Coincidence Analysis with UD of GP13

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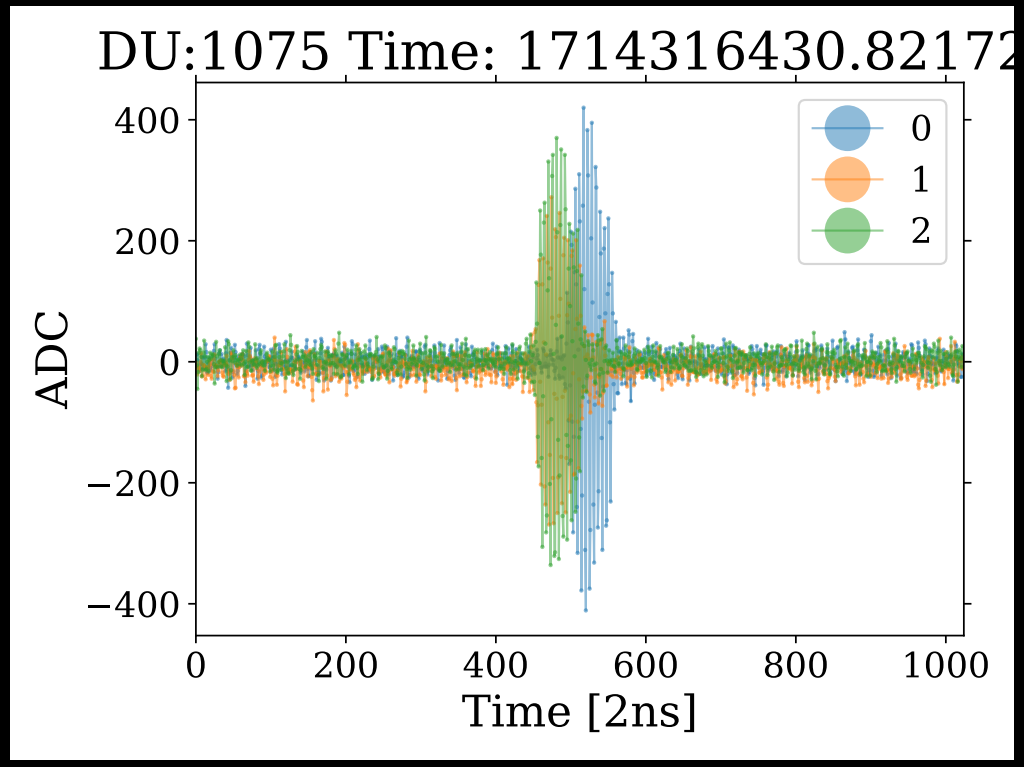
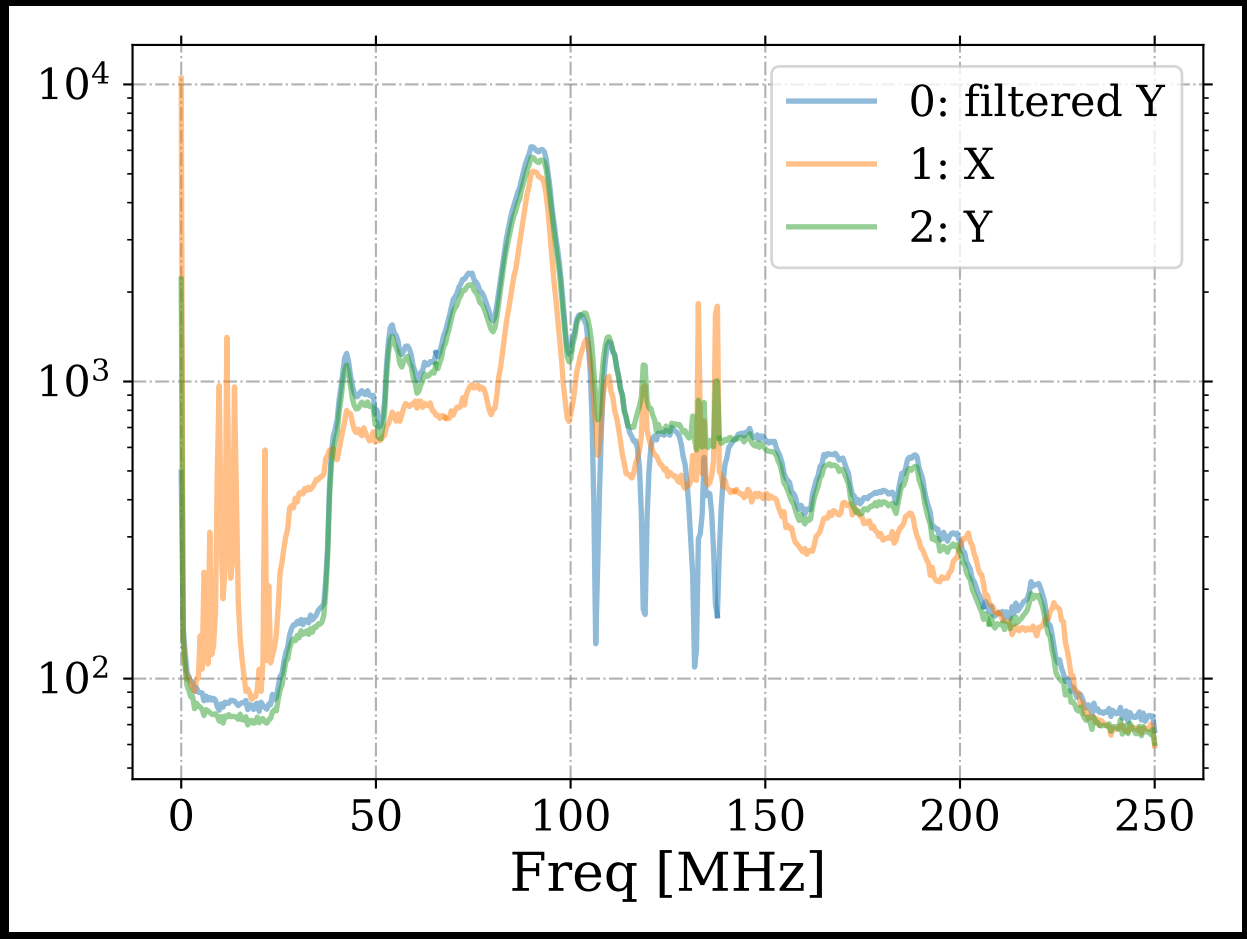
Data

- File:
  - GP13_20240428_150018_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_001.root
  - GP13_20240428_150756_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_001.root
  - GP13_20240428_150857_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_002.root
  - GP13_20240428_150957_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_003.root
  - GP13_20240428_151054_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_004.root
  - GP13_20240428_151128_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_005.root
  - GP13_20240428_151203_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_006.root
  - GP13_20240428_151234_RUN127_UD_RAW_ChanXYZ_20dB_13dus_BeaconTest_100M_007.root
- Number of DUs: 13
- Number of UD events: 6051

Beacon Signal

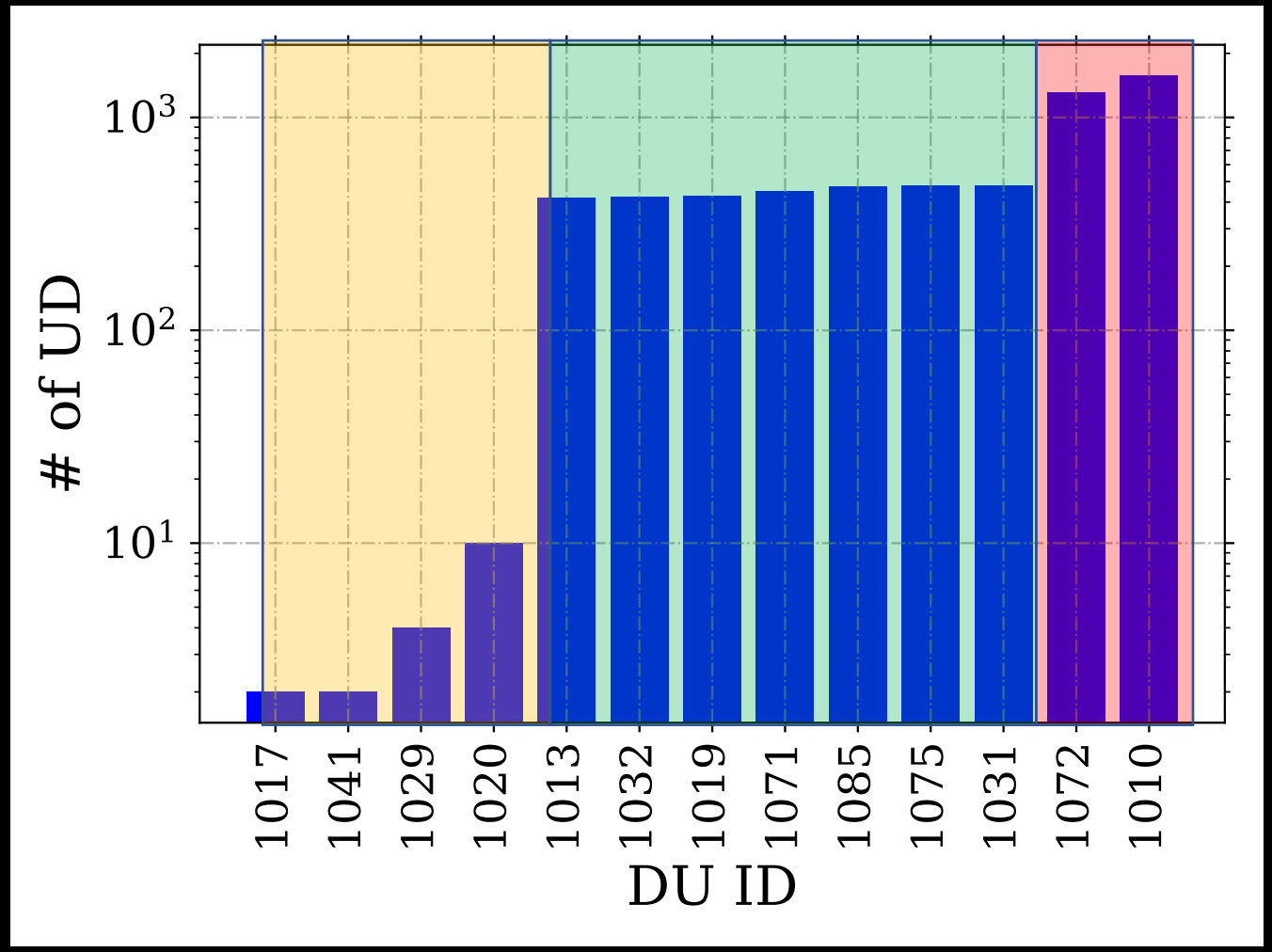
- Pulse at time domain
- 100MHz at FFT spectrum





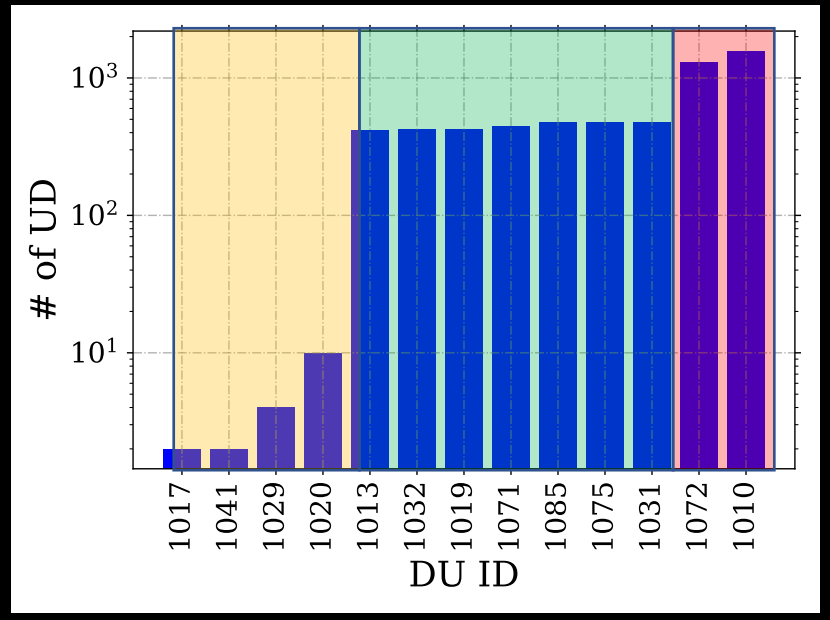
Number of Pulses

- Three groups
- 1010, 1072: ~1k pulses
- Seven DUs: ~400 pulses
- 1017, 1014, 1029, 1020: <100 pulses

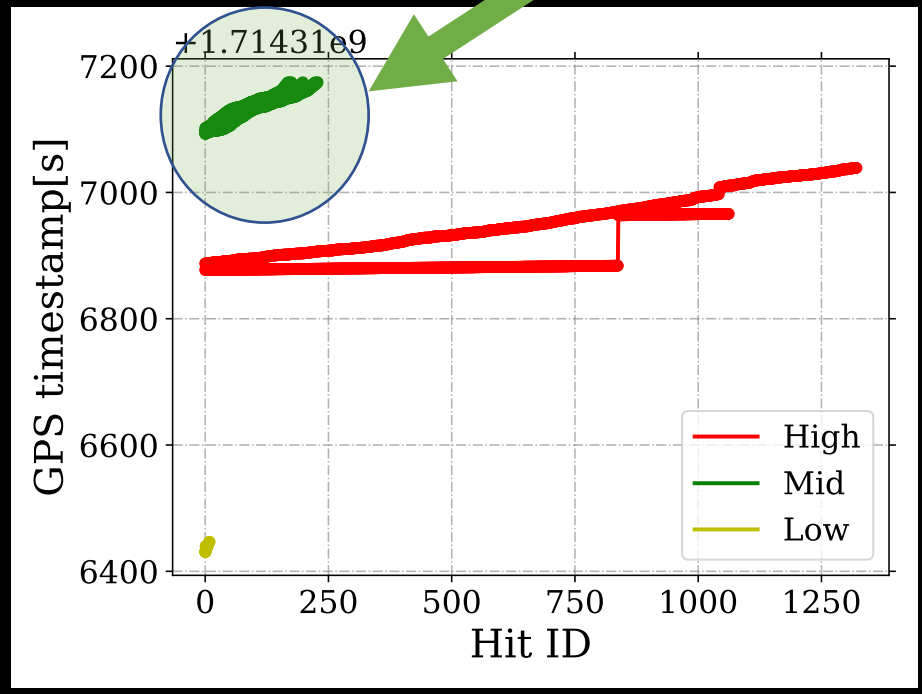


GPS Timing by DUs

- Three groups divided by pulse number:
  - High: [1010, 1072]
  - Mid: [1031, 1075, 1085, 1071, 1019, 1032, 1013]
  - Low: [1017, 1041, 1029, 1020]

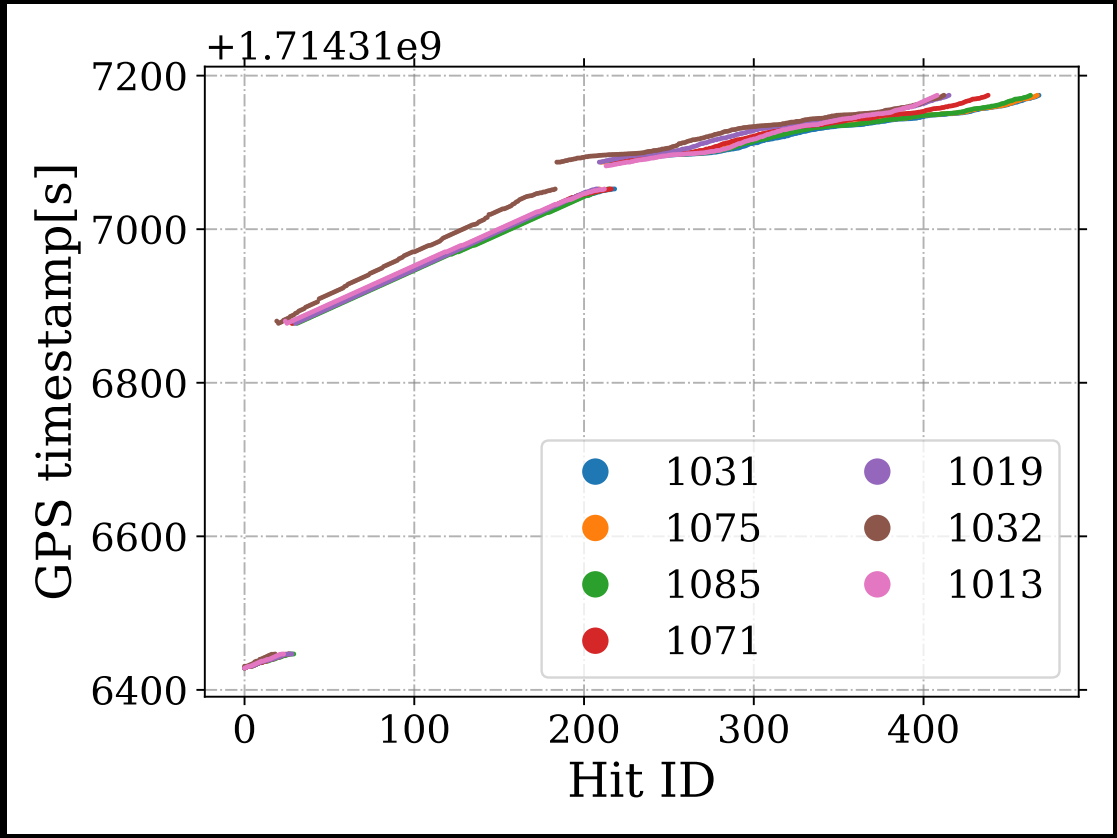


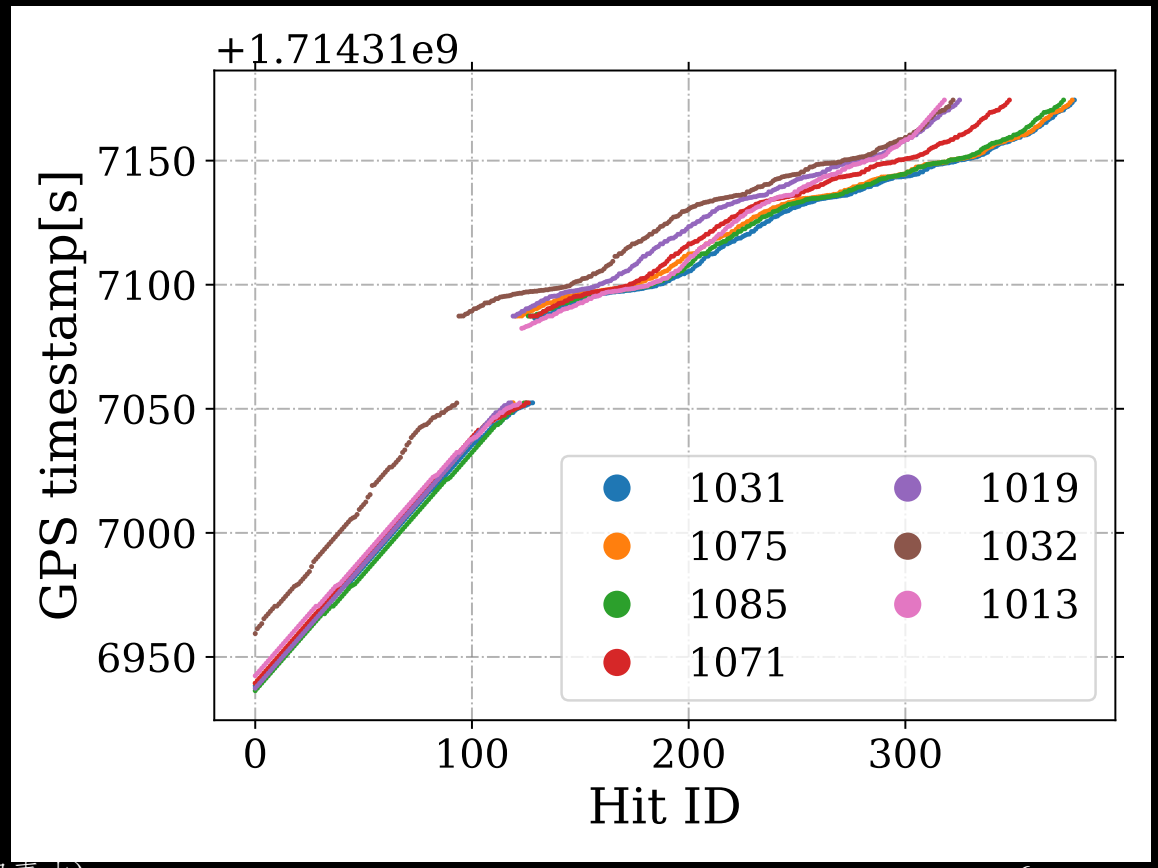
Only these DUs are correct /suitable for coincidence analysis



Zoom-in of Hit Time

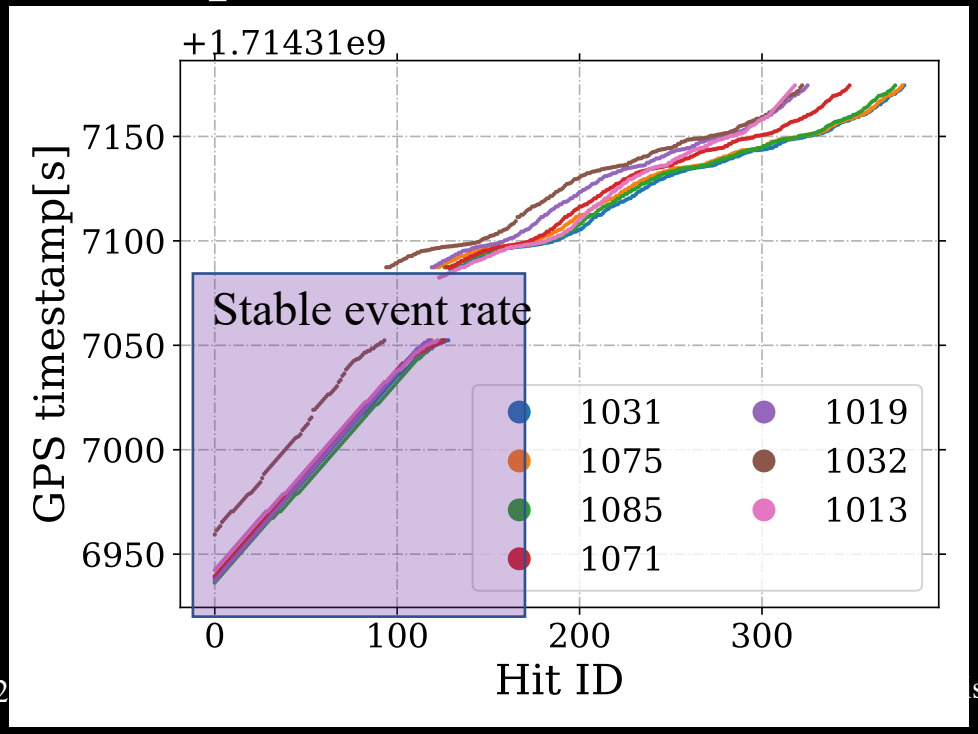
- Discontinuity of the GPS timing, change of burst rate?

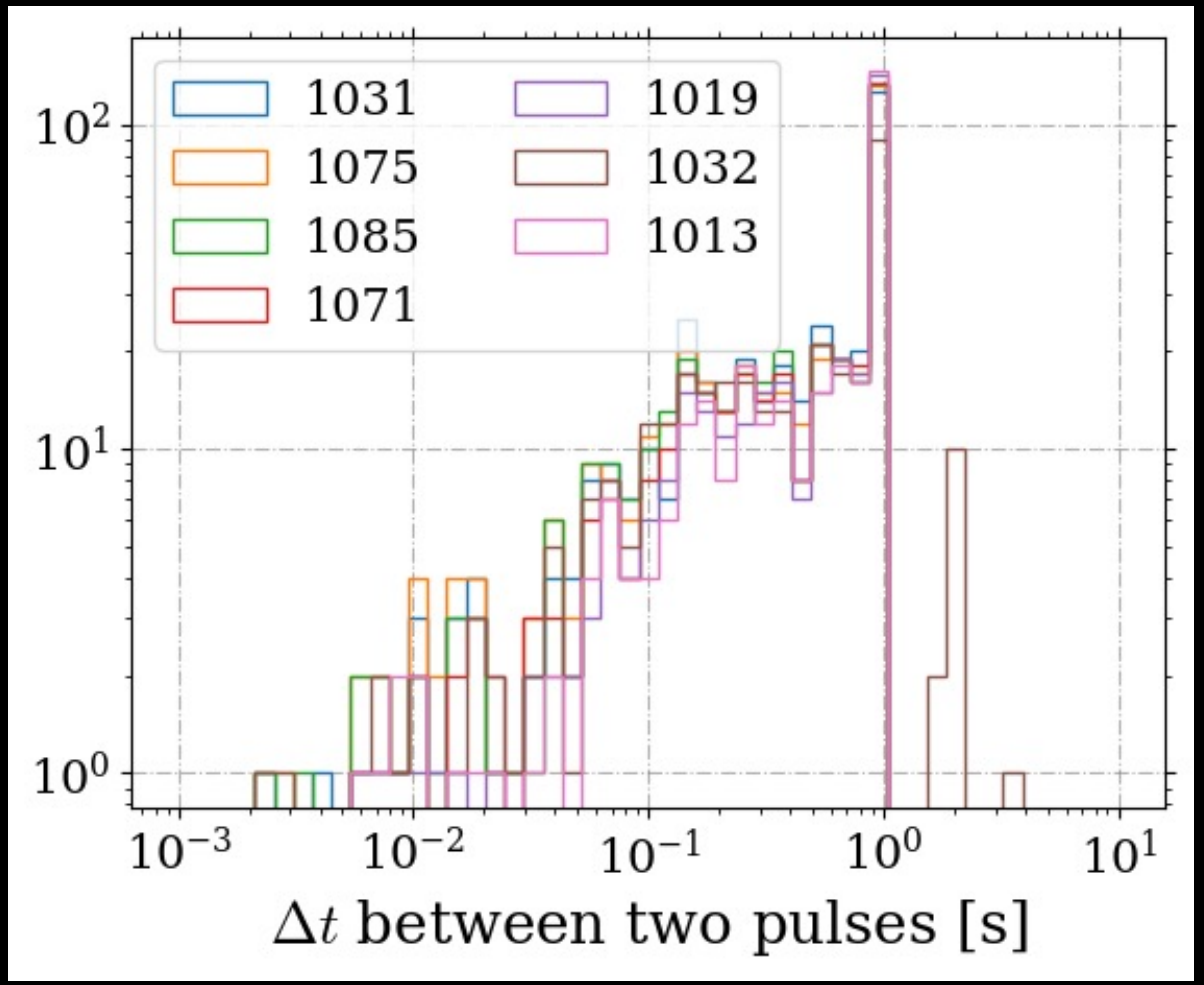




Burst Rate

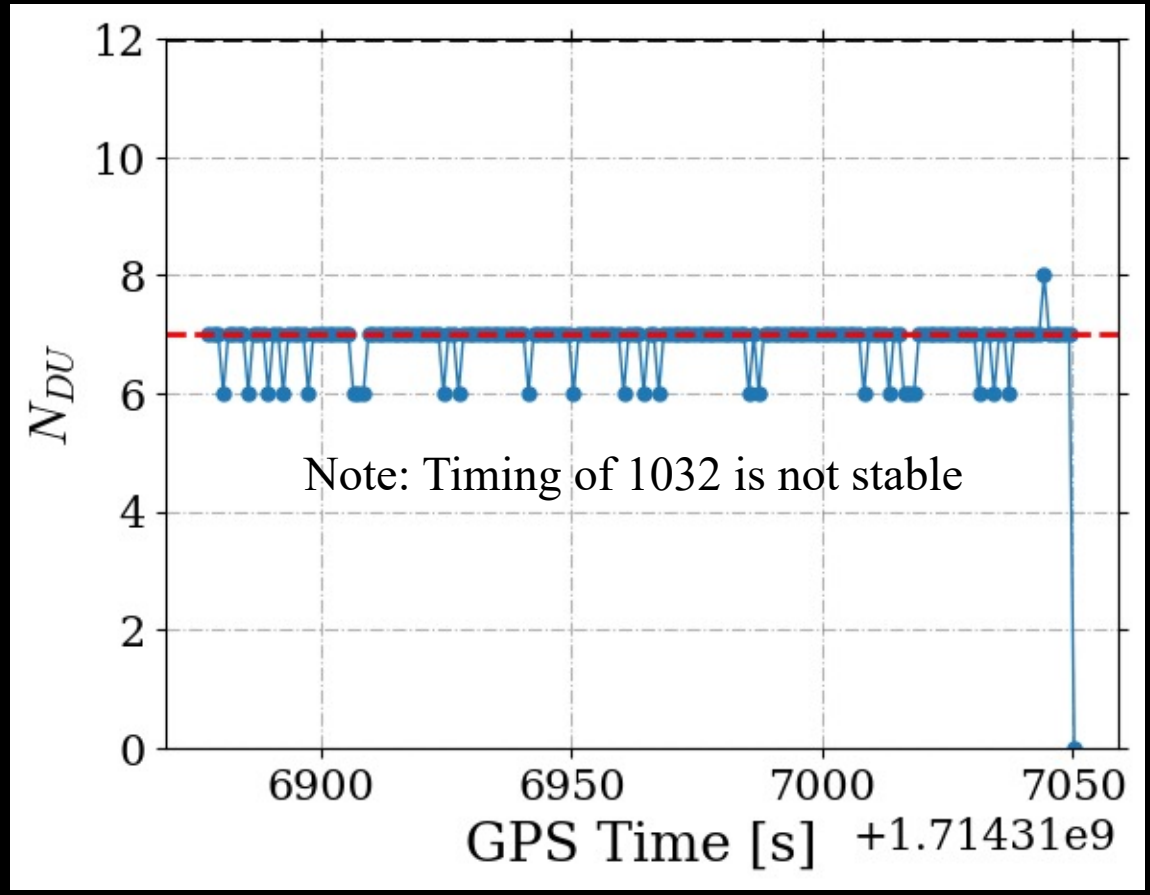
- Peak at 1Hz -> The beacon rate?
- Gaussian/Poisson process as noise
- 1032 peaks around 0.5Hz.





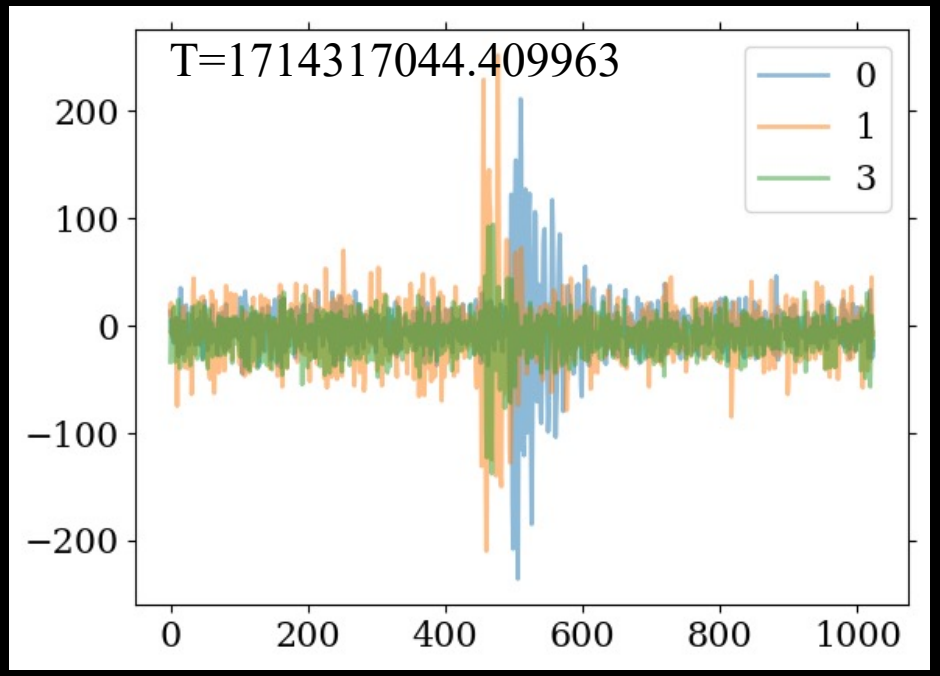
Coincidence

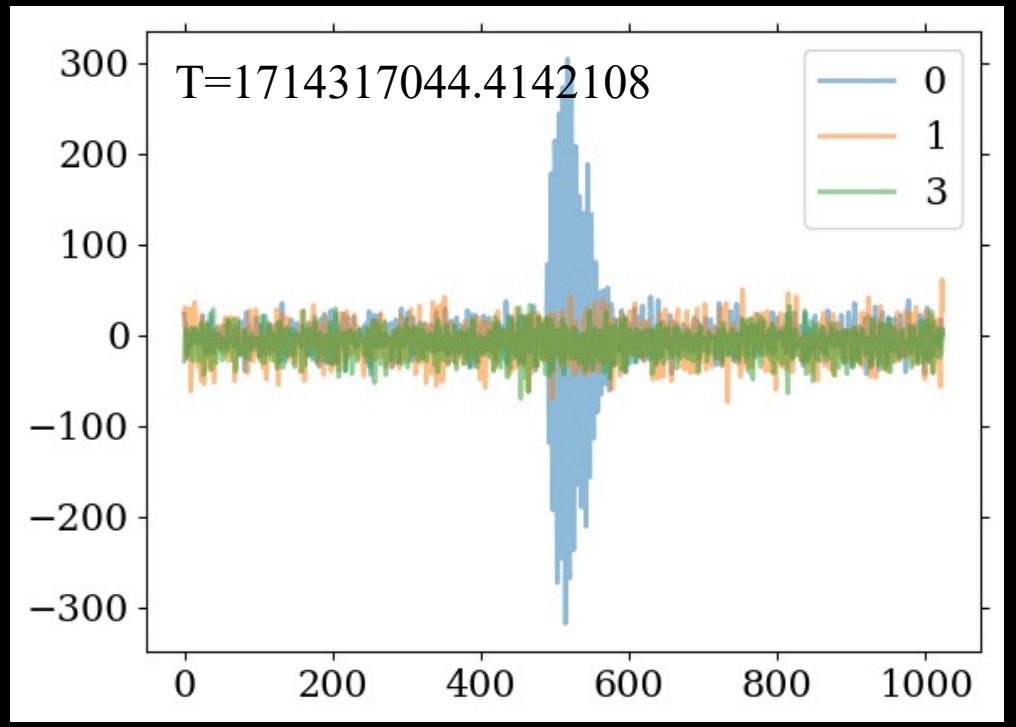
- Coincidence window: 10ms
- Minimum DUs for a CD: 3
- Timestamp to be searched: from 1714316877.41 to 1714317051.41 with stepsize=1s
- Expected 174 events
- Observed 173 events (one event where 1031 occurs twice.)
- Timing of 1032 is off from others.



Non-beacon Pulse for DU1031

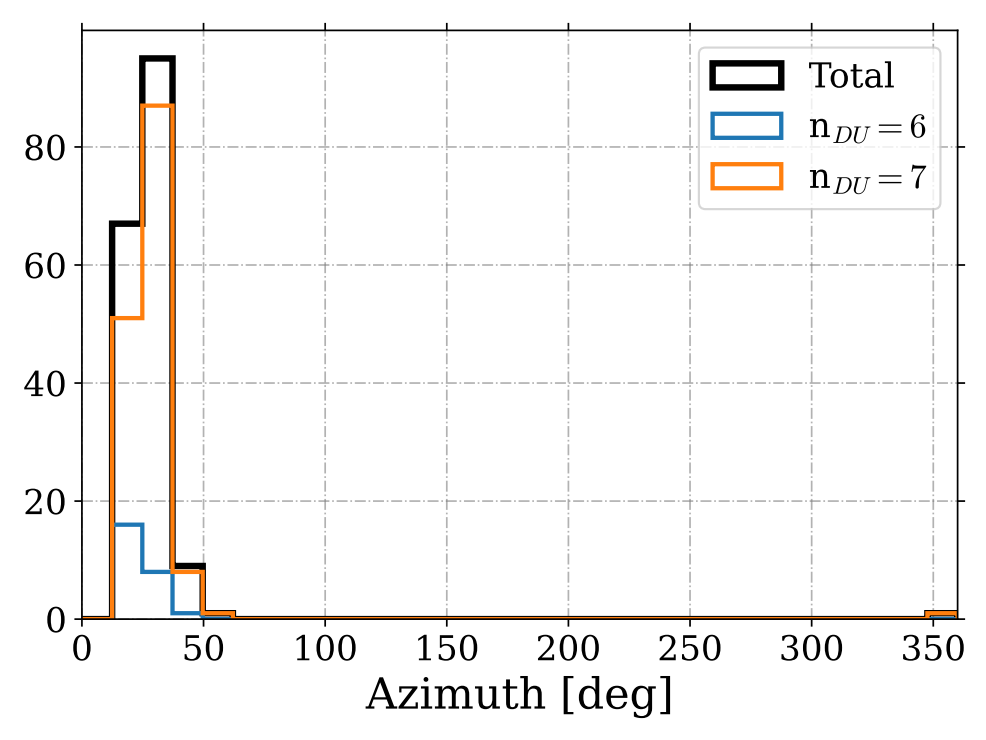
- Another pulse likely induced by another source triggered 1031 at a similar time. So, DU1031 appeared twice. But this event is discarded for reconstruction.

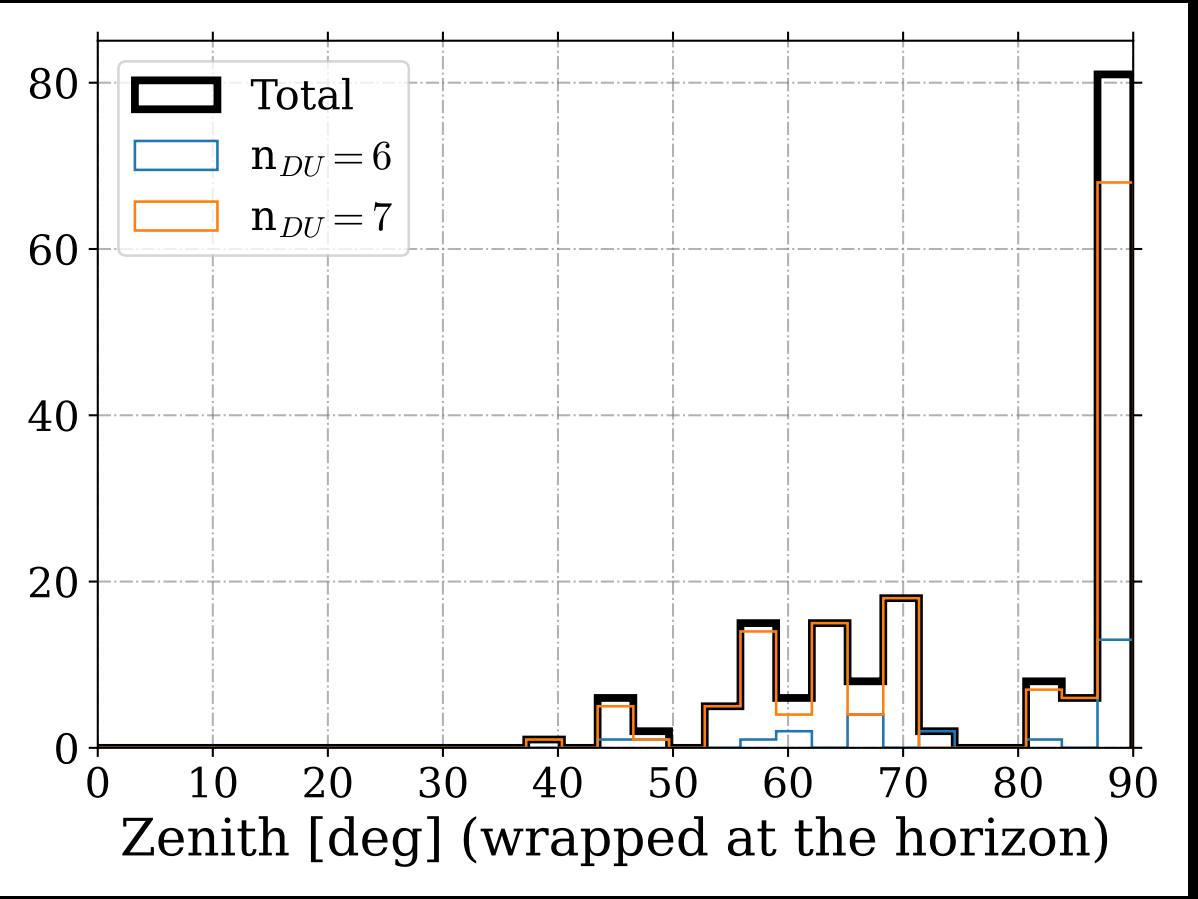




Direction Reconstruction

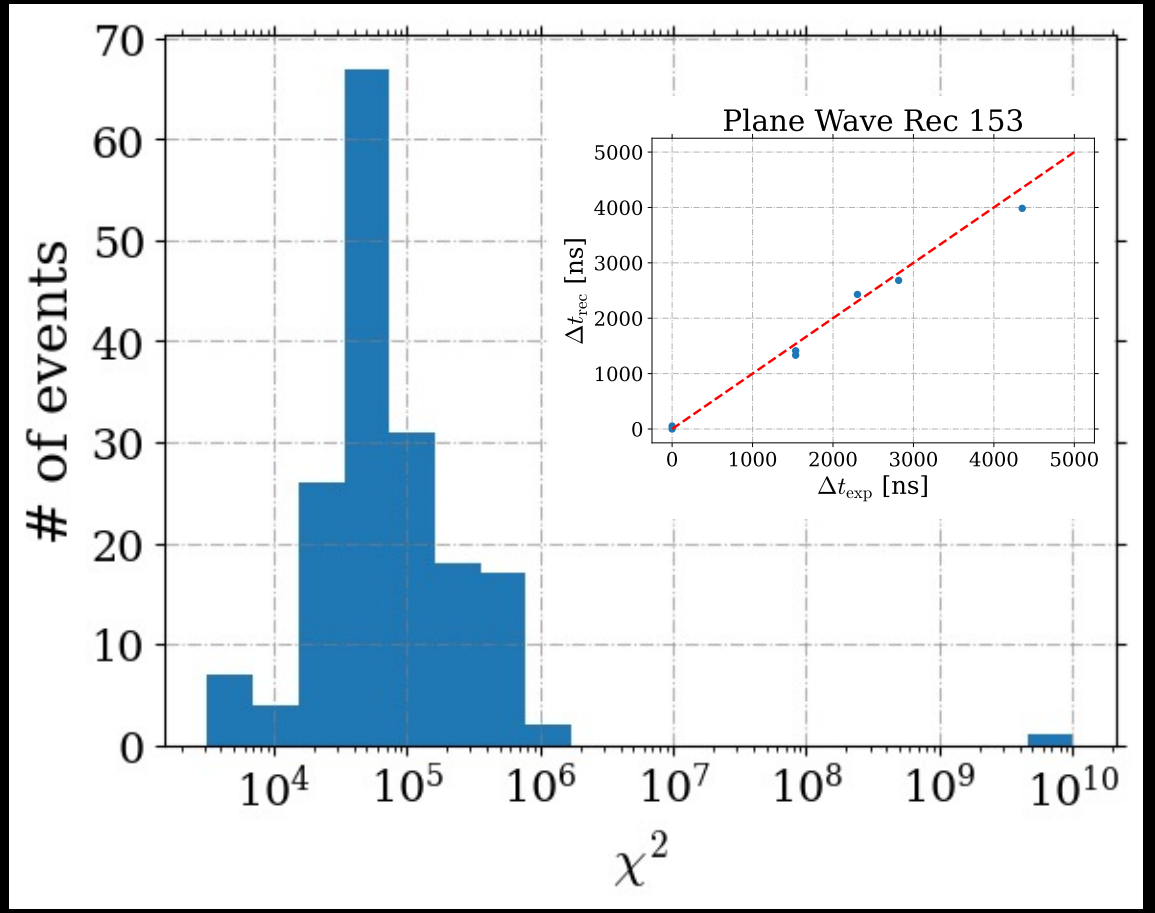
- Plane wave fitting
- Spherical wave fitting mostly failed.





χ^2 Distribution

- The distribution peaks around 40000.
- Considering the GPS timing (PPS signal error):
  - Fixed mode: $\sigma \approx 15\text{ns}$, $\chi^2_\nu \approx 177$
  - Survey mode: $\sigma \approx 50\text{ns}$, $\chi^2_\nu \approx 16$
- In order to have a χ^2around one: $\sigma \approx 200\text{ns}$



Conclusion

- To run in trigger mode, GPS should be stable and accurate.
- Variation among DUs.
- The change of trace length during one run.
- Needs more investigation on the data.

- Test GPS in the lab, e.g., measuring the PPS signal
- More realistic (shower) signals should be used to tune the trigger parameters in the lab.