

## PROPOSAL FOR EXPERIMENT AT RCNP

September 16, 2009

**TITLE:**

**Test Experiment: ( $^3\text{He}, ^3\text{He}'$ ) Reaction at 175 MeV/nucleon  
- for the precise study of  $E1$  response of nuclei -**

**SPOKESPERSONS:**

| Full Name            | Institution               | Title or Position              |
|----------------------|---------------------------|--------------------------------|
| Y. Fujita            | Osaka University          | Associate Professor            |
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**EXPERIMENTAL GROUP:**

| Name         | Institution            | Title or Position   |
|--------------|------------------------|---------------------|
| T. Adachi    | KVI, Netherlands       | Researcher          |
| K. Hatanaka  | RCNP, Osaka University | Professor           |
| T. Kawabata  | Kyoto University       | Associate Professor |
| H. Matsubara | RCNP, Osaka University | Ph.D. Student       |
| H. Okamura   | RCNP, Osaka University | Professor           |
| H.J. Ong     | RCNP, Osaka University | Assistant Professor |
| T. Shima     | RCNP, Osaka University | Assistant Professor |
| Y. Shimbara  | Niigata University     | Assistant Professor |
| T. Shizuma   | Kizu Institute, JAERI  | Researcher          |
| G. Susoy     | Istanbul University    | Master Student      |
| T. Suzuki    | RCNP, Osaka University | Researcher          |
| J. Thies     | Muenster University    | Ph.D. Student       |
| Y. Yasuda    | RCNP, Osaka University | Researcher          |

**RUNNING TIME:**

total 3 days

Beam tuning for the background reduction and dispersion matching 2 days

Study of the properties of the ( $^3\text{He}, ^3\text{He}'$ ) reaction 1 day**BEAM LINE:**

Ring : WS course

**BEAM REQUIREMENTS:**

|                     |  |
|---------------------|--|
| Type of particle    | $^3\text{He}$  |
| Beam energy         | 525 MeV (175 MeV/nucleon)                                      |
| Beam intensity      | $\leq 20$ nA   |
| Beam transportation | dispersive mode of the WS beam line                            |
| Other requirements  | energy resolution $\leq 100$ keV<br>halo-free, small emittance |

**BUDGET:**

No special budget is required.

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- for the precise study of  $E1$  response of nuclei -**

**Spokespersons:** Y. Fujita, A. Tamii and H. Fujita

**Summary of the Proposal**

The largest concentration of the isovector  $E1$  strength in nuclei, i.e., the Isovector Giant Dipole Resonance (IVGDR), has been observed systematically at the excitation energy  $E_x = 31.2A^{-1/3} + 20.6A^{-1/6}$  MeV ( $E_x = 15 - 23$  MeV) as a broad bump-like structure. The  $E1$  strengths in the IVGDRs situated above the neutron separation energy  $S_n$  were studied by the  $(\gamma, n)$  reaction. On the other hand,  $(\gamma, \gamma')$  reactions [nuclear resonance fluorescence (NRF) method] or  $(\alpha, \alpha'\gamma)$  coincidence experiments have been used for the study of the  $E1$  responses in the region below the  $S_n$  energy, where  $E1$  states are observed as discrete states. In order to obtain the whole  $E1$  response of a nucleus, these two methods should be combined. The largest difficulty, however, was that the connection was not always smooth.

Here we propose the  $^3\text{He}$  inelastic scattering reaction [ $(^3\text{He}, ^3\text{He}')$  reaction] at an incoming energy of 525 MeV (175 MeV/nucleon) as a potentially good tool to study the overall view of the  $E1$  responses in nuclei, not affected by the  $S_n$  energy. Due to this high energy of the  $^3\text{He}$  beam available at RCNP, it is expected that the  $E1$  states excited by the Coulomb interaction become pronounced in a measurement at  $0^\circ$ . In addition, the high energy-resolution of the measurement that will be achieved by the realization of beam matching techniques will reveal the fine structures of the  $E1$  response in nuclei.

The Grand Raiden spectrometer and the standard VDC focal plane detector system will be used for the analysis and detection of outgoing  $^3\text{He}$  particles. We request a good quality single-turn extracted 175 MeV/nucleon  $^3\text{He}$  beam of up to 10 nA. We seek to realize the complete beam matching conditions to achieve a high energy-resolution of about 30 keV. In addition, an appropriate condition of the vertical off-focus mode will be studied to realize an effective background subtraction. For such purposes, we plan to do  $(^3\text{He}, ^3\text{He}')$  measurements on  $^{26}\text{Mg}$ ,  $^{56}\text{Fe}$  and  $^{58}\text{Ni}$  targets, and also on a heavier mass target such as Sn isotopes. It is expected that the obtained results will show the overall view of the  $E1$  strengths, and they are compared with the existing  $(\gamma, \gamma')$  and  $(\alpha, \alpha'\gamma)$  data and also the  $(\gamma, n)$  results showing the  $E1$  response in the energy region below and above  $S_n$ , respectively.