PROPOSAL FOR EXPERIMENT AT RCNP

September 22, 2004

TITLE:
High Resolution Study of Gamow-Teller and Fermi Excitations in ^{56}Co via the (^{3}He,t) Reaction at 140 MeV/u

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RUNNING TIME: Beamline tuning for the dispersion matching 1.5 days
+ Data taking time 5.5 days

BEAM LINE: Ring : WS course

BEAM REQUIREMENTS:

Type of particle	^{3}He
Beam energy	420 MeV
Beam intensity	$\leq$ 20 nA
Other requirements	energy resolution $\leq$ 100 keV halo-free, small emittance

BUDGET: Experimental expenses : 100k yen for a new Faraday cup
Support for the stay of the researchers from foreign countries is appreciated.

RCNP EXPERIMENT E252

TITLE:
High Resolution Study of Gamow-Teller and Fermi Excitations in ^{56}Co via the (^{3}He,t) Reaction at 140 MeV/u

SPOKESPERSONs: N. T. Botha and H. Fujita

SUMMARY OF THE PROPOSAL

We propose a high resolution study of ^{56}Fe(^{3}He,t)^{56}Co reaction at 140 MeV/nucleon. One of the main issues is isospin mixing of 0^+ states in ^{56}Co. In Refs. [1, 2], isospin mixing between the IAS (0^+) at 3.599 MeV and neighboring 0^+ state at 3.527 MeV are discussed using the (^{3}He,t) and (p,n) reactions on ^{56}Fe. In order to resolve these 0^+ states, however, they used a lower incident energy beam ($E_{\rm He}$ = 24.6 MeV, E_p = 17 MeV), where contributions of 2-step reactions are not negligible. Another (p,n) reaction measurement at 160 MeV on ^{56}Fe is reported in Ref. [3], where due to the lack of energy resolution, these 0^+ states were observed as one peak at 3.5 MeV. They also suggested the existence of a strong GT (1^+) state in this region.

The high resolution (^{3}He,t) measurement facility at RCNP allows us to observe these states separately without suffering from contributions of 2-step reaction processes. Recently, with further development of the Grand Raiden spectrometer, the WS beamline and the accelerator complex; the AVF cyclotron and the Ring cyclotron, a resolution of less than 40 keV has been obtained rather stably. In order to distinguish 0^+ states from 1^+ states, an angular distribution of cross sections will be required. We plan to take data at 0°, 4° and 8°. For the measurement at 4°, we plan to make a new Faraday cup. Since absolute cross section at 0° may be ambiguous if dispersive mode is applied, we will take data with both achromatic and dispersive beam at 0°.

We also plan to study the GT strength distribution from the ^{56}Fe(^{3}He,t) spectrum. Due to the lack of a standard B(GT) value from β decay measurements, we plan to use

GT unit cross section of ^{58}Ni(^{3}He,t) reaction to estimate the absolute B(GT) value. By comparing the GT strength distribution in ^{56}Co with the analogous $M1$ (1^+) strengths in ^{56}Fe, which will be measured by ^{56}Fe(p,p') measurement at iThemba LABS, the isospin T values of the analog 1^+ states will be investigated. These informations are astrophysically very important. This is because in a supernova explosion process the iron-mass range core nuclei collapse by electron capture and emit neutrinos, which are dominated by GT$_+$ transitions [4].

The Grand Raiden spectrometer and the standard VDC focal plane detector system will be used for the analysis and detection of outgoing tritons. We request a good quality single-turn extracted 140 MeV/nucleon ^{3}He beam of up to 40 nA. Complete matching conditions and over-focus mode will be applied for high resolution measurement.

References

[1] T.G. Dzubay, R. Sherr, F.D. Becchetti, Jr, and D. Dehnhard, Nucl. Phys. **A142** (1970) 488.

[2] H. Orihara, K. Ogawa, T. Murakami, S. Nishihara, T. Nakagawa, and K. Maeda, Nucl. Phys. **A403** (1983) 317.

[3] J. Rapaport, T. Taddeucci, T.P. Welch, C. Gaarde, J. Larsen, D.J. Horen, E. Sugarbaker, P. Koncz, C.C. Foster, C.D. Goodman, C.A. Goulding, and T. Masterson, Nucl. Phys. **A410** (1983) 371.

[4] J. Toivanen, E. Kolbe, K. Langanke, G. Martínez-Pinedo, P. Vogel, Nucl. Phys. **A694** (2001) 395.