Absolute timing of XMM-Newton and news from the time jump front

M.G.F. Kirsch¹, E. Kendziorra², M. Freyberg³

¹ ESA XMM-SOC, ESAC Spain
² IAAT, University of Tuebingen, Germany
³ MPE Garching, Germany
• absolute timing
  – Crab monitoring
  – peak fitting

• time jumps
  – refined frame times
  – new time jump search
• used timing and burst mode Crab observation
• select nearest radio observation from Jodrell Bank before XMM observations
• use those ephemeris (epoch, P, P’, P’’) of to fold X-ray data

• shift of main X-ray peak with respect to (radio) phase 0 gives absolute timing difference
• monitor absolute timing accuracy over mission life time
folded light curves

radio glitch

low stat (time jump)
• asymmetric Mofat functions to fit the first crab pulse
• take only phase 0 +/- 0.03 for the fit
• 70 $\mu$ sec standard deviation (requirement was : better than 1 ms)

• -350 $\mu$ sec earlier than radio peak

• statistical errors much smaller than standard deviation --> possibly still systematic effect (GS delays have recently been updated. This is not implemented in time correlation for archived data)

• TC may be managed via CCF in the future --> on the fly SAS reprocessing of TCX
If the time difference between the two arrival times of photon \( a \) and photon \( b \) is not a multiple of the frame time, it results in a \textit{TIME JUMP}. 

\[ n \times \text{frame time} \]
how to detect the jump

- take all frame times in array: $T$
- $\Delta = (T(i+1) - T(i))/\text{frametime}$
- $\epsilon =$ difference of $\Delta$ to next full frametime
- plot $\epsilon(\Delta)$
- if $\epsilon > \text{tolerance} \rightarrow \text{time jump}$

\[ \epsilon \]

\[ \Delta \]

Time jumps

Counting mode
• processing of all public and non public available archive data at ESAC
  --> implemented frame times are not correct
  --> refine frame times using this analysis before time jump analysis can be followed up
- Oscillator stable, otherwise relative differences should show same shift
- Different slopes for different modes
  --> sequencer clocks have not been counted fully correct
  --> errors < $10^{-5}$ frame times per frame
  (< 20 clocks, 1 clock = 40 ns)
- Slight drift in frame times (see MJF Escorial proceedings)
- refined frame times on that basis not violating quantumization of oscillator clocks
• with that correction still residual drifts caused by temperature changes and aging of the quartz
• can mimic in case of large event differences (counting mode) time jumps
refined search algorithm

- subtracting individual drifts into account
- equivalent to search with variable tolerance depending on event difference
- used:
  - corrected new frame times
  - threshold parameter that determines time jump: $0.02 \times FT$

<table>
<thead>
<tr>
<th>Revolution</th>
<th>Events</th>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 200</td>
<td>8</td>
<td>FF</td>
<td>1.34%</td>
</tr>
<tr>
<td>200 - 400</td>
<td>60</td>
<td>EFF</td>
<td>23.17%</td>
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<tr>
<td>400 - 600</td>
<td>2</td>
<td>SW</td>
<td>1.96%</td>
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<tr>
<td>600 - 800</td>
<td>4</td>
<td>LW</td>
<td>2.19%</td>
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<tr>
<td>800 - 1000</td>
<td>2</td>
<td>T</td>
<td>2.35%</td>
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<tr>
<td>1000 - 1200</td>
<td>1</td>
<td>B</td>
<td>7.69%</td>
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<tr>
<td>Total</td>
<td>77</td>
<td></td>
<td>6.20%</td>
</tr>
</tbody>
</table>
• BACK UP VGs
resulting absolute error

• Burst, Timing and Small Window mode do show negligible absolute errors
• FF, eFF and LW show room for improvement

→ frame times are not fully correct
→ can be calibrated using the result of that analysis

Not critical for exposure time and timing

Analysis can be used to refine frame times with very high accuracy