Correlation Length of Energy at the Base of Coronal Holes and its Relation with the Fast Solar Wind

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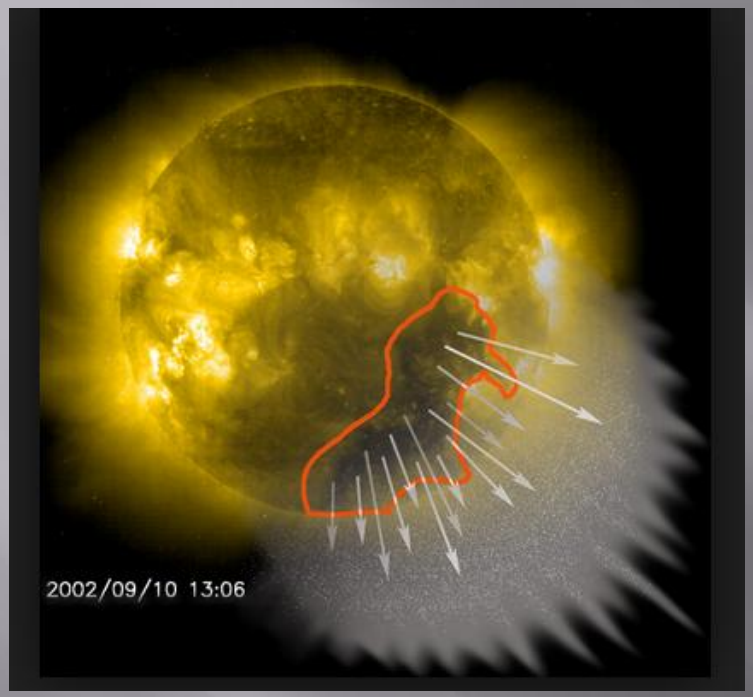
Fast Solar Wind Acceleration



Photospheric dynamics is immediately transferred into the chromosphere and corona

The ***heating rate*** of the fast solar wind is defined by the ***correlation length*** λ of energy-containing structures at the base of the corona:

Matthaeus et al. 1999:

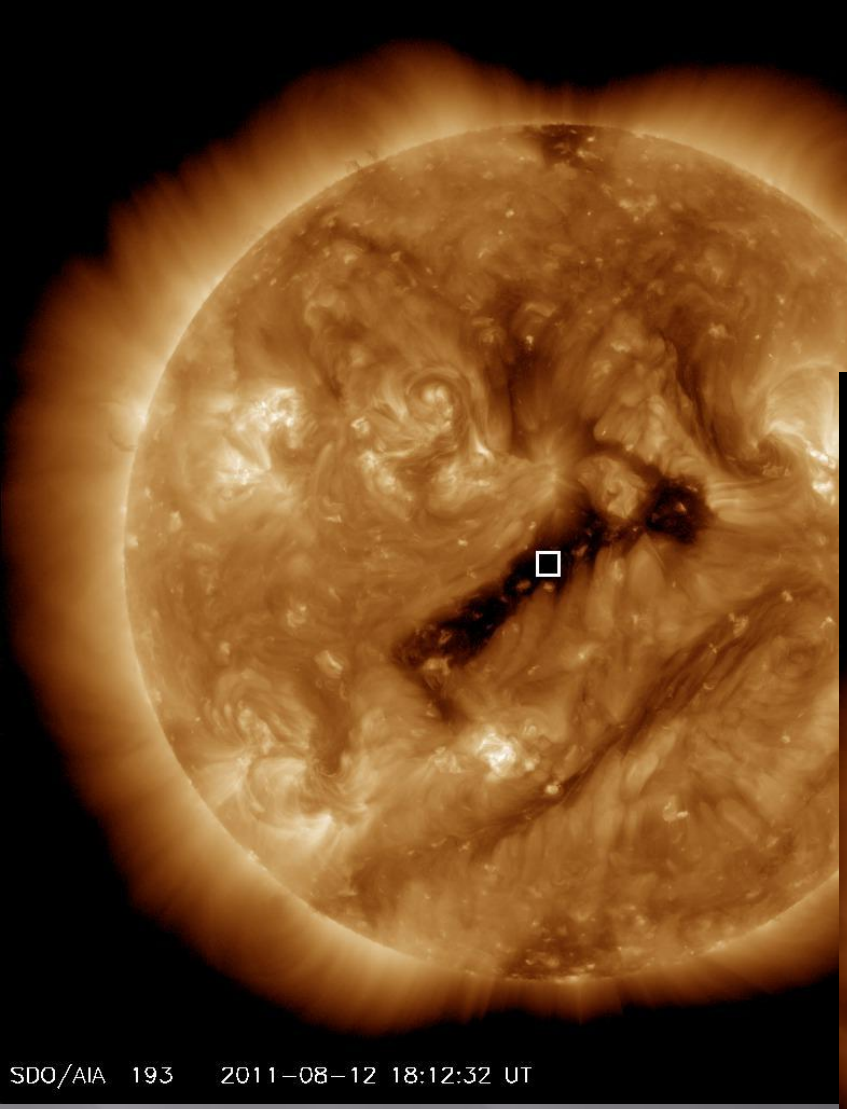
$$\epsilon = \alpha \frac{Z_-^2 Z_+ + Z_+^2 Z_-}{\lambda_\perp}$$

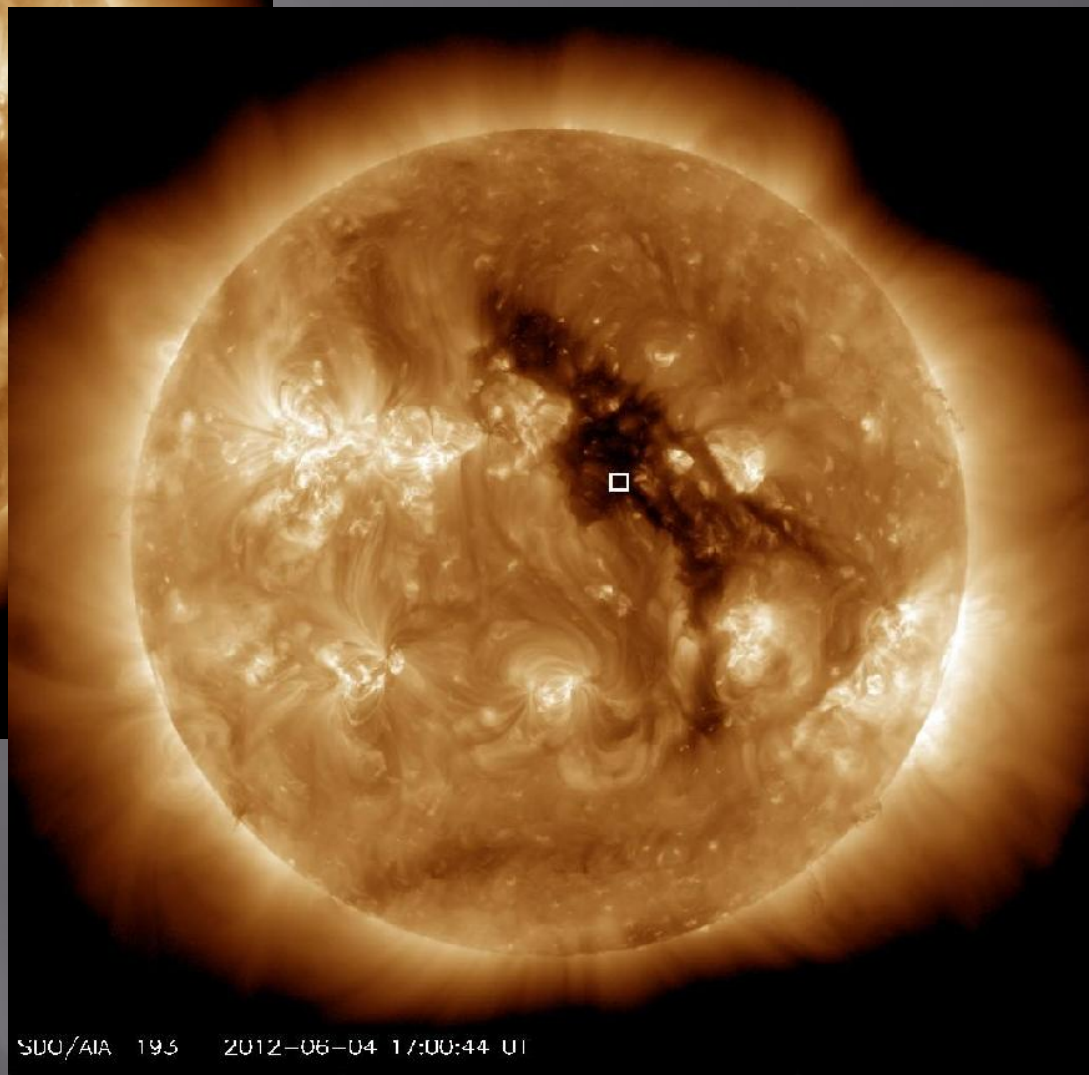
Energy-containing structures are squared transverse fluctuations of velocity , u^2, and of magnetic field, b^2

Zank et al. 2012:

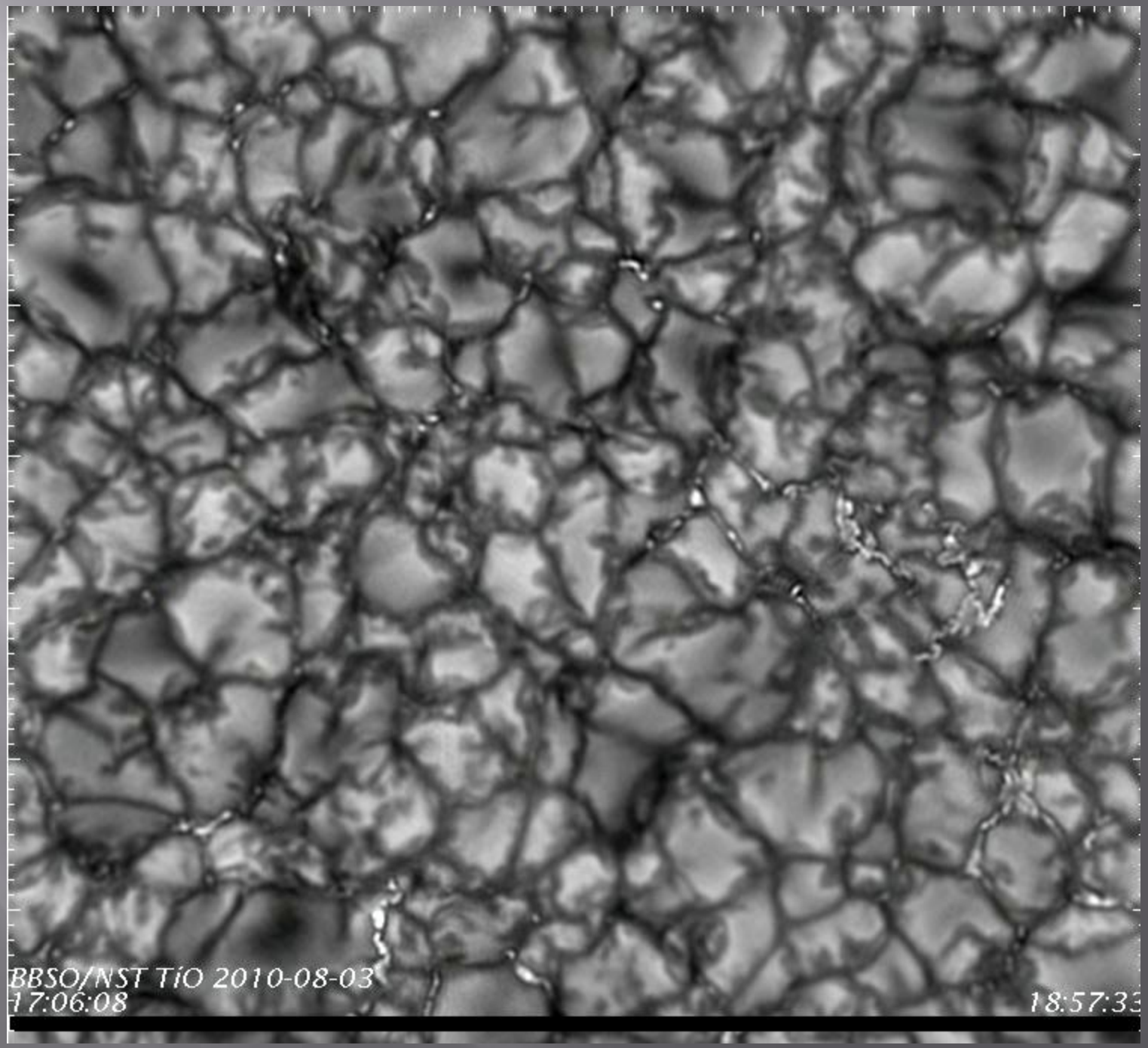
$$NL_\pm = -\mathbf{z}^\pm \frac{\langle z^{\mp 2} \rangle^{1/2}}{\lambda^\pm}$$

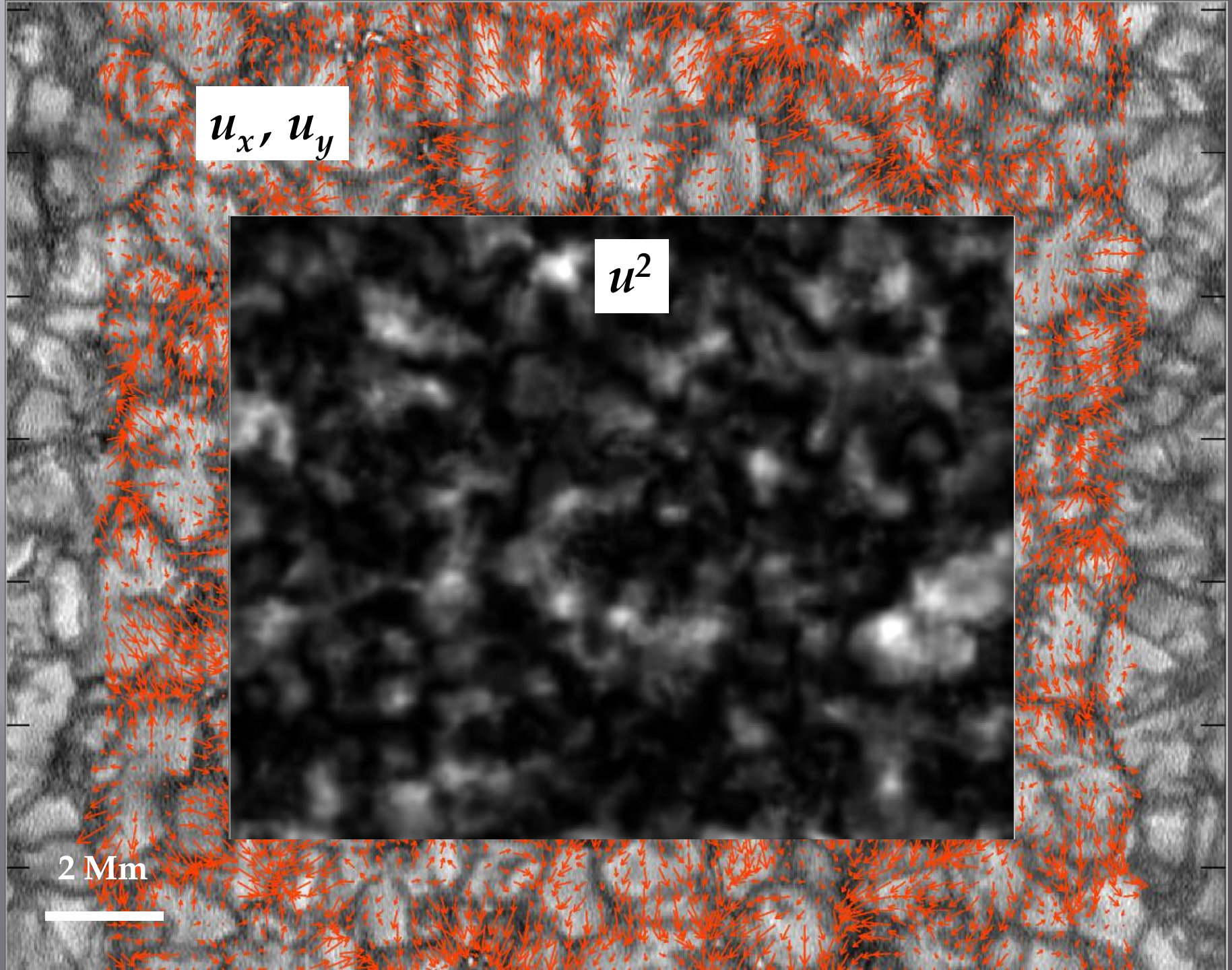
Magnetic and velocity fluctuations in the photosphere inside coronal holes determine the Solar Wind acceleration





u^2, b^2

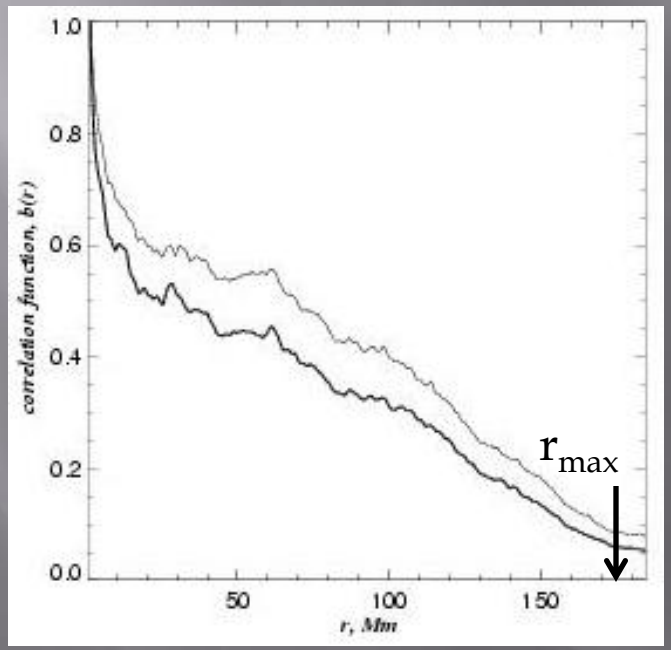

BBSO/NST TiO 2010-08-03
H 7:06:08
18:57:33


u_x, u_y
u^2
2 Mm

Correlation Function of u^2 :

$$B(r) = \langle u^2(\mathbf{x}+\mathbf{r}) \cdot u^2(\mathbf{x}) \rangle / \sigma^2$$

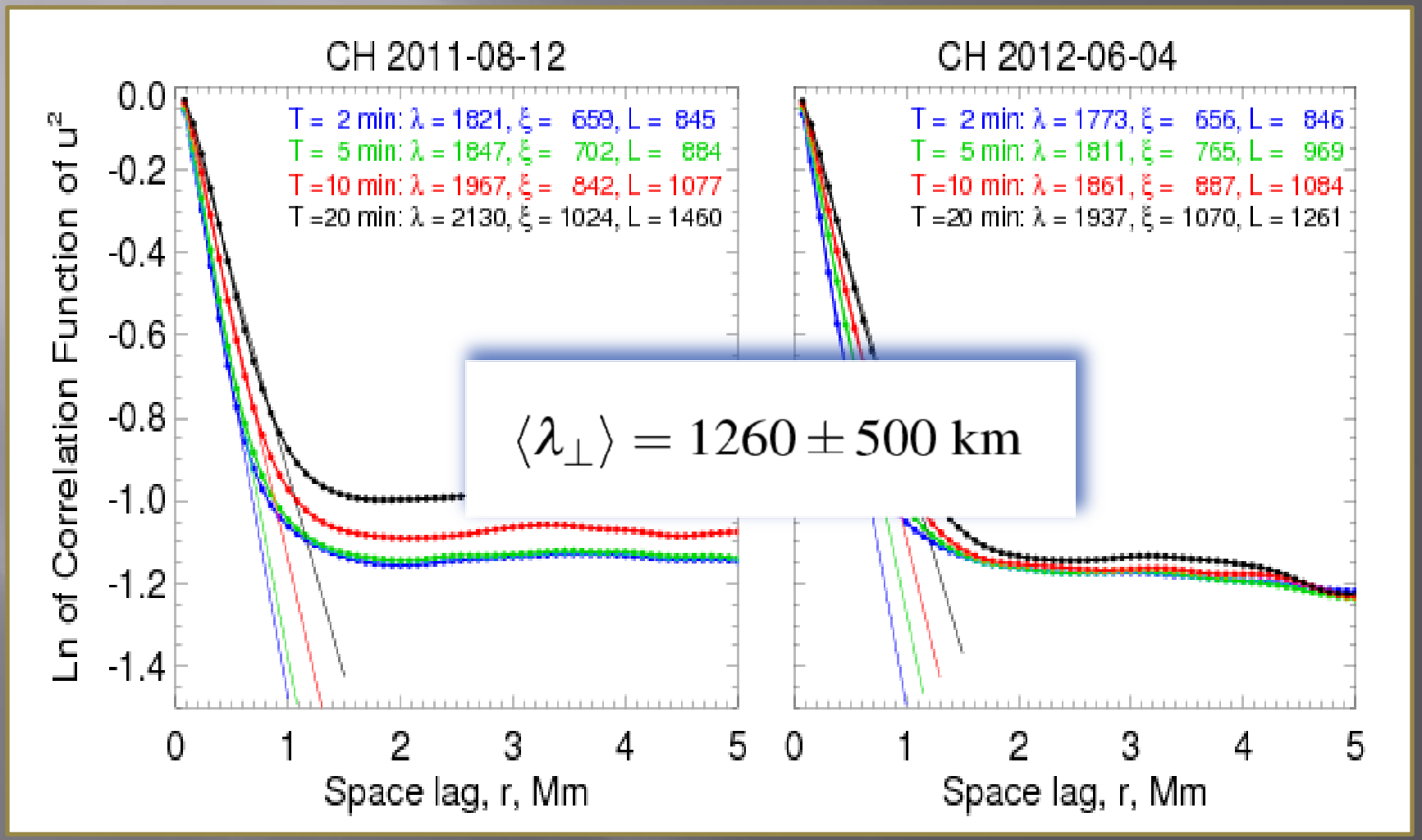
Correlation function allows to estimate a characteristic length λ of energy containing structures as the Batchelor integral scale:



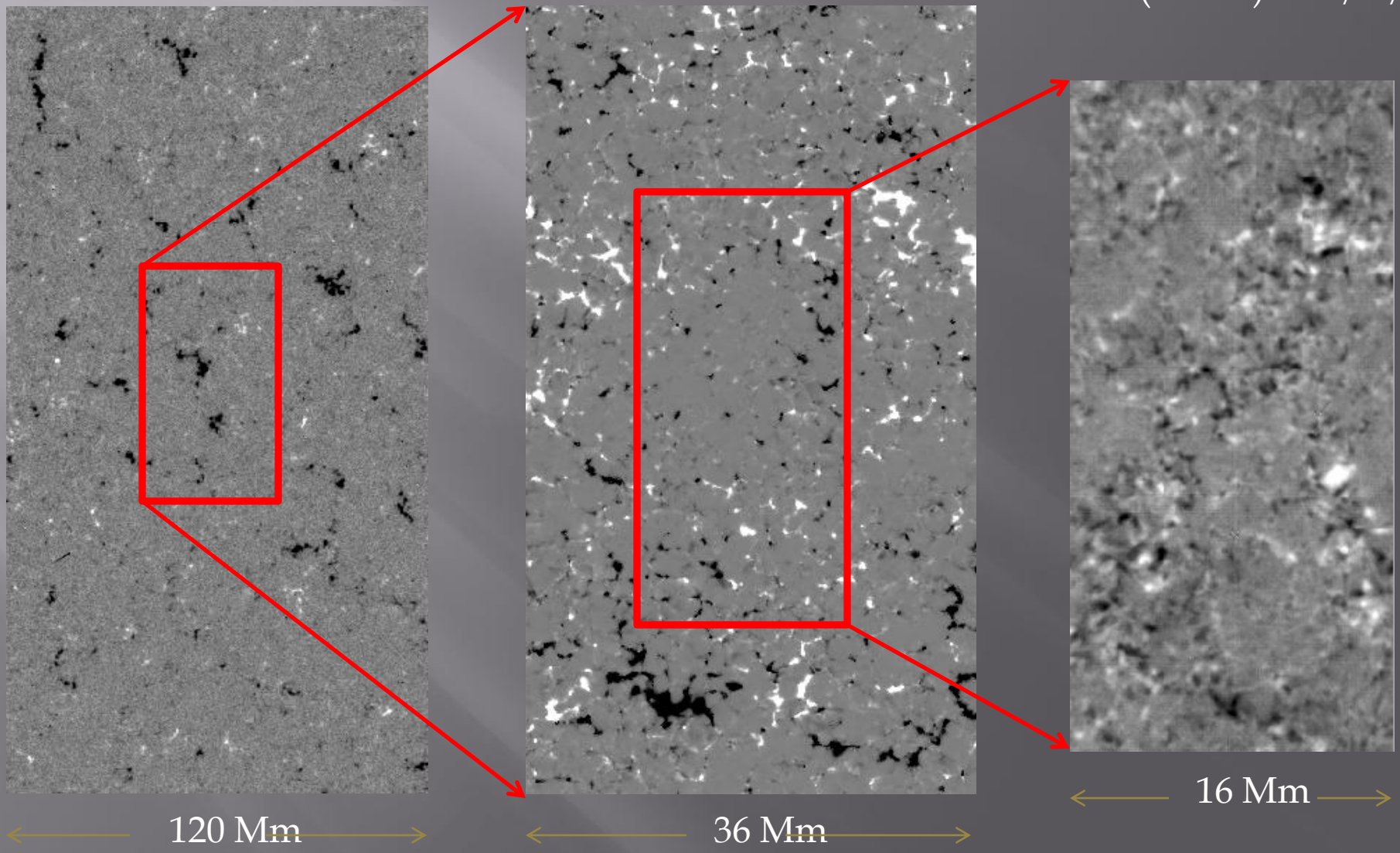
$$\lambda = \int_0^{r_{max}} B(r) dr,$$

Abramenko et al 2013, ApJ 773

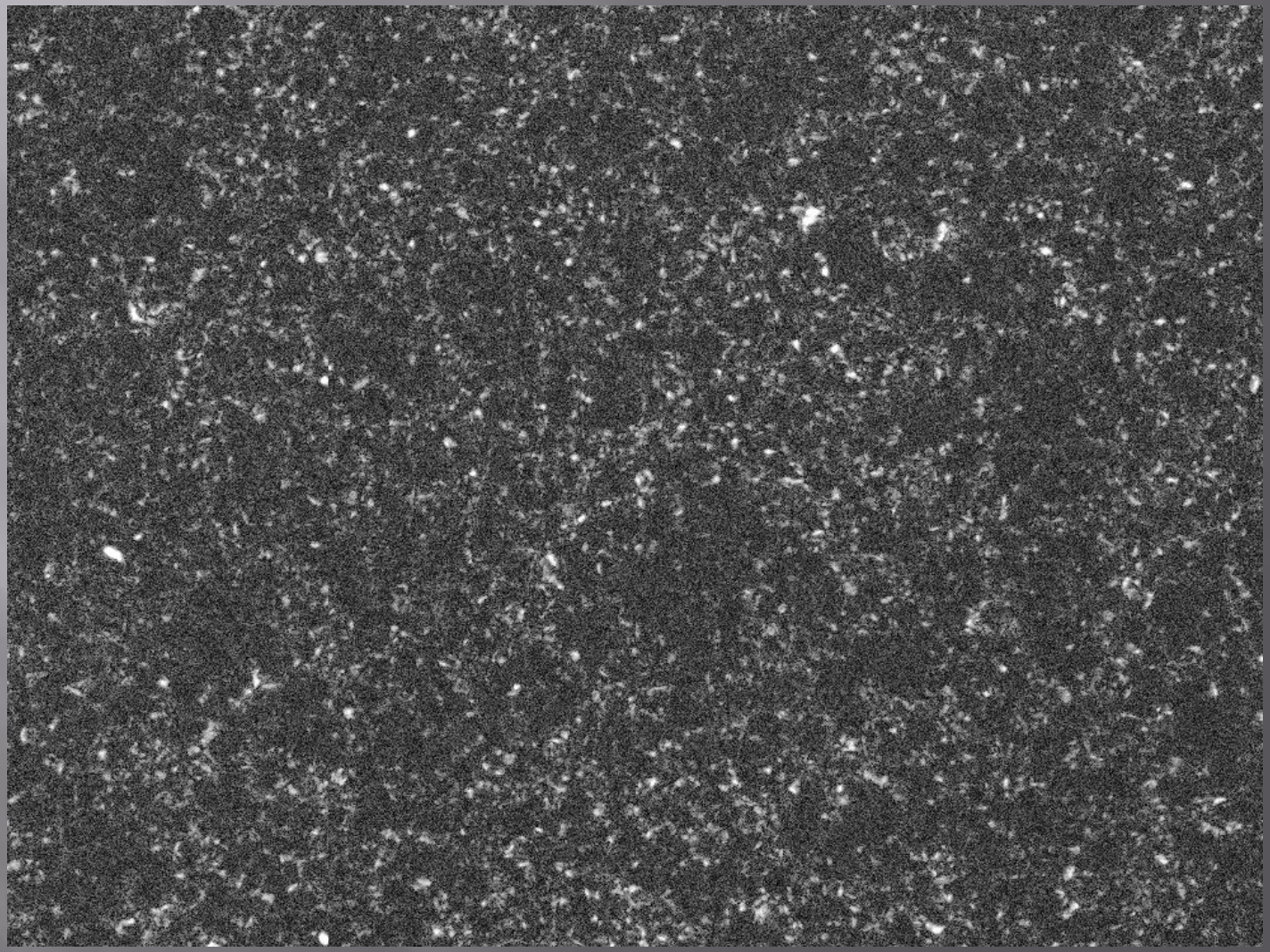
Calculated Correlation Functions of u^2 structures



Magnetic Field in Coronal Holes

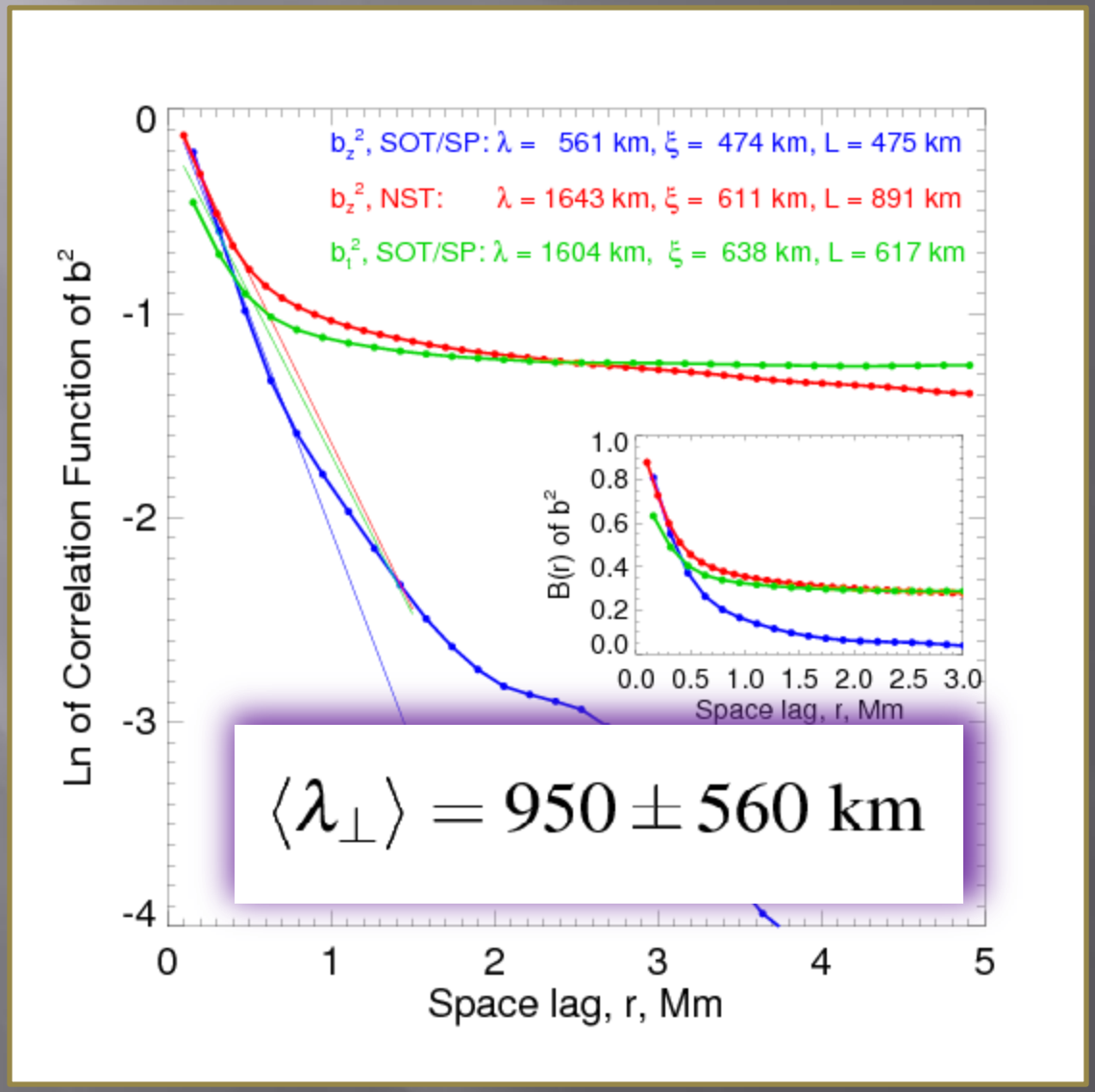


Transverse magnetic field in a quiet sun area (courtesy of B.Lites, Hinode SOT/SP)



10 Mm

Correlation Functions from magnetic field fluctuations



The correlation length defines directly the heating rate of the fast solar wind:

Matthaeus et al. 1999:

$$\epsilon = \alpha \frac{Z_-^2 Z_+ + Z_+^2 Z_-}{\lambda_\perp}$$

Zank et al. 2012:

$$NL_\pm = -\mathbf{z}^\pm \frac{\langle z^{\mp 2} \rangle^{1/2}}{\lambda^\pm}$$

Previously used λ=30 Mm

We report $\lambda < 1.5$ Mm

Conclusions

- The characteristic length scale of energy containing structures at the photosphere level seems to be of order of 1000 km (characteristic granule scale), but not 30 000 km (characteristic super-granular scale) as it was adopted in various SW models so far.

- Bulk of photospheric dynamics is concentrated in inter-granular lanes.

Table 1: Characteristic lengths of the squared transverse velocity fluctuations, u^2

	λ, km	ς, km	L, km
CH 2011-08-12			
T= 2 min	1821	659	845
T= 5 min	1847	702	884
T=10 min	1967	842	1077
T=20 min	2130	1024	1460
CH 2012-06-04			
T= 2 min	1773	656	846
T= 5 min	1811	765	969
T= 10 min	1861	887	1084
T= 20 min	1937	1070	1261
$\langle\lambda_\perp\rangle$	1893±115	826±160	1053±219