ABSTRACT

ABSORPTIOMETRY WITH A LINEAR POSITION-SENSITIVE PROPORTIONAL COUNTER

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Use of a linear position-sensitive proportional counter (PSPC) as a detector for absorptiometry of bone mineral content (BMC) was studied. Conventional absorptiometric scanning has precision errors (2%) due to 1) the subject movement during a scan and 2) the relocation of a linear scan site between measurements. PSPCs could possibly reduce measurement time and the errors caused by subject motion. Also, area measurements could be done with a PSPC in order to have a visual display which would aid in repositioning.

Characteristics of PSPCs particularly pertinent to absorptiometry are 1) spatial resolution, 2) energy resolution, and 3) detection efficiency. Sufficient spatial (<2 mm) and energy resolution (3 keV FWHM) are available with PSPCs. At modest pressure (>3 atm) with xenon gas, PSPCs have adequate detection efficiency (>50%) for medium energy photons (<45 keV). However, the reduced electron mobility at these gas pressures limits the spatial resolution and the count rate capability.

A specific linear PSPC (2M1D) was investigated. The 2M1D PSPC was 60 cm long, had a 4.8-cm-diameter cathode, and was filled with 3 atm of a 97% Xe-3% CH_4 gas mixture; the predicted detection efficiency was ≃55% for 28 keV photons. The optimal spatial resolution (2 mm) of 2M1D

occurred at a bias potential of 3200 V, but optimal energy resolution occurred at a bias potential of 2100 V. Most of the measurements, however, had to be done in a non-proportional region at 3200 V without energy resolution in order to achieve adequate spatial resolution. High count rate affected spatial resolution and contrast. Degradation of spatial resolution and contrast occurred $>10^5$ cps. Pulse pile-up within the shaping amplifiers caused inaccurate decoding of the spatial information. Ideally, the amplifier's shaping constant should be very short to minimize pulse pile-up. A shaping constant, optimized for spatial resolution, was used (0.6 μsec). There was a substantial parallax error when using a point radionuclide source with the 2M1D linear PSPC which restricted absorptiometry to a source-to-detector distance of >50 cm. Parallax would be reduced by a thinner detector.

Absorptiometry was done using the 2M1D PSPC and a point source of ^{125}I. Scattered radiation contributed ≃6% of the transmitted intensity but did not appear problematic. The detection of scattered radiation caused nonexponential attenuation of bone mass >0.8 g/cm. A collimator was designed but not used. The radius BMC of 7 subjects measured with the PSPC correlated (r= 0.99) with the conventional scanning method. Precision *in vivo* was 0.8 to 1.2%.

A new type of PSPC using multiple (6) anodes was designed and built. The multianode PSPC, because of its increased electric field strength, has a larger electron drift velocity and a faster rise-time (≃100 nsec) than 2M1D. A faster rise-time allowed for a higher count rate ($>10^5$ cps) and improved spatial resolution (≃1 mm). These advantages make the multianode PSPC suitable for absorptiometry. However, single-anode PSPCs would also be more suitable with changes. Use of a thin-wire anode would allow both energy and spatial resolution, while collimation, fast electronics, and a small detector size would reduce measurement times. These changes would favor use of PSPCs for absorptiometry.