Runtime *estimate*

Co-Nab-oration meeting

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Handpicked data of the finest quality

- Used production runs from Fall 2025 beam cycle (pre-blinding)
- Full runs (all subruns, rip my scratch directory storage)
  - Runs 8664, 8670, 8672, 8679, 8789, 8796, 8797, 8814
- Analyzed 133 hours of standard production data
  - Magnet -137.2 A, HV -27 kV, UM/LM -300 V, ExB -1.5 kV
- Using the trigger data

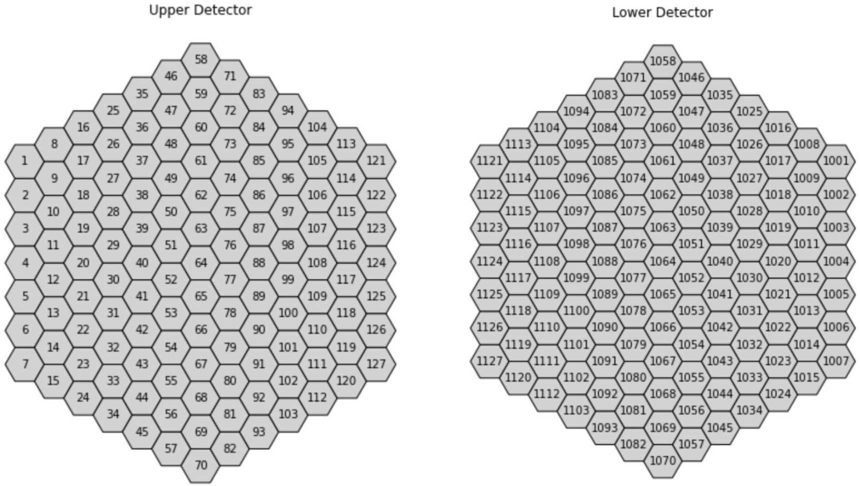
How I parse the data

Step 1A: Apply some corrections/cuts

- Timing synchronization: 472 ns
  - If the trigger event is on the upper detector (pixel < 1000), I subtract 472 ns from the timestamp
- Cutting out gamma flash
  - This removes the spike in events due to the accelerator pulse
  - This is also cut out part of my run duration (I think this is something that differs from Andrew H.)
- For the runtime estimate: using only inner 33 pixels (same as Andrew H.)

Step 1B: Particle identification

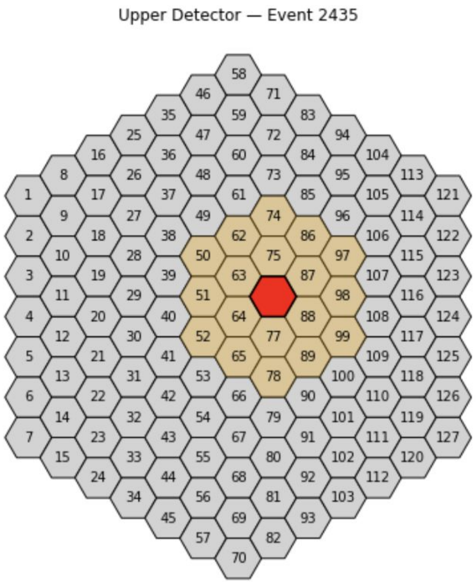
- Protons have an energy range from 40-80 ADC and are only detected in the upper detector (pixels 1-127)
- Electrons have an energy range from 80-3000 ADC and can be detected in both upper and lower detector (pixels 1001-1127)

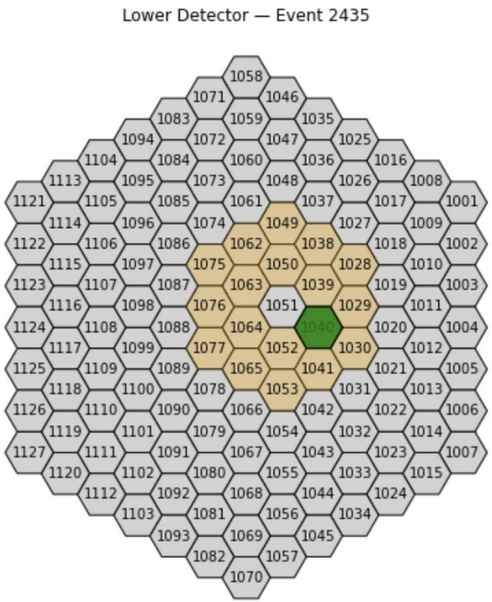


	timestamp	bc	energy	pixel
0	4427946238216	28	65514	43
1	4427946089352	69	1715	118
2	4427946329312	146	998	1030
3	4427946187056	186	300	1044
4	4427946439792	206	89	1115
...	...	...	...	...
15684834	5567059569808	147	86	1039
15684835	5567059974744	145	385	1077
15684836	5567059693632	155	278	1067
15684837	5567059626224	171	163	1097
15684838	5567059964408	197	105	1118

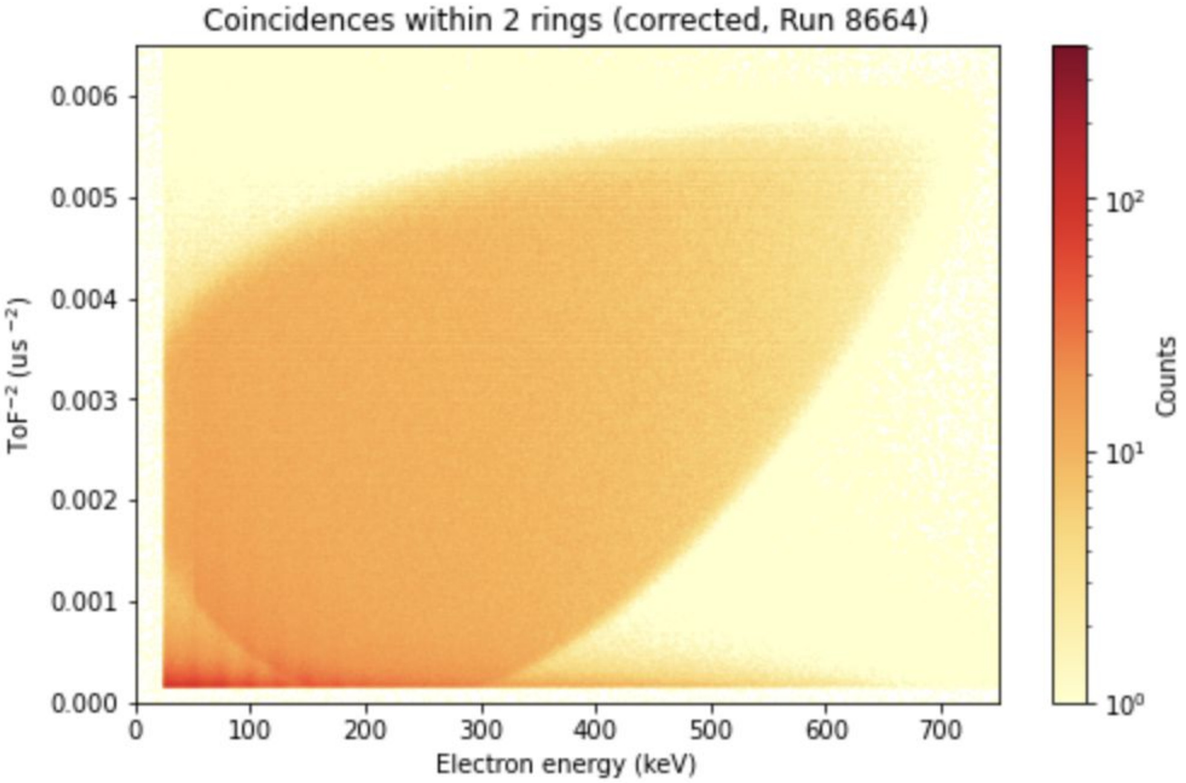
Step 1C: C is for Coincidence

- Coincidence window is 10 - 80 us before the proton
- I only keep electrons that fall within 2 rings of the proton



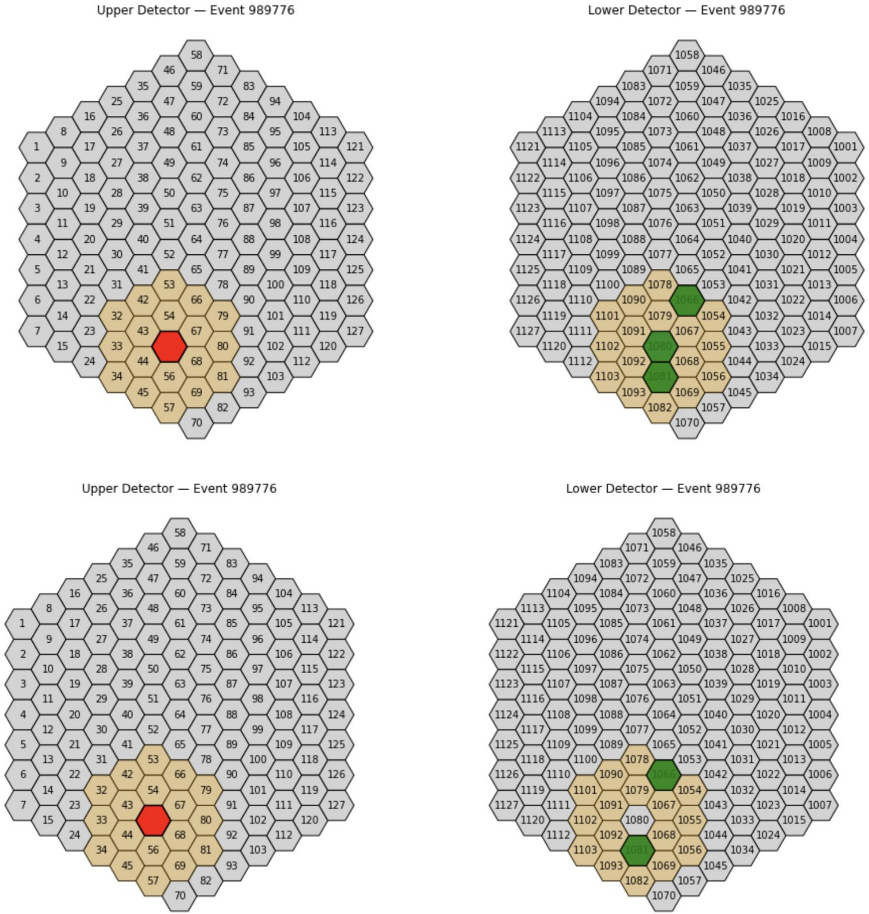


The first tear

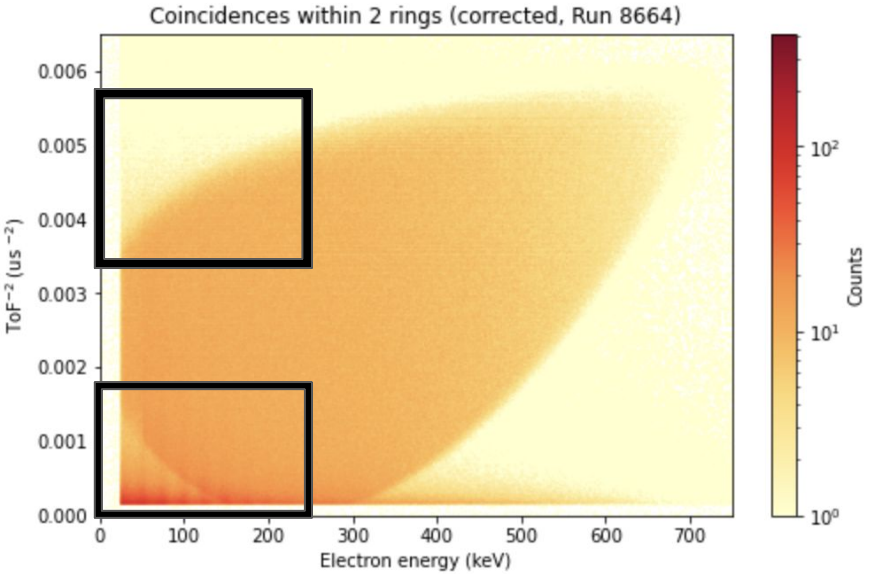


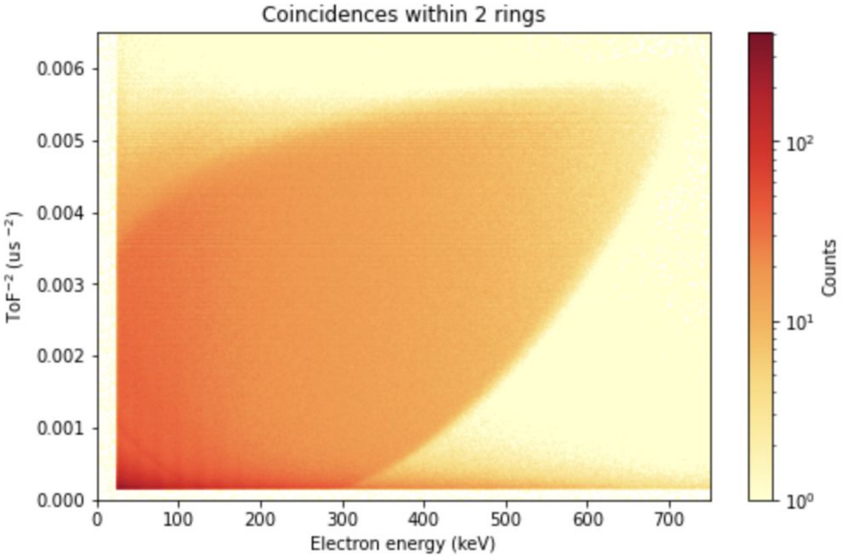
Step 2: Apply backscatter logic

- For electrons in a coincidence event, I look to see if the subsequent electron falls within 0.2 us of the first
- If so:
  - The energies are summed
  - I keep the timestamp of the first electron
  - If the final electron in the window falls on the upper detector, I add an energy correction of 81 ADC (or 27 keV) to the summed energy
- Electrons in the coincidence event but outside the telescoping window are treated normally



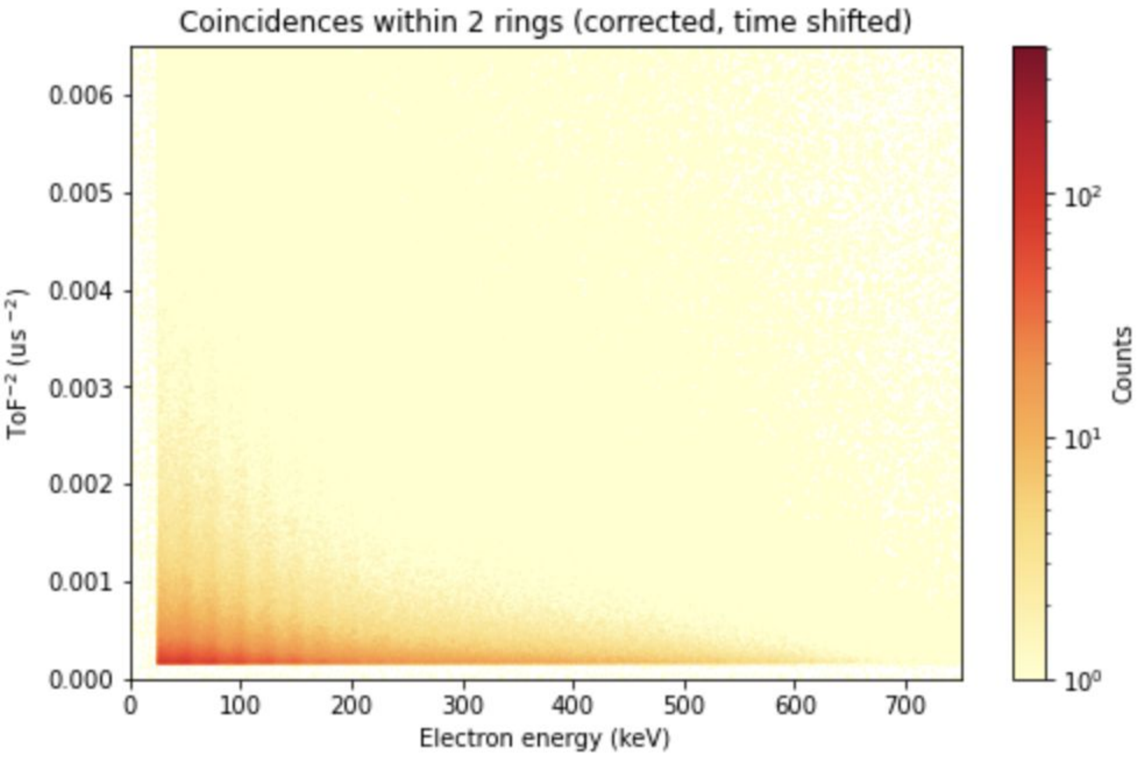
The second tear



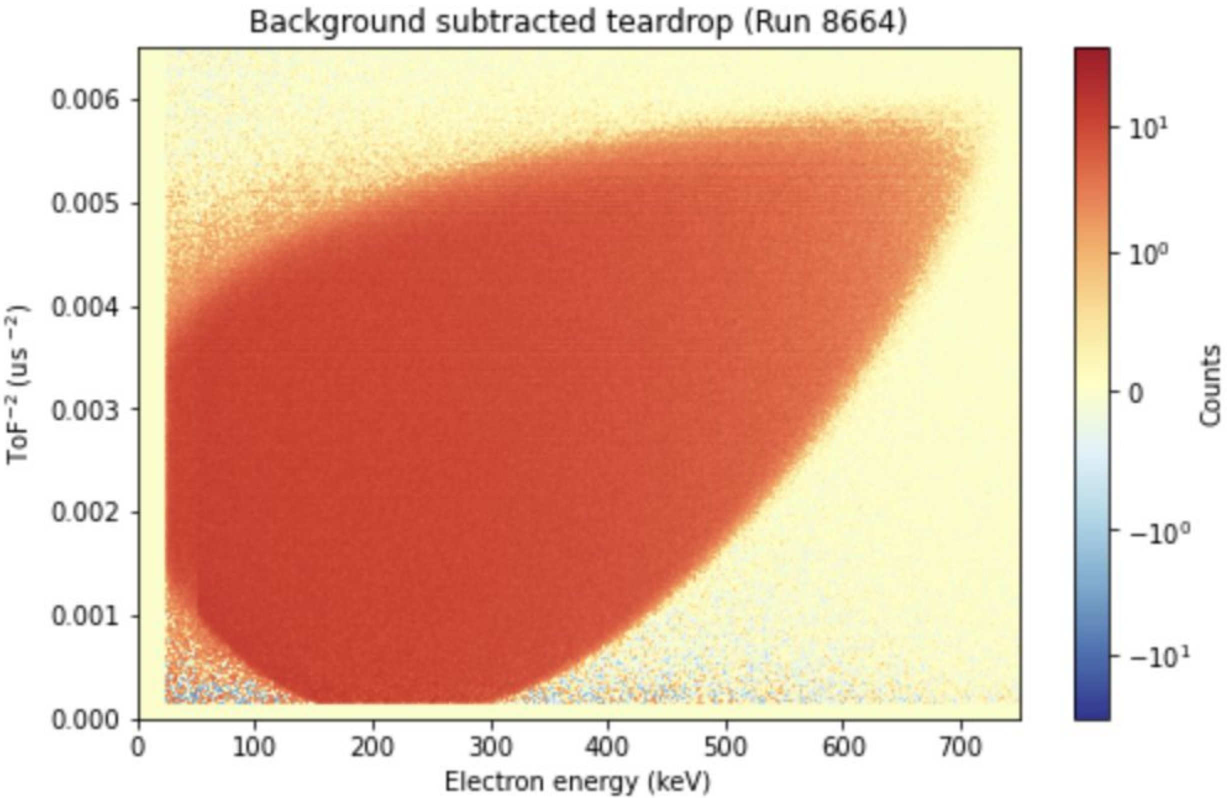


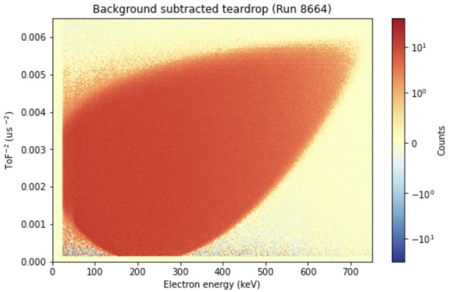
Step 3: Time shift

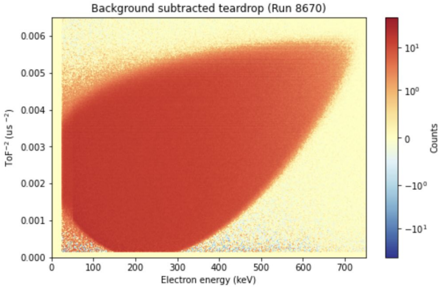
- I add a time shift to the proton timestamp
- Run the same coincidence logic on the new dataframe
- Apply the same backscatter logic

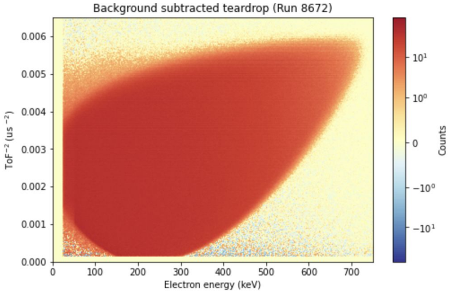


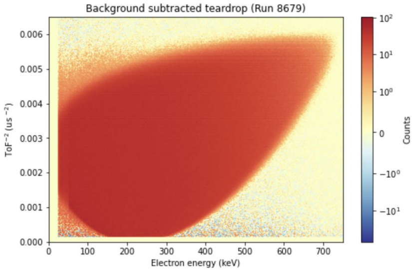
Behold: THE tear





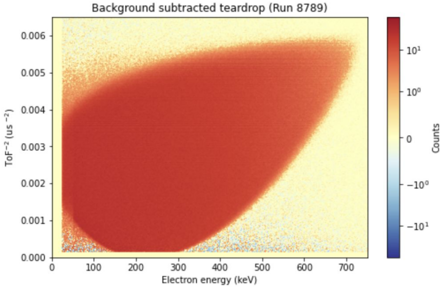


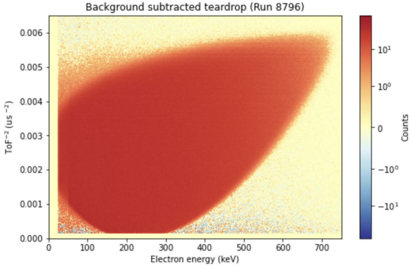


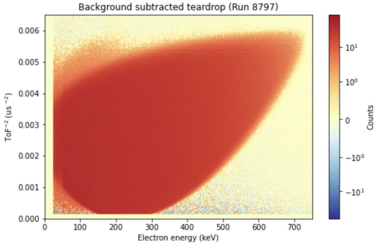


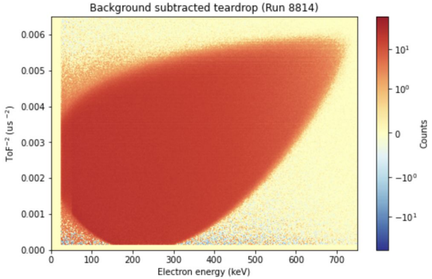
What do we do with all these tears?

Bottle them up
Oh wait that's a different type of experiment









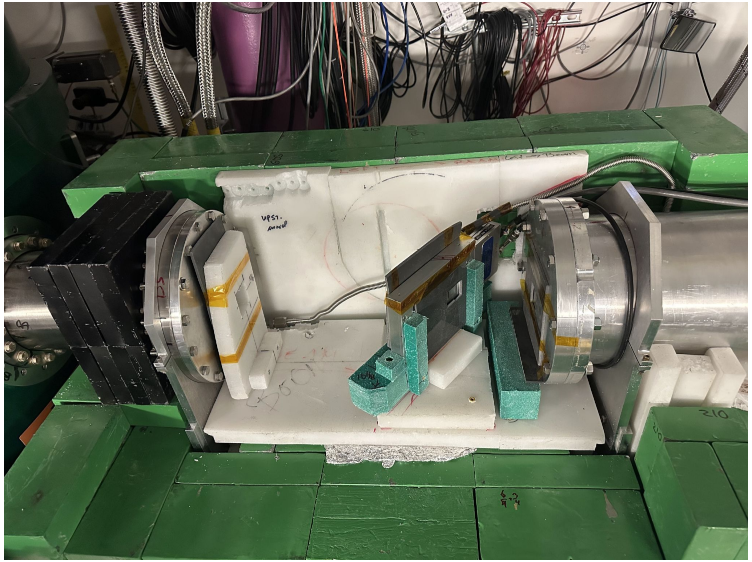
Summary of runs (using 12-40 us window, inner 33 pixels)

	Run 8664	Run 8670	Run 8672	Run 8679	Run 8789	Run 8796	Run 8797	Run 8814
Duration (s)	22902.88	38172.92	81763.435	86474.346	55421.129	66266.772	82217.018	47162.238
Decays	4172468	6028763	14314367	15827701	8277851	11593192	13591183	8597852
Background	344355	499735	1195181	1337194	688022	980358	1149575	718553

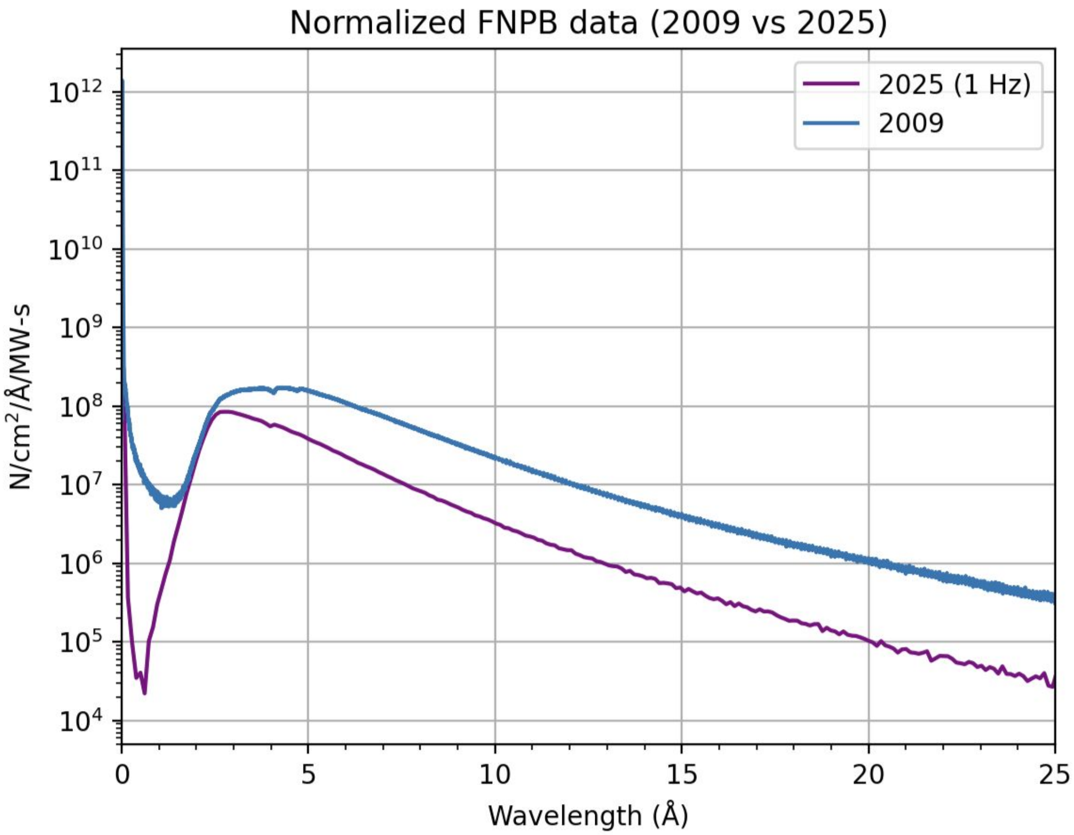
Total duration (s)	Total decays	Total background	Rate (s^{-1})	Background rate (s^{-1})
480380.739	82403377	6912973	171.5	14.4

Quick side quest: 2025 Ordela measurements

- Installed downstream of the Nab magnet (18.8 m away from the moderator)
- Used a 0.88” x 0.88” borated-poly collimator
- Took data during accelerator physics studies at 1 Hz
- Compared results to the 2009 FNPB flux measurement



Comparing 2025 to 2009

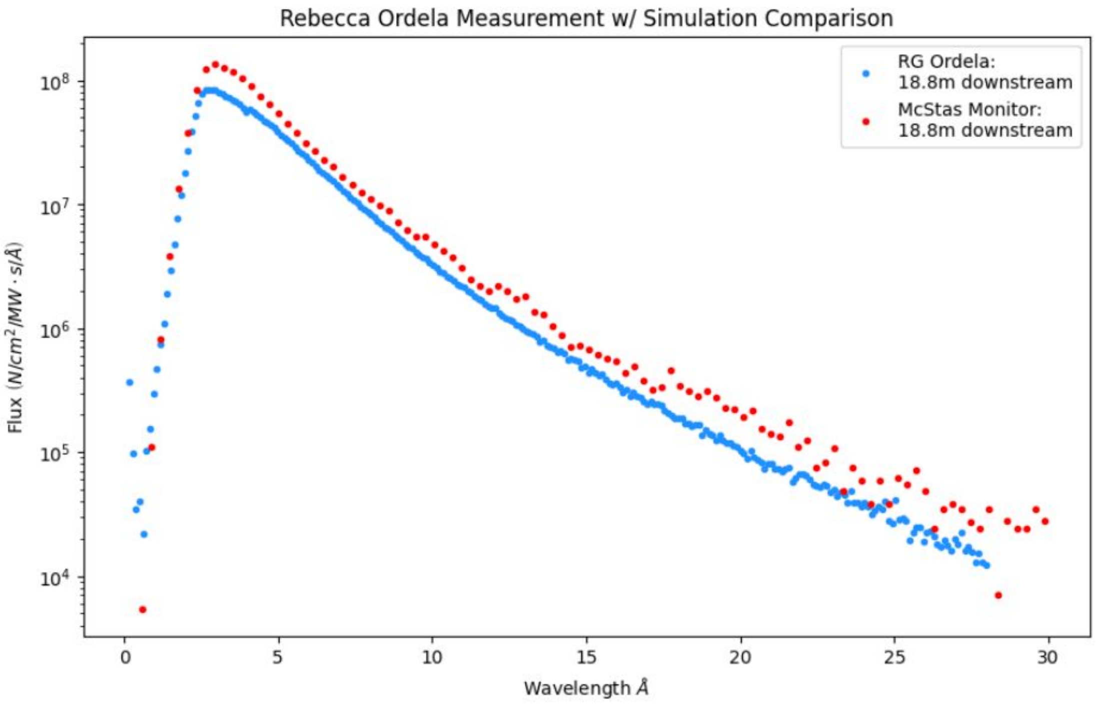


Measured vs McStas

Flux from 2025 measurement: 2.67E8

Simulated flux: 4.01E8

Relative difference: 40.18%



Possible sources of differences (E. Iverson)

- Beam energy change – neutron production “zone” moves slightly deeper into the target, so the moderator should be as much as 10% brighter now than it was in 2009
- Commissioning the orthohydrogen catalyst, which could cause some spectral changes (less in the 1-4 Å region and more in the 5 Å region)
- Guide deterioration
- Attenuation/scattering/blocking from stuff inside the Nab magnet region
- May have some air in the guide
- Maybe our collimator wasn’t good enough

At long last: the runtime estimate

- Measured flux from Spring 2025 beam cycle (from Ordela measurements): **2.67E8 neutrons / cm^2 / s**
- Nab's ultimate goal is Δa_{stat}= 7E-5 and Δa_{total}= 1E-4
- To achieve that goal, we need Δa_{total}= (5.0/(7E-5))^2
    - (worst case scenario; uses 31% background)
- 3.5E9 coincidences after threshold cuts
- From Fall 2025, we have a count rate of 171.5 counts per second and a background rate of 14.4 counts per second
- How long do we need to run to get 3.5E9 coincidences?

(171.5)(3600)(x) = 3.5E9 -> **5669 hours**

of uninterrupted, perfect beam.