OCCASIONAL REPORT

Sary Shagan and Kyshtym

A Visit to Soviet Nuclear Facilities

On 7–8 July 1989, during a trip arranged by the Natural Resources Defense Council (NRDC) and the Soviet Academy of Sciences, a group of Americans visited the Soviet ballistic missile defense test site at Sary Shagan, in Kazakhstan, and the Soviet nuclear materials production complex, near the city of Chelyabinsk in the Ural Mountains. The following is a series of fact sheets on these visits based on briefings given by the resident Soviet scientists and on the visitors' own observations; from the notes of Thomas Cochran, Senior Staff Scientist with the NRDC, Christopher Paine, assistant for arms control to Senator Edward Kennedy, and Frank von Hippel, physicist, Princeton University.

This is a slightly revised version of the fact sheets released by the NRDC, 11 July 1989, Washington DC.

Many pictures were taken at both facilities, a few of which are shown below.

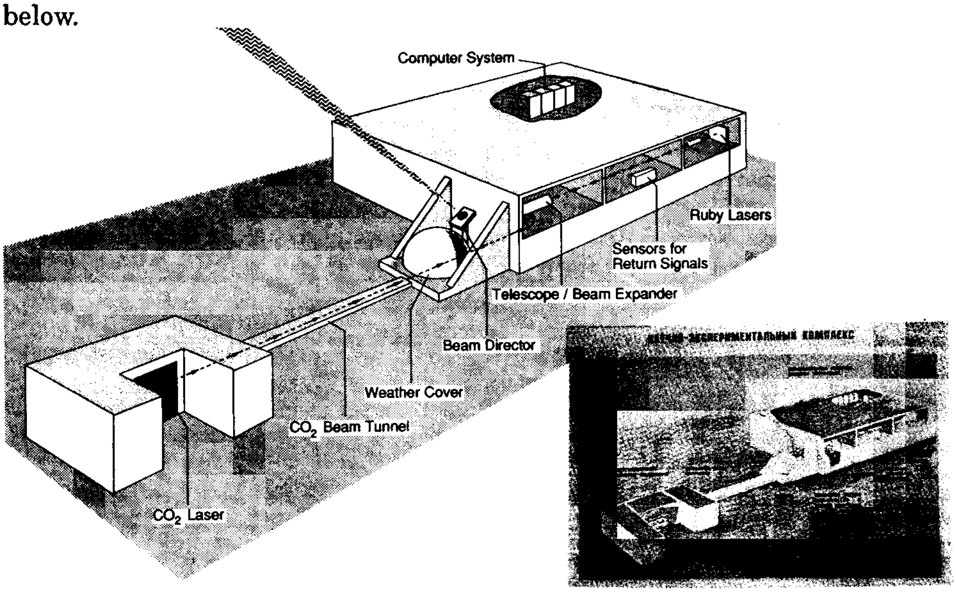

Figure 1: Sary Shagan Laser-Ranging Facility. For scale, the large building is 12-15 meters high and the base diameter of the weather cover is about 7 meters.

Source: Congressman Robert Carr

SARY SHAGAN LASER FACILITY

LOCATION

Near the eastern shore of Lake Balkhash in Kazakhstan (45° 55′ N, 73° 30′ E).

PURPOSE

To conduct research on laser radar.

HISTORY

Main building completed late 1970s. CO_2 laser building completed in mid 1982. Optical system is currently being "optimized." Last attempt to track a space target was in August 1988.

DESCRIPTION

Two low-power laser systems are optically combined into a single beam for target ranging. One laser system consists of a 10.6-micron pulsed CO_2 laser and the second is a pulsed ruby-laser system. The 0.7-micron ruby laser beam is formed by optically combining the output of 19 five-watt lasers.

SYSTEM CHARACTERISTICS

Ruby laser system

19 lasers each with 5 watts average power.
10 pulses per second.
30 nanosecond pulse length.
Lasers probably fired in sequence.

Optics

The beams are combined into one beam, then transmitted through a hole in the middle of the back of the main mirror of a 1.5-meter reflecting telescope to a 15-centimeter-diameter secondary which reflects and spreads the beam back onto the front of the 1.5-meter gold-plated primary mirror. The wide beam is then reflected to the beam director mounted on the outside of the end of the building. The beam director has an aperture of about 1 meter and contains two flat mirrors.

The telescope is also used to collected the light reflected from the target, which returns to along the optical path to a television camera and a photomultiplier.

There are no adaptive optics or cooling of optical elements, and the mirrors in the beam director are exposed to the building atmosphere and also to the outside air when uncovered.

/more

/system characteristics

CO_2 Laser

One 20 kilowatt output pulsed power laser, 60–100 hertz repetition rate with a pulse length of approximately 10 microseconds.
1–2 kilowatts transmitted through the optics to the beam director.
15 percent optical efficiency (light energy/electrical energy).
5 percent efficiency (light energy/total energy consumption.
Therefore approximately 400 kilowatts total energy consumption.
Laser beam initial diameter: 1.5–3 centimeters (port window seems to be 5 centimeters in diameter); 250 kilovolt high-voltage generator for electron beam gun; water cooling.

Optics

The beam is transmitted through an underground tunnel to the basement of the main (ruby laser) building. There it is reflected onto a vertical path up to a 30-centimeter-diameter 45° mirror, located between the 1.5-meter telescope and the beam director, which sends the light to the beam director. Thus the CO_2 laser beam is less than 30 centimeters in diameter when it leaves the beam director.

The 45° mirror, which appears to be gold-plated, is uncooled and exposed to the building atmosphere.

Computer control equipment

1960s computer technology with hard-wired transistor circuitry; punch card input.

Power Supply

5 megawatts for entire complex, including lasers, computers, lighting, and cooling.

OTHER INFORMATION

The facility has been used a few times per week to track aircraft equipped with retroreflectors and beam sensing equipment at ranges of up to 60–70 kilometers. Attempts have also been made to track a multi-purpose Cosmos satellite equipped with a retroreflector. Continuous tracking of the satellite has not been achieved.

High saline content of CO_2 laser cooling water from Lake Balkhash requires pipe replacement after three years.

Total project cost to date

"A few tens of millions of rubles."

Large underground room

Nearby, there is a very large underground room (perhaps 70 meters long, 30 meters wide, and 10 meters high). The room was unfinished and empty. The group was told that it had originally been built around 1970 for a high-powered laser. It was underground and equipped with blast doors because one idea had been to power the laser with electromagnetic pulses generated by chemical explosions. There was a heavy blast wall on the ground above and next to the room which was evidently designed to protect the roof of the room from the blast waves. However the project had been abandoned at an early stage.

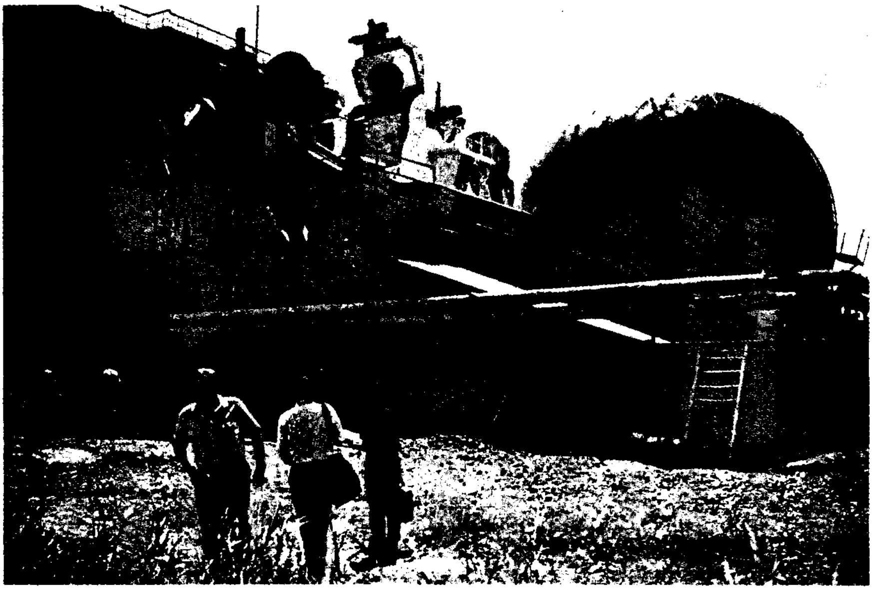

Figure 2: View of the beam director with its weather cover to the right.

Source: Congressman Robert Carr

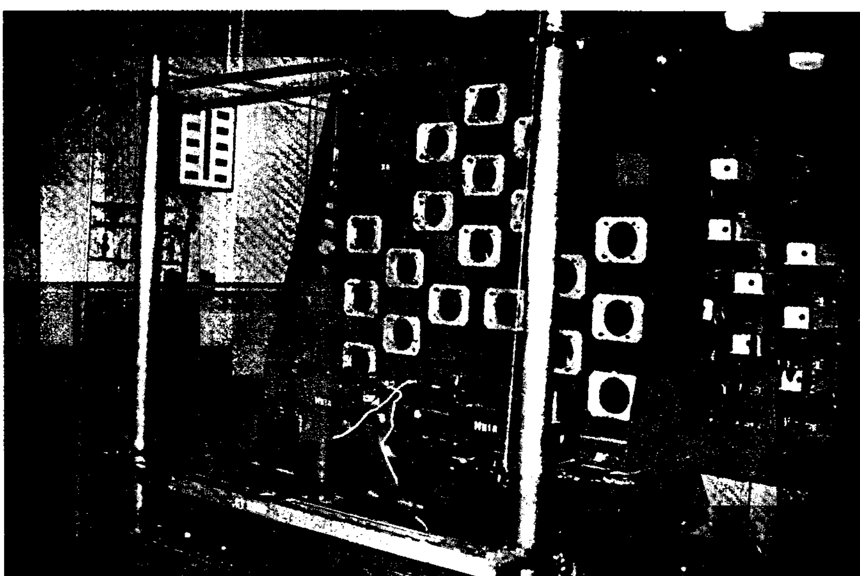

Figure 3: View of the 19 apertures through which ruby laser beams pass before being directed into one-beam line. The fronts of eight of the lasers can be seen at right. The beam ports are 1-1.5 cm in diameter.

Source: Congressman Robert Carr

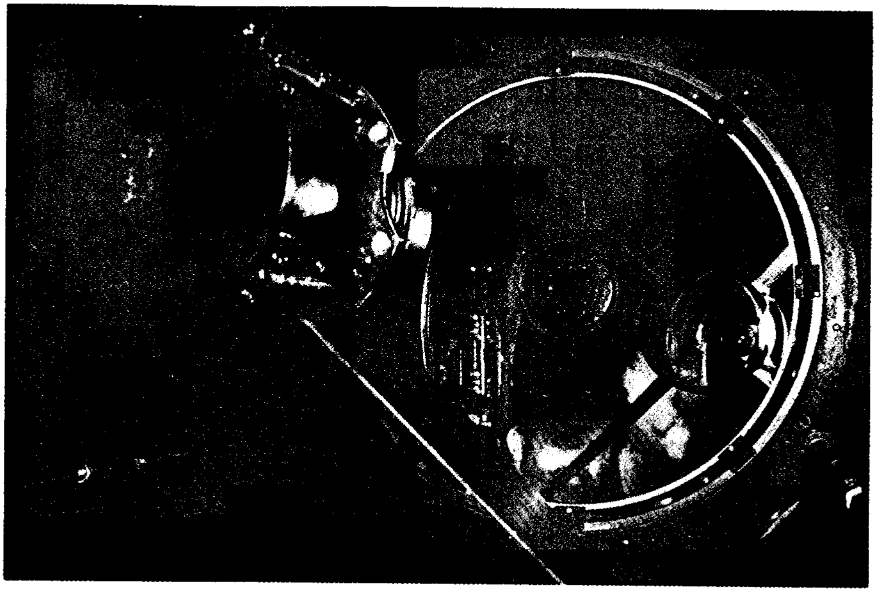

Figure 4: Telescope/Beam Expander. The beam from the ruby lasers comes through the port in the center of the 1.5-meter gold-plated parabolic main mirror at right, is reflected off secondary mirror at left back onto main mirror and then is directed as a 1-meter-diameter beam to the beam director.

Source: Congressman Robert Carr

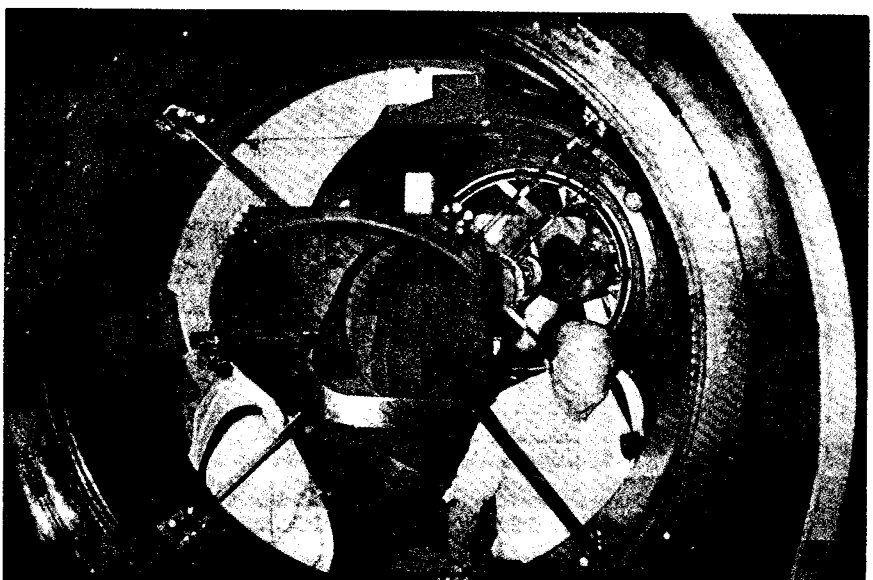

Figure 5: The 0.3-meter-diameter mirror hung at 45° in beam line between ruby-laser beam expander and beam director redirects vertical beam from CO_2 laser coming up from basement to horizontal line in center of ruby beam.

Source: Thomas B. Cochran, NRDC

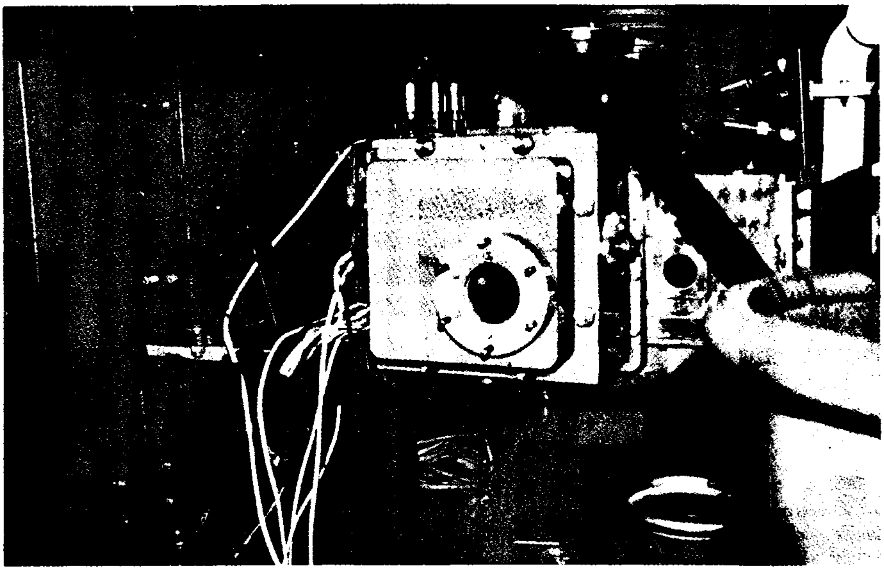

Figure 6: Beam port of CO_2 laser is about 5 centimeters in diameter.
Source: Congressman Robert Carr

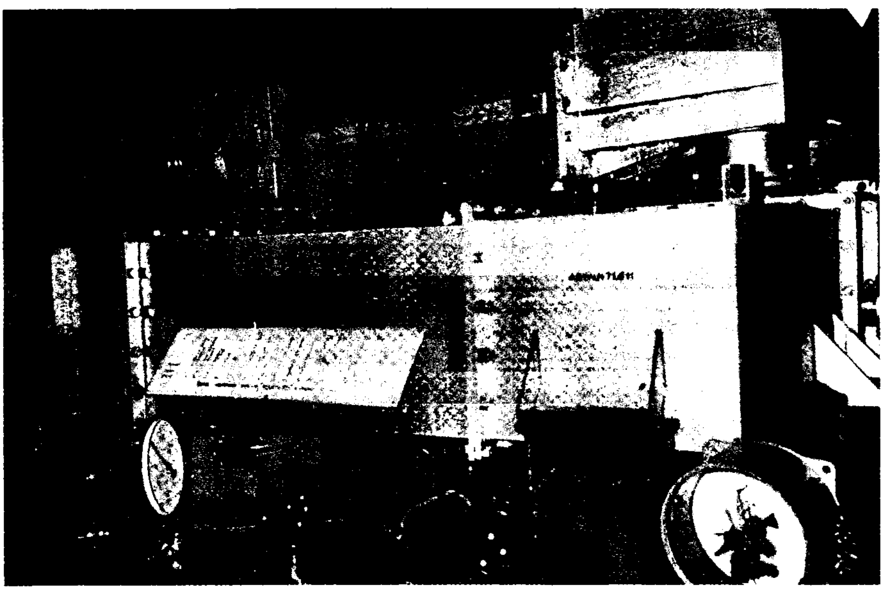

Figure 7: Gas recirculation ducts for CO_2 laser. Vertical dimension on large horizontal duct is about 0.4 meters.
Source: Thomas B. Cochran, NRDC

KYSHTYM AND SOVIET NUCLEAR MATERIALS PRODUCTION*

KYSHTYM COMPLEX

LOCATION

East of Ural Mountains, near the town of Kyshtym (55° 44′ N, 60° 54′ E). The site is also referred to by its post office box address, "Chelyabinsk 40."

FACILITIES IDENTIFIED

5 graphite-moderated water-cooled production reactors; 3 in earliest production area and two in another area. 3 reactors are operating, one of which will be shut down in August 1989 and two more in 1991.

1 chemical separation plant.

3 BN-800 (800 megawatts electric) liquid metal fast breeder reactor power plants proposed; one of the reactor foundations is laid; construction is delayed pending review of entire program.

HISTORY AND STATUS OF IDENTIFIED FACILITIES

A-Reactor

The first Soviet plutonium production reactor and the source of plutonium for the first Soviet atomic bomb. Construction began in 1946, and initial operation started 19 June 1948. Shutdown occurred in 1987, after 39 years of operation; now being dismantled.

Initial power level: 100 megawatts thermal.
Final power level: 500 megawatts thermal.

Vertical fuel tubes with gravity fuel discharge; initially operated with continuous refueling, but forced to switch to batch refueling during reactor shutdown as a result of raising the reactor power level.

1168 holes in the graphite block.
Aluminum-clad natural uranium fuel.
Core diameter 9.4 meters; height: 9.2 meters; top of reactor is 9.3 meters below grade; core is located in a concrete well with walls up to 3 meters thick.

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** Most of the information, except for that about the A- and B- reactors, was provided by Evgeny I. Mikerin, head of the main department of manufacture and technology of the USSR State Committee for the Utilization of Atomic Energy*

/history and status of identified facilities

A-Reactor

Emergency Containment/Confinement System

Accidental fission product releases are vented into a 100-cubic-meter tank. Gas and particulates enter from one side and travel through a "labyrinth," gas holdup allows short-lived activity to decay; filters made from special textiles capture cesium and strontium isotopes. For iodine-131 there are absorber columns of activated carbon.

Cooling water discharge

Cooling water from lake pumped directly through the core. Average 70° centigrade discharge into the lake (high: 80°–85°).

Reactor Dismantling Stages

First stage: Shutdown, fuel unloaded.

In the future: dismantling of hardware, filling empty spaces with concrete. After 20–25 years a decision will be made to bury or remove.

No history of tritium production in this reactor.

B-Reactor

Dual purpose: fuel rod research and plutonium production. Now being dismantled.

Power level: 65 megawatts thermal—more or less the same throughout its history; used to test fuel assemblies for the RBMK.

Third Reactor

Initial power level: 100 megawatts thermal.
Final power level: 500 megawatts thermal.
Scheduled shutdown: August 1989.

Fourth and Fifth Reactors

Now in operation; built more recently, with higher power levels; in a separate area of the complex. Shutdown planned for 1991.

Chemical Separation Plant

In 1978 the plant shifted from processing military production reactor fuel to processing fuel from Soviet 440-megawatt-electric light-water moderated and cooled (VVER) power reactors and naval reactors.

Approximately 20 tonnes of civilian plutonium has been separated, corresponding to a capacity of about 400 tonnes of uranium per year.

/more

/history and status of identified facilities

Waste Management

Apparently high-level waste containing an estimated 120 million curies of 30-year–halflife strontium-90 and cesium-137 was discharged directly into a small lake. The lake is now slowly being entombed in concrete to prevent the dispersion of radioactivity.

The dose rate for a trip to visit the lake would have resulted in an exposure of about 500 millirems per person.

At an unspecified date, the mode of waste management was shifted to storage in double-walled stainless steel tanks. Leaks in tanks have occurred once or twice; the inventory in these leaky tanks was shifted and the tanks repaired. Waste vitrification began "a few years ago."

The famous 1957 accident, which contaminated an area of hundreds of square kilometers with airborne long-lived fission products, was caused by a chemical explosion in a high-level waste tank that was allowed to boil dry. The chemicals involved included ammonium nitrate and ammonium ethanoate. After the explosion, there was a shift to a process similar to the "Purex" extraction process used by the US.

OTHER NUCLEAR MATERIALS PRODUCTION FACILITIES

PRODUCTION REACTOR SITES

Kyshtym complex: 3 reactors operating July 1989, one of which is scheduled to be shut down in August 1989.

Tomsk

Krasnoyarsk (i.e. Dodonovo)

TRITIUM PRODUCTION

This occurs in dedicated heavy water reactor campaigns at Tomsk or Krasnoyarsk. (Location and number of heavy-water reactors not given.)

Tritium is sometimes made in production reactor control rods at all reactor sites.

CHEMICAL SEPARATION FACILITIES

Chelyabinsk 40

See above.

Krasnoyarsk

Large facility for storing and reprocessing 1,000-megawatt-electric light-water reactor (VVER-1000) and other reactor fuels. Krasnoyarsk reprocessing plant expected to be operational in late 1990s. Plant construction is 30 percent complete.

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URANIUM ENRICHMENT FACILITIES

Sites

Angarsk
Krasnoyarsk
Verkhniy-Neyvinskiy

Technologies

Initially used gaseous diffusion technology; 5 plants total with phase-out nearly complete.

Shifting to gas centrifuge technology. Ten plants with capacities of approximately 1 million kilogram separative work units (SWU) per year per plant.

Individual machines have less capacity than European machines.

NUCLEAR MATERIAL QUANTITIES AND SPECIFICATIONS

Spent fuel from graphite-moderated, water-cooled Chernobyl-type (RBMK) reactors is being stored at the reactors.

The Soviet Union has produced "a little more" weapon-grade plutonium than the US (which has produced about 100,000 kilograms).

Soviet weapon-grade uranium is about 95 percent uranium-235.

Soviet weapon-grade plutonium: less than 5 percent plutonium-240.

Soviet naval-reactor uranium is about 10 percent uranium-235 (US naval-reactor uranium is 97.3 percent uranium-235, French naval-reactor uranium is 7 percent uranium-235).

BREEDER PROGRAM AND PLUTONIUM RECYCLING

1 BN-350 (350 megawatts electric equivalent) breeder, tested with plutonium core.

1 BN-600 (600 megawatts electric) operating at half-power with enriched uranium core.

3 BN-800 (800 megawatts electric) planned for Chelyabinsk 40. A plutonium core is planned.

1 BN-1600 (1,600 megawatts electric) breeder being designed but construction not expected to begin earlier than 2020–2030.

The breeder program is delayed by concerns about safety (leaks in sodium–water heat exchangers and the possibility of a runaway chain reaction during an overheating accident) and lack of need.

Electricity cost from breeders is estimated at 2.5 x that from current nuclear power plants.

Research is expected to be completed "in the near future" on MOX (mixed plutonium and uranium oxides) fuel for recycle in existing power reactors, leading to construction of a MOX fuel plant and possible commercial export of MOX fuel to other countries.