= Leona Woods =

Leona Harriet Woods ( August 9 , 1919 ? November 10 , 1986 ) , later known as Leona Woods Marshall and Leona Woods Marshall Libby , was an American physicist who helped build the first nuclear reactor and the first atomic bomb .

At age 23 , she was the youngest and only female member of the team which built and experimented with the world 's first nuclear reactor ( then called a pile ) , Chicago Pile @-@ 1 , in a project led by her mentor Enrico Fermi . In particular , Woods was instrumental in the construction and then utilization of geiger counters for analysis during experimentation . She was the only woman present when the reactor went critical . She worked with Fermi on the Manhattan Project , and , together with her first husband John Marshall , she subsequently helped solve the problem of xenon poisoning at the Hanford plutonium production site , and supervised the construction and operation of Hanford 's plutonium production reactors .

After the war , she became a fellow at Fermi 's Institute for Nuclear Studies . She later worked at the Institute for Advanced Studies in Princeton , New Jersey , the Brookhaven National Laboratory , and New York University , where she became a professor in 1962 . Her research involved high @-@ energy physics , astrophysics and cosmology . In 1966 she divorced Marshall and married Nobel laureate Willard Libby . She became a professor at the University of Colorado , and a staff member at RAND Corporation . In later life she became interested in ecological and environmental issues , and she devised a method of using the isotope ratios in tree rings to study climate change . She was a strong advocate of food irradiation as a means of killing harmful bacteria .

= = Early life = =

Leona Harriet Woods was born on a farm in La Grange , Illinois on August 9 , 1919 , the second of five children of Weightstill Arno Woods , a lawyer , and his wife Mary Leona Holderness Woods . She had two sisters and two brothers . She graduated from Lyons Township High School in La Grange at 14 , and received her BS in chemistry from the University of Chicago in 1938 , at the age of 18 .

After passing her qualifying exams in chemistry , she approached the Nobel Prize for Physics laureate James Franck about being his graduate student , having been impressed by a talk he gave in 1939 on Brillouin zones . Franck accepted , but told her that when he was young his professor had warned him that as a Jewish academic , he would starve to death . Franck therefore warned Woods that " You are a woman and you will starve to death . " Despite the fact that Franck did not look malnourished , she took the warning seriously , and decided to instead become a graduate student of Robert Mulliken , who would one day become a Nobel laureate himself .

Mulliken allowed her to choose her own research problem , and edited the final version before it appeared in the Physical Review . Her doctoral thesis , " On the Silicon Oxide Bands " , prepared under the supervision of Mulliken and Polish chemist Stanis?aw Mrozowski was accepted in 1943 . Mulliken , she later recalled , had twice told her " that perhaps not all he taught me was wasted . " His students , she noted , " agree that this is his highest praise . "

= = Manhattan Project = =

By 1942 , when she was finishing writing up her thesis , she was the youngest and last of Mulliken 's pre @-@ war students , and was working alone because all her fellow students had become involved with war work . She met Herbert Anderson , who was working for Enrico Fermi . The two would go swimming together in Lake Michigan every afternoon at 5 pm . Anderson discovered that Woods was adept with vacuum technology from her research , and as soon as her PhD was finished , he hired her to work with the boron trifluoride detectors used to measure neutron flux .

Fermi 's group constructed a nuclear reactor known as Chicago Pile @-@ 1 under the stands of Stagg Field , the University 's abandoned football stadium , where Woods had once played squash . Walter Zinn did not want a woman involved in the dirty work of placing the graphite blocks , but

Woods had plenty of work to do with the detectors and thermocouples , and used a small stack of graphite of her own to measure the effects of a radium @-@ beryllium source on manganese foil to obtain a measure of the neutron cross section in order to calibrate the detectors . Woods was the only woman present when the reactor went critical , asking Fermi " When do we become scared ? "

Laura Fermi remembered Woods as " a tall young girl built like an athlete , who could do a man 's job and do it well . She was the only woman physicist in Enrico 's group . At that time , her mother , who was also endowed with inexhaustible energy , was running a small farm near Chicago almost by herself . To relieve Mrs. Woods of some work , Leona divided her time between atoms and potatoes . "

Like many scientists working on the project , Woods affected a casual attitude towards the danger posed by radiation . After a morning with Willard Libby soldering a canister containing a mixture of radium salt and beryllium metal , Woods absorbed about 200 roentgens , and her white blood cell count halved . The doctors gave her a lecture on how a woman has only a fixed number of egg cells , a proposition that Woods was skeptical of . She considered that the important thing was that the solder was done correctly . When the team moved to their new home at Argonne , Woods had a dormitory all to herself .

Woods married John Marshall in July 1943 . Soon after , she fell pregnant . While she told Enrico Fermi , they agreed not to let Walter Zinn know , for fear that he would insist that she leave the reactor building . She covered up her pregnant belly with her baggy denim work clothes . She rode to work each day on an unheated Army bus , " arriving each morning barely in time to vomit before starting the day 's work . " The child , a boy called Peter , was born in 1944 . She returned to work a few days later .

A team from Argonne was on hand for powering up the first reactor at the Hanford Site , where large reactors would produce plutonium for bombs . They watched the reactor in shifts , with John Marshall and others on the day shift , Enrico Fermi and Leona Marshall on the night shift , ending at midnight , and Don Hughes and John Wheeler on the swing shift . While the Marshalls were babysitting the reactor in Hanford , they left Peter with Leona 's mother .

The reactor was powered up successfully , but after a few hours the power level dropped and the reactor shut down . Leona speculated that a water leak was the problem , rather than a radioactive poison . However , during the night the operators were able to power the reactor up again only to have it once more die away . 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 , which turned out to be xenon @-@ 135 . Fortunately , the DuPont engineers had equipped the reactor with 50 per cent more fuel tubes that the physicists had called for , and by loading them up , they managed to get the reactor started .

Asked many years later about how she felt about her involvement in the Manhattan Project , she said :

I think everyone was terrified that we were wrong ( in our way of developing the bomb ) and the Germans were ahead of us . That was a persistent and ever @-@ present fear , fed , of course , by the fact that our leaders knew those people in Germany . They went to school with them . Our leaders were terrified , and that terror fed to us . If the Germans had got it before we did , I don 't know what would have happened to the world . Something different . Germany led in the field of physics . In every respect , at the time war set in , when Hitler lowered the boom . It was a very frightening time .

I certainly do recall how I felt when the atomic bombs were used . My brother @-@ in @-@ law was captain of the first minesweeper scheduled into Sasebo Harbor . My brother was a Marine , with a flame thrower on Okinawa . I 'm sure these people would not have lasted in an invasion . It was pretty clear the war would continue , with half a million of our fighting men dead not to say how many Japanese . You know and I know that General ( Curtis ) LeMay firebombed Tokyo and nobody even mentions the slaughter that happened then . They think Nagasaki and Hiroshima were something compared to the firebombing .

THEY 'RE WRONG !

I have no regrets . I think we did right , and we couldn 't have done it differently . Yeah . I know it

has been suggested the second bomb , Nagasaki , was not necessary . The guys who cry on shoulders , when you are in a war , to the death , I don 't think you stand around and ask , " Is it right ? "

= = Post @-@ war career = =

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

After Fermi died in 1954 , the Marshalls separated . John Marshall returned to the Los Alamos Laboratory , while Leona , now effectively a single mother , became a fellow at the Institute for Advanced Studies in Princeton , New Jersey in 1957 . The following year she became a fellow at the Brookhaven National Laboratory , at a time when the focus of research in physics was shifting away from the nucleus and towards elementary particles . In 1960 , she joined New York University as an associate professor of physics . She became a professor in 1962 .

Three years later , she became a professor at the University of Colorado , researching high @-@ energy physics , astrophysics and cosmology . She then became a staff member at RAND Corporation , where she worked until 1976 . In 1966 , she divorced John Marshall , and married Willard Libby , who had won the Nobel prize in 1960 . She later joined him at UCLA , where she became a visiting professor of environmental studies , engineering , engineering archaeology , mechanical aerospace and nuclear engineering in 1973 .

Now known as Leona Marshall Libby , she 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 ( 1969 ) . Her works include the autobiographical The Uranium People ( 1979 ) , a history of early atomic research . After Libby died in 1980 , she edited his papers with Rainer Berger , and published The Life Work of Nobel Laureate Willard Libby ( 1982 ) . 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 . She was survived by her sons Peter and John , and four grandchildren . She also had two stepdaughters , Janet Eva Libby and Susan Charlotte Libby from her second marriage .

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