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4.46 Superlinearity, Saturation, and the PMT—Tailoring and Calibration Methodology for Prompt Radiation Detectors

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Photomultiplier tubes, particularly those for high energy density physics, ideally operate over many orders of magnitude with linear response. We examine nonlinear response and mitigation strategies to extend the maximum linearity for metal mesh, plate, or glass MCP PMT. Superlinearity here means a positive nonlinear response and extension of linear operational limits by counteracting saturation mechanisms—charge depletion, space-charge field, and secondary emission surface effects. Our detector calibration methodology uses NIST-traceable calibrated standard laboratory equipment, and absolute input-referenced techniques to examine impulse or step responses separately as these are no longer related through linear integration. Quantitative analysis reveals nonlinearity strength independent of charge depletion. We further present a whole-detector radiation sensitivity calibration method using high-activity Co-60 sources, precise collimation, and NIST-calibrated flux measurement. Accurate characterization of nonlinear response and tailoring of the PMT circuitry can effectively produce higher linear current and charge limits. Recent results are also applicable to MCP PMT. This work was done by MSTS, LLC under Contract DE-NA0003624 with the U.S. Dept. of Energy. DOE/NV/03624—0027

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