Critical Design Review (CDR)
Of
ULTRA VIOLET IMAGING TELESCOPE (UVIT)

(June 17th -18th 2011, ISAC, Bengaluru)

Calibration with Assembled Telescope

UVIT-CDR-00-08

Indian Institute of Astrophysics
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Critical Design Review
Ultra Violet Imaging Telescope

Tests and Calibration of Optics

Calibrations with Assembled Telescope

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Abbreviations

CREST	Centre For Research & Education in Science & Technology
UVIT	Ultra Violet Imaging Telescope
TIR	Telescope Invar Ring
TT2	Telescope Tube 2
SC	Satellite Cube
SA	Satellite Adaptor
RMS	Root Mean Square
PTV	Peak To Valley
IIA	Indian Institute of Astrophysics
NUV	Near Ultra Violet
PMA	Primary mirror assembly
PM	Primary Mirror
SMA	Secondary mirror assembly
FM	Flight Model
VIS	Visible
DB	Detector Bracket

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1.0 Introduction

This report describes about various optical tests and calibration on FM UVIT integrated telescope and Integrated FM-Payload. UVIT unit telescope integration started with Primary mirror surface figure deformation test due to the torquing of mechanical interface of Primary mirror assembly to the telescope structure. Next activity is to find the optical axis from the primary mirror and then alignment of secondary mirror to the axis with interferometer. As a part of integration, the gravity effect on the alignment of mirrors is checked with interferometer and from there 0-g effect is also obtained. After the gravity test unit integrated telescope under goes thermal test. The thermal test is to check the effect of change in temperature on telescope focus. To reach the intended image quality from the integrated telescope, the integrated telescope is calibrated for defocus. This defocus test is carried out in a vacuum tank with the help UV collimator. During the defocus test, alignment check on telescope Field of view , detector center alignment wrt the optical axis and detector read out direction orientation with respect to telescope pitch axis is planned. Parallelism between the telescope axis , alignment between the telescope axis and the S/C cube, Detector illumination test are planned on Integrated FM –Payload. Details of all the optical tests and calibration on FM-integrated telescope and Integrated Payload are documented as in the reference.

2.0 Gravity Test

Collimation between secondary and primary of unit telescope has to be carried out at 0g condition. As the collimation test can not be carried out at 0g as such, it is decided to find the effect of gravity on misalignment of primary and secondary mirror during integration of telescope. During the interferometric alignment of unit telescope, the gravity test is being carried out on optical table of MGKML. The g effect on alignment of Primary secondary mirror is quantified by measuring the zenike coefficients (Coma & Astig) from interferometer. Mean Wavefront error of unit telescope at 0degree and 180degree rotation about the optical axis will give the measure of effect of gravity on unit telescope

2.1 Wavefront error measurement at 0degree orientation

At the end of the integration and testing with interferometer, the wavefront error (RMS, PTV, zernike coefficients- XAstig &Yastig, X coma & YComa) is recorded. In this case wavefront error is for the combination of telescope + g .The difference between the successive interferogram is taken and look for the measurement stability. The coma and astig values in 36 Zenike coefficients are noted down.

2.2 Wavefront error measurement at 180 degree orientation

Integrated telescope is rotated 180 degree about the optical axis at the TT2/Telescope mounting fixture interface. Interferometer is aligned to get interferogram and the wavefront error (RMS, PTV, zernike coefficients- XAstig &Yastig, X coma & YComa) is measured as in the previous case. In this case the wavefront is for the combination of telescope –g. The average of the wavefront error meaured in both the orientation are obtained and the result gives residual misalignment in the telescope. Look for residual XAstig &Yastig, X coma & YComa.

2.3 g- Effect correction

If the asymmetry of is found in Zernike coefficients - XAstig &Yastig, X coma & YComa measured in 0 degree and 180 degree orientation then, secondary has to be fine tuned to reduce the asymetricity. Secondary mirror is aligned (tilt and decentricity) to reduce the coma /astig half in the present orientation. Then check the wavefront error in the 180 degree rotation with respect to the present orientation. Fine tune the secondary till we get similar wavefront error (coma/astig) in both orientation

3.0 Thermal effect on Focus

As the defocus is one of the parameter which can blur the image hence degrade the resolution of the telescope, we need to find the cause which can affect the defocus. Temperature variation on the telescope structure is one of the causes which can affect the focus largely as the magnification between primary and secondary mirror is ~3. 10micron change in separation between primary and secondary can cause the defocus of 110micron which is beyond the tolerance(allowed defocus is 50micron). Hence the thermal effect on focus needs to be studied in the laboratory

3.1 Test Setup

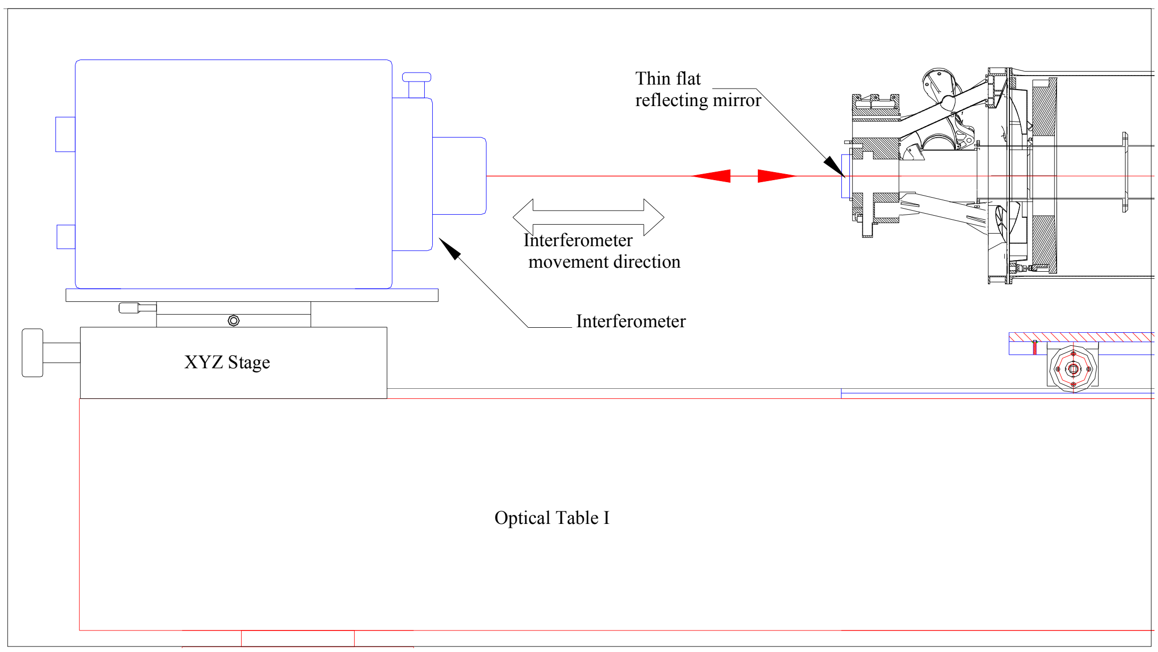


Figure 1. Layout for thermal effect on focus setup. Interferometer moves along optical axis for getting minimum defocus for the case of thin reflecting mirror as well telescope in 100Class.

3.2 Test Method

1. Take interferograme at nominal temperature (22 deg) tune interfeometer for zero defocus Xnt
2. Mount flat mirror at the focal plane of telescope and tune interferometer for zero defocusXnm
3. Find the change in location of interferometer (dxn)
4. Change the temperature to 22+5 degree and repeat the measurement (Xht, Xhm)
5. Find the change in location of interferometer (dxh)
6. Change the temperature to 22-5 degree and repeat the measurement (Xlt, Xlm)
7. Find the change in location of interferometer (dxl)
8. Defocus D**hf** = dxh – dxn ; D**lf** = dxl – dxn

4.0 FOV Test

Field of view test is carried out on integrated FM Unit telescope to check the following requirements.

1. ***Alignment check on Centre of FOV of NUV/VIS telescope to the optical Axis***

This test is to check the alignment of NUV and VIS fields wrt the optical axis of the NUV/VIS telescope. Accuracy of finding the field alignment is better than 20 arc sec.

2. ***Alignment check of centers of the NUV and VIS fields***

This test is to check the overlapping of centers of the NUV/VIS fields. This overlapping can be achieved better than 30 arc second with an accuracy of 20 arc second. The requirement is <1'

3. ***Alignment check on Centre of FOV of FUV telescope to the optical Axis***

This test is to check the alignment of FUV field wrt the optical axis of FUV telescope. Accuracy of finding the field alignment is better than 20 arc sec.

4. ***Alignment check of centers of the VIS and FUV fields by measuring the parallelism between the optical axis***

This test is to check the overlapping of FUV and VIS filed centers. In order to maximize the overlapping of the detector centers, axes of the two telescopes are checked to be aligned to <30”

The first three tests in the above list is carried out in Unit integrated telescope level on the optical table while the last activity is carried out on Integrated payload level on Satellite adaptor. The test method and set up is explained in the CDR document : ***Document No.** : UVIT-CDR-00-10- **Version 0.2***

5.0 Detector Defocus test

Axial position of the detectors on the unit telescope should be correct to 100micron for the mid wavelength of selected filter. In laboratory the axial location of detector can be achieved close to 50micron. This test is carried out inside vacuum chamber along with UV collimator. UV collimator is made by LEOS and is integrated inside the vacuum chamber. Pinhole (20micron) positioned at the on axis focus (pre aligned interferometrically) of the collimator is illuminated with monochromator mounted on the vacuum chamber port. The integrated unit telescope is aligned to the collimator axis for defocus measurement

5.1 Finding/correcting of defocus for nominal filter

The integrated unit telescope is positioned inside the vacuum chamber aligned to the collimator axis for defocus test as shown figure 2. The vacuum chamber is evacuated to pressure <10^-5 mbar. Collimator pinhole imaged on the detector by the telescope. The RMS size of image of the pinhole is obtained from the detector output for a selected filter(nominal filter) in the filter wheel. Then the pinhole will be moved along the optical axis with the help of XY stage and every 100micron movement of the pinhole, the image is recorded and the RMS size of the image is estimated from detector. Pinhole location from its nominal position for minimal RMS image size (best RMS) measured as detector defocus. This defocus correction is given to the detector by appropriate spacer between CPU flange and DB. After correction of defocus, defocus test is repeated for the residual error in focus.

5.2 Measuring image blur dia for other filters

After correcting the defocus for the nominal filter in the filter wheel, the RMS size(blur) of the pinhole image is measured for other filters in the filter wheel in their respective canter wavelength.

Focal Plane tilt measurement (+/- 0.24 Deg)

Requirement on the tilt of the focal plane in the unit telescope is <4 arc min. The tilt of the focal plane is estimated by measuring the blur of the image for +/-0.24 deg off-axis filed angle. For off-axis measurement, the telescope is tilted wrt the collimator axis with the help of telescope mounting fixture and tilt is measured with theodolite by sighting the alignment cube on DB.

5.3 Plate scale measurement on Window/ on Chip

The aperture (mechanical stop)of the detector window is 39mm. Acquire image of pinhole at the diametrically opposite edges (along pitch axis) of the CPU window by tilting the telescope wrt to the collimator axis. Measure the tilt of the telescope from theodolite. From the filed angle corresponds to 39mm, the plate scale of the telescope on window can be calculated.

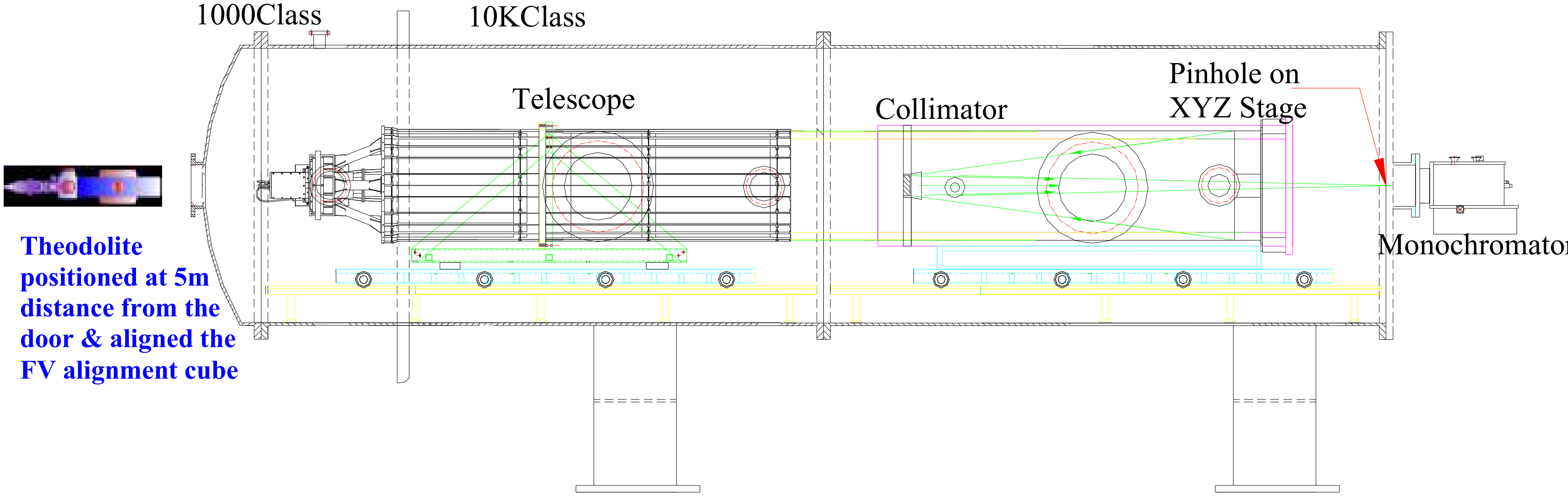
Measure the centroid separation between the two images recorded on the CPU chip. The ratio of the centroid separation to the filed angle gives the plate scale of the telescope on CPU Chip

The ratio between the Plate scale of on window to on chip gives the gain of fiber tapper.

5.4 Measurement of Alignment detector (Rows/Columns) wrt to pitch axis

Measurement accuracy of finding the orientation of CPU rows/coloumns wrt to the telescope pitch axis is 3 arc min. Fore this test, the telescope inside the chamber is tilted

+/-0.24 degree along the pitch axis wrt the collimator axis. The tilt of the telescope is monitored by theodolite and the pinhole image is recorded on the detector. The position of the images aligned to the row/columns is measured from the detector and this gives the orientation of rows/coloumns in the CPU.



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