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PERFORMANCE OF NOVEL MODERATOR FOR PULSED NEUTRON DIFFRACTION

R.E.Mayer*, J.R.Granada*, J.Dawidowski**, and V.H.Gillette*

Centro Atomico Bariloche, 8400 S.C. de Bariloche (RN) - Argentina
* Also at Instituto Balseiro, Univ. Nac. de Cuyo
** Fellow of Consejo Nacional de Investigaciones Cientificas y Tecnicas. Also at CRUB, Universidad. Nacional del Comahue

ABSTRACT
Measurements of neutron pulse time-width and intensity have been carried out on grids of small moderators placed side by side and decoupled by cadmium strips. This moderator concept had been introduced at ICANS-10. The present measurements explore greater moderator thicknesses than those previously attained, yielding information on thickness optimization, while confirming the previous results on resolution which make this moderator a favourable choice in front of the conventional sandwich set-up.

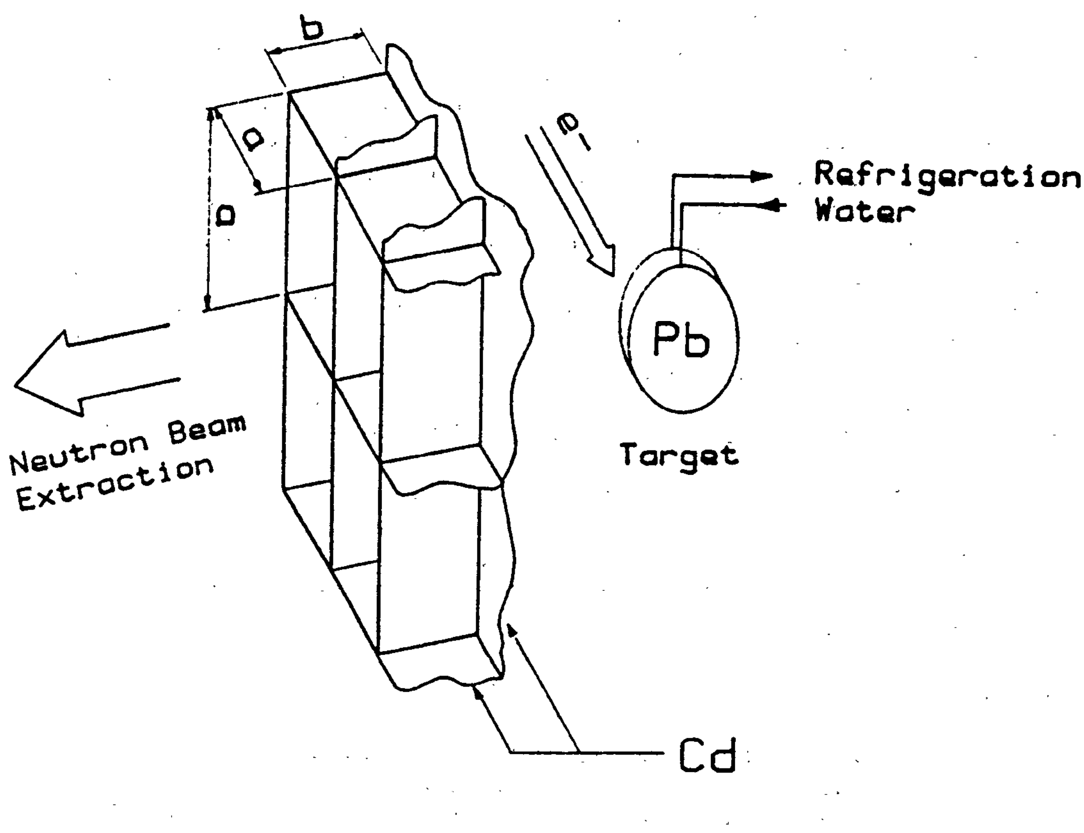

Fig. 1- Scheme of cadmium grid to be filled by moderating material, with neutron generating target shown behind.

I. INTRODUCTION

The long sought goal of finding more efficient means to slow down the fast neutrons from an accelerator's target, seems to be a subject still open for innovation. We have thus undertaken to continue exploring a concept introduced during ICANS-10 [1], and more extensively explored in a recent paper [2].

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 sets of moderators tested consist of cadmium grids (fig. 1) filled with paraffin, which was chosen because of ease of manufacture. The aim is to selectively absorb those slow neutrons prone to have a longer residence time within the moderator and which contribute a poorer time resolution, while still retaining the possibility to increase moderator thickness in order to slow down a greater portion of the incident fast flux, without loosing time resolution; this proved to be true [1;2], and we present here a test of greater moderator thicknesses which were not available with the previous experimental set-up.

The present array differs from that studied by Day and Sinclair [3], which they later discarded, in that the depth of moderator elements is not related to their lateral size because they *are not* defined as cubes, being thus free to vary independently and reach an optimum value.

II. EXPERIMENTAL

Raw data was normalized to equal fast neutron production of the 25 MeV electron LINAC through monitor counts, and diffraction spectra from one powdered Cu sample recorded for each moderator tested, were fitted with an appropriate peak shape function [4]. The latter is the result of the analytical convolution of an exponential decay with a Gaussian; it has four parameters : peak position, its area, and the two resolution parameters ALPHA and SIGMA. ALPHA takes accout of all nonsymmetrical contributions strongly reflecting -besides minor effects- the time response of the moderator; it is the reciprocal decay constant intervening in the convolution. SIGMA is the width parameter of the convoluted Gaussian, and collects the effects of all symmetrical contributions to the time distribution, arising mostly from the geometrical characteristics of the instrument (source included). It is not greatly affected by the changes of moderators of this experiment.

For comparison purposes also a slab and a heterogeneously poisoned "sandwich" moderator were tested. The latter, according to a concept studied during 1969 [3] and of very similar dimensions as described by Windsor and Sinclair in 1976 [5].

The "sandwich" consisted 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. All moderator systems were wrapped in 0.8 mm thick cadmium, except on their emitting faces.

III. RESULTS

In the figures, open symbols will identify points from references [1;2], while closed symbols will be assigned to new data.

Figs. 2, 3 and 4 show how *moderator related time resolution changes from* grid to grid (characterized by "a") and also that **this parameter is** independent of the particular moderator thickness ("b") tested.

This was a fundamental result put through by the previous work [1;2] which now appears to still hold even for thicknesses "b" much greater than that of optimal slow neutron production.

Fig. 5 is intended to show the general trend of the magnitude with which we have been dealing, while the behaviour of the other important magnitude, neutron production, is described by fig.6.

There was a (1 x 1 x 2) moderator which through extra irradiation time, was allowed to *swell* in the sense of deformation of the paraffin contained in the Cd grid, till it protruded outside of the grid boundary a few millimeters. As expected, this collapse of the boundary conditions of the experiment, produced the worsening of the time resolution and the related thermal neutron production increase visible in the figures.

This work does not intend to find "the best" moderator; its purpose, instead, is to describe the behaviour of the configuration proposed herein, and to do so in terms of parameters useful for designers. We believe it constitutes a valid alternative to other choices, especially where short flight paths are to be used, as when a premium is put on maximizing intensity in the absence of shielding limitations, or while avoiding the installation of thermal neutron guides.

REFERENCES

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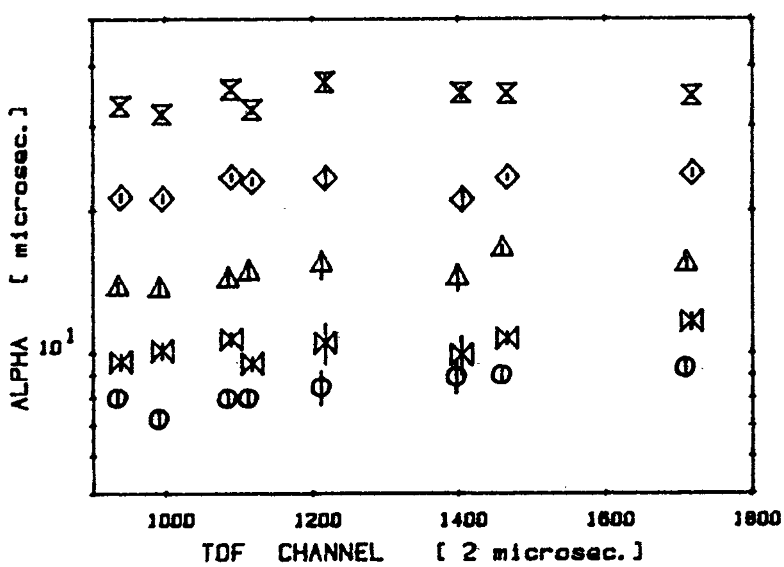

Fig. 2- ALPHA, the reciprocal exponential decay constant that intervenes in the analytical convolution with a Gaussian to yield the peak shape function [4], is most sensitive to the time response of the neutron moderator. This figure from ref. [2] displays the time response behaviour of the neutron emission for different moderator families identified by their conventional symbols (Table 1).

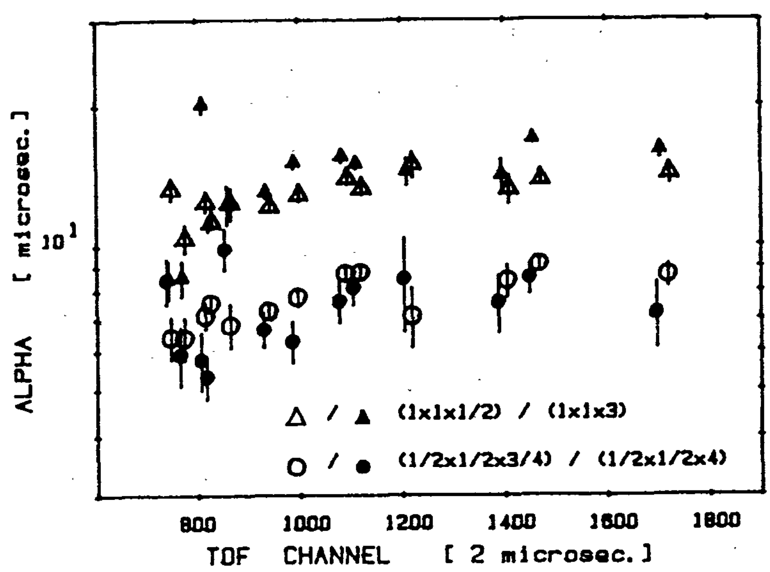

Fig. 3- Fitted ALPHA values (as explained for fig. 2) for grid spacing 1 and 1/2 in., showing the family behaviour of each grid through the insensitivity of ALPHA to very different moderator thicknesses (indicated in the plot). The (1 x 1 x 4) fit is not shown because of the low statistics of that short measurement, for which this general conclusion, anyhow, still holds.

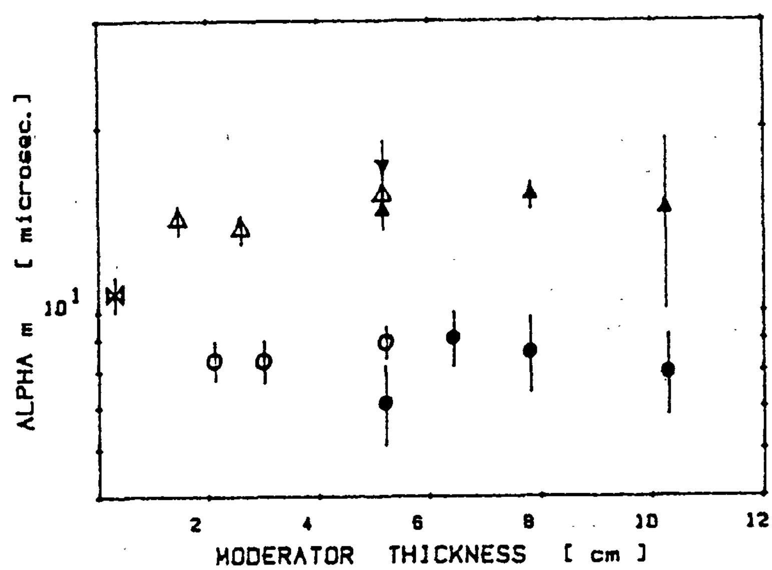

Fig. 4- ALPHAm is defined as the mean of the last four ALPHA values fitted on the lower side of the observed momentum transfer range (reflections 220; 311; 222; 400 form the Cu sample). This mean associated to the "quasi-plateau" region of each moderator, plotted against moderator thickness, better visualizes the insensitivity of neutron emission time response with the addition of moderating material. The moderator which was allowed to swell out of the Cd grid (▼) is seen to have a poorer time response, as expected. Open symbols: [1;2]; closed: new data.

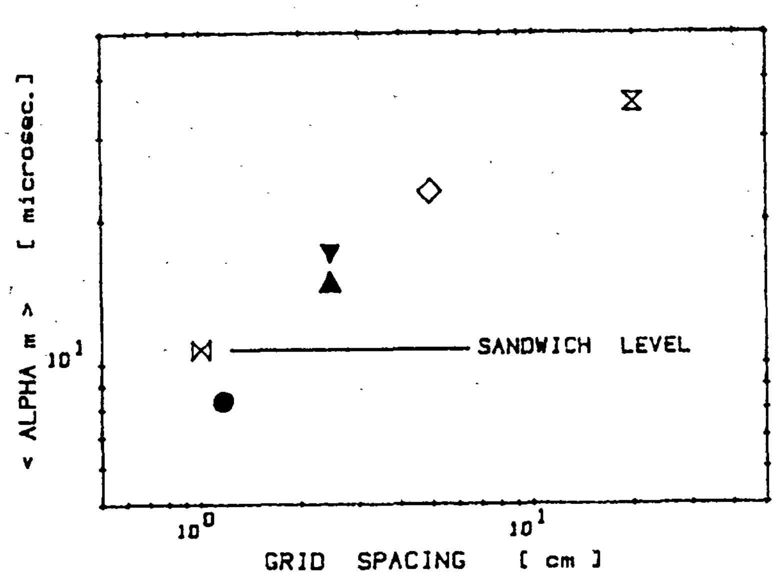

Fig. 5- <ALPHAm> is the mean of the ALPHAm values belonging to each grid family. The trend of neutron emission time response with grid spacing is clear. Slab is plotted according to its lateral dimensions as a "one-element grid". Reference sandwich moderator value is provided for comparison purposes. Open symbols: [1;2]; closed: new data.

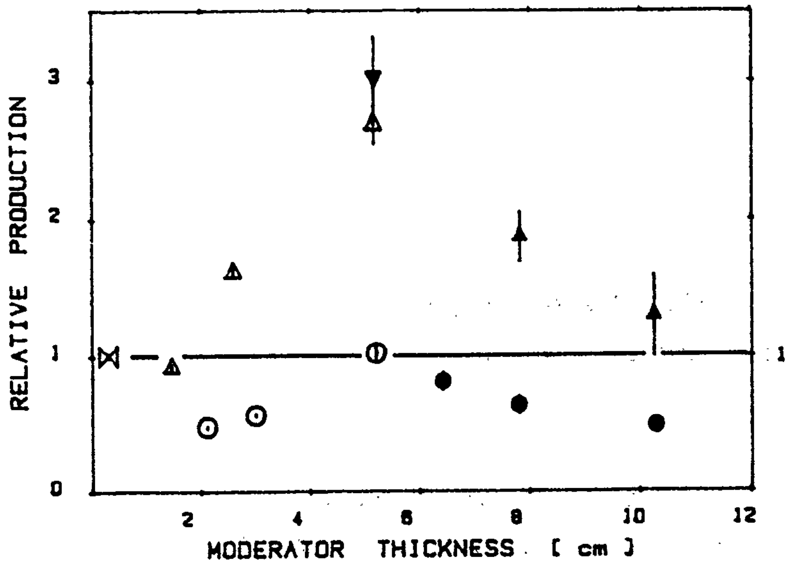

Fig. 6- Neutron production taken as the summation of eleven integrated intensities normalized by fast neutron production (monitor counts), and referred to the corresponding values of the reference moderator (sandwich). The moderator allowed to swell out of the Cd grid (▼) is exposed to less thermal neutron absorption and correspondingly exhibits a higher neutron production.

TABLE 1

Moderators identified as (a x a x b) according to Fig. 1 with their values given approximately in inches for mnemonic reasons

MODERATOR	SYMBOL	a [cm]	b [cm]
SLAB	⧗	20.0 ± 0.20	2.40 ± 0.05
(2 × 2 × 1)	◇	4.91 ± 0.01	2.54 ± 0.01
(1 × 1 × 4)	▲	2.46 ± 0.01	10.24 ± 0.06
(1 × 1 × 3)	▲	"	7.81 ± 0.19
(1 × 1 × 2)	△	"	5.15 ± 0.05
(1 × 1 × 1)	△	"	2.59 ± 0.11
(1 × 1 × 1/2)	△	"	1.45 ± 0.13
SANDWICH	⋈	-	-
(1/2 × 1/2 × 4)	●	1.17 ± 0.01	10.28 ± 0.06
(1/2 × 1/2 × 3)	●	"	7.80 ± 0.10
(1/2 × 1/2 × 5/2)	●	"	6.41 ± 0.15
(1/2 × 1/2 × 2)	O	"	5.20 ± 0.05
(1/2 × 1/2 × 5/4	O	"	3.00 ± 0.29
(1/2 × 1/2 × 3/4	Ɔ	"	2.11 ± 0.29

Cadmium separating strips thickness: (0.7 ± 0.012) mm.
Figures listed belong to moderating elements' dimensions and do not include thickness of Cd strips.