Advanced Research Center for Beam Science
– Particle Beam Science –

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Assoc Prof
IWASHITA, Yoshihisa
(D Sc)

Techn Staff
TONGU, Hiromu

Researchers (pt)

KAZAMA, Ichiro
CENNI, Enrico (Ph D)

Lect (pt)

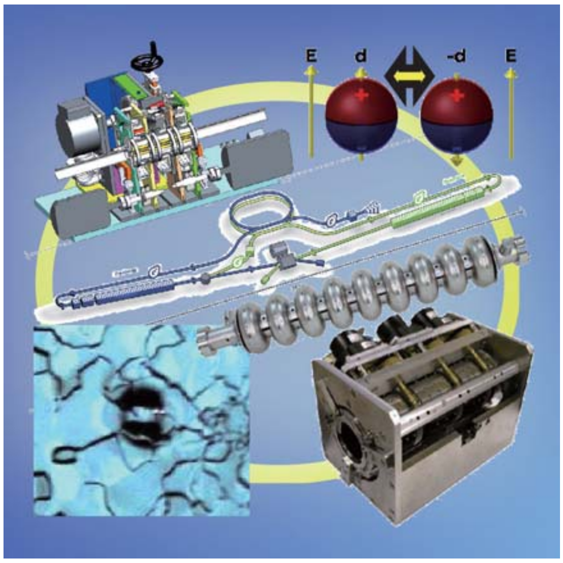
SHIMIZU, M. Hirohiko (D Sc) Laboratory for Particle Properties, Department of Physics, Nagoya University

Students

IMAJO, Sohei	(D3)	KITAHARA, Ryunosuke	(D1)
FUWA, Yasuhiro	(D2)	IKEDA, Hideki	(M2)

Scope of Research

Particle accelerators have been contributing on progress of science in a variety of fields. Among these fields, our current activity covers neutron science and participation in International Linear Collider (ILC) project. Including subsidiary subjects, the following subjects are being studied: neutron beam focusing by modulating sextupole magnets, neutron acceleration/deceleration, compact neutron source including ion source, permanent quadrupole magnets for final focusing of ILC, nondestructive inspections for superconducting accelerating tube towards higher yield and performance and multi layered film structure for RF.



KEYWORDS
Beam Physics
Accelerator Physics
Neutron Optics
Phase Rotation
International Linear Collider

Selected Publications

Arimoto, Y.; Geltenbort, P.; Imajo, S.; Iwashita, Y.; Kitaguchi, M.; Seki, Y.; Shimizu, H. M.; Yoshioka, T., Demonstration of Focusing by a Neutron Accelerator, *Phys. Rev. A*, **86,** 023843 (2012).
Yamada, M.; Iwashita, Y.; Kanaya, T.; Yamada, N. L.; Shimizu, H. M.; Mishima, K.; Hino, M.; Kitaguchi, M.; Hirota, K.; Geltenbort, P.; Guerard, B.; Manzin, G.; Andersen, K.; Lal, J.; Carpenter, J. M.; Bleuel, M.; Kennedy, S. J., A Compact TOF-SANS Using Focusing Lens and Very Cold Neutrons, *Physica B: Condensed Matter*, **406(12),** 2453-2457 (2011).
Arimoto, Y.; Yoshioka, T.; Shimizu, H. M.; Mishima, K.; Ino, T.; Taketani, K.; Muto, S.; Kitaguchi, M.; Imajo, S.; Iwashita, Y.; Yamashita, S.; Kamiya, Y.; Yoshimi, A.; Asahi, K.; Shima, T.; Sakai, K., Longitudinal-gradient Magnet for Time Focusing of Ultra-cold Neutrons, *Physics Procedia*, **17,** 20-29 (2011).
Iwashita, Y.; Ichikawa, M.; Yamada, M.; Sugimoto, T.; Tongu, H.; Fujisawa, H.; Masuzawa, M.; Tauchi, T.; Oku, T.; Hirota, K.; Shimizu, H. M.; Zhu, C.; Shi, Y., Practical Applications of Permanent Magnet Multipoles, *IEEE Trans. on Applied Supercond.*, **20(3),** 842-845 (2010).
Iwashita, Y.; Tajima, Y.; Hayano, H., Development of High Resolution Camera for Observations of Superconducting Cavities, *Phys. Rev. S.T. -Accel. Beams*, **11,** [093501-1]-[093501-6] (2008).

Production of Pulsed UCN in J-PARC MLF

Ultracold neutrons (UCNs) are neutrons whose kinetic energies are lower than 240 neV. The de Broglie wavelength of UCN is longer than 58 nm. UCN interacts with a spatially averaged step-like potential of millions of nuclei. Therefore UCN can be stored in a vessel with interior surface made of the materials whose averaged potential is higher than the kinetic energy of UCN. UCN is used for longtime storage experiments such as searches of the neutron electric dipole moment (nEDM) or measurements of the neutron lifetime.

UCNs can be produced with a neutron Doppler shifter, which reflects neutrons by a neutron mirror rotating with the half tangential velocity of the target neutrons and decelerates them into the UCN region by the Doppler effect. We have developed the Doppler shifter in order to carry out the R&D of the apparatus for our nEDM searches or other UCN experiments in Japan. It is installed in the BL05 of Materials and Life Science Experimental Facility (MLF) at J-PARC (Figure 1).

We have succeeded in producing pulsed UCNs by decelerating the neutrons of 136 m/s in 2010 and have obtained the UCNs of 0.17 cps at 113.2 kW beampower. The repetition frequency of UCN production is 8.33 Hz. However, this output of UCNs was too weak for the R&D. Hence we tried to improve the output of UCNs by increasing the flux of the neutrons injected into the Doppler shifter.

We newly installed the supermirror guides and focusing guides in a neutron beamline and inserted the nickel-coated UCN extracting guide in the Doppler shifter. As a result, the UCN count rate became 48 cps at the beam power of 300 kW. Their count rate increased about 34 times and the count rate of UCNs increased about 80 times in the same beampower and detection efficiency. Considering the beampower increase of J-PARC, the count rate of UCNs increased to about 250 times (Figure 2).

By using the Doppler shifter, we have already started the R & D of the apparatuses for our nEDM searches, for example, the UCN transport experiment with nickel-coated UCN guides, whose length is 5.6 m and the mean reflectivity at one reflection is evaluated to be 97 % (Figure 3). At present we are developing the UCN accelerator, which produces high density UCNs by time focus, and planning the experiment of the performance evaluation of the accelerator by using the Doppler shifter and the UCN guides (Figure 4).

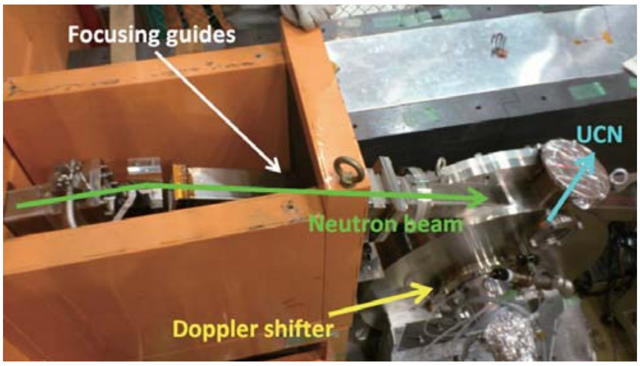


Figure 1. Layout of the Doppler shifter and the focusing guides.

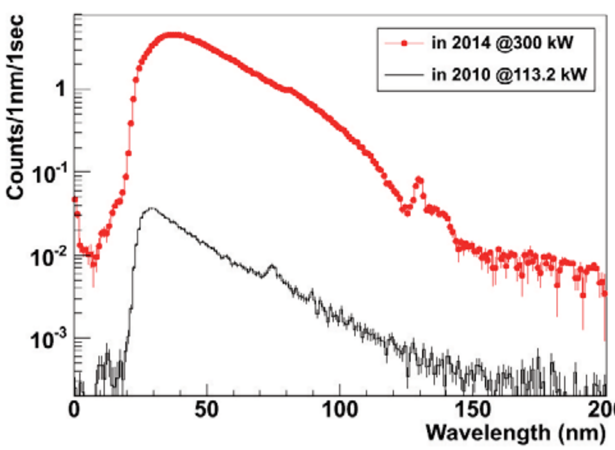


Figure 2. UCN spectra from the Doppler shifter before and after improvement.

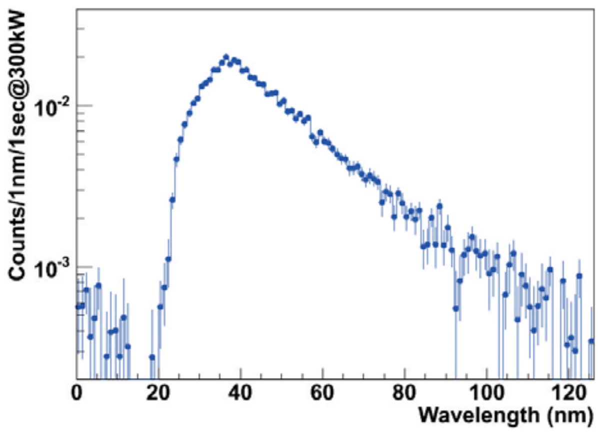


Figure 3. Result of the UCN transport experiment. We succeeded in measuring the UCN spectrum through the UCN guides of 5.6 m length.

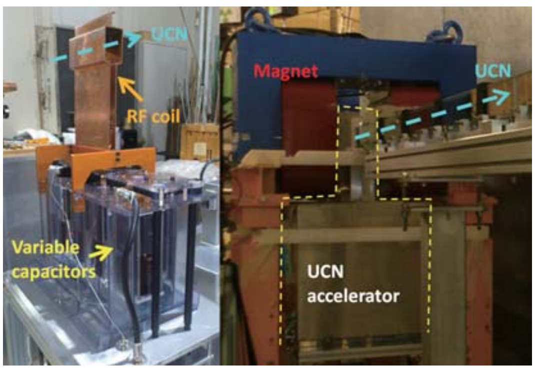


Figure 4. Photograph of the inner machinery of UCN accelerator (left) and experimental setup (right).