

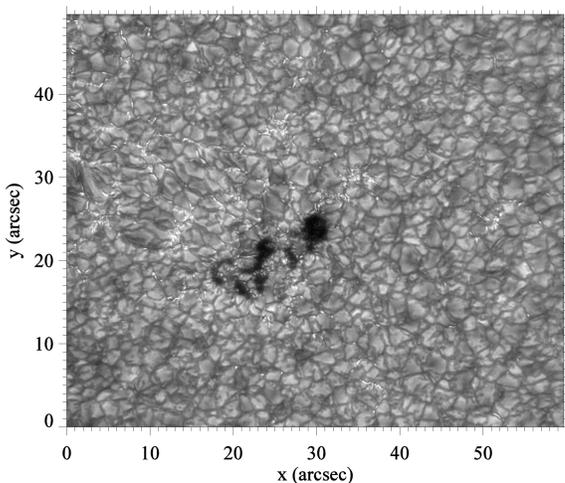
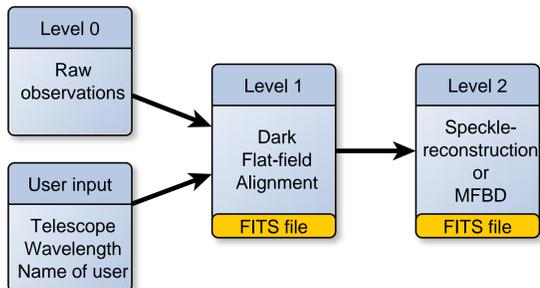
# sTools – a data reduction pipeline for the GREGOR Fabry-Pérot Interferometer (GFPI) and the High-resolution Fast Imager (HiFI) at the GREGOR solar telescope

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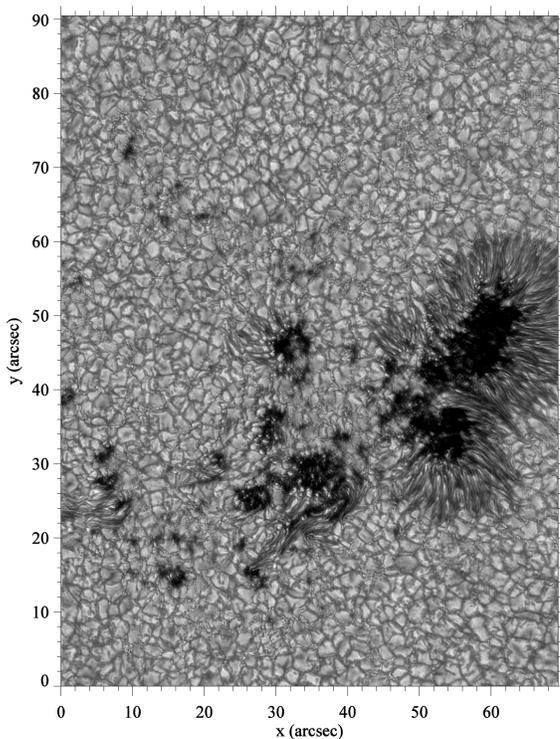
## Imaging

The sTools pipeline performs the data reduction of two imaging systems located at the GREGOR<sup>1</sup> telescope: (1) the PCO-4000 and (2) the newly acquired HiFI cameras inside the Blue Imaging Channel (BIC) of the GFPI instrument. The following flow chart describes the steps carried out by the pipeline:



Speckle-reconstructed image from HiFI at 4307 Å (G-band) of active region NOAA 12530. The observations were taken at GREGOR on 2016 April 11.

Once the data is reduced (Level 1), image reconstruction is carried out using the KISIP<sup>3</sup> package (Level 2). Therefore, the pipeline selects the 100 best images of each burst of images according to their Median Filter Gradient Similarity (MFGS<sup>4</sup>) value. The MFGS algorithm is a method to evaluate the image quality, i.e., the seeing conditions of the observations.

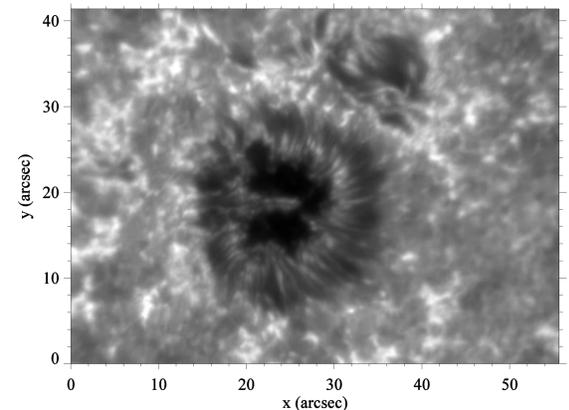
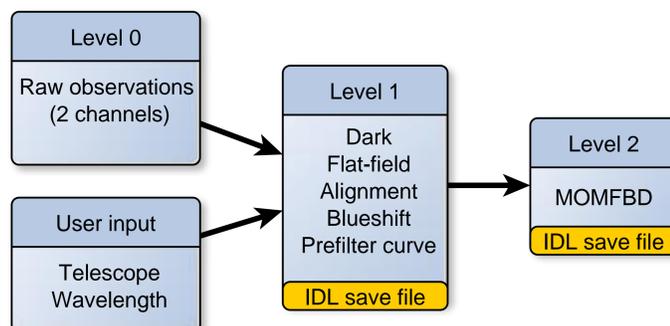


Speckle-reconstructed image from the PCO-4000 camera at GREGOR using KISIP. The target was active region NOAA 12567 on 2016 July 19 and the wavelength was 4505 Å. Observations were part of Solarmet access time (PI Cauzzi).

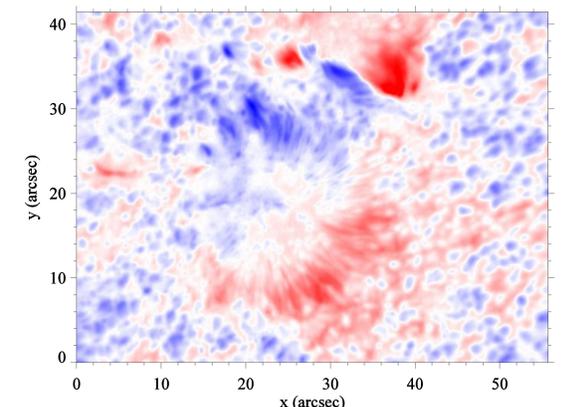
## Fabry-Pérot Spectral Imaging

The GFPI<sup>2</sup> consists of two synchronized CCD cameras: the narrow-band channel and the broad-band channel. The instrument operates in the visible and near infrared and has a collimated setup.

For the data reduction sTools requires where the data is stored and saved, the observed wavelength, and the name of the telescope. Afterwards, the pipeline generates, without any user interaction, IDL save files with the calibration data and the reduced observations. The flow chart below shows the corrections carried out by the pipeline. The user has also the possibility to reconstruct the data with the MOMFBD<sup>5</sup> code (Level 2), which has to be separately installed on the computer. The reconstruction process is very time-consuming and requires powerful multi-core processors with large memory.



MOMFBD-reconstructed narrow-band GFPI line-core image of 6173 Å. The sunspot belongs to NOAA 12544 on 2016 May 15. Observations as part of the international time (PI Rajaguru).



Line-of-sight velocities clipped between  $\pm 1.7 \text{ km s}^{-1}$  derived with the Fourier phase method.

# sTools

A huge data volume has been acquired at the GREGOR Telescope (Tenerife, Spain) with the GREGOR Fabry-Pérot Interferometer (GFPI), large-format facility cameras, and since 2016 with the High-resolution Fast Imager (HiFI). These data are processed in a standardized procedure with the aim of providing science-ready data for the solar physics community. For this purpose, as a team effort, we have developed a user-friendly data reduction pipeline called sTools based on the Interactive Data Language (IDL). The pipeline delivers calibrated and image-reconstructed data with a minimum of user interaction.

## Webpage

After the data reduction is completed, sTools generates a webpage including a general overview of the day:

1. a detailed overview of the available data (Fig. 1),
2. images of the average dark and flat-field data,
3. the MFGS values for each scan or burst of images to easily find the best data set of the day (Fig. 2),
4. the GFPI blueshift and prefilter curve (Fig. 3),
5. quicklook GFPI science data including: broad-band, line-core, full-width-at-half-minimum, equivalent width, and line-of-sight velocity images.

All reduced GFPI and HiFI data will be stored as a backup at the servers of AIP. Access to the quicklook webpages is provided through <https://gregor.aip.de> (for now only accessible to scientists of observing campaigns at GREGOR and the GREGOR consortium). In the near future the archive will be available to the whole solar physics community.

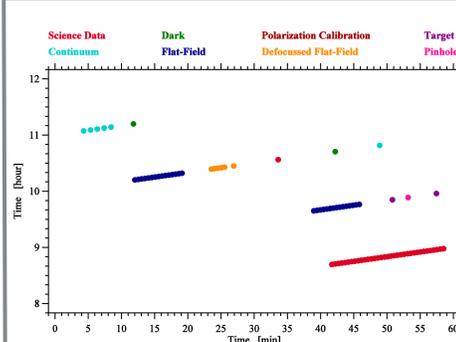


Fig. 1: Overview of the data taken on one observing day at GREGOR with the GFPI. The axes show the time in hours and minutes and the colored dots represent the type of data which was taken at each time.

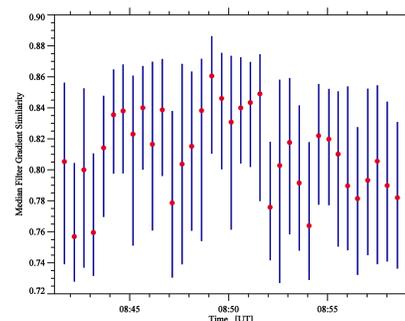


Fig. 2: The MFGS algorithm provides valuable information about the data quality during the day. The higher the number the better the seeing. sTools computes the MFGS for each image.

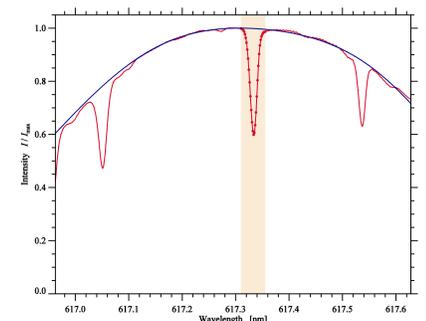


Fig. 3: Computed prefilter curve (blue) for the GFPI narrow-band channel. The red curve corresponds to a GFPI long scan. The shaded area represents the spectral range used for the observations.

## More information about sTools

sTools is developed by the optical solar physics group of AIP and licensed under a creative commons license. The pipeline is planned to be publicly released by March 2017. If you already wish to test our preliminary version of the pipeline please contact us.

## References

1. Schmidt et al., *AN*, Vol. 333 (9), p. 796, 2012
2. Puschmann et al., *AN*, Vol. 333 (9), p. 880, 2012
3. Wöger & von der Lühe, *SPIE*, Vol. 7019, id. 70191E, 2008
4. Deng et al., *Sol. Phys.*, Vol. 290 (5), p. 1479, 2015
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