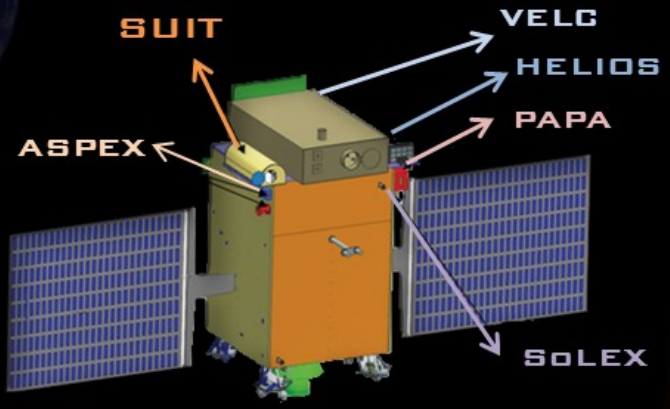
SOLAR ULTRAVIOLET IMAGING TELESCOPE (SUIT)

Onboard ISRO ADITYA-L1



IUCAA
Inter-University Centre for Astronomy and Astrophysics
Pune, India

Payload Scientific Objectives

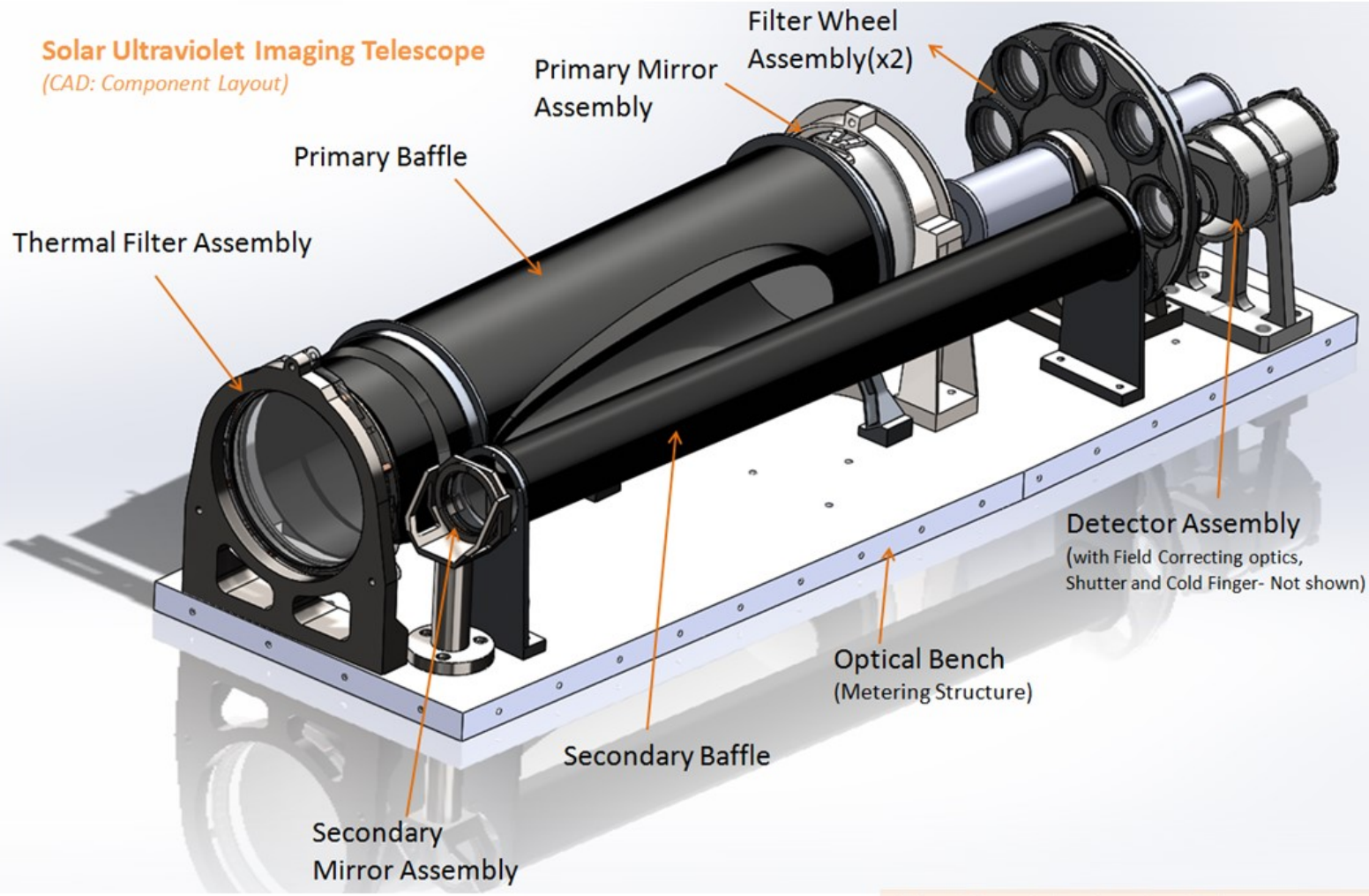
SUIT instrument proposed on-board Aditya-L1 mission will open up an unprecedented observing mode of the Sun at near UV domain (between 200-400nm), with a combination of filters with medium and narrow bandwidth. It will provide near simultaneous 24x7 observations of the various layers of the sun from photosphere up-to corona that will help to address the following main questions:

A. Coupling and Dynamics of the Solar Atmosphere: What are the processes through which the energy is channelized and transferred from the photosphere to the chromosphere and then to the corona?

B. Prominence Studies from SUIT: What are the mechanisms responsible for stability, dynamics and eruption of solar prominences?

C. Initiation of CMEs and Space Weather: What are the kinematics of erupting prominences during the early phase?

D. Sun-Climate studies with SUIT: How strongly does the solar irradiance of relevance for the Earth's climate variations?


Solar Ultraviolet Imaging Telescope
(CAD: Component Layout)
Filter Wheel Assembly(x2)
Primary Mirror Assembly
Primary Baffle
Thermal Filter Assembly
Detector Assembly
(with Field Correcting optics, Shutter and Cold Finger- Not shown)
Optical Bench
(Metering Structure)
Secondary Baffle
Secondary Mirror Assembly

Major Components

All major components except science filters and detector are being developed in India.

Thermal Filter: This is a metal dielectric coated fused Silica substrate that has been designed to reject radiation outside the 200-400 nm NUV band.

Optics: The optical design is an off-axis system that consists of primary and secondary hyperbolic mirrors. These are being designed and developed with IIA and LEOS in Bangalore.

Detector: The proposed detector is a 4096X4096 pixels back-illuminated CCD with a spatial resolution of 0.7"/pixel and a full-well capacity of 175k e-.

Science Filters: We have 11 science filters (8 narrowband and 3 broadband). The narrowband filters are centred at 214 nm, 300 nm, 388 nm, 274.7 nm , 279.6 nm, 280.3 nm, 283.2 nm, 397.8 nm whereas the broadband filters are 200-242 nm, 242-300 nm and 320-360 nm.

Filter Wheel Mechanism: The science filter will be moved into optical path by two independent filter wheel mechanisms that are being developed by IISU, Trivandrum.

Electronics: The payload electronics and control systems are being developed by IUCAA and ISRO SSIF/ISITE.

Focusing mechanism: A linear positioner will be used to move a field corrector lens placed between science filters and the detector.

Entrance Door: The entrance aperture will have a multioperation door mechanism that will protect the payload from contamination during pre-flight and in-orbit operations.

Performance Modelling

The incoming solar flux within 200-400 nm band varies typically as is seen in fig. With the use of appropriate thermal filters and science filters with given spectral responses and quantum efficiencies we ensure that the CCD is never saturated.

The Point Spread Function (PSF) of the CCD is assumed to be a 2-D Gaussian with a FWHM of 2 pixels.

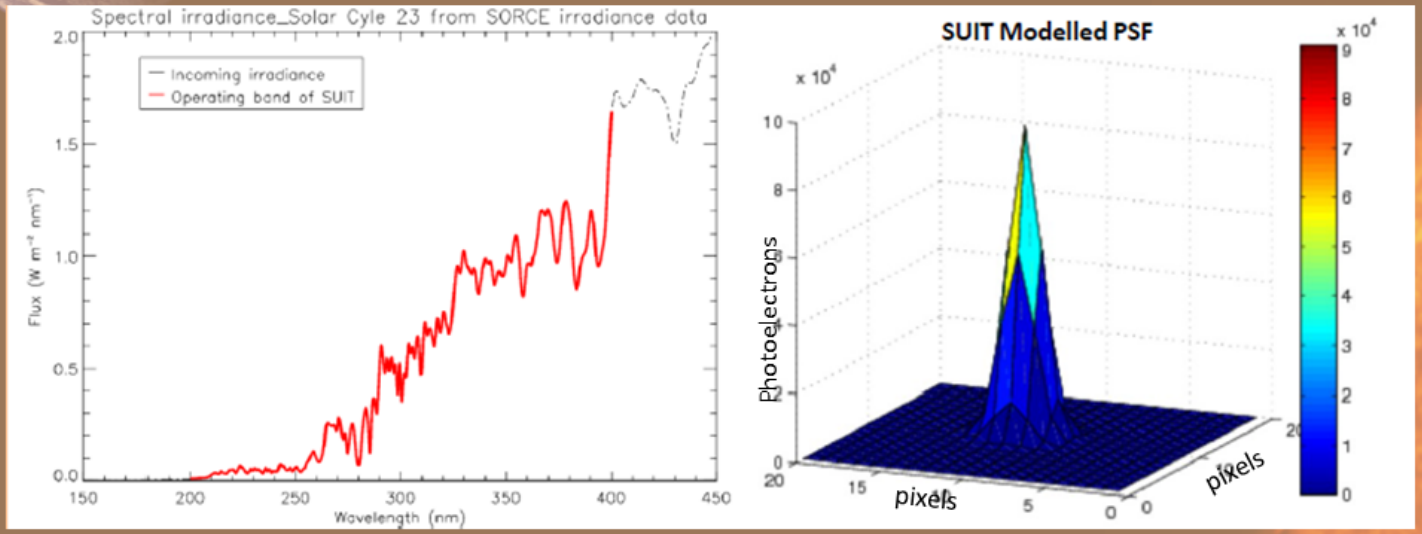


Figure: (Left)Solar spectral irradiance between 200-400 nm, (Right) SUIT Modelled PSF

Data Compression

SUIT will take images of the sun 24x7 at L-1

- Estimated data volume is 336 Gigabits over 24 hours of observation,
- Whereas, available downlink is 90 Gigabits. So, a compression by a factor of 5 is desirable.

With AIA 1600 Angstrom images as input Frame Difference Image (FDI) and Running Difference Image (RDI) were created on which we apply Rice-Golub compression code. With this technique a lossless compression by a factor of ~2 was achieved.

However, to achieve a compression factor of ~5, assessment study is being conducted to determine what kind of losses we can afford as lossless compression by a factor of 5 is difficult to achieve.

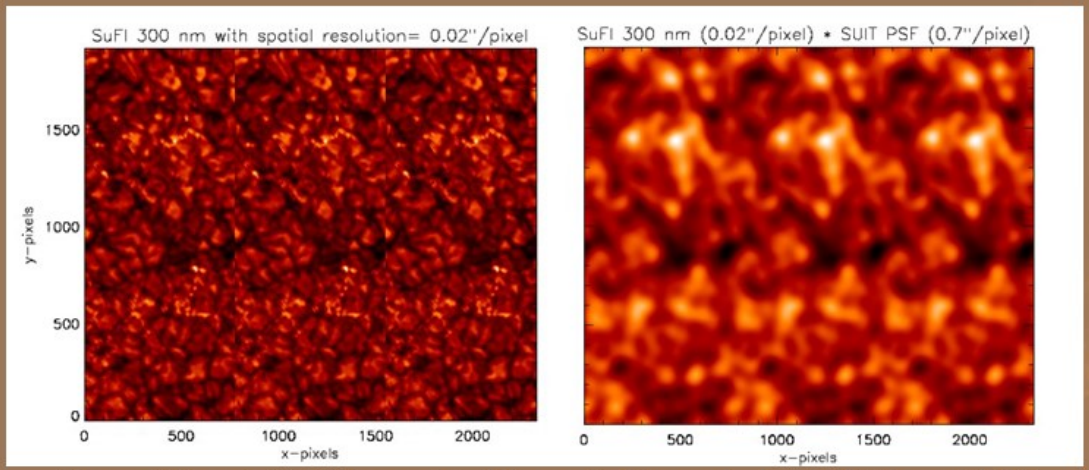


Figure: 300 nm SuFI (0.02 arcsec/pixel) Image (Left) convolved with SUIT's model PSF (spatial scale 0.7 arcsec/pixel)

Tolerance and Scattering Analysis

Contamination Control Requirements

SUIT contamination control requirements are defined by 2 limiting factors:

- Scattering (due to particulate contamination)
- Photo-polymerisation (due to molecular contamination)

Contamination Control Plan

- Baseline estimation of contamination control requirement completed .
- General procedural requirements have been recognized and defined in a contamination control plan.

Contamination Control Facility

- The payload is proposed to be integrated in a clean room facility at SSIF/ISITE facility in Bangalore.
- A detailed discussion on development of cleanroom facility at SSIF is in progress.
- The integration process will be conducted in a Class 100 clean tent placed in a Class 1000 cleanroom.

	Activity	Optical Components	
		Particulate (ppm)	Molecular (ng/cm2)
A	Post clean	40	10
B	Pre-Integration testing and measurement - Optical	26	35.1
C	Assembly/Integration/alignment and calibration	130	27
D	Vibration and Environmental Test	825	30
E	Post Test Checks, alignment and calibration	120	15.4
F	Transport and Storage	0	0
G	Satellite Integration and Pre-Launch Tests	1237.5	45
H	Pre-Launch Operations	412.5	15
I	Launch	1525.5	127.9
J	Scientific operations	1525.5	127.9
	Total - End of Mission: Optical	6206	699.3

Table: SUIT Contamination Budget for particulate and molecular contamination levels in phases

Operational Modes

SUIT has two operational modes:

A. Normal Mode: In this mode, SUIT will take images 24 x 7 based on a predetermined procedure.

B. Flare Mode: This mode is triggered by a flare event (external trigger provided by SoLEX or HELIOS) during which it will take images of the flaring region for a small duration.

Tolerance and Scattering Analysis

Tolerance Analysis

Tolerance analysis of optical design was conducted to understand tolerances on different parameters of the system according to acceptable performance criteria.

Zeemax© was used for Monte Carlo simulation to find worst case based on bounds on individual parameters and a given performance criteria.

Mechanical/fabrication and Thermal tolerances were found to be within manufacturing and operational limits, respectively.

Scattering Analysis

Scattering is a major concern as

- The payload operates in the UV region (scatter is inversely proportional to wavelength).
- The science requirement demands a high image contrast that limits the acceptable level of scattering.

ASAP Pro© was used to model scattering due to:

- Surface micro-roughness: Surface micro roughness of 15 Å rms was acceptable for the optical surfaces
- Surface particulate contamination: Surface particulate cleanliness level better than Class 200 (as per MIL Standard) was prescribed for the contamination control plan.

Why is this Important?

- Provides coverage of solar atmosphere from lower photosphere to upper chromosphere and lower transition region – solar atmospheric dynamics.
- Provides unique opportunity to study spatially resolved solar spectral irradiance in NUV – relevant for sun climate relations – atmospheric dynamics of Earth.
- Has not been done from space before – except two balloon borne experiment

Instrument Collaborators

IUCAA · IIA · IISER KOLKATA · ISRO

Science Collaborators

NCRA • TIFR · IISER PUNE · MPS