PRELIMINARY DESIGN REVIEW

ULTRAVIOLET IMAGING TELESCOPE (UVIT)

UVIT-PDR-012 - VERSION 1.0

MISSION OPERATIONS

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1. Overview

Mission planning is necessary to ensure that optimum use is made of expensive instrument and spacecraft resources. These include both safety aspects such as ensuring that the Sun, Moon, or Earth angle constraints are not violated as well as optimizing the observations to maximize the spacecraft efficiency, especially when taking into account the other instruments on this multiwavelength mission.

There is a considerable resource requirement in supporting the operation of the spacecraft and the instruments. This document concentrates on the aspects of the mission operations that deal with the UVIT instruments and their operation.

We note that many details of the mission planning remain to be worked out and this document will be updated as this happens.

2. Mission Planning

A. Turn-On

The instrument doors will not be opened for TBD days after the nominal orbit is reached to minimize contamination from outgassing of the spacecraft surfaces. After door opening, the instrument will be allowed to outgas for a further TBD days before the power is turned on. The first field observed will be a dark field with no bright sources, such as the North Galactic Pole. The observation will be at night with TBD constraints on the Sun, Moon, and Earth angles. The turn-on sequence will be as follows:

1. Filter to be in closed position.
2. HV set to minimum gain.
3. Ramp gain to operating value in TBD steps.
4. HV set to minimum gain.
5. Move filter to open position.
6. Ramp gain to operating value in TBD steps.
7. Observe for TBD minutes.
8. Turn power off.

The turn off sequence will be as follows:

1. HV set to minimum gain.
2. Filter moved to closed position.
3. Ramp to operating gain in TBD steps.
4. Turn power off.

We will require real time monitoring of the instrument health and operation parameters during the turn-on phase.

B. Characterization Phase

The characterization phase will occupy the first 6 months of the mission. This is a special phase in which priority is given to those observations which help to show how the instrument is behaving after launch. Targets will be chosen to achieve these calibration goals and will include both photometric and astrometric standards.

The turn on and turn off sequences will be the same as in the *Turn On* phase. There may be special modes in which different command sequences are used, such as modes in which the entire CCD is read out to check the instrument centroiding

However, there is no requirement for real time monitoring of the payload.

C. *Normal Operations*

Mission planning for the bulk of UVIT operations must be done in conjunction with the science planning, the requirements of the other payloads and the operational constraints on the payloads and the spacecraft. We will plan operations to maximize the efficiency of the mission operations.

Calibration observations will be scheduled at TBD intervals which may be more or less frequent depending on the performance of the payload. There may be special command sequences and data requirements during such observations including some with significantly higher data rates where the entire CCD is read and transmitted to the ground.

The turn on and turn off sequences will be as in Section A except for some of the characterization observations.

There are no special requirements on mission control during this phase.

3. Ground Station

A. *Overview*

The mission control for ASTROSAT will be at ISTRAC and both commands to the spacecraft and telemetry from the mission will be routed through the mission operations center. The responsibility for generation the commands and for processing the data will be with the instrument team. However, the mission operations team must check the integrity of the commands and of the telemetry from the spacecraft.

B. *Requirements*

We require a dedicated ground station for UVIT which will be used for preprocessing the UVIT data and for quick look analysis of the data, particularly for instrument verification. Real time operation is required during the instrument turn on and in the case of anomalies in the instrument operation. At other times, the data will be processed using the quick look programs and any deviations from nominal levels will be redlined. A procedure will be evolved to identify personnel who will be available at any time in case of an instrument emergency.

C. Spacecraft Commands

There are a limited set of commands used during routine UVIT operation including:

1. Move filter to position N.
2. Use standard turn on sequence.
3. Use standard turn off sequence.

In addition, there will be commands used as part of the instrument characterization for which individual provision will have to be made.

GROUND CALIBRATION

1. Overview

One of the most important tasks in the operation of an astronomical telescope is the calibration of the instrument, particularly in space. Despite the best efforts of the ground calibration, the performance in space may be entirely different, perhaps due to surface contamination, flexing in the fixtures, or other factors. Therefore it is necessary to have a well-thought out calibration plan which continues throughout the mission. Note that the primary purpose of the instrument calibration is to ensure that the instrument is well-characterized, with science from those data as only a secondary object. Without such a plan, the science return will be compromised.

In this document, we present our plans to ensure that the instrument is well characterized throughout the mission. Part of the on board calibration plan includes the creation of the necessary software to feed the information back into the science pipeline.

It should be noted that this document is, as yet, a shell containing place holders for the different activities. As details are worked out, including detailed mission plans, this document will be updated.

2. Calibration Activities

A. Photometric Calibration

We will choose a number of calibration stars over the entire sky. The pool of stars must include a range of magnitudes to explore the full dynamic range of the instrument and must be of different spectral types because of the differing spectral ranges of the three UVIT detectors. Care must be taken such that the field in which the calibration star lies is not so bright as to have the potential to damage the detectors.

The first choice for calibration stars will come from the grid drawn up from the Hubble Space Telescope and will include their primary calibrators - white dwarfs. Note that we will not be able to perform a spectral calibration in space - that must come from the ground calibration.

The evolution of the sensitivity with time will be followed by repeated visits to calibration stars.

B. Distortion

Instrumental distortion may come from several sources and is difficult to measure on the ground because of measurement difficulties. We will observe selected clusters such as the Hyades to study the distortion on different scales.

C. Flat Field

Flat fielding is normally done from space by observing a uniform background such as the Earth's atmosphere. It will also be possible to map out the uniformity of the detector through slow scans through a star field where the brightness variations can be mapped out as a function of stellar position.

D. Alignment

The alignment of the 2 telescopes (3 detectors) will be checked by repeated visits to clusters such as the Hyades. It may be that as the thermal environment of the payload changes, flexing may cause alignment changes between the different telescopes.

E. Out of Field Rejection

Off-axis scattering is important to characterize particularly near bright stars. We will do this in two ways: one by slowly approaching the Moon and the other by approaching bright stars such as Sirius. The scattering as a function of angle from the source can be derived.

3. Mission Timeline

The first TBD months of the mission will be devoted to calibration and characterization of the instruments including a determination of the sensitivity limits at both the bright and faint ends of the dynamic range. After the initial characterization, we will revisit targets at TBD intervals to monitor the stability of the calibration.

4. Software Development

It is important that the results of the mission calibration be fed back into the software development as soon as they are derived. We will develop tools before the start of the mission to do this in a rapid and transparent manner.

5. Ground Calibration

From the point of view of the on board calibration, the calibrations performed on the ground will serve only as a first estimate of the instrument calibration. The primary calibration of the instrument must come from actual observations while the instrument is operating in space. The only exception to this is in the spectral calibration which cannot be done from space.