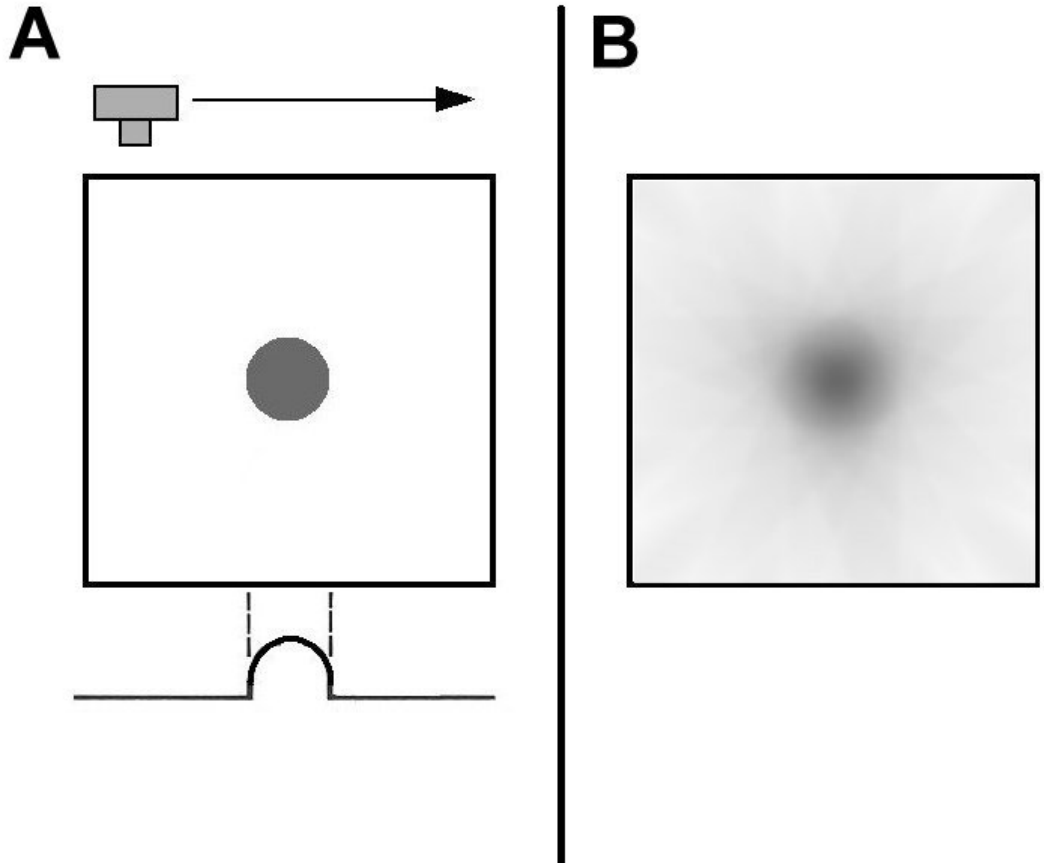
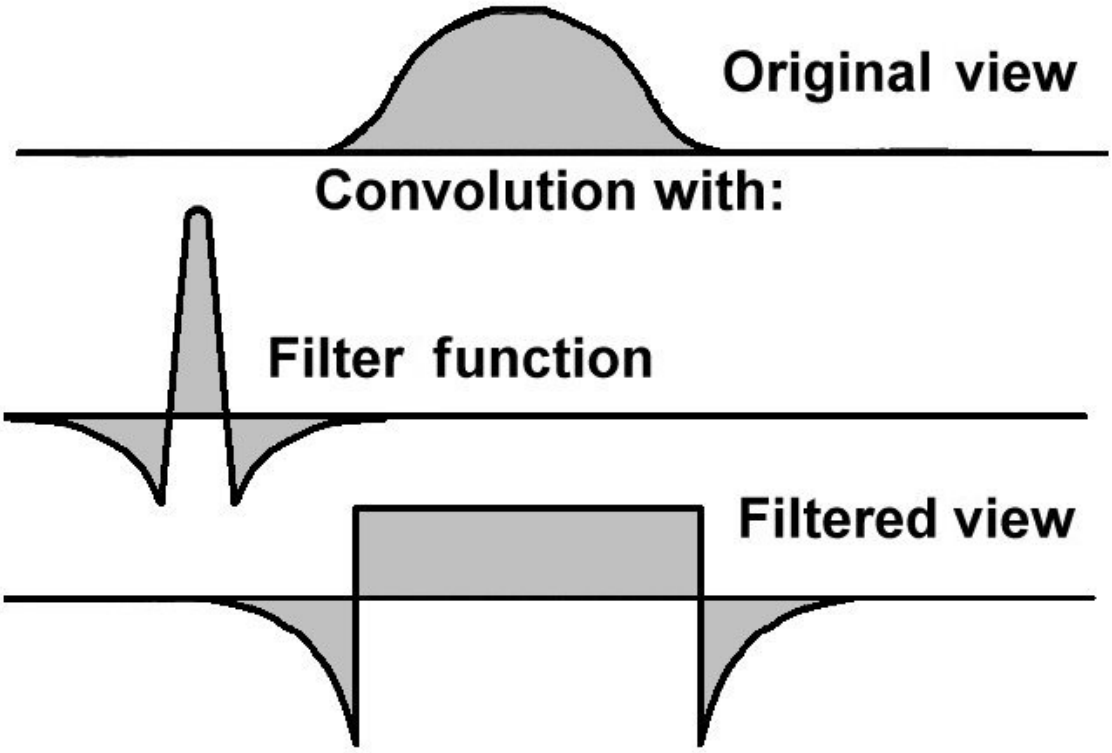
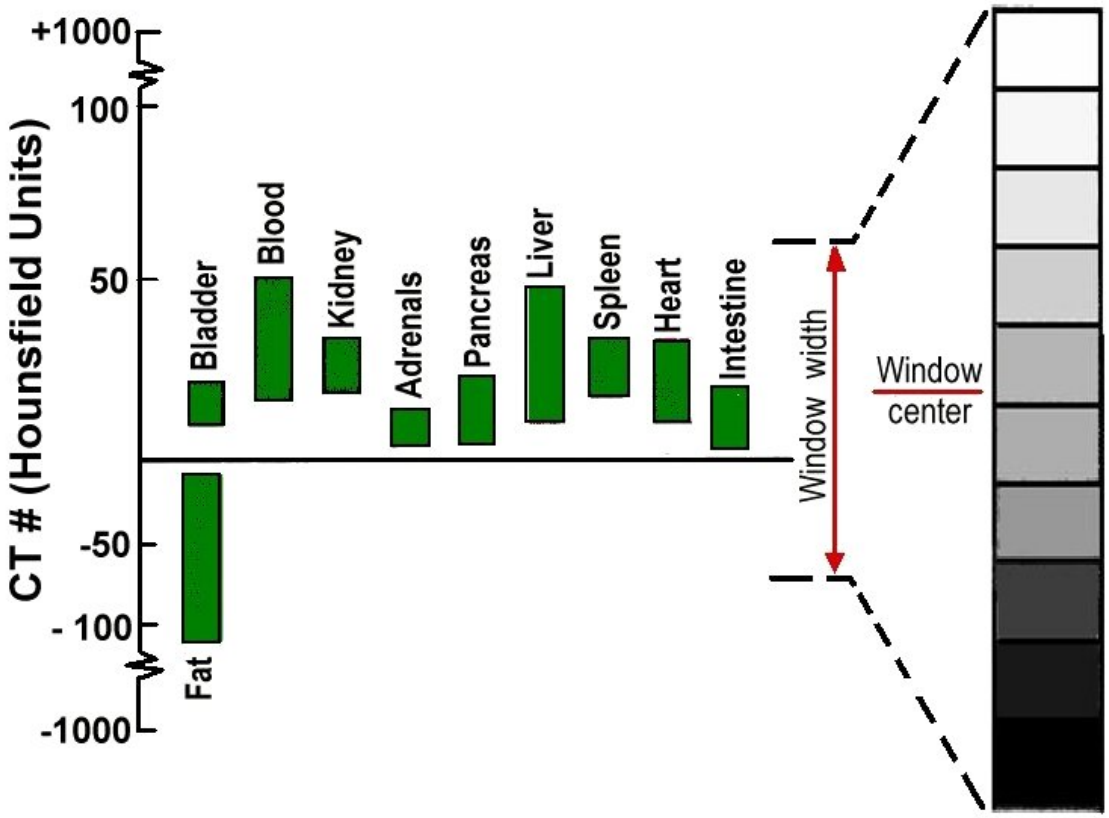


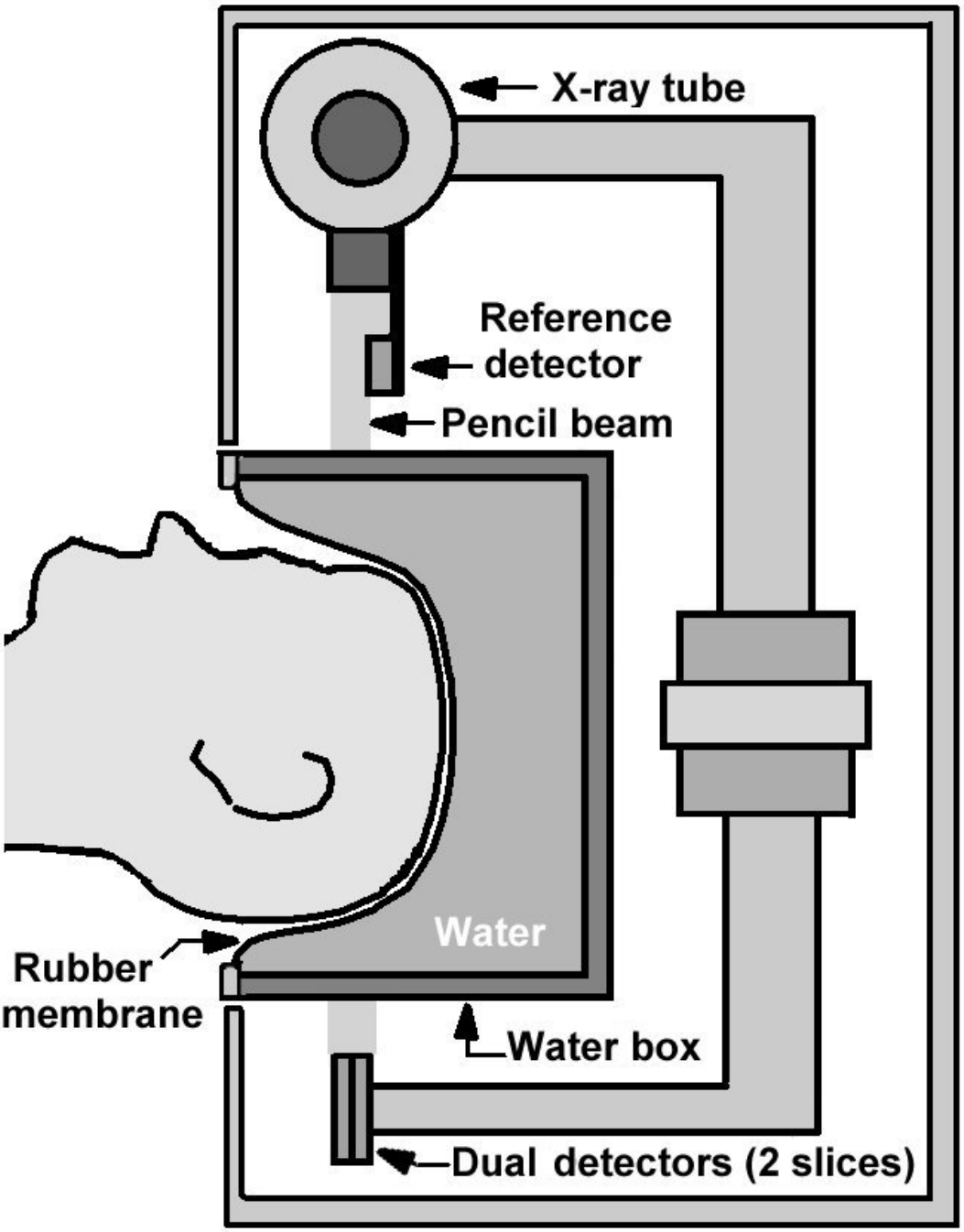
SUPPLEMENTAL FIGURE 1. Backprojection Blur: (A) The nature of x-ray attenuation yields a view profile of a cylinder that is a maximum through its center and less toward the edges. (B) Backprojecting the profile of (A) builds a blurred image of the cylinder.



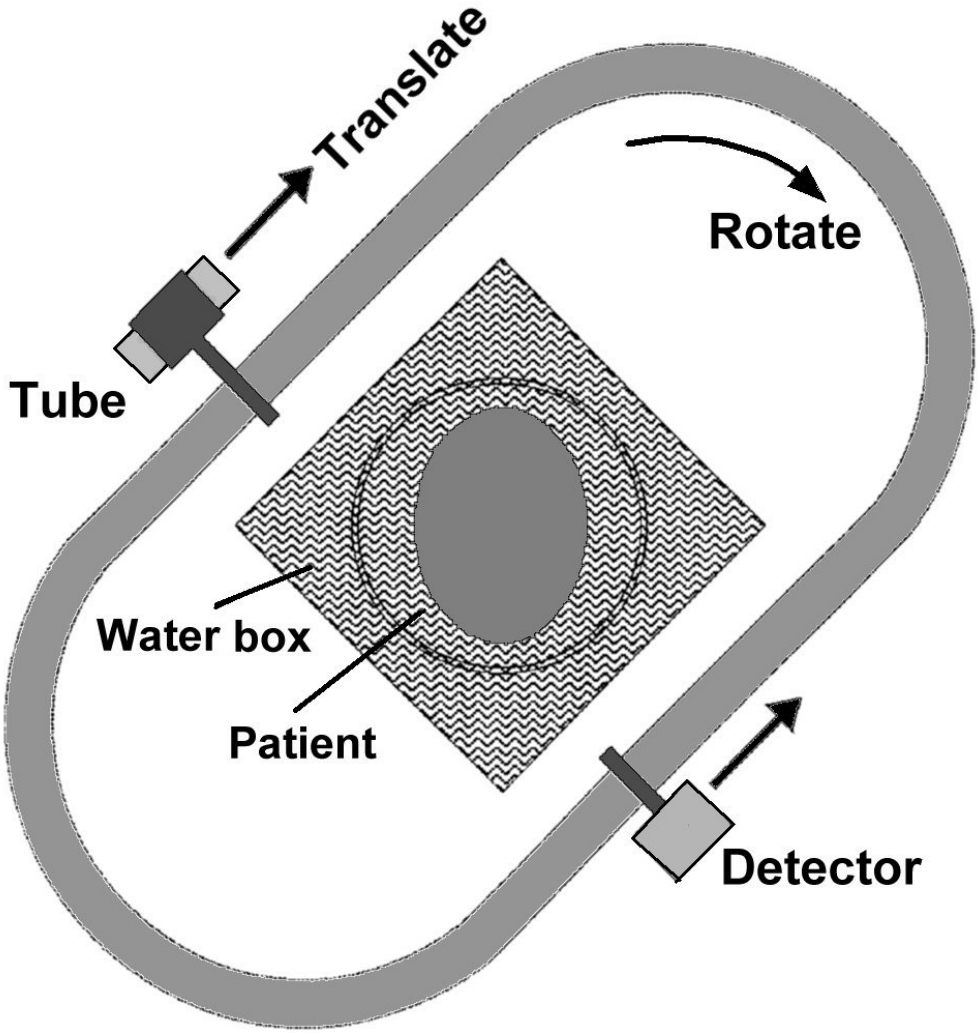
SUPPLEMENTAL FIGURE 2. Filtering: A mathematic filter function (center) is applied to each original view (top) by a process called convolution, generating a filtered view (bottom) that has been deblurred.



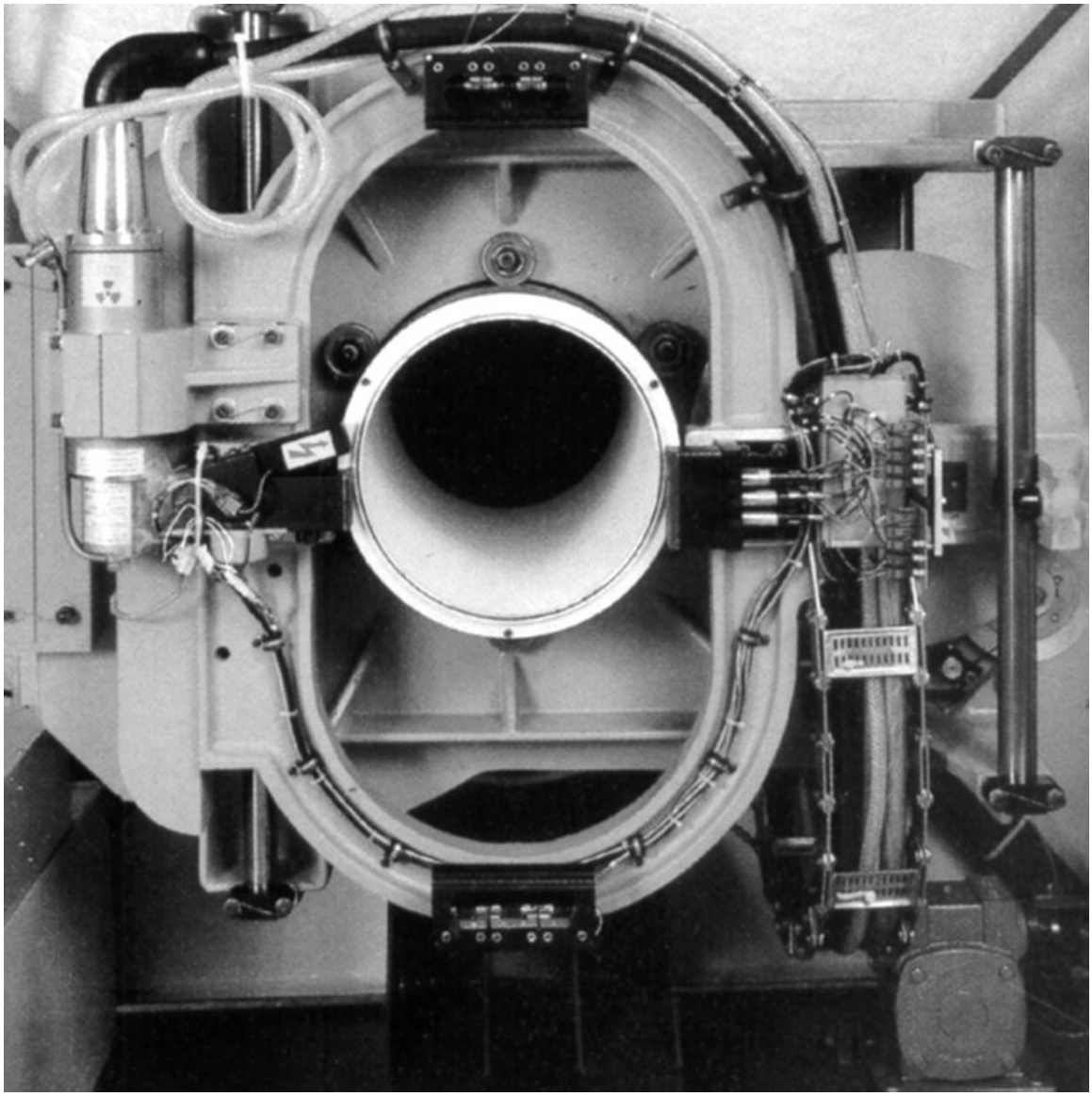
SUPPLEMENTAL FIGURE 3. CT Number Display: "Windowing" was developed to allow a large potential CT number range to be displayed using a limited gray-scale range. Two user-controlled parameters (window width and level) allow the limited gray-scale range to be used for different CT number ranges according to the user's need.



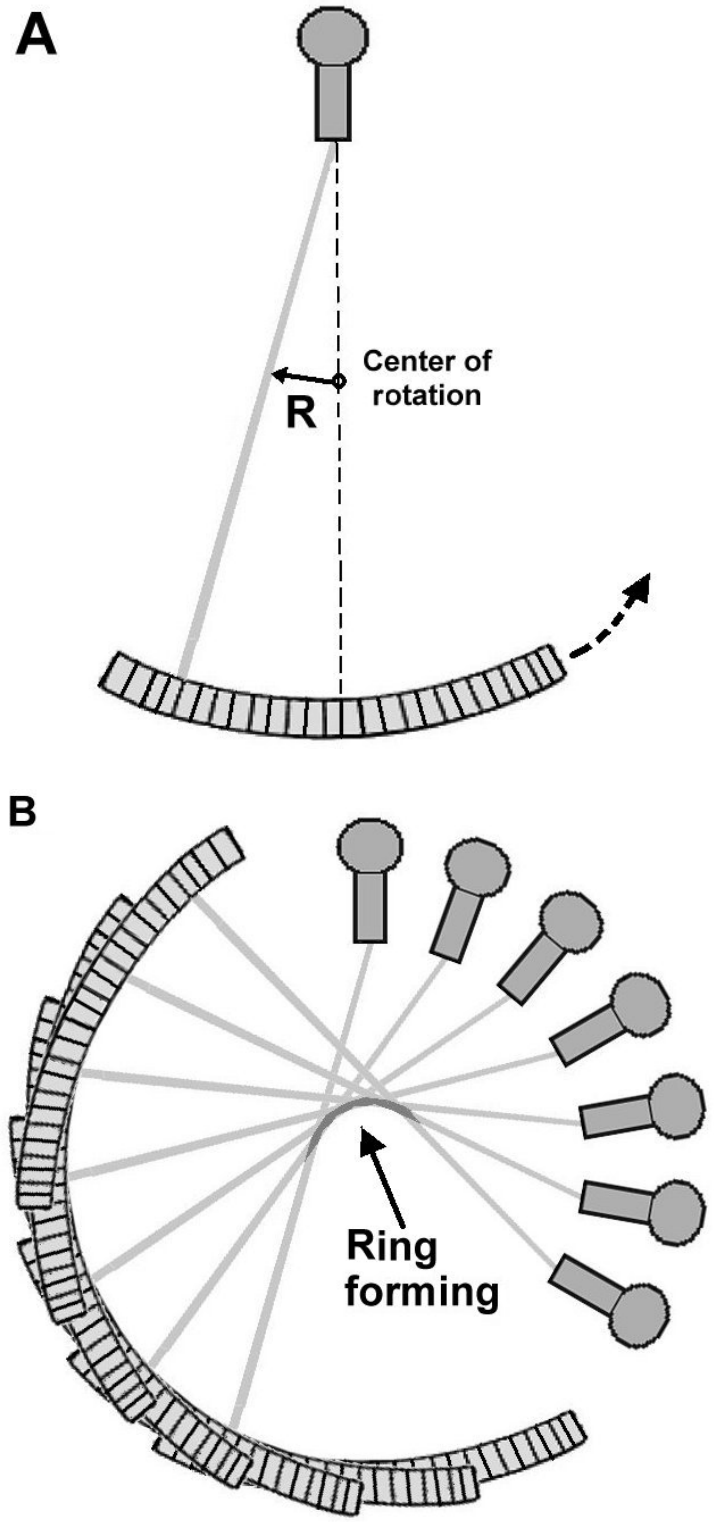
SUPPLEMENTAL FIGURE 4. First-Generation Water Box Design: The patient's head was recessed into a water box via a rubber membrane. The water box helped eliminate beam hardening artifacts. Each scan required 5–6 min. To reduce procedure time, 2 adjacent detectors simultaneously collected data for 2 adjacent slices.



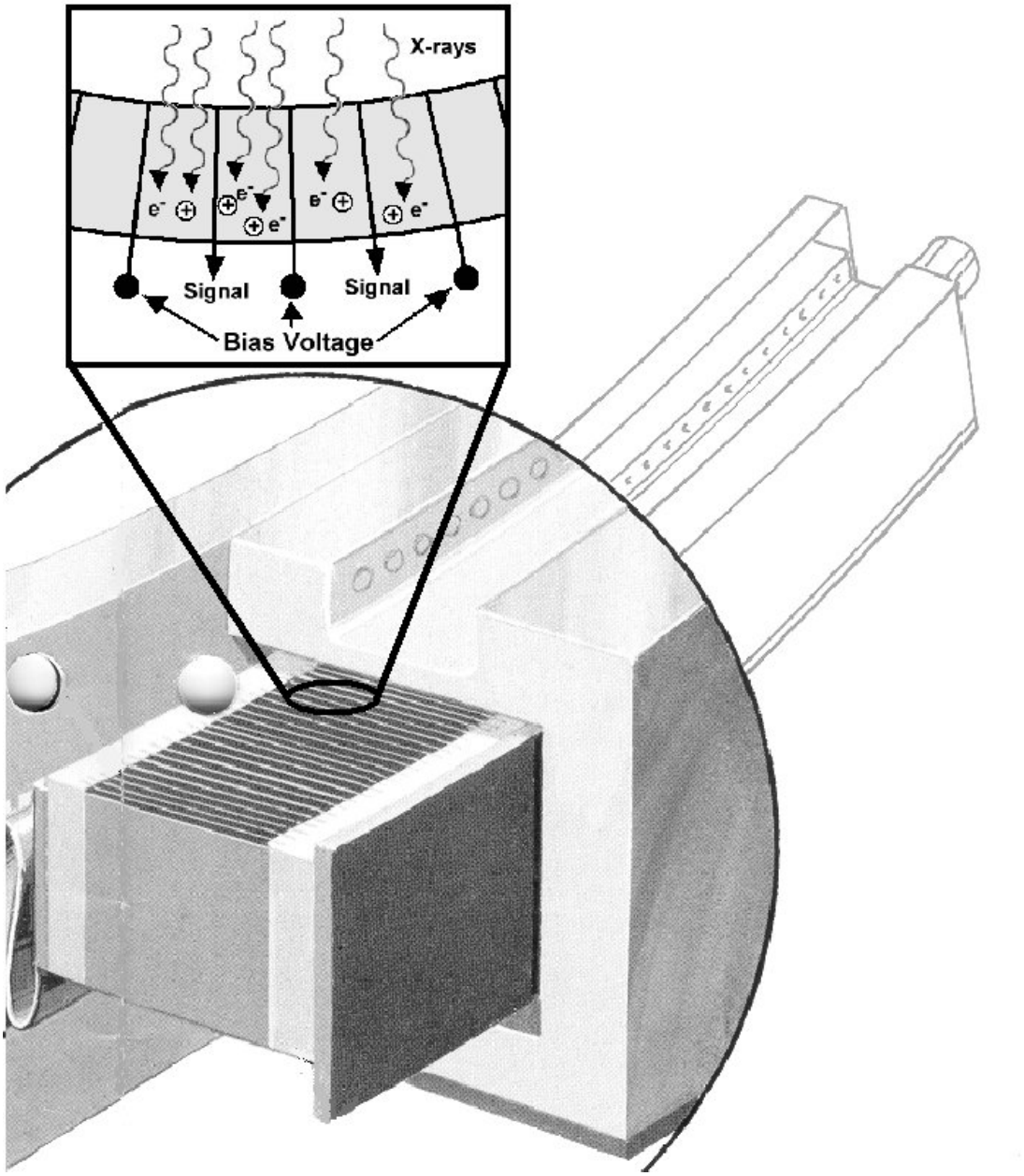
SUPPLEMENTAL FIGURE 5. EMI First-Generation Scan Motion: A rigidly linked tube-detector assembly performed linear translations along rails in 1° angular increments. The water box, into which the patient head was recessed, rotated along with the tube, so the total pathlength of x-rays through the patient plus water was constant.



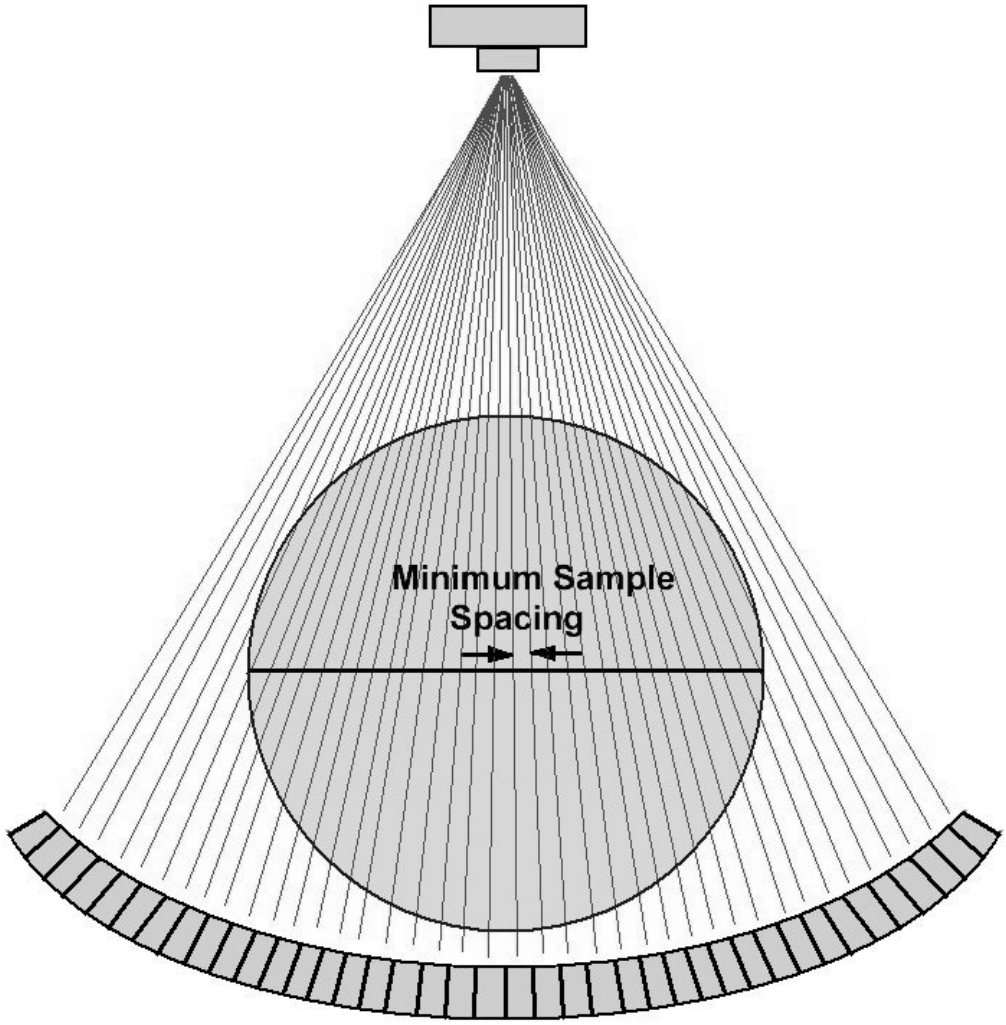
SUPPLEMENTAL FIGURE 6. Second-Generation Scanner: Second-generation scanners used multiple pencil beams and detectors to speed data collection but still used translate–rotate motions. This early model used 3 detectors, whose light-colored photomultiplier tubes are seen to the right of the patient aperture.



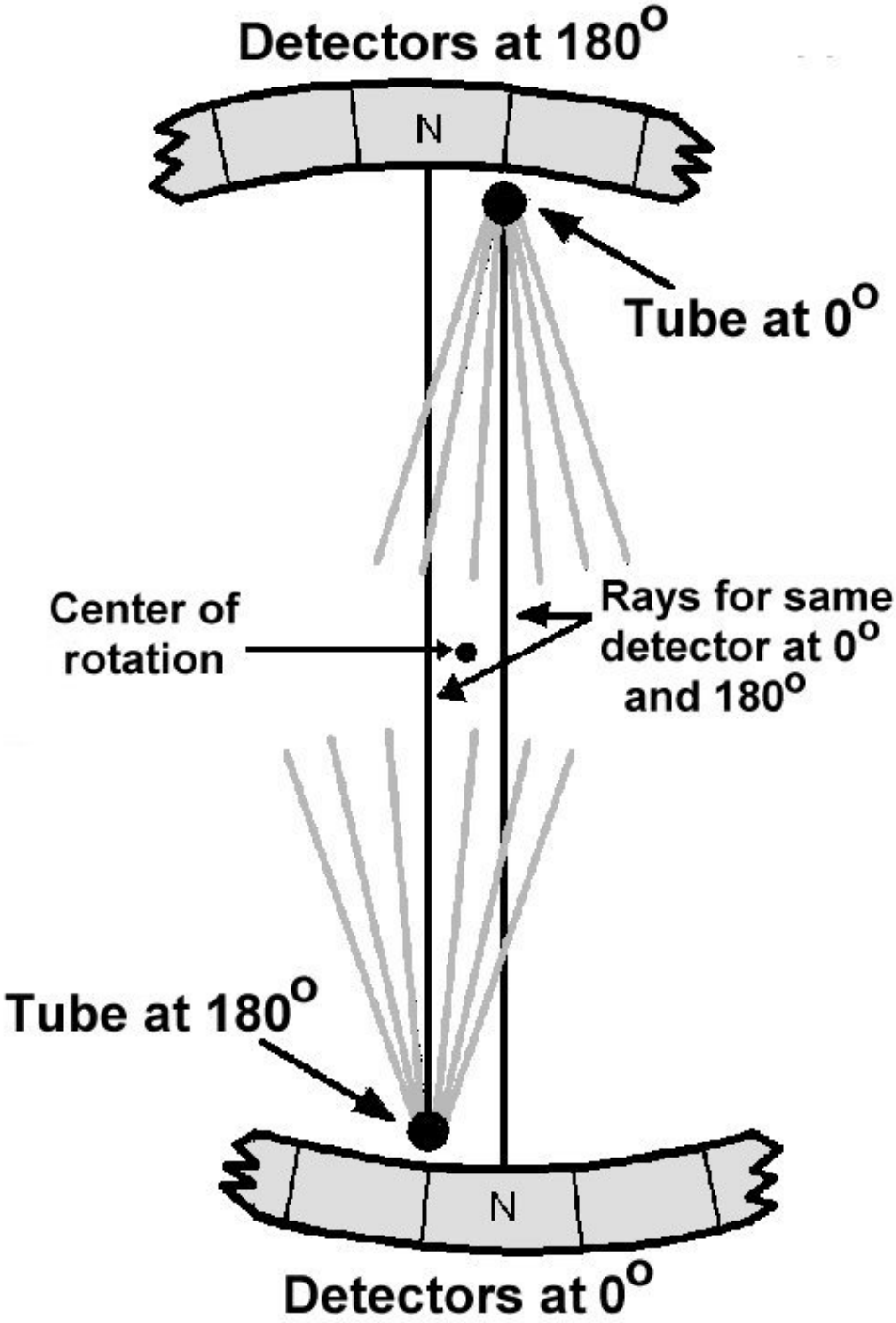
SUPPLEMENTAL FIGURE 7. Ring Artifacts in Third-Generation CT: (A) The rigid x-ray tube-detector linkage allowed each detector to measure rays only at a fixed distance "D" from the center of rotation. (B) Calibration drift or other errors in a particular detector's data are backprojected and reinforce along a ring of radius "D," generating a ring artifact in the image.



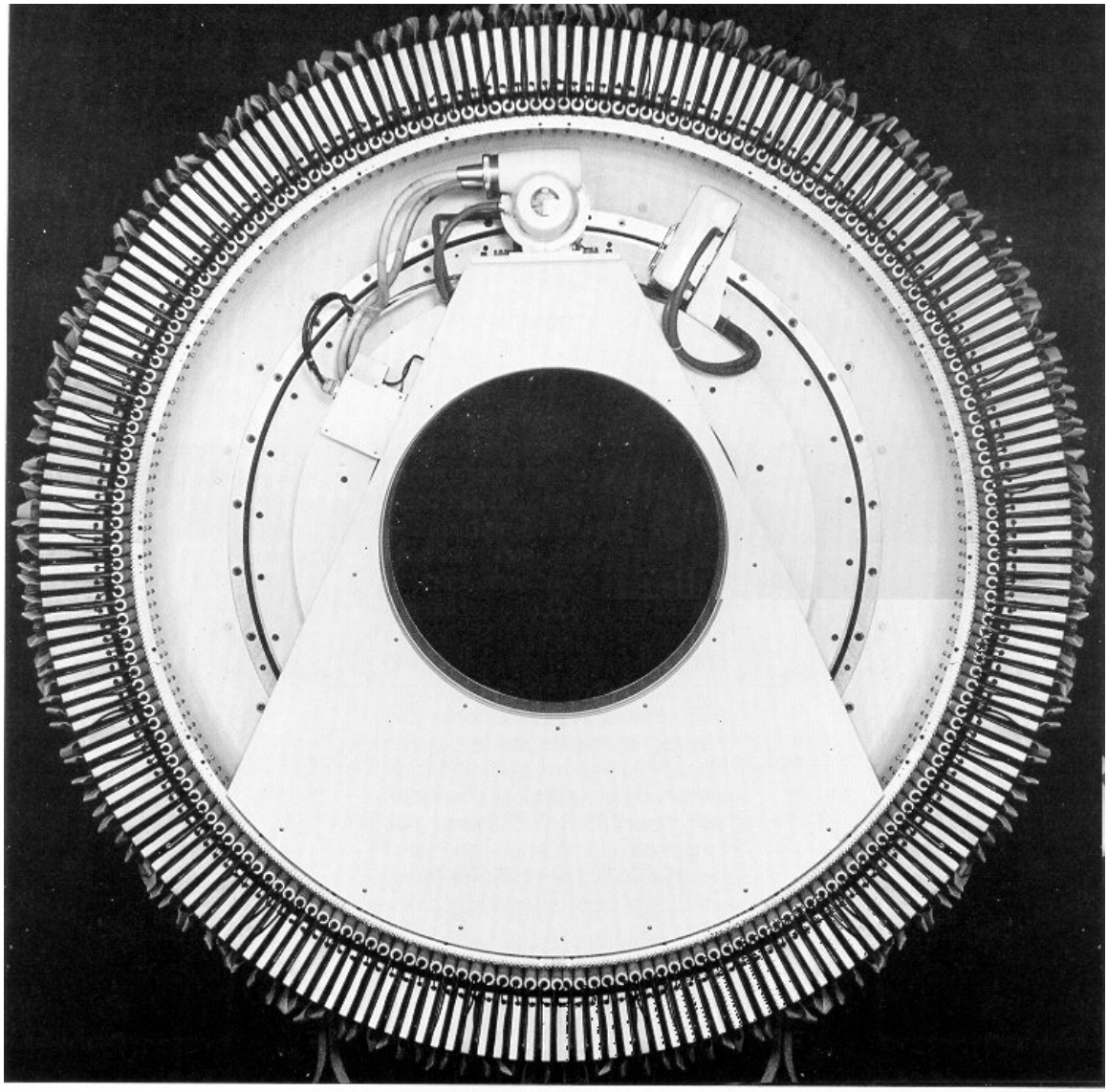
SUPPLEMENTAL FIGURE 8. Xenon Detector Array: Ring artifacts were minimized by using an inherently stable xenon array. Each small chamber acted as an ionization chamber. Factors affecting detector response were common to all elements (bias voltage, gas pressure) or were fixed over time (volume). Pressurized xenon was used to maximize x-ray absorption efficiency.



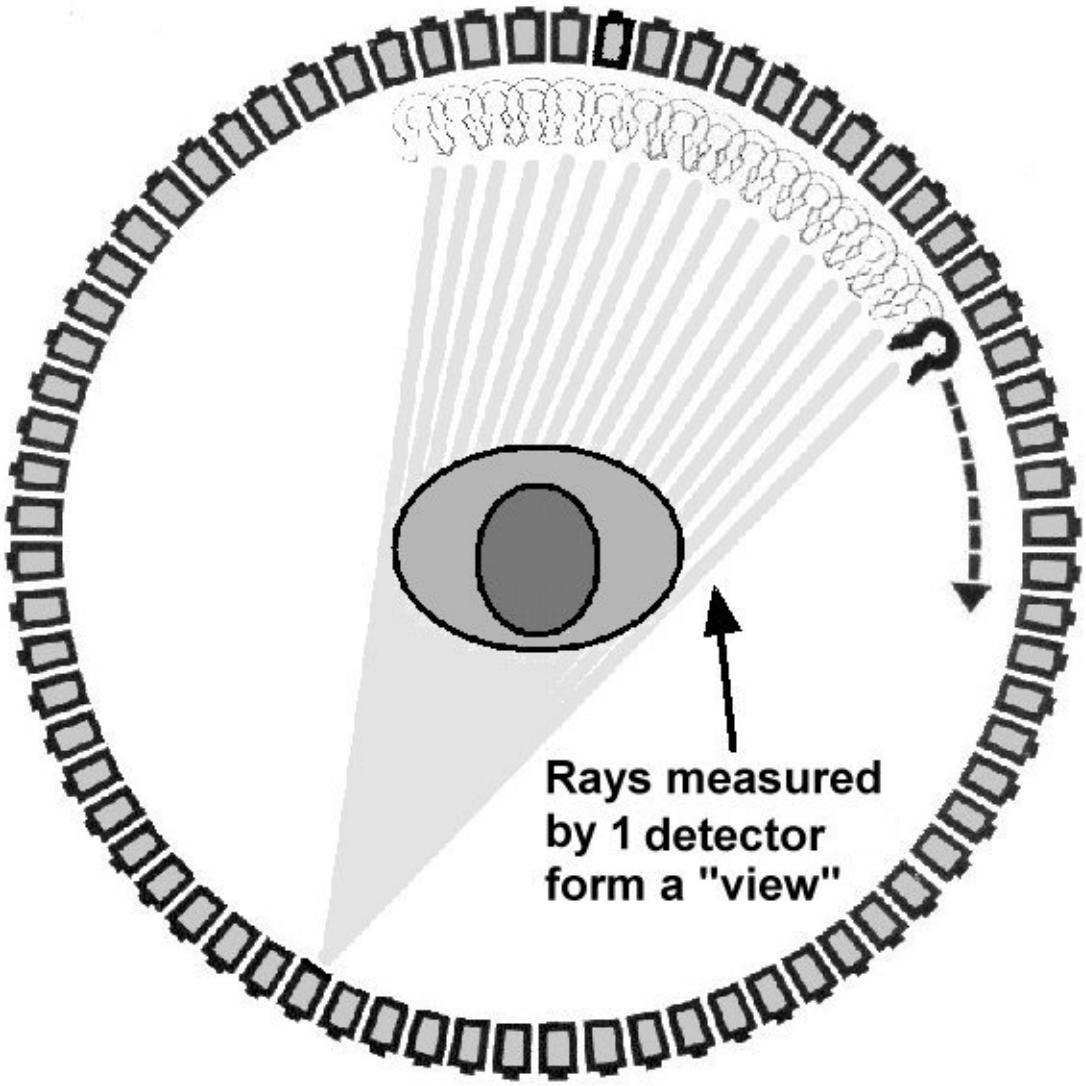
SUPPLEMENTAL FIGURE 9. Sampling in Third-Generation CT: The tube-detector linkage fixed the locations across the fanbeam where measurements (samples) could be made: They can be no closer together than the distance between adjacent rays at the level of the center of rotation. Closer samples require smaller and more detector elements in the detector array.



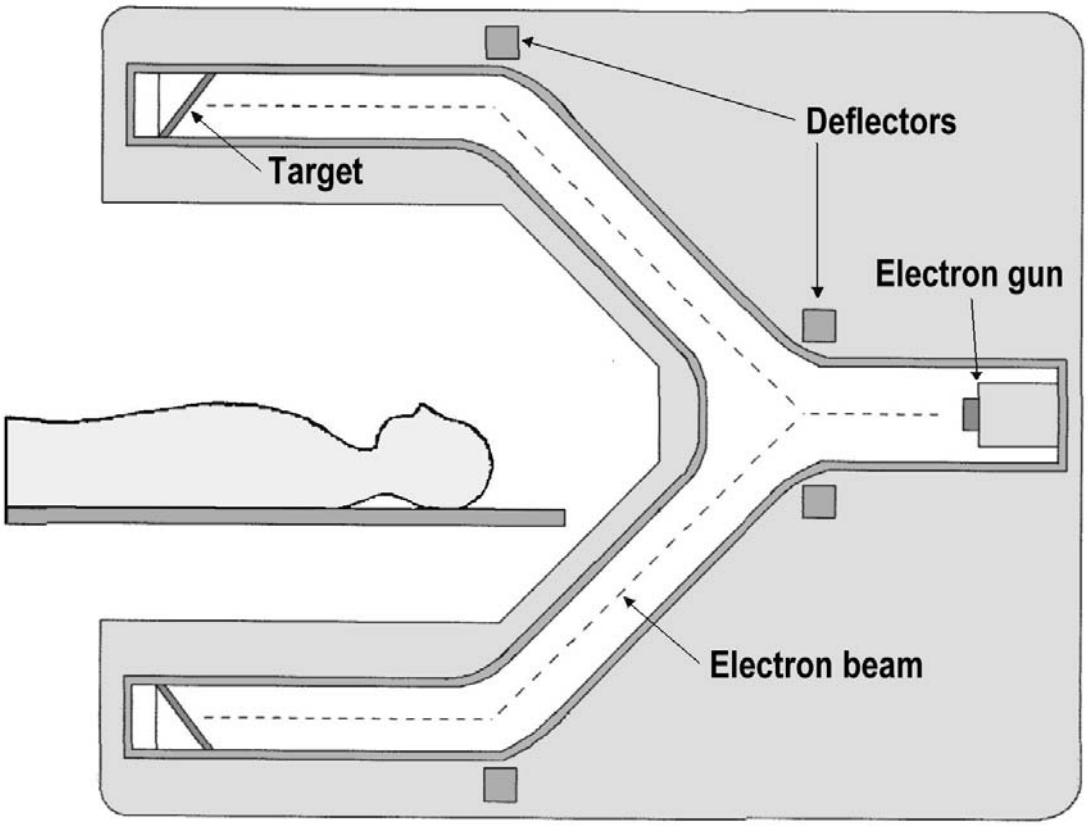
SUPPLEMENTAL FIGURE 10. ¼ Ray Offset Technique: Third-generation sample density can be increased by shifting the detector array relative to the center of rotation by ¼ of the width of one detector and scanning over 360°. Rays that are 180°-opposed (coming from opposite directions) become interleaved, doubling sample density.



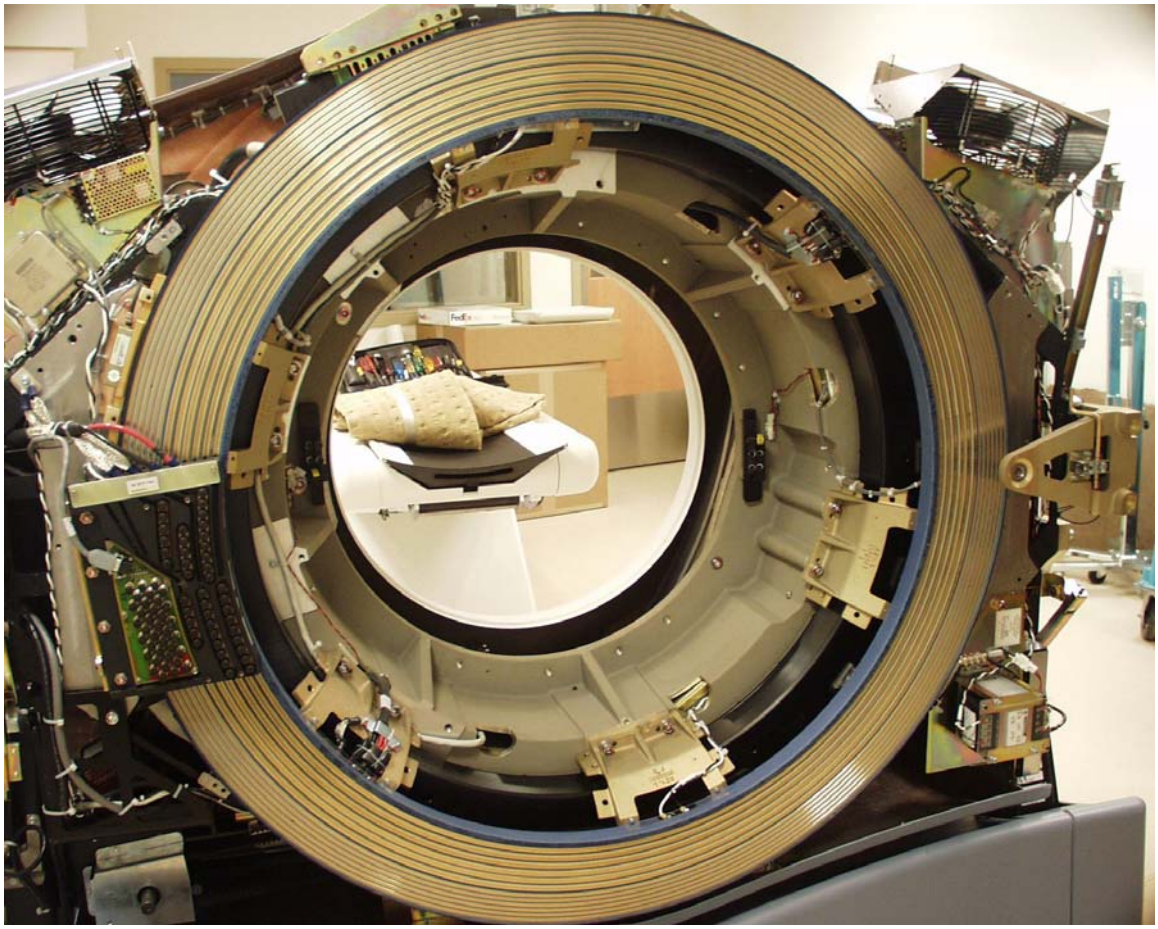
SUPPLEMENTAL FIGURE 11. Fourth-Generation CT Scanner: Fourth-generation scanners achieved faster scans by using a fixed, stationary ring of detectors with only the x-ray tube rotating. The number and size of detectors were initially limited to 600 in order to minimize cost while maintaining acceptable spatial resolution. The result was gaps between detectors and reduced geometric absorption efficiency.



SUPPLEMENTAL FIGURE 12. Sampling in Fourth-Generation CT: Each detector collected a full "fanbeam view" equivalent to one third-generation angular view. Since the tube and detectors were not linked, many closely spaced samples could be made as the tube swept across the detector's field of view, allowing for high sample density. However, the number of views—and thus the size of the matrix—was limited by the number of detectors.



SUPPLEMENTAL FIGURE 13. Electron-Beam CT: Ultra-fast scan times were achieved by a design using a large bell-shaped x-ray tube. A narrow electron stream from the cathode was electronically steered and swept along an annular target surrounding the patient, producing x-rays at each point impinged by the electron stream. With no moving parts, scan times as short as 10–20 ms became possible.



SUPPLEMENTAL FIGURE 14. Slip-Ring CT: Continuous, nonstop rotation was enabled by the slip ring, shown here for one model. The slip ring was an annulus or drum with grooves along which electrical contactor brushes slid, to provide power to the rotating components. The idea is similar to that used by bumper cars.