

High-Resolution Observations of Chromospheric Activity Associated with Small-Scale Emerging Flux

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General Properties

- Upward motion followed by rapid fading w/o observable downward phase
- Lifetime 10—100s; velocity 50-150km/s; width-150-700km
- Swaying, oscillating and torsional motions
- Also see Pereira et al. 2012, Sekse et al. 2012

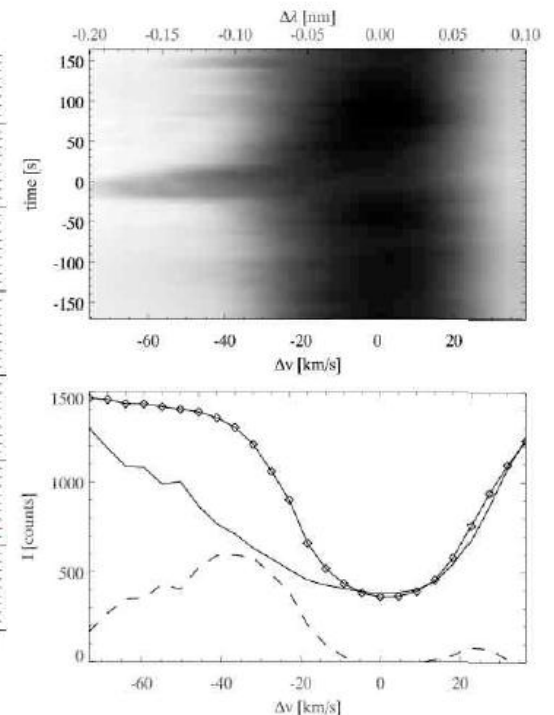
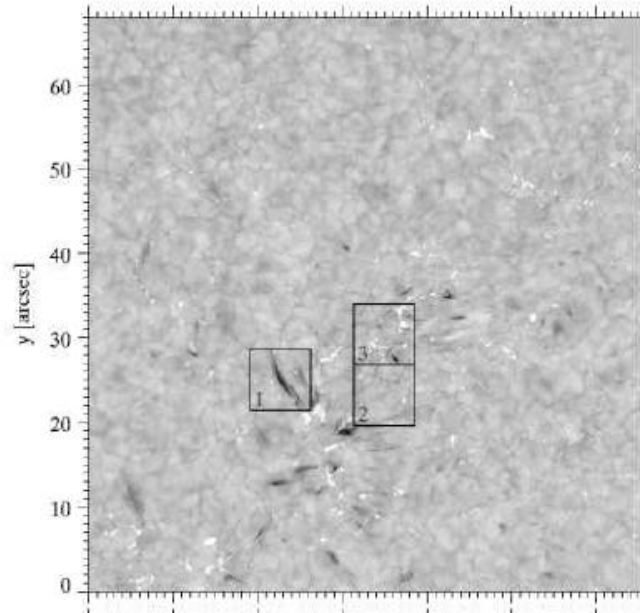
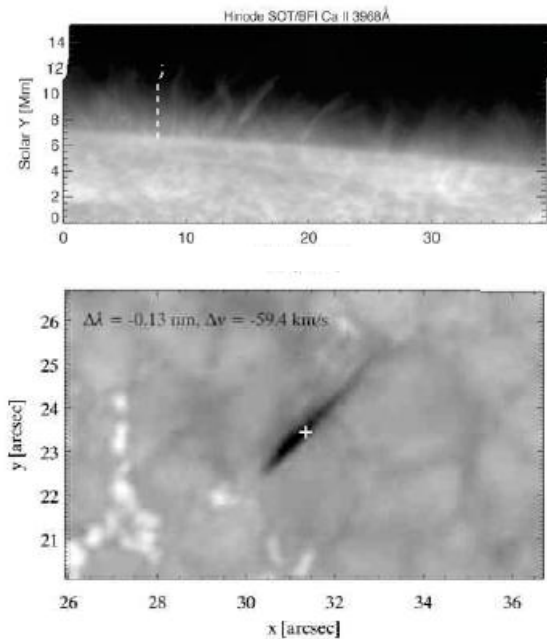


Image credit: de Pontieu et al. 2007, Rouppe van der Voort et al. 2009

11/12/2013

Hinode 7 Meeting, Takayama, Japan

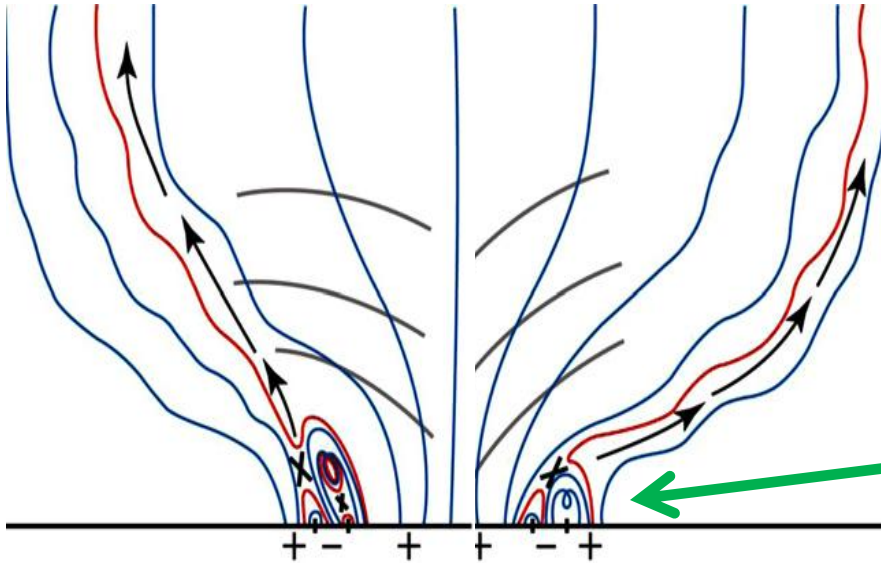
Important Questions

- Role of RBEs/type II spicules: transfer mass into the corona and may be important part of solar wind acceleration process (de Pontieu et al. 2007, 2009, 2011)
- Origin of RBEs/type II spicules:
 - reconnection process (Isobe et al. 2008; de Pontieu et al. 2007; Archontis et al. 2010, Moore et al. 2011)
 - oscillatory reconnection (McLaughlin et al. 2012)
 - strong Lorentz force (Martinez-Sykora et al. 2011)
 - propagation of the p-modes (de Wijn et al. 2009)
 - Judge et al. (2011) argues that spicules II could be warps in 2D sheet like structures (as opposed to tube-like structures)
 - Zhang et al. (2012) questions the existence of spicules II as a distinct class altogether.

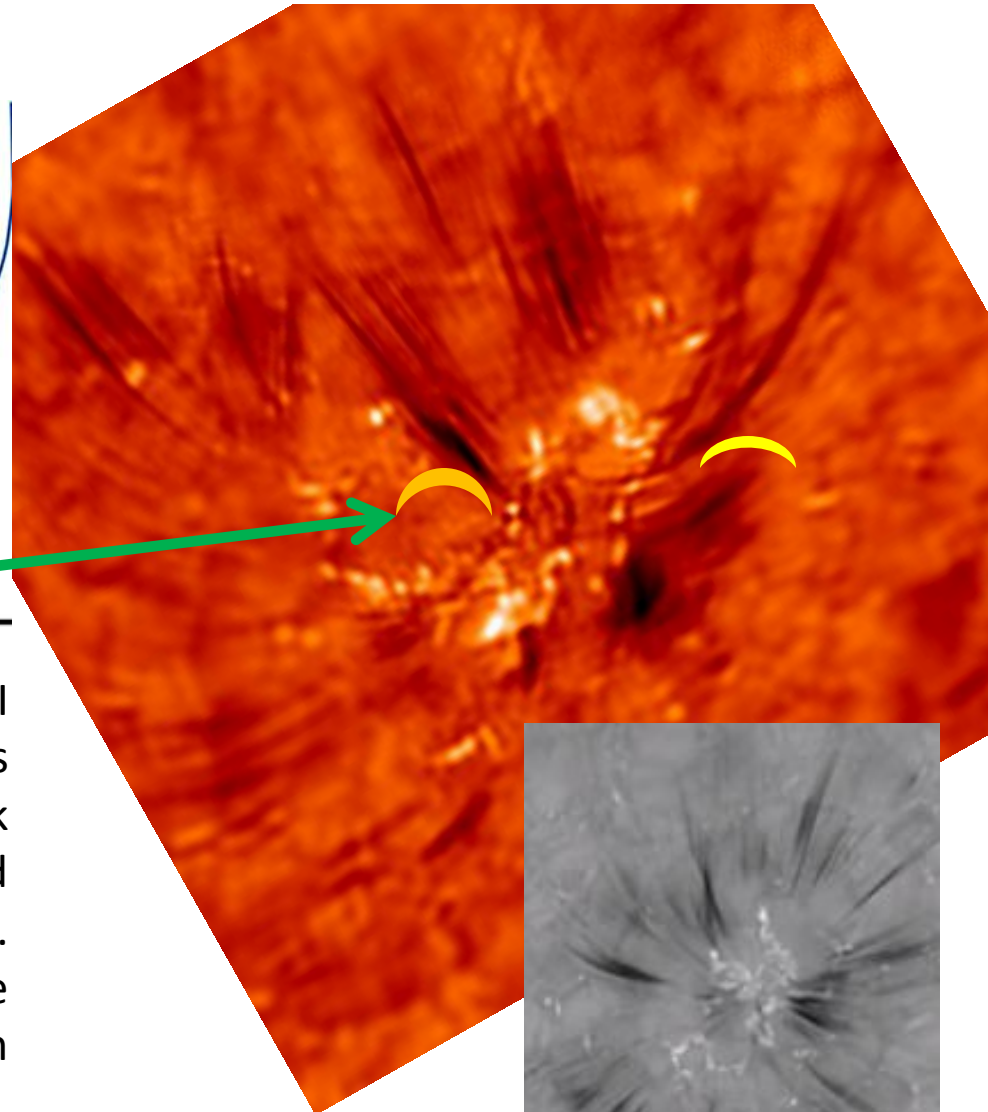
We present data in favor of reconnection as a driver of RBEs

- new small-scale fields emerge everywhere on the Sun into the canopy fields, created by the expanding flux associated with clusters of bright points, pores, and sunspots
- Only about 30% of emerging bipoles survive long enough to reach the chromosphere (*Martinez Gonzalez & Bellot Rubio, 2009*)
- spicules II mainly limited to the surface that envelopes the flux tube associated with the BP cluster or a pore
- there seem to be

Reconnection Driven Outflows?



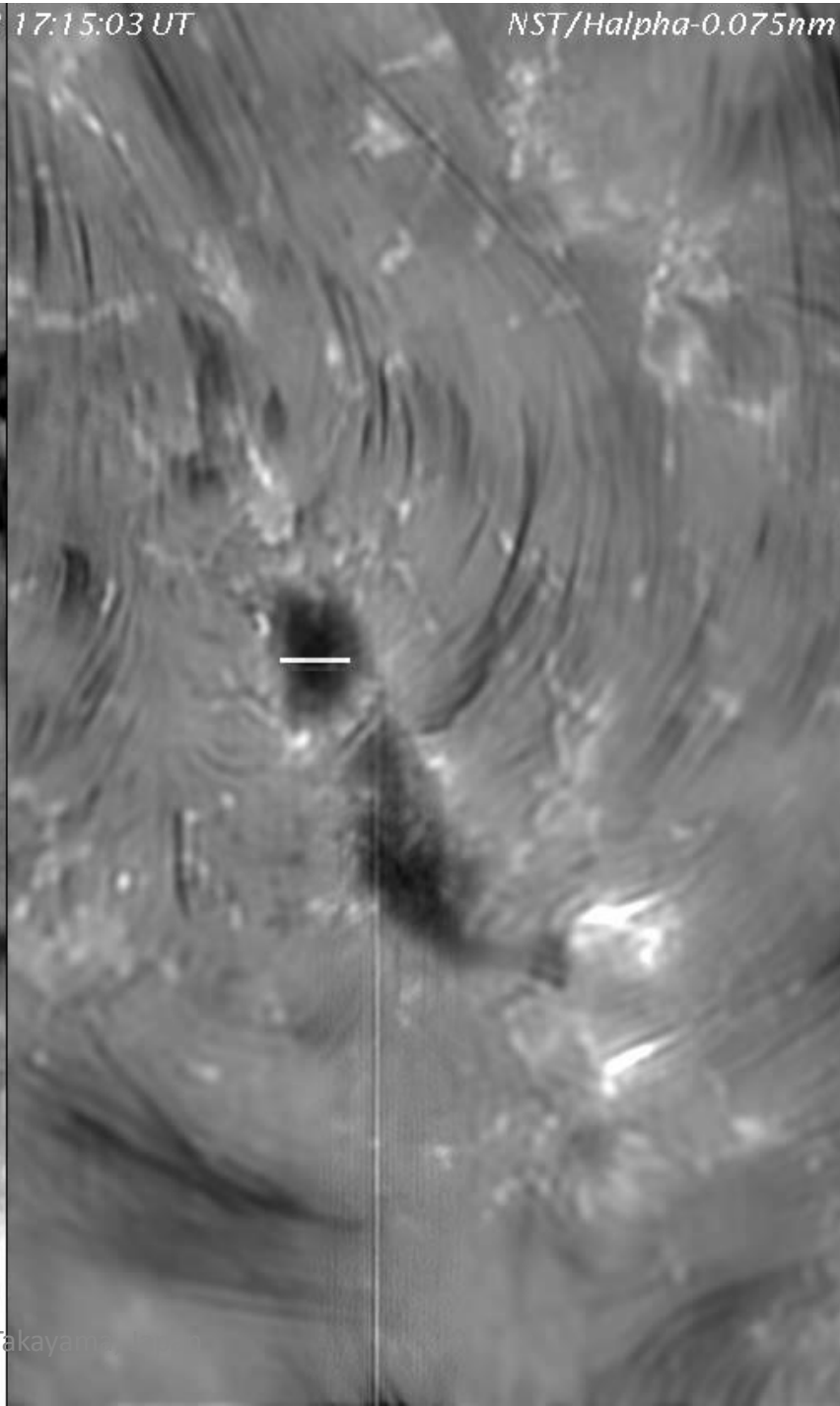
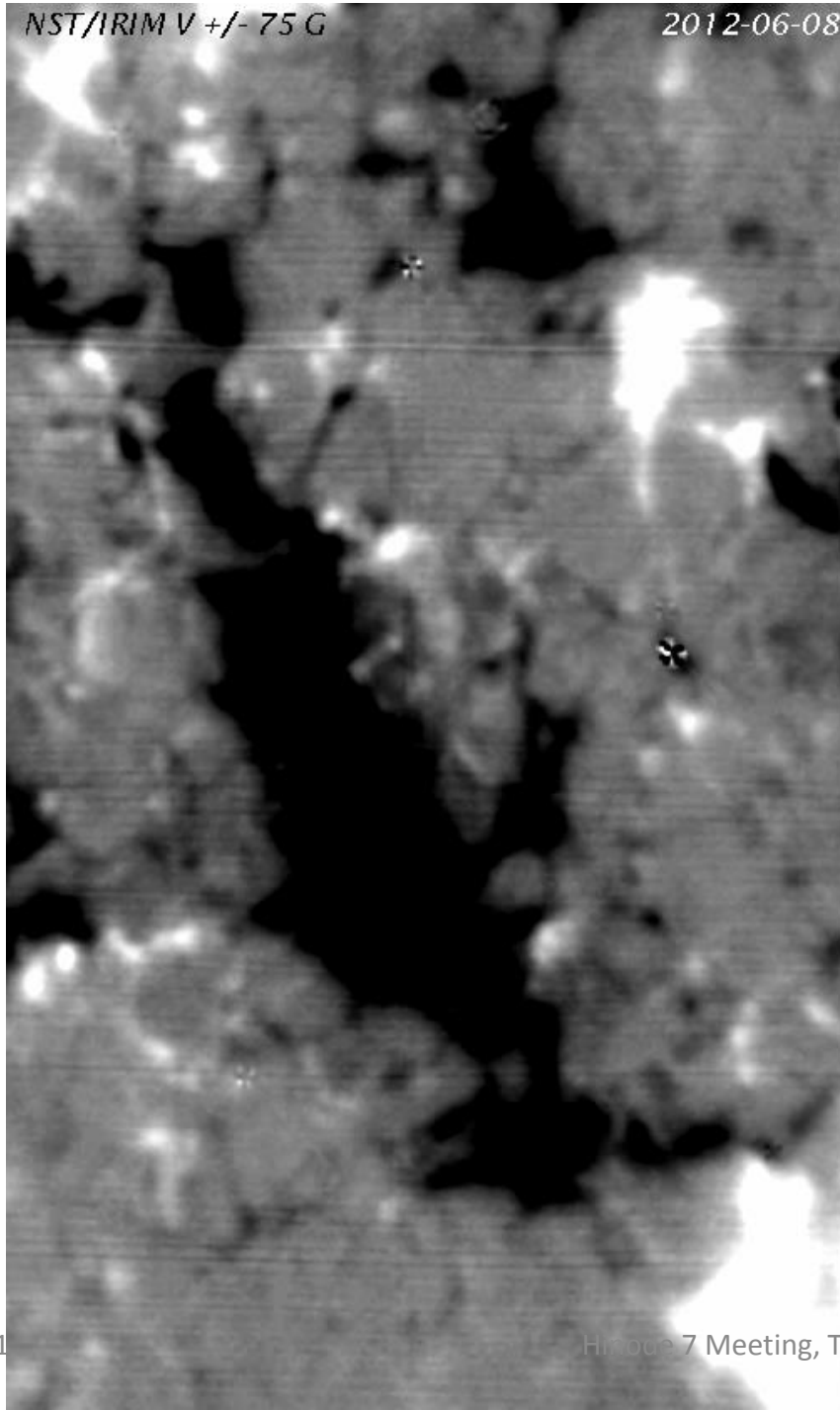
Production of MHD waves and Type-II spicules by emerging dipoles. Black Xs symbolize magnetic reconnection. Black arrows represent type-II spicules. Red curves are newly reconnected field lines. The wiggles in the field lines are the undulations of upward propagating Alfvén waves. (cartoon from Moore et. al. 2011)



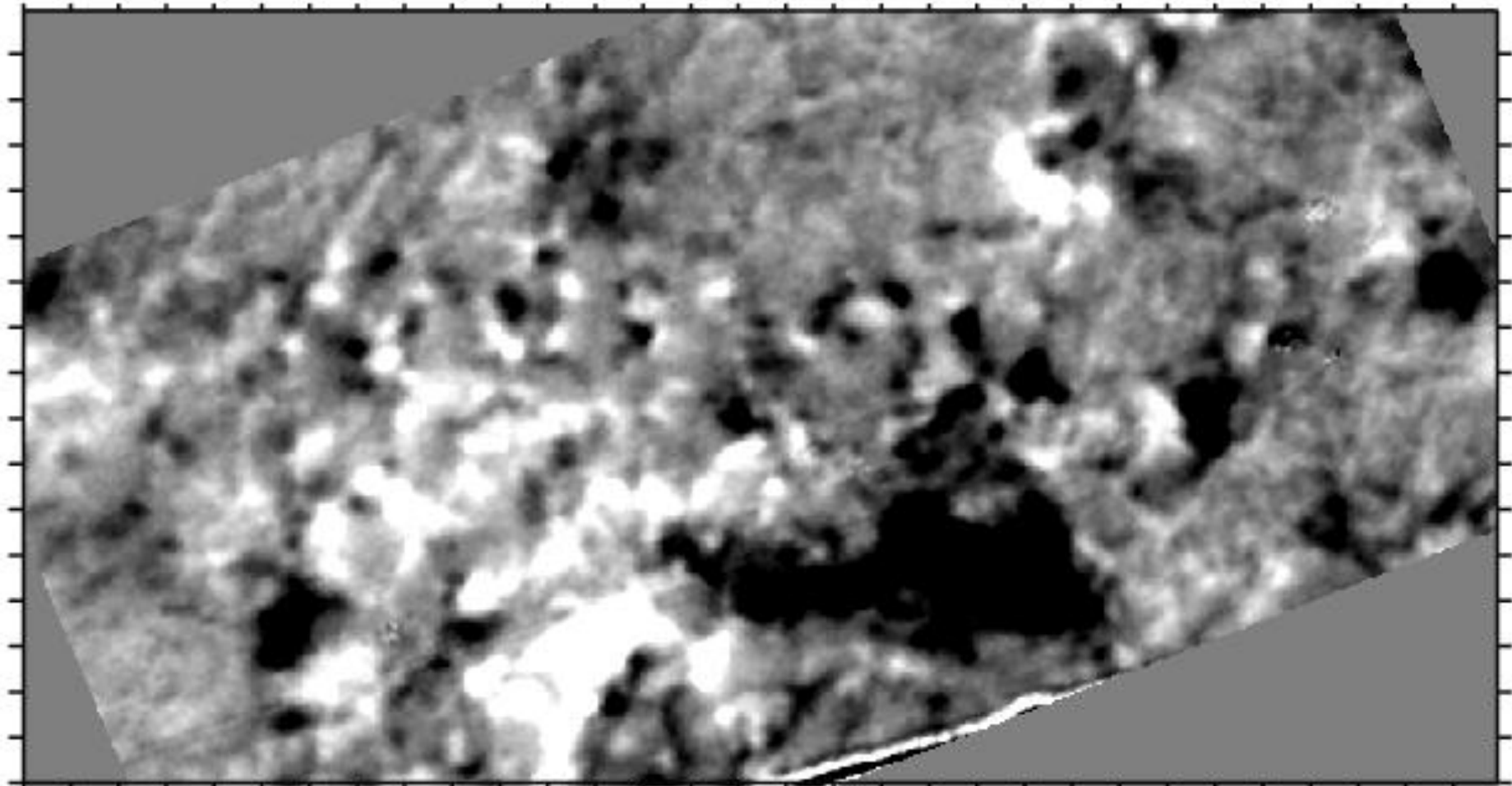
NST/IRIM V +/- 75 G

2012-06-08 17:15:03 UT

NST/Halpha-0.075nm



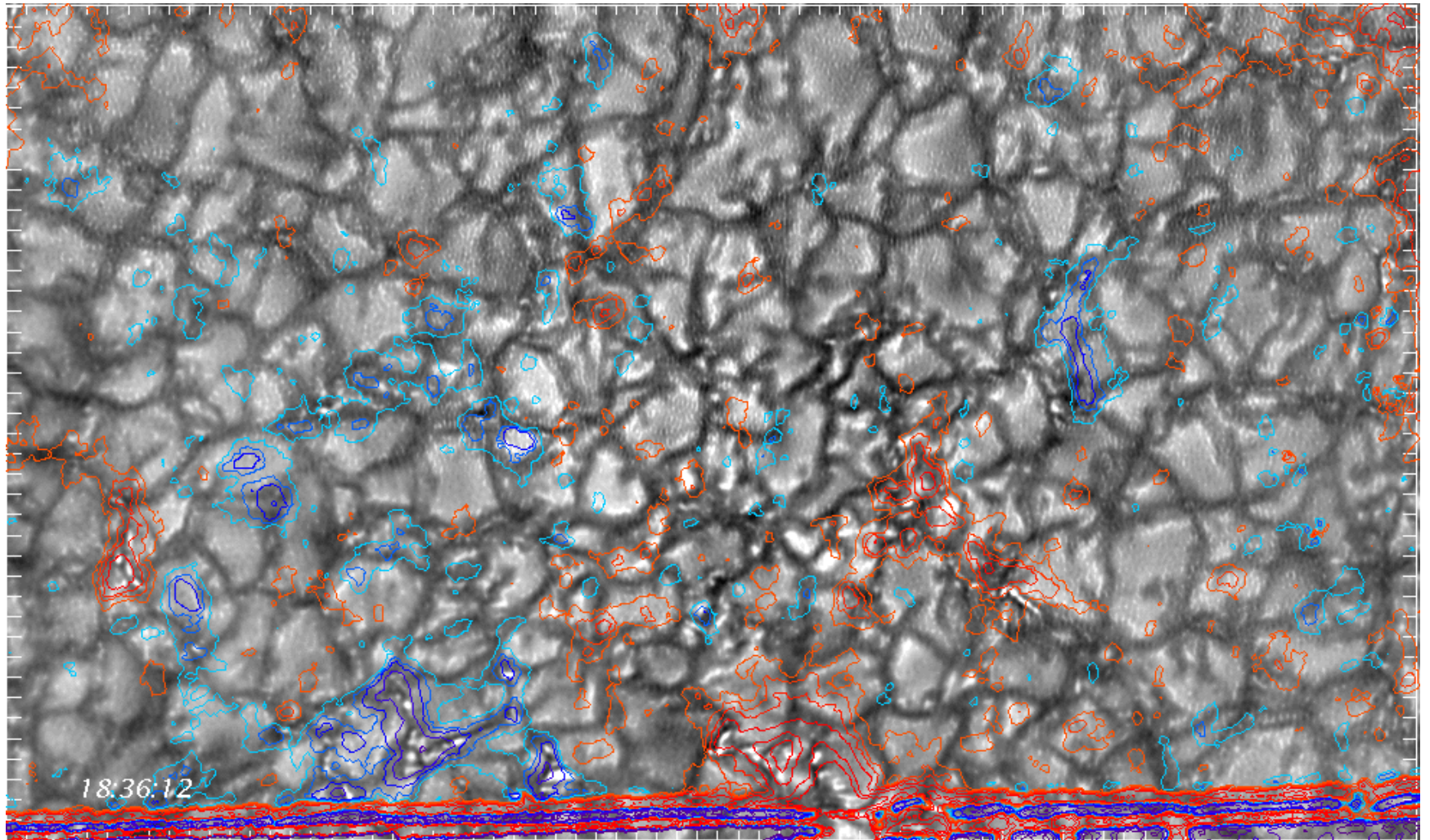
NST/IRIM Magnetic Fields



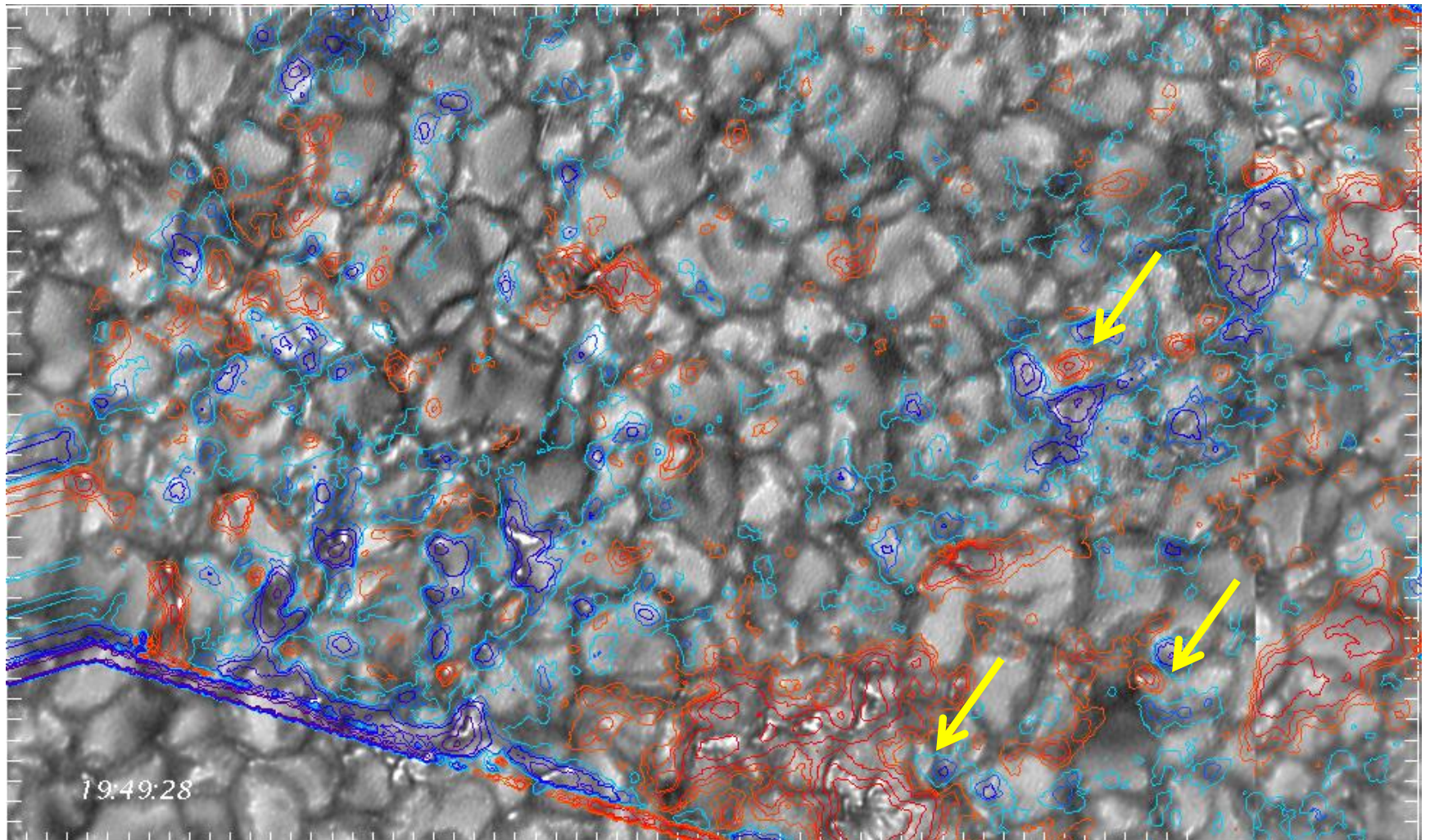
The internetwork magnetic field is very dynamic and small-scale magnetic dipoles constantly appear and cancel around clusters of BPs and pores

NST IRIM 15600 Å circular polarization; Scale: 1 Mm between tickmarks

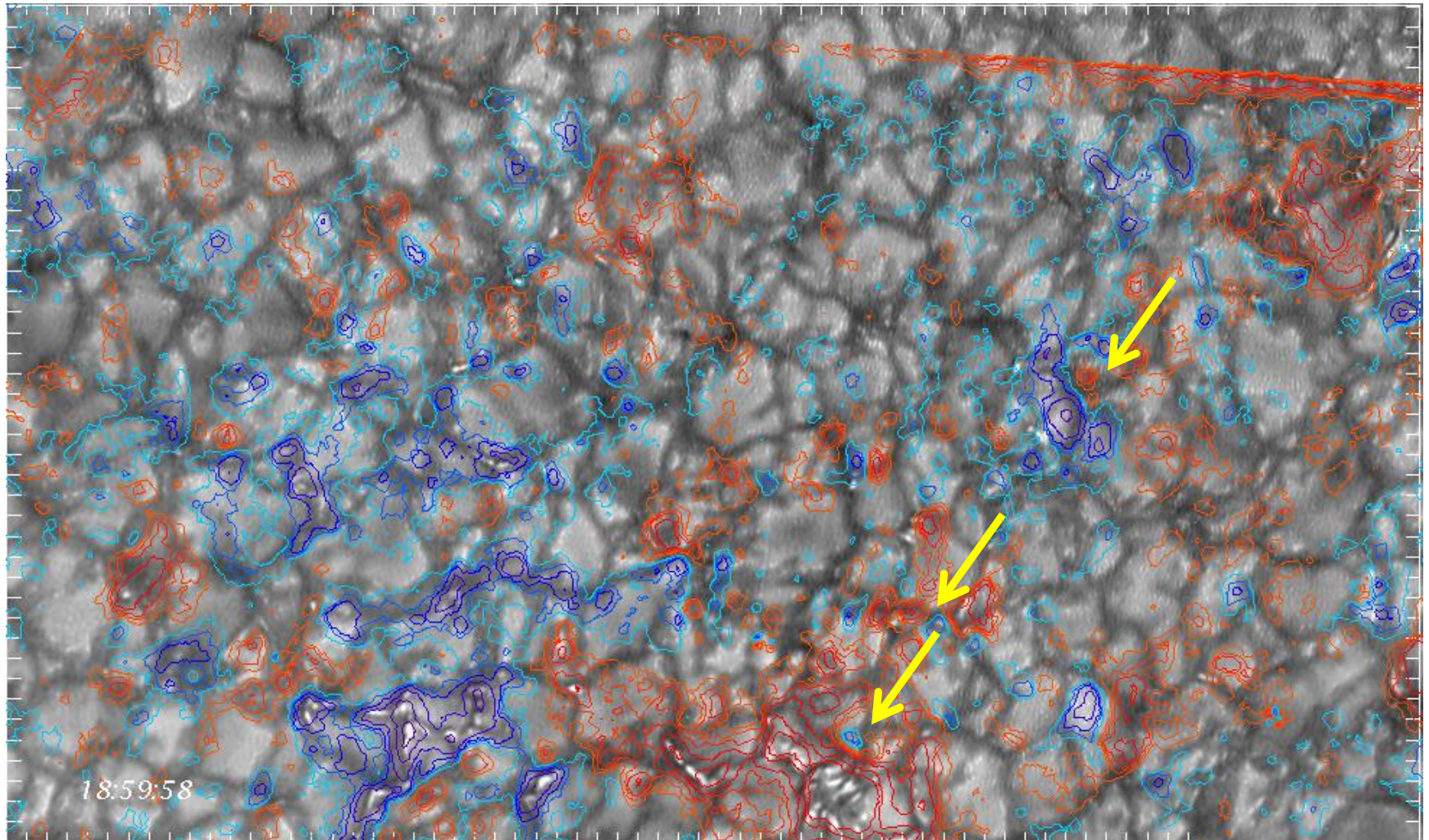
Granulation and IRIM LoS



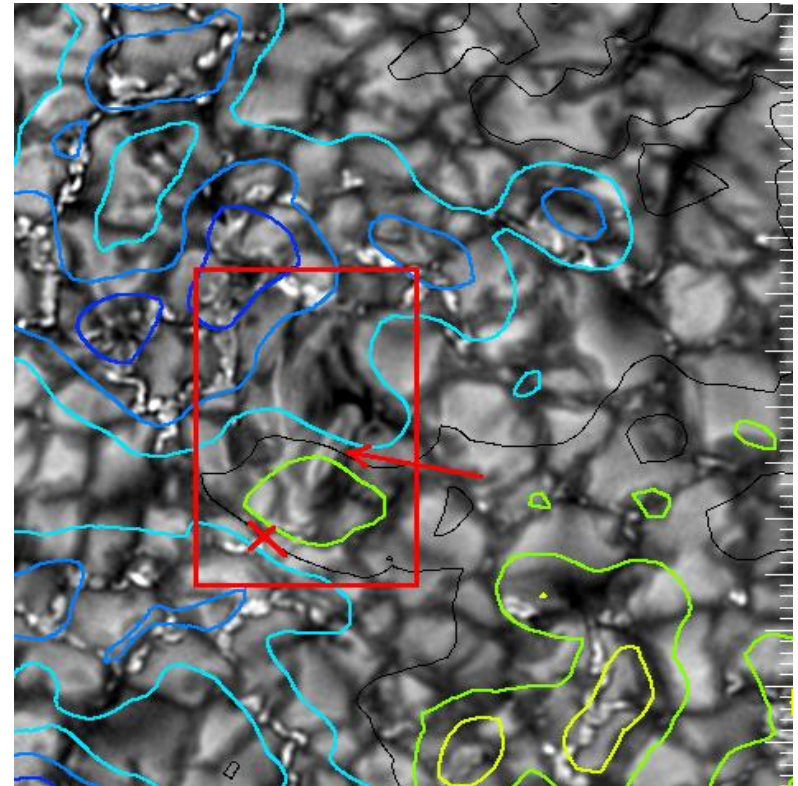
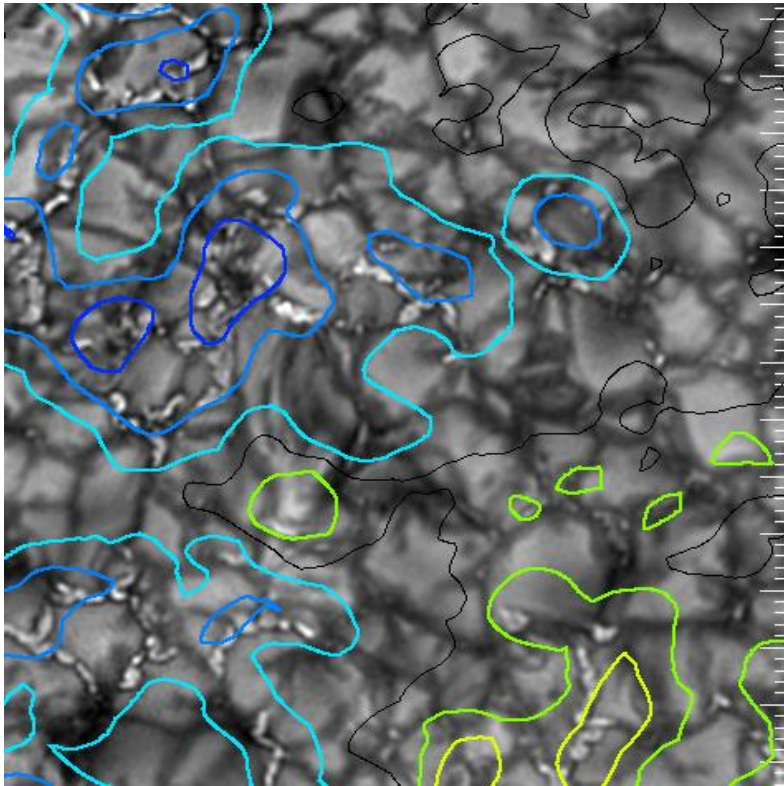
Granulation and IRIM LoS



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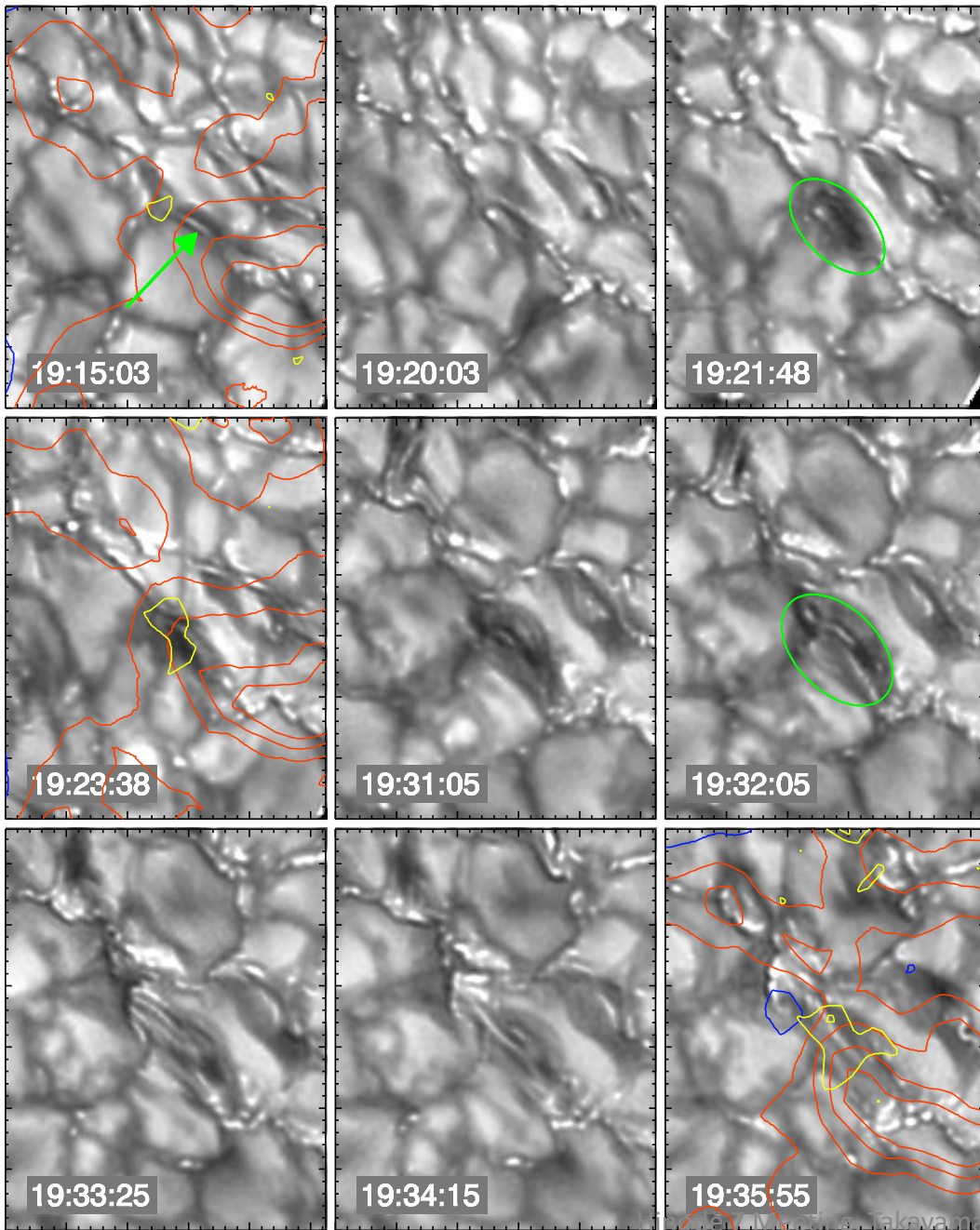


Photospheric foot print of flux emergence



The maximal dipole size was 5Mm (7"). Blue (green) contours show SDO/HMI Stokes V maps at 30 and 100 DN levels. The red arrows indicate a **filamentary pattern in granulation field**. The large tick marks separate 1Mm intervals.

The appearance of magnetic signal is delayed relative to the appearance of filamentary structure and bright points.



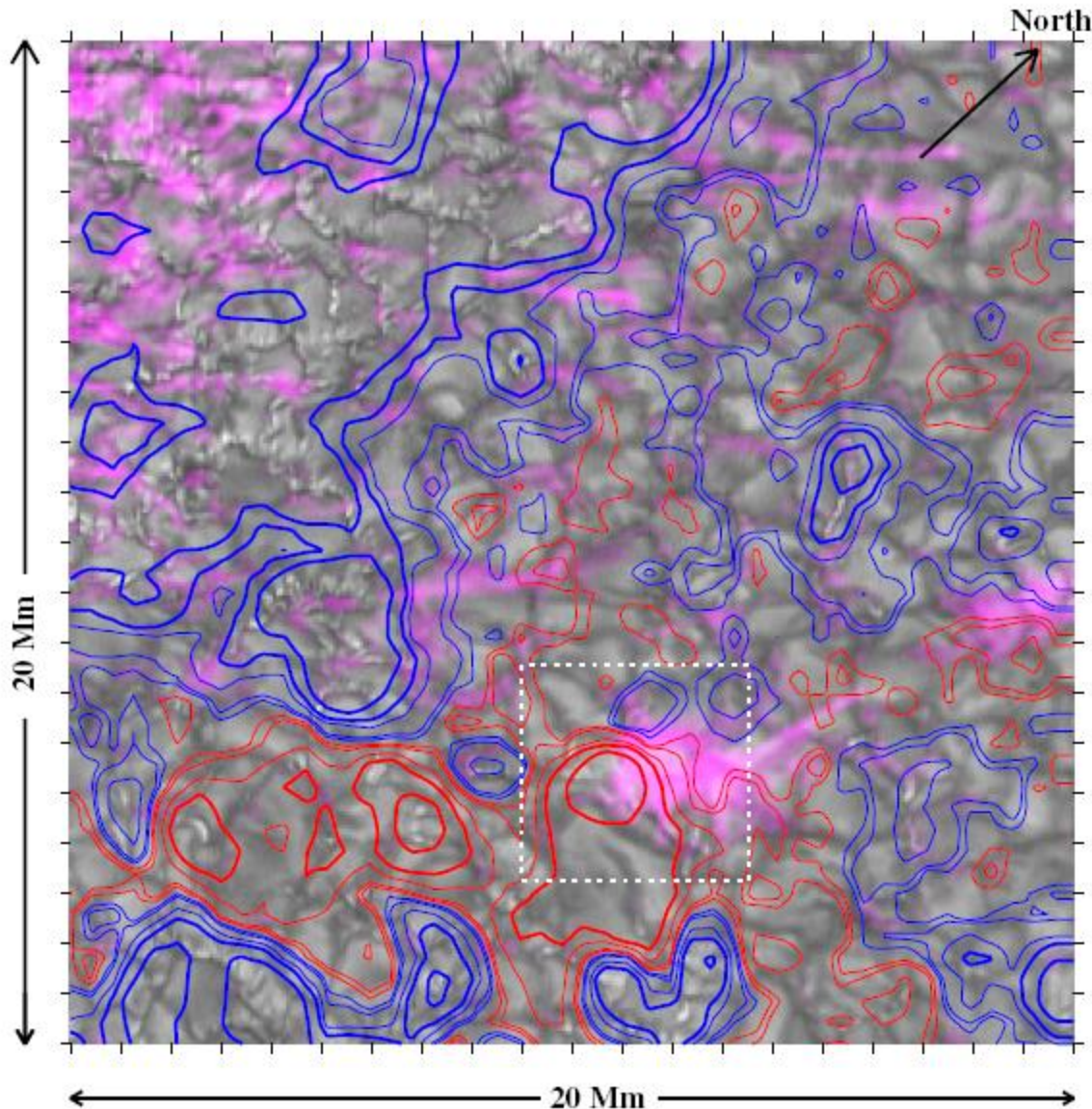
•TiO images showing response of a granular field to flux emergence.

•Red (blue) contours show SDO/HMI negative (positive) line-of-sight flux density . The red contours are plotted at 50, 100, 150, and 200G levels. The blue contour is the polarity inversion outlining weak positive fields.

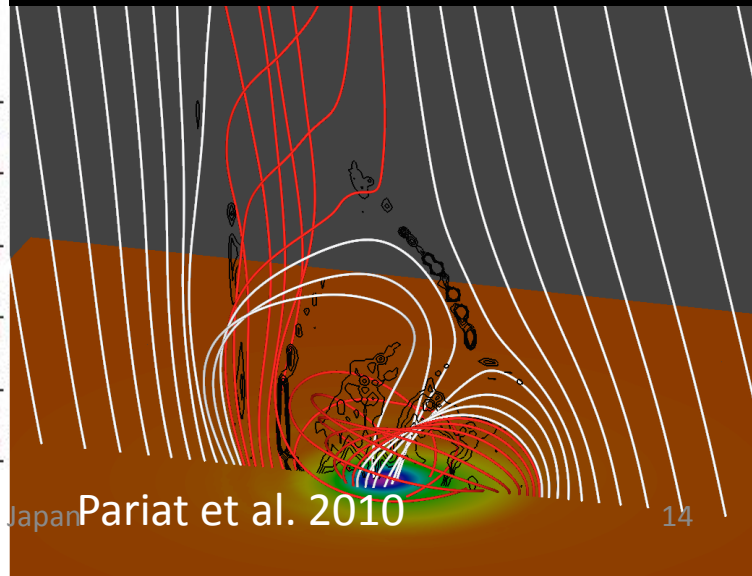
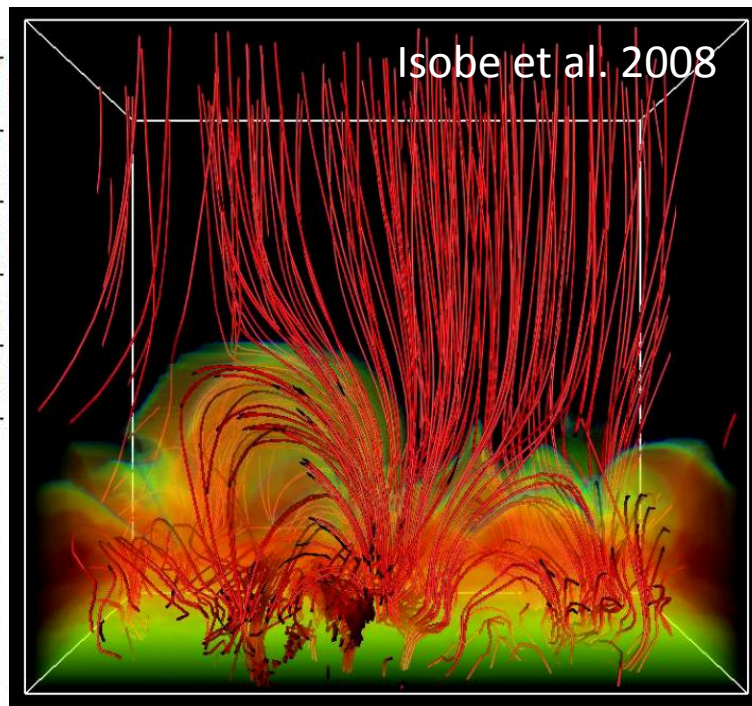
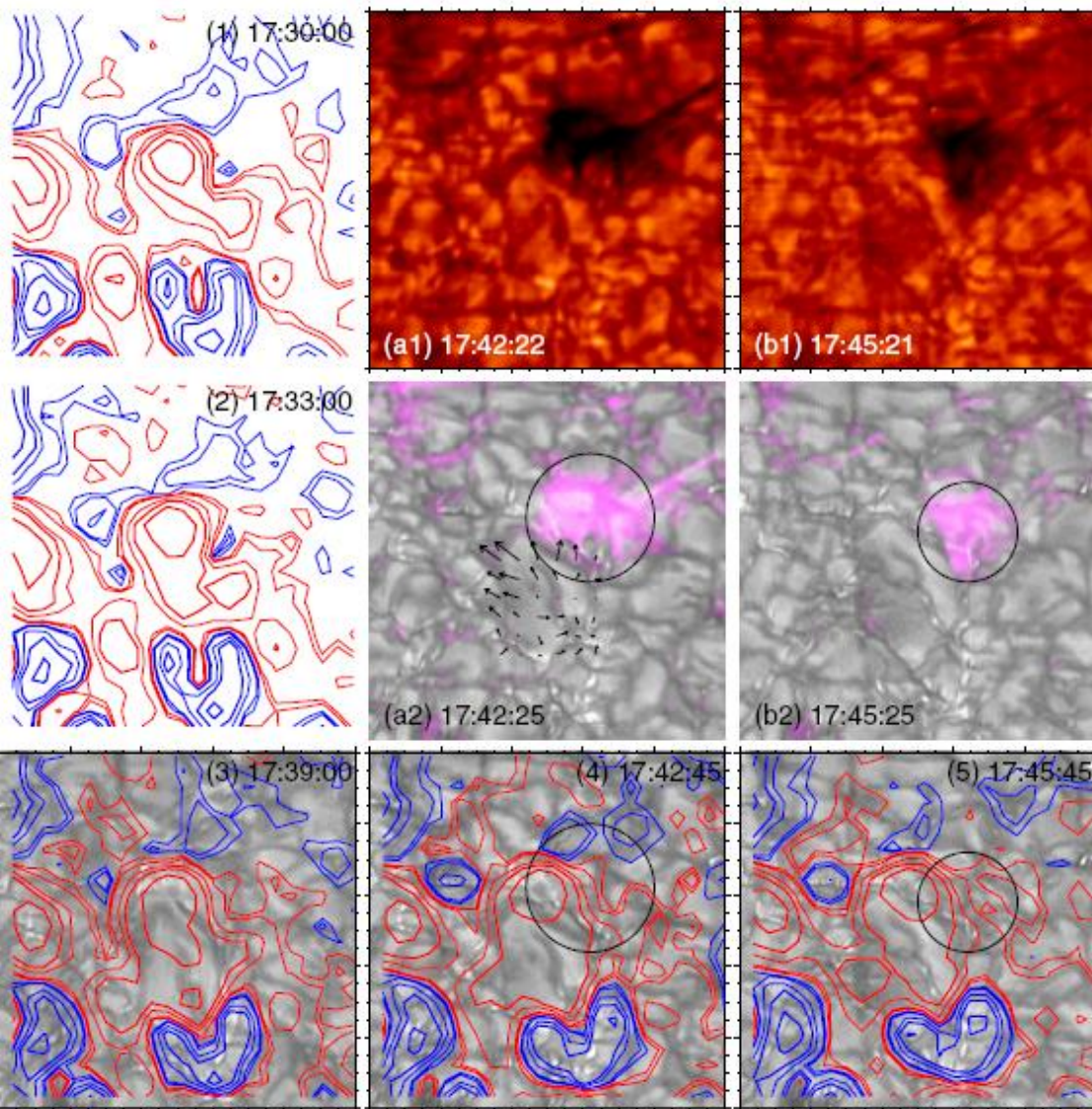
•Yellow contours are total SDO/HMI linear polarization. The yellow contours are plotted at 100 and 140G levels.

•Short tick marks separate 0.2Mm spatial intervals..

He 10830Å Jet and Flux Emergence

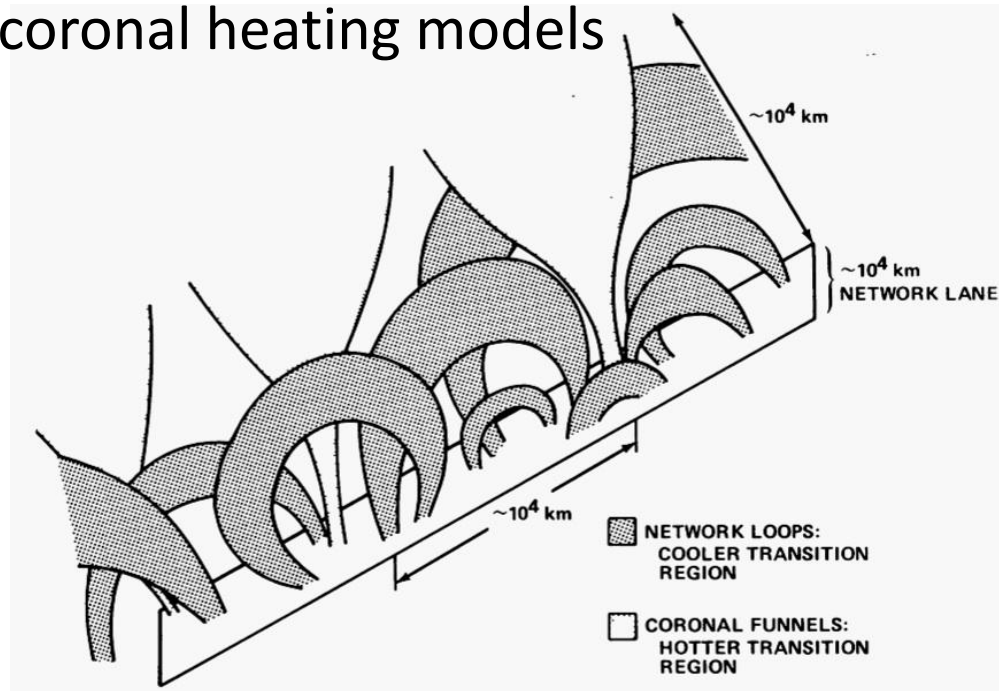
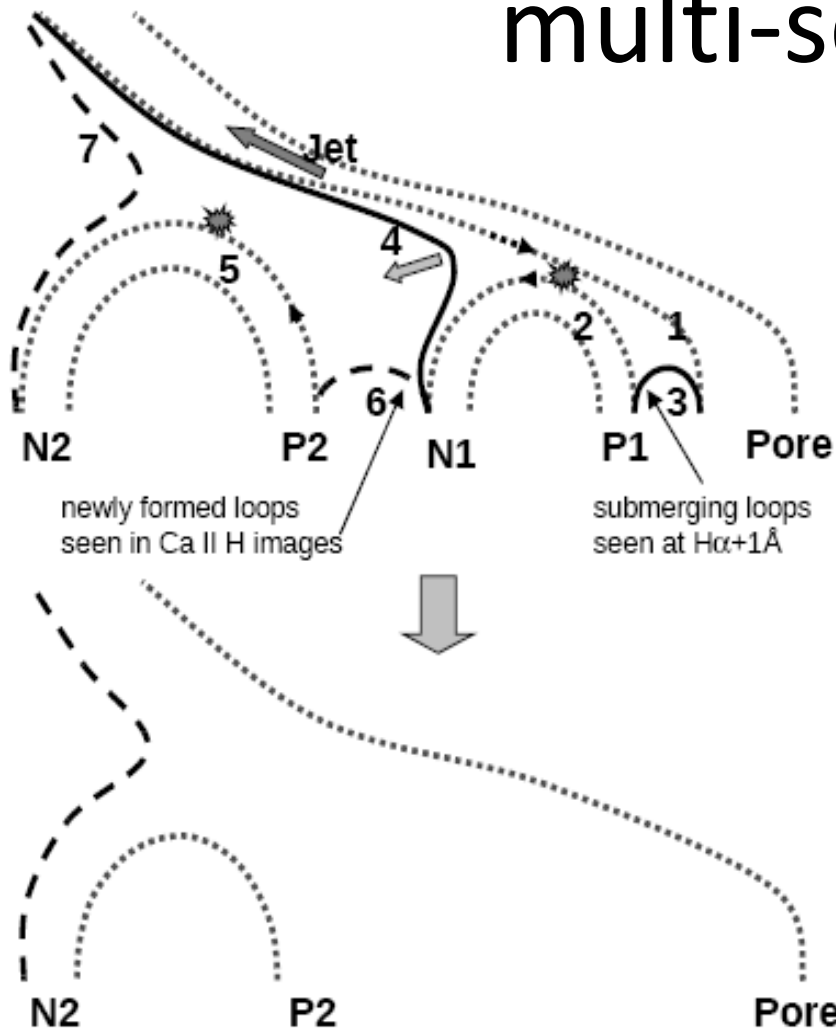


Reconnection driven by granular scale emergence



Emerging magnetic fields create a multi-scale system

small-scale flux couples different layers of the solar atmosphere; important for chromospheric and coronal heating models



Therefore, one should not expect one-to-one correspondence between a flux emergence event and chromospheric activity

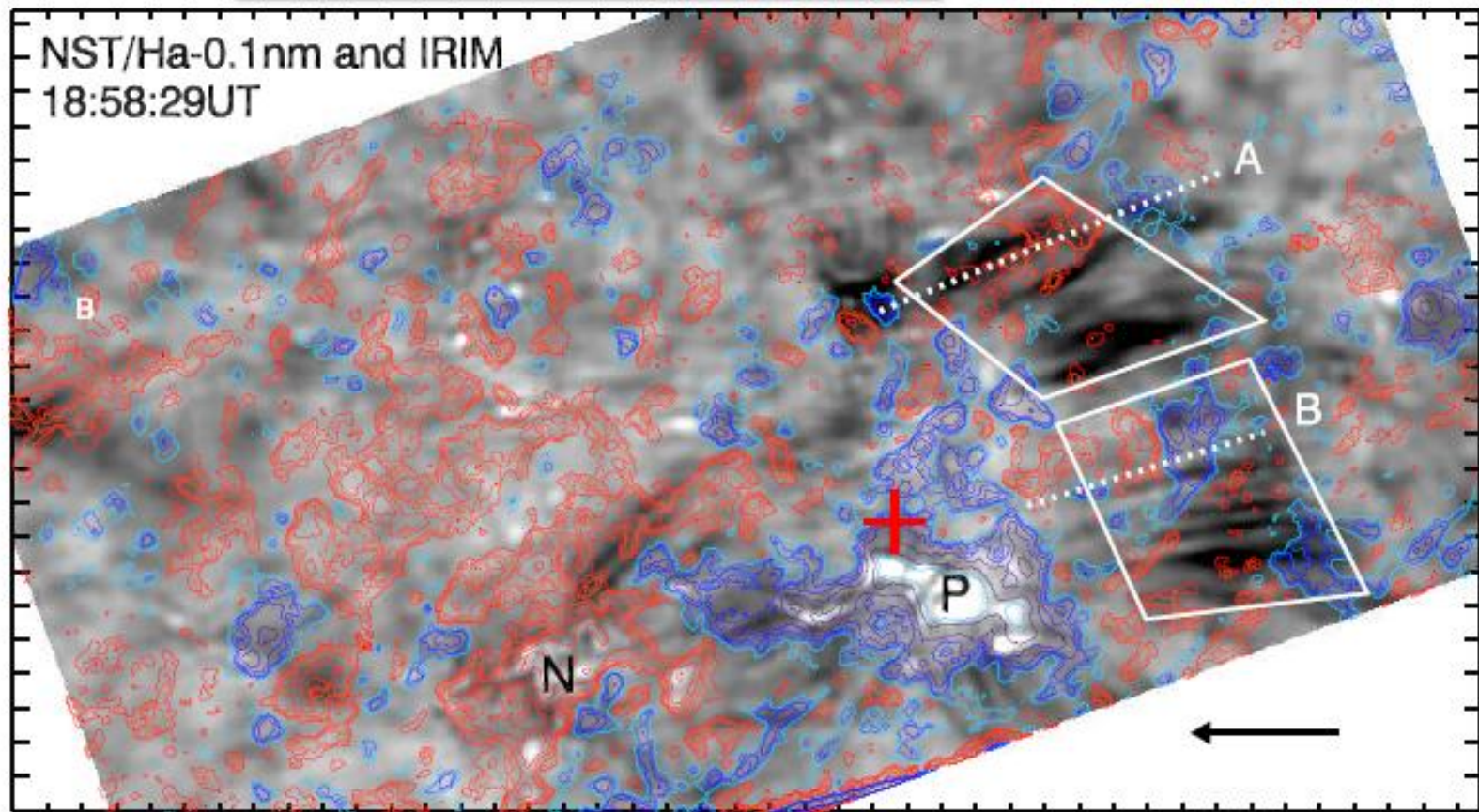
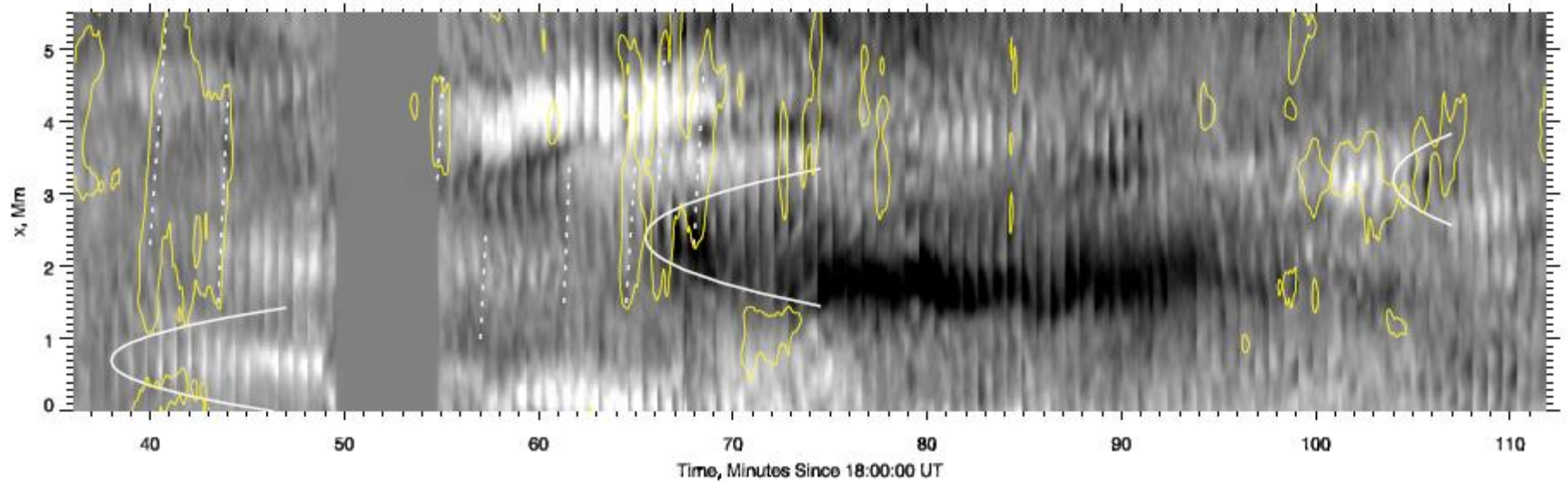
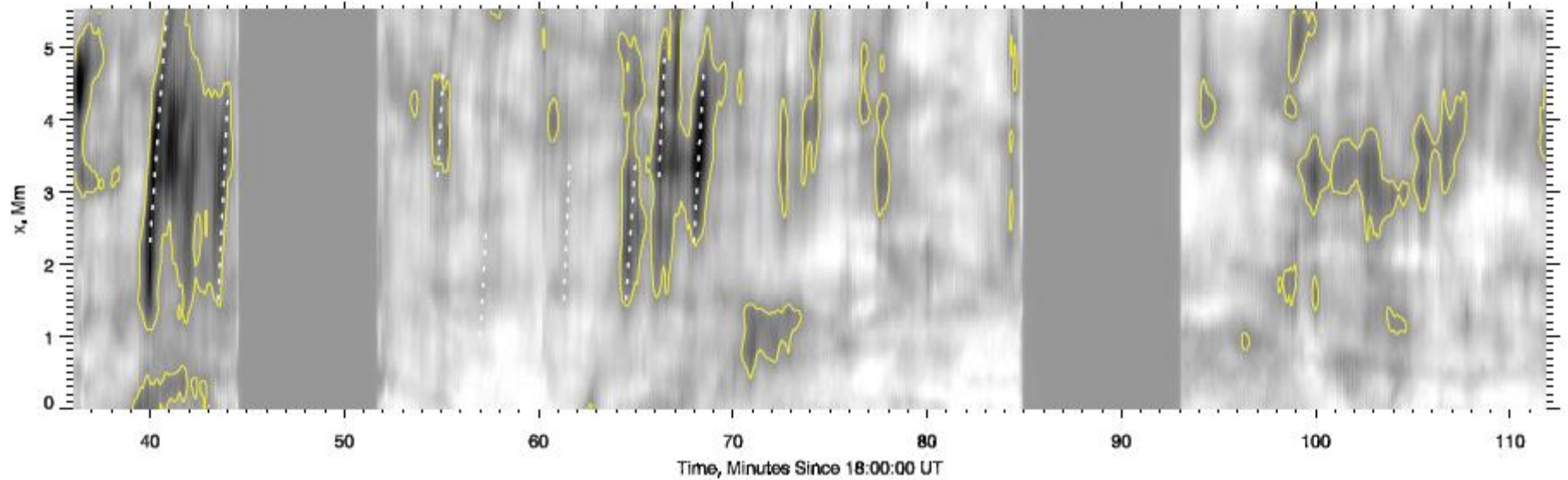


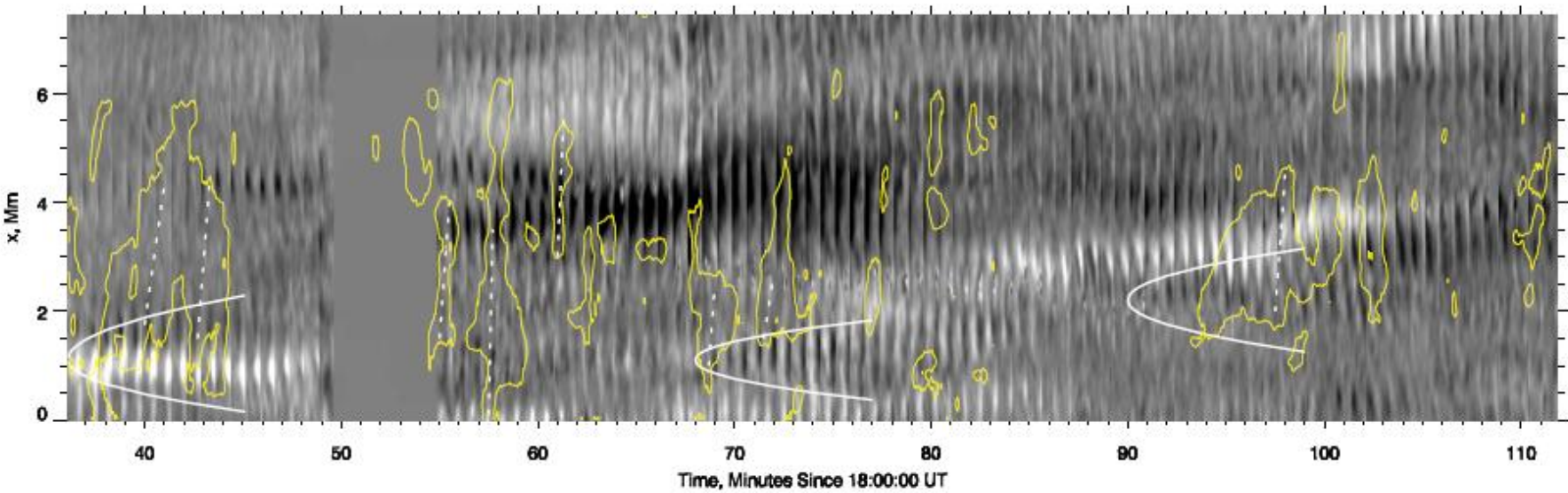
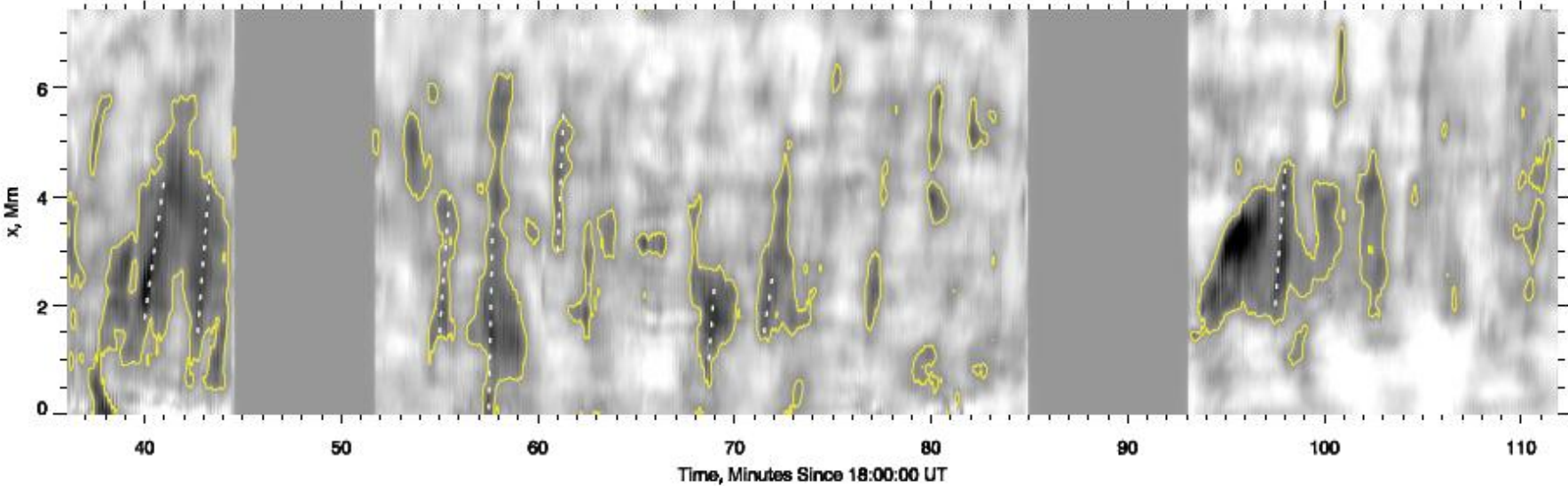
Fig. 1.— IRIM line-of-sight magnetic fields (contours) plotted over a co-temporal $H\alpha$ -0.1 nm image. In this image the bright patches are clusters of magnetic bright points, while the dark jet-like features are rapid blue-shifted events (RBEs). The blue/red contours outline positive/negative polarity and are drawn at 20, 30, 40, 60, 100, 200, and 300 G levels. The two dotted lines mark the location of x-t plots shown in Figures 2 and 3. The red cross indicates the location of a flux emergence episode discussed in Fig. 4. The location of the

Dynamics of Mag. Fields and RBE (case A: along the spine)



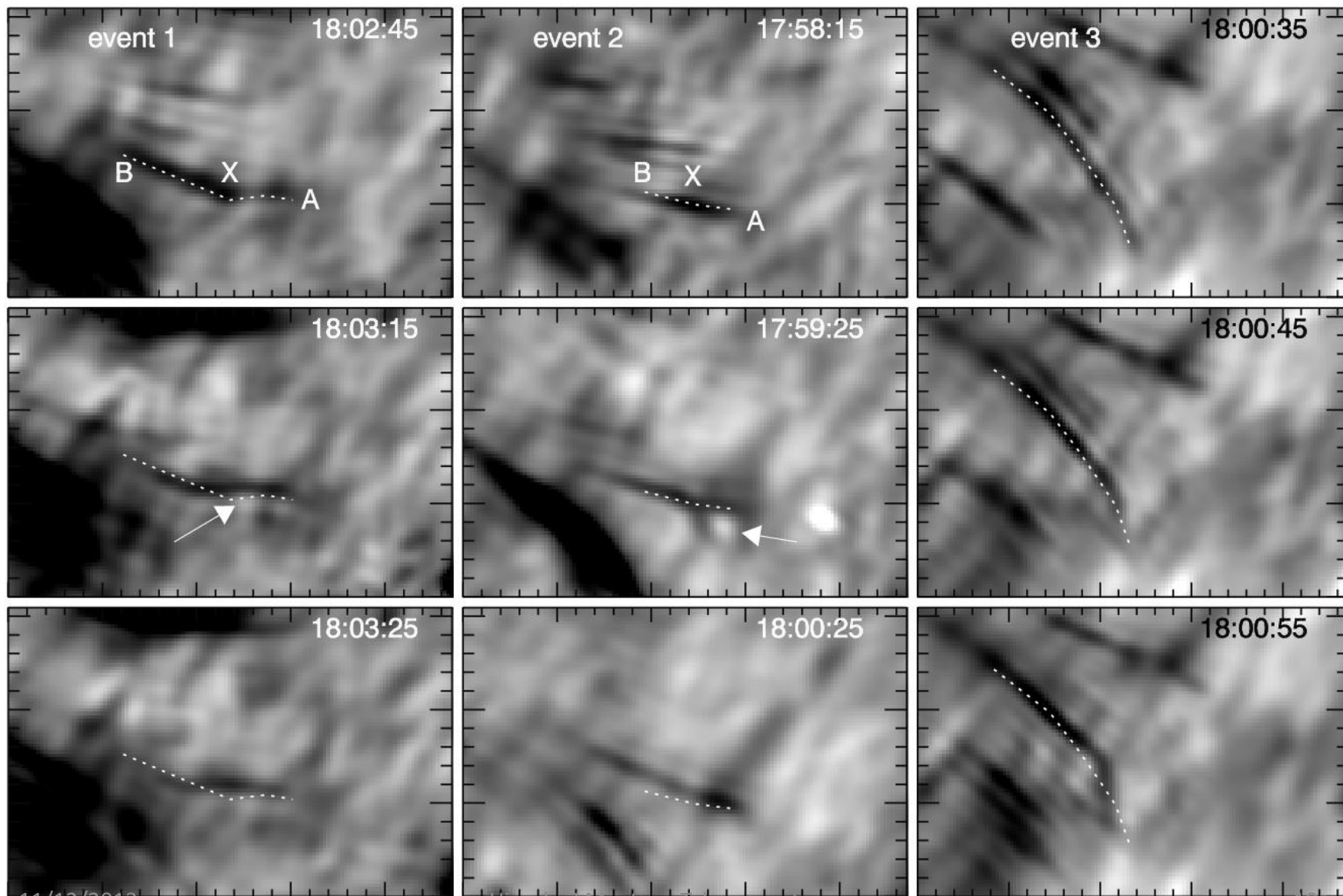
RBEs seem to be correlated with the appearance of opposite polarity elements

Dynamics of Mag. Fields and RBE (case B: across several RBEs)



RBEs seem to be correlated with the appearance of opposite polarity elements

Kinked and λ shaped loops



Summary

- Onset of RBEs seems to be correlated with the appearance of episodes of flux emergence immediately next to the flux concentration
- Some RBEs show develop kinks and are inverse “Y” shaped
- RBEs production is limited to the boundary of the flux tube associated with a cluster of BPs and/or a pore
- The RBE activity appears to be intermittent in time and space
- Time delay between the first signs of emergence and the onset of chromospheric activity is in the range of 3-5 min
- Flux emergence and reconnection may also increase dynamics of footpoint motions thus make the process of MHD wave generation more productive