PORTABLE SEEING MONITOR (DIMM4/DIMM5/DIMM6)

1 Description

DIMM4/5/6 are adapted from original ESO DIMMs (1/2/3) with higher portability and lower cost. The original Software, written in Turbo Pascal 7.0, was provided by Peter Wood, MS-SSO, Australia. The MS-SSO seeing monitor is based on a C11 Celestron and a ST4 SBIG (Santa Barbara Instrument Group) commercial CCD camera. The software was ported to the new ST5 SBIG Camera Universal CPU command structure with the help of M. Nastvogel (ESO Software Dept. Garching) and Rolf Lengenfelder (Gamsberg, Namibia).

DIMM4/5/6 are based on C11 Celestrons which allow for twin apertures diameters up to 9 cm, obtained with a mask placed on the entrance pupil of the telescope, above the Schmidt plate. On one of the holes, a Lambda/4, prismatic window (Herasil I (DIMM4/5) index 1.46 or BK7 (DIMM6) index 1.52, thickness 12 mm, diameter 100 mm, angle 162" (DIMM4), 195" (DIMM5) and 150" (DIMM6)) is used to shift one of the beams in the image plane.

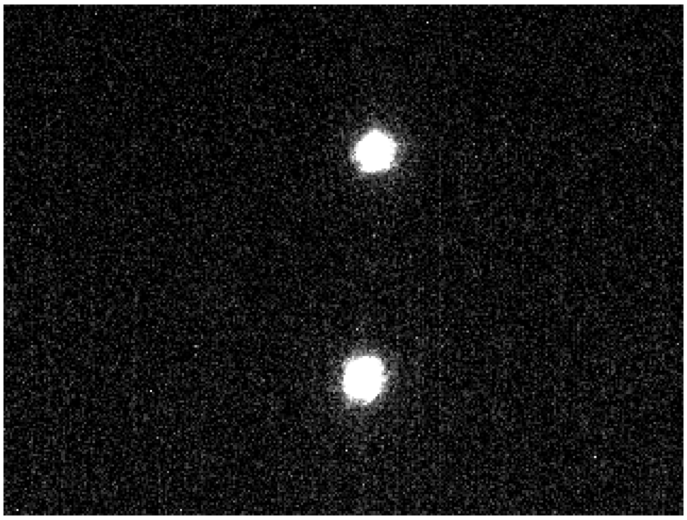
The ST5 CCD has 10x10 μm square pixels corresponding to 0.74 arcsec on the sky with the F/10 C11 telescope. The two star images are thus separated respectively by 101 (DIMM4), 121 (DIMM5) and 93 (DIMM6) pixels at the nominal focus.

2 Mechanical set-up

The prismatic window has first to be oriented so that the beam is shifted in the direction of the hole separation, towards the optical axis of the telescope to prevent vignetting. When the window tilt axis is known (+/- signs indicated by the manufacturer, the (+) mark is in the inner side of te mask, pointing to the second sub-pupil. In the opposite case, the correct set-up can be achieved with a laser in the lab, but also on the sky by rotating the window until a position is found where defocusing the telescope produces only changes in image separation without rotation in the image plane.

The top cover mask is first rotated to place the apertures along the declination axis of the mount for more commodity in guiding. At that stage, the two images should also appear in the ocular, aligned along the declination axis (if not, the window is not properly oriented).

When the DIMM software is running, the CCD is then rotated until the two images are aligned along its columns (vertical axis on the screen image) which then corresponds to the axis of the pupil separation on the mask, parallel to the declination axis of the telescope.



3 Measurement sequence

The computer looks for the fastest baud rate for communicating with the CCD CPU via the serial line (Max 115KBd), then displays the full frame (320x240 pixels with a 4x4 binning factor for faster frame rate). The star images have to be centered in the field to begin seeing measurements, as shown on the sample image. An automatic centering procedure is available, as well as remote handset control from the computer arrow keys. When using a standard celestron mount, the CCD CPU relay output should be connected to the CCD input of the mount control board, **with the slewing velocity factor set to 2x**.

During the centering process , the images are taken with a 200 ms exposure time while seeing is measured out of 10 ms (and 20 ms) exposures. This parameters may be changed by the user by editing the parameter file 'testbg.in'. So, while it is normal that saturation occurs during centering , no saturation should be accepted for seeing measurements (saturation is indicated by black pixels in the center of the star image). A 2 to 3rd magnitude star is convenient with 8 cm diameter apertures. Additional rings are provided to reduce the aperture to 5 cm diameter for very bright objects (the parameter *HoleDiam* has then to be updated in the file *'testbg.in'*). The image signal-to-noise ratio is controlled during the measurements so that low flux images (star too faint, clouds or scintillation) are eliminated. For both types of apertures, the center-to-center separation is equal to 19.2 cm (19.0 cm, DIMM6).

During seeing measurements, only the center part of the field is read and displayed (81x180 pixels) with a 8 bits intensity coding. However the full 14 bits dynamics of the ST5 is used for centroid calculation by the camera CPU itself. The image display should be disabled in normal operation to increase mesurement speed.

One seeing estimate is stored on the disk every N=100 validated exposures. With a correctly installed mount, a limited number of autoguiding corrections is needed, the measurement cycle (N=100 exposures) is then approximately 8 minutes. However, the display is updated at every exposure with a moving average on the past N=100 exposures.

The actual pixel angular size is permanently recomputed as a function of the average image separation during the seeing measurements, to take into account focus variations due to temperature changes. Measurements with pixel size at more than +/- 5% of the nominal value (ie: outside the range $]0.70, 0.78[$) are not valid and the telescope has to be manually refocused.

4 Operation

Install the software onto a 386 PC or higher. Connect the SBIG CPU to the COM1 serial port. Remove from your autoexec.bat and config.sys files all unnecessary functions so that the 115 KB communication speed with the CPU is reached. If the PC has a TURBO function, set it on. The time is given by the PC clock, check it has accurate UT.

Check that the file 'setup.in' contains the correct parameters. If using autoguiding mode, check the mount velocity factor is set to 2x.

Start the monitor, typing 'dimm' in the directory c:/sbig/dimm, the data will be automatically logged into two files:

c:/sbig/data/MMDDHHmm.all (eg: 10200415.all for 20 Oct 4h15)
c:/sbig/data/MMDDHHmm.see

The *.all files records correspond to individual exposures and include:

"*Time , Exposure rank (n), Intensity spot1, Intensity spot2, centroid(X1,Y1), centroid(X2,Y2), fwhm para(10 ms), fwhm perp(10 ms), fwhm para(20 ms), fwhm perp(20 ms), airmass*". FWHM para and perp are NOT CORRECTED FROM AIRMASS and estimated from the n previous exposures. The *.all files are normally not used in regular operation.

5 Results

The *.see files records correspond to N (N=100) exposures statistics and include:

"*Time , Intensity spot1, Intensity spot2, fwhm para, fwhm perp, pixel size, scintillation index, airmass, average fwhm at zenith, exposure time*".

The FWHM is computed in arcsec at 0.5 mu. FWHM para and perp are NOT CORRECTED FROM AIRMASS. The values for parallel and perpendicular motion should be similar within the statistical error which is inversely proportional to the square root of the number of exposures. Larger discrepancies arise from the unstability of the turbulence in the course of a measurement: it is recommended to reject data with a parallel to perpendicular difference larger than +/-40%. The average fwhm at zenith is obtained by averaging FWHM para and perp and correcting for airmass.

The minimum exposure time permitted by the frame transfer CCD (10 ms) is sometimes too long to freeze the wavefront and seeing is then underestimated. A second series of exposures at 20 ms has been intentionally interlaced to detect such events [1]. The recommended post-processing is to correct for an assumed linear exposure time averaging using the two estimates of each loop along:

$$\mathrm{FWHM} = \mathrm{FWHM}(10\mathrm{ms})\frac{\mathrm{FWHM}(10\mathrm{ms})}{\mathrm{FWHM}(20\mathrm{ms})} \tag{1}$$

This procedure has the unconvenient to increase the measurement noise, it is thus recommended to compensate by some data binning (eg. 20 minutes duration moving average) for presenting the results.

6 Possible reasons of unreliability

Although image quality checks have been introduced in the JUN95 release, it is still possible to obtain unreliable data without warning from the instrument side when:
-the telescope focus is changed during the measurement
-the star is too bright
-the exposure time is too long (>10 ms)
-the sub-aperture characteristics are not updated in the parameter file.
-the telescope does not deliver circular images (coma or vignetting).

7 Items included with the System

- - SBIG ST5 CCD camera with Universal CPU, Pentax 50 mm objective + adapter.
- - Entrance pupil mask for C11 Celestron made of two holes of 8 cm diameter, separated by 19.2 cm (19.0 cm - DIMM6) + 2 additional 5 cm diameter rings.
- - Entrance pupil prismatic window, 10 cm diameter.
- - Software package including SBIG standard software, DIMM executable and source code, Turbo Pascal 7.0 compiler.
- -Documentation: SBIG CCD camera operating manual SBIG Universal CPU command structure Turbo Pascal 7.0 (4 volumes).
  Losmandy Mount operating manual.

M. Sarazin, October 20, 1994; updated July 1995, August 1996, April 1998.

[1] M. Sarazin; Automated Seeing Monitoring for Queue Scheduled Astronomical Observations ; SPIE 3125, Propagation and Imaging through the Atmosphere. San Diego, July 1997