# Neutron decay from the spin-isospin excitations in $^{208}$Bi via the $^{208}$Pb($^3$He,$t+n$) reaction

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Neutrinos and anti-neutrinos are emitted within a few tenth of seconds after the supernova explosion. Neutrino observation is quite important for studying the collapse of star core and neutrino oscillation. Various laboratories all over the world have started to make their observation plans. One of them is the OMNIS (the Observatory for Multifalavor NeutrInos from Supernovae) [1, 2, 3] in U.S.A. In the OMNIS, the Pb($\nu$, n) reaction is used to detect supernova neutrinos. It is expected that the energy and time distributions of the supernova neutrinos will provide precious information on the physical mechanisms of neutrino oscillation and supernova explosion. However, detailed knowledge of the response function for the Pb $+\ \nu$ reactions, and of the decays from the residual excited nucleus is indispensable to estimate the total weight necessary for the OMNIS detector that detects $\sim$ 1000 neutrinos in 1 $\sim$ 20 seconds. In order to obtain information on the energy release after the Charged-Current (CC) reaction in which electron neutrinos are absorbed by Pb, we have measured neutron decay from the spin-isospin resonances in $^{208}$Bi [4, 5, 6, 7].

The $^{208}$Pb($^3$He,$t+n$) reaction has been studied in coincidence with neutrons emitted from the excited $^{208}$Bi. The spectrometer, Grand Raiden [8] and 48 liquid scintillators were used in the experiment with a 150 MeV/u $^3$He beam from the ring cyclotron at RCNP. Liquid scintillators were set up almost in the same way to the past experiments [9].

The combination of fast- and slow-gates for one signal pulse could distinguish neutron and $\gamma$-ray events in each counter [9]. All liquid scintillators were calibrated the QDC channel and the light output by using Monte Carlo fitting to determine Compton edges of $\gamma$-ray source spectra [10]. The detection efficiency was obtained on the base of the computer simulation calculation using the measured threshold of the constant fraction discriminator (CFD). The neutron energies were measured via the time-of-flight (TOF) method with a flight path of 1.5 m. The time interval of the beam bunch was determined by the radio frequency of the cyclotron. For the neutron measurement, a beam buncher in the beam transport system was used to avoid overlapping of neutron events. The pulsing ratio was chosen to be three, making a beam period of 250.5 nsec.

We observed clear increases and decreases for observed neutron- and $\gamma$-decay at the 1n, 2n, 3n and 4n thresholds (see Figure 1 d) and e) ). Neutron energy distributions from the excited states in $^{208}$Bi at $E_x < 32$ MeV have a Maxwell-Boltzmann like structure with peak energy of 2.3 MeV (Figure 2). The simulation calculation 'CASCADE' [11] well reproduces the global structure for the neutron decay multiplicity. Neutron decay from the isobaric analog state (IAS) was identified by subtracting the neutron yields of the Gamow-Teller (GT) resonance from those of the IAS and the GT resonance. Particle decay from the IAS was reexamined

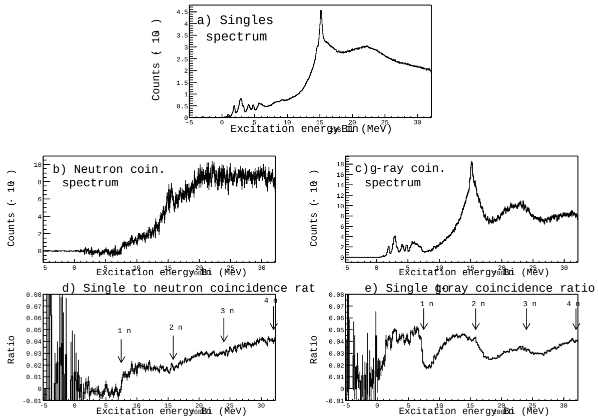

Figure 1: Single, coincidence spectra and neutron, $\gamma$ dacay ratios.

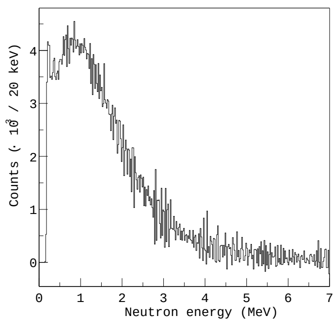

Figure 2: Energy distributions for decay neutrons from the excited states in $^{208}$Bi at $E_x < 32$ MeV.

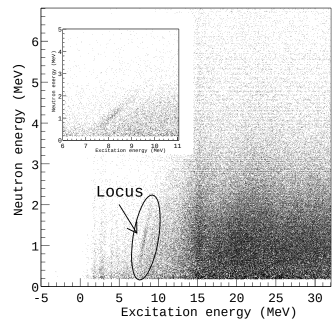

Figure 3: Two-dimensional scatter plot of neutron-triton coincidence events at 0°.

to occur by both neutron and proton decays.

Although all neutron decays were generally thought to be statistical, we observed, at least, one clear locus in the two-dimensional scatter plot for neutron decays (Figure 3). This is strong evidence for that the neutron energy leading to this locus is stemmed from the two body decay from the excitation energy of $E_x = 7 \sim 10$ MeV in $^{208}$Bi.

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