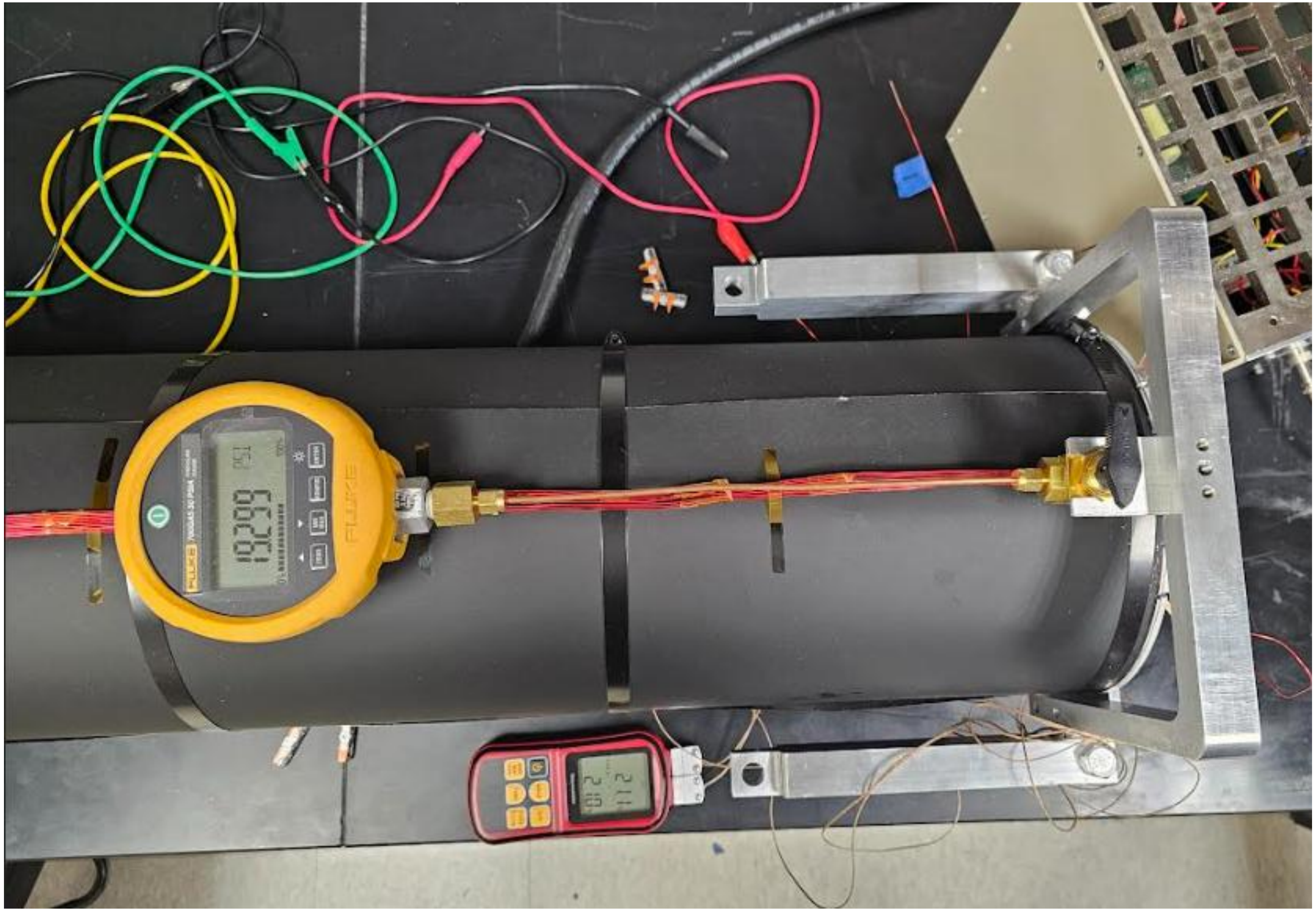
Agenda today:

1. Discussion of pressure measurement of magnet vessels - Yuri - 20'
2. Intensity and counting effect in 2021 (2024) - James - 15'
3. nTMM data analysis update - Alina - 10’
4. COMSOL update - Linus 5’
5. Proposal submitted to DOE/NP for 3-years nn’ search - Leah, Yuri - 5’
6. AOB

Pressure Measurement in Magnets after nTMM Experiment on 06 November 2025

Magnet #2 Leak Test October 24 – November 27, 2024 at UT (Magnet filled with CO_2 to 19.3 psia)



Normal atm pressure at see level in 14.7 psia

Pressure

Temperature

Measurements on 06 November 2025 by YK and SV at ~ 10 am

Magnet #7

Temperature on both magnet windows

$$22.6°C \pm 0.1°C$$

Pressure inside magnet

$$19.374 \pm 0.001\ psia$$

Atmospheric pressure was

$$14.423\ psia$$

Magnet #8

Temperature on both magnet windows

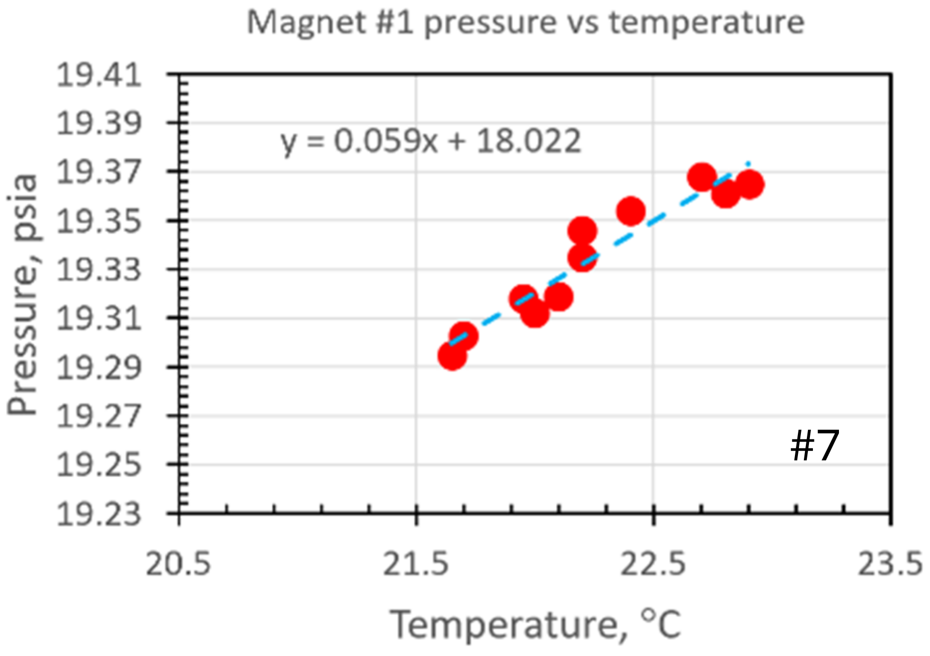
$$23.4°C \pm 0.1°C$$ (more sunlight)

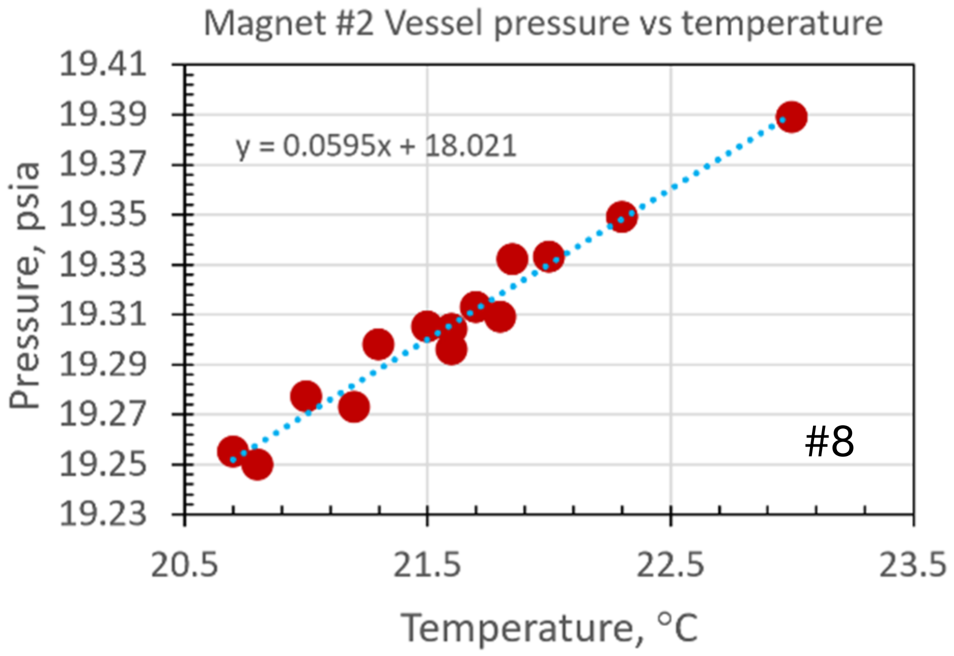
Pressure inside magnet

$$18.887 \pm 0.003\ psia$$

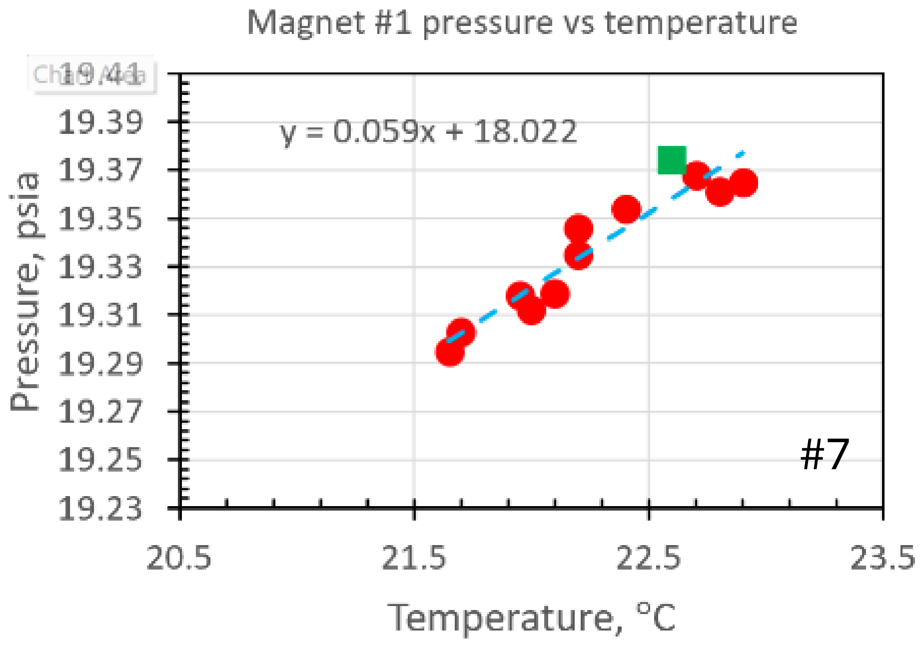
Measurement on Downstream end
(measurement on the upstream end was leaky
and show slightly lower pressure 18.792
due to difficult thread of connection)

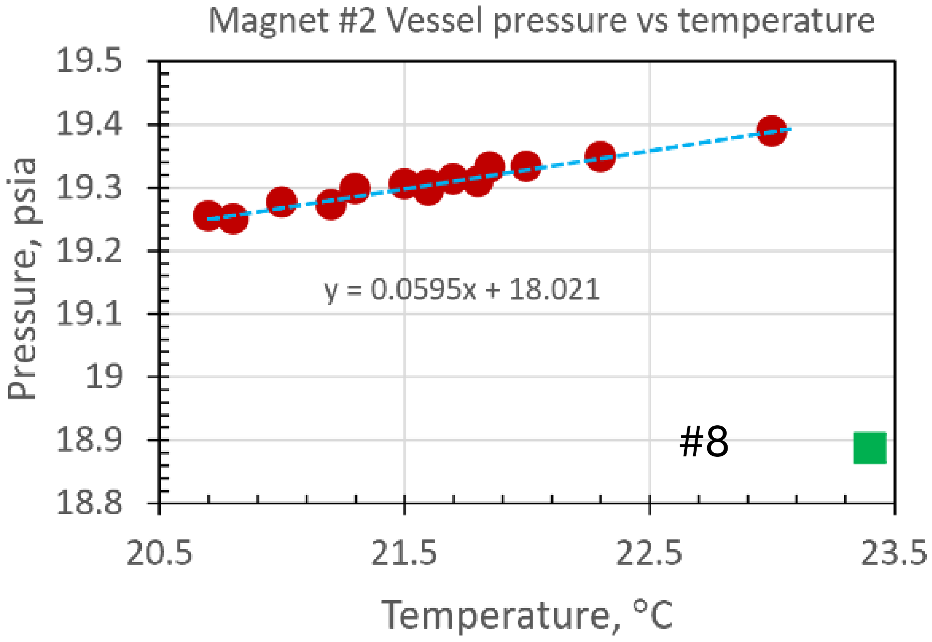
Red points:
October 2024 – February 2025 before nTMM

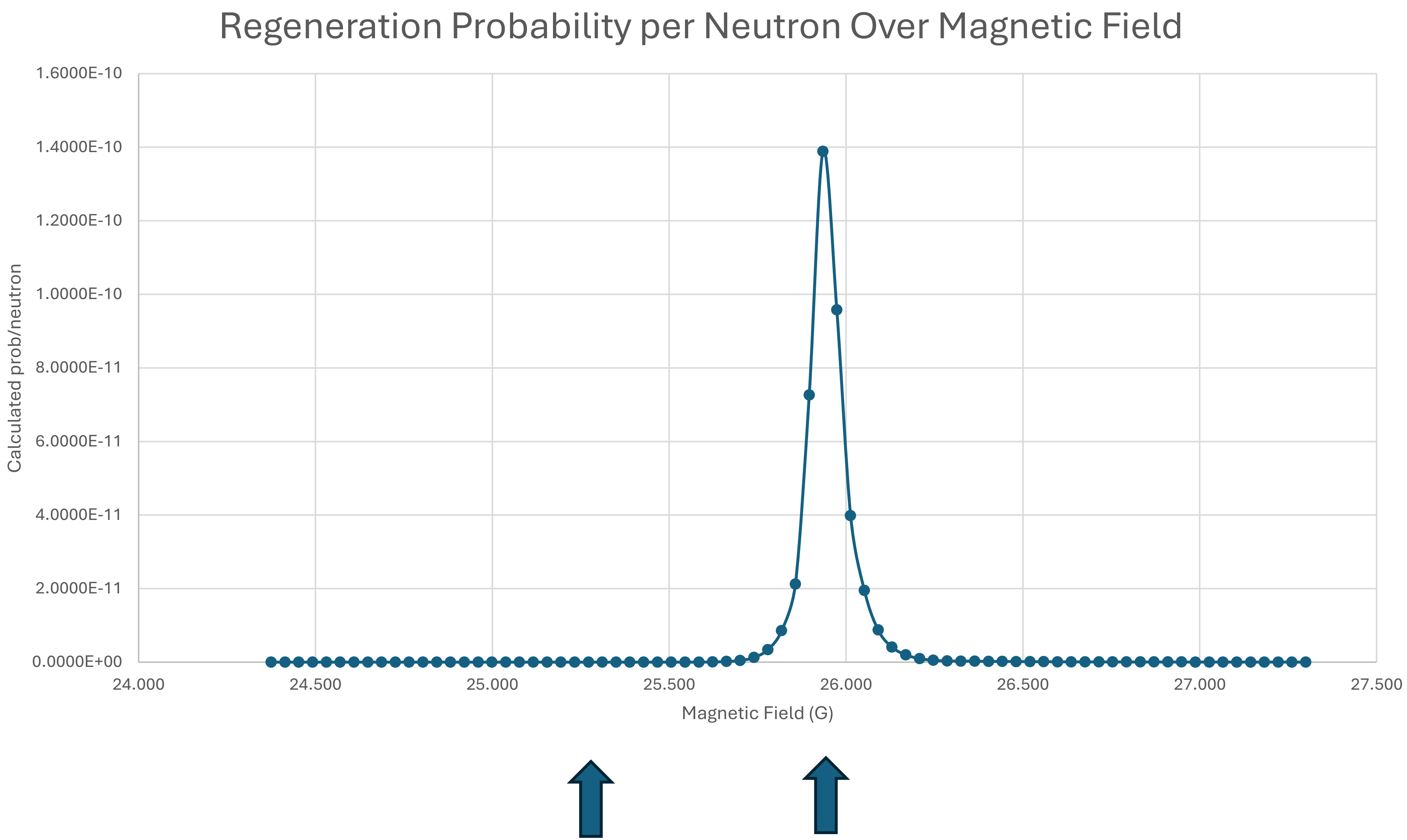




+ Green points measured Nov-06-2025 after nTMM

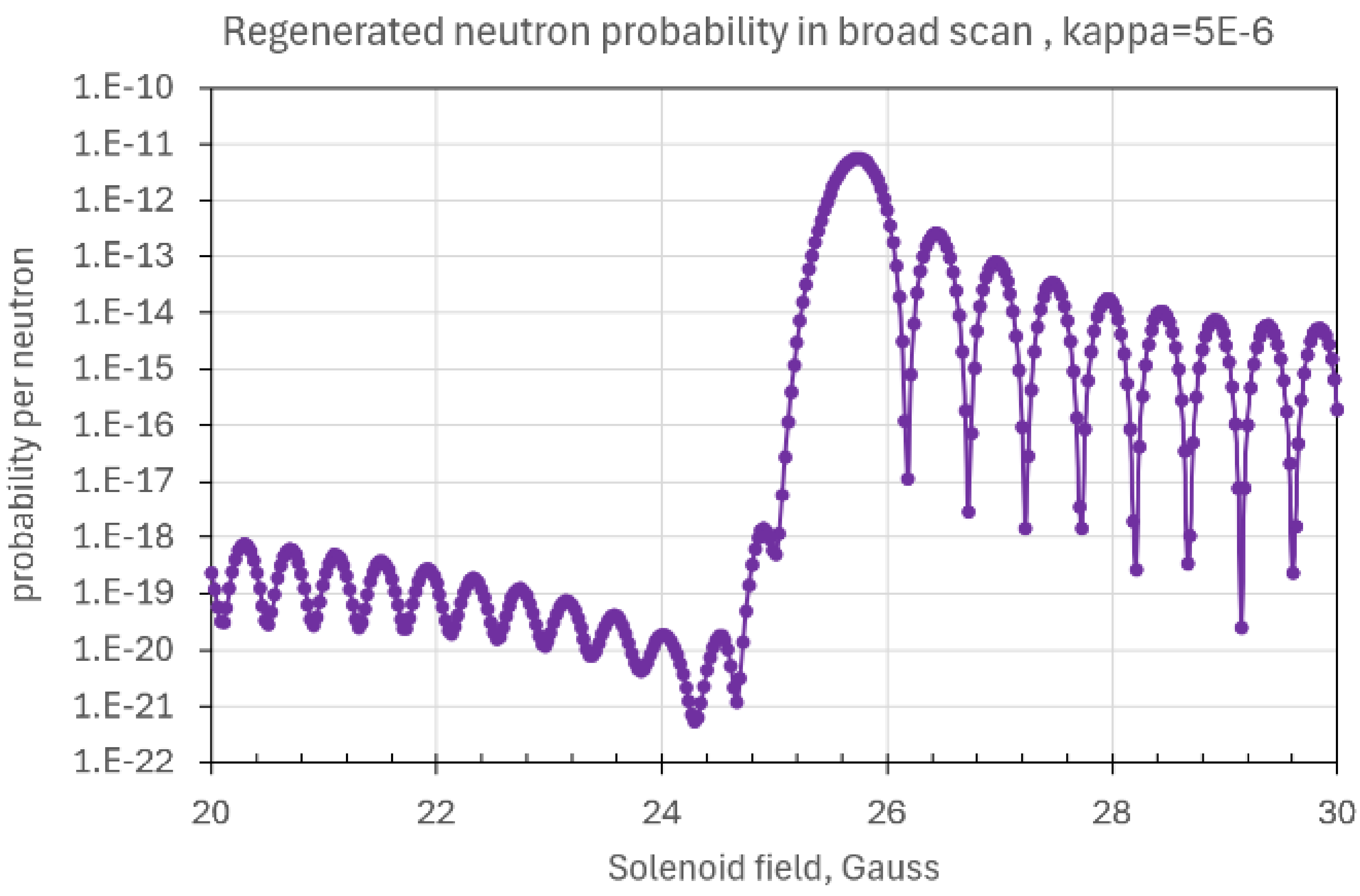






25.928 G
$p = 18.887\ psia$

25.935 G
$p = 19.372\ psia$



Regenerated neutron probability in broad scan , kappa=5E-6
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1.E-16
1.E-17
1.E-18
1.E-19
1.E-20
1.E-21
1.E-22
probability per neutron
20
22
24
26
28
30
Solenoid field, Gauss

What we do next:

1. Continue existing analysis to understand the significance of point-to-point fluctuations in fit

2. Simulate the nTMM effect with pressure difference

3. In February 2026 make IPTS proposal for GP-SANS beam time in the Fall 2026 (for 4 days)

4. To solve potential future "pressure difference problem"
    a. Connect after installation two vessels together with thin tube (equal pressure)
    b. Find precision electronic gauge for online pressure monitoring (with $\sim 10^{-4}$accuracy)
    e.g. https://www.dwyeromega.com/en-us/ 0.03%)

5. Finish mu-metal magnetic study and with COMSOL understand impact of field non-uniformity

6. Study alternative to Cd absorber (B_4C or in combination with Pb, Fe) with GEANT

7. We submitting today UT-ORNL 3-year proposal to DOE-NP for continuation of HFIR-based research
   Within this proposal nTMM-2 experiment (with 8 magnets) in 2027 and neutron disappearance in 2029.

2021 and 2024 Intensity Summary
2021 Analysis Summary
IPTS 24916, 27957

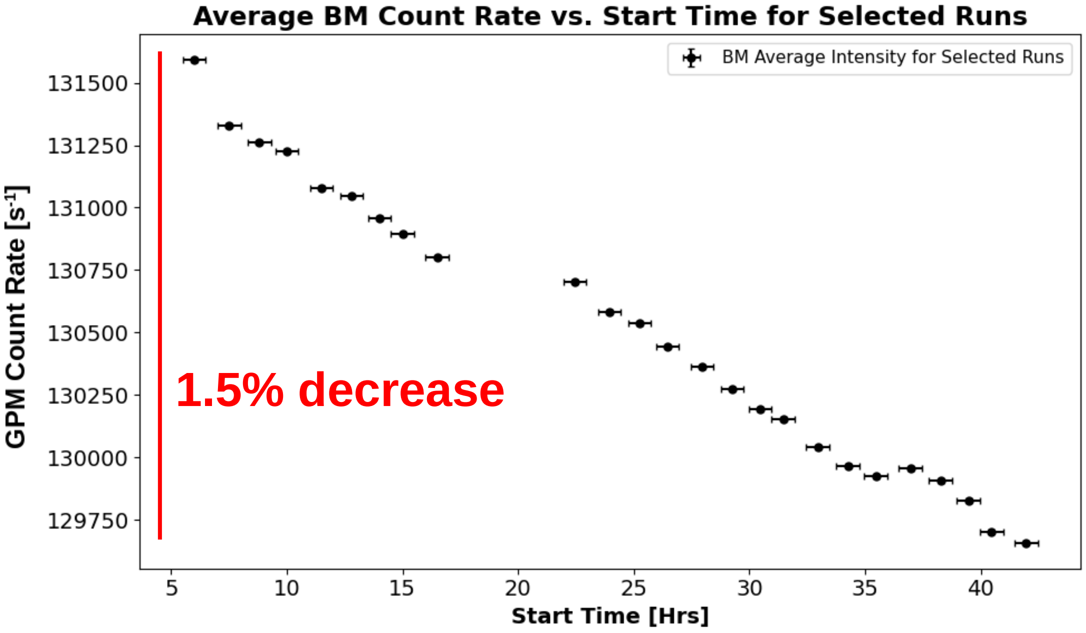
James Rogers
jroger87@vols.utk.edu

November 3, 2025

THE UNIVERSITY OF TENNESSEE KNOXVILLE
DEPARTMENT OF PHYSICS & ASTRONOMY

GPM Intensity Calculation 2021 Experiment

→ **Calculating intensity at Magnet position using GPM measurement**



- GPM countrate avg = $1.305 \cdot 10^5$ cps
- GPM variation = $0.019 \cdot 10^5$ cps
- GPM Intensity = $1.305 \cdot 10^5$ cps · CF · T / η'

➔ GPM Intensity = $(9.133 \pm 0.635) \cdot 10^8$ n/s

Matt estimated $9.93 \cdot 10^8$ n/s in 2021 assuming:
- 5% loss due to deadtime
- Using BM ~28 500 avg. countrate
- Spectrum weighted efficiency from McStas: η' = $3.0121 * 10^{-5}$ counts / neutron

➔ McStas predicts $T_1 = (18.7 \pm 1.1)\%$ intensity transmission from GPM to Magnet position
➔ Mubi transmission through sapphire windows $T_2 = (0.900 \pm 0.021)^2$
➔ McStas predicts η' = $(3.108 \pm 0.006) \cdot 10^{-5}$ counts / neutron spectral efficiency
➔ Deadtime correction factor CF = $(143.6 \pm 1.2)\%$
➔ Estimated intensity = GPM Countrate · CF · $T_1 \cdot T_2$ / η' = GPM Countrate · (6998.4 ± 475.8)

Intensity at Magnet Position in 2021 Experiment

*LEM was not worth including here because of unrealistically high countrate

Method:	Intensity [n/s]
GPM Propagation	$(9.133 \pm 0.635) \cdot 10^8$
Au Foil	$(7.403 \pm 0.756) \cdot 10^8$
Mean w/ RMS	$(8.268 \pm 0.865) \cdot 10^8$

→ 10.5% rel. error (from difference of GPM, Au Foil measurements)

Summary of analysis:

- 30.3% loss due to deadtime (143.6% correction)
- GPM countrate $(1.305 \pm 0.019) \cdot 10^5$ cps
- ➔ (18.7 ± 1.1)% McStas simulated Transmission from GPM to Magnet
- ➔ (90.0 ± 2.1)% transmission through 2 sapphire windows, from Mubi
- $\eta' = 3.108 \pm 0.006) \cdot 10^{-5}$ counts / neutron

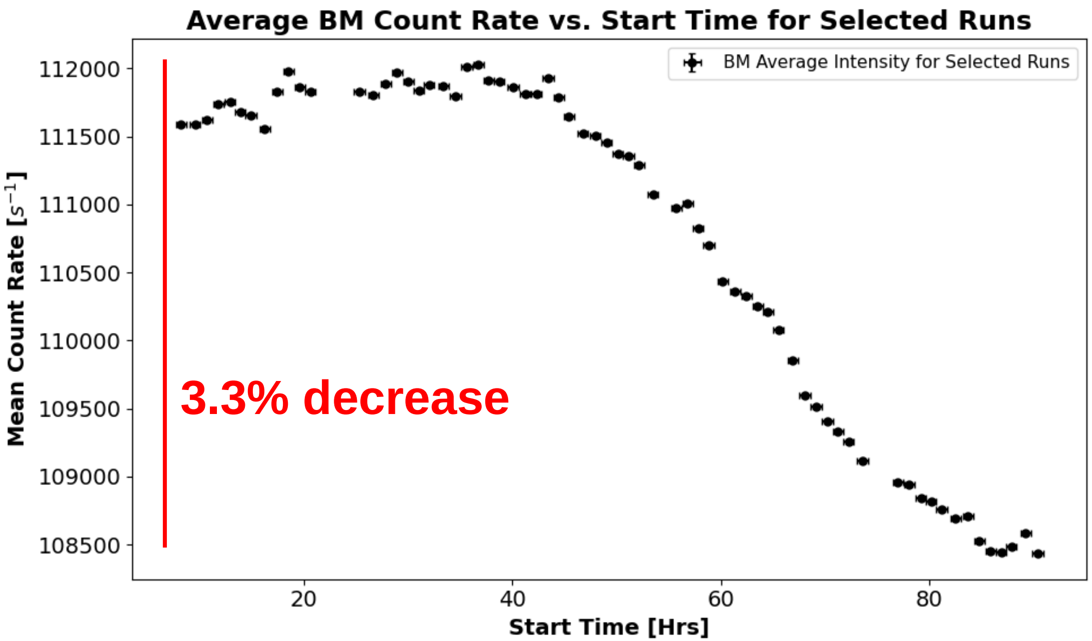
Gold Foil calculation:

- $(2.04 \pm 0.05) \cdot 10^8$ n/cm^2/s
- (3.629 ± 0.36) cm^2 (**completely arbitrary error)

  → intensity = $(7.403 \pm 0.756) \cdot 10^8$ n/cm^2/s

GPM Intensity Calculation 2024 Experiment

→ **Calculating intensity at Magnet position using GPM measurement**



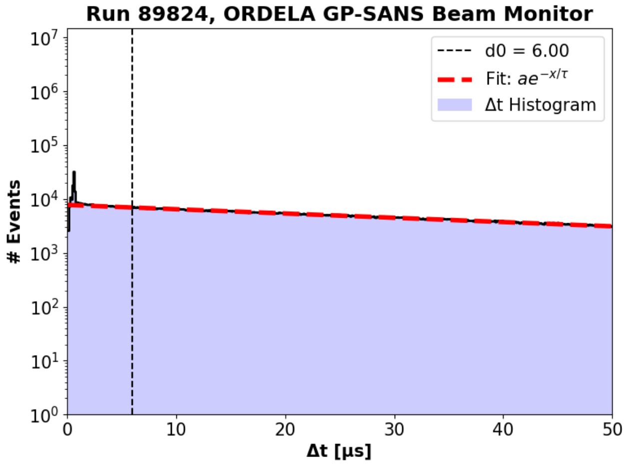
- GPM countrate avg = $1.107 \cdot 10^5$ cps
- GPM variation = $0.036 \cdot 10^5$ cps
- GPM Intensity = $1.107 \cdot 10^5$ cps · CF · T / η'

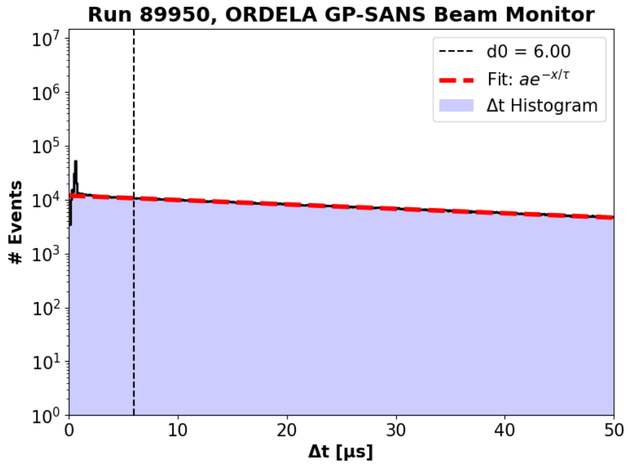
→ GPM Intensity = $(6.183 \pm 0.467) \cdot 10^8$ n/s

- McStas predicts $T_1 = (18.7 \pm 1.1)\%$ intensity transmission from GPM to Magnet position
- Mubi transmission through sapphire windows $T_2 = (0.900 \pm 0.021)^2$
- McStas predicts $\eta' = (3.108 \pm 0.006) \cdot 10^{-5}$ counts / neutron spectral efficiency
- Deadtime correction factor CF = $(114.6 \pm 1.1)\%$
- Estimated intensity = GPM Countrate · CF · $T_1 \cdot T_2 / \eta'$ = GPM Countrate · (5585.1 ± 381.6)

LEM Intensity Calculation 2024 Experiment

→ Calculating intensity at Magnet position using LEM measurement





Step:	89824 (219s)	89950 (318s)
Raw counts [c]	$(3.614973 \pm 0.001901) \cdot 10^6$	$(5.445961 \pm 0.002334) \cdot 10^6$
Raw countrate [c/s]	$(1.65067 \pm 0.000868) \cdot 10^4$	$(1.71257 \pm 0.000734) \cdot 10^4$
Fit Tau [us]	(-54.650 ± 0.007)	(-53.049 ± 0.004)
1/Tau [c/s]	$(1.8298 \pm 0.0002) \cdot 10^4$	$(1.8851 \pm 0.0002) \cdot 10^4$
Correction Ratio	1.1085 ± 0.0005	1.1007 ± 0.0005

Intensity at Magnet Position in 2024 Experiment

Method:	Intensity [n/s]
GPM Propagation	$(6.183 \pm 0.467) \cdot 10^8$
LEM Measurement	$(6.021 \pm 0.125) \cdot 10^8$
Weighted Mean	$(6.032 \pm 0.121) \cdot 10^8$

Summary of analysis:

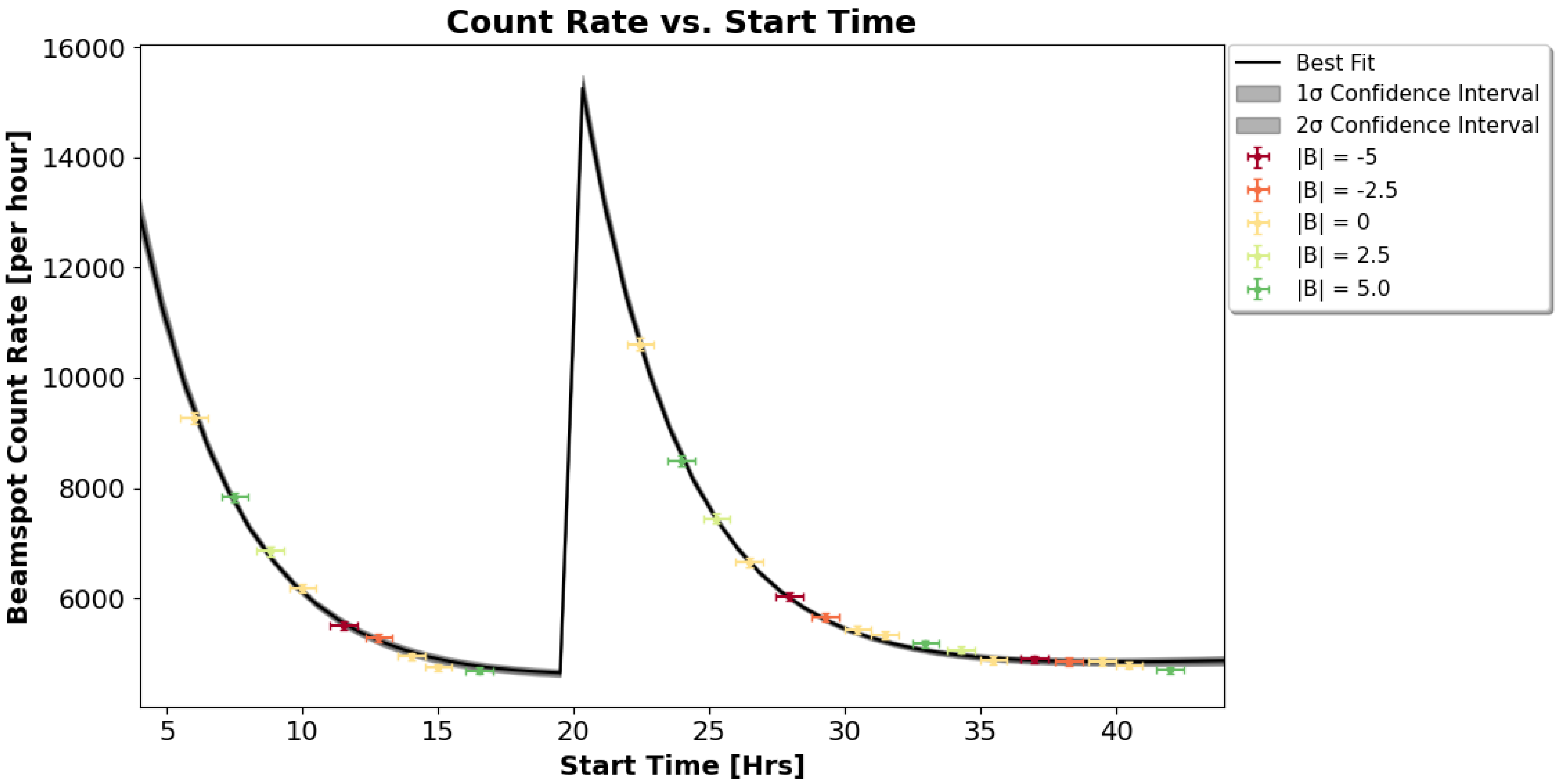
- 12.7% loss due to deadtime (114.6% correction)
- GPM countrate $(1.107 \pm 0.036) \cdot 10^5$ cps
- ➔ (18.7 ± 1.1)% McStas simulated Transmission from GPM to Magnet
- ➔ (90.0 ± 2.1)% transmission through 2 sapphire windows, from Mubi
- $\eta' = (3.108 \pm 0.006) \cdot 10^{-5}$ counts / neutron

LEM Measurement:

- 9.5% loss due to deadtime (110.5% correction)
- LEM countrate $(1.682 \pm 0.031) \cdot 10^4$ cps
- Spectral efficiency:
  $\eta' = (3.085 \pm 0.009) \cdot 10^{-5}$ counts / neutron

➔ 2.0% rel. error on weighted mean

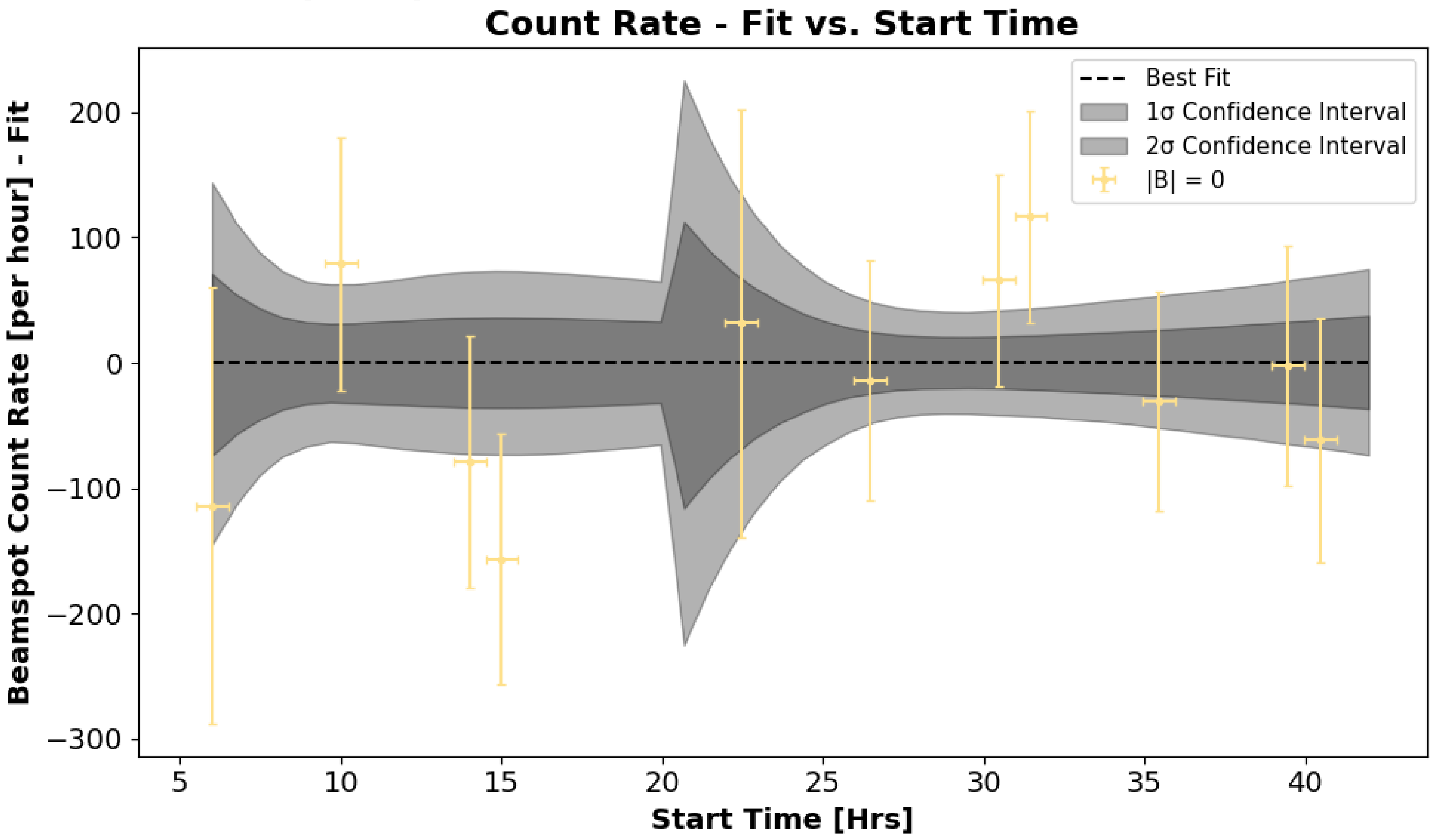
Beam ROI Countrate (2021)



NOTE:
Second half has ROI shifted 20cm to the right
Fit has ^{56}Mn τ fixed, fit only to |B|=0 runs

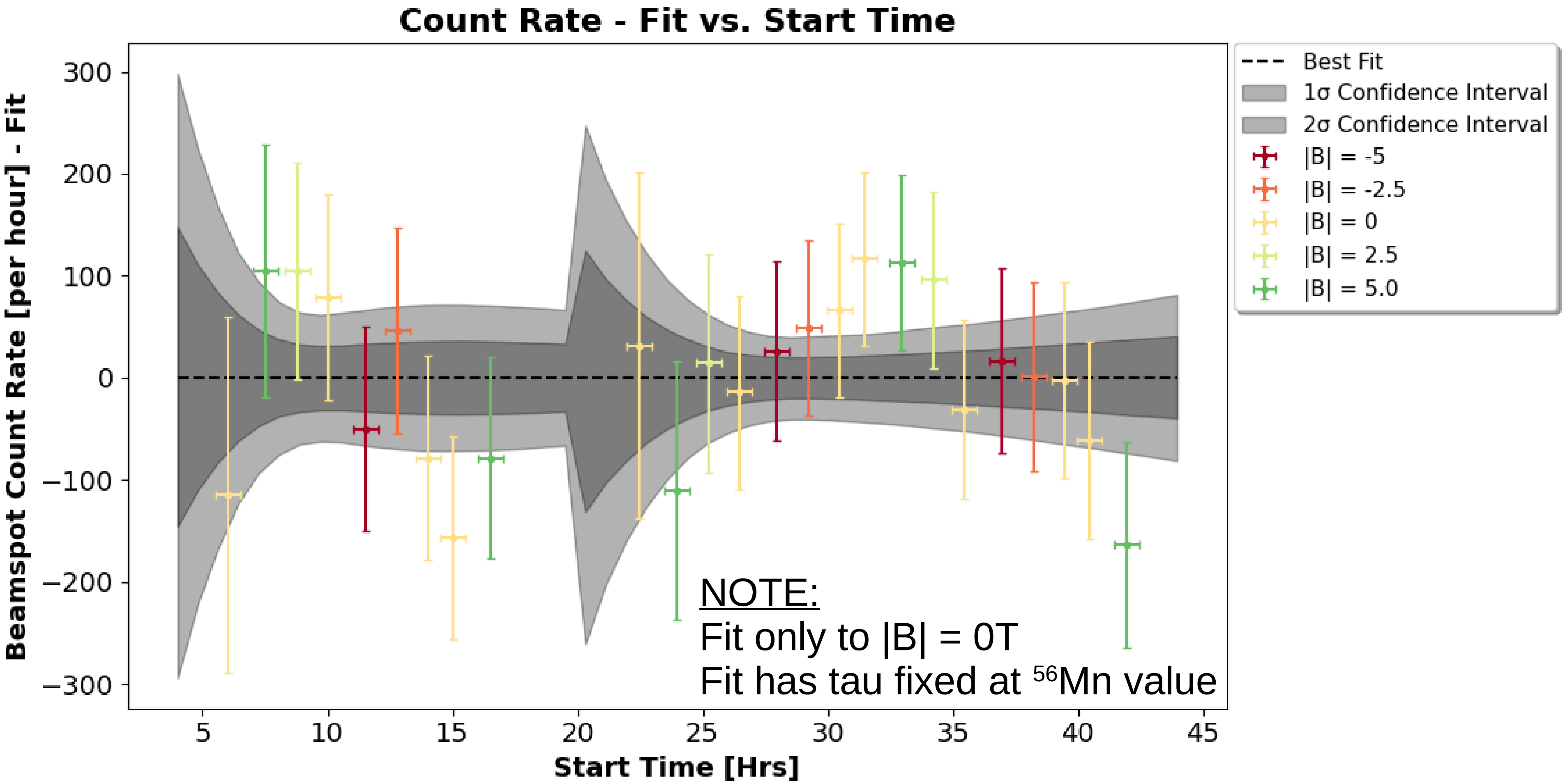
Fit Residuals, |B|=0 Runs

Beam ROI Countrate (2021)

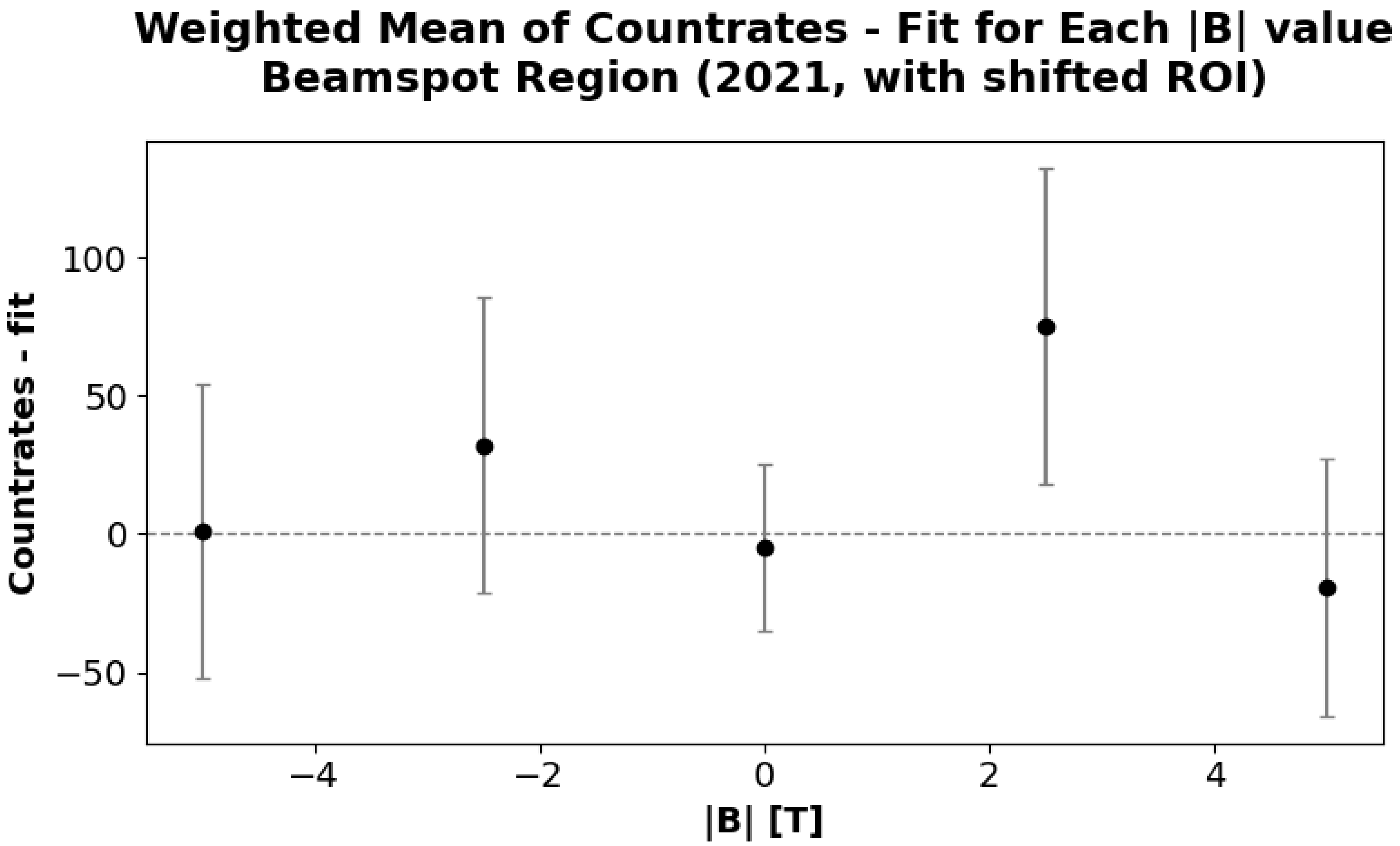


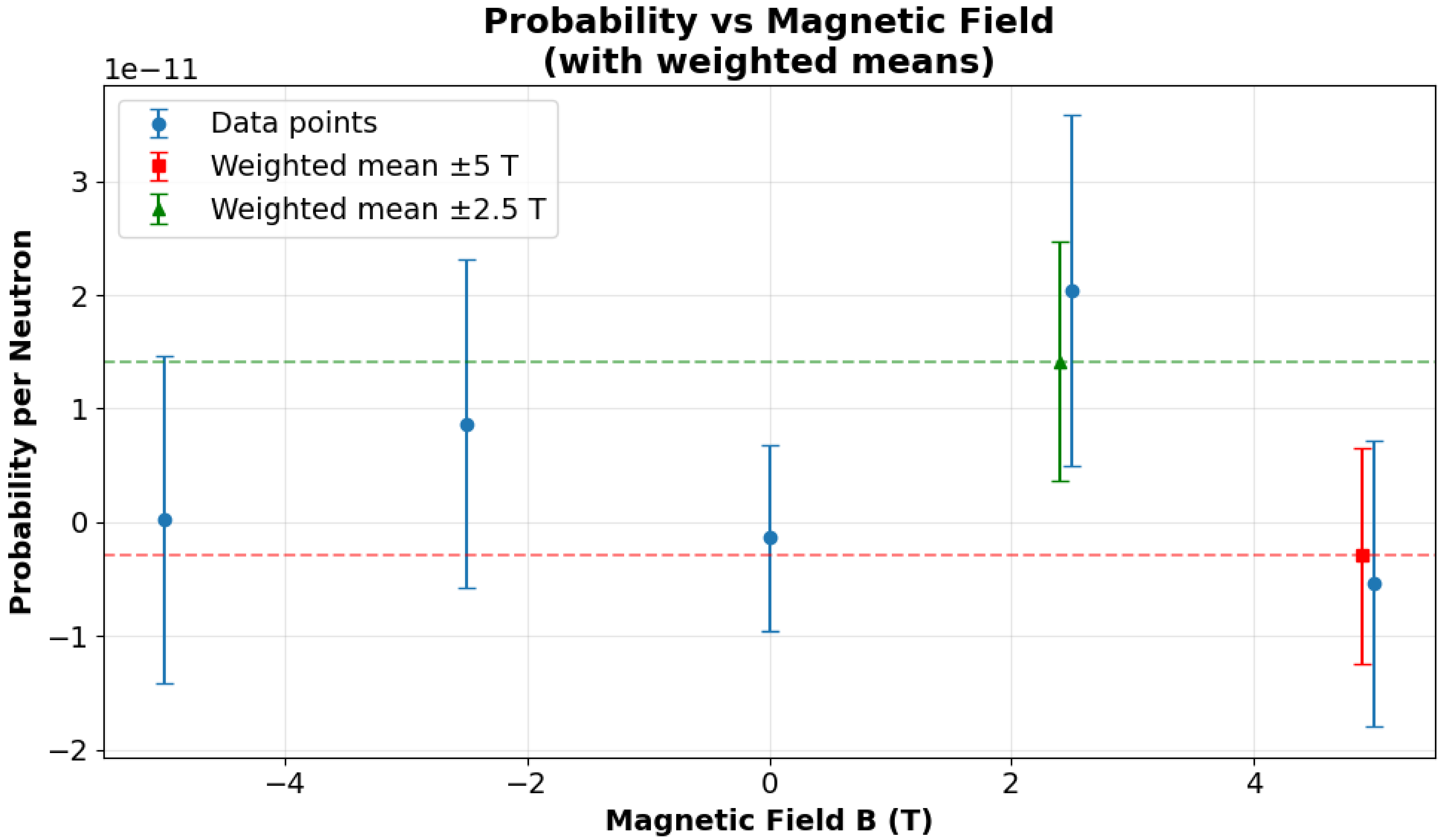
Fit Residuals, All Runs

Beam ROI Countrate (2021)



Summarized Residual Countrates (Beam ROI)





Probability vs Magnetic Field
(with weighted means)
1e−11
Data points
Weighted mean ±5 T
Weighted mean ±2.5 T
Probability per Neutron
Magnetic Field B (T)
−4
−2
0
2
4
−2
−1
0
1
2
3

Final Feldman-Cousins Limits (2021 Data)

Calculating Feldman–Cousins limits:

-5.0

Feldman–Cousins (approx) for x0 = 2.283e-13 ± 1.445e-11: upper = 2.854e-11 (CL=0.95)

-2.5

Feldman–Cousins (approx) for x0 = 8.677e-12 ± 1.446e-11: upper = 3.702e-11 (CL=0.95)

0.0

Feldman–Cousins (approx) for x0 = -1.388e-12 ± 8.176e-12: upper = 1.464e-11 (CL=0.95)

2.5

Feldman–Cousins (approx) for x0 = 2.036e-11 ± 1.543e-11: upper = 5.060e-11 (CL=0.95)

5.0

Feldman–Cousins (approx) for x0 = -5.367e-12 ± 1.261e-11: upper = 1.934e-11 (CL=0.95)

For combined weighted means:

+-5.0

Feldman–Cousins (approx) for x0 = -2.948e-12 ± 9.499e-12: upper = 1.567e-11 (CL=0.95)

+-2.5

Feldman–Cousins (approx) for x0 = 1.414e-11 ± 1.055e-11: upper = 3.482e-11 (CL=0.95)

Questions?

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DEPARTMENT OF PHYSICS & ASTRONOMY

Summarized Probability Per Neutron (Beam ROI)

Probability per neutron = residual countrate / (Intensity * eff_1 * eff_2 * eff_3)

efficiencies = ROI efficiency, transmission through Si window

TODO include how the residuals are I counts per hour vs intensity in n/s

Correction Factors:

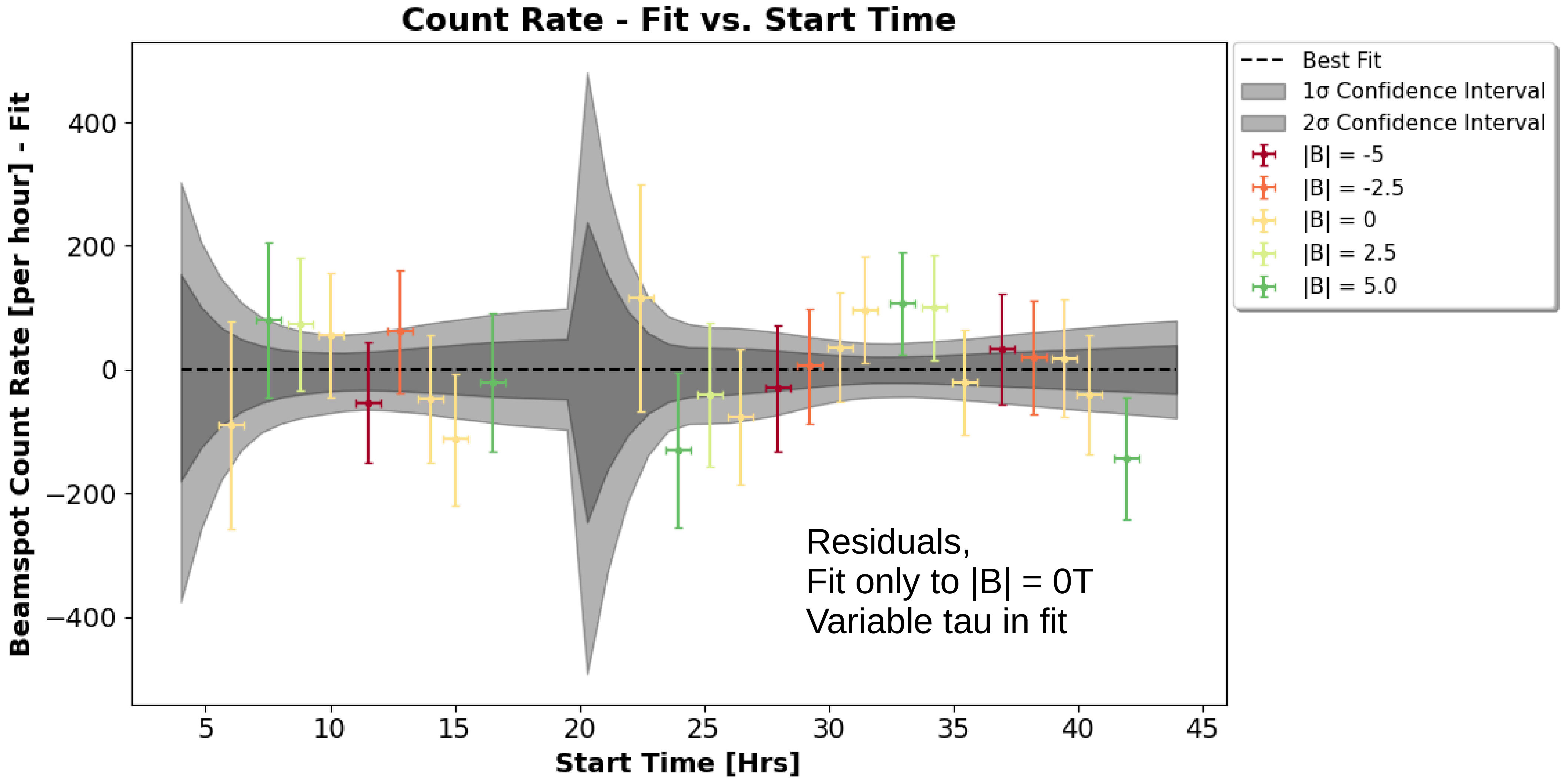
I=6.07e+08

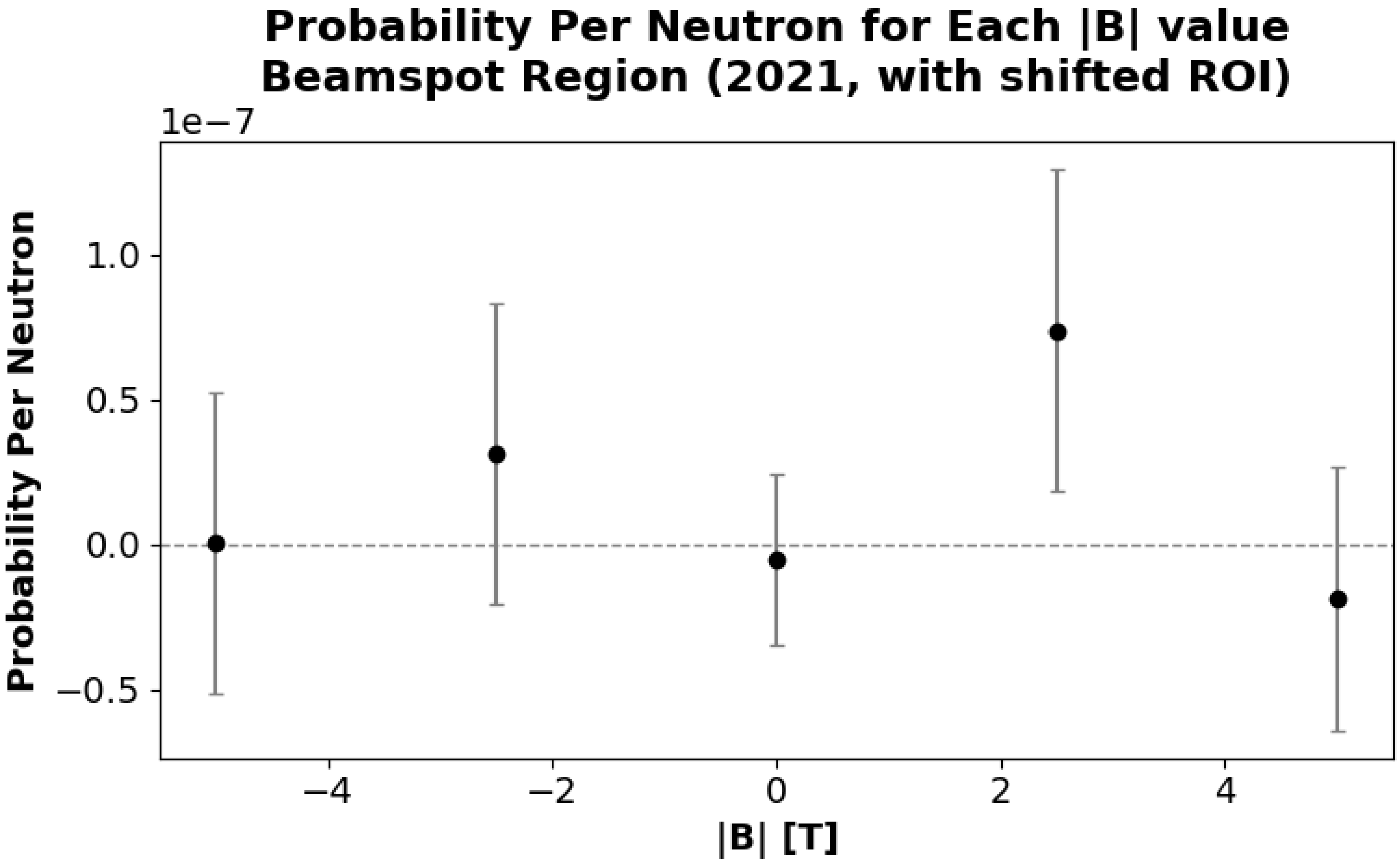
eff_1=1.0000

eff_2=0.6506

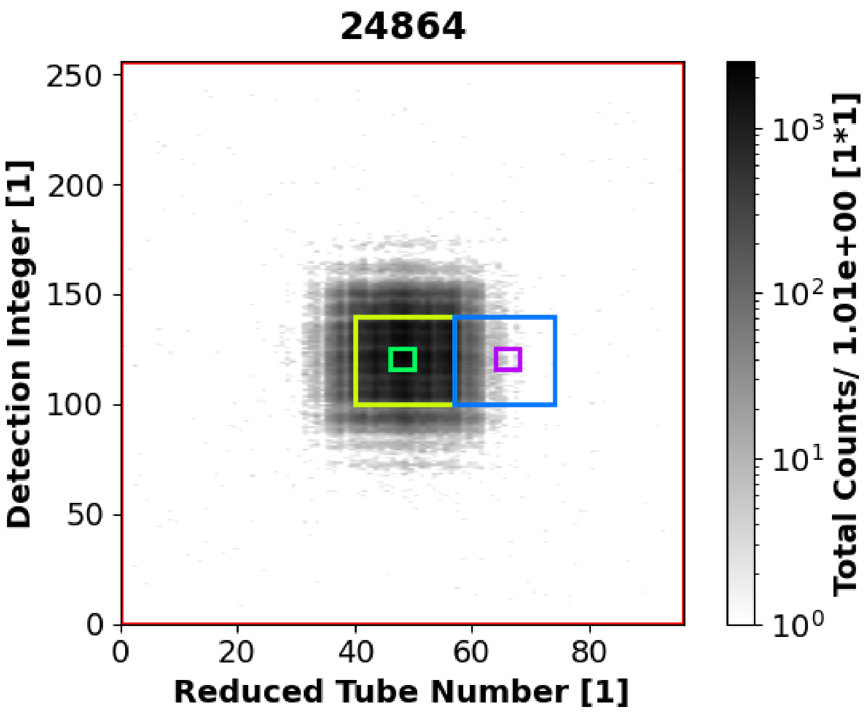
eff_3=0.9110

B,	Probability Per Neutron,	Probability Per Neutron Error
-5.0,	8.219910296875362e-10,	5.200382363469307e-08
-2.5,	3.1237605867991965e-08,	5.2059218546766464e-08
0.0,	-4.9974254724888116e-09,	2.9433425211020176e-08
2.5,	7.330178739213323e-08,	5.554991266369286e-08
5.0,	-1.9321563617189256e-08,	4.5386960894159884e-08


Count Rate - Fit vs. Start Time
Beamspot Count Rate [per hour] - Fit
Start Time [Hrs]
400
200
0
−200
−400
5
10
15
20
25
30
35
40
45
Best Fit
1σ Confidence Interval
2σ Confidence Interval
|B| = -5
|B| = -2.5
|B| = 0
|B| = 2.5
|B| = 5.0
Residuals,
Fit only to |B| = 0T
Variable tau in fit


Probability Per Neutron for Each |B| value
Beamspot Region (2021, with shifted ROI)
1e−7
1.0
0.5
0.0
−0.5
Probability Per Neutron
−4
−2
0
2
4
|B| [T]

ROI Efficiency



24864 BM Intensity Avg: 2.199e+03 ± 1.733e-01 Counts/ Hour

ROI 0 Total Counts: 811667 ± 900.93
ROI 1 Total Counts: 528058 ± 726.68
ROI 2 Total Counts: 58315 ± 241.48
ROI 7 Total Counts: 28659 ± 169.29
ROI 8 Total Counts: 128 ± 11.31

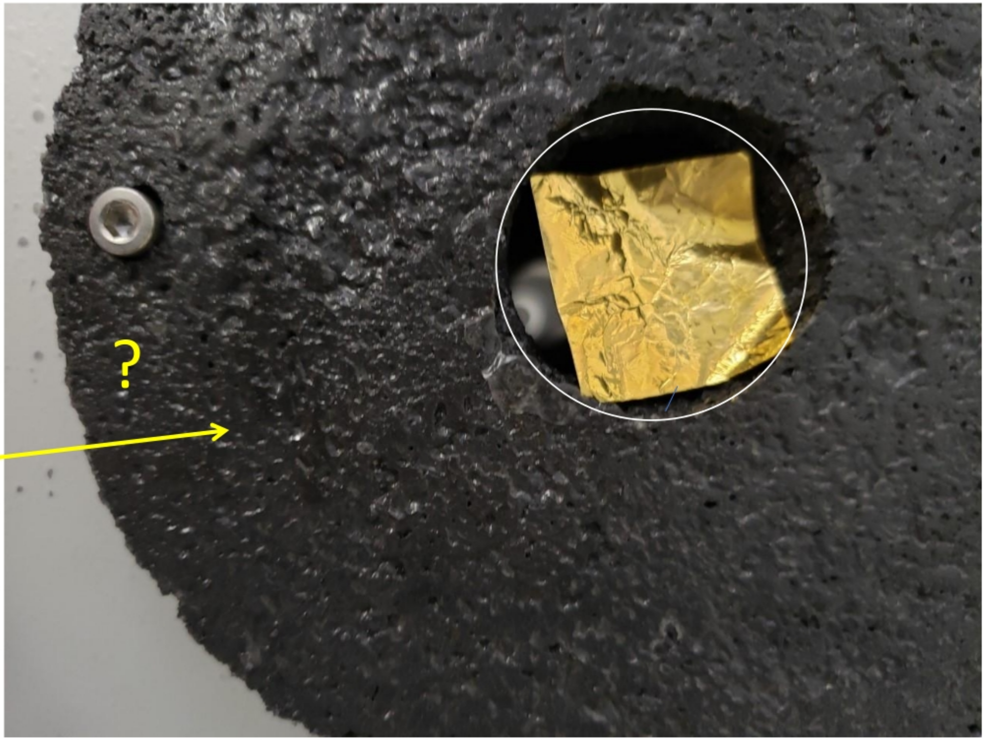
ROI Efficiency ≈ Beamspot countrate / Total Countrate

= ROI 1 / ROI 0
= 65.06 ± 0.12 %

Gold Foil Error estimation

Gold foil

mass 103.3 mg

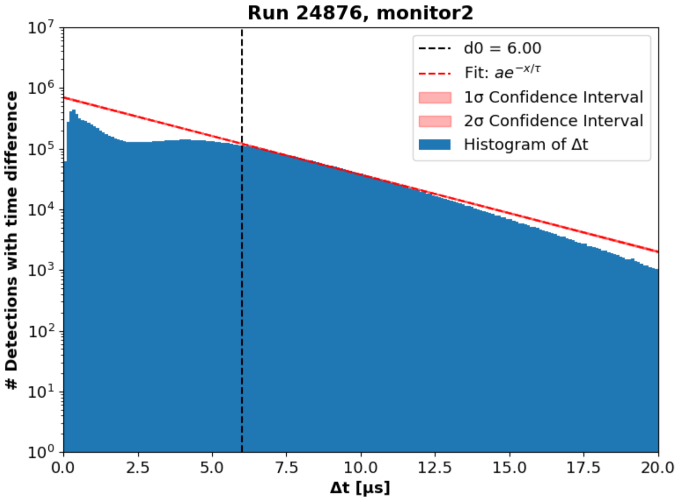


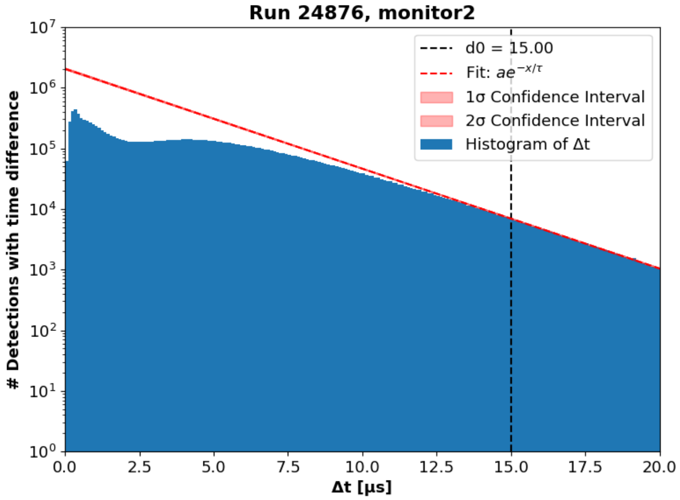
Foil area ?
¾” × ¾”

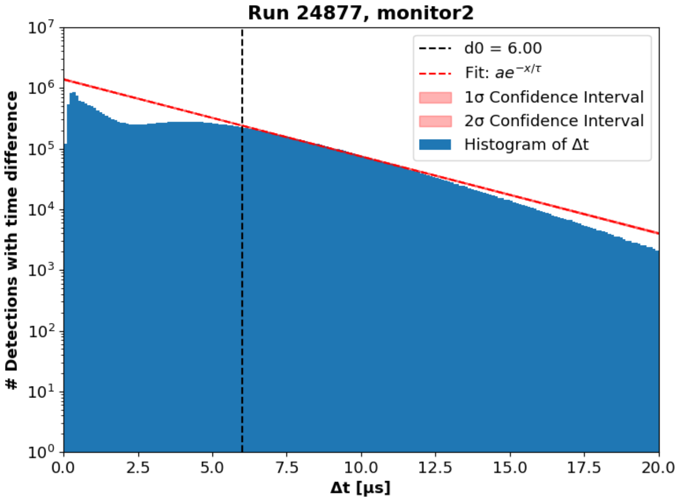
Then thickness 14.73 μm ?

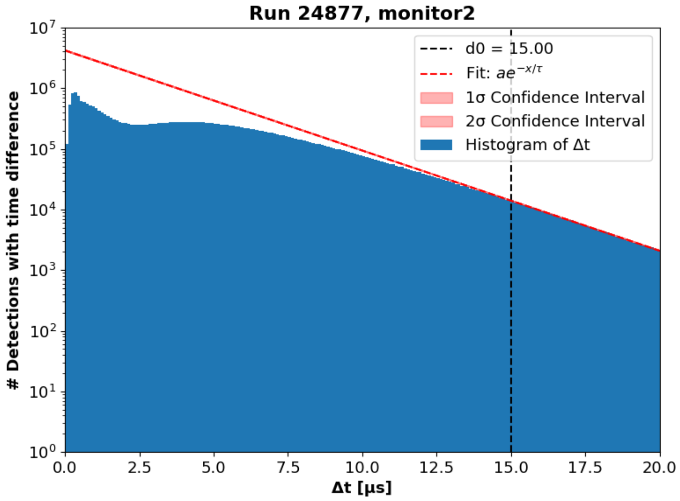
- Gold foil area estimation is difficult due to improper placement
- Assume 10% error on area estimation

LEM 2021


Run 24876, monitor2
d0 = 6.00
Fit: $ae^{-x/\tau}$
1σ Confidence Interval
2σ Confidence Interval
Histogram of Δt
Detections with time difference
Δt [μs]


Run 24876, monitor2
d0 = 15.00
Fit: $ae^{-x/\tau}$
1σ Confidence Interval
2σ Confidence Interval
Histogram of Δt
Detections with time difference
Δt [μs]


Run 24877, monitor2
d0 = 6.00
Fit: $ae^{-x/\tau}$
1σ Confidence Interval
2σ Confidence Interval
Histogram of Δt
Detections with time difference
Δt [μs]


Run 24877, monitor2
d0 = 15.00
Fit: $ae^{-x/\tau}$
1σ Confidence Interval
2σ Confidence Interval
Histogram of Δt
Detections with time difference
Δt [μs]

LEM Shows Extreme Counting Rate in 2021 Experiment

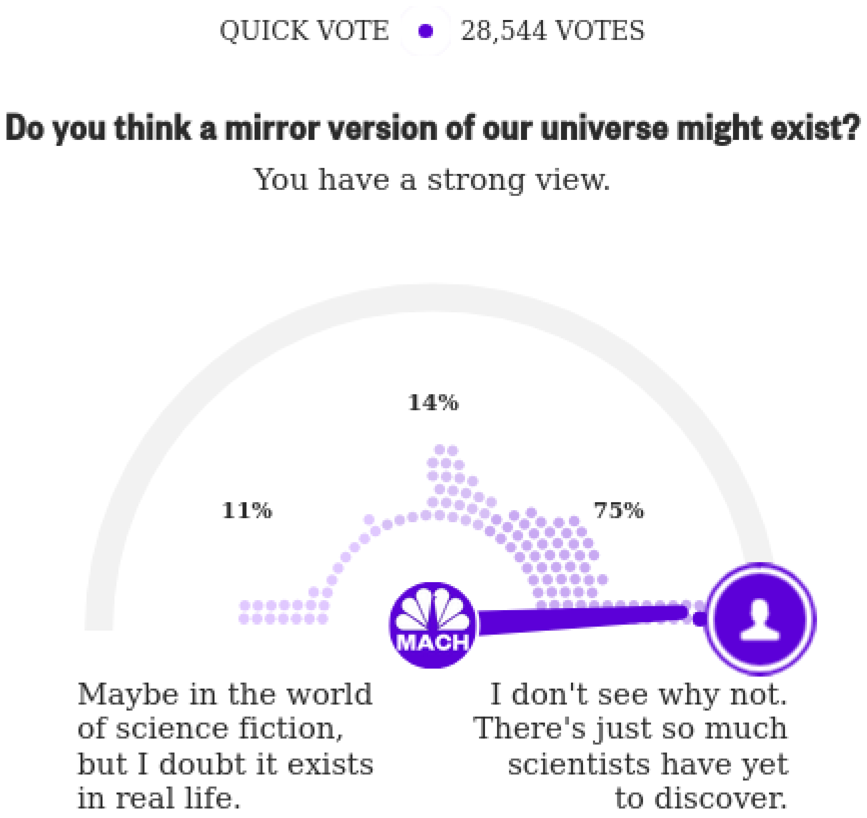
Run:	Original counts	d=6us	d=15us
24876 (61s)	1.3952502e7 c	2.3755555e7 c	5.3907428e7 c
24877 (123s)	2.7716026e7 c	4.7226189e7 c	11.0063308e7 c
AVG rate	2.27032e5 cps	3.86694e5 cps	8.89276e5 cps
Correction ratio avg	1	1.70	3.9
I (est) n/s	7.35922e9	1.25347e10	2.8825e10

Deadtime corrected count rate is 3.86694e5 cps (trusting the low dt slope), or if you consider the range between different deadtime estimates, (6.37985e5 +- 2.51291 cps)

Divide by $\eta' = (3.085 \pm 0.009) \cdot 10^{-5}$ counts / neutron to get estimated intensity

→ 2.068e10 n/s (insane prediction)

Popular Opinion Towards Feasibility of Mirror Matter



- Definitely a biased sample of the population, but if the graph is interpreted as histogram then it seems to suggest high confidence in mirror matter feasibility
- Unclear what the percentages represent
- Ignore the marker at the “full believer” side, you have to vote to see the results

https://www.nbcnews.com/mach/science/scientists-are-searching-mirror-universe-it-could-be-sitting-right-ncna1023206

Data Analysis Updates

Alina Moore - UTK - 11/9/2025

About region of interest

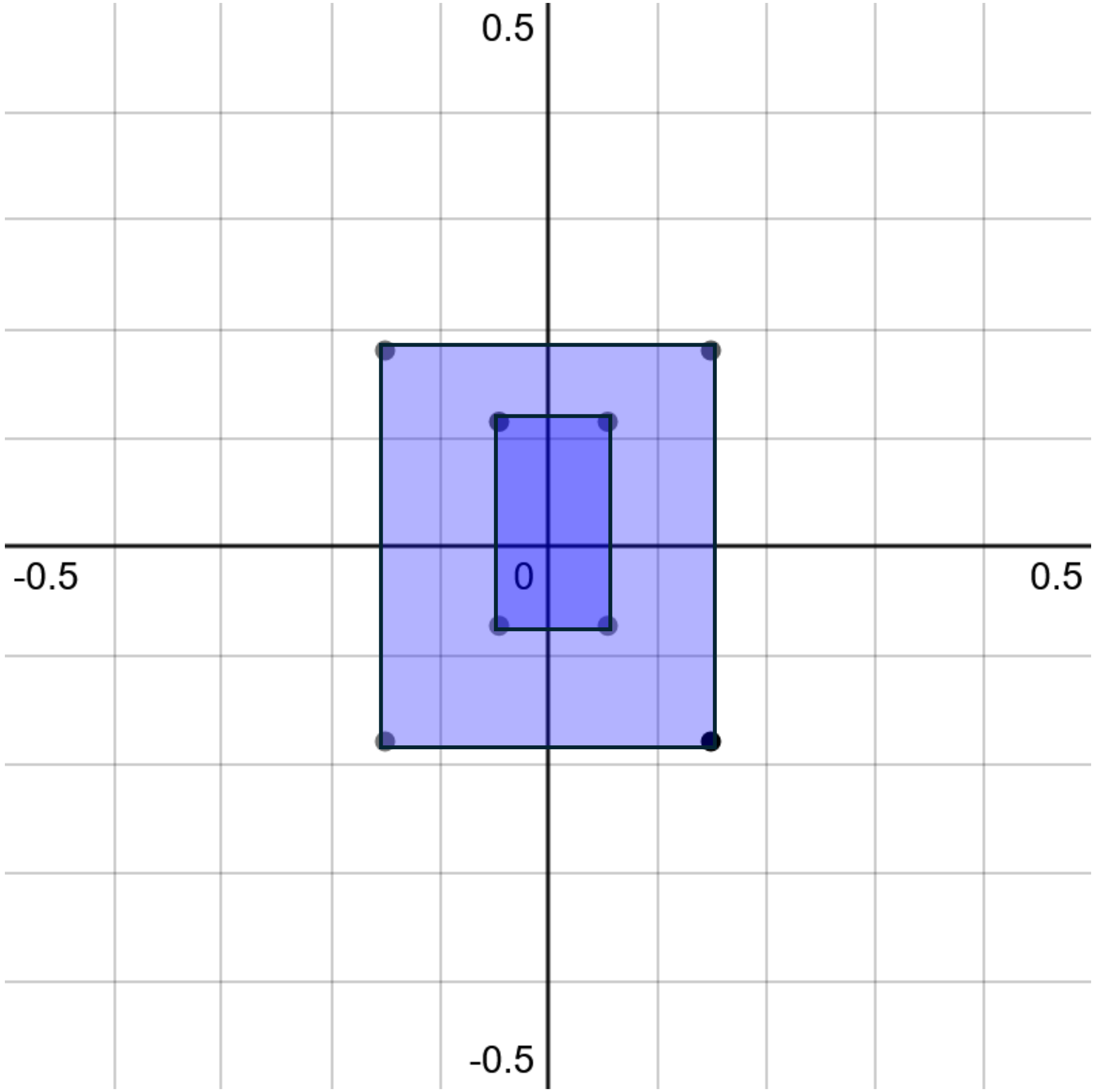
- Region of interest defined to be

  $ROIx = x \pm 0.15$ and ROIy $= y \pm 0.18$ (m)

- During experiment, punchthrough spot was removed (filtered out of the data).
  - This spot was defined as

  $-0.045 < x < 0.055$ and $-0.0735 < y < 0.1145$ (m)

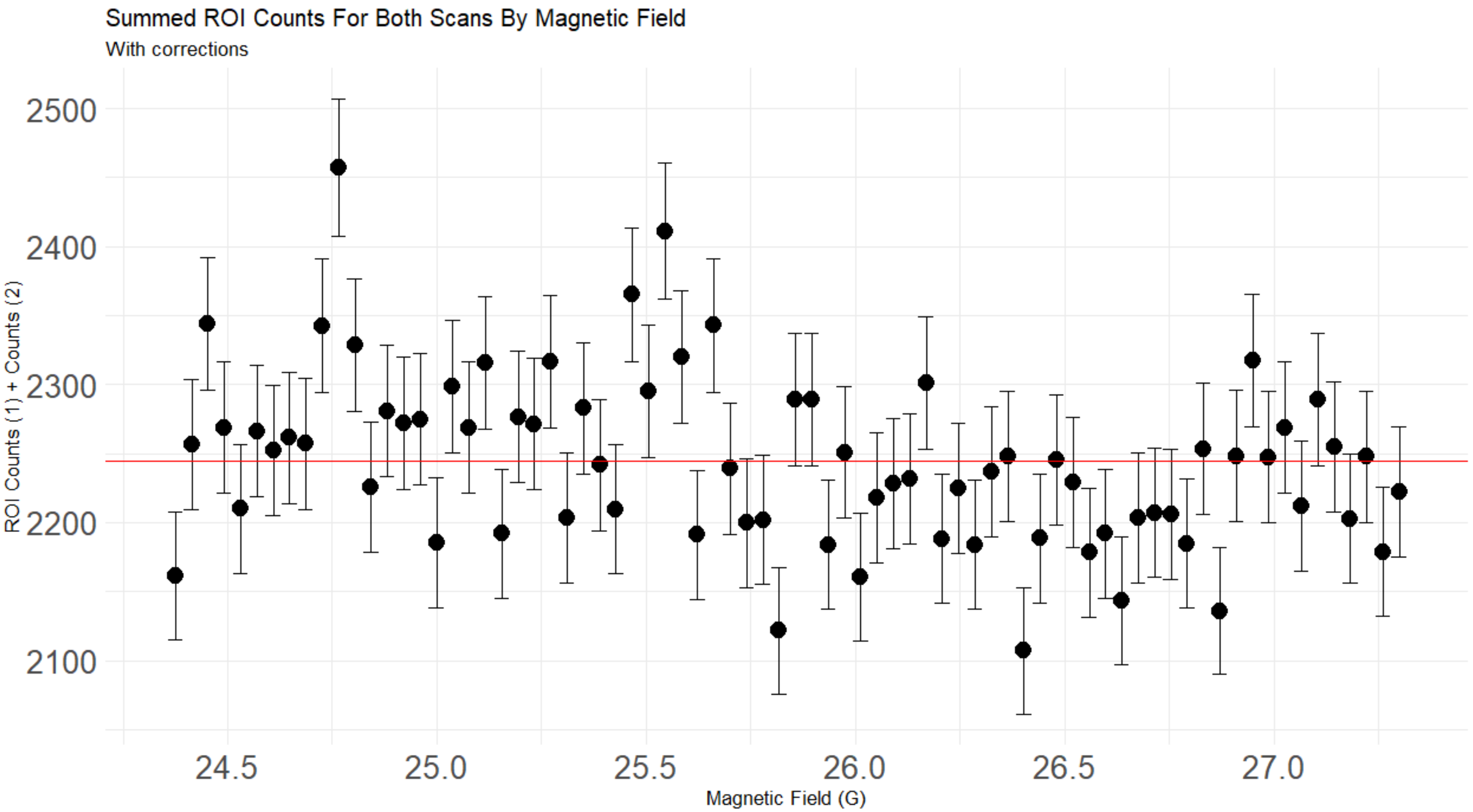
- Created a large constant background because the cadmium can't block fast neutrons very well
- Analysis so far has been done with this still removed
  - If it should be added back from here on out, that can be done



Part 1: Other ways of looking at the data

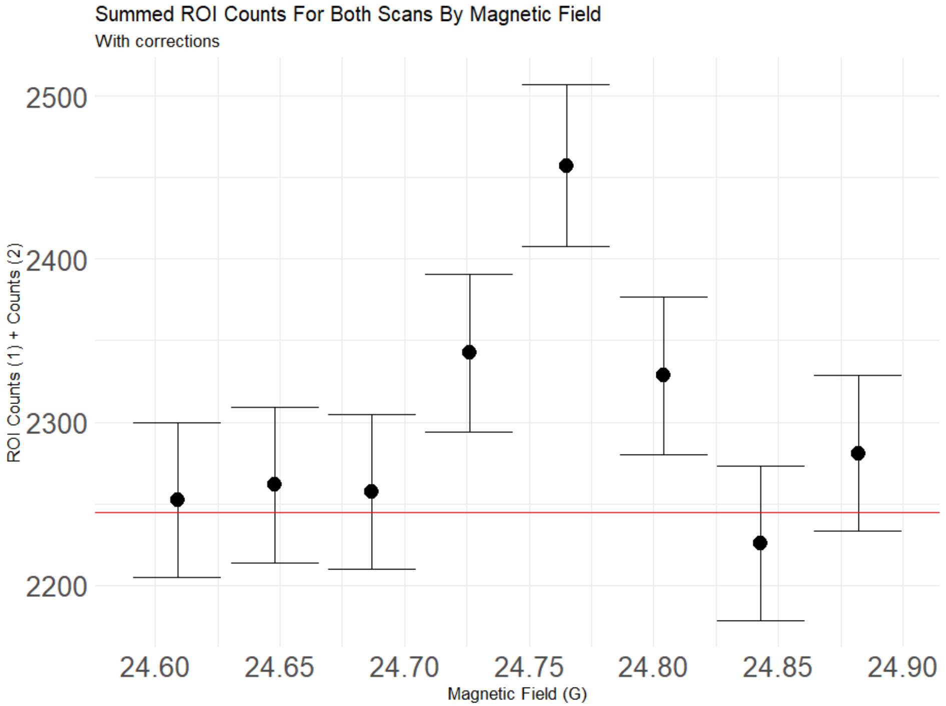
Summing the counts

- Sort both scans by magnetic field and add them, artificially creating one 50 minute scan instead of two separate ones
- Corrections for ROI are GPM variation, aluminum and silicon transmissions , ROI and detector efficiencies
  - Now using Mubi’s new numbers

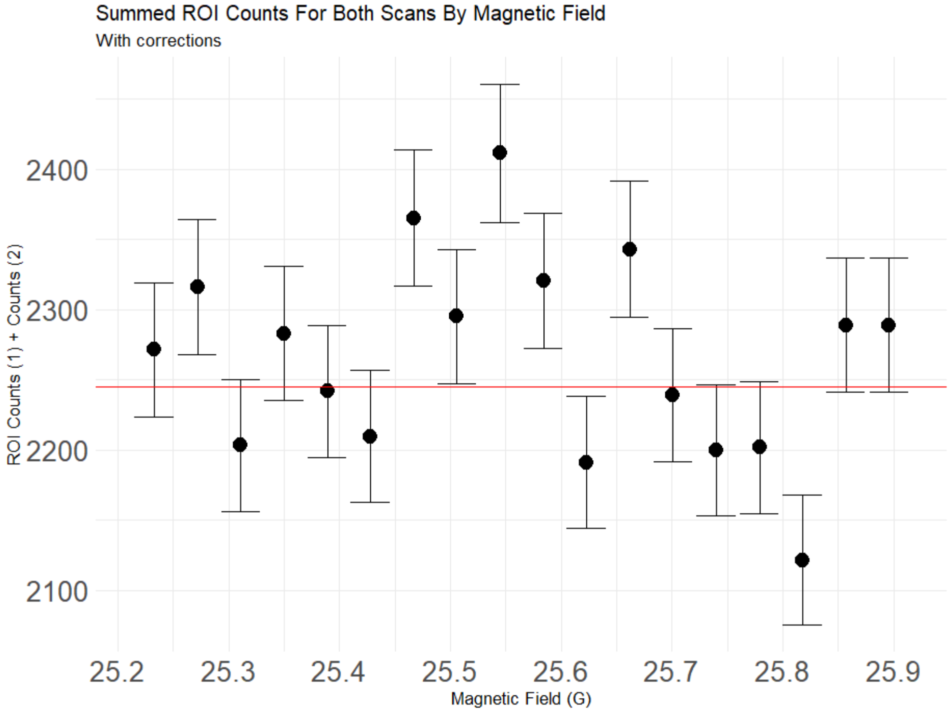


Two interesting sections

- Fluctuation, but still an increase.
- Not centered at 25.5 (seen in last week's a parameter estimates), but close to it
- Wider?



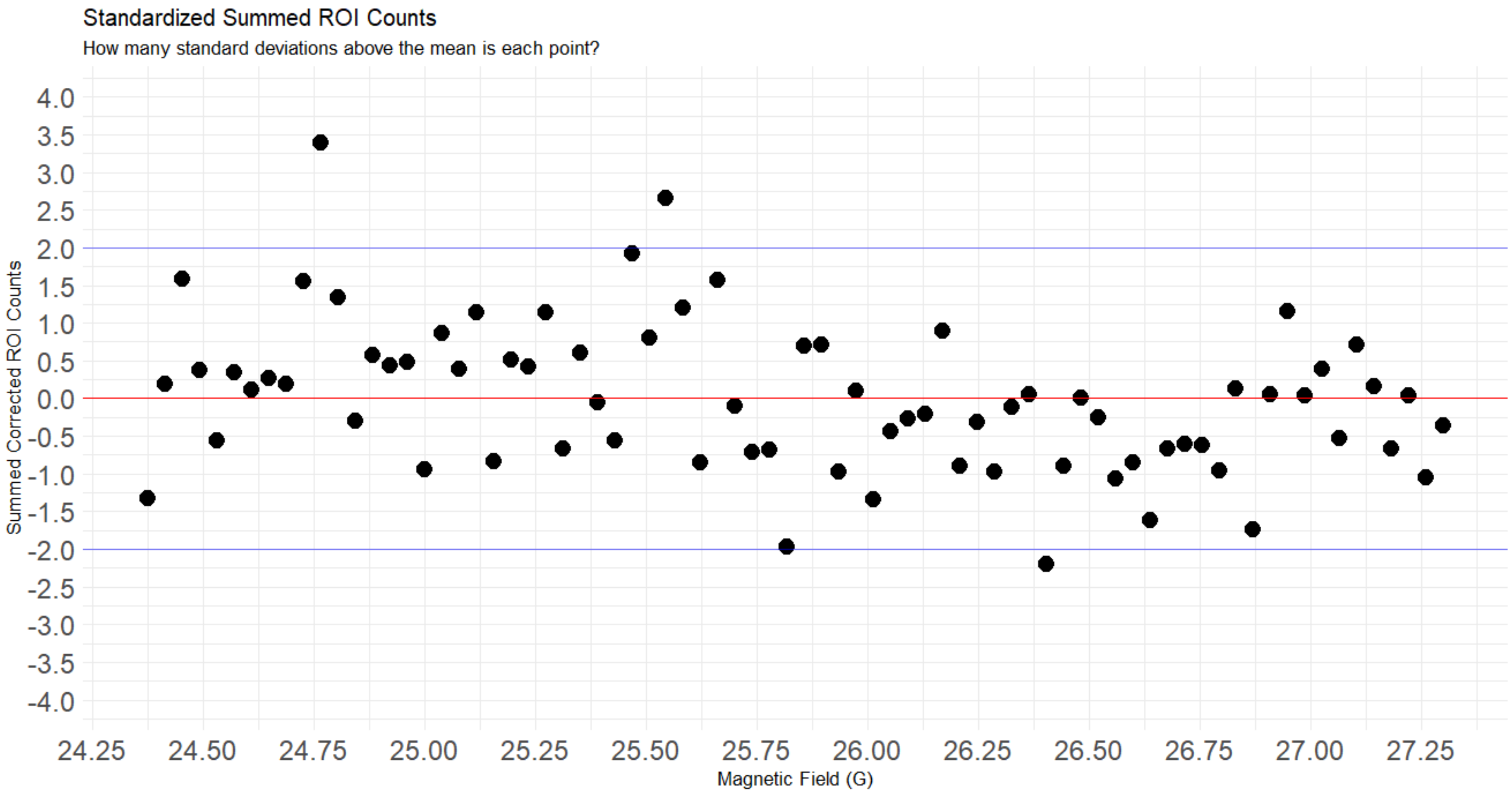
- About 5 organized points increasing then decreasing
- High point at 24.765
- Tighter and more extreme



Fun statistics trick

- Standardize the data to have a mean of 0 and sd of 1.
- Shows how many standard deviations above the mean each point is

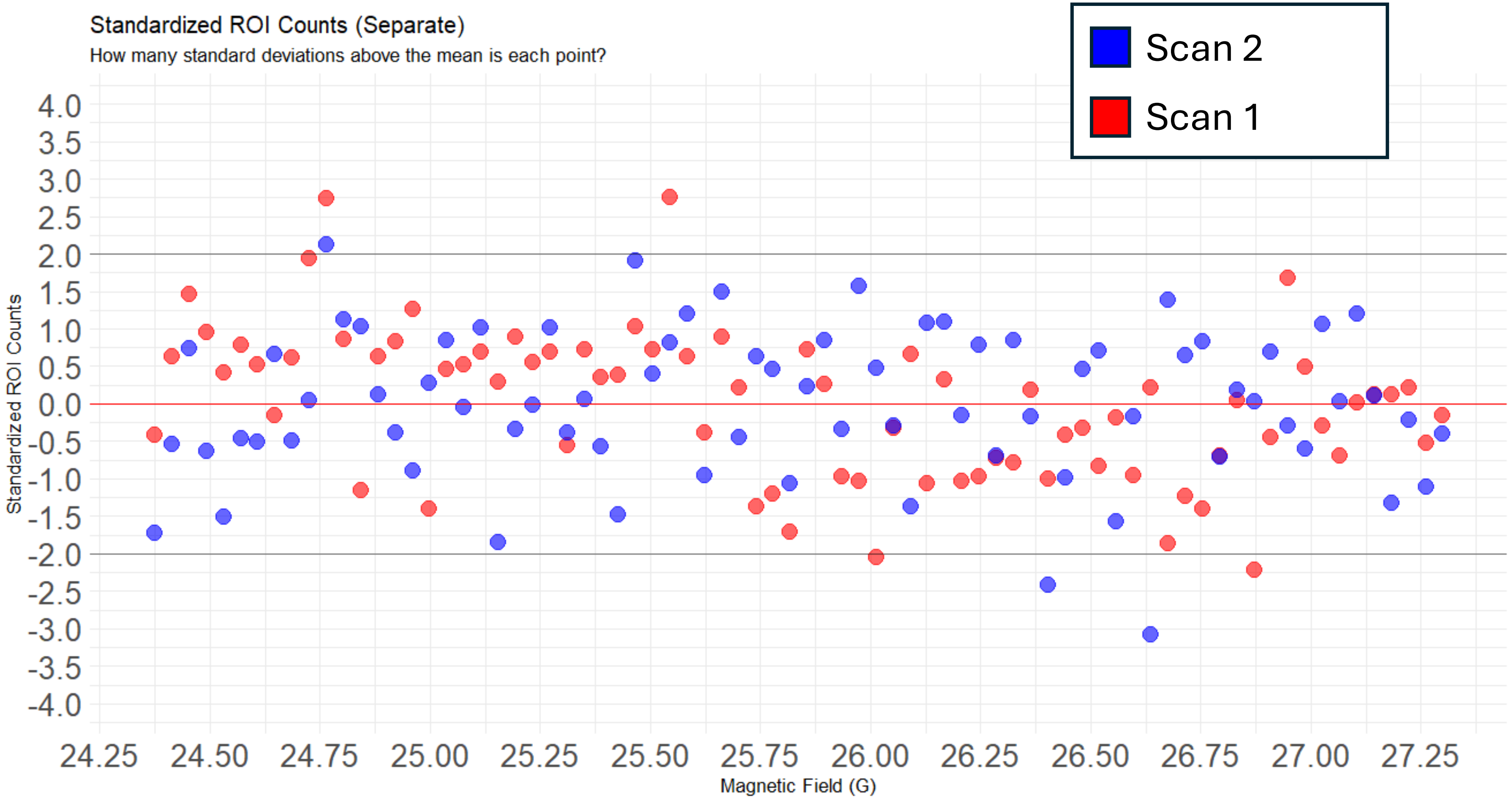
$$Z = \frac{X - \mu_x}{\sigma_x}$$



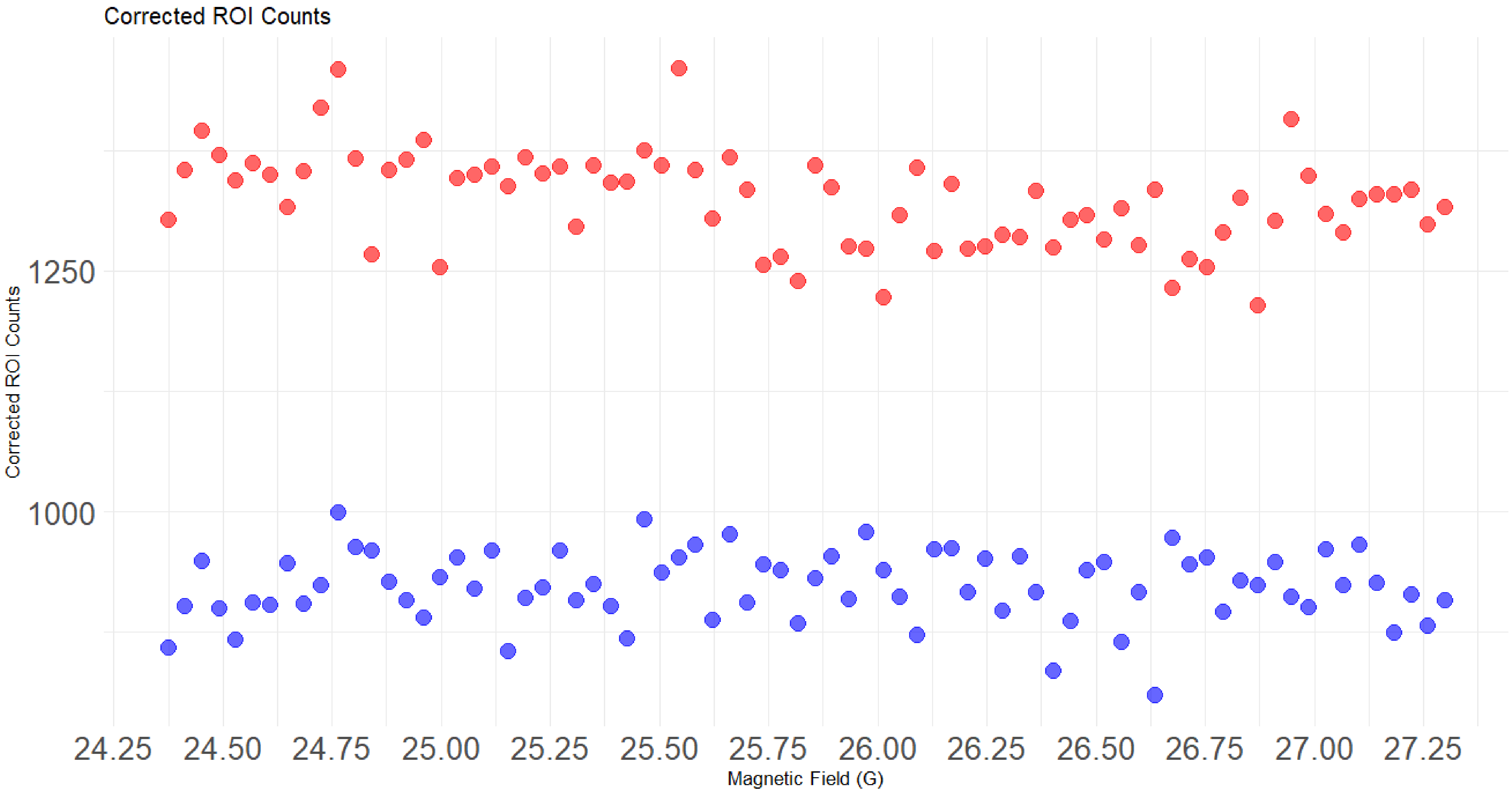
Standardization continued

- Look at them separately, similar movements still appear when done in terms of σ

- After dividing ROI by Intensity, this could be another way to represent data when super small numbers are inconvenient



Scatterplot of corrected ROI counts



Part 2: Fitting updates and issues

Current fitting problems

- Extremely large errors on estimates. Unreasonable
  - Code runs and distributions look good, but the errors are massive
- Failure to estimate when limits on the parameters are introduced (nonnegativity)

- What can be done to fix this? Thoughts and suggestions?
  - Manipulate data temporarily?
  - Main focus of mine right now is how to lower these because the estimate shapes are appealing and it would be nice to use them.

Updated visualizations

- Parameter estimates again, now with corrected ROI counts divided by intensity (1.63E9)
  - Same shape without intensity, just larger
  - Got rid of the 0.76 factor since origins of that were unclear