Leona Woods Marshall Libby (chemist, physicist, nuclear scientist)

(August 9, 1919 - November10, 1986)

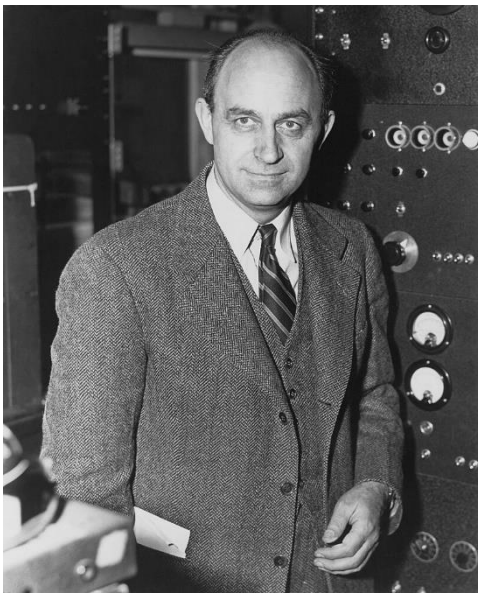
I have read stories about the Chicago Pile-1 (CP-1), the world's first artificial nuclear reactor and how the first human-made self-sustaining nuclear chain reaction was initiated under the stands of an abandoned football stadium at the University of Chicago. But I always see the name of Enrico Fermi and other famous male scientists e.g. Leo Szilard and Arthur Compton mentioned in these stories. There was no mention of a woman in these stories so imagine my surprise when I read that there was a woman present when this event took place. And she was not just a witness or a bystander, she was actively involved in the experiment. To be honest, I have not heard of Leona Woods Marshall Libby before. I was doing research on women who were working with Robert Oppenheimer in the Manhattan Project since *Oppenheimer the Movie* was very popular last year and won the Best Picture Award. By chance I saw the name of Leona Woods being present at the Chicago Pile -1 and that piqued my interest! Her story is as fascinating as any other scientist in this blog!

History does treat women differently! Leona Woods is one of the most famous physicists in the world but the only book I can find written solely about her is the book written by an Italian quantum physicist and author Gabrielle Greison *La Donna Della Bomba Atomica*.

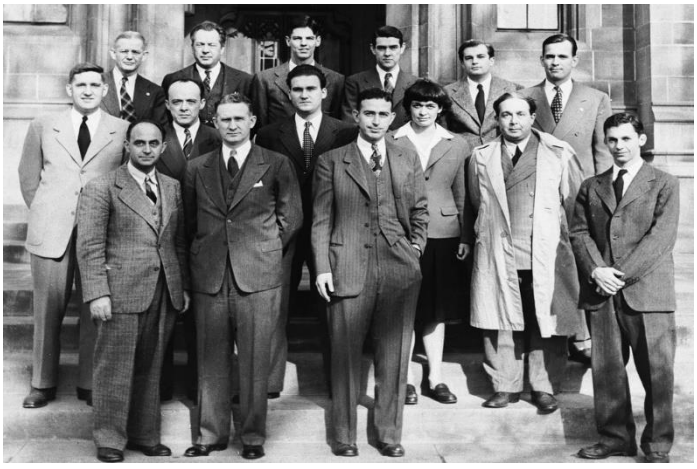
Her science journey began when Leona Harriet Woods was born in La Grange, Illinois on August 9, 1919, to Weightstill Arno Woods and his wife Mary Leona Holderness Woods. Both Weightstill Arno and his wife graduated from the University of Chicago. Weightstill Arno received his law degree in 1913. From an early age, Leona has been academically strong and graduated from Lyons Township High School at 14 years old. She received her BS in Chemistry

at the University of Chicago at 18 years old. She then pursued her PhD in Chemistry and graduated at 23 years old. As a PhD student, she was supervised by noted chemists Robert Mulliken and Stanisław Mrozowski. Her graduate studies included vacuum technology. One of her friends, physicist Herbert Anderson, was looking for someone who had knowledge of vacuum technology to build boron fluoride detectors for the Chicago Pile-1, an experiment under the leadership of Enrico Fermi. After her doctorate was approved, Herbert Anderson recruited her to work in Enrico Fermi's team. At 23 years old, she was the youngest and only female member of the group.

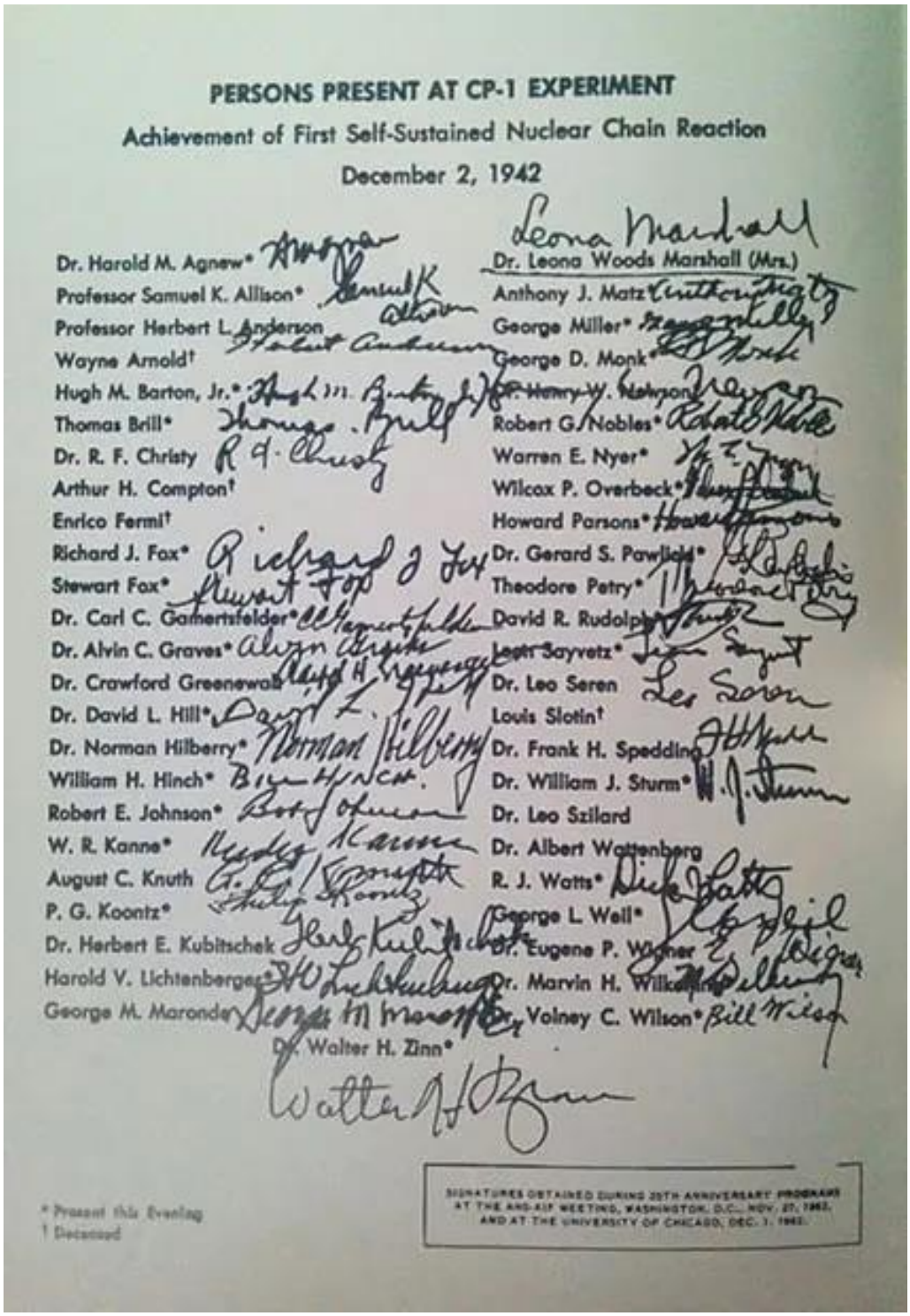
WORKING WITH ENRICO FERMI



Enrico Fermi was an Italian American physicist who won the 1938 Nobel Prize in Physics for his work on induced radioactivity by neutron bombardment and for the discovery of trans uranium elements. He emigrated to the United States with his family in 1938 to escape Mussolini's fascist dictatorship. At the time Leona met him, he was the head of the Metallurgical Laboratory at the University of Chicago. Enrico's team was trying to create a self-sustaining nuclear chain reaction. Creating the reaction would help understand how to construct an atomic bomb. The experiment was going to be built in the squash court under the stands of the abandoned University of Chicago's Stagg Field stadium. The construction of the pile began on November 6, 1942. The "Chicago Pile 1" was 20 feet high by 25 feet wide. It has 57 layers of material with 380 tons of graphite, 50 tons of tubealloy (uranium) oxide, and 6 tons of tubealloy metal. The experiment was carried out to determine if nuclear fission could be created using these materials. The Chicago Pile-1 went critical on December 2, 1942. It was witnessed by 49 scientists, 48 males and 1 female, Leona Woods. She was there to mesure the neutron activity using the boron trifluoride counter she has created. The experiment was risky enough that a "suicide squad" was on standby to halt proceedings in case they got out of hand. If the reaction had to be stopped an emergency bell would ring and rods covered in neutron-absorbing cadmium could be inserted into the matrix, stopping the reaction. Since this had not been done before no one really knew how large the chain reaction would go.



Below is the document that those in attendance at the CP-1 Experiment signed during the 20th anniversary program at the ANS-AIF meeting at Washington, DC on November 27, 1962.



PERSONS PRESENT AT CP-1 EXPERIMENT

Achievement of First Self-Sustained Nuclear Chain Reaction

December 2, 1942

Dr. Harold M. Agnew*
Professor Samuel K. Allison*
Professor Herbert L. Anderson
Wayne Arnold†
Hugh M. Barton, Jr.*
Thomas Brill*
Dr. R. F. Christy
Arthur H. Compton†
Enrico Fermi†
Richard J. Fox*
Stewart Fox*
Dr. Carl C. Gamertsfelder*
Dr. Alvin C. Graves*
Dr. Crawford Greenewalt*
Dr. David L. Hill*
Dr. Norman Hilberry*
William H. Hinch*
Robert E. Johnson*
W. R. Kanne*
August C. Knuth
P. G. Koontz*
Dr. Herbert E. Kubitschek
Harold V. Lichtenberger*
George M. Maronde*
Dr. Walter H. Zinn*

Dr. Leona Woods Marshall (Mrs.)
Anthony J. Matz
George Miller*
George D. Monk*
Dr. Henry W. Nelson*
Robert G. Nobles*
Warren E. Nyer*
Wilcox P. Overbeck*
Howard Parsons*
Dr. Gerard S. Pawlicki*
Theodore Petry*
David R. Rudolph*
Lester Sayvetz*
Dr. Leo Seren
Louis Slotin†
Dr. Frank H. Spedding
Dr. William J. Sturm*
Dr. Leo Szilard
Dr. Albert Wattenberg
R. J. Watts*
George L. Weil*
Dr. Eugene P. Wigner
Dr. Marvin H. Wilkening
Dr. Volney C. Wilson*

SIGNATURES OBTAINED DURING 20TH ANNIVERSARY PROGRAMS AT THE ANS-AIF MEETING, WASHINGTON, D.C., NOV. 27, 1962, AND AT THE UNIVERSITY OF CHICAGO, DEC. 1, 1962.

* Present this Evening
† Deceased

In her book *The Uranium People,* Leona Marshall Libby explained the tasks which the Manhattan Project assigned to each laboratory. The Chicago Metallurgical Laboratory was tasked

with developing a controlled chain reaction with natural uranium; Hanford used that pile design to produce kilogram quantities of plutonium for explosive weapons; Oak Ridge extracted uranium-235 from natural uranium, which is a mixture of uranium-235 and uranium-238; and Los Alamos designed and built devices for the uncontrolled explosions. It seems that Leona Woods was involved in almost all facets of these tasks.

MARRIAGE TO JOHN MARSHALL

While working in Chicago, Leona married another physicist working with Enrico Fermi on the Chicago Pile-1. John Marshall received his PhD in Physics at the University of Rochester. He was from a large and prosperous family. His father, John Marshall Sr. was the director of DuPont Fabrics and Finishes Department. John was hired to be an assistant for Leo Szilard when the Metallurgical Laboratory was at Columbia University. Leo Szilard was a theoretical physicist and needed someone who could do hands-on experiments. John went with Leo when the Metallurgical Laboratory was moved to the University of Chicago. Leona and John got married in July 1943 and she became known as Leona Woods Marshall. When Leona became pregnant, she concealed her pregnancy by wearing baggy work overalls. She told Enrico Fermi about her pregnancy, but no one else aside from her husband knew she was pregnant. She would go to work early so no one would see her morning sickness. The next experiment, known as CP-2, moved to a forest preserve west of Chicago. It was some distance away from the university, so Fermi asked his wife for instructions on delivering a baby, just in case.

In June 1944, John and Leona moved to Hanford, Washington to help power up the first reactor that would produce fuel for the atomic bomb. The Hanford site is a 580-square-mile section of semi-arid desert in southeast Washington, established in 1943 to produce plutonium for the Manhattan Project. A team of scientists from Argonne moved to Hanford to watch the reactor in shifts: John Marshall and others on the day shift, and Enrico Fermi and Leona Marshall on the night shift ending at midnight. Don Hughes and John Wheeler worked on the swing shift. While John and Leona are babysitting the reactor, Leona's mother was babysitting their child Peter. It was during this time that they discovered that xenon-135 was poisoning the reactor called B Reactor. It was powered up

successfully but after a few hours the power level dropped, and the reactor shut down. Leona at first thought it was a water leak. However, during the night the operators were able to power the reactor up again only to have it die once more. The timings now pointed to a radioactive poison. After working through the numbers with slide rules and hand calculators, they determined the neutron cross section of the poison – that of xenon-135. The Du-Point engineers had equipped the reactor with 50 per cent more fuel tubes than the physicists had called for; so, using them, they were able to power up the reactor successfully.

After World War II, Leona returned to the University of Chicago where she became a fellow at Fermi's Institute for Nuclear Studies. Now working with the Chicago Pile-3 heavy water reactor, she found a way to spin polarize neutron beams 100% and determined the refractive index for various materials. Her second child John Marshall III was born in 1949. She became an assistant professor in 1953.

In 1954 after the death of Enrico Fermi, Leona and John separated. John Marshall returned to the Los Alamos Laboratory in New Mexico and Leona became a fellow at the Institute for Advanced Study in Princeton, New Jersey. She was basically raising her two sons as a single mother. In 1955, she became a fellow at Brookhaven National Laboratory. In 1960, she became an associate professor of physics at New York University. After two years she became a professor.

In 1965, she became a professor at the University of Colorado, and did research on high-energy physics, astrophysics, and cosmology. She then became a staff member of RAND Corporation where she worked until 1976.

MARRIAGE TO WILLARD LIBBY

In 1966, she divorced John Marshall, and married Willard Libby, who had won the Nobel prize in 1960. Libby was another colleague at the Chicago Metallurgical Laboratory. He was an American physical chemist noted for his role in the 1949 development of radiocarbon dating, a process which revolutionized archaeology and paleontology. For his contributions to the team that developed this process, Libby was awarded the Nobel Prize in Chemistry in 1960. After she married Willard Libby, Leona became known as Leona Marshall Libby. When Libby became a professor at UCLA in 1973, Leona joined him and became a visiting professor of environmental studies, engineering, engineering archaeology, mechanical aerospace, and nuclear engineering. Leona became interested in ecological and environmental issues, and she devised a method of using the isotope ratios of oxygen-18 to oxygen-16, carbon-13 to carbon-12, and deuterium to hydrogen in tree rings to study changes in temperature and rainfall patterns hundreds of years before records were kept, opening the door to the study of climate change.

Like Willard Libby, she was a strong advocate of food irradiation as a means of killing off harmful bacteria, and advocated that legal and regulatory restrictions on its use be relaxed. She

proposed that, instead of it being sprayed with malathion, fruit affected by the Mediterranean fruit fly could be treated with gamma rays.

She was a prolific author, publishing over 200 scientific papers. While at RAND she wrote a paper on *Creation of an Atmosphere for the Moon*. Her books include *The Uranium People*, a history of early atomic research in the United States. After her husband died in 1980, she edited his papers with Rainer Berger, and published *The Life Work of Nobel Laureate Willard Libby*. She also wrote books on environmental science. One of these books is *Past Climates: Tree Thermometers, Commodities, and People.* Her last paper, on quasi-stellar objects, appeared in 1984.

She died at St. John's Medical Center in Santa Monica, California, on November 10, 1986, from an anesthesia-induced stroke.

HER LEGACY

Leona will be remembered as the youngest and only female member of the Chicago Pile 1 Experiment team and for her contributions to the Manhattan Project. She will also be remembered for helping solve the "xenon poisoning" of the B Reactor at the Hanford Site. She will be known for her pioneering work in nuclear science and physics. She will be remembered for her research work in environmental studies, engineering archeology, mechanical aerospace, and nuclear engineering.

In August 2016, the Leona Marshall Libby Middle School opened in West Richland, Washington. Its mission is to inspire students' imagination, creativity, and perseverance to achieve their goals and shape the community through the power of science, technology, engineering, the arts, and mathematics. It is the STEAM-focused middle school in West Richland.

In 2017, the Leona Woods Distinguished Postdoctoral Lectureship Award was established by the Physics Department of the Brookhaven National Laboratory to celebrate the scientific accomplishments of outstanding female physicists and physicists from underrepresented minority groups. The recipients of the Leona Woods Distinguished Postdoctoral Lectureship Award receive a $1,000 prize and are invited to spend at least one week at Brookhaven National Laboratory to discuss their research informally with local physicists and give a general-interest colloquium and a technical talk in their area of expertise. The colloquium is open to the public.

HER SCIENCE JOURNEY

1919 - Leona Harriet Woods was born in La Grange, Illinois

1934 - Graduated from Lyons Township High School

1938 - Received her BS Chemistry from the University of Chicago

1942- PhD approved and recruited to work with Enrico Fermi

1942 - Witnessed the first self-sustaining nuclear chain reaction

1943 - Married John Marshall

1944 - Moved with John Marshall to Hanford, Washington

1946 - Fellow at Fermi's Institute for Nuclear Studies

1953 - Assistant Professor at the University of Chicago

1954 - Fellow at the Institute for Advanced Studies at Princeton

1955 - Fellow At Brookhaven National Laboratory

1960 - Associate Professor at New York University

1962 - Professor at New York University

1965 - Professor at the University of Colorado and Staff member of RAND Corporation

1966 - Divorced John Marshall and married Willard Libby

1973 - Professor at UCLA

1979 - Wrote the book *Uranium People*

1980 - Published *The Life Work of Nobel Laureate Willard Libby*

1983 - Wrote *Past Climates, Tree Thermometers, Commodities, and People*

1986 - Died in Santa Monica, California due to an anesthesia-induced stroke

2016 - Leona Marshall Libby Middle School was opened

2017 - The Leona Woods Distinguished Postdoctoral Lectureship Award was established by the Physics Department of the Brookhaven National Laboratory

BIBLIOGRAPHY

1. Libby, Leona Marshall. *The Uranium People*. New York: Crane, Russak &Company, Inc.,1979.
2. Montillo, Roseanne. *Atomic Women The Untold Stories of the Scientists Who Helped Create the Nuclear Bomb*. New York: Little, Brown and Company, 2020.
3. Kiernan, Denise. *The Girls of Atomic City The Untold Story of the Women Who Helped Win World War II*. New York: Simon and Schuster, 2013.
4. Greison, Gabriella. *La Donna della Bomba Atomica*. Milan, Italy: Mondadori,2024.

The photos and some of the information were taken from these websites:

https://en.wikipedia.org/wiki/Leona_Woods

https://en.wikipedia.org/wiki/Enrico_Fermi

https://en.wikipedia.org/wiki/Chicago_Pile-1

https://www.ans.org/news/article-2112/honoring-dr-leona-woods-herstory/

https://ahf.nuclearmuseum.org/voices/oral-histories/john-marshalls-interview/

https://en.wikipedia.org/wiki/Willard_Libby

https://leonalibby.rsd.edu/

https://www.nps.gov/articles/000/leona-woods-marshall-libby.htm

https://ahf.nuclearmuseum.org/ahf/key-documents/chicago-pile-1-participants/

https://www.ne.anl.gov/About/cp1-pioneers/

https://www.bnl.gov/newsroom/news.php?a=212510