# proton

April 16, 2023

**Abstract**

This task, `proton`, uses the spectral fitting results from Xspec and model soft proton detector maps to create model soft proton contamination maps for a given observation. This task was originally a subtask of the SAS *esas* task named *proton* prior to SAS-21 and retains all of its functionality.

## 1 Instruments/Modes

| Instrument | Mode |
|---|---|
| EPIC MOS | IMAGING |
| EPIC PN | IMAGING |

## 2 Use

| | |
|---|---|
| pipeline processing | no |
| interactive analysis | yes |

## 3 Description

*proton* uses the spectral fitting results from Xspec and model soft proton detector maps to create model soft proton contamination maps for a given observation.

**Warning and requirements:** `proton` was part of the package *esas*, integrated into SAS, but (still) limited to work within *esas*' data reduction scheme. This is specially true wrt input files structure and names. In particular, `proton` assumes that another task from the package, `mosspectra` / `pnspectra`, and `mosback` / `pnback`, have been successfully run for the mos / pn exposures to be used.

## 4 Parameters

This section documents the parameters recognized by this task (if any).

| **Parameter** | Mand | Type | Default | Constraints |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **imagefile** | yes | dataset | | |

Input object image in detector coordinates.

| | | | | |
|---|---|---|---|---|
| **specfile** | yes | dataset | | |

Input spectral file (to obtain EXPOSURE).

| | | | | |
|---|---|---|---|---|
| **spmapdet** | no | dataset | default | |

User-specified SP det coord map (will derive name if not given)

| | | | | |
|---|---|---|---|---|
| **ccds** | no | boolean | true | T T T T T T T |

Include CCD (MOS)/Quad (PN)?

| | | | | |
|---|---|---|---|---|
| **elow** | no | integer | 400 | $1 < maxchannels - 1$ |

The low energy for the band in eV

| | | | | |
|---|---|---|---|---|
| **ehigh** | no | integer | 1250 | $2 <= maxchannels$ |

The high energy for the band in eV

| | | | | |
|---|---|---|---|---|
| **speccontrol** | no | integer | 1 | 1 : 2 |

1 for a power law model, 2 for a broken power law

| | | | | |
|---|---|---|---|---|
| **pindex** | no | real | 1.2 | $-10 <= pindex <= +10$ |

Fitted power law index, only if spectrumcontrol=1

| | | | | |
|---|---|---|---|---|
| **pnorm** | no | real | 0.0250005 | $0 <= pnorm <= 1$ |

Scale factor for power law index, only if spectrumcontrol=1

| | | | | |
|---|---|---|---|---|
| **bindl** | no | real | 1. | |

Fitted soft broken power law index, only if spectrumcontrol=2

| | | | | |
|---|---|---|---|---|
| **bindh** | no | real | 0.5 | |

Fitted hard broken power law index, only if spectrumcontrol=2

| | | | | |
|---|---|---|---|---|
| **bbreak** | no | real | 3.0 | $1 <= bbreak <= 12$ |

Break energy for broken power law model, only if spectrumcontrol=2

| | | | | |
|---|---|---|---|---|
| **bindex** | no | real | 0. | |

Broken power law index from Xspec fits, only if spectrumcontrol=2

| | | | | |
|---|---|---|---|---|
| **bnorm** | no | real | 0. | |

Normalization for broken power law, only if spectrumcontrol=2

# 5 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

**noINST** *(error)*
Instrument from image must be M1/M2/PN

**elowGEehigh** *(error)*
Parameter elow must be less than ehigh

**badIMGpixSize** *(error)*
Object image array must be 780x780

**imgNEspec** *(error)*
Object Image and Spectrum must be from same EVLI

# 6 Input Files

The filtered image files, products from running `mosback` or `pnback`, eg.:*mos1S001-fovimdet-elow-ehigh.fits* or *pnS001-fovimdet-elow-ehigh.fits*.

The filtered spectral files, products from `mosspectra` or `pnspectra`, e.g. *mos2S004-fovt.pi* or *pnS001-fovt.pi*

# 7 Output Files

Where MOS data are processed:

mos*prefix*-`protimdet-`*elow-ehigh*`.fits` – The soft proton image in detector coordinates, e.g. *mos1S009-protimdet-400-1250.fits*
Where PN data are processed:
pn*prefix*-`protimdet-`*elow-ehigh*`.fits`, e.g. *pnS002-protimdet-400-1250.fits*
– The soft proton image in detector coordinates.

# 8 Algorithm

```
Read parameters
Open and check Object Image file in det coords.
Open and check Object Spectral file.
Open output Soft Proton Image file.
Copy keywords from Object Image file to SP Image file.
Set the energy bands to be included.
Determine which flaremaps from CCF FLARE file to co-add for filter.
Co-add FLAREMAPS for selected bands.
Mask chips (if necessary)
Calculate total counts for detector map.
Calculate Soft Proton counts.
Check orbit for loss of MOS 1 CCD6, mask if true.
Calculate Scale Factor and apply.
Write new SP map to template image file.
```

```
Update COMMENT, HISTORY keywords in new SP map image file.
```

# 9 Comments

The original code for this task appeared in the *esas* subtask *proton* 2009-2021. It was modularized, removed from *esas*, and began utilizing the CAL for accesing the XMMGOF-produced flare map type CCFs (e.g. EMOS1_FLARE_0000.CCF). The algorithm remains largely unchanged, but parameters, output messages, and some output keywords are aesthetically different. In versions after SAS-20, the user must have the new XMM_FLARE_nnnn.CCF file in their CCF directory to use this task. The *esas* task was removed in SAS-21.

# References