COST
Short Term Scientific Missions
Report – 12 May 2014

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Host Institution: Astronomical Institute Slovak Academy of Sciences, Tatranska Lomnica (SK)

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Period: 6 – 12 April 2014

STSM Title: Polarimetry of the solar corona with the Turin-filter at Lomnicky Observatory

COST STSM Reference Numbers: COST-STSM-MP1104-16840;
COST-STSM-MP1104-16841;
COST-STSM-MP1104-16844;

Scientific Report

Backgroud and Objectives of the STSM

The overreaching goal of this STSM was to complete the integration of the liquid crystal Lyot filter, for the FeXIV 530.3 nm line, developed by the INAF - Turin Astrophysical Observatory (OATo), Italy, to the Zeiss coronagraph of the Lomnicky Peak Observatory, Astronomical Institute of the Slovak Academy of Sciences (AISAS), in Tatranská Lomnica, Slovakia. The result of this STSM was positive and we successfully completed the integration of the Turin coronal magnetograph (CorMag) to the Zeiss coronagraph of the Lomnicky Peak Observatory.

During our first STSM to Lomnicky Peak Observatory in October 2013, we had achieved the following goals:

1. Design and manufacturing of dedicated opto-mechanical interfaces to integrate the Turin CorMag to the Lomnicky Zeiss coronagraph;
2. Integration of CorMag on the Zeiss coronagraph and optical alignment;
3. Integration of CCD camera detector and of Lyot filter driving electronics;
4. installation on local PC of the Lyot-filter/camera control & data acquisition (C&DAQ) s/w.

In this second STSM, last April, we completed the following tasks:

1. Manufacturing of a baffle installed between the CorMag and the focal plane of the Zeiss coronagraph in order to suppress the “light-leak”;
2. Manufacturing of a mechanical interface to integrate a “hot mirror” filter to block a red leak responsible of a low contrast in images;
3. Manufacturing of a screen used for aligning the solar image with the internal occulter;
4. Training of the AISAS staff to operate the CorMag by the INAF team;
5. Update of the the Lyot-filter/camera control & data acquisition (C&DAQ) s/w;
6. CorMag First-light and data archiving.

Activities performed in preparation for the STSM (G. Massone).

After the first installation during past October run, some improvements have been agreed between the Italian and Slovak team to optimize the filter-coronagraph performances:

- A new pass-band filter had to be added in order to cut a red leak responsible of a low contrast in images; the new filter (“hot mirror”) was mounted in front of the Lyot filter on a new interface built in Torino Observatory workshop (Figure 1).

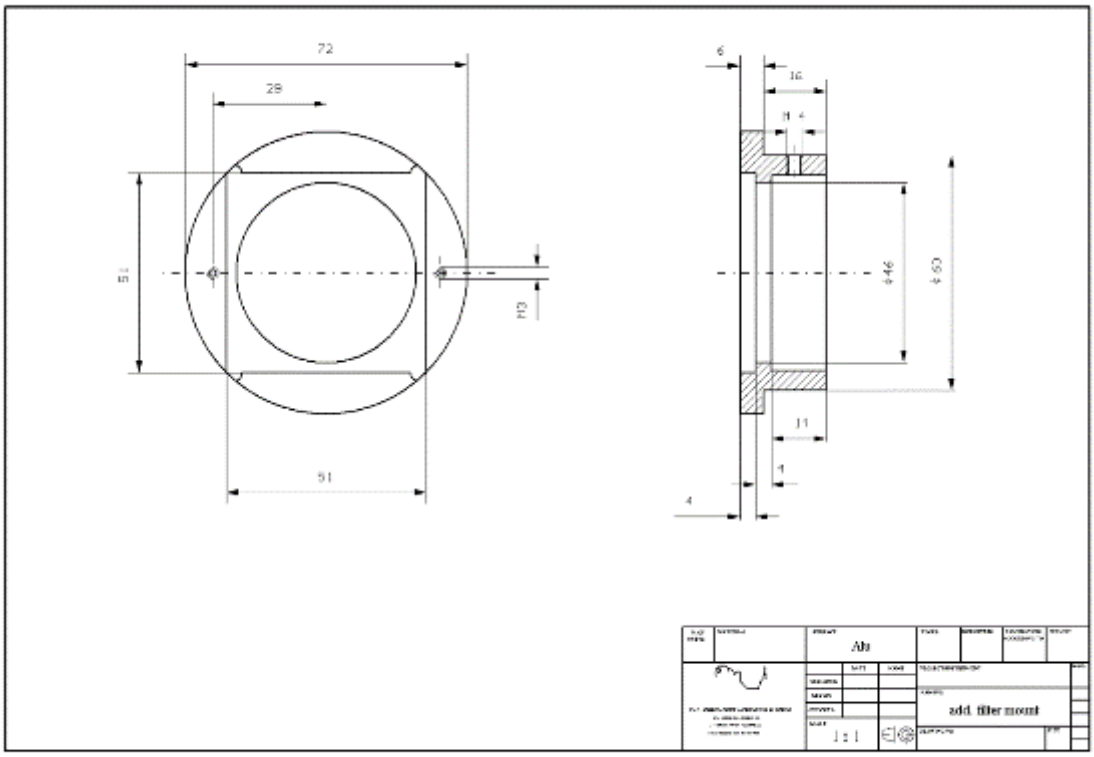

Figure 1 Opto-mechanical drawing of the interface built in Torino Observatory workshop for the “hot mirror” filter that had to be added in order to cut a red leak responsible of a low contrast in images.

- An observational screen was built at the same shop to facilitate the exact alignment of solar image with the internal occulter (Figure 2); the refocused image in projected in front of the filter entrance and the final alignment is done looking visually at this image, the screen is to be mounted in the same interface and is interchangeable with the calibration pre-polarizer previously built

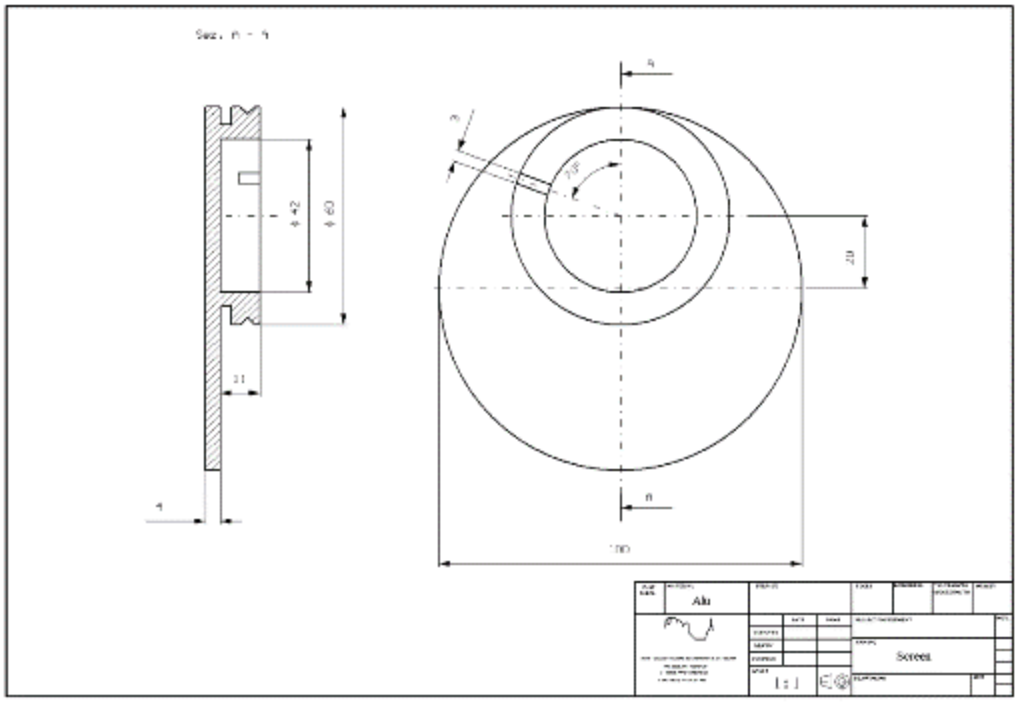

Figure 2 Opto-mechanical drawing of the observational screen to facilitate the exact alignment of solar image with the coronagraph internal occulter;

- At this same interface a baffle to screen stray light coming from outside the telescope is added during observations (Figure 3).

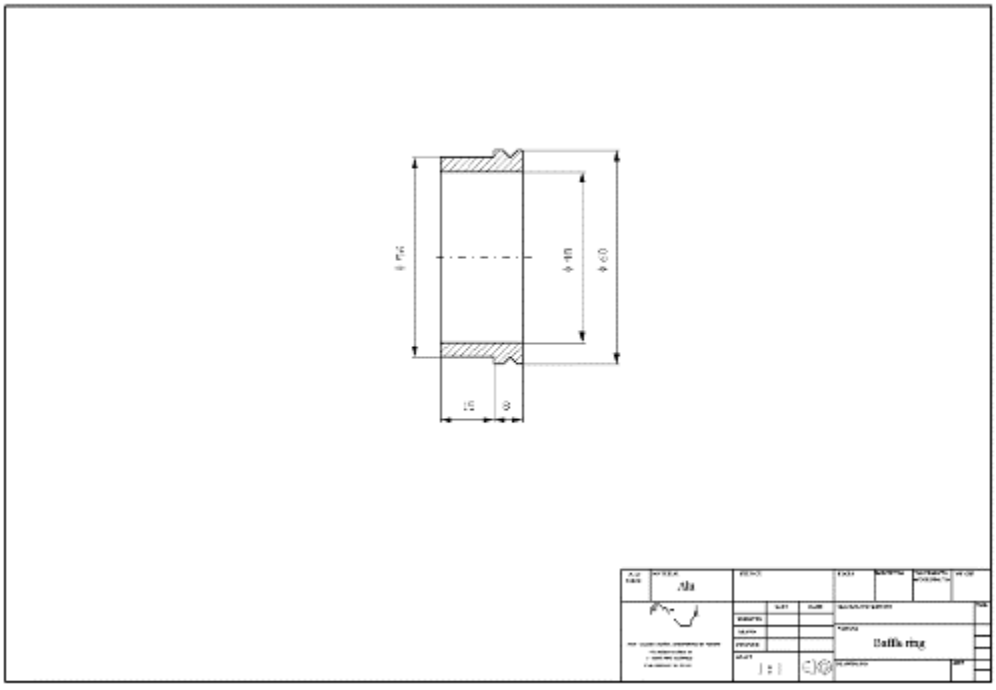

Figure 3 Opto-mechanical drawing of the baffle to screen stray light coming from outside the telescope

Activities carried out during the STSM.

Implementation of the Opto-mechanical interfaces (G. Massone)

During the STSM, we have installed at the Lomnicky Zeiss Coronagraph the opto-mechanical interfaces manufactured at the OATo Mechanical Workshop. Figure 4 shows the “hot mirror” filter installed on the Zeiss coronagraph in order to cut a red leak responsible of a low contrast in images.

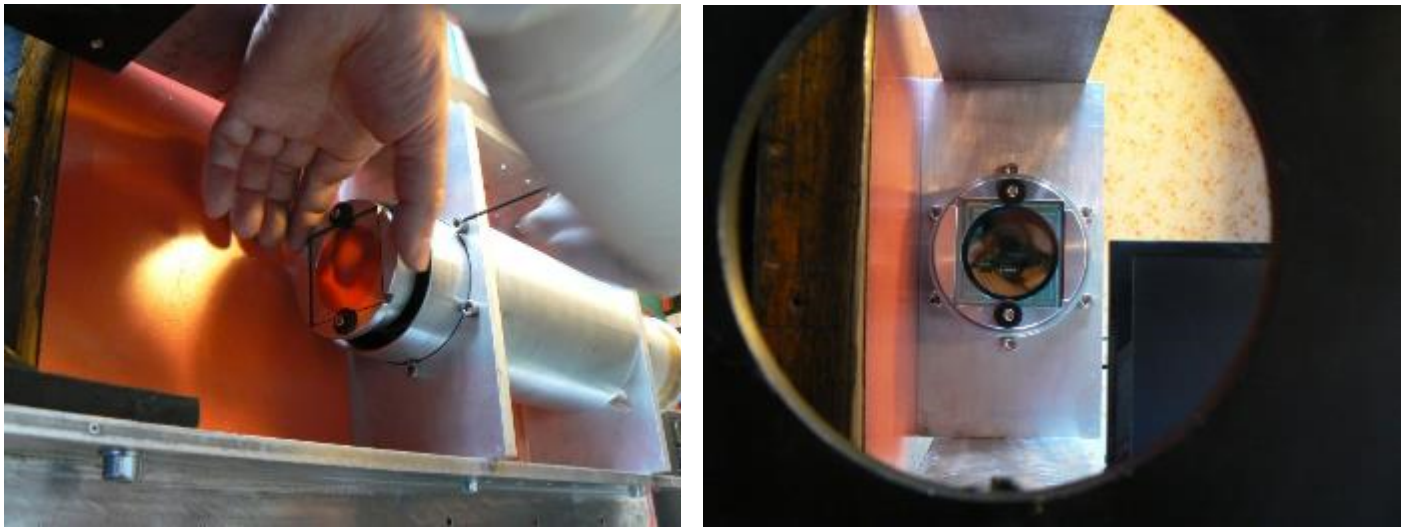

Figure 4 Side view (Left) and top view (Right) of the “hot mrror” filter added to cut a red leak responsible of a low contrast in the images;

Figure 5 shows he observational screen installed in the Zeiss coronagraph to facilitate the exact alignment of the solar image with the internal occulter*;*

Figure 5 The observational screen installed in the Zeiss coronagraph to facilitate the exact alignment of the solar image with the internal occulter.

Instrument Control, Data Acquisition and Data Storage System (G. Capobianco)

Figure 6 shows a schematic diagram of the architecture of the data acquisition, instrument control and data storage (C&DAQ). The components of the CorMag instrument (i.e., CCD Camera and Liquid Crystals Tunable Filter) are connected to the control computer (ICC) through a 30-meter fiber-optics with the USB/FO extender. The ICC is the computer controlling the instrumentation, acquiring data and responsible for the temporary data storage. This computer is remotely connected to the Remote Computer (RC). The data acquired will be downloaded everyday on the Data Storage (DSAISAS) hosted by the Astronomical Institute of the Slovak Academy of Science. A copy of this data will be downloaded with the same frequency on the Data Storage (OAToDS) hosted by the Astronomical Observatory of Torino. From the OAToDS the dataset will be available. The report of the 2013 STSM also describes the architecture.

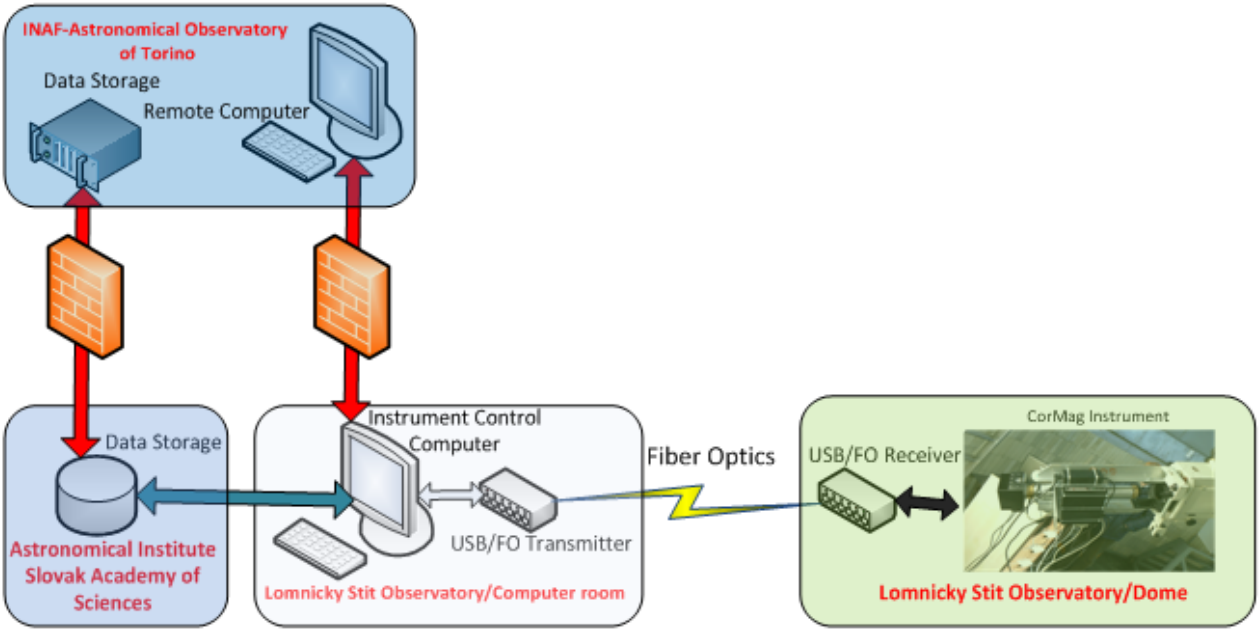

Figure 6 - Schematic diagram of the instrument control, data acquisition and data storage architecture.

A new release of the control & data acquisition software has been developed during this STSM. The release 3.0 is now available. The relevant modifications to respect the old version are:

- Control of the Diffuser insertion;
- Direct control of the “auxiliary” parameters (i.e. prepolarizer position, …)
- Development of guided procedure for calibrations;
- Insertion of some useful keywords in the acquired fits files (level 0 data), i.e. sequence ID;
- Automatically Running the DAQ scripts a selectable numbers of times;
- Camera Video mode in manual procedures;
- Definition of 4 types of data (Calibration, Dark, Light and Flat).

The software is actually available for 32- and 64-bit computers. The ICC computer has been optimized for the CorMag control. Some dataset has been acquired during the STSM in different

configurations (using a set of masks) in order to estimate the instrument challenges. Due to the "non coronal" sky during the week, no data of the Fe XIV line have been acquired. The Cormag is now permanently installed and operational.

First Light of the CorMag at Lomnicky Observatory (S. Fineschi)

The Turin CorMag focal-plane instrumentation comprises a CCD camera and a four-stage Lyot filter with an electro-optically tunable bandpass. The full width at half maximum of the filter is 0.15 nm. The center wavelength of the bandpass is tuned by using nematic liquid crystal variable retarders (LCVR's). A separate LCVR, in tandem with the filter, is used for polarimetric measuremens.

During this STSM, we successfully installed the Turin CorMag to the Lomnicky Zeiss coronagraph. This result will allow the implementation of a long-term observation plan (1 year at least), to carry out spectro-polarimetric observations of the coronal "green-line" emission (FeXIV, 530.3 nm). The science goal of these observation is to study the coronal magnetic fields that drive the dynamics of the solar wind.

Figure 7 shows the CorMag with the CCD camera (left), the LC Lyot filter (center) mounted on the focal plane of the Zeiss coronagraph (right).

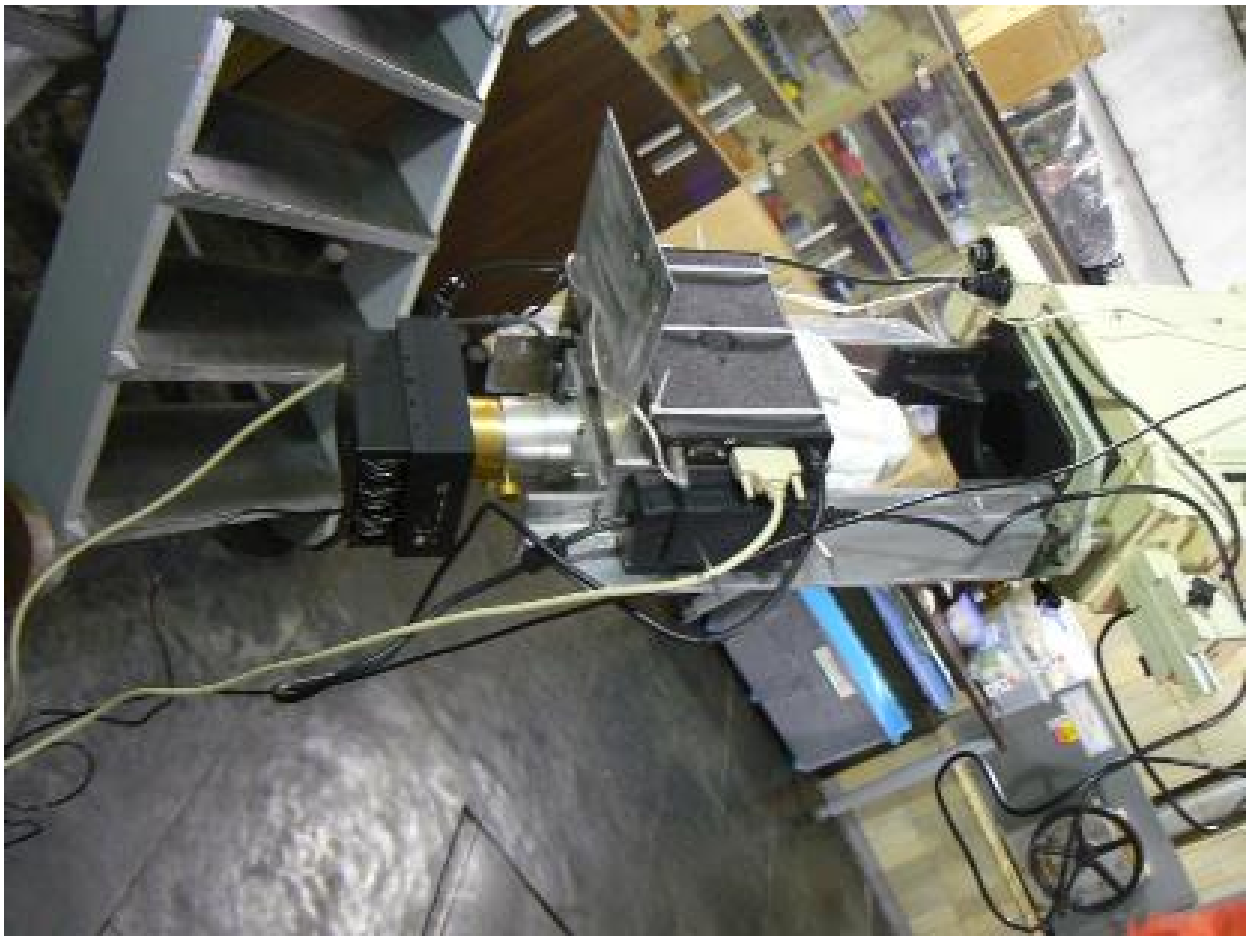

Figure 7 The Turin CorMag focal-plane instrumentation with the CCD camera (left), the LC Lyot filter (center) mounted on the focal plane of the Zeiss coronagraph (right).

During this STSM, we achieved a major milestone by successfully acquiring the first light of the Turin CorMag. Figure 8 shows the image acquired by CorMag with a diffuser inserted in front of the Zeiss coronagraph for the purpose of flat-fielding.

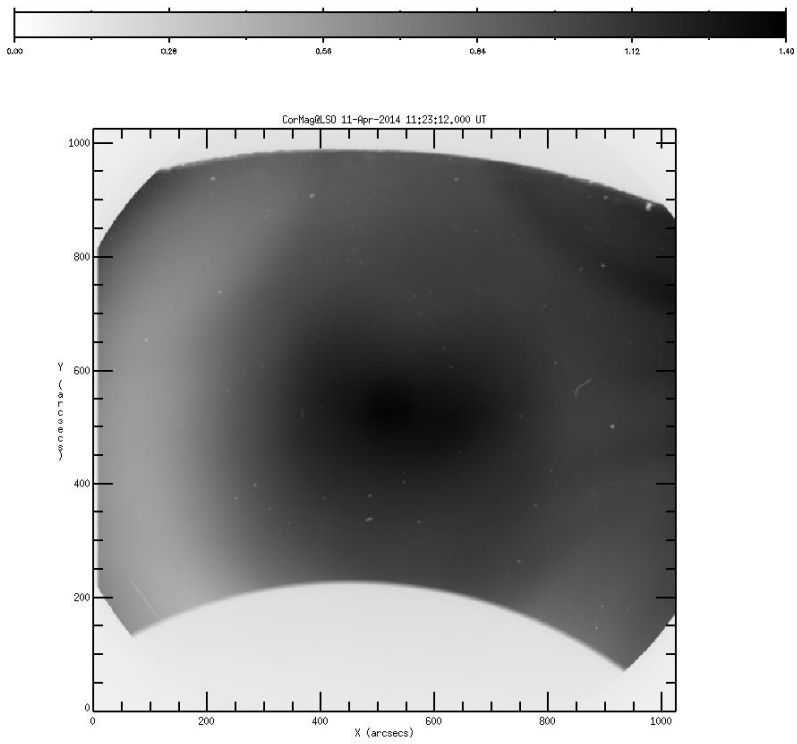

Figure 8 Image acquired by CorMag with a diffuser inserted in front of the Zeiss coronagraph for the purpose of flat-fielding.

Figure 9. Zeiss coronagraph at the Lomnicky Observatory and morning sky conditions during the STSM.

During the STSM, there were no “coronagraphic sky” conditions and the bad weather only cleared up in a couple of occasions, in the early morning. During these openings, we were able to carry out first-light tests of the CorMag under actual solar illumination conditions (Figure 9).

Under those conditions, we tested the various CorMag capabilities: imaging, spectroscopy and polarimetry. We also tested the updated C&DAQ s/w that was used to operate CorMag in the different observing modes (i.e., spectroscopic and polarimetric).

Figure 10 shows an example of a CorMag acquisition of four polarimetric images of the diffuser at different orientations of the LC polarimetr. This is the baseline sequence used for the measurement of the linearly polarized coronal “green-line” (FeXIV, 530.3 nm).

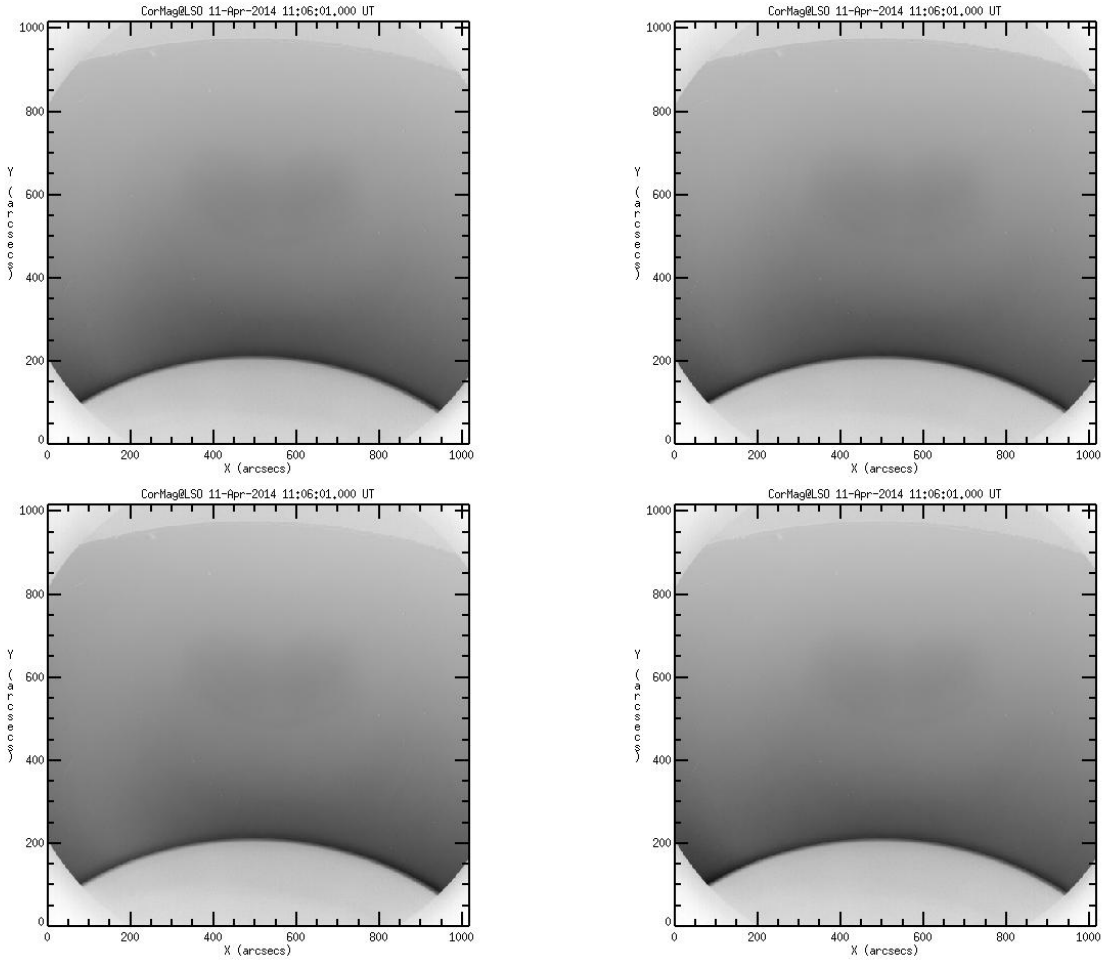

Figure 10 Example of CorMag acquisition of four polarimetric images of the diffuser at different orientations of the LC polarimeter. This is the baseline sequence for measuring the linearly polarized coronal "green-line" (FeXIV, 530.3 nm). The solar limb is the circular sector at the bottom of each image.

The CorMag first-light tests revealed the presence of "ghost images" at the center of the frames (Figure 10). We have carried out several tests in order to locate the source of the "ghosts". A candidate source is the narrow bandpass pre-filter of the LC Lyot filter. This pre-filter is an interferential one with plane-parallel faces on the collimated beam path. The internal reflections in the pre-filter may cause the observed "ghost". AISAS personnel at Lomnicky Observatory, together with the INAF-OATo team, will carry out several, different tests to confirm and eliminate the source of these "ghosts". These internal reflections are not polarized (cfr. Figure 10) and therefore, they will cancel out when the polarized coronal image is obtained from the differences of the four polarimetric frames. This will allow us to start and continue the science observations while we address the "ghosts" issue in order to eliminate it.

Results achieved during the STSM and future work.

This Short-term Scientific Mission was highly successful and we achieved the original goals:

1. Manufacturing of a baffle installed between the CorMag and the focal plane of the Zeiss coronagraph in order to suppress the "light-leak";
2. Manufacturing of a mechanical interface to integrate a "hot mirror" filter to block a red leak responsible of a low contrast in images;

3. Manufacturing of a screen used for aligning the solar image with the internal occulter;
4. Training of the AISAS staff to operate the CorMag by the INAF team;
5. Update of the the Lyot-filter/camera control & data acquisition (C&DAQ) s/w;
6. CorMag First-light and data archiving

After this STSM, the programming of preliminary science observations with CorMag at Lomnicky Observatory can start when “coronagraphic sky” conditions will occur. At the same time AISAS personnel, trained to operate CorMag, together with the INAF-OATo team will carry out several, different tests to study and eliminate the source of the “ghosts” images due to internal refelction.

Colleagues from INAF-Osservatorio Astrofisico di Arcetri, Florence (Italy) have planned a STSM to Lomnicky Observatory in June 2014, to complete and initiate the following tasks:

1. Tests to characterize and locate the source of the “ghost images”;
2. Tests of science observing sequences;
3. Simultaneous coronagraphic observations with CorMag and with the Coronal Magnetograph and Polarimeter – Slovak (CoMP-S) on the other twin Zeiss coronagraph at Lomnicky Observatory (Figure 11). This will allow the cross-check of the CorMag and CoMP-S performances and the cross-calibration of the two filters at 530.3 nm;
4. Polarimetric calibration of CorMag/Zeiss optical system by observations of the sky polarization brightness.

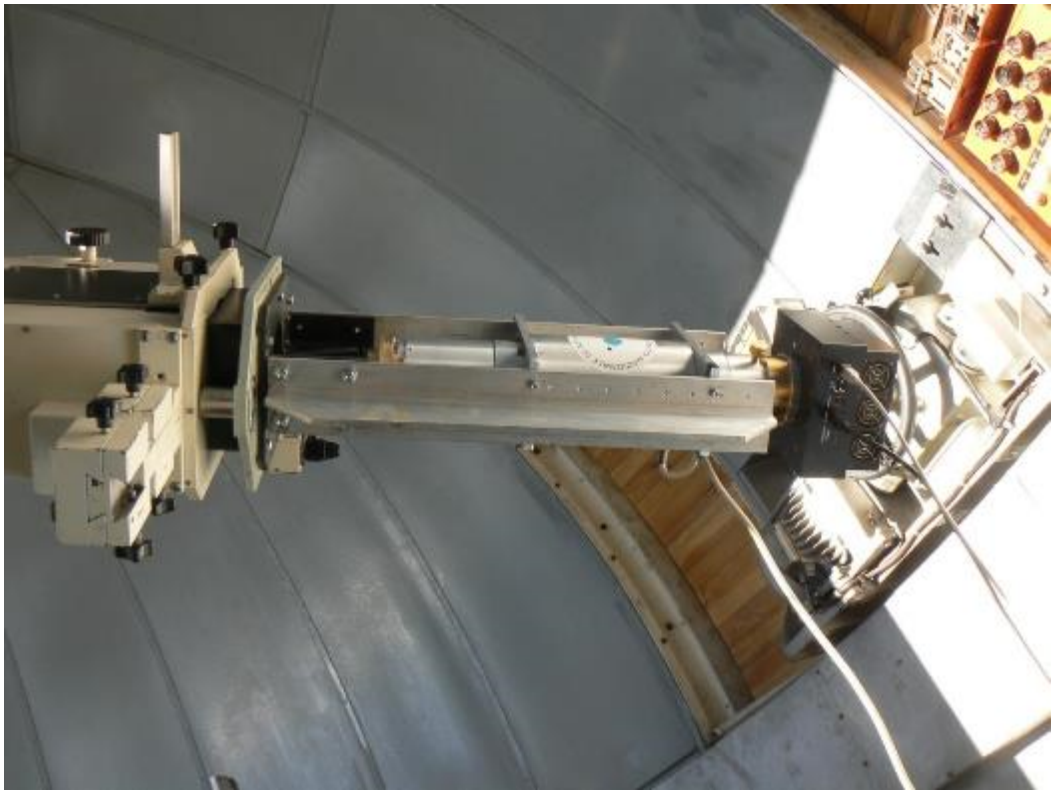

Figure 11 Turin CorMag, comprising the Lyot Filter (center) and the CCD camera (right), on the mechanical interface installed at the focal plane of the 20-cm Zeiss coronagraph at Lomnicky.