New moderator for pulsed neutron diffraction

R. E. Mayer, J. R. Granada, V. H. Gillette and J. Dawidowski
Centro Atomico Bariloche and Instituto Balseiro
8400 S. C. de Bariloche (RN)
ARGENTINA

ABSTRACT: Experiments of neutron diffraction, leakage spectrum and pulse decay have been carried out on a new geometry, heterogeneously poisoned, set of moderators and on conventional "sandwich" and slab moderators for comparison purposes. For a given time pulse width, great increase in neutron leakage intensity has been found in these assemblies, up to 2.7 times that of a sandwich moderator. Clues to implementation of desired time-response in moderator design and of further increases in neutron yields are suggested by present results.

Introduction

Since the early days of pulsed neutron diffraction, efforts have been aimed at producing ever more efficient devices to moderate the fast neutrons from an accelerator's target down to the wanted range of energies[1,2].

Development has found its way in different directions through the cooling of the moderator[3], or new geometries[4] and even new materials[5]. Even old moderators have been restudied[6] recently.

Considering the subject is still open for innovation, we have undertaken the testing of a set of moderators based on a completely different design conception from those that are widely used today in pulsed neutron diffraction work.

The moderator

From our previous experience with thin moderators, we became convinced that their lateral dimensions are the determining parameters as far as time response is concerned. Consequently, a new system was conceived consisting of an array of small moderators placed side by side and decoupled by cadmium strips. The actual moderator concept is based on a Cd square grid with moderating material in the form of square base prisms inserted in the spaces defined by the grid.

The present array differs from that studied by Day and Sinclair[2], which they found to be of no benefit in realistic experimental conditions, in that the depth of moderator elements is not restricted by the lateral size because they *are not* defined as cubes.

Throughout this work we will characterize each of the arrays tested by (a x a x b), where a and b are the lateral dimension (or "grid spacing") and the moderator depth, respectively, both given as their most approximate value in inches for mnemonic reasons. Also, the same symbol will identify each moderator in the graphs, as given in Table 1.

Tabel 1

MODERATOR	SYMBOL
SLAB	⧖
(2 x 2 x 1)	◇
(1 x 1 x 2)	■
(1 x 1 x 1)	▲
(1 x 1 x 1/2)	●
SANDWICH	⋈
(1/2 x 1/2 x 2)	□
(1/2 x 1/2 x 5/4)	△
(1/2 x 1/2 x 3/4)	○

The "sandwich" consists of a polypropylene pre-moderator slab 20 x 20 x 1.8 cm^3, and a thin circular post-moderator 15 cm in diameter and 0.6 cm thick, decoupled from the pre-moderator by a 0.6 mm thick Cd sheet. The slab is polypropylene 20 x 20 x 2.4 cm^3.

The grids are filled with paraffin because of ease of manufacturing, and their exact measures taken individually. Except on their emitting faces, all moderator systems were wrapped in 0.8 mm thick cadmium.

Experimental

Three types of experiments were performed:

a) neutron leakage spectrum, measured by time of flight;
b) thermal neutron pulse decay, as see by a ^{235}U miniature fission chamber placed in the vicinity of each moderator; and
c) neutron diffraction on a powdered copper sample.

We will report here the results from the last experiment (c). Neutron diffraction measurements were done using our wide-angle backscattering diffractometer, which has a bank of 32 He-3 tubes arranged on a conical geometry dictated by a focussing concept[7]. The powder diffraction patterns were fitted with the use of a peak shape function developed some time ago[8].

The pulsed neutron source is based on a 25 MeV electron linac with a cooled lead target. All moderators were placed at the same position within centimeters of the target in such a way that fast neutrons reached the assemblies from a face opposite to the emitting one (not as in a "wing configuration").

Results

A part of the diffraction spectrum corresponding to the thickest representative of each moderator "family" (same a) is plotted in Fig. 1, where it is clearly seen that resolution varies with the value of a (or grid spacing) in an expected manner.

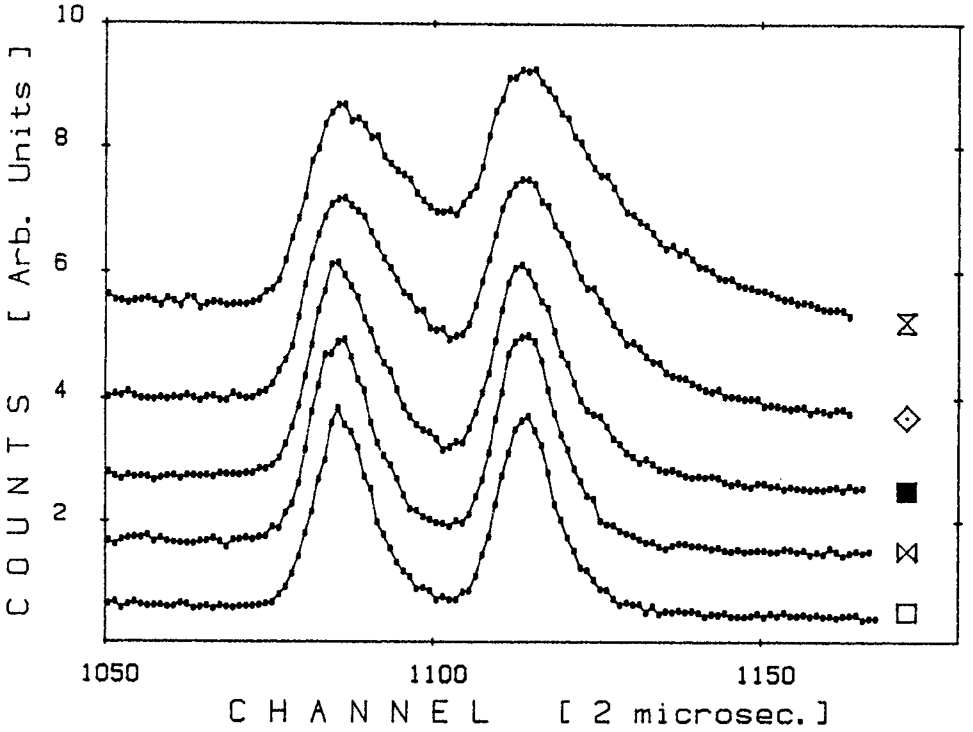

Fig. 1 Part of the diffraction spectra of powder copper as obtained with different moderators. Symbols are listed in Table 1. Lines are guides for the eye. Spectra have been arbitrarily displaced vertically for display purposes.

The second result is not so obvious. Our peak shape function has two resolution parameters[8]:

i) *sigma*, which collects the effects of all symmetrical contributions to the time distribution, and
ii) *alpha*, which takes account of all non-symmetrical contributions and—

besides some minor effects—strongly reflects the time response of the moderator.

As shown in Fig. 2, the alpha values naturally group into families belonging to each grid family, thus showing a clear tendency to grow with grid spacing rather than with moderator thickness.

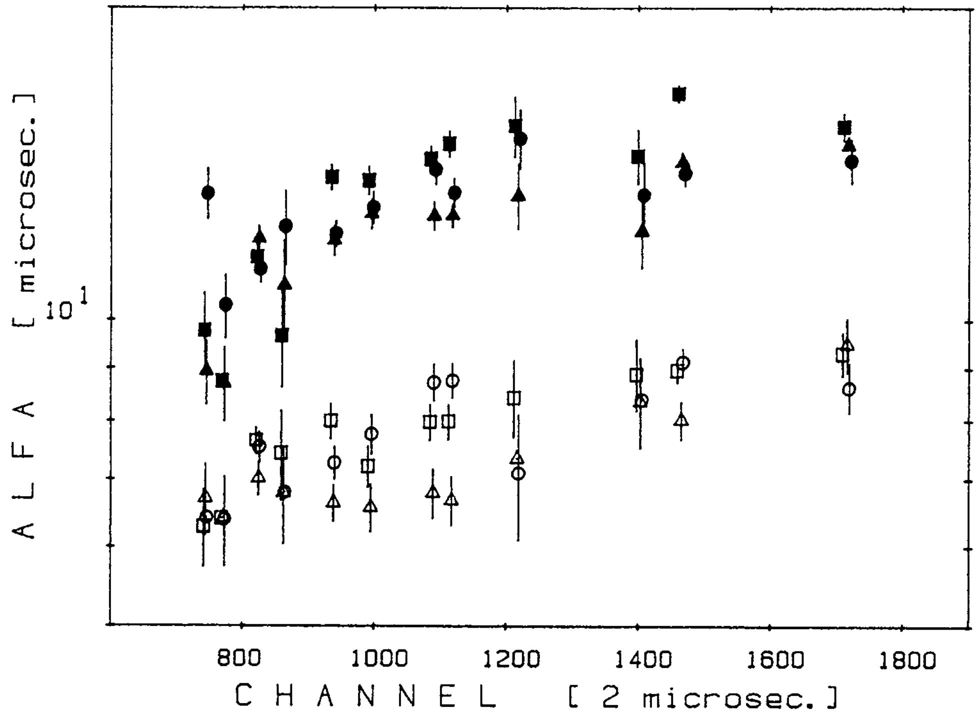

Fig. 2 Fitted ALFA values for different moderators of two grid families (conventional symbols).

The sigma values are all rather similar, as should be expected; nevertheless, they also show this "family" behavior and tend to grow in the same sense as the alphas, rendering a greater overall resolution for the smaller grid spacing systems than is accounted for by alpha alone.

The moderators tested in this experiment do not reach a complete constant value of alpha in the lower side of the observed momentum transfer range. Nevertheless, a mean alpha value can be associated to the "quasi-plateau" region for each moderator, and those are shown in Fig. 3 as "ALFAm". The well-defined tendency observed as a function of grid spacing constitutes one of the main results of this study, as it suggests the possibility of selecting the adequate value of (a) to match any desired time response for our moderator systems. For comparison purposes, the alpha value corresponding to our standard sandwich moderator is also included in Fig. 3.

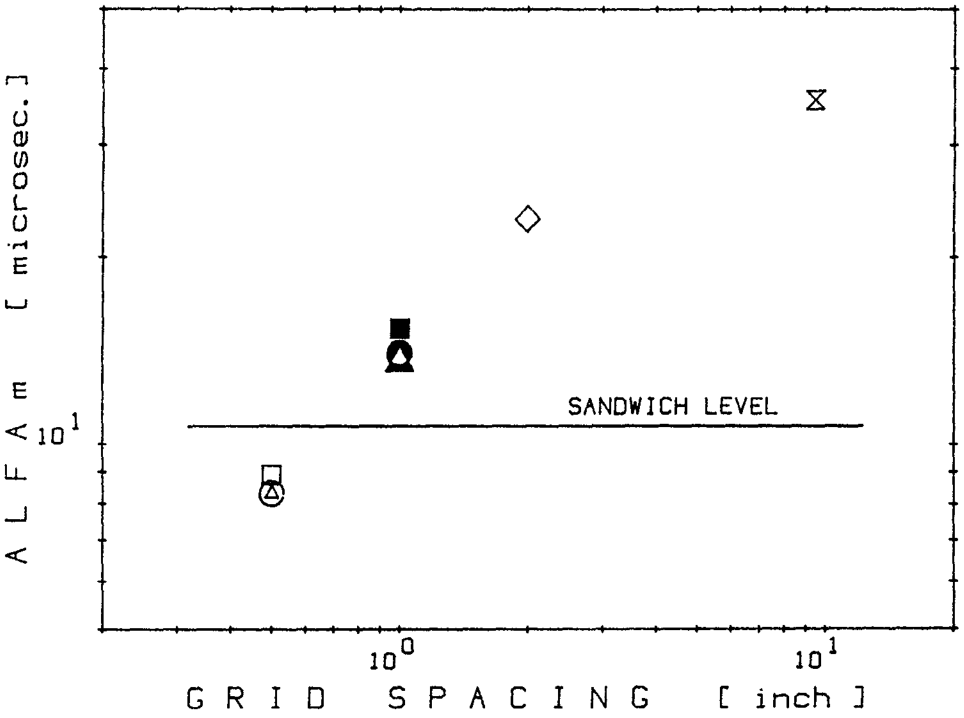

Fig. 3 Trend of ALFAm with lateral dimensions of grid or of slab (see text for details).

Finally, the relative neutron production is represented in Fig. 4. The areas of 13 diffraction peaks, divided by monitor counts and normalized by the corresponding values for the sandwich, were summed up to give one point in the graph for each moderator. This magnitude still shows a tendency to grow with moderator thickness so that greater intensities can be expected for each grid with no important increase in time spread (Fig. 3).

No *figure of merit* is proposed in this work, as it is not intended to find "the best" moderator; instead its purpose is to display the behavior of these moderator systems in terms of parameters that are relevant to design and optimization for specific situations.

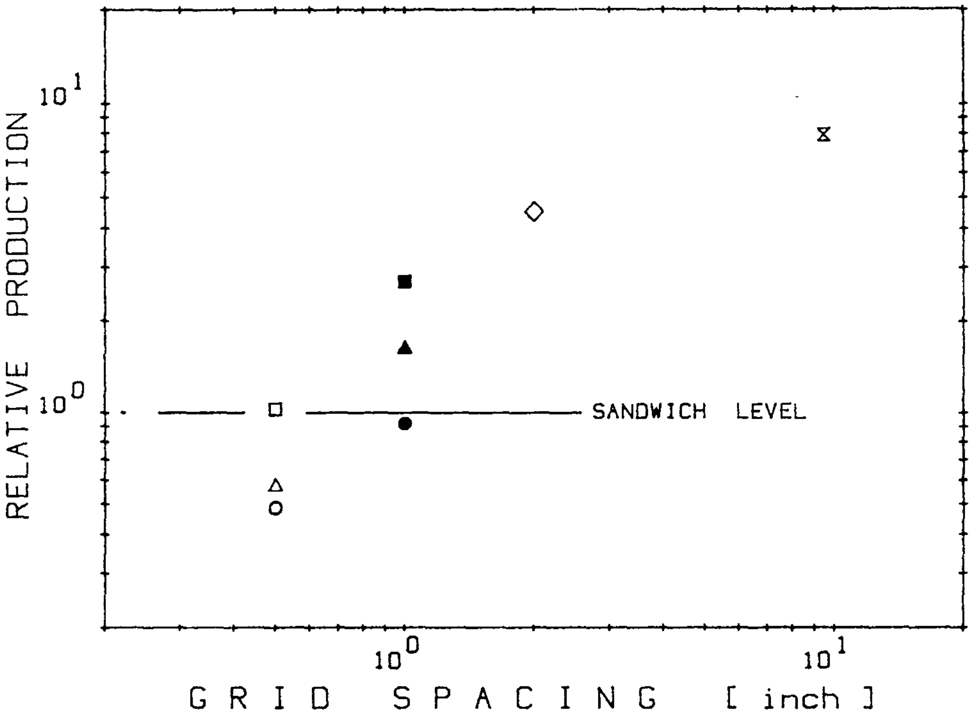

Fig. 4 Trend of the relative neutron production as defined in the text, with lateral dimensions of grid or of slab.

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