

THE SECOND WORLD WAR

THE ATOMIC BOMBING OF HIROSHIMA AND NAGASAKI THROUGH
THE EYES OF PROF. BUNSAKU ARAKATSU*

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On August 6, 1945, a B-29 Superfortress bomber, the “Enola Gay,” dropped an atomic bomb on Hiroshima, Japan. Three days later, Nagasaki was the target of a second atomic bomb. On August 15, after years of war and following the recent withdrawal of the Soviet Union from a Japan-Soviet non-aggression pact, Japan agreed to surrender unconditionally. During the war, Lieutenant General Leslie R. Groves served as the military commander of the Manhattan Project, the massive \$2 billion “top secret” project to develop the atomic bomb.

Following the Japanese surrender, the Manhattan Project’s Atomic Bomb Investigating Group, also known as the Atomic Bomb Mission, or ABM, began investigating the possibility of a Japanese atomic program. After the American General Headquarters (GHQ) sent a team of scientists and military technicians to the Pacific Theater at Tinian (where assembly of the Hiroshima and Nagasaki atomic bombs took place), the team paid a visit to Japan where their investigation began. A month later, on September 30, 1945, General Groves’s assistant, Maj. Robert R. Furman, issued a summary report. Addressed to Brigadier General J. B. Newman, Furman’s “Investigation into Japanese Activity to Develop Atomic Power” came to three conclusions:

(1) Normal research continued until 1943.

(2) Activity continued on a reduced scale after 1943 because of difficulties over priorities, manpower, evacuation, and diversion to war research which was of direct interest to the military who sought to evade at least the effect of air raids upon their military forces and homeland.

(3) Activity increased after the August 6 Hiroshima bombings. Some of this interest has appeared to be other than medical. “The [Japanese] government and the military gave no priority to research in the field of nuclear physics and had no program to produce a bomb”¹. According

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*I would like to thank the staff at Amherst College (Amherst, Mass., USA) and the Hiroshima Peace Memorial Museum (Hiroshima, Japan) for providing Prof. Bunsaku Arakatsu’s scientific field surveys of Hiroshima and Nagasaki, respectively. I would also like to thank Xu Zhibin (Xiamen University) for the English translation of Arakatsu’s survey of Nagasaki; Irek Sabitov (a Russian journalist), Tatsuo Tabata (Kiichi Kimura’s former student), and Frank Kawamoto (former Japanese soldier in China during WWII and later a member of the U. S. State Dept.) for providing translations and other valuable information; the Japan Society for the Promotion of Science for granting the author permission to publish excerpts from the English translation of Prof. Bunsaku Arakatsu’s scientific survey of Nagasaki, Japan after an atomic bomb fell on that city (Appendix I); and Kenneth N. Ricci, PhD (Physics) for providing an analysis of a small portion of that scientific survey (Appendix II).

¹ Furman, Maj. Robert R. to Brigadier General J. B. Newman. Report on Investigation into Japanese Activity to Develop Atomic Power, Sept. 30, 1945. Report No. 11-a(28), USSBS Index, Section 6.

to the authors of a book on uranium and international politics, however, the Japanese project seemed to be “further advanced than had been assumed” [Zeman, Karlsch, 2008, pp. 15–16]:

After the two nuclear attacks on Japan, and the country’s subsequent unconditional surrender, the history of its atomic project was suppressed. Japan came to regard itself as a victim of American raids. The scientists who had taken part in the nuclear program remained silent, or insisted that they had taken part in developing atomic energy for peaceful purposes [idid.].

We now know that Japan had two, largely independent, nuclear weapons programs. The first and most well-known was *Ni-go*, financed by the Imperial Japanese Army, or IJA. Dr. Yoshio Nishina led the *Ni-go* atomic program at the Institute of Physical Research (Riken) in Tokyo. *Hankyoreh* 21, the Korean weekly magazine, quoted Nishina: “If we had succeeded before the Americans, we would have been the ones who dropped the bomb”². Far less known is *F-go*, the atomic program led by Prof. Bunsaku Arakatsu, a professor of physics at Kyoto Imperial University, financed by the Imperial Japanese Navy, or IJN.

Both of Japan’s leading atomic scientists, Nishina and Arakatsu, had mentors of the highest caliber. Nishina, the father of modern physics in Japan [Kim, 2007], was a student of Niels Bohr, the Nobel Prize-winning physicist who later worked for the Manhattan Project. Arakatsu, who studied under Albert Einstein at Berlin University, later became a member of Einstein’s close circle of friends [Zeman and Karlsch, p. 15]. When Arakatsu retired in 1950, Prof. Kiichi Kimura succeeded him as head of the laboratory³. When Konan University in Kobe, Japan was founded in 1951, Arakatsu was appointed its first president⁴.

Early in 1939, when German scientists, Otto Hahn and Fritz Strassmann, announced the fission of uranium and thorium, Sakae Shimizu said it gave all Japanese physicists and chemists involved in the study of the atomic nuclei a “great shock” [Shimizu, 1982, pp. 39–54]. The announcement, he said, provided researchers in the field the impetus to immediately begin research into this particular nuclear phenomenon. When Arakatsu’s group at Kyoto Imperial University heard the news, they immediately began to investigate certain aspects of the nuclear fission process. Within ten months, they published the results of experiments that showed that the fission of the uranium nucleus by slow (thermal) neutrons produced 2.6 neutrons ($\nu = 2.6$), thus proving a nuclear chain reaction was indeed possible. Following the outbreak of war, however, two active members of Prof. Arakatsu’s group, Drs. Uemura and Sonoda, were forced to leave the laboratory when they were mobilized into military service. At that point, Arakatsu’s laboratory of experimental physics at Kyoto Imperial University was left with only two staff members: Assist. Prof. Kiichi Kimura⁵ and Lecturer Shimizu, plus a few graduate students and several undergraduate students who were engaged temporarily in experimental work [Ibid.].

KONAN, KOREA

Despite the claim by the Atomic Bomb Mission that “[Japanese nuclear research] activity was continued on a reduced scale after 1943...” Prof. Arakatsu had actually organized a research committee with the financial support of the Navy during “the later [*sic*] half of the war” [Shimizu, 1982, pp. 39–54]. Members of Arakatsu’s team included the following atomic scientists: Kyoto Imperial University professors S. Okada, S. Sasaki, M. Kobayashi and Hideki Yukawa; Prof. T. Okuda of Osaka University; Prof. E. Kanda of Tohoku University; and Sakai Shimizu and

² “アメリカより先に成功していたら‘加爆国’になっていたかも”; *Hankyoreh* 21 (Korean weekly magazine), No. 268, July 7, 1999.

³ “The Arakatsu and Kimura Laboratories,” Kyoto University, Feb. 2, 1951 (The Commemoration Volume for the Silver Jubilee, 1951, pp. 179–193).

⁴ “Directory of Research Institutions in Japan: List of universities and Colleges in Japan,” Japan Society for the Promotion of Science, 1963; in conversations with the author, Tatsuo Tabata said that Konan University in Kobe, Japan and Konan in northern Korea (mentioned later in this article) are written differently in Chinese characters. The former is written as 興南 and the latter as 甲南; Tabata, Tatsuo. “From Fujioka’s Fluid Drop Model of Atoms to Einstein–Arakatsu Relationship,” IDEA & ISAAC: Femto-Essays, July 13, 2015; <https://ideaaisaac.blogspot.com/>.

⁵ One of Prof. Kimura’s students, Tatsuo Tabata, later became Professor Emeritus at Osaka Prefecture University.

Kiichi Kimura from Arakatsu's laboratory. According to Dr. Shimizu, however, most members of Arakatsu's committee could not complete their planned work due to "difficult wartime confusion and very meager budget and materials" [Ibid.], nor had they received – throughout the war – any information concerning the top secret "Manhattan Project," a large-scale Allied nuclear weapons program. The only hint came in 1943, Shimizu said, when a British military unit thoroughly destroyed the Norsk Hydro plant in Norway where the Germans were carrying out large-scale heavy water production⁶.

Then in August 1999, more than half a century after WWII had ended, new evidence came to light that suggests the Japanese conducted atomic research at Konan (now Hungnam, North Korea), and that Hideki Yukawa, one of Arakatsu's men, had frequented that city. According to "Atom Bomb Experiment Undertaken by Former Japanese Armed Forces in Korean Peninsula Just Prior to the End of the War, According to Secret Investigation by GHQ" ["Atom Bomb Experiment...", 1999, p. 22] in *Tokyo Shimbun*, Nishina knew that the enrichment of uranium by gaseous diffusion from uranium hexafluoride required a tremendous amount of electricity [Ibid.].⁷ For that reason, the Japanese elected to develop a nuclear weapon in the industrial port-city of Konan, a rich source of electric power. *Tokyo Shimbun* then cited MBC (Munhwa Broadcasting Corporation), a leading South Korean television and radio network, who discovered demonstrative evidence at NARA (National Archives and Records Administration) in the form of a 1947 U. S. Army Headquarters (GHQ) report⁸.

According to MBC, Japan conducted uranium research at Konan, being a top-notch district in the chemical industry with reasonably abundant electric resources⁹. However, due to the fact that Konan was an extremely guarded place, the Korean report could only guess that the project was located there for the development of "rockets and uranium." Also, according to an eyewitness who worked at the [Jun] Noguchi Institute in Konan, Hideki Yukawa, who later received the Nobel Prize in Physics, had visited Konan repeatedly¹⁰. *The Hankyoreh* 21 surmised that Yukawa was involved in the Japanese Navy's program to develop the atomic bomb¹¹.

According to the testimony of Ryohei Nakane, a junior member of Nishina's group who served as an analyst, minerals vital to the program were available at Konan in abundance¹². As he related to Kenji Hall of the *Japan Times*, Nakane was enriching uranium for Japan's "super bomb" at Nishina's Riken plant in Tokyo the night American B-29 bombers arrived [Hall, 2003]. By the next morning (April 13, 1945), Nakane said all that remained of his samples and laboratory was charred and splintered wood, and broken glass. Kenji Hall left his readers with an open question: "Now seven decades later, historians have been unable to solve one of the mysteries of Japan's wartime A-bomb project: How close were Japanese scientists to building an atomic bomb before a B-29 firebombing raid on Tokyo stopped them?" [ibid.].

⁶The heavy water process use by the Germans at Norsk Hydro was developed in the 1930s by Dr. Fritz J. Hansgirg, a brilliant Austrian chemist, metallurgist, and prolific inventor. Dr. Hansgirg's biography and his patented heavy water process is thoroughly discussed in the author's book-in-the-works: "Dr. Fritz J. Hansgirg: The Father of Wartime Heavy Water Production," co-authored by Kenneth N. Ricci, PhD (Physics, Stanford University).

⁷仁科はフッ化ウラン、ひいてはウラン235の濃縮には莫大な電力が必要であると考えがっていたのですが、これとどう結びつくのか、電力が豊富な朝鮮の興南で核兵器の開発が行なわれていました。

⁸Ibid.; その決定的な証拠をMBC局はアメリカ公文書館で発見したようでした。その証拠とは1947年に連合軍司令部が作成した報告書でした。

⁹Ibid.; どうやら、湯川秀樹は日本海軍が推進していた原爆開発計画に関係していたようです。韓国の『ハンギョレ21』誌は1999年にこう記しました。

¹⁰Ibid.; また、興南には警備がきわめて厳重な一角があったとのことで、番組はそこがロケットおよびウラン開発の拠点ではないかと推測しました。さらに興南のノグチ研究所に勤務していた目撃者によれば、後日ノーベル賞を受賞した湯川秀樹がたびたび興南を訪れていたとのことでした。

¹¹Ibid.; どうやら、湯川秀樹は日本海軍が推進していた原爆開発計画に関係していたようです。韓国の『ハンギョレ21』誌は1999年にこう記しました。

¹²Ibid.; そこには日本が朝鮮の興南市でウランの研究を行っていたことが指摘されました。興南は朝鮮で最大級の電気・化学工業地帯であり、もちろん電力資源も豊富でした。また、周辺はウラン鉱石も豊富であることが、分析を担当したナカネ・リョウヘイ氏の証言で明らかにされました。

In 1999, to refute a claim made by an American reporter in 1946 that Japan had conducted an atomic test at sea off the coast of Konan during the closing days of the war [Snell, 1946, p. 1]; *Tokyo Shimbun* interviewed Sakae Shimizu, 67¹³, a former member of Arakatsu's group at Kyoto Imperial University. In "Can't be an Atomic Bomb"¹⁴, Shimizu, a Professor Emeritus of Physics at the Institute for Chemical Research at Kyoto University, said the Japanese were "nowhere close to making the bomb" [ibid.]. Although the separation of U-235 and other difficult problems had not yet been solved, Shimizu flatly stated that Arakatsu's group was "far more advanced" than Nishina's. He also made it very clear that nuclear research in Japan began early and advanced quickly. When interviewed, Prof. Arakatsu, however, branded the story "false and fantastic"¹⁵. He said he was personally acquainted with the few men capable of furnishing the necessary technical knowledge for such an undertaking, and their combined efforts had not progressed beyond the laboratory stage. "No thought was ever given to the construction of a pilot plant for the production of fissionable material or the assembly of an atomic bomb," Arakatsu said. "The laboratory results of the experimenters had not even convinced them that such a bomb was possible" [ibid.].

HIROSHIMA AND NAGASAKI

In 1982, Dr. Sakae Shimizu described how Arakatsu's group heard the incredible news that the Americans had dropped an atomic bomb on Hiroshima, Japan. In Kyoto University's *Bulletin of the Institute for Physical Research*, Shimizu said they knew that enriching uranium was a "very difficult process," and how, in retrospect, such a project would require an "unimaginable large-scale cooperative" effort:

In the afternoon of August 6, we received astonishing information that in this morning (8:15 am), Hiroshima was destroyed thoroughly by only one particular bomb dropped upon its center. When we heard this news, we could not believe that it might be [a] so-called 'atomic bomb,' because we knew well that the fission chain reaction of uranium cannot be realized unless considerable amount of highly enriched U-235 can be separated, and such a very difficult project necessitates unimaginable large-scale cooperative works of a great number of leading scientists, engineers, military personnel, and laborers under a supreme commanding organization with a high-minded leader. But we were trembled with fear for the last weapon had just come to us [Shimizu, 1982, pp. 39–54].

In "Historical Sketch of the Scientific Field Survey in Hiroshima Several Days after the Atomic Bombing," Shimizu explained how they learned of "the disaster," how a single bomb had thoroughly destroyed Hiroshima. According to Shimizu, Arakatsu immediately organized survey teams of experimental nuclear physicists and pathologists. Rushed to the site of the explosion, their goal was to determine the nature of this "terrible bombing" by observing the actual state of the disaster and to measure the "tremendous radiation, if it was produced."

One party, led by Arakatsu, consisted of ten men: four experimental nuclear physicists (Prof. Arakatsu, Asst. Prof. Kimura, Lecturer Shimizu, and graduate student T. Hanatani), three pathologists from their medical school (Prof. S. Sugiyama, Drs. M. Shimamoto and M. Kimura), a Navy Technical Lieutenant (R. Ueda), a Navy Engineer (S. Ishida), and an Army Technical First Lieutenant (Ikeno). According to Shimizu, Arakatsu's survey team left Kyoto Central [Train] Station for Hiroshima at 9:30 pm on August 9, three days after the bombing. At the station, they heard the news that the Soviet Union had entered the war and how Russian troops had advanced into Manchuria and the "Japanese Southern Sakhalin" the morning of the preceding

¹³ Dr. Shimizu was born in Tokyo on July 18, 1915. [*Bulletin of the Institute for Chemical Research*, Kyoto University, Vol. 57, No. 1, Jan. 1979, p. ii].

¹⁴ "Can't be an Atom Bomb" (in Japanese) with English translation by Frank Kawamato, accompanied "Atom Bomb Experiment Undertaken by Former Japanese Armed Forces in Korean Peninsula Just Prior to the End of the War, According to Secret Investigation by GHQ." [*Tokyo Shimbun* (Jiji, Washington 5th), Aug. 6, 1999, p. 22].

¹⁵ Filed Report (Oct. 8, 1946): "Inspection of Activities at Kyoto Imperial University," Oct. 21, 1946.

day. Arriving at Hiroshima at noon on August 10, Shimizu said they were “shocked marvelously” at first glance of the carnage.

The whole city was destroyed completely and remained in ruins with a special smell of death and with few collapsed ferroconcrete buildings standing ghostlike. Green leaves of all pine trees on the hill, some 1 km to the north of the central station, were changed to dark brown. Few people entered into the city for the victims’ rescue were wandering on the street. Even near the central station we witnessed killed bodies still not evacuated [ibid.].

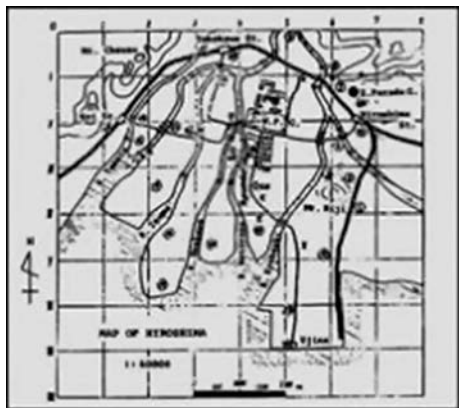


Fig. 1. Arakatsu’s scientific survey (map) of Hiroshima

Figure 1 (a hand-drawn map of Hiroshima) shows the locations where the team took samples collected on August 10, 13, and 14. Also marked is the “hypocenter” of the explosion (also known as the “epicenter”). Shimizu said this wasn’t the spot where the team presumed was the point of explosion. Rather, it was probably a drafting error, since their estimated point – about 300 meters south of Gokoku Shrine – was actually located north (not southeast) of Motoyasu Bridge. Arakatsu later explained to the press how the survey of Hiroshima had greatly advanced his knowledge of the atomic bomb, although it was probably too late to make much use of the information gained [“Japanese Believes Russia Has It”, 1945, p. 4]. A top-secret report by SCAP (Supreme Commander for Allied Powers) confirms what Arakatsu told the press:

Japanese scientists and technologists, through studies made immediately after the explosion of atomic bombs over Hiroshima and Nagasaki, obtained important information concerning the psychological effects and the physical damage caused by the explosion and, it is believed, made estimates of design and performance features of the bombs¹⁶.

Nevertheless, it was considered “highly desirable” that the Japanese “continue their investigations at Hiroshima and Nagasaki since the opportunity presents itself nowhere else”¹⁷.

When the group paid their first visit to the Headquarters of the Second General Army, to obtain a summarized report of the disaster, as well as to request a guide in the damaged city, Shimizu said they lodged in tents temporarily installed at the East Parade Ground [Shimizu, 1982, pp. 39–54]. There, the group participated in a conference urgently held in a building of the Hiroshima Army Base of Supplies. In attendance was Dr. Yoshio Nishina of the Institute of Physical and Chemical Research (Riken) who had rushed there from Tokyo on the afternoon of August 8. Also in attendance were surviving local military staffs, Army and Navy higher staff officers from the General Supreme Headquarters in Tokyo, and members of the technical and hospital staffs from Kure Naval Station, as well as science teachers from the Naval Academy at Edajima Island in Hiroshima Bay.

During their conference, attendants exchanged information on various aspects of the bombing and discussed how to protect, or at least to mitigate, the terrible effects of such a bomb. A serious discussion, focused on the nature of this new type of bomb, and it was strongly hoped that a further investigation would follow. All conference members were thrown into a state of despair, however, when they belatedly received news that a bomb, similar to the one that had demolished Hiroshima, was dropped on Nagasaki in the morning of the previous day.

¹⁶ General Headquarters, Supreme Commander of Allied Powers (SCAP), Economic and Science Section (ESS), memorandum for Chief of Staff, subject: “Security of Information in Possession of Japanese Scientists Pertaining to the Atomic Bomb” (undated, post-March 7, 1947).

¹⁷ Ibid.

After the team walked around the damaged city for several hours, Shimizu said they were determined to return to Kyoto by train as soon as possible because of a rumor that “our Kyoto might be attacked by a similar bomb within [a] coming few days.” So they left Hiroshima by train at around 11:00 pm, arriving in Kyoto before noon on August 11, to determine the “nature of the bombing and terrible aspects of the tremendous damage.” Appendix I contains the English translation of excerpts of Arakatsu’s scientific field survey of Nagasaki [Fig. 2], first published in Japanese by the Japan Society for the Promotion of Science in Tokyo in 1953¹⁸.

POST-WAR JAPAN

In a radio broadcast out of Tokyo two months after WWII had ended, Larry Tighe of ABC News interviewed Prof. Bunsaku Arakatsu who the *New York Times* described as one of Japan’s foremost physicists [“Russians Believed Near Atom Secret”, 1945, p. 4]. According to Arakatsu, Japan could have perfected an atomic bomb of her own “within five to ten years,” and had already made “tremendous strides” in that direction when U.S. forces cut off the electric power to his laboratory. He said the information they gained from a study of Hiroshima cut his own research by “forty years.” When Tighe and Keith Wheeler of the *Chicago Times* visited Arakatsu’s laboratory, they were “shocked speechless” at the progress Japan had already made. Only two weeks earlier, Maj. Furman’s summary report described Japanese laboratories as “small” and “poorly equipped, often with homemade equipment”¹⁹. How could Furman have so badly misjudged Japan’s nuclear capability?

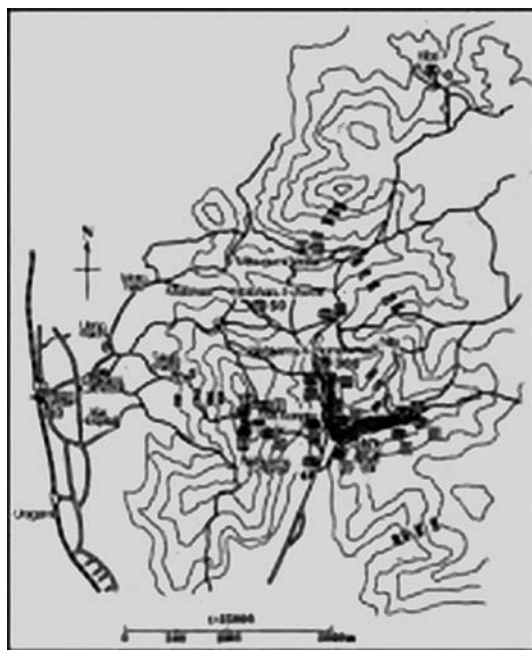


Fig. 2. Arakatsu’s scientific survey (map) of Nagasaki.

When Allied Occupation Forces arrived in Tokyo, they began dismantling Nishina’s cyclotrons. He pled for his equipment: “This is ten years of my life,” he said. “It has nothing to do with bombs.” Meanwhile, his wife and secretary silently wept [“Cyclotron Smashing”, 1945, p. 26]. By then, Nishina had ordered the destruction of all documents related to his nuclear program. When the Americans later raided Arakatsu’s laboratory in Kyoto, however, he accepted their decision to destroy his cyclotron but fiercely protesting when the Americans said they were going to confiscate his research notes. “We purely conducted academic research and our project has nothing to do with the war,” he said. Unable to suppress his emotion, Arakatsu tearfully added, “In the United States, it’s impossible to find someone who has knowledge of physics, English and Japanese, as well as calligraphy [Kanji], which are indispensable for these translations. Even if I hand over the notes to you, they’ll be useless” [ibid.]. The author of this article, Bill Streifer,

¹⁸ Ms. Rie Nakanishi (Ms.), Curatorial Division, Hiroshima Peace Memorial Museum; Japan Society for the Promotion of Science, 1951.8–1953, ID: BN1025957X, editor in charge: Japan academic conference, committee of publishing of report on atomic bomb damages.

¹⁹ Furman, Maj. Robert R. “Summary Report, Atomic Bomb Mission, Investigation into Japanese Activity to Develop Atomic Power.” Source: GHQ, Tokyo, Memorandum to Brigadier General J. B. Newman. Report No. 3f(14), USSBS Index Section 2. [NDL citation]

has acquired some of Arakatsu's research notes, and with the assistance of Japanese translators and a nuclear physicist was able to access their value for later publication.

PROF. ARAKATSU AND THE SOVIET ATOMIC PROGRAM

When the *New York Times* informed Arakatsu that the Americans intended to prevent the secret of the atomic bomb from falling into other hands, he laughed, saying, "Any country which could afford production costs could be manufacturing atomic bombs very soon" ["Russians Believed Near Atom Secret", 1945, p. 4]. According to the *Times*, Arakatsu then "dropped the biggest bombshell our way" when he said he had studied at Cambridge University (Cavendish Laboratory) with Prof. Pyotr Kapitsa, who he described as the "foremost Russian scientist in atomic research," and that Kapitsa was working on "nuclear theories" at the time. He also believed, and "managed with almost no effort to convince us," that Russia at least was "very close to the core of the atomic bomb problem" [ibid.].

When the article, "Russians Believed Near Atom Secret" appeared in the *New York Times* in October 1945, Soviet scientists had actually only just begun the practical stage of nuclear weapon development and an atomic industry²⁰. Yes, Kapitsa was a distinguished physicist, but he was neither a nuclear physicist nor was he an active member of the Soviet nuclear weapons program. Only on August 20, 1945, a few days after WWII had ended, was a "Special Committee" formed to lead atomic bomb development. Then on October 3, and again on November 25, Kapitsa asked Stalin to be removed from the list of members; and on December 21, Kapitsa's petition was granted. Nevertheless, the first Soviet atomic test on August 29, 1949 at 4:00 am Moscow time (7:00 am local time)—years before U.S. intelligence expected—came less than four years later. Codenamed *Pervaya Molniya*, or First Lightning, the test, on a range near Semipalatinsk in northeastern Kazakhstan (USSR), came as a "shock" to American nuclear experts (see Streifer & Sabitov, 2013, pp. 54–58).

Appendix I

Remaining Radioactivity in Nagasaki

(An extract of the English translation)

Researcher: Bunsaku Arakatsu

Prof. of Physics, Faculty of Science, Kyoto Imperial University

also Takeo Hayashi & Kiyoshi Nishikawa

I. Research in the Original Place

At about 11:00 am on August 9, 1945, an atomic bomb was dropped on Nagasaki, Japan. In 1946, during a 3-day period (Nov. 27, 28, and 29), Arakatsu's team carried out research on Nagasaki to measure the strength of remaining radioactivity around the "hypocenter" as well as in the Nishiyama area to provide reference data for the parallel medical research being conducted. The measuring instrument used was a Geiger-Mueller counter—about the same as the instrument formerly used in research at Hiroshima. Made of an aluminum tube 15 cm in diameter and 1/10 mm thick, the functional part of the counter was 30cm long.

The Geiger-Mueller counter's natural counts-per-minute was on average 10, and any value measured and recorded later was compared to this average value, which they recorded about every five minutes. When measuring radioactivity on the ground in this manner, the counter tube was kept parallel to the earth's surface, and the tube's shell was kept 1 cm off the ground. Since

²⁰ At the time of Arakatsu's interview, the Russians were only at the very start of the practical stage of nuclear weapon development and an atomic industry, which only began on August 20, 1945 when the Special Committee of the GKO [State Defense Committee] was established by Stalin to develop an atomic bomb. In addition, it was Igor Kurchatov, not Kapitsa, who was the scientific leader of the project.

they did not have mechanical recording devices, they took measurements by “listening to the instruments.”

When measuring collected sample data, they ladled the collected soil with thick paper (6 cm long, 4 cm wide and about 1 cm thick) and pulled the soil into the lower part of counter tube,²¹ 3 cm from the top. To distinguish between β [beta] and γ [gamma] particles, they inserted into the counter a lead plate about 1.6mm thick of sufficient width, and measured again without the plate, comparing the two results. Arakatsu conducted his research mainly at two locations: (1) around the hypocenter, and (2) in the Nishiyama area, about 3.5 km from Nagasaki.

(1) Radioactivity around the Hypocenter

The values of radioactivity around the hypocenter was 11.4 (above a dry field 15 mm northeast of the hypocenter, as measured on the map) [Fig. 2] and 7.5 when lead was pulled in the counter; 9.6 above a dry field 30 mm north of the hypocenter (on the map) and 5.4 when the lead was pulled in. Thus, a slight amount of remaining radioactivity was detected.

From the results above, and by comparing β and γ performances, γ appeared more in all places. In general, γ was thought to be found from a rather vast range and depth of soil, whereas measurable β 's samples in the counter were only encountered from very much closer to the earth's surface. Considering its effectiveness, the counter reacted to γ and resistance of 0.1 mm aluminum wall to β , etc. A comparison of the two did not hold a distinct meaning.

To compare the radioactivity in the soil by neutron penetration, the soil about 50 cm beneath the hypocenter's ground was collected, but no conclusion concerning the soil's radioactivity (above and below ground) was drawn by comparing them. Locations other than the hypocenter, such as 500 m to the center (Uenomachi), 800 m to the center (Uenomachi), and 1500 m to the center (Takaomachi), were measured, but the level of radioactivity could not be determined.

In the vicinity of the hypocenter, where they collected human bone marrow, lead tablets, and iron tablets, the corresponding radiation also could not be determined.

(2) Radioactivity in the Nishiyama Area

In the yards of residential homes and indoors at four locations: Motohara Chōme,²² Nishiyama 3-Chōme, Nishiyama 4-Chōme, and at the farmer house near a lumberyard in Miyama-chō, measurements were carried out, where direct counters were placed. The results were shown as Table 1 [not reprinted here]. None of the tables were reproduced here due to copyright concerns.

Later, in the Medical Department of Kyoto University, through research on the syndrome of overproduction of leukocytes at the lumberyard in Miyama-chō and soil samples near several patients' residences, radioactivity was not determined. While in Nishiyama 3-Chōme, soil from families with the same syndrome were found with similar radiation to the soil from the transformer station's staff dormitory.

Considering the results above, Arakatsu's team concluded that the radioactive matter in the Nishiyama area was dropped from the sky; it was then dragged by wind and rain, collecting in the low, flat ground, penetrating to a shallow depth of earth. With regard to the present time, the distribution of radioactivity had an obvious regionality; places even exist that reached thirty times the natural radiation level. This remaining radioactive matter of β and γ resulted from any of the following:

²¹ The counter tube was hung with its axis parallel to the ground.

²² Big cities are divided into Ku (区), “wards.” Wards are further divided into Chō (町) which are sometimes are divided into Chōme (丁目), which are numbered divisions of a Chō. Then the blocks are numbered and, at the lowest level, the building has a number.

- (i) When exploded, induced radioactive soil near the hypocenter that was blown up by updraft.
 - (ii) When exploded, matters generated from nuclear fission.
 - (iii) Induced radioactive matter generated from components of the bomb.
- Moreover, (i) was realized from the strong radiation remaining near the hypocenter.

II. Research in the Laboratories

To carry out research in our laboratories, the teams collected ample amounts of soil from several representative locations. Among the material taken back was soil in a yard from Nishiyama substation's staff dormitory (Data VII) that showed especially strong radiation. The counter tube used was the same as the one used at the place of origin.

(1) Energy of β Particles

Sample of 7.99 gr into a petri dish of 86 mm's inner diameter, dish's bottom placed 52 mm underneath β 's counter tube, and β 's absorption of lead, aluminum etc. were measured, and β particles' maximum energy was determined to be 2 MeV. But γ particles' measurements on these samples were far less than β particles (about 1/15, or 6.7%), thus the measurements of this energy did not show clear results.

(2) Condition of β Radiation's Attenuation

Two Specimen of Soil: No. VII (From Backyard of Employee Houses near the Nishiyama Substation) and No. X (From Mikumi Kawanai Graveyard):

The size of the soil sample was 7.99 mg. each. Seven measurements were taken by Geiger-Mueller counter between Dec. 28, 1946 and Nov. 26, 1949. The half-life measurements of the two samples were quite consistent and increased as a function of time. For example: 116 days on 02/28/1947 and 330 days on 11/29/1949. Arakatsu's group concluded that more than two isotopes must have been included in both samples. Raw count number per minute (excluding background) was approximately 80 on December 28, 1946 and 8.5 on November 26, 1949, shrinking to about 10 percent of an earlier value.

An analysis of the above paragraph by Kenneth N. Ricci, PhD (Physics) appears in Appendix II.

(3) Chemical Analysis of the Radioactive Matters

Arakatsu's men tried chemical analysis to further realize the class of radioactive matters retrieved. Since they weren't familiar with microanalysis technology, however, they could only get general results, not accurate results, i.e., the radioactive matter below could not be verified:

- (i) Parts not dissolved in aqua regia [nitrohydrochloric acid or "Royal water"].
- (ii) Parts analytically belonging to Fe [Iron] class.
- (iii) Sr [Strontium] in the form of the mineral celestine (SrSO_4).
- (iv) Experiments on α [alpha] radiation.

Lastly, regarding the data soil (measuring whether alpha radiation existed or not), the α -particle counter did not acknowledge results other than natural measurements.

Shimizu's report acknowledged having received "much help" during their research. He then thanked Dr. Nagai from the Medical University of Nagasaki, members of the Department of Physiotherapy, Dr. Wakisaka and M. A. Yoda from the Medical Department of Kyoto University, and to Dr. Okuda and M. A. Kasai from Agricultural Department.

Appendix II

An Analysis of Condition of β Radiation's Attenuation

Dr. Kenneth N. Ricci, Ph.D.
(Stanford University)
Applied Nuclear Physicist

This paragraph describes a simple experiment. Radioactive soil samples from two locations in Nagasaki were placed in separate containers, and measured with a simple Geiger counter – probably the only radiation detecting instrument available in post-war Japan at that time. This kind of detector measures radioactive “counts per minute,” but it cannot distinguish between individual gamma rays from different isotopes. The two samples were each measured 7 different times over a 3-year period; the two samples showed similar behavior to each other over time. There were 80 counts per minute in December 1946 and only 8 counts per minute by November 1949. If the radioactivity had come from a single radioisotope, the decreasing count rate between the 7 different sampling times would have fit an exponential radioactive decay curve with a well-defined half-life. Proven false was this “single isotope” hypothesis because the apparent half-life of the exponential decay curve was 116 days for the sample intervals in the first two months of the experiment, while the apparent half-life increased with successive measurements to 330 days by the last two sample intervals. Arakatsu’s team correctly understood that this change in apparent half-life could only have occurred if there were at least two isotopes present, one with a half-life shorter than 116 days and one with a half-life longer than 330 days.

With the benefit of 70 years of hindsight, we now know there were dozens of radioisotopes present from the fission product residue of the Plutonium-239 weapon detonated over Nagasaki. In December 1946, 17 months after the bombing, most of the radiation in the soil would have been emitted by a mixture of zirconium-95, molybdenum-99, ruthenium-103, cesium-134, cerium-144, and promethium-147, with half-lives of 64 days, 66 days, 103 days, 754 days, 285 days, and 957 days respectively, while the remaining radiation would have been from longer-lived isotopes that are less radioactive. In November 1949, 52 months after the bombing, the radiation had dropped to about 10% of its previous radioactivity, the shorter-lived isotopes were mostly gone, and this remaining 10% of the radiation was produced about half by cesium-134, cerium-144, and promethium-147, and about half by longer-lived isotopes including cesium-137 and strontium-90.

In this study, Arakatsu’s team performed an excellent measurement of the total radioactivity of the soil, even including careful subtraction of the background radiation counts, which are always present in any environment; but he did not really have any idea how complex the isotope mixture was. It is hopeless to try to measure the separate behaviors of a mixture of many isotopes using a Geiger counter alone. This was first-rate science, given the extreme limitations of his equipment and his knowledge of nuclear fission at that time.

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