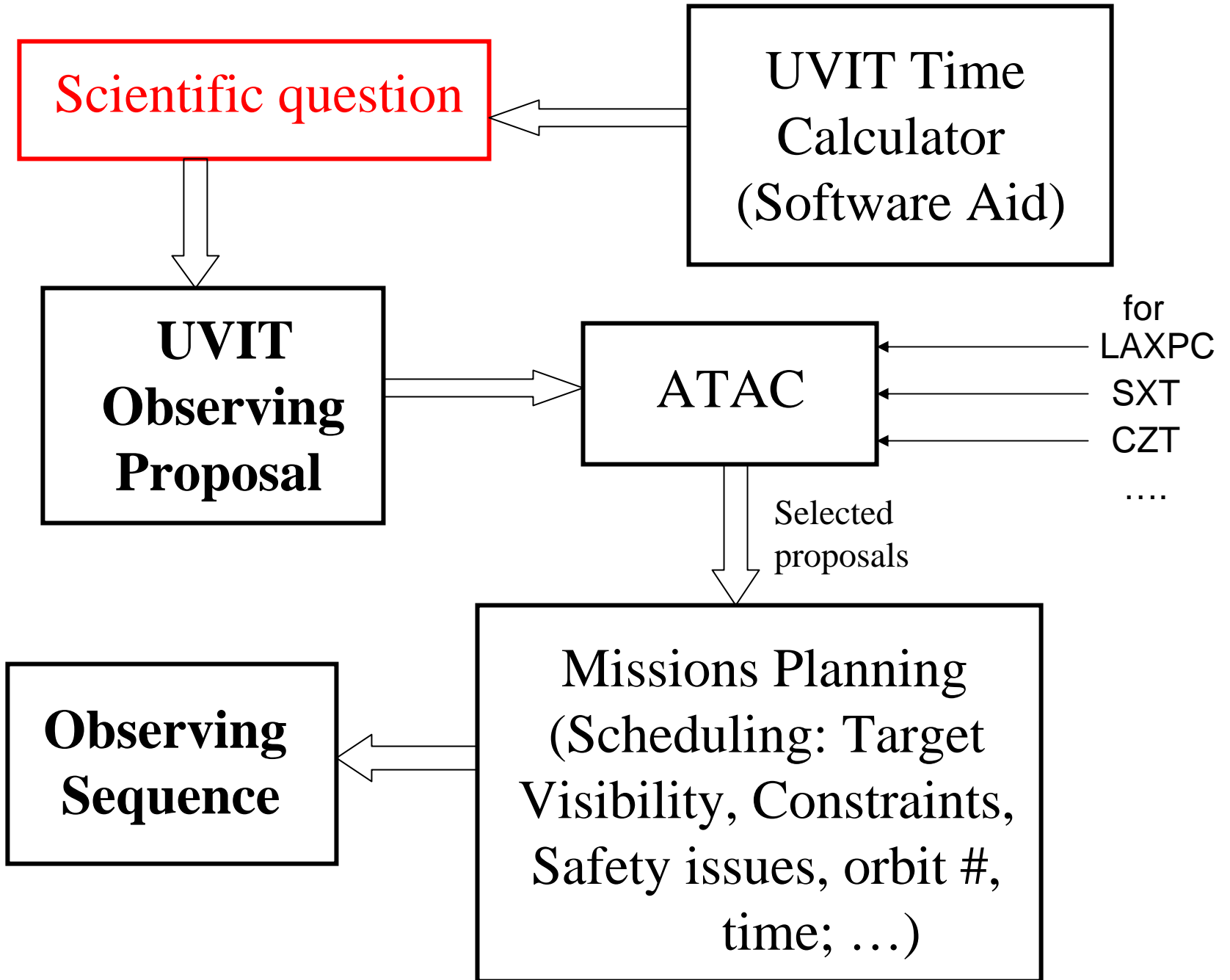
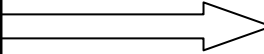


Observing with Ultra-Violet Imaging Telescope

Swarna K Ghosh
(TIFR)



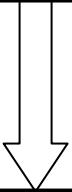
Observing Plan



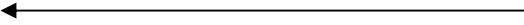
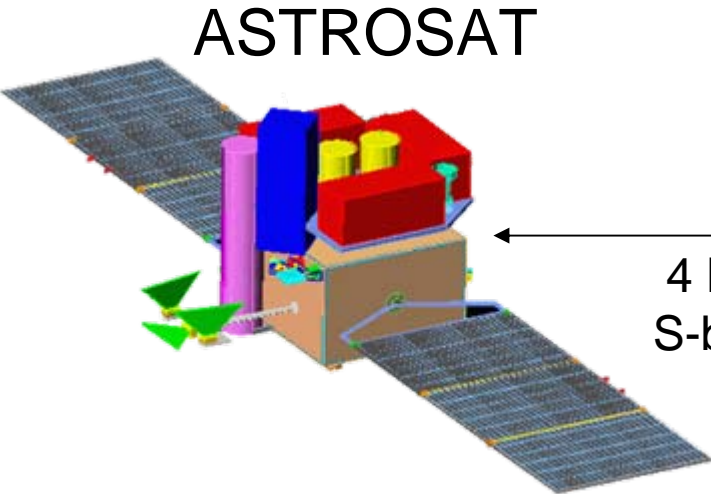
Sequence of
Tele-commands



Ground Control



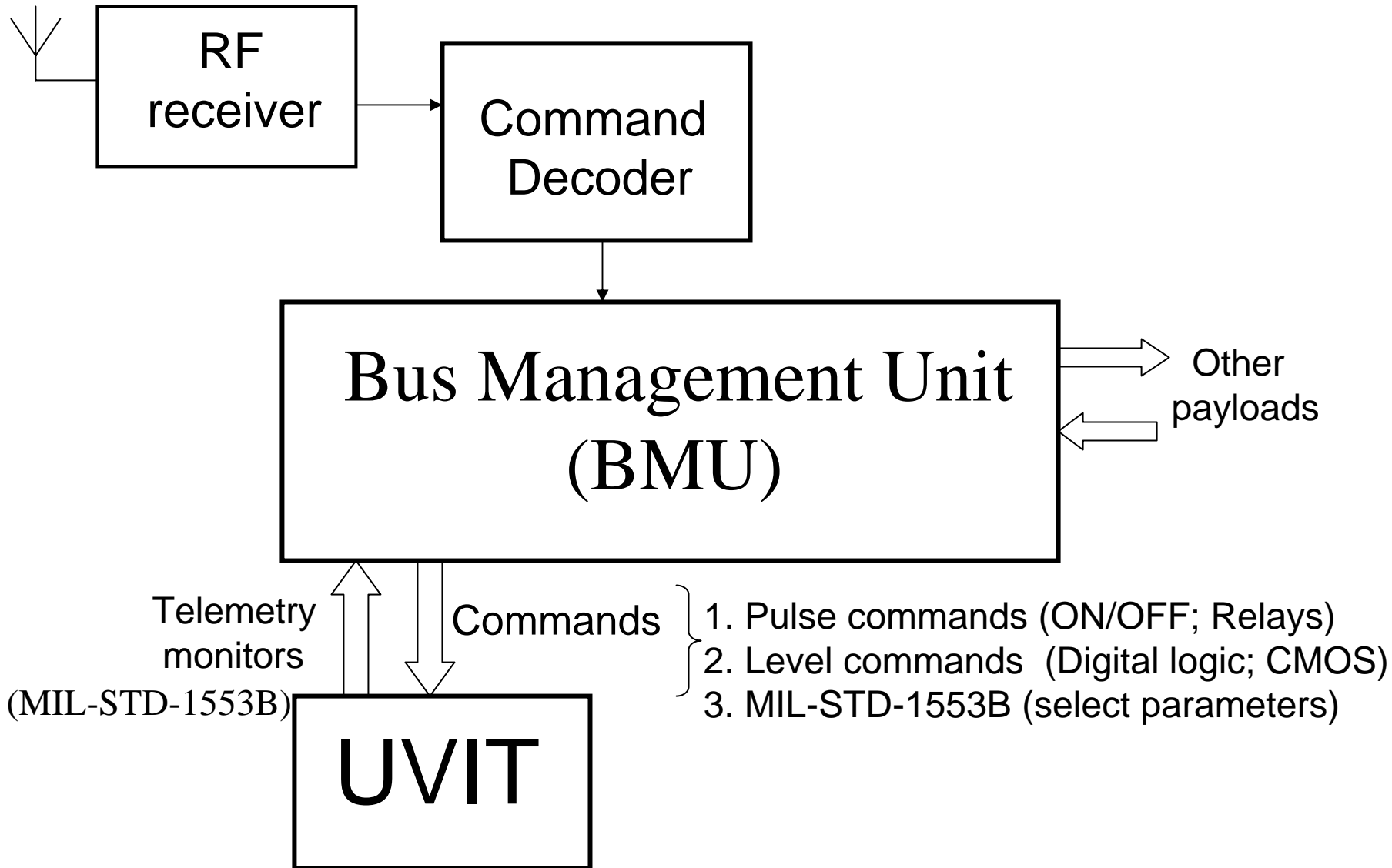
Command Transmission



4 KBPS over
S-band RF link

Typical rate of command frames : ~ 5 /second

On-board spacecraft :



Examples of UVIT commands :

- Pulse : Raw Power Bus select (A/B)
Power ON/OFF for Detector Electronics,
Filter Wheel Drive, De-contamination Heaters, etc
Telescope Door Open;
- Level : Detector System RESET,
Enable / Disable Filter wheel motion,
'SAFE' parking of Filter wheel (light block),
Enable/Disable 'Override' for Emergency Flag,
(Emergency : Bright Object Detect = BOD)
- 1553B : Selectable parameters for Detector systems
(Imaging parameters, High Voltage Unit parameters)

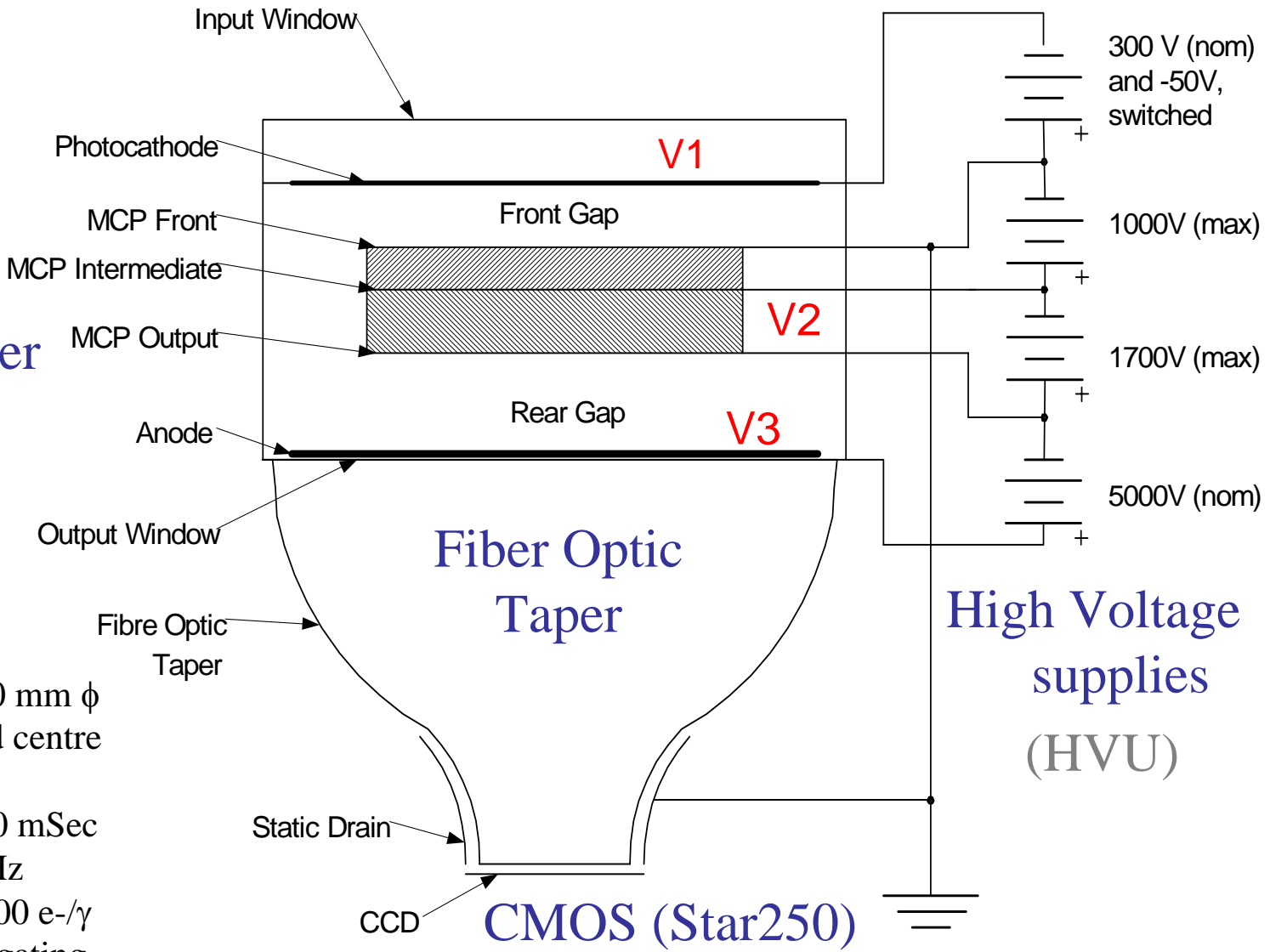
Positioning of the Filter wheel for observing through a particular Filter :

- select filter angle by DATA command;
- Enable wheel motion;
- Start wheel motion;
- Disable wheel motion (after $\Delta T \sim 15$ seconds);

**Components
in each
Detector**

Intensifier

(DM)

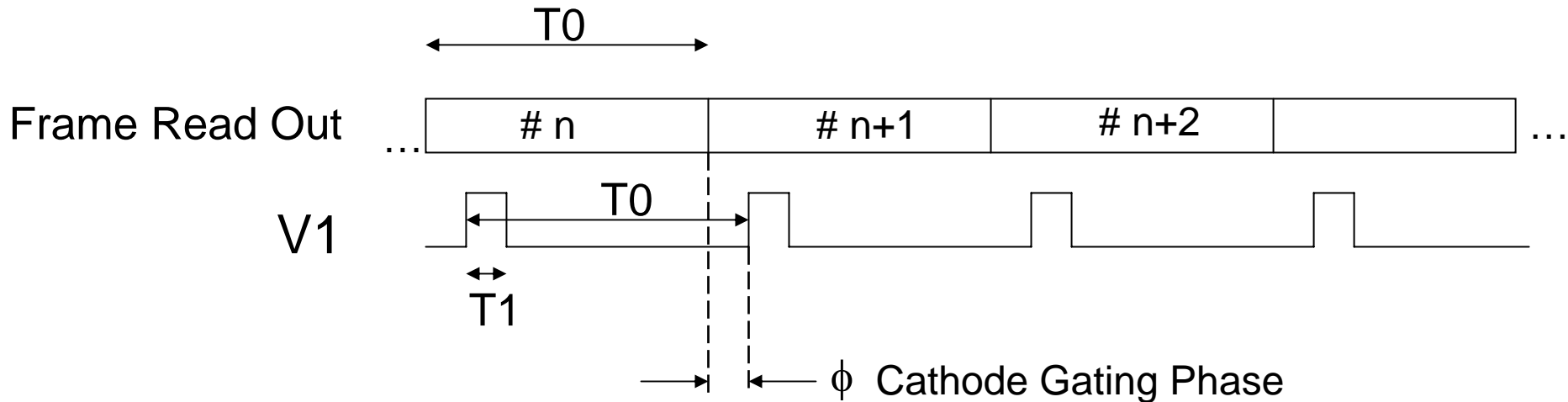


Imaging area : ~ 40 mm ϕ
 QE :> ~5% in band centre
 Pos. res. < 100 μ m
 Exposure : 10-1000 mSec
 Frame rate : > 20 Hz
 Gain : 2000 – 20,000 e-/ γ
 Safety : electronic gating

(Need High Voltage Power Supplies;
up to 8000 V)

V1 : Cathode Gating
 V2 : Gain

Neutral Density Filter by 'Cathode Gating' :



T_0, T_1, ϕ : Command selectable parameters;

ND Filter transmission 't' $\sim T_1 / T_0$

Due to rise / fall time effects of 'V1',

t (minimum) $\sim 1/5$ (@ ~ 30 Hz Frame Rate)

Crucial role of VIS channel :

UVIT requirement of pointing : ~ 1 arc second

Satellite pointing accuracy : ~ 3 arc minutes !

However, S/C drift is low : < 0.2 arc sec. / sec.

VIS channel images provide star field (27' dia.)

if read out at (or faster than) 1 Hz;

Use detected stars for off-line aspect re-construction;

At shorter than 1 sec. time scale, use satellite sensors (Rate Gyroscopes) to correct other effects like 'jitter';

Are there enough stars (VIS) for aspect fix ?

Expected number of stars brighter than Photographic Magnitude 'm_pg', per UVIT field of 0.2 square degrees (27' dia → X 0.8) :

| Galactic Latitude | 'm_pg' =15.0 | 'm_pg' =14.0 | 'm_pg' =13.0 | 'm_pg' =12.0 |
|-------------------|--------------|--------------|--------------|--------------|
| 0 deg. | 259 | 103 | 39 | 15 |
| + -10 deg. | 149 | 59 | 23 | 8.8 |
| + -30 deg. | 57 | 26 | 11 | 4.6 |
| + -60 deg. | 25 | 12 | 5.8 | 2.6 |
| + -90 deg. | 18 | 10 | 4.8 | 2.1 |

Read out modes :

UV Channels (FUV, NUV): **Photon Counting**

(Frames read out fast enough; 29 Hz)

On-board 'Centroid-ing' of each detected photon;
photon list sent to ground;

VISIBLE Channel (VIS) :

Integration mode; too many photons per frame;

(Frames read out @ ~ 1 Hz)

Full image sent to ground;

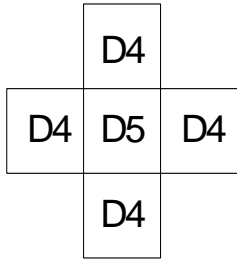
Command selectable parameters for typical observations (target dependent)

| | |
|---------------------------------|--|
| Integration time (per exposure) | : < 20 m-sec to 1 second; |
| Frame read out rate | : ~ 29 Hz full field (512x512), max. : ~ 200 Hz for 50 x 50 window; |
| Exposure stacking | : 1, 2, ..., 16 |
| Window selection | : any rectangular part of 512x512 |
| Centroid-ing Algorithm | : 3x3 cross, 3x3 square, 5x5 cross, 5x5 'circle' |

Other parameters - (typically 'default' values OK)

Setting High Voltages (HVU),
Ramp up/down times for HVUs,
Mode (Photon counting, Integration, Dark frame: V1=OFF),
ND filter (attenuation & phase),
Safety related (HVU current limit; BOD logic;

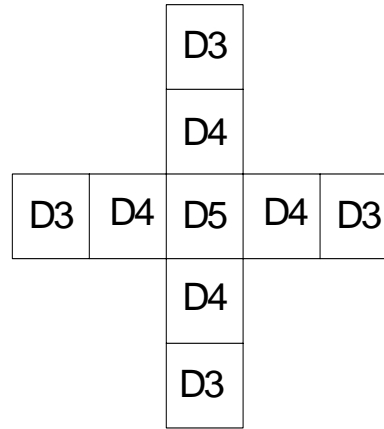
Choices for Centroid-ing Algorithms



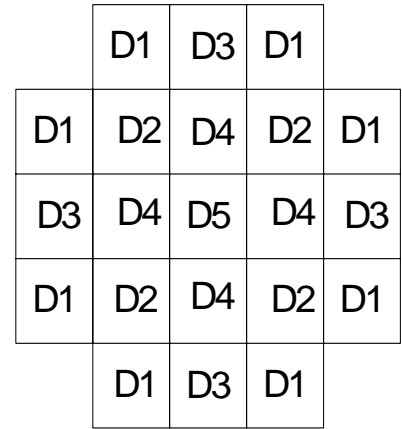
3X3 Cross



3X3 Square



5X5 Cross



5X5 Circle

States of UVIT Detector System :

-OFF

-Low Power (before/ after 'OFF', 'Standby')

-Standby

-Ramp Up

-Active

-Ramp Down

-Fail Safe (Single Event Latchup)

-Bright Object Detected (HV low; Alarm)

Normal command sequence :

Power ON → Low Power → Standby → Ramp Up
→ Active → (Start-Stop Imaging) x n
→ Ramp Down → Standby

Typical sequence of operations (over-heads !)

Large angle slew :

HV at low value;

Filters in 'block' position;

Satellite slew for target acquisition (peak ~ 0.4 deg/sec)
(target as well as slew path free of ALL constraints);

Turning ON for Observations :

NUV & FUV in Photon Counting mode, VIS on Integration;

Data collection begins;

Bright Object Detect logic ON;

Filter to selected position; (~ 15 seconds)

HV ramp up to selected value (~ 10 seconds);

Safety of UVIT Detectors

- Bright Object Detection logics → **shutdown till intervention from ground (Reset)**;
(during ‘window-ed’ mode in one channel, another channel continues to monitor full FoV)
- Planned ‘modulation’ for target fields with bright sources : Slow spiral motion (~10 arc sec max. radius); → **implication for very small selected window** ;

Absolute Timing Accuracy of UVIT :

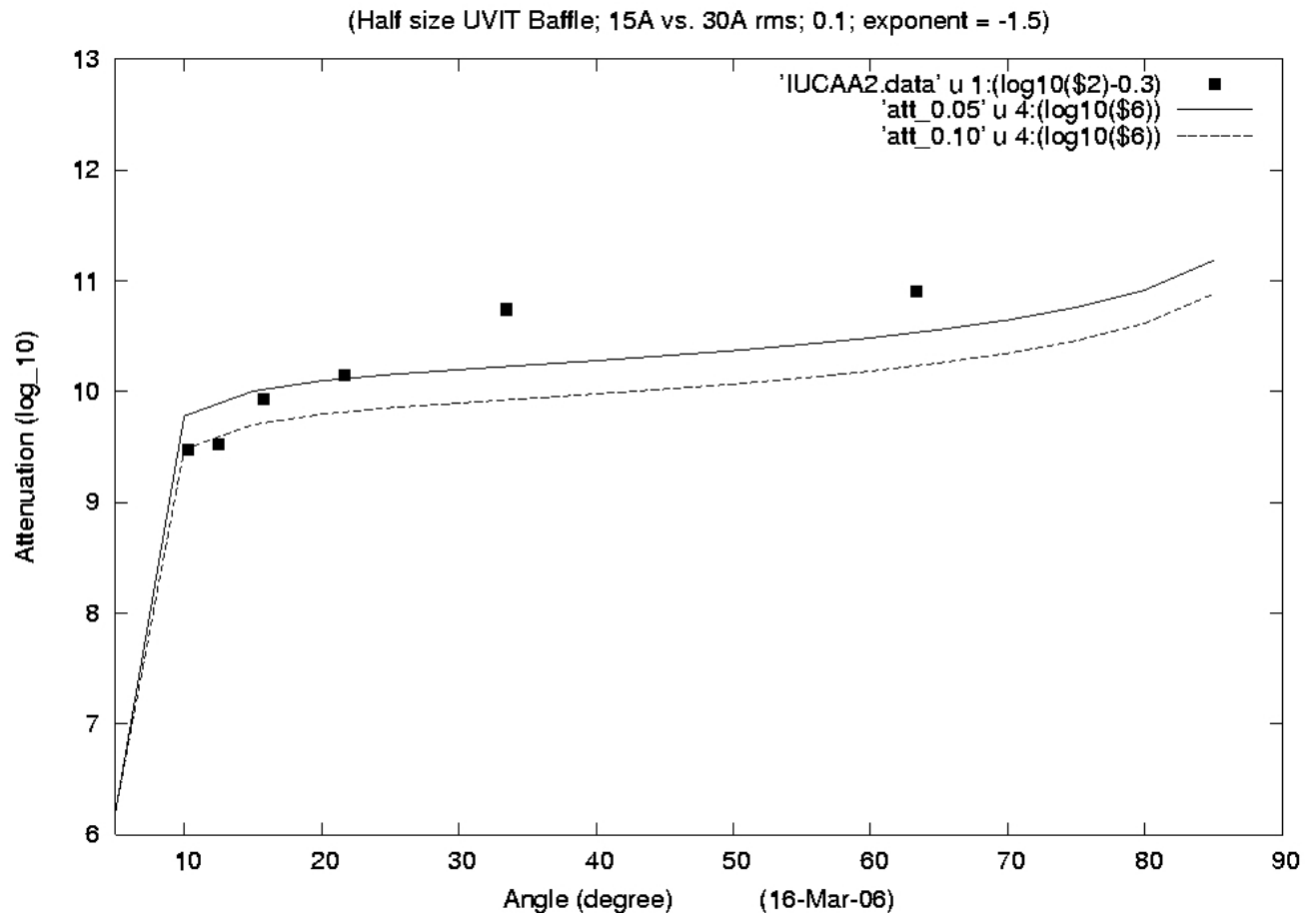
Original projected requirement :
better than 1 second

Using Onboard Timer pulses (PPS)
to calibrate UVIT's clock : < 10 mSec

Background due to nearby bright object : estimation from baffle efficiency

Large angles (> 10 deg.):

(filter specs to be folded)

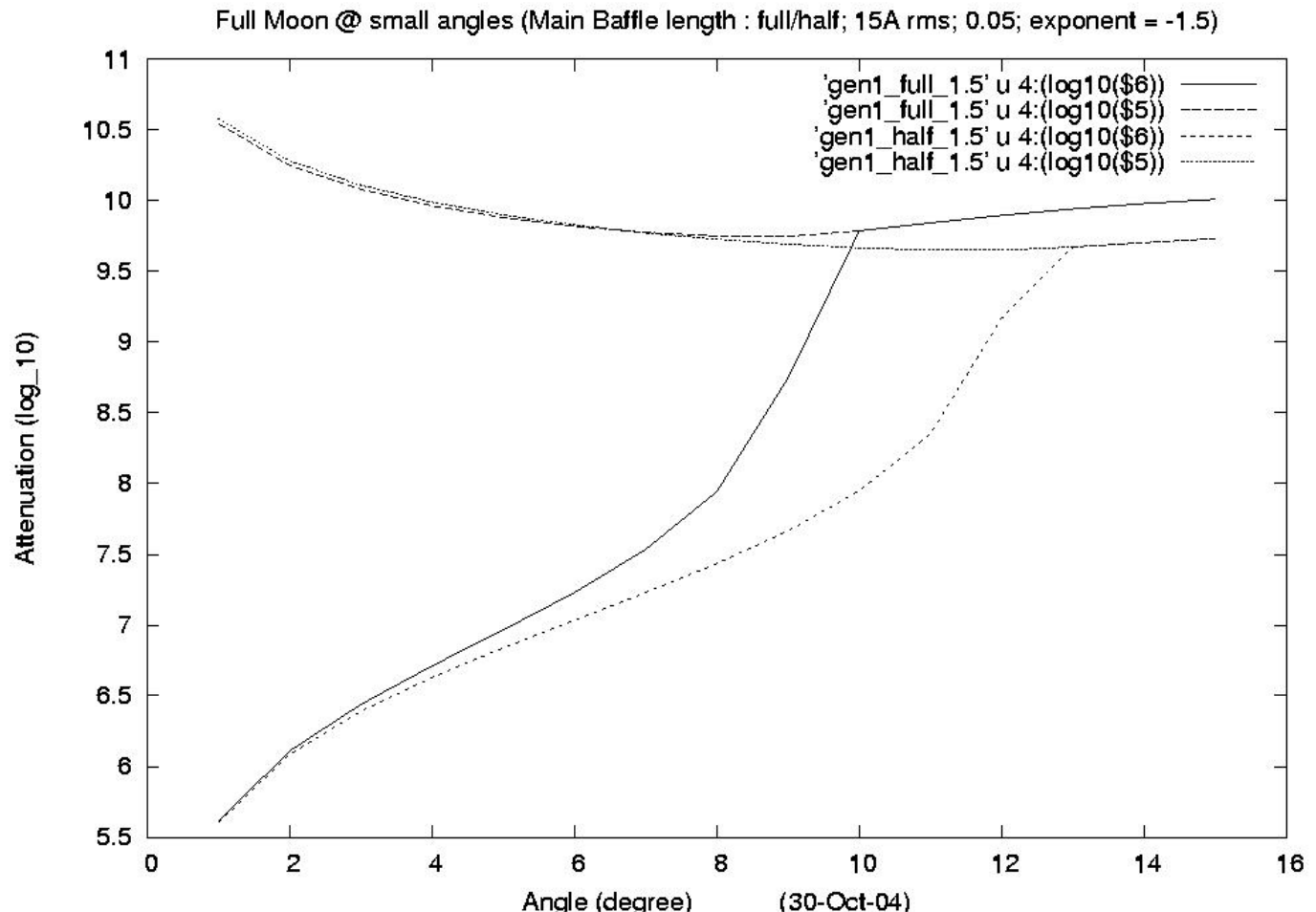


Background due to nearby bright object : estimation from baffle efficiency

#2

(filter specs to be folded)

Small angles (< 10 deg) :



Estimated loss of sensitivity near Earth's limb

| Angle (deg.) | Background | sensitivity loss (mag.) |
|-----------------|-------------------|----------------------------|
| 65 | = 1.0 | =0.00 |
| 32 | 1.7 | 0.29 |
| 10 | 780 | 3.6 |
| 8 | 1.3×10^6 | 7.6 |
| 6 | 5.0×10^9 | 12.1 |

Thank you !

Estimated loss of sensitivity near Earth's limb

| Angle (deg.) | Background | sensitivity loss (mag.) |
|-----------------|-------------------|----------------------------|
| 65 | = 1.0 | 0.00 |
| 32 | 1.3 | 0.14 |
| 10 | 28 | 1.8 |
| 8 | 1120 | 3.8 |
| 6 | 7.1×10^4 | 6.0 |
