Rope Background Implications
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Introduction

The purpose of this report is to present the basic neutron background information associated with the rope suspension system in order to facilitate decisions about the acceptability of various suspension designs and rope specifications. The heavy water neutron production from the ropes will be compared directly with the neutrons from the acrylic vessel. The neutrons from these two sources have the same radial pattern and therefore affect the neutral current signal-to-noise ratio in the same way. This means that acceptable levels of rope activity can be determined using the criteria previously ascertained for the acrylic activity. These have been laid out in SNO-STR-90-153, STR-91-019 and STR-91-025, and will be discussed below.

Acrylic Vessel

Calculations of neutron generation in the acrylic vessel were done assuming a 2" thick acrylic shell with a 6 m radius and a shell mass of 30 tonnes. For acrylic at 1.9×10^{-12}

g/g of thorium and 3.6×10^{-12} g/g of uranium 6.43 neutrons per day are created in the heavy water. (Accounting for escapes, this means that 197 neutrons per year would be captured in the detector with a heavy water alone fill and 1122 captures per year for the standard salt fill. In comparison the SSM rate would be 1202 captures per year for heavy water alone and 3794 captures per year for the salt fill.)

Default Rope Suspension

It was assumed that the vessel was supported by 10 loops of 1" diameter rope (two ropes per loop). The total "active" length per rope (inside the PMT sphere) above the equator of the vessel is 6 meters, giving a total rope mass above the equator of 87.56 kg. The length per loop below the equator is 1.6 meters, corresponding to a total mass of 11.68 kg below the equator. For a rope activity of 4×10^{-10} g/g of uranium and thorium a total of 1.00 neutrons per day will be created. This is to be compared to the value of 6.43 generated per day from the acrylic vessel.

Basket Suspension

In the case of a basket suspension, it has been assumed that the twenty ropes are carried on down around the acrylic vessel to within 45° of the bottom, where they are joined to a rope loop. In this case the ropes have a total mass of 34.38 kg and the rope ring has a mass of 311.2 kg if a 4" diameter is assumed for the rope of that ring. In this case 12.44 neutrons per day are generated. This is twice the number generated by the acrylic vessel. The number is reduced to approximately 4.44 neutrons per day if the diameter of the loop rope is reduced to 2".

Discussion

For the default rope suspension case the rope provides a neutron background which is only 16% of that from the acrylic at White Book levels, and clearly is at an acceptable level. The basket case provides a rope background that is almost twice that from the acrylic. This is not a desirable situation, but to decide whether it is unacceptable, or more generally what would comprise an unacceptable activity level in the ropes it is worthwhile reviewing the criteria developed earlier for the acceptance of the acrylic backgrounds.

The following numbers are extracted primarily from SNO-STR-91-19. Four figures of merit can be developed and are presented in the table below as a function of acrylic radioactivity, where x1 stands for the standard White Book levels of acrylic radioactivity. The numbers are those extracted for 1 year of running with the salt fill (Year 3 in our old jargon) for 1/3 SSM flux and no spectral distortions. The four figures of merit are:

- 1. The intersection of the energy spectrum of the CC events with the internal β-γ wall (dominated by the acrylic radioactivity).
- 2. The intersection of the radial distribution of the CC events with the NC background induced by the acrylic radioactivity.
- 3. The ratio of the number of NC events extracted to the input number. The number in parenthesis is the statistical error only.
- 4. The ratio of the number of NC events extracted from the analysis to the number of CC events extracted. Again the number in parenthesis is the statistical error only and includes the correlation effects. The input number is 1.03.

Figures of Merit				
Acrylic x White Book	CC Acr E(MeV)	NC Acr Radius	NC(Ext)/NC(Inp) Value = 1	NC(Ext)/CC(Ext) Value = 1.03
x1	5.0	x	1.02(0.05)	1.10(0.11)
x10	5.8	5.1	1.06(0.05)	1.22(0.12)
x20	6.0	4.6	1.10(0.06)	1.34(-)
x100	6.5	4.0	1.23(0.06)	1.85(0.22)

The first figure of merit (CC Acr) was obtained using the most recent Monte Carlos rather than from SNO-STR-91-19 to account for the updated information about the spectral response of the PMTs. The x in the second figure of merit indicates that there is no radius at which the two levels meet. The acrylic-induced neutron intensity is always lower than the CC intensity.

At the level of ten times the White Book value for the acrylic radioactivity things start to become uncomfortable for three of the four figures of merit.

- 1. The couting rate from the acrylic induced NC doesn't drop to the level of the CC until a radius of 5.1 meters, or about 60% of the volume.
- 2. The energy distribution of the acrylic induced CC background wall moves its intersection with the CC signal out by 0.8 MeV, to 5.8 MeV.
- 3. There is a systematic error of $\approx$ 10% in the extracted NC/CC ratio. Of course there would be no such error if the distributions were parameterized perfectly, but it still showed up in spite of best efforts to do so. (Can we expect to parametrize the real data better than the MC?)

If we accept a value of $\approx$ 10 $\times$ White Book as the limit of acceptability, then it is clear that the basket suspension, although not at a desirable level, is also not

unacceptable. The level at which the basket case rope would become unacceptable would be 2 ppb. The corresponding limit for the default suspension rope would be 25 ppb, both cases assuming that the acrylic remains at 1 $\times$ White Book. If the acrylic increases then the unacceptability limit must be taken for the *sum* of the acrylic and rope contributions.

It must be emphasized that the above unacceptability limit does *not* imply that if a level of $\times$ 8 or 9 were reached that no further effort at rope background reduction should be carried out. The desirable situation remains that the rope contribution to the background be significantly smaller than the $\times$ 1 acrylic case.