RCNP EXPERIMENT E322

PROPOSAL FOR EXPERIMENT AT RCNP

February 24, 2009

TITLE:

Measurement of ^{130}Te $\beta\beta$-decay matrix element using high resolution (^{3}He, t) reaction

SPOKESPERSON(s):

Full Name	Dieter Frekers
Institution	Institut für Kernphysik, Universität Münster
Position	Professor
Address	Wilhelm Klemm-Str. 9, D-48149 Münster, Germany
Phone number	+49-251-833-4996
FAX number	+49-251-833-4962
E-mail	frekers@uni-muenster.de

Full Name	Remco Zegers
Institution	National Superconducting Cyclotron Laboratory, Michigan State University
Position	Professor
Address	East Lansing MI, USA
Phone number	+1-517-333-6473
FAX number	+1-517-333-5967
E-mail	zegers@nscl.msu.edu

Full Name	Jan H. Thies
Institution	Institut für Kernphysik, Universität Münster
Position	PhD
Address	Wilhelm-Klemm-Str. 9, D-48149 Münster, Germany
Phone number	+49-251-833-4966
FAX number	+49-251-833-4962
E-mail	thiesjh@uni-muenster.de

Full Name	Hiro Ejiri
Institution	Department of Physics, Osaka University
Position	Professor
Address	Machikaneyama, Toyonaka, Osaka, 560-0043
Phone number	+81-6-6879-8908
FAX number	+81-6-6879-8899
E-mail	ejiri@rcnp.osaka-u.ac.jp

EXPERIMENTAL GROUP:

Full Name	Institution	Title or Position
T. Adachi	RCNP, Osaka University	Researcher
H. Ejiri	RCNP, Osaka University	Professor (Em.) & Science Advisor JASRI
D. Frekers	IKP, Univ. Münster, Germany	Professor
H. Fujita	RCNP, Osaka University	Researcher
K. Fujita	RCNP, Osaka University	D4
Y. Fujita	Dept. of Physics, Osaka University	Associate Professor
M. Fujiwara	RCNP, Osaka University	Associate Professor
C. Guess	MSU/NSCL, East Lansing, Michigan, USA	Grad. Student
K. Hatanaka	RCNP, Osaka University	Professor
P. Heinrichs	IKP Univ. Münster, Germany	PhD Student
T. Ruhe	IKP Univ. Münster, Germany	PhD Student
Y. Sakemi	RCNP, Osaka University	Associate Professor
Y. Shimbara	Niigata University, Japan	Ass. Professor
Y. Shimizu	RCNP, Osaka University	Post-doc
Y. Tameshige	RCNP, Osaka University	D3
J. H. Thies	IKP, Univ. Münster, Germany	PhD Student
T. Wakasa	Dept. Physics, Kyushu University	Associate Professor
M. Yosoi	RCNP, Osaka University	Associate Professor
R. Zegers	MSU/NSCL, East Lansing, Michigan, USA	Assistant Professor
2 Master Students	IKP, Univ. Münster, Germany to be named at a later stage	

RUNNING TIME:

^{130}Te data taking runs	5.5 shifts
Measurement time with calibration target ^{128}Te	2 shifts
Measurement time with calibration target ^{nat}Te	1.5 shifts
Beam tuning and beam preparation time	3 shifts
Total	12 shifts

BEAM LINE: Ring : WS course

BEAM REQUIREMENTS:

Type of particle	^{3}He
Beam energy	420 MeV
Beam intensity	20 nA
Energy resolution	$\Delta E \leq 100$ keV, small emittance

BUDGET: Support to the PhD students and Postdocs from Münster for their stay in Japan of about week. Local support for non-RCNP participants

SCHEDULE: We request the beam time preferentially in the period from end of 2008 to middle of 2009.

1 Summary of Experiment

• **Proposed experiment:** We propose to measure the GT$^-$ strength distribution in the reaction ^{130}Te(^{3}He,t)^{130}I with highest possible resolution. The GT$^-$ strength defines one of the two "legs" for the $2\nu\beta\beta$ decay, but also enters into the dynamics of the neutrinoless decay. The nucleus ^{130}Te is one of the key nuclei that are presently at the center of $\beta\beta$ decay studies.
The results of this experiment will therefore furnish important information about the nuclear physics relevant for $\beta\beta$ decay. This information will directly feed into model calculations, which are aimed at describing reliably the nuclear physics (i.e. the $\beta\beta$ decay matrix elements) around both decay variants, the $2\nu\beta\beta$ decay and the $0\nu\beta\beta$ decay. One must note that the level of confidence with which a neutrino mass can be extracted in case the neutrinoless decay is observed in one of the present counting experiments like COBRA or CUORE will ultimately be determined by these calculations.
Charge-exchange data on ^{130}Te are already available from (p,n) experiments at IUCF, however, at a rather poor resolution of about 330 keV. A high energy resolution of the order of 30 keV, which can presently only be obtained at the RCNP facility, allows a precise determination of the GT strength distribution, as was shown in several previous publications by various members of this group. The high resolution can give significant insight into the details of the nuclear structure, like e.g. the effect of the intrinsic deformation of the mother and grand-daughter nucleus on the structure of matrix elements. Here, a strong effect was observed in the case of ^{48}Ca or recently even more enhanced in the case of ^{76}Ge (from our expmt E294 in Dec-07). Further, it may be important to understand if the concentration of the low-energy $B(GT)$ strength within a single strong transition, as was observed in the case of ^{96}Zr and ^{100}Mo (from E294 in Dec-07), is a somewhat general feature of nuclei with masses $A \sim 100$ or above. Clearly, these effects have significant bearing on the $\beta\beta$ decay rate.

• **Apparatus and beam properties:** The proposal asks for a 140 MeV/nucleon ^{3}He beam from the RCNP Ring Cyclotron. The Grand Raiden spectrometer and the standard focal plane detection system will be used for the detection of outgoing tritons. The momentum and angular dispersion matching technique will be employed to achieve a high momentum and high angle resolution. The over-focus mode of the spectrometer is essential for good angular resolution in vertical direction and, moreover, for correcting kinematic aberrations. We have seen in the E220 experiment on ^{48}Ca and in the E294 experiment on ^{76}Ge, ^{96}Zr and ^{100}Mo that an angular distribution up to 4° can be obtained by measuring at two angle settings, one at 0° and one at 2.5°. This is sufficient to unambiguously identify GT transitions leading to 1^+ levels. We request $\approx$ 20 nA single-turn extracted ^{3}He beam of good quality. In order to realize various matching conditions, the capabilities of the WS course will be employed.

• **Target:** High-resolution (^{3}He, t) measurements demand that the effect of energy spread in the target be minimized. The energy spread in the target is mainly caused by the energy losses of ^{3}He and t particles, and thus, a sufficiently small target thickness is important. A thin ^{130}Te target of about 1 mg/cm^2 together with thin $^{\mathrm{nat}}$Te and ^{128}Te for absolute calibration runs of $B(GT)$ values will be made available by the Münster group. The relevant expertise is locally available in Münster.

• **Beam time request:** The requested beam time consists of (1 shift equals 8 hrs): (1)^{130}Te target runs: **5.5 shifts**, (2) calibration runs with $^{\mathrm{nat}}$Te and ^{128}Te: **3.5 shifts**, (3) beam tuning time: **3 shifts**.

• **Schedule:** We request beam time in the period from end of 2008 to middle of 2009.