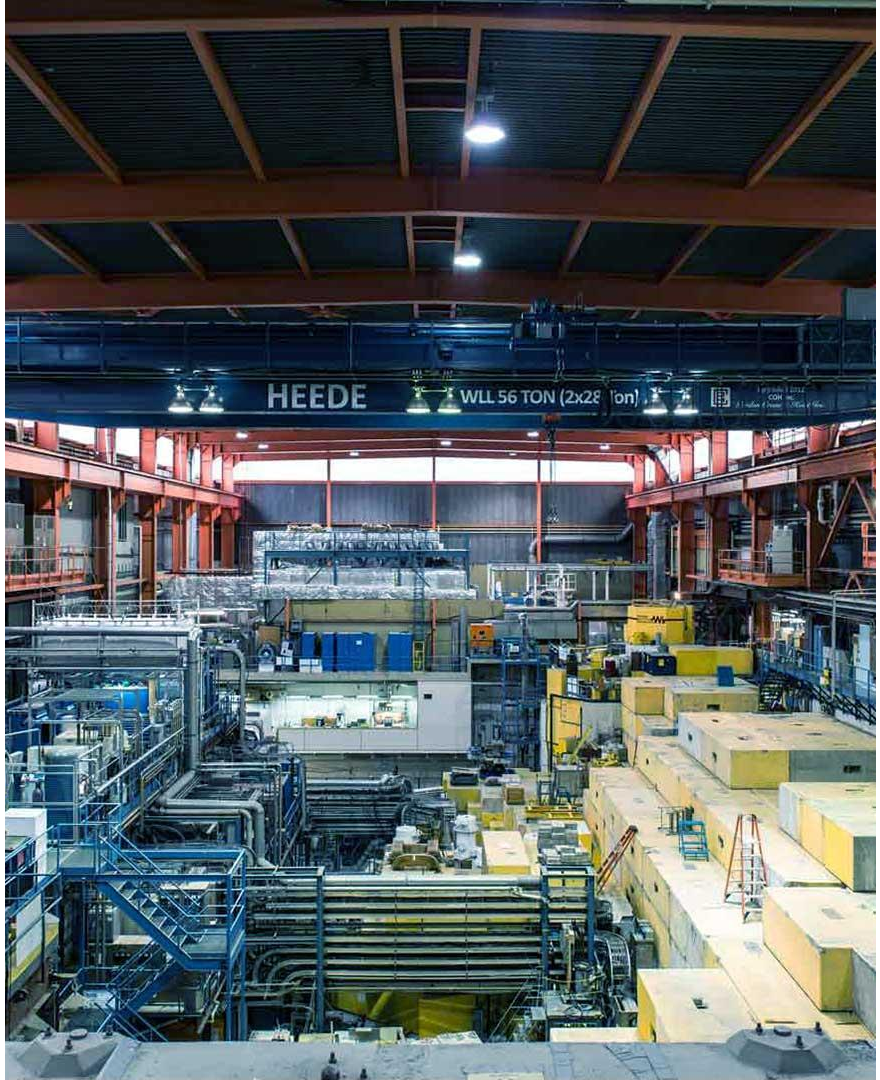
QA 6Li Detector Analysis, November 2017 Dataset.



Pietro Giampa
Physical Sciences Division

2018-01-26

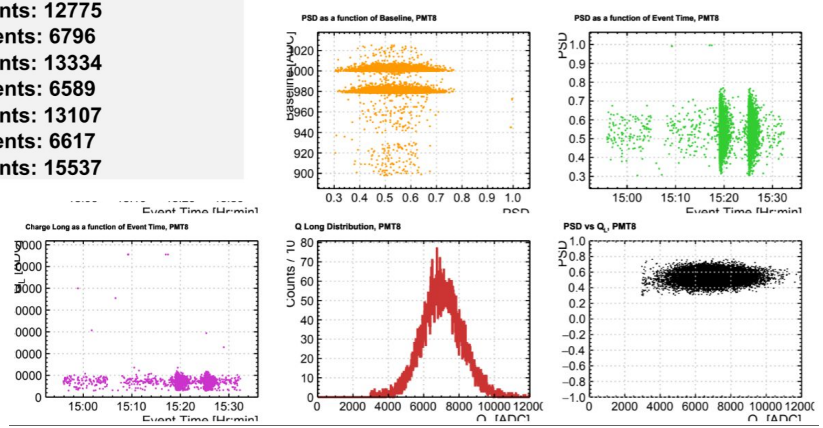
Data Quality Report

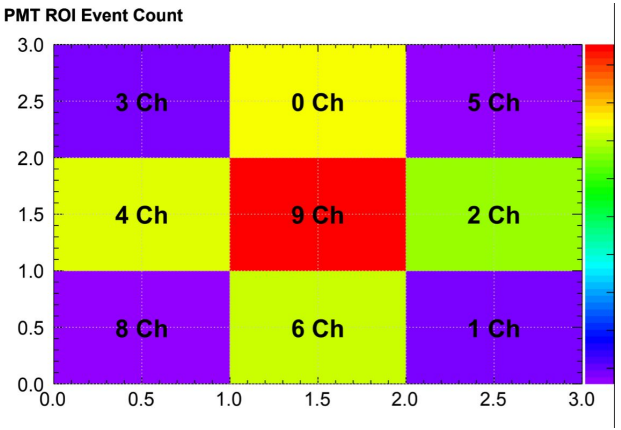
Code for Data Quality Reports: /home/ucn/DataQuality/DataQualityReport.c

Analyzed Run: 541

Run Time: 2203.102586 [s]
Total ROI Events: 94957, Rate: 43.101488 [evt/s]
Total BKG Events: 52488, Rate: 23.824583 [evt/s]

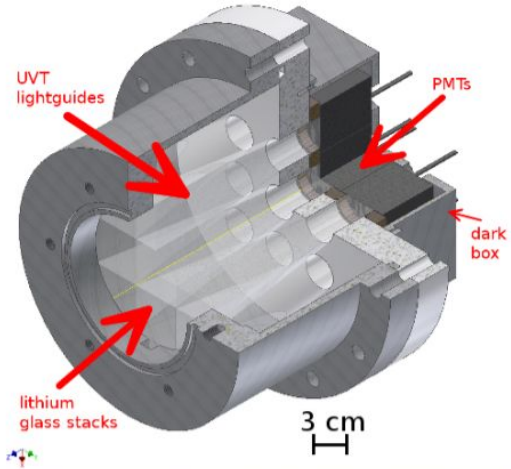
Channel-0 ROI Events: 13390
Channel-1 ROI Events: 6815
Channel-2 ROI Events: 12775
Channel-3 ROI Events: 6796
Channel-4 ROI Events: 13334
Channel-5 ROI Events: 6589
Channel-6 ROI Events: 13107
Channel-8 ROI Events: 6617
Channel-9 ROI Events: 15537



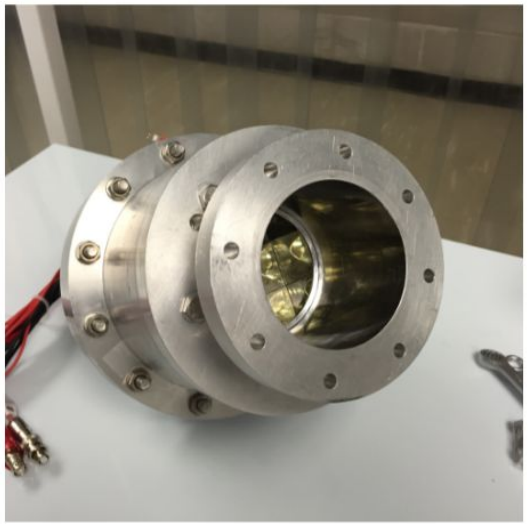


Discovery, accelerated

6Li Detector and DAQ/Trigger

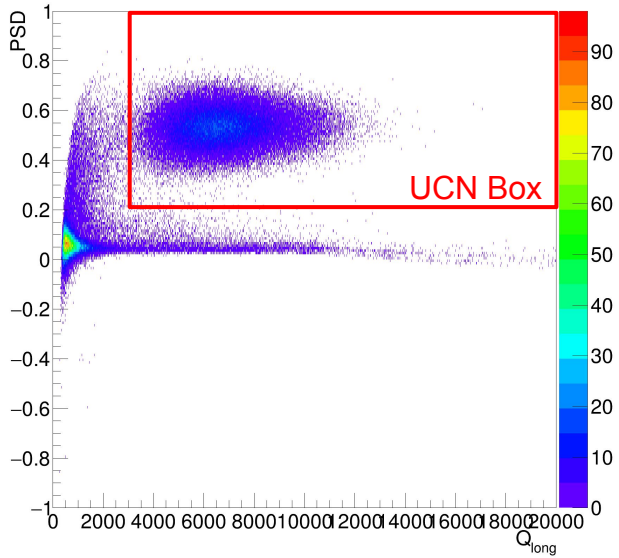


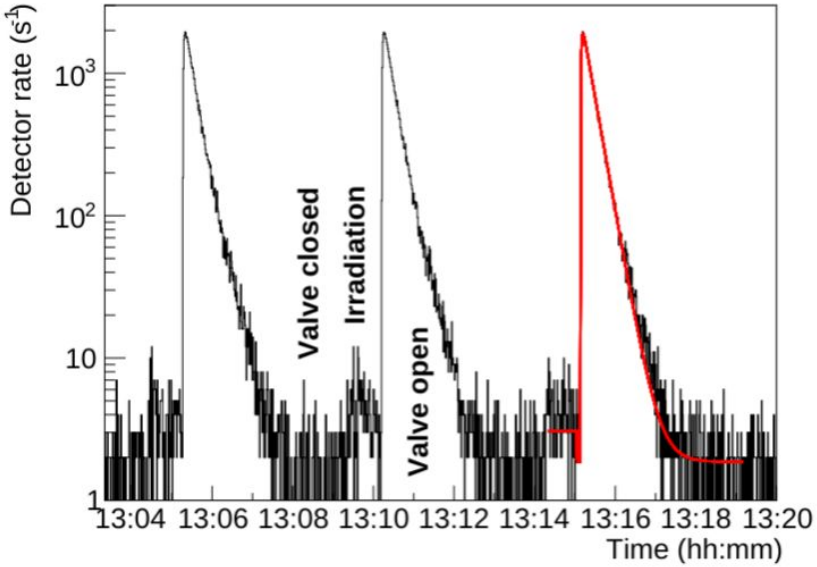
- 9 PMTs, the gain was corrected before running (https://ucnelog.triumf.ca/elog/UCN+Detectors+and+Run+Log/35).
- The Li glass sandwich is coupled to the PMTs via 9 UVT lightguides (LGs).
- The 9 UCT LGs are optically isolated, but there could still be some cross-talk.
- The internal “backgrounds” rate is negligible compared to the pulse shape discrimination rejection power.
- PSD = (Ql - Qs) / Ql..
- Short Window 40 ns.
- Long Window 200 ns.
- Individual PMT threshold trigger. (1 Evt = 1 PMT).
- V1720 Digitaziers 4ns binning.



$$^{6}Li + n = t(2.05\ \mathrm{MeV}) + \alpha(2.73\ \mathrm{MeV})$$

Detector Effects in UCN Counts





Are we missing anything? Any detector effects that we are not accounting for?

Detector Effects in UCN Counts

Deadtime = minimum time difference between UCN events in the same PMT. [possible loss in UCN count].

Crosstalk = multiple trigger events occuring in neighbouring channels within a few ns, originated from the same UCN. [possible over-estimation of the UCN count].

Pileup = Combination of multiple events into a single event. Four types of pileup: UCN+UCN, UCN+gamma, gamma+UCN, gamma+gamma. [possible loss in UCN count]

Detector Effects in UCN Counts

$$N_{ucn}^{true} = [N_{ucn}^{raw} \cdot (1 + \alpha_{pl} - \alpha_{ct})] \cdot A_{box}$$

True UCN Count | Raw UCN Count | UCN-UCN PileUp Prob | Cross-Talk Prob | UCN Box Efficiency

A_{box} = Boundaries set from Data/MC, Efficiency estimated using Monte-Carlo.

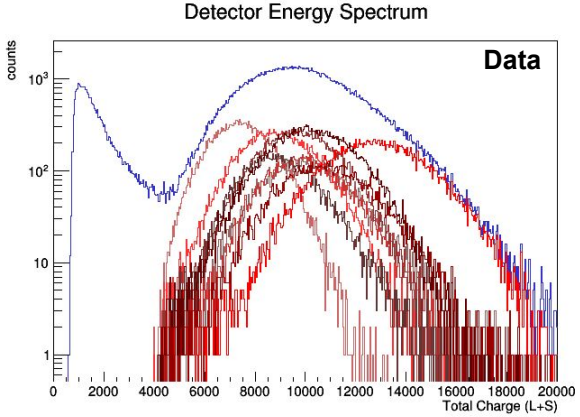
A_{pl} = Estimate from data and from independent calculations (assuming Poisson statistics).

A_{ct} = Estimated using time-coincidence analysis on Data.

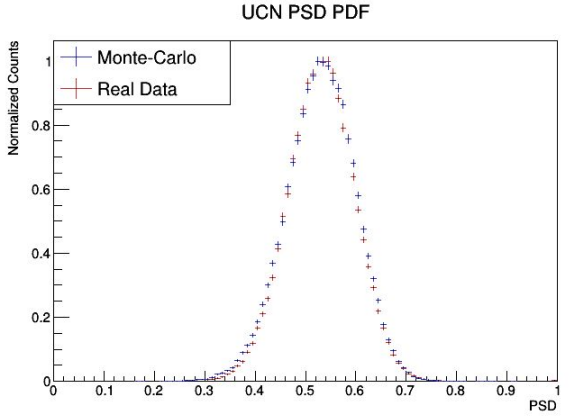
* UCN+gamma and gamma+UCN pileups are not a concern for UCN counting (MC verified).
* gamma+gamma pielup does not leak into the UCN box (a true leakage needs to be estimated with MonteCarlo).

Monte-Carlo Package (Thanks to Blair)

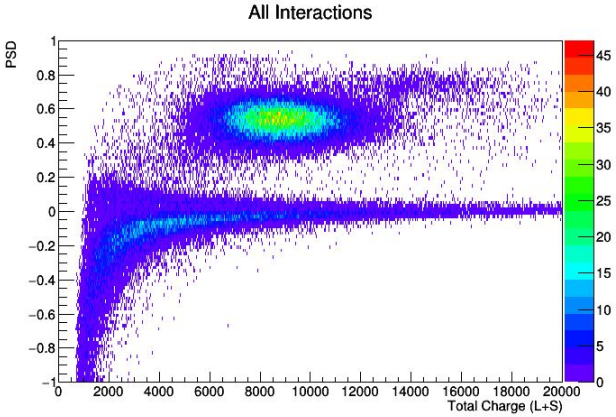
1)

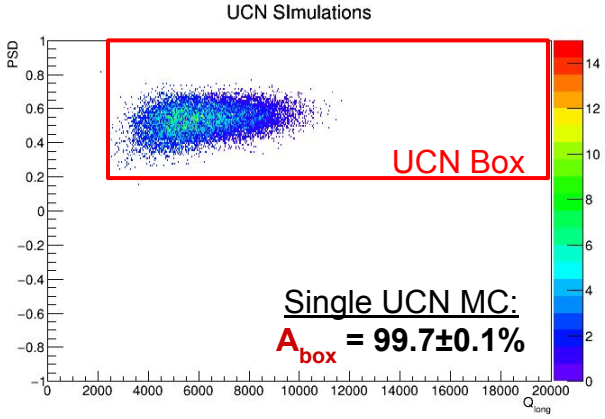


2)



3)





1) PMT Gains implemented in MC. Important for Ql Comparisons.
2) Single UCN PSD Spectrum Matches.
3) Need some work on Gamma simulations, not a good match between MC and Data.
4) UCN Box acceptance estimated, using single UCN, at 99.7±0.1%.

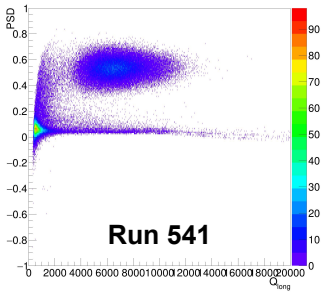
RAT Simulations under construction

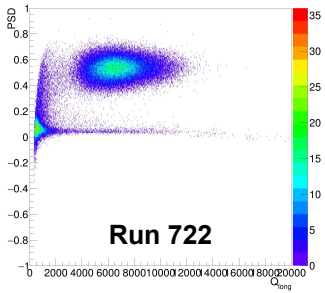
RAT Reactor Analysis Tool

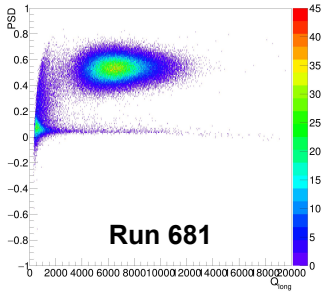
Discovery, accelerated

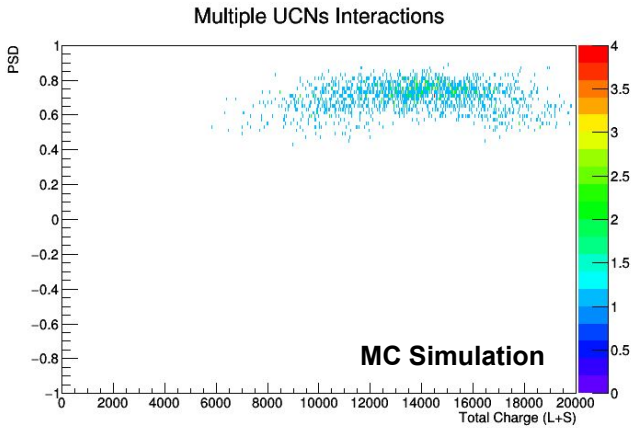
UCN+UCN Pileup Measurement

Only counting events when the valve was open (120 s).
Compare data from runs at different Irr current.
Define UCN+UCN Pileup Box using MC Data.









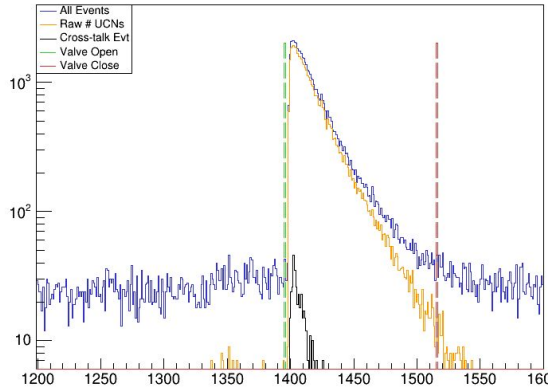
Run	I [uA]	# ucn	R_{ucn} [Hz]	# ucn+ucn	Ruu [Hz]
541	1.0	46198	384.9	9	0.075
722	2.5	92189	768.3	17	0.142
681	5.0	176271	1468.9	36	0.320

Cross-talk Measurement

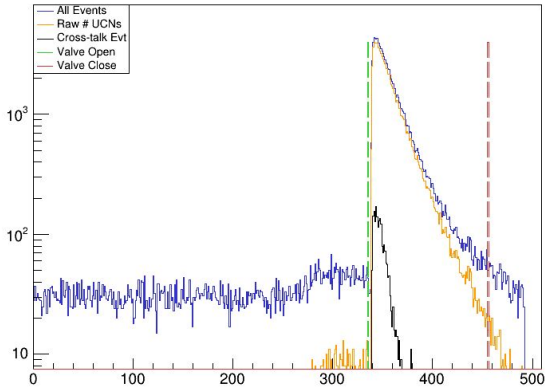
Studying cross-talk using Time-Coincidence Analysis and Data with different I but same Irr time.
(NB: Thanks to Cameron for fixing the time issue LINK).
CT = UCN event that occurs within 8 ns from a UCN event in a near-by PMT.

1.0 [uA]	2.5 [uA]	5.0 [uA]
1.2 %	3.33 %	10.1 %

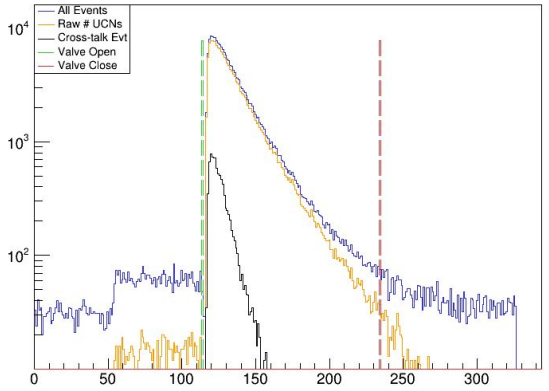
Run 541, 1.0 [uA]



Run 722, 2.5 [uA]



Run 681, 5.0 [uA]

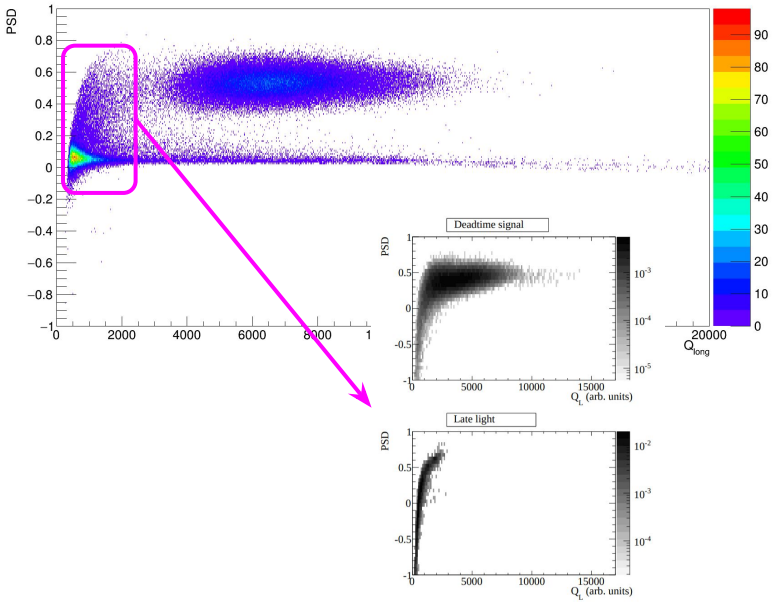


Anything Missing?

The Gamma rate is constant and independent of the UCN production. Therefore, gamma+gamma pileup rate should also be constant. (Confirmed with Data).

But the event rate in the high PSD region (>0.2) but low energy (QI<3000) increases as a function of source strength.

<u>Dead time, Late Light or a combination.</u>



RUN	I [uA]	ucn [Hz]	ucn+ucn [Hz]	ɣ [Hz]	ɣ+ɣ [Hz]
541	1.0	384.980	0.075	3.39	3.01
722	2.5	768.242	0.142	3.75	9.16
681	5.0	1468.90	0.329	3.52	22.6

Ideas for the Fall-Run 2018

Crosstalk = Take at least one run in which, we save traces from all PMTs when a trigger occurs, keep the same trigger scheme and just change what is saved to file. (could also be useful for deadtime).

Detector Stability = Take >1 hour long run to test the detector variations and constrain the stability over time.

Late Light = Take data with a much longer DAQ time window (600 ns or 1us). We could use that data to perform a waveform analysis and carefully characterize the late light effect (could also be useful for deadtime).

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Conclusions

- Data Quality Reports ready for all Nov2017 analysis runs. Code can be used for new data, can be automated if needed.
- Still some work left to do on the MC side, gamma simulations needs improvement. RAT module under development.
- UCN Box acceptance estimated at 97±0.1 %.
- The rate of UCN+UCN pileup at 1 [uA] (60 s) was measured to be 0.075 [Hz], <1% effect.
- Time-Coincidence Analysis wrt neighbouring Channels shows very little evidence for cross-talk effects (different t considered).
- Evidence of late light (or deadtime) effects that could lead to some UCN counting loss (2% effect max). Need a waveform analysis and MC model to fully characterize this.

Thank you
Merci

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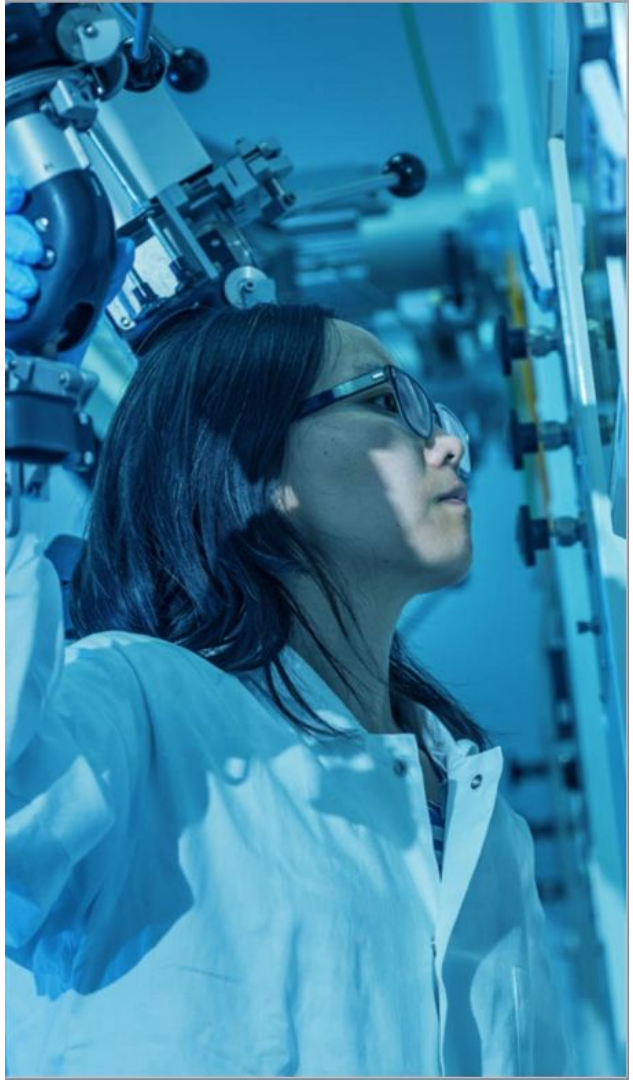
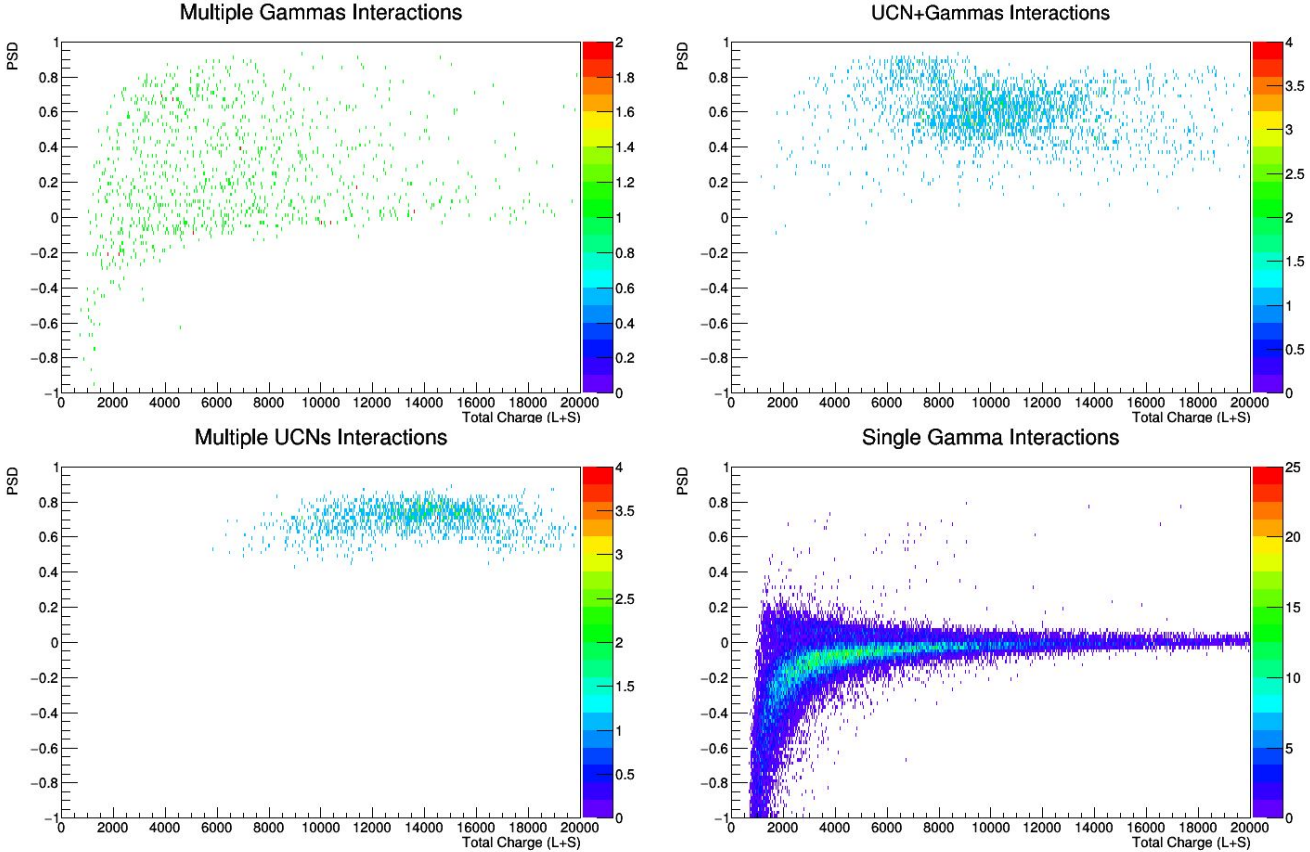


Discovery, accelerated

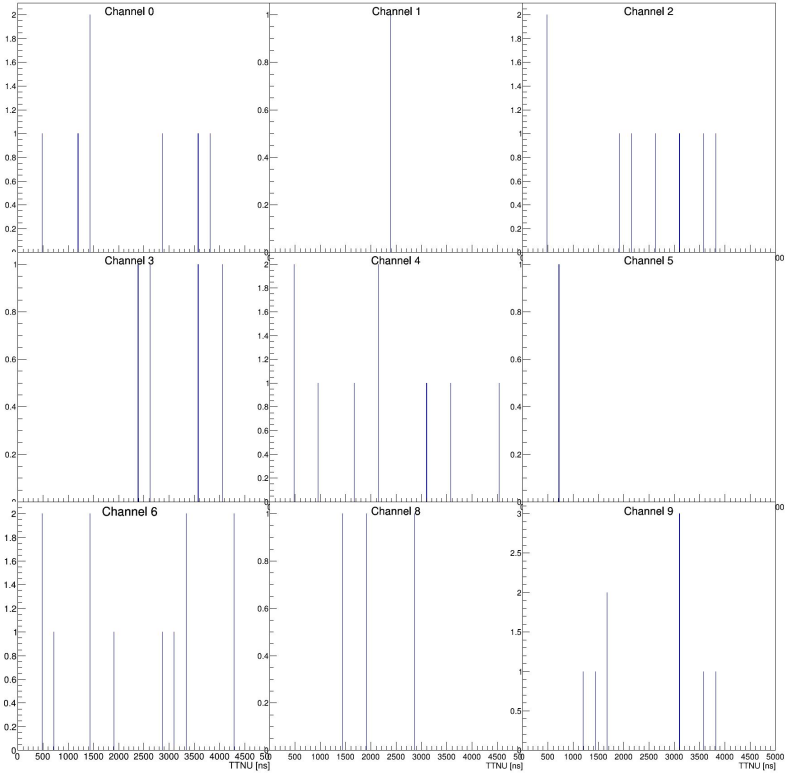
Backup Slides

Monte-Carlo Package (Thanks to Blair)



Cross-talk Measurement

Run 541, 1.0 [uA]. Time-To-Next UCN Same PMT.



Run 541, 1.0 [uA]. Time-To-Next UCN Near PMTs.