COST
Short Term Scientific Missions
Report – 24 November 2014

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

COST STSM Reference Numbers: ECOST-STSM-MP1104-181114-052079

<u>Scientific Report</u>

Background and objectives of the STSM

During the previous STSMs of October 2013 (Capobianco G., Fineschi S., Massone G.), April 2014(Capobianco G., Fineschi S., Massone G.) and June 2014 (Romoli M., Pancrazzi M.), 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 was successfully completed, as some many other objectives was reached (see reports of activities). The main objectives of this STSM has been:

1. to coordinate the CorMag observational campaign with the Coronal Magnetograph and Polarimeter – Slovak (CoMP-S) coronagraphs, also installed at the Zeiss- coronagraph of the Lomnicky Peak Observatory;

2. to verify the co-alignment between CorMag and COMP-S;

3. to develop a preliminary version of the pipeline for data calibration and data reduction with different observation modes.

The scheduled point #4 (produce 2-dimensional maps of K-corona emission and quick-look movies showing the overall evolution during the observational campaign) was not performed due to the bad weather.

Activities in preparation of the STSM

Before the STSM, the sources of the ghosts have been identified. The most intense source of was the narrow bandpass filter. In august 2014, a calibration has been performed in the laboratory of the INAF-OATo, measuring the variations of bandpass, central wavelength and ghosts in imaging, at different tilt angles of the device in the plane perpendicular to the optical axis. In Figure 1 is shown the position of the ghosts at different values of the tilt angle and in Figure 2 the transmissivity in arbitrary units. The final decision was to install the prefilter tilted of 5 deg. The bandpass is of about 1.80 nm and the central wavelength 530.48nm for 5 deg tilt (Figure 3).

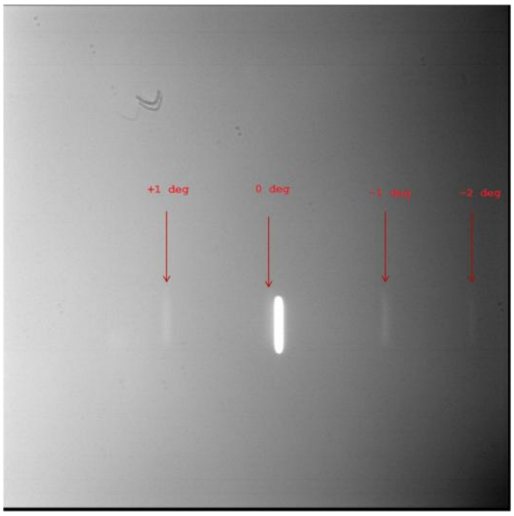

Figure 1 – Overplot of the ghosts at different tilt angles applied to the prefilter

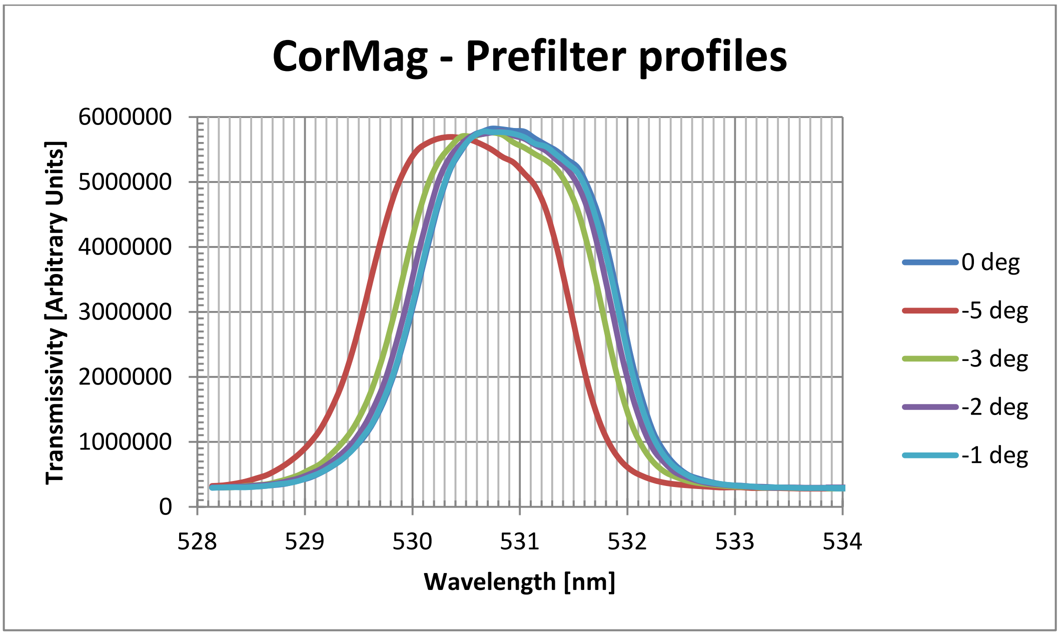

Figure 2 – Transmissivity of the prefilter

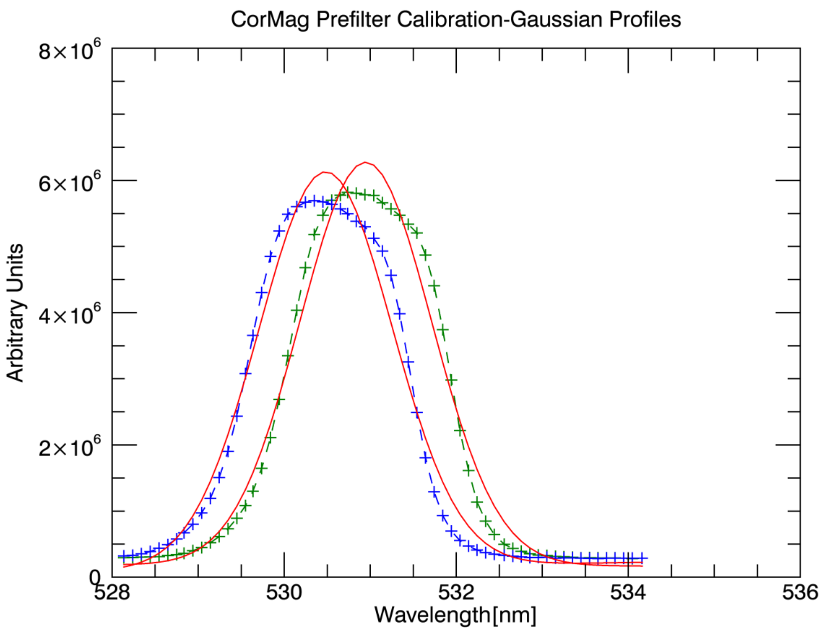

Figure 3 - Gaussian fits of the profiles at 0 (green) and -5 (blue) deg tilt

The relay optics have been removed and actually the CorMag is installed working in convergent beam (Figure 4).

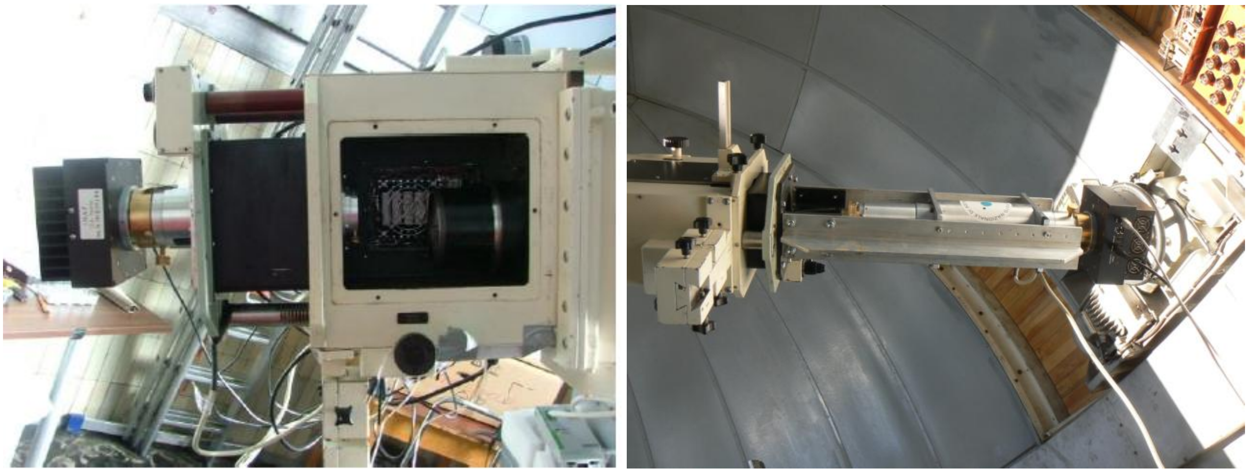

Figure 4 – New installation in convergent beam (left) and the old in collimated beam (right)

The transmission profile of the CorMag with the tilted prefilter has been also measured and shown in Figure 5. The Gaussian fit shows a central wavelength of 530.33 nm and a FWHM of 0.17nm in good agreement with the expected performances and the previous calibration.

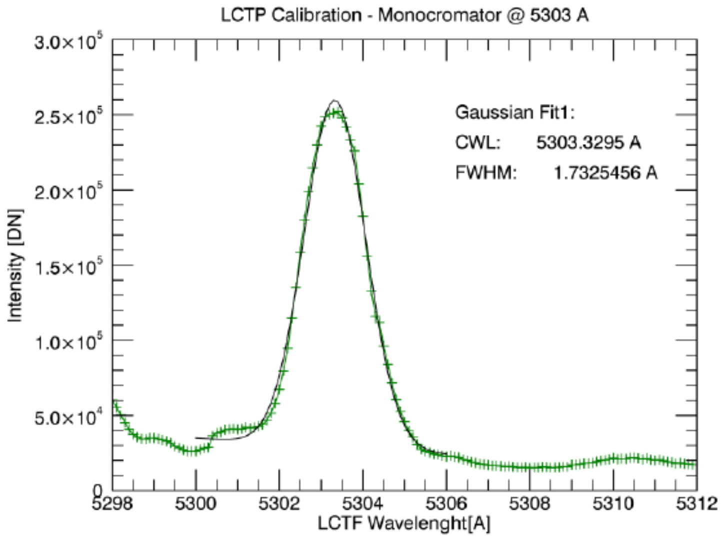

Figure 5 – Transmissivity of the CorMag with the prefilter tilted of 5 deg

Coordinate observations CorMag and COMP-S

The coordinate observations has been done in September 18th and October 19th, when the October acquisition is very promising, but the data analysis is still in progress. This combined acquisition done for the first time, shows some criticism:

1. Some problems and loss of simultaneously pointing of one of the coronagraphs a few times during acquisition;
2. No synchronization of the acquisitions (due to different acquisition times, time per sequence and operations).

Part of the general log file is the follow:

LSO GENERAL OBSERVER LOF FILE

2014/10/19

Observer: Rybak

HOP265: coordinated observing programne Hinode/EIS+CoMP-S+CorMag/LSO,
08-10UT, X/T/P=-1000/-200/+100
CoMP-S: obs_prog 005
CorMag: obs_prog 001

04:50 dome open, temperatures

05:20 uhrgang on

PA0=+26.0
PA=100

cirruses on the E horizont
no change for pointers

06:20 roughly pointed
06:30 pointer R closed loop on
06:30 pointerH ON home -0.15/-0.15
06:34 flats still some weak cirruses + airplane jet lines
ComP-S: run_flat, run_orex

CorMag: FLAT 10x 2 times
06:56 pointer R closed loop off
06:57 eclipse precisely
07:05 pointer R + pointer H closed loop ON +0.19/0.09
07:10 pointer R + pointer H closed loop ON again
07:13 pointer R + pointer H closed loop ON again
07:14 observation using both coMP-s and CorMag
07:26 check eclipse OK
07:30 CoMP obse + CorMag data+pola
07:40 check eclipse OK
flats on both instrument
07:56 start obse on both
08:07 restart CorMag PC filament

obse both
08:37 pointer H +0.28 / +0.08
09:06 .30 / .02

09:24 pointer R problems twice for a short time - temperature efect?
09:37 Pointer H +0.30 / +0.01

09:38 pointer R problem - simple reason dome has not revolved!
all data acqusition stopped for a while
after eclipse adjustment pointer R 163.XXX
new eclipse with higher values

09:59 obse both again

diffuser IN + pointing with pointer R and H again
calibrations: since 10:20 CorMag, since 10:25 CoMP-S
10:37 pointer H closed loop off
calibrations with pointer R ON continue on until CoMP-S abso+targ+dark
12:55 pointer R shutdown
13:00 uhrgang off
14:30 dome closed

Data Pipeline

The data pipeline is shown in Figure 6. From LEVEL 0 data, a routine that automatically produce LEVEL 1 data has been developed during this STSM. The transition to LEVEL 2 is still under development

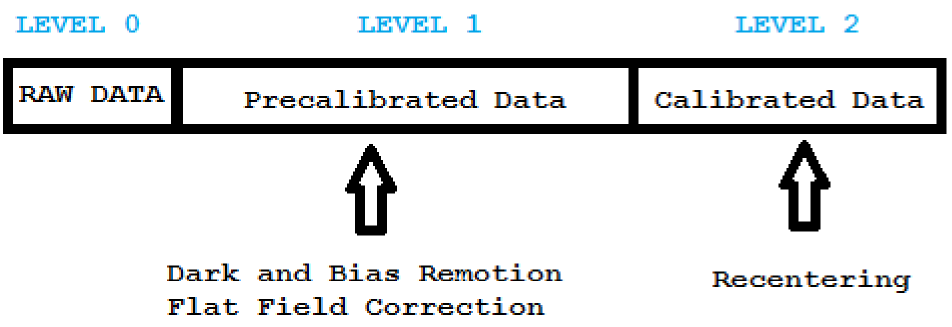

Figure 6 – CorMag data pipeline

A script for populate a database has been also developed before the STSM and preliminarily tested during the STSM.

Test for data calibration and reduction

An example of a single image acquired during the sequence and the corresponding flat field is shown in Figure 6 (left and right panels, respectively).

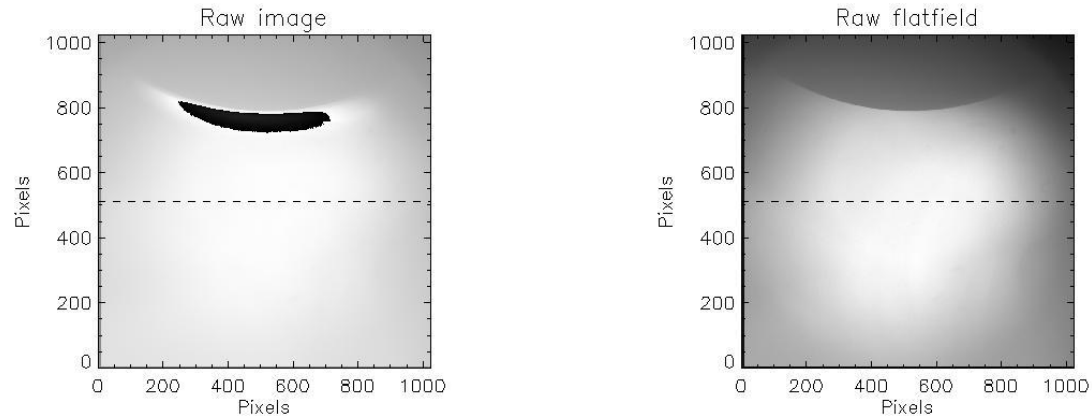

Figure 6: example of a raw image (left) and the corresponding flat-field image (right) before the correction described in the text.

As an example of a typical intensity profile across the image, Figure 7 shows the intensity distribution along the row outlined with an horizontal dashed line in both panels of Figure 6. In particular, as Figure 7 clearly shows, the problem with this sequence is that the flat-field has an intensity distribution which is larger than the coronal image distribution at the image center, and smaller at the image sides. In order to correct this effect, each row of both coronal and flat-field images has been corrected by subtracting to the intensity array the array corresponding to a straight line passing through the left and right edges of the intensity distributions. Resulting profiles after this subtraction are shown in Figure 7.

After this subtraction it was possible to verify that the ratio between the resulting coronal image and flat-field image is nearly constant around the image center. Hence, each coronal image has been divided by the corrected flat field and multiplied by this costant ratio, in order to enhance as more as possible the contrast of coronal features. An example of an image resulting after this normalization process is shown in Figure 8.

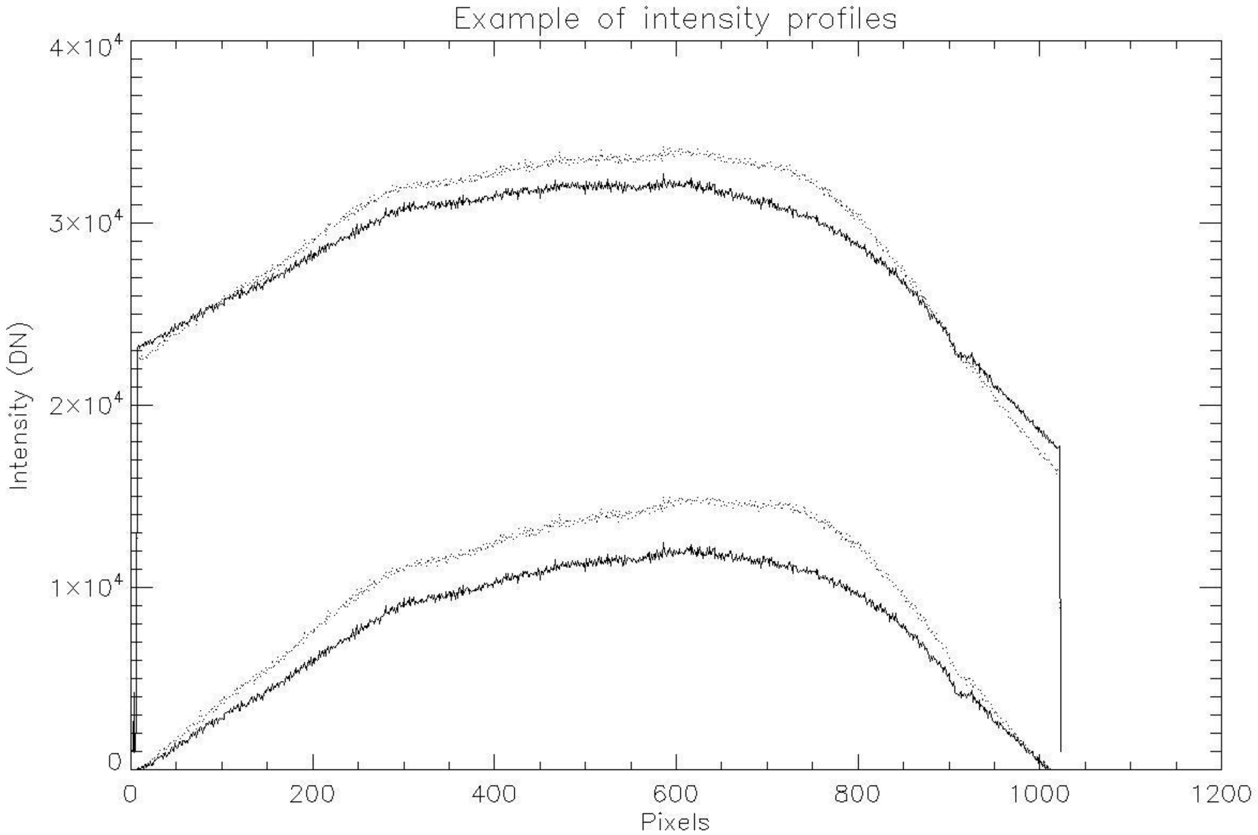

Figure 7: intensity distribution along a row of the image for the coronal observations (top solid curve) and the flat-field (top dotted curve). Both intensity profiles have been corrected as described in the text: the resulting corrected profiles are shown by the below solid and dotted curves.

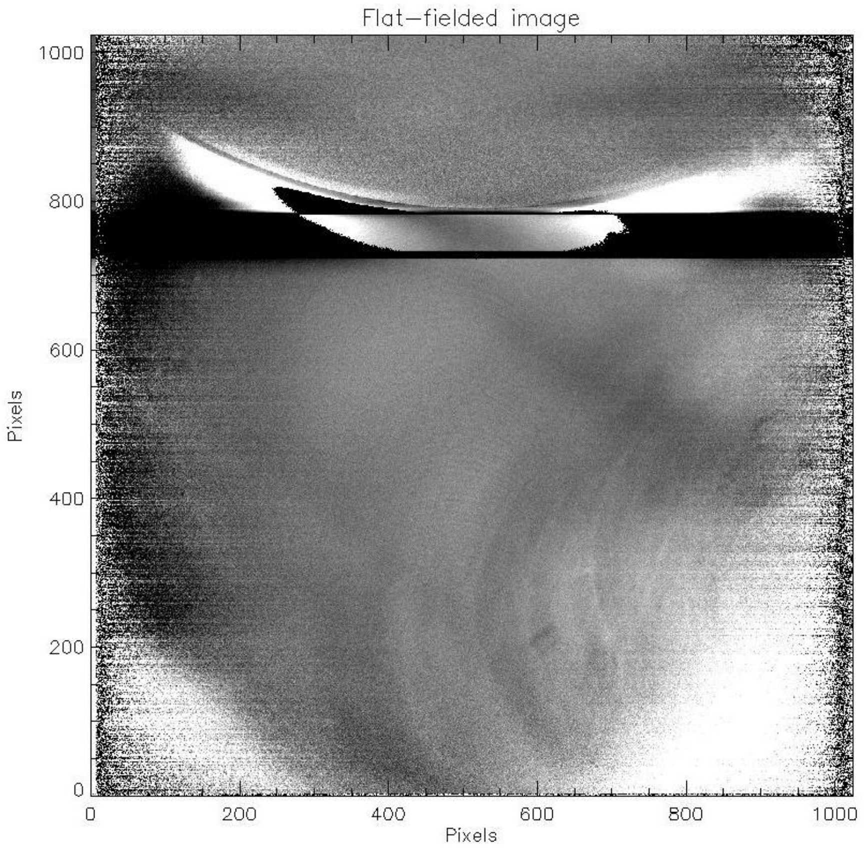

Figure 8: example of a coronal image resulting after image and flat-field correction and normalization (see text).

As an example, the IDL code used to get this image is given below:

```
img_names=find_files('*.fits',img_dir)
img_num=n_elements(img_names)
img_read=readfits(img_names(0),hdr)
img_dim=size(img_read)
flt_names=find_files('*.fits',flt_dir)
flt_num=n_elements(flt_names)
flt_read=readfits(flt_names(0),hdr)
flt_dim=size(flt_read)

hdr_dim=n_elements(hdr)

cormag_img=fltarr(img_dim(1),img_dim(2),img_num)
cormag_img(*,*,0)=img_read
cormag_flt=fltarr(flt_dim(1),flt_dim(2),flt_num)
cormag_flt(*,*,0)=flt_read
cormag_hdr=strarr(hdr_dim,img_num)

for i=1,flt_num-1 do begin
cormag_flt(*,*,i)=readfits(flt_names(i),hdr)
cormag_hdr(*,i)=hdr(*)
endfor

for i=1,img_num-1 do begin
cormag_img(*,*,i)=readfits(img_names(i),hdr)
endfor

cormag_flt_c=fltarr(flt_dim(1),flt_dim(2),flt_num)
cormag_img_c=fltarr(img_dim(1),img_dim(2),img_num)

for j=0,flt_num-1 do begin
for i=0,flt_dim(2)-1 do begin

  flt_arr=cormag_flt(*,i,j)
  flt_y0=average(flt_arr(10:12))
  flt_y1=average(flt_arr(flt_dim(1)-13:flt_dim(1)-11))
  flt_x=findgen(flt_dim(1))
  flt_y=flt_y0+((flt_y1-flt_y0)/flt_dim(1))*flt_x

  cormag_flt_c(*,i,j)=cormag_flt(*,i,j)-flt_y(*)

endfor
endfor

for j=0,img_num-1 do begin
for i=0,img_dim(2)-1 do begin

  img_arr=cormag_img(*,i,j)
  img_y0=average(img_arr(10:12))
  img_y1=average(img_arr(img_dim(1)-13:img_dim(1)-11))
  img_x=findgen(img_dim(1))
  img_y=img_y0+((img_y1-img_y0)/img_dim(1))*img_x

  cormag_img_c(*,i,j)=cormag_img(*,i,j)-img_y(*)

endfor
endfor

cormag_img_cc=fltarr(img_dim(1),img_dim(2),img_num)

for j=0,img_num-1 do begin
for i=0,img_dim(2)-1 do begin

fact=average(cormag_flt_c(412:612,i,j)/cormag_img_c(412:612,i,j))
cormag_img_cc(*,i,j)=fact*cormag_img_c(*,i,j)/cormag_flt_c(*,i,j)
```

```
endfor
endfor
```

This Figure clearly shows that some instrumental artifacts are still present and are not removed by the flat-field. Hence, for the future it will be necessary to understand the origin of these artifacts and to acquire new observational sequences. This work will be carried out in the near future. Because of the above unforeseen difficulties, it was not possible to coalign different coronal images and to use them to derive a preliminary estimate of coronal plasma physical parameters.