Present Status of the High Intensity Fast Neutron Beam Facility

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journal or publication title	CYRIC annual report
volume	2009
page range	22-24
year	2009
URL	http://hdl.handle.net/10097/50481

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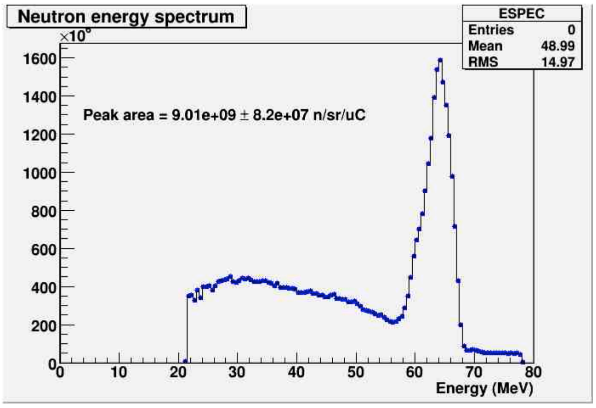
The improvements of the beam line to test the radiation damage of the integrated circuits of the CPU, FPGA (Field Programmable Gate Array), and different kinds of memories such as the S-RAM and D-RAM etc, were continued. The two beam lines are ready for the radiation damage test of the semiconductors; one is the beam line (32 course) to supply the high intensity neutron beam, and another is the beam line (33 course located at the TR3) to supply the ion beam. These beam lines were used by many semiconductor developing companies, typically once or twice a month, so we need to improve the beam quality and intensity, the experimental support structures for the users to be able to install the target materials such as the semiconductors, CPU boards, and servers easily to realize the smooth experimental preparation and efficient irradiation experiments. In this report, we will describe the present status of the neutron beam line.

The quasi-monoenergetic neutron beam is produced with the charge exchange reaction such as (p,n) reaction using the thick ^{7}Li target. We have already obtained the high intensity neutron beam with the energy over than 11 MeV up to 66 MeV. The maximum neutron flux with 1×10^{6} n/(cm^{2} • s • μA) was achieved at the primary proton energy of 70 MeV. The obtained typical neutron spectrum is shown in Fig. 1. The Li target with the thickness of 8 mm is used in the standard experiment. We can use the thicker target to increase the beam flux, although the neutron beam energy resolution becomes worse. In this year, we tried to get the quasi-monoenergetic neutron beam with lowest energy such as 11 MeV. The obtained neutron beam energy distribution is shown in Fig. 2. We can see the two peaks, where higher energy peak can be interpreted as the real neutron from the ^{7}Li(p,n)^{7}Be reaction, but another peak can not be understood still. We need to understand this beam energy distribution to get the low energy quasi-monoenergetic neutron beam from 930 AVF cyclotron, or another option is to use the FNL.

This beam line is originally designed to supply the high intensity neutron beam, but this course is also utilized to supply the high intensity proton beam to study the radiation damage of the silicon detector, since this beam course was configured with a straight line from the exit of the AVF cyclotron, and the ion optics for the primary beam transport is simple and it is expected that there is almost no beam loss along the beam line. However we need to be careful for the radiation in the experimental room when we extract the primary proton beam from the vacuum chamber to the external area. Then, we also prepared the new movable beam dump system consisting of the concrete blocks and irons to stop and collect the extracted proton beam efficiently by setting the dump near the beam extraction window. By this new beam dump system, we can minimize for the air to be exposed to the radiation in the nuclear reaction area. Also we set the ozone monitor to protect the human health when the people prepare the experiment during and after the proton irradiation experiment.

The data acquisition system (DAQ) was also upgraded. The measurement of the neutron flux is important for the accurate determination of the memory soft error. The error rate becomes decreased gradually, as the production process and package structure of the integrated circuits and the semiconductor material itself are modified to protect the radiation damage. This means that the low dead time DAQ system is required, since it is necessary to know the accurate error rate with limited beam time. So we have upgraded the DAQ system as shown in Fig. 3 to measure the high neutron flux with the neutron counter consisting of the liquid scintillaters, NE213. The new system is based on the standard CAMAC readout system, and the DAQ software is prepared by modifying the "nagiDAQ" system developed by K. Shouji at Kyoto Univ. To check the neutron flux, we compared it with new DAQ system and also the existing system which have been used so far. It became clear that there is no difference on the measured flux between new and existing DAQ system, so we will move to the new system gradually. Also the slow control system is upgraded to realize the user friendly interface to control the vacuum pumps, beam line slits, and other devices with LabVIEW.

The new DAQ and control system are used with the stable operation during the long irradiation experiment at present. In the next step, we need to get the smaller sized neutron beam to confine the irradiation area more precisely, and the further user friendly interface to start/stop the beam and control the devices need to be prepared.



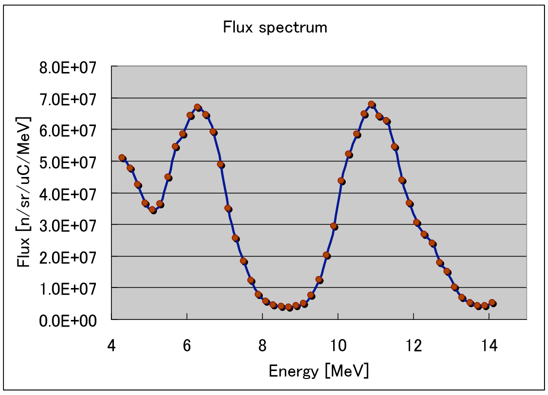


Figure 1. The typical neutron energy spectrum with the proton beam energy at 70 MeV. The obtained energy resolution with FWHM is about 6 MeV measured by Time of Flight (TOF) method.

Figure 2. The energy distribution of the neutron beam with 11 MeV.

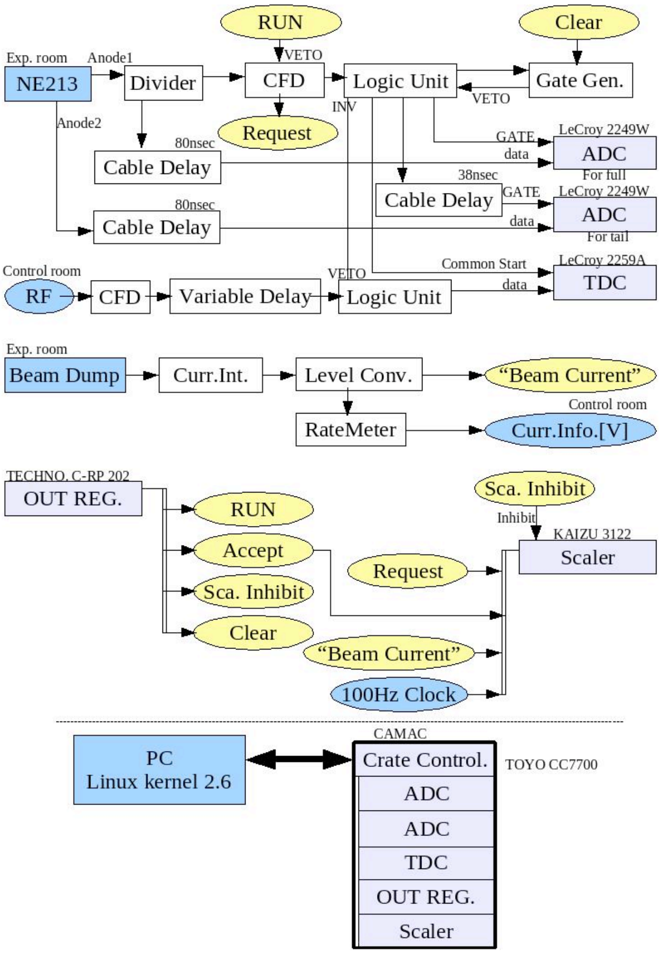


Figure 3. The configuration of the new DAQ system.