First results from the He I 1083 nm spectrolarimeter at GREGOR

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and the GRIS Team#

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IRIS-6: The Chromosphere – June 20-23, 2016

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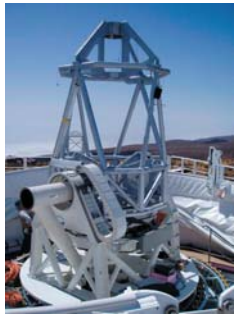
First results from the He I 1083 nm spectropolarimeter at GREGOR

GREGOR

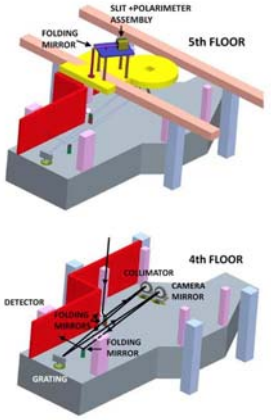


GRIS: GREGOR Infrared Spectrograph

[Collados et al., 2012, AN, 333, 872]

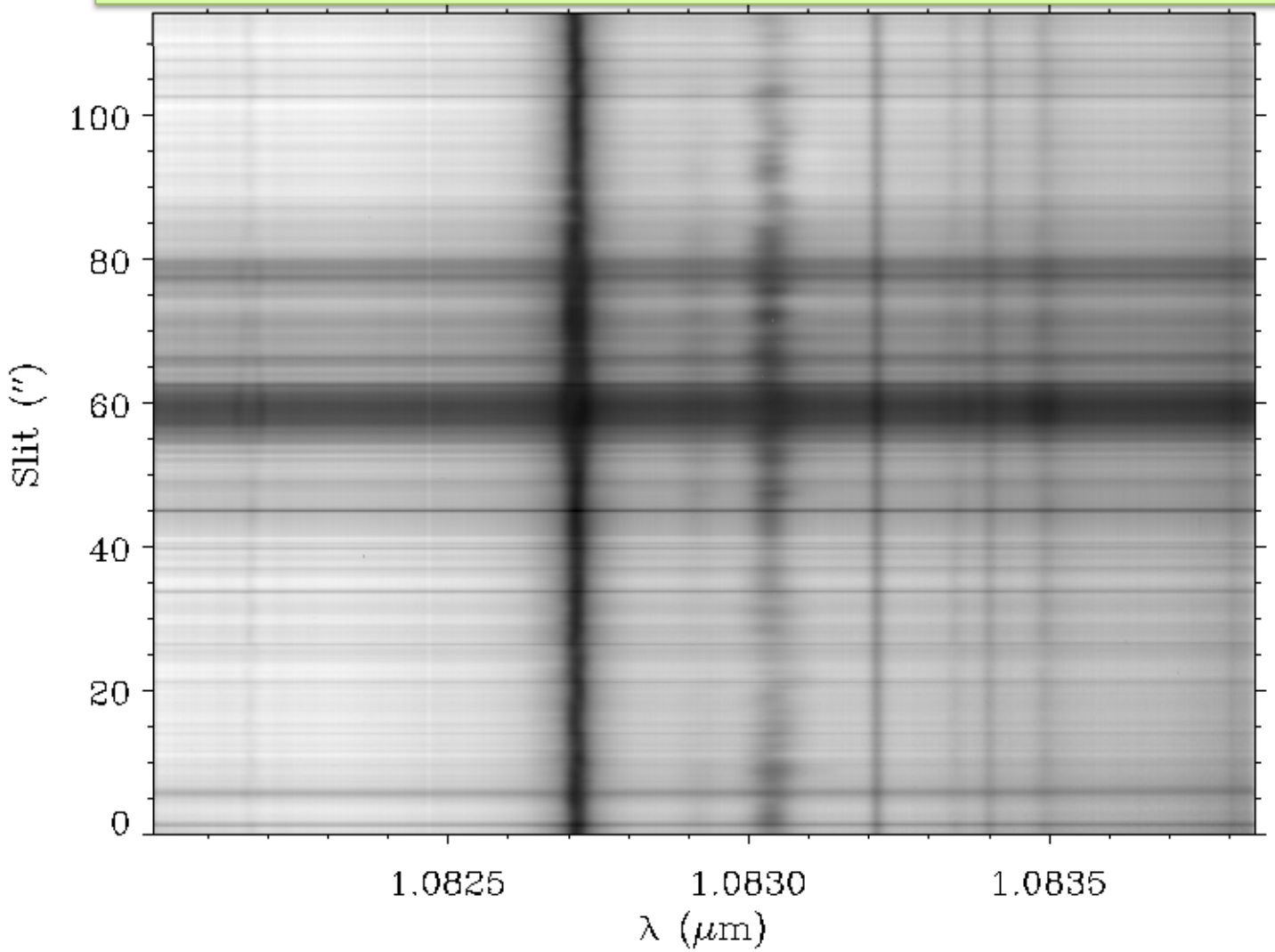
★ A standard Czerny-Turner spectrograph fed with light from a 1.5 m diameter telescope

Wavelength range:	≈ 7000 – 2300 nm
Spectral resolving power:	λ/Δλ ≈ 200,000
Field of view:	≈ 65 arcsec (slit direction)
Spatial sampling:	0.126 arcsec/pixel @ 1083 nm
Diffraction limited resolution (1083 nm)	**0,18”**

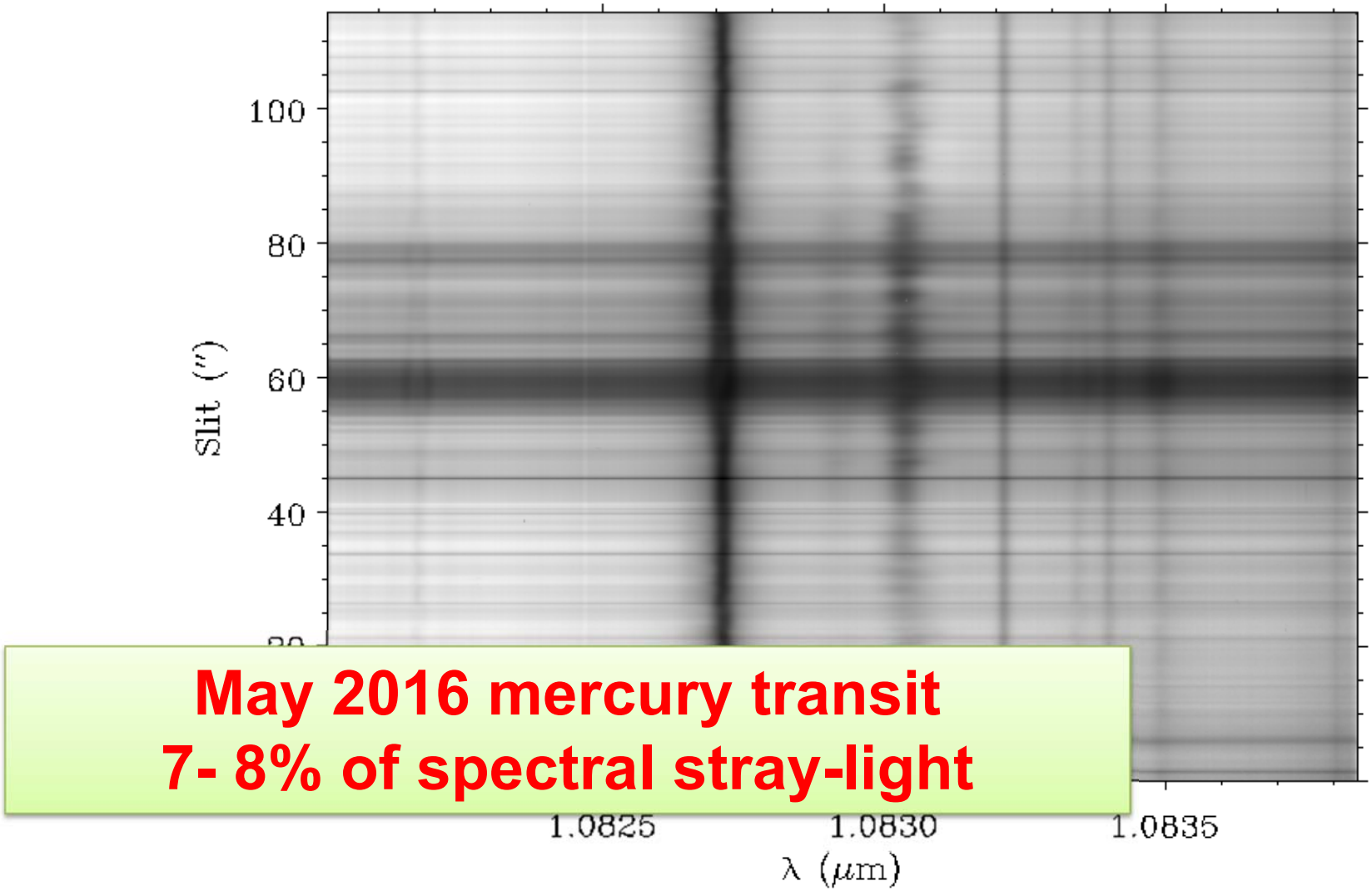


GRIS first light at the 1083 nm spectral region

First light in 2012

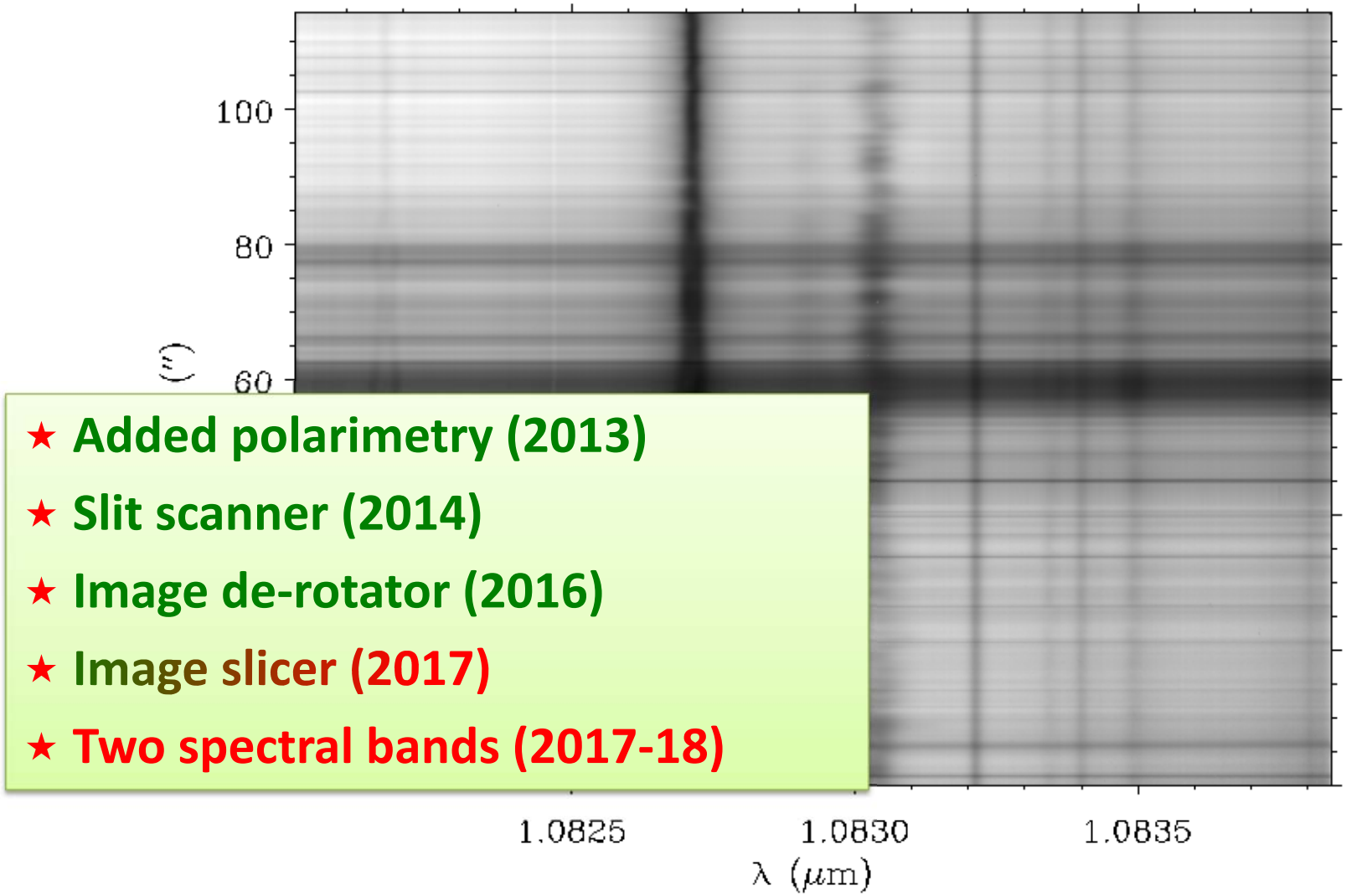


GRIS first light at the 1083 nm spectral region



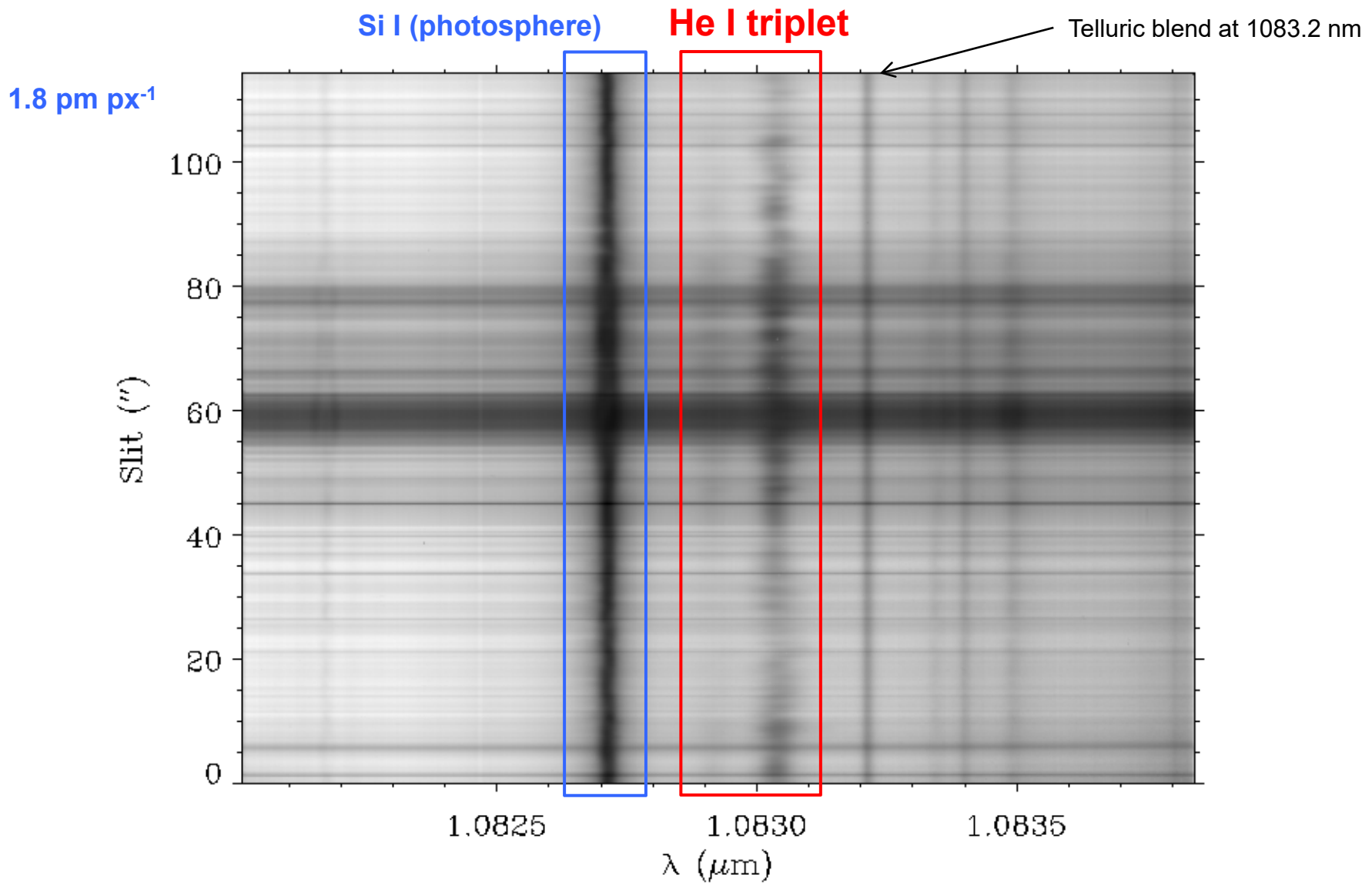
May 2016 mercury transit
7- 8% of spectral stray-light

GRIS first light at the 1083 nm spectral region

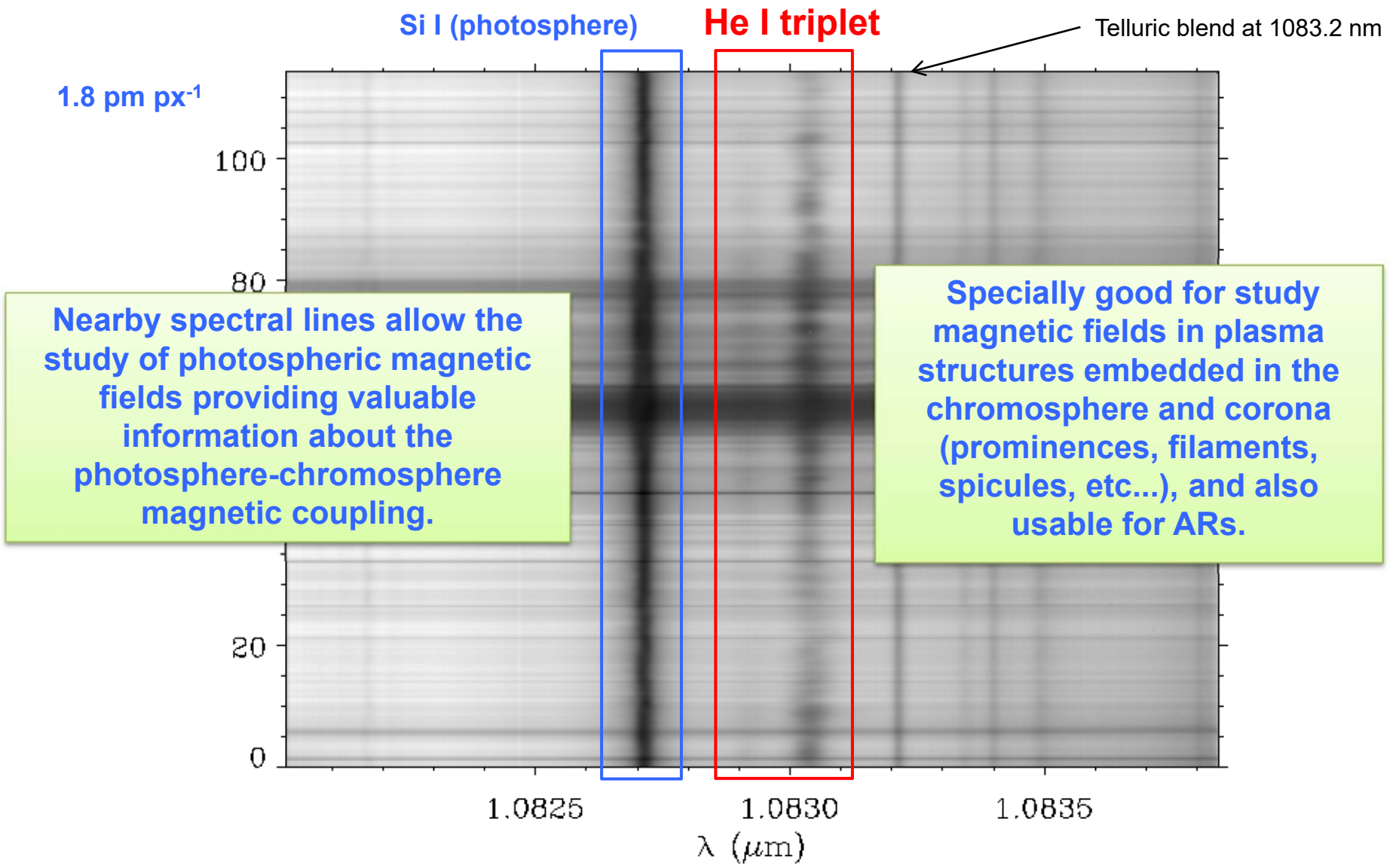


- ★ Added polarimetry (2013)
- ★ Slit scanner (2014)
- ★ Image de-rotator (2016)
- ★ Image slicer (2017)
- ★ Two spectral bands (2017-18)

GRIS first light at the 1083 nm spectral region



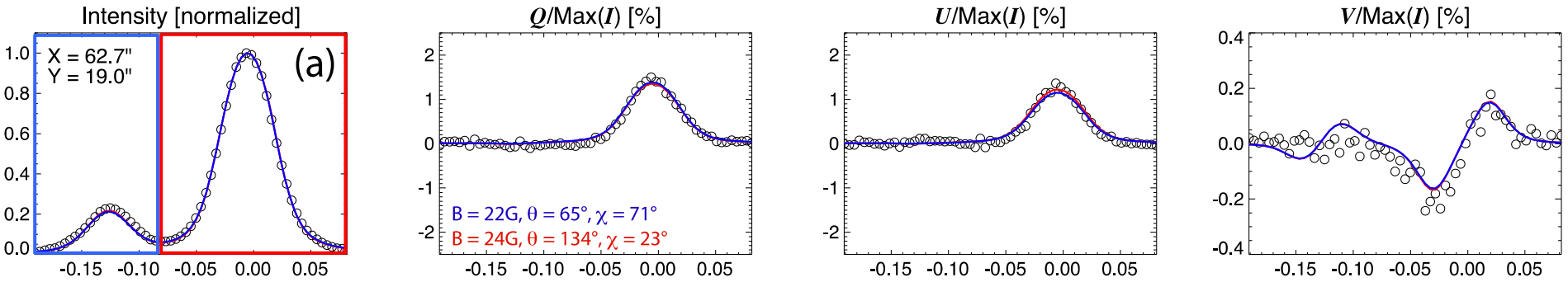
GRIS first light at the 1083 nm spectral region



Nearby spectral lines allow the study of photospheric magnetic fields providing valuable information about the photosphere-chromosphere magnetic coupling.

Specially good for study magnetic fields in plasma structures embedded in the chromosphere and corona (prominences, filaments, spicules, etc...), and also usable for ARs.

The 1083 nm multiplet line: Why He I 1083 nm?



The He I 1083.0 nm triplet is sensitive to the joint action of atomic level polarization (i.e., population imbalances and quantum coherences among the level's sublevels, generated by anisotropic radiation pumping) and the Hanle (modification of the atomic level polarization due to the presence of a magnetic field) and Zeeman effects.

Trujillo Bueno et al, 2002, Nature - Trujillo Bueno & Asensio Ramos 2007, ApJ - Based on the quantum theory of polarization (Landi and Landolfi 2004)

* The physics of the polarization in the He I 10830 Å triplet is well known and Stokes inversion of the magnetic field vector is possible

The 1083 nm multiplet line: Why Near Infrared?

- Pros:
  - Less seeing effects $r_0 = \lambda^{6/5}$
  - Larger isoplanatic patch
  - Larger Zeeman sensitivity
  - Less scattering $(\sigma/\lambda)^2$
  - Smaller instrumental polarization

- Cons:
  - Spatial resolution
  - Number of available photons

GRIS preliminary results (in 1083 nm triplet)

- GREGOR/GRIS database:
  - http://archive.kis.uni-freiburg.de/pub/gris/index.html

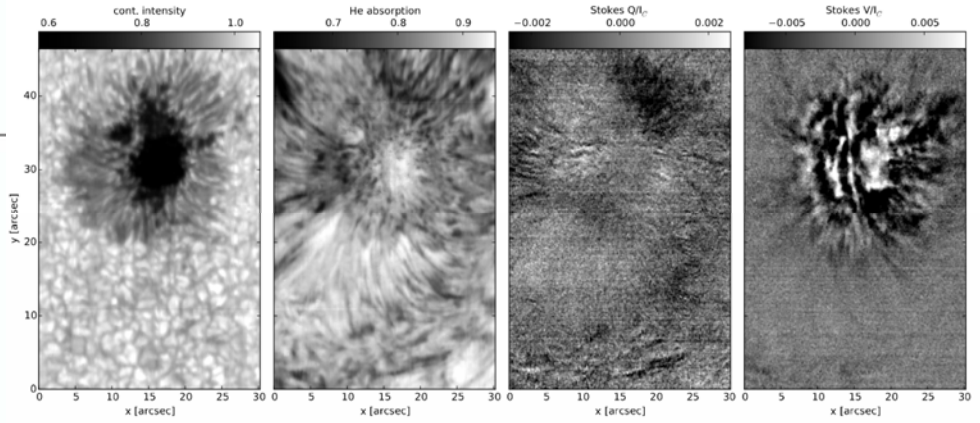
GREGOR GRIS archive

2015

April:	15	16	17	18	19	21	23	26	27	29	30							
May:	01	02	07	08	09	10	11	18	19	21	22	23	24	25	28	29	30	31
June:	01	02	03															
August:	04	06	19															
September:	08	09	10	12	13	14	15	16	17	19	20							

2014

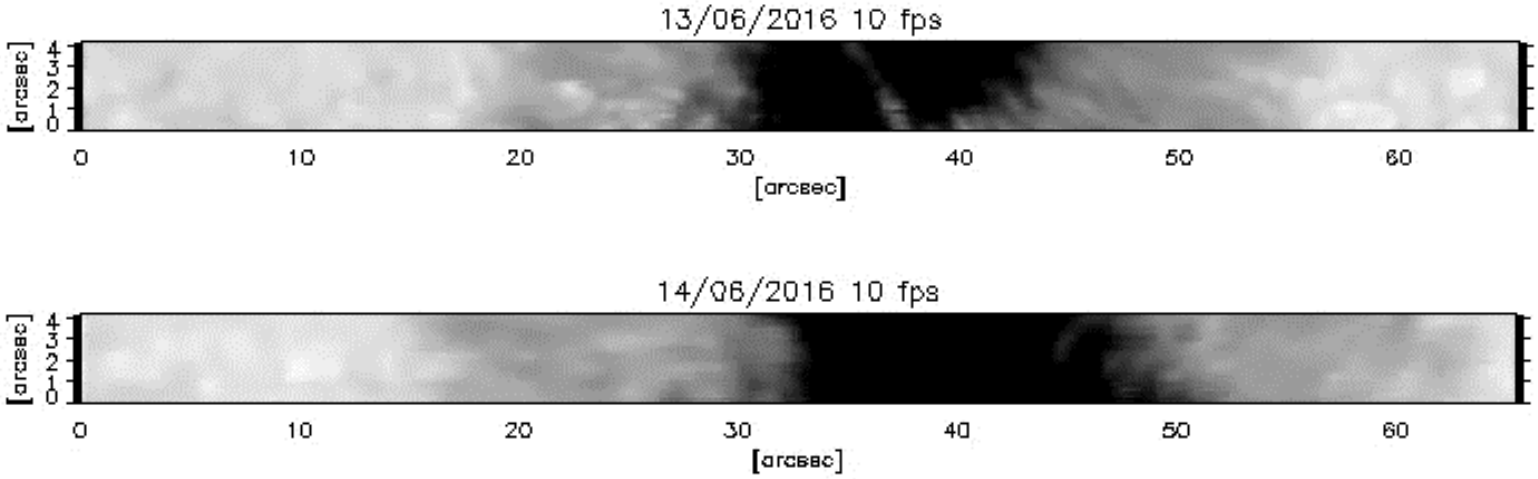
April:	26	27	28	29	30								
May:	01	02	03	05	07	08	09	10	11	12			
June:	17	18	19	20	21	22	23	24	25	26	27	28	29
July:	01	02	03	05	08	09							
September:	02	03	04	05	08	10	11	13	17	18	20	22	23



color coding: 1083 nm data 1565 nm data multiple and/or other wavelength regions within an observing day
format coding: at least one spectropolarimetric dataset *spectroscopic data only*

Spectroscopic data

- GRIS@GREGOR is able to scan very fast a small solar region
- For reference, it takes **10 seconds** to scan a 4”x75” area: 30 slit positions with a 0.135” pixel scale.
- New window for science: He I 1083 nm dynamics



DATA TAKEN LAST WEEK

Spectroscopic data

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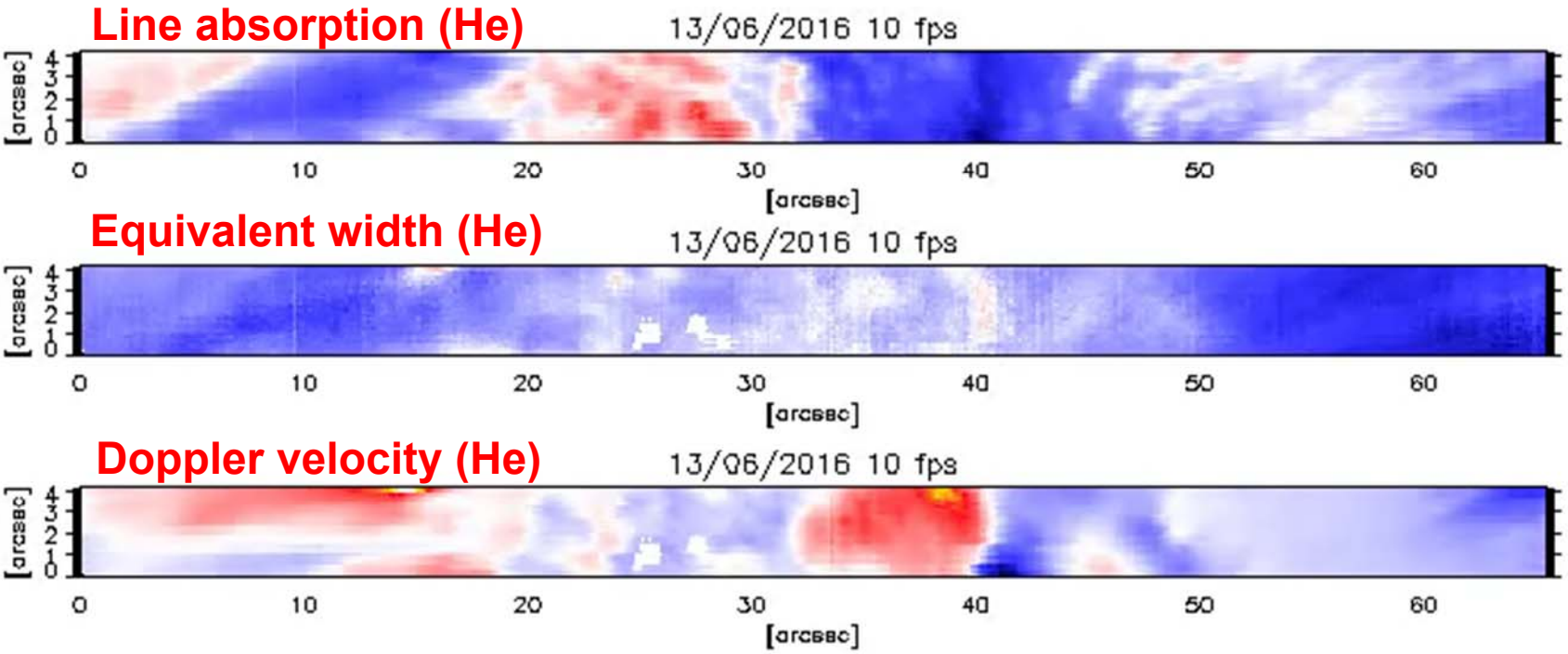

DATA TAKEN LAST WEEK

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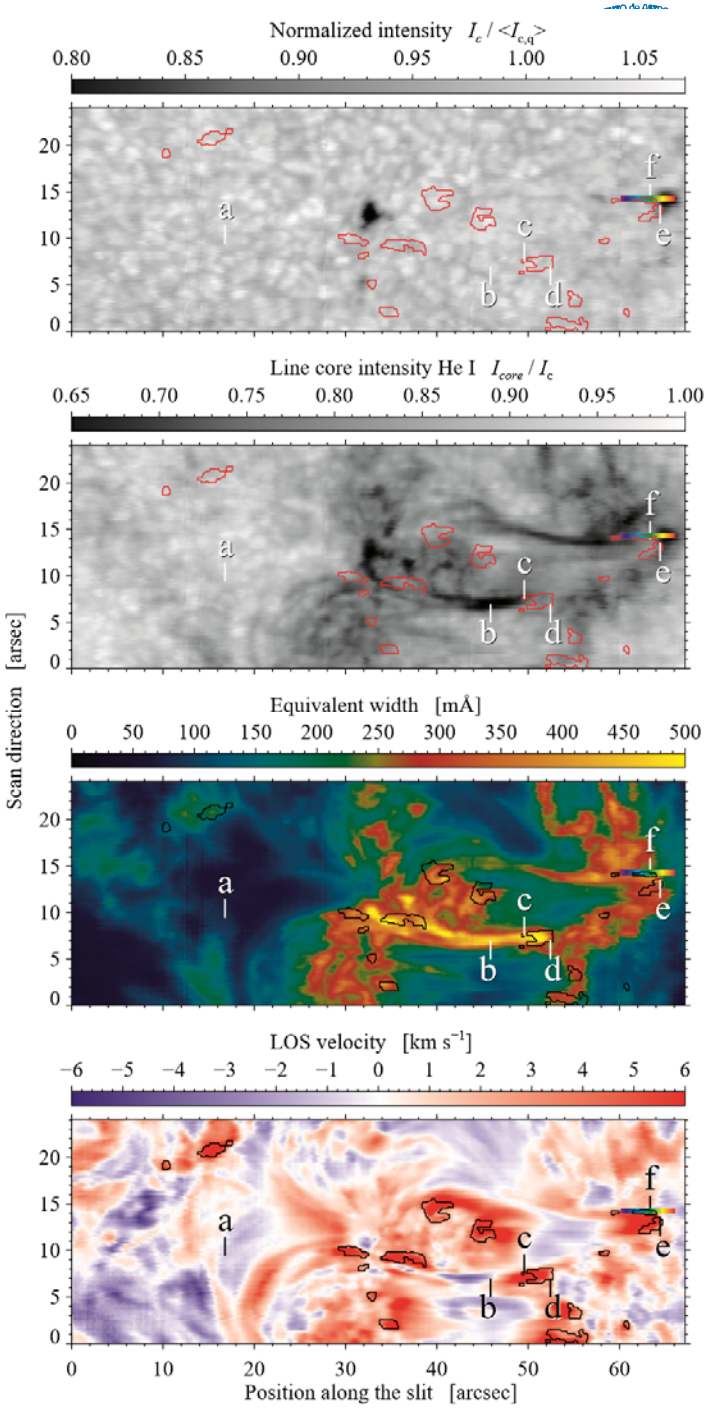
Filament data

- ★ S.J. González Manrique et al., 2016, AN
- ★ Data taken in very fast spectroscopic mode (1 minute cadence)
- ★ Describe a new technique to fit He I 1083 nm profiles when they are blended
- ★ They find **supersonic downflows velocities up to 32 km s^{-1}** in the footpoints of a small filament with a mean of 16 km s^{-1}



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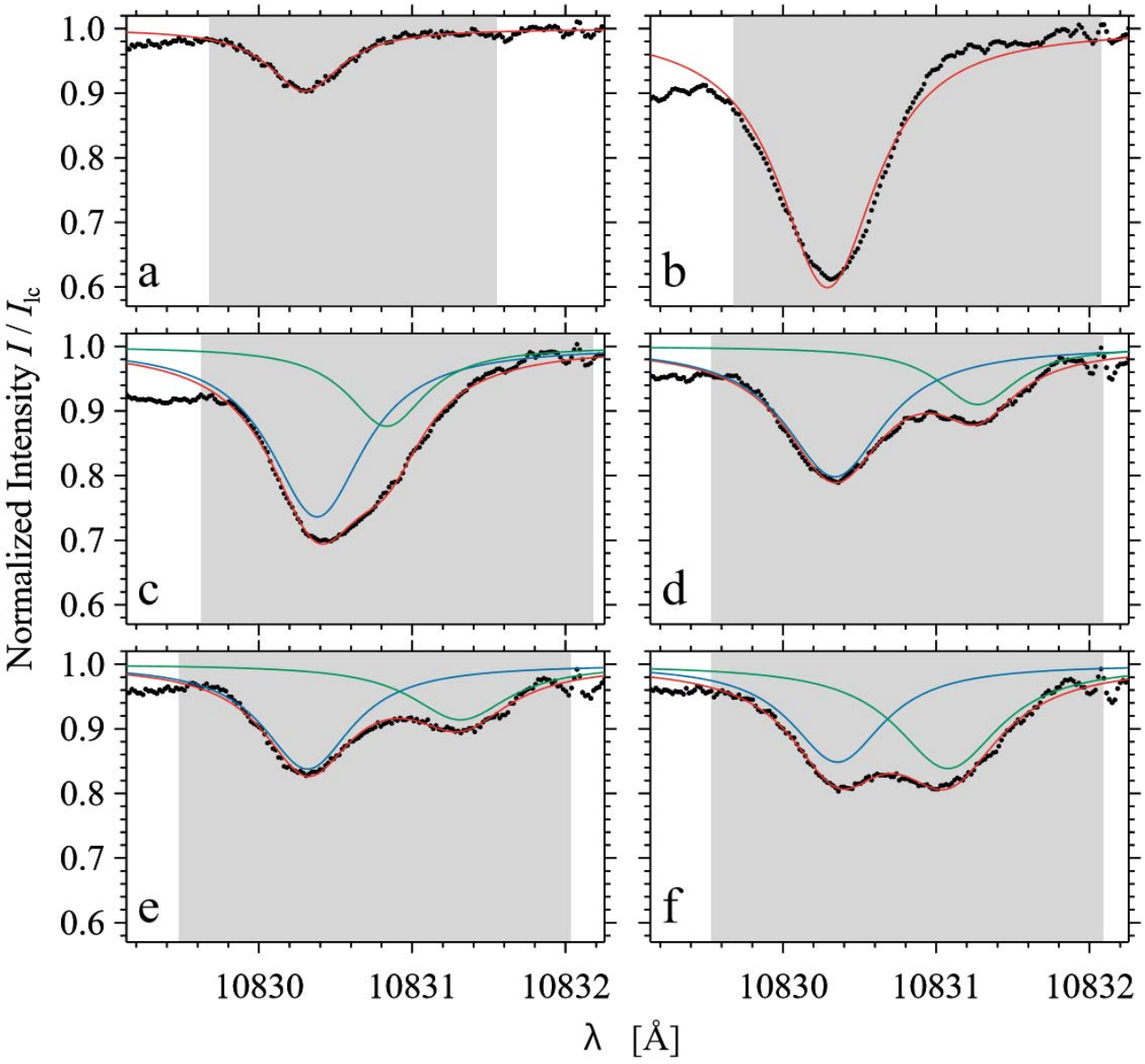

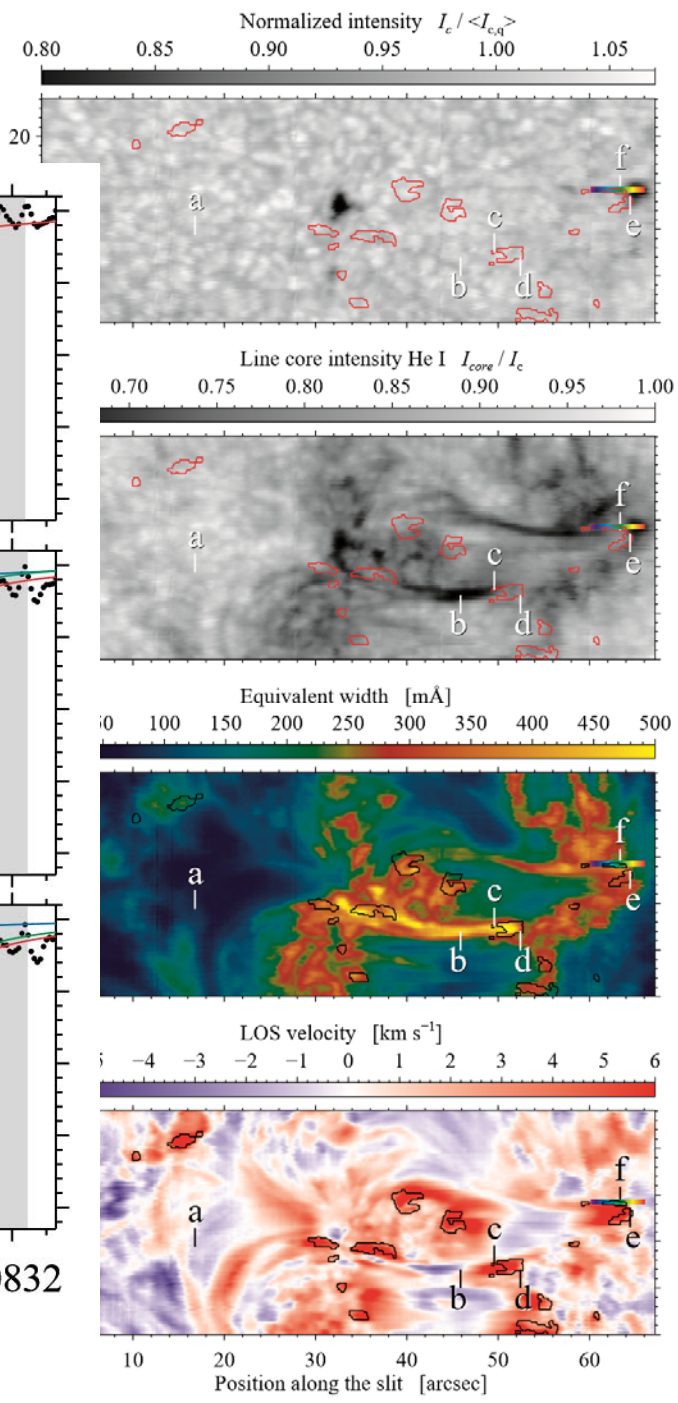

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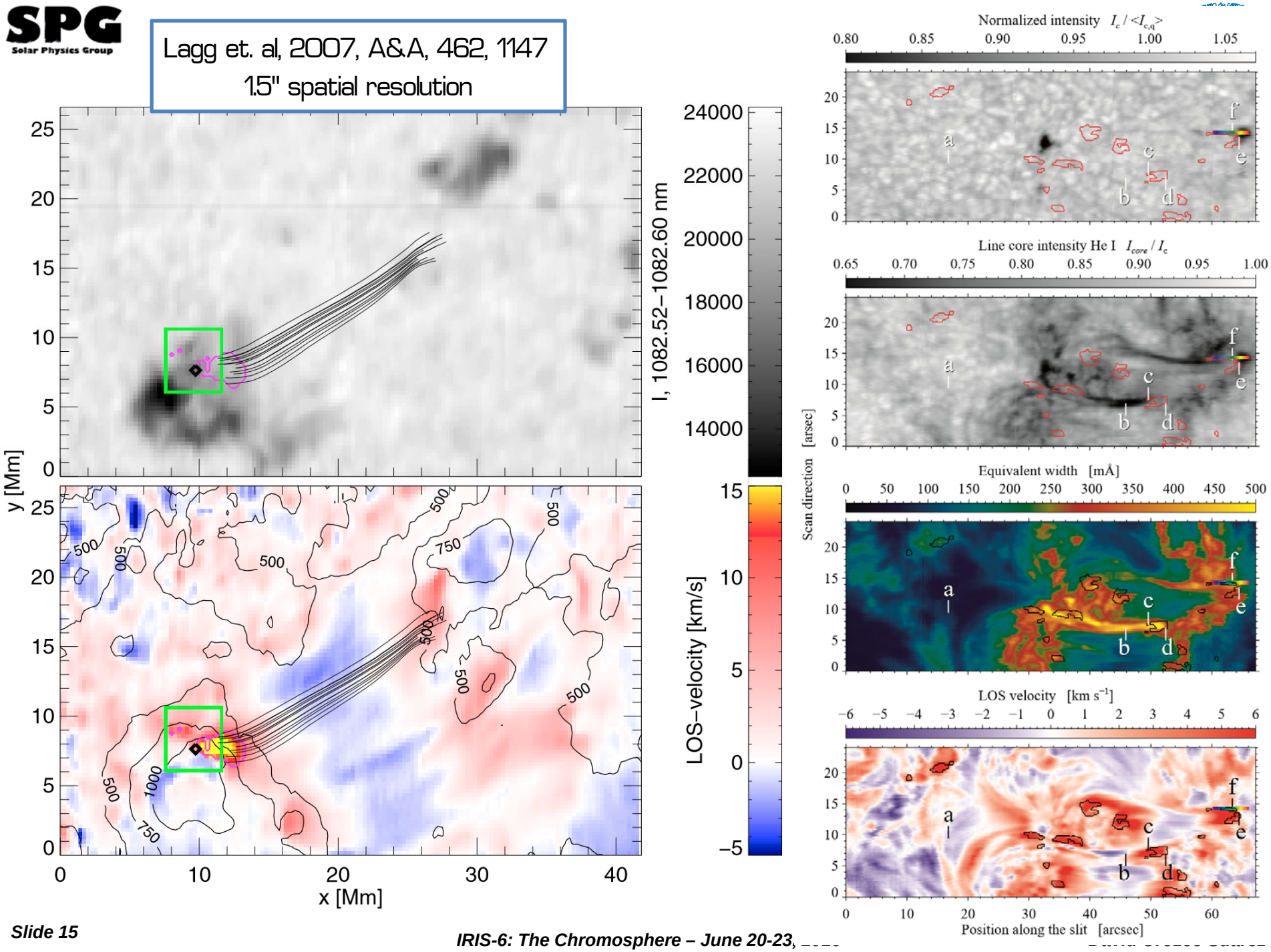
Lagg et. al, 2007, A&A, 462, 1147
1.5" spatial resolution



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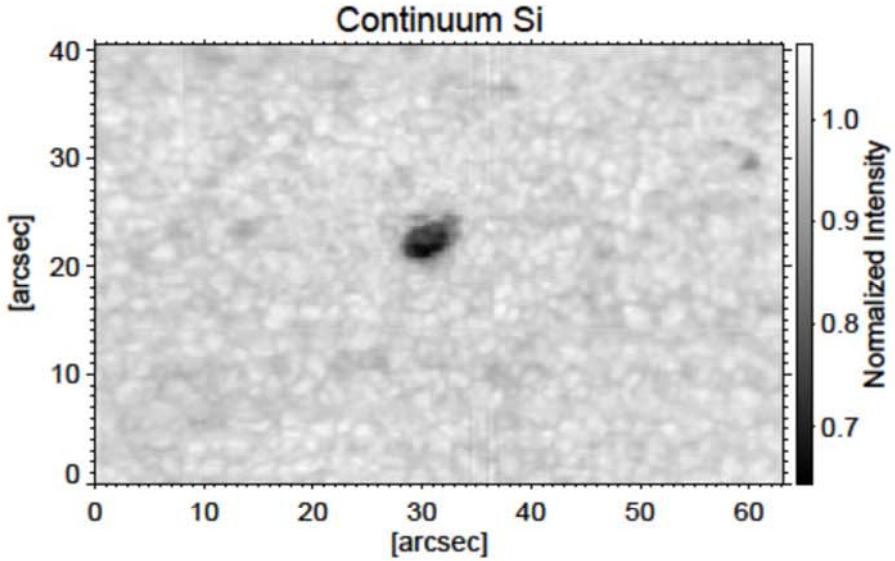
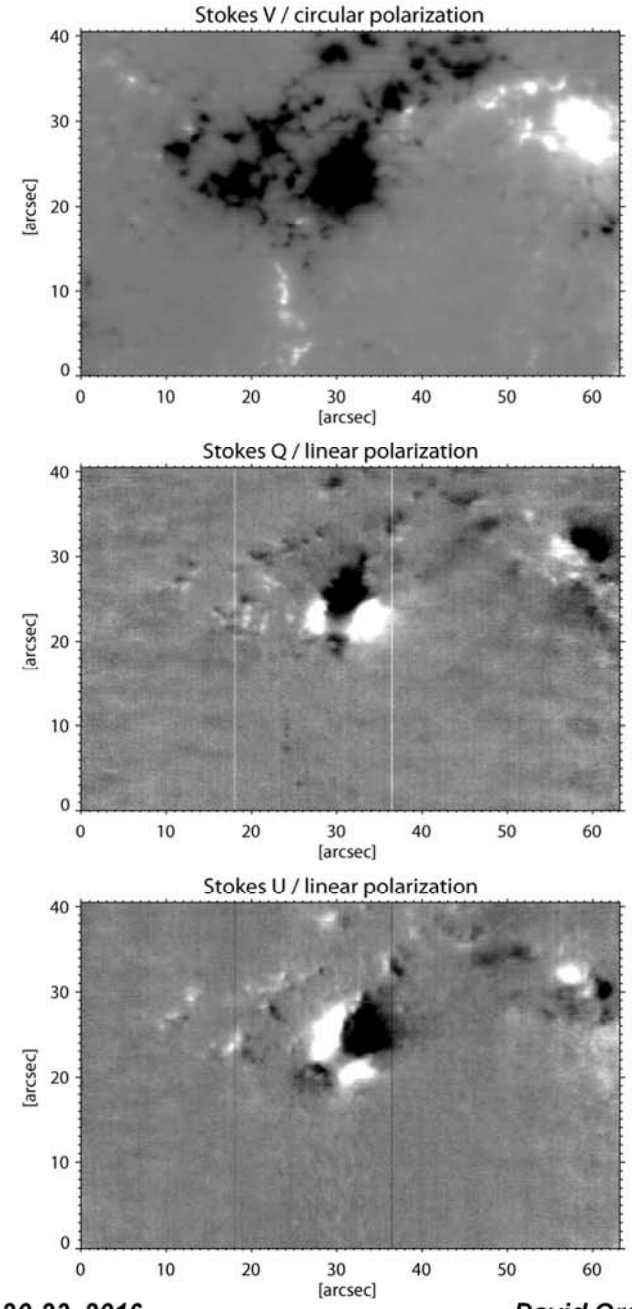
Spectropolarimetric data: PORES

- Polarimetry with a signal-to-noise above 1000



Si 1082.9 Line



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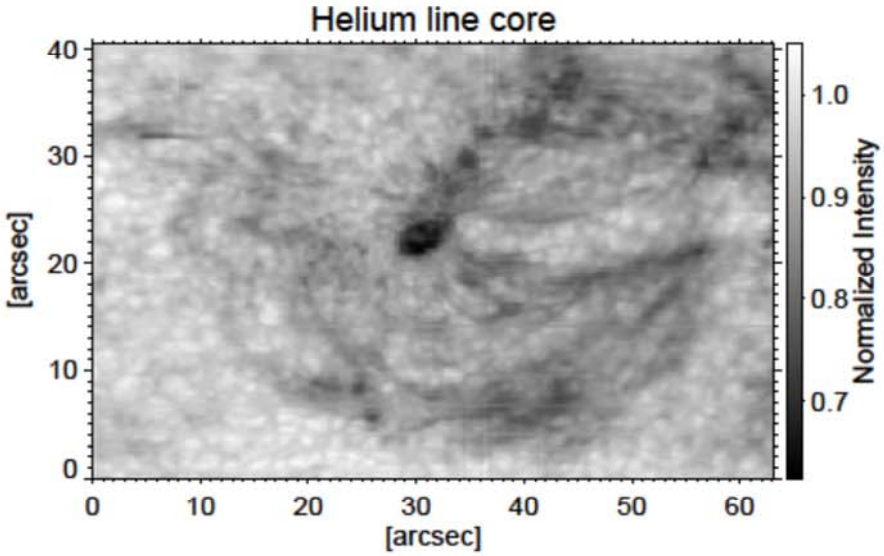
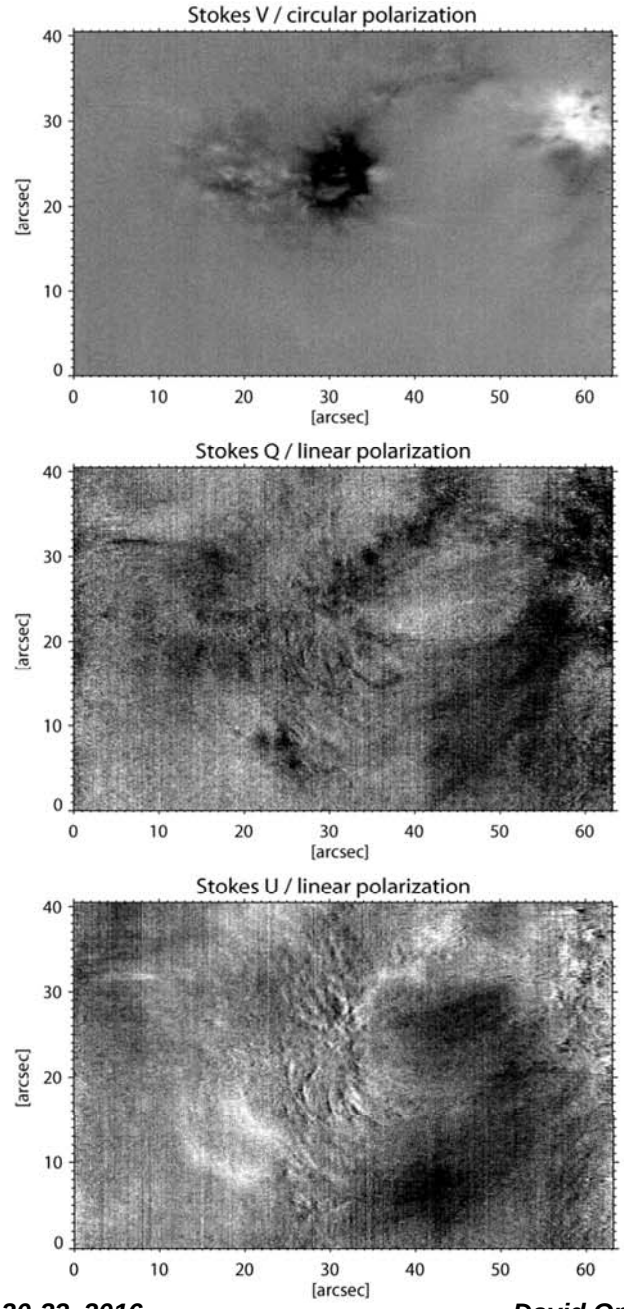
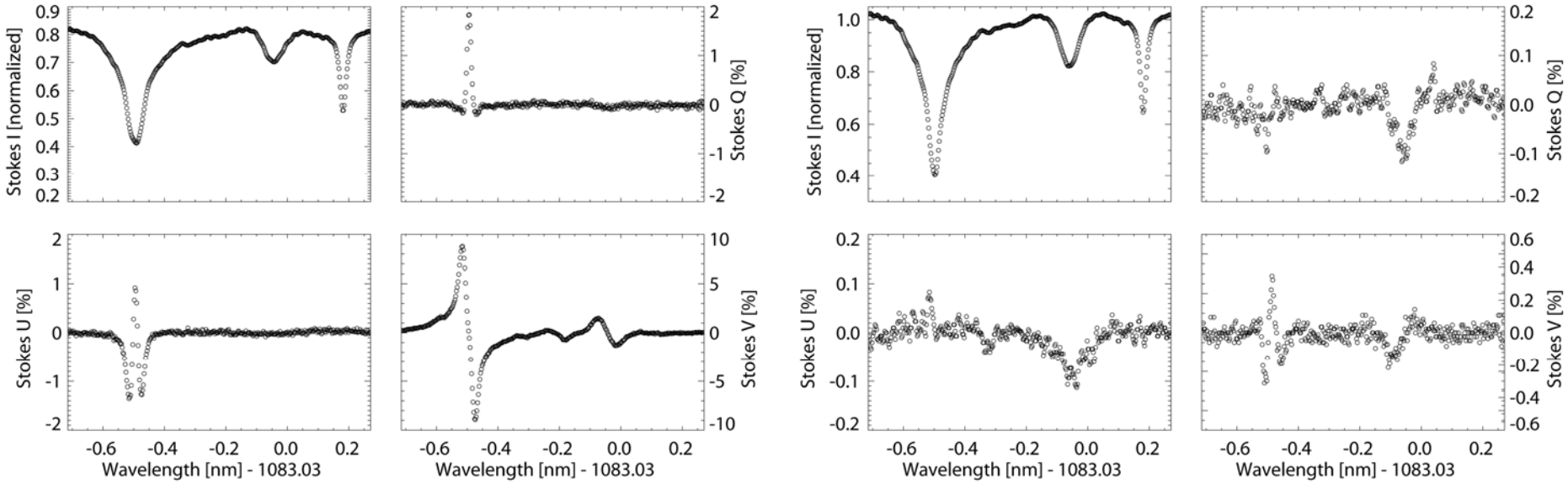


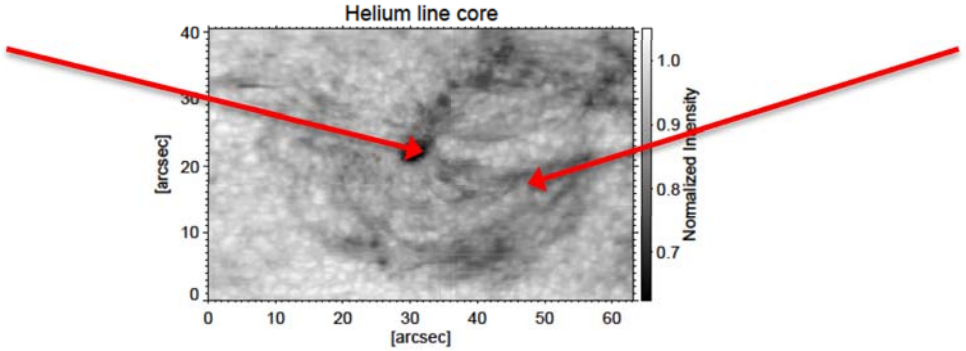
He I 1083.0 triplet



Spectropolarimetric data: PORES

- ★ Simultaneous photospheric and chromospheric information





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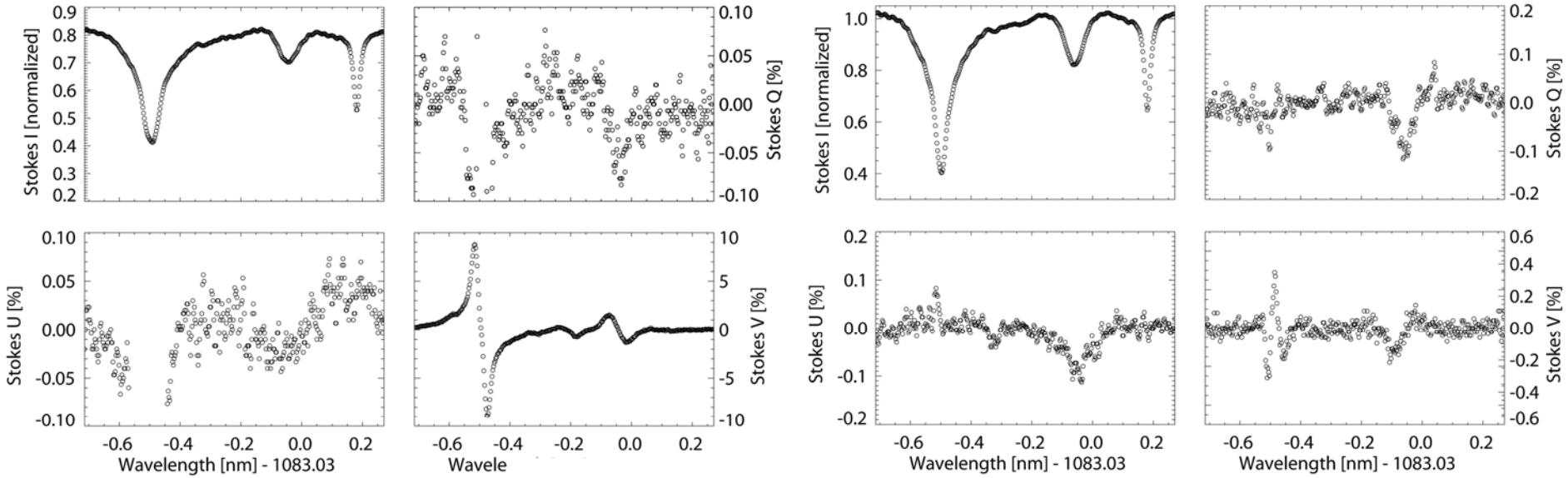
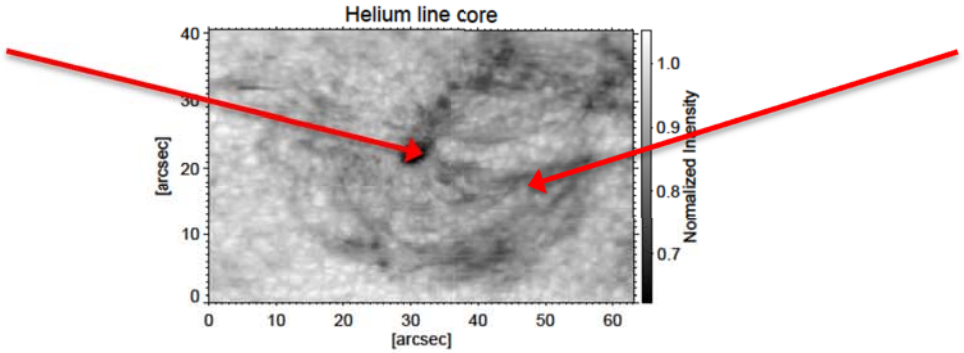
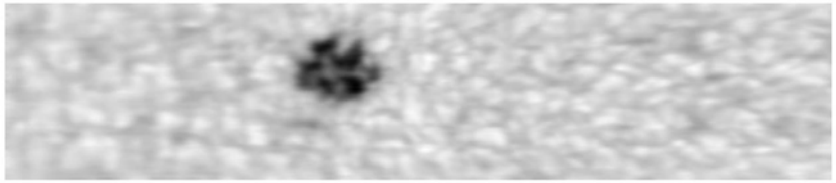




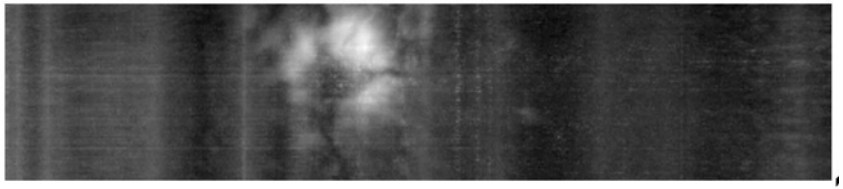
Spectropolarimetric data: PORES

- High-resolution fine structure of small pores

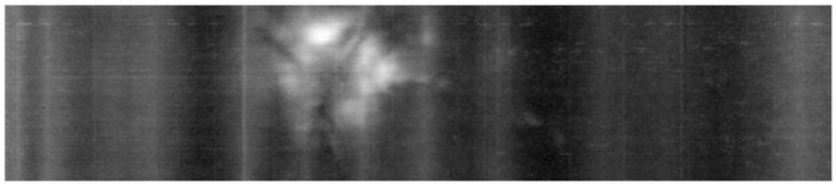
Stokes I



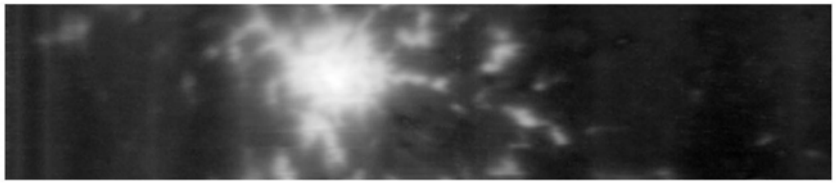
Stokes Q



Stokes U



Stokes V

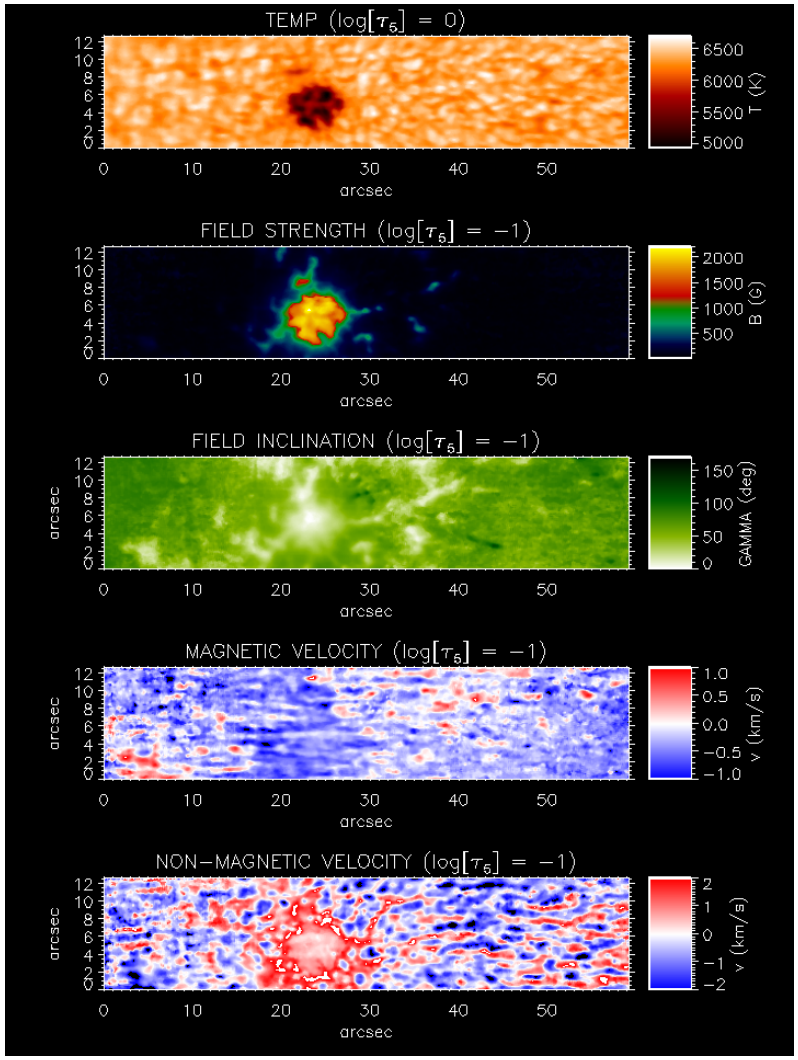


Collados, M., et. al, 2016, in prep

- 100 ms integration time
- 20 Accumulations
- 100 slit steps 59”x12.6”

Spectropolarimetric data: PORES

- High-resolution fine structure of small pores



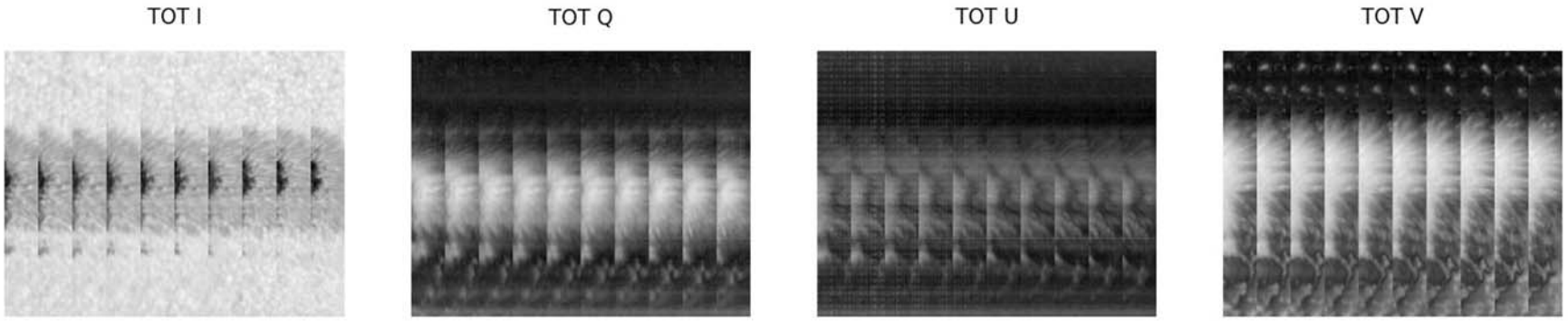
Collados, M., et. al, 2016, in prep

- The pores are formed by intense magnetic small nuclei with a diameter of 0.5-1 arcsec
- Larger field strengths are accompanied by smaller temperaturas
- The fine structure is not detected in magnetic field inclination
- Upflows are observed (~400 m/s small pore, ~100 m/s medium-sized pore) with a dispersion of ± 200 m/s, unrelated to magnetic field fluctuations
- The magnetic fine structure of the small pore tends to disappear with height

Spectropolarimetric data: SUNSPOTS

- J. Joshi et al., 2016, A&A, submitted (Monday talk)

- 1083 nm high spatial resolution observations of sunspot penumbra: 0.35” (0.135” pixel size).
- Give the possibility to infer the vector magnetic field simultaneously in the photosphere and in the chromosphere.
- First direct comparison of the small scale variations of the chromospheric and photospheric field in a sunspot penumbra.



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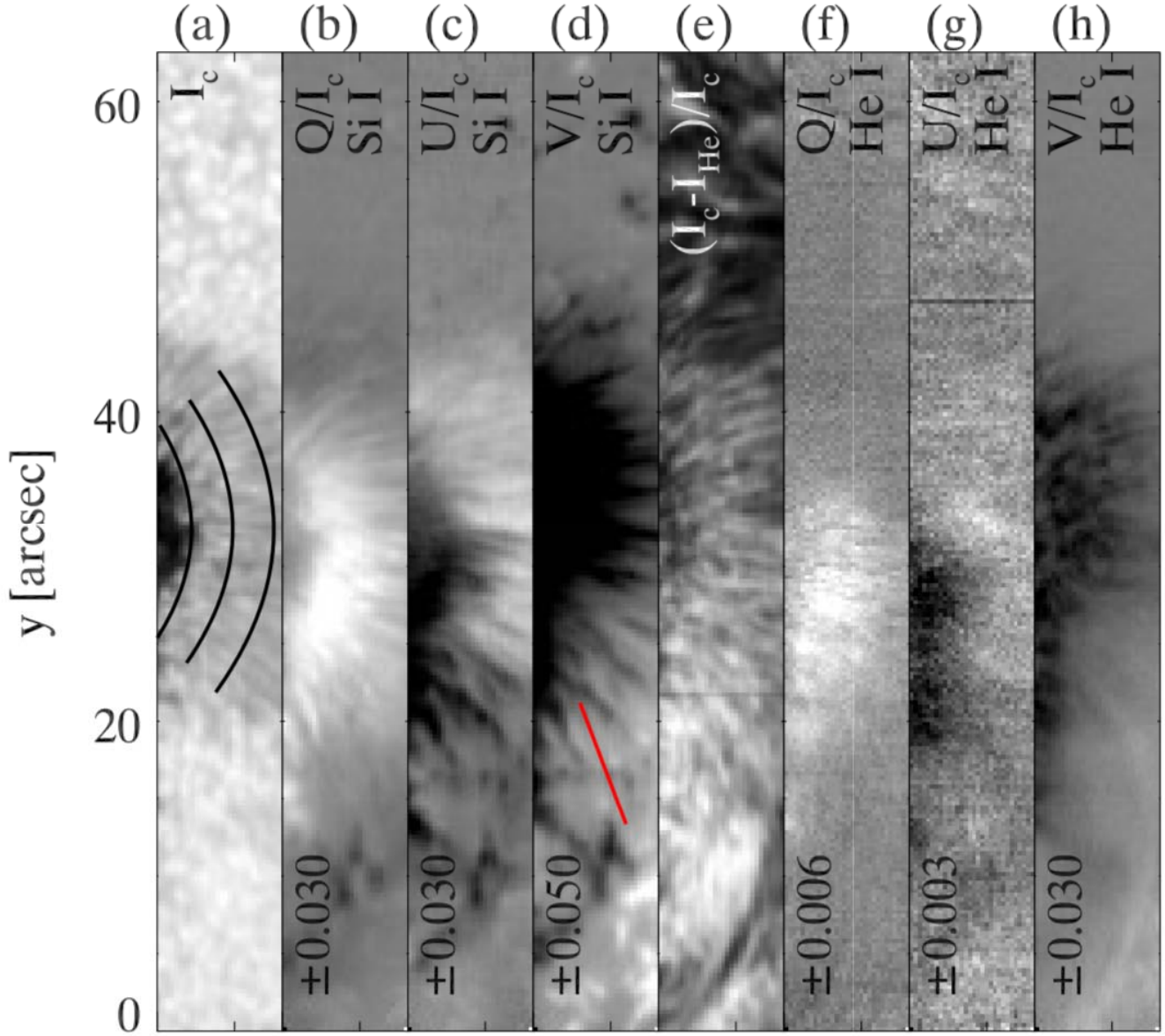

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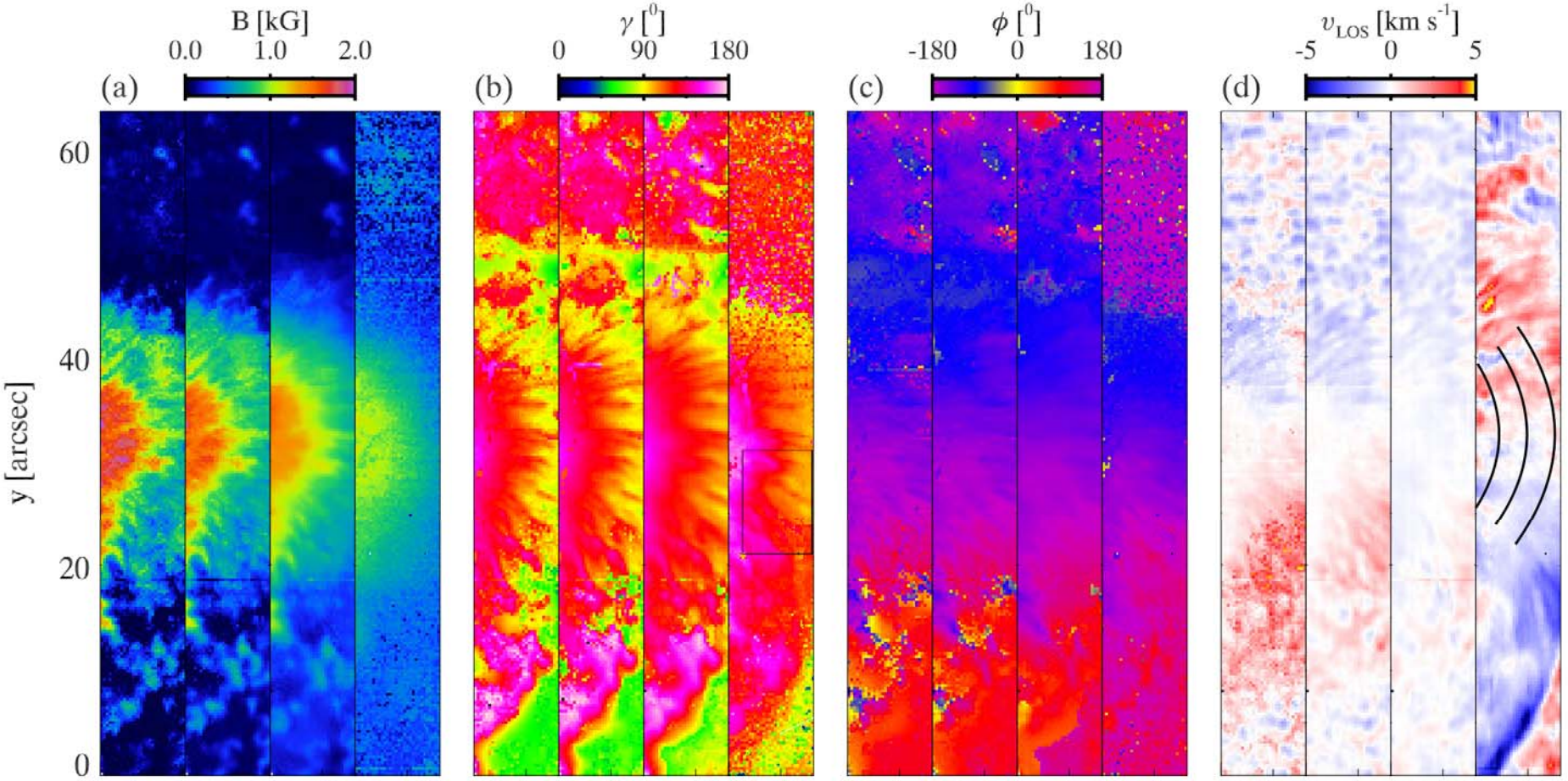
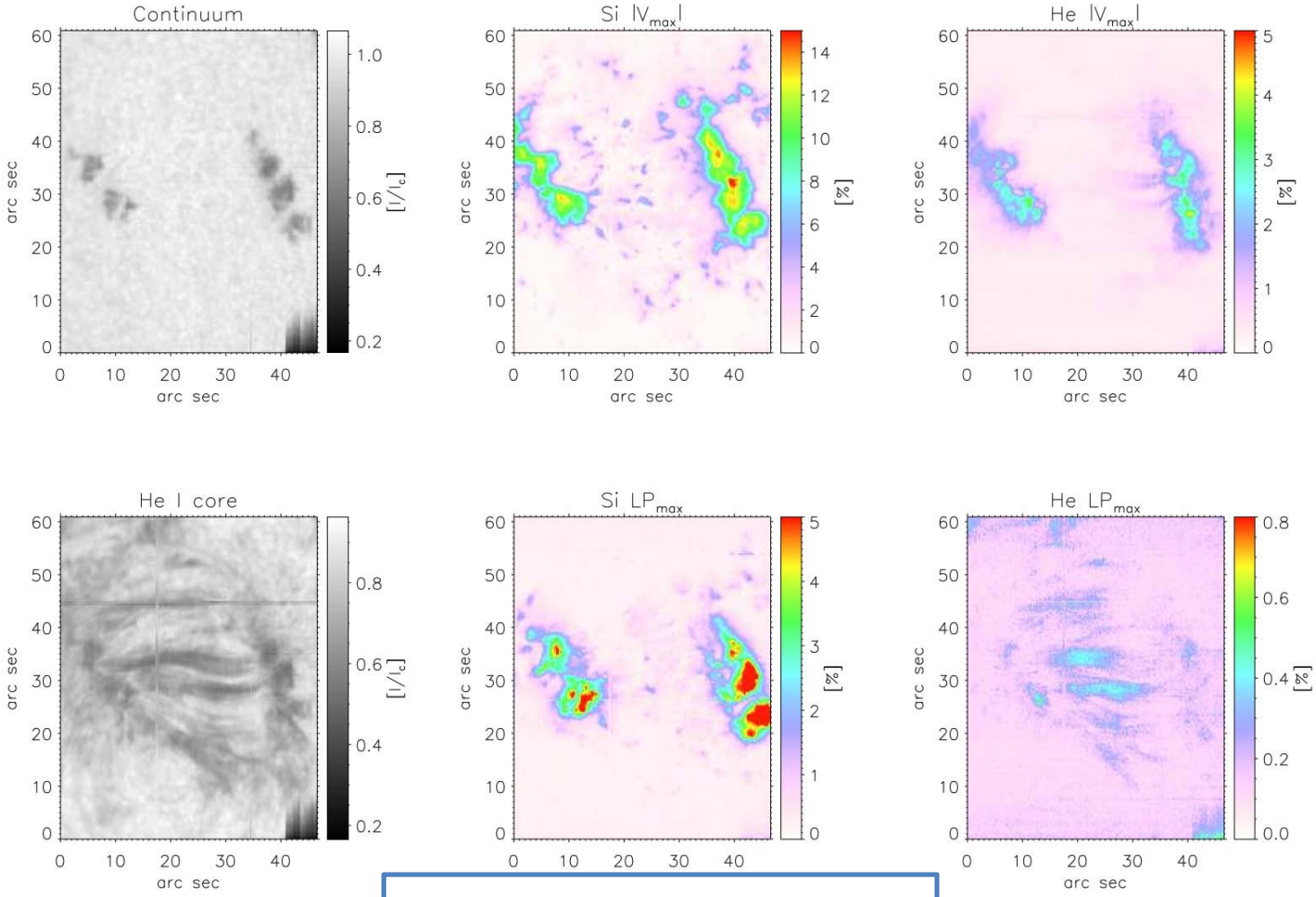
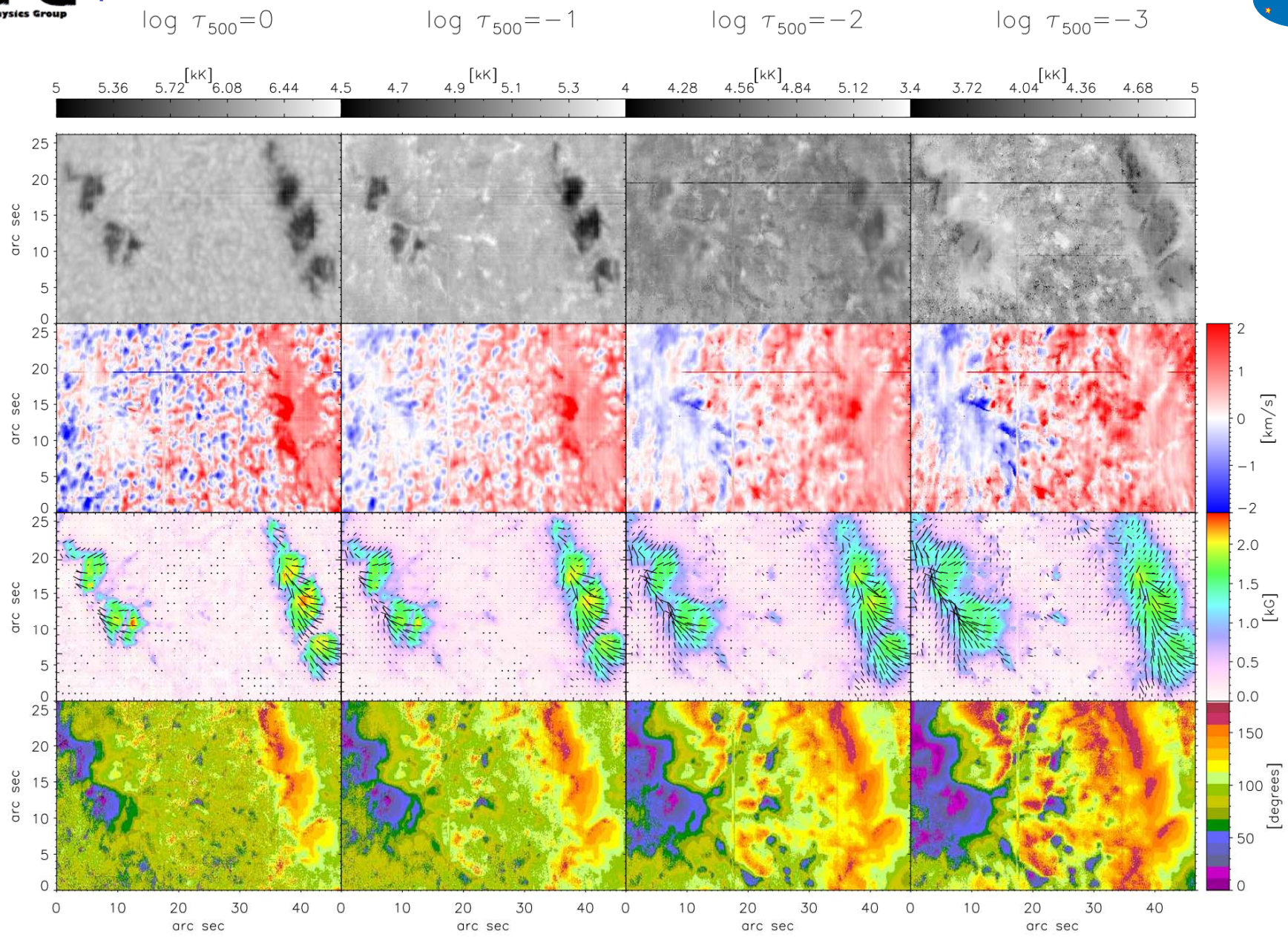


Spectropolarimetric data: Active Regions

★ Observation of an Active Region with normal seeing

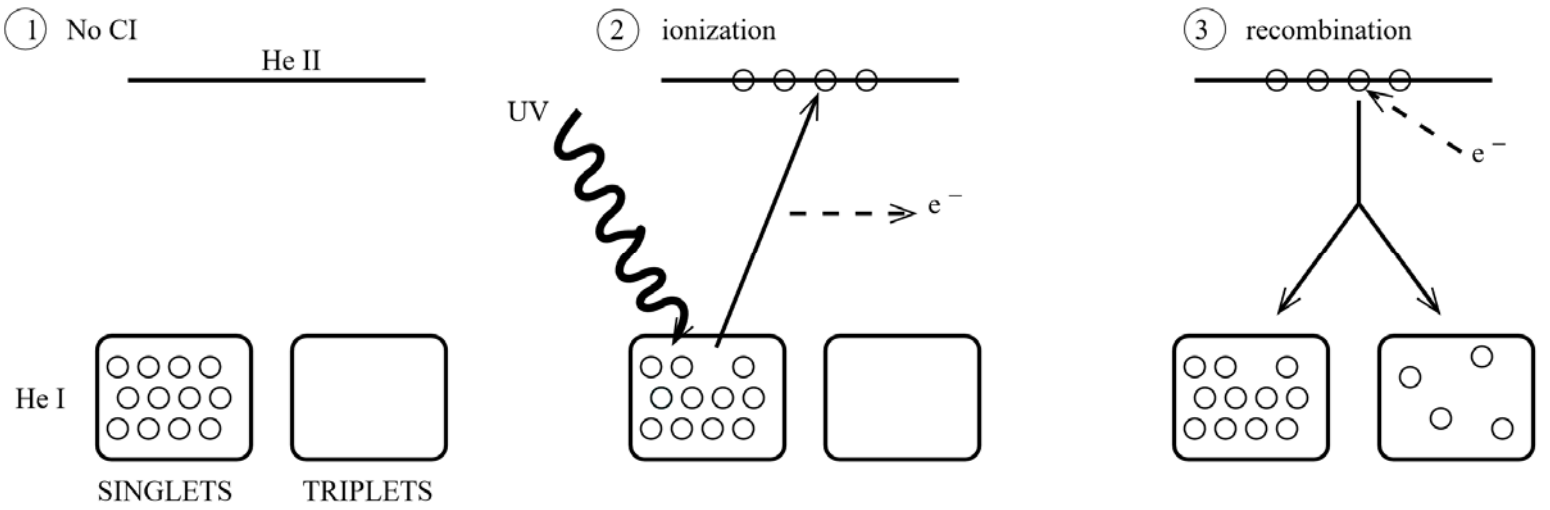


Quintero Noda et. al, 2016, in prep.

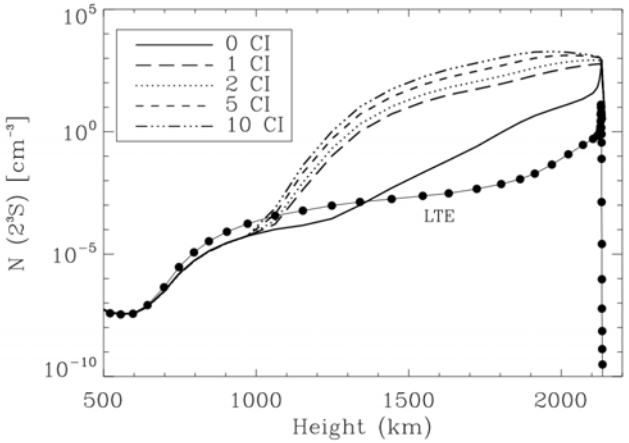

log τ_{500}=0
log τ_{500}=−1
log τ_{500}=−2
log τ_{500}=−3
[kK]
arc sec
[km/s]
[kG]
[degrees]

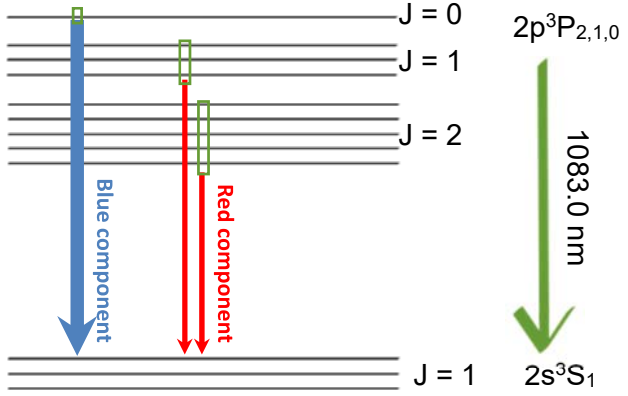
The romance between He I 10830 triplet and The EUV irradiation

- **Fundamental mechanisms for the population of the energy levels in the Helium triplet**



Centeno et. al, 2007, ApJ, 666, 137

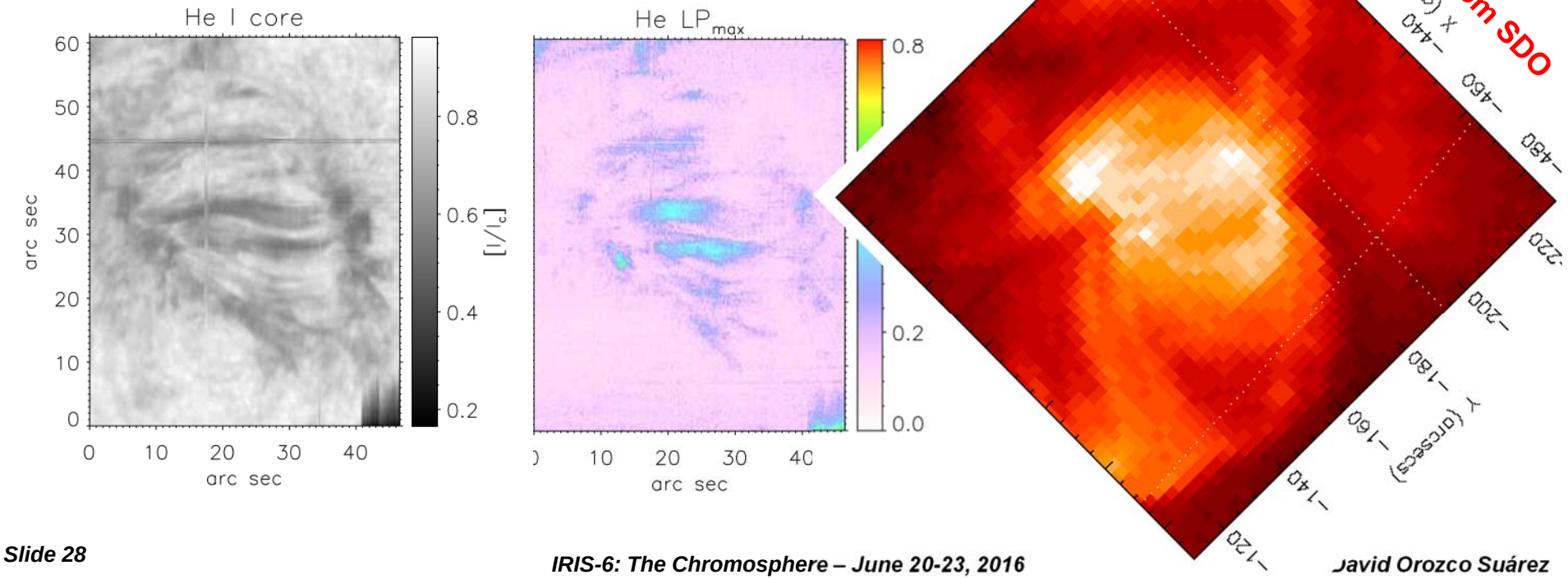




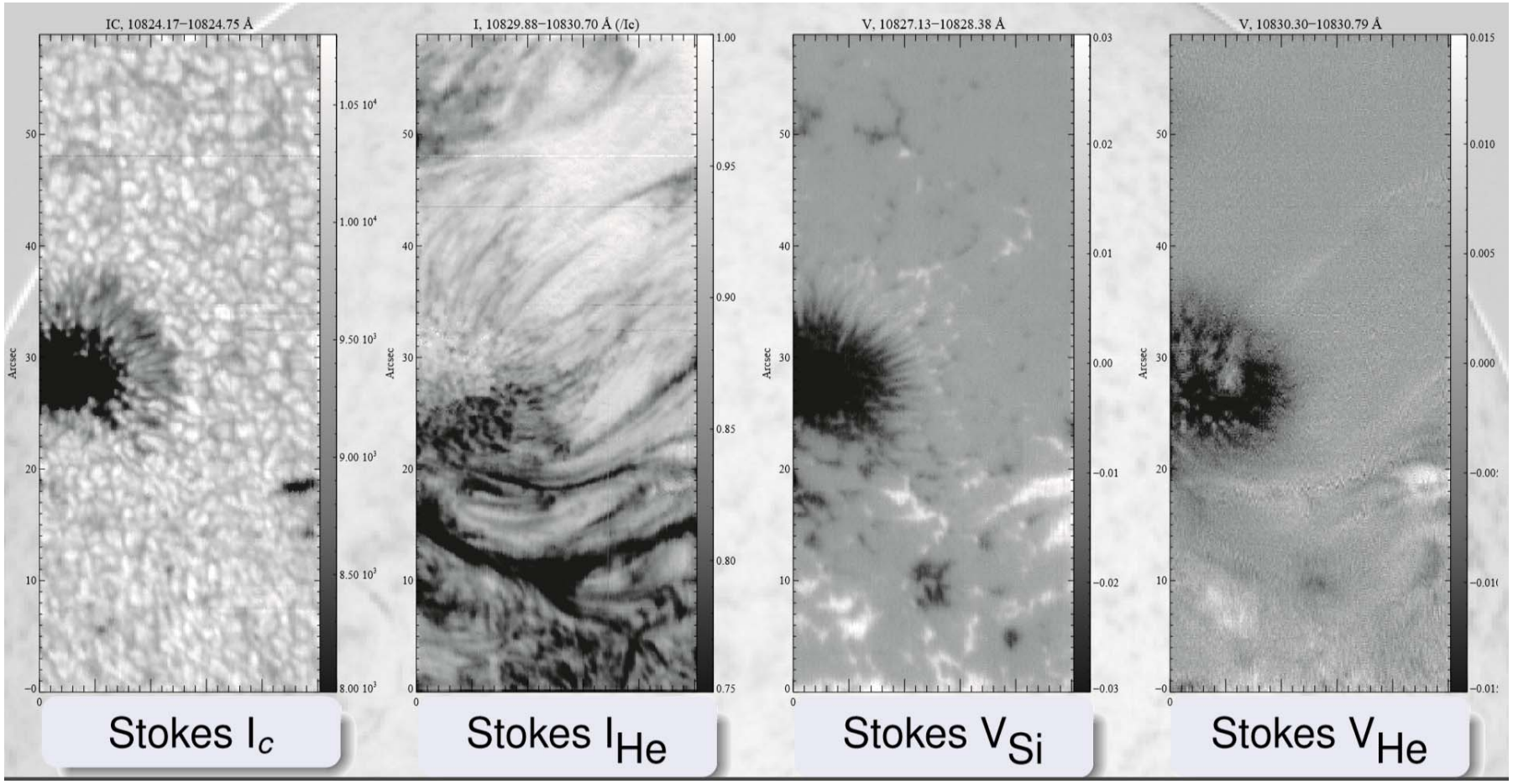
Spectropolarimetric data: Active Regions

- ★ Local variations in the EUV radiation field
- ★ So far, the EUV is not taking into account in the line formation mechanisms when analyzing polarization signals
- ★ In progress!!!

Jorrit Leenaarts cutting-edge poster

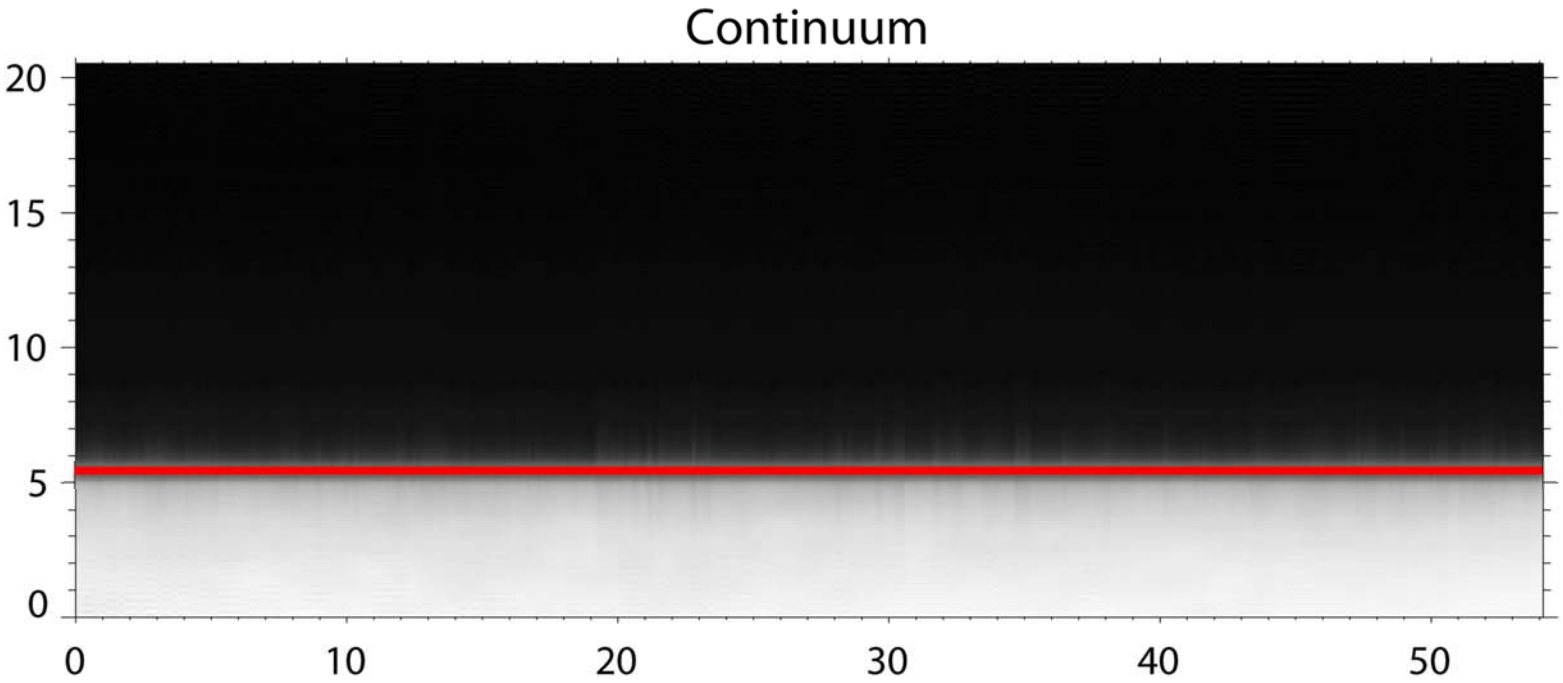


Spectropolarimetric data: Filaments



Spectropolarimetric data: SPICULES ☹

- ★ Observations of spicules from the ground with full polarimetry are extremely difficult
- ★ We have some but neither enough S/N (polarimetry) nor seeing



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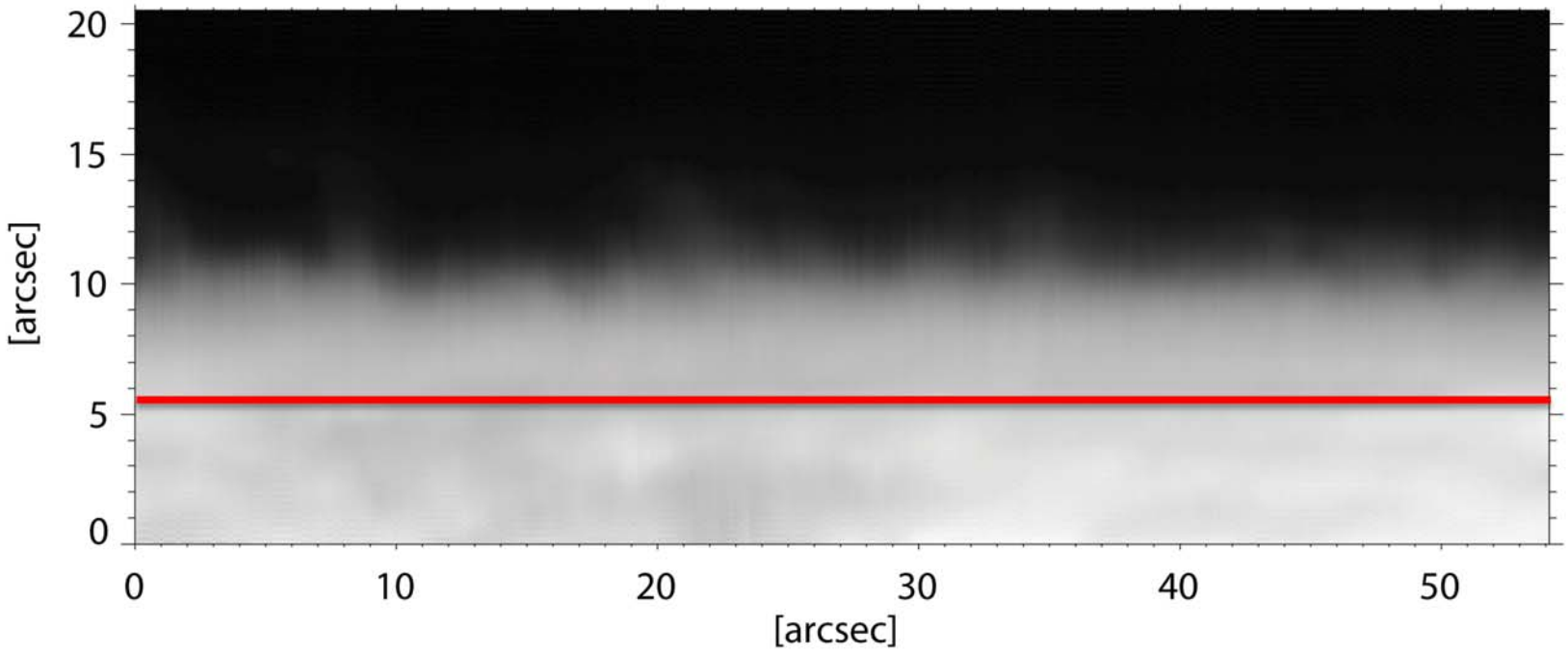

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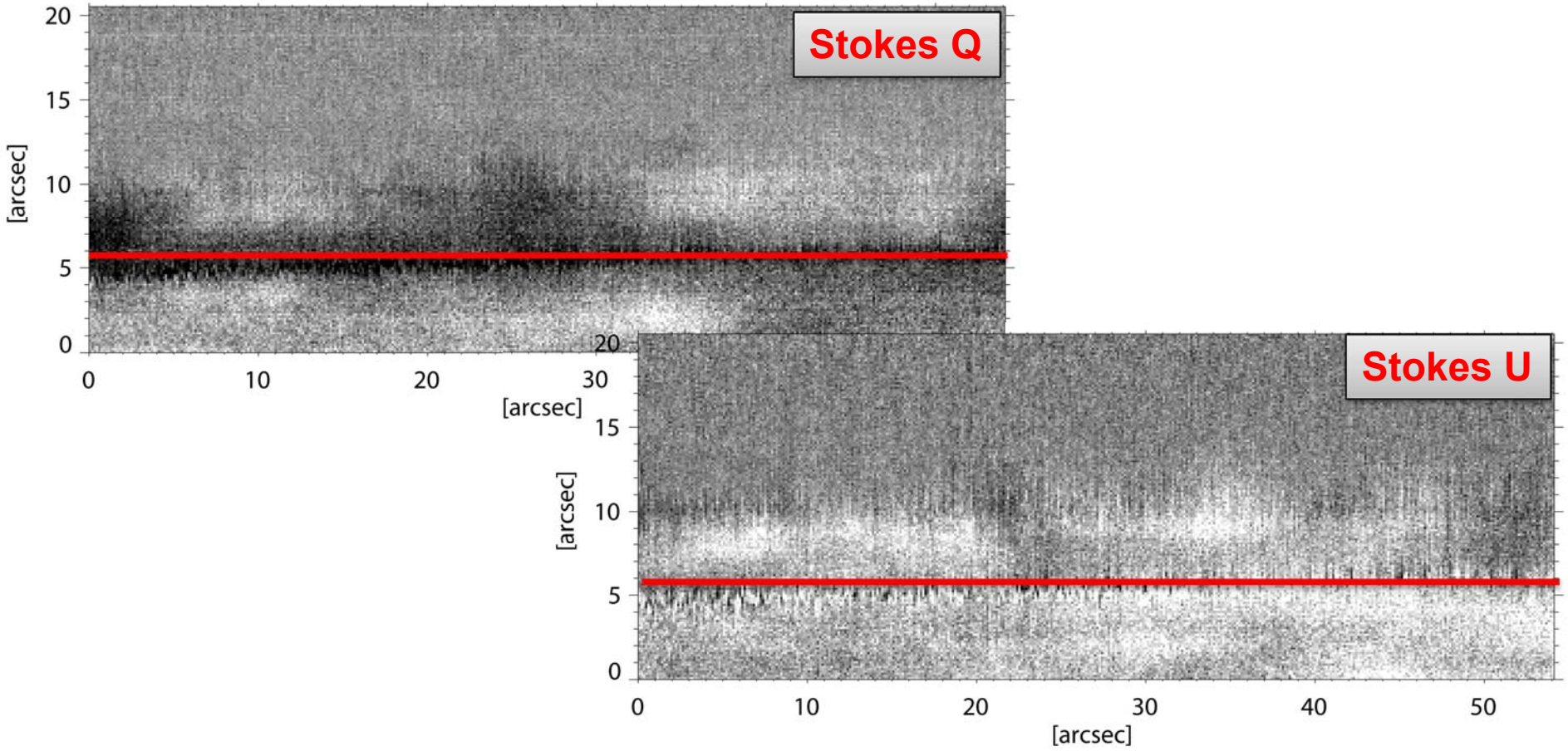
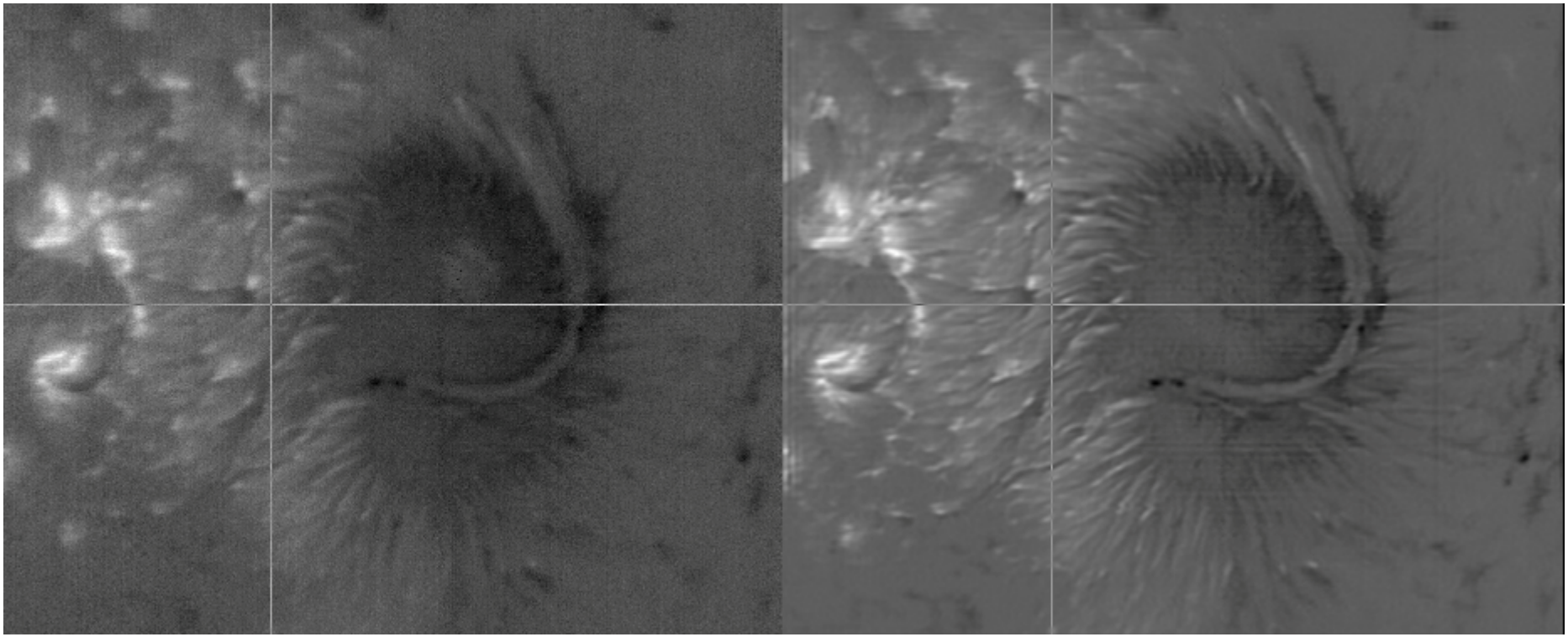


Spectropolarimetric data: Deconvolution

- Starting to include deconvolution techniques in spectropolarimetry



Original **Deconvolved**

- Not easy
- Not free from ambiguities, but doable in very near future

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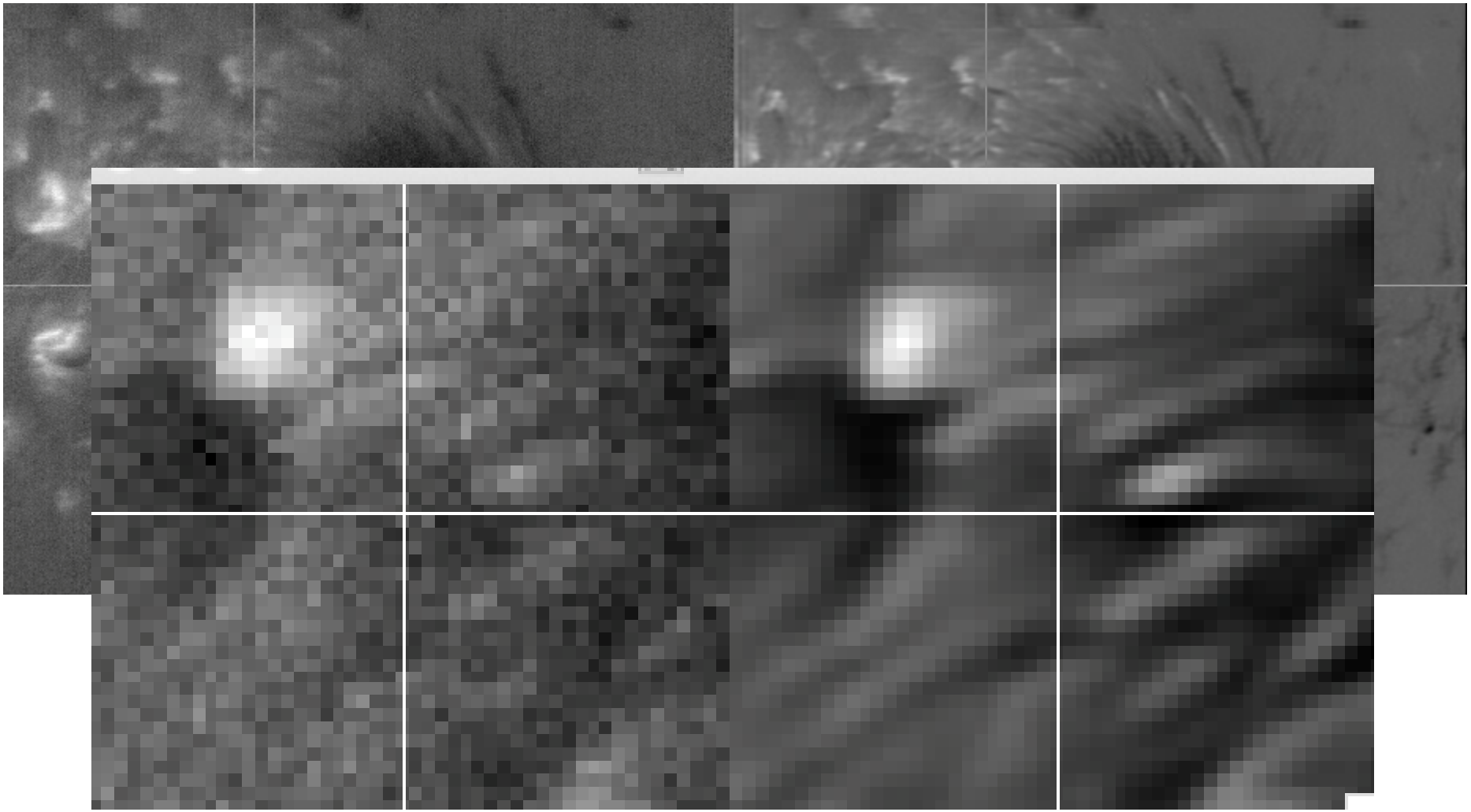

Good things will come!

Thanks for your attention