National Defence Défense nationale

THE NEW DREO MOBILE NUCLEAR LABORATORY (U)

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DEFENCE RESEARCH ESTABLISHMENT OTTAWA

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ABSTRACT

The new DREO Mobile Nuclear Laboratory (MNL) has just recently completed successful field trials. The capabilities of the new MNL are examined, and seen to be far superior to its predecessor. This lab will help keep DREO at the forefront of nuclear radiation research within the NATO community for many years to come, as well as providing the DND Nuclear Emergency Response Team (NERT) with unique capabilities in the event of any crisis.

RESUMÉ

Les essais du nouveau laboratoire nucléaire mobile (LNM) du CRDO on été récemment complétés. Les capacités du nouveau LNM ont été examinées et jugées très supérieures à celle des modèles précédant. Ce laboratoire permettra au CRDO de se maintenir pour plusieurs années à la fine pointe de la recherche sur les radiations nucléaires parmi ses partenaires de l'OTAN, ainsi qu'il mettra à la disposition de l'équipe d'intervention d'urgence nucléaire du MDN un outil unique dans les cas de crises.

EXECUTIVE SUMMARY

The new DREO Mobile Nuclear Laboratory (MNL) has just recently completed successful field trials. The capabilities of the new MNL are examined, and seen to be far superior to its predecessor. This lab will help keep DREO at the forefront of nuclear radiation research within the NATO community for many years to come.

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1.0 INTRODUCTION

The Mobile Nuclear Laboratory (MNL) has for the past 10 years played a major part in the radiation shielding and dosimetry project within the Nuclear Effects Section (NES) at Defence Research Establishment Ottawa (DREO). The MNL provides a self-powered mobile facility capable of on- and off-site data acquisition and analysis pertaining to neutron and gamma-ray radiation fields. Among the many tasks the MNL was required to support were:

(1) On-site experiments involving DREO staff and visiting scientists;

(2) Measurement of radiation fields at other Canadian and foreign experimental facilities;

(3) Provision of scientific advice for any nuclear incident in which DND (or other) personnel were possibly at risk.

The original MNL performed these tasks well, but suffered from some shortfalls relating to its ten-year-old technological base. Perhaps chief among these shortfalls was its large size, necessitated primarily by its mainframe (PDP 11/34) computer system used for almost all data acquisition and analysis. This large physical size meant that the old MNL was not transportable by CF Hercules, and that the MNL could not participate directly in planned experiments in France, the COSMOS 954 re-entry project or the post-Chernobyl evaluation at CFB Lahr, FRG, all of which required NES staff. The old MNL was also required at DRES for radioactive contamination evaluation (1), and this lack of an air-transportable lab caused considerable delay.

For these, and other reasons it was decided in 1990 to replace the old MNL with a newer, smaller vehicle which would take advantage of smaller and more powerful modern computers. A considerable reduction in the overall vehicle dimensions is achieved, allowing air transport. Although more compact, the new MNL is much more versatile and capable than its predecessor, as will be pointed out in the balance of this report. The new MNL successfully completed its first field trial in June 1991 at Royal Military College, Kingston (2).

2.0 THE NEW MNL

2.1 Physical Description

Table (1) lists some relevant physical parameters comparing the old and new MNLs.

TABLE (1)
PHYSICAL PARAMETERS OF MNLS

	Old	New
Overall length	30'2"	23'9"
Overall height		
- with A/C	10'2"	9'9"
- without A/C	8'11"	8'7"
Overall width	7'11"	7'11"
Office/lab space l×w×h	18'2"×7'7"×6'3"	11'8"×7'7"×6'2"
storage space l×w×h (some taken up by generators)	5'3"×7'7"×6'3"	4'4"×7'7"×6'2"
Gross Vehicle Weight	19,500 lbs.	15,500 lbs.
Generators	two 6 kW	two 6 kW

Fig (1) shows the old and new labs back-to-back to put the numbers in perspective.

2.2 The New MNL - Experimental Capabilities

The dosimetry and spectroscopy capabilities of the new MNL are compared to the old MNL in tables (2) and (3) below. The complete set of equipment listed here may be carried at one time, and indeed is necessary for many applications. The designations in the left-hand column indicate whether a system is used in the old MNL, the new MNL or both.

The gamma-ray spectrometers are divided into 'field' and 'contamination/lab' types. A 'field' spectrometer is normally deployed at some distance, typically 100', from the MNL, and measures free-in-air spectra either from a (experimental) long-range radioactive source or distributed ground contamination. A 'lab-contamination' spectrometer is one which is fixed (either in the MNL or some other laboratory) and receives possibly radioactive samples which are then counted for (induced) radioactivity. Note here that either BGO or NaI(Tl) could be used as a 'lab-contamination' spectrometer, but the Ge detector (having much superior resolution) is the preferred choice. The idea of a 'field' Ge spectrometer is currently being investigated by NES.

Note that normally there is no need for a 'lab-contamination' neutron spectrometer. However, should the occasion arise (delayed neutron monitoring, etc.) the ROSPEC would be ideally suited.

TABLE (2)
DOSIMETRY CAPABILITIES

(a) Gamma-Ray Dosimetry

Lab	System	Reference	Measurable Dose/ Dose Rate Range
Old + New	CaF_2:MN TLDs [Harshaw Reader]	(3)	10 mRad - few MRad
Old + New	Eberline ASP-1 Hand held Geiger Monitor	(1)	Background - few Rads/h
New	Al_2O_3 TLDs [Harshaw Reader]	(4)	0.2 mRad - few kRads

(b) Neutron Dosimetry

Lab	System	Reference	Measurable Dose Range
Old + New	BD100R Bubble Detectors + reader	(3)	Background - 1 Rad
New	'TREE' Bubble Detector + Reader	(5)	1 Rad - 100 Rad
New	Rh - foil activation system	(6)	1 Rad - many kRad

Note: Both vehicles are capable of carrying the Humanoid RT-200 anthropomorphic phantom for internal dosimetric mapping. The extended capabilities of the new MNL make this type of work much simpler to perform and more accurate.

TABLE (3)
SPECTROSCOPY CAPABILITIES

Gamma-Ray Spectroscopy

(a) Field Spectroscopy

Lab	System/Computer-Data Analysis System	Reference	Measurable Energy Range
Old	BGO/PDP 11-34	(7)	0.1 MeV - 12 MeV
New	BGO/Canberra PC		

(b) Lab/Contamination Spectroscopy

Lab	System/Computer-Data Analysis System	Reference	Measurable Energy Range
New	Ge (High Resolution) Aptec PC	(1)	0.05 MeV - 4 MeV

Neutron Spectroscopy

Lab	System/Computer-Data Analysis System	Reference	Measurable Energy Range
Old	NE213/BF_3/PDP11-34	(7)	0.7 MeV - 16 MeV directly
New	NE213/Canberra PC BF_3/Compaq PC		thermal to 0.7 MeV inferred
New	ROSPEC/BTI PC	(7)	0.06 MeV - 4.5 MeV
New	Bubble Spectrometer & Reader	(8)	0.01 MeV - 20 MeV

Figs. 2-4 illustrate some of these spectroscopic and dosimetric capabilities.

2.3 Applicability of New MNL

To illustrate some possible uses of the new MNL a variety of scenarios are discussed below, together with the equipment which would be best suited to serve the CF in each.

a. Long Duration or Very-Low Level Exposures

The new International Commission on Radiation Protection (ICRP) dose limits (recently agreed to by Atomic Energy Control Board of Canada) are 2 Rad/y for radiation workers and 0.1 Rad/y for non-radiation workers. This last value is of the order of the ambient background radiation levels (roughly 50% of which is gamma-ray).

In any event it is clear that dose rates of the order of μRad/h - mRad/h must be accurately measured to ensure absolute compliance. The clear dosimetric choice would be Al_2O_3 TLDs and bubble detectors. All spectrometers mentioned in the table will operate in the mRad/h range.

b. Accident Scenarios

For all accidents (including criticality) the fields are in general unknown and may fluctuate widely. Thus the entire gamut of doses from background up to lethal (~ 450 rads) and above must be measurable. For dosimetric purposes a combination of Al_20_3 and CaF_2Mn TLDs coupled with bubble detector/Rh-foils would constitute the optimum criticality dosimetric system. All spectrometers, save the bubble spectrometer will not operate above a few mrad/h due to dead-time effects, and thus accurate dosimetry before spectroscopy is essential.

c. TREE Experiments

In support of Transient Radiation Effects on Electronics (TREE) experiments neutron fluences of 10^{12}n/cm^2 (~ 1000 Rads), gamma-ray doses of 1000's of Rads and dose rates of 10^9 Rads/s must routinely be measured - although a few percent of these values can sometimes be obtained by facility adjustment. Thus CaF_2:Mn TLDs and Rh-foils and bubble detectors and spectrometers are the choices here.

3.0 CONCLUSIONS

The new DREO mobile nuclear laboratory is a unique facility capable of neutron and gamma-ray dosimetry, spectroscopy and calculations, either on or off-site, at an extremely high (scientific) level. The new lab is more compact (and thus, transportable) than its predecessor, while at the same time offering much greater technical capabilities and accuracy. The new MNL will be able to serve DND's needs in nuclear radiation research, accident and weapon scenarios for many years to come.

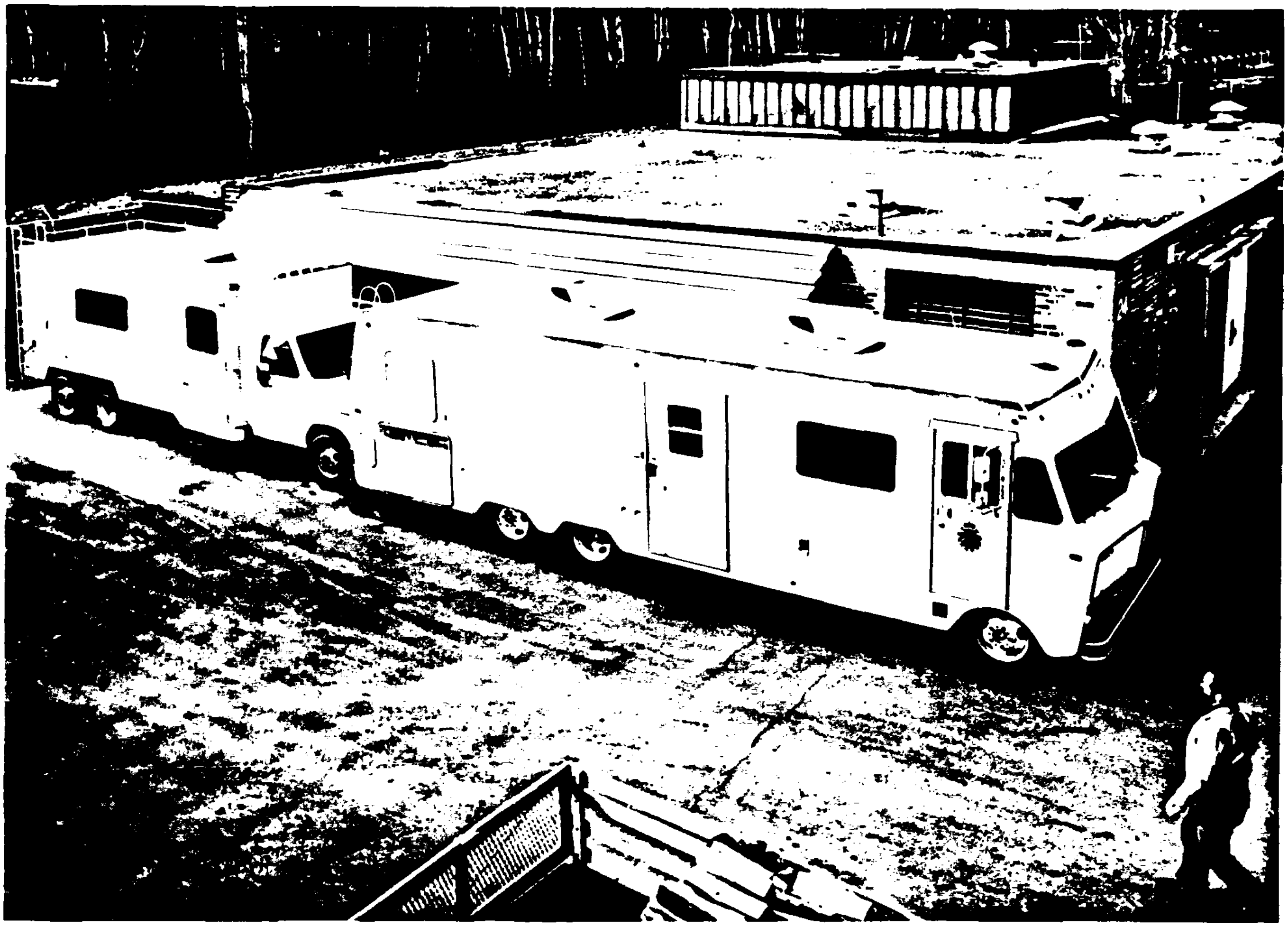

Figure 1: Old (right) and new (left) MNLs at DREO
Note the important difference in length.

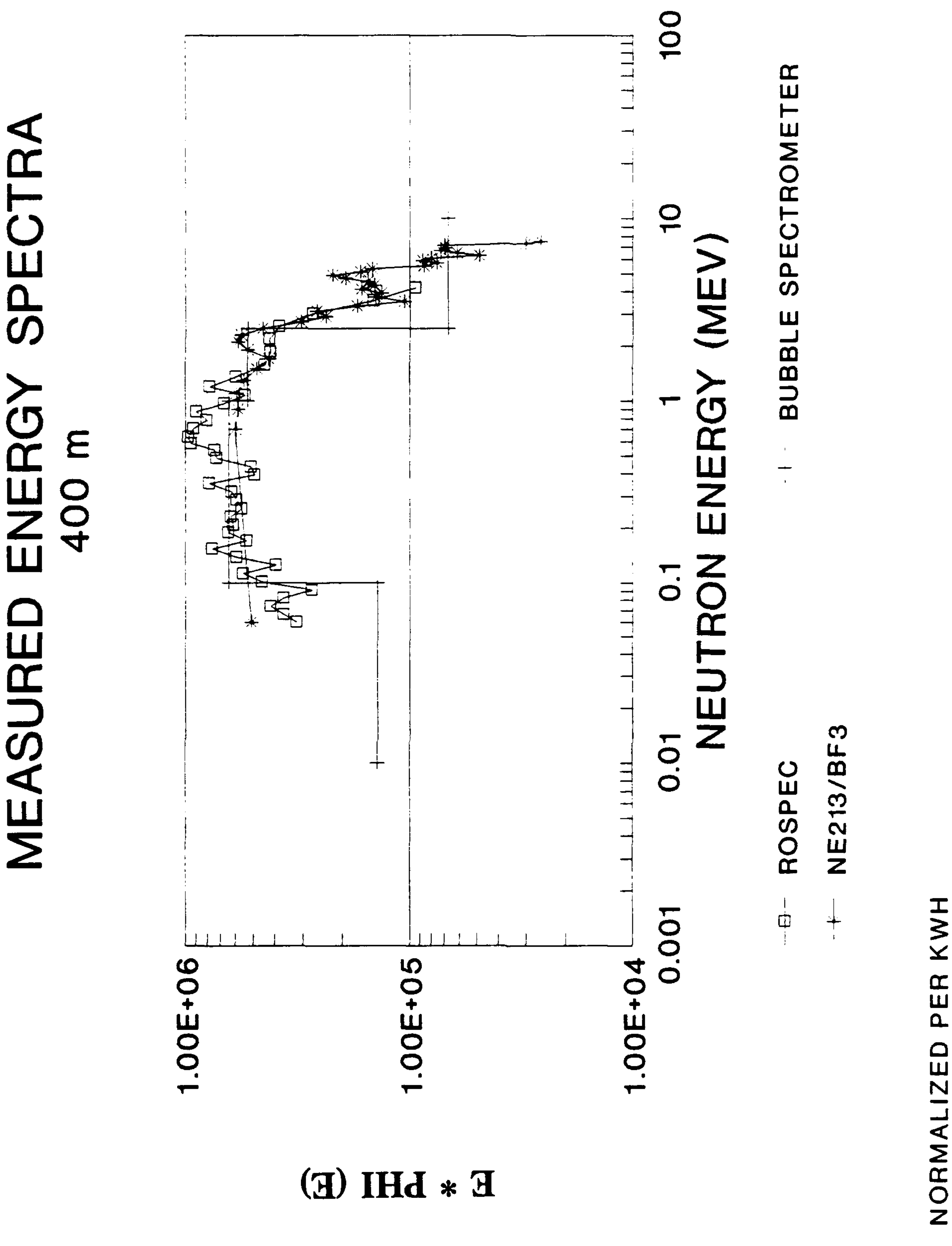

Figure 2: Measured neutron energy spectra at NATO standard reference point (400m) at Aberdeen Proving Ground. The figure is illustrative of the relative energy ranges and resolutions for the various MNL detectors.

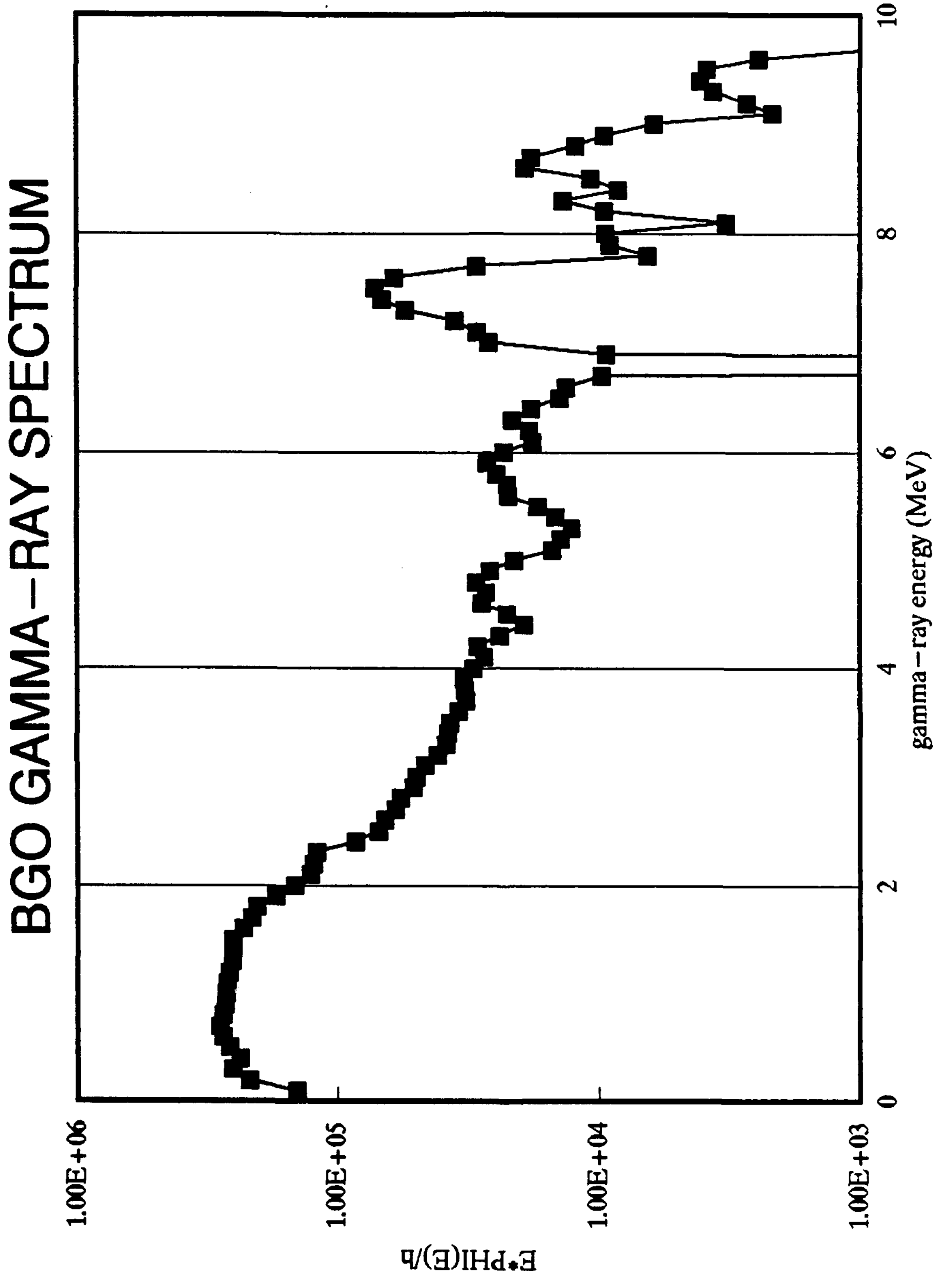

Figure 3: BGO-measured gamma-ray energy spectrum in the area above the RMC SLOWPOKE II facility. Note the presence of peaks (due to neutron capture) riding on a continuum.

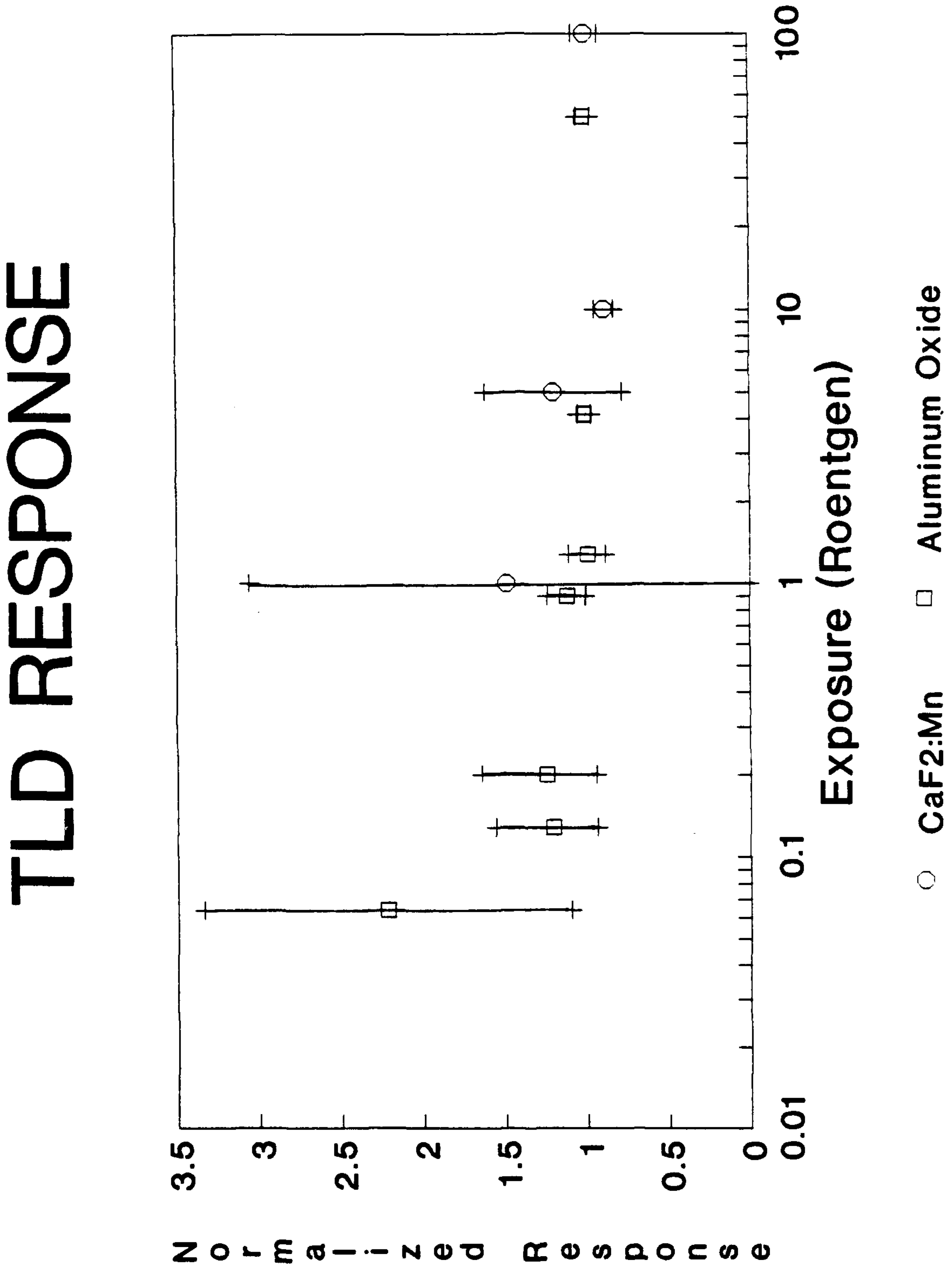

Figure 4: Gamma-ray dosimetric capabilities of DREO TLD systems. A 'perfect' dosimeter here would have a flat (=1) response, with small error bars. Note that with Al_2O_3 the measurable limit (defined as 10% accuracy has been reduced from ~ 10 mRad to ~ 0.2 mRad.

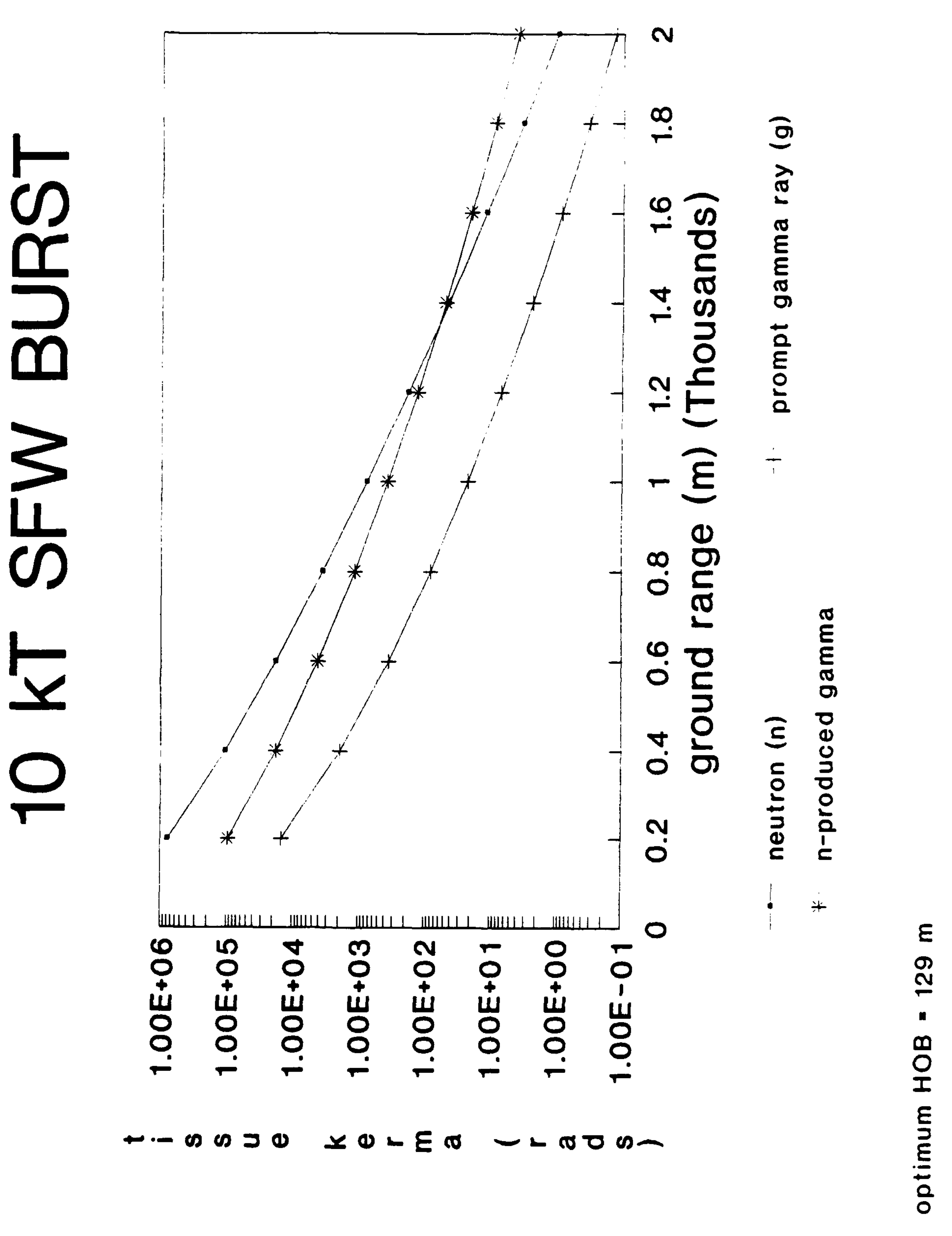

Figure 5: ATR5 output prediction of prompt nuclear radiation from a 10kT standard fission weapon.

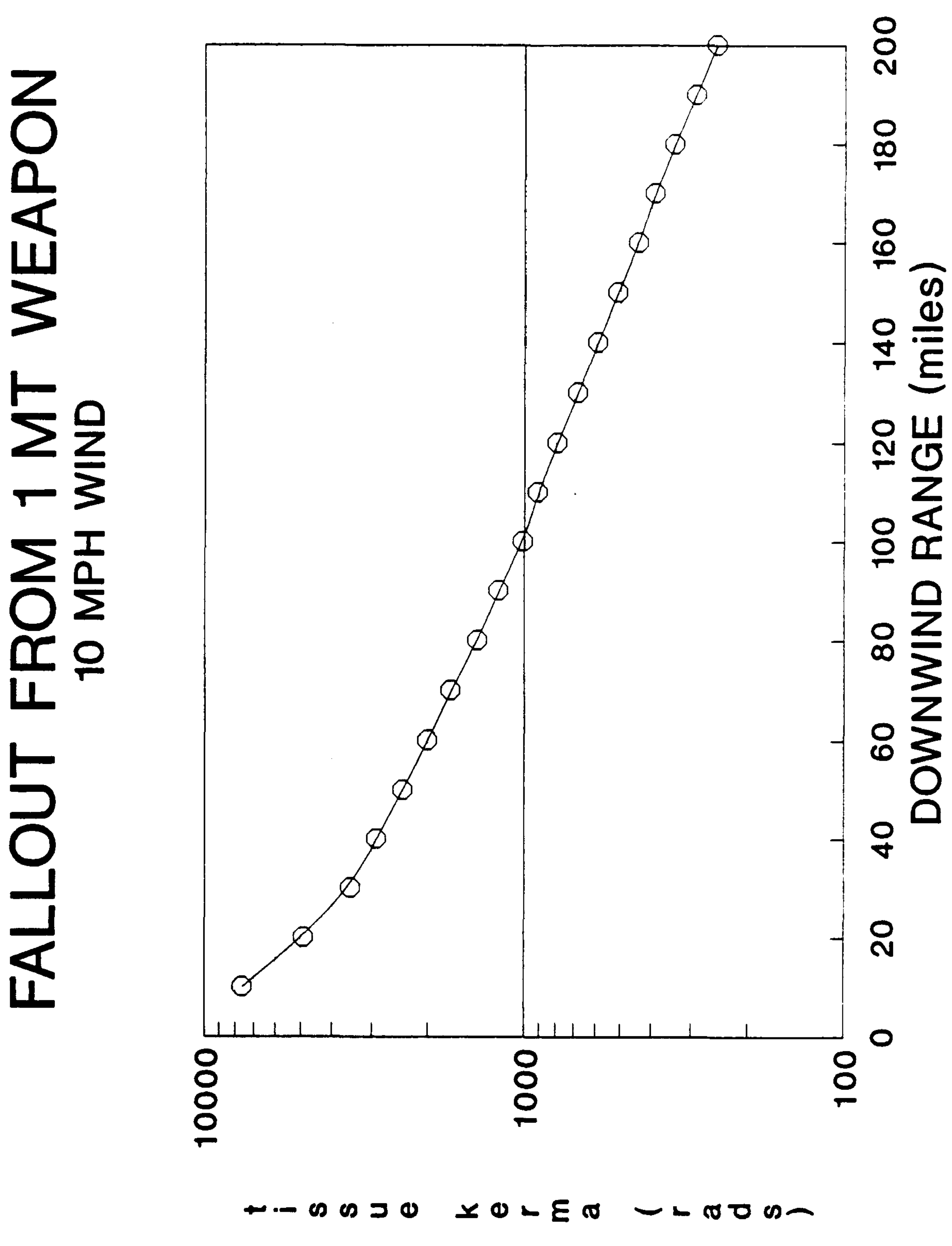

Figure 6: 'Weapons Effects' output prediction of long-range fallout from a 1 MT standard fission weapon.

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