

CHROMOSPHERIC MAGNETIC FIELDS

ANDREAS LAGG
MPI FOR SOLAR SYSTEM RESEARCH, GÖTTINGEN



ADS: IRIS + CHROMOSPHERE IN ABSTRACT



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AUTHORS

- De Pontieu, B 72
- Carlsson, M 42
- Hanstee, V 26
- Pereira, T 26
- Kleint, L 24

COLLECTIONS

- astronomy 293
- physics 53

REFEREED

- non-refereed 153
- refereed 140

KEYWORDS

PUBLICATIONS

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1 2018arXiv180603573L 2018/06 📄 ☰ 🗄️
Non-damping oscillations at flaring loops
Li, D.; Yuan, D.; Su, Y. N. *and 3 more*
-damping oscillations at flaring loops. Methods. We used the IRIS to measure the spectrum over a narrow slit. The double

2 2018ApJ...859..158S 2018/06 📄 ☰ 🗄️
Statistical Investigation of Supersonic Downflows in the Transition Region above Sunspots
Samanta, Tanmoy; Tian, Hui; Prasad Choudhary, Debi
The Interface Region Imaging Spectrograph (IRIS) has provided a wealth of observational data of sunspots at high

3 2018PASJ..tmp...61T 2018/05 cited: 1 📄 ☰ 🗄️
Blue-wing enhancement of the chromospheric Mg II h and k lines in a solar flare

0 selected

Years Citations Reads

■ refereed ■ non refereed

Year	Refereed	Non-refereed	Total
2013	5	2	7
2014	15	45	60
2015	40	35	75
2016	35	35	70
2017	30	30	60
2018	18	5	23

ADS: IRIS + CHROMOSPHERE + MAGNETIC IN ABSTRACT



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QUICK FIELD: Author First Author Abstract Year Fulltext **All Search Terms**

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Your search returned **172** results

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AUTHORS

- De Pontieu, B 36
- Carlsson, M 21
- Hansteen, V 18
- Tian, H 17
- Kleint, L 13

COLLECTIONS

- astronomy 172
- physics 35

REFEREED

- non-refereed 94
- refereed 78

KEYWORDS

PUBLICATIONS

Hide highlights Show abstracts

1 2018arXiv... Non-d...
Li, D.; Y...
after
flarin

2 2018MNRAS...
Synchronized observations of bright points from the solar photosphere to the corona
Tavabi, Ehsan
One of the most important features in the solar atmosphere is the **magnetic** network

3 2018nova.pres.3504K 2018/04
Heating the Chromosphere in the Quiet Sun
Kohler, Susanna

0 selected

Years Citations Reads

■ refereed ■ non refereed

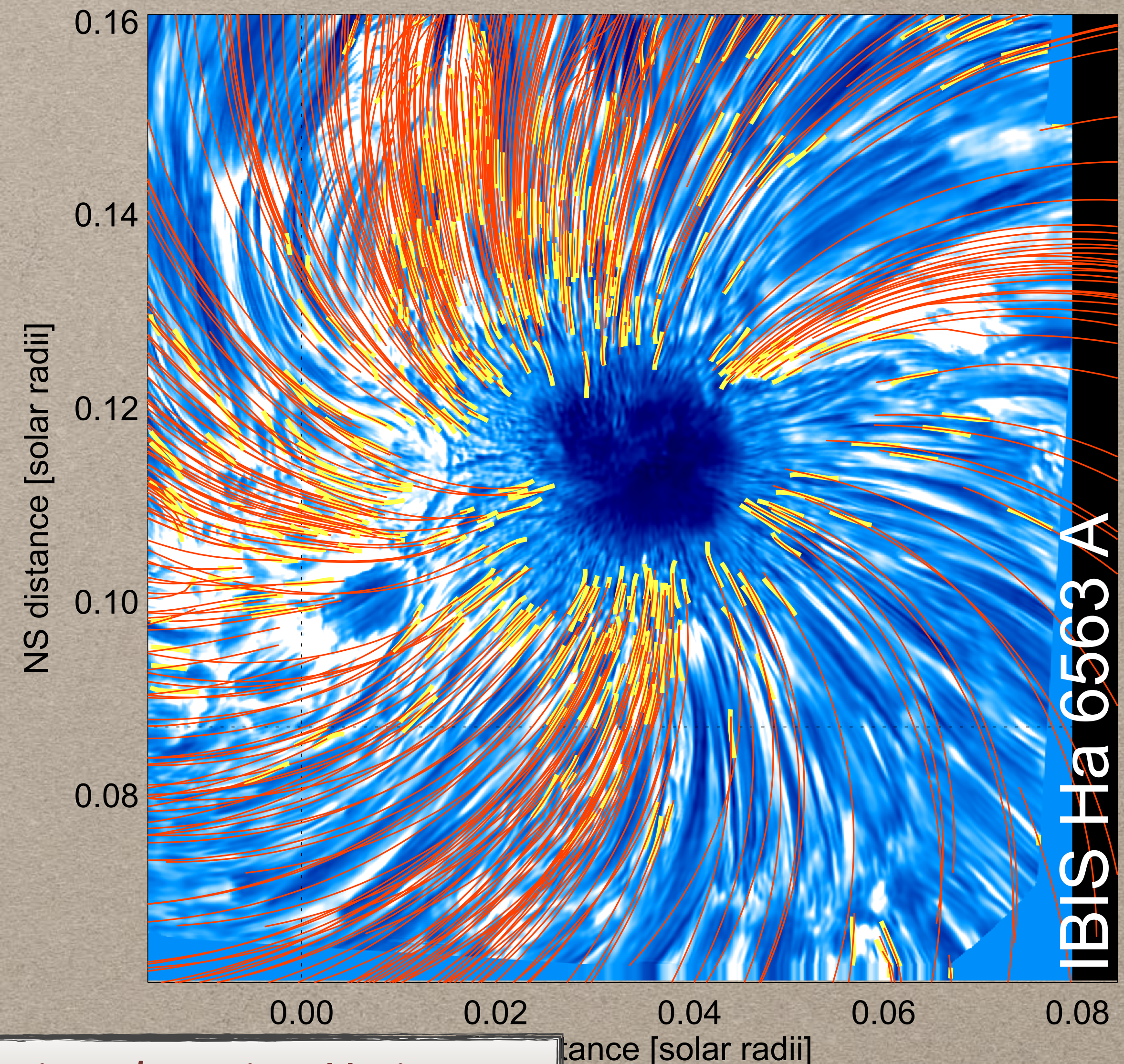
Year	Refereed	Non-refereed
2013	0	2
2014	9	21
2015	21	22
2016	21	24
2017	21	22
2018	7	1

60% of the chromospheric IRIS publications (2013-) are magnetized!

Aschwanden et al. (2016):

Tracing the chromospheric and coronal magnetic field with AIA, IRIS, IBIS and ROSA data

- Alignment of curvi-linear structures to magnetic field
- Compute free energy: 2-4 times higher than from coronal estimates
- Determine height range of chromospheric features ($h \leq 4000$ km, corona: up to 35 Mm)
- Determine plasma- β 10^{-5} - 10^{-1}



Also: Wiegelmann et al. (2008): *Improving NLFF Extrapolations by using $H\alpha$ -images*

IRIS DIAGNOSTICS: (SEE ALSO TUTORIALS YESTERDAY)



- Mg II h&k model atom
- Mg II h&k formation
- Mg II h&k IRIS images
- Mg II h&k for chrom. heating
- C II 133.5nm model atom
- C II 133.5 diag. potential
- O I 135.56nm formation
- C II 133.5 IRIS observations
- C I 135.58 nm formation

THE ASTROPHYSICAL JOURNAL, 772:89 (13pp), 2013 August 1
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doi:10.1088/0004-637X/772/2/89

THE ASTROPHYSICAL JOURNAL, 772:90 (15pp), 2013 August 1
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doi:10.1088/0004-637X/772/2/90

THE FORMATION OF *IRIS* DIAGNOSTICS. II. THE FORMATION OF THE Mg II h&k LINES IN THE SOLAR ATMOSPHERE

J. LEENAARTS¹, T. M. D. PEREIRA^{1,2,3}, M. CARLSSON¹, H. UITENBROEK⁴, AND B. DE PONTIEU^{1,3}

THE ASTROPHYSICAL JOURNAL, 806:14 (8pp), 2015 June 10
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doi:10.1088/0004-637X/806/1/14

THE ASTROPHYSICAL JOURNAL, 811:80 (14pp), 2015 October 1
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doi:10.1088/0004-637X/811/2/80

THE FORMATION OF *IRIS* DIAGNOSTICS. V. A QUINTESSENTIAL MODEL ATOM OF C II AND GENERAL FORMATION PROPERTIES OF THE C LINES AT 133.5

THE ASTROPHYSICAL JOURNAL, 811:81 (12pp), 2015 October 1
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doi:10.1088/0004-637X/811/2/81

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THE ASTROPHYSICAL JOURNAL, 813:34 (10pp), 2015 November 1
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doi:10.1088/0004-637X/813/1/34

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THE ASTROPHYSICAL JOURNAL, 814:70 (10pp), 2015 November 20
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doi:10.1088/0004-637X/814/1/70

THE ASTROPHYSICAL JOURNAL, 846:40 (10pp), 2017 September 1
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<https://doi.org/10.3847/1538-4357/aa8458>



The Formation of *IRIS* Diagnostics. IX. The Formation of the C I 135.58 NM Line in the Solar Atmosphere

Hsiao-Hsuan Lin¹, Mats Carlsson¹ , and Jorrit Leenaarts^{1,2} 

¹ Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, NO-0315 Oslo, Norway; mats.carlsson@astro.uio.no, jorrit.leenaarts@astro.su.se

² Institute for Solar Physics, Department of Astronomy, Stockholm University, AlbaNova University Centre, SE-106 91 Stockholm, Sweden

Received 2017 July 16; revised 2017 August 1; accepted 2017 August 4; published 2017 August 30

IPLET

What questions do we ask
to the chromospheric
magnetic field?

Simulations /
Modelling

Observations

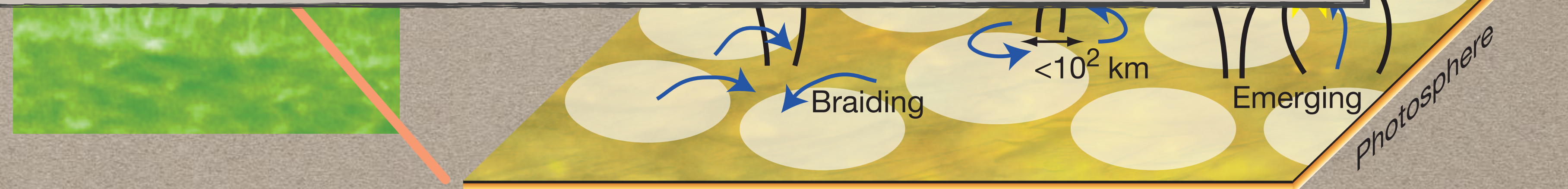
Inversions



Main topic: Energy transfer photosphere → chromosphere → corona

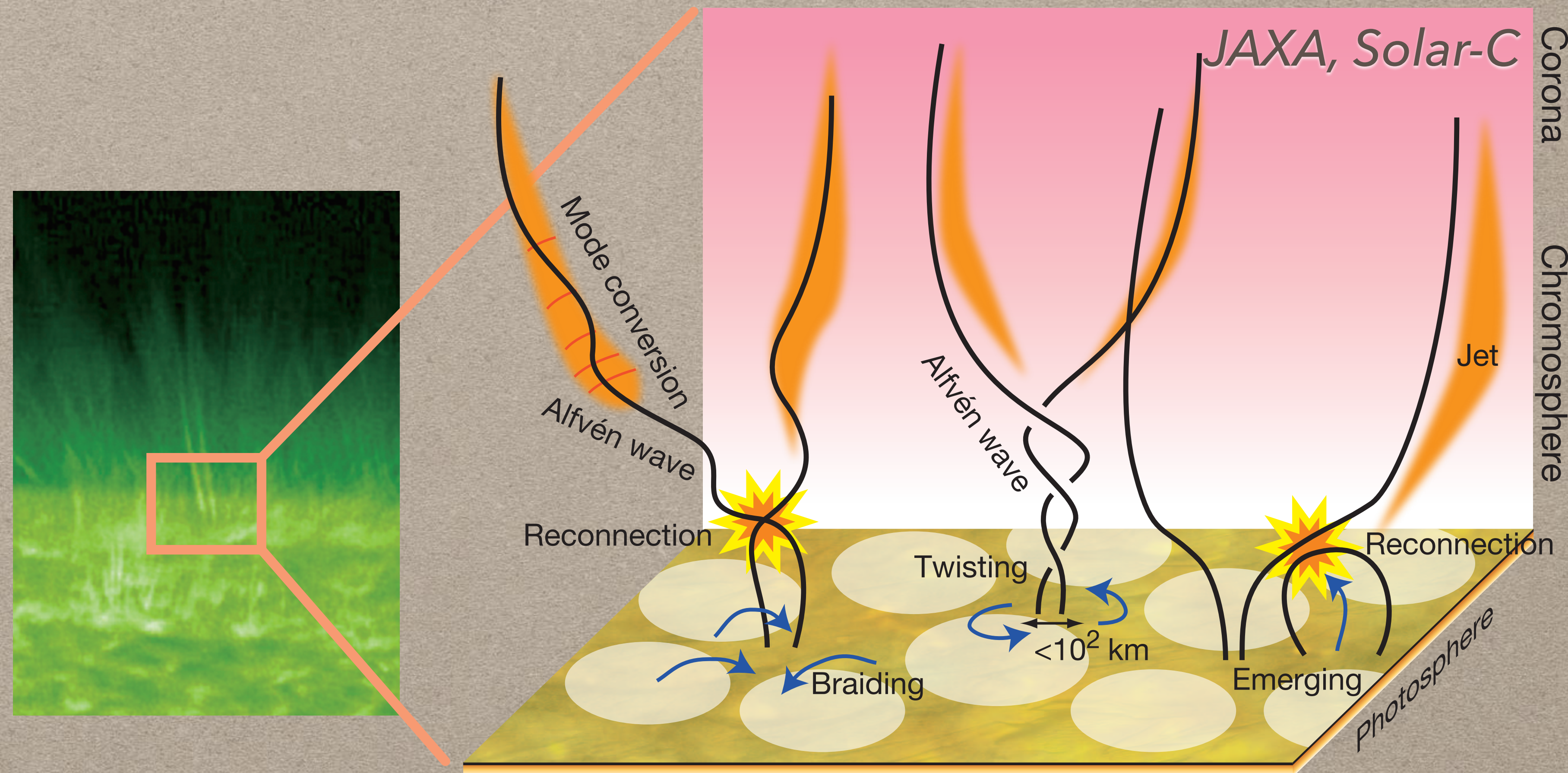
Oslo SAM project (2011/2016)

- Which types of non-thermal energy dominate in the chromosphere and beyond?
- How does the chromosphere regulate mass and energy supply to the corona and the solar wind?
- How do magnetic flux and matter rise through the lower atmosphere?
- How does the chromosphere affect the free magnetic energy loading that leads to solar eruptions?



Main topic: Energy transfer photosphere → chromosphere → corona

- Reveal the details of spicules
- Verify nano flare hypothesis
- Verify wave heating
- Energy build-up & triggers for flares, CMEs
- ...



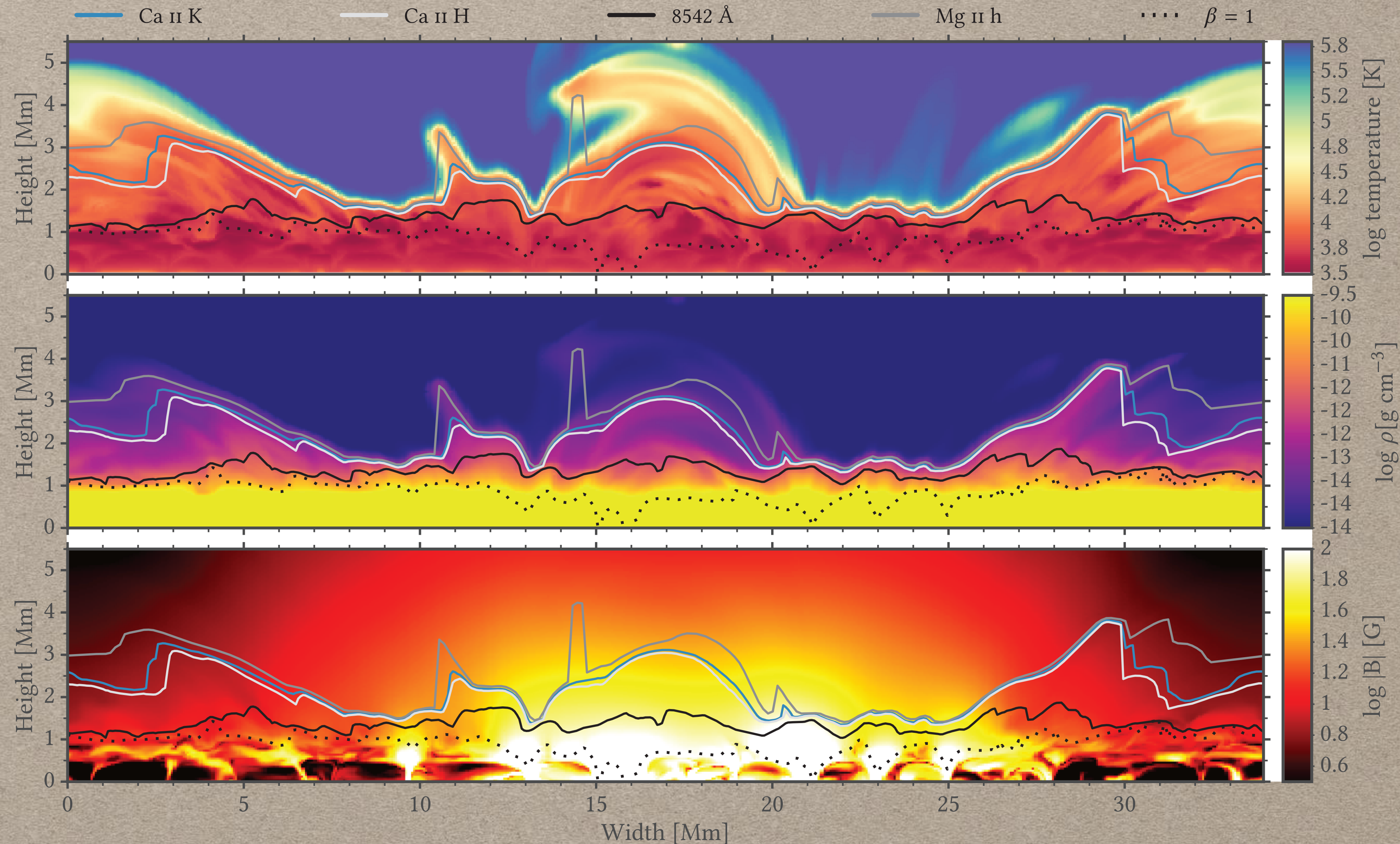
Talks

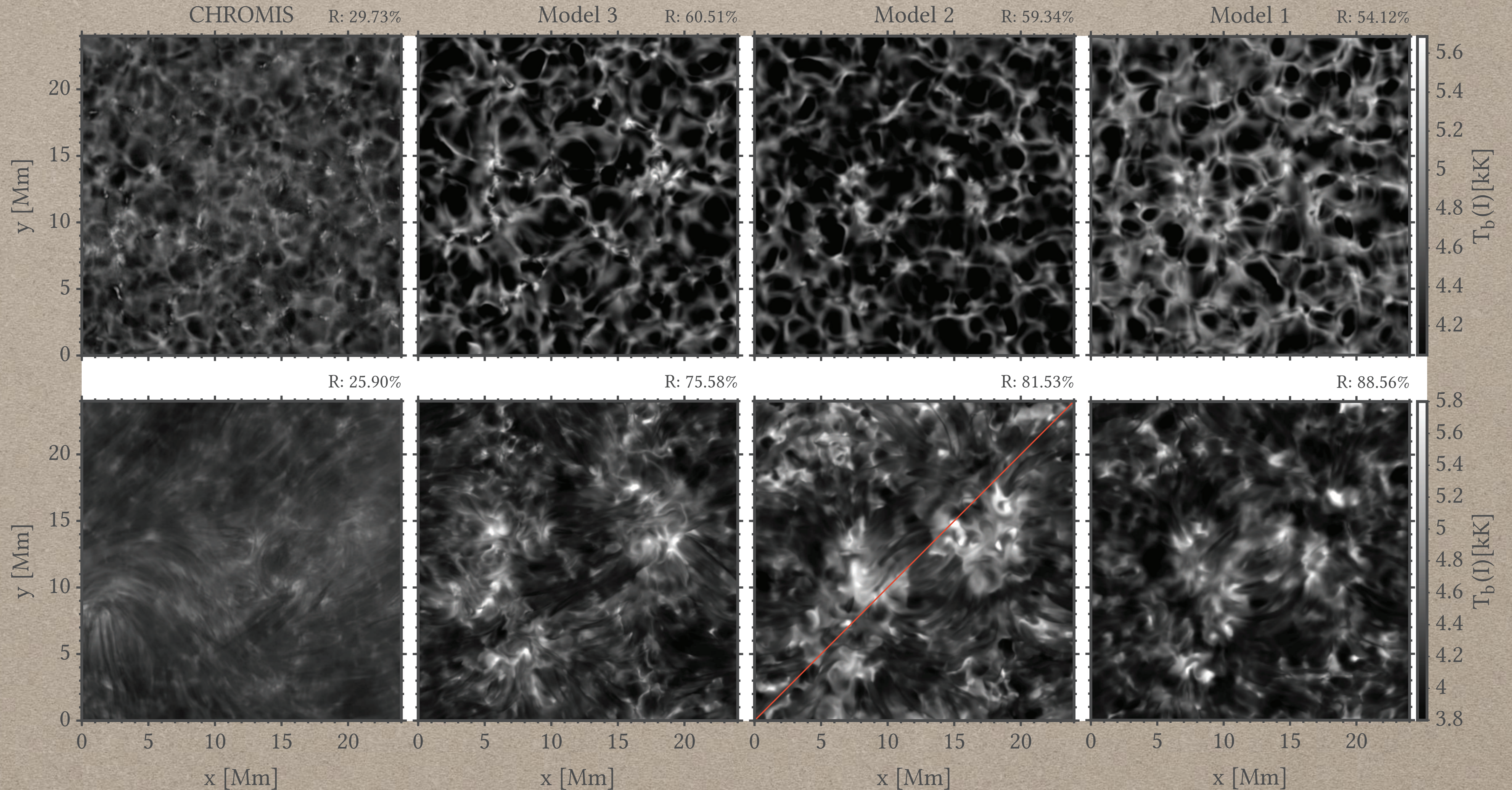
1. Fundamental physical processes and modeling

Tue	09:45	J. Martinez-Sykora	Chromospheric modeling on ion-neutral interaction effects and non-equilibrium ionization	1	
Tue	10:15	J. Leenaarts	Studying radiation-MHD simulations in the Lagrangian frame ...	2	
Tue	10:30	A. Sukhorukov	Simulating CLASP-IRIS co-observations in H I Ly- α and Mg II h	3	
Tue	11:45	L. Ni	Magnetic reconnection in strongly magnetized regions around the solar TMP	4	
Tue					
	Wed	11:45	M. Carlsson	An IRIS Optically Thin View of the Dynamics of the Solar Chromosphere	19
	Wed	12:00	J. Bjørgen	Three-dimensional modeling of chromospheric spectral lines in a simulated active region	20
	Wed	12:15	K. Barczynski	A disturbance propagating from the chromosphere into a heated coronal loop	21
Tue					
Tue	15:00	J. Warnecke	Twisted currents of coronal loops in 3D MHD simulations	9	
Tue	15:15	C. Gontikakis	Resonant scattering processes at work in an active region as detected in the transition region Si IV lines near 140 nm with IRIS	10	
Tue	15:30	J. Dudík	Transition-Region lines with strong wings: Non-Maxwellian analysis of line profiles and intensities	11	

Three-dimensional modelling of the Ca II H and K lines in the solar atmosphere, Bjørgen et al. 2018

- Based on Bifrost (Gudiksen et al. 2011)
- Compute line profiles
- Compare with hi-res observations (CHROMIS/SST, Scharmer et al. 2018)



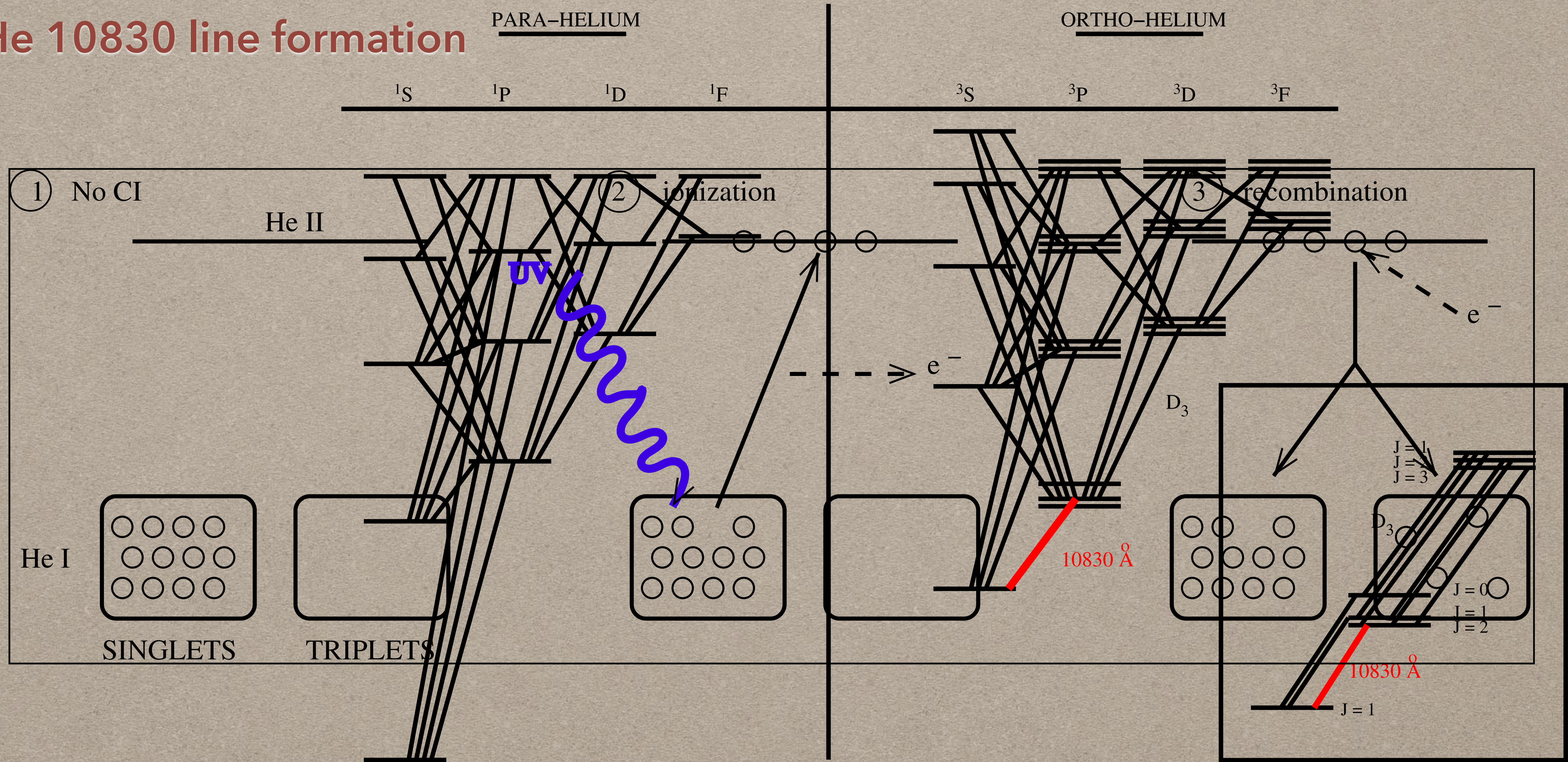


TOOLS FOR CHROM. B-DIAGNOSTIC: SIM/MOD

He 10830 line formation

PARA-HELIUM

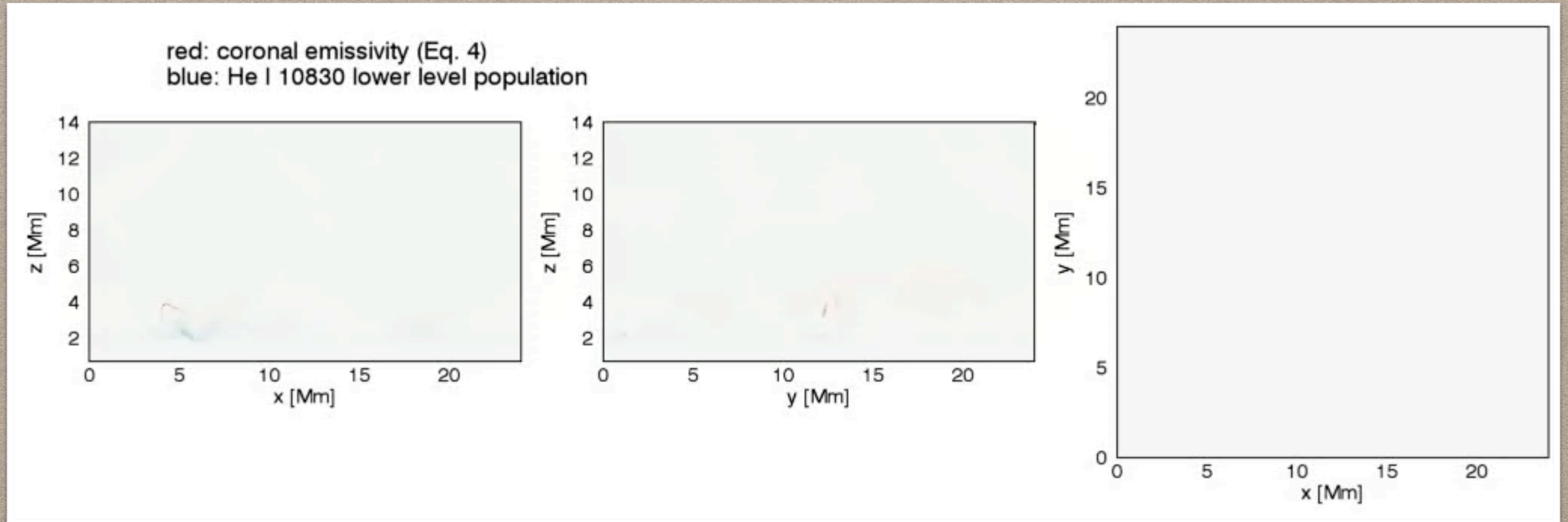
ORTHO-HELIUM



He 10830 LINE FORMATION

The cause of spatial structure in solar He I 1083 images (Leenaarts et al., 2016)

- He images show fine structure at the resolution limit ($<100\text{km}$)
- Result of the complex 3D structure of the chromosphere and corona
- 2 sources of ionising radiation: coronal (0.5-2 MK) & TR (80-200 kK)



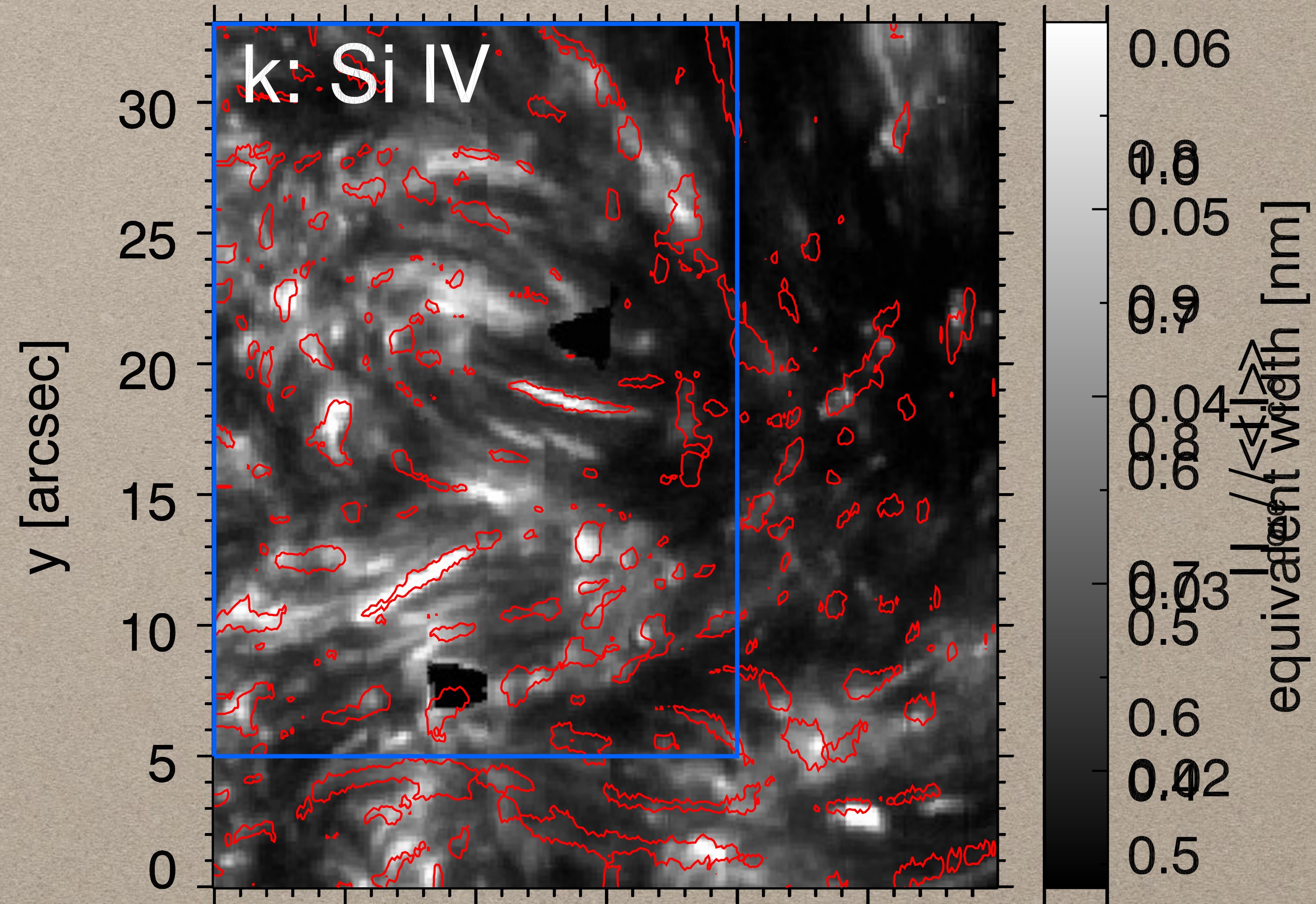
He 10830 LINE FORMATION

The cause of spatial structure in solar He I 1083 images (Leenaarts et al., 2016)

Comparison

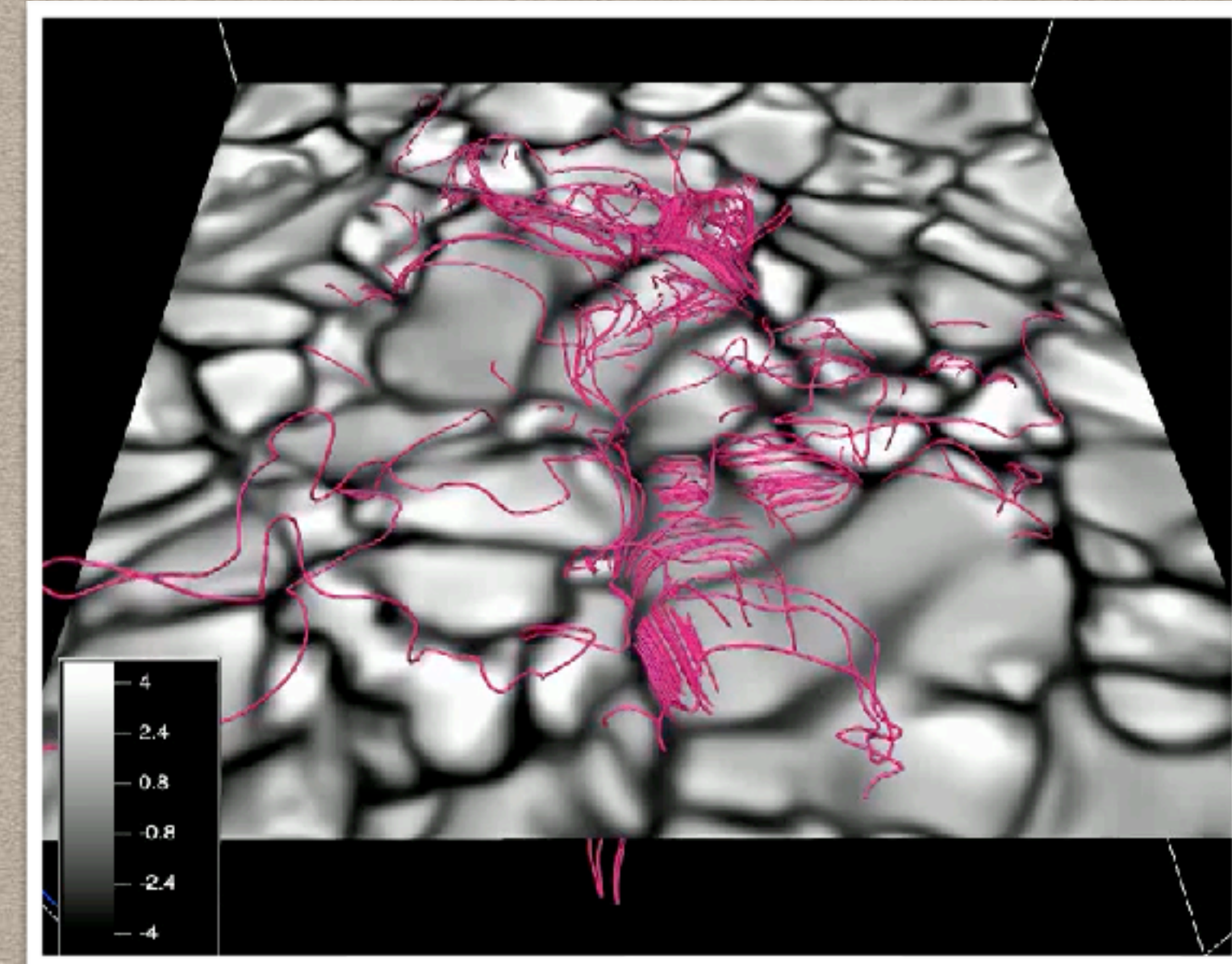
He 10830 \leftrightarrow Si IV 139.38

- Samples 80 kK
→ TR source for ionisation
- Good correlation of small-scale He patches with Si IV emission
- Correlation absent in AR filament

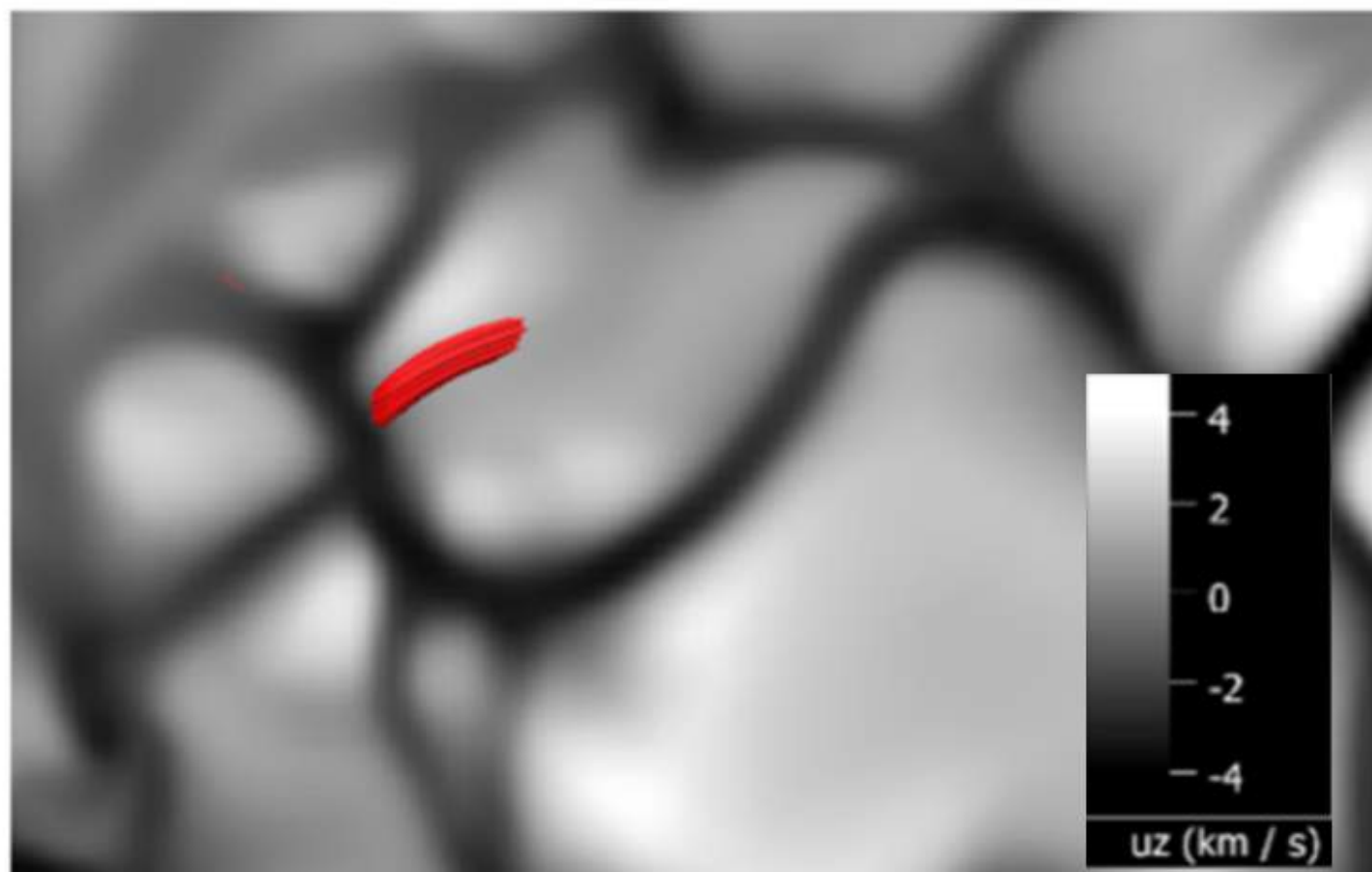


Small-Scale Flux Emergence in the Quiet Sun (Moreno-Insertis et al. 2018)

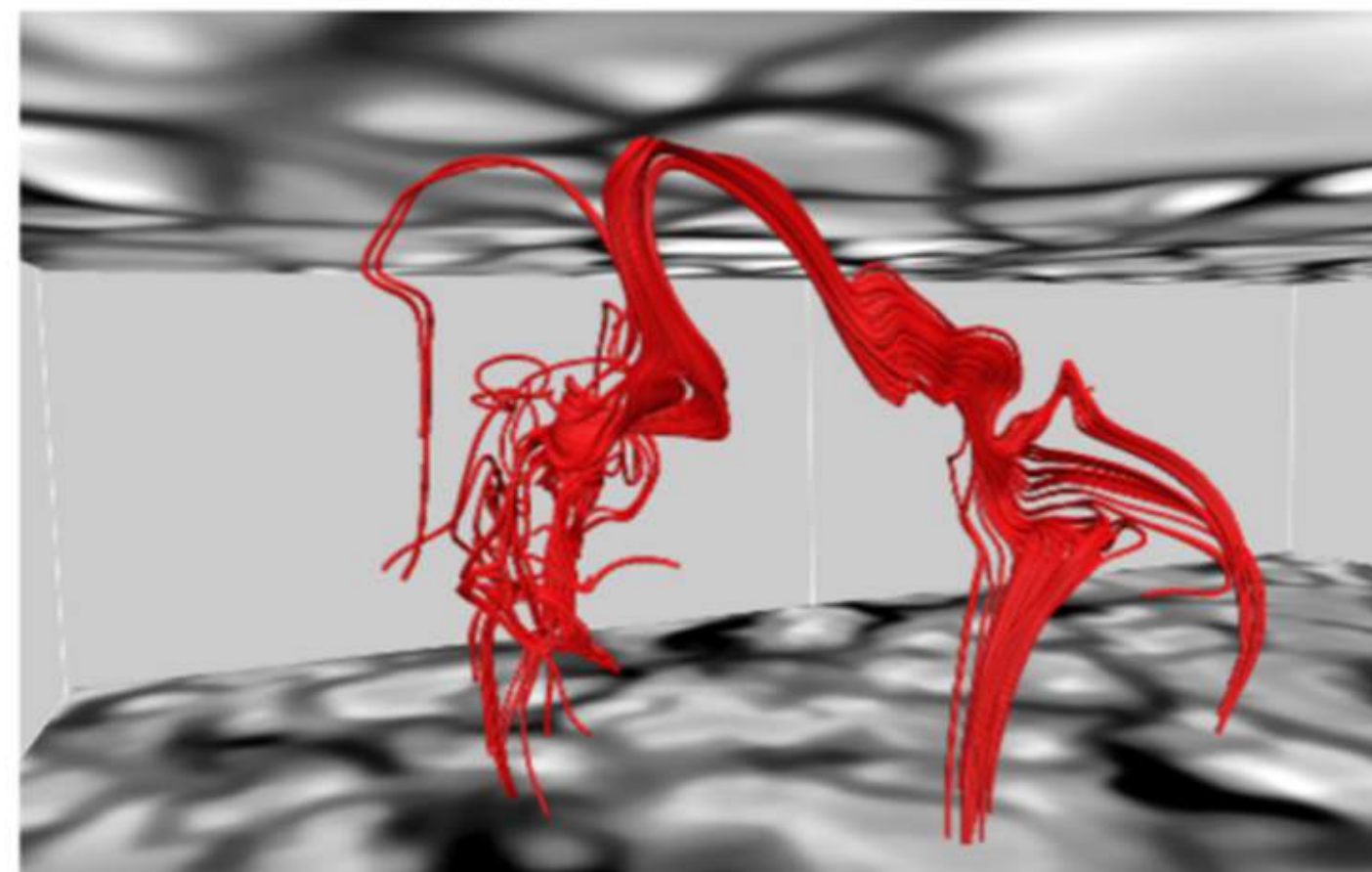
- Based on Bifrost (Gudiksen et al., 2011)
- Two types of flux emergence: sheets & tubes
- Tubes: observed since 10 years
- Sheets only recently confirmed by observations (Sunrise-II quiet-sun granule-covering flux sheets, Centeno et al. 2017)



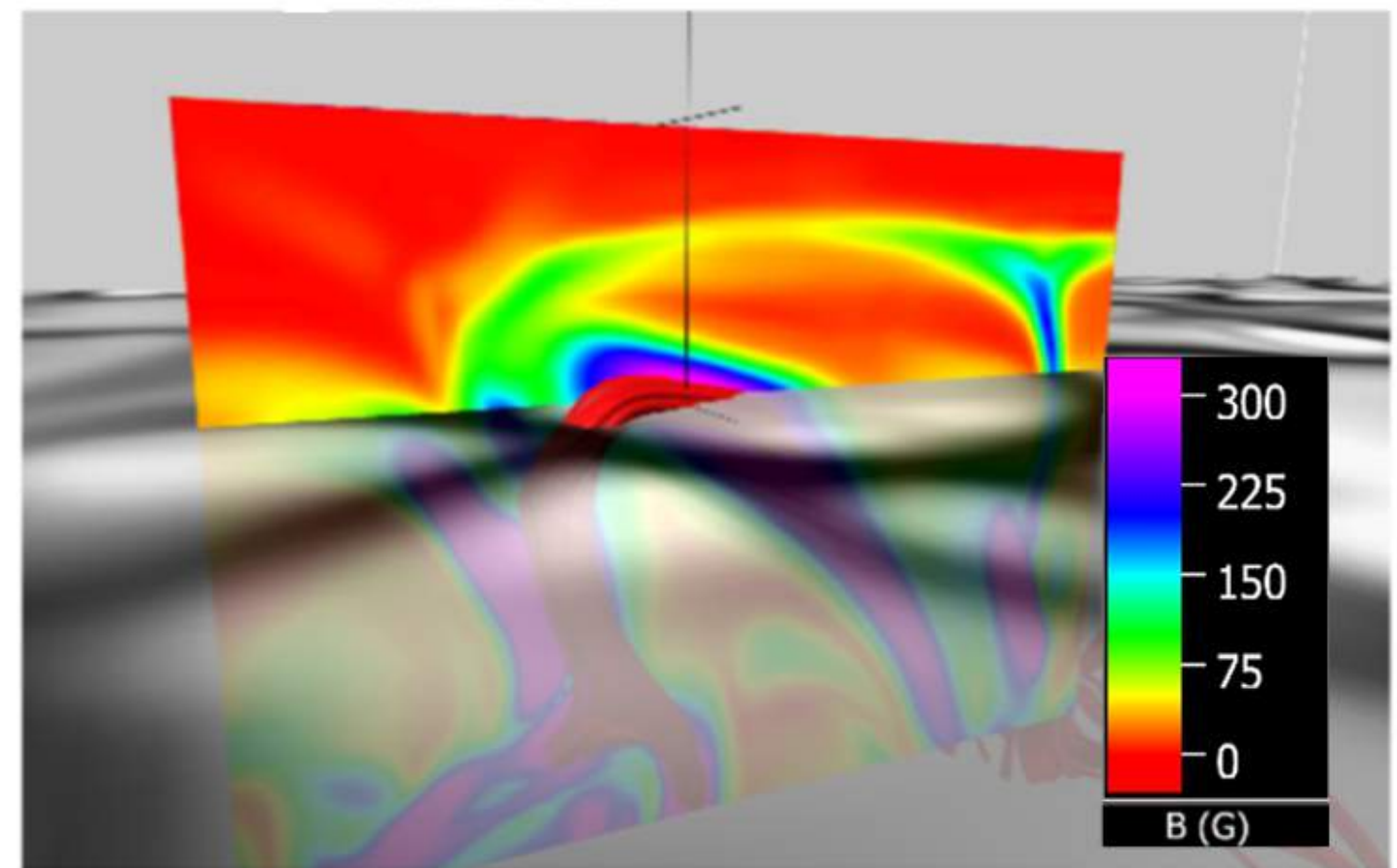
E $t_{\text{GMFE}} = 80.2 \text{ min}$



F $t_{\text{GMFE}} = 80.2 \text{ min}$



G $t_{\text{GMFE}} = 80.2 \text{ min}$



○ Milic 2018: SNAPI

Spectropolarimetric NLTE inversion code SNAPI

I. Milić¹ and M. van Noort¹

Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany
e-mail: milic@mps.mpg.de; vannoot@mps.mpg.de

○ De la Cruz Rodríguez

Inversions are the bridge between simulations / modelling and observations.

TRIPLET LINES

ASSENSIO RAMOS^{2,3}

¹Institute for Solar Physics, Dept. of Astronomy, Stockholm University, AlbaNova University Centre, SE-106 91 Stockholm Sweden

²Instituto de Astrofísica de Canarias, E-38205, La Laguna, Tenerife, Spain

³Departamento de Astrofísica, Universidad de La Laguna, E-38205 La Laguna, Tenerife, Spain

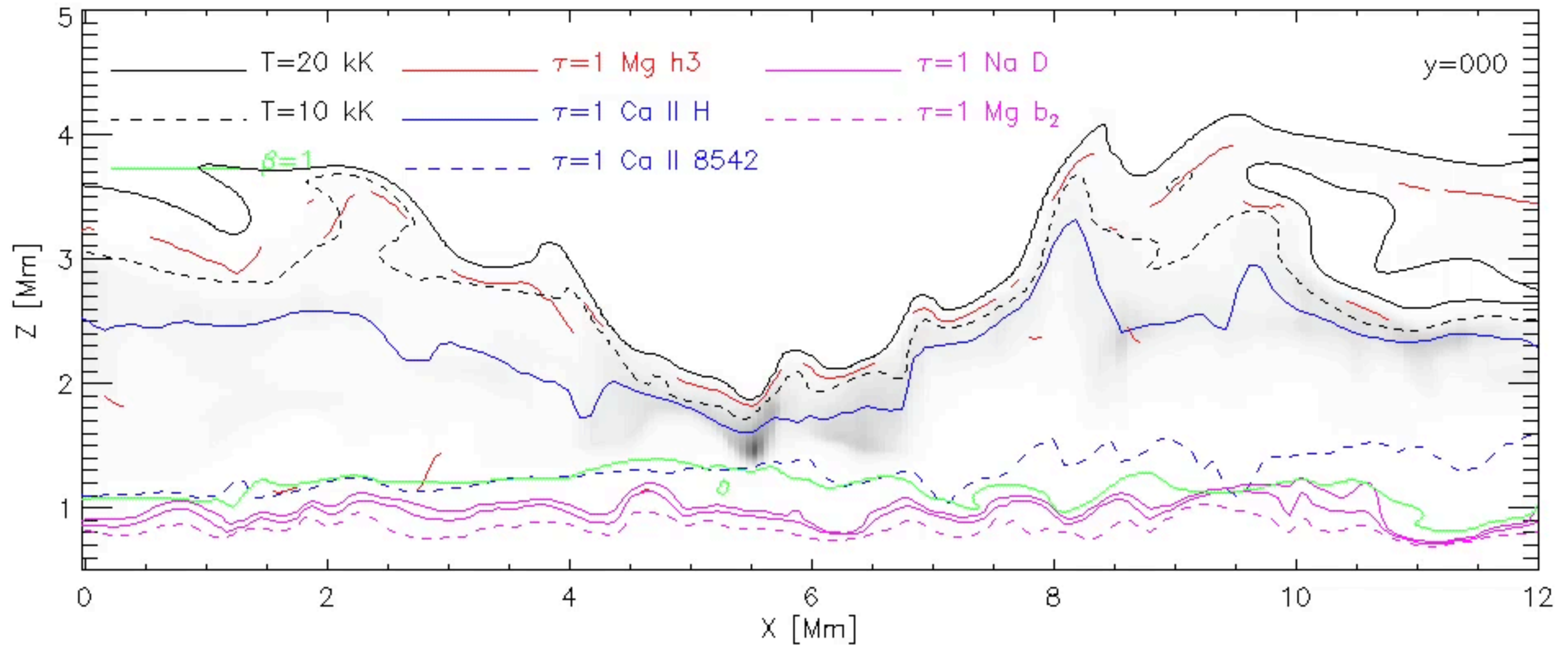
29; published 2016 October 18

Required: High-quality observations.
What makes it so difficult?

○ Socas-Navarro: NICOLE

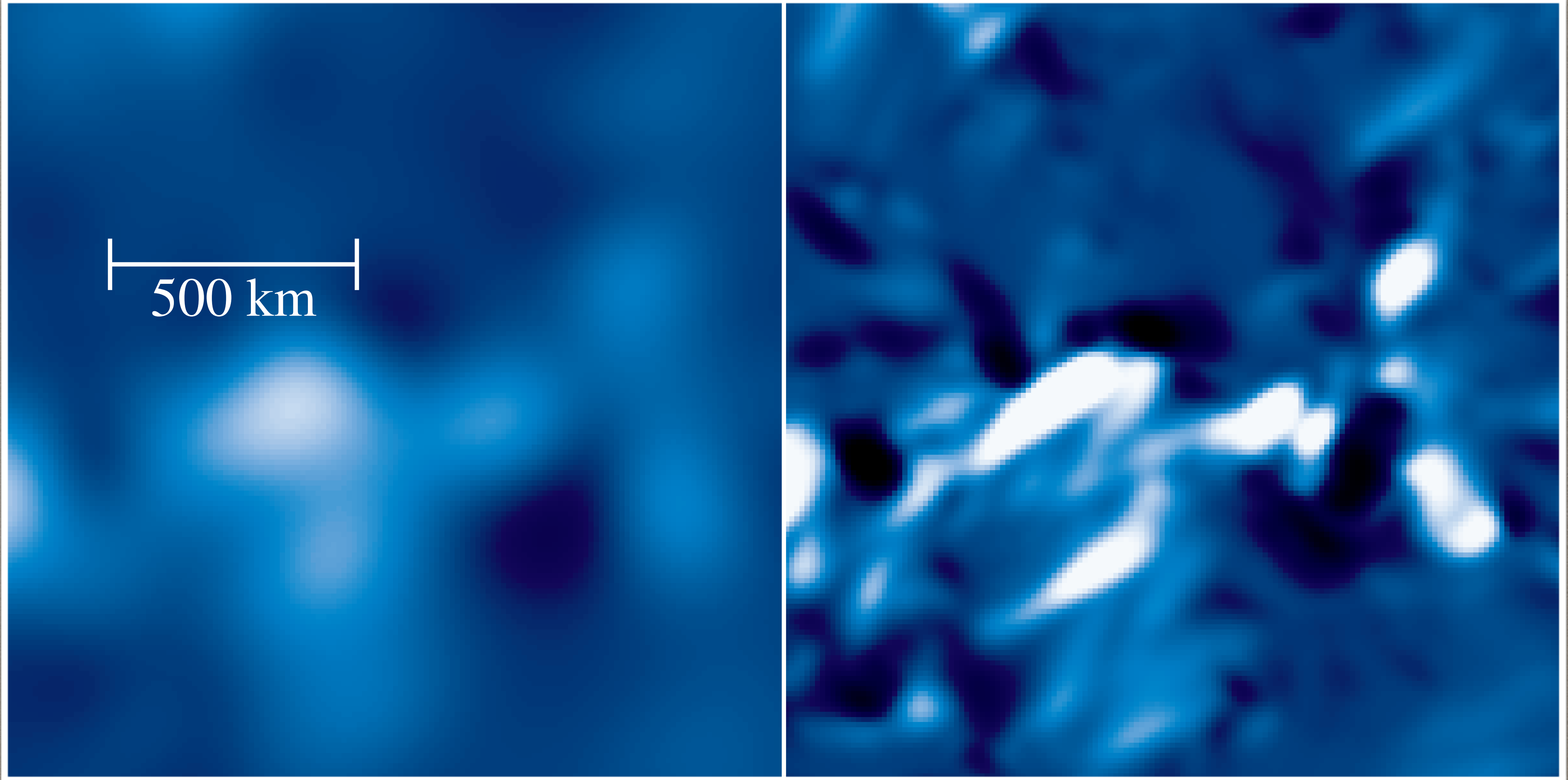
An open-source, massively parallel code for non-LTE synthesis and inversion of spectral lines and Zeeman-induced Stokes profiles[★]

H. Socas-Navarro^{1,2}, J. de la Cruz Rodríguez³, A. Asensio Ramos^{1,2}, J. Trujillo Bueno^{1,2,4}, and B. Ruiz Cobo^{1,2}

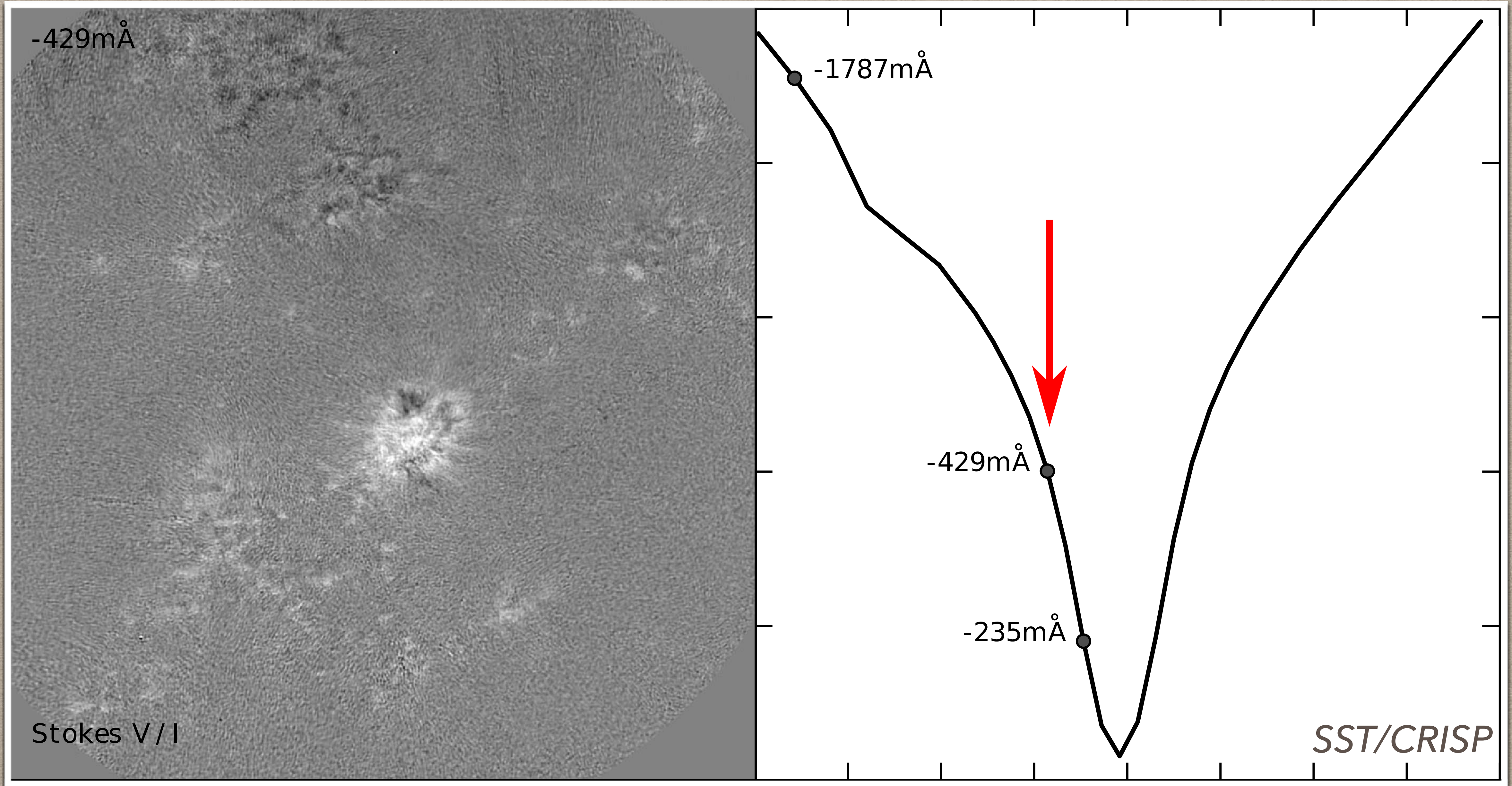


Courtesy: Mats Carlsson

THE CHALLENGES FOR SPECTROPOLARIMETRY



THE CHALLENGES: PHOTON BUDGET



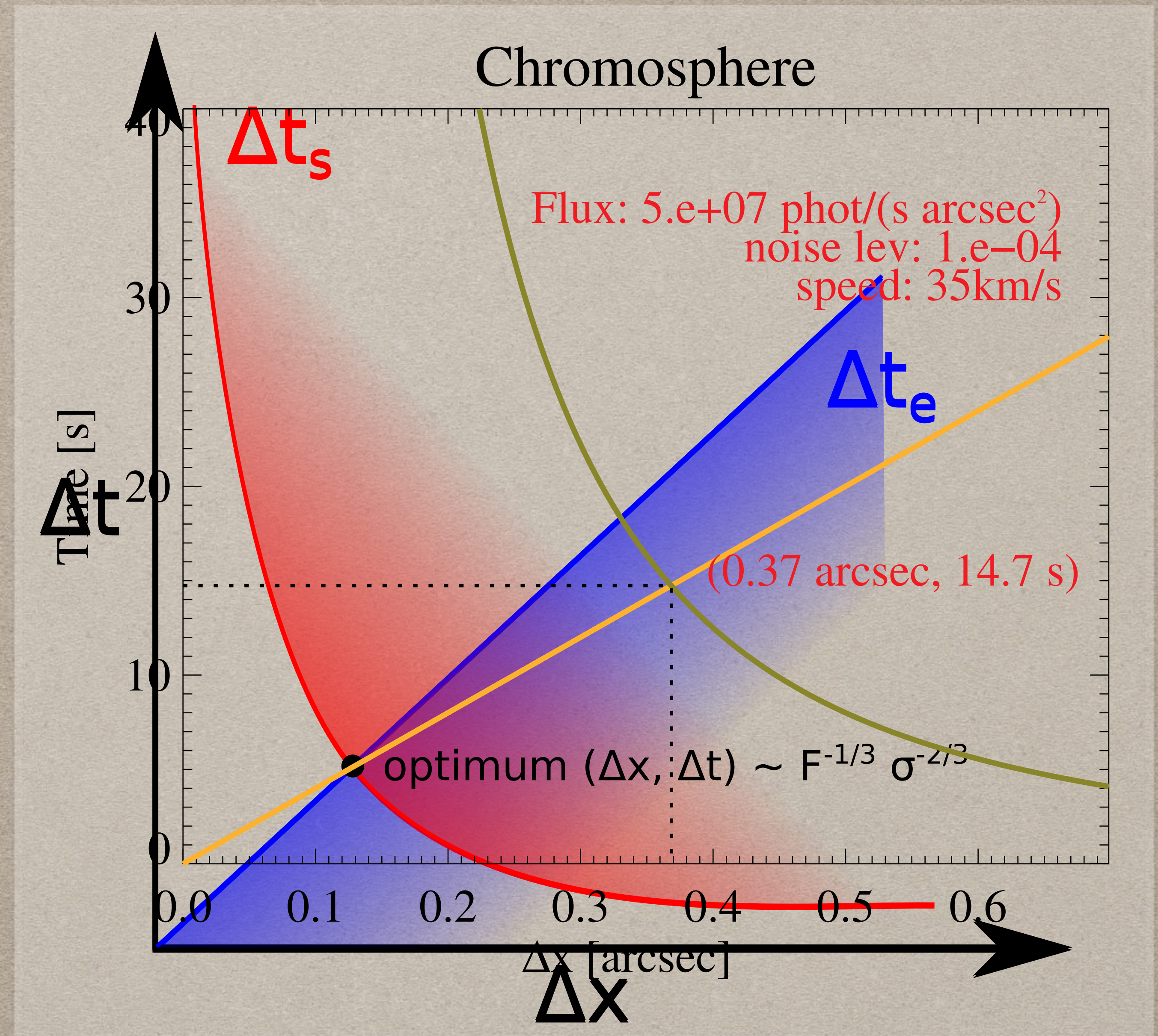
THE DILEMMA: SPATIAL RESOLUTION VS. TIME

- Maximum integration time allowed by solar evolution:

$$\Delta t_e = \frac{2 \Delta x}{v}$$

- Minimum integration time to reach a given required rms noise level

$$\Delta t_s = \frac{1}{F \sigma^2 \Delta x^2}$$



Existing instruments / observatories

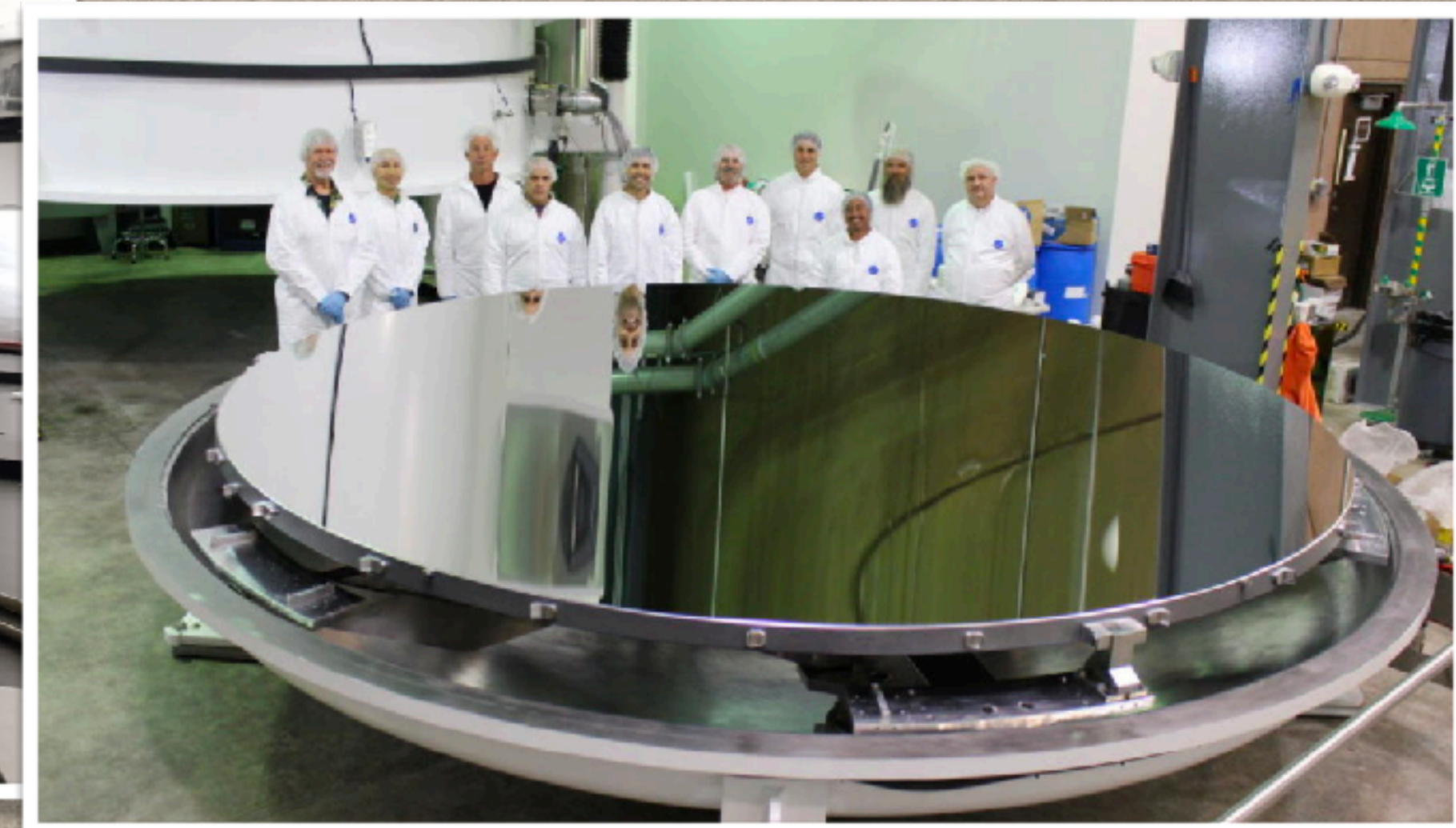
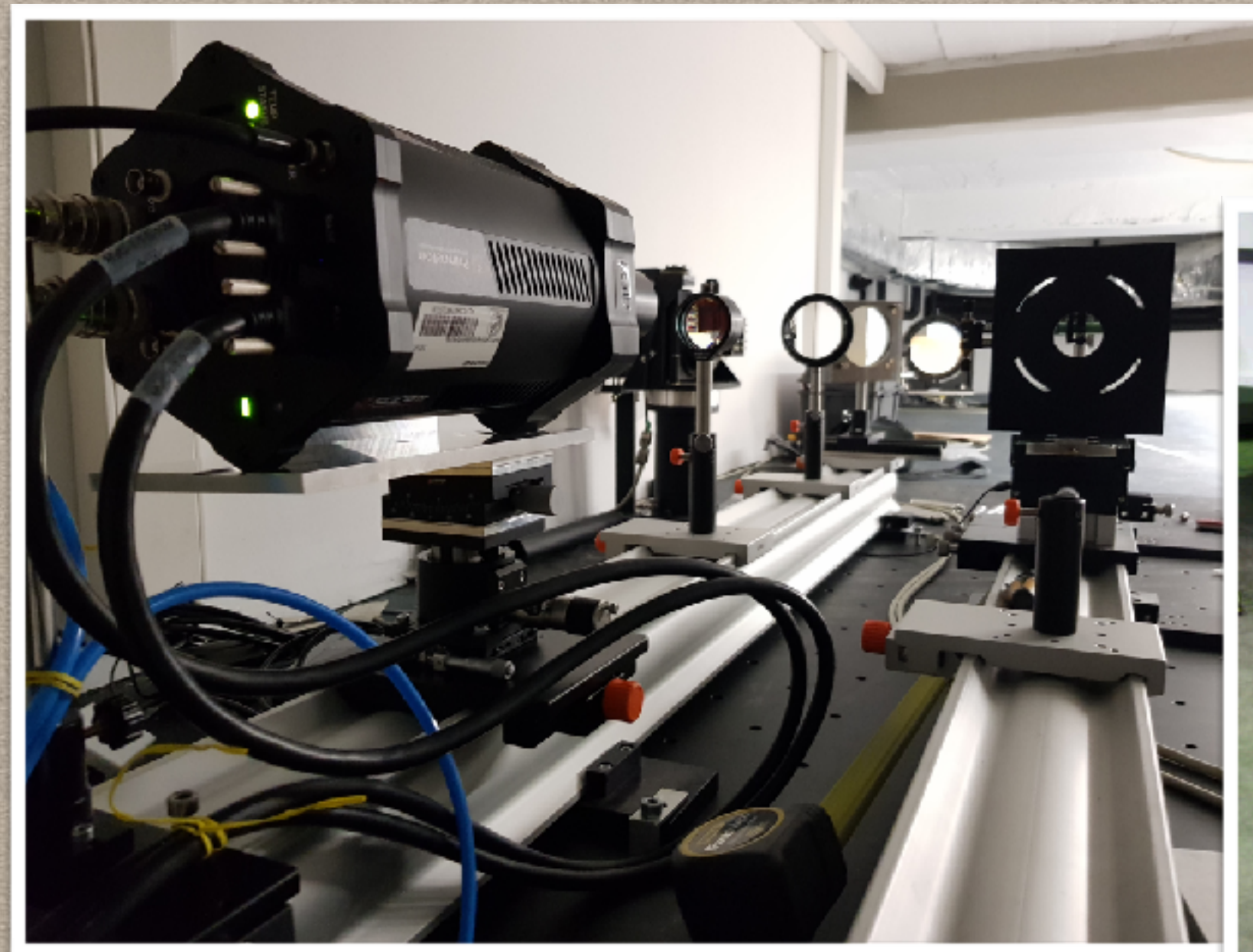
- IRIS
- FISS@GST
- GRIS@GREGOR
- CRISP & CHROMIS @SST
- FIRS @DST
- ALMA: See special session on Thursday

This year

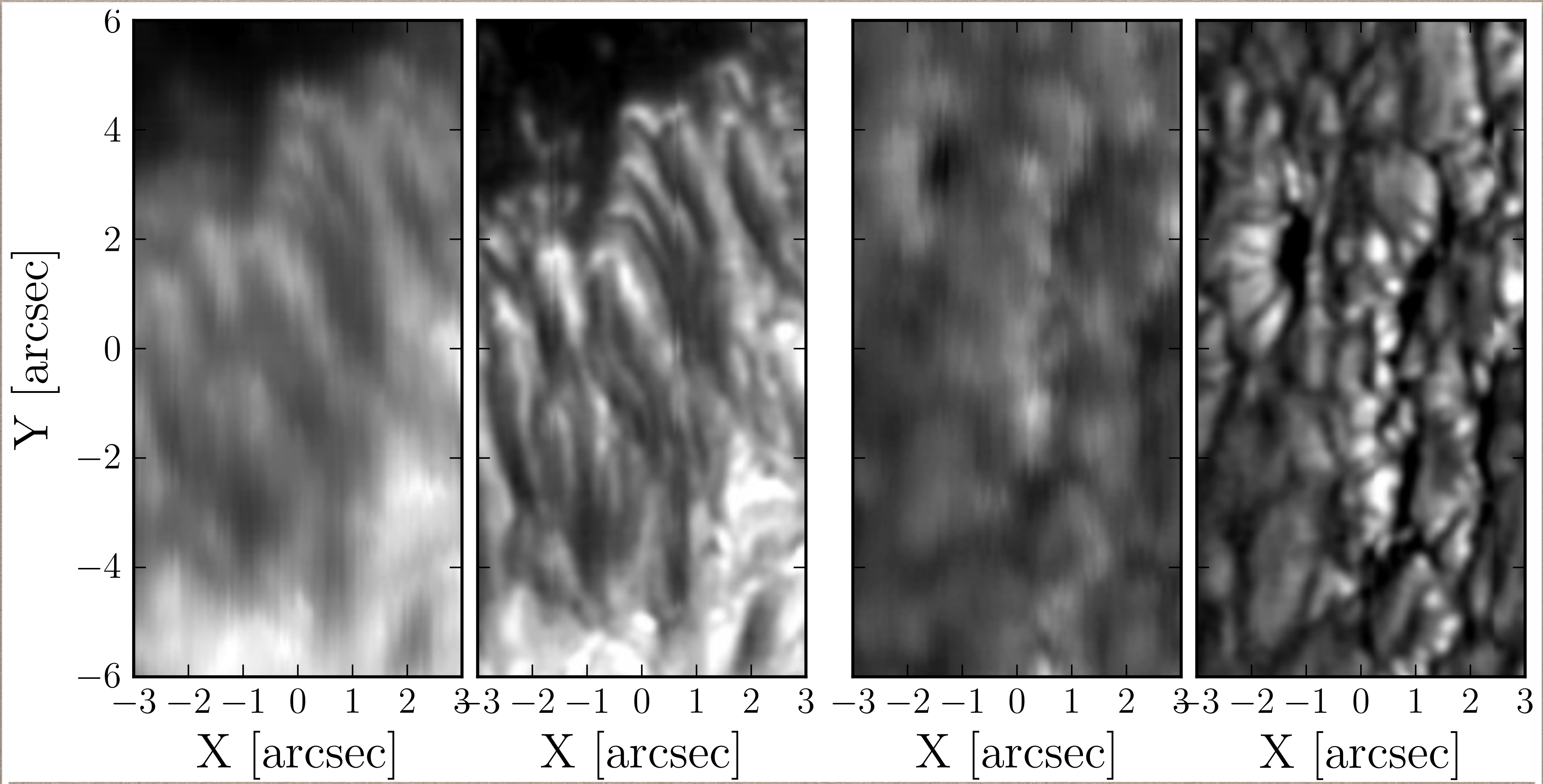
- GRIS+ @GREGOR
- HeSP @SST

Future

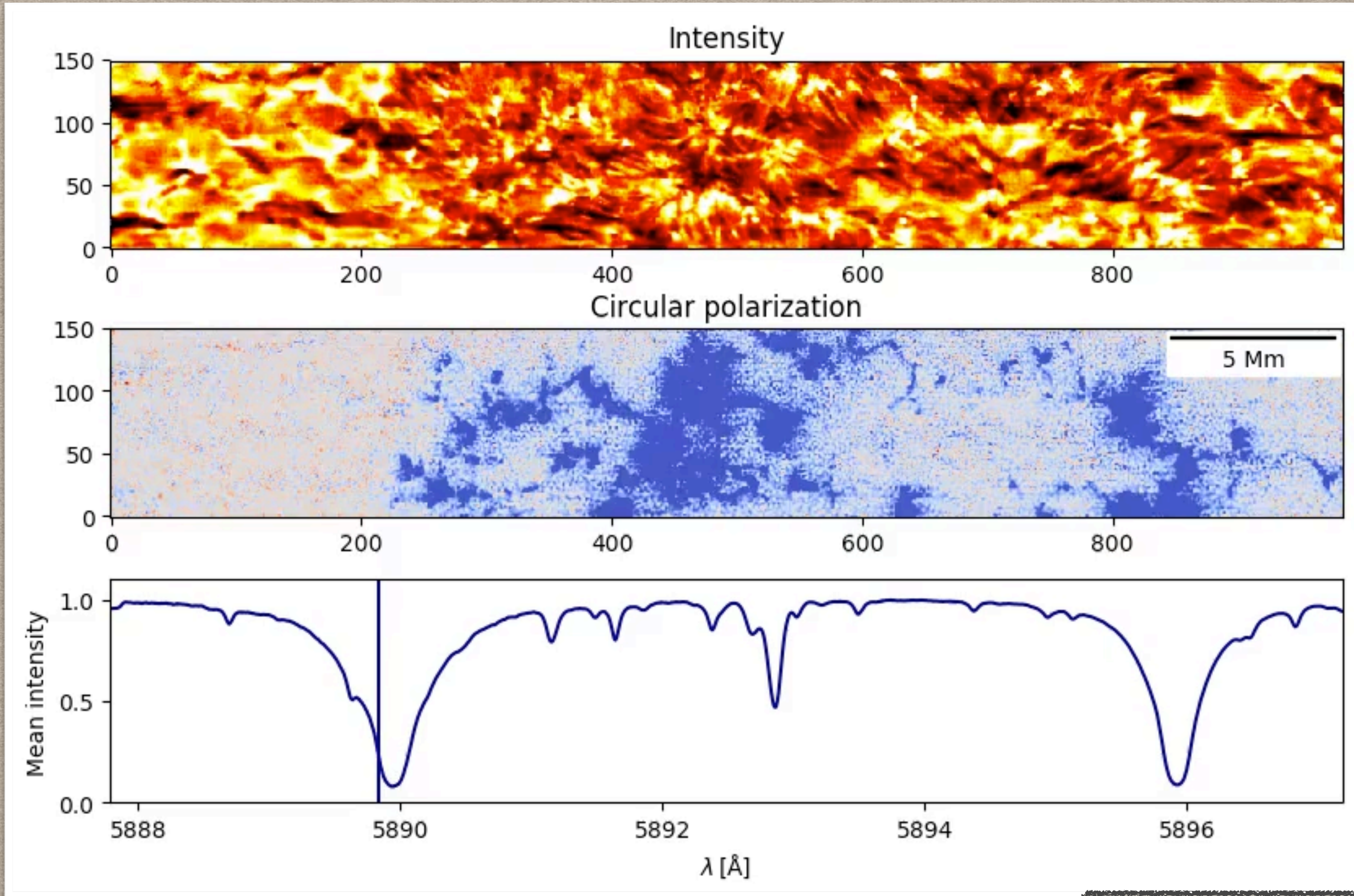
- DKIST: whole suite of instruments dedicated to chromosphere
- Sunrise-III



SPECTRAL RESTORATION: VAN NOORT (2017)

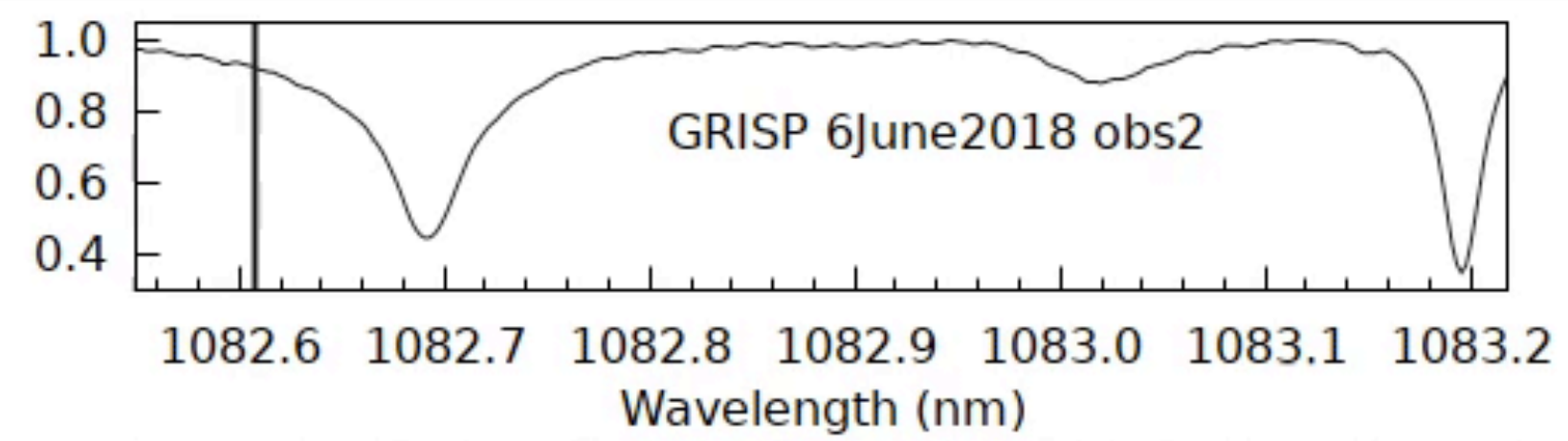


SPECTRAL RESTORATION: NA I STOKES V (SST)

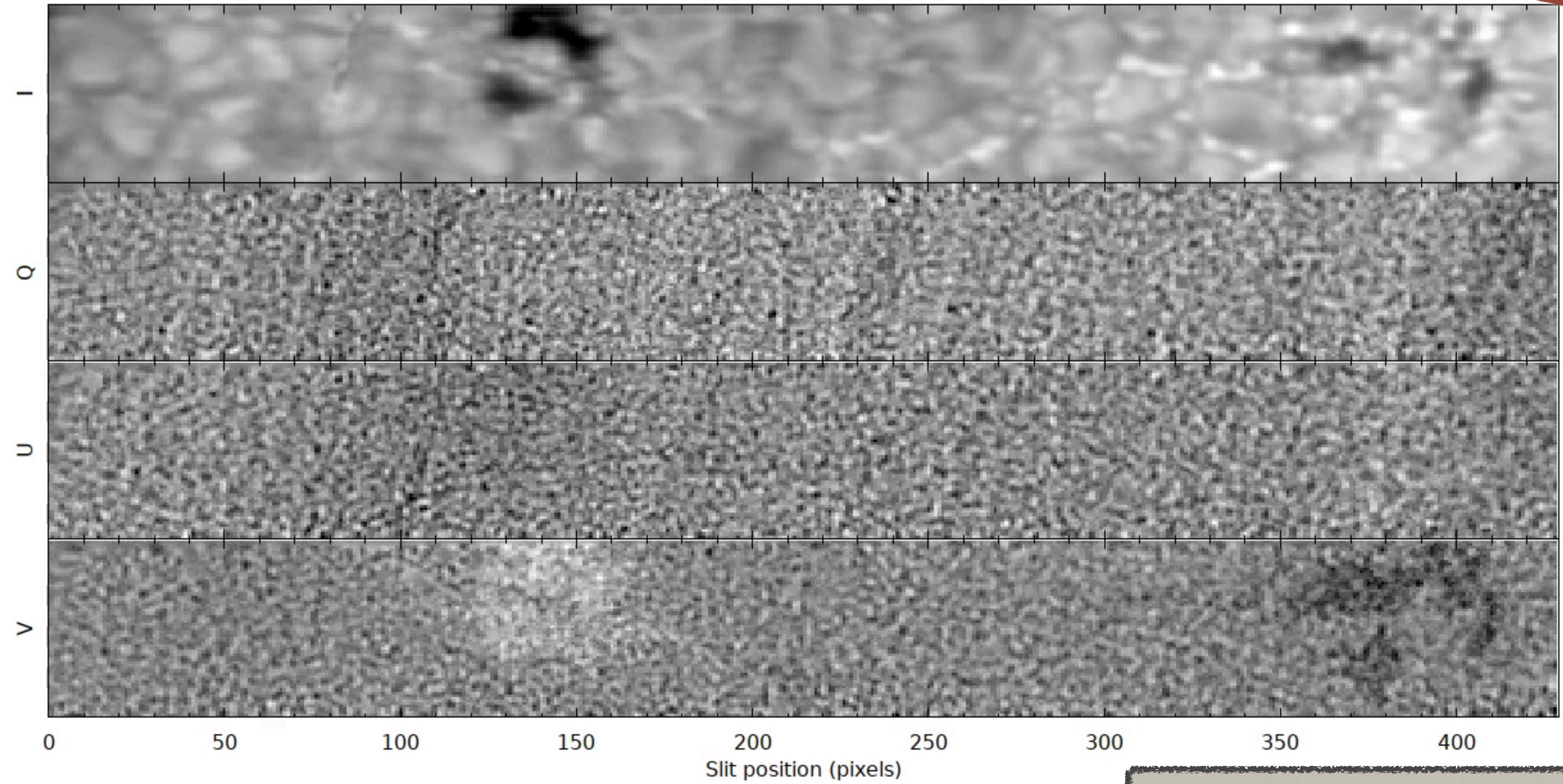


Van Noort et al., MPS 2018

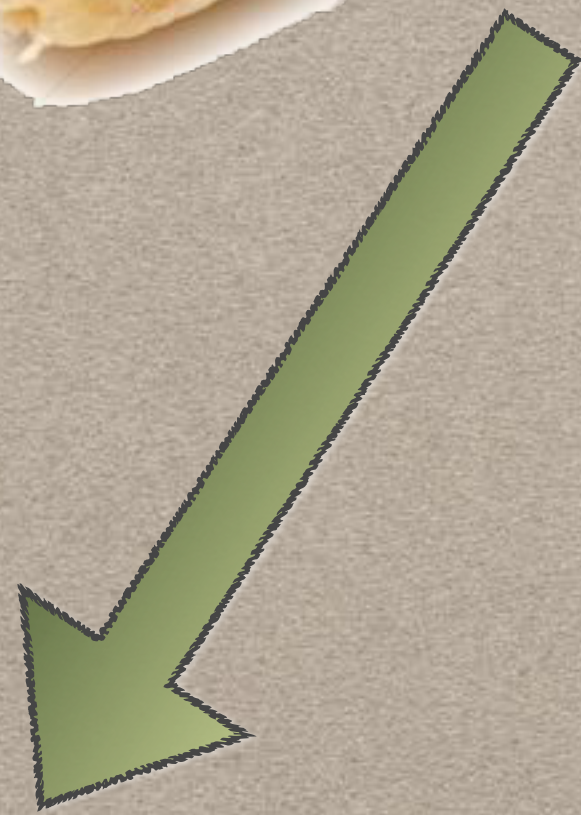
SPECTRAL RESTORATION: He 10830 (GREGOR)



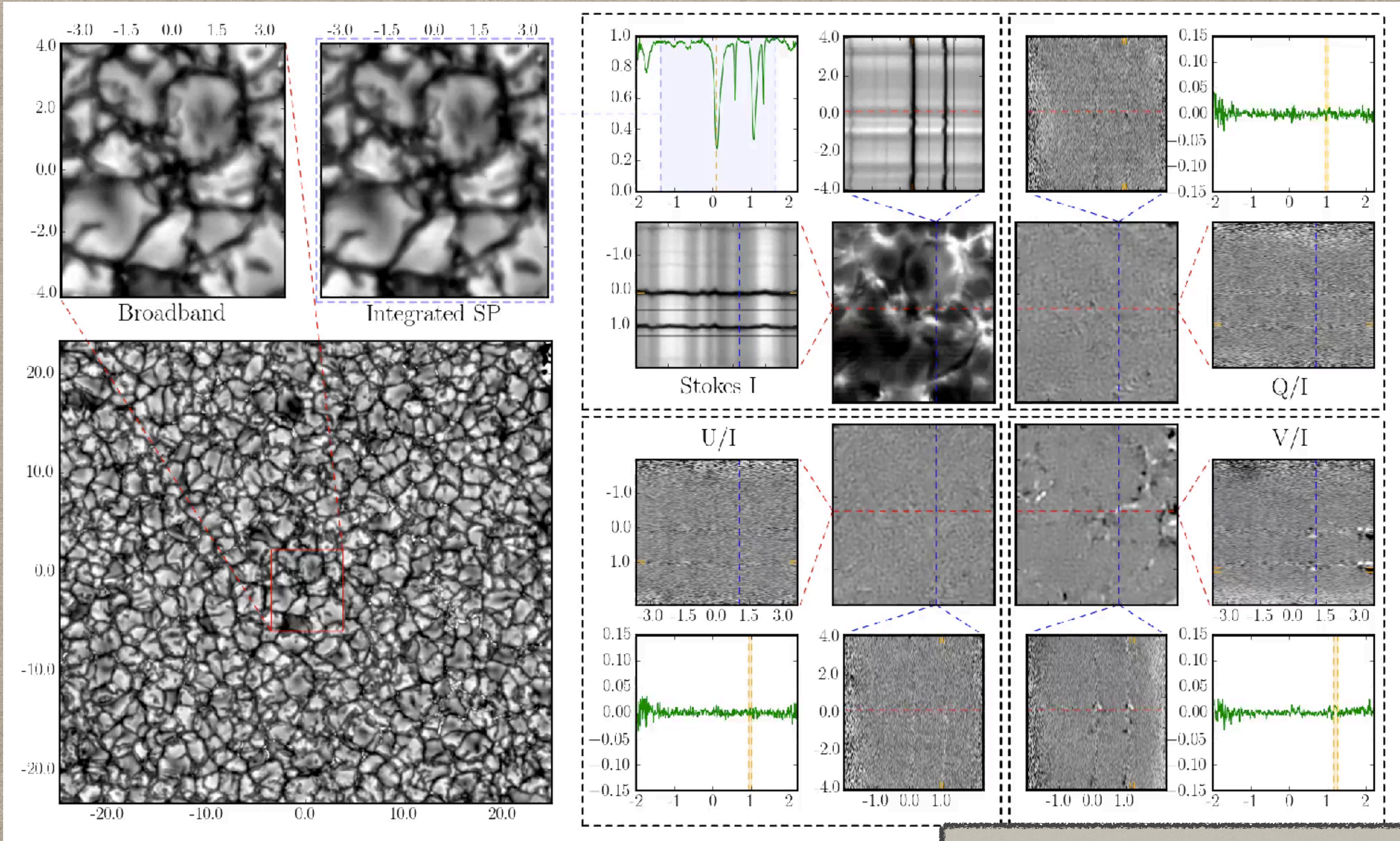
VERY PRELIMINARY DATA REDUCTION!!!



Doerr et al., MPS 2018

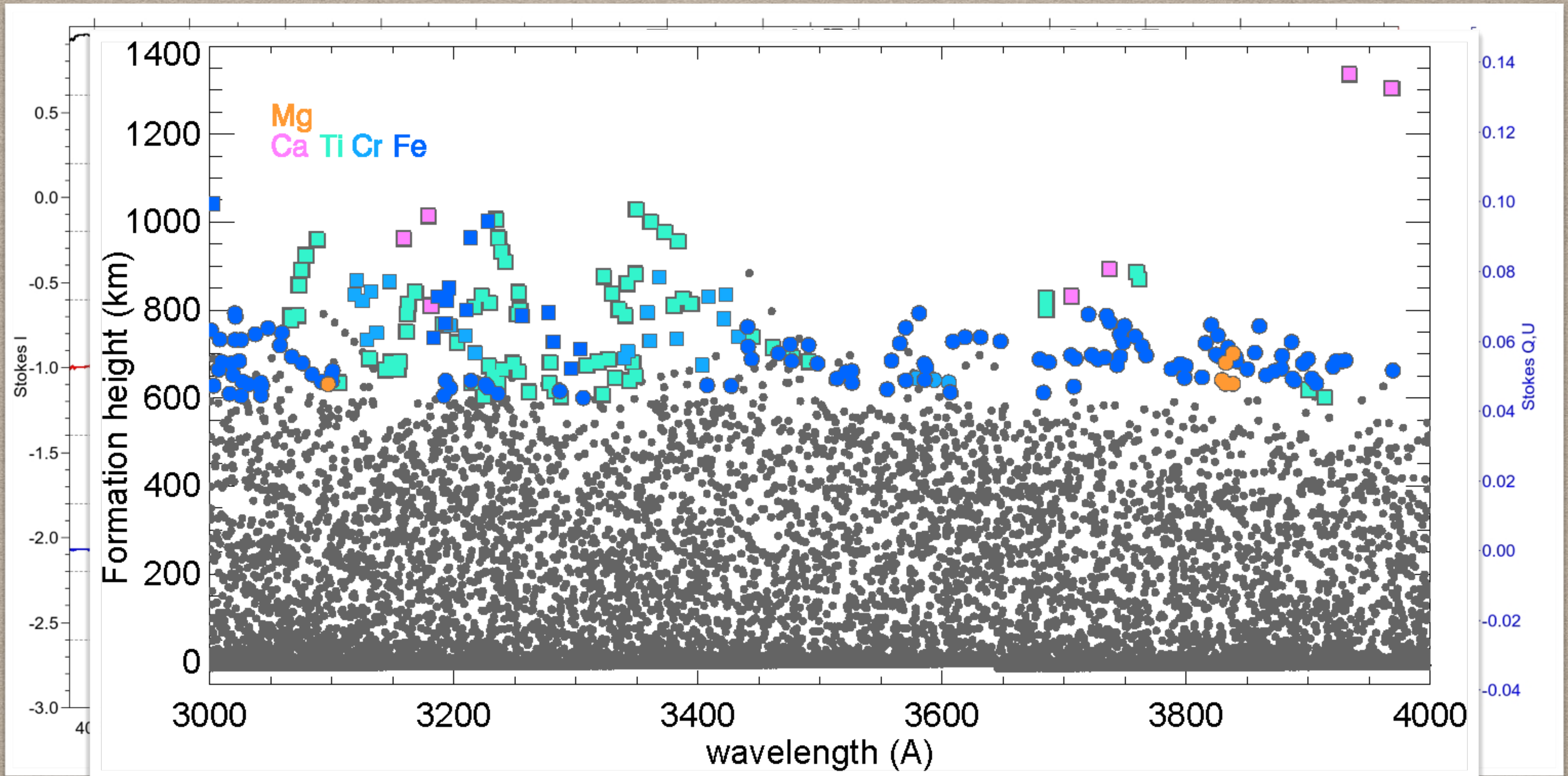


3D SPECTROPOLARIMETER MIHI (SOON HESP)



Van Noort et al., MPS 2018

SUNRISE-III: SEAMLESS PHOT -> CHROM. MEASUREMENTS



Riethmueller, Manso-Sainz, MPS 2018

- The chromospheric diagnostics of IRIS significantly deepened our understanding of the chromosphere
- Important side-effect: huge benefit for numerical simulations (MHD, radiative transfer)
 - essential prerequisite to understand the chromosphere
- Only now available: Instrumentation allowing for hi-res (temporal, spatial, spectral) reliable chromospheric magnetic field measurements