Epic Detector Matrices

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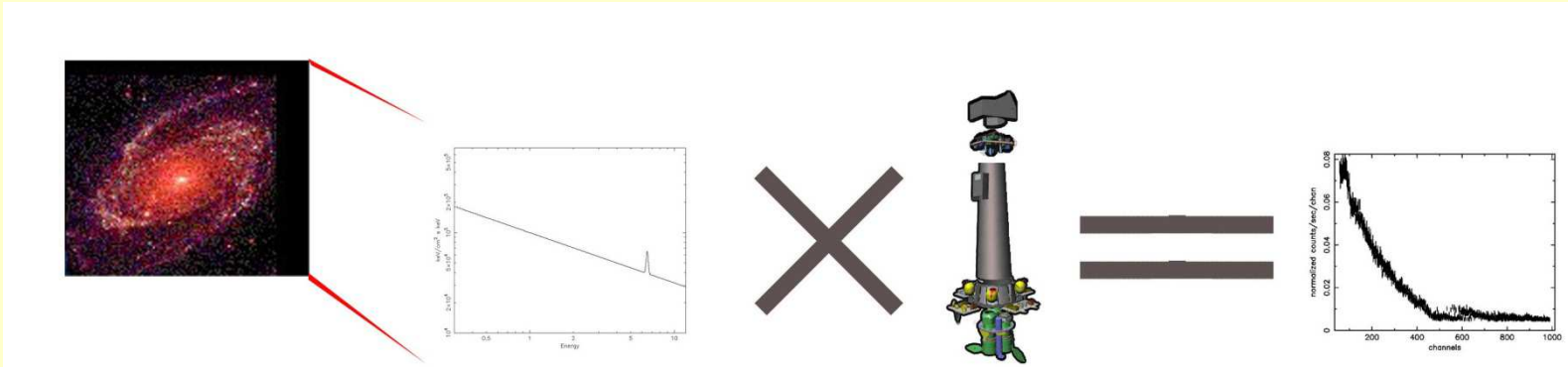
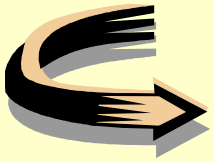
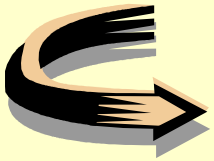
Why do we need detector matrices ?

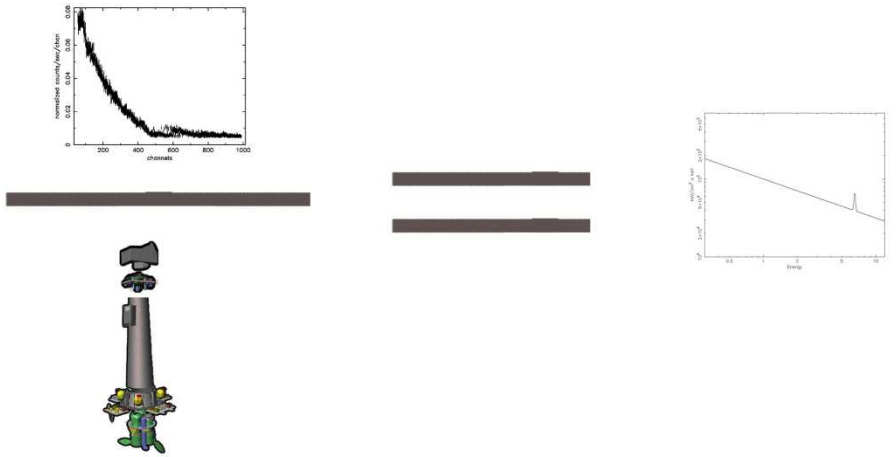




Initial source spectrum



Source flux



How do we use them ?

- **Spectral fitting:**

  - **xspec, CIAO …**
    Try a spectral model and see if it fits the data

- **Direct deconvolution of the detector response**

  - **efluxer**
    Mathematical technique to divide the observed spectrum by the effective area and redistribution

What does the SAS provide ?

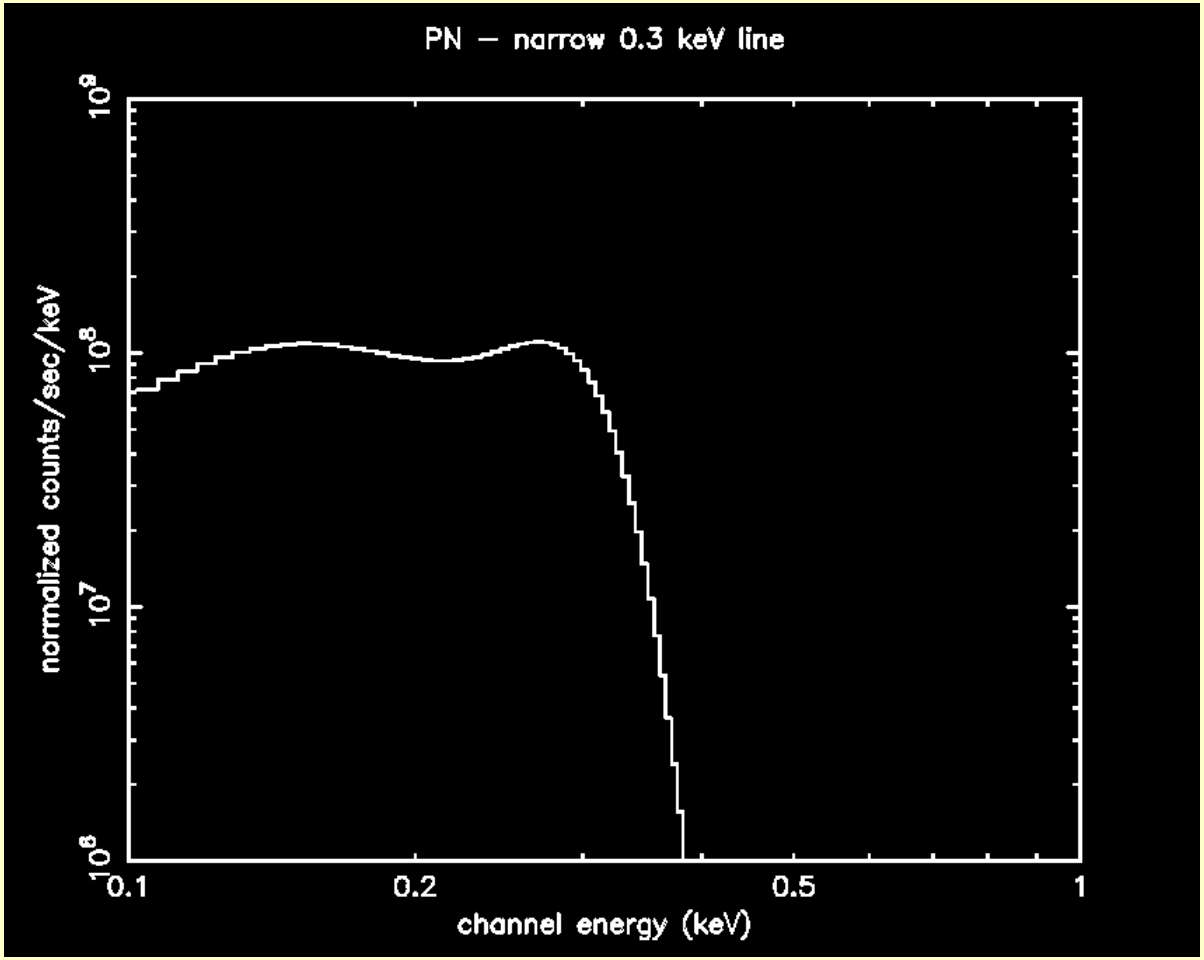
rmfgen *- Calculates the redistribution matrix (RMF)*

e.g. **rmfgen spectrumset=spectrum.ds rmfset=myspec.rmf**

arfgen *– Calculates the instrument effective area (ARF)*

e.g. **arfgen spectrumset=spectrum.ds arfset=myspec.arf**

The EPIC redistribution function



Standard Matrices

The SAS provides a set of standard RMFs to allow calibration developments to proceed independently of SAS releases.

These are available from:

http://xmm2.esac.esa.int/external/xmm_sw_cal/calib/epic_files.shtml

EPIC-MOS: RMFs

Standard Matrices:

m1_e1_im_pall_c.rmf - Mos-1, epoch 1, imaging mode, event patterns 0-12, centre-patch

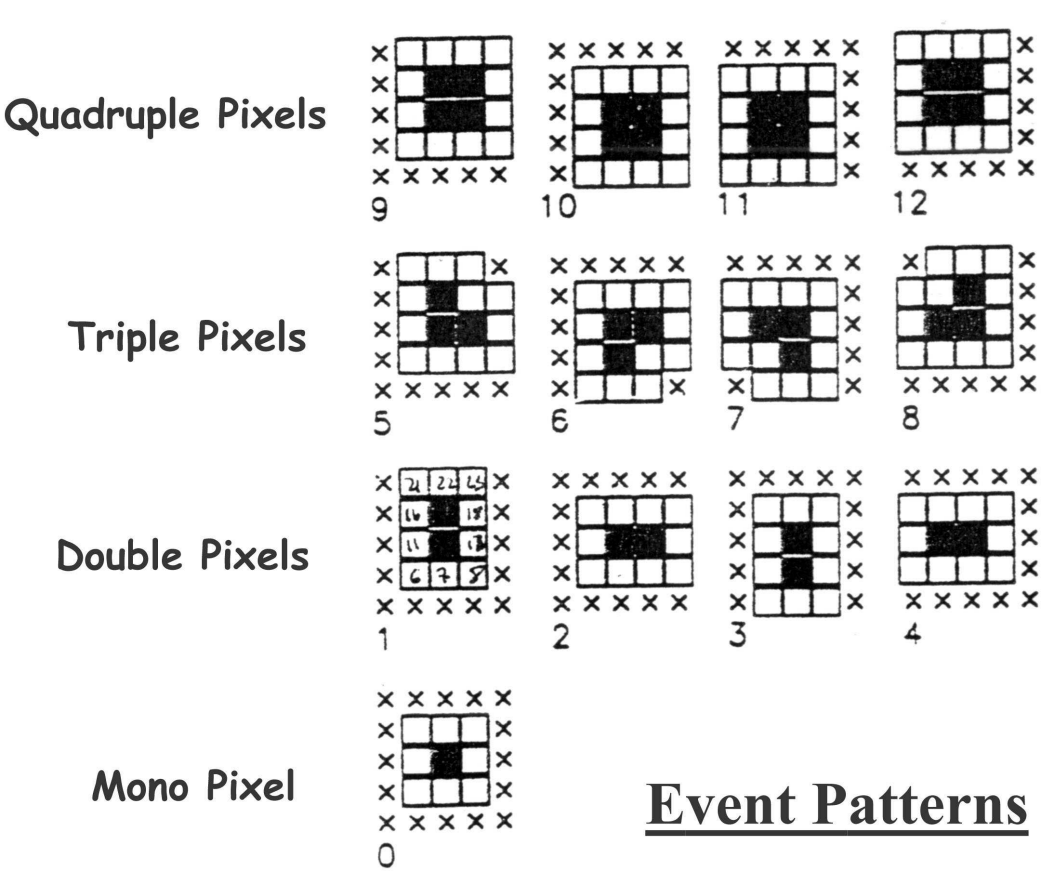
m2_e6_im_p0_w.rmf - Mos-2, epoch 6, imaging mode, event patterns 0, wings of patch

m1_e11_tu_p0_o.rmf - Mos-1, epoch 11, timing mode event pattern 0, off the patch

Time-dependent matrices, currently 13 epochs.

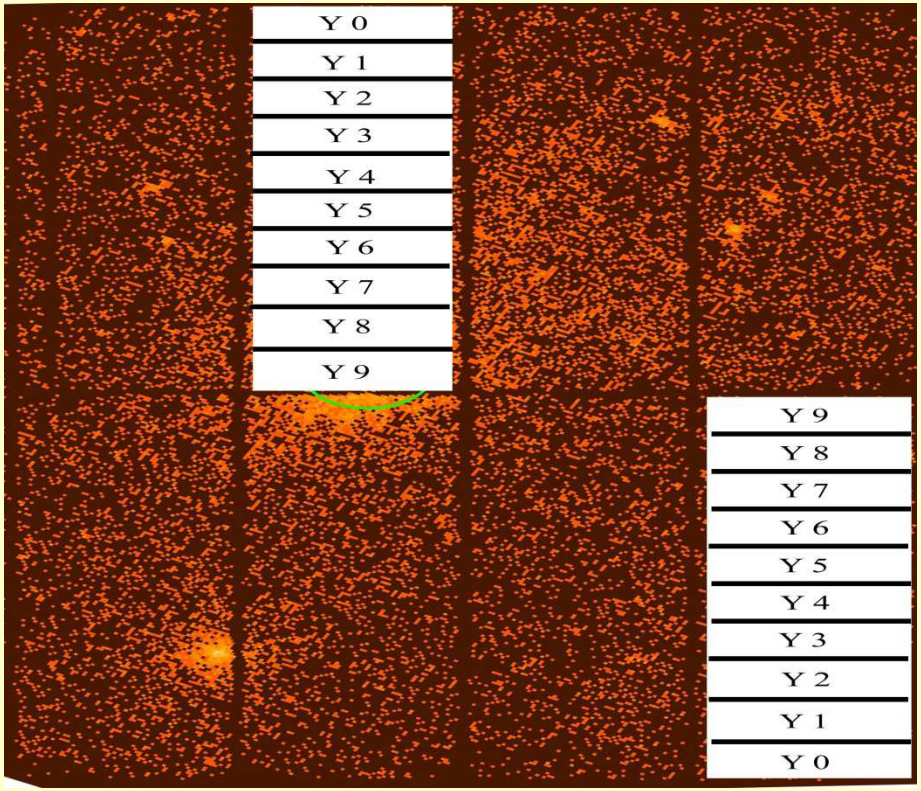
There are two versions of each matrix one for 5eV and the other for 15 eV spectral binning.

Event Patterns



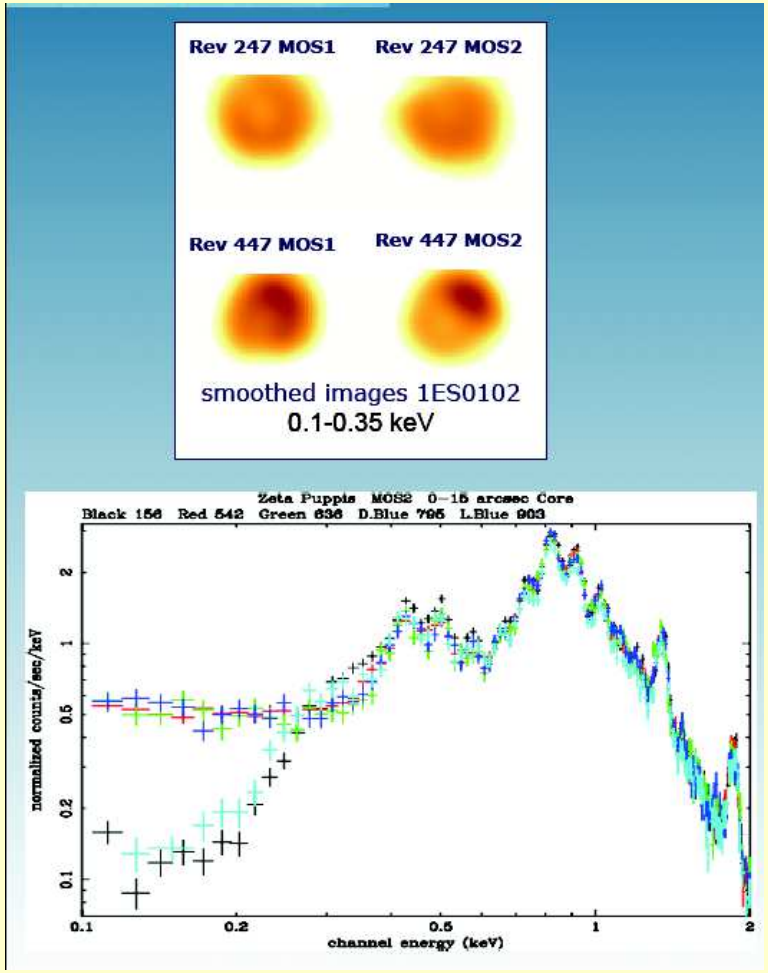
EPIC-PN: RMFs (II)

Function of observing mode, patterns, position

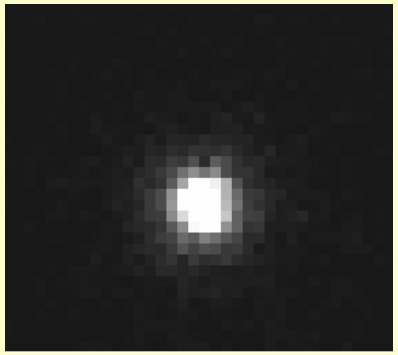


The MOS ‘patch’

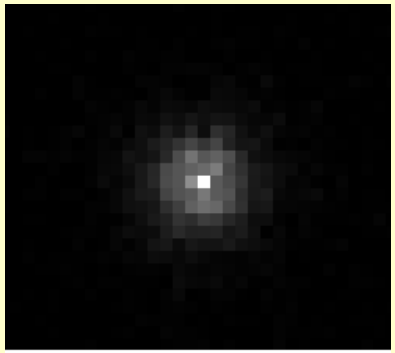
- A small patch (width 30”) has been discovered on each of the MOS cameras where the spectral response is degraded.
- The calibration is divided into ‘centre’, ‘wings’ and ‘off’ patch regions, each of which have their own response function.
- The patch coincides with the instrument boresight and is believed to be due to the accumulated X-ray dose.
- Its effect is increasing with time although it appears to be stabilising now.



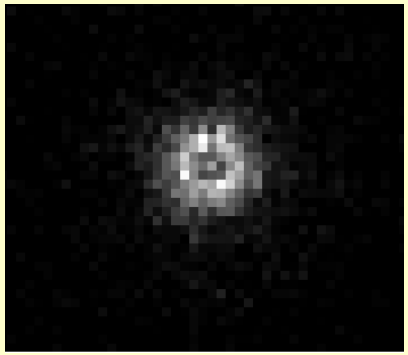
Correcting for EPIC-pn pile-up



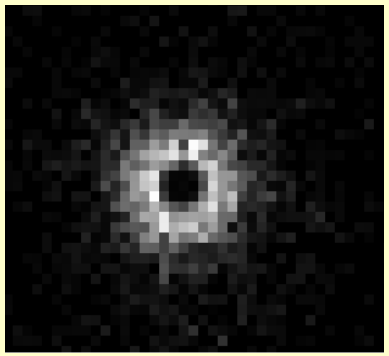
0.5 c/frame



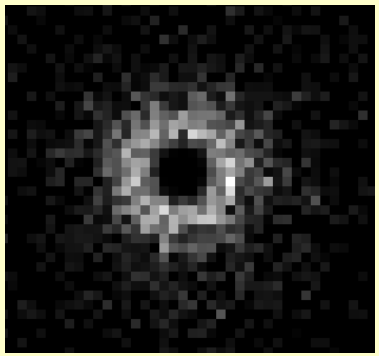
5 c/frame



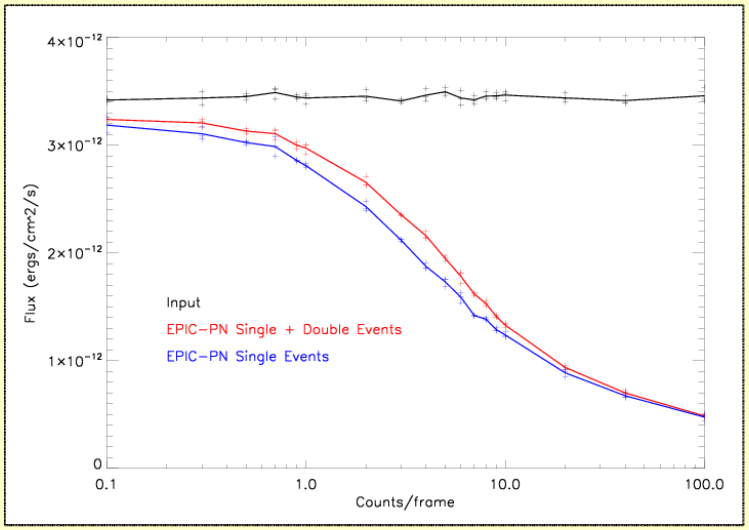
10 c/frame



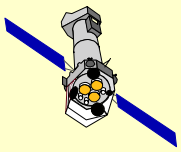
20 c/frame



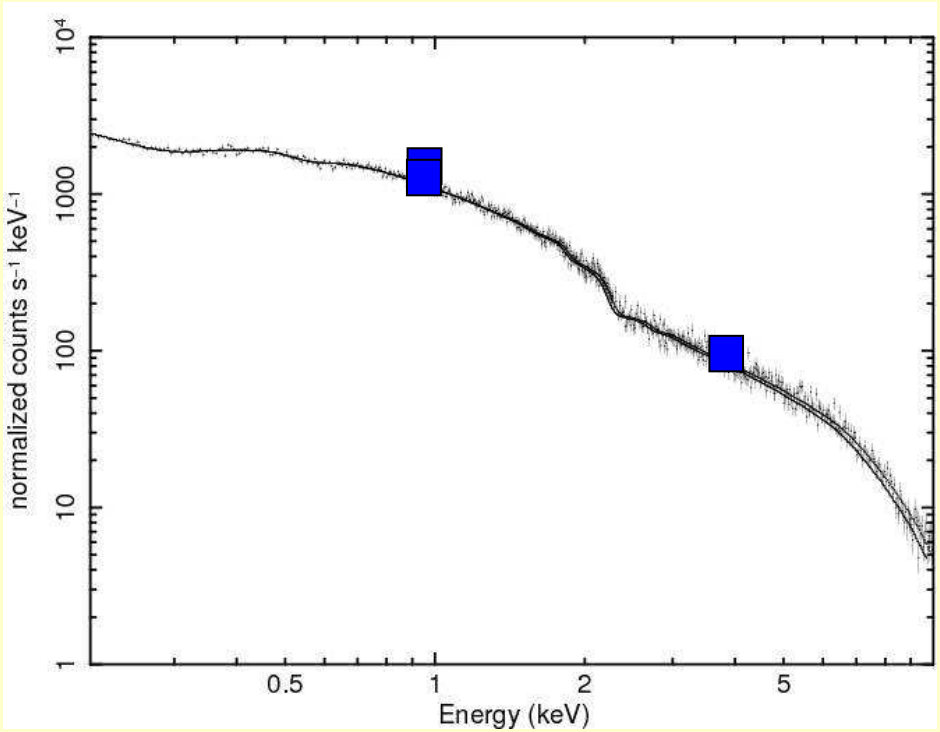
50 c/frame



XMM-Newton



Correcting for EPIC-pn pile-up



Calculate pile-up from the effect of test events adding to the raw charges which fell on the CCD.

Raw event file obtained from:

> epchain keepintermediate=all
or
> epproc pileuptempfile=yes

rmfgen spectrumset=myspec correctforpileup=yes raweventfile=events04.ds

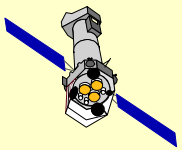
EPIC-PN: RMFs

Standard Matrices:

epn_ff20_sY9.rmf - Full frame mode, pattern 0 only, on-axis
epn_ff20_sY0.rmf - Full frame, pattern 0 only, at edge of field
epn_ff20_dY5.rmf - Full frame, patterns 1-4, centre of CCD
epn_ff20_sdY9.rmf - Full frame, patterns 0-4, on-axis
epn_ef20_sY9.rmf - Extended full frame, pattern 0, on-axis
epn_sw20_sY9.rmf - Small window mode, pattern 0, on-axis
epn_lw20_sY9.rmf - Large window mode, pattern 0, on-axis
epn_ti20_sY9.rmf - Timing mode, pattern 0, on-axis
epn_bu20_sY9.rmf - Burst mode, pattern 0, on-axis
etc.

SAS command:

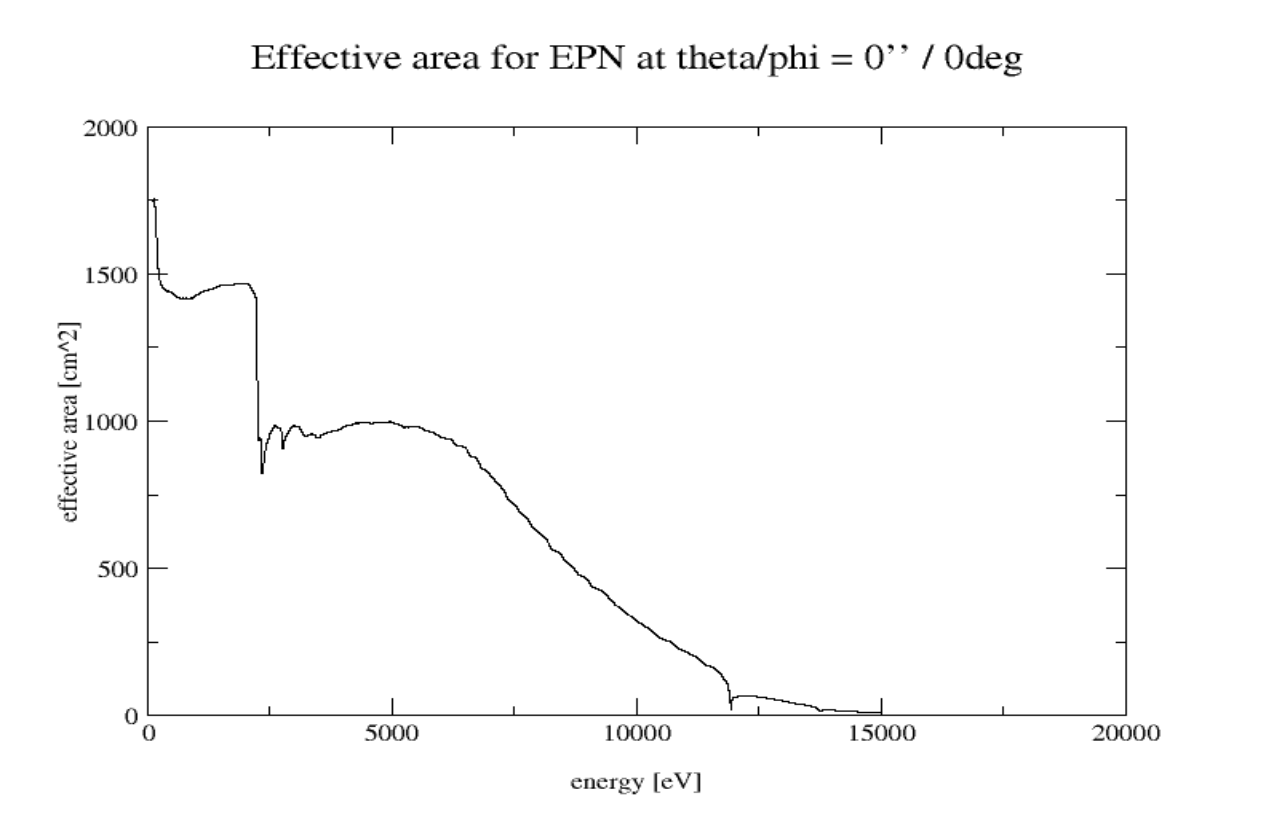
rmfgen spectrumset=spectrum.ds rmfset=myresp.rmf



arfgen: effective area contributions

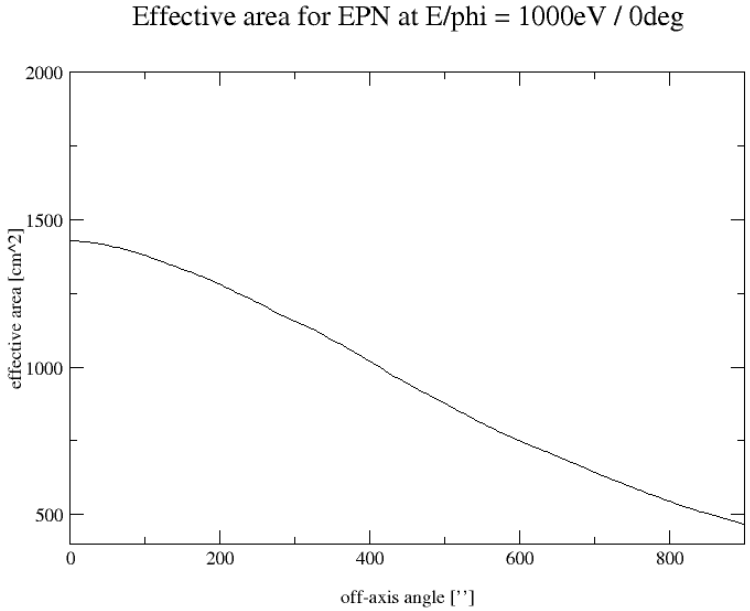
- Telescope effective area
- Vignetting
- Filter transmission
- Detector quantum efficiency
- Encircled energy correction
- Flux loss due to CCD gap, bad pixels and offset columns

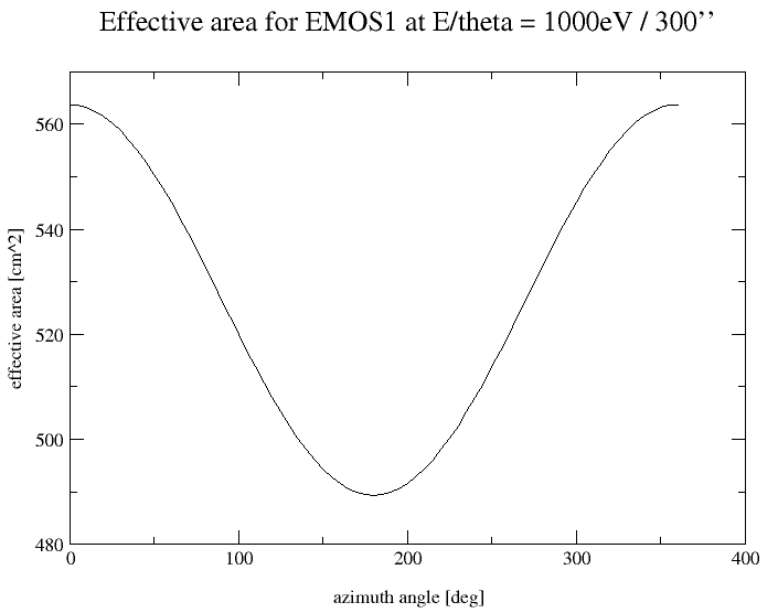
Mirror Effective Area



Option: *modeleffarea*=yes (default)

Vignetting

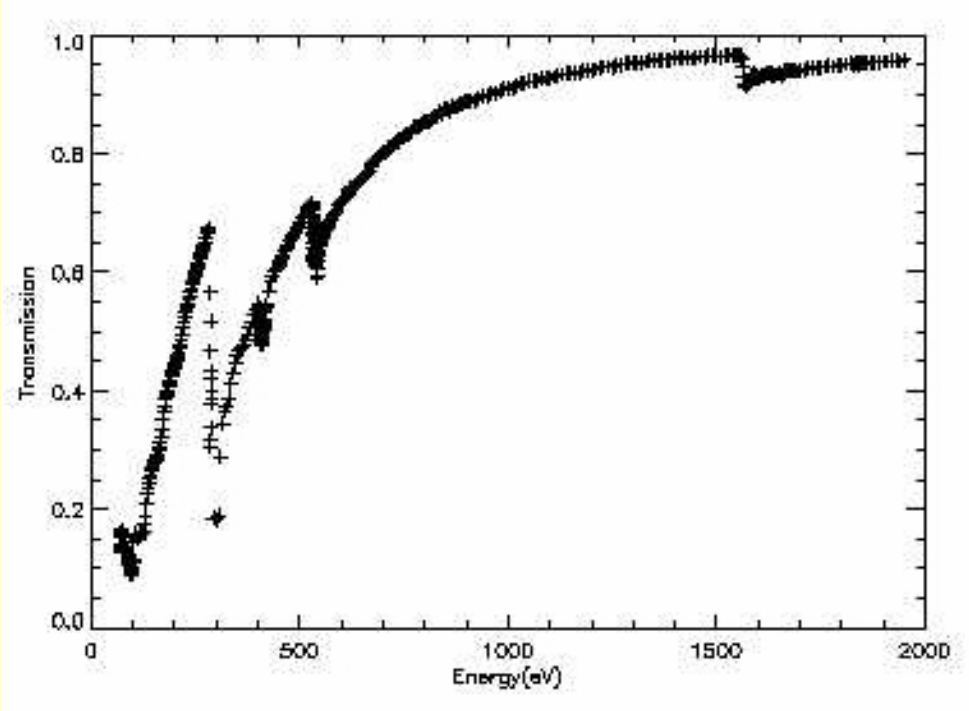




The vignetting of the MOS field of view includes an azimuthal component due to the gratings which capture ~50% of the light.

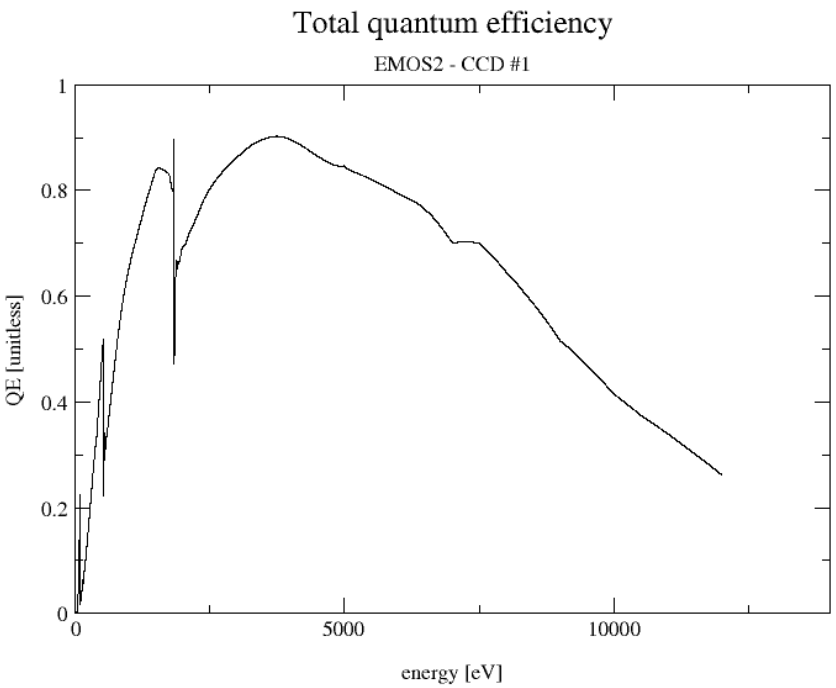
Filter Transmission

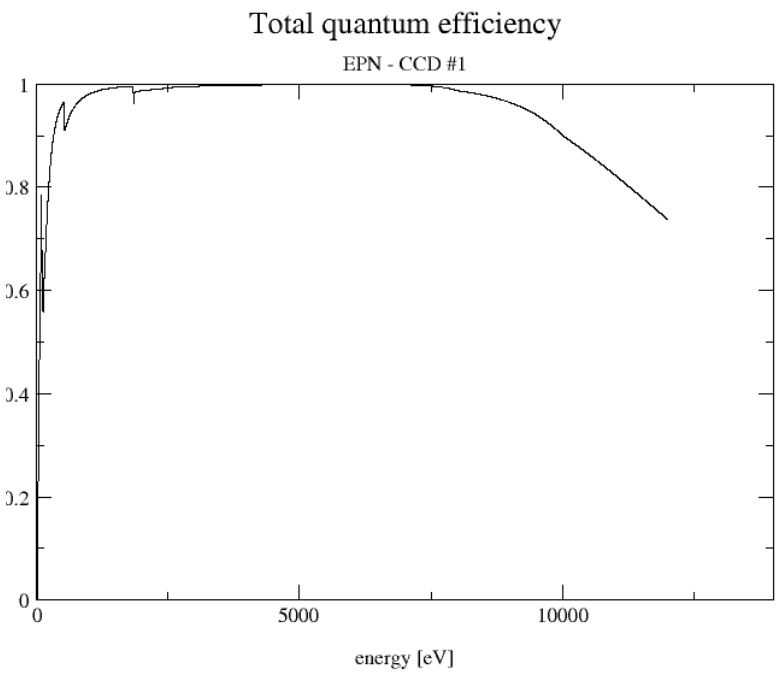
Epic medium filter



Option: *modelfiltertrans*=yes (default)

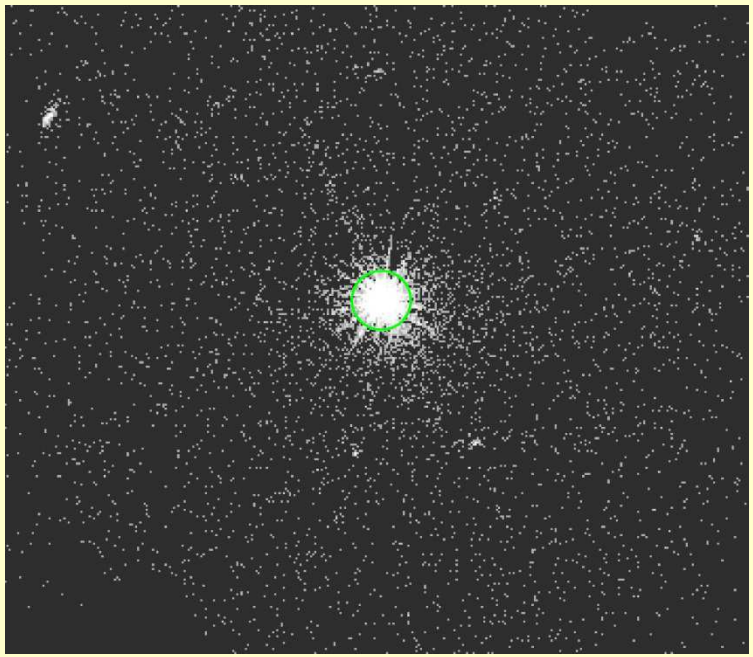
Detector Quantum Efficiency

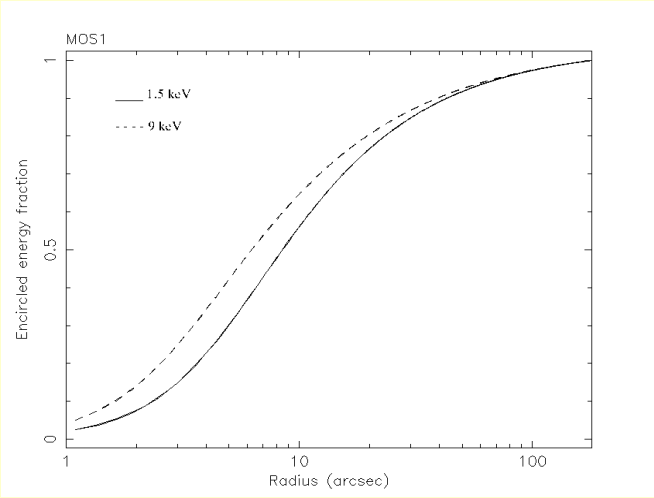




Option: *modelquantumeff*=yes (default)

Encircled Energy Correction



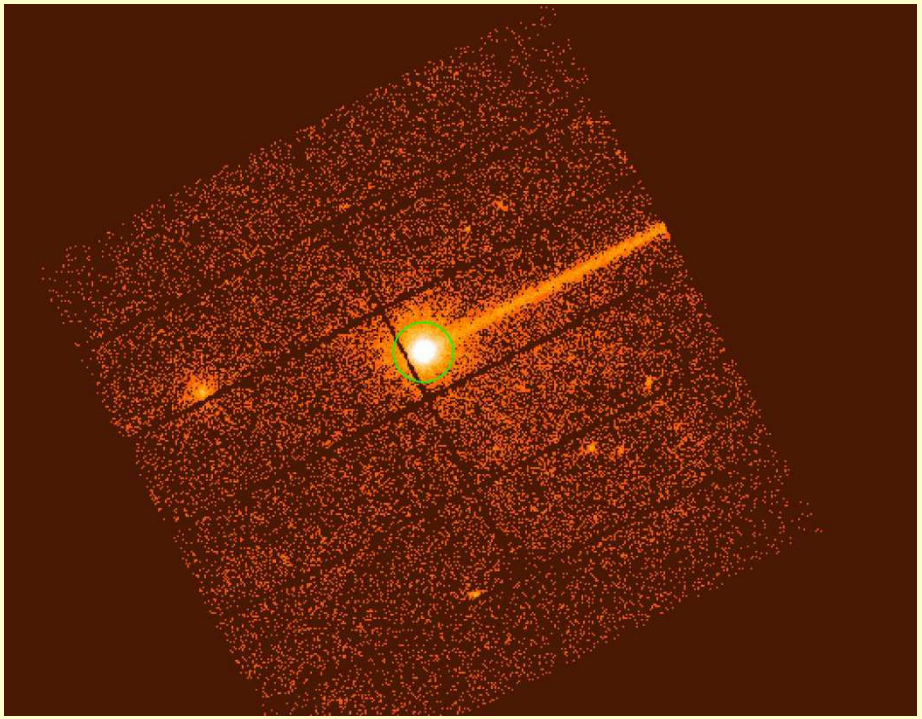


arfgen corrects for flux scattered out of the source extraction region.

Option: *modelee*=yes (default)

This is weakly dependent on energy and off-axis angle.

CCD gaps and Bad Pixels



arfgen corrects for the effective area lost due to chip gaps, bad pixels and offset columns.

Bad pixel and offset column information is stored in the event file header

Options: *withbadpixcorr*=yes (default) *badpixlocation*=myevents.fit

Point source: *arfgen* commands

Point source:

> arfgen spectrumset=spectrum.ds arfset=myspec.arf
badpixlocation=myevents.FIT detmaptype=psf

Using an RMF to define the channel array:

> arfgen spectrumset=spectrum.ds arfset=myspec.arf
badpixlocation=myevents.FIT detmaptype=psf withrmfset=yes
rmfset=***epn_ff20_sdY9.rmf***

Extended source: *arfgen* commands

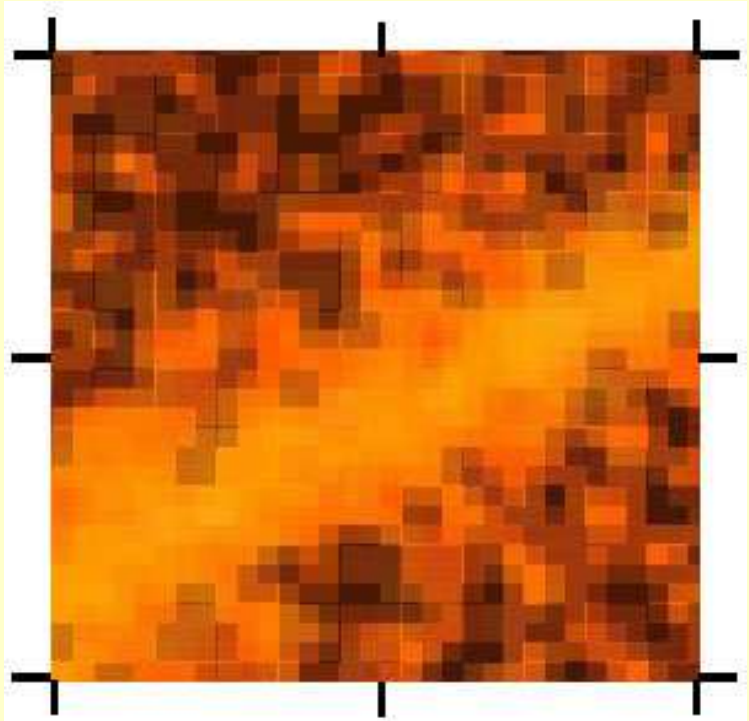
Extended source:

> arfgen spectrumset=spectrum.ds arfset=myspec.arf extendedsource=yes
badpixlocation=myevents.FIT detmaptype=flat

Using a detector map:

> arfgen spectrumset=spectrum.ds arfset=myspec.arf extendedsource=yes
badpixlocation=myevents.FIT detmaptype=dataset
datamaparray=coarseimage.ds

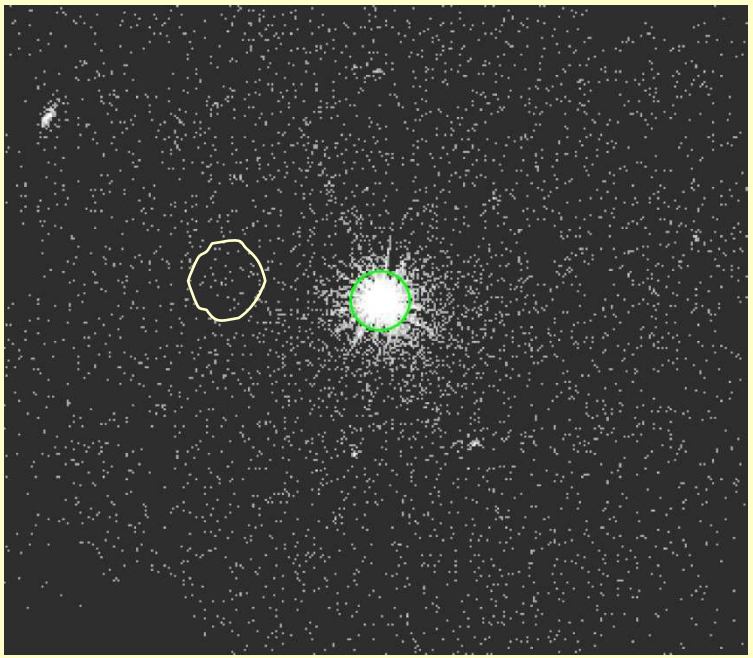
Extended source: detector map



- Create a coarsely binned image in detector coordinates**.**
- Run ***arfgen*** in extendedsource mode and flux-weight the ARF

arfgen spectrumset=spec.ds arfset=myspec.arf extendedsource=yes detmaptype=dataset detmaparray=coarseimage.ds

Influence of other sources



```
> arfgen spectrumset=cluster.ds
        detmaptype=dataset
datamaparray=coarseimage.ds
        crossregionarf=yes
crossreg_spectrumset=pointsource.ds
```

To calculate the contribution of flux from one region onto another region use the CROSSARF technique. The detector map must cover both regions and have at least 300 pixels within each area.

When should you use the canned matrices ?

For all instruments and observing modes, always use ***arfgen*** and either ***rmfgen*** or canned RMFs.

In general use ***rmfgen*** as it can be more accurate.
But…

*Canned RMFs can save time as **rmfgen** takes ~5 minutes to run.*

Canned RMFs may be issued between SAS releases to give access to the latest calibration.

Making life easy

Single task ***especget*** available:

- ✓ Takes source and background region
- ✓ Calculates centroid and optimum extraction radius
- ✓ Produces source and background spectra
- ✓ Generates appropriate ARF
- ✓ Optionally generates RMF
- ✓ Prepares files for spectral fitting

Use directly from ***xmmselect,*** ***"***OGIP spectral products***"***

Useful links

ESPECGET:

http://xmm.esac.esa.int/sas/current/documentation/threads/EPIC_egetspec_thread.shtml

MOS:

http://xmm.esac.esa.int/sas/current/documentation/threads/MOS_spectrum_thread.shtml

PN:

http://xmm.esac.esa.int/sas/current/documentation/threads/PN_spectrum_thread.shtml