SMALL-SCALE CHROMOSPHERIC JETS ABOVE A SUNSPOT LIGHT BRIDGE

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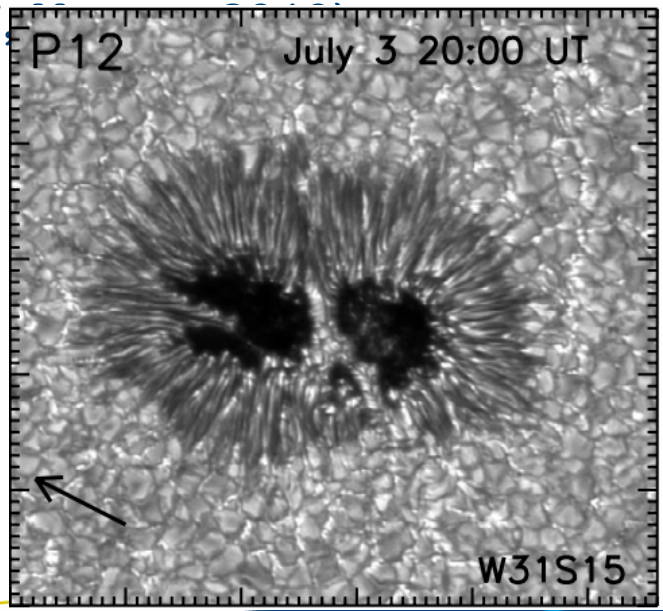
Introduction

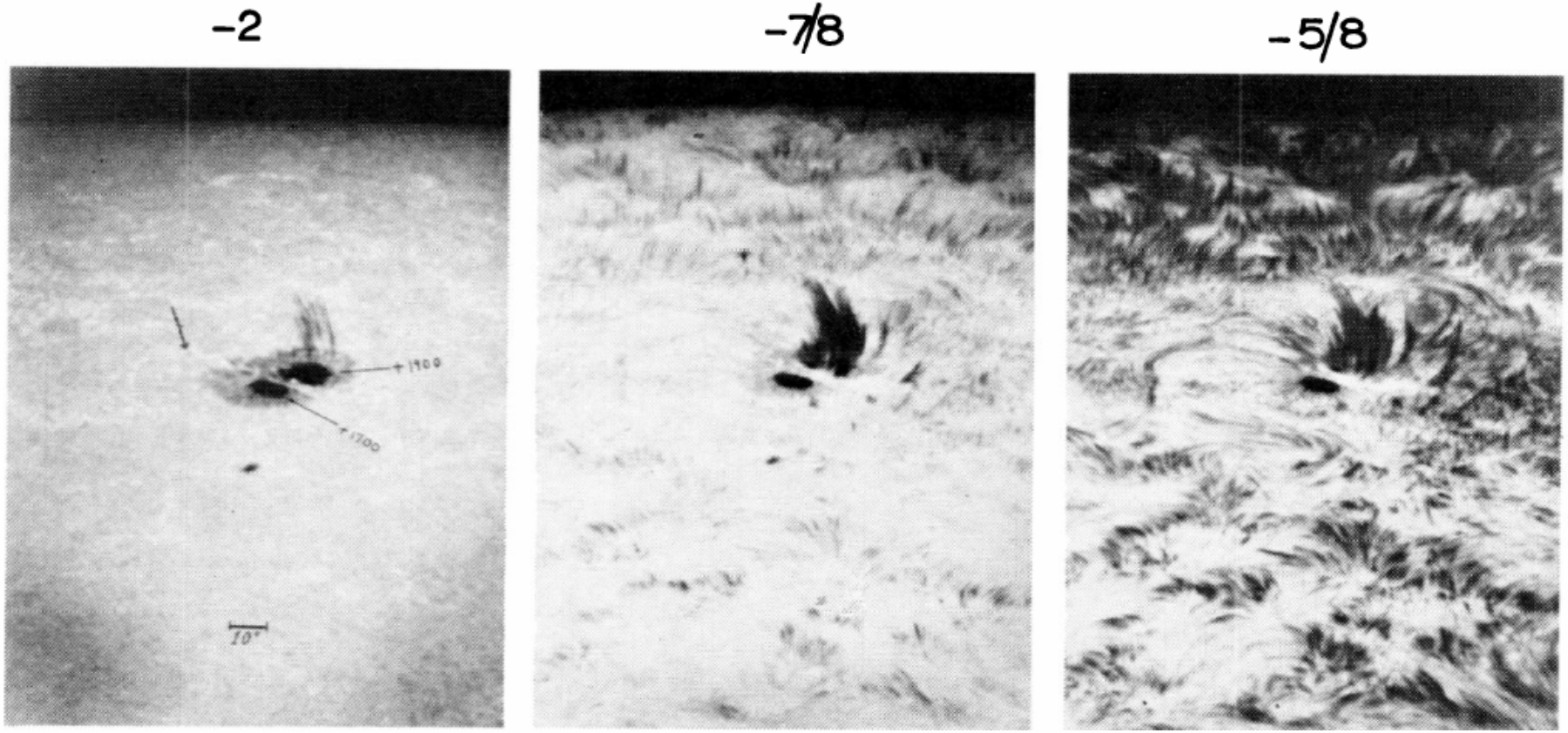
- Chromosphere above sunspots → highly dynamic phenomena
  - Umbral flashes (Wittmann, 1969, Rouppe van der Voort et al. 2003)
  - Running penumbral waves (Zirin & Stein 1972, Tziotziou et al. 2006, Kobanov et al. 2006, Bloomfield et al. 2007, Löhner-Böttcher & Bello González 2015)
  - Penumbral microjets (Katsukawa et al. 2007,



- Perturbation in the sunspot magnetic field → Chromospheric Heating
- Convective disruption most apparent in light bridges – transition from ß>1 to ß<1 rapid

Hα Surges above LBs

- 80% of surges on edge of LB adjacent to strongest umbral core

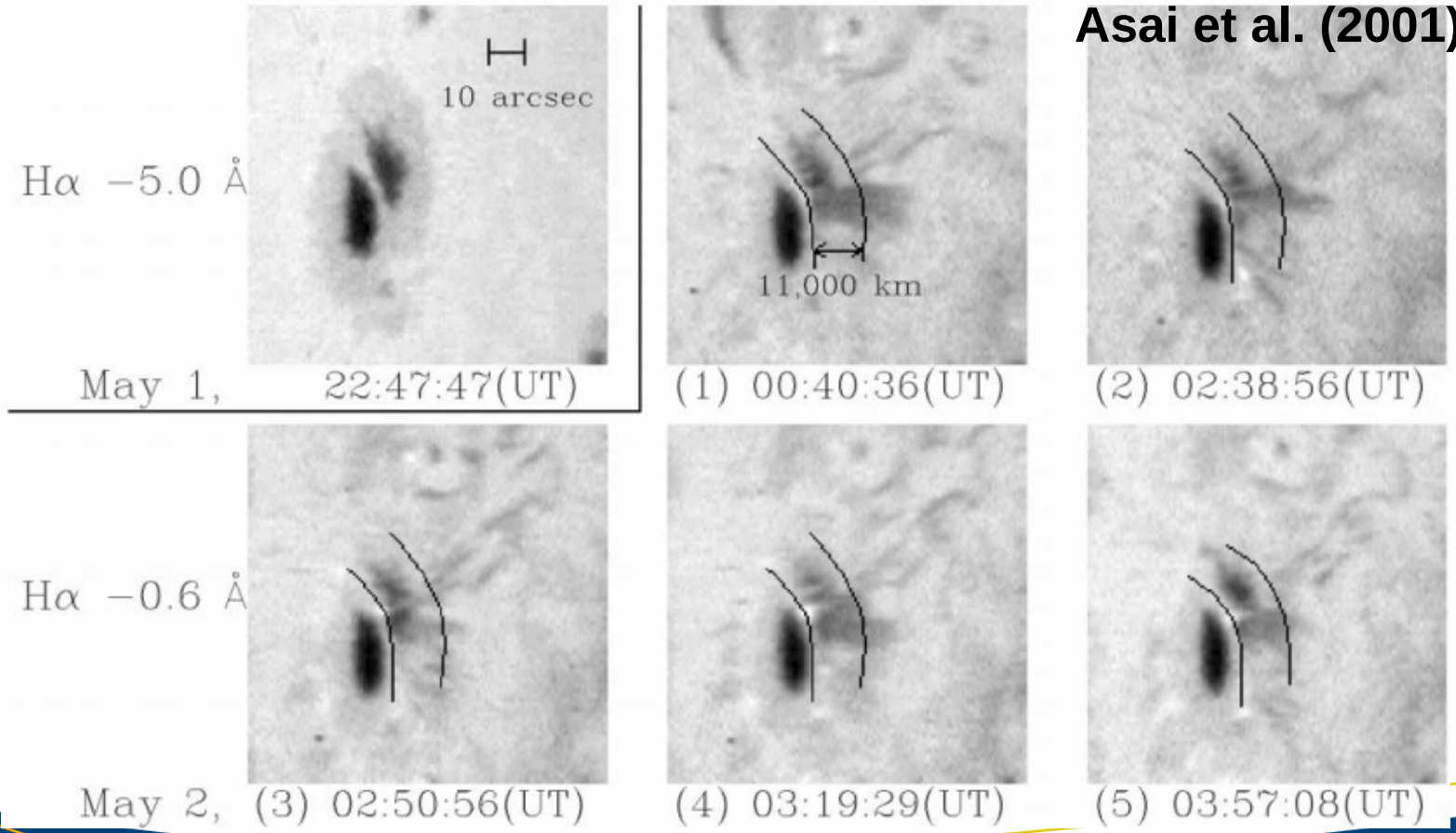


Roy (1973)

Hα Surges & EUV Brightenings

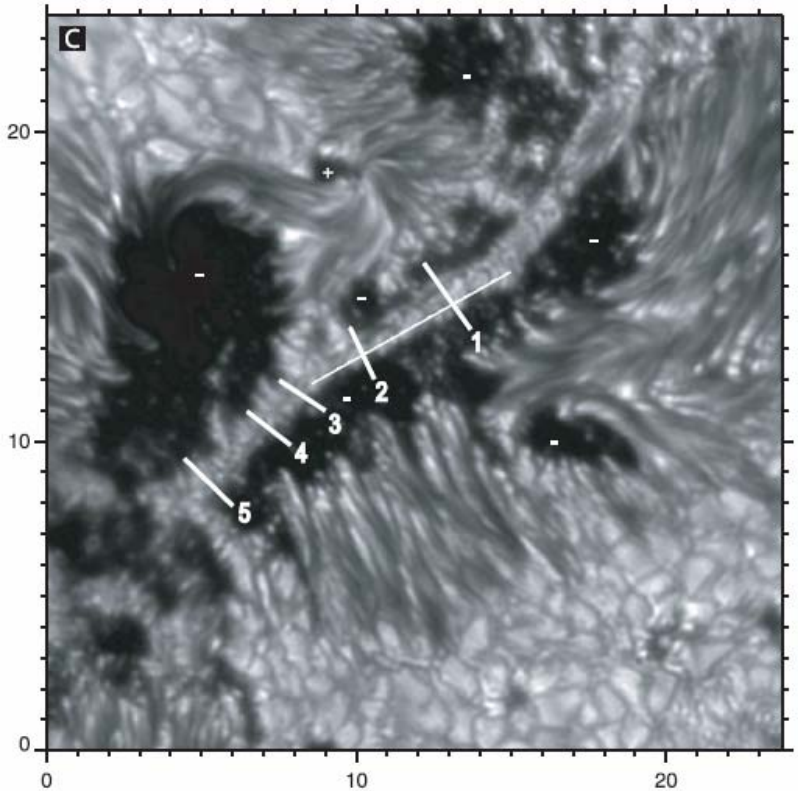
- Recurrent and intermittent surges, Speeds of 50 km/s
- Coincide with TRACE 171Å brightenings

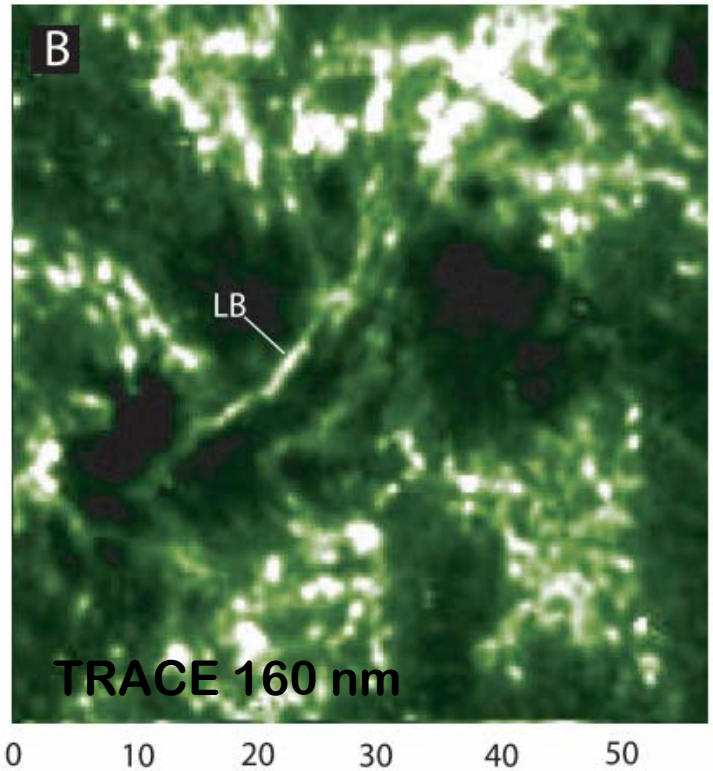
Asai et al. (2001)



Flaring activity in LBs

- Overturning motions in LB, constant brighteness enhancement in TR
- C2.0 flare 4 hrs later, ribbon over LB

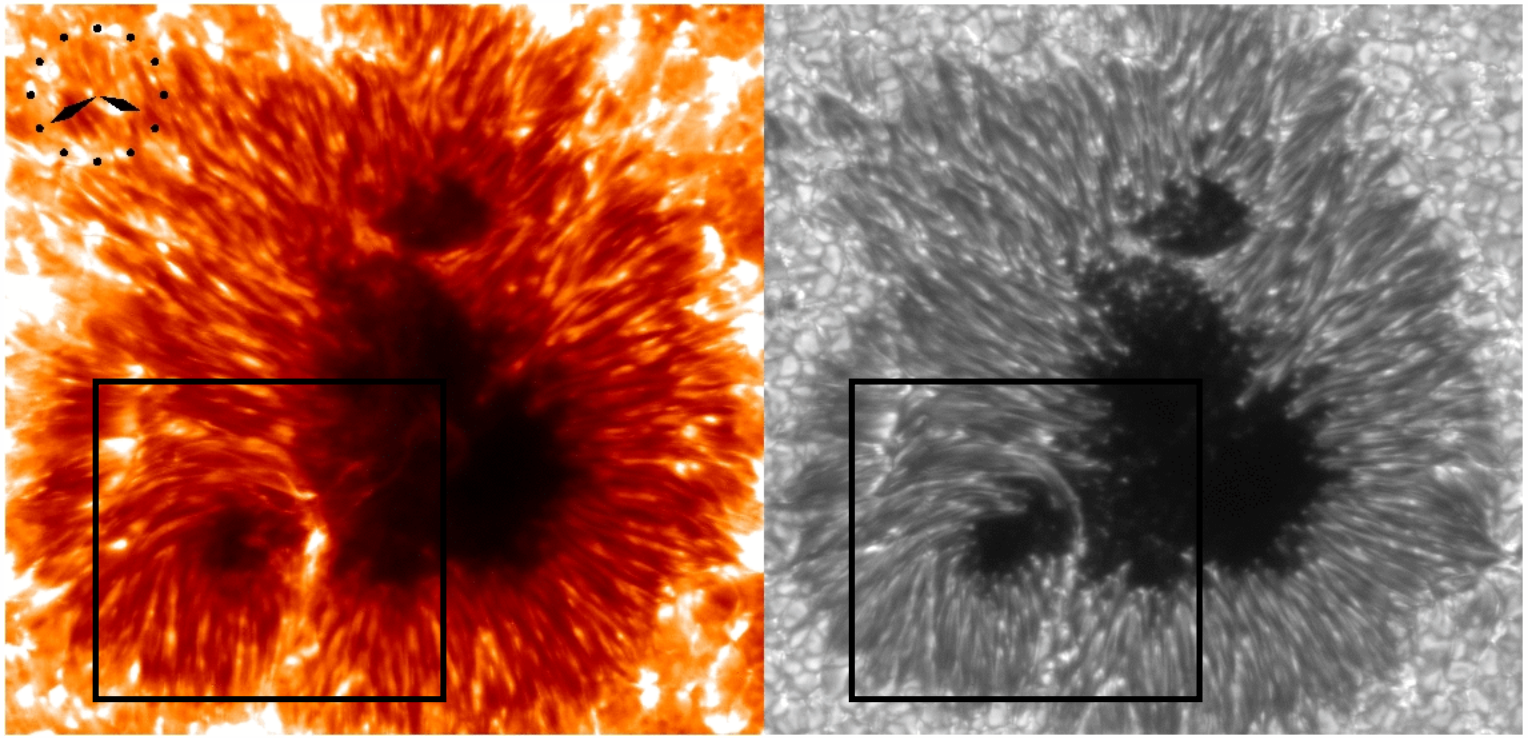




Berger & Berdyugina (2003)

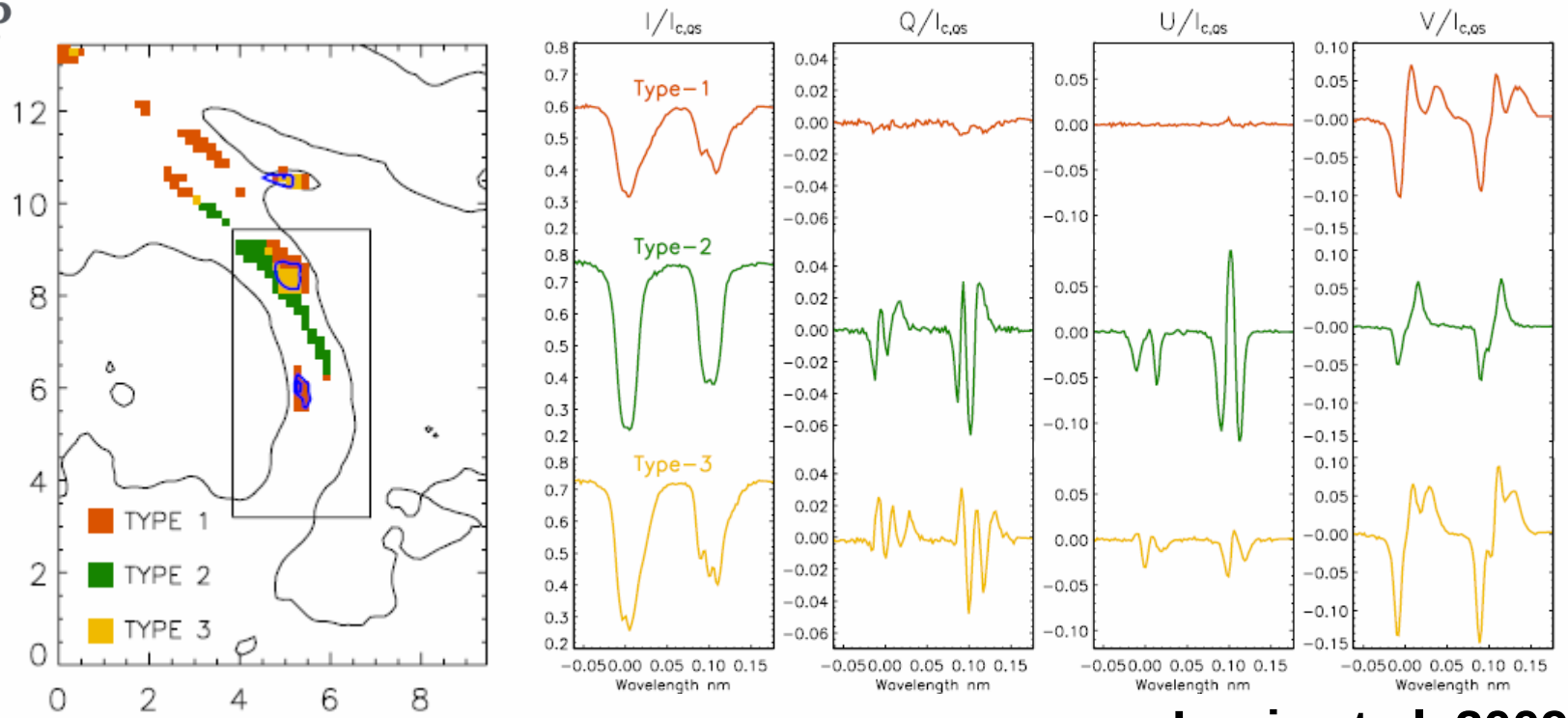
HINODE sheds light !!!

Louis et al. 2008, 2009



- **Persistent, recurrent brightenings over penumbral LB in Ca II H**
- **Jets along LB & arch-shaped brightenings across the LB extending to QS**

Underlying photospheric conditions

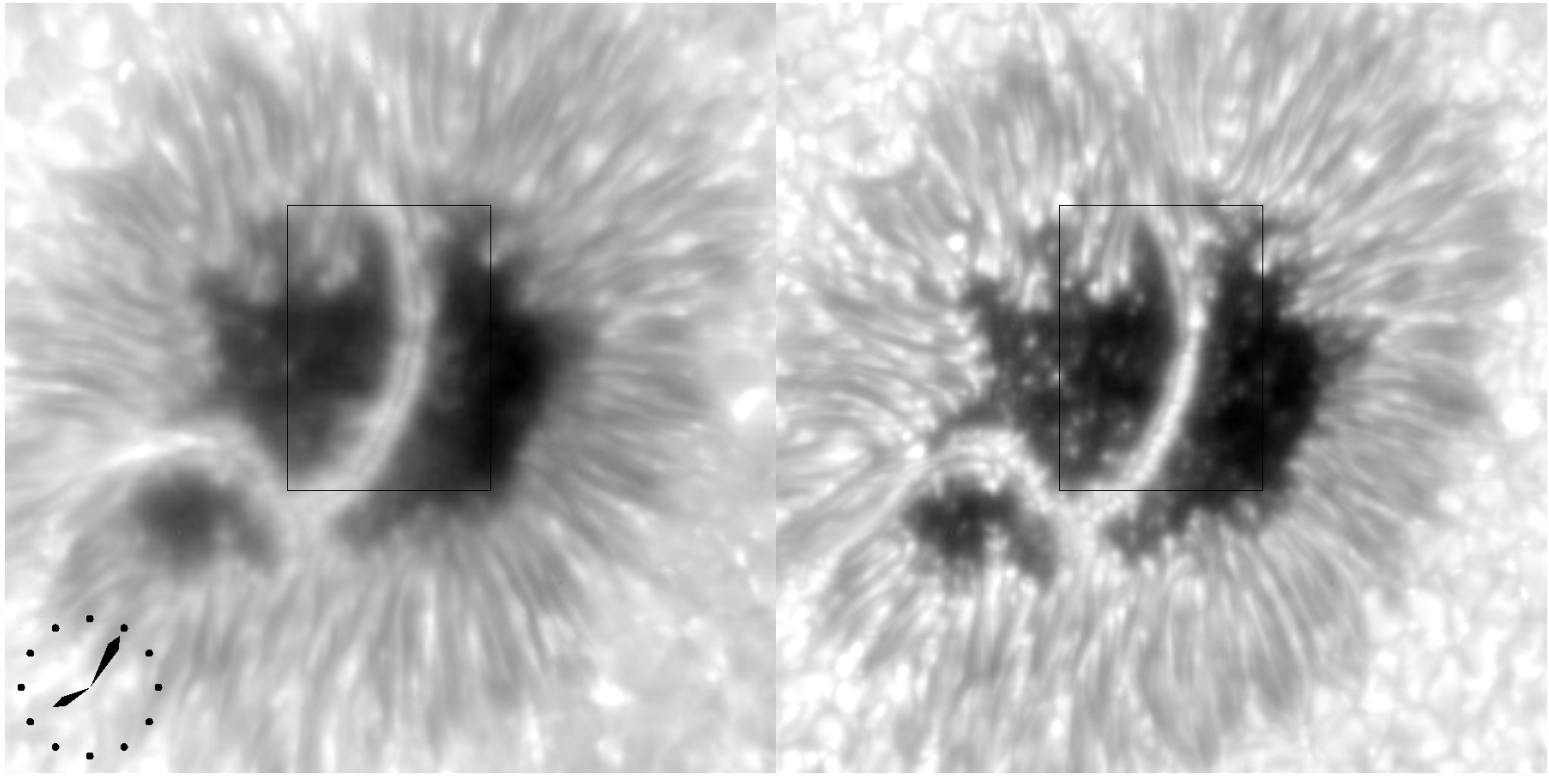


Louis et al. 2009

- **Anomalous profiles in LB, supersonic downflows co-spatial, temporal with chromospheric brightenings**
- **Similar obs. at umbra-penumbra border – Louis et al. 2011**

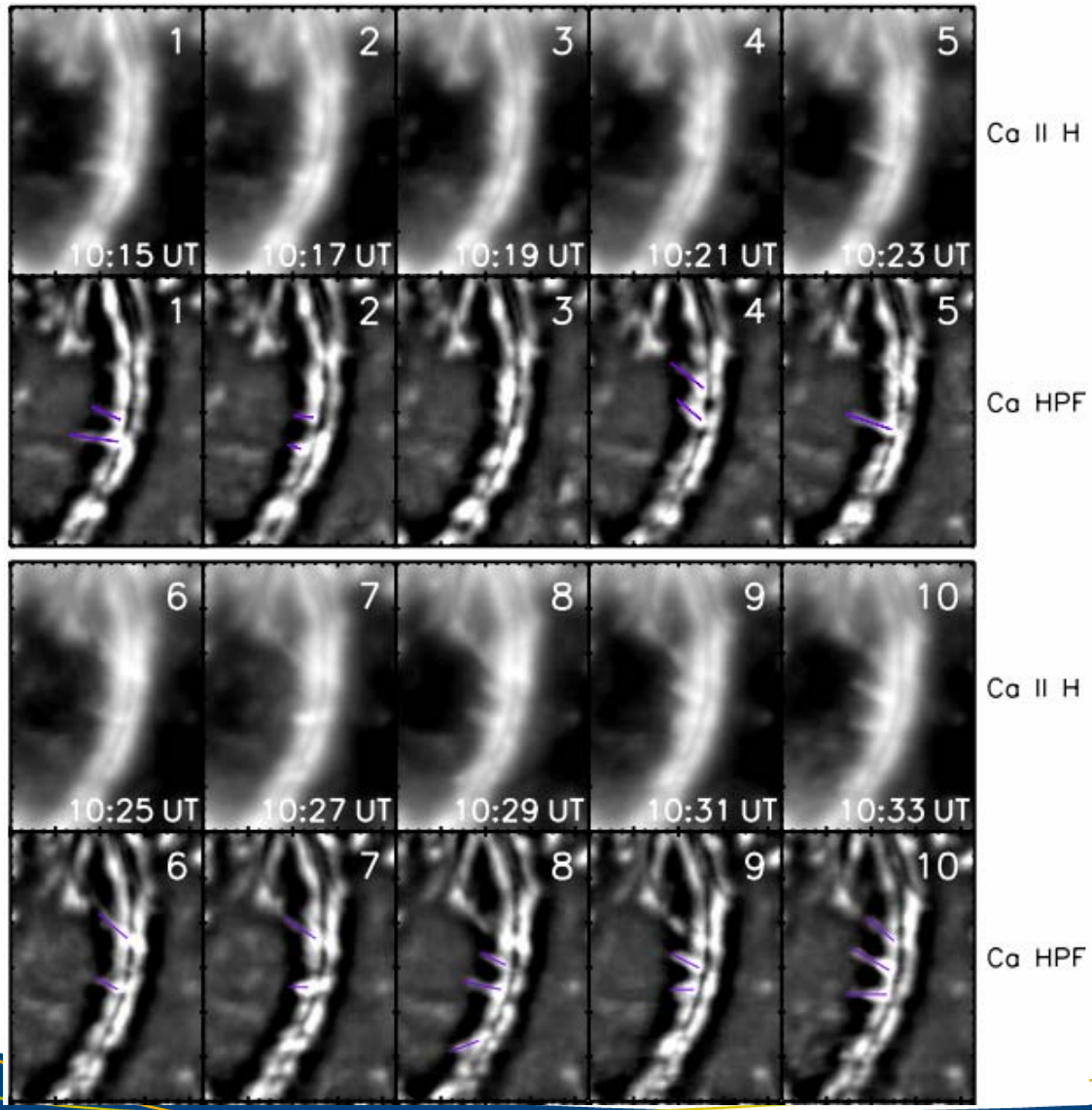
CAUSE AND EFFECT ????

Small-scale chromospheric jets in light bridges

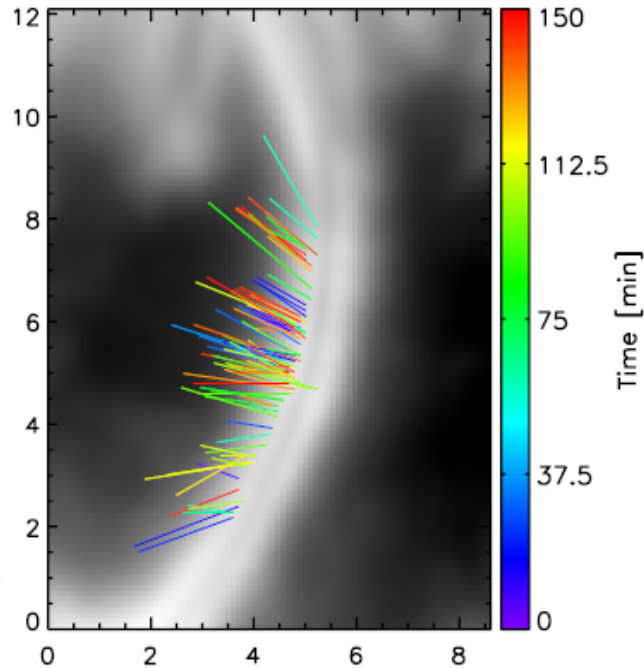


Louis, Beck, Ichimoto 2014, A&A, 567, 96

Detection of jets

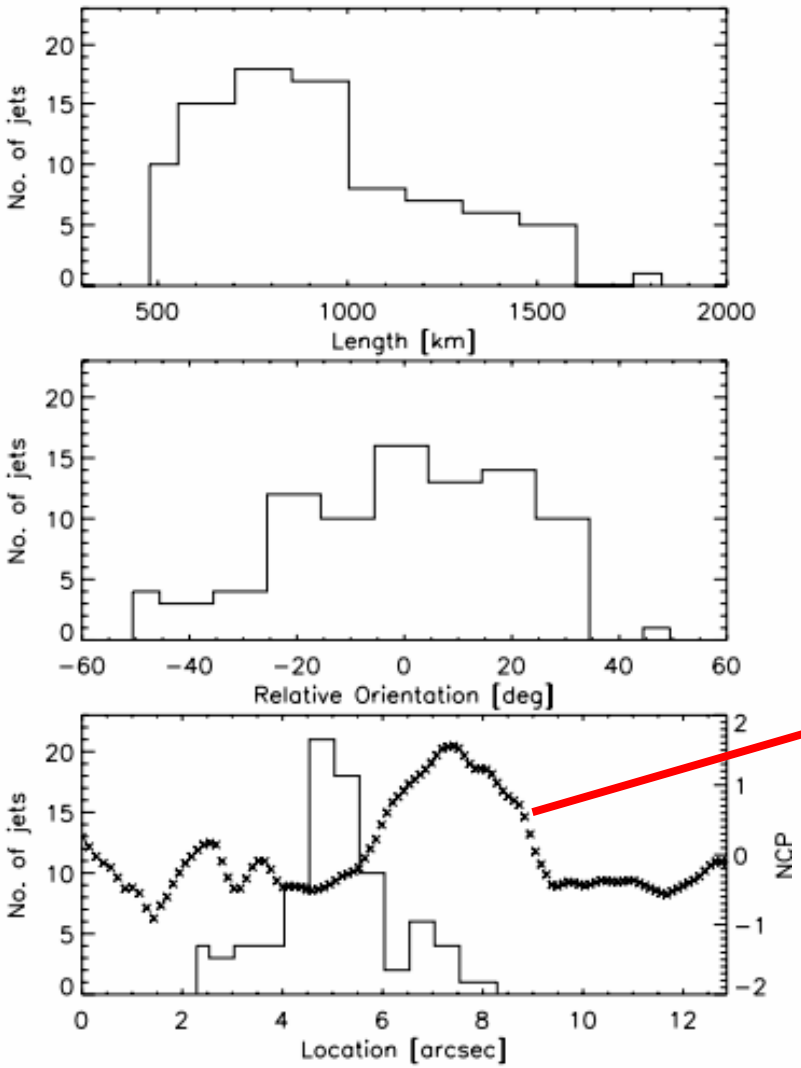


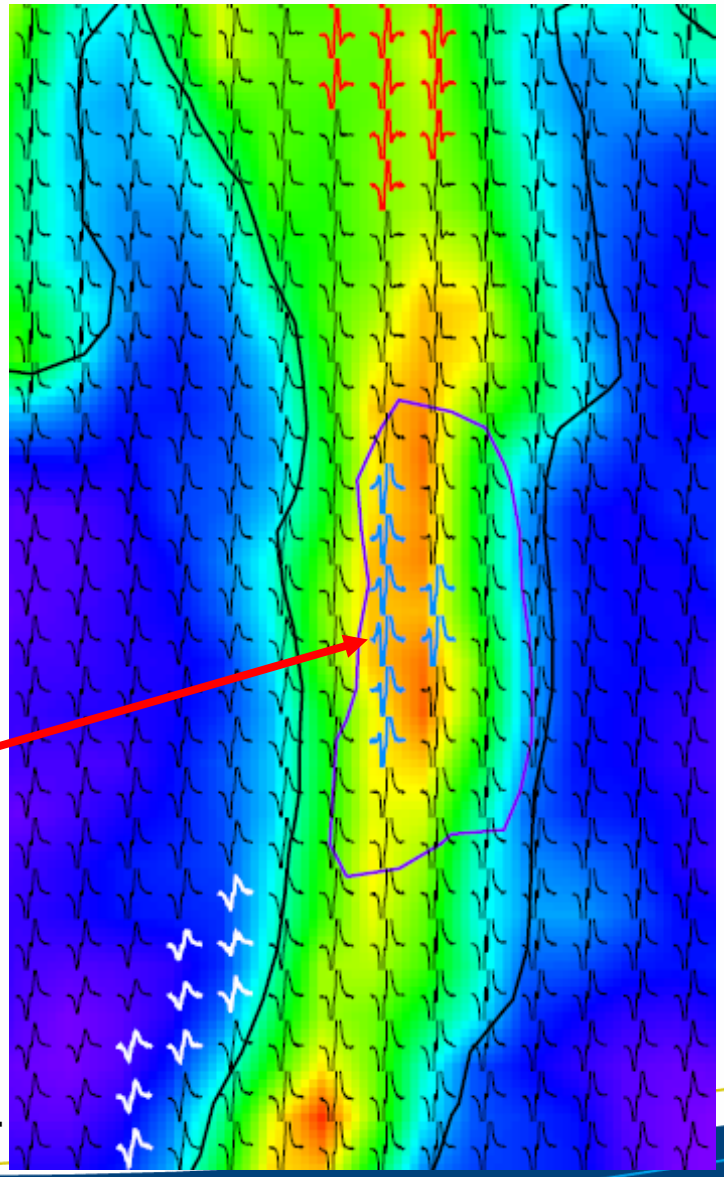
- Base of jets : Triangular-shaped blob
- Spike-like jets launched towards UC



Louis et al. 2014

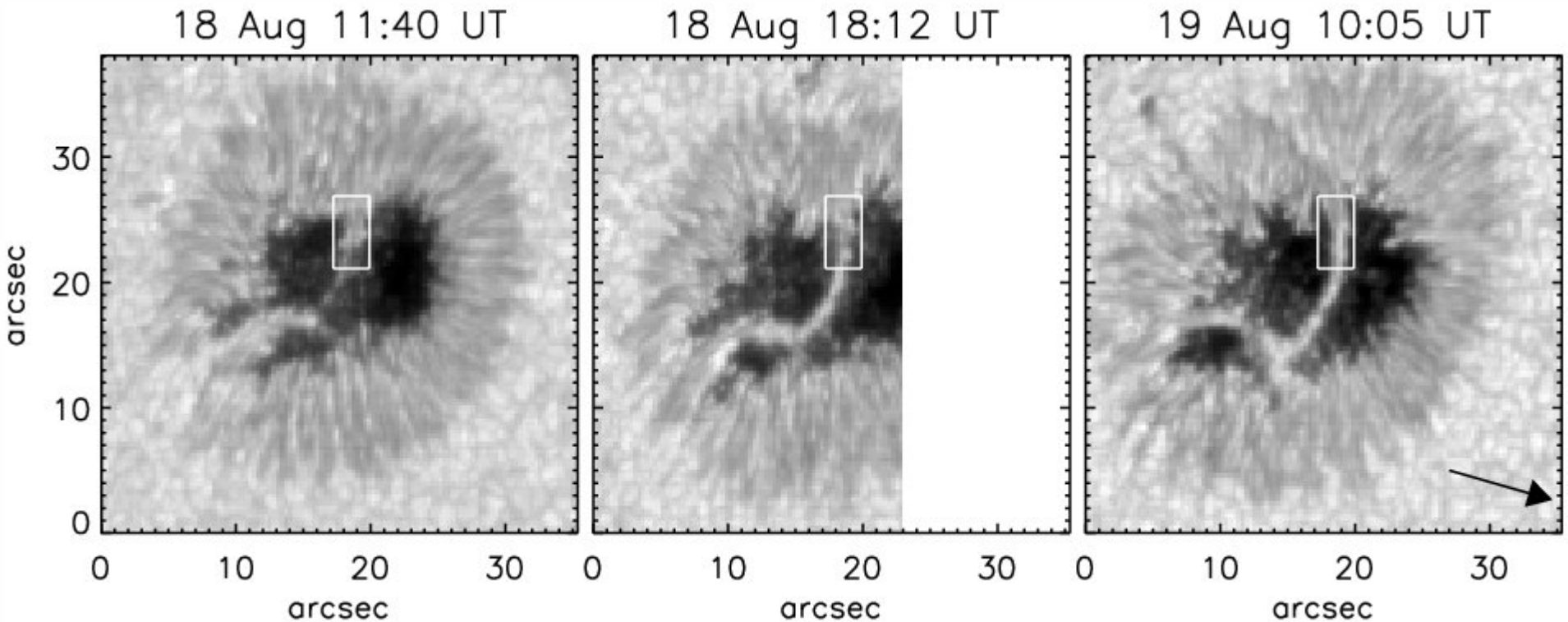
Properties of jets





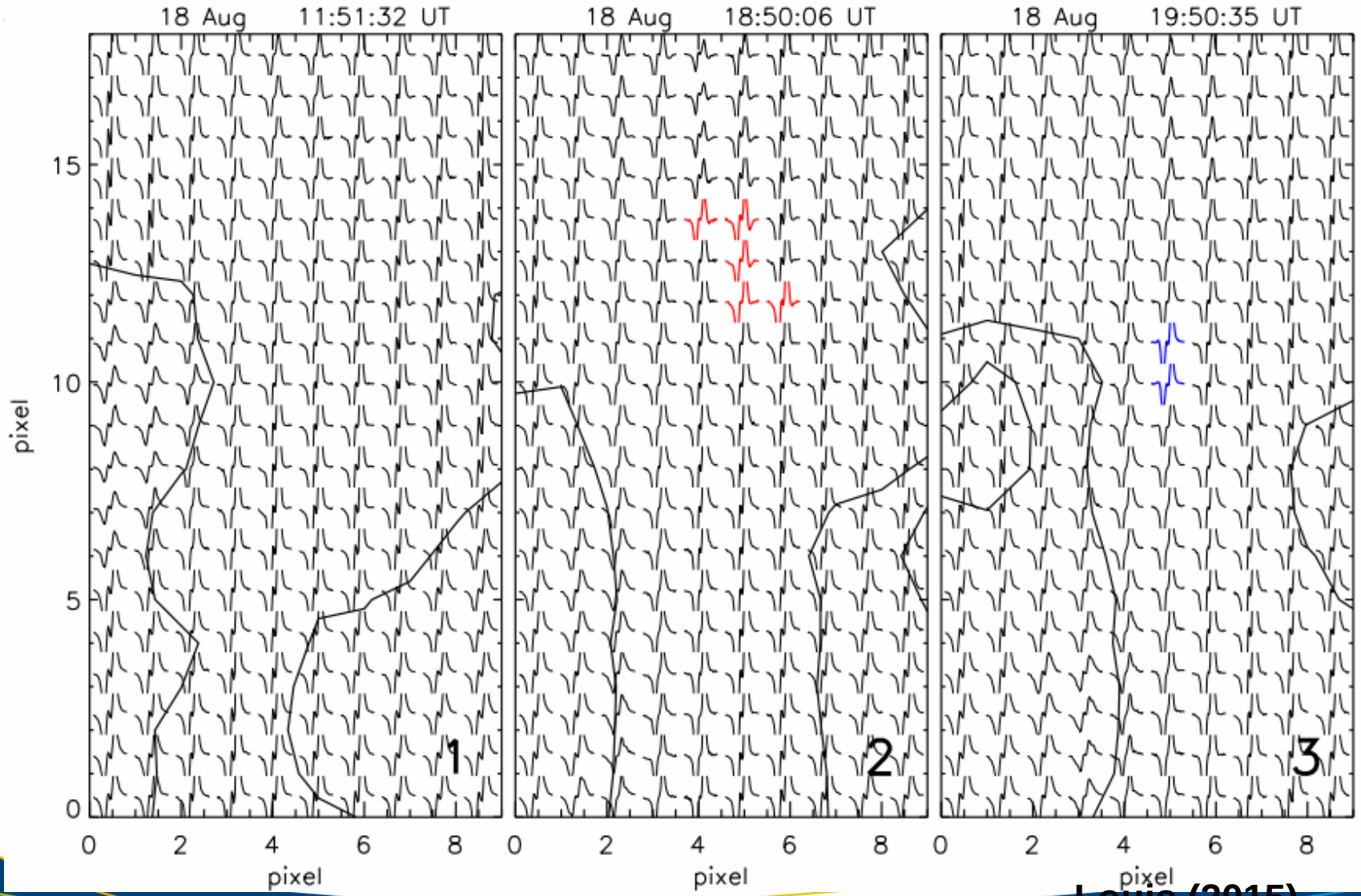
Louis et al. 2014

Timeline of the small-scale jets



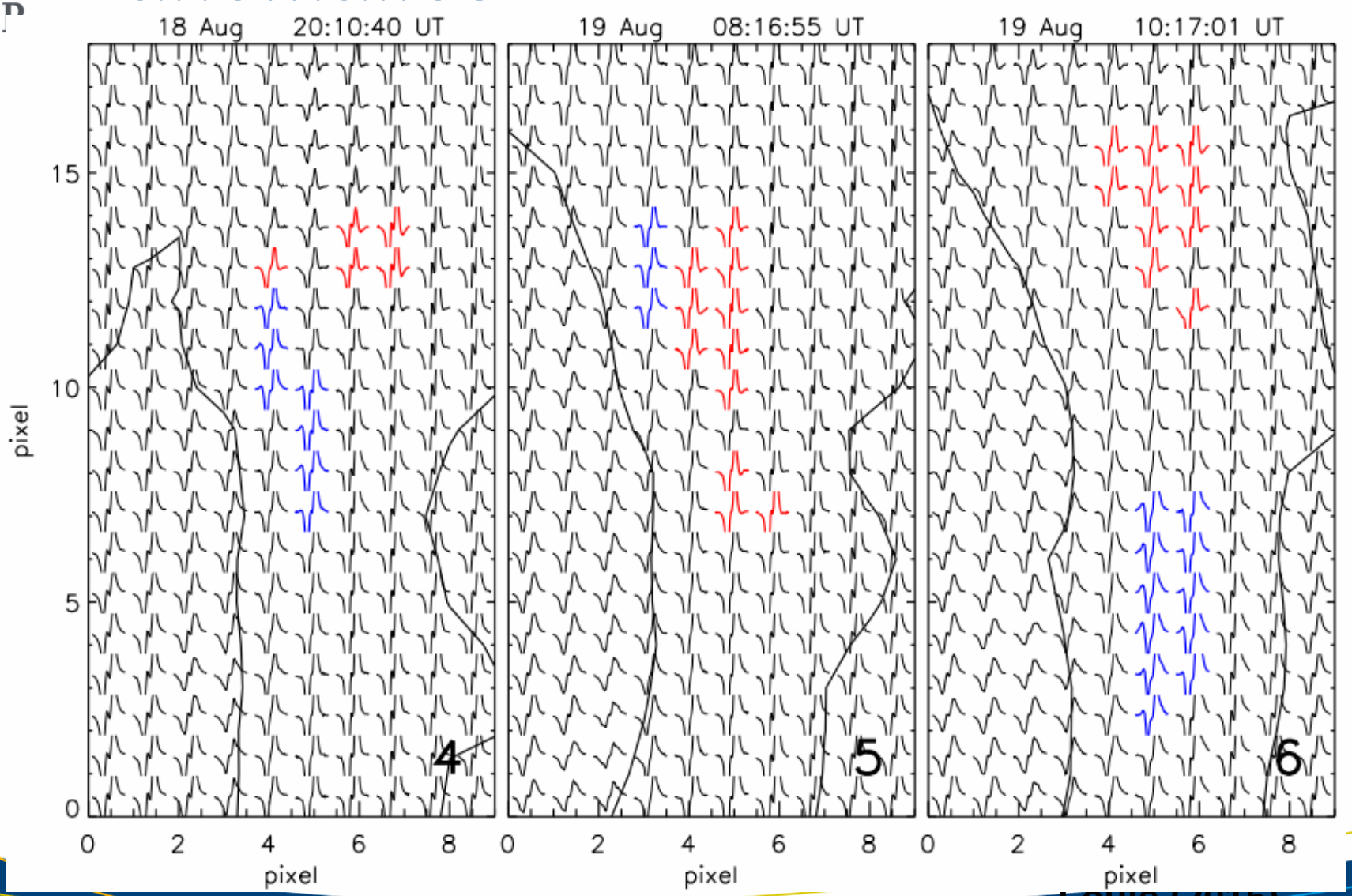
- Frequent transition formation and fragmentation over 3 days
- LB intact from latter half of Aug 18 till end of Aug 19
- No jets observed during early phase of LB, but soon after formation

Small-scale velocity & magnetic anomalies



Louis (2015)

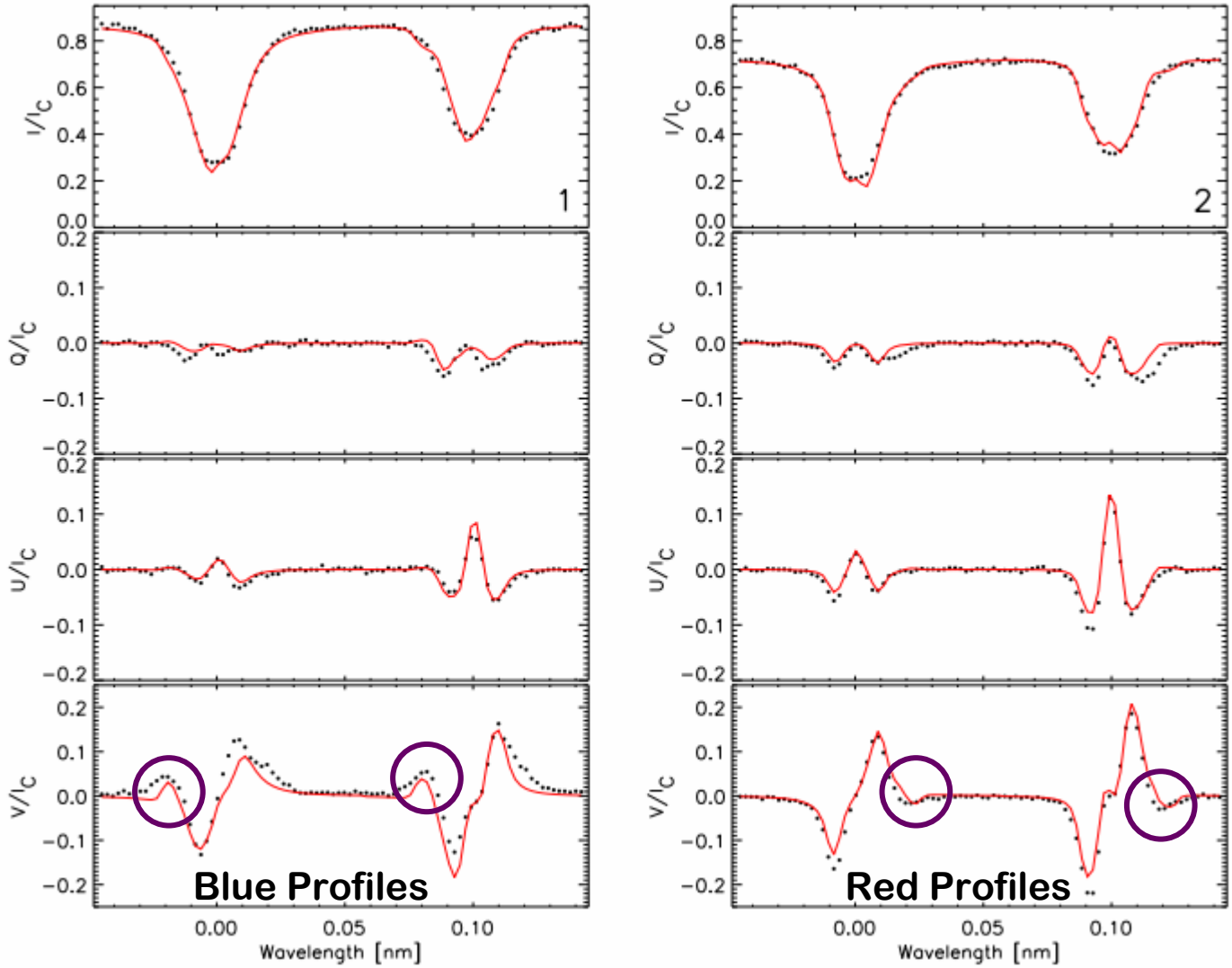
Small-scale velocity & magnetic anomalies



Louis (2015)

Two-component inversion

Louis (2015)

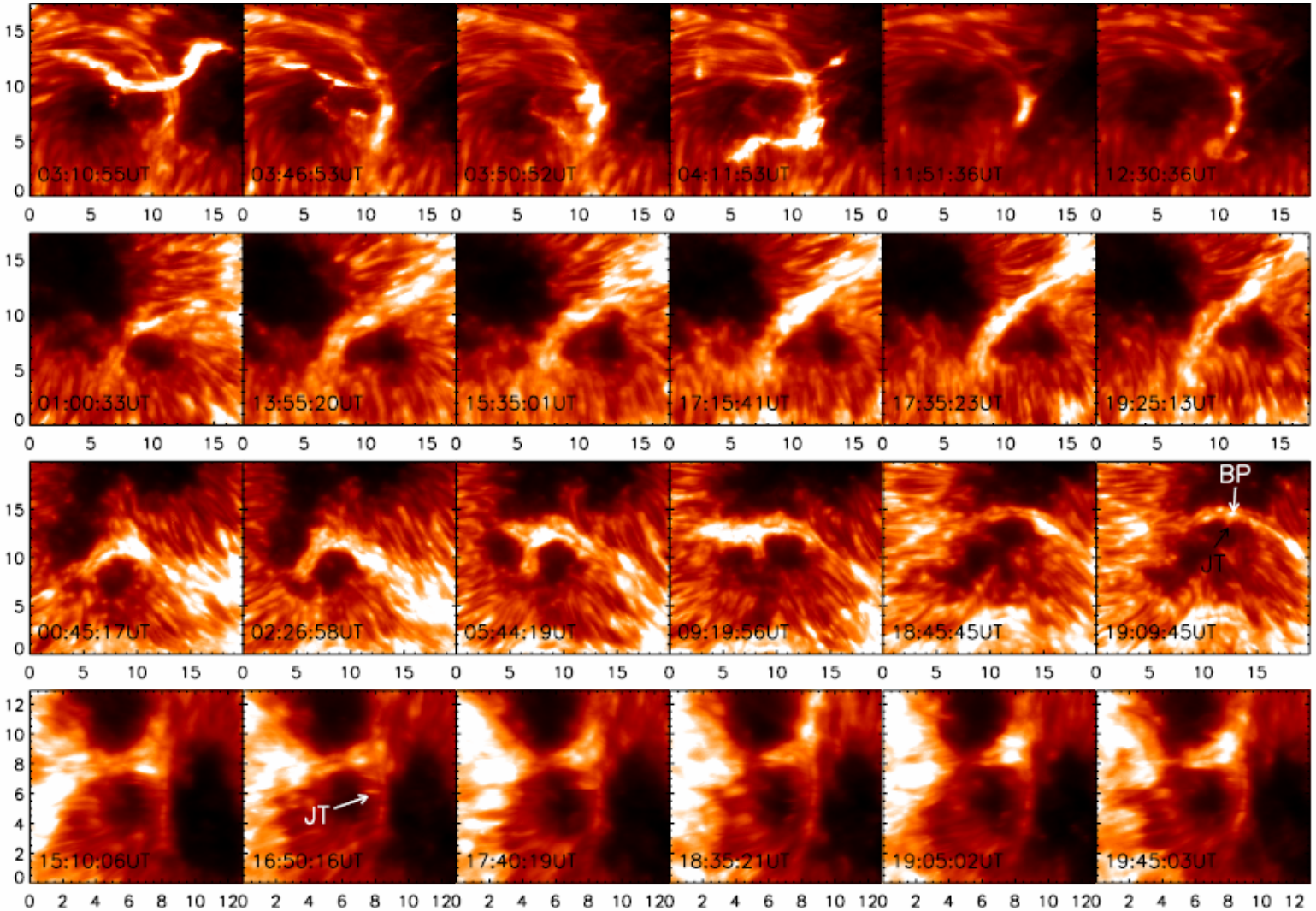


Strong Doppler shifts of either sign with opposite polarity!!!

Two-component inversion

	BP	RP	LB	Umb
Field Strength [G]	1554 1535	1581 1747	1688 0	2611 0
Field Inclination [deg]	150 59	145 54	156 0	164 0
LOS Velocity [km s^{-1}]	0.6 -5.2	0.3 6.7	0.2 0.0	0.3 0.0
Fill Fraction	0.91 0.09	0.96 0.04	1.00 0.00	1.00 0.00

Chromospheric activity in LBs



Louis (2010)

Summary & Conclusion

- One-to-one (spatial & temporal) correspondence between photospheric inhomogeneities (velocity & magnetic) & chromopsheric jets → causal relationship
- Strong/supersonic velocities imply strong pressure gradients, capable of producing Doppler shifts of either sign & in close spatial proximity
- Jets associated with LBs at different epochs of sunspot evolution, recurrent and long-lived

- Small-scale inhomogeneities likely driven by magneto-convection
- Evidence for small-scale flux emergence in LBs (Louis et al. 2015)
- LB associated large-scale convective flows in EARs (Toriumi et al. 2015a, 2015b)
- Magnetic reconnection with overlying sunspot field → jets/surges?

THANK YOU