ICANS-XIII
13th Meeting of the International Collaboration on
Advanced Neutron Sources
October 11-14, 1995
Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

HIGH-EFFICIENCY CRYOGENIC MODERATOR SYSTEM FOR SHORT PULSE COLD-NEUTRON USE

Y. Kiyanagi, N. Kosugi, Y. Ogawa, H. Iwasa, F. Hiraga, M. Furusaka* and N. Watanabe*

Faculty of Eng., Hokkaido University, Kita-13 Nishi-8 Kita-ku, Sapporo 060, Japan

*National Laboratory for High Energy Physics, Oho 1-1, Tsukuba-shi 305, Japan

ABSTRACT

Two kinds of methods were examined to improve pulse shapes of cold neutrons from a coupled liquid-hydrogen moderator with a premoderator. One is to decouple a premoderator from the reflector and the other is to use a poisoned premoderator. In the former case, the pulse shapes became narrower with a slight decrease of pulse peak height by reducing the premoderator thickness. The pulse shape was further improved by using a poisoned premoderator.

1. Introduction

Broader pulses from a coupled-liquid hydrogen moderator with a premoderator are quite acceptable for the majority of cold neutron experiments such as small angle scattering, reflectometry, etc., because the figure of merit (FOM) of source, in this case, is proportional to the time-integrated intensity of cold neutrons per pulse within a realistic range of repetition rate[1]. On the other hand for high-resolution spectroscopy using an inverted-geometry type spectrometer, the FOM of the source is proportional to the peak height, independent of pulse width and repetition rate, provided that a neutron guide of the required length is available between moderator and sample[1]. However, from a practical point of view, a long guide tube (say more than 200 m) may not be acceptable. A moderator which can provide a narrower pulse without sacrificing the peak height, then becomes preferable. From extensive measurements, we found that the pulse characteristics can be controlled to some extent by decoupling the composite moderator system (liq.H_2+premoderator) from the reflector[2].

We performed further optimization studies on a decoupled composite moderator system by changing premoderator thickness. A poisoned premoderator was also proposed and tested.

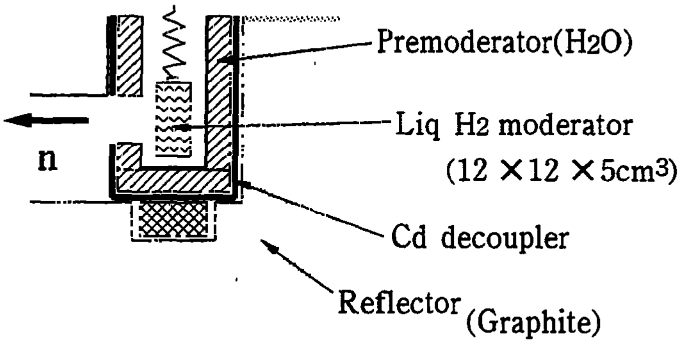
2. Experimental

The moderator systems used in the present measurements are shown in Fig. 1. Fig. 1(a) is a composite moderator with a decoupled premoderator and (b) a poisoned premoderator. The measuring system is essentially the same as that used in the previous measurements[3]. The moderator system consists of a liquid-hydrogen moderator (12x12x5 cm^3) surrounded by a light-water premoderator of various thicknesses at ambient temperature coupled or decoupled to a graphite reflector of about 1 m^3. A 0.5 mm thick Cd plate was used for both the decoupler and the interleave poisoning plate. As a pulsed neutron source, the electron linac at Hokkaido University was used with a lead target.

3. Experimental Results

Keywords: Pulsed neutrons, Cold neutrons, Liquid hydrogen, Short pulses

(a) Decoupled premoderator



(b) Poisoned premoderator

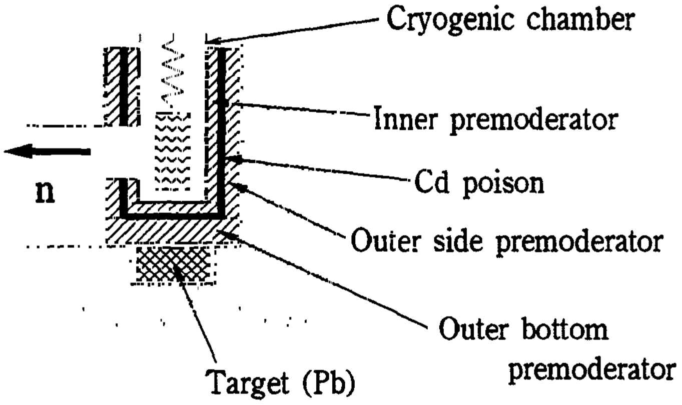


Fig. 1 Composite moderator with a decoupled premoderator (a), and with a poisoned premoderator (b).

Figure 2 compares the pulse shapes of cold neutrons at 3.94 Å and 6.57 Å from the moderator with three premoderator thickness, 1, 2 and 3 cm. The pulse shapes from the eference coupled composite moderator (5 cm thick Liq-H_2 + 3 cm thick H_2O premoderator) are also plotted for comparison. The pulse width in full width at half maximum, FWHM, from the decoupled one is considerably improved with a small sacrifice of the peak intensity. The long time tails are also improved to some extent.

Next, we studied some moderator system with poisoned premoderators (see Fig. 1 (b)). In these measurements, we studied two inner premoderator thicknesses of 0.5 and 1.0 cm, by changing the outer premoderator thickness. By removing the outer side premoderator but leaving the outer bottom premoderator, the intensity was increased by about 5%. This is due to the fact that since the neutrons entering liquid hydrogen from the sides are well moderated, outer side premoderator simply acts as an attenuater, while the outer bottom premoderator is still effective for providing low energy neutrons to liquid hydrogen.

Therefore, we removed the side premoderator and changed the thickness of the outer bottom premoderator. Figure 3 shows integrated intensity of cold neutrons in the range of 4.3-5.7 Å as a function of outer bottom premoderator thickness for two different inside premoderator thicknesses. The intensities increase slightly with increasing outer premoderator thickness (almost unchanged). As a reference the intensity from the moderator with 1 cm inner and 1 cm outer premoderator (namely 1 cm outer side premoderator was attached) is also depicted in the figure as a dot.

We performed pulse shape measurements on the moderator with a 0.5 cm thick inner and 1.0 cm thick outer bottom premoderator. We chose 0.5 cm thick inner premoderator since this will give narrower pulse width than the 1.0 cm one and we placed only the 1.0 cm thick outer

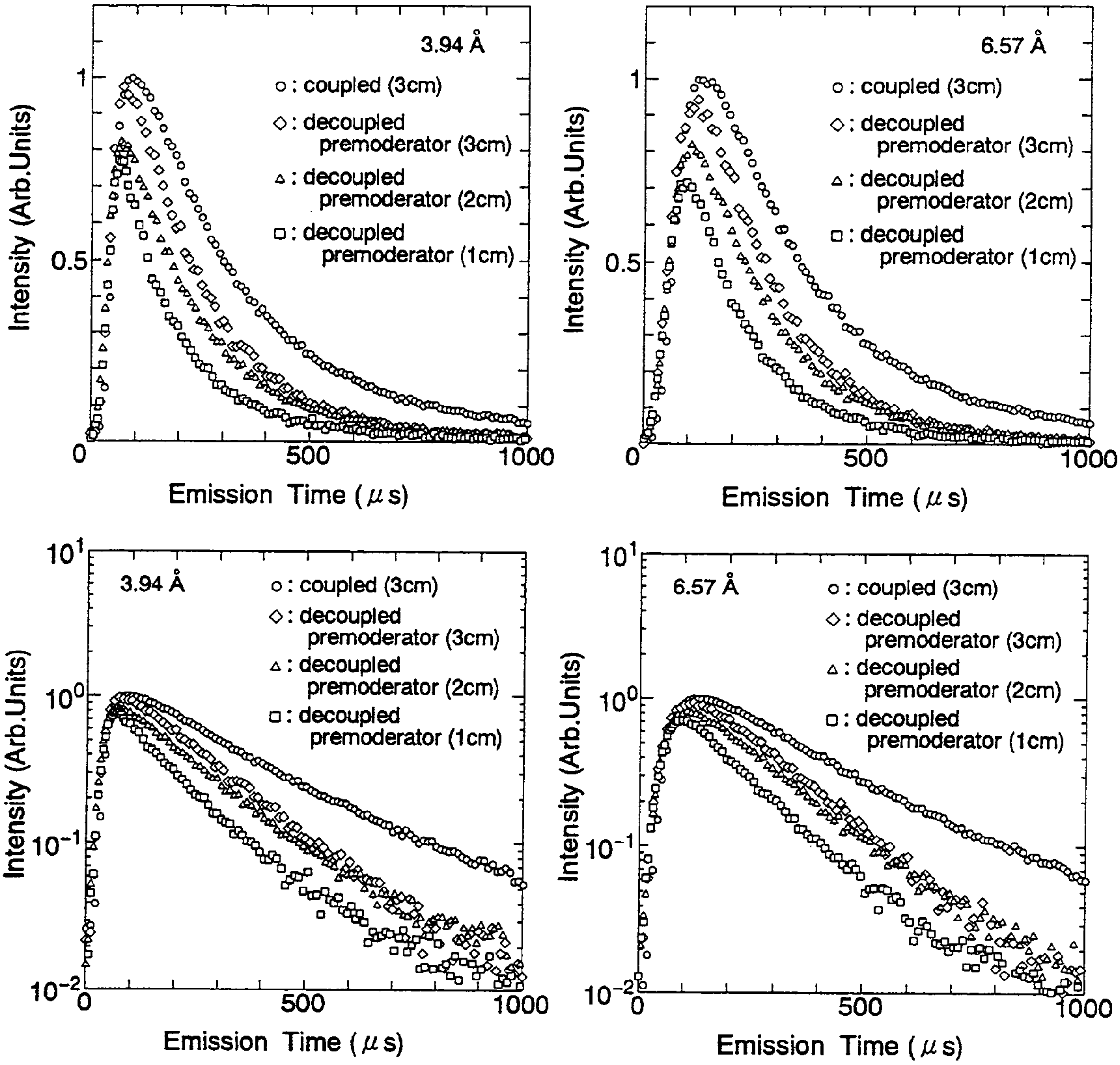


Fig. 2 Comparison of pulse shapes (linear and semi log) from the moderators with different thicknesses of the decoupled premoderator.

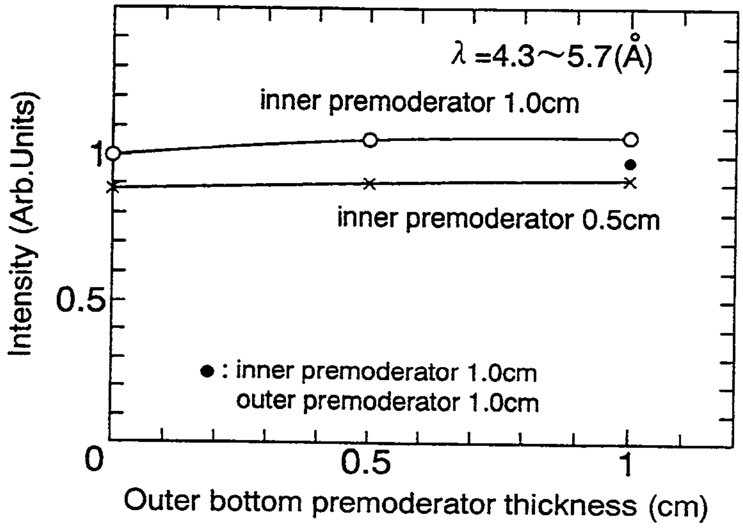


Fig. 3 Effect of thickness of the outer bottom premoderator on the cold neutron intensity.

premoderator at the bottom. This premoderator was confirmed to enhance the intensity to some extent.

Figure 4 shows pulse shapes of cold neutrons from this moderator at two wavelengths 3.94 Å and 6.57 Å compared with the decoupled composite moderator of 1 cm thick premoderator (that is 1 cm inner and 0 cm outer). The pulse width was improved somehow keeping the peak intensity. Long-time tail also improved to some extent compared to the premoderator (1 cm thick) decoupled system.

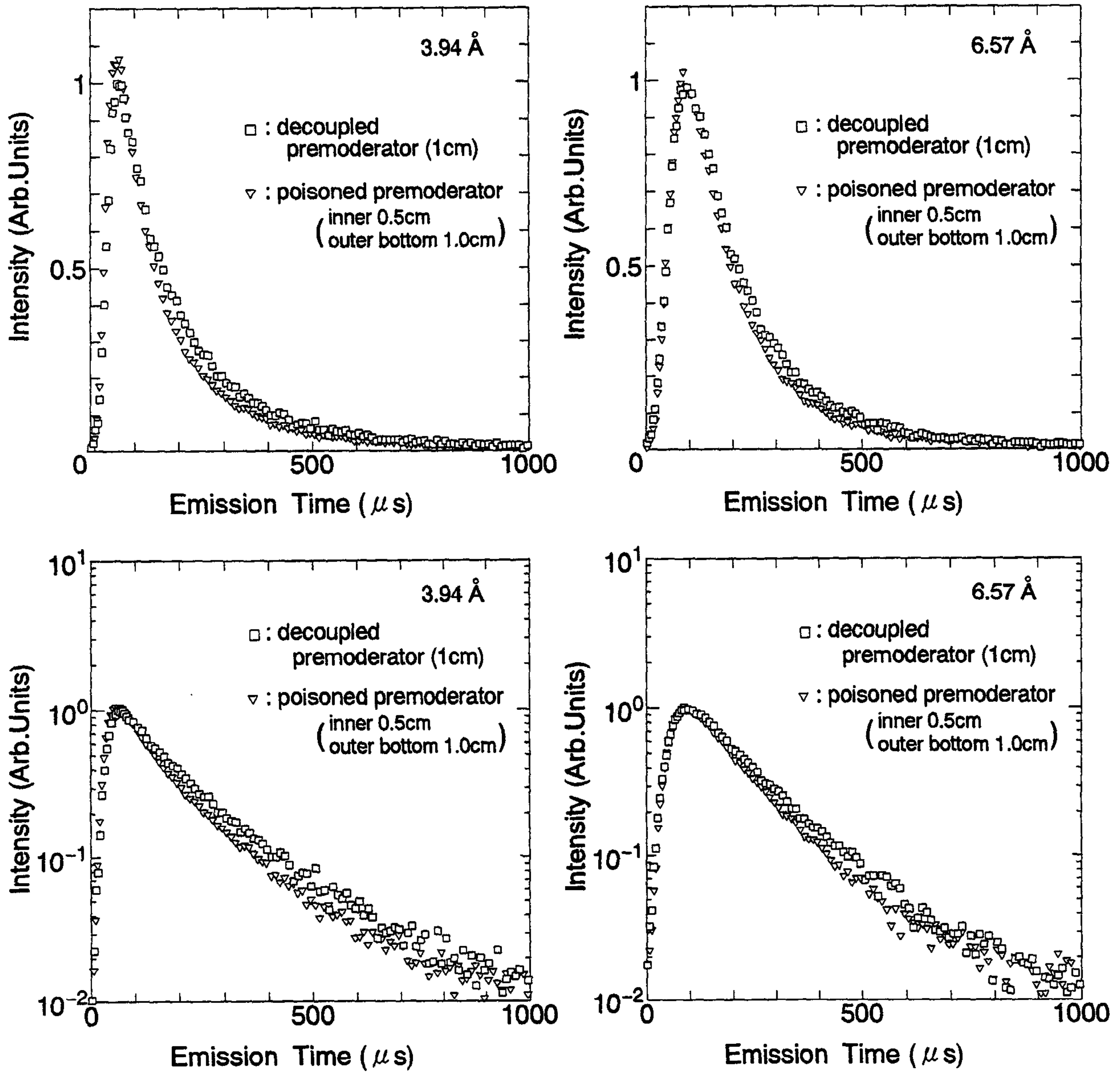


Fig. 4 Comparison of pulse shapes (linear and sem log) from moderators with decoupled premoderator and poisoned premoderators.

Figure 5 compares the pulse shapes from various composite moderators with the 5 cm thick decoupled solid methane (20 K). Pulse shapes from a decoupled liquid hydrogen are also indicated as a reference. At about 4 Å superiority of solid methane moderator is apparent while at the longer wavelength region the composite moderator with a poisoned premoderator gives closer pulse characteristics to the decoupled solid methane moderator.

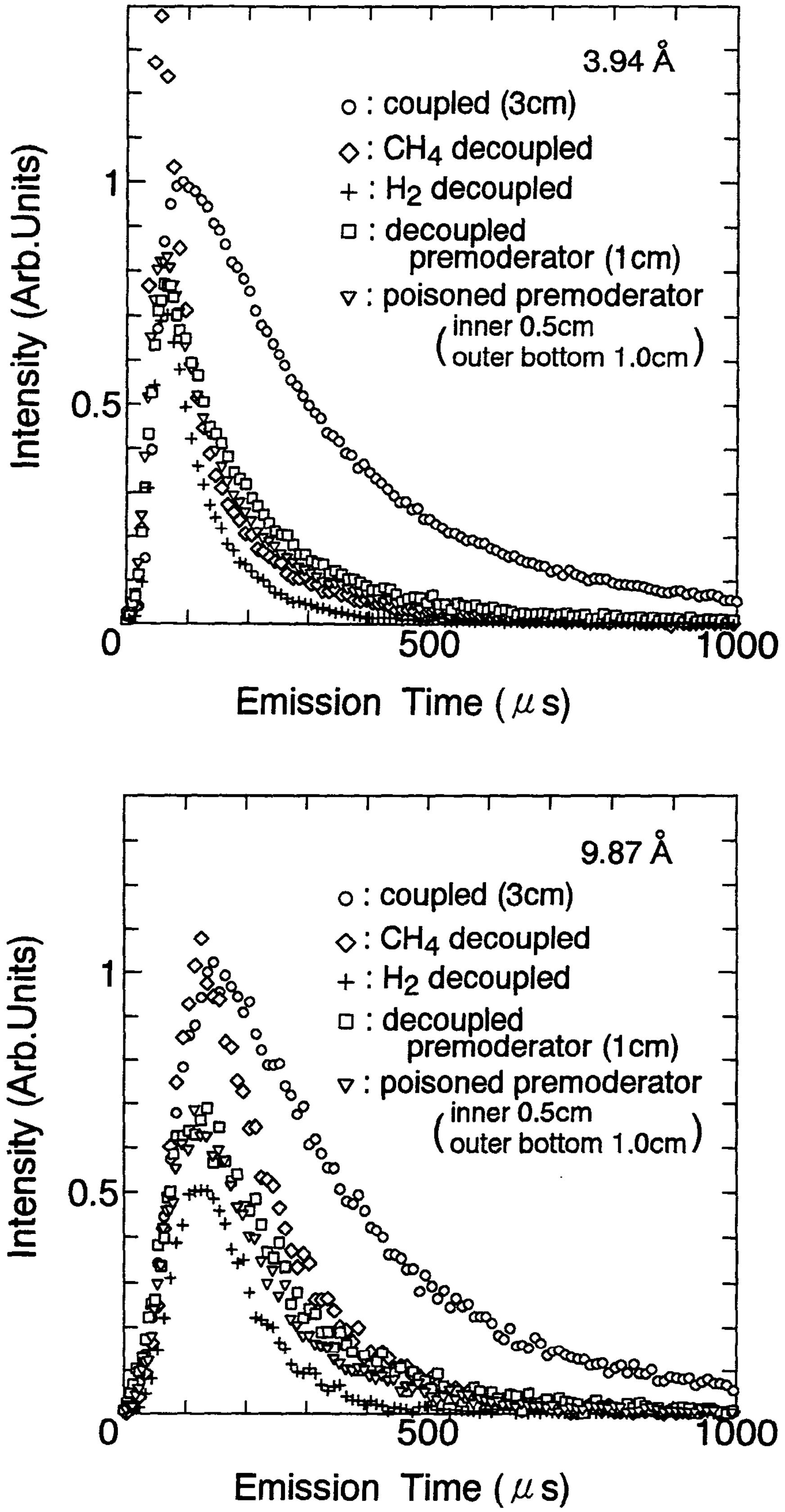


Fig. 5 Comparison of pulse shapes from various types of moderator system.

4. Conclusion

The pulse shapes of cold neutrons were considerably improved by using a poisoned premoderator in comparison with those from a coupled liquid-hydrogen moderator with a premoderator. The pulse characteristics from a liquid-hydrogen moderator with a poisoned premoderator were close to those from a decoupled solid methane moderator at a long wavelength region.

5. References

[1] N. Watanabe and Y. Kiyanagi, Physica B 180&181(1992)893.

[2] Y. Kiyanagi, J. M. Carpenter, N. Kosugi, H. Iwasa, F. Hiraga and N. Watanabe, Physica B 213&214(1995)854.

[3] Y. kiyanagi, H. Iwasa and N. Watnabe, Nucl. Instr. Methods A312(1992)561.