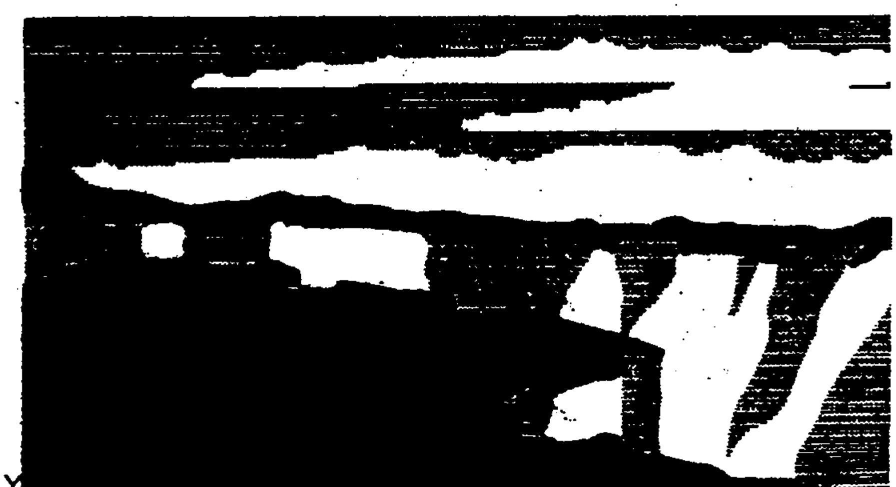
LA-UR-94- 3859

SNO-STR-94-054

Title: Status of Optically Tagged Neutron Source Development

Author(s): Malcolm Fowler, Russ Gritzo, and Jerry Wilhelmy

Submitted to: Sudbury Neutrino Observatory Technical Report



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Form No. 836 R5
ST 2629 10/91

Status of Optically Tagged Neutron Source Development

M. Fowler, R. Gritzo, J. Wilhelmy

Los Alamos National Laboratory
Group CST-13
February 28, 1994

Some time ago we proposed to use a ^{252}Cf source in part of the calibration of the SNO detector. This approach would be particularly useful when used in conjunction with proposed discrete neutral current detectors

For this application, it is desirable to know when the source emits neutrons so that events registered in the SNO detector can be time correlated with the source emission. We proposed to incorporate the ^{252}Cf in a small piece of plastic scintillator so that the scintillator would be excited by the fission fragments that are accompanied by neutron emission. The light from the scintillations could be detected by the SNO array and that would mark the start time to look for neutrons. The neutrons that are emitted at essentially the same time as the fission fragments would be thermalized in the heavy water of the SNO detector and then be captured, hopefully, in some discrete detector in the heavy water. The distribution of capture times relative to the fission event should then represent the thermalization time for the neutrons in the heavy water (and to some extent the geometry of the detectors). Since the thermalization time is relatively long (milliseconds), the emission rate of the source must be kept low (~10 Hz) to prevent confusion of one event with the next one.

For proof of principle, we mounted a thin disc of plastic scintillator (BC-418, 5 cm diameter, 1 mm thick) on a RCA 6342-A photomultiplier tube and then positioned an uncovered ^{252}Cf source ~0.05 mm from the scintillator. We then recorded the pulse height spectrum using conventional electronics. We were able to clearly define the alpha particle peak along with a broad distribution due to both ß-particles and fission fragments. We found that the broad distribution peaked at a pulse height 3-4 times greater than that for the alpha particles. We found that the detection efficiency for the alpha particles associated with the decay of ^{252}Cf in this configuration was ~41% and that the fission fragment detection efficiency was ~35%. The difference in the apparent alpha and fission detection efiiciency is due, at least in part, to the method of integration of the fission distribution and to the inaccuracies in the estimation of the background shape under the broad fission distribution. In addition, we found that the beta particle sensitivity was sufficient to account for about one third of the counts detected with pulse heights greater than the alpha events. Subtraction of this component also contributes to the fissionrate uncertainty.

Next, we tried to reduce the beta sensitivity by making a thinner scintillator. For this test we used Bicron BC-418 that was 0.25 mm thick. Now we found that the alpha and fission distributions were essentially unchanged but the beta contribution was only about 3-4% of the events with pulse amplitudes greater than the alpha events.

Based on data furnished by Bicron for photon yield from alpha particles, we estimated that the light output caused by a fission event was about 14000 photons.

Next we made a sandwich detector to try to obtain more light from the fission events. We evaporated a small amount of ^{252}Cf solution on a 1 cm diameter disc of 0.25 mm thick scintillator. We then covered the deposit with a second disk of scintillator to make a "4π" scintillator. We then encapsulated the two scintillator disks in a larger disk of acrylic plastic 5 cm in diameter by 2 cm thick.

We recorded the pulse height spectra as before and found that the pulse amplitude distribution of the fission fragments was broadly peaked at amplitudes about 5 times that of the alpha particles and corresponding to about 19000 photons per fission. This was less than we had hoped for as we had expected to double the amplitude relative to the alpha particles and that should have given a ratio of 6-8 corresponding to about 30000 photons per fission. One possible explanation is that the ^{252}Cf deposit was relatively thick and that results in some significant energy loss for some of the fission fragments.

In the next test, we coated the acrylic disk with Eastman Kodak White Reflectance paint on all sides except for the one coupled to the phototube. We found that this increased the amount of light collected by the phototube by a factor of 2.5. The ratio of the pulse amplitudes for the alphas and fission fragments remained unchanged as would be expected if one assumed that the relative fractions of scintillation light collected for alpha events and fission fragment events was the same in both the coated and uncoated cases.

We have shown that it is possible to separate the fission events from the alpha events based on pulse height and that the fission fragment(neutron emission) detection efficiency is sufficient to make this approach attractive as a neutron calibration source for the SNO detector.

Next, we propose to try to disperse some ^{252}Cf in a small amount of plastic scintillator and repeat the pulse height tests. As long as the size of the scintillator is kept as small as practical, this configuration should give the optimum chance for fission fragment detection while minimizing beta sensitivity