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AN UPDATE ON ISIS DETECTORS

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At the last ICANS meeting we reported the successful trial of a lithium loaded ZnS scintillator material and predicted that this would be the basis of new ISIS detectors of the next few years. This has in fact been the case, and in this paper we report on the construction and performance of three detector types that have been put into successful operation. A fourth, PSD design, is at the prototype stage.

IRIS DETECTOR

The simplest of the designs is that for the IRIS backscattering spectrometer at ISIS shown in Figure 1. The detector consists of 51 elements each with an active area of 52 x 12 mm situated 610 mm from the graphite or mica analyser. The detector must be capable of running in the IRIS vacuum tank, and Figure 2 shows a close-up of both the PM manifold (enabling the PMs to run at ambient pressure) and the reflectors dividing the detector elements.

The light collection on this directly-viewed geometry is very good (Figure 3) and as a result the gamma discrimination ($ef_{\gamma} = 10^{-8}$) is the best of the detector types so far constructed.

The intrinsic background is also low, at 2 cts/element hour and as a consequence some excellent science has been performed on IRIS since the modifications. As an example, Figure 4 shows the rotor minimum in the ^{4}He at 1.2K. The signal is a weak one which could well have been swamped if the detector was at all noisy. In fact, the majority of background counts in this pattern are either 1 or 0, enabling the signal to be clearly seen.

HRPD 90° DETECTOR

The HRPD module was constructed, both to provide the excellent noise characteristics available for the ZnS detector, but also to provide the large solid angle/high θ resolution necessary at the HRPD 90° position. The detector consists of six modules stacked vertically on top of each other, each module consisting of 66 vertical strips 3 mm wide by 200 mm high. These are placed 1300 mm from the sample position and hence the completed detector will subtend a solid angle of 0.141 sr with a θ resolution of $\Delta\theta = 0.001$ rad.

The geometry of the scintllator and light coupling to the optical fibres is shown in Figure 5 and a picture of a completed module is shown in Figure 6. The use of optical fibres enables more efficient use of PMs, but results in a less efficient light collection. As a result, the γ rejection is slightly worse (at $ef_{\gamma} = 10^{-6}$) than that for the directly viewed IRIS detector, but is still close to that of a ^{3}He detector. The lowering of the background from this detector is illustrated (Figure 6a) by the patterns recorded for mythyl pyridine both in back scatter (using Li glass scintillator) and at 90° (using ZnS).

SANDALS 10°-20° DETECTOR

The SANDALS detectors for this angular range have been constructed in modules of 20 detectors, each detector having an active area of 10 x 200 mm. The modules use 21 PMs in a 'walking coincidence' arrangement to directly view the ZnS scintillator packs on edge (Figure 7). By adopting this geometry, a large number of scintillator elements may be placed in the path of the scattered neutron, and efficiencies of roughly 1.8 times that of a ^{3}He (10 bar) gas detector achieved at high neutron energies (10 eV). A photograph of the completed module together with the scintillator packs is shown in Figure 8.

Glass spacers are used to separate the individual ZnS elements in the scintillator pack, and it is believed that this relatively high mass of viewed material is contributing to the high intrinsic background of around 6 cts/element minute. The cause is thought to be Cerenkov radiation from cosmic ray events stopped in the scintillator path. While this background rate is not a serious problem on SANDALS, efforts to reduce it are being investigated by using 'air gaps' in the scintillator assembly.

PSD MODULE

Because of the intrinsically high light output from the ZnS scintillator, it has become clear that an x-y coded fibre-coupled PSD is a real possibility.

An outline for such a geometry is shown in Figure 9, illustrating how a bundle of four 1 mm optic fibres will be used to view each 3 x 3 mm active area of the detector. The fibres will then be used (2x, 2y) in a block coding system requiring only 32 PMs to code a 64 x 64 area PSD. An example of the quality of the data that can be recorded from such a system is shown in Figure 10, a prototype 16 x 16 module in use on the SXD machine at ISIS.

To summarise, we believe the use of ZnS scintillation in place of the Li-loaded glass of earlier designs is a great success, and has enabled new science and better results to be recorded on ISIS instruments. To give others some idea of the performance of these devices the results of the detectors is summarised in Table 1.

TABLE 1

Detector	$effic_n$	$effic_\gamma$	Intrinsic background cts/element hour
IRIS	36% @ 1Å 90% @ 6Å	10^{-8}	< 2
HRPD	36% @ 1Å	10^{-6}	3
SANDALS	9% at 10 eV	10^{-4}	360

Fig.1

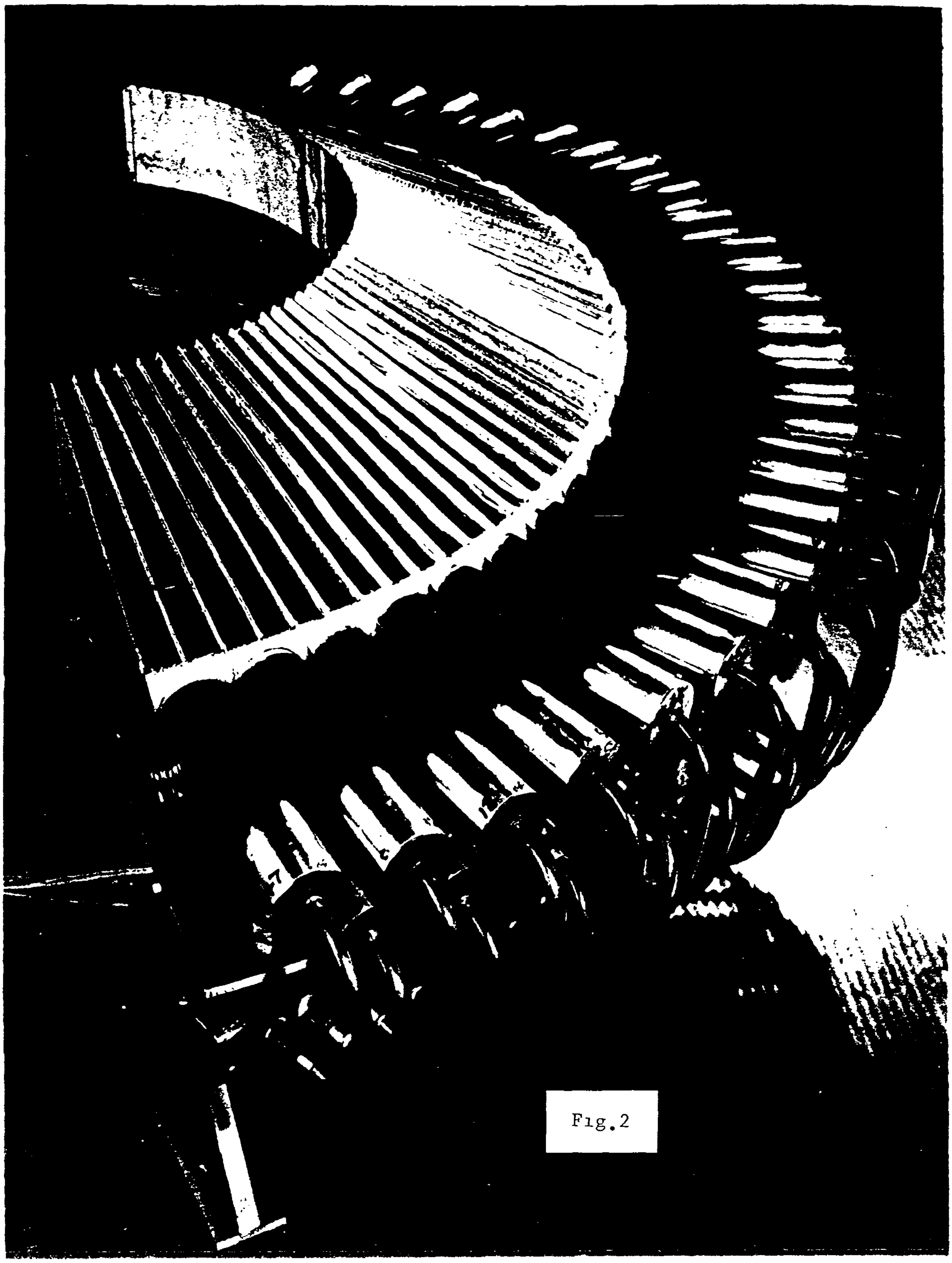


Fig.2

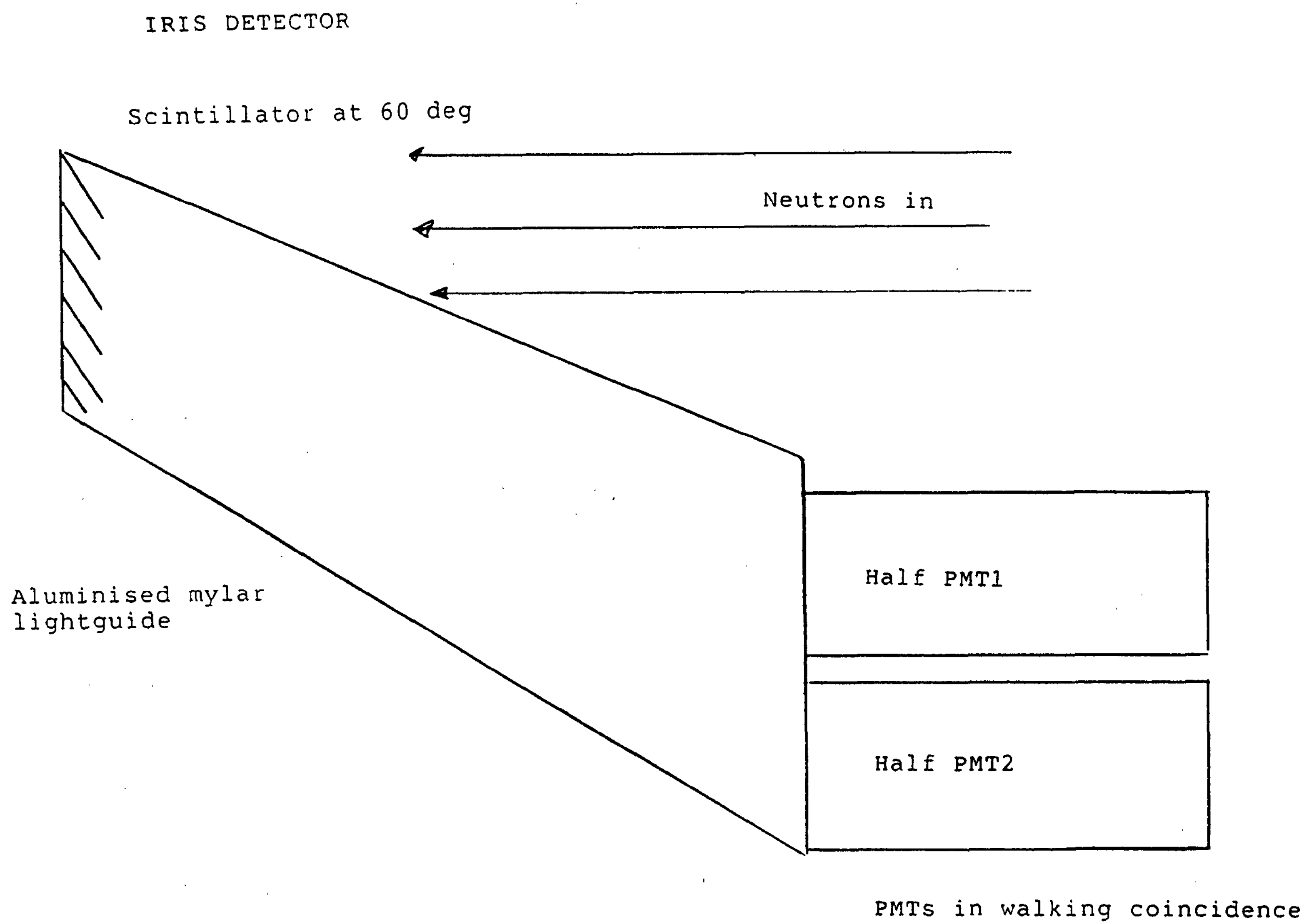
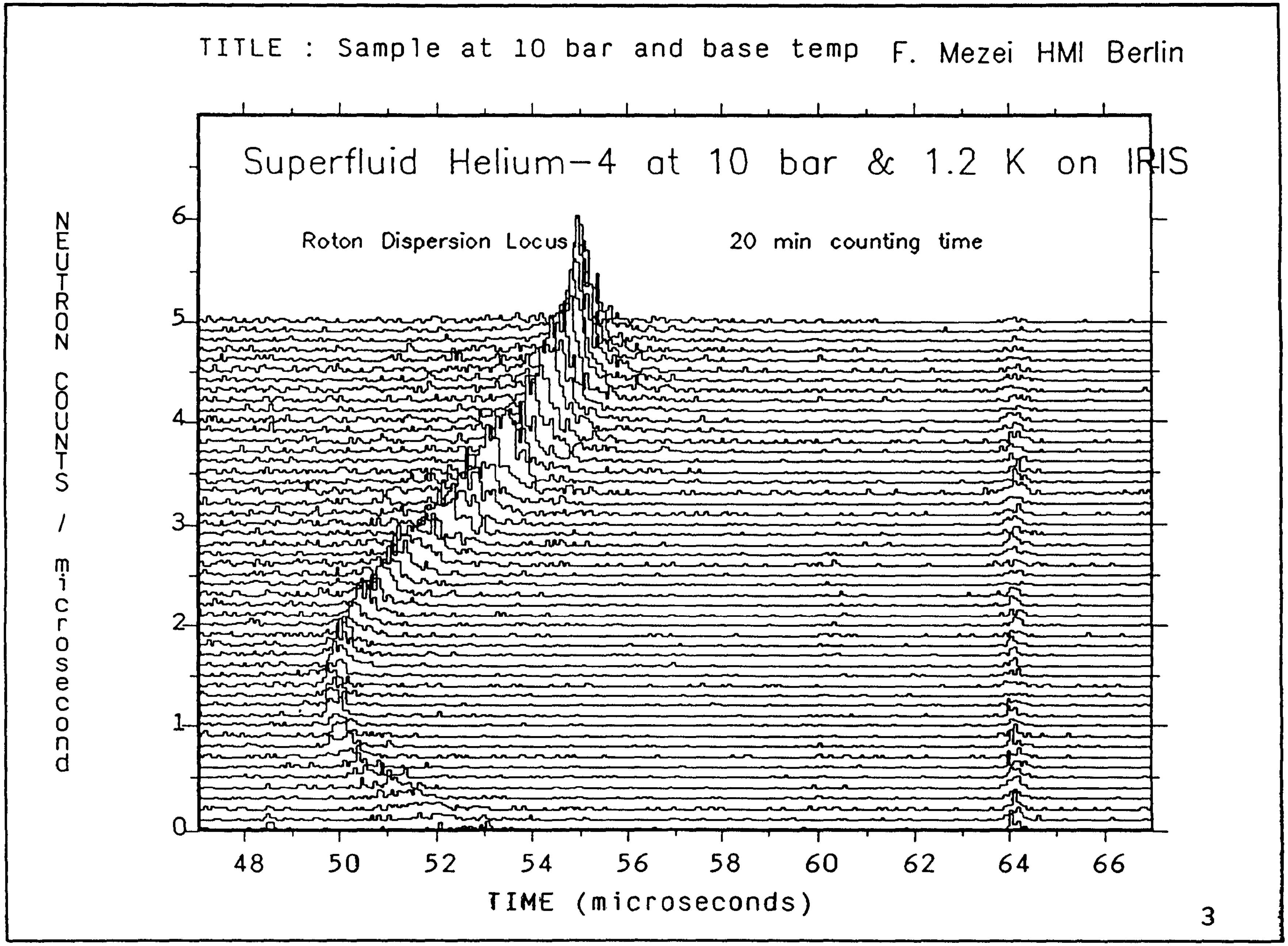

IRIS DETECTOR
Scintillator at 60 deg
Neutrons in
Aluminised mylar
lightguide
Half PMT1
Half PMT2
PMTs in walking coincidence

Fig.3

Fig.4


TITLE : Sample at 10 bar and base temp
F. Mezei HMI Berlin
Superfluid Helium-4 at 10 bar & 1.2 K on IRIS
Roton Dispersion Locus
20 min counting time
NEUTRON COUNTS / microsecond
0
1
2
3
4
5
6
48
50
52
54
56
58
60
62
64
66
TIME (microseconds)
3

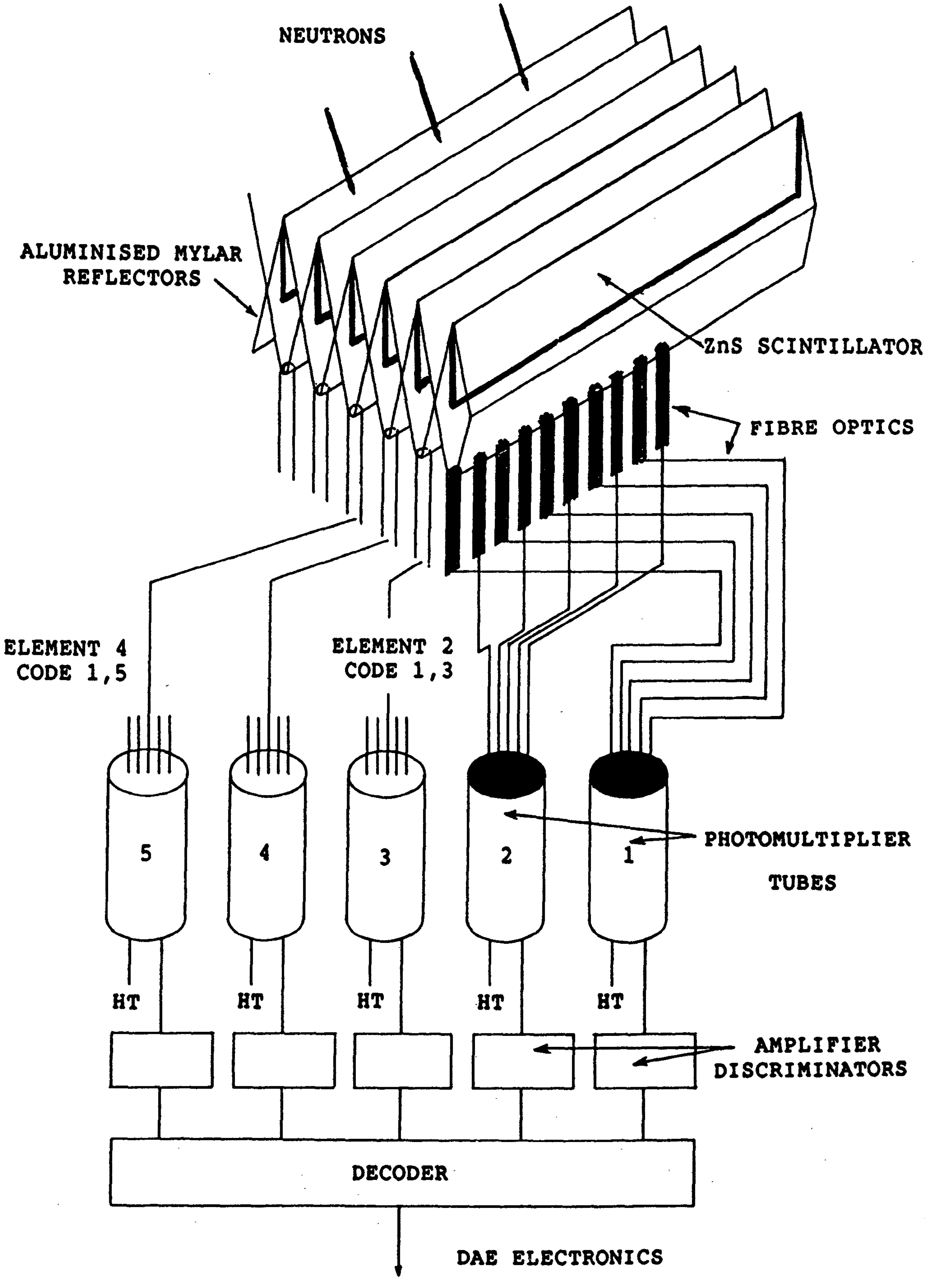

NEUTRONS
ALUMINISED MYLAR
REFLECTORS
ZnS SCINTILLATOR
FIBRE OPTICS
ELEMENT 4
CODE 1,5
ELEMENT 2
CODE 1,3
5
4
3
2
1
PHOTOMULTIPLIER
TUBES
HT
HT
HT
HT
HT
AMPLIFIER
DISCRIMINATORS
DECODER
DAE ELECTRONICS

Fig.5

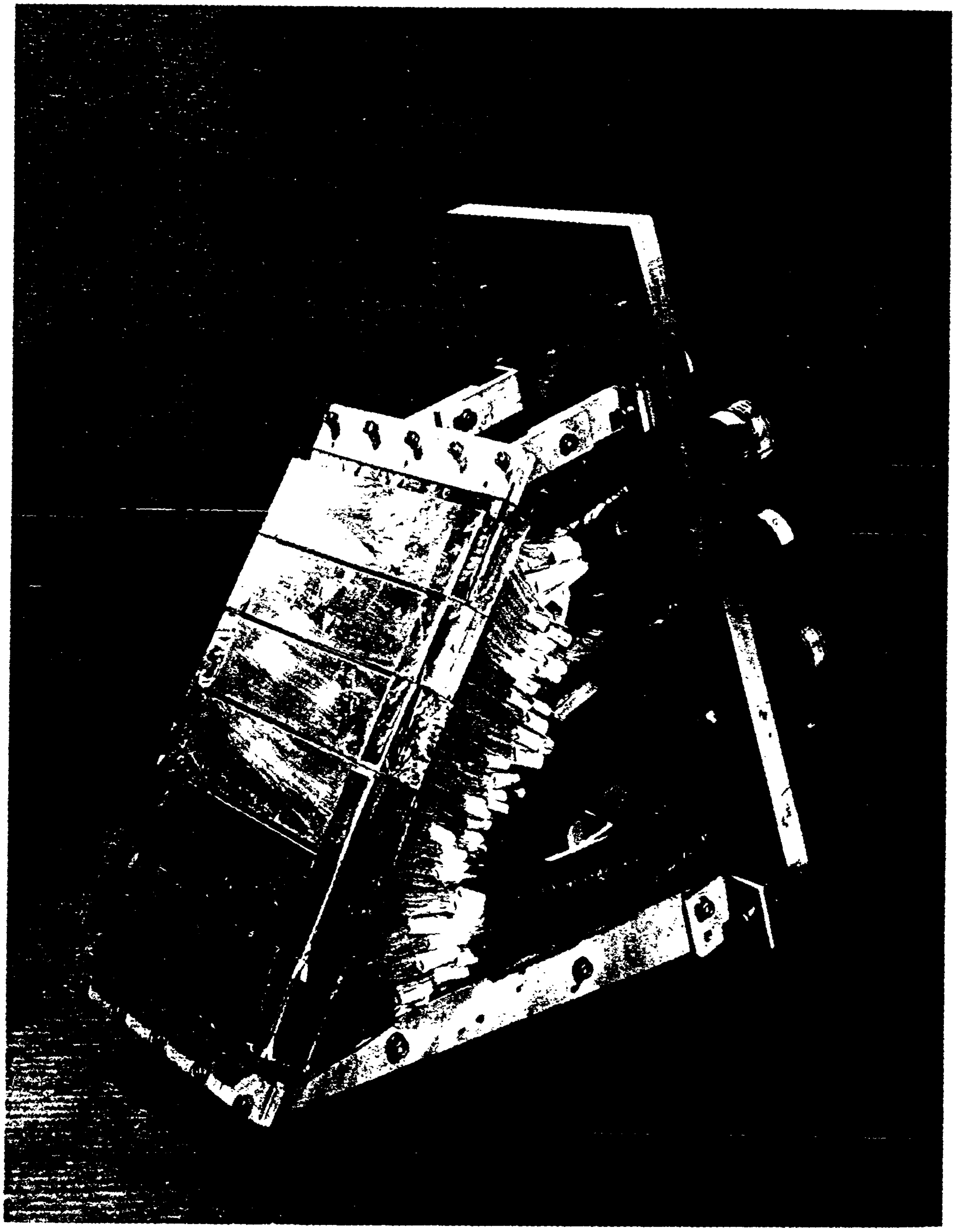


Fig.6

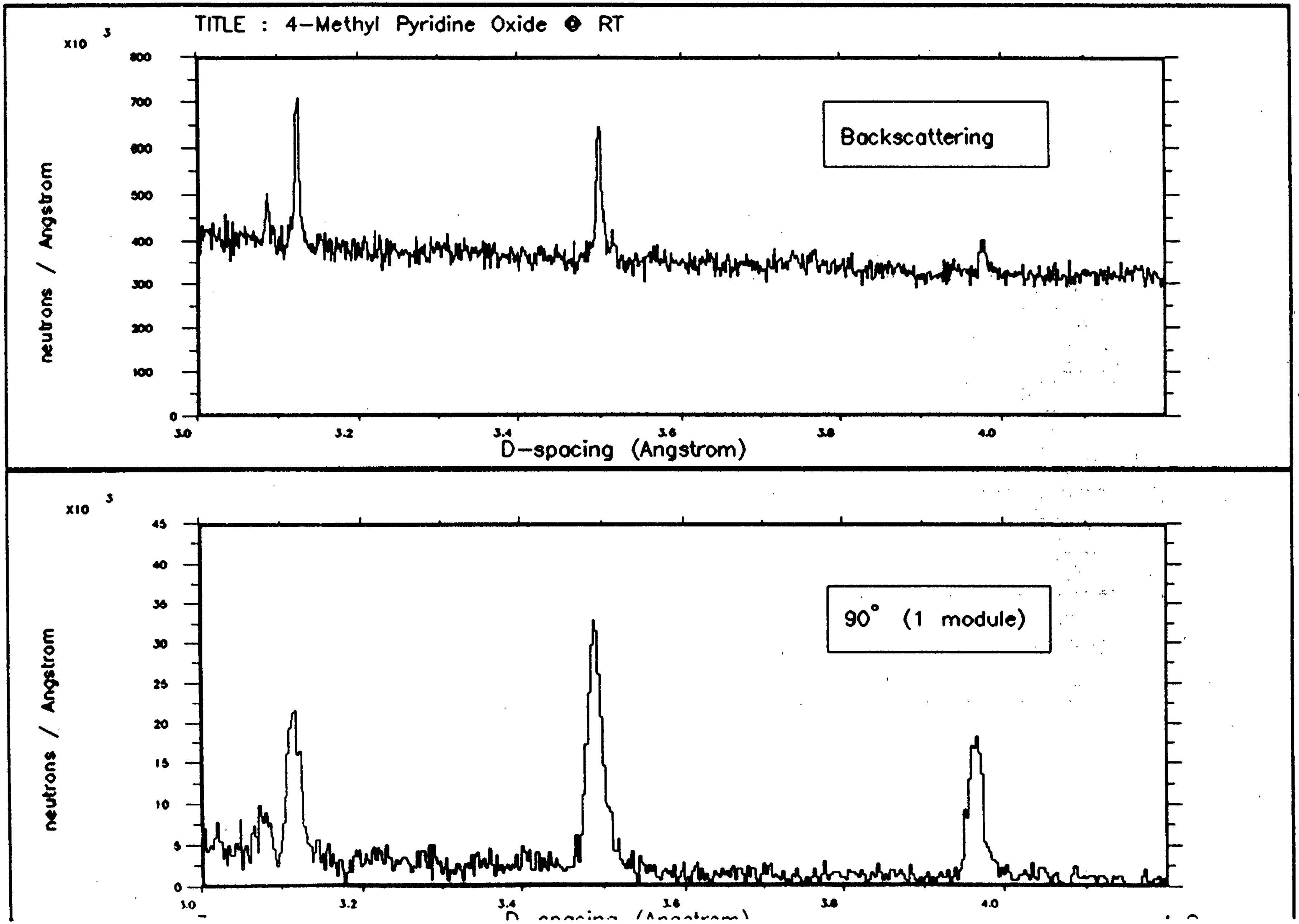
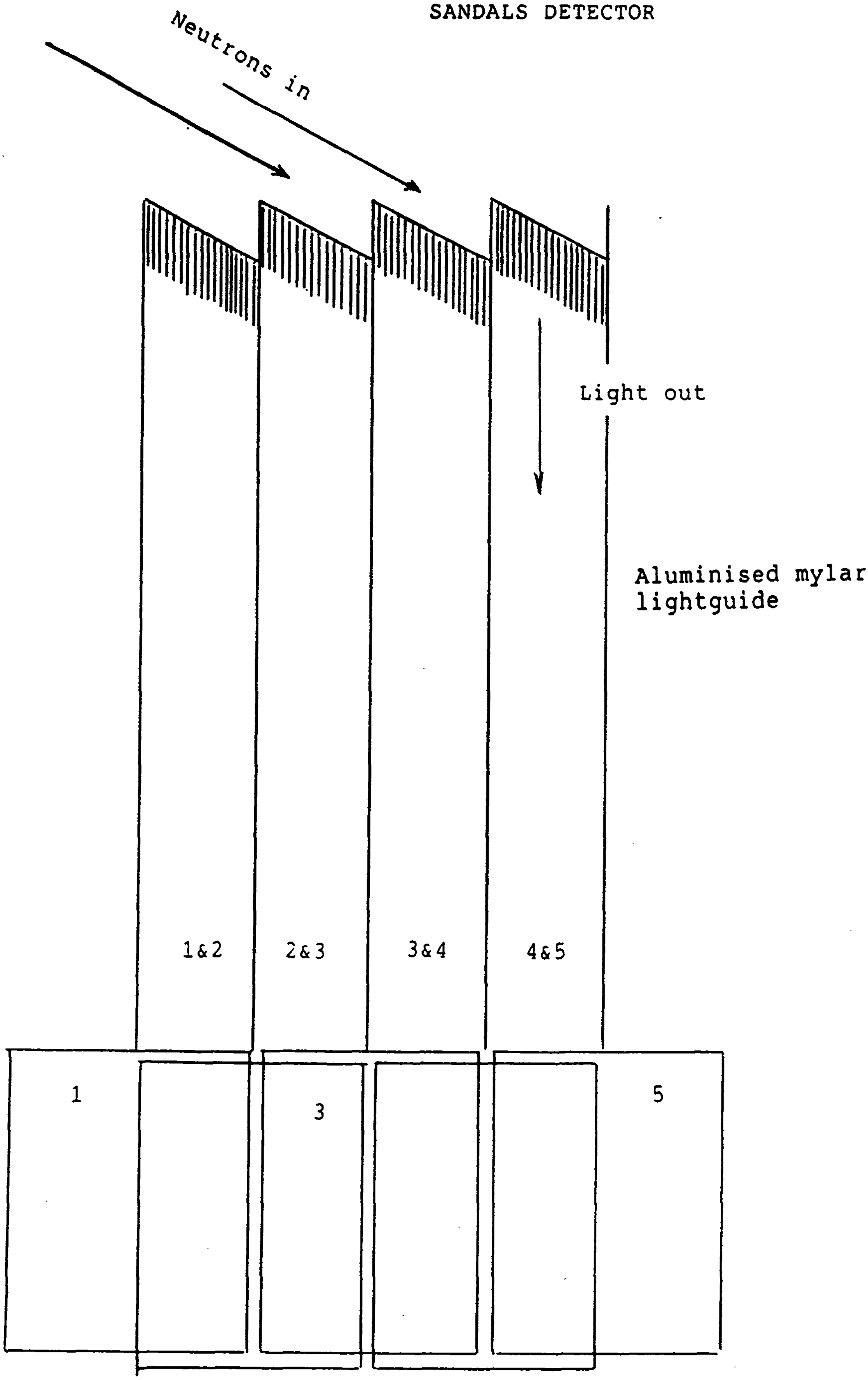

TITLE : 4-Methyl Pyridine Oxide @ RT
Backscattering
x10 3
neutrons / Angstrom
D-spacing (Angstrom)
90° (1 module)
x10 3
neutrons / Angstrom

Fig.6a

SANDALS DETECTOR



PMTs in walking coincidence

Fig.7

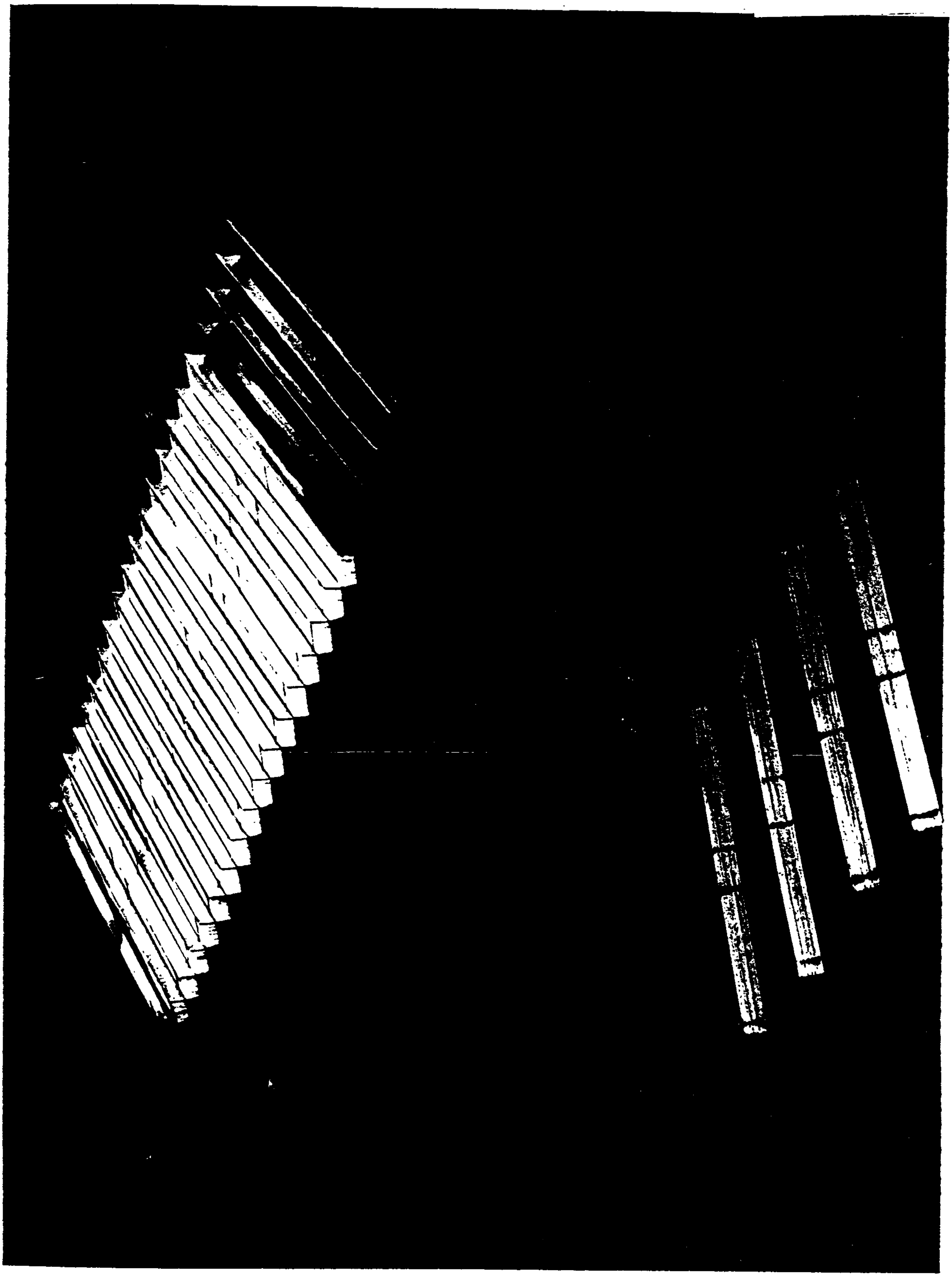


Fig.8

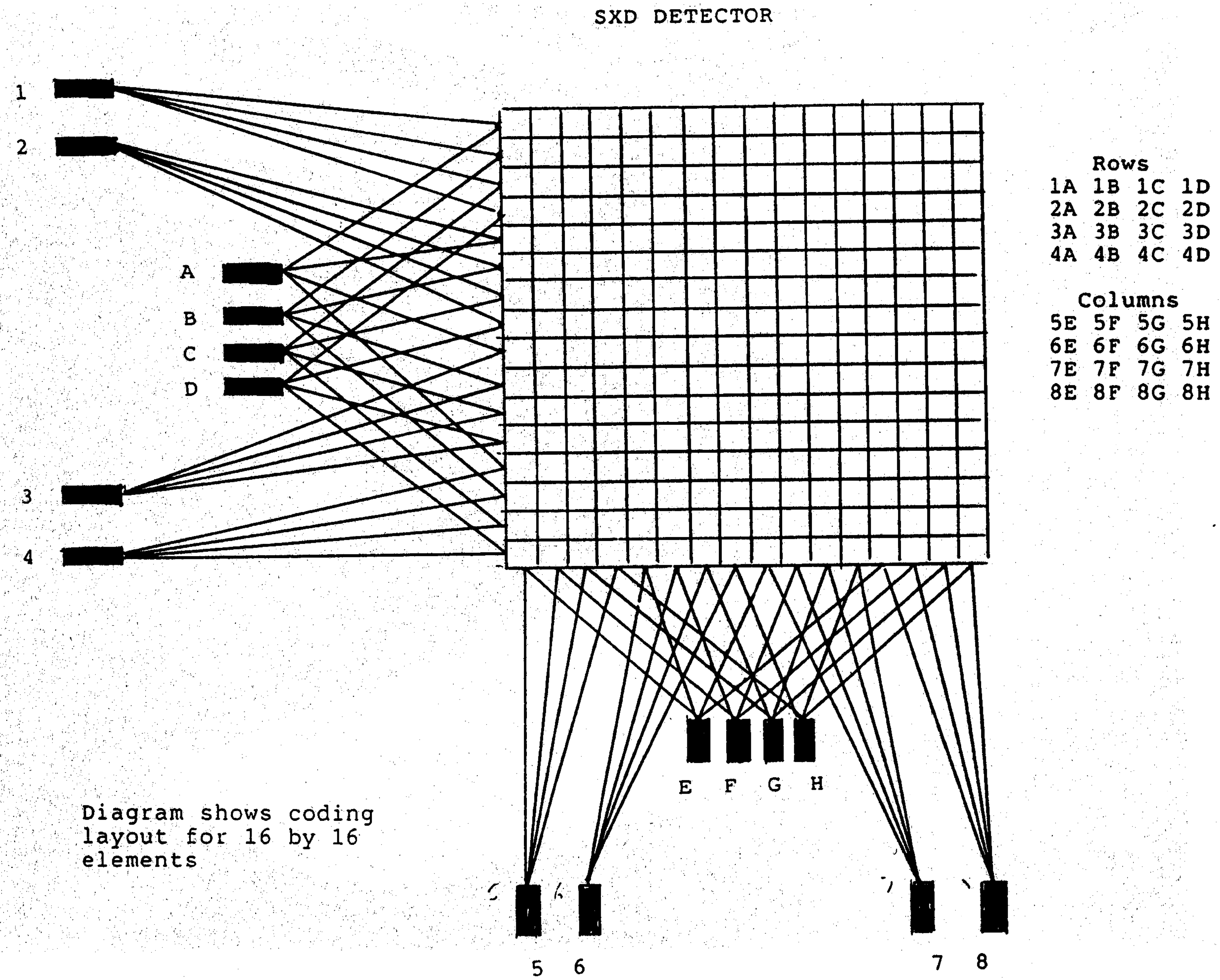


Diagram shows coding layout for 16 by 16 elements

Fig.9

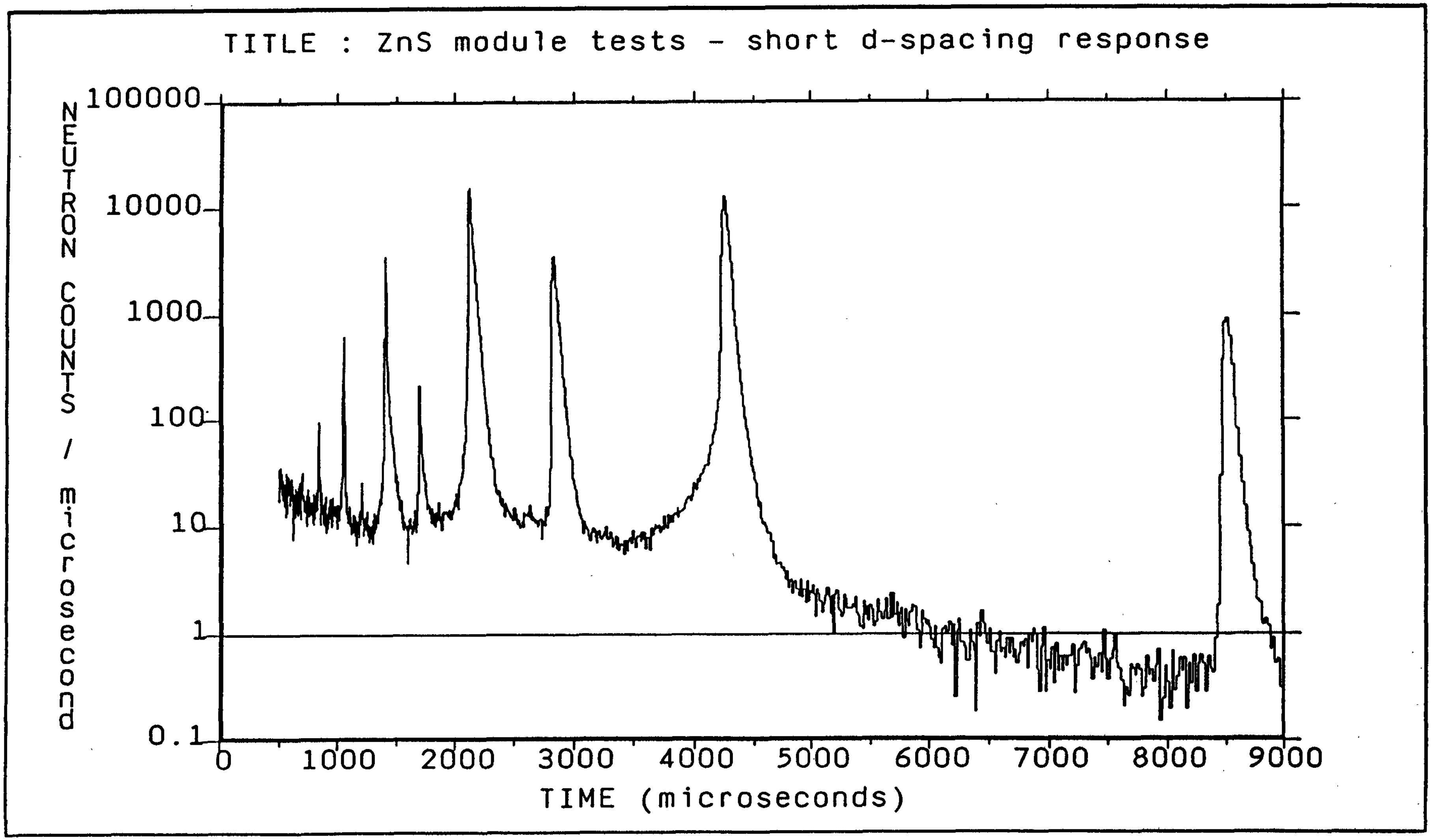

TITLE : ZnS module tests - short d-spacing response
NEUTRON COUNTS / microsecond
100000
10000
1000
100
10
1
0.1
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
TIME (microseconds)

Fig.10

Q(Y.Masuda): Why did you use two phototubes for one detector?

A(M.W.Johnson): By using a coincidence technique, it gives a lower quiet count rate by eliminating much of the inherent noise from a single photomultiplier tube.

Q(J.B.Hayter): What count-rate can be handled by your 2-D detectors?

A(M.W.Johnson): The dead time for ZnS is about 2 μs, with some possibility to reduce it to about 1 μs. The 2-D detector can therefore easily run at 50-100kHz without major dead-time corrections.

Q(N.Niimura): Why do you think the S/N ratio of ZnS is so good, if we compare it with Li-glass scintillator? Is it the difference of the photon production?

A(M.W.Johnson): Yes, It is simply that the light output for ZnS is approximately ten times that of Li loaded glass.

Q(C.C.Wilson): Can the efficiency of ^{6}Li-loaded ZnS scintillator be increased by using thicker scintillator than the 0.4 mm used commonly?

A(M.W.Johnson): Not at present. The binder used with ZnS is not fully transparent and increasing the thickness will simply reduce the light output. What we need is a high refractive index transparent binder to hold the ZnS scintillator crystals.