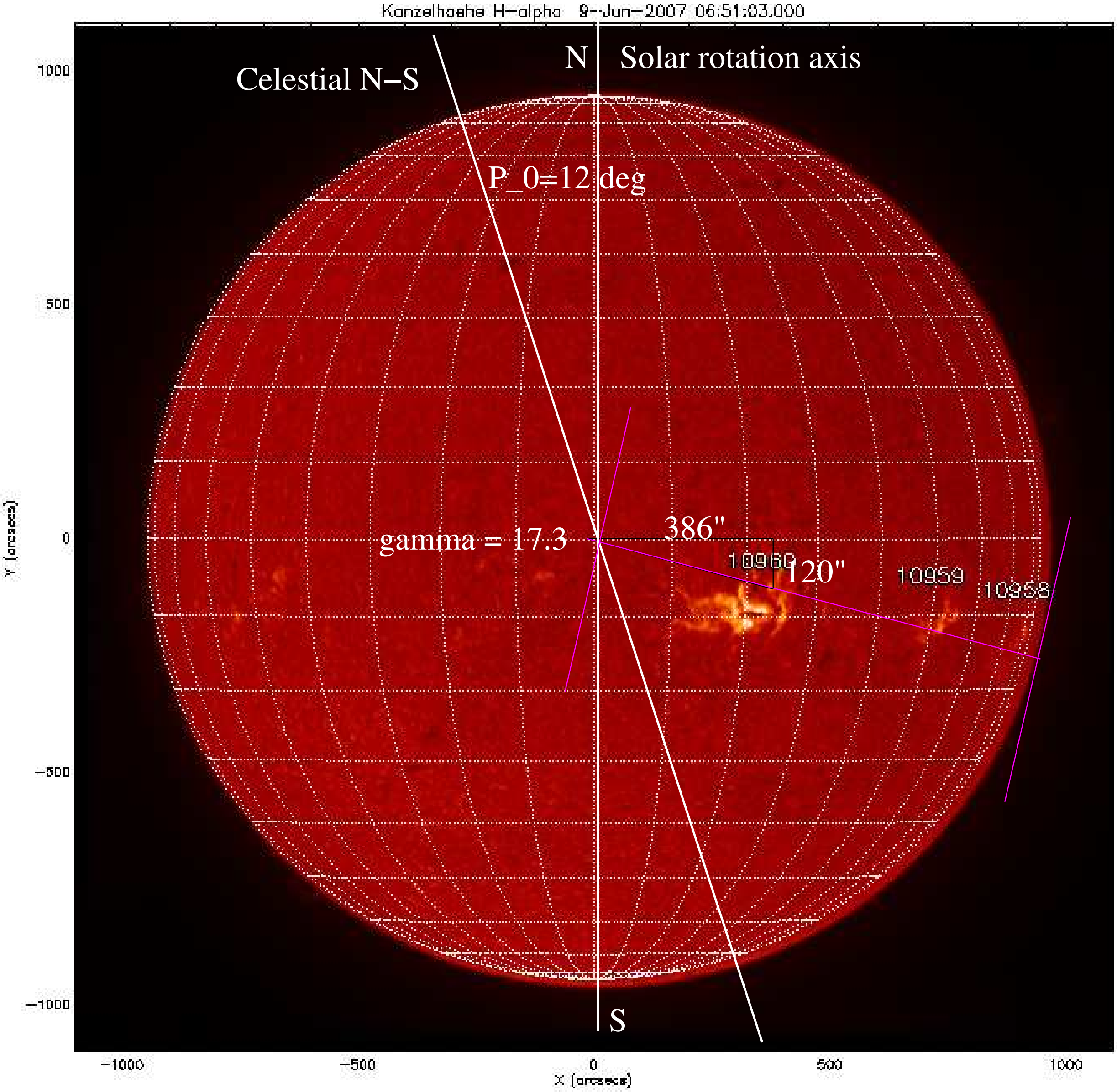
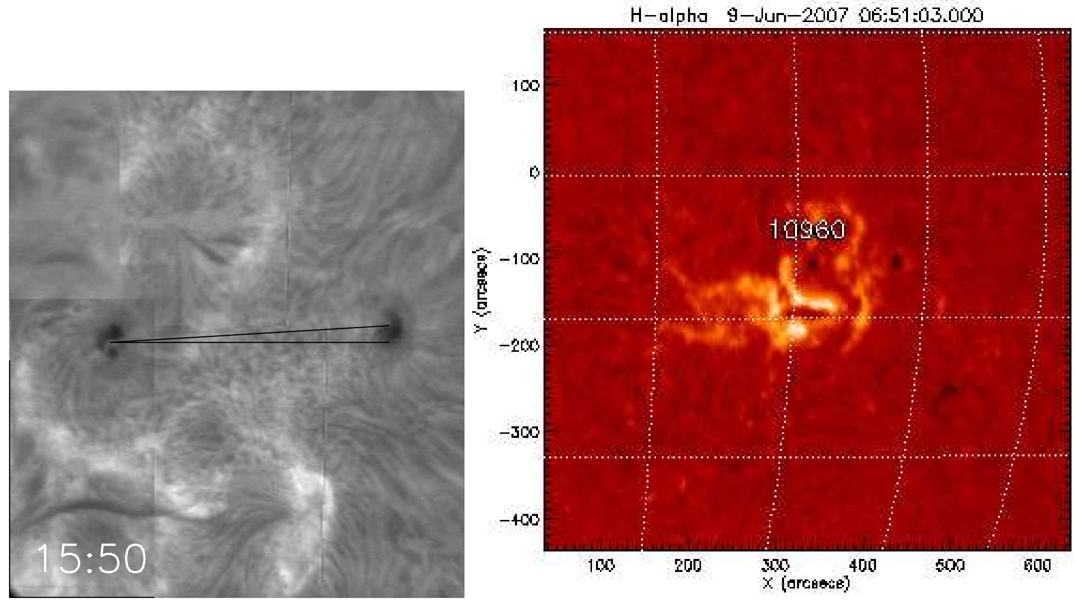
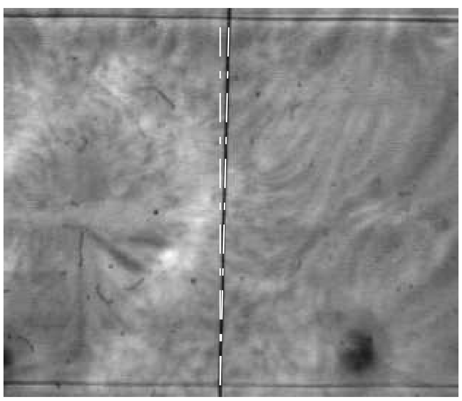


Full disc H-alpha image. Solar rotation axis is vertical. The solar rotation axis was inclined by P_0= 12 deg (B_0 = 0.3 deg) to the celestial N-S (CNS) direction. The CNS is the reference of +Q in the telescope model that corrects for the instrumental polarization.

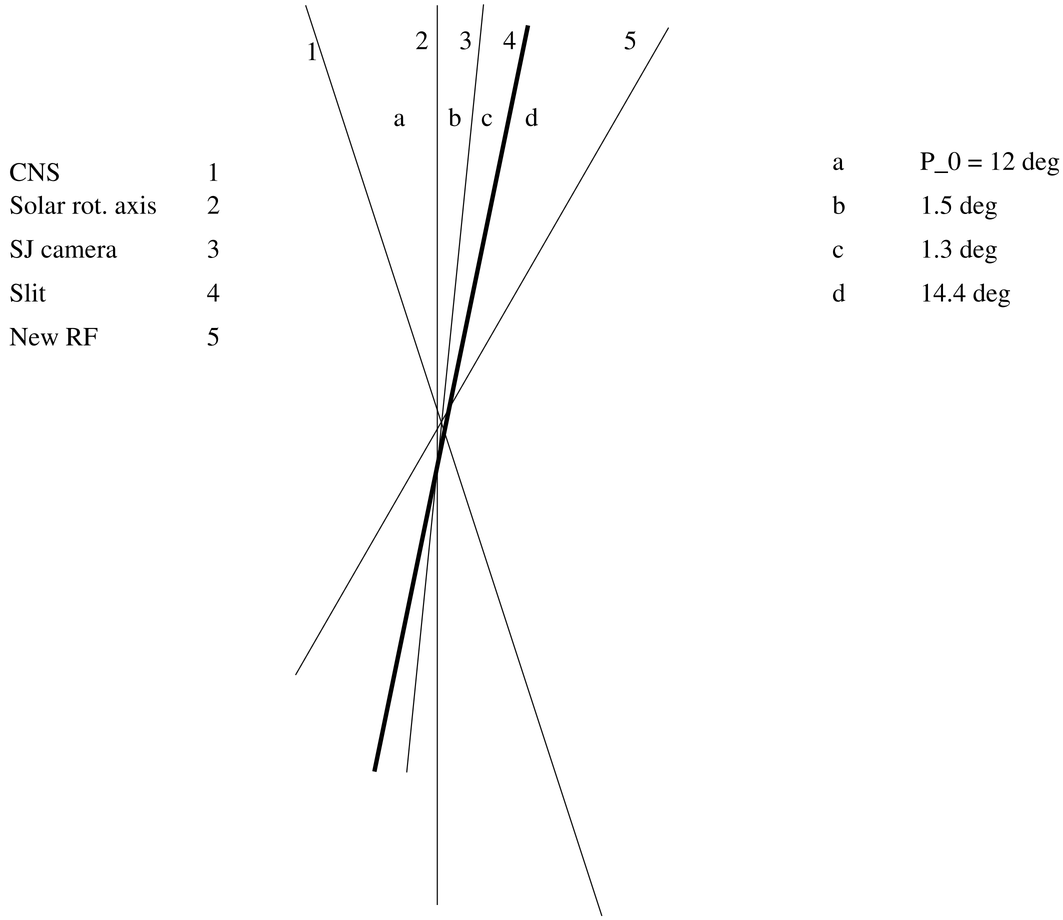
The active region was located at solar x/y = 386"/-120" (taken from TIP file header of 09jun07.011-01cc, UT 09:57:03 until 11:12:37). MDI coordinates for the active region arae 275"/-119" on 8.6., UT 19:15 and 484"/-137" on 9.6., UT 21:06. The angle γ= 17.3 deg measures the position angle relative to the horizontal E-W direction; it was derived by arctan(120/386). The desired new reference frame should have +Q parallel to the limb, which implies it makes an angle of 17.3 deg to the rotation axis.



Orientation of TIP SJ-images relative to Kanzelhoehe H-alpha image. The connection between the two sunspots makes an angle of $\gamma_1 = 3.4$ deg to the horizontal in the SJ mosaique (left). In the section of the full-disk image (right), the same angle to the horizontal is only $\gamma_2 = 1.9$ deg. The SJ camera system is thus rotated by 1.5 deg more than the full-disc image.

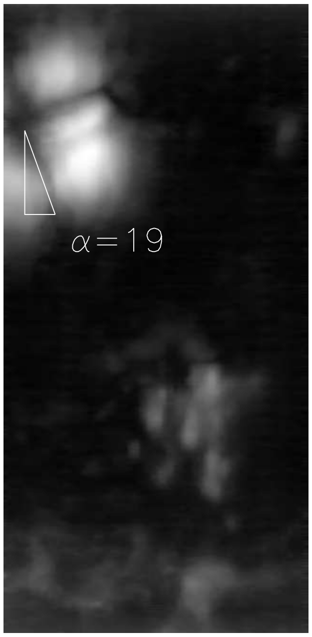


Orientation of the slit inside the SJ images. I used a non-flatfielded SJ image. Slit and vertical direction are given by dash-dotted white lines. The slit makes an angle $\gamma_3 = 1.3$ deg to the vertical of the SJ image. Together with the upper part, this implies that the slit was at an angle $\gamma_3 + (\gamma_1 - \gamma_2) = 2.8$ deg to the solar rotation axis. This has to be compared with the default orientation of the spectrograph that was put to 196 deg. With subtraction of $P_0 = 12$ deg, the slit should have been at +4 deg to the rotation axis, which, however, agrees with the 2.8 deg derived from the SJ images.

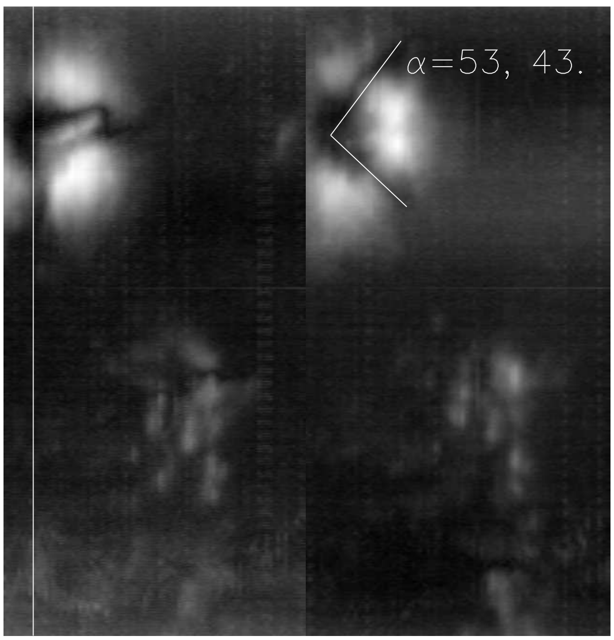


The figure above collects all orientations derived so far. From left to right the lines imply the CNS (1), the solar rotation axis (2), the vertical direction of the SJ camera system (3), the slit (4), and the orientation of the desired new reference frame (RF) with +Q parallel to the limb. The slit makes an angle of 2.8 deg to the rotation axis (4 deg using the spectrograph orientation of 196 deg). The new RF has an angle of 17.3 deg to the rotation axis, and thus, 14.4 deg to the slit.

Note that for the rotation of the polarization signal **the slit orientation can be totally ignored**. The slit orientation is only important insofar as it determines in which direction the +Q (or zero field azimuth) goes in the 2-D maps. For the rotation of spectra from CNS to the new RF only two contributions have to be taken into account: $P_0 = 12$ deg, and $\gamma = 17.3$ deg. A rotation by P_0 should bring the +Q direction onto the solar rotation axis, another by 17.3 deg in the same direction to the new RF.



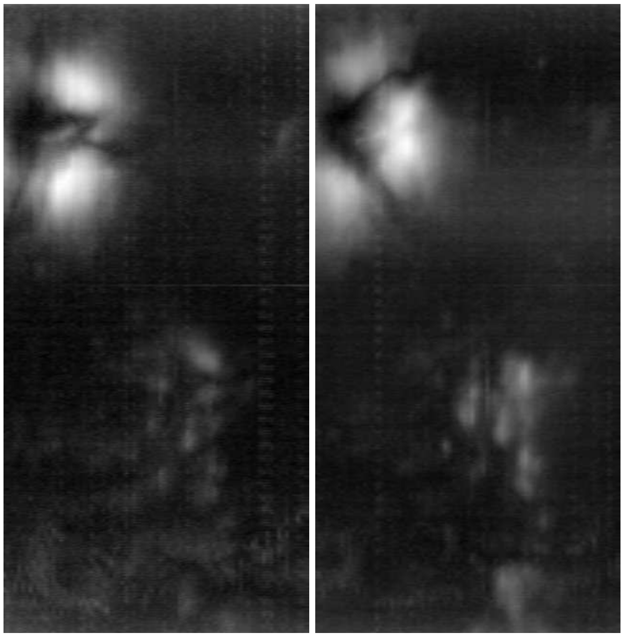
Left: The integrated Stokes-U map of the original data, without any changes applied to the spectra. Thus, the direction of +Q (= zero U) is along the CNS as given by the telescope model. The orientation of CNS is fixed in space, but the angle, under which +Q then appears in the 2-D maps, depends on the slit orientation to CNS. To be more precise, it depends both on the orientation of the slit and on the scanning direction relative to CNS. The 2-D map of the TIP data is constructed by putting together the individual scan steps assuming a scanning perpendicular to the slit, but there may be an offset angle as well. Taking the results of the previous page, the slit was at an angle of 12 deg+2.8 deg = 14.8 deg to CNS. Using the default spectrograph orientation of 196 deg, the angle should be 16 deg. The line of approximative zero Stokes U signal makes an angle of 19 deg to the vertical. The 3-5 deg difference are fine with me. Note that the image orientation corresponds to that of the H-alpha images and CNS is inclined to the left from the vertical, as would be required by the sketch of p.1.



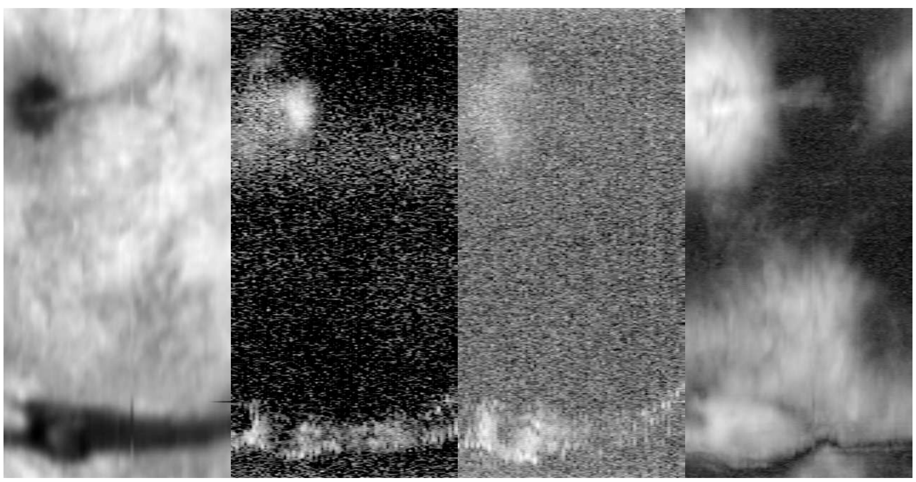
Integrated Stokes U (left) and Stokes Q (right) after a rotation by +16 deg. The rotation was applied to Stokes Q and U spectra by

$$
\begin{aligned}
Q' &= \cos(2\cdot 16)\cdot Q - \sin(2\cdot 16)\cdot U \\
U' &= \sin(2\cdot 16)\cdot Q + \cos(2\cdot 16)\cdot U.
\end{aligned}
\tag{1}
$$

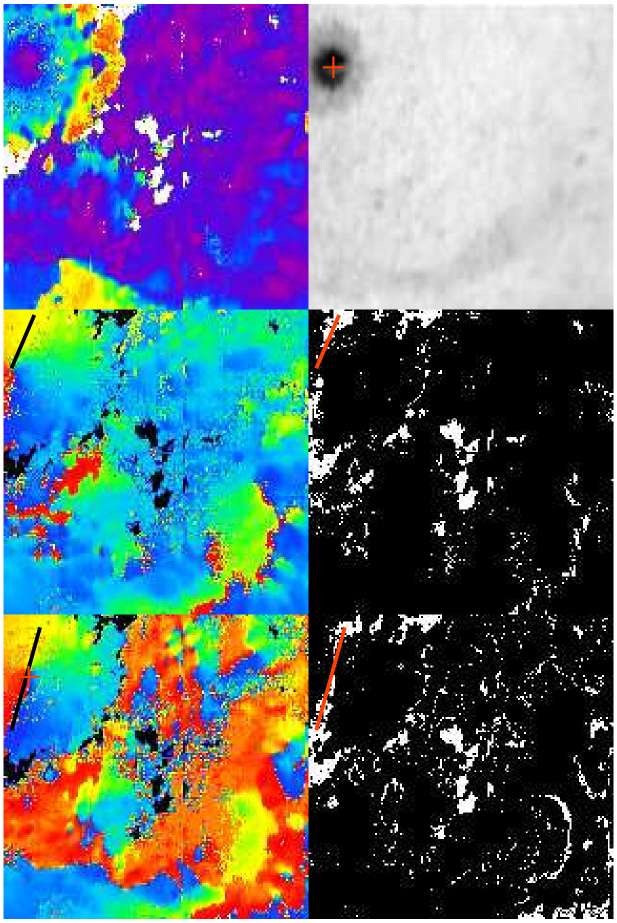
After the rotation, zero Stokes U signal is app. along the slit, and the zero Q signal makes an angle of 45 deg to the horizontal. This implies that a forward ration is needed to come from CNS to solar rotation axis.



Integrated Stokes U (left) and Stokes Q (right) after a rotation by 12 deg+γ = 29.3 deg. +Q makes an angle of 15 deg to the vertical, but this time to the right. The value should be 17.3 - 2.8 = 14.5 deg.



The integrated Stokes IQUV signal of the He 1083 line. Stokes Q and U have about equal strength in the filament. With the E-W-orientation of the filament in the image and the orientation of +Q of 15 deg to the vertical, the filament axis thus also makes an angle of 15 deg to the +Q direction. This fits to the Q and U signals: sin (2*15) = .5, cos (2*15) = 0.866 $\rightarrow$ Q $\sim$ U, with Q a bit smaller than U.



Consistency check with inversion results of rotated spectra. The spectra wer rotated by 29.3 deg prior to the inversion. Left column, bottom to top: field azimuth in local reference frame (LRF, z=local vertical, +Q= 0 deg in new RF), field azimuth in LOS RF (z=LOS, +Q=0 deg in new RF), field inclination to local vertical in LRF. Note the jump of the azimuth center between LOS RF and LFR, from the penumbra in LOS RF to the center of the spot (red crosses). Right column, bottom to top: locations with field azimuth of ±5 deg, 180 ±5 deg in LRF, same in LOS RF, Stokes I continuum. The angle between the vertical and the 0/180 deg azimuth direction is 23 deg for the LOS RF (black/red line in middle panels) and 15 deg for the LRF frame (black/red line in bottom panels). Default value would be 14.5 deg again (17.3-2.8 deg). The fact that the LRF inclination has its smallest values in the umbra (purple ∼0 deg, red ∼180 deg) with a smooth radial increase throughout the penumbra also suggests that the angles used in the conversion from LOS to LRF have to be correct to first order.

Conclusion:
With a clockwise rotation by app. 30 deg, one can transform from CNS to the RF with +Q parallel to the limb. The error is of the order ±5 deg. For the rotation only the angle between CNS and solar rotation axis and between rotation axis and the desired RF is needed. The first angle is taken to be P_0, the 2nd angle derived from the location as given by the TIP file header, i.e. the telescope pointing information at the time of the observation. Agreement is especially well with the 0/180 deg field azimuth direction after conversion to LRF.

Error sources: determination of the 2nd angle, residual QU↔UQ cross-talk in the polarimeter and telescope calibration.