is typified by a mixture of cadmium and zinc, each of which is most easily measured at 0.511 MeV, the positron annihilation peak. Improved detector energy resolution is of no value; the gamma rays are identical. To make matters worse, the elements in this example do not produce particularly good photopeaks other than 0.511 MeV.

The solution in such a case is to count the sample twice, using different decay times following irradiation. Then, calculation of the contribution of the two elements is facilitated by knowledge of the different decay properties of the radioisotopes.

The multicount technique also can be used on related energy gammas. If a second count station is available, multiple counting can resolve some interferences with little loss of sensitivity. Precision is degraded, but often much less than in the choice of a solid-state detector.

The second type of interference results from both Compton scattering and other energy loss phenomena in the detector, particularly with sodium iodide detectors. Each gamma spectral peak has associated with it a plateau of lower energy counts.

Multielement analysis systems based on NAA already are in use in the USSR. The next decade will witness innovations in the application of NAA and in auxiliary equipment. But the fundamental technology will undergo only minimal change.

The buildup of this interfering body of counts in the multielement case produces a Compton base-spectrum that is inconveniently high in the low-energy region. In any given channel, the actual count easily can deviate from the value in the adjacent channel or from its own proper mean value by about the square root of the channel count. This occurs because of purely statistical reasons unrelated to the sample composition.

The counts read from a photopeak are superimposed on the Compton base, and have their own statistical fluctuations. The peak must be of significant size both absolutely and relative to the fluctuations in the Compton base to be measurable with confidence. A 100-count peak superimposed on a 100-count base area usually yields a net peak measurement with a probable error of about 15 to 20%, a reasonable detection limit.

The germanium detector provides peak-to-Compton ratios on the order of 30, about an order of magnitude better than that achieved with sodium iodide. But a series of peaks still causes enough Compton buildup to limit the detectability or the measurement precision at lower energy. In some cases, increased delay before counting reduces this Compton problem.

The third type of interference, in which two elements can produce the same radioisotope, is the most acute. There is no way to tell, for example, whether a decaying aluminum-28 nucleus was produced from the bombardment of silicon or of phosphorus.

Fortunately, both silicon and phosphorus produce additional gamma ray energies. And equally fortunately, the computer is not disturbed by the tedious task of unfolding the interferences.

The net conclusions regarding interference are two-fold:

- Most interferences are resolvable without radiochemical separations, but with some loss of sensitivity relative to the single element values.
- The computer must have available all reasonable sources of information, perhaps including counts at different times, from both types of detectors, and possibly also from fundamentally different analysis modes, including both fast and thermal neutron activation. From 5 to 10 or more elements typically can be determined in a single sample.

NAA in food analysis

The most common fast neutron activation analysis application in the food industry is nitrogen measurement for protein determination. Under ideal conditions, one requires only a relatively simple system, using some empirical corrections to adjust for the various interferences.

The interfering elements must be of limited and reasonably fixed concentration for a simple single element measurement. The protein content of some grains can be measured in this manner.

In the more typical application, either variation in sample composition or the desire for more analytical data compels a more sophisticated system. Often the user wants simultaneous analysis for nitrogen, phosphorus, and potassium.

Magnesium also is determined simultaneously without difficulty. As a practical matter, many natural and processed materials have significant quantities of silicon or chlorine. These elements must be determined at the same time because of the interferences which they may contribute.

Sodium iodide detectors usually are used for food analysis because the range of elemental composition of food materials is limited and known qualitatively. The interferences that occur are corrected in the computer with acceptable loss of precision.

If the application involves analysis of materials of reliably low silicon content, the remaining five elements can be determined with a single count station. In the more general case, the sequence for the six elements includes two periods of counting, commencing approximately 3 and 14 min following neutron bombardment.

The total time from sample input to the instrument until data output is about 18 min. The throughput is 250 samples in 8 hours.