Preliminary Assessment of Fallout from the 1976-78 Nuclear Weapons Tests Conducted by the People's Republic of China

R. A. LLEWELLYN, M. J. LLEWELLYN, and R. L. COOK[1]
Department of Physics, Indiana State University
Terre Haute, Indiana 47809

In September 1976 the People's Republic of China began conducting a series of tests of nuclear weapons. The tests conducted to date have all been carried out at Lop Nor in the Sinkiang Uighur Autonomous Region. The dates, times, and yields of those tests conducted through 1 November 1978 are listed in Table I (1).

TABLE I *Nuclear Weapons Tests '76-'78 People's Republic of China*

	DATE	TIME	YIELD
I	26 SEPT 76	0600 GCT	20-200 ktons
II	17 OCT 76	0500 GCT	$<$20 ktons*
III	17 NOV 76	0600 GCT	4 megatons
IV	18 SEPT 77	0700 GCT	$<$20 ktons
V	14 MAR 78	0500 GCT	$<$20 ktons

*underground

Four of the five detonations were in the atmosphere and posed potential hazards to the U.S. population, as well as others, as a consequence of fallout from radioactive debris transported throughout the northern hemisphere by normal weather systems. As an example, the projected path of the cloud from the blast of 17 November 1976 is shown in (Fig. 1) (4). On the occasion of each atmospheric test the Environmental Protection Agency (EPA) activated the Environmental Radiation Ambient Monitoring System to measure possible activity due to several fission fragments, including Sn, La, Ba, Cs, I, Ru, and Ce.

When announcement of the 26 September 1976 test was made in the news media, we decided to evaluate the ability of the Indiana State University Physics Department's gamma coincidence spectrometer to detect fallout from the cloud, should it pass over Terre Haute as predicted. We had available a battery of high volume air samples calibrated to EPA standards (2) and a very sensitive, low-level two-dimensional gamma coincidence spectrometer capable of routine activity measurements in the sub-picocurie range. The spectrometer has been described by Grismore, et al (3).

It was determined that the best opportunity for measuring fallout with the system would be to look for coincidences in the decay of the fission product ^{140}Ba and its decay products ^{140}La and ^{140}Ce. Atmospheric particulate samples were

---

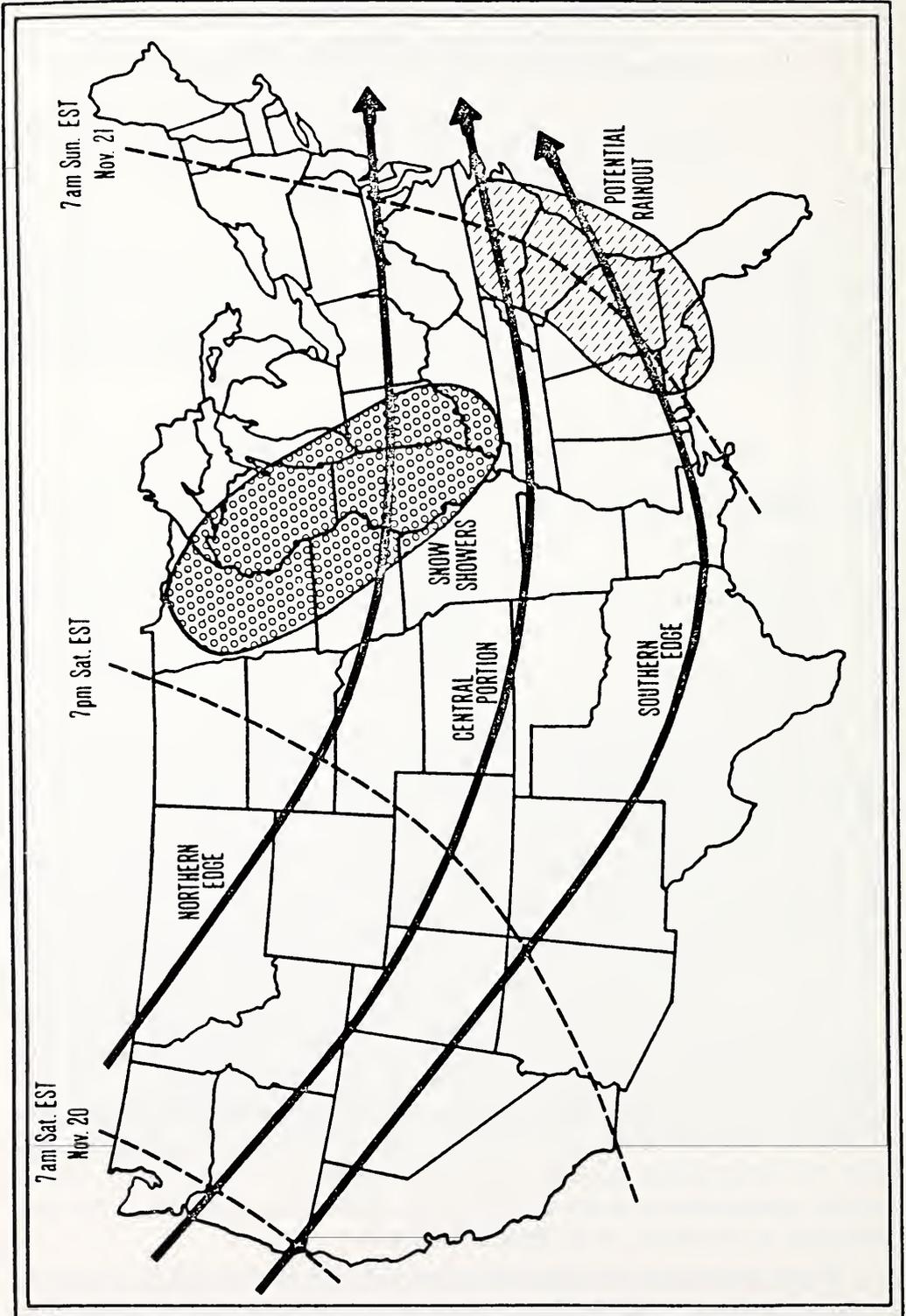[1]Present address: 2330 South Park Drive, Diamond Bar, California 91765

Figure 1. *Predicted movement of air mass containing radioactive debris across the United States and possible areas of rainout from this air mass following the Chinese nuclear detonation of November 17, 1976.*

collected on dried, pre-weighed standard glass fiber filters by high volume samplers located on the roof of the Science Building on the Indiana State University Terre Haute campus. Sample collection in each case was begun within a day or two following the announced time of the test in order to establish baseline background coincidence rates. Sampling was continued for seven to ten days following the initial detection of activity in excess of background. The arrival of the radioactive cloud was quite pronounced as illustrated by the example of test IV shown in (Fig. 2).
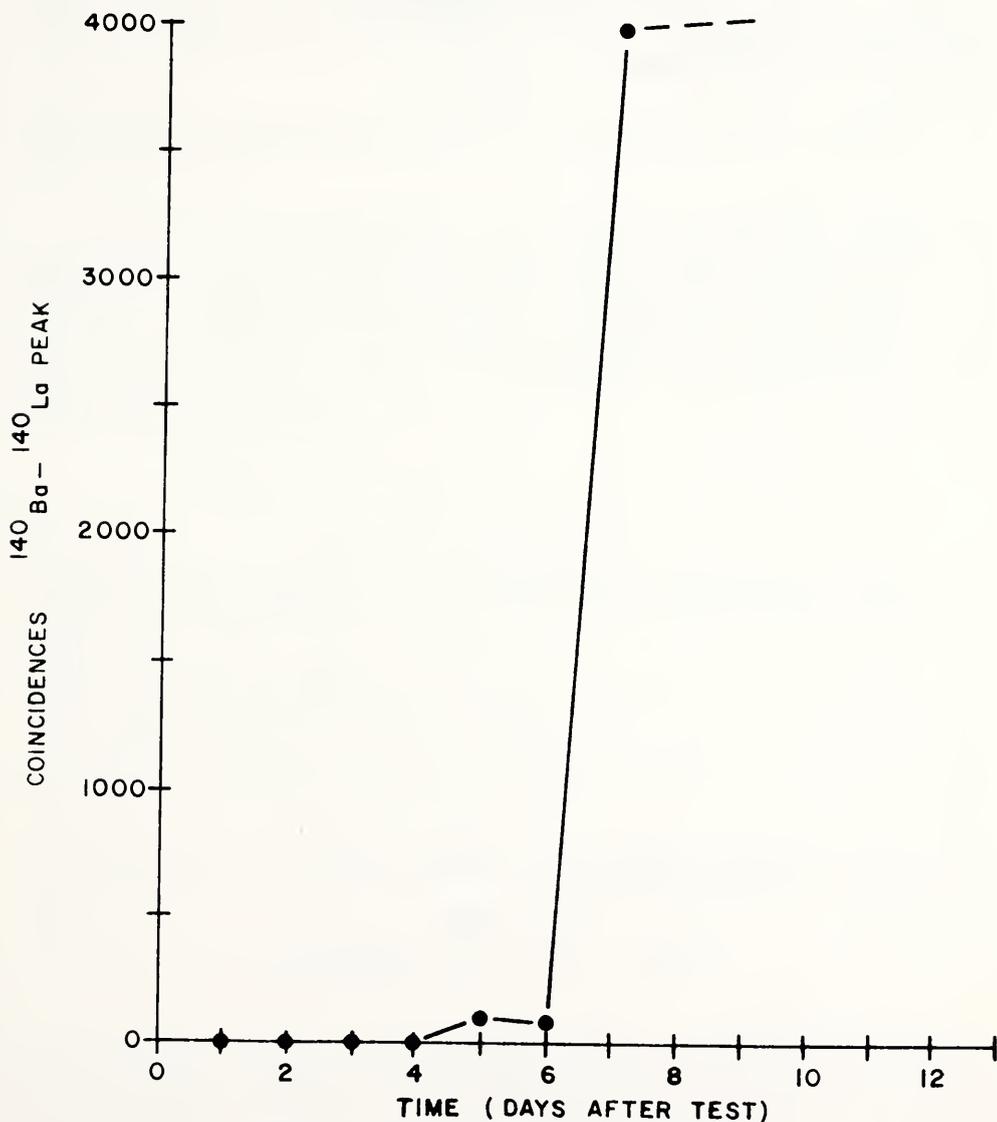
FIGURE 2.   *Arrival of Radioactive Cloud Test IV*

The radioactivity collected in the particulate sample was measured by placing the dried, weighed filter into the counting volume and recording coincidences for approximately 22 hours. After background correction,[2] the

---

[2]The coincidence background rate is 6.24 ± 0.04 per 32 kev x 32 kev channel per 24 hours in the energy region of interest.

data were printed out in a two-dimensional array and compared manually with standard coincidence spectra. In the series of experiments reported in this paper analysis was done only for ^{140}Ba - ^{140}La, the decay whose coincidence rate was expected to be most favorable. Standards of ^{140}Ba - ^{140}La from two different suppliers were used to prepare comparison spectra. To provide additional verification that the coincidence peaks identified with ^{140}Ba - ^{140}La were really associated with those isotopes, the decay of activity in several of the samples was monitored for about two months with the results as shown in (Fig. 3). The data fit ^{140}Ba very well. Considering the time elapsed since production, it is reasonable to assume that ^{140}La was in equilibrium in the particulate samples collected for these experiments.
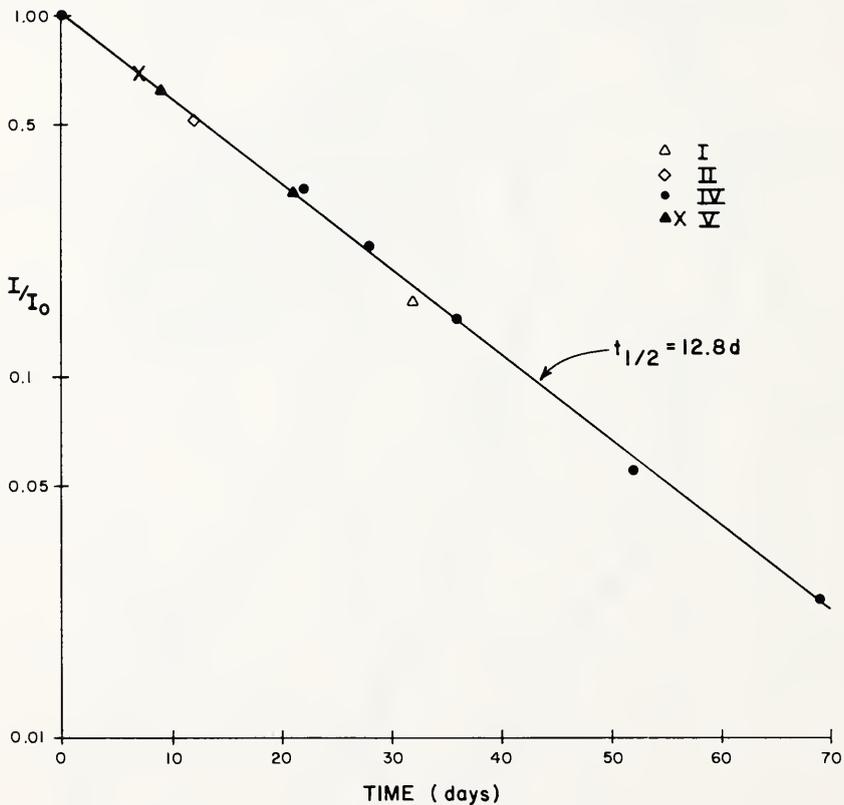

FIGURE 3. *Decay of Hi Vol Samples*

The concentration C of ^{140}Ba - ^{140}La in pCi/m^3 of air based on the measured gamma coincidence rate in ^{140}La and its daughter ^{140}Ce is given in Table II for the tests of 18 September 1977 and 14 March 1978. The daily radiation dose ID delivered to individuals in the population by these concentrations were computed from equation 1 below:

$$ID = 24 \ C \ (DF) \qquad (1)$$

where ID = the individual dose in mrem per day, C = radionuclide concentration in pCi/m^3 of air, 24 = hours in one day, and DF = dose factor for total body submersion in mrem/hr per Ci/m^3 (6).

The total dose received by individuals from this source is determined by integrating the daily contributions over the period of exposure. Preliminary

experimental values determined for ID are also given in Table II for the weapons test of 18 September 1977 and 14 March 1978. The values of ID shown are for exposure to ^{140}Ba - ^{140}La only; they are of the same order of magnitude as those for the weapons tests of 26 September 1976 and 17 November 1976 published recently by Smith, et al (5).

TABLE II *Results*

TEST	MAXIMUM CONCENTRATION	DOSE*
	C (pCi/m³	ID (mrem)
IV	0.047 ± 0.002	3.55 x 10^{-5}
V	0.131 ± 0.005	9.9 x 10^{-5}

*ID = 24 C (DF)

Contributions to the total dose would also accrue from other radionuclides present in the fallout; e.g. one would expect the contribution from ^{131}I to exceed that from ^{140}Ba - ^{140}La by about a factor of ten. The measured dosages, while significant, are well below currently accepted maximum permissable exposure limits. Analysis of the data to determine the contributions from other radionuclides is continuing.

Literature Cited

1. ENERGY RESEARCH and DEVELOPMENT ADMINISTRATION and DEPARTMENT of ENERGY. Press Releases 26 September 1976, 17 October 1976, 17 November 1976, 18 September 1977, and 14 March 1978.
2. CODE of FEDERAL REGULATIONS. 1972. 121:0105-121:0107.
3. GRISMORE, R., A. W. BARBEE, M. L. BERRY, A. L. TABOAS, and D. R. EMMONS. 1975. Multidimensional Gamma-ray Spectrometer with a Liquid-Scintillation-Counter Antiocoincidence Ring. Rev. Sci. Instrum. 46:243-245.
4. NATIONAL OCEANIC and ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT of COMMERCE. Press Release 19 November 1977. (Special for EPA).
5. SMITH, J. M., J. A. BROADWAY, A. B. STRONG. 1978. United States Population Dose Estimates for Iodine—131 in the Thyroid After the Chinese Atmospheric Nuclear Weapons Tests. Science. 200:44-46.
6. STRONG, A. B., J. M. SMITH, and R. H. JOHNSON. 1977. EPA Assessment of Fallout in the United States, EPA—52/5-77-002, Washington, D.C.