

Low Energy Background in the NCD Phase of the Sudbury Neutrino Observatory

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Abstract

The Sudbury Neutrino Observatory (SNO) was a 1 kilotonne heavy water Čerenkov detector. Evidence for flavour changing neutrino oscillations was found by comparing the rate of Charged Current interactions with that of Neutral Current (NC) interactions.

This thesis is concerned with the accurate determination of the NC flux in the Neutral Current Detector (NCD) phase of SNO. The measurement and understanding of radioactive backgrounds arising from decays of naturally occurring ^{232}Th and ^{238}U chain nuclei is crucial. This is because their daughter nuclei can produce neutrons via photo-disintegration of deuterium. These would be indistinguishable from those produced by NC neutrino interactions. As the probability of neutron production was dependent upon the nature and location of activity, each contribution had to be determined separately. Of particular concern were ^{232}Th and ^{238}U in the D_2O and Neutral Current Detectors (NCDs). A maximum likelihood method was developed that exploited differences in the event isotropy and radial profile of each event class. These results were in agreement with water assay results and pre-deployment radioassays of the NCDs.

An independent measurement of the ^{232}Th content in the D_2O and H_2O was made by regularly assaying the water using filters loaded with hydrous titanium oxide. The concentration of ^{232}Th in the water was determined by coincidence counting of the final assay sample. A new counter system was designed and built and the calibration and use of this system are presented.

Two areas of increased activity were discovered on two of the NCDs deployed in the detector which would have prevented an accurate measurement of the NC flux. A method was devised to determine the composition and activity of one of these hotspots. The results were in good agreement with two independent methods and the uncertainty on the NC flux was reduced from $> 7\%$ to $< 1\%$.

The total number of neutrons produced per day by photodisintegration for ^{232}Th and ^{238}U in the D_2O and NCDs was measured to be $0.66^{+0.08}_{-0.07}$. This was significantly less than the expected 12.6 NC neutrino interactions per day.

In the third phase, two independent data streams existed: PMT and NCD. A Monte Carlo study was undertaken to determine whether an accurate measure of the NC flux could be obtained using only PMT data. Results showed that no improvement could be made upon results from previous phases and the best measurement of the NC flux in the final phase would be made using PMT and NCD data.