Properties of EPIC pn at low energies: LW mode
Long closed LW exposures

<table>
<thead>
<tr>
<th>revolution</th>
<th>data set</th>
<th>exposure [s]</th>
<th>date</th>
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<tbody>
<tr>
<td>0546</td>
<td>0134522001_PNS005</td>
<td>18 760</td>
<td>2002-12-03</td>
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<td>0125320901_PNS010</td>
<td>12 267</td>
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<td>0154150601_PNS002</td>
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<td>0134720801_PNS005</td>
<td>61 096</td>
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<td>0974</td>
<td>0305920301_PNU027</td>
<td>12 534</td>
<td>2005-04-04</td>
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116 855
EPIC-pn at low energies (LW)

Correction of offset shifts
offset correction: before
offset correction: after
EPIC-pn detector noise (LW)

residual offset map

rev 546
EPIC-pn detector noise (LW)

residual offset map

rev 553
EPIC-pn detector noise (LW)

residual offset map

rev 730
EPIC-pn detector noise (LW)

residual offset map

rev 790
EPIC-pn detector noise (LW)

residual offset map

rev 974
individual offset maps

median of offset maps

EPIC pn at low energies: LW mode
residual offset maps

EPIC Calibration Meeting, MPE

K. Dennerl, 2006 May 04
cleaned residual offset maps

EPIC pn at low energies: LW mode
cleaned residual offset map

residual offset map

rev 546
20 adu image, rev 546
20 adu image, rev 546

before the correction of offset shifts
20 adu image, rev 546

after the correction of offset shifts
offset correction: before

rev 546

rev 553
offset correction: after
offset correction: before
offset correction: after

rev 730

rev 974
EPIC-pn at low energies (LW)

Low energy noise
EPIC-pn detector noise

50.7 ks closed FF (rev 059)

Quadrant 0
Detector noise in FF and eFF mode

- FF: 2.16 times higher per sec than in eFF
- eFF: Detector noise per sec is ~2.16 times higher in FF than in eFF
Detector noise in FF and eFF mode

Detector noise per sec is ~2.16 times higher in FF than in eFF
Detector noise in LW and FF mode

detector noise per sec is ~1.7 times higher in LW than in FF*

*in the LW area

LW

1.71 : 1

FF
EPIC-pn: low-energy background (FS, 16 – 40 adu)
closed    FF    rev 462    23.2 ks

EPIC pn at low energies: LW mode
Vela SNR  FF  rev 534  38.8 ks

Energy fraction lost in invalid patterns in [1.0–32.8] keV: 4.06%
Vela SNR    FF    rev 534    38.8 ks

with eproject

Energy fraction lost in invalid patterns in [1.0–32.0] keV: 3.81%
EPIC-pn detector noise in LW mode

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EPIC pn at low energies: LW mode

K. Dennerl, 2006 May 04
EPIC-pn detector noise (LW)

Original method (“method 1”):

Suppression of events below 50 adu according to a reference noise distribution deduced from long closed exposures.

Shown in blue is the result of this method applied to a (long) closed exposure, to illustrate the effect on a very faint X-ray source.

100% suppression
EPIC-pn detector noise (LW)

Original method (“method 1”):

Suppression of events below 50 adu according to a reference noise distribution deduced from long calclosed exposures

Shown in blue is the result of this method applied to a (long) calclosed exposure, to illustrate the effect on a very faint X-ray source

99% suppression
**EPIC-pn detector noise (LW)**

Original method (“method 1”):

Suppression of events below 50 adu according to a reference noise distribution deduced from long calclosed exposures

Shown in blue is the result of this method applied to a (long) calclosed exposure, to illustrate the effect on a very faint X-ray source

90% suppression
EPIC-pn detector noise (LW)

Original method ("method 1"):

Suppression of events below 50 adu according to a reference noise distribution deduced from long closed exposures.

Shown in blue is the result of this method applied to a (long) closed exposure, to illustrate the effect on a very faint X-ray source.

70% suppression
EPIC-pn detector noise (LW)

Original method ("method 1"):
Suppression of events below 50 adu according to a reference noise distribution deduced from long closed exposures

Shown in blue is the result of this method applied to a (long) closed exposure, to illustrate the effect on a very faint X-ray source

50% suppression
This method works well for bright sources, but may cause an apparent deficit of photons between ~150 and 250 eV for faint sources.

Other problem: inhomogeneous residual noise at ~20 adu
EPIC-pn detector noise (LW)

Alternative method (“method 2”):

Try to determine the noise properties at higher energies and extrapolate them down to 20 adu
EPIC-pn detector noise (LW)

rev 790, all events

range used for fit: 40-100 adu

range shown: 20-400 adu

log-log

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EPIC pn at low energies: LW mode
EPIC-pn detector noise (LW)

range used for fit: 40-100 adu
range shown: 20-400 adu
x lin y log

rev 790, all events

EPIC pn at low energies: LW mode
EPIC-pn detector noise (LW)

range used for fit: 40-100 adu
range shown: 20-100 adu
x lin y log

rev 790, all events
EPIC-pn detector noise (LW)

rev 790, all events

range used for fit: 40-100 adu

range shown: 20-400 adu

x lin     y log

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EPIC pn at low energies: LW mode

K. Dennerl, 2006 May 04
EPIC-pn detector noise (LW)

rev 790, all events

range used for fit: 40-100 adu

range shown: 20-400 adu

x log               y log

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EPIC pn at low energies: LW mode

K. Dennerl, 2006 May 04
EPIC-pn detector noise (LW)

range used for fit: 40-100 adu
range shown: 20-400 adu
x log y log

rev 790, all events
EPIC-pn detector noise (LW)

rev 790, all events

range used for fit: 40-100 adu

range shown: 20-400 adu

x log                  y log

for comparison: method 1

EPIC pn at low energies: LW mode
EPIC-pn detector noise (LW)

method 2, rev 546
EPIC-pn detector noise (LW)

method 2, rev 553
EPIC-pn detector noise (LW)

method 2, rev 730
EPIC-pn detector noise (LW)

method 2, rev 974
EPIC-pn detector noise (LW)

→ Method 2 would work well if there were no temporal changes of the low-energy noise

Whenever the noise properties of the sample and template are (slightly) different, the subtraction leads to residuals in the spectra and the images

Other problem: assumption of constant noise properties along CCD rows (required in order to get enough statistics) not valid for raw events:
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

20 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

21 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed after offset corrections all events

22 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

23 adu
EPIC-pn detector noise (LW)

rev 790

61 ks closed
after offset corrections
all events

24 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

25 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

26 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

27 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

28 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

29 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

30 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

31-35 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

36-40 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

41-45 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

46-50 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

51-55 adu
rev 790
61 ks closed
after offset corrections
all events

56-60 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

61-70 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

71-80 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

81-90 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

91-100 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

101-120 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

121-140 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

141-180 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

181-250 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
after offset corrections
all events

251-400 adu
EPIC-pn detector noise (LW)

At which stage of the processing should the noise be suppressed?

Comparison of raw data with processed data (after pattern recognition and recombination):
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
all events

raw data

20 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
singles

processed data

20 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
all events

raw data

30-50 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
all “entries”

processed data

30-50 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
non-singles

processed data
30-50 adu
EPIC-pn detector noise (LW)

rev 790
61 ks closed
no offset corrections
singles

processed data

30-50 adu
EPIC-pn detector noise

Comparison with FF:
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
all events

raw data

20 adu
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
singles
processed data
20 adu
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
all events

raw data

30-50 adu
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
all "entries"

processed data

30-50 adu
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
non-singles

processed data

30-50 adu
EPIC-pn detector noise (FF)

rev 462
23 ks closed
no offset corrections
singles

processed data
30-50 adu
EPIC-pn detector noise

At which stage of the processing should the noise be suppressed?

→ Noise near the CCD edges can be most efficiently suppressed by rejecting invalid patterns

→ Noise suppression should be done after the pattern recognition
EPIC-pn detector noise properties (FF)

SAS CCF:

⇒ Also for FF, epreject may need some refinement..
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EPIC pn at low energies: LW mode

K. Dennerl, 2006 May 04