Proposed analysis protocol for n-^{3}He asymmetry data.

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The goal of this analysis is to isolate the PV or PA 30Hz component of the detector signals from 30Hz signals produced by 0.1Hz dropped pulses. Dropping pulses may produce 30Hz signals by altering beam properties or by nonlinearity and/or hysteresis in the DAQ. We encountered such behavior (false asymmetries ~ 10^{-7}) in the NPDγ experiment when we read out the ADC's every ninth pulse; changing the period from 60 Hz to 60/9 Hz . A point to bear in mind is that the basic periodicity of the beam when every 600th pulse is 0.1 Hz not 60 Hz. Any nonlinearity in the signal processing chain will produce a 30 Hz signal as the 300th harmonic of .1 Hz. The above considerations lead to take the basic objects of analysis to be sequences of 600 pulses, each beginning with a dropped pulse.

There are 4 sources of 30 Hz signals in our data.
1. 30 Hz signals caused by PV or PA interactions of neutrons with the ^{3}He
2. 30 Hz signals caused by the accelerator when proton bursts are deliberately dropped
3. 30Hz signals caused by non-linearity and/or hysteresis of the DAQ
4. Stern Gerlach steering of the neutrons

I estimated 4. and reported in a ^{3}He analysis meeting that the asymmetry is negligible: ~10^{-9}; compared to the goal statistical uncertainty of 10^{-8}.

We know from looking at the data that 30Hz signals from 1., 2., and 3. are or order 10^{-7}. The basic assumption in the following approach to separating 1. from 2. And 3. Is that 1., 2., and 3. add linearly. This assumption seems reasonable because $\left(10^{-7}\right)^2 = 10^{-14} << 10^{-7}$.

A few weeks ago during a ^{3}He analysis meeting, we discussed a method to the isolate the desired PV and PA asymmetries, 1., from 2., and 3.

I will write out the method:
0. Separate (as first proposed by Vince) the runs into two types, A and B.

Type	First pulse after dropped pulses
A	spin up
B	spin down

For each run find the deliberately dropped pulses. (every 600th pulse). If the deliberately dropped pulses are spin flipper on, call the run type A. If the SF is off call the run type B.

2. For each wire, *w*, and 600 pulse sequence, *s*, find the DC offset voltage of the wire from the minimum Voltage during the deliberately dropped pulse. Call this offset $Q(s,w)$.

3. For each wire and each pulse, p, find the net voltage

$$Net(s,p,w,t) \equiv V(s,p,w,t) - Q(s,w)$$

$Net(s,p,w,t)$ depends on the time bin, *t*.

Define the intensity signal for each pulse, *p*, as $I(s,p,w) \equiv \sum_{w,t} Net(s,p,w,t)$. The range of *t* in the sum is over time bins where both choppers are either completely open or

closed.
Define the intensity corrected signal for pulse, p, and wire, w,

$$Y(s,p,w) \equiv \sum_t Net(s,w,p,t) \Big/ I(s,p,w)$$

$Y(s,p,w)$ is independent of intensity of the pulse because we have divided out the intensity.

4. Next find the asymmetry signal for a pulse pair q. There are 299 pulse pairs for each pulse sequence of 600 pulses. If the dropped pulse is pulse 0, then the pairs are p=2q-1 and p=2q.
p=1, 2, 3, 4, 5,6,7,8 ...
q=1 2 3 4 ...
Define the 299 pair asymmetries

$$A(s,q,w) \equiv \big(Y(s,2q-1,w) - Y(s,2q,w)\big) \Big/ \big(Y(s,2q-1,w) + Y(s,2q,w)\big)$$

Exclude from further analysis 600 pulses sequences that have any randomly dropped pulses or sequences following such sequences.

5. Calculate the average asymmetry for each wire and sequence,

$$B(s,w) \equiv \frac{1}{299} \sum_q A(s,q,w)$$

6. For each run, r, calculate the run average asymmetry for each wire,

$R(r,w) = \frac{1}{Ns} \sum_s B(s,w)$, and the uncertainty in the run average asymmetry

$$\sigma R(r,w) = \frac{1}{\sqrt{Ns}} \sqrt{\frac{1}{Ns} \sum_q B(s,w)^2 - \frac{1}{Ns} \left(\sum_s B(s,w) \right)^2} .$$

These quantities can also be calculated by histograming the $B(s,w)$'s and fitting the histogram to a Gaussian distribution.

For each run, we now have the values of the average asymmetry, $R(r,w)$, and it's uncertainty, $\sigma R(r,w)$.

Calculate the weighted average asymmetry and the uncertainty for all type A and type B runs separately over the entire data set. For A type runs,

$$AveRA = \sum_{Atype\,runs} \frac{R(r,w)}{\sigma R(r,w)^2} \Bigg/ \sum_{Atype\,runs} \frac{1}{\sigma(r,w)^2}$$

$$\sigma(AveRA)^2 = 1 \Bigg/ \sum_{Atype\,runs} \frac{1}{\sigma(w)^2}$$

and the same for B type runs.

7. The PV or PA asymmetries enter $AveRA(w)$ and $AveRB(w)$ with opposite signs while 2. And 3. (see introduction) asymmetries from the dropped pulses enter with the same sign.

$$PV(w) = \frac{AveRA(w) - AveRB(w)}{2}$$

$$\sigma PV(w) = \frac{\sqrt{\sigma(AveRA)^2 + \sigma(AveRB)^2}}{2}$$

$$A23(w) = \frac{AveRA(w) + AveRB(w)}{2}$$

$$\sigma 23 = \sigma PV$$

The set of $PV(w)$'s and their uncertainties are the data needed to calculate the *PV* asymmetry for n-^{3}He interactions or for *PA* interactions. The set of $A23(w)$'s and their uncertainties contain information on beam variations caused by deliberately dropping pulses and/or 30 Hz signals caused by nonlinearity or hysterias in the DAQ. The validity of this procedure can be tested by fitting the $PV(w)$'s to the geometric factors and physics asymmetries and obtaining a value of $\chi 2$ consistent with statistics.

The ideas developed in this technical note provide an approach to isolating the desired signal and the 30 Hz signal caused by the accelerator and DAQ. The basic assumption in this analysis is that second-order variations in the 30Hz signals can be neglected.
It may be possible to determine PV and PA in n-^{3}He interactions without understanding all aspects of asymmetries caused by the accelerator and DAQ.