Calibration of the *XMM-Newton* RGS

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Summary for EPIC CAL/Ops

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XMM-SOC@ESAC & SRON Utrecht
Outline

- Review of ground calibration
- RGS stability
- RGS effective area
- Example comparisons of the newly recalibrated RGS with EPIC
- WHIMs
Ground calibration

Grating efficiency $\otimes$ CCD QE = effective area

⇒ RGS calibration reference band $10 \leq (\cdot) \leq 25$

$\quad (6 \leq (\cdot) \leq 38)$

RGS calibration

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RGS calibration

SNR 1ES0102–7219 RGS fluxed spectrum

OVIII Ly

NeX Ly

CVI Ly

Flux (cm$^{-2}$ s$^{-1}$ Å$^{-1}$)

Wavelength (Å)

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38

RGS stability from SNR observations
RGS stability from SNR observations

\[ \text{Ne X}(12.132) \text{ and O VIII}(18.967) \text{ stable within a few \%} \]

SNR 1ES0102-7219 CVI Ly
RGS effective area

- large scales and small scales
- correction strategy $\Rightarrow$ EFFAREACORR* CCF for large scales
- 900ks accumulated Mkn421 data $\Rightarrow$ COOLPIX* CCF for small scales
- this means a new CCF*
RGS effective-area corrections

- empirical approach
- “featureless” blazar spectra show the same shape
- blazars have absorbed power-law spectra (LETGS ratios $\Rightarrow$ no RGS breaks)
- calibrate $\alpha$ and normalisation with the Crab
- $N_H$ (and absorption chemistry) vital
These two blazars have significantly different RGS fluxed spectra but look very similar after multiplying by a powerlaw and correcting for ISM absorption. Such a plot would be flat for a properly calibrated effective area.

\[ g(\lambda) = 2 \cdot f(\lambda) \exp(+N_H(\lambda)) \]
RGS effective-area corrections

• fit blazar spectrum with ISM-absorbed powerlaw $10^<(\AA)<25$
• model residuals by sum of Chebyshev polynomials
• repeat throughout the mission $\otimes$ Crab normalisation and slope adjustments
• correction calculated at 5 epochs $\Rightarrow$ EFFAREACORR$^*$ CCF
• 8 example epochs shown here ($r==XMM\ rev$)
Corrected-RGS comparison with EPIC : PKS2155-304

PKS2155–304 0545_0124930601

RGS1 RGS2 pn MOS1 MOS2

normalized counts s⁻¹ Å⁻¹

ratio

Wavelength (Å)

RGS calibration

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Corrected-RGS comparison with EPIC : 3C273

RGS response to Stuhlinger et al. XCal document spectrum without adjustment
Moving on to small-scales in the RGS response using 900ks of accumulated data on Mkn421…
Mkn421’s accumulated 900ks RGS1

0084 ≤ rev ≤ 1084 Mkn421 RGS1 0.7<order<1.2 & & 1.7<order<2.2

Event Count

CHIPX+(CCDNR−1)×343

0 500 1000 1500 2000 2500 3000

0 1000 2000 3000 4000 5000 6000 7000 8000

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Mkn421’s accumulated 900ks RGS2

0084 <=rev<= 1084 Mkn421 RGS2 0.7<order<1.2 & & 1.7<order<2.2

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Mkn421’s accumulated 900ks

- 85% of RGS data obey Poisson statistics
- 14% exceed $e^{-\mu} \frac{\mu^n}{n!}$ by <5%
- 1% hot pixels or columns
- 1% (new class of) cool columns

⇒ Nicastro et al.’s Mkn421 WHIMs were statistical fluctuations