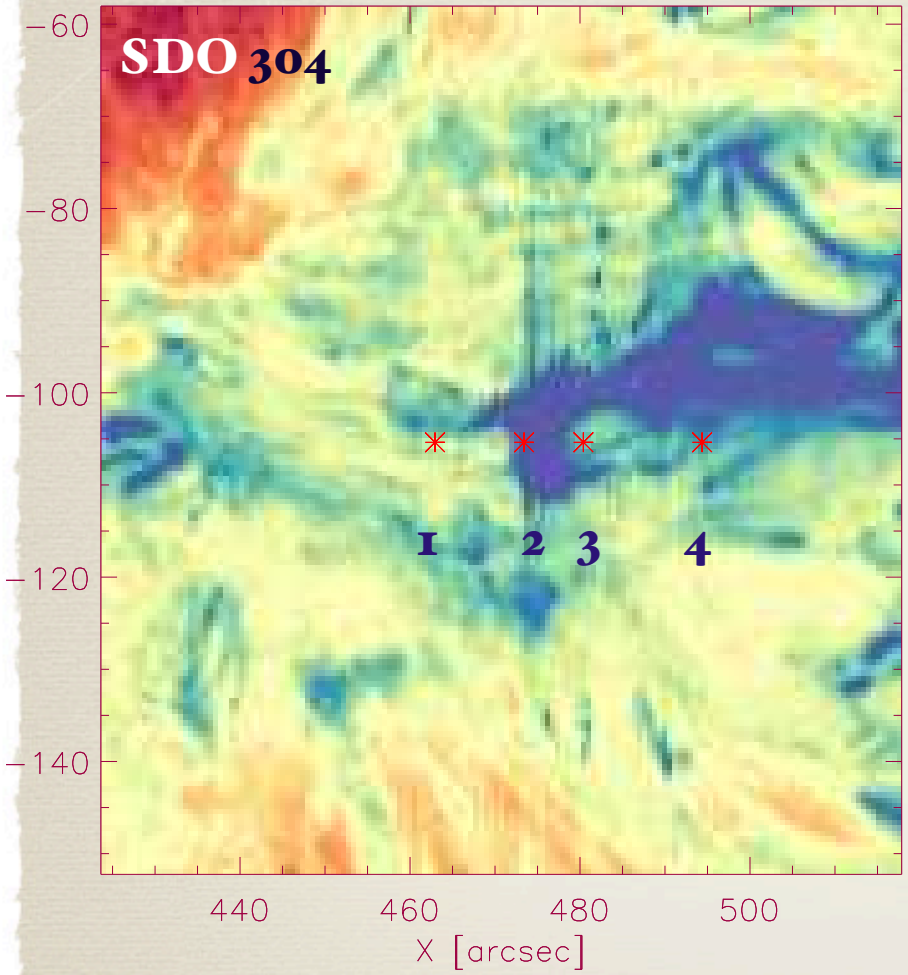

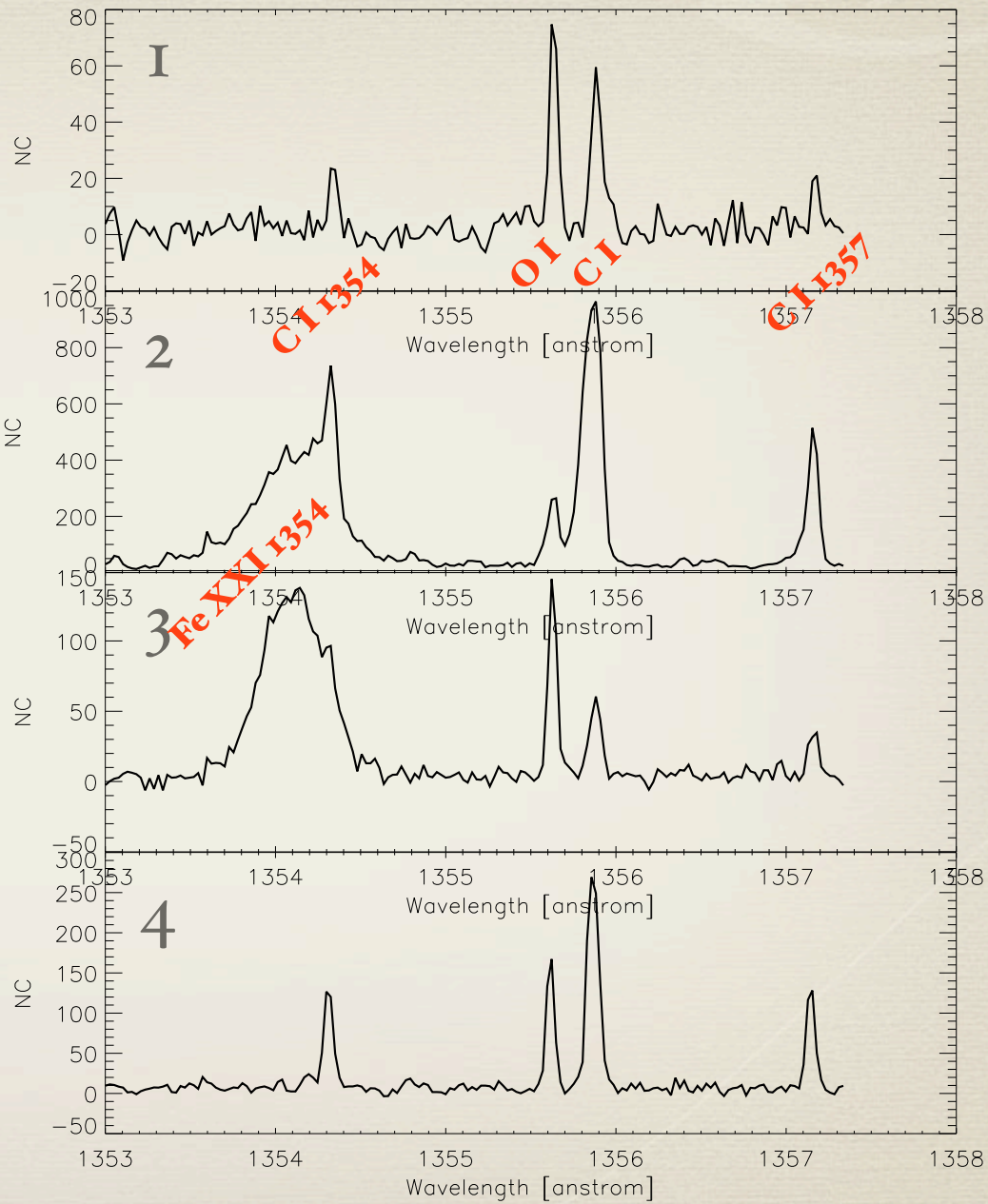

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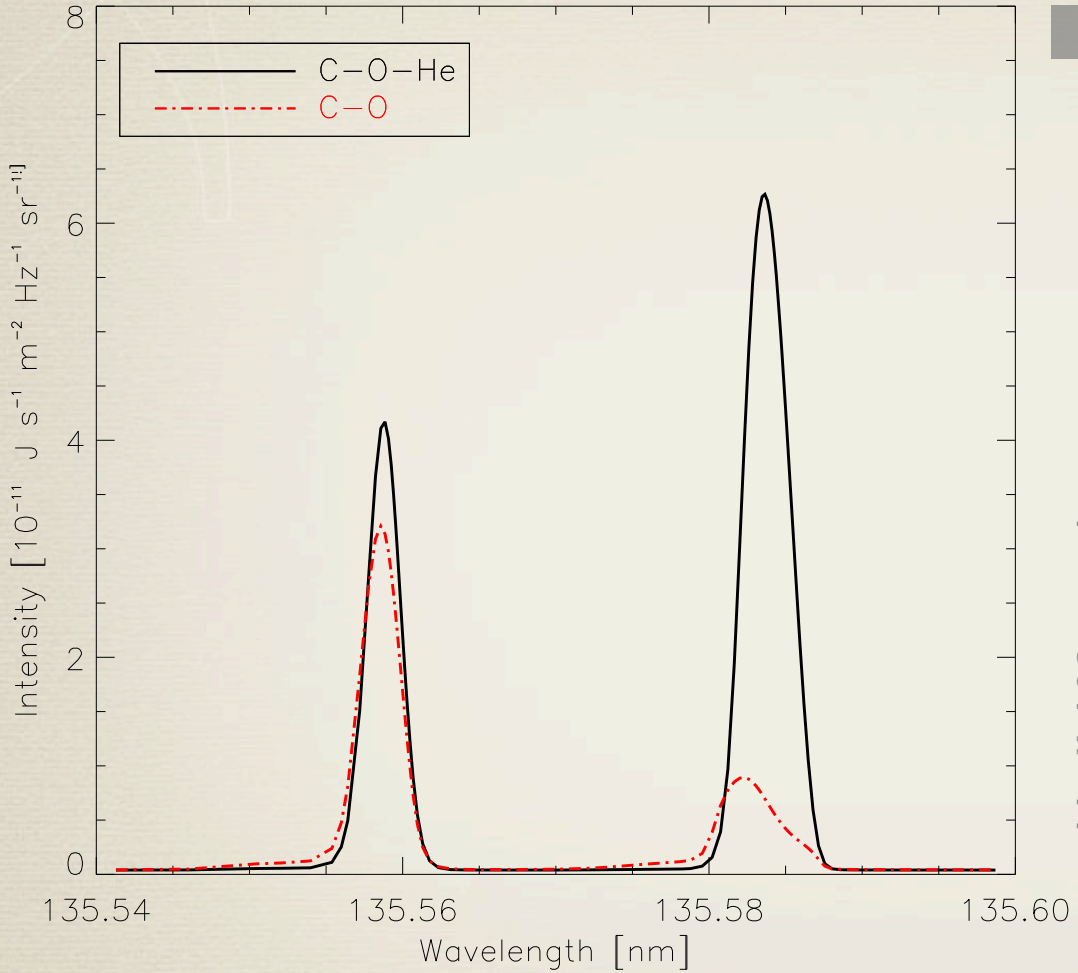

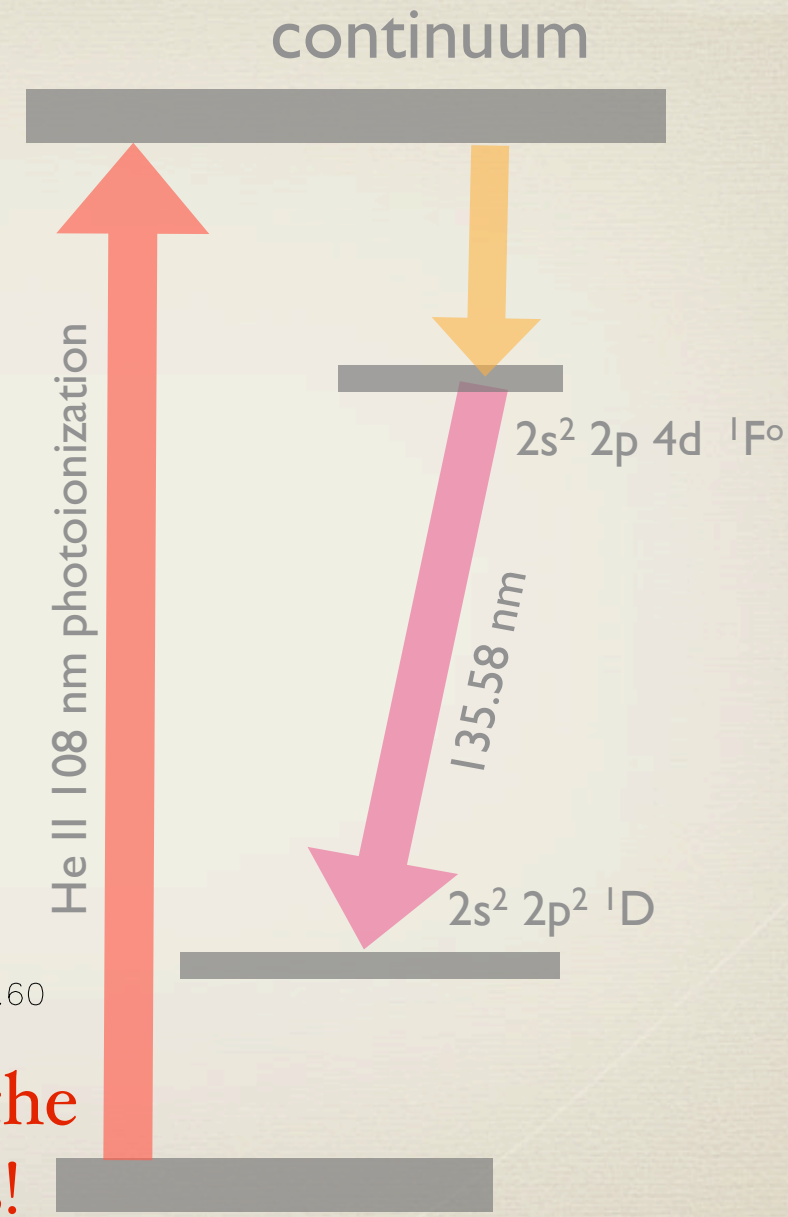

He II line changes the ionization process!

Conclusion

- Both the O I and the C I lines can be good velocity diagnostics.
- O I and C I together → velocity gradient.
- The O I line intensity have Ne^2 dependency.
- The O I line width provides the constraint of non-thermal broadening.
- The C I / O I line ratio during flare might give different diagnostics than the quiet sun.

THANKS FOR YOUR ATTENTION!

SEVENTH FRAMEWORK PROGRAMME