GLAST Large Area Telescope

What Time Is It?

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What we get

• LAT clock runs at 20MHz
  – or so
• GEM keeps track of the clock ticks
• Every second, on the second, the GPS receiver on the spacecraft sends the LAT an interrupt (Time Tone)
• The GEM makes a note of it
  – time and ticks
• So we get a list of times, and the corresponding elapsed ticks
• When we get an event, the GEM records the elapsed ticks at trigger time
• Interpolate event ticks into the list of ticks vs. time to get event time
My Model

- We get a time tone every second
  - pretend GPS is perfect
- But we can't react to it until the next tick
- Time tones will not be an integer number of ticks apart
- But the GEM can only report integer separations
- Long term, elapsed ticks must add up to the right average value
- So we see dithering between 2 adjacent numbers
• We actually see dithering between 3 adjacent values
  – so there is some real scatter
  – but it's \(<\sim 1\) tick
• Also see long term drift in rate
• See my talk from 2006/06/30
Simple Approach

- Interpolate event time between time tones immediately before and after event
  \[ t_{\text{event}} = t_{\text{prevTone}} + \frac{(\text{ticks}_{\text{event}} - \text{ticks}_{\text{prevTone}})}{(\text{ticks}_{\text{nextTone}} - \text{ticks}_{\text{prevTone}})} \]
- This assumes no knowledge of when, within the reported ticks, the tones or event occurred
  - best estimate is that it happened in the middle
- We can never know, better than a tick, when the event was
- But we might be able to do better with the tones
- The error in the time assigned to an event by this method has a distribution with width = 3 ticks, \( \sigma = 0.5 \) ticks
  - it's the convolution of 3 1-tick-wide "box" distributions
Try Fitting Rate vs. Time

- If we fit (elapsed ticks between tones) vs. time, we may be able to get better estimates of tick rate
- Try fitting polynomials
  - increase order until $\chi^2$ stops decreasing
  - for run 077005067, this gave a 4th order polynomial
More Rate vs. Time

Residuals from linear fit
\[ \chi^2/\text{dof} = 2654/1799 \]

Residuals from 4\textsuperscript{th} order fit
\[ \chi^2/\text{dof} = 2292/1796 \]
Looks a lot like the expected width 2 triangle
Try Fitting Ticks vs. Time

- Maybe, if we fit ticks vs time instead of deltas vs time, we can fix the time of the tone to better than 1 tick
- If a 4\textsuperscript{th} order poly fits deltas vs time, a 5\textsuperscript{th} order fit should work for ticks vs time, right?

Or maybe not

Residuals from 5\textsuperscript{th} order fit
Tentative conclusions

- It looks like we can make better-than-integer estimates of tick rate vs time
- It's not clear that we can do so for ticks vs time
- Not clear how useful sub-tick measurement of rates is if it's not accompanied by sub-tick measurement of time tone arrival
- Maybe a linear, single-frame interpolation is the best we can do
- But I'm not giving up yet