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Background from the Walls and Floor of the SNO Cavity

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1 Introduction

The calculation of the background due to materials in the cavity walls and the liner of the SNO detector has been broken into two parts because of the severe statistics problem associated with deep penetration γ-ray transport. The main calculation uses an 8 metre high section around the waist of the detector. This report describes how the results of the main calculation can be corrected for the contributions from the upper wall, the lower wall, and the floor. The contribution from the top is not included and must be calculated separately.

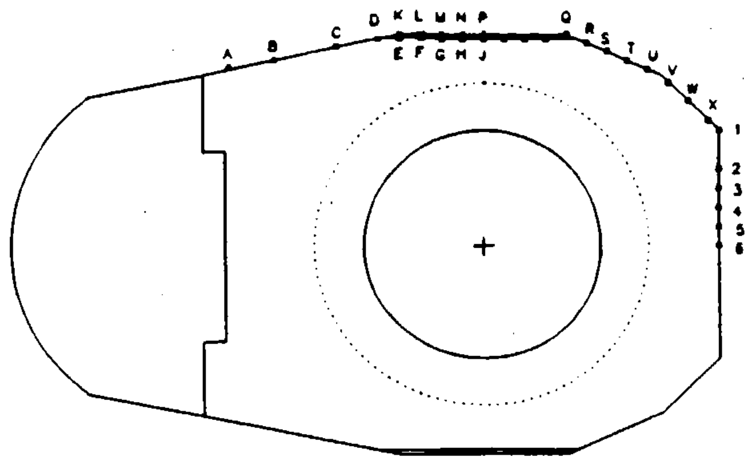
2 Description of the Cavity

The model used is the 22-metre diameter "barrel"-shaped cavity. (See Figure 1.) The waist region, which is 8 metres high is lined with 20 cm of sulfurcrete (S.C.) shielding. (In the Table 3, a correction has been applied to give results for 25 cm of sulfurcrete.) The cavity is lined with a layer of stainless steel.

3 Outline of the Calculation and Results

The correction is deduced as follows. The γ-rays from the norite that are important, originate in a layer about 17 cm thick on the cavity surface. This layer of material was divided into a series of volume elements. For each volume element, it was calculated what fraction of its γ-rays would reach the 6 metre radius of the detector. Then, the contributions from those volume elements which lie along the waist were totalled up, and compared to the grand total reaching 6 metres from all volume elements. This resulting ratio allows one to take a calculation that uses, as a source, only the waist region of the cavity, and from that, deduce the effect of including the entire wall and the floor as a source. The procedure for the norite was repeated for the stainless steel.

A number of simplifications and approximations were made.



- In the calculation, each element of volume was represented by a point source. The intensity of each source would then be proportional to the volume of the element.
- Since the thickness is the same for every volume element, it is a common factor throughout the problem and has been removed from the start: the volume elements have been replaced by elements of area.
- The γ-ray spectrum of consequence, which ranges from 5 to 9 MeV has been approximated by a monchromatic 7 MeV source.
- Note that these calculations have been done for a sulfurcrete thickness of 20cm, and therefore, there is a correction that must be applied to get the results for a 25 cm thick wall.
- These calculations give corrections for the walls and floor only. The top contribution must be added separately.

The series of points along the wall were used as sources of γ-rays in the program SANDYL[1]. The attenuation to the 6 metre radius of the detector was calculated for each point. Each of the points used is plotted in Figure 1. In order to get a reasonably low statistical uncertainty in the results, the variance reduction techniques of ***weight-splitting*** and ***Russsian roulette*** were used. The results of these calculations are shown in Table 1. Also included in the table is the attenuation to

Table 1: γ-Ray Attenuation

Location			6 Metres		8.5 Metres	
	y	z	Attenuation	% Error	Attenuation	% Error
A	940.	−1220.	3.42×10^{-13}	38.7	3.49×10^{-10}	28.0
B	974.	−1000.	2.82×10^{-11}	25.8	2.78×10^{-08}	19.5
C	1038.	−700.	1.42×10^{-09}	30.5	1.67×10^{-06}	20.4
D	1080.	−500.	1.17×10^{-08}	21.6	1.07×10^{-05}	14.2
E	1081.	−400.	2.15×10^{-08}	21.1	2.88×10^{-05}	12.3
F	1081.	−300.	8.73×10^{-08}	15.1	9.12×10^{-05}	8.3
G	1081.	−200.	1.47×10^{-07}	10.8	1.52×10^{-04}	6.0
H	1081.	−100.	2.17×10^{-07}	8.9	2.25×10^{-04}	5.5
J	1081.	0.	2.14×10^{-07}	8.9	2.46×10^{-04}	5.0
K	1101.	−400.	1.01×10^{-08}	44.4	1.01×10^{-05}	23.2
L	1101.	−300.	2.73×10^{-08}	27.7	2.09×10^{-05}	18.0
M	1101.	−200.	3.33×10^{-08}	19.4	4.20×10^{-05}	10.8
N	1101.	−100.	7.04×10^{-08}	17.0	6.53×10^{-05}	9.9
P	1101.	0.	6.21×10^{-08}	16.1	6.41×10^{-05}	9.7
Q	1101.	402.	8.01×10^{-09}	40.7	7.42×10^{-06}	24.9
R	1056.	500.	1.68×10^{-08}	9.8	1.61×10^{-05}	6.2
S	1010.	600.	1.38×10^{-08}	12.2	1.37×10^{-05}	7.8
T	965.	700.	8.30×10^{-09}	12.8	8.18×10^{-06}	8.8
U	919.	800.	3.41×10^{-09}	19.3	3.39×10^{-06}	11.3
V	853.	900.	2.89×10^{-09}	21.9	2.37×10^{-06}	15.9
W	753.	1000.	1.63×10^{-09}	31.3	1.81×10^{-06}	21.9
X	653.	1100.	5.18×10^{-10}	36.0	7.57×10^{-07}	26.5
1	600.	1153.	3.82×10^{-10}	75.2	4.88×10^{-07}	52.7
2	400.	1153.	4.48×10^{-09}	42.9	3.86×10^{-06}	24.3
3	300.	1153.	8.61×10^{-09}	27.6	7.13×10^{-06}	16.5
4	200.	1153.	1.34×10^{-08}	19.2	1.40×10^{-05}	10.8
5	100.	1153.	2.47×10^{-08}	13.4	2.48×10^{-05}	8.7
6	0.	1153.	1.98×10^{-08}	13.6	2.13×10^{-05}	8.4
FF	1081.	300.	7.09×10^{-08}	14.3	7.87×10^{-05}	8.6
GG	1081.	200.	1.55×10^{-07}	11.2	1.58×10^{-04}	6.5
HH	1081.	100.	2.04×10^{-07}	8.4	2.10×10^{-04}	5.3

Table 2: γ-Ray Attenuation — No Sulfurcrete

Location			6 Metres		8.5 Metres	
	y	z	Attenuation	% Error	Attenuation	% Error
K	1101.	−400.	2.83×10^{-08}	27.7	2.30×10^{-05}	16.2
L	1101.	−300.	5.06×10^{-08}	17.7	5.49×10^{-05}	9.4
M	1101.	−200.	9.25×10^{-08}	12.7	9.06×10^{-05}	7.8
N	1101.	−100.	1.44×10^{-07}	11.4	1.47×10^{-04}	7.4
P	1101.	0.	1.69×10^{-07}	11.0	1.57×10^{-04}	7.3

8.5 metres. In Table 2 are results for the case that the sulfurcrete shielding at the waist has been removed.

The percentage of γ-rays reaching 6 metres from the waist, the walls, and the floor are given in Table 3. This is shown for the stainless steel (S.S.) and for the norite. Also shown in Table 3 is the the case of a cavity with no sulfurcrete liner.

References

[1] H.M. Colbert, *SANDYL, a Computer Program for Calculating Combined Photon-Electron Transport in Complex Systems* (1974) SLL-74-0012