MODIFICATION OF A RECTILINEAR SCANNER TO IMPROVE ^{67}Ga SCANS

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A simple and inexpensive electrical modification of the pulse-height analyzers of the Ohio-Nuclear Model 84FD rectilinear scanner, which allows the use of wide pulse-height intervals, is described. The modified instrument is applied to ^{67}Ga scanning, in which the increased acceptance of gamma rays produces scans of increased count density and improved image quality.

The use of ^{67}Ga as a tumor-scanning agent was first suggested by Edwards and Hayes (*1*). Subsequently ^{67}Ga was recognized as a useful tool for the detection of abscesses (*2,3*). Unfortunately the counting rates achieved during ^{67}Ga scanning are usually low, resulting in scans of low count density and poor image quality. Thus, any modification in technique that improves the counting rate should be advantageous, provided other parameters affecting image quality are not unduly compromised.

The ^{67}Ga decay scheme (inset, Fig. 1) is complex, with several branches, each associated with one or more gamma photons of differing energies. Figure 1 shows the pulse-height spectrum resulting from exposure of the radiation detector of a commercial rectilinear scanner (Ohio-Nuclear Model 84FD) to a point source of ^{67}Ga in air. Four prominent peaks are seen, corresponding to photons of energies 93, 185, 296, and 389 keV. Often the detectors of clinical scanning devices are equipped with a single pulse-height analyzer capable of accepting pulses only within limited voltage intervals. In this case, only photons corresponding to a single photopeak may be used for scanning. The highest counting rates can be achieved by selecting the 93-keV radiation, but this region of the spectrum is severely contaminated by radiation scattered in the patient from the higher energy gamma photons. The choice of a higher energy peak for scanning results in images less degraded by scatter, but of lower count density.

Counting rates can be improved by modifying the scanner so that a more extended region of the ^{67}Ga spectrum, including several photopeaks, can be used. An excellent approach consists of connecting each detector system to two or more additional pulse-height analyzers, which can be set independently to accept photons of different energies. This solution has been used at institutions where the funds and appropriate technical expertise are available (*4*). On the other hand, it might be possible to obtain comparable scans of higher count density by properly selecting a single pulse-height interval wide enough to include several photopeaks. Edwards and Hayes (*1*) used a pulse-height interval corresponding to 160 keV, which included the 185 and 296 keV photopeaks. Our own analysis of ^{67}Ga scintillation-counter spectra (including spectra obtained from patients with a rectilinear scanner) indicated that the increased amount of scatter from the patient would not badly degrade the scans, provided that only the three higher-energy gamma photons at 185, 296, and 389 keV were used. We therefore tentatively chose the latter route, since it is inexpensive and technically much easier.

While the discussion below applies to the Ohio-Nuclear Model 84FD scanning device, we believe that comparable results can be achieved with similar scanners, provided a method of enlarging the usable energy interval can be found. The manufacturer of our instrument offers an option that allows scanning with "windows" up to 1 MeV in width, and they will modify scanners already in clinical use. Also, Yeh (*5*) has observed that a relatively wide region of the ^{67}Ga spectrum can be counted if the gain of the photomultiplier tube is reduced. Unfortunately

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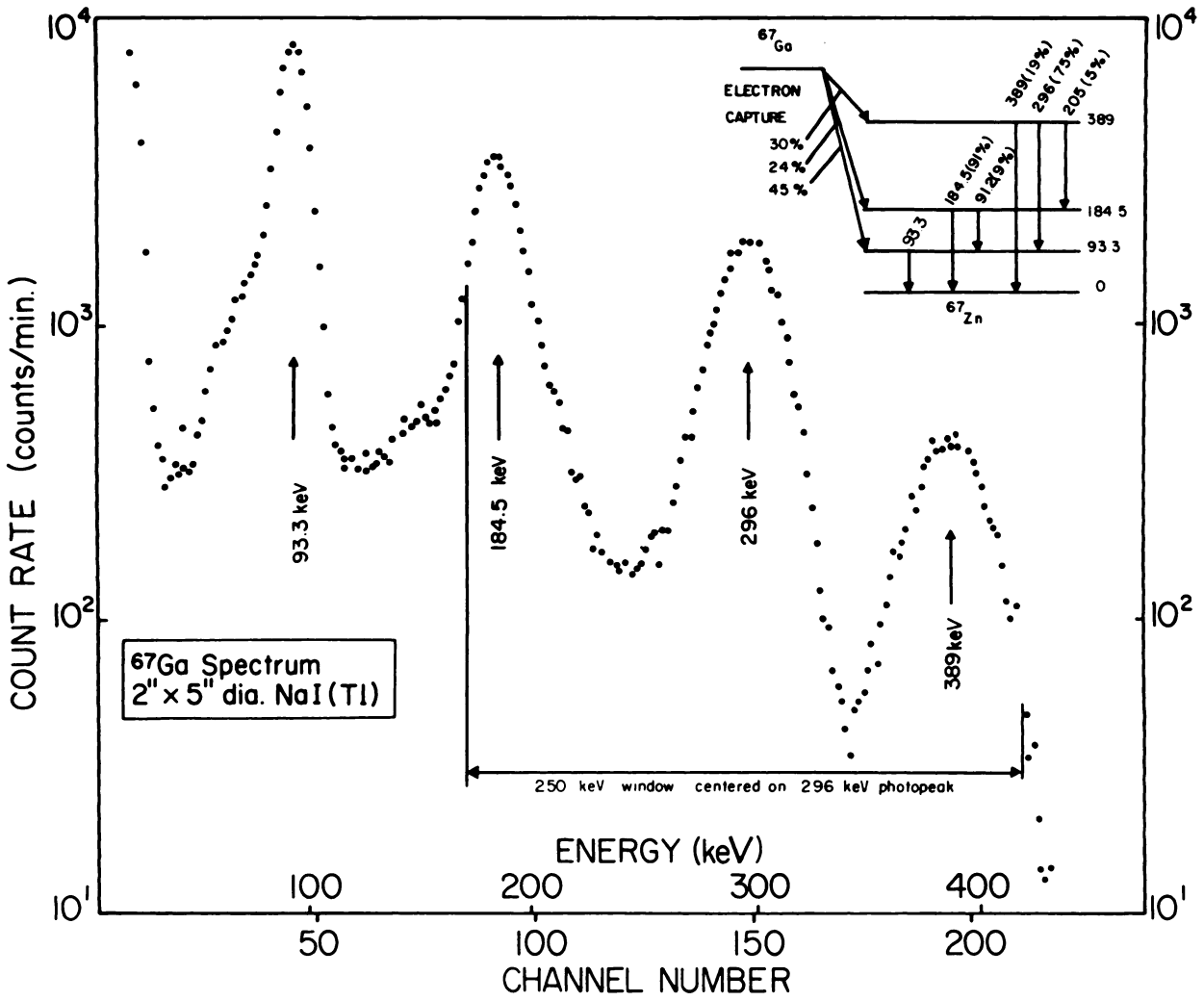

FIG. 1. Gallium-67 spectrum obtained with scintillation counter of Ohio-Nuclear 84FD rectilinear scanner ("point source" in air). Region of spectrum included in 250-keV window, centered at 296 keV, is indicated. Inset at upper right shows ^{67}Ga decay scheme.

this procedure increases the likelihood of counting electronic noise and requires recalibration of the spectrometer before and after scanning with ^{67}Ga. We wish to offer a very simple modification of the pulse-height analyzers which enlarges the usable energy interval without decreasing the gain.

For the pulse-height analyzers of our scanner, the window width is set by adjusting the bias on the wipers of the ganged "window" helipots located on the front panel. To achieve a wider window than the maximum the manufacturer has allowed, one only needs to increase this bias by introducing additional resistance between the low-voltage side of the helipots and ground, each ohm of resistance being equivalent to about 10 keV on our instrument. To include ^{67}Ga photons at 185, 296, and 389 keV, a total window width of 250 keV is needed. The pulse-height analyzer in our scanner was modified (Fig. 2) so

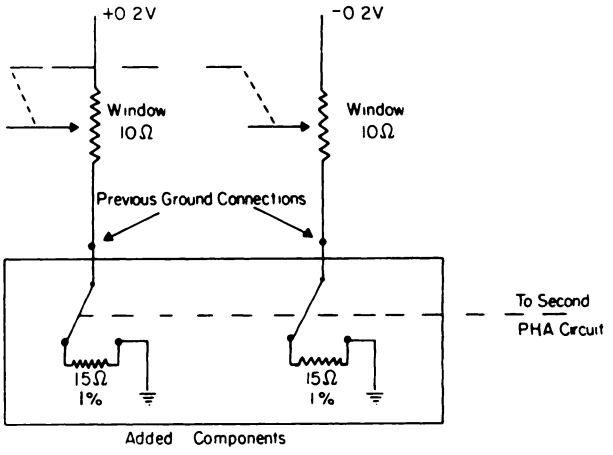

FIG. 2. Circuit modification of pulse-height analyzer with added components enclosed by box. Switch (shown in wide-window mode) actually has four poles and is used to change pulse-height interval for both probes simultaneously.

that 15-Ω resistors could be switched into the circuits for wide-window operation or removed for normal narrow-window operation. Since a resistor and switch must be added to each of four window helipots, a four-pole double-throw switch was used, mounted on the front panel. The electrical alterations can be made in about 1 hr and the required components cost less than ten dollars.

The adjustment of the instrument for ^{67}Ga scanning with the wide window proceeds as follows: With the switch in the narrow-window mode the probes are peaked on the 296-keV photon. The helipots are then set for maximum window width and the switch is placed in the wide-window mode, after which scanning proceeds as usual. When using the wide window, extra care should be taken to keep the center line of the window set high enough to prevent the lower edge from falling below zero volts.

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