ASTROSAT SC. MEETING SEPT. 27-29, 2006, IIA

UVIT INSTRUMENT
and its
CAPABILITIES: 1

S N Tandon

COLLABORATING INSTITUTIONS

- INDIAN INSTITUTE OF ASTROPHYSICS, BANGALORE
- INTER UNIVERSITY CENTRE FOR ASTRON. & ASTROPH.
- PHYSICAL RESEARCH LABORATORY
- TATA INSTITUTE OF FUNDAMENTAL RESEARCH
- ISRO SATELLITE CENTRE
- LABORATORY FOR ELECTRO-OPTICS SYSTEMS, ISRO

- CANADIAN SPACE AGENCY & CANADIAN SCIENCE TEAM LED BY JOHN HUTCHINGS
- *PHOTEK, UK SUPPLIES DETECTOR MODULES*
- *MULLARD SPACE SCIENCE LABORATORY, UK, SUPPLIES HIGH VOLTAGE UNITS FOR DETECTOR MODULES*

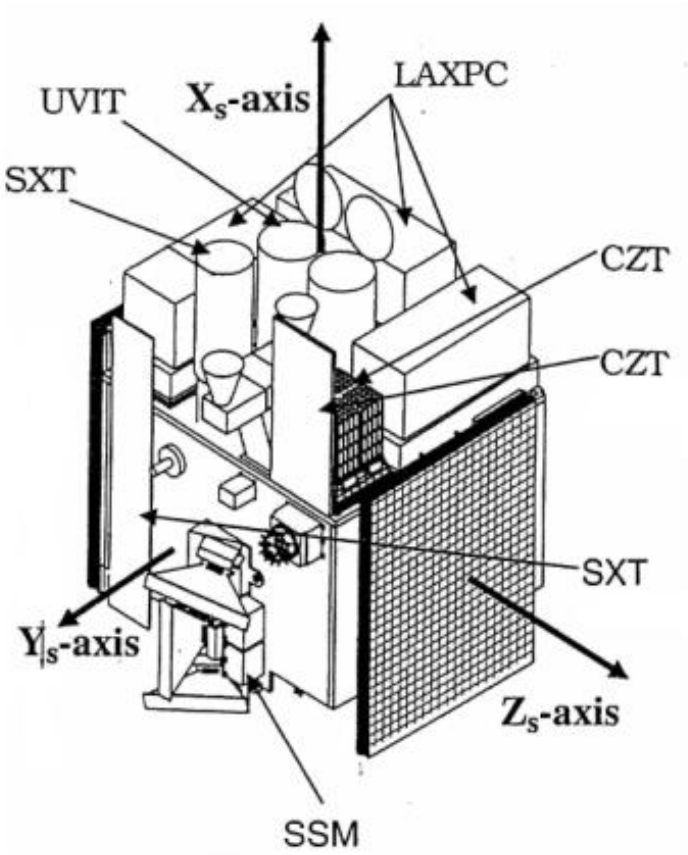
FUNCTIONAL REQUIREMENTS

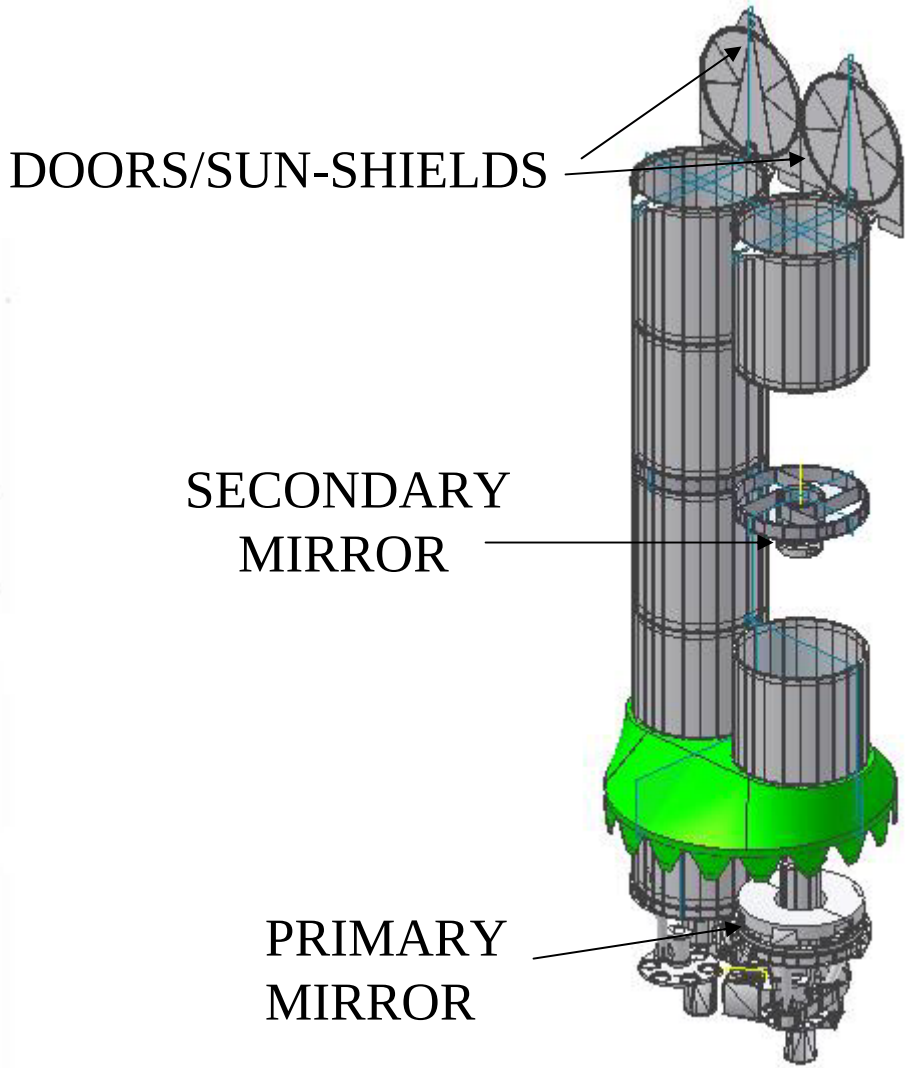
SIMULTANEOUS WIDE ANGLE (~ 28') IMAGES IN :
FUV (130-180 nm), NUV (200- 300 nm),
and VIS (350-550 nm)

- SPATIAL RESOLUTION < 1.8"

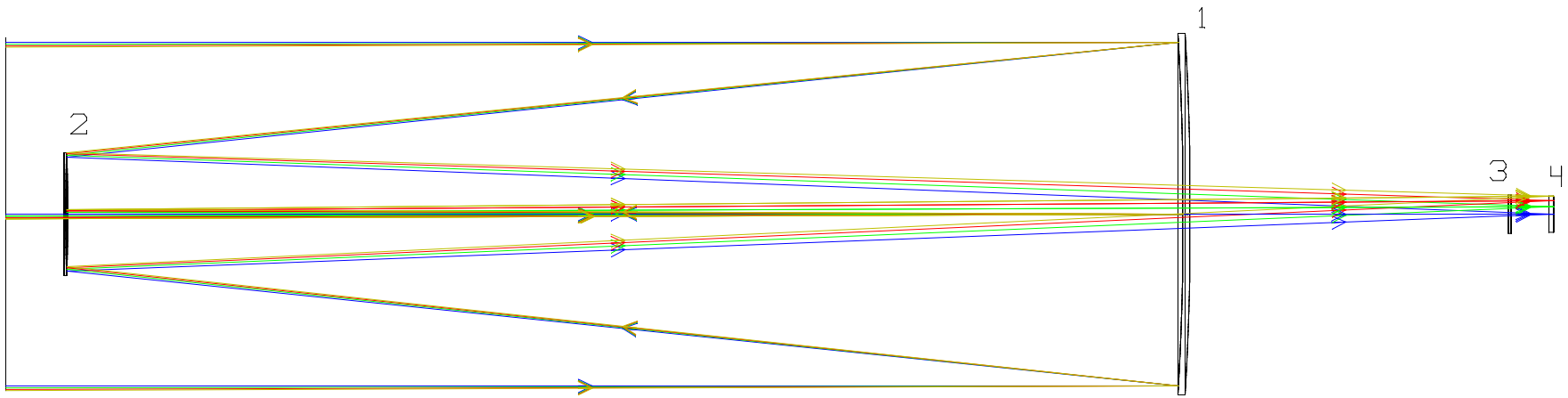
- SENSITIVITY IN FUV mag. 20 in 1000 s
- TEMPORAL RESOLUTION ~ 30 ms, full frame
(< 5 ms, small window)
- GRATINGS FOR SLIT-LESS SPECTROSCOPY
IN FUV AND NUV CHANNELS

CONFIGURATION OF PAYLOADS ON ASTROSAT





OPTICAL LAYOUT -- FUV CHANNEL

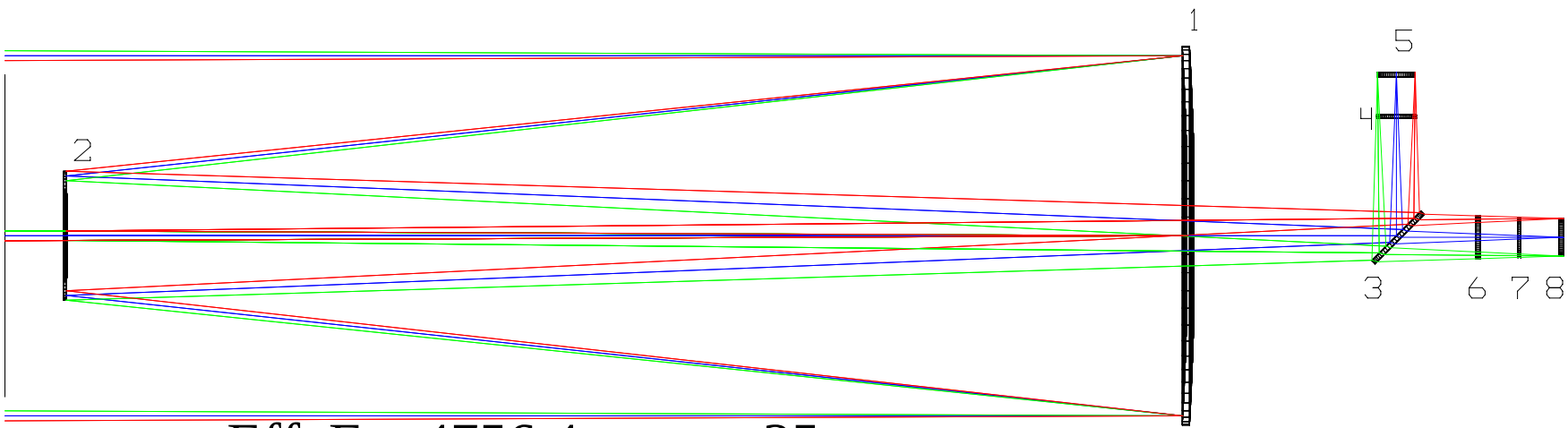


Eff. F = 4756.4 mm +- 35 mm

Detector > 39 mm dia.

1- PRIMARY MIRROR
2- SECONDARY MIRROR
3- FILTER / GRATING
4- DETECTOR WINDOW

OPTICAL LAYOUT – NUV & VIS



Eff. F = 4756.4 mm +- 35 mm

Detectors > 39 mm dia.

1- PRIMARY MIRROR /GRATING
2- SECONDARY MIRROR
3- BEAM SPLITTER
4- NUV FILTER
5- NUV DETECTOR WINDOW
6- VIS CORRECTOR
7- VIS FILTER
8- VIS DETECTOR WINDOW

FILTERS-FUV

MgF2: passes > 120 nm

CaF2 passes > 125 nm

BaF2 passes > 140 nm

Sapphire passes > 150 nm

FUVB1 125 – 150 nm, 15%

CaF2 Grating: Blazed at 140 nm, 400 l/m

Resolution ~ 100

FILTERS - NUV

Dichroic Mirror 180 - 300 nm, > 80%
or 200 - 300 nm, > 80% ??
Silica > 170 nm
NUVN1 187 - 195 nm, > 50%
NUVB2 200 - 230 nm, > 50%
NUVB3 230 - 250 nm, > 50%
NUVB4 250 - 280 nm, > 60%
NUVN2 275 - 285 nm, > 60%
CaF2 Grating, Blazed at ~ 270 nm, 400 l/mm

FILTERS - VIS

Dichroic Mirror	320 - 600 nm, > 80%
Bk7	> 300 nm
VIS1	320 - 360 nm, > 85%
VIS2	370 - 410 nm, > 85%
B	390 - 470 nm, > 85%
VIS3	400 - 530 nm, > 85%

BACKGROUND

- UV background in Night

  Lyman Alpha 4500 – 6900 R

  OI 1304 A 70 R

  OI 1356 A 22 R

(ref: Waller et al, p. 1275,AJ,vol 110, 1995)

NUV ~ 3000 ph/s/sq cm/A/s

Day background is a factor ~ 10 more

BACKGROUND COUNTS

- FUV- full band

  Eff. area 10 sq. cm, field ~ 30’ dia.

  OR ~ 47 ph./R/s

  a) with MgF2 filter ~ 2.2 - 3.3 X 10^5/s

  b) with CaF2 filter ~ 4700/s

  For 30 frames/s, count rate is unacceptably large for MgF2 filter.

BACKGROUND COUNTS

- NUV – full band

  Eff. Area is ~ 30 sq cm, field is 30’ dia

  OR ~ 140 ph/R/s

  background in NUV (2000 – 3000 A) is equivalent to ~ 40 R

  Background count rate is ~ 5600/s, or

  ~ 190 per frame, at 30 frames/s

COUNTS for SOURCES

- FOR 0-mag (AB scale) stars
  FUV has ~ 420 ph/s/sq cm/A
  NUV has ~ 940 ph/s/sq cm/A
- For a mag. 20 source
  1300 – 1700 A ~ 17 ph/ 1000s
  backgd. in 1.8” ~ 4 ph/ 1000s

  2000 – 2800 A ~ 23 ph/ 100s
  backgd. in 1.8” ~ 0.5 ph/ 100 s

VISIBLE BAND

- Background counts are > 10^5/s
- Photon Counting is not possible for exposures > 10 ms
- Low-gain integration mode gives a resolution ~ 5”
- A mag 15 star gives ~ 30 ph/s in 1000 A, and background in 5” ~ 1 ph/s
- A mag 20 star may be seen in 100 s

VISIBLE BAND

- For a 10’x10’ field, exposures of 5 ms and hence ph. Counting are possible
- Resolution improves to 2”, and background is down to ~ 2 ph/10s
- A mag 21 star may be seen in 100 s

RELATIVE ALIGNMENTS

- Relative alignments of VIS, NUV,& FUV are better than 1’
- The relative alignments can drift with aging and due to thermal effects during an orbit.
- l

However pointing accuracy is 3’

SPATIAL RESOLUTION

- FOUR MAIN CONTRIBUTIONS TO BLURR

	VARIANCE
DEFOCUS ETC. IN OPTICS	< 75 (225) !!
DETECTOR	< 250
JITTER OF SATELLITE	< 50
ATTITUDE DETERMINATION	< 25

VARIANCE FOR 1.5 “ (1.8 “) FWHM IS 400 (550) SQ. MICRONS

CLOSE THERMAL CONTROL REQUIRED TO MINIMISE DRIFT RELATIVE TO VIS

SCATTERED LIGHT

- FOR MOON AT 45 DEG. SCATTERED VIS-LIGHT IN FIELD IS LESS THAN NIGHT BACKGROUND
- FOR SMALLER ANGLES, SCATTERED LIGHT INCREASES SLOWLY , BUT

  FOR ANGLES < 10 DEG., THE INCREASE IS RAPID.

  AS RADIATION HITS THE PRIMARY MIRROR

- CLOSE NEIGHBOURHOOD OF A BRIGHT SOURCE

  TO BE AVOIDED FOR FULL SENSITIVITY.

MAGNITUDE RANGE

- mag 8 GIVES ~ 1200 c/s, IN 130-180 NM;
- TO AVOID SATURATION RATE < 1 c/frame
- IF MAX. PARTIAL-FRAME RATE IS 200/S,
  BRIGHT LIMIT IS ~ mag. 10

LONG EXPOSURES TO SUCH BRIGHT OBJECTS CAN DAMAGE DETECTOR

In principle, photometry of brighter objects can be done by counting frames with NO phoons

SAFETY ISSUES

- SAFETY FROM BRIGHT OBJECTS/FIELDS IS OBTAINED BY

  DETECT LARGE COUNT RATE

  PUT DETECTOR OFF &

  RELAY A PULSE TO SATELLITE

  SATELLITE ISSUES COMMANDS TO:

  PUT ALL DETECTORS OFF

  PUT ALL FILTERS IN BLOCK MODE

• AVOIDANCE OF

SUN (BY > 45 DEG.)

RAM DIRECTION (BY > ~ 10 DEG.)

LIMB OF BRIGHT EARTH (BY > 20 DEG.)

OBTAINED BY CONTROL OF ATTITUDE AND ROLL

THESE AVOIDANCES ARE BASED ON WHAT WE LEARNT ON OBSERVATIONS WITH FUSE & GALEX, AND OTHER MISSIONS

THROUGH FURTHER DISCUSSIONS WITH ASTROSAT TEAMS, A PROTOCOL WOULD BE DEVELOPED TO KEEP A CLOSE EYE ON SENSITIVITY OF UV-CHANNLS, AND REDUCE THESE CONSTRAINTS AS FAR AS POSSIBLE.

CONTAMINATION ISSUES

- MATERIALS ARE TESTED FOR DEGASSING
- SUASSEMBLIES ARE PRE-BAKED IN VACUUM
- OPTICAL ASSEMBLY IN CLASS 100/1000 CLEAN ROOM
- WITNESS MIRRORS /WINDOWS USED TO MONITOR CONTAMINATION DURING ASSEMBLY/STORAGE
- NITROGEN PURGE IN STORAGE/TRANSPORT
- DOORS OPENED AFTER WEEKS IN ORBIT

CONTAMINATION …

SOME CONCERNS

NITROGEN PURGING NOT POSSIBLE FOR LAST 3 DAYS BEFORE LAUNCH

GAS-THRUSTERS MIGHT GIFT SOME CONTAMINATION