Flocculent flows

A case of chromospheric rain?

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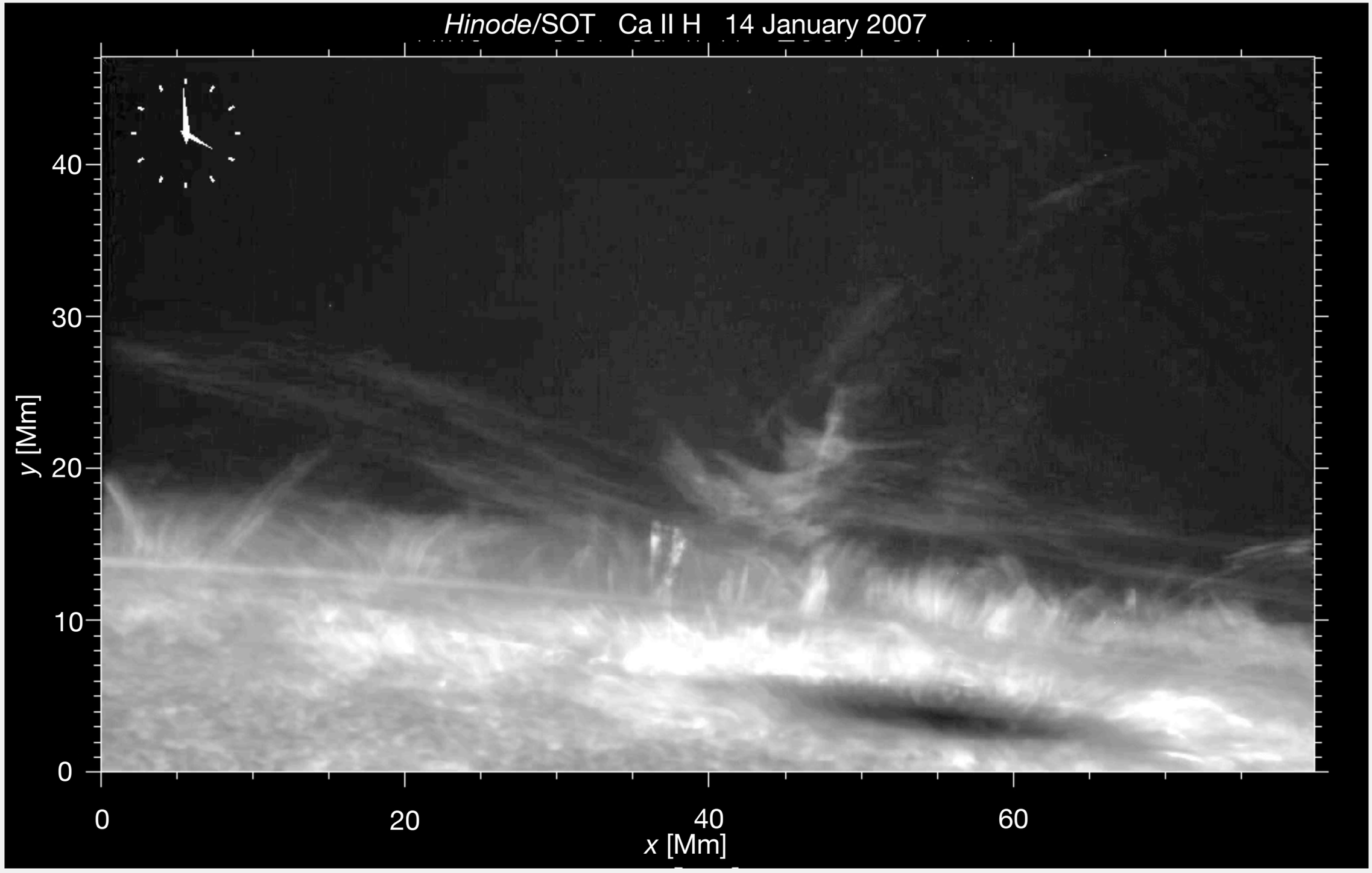
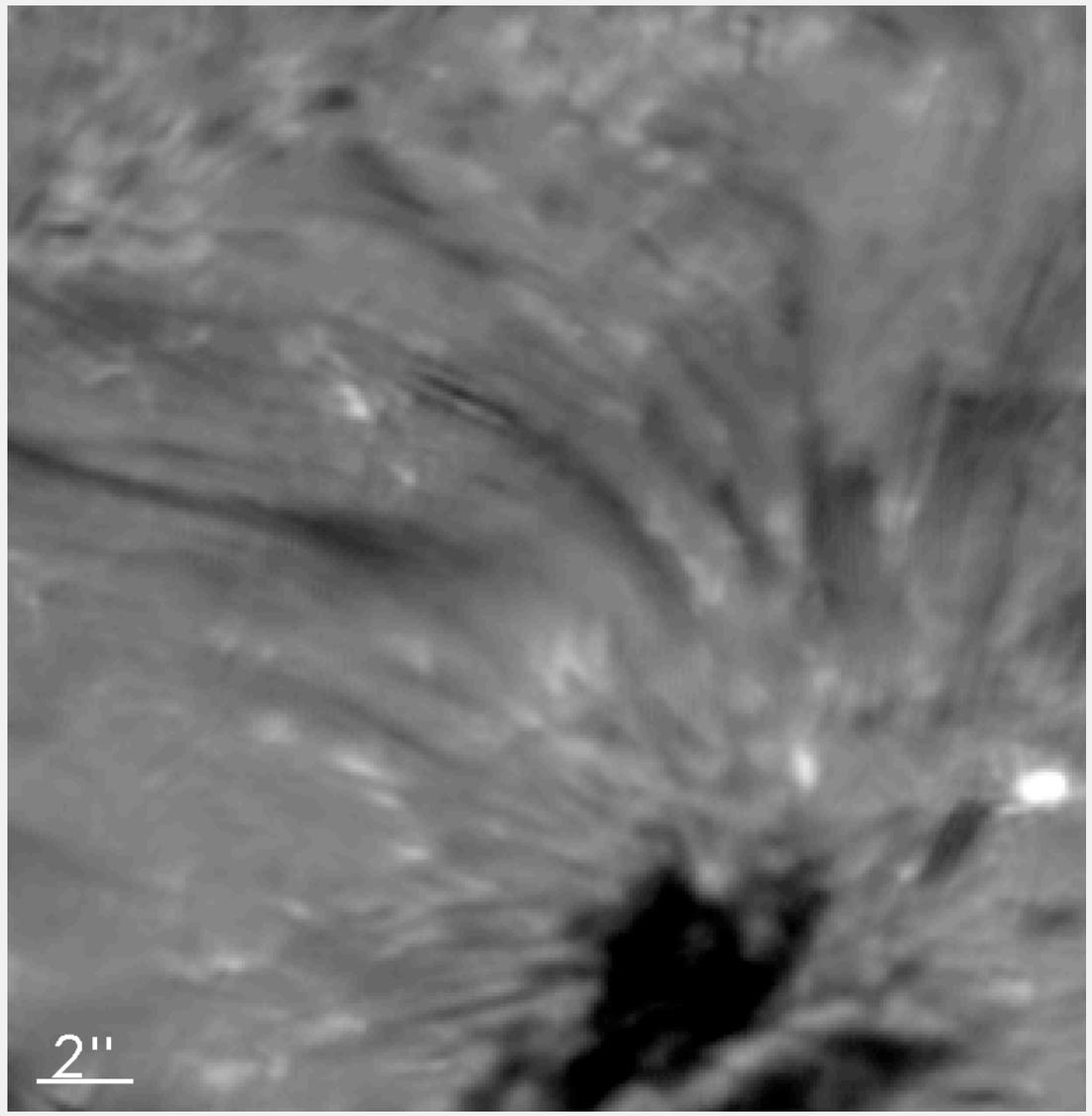
There is an abundance of dynamic fine structure

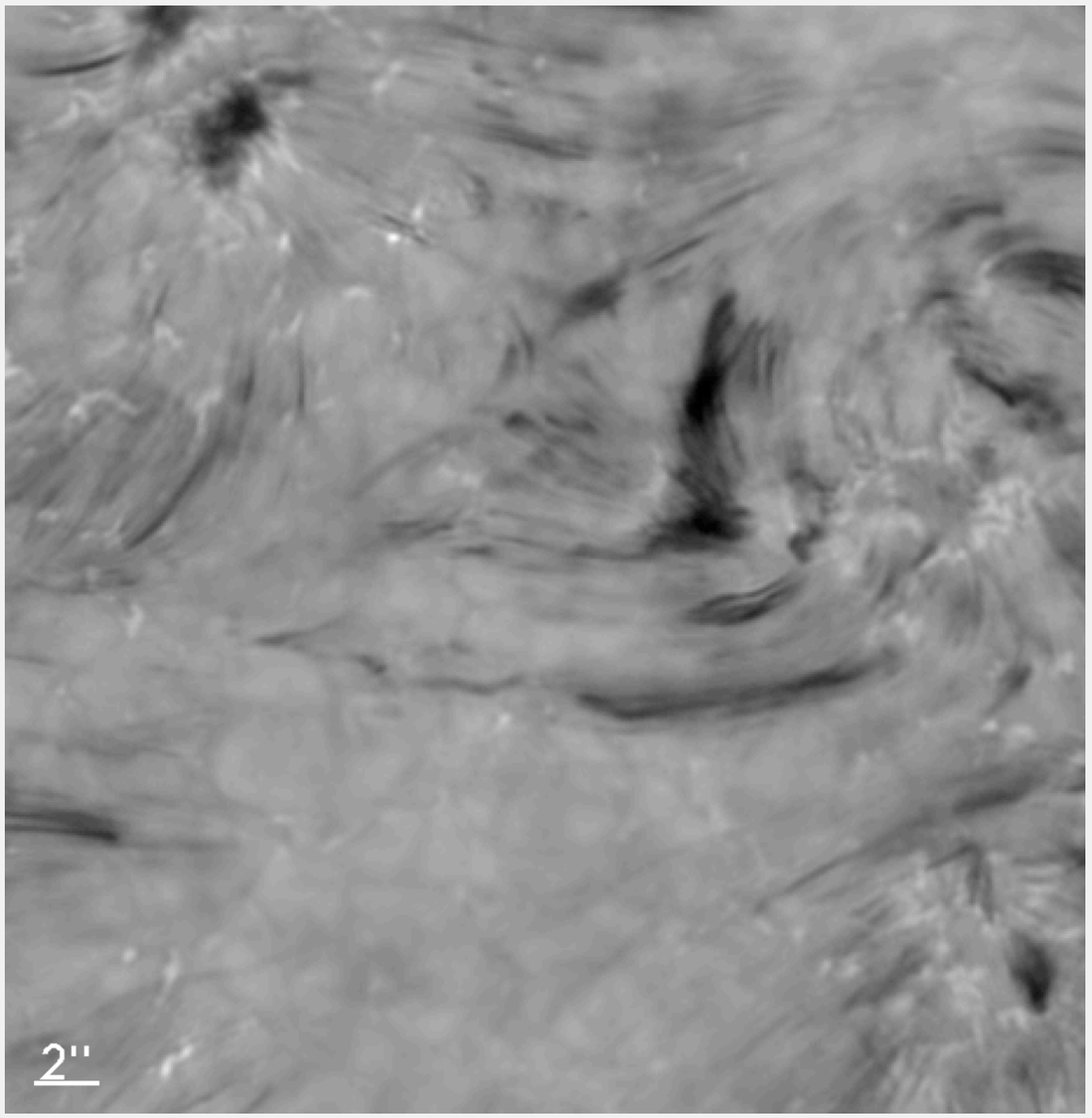


Movie courtesy: Patrick Antolin

We observe intermittent streams in the chromospheric canopy

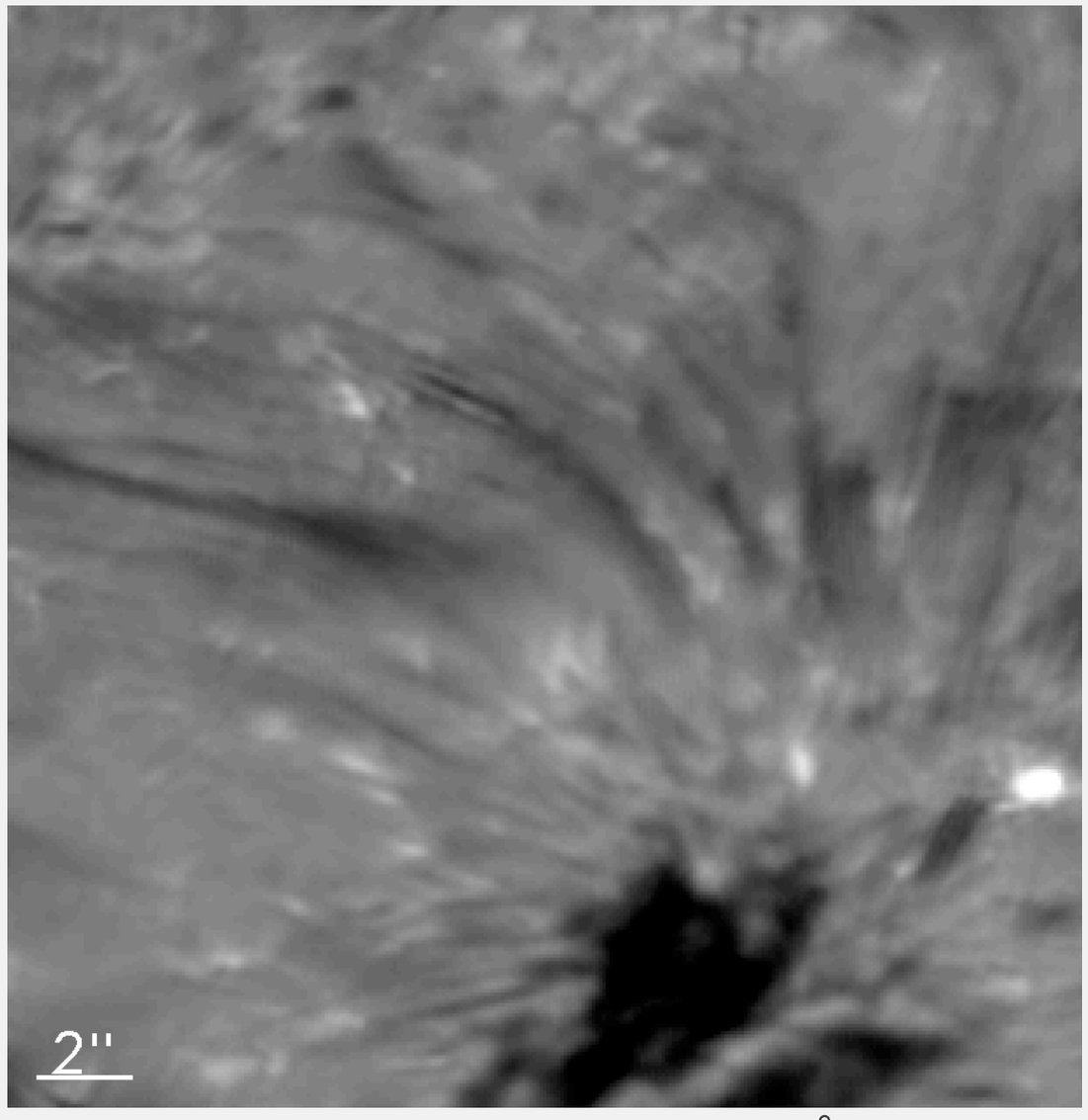


SST/CRISP, 11 June 2008, Hα – 0.7Å

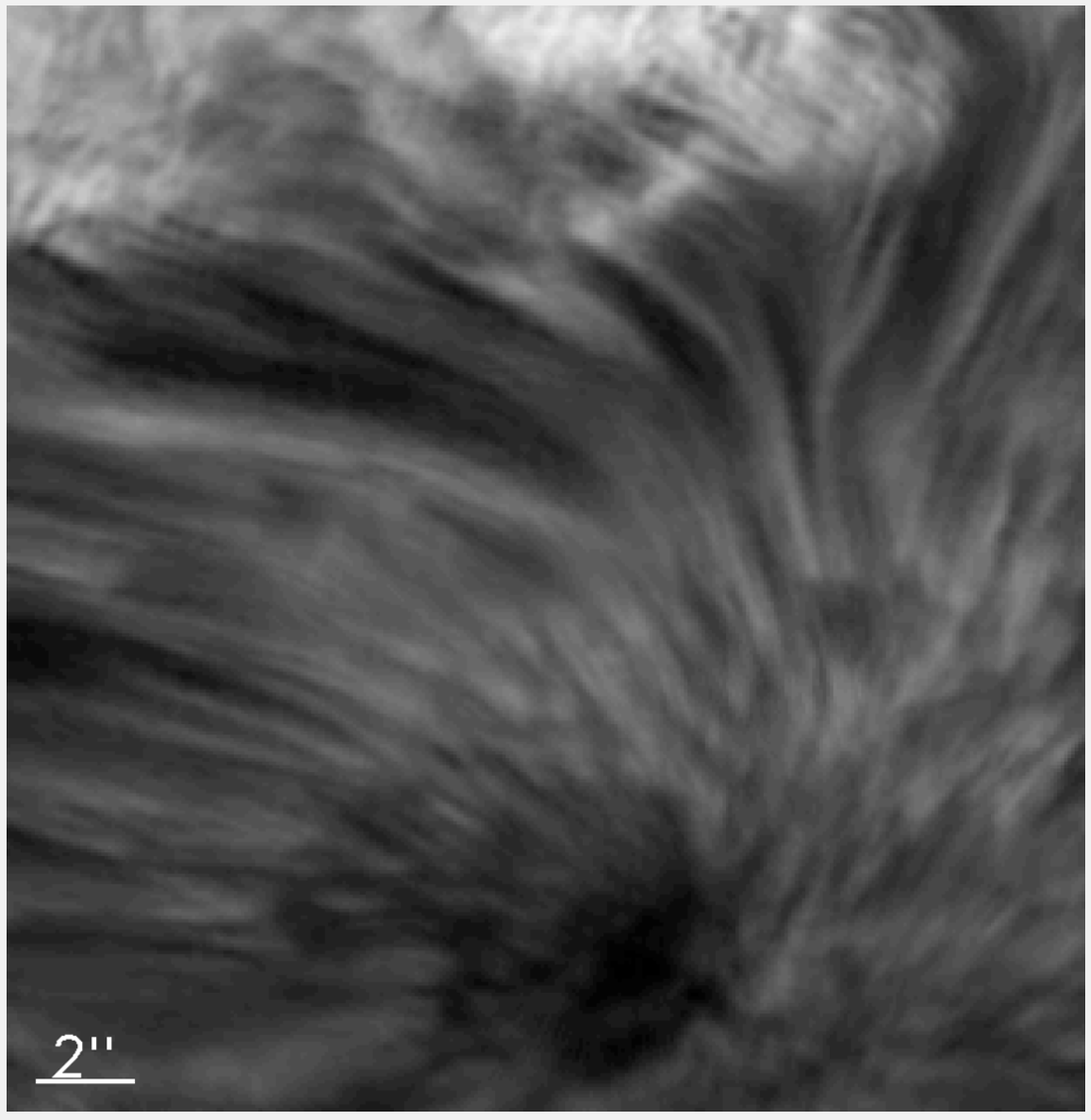


SST/CRISP, 13 June 2008, Hα + 0.6Å

The clumps appear to follow the canopy or superpenumbra

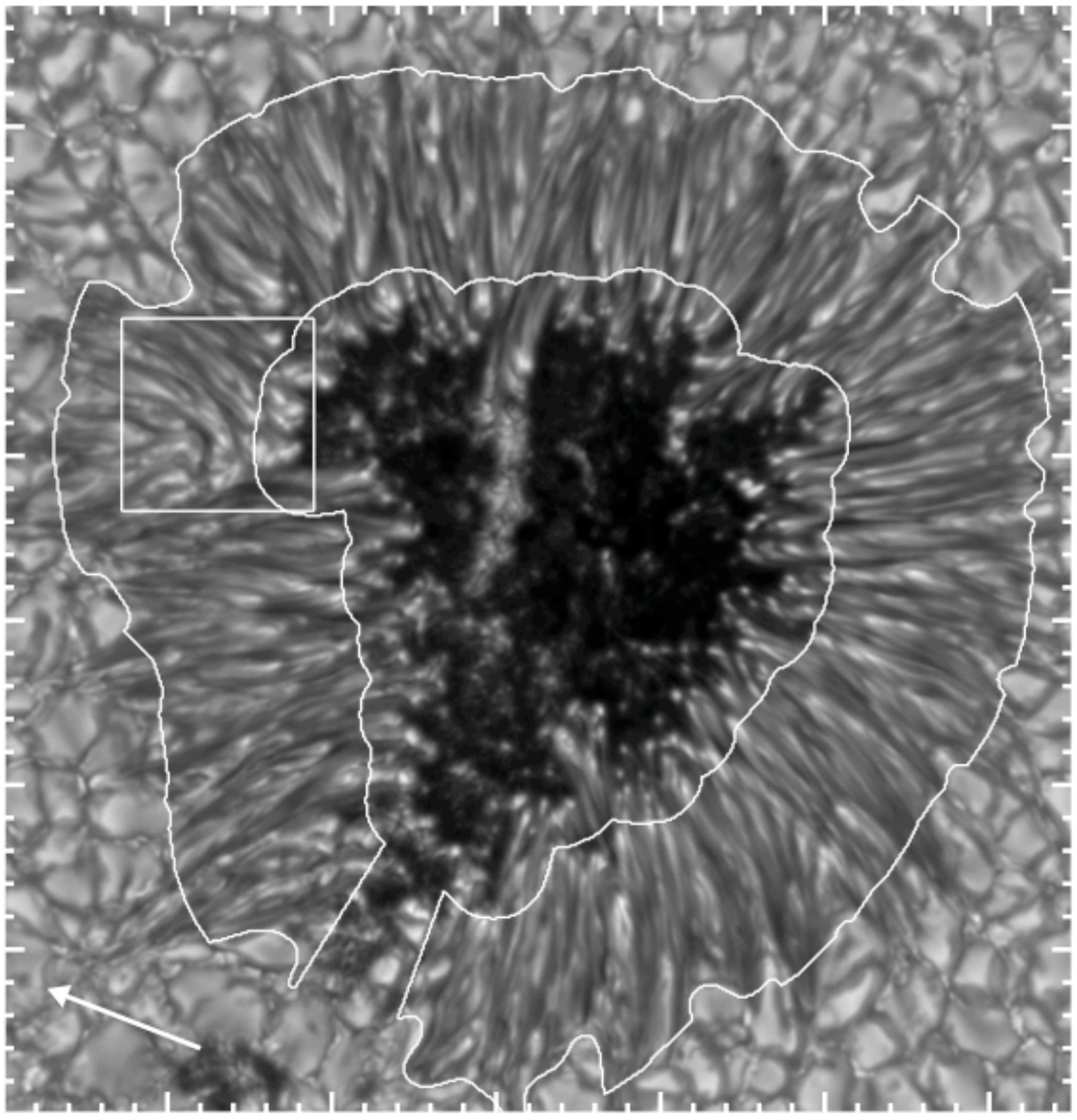


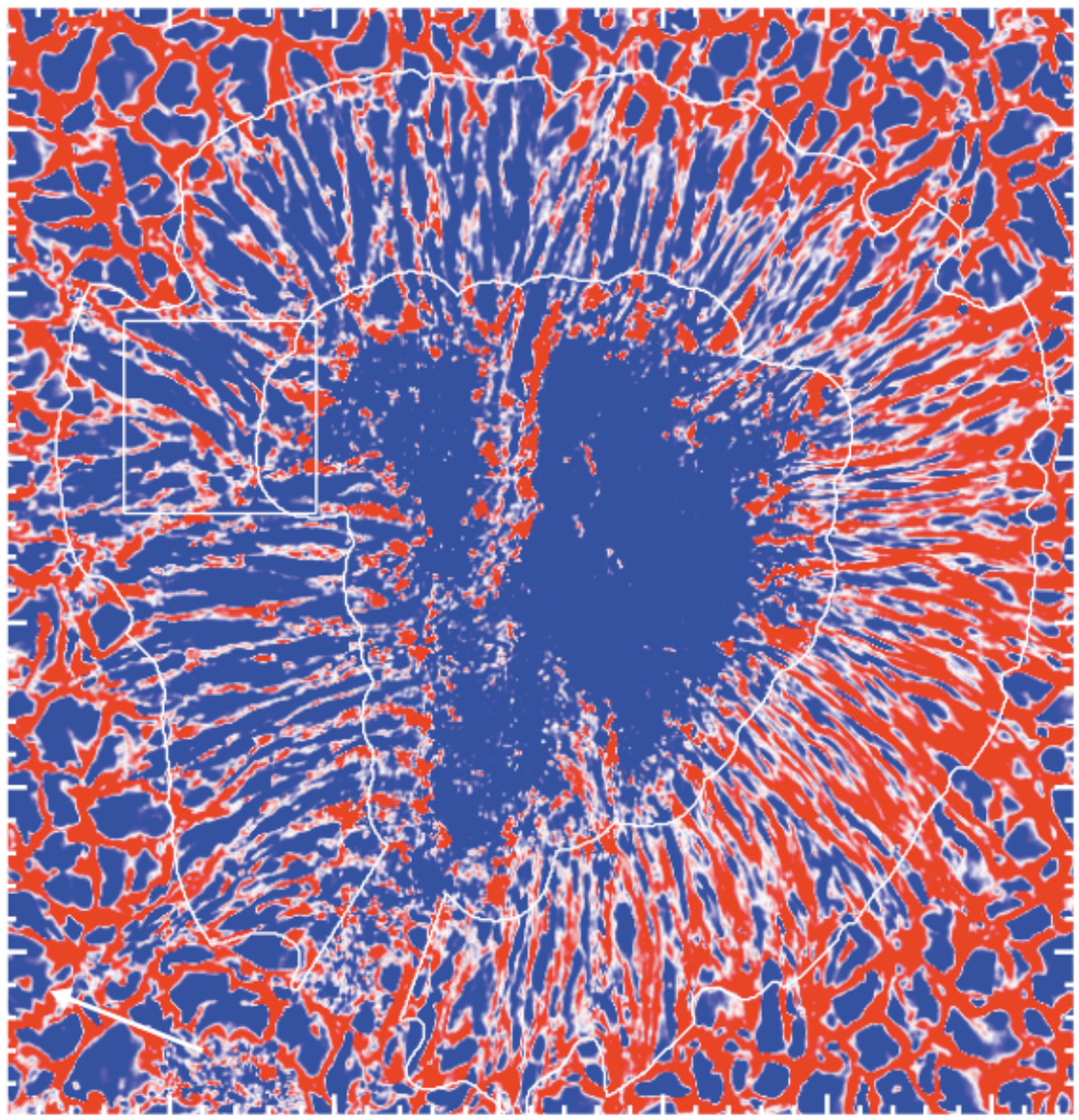
SST/CRISP, 11 June 2008, Hα – 0.7Å

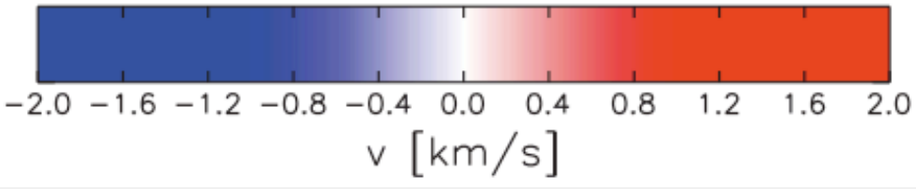


SST/CRISP, 11 June 2008, Hα core

The Evershed effect is an outflow in the photospheric penumbra

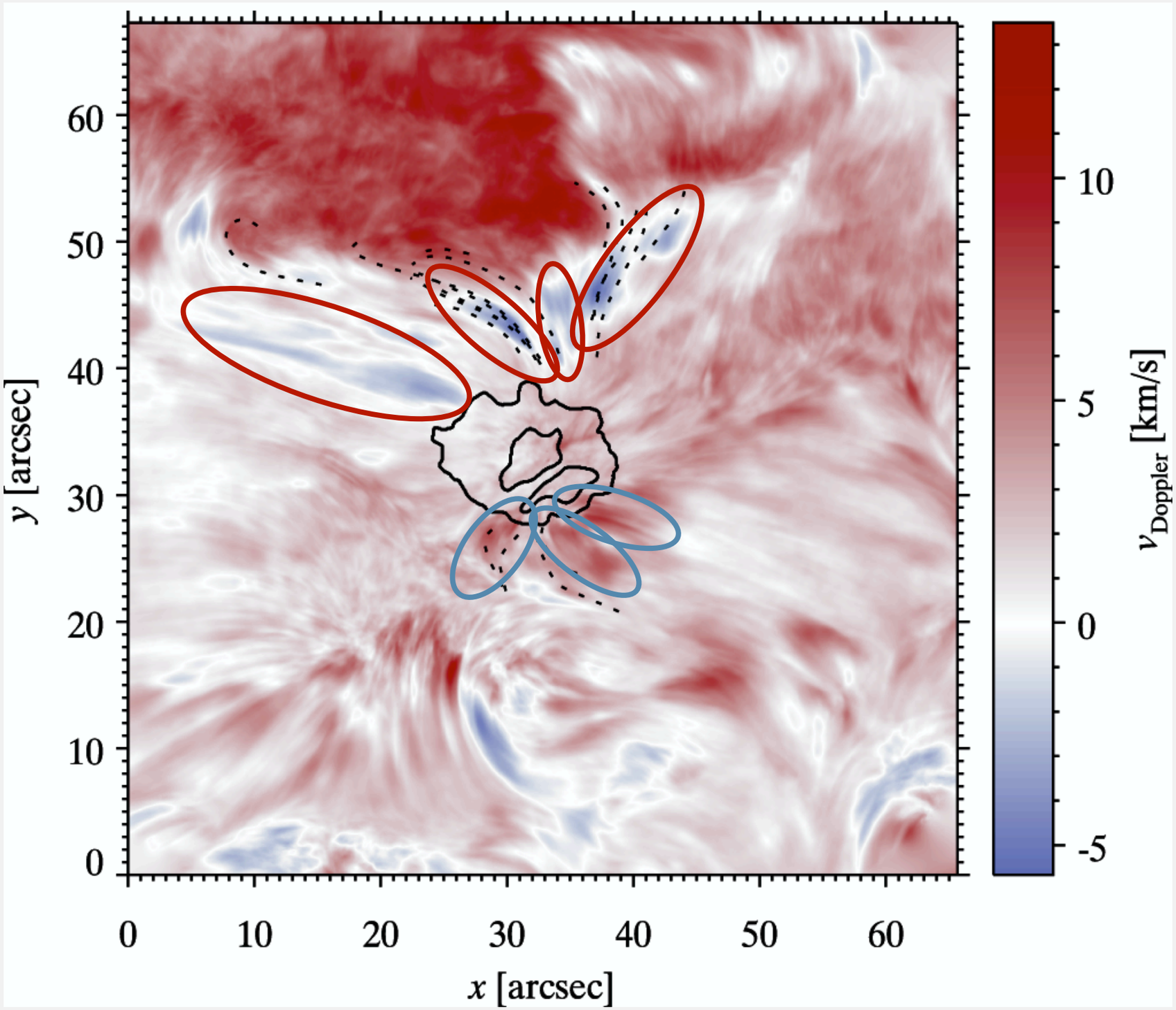




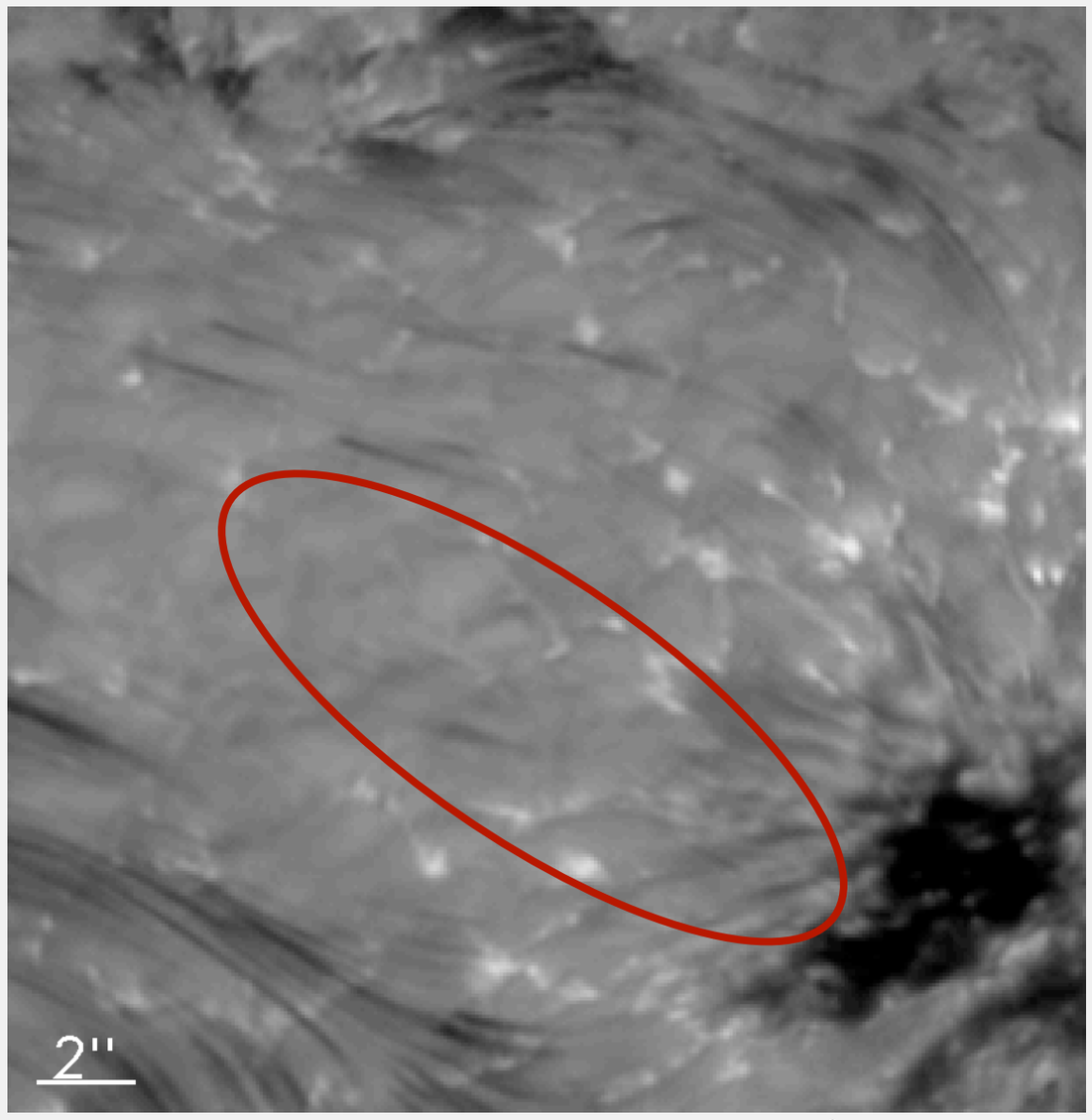


Scharmer et al. (2011)

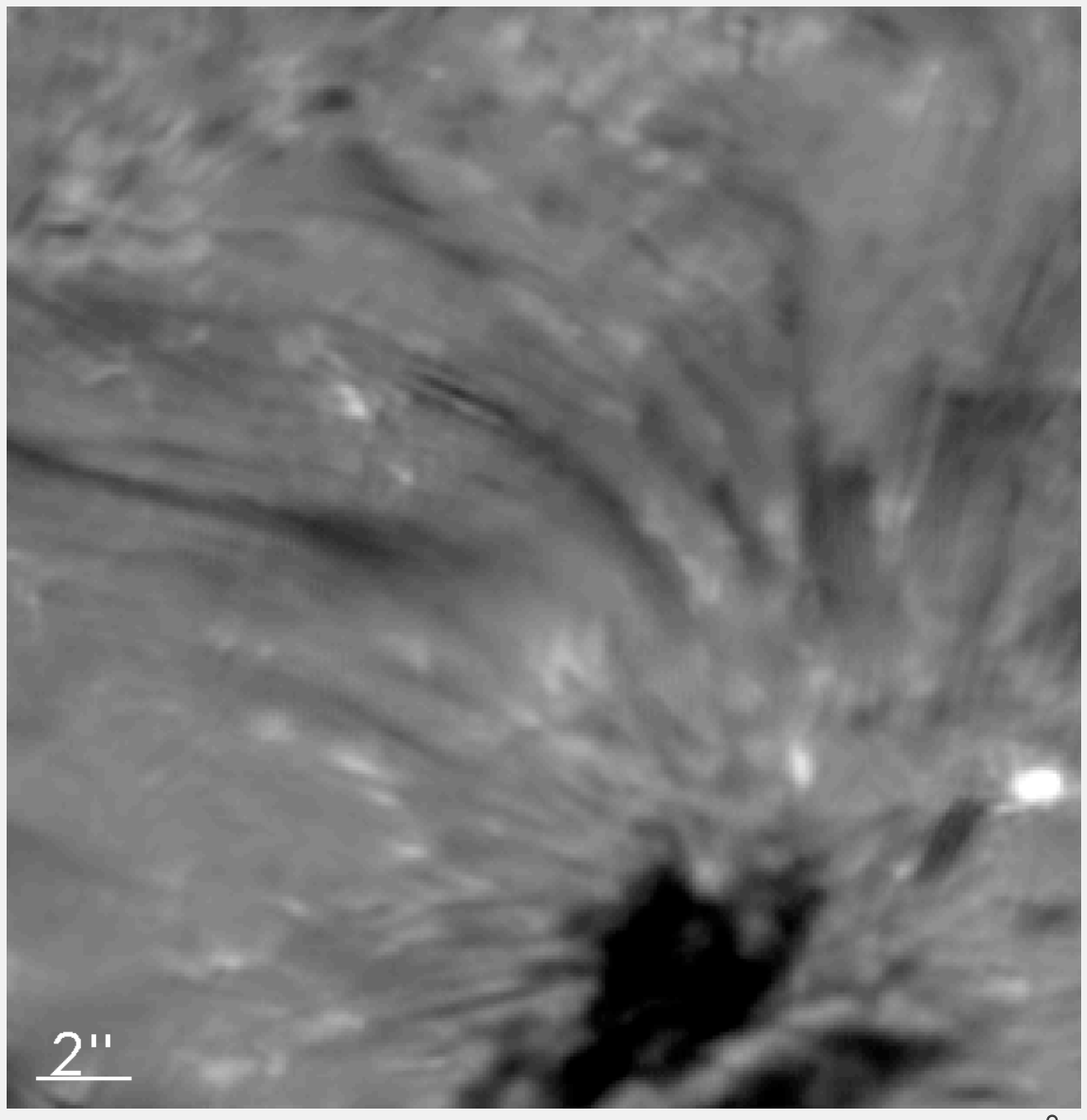
The paths traced by the blobs correspond well with concentrations of inverse Eversher flows



The morphological resemblance with coronal rain is striking



SST/CRISP, 11 June 2008, Hα + 0.7Å



SST/CRISP, 11 June 2008, Hα – 0.7Å

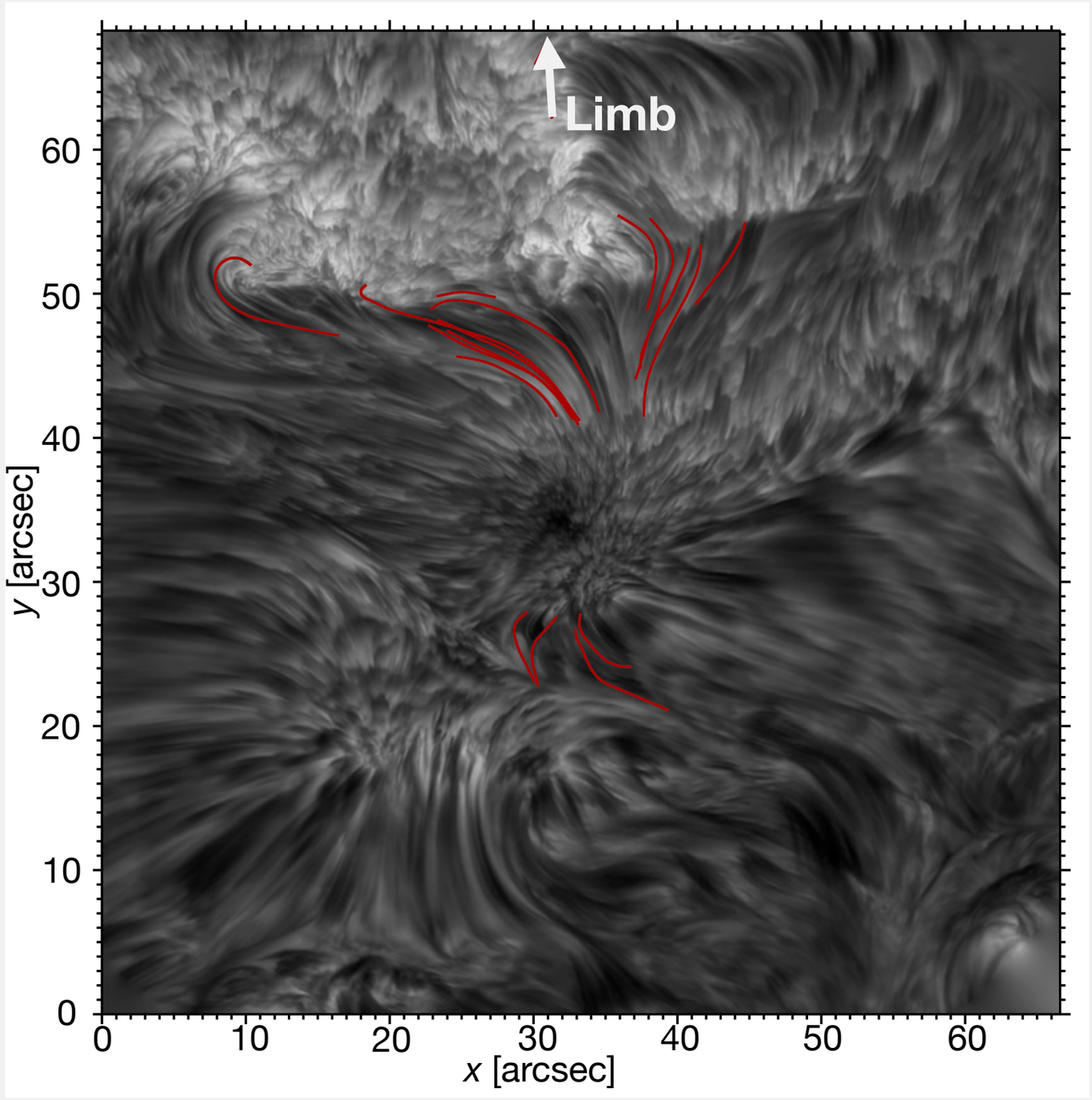
The morphological resemblance with coronal rain is striking

Similar morphology, similar driving mechanism?

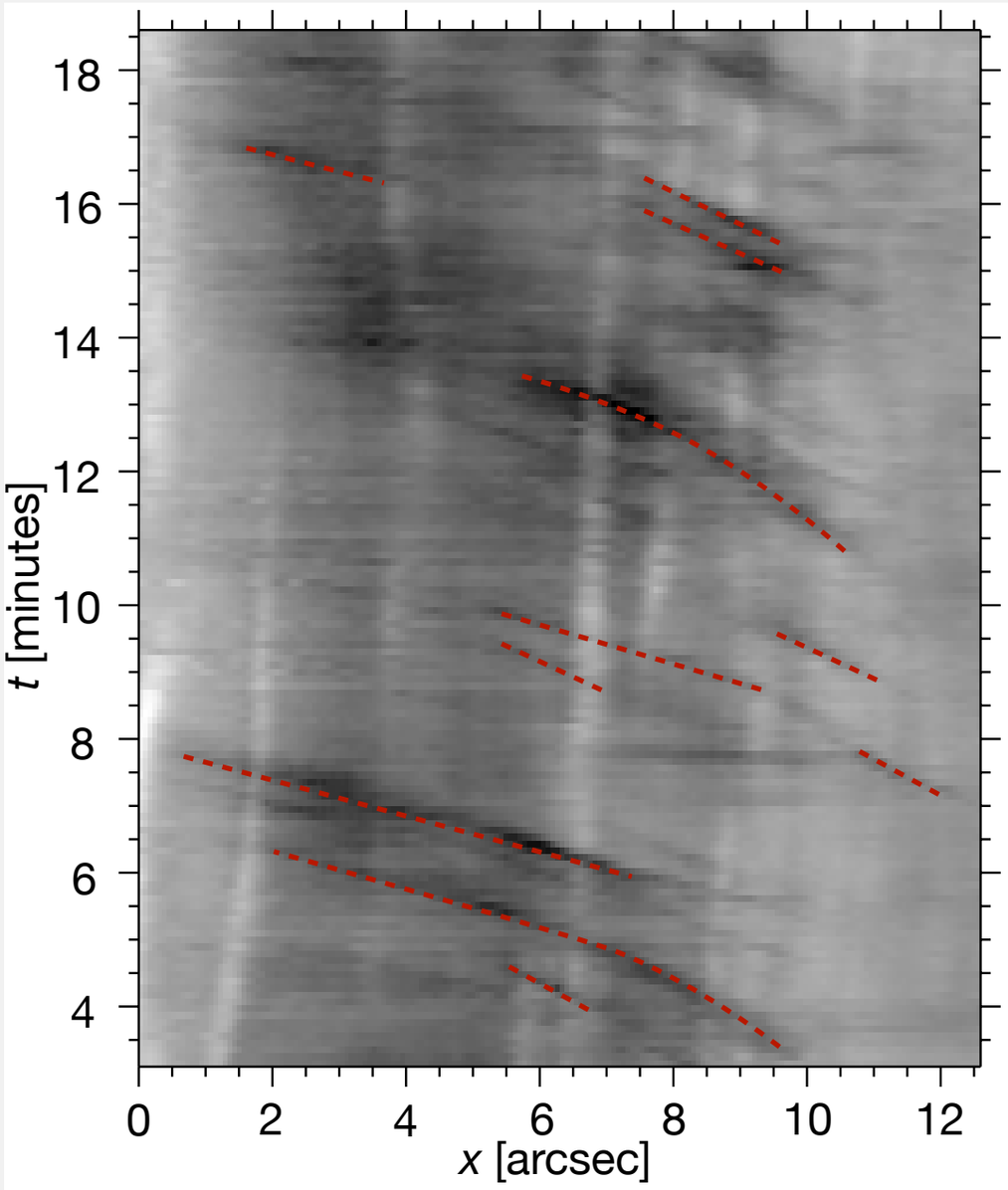
Can understanding of coronal rain help out (and vice versa)?

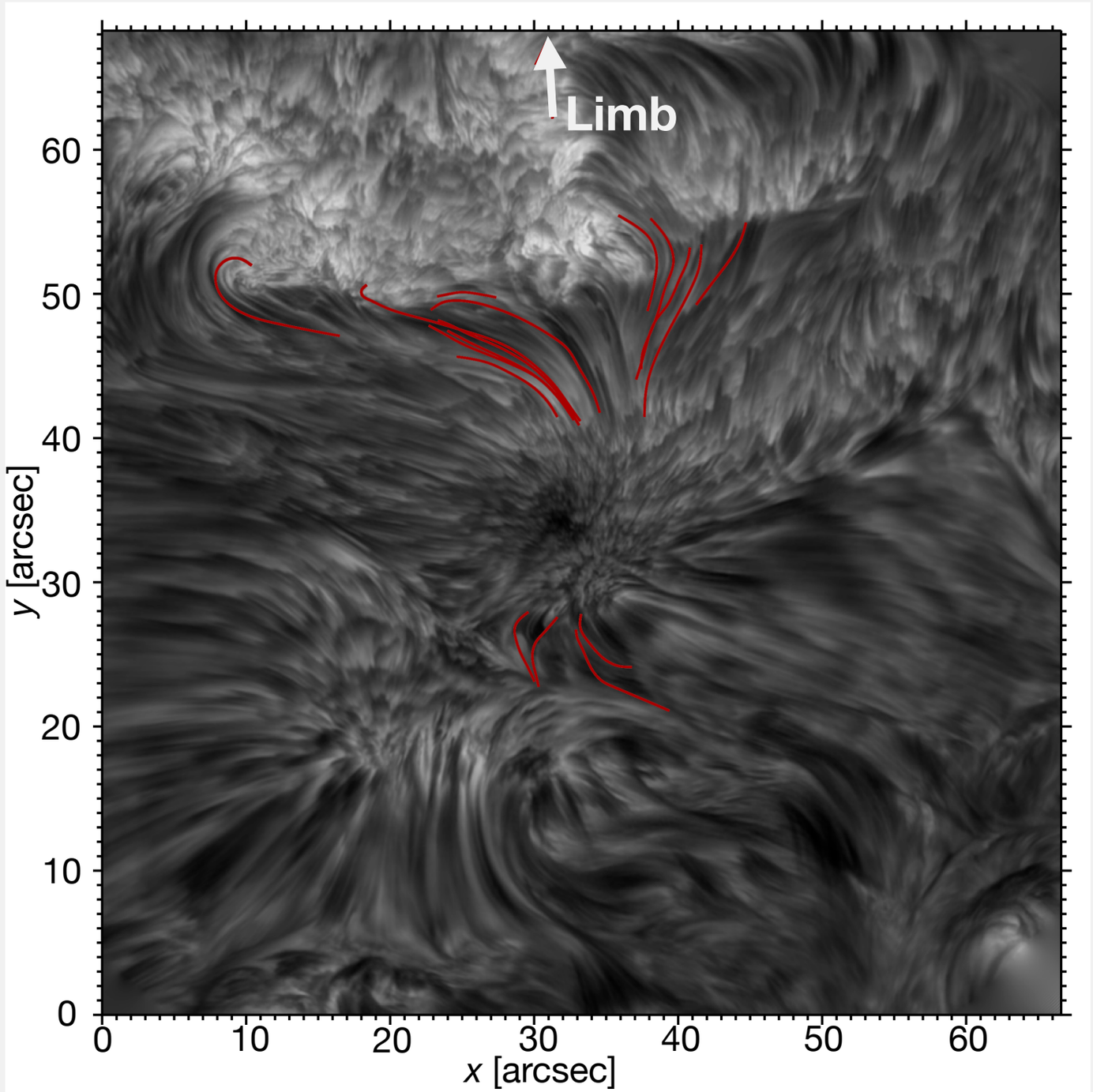
Is this in fact chromospheric rain?

Trace blobs in the Hα wing images and isolate them in the space-time diagrams

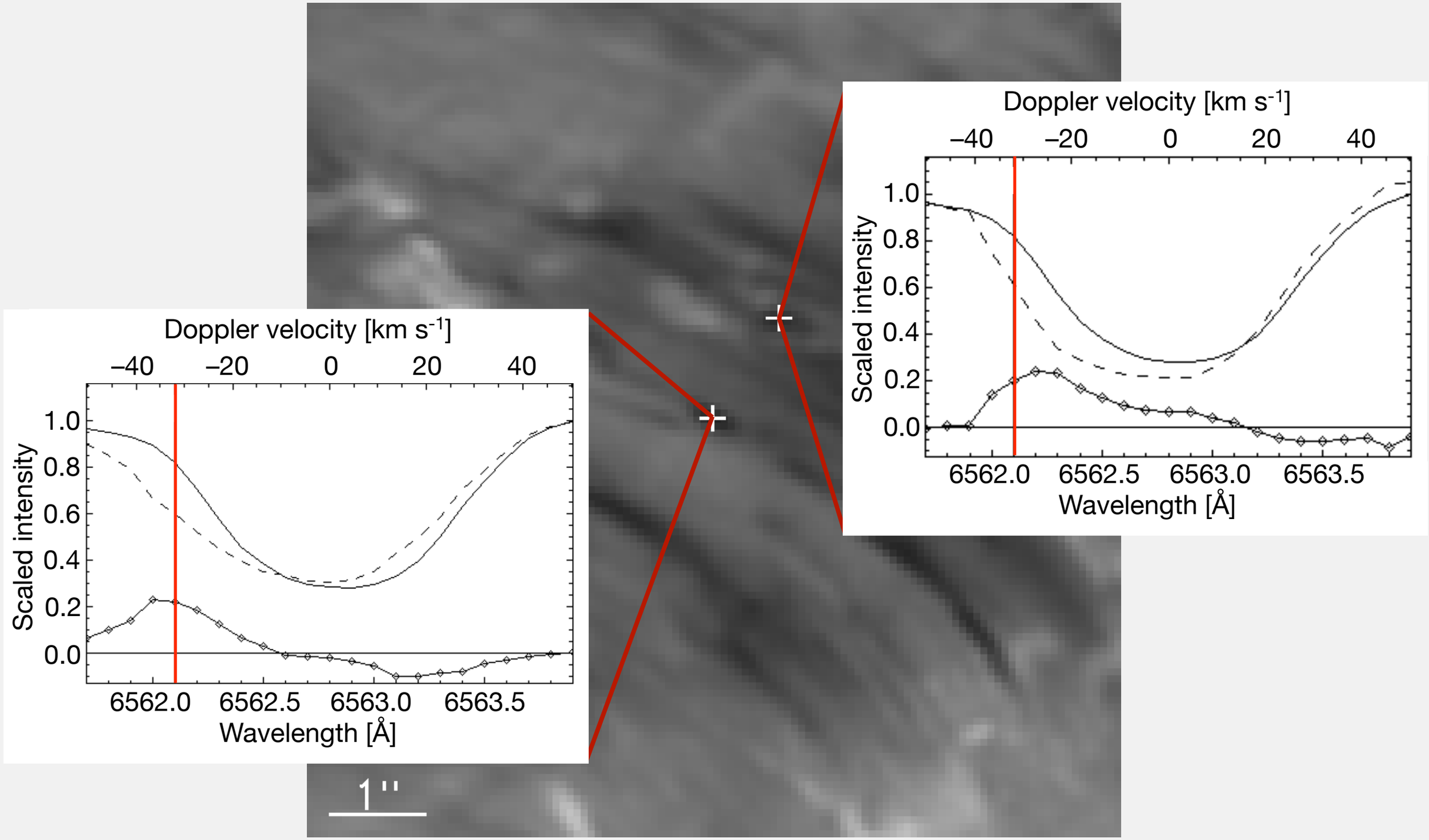


Trace blobs in the Hα wing images and isolate them in the space-time diagrams



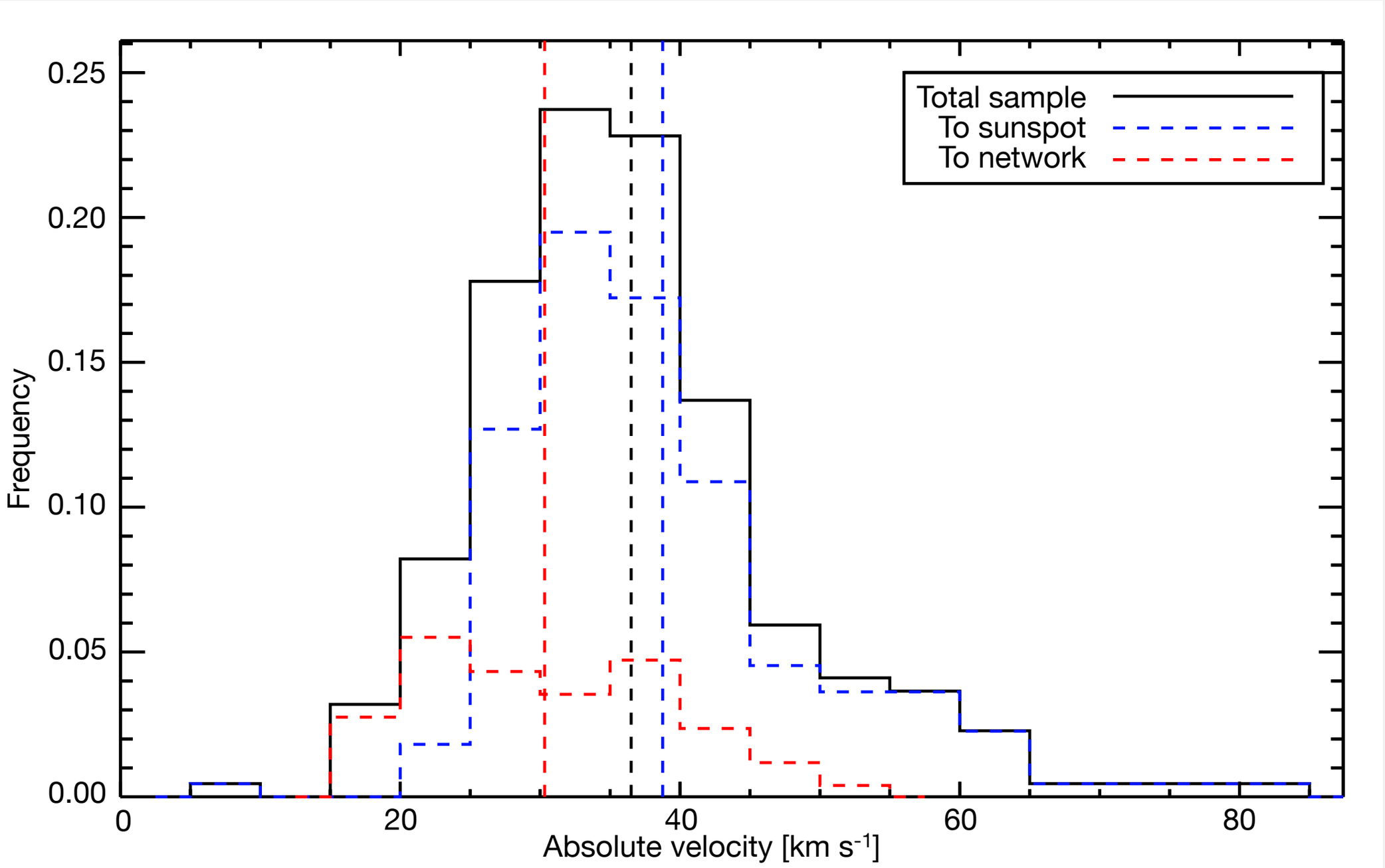


The blobs have a clearly separating Doppler signature

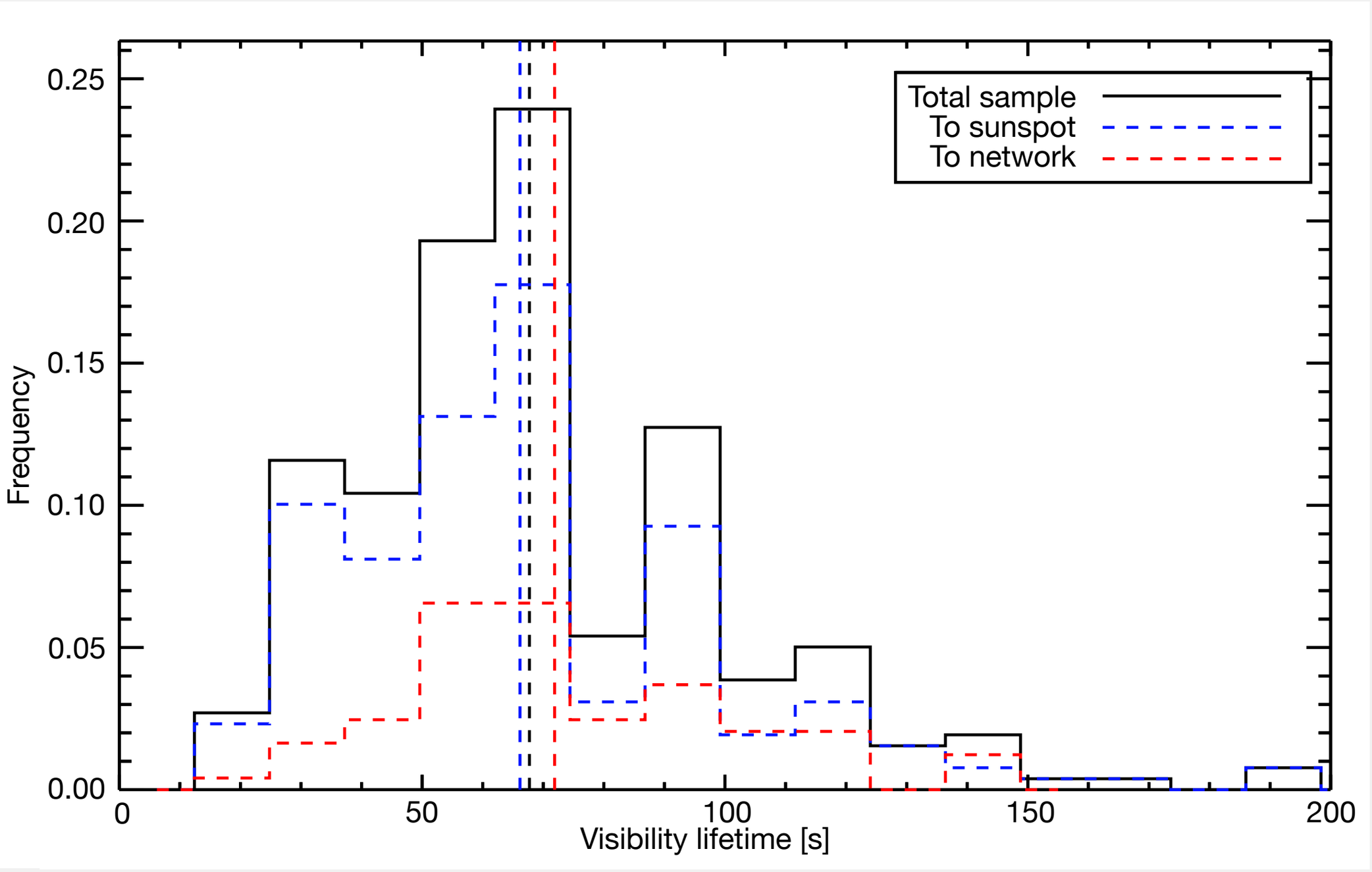


SST/CRISP, 11 June 2008, Hα – 0.7Å

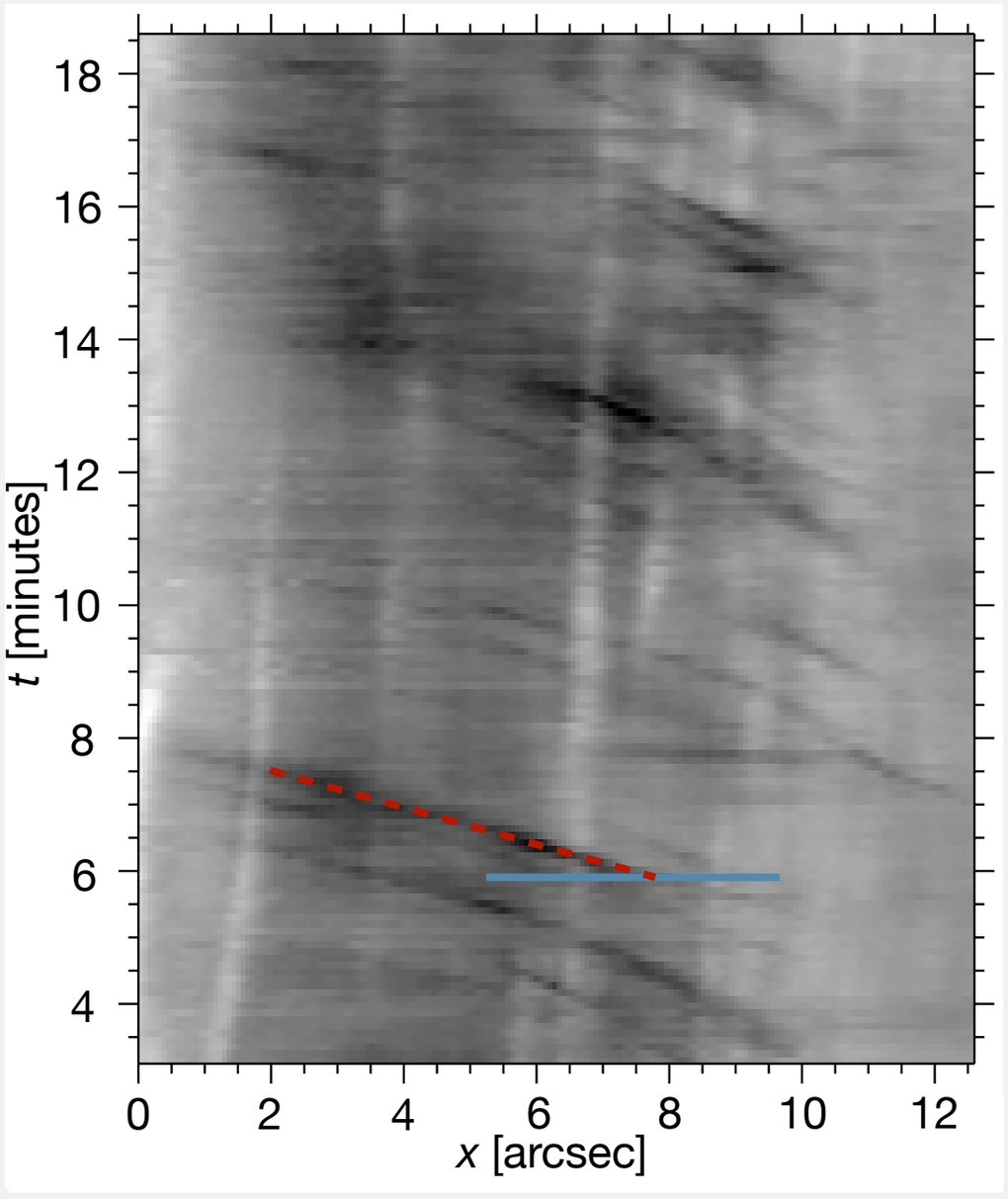
There is a velocity difference between blobs moving towards and away the sunspot

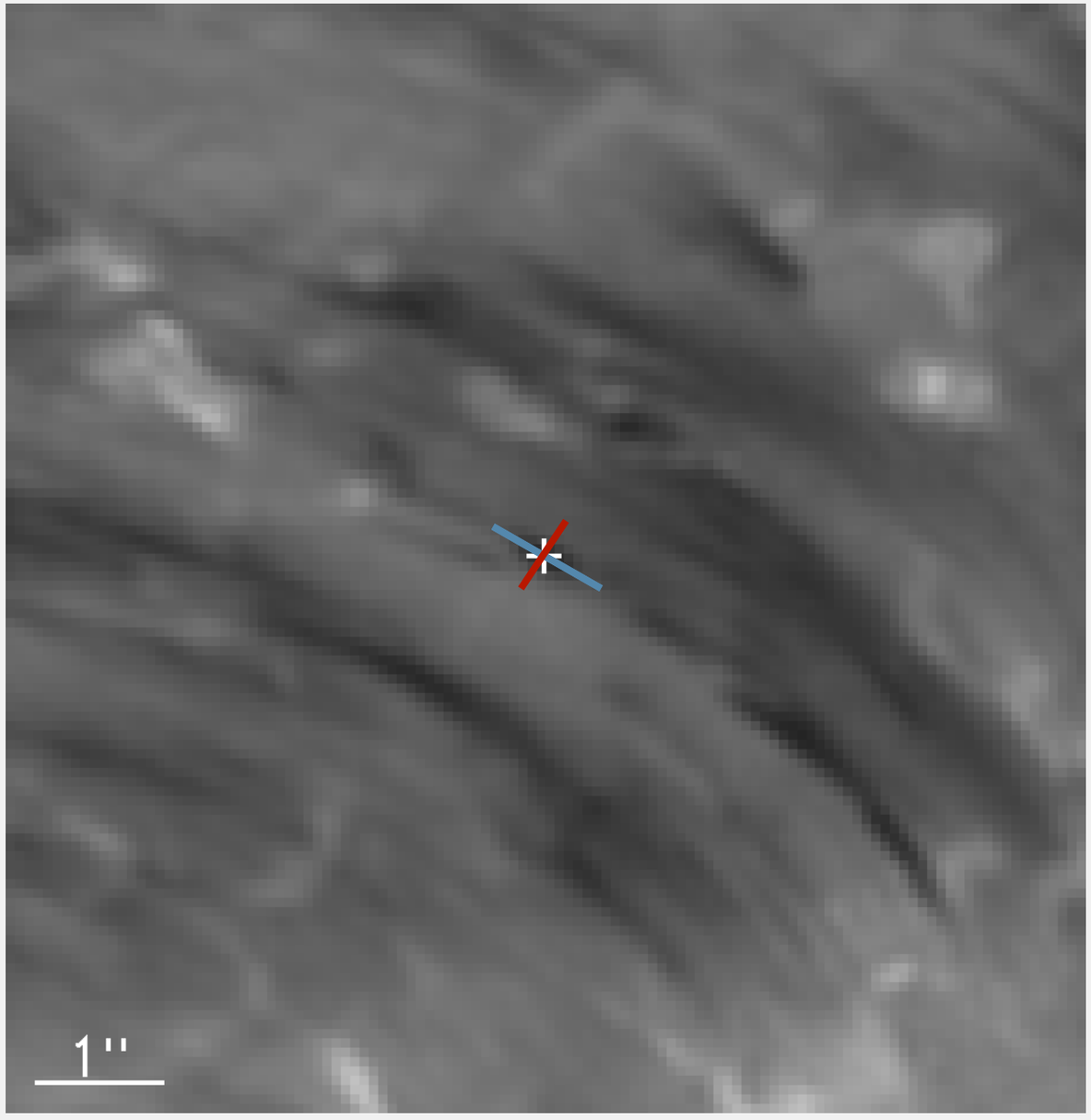


The visibility lifetime averages out around 70s

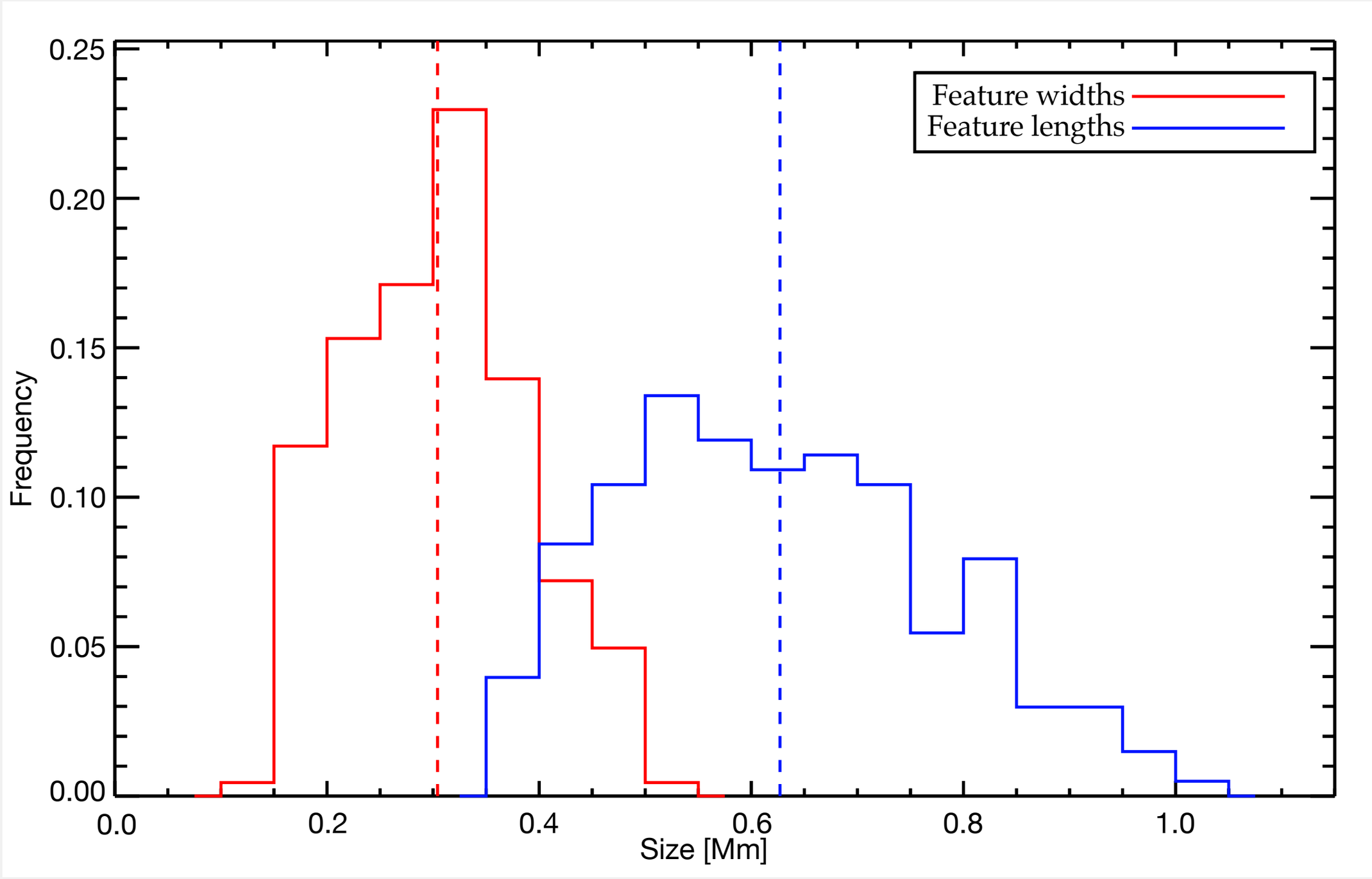


Sizes were determined from the space-time diagrams and perpendicular to the path

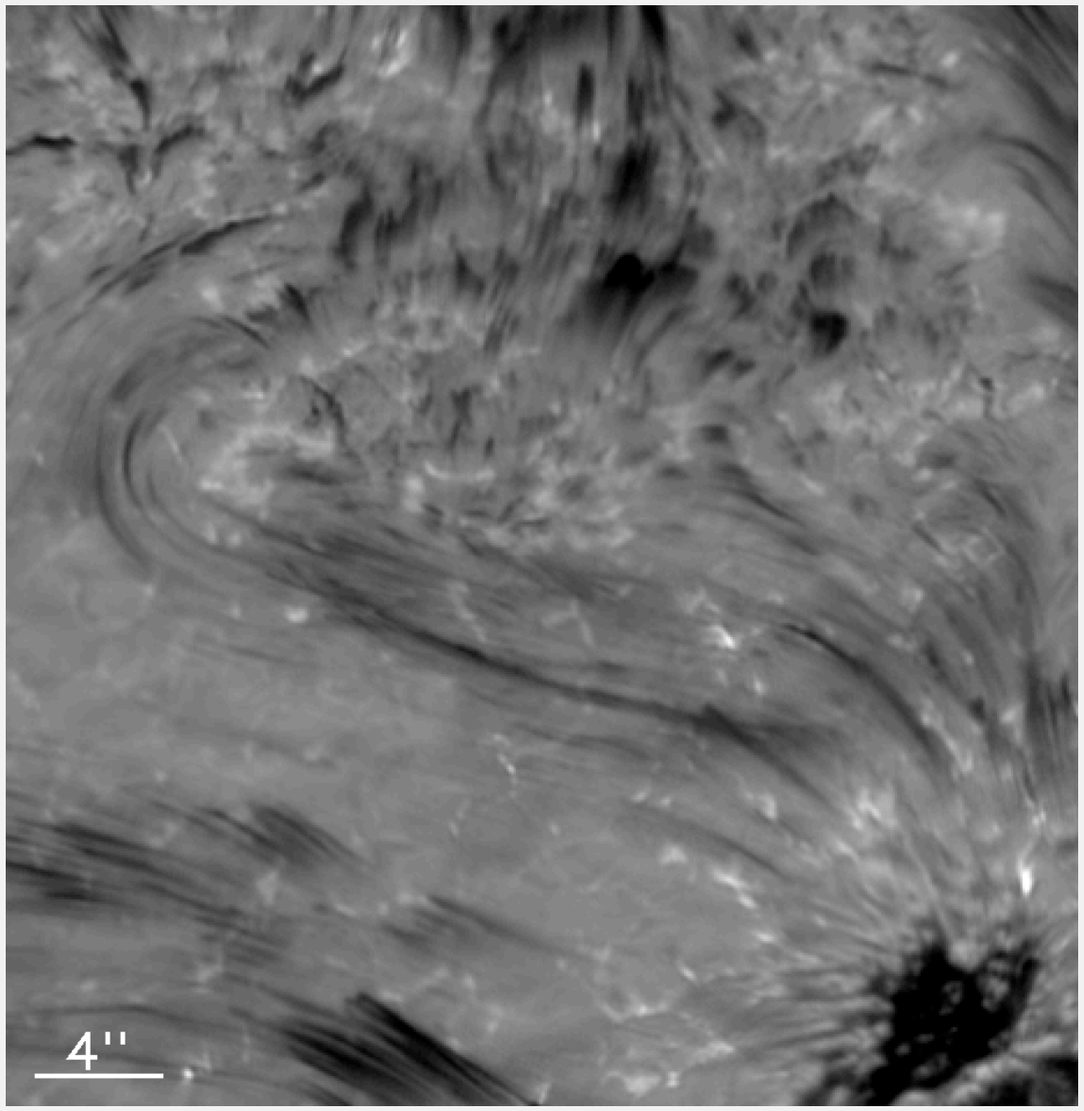




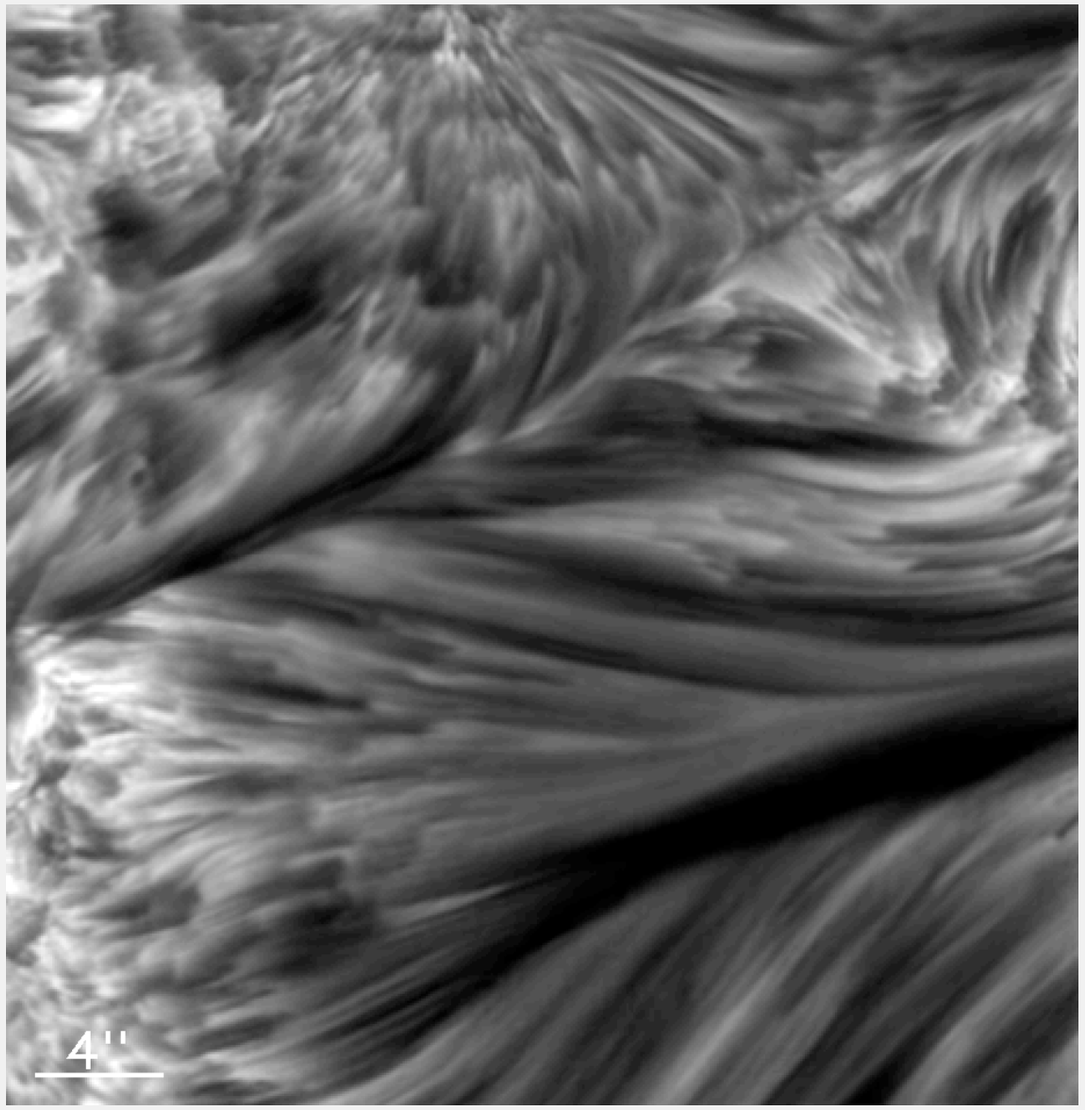
On average the blobs are twice as long as they are wide



Flocculent flows represent high-speed flows, with lifetimes on the

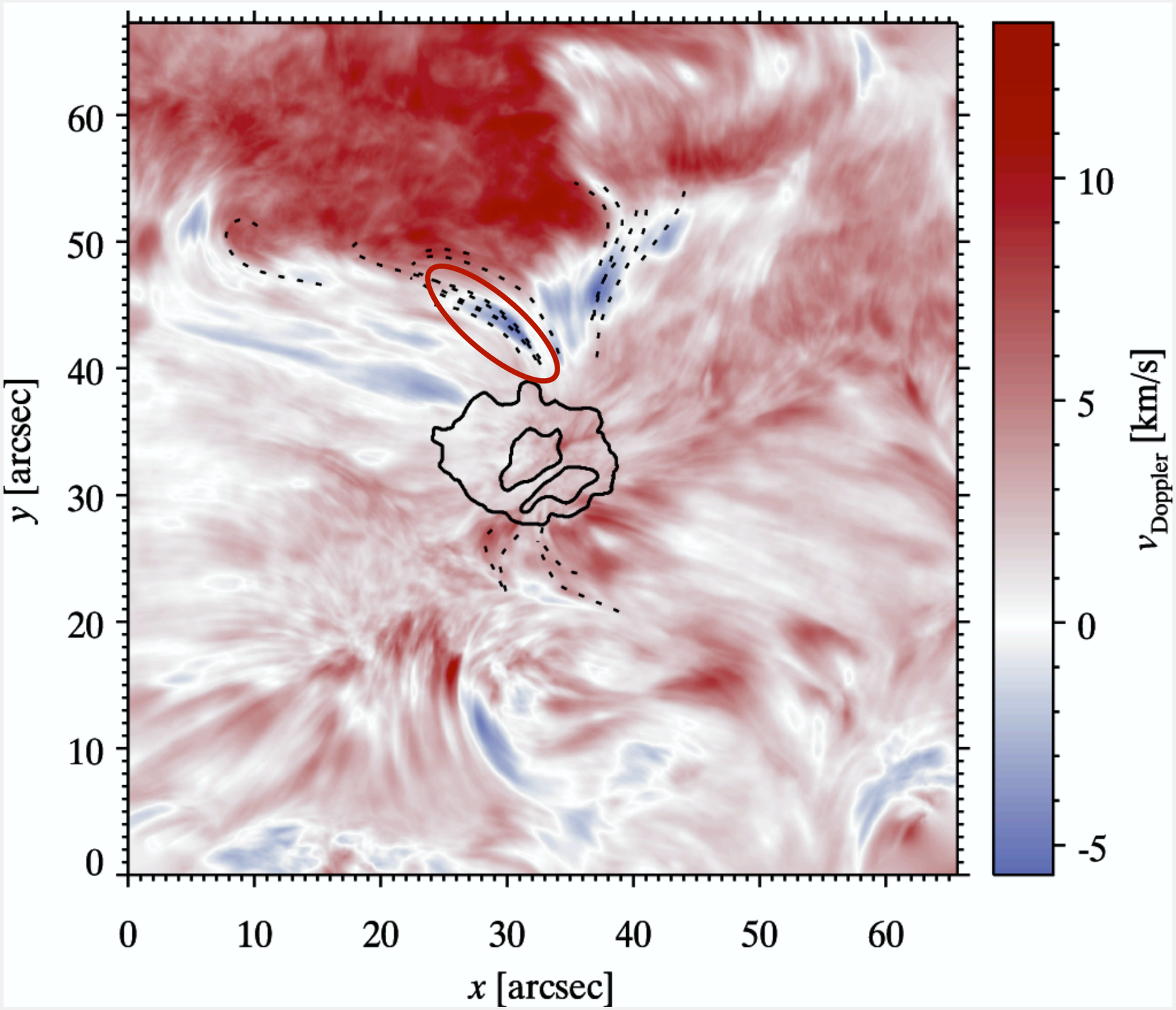


SST/CRISP, 11 June 2008, Hα – 0.7Å



SST/CRISP, 13 June 2008, Hα core and + 0.6Å

The inverse Evershed effect appears located in quasi-static patches in the superpenumbra



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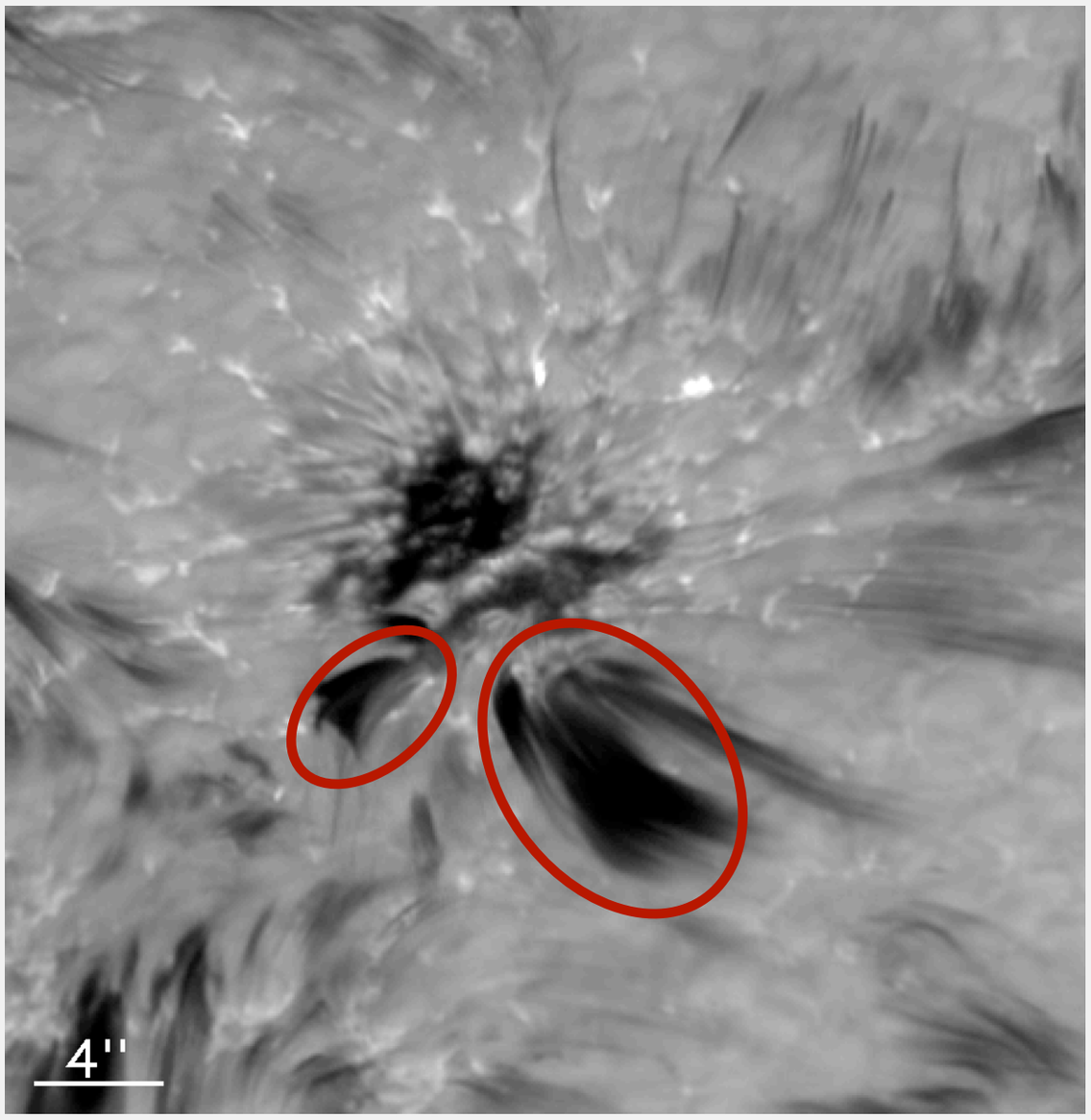
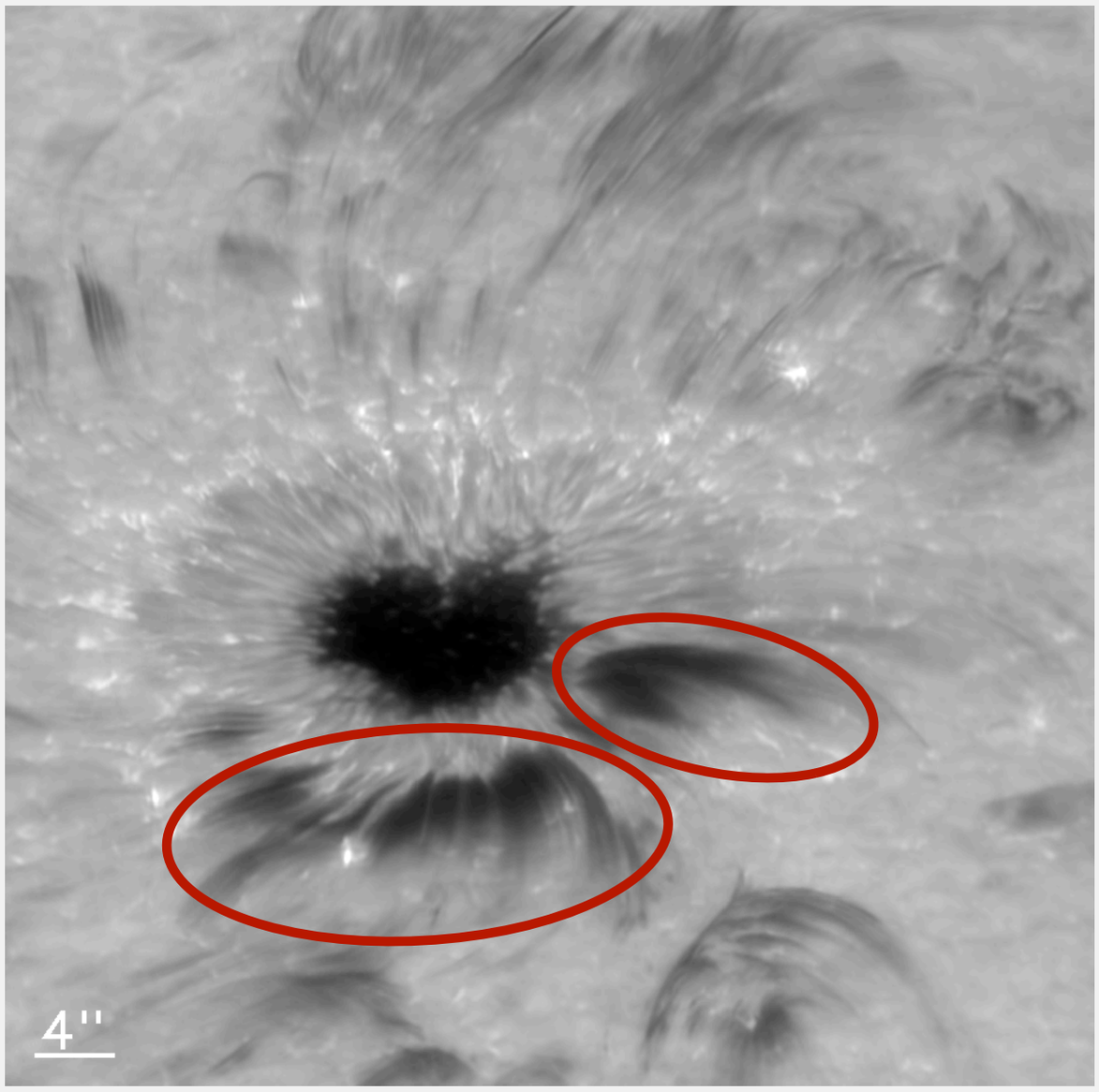
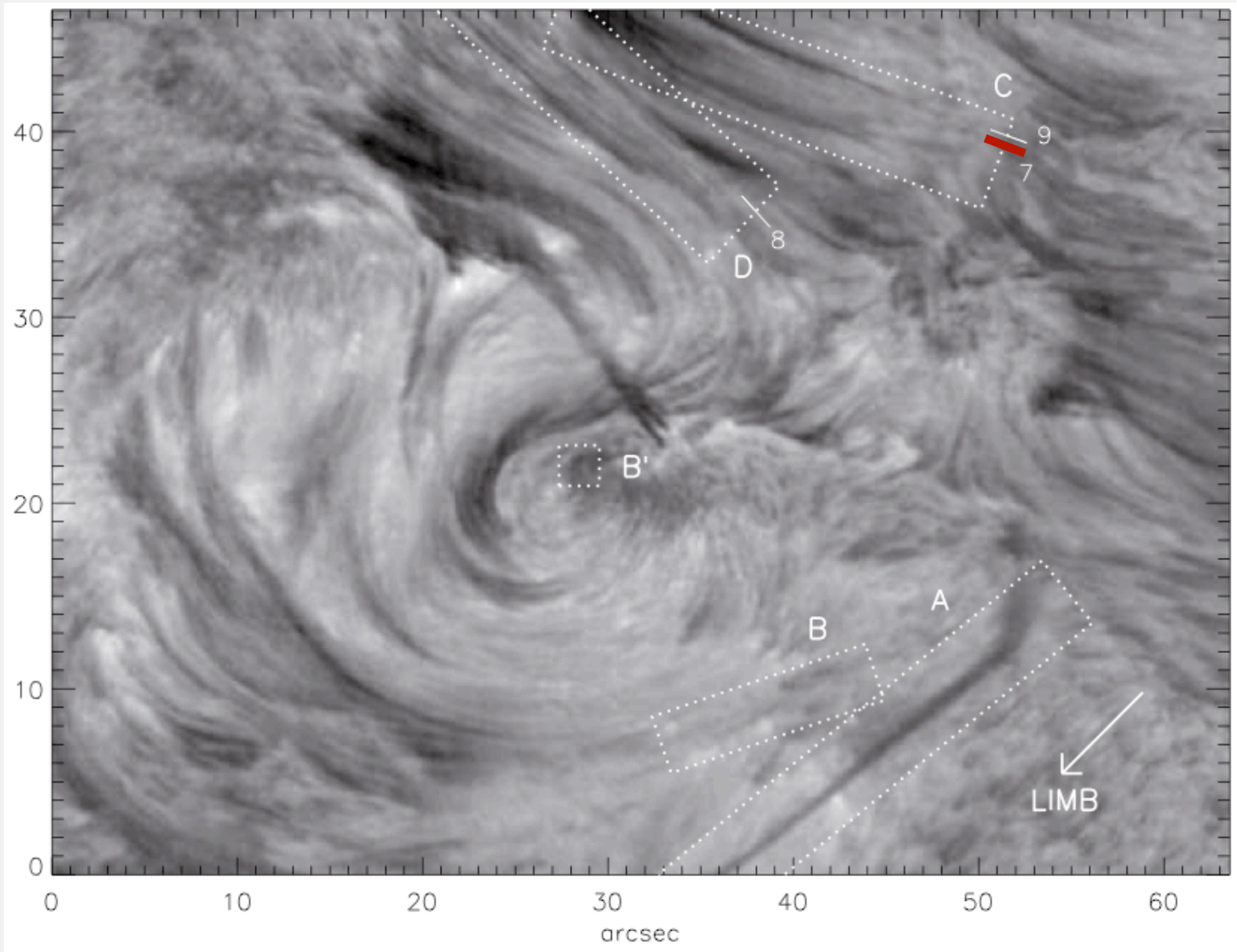


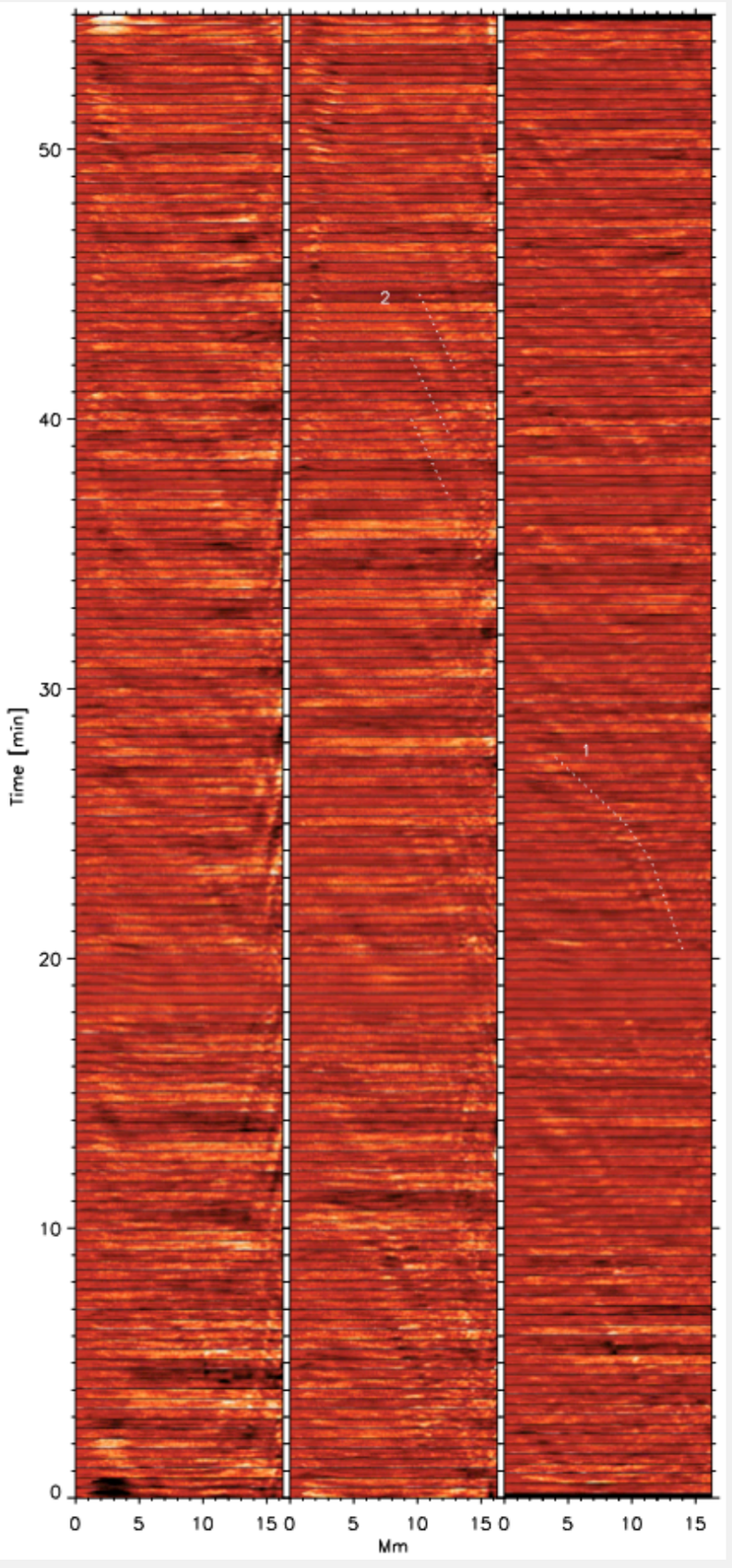
SST/CRISP, 11 June 2008, Hα + 0.7Å, Δt = 6.2 s



SST/CRISP, 28 June 2010, Hα + 0.7Å, Δt = 22 s

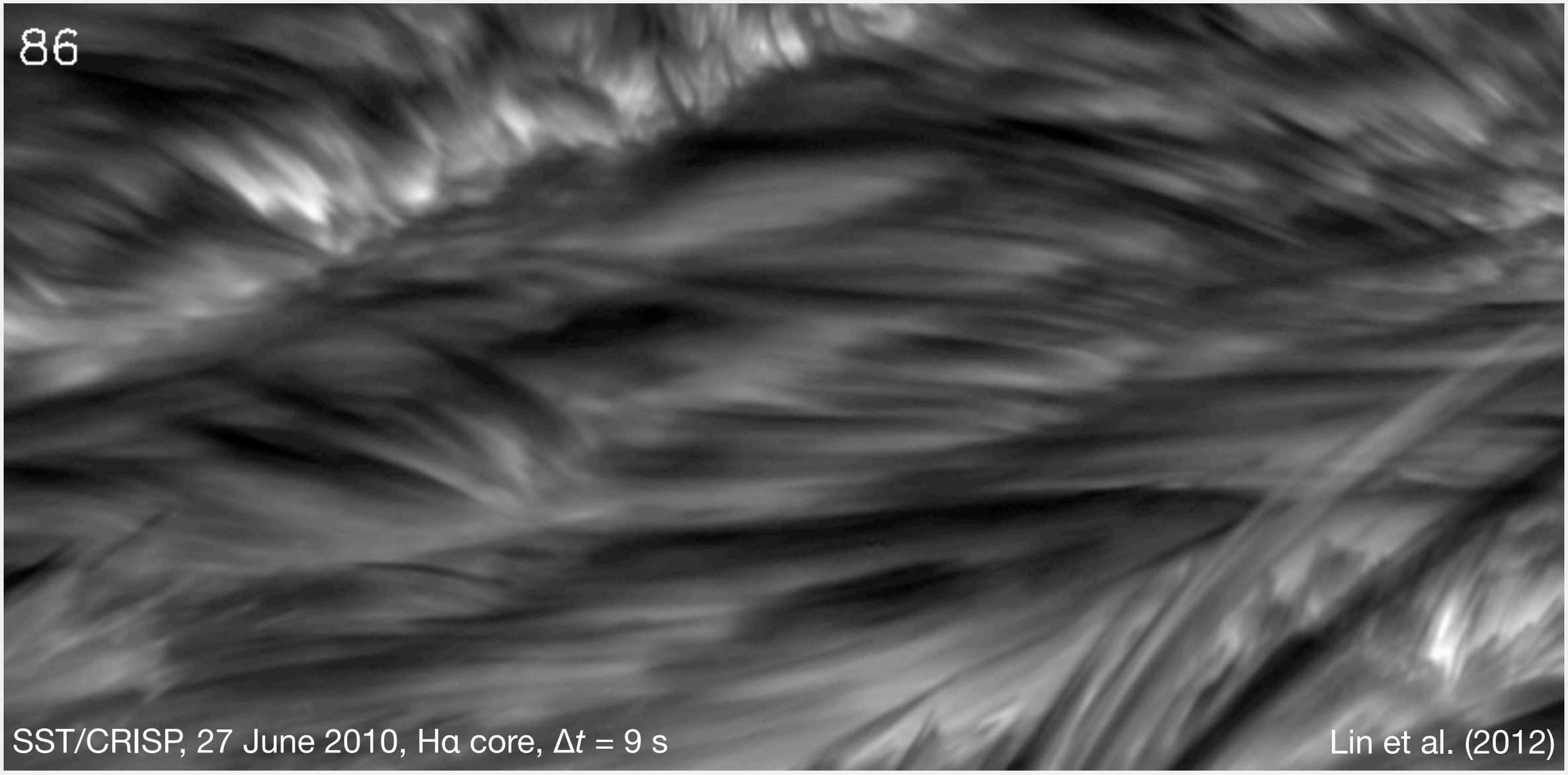
Similar blob-like features have been attributed to magnetoacoustic waves



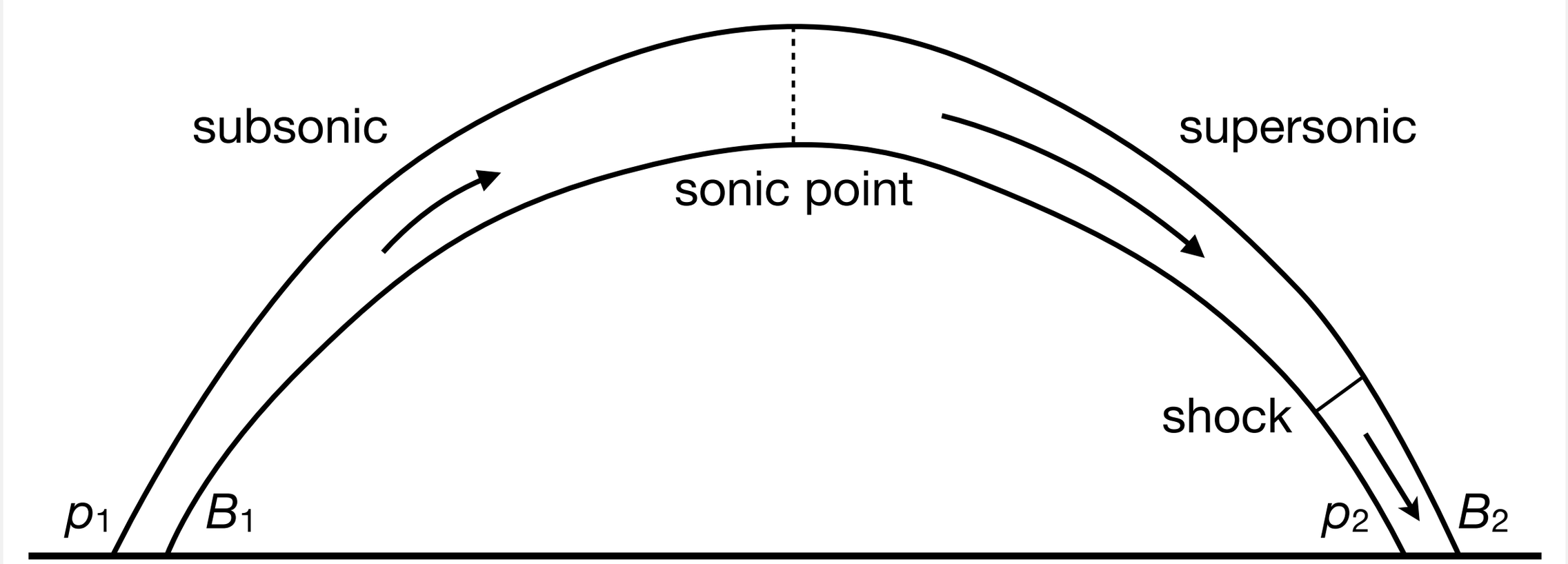


Sánchez-Andrade Nuño et al. (2008)

“Dynamic bright blobs” share several properties with the observed flocculent flows

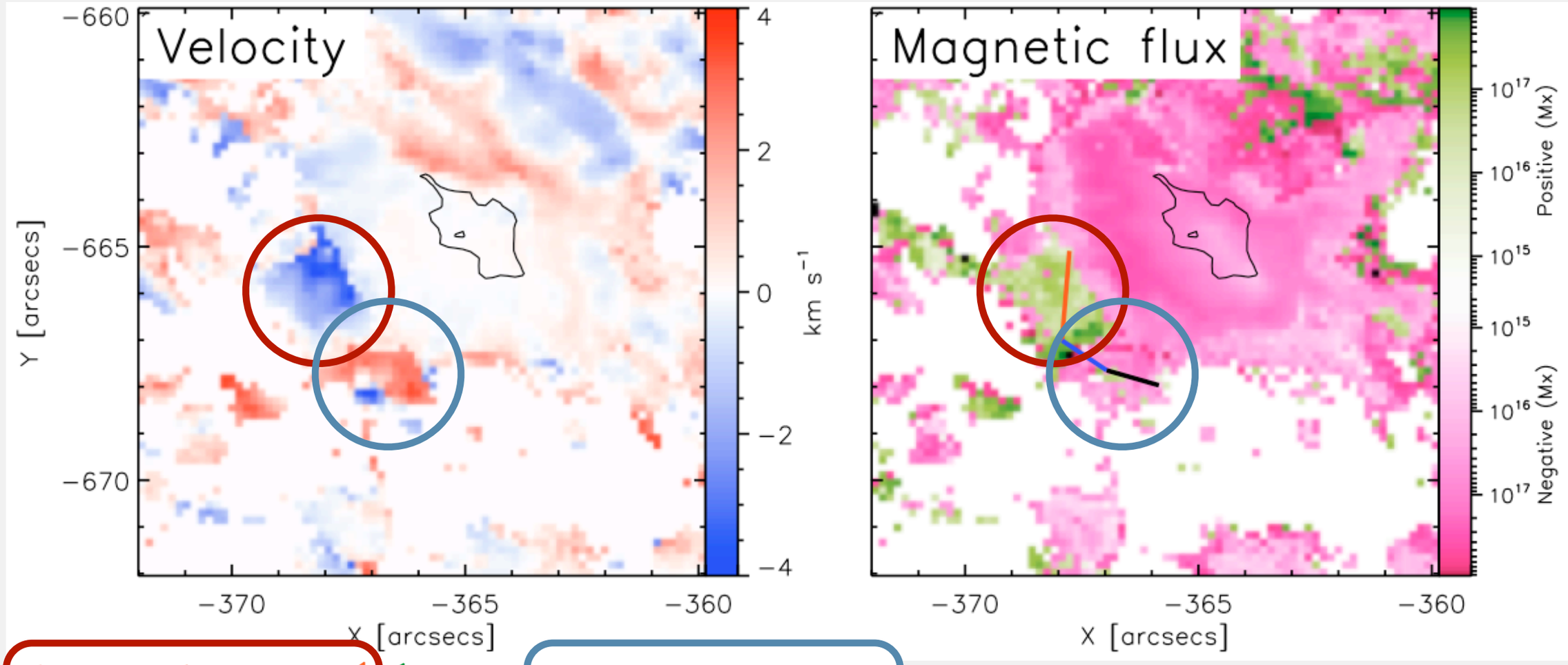


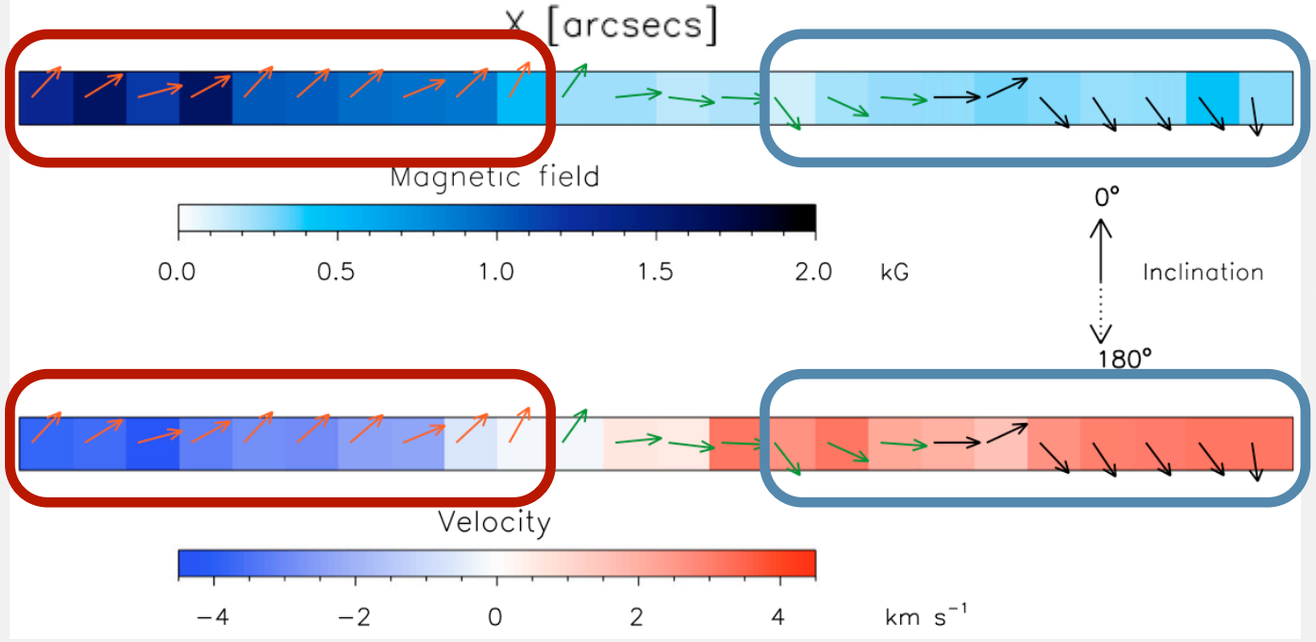
Siphon flows are attractive because of the inverse Evershed effect and the presence of sub- and supersonic flows



Meyer & Schmidt (1968), Stix (2002)

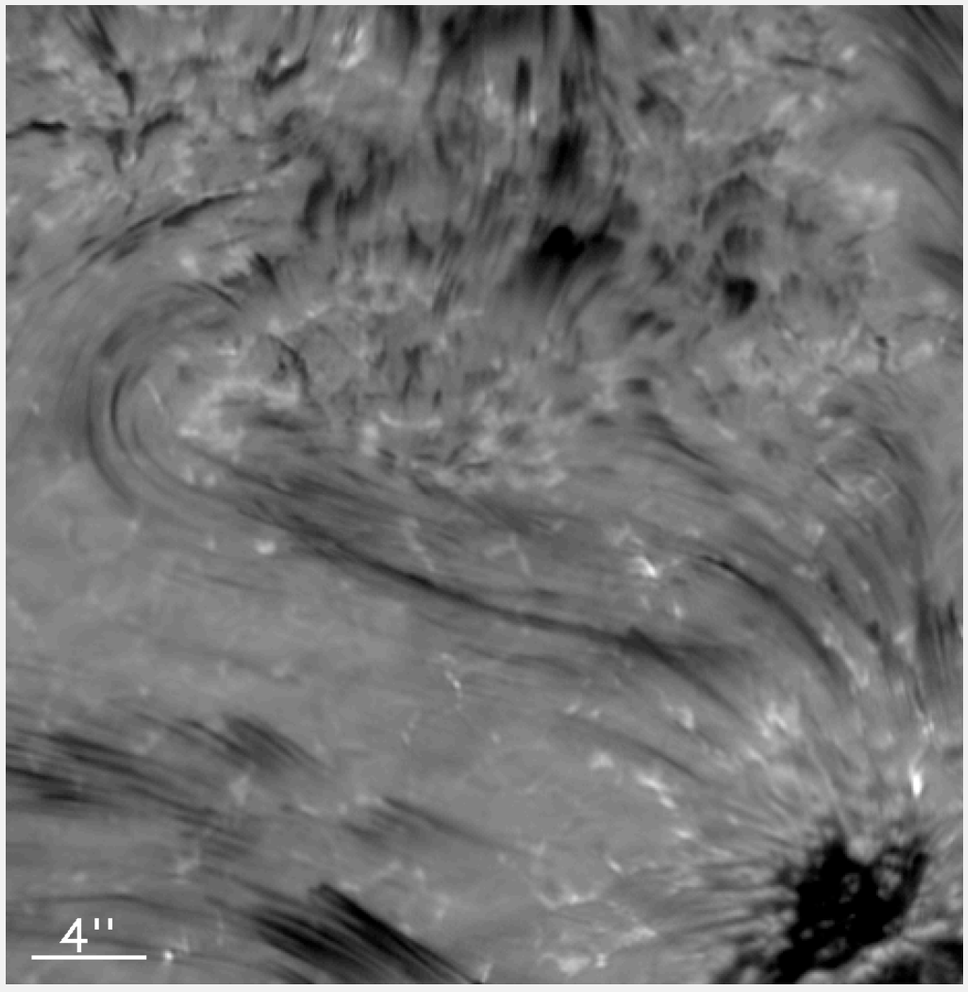
Counterflows have also been predicted and observed



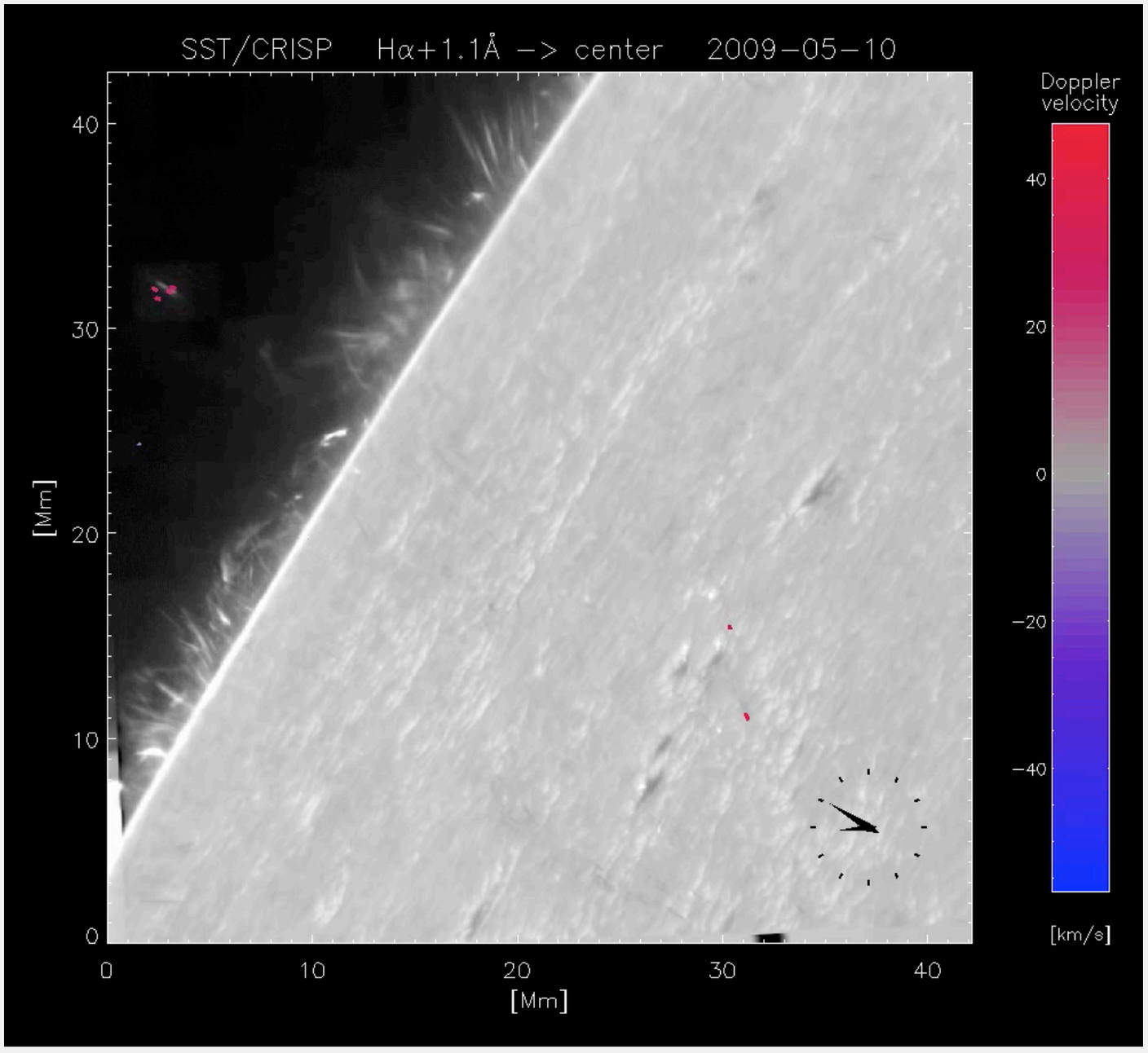


Guglielmino & Zuccarello (2011), but see also Cargill & Priest (1980)

Flocculent flows show striking similarity with coronal rain morphology

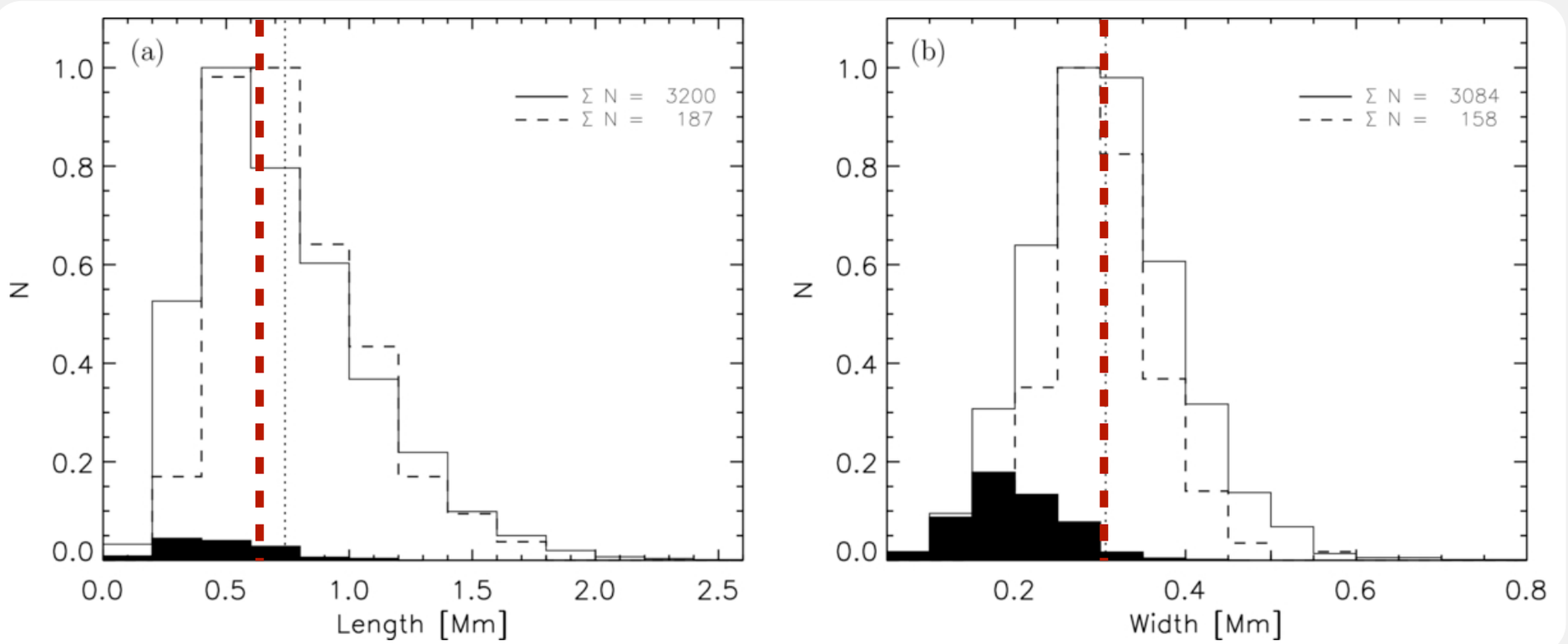


SST/CRISP, 11 June 2008, Hα – 0.7Å

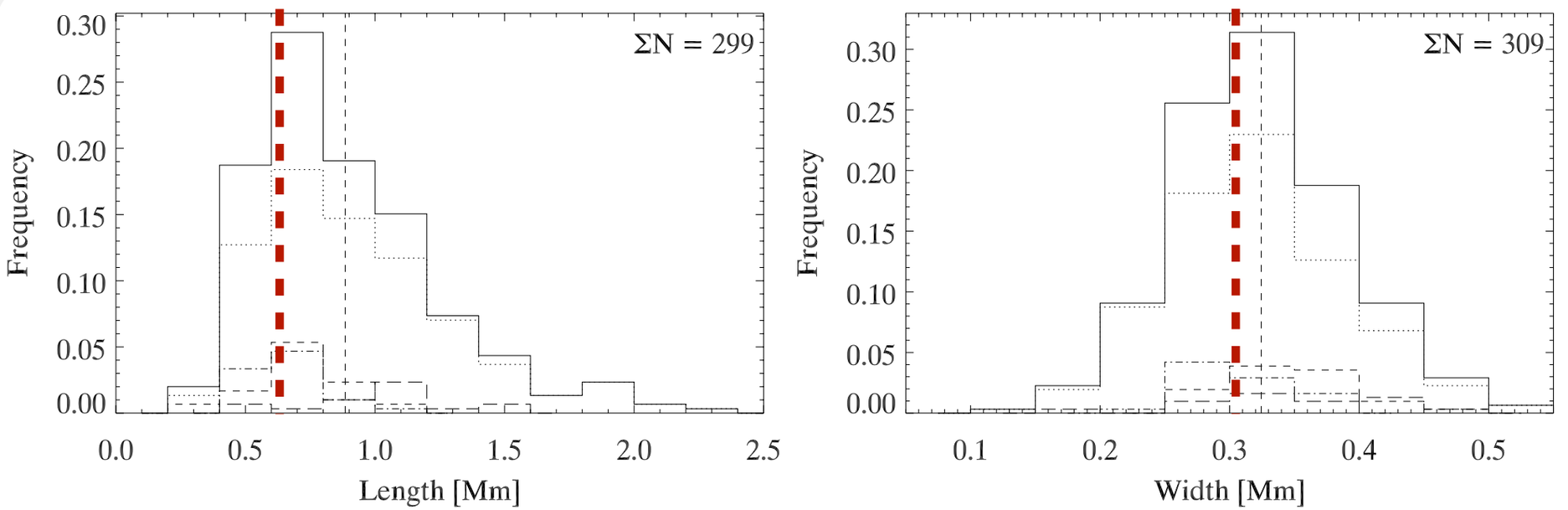


Antolin & Rouppe van der Voort (2012)

Coronal rain blobs show similar size distributions, but with longer high-length tails



Antolin & Rouppe van der Voort (2012)



Antolin et al. (2012)

Flocculent flows as chromospheric rain?

Ubiquitous, intermittent flows in chromospheric canopy

Distinct from classical inverse Evershed effect

Unlikely to be waves

Reminiscent of coronal rain, especially morphologically

Maybe a combination of mechanisms: siphon flow in thermally unstable fibrils, where outside influence causes flocculence?