# PROPOSAL FOR EXPERIMENT AT RCNP

Feb. 14, 2008

**TITLE:** Feasibility study of the $(d, pp)$ reaction in inverse kinematics as a possible probe for $B(\mathrm{GT}^+)$ strengths in neutron-rich nuclei

**SPOKESPERSON:**


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**EXPERIMENTAL GROUP:**


| Name | Institution | Title or Position |
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| D. Ishikawa | RCNP, Osaka Univ. | M1 |
| I. Tanihata | RCNP, Osaka Univ. | P |
| H.J. Ong | RCNP, Osaka Univ. | A |
| A. Tamii | RCNP. Osaka Univ. | AP |
| H. Matsubara | RCNP, Osaka Univ. | D2 |
| K. Suda | RCNP, Osaka Univ. | R |
| H. Otsu | RIKEN Nishina Center | R |
| K. Sekiguchi | RIKEN Nishina Center | R |
| H. Iwasaki | Dept. of Phys., Univ. of Tokyo | A |
| D. Suzuki | Dept. of Phys., Univ. of Tokyo | D2 |


**RUNNING TIME:**

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|---|---|
| Tuning | 24 hrs |
| Data runs | 72 hrs |
| Total | 4 days |

**BEAM LINE:**

Ring: EN (or ENN) course

**BEAM REQUIREMENTS:**

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|---|---|
| Type of particle | $^{12}$C |
| Beam energy | 100 MeV/$A$ |
| Beam intensity | 10 pnA |

**BUDGET:**

Travel expense 1.5 M JPY

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## SUMMARY OF THE PROPOSAL

The $(d, {}^2\mathrm{He})$ reaction has been extensively used to extract $\beta_+$ Gamow-Teller strength $B(\mathrm{GT}^+)$ making the most of its advantages over the $(n, p)$ reaction; the selectivity in spin-transfer, relatively high energy-resolution and high count-rate. Here the ${}^2$He denotes a $p$-$p$ pair in ${}^1S_0$ state and is experimentally measured by the coincidence detection of two protons with relative energies $\epsilon_{pp}$ less than 1 MeV, where the ${}^1S_0$ amplitude is expected to be dominant due to the strong $p$-$p$ final-state interaction. It is the second simplest $(n, p)$-type reaction and, although it is a three-body reaction, can be theoretically treated with less ambiguities than other composite-projectile reactions. It is fascinating to apply the $(d, {}^2\mathrm{He})$ reaction to neutron-rich unstable nuclei. The $B(\mathrm{GT}^+)$ of such species will provide precious information for studies of nucleosynthesis in stars, double $\beta$-decay nuclear matrix elements, and other various fields.

For unstable nuclei, however, the $(d, {}^2\mathrm{He})$ reaction is not easy to measure. One of the most powerful methods for producing short-lived unstable nuclei is to use the projectile-fragmentation at intermediate energies. Since the produced nuclei form beams with relatively small angular and momentum spreads, direct reactions on such nuclei are usually measured in inverse kinematics. A common and serious problem is the low energy of recoiled ejectiles in small momentum-transfer regions, which are relevant to direct reactions. For the case of $(d, {}^2\mathrm{He})$ reaction at several 100 MeV/$A$, protons with energies as low as 0.6 MeV have to be measured to keep $\epsilon_{pp} \leq 1$ MeV.

A reasonable compromise is to measure protons with higher energies, 5 MeV for example, in coincidence. Although $\epsilon_{pp}$ increases up to 10 MeV in this case thus contributions from higher partial-waves than ${}^1S_0$ increase, it will be still useful to extract $B(\mathrm{GT}^+)$ because, among isovector central parts of the $N$-$N$ effective interaction, the relative strength of spin-flip part to non-spin-flip one is known to increase as increasing energy and reaches maximum at ∼300 MeV/$A$. The reaction may be extensively utilized at RIKEN/RIBF, which can provide intense RI-beams with such energies. For this purpose, a theoretical treatment properly describing contributions from higher partial-waves must be established. Also the experimental feasibility is not clear; low-energy protons are emitted to large angles thus have to be measured without using a magnetic spectrometer under huge backgrounds, particularly from accidental coincidence of inclusive $(d, pX)$ breakup protons. We thus propose to measure the $(d, pp)$ reaction in inverse kinematics using the 100-MeV/$A$ ${}^{12}$C beam, which is known to have a large spin-flip transition strength to ${}^{12}\mathrm{B}_{\mathrm{gnd}}$ isolated from other excited states, to examine its feasibility for extracting $B(\mathrm{GT}^+)$ strength.