EPIC-pn background issues: 20 (or so) Q&A ;-)
EPIC background workshop in Milano (6-8 Oct 2003)

The Menu: what is it all about

- particle induced background
- detector noise
- soft proton background
- out-of-time events
- cosmic X-ray background
EPIC-pn: Closed filter observation

singles, doubles, 313 ks, FF mode
Al-K, Ni-K, Cu-K, Zn-K, Mo-K
Ti-K, Cr-K, Fe-K, Au-L
Mo-K only in doubles, line position better than 0.3%
background higher than in MOS (factor 2-4)
could "easily" be reduced (factor ~ 5, graded shielding)
**EPIC-pn: particle induced background**

Printed circuit board: Cu + Mo (Ni + Au)
EPIC-pn: particle induced background
Ratio of spectra: 10 eV bins

CalClosed (Rev.80) / Closed (Rev.59): cts/s/10eV
identical above 7 keV
Background correlations: lines and continuum

- high-energy continuum more increased than Cu line, i.e. below 1-to-1
- dotted line: 1-to-1 correlation
- blue dashed line: all data used for linear regression
- red solid line: low-intensity data used for linear regression
Pattern distributions

![Graph](image)

- singles
- doubles
- triples
- quadruples
- invalid patterns

Energy fraction test in invalid patterns in (1.0–32.8) with 7.25%
Pattern fractions

singles more abundant, doubles less abundant than for mirrored X-rays
Pattern distribution + fraction: LW + SW modes

note the deficiency in Ni-K and Cu-K lines compared to FF/PP mode because of the ventilation hole at the center

singles more abundant, doubles less abundant than for mirrored X-rays
Pattern distribution + fraction: FF spatial: close to CAMEX

labelled Y# with
# = INT(RAMT/20)
as for response matrices
here: # = 0,1,2,3
EPIC-pn frame times for FF + eFF modes

Frame time parameter $F1294$: FF $\rightarrow$ eFF mode

FF is special case of eFF mode : $F1294 = 0$

$$FT(\text{eFF}_{F1294}) = 73.36432 + F1294 \times 41.94304 [\text{ms}]$$

<table>
<thead>
<tr>
<th>Mode</th>
<th>integration time [ms]</th>
<th>cycle time [ms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>eFF₀</td>
<td>68.702</td>
<td>73.36432</td>
</tr>
<tr>
<td>eFF₁</td>
<td>194.531</td>
<td>199.19344</td>
</tr>
<tr>
<td>eFF₅</td>
<td>278.417</td>
<td>283.07952</td>
</tr>
<tr>
<td>eFF₇</td>
<td>362.303</td>
<td>366.96560</td>
</tr>
<tr>
<td>eFF₉</td>
<td>446.190</td>
<td>450.85168</td>
</tr>
<tr>
<td>eFF₁₅</td>
<td>697.848</td>
<td>702.50992</td>
</tr>
</tbody>
</table>
## EPIC-pn: detector noise

<table>
<thead>
<tr>
<th>Mode</th>
<th>cycle [ms]</th>
<th>data set</th>
<th>exposure [s]</th>
<th>counts</th>
<th>rate [cts/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW</td>
<td>5.67176</td>
<td>HK040324.012</td>
<td>4793</td>
<td>854421</td>
<td>178.25 ± 0.19</td>
</tr>
<tr>
<td>LW</td>
<td>47.69444</td>
<td>HK040325.004</td>
<td>21766</td>
<td>510944</td>
<td>23.475 ± 0.033</td>
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<tr>
<td>FF</td>
<td>73.30443</td>
<td>HK031029.001</td>
<td>3002</td>
<td>63365</td>
<td>17.301 ± 0.069</td>
</tr>
<tr>
<td>eFF(_2)</td>
<td>199.19344</td>
<td>HK040407.013</td>
<td>3000</td>
<td>25817</td>
<td>8.605 ± 0.084</td>
</tr>
<tr>
<td>eFF(_7)</td>
<td>283.07952</td>
<td>HK040420.002</td>
<td>3600</td>
<td>23456</td>
<td>5.15 ± 0.043</td>
</tr>
<tr>
<td>eFF(_7)</td>
<td>366.96560</td>
<td>HK041014.005</td>
<td>1800</td>
<td>10637</td>
<td>5.910 ± 0.057</td>
</tr>
<tr>
<td>eFF(_7)</td>
<td>366.96560</td>
<td>HK041014.005</td>
<td>2530</td>
<td>15086</td>
<td>5.962 ± 0.049</td>
</tr>
</tbody>
</table>

- CCDHR.eq.4 .and. PAT_TYP.eq.1
-PHA.ge.16 .and. PHA.le.40
-RAWX.ge.3 .and. RAWX.le.62
-RAWY.ge.139 .and. RAWY.le.198
-RAWX.ne.18 .and. RAWX.ne.39 .and. RAWX.ne.55
-.not. (RAWX.eq.61 .and. RAWY.eq.179)
EPIC-pn: detector noise
EPIC-pn: detector noise

\[
\text{ABS RATE} = C \times (\text{NUMBER OF READOUTS PER SECOND} + B)
\]

\[
C = 0.0924 \pm 0.0030 \, \text{cts s}^{-1}, \quad B = 3.28
\]
EPIC-pn: detector noise

\[ \text{ABS RATE PER PIX} = D \times (\text{NUMBER OF READOUTS PER SECOND} + B) \]

\[ D = 0.2002 \pm 0.0007 \text{ (cts s}^{-1} \text{ pixel}^{-1}) \]

\[ B = 3.28 \]
Low-energy background (0.2 – 0.5 keV): doubles

- spatial inhomogeneities in RAWX direction
- enhanced intensity close to CAMEX
- recommended to use only singles below 0.5 keV as in pipeline processing and singles + doubles above 0.5 keV
EPIC-pn: low-energy comments

- below 500 eV: PATTERN==0 (inhomogeneous PATTERN>0)
- above 500 eV: PATTERN≤4
- CAMEX region has higher noise (e.g. MIPs)
- SAS task eproject to shift low-energy patches and to flag noise events
  → cleaner low-energy images, can go down to 120 eV (KOD, HB)
- a few columns in quadrants 0,1,2 show different gain compared to ground
  calibrations (KOD):
  → this too low gain in the CCF shifts the noise to too high energies
  → columns appear too bright (CCD1, CCD5)
  quadrant 3 shows general gain scatter compared to ground calibrations
  → will be corrected in EPN.ADUCONV.CCF (MS, KOD)
- epatplot now accepts background event file, e.g. Closed filter, to remove
  non-XRT X-rays from pattern distributions (sky background does not matter !)
EPIC-pn: soft proton background

- is vignetted
- has continuum spectrum
- is highly variable in intensity (and spectral slope)
- pattern distribution similar to genuine X-rays
- RMF different (escape peak): model (SM, SFS, SLS, KK)?
**EPIC-pn: out-of-time events**

- Suggestion: produce OoT event files during XSA reprocessing (epchain)
- useful for low SB objects, very large targets, point sources in field, etc.
- OoT also affect out-of-FOV area
- pattern distribution same as for true X-rays
- problem: extra disk space
- idea: store only information different from original event file and provide script/tool to explode/implode OoT event file
- assumes that both event files have same number of events (RAWY, PI)
- does not work in the case of a threshold like 150 eV
- solution: run eproject and remove flagged events in both event files to reduce (combined) size?
Cosmic X-ray background

- SXRB \([E < 2 \text{ keV}]\) one can do simultaneous fit with ROSAT Survey
  (or ROSAT pointed data) (frool, SLS)
- CXRB \([E > 2 \text{ keV}]\) use blank sky fields (with brighter sources excluded)
  to determine power-law