Detector Intensity Corrections
IPTS 27957

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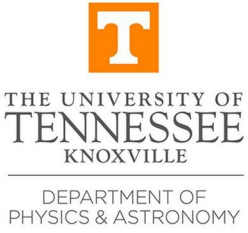


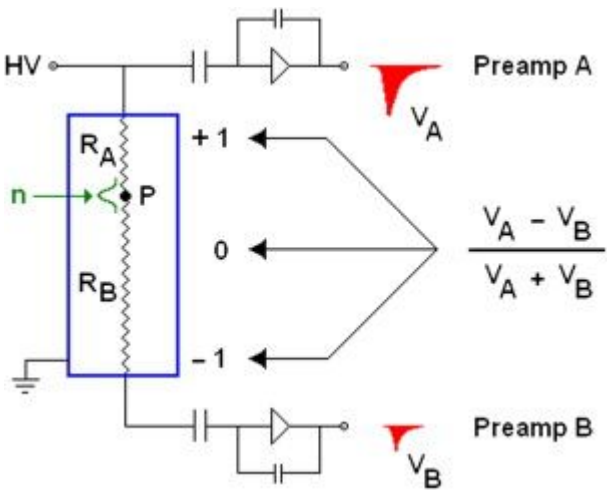
GPM, LEM, and GP-SANS

Outline:

- Deadtime effect
- Monitor data (Δt histograms)
  - GPM – pretty Δt histogram, deadtime seems to be 1200ns. 100ns time resolution
  - LEM – Odd peak, possible double counting effect altering histogram. 100ns time resolution
  - GP-SANS – 48 banks of 4 tubes each. Each bank has a different countrate. 1us time res.
- Correction methods
  - Formula correction
  - Δt extrapolation
  - BEX – from paper
- Comparison of different methods for deadtime correction
  - Determine error on correction methods

Detector “Dead Time”

- Neutron detection involves deadtime due to reality constraints
- 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

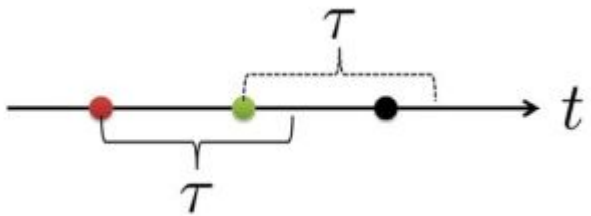


[1] K. D. Berry et al., “Characterization of the neutron detector upgrade to the GP-SANS and Bio-SANS instruments at HFIR,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 693, pp. 179–185, 2012, doi: https://doi.org/10.1016/j.nima.2012.06.052.

Paralyzing vs Non-Paralyzing Deadtime

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

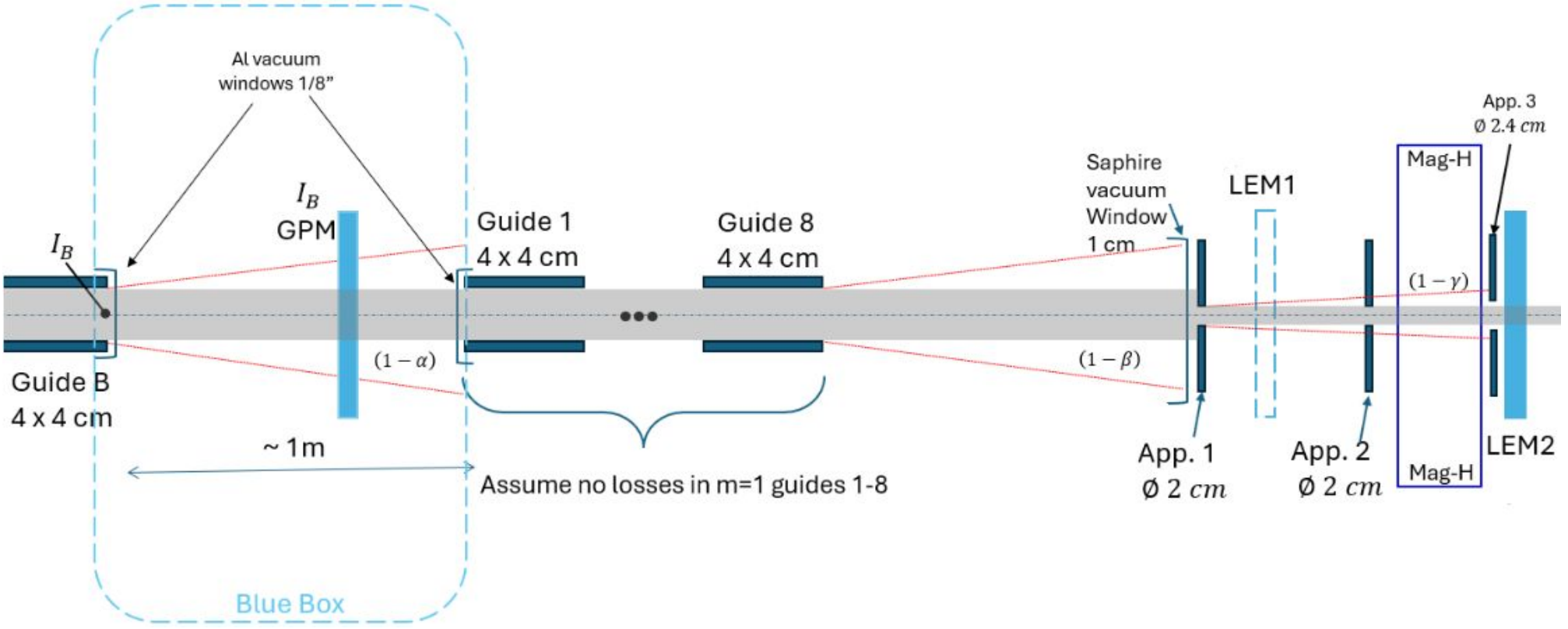
- In the example below, the first event (Red) is detected, causing deadtime Tau to block the detection of the second event (Green).



- 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.

IPTS 27957 Configuration



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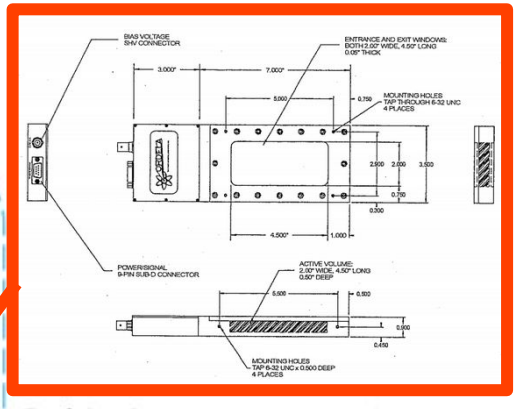


ORDELA
low efficiency
gas proportional counter

Al vacuum windows 1/8”

I_B

I_B GPM

Guide 1 4 x 4 cm

Guide 8 4 x 4 cm

Saphire vacuum Window 1 cm

LEM1

Mag-H

App. 3 Ø 2.4 cm

$(1-\gamma)$

$(1-\alpha)$

$(1-\beta)$

Guide B 4 x 4 cm

~ 1m

Assume no losses in m=1 guides 1-8

App. 1 Ø 2 cm

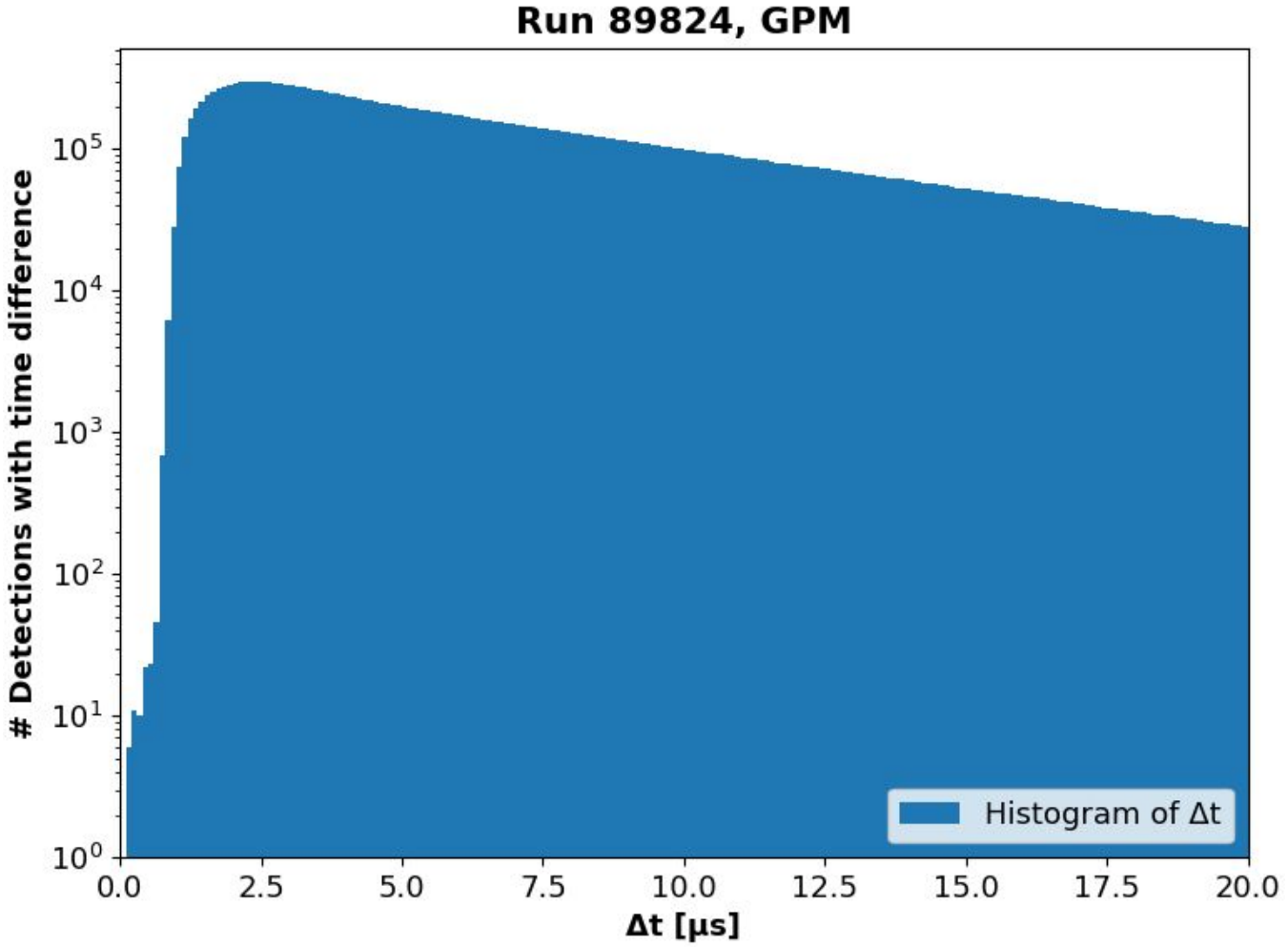
App. 2 Ø 2 cm

Mag-H

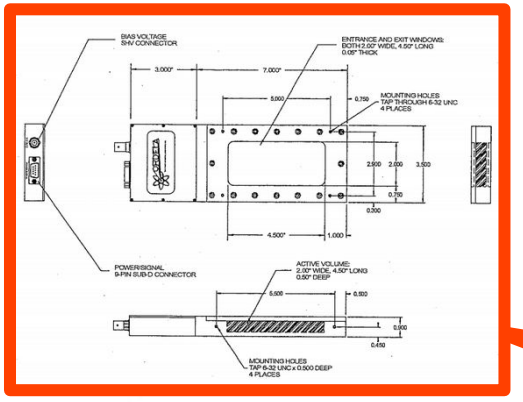
LEM2

Blue Box

GPM ΔT Histogram



IPTS 27957 Configuration



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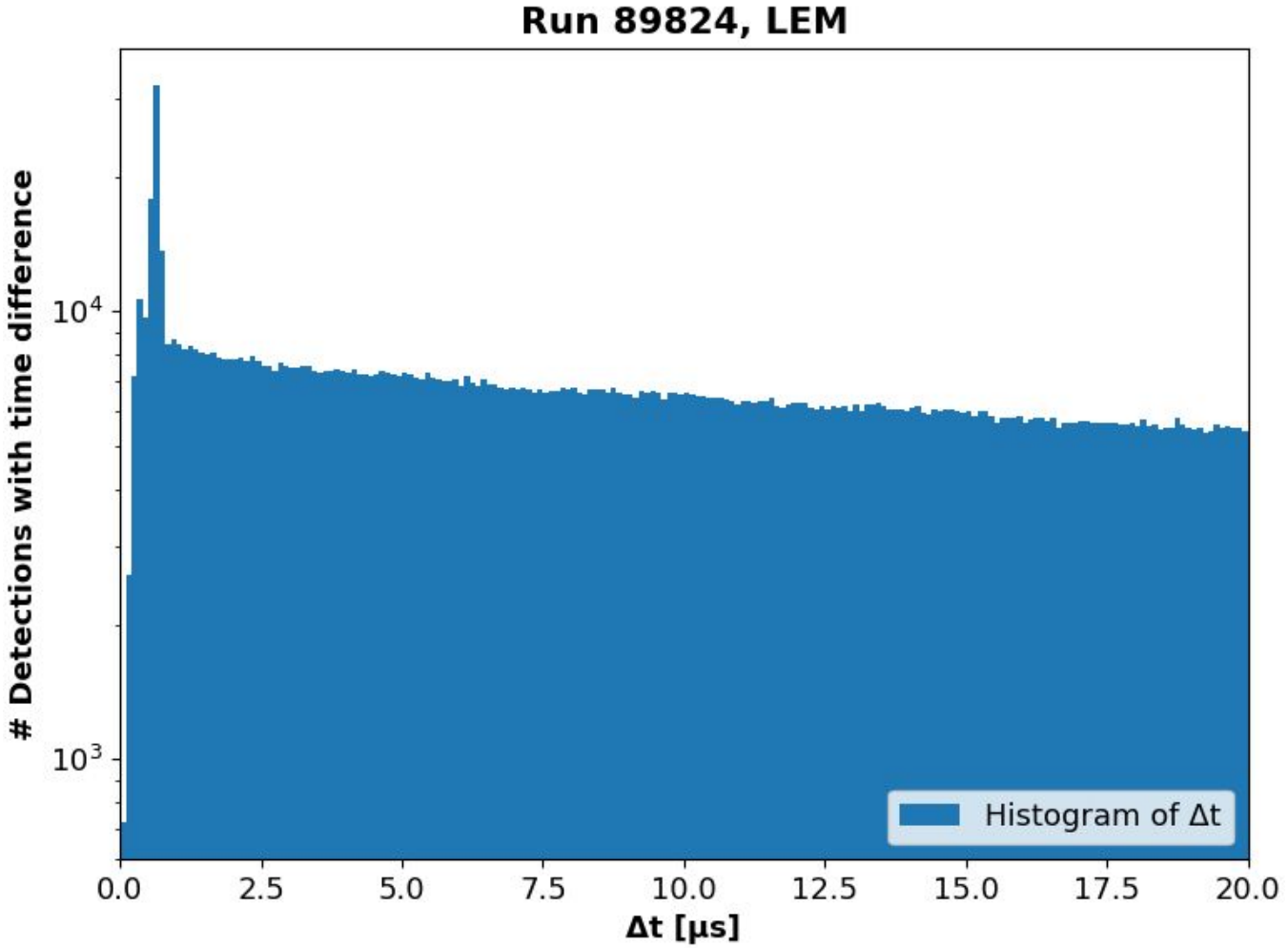
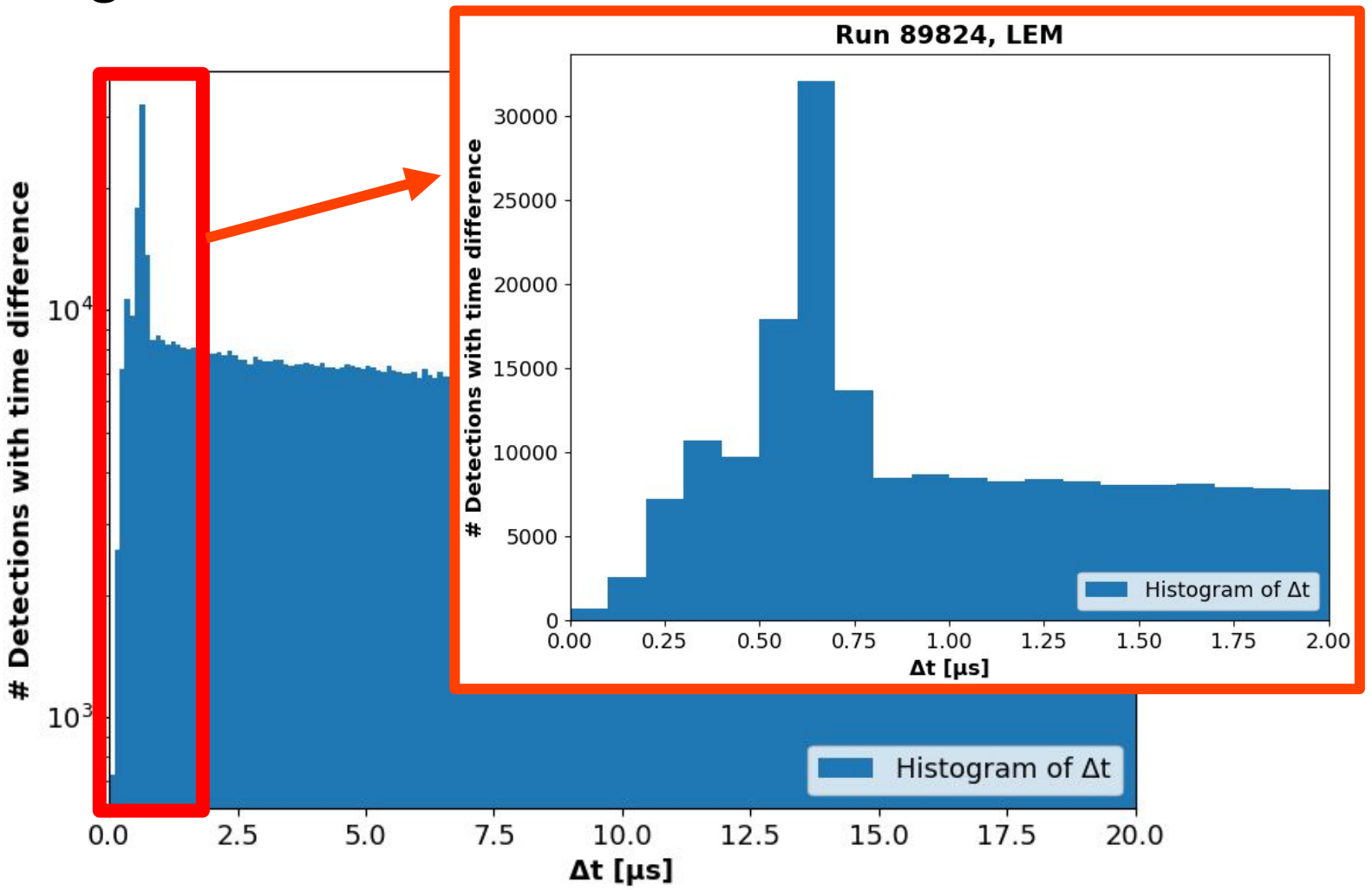
LEM ΔT Histogram



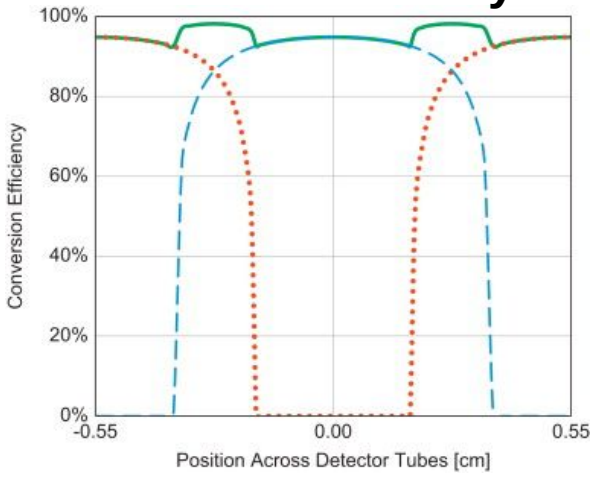
LEM ΔT Histogram



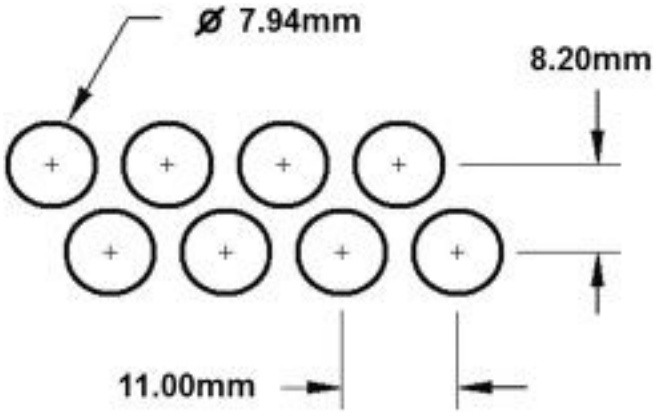
GP-SANS Detector Configuration

Detector Picture

Tube Efficiency



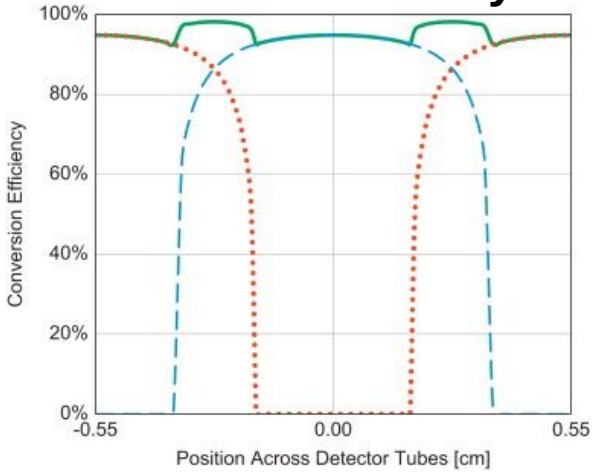
Top View



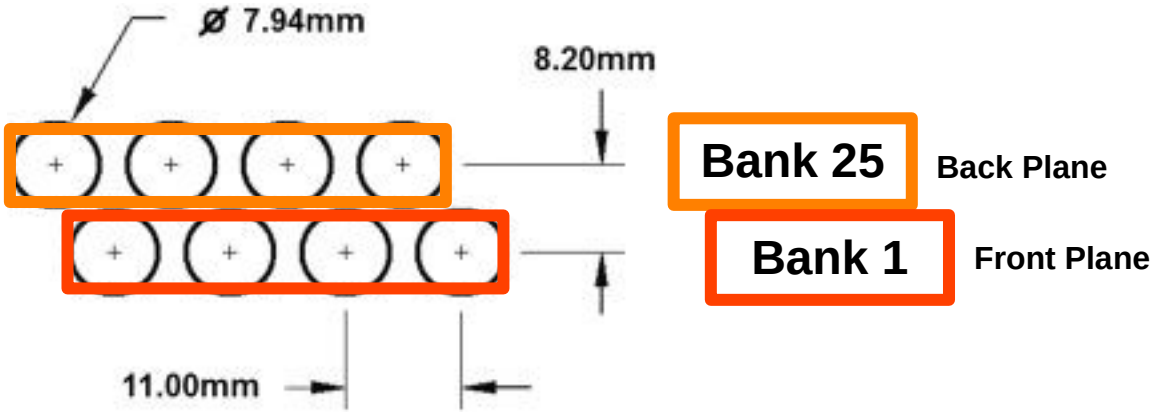
GP-SANS Detector Configuration

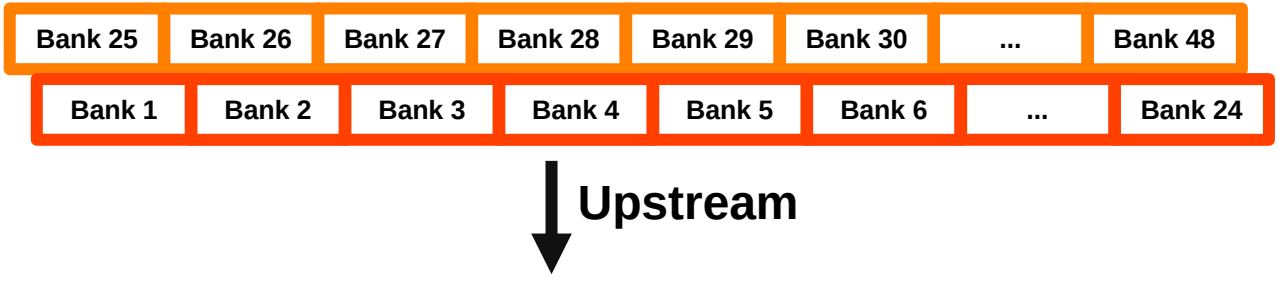
Detector Picture

Tube Efficiency

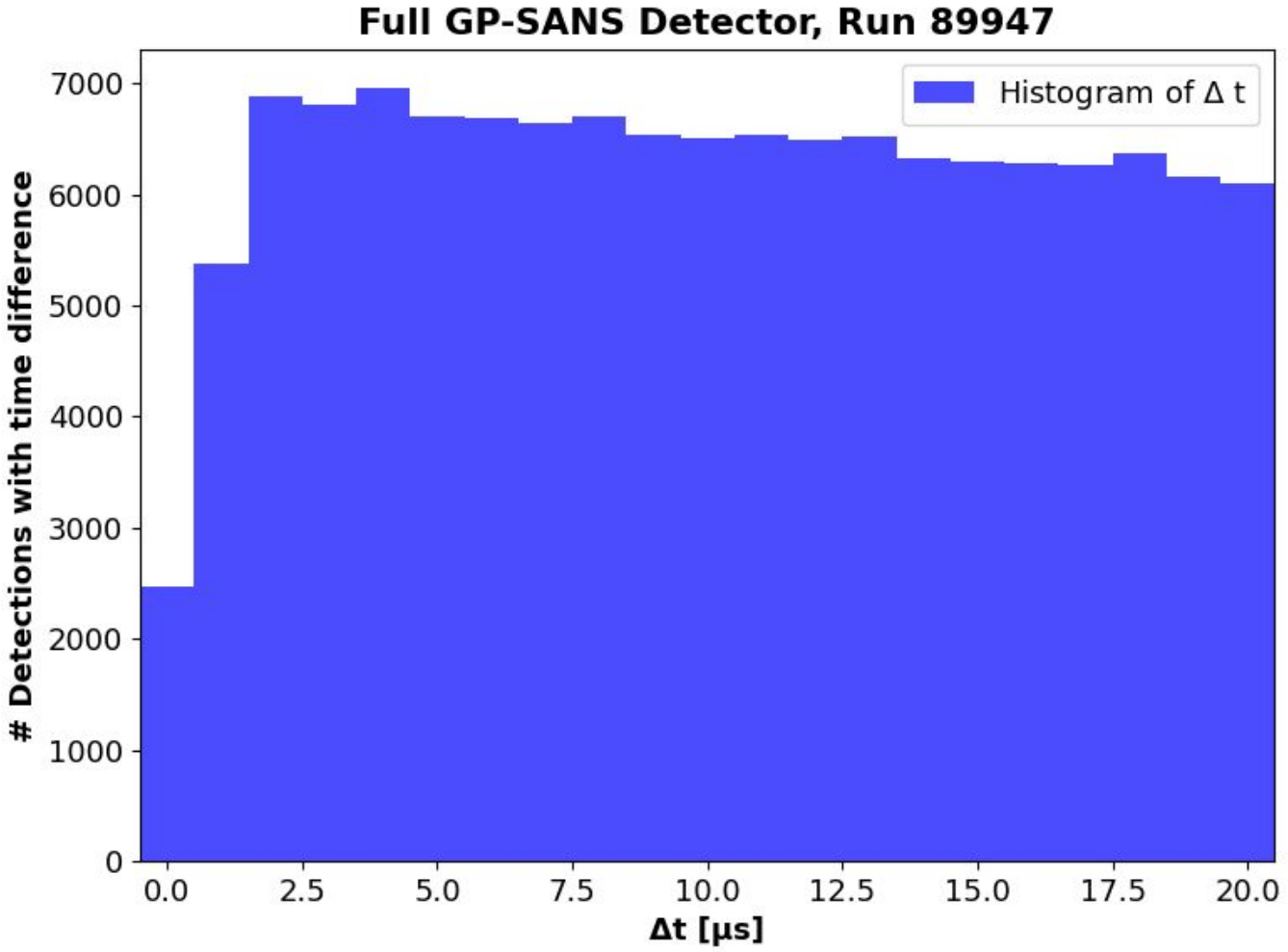


Top View



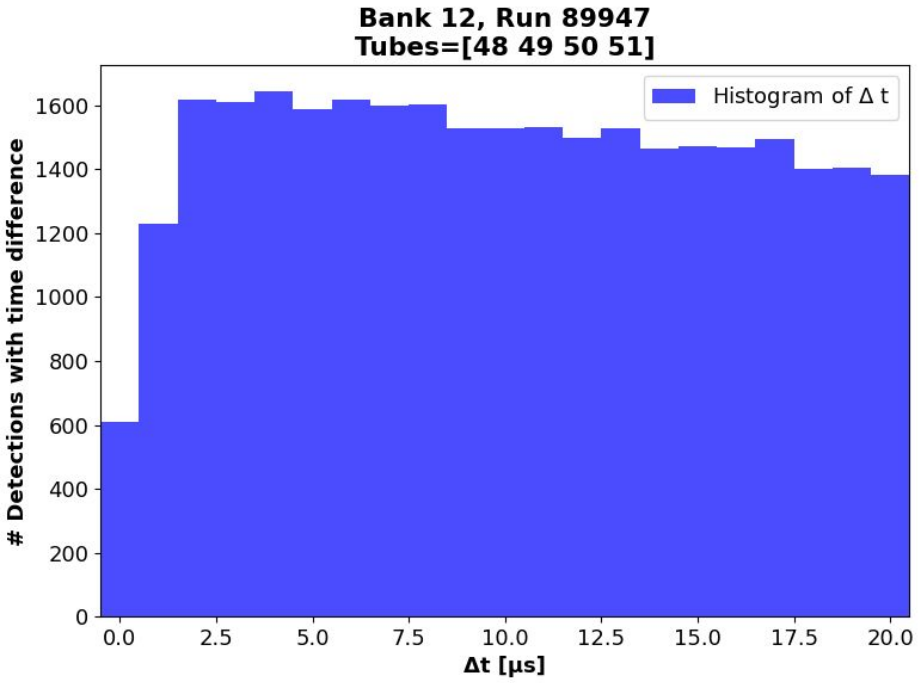


GP-SANS ΔT Histogram

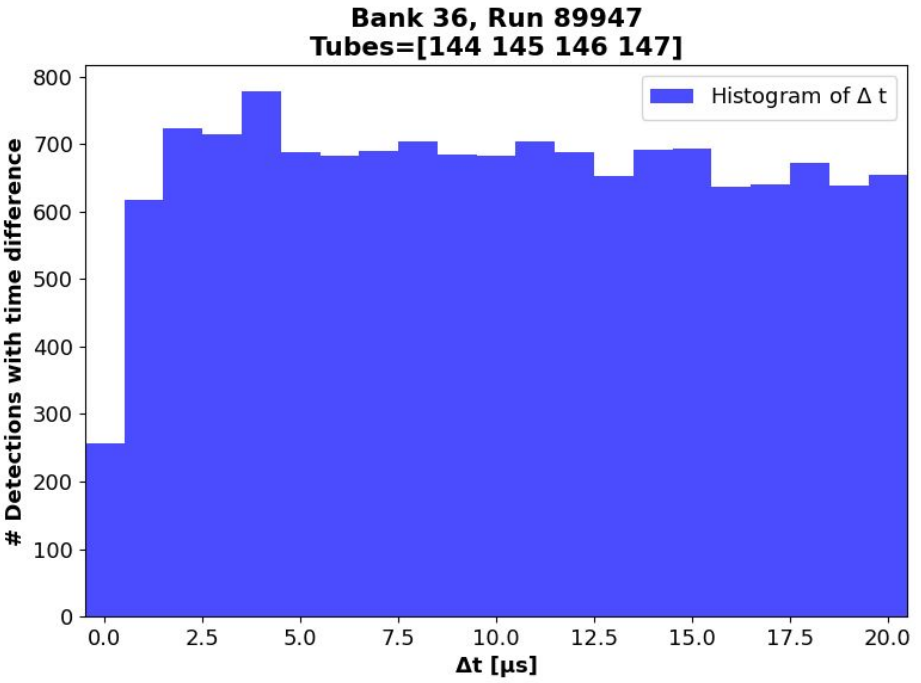


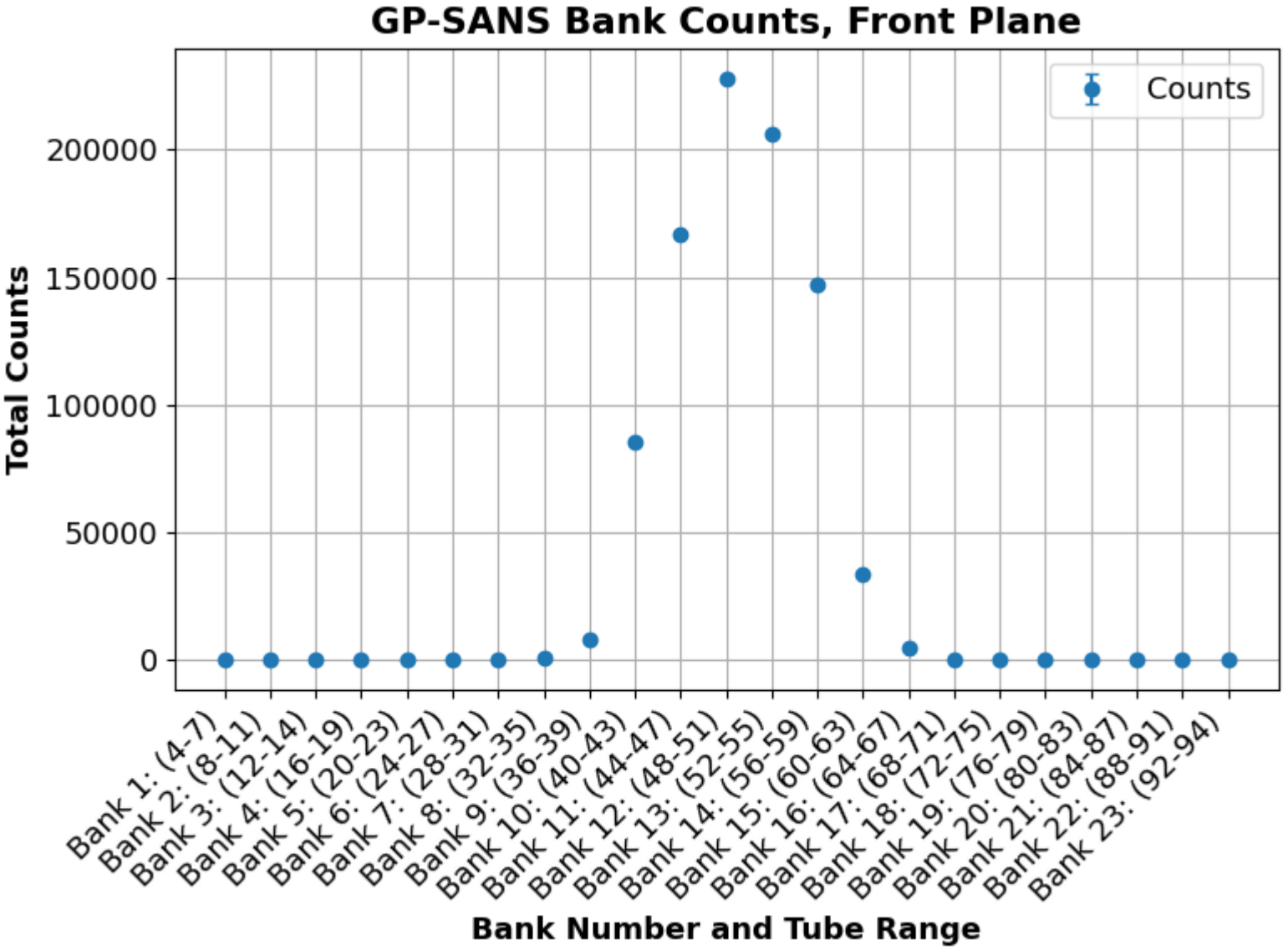
Example Bank Δt Histograms

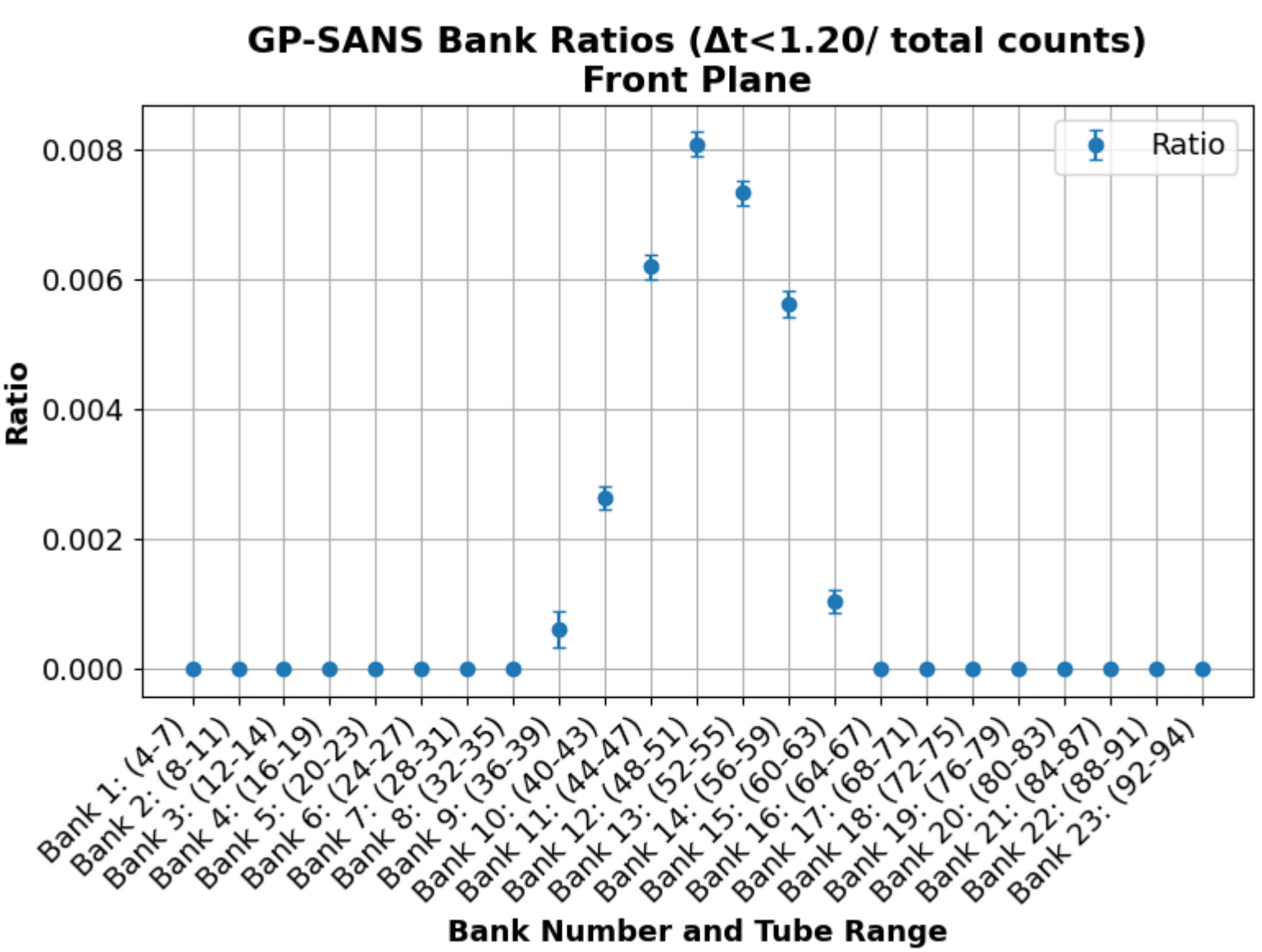
Front Plane Example



Back Plane Example




GP-SANS Bank Counts, Front Plane
Counts
Total Counts
0
50000
100000
150000
200000
Bank 1: (4-7)
Bank 2: (8-11)
Bank 3: (12-14)
Bank 4: (16-19)
Bank 5: (20-23)
Bank 6: (24-27)
Bank 7: (28-31)
Bank 8: (32-35)
Bank 9: (36-39)
Bank 10: (40-43)
Bank 11: (44-47)
Bank 12: (48-51)
Bank 13: (52-55)
Bank 14: (56-59)
Bank 15: (60-63)
Bank 16: (64-67)
Bank 17: (68-71)
Bank 18: (72-75)
Bank 19: (76-79)
Bank 20: (80-83)
Bank 21: (84-87)
Bank 22: (88-91)
Bank 23: (92-94)
Bank Number and Tube Range


GP-SANS Bank Ratios (Δt<1.20/ total counts)
Front Plane
Ratio
0.008
0.006
0.004
0.002
0.000
Ratio
Bank 1: (4-7)
Bank 2: (8-11)
Bank 3: (12-14)
Bank 4: (16-19)
Bank 5: (20-23)
Bank 6: (24-27)
Bank 7: (28-31)
Bank 8: (32-35)
Bank 9: (36-39)
Bank 10: (40-43)
Bank 11: (44-47)
Bank 12: (48-51)
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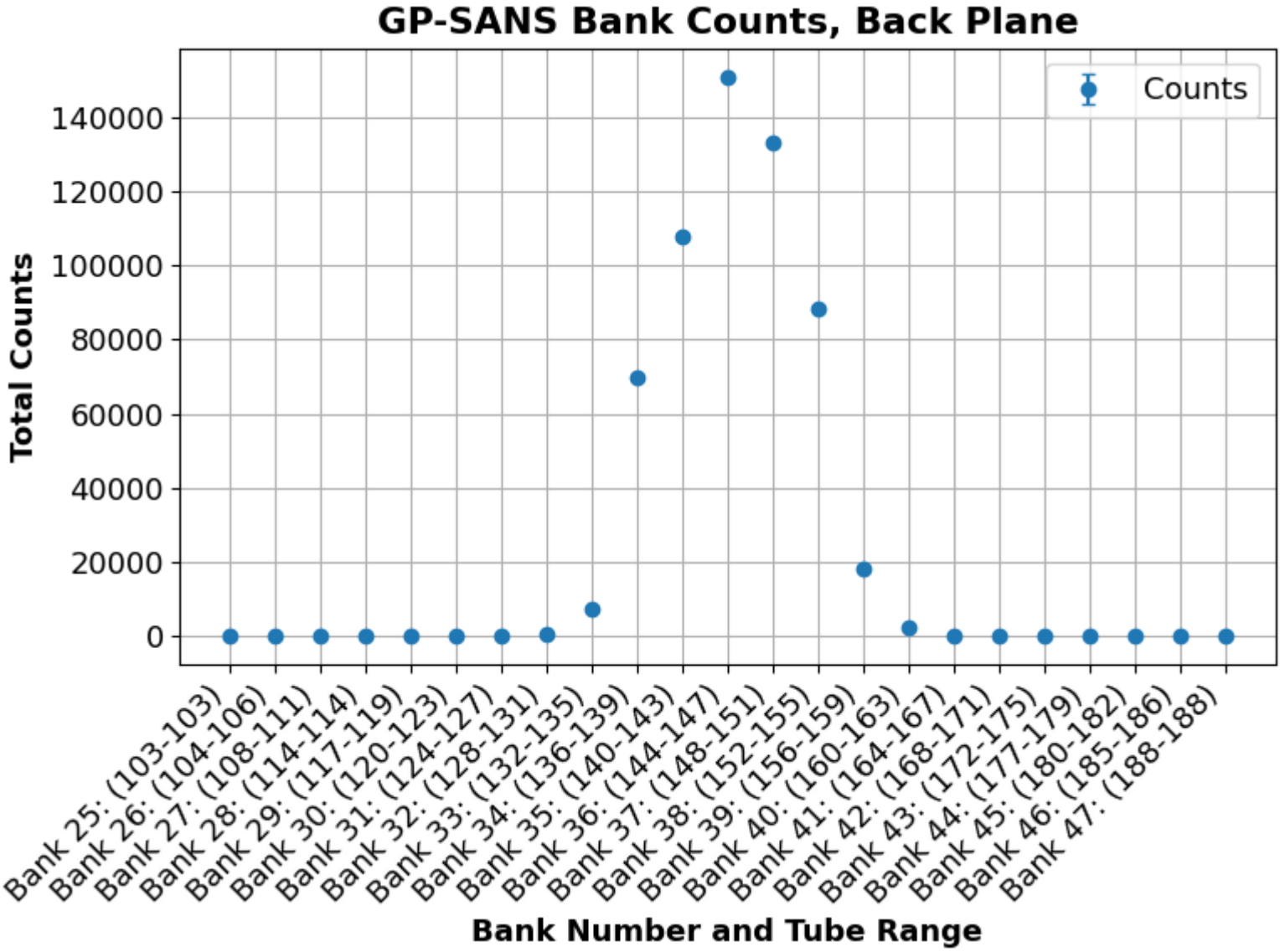
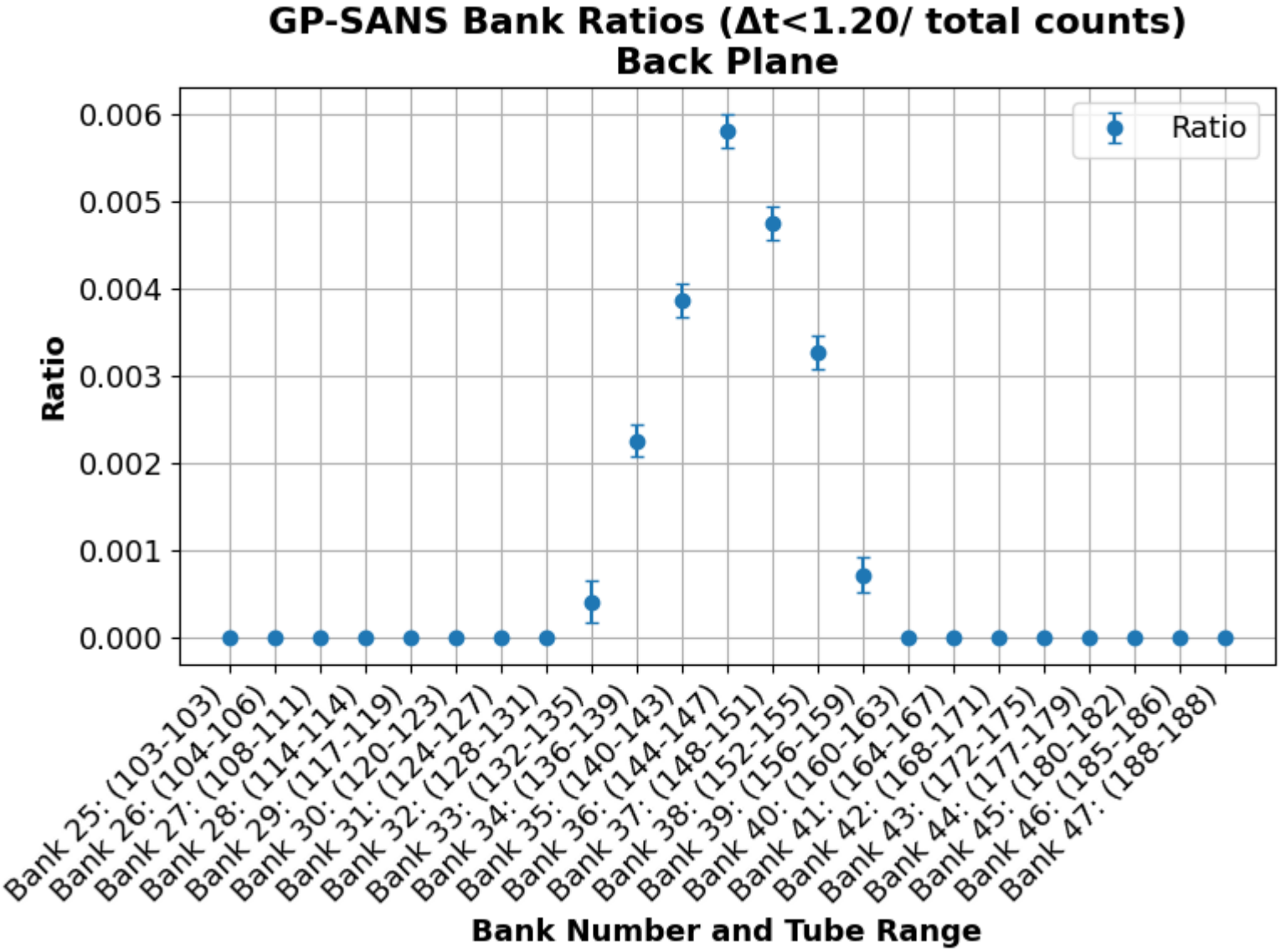
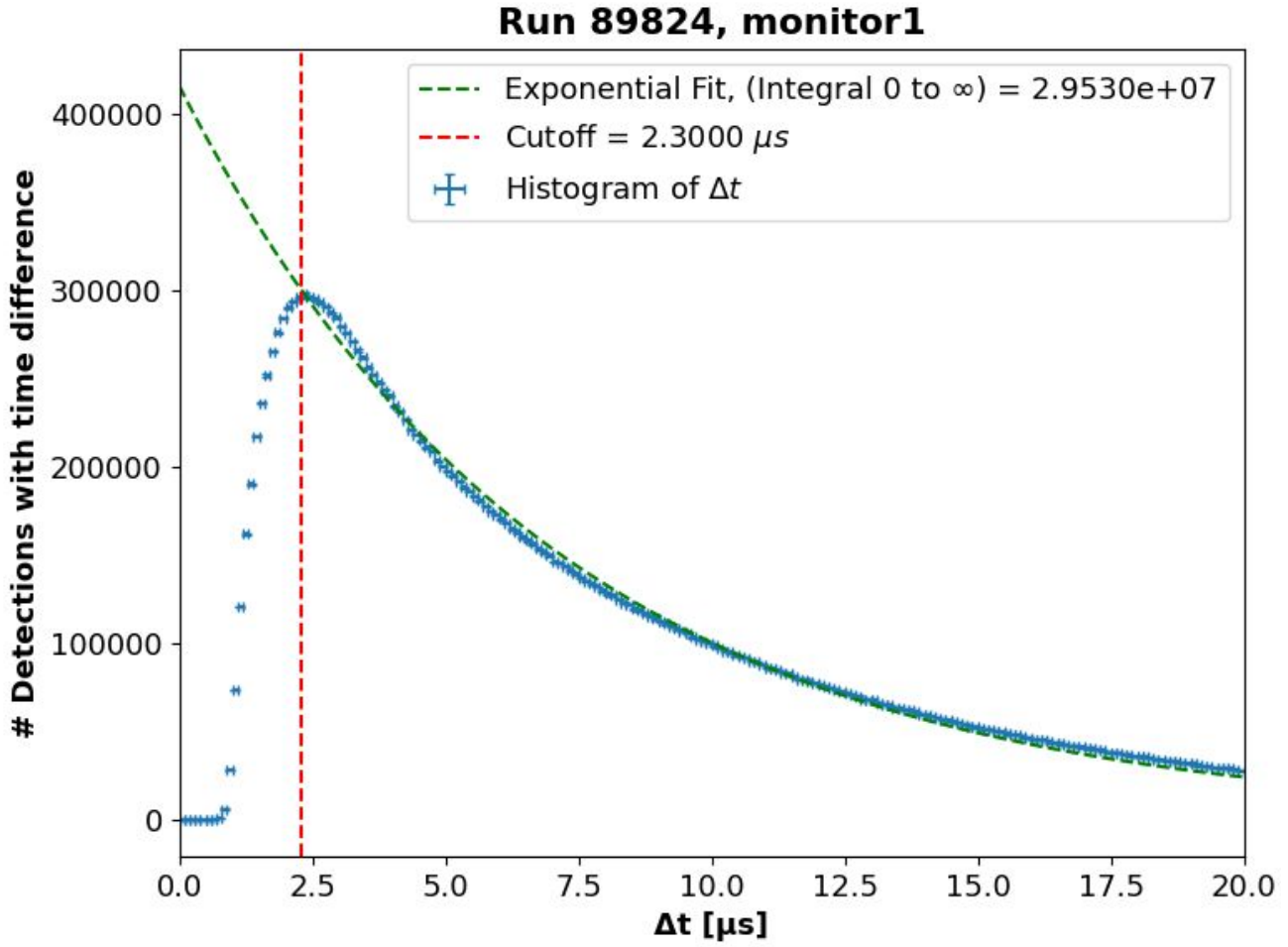
Bank Number and Tube Range


GP-SANS Bank Counts, Back Plane
Counts
Total Counts
0
20000
40000
60000
80000
100000
120000
140000
Bank 25: (103-103)
Bank 26: (104-106)
Bank 27: (108-111)
Bank 28: (114-114)
Bank 29: (117-119)
Bank 30: (120-123)
Bank 31: (124-127)
Bank 32: (128-131)
Bank 33: (132-135)
Bank 34: (136-139)
Bank 35: (140-143)
Bank 36: (144-147)
Bank 37: (148-151)
Bank 38: (152-155)
Bank 39: (156-159)
Bank 40: (160-163)
Bank 41: (164-167)
Bank 42: (168-171)
Bank 43: (172-175)
Bank 44: (177-179)
Bank 45: (180-182)
Bank 46: (185-186)
Bank 47: (188-188)
Bank Number and Tube Range


GP-SANS Bank Ratios (Δt<1.20/ total counts)
Back Plane
Ratio
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Ratio
Bank 25: (103-103)
Bank 26: (104-106)
Bank 27: (108-111)
Bank 28: (114-114)
Bank 29: (117-119)
Bank 30: (120-123)
Bank 31: (124-127)
Bank 32: (128-131)
Bank 33: (132-135)
Bank 34: (136-139)
Bank 35: (140-143)
Bank 36: (144-147)
Bank 37: (148-151)
Bank 38: (152-155)
Bank 39: (156-159)
Bank 40: (160-163)
Bank 41: (164-167)
Bank 42: (168-171)
Bank 43: (172-175)
Bank 44: (177-179)
Bank 45: (180-182)
Bank 46: (185-186)
Bank 47: (188-188)
Bank Number and Tube Range

Exponential Δt Correction

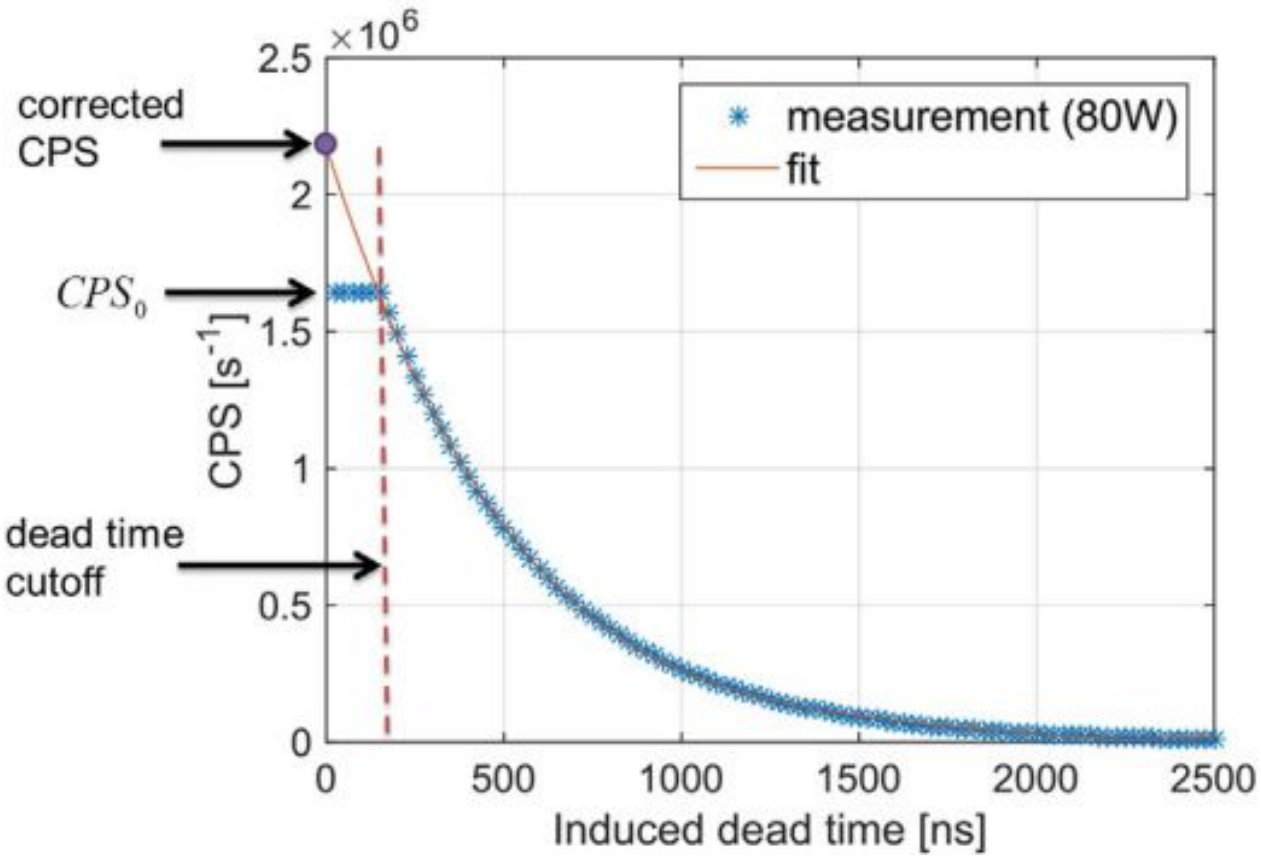
- Fit exponential to Δt curve, and integrate over all bins



Backwards Extrapolation Method (BEX)

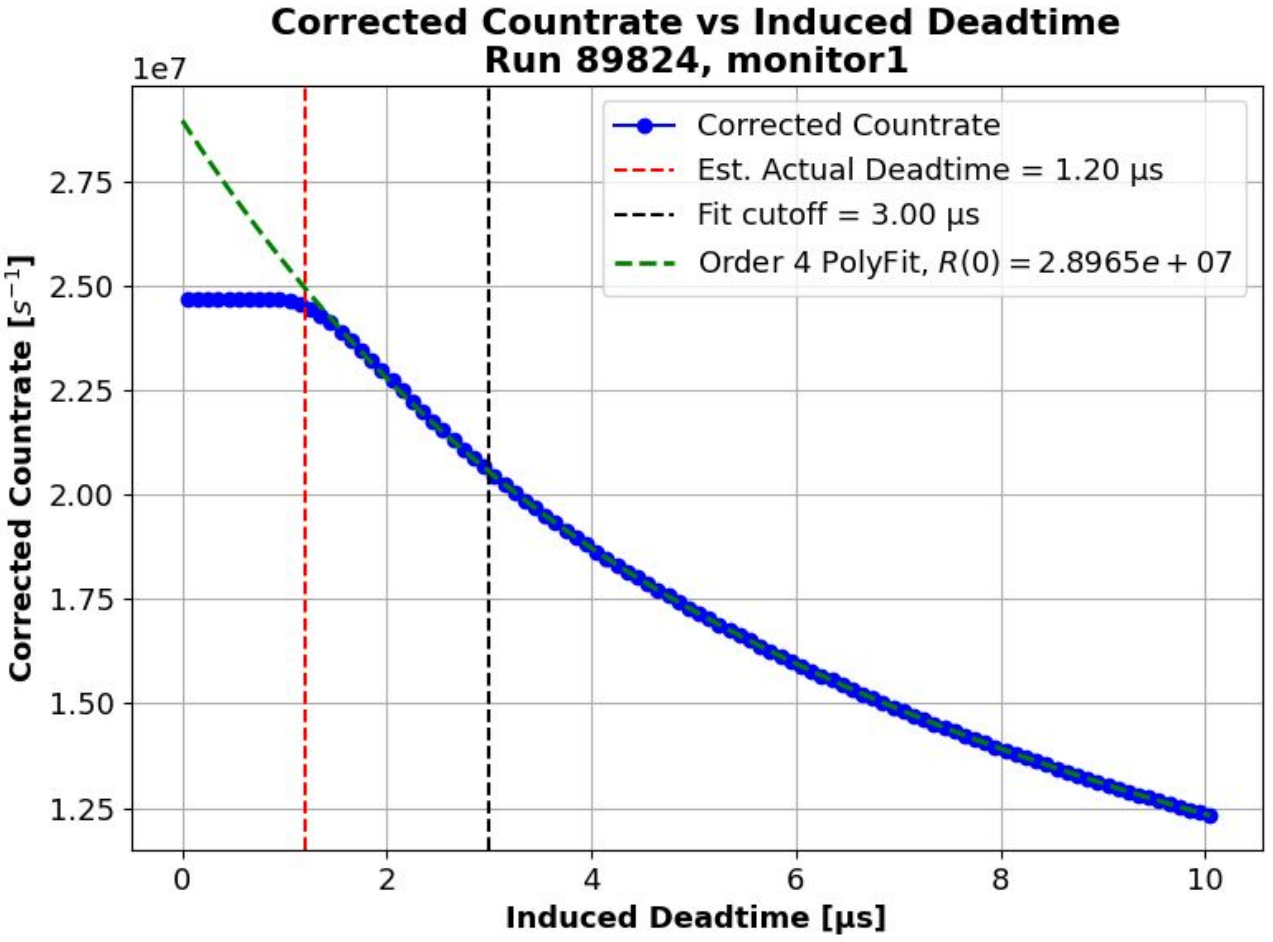
In Gilad 2017, the BEX method is explored and tested on known reactor countrates to quantify its performance in finding the deadtime-corrected countrate.

- 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.

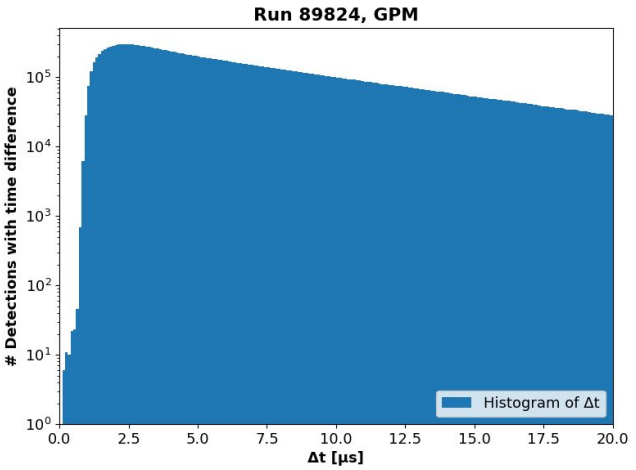


[2] E. Gilad, C. Dubi, B. Geslot, P. Blaise, and A. Kolin, “Dead time corrections using the backward extrapolation method,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 854, pp. 53–60, 2017, doi: https://doi.org/10.1016/j.nima.2017.02.026.

BEX Method Applied to GPM in 89824

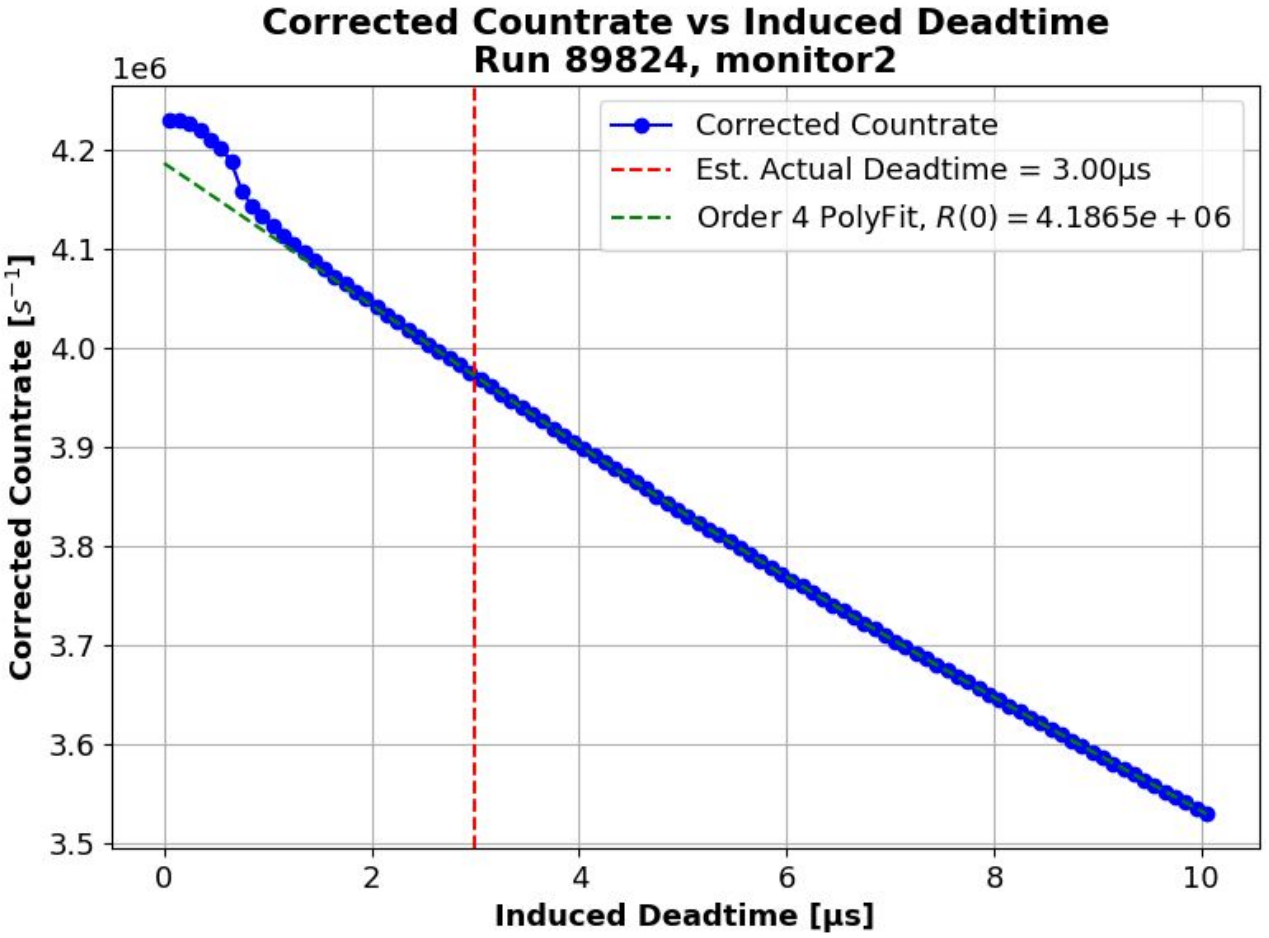


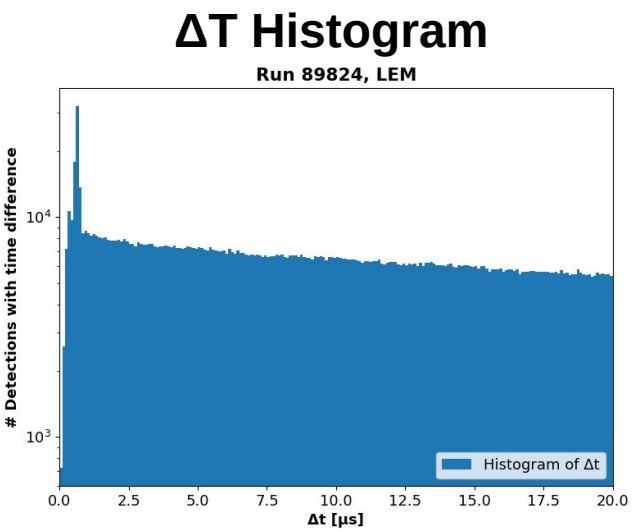
ΔT Histogram



- Using BEX Method, extrapolation (green line) to deadtime=0 gives ~17% increase in total counts
- Red line represents cutoff for fitting routine (green curve is fit to points with induced deadtime>3000ns)

BEX Method Applied to LEM in 89824





- BEX obviously does not work for this detector

Δt Intensity Correction Methods for GPM

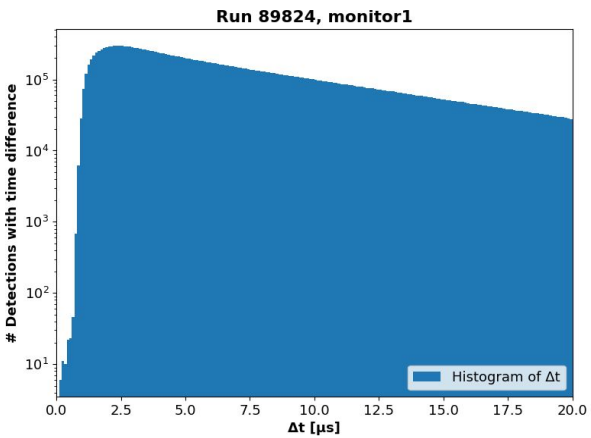
Run	GPM Counts	BEX Correction	Exp Correction	Formula Correction
89824 219s	2.47e7 (1.13e5 cps)	2.90e7 (+17%)	2.95e7 (+20%)	2.86e7 (16%)
89949 86s	9.53e6 (1.11e5 cps)	1.12e7 (+17%)	1.13e7 (+18%)	1.10e7 (15%)
89950 318s	3.49e7 (1.10e7 cps)	4.09e7 (+17%)	4.14e7 (+19%)	4.02e7 (15%)

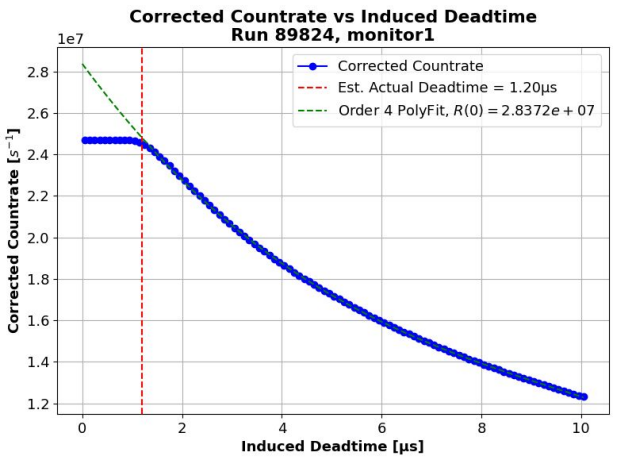
Exp Formula Correction

$$N_0 = \frac{n}{1 - \frac{n\tau}{T}}$$

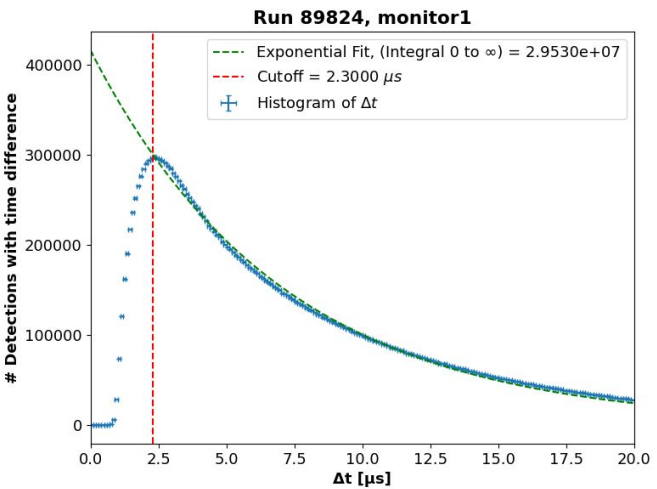
T= Duration, τ=1.2μs, n=original counts

BEX Correction





Exp ΔT Correction



Questions?

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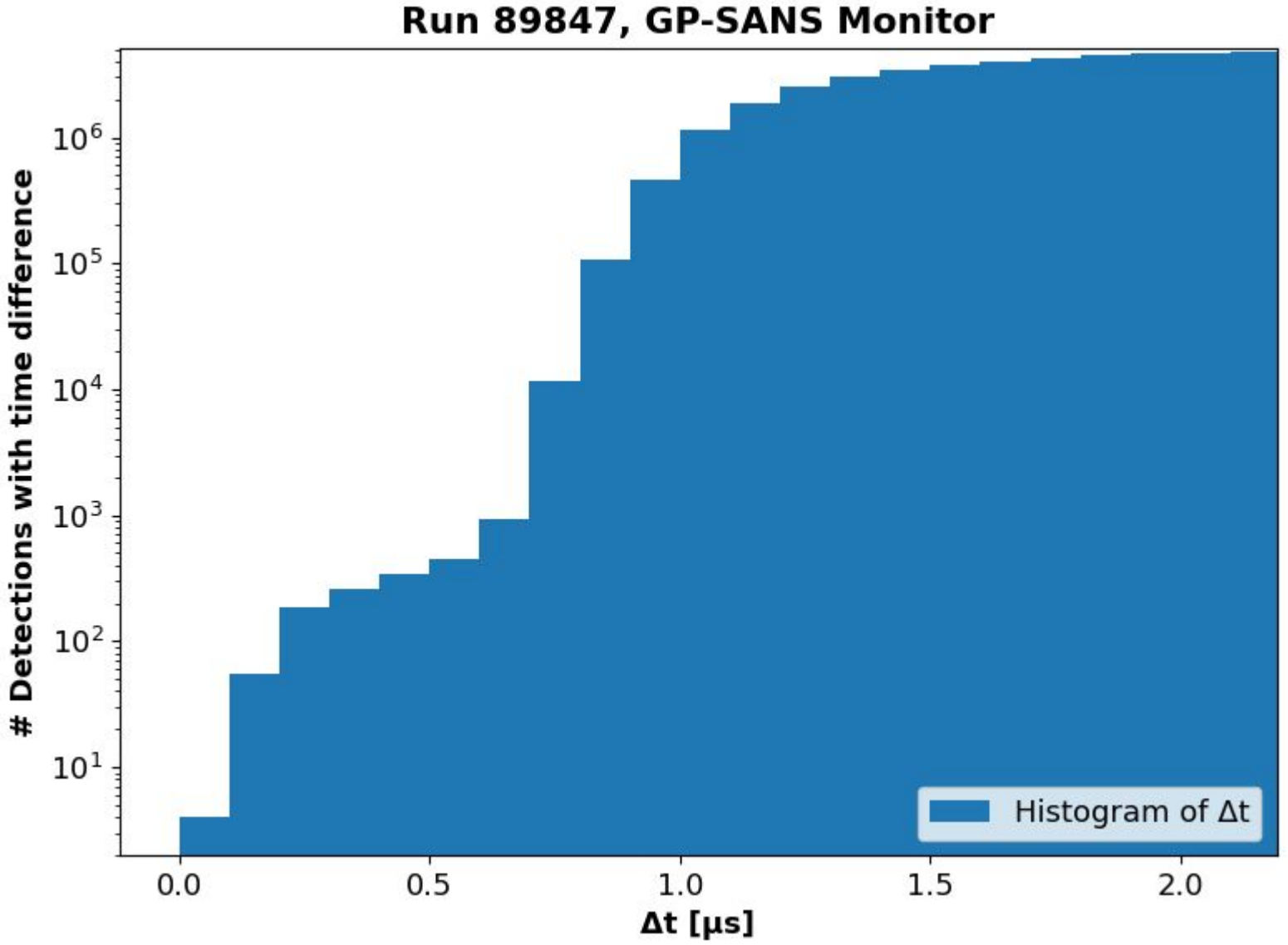
THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

DEPARTMENT OF
PHYSICS & ASTRONOMY


Run 89847, GP-SANS Monitor
Detections with time difference
10^6
10^5
10^4
10^3
10^2
10^1
0.0
0.5
1.0
1.5
2.0
Δt [μs]
Histogram of Δt