E452

RCNP EXPERIMENT Exxx

PROPOSAL FOR EXPERIMENT AT RCNP

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TITLE:

Using high resolution (^{3}He, t) reactions on ^{116}Cd and ^{116}Sn for nuclear structure and neutrino physics

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RUNNING TIME (in order of priority):

^{116}Cd and ^{116}Sn data taking run — 2 x 2.5 days

Measurement time tuning and for calibration — 2.0 days

In order to get the GT strength from the cross section, one needs a ^{114}Cd calibration measurement with known GT nuclear matrix element from β-decay. Furthermore, because of the low Q-value of ^{116}Cd also a calibration with ^{100}Mo is required. To get good coverage over a wide energy range also ^{26}Mg and ^{24}Mg is foreseen. In addition a background run and tuning is required.

BEAM LINE: Ring : WS course

BEAM REQUIREMENTS:

Type of particle	^{3}He
Beam energy	420 MeV
Beam intensity	10 $\sim$ 20 nA
Energy resolution	ΔE 35 keV, small emittance

BUDGET: Local support for non-RCNP participants

SCHEDULE: We request the beam time in September/October 2015 at the earliest

1 Summary of Experiment

- **Proposed experiment:**

We propose to study the GT^- strength distributions with the highest possible resolution in the nuclei ^{116}Cd and ^{116}Sn by means of the (^{3}He,t) reaction at 420 MeV. The first nucleus is presently in focus of the study of double-beta decay (DBD), where various other double beta emitters have already been explored within RCNP experiment E294 providing extremely valuable information for the field of neutrino physics and nuclear matrix elements (NME) for double beta decay. Since 1990's (^{3}He,t) measurements on most of the prefered DBD nuclei (Ge,Se, Mo, Te, Xe) have been studied with improved energy-resolution by the Charge Exchange Reaction DBD group at RCNP [1]. This isotope also might serve as a very good candidate for future detection of solar and supernova neutrinos. ^{116}Sn, the daughter of the ^{116}Cd DBD, is very important for nuclear structure studies as it would extend an already proposed sensitive study (measuring CER on ^{118}Sn and ^{120}Sn) of a series of isotopes with equal mass but different isospin.

The (^{3}He,t) reaction at $E/A \sim 150$ MeV is a good probe to study the intermediate states in the $\beta\beta$-decay from the GT^- direction as discussed in a recent review articles and references therein [2]. Together with data from experiments using the (d,^{2}He) reaction on ^{116}Sn [3] at KVI, which excite the same states from the GT^+ direction, our results will provide important experimental information about the matrix elements of the two-neutrino double-beta ($2\nu\beta\beta$) decay. Further, the data will be equally important for model calculations, which are needed to determine the matrix elements of the neutrinoless double beta decay ($0\nu\beta\beta$), because at small angles also the spin-dipole component can be measured. These are the key for the extraction of the neutrino mass if such a decay is observed in any of the present counting experiments, like COBRA, GERDA, CANDLES, EXO or KamLAND-Zen and future experiments like MAJORANA, MOON, CUORE and others. In addition, the obtained data will precisely determine the potential of a large scale detector based on ^{116}Cd for supernova and solar neutrino detection.

RCNP is the only facility world wide, where the proposed (^{3}He, t) reaction experiments at a resolution on the order of 40 keV can be carried out. Activities have already started around 1990 at RCNP to achieve a superb energy resolution. Actually, the resolution is now improved by about one order of magnitude compared with previous experiments in the 1990's. Thus, we propose to use a 140 MeV/nucleon ^{3}He beam from the RCNP Ring Cyclotron in high resolution mode. The outgoing tritons will be momentum analyzed by the Grand Raiden spectrometer. The ion-optical conditions *dispersion matching* and *angular dispersion matching* will be realized between the spectrometer and the WS beam line to achieve a high momentum resolution and good angular resolution. The over-focus mode of the spectrometer is essential in realizing good angular resolution in vertical direction and also in correcting kinematic aberrations.

- **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 ≈ 10 nA of good quality single-turn extracted 140 MeV/nucleon ^{3}He beam. In order to realize various matching conditions, various capabilities of the WS course will be fully utilized.

• Beam time request:

High-resolution (^{3}He, t) spectra will be measured at 0° and small angles. In order to achieve a high resolution, the effect of energy spread in the target should be minimized. The energy spread in the target is mainly caused by the different energy losses of ^{3}He and t particles, and thus, a sufficiently small target thickness is important. The thin target should be made out of isotopically enriched ^{116}Cd which is commercially available with 90% abundance. A parallel development of a ^{116}Sn target is proposed which would allow to study a nucleus with the same mass as other tin isotopes already proposed but different isospin in great detail. This is a very interesting nuclear structure topic by itself as there is already an submitted proposal for studying ^{118}Sn and ^{120}Sn. By realizing the angular dispersion matching and over-focus mode of the spectrometer, we can achieve a good angle resolution. In the E220 experiment on ^{48}Ca we have seen, that an angular distribution up to 4° can be made available by measuring at 0° and 2.5°. Therefore, we ask to perform the measurement also at angles up to 4° to identify unambiguously the 1^+ levels and to study the spin-dipole 2^-states. In the past, it was also found that a high quality ^{3}He beam with small emittance and momentum spread results in better experimental conditions.

For the measurement we need 2.5 days for each real target run (at two angles), as will be described in Sec. 4.

The total requested beam time consists of
(1) measurements for the both targets : 2 targets x 2.5 days
(2) background subtraction, tuning and energy calibration runs : 2.0 days

• Schedule:

We request the beam time preferentially in the period end of 2015 to beginning of 2016. The beam time could be attached to a recently submitted proposal of the E424 experiment to study the Gamow-Teller strength in odd-A high S_p nuclei.