

COSPAR @ IISER, Mohali (March-2019)

*UVIT pipeline for Automated
Generation of Sky Images*

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***on behalf of SAC-ISRO & UVIT team**

End-to-end overview :

UVIT --> Science stream data -->
S/C Data Handling Unit -->
Solid State Recorder -->
Transmission to ground
(+ House Keeping; LBT; Aux ...)



Ground reception -->
Data Ingest Front End Processor (DIFEP)-->
Raw data --> Level-0 --> Level-1
Level-1 data --> Data Processing Pipeline-->
Level-2 data --> (end-user / astronomer
friendly)

.....



**Do astronomers planning to
use UVIT data,
need to **run** the Pipeline by
themselves ?**

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NO !!

(not in general)

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Because :

**The astronomer ready images
& other products already
made available at the
ISSDC/ISRO !**

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Because :

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***UVIT Level-2 Pipeline (UL2P) is run by the
UVIT Payload Operations Centre (POC) at
Indian Institute of Astrophysics (IIA, Bangalore)***

ASTROSAT Archive (at ISSDC / ISRO)

AstroSat Archive - Mozilla Firefox

//astrobrowse.issdc.gov.in/astro_archive/archive/Home.jsp

Air India IRISIS_Cloud UL2P Atrosat Archive ASTROSAT-IUCAA NSF1



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ckg74

Enter the code

Submit

Reset

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Instruments

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Welcome to ISRO Science Data Archive for AstroSat Mission

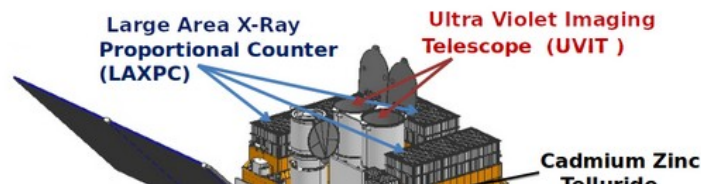
Utilization of Astrosat Archival Data (with limited financial assistance) [click here](#) for more details

The science data from observations made by the instruments on board the spacecraft are available for download after the [proprietary period](#) from this portal.

ASTROSAT is India's first dedicated multi wavelength space observatory. This scientific satellite mission endeavours for a more detailed understanding of our universe. AstroSat observes universe in the optical, Ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum. Multi-wavelength observations of ASTROSAT are further extended with co-ordinated observations using other spacecraft and ground based observations.

AstroSat with a lift-off mass of about 1513 kg was launched by India's Polar Satellite Launch Vehicle (PSLV) on 28th September 2015 into a 650 km circular orbit with an inclination of 6 deg. The spacecraft control centre at Mission Operations Complex (MOX) of ISRO Telemetry, Tracking and Command Network (ISTRAC) at Bangalore carries out the spacecraft health monitoring and control operations. The science data from the spacecraft is downloaded at a dedicated ground station established at Bylalu , Bengaluru and the data is made available to the users through the co-located Indian Space Science Data Centre (ISSDC). Science data processing, archival and dissemination are carried from ISSDC, the nodal point for the interface with the global scientific and user community.

AstroSat is a proposal -driven, multi –wavelength observatory operated by Indian Space Research Organization (ISRO). ISRO releases periodic calls for proposal submission. Users can submit proposals for operating the science instruments on board using the web based utility AstroSat Proposal Processing System [APPS](#) hosted at ISSDC. **The science data along with the related software for processing can be downloaded from this portal**




Location of Level-1 (L1) & Level-2 (L2) products :

AstroSat Archive - Mozilla Firefox

https://astrobrowse.issdc.gov.in/astro_archive/archive/Search-Record.jsp

NASA ADS SIMBAD Air India IRSIS_Cloud UL2P Atrosat Archive ASTROSAT-IUCAA NSF1



WELCOME : swarna

Search results for :- INSTRUMENT : UVT and PRINCIPLE INVESTIGATOR : swarna

1- 7 OBSERVATIONS out of 7 rows

Download Dataset	Product Details	Sky Map	Proposal Id	Target Id	Observation Id	PI Name	Orbit	Version	Source Name	RA	DEC	Instrument	Date Of Observation	Release Date	Modes
Q L1 L2	Q	Q	G07_066	T01	G07_066T01_9000001510	swarna	10431	2.2	NGC 1433	55.506458	-47.222081	UVT	01-Sep-2017	27-Oct-2018	NIIPC00F2,NIIPC00F3,NIIPC00F5,NIIPC00F6,FIIPC00F2,FIIPC00F3,VIIIM00F3
Q L1 L2	Q	Q	T01_135	T01	T01_135T01_9000000632	swarna	4984	2.2	NGC 7217	331.968167	31.359256	UVT	29-Aug-2016	14-Sep-2019	FIIPC00F2,FIIPC00F1,NIIPC00F3,NIIPC00F5,VIIIM00F4
Q L1 L2	Q	Q	T01_136	T01	T01_136T01_9000000662	swarna	5226	2.2	NGC 1291	49.3275	-41.108069	UVT	07-Dec-2017	16-Mar-2019	VIIIM00F4,NIIPC00F2,FIIPC00F2,FIIPC00F3,NIIPC00F6
Q L1 L2	Q	Q	G08_048	T01	G08_048T01_9000001752	swarna	11868	2.2	NGC 1291	49.3275	-41.108069	UVT	07-Dec-2017	16-Mar-2019	NIIPC00F6,NIIPC00F5,NIIPC00F3,NIIPC00F2,FIIPC00F3,FIIPC00F2,FIIPC00F1,VIIIM00F4
Q L1 L2	Q	Q	G06_135	T03	G06_135T03_9000000944	swarna	6852	5.2	NGC 5474	211.256667	53.662194	UVT	02-Jan-2017	03-Apr-2019	NIIPC00F3,NIIPC00F5,FIIPC00F2,VIIIM00F4
Q L1 L2	Q	Q	G06_135	T01	G06_135T01_9000000908	swarna	6670	2.2	NGC 1512	60.97625	-43.348861	UVT	21-Dec-2016	16-Mar-2019	NIIPC00F3,NIIPC00F5,VIIIM00F4,FIIPC00F2
Q L1 L2	Q	Q	G06_135	T02	G06_135T02_9000000918	swarna	6710	2.2	NGC 2541	123.666667	49.061444	UVT	24-Dec-2016	16-Mar-2019	FIIPC00F2,NIIPC00F6,NIIPC00F2,VIIIM00F4

Download VOTable Format

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This site is best viewed in Mozilla firefox 10.0 or above

ISSDC/ISRO provides L1, which is processed at POC/IIA to generate L2 using **“default”** settings of selectable parameters of the UVIT Level-2 Pipeline (UL2P)

When would anyone need to **run** the **UVIT Level-2 Pipeline (UL2P)** ?

- 1) astronomer wants any of the selectable parameters **different** from the “**default**” values used at the POC;*

- 2) needs additional processed products not archived at the ISSDC/ ISRO*
 - driven by science needs;*
 - access to intermediate products for diagnosing;*
 - etc ...*

Resources at :

<http://www.tifr.res.in/~uvit/>

[UVIT_Pipeline_Cookbook_v5.pdf](#)

[UL2P_quick_installation_and_output_product_help_v8.pdf](#)

[Master_list_of_UVIT_DriverModule_Parameters.xlsx](#)

Key data processing done by UVIT Level-2 Pipeline (UL2P) :

Generate sky images in Far-UltraViolet (**FUV**) & Near-UltraViolet (**NUV**), corrected for various instrument effects, spacecraft drifts, jitters, thermal effects, ...

*Recover : angular resolution,
& absolute aspect*

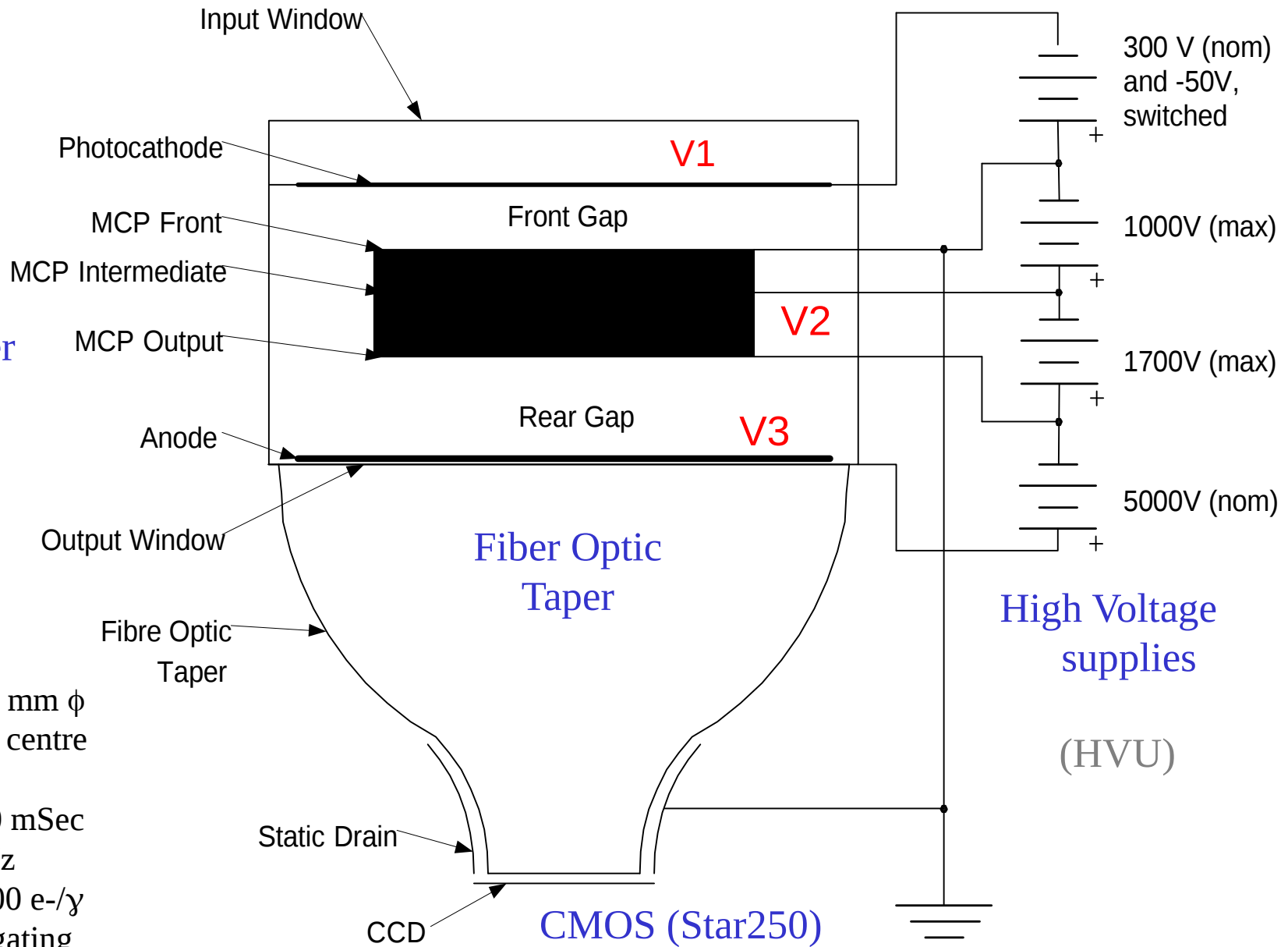
(Development initiated by SAC-ISRO & UVIT teams in collaboration – completed & improved at NCRA-TIFR;
open source)

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



V1 : Cathode Gating
V2 : Gain

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

How UVIT Images the Sky

- **Telescope produces image at detector photocathode input**
- **Photocathode produces an electron from photons**
- **Microchannel plate (dual stacked) produces $> 1e6$ electrons**
- **Phosphor screen produces a small spot flash of green photons**
- **Fibre optic coupling transfers screen to CMOS image sensor**
- **Image sensor produce image of screen at ~ 30 frames/s**
- **Images are digitized**
- **Digital hardware (FPGA) finds events, calculates centroid positions**
- **Positional data is sent to satellite high speed telemetry sub-system**
 - 48 bits per event
- **Final images are constructed on the ground**
 - Accumulate many photon events as a high resolution image

Read-Out modes :

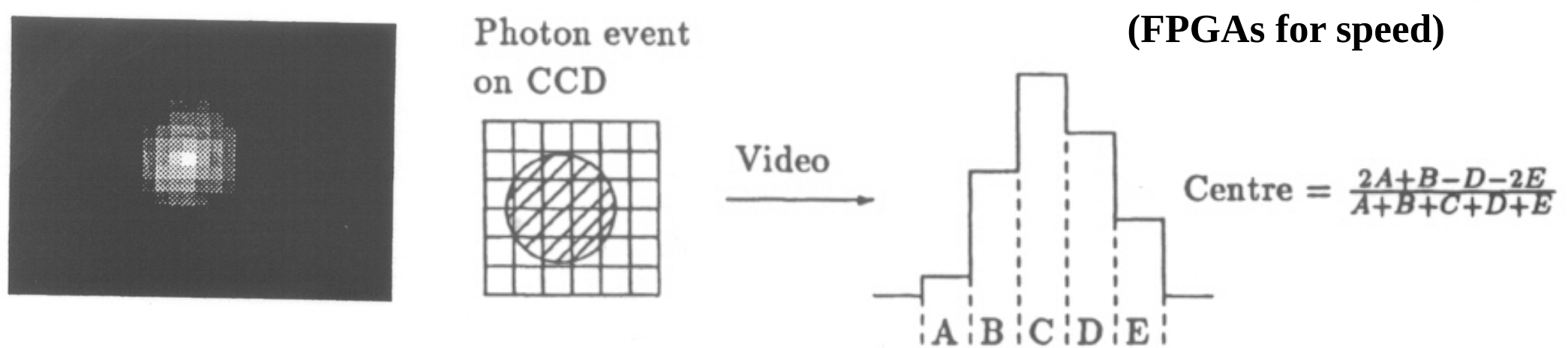
UV Channels (FUV, NUV): **Photon Counting**
(Frames read out fast enough; 29 Hz)
on-board 'Centroid-ing' of each detected photon;
photon list sent to ground;

VISIBLE Channel (VIS) :
Integration mode; too many photons per frame;
(Frames read out @ ~ 1 Hz)
full image sent to ground;

Detector signal processing :

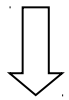
Photon counting \square precise position of each photon

High data rate \square onboard processing to get 'centroid' for each event



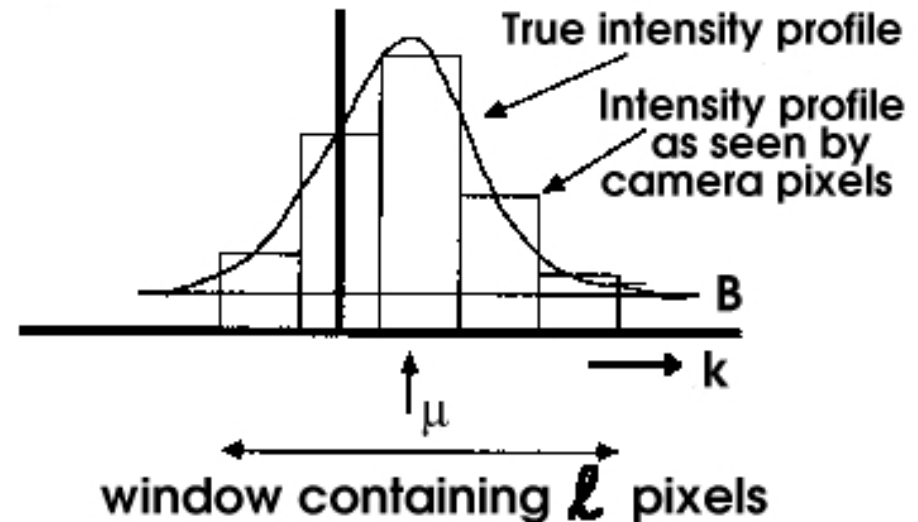
Inherent biases due to :

- undersampling;
- windowing;
- error in background estimation;
- noise (asymmetric truncation);



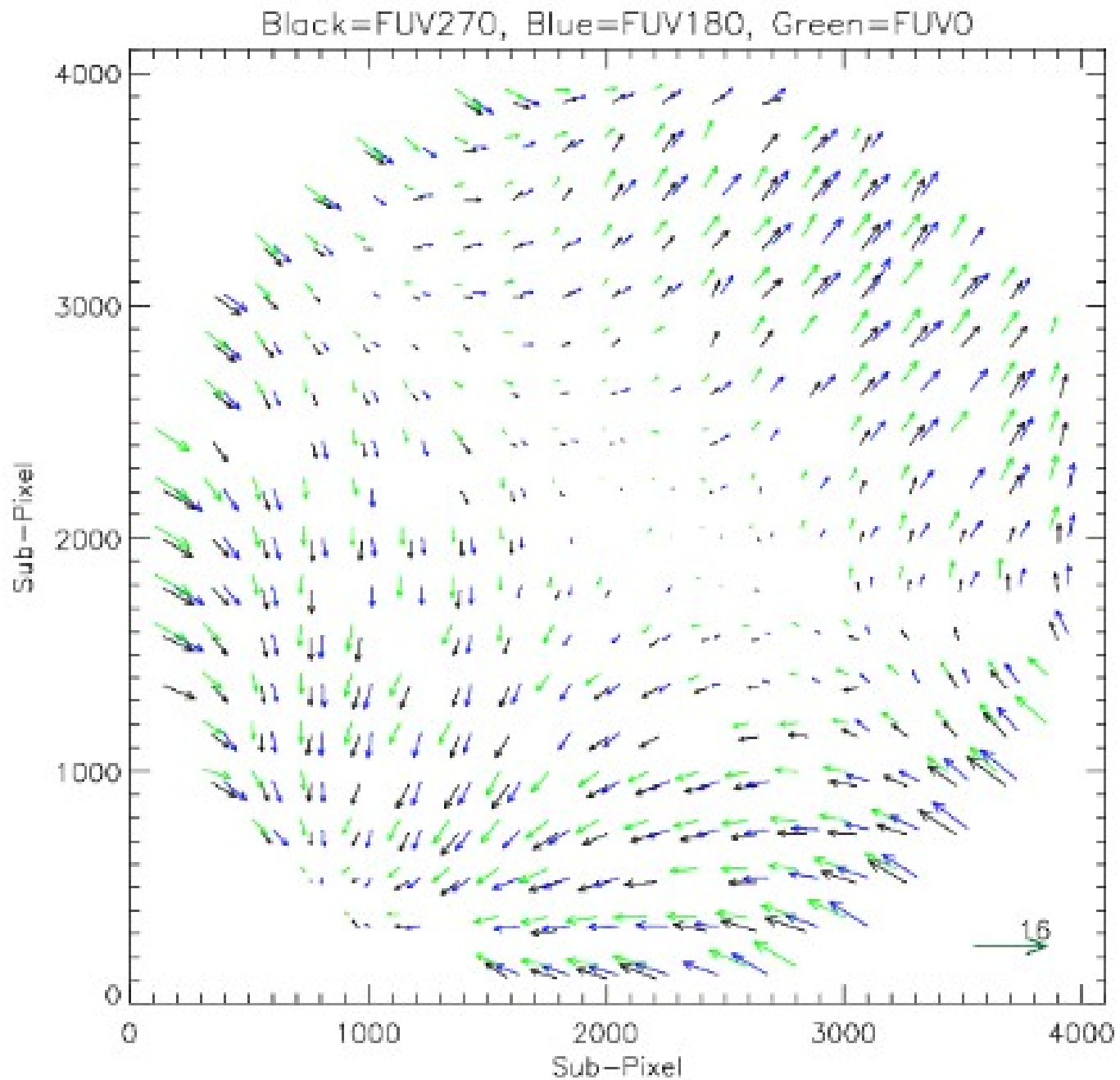
pattern noise, ... **correct by look-up-table**

$$\mu_{\text{est}} = \frac{\sum k \cdot I_k}{\sum I_k}$$



Detector Distortion : FUV

... needs to be corrected !



For Photon Counting (PC : FUV, NUV) & Integration (IM : VIS) Modes -

handle affected data : parity / CRC errors, cosmic rays,
(L1 issues : erroneous inserts / duplicates / drop-outs), ...

Instrumental effects (within UVIT) corrected for :

- response variation over FoV; bad pixels
- temperature dependence of QE
- temperature dependence of MCP gain (IM only)
- distortion introduced by Detector assembly
- distortion introduced by Optic assembly
- systematic effects in extraction of photon location from event centroid (PC only) – dark, bias,
- thermal effects on inter-channel mis-alignment;

Spacecraft Drift :

normally -

recovered from series of sky images in **VIS** channel taken in Integration Mode (**IM**) at ~ 1 image/sec; relative shifts / rotation extracted by comparing a set of detected bright stars;

if optical (VIS) channel data not available -

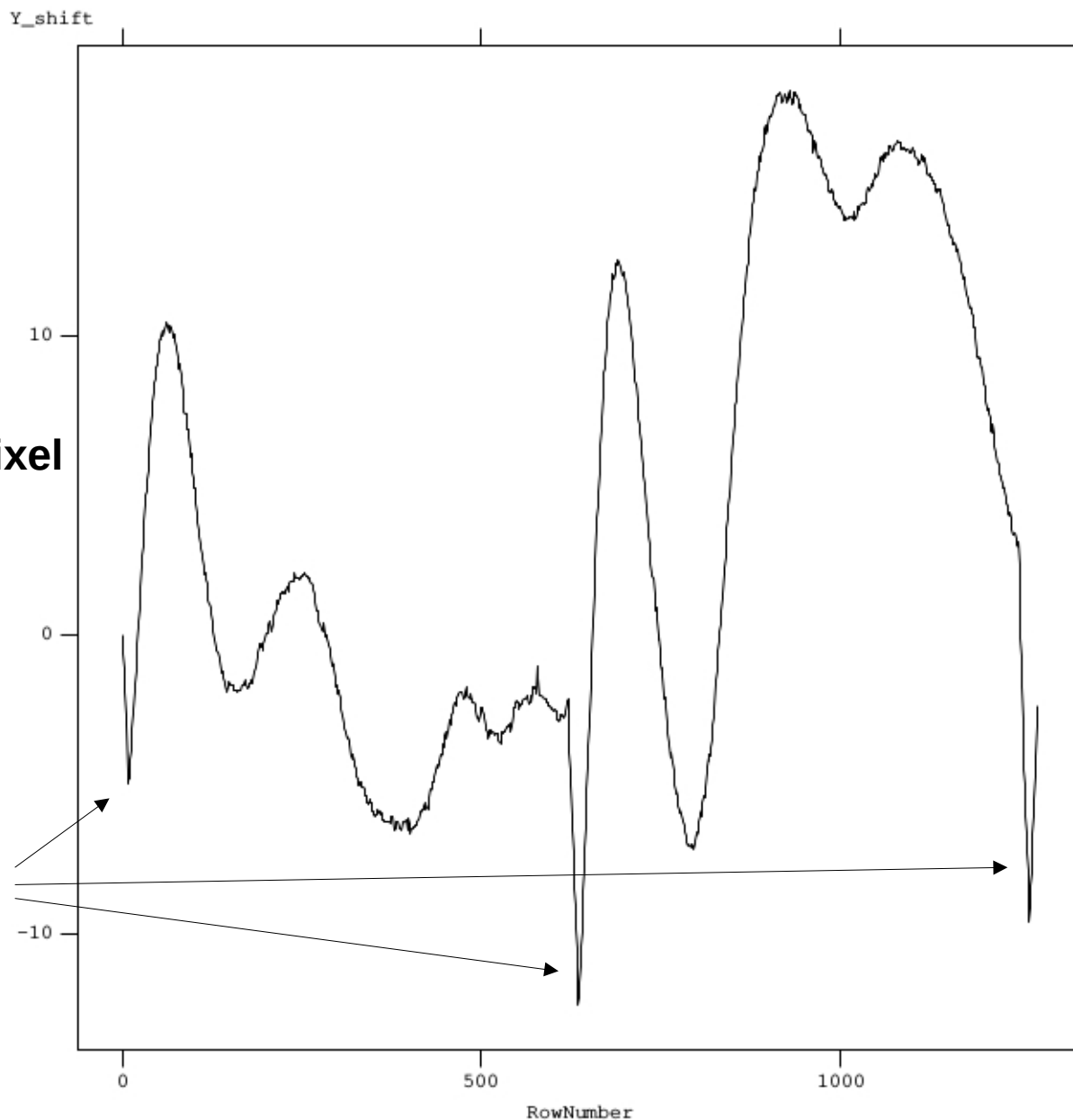
recovered from NUV channel images in PC mode (works only if star/(s) bright in NUV available in field incorporated FUV tracking also; V5.7+);

Spacecraft Jitter :

recovered from Gyro signals after filtering & integration (currently NOT needed !);

Drift along 'Y' (time series) :

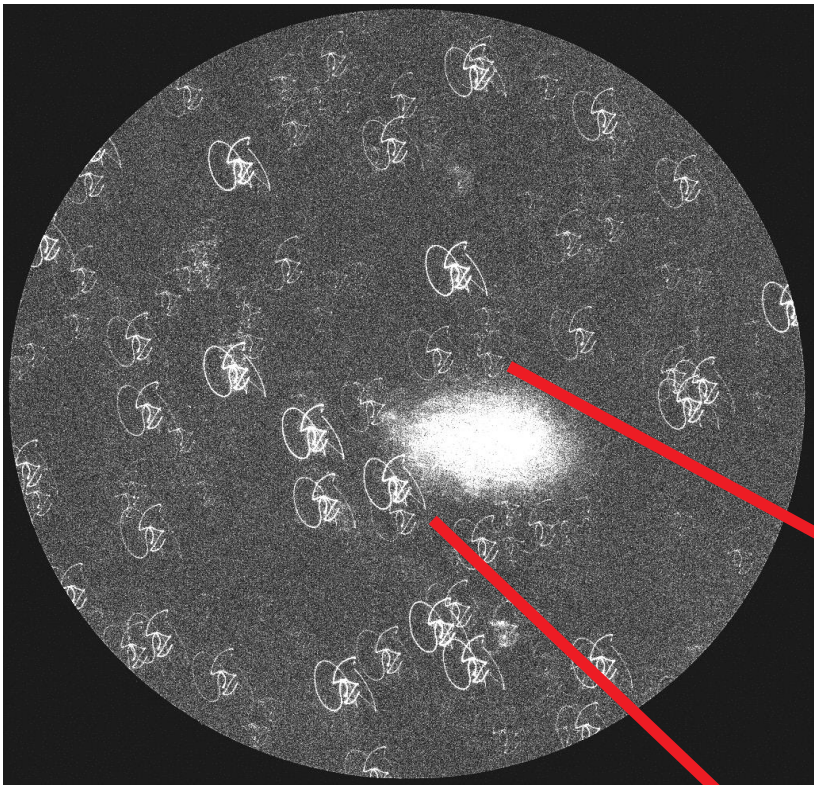
AS1G06_087T01_9000000926uvvVIIM00F3_l2_dr.fits(Y_shift_1-1274)



Y axis unit = 1 pixel
~ 3.3 arc-sec

SSM motions

X-axis unit ~ 1 sec



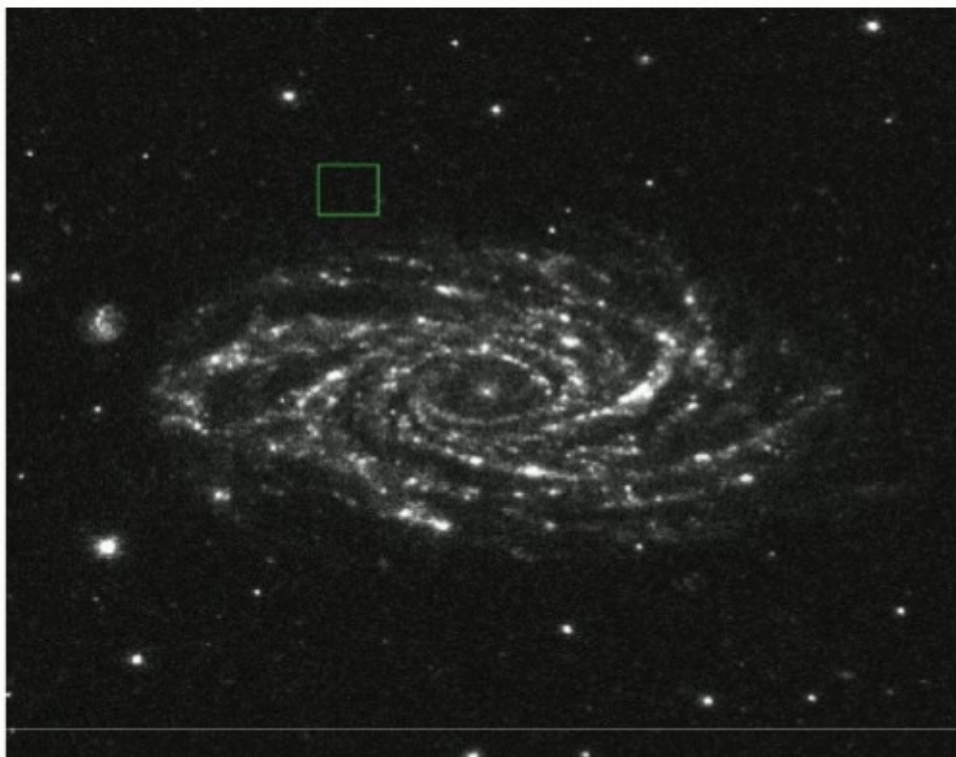
← **Raw
Image**



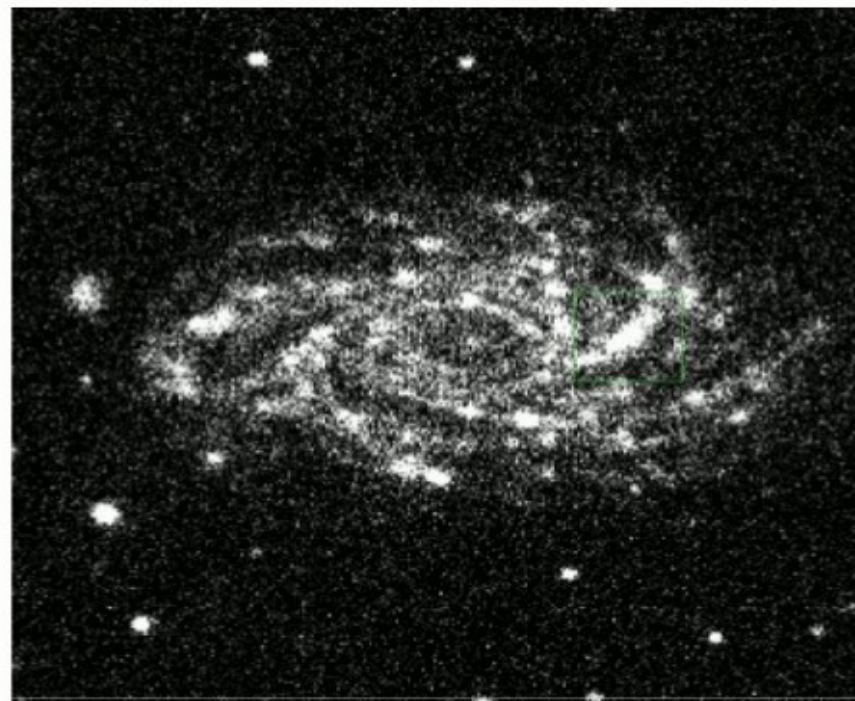
Processed image →

Comparison : NGC 2336 (NUV)

UVIT



GALEX



Major Processing Chains / Blocks :

DataIngest (CRC; GTI; TCT; ...choice of clock)

uvtDetectStar

uvtComputeDrift

Relative Aspect Series (Integration Mode) “RA_IM”

Relative Aspect Series(Photon Counting Mode)“RA_PC”

Sky Imaging (Integration Mode) “Level2_IM”

Sky Imaging (Photon Counting Mode) “Level2_PC”

**Most common sequence
for a single (sub-)orbit dataset :
(when VIS data available)**

**Run RA_IM chain on VIS data to generate
Relative Aspect Series (RAS) ;**

**Use RAS to run L2_PC chain on NUV data
& generate sky image in NUV;**

**Use RAS once again to run L2_PC chain
on FUV data & generate sky image in FUV;**

Rare sequence
for a single (sub-)orbit dataset :
(when VIS data NOT available)

Run RA_PC chain on NUV data to generate
Relative Aspect Series (RAS)
(successful only if bright NUV star/(s) present)

Use RAS to run L2_PC chain on NUV data;
Use RAS once again to run L2_PC chain
on FUV data;
(when only FUV data available, then recover
RAS from FUV !)

Calibration Database

readme.txt
change.log

Directories :

AV_PH_ENERGY

BIAS_CORR

DARK_NOISE

EXPOSURE_TEMPLATE_v1.5

BAD_PIXELS

DISTORTION

FLAT_FIELDS_FILTER

BAD_PIXELS_v1.5

DARK

EXPOSURE_TEMPLATE

QE_TEMP

RA_IM chain (1 of 2)

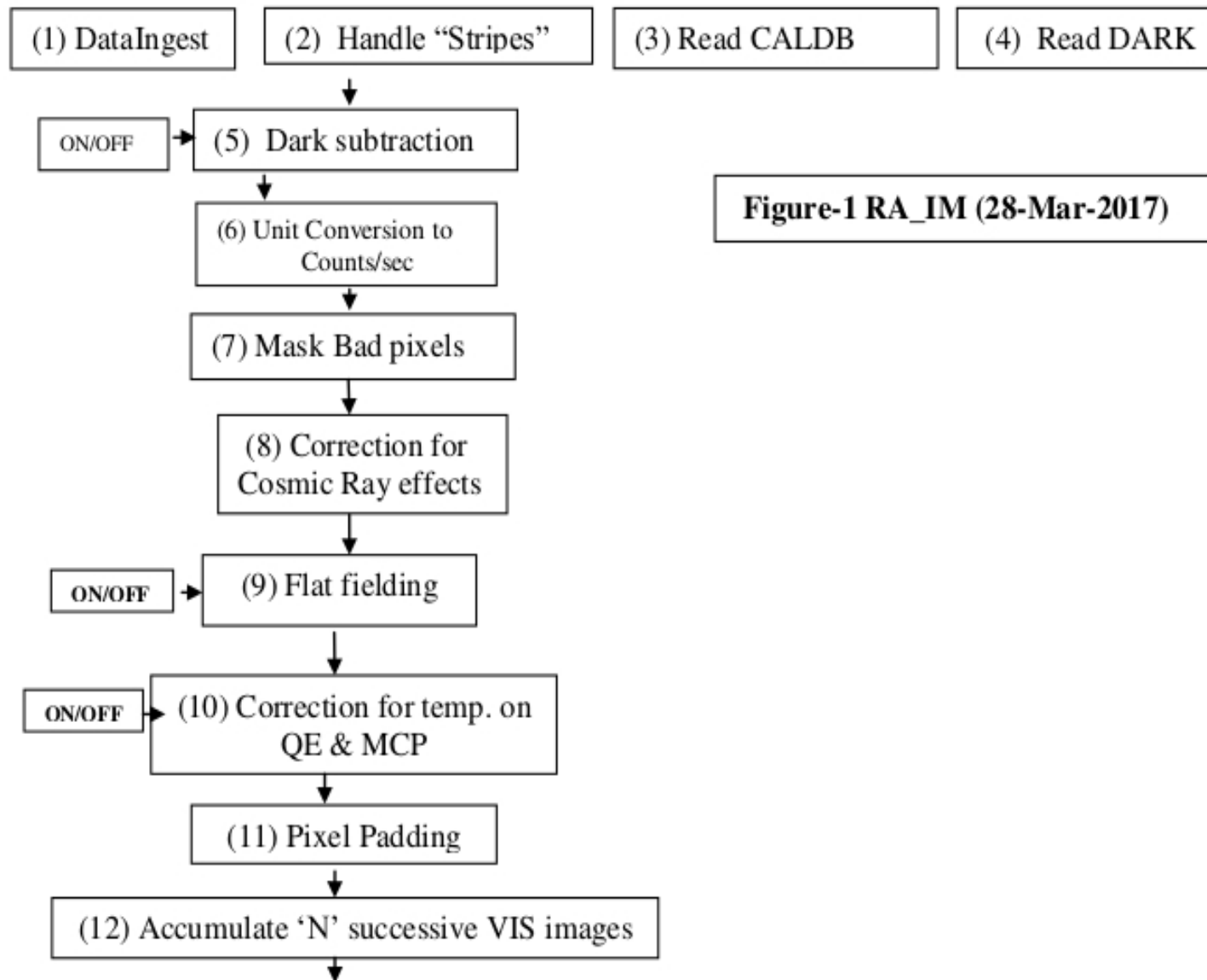
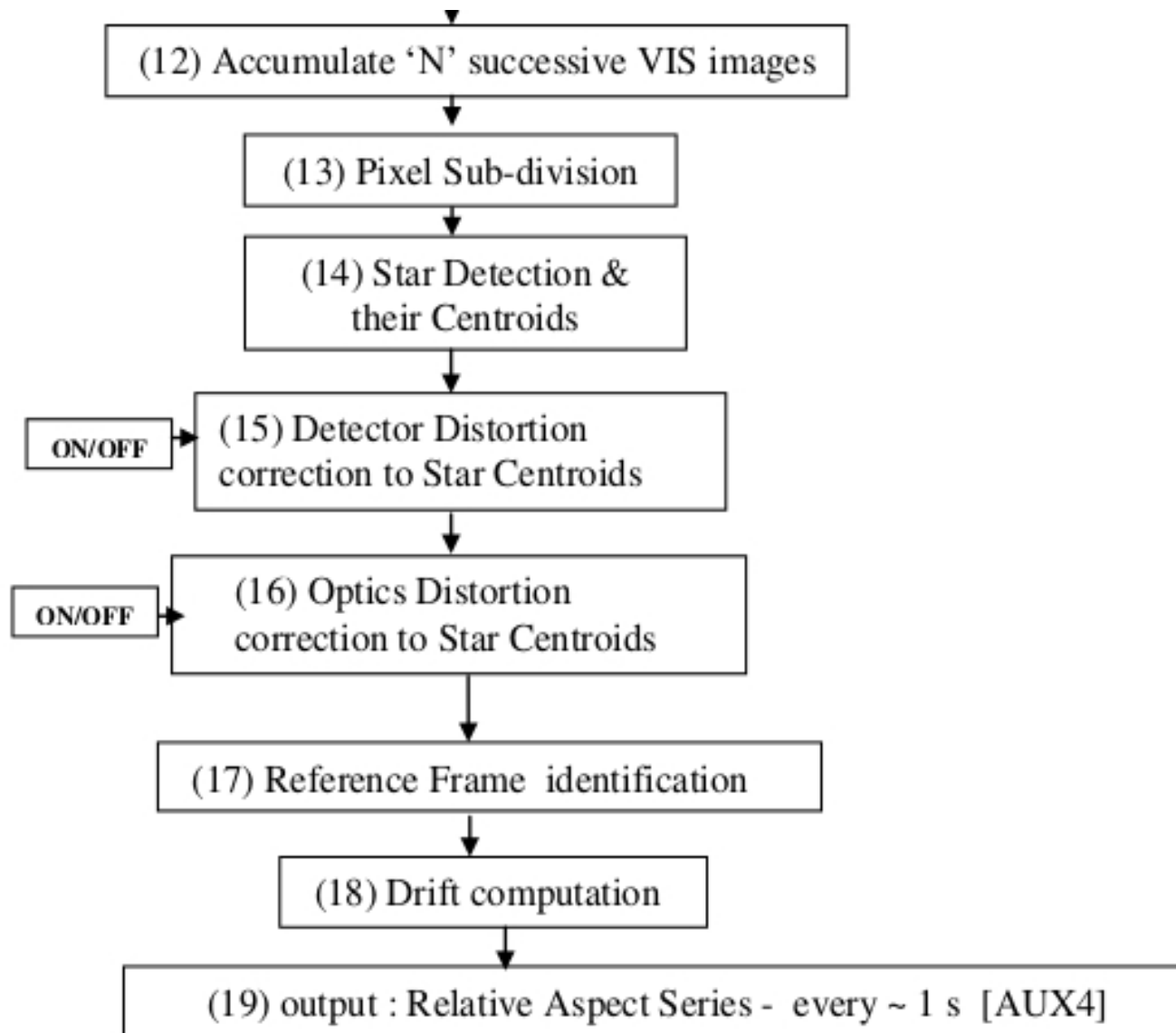


Figure-1 RA_IM (28-Mar-2017)

RA_IM chain (2 of 2)



L2_PC chain (1 of 2)

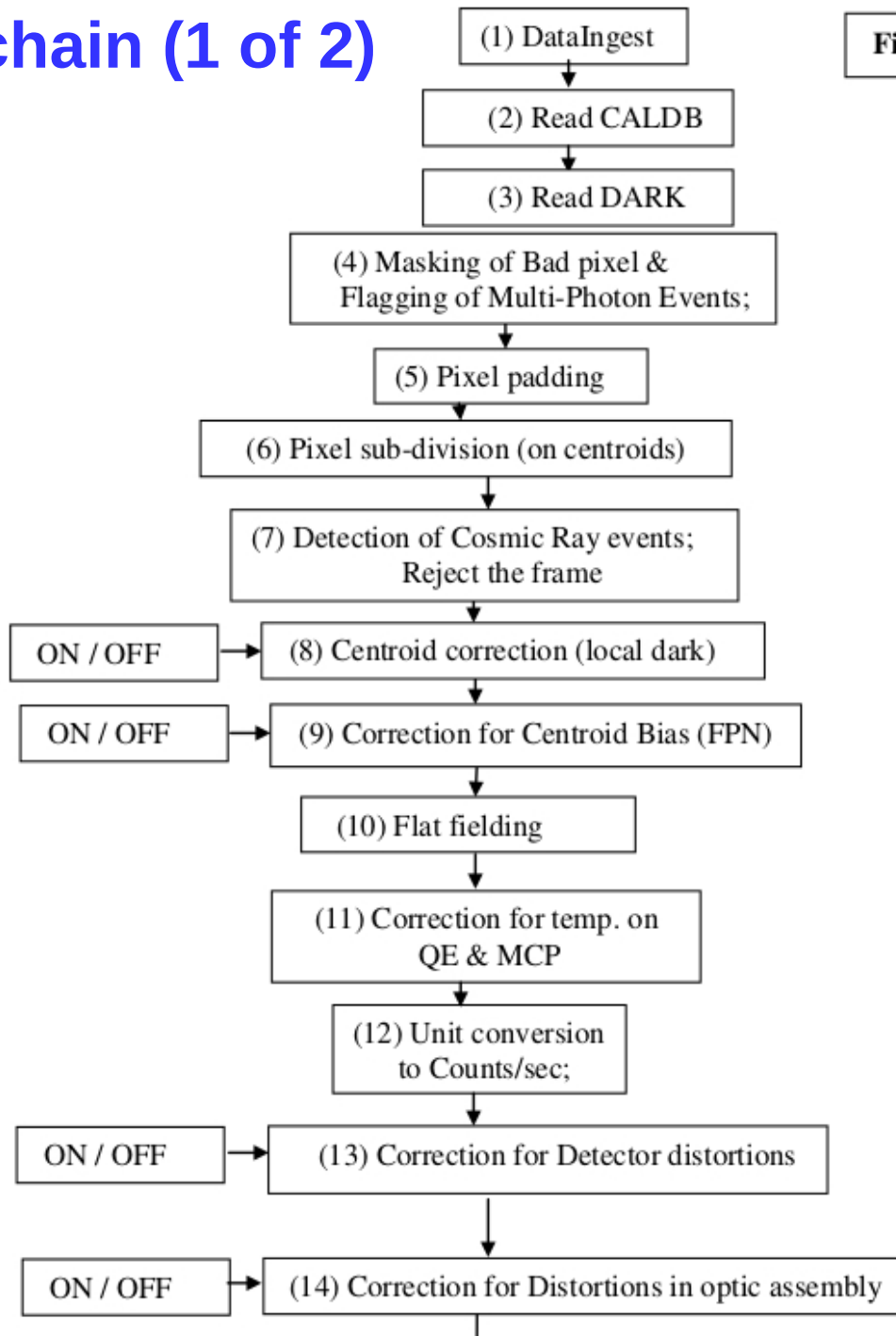
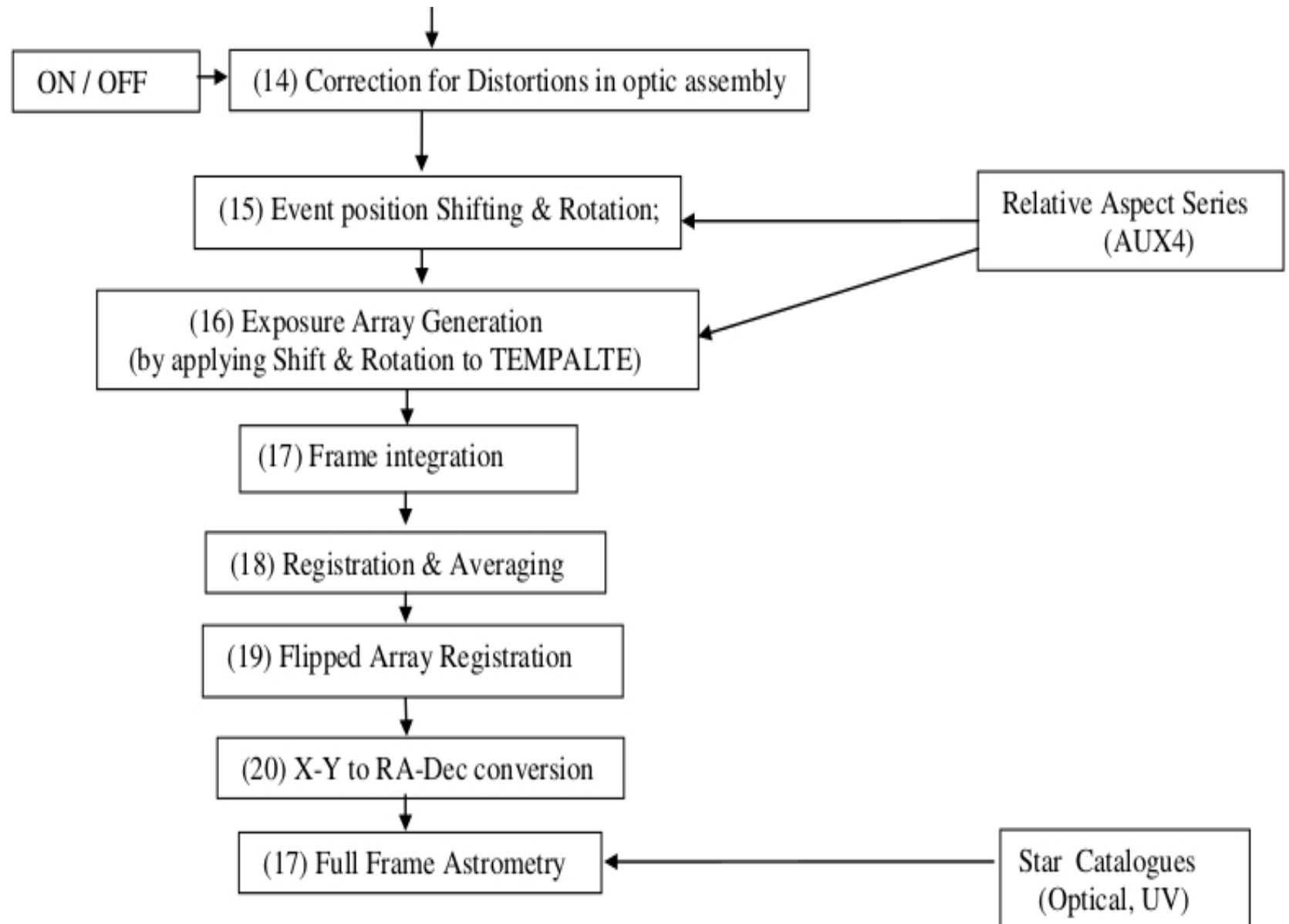


Figure-2 L2_PC (28-Mar-2017)

L2_PC chain (2 of 2)



***Efficient usage for Multi-Orbit
(multi-Filter; multi-Window)
“Merged” datasets -
standard ISSDC L1 product)***

Automated script : simple to run

“UVIT_DriverModule” -

Combines multiple orbit data for same 'Filter' & 'Window' settings; Incorporated new strategies for tracking in crowded fields, NUV & FUV tracking, additional selectable parameters, defense against 'new' L1 issues, ...

(Developed at NCRA-TIFR; processed at POC-IIA & L2 products hosted at ISRO/ISSDC)

Generate image products for individual datasets (sub/orbit)

All sky images based on corrected centroids;

[UV image, uncertainty map, Exposure map, ...

*In both, Detector (X-Y) as well as Astronomy (RA-Dec;
J2000) coordinate systems]*

Identify image products for same Filter & Window setting

Choose 'Reference' image [with largest EXP_TIME]

Attempt aligning every 'other' image with Reference (V5.7)
(using brightest detected stars; apply shift & rotation)

A fraction will succeed (not 100%)

Improved strategy : correct photon coordinates ! (V6.3)

Astrometry: using USNO-A2; < 5" (when successful)

***Alternate platforms (e.g. IRAF, ...) may be useful to
combine multi-orbit images ...***

Actual running : UVIT_DriverModule

*Any UNIX Operating System & Shell OK
'tar' or 'zip' file as input OK*

Interactive Mode :

[uvit@localhost ~]\$ UVIT_DriverModule

*type in inputs (input data file, output directory, 'zip' or 'tar',
NUV-only or VIS+NUV or FUV-only for drift tracking,
manual star selection, UTC bypass or not, ...)*

Batch Mode :

**Edit “UVIT_DriverModule.par” file to make all inputs
'hidden' (from 'query-learn' mode; PIL);**

Then type :

nohup UVIT_DriverModule >log1_target1 2>log2_target1 &

“UVIT_DriverModule” (outputs) SINGLE ORBIT !

```
[swarna@swarna driver_out]$ pwd
/data2/swarna/uvit/udata1/m6018_v63/driver_out
[swarna@swarna driver_out]$ l
```

total 11148

drwxrwxr-x. 3 swarna swarna	32 Jul 4 04:10 FUV_FullFrameAst_F2	
drwxrwxr-x. 2 swarna swarna	89 Jul 4 04:10 FUV_Final_F2_W511	MULTI-ORBIT
drwxrwxr-x. 3 swarna swarna	32 Jul 4 04:03 NUV_FullFrameAst_F6	
drwxrwxr-x. 2 swarna swarna	89 Jul 4 04:03 NUV_Final_F6_W511	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 01:26 _RAPC_FUV_4	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 01:17 _RAPC_NUV_4	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 01:09 _RAPC_FUV_3	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:59 _RAPC_NUV_3	NUV tracking
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:53 _RAPC_FUV_2	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:44 _RAPC_NUV_2	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:37 _RAPC_FUV_1	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:29 _RAPC_NUV_1	
drwxrwxr-x. 3 swarna swarna	17 Jul 4 00:26 _RAPC	← drift series
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:25 _FUV_4	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:22 _NUV_4	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:19 _FUV_3	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:16 _NUV_3	VIS tracking
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:14 _FUV_2	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:14 _NUV_2	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:14 _FUV_1	
drwxrwxr-x. 3 swarna swarna	17 Jul 3 23:13 _NUV_1	
drwxrwxr-x. 3 swarna swarna	18 Jul 3 22:39 uvit	← drift series

-----*Individual orbit products* : -----

[swarna@swarna uvtN.32]\$ pwd

/data2/swarna/uvit/udata1/m6018_v63/driver_out/_NUV_4/uvit/06018/uvtN/uvtN.32

[swarna@swarna uvtN.32]\$ l

total 24

drwxrwxr-x. 2 swarna swarna 4096 Jul 3 23:24 uvtShiftRot_6.3
drwxrwxr-x. 2 swarna swarna 4096 Jul 3 23:24 uvtFullFrameAst_6.3
drwxrwxr-x. 2 swarna swarna 4096 Jul 3 23:24 uvtRADECImage_6.3
drwxrwxr-x. 2 swarna swarna 4096 Jul 3 23:24 uvtFlippedRegImage_6.3
drwxrwxr-x. 2 swarna swarna 4096 Jul 3 23:24 uvtRegAvg_6.3
drwxrwxr-x. 5 swarna swarna 80 Jul 3 23:23 uvtFrameIntegration_6.3
drwxrwxr-x. 2 swarna swarna 75 Jul 3 23:23 uvtExposureFrames_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtOpticDistCorr_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtDetectDistCorr_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtUnitConversion_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtFlatFieldCorr_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtCosmicRayCorrection_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtSubDivision_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtPixPadding_6.3
drwxrwxr-x. 2 swarna swarna 60 Jul 3 23:22 uvtMaskBadPix_6.3
drwxrwxr-x. 3 swarna swarna 4096 Jul 3 23:22 DataIngest_6.3

[swarna@swarna uvtN.32]\$

“UVIT_DriverModule” (outputs) COMBINED ORBIT !

```
[swarna@swarna driver_out]$ pwd  
/data2/swarna/uvit/udata1/m6018_v63/driver_out
```

```
[swarna@swarna driver_out]$ l  
total 11148
```

```
drwxrwxr-x. 3 swarna swarna      32 Jul  4 04:10 FUV_FullFrameAst_F2  
drwxrwxr-x. 2 swarna swarna     89 Jul  4 04:10 FUV_Final_F2_W511  
drwxrwxr-x. 3 swarna swarna     32 Jul  4 04:03 NUV_FullFrameAst_F6  
drwxrwxr-x. 2 swarna swarna     89 Jul  4 04:03 NUV_Final_F6_W511
```

```
drwxrwxr-x. 3 swarna swarna     17 Jul  4 01:26 _RAPC_FUV_4  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 01:17 _RAPC_NUV_4  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 01:09 _RAPC_FUV_3  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:59 _RAPC_NUV_3  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:53 _RAPC_FUV_2  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:44 _RAPC_NUV_2  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:37 _RAPC_FUV_1  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:29 _RAPC_NUV_1  
drwxrwxr-x. 3 swarna swarna     17 Jul  4 00:26 _RAPC  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:25 _FUV_4  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:22 _NUV_4  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:19 _FUV_3  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:16 _NUV_3  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:14 _FUV_2  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:14 _NUV_2  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:14 _FUV_1  
drwxrwxr-x. 3 swarna swarna     17 Jul  3 23:13 _NUV_1  
drwxrwxr-x. 3 swarna swarna     18 Jul  3 22:39 uvit
```

Combined orbit products -

Pre-Astrometry :

```
[swarna@uvtiserv FUV_Final_F2_W511]$ pwd
/home/swarna/uvtiserv/m7985e/driver_out/FUV_Final_F2_W511
[swarna@uvtiserv FUV_Final_F2_W511]$ ls
total 270636
-rw-rw-r--. 1 swarna swarna 92373120 Jan 23 18:51 F2_W511_FinalImage_NoiseMap.fits
-rw-rw-r--. 1 swarna swarna 92373120 Jan 23 18:51 F2_W511_FinalImage_Exp.fits
-rw-rw-r--. 1 swarna swarna 92373120 Jan 23 18:51 F2_W511_FinalImage_Sig.fits
[swarna@uvtiserv FUV_Final_F2_W511]$
```

Post-Astrometry :

```
[swarna@uvtiserv uvtFullFrameAst_6.3]$ pwd
/home/swarna/uvtiserv/m7985e/driver_out/FUV_FullFrameAst_F2_W511/uvtFullFrameAst_6.3
[swarna@uvtiserv uvtFullFrameAst_6.3]$ ls
total 270548
-rw-rw-r--. 1 swarna swarna 92404800 Jan 23 18:52 AS1G06_077T01_9000001090uvtFIIPC00F2_I2_as_Exp.fits
-rw-rw-r--. 1 swarna swarna 92404800 Jan 23 18:52 AS1G06_077T01_9000001090uvtFIIPC00F2_I2_as_NoiseMap.fits
-rw-rw-r--. 1 swarna swarna 92217600 Jan 23 18:52 AS1G06_077T01_9000001090uvtFIIPC00F2_I2_as_Sig.fits
-rw-rw-r--. 1 swarna swarna 467 Jan 23 18:52 star_raDec_frmOptics_catalogueWith_5Stars.txt
-rw-rw-r--. 1 swarna swarna 589 Jan 23 18:52 star_radec.txt
[swarna@uvtiserv uvtFullFrameAst_6.3]$
```

All 3 images (Sig, Noise & Exposure)

Tracking components in combined image (via HDUs)

fv: Summary of FinallImage_Sig.fits in /data2/swarna/uvit/udata1/m6018_v46b/driver... x

File Edit Tools Help

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	4800 X 4800	Header Image Table
<input type="checkbox"/> 1	uvfF.16	Image	0 X 0	Header Image Table
<input type="checkbox"/> 2	uvfF.13	Image	0 X 0	Header Image Table
<input type="checkbox"/> 3	uvfF.18	Image	0 X 0	Header Image Table
<input type="checkbox"/> 4	uvfF.15	Image	0 X 0	Header Image Table
<input type="checkbox"/> 5	uvfF.26	Image	0 X 0	Header Image Table
<input type="checkbox"/> 6	uvfF.27	Image	0 X 0	Header Image Table
<input type="checkbox"/> 7	uvfF.17	Image	0 X 0	Header Image Table
<input type="checkbox"/> 8	uvfF.14	Image	0 X 0	Header Image Table
<input type="checkbox"/> 9	uvfF.01	Image	0 X 0	Header Image Table

File Edit Tools

Help

Search for:



Find

Case sensitive?

No

```
HISTORY GTI filtering = NO
HISTORY Total ROWS in first HDU of LEVEL1= 35434
HISTORY NUMBER OF ROWS WITH VIS CLOCKMASTER= 35434
HISTORY NUMBER OF ROWS WITH NUV CLOCKMASTER= 0
HISTORY NUMBER OF ROWS WITH FUV CLOCKMASTER= 0
HISTORY SPS of TCT file time continues = YES
HISTORY clobber = yes
HISTORY history = yes
HISTORY Parameter List END
NAMEPRFX= 'AS1G06_086T01_9000000774uvtFIIPC00F2_12'
XSIZE = 4800
YSIZE = 4800
EXP_TIME= 2320.864
HIERARCH ROLLAPPLIED = 344.9052
HIERARCH INTEGRATION_TIME.UTC = 0.0355179388992509
HIERARCH INTEGRATION_TIME_CURR_OPTION = 0.0348217810582275
HISTORY Reference_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_FUV_17,
HISTORY uvtF,13
HISTORY Matched_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_FUV_14, u
HISTORY vtF,15
HISTORY Matched_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_FUV_15, u
HISTORY vtF,14
HISTORY Matched_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_FUV_13, u
HISTORY vtF,16
HISTORY Matched_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_RAPC_FUV_
HISTORY 4, uvtF,17
HISTORY Matched_Orbit= /data2/swarna/uvit/udata1/m6018_v46/driver_out/_FUV_18, u
HISTORY vtF,12
END
```

HIERARCH INTEGRATION_TIME_CURR_OPTION = 0.0348217810582275

All image products in FITS format (4800 x 4800)

Two kinds :

Detector (X-Y) coordinates

Astronomy (RA-Dec; J2000) coordinates

[+ final event list product for timing studies]

UV sky image arrays in unit of 'count/sec' (**Sig**)

Uncertainty image arrays in unit of 'count/sec' (**Noise**)

Sky Exposure image arrays in unit of 'frames' (**Exp**)

[exposure_in_seconds = no_of_frames * frame_time;

“EXP_TIME” keyword]

Relative Aspect (Drift) series in FITS table format

Spacecraft coordinate system : Roll-Yaw-Pitch

Detector coordinate system : X-Y-rotation

Treatment of important systematic effects (including subtle effects)

- 1) Variation of Detector response (“**Flat Fielding**”) is corrected on individual photons based on event locations (hence, unaffected by spacecraft drifts)
- 2) Precise tracking of **Exposure** across the sky field
- 3) Handling **Cosmic Ray** (CR) showers : detailed analysis to identify CR affected exposures (frames) individually & discarding - parameter selection available for tweaking;
- 4) Proper treatment of **missing & anomalous** exposures (frames) in L1 data
- 5) Proper handling of exposures (frames) with ZERO photon events (significant for smaller **Window-mode** observations)

Event selections affecting UV photometry & their corrections :

CRC error (one check per 'packet') :

- either ignore or drop entire frame;

Reject initial ~ 20 seconds (ramping up of High Voltages of Detector)

Frames with ZERO photon events :

corrected for exactly;

Photon events with coordinate/(s) affected by 'parity' error :

corrected for statistically;

Multi-photon events :

- either ignore or drop entire frame;

[a large fraction of frames may get dropped !]

Large spacecraft drift :

Some parts of the frames could get rejected due to array size limit ! **(BUT no photometric error introduced)**

User choices (beyond “default”) :

RA_IM :

**brightness threshold for stars (for drift tracking);
'manual' star selection (in complex field);
low pass filtering (time domain) of drift series;**

RA_PC *(both NUV & FUV tracking possible)* :

**Brightness threshold for stars (for drift tracking);
No of successive frames to accumulate to
generate successive images for tracking;**

L2_PC :

**Multi-photon event strategy (threshold);
Cosmic Ray affected frame handling strategy;
Dividing dataset into smaller parts (Frame Integration);**

ABSOLUTE TIME INFO : UTC switch (MJD / UVIT)

Key selectable parameters : (1 of 2)

UVIT_DriverModule :

**“thresholdpc” = Criterion for star detection
(multiplier to Sigma; to align orbits & Astrometry)**

“minimum_targetedstarspc” = For Astrometry

RA_IM :

“flag_thetaComp” = Rotation Switch (RA_IM; drift computation)

“shiftRotDetAlgoFlag” = Selection of Drift Computation Algorithm

**“FreqDomainFilterFlag” = Parameter for filtering Drift Series
(low pass filtering)**

Key selectable parameters : (2 of 2)

L2_PC :

“frameIntFlagpc” = Frame Integration Flag: MULTI/SINGLE

“framesComputepc” = Total number of frames to be combined together

“flag_thetaComppc” = Rotation Switch

“thresholdpc” = Sigma criteria for star detection in Astrometry

RA_PC :

“thresholdrapc” = First-cut threshold for star detection

“framesComputerapc” = Number of successive frames to be
accumulated for generating
images to be used for extracting drift

“flag_thetaComrapc” = Rotation Switch (for drift computation)

Effects needing special attention :

- 1) **Bright objects** : effects of Saturation / non-linearity
- 2) Crowded fields (photometry affected)
- 3) Deep fields (needs removal of Cosmic Ray shower affected frames)

Selectable parameters for the “UVIT_DriverModule”

	A	B	C	D
1				
2	<u>SELECTABLE</u>	<u>PARAMETERS</u>	<u>OF</u>	<u>UVIT_DRIVERMODULE (V6.3) [16-MAY-2018]</u>
3				
4	Parameter name	Processing Chain	Current DEFAULT value	Description (switch logic : '1/' 'y' for ON; '0/' 'n' for OFF)
5				
6				
7	<u>Parameters for DriverModule :</u>			
8	<u>NUVOnNUVflag</u>	<u>DRIVERMODULE</u>	NO	Forcing all drift generations using <u>NUV</u> only (i.e. ignore all <u>VIS</u>)
9	<u>FUVonFUVflag</u>	<u>DRIVERMODULE</u>	NO	Forcing all drift generations using <u>FUV</u> only (i.e. ignore all <u>VIS</u> & <u>NUV</u> for <u>FUV</u> data)
10	<u>ManualMode</u>	<u>DRIVERMODULE</u>	NO	Manual selection of stars On/Off
11	<u>previousOutputL2</u>	<u>DRIVERMODULE</u>	path	Base directory of <u>RAIM</u> output in Auto mode; [Needed only in MANUAL mode of star selection for drift tracking; First AUTO mode must have been run before running MANUAL mode;]
12	<u>thresholdpc</u>	<u>DRIVERMODULE (& L2PC-NUV)</u>	50	Criterion for star detection (multiplier to Sigma; starting value) : needed to align orbits as well as <u>Astrometry</u>
13	<u>minimumTargetedStars</u>	<u>DRIVERMODULE</u>	6	To align images from different orbits
14	<u>minimum_targetedstarspc</u>	<u>DRIVERMODULE (& L2PC-NUV)</u>	5	For <u>Astrometry</u>
15				

Selectable parameters for **Drift Extraction Chain** (RA_IM) :

(1 of 3)

	A	B	C	D
16				
17				
18	For Relative Aspect Series chain	RA_IM		For 'drift' extraction from <u>VIS</u> images (in Integration Mode)
19				
20	<u>crcflag</u>	RAIM	NO rejection	Switch to reject <u>CRC</u> failed packets or not
21	<u>ZipFlag</u>	RAIM	NO (tar)	switch to choose 'tar' or 'zip'
22	<u>utcFlag</u>	RAIM	OFF	switch for <u>UTC</u> correction (On/Off)
23	<u>ManualMode</u>	RAIM	NO	Manual selection of stars On/Off [used in " <u>uvtComputeDrift</u> " block]
24	<u>level1indir</u>	RAIM	-	Input level 1 tar file path
25	<u>caldbdir</u>	RAIM	-	<u>Caldb</u> directory path
26	<u>level2outdir</u>	RAIM	-	Output level2 directory path
27	<u>channel</u>	RAIM	<u>VIS</u>	channel for which user wants to run (can be <u>VIS,NUV,FUV</u>)
28	<u>history</u>	RAIM	1	Switch for history to be written or not?History contains the input parameter information with which current pipeline has ran.
29	<u>clobber</u>	RAIM	1	YES then this directory will be removed and again created by pipeline and if clobber is NO then pipeline will exit with the error message such that "output directory is already exist."
30	<u>GTI_FLAG</u>	RAIM-Dataingest	0	<u>GTI</u> filtering to be done(1) or not(0).
31	<u>junkfileflag</u>	RAIM	1	Switch for handling 'horizontal stripe' affected <u>VIS</u> frames : '1' = handler ON; '0' = OFF. (<u>VIS</u> stripe handler flag)
32	<u>thresholdforjunkFrame</u>	RAIM	5000	Threshold (pixel ADU) value for identifying 'stripe' (in <u>VIS</u> images). Used only when 'junkfileflag' is ON , else ignored.(Threshold for stripe detection)
33	<u>darkframeFlag</u>	RAIM	1	Dark <u>Substraction</u> Switch : '1' = subtract DARK; '0' = no action.(Dark subtraction Flag)
34	<u>dropframe</u>	RAIM-Dataingest	0	Action in case <u>CRC</u> check fails : ('1') Entire frame to be removed; or ('0')only those packets (2048 byte) to be removed which fails at <u>CRC</u> check.(flag for <u>CRC</u> failure action)
35	<u>ThresholdValue</u>	RAIM	400000	threshold for identifying Cosmic Ray effected pixel (threshold for CR affected pixels in IM mode)

Selectable parameters for **Drift Extraction Chain**

(**RA_IM**) :

(2 of 3)

36	<u>paddingDim</u>	<u>RAIM</u>	600	<u>uvrPixPadding</u> parameter for size of output image to ensure full coverage despite Drift (Final Padded Size)
37	<u>flatfieldFlag</u>	<u>RAIM</u>	1	Flat Field correction Switch : '1'= apply flat field correction; '0'= no action.(Flat Field Flag)
38	<u>qemcpFlag</u>	<u>RAIM</u>	0	Switch for <u>QE/MCP_gain</u> correction for temp : '1' = apply; '0' = no action.(<u>QEMCP</u> Flag)
39	<u>Nacc</u>	<u>RAIM</u>	1	Number of successive raw frames to be accumulated to generate individual 'image units'.(No. Of raw frames for accumulation)
40	<u>subdivisionFlag</u>	<u>RAIM</u>	0	Pixel-Sub-Division Switch : '1'= carry out SUB DIVISION; '0' = no action (continue with 600x600).(Sub-division Flag)
41	<u>subdivisionsize</u>	<u>RAIM</u>	2400	Size after Pixel Sub-Division : 1200x1200 / 2400x2400 / 4800x4800. Ignored if SUB-DIVISION is OFF.(Sub-division size)
42	<u>algoFlag</u>	<u>RAIM</u>	3	parameter for deciding the algorithm for finding the stars from the frame.(Star finding algorithm)
43	<u>refineWindow</u>	<u>RAIM</u>	15	Refine window size for identify brightest pixel among <u>NxN</u> window where N is refine window size in padded image(or Subdivide image if Subdivision <u>swich</u> is ON).-(<u>Neighbourhood criterion</u> for identifying stars.)
44	<u>centroidWindow</u>	<u>RAIM</u>	3	<u>Centroid</u> window size for identify the <u>Centroid</u> value for the each and every pixel within refine pixel list.(Box Size to compute <u>Centroid</u> for detected stars)
45	<u>threshold</u>	<u>RAIM</u>	10	threshold for identifying first cut peaks from the frame(First-cut threshold for star detect
46	<u>framesToBeDiscard</u>	<u>RAIM</u>	1	Total number of 'accumulated' frames (each comprising of ' <u>Nacc</u> ' raw frames) to be discarded before proceeding to generate Reference Frame.(No. of accumulated frames TO BE discarded at beginning)
47	<u>averageFactor</u>	<u>RAIM</u>	1	Total number of 'accumulated' frames (each comprising of ' <u>Nacc</u> ' raw frames) to be averaged to generate Reference Frame.(No. Of accumulated frames used to construct Reference frame).
48	<u>freqDomainFilterFlag</u>	<u>RAIM</u>	2	Parameter for filtering Drift Series (low pass filtering) : 0= Time domain; 1= Frequency domain; & 2= no Filtering. (Frequency domain filtering flag)

Selectable parameters for **Drift Extraction Chain** (RA_IM) :

(3 of 3)

	A	B	C	D
49	freq_value	<u>RAIM</u>	0.2	Cut-off frequency for performing low pass filtering.
50	<u>orderPitch</u>	<u>RAIM</u>	1	Polynomial order of PITCH
51	<u>orderYaw</u>	<u>RAIM</u>	1	Polynomial order of YAW.
52	<u>orderRoll</u>	<u>RAIM</u>	1	Polynomial order of ROLL
53	<u>typeFiltering</u>	<u>RAIM</u>	2	if one has selected time domain filtering (<u>freqDomainFilterFlag</u> = 0) then one has THREE option . 0=Spatial domain filtering; 1=polynomial filtering; 2= Sliding (polynomial) filtering;
54	<u>deltaTime</u>	<u>RAIM</u>	4 (seconds)	if Polynomial / Sliding polynomial filtering is selected then this parameter needs to be set. Value of this parameter leads to fitting of that much chunk of time data (at each instance of fitting) over the entire <u>dataset</u> .
55	<u>fittingflag</u>	<u>RAIM</u>	y	DUMMY! This parameter decides if fitting to be done or not.
56	<u>diffDist</u>	<u>RAIM</u>	1	Parameter needed for drift computation. Value decides the starting <u>neighbourhood</u> distance between two consecutive frames for searching the same star.(Minimum search distance for star match in <u>successive</u> frames.)
57	<u>GenMatchStarsFile_flag</u>	<u>RAIM</u>	0	parameter for listing the matched star pairs of two consecutive frames.if <u>valu</u> of this parameter is 1 than this list is written. If value is 0 then list will not be created.(flag for writing matched star-pair list).
58	<u>shiftRotDetAlgoFlag</u>	<u>RAIM</u>	1	parameter for selecting the algorithm for finding shifts between two consecutive frames.(Drift Computation Algorithm).
59	<u>flag_thetaComp</u>	<u>RAIM</u>	0	Rotation Switch (RA_IM; drift computation) : '1' = 'Theta' parameter is also to be included along with ' <u>Xshift</u> ' and ' <u>Yshift</u> ' for computing drift between two consecutive frames; '0' = only <u>Xshift</u> & <u>Yshift</u> to be used (i.e. NO ROTATION).(Theta switch)
60				

Selectable parameters for Sky Image generation

Chain (L2_PC) :

(1 of 3)

	A	B	C	D
64	For Level2_PC chain	NUV		
65				
66	crcflagpc	RAIM	NO rejection	Switch to reject CRC failed packets or not
67	ZipFlag	L2PC-NUV	NO (tar)	switch to choose 'tar' or 'zip'
68	utcFlag	L2PC-NUV	OFF	switch for UTC correction (On/Off)
69	pathToOutputTarpc	L2PC-NUV	-	path for creating the output path for the tar generation.(Output tar location)
70	GTI_FLAGpc	L2PC-NUV-Datainges	0	GTI filtering to be done (1) or not(0).
71	parityFlagpc	L2PC-NUV	2	parameter for Parity check(1 for All three words including X,Y and MIN_MAX & minimum corner value)/(2 for only X,Y).(parity check flag for photon event.)
72	historypc	L2PC-NUV	1	Switch for history to be written or not?History contains the input parameter information with which current pipeline has ran.
73	clobberpc	L2PC-NUV	1	if output directory given by the user is already exist than what to do? If clobber is YES than this directory will be removed and again created by pipeline and if clobber is NO than pipeline will exit with the error message such that "output directory is already exist."
74	thresholdMultphpc	L2PC-NUV	9999	threshold for identifying multiple photon events.(threshold for multi-photon events.)
75	dropframepc	L2PC-NUV-Datainges	0	Action in case CRC check fails : ('1') Entire frame to be removed; or ('0')only those packets (2048 byte) to be removed which fails at CRC check.(flag for CRC failure action)
76	thr_One_crpc	L2PC-NUV	9999	Ray affected frame(CR threshold parameter-1-"_N_" ir threshold=AVG+N*sqrt(avg_events)+ST/(sqrt(avg_events)) to identify Cosmic Ray affected frame).
77	thr_Two_crpc	L2PC-NUV	9999	"_ST_" in threshold = AVG+N*sqrt(avg_events)+S1/(sqrt(avg_events)) to identify Cosmic Ray affected frame((CR threshold parameter-2-"_ST_" ir threshold=AVG+N*sqrt(avg_events)+ST/(sqrt(avg_events)) to identify Cosmic Ray affected frame))

Selectable parameters for Sky Image generation

Chain (L2_PC) : (2 of 3)

78	<u>CentCorr_tobedonepc</u>	L2PC-NUV	0	Switch for Centroid correction (Dark) : '1' = apply; '0' = no action. [L2PC NUV](Centroid DARK Correction Flag)
79	<u>CentBias_tobedonepc</u>	L2PC-NUV	0	Switch for Centroid correction (FPN) : '1' = apply; '0' = no action. [L2PC NUV](Centroid Bias Flag)
80	<u>DetectDist_tobedonepc</u>	L2PC-NUV	1	Switch for Detector Distortion correction : '1' = apply; '0' = no action. [L2PC NUV] (Detector distortion Flag)
81	<u>OpticDist_tobedonepc</u>	L2PC-NUV	1	Switch for Optical Distortion correction : '1' = apply; '0' = no action. [L2PC NUV](Optics Distortion Flag)
82	<u>frameIntFlagpc</u>	L2PC-NUV	0	Method for 'Frame Integration' : '1' = in multiple parts; '0' = all data to be used together as a single set. [L2PC NUV](Frame Integration Flag:MULTI/SINGLE)
83	<u>framesDiscardpc</u>	L2PC-NUV	2	Total number of initial frames to be discarded(Number of INITIAL frames to be discarded for MULTI case)
84	<u>framesCompute</u>	L2PC-NUV	9400	Total number of frames to be combined together in the <u>FrameIntegration</u> stage (when method is selected for "multiple-parts") (Number of frames to be combined in MULTI case)
85	<u>refinedWinSizepc</u>	L2PC-NUV	15	Refine window size for identify brightest pixel among NXN window where N is refine window size in padded image(or Subdivide image if Subdivision swich is ON). (Neighbourhood criterion for identifying stars)
86	<u>centroidWinSizepc</u>	L2PC-NUV	3	Centroid window size for identify the Centroid value for the each and every pixel within refine pixel list.(Box Size to compute Centroid for detected stars)

Selectable parameters for Sky Image generation

Chain (L2_PC) :

(3 of 3)

87	<u>diffDistpc</u>	L2PC-NUV	1	This parameter is need for drift computation. Value of this parameter decides the starting <u>neighbourhood</u> distance between two consecutive frame for searching the same star. (Minimum search distance for star match in <u>successive</u> images of <u>FrameIntegration</u> stage.)
88	<u>shiftRotDetAlgoFlagpc</u>	L2PC-NUV	1	parameter for selecting the algorithm for finding shifts between two consecutive frames for generation of final registered image.(Algorithm to find offsets of current image w.r.t reference image)
89	<u>flag_thetaComppc</u>	L2PC-NUV	0	Rotation Switch (L2_PC; drift computation) : '1' = 'Theta' parameter is also to be included along with 'Xshift' and 'Yshift' for computing drift between two consecutive frames; '0' = only Xshift & Yshift to be used (i.e. NO ROTATION).(Theta switch)
90	<u>att_timecolpc</u>	L2PC-NUV	Time	time column name in attitude file.
91	<u>att_qcolpc</u>	L2PC-NUV	Q_SAT	Quaternion column name in attitude file.
92	<u>thresholdpc</u>	L2PC-NUV (& DRIVERMODULE)	50	Sigma criteria for star detection in full frame <u>astrometry</u> .(parameter in <u>fullframe astrometry</u> to identify outliers : multiplier to sigma; starting value)
93	<u>database_namepc</u>	L2PC-NUV	-	Path of <u>catalogue</u> database for searching the RA-DEC to that of actual <u>catalogue</u> .
94	<u>search_algo_forFullFrameAstpc</u>	L2PC-NUV	2	Search area in the Catalog : (1=Rectangle; 2=Circular; 3=Rectangle-FUV; 4=Circular-FUV; 5=Rectangle-NUV; 6=Circular-NUV)
95	<u>Radi_searchpc</u>	L2PC-NUV	0.05	Radial distance for searching the matching star from the <u>catalogue</u> .(search radius (in degrees) for star match with star catalogue.)
96	<u>minimum_targetedstarspc</u>	L2PC-NUV	5	minimum targeted stars requirement for full frame <u>astrometry</u> module.(Targeted number of star matches with <u>catalogue</u>); also used for Frame Integration stage if <u>multi-part</u> selected;

Some details :

When time overlap is partial between VIS & NUV / FUV :
'force' use of NUV tracking (*products archived from
“default” run at POC / IIA*);
'force' use of FUV tracking (to generate FUV image)
when FUV-NUV overlap partial;

In crowded fields (e.g. Globular Cluster) -
NUV tracking (when VIS data not available) success can be
improved by turning ON rejection of **'multi-photon events'**
(*but photometric uncertainty increases!*)

Thank you !