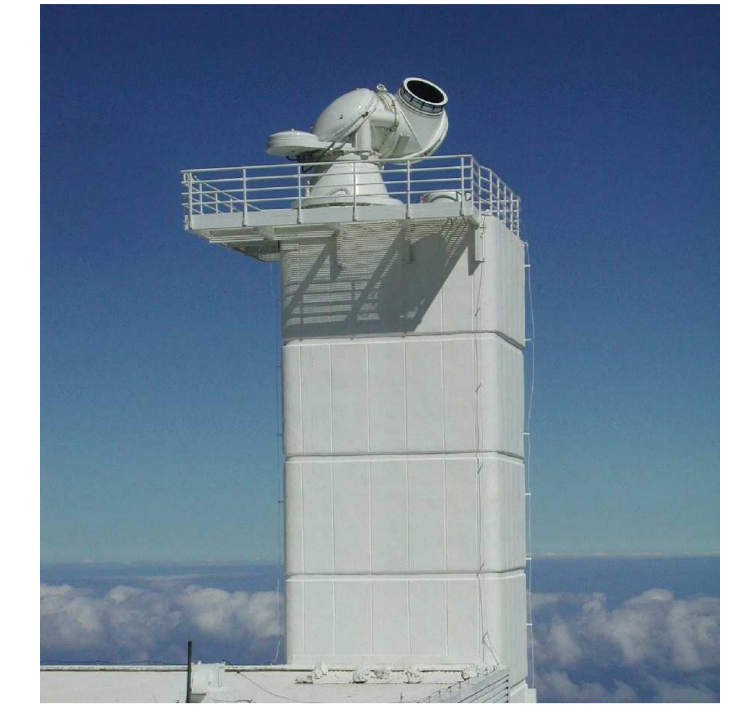




The Swedish 1-m Solar Telescope



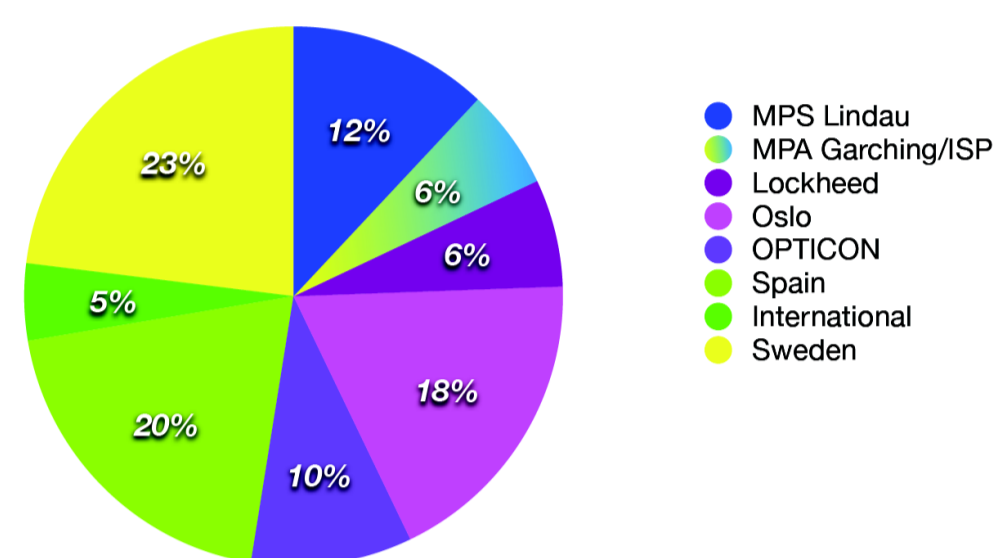
D. Kiselman, M. Löfdahl, G. Scharmer & M. van Noort

The Institute for Solar Physics of the Royal Swedish Academy of Sciences
Stockholm Observatory, AlbaNova University Center, SE-106 91 Stockholm

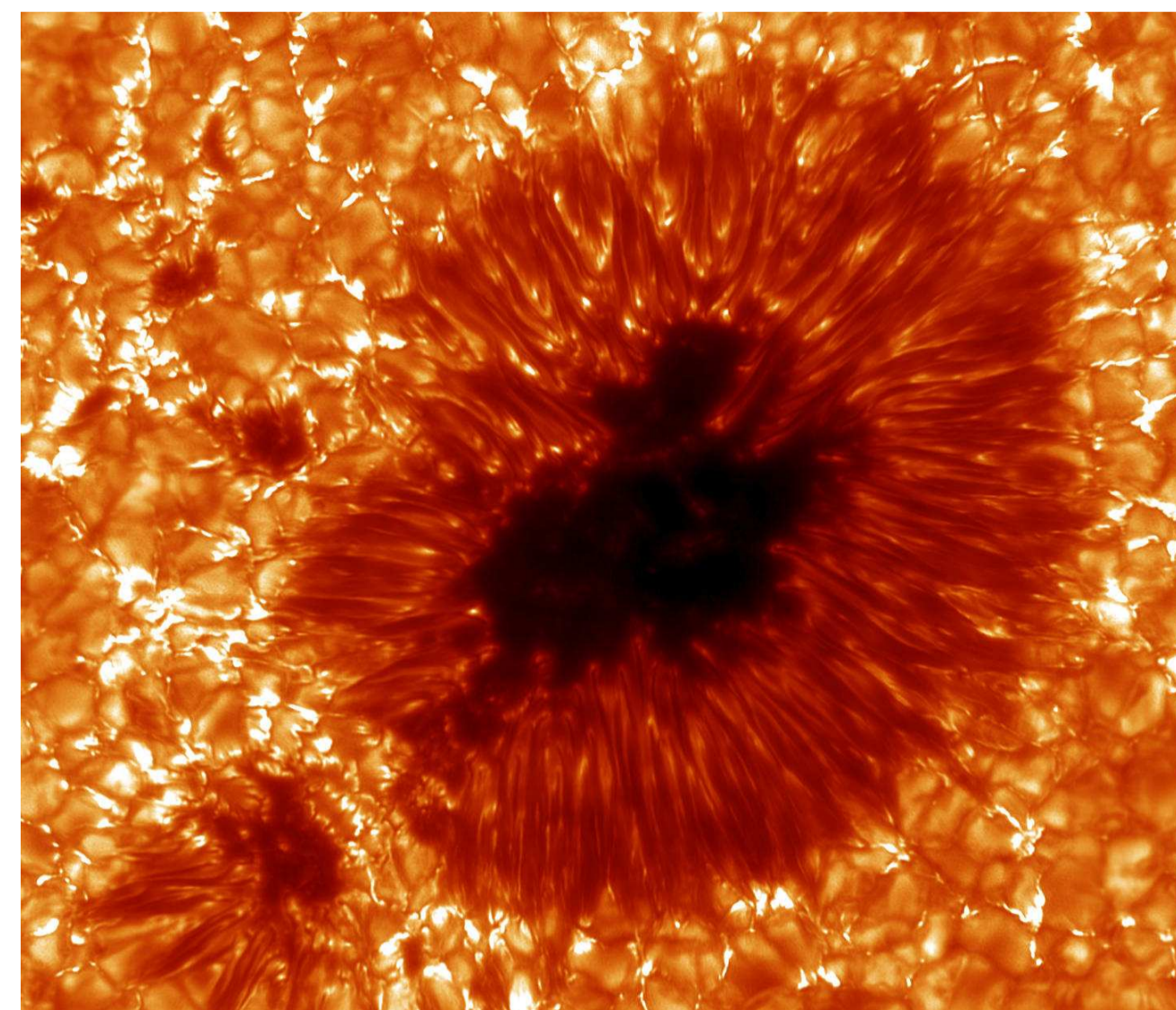
1. SST usage

The Swedish 1-m Solar Telescope (SST; Scharmer et al. 2003) remains the sharpest solar telescope in the world. There are around 30 scientific papers published each year on SST data of which about 20 in refereed journals. Apart from that, SST imagery serves an educational purpose for illustrating solar phenomena and appear 'everywhere'.

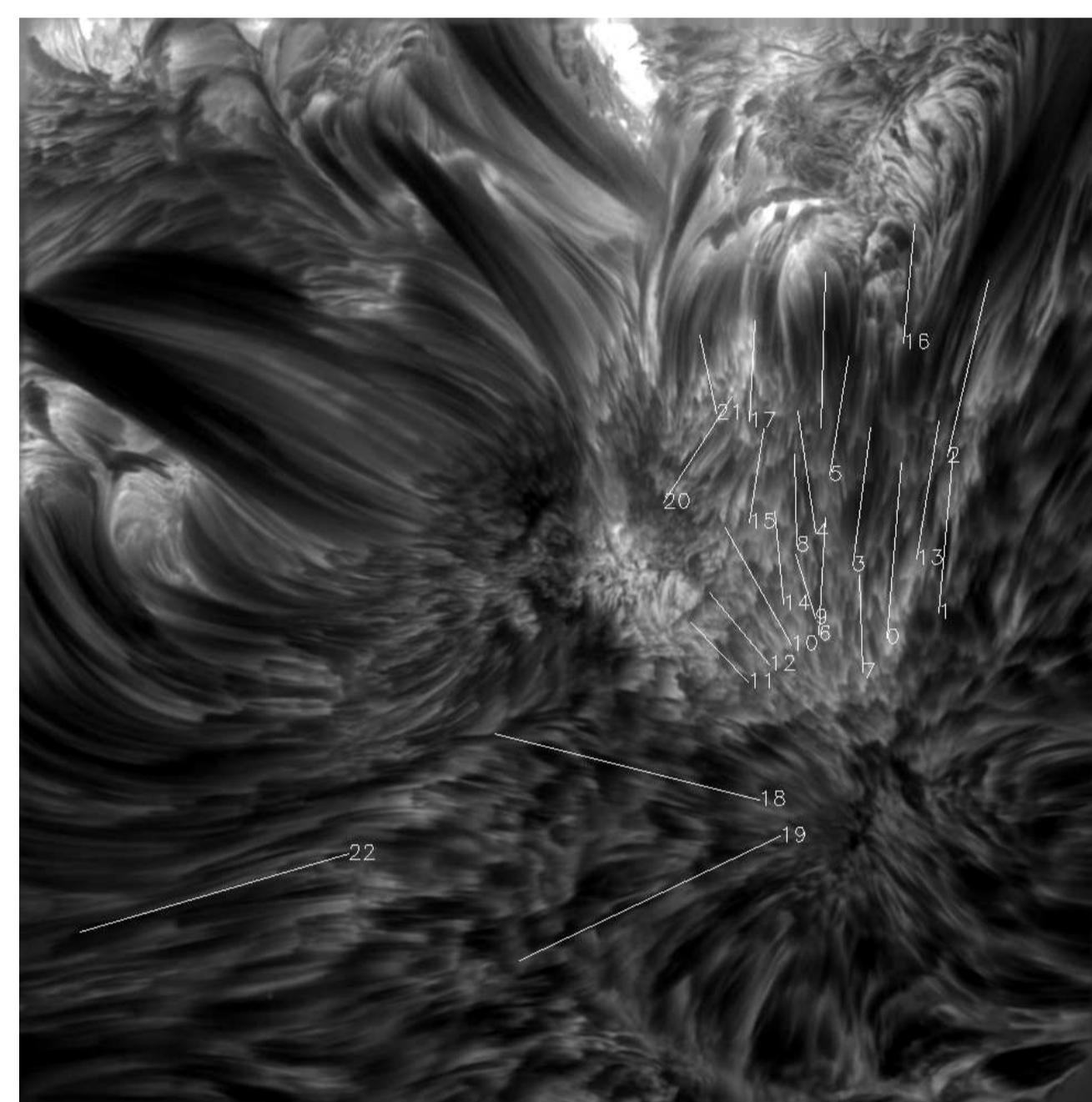
SST observing time 2007: 217 days



The diagram shows the observing time distribution in 2007. This year, there are 17 observing campaigns scheduled and the mean duration of a campaign is 13 days.



Observations by Scharmer.



de Pontieu 2007.

2. Scientific highlights

Since its opening in 2002, the SST has been used for studying several long-standing problems of solar physics. Here is a selection of some of the most important results.

Penumbral structure (Fig. to the left.)

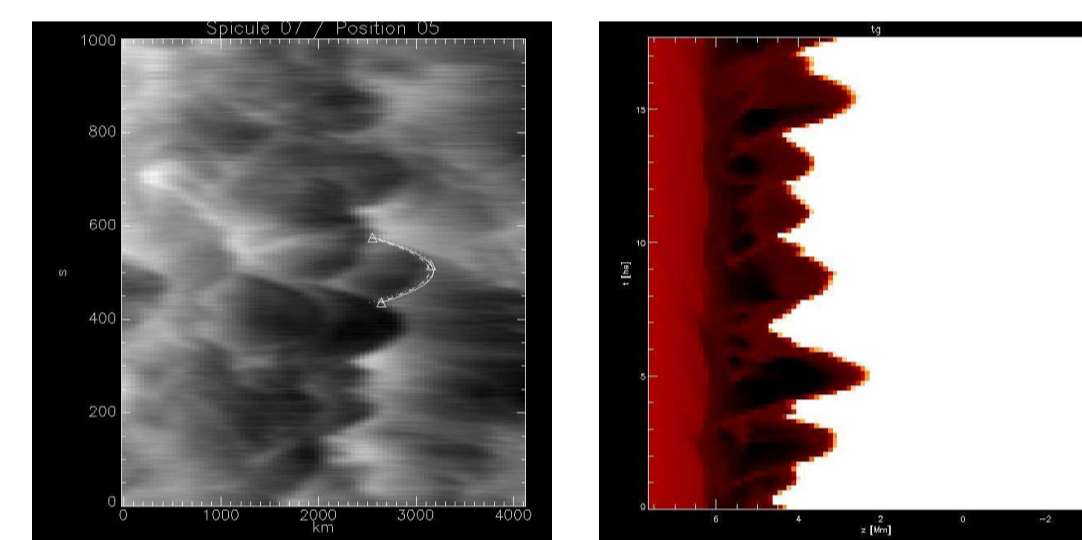
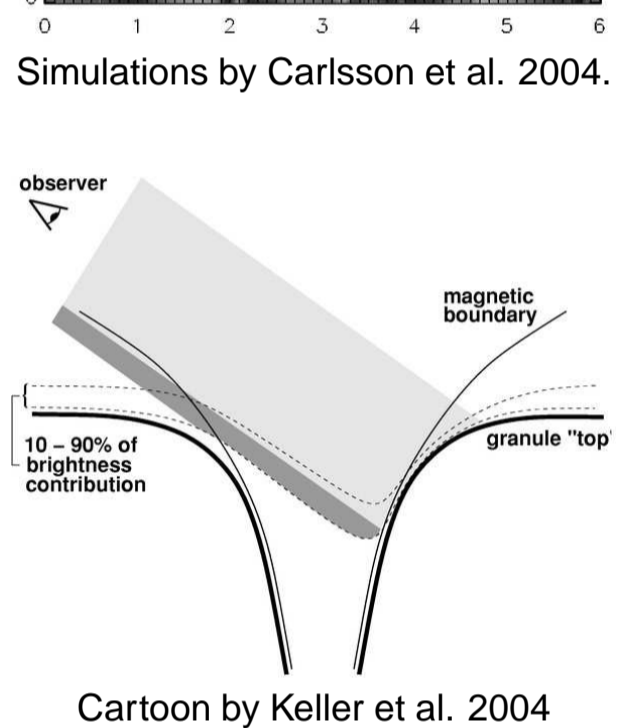
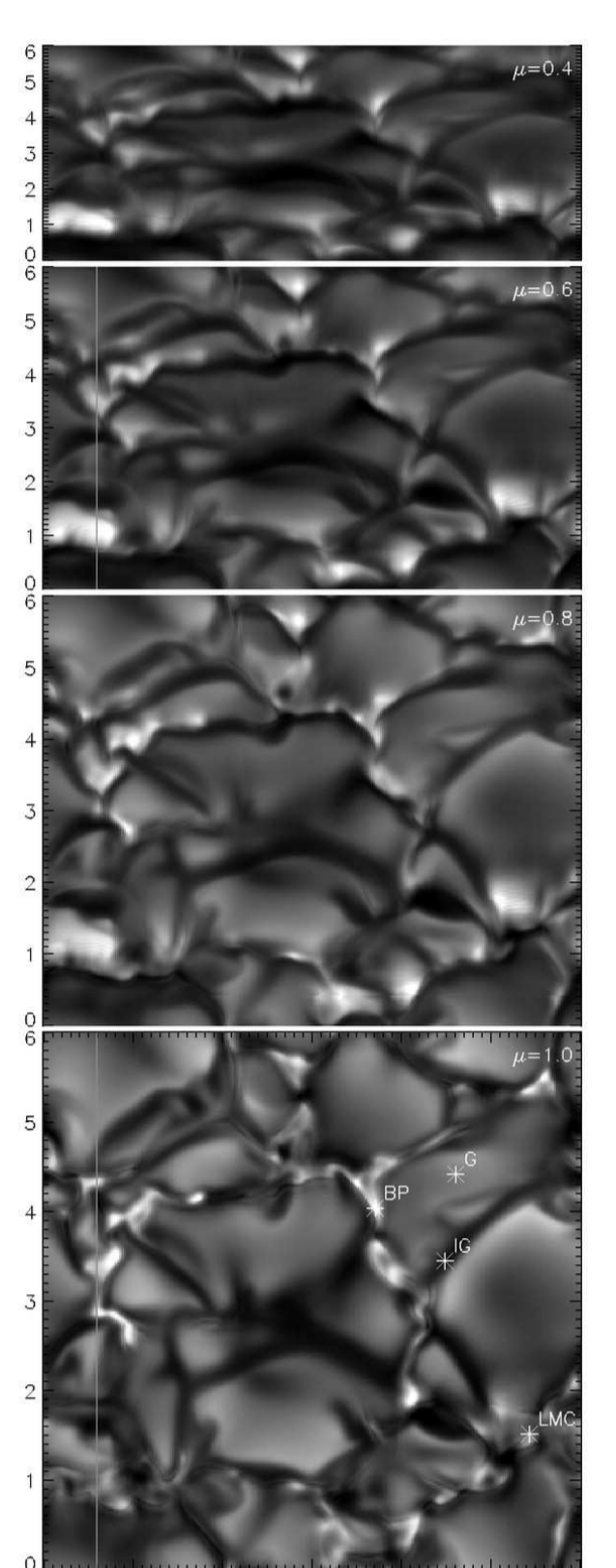
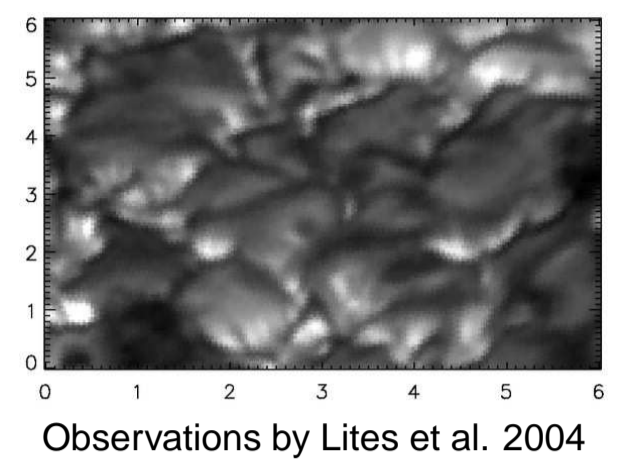
Imaging at $0''.1$ resolution immediately revealed hitherto unseen structures in magnetic regions (Scharmer et al. 2002). Notably, the discovery of dark-cored penumbral filaments in sunspots was unexpected and has stimulated theoretical efforts to explain penumbral structure. We know now that these dark cores are common, contain weaker and more horizontal magnetic fields and stronger Evershed flow, and that their appearance depend strongly on viewing angle. The latter implies that the penumbral surface is strongly warped. (Langhans et al. 2005, 2007)

Faculae (Fig. to the right.)

The clear view of solar faculae made possible by the SST together with numerical simulations, have shown that they are formed by side-wise radiation leakage from granules due to lower opacities in magnetic flux concentrations. Work by several groups: Lites et al. 2004, Carlsson et al. 2004, Keller et al. 2004, Steiner 2005.

Dynamic fibrils and spicules (Fig. to the left and below.)

A coherent picture seems to emerge from high-spatial and high-temporal resolution H- α observations where these chromospheric phenomena as driven by acoustic waves leaking from the photosphere along magnetic field lines and forming shocks in the chromosphere. Work mainly by Oslo and Lockheed groups: de Pontieu et al. 2004, 2007, Hansteen et al. 2006.

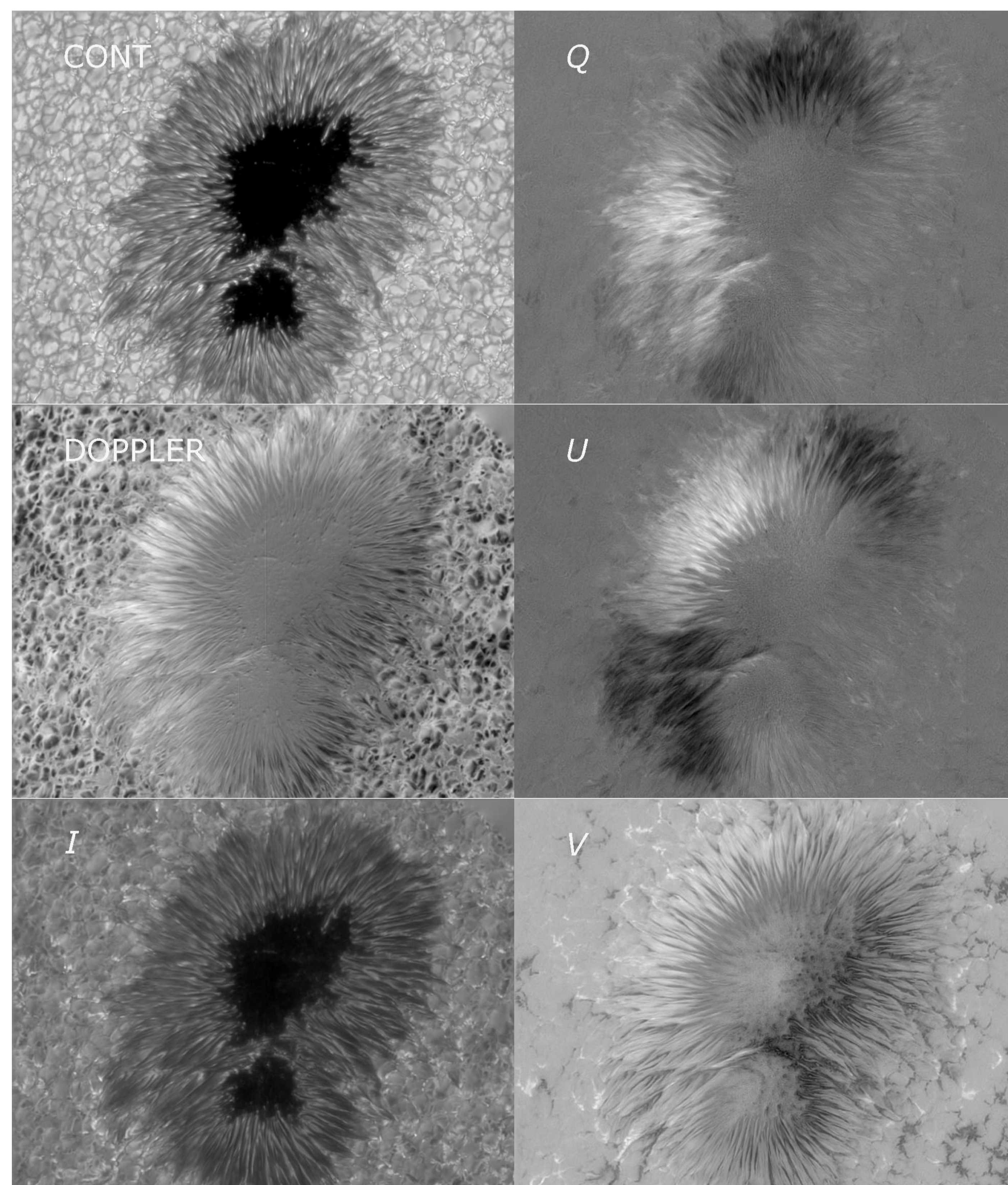


Left: observations. Right: simulations. de Pontieu 2007.

3. Full-Stokes imaging polarimetry

There is now a model of the telescope polarization. This is used to calibrate polarimetric data so that full Stokes measurements are possible. The figure below is an example of full-Stokes imaging in the 630.2 Fe I line with the SOUP Lyot filter. MOMFBD (see Sect. 4) was used for image restoration.

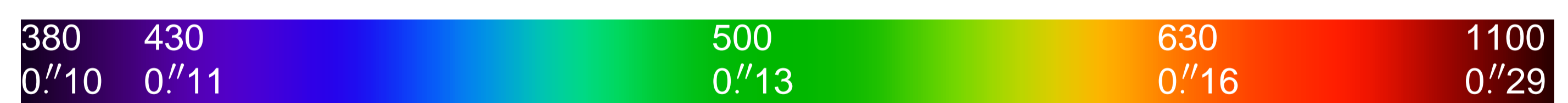
For the next season we should have our new Fabry-Pérot filter operational. This will significantly increase efficiency, allowing, e.g., sampling of many points in a spectral line.



Observations by van Noort

4. Instrumentation overview

The spectral range of the SST and the corresponding Rayleigh resolution.



Spectroscopy

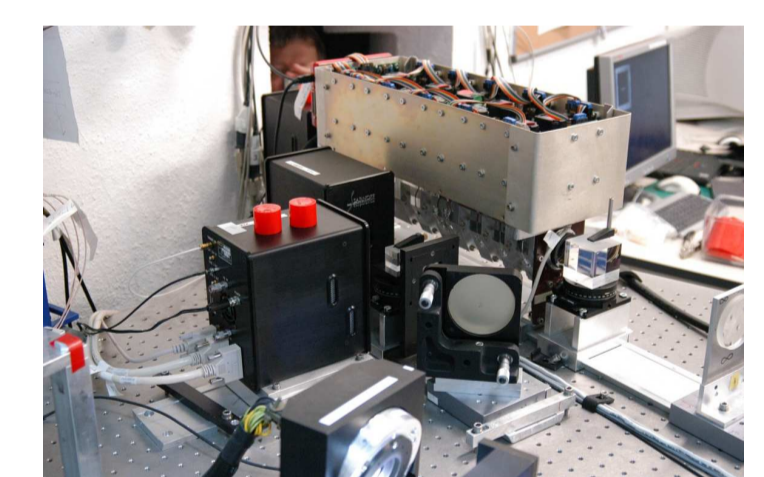
The TRIPPEL spectrograph with polarimeter has three spectral ports and provisions for slit-jaw imaging. The spectral resolution is around $R = 230\,000$ or 1.3 km/s .



Imaging

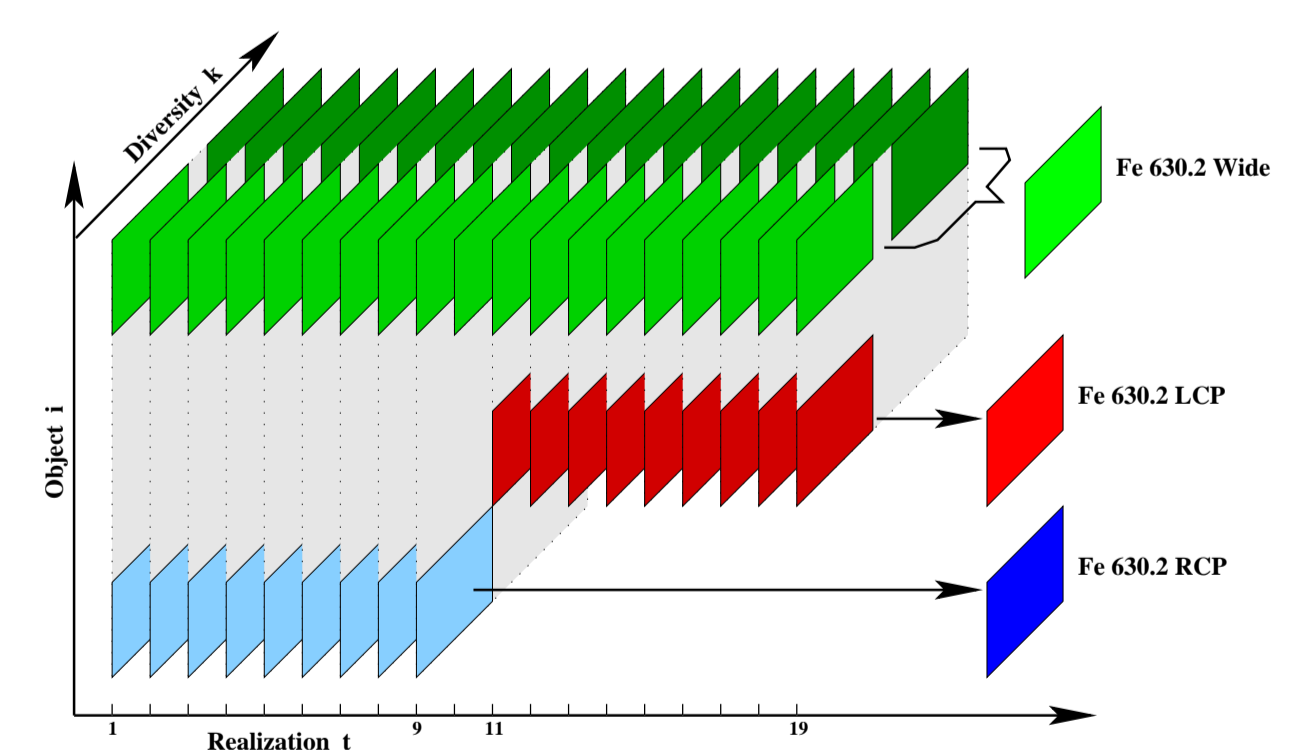
Blue beam: (Left.) 4 Megapixels II 4020 CCDs, tunable and fixed Ca II H, G-band, etc. ~ 10 frames/s.

Red beam: (Right.) 3 Sarnoff CCDs, SOUP tunable filter, polarimetry. 37 frames/s. Waiting for Fabry-Pérot. Total compressed data flow $\sim 1\text{ Tb/h}$!



MOMFBD

The Multi-Object Multi-Frame Blind Deconvolution (MOMFBD; van Noort et al. 2005) technique is used for all imaging observations. It is a model fitting method, that finds the estimates of the objects (the solar scenes) in multiple wavelengths and the pupil wavefront phase (the instantaneous seeing) that best fits the observed data. By combining many short exposure frames, we reach the resolution of a diffraction limited short exposure and the SNR of a long exposure.



A MOMFBD data set with two wideband phase diversity cameras and one tunable filter camera.

5. Acknowledgements and References

The Swedish 1-m Solar Telescope is operated on the island of La Palma by the Institute for Solar Physics of the Royal Swedish Academy of Sciences in the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofísica de Canarias.

Carlsson et al., *ApJL*, **610**, 2004.
Lites et al., *Solar Physics*, **221**(1), 2004.
Keller et al., *ApJL*, **607**(1), 2004.
Langhans et al. *A&A*, **464**(2) 2007
Langhans et al. *A&A*, **436**(3) 2005
Hansteen et al., *ApJL*, **647**(1), 2006

de Pontieu et al., *Nature*, **430**, 2004.
de Pontieu et al., *ApJ*, **655**, 2007.
Scharmer et al., *Nature*, **420**, 2002.
Scharmer, G.B. et al., *Proc. SPIE*, **4853**, 2003.
Steiner, *A&A*, **430**, 2005.
van Noort et al., *Solar Physics*, **228**, 2005