The 21 Century COE
Exploring New Science by Bridging Particle-Matter Hierarchy

Short-term Foreign Researchers

Research Report

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Your Stay Period in Japan: From 2004/01/15 to 2004/03/31

Title of Research in Japan: Supernova detection using proton recoil in Kamland detector.

There are a few percent chances to see a supernova in the Galaxy during the lifetime of the Kamland detector. There are several well-defined signatures in neutrino detection of such events [J.F.Beacom, W.M. Farr & P. Vogel Phys. Rev. D 66, 033001 (2002)]. One of them is the presence of a few tens low energy proton recoils which can only be seen in a scintillation detector.

Those low energy events are spread over a few seconds and are in the midst of a rather high background [20 Hz]. As the recoil protons are peaked at very low apparent energy it is better to avoid any cut based on energy to keep all the events compatible with data acquisition rate. In order to bring the background to a more manageable 2-3 Hz, events outside a 5.5 m sphere are cut off. This halves the detection volume but increases the signal/noise ratio by a factor 6 to 10.

The method tested consists in the detection of a high counting rate not compatible with fluctuations of a pure time uniform background. The time difference between the last and first events of any sequence of N consecutive uniformly time distributed noise events with frequency fnoise follows a distribution gamma(N, 1/fnoise), allowing one to compute the probability that the duration of a pure noise sequence is below a given threshold. The threshold is chosen so that the number of supernova candidates selected for further examination does not exceed a few per month. Once a candidate is found the event sequence is built as long as the high frequency condition holds, together with the list of muons found during the sequence: later one can assess the probability of a spallation, check the uniformity in volume, the energy distribution and the presence of relatively high energy antineutrino characteristic of supernova events.

The method is tested using its natural background, i.e. the high counting rates due to spallation events following high-energy muons. There are in mean 3 muons in the detector during a supernova event. The low energy events are cut off during 100 ms following any muon. Using 34 days of data taken In September and October 2003 I looked for sequences of 9, 16 and 64 events. The cuts were tuned only for the 16-event sequence. Only one supernova candidate was found and it was actually due to a very long cluster [1s] of spallation events following a high-energy muon. The method is very fast and the algorithm can be easily improved by very simple means, as checking the spatial clustering of hits near the preceding muons, or checking for the time spread of the hits inside the sequence.

There are indications that one can use low length sequences ($N < 9$) by checking the total duration of the sequence (for instance currently a supernova candidate is found by requiring that 16 events are clustered in less than 1.2 s but this condition may last for several seconds, in which case the cluster is probably not due to spallations following a single muon event). This promising possibility was not explored by lack of time but the algorithm already keeps clustering as long as the high frequency condition is met. Furthermore extracting the antineutrino seems mandatory to reach a very low level of false alarms.

Sendai, March 29th 2004.
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