SNS 2020 Run Data Analysis

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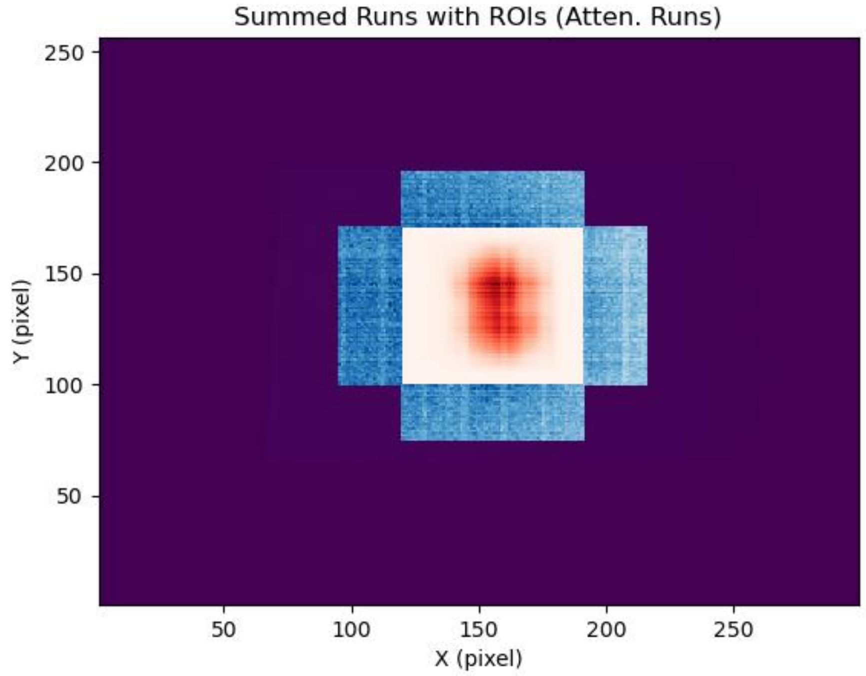
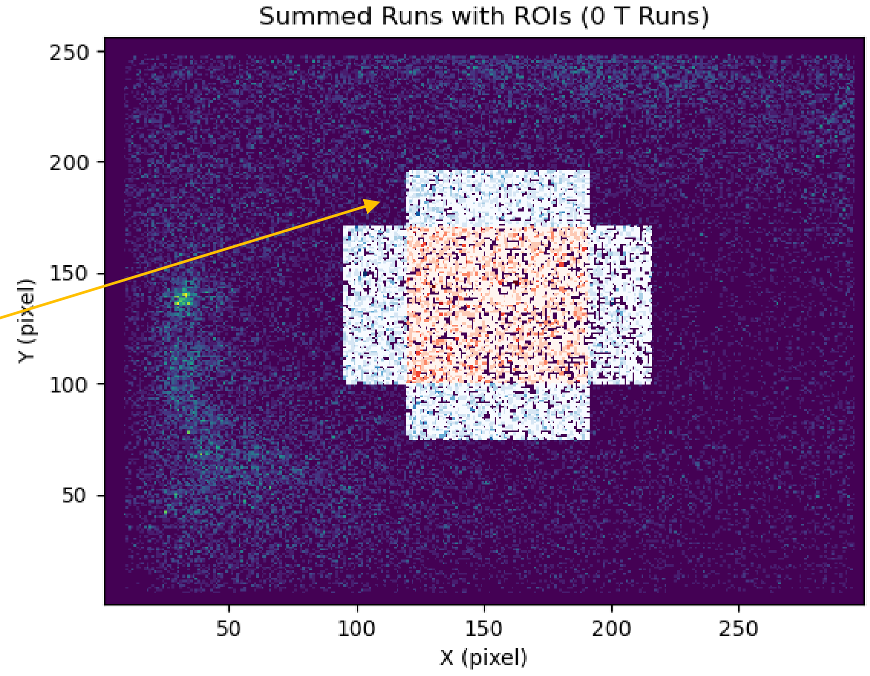
Cuts on the Data

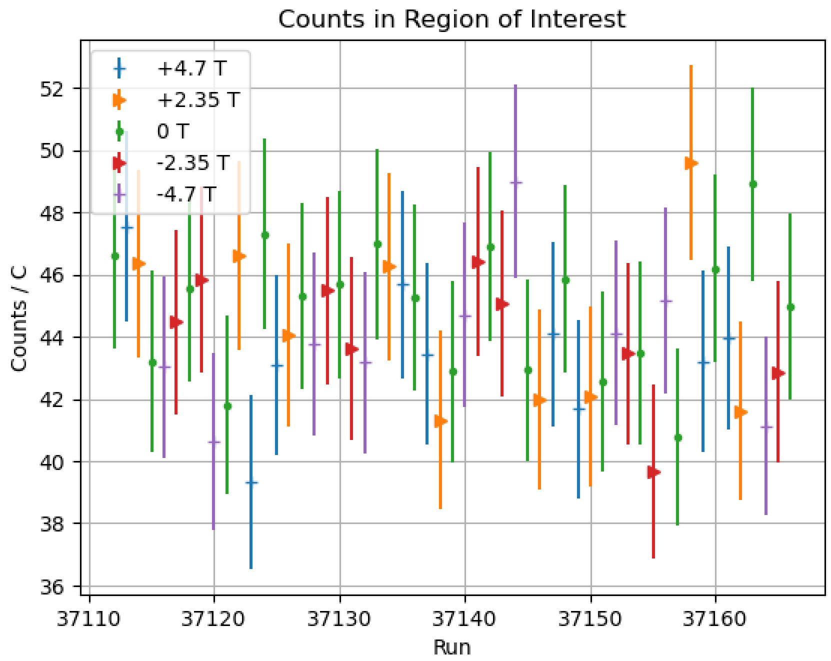
- Runlists:
  - Using runs 37112-37166 as “Production” runs
  - Using runs 37102-37107 as “Attenuation” runs
- Event/Pulse Cuts
  - Fast Neutron cuts: Remove (16662 us < TOF < 16717 us)
  - Remove pulses with charge < 2.3e-5 C
- Region of Interest:
  - Foreground pixels:
    - $120 \leq x \leq 190$ (maybe not centered?)
    - $100 \leq y \leq 170$ (maybe too small?)
  - Background is 25 pixels off each edge of this square
    - Too close to “top” region?

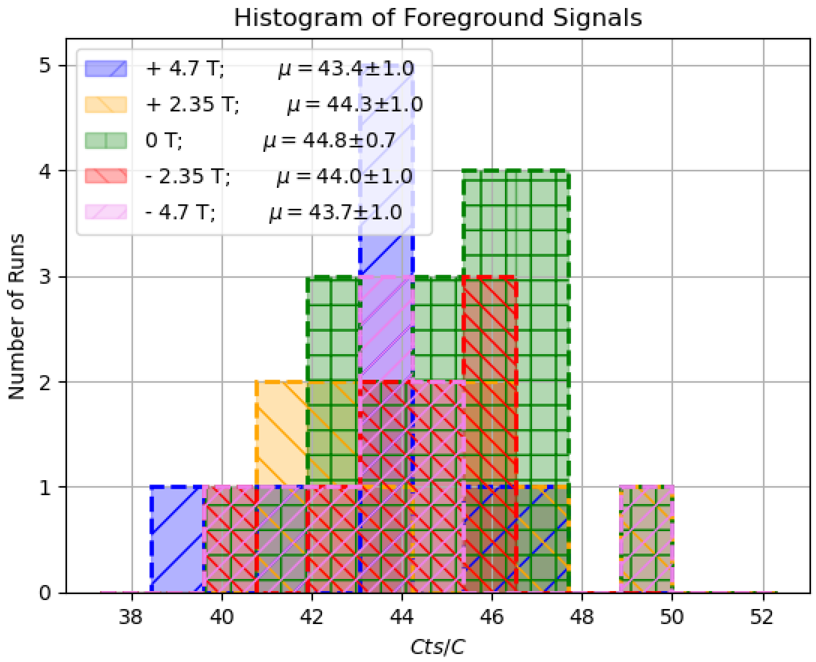




Raw Counts in Production Runs

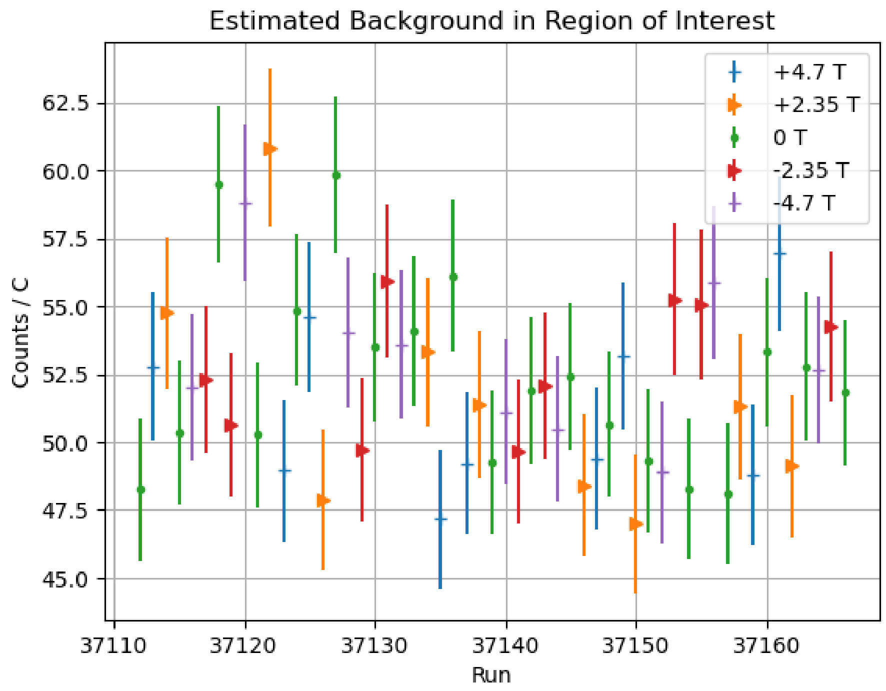
- Use sum of counts (~200 / run) + Gaussian uncertainties
  - Compare directly with total charge (~5 C /run)
- Calculate weighted mean:
  - $\bar{x} = \frac{\sum \frac{x_i}{\sigma_i^2}}{\sum \sigma_i^2}, \ \sigma_{tot} = \sqrt{\frac{1}{\sum \sigma_i^{-2}}}$
  - 0 T sees largest number of runs and thus most counts/lowest uncertainties
- For the 5 fields:
  - $1.4 < (\chi^2 / \, DOF) < 2.8.$
  - 9 runs at each field except 0T, which has 19.

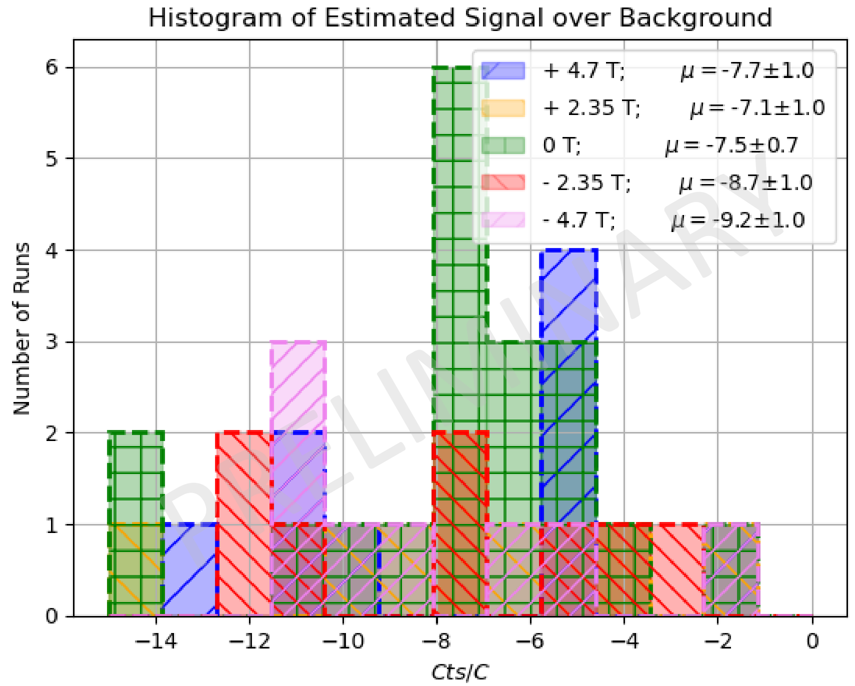




Background Counts in Production Runs

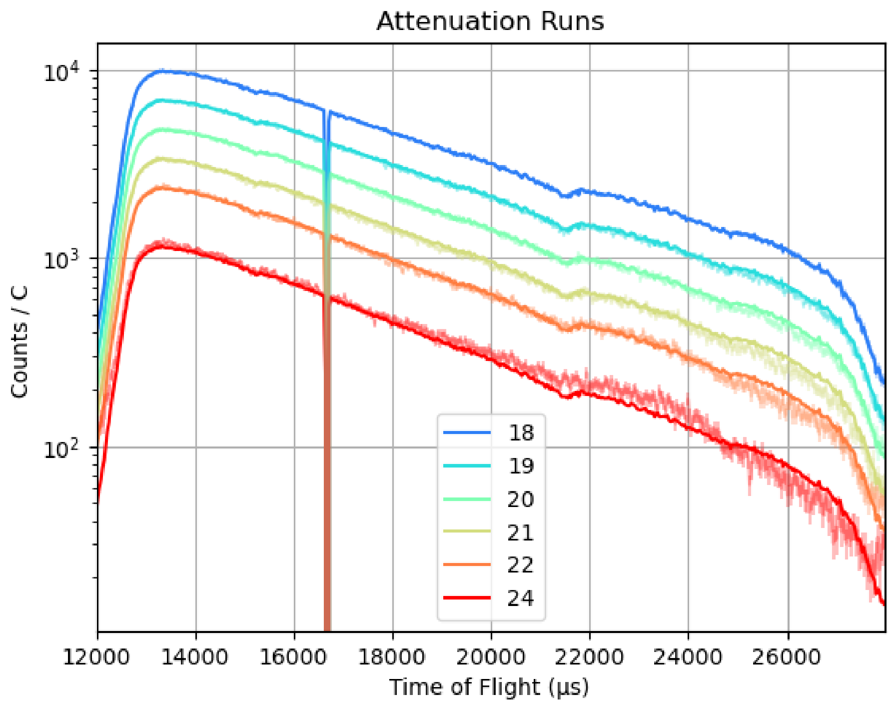
- Background rate calculated on a run-by-run basis:
  - $B_{(fgd\ ROI)} = \frac{Cts_{(bkg\ ROI)}}{Bins_{(bkg\ ROI)}} \times Bins_{(fgd\ ROI)}$
- Uncertainty on each point is Gaussian (no model dependence). For each B-field, again calculate weighted average
  - $2.2 < (\chi^2/\ DOF) < 7.0$
  - Significantly over-estimates background!
- TODO: Extra scatter (time-dependence?) and too-high backgrounds (ROI? Better fit function? Understand position dependence?)

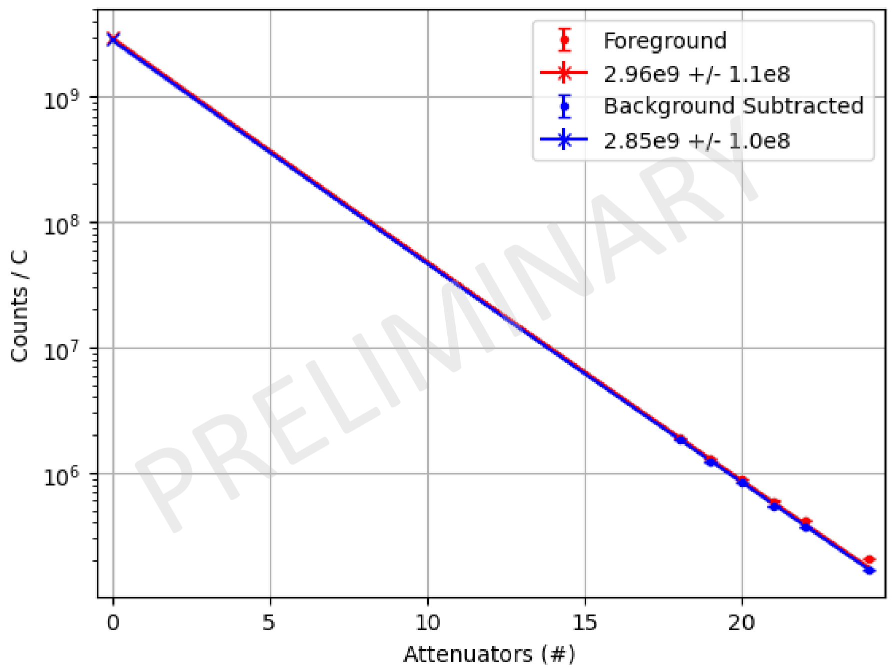




Intensity Model

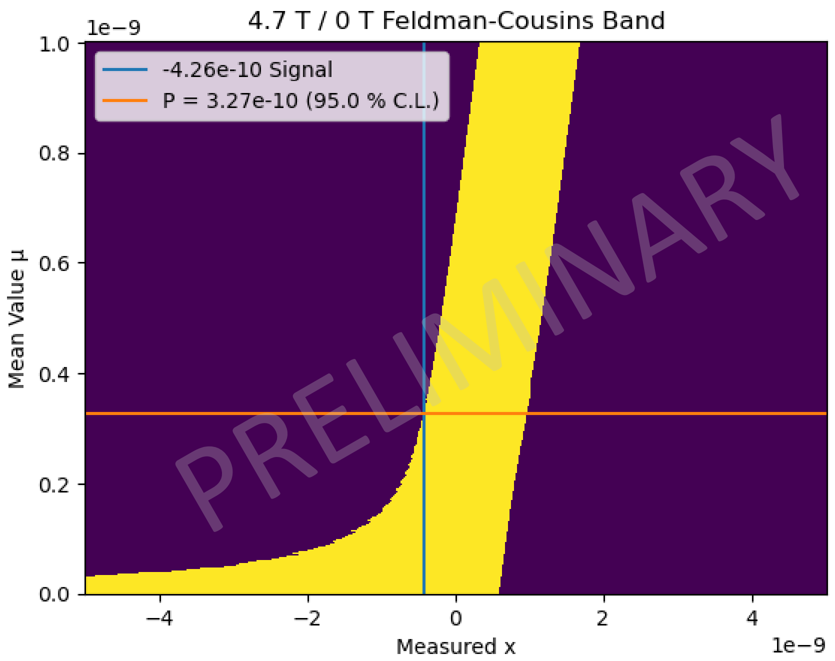
- Use PC runs ($p = 18$ to 24) to extrapolate to $p = 0$
- Assume TOF t dependence to intensity I:
  - $I(t, p) = (\eta_1 + \eta_2 t)^p$
  - Simultaneously fit 6 attenuation runs between TOF=13000 us and TOF=24000 us for $\eta_1 = 0.755$ and $\eta_2 = -4.24 \times 10^{-6}$ (Similar to Michael's)
  - Use diagonals of covariance matrix to find the uncertainty of fit
- Note 1: This model ($2.9(1) \times 10^9$ counts/C) disagrees with other intensity calculations $\sim 2.07(1) \times 10^9$ counts/C
- Note 2: Uncertainty of $p = 0$ isn't great…
- Note 3: Using attenuation runs 37039-37047 (or somewhere around there) gives $1.93(8) \times 10^9$ counts/C

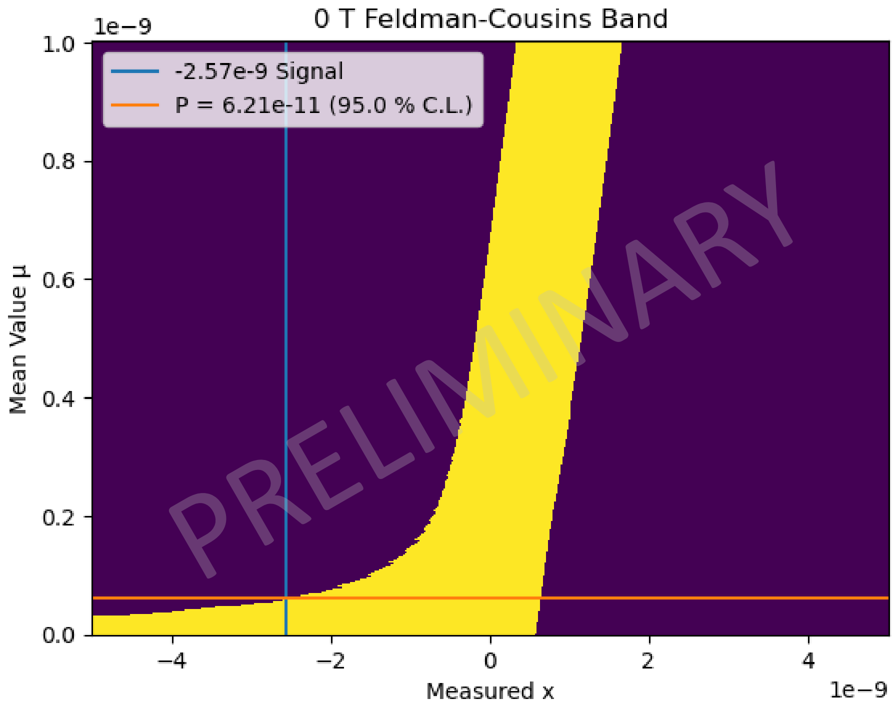




Limits on the Intensity

- Use Feldman-Cousins method:
  - It's going to fail for background data since we're significantly overestimating background (and thus skewed negative)
- Results:
  - $P = 3.27 \times 10^{-10}$ (+/- 4.7 vs. 0 T)
  - $P = 6.21 \times 10^{-11}$ (0 T signal vs. background)
    - This is way too low – need better background model or to increase systematic uncertainties on background. We need to do this.





Cadmium Transmission Simulations

- Now using Cadmium (instead of B4C) as absorber
  - Now have "void region" around $\Delta m \sim 350$ neV
  - This is fine because we have increased sensitivity since this is where the magnetic field is
- Limit reduced by $\sim 8\times$
  - $P = 3.2 \times 10^{-10}$
    - Using only my numbers
    - Obvious caveats of "preliminary" etc.
  - Using Matt's intensity $I(0) = 2.07(1)$:
    - $P = 4.5 \times 10^{-10}$
    - Doesn't significantly affect limits as $\Delta m \to \infty$