A modeler's perspective on UV bursts

Sanja Danilovic

Thanks to
Johan Bjørgen, João da Silva Santos, Tine Libbrecht, Gregal Vissers,
Pradeep Chitta, Hardi Peter, Hui Tian, Shin Toriumi,
Luc Rouppe van der Voort

IRIS-9, Göttingen, 25-29 June 2018

Invited Talk

2. Chromospheric heating and dynamics

A modeler's perspective on UV bursts

Sanja Danilovic[1]

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UV bursts are small, intense, transient brightenings visible in ultraviolet images of solar active regions. They are usually associated with small-scale flux cancellation in emerging flux regions, moving magnetic features in sunspot moats, but also sunspot light bridges. They show complex spectral signatures that also indicate that the underlying process might be magnetic reconnection taking place in the lower solar atmosphere. In this talk, I will review some the efforts to model these features and try to identify the requirements that have to met in order to reduce or eliminate current discrepancies between models and observations.

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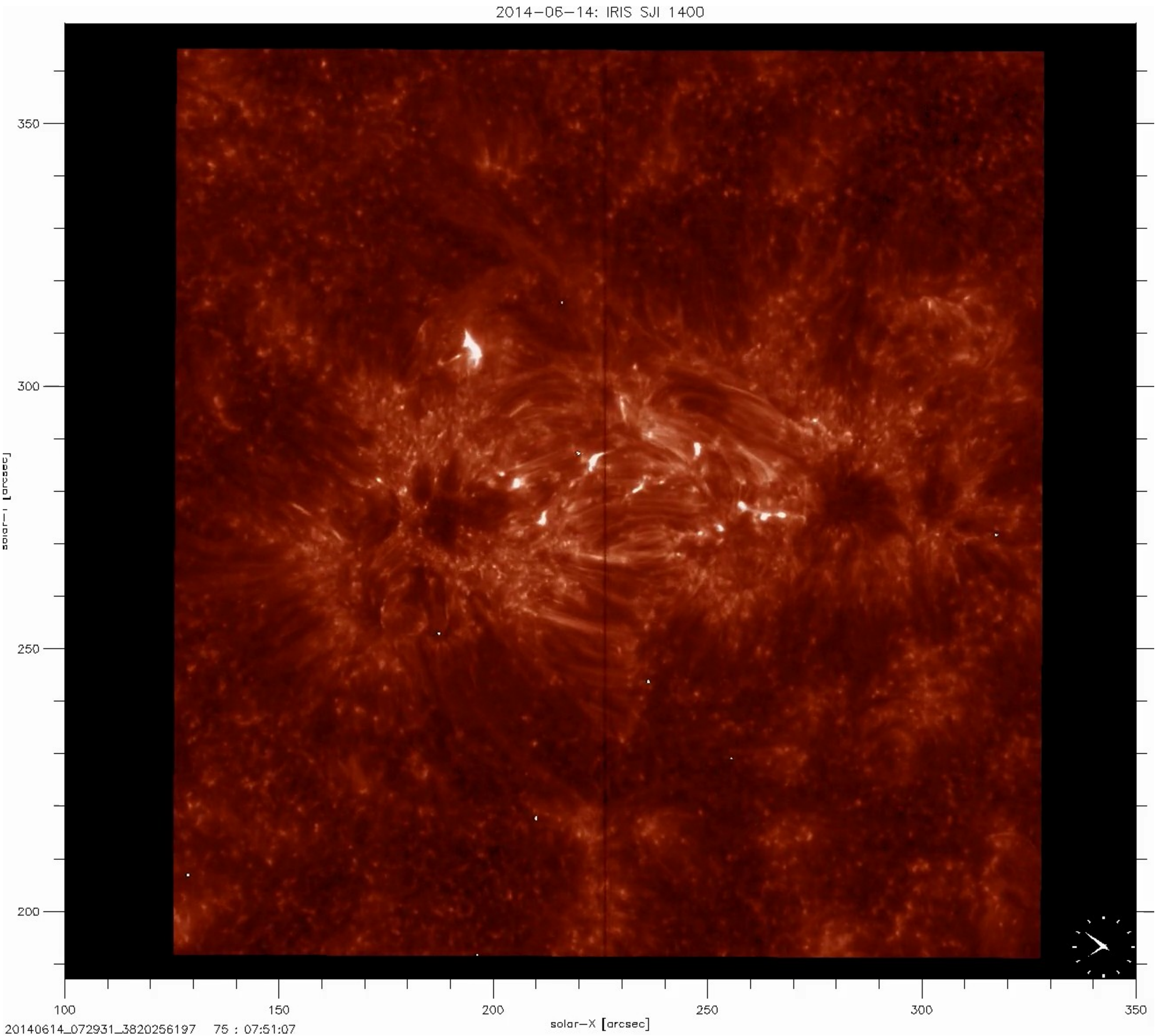

2014-06-14: IRIS SJI 1400
350
300
250
200
solar-Y [arcsec]
100
150
200
250
300
350
solar-X [arcsec]
20140614_072931_3820256197 75 : 07:51:07

Definition

"ultraviolet (UV) burst"

observed in UV wavelength range 465-1550 A

the brief duration of the brightening event

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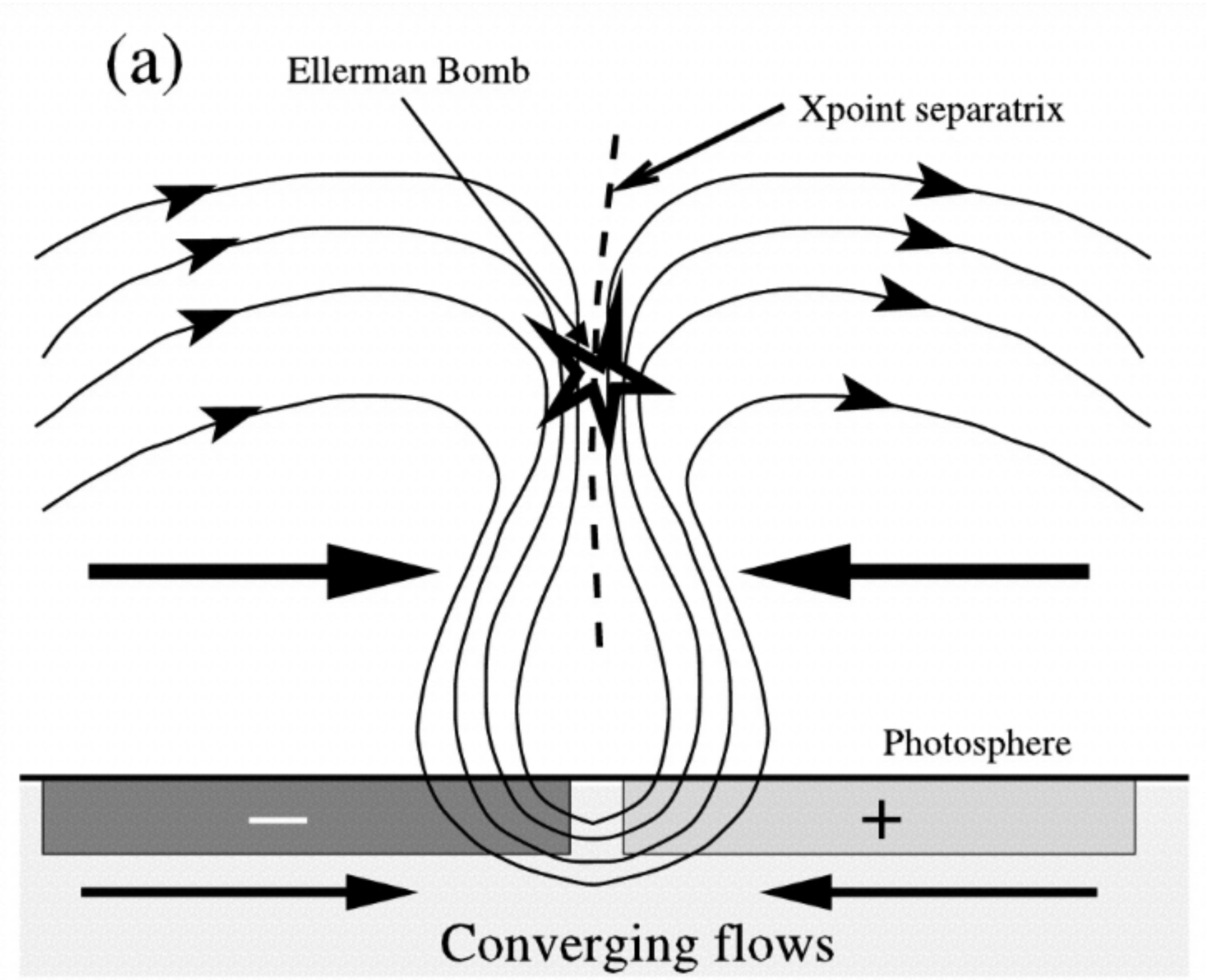
Properties:

- Compactness - core brightenings <2 arcsec in size; can have extended flame like morphology
- Duration - lifetimes ranging from tens of seconds to over an hour; flickering, recurrent
- Intensity - significantly brighter than the surroundings; Si IV lines enhanced by factor ~1000
- Motion – short distance with velocities ≤10 km/s; track photospheric magnetic features
- Location – emerging active regions, MMF, light bridges – not directly connected with flares

Definition



Georgoulis et al. 2002

see talk by Pradeep Chitta

Small, but important

- Underlying process – magnetic reconnection
- Chalenge for all our current models

Observational constraints

		UV burst		
Observables	EB		FAF	IB
Halpha, Hbeta	Moustache, flame-like morphology		jet like morphology	moustache in 10-20% cases
Na I D2	non-visible			
Mg I b2	non-visible			
Ca II H& K	Moustache, flame-like morphology			
Ca II8542	Moustache, flame-like morphology			
AIA 1600, 1700	bright		bright	bright
AIA hot channels	non-visible		bright	
Mg II h& K	enhanced, sometimes self-reversal			enhanced, broad
Mg II triplet	in emission, correlates with Halpha			
C II 1330			multiple components	double component
Si IV 1400	enhanced, sometimes self-reversal	enhanced, narrow		wide, triangular shape, Ni II blends
O IV 1400				low Si IV/O IV
He I D3 He I 10830	emission component			

Compiled from:
Grubecka et al. 2016, Gupta & Tripathi 2015, Hong et al. 2017, Hou et al. 2016, Huang et al. 2017, Libbrecht et al. 2017; Nelson et al 2017, Peter et al. 2014, Rouppe van der Voort et al. 2016, Rutten et al. 2015, Tian et al. 2016, 2018; Toriumi et al. 2017; Vissers et al. 2013,2015; Watanabe et al. 2011; Yan et al. 2015; Zhao et al. 2017

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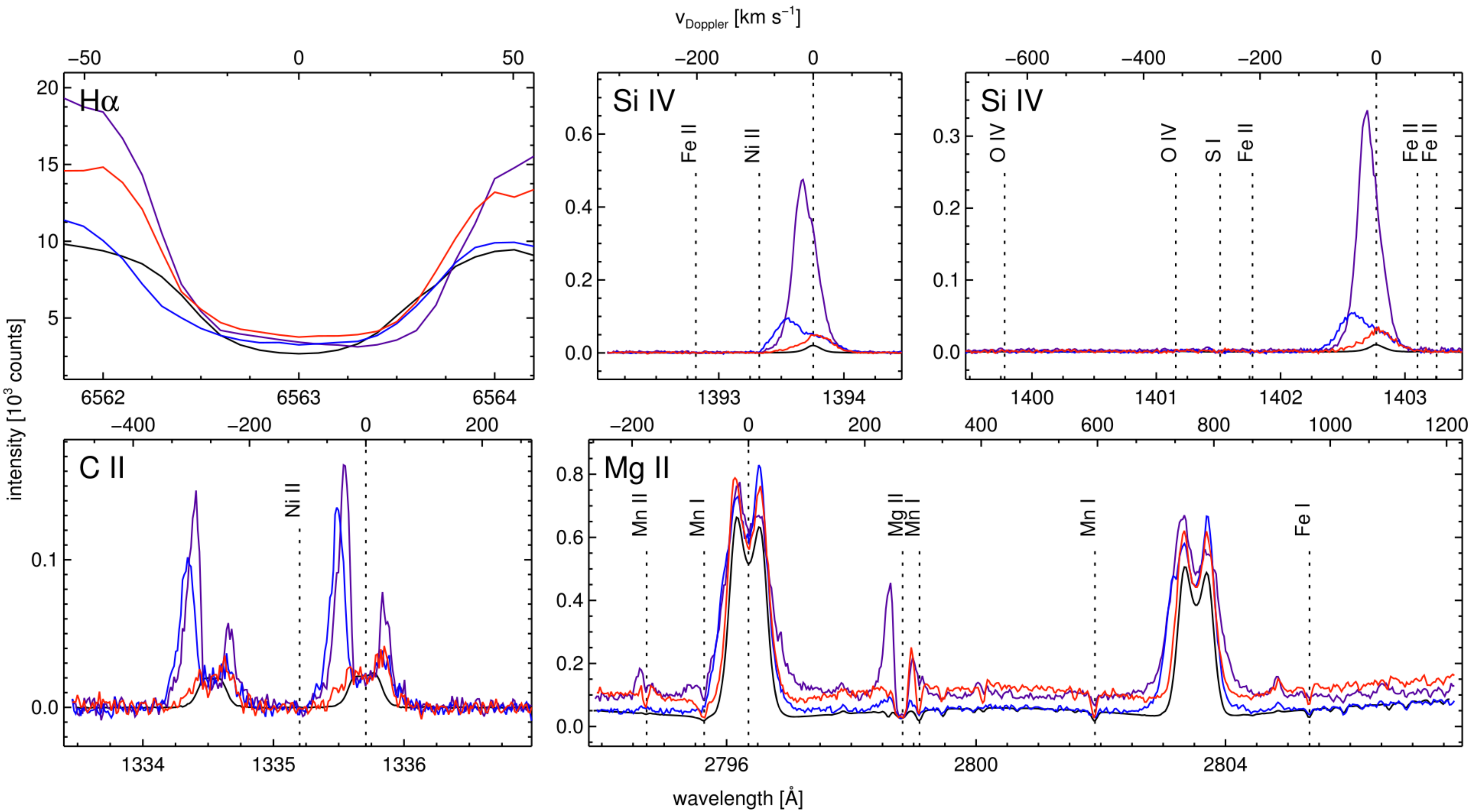

Watanabe et al. 2011; Yan et al. 2015; Zhao et al. 2017

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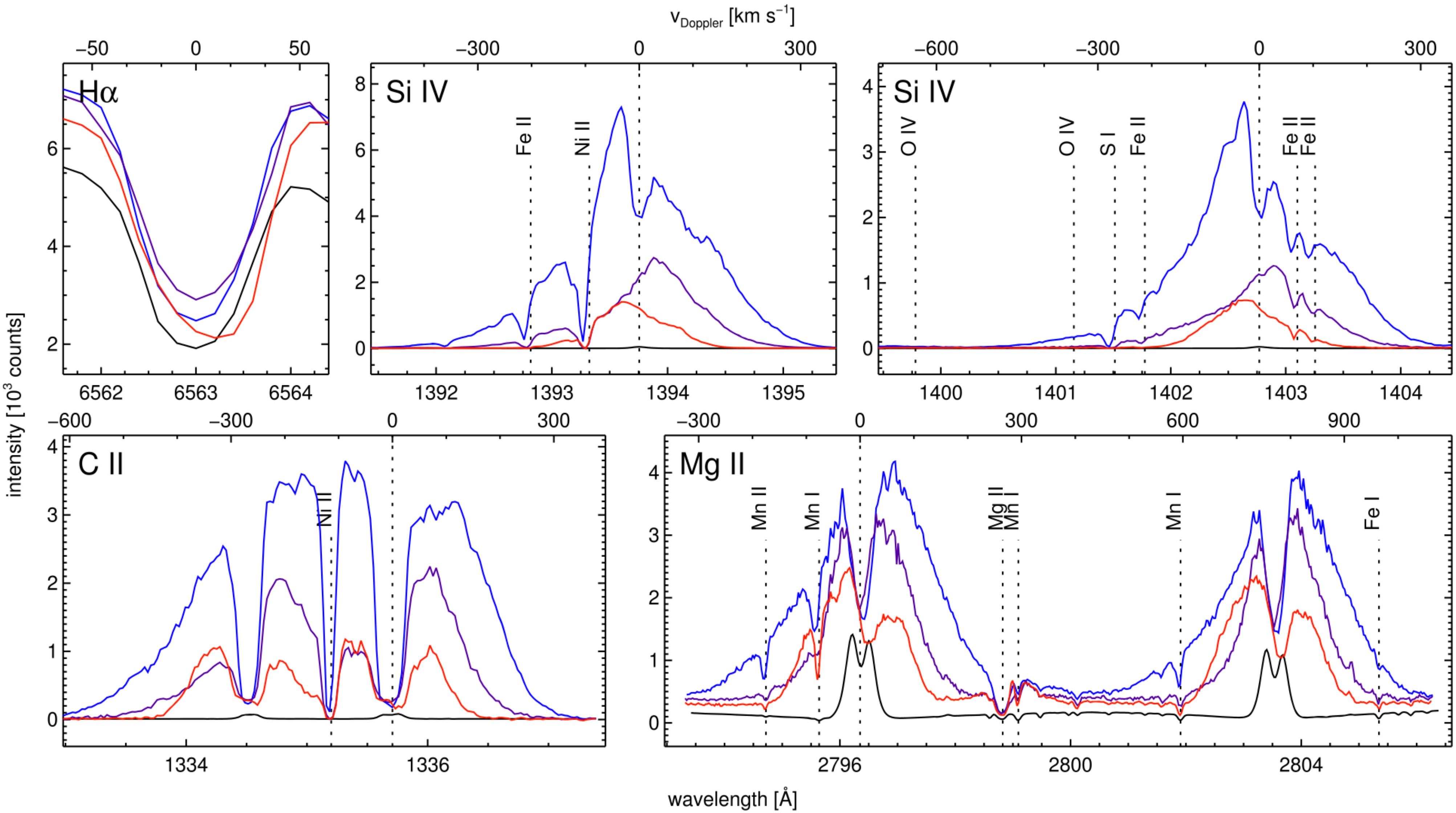

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From 10-15 kK to 50-80kK!

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Modeling experiments

- One- and two-dimensional models – temperature bump somewhere in the lower atmosphere – Kitai (1983), Berlicki et al. (2010), Berlicki and Heinzel (2014), Grubecka et al. (2016), Fang et al. (2017), Bello Gonzalez et al. (2013), Hong et al. (2017), Reid et al. 2017

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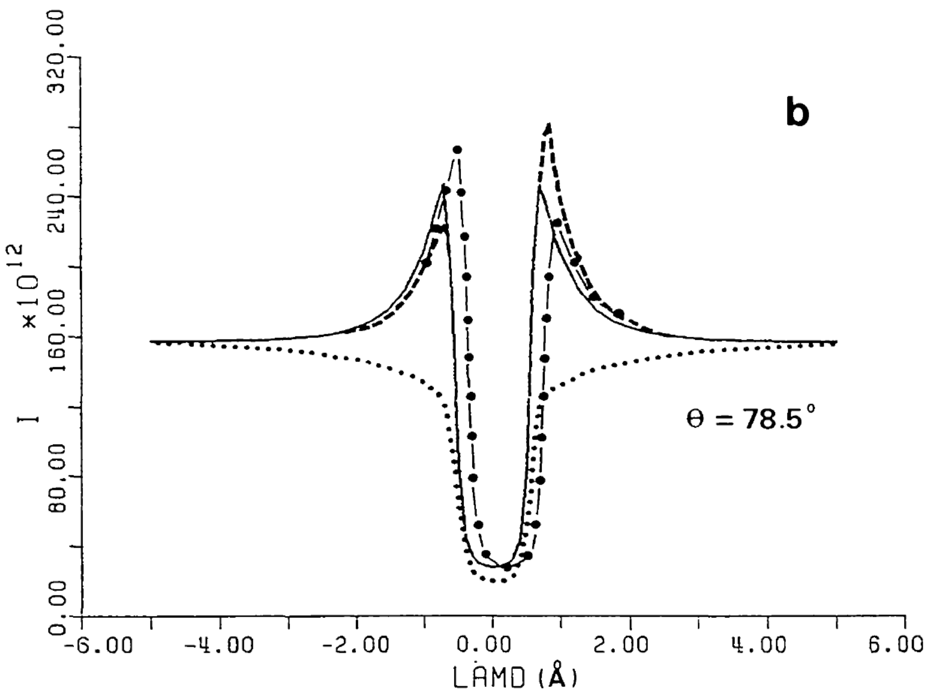

Kitai 1983

- Putting T increase too low results in too high continuum I
- T increase from few 100 to few 1000 K fits chromospheric lines
- Fitting Si IV results in inconsistent chromospheric signatures
  see Gregal Vissers talk!

Modeling experiments

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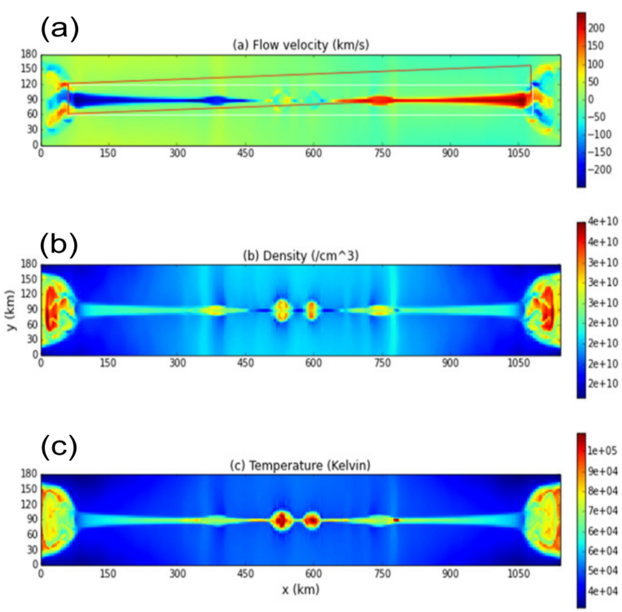
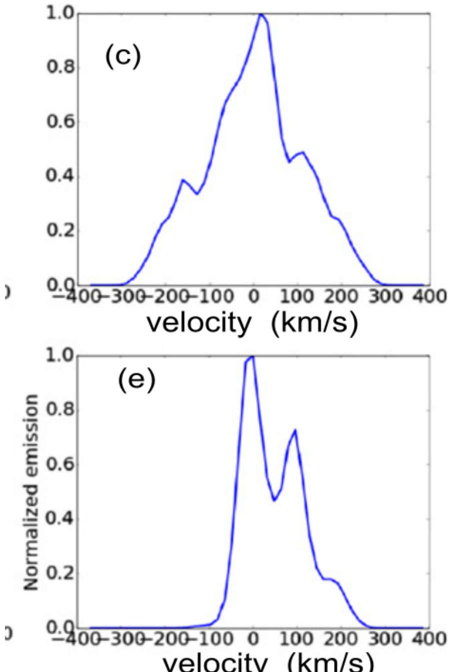
- 2.5- dimensional models – role of plasmoids in TR line formation – Innes et al. (2015) , Ni et al. (2016), Nobrega-Siverio et al. (2017) and Rouppe van der Voort et al. (2017)





Innes et al. 2015

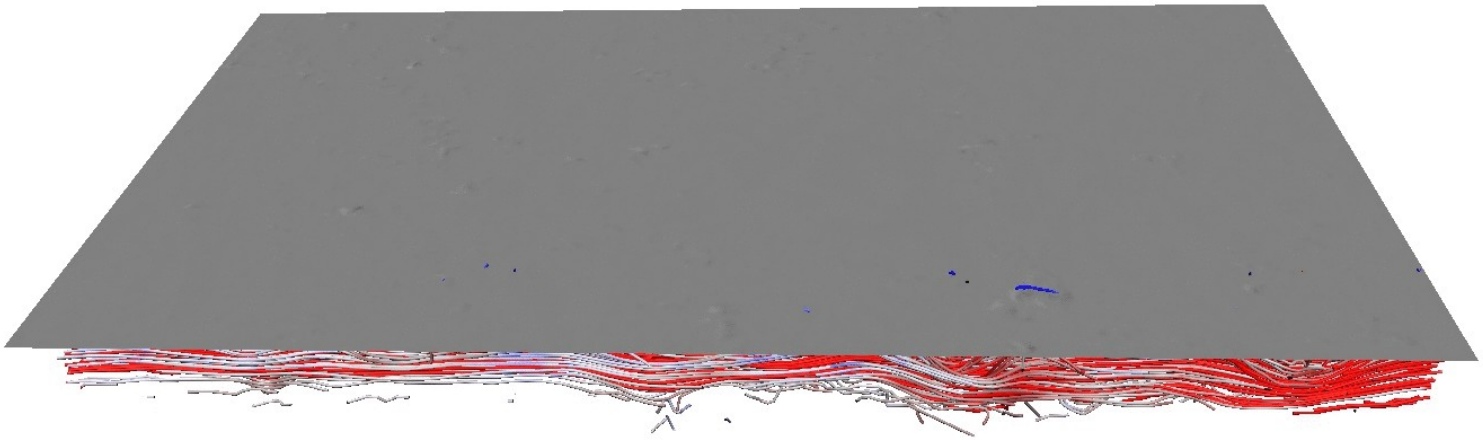
What has been done?

Quick overview

Modeling experiments

- One- and two-dimensional models – temperature bump somewhere in the lower atmosphere – Kitai (1983), Berlicki et al. (2010), Berlicki and Heinzel (2014), Grubecka et al. (2016), Fang et al. (2017), Bello Gonzalez et al. (2013), Hong et al. (2017), Reid et al. 2017
- 2.5- dimensional models – role of plasmoids in TR line formation – Innes et al. (2015) , Ni et al. (2016), Nobrega-Siverio et al. (2017) and Rouppe van der Voort et al. (2017)
- Three dimensional models – try to reproduce the serpentine like emergences – Isobe et al. 2007, Archontis and Hood (2009), Danilovic et al. (2016), Danilovic (2017), Hasteen et al. (2017)

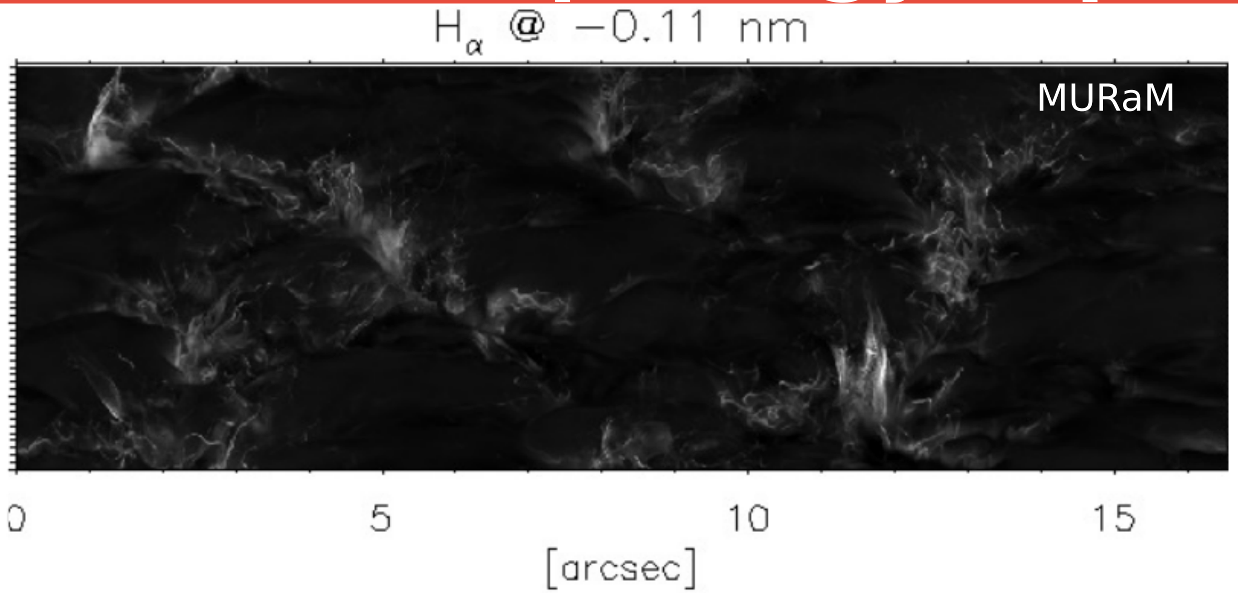
Modeling experiments



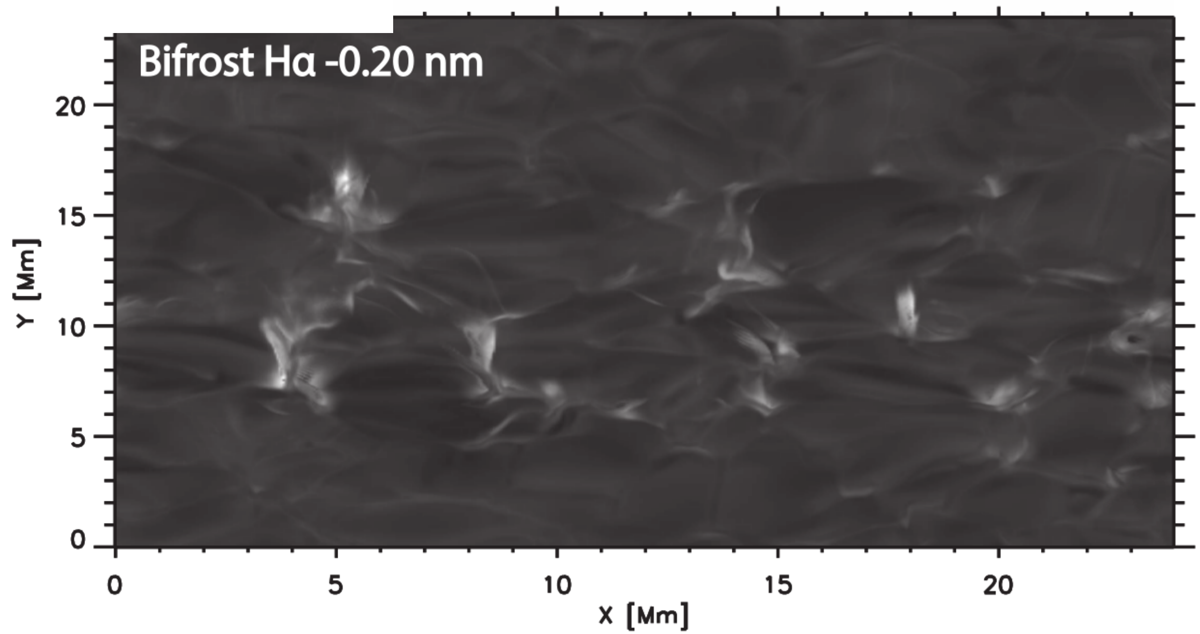
What has been done?

Quick overview

Flame morphology explained

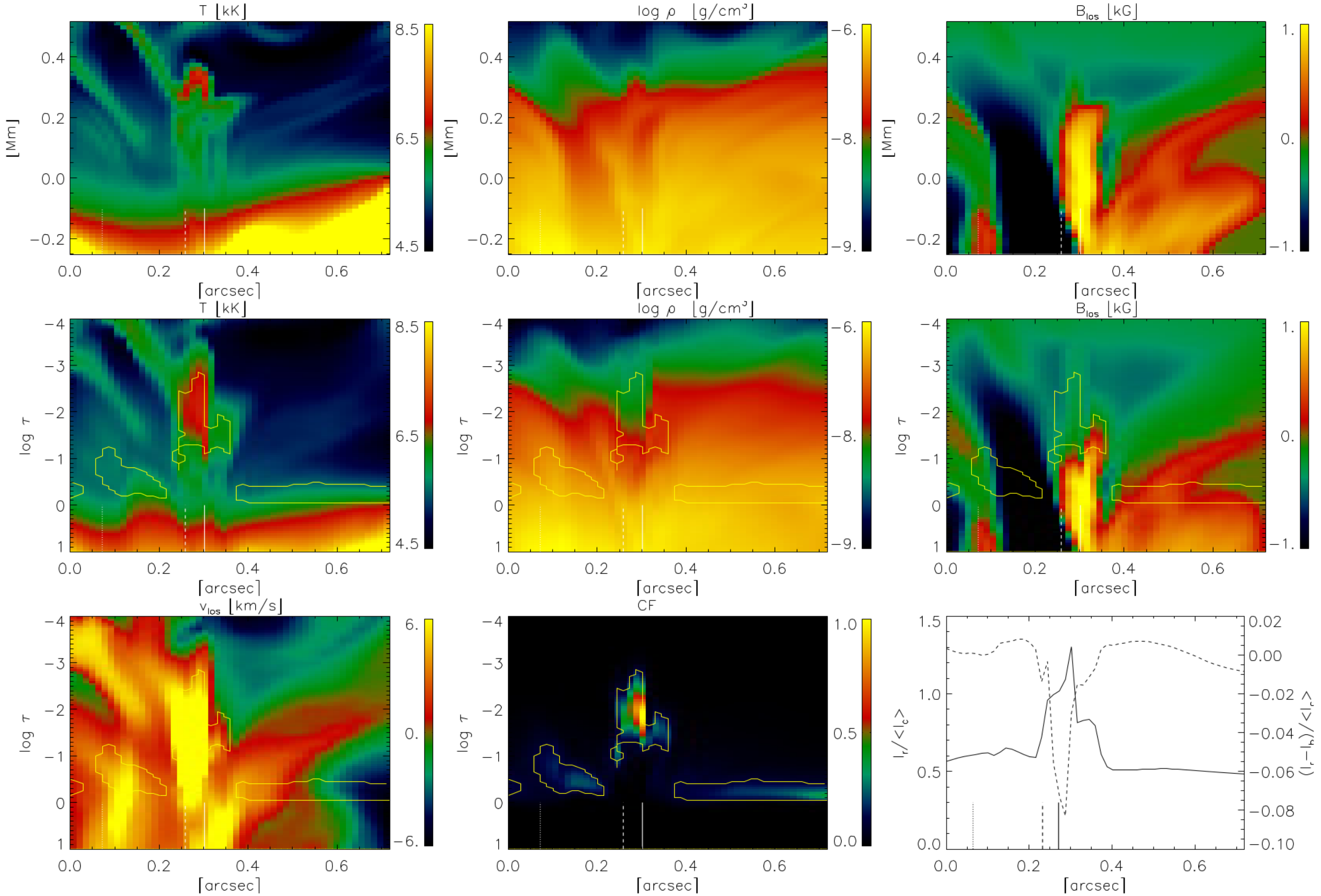


Danilovic 2017



Hansteen et al. 2017

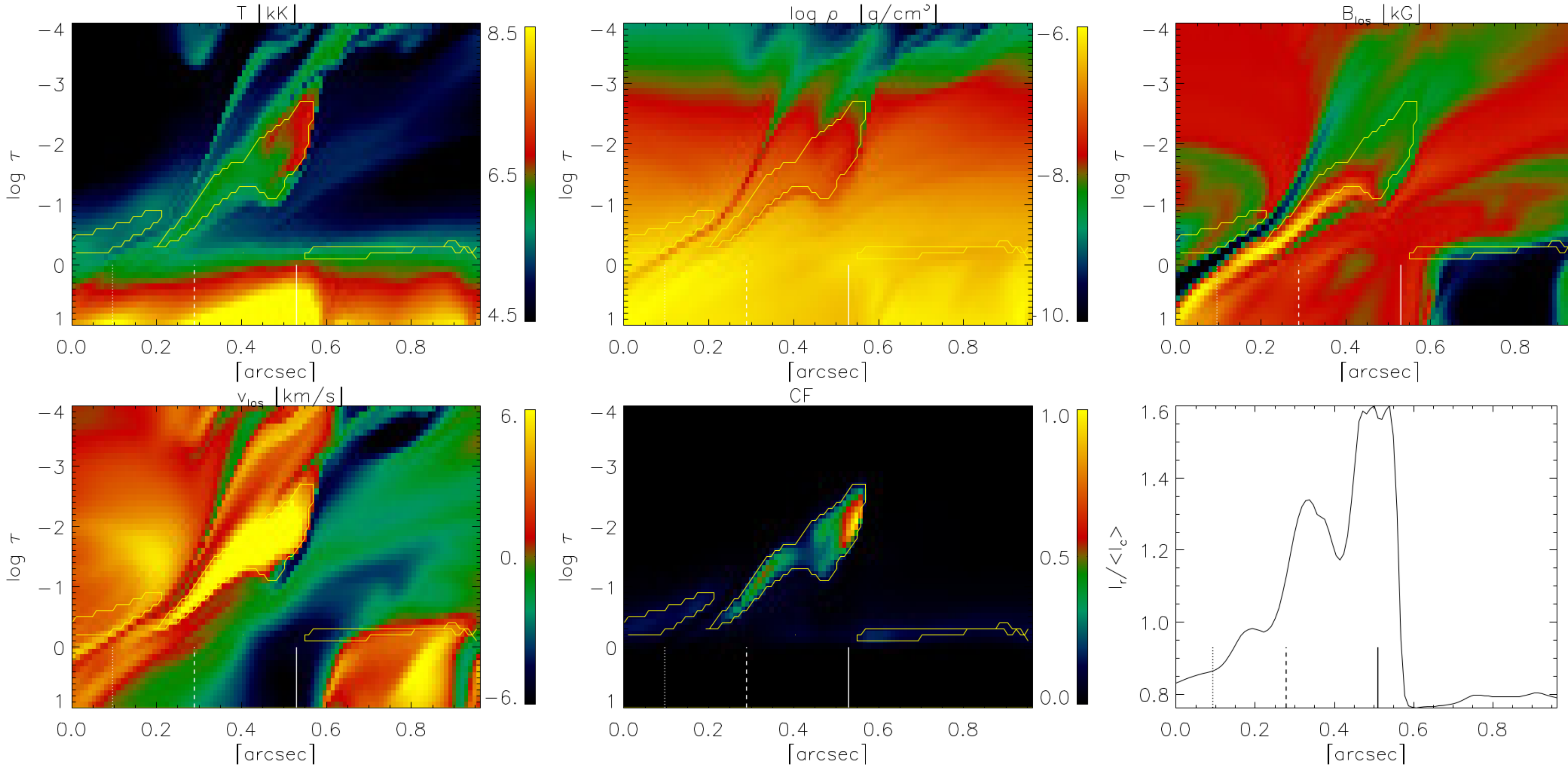
Flame morphology explained



Where are we now?

Present

Flame morphology explained



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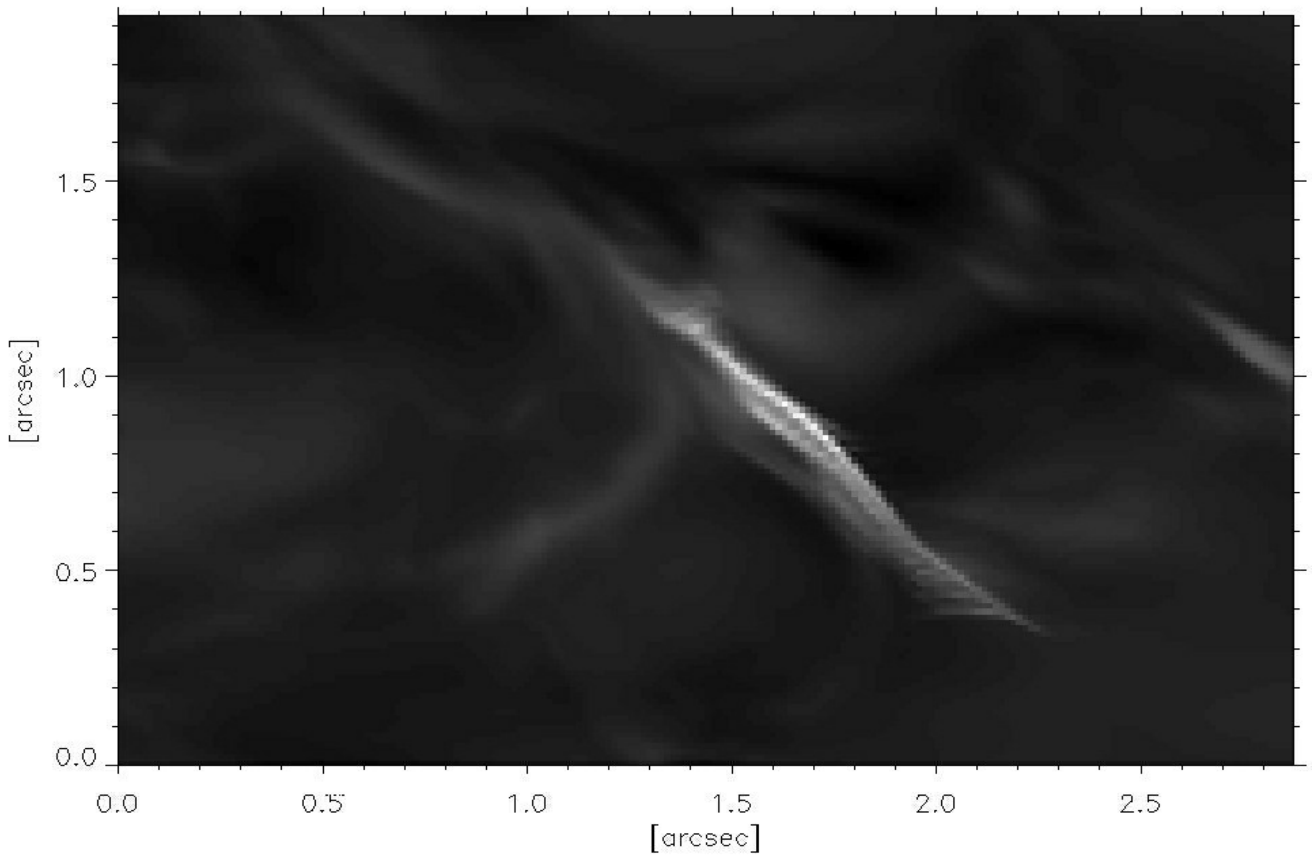
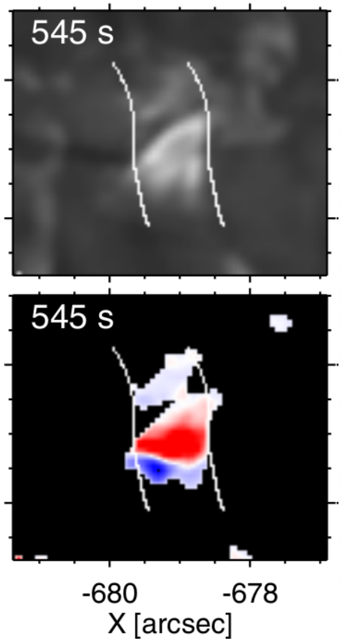


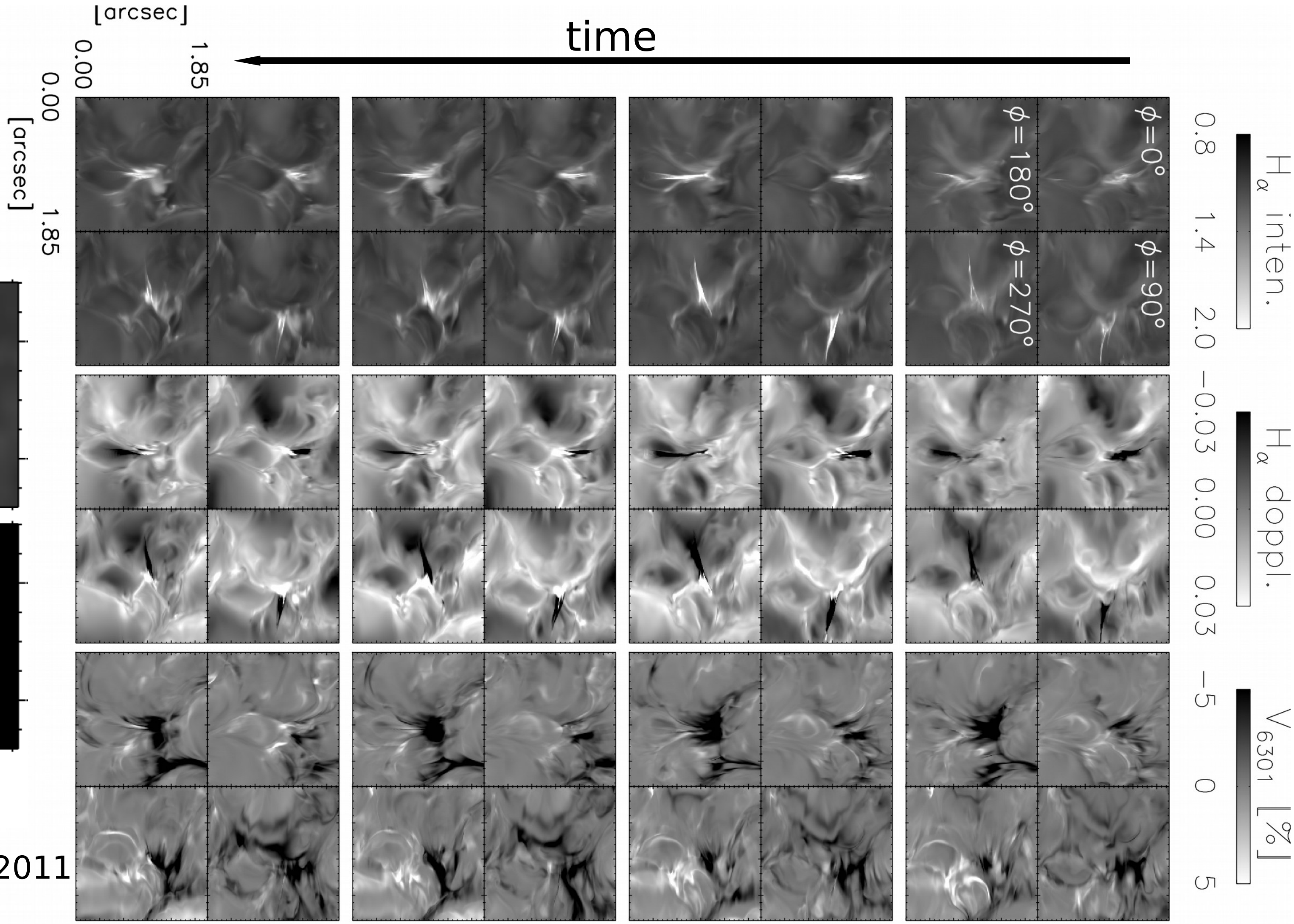
Where are we now?

Present

So is the wing asymmetry and unipolarity



Watanabe et al. 2011

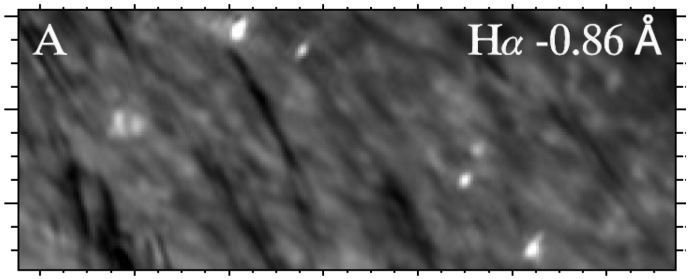


Where are we now?

Present

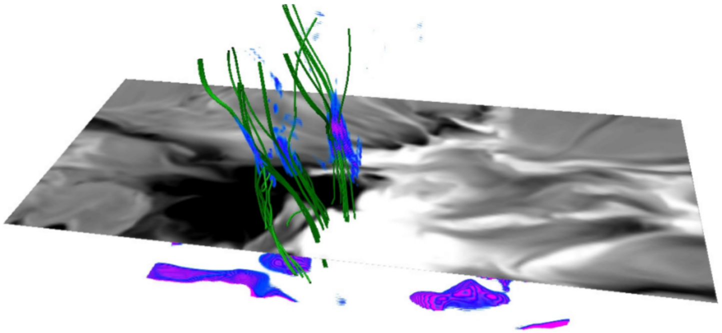
Flame morphology more complex in AR

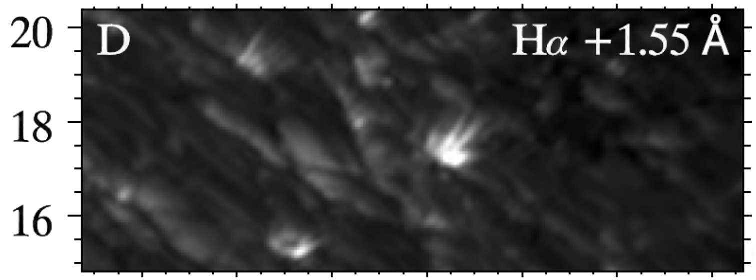
QS case

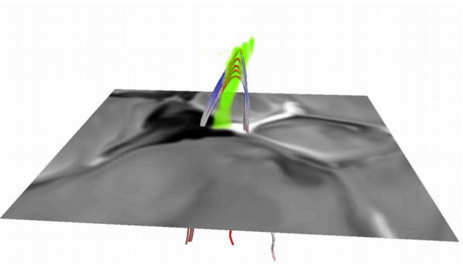


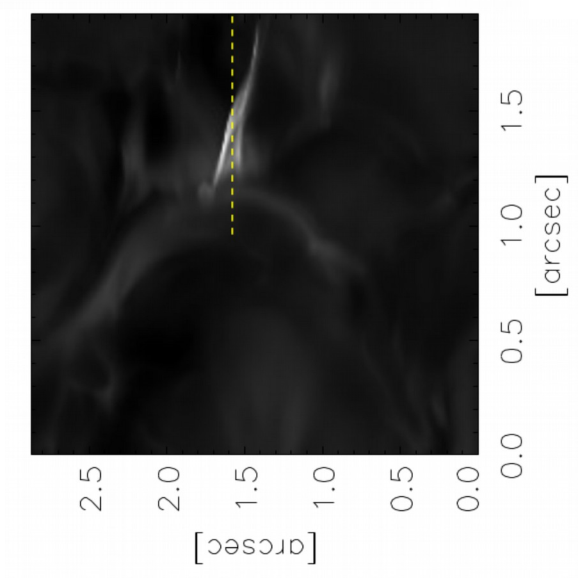
Rouppe van der Voort
et al. 2016

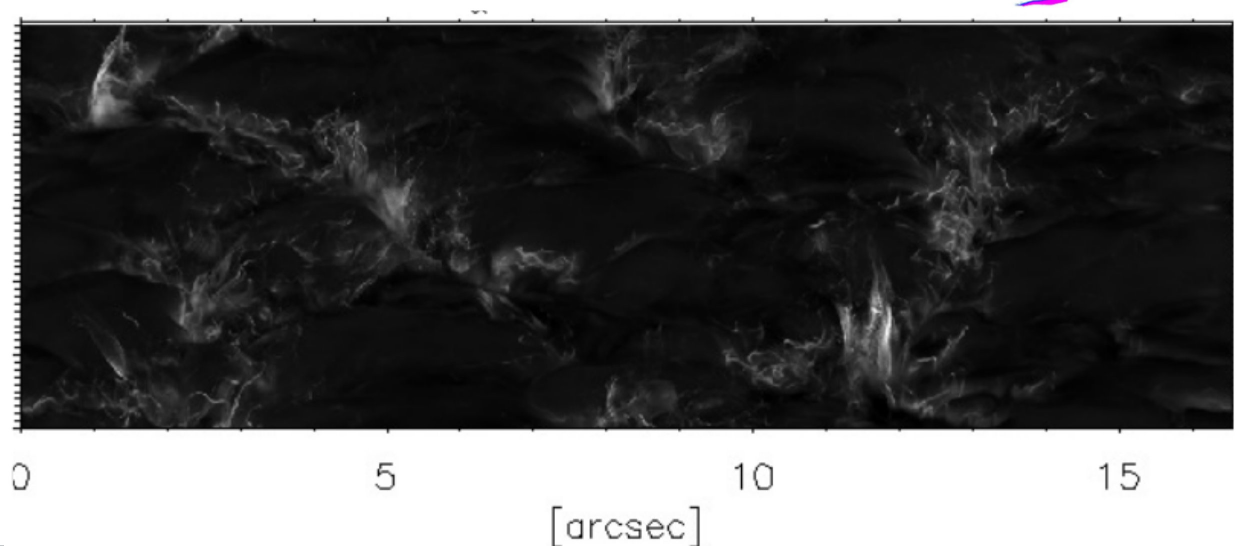
AR case



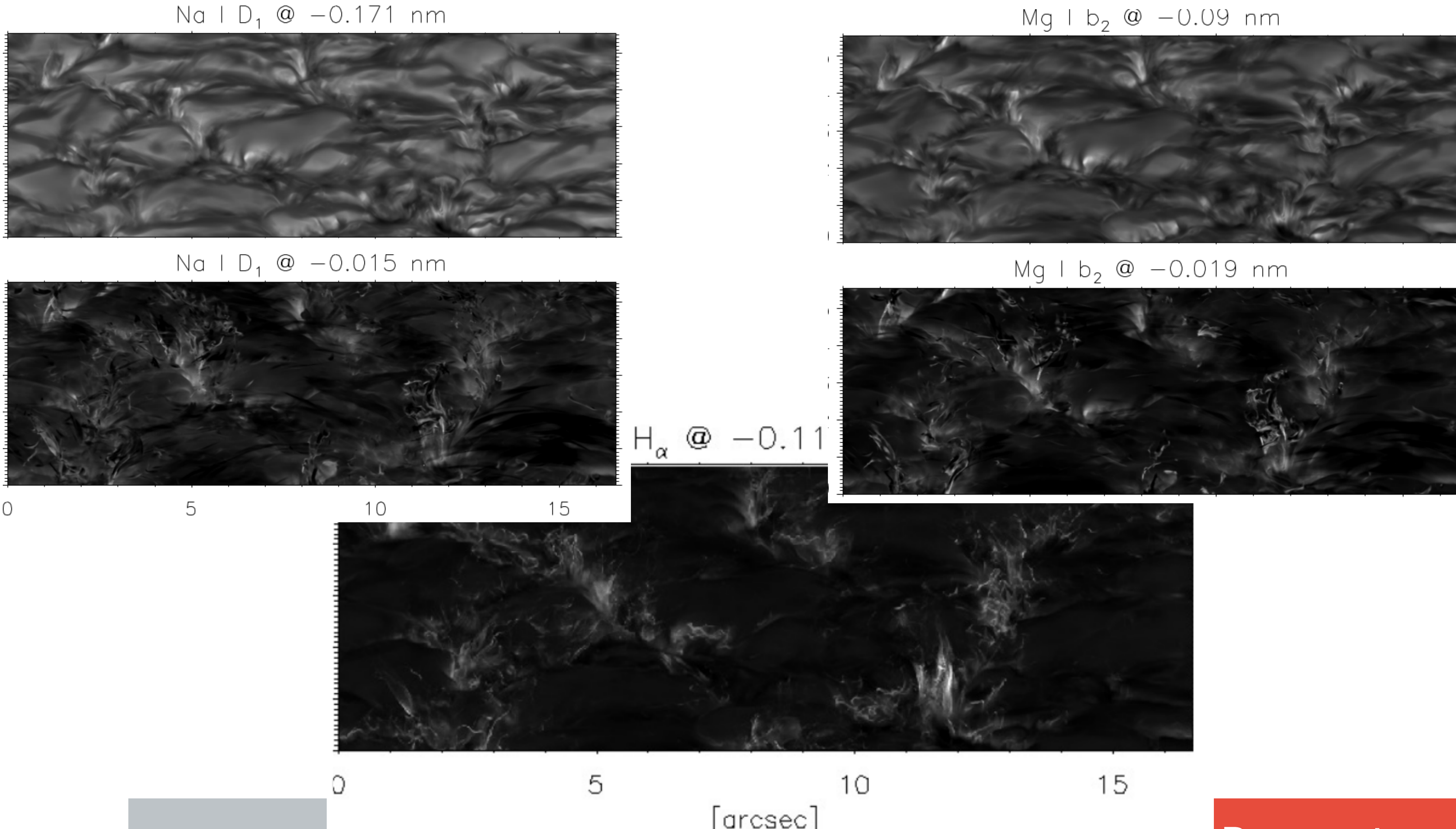




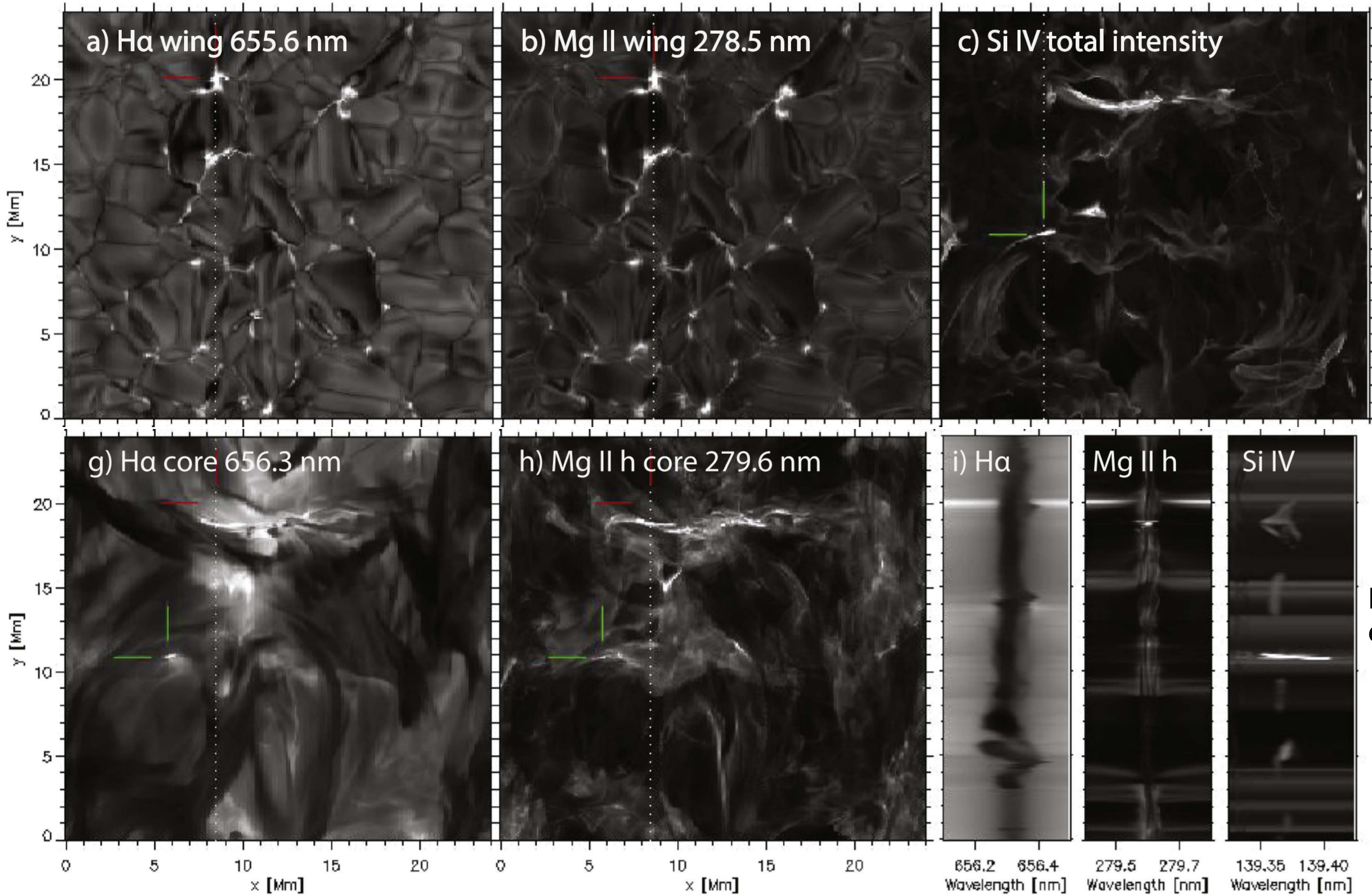




Unvisibility in Na I and Mg I reproduced



UV formed higher up

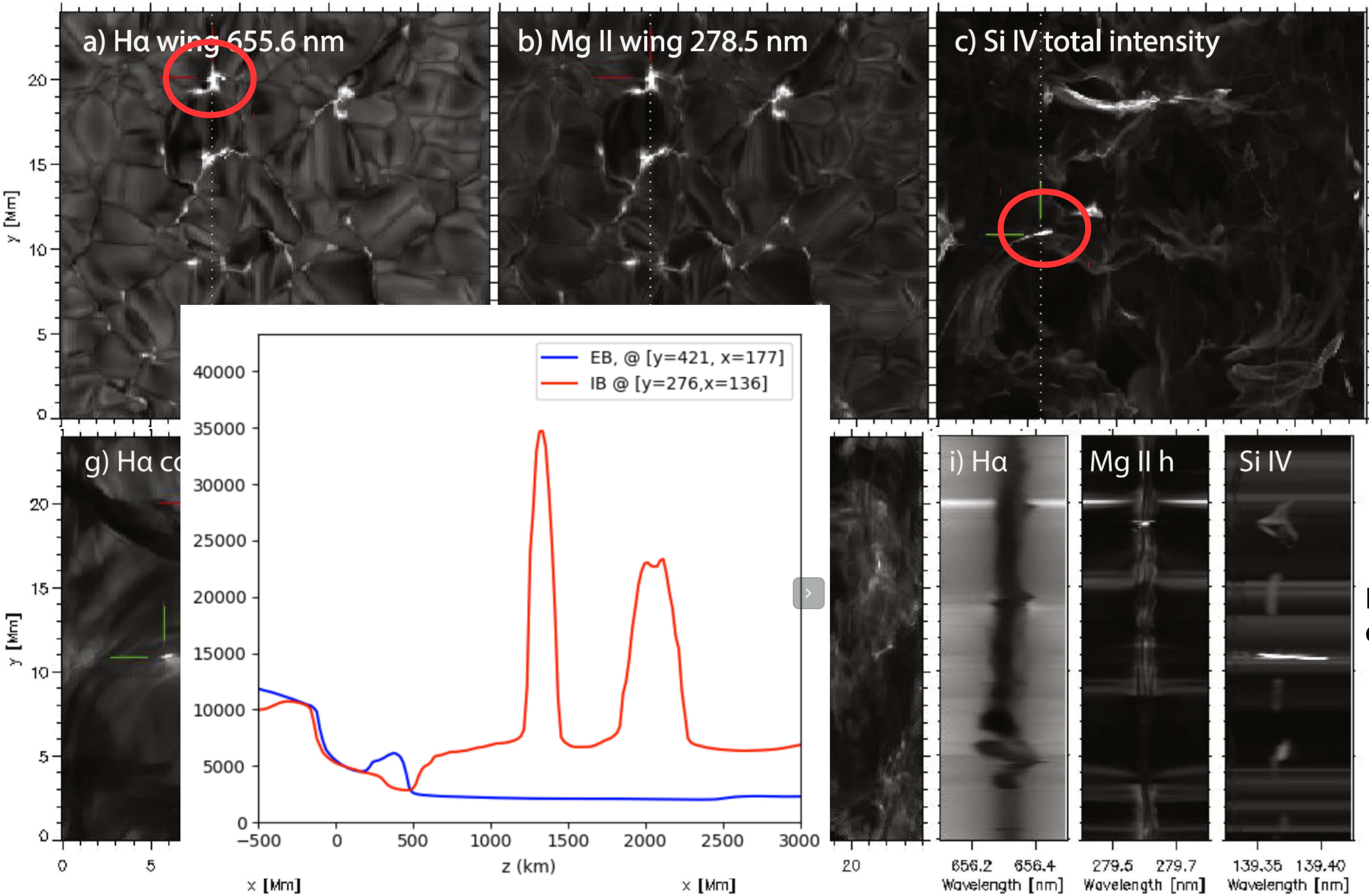


Hansteen et al. 2017

Where are we now?

Present

UV formed higher up



Hansteen et al. 2017

Where are we now?

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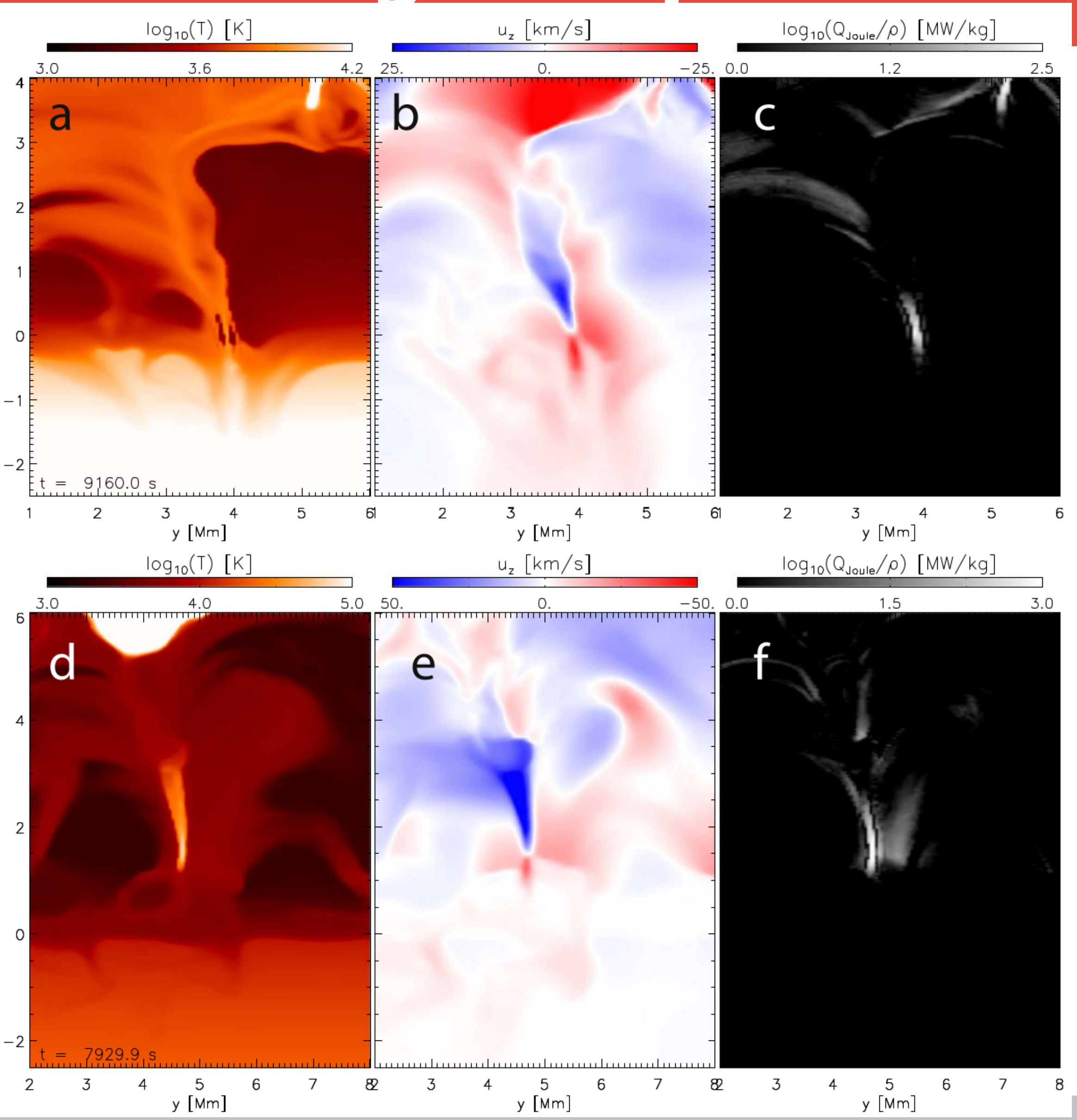
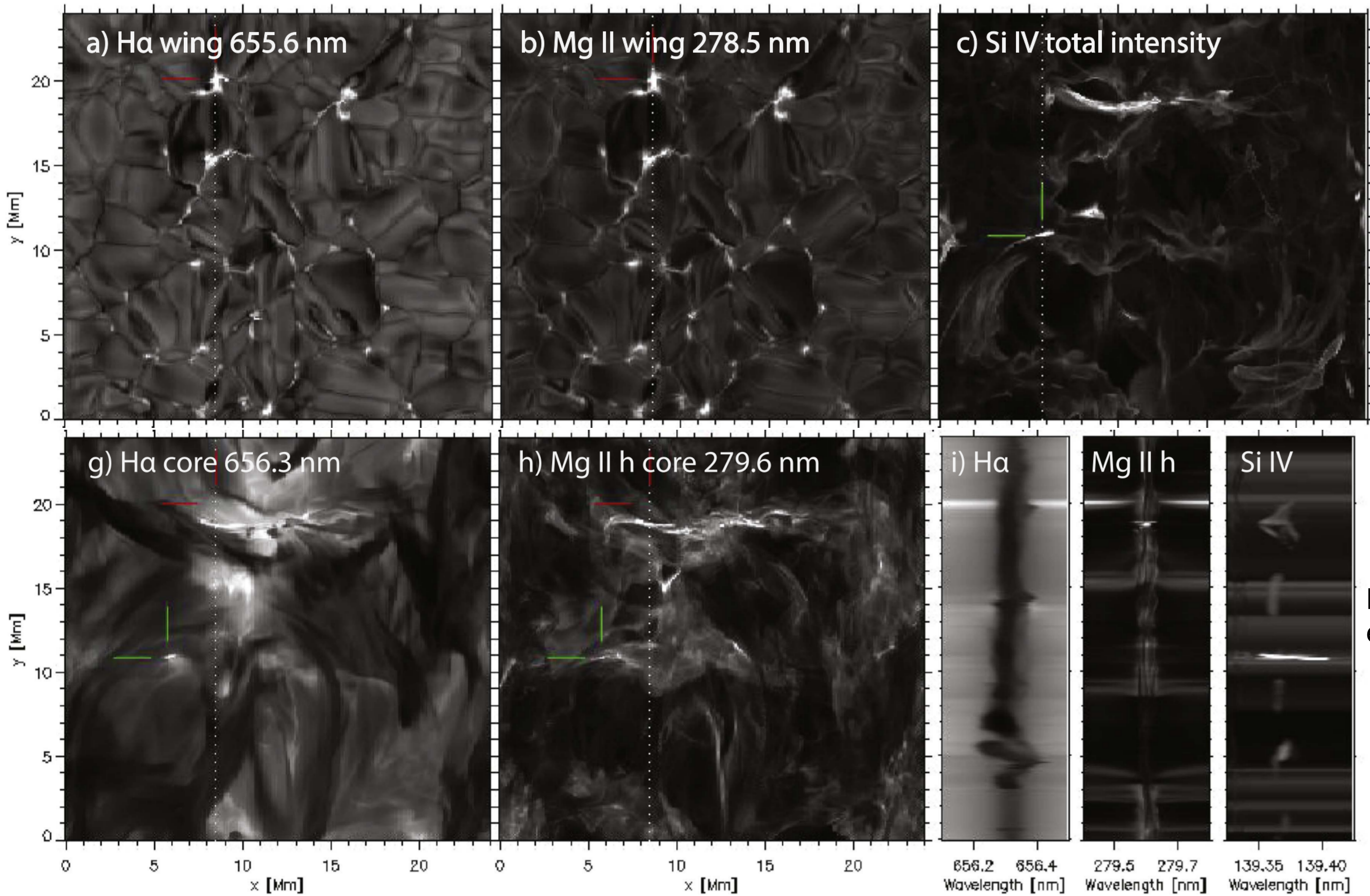


Hansteen et al. 2017

Unable to get EB and UV simultaneously



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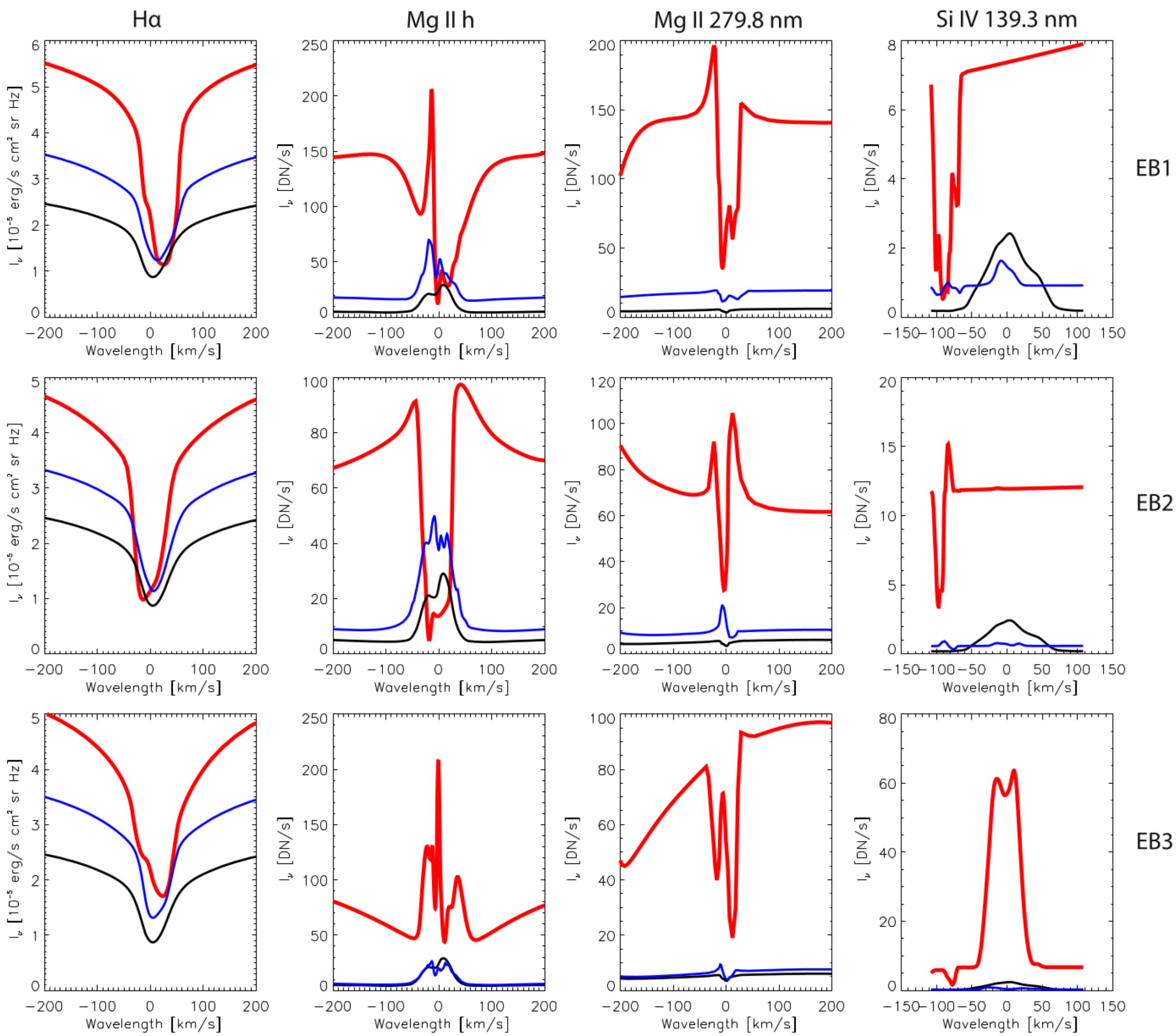

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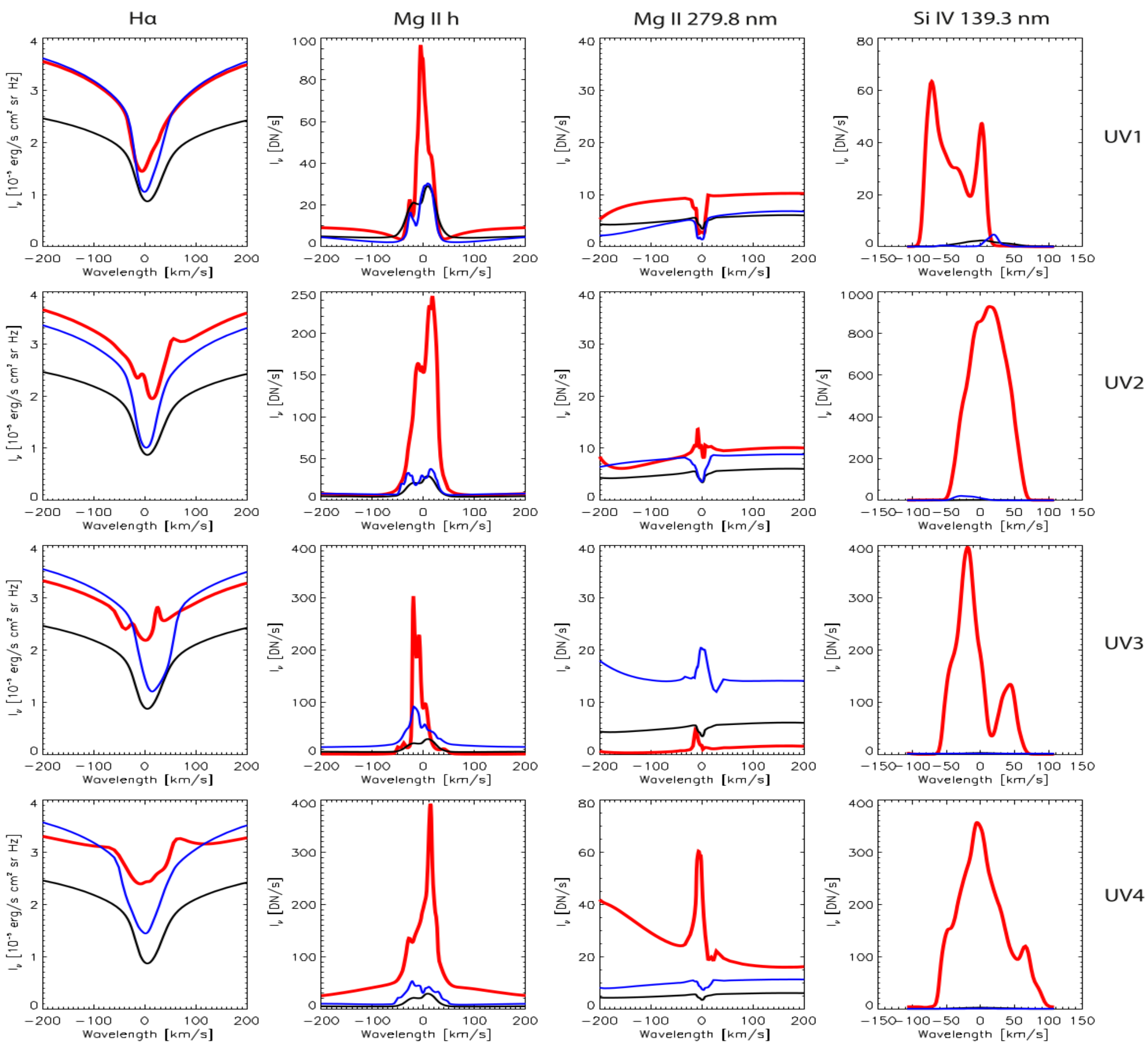
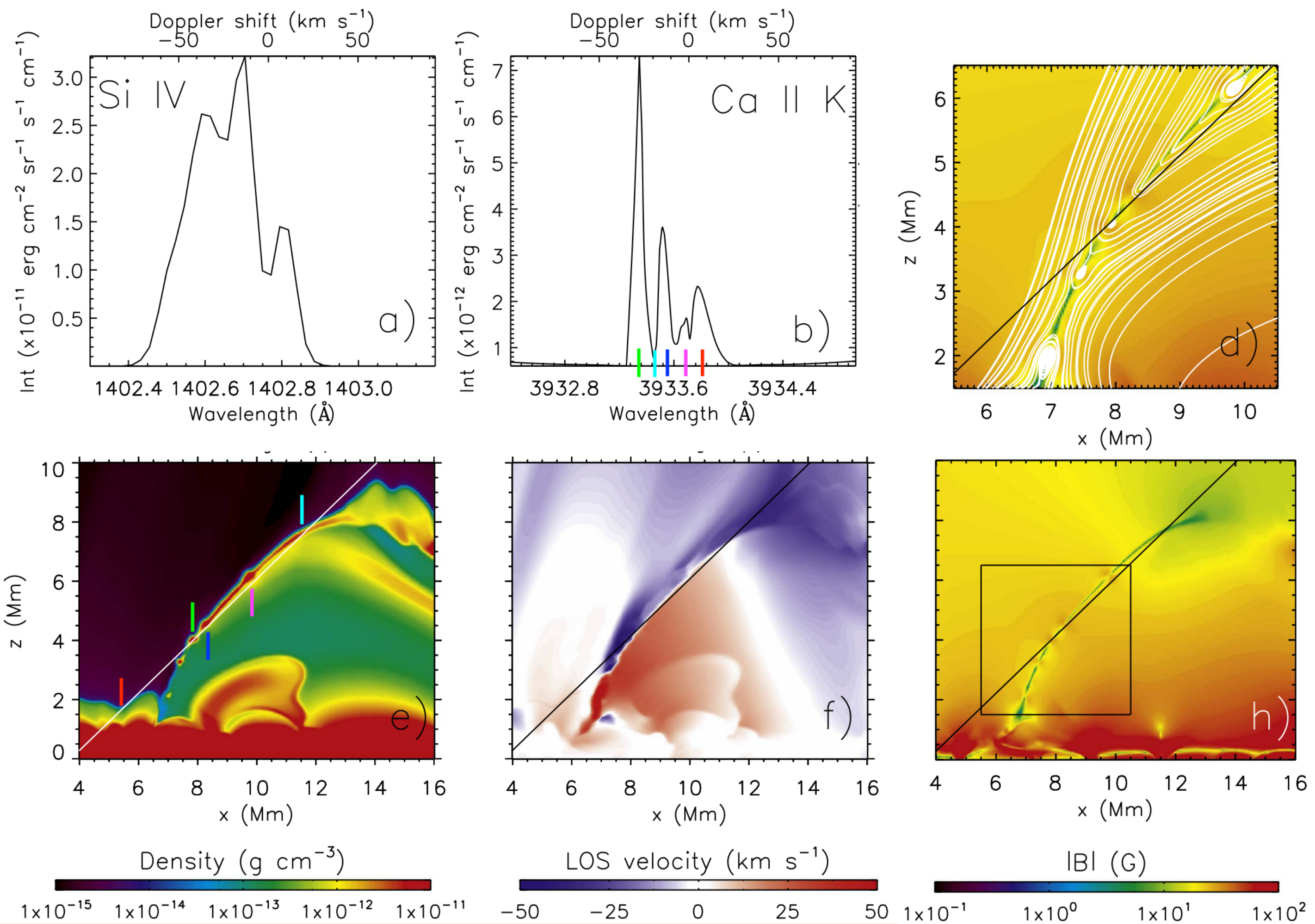


Hansteen et al. 2017

Plasmoids crucial for Si IV?



Rouppe van der Voort et al. 2017

- See his poster!

Where are we now?

Present

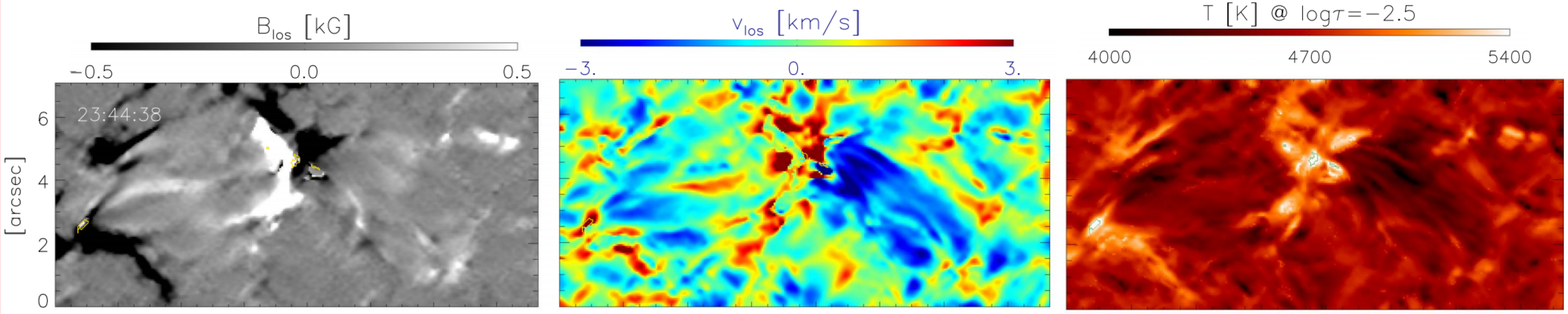
A perfect model

- A more realistic field configuration

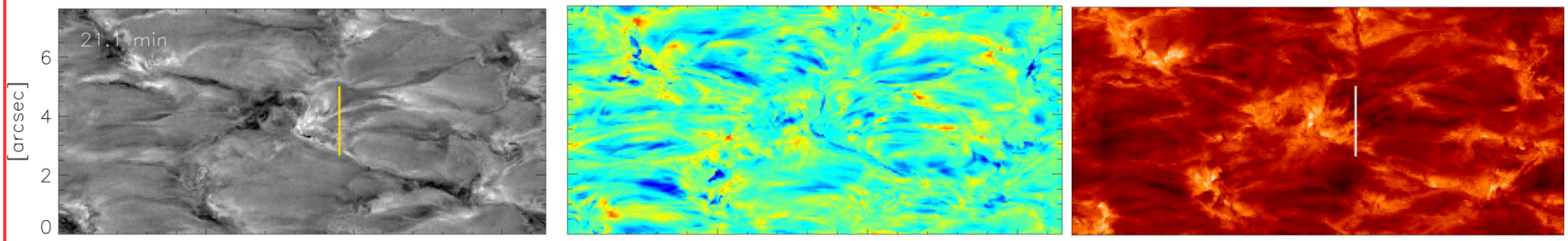
A perfect model

- A more realistic field configuration - more Pointing flux needed to reach the magic numbers of T~10-20 kK and N_H~1.e15 cm^{-3} suggested by Rutten (2016)

observations



simulations

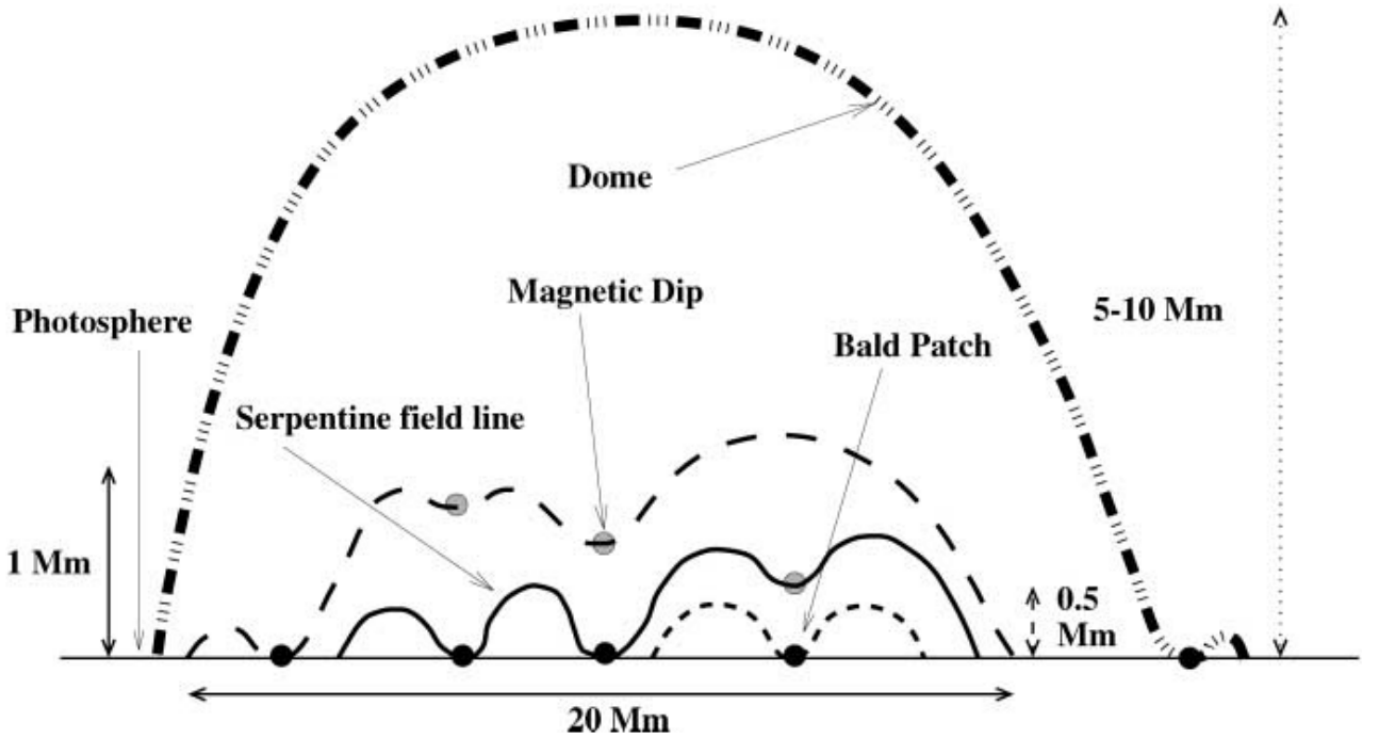


What do we need?

Future?

A perfect model

- A more realistic field configuration

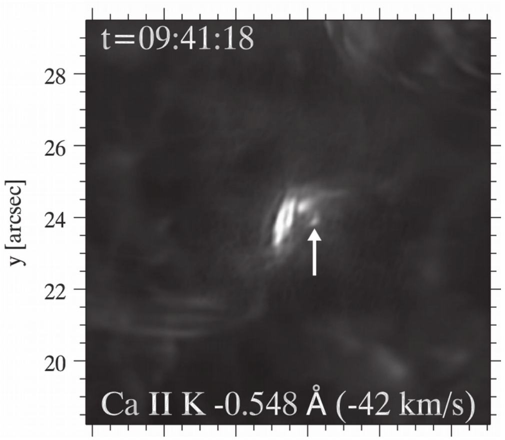


Pariat et al. 2004

see talk by
Johan Bjorgen!

A perfect model

- More realistic field configuration
- Large and small scales at the same time



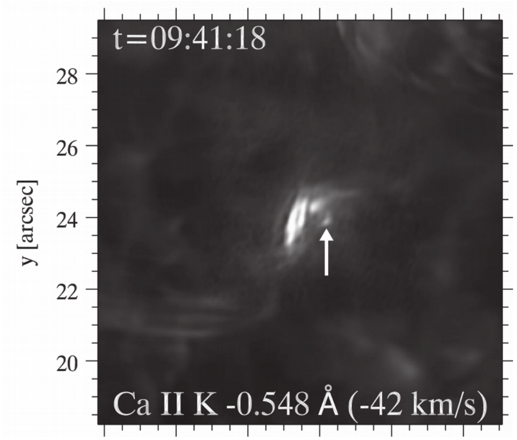
SST/CHROMIS
spatial resolution of 60 km

What do we need?

Future?

A perfect model

- More realistic field configuration
- Large and small scales at the same time
- Non equilibrium ionization



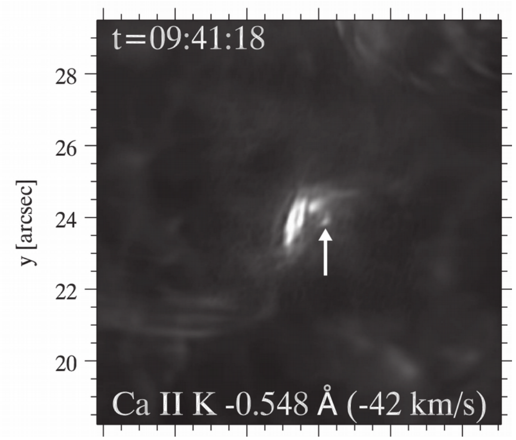
SST/CHROMIS
spatial resolution of 60 km

What do we need?

Future?

A perfect model

- More realistic field configuration
- Large and small scales at the same time
- Non equilibrium ionization
- Non-mhd add ons
  - ambipolar diffusion
  - non-thermal effects (Hong et al. 2017)



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What do we need?

Future?

A perfect model

- More realistic field configuration
- Large and small scales at the same time
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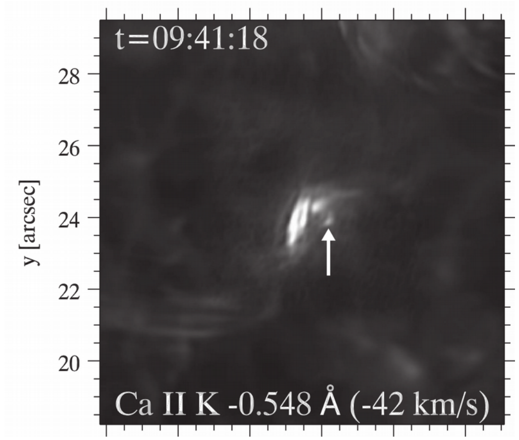
- Non-mhd add ons
  - ambipolar diffusion
  - non-thermal effects
- Forward synthesis done the right way



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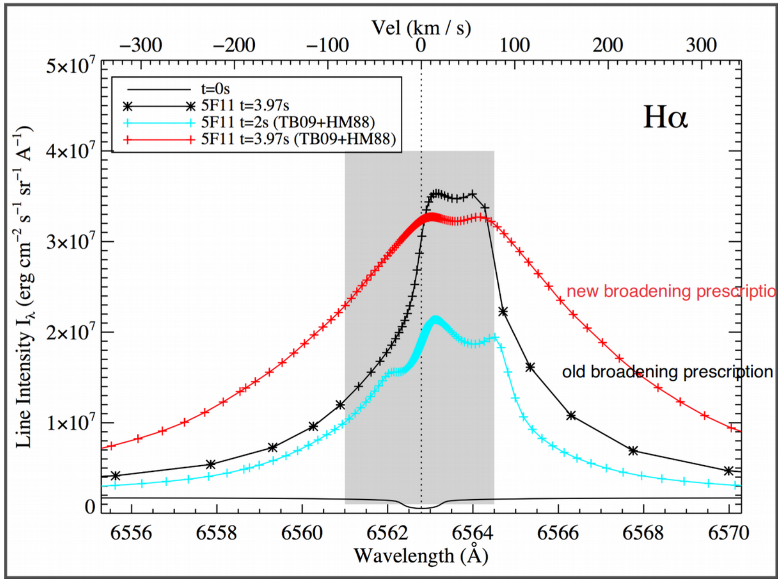

Kowalski et al. 2017

What do we need?

Future?

Recommendation

More in our review paper

Solar ultraviolet bursts
by
ISSI team
UV bursts in active regions - new insights into magnetic reconnection