COST
Short Term Scientific Missions
Report – 24 July 2014

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Period: 9-15 June 2014

STSM Title: Polarimetry of the solar corona with the Turin-filter at Lomnicky Observatory: stray light characterization and data pipeline test.

COST STSM Reference Numbers: COST-STSM-MP1104-16828;

COST-STSM-MP1104-16829;

Scientific Report

Backgroud and Objectives of the STSM

The goal of this STSM was the optimization of the CorMag control and data acquisition software developed by INAF-Turin and the characterization of the stray light of the instrument.

CorMag accommodates the liquid crystal Lyot filter, for the FeXIV 530.3 nm line, developed by the INAF - Turin Astrophysical Observatory (OATo), Italy and has been integrated to the Zeiss coronagraph of the Lomnicky Peak Observatory (LSO), Astronomical Institute of the Slovak Academy of Sciences (AISAS), in Tatranská Lomnica, Slovakia.

The result of this STSM was positive as we tested the control and data acquisition software and we identified the origin of the “ghosts” detected during the past STSM and tested a new optical configuration for CorMag.

Summary of all the STSM at Lomnicky Peak Observatory

During the 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 the 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.

In this third STSM, last June, we completed the following tasks:

1. Feasibility of new optical configuration to minimize the “ghosts”:
2. Implementation of the CorMag optical configuration inside the Zeiss coronagraph converging beam;
3. Test of the new CorMag optical configuration;
4. Update of the the Lyot-filter/camera control & data acquisition (C&DAQ) s/w
5. Detailed definition of future activity in preparation of the next campaign in September 2014.

Activities performed in preparation for the STSM (J. Rybak at LSO).

In order to minimize the presence of “ghosts” in the CorMag image a new optical configuration has been studied to reconfigure the filter from the current collimated beam to the f/20 converging beam of the Zeiss coronagraph, similar to the Coronal Magnetograph and Polarimeter – Slovak (Comp-S) of the twin Zeiss coronagraph:

- The camera optics will be dismounted without changing the connection of the camera and rear part of the filter
- The bandpass filter can be fixed directly to the rear plane of the coronagraph placing the body of the filter into the rear box of the coronagraph body
- Collimating optics in front of the filter and its holder will be removed

Activities carried out during the STSM.

Implementation of the CorMag interfaces inside the converging beam

During the first day of the STSM, the Lyot filter body was dismounted from the arm, the relay lenses removed on both side of the filter, the IR blocking filter, the structure holding all electronics devices and the camera were removed.

The Lyot filter body was mounted to the rear plate of the coronagraph and the structure holding all electronics devices mounted to the rear part of the coronagraph, as shown in Fig. 1.

The camera was mounted to the filter and the focus adjusted.

The IF “hot-mirror” filter was mounted in front of the bandpass filter with different tilt angles to test the presence of “ghosts” on the image.

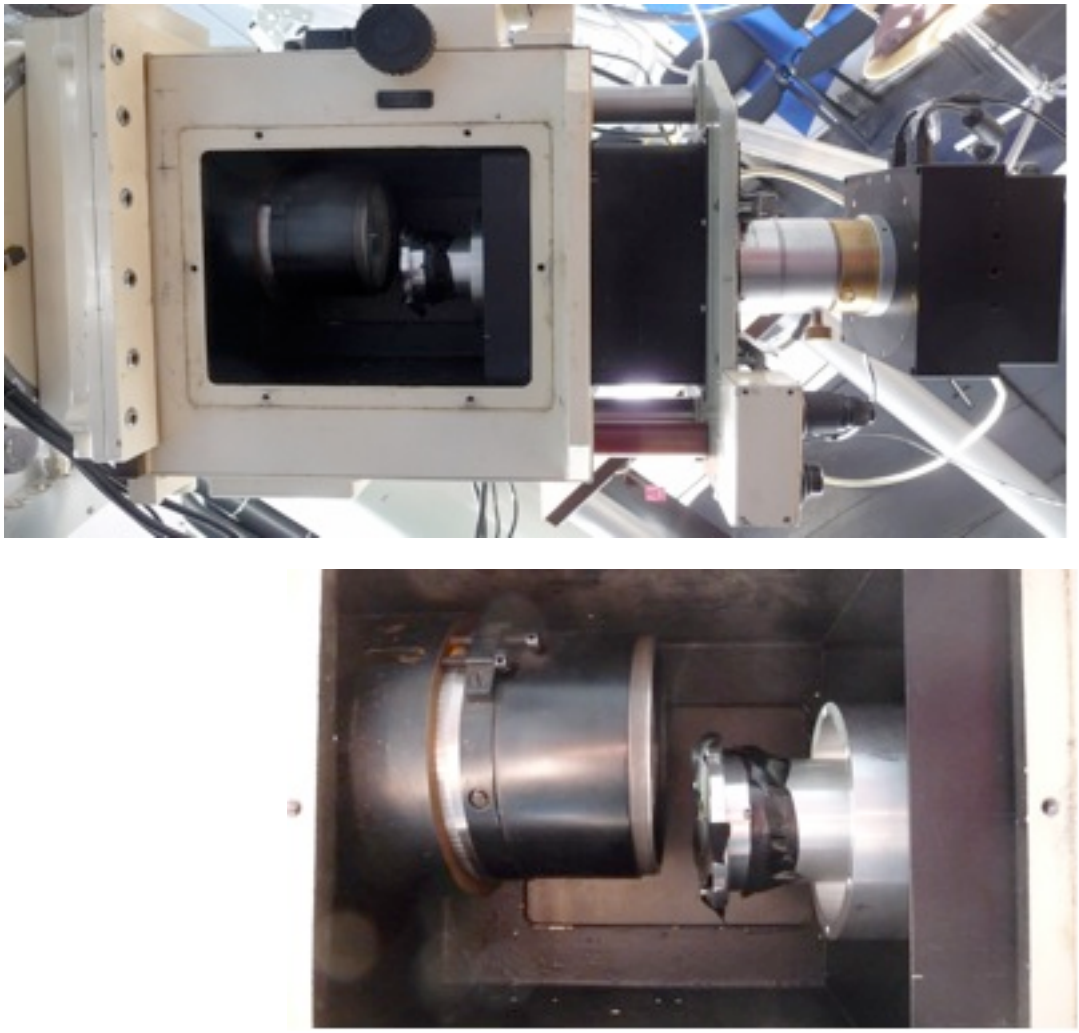


Fig. 1 General view of the CorMag present mechanical accommodation

Test of new CorMag optical configuration

The former accommodation of the Lyot filter assembly was on the coronagraph translation stage positioned at 70mm. The new accommodation will be with the translation stage at 100mm. The fixed distance re-imaging lens - CCD box is 369 mm. This implies that the CCD has to be moved toward the coronagraph by 30mm (see Fig. 2).

The CorMag first-light tests of past STSM revealed the presence of “ghost images” at the center of the frames (Fig. 3).

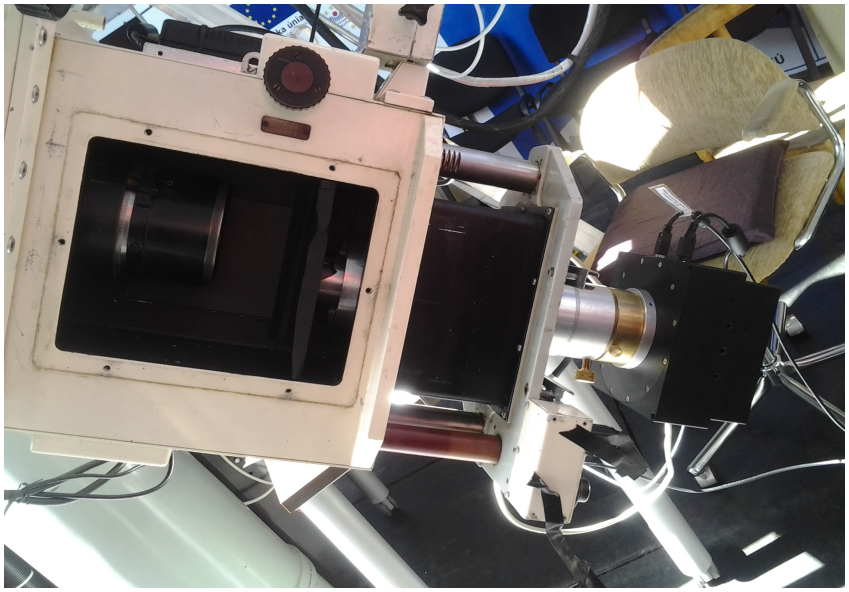


Fig. 2 CorMag general view without the IR blocking filter in front will long interface between flange and CCD camera

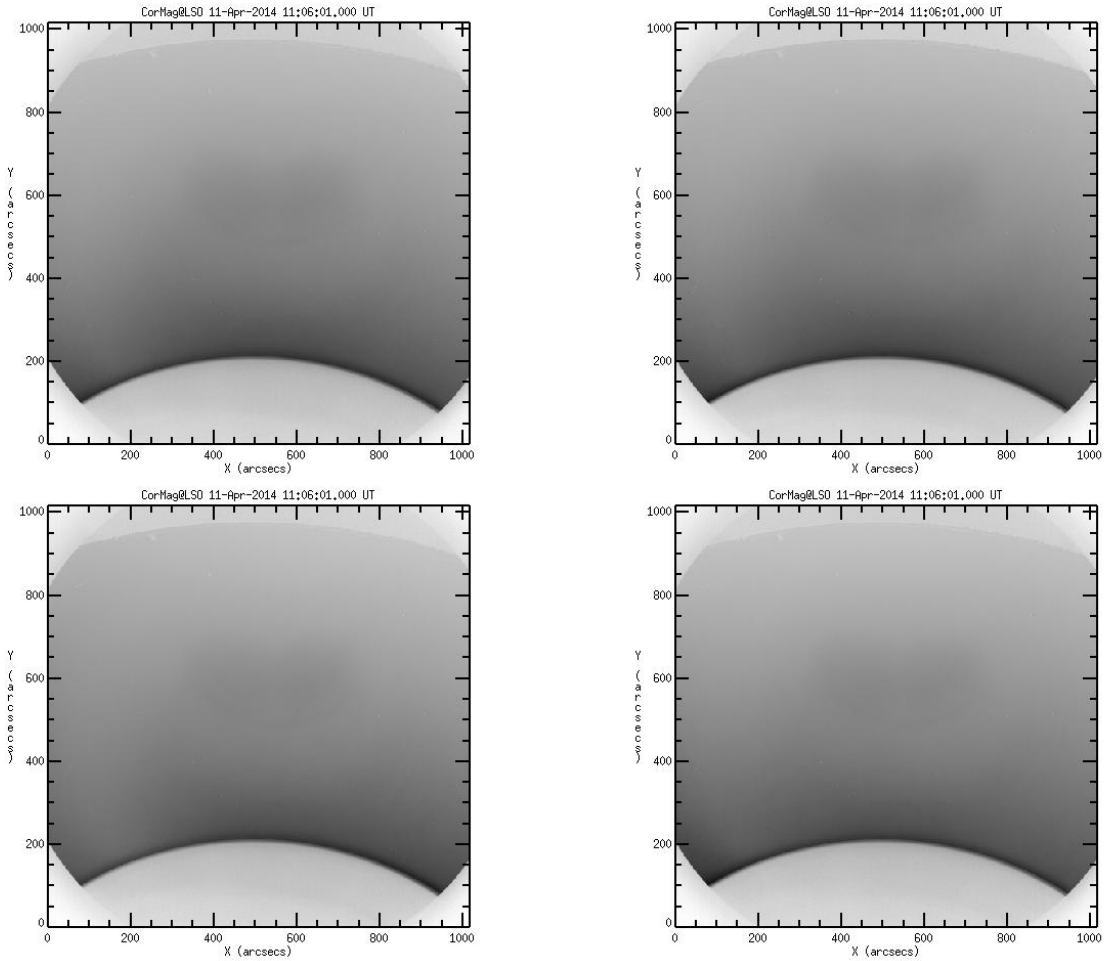


Fig. 3 - Example of CorMag acquisition of four polarimetric images of the diffuser at different orientations of the LC polarimeter showing several ghosts distributed on the image. The solar limb is the circular sector at the bottom of each image.

During the STSM, there were no “coronagraphic sky” conditions and the skies were dominated by the presence of cirruses, allowing to calibrate CorMag for ghosts, but no data of the Fe XIV line could be acquired.

The CorMag tests revealed the presence of “ghost images” at the center of the frames but of reduced extension with respect to the previous collimated optical configuration, leaving a region located near the center and close to the limb clean from “ghosts” (*Fig. 4*). We have carried out some tests in order to locate the source of the “ghosts”. Candidate sources are the narrow bandpass pre-filter of the LC Lyot filter, the hot-mirror filter and the back surface of the Coronagraph camera lens.

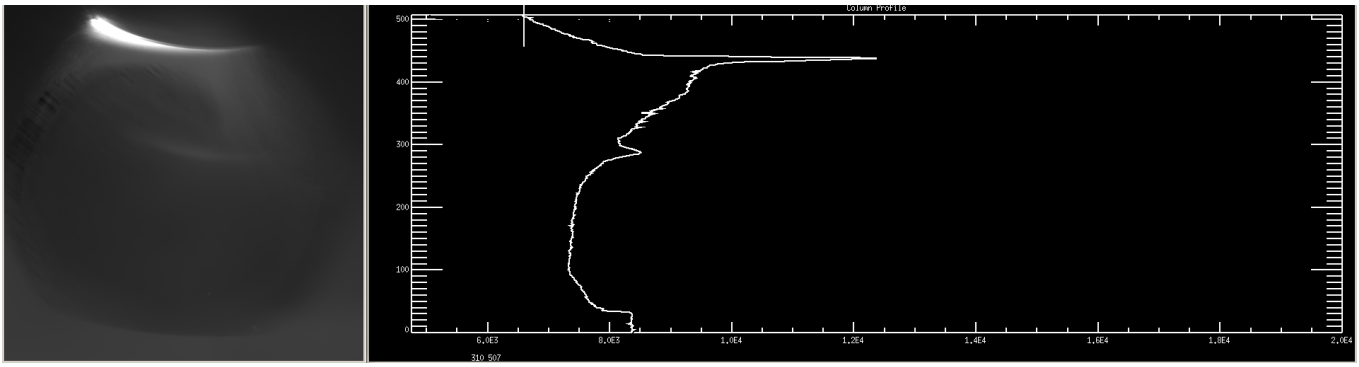


Fig. 4 CorMag image (after mDC and mFF corrections) obtained with normal incidence NB prefilter + IR blocking filter in front of itIt is the sum of the total emission in 11 spectral positions around 530.28nm.

Update of the the Lyot-filter/camera control & data acquisition (C&DAQ) s/w

Fig. 5 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 are downloaded on the Data Storage (DSAISAS) hosted by the Astronomical Institute of the Slovak Academy of Science. The report of the 2013 STSM also describes the architecture.

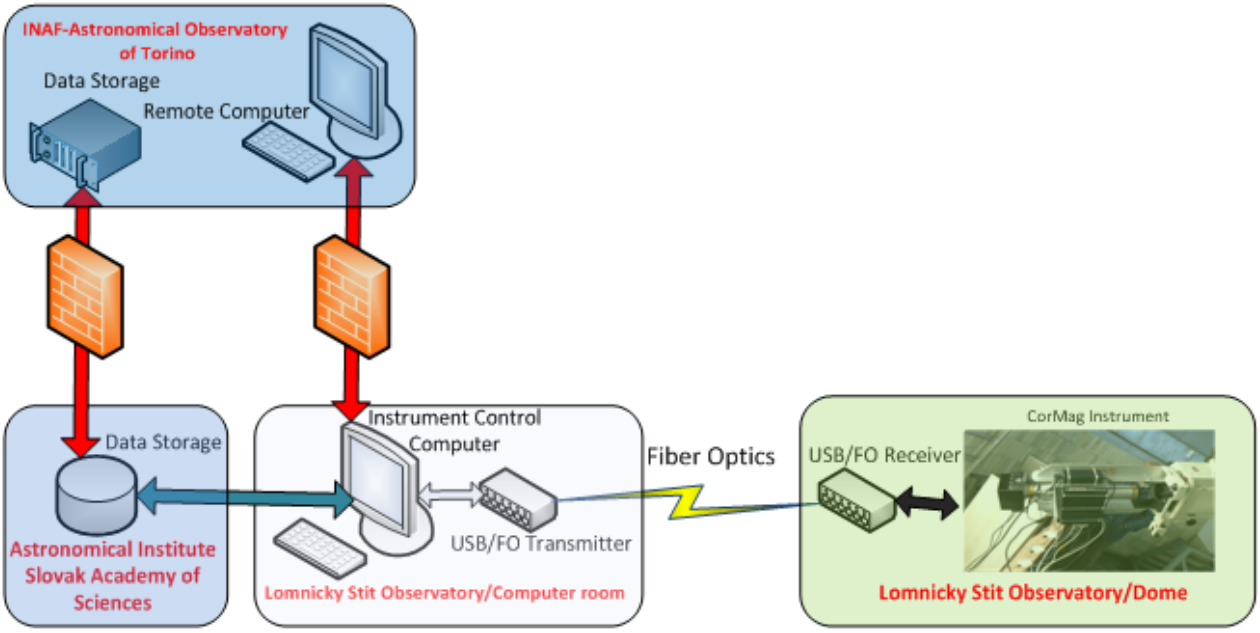


Fig. 5 - Schematic diagram of the instrument control, data acquisition and data storage architecture.

The release 3.0 is now available.This new release of the Lyot-filter/camera control & data acquisition (C&DAQ) s/w was tested and one bug repaired in the code for Manual mode.

Future activity in preparation of new STSM campaign of September 2014

The next STSM campaign has been scheduled in September. The September/October period is usually the best time of the year in terms of weather for coronagraphic observations from the Lomnicky Stit Observatory. This will provide the best opportunity for testing the improved interface configuration for the CorMag/Zeiss-coronagraph discussed in this report.

In summary, the activity to be carried on in preparation of next September campaign is:

- Preparation of CorMag in order to work inside the coronagraph converging beam
- Check of new CorMag configuration with optical CAD
- Mechanical modifications to the Lyot filter mount

Preparation of CorMag for the coronagraph converging beam

The CorMag assembly will be modified in order to:

- Place the Lyot filter in the converging beam.
- Place the Lyot filter as close as possible to the focal plane in order to:
    - Limit the vignetting of the coronograph converging beam
    - minimize multiple reflections between the coronagraph re-imaging optics and the Lyot filter
    - Allow the insertion and the removal of auxiliary optics, such as the pre-polarizer
- Have the option of moving the pre-filter more distant from the Lyot filter
- Have the option of mounting a new pre-filter tilted to the optical axis

- Have the option of mounting the hot mirror in front of the pre-filter or alternatively, mount the hot filter in front of the CCD camera.
- Interface the pre-polarizer and the white screen with entrance aperture of the Lyot stop.

Possible configurations:

- (Pre-pol) - Hot mirror - Pre-filter - Lyot filter - CCD
- (Pre-pol) - Pre-filter - Lyot filter - Hot mirror - CCD

The Lyot filter assembly will be mounted inside the box that contains the re-imaging lens (called in the following black-box) in order to take advantage of the implementable thermal control.

The Lyot filter assembly will be attached with screws by the side facing the CCD on the black interface flange (shown in Fig. 6), which will be attached to the translation stage of the black-box.

The present accommodation of the Lyot filter assembly is on the translation stage positioned at 70mm. The new accommodation will be with the translation stage at 100mm. The fixed distance re-imaging lens - CCD box is 369 mm. This implies that the CCD has to be moved toward the coronagraph by 30mm (see Fig. 9).

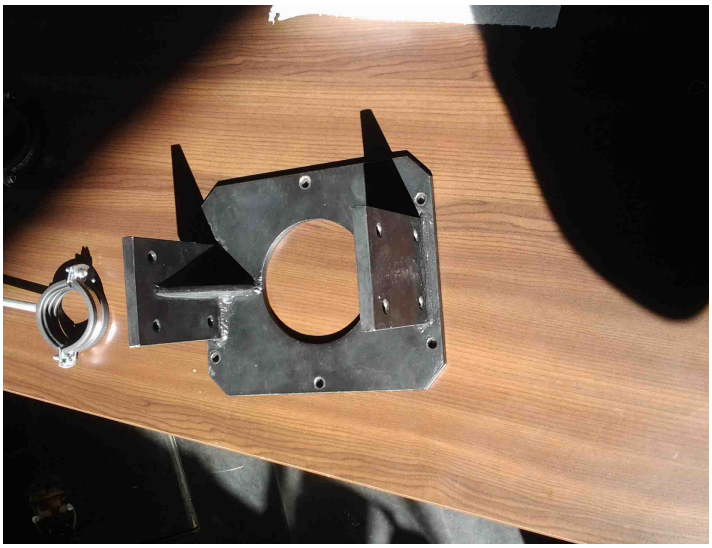


Fig. 6 Black interface flange (its ears will be not needed)

Things to be checked with optical design software

1. Size of converging beam to assess vignetting (adapting the aperture diameter to an optimum vignetting)
2. Best position of the Lyot filter with respect to the coronagraph focal plane in order to minimize the vignetting of the coronagraph converging beam.
3. Tilt of hot mirror in both options (in order to minimize effects of the reflactions in the rest of the CorMag and coronagraph optics)
4. Tilt of pre-filter (in order to minimize effects of the reflactions in the rest of the CorMag and coronagraph optics) considering a purchase of a new NB prefilter prepared for the green

line with the desired inclination

5. Aperture and the pre-polarizer mounting flange (see Fig.4)

Fig. 7 Instrument entrance aperture and the pre-polarizer mounting flange

Mechanical modifications to the Lyot filter mount are needed (see CAD drawing – Fig. 9**):**

1. Front section (Part B) redesign to accommodate the hot mirror (Option 1) and to allow a repositioning of the pre-filter more advanced with respect to the Lyot filter and, if possible, its rotation in azimuth.

2. Flange to interface the pre-polarization mount and the white screen to the outer envelope (Part A)

3. Back section (Part C) redesign to accommodate the hot mirror (Option 2) and, if possible, its rotation in azimut

4. Redesign of the three sections (Part D, E, and F) to shorten the distance of the CCD to the Lyot filter assembly by 30 mm

5. Design extension of Lyot filter device (Part L) to reposition the pre-filter

The described configuration keeps the Lyot filter assembly inside the black-box, which will allow to implement a thermal control inside the black-box by means of a controlled heater (AISAS task for October 2014).

Alternatively the Lyot filter can be moved closer to the focal plane up to 50 mm. In this modification the filter will be farther from the re-imaging optics but it will extent outside of the black box and its heating will be more difficult.

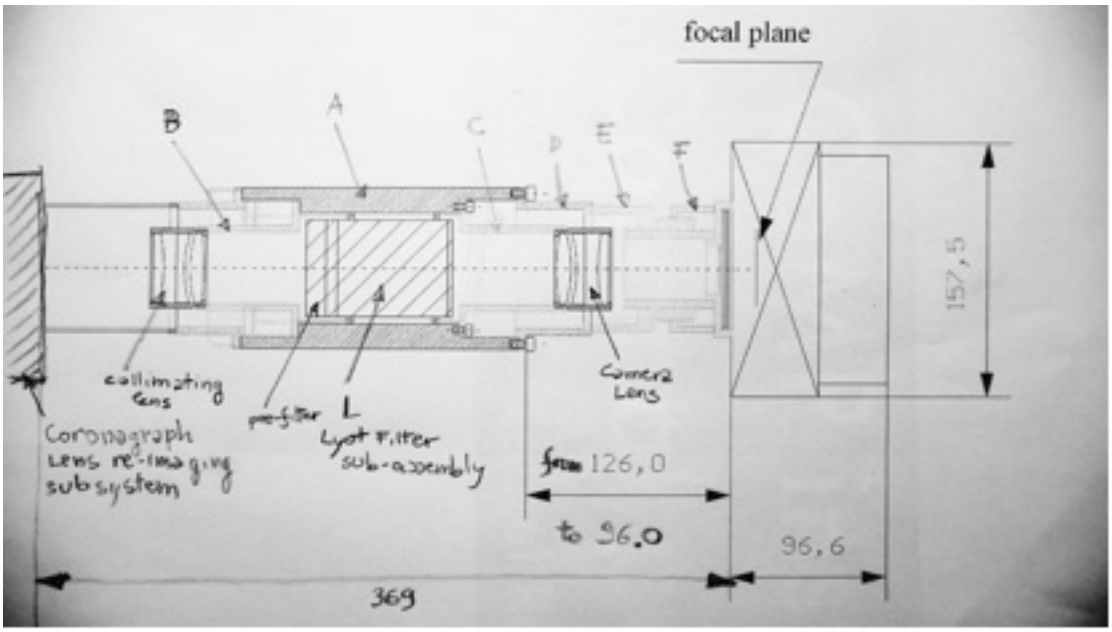
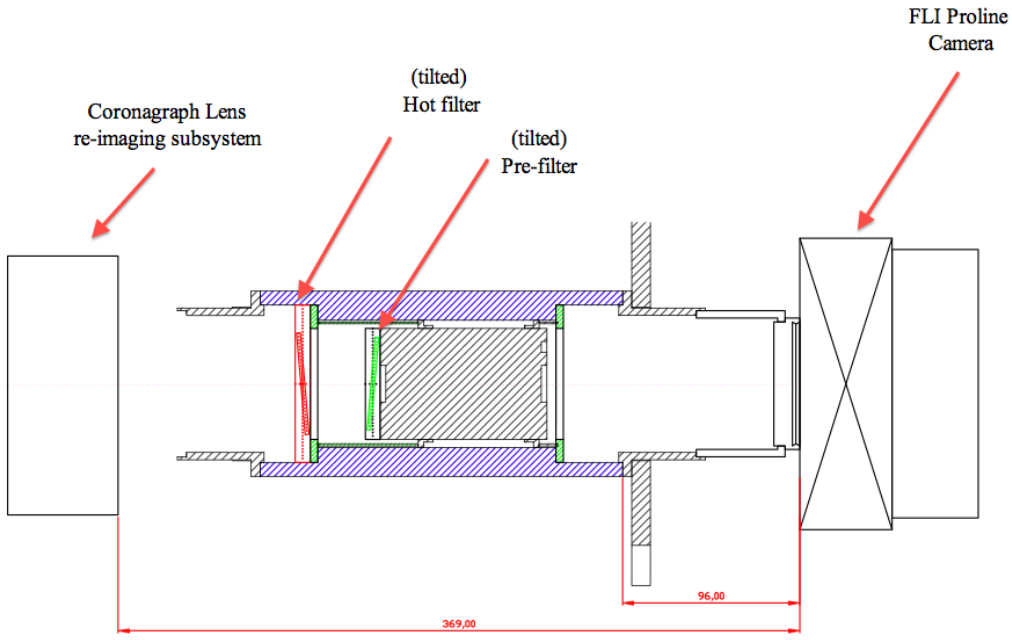


Fig. 8 Mechanical modifications to the Lyot filter mount

In Fig.6 is shown a concept for the accommodation of the filter for both option 1 and option 2.



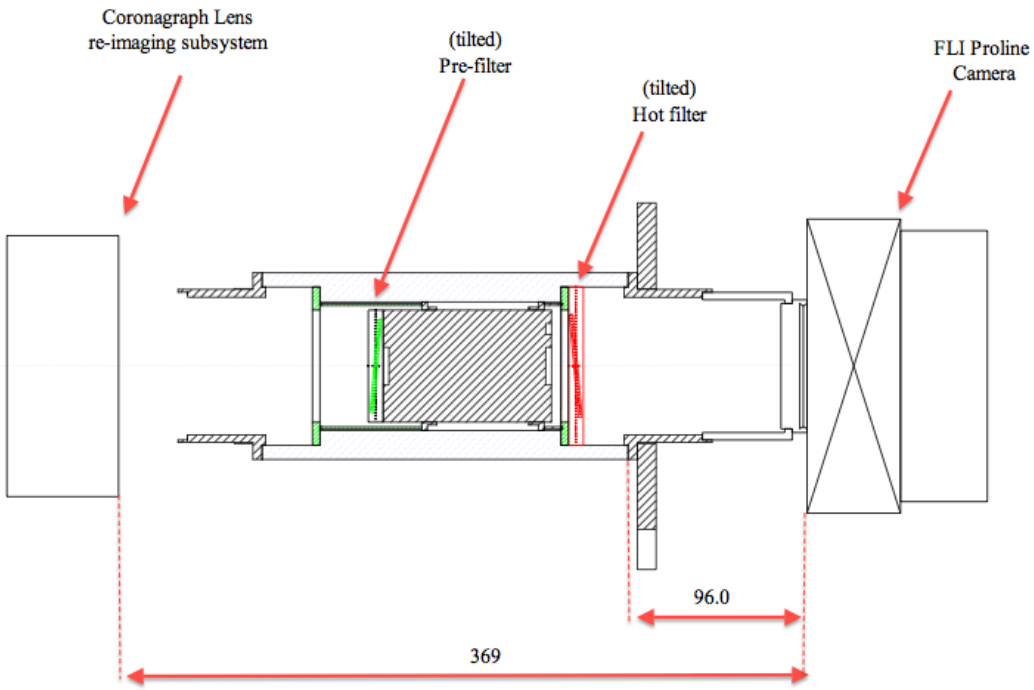


Fig. 9 Concept for the accommodation of the hot filter and the pre-filter for option 1 (above and option 2 (below).