Timing Tutorial

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Outline

- Reminder of Timing Problem
    - Previous Event Timing
- New time correction using PMC + USB ADU5 data
- GPS photo-shutter event time stamps
    - Method
    - Performance plots (Run 1028 & Run 1054)
- Introduction to new timed data
- Timing summary
- “Interesting” Features

The Infamous Timing Problem

- System clock had no battery
- Used the G12 as the absolute time reference (via NTP)
  - G12 unit stopped working above 60,000 feet
  - CPU time (payloadTime) disconnected from real world time (realTime)
- But...
  - Have GPS time of day stamps on the position data from the ADU5 (but only time within day)
  - Used this information to try and map payloadTime on to realTime.
    - Day ambiguities in places

Event Timing Primer

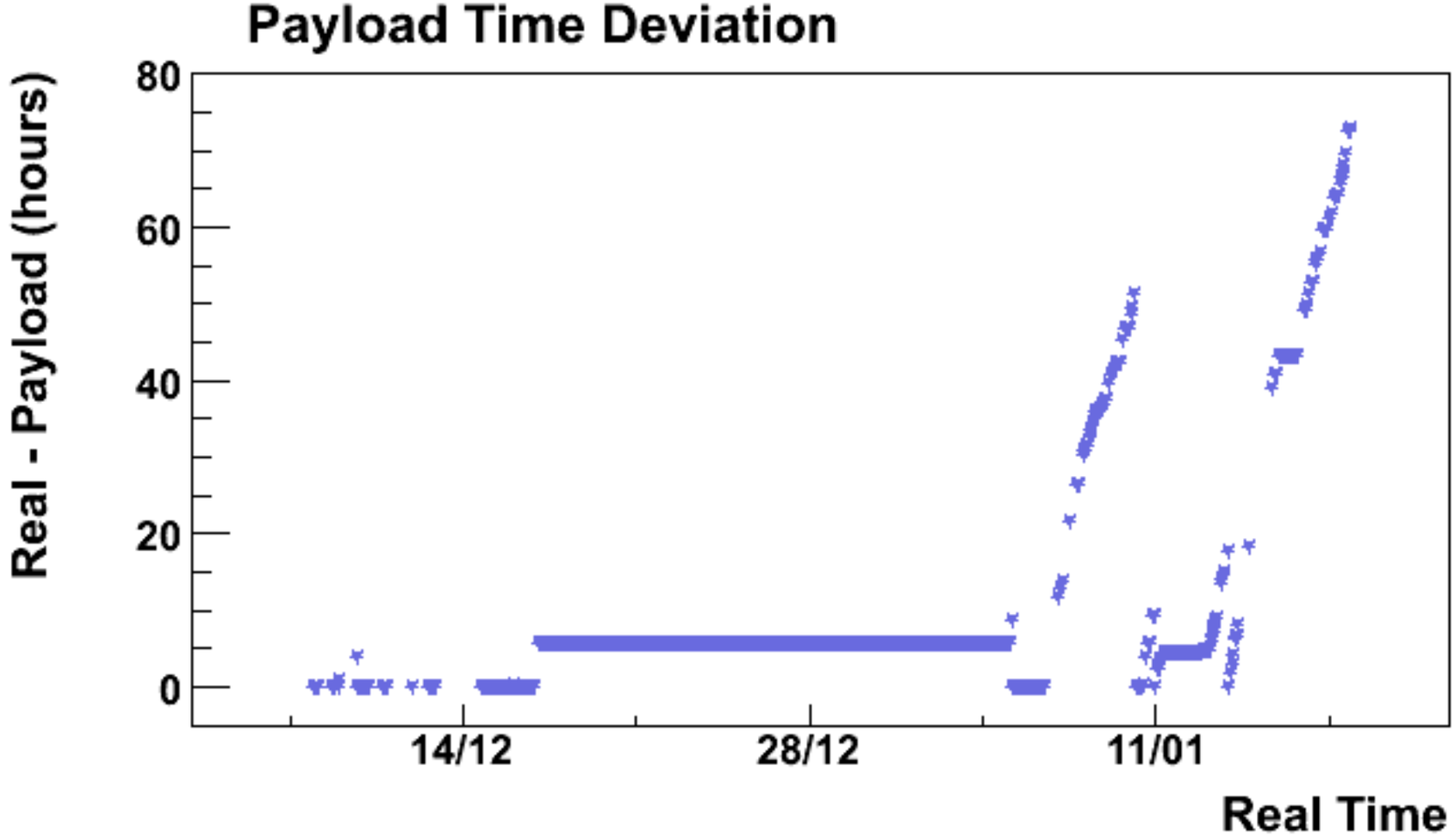
- Events have up to three time stamps
  - The payloadTime they were read out.
  - Relative time from TURF that the trigger occurred
    - TURF clock is policed by ADU5 via PPS
    - Some events have GPS photo-shutter time tag from ADU5
      - Only ~40% of events (in theory should be 50%, but there are inefficiencies and data losses)
      - Previously unused as the onboard matching broke down due to the large realTime to payloadTime differences.

Event Timing Primer

- The header ROOT files has many times:
  - payloadTime -- time of readout in seconds from CPU clock
  - payloadTimeUs -- microseconds of the same
  - realTime -- payloadTime mapped in to realTime using lookup function
  - ppsNum -- Number of seconds (actually number of ADU5 PPS pulses received) since last ClearAll from TURF
  - trigTime -- Sub-second of trigger from 133MHz TURF clock
  - triggerTime -- Attempt to map ppsNum to realTime (better than realTime but not very robust)
  - triggerTimeNs -- Conversion of trigTime to ns

Payload to Real Time

- Data from the PMC drive helped to resolve day ambiguities in USB data set (as some shorter runs were written to the fast PMC and not the slow USB).
- The uncertainty on the correction is generally, ± 1 second



GPS Photo-Shutter Timing

- From the disks we had 2427200 GPS event time tags that were disassociated from the events.

- In order to match the GPS times to the events need to:

1) Create time-ordered list of GPS time tags within each run (made more difficult by a bug which set the day of the time tag to the payload time day rather than the real time)

2) Create a list of event epochs (i.e. sets of events between ppsNum resets where the ppsNum --> gps second conversion will be the same)

3) For each epoch test a series of ppsNum -> gps second conversions to find which is optimal.

4) Apply this conversion to create new trigger times.

GPS Photo-Shutter Timing

- Points to note:

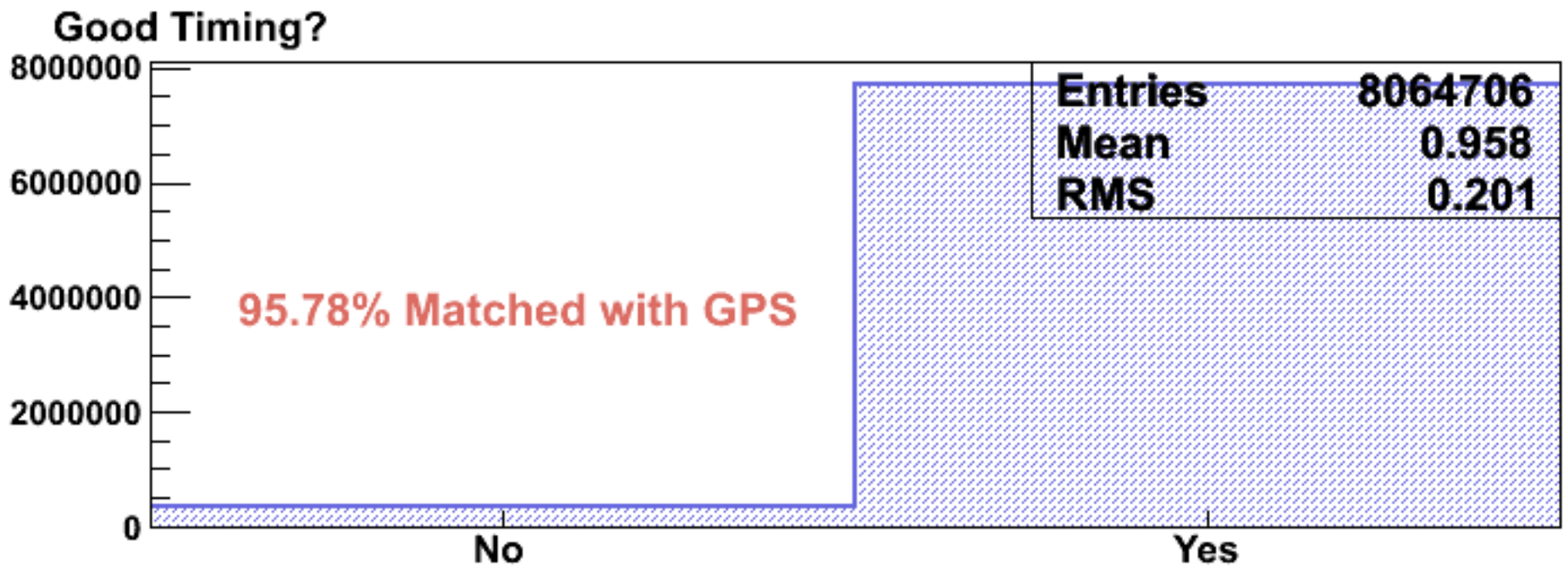
  i) Neither data set is complete (ie. have both events with missing gps time tags and gps time tags for missing events)

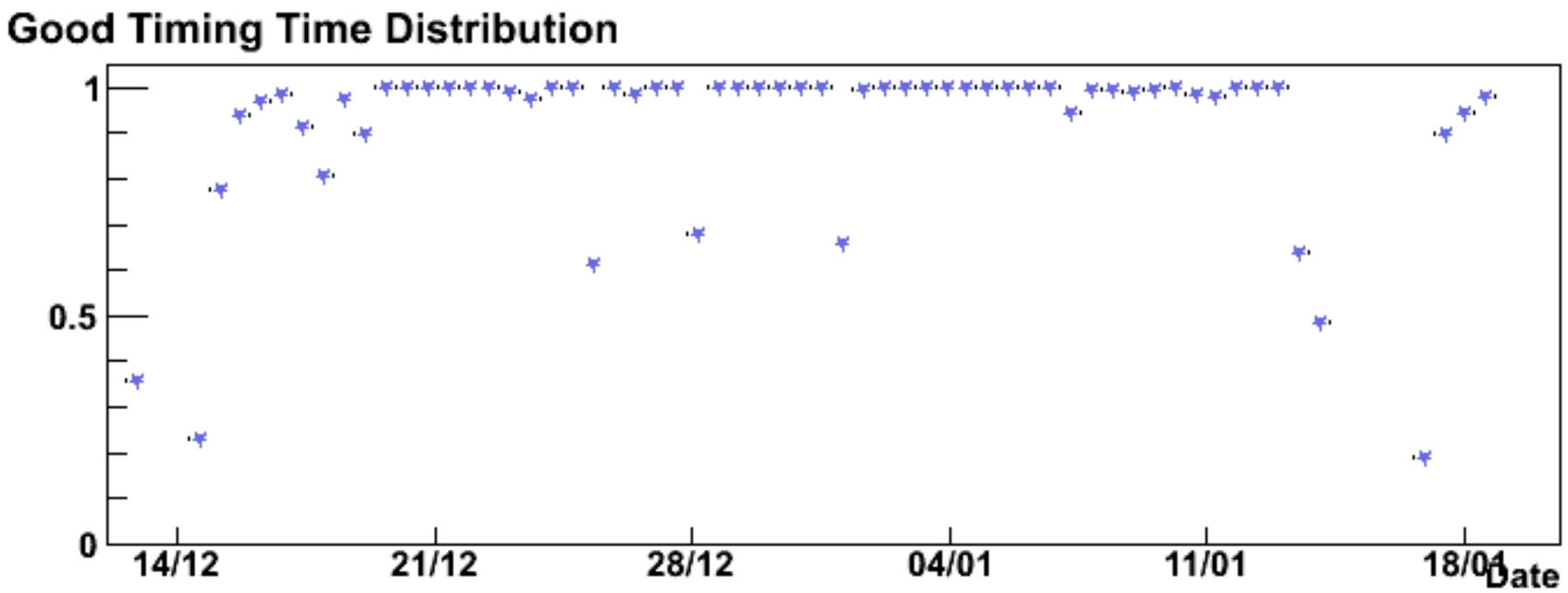
  ii) During periods of regular (i.e GPS) triggers many hypotheses provide good figures of merit.

  iii) For some epochs no good match was found so one has to “guess” what the correct ppsNum --> trigger time conversion is.

  iv) There are periods of seemingly unreliable TURF data (where the ppsNum counted at a seeming multi Hz rate), for this data have to rely on the readout time.

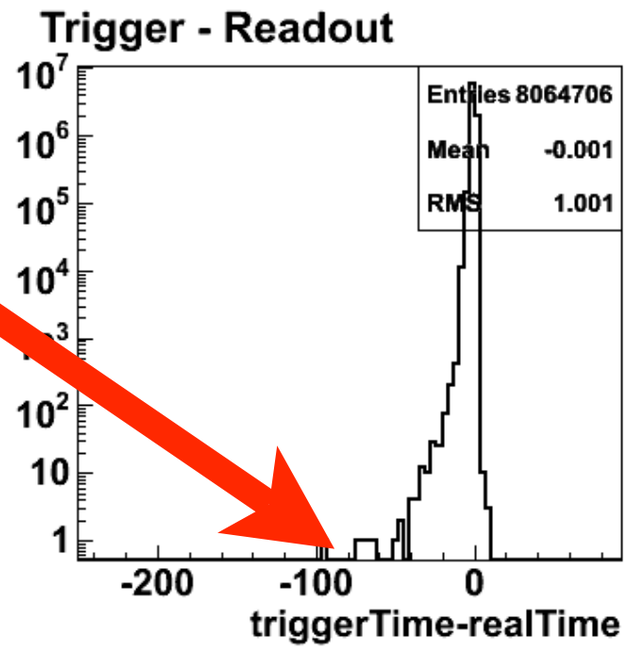
Overall Performance Plots

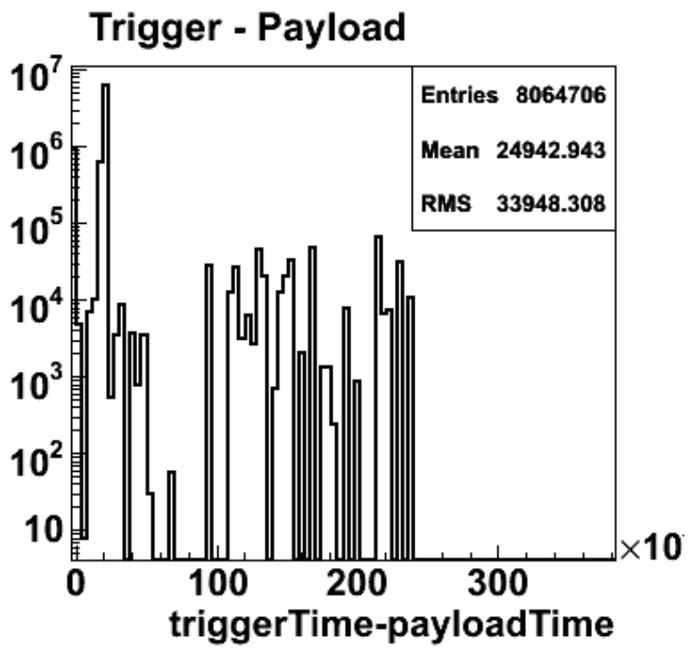


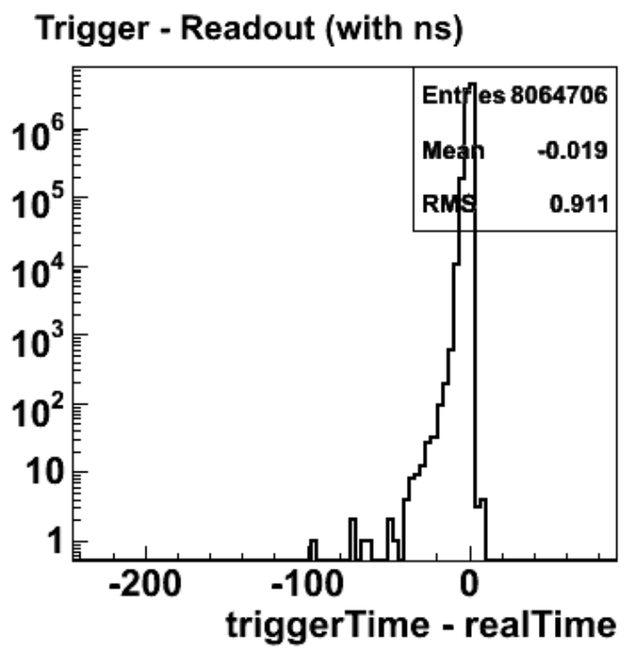


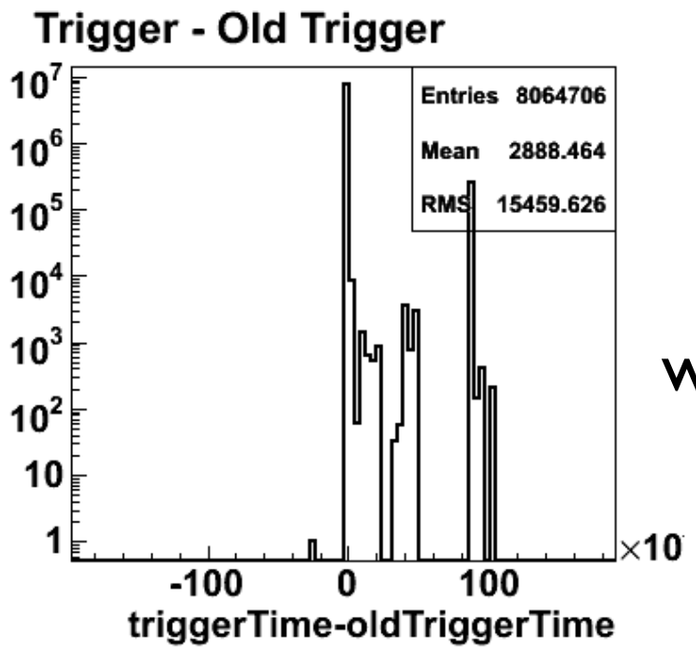
Timing Plots

CPU really goes AWOL for over a minute!



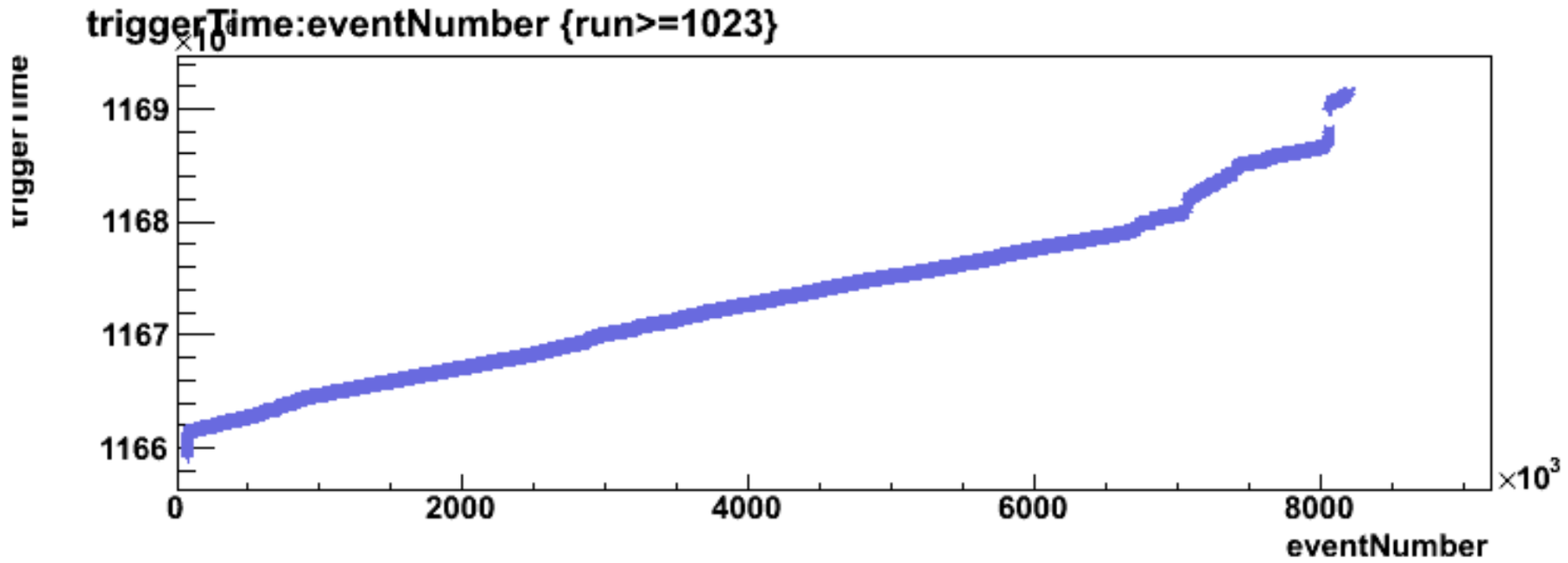


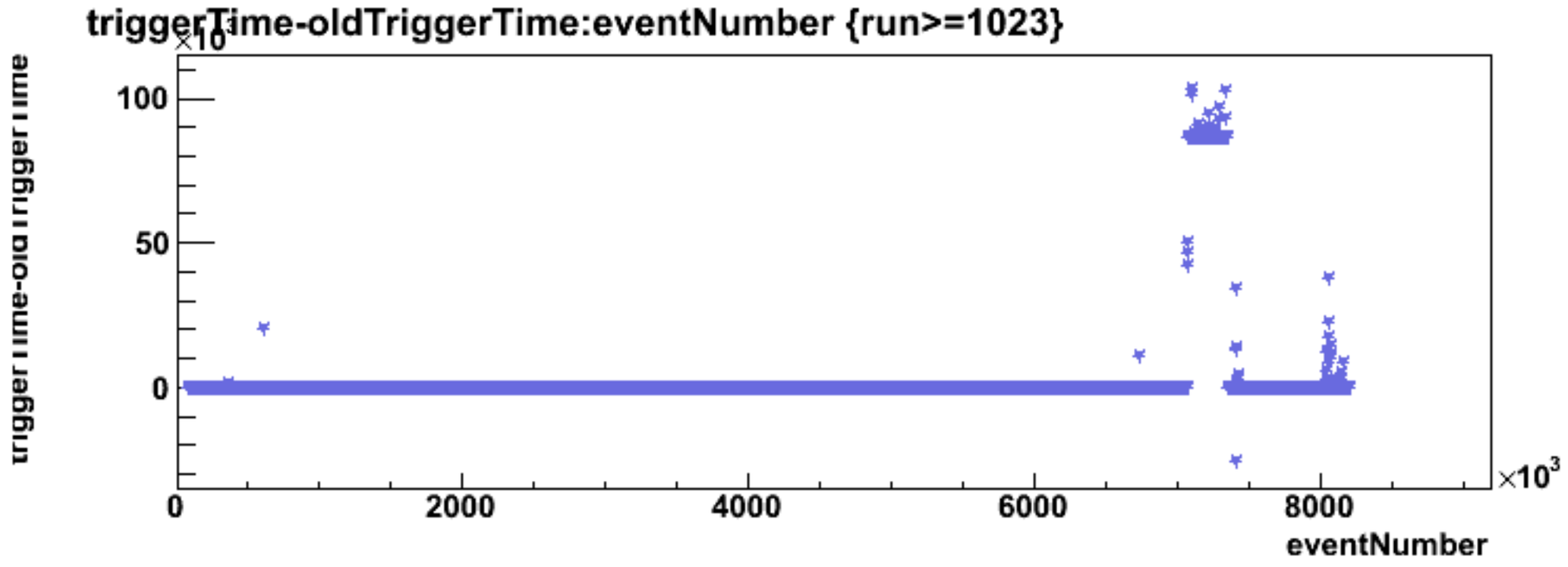




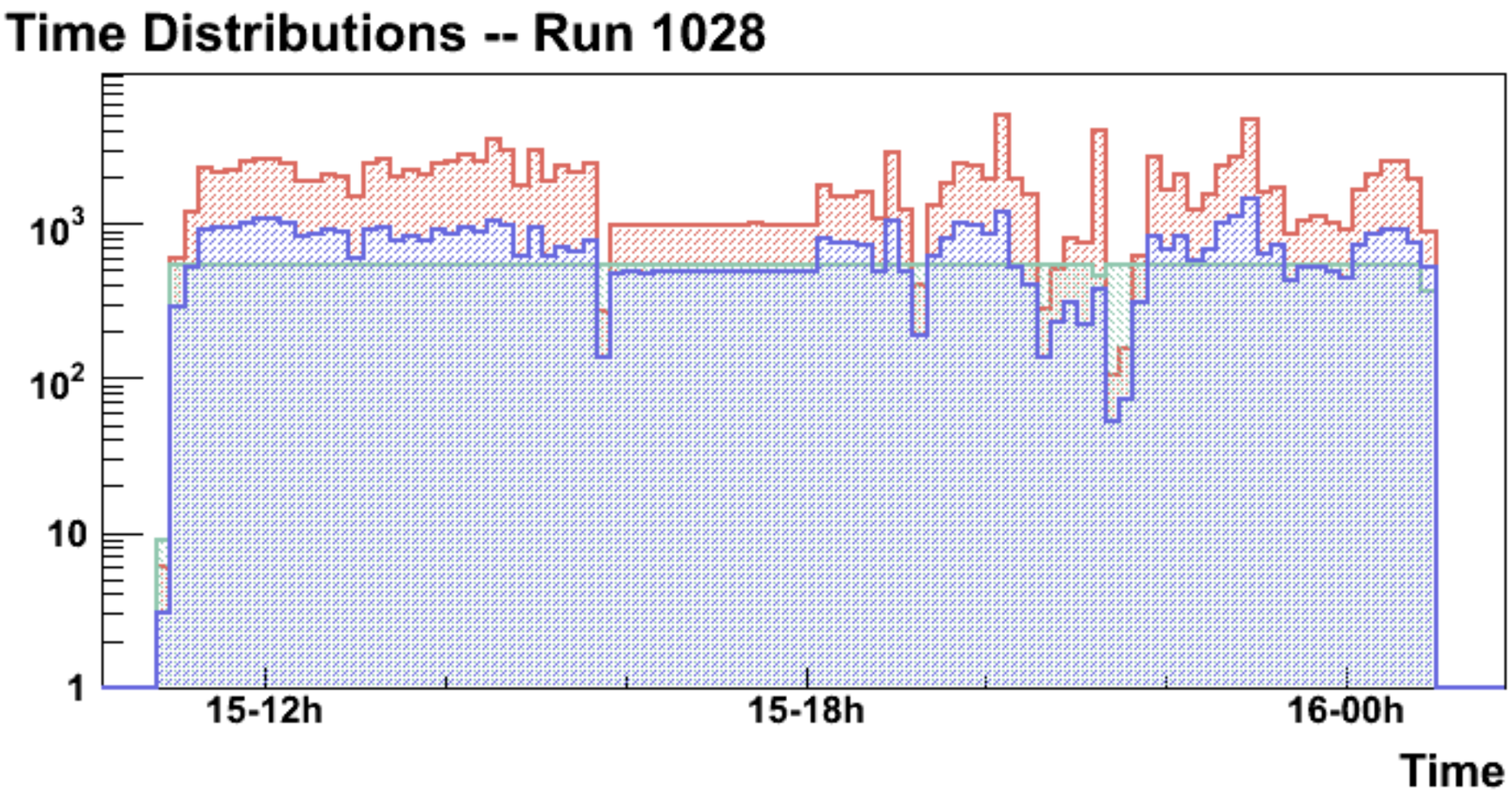
Some runs had the wrong day with the previous timing

More Timing Plots

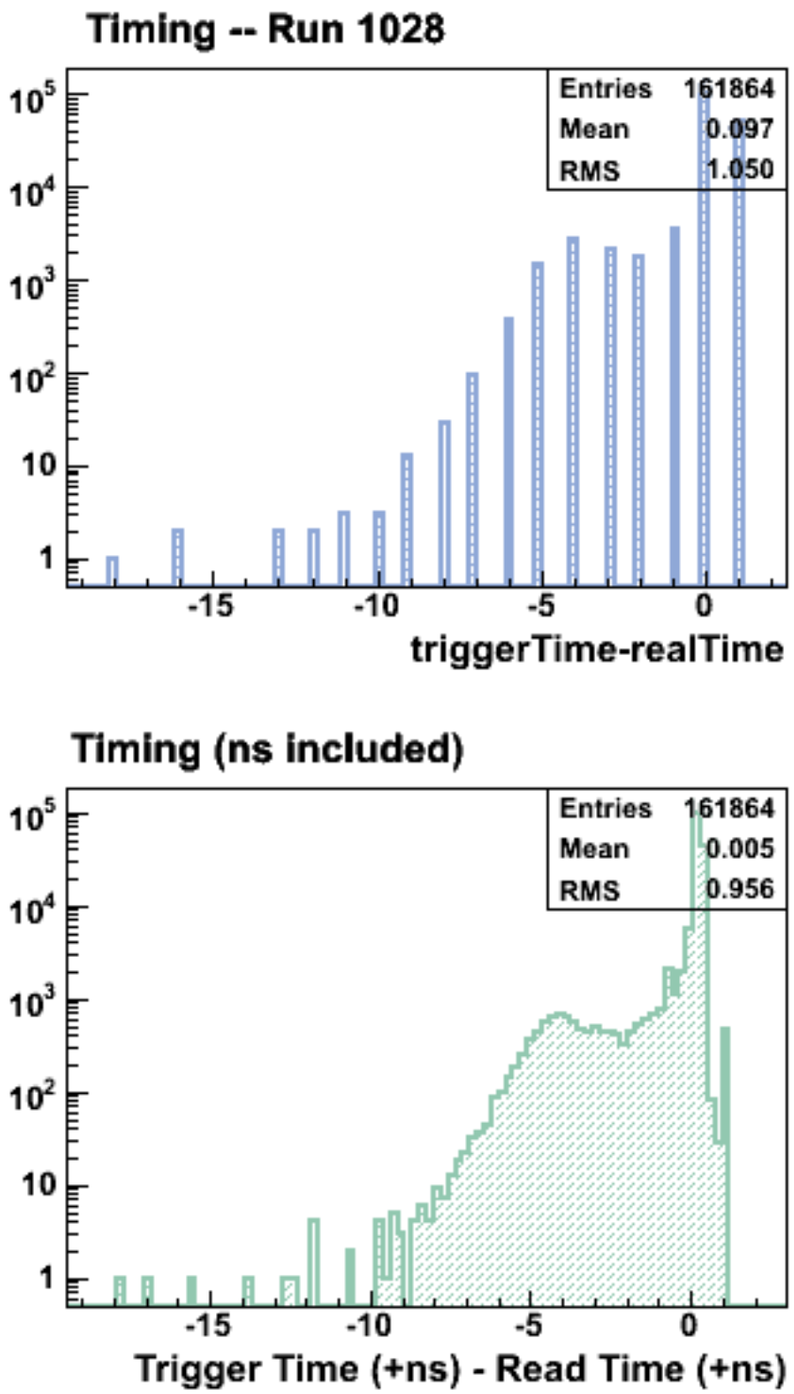


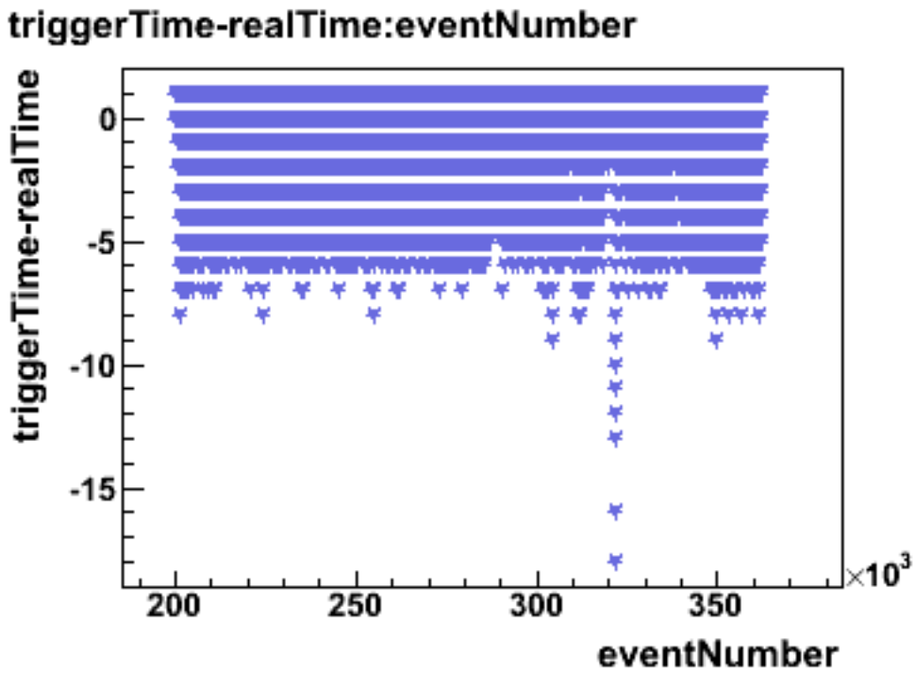


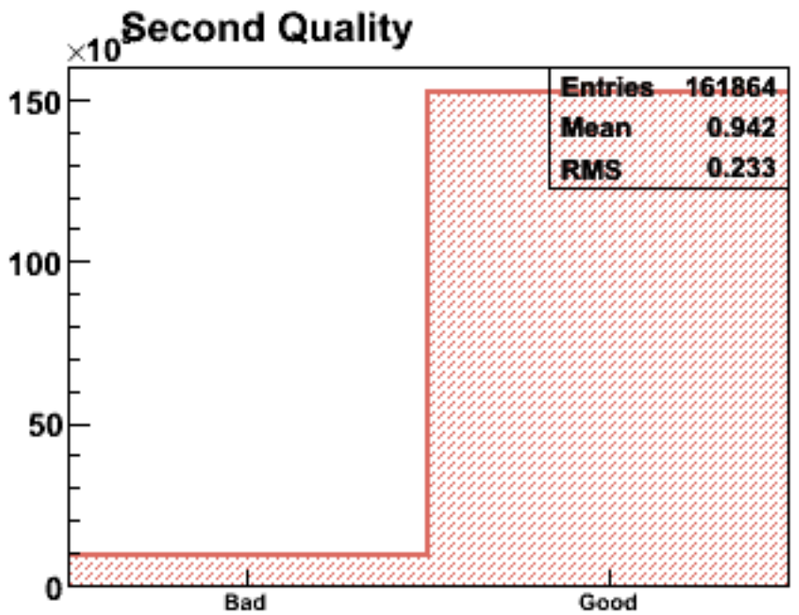
- Red is new Trigger time
- Blue is GPS photo-shutter time tag
- Green is ADU5 Position (read at 1Hz)



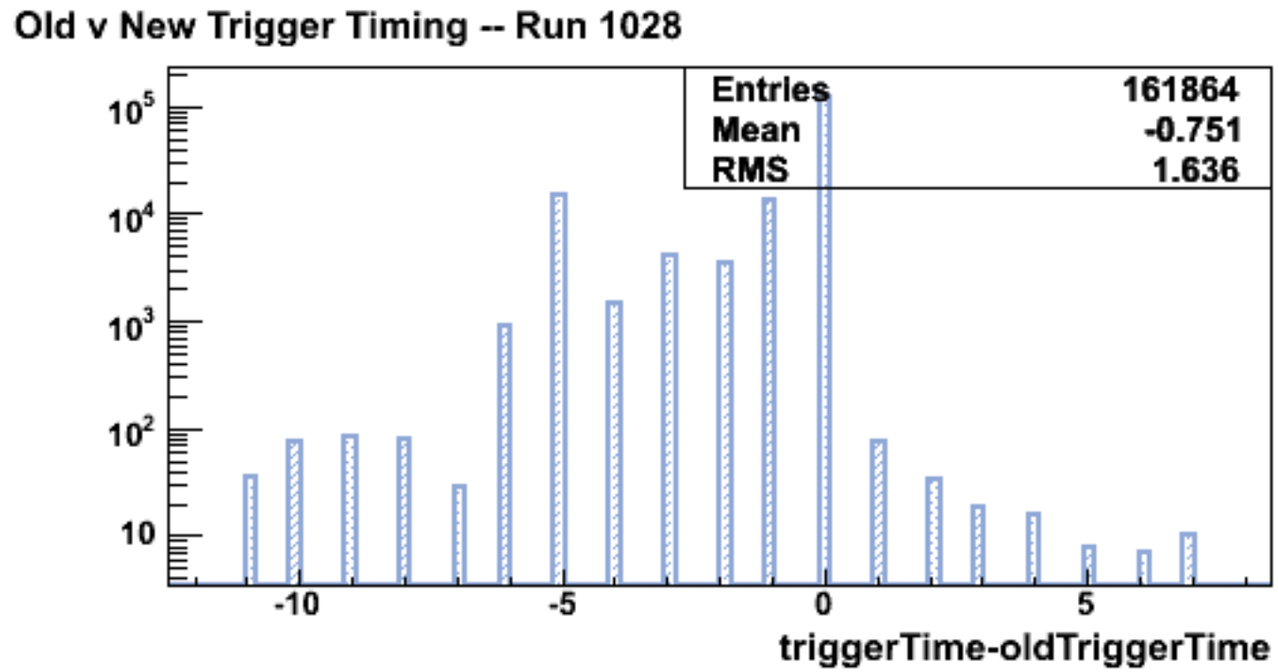
Run 1028 (cont.)

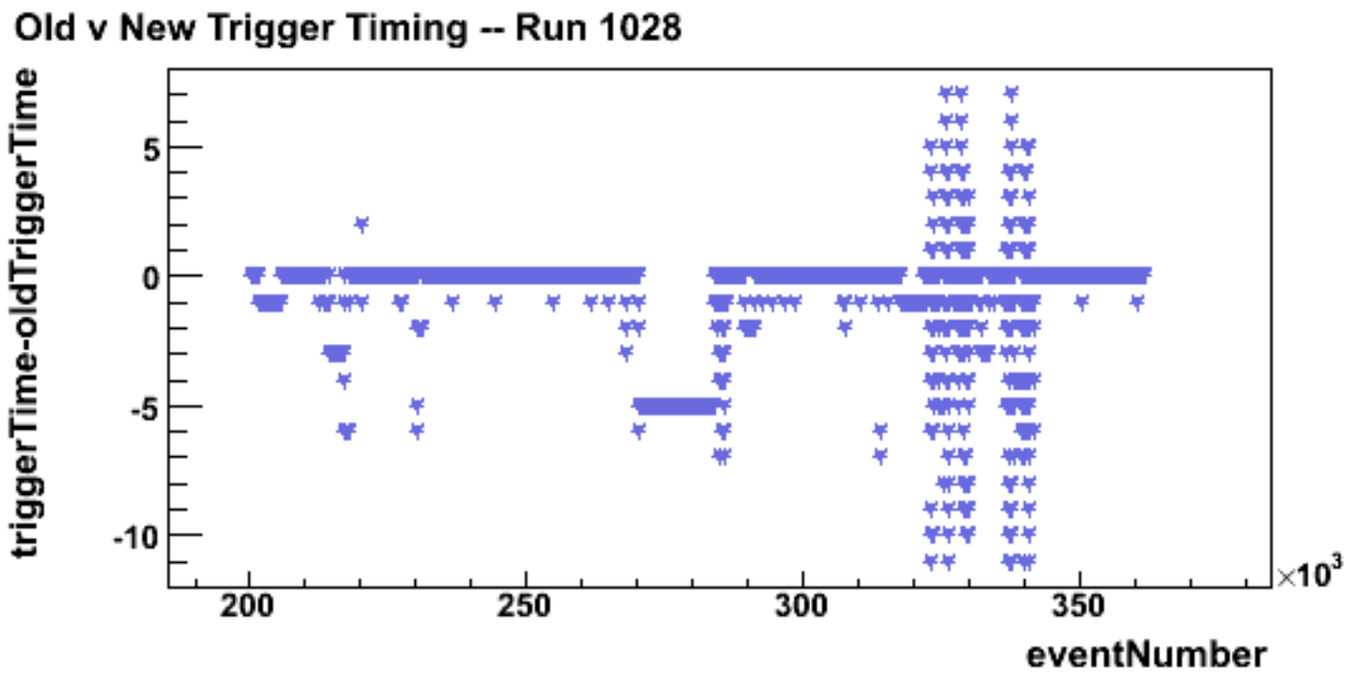




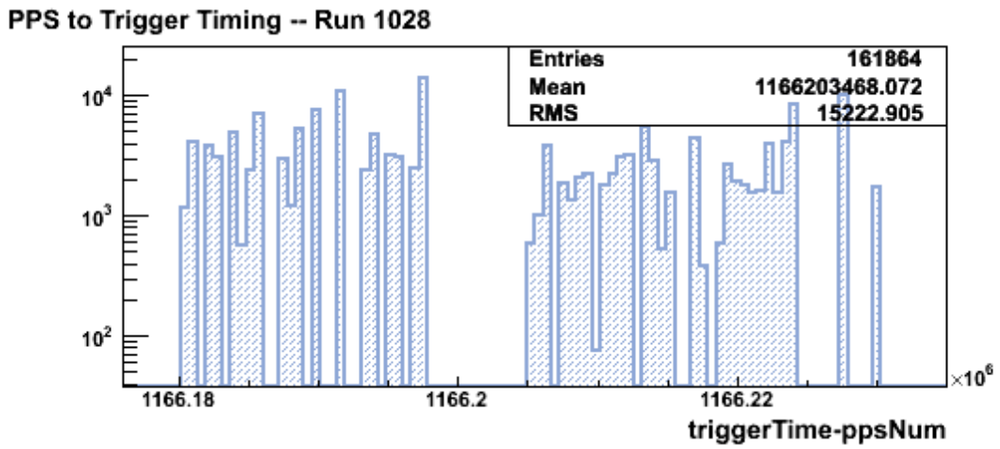


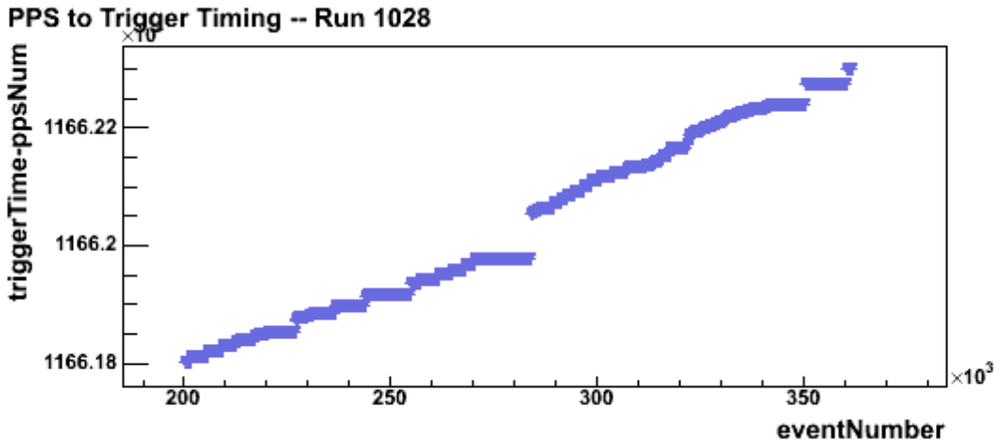
Run 1028 (cont)

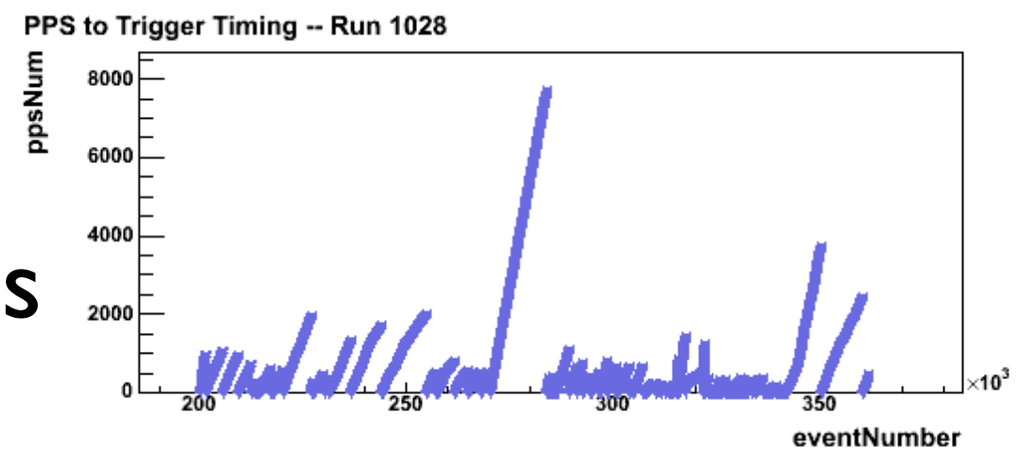




Run 1028 (cont)



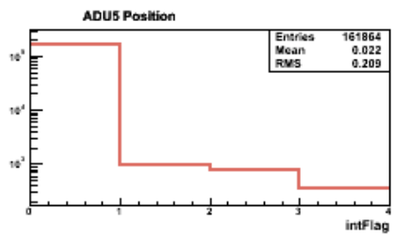


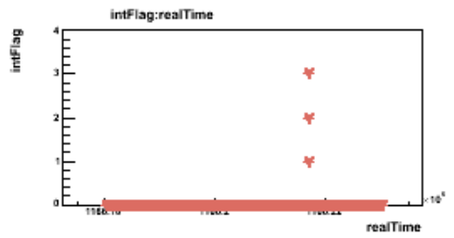


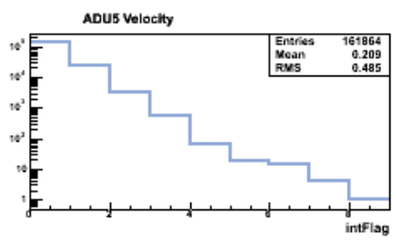
Many short runs

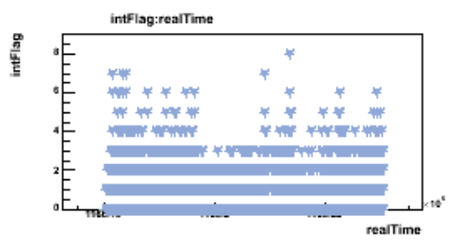
Run 1028 (cont.)

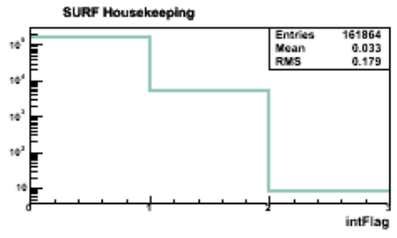
Interpolation time to nearest housekeeping reading.

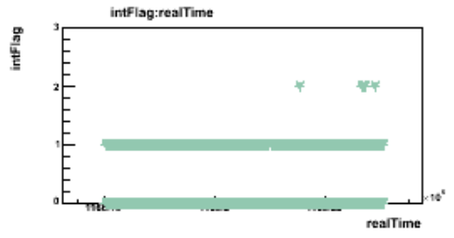


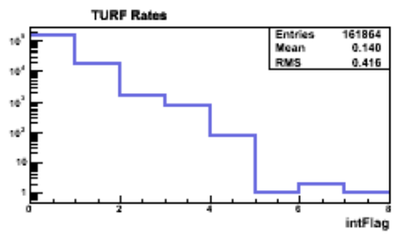


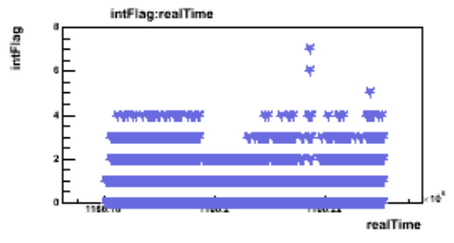


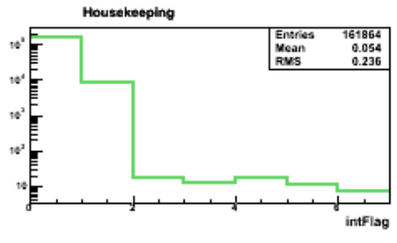


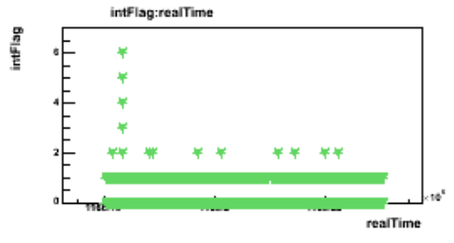




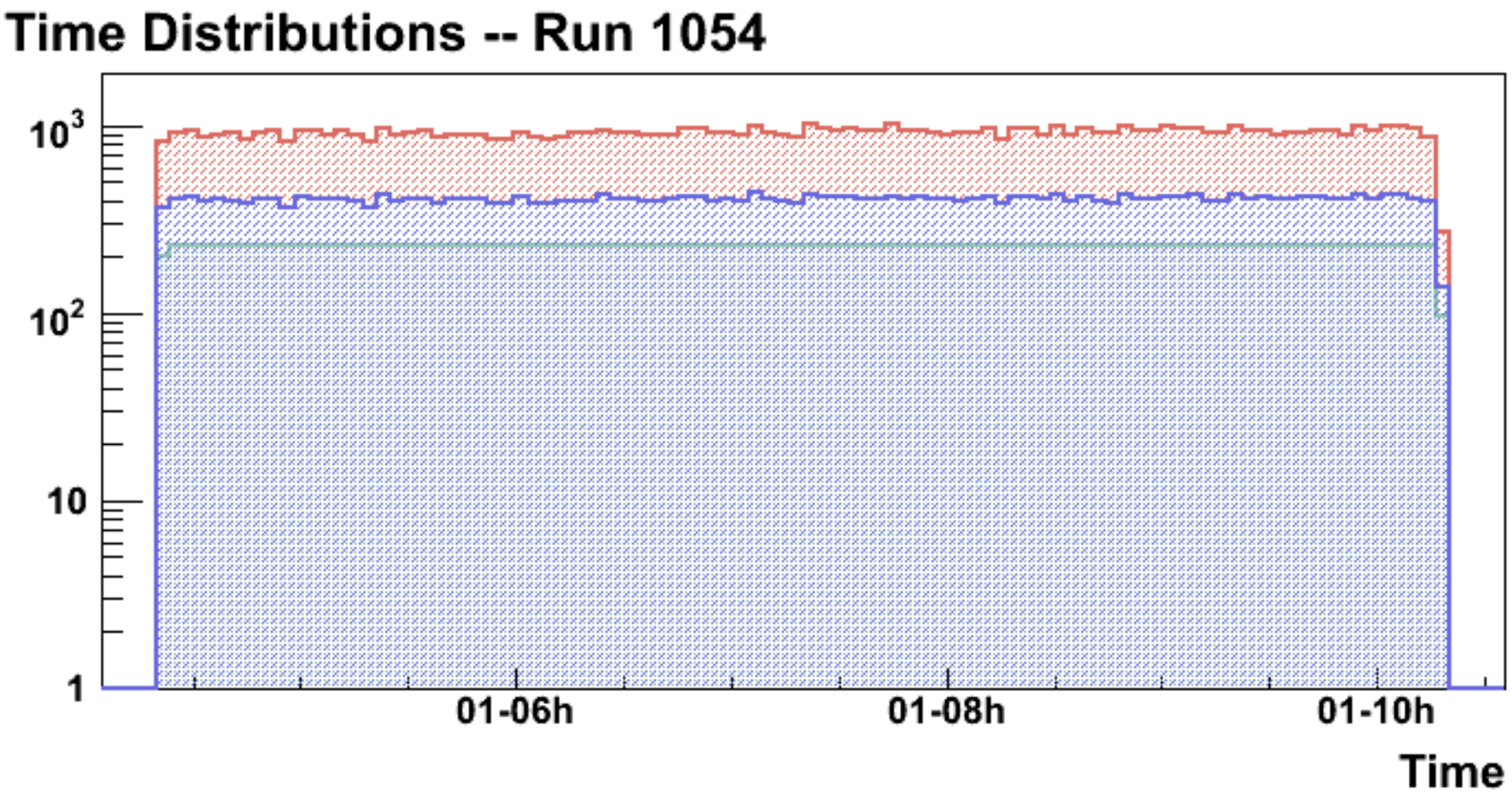




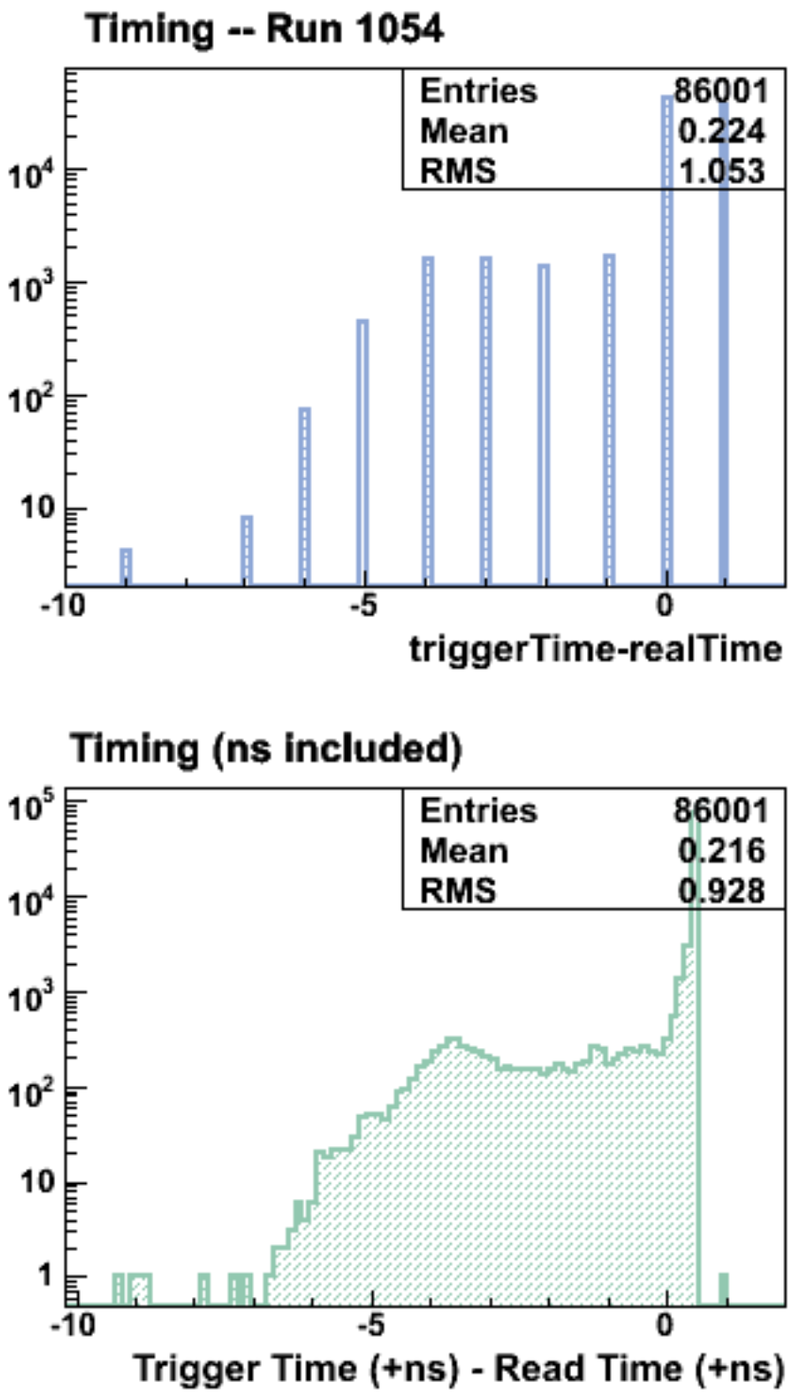


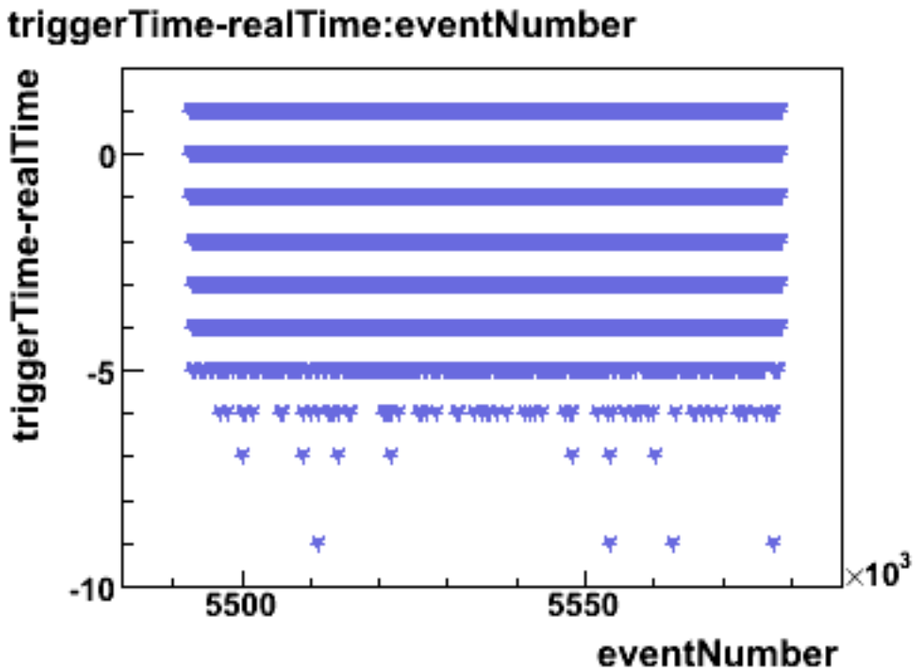


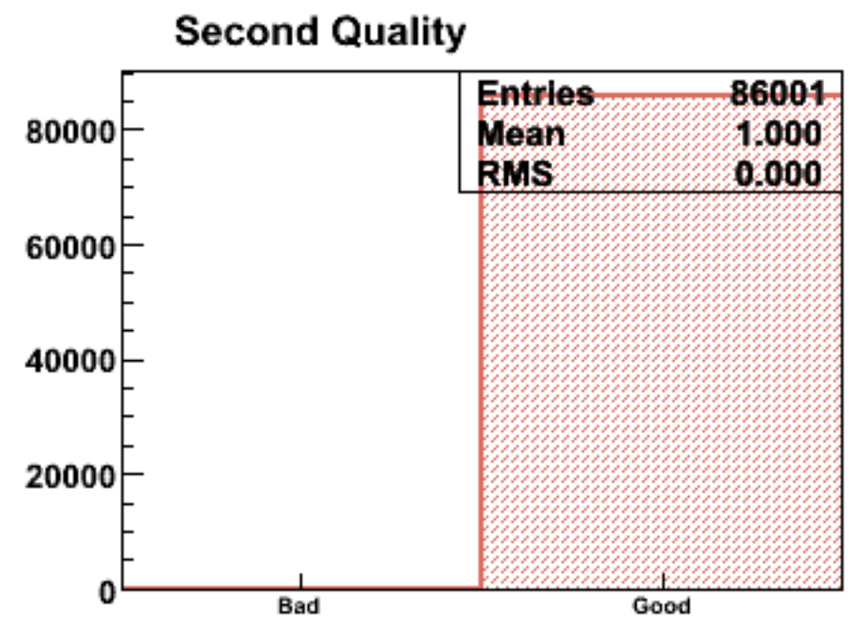
Run 1054


Time Distributions -- Run 1054
10^3
10^2
10
1
01-06h
01-08h
01-10h
Time

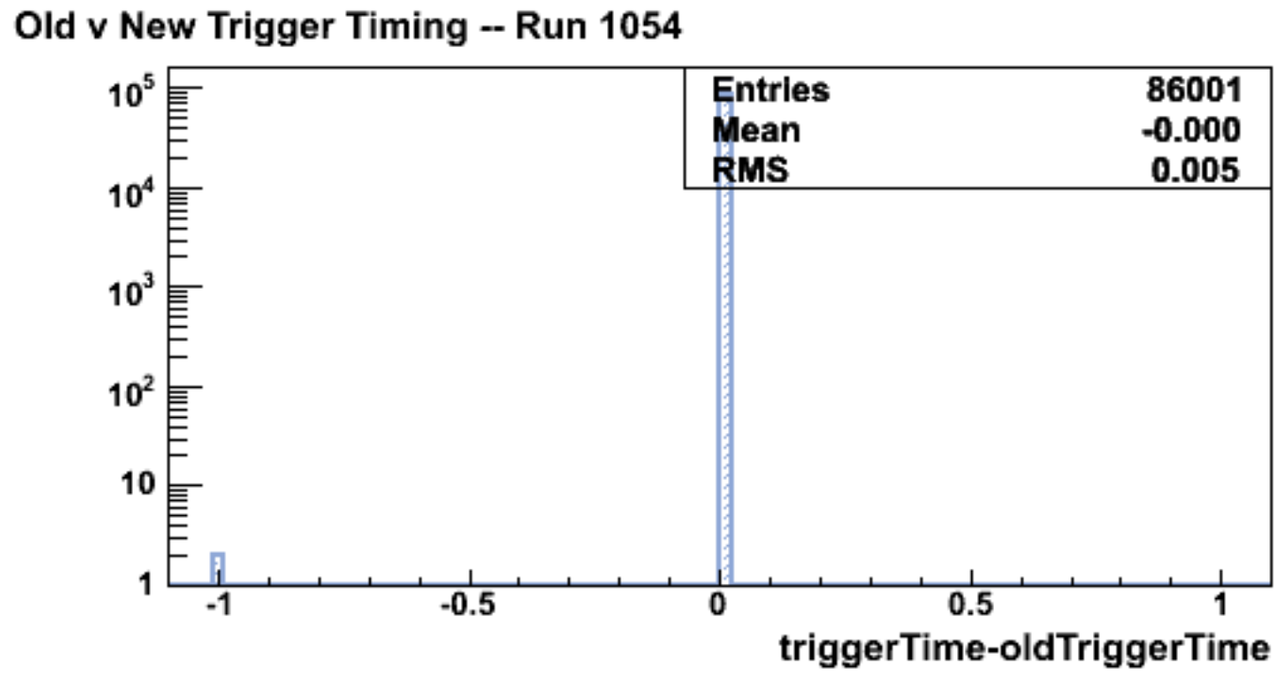
Run 1054 (cont)

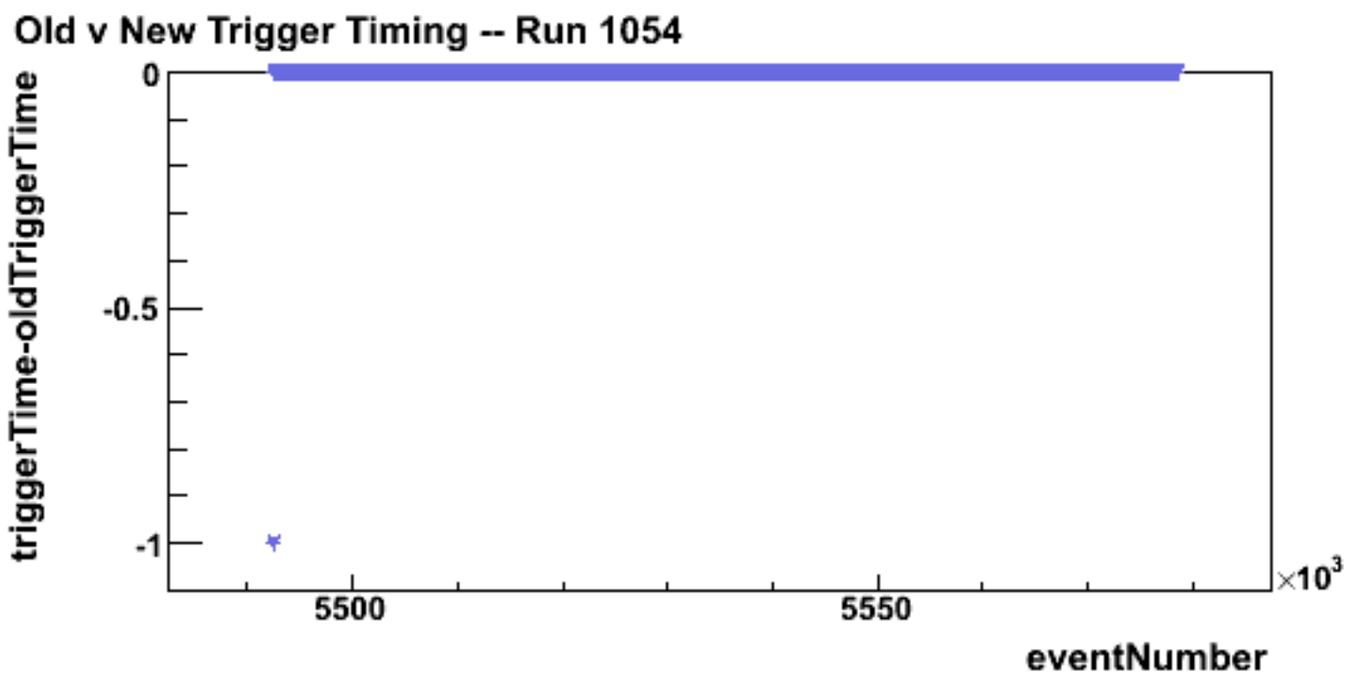




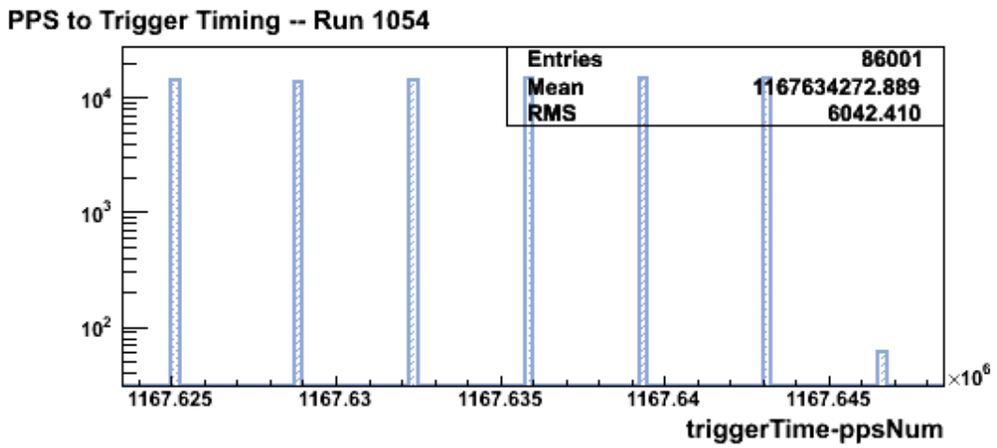


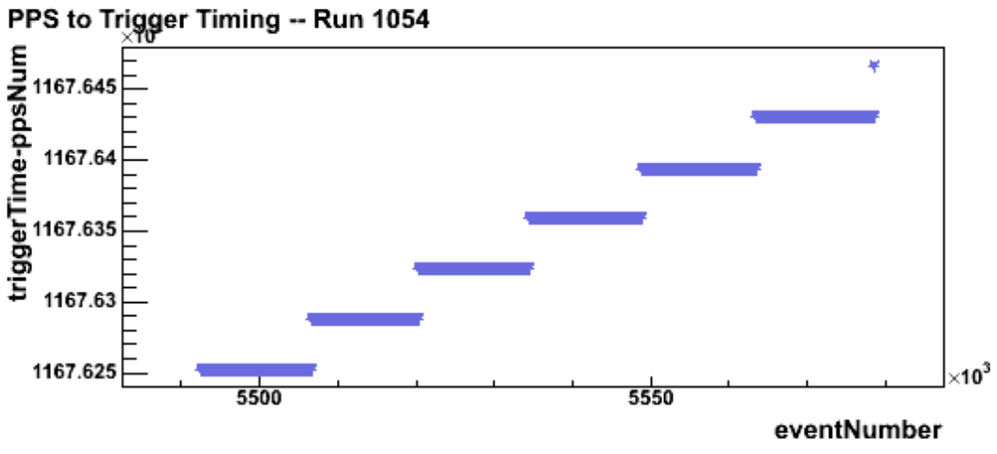
Run 1054 (cont)

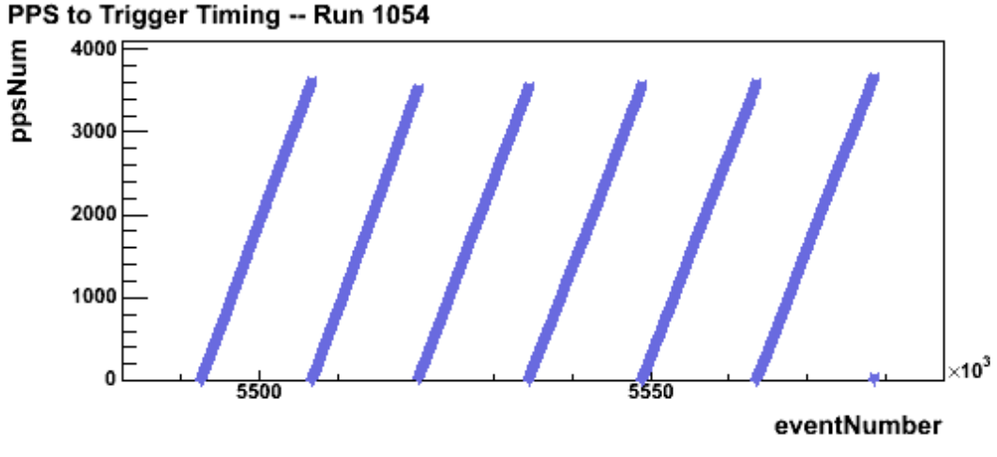




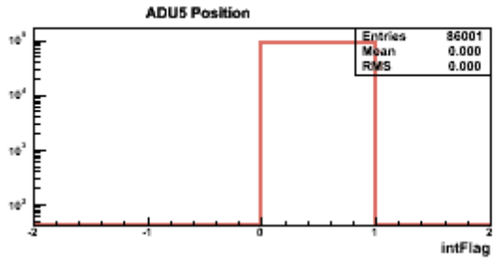
Run 1054 (cont)

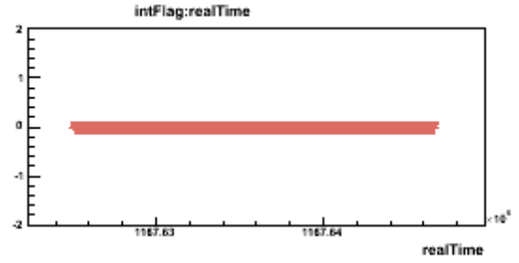


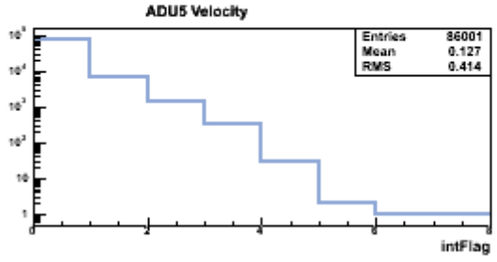


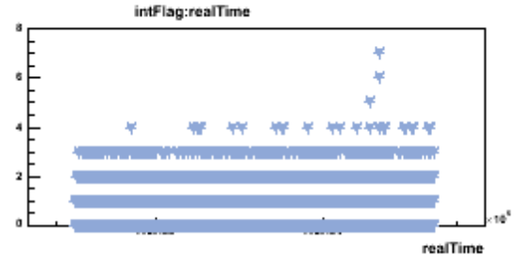


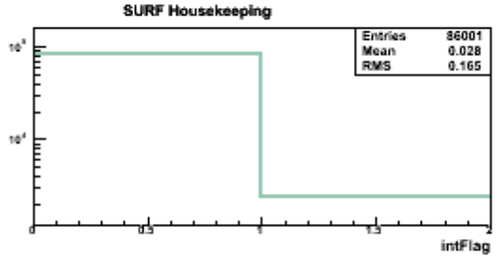
Run 1054 (cont.)

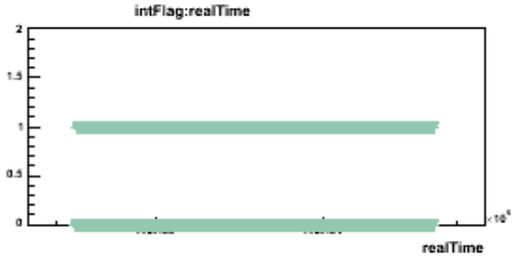


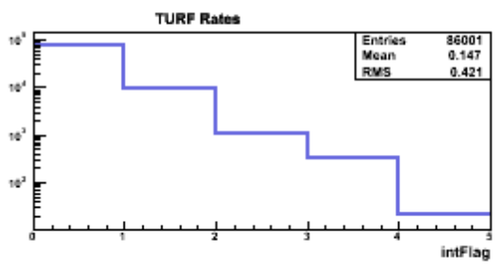


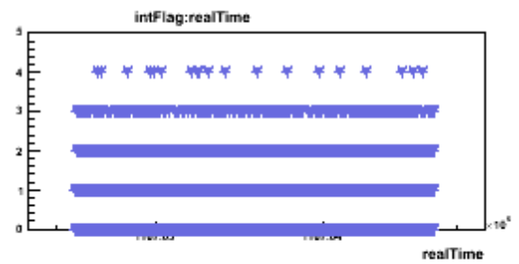


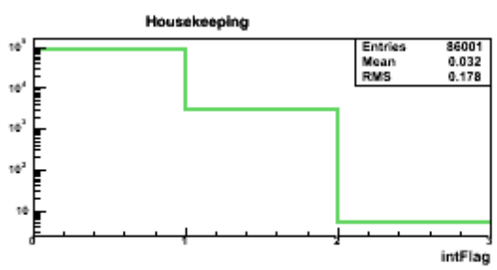


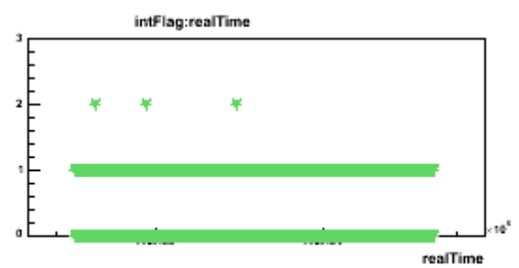












New (Re-Timed) Data Available

- The following data sets are available:
  - The new payload --> real time function (E-Log 331)
    - http://www.phys.hawaii.edu:8080/anita_notes/331
  - New header and housekeeping root files (as complete hk files, interpolated hk files and interpolated initial 10% files -- the latter two of which can be downloaded as tar files).
    - http://www.physics.ohio-state.edu/anita/private/flightData/newTimes/
  - Text files for raw data users who want the new times
    - http://www.physics.ohio-state.edu/anita/private/flightData/newTimes/timeLists/

Event Timing Summary

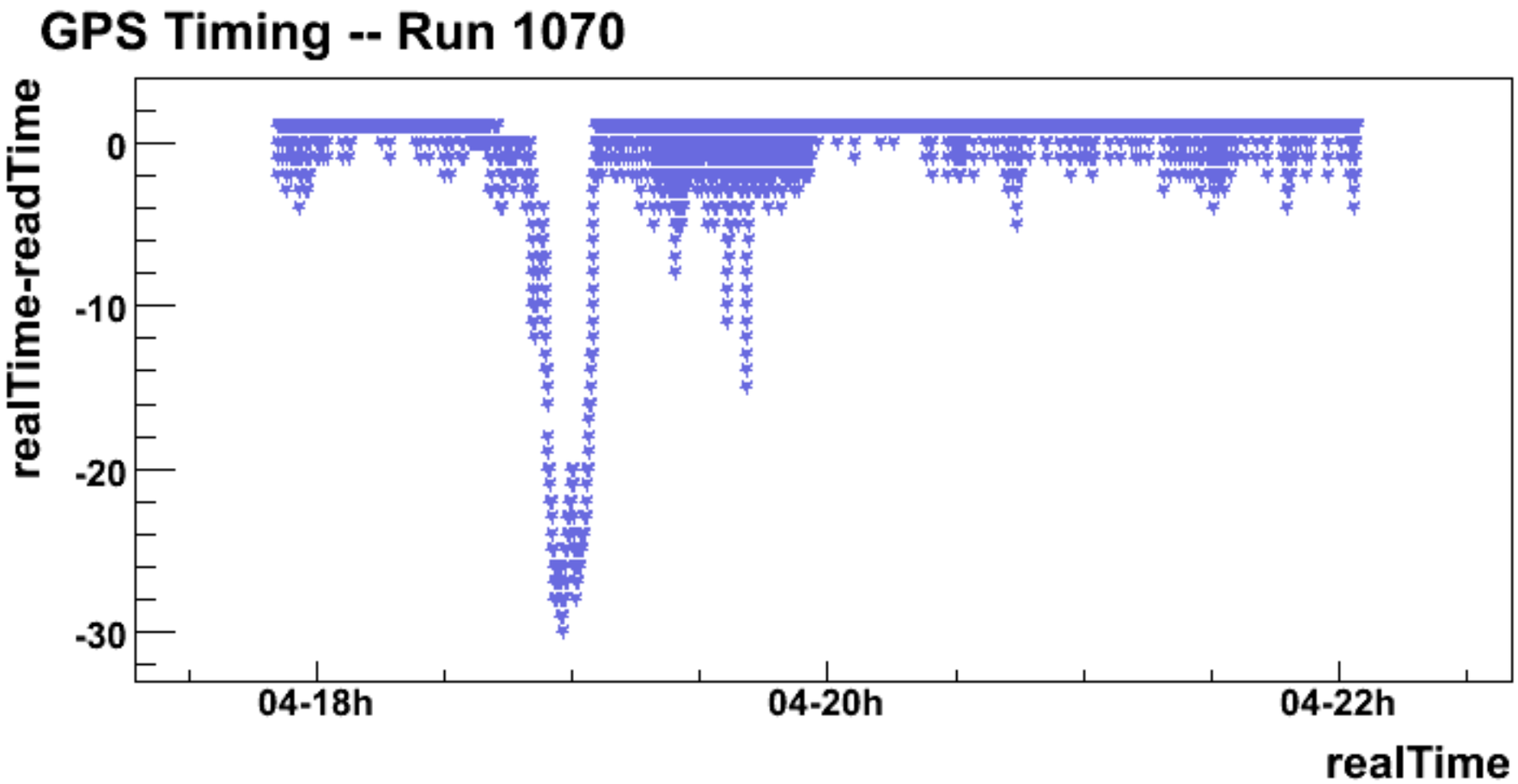
- Everyone is encouraged to use:
  - triggerTime and triggerTimeNs for event timing
- The following flags in the ROOT files can be checked for timing quality:
  - secQualFlag (1 == good gps timing, 0 == guessed epoch time)
  - goodTimeFlag (0 == good ns timing, 1 == bad ns timing)
  - otherFlag2 (0 == good, 1 == possible sync slip)
- (I realise that secQualFlag switches up the convention but there you are, that's how it is.)

Timing Summary

Type	Variable	When	Quality Flags
Header	triggerTime triggerTimeNs	Trigger (from TURF clock)	secQualFlag goodTimeFlag otherFlag2
ADU5 Position	realTime (on second boundary)	Acquisition (i.e. direct from GPS)	intFlag (interpolated data only)
ADU5 Velocity	realTime payloadTimeUs	CPU Readout Time (i.e always late)	intFlag (interpolated data only)
Housekeeping	realTime payloadTimeUs	Start of Acquisition Loop	intFlag (interpolated data only)
SURF Hk	realTime payloadTimeUs	Start of Acquisition Loop	intFlag (interpolated data only)
TURF Rate	realTime payloadTimeUs	CPU Readout Time (i.e. always late)	intFlag (interpolated data only)

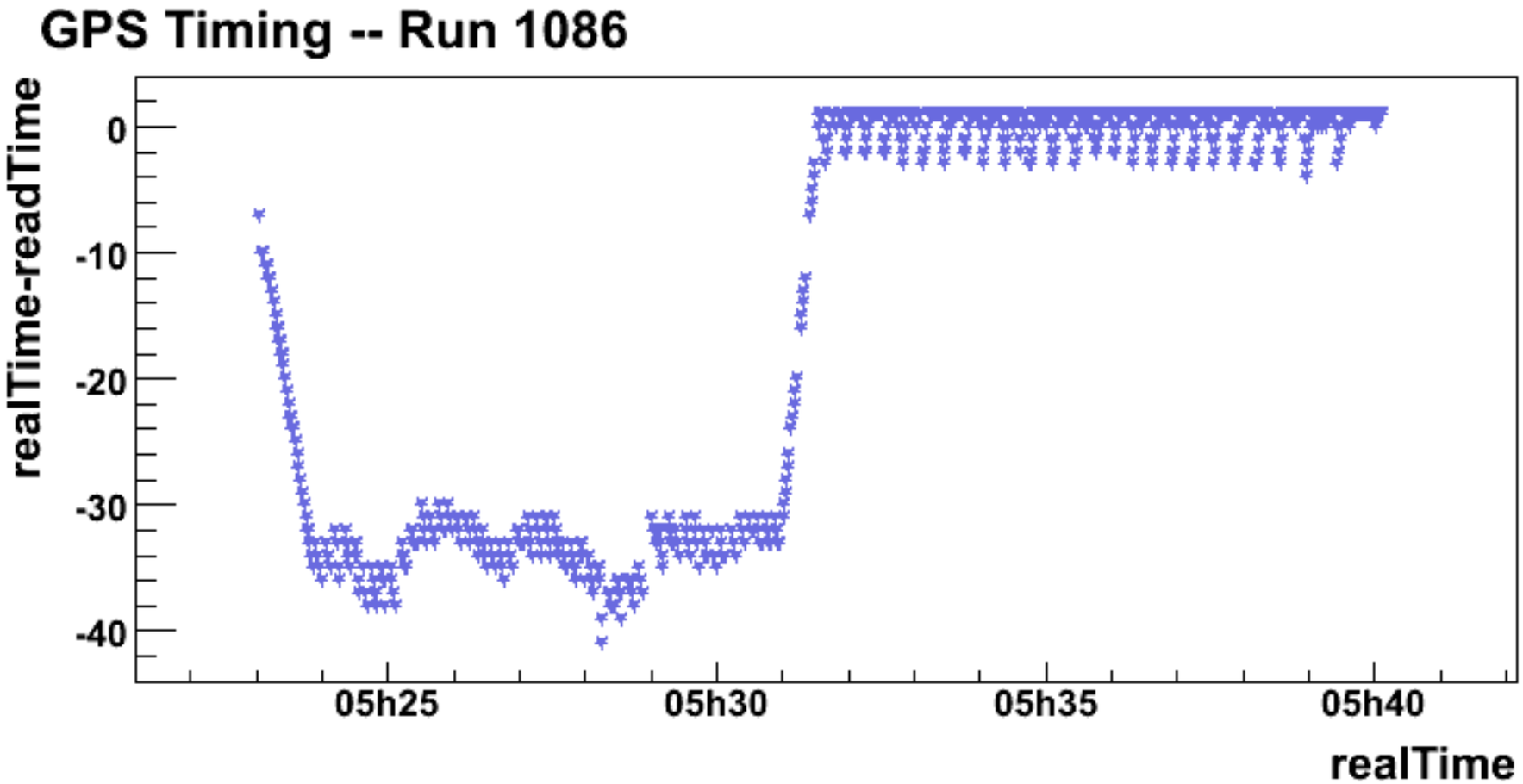
“Interesting” Plots -- Missing CPU

- Where did the CPU go?



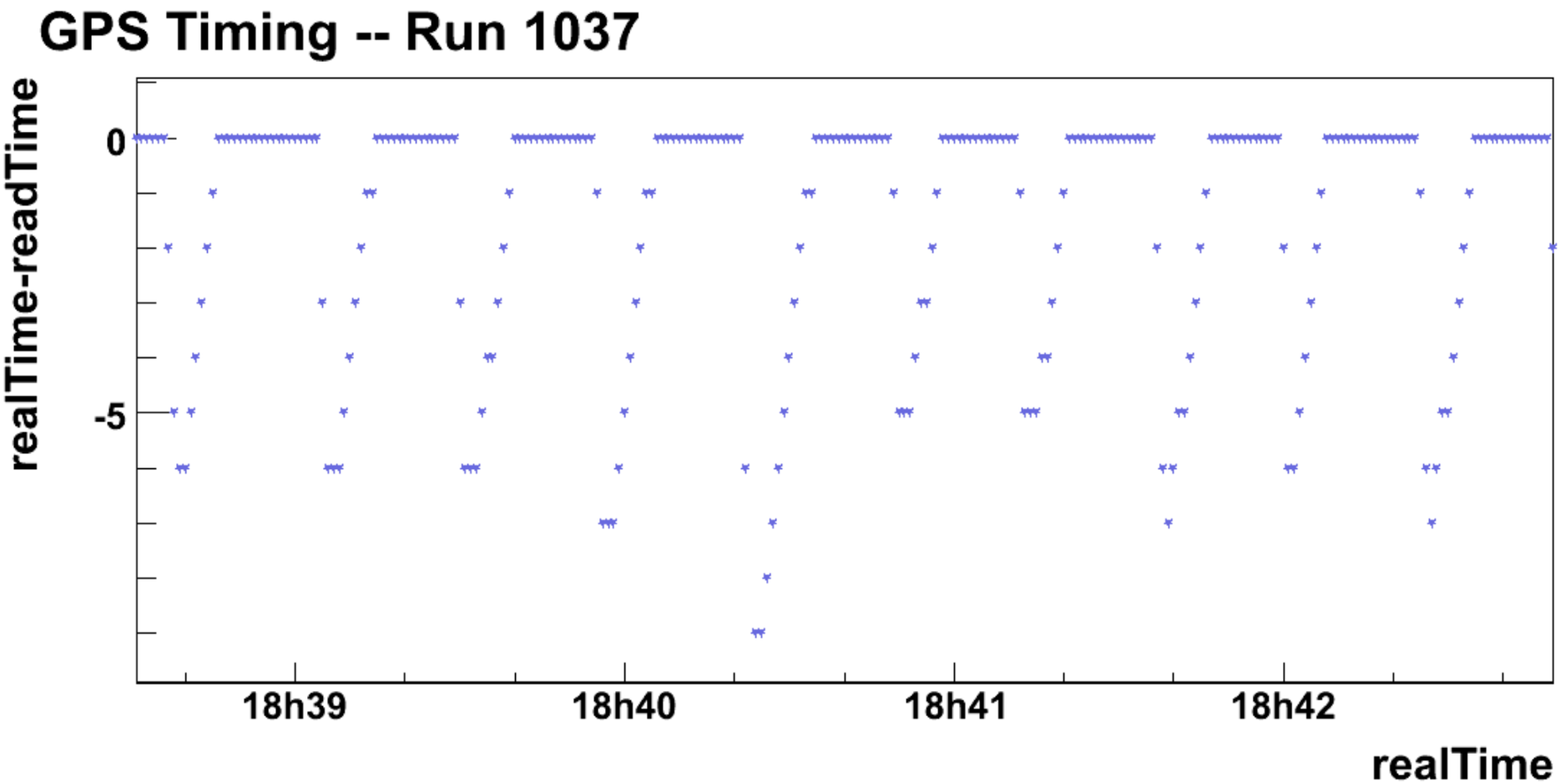
Missing CPU 2

- Why did it recover after six minutes?

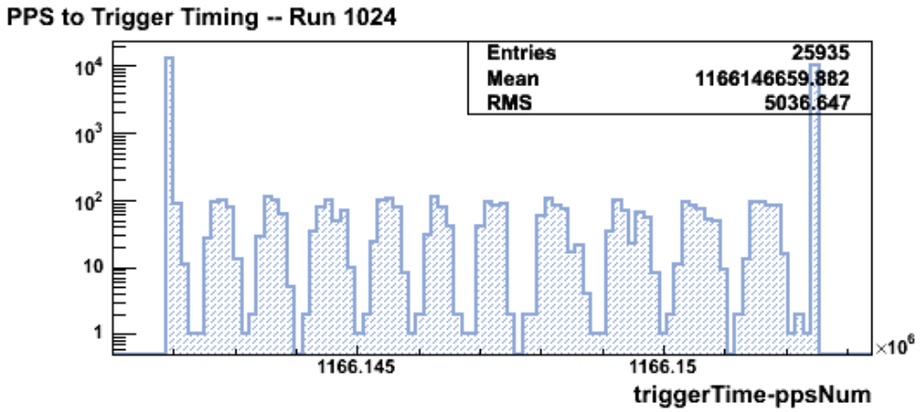


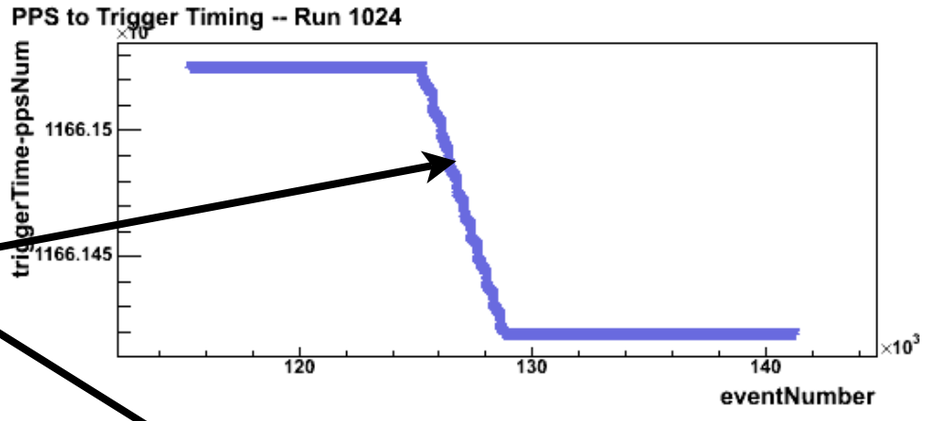
Missing CPU 3

- In zoomed plot notice the repetitive nature, GPSd is keeping up with the ADU5 packets and then disappears for 5-10 seconds.
    - Writing to disk?

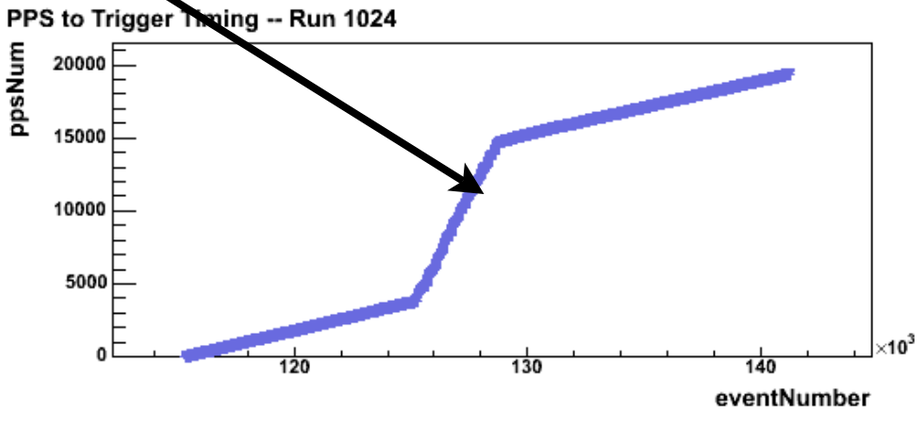


Strange TURF PPS





What happened?



GPS off?
TURF crazy?

More Plots

- Many more plots at:
  - http://www.hep.ucl.ac.uk/~rjn/anita/timing
- ROOT and Timing Data at:
  - http://www.physics.ohio-state.edu/anita/private/flightData/newTimes