XRT PSF Investigations

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- Bright on-B/S target
- Annular extraction regions for EPIC
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- Annular extraction regions for EPIC

- High-energy refinement of the XRT3 (=PN) PSF
- Based on TI mode data (Mkn 421)
- Optimise parameters describing PSF wings in order to obtain constant measured flux independent of number of excised columns
Annular spectra for individual sources (PN)

NGC 5506 (Seyfert 2)

Dominated (>90%) by point source emission.

PN spectral comparison:
- annuli from 20′′-25′′ to 40′′-45′′
- compared with 20′′ circle

Similar results for HE1136-2304 (in out-burst)
Annular spectra for sample of sources (PN)

Sample of 26 bright non-piled-up point sources located at the bore-sight (FF mode).

Spectra well modelled by curved power-law models.

Determine flux ratios of annular v. circular spectral extractions:
- Annuli ranging from 10''-20'' to 40''-45''
- Compared with 20'' circle

Flux ratios show large obs-to-obs scatter

On average, XRT3_XPSF 0016 better than 0014 at larger annuli

However, PN possibly overcorrected > 3 keV
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On average, both MOSs would require similar order of magnitude corrections as done for PN
Systematics in the current PSF modelling for all 3 XRTs

Hopefully can be improved by tuning the PSF model parameters

Any changes should decrease systematics for a variety of source types
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Current ELLBETA implementation: 240 parameters per XRT
- 5 PSF model parameters ($r_0$, $\alpha$, $\varepsilon$, FWHM, norm)
- 8 energies (0.10, 1.50, 2.75, 4.25, 6.00, 8.00, 10.25, 15.00 keV)
- 6 off-axis angles (0′, 3′, ..., 15′)
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Limit the problem to 28 parameters per XRT
• 2 PSF model parameters ($r_0$, $\alpha$)
• 7 energies (15.00 keV $\equiv$ 10.25 keV)
• 2 off-axis angles (0’, 3’) – on-B/S $\approx$ 1.2’ off-axis
Iterative correction scheme

Iterative scheme for the empirical correction of XRT XPSF parameters

- Per source:
  - Extract spectrum from circular region
  - Extract spectra from several annular regions
  - Create respective RMFs
  - Create respective ARFs
  - Fit model to circular region spectrum
  - Apply this reference model to the annular spectra

- For all annular spectra and all sources, determine a suitable statistic, e.g.:
  \[
  \sum_{i} (d_i - m_i)^2 / e_i
  \]

- Modify ELLBETA parameters in order to minimise the statistic
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Currently running for each XRT on a sample consisting of 9 observations:

- 7 bright non-piled-up point sources located at the bore-sight with low background (FF mode)
- 2 observations of NGC 5506 (SW mode)

7 annuli being compared (up to 45” outer radius)

2 PSF model parameters (r0 and a) being varied
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Optimisation is still running...
Interim results: average flux ratios

![Graph showing flux ratios for different intervals]
Interim results: average flux ratios

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Interim results: average flux ratios

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Interim results: average flux ratios
Interim results: NGC 5506 spectral residuals

PN

MOS1

MOS2
Interim results: changes to the ARF
XRT XPSF history: 2011

MOS1

On-axis

3’ Off-axis

XRT3_XPSF_0013

α

XRT[1,2]_XPSF_0013

On-axis

3’ Off-axis

XRT3_XPSF_0013

PN
XRT XPSF history: 2012

XRT\[1,2\]_XPSF_0013
XRT\[1,2\]_XPSF_0014

\( r_0 \)
\( a \)
\( \alpha \)
On-axis
On-axis
3’ Off-axis
3’ Off-axis
MOS1
MOS2
PN
XRT XPSF history: 2014

- XRT[1,2]_XPSF_0013
- XRT[1,2]_XPSF_0014
- XRT3_XPSF_0013
- XRT3_XPSF_0014
- XRT3_XPSF_0016

Graphs showing data for MOS1, MOS2, and PN.
XRT XPSF history: 2014...

- XRT[1,2]_XPSF_0013
- XRT[1,2]_XPSF_0014
- XRT3_XPSF_0013
- XRT3_XPSF_0014
- XRT3_XPSF_0016

Graphs showing XRT, MOS1, MOS2, r₀, d, and PN variations with keV.