TOF Measurement of Cold Neutrons from D_2O Moderator

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We have been developing a high intensity ultracold neutron (UCN) source where superfluid helium (He-II) is used as a UCN converter. A UCN density of 26 UCN/cm^3 at the critical energy of 90 neV was achieved at the exit of the UCN source, which was the world competitive value [1].

Toward the measurement of the neutron electric dipole moment (nEDM), we are developing a new He-II UCN source at RCNP. Figure 1 shows the schematic structure of the new UCN source. In the new source, fast neutrons are produced by a spallation reaction of a tungsten target and a 400 W proton beam. These fast neutrons are moderated to cold neutrons in a room temperature heavy water (D_2O) and a 10 K solid D_2O. The cold neutrons are converted to UCN by phonon scattering in He-II. The produced UCN are extracted through the horizontal UCN guide connected to the He-II bottle. The main improvement is horizontal extraction of UCN, which will give us much more UCN density than the previous UCN source.

We firstly developed the room temperature and 10 K D_2O moderators and measured TOF of the cold neutrons from the D_2O moderators. We filled the solid D_2O bottle with about 120 liters of D_2O and solidified them by cooling with a Gifford-McMahon refrigerator. The D_2O solidification needed about one week. After that, the solid D_2O was cooled down to 5 K in about a week. After the cooling to 5 K, we bombarded the tungsten target with a proton beam from the ring cyclotron at RCNP, and moderated the produced fast neutrons to cold neutrons in the D_2O moderators. The cold neutrons are measured by two ^{3}He neutron detectors installed outside the iron and concrete shields. The near detector was installed at a distance of 2.7 m from the core of the D_2O moderators, and the far detector was at 5.2 m from the core.

Figure 2 shows the observed cold neutron counts as a function of time. The proton beam was irradiated for 100 μs. The peak of the neutron counts observed by the near detector was at 1.8 ms, and the peak of the far detector was at 3.3 ms. The neutron TOF between the near and far detectors was $3.3 - 1.8 = 1.5$ ms. Since the distance between them was 2.5 m, the average neutron velocity was roughly estimated to be 2.5 m/1.5 ms $= 1.7 \times 10^3$ m/s, which corresponded to a neutron temperature of 170 K.

Then, the solid D_2O temperature was changed to 15, 40 and 60 K. While the cold neutron counts did not almost change below 40K, the neutron counts around 1 meV where cold neutrons are efficiently converted to UCN decreased at 60K. It was suggested that the solid D_2O temperature should be below 40K.

Now we are developing the He-II cryostat. Our next plan is to couple the He-II cryostat with the D_2O moderators and produce UCN in He-II.

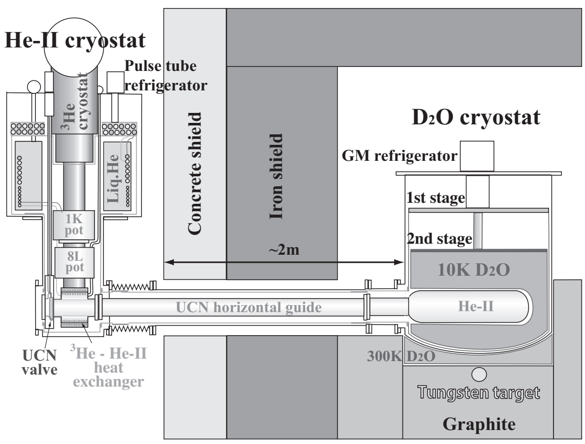

Figure 1: Scheme of the new UCN source.

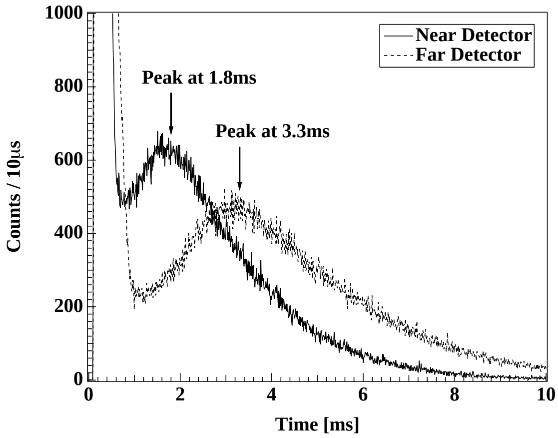

Figure 2: Cold neutron counts observed by the near and far detectors.

References

[1] Y. Masuda *et al.*, Phys. Rev. Lett. **108**, 134801 (2012).