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# High Cadence Digital Full Disk H$\alpha$ Patrol Device at Kanzelhöhe

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**Abstract.** The need for monitoring the sun in the prominent H$\alpha$-line is evident. For a long time this recording was done on photographic film at Kanzelhöhe Solar Observatory. Now with the evolution of CCDs and digital mass storage devices it is possible and even more economical to do this job digitally. A 1kx1k CCD camera and a standard frame grabbing system on a conventional PC are attached to the established Kanzelhöhe Patrol Instrument with a narrow band H$\alpha$ filter. At the present state a very simple frame selection mechanism is installed to improve the image quality. The data are archived on CDs. The development of a standard image processing and evaluation system is in progress. Low cadence synoptic images are currently fed into the SOHO synoptic database. Instant data access from the Kanzelhöhe database via WWW is planned.

## 1. Introduction

In order to understand the evolution and the dynamics of the solar atmosphere and its relation to the earth, long-term ground based H$\alpha$ observations complement the space observations. Therefore the sun is monitored by several stations all over the world, e. g. Big Bear Solar Observatory in California, Holloman Air Force Base in New Mexico, Kiepenheuer Institut für Sonnenphysik at the Observatorio del Teide/Tenerife in Spain, Learmonth Solar Observatory in Australia, National Solar Observatory at Sacramento Peak in New Mexico and Observatoire de Paris Meudon in France. For several decades full disk H$\alpha$ observations have been performed at Kanzelhöhe Solar Observatory using photographic film as recording media. Mainly intended for flare patrol, the observations have also been used to study the rotation of the chromosphere and the evolution of prominences (e. g. Brajsa et al. 1991, Rudzjak et al. 1989, Rudzjak et al. 1995, Zebedin et al. 1994 ).

Film handling, processing and finally the digitization process imply a heavy manual work, and also a time delay which precedes any scientific work. Direct digital recording and archiving should reduce these problems and simultaneously provide higher quality and easier access to the archive. With the availability of CCDs with sufficient resolution at a reasonable price and a mass storage system of widely accepted data format (WORM CDs), at Kanzelhöhe we started to move to this new technology.

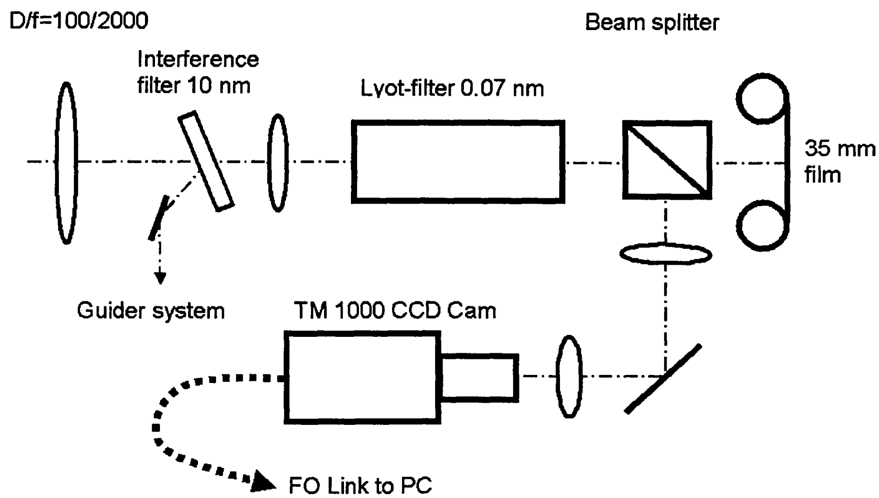


Figure 1. The layout of the Kanzelhöhe Digital Full Disk Hα Patrol System. An interference filter (10 nm FWHM) preselects the wavelength and prevents the ZEISS Lyot filter (0.07 nm FWHM) from thermal stress. The beam splitter enables the simultaneous operation of the old analog and the new digital system.

## 2. Instrumentation

The Kanzelhöhe Patrol Instrument houses several telescopes on a common mounting: A white light telescope with a projection system for the sunspot drawings, a coronagraph, the photoheliograph (Pettauer, 1990), a Magneto-Optical Filter operated in the Na-D lines (Cacciani et al., 1998) and finally the Hα Instrument (The layout is shown in figure 1). Attaching the new device required only minor changes to the system. A beam splitter allows to record simultaneously analog images on photographic film and digital ones using a PULNIX TM-1000 progressive scan camera with a 8-bit digital read-out. A parallel fibre optics links the camera to a DIPIX XPG-1000 frame grabber in a 486/66 PC running Windows 95.

To allow observation of prominences, the solar disk is scaled to about 860 pixels in diameter. The image scale is therefore 2.2"/pix, with a diffraction limit of the instrument of 1.65" at $\lambda$=656.3 nm. The image is undersampled but sufficient for the mean seeing conditions at Kanzelhöhe. Though the maximum frame rate of the camera itself is up to 15 frames/sec and in frame selection mode still about 8 frames/sec, the overall recording cadence is reduced to 1 image per 2 seconds limited by the data transfer from the grabber to the hard disk of the PC.

## 3. Image Aquisition and Processing

The software driving the frame grabber allows to save single frames or the "best" image of a preselected number of consecutive acquired frames (frame selection

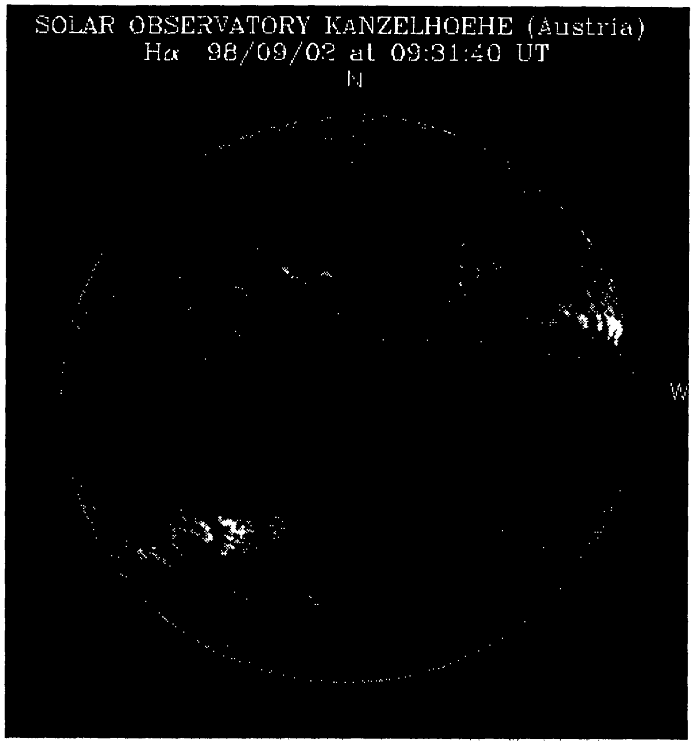


Figure 2. A processed composite image from the quick-look series as published online according to the standards for SOHO Ground Based Synoptic Observations. Asymmetries and CLV are removed, the region outside the disk is intensified to make prominences better visible. The disk is unsharp masked to enhance the structures. Annotations are only displayed in the quick-look series saved in GIF or JPEG format, the full sized data contain the relevant information in their FITS header.

mode) to a 1 Gbyte HDD. These two modes can be repeated at selectable time intervals (for patrol operation). The raw images are copied to CDs for the basic archive. At the present state and in low cadence mode the further image processing is performed using IDL after the end of the acquisition process.

## 3.1. Frame Selection

To select the "best" one among a number of consecutive acquired frames, we look for the frame with the maximum variance in a subsection of the frame near disk center. The variance is directly correlated to the average contrast of the image and can be calculated using a fast internal routine of the frame grabber's on-board DSP.

## 3.2. Flat Fielding

The read-out noise of the system is very low. Only two pixels are different from zero in dark images, although one pixel column is corrupt and shows an arbitray shift in intensity. But investigation of correlation to the neighbouring columns and autocorrelation of the column showed the column to be consistent itself.

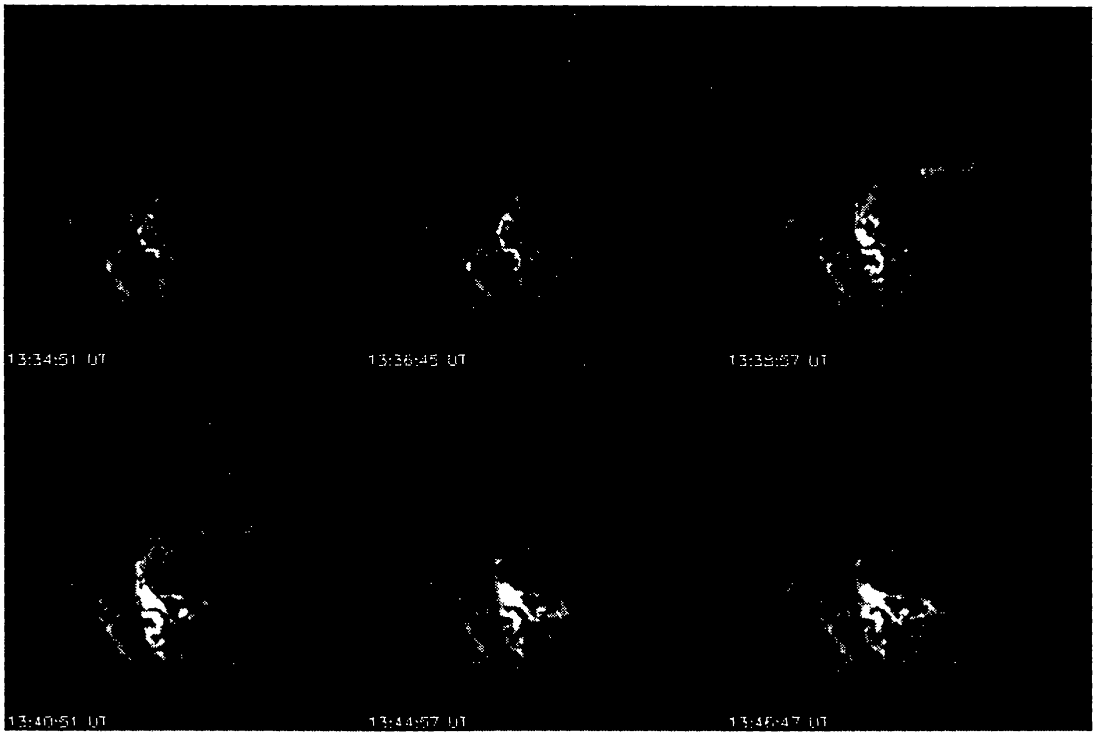


Figure 3. Temporal evolution of a X1/3B flare observed in region NOAA 8210 during the UVCS campaign on May $2^{nd}$, 1998 with maximum near 13:46 UT. These frames are selected from the increasing phase. The original cadence was 1 image per minute. This event triggered a Moreton wave which was clearly visible in a movie created from these observations. The movie can be downloaded from the Kanzelhöhe WWW server.

So one can determine the shift for each image and correct it by subtraction. Further a large scale asymmetry can be observed. It can be removed by using a flat fielding method developed by K. Burlov-Vasiljev at KIS Freiburg, Germany. This method, which uses a single frame, divides the solar disk into concentric rings and fits polynomials into these. As the disk is supposed to be radially symmetric at large scales, the polynomials give the image distortion similar to a Fourier decomposition. Combining the polynomials of the rings this method gives also the center-to-limb variation of the sun.

### 3.3. Image Centering and Orientation

Image center coordinates $(x_0, y_0)$ are determined by looking for the middle point between the maximum gradient positions along several pixel rows (for $x_0$) and columns (for $y_0$) and averaging the row and column data. The image is shifted near to center by an integer amount of pixels to avoid data distortions due to pixel averaging.

Because of the equatorial mounting of the telescope we don't have a systematic image rotation during the day. Therefore the correction angle $\Delta P$ which denotes the inclination of the E-W-direction with respect to the frame axes is constant apart some small variations (less than $\pm 0.2°$) due to small shortcomings of the telescope and the mounting. It can be determined and checked from time to time by recording a set of images with turned-off tracking system and computing the track of the disk centers. Heliographical positions can be given with a precision better than $\pm 0.5°$.

### 3.4. Image Cosmetics

For quick-look purposes a composite image is created. It consists of a processed, CLV removed, structure and contrast enhanced disk image superimposed with a coronagram to enhance the visibility of the prominences. The coronagram is calculated by subtracting the disk from a raw frame and intensifying the residual image. From the time of observation we calculate the physical ephemeris $(P, B_0, L_0)$ and rotate the disk to have Solar North up as generally used.

## 4. Data Archive

The basic archive consists of patrol observations with a cadence of 1 image per 4 minutes to continue the existing recordings. Data are saved in a raw image format on CDs. A software library will be provided for the basic data handling. It is planned to have also a quick-look set of downsized, processed images to meet most of the requirements but allowing a much faster data access. Low cadence data - extracted from the basic data - are processed to meet the standards of the SOHO Ground Based Synoptic Observations. These images are available online from the Kanzelhöhe WWW server (`http://www.solobskh.ac.at`) and are mirrored by the SOHO-WWW site. We plan to be fully operational in mid of 1999.

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