# PROPOSAL FOR EXPERIMENT AT RCNP

25 January 2004

**TITLE:**

## Investigation of the Characteristics of ($^3$He, $t$) reaction at 140 MeV/nucleon

**SPOKESPERSON(s):**


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**EXPERIMENTAL GROUP:**

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**RUNNING TIME:** Data runs 3 days (1.5 days × 2)
(In addition, we usually need 2 days for the beam tuning, and 0.5 days for setting up the matching conditions between the beam line and the spectrometer, but these preparation time can be spared by combining with other accepted beam time.)

**BEAM LINE:** Ring : WS course

**BEAM REQUIREMENTS:**

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| Type of particle | $^3$He |
| Beam energy | 420 MeV |
| Beam intensity | up to 40 nA |
| Energy resolution | $\Delta E \leq 100$ keV (Achromatic mode), small emittance |

**BUDGET:** For the preparation of targets 0.5 Million yen

**IMPROVEMENT OF GRAND RAIDEN:**

As we gat a higher resolution, we started to suffer from the 2nd order aberrations of Grand Raiden. It is estimated that this large aberration can be reduced by strengthen the sextupole part of the multipole magnet. We request to install more powerful power supply for this magnet.

# 1 Summary of Experiment

• **Proposed experiment:**

It has become evident that a high-resolution ($^3$He, $t$) reaction at 140 MeV/nucleon is a powerful tool for the study of Gamow-Teller (GT) excitations in various nuclei. Recently, with the development of the spectrometer Grand Raiden, WS beam line and the accelerator complex, AVF cyclotron + the Ring cyclotron, a resolution less than 40 keV has been obtained rather stably, and fine structures of GT resonances have been revealed. Assuming the proportionality between the cross section and the reduced GT transition strength $B$(GT), the investigation of GT transition strengths is underway for various nuclei. In addition, with such a resolution, we started to see even the level widths of the states above particle separation energies.

In using the ($^3$He, $t$) reaction at 140 MeV/nucleon as the real spectroscopic tool, however, we have to overcome the difficulties:
1) how the proportionality constant depends on mass $A$,
2) with which accuracy the level width can be studied.

We propose to study "key" GT transitions in $p$, $sd$, $fp$-shell, and middle $A$ nuclei whose analog transitions, or the transition in a reverse direction have been investigated in $\beta$-decay studies. In addition, there are a few nuclei whose decay widths are well studied up to high excited states. The candidates of target nuclei are $^7$Li, $^9$Be, $^{13}$C, $^{30}$Si, $^{42}$Ca, $^{68}$Zn, $^{78}$Se, $^{80}$Se, $^{118}$Sn, $^{136}$Ba, $^{140}$Ce, $^{144}$Sm, and $^{178}$Hf.

• **Apparatus and beam properties:**

The spectrometer Grand Raiden 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. In order to realize various matching conditions including *dispersion matching*, *angular dispersion matching* and *focus matching*, various capabilities of the WS course will be fully utilized.

• **Beam time request:**

In order to avoid the energy-loss broadening in a target, a target thickness less than 1.5 mg/cm$^2$ is desirable. Therefore, a longer measuring time is needed for heavier mass nuclei. Our experience shows that under a practical beam intensity of 20-30 nA, we need 6-8 hours of run time for nuclei with mass $A = 60$ (Nickel region) in order to get a count of 1,000 (3% statistical error) for a relatively strong GT transition with $B$(GT) of 0.15, and this is the strength we have to study. In addition, a narrower angle cut is needed for a larger $A$ nuclei. Therefore, the run time needed for the measurement increases as a function of mass number $A$. In addition some targets are fragile and cannot survive a large intensity beam. The details are discussed in the later section. Minimum 3 days are needed for the data taking of various nuclei. We perform experiments starting from available targets. We want to run two times 1.5 days.

• **Schedule:**

We request the first 1.5-day beam time end of April - beginning of May, attached to the beam time of already approved experiments E220 (Spokespersons : S. Rakers et al.) and E221 (Spokespersons : P. von Neumann-Cosel et al.)

• **Budget request:**

For the preparation of targets: 0.5 Million yen.