Neutral Current Detectors electronics calibration and modeling

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A signal produced in the Neutral Current Detector (NCD) is recorded simultaneously by a digital oscilloscope at 1 GHz sampling rate and an integrating shaper. For events (such as a Supernova) which rate extend beyond the oscilloscope recording capacities, only the shaper information is available. The electronics circuitry of the NCDs is described as a serie of low-pass and high-pass filters, followed by a preamplifier and a logarithmic amplifier at the end of the electronic chain. The electronic constants of this system are known from circuit design. They have also been deduced from *in situ* differential tests using known pulses sent through part of the electronics. In addition to these characterization studies, regular calibration runs are taken to determine the constants of the logarithmic amplifier and to monitor the stability of the electronics and calibration constants used for analysis with time.

During these electronic calibration (ECA) runs, three different type of task are performed:

1. logamp calibration
2. threshold calibration
3. gain and linearity calibration

The aim of the first task is to extract the necessary parameters to de-log the digitized waveform. In order to do this a square pulse waveform (acting as a trigger for the multiplexer in charge of dispatching the signal to the oscilloscopes) followed by a half sine wave is sent through all individual channels. By fitting the recorded output to a waveform computed from an electronics model that simulate the signal transformation through the individuals electronic components, each parameter is extracted for each individual channel and the electronic response change can also be monitored as a function of the time.
The second task is extracting the threshold settings for each multiplexer and shaper channel in term of input pulse amplitude and total charge. By choosing a set of sine waves of same width and different amplitudes and pulsed through each individuals channels, we are able to determine which of them have not been recorded by the shaper or the oscilloscope because their amplitude was below the threshold setting.
The third task uses a simple square wave with different amplitude in each individual channel. By finding the shaper ADC value of the centroid of the distribution in the shaper value for each amplitude, we can plot them as a function of the injected charge and looking at the slope and offset derive the relative gain and linearity parameters. By comparing the ADC value to the total charge injected with data obtained during neutron-calibration runs, we also determine the ADC/energy conversion factor.
In 2005 the, NCD calibration group pursued a big effort in producing a comprehensive electronics model (see Figure 1) describing the NCDs electronics and signal propagation.

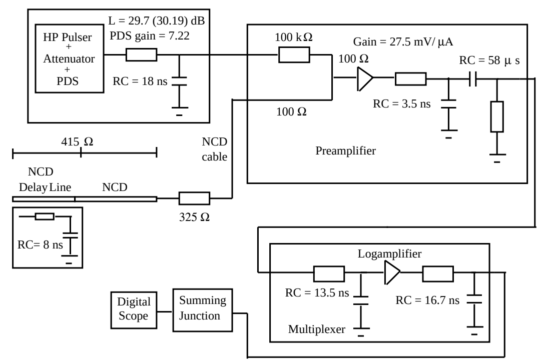

FIG. 1: NCD electronic model

This model serves to determine the logarithmic constants by fitting the theoritical pulse (transformed by the low-pass and high-pass filter equations described in the model) to the pulsed data.
Using Monte-Carlo data, the model serves also to understand how the uncertainties on the response of the electronics will affect the physics data reconstruction.
It is important to understand at this point if the neutron-alpha separation or resolution on physics variables reconstruction such as the energy or the position of the particle can be affected by the electronics circuitry. The electronic model is detailed enough to take into account every electronics components involved in the determination of the logarithmic amplifier output and many of the effective components calibration are well established [1].
However, we have not proven yet that our understanding of the electronics and electronic model is refined enough for the final physics signal analysis. Now that the electronics components of the NCD system are well-described and understood, the calibration group is preparing the analysis using detector pulses including pulse-shape analysis and background pulse (detector and instrumental) studies. The last step of the physics analysis will be the signal extraction analysis, extracting the NC rates and converting these rates into solar neutrino flux determinations.

[1] T. B. et al., SNO UNIDOC (November 9, 2005).