Assessment of spectral quality in EPIC Fast Modes

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Outline

• EPIC-pn rate-dependent CTI
  • Status
  • Future work

• Assessment of spectral quality in:
  • EPIC-pn Timing Mode
  • EPIC-pn Burst Mode
  • EPIC-MOS Timing Mode

• User’s perspective
Rate-dependent CTI (RDCTI) status

- **Released on December 2, 2008**

- **Outline of the method currently used:**
  - Define sample of non-variable sources
    - 42 Timing, 36 Burst
  - Extract one spectrum for each of the 4 columns surrounding the boresight
  - Gain fit the spectrum in the 1.5-3 keV with a \( \text{wabs}^* (\text{po} + \text{bb}) \) model \( \Rightarrow G_{corr} \)
  - Calculate for each spectrum the number of shifted electrons, \( N_e \)
  - Fit the \( G_{corr} = a_0 N_e a_1 + a_2 \Rightarrow a_i \) go into the CCF
RDCTI results

**Rate dependent CTI - pn timing mode**

- 1-σ confidence interval
- Fit: \( y = a_0(x^{a_1}) + a_2 \)
  - \( a_0 = 0.9933 \)
  - \( a_1 = 0.0029 \)
  - \( a_2 = -0.0068 \)

**Rate-dependent CTI - pn burst mode**

- 1-σ confidence interval
- Fit: \( y = a_0(x^{a_1}) + a_2 \)
  - \( a_0 = 0.047 \)
  - \( a_1 = 0.121 \)
  - \( a_2 = 0.854 \)

**SASv8.0-based calibration**

**Special Burst gain correction reverted to ground-based values**
Spectral quality assessment method

- Quality of the residuals in the 1.5-3 keV energy band
- Comparison between measured and expected (laboratory/astrophysics) narrow-band spectral features
- Testbed sample:
  - 48 observations in Burst Mode (21 on the Crab)
  - 142 observations in Timing Mode
Residuals in the 1.5-3 keV band

Overall satisfactory, but the correction fails miserably in a few cases.
Energy reconstruction accuracy (Timing)

Circled measures correspond to N132D and CasA

Energy shifts - pn Timing Mode - CCF#20

$(E_{pn} - E_{laboratory}) / E_{laboratory}$

- Absorption lines
- Emission lines

(Symbol size proportional to count rate)
CCF#19: $E=6.93 \pm 0.02$ keV

CCF#20: $E=6.982 \pm 0.017$ keV

Nominal: 6.969-6.983 keV
MOS Timing Mode: method

- Comparison between the centroid energy measured in CasA and N132D between:
  - MOS Timing and pn Full Frame exposures
  - MOS Timing and imaging Modes

- Comparison (via gain fit) between RGS (phenomenological) model and MOS2 Timing Mode spectrum of Au Microscopii
CasA and N132D spectra
Line spectral accuracy

MOS1 versus pn

\[ \text{100}\% \left( \frac{E_{\text{model}} - E_{\text{pn}}}{E_{\text{pn}}} \right) \]

\begin{align*}
\text{pn Energies (E_{\text{pn}} \text{ keV})} & \\
\text{N132D} & \text{CasA}
\end{align*}

MOS2 versus pn

\[ \text{100}\% \left( \frac{E_{\text{model}} - E_{\text{pn}}}{E_{\text{pn}}} \right) \]

\begin{align*}
\text{pn Energies (E_{\text{pn}} \text{ keV})} & \\
10 \text{ eV} & 30 \text{ eV}
\end{align*}

MOS1 Imaging versus Timing Modes

\[ \text{100}\% \left( \frac{E_{\text{model}} - E_{\text{pn}}}{E_{\text{imaging}}} \right) \]

\begin{align*}
\text{1 Imaging Mode Energies (E_{\text{imaging}} \text{ keV})} &
\end{align*}

MOS2 Imaging versus Timing Modes

\[ \text{100}\% \left( \frac{E_{\text{model}} - E_{\text{pn}}}{E_{\text{imaging}}} \right) \]

\begin{align*}
\text{1 Imaging Mode Energies (E_{\text{imaging}} \text{ keV})} &
\end{align*}
Au Mic MOS2 vs. RGS

gain fit offset: 18.8±0.4 eV
MOS2/RGS relative normalization: 97.9±0.5 %
Following an explicit recommendation of the User’s Group, two Technical Notes have being prepared – to be made public before the next User’s Group Meeting.

**XMM-Newton SOC Technical Note**

**XMM-SOC-CAL-TN-0082**

**Accuracy of energy reconstruction in EPIC-MOS Timing Mode**

M. Guainazzi

March 21, 2009

**History**

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<td>0.1</td>
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**XMM-Newton Calibration Technical Note**

**XMM-SOC-CAL-TN-083**

**Evaluation of the spectral calibration accuracy in EPIC-pn Fast Modes**

Matteo Guainazzi (ESA-ESAC, Villafranca del Castillo, Spain), Marcus Kirsch (ESA-ESOC, Darmstadt, Germany), Frank Haberl (MPE, Garching, Germany) et al. *(other institutes)*

March 21, 2009

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Conclusions

- Numbers for the EPIC Calibration Status Document on the energy reconstruction accuracy:
  - EPIC-MOS: $\lesssim 20$ eV
    - Are we happy with this level?
  - EPIC-pn Timing: $\lesssim 20$ eV ($E<2$ keV), $\lesssim 50$ eV ($E\approx 6$ keV)
    - See later for a possible strategy to improve
  - EPIC-pn Burst: good agreement in the only case where this measurement has been possible so far
    - More archival observations? NRCO?
Further work on EPIC-pn

- Re-calibration after the Timing PSF arfgen fix
- Expansion of the objects sample used for the calibration of the RDCTI
  - Time-dependent effects?
- Recalibration of the pn pattern fraction in Fast Modes
- Inclusion of a linear term in the RDCTI gain correction
- Observation-based RDCTI
Zoom on the RDCTI

Rate dependent CTI - pn timing mode

fit: $y = a_0(x^{a_1}) + a_2$

$a_0 = 0.9933$

$a_1 = 0.0029$

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