OCCASIONAL REPORT

The Black Sea Experiment

US and Soviet Reports from a Cooperative Verification Experiment

On 5 July 1989, in a remarkable display of military glasnost, a team of US scientists organized by the National Resources Defense Council (NRDC) and a team of Soviet scientists from the I.V. Kurchatov Institute of Atomic Energy measured the radiation emitted by the nuclear warhead of a cruise missile aboard the Soviet ship Slava. *The measurements took place in the Black Sea off Yalta. We publish here two papers that summarize the results of these experiments: the first, by Steve Fetter and Frank von Hippel, is adapted with permission from an article that appeared in* Physics Today, *November 1989. A technical research paper describing the results of the experiment is forthcoming in* Science.

The second paper, by S.T. Belyaev, V.I. Lebedev, B.A. Obinyakov, M.V. Zemlyakov, V.A. Ryazantsev, and V.M. Armashov of the Kurchatov Institute, and S.A. Voshchinin of the Soviet Navy, briefly describes the Soviet helicopter-mounted neutron-detection detection system and its use in the detection of nuclear warheads, including the experimental results in the Black Sea.

MEASUREMENTS OF RADIATION FROM A SOVIET WARHEAD

Steve Fetter and Frank von Hippel

One of the main problems that has slowed movement toward a Strategic Arms Reduction Treaty is that of limitations on long-range nuclear-armed sea-launched cruise missiles (SLCMs).

The Soviet government has argued that unless the multiplication of this new type of long-range nuclear weapon is restricted, an agreement limiting other types of strategic nuclear weapons could be rendered meaningless. It believes that limits on nuclear SLCMs could be adequately verified, and it has proposed a joint US–Soviet verification experiment on nuclear-warhead detection on ships.

In contrast, the US government, which is ahead in the deployment of both nuclear and non-nuclear variants SLCMs, feels no urgency about achieving a limitation agreement. It argues, furthermore, that the manufacture, storage, and deployment of the small missiles can be so inconspicuous that verification of limits would be impossible. Finally, the US Navy has made it clear that it opposes any verification arrangement that would allow Soviet officials to inspect US ships or would reveal the presence of warheads to the general public. (Because the presence of nuclear warheads is a politically sensitive issue in many of the foreign ports that US warships visit, the Navy has a policy of neither confirming nor denying the presence of nuclear warheads on its ships.)

In an attempt to break this impasse, on 5 July 1989 the Soviet government joined with the Natural Resources Defense Council in to demonstrate warhead detection on one of its ships, the guided-missile cruiser *Slava* (see figure 2 below). The demonstration occurred in the Black Sea off Yalta.

The warhead was easy to detect because the cruise-missile launcher was unshielded and in an exposed location above the deck. Even so, this was the first time that either government had knowingly let anyone other than its own technicians close to one of its warheads with a high-resolution gamma detector—the instrument that the NRDC group brought along.

For this experiment, Thomas Cochran of the NRDC had recruited four other physicists: Steve Fetter of the University of Maryland, the lead author of the study "Detecting Nuclear Warheads", which appears in this issue of *Science & Global Security*; Lee Grodzins of MIT; Harvey Lynch of Stanford; and Martin Zucker of Brookhaven.

The NRDC group used a high-purity 150-cm^3 germanium crystal scintillation detector with a resolution of about 2 keV. The detector was placed on the launcher at a location directly over the warhead designated by the Soviet team. The gamma rays had to penetrate the launcher casing.

The background-subtracted gamma spectrum resulting from a total of about 10 minutes of observing time is shown in figure 1 below. It clearly shows peaks associated with the alpha decays of the fissile isotopes uranium-235 (especially at 186 keV) and plutonium-239 (especially at 375 and 414 keV). It also shows gammas from the alpha decay of americium-241, itself a decay product of plutonium-241 (722 keV) and from thallium-208, a decay product of the artificial isotope uranium-232 (especially at 2,614 keV). The presence of uranium-232 indicates that some of the uranium in the warhead must have been exposed to neutrons—implying that the Soviets must have recycled uranium from their production reactors for use in weapons.

The spectrum was surprising in two principal ways to the US experimenters, whose expectations were formed by calculations of the radiation from a number of highly simplified models of nuclear warheads.* First, the number of 1.001-MeV gammas from the decay of uranium-238 was unexpectedly low, indicating that all the uranium in the warhead is highly enriched (only about 4 percent uranium-238). And second, the observation of the low-energy gammas from the uranium-235 decays indicates that there is almost no heavy-metal shielding between the uranium-235 and the detector, since the mean free path of these gammas is only about a millimeter in lead.

Nevertheless, analysis of the results of the experiment has shown that no sensitive design information is revealed by the gamma measurements.

A group from the Soviet Academy's Institute of Earth Physics carried out measurements similar to those of the NRDC group on top of the launcher with an instrument of somewhat poorer resolution, and a group from the academy's Geochemistry Institute attempted—unsuccessfully—to detect the warhead with a 0.25-square-meter array of sodium iodide counters from a landing ship passing along the side of the cruiser.

The most interesting Soviet experiment was done, however, by a

* See Steve Fetter et al., "Detecting Nuclear Warheads" (this issue).

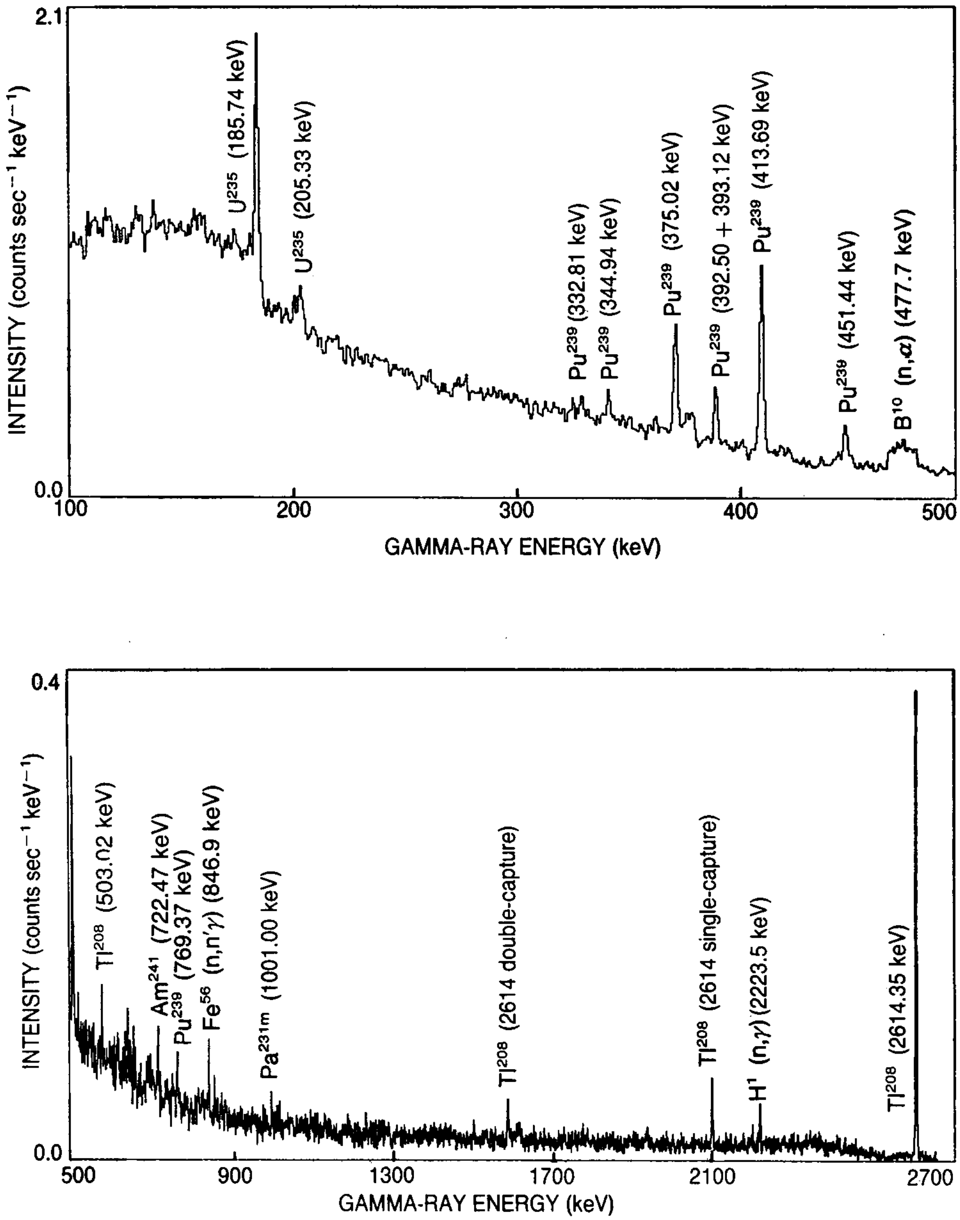

Figure 1: The gamma-ray signal recorded by a germanium detector placed on top of a cruise-missile launcher 3.4 meters from the lid for 10 minutes

group from the Kurchatov Institute's physics division. As decribed in the research nore following, this group conducted neutron measurements from a helicopter using a set of helium-3 proportional counters with a total area of 2.5 square meters. The helicopter detected statistically significant signals at distances of up to 76 meters (where the signal was about 1 neutron per second) from neutrons emitted as a result of the spontaneous fission of plutonium-240 in the warhead.

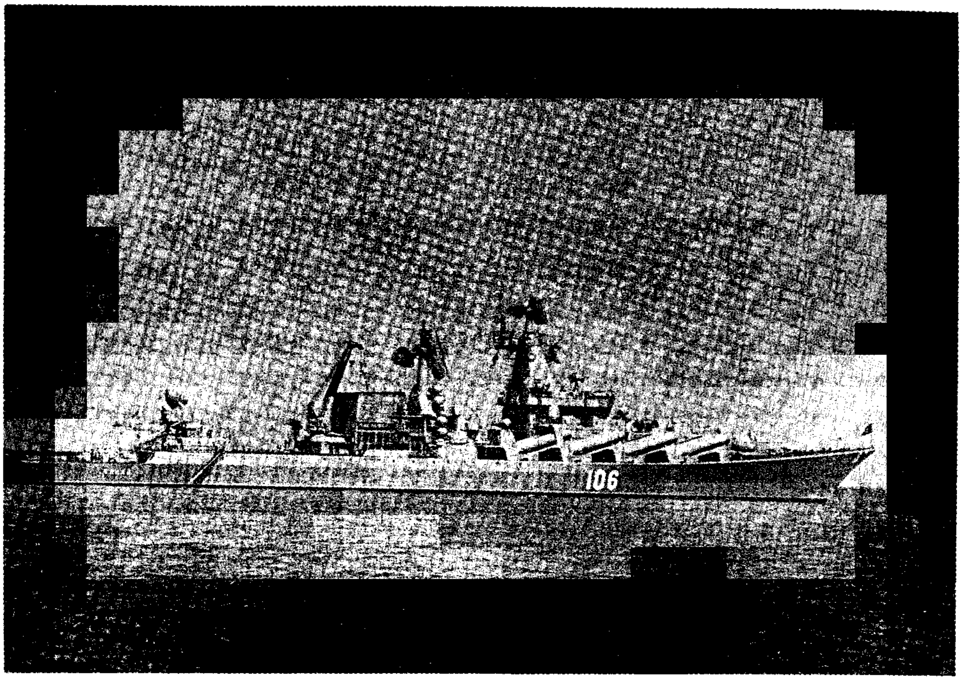

Figure 2: The Soviet cruiser *Slava*