

**E357**

## PROPOSAL FOR EXPERIMENT AT RCNP

July 8, 2010

**High resolution study of the  $^{136}\text{Xe}(^3\text{He},t)^{136}\text{Cs}$   
reaction at 420 MeV and  $\beta\beta$  decay matrix elements****SPOKESPERSON(s):**

Full Name D. 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 H. Ejiri  
Institution Research Center for Nuclear Physics (RCNP), Osaka University  
Position Professor  
Address 10-1 Mihogaoka, Ibaraki, Osaka, 567-0047, Japan  
Phone number +81-6-6879-8908  
FAX number +81-6-6879-8899  
E-mail ejiri@rcnp.osaka-u.ac.jp

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

## EXPERIMENTAL GROUP:

Full Name	Institution	Title or Position
T. Adachi	RCNP, Osaka University and KVI Groningen	Researcher
H. Akimune	Konan University	Associate Professor
H. Ejiri	RCNP, Osaka University	Professor (Emeritus) & Visiting Professor CTU Prague
D. Frekers	IKP, Univ. Münster, Germany	Professor
H. Fujita	RCNP, Osaka University	Researcher
Y. Fujita	Dept. of Physics, Osaka University	Associate Professor
M. Fujiwara	RCNP, Osaka University	Associate Professor
E. Ganioglu	Istanbul University	Assistant Professor
K. Hatanaka	RCNP, Osaka University	Professor
M. Harakeh	KVI Groningen	Professor
P. Heinrichs	IKP Univ. Münster, Germany	PhD student
A. Lennarz	IKP Univ. Münster, Germany	PhD student
H. Matsubara	CNS, Tokyo University	Post-doc
P. Puppe	IKP Univ. Münster, Germany	PhD student
Y. Sakemi	RCNP, Osaka University	Associate Professor
Y. Shimbara	Niigata University, Japan	Ass. Professor
G. Susoy	Istanbul University	PhD student
T. Suzuki	RCNP, Osaka University	Assistant Professor
A. Tamii	RCNP, Osaka University	Associate Professor
J. H. Thies	IKP, Univ. Münster, Germany	PhD student
T. Wakasa	Dept. Physics, Kyushu University	Associate Professor
M. Yosoi	RCNP, Osaka University	Associate Professor
Y. Yasuda	RCNP, Osaka University	Post-doc
R. Zegers	MSU/NSCL, East Lansing, Michigan, USA	Associate Professor
J. Zenihiro	RCNP Osaka University	Post-doc
2 Master Students	IKP, Univ. Münster, Germany to be named at a later stage	

<b>RUNNING TIME:</b>	$^{136}\text{Xe}$ data taking runs	10.5 shifts
	Measurement of background/ empty gas cell	10.5 shifts
	Beam tuning time	3 shifts
	Total	24 shifts

**BEAM LINE:** Ring : WS course

### BEAM REQUIREMENTS:

Type of particle	$^3\text{He}$
Beam energy	420 MeV
Beam intensity	20 pA
Energy resolution	$\Delta E \leq 50$ keV, small emittance

**BUDGET:** Support to the PhD students and post-docs from Münster for their stay in Japan of about two weeks. Local support for non-RCNP participants.

**SCHEDULE:** We prefer beam time in the December (Christmas) period of 2010 or 2011.

# 1 Summary of Experiment

- **Proposed experiment:**

We propose to measure the  $^{136}\text{Xe}(^3\text{He}, t)^{136}\text{Cs}$  charge exchange reaction at 420 MeV using the RCNP WS course and the Grand Raiden spectrometer. The measured  $1^+$  excitation energies and their  $\text{GT}^-$  strengths will furnish important information about the  $2\nu\beta\beta$  nuclear matrix element and will shed light on why the  $2\nu\beta\beta$  decay rate of  $^{136}\text{Xe}$  is so excessively small. In fact, the  $2\nu\beta\beta$  decay has so far evaded detection and the presently accepted lower limit of its lifetime is  $T_{1/2}^{2\nu} \geq 8.5 \cdot 10^{21}$  yr (90% C.L.) [1].  $\text{GT}$  and low-lying  $l = 1$ , (i.e.,  $2^-, 1^-, 0^-$ ) transitions will be hunted for in this experiment. Whereas the former is important foremost for the  $2\nu$  decay, the latter can furnish information about the neutrinoless decay as well. We note that there is not even a single level known in the intermediate nucleus  $^{136}\text{Cs}$ . Any information about the level structure and the transition strength is highly warranted, especially in view of upcoming  $\beta\beta$  decay counting experiments like, e.g. EXO [2, 3]. We hope that the present measurement provides information about the  $2\nu\beta\beta$  matrix element of  $^{136}\text{Xe}$  (despite the missing second "leg" of the nuclear matrix element), and further give guidance to theoretical models for the  $0\nu\beta\beta$  decay.

At the RCNP facility the measurement can be done with the world's best resolution of about  $\approx 30$  keV. We propose to use the existing gas target for this experiment, which was recently successfully put into operation at RCNP. It will be filled with isotopically enriched  $^{136}\text{Xe}$  up to about 0.5 bar, giving a thickness of about  $2 \text{ mg/cm}^2$ . Previous experiments with this target have demonstrated that a resolution of order 40 keV can be obtained.

- **Apparatus and beam properties:** We ask for a 140 MeV/nucleon  $^3\text{He}$  beam from the RCNP Ring Cyclotron with an intensity of 20 pA (single turn extraction). Matching conditions for optimum momentum and angle resolution will be set up by using the WS course line. The Grand Raiden spectrometer will be operated in over focus mode to ensure highest acceptance. Two angle settings, at  $0^\circ$  and  $2.5^\circ$ , are sufficient for  $J^\pi$  identification of relevant transitions. The standard focal-plane detection system will be used for track identification of scattered tritons. An improved drift-chamber decoding software has been developed by the Münster group to be used for off-line analysis.

- **Target:** A new target gas cell with a remote gas handling system will be employed. The target thickness of about  $1 - 2 \text{ mg/cm}^2$  of  $^{136}\text{Xe}$  will ensure an acceptable counting rate at a good energy resolution. Since the gas cell windows are constructed of aramid foils (containing C,N,O and Cl, thickness 4 - 6  $\mu\text{m}$ , equiv. to 0.6 - 0.9  $\text{mg/cm}^2$  for each window), which could produce a significant background, a meaningful measurement requires empty cell runs with approximately equal integrated charge on target. A member of the University of Münster (P. Puppe) has recently participated in a gas target run at RCNP (experiment E328) to gain expertise in the operation of the system and has since provided an operation manual to the users. Enriched  $^{136}\text{Xe}$  gas (1-2 liter at 1 bar) will be supplied by the University Münster.

- **Beam time request:**

The total requested beam time consists of (1 shift corresponds to 8 hrs)

- (1) measurements of the  $^{136}\text{Xe}$  gas target : 10.5 shifts,
- (2) measurements of the empty gas cell : 10.5 shifts,
- (3) beam tuning time : 3 shifts.

- **Schedule:**

We prefer beam time in the December (Christmas) period of 2010 or 2011.