Content of the main distribution directory :

1) readme.pdf (this file; pdf version of readme/help file)
2) readme.html (html version of readme/help file)
3) install_sxtEEFModule.csh (installation shell script for CSHELL users)
4) install_sxtEEFModule.sh (installation shell script for Bourne SHELL users)
5) sxt_ARFModule_v03.py (python script called for sxtARFModule tool)
6) make_sxt_EEF_v03_py2.py (python script called for sxtEEFmaker tool)

*********Readme file for ****sxtARFModule **** is written in python**********

* The ARF v04_20190608 is most recent version of SXT ARF which with combination of a command line tool sxtARFModule can be used for spect
object observed by AstroSat-SXT. This tool takes the recent versions of ARFs as input and scales this as per the observation specific par
region and the distance of source centriod from the bore-sight/optical axis (causing Vignetting), and write a new ARF file which can dire

* This version of ARF is applicable for most of the non-piled SXT targets. However one may expect 1-3% uncertainities in flux estimations

* This version of ARF is tested for thermal SNR 1E0102, CasA, and blazars 1ES1959+650 +, and results are within the acceptable limits.

* If using this ARF and Module for your scientific investigations please refer the url of TIFR-POC (www.tifr.res.in/~astrosat_sxt) in dat

"This work has been performed utilyzing the calibration data-bases and auxillary analysis tools developed, maintained and distri

* According to most recent studies of SXT point spread function (PSF) of point sources, a circle of 15' radii centered at source positior
users can choose any circular radius between 13-17 arcm for lowest possible systematic. Note that the sxtARFModule tool is optimized for
sources, however, in cases it is not possible the sxtARFModule will anyway generate appropriate ARF by approximating the area to an area
source regions the ratio major-axis/minor-axis [a/b] is more than 2.
For a source with piled-up observations one may need to remove central a few arcmins and hence annulus/elliptical annulus will be a most
The sxtARFModule is suggested to use with spectrum file + events file + other input options, which in principle, will generate appropriat

* The second component of PSF (broad component of double King's profile) is still found to contribute mildly to the regions/outer rings u
background regions from same frame as it will always be an overestimation of back-ground. The users are suggested to use background spect
One may estimate constant background count rates for a source region and substract it to get background substracted lightcurve. This subs
satellite orbit time scale variations. These may be crucial for the sources with count rate ~ 0.5 or less.

* As stated earlier the recent ARF and the modified ARFs using this tool are readily usable for spectral analysis. Users are free to use
https://www.sron.nl/astrophysics-spex) or any other similar tools. Please refer to respective mannuals for the basics of the spectral fi

* The users are encouraged to contact nilima@tifr.res.in and/or sunil.chandra355@gmail.com in case of any bug-reports or suggestions or t

* Please install/upgrade the pre-requisite python libraries (see the end of this document for a list of these libraries) before use of sx
important libraries which you should upgrade to recent versions.

* The present version of SXT pipeline does not correct for the gain shifts. The users are requested to check for gain shift for a partcul

> gain fit

One should use fixed gain slope = 1. Only gain offset should be kept free.
Once you have decided appropriate gain offset value (best fit) then these values can be forzen in the model so that the model fitting doe

After removing your gain fit component one can use

> gain 1 1 gain-offset-value

*PYTHON libraries HELP is given at the end of file.

* For Linux machines, please install it using this method...
#----------Installation Part ----------
A) for BASH shell users:
1) Download the attached tarfile
2) Untar it using
-> tar xzvf SXTEEFModule.tar.gz
-> cd SXTEEFModule
-> chmod u+x install_sxtEEFModule.sh
-> ./install_sxtEEFModule.sh
-> source ~/.bashrc [or ~/.profile based on text outputs on terminal, while running above command]

B) For CSHELL users:

1) Download the attached tarfile
2) Untar it using
-> tar xzvf SXTEEFModule.tar.gz
-> cd SXTEEFModule
-> chmod u+x install_sxtEEFModule.csh
-> ./install_sxtEEFModule.csh
-> source ~/.cshrc [or ~/.profile based on text outputs on terminal, while running above command]

These will enable users to utilyze two tools (sxtEEFmaker and sxtARFModule) available from terminal window. Please run following to te

sxtARFModule -h [OR sxtARFModule --help]

and

sxtEEFmaker -h [OR sxtEEFmaker --help]

#----------

Following lists details of the input options...

You can generate this by running following in a terminal window

-> python sxt_ARFModule_v03.py -h (if you directly use this python file)

or

sxtARFModule -h (If you install it as per guidelines)

```
======================================================================
         Running Task: sxt_ARFModule_v03.py
                 Version: 0.01 Release Date: 2019-06-16
                 Developed By : Sunil Chandra,
         CSR, North-West University, 10, June, 2019
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
The estimations provided by this script is based on actual SXT observations. The profiles used here are corrected for background counts.
We may expect ~5 % uncertainity in flux estimations when extracting ARFs for sources with fluxes ~ 1 Crab or brighter...
The parametric way of estimating the factor uses  kings's profile as functional form + best fit archived parameters
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
======================================================================

Usage: sxt_ARFModule_v03.py [options]

Options:
  -h, --help            show this help message and exit
  -m MODE, --mode=MODE  Mode for extraction;   Two options a) using table and
                        b) using fit parameters   Default is b)   Input
                        options are ['a', 'tbl', 'tab', 't', 'table'] for a)
                        and one of ['b', 'par', 'param', 'fit', 'fitpar'] for
                        b)
  -r RADIUS, --radius=RADIUS
                        Source Region Size in arcmin.. Always use for cicular
                        regions...  Multiple radii (r1, r2, r3) can be entered
                        in format or 'r1nr2nr3' or 'r1ANDr2ANDr3' or
                        'r1ORr2ORr3'  Default is 15 arcm
  --sxtarf=SXTARF       The Full Path of Base ARF provided by SXT Team...
                        For Example 'sxt_pc_excl00_v04.arf'
  -e EVTFILE, --evtfile=EVTFILE
                        The Events file in case you are entering source
                        postion in sky pixels instead of detector
                        coordinates.....Default = None
  --sxtpha=SXTPHA       The Name of the input SXT spectrum [needed to fetch
                        source region related information]...   For Example
                        'sxt_pc_mytarget_src.pha'  Default is None..[This
                        means source coordinates should be entered manually]
  -x XPIX, --xpix=XPIX   X coordinate (RA) of the source position [sky/RAW
                        pixels] ...  Default is None [If None you should
                        provide spectrum as input file
  -y YPIX, --ypix=YPIX   Y coordinate (DEC) of the source position [sky/RAW
                        pixels] ...  Default is None [If None you should
                        provide spectrum as input file
  -o OUTSTEM, --outstem=OUTSTEM
                         Stem for output ARF File...
  --coordtyp=COORDTYP   Input Coordinate Type, .i.e., Detector Coordinates or
                        Sky Coordinates...Default is Sky   The input options
                        are ['Sky', 'sky', 'SKY', 's', 'S', 1, True] and/or
                        ['RAW', 'raw', 'Raw', 'R', 'r', 0]   Default is 'SKY'
  --vigcorrflag=VIGCORRFLAG
                        The flag for Vignetting Correction for off-axis SXT
                        observations, if needed...  Accepted options are [1.,
                        True, 'yes', 'YES', 'y', 'Y']   Default is 'no'
  --pltflag=PLTFLAG     The flag used for making the ARF diagnostics plot to
                        display various versions...  Accepted options are [1.,
                        True, 'yes', 'YES', 'y', 'Y']   Default is 'no'
  --onlyceoff=ONLYCEOFF
                        The flag to print only the coefficients for the input
                        radii..No ARF files will be generated.....  Accepted
                        options are [1., True, 'yes', 'YES', 'y', 'Y']
                        Default is 'no'



Descriptions:

This tool can be used in two ways a) Just to estimate the correction factor (f) to estimate the actual normalization after fitting some s
corrected Norm. (Flux )  =  (2-f) * Norm (Flux)

Here you just need to enter following important parameters...

i) radius (R) or radii (in format of R1nR2nR3 or R1ANDR2ANDR3 or R1ORR2ORR3 )

ii) coeffonly=yes ; a flag to confirm that we want only coefficients no ARF generations

iii) Mode of estimation [optional] : you may either choose pre-calculated table (A) or pre-estimated Kings profile (B)
(Both the results agree within the uncertainities)

For this options users can ignore other options ... i.e. Default valuse if users are not defining then explicitly

Example :

python ~/Desktop/SXTEEFModule/sxt_ARFModule_v03.py --radius=20n15n10n5 --onlyceoff=1 --mode=b --coeffonly=yes

                    or

python ~/Desktop/SXTEEFModule/sxt_ARFModule_v03.py -r 20n15n10n5 --onlyceoff=1 -m b --coeffonly=yes


b) To generate the corrected ARF for your particular source extraction region.

The important input options for this step are

i) radius (R) or radii (in format of R1nR2nR3 or R1ANDR2ANDR3 or R1ORR2ORR3 )

ii) coeffonly=yes ; a flag to confirm that we want only coefficients no ARF generations

iii) Mode of estimation [optional] : you may either choose pre-calculated table (A) or pre-estimated Kings profile (B)
(Both the results agree within the uncertainities)

iv) Name of events file with full path if not in current directory [if not entered with command line, it will ask you when calling this t
```

v) Name of spectrum file (.pha file) to extract information about source regions...

vi) Name of reference SXT ARF file.. [if not entered with command line, it will ask you when calling this file in module]

The inclusion of events file and spectrum file are kept at higher priority than manual entry of source position and source region inforr
This gives more flexibility to user to opt how to go...

vii) --vigcorrflag=yes [default is no] option is optional but recommended to use for any kind of spectral study...

viii) --pltflag=yes [default is yes] option makes a png file comparing the resulting ARF with original ARF..

The resulting ARFs thus generated are readily usable in xspec for spectral fitting ... No additional correction is needed for normalizat

Example : Case - 1 (estimating factors with no ARF outputs)

The radius input here is for multiple radii in one run of the script...Users, however, can give a single radius as input same way (i.e.,

(using bash script):-->

```
sxtARFModule --radius=20n15n10n5 --onlyceoff=yes --outstem=ARFTESTS1 --mode=b
                        or
sxtARFModule -r 20n15n10n5 --onlyceoff=yes -o ARFTESTS1 -m b
```

OR
(using python code) :-->

```
python sxt_ARFModule_v03.py --radius=20n15n10n5 --onlyceoff=0 --outstem=ARFTESTS1 --mode=b
                       or
python sxt_ARFModule_v03.py -r 20n15n10n5 --onlyceoff=0 -o ARFTESTS1 -m b
```

Users can avoid giving ARF, spectra and events file as input as with --coeffonly=yes will force program to generate the numbers for sourc
(If you are using source regions other than circle please estimate the total area of that region and calculate the radius of a cicle with

Case - 2 (estimating the factors and generate ARF for input spectra and based on input ARF...)

Since you are provinding spectra and events file for the reference of source region information and hence the radius input will not be us
--coeffonly=no [--coeffonly=0] is mandatory.

```
sxtARFModule --onlyceoff=0 --outstem=ARFTESTS1 --mode=b --evtfile=RX1856/RX1856_or15427_15444_merged_cl.evt --sxtpha=RX1856/src10arcm_g0
                        or
sxtARFModule --onlyceoff=0 -o ARFTESTS1 -m b -e RX1856/RX1856_or15427_15444_merged_cl.evt --sxtpha=RX1856/src10arcm_g0.pha --sxtarf=/home
```

OR
(using python code) :-->

```
python sxt_ARFModule_v03.py --radius=20n15n10n5 --onlyceoff=0 --outstem=ARFTESTS1 --mode=b --evtfile=RX1856/RX1856_or15427_15444_merged_c
                       or
python sxt_ARFModule_v03.py -r 20n15n10n5 --onlyceoff=0 -o ARFTESTS1 -m b -e RX1856/RX1856_or15427_15444_merged_cl.evt --sxtpha=RX1856/sr
```

If you have set --vigcorrflag=yes then two output ARFs will be generated one with Vignetting correction and other without it. Users are
some other regions. Anyway this option is essential for any observations with SXT as not a primary instrument.

------------------------------Requisites Modules or python libraries ------------------------------

* Important python libraries [Users should check whether these are installed or not]

1) astropy
2) numpy
3) scipy
4) lmfit
5) shutil
6) glob
7) matplotlib
8) pip [optional for Installation of python packages]
9) Kapteyn [optional; needed only if users want to use sxtEEFmaker fot modelling the profile]

*please upgrade astropy, numpy and scipy if using old Installations...

astropy version : 2.0.12 or later
numpy version: 1.16.3 or later
For upgrading users can take follow instructions as below :
For pip users :
Download get-pip.py from https://bootstrap.pypa.io/get-pip.py
sudo python get-pip.py
sudo pip install pip --upgrade
sudo pip install --upgrade astropy
sudo pip install --upgrade numpy
In case you use both python-2 and python-3 (2:default)
sudo python3 get-pip.py
sudo pip install pip --upgrade
sudo pip install --upgrade astropy
sudo pip install --upgrade numpy
*check the version of your working astropy and numpy
python (or python3)
> import astropy
> print (astropy.version.version)
> print (numpy.version.version)

++SXTEEFMAKER Module help ++++++++++++++++++++++++++++++++++++++

This distribution of modules include another python module which can be used to generate encircled energy profile (EEF) for any particula
This module is basically of importance for POC related work, however, is for users interest in case one wants to study non-standard sourc

This takes events file and source position (centriod in Sky Pixels or detector pixels)
Following summarizes the input details of this module :

This tool is also installed itself (added in your .bashrc file as

```
chandra@blazars:~$ sxteefmaker -h
================================================================================
 Running 'SXT EEF Maker' Tool
   Task: /home/chandra/auxpyscrpt/make_sxt_EEF_v03_py2.py
   Version: 02 Release Date: 2018-11-14
 Originally Developed By :

  Sunil Chandra,
  TIFR, Mumbai, 15 January, 2017
  Updated on 03 July, 2019
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

Description: This tool makes Encirled Energy Fraction (EEF) profile for sources by using merged clean events files as input. The profile
containing 90% and 60% of total incoming photons. This version provides an option to correct profiles for background [Default].
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
================================================================================

Usage: make_sxt_EEF_v03_py2.py [options]

Options:
  -h, --help            show this help message and exit
  -e EVTFILE, --evtfile=EVTFILE
                        Input Events file Name;   The most important input of
                        script give with full path if not in same directory
  -r RA, --ra=RA        Input RA in Sky pixels   Note that open your events
                        file with ds9 and note the position of centriod for
                        the source in pixels
  -d DEC, --dec=DEC     Input DEC in Sky pixels
  -o OUTFILE, --outfile=OUTFILE
                        Stem for output files
  -x MINR, --min=MINR   Radius of inner circle for annulii (in Sky pixel);
                        Default value is 8 pix (~0.5 arcm)
  -y MAXR, --max=MAXR   Radius of outer circle for annulii (in Sky pixel);
                        Default value is 328 pix (~22.5 arcm)
  -s STEPS, --steps=STEPS
                        Steps size to decide number of data points in outpur
                        profile [N = int((r_out - r_in)/stepsize)];  default
                        is 8 pixel
  -p PROCESS, --process=PROCESS
                        Plot type: 'plot' or 'both'; Whether you wish to make
                        plot only or make tables as well; You may use any of
                        [&quot;BOTH&quot;, &quot;AUTO&quot;, &quot;B&quot;, &quot;A&quot;, &quot;PROCESS&quot;] for default way
                        [making profile and plot] and any of [&quot;PLOT&quot;, &quot;PL&quot;,
                        &quot;P&quot;] for plot-only option if you already have tables
                        with you
  --estring=ESTRING     String for energy selection; the acceptable input
                        format is 0p3to7p0 (for 0.3-7.0 keV)   Default is
                        0.3-7.0 keV
  -g GRADE, --grade=GRADE
                        String for grade selections in the format 0-12
                        Default is all grades 0-12
  -t SIMEEF, --simeef=SIMEEF
                        Filename with full path for EEF from simulation;
                        Needed only for POC releted bussiness, you make ignore
                        it, Default is None, which mean no
  -l IPACFILE, --ipacfile=IPACFILE
                        IPAC file name with data; needed for 'plot' option for
                        process, Default = None
  --coordtyp=COORDTYP   Input Coordinate Type, .i.e., Detector Coordinates or
                        Sky Coordinates...Default is Sky   The input options
                        are ['Sky', 'sky', 'SKY', 's', 'S', 1, True] and/or
                        ['RAW', 'raw', 'Raw', 'R', 'r', 0]   Default is 'RAW'
  --bkgcorr=BKGCORR     The flag for back-ground correction, Default options
                        is 'yes'
  --NrefStyl=NREFSTYL   The flag for using method to normalize the profile,
                        options are either use total counts from largest safe
                        radius of source extraction or the counts from a
                        source region of 20 arcm [extra-polated, in cases
                        20arcm is not possible] to use.   Input options =
                        ['extrapolate', 'ff', 'full', '20arcm', 'auto', 1] for
                        using 20arcm anything else except ['both', 'BOTH',
                        'debug', 2] will result in using largest possible safe
                        radius for normalization of profiles; You may also
                        chose for any of ['kings', 'fit', 'model', 0]
  --normradius=NORMRADIUS
                        The radius [in arcm] what script should use in case
                        user is confident with source PSF
  --logfile=LOGFILE     The Name of logfile ..Default is
                        'LogFile_DateTimeFormat.log'
  --usepoly3flag=USEPOLY3FLAG
                        The Flag whether polynomial of order 3 should be used
                        for fitting or not.. Default = 'no'
```