

# Agenda of ORNL-UTK-UKY-LU zoom meeting

March 3, 2026, at 3:30 PM EST

Please, send your slides for INDICO posting

<https://indico.phy.ornl.gov/event/979>

## Agenda:

1. Kyle Grammer/ORNL - spectrum of GP-SANS fast n 10 min
2. Yuri - discussion of HFIR beam proposal for nTMM 10 min
3. Nathan/Linus - Status of calculations for the paper 10 min
4. Yuri - New paper on n-n' from PSI (include in plots) 5 min
5. Mubi-UKY update 10 min
6. Linus-LU update 10 min
7. Yuri/Alina nTMM ROI background reduction 5 min
8. John - update on nTMM pressure system 5 min
9. AOB

# Fast neutron flux at the GP-SANS sample position

Kyle Grammer

March 3, 2026



# Geometry

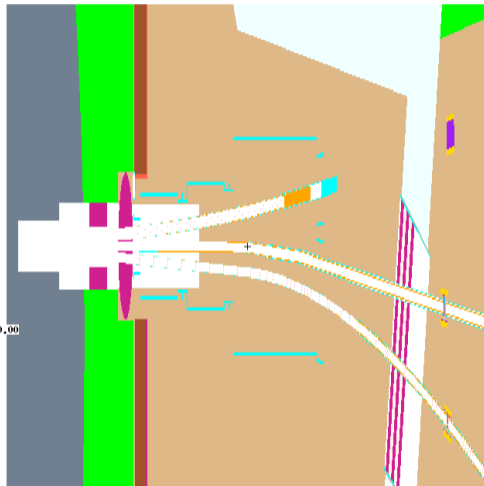
- Used future GP-SANS configuration, similar to current.
- PD contributions from optical filter glass, aluminum casing, HB4 shutter, and nearby shielding.

```
probid = 02/21/25 08:45:04
basis: XZ
( 0.000000, 0.000000, 1.000000)
( 1.000000, 0.000000, 0.000000)
origin:
( 0.00, 0.00, 950.00)
extent = ( 1000.00, 100.00)
```



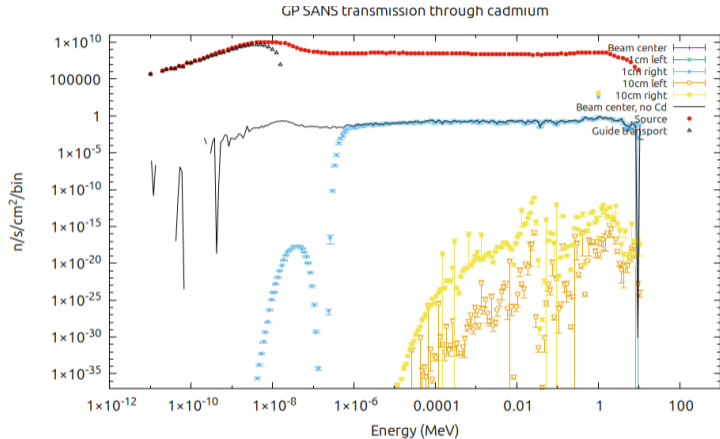
```
Value for mat 0
in Cell 30051
xyz = 0.00, 0.00, 950.00
```

CURSORS	Restore	No Lines
PostScript	ROTATE	
COLOR	SCALES 0	LEVEL
XY	YZ	ZX
LABELS	L1 sur	L2 off
HBODY		LEGEND off

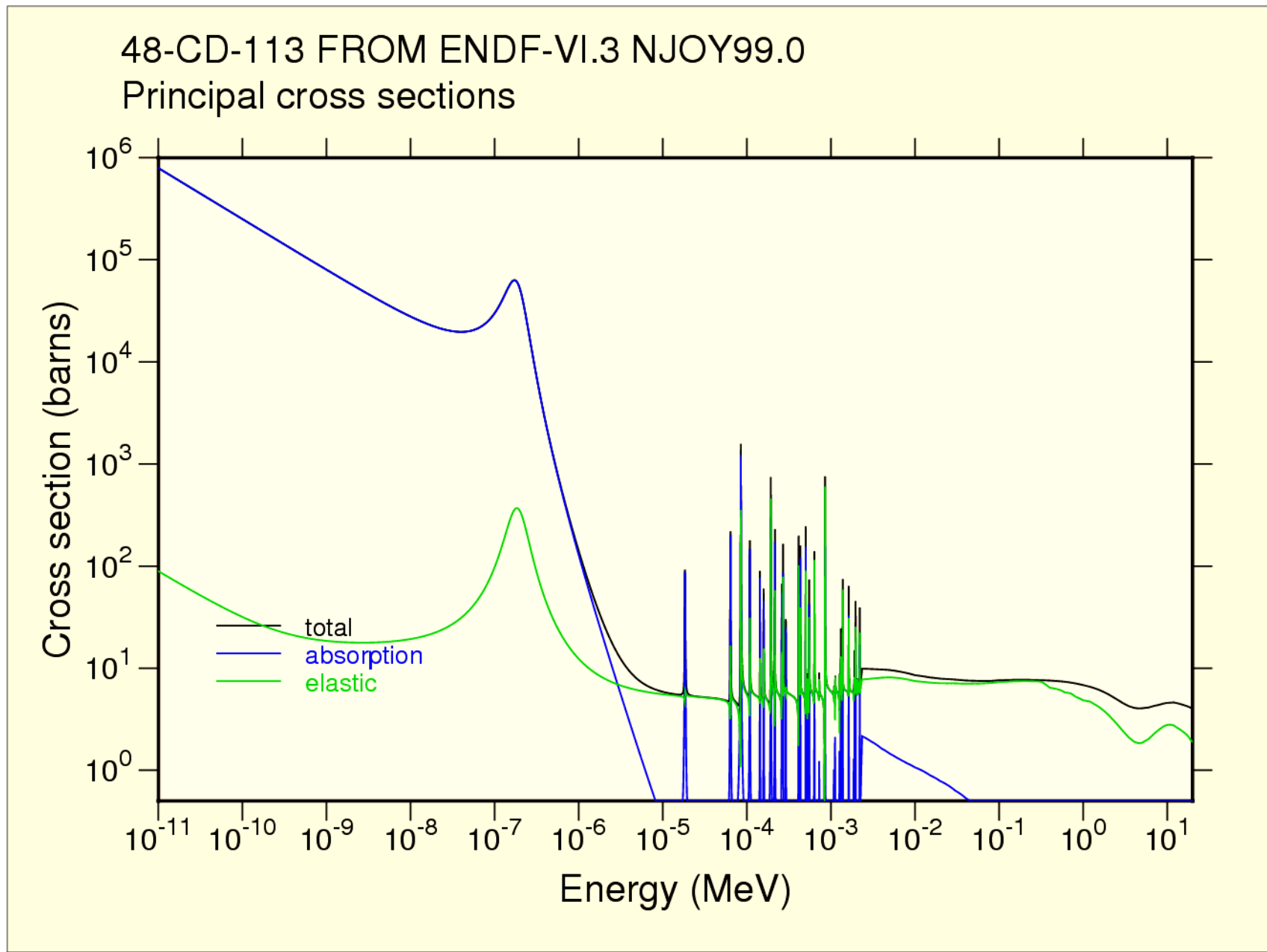


# Results

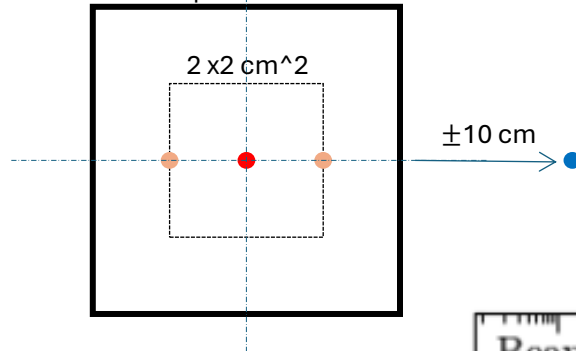
- Flat across beam area, very low 10 cm from beam.
- 25 n/cm<sup>2</sup>/s
- 400 n/s over 16cm<sup>2</sup>
- Est. efficiency  $\approx 3 \times 10^{-3}$
- 132 counts/30m/cm<sup>2</sup>
- 2100 counts/30m over 16cm<sup>2</sup>



Cd cross sections from  
ENDF-VI.3 NJOY99.0



At the sample with Cd in front

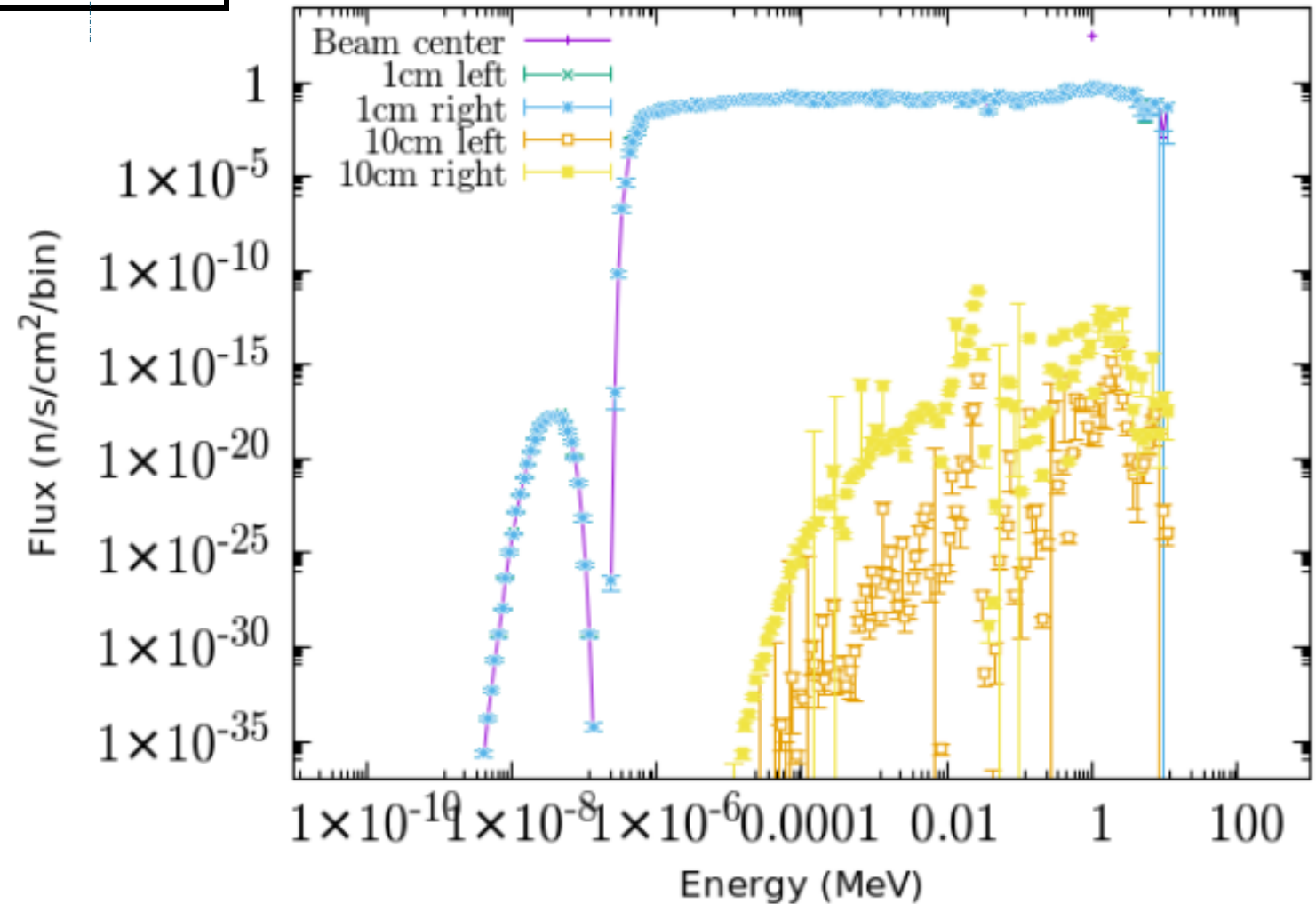


## Kyle Grammer's plot

- Absolute units for flux !
- Bin size (uniform in  $\text{Log}_{10}$ ) is not specified
- Cold spectrum suppression (max 38 meV)
- Flat fast n spectrum 0.5 eV to 8.6 MeV
- there is a halo of fast neutrons to  $\pm 10$  cm
- Total fluence  $\sim 400$  n/s through  $4 \times 4$  cm<sup>2</sup>
- (without detector efficiency)
- Paper of He-3 (10 atm) detector efficiency to fast neutrons

<https://link.springer.com/article/10.1140/epjp/s13360-020-00600-8>

## GP-SANS flux through 3.5mm Cd



For calculation of attenuations of fast neutrons in GP-SANS beam by beam shutters (runs 142385-6) and by plate of BN used in the run 142231 Lisa provided the following information:

1. The shutters are an aluminum 0.09 inches thick enclosure on both sides. with 0.08 inch thick cadmium and 0.126 inch Lithium-6 carbonate. Li is upstream of the cadmium to minimize gammas. It was designed to not exceed 1 neutron per second per square centimeter transmitted when closed.
2. Secondary shutter is 30.5 meters from the reactor center. Instrument shutter is 14.84 m from the reactor core.
3. Boron nitride (BN) was roughly 2.25 inches tall 2.048 inches wide with a thickness of 0.25 inches. That is a boron nitride insert to the attenuator package

Discussion of HFIR beam time proposal for *n*TMM  
IPTS - 34190

submission due March 4 at noon

# Simulation Updates

Nathan Whittington, UTK

2/20/26

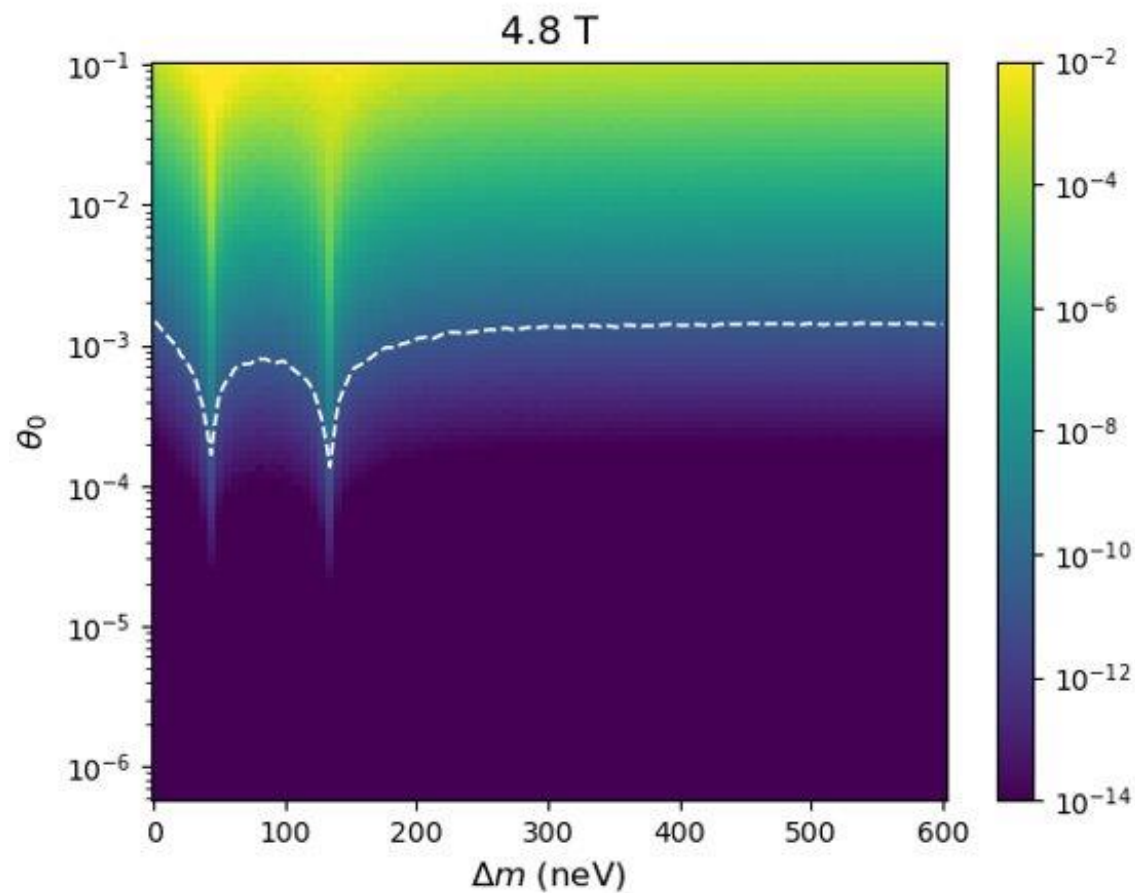
# Two Beam Polarizations

- We want:  $V - \Delta m \pm \mu B = 0$
- $\mu B > 0$  for positively polarized  $n$
- $\mu B < 0$  for negatively polarized  $n$
- Beam in experiment is unpolarized

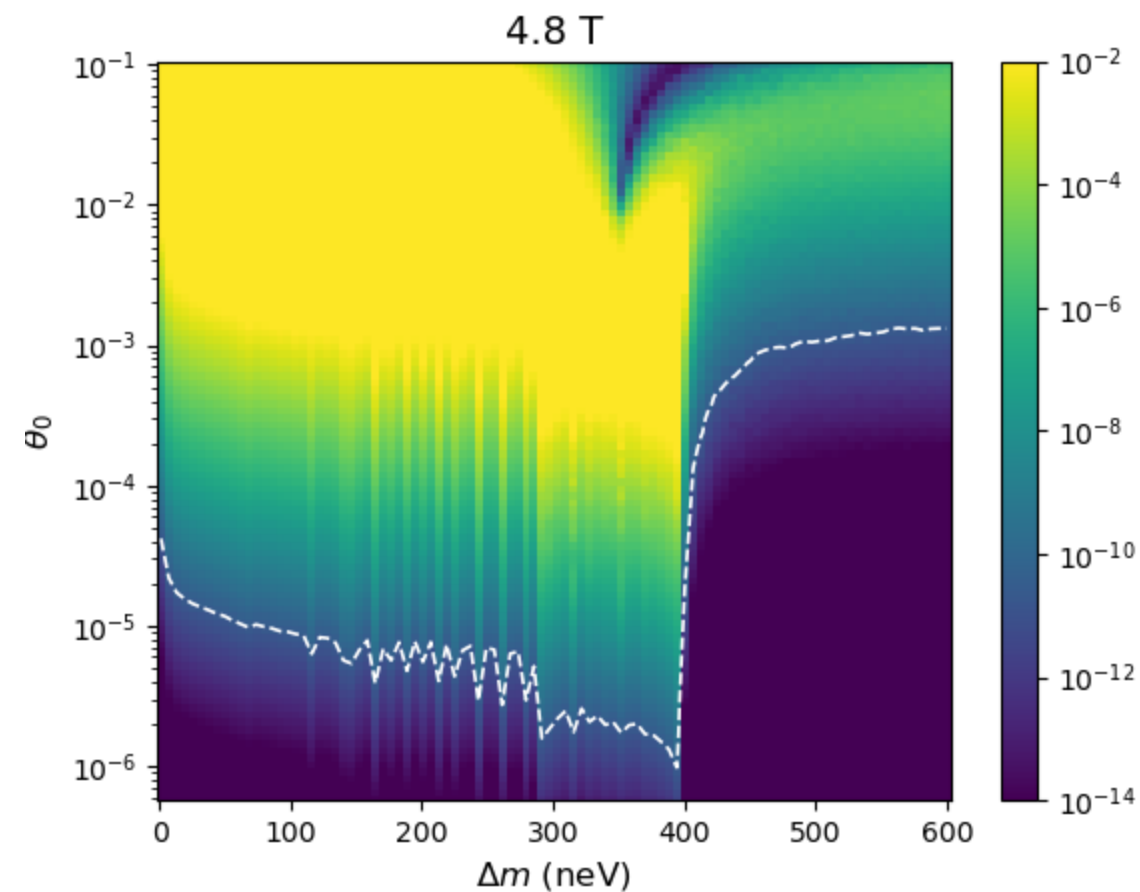
# Positive $\Delta m$

- 1mm
- 100 vel

- $V_{cd} = 59 \text{ neV}$
- B extrap. at 30 cm



$V - \Delta m + \mu B$

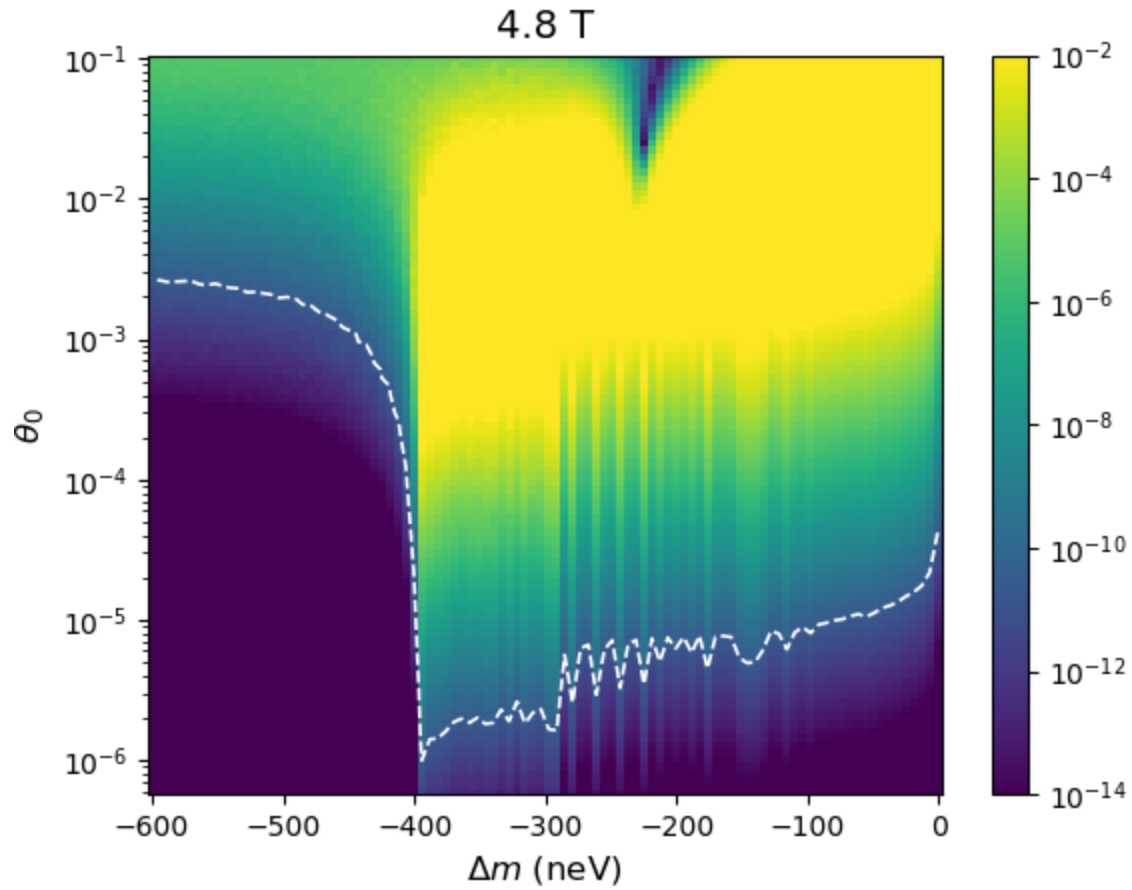


$V - \Delta m - \mu B$

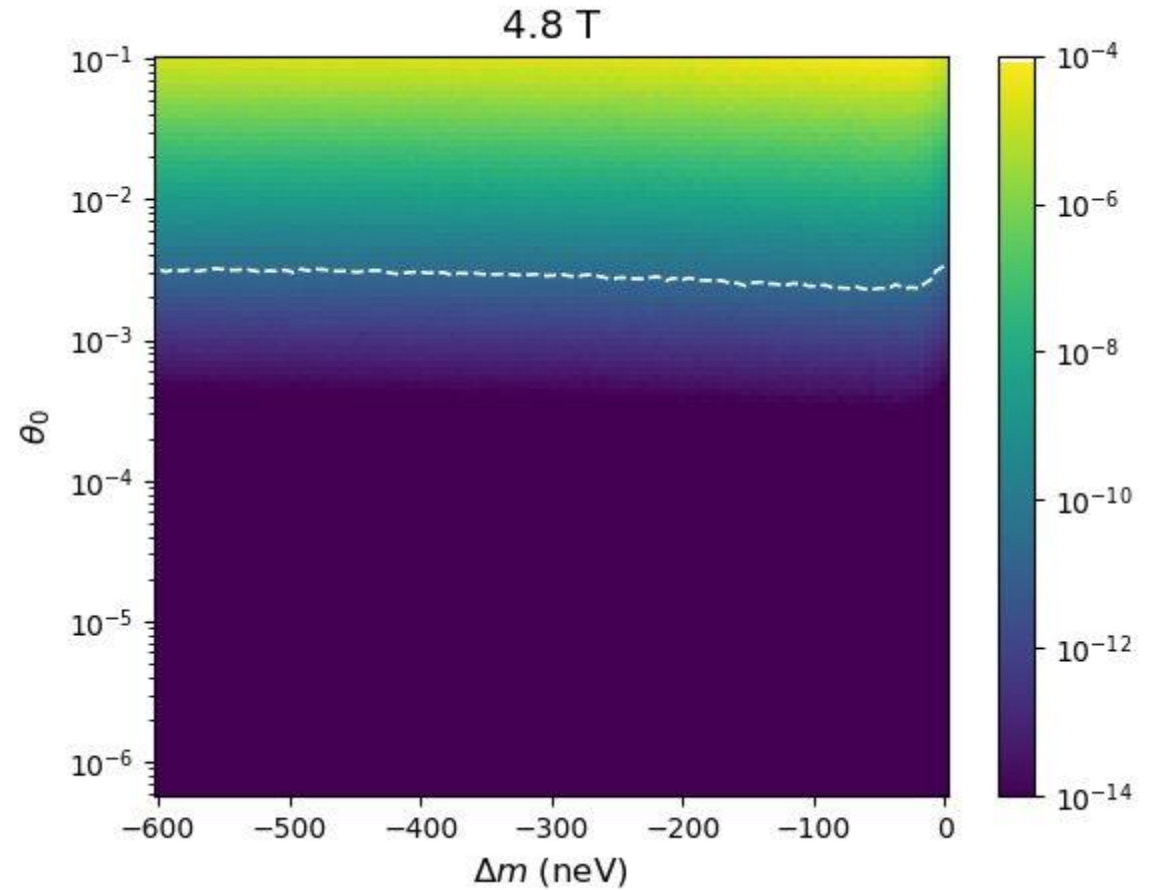
# Negative $\Delta m$

- 1mm
- 100 vel

- $V_{Cd} = 59 \text{ neV}$
- B extrap. at 30 cm



$V - (-\Delta m) - \mu B$



$V - (-\Delta m) + \mu B$

# Combining Polarizations

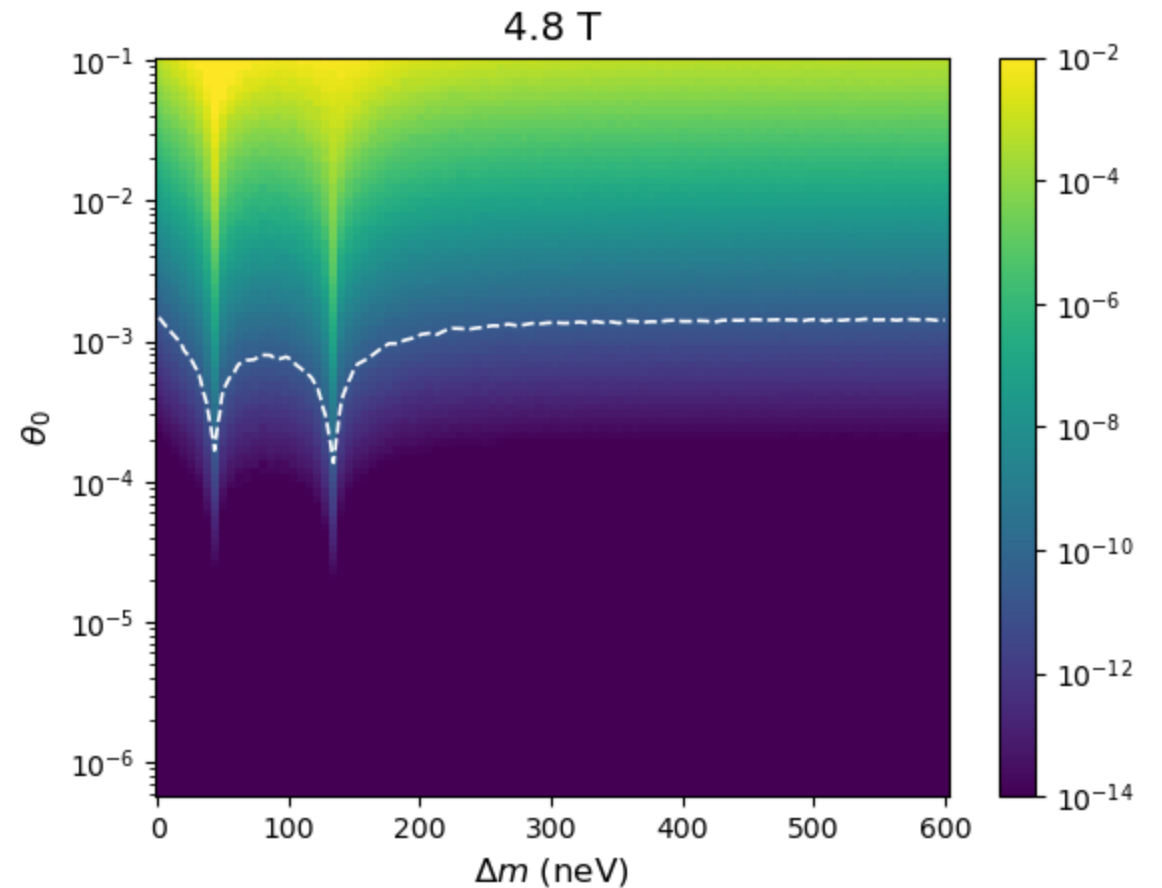
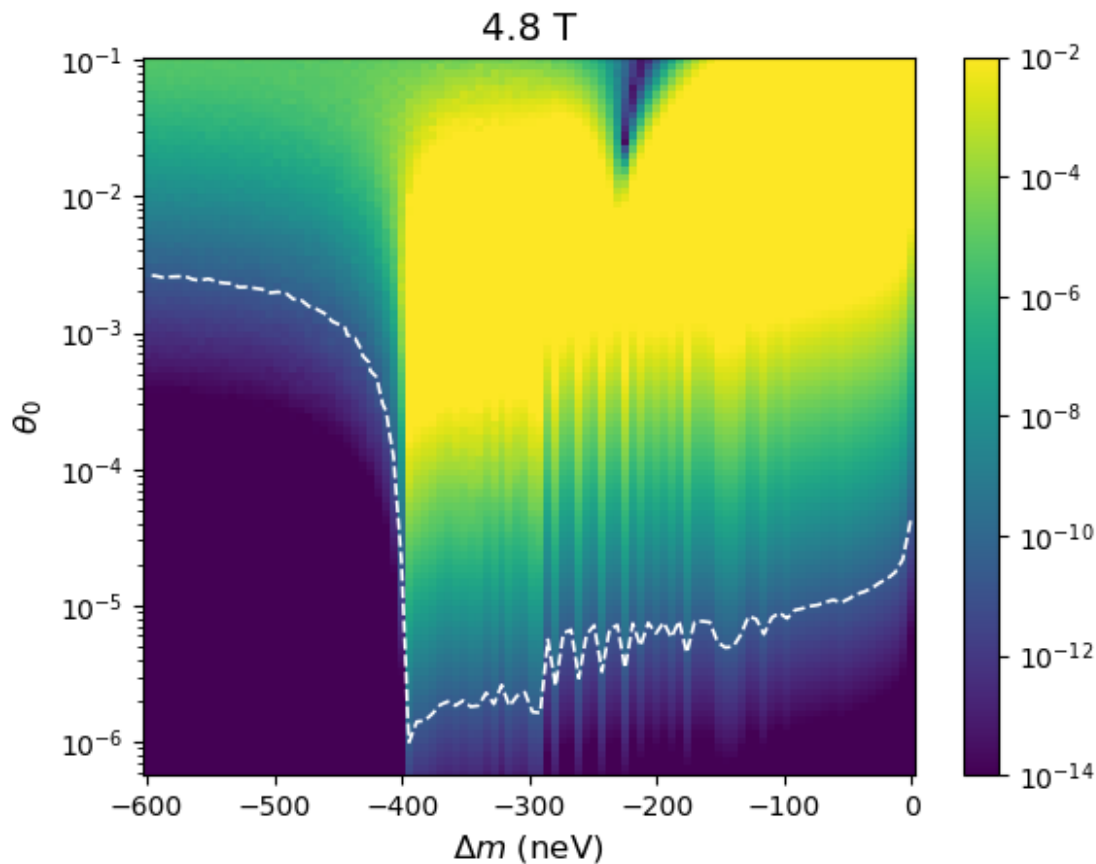
- In experiment, the limit of regeneration probability  $O(10^{-11})$  is in units "per neutron"
- So, in simulation two polarizations should be averaged compare with the "per neutron" analysis
- EX: IF you have a two neutron beam (unpolarized)
  - The expected number of regenerated neutrons is  $\langle N \rangle = P(+\mu B) * N_+ + P(-\mu B) * N_-$
  - This is a direct sum, but the  $P(N) = \langle N \rangle / N_{\text{tot}}$  (average over intensity)
  - $P(N)$  = probability that ONE neutron will  $n \rightarrow n' \rightarrow n$
- In simulation, I average over velocity which is essential the same as intensity

# Study on Changing $V_{Cd}$

- $V_{Cd} = 58.77$  neV
- Limit min at  $-394.3$  neV
- Abs. Res. Tip at  $-225$  neV

- 1mm
- 100 vel
- $-\mu B$

- $V_{Cd} = 59$  neV
- Peaks at  $43.4$  and  $131.4$  neV

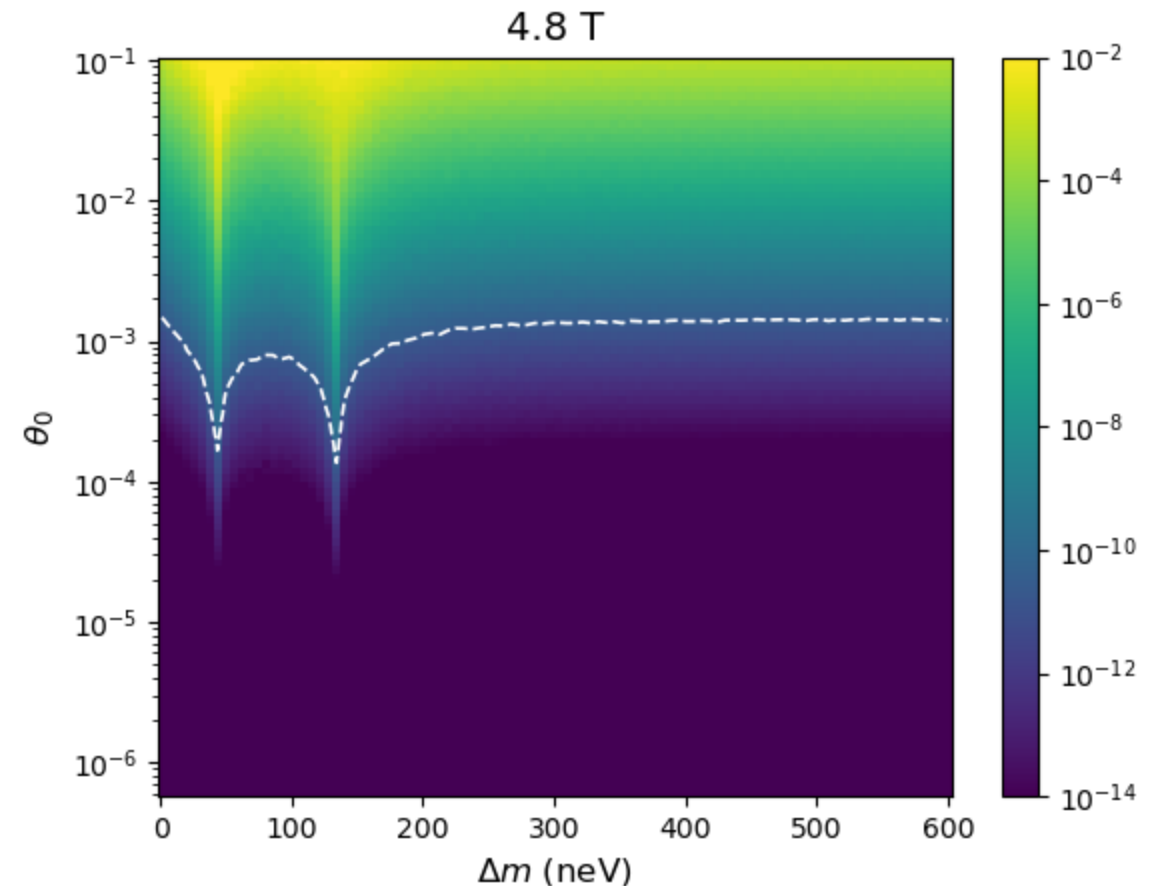
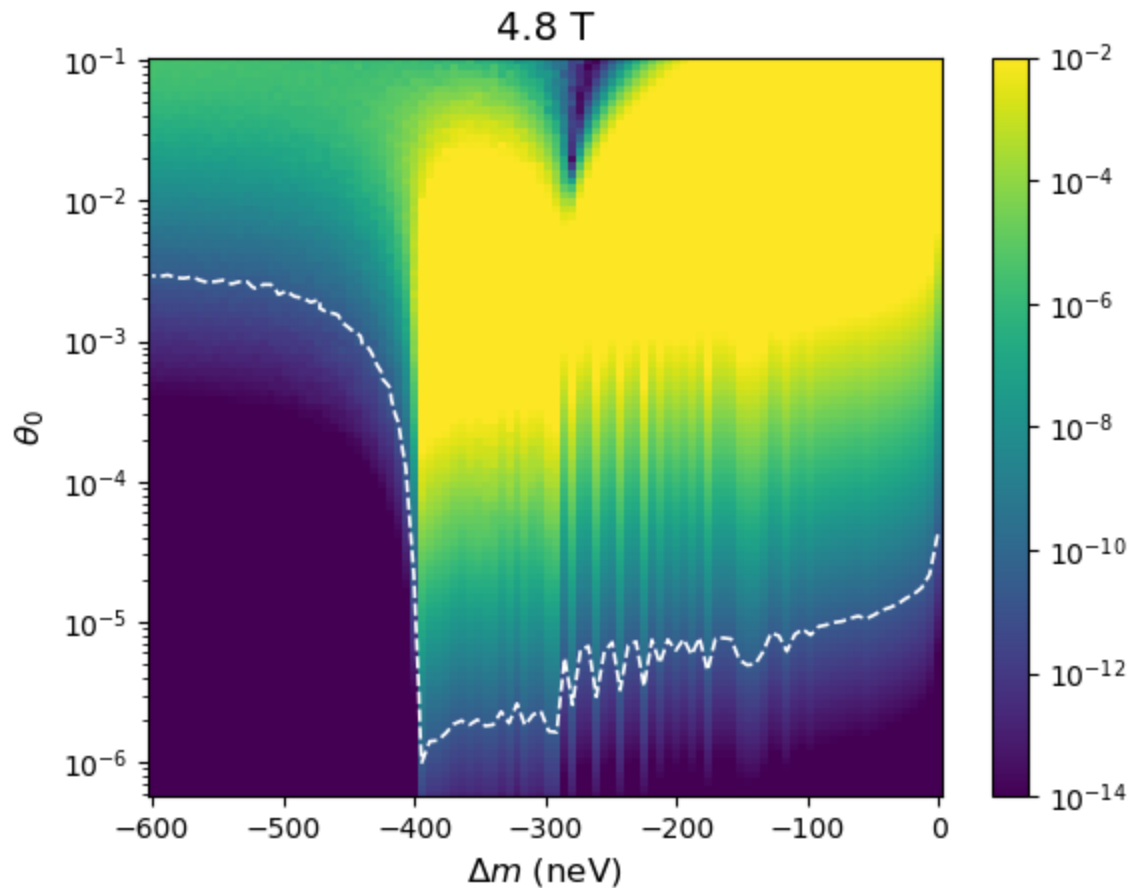


# Study on Changing $V_{Cd}$

- $V_{Cd} = 5$  neV
- Limit min at -394.3 neV
- Abs. Res. Tip at -279.3 neV

- 1mm
- 100 vel
- $-\mu B$

- $V_{Cd} = 5$  neV
- Peaks at 43.4 and 134 neV

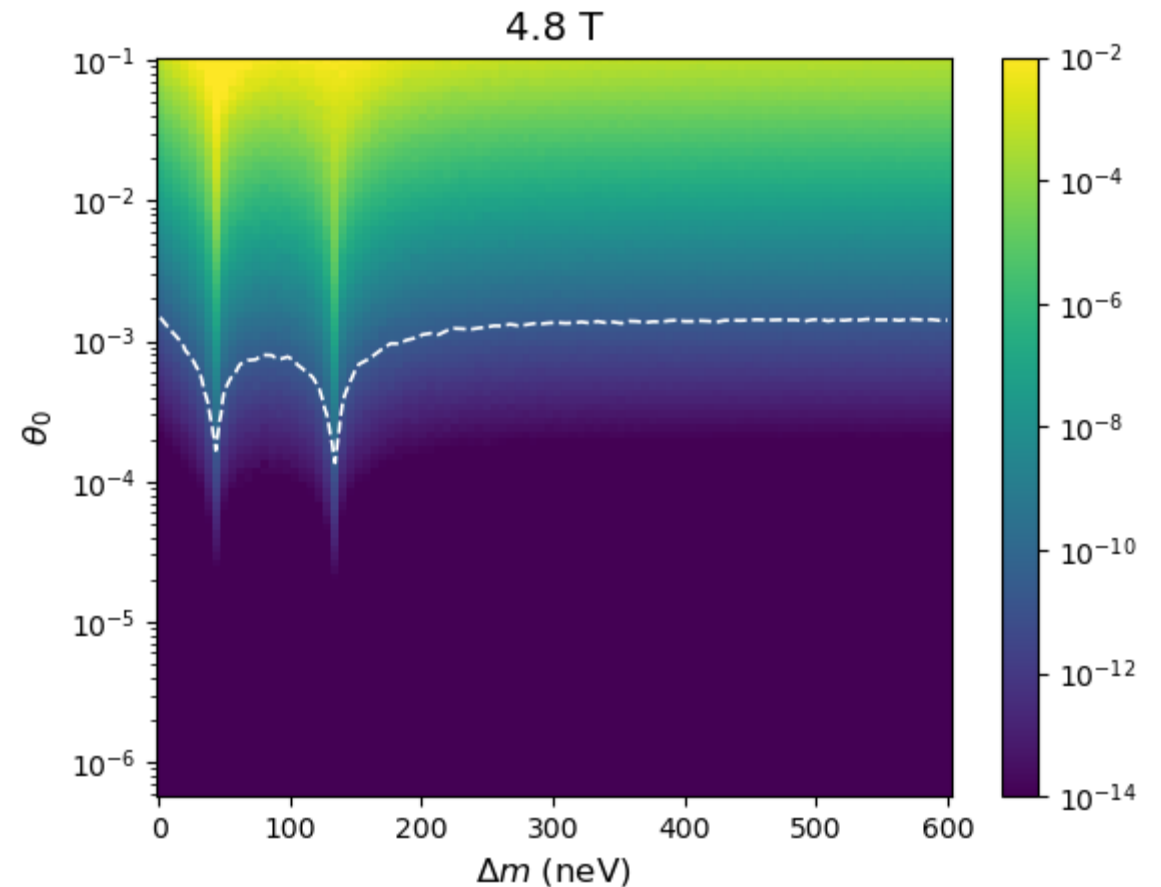
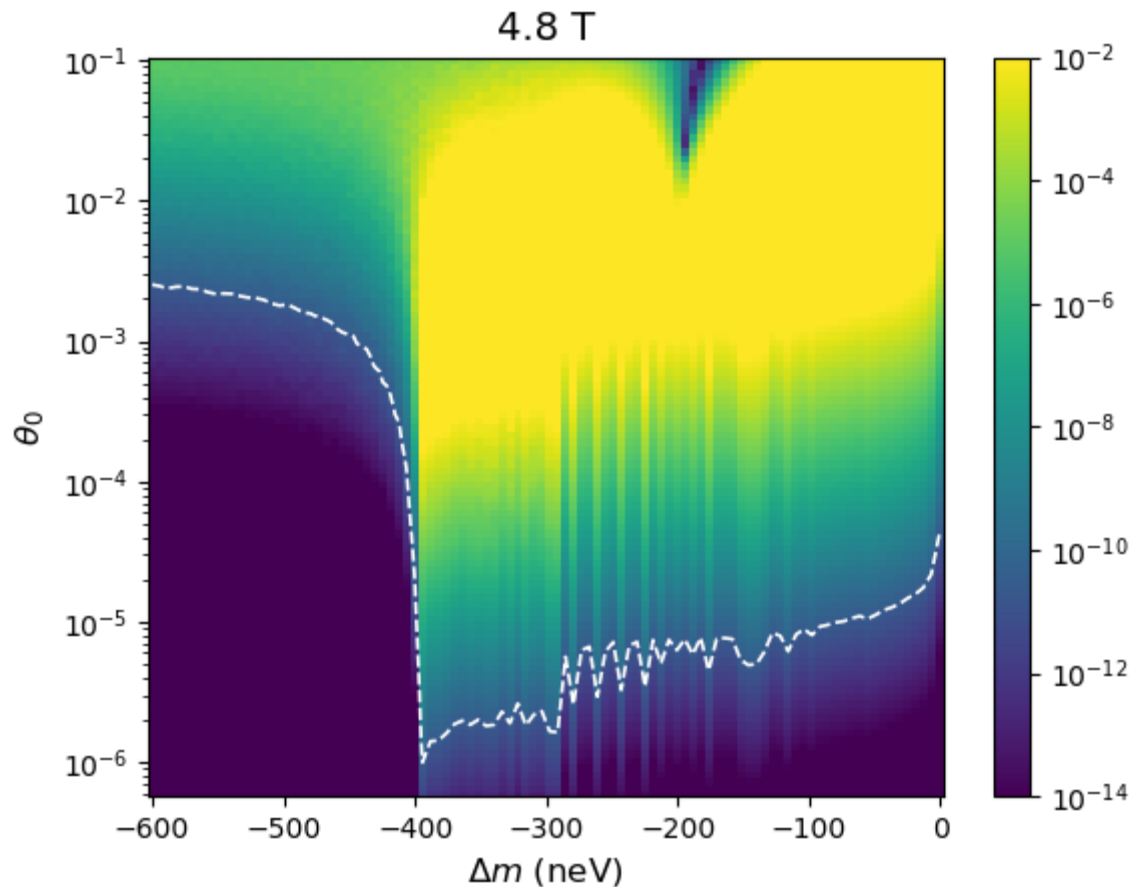


# Study on Changing $V_{Cd}$

- $V_{Cd} = 90$  neV
- Limit min at -394.3 neV
- **Abs. Res. Tip at -193.9 neV**

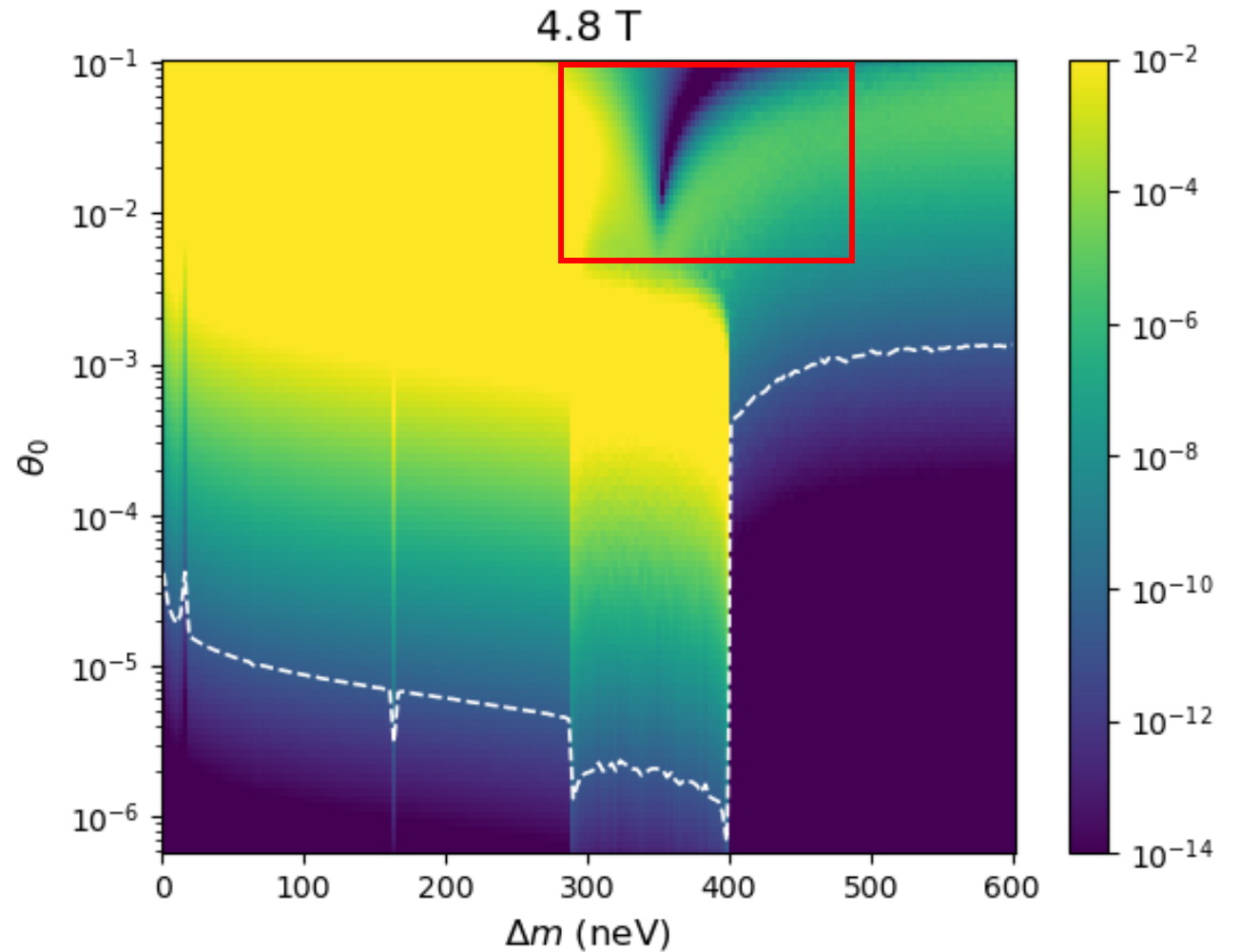
- 1mm
- 100 vel
- $-\mu B$

- $V_{Cd} = 90$  neV
- Peaks at 43.4 and 134 neV



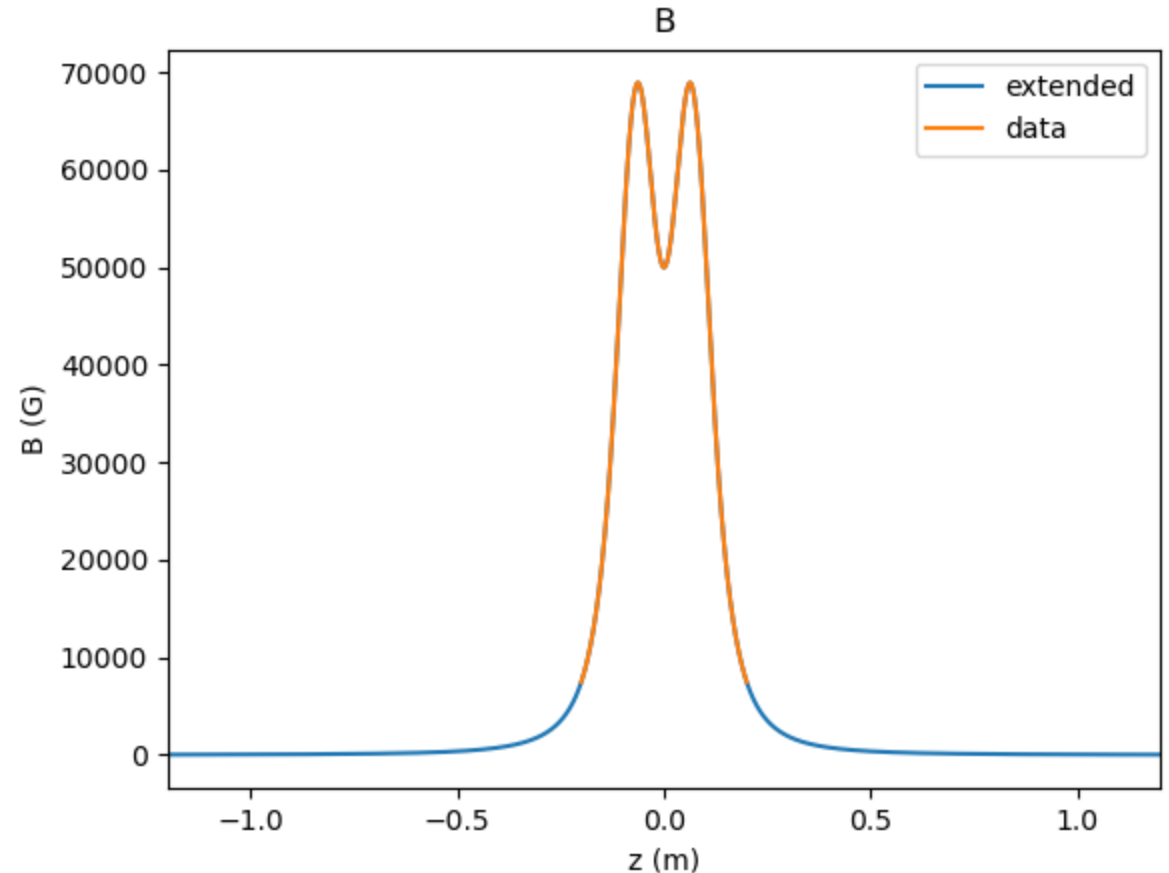
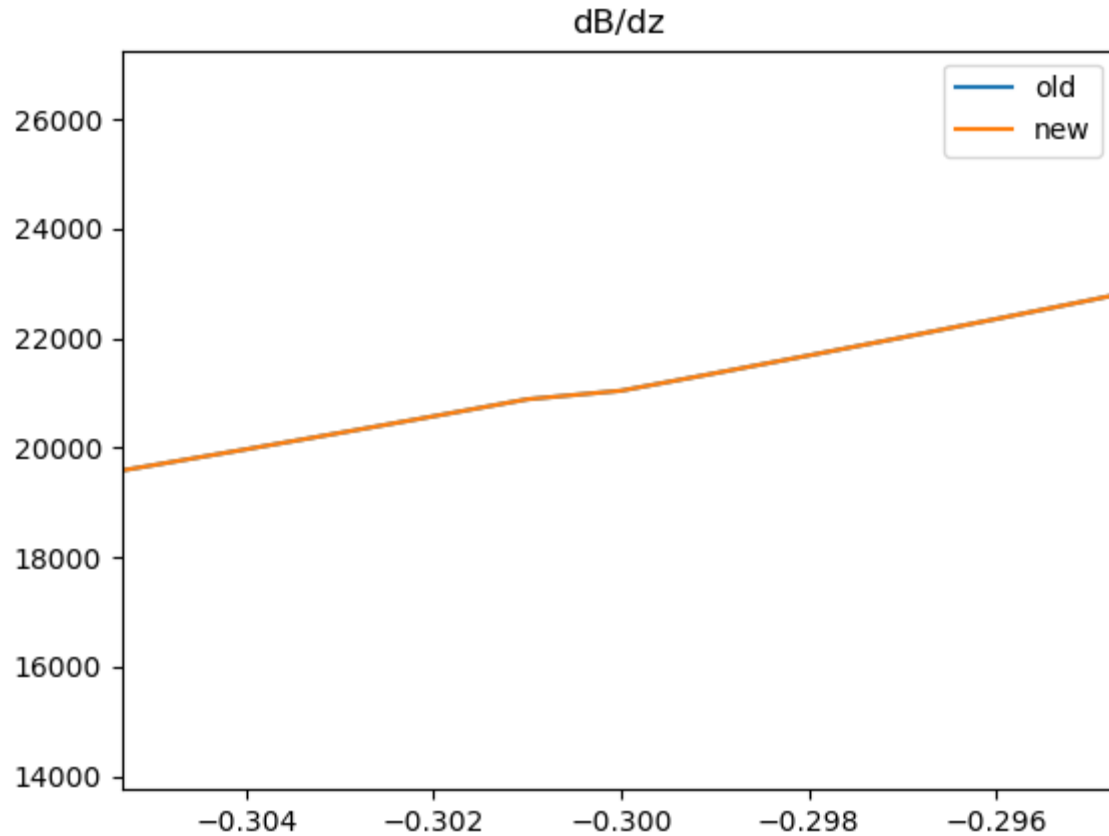
# Absorption Resonance

- When  $dm = \mu B + V$ , and  $\theta$  is large
- Mirror neutrons oscillate strongly in the Cd and are absorbed



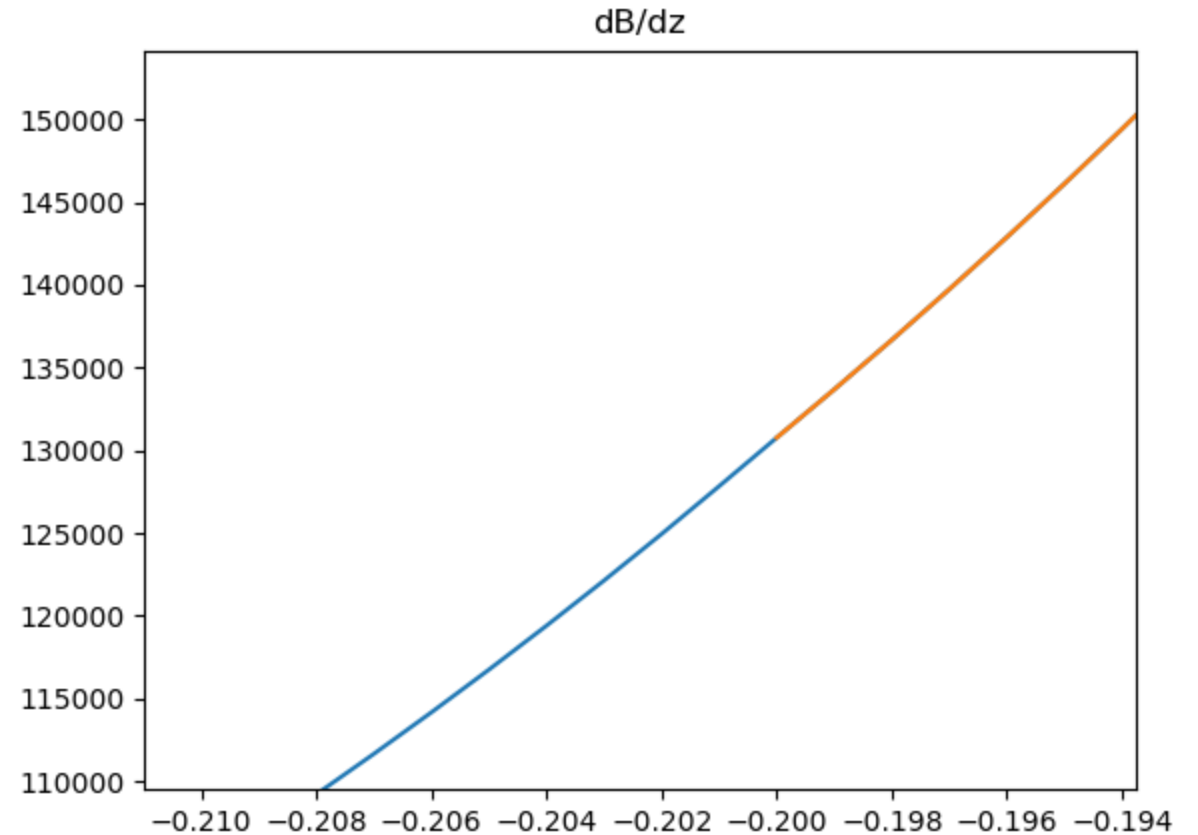
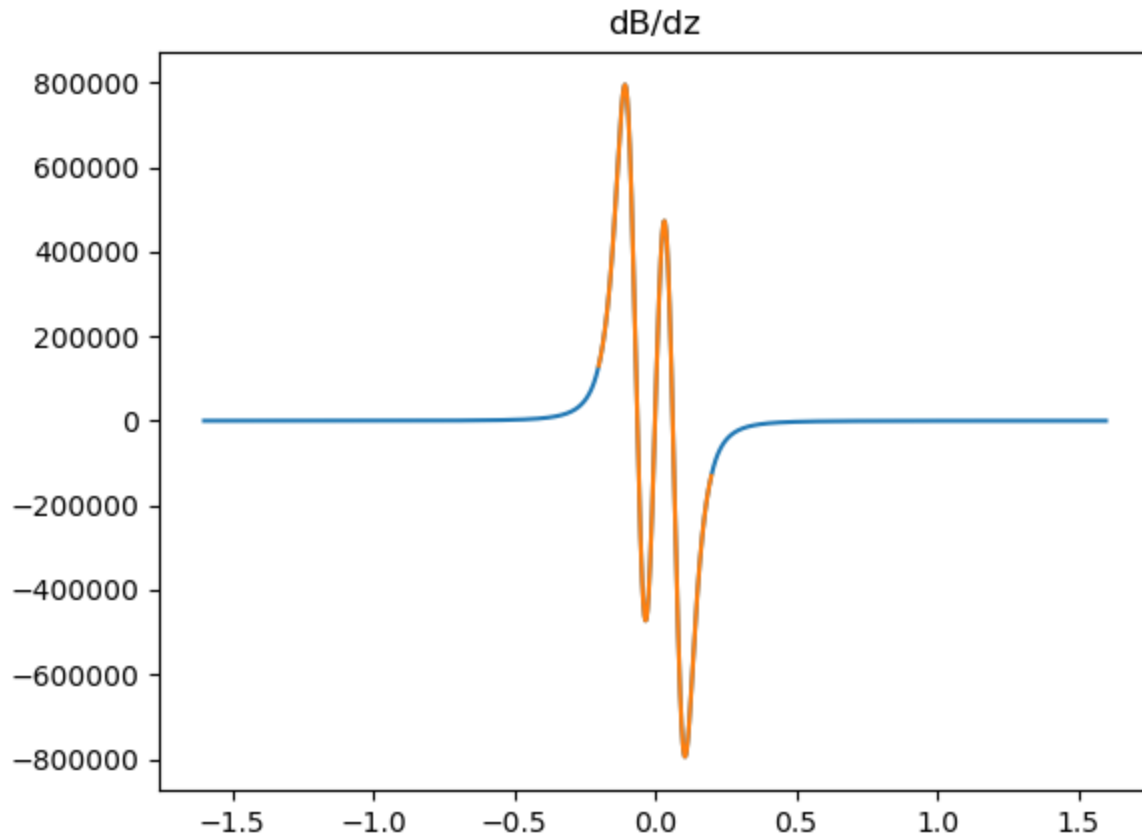
# Study on Changing $B$ extrapolation

- @30cm,  $B = 1870$  G,  $\mu B = 11.228$  neV
- Tail:  $B_{\min} = 9.24$  G,  $\mu B = 0.05556$  neV



# Study on Changing $B$ extrapolation

- @20cm,  $B = 7490$ ,  $\mu B = 45$  neV
- Tail:  $B_{\min} = 10.08$  G,  $\mu B = 0.0606$  neV
- $B_{start} = \pm 20$ cm
- @20cm => No jump in derivative

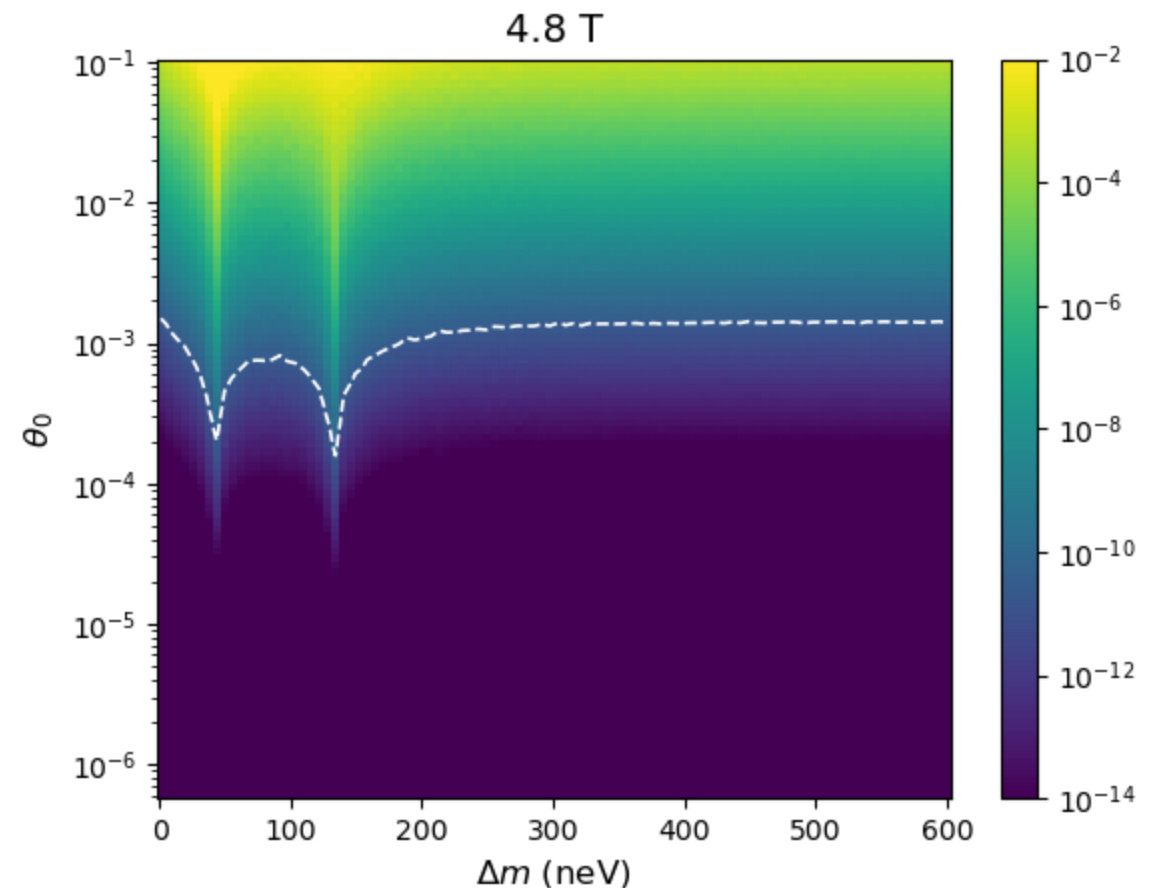
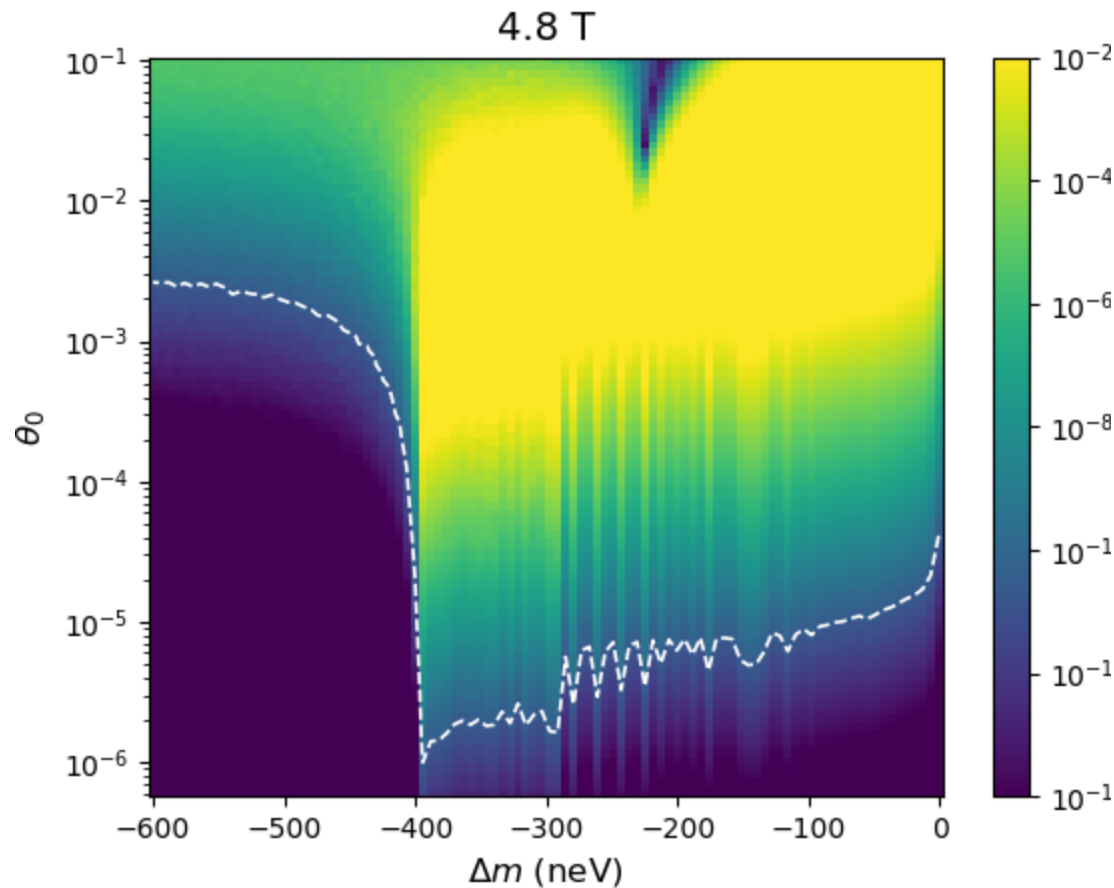


# Study on Changing $B$ extrapolation

- ext. @20cm
- Limit min at -394.3 neV
- Abs. Res. Tip at -225 neV

- 1mm
- 100 vel
- $-\mu B$

- Peaks at  $dm = 43.4$  and  $134$  neV
- (no change)



# B extrapolation at +/-20cm

- Spike at  $\Delta m = 164$  neV (both)

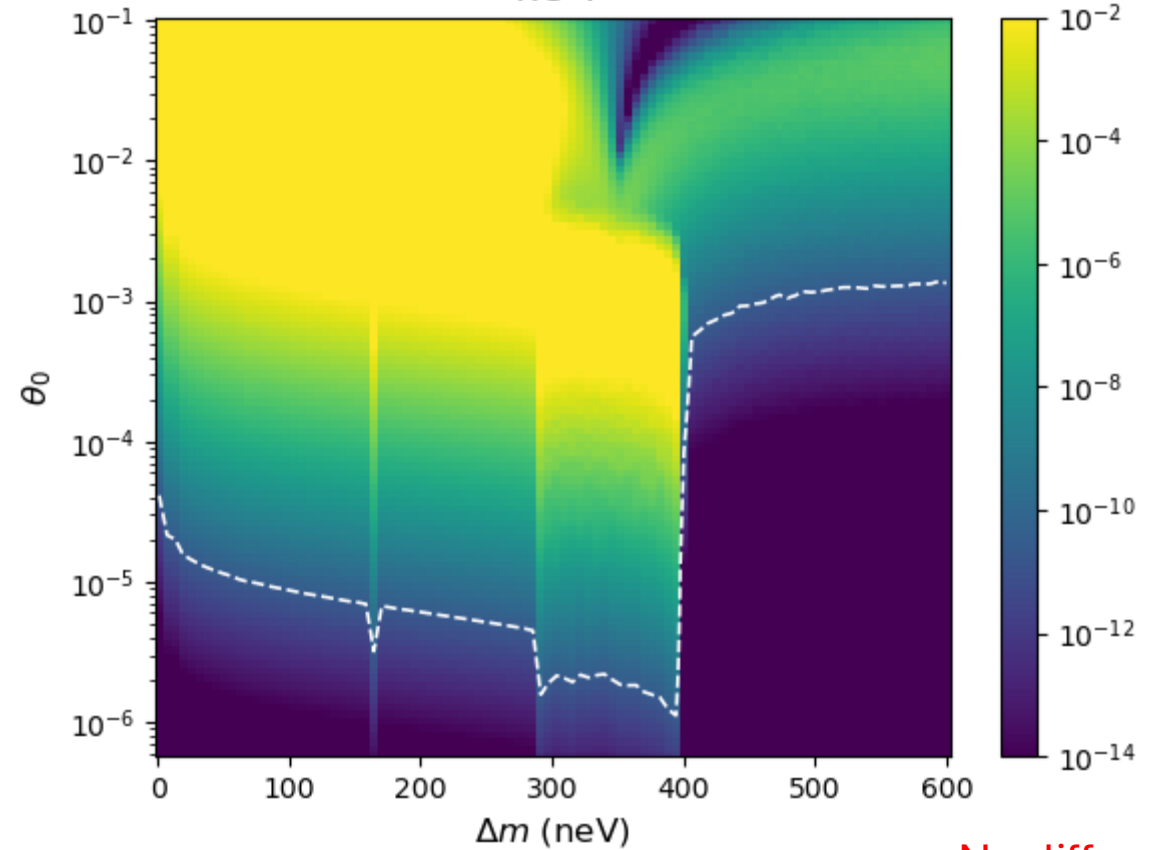
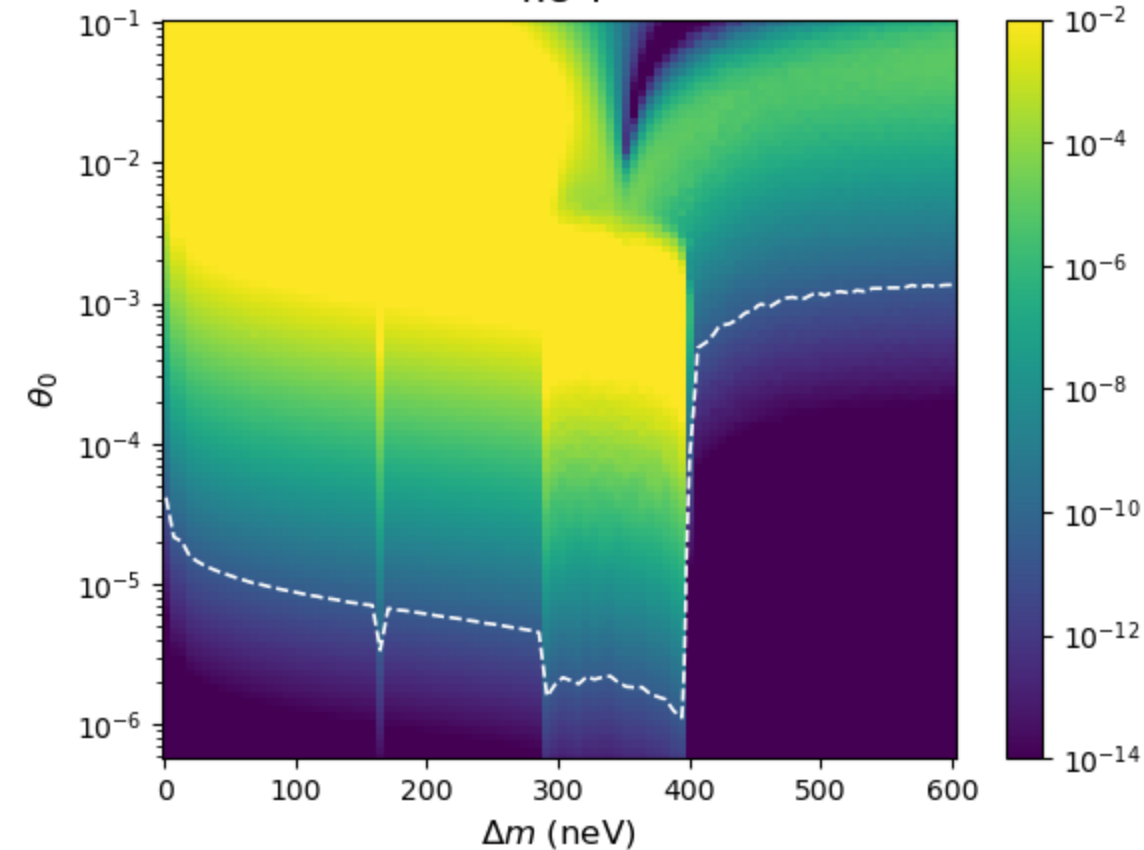
- 100 vel
- $+\mu B$
- $Dm > 0$

0.1mm stepsize

0.01mm stepsize

4.8 T

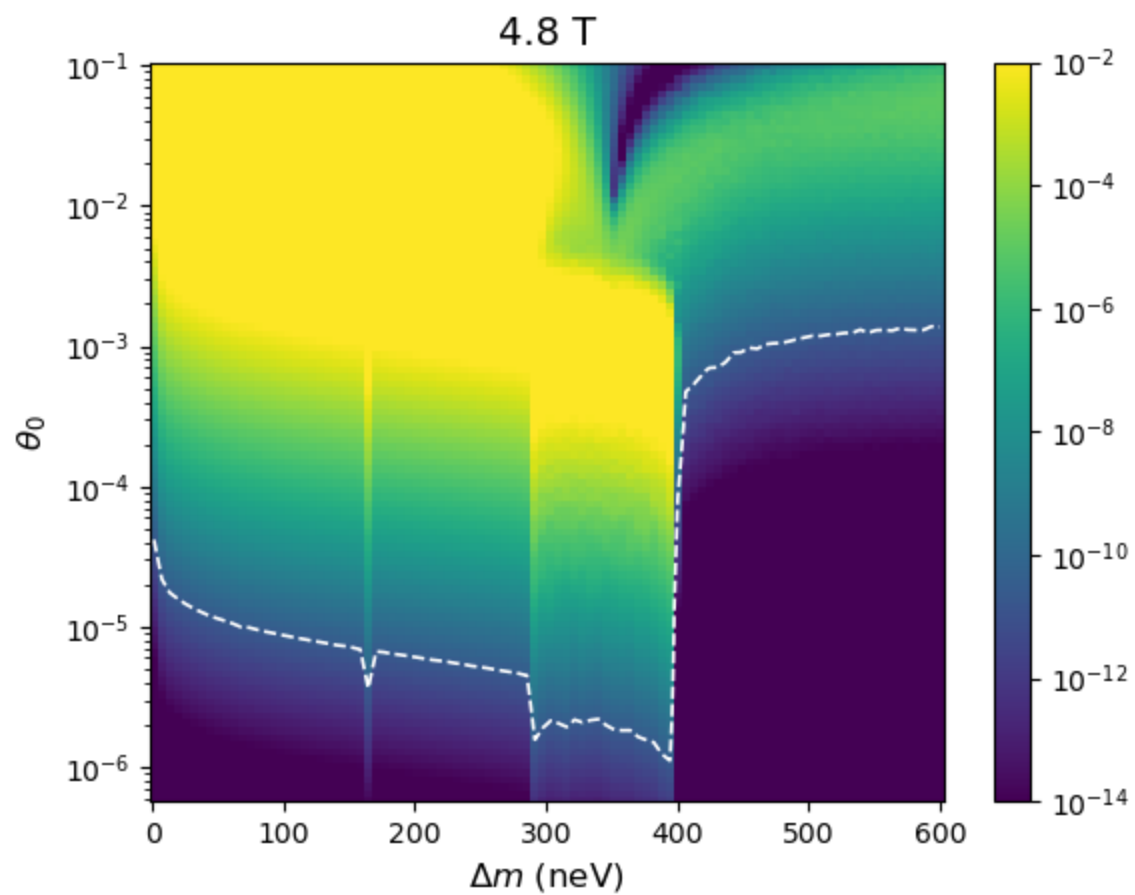
4.8 T



No difference

- 0.1 mm
- 100 vel
- $+\mu B$

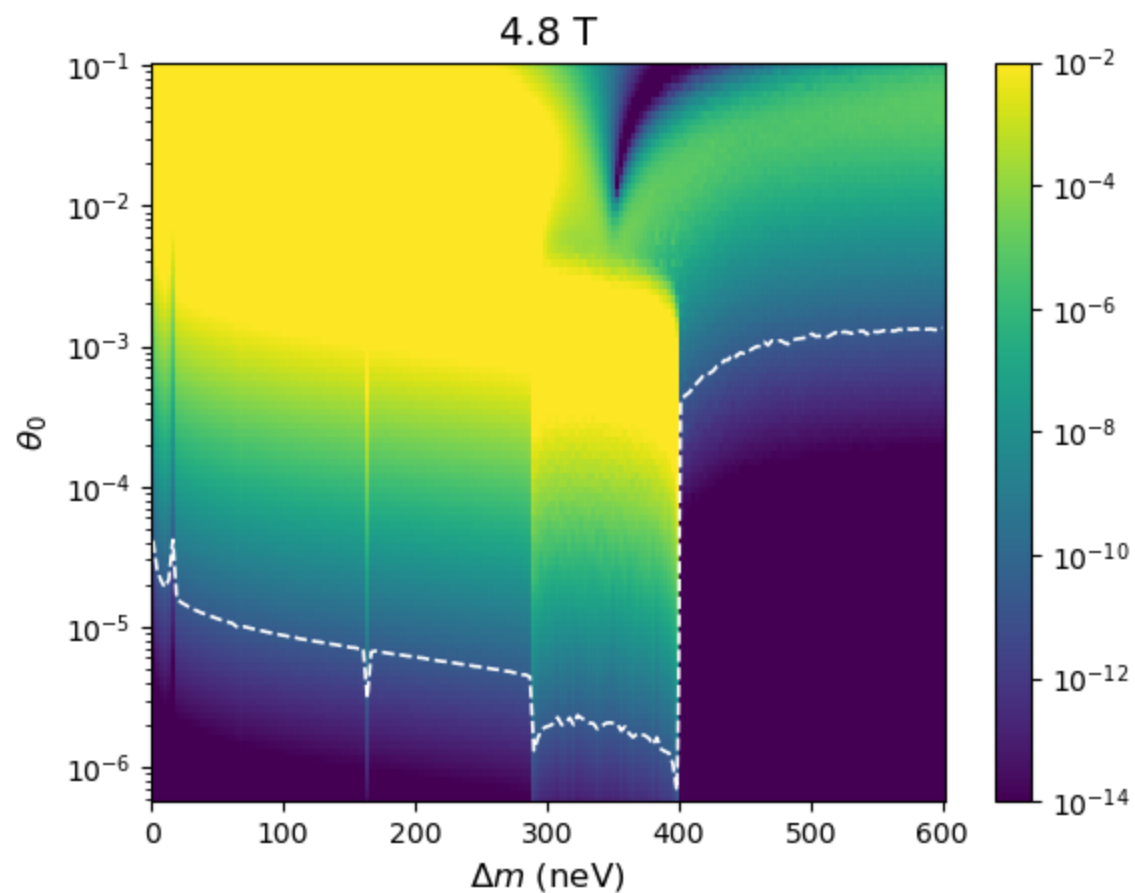
- Spike at  $\Delta m = 164$  neV



# More parameters

- 100 vel
- $+\mu B$
- $Dm > 0$

- B extrapolation at  $\pm 20\text{cm}$
- Spikes at  $Dm = 16.1, 164\text{ neV}$
- Spikes more narrow (one dm strip)



# New PSI paper with limits for $n$ - $n'$ for mirror magnetic field range $< 1$ Gauss

<https://arxiv.org/pdf/2602.23487>

## New high-sensitivity search for neutron to mirror-neutron oscillations at the PSI UCN source

N. J. Ayres,<sup>1</sup> Z. Berezhiani,<sup>2</sup> G. Bison,<sup>3</sup> K. Bodek,<sup>4</sup> V. Bondar,<sup>1</sup> P.-J. Chiu,<sup>1,3,\*</sup> M. Daum,<sup>3</sup> C. B. Doorenbos,<sup>1,3</sup>  
S. Emmenegger,<sup>1</sup> K. Kirch,<sup>1,3</sup> V. Kletzl,<sup>1,3,†</sup> J. Krempel,<sup>1</sup> B. Lauss,<sup>3,‡</sup> D. Pais,<sup>1,3</sup> I. Rienäcker,<sup>3</sup> D. Ries,<sup>3</sup>  
D. Rozpędzik,<sup>4</sup> P. Schmidt-Wellenburg,<sup>3</sup> K. S. Tanaka,<sup>3,§</sup> J. Zejma,<sup>4</sup> N. Ziehl,<sup>1,¶</sup> and G. Zsigmond<sup>3,||</sup>

<sup>1</sup>*Institute for Particle Physics and Astrophysics, ETH Zürich, 8093 Zürich, Switzerland*

<sup>2</sup>*INFN, Laboratori Nazionali del Gran Sasso, Assergi, 67100 L'Aquila, Italy*

<sup>3</sup>*Laboratory for Particle Physics, PSI Center for Neutron and Muon Sciences,  
Paul Scherrer Institute (PSI), 5232 Villigen, Switzerland*

<sup>4</sup>*Marian Smoluchowski Institute of Physics, Jagiellonian University, 30-348 Cracow, Poland*

In a search for potential signals of neutron ( $n$ ) to mirror-neutron ( $n'$ ) oscillations, a collaboration centered at the Paul Scherrer Institute (PSI) investigated the remaining parameter space claimed by anomalies with a dedicated high-sensitivity apparatus. An elaborate magnetic-field-mapping analysis and Monte Carlo simulation of the cumulative  $n - n'$  oscillation probabilities along the neutron trajectories inside the storage vessel complemented the neutron data analysis. Magnetic fields were scanned in the range  $5\mu\text{T} < B < 109\mu\text{T}$ . No evidence of anomalous neutron losses was found. Consequently, new limits for the  $n - n'$  oscillation time constant were set. The parameter space, previously claimed for potential signals, has been excluded to 99.98 %.

All previous possible “Berezhiani anomalies” with UCN are excluded

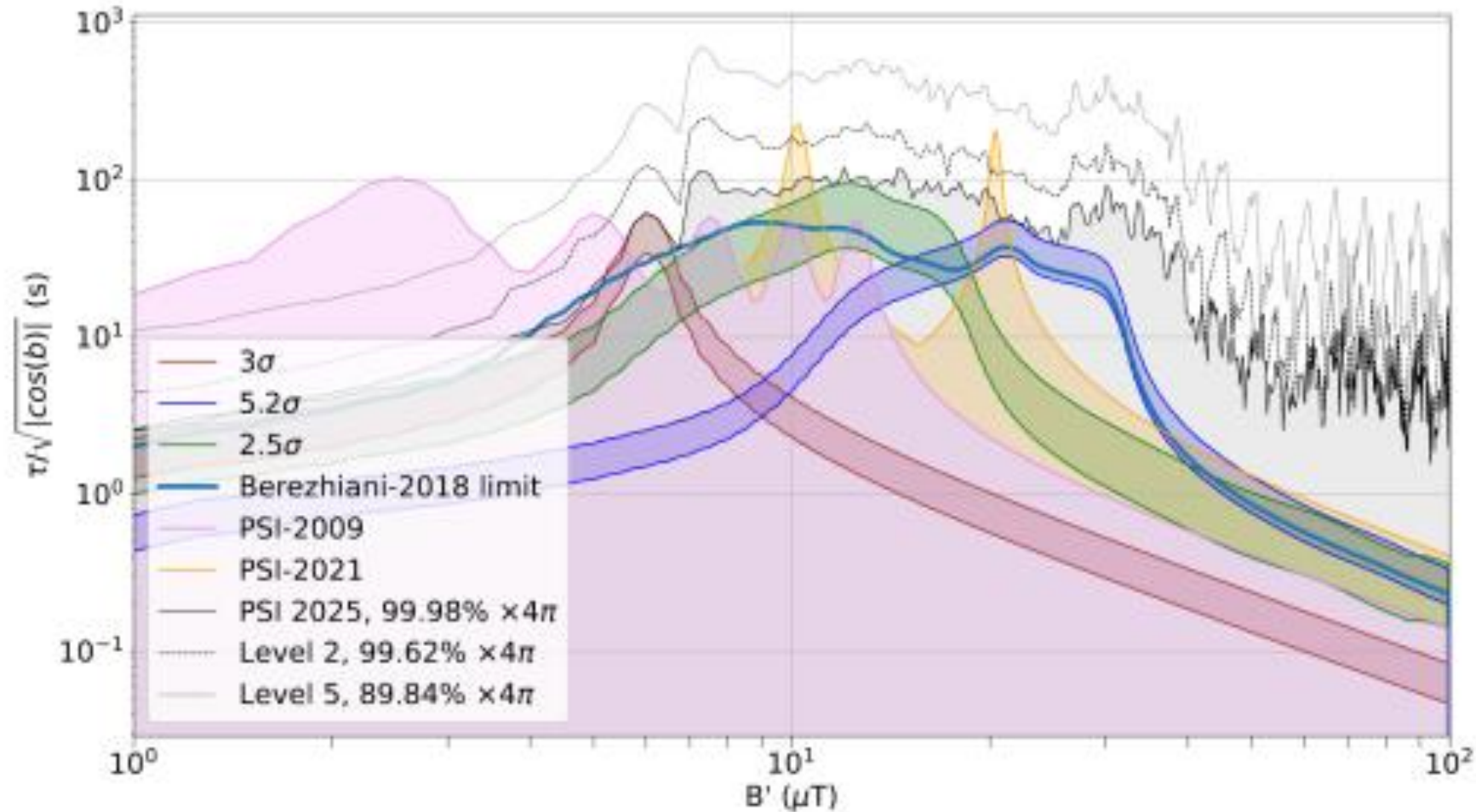


Figure 4: The anomalous signal regions of Berezhiani-2018 [42] from data in [37] ( $3\sigma$ , red), [40] ( $5.2\sigma$ , blue) and [42] ( $2.5\sigma$ , green) together with the 95% C.L. limits on  $\tau_{n\nu}/\sqrt{|\cos(b)|}$  from PSI-2009 [41], PSI-2021 [43] and this work as a function of the magnitude of the mirror-magnetic-field,  $B'$ . Along with the most conservative PSI-2025 limit (black line) excluding 99.98% of the full solid angle ( $4\pi$ ), two higher limit curves but with less solid angle exclusion (99.62% and 89.84%) are plotted, corresponding to levels of factor 2 (dashed line) and 5 (dotted line) above the anomalous signals.

These new UCN limits can be included in our new paper with 2024 data

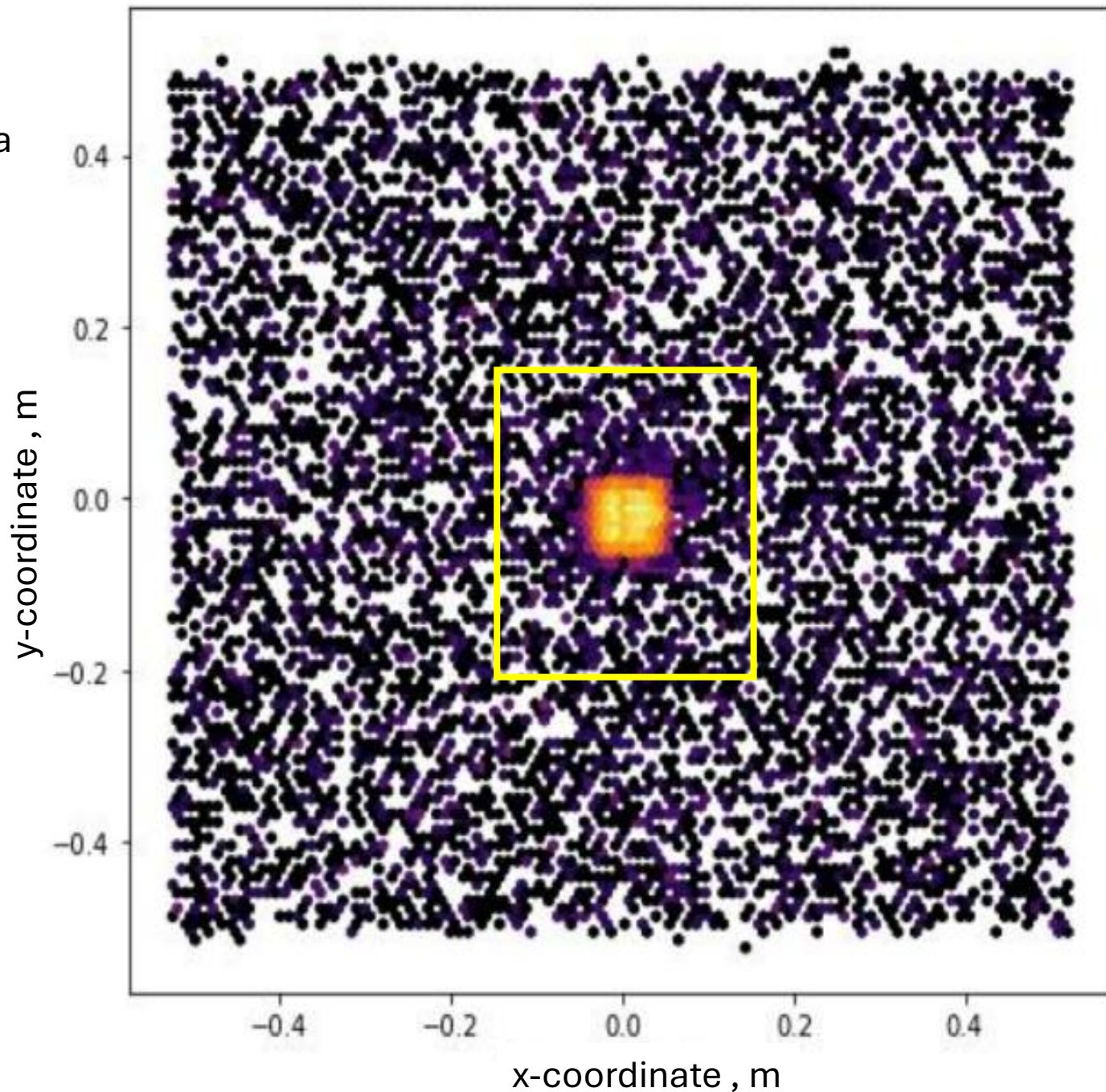
however, they are outside our range of measurements:

we are equivalently above 10 Gauss;

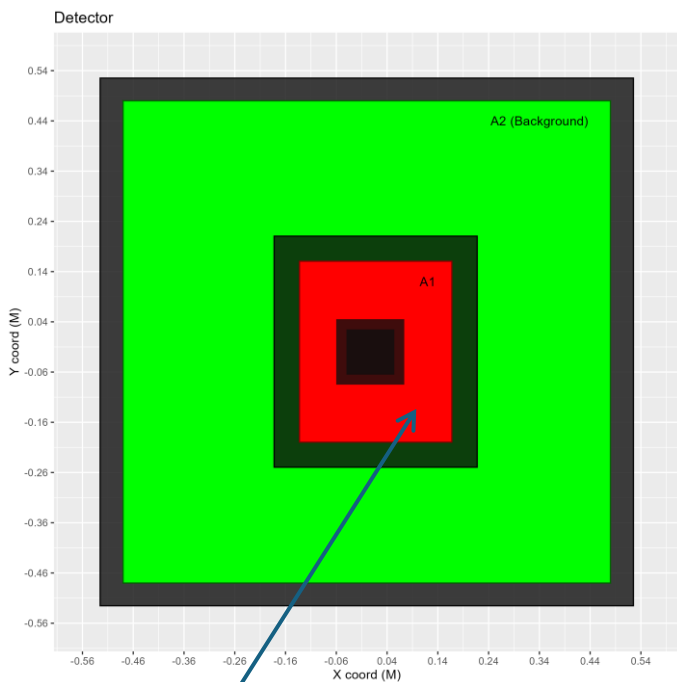
all new PSI limits are in the range 0.01 – 1 Gauss

I have asked Klaus Kirch and he promised that his people will send their limits in digital form to us

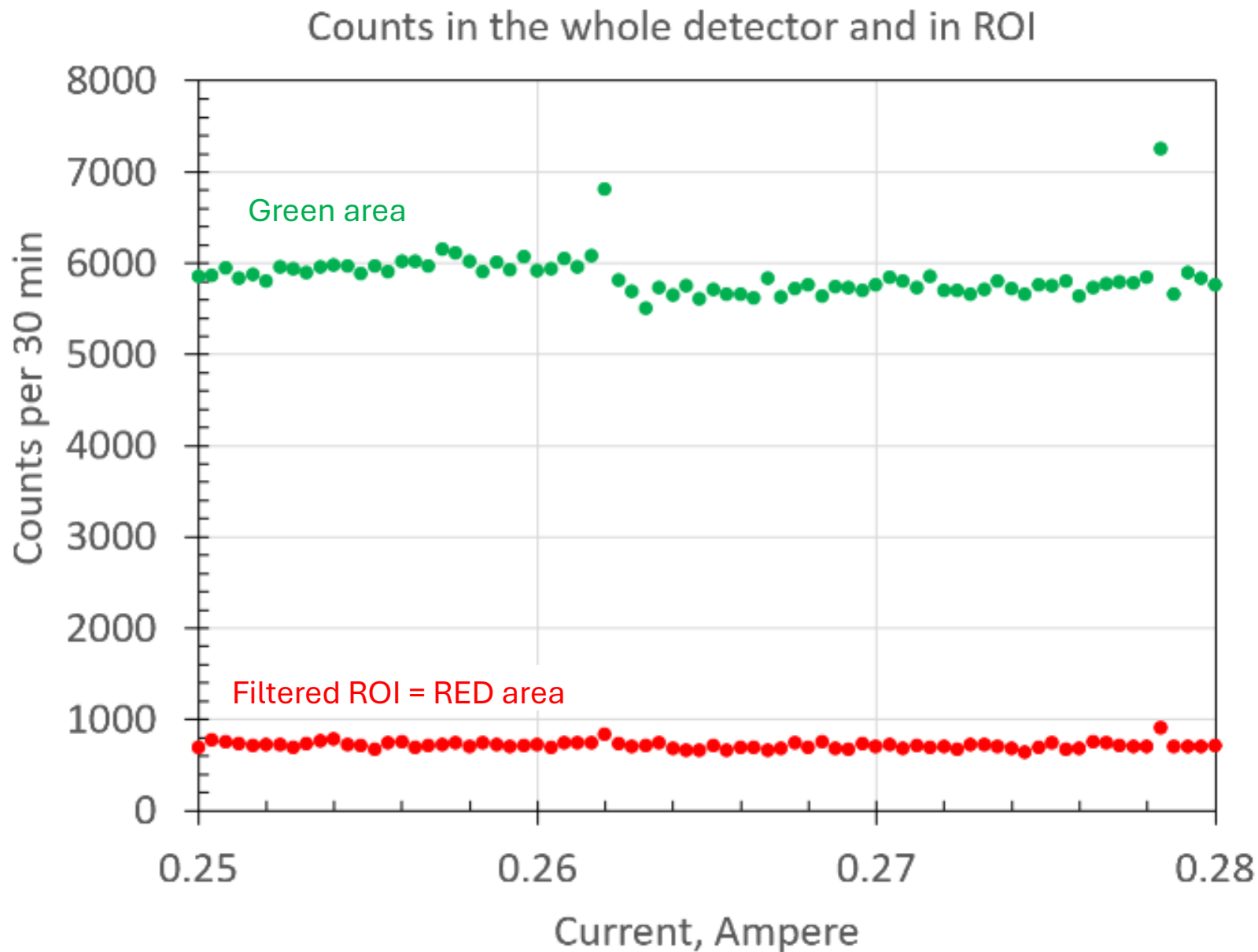
Reduction of ROI  
background in  
2025 GP\_SANS data



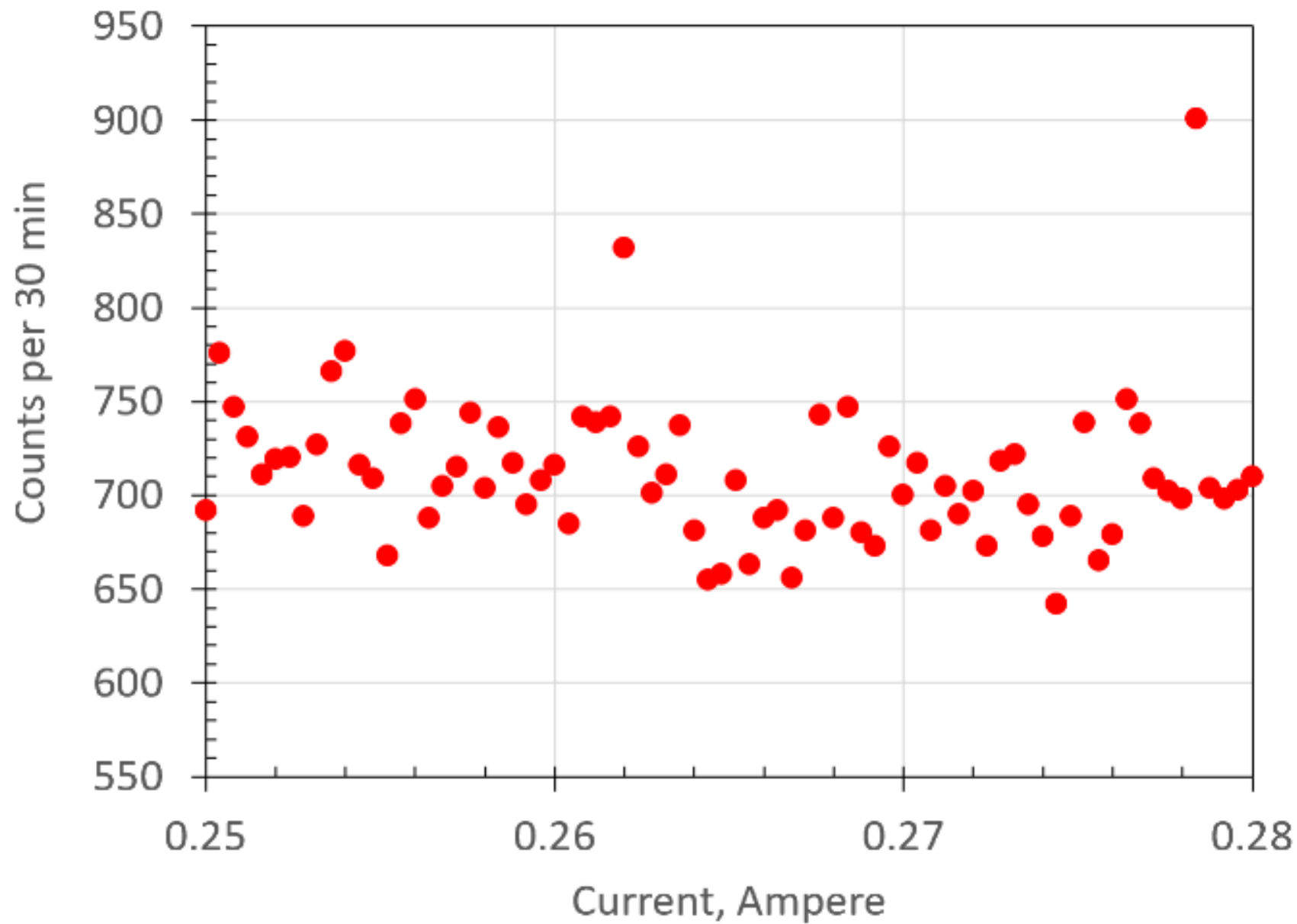
Notice ~ uniformity  
of background in  
the whole detector  
(minus hot spot).  
This uniformity can  
be used with area  
rescaling for per run  
background subtraction  
in ROI. The anomalous  
run can be tamed in ROI

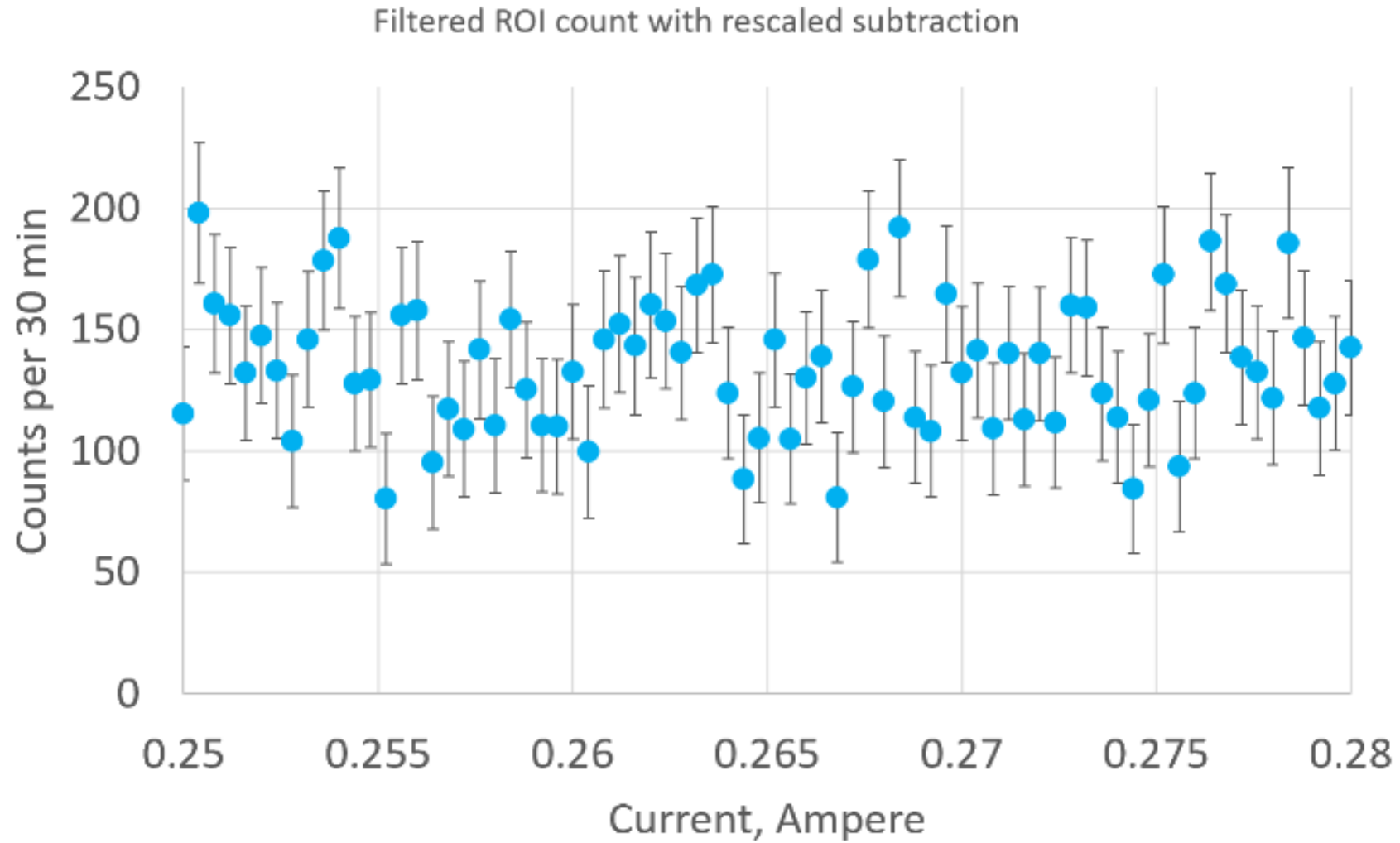


“Filtered ROI” corresponds to the RED area



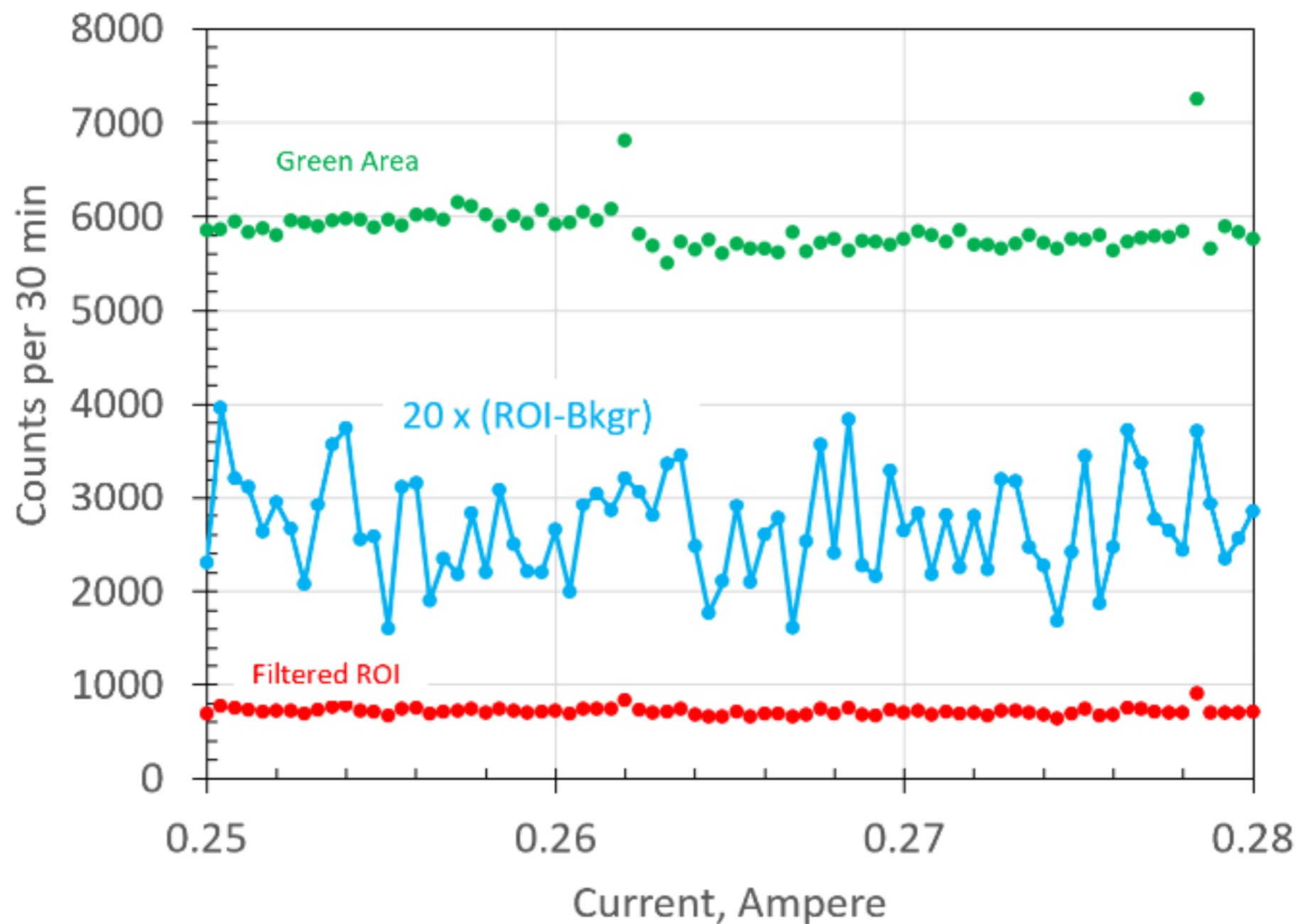
Counts in filtered ROI

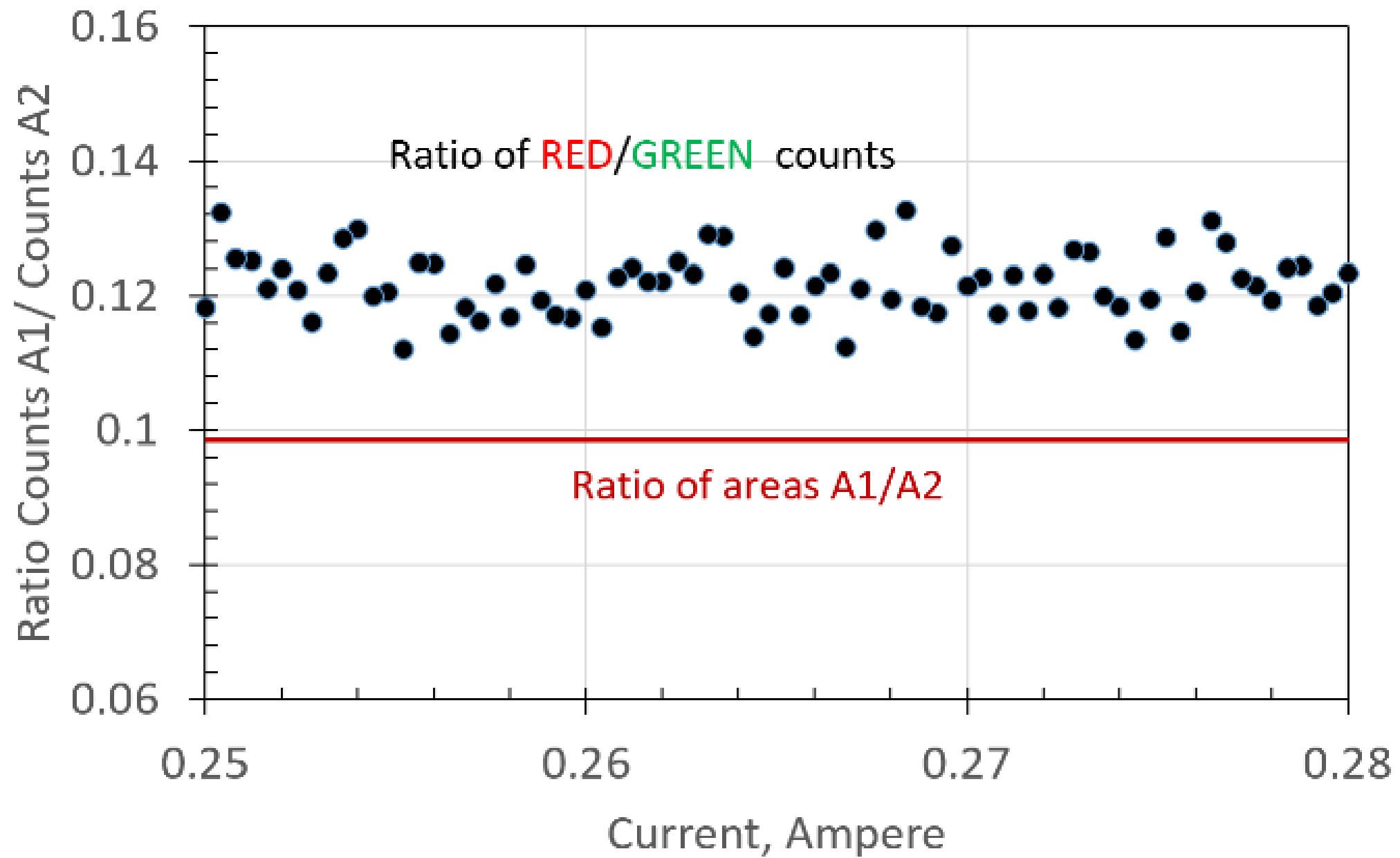




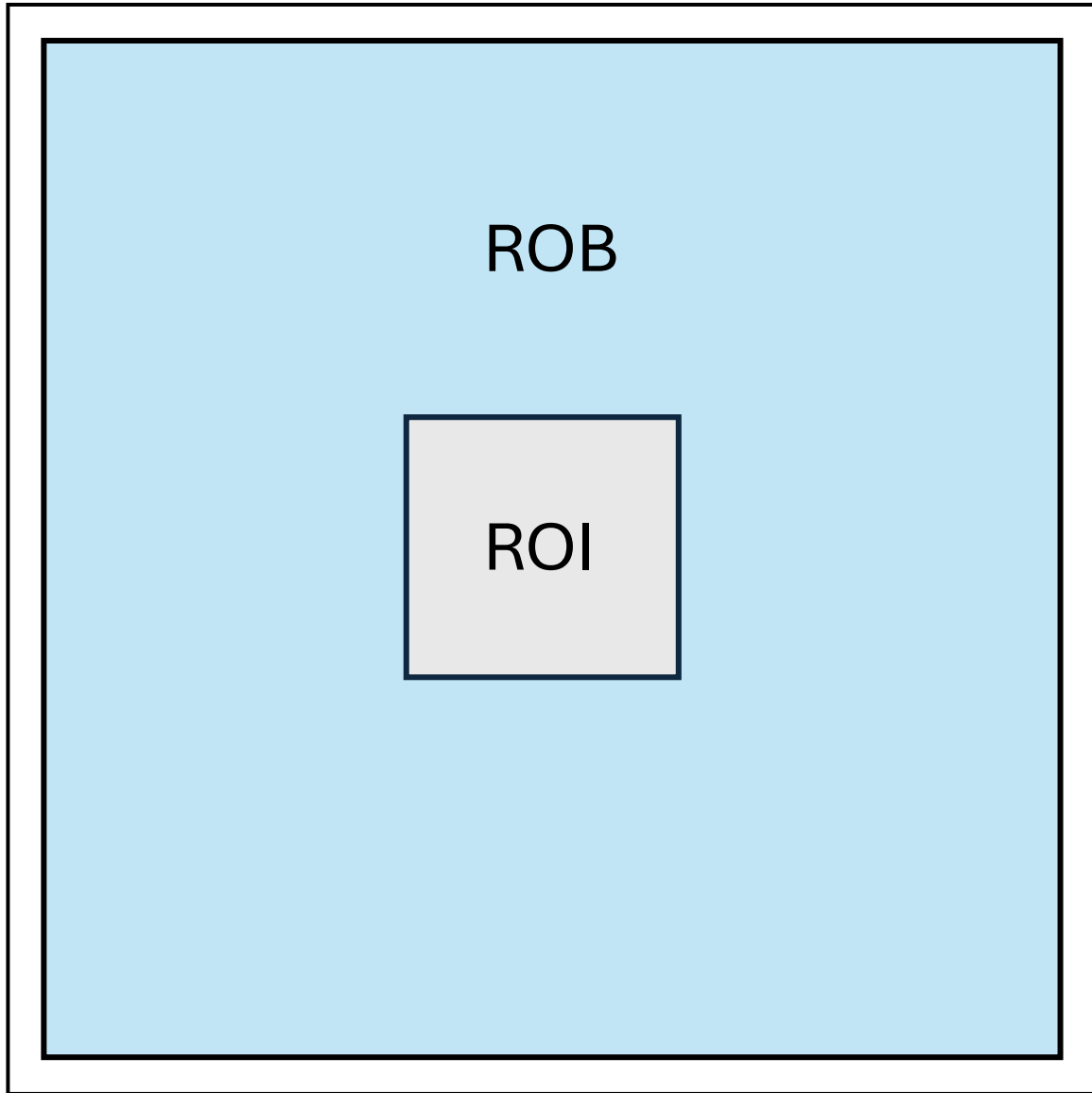
If background would be perfectly uniform, then counts should be centered around zero. Current plot is indication that background has some bump around beam center. It might possibly be a halo of fast scattered neutrons indicated by Kyle.

Counts in the whole detector and in ROI









$A1 \equiv \text{ROI area } 0.3 \times 0.36 \text{ m}^2 = 0.108 \text{ m}^2$  with counts  $C1$

$A2 \equiv \text{ROB area:}$

$0.95 \times 0.95 \text{ m}^2 - 0.3 \times 0.36 \text{ m}^2 = 0.794 \text{ m}^2$  with counts  $C2$

For each 30 min (20 min) run  $i$  we can subtract from ROI area-rescaled background from ROB to obtain signal  $S$

$$S_i = C1_i - C2_i \cdot A1/A2$$

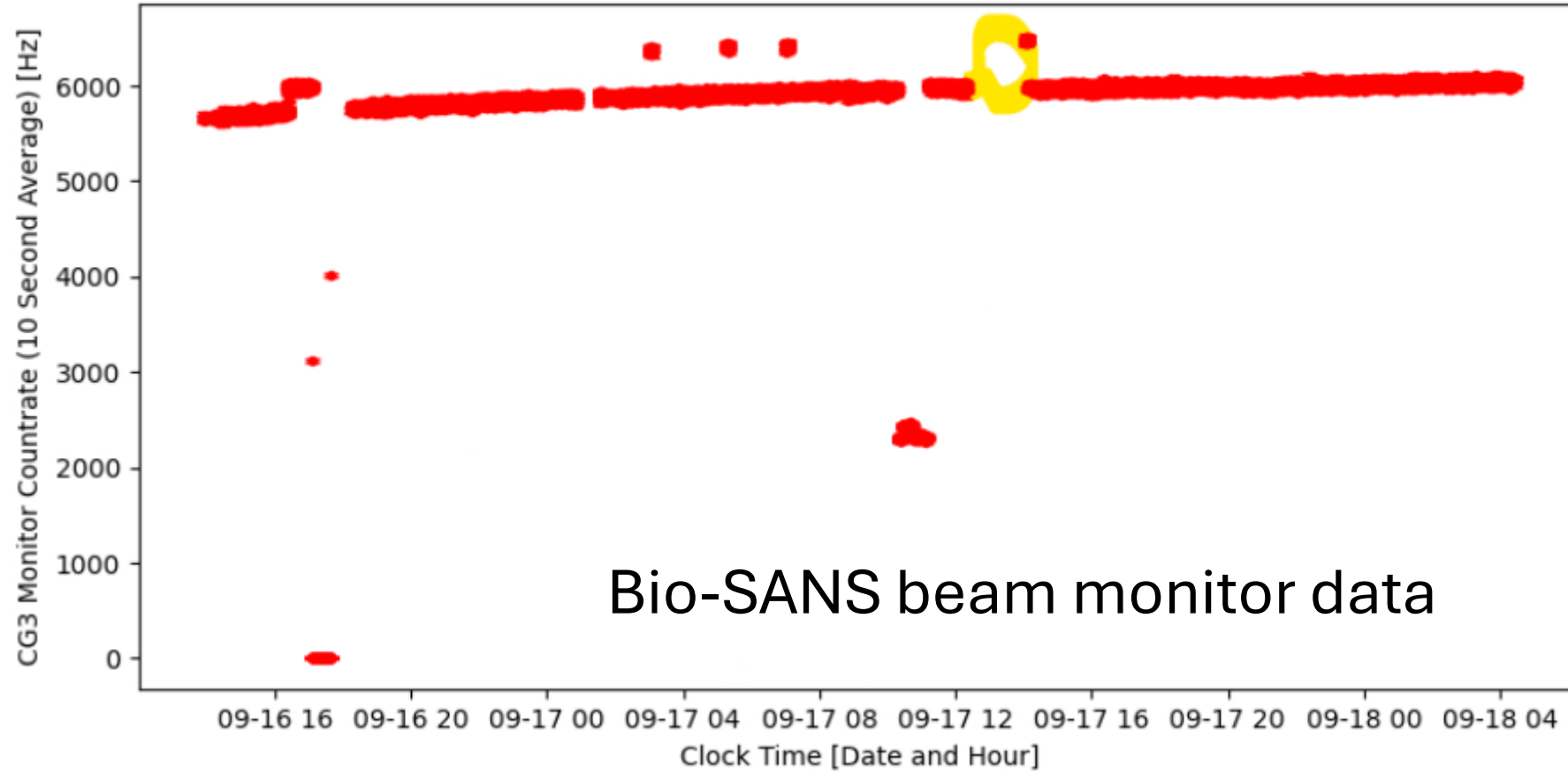
- Statistical error of  $S_i$  will be slightly increased compared to  $C1$
- Peak (from Bio-SANS) can be removed
- Signal in every run should be not affected
- $S_i$  for  $i = 1,76$  can be used for fitting nTMM effect

Leah suggested to look at the ratio:

$$R_i = C2_i / C1_i \quad i = 1,76 \quad (\text{for } 30' \text{ and } 20' \text{ runs})$$

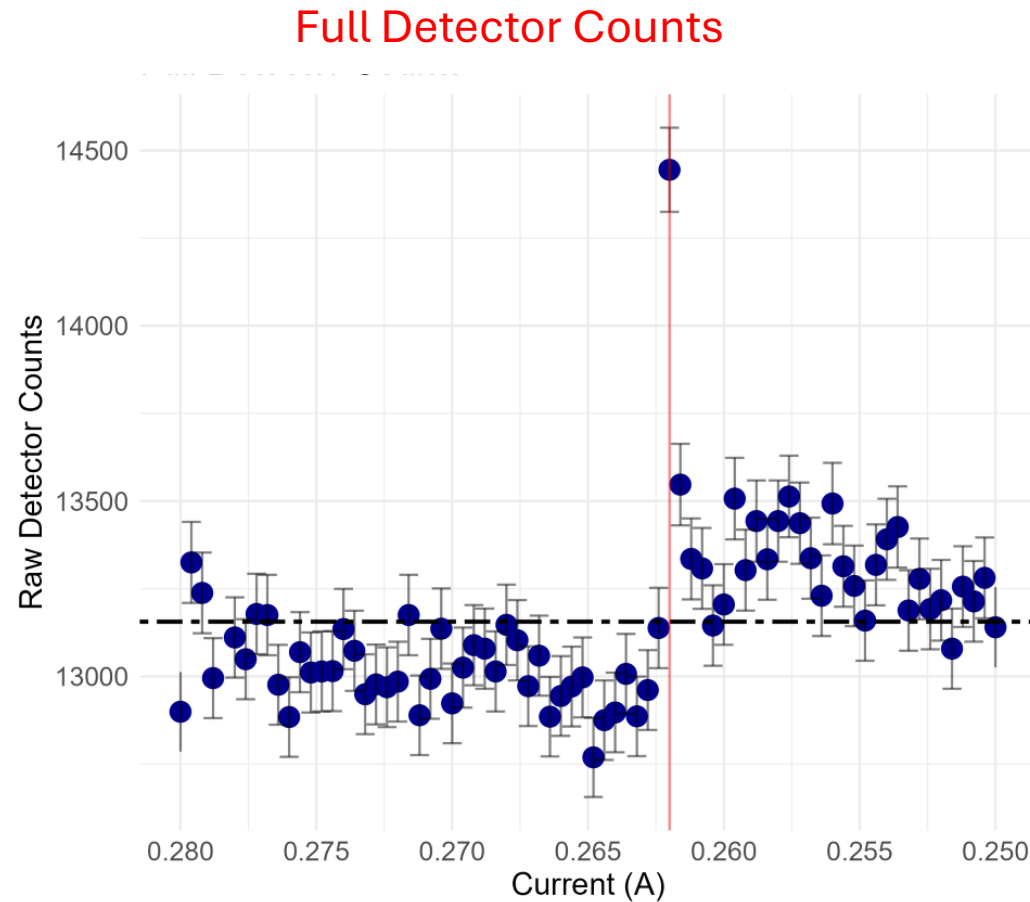
## Lisa, what was happening in Bio-SANS?

At the time of the peak of background in GP-SANS on **September 17 - 2025** between **12:50 pm** and **1:21 pm**  
DAQ of Bio-SANS was not working



# An idea for nTMM analysis

ROI: 30 x 36 cm<sup>2</sup>



## Filtered ROI (Punchthrough Removed)

