ESAS into SAS

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What is ESAS?

• Extended Source Analysis Software (ESAS):
  * package for the analysis of EPIC MOS and pn observations (by SS & KK),
    [suited especially for analysis of extended sources and diffuse background]

• ESAS includes routines creating
  * source and model quiescent particle background spectra and
  * exposure-corrected, background-subtracted (particle and soft proton) images

• Spectra and images produced for user-defined regions within the FOV

+ software for mosaicking multiple (not necessarily co-aligned) observations

Whole package composed of f77 routines, Perl scripts and FITS calibration files
ESAS integration into SAS

Motivation:
- ease and secure the future maintenance,
- avoid diverging development,
- immediate profit on both development sides,
- make it more comfortable to users.

ESAS integrated in SAS as single package (esas)
  >> all programs and scripts included (called individually),
  >> should be complemented with workflow

> Integration performed mainly by Aitor
> future maintenance (of “new” code) by Steve in SAS environment
Integration of f77 code

• Integration through Fortran-90 wrappers
  - every f77 routine called through a corresponding F90 module,
  - F90 code in charge of setting up SAS I/F (param files) and call routine,
    >> mapping of “old” ESAS parameters to new SAS param file.

• F90 wrapper
  - checks standard SAS environment variables,
  - use of all the standard SAS functionalities (-p, -d, -version),
  - replace f77 compiler with NAG F95 compiler,
  - minor changes done during this process (data types and initializations).

>> GUI for each of the executables
>> solidity of S/W
Integration of Perl code

- ESAS contains a set of perl scripts and binaries
- The perl scripts call several SAS tasks (evselect, eexpmap, ...) and also native ESAS binaries
- param and lyt files added to original Perl modules >> SAS like

- ESAS processing = perl scripts + f77 calls + ftools calls.
  “ESAS chain”

We can easily implement this processing chain as a new workflow inside “psechain”
ESAS workflow scheme

Source detection

- Intermediate files (spectra and images) from user-defined regions
- Model particle background spectra and images - plot files with source and model background
- Rotate the detector coordinate bkg images into images in sky coordinates
- Find the solid angle for the region to include in the spectral fitting
- Uses the fitted soft proton parameters to create images of the soft proton contamination in detector coord.

mos-filter
pn-filter

Cheese

mos-spectra
pn-spectra

mos_back
pn_back

rot-im-det-sky

rename files grppha

adapt_900

comb

Adaptively smoothes the images (excluding point sources)

rot-im-det-sky

adapt_900

comb

Clean

Combine the MOS1 and MOS2 images, as well as images from multiple exposures (with no point source screening)

espfilt, filters, clean, qpd
ESAS workflow scheme 1x1: Xfilter

Originally running `cifbuild, odfingest + e[m][p]chain`

In `esas`, just taking event files from `emchain` (`emproc` in near future)

`espfilt` : light curve filtering through count rate histogram

Output:

`espfilt`: light curve filtering

`qdp` file showing selection (and quality)

`mos'prefix'-obj-image-det-soft.fits` = [0.2-0.9] keV image for finding anomalous state mos CCDs
ESAS workflow scheme 1x1: Xfilter

Originally running cifbuild, odfingest + e[m][p]chain

In esas, just taking event files from emchain (emproc in near future)

>> espfilt : light curve filtering through count rate histogram

Output:

>> eg. mos1S001-clean.fits pnS003-clean.fits

>> qdp file showing selection (and quality)

>> mos'prefix'-obj-image-det-soft.fits

="[ ]" or 0.2-0.9 keV image for finding anomalous mos CCDs

Originally running cifbuild, odfingest + e[m][p]chain
ESAS workflow 1x1: point sources

Running source detection for excising sources from spectra and images
ESAS workflow 1x1: [mos][pn]spectra

produce intermediate files (spectra and images) from user-defined regions + RMFs, ARFs and exposure maps

empty region >> full FOV

- Use of filter-wheel closed calibration files for producing spectrum from selected region
- corner spectrum from observation and from fwc data also produced
- for PN data also OOT data processing in addition to normal data processing
ESAS workflow 1x1: [mos][pn]back

- model particle background spectra and images - plot files with source and model background

creation of model particle background spectra and images for the selected region

>> use of qpb files from CALDB
ESAS workflow 1x1: proton & scale

preparation for soft proton background determination >> spectral parameters for soft proton contamination
>> solid angle for the region to be included in spectral fitting: proton_scale

soft proton contamination maps from model sp detector maps + spectral fitting results: proton

+ use of rot-im-det-sky to get image in sky coordinates
ESAS workflow 1x1: proton & -scale

preparation for soft proton background determination >> spectral parameters for soft proton contamination
>> solid angle for the region to be included in spectral fitting: proton_scale

soft proton contamination maps from model sp detector maps + spectral fitting results: proton

+ use of rot-im-det-sky to get image in sky coordinates
Spectral analysis - outside ESAS

Spectral analysis is not a specific part of ESAS, but it is providing input and using the output of the analysis - here performed through Xspec.

- background subtracted and fitted spectrum
- observed spectrum
- fitted cluster spectrum
- fitted cosmic background spectrum
- fitted soft proton component
- Al Kα and Si Kα instrumental lines

from SS & KK Cookbook

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ESAS calibration files

- Set of calibration files.
  - Filter wheel closed data: per instrument and CCD (including diverse quality) = 26+
  - Quiescent particle background data: per instrument and CCD = 26
  - SP flare data: per instrument and filter * 6 levels + expmap = 63

>> need of simplification of calibration files (Kip’s proposal?)

>> future of CALDB into CCF ??

>> access of calibration data through DAL instead of ftools?
  >> implies re-writing f77 code
Tests going on

Test run on M101 (obsid: 0104260101,0212480201) locally

SS reports some issue with source detection ... working on it
PN in ESAS

- PN software nearly complete
  - Needs testing on additional data sets
  - Possible over-estimation of background
  - Data probably not useful below ~0.4 keV or above 7.2 keV
Progress on ESAS for the PN model particle background.

Radial profile spectral fit of Abell 1795 using 10 annuli and a RASS spectrum.

$\chi^2\nu \sim 1.5$ for 7829 DOF
PN Soft Proton Vignetting

Instrument maps from low to high energy with an exposure map for reverence
PN Soft Proton Vignetting

Radial profiles, again with photon vignetting
Future work

• Finish testing both in ESAC and GSFC, incl. PN upgrade (needed for SAS 9)

• Document the single tasks (needed for SAS 9)

• Transform the CALDB files into CCF, following simplification (SAS 10)

• Upgrade ESAS error and warning messages >> standard SAS msg (SAS 10)

• Replace low level cfitsio call for dal calls ?
  - not possible in f77  >> coding everything in F90 ?

• ESAS workflow to be implemented into “psechain” (SAS 9 / SAS 10)

• Inclusion of test-harness cases (SAS 9 / SAS 10)