Activity of the Experimental Group at the RCNP Cyclotron Facility 2012

Research subjects of the experimental group at the RCNP Cyclotron Facility cover various fields of nuclear physics, fundamental physics, engineering, nuclear chemistry, and nuclear medicine. Eight permanent staff members, visiting professors, postdocs and graduate students are leading the projects in collaboration with various groups from universities and institutes in Japan and overseas. Student experiments for Osaka University and other universities are also performed. Our activities in 2012 are briefly introduced below.

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Pygmy Dipole Resonance:

Concentration of electric dipole (*E1*) strength in the vicinity of the neutron threshold has recently been found in several stable and unstable heavy nuclei. The strength is called the low-energy dipole strength or the Pygmy Dipole Resonance (PDR) in relation to the theoretical predictions of the dipole oscillation of the neutron skin against the isospin-saturated core. The PDR strength has been studied by applying the proton inelastic scattering at forward angles employing the high-resolution spectrometer Grand Raiden. The PDR strength in ^{90}Zr has been clearly separated from the spin-M1 contribution (Fig. 1) [1]. Concentration of the skin-oscillation type transition density is also found in ^{208}Pb [2].

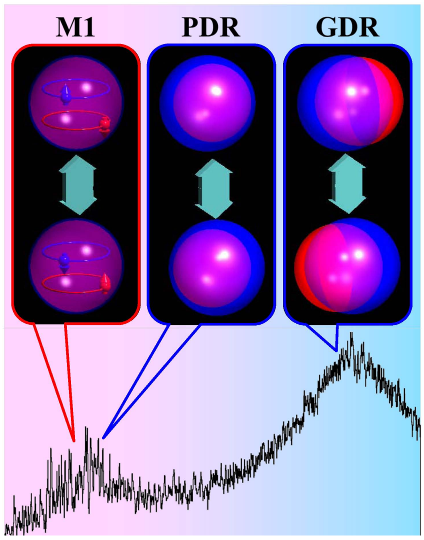

Fig.1: Observation and separation of PDR and spin-M1 contributions in the lower excitation energy bump in ^{90}Zr [1].

Gamow-Teller Strength and the double-beta decay matrix element

The Gamow-Teller strength distribution has been determined by (^{3}He,*t*) charge-exchange rations on ^{136}Xe [3], ^{71}Ge [4], ^{76}Ge [5], ^{128,130}Te [6], ^{100}Mo [7] and ^{96}Zr [8]. The data are important to study the double-beta decay nuclear matrix-elements as well as the charged-current reaction cross sections of neutrino detectors.

EN course

Extension of the radio-isotope beam line, the EN course, for a new F3 focal plane formally took off in 2012,

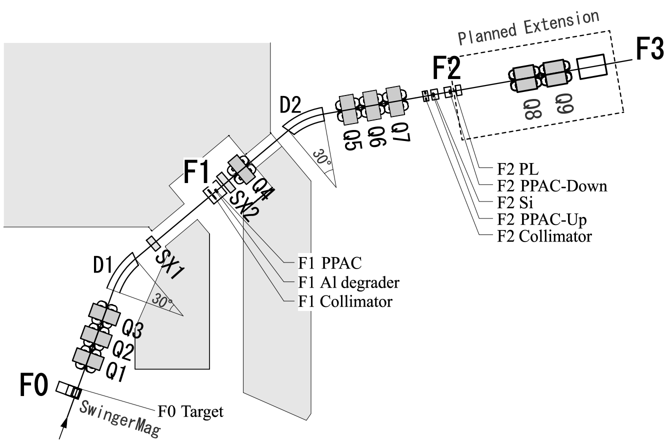

Fig. 2: Layout of the EN course.

thanks to the kind donation of two quadrupole magnets by RIKEN Nishina Center. The extended beam line was completed at the end of the 2012 fiscal year, and will be commissioned in the early 2013 fiscal year. Meanwhile, a MUlti-Sampling Ion Chamber (MUSIC) for the measurements of charge-changing cross sections to determine the proton-distribution radii of neutron-rich light *p-sd* nuclei was completed and tested. The extended beam line and the MUSIC detector will help open up new opportunities for RI beam experiments at the EN course.

Ultracold Neutron:

Ultracold neutrons (UCN), which are extremely slow neutrons and can be confined in a vessel, are useful for fundamental physics experiments like a precise measurement of neutron electric dipole moment (EDM). Subsequently to the first UCN source [9], the much higher intensity UCN source is being developed by the KEK-RCNP UCN group (Fig.3). In this new UCN source, fast neutrons are produced by a spallation reaction induced by 400 MeV protons on a tungsten target. These fast neutrons are moderated to cold neutrons in the 300K and 10K heavy water (D_2O) moderators. Then, the cold neutrons are converted to UCN in superfluid helium (He-II). In 2012, the D_2O cryostat of the new UCN source has been constructed. We succeeded in producing cold neutrons with the D_2O moderators.

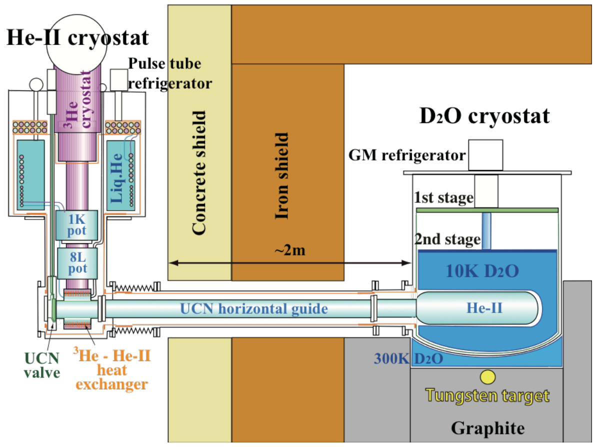

Fig.3: Schematic structure of the new UCN source.

MuSIC:

Muon yields at the end of the 36 degrees solenoid channel were measured. The yields (~10^8muons/sec/μA) show good agreement with the simulated results. Then the system was successfully operated with a higher power (1 μA) proton beam. From these results, we confirmed that the MuSIC works as designed. The feasibility study of muon capture isotope detection has been performed experimentally by using capture reactions on Mo isotopes at MuSIC [10].

Nuclear chemistry and Nuclear medicine

Recently, positron emission tomography (PET) has been remarkably developed for visualizing the distribution of a radionuclide in the human and animal's body. Now the PET is widely used for the diagnosis of cancer. Clinical application of the PET has been made possible with the development of ingenious techniques for rapid synthesis of radiopharmaceuticals, suitable for in vivo studies, using cyclotron within a medical complex. We produced many positron-emitting radioisotopes for nuclear medicine and other radioisotopes for nuclear chemistry by using the AVF cyclotron. The schematic flow of the preparation of the labeled compound used for PET is shown as follows. The ^{62}Zn and ^{124}I were produced by the ^{63}Cu(p,2n)^{62}Zn and ^{124}Te(p,n)^{124}I reactions for PET, furtherαemitter ^{211}At by the ^{209}Bi(α,2n)^{211}At reaction was examined for radiation therapy.

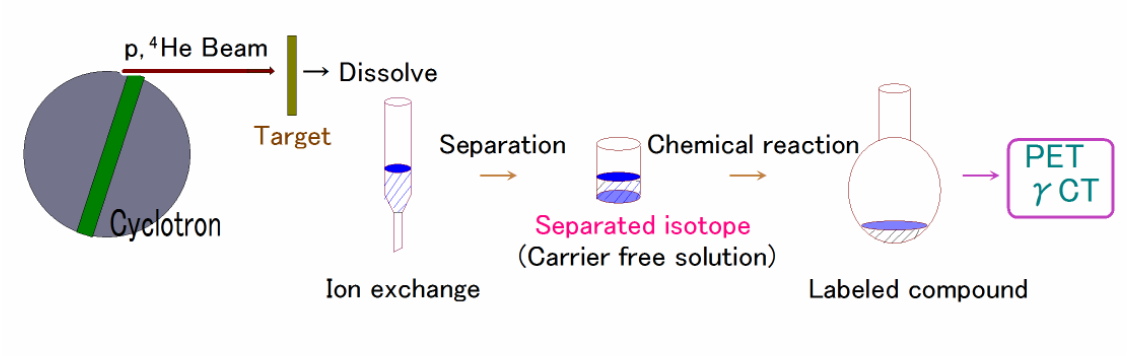

Fig. 3: Schematic flow diagram of the preparation of the labeled compound for PET.

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