**Introduction:** "Timing alignment" of a PET scanner refers to the estimation of the individual time offsets of each detector so as to ensure that each time a pair of γ-rays is detected in coincidence, their times of arrival are actually recorded as identical. Accurate timing alignment allows a narrower coincidence timing window in order to reduce random count rates. In modern time-of-flight enabled PET scanners, timing alignment is even more important to improve the localization of each positron along the line of response to enhance the accuracy and rapidity of convergence of the image reconstruction.

**The Instrument:** Scanwell Systems has recently commercialized a novel device for performing the timing alignment of a PET scanner. Scanwell Systems’ patented PET Scanner Central Timing Alignment Probe detects the positron decay of 22Na atoms just before each positron annihilates with an electron producing two 511 keV γ-rays. The time between the positron decay and the detection of the γ-ray by any of the PET scanner’s crystals is the “time offset” which must be associated with all γ-ray detections by that crystal.

**The Source and Theory of Operation:** The probe contains a 3.7 MBq 22Na point source embedded in a small cylinder of plastic scintillator using a proprietary process developed by radio-chemists at Eckert & Ziegler Isotope Products. As each 22Na atom decays, the positron’s kinetic energy is absorbed in the plastic scintillator prior to the formation of positronium with an electron and annihilation to produce two 511 keV γ-rays. The energy is immediately released from the plastic scintillator as a very fast light flash which is detected with a fast photo-multiplier. These pulses are like the “ticks from a reference clock” with respect to which the times of pulses from detected γ-rays can be measured and then histogrammed to determine a precise time offset for each crystal.

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**Scanwell Systems PET Scanner Central Timing Alignment Probe**

**Source:** 3.7MBq 22Na

**Scintillator:** Plastic (PVT)

**Power:** -1000 to -2500 V

**Signal:** ~ 1 V into 50 Ω @ -2000V

**Shape:** Rise < 1 nsec, Fall ~ 5 nsec.

**FWHM:** 400 psec. (WRT BaF2)

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Scanwell timing alignment probe specifications
**Unique Features:**

- This patented instrument is a “certified device” by the Canadian Nuclear Safety Commission and, since it contains less than 10 MBq of $^{22}$Na, no radioactivity license is required for its possession or use*. 
- When placed at the center of the PET scanner, the transit times of all γ-rays to the detectors are all identical eliminating time-of-flight errors from the timing spectra during timing alignment.
- All crystals in the scanner are aligned simultaneously to a common reference “clock”, rather than to each other, as in the conventional, slow, iterative process.
- Since all the detectors are aligned simultaneously, to a very accurate common reference, the time offsets of individual crystals may be used, (rather than one average offset per detector block) improving the time-of-flight performance of PET scanners.
- The source remains stationary during the timing alignment since it need not be moved to measure each line of response.
- Timing alignment data is acquired as “time-stamped singles” rather than in coincidence mode, and since all detectors are aligned simultaneously, the acquisition time is reduced by at least an order of magnitude.

![Counts per million positrons](image)

Comparison of the efficiency of timing alignment performed with the rotating transmission sources compared to that from the central source. There is a six fold increase in efficiency as shown above plus the improvement due to aligning all detectors to a common source.

![The apparent γ-ray arrival times for the 144 crystals in a detector from the MicroPET Focus® scanner.](image)

(The spread between the central and edge crystals is over 1.5 nsec) This demonstrates the need to time align individual crystals rather than detector blocks.

**Bibliography:**


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