IRIS-9, MPS, Göttingen
June 26, 2018

Simulating CLASP-IRIS co-observations in H I Ly-α and Mg II h

Andrii V. Sukhorukov (*IAC*)
Jorrit Leenaarts (*ISP, SU*)
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EXCELENCIA SEVERO OCHOA

IRIS-9, Göttingen, 25-29 June 2018

Contributed Talk

1. Fundamental physical processes and modeling

Simulating CLASP-IRIS co-observations in H I Ly-α and Mg II h

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On September 3, 2015, the Chromospheric Lyman Alpha Spectropolarimeter (CLASP) and the Interface Region Imaging Telescope (IRIS) observed the Sun co-spatially and co-temporally in the H I Ly-α and the Mg II h lines. Slits of the instruments recorded the center-to-limb variation of the line intensities along the same direction towards the solar limb. The slit spectra exhibited some similarities in their profile shapes suggesting that the lines are formed close to each other between the upper chromosphere and the transition layer, as predicted by canonical model atmospheres such as by Vernazza et al. (1981). For both lines, we calculated synthetic spectrograms in non-LTE including effects of the lateral transfer of radiation (3D) and the resonance-line scattering (PRD) using an enhanced-network model atmosphere produced with the radiation-MHD code Bifrost. Contrary to the public release by Carlsson et al. (2016), this non-public model includes additional effects of the non-equilibrium ionization of helium. We reduced the synthetic spectrograms to finite spatio-spectral resolutions of the CLASP and IRIS spectrographs and studied the correspondence between various profile properties. We found that synthetic profiles are less similar than the observed ones because their formation heights are very variable depending on the magnetic structure of the underlying atmosphere. We demonstrated that velocities in the upper chromosphere and the transition layer can be measured using both lines. In addition, we discuss what is important for the modeling of chromospheric lines, which shortcomings have current model atmospheres, and what needs to be improved.

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Three “disclaimers”

1) Institutet för solfysik, Stockholms universitet

2) Collaboration with the CLASP team

Andrii V. Sukhorukov

Donald J. Schmit

Christian W. Bethge

Jorrit Leenaarts

Bart W. De Pontieu

Amy R. Winebarger

The CLASP Team

3) First paper: observations

The Astrophysical Journal, 847:141 (10pp), 2017 October 1 https://doi.org/10.3847/1538-4357/aa890b
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CrossMark

Comparison of Solar Fine Structure Observed Simultaneously in Lyα and Mg II h

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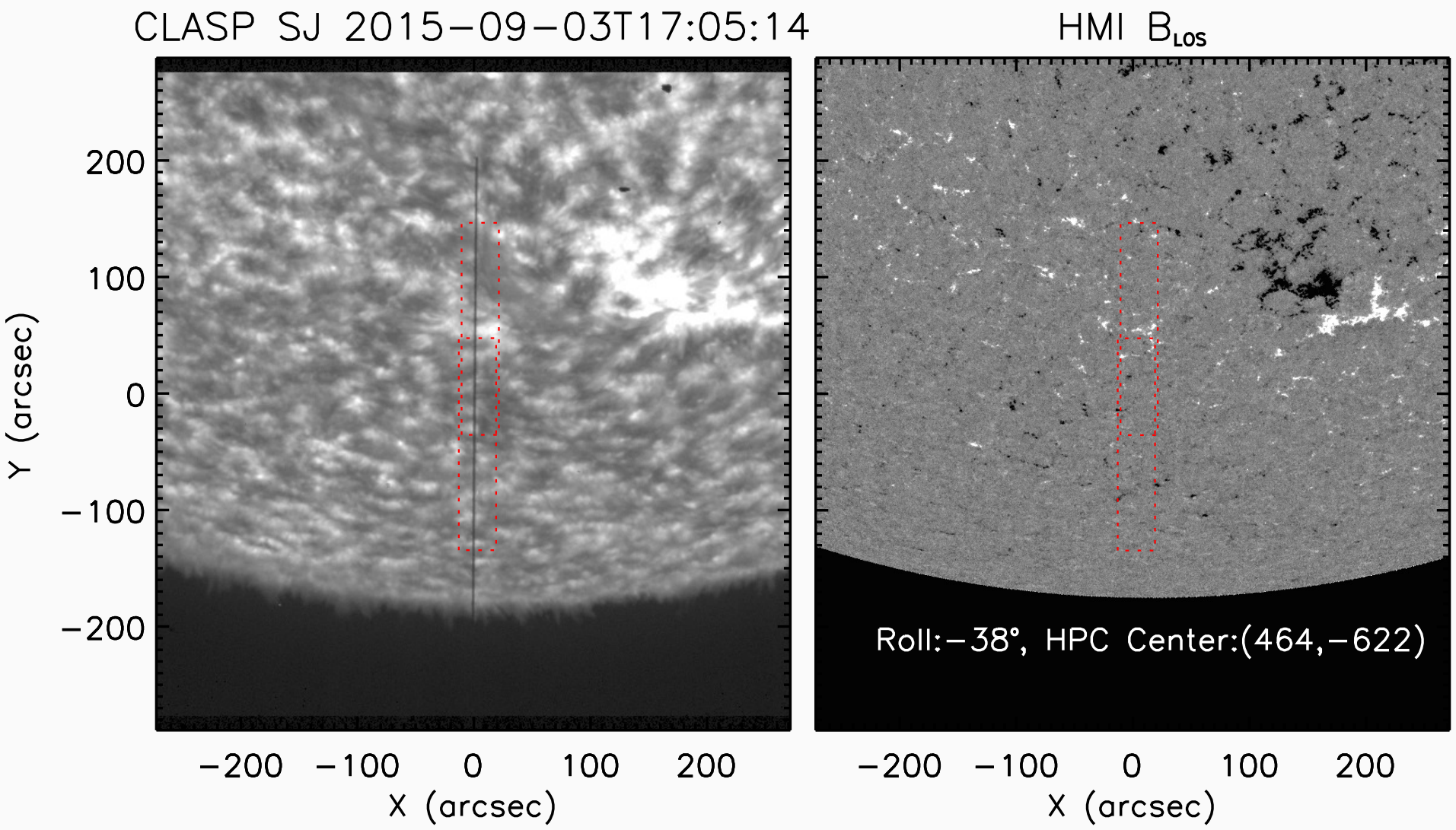
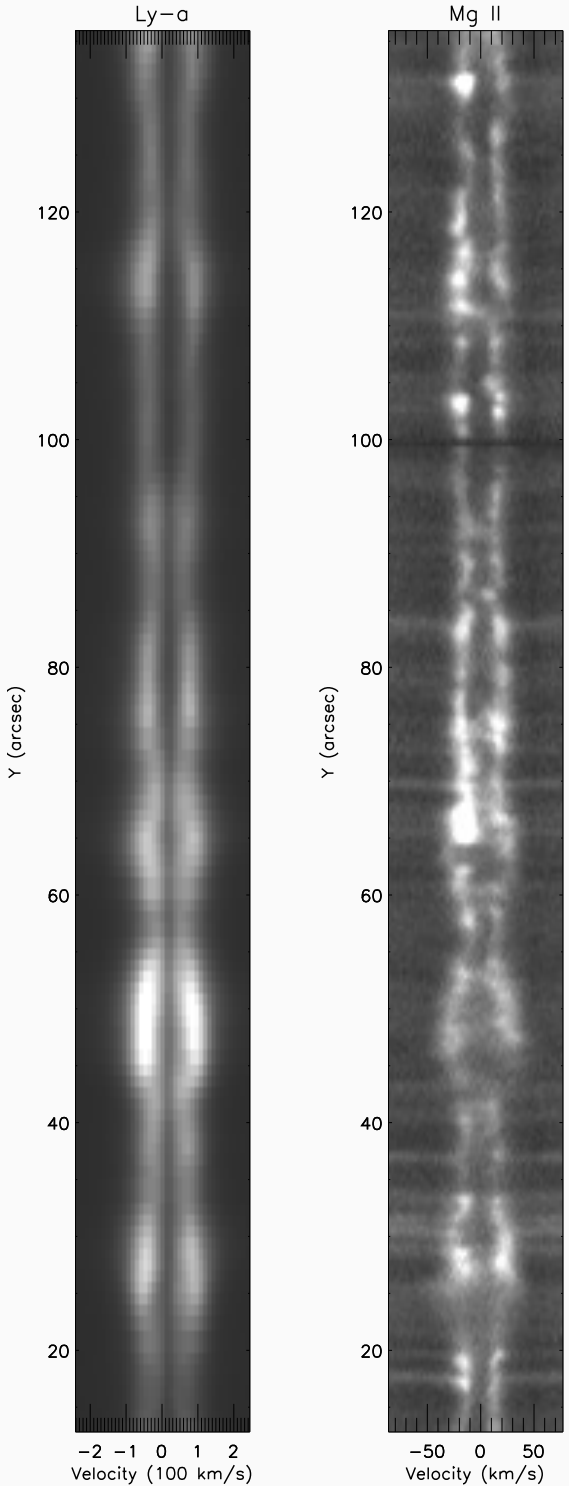
Observations


CLASP SJ 2015−09−03T17:05:14
HMI B_{LOS}
Y (arcsec)
200
100
0
−100
−200
X (arcsec)
−200 −100 0 100 200
Roll:−38°, HPC Center:(464,−622)
Courtesy of D. J. Schmit & The CLASP Team

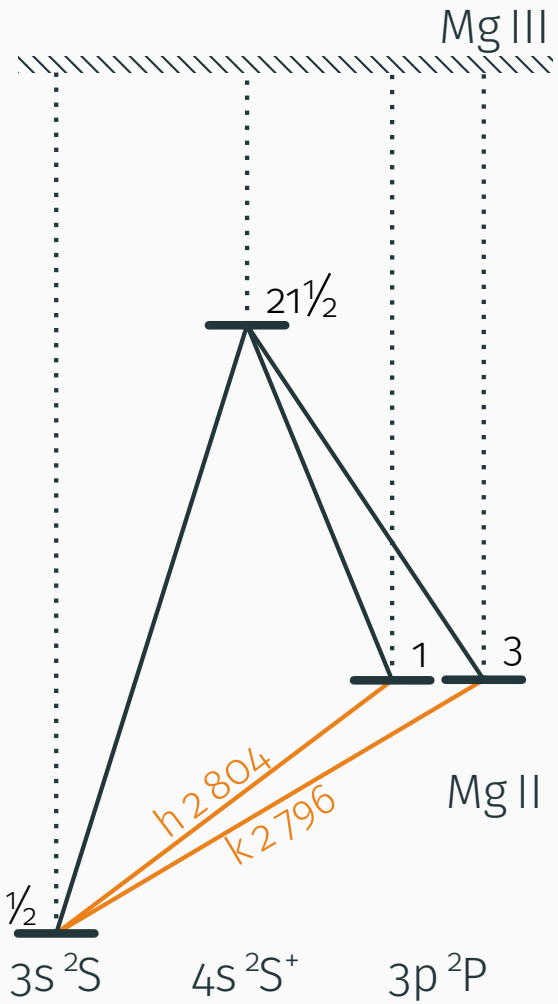
μ = 0.29–0.75

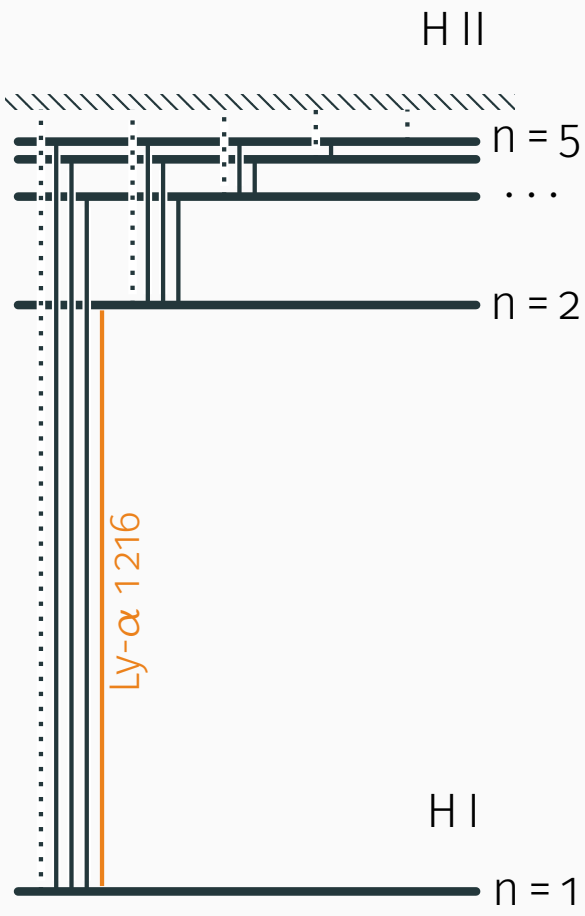


Courtesy of D. J. Schmit & The CLASP Team

Computational setup

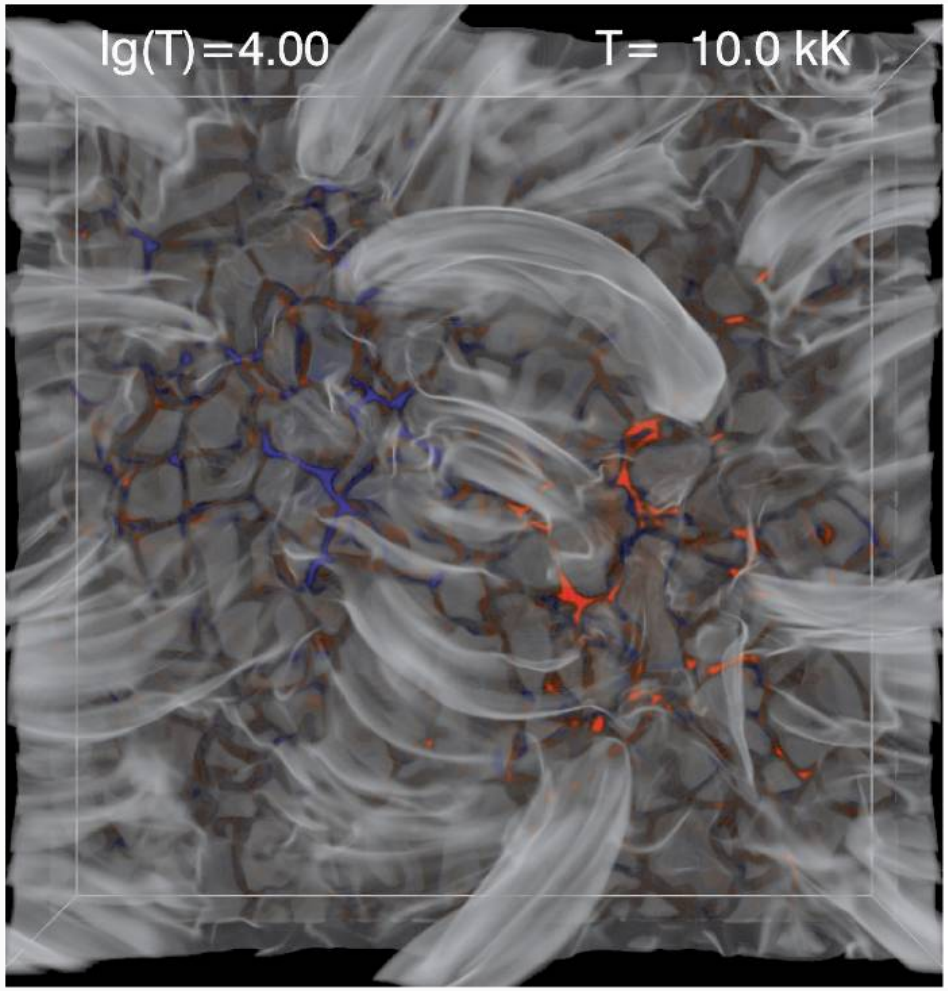
Model atoms

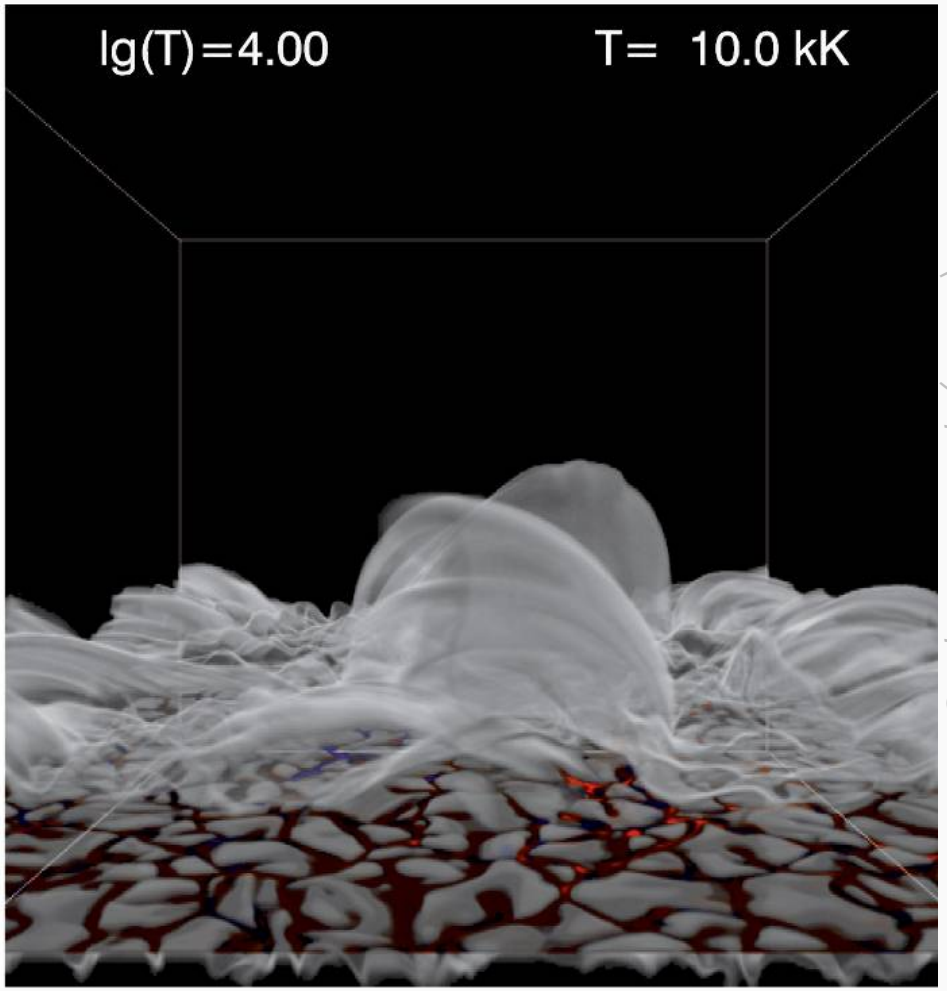

Mg III
21½
1
3
h 2 804
k 2 796
Mg II
½
3s ²S
4s ²S⁺
3p ²P


H II
n = 5
. . .
n = 2
Ly-α 1 216
H I
n = 1

Model atmospheres

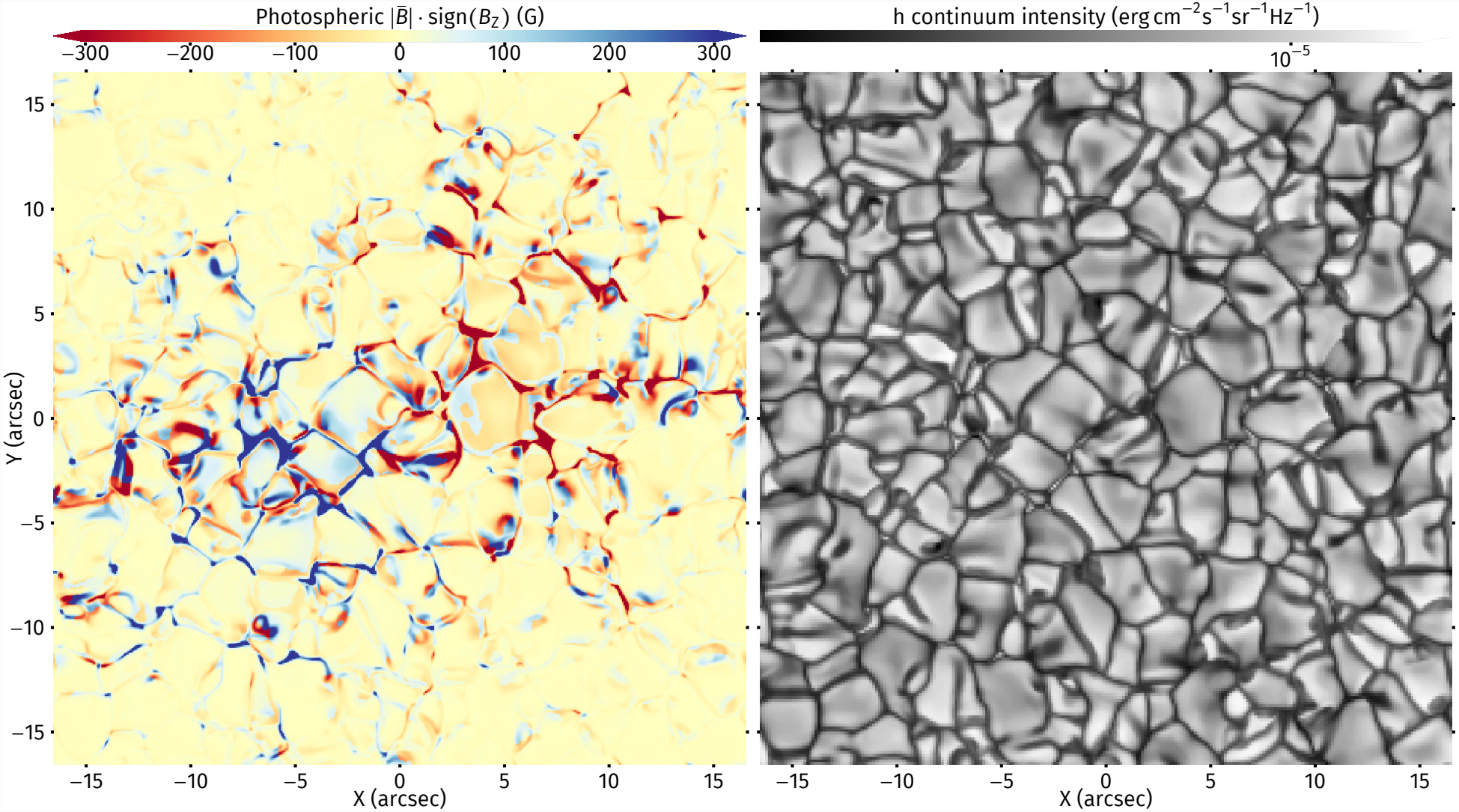
Radiation-MHD Bifrost snapshots





Carlsson et al. (2016)

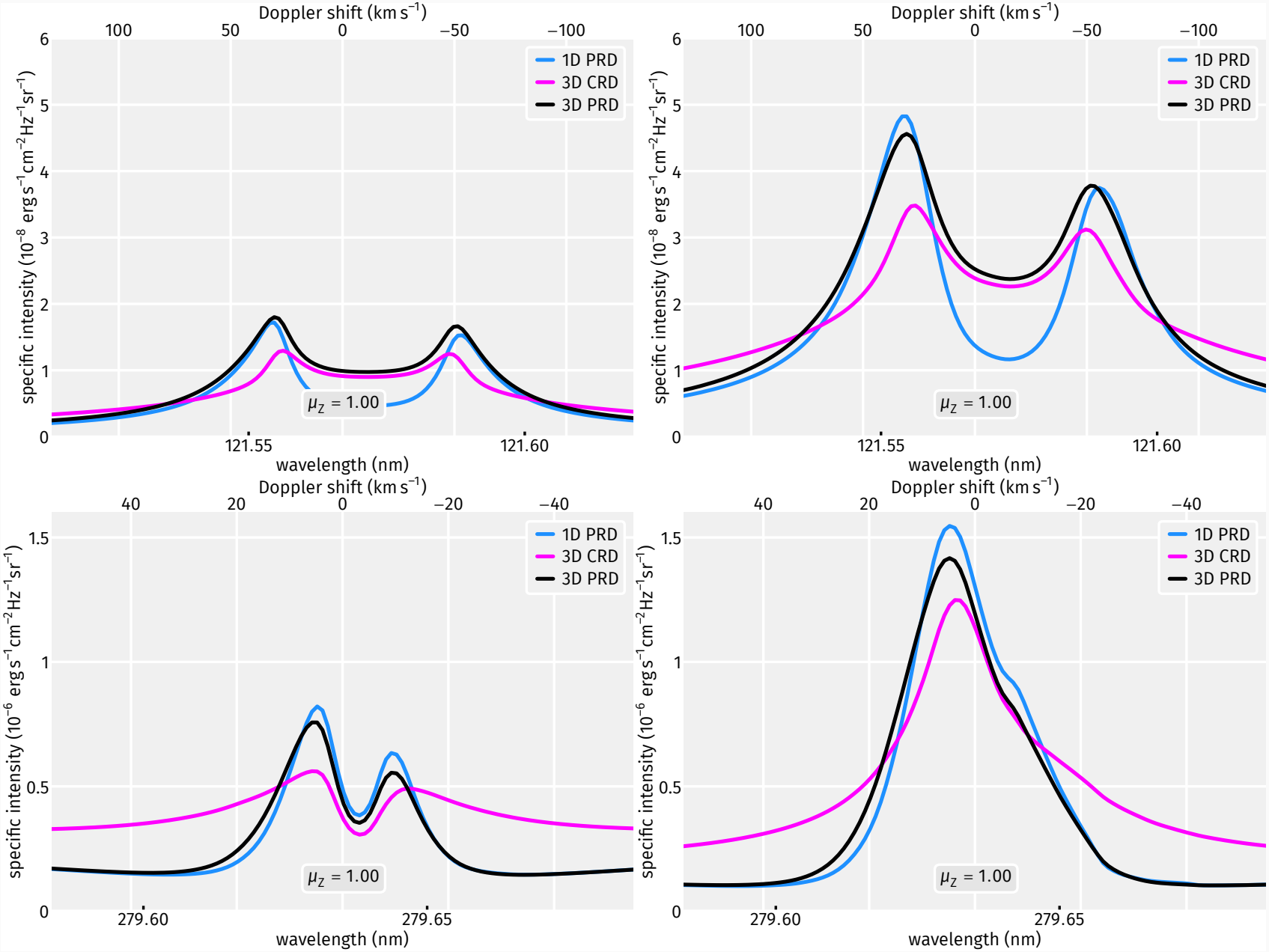
Models of an enhanced network



Importance of 3D/PRD/non-E effects

H I Ly-α

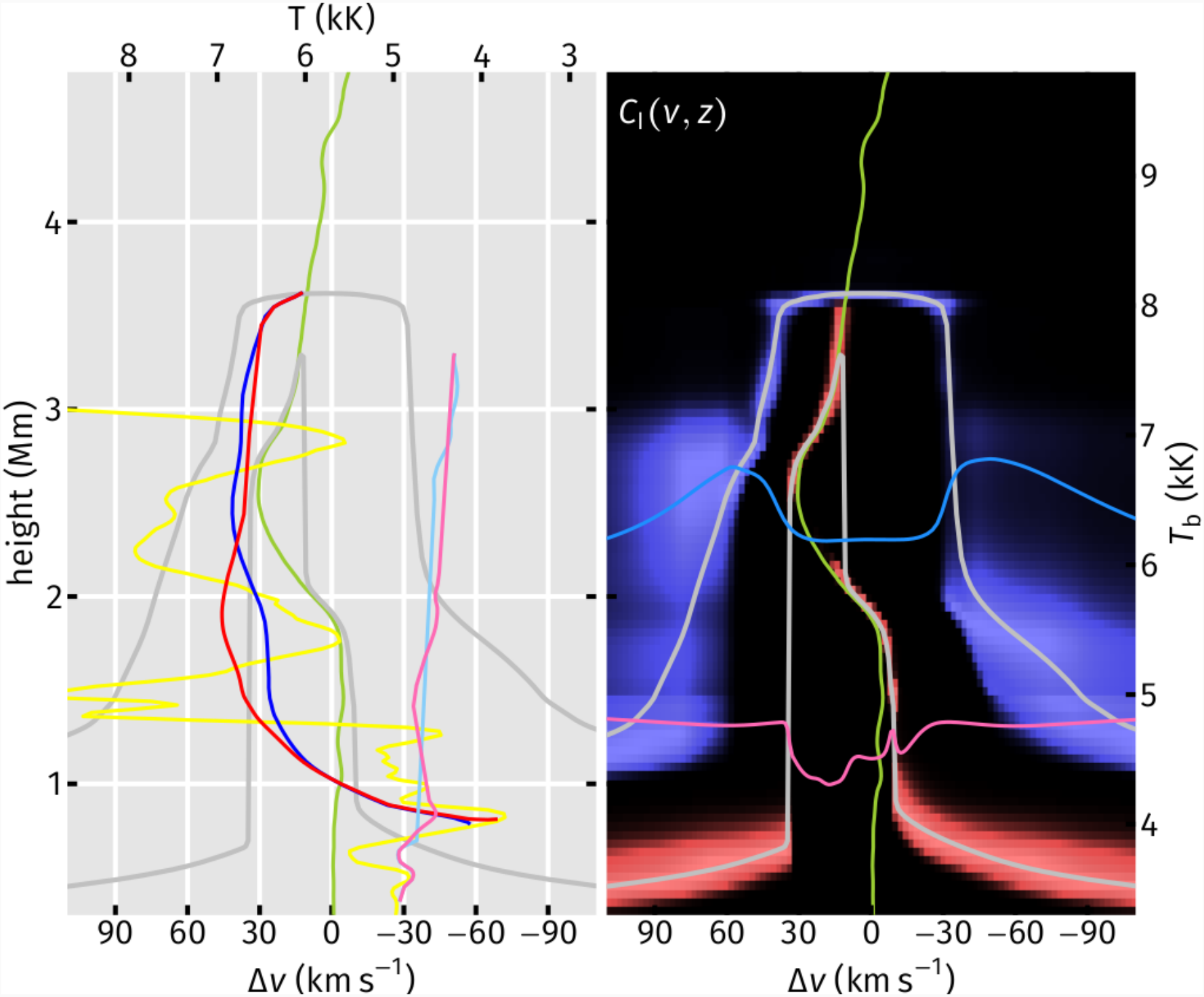
Mg II h



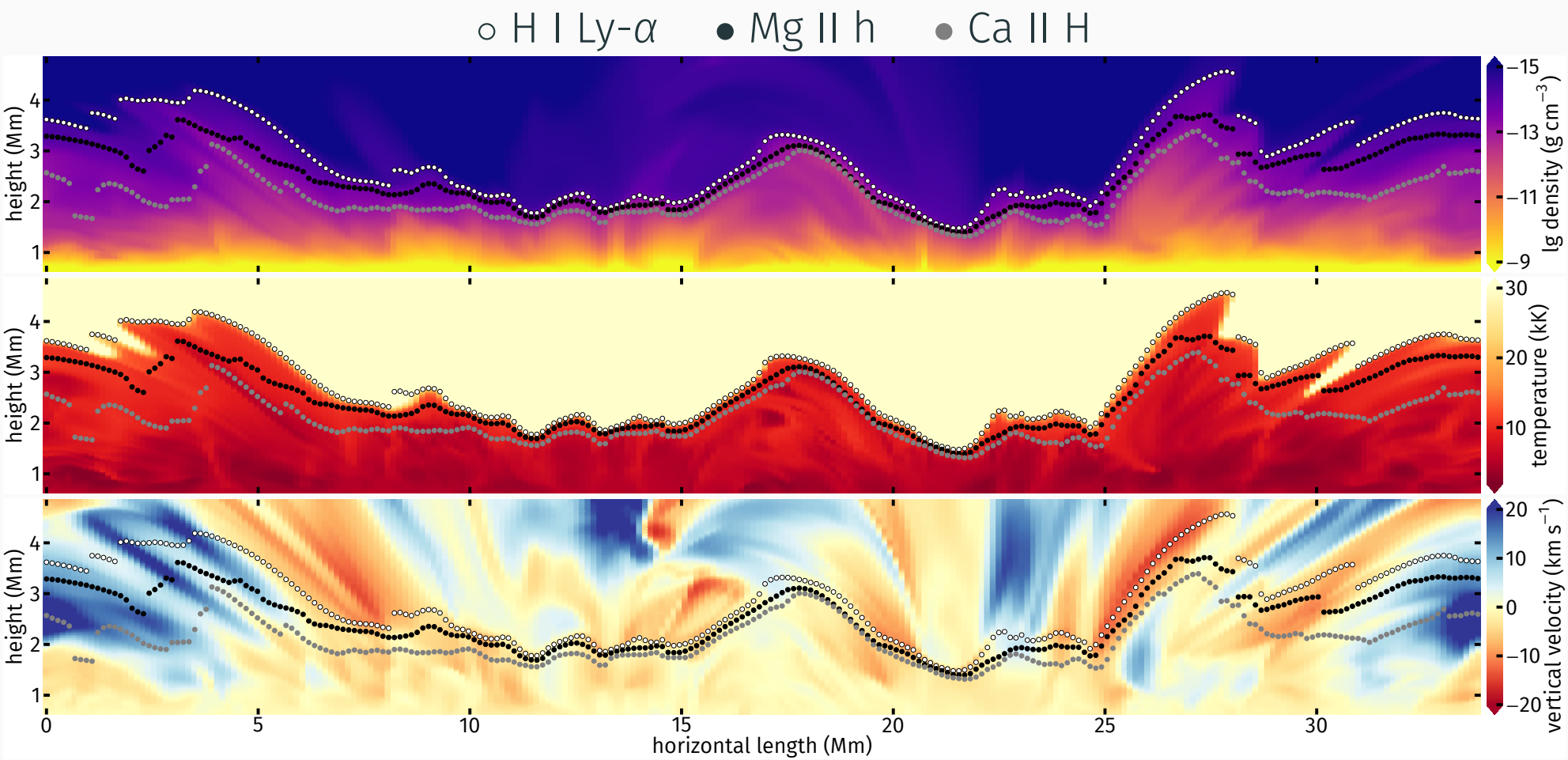
non-E ionization of H

non-E ionization of H + He

What these lines are good for?

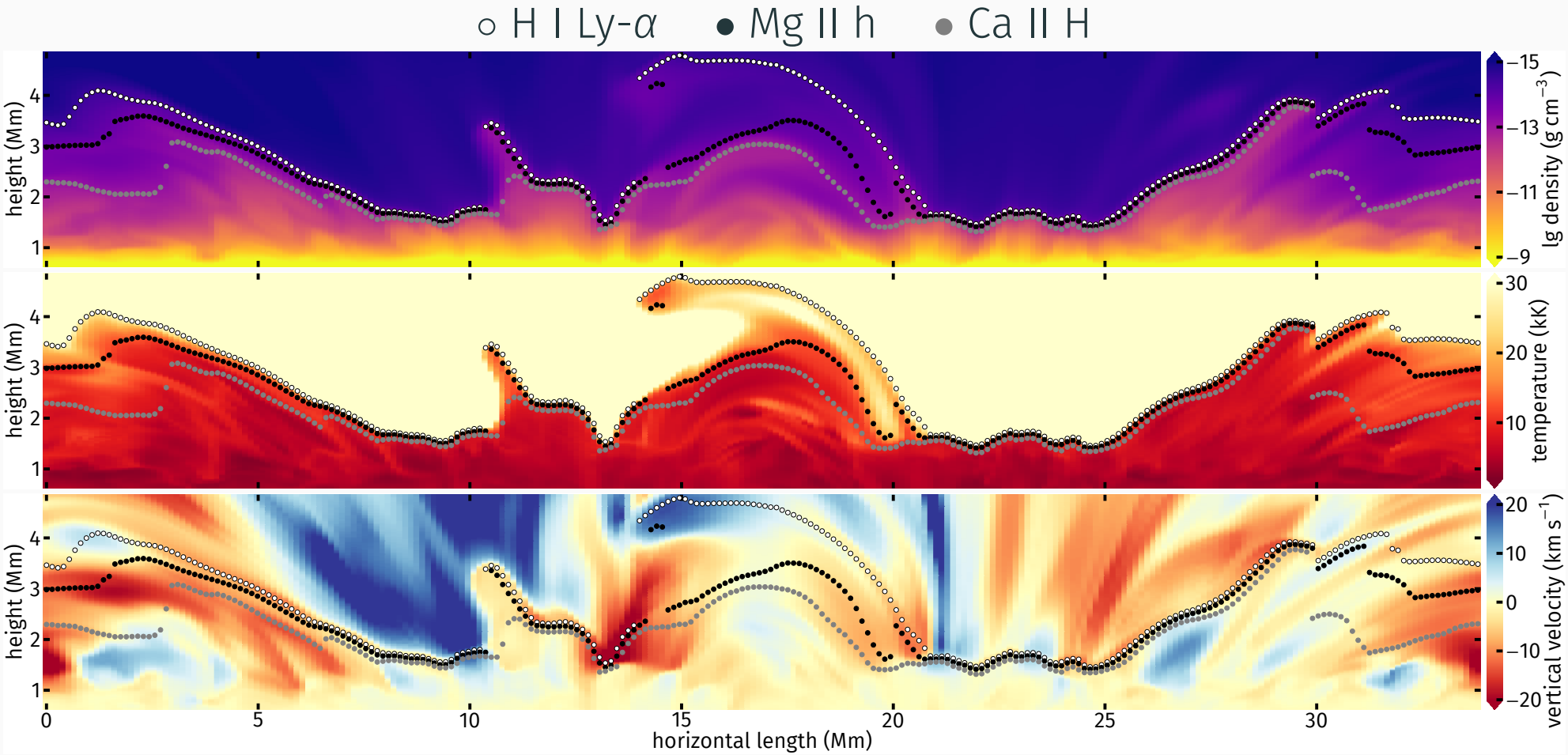

T (kK)
8
7
6
5
4
3
height (Mm)
4
3
2
1
90
60
30
0
−30
−60
−90
Δv (km s⁻¹)
$C_l(v, z)$
9
8
7
6
5
4
T_b (kK)
90
60
30
0
−30
−60
−90
Δv (km s⁻¹)

Where line cores are formed?



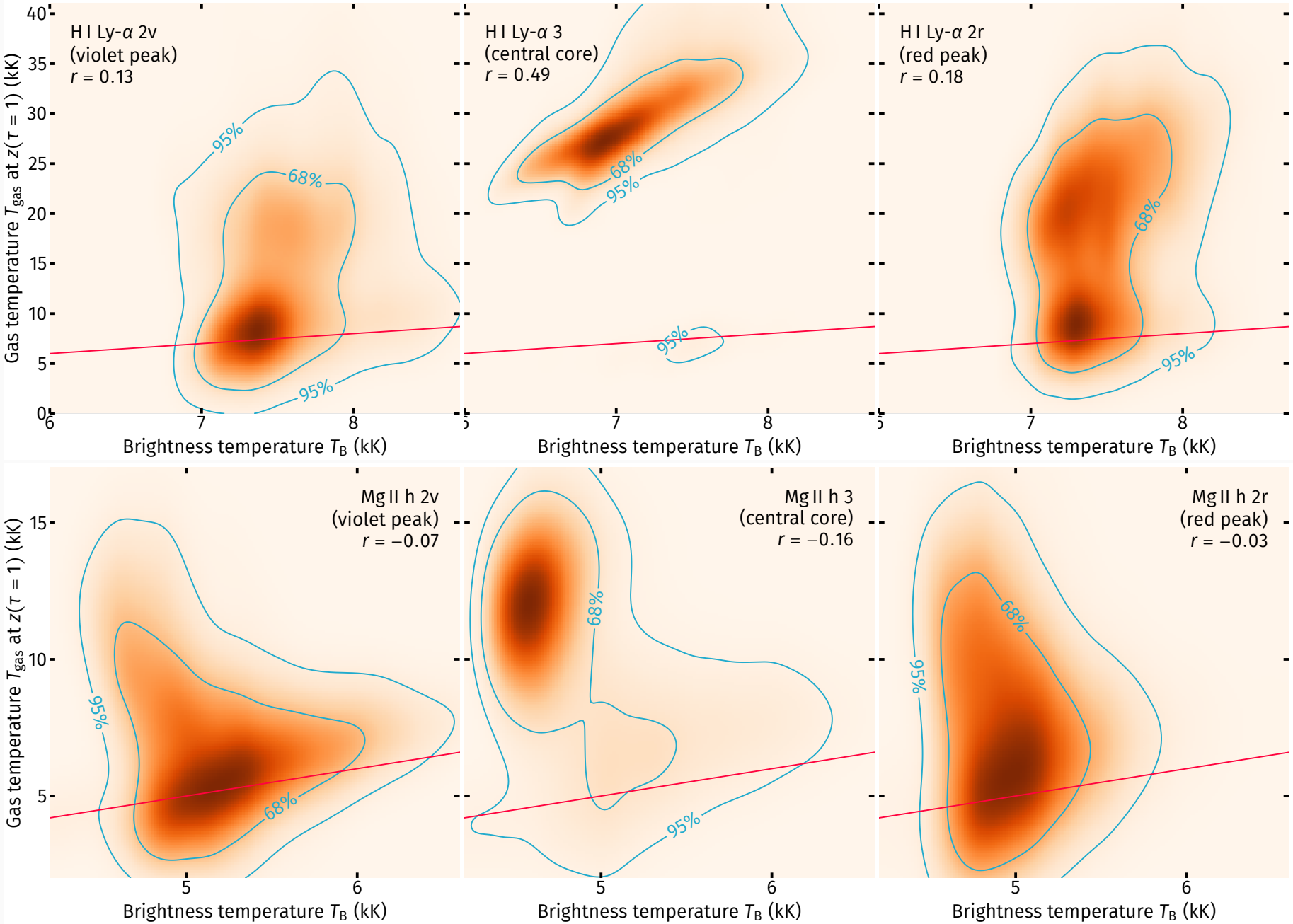
non-E ionization of H

Where line cores are formed?

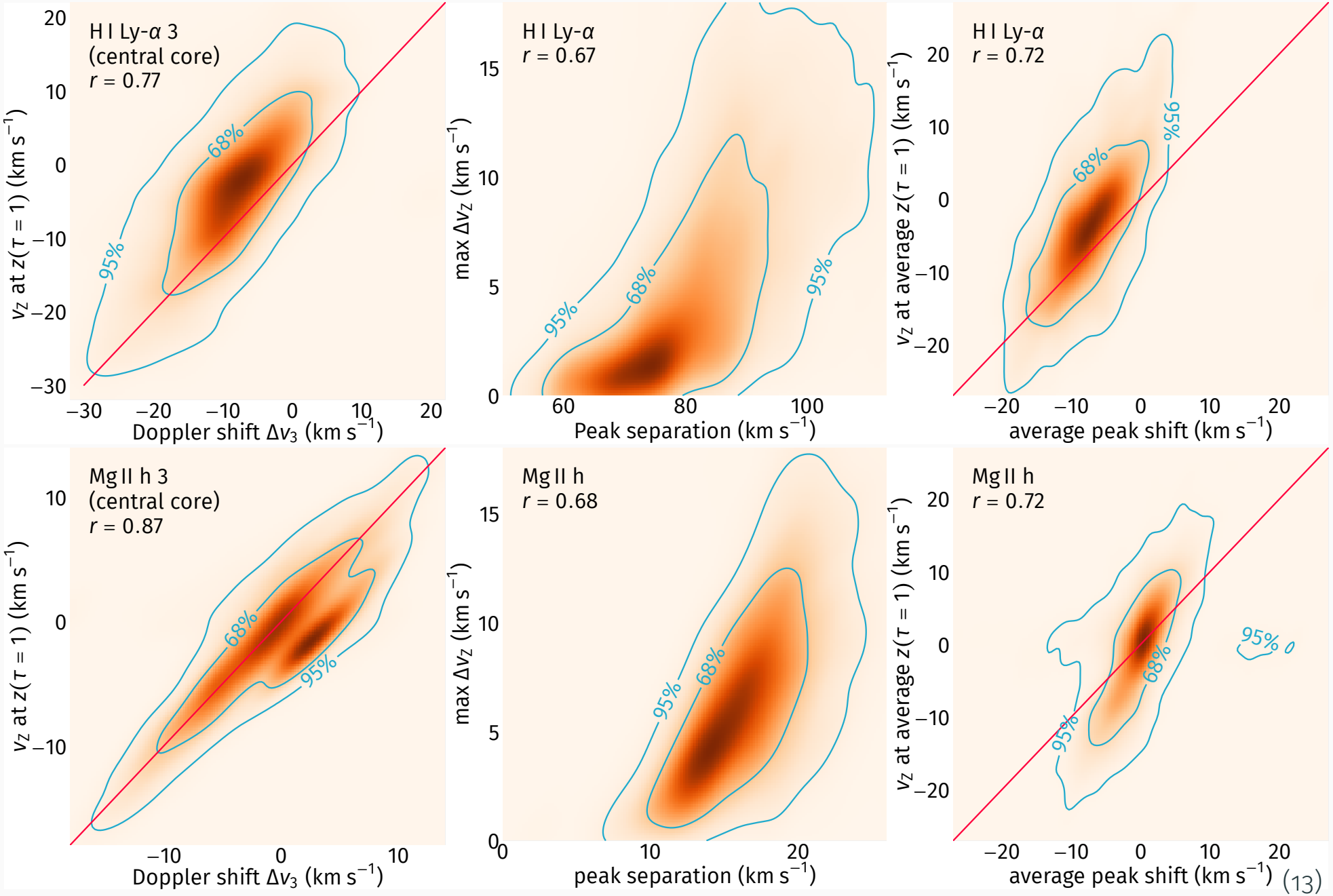


non-E ionization of H + He

Measuring temperatures



Measuring velocities



Reduction procedure

Old reduction procedure

2.3. Spatial and Spectral Smearing

In the NUV window, the *IRIS* spectrograph has a spatial resolution of about 0.″4 and a spectral resolution of about 6 pm (B. De Pontieu et al. 2013, in preparation). To account for this finite resolution, the synthetic spectra were spatially and spectrally smeared to mimic the instrumental profile. Following the path of light, the spectrograms were first spatially smeared and then spectrally smeared. The spatial convolution was made with a preliminary point-spread function (PSF) based on pre-launch calculations (B. De Pontieu 2013, private communication) and similar in shape to an Airy core with 0.″33 full width at half-maximum (FWHM). For the spectral convolution, we assumed a Gaussian profile with a FWHM of 6 pm and a spectral pixel size of 2.546 pm (corresponding to a velocity dispersion of about 2.7 km s^{-1} $pixel^{-1}$). To mimic the observational conditions, the 3D spectrograms were binned into "synthetic slits" with a width of 0.″33 and a spatial pixel size of 0.″166; with our box size of 24×24 Mm^2, this amounted to 100 slits of 200 spatial pixels per snapshot.

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Pereira *et al.* (2013) // ApJ 778 143

Correct reduction procedure

Spatial and Spectral Resolution of
CLASP
and
Degradation Process

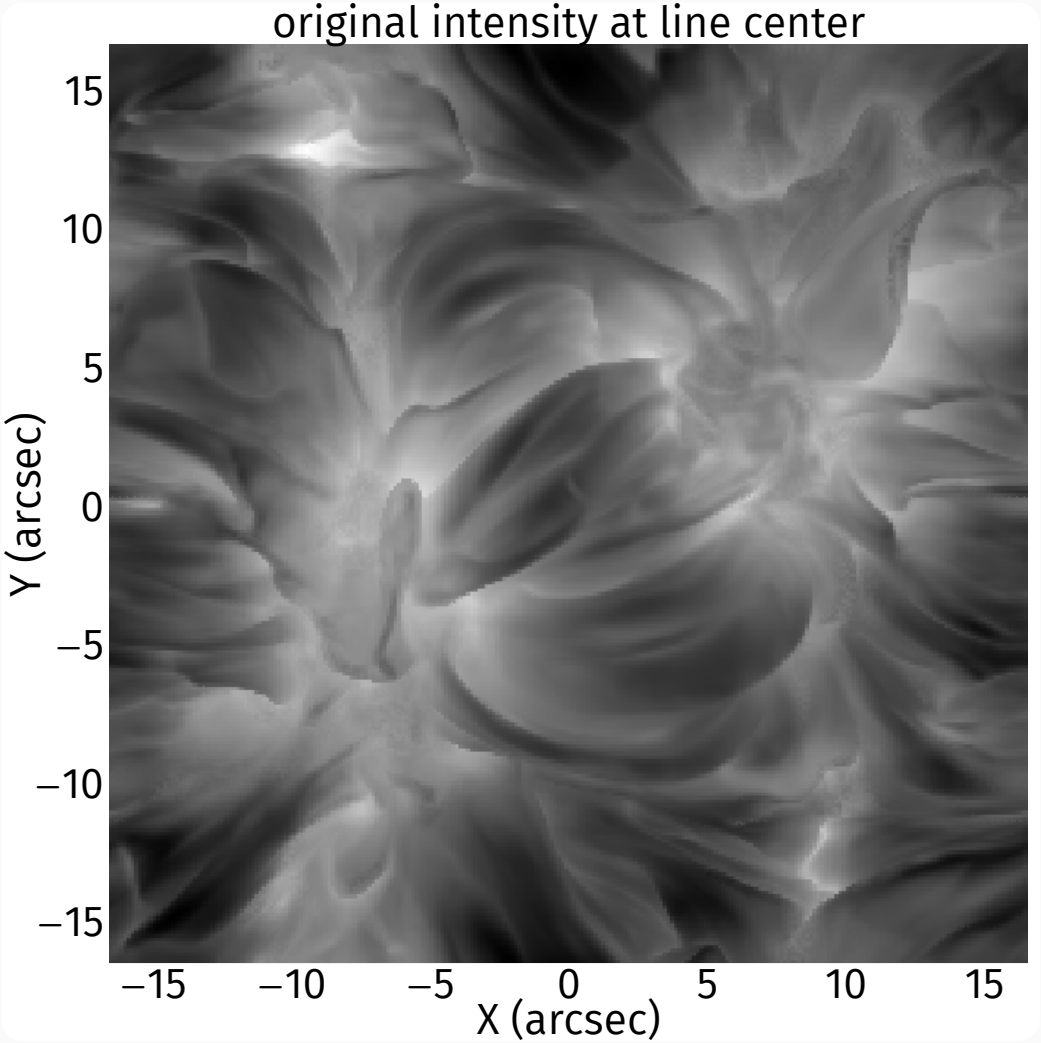
Ver.E 2017.06.26

R. Ishikawa & R. Kano (NAOJ)

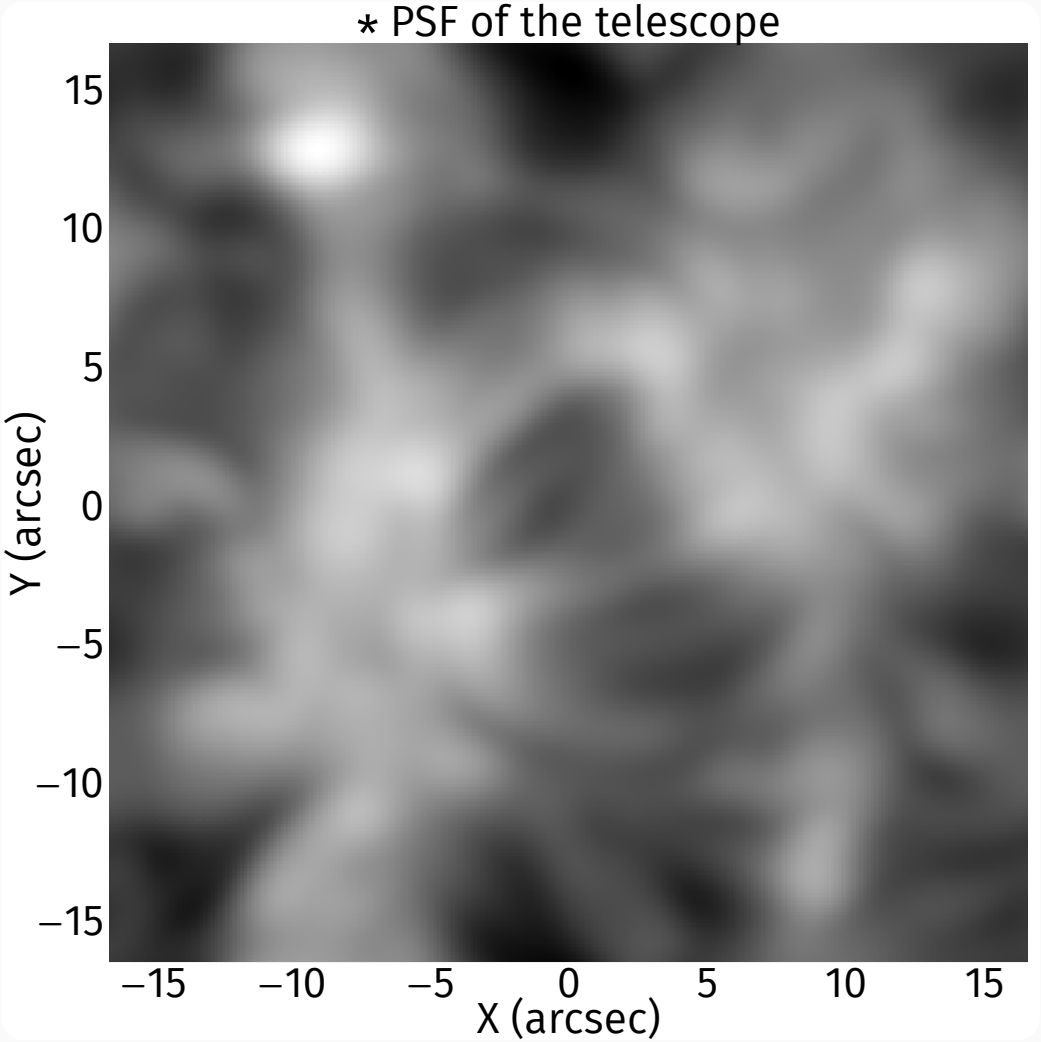
1

Courtesy of R. Ishikawa

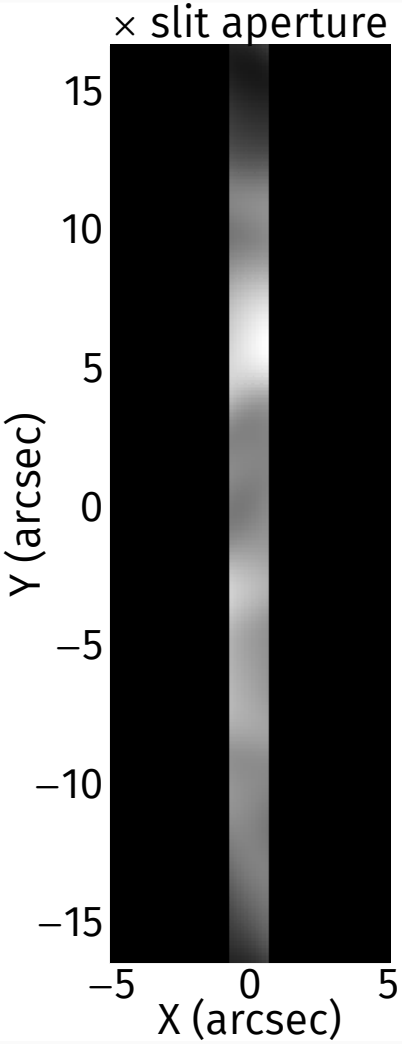
Correct reduction procedure



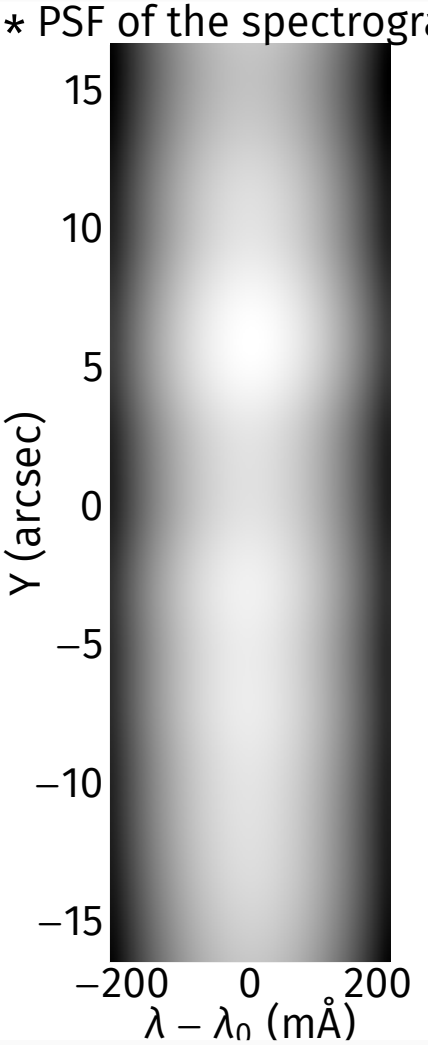
Correct reduction procedure



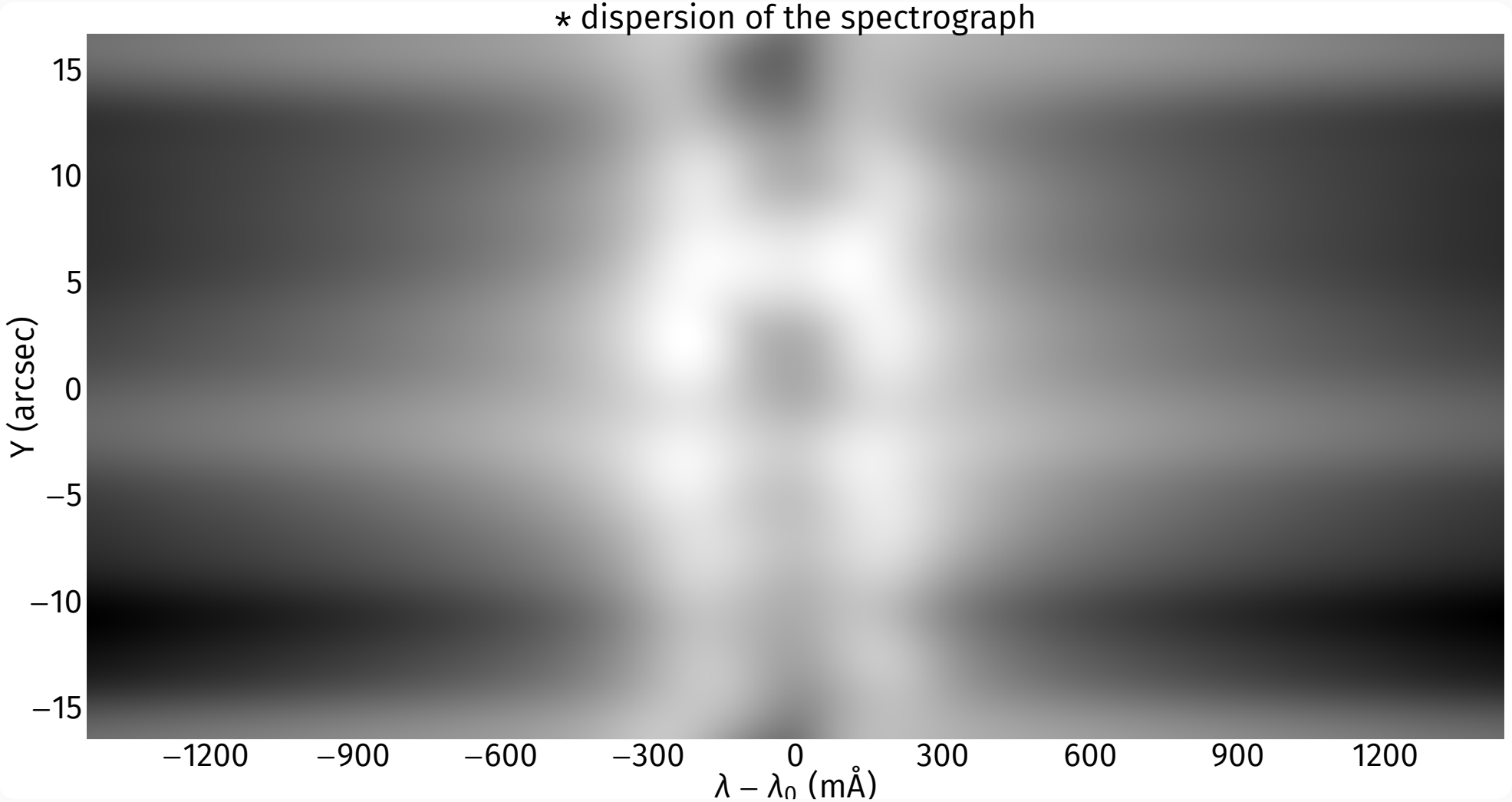
Correct reduction procedure



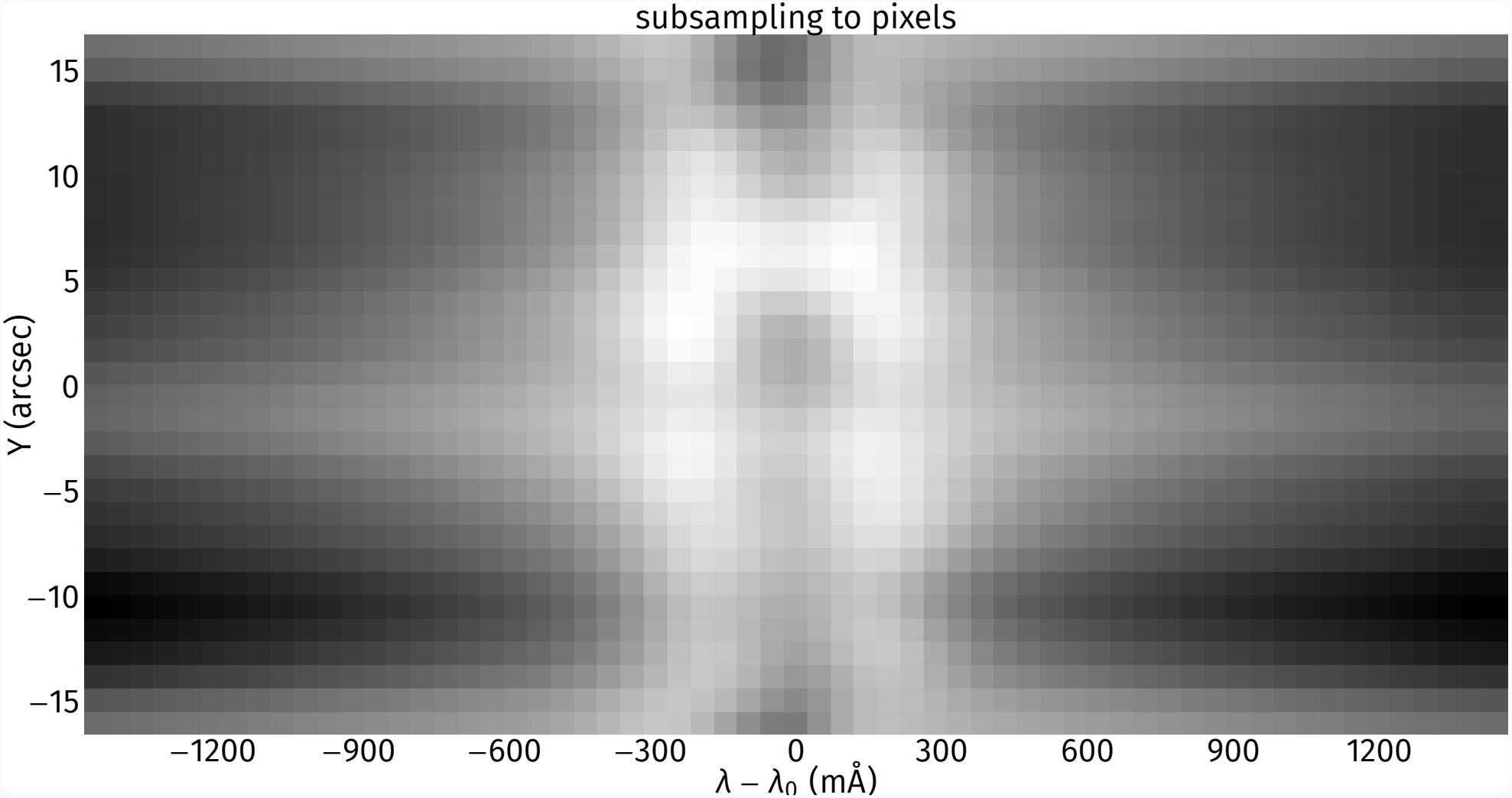
Correct reduction procedure



Correct reduction procedure



Correct reduction procedure

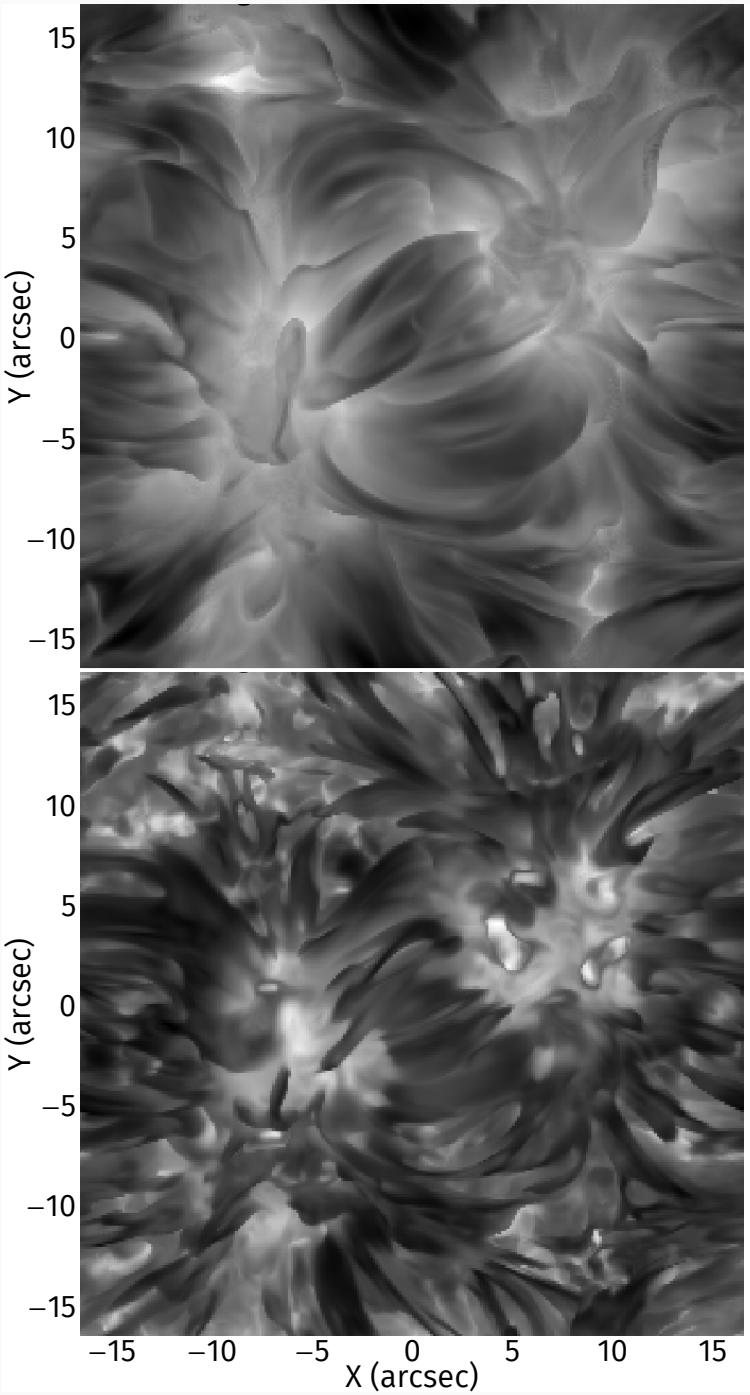


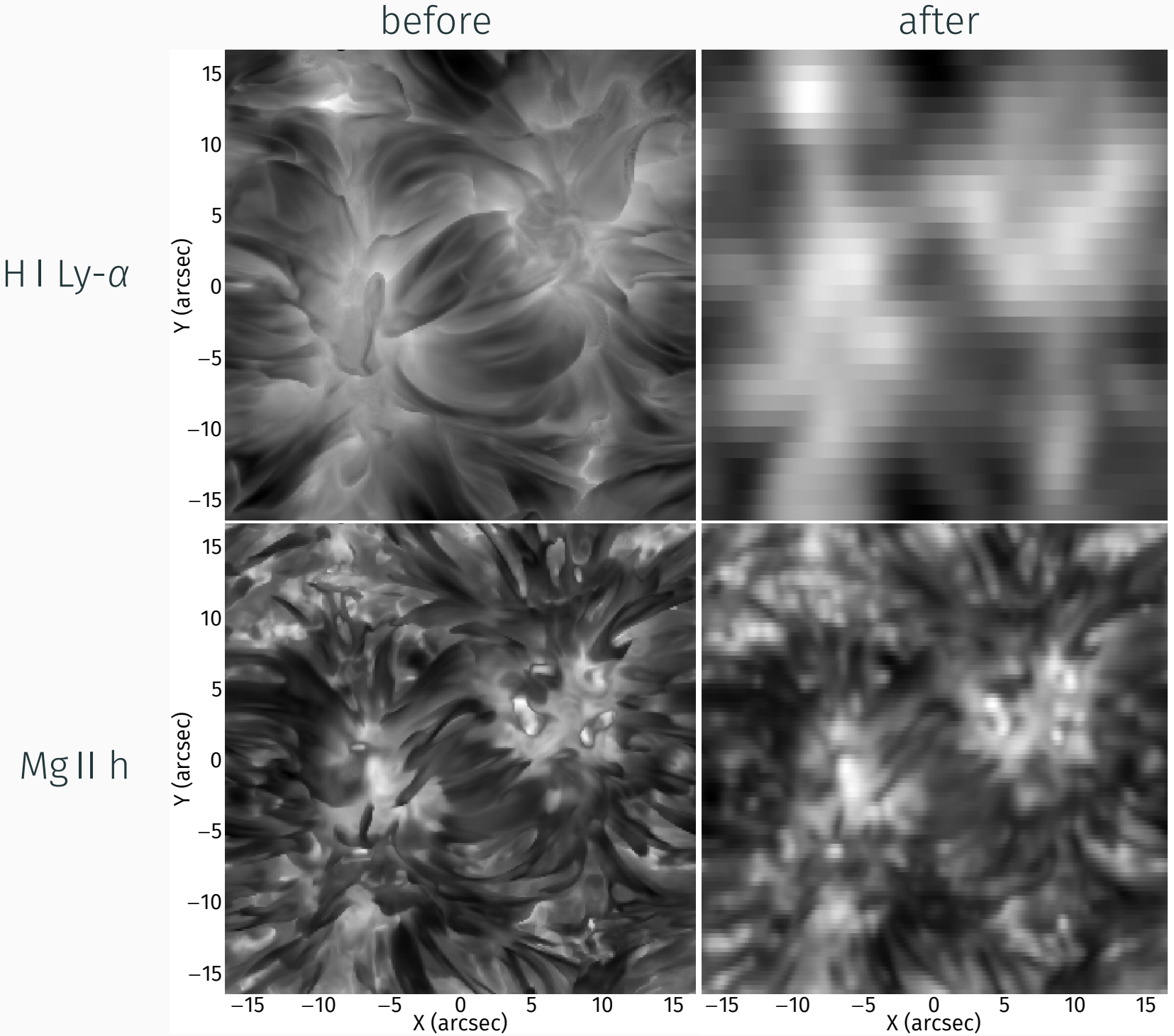
before

after

H I Ly-α

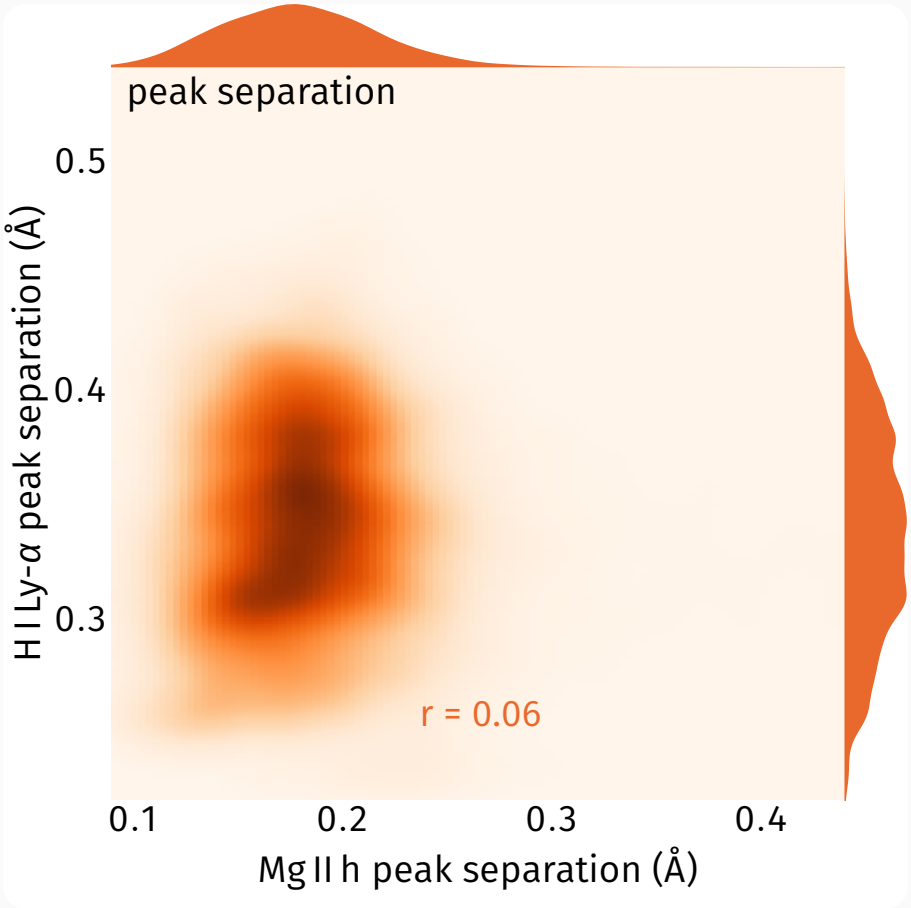
Mg II h



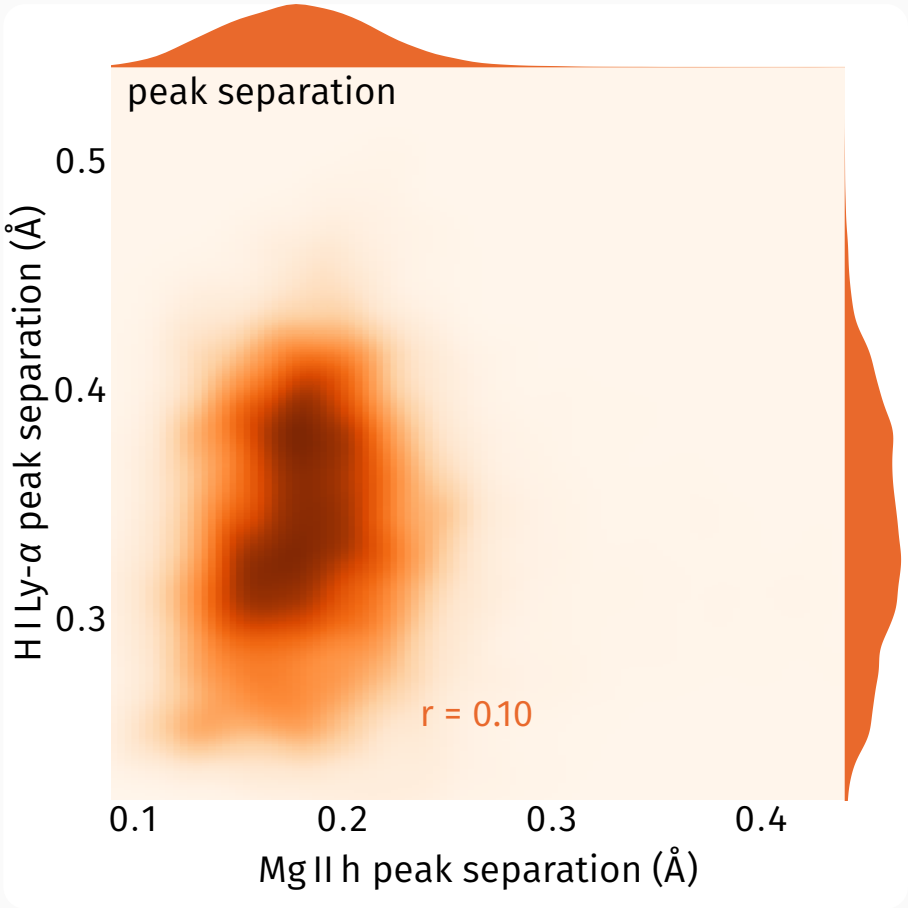

before
after
H I Ly-α
Mg II h
Y (arcsec)
X (arcsec)
15
10
5
0
−5
−10
−15

How this improves?

old reduction



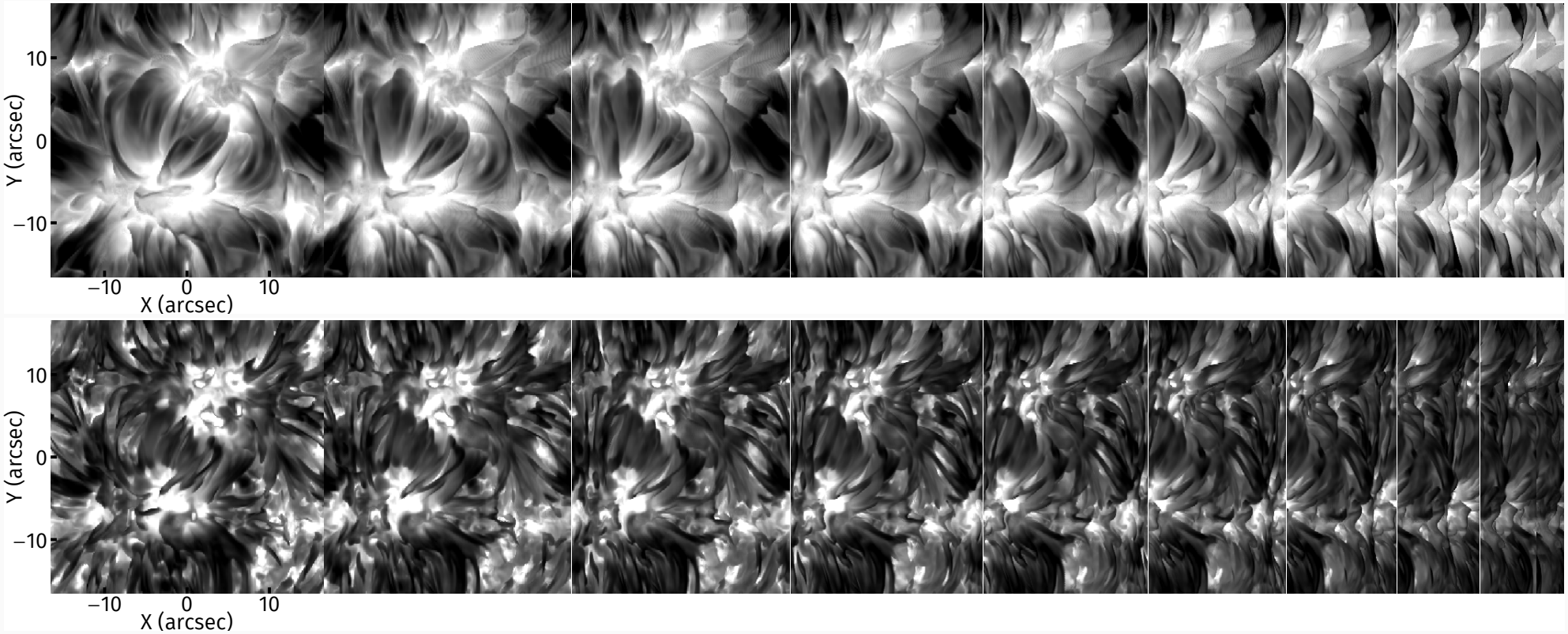
new reduction



Simulations vs. observations

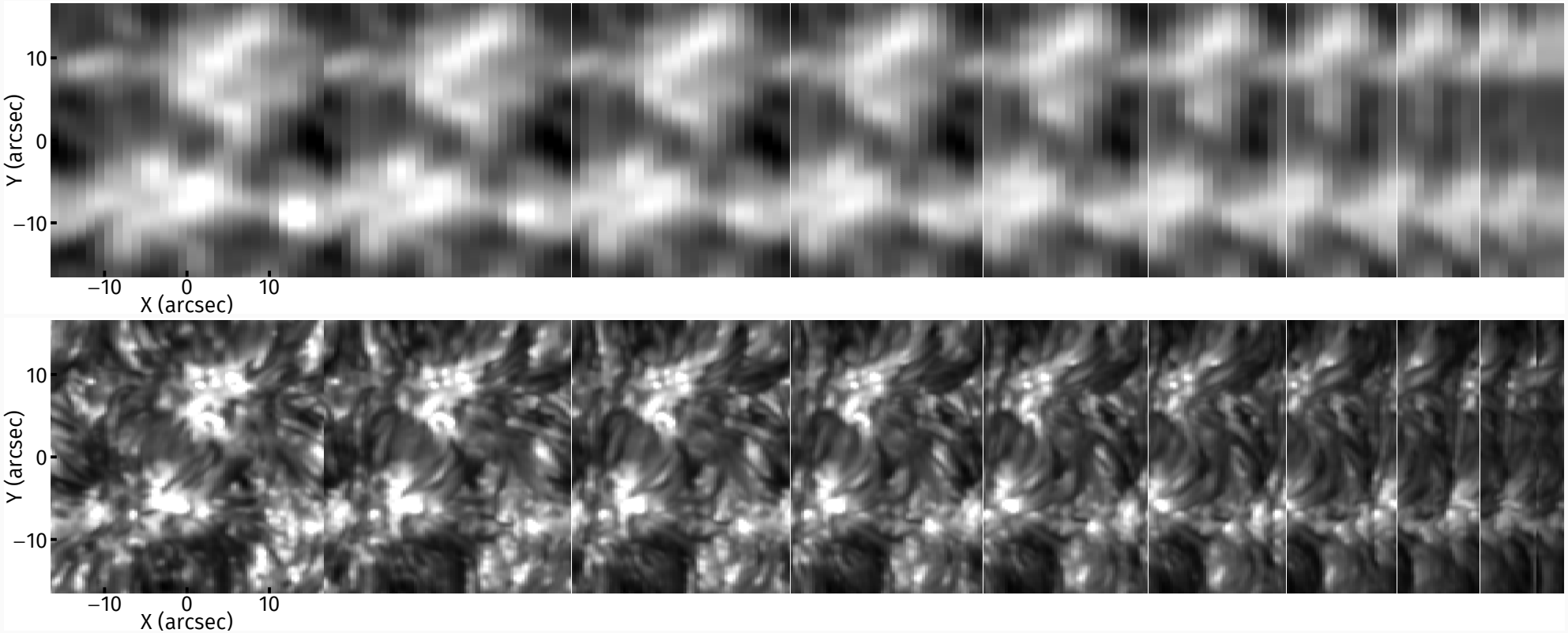
Simulated spectrograms

original

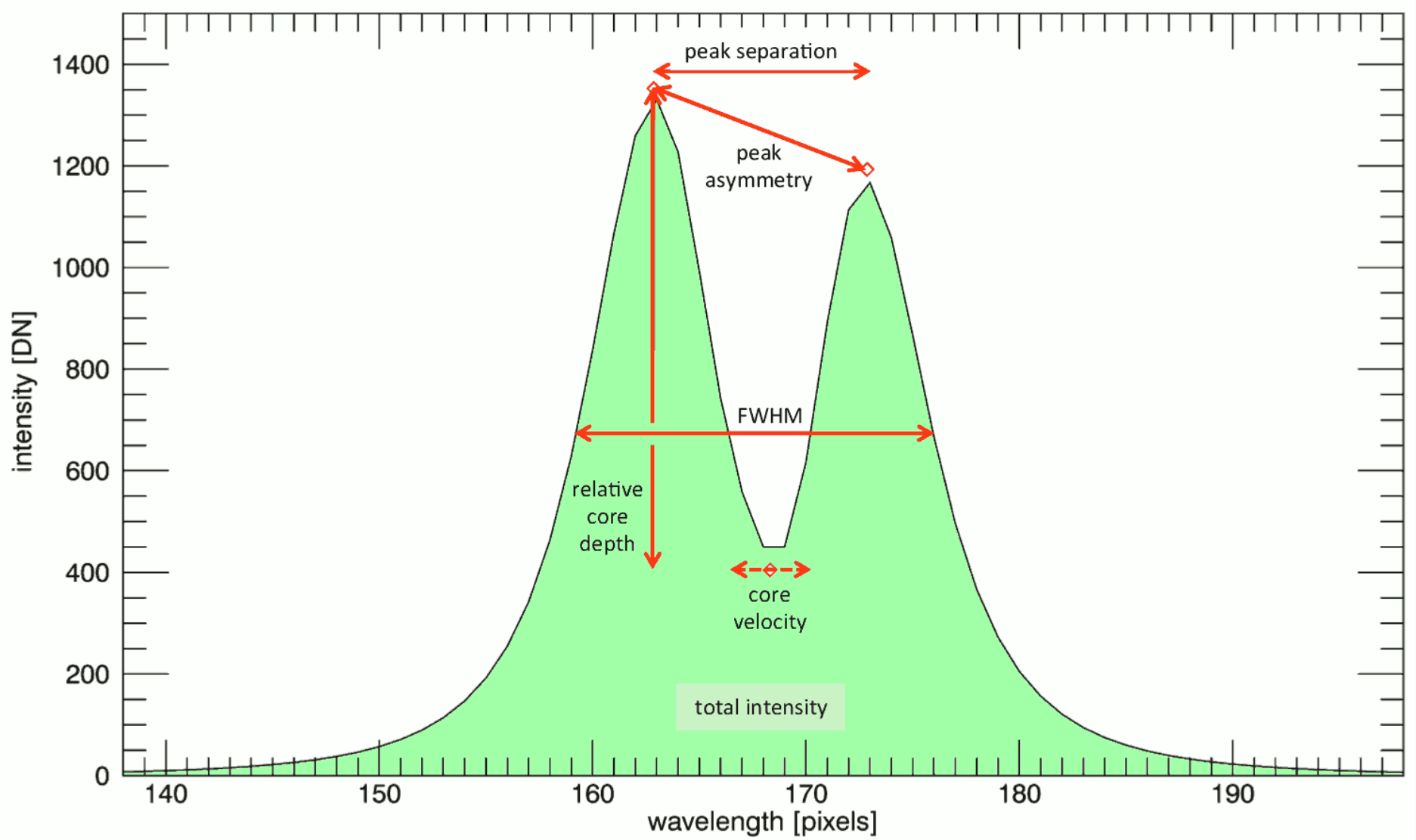


Simulated spectrograms

reduced

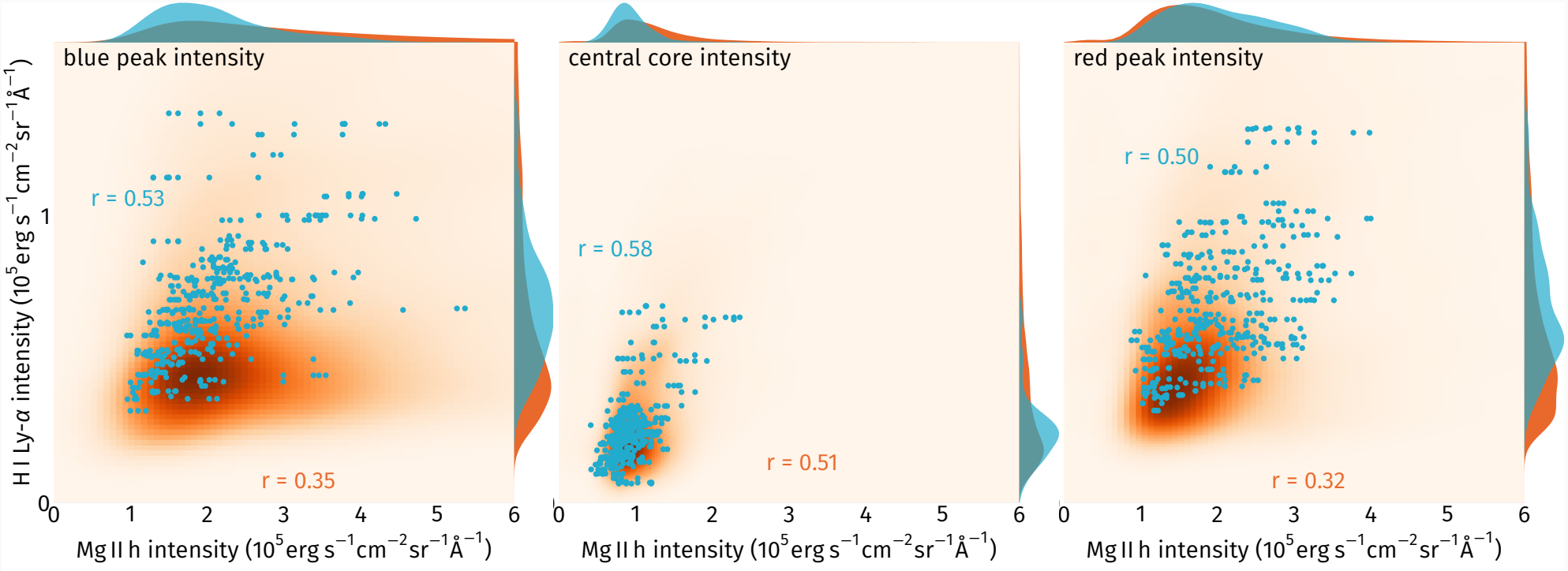


Fitted line parameters

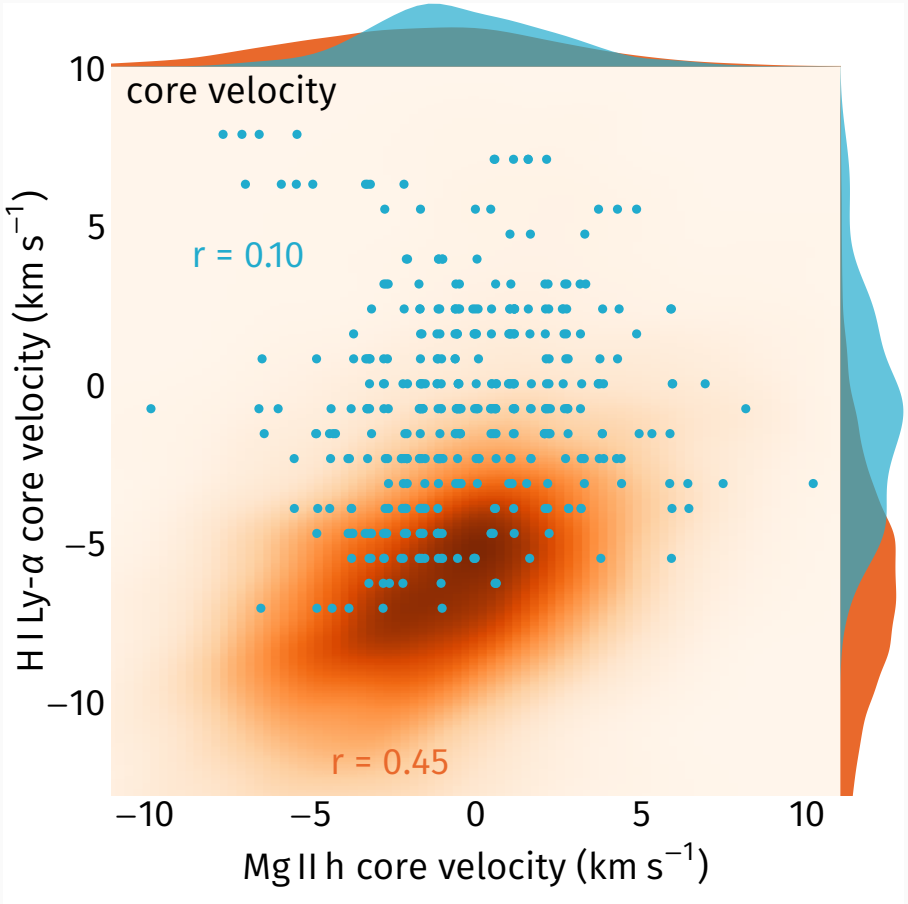


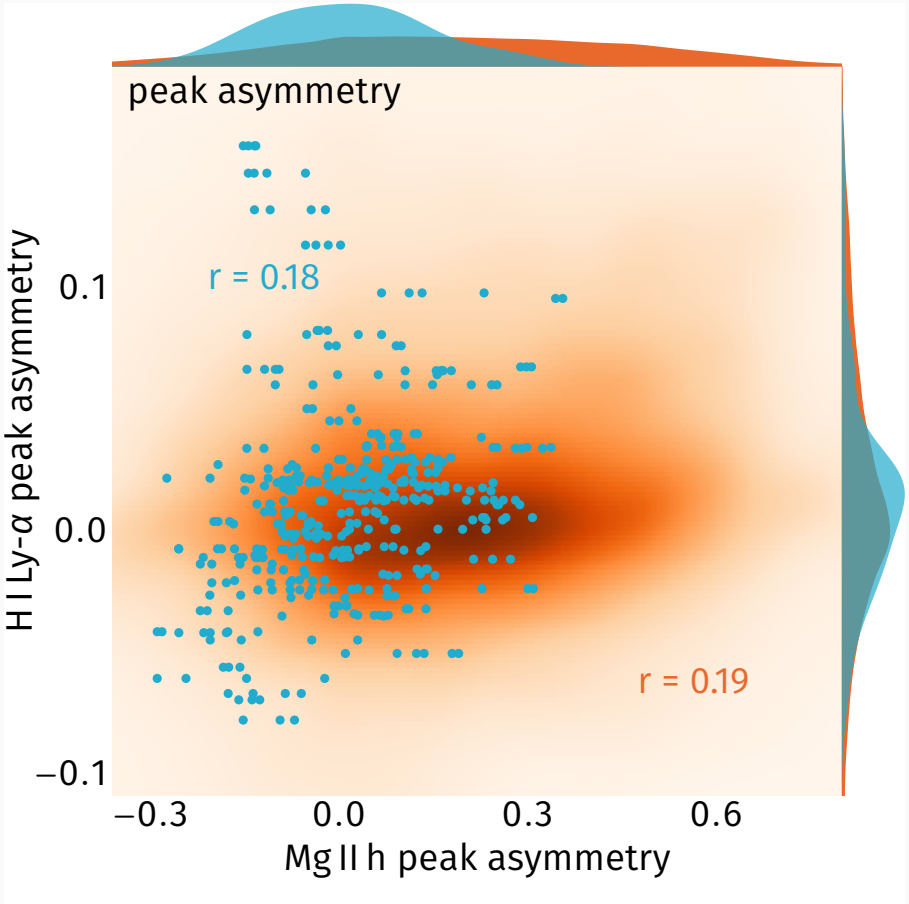
Courtesy of C. W. Bethge

2v-, 3-, 2r-intensities

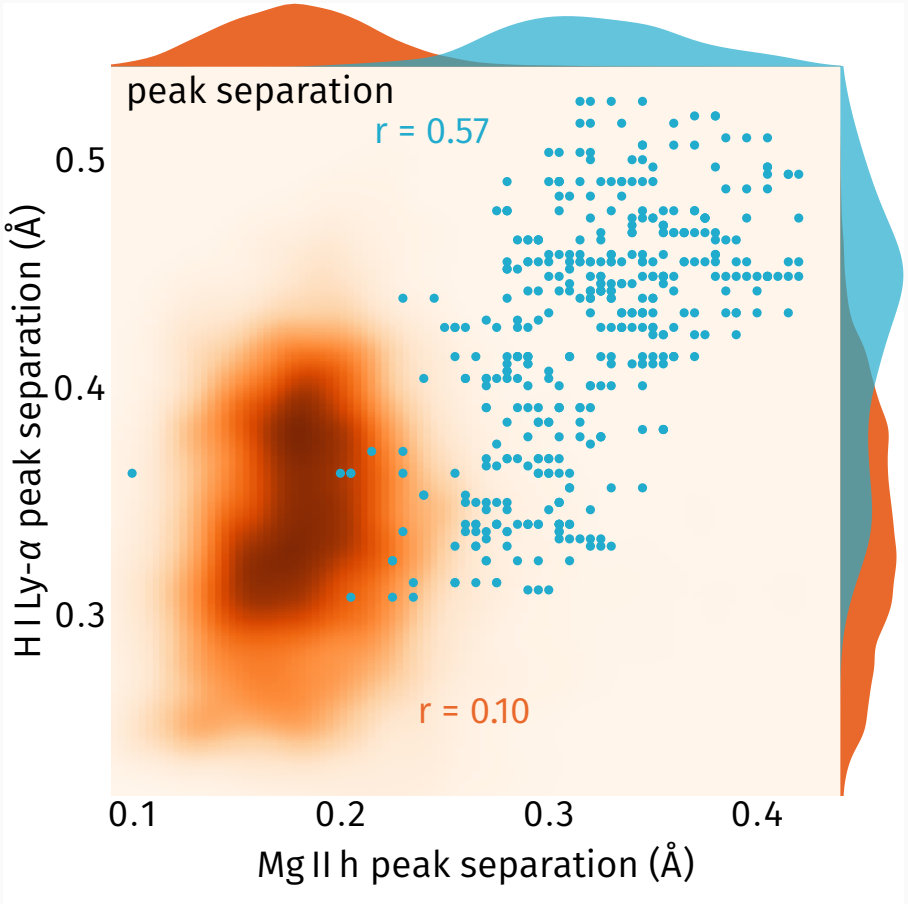


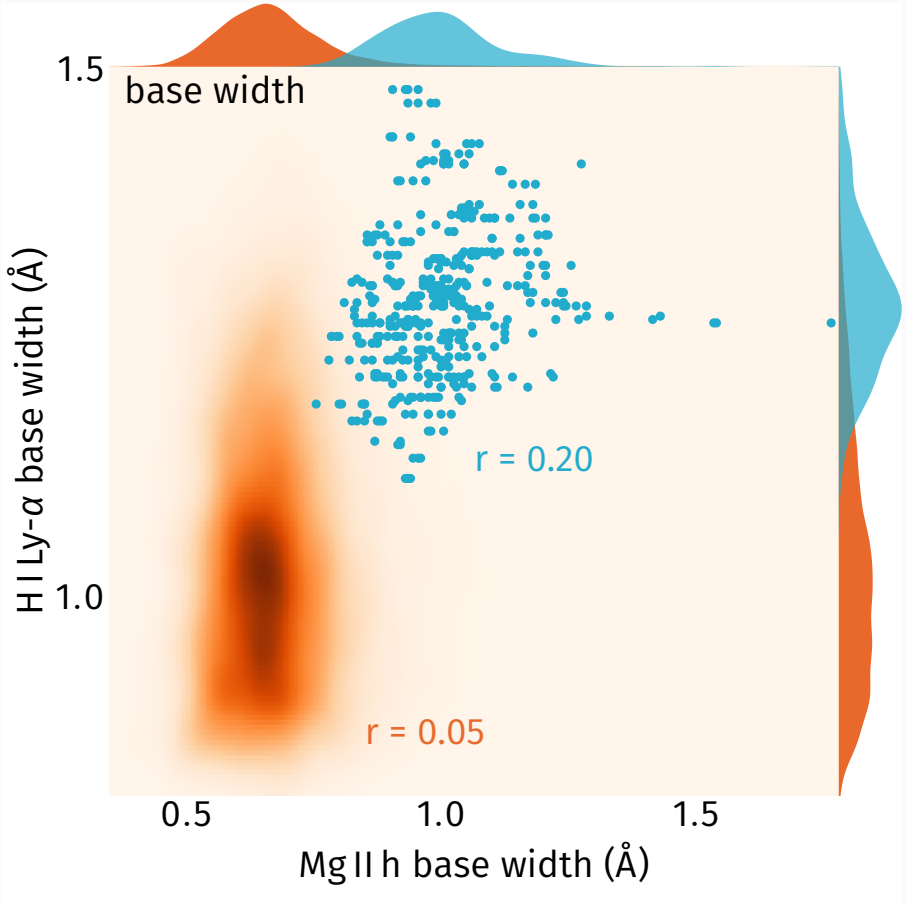
Core velocity, peak asymmetry

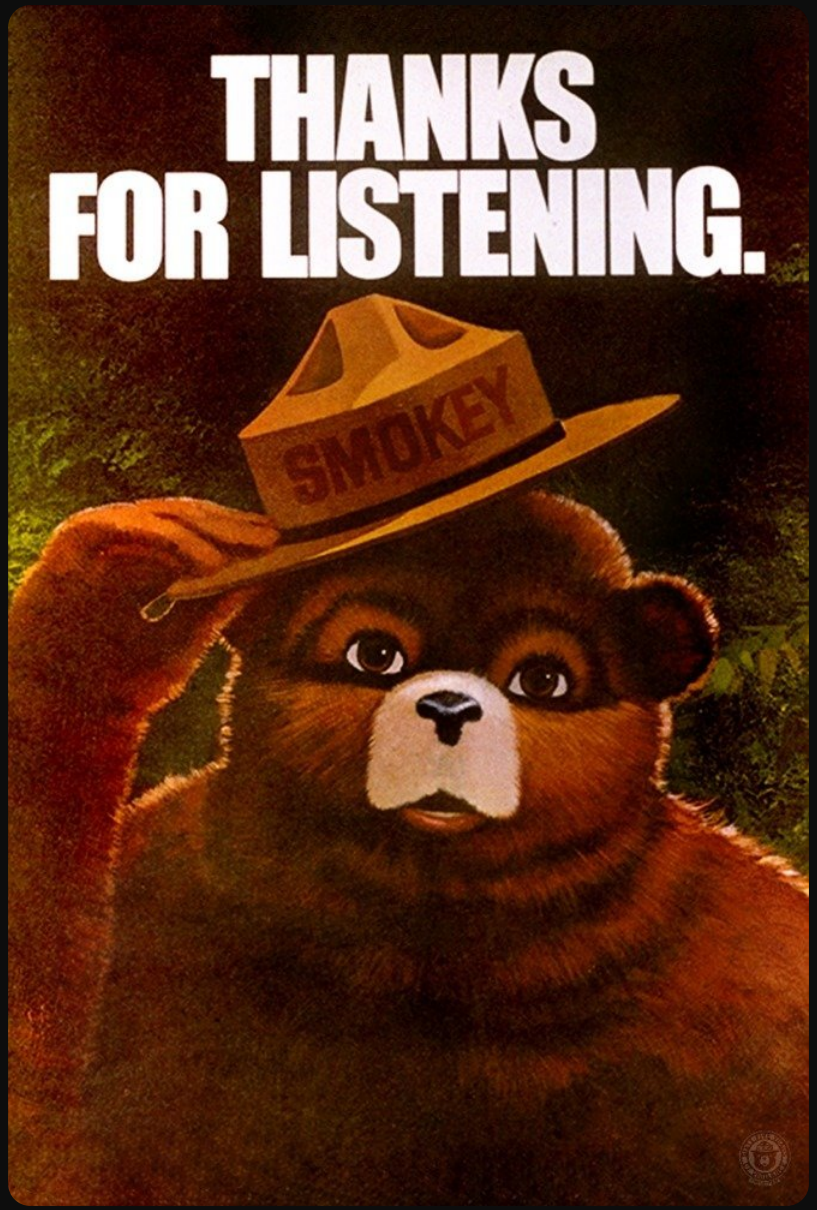




Peak-to-peak & line widths






THANKS
FOR LISTENING.
SMOKEY