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The Black Sea Experiment: The Use of Helicopter-Borne Neutron Detectors to Detect Nuclear Warheads in the USSR-US Black Sea Experiment

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The Soviet Navy used a helicopter/ship system called "Sovietnik" to detect a cruise-missile warhead in the joint USSR-US experiment on the Black Sea, which took place on 5 July 1989. The system consists of a ship-based helicopter, equipped with a neutron detector and processing equipment, and associated ship-based equipment. The system was developed at the I.V. Kurchatov Institute of Atomic Energy. Its operation is based on detecting the neutrons emitted from the spontaneous fission of the plutonium-240 contained as an impurity in weapon plutonium. The Sovietnik neutron detector is based on helium-3 counters in a moderator. It is designed to detect the neutron flux from a single nuclear warhead at distances up to 100–150 meters. At these distances, the flux does not exceed 10 percent of the natural background and is comparable with its variations. Therefore when developing the Sovietnik system, great attention was given to factors affecting the value and behavior of the background.

The neutron detector, together with instrumentation for recording am preliminary processing and analysis of initial information, is located on the helicopter, which, carries out the measurement while flying slowly past the ship in question. The presence of fissile material on the ship is considered to be established if the measured neutron-radiation signal in the ship zone is higher than a "threshold" defined as a level that exceeds expected background fluctuations

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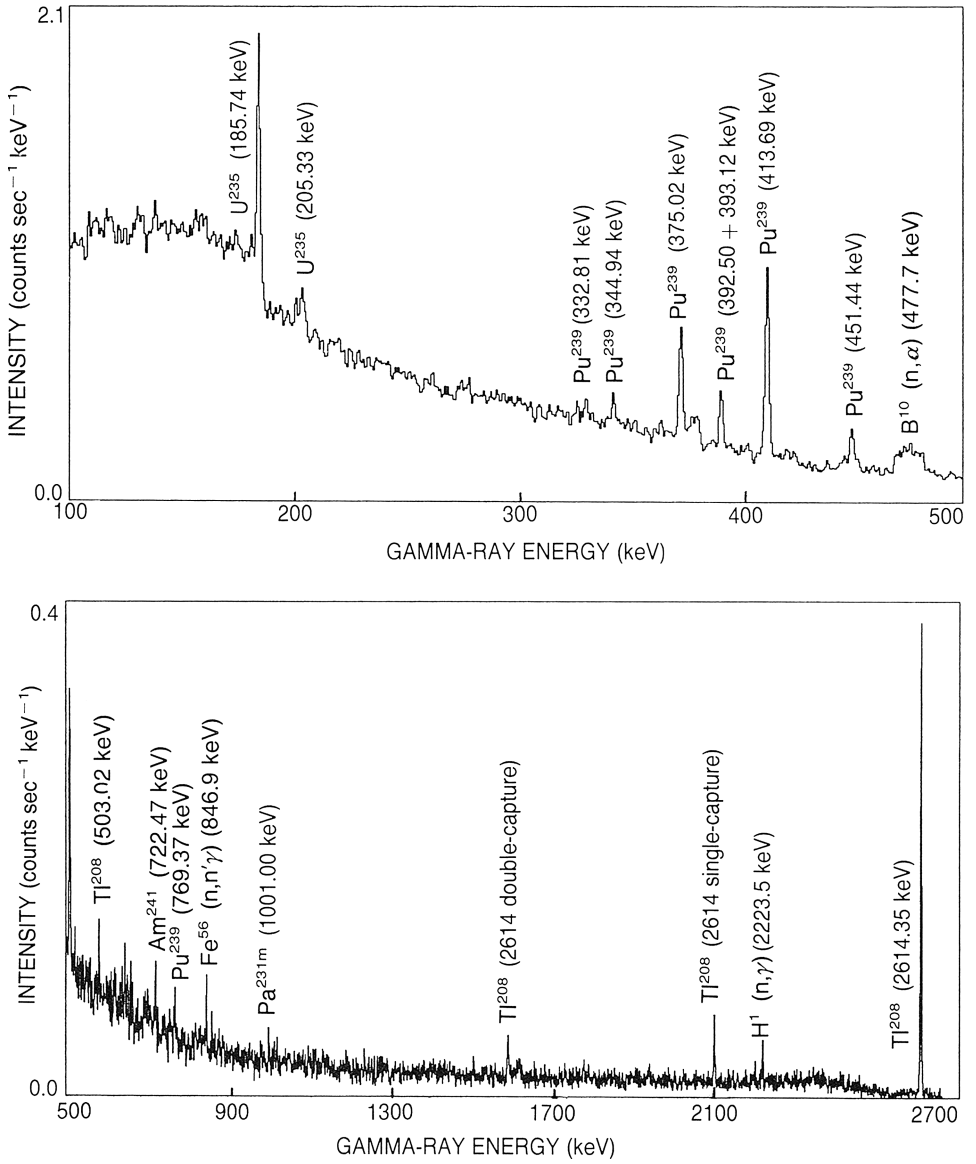

Figure 1: The gamma-ray signal recorded by germanium detector placed on top of a cruise-missile launcher 3.4 meters from the lid for 10 minutes.

by three standard deviations, allowing for possible background variations and other uncertainties of statistical and nonstatistical character.

The instrumentation system includes a helicopter altimeter and a laser range finder. The data from these instruments are recorded synchronously with those from the neutron detector. The laser range-finder measures the distance to the ship, which makes it possible to estimate the absolute

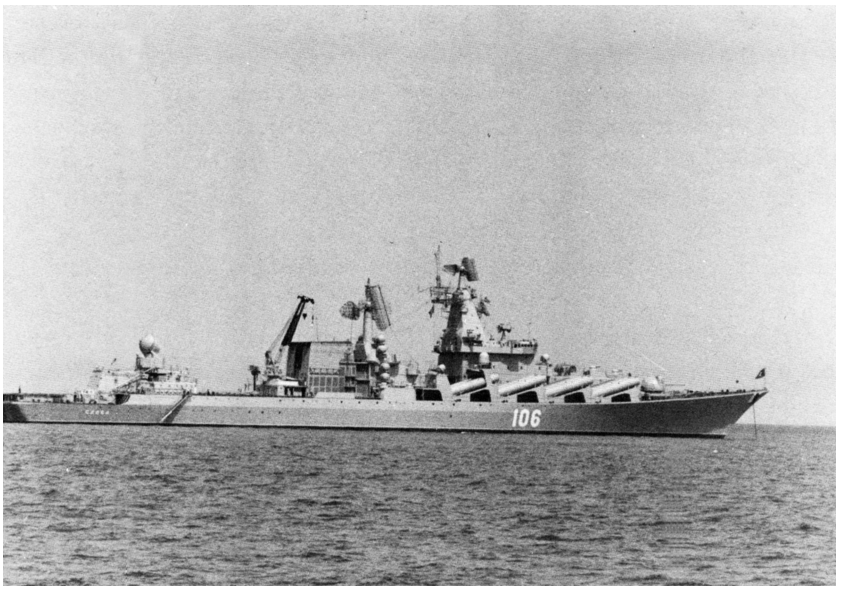

Figure 2: The Soviet cruiser Slava.

neutron flux and thus, in some cases if information about the isotopic composition of the plutonium is available, to estimate the amount of plutonium. The helicopter is also equipped with a videorecorder, making possible the visual correlation of information from the neutron detector with a particular region of the ship.

Additional equipment is located on an accompanying ship, where detailed processing and analysis of the data recorded on the helicopter takes place. This system includes a computer, database, and video-reproduction system. Operators on the ship see the image recorded by the helicopter video recorder on a TV monitor in real time. The ship instrumentation also includes a neutron detector to measure the background during the helicopter system's operation. A block diagram of the Sovietnik complex is presented in Figure 3.

The Sovietnik system operates in several modes: background measurements, measurements taken from the helicopter when it is hovering over the ship, and measurements taken on the helicopter when it is not close to a ship. The measurement results, after preliminary analysis on the helicopter, are displayed on the helicopter control panel for the pilot-operator to decide whether a repeat-flight is required. Detailed processing is done later on the accompanying ship, using either an integrating algorithm that calculates the average neutron radiation from the entire ship, or a zone-processing algorithm that calculates the neutron radiation from individual zones along the length of the ship. The zone algorithm can distinguish between multiple radiation sources if the distance between them is at least comparable with distance between the

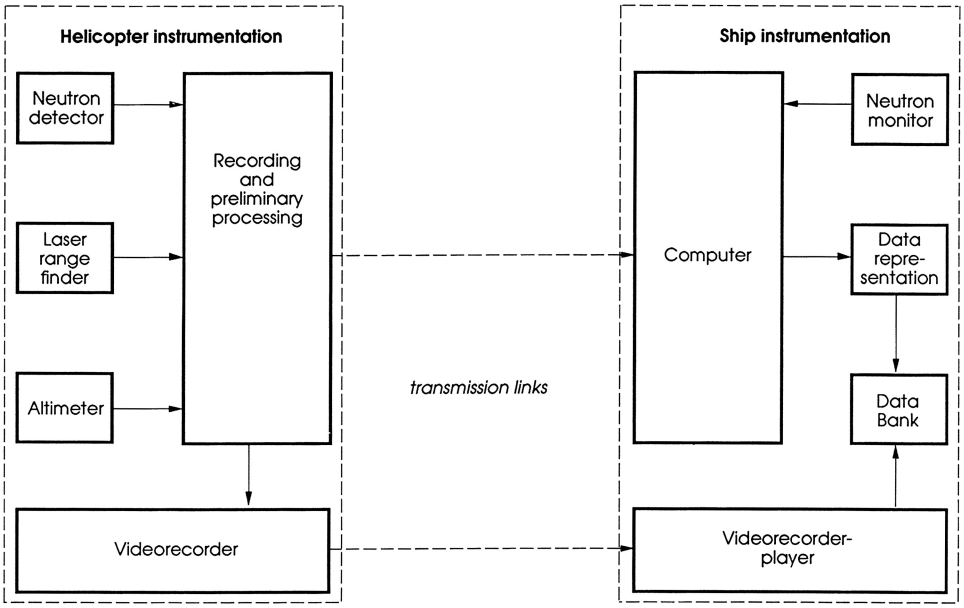

Figure 3: The Sovietnik complex.

ship and helicopter. If this is the case, the Sovietnik system can detect nuclear weapons even on ships with a nuclear reactor.

The ability of the Sovietnik system to detect sea-based nuclear weapons has been verified by tests carried out under natural conditions in the Black Sea and the Mediterranean during 1978–79. During the tests several NATO ships,

Table 1: Helicopter about 30 meters from ship

Bin	Distance to stem meters	Measurement length second^{-1}	Counts second^{-1}	Count minus background second^{-1}	3σ detection threshold* second^{-1}	Above threshold?
0	0–17.59	14	14.07	1.28	2.25	no
1	37.45	10	14.20	1.40	2.60	no
2	56.17	11	13.36	0.41	2.49	no
3	74.85	10	14.90	1.85	2.60	no
4	92.88	8	13.63	0.66	2.89	no
5	111.83	10	13.90	1.00	2.60	no
6	130.11	13	13.54	0.71	2.32	no
7	150.29	11	20.18	6.87	2.49	yes
8	166.91	7	16.71	2.58	3.07	no
9	187.00	13	15.85	2.33	2.32	may be

Table 2: Helicopter about 76 meters from ship

Bin	Distance to stem meters	Measurement length second^{-1}	Counts second^{-1}	Count minus background second^{-1}	3σ detection threshold* second^{-1}	Above threshold?
0	0–17.77	8	13.50	1.95	2.71	no
1	37.76	9	12.22	0.41	2.57	no
2	55.99	8	11.63	0.86	2.72	no
3	74.39	8	10.63	–0.03	2.72	no
4	92.89	8	10.88	0.30	2.72	no
5	111.39	8	11.75	1.21	2.72	no
6	131.47	9	11.44	0.88	2.58	no
7	149.24	8	13.25	2.92	2.73	yes
8	169.23	9	11.56	1.21	2.58	no
9	187.00	8	11.50	1.26	2.72	no

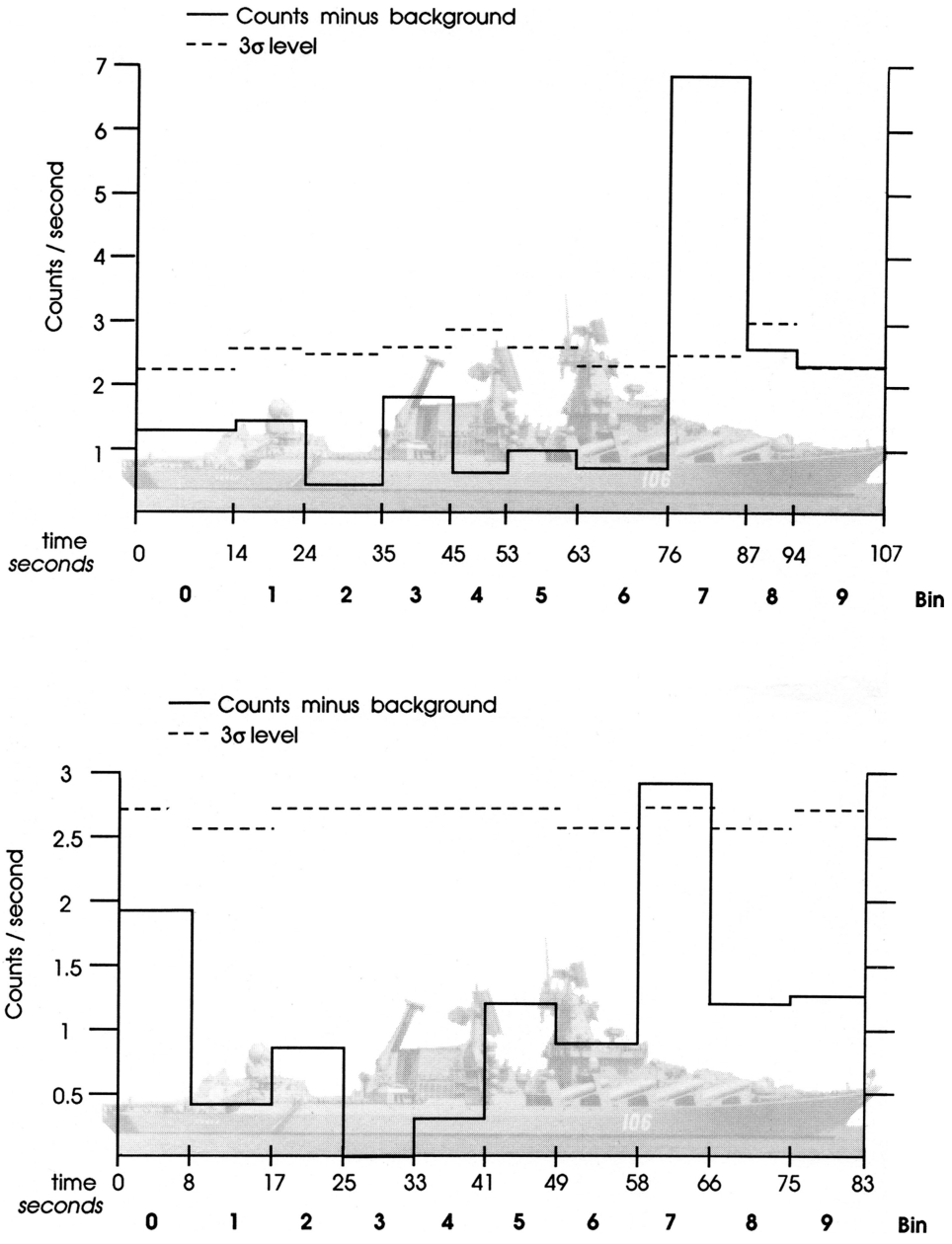

Figure 4: Plots of tables 2 and 3: helicopter about 30 meters from ship (above) and 75 meters from ship. The missile is in the forward launcher (see ship outline).

including some from the U.S. Navy, were inspected. Nuclear weapons were detected on some U.S. ships in the Mediterranean. For example: the frigate *Truett*, was inspected on 21 January 1978 in the Mediterranean at the point 32° 35′ N, 25° 50′ E; the aircraft carrier *America* was inspected on 7 February

1978 at the point 38° 31′ N, 18° 35′ E; the destroyer *Barry* was inspected twice, on 30 January 1978 at the point 33° 58′ N, 21° 00′ E, and on 11 May 1979 at the point 42° 27′ N, 06° 16′ E; and the weapons and special equipment transport ship *Mount Baker* was inspected on 16 April 1979 in the Mediterranean at the point 40° 17′ N, 13° 39′ E.

In the experiment on the Black Sea, the missile cruiser *Slava* was inspected by two helicopters equipped with the Sovietnik system and flying from the base ship *Apserhon.* One helicopter flew by the *Slava* at a distance of about 30 meters, the other, at a distance of about 80 meters. The results are shown in Tables 1 and 2, and in Figure 4. They give the distribution of the neutron radiation in 10 spatial zones along the length of the ship. It follows from the integral processing of the data obtained from the 30-meter flight, that with a probability not lower than 0.95, the missile cruiser *Slava* had a neutron source on board. The results of zone processing of the data obtained at both distances show that this source is in spatial zone number 7, corresponding to the location of the launcher containing a cruise missile known to have a nuclear warhead. The detection time in this zone did not exceed 10 seconds.

The Sovietnik system should be considered only as one part of a monitoring system to provide remote detection of nuclear weapons on board ships. There are a number of issues which have not been considered here, such as the problems relating to concealment of nuclear weapons. It also appears that the identification of nuclear-weapon types during the measurements can only be accomplished by closer inspection. Nevertheless, the Black Sea experiment using the Sovietnik system has proven the possibility of confidence building through cooperative remote monitoring.

We hope to be able to publish a fuller description of the Sovietnik neutron detector in the near future.