rgsregions

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Abstract

This task constructs RGS event-selection regions. It reads an event list processed by **rgsfilter** and modifies a source list created by **rgssources**. Flag columns in the `SRCLIST` table determine which regions are added to the source list. This task should be run any time the existing set of regions gets out of date. Existing regions are replaced only as necessary. As a convenience, this task may also be used to edit the flag columns in the `SRCLIST` table.

1 Instruments/Modes

Instrument	Mode
RGS	Spectroscopy
RGS	High Time Resolution

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

rgsregions defines and constructs the various RGS event-selection regions, and adds them to the source list (see **rgssources**). Event-selection regions are closed two-dimensional shapes that may be used to filter the event list for the purpose of spectral analysis (see **rgsspectrum**). The regions are stored as extension tables in the source list, formatted according to the specifications of the "ASC FITS File Designers' Guide". Image regions and the spatial background region refer to the plane of dispersion versus cross-dispersion (*image plane*) and select events based on their spatial coordinates. An image region selects events from a specific astrophysical source, while the spatial background region selects events that are presumed consistent with the lack of any particular source. The order regions refer to the plane of dispersion versus calibrated pulse-height (*energy plane*) and select events from a specific astrophysical source within a particular reflection order. The order regions exploit the over-determined nature of coordinates in the energy plane to greatly reduce spurious detections.

In High Time Resolution (HTR) mode the entire cross-dispersion dimension is collapsed into one row, inextricably mixing source and background events together. There is no spatial background region in this

mode, and all image regions simply outline the exposure map with no dependence on source position. Reproducing the same degenerate image region for each source is redundant, of course, but nevertheless preferable to specifying a separate region naming convention just for HTR mode data. The missing spatial background region is replaced by a collection of order-specific background regions in the energy plane. Throughout this document a † marks items that do not apply to HTR mode data and a ‡ marks items that apply only to HTR mode data.

The SRCLIST table contains two columns, SRC_SELECT and BACK_SELECT, which control the default behavior of **rgsregions**. Each source with SRC_SELECT set true is given one image region and an order region for each reflection order from one to the value of the maxorder parameter. In HTR mode only there is an order background region paired with each order region. The spatial background region is the entire exposed surface in the image plane with regions around the more significant identified sources excluded: each source with BACK_SELECT set true is excluded from this region. The task parameters, procsrcsexpr and exclsrcsexpr†, allow the user to override these default selections without having to edit the SRCLIST table. The procsrcsexpr expression replaces the list derived from SRC_SELECT and the exclsrcsexpr expression replaces the list derived from BACK_SELECT. Specifying setflags=yes (non-default) makes these replacements permanent in the SRCLIST table itself (in HTR mode exclsrcsexpr is ignored and BACK_SELECT is set to false for all sources). The selection expressions are parsed in the context of the whole SRCLIST table, including all of its columns and attributes.

The same basic procedure applies to the construction of all regions. A region is an assemblage of separate polygons, each corresponding to a specific node and source. Only nodes with an exposure map extension in the event list are considered. The exposure map sets the bounding limits of the polygon, and a parameter—spatialres† in the image plane and orderres in the energy plane—sets the number of opposing vertex pairs. The pairs are distributed evenly across the dispersion axis so that the first and last pairs align with the extreme edges of the node. Each vertex in a pair has the same dispersion coordinate value, and with the other coordinate the pair spans some portion of the applicable model curve: the canonical cross-dispersion PSF in the image plane and the canonical pulse-height (PI) distribution in the energy plane. This portion is specified differently for each type of region. Note that in the case of the spatial background region each of these polygons define a region that is excluded from the larger region defined by the limits of the exposure map. The list of sources excluded from the spatial background region is recorded in its extension by a non-standard (not part of the ASC standard) attribute, EXCLSRCS. For all regions (except for HTR image regions) the number of vertex pairs per node is recorded by the non-standard SPACING attribute.

The PI limits of an order region (at each vertex pair) are chosen to provide the narrowest span that covers at least the specified percentage of the model PI distribution. This percentage is specified by the pdistincl parameter and is recorded in the region extension by the non-standard COVERAGE attribute. For all spatial regions the cross-dispersion off-axis angle of the relevant astrophysical source divides the model cross-dispersion PSF into two parts: upper and lower. The upper limit of an image region (at each vertex pair) is chosen to cover at least the specified percentage of the upper part. This percentage is specified by the xdspabove† parameter and is recorded in the region extension by the non-standard COVABOVE† attribute. Similarly the lower limit is specified by the xdspbelow† parameter, which is recorded as COVBELOW†. For each excluded source in the spatial background region a single parameter, xpsfexcl†, specifies both the upper and lower limits, and is recorded in the region extension as COVERAGE.

The on-board calibration sources are characterized simply as rectangles in the energy plane. These rectangles are always excluded from the order regions if there is overlap. This can usually be seen in the second order region, but not in the first order region for an on-axis source. The image plane footprint of the calibration sources is not excluded from the spatial regions because that would eliminate too many valid photons for off-axis sources. Another peculiarity of the order regions is the silicon edge, where the PI distribution function changes shape abruptly. To ensure that this edge is properly resolved, two extra pairs of vertices are added to the relevant polygon just on either side of the edge. The HTR mode order background regions are just the regular order regions transformed by reflecting each vertex pair vertically around the upper vertex. To avoid overlapping the second-order region the vertex pairs of the

second-order region are used in the first-order background region for chips 1, 2 and 3.

If the source list already contains a region that **rgsregions** is supposed to add, that region is inspected to determine whether it was constructed to the specifications established under the current task parameters; if so (or if it is protected) it is left in place, otherwise it is deleted and replaced. A region is considered protected if the non-standard `PROTECT` attribute is missing or set true. The `protect` parameter can be used to mark each region added or replaced as protected, and once a region is so marked it must be manually deleted by the user before it can be replaced by **rgsregions**. This feature should be used very selectively. At verbosity level four (Sparse) the name of each region added or replaced is noted.

Two final non-standard attributes of all regions, which are provided solely for their diagnostic value, are `PIX_ENCL` and `PIX_AREA`. These describe the enclosed area of the region in terms of the number of pixels enclosed and the area of a pixel. The dimensions of a pixel are: one dispersion channel width by one cross-dispersion channel width in the image plane, and one dispersion channel width by one PI unit in the energy plane. The channel widths are as defined in the event list.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
srclist	yes	dataset	srclist.ds	

Source definition list: a dataset containing the `SRCLIST` table, and to which the region extensions will be added.

evlist	no	dataset		

Event list: a dataset containing the EVENTS table and exposure map extensions. Not modified. The default file name is inferred from the input `srclist` name as: `*EVENLI????.*` if there are ten characters before the suffix, and otherwise just `evlist.*`.

maxorder	no	integer	2	1-

The number of reflection orders to be processed for each selected source. One order region is added for each order, starting from first order.

spatialres	no	integer	5	2-

The dispersion-axis spacing of vertices for image regions and the spatial background region, specified as the number of vertices across a node. *Not applicable in HTR mode.*

orderres	no	integer	3	2-

The dispersion-axis spacing of vertices for order regions, specified as the number of vertices across a node.

xpsfbelow	no	real	90	0-100

Downward size of image regions, specified by the percentage of the cross-dispersion PSF covered between the source cross-dispersion off-axis angle and the lower of each pair of vertices with the same dispersion coordinate. *Not applicable in HTR mode.*

xpsfabove	no	real	90	0-100

Upward size of image regions, specified by the percentage of the cross-dispersion PSF covered between the source cross-dispersion off-axis angle and the upper of each pair of vertices with the same dispersion coordinate. *Not applicable in HTR mode.*

xpsfexcl	no	real	95	0-100

Size of the exclusion regions in the spatial background region, specified by the percentage of the cross-dispersion PSF covered between each pair of vertices with the same dispersion coordinate and associated source. *Not applicable in HTR mode.*

pdistincl	no	real	90	0-100

Size of order regions, specified by the percentage of the pulse-height distribution covered between each pair of vertices with the same dispersion coordinate.

procsrcsexpr	no	string		

Selection expression indicating which sources to process for image and order regions. The default specifies the sources flagged with `SOURCE_SELECT` in the `SRCLIST` table.

exclsrcsexpr	no	string		

Selection expression indicating which sources to exclude from the spatial background region. The default specifies the sources flagged with `BACK_SELECT` in the `SRCLIST` table. *Not applicable in HTR mode.*

setflags	no	boolean	no	

If true, the selection expressions given by `procsrcsexpr` and `exclsrcsexpr` are used to set the respective `SRCLIST` table flag columns, `SOURCE_SELECT` and `BACK_SELECT`. In HTR mode the inapplicable `BACK_SELECT` is simply set to false for all sources.

protect	no	boolean	no	

Value for the `PROTECT` attribute in each region added or replaced. Regions created with `protect`=yes cannot be replaced by **rgsregions** without prior manual intervention.

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.

noExposureMaps *(error)*
The event list file does not contain any exposure map extensions. The exposure map for at least one node is a required input. See task **rgsfilter**.

fractionalCoverage *(warning)*
The indicated region coverage parameter (`xpsfincl`, `xpsfexcl`, or `pdistincl`) was given a value greater than zero but less than one, suggesting that the user has forgotten that these parameters are specified as percentages.
corrective action: No corrective action is taken, but these regions will be too narrow to have any practical value. Specify zero to avoid this warning and get effectively the same result.

protectedRegion *(warning)*
A region selected for update is protected. Use a FITS editor to delete the region extension and then try again.
corrective action: The requested update of the region does not occur.

emptyRegion *(warning)*
A region has been produced which encloses no pixels in the channel space. This is most likely to occur with the spatial background region, particularly when more than one source is designated for exclusion.
corrective action: No corrective action is taken, but this warning should be taken seriously by the user, especially if the region in question is not the spatial background region.

6 Input Files

- srclist

  The SRCLIST table, as created by **rgssources**, is a required input, and is not modified. The PRIMESRC attribute and the following columns are accessed.

INDEX	int32	source identifier
RGS_DISP RGS_XDSP	real32	RGS offaxis angles (arcmin)
SRC_SELECT	int8	flag for standard processing
BACK_SELECT	int8	flag for background exclusion

- evlist
  - Attribute INSTRUME is required.
  - EVENTS table

    The EVENTS table, as last modified by **rgsangles**, is a required input, and is not modified. Columns BETA_CHANNEL and XDSP_CHANNEL are accessed for the following attributes: TCDLT, TCRVL, TCRPX, TLMIN and TLMAX.
  - EXPMn_nn

    A set of node-specific exposure map extensions, as created by **evlistcomb**, is a required input. These are not modified. The array dimensions and the attributes, CCDID, CCDNODE, CDELT1, CRVAL1, CRPIX1, CDELT2, CRVAL2, CRPIX2 are accessed.

7 Output Files

- srclist

  The region extensions added to the source list comply with the "ASC FITS File Designers' Guide" specifications. Some non-standard attributes are also provided with every region:

PROTECT	protected from routine replacement
SPACING	number of vertices across each node
PIX_ENCL	number of pixels enclosed
PIX_AREA	area of a pixel (units vary)

  Additionally, the non-standard COVERAGE attribute is provided for order regions and the spatial background region, and the non-standard pair, COVBELOW† and COVABOVE†, is provided for image regions. These document the percentages used in constructing the regions. Unless protected, existing versions of the regions may be overwritten if they are not compatible with the given parameters. The regions are of four kinds:
  - spatial background region†

    RGS<*instrument number*>_BACKGROUND

    There is only one extension of this kind. In addition to the attributes described above, the list of source identifiers for the image regions excluded from the background is also provided as EXCLSRCS.
  - image regions

    RGS<*instrument number*>_SRC<*source identifier*>_SPATIAL

    There is one extension of this kind for each selected source. In HTR mode the inapplicable attributes SPACING, COVBELOW and COVABOVE are omitted.
  - order regions

    RGS<*instrument number*>_SRC<*source identifier*>_ORDER_<*reflection order*>

    There is one extension of this kind for each requested order, for each selected source.

– order background regions[‡]
RGS<*instrument number*>_SRC<*source identifier*>_ORD<*reflection order*>_BKG
There is one extension of this kind for each requested order, for each selected source.

8 Algorithm

• Source Selections

```
if --procsrcsexpr is non-empty:
  use --procsrcsexpr to select sources for image and order regions
  if --setflags is true:
    update SRC_SELECT column with this result
else:
  initialize selected sources from SRC_SELECT column
```

• Excluded Source Selections

```
if --exclsrcsexpr is non-empty:
  use --exclsrcsexpr to select sources for exclusion from background region
  if --setflags is true:
    update BACK_SELECT column with this result
else:
  initialize excluded sources from BACK_SELECT column
```

• Spatial Background Region

```
unless a correctly specified or protected background region exists:
  initialize empty region
  for each node:
    add polygon bounding the exposed surface
    for each excluded source:
      intersect polygon excluding --xpsfexcl percent of cross-dispersion PSF
  scan region for total number of enclosed pixels
  add region to source list
```

• Image and Order Regions

```
for each selected source:

  unless a correctly specified or protected image region exists:
    initialize empty region
    for each node:
      if Spectroscopy:
        add polygon enclosing the xdsp PSF from --xpsfbelow to --xpsfabove
      else: (High Time Resolution)
        add polygon enclosing all exposure
    scan region for total number of enclosed pixels
    add region to source list

  for each order (1 to --maxorder):

     unless a correctly specified or protected order region exists:
       initialize empty region
       for each node:
         add polygon enclosing --pdistincl percent of PI distribution
       add excluded rectangle to each node with a calibration source
       scan region for total number of enclosed pixels
       add region to source list

     unless Spectroscopy or a correctly specified or protected background order region exists:
       initialize empty region
       for each node:
         if first order and CCD < 4: switch to second order
         construct polygon enclosing --pdistincl percent of PI distribution
         transform it by reflecting around top vertex at each vertex pair
         add transformed polygon to region
       add excluded rectangle to each node with a calibration source
       scan region for total number of enclosed pixels
       add region to source list
```

9 Comments

There are a few hardwired calibration constants that ought to be obtained via the CAL:

- position and width (in dispersion) of the silicon edge
- positions and widths (in PI) of the calibration source footprints

References