High resolution observations of a light bridge in a decaying sunspot

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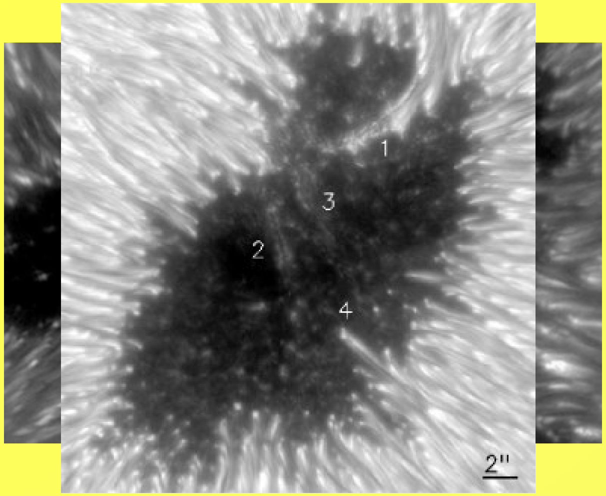
What is a Light Bridge?

A bright and elongated structure delineating the borders between dark umbral fragments.

- Observed during:
  - the assembly process of a sunspot
  - the decay phase of a sunspot

- Classification:



- **LBs segmented** along their length by tiny granules separated by narrow dark lanes oriented perpendicular to the axis of the bridges
- **LBs unsegmented** more resembling the elongated bright filaments seen in the penumbra

Properties of the LBs

<u>Magnetic Field</u>: field strength lower and more horizontal than in the umbra. LBs are a discontinuity in the regular umbral field

<u>Plasma motions</u>: previous observations showed evidence of sinking plasma in the axial channel → Convective origin of the LBs.

Rimmele (2008): upflows in the dark lane and downflows on both sides of it

Magnetoconvection origin

vs

Convection penetrating from the sub-photospheric layers into a field-free gap

→

Observational Campaign at the Swedish Solar Telescope (SST)

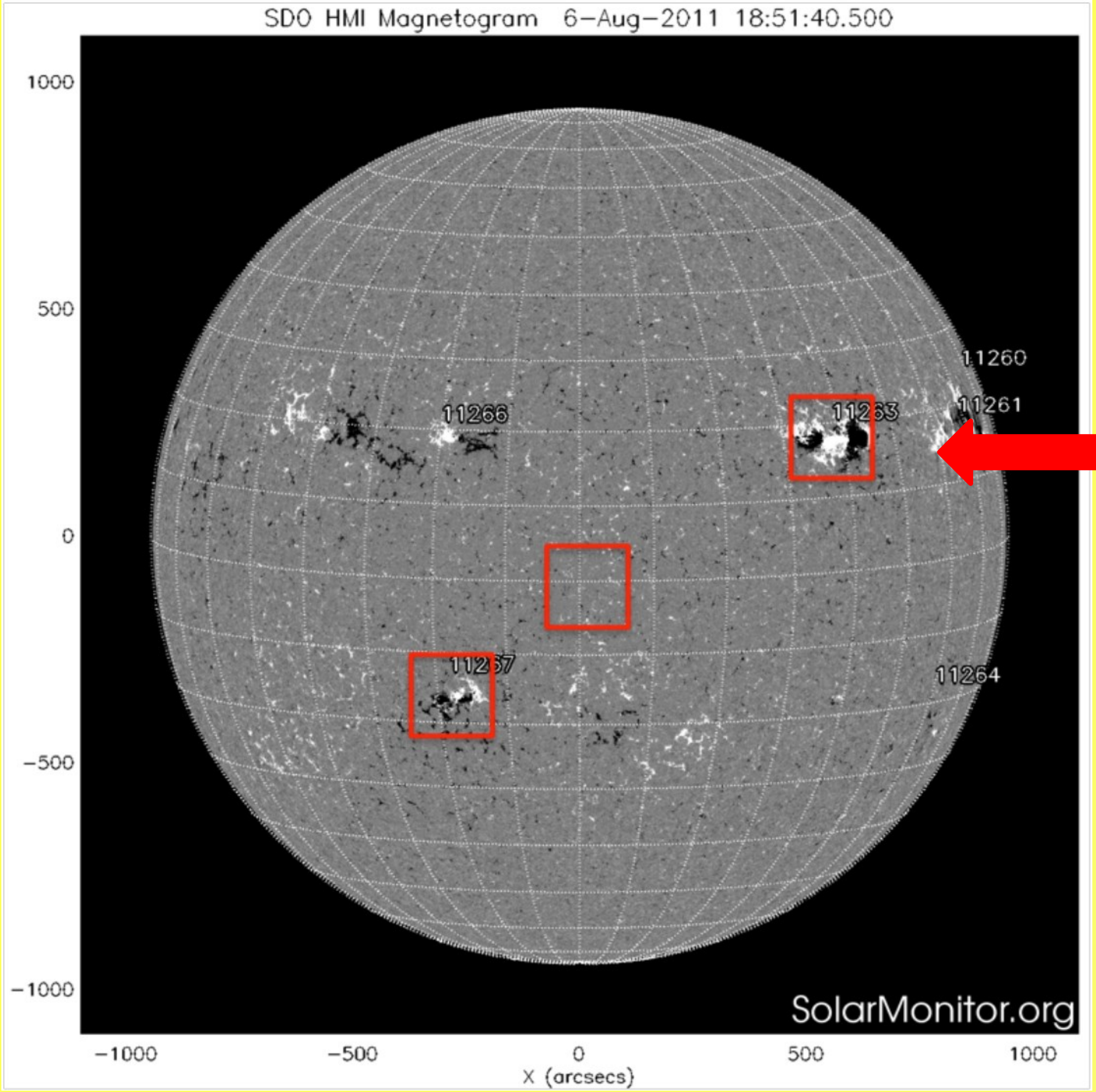
6-19 August 2011, La Palma (Canary Islands)

S. Criscuoli (PI), I. Ermolli, S. L. Guglielmino, A.Cristaldi, M. Falco, F. Zuccarello

Observational Campaign data-set

Instrument	Wavelength	Spectral points	Pixel size (arcsec)	Time Resolution (sec)	Observation days
SST	Fe I 5576 Å	20	0.0592	28	6 - 19 Aug 2011
	Fe I pair 6302 Å	15	0.0589	28	6 - 19 Aug 2011
	Ca II H core	1	0.0338	9	6 - 19 Aug 2011
DOT	G band	-	0.071	30	7 - 19 Aug 2011
	Hα	7	0.109	30	
Hinode	G band	1	0.108		6 Aug 2011
	Ca II H	1	0.108		
	Mg I at 5172 Å (I/V)	2			
	Fe I pair 6302 Å (SP)	140	0.32	5 maps in 3 h	
SDO	HMI continuum	-	0.5	720	2 - 7 Aug 2011

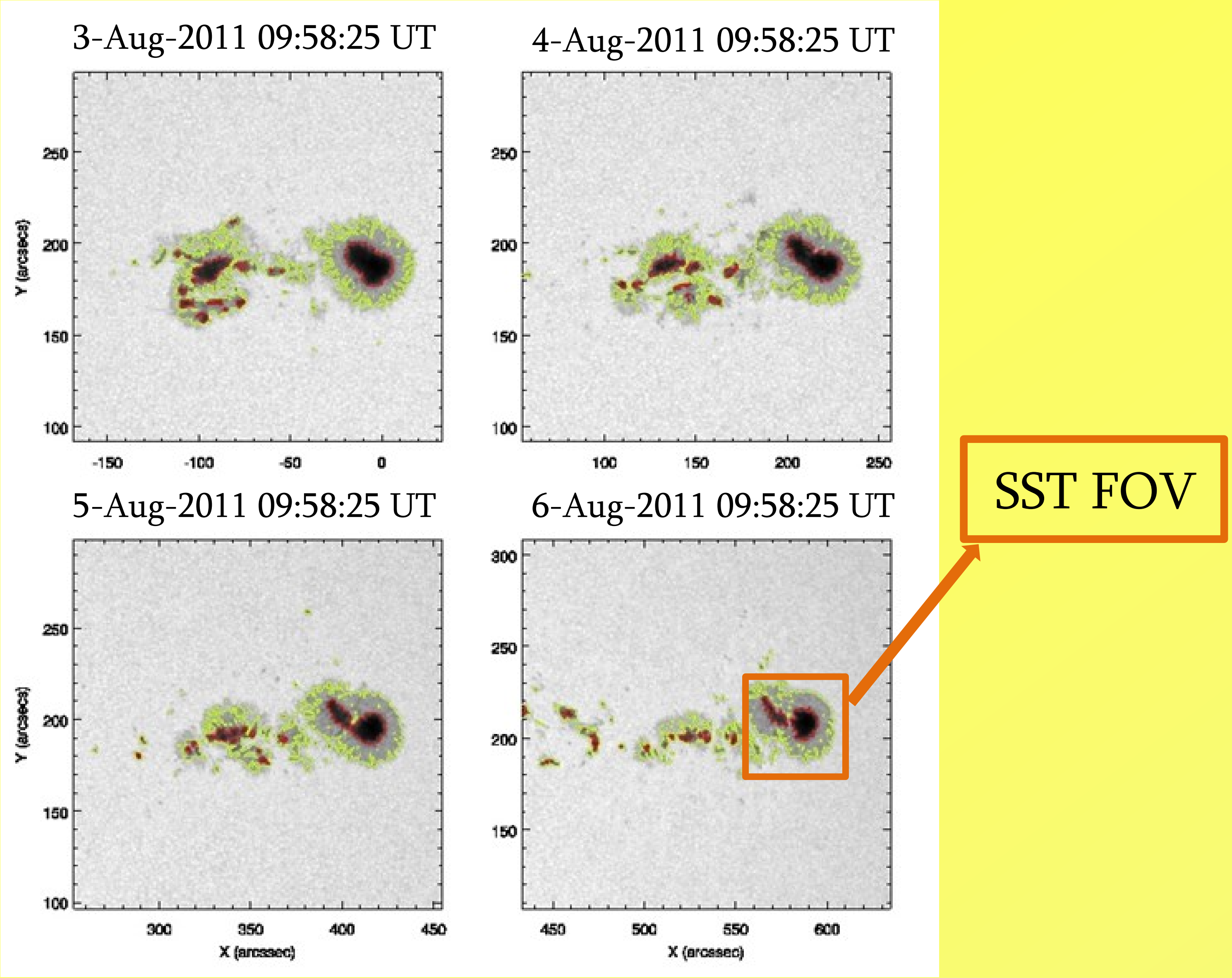
HMI/SDO on August 6, 2011



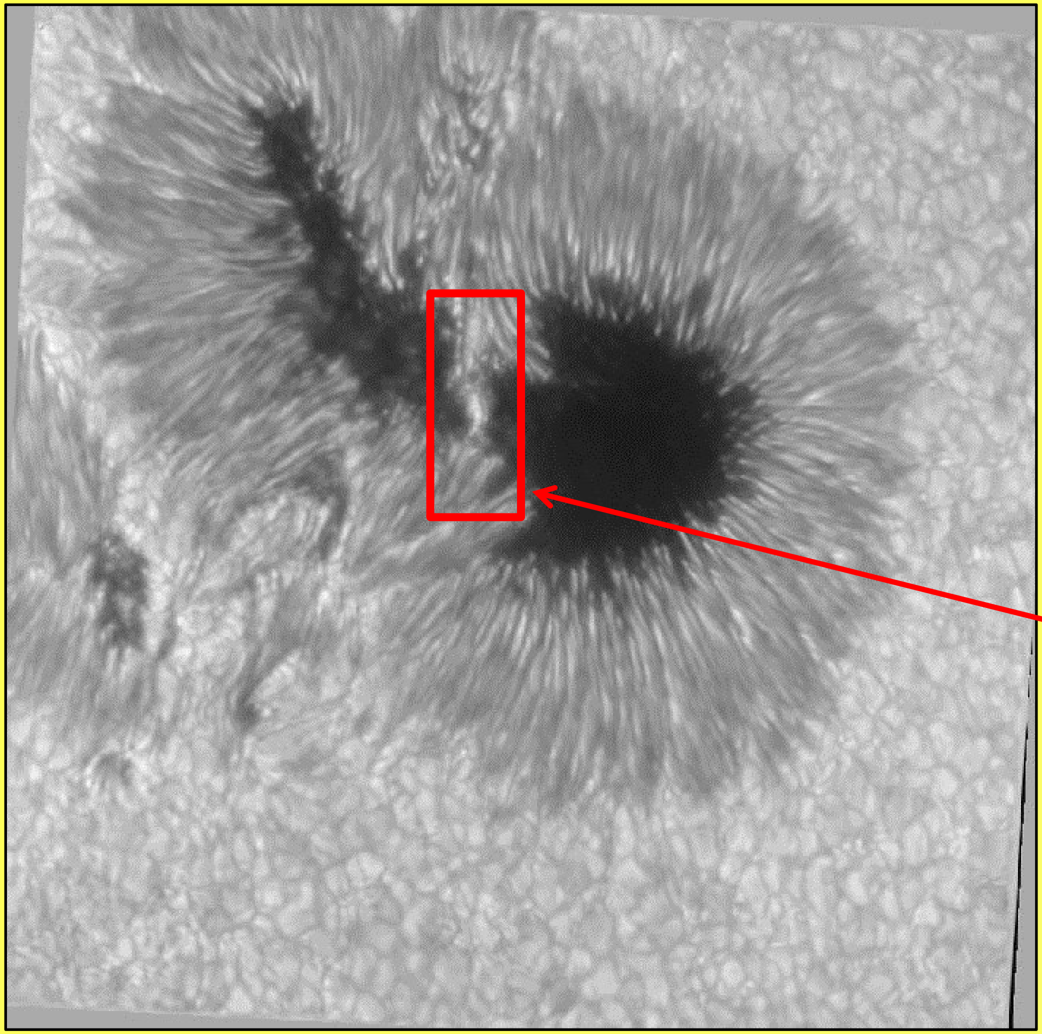
NOAA 11263

Coord: N16 W43
(621",188")

NOAA 11263 evolution: HMI continuum

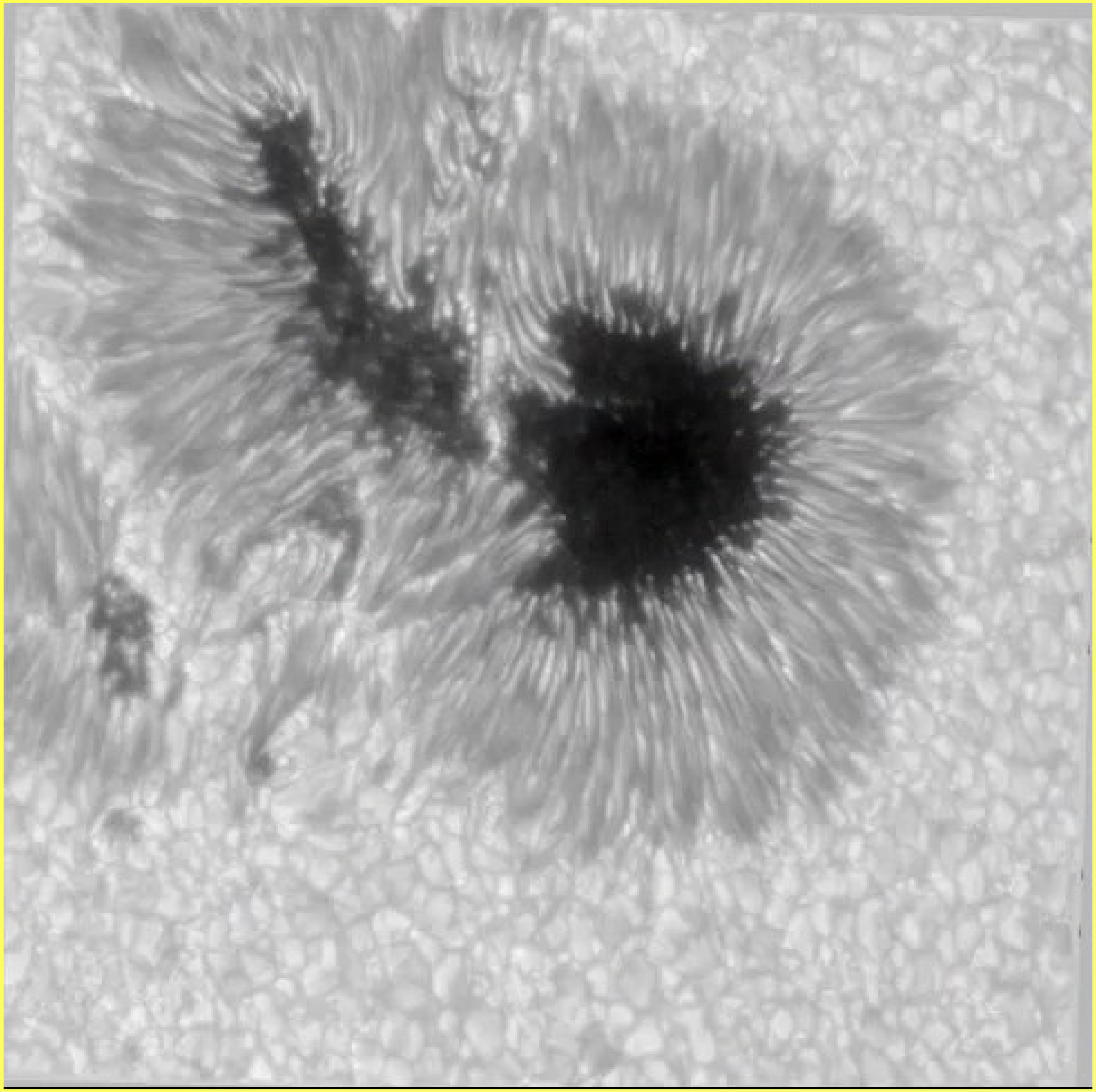


NOAA 11263: SST data

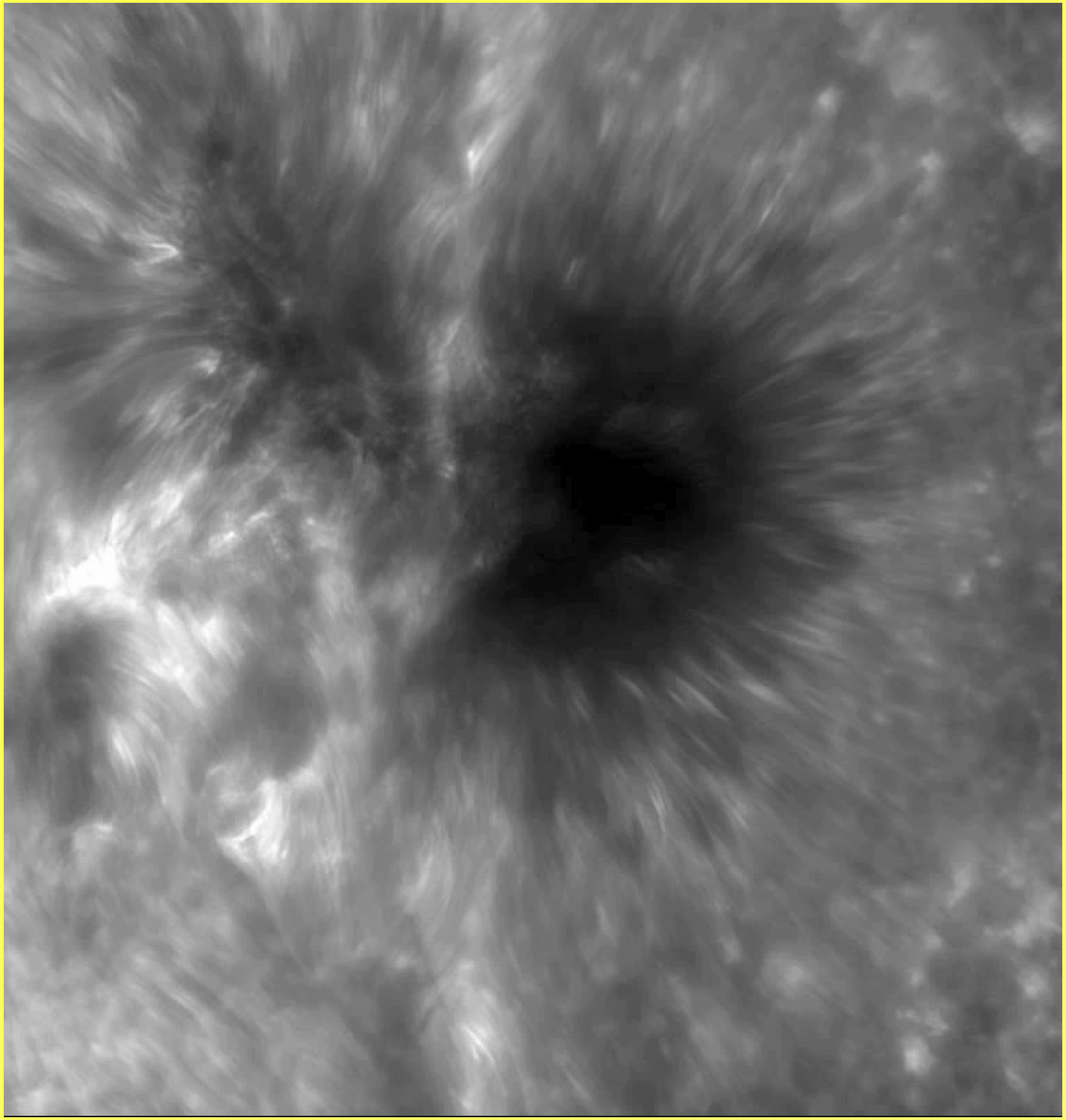


Wide Band 5576 Å with FOV 57.5 x 57.8 arcseconds (41700 x 41900 Km)

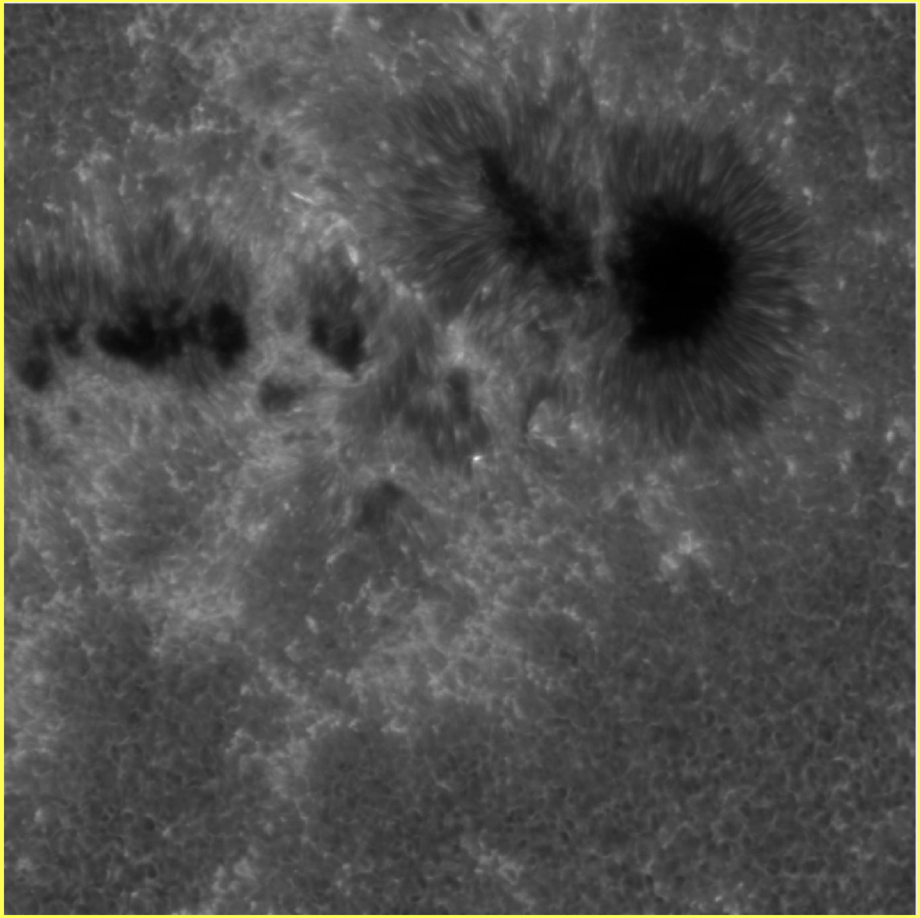
CRISP Continuum - Fe I 5576 Line



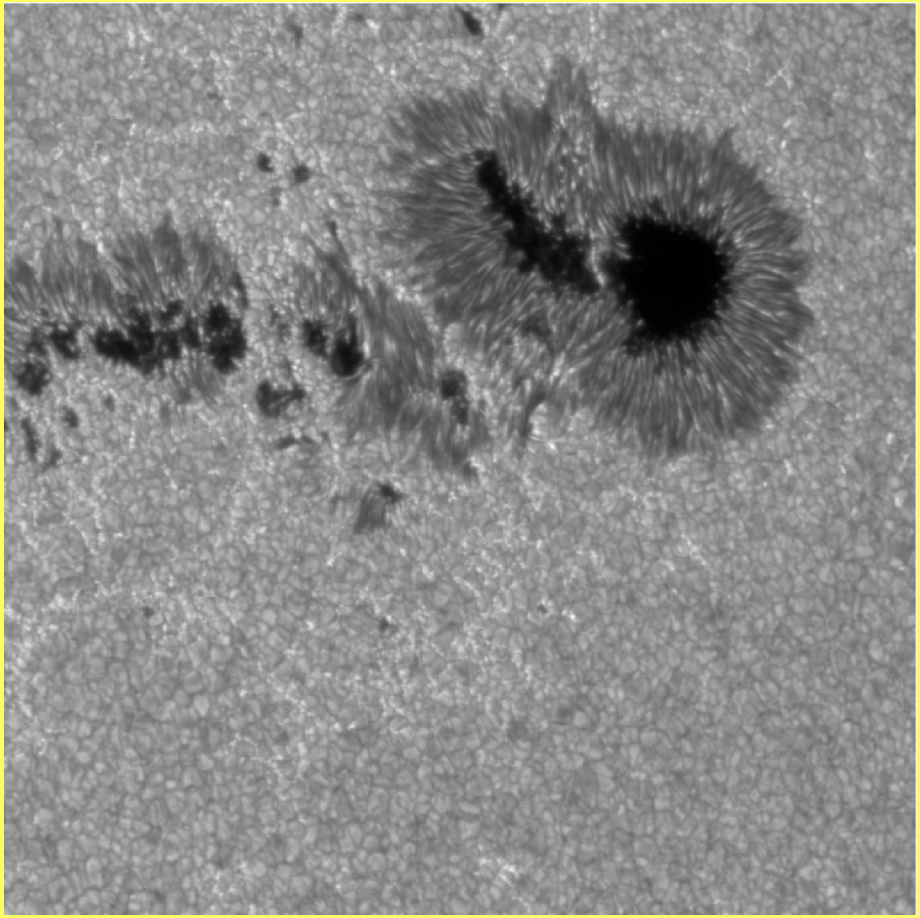
Ca II H core



Hinode filtergrams



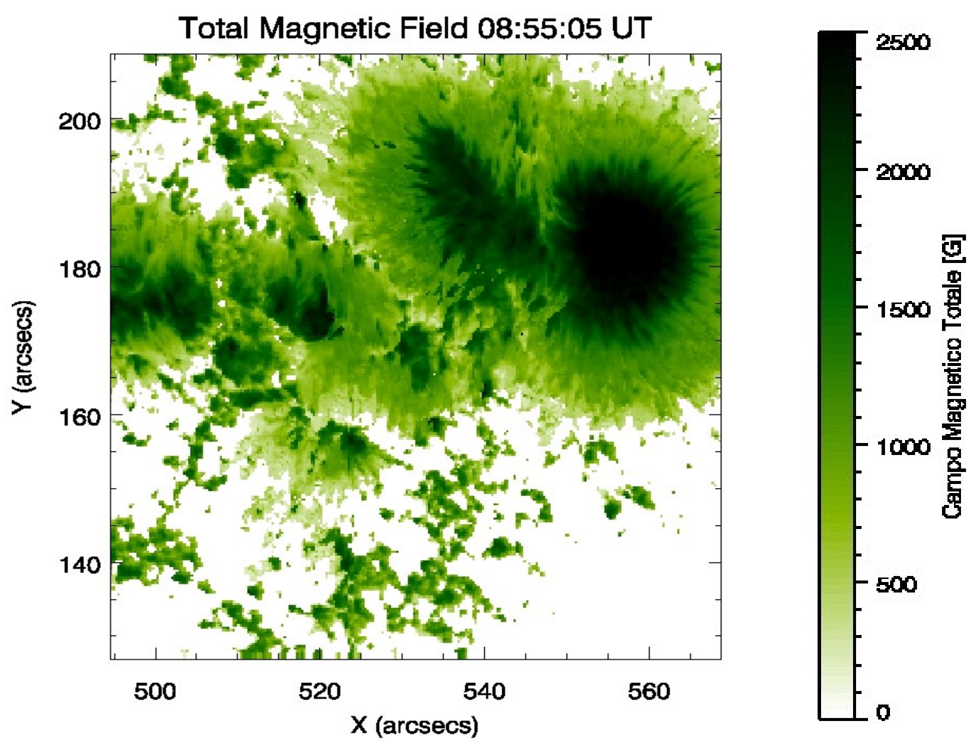
NOAA 11263, Ca II H line



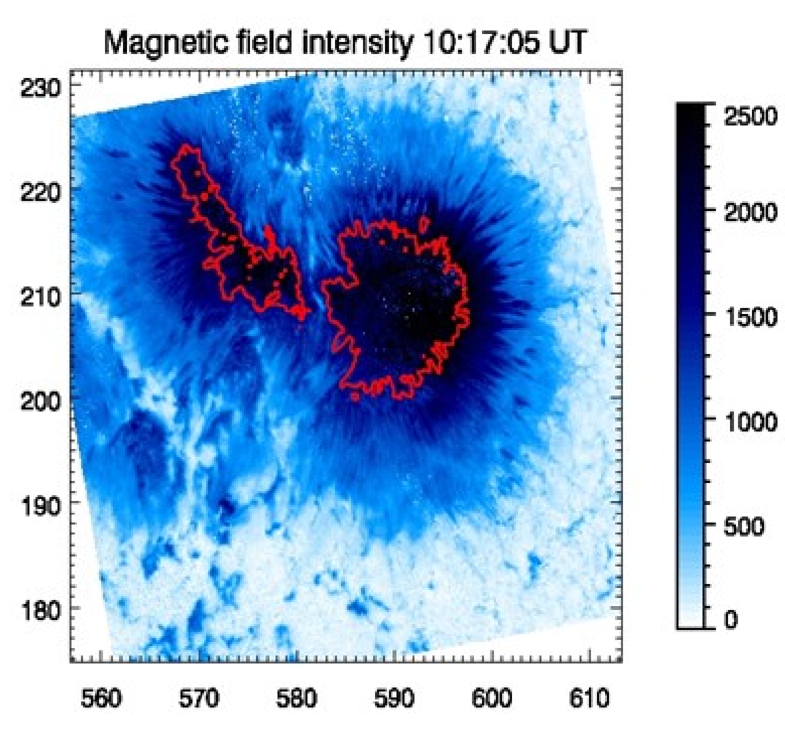
NOAA 11263, G-band

SST and Hinode data-set inversion

Hinode inversion

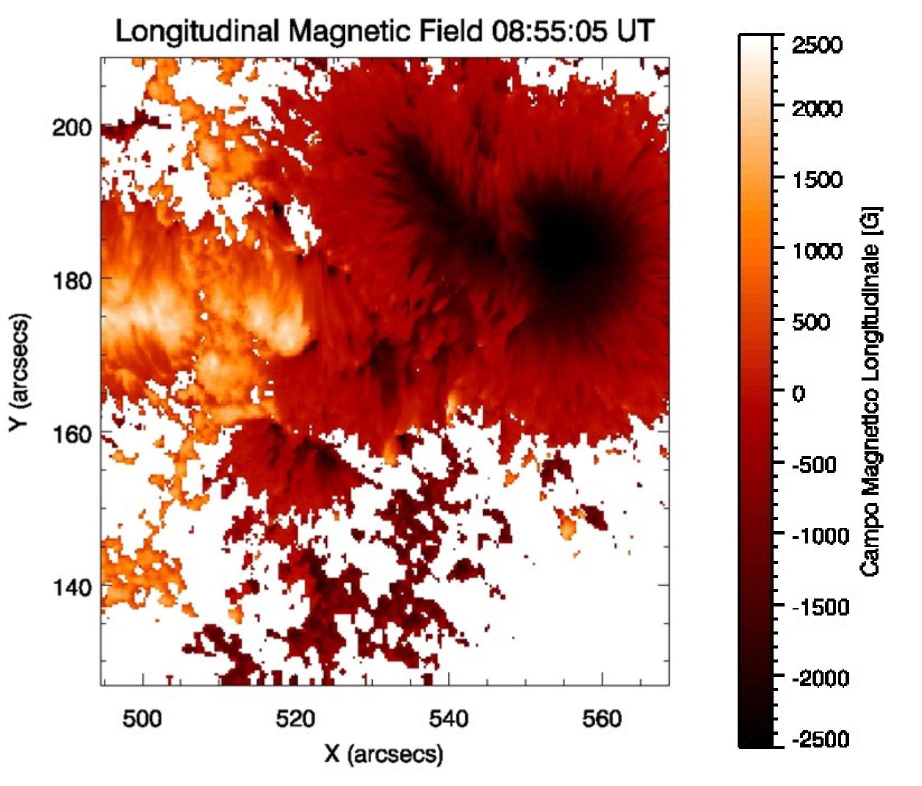


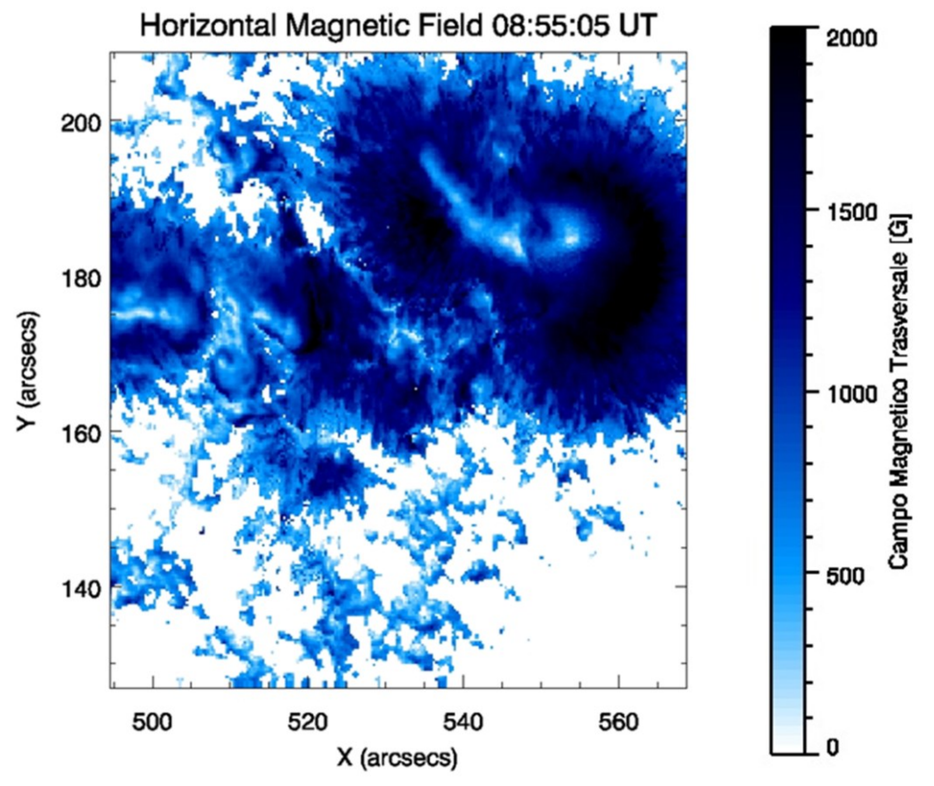
SST/CRISP inversion



The results obtained from the inversion confirm for both dataset that the magnetic field strength in the LB is lower than in the umbra and is comparable with that of the penumbra

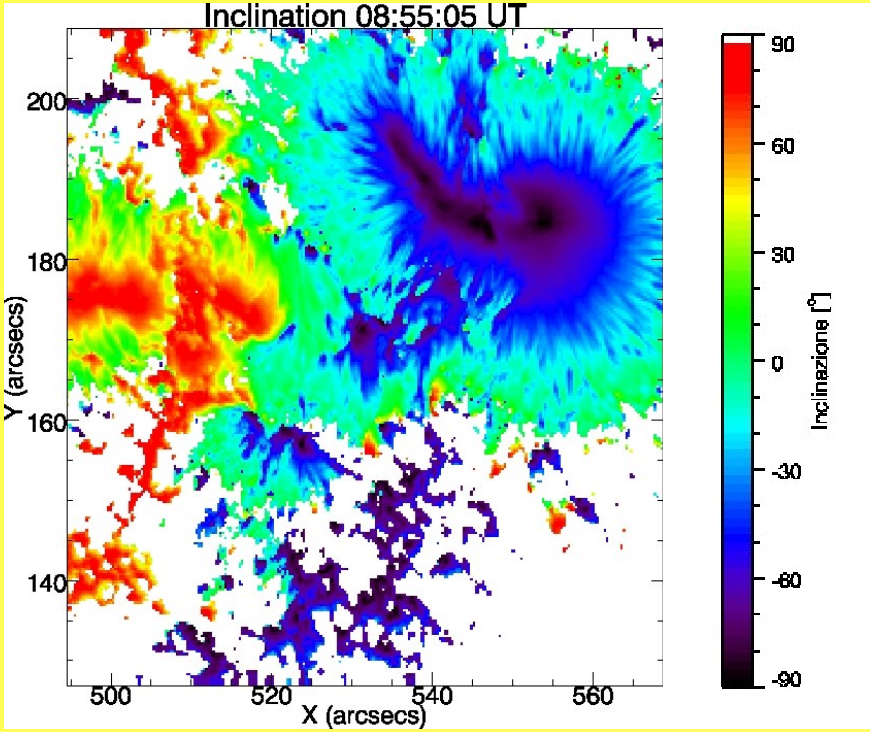
Hinode: Magnetic components

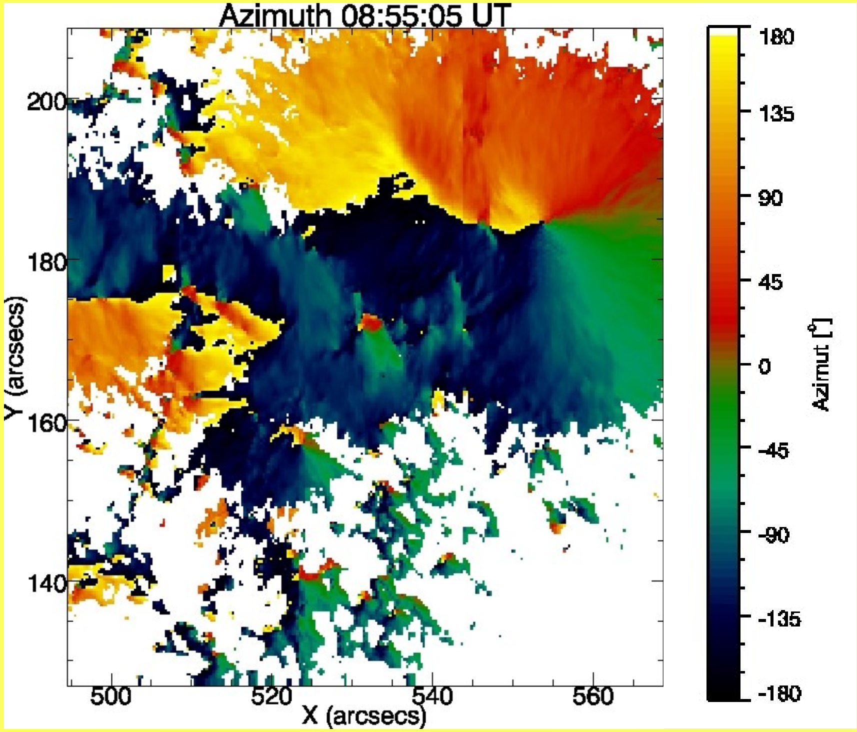




The longitudinal magnetic field is weaker in the LB, while the horizontal magnetic field is stronger in this area

Hinode: Inclination and Azimuth angles

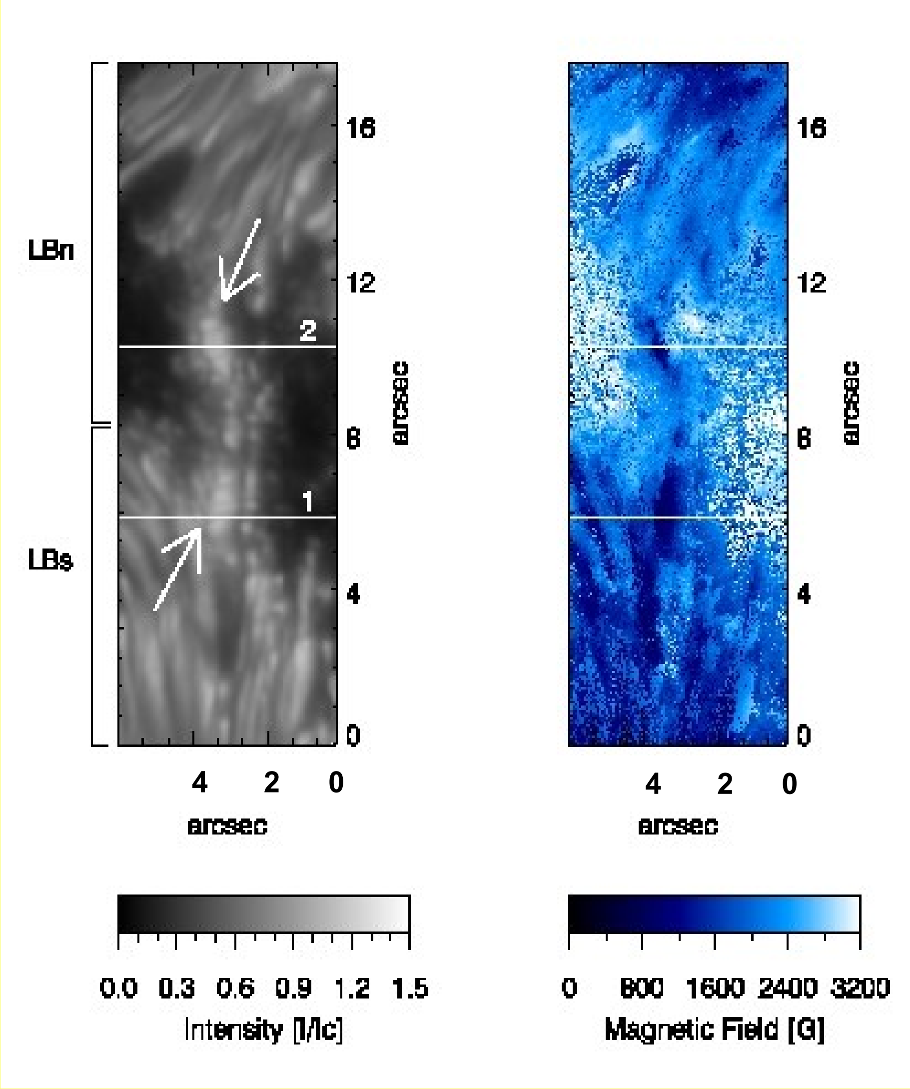




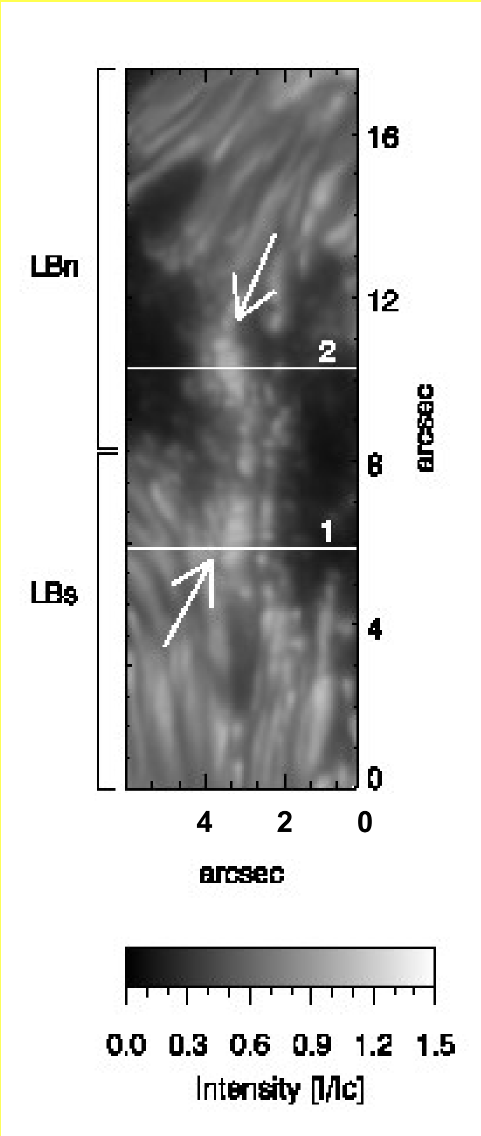
In the LB the magnetic field inclination ranges between -30 and -70 degrees

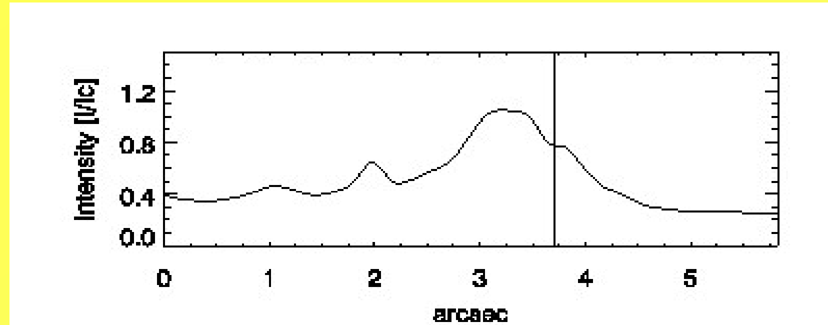
The azimuth map shows a discontinuity in the site hosting the LB

SIR Inversion: LB Analysis

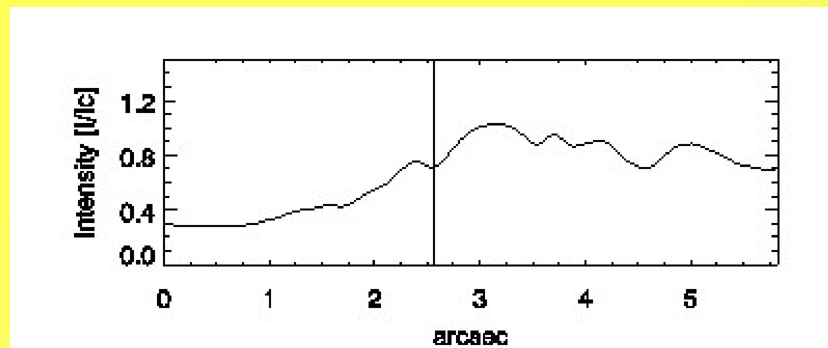


LB Intensity





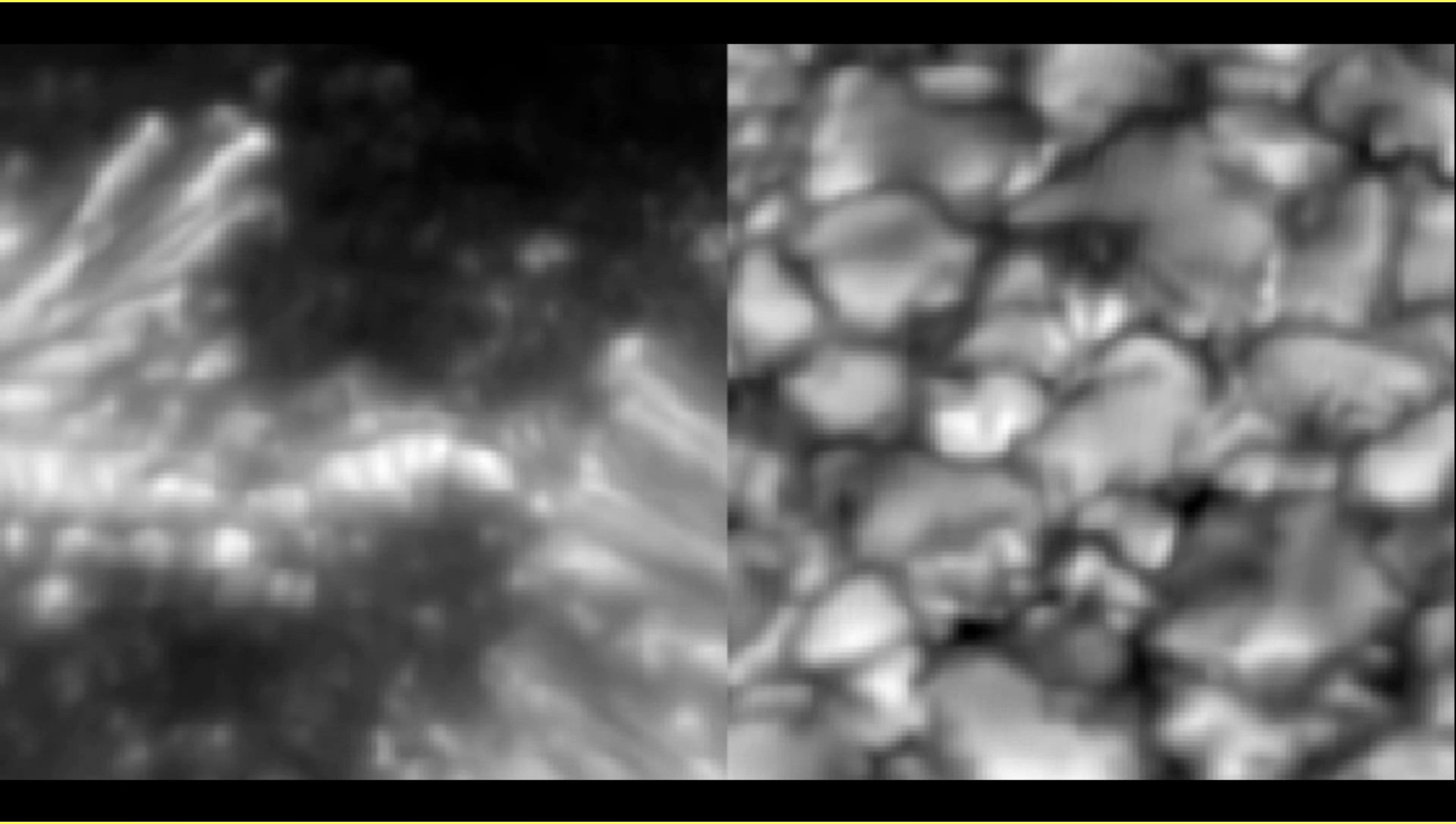
(2)



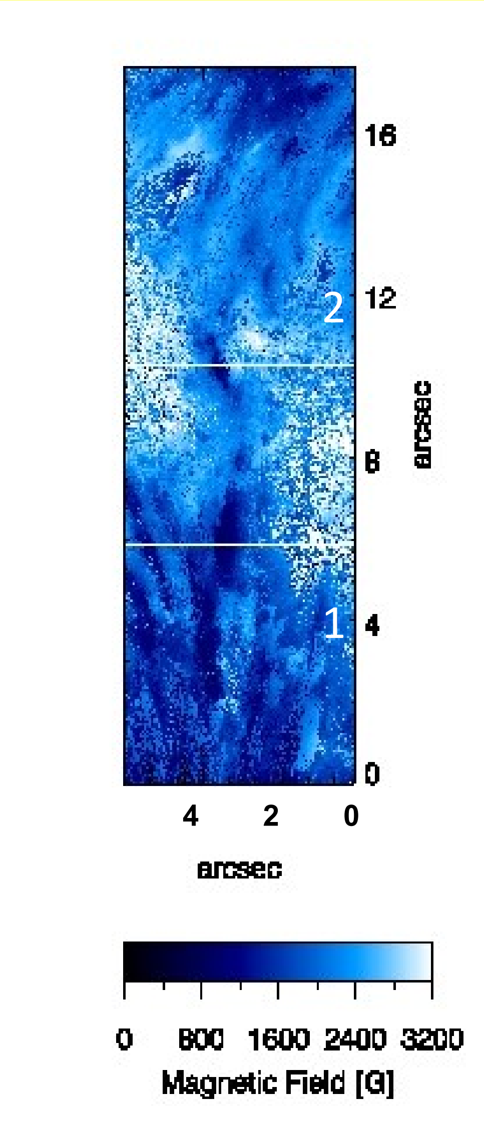
(1)

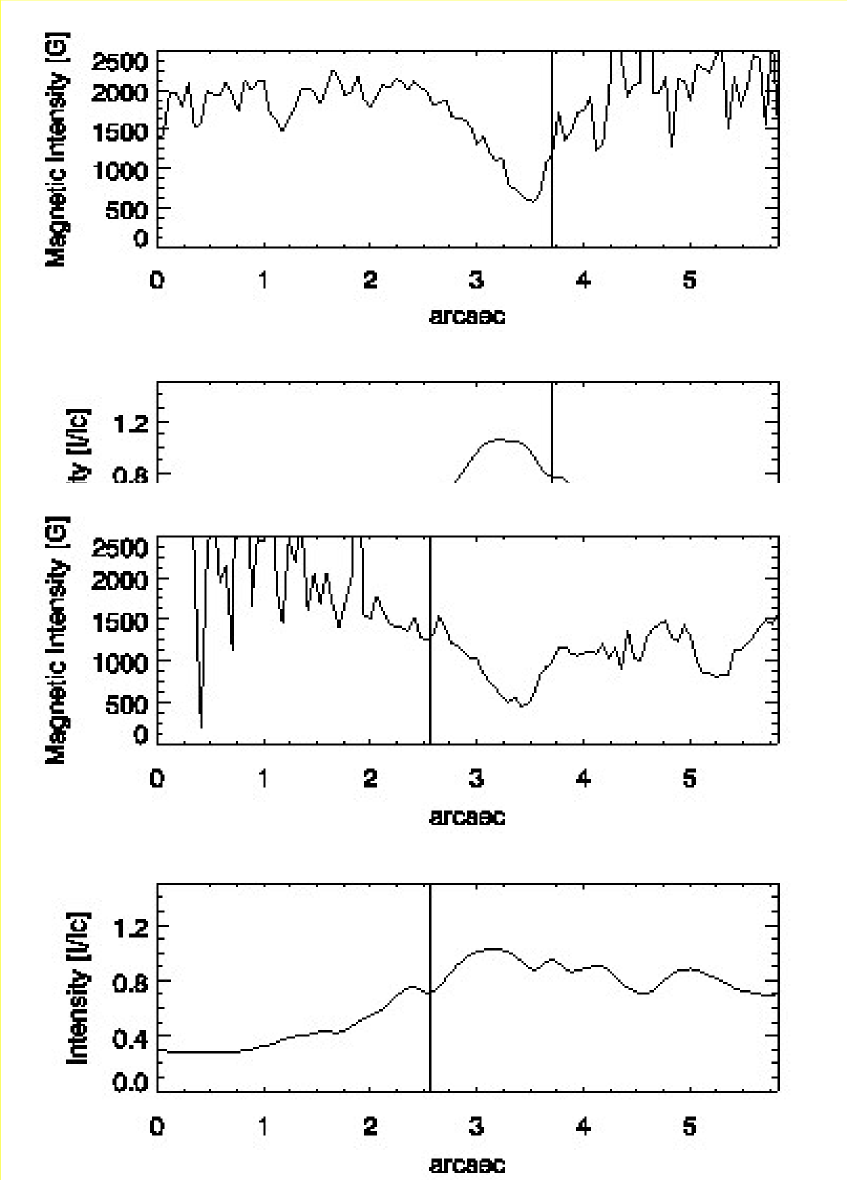
- Different granular area and intensity along the dark lane
- Intensity of large grains: 1.1
- Intensity of small grains: 0.8

LB granulation vs Quiet Sun granulation



LB Magnetic Field





(2)

(1)

Results

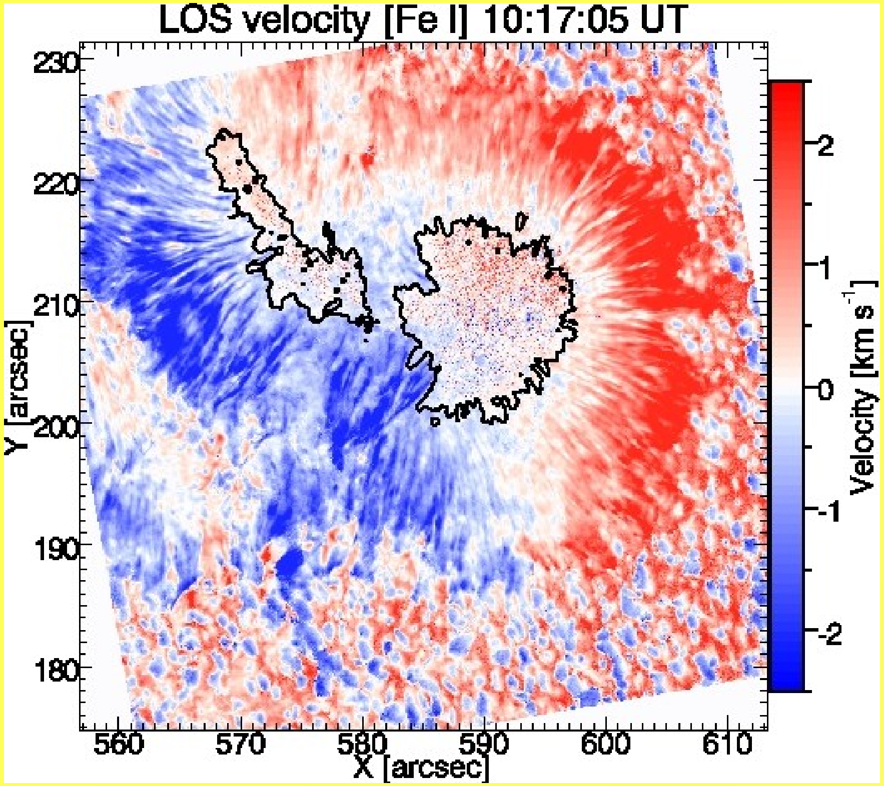
Parameter	Dark Lane	LB large granulation	LB small granulation
Intensity (Fe I 6302 Å)	0.7	1.1	0.8
Magnetic Field (Fe I 6302 Å)	1600 G	600 G	1300 G
Size (arcsec)	0’’.3	0’’.4	0’’.2

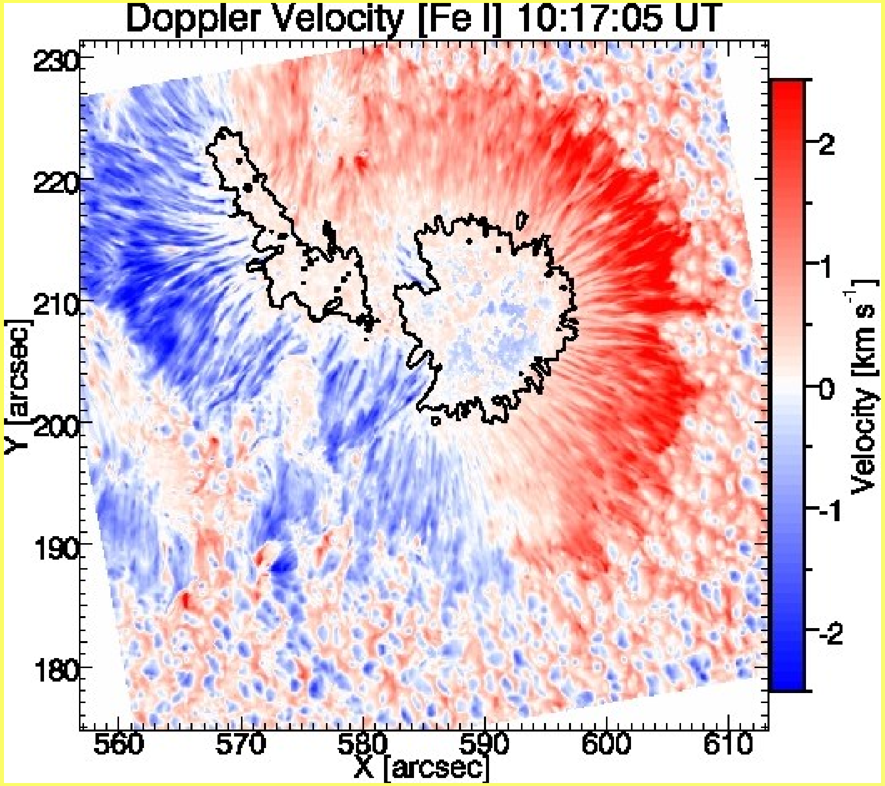
There are differences in intensity and magnetic field between the DL and the small and large LB granulation

CRISP: Velocity maps

Plasma velocity map deduced from the SIR inversion

Plasma velocity map deduced from Gaussian fit of the Fe I line at 5576 Å

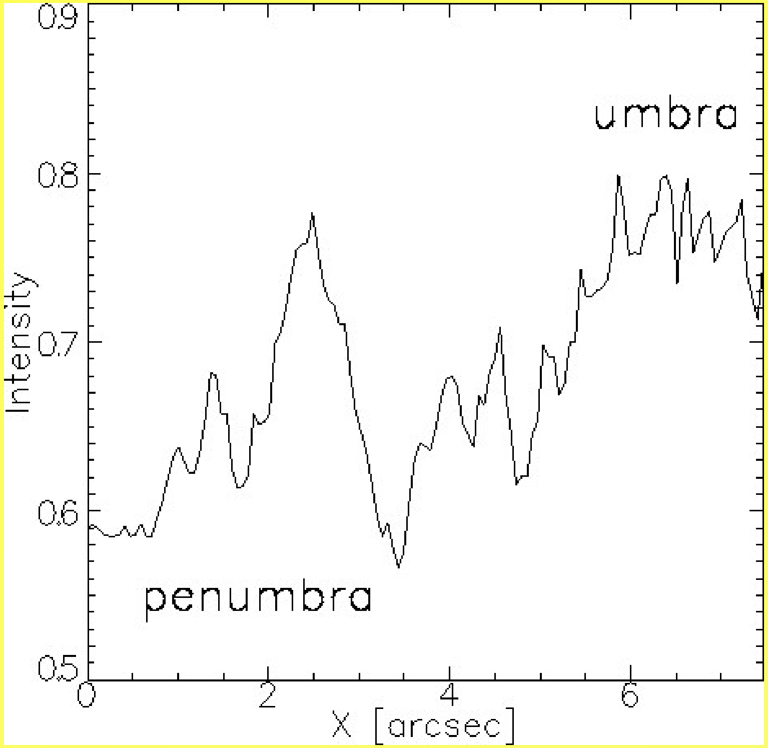


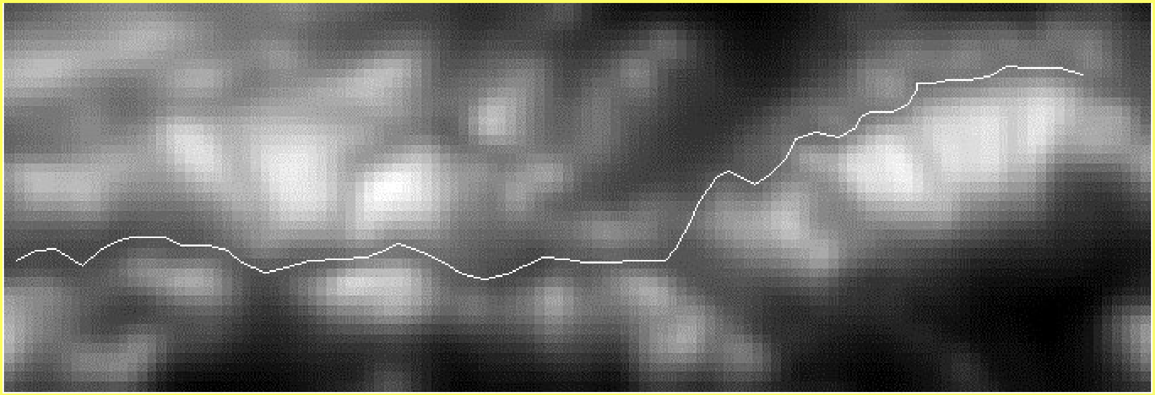


Dark Lane intensity

Fe I 5576 Å

The intensity of the DL is lower in the penumbral region than in the umbral one



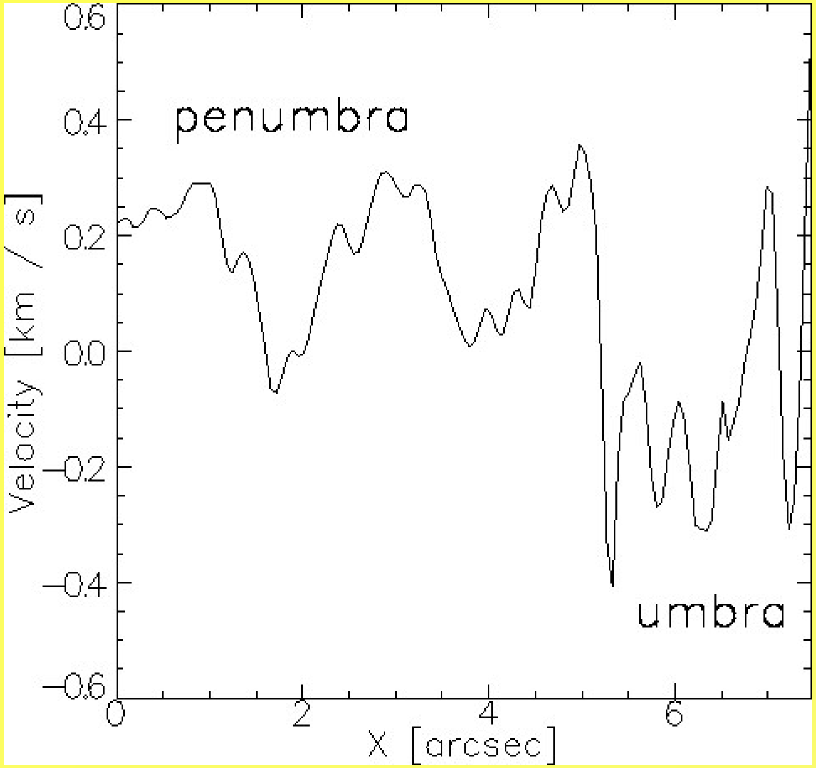


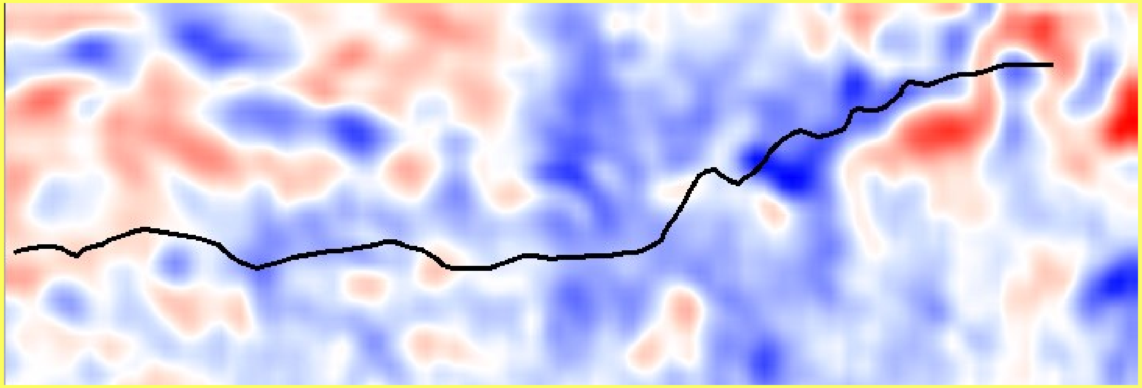
Dark Lane velocity

<u>Fe I 5576 Å</u>

There are upward motions along the DL in the umbral region

In the penumbral region the plasma motions in the DL are more variable





Conclusions

1) The DL of the umbral zone is characterized by upflows
2) The DL of the penumbral zone shows both downflows and upflows

The results of the SIR inversion confirm that where the magnetic field is lower, convection is more effective and the intensity of the grains of the LB is higher

↓

Convection penetrating from the sub-photospheric layers into a quite field-free gap

Thanks!