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THE RESPONSE OF SURVEY METERS TO PULSED RADIATION FIELDS†

Richard C. McCall and Nisy E. Ipe
Stanford Linear Accelerator Center
P. O. Box 4349, Stanford, CA 94305

The response of most survey meters to steady radiation fields is fairly well known and documented. However hardly any data is available in the literature regarding the response of these instruments to pulsed radiation. Pulsed radiation fields are encountered e.g., in the vicinity of linear electron accelerators or klystrons. Linear accelerators can deliver pulses up to a few microseconds long at repetition rates of a few hundred Hz. The fraction of operating time during which the beam is on (i.e., pulse width × repetition rate) is called the duty factor (D.F.). Typically duty factors for linear electron accelerators are less than 0.001. These small duty factors impose severe limitations on the radiation detection instruments as is shown below. The peak or instantaneous intensity (I_P) will be $I_P = I_{av}/D.F.$, or more than 1000 times the average intensity (I_{av}).

An instrument that ordinarily responds well to the average dose rate spread out evenly in time may not be able to cope with such a high dose rate. Instruments which have long dead times such as Geiger Mueller and proportional counters tend to become saturated in such fields and only count repetition rate. Ionization chambers are less influenced however, they must be operated with adequate voltage to overcome recombination losses. Scintillation survey meters may become non-linear at higher dose rates for pulsed radiation because the photomultiplier cannot handle the instantaneous currents that are required. Because of the need to test the response of different radiation detection instruments to pulsed fields, a pulsed x-ray facility has been built (Ip87). A brief description of this facility is given below along with tests of several different instruments.

Figure 1 shows a partial cut-away view of the pulsed x-ray facility. The major part of the x-ray tube is the electron gun which provides a stream of pulsed electrons that can be accelerated towards a combined target-window located directly below it. The window consists of aluminum 510 μm thick plated on the vacuum side with a layer of gold 6.4 μm thick. The frequency of the electron pulses can be varied by an internal pulser from 60 to 360 Hz with pulse widths from 360 ns to 5 us. The pulse amplitude can be varied over a wide range of currents. An external pulser can be used to obtain other frequencies or special pulse shapes. The voltage across the gun can be varied from 0 to 100 kV. The major part of the x-ray tube is enclosed in a large walk-in cabinet made of plywood lined with 0.32 cm thick lead, thus adequate shielding is provided.

A precision ionization chamber* (Farmer type) mounted directly below the x-ray tube facilitates remote readout of radiation levels

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*Model 30-35I, Victorean Inc., Cleveland, OH 44104

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inside the cabinet. Experimental data indicated that this chamber and the Radcal ion chamber* (used with a 2025AC radiation monitor) were in good agreement therefore, the readings taken with the Radcal are considered to be the "true dose rate". The Radcal has a fairly uniform response between 30 keV and 1.33 MeV.

A brief study was made of the response of a cylindrical GM counter to pulsed radiation. Because of a non-pulsed dark current from the x-ray tube, it was not possible to study this in great detail. However, 5 mR/hr of non-pulsed x-rays at 80 kV gave 410 counts/second. An additional 5 mR/hr of pulsed x-rays at 100 Hz (pulse width = 2 μS) gave an additional 87 ± 11 counts/second. This shows that even at 5 mR/hr the GM counter is essentially only counting pulse repetition rate.

The "Radector II" consists of a pressurized argon filled ionization chamber (Neher White) which has a uniform response for photon energies between 80 keV and 1.2 MeV. Its response to pulsed x-rays (pulse width = 1 μS) at 100 kV (with aluminum filtration 1.6 mm thick) at 100 Hz is shown in Figure 2. The response departs significantly from linearity for dose rates above 1 mGy/h. This is probably inherent in Neher-White chambers due to the low collecting voltage. Part of the spectrum of the pulsed x-rays was below the flat response range of the Radector and this caused it to read only 45% as high as the Radcal at low dose rates.

The SLAC scintillation survey meter is built in house and consists of a Bicron air equivalent plastic scintillator doped with arscenic to increase the effective atomic number to that of air. Its decay constant is in the nanosecond range. Figure 3 shows its corrected response to pulsed x-rays (pulse width = 2 μS) at 70 kV and 120 Hz. The response begins to deviate from linearity above 1.0 mGy/h. There are several causes of non-linearity in photomultipliers. It is not certain but we believe the cause in this case is due to the photocathode resistance. The data has been corrected for the small difference in spectral response of the instrument from the ionization chamber.

The Xetex 303B is specifically designed for use around pulsed radiation sources. It consists essentially of a calcium fluoride scintillator and a vacuum photodiode and has a response fairly independent of energy between 60 keV and 2 MeV. It's response to pulsed x-rays (pulse width = 2 μS) at 70 kV and 120 Hz is shown in Figure 4. The response is quite linear up to 40 mGy/h. The data is corrected for the somewhat low response of the 303B to this x-ray spectrum.

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*Model 20X5-180 Radcal Corporation, Monrovia, CA 91016.

REFERENCES

I_p 87. Ipe, N.E., McCall, R. C. and Baker, E. D., Health Phys. 524, 463-468 (1987).

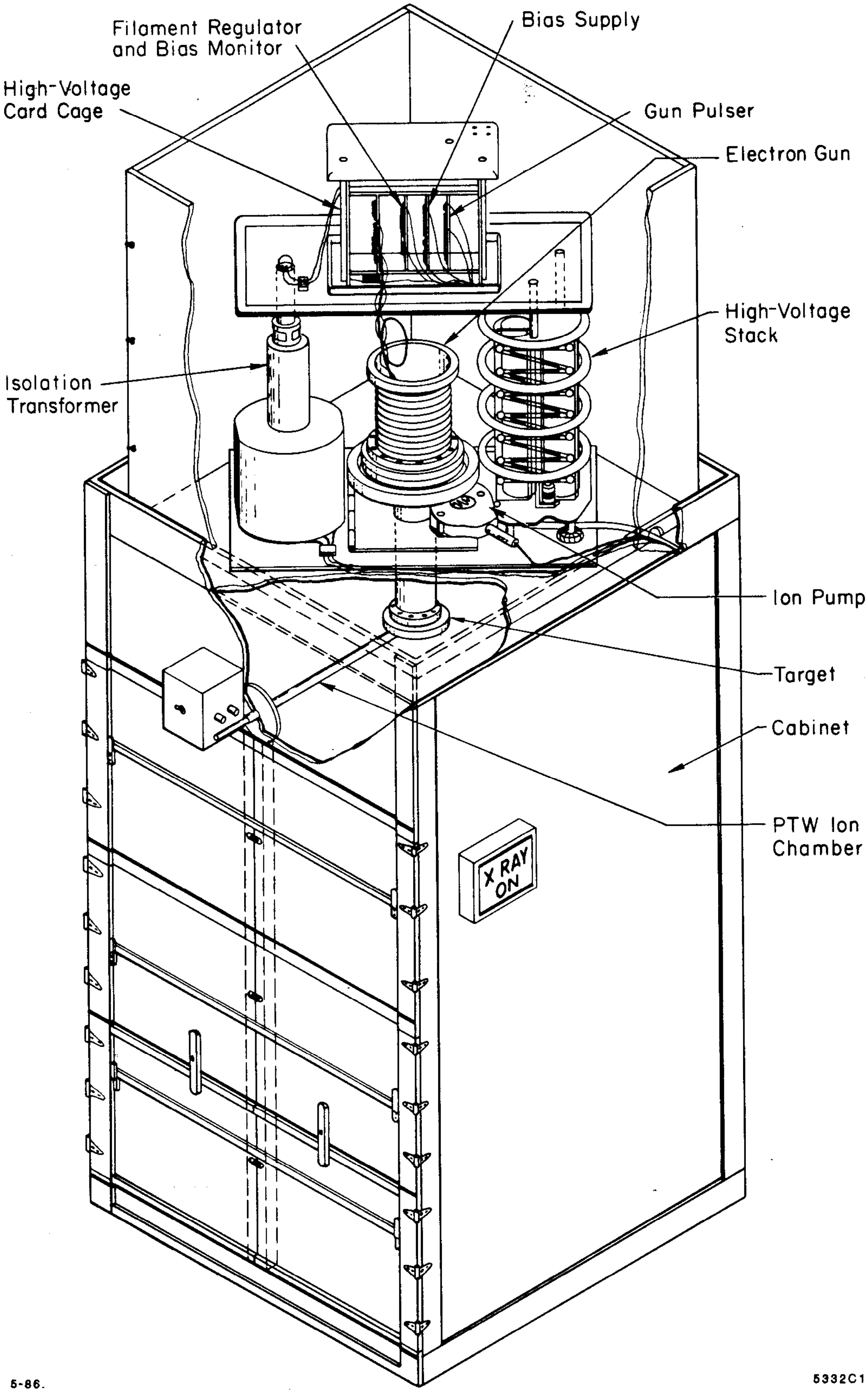

Fig. 1. The SLAC pulsed X-ray Facility.

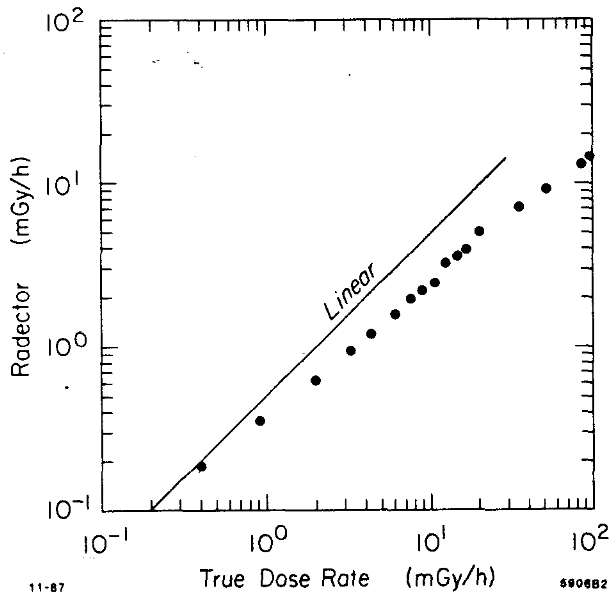

Fig. 2. Response of Radector.

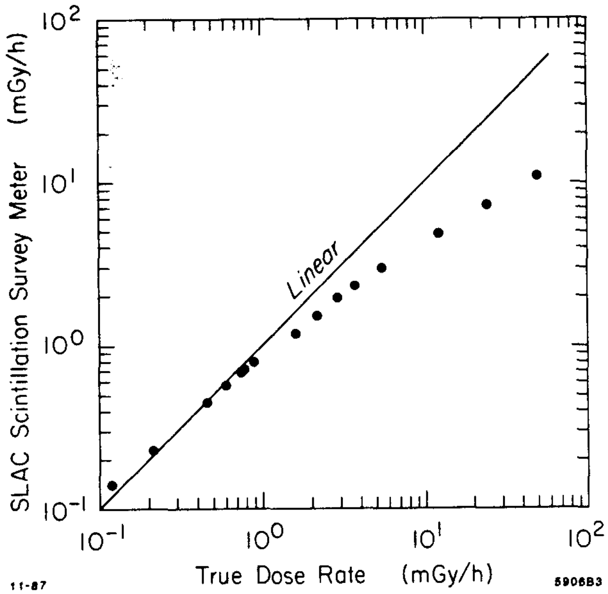

Fig. 3. Response of SLAC Scintillation Survey Meter.

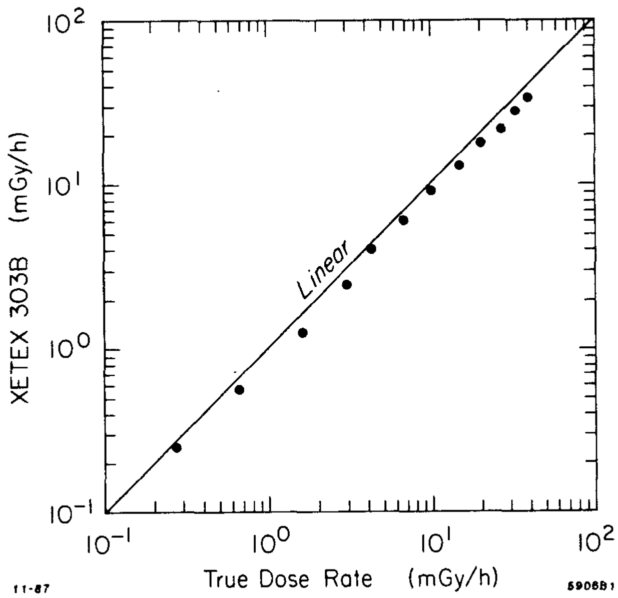

Fig. 4. Response of XETEX 303B.