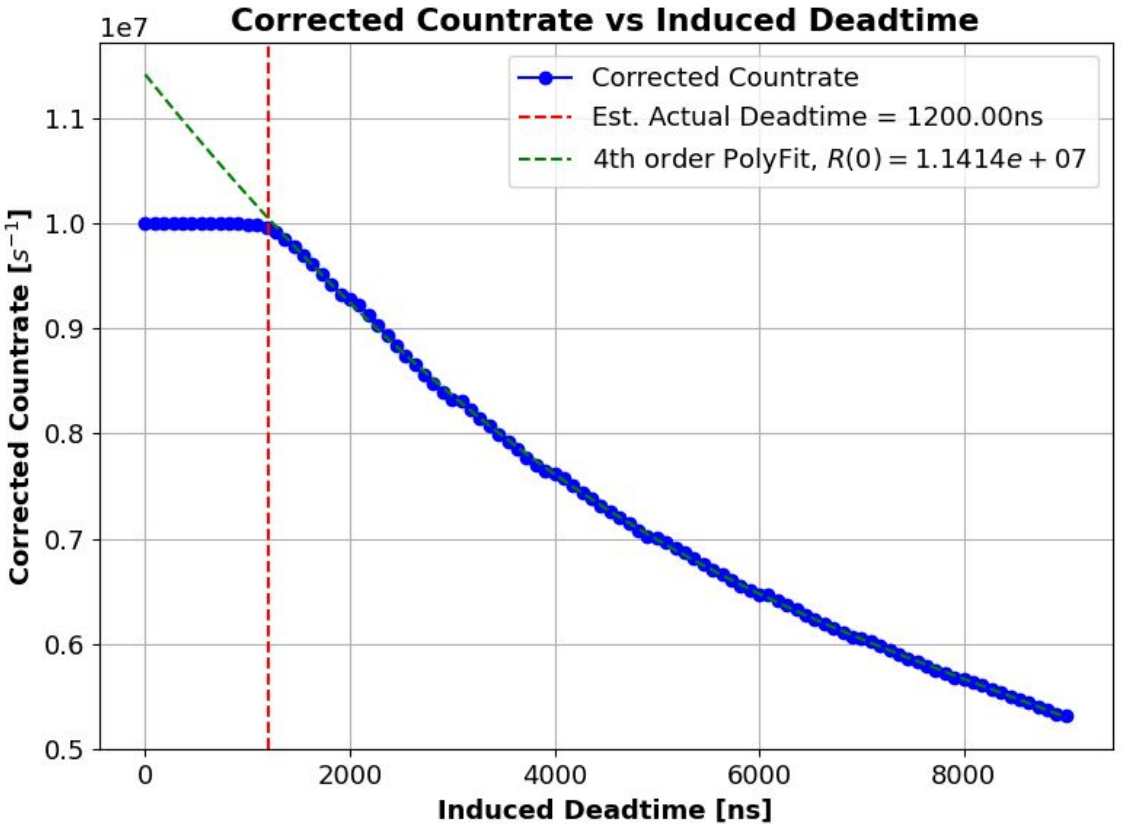
Detector Deadtime Effect on Intensity Measurement
GP-SANS Beam Monitor, IPTS 27957

James Rogers
jroger87@vols.utk.edu

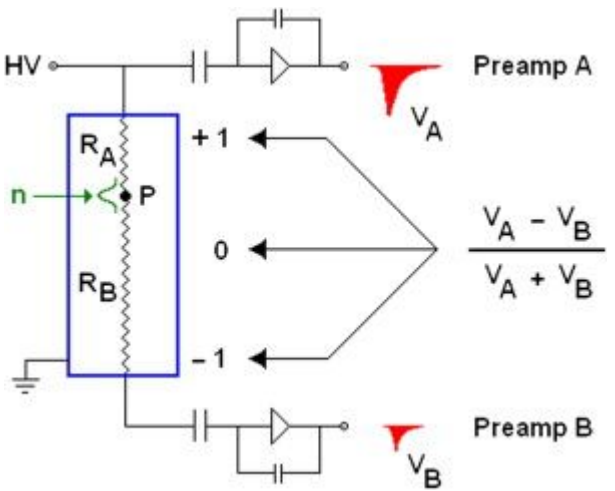
August 30, 2024

THE UNIVERSITY OF TENNESSEE KNOXVILLE
DEPARTMENT OF PHYSICS & ASTRONOMY



Detector “Dead Time”

- Neutron detection involves
- Quantifying dead time losses is complicated
  - Requires intricate knowledge of the monitoring system (physical and electronic components)
  - Stochastic nature of detection events
  - Variance in actual dead time

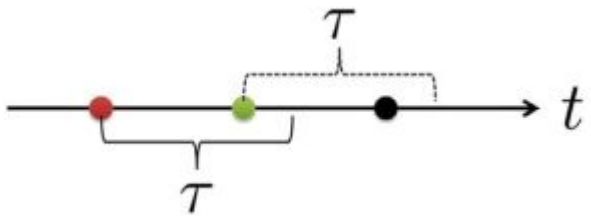


[1] K. D. Berry et al., “Characterization of the neutron detector upgrade to the GP-SANS and Bio-SANS instruments at HFIR,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 693, pp. 179–185, 2012, doi: https://doi.org/10.1016/j.nima.2012.06.052.

Paralyzing vs Non-Paralyzing Deadtime

Dead time effects can be “Paralyzing” or “non Paralyzing” (usually a combination exists)

- In the example below, the first event (Red) is detected, causing deadtime Tau to block the detection of the second event (Green).



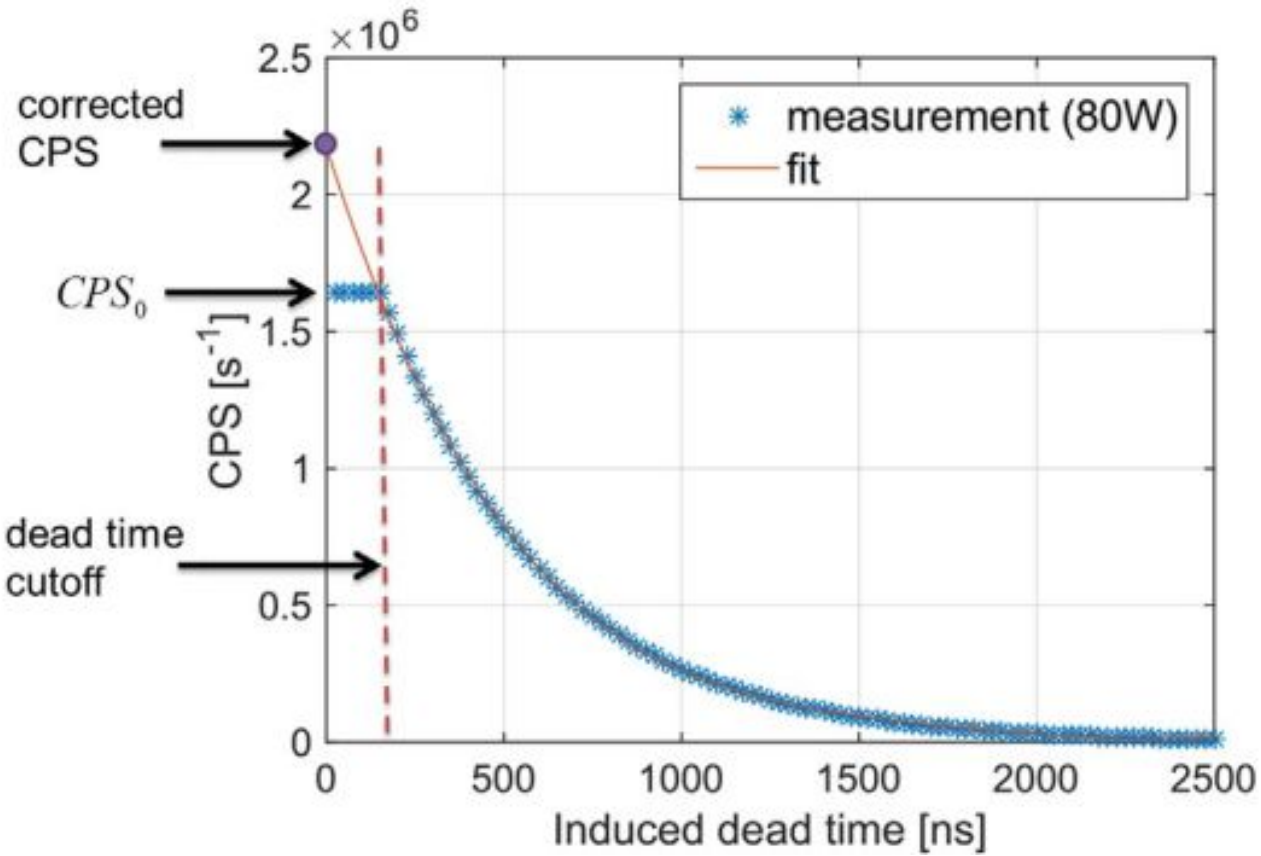
- If it is “Paralyzing”, then every event will cause the detector to experience deadtime. In this case, although green is not “detected”, it will cause another deadtime period Tau that will prevent the detection of the third event (Black).
  - Only Red will be counted
- If it is “Non-Paralyzing”, the green event will still not be detected, but this time it will not cause an additional deadtime.
  - The Red and Black events will be counted

[2] E. Gilad, C. Dubi, B. Geslot, P. Blaise, and A. Kolin, “Dead time corrections using the backward extrapolation method,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 854, pp. 53–60, 2017, doi: https://doi.org/10.1016/j.nima.2017.02.026.

Backwards Extrapolation Method (BEX)

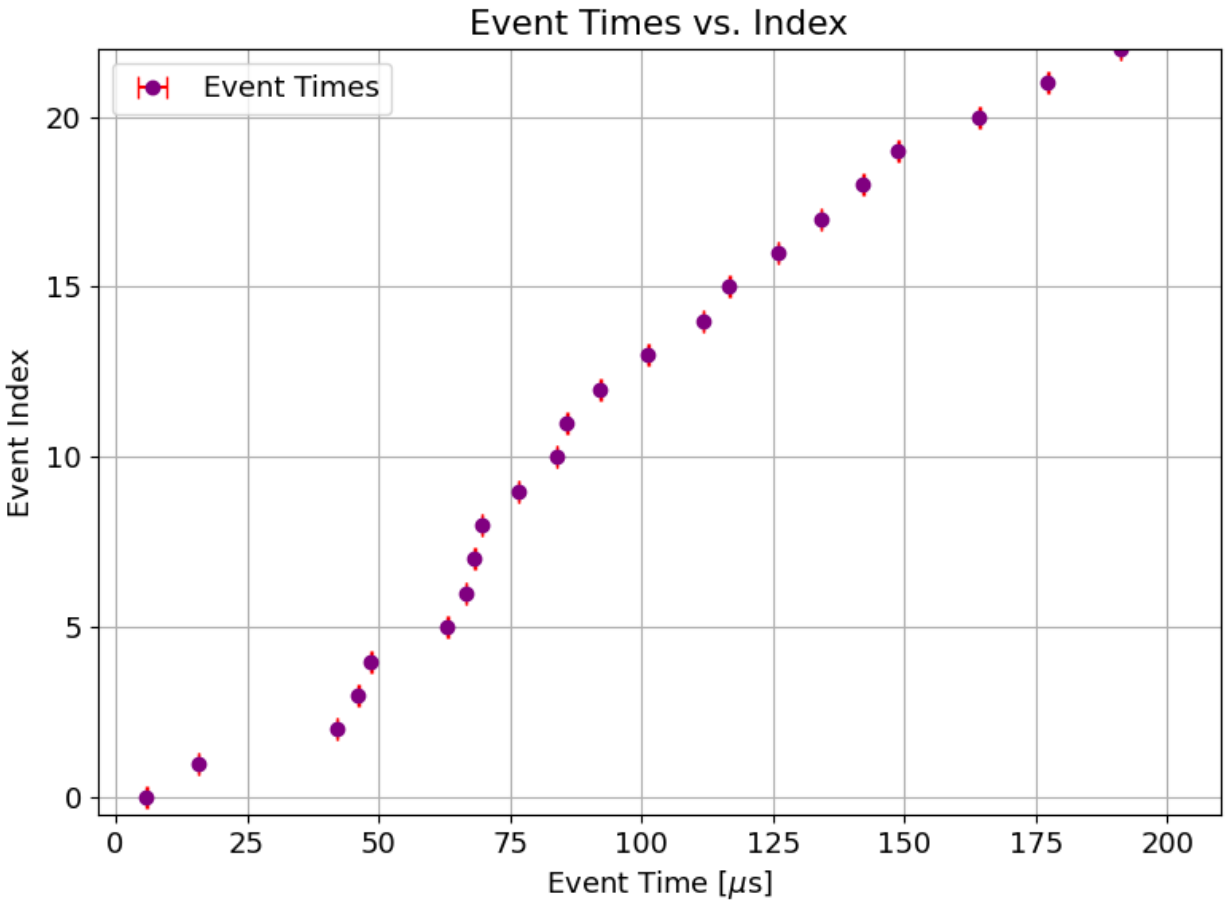
In Gilad 2017, the BEX method is explored and tested on known reactor countrates to quantify its performance in finding the deadtime-corrected countrate.

- Using detection event times, an “artificial” deadtime can be imposed on the signal, to find what would be the countrate if that were the true deadtime. This involves choosing Paralyzing or non paralyzing, and selecting events which are not blocked by the artificial deadtime.
- The countrate as a function of artificial deadtime can be extrapolated to 0 to estimate the effect of deadtime.



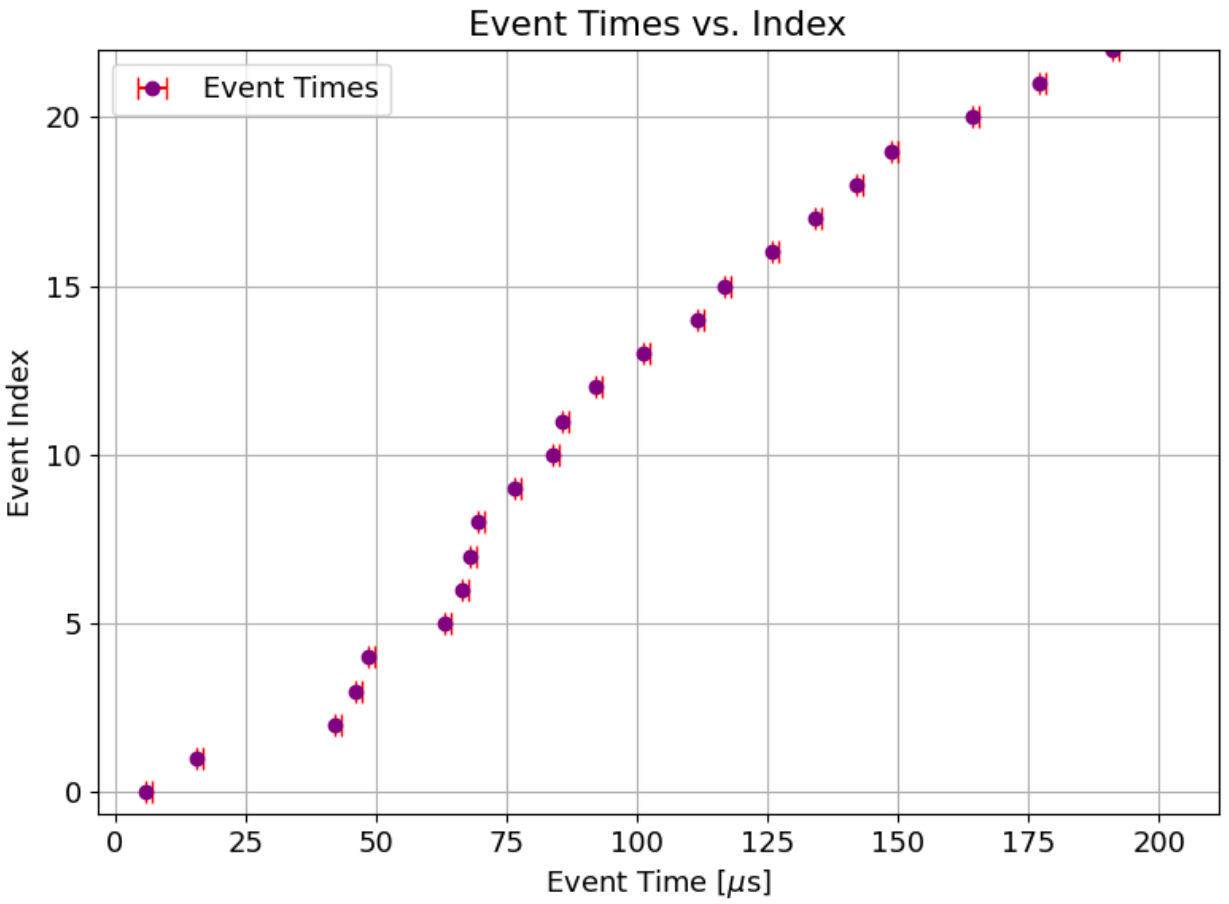
[2] E. Gilad, C. Dubi, B. Geslot, P. Blaise, and A. Kolin, “Dead time corrections using the backward extrapolation method,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 854, pp. 53–60, 2017, doi: https://doi.org/10.1016/j.nima.2017.02.026.

89847 Detections vs Time



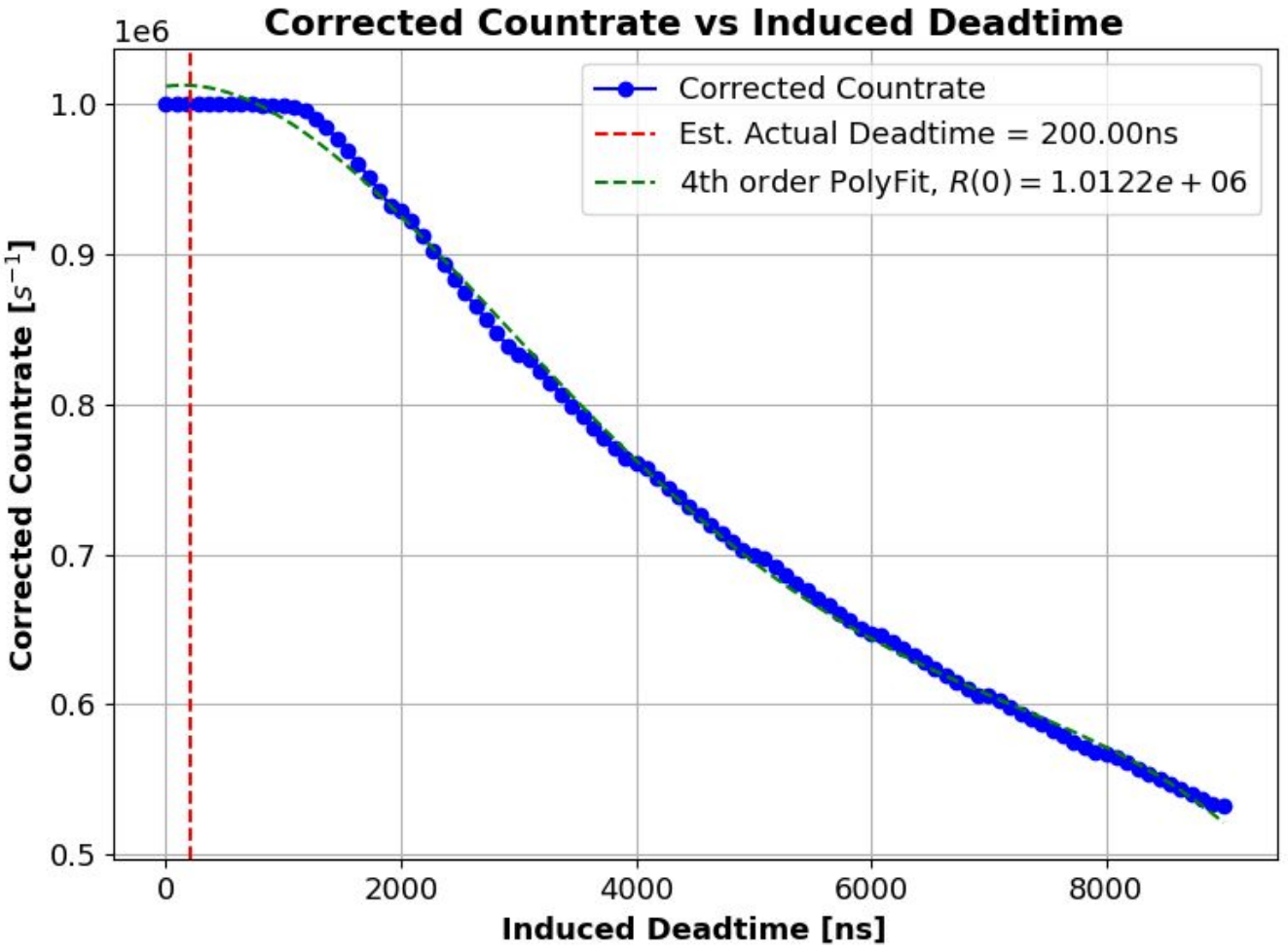
- First 20 events plotted with their recording time
- Event time resolution 100ns
- Errorbar (red) corresponds to **200ns** possible deadtime

89847 Detections vs Time



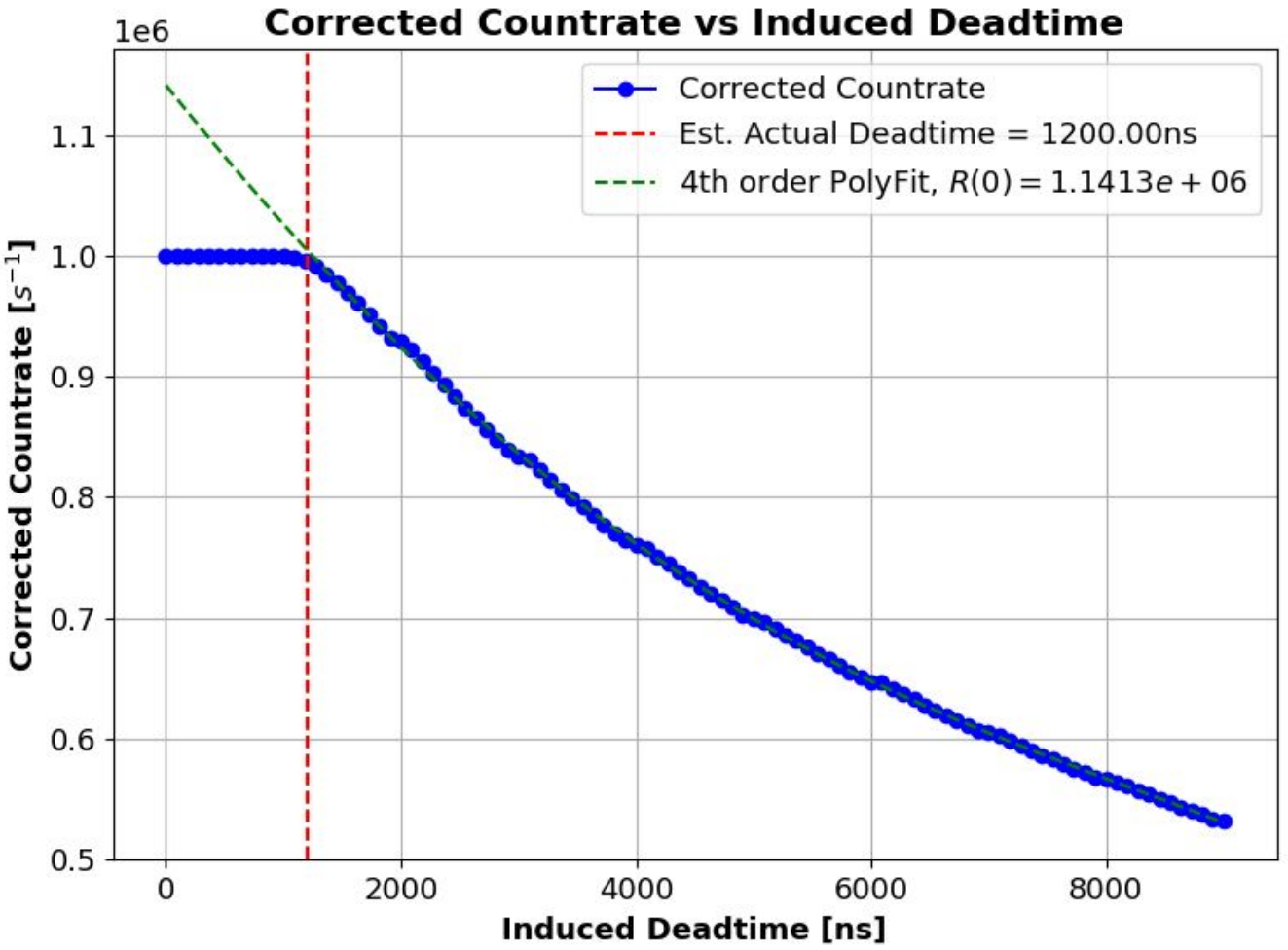
- First 20 events plotted with their recording time
- Event time resolution 100ns
- Errorbar (red) corresponds to **1200ns** possible deadtime

89847 BEX Plot: 200ns deadtime



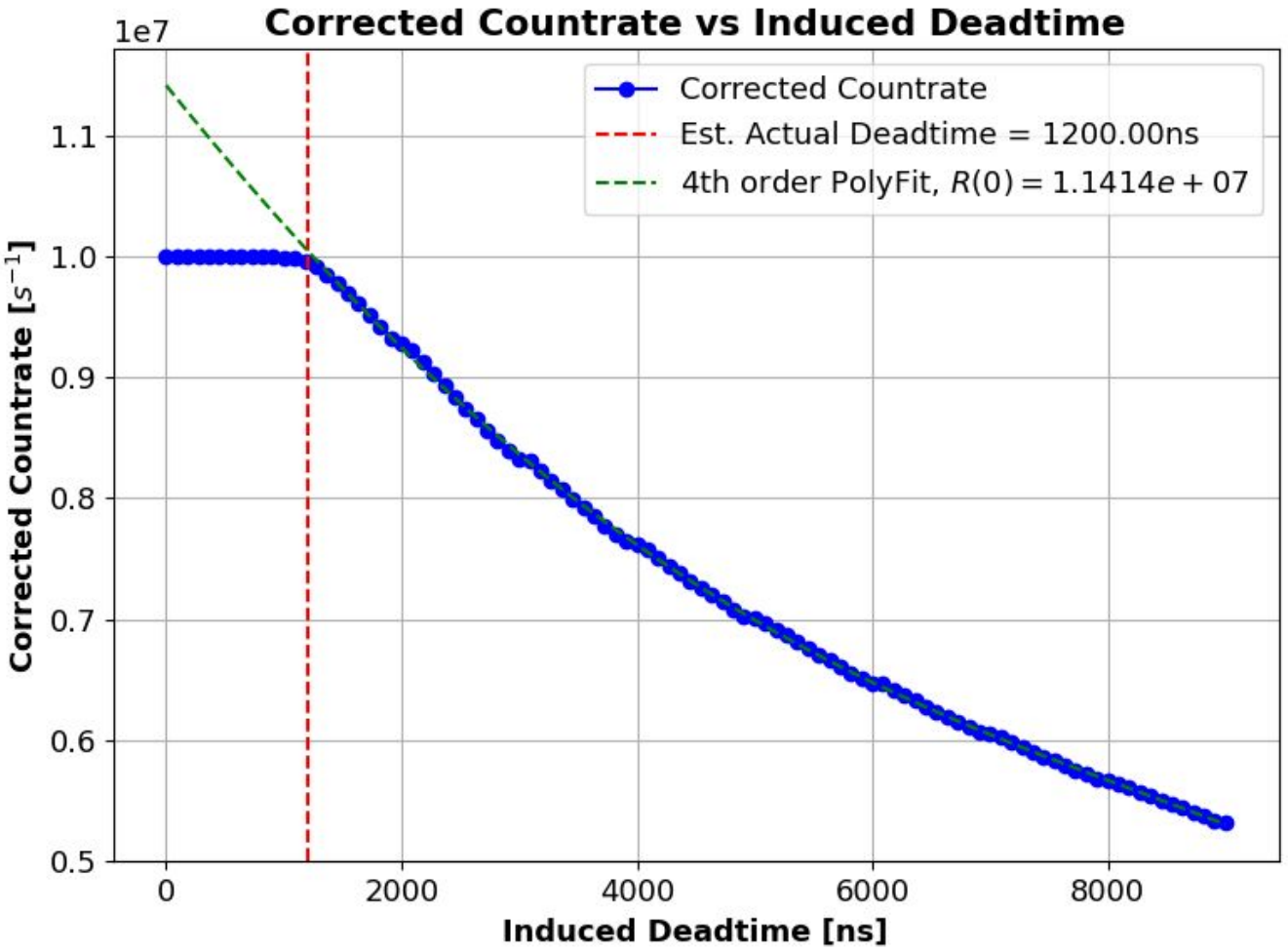
- First 1e6 counts of run 89847
- Using deadtime 200ns
- Poly fit gives ~1% effect

89847 BEX Plot: 1200ns deadtime (1)



- First 1e6 counts of run 89847
- Using deadtime 1200ns
- Poly fit gives ~14% effect

89847 BEX Plot: 1200ns deadtime (2)



- First **1e7** counts of run 89847
- Using deadtime 1200ns
- Poly fit gives ~14% effect

89847: BEX Conclusions

- Seems that deadtime is closer to 1200ns
- Possible that deadtime effect is up to 14%
- Additional information from time interval analysis (Supplementary Slides)

Questions?

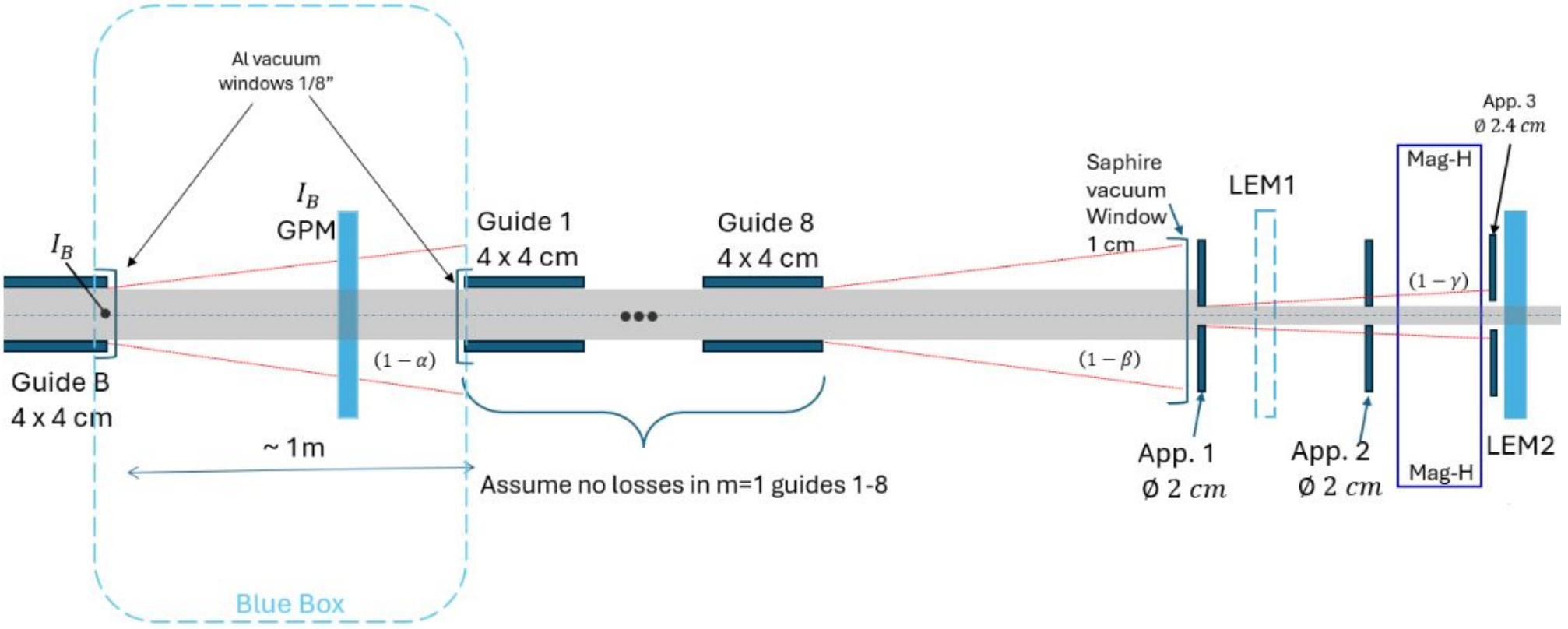
jroger87@vols.utk.edu

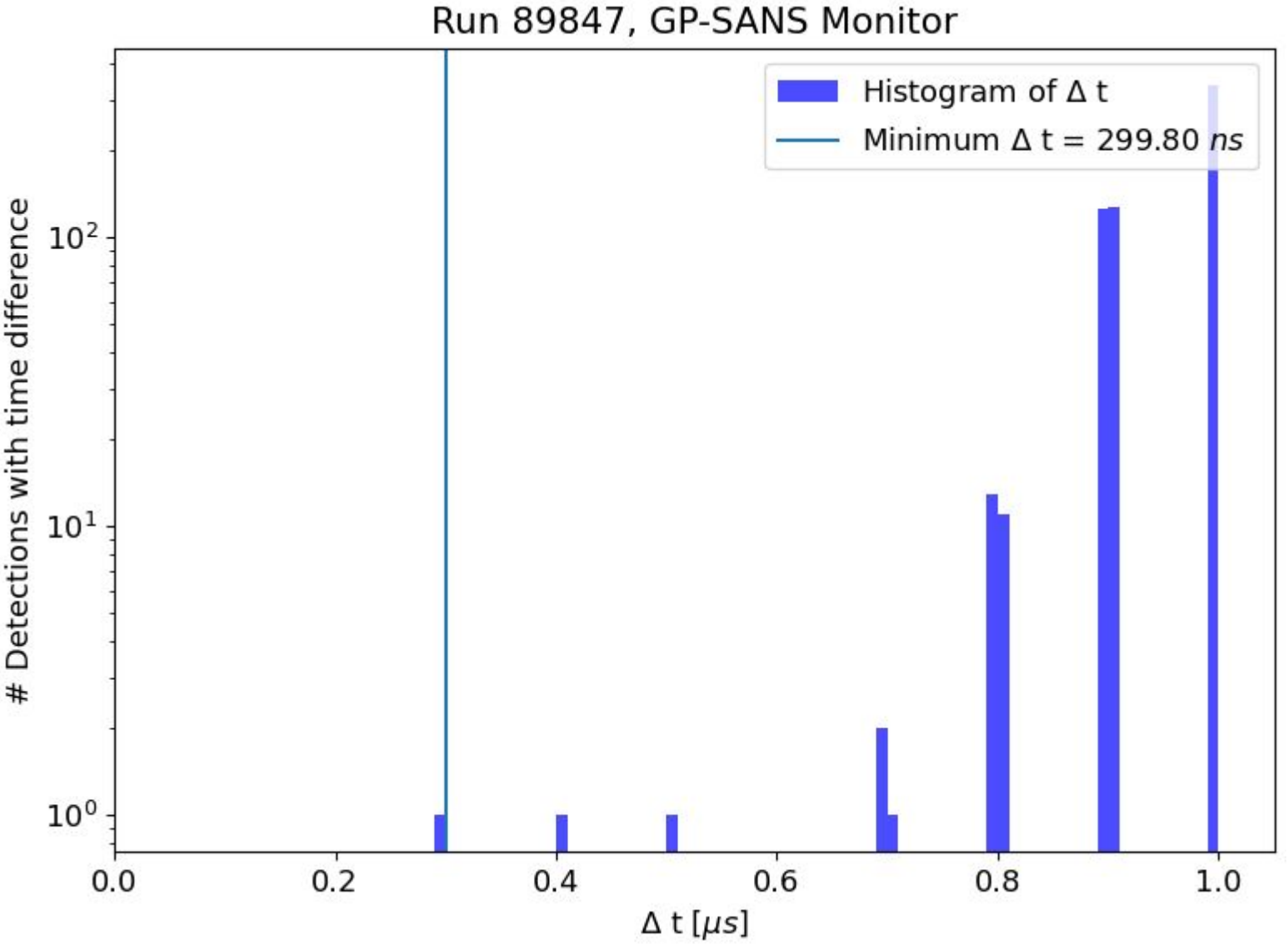
THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

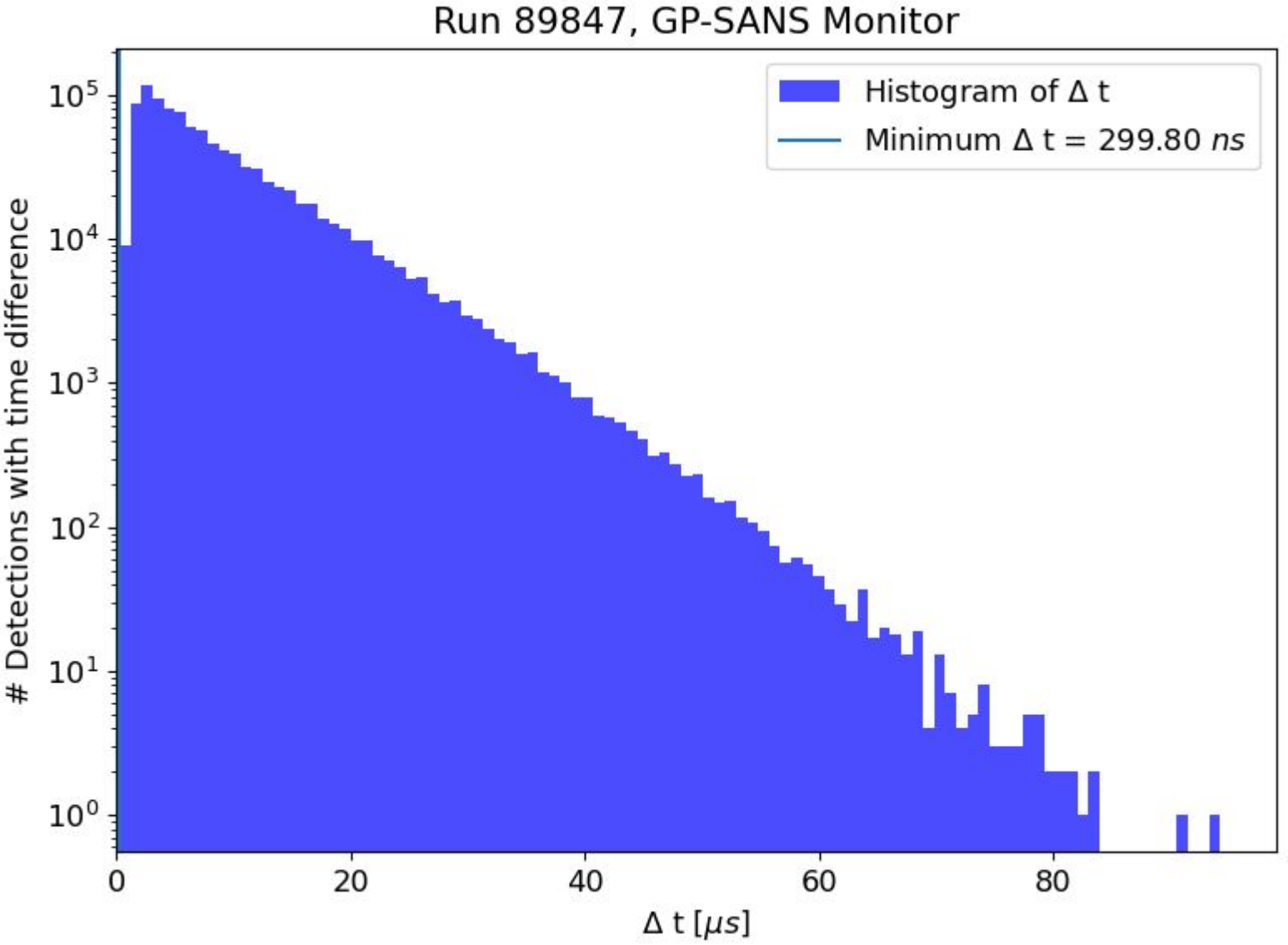
DEPARTMENT OF
PHYSICS & ASTRONOMY

Supplementary

Yuri's Schematic




Run 89847, GP-SANS Monitor
Histogram of Δ t
Minimum Δ t = 299.80 ns
Detections with time difference
10^2
10^1
10^0
0.0
0.2
0.4
0.6
0.8
1.0
Δ t [μs]


Run 89847, GP-SANS Monitor
Histogram of Δ t
Minimum Δ t = 299.80 ns
Detections with time difference
10^5
10^4
10^3
10^2
10^1
10^0
0
20
40
60
80
Δ t [μs]