Steps for first time use of UVIT data & typical products:

(document name 'UL2P_quick_installation_and_output_product_help_**v7**.docx/pdf'
date = **30-October-2017**;
for queries contact : swarna@ncra.tifr.res.in; mobile : 95455 14645 / 98672 04645)

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1) Download the following 3 files from the site : **"ftp://wm.ncra.tifr.res.in/swarna/"**

A) 'AS1UVITLevel2DataPipeline-L2TEAM-**5.6**-linux-x64-installer.run'
(this is the **stable & recommended** version for UVIT Level-2 Pipeline "UL2P")
B) 'CALDB_L2_ver**1.6**.zip' released by POC/IIA
(this is the Calibration Database 'CALDB' with various instrument details needed while running the "UL2P")
C) 'cat2.zip' [containing 'USNOA2_VIS_GALEX_NUV_FUV_catalogue.db']
(this is the star catalogue - Optical+ UV, used by "UL2P" to correct for absolute astrometry)

2) Expand the CALDB at an area of your choice with adequate disk space
(by using 'unzip' command)

3) Install the "UL2P" by typing :
"./AS1UVITLevel2DataPipeline-L2TEAM-5.6-linux-x64-installer.run" & then 'Enter' key;
Answer the queries during the installation process (e.g. PATH to where the base directory of the installation be; etc)

N.B. If *ANY* warning message appears, the installation is SUSPECT (even if it creats all the executable files etc);
One of the most common reasons for failure of installation (Ubuntu OS) is related to 'sqlite3' library : the file “sqlite3.h” is not found at its expected location. This can be fixed by an one-time copying it to '/usr/include/' directory as 'su' [& also ensure that “libsqlite3.so” is located at '/usr/lib/x86_64-linux-gnu/' directory ; etc]. These 2 files are also made available on the FTP site.

4) After successful installation of "UL2P", carry out the following ONE TIME exercise :
edit the 'parameter' file (UVIT_DriverModule.par) located at :
../AS1UVITLevel2DataPipeline-L2TEAM-5.6/as1/uvit/paramfiles/UVIT_DriverModule.par"
at the following 5 places (identifiable by searching the string "Editable line" :

```
# $$$$$$$$$$$$$$$$$$$$$$$$$$$
# Editable line 'A' (only one-time per installation) - see line below [CALDB path]
caldbdir,f,h,"/data2/swarna/uvit/CALDB_L2_ver1.6/",,,"Enter caldb directory path"
# $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

# $$$$$$$$$$$$$$$$$$$$$$$$$$$$
# Editable line 'C1' (only one-time per installation) - see line below [output TAR path (for NUV)]
pathToOutputTarpc,s,h,"/data2/swarna/uvit/udata1/tarout1/L2_Driver_tar_outN",,,"Enter the PATH for Output TAR file (for NUV)"
# $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

```
# $$$$$$$$$$$$$$$$$$$$$$$$$$$
# Editable line 'B1' (only one-time per installation) - see line below [CATALOGUE path (for NUV)]
database_namepc,s,h,"/data2/swarna/uvit/CATALOG2/USNOA2_VIS_GALEX_NUV_FUV_catalogu
e.db",,,"path of Catalogue Database"
# $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

# $$$$$$$$$$$$$$$$$$$$$$$$$$$$
# Editable line 'C2' (only one-time per installation) - see line below [output TAR path (for FUV)]
pathToOutputTarpcfuv,s,h,"/data2/swarna/uvit/udata1/tarout1/L2_Driver_tar_outF",,,"Enter the PATH
for Output TAR file (for FUV)"
# $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

# $$$$$$$$$$$$$$$$$$$$$$$$$$$$
# Editable line 'B2' (only one-time per installation) - see line below [CATALOGUE path (for FUV)]
database_namepcfuv,s,h,"/data2/swarna/uvit/CATALOG2/USNOA2_VIS_GALEX_NUV_FUV_catalo
gue.db",,,"path of Catalogue Database"
# $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

The above 5 lines (which are to be one-time edited) provide the directory paths to :
'A' : CALDB (base directory of the Calibration Database)
'B1' & 'B2' : location of Star Catalogue (both paths could be identical)
'C1' & 'C2' : directory to keep output 'tar' product (two directories must be **DIFFERENT; & THEY MUST EXIST !**)

5) At this stage UL2P is ready to run, provided you have proper UVIT Level-1 data file
(e.g. ' /data2/swarna/uvit/udata2/z8202_56/LEVL1AS1UVT20170404A03_103T01_9000001132_08202.zip ').

PLEASE NOTE THE INPUT DATA CAN BE “TAR” OR “ZIP” FORMAT !
ALSO, ALL UNIX SHELLS ARE SUPPORTED IN VERSION 5.6 !

Running the pipeline :

Interactive mode :

Type : UVIT_DriverModule (& then 'Enter' key),
The UL2P process initiates and asks the following interactive inputs :

i) input data format 'zip' or 'tar' [usually data downloaded from ISSDC is 'zip'];
ii) complete path & file-name of the input (Level-1) data that is to be processed;
iii) do you want to ***force*** NUV tracking (even if VIS is present) ? (default : 'n' = NO);
iv) the base directory address where all intermediate & final results will be written (in a well defined sub-directory structure);
v) do you want to *MANUALLY SELECT* stars for drift tracking ? (default : 'n');
Before running in MANUAL mode, it is mandatory to run first an in the DEFAULT (AUTO) mode !! (see other documents);
vi) in case of *MANUAL SELECTION* of stars, base directory of earlier RA_IM run output;

Many messages / logs will continue to scroll on your screen, which is normal.
The processing time can be large (depends on size of the dataset), hence one way to release the

terminal without hampering the execution of the UL2P job [particularly useful if running via remote login (“ssh”) over network / internet] :
Type “Ctrl-Z”, “bg”, “disown -h”.
Now one may close the terminal (logout).

Batch mode : [STRONGLY RECOMMENDED !]

Edit “UVIT_DriverModule.par” file (located in the directory : …/AS1UVITLevel2DataPipeline-L2TEAM-5.6/as1/uvit/paramfiles) by replacing the following **SIX** lines (to change the 'query-learn' [ql] mode to 'hide' [h] mode for all interactive inputs; Parameter Interface Library, PIL language) :

#ZipFlag,b,**ql**,y,,,"Input leve1l is in Zip format or not?('y' for ZIP format/'n' is for TAR format)"
ZipFlag,b,**h**,y,,,"Input leve1l is in Zip format or not?('y' for ZIP format/'n' is for TAR format)"

#level1indir,f,**ql**,"/data2/swarna/uvit/udata2/z8202_56/LEVL1AS1UVT20170404A03_103T01_9000001132_08202.zip",,,"Enter Level-1 data (merged or orbit-wise) directory path"
level1indir,f,**h**,"/data2/swarna/uvit/udata2/z8202_56/LEVL1AS1UVT20170404A03_103T01_9000001132_08202.zip",,,"Enter Level-1 data (merged or orbit-wise) directory path"

#NUVonNUVflag,b,**ql**,n,,,"RAS from NUV data?('y' for YES,'n' for NO)"
NUVonNUVflag,b,**h**,n,,,"RAS from NUV data?('y' for YES,'n' for NO)"

#level2outdir,f,**ql**,"/data2/swarna/uvit/udata2/z8202_56/driver_out/",,,"Enter level2 directory"
level2outdir,f,**h**,"/data2/swarna/uvit/udata2/z8202_56/driver_out/",,,"Enter level2 directory"

#ManualMode,b,**ql**,n,,,"Auto mode('n') or Manual selection of stars for generating RAS('y')?"
ManualMode,b,**h**,n,,,"Auto mode('n') or Manual selection of stars for generating RAS('y')?"

#previousOutputL2,f,**ql**,"otuput_6740",,,"Base directory of RAIM output in Auto mode"
previousOutputL2,f,**h**,"otuput_6740",,,"Base directory of RAIM output in Auto mode"

Now use the following command to submit as a batch job :

nohup UVIT_DriverModule >log1_target1 2>log2_target1 &

The two files 'log1_target1' & ' log2_target1' will contain all the text that would have scrolled on terminal screen if it was used in interactive mode.

6) The sky image outputs from individual sub/orbits as well as from combining all orbits for each unique combinations of : (i) channel (NUV/FUV), (ii) UV Filter & (iii) selected Window-size, will be generated as FITS files (4800x4800).
In addition, Exposure & Uncertainty images are also generated (again FITS).

TYPICAL OUTPUT DIRECTORY STRUCTURE & SOME DETAILS :

[swarna@swarna driver_out]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out

[swarna@swarna driver_out]$ ls -lt
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:20 FUV_FullFrameAst_F3_W511

```
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:20 FUV_Final_F3_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:18 FUV_FullFrameAst_F2_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:18 FUV_Final_F2_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:14 NUV_FullFrameAst_F6_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:14 NUV_Final_F6_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:14 NUV_FullFrameAst_F5_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:14 NUV_Final_F5_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:13 NUV_FullFrameAst_F3_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:13 NUV_Final_F3_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:13 NUV_FullFrameAst_F2_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:13 NUV_Final_F2_W511
drwxrwxr-x. 3 swarna swarna 32 Aug 17 00:11 NUV_FullFrameAst_F1_W511
drwxrwxr-x. 2 swarna swarna 89 Aug 17 00:11 NUV_Final_F1_W511
drwxrwxr-x. 2 swarna swarna  6 Aug 17 00:09 _RAPC_FUV_1
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:08 _RAPC_NUV_1
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:08 _RAPC
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:06 _FUV_10
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:04 _NUV_10
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:03 _FUV_9
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:01 _NUV_9
drwxrwxr-x. 3 swarna swarna 17 Aug 17 00:00 _FUV_8
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:57 _NUV_8
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:54 _FUV_7
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:50 _NUV_7
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:46 _FUV_6
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:43 _NUV_6
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:38 _FUV_5
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:34 _NUV_5
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:28 _FUV_4
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:24 _NUV_4
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:19 _FUV_3
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:15 _NUV_3
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:14 _FUV_2
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:12 _NUV_2
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:08 _FUV_1
drwxrwxr-x. 3 swarna swarna 17 Aug 16 23:06 _NUV_1
drwxrwxr-x. 3 swarna swarna 18 Aug 16 22:58 uvit
```

The directories '_NUV_1', '_FUV_1', …. etc hold outputs from processing of individual orbits using VIS tracking and '_RAPC_NUV_1', '_RAPC_FUV_1' etc using NUV tracking (when no VIS data was found with any time-overlap with the NUV / FUV data) .

The directories “NUV_Final_F3_W511” & “NUV_FullFrameAst_F3” hold multi-orbit combined sky image results (for each specific combination of selected UV Filter & Window size).

The most users may need only the multi-orbit combined sky image products (unless there are some special needs). Typical examples of contents and locations of astronomer ready products are presented below for both cases (multi-orbit-final or single-orbit).

MULTI ORBIT CASE :

Example of "NUV_Final_F3_W511" directory [NUV channel, Filter 'F3' & 512x512 Window]

[swarna@swarna NUV_Final_F3_W511]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/NUV_Final_F3_W511

[swarna@swarna NUV_Final_F3_W511]$ l
total 270156
-rw-rw-r--. 1 swarna swarna 92211840 Oct 29 08:56 F3_W511_FinalImage_NoiseMap.fits
-rw-rw-r--. 1 swarna swarna 92211840 Oct 29 08:56 F3_W511_FinalImage_Exp.fits
-rw-rw-r--. 1 swarna swarna 92211840 Oct 29 08:56 F3_W511_FinalImage_Sig.fits

The above three FITS files refer to NUV image ("F3_W511_FinalImage_Sig.fits"; unit : photon/second), Statistical Error ("F3_W511_FinalImage_NoiseMap.fits"; unit : photon/second), and Sky Exposure ("F3_W511_FinalImage_Exp.fits"; unit : number of Frames) in RA-Dec (J2000) coordinate system.

Example of "NUV_FullFrameAst_F3" directory

[swarna@swarna uvtFullFrameAst_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/NUV_FullFrameAst_F3_W511/uvtFullFrameAst_5.6

[swarna@swarna uvtFullFrameAst_5.6]$ ls -lt
total 90132
-rw-rw-r--. 1 swarna swarna 92214720 Oct 29 08:56 AS1A03_103T01_9000001132uvtNIIPC00F3_l2_as.fits
-rw-rw-r--. 1 swarna swarna 1172 Oct 29 08:56 star_raDec_frmUV_catalogue.txt
-rw-rw-r--. 1 swarna swarna 8904 Oct 29 08:56 Diff_Final_j2016.txt
-rw-rw-r--. 1 swarna swarna 2844 Oct 29 08:56 FinalCatalogueMatch_JOBS.txt
-rw-rw-r--. 1 swarna swarna 38293 Oct 29 08:56 star_radec.txt
-rw-rw-r--. 1 swarna swarna 1839 Oct 29 08:56 Diff_Final.txt
-rw-rw-r--. 1 swarna swarna 6660 Oct 29 08:56 star_raDec_frmOptics_catalogueWith_10Stars.txt
-rw-rw-r--. 1 swarna swarna 3747 Oct 29 08:56 star_raDec_frmOptics_catalogueWith_5Stars.txt

Above, the FITS file "AS1A03_103T01_9000001132uvtNIIPC00F3_l2_as.fits" holds the NUV Filter F3 & 512x512 Window final sky image in RA-Dec coordinates.

SINGLE ORBIT CASE :

Example of "_NUV_3" directory

[swarna@swarna uvtN.09]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09

[swarna@swarna uvtN.09]$ ls -lt
total 24
drwxrwxr-x. 2 swarna swarna 4096 Oct 29 07:58 uvtFullFrameAst_5.6

drwxrwxr-x. 2 swarna swarna 4096 Oct 29 07:58 uvtRADECImage_5.6
drwxrwxr-x. 2 swarna swarna 4096 Oct 29 07:58 uvtShiftRot_5.6
drwxrwxr-x. 2 swarna swarna 4096 Oct 29 07:58 uvtFlippedRegImage_5.6
drwxrwxr-x. 2 swarna swarna 4096 Oct 29 07:57 uvtRegAvg_5.6
drwxrwxr-x. 5 swarna swarna 80 Oct 29 07:57 uvtFrameIntegration_5.6
drwxrwxr-x. 2 swarna swarna 75 Oct 29 07:57 uvtExposureFrames_5.6
drwxrwxr-x. 3 swarna swarna 4096 Oct 29 07:54 DataIngest_5.6

The above set of directories hold outputs from ***selected*** intermediate processing blocks, as per DEFAULT setting (about writing on disk ON or OFF). A complete list of all intermediate blocks (one needs to turn ON all the disk writing switches in 'UVIT_DriverModule.par' file; see the enclosed block diagram below) is presented below :

DataIngest_5.6 : Block '1'
uvtMaskBadPix_5.6 : Block '4'
uvtPixPadding_5.6 : Block '5'
uvtSubDivision_5.6 : Block '6'
uvtCosmicRayCorrection_5.6 : Block '7'
uvtFlatFieldCorr_5.6 : Block '10'
uvtUnitConvertion_5.6 : Block '12'
uvtDetectDistCorr_5.6 : Block '13'
uvtOpticDistCorr_5.6 : Block '14'
uvtShiftRot_5.6 : Block '15'
uvtExposureFrames_5.6 : Block '16'
uvtFrameIntegration_5.6 : Block '17'
uvtRegAvg_5.6 : Block '18'
uvtFlippedRegImage_5.6 : Block '19'
uvtRADECImage_5.6 : Block '20'
uvtFullFrameAst_5.6 : Block '21'

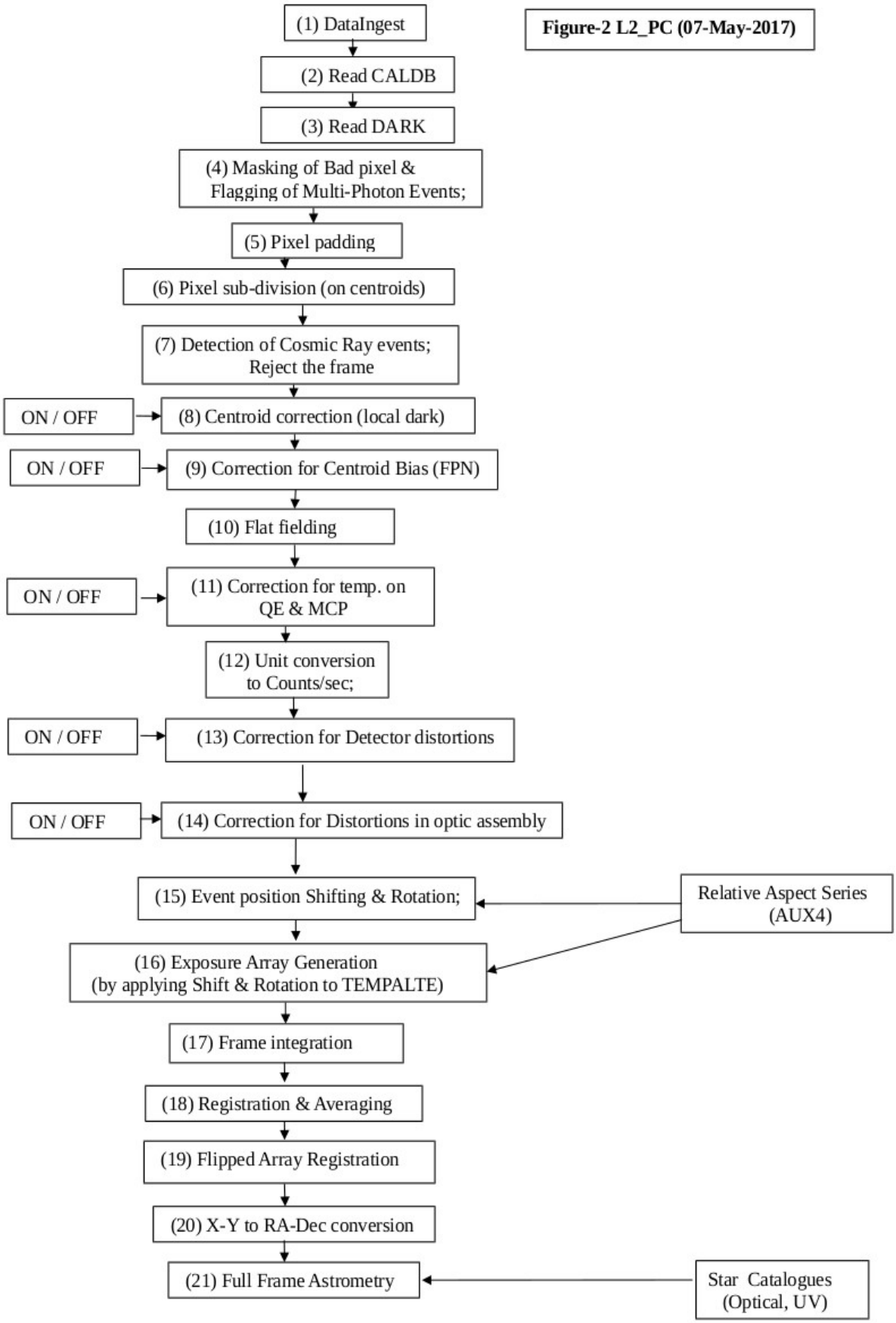

Figure-2 L2_PC (07-May-2017)

Contents of ***selected*** intermediate directories are described below.

Example of "uvtFullFrameAst_5.6" directory

[swarna@swarna uvtFullFrameAst_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09/uvtFullFrameAst_5.6

[swarna@swarna uvtFullFrameAst_5.6]$ ls -lt
total 90168
-rw-rw-r--. 1 swarna swarna 92203200 Oct 29 07:58
AS1A03_103T01_9000001132uvtNIIPC00F6_l2_as.fits
-rw-rw-r--. 1 swarna swarna 1172 Oct 29 07:58 star_raDec_frmUV_catalogue.txt
-rw-rw-r--. 1 swarna swarna 4901 Oct 29 07:58 FinalCatalogueMatch_JOBS.txt
-rw-rw-r--. 1 swarna swarna 14168 Oct 29 07:58 Diff_Final_j2016.txt
-rw-rw-r--. 1 swarna swarna 69951 Oct 29 07:58 star_radec.txt
-rw-rw-r--. 1 swarna swarna 1718 Oct 29 07:58 Diff_Final.txt
-rw-rw-r--. 1 swarna swarna 8676 Oct 29 07:58 star_raDec_frmOptics_catalogueWith_10Stars.txt
-rw-rw-r--. 1 swarna swarna 4755 Oct 29 07:58 star_raDec_frmOptics_catalogueWith_5Stars.txt

Above, the FITS file " AS1A03_103T01_9000001132uvtNIIPC00F6_l2_as.fits" holds the NUV sky image in RA-Dec coordinates generated using the single data collection episode "_NUV_3".

Example of "uvtExposureFrames_5.6" directory

[swarna@swarna uvtExposureFrames_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09/uvtExposureFrames_5.6

[swarna@swarna uvtExposureFrames_5.6]$ ls -lt
total 90012

-rw-rw-r--. 1 swarna swarna 92171520 Oct 29 07:57 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_t0.0000_f1_exp_fi.fits

The file/(s) in this directory contain Exposure array/(s) for individual Frame Integration sub-set/(s) (in DEFAULT setting, the entire data is put into one single sub-set).

Example of "uvtFrameIntegration_5.6" directory

[swarna@swarna uvtFrameIntegration_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09/uvtFrameIntegration_5.6

[swarna@swarna uvtFrameIntegration_5.6]$ ls -lt
total 0
drwxrwxr-x. 2 swarna swarna 92 Oct 29 07:57 NOISE_MAP
drwxrwxr-x. 2 swarna swarna 97 Oct 29 07:57 SignalFrames_DividedWithExposure
drwxrwxr-x. 2 swarna swarna 81 Oct 29 07:57 SignalFrames

The directory “SignalFrames” contains individual stacked up UV images (2-D; X-Y) from selected number of Frames for the Frame_Integration stage. The corresponding Statistical Error arrays are held in the directory “NOISE_MAP”. The directory “SignalFrames_DividedWithExposure” contains sky images in 'photon/sec' units.

Example of “uvtRegAvg_5.6” directory

[swarna@swarna uvtRegAvg_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09/uvtRegAvg_5.6

[swarna@swarna uvtRegAvg_5.6]$ ls -lt
total 180032
-rw-rw-r--. 1 swarna swarna 92180160 Oct 29 07:58 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_t0.0000_f1_sig_regAvg.fits
-rw-rw-r--. 1 swarna swarna 92171520 Oct 29 07:57 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_t0.0000_f1_exp_regAvg.fits

These two FITS files refer to the final UV and the Exposure images of the sky in Detector (X-Y) coordinates after carrying out the Registration and Averaging process.

Example of “uvtShiftRot_5.6” directory

[swarna@swarna uvtShiftRot_5.6]$ pwd
/data2/swarna/uvit/udata2/z8202_56/driver_out/_NUV_3/uvit/08202/uvtN/uvtN.09/uvtShiftRot_5.6

[swarna@swarna uvtShiftRot_5.6]$ ls -lt
total 348212
-rw-rw-r--. 1 swarna swarna 158627520 Oct 29 07:58 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_radec.fits
-rw-rw-r--. 1 swarna swarna 92185920 Oct 29 07:58 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_t9999.0000_f1_img_fi.fits
-rw-rw-r--. 1 swarna swarna 105747840 Oct 29 07:57 AS1A03_103T01_9000001132uvtNIIPC00F6_l2_snr.fits

The files “AS1A03_103T01_9000001132uvtNIIPC00F6_l2_snr.fits” & “AS1A03_103T01_9000001132uvtNIIPC00F6_l2_radec.fits” contain the final photon event list with their centroid values corrected for all effects that have been selected (e.g. Drift, Distortions, ...etc). The latter also includes pixel-coordinates in RA-Dec (J2000) system for each photon event. **This product is relevant for studies involving TIMING (each photon event has time stamp).**

The file “AS1A03_103T01_9000001132uvtNIIPC00F6_l2_t9999.0000_f1_img_fi.fits ” provides a UV sky image in Detector X-Y coordinate system.

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