# Chapter 4

# Spectra

## 4.1 Region definition

First we make a single spectrum from a large region in order to obtain the emission measure for the gas density profile normalisation. For this, you need to define the regions where to extract spectra. This information must be put into a file */your_data_path/***data***/outdir/name/obsid/source_region*. The name of the *source_region* file was set in the "**run_sas.par**" file (see above). In Stages 1-3 your region definitions are not used. Thus, in this point you can change the name of the *source_region* if you want to change the regions where to extract spectra. First, do a big circle or annulus for normalising the best-profile. After changing the region file (and the *source_region* name) you should execute "**source run_sas.par**" to activate the new region file.

The regions are defined in sky coordinate system. For circular regions, the syntax is:
circle(23971,33031,1200,X,Y)
, where 1. and 2. value give the coordinates of the center of the circle and the 3. value the radius. The values are in "physical" coordinate system, i.e. unbinned sky coordinate frame. 1200 pixels correspond to 1 arcmin. Do not change X and Y. For annular regions, the syntax is
circle(23971,33031,6000,X,Y)&&!circle(23971,33031,1200,X,Y)
, where the region defined by the latter circle is excluded from the region defined by the former circle.

In *source_region* - file, each line corresponds to a different region. For example, the file may look like this:
circle(26400,27800,1200,X,Y)
circle(26400,27800,2400,X,Y)&&!circle(26400,27800,1200,X,Y)
where the first line defines a circle with a radius of 1 arcmin and the second line defines an annulus with inner and outer regions of 1 and 2 arcmin. The names of these different regions must be given in a file */your_data_path/***data***/outdir/objname/obsid/source_name* , where the name of the *source_name* file is given in the "**run_sas.par**" file. Each line in this file contain the code to be added to the spectra extracted in this region. In our case, the file could look like this:
circle1
annulus12
If you change your region definitions, you should also change the names in this file.

## 4.2 Point sources

In order to exclude unwanted point sources from the data, you need to create the point source region files. Look at the images created before to define the point source regions and write them into files
*/your_data_path/***data***/outdir/name/obsid/***points_pn_xy.reg**
(see */your_data_path/***scripts***/points_pn_xy.reg* for an example). The file start with "**!**" sign and the different point regions are separated by "**&&!**". The point source region is defined using syntax **circle(18900,31900,300,X,Y)** where 1. and 2. value give the coordinates of the point source center and the 3. value the radius. The values are in "physical" coordinate system, i.e. unbinned sky coordinate frame. Do not change X and Y.

You can test the source and point source region definition by running

```
run_sas dummy test_reg
```

where ("dummy" is a placeholder for 1. parameter which is not used here. The program makes the images filtered with the hard band filter.) This will produce images with a code "**testimage**" in their name. The images are located at */your_data_path/***data***/outdir/name/obsid/PN*. Look at the images with ds9 to verify that your region definitions are OK.

## 4.3 Extracting spectra

Now you are ready to extract the spectra. A lot of things will happen when you execute

```
run_sas gt10 5
```

The products (see below) are located at */your_data_path/***data***/ outdir/name/obsid/PN*.

### 4.3.1 Spectra

The software uses the GTI-files and point source region definitions from above and, using these filters, produces images of your extraction regions, named "***_XY_0870_***detimbinsize***_points_***timebinsize***s_gt10_***lolim-uplim***_{***source_name(*)***}.im**".

The program extracts spectra, and performs out-of-time correction to spectra, producing files "***_gt10_{***source_name(*)***}.pha**". Additionally, a full FOV spectrum for scaling purposes later is also extracted, called "***_gt10_fov.pha**".

The program produces energy redistribution matrices "***_gt10_{***source_name(*)***}.rmf**" and auxiliary response matrices "***_gt10_{***source_name(*)***}.arf**" Program additionally computes the number of pixels used when accumulating the spectra (i.e. after rejecting the CCD gaps, and point sources), and produces files "***_gt10_{***source_name(*)***}backscal.pha**" The keyword BACKSCAL in the header contains the number of pixels. Each pixel has a size of 0.05'×0.05' . Nevermind the numerous warnings, I have tested that this is accurate.

### 4.3.2 Background

The program reads the blank sky and closed cover data from directory set as *XMM_BKG_PATH* in "**.cshrc**" file and casts the event files to match the orientation of the pointing in you observation. This is required so that your sky

coordinate definitions can be used to extract the background spectra in the same regions as your data. Then the programs extract the blank sky spectra "***_gt10_**{*source_name(*)*}**.bkg**" using your region definitions.

### 4.3.3 Combining the results

Finally, the software links the responses and the background to the header of the spectrum. The spectra are binned requiring that each channel has a minimum of 100 counts. The final spectra are ***_gt10_**{*source_name(*)*}**_min100.pha**.