The n^3He Experiment

The n^3He experiment at SNS is a high-precision measurement motivated to probe the hadronic weak interaction by measuring the parity violating asymmetry of the proton in the reaction:

\[ \text{n}^3\text{He} \rightarrow p + \alpha + 7.656\text{eV} \]

This asymmetry is expected to be extremely small (of the order $10^{-7}$). Our goal is to measure an asymmetry in the reaction to a precision of $2 \times 10^{-8}$.

Experimental Setup

- n^3He is using a spin flipper with transverse windings which allows for both longitudinal and transverse spin rotation.
- n^3He ion chamber – both target and detector
- Detectors work in current mode.

DAQ for n^3He: Expectations

General expectations:

- Capable of dealing with large amount of data at high sample rate but maintain very low ADC noise.
- Has high channel density with simultaneous input.
- Maximum sampling rate but the file size manageable / durable.
- Triggering using software taking accelerator T0 as input.

To fulfill all these expectations we use the DAQ by D-tAcq with the following features:

- 2x24 Channels per module.
- 24 bit ADC per channel for true simultaneous analog input.
- External clock, trigger, internal clock.
- Supports EPICS CSS for controlling the DAQ.
- Data and run time parameters can be viewed in real time using CSS.
- Checksum algorithm to detect corrupt data.
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- Maximum sampling rate but the file size manageable / durable.
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Data Acquisition System(DAQ) for the n^3He Experiment at SNS

Latiful Kabir, C.B. Crawford, Iariki Garishvili for the n^3He Collaboration

Abstract: The n^3He experiment at the Spallation Reaction source will measure the parity violating asymmetry of the recoil proton in the reaction n^3He→p+α+7.656 eV. This is sensitive to J=2 and 3 components of the Hypernuclear Weak interaction (HWW), and is expected to be extremely small (10^-7). Protons from the reaction are recorded in current mode in order to achieve a statistical sensitivity of 10^-10 for a reasonable amount of time. In addition instrumental asymmetries must be suppressed by an additional order of magnitude. The asymmetry is measured as a function of time-of-flight of the neutron to study the energy dependence of any systematic effects. Here we present details and preliminary tests of the 144 channel data acquisition system designed to meet these requirements.

Measurements: Resynchronization and Jitter

The ADC has a 30 MHz internal clock which is used as the reference for the sample clock (rate). Because of the importance of neutron’s time of flight for the experiment, a jitter of the order of kHz is too high. So the ADC was customized to resynchronize after each event to give a jitter of the order of MHz. Following is a test to confirm the desired jitter of the ADC.

60 Hz pulse with ramp, which has a width of 320 μs, a rising edge of 100 μs and a falling edge 100 μs, was fed to the ADC in repeating gate mode with trigger on leading edge. Then each rising edge of the pulse (5 points in the middle of leading edge) is fitted to the linear equation y=aX+b using least square method. This gives x-intercept and the slope of the leading edge. For each fit, the x-value for the header is subtracted from the x-intercept of the rising edge. This constitute: "t_p-t_o Where, t_intercept from fit, x-value for header. This is done for all the pulses. Finally, t_p vs Pulse number is plotted. A histogram for all the t_p is drawn. The histogram shows that the jitter is of the order of 20 nano sec.

Measurements: ADC noise and rise time

Bare ADC noise was measured to be 27 micro volt at 50 kHz sample rate. Performance of ADC and its noise with different sample rate shows that the noise jumps after a cutoff, this is because it has two different modes (resolutions) of operation. Thus based on counting statistics, running the DAQ at 50 kHz and then averaging 20 successive points will give most optimal ADC noise.

The autocorrelation plot confirms no apparent correlation for ADC noise and the rise time is found to be as expected.

Measurements: Averaging & Decimation

To keep the data file size manageable but at the same time utilize the maximum sample rate, the ADC was customized to do averaging and decimation of desired number of entries. Following are the tests that were performed to confirm this feature:

- Suppose we have a pulse/signal as shown on the right. Where all entries are effectively(close to) zero except one entry. Here the first diagram (on left) is just one pulse. And second diagram(on right) is what we see if we take data for certain time(n in Resync mode) and plot using ROOT i.e. it will squeeze so many pulses in a small range that it will appear as just two lines. Now what we are interested in is just the height of the upper line. Because, if we find the height without any averaging to be ‘Y’, then when we merge ‘x’ entries, the height of the upper line will be shifted to ‘x’Y. This is exactly what we observe when we enable the averaging option.

- Following by plotting data without averaging, with averaging and data from interpolation on a single plot we re-confirmed the same feature.

Measurements: Instrumental Asymmetry

Finally our most important test is the measurement of instrumental asymmetry with the spin flipper. Here our sources of false asymmetries can be ground loops, electrostatic couplings, power supply couplings, circuit to circuit couplings and many others.

The schematic of the set up is shown on the right.

Following is the algorithm that we follow in measuring the instrumental asymmetry with the spin flipper. Here our sources of false asymmetries can be ground loops, electrostatic couplings, power supply couplings, circuit to circuit couplings and many others.

We have a DAQ system that fulfills all of our expectations and gives instrumental asymmetry as small as $(2.64 ± 1.64) \times 10^{-10}$. Thus we achieved our goal.

Conclusion

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