**International Conference on History of the Neutrino**

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Yesterday I told you about the compromise between scientists and political power at the close of the War we call *Big Science*. This compromise had been stabilized by the constant preparedness for war that the United States, Europe, and the USSR continued to experience during thirty years. This period is obviously what we know as the Cold War, and was also a kind of Golden Age for nuclear and particle physics, alongside space sciences, that ensured spendings to continue to flow and the number of scientists involved to grow. Spendings were coming from the States, and from national companies, since these countries knew during this period a constant economic growth borne by the States protection and investments towards national industries. Eisenhower dubbed this intricacy among the State, scientific research, industry, and military goals in a famous speech in 1961 as "the military-industrial complex".

This led to the invention of the concept of *research & development* in these big national companies. The idea that we could apply the methods of organization of scientific research invented during the War to innovation for the industry, with cycles from fundamental research to industrial applications. In the United States the most famous example was *Bell Labs,* created by the monopolistic phone company AT&T. From Bell Labs came an impressive number of Nobel Prizes and breakthroughs that contributed in a major way to communication technologies and material sciences. We could practically say that the modern field of condensed matter physics emerged there. To give an idea, we could name Claude Shannon, who wrote there his mathematical theory of communication during the war, Arthur Schawlow and Charles Townes who built the first LASER in 1960 (in parallel with a Soviet team), Penzias and Wilson who discovered the cosmic microwave background in 1964, or John Bardeen William Shochkley and Walter House Brattain who produced in 1947 the invention that maybe changed the second half of the twentieth century in the most profound way: the transistor, that gave birth to the whole field of microelectronics.

In France, the best example of this intricacy between industry, fundamental physics, and military goals, was the creation of the Commissariat à l'énergie atomique (CEA) in 1945, under the direction of the famous physicist Frédéric Joliot-Curie and Raoul Dautry, former minister for weaponry. The first goal of the CEA was to take over the work Joliot-Curie and his team stopped in 1939 on nuclear fission, and be among the first after the Americans to produce a reactor based on controlled nuclear chain fission. This was done in 1948.

In Europe, the intricacy between political goals, industry, and science took a specific shape with the construction of a European union. Far from nowadays European Union, the aim was to create an intergovernmental space between the States that were opposed during the conflict, to share strategic technologies and resources, and thus ensure the end of the national rivalries that made the first half of the century. This was done with the European Coal and Steel Community, pooling these strategic industries for war economies together. And of course with nuclear science and industry with the EURATOM organization and the CERN.

I will not say too much about the CERN, because a lot of people in this room know far better than me this story. But I think I have set the scene to see more clearly the very special historical moment that allowed this unique project: the sharing of the most frightening science and technologies that came out of the war, between former enemies, for civil uses.

However, this compromise of the *Big Science* was a critical deal for a lot of scientists. Hiroshima had been, of course, a moral rupture for a lot of physicists. Fundamental science would no longer be considered as a neutral and purely intellectual adventure. Fundamental science *can* be harmful by itself. On their side, medicine and biology had Auschwitz. Eugenics had been invented as a medical specialty, with its journals and learned societies, advocating for mass sterilization for the greater good. And the trial of the Nazi doctors who enjoyed to experiment freely on humans in the extermination camps led to the *Nuremberg Code* in 1947 —the first international text for ethics principles restricting human subject experimentations.

In the same movement, nuclear weapons had become the *physicists'* burden. To index the freedom of physicists to decide on their research lines, on the power capacity they could give to their country starts to be a problem, when the consequences of their research can be so big and tragic. And so, a lot of physicists, even those who worked on the Manhattan Project, started to join the pacifist movement and campaigned for denuclearization. Not all of them, of course. John von Neumann or Edward Teller fell on bad terms with their former colleagues for their support of the thermonuclear bomb program. But Oppenheimer and Sakharov – the leader of the Soviet nuclear program – made their public soul-searching some years after. Leo Szilard, who wrote the famous letter to Roosevelt signed by Einstein in 1939 that led to the Manhattan Project, initiated a petition in July 1945, signed by a hundred of physicists, to ask president Truman to use the bomb against Japan only if surrender discussions would not succeed. This petition was banned, but Szilard and Einstein created the *Emergency Committee of Atomic Scientists* the year after to publicly contest the development of nuclear weapons. Linus Pauling won fame campaigning alongside Szilard and Einstein, and finally became recipient of the Nobel Peace Prize in 1962. Joliot-Curie, in France, initiated the international *Stockholm Appeal* in 1950, calling for an international ban on nuclear weapons. He was then dismissed from the head of the CEA, and after his departure, the CEA finally engaged in the production of the French atomic bomb.

I would like to mention one last important feature of this period, concerning especially particle physics. The quantitative expansion and the new way to organize big collaborations between different specialties, born in the War, led to an impressive diversification of subspecialties, particularly in microphysics. The historian of science Peter Galison produced a masterful analysis of this evolution. He showed how different communities and experimental traditions came to work together in huge collaborations around big instruments like the accelerators. These *subcultures* can be organized around experimental, theoretical, instrument-making, or data analysis goals. Each of these communities follows its own scientific aims, and works in a way modeled by its own material culture, but develops communication interface with the others, that Galison dubbed *trading zones*, where a specific language, mixing vocabularies coming from the different scientific subcultures, is used. This fragmentation-cooperation, very specific to contemporary physics, dissolved the very notion of the author of a scientific result, as a lot of the talks given during this conference showed.

Thank you for you attention, and I hope this short trip across twentieth century science could have enlightened you a bit on the strong trends inside which neutrino physics has evolved and will continue.