

Magnetic Setting and Transition-Region/Coronal Signatures of Sunspot Penumbral Jets

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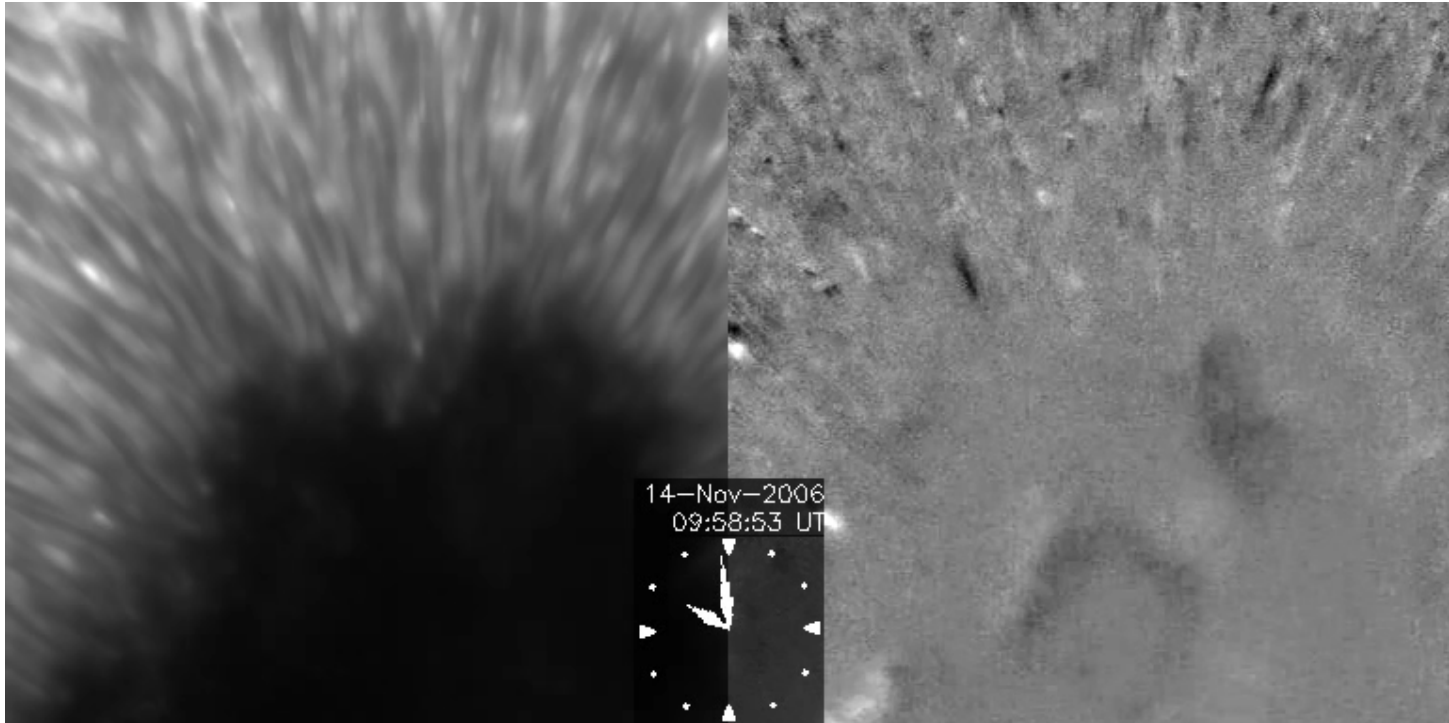
Feb 25, 2016

Dynamic Sun, BHU, Varanasi

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Introduction:

Hinode (SOT/FG) Observations

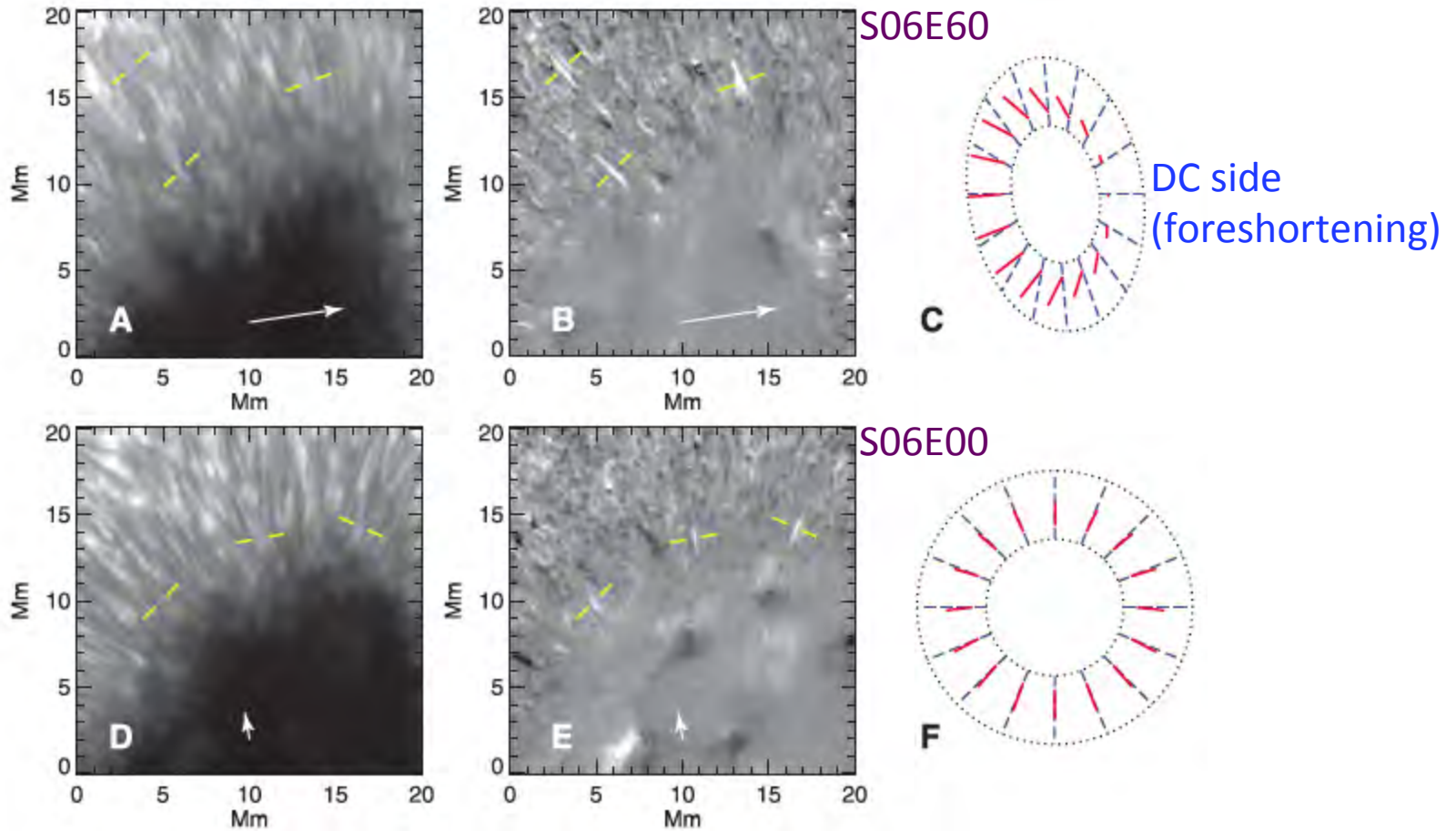


Katsukawa et al., 2007, Science

Jet's characteristics

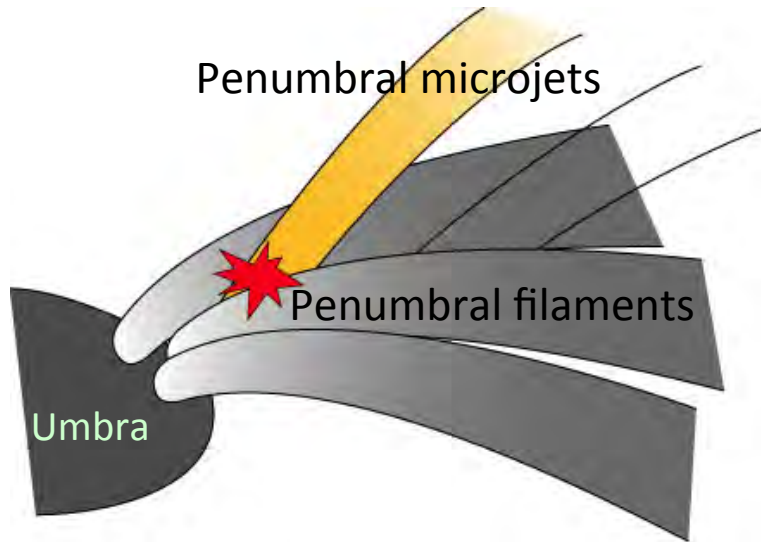
- Length 1000 – 4000 km
- Width 300 – 400 km
- Lifetime < 1 minute
- Apparent velocity 50-100 km/s
- Near Bright Dots (which are heads of penumbral filaments: [Tiwari et al., 2013](#))

Visibility of these jets depends on the position of sunspots on the solar disk; difficult to see when close to disk center

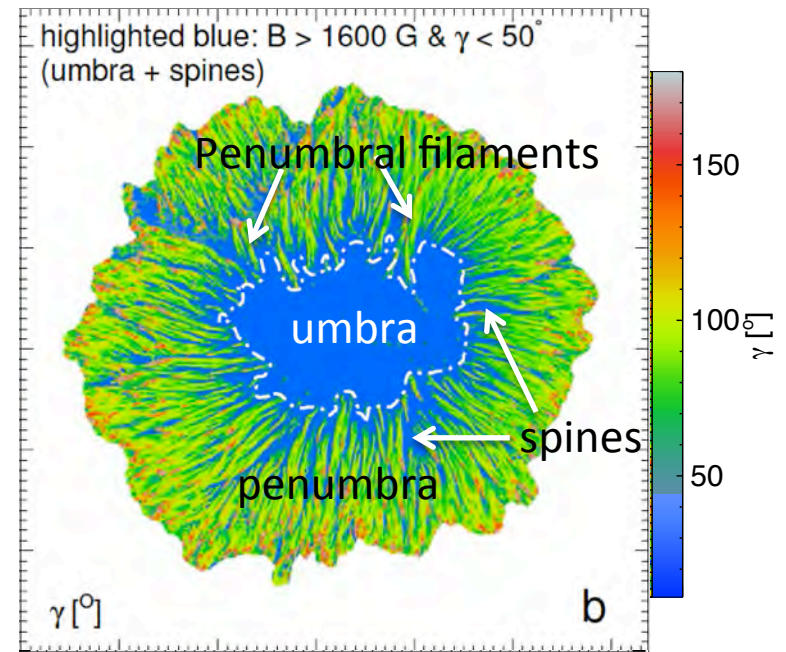


Katsukawa et al., 2007, Science

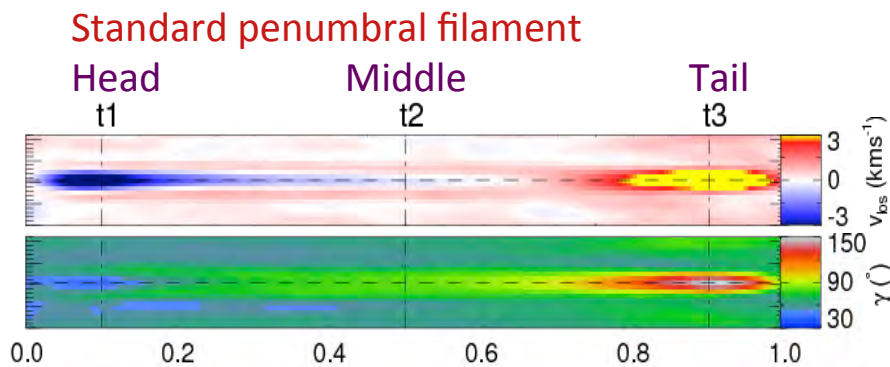
Jet's origin: magnetic configuration



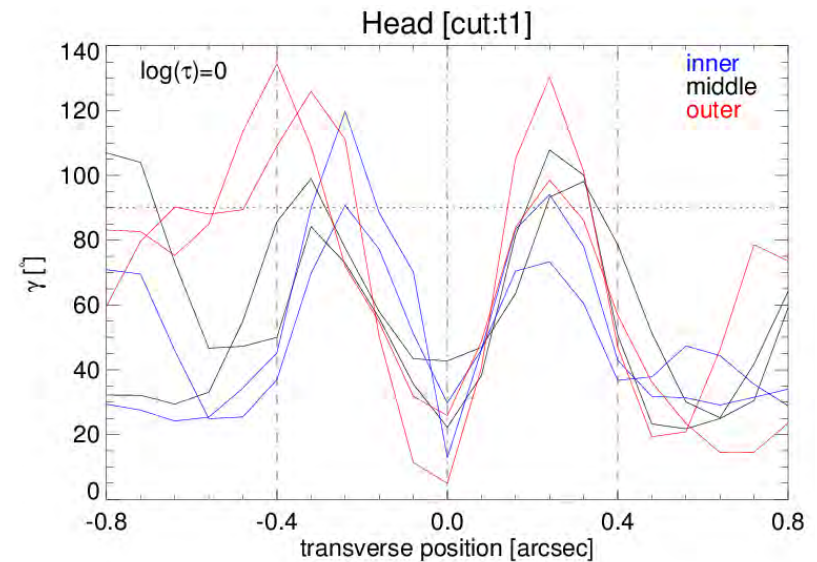
Katsukawa et al., 2007, *Science*



Tiwari et al., 2015, *A&A*

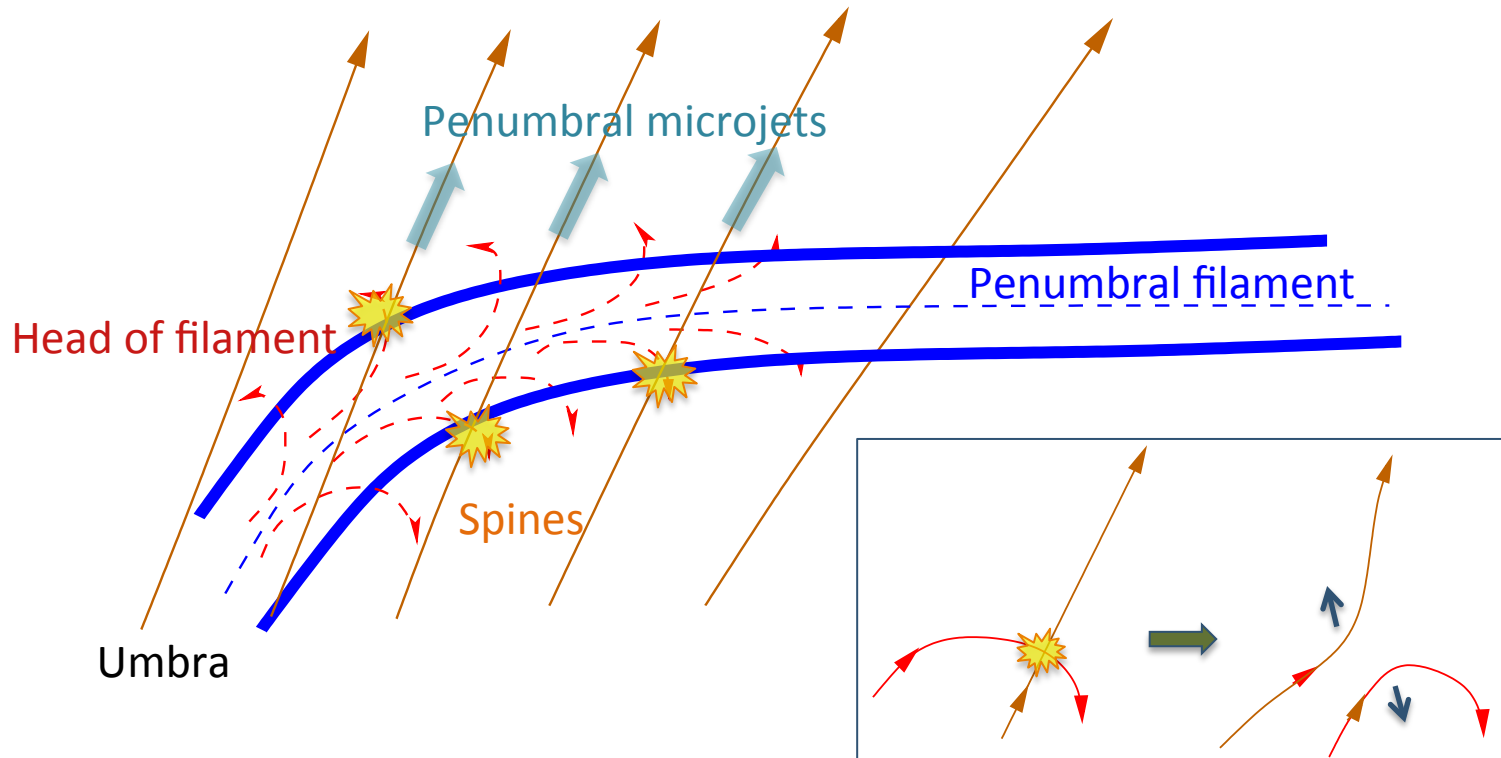


Tiwari et al., 2013, *A&A*



For opposite polarity field at sides of penumbral filaments, see also: Rempel 2012; Ruiz Cobo & Asensio Ramos, 2013; Scharmer et al 2013

Jet's origin: magnetic configuration



Transition-region/coronal signatures of microjets

Calculation of chromospheric thermal energy

$$\frac{3}{2} nk_B TV \approx 2 \times 10^{16} \text{ J} \approx 2 \times 10^{23} \text{ erg};$$

$$n = 10^{18} \text{ m}^{-3}; k_B \approx 1.38 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1};$$

$$T \approx 10^4 \text{ K}; V \approx 2000 \text{ km} \times (300 \text{ km})^2$$

Of the order of that of a coronal nanoflare!

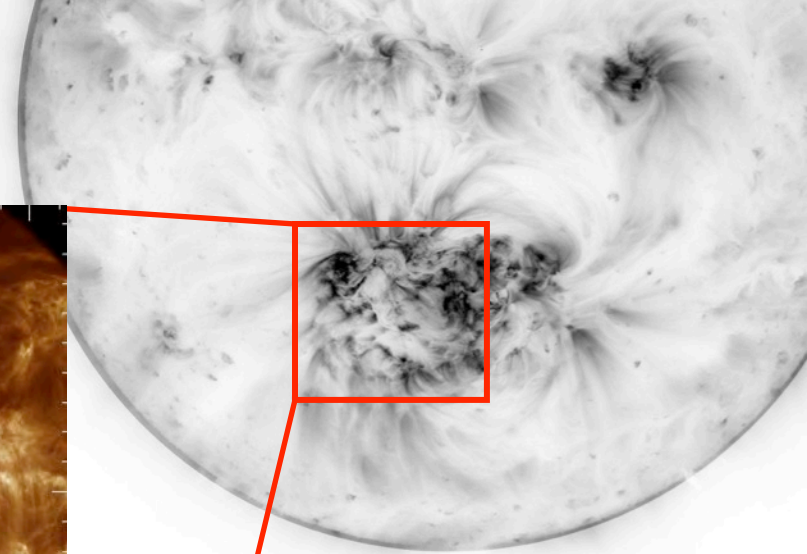
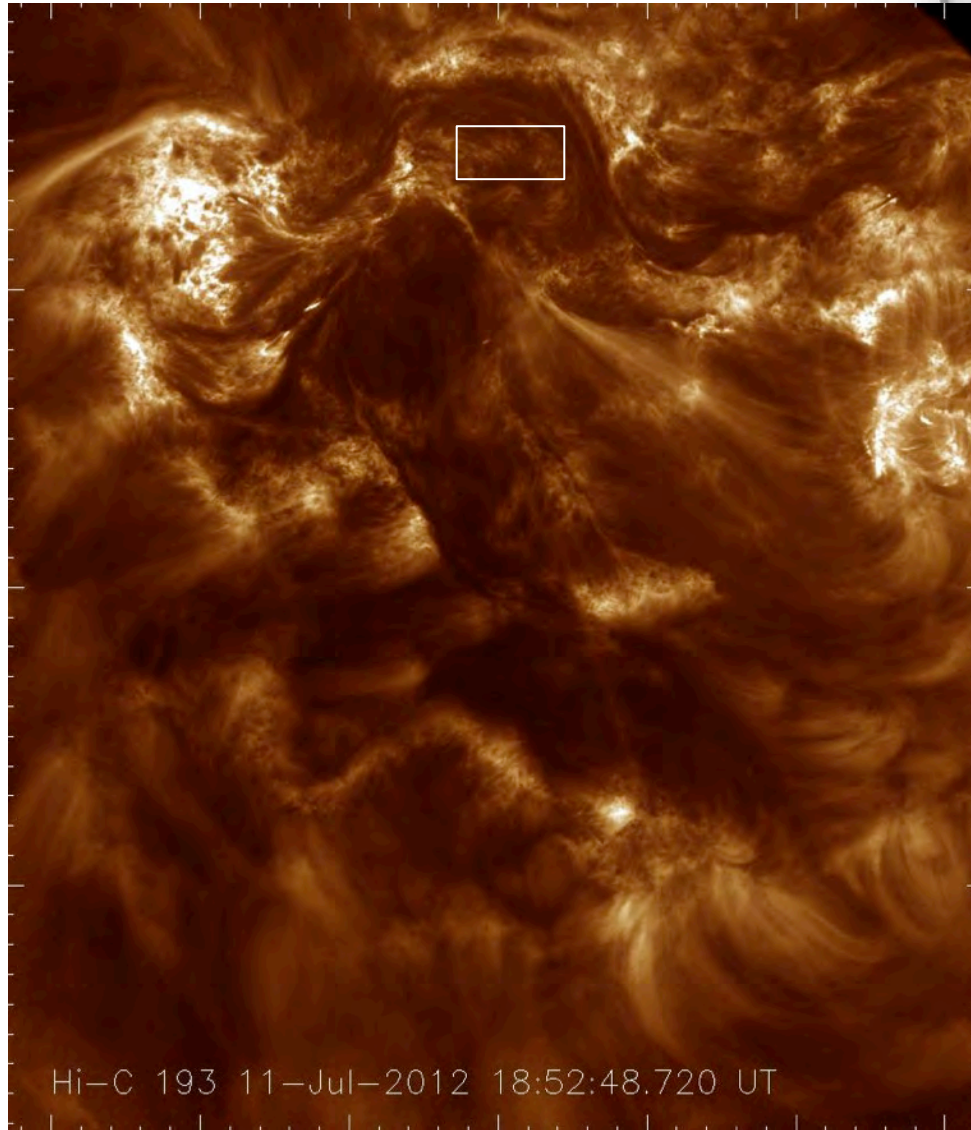
Telescope Resolution:

Hinode (SOT/FG): 0.2 arcsec \approx 145 km

SDO (AIA) : 1.2 arcsec \approx 890 km

Hi-C : 0.2 arcsec \approx 145 km

Hi-C Observations

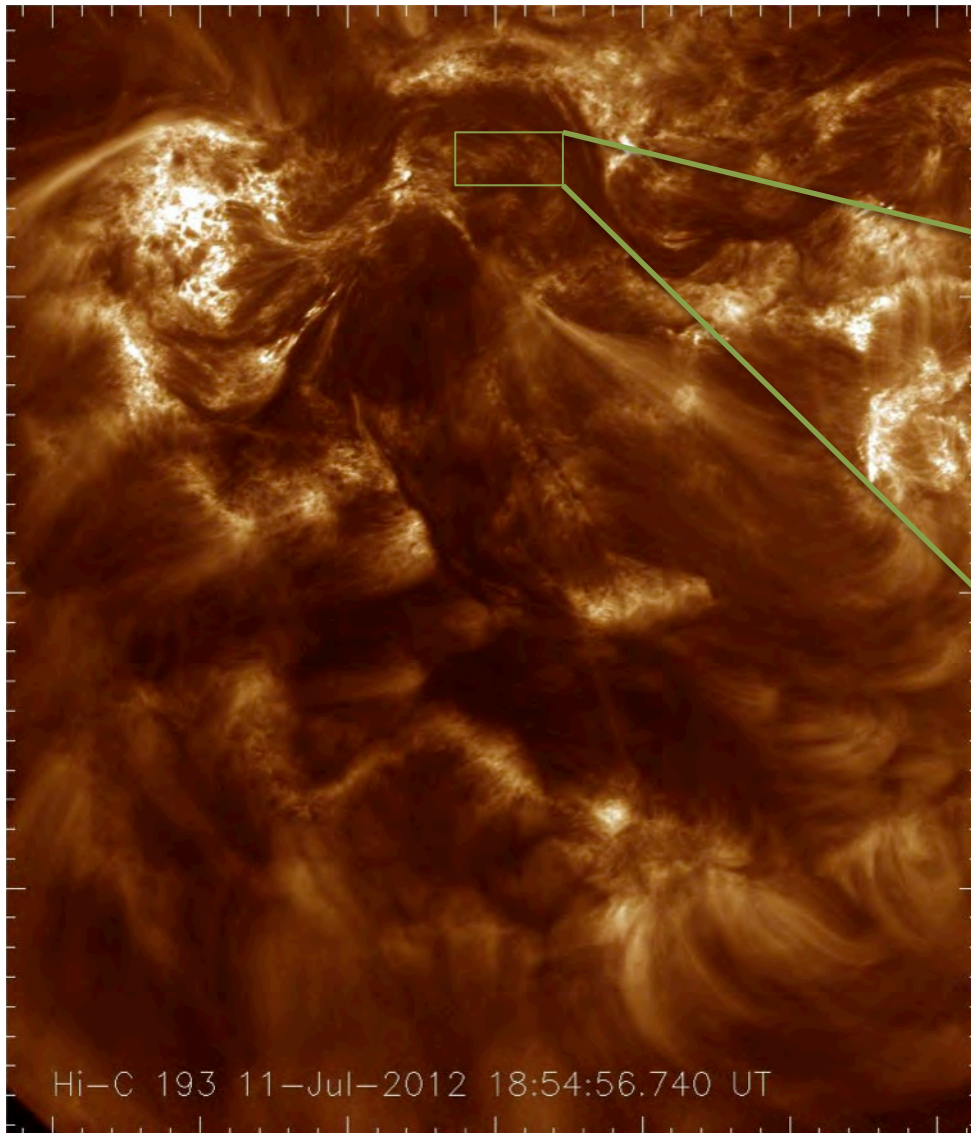


Hi-C: centered@193
Å; resolution 0.2
arcsec; cadence 5 s;
~6 min of AR 11520:
Jul 11 2012,
18:51-18:57UT

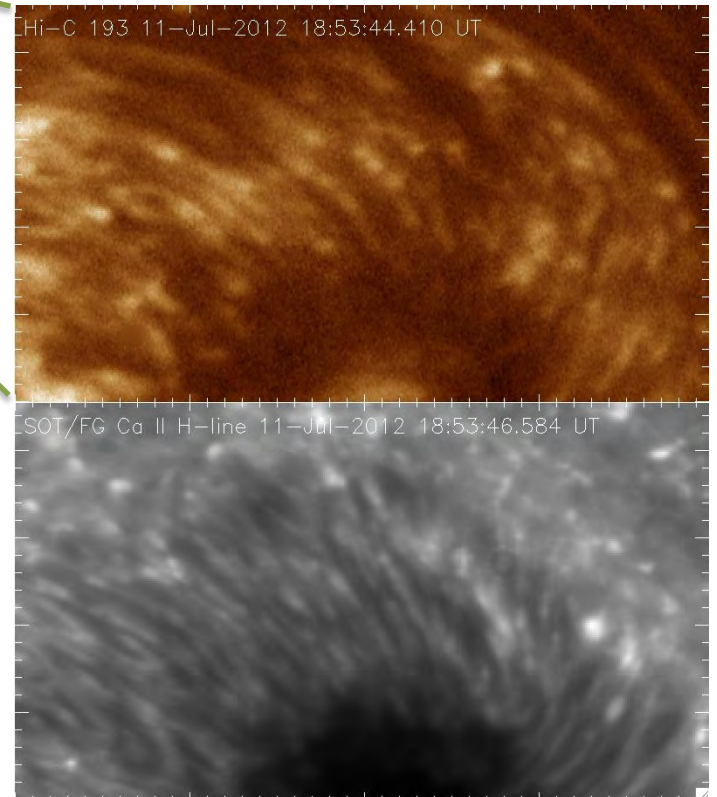
Cirtain, Golub,
Winebarger et al. 2013,
Nature;

Kobayashi, Cirtain,
Winebarger et al, 2014,
Sol. Phys.

Hi-C 193 Å



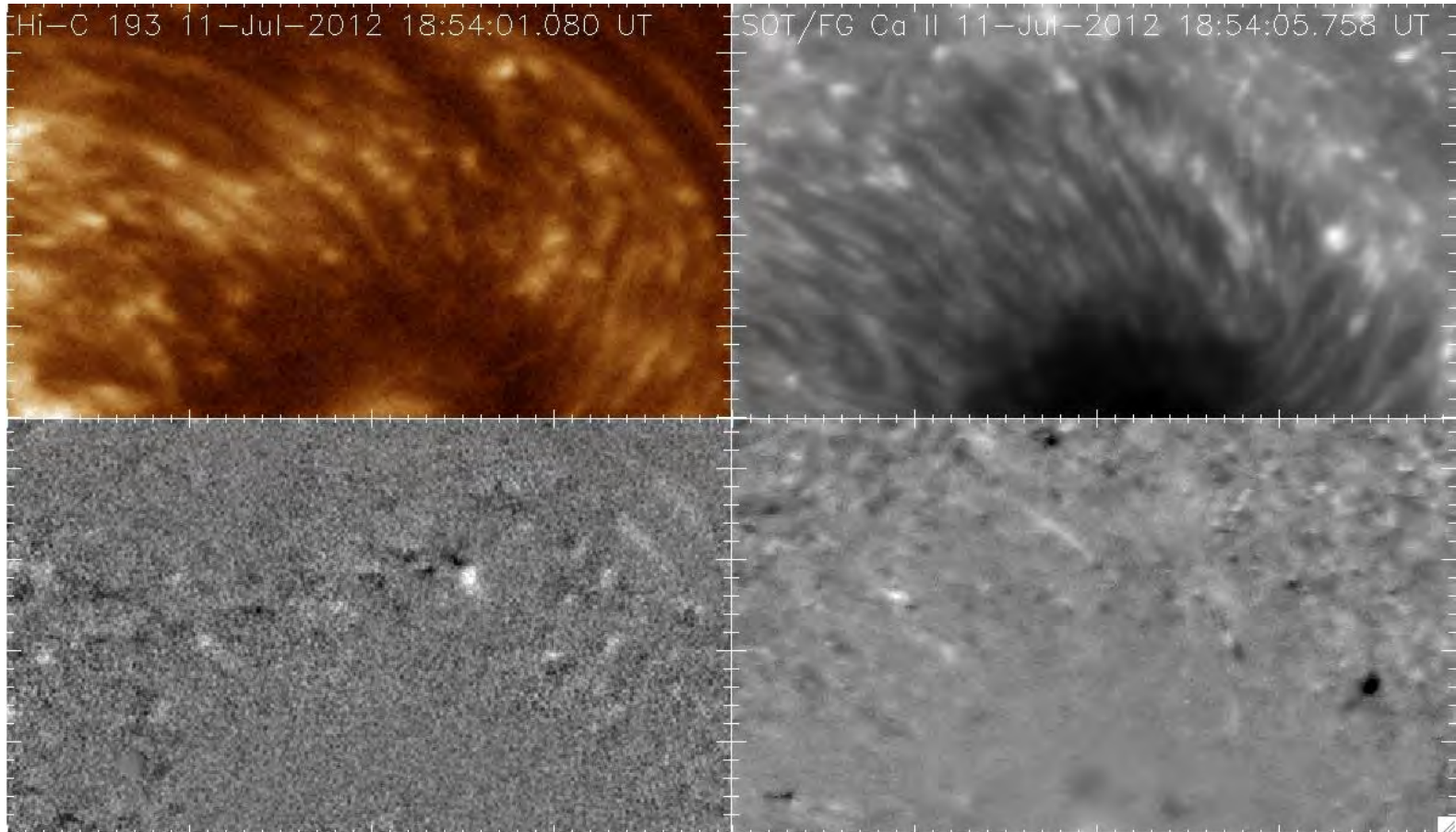
Penumbra; 18:53:44-18:55:30UT



Hinode/SOT/FG Ca II H-line

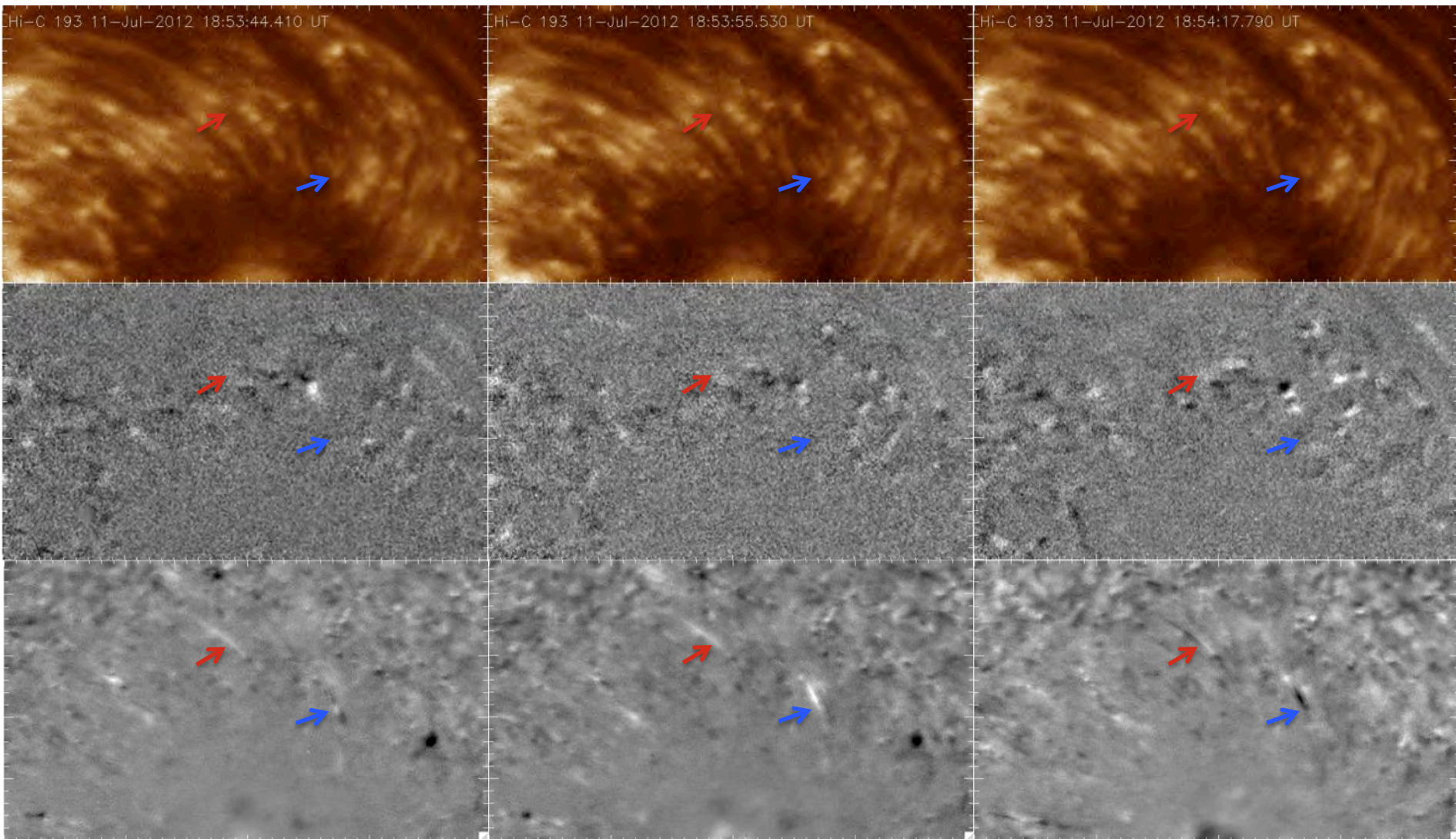
Hi-C 193 Å

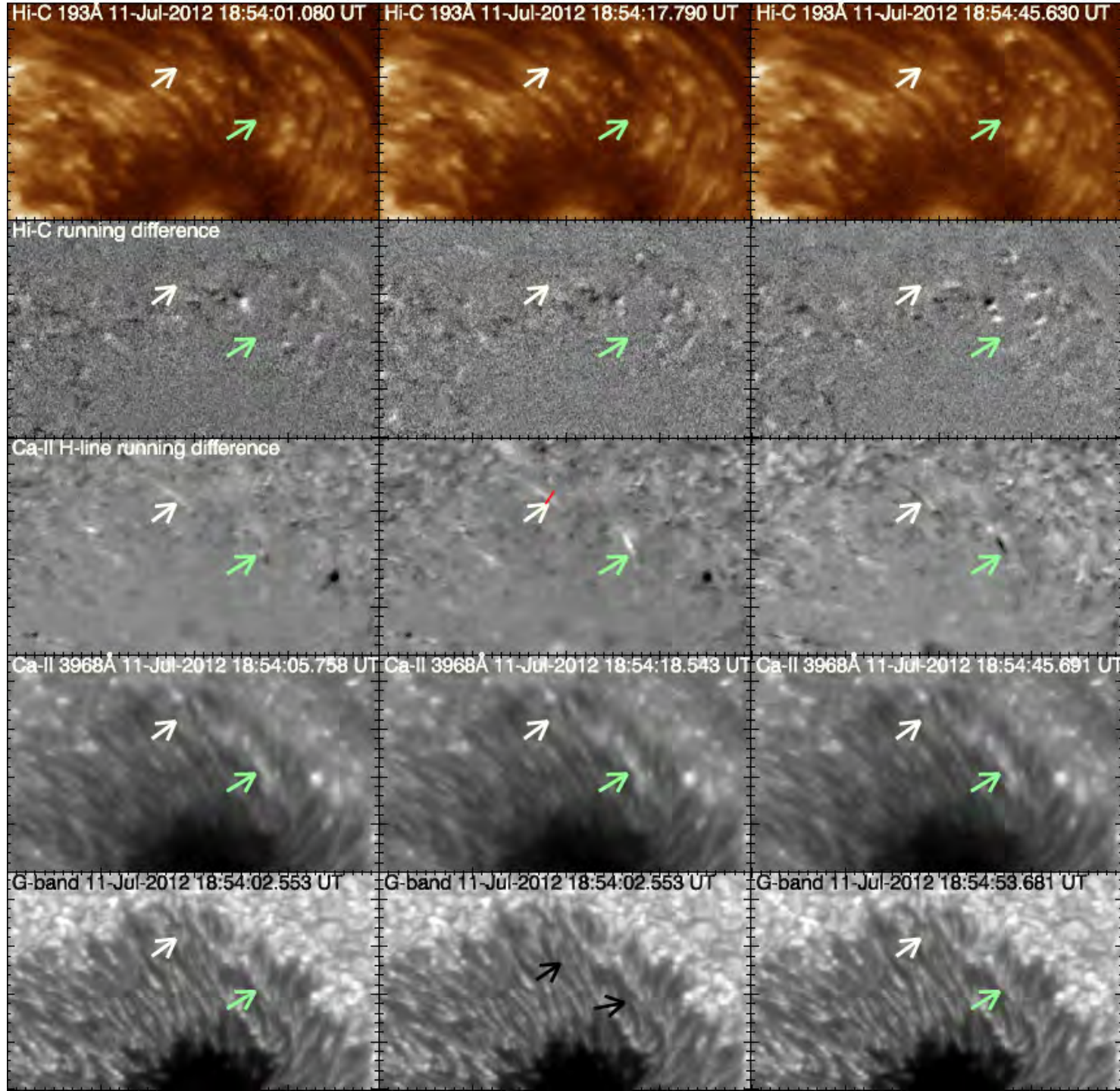
SOT/FG Ca II H-line



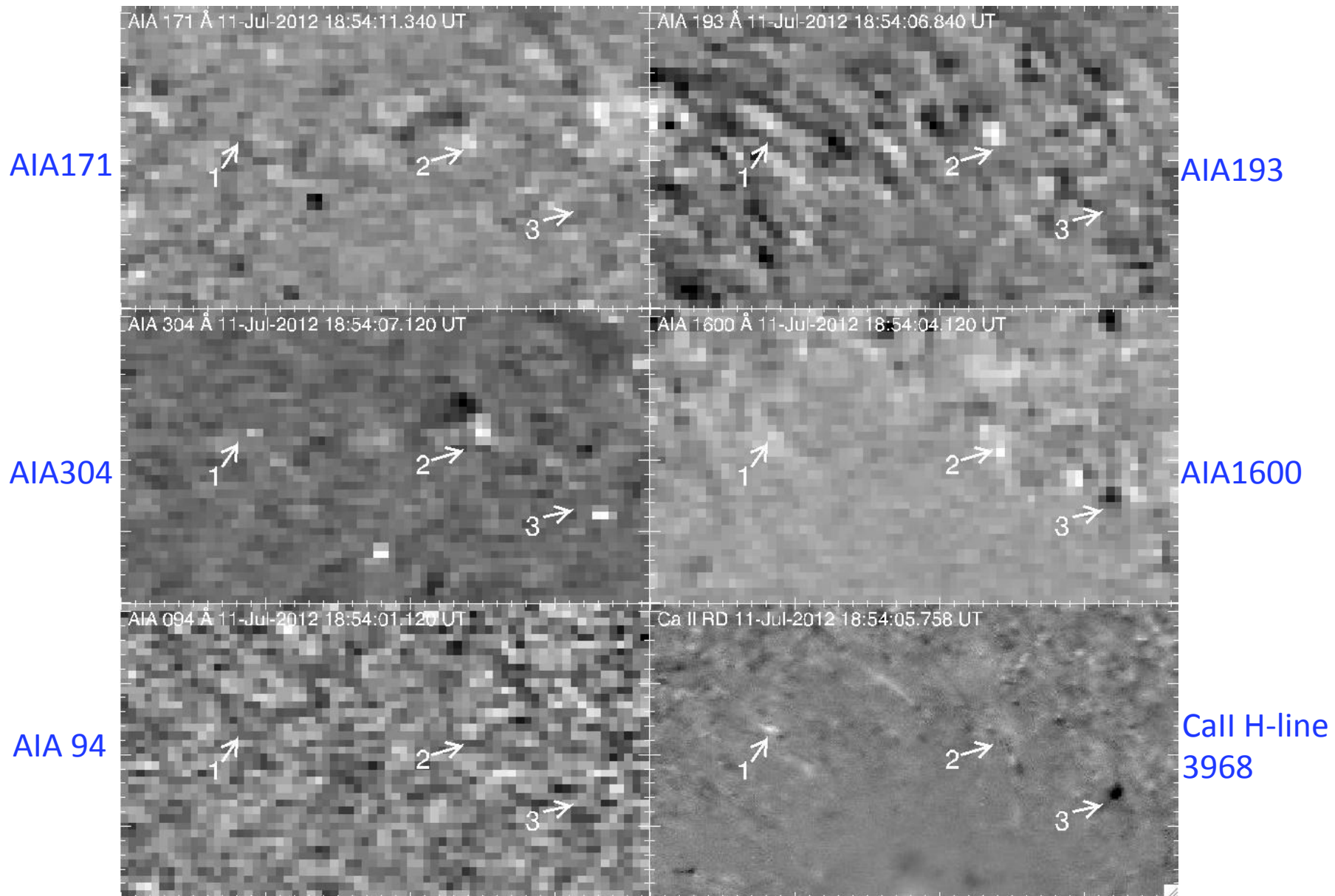
Lower frames are running differences

Example jets

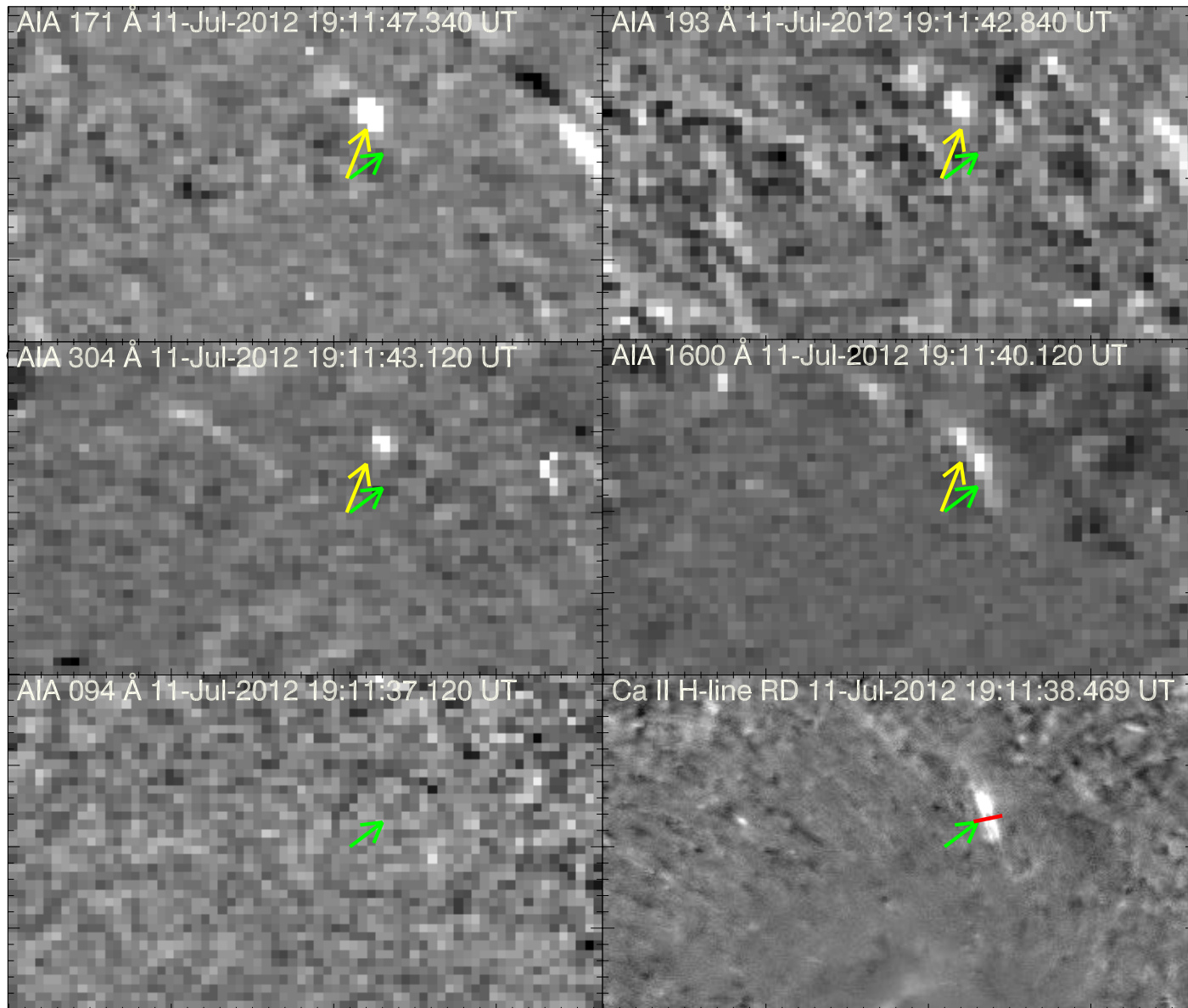




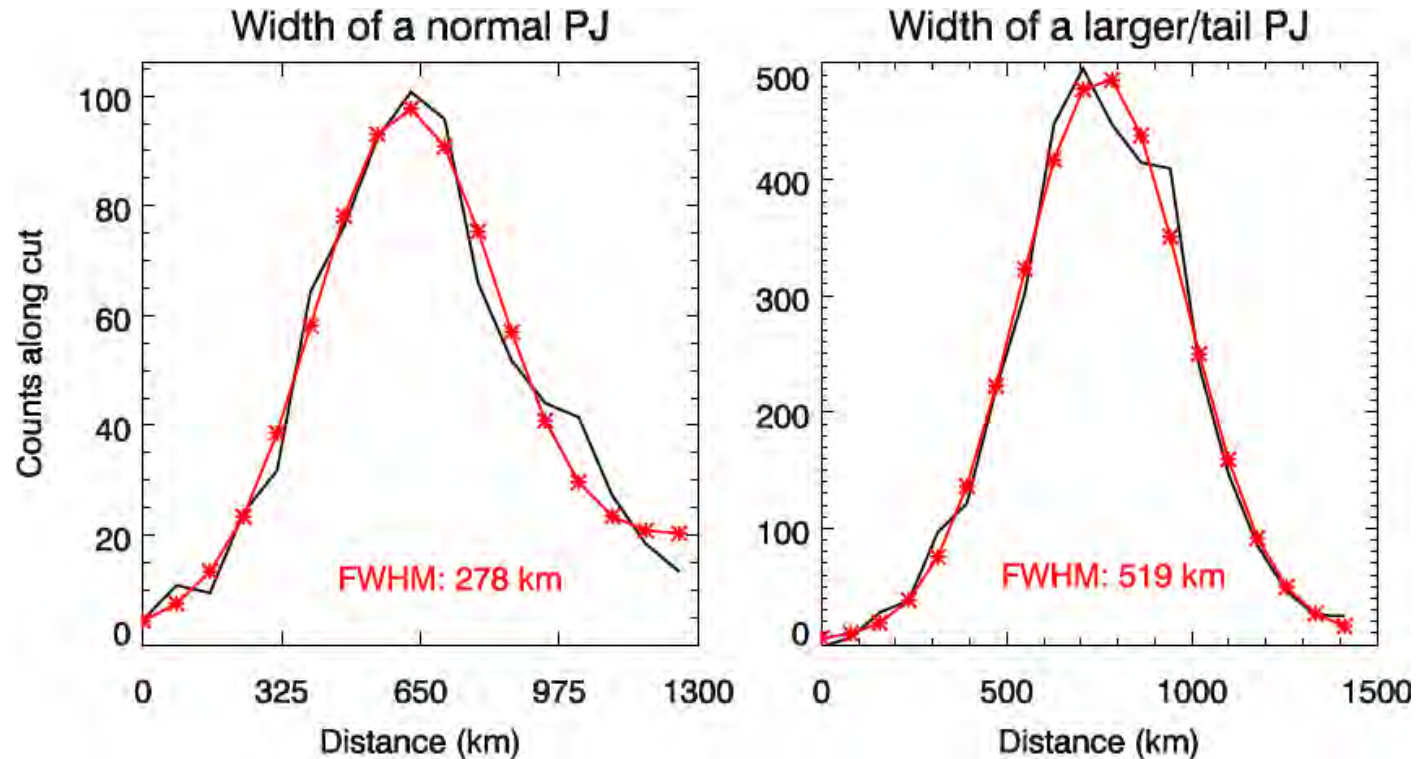
1 hour Ca II H line and AIA running difference movies



Example of a larger jet

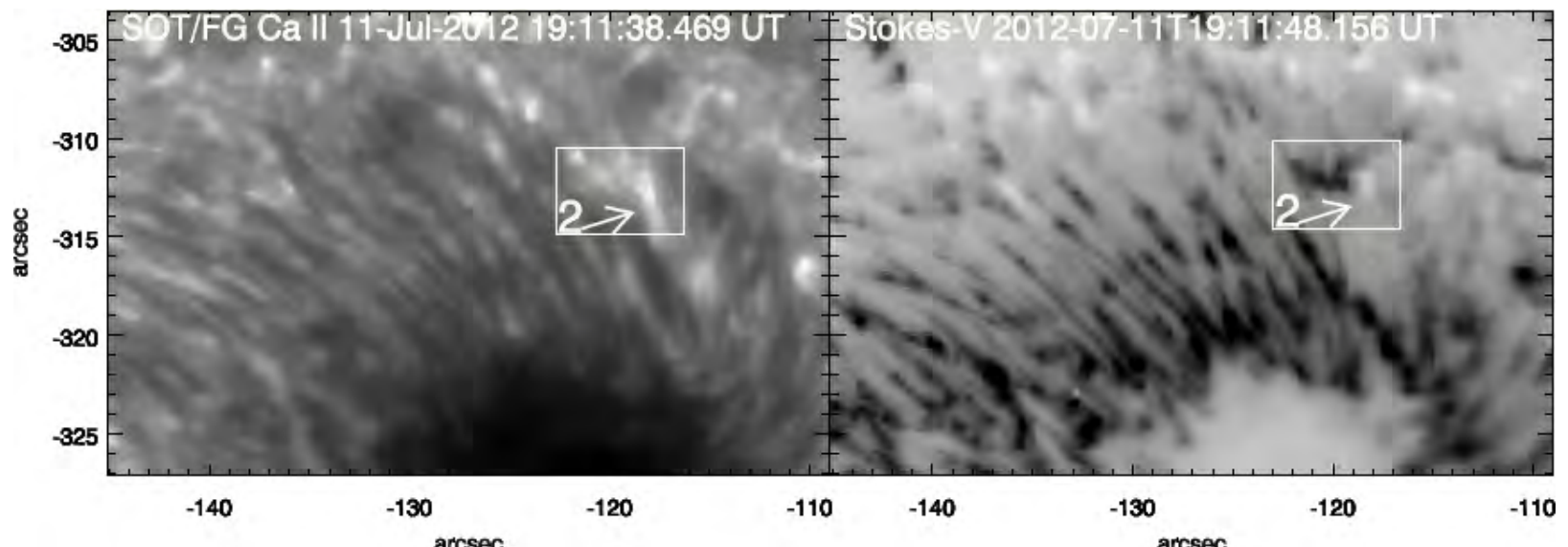


Widths of a normal jet and a larger jet using a Gaussian function fitting

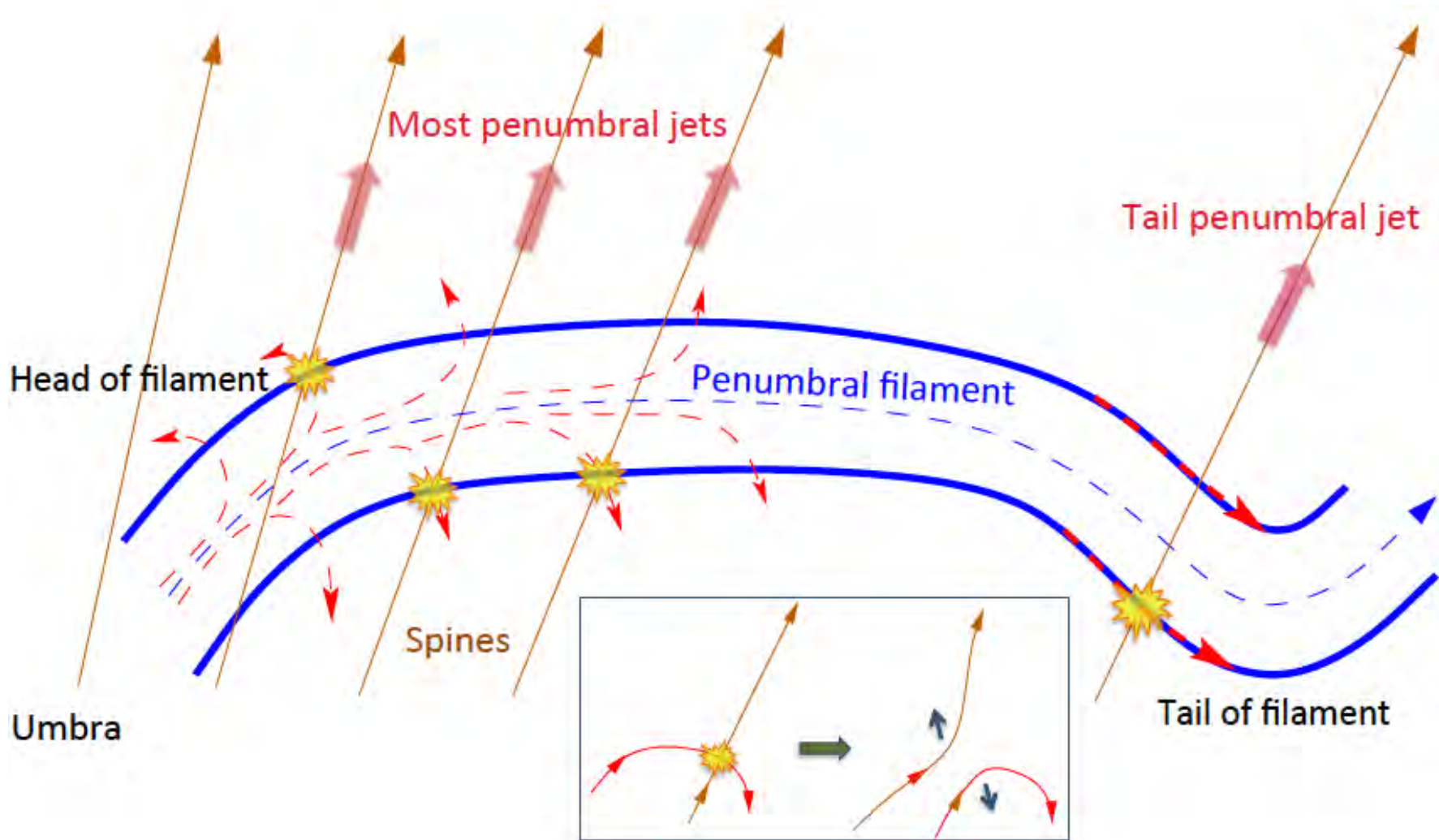


- Width of the widest jet: 600 km
- Speed of fastest jet found: 250 km/s
- Length: 420 km (subject to projection)

Stokes-V images (equivalent to LOS magnetograms)



Cartoon diagram depicting the formation mechanism of penumbral jets



Summary

- Penumbral microjets form a la Katsukawa et al., 2007 but by reconnection of oppositely directed field (Tiwari et al. 2016)
- Normal microjets show hardly any TR/coronal signature
- Larger jets, which flash repeatedly, show TR signatures; opposite polarity field patches are observed underneath those locations
- Need more TR/coronal observations at a resolution similar to that of Hi-C or better to verify these results.

Thanks!