IL NUOVO CIMENTO Vol. 37 C, N. 5 Settembre-Ottobre 2014
DOI 10.1393/ncc/i2014-11827-x

Colloquia: The Legacy of Bruno Pontecorvo

Major events and minor episodes

U. Amaldi
TERA Foundation and Technische Universität München - München, Germany

Summary. — Bruno Pontecorvo was a freshly graduated twentyone years old physicist when he joined, in the summer of 1934, the research group led by Enrico Fermi. In October the Panisperna boys would make their most important discovery – radioactivity induced by slow neutrons – and shortly thereafter would be parted by personal and historical events. This paper describes some episodes of those early years and of later periods, sketching a portrait of the team: starting from the extraordinary human and scientific experience of via Panisperna, up to the patent negotiations in USA, to which Pontecorvo's flight to URSS put an end with unexpected consequences; getting to his first return in Italy, allowed by the sovietic government in 1978, on the occasion of the conference celebrating Edoardo Amaldi's 70th anniversary. That was the first of several encounters of the author of this paper with Bruno Pontecorvo, which are here briefly recounted, as minor episodes giving a personal perspective on the man.

1. – Fast neutrons, slow neutrons

At the beginning of 1934, after reading the papers by Joliot and Curie reporting the discovery of artificial radioactivity produced by alfa particles, Enrico Fermi tried to create artificial radioisotopes irradiating many elements with neutrons. The neutrons were produced by a Po_α + Be source, prepared by Franco Rasetti and similar to the one used by the Joliot-Curies. No activity was detected and Fermi had then the idea to use a much stronger Rn_α + Be source, since the beta and gamma radiations (absent in Po_α + Be sources) were no objection to the observation of a delayed effect. The source was provided to him by Giulio Cesare Trabacchi, director of the *Laboratorio Fisico della Sanità Pubblica* (Physics Laboratory for Public Health), which occupied a few offices and laboratories in the same building of Via Panisperna (Fig. 1a). The radon was extracted from one gram of radium, which was well shielded in the basement of the Via Panisperna building.

The Rome group worked very actively together and by summer 1934 about forty new radioactive isotopes had been found. Before the end of May three articles had been published, the first two with the signature of Enrico Fermi [1] and the third one – "Radioattività 'beta' provocata da bombardamento di protoni - III" – was signed by

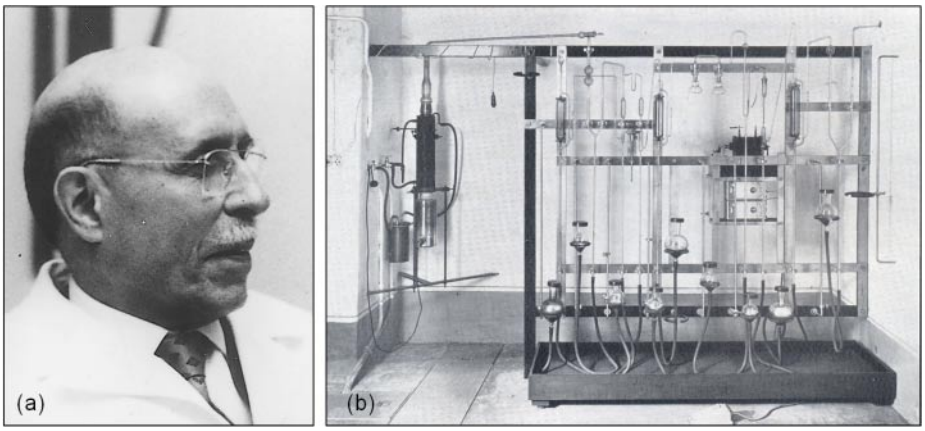


Fig. 1. – (a) Giulio Cesare Trabacchi was known among the Via Panisperna boys as "Divine Providence" for the generosity with which he provided them instruments and materials, scrupulously kept and ordered in his well-equipped laboratory. (b) Apparatus used to extract radioactive radon contained in the radium source, which was used by *Laboratorio Fisico della Sanità Pubblica* for medical applications. (Credit: (a) Dipartimento di Fisica, Università La Sapienza, Roma; (b) Nella Mortara, "L'ufficio del radio", *Rivista di radiologia e fisica medica* IV, 4 (1931-32) 462).

E. Amaldi, O. D'Agostino, E. Fermi, F. Rasetti and E. Segrè. Overall three consecutive papers were published with all the names in *La Ricerca Scientifica* [2], where at the time Ginestra Giovene – who was since 1933 Amaldi's wife – worked as deputy editor. Through her, the articles were made available within days, so that they could be sent by mail to a selected list of prominent physicists: the Rome group was the first to use 'preprints' to spread its results rapidly. Later they would publish more extensive and detailed articles on international journals. Because of the unitary organisation of the work and the innovative use of 'preprints', the Rome group, as discussed by Gerald Holton [3], was the first team of physicists acting as it has become customary after the Second World War. They also played tennis and spent winter and summer vacations together. Already at the time in USA and in England somebody used to call them the "Italian team." The way to the second fundamental discovery, the extraordinary efficacy of slow neutrons for producing artificial radioactivity, was opened in fall 1934. In his *Physics Report* article Amaldi wrote [4]:

"Around the middle of September 1934, we decided to try to establish a quantitative scale of activities which for the moment could be in arbitrary units. This work was assigned to me and B. Pontecorvo (b. 1913), one of our best students, who had taken the degree (laurea) in July 1934 [A/N: Pontecorvo got his laurea the year before, in November 1933] *and after the summer vacations had joined the group.*

We immediately found, however, some difficulty because it became apparent that the activation depended on the conditions of irradiation. In particular in the dark room, where usually we carried out the neutron irradiation, there were certain wooden tables near a spectroscope that had miraculous properties. Silver irradiated on those tables gained more activity than when it was irradiated on the usual marble table in the same room.

These results, daily reported to Fermi and the others, were friendly, but at the same

time strongly criticised by Rasetti who, in a teasing mood, insinuated that I and Pontecorvo were unable to perform clean and reproducible measurements'. In order to clarify the situation I started a systematic investigation [...]

On the morning of October 22 most of us were busy doing examinations and Fermi decided to proceed in making the measurements [...] *At the moment of using the lead Fermi decided suddenly to try it with a wedge of some light element and paraffin was used first* [...] *Towards noon we were all summoned to watch the extraordinary effect of the filtration by paraffin: the activity was increased by an appreciable factor."*

The very same day, in the evening (it was the 20th of October 1934, on Saturday, not the 22nd as mentioned by Laura Fermi, Segrè and Amaldi in their writings [5]), the Panisperna boys met in the apartment of the Amaldi's and with great excitement wrote a letter to *La Ricerca Scientifica*. Emilio Segrè gave a nice account of the scene [6]: "*Fermi dictated while I wrote. He stood by me; Rasetti, Amaldi and Pontecorvo paced the room excitedly, all making comments at the same time. The din was such that when we left, Amaldi's maid* [A/N: who had been engaged to take care of a two month child, myself...] *discreetly asked whether the evening guests were tipsy. Ginestra Amaldi handed the paper to her boss at* La Ricerca Scientifica *the following morning.*" Bruno Pontecorvo, in his book on Enrico Fermi, described what happened immediately after the first observation [7]:

"*The results were most surprising: the silver activity was hundreds of times greater than the one previously measured. Fermi stopped the confusion and agitation of his collaborators pronouncing a famous sentence that, they say, he repeated eight years later at the start-up of the first nuclear reactor: 'Let us go for lunch'* [...] *In the discovery of the effect of slow neutrons some accidental circumstances and the depth and intuition of a great mind, both played a crucial role. When we asked Fermi why he had used paraffin instead of lead, he smiled and teasingly said 'C.I.F.', that in Italian can be read 'Con Intuito Formidabile' (with formidable intuition). If the reader would conclude that Fermi was immodest he would be grossly wrong. He was direct, very simple and modest, but he was well conscious of his qualities. To this point I can add that, after lunch when he came back to the Institute and explained very clearly the effect of the paraffin block – thus introducing the concept of the slowing down of neutrons – with total sincerity he told us: 'What a stupidity to have discovered this effect by chance without having being capable of predicting it'.*"

C.I.F. was an expression invented and used in the Rome group, as reported by Emilio Segrè in his autobiography: "C.I.F. (Con Intuito Formidabile) [was] a joking acronym we used for statements by Fermi that were true, but that he could not prove" [6, p. 151].

2. – The patent

On October 26, only six days after the discovery Amaldi, the chemist D'Agostino, Fermi, Pontecorvo, Rasetti, Segrè and Trabacchi jointly applied to obtain a patent for their process to produce artificial radioactivity with slow neutrons (Fig. 2).

The beginnings of this story can be traced back to Orso Mario Corbino, the Director of the Institute and Fermi's mentor. As described by Laura Fermi, the first scene went as follows [8]:

"*One morning, a couple of days after [the discovery], Corbino came to the laboratory; although he did not actively participate in research, he kept informed and often gave good advice. He had followed the younger men's work step by step, and on that morning also he asked to be told what they were at. They were preparing to write a more extensive*

REGNO D'ITALIA

MINISTERO DELLE CORPORAZIONI

UFFICIO DELLA PROPRIETÀ INTELLETTUALE

Attestato di Privativa Industriale

N. 324458

Nel Registro degli attestati di privativa industriale di questo Ufficio è stata regolarmente inscritta la domanda depositata, coi documenti voluti dalla legge, all' Ufficio stesso
nel giorno ventisei *del mese di* ottobre *1934 alle ore* 12,15
da Fermi Enrico, Amaldi Edoardo, D'Agostino Oscar, Pontecorvo Bruno, Rasetti Franco, Segrè Emilio e Trabacchi Giulio Cesare (a Roma
per ottenere una privativa industriale per il trovato designato col titolo:

Metodo per accrescere il rendimento dei procedimenti per la produzione di radioattività artificiali mediante il bombardamento con neutroni.

Il presente attestato non garantisce che il trovato abbia i caratteri voluti dalla legge perché la privativa sia valida ed efficace, e viene rilasciato senza esame preliminare del merito e della novità di esso

Roma, li -2 FEB. 1935 Anno XIII

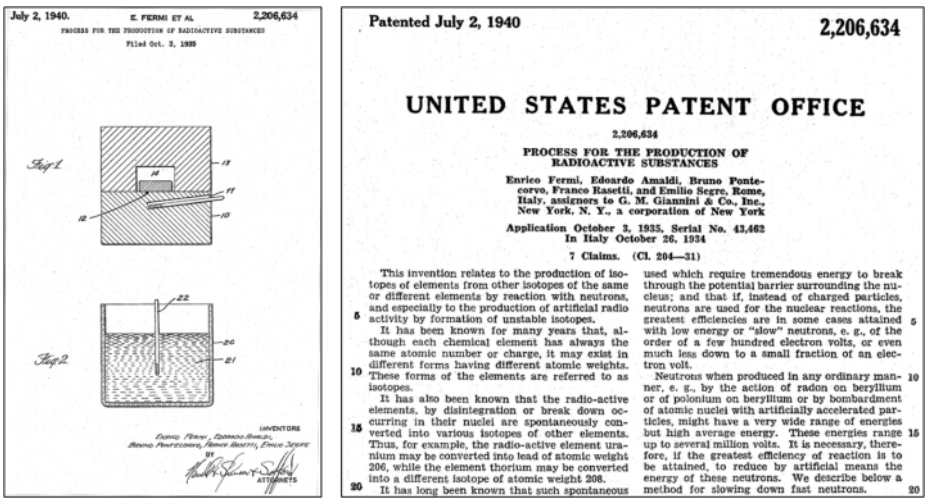
Il Direttore

Nei riferimenti al presente *attestato* richiamare *soltanto* il suindicato numero, adottando la dizione PRIVATIVA ITALIANA N. 324458

B

La Tipografica - Roma XII - Ord. 7543 - (5.000)

Fig. 2. – The patent was signed also by Giulio Cesare Trabacchi, who had provided the neutron source and had followed daily the work of the younger colleagues (credit: Amaldi Archive, Department of Physics, Sapienza University, Rome).



July 2, 1940. E. FERMI ET AL 2,206,634

PROCESS FOR THE PRODUCTION OF RADIOACTIVE SUBSTANCES

Filed Oct. 3, 1935

Fig. 1. Fig. 2.

INVENTORS

BY

ATTORNEYS

Patented July 2, 1940 2,206,634

UNITED STATES PATENT OFFICE

2,206,634

PROCESS FOR THE PRODUCTION OF RADIOACTIVE SUBSTANCES

Enrico Fermi, Edoardo Amaldi, Bruno Pontecorvo, Franco Rasetti, and Emilio Segrè, Rome, Italy, assignors to G. M. Giannini & Co., Inc., New York, N. Y., a corporation of New York

Application October 3, 1935, Serial No. 43,462
In Italy October 26, 1934

7 Claims. (Cl. 204—31)

This invention relates to the production of isotopes of elements from other isotopes of the same or different elements by reaction with neutrons, and especially to the production of artificial radio activity by formation of unstable isotopes.

It has been known for many years that, although each chemical element has always the same atomic number or charge, it may exist in different forms having different atomic weights. These forms of the elements are referred to as isotopes.

It has also been known that the radio-active elements, by disintegration or break down occurring in their nuclei are spontaneously converted into various isotopes of other elements. Thus, for example, the radio-active element uranium may be converted into lead of atomic weight 206, while the element thorium may be converted into a different isotope of atomic weight 208.

It has long been known that such spontaneous used which require tremendous energy to break through the potential barrier surrounding the nucleus; and that if, instead of charged particles, neutrons are used for the nuclear reactions, the greatest efficiencies are in some cases attained with low energy or "slow" neutrons, e. g., of the order of a few hundred electron volts, or even much less down to a small fraction of an electron volt.

Neutrons when produced in any ordinary manner, e. g., by the action of radon on beryllium or of polonium on beryllium or by bombardment of atomic nuclei with artificially accelerated particles, might have a very wide range of energies but high average energy. These energies range up to several million volts. It is necessary, therefore, if the greatest efficiency of reaction is to be attained, to reduce by artificial means the energy of these neutrons. We describe below a method for slowing down fast neutrons.

Fig. 3. – Two activation methods are described in the American patent [6, p. 151]. In the first one the moderator is 'not homogenous' – as at the time of the discovery – while the second one is 'homogeneous', because the moderator and the activated element are mixed. (Credit: United States Patent Office).

report on their experiments, they answered. Corbino became incensed. 'What? Do you want to publish more than you have already?' he asked in a swift rush of words, helping the oral expression with brisk gestures, as all Sicilians do. 'Are you crazy? Can't you see that your discovery may have industrial applications? You should take a patent before you give out more details on how to make artificial radioactive substances!'."

In the 1984 *Physics Report* Edoardo Amaldi wrote [4, p. 155]: "*We were extremely pleased and amused, not so much because a patent could result, sometime in the future, in a financial benefit for the 'inventors', but rather because a work, carried out with great energy and dedication, only for its intrinsic merits, had, unexpectedly, brought us to applications, which, in addition, would be mainly of scientific and medical nature.*"

The boys of Via Panisperna had not thought about this possibility and at the beginning they considered it completely at variance with what respectable scientists do of their discoveries. But Corbino was a very practical man connected with many industries and had a lot of influence on the people around him.

From 1935 the responsibility of following the group patent was given to Gabriello Maria Giannini, who had got his physics degree on the same day as Edoardo Amaldi and Ettore Majorana. Giannini did not want to pursue an academic career and had decided to become a businessman. He was moving very well in this new environment so that he immediately got from the inventors an equal share of the patent. Due to his intervention, already in 1935 an agreement was signed with Philips, which obtained the European rights for only 3200 dollars. An American patent was granted in July 1940 (Fig. 3).

On the American patent the name of Giannini appears while the ones of Trabacchi and D'Agostino are no longer there. Simone Turchetti has recounted the interesting story of this patent [9].

In 1935 Giannini founded G. M. Giannini & Co., Inc. (New York), which deposited

in Great Britain and in the United States much more detailed patents. He actively followed for many years this affair so that the patent was granted when Fermi was at Columbia and all the physicists involved in these activities, *in primis* Leo Szilard, had well understood the importance of the augmented efficacy of slow neutrons to produce a chain reaction.

In June 1945, as soon as the war was stopped in Europe, Gabriello Giannini wrote to Vannever Bush, Director of the *Office of Scientific Research and Development* (OSRD). In the first discussion he got convinced that Bush was ready to agree on one million dollar compensation for the exploitation of the patented activation methods. To speed the process, Giannini chose a very well known lawyer: Lawrence J. Bernard.

After the creation in 1946 of the Atomic Energy Commission (AEC), the difficult discussions, which concerned the many patents taken by physicists before and during the war, were passed to the newly created "*Patent Compensation Board*" (PCB). In October 1948 - only nine years before the patent expiration date - Bernard requested to PCB 1.9 million dollars. Since the AEC legal service gave a negative opinion, in August 1950 Bernard and Giannini, against Fermi's opinion, brought the American Government to trial to obtain 10 million dollars. At the time I was fifteen years old so that I well remember my parents talking around the family table about a mysterious 'brevetto'. They looked worried, but only later I understood the reason.

Edoardo Amaldi explained it very clearly to Piero Angela, an important Italian scientific journalist host of the most appreciated TV science program in Italy, who published a long interview with my father made in 1979 [10]. In this book one can read: "*I recall that at that time with Ginestra we made some calculations. Once obtained, this sum - after having paid the lawyers - would have to be divided in eight parts, so that each one of us could think to receive one million dollars. With Ginestra we immediately agreed: 'If we get all this money it will be a disaster, our life will be disrupted. We would be obliged to change life and this we do not want.' We thus made a plan: we would take for us only a small part of the money and we would use the rest for building an Italian cyclotron. If the money would not have been sufficient, we would look for somebody else to contribute.*"

In California the trial was just started and the jury had already given notice that the request was considered favourably, when an unexpected event made an enormous impression on the world public opinion. On September 1st, 1950 Bruno Pontecorvo and his family left Rome, where they were on vacation, and disappeared. Clearly they had secretly left the West for the Soviet Union. Most naturally the media accused Pontecorvo to have brought with him important military secrets, a fact that Edoardo Amaldi always contested since Bruno had never been working on the developments of the atomic bomb.

To Piero Angela he said [10, p. 44]: "*It was the time of the Corea war, of the cold war, and the Americans were hit very strongly by this act, even offended I would say. Giannini found himself in a very delicate situation, also because his Company was building instruments for military planes and thus had contracts with the American Air Forces. The Washington lawyers took the occasion and made an offer that was hundred times lower than the request. This was immediately accepted by Giannini to close the deal.*"

In November 1952 each inventor received 28000 dollars. At that time my father was spending a large fraction of his time in Geneva, since he was the Secretary General of the provisional organization, which became in 1954 the present CERN. Many years later he told me that he deposited this not large sum at the central seat of the *Société de Banque Suisse* (SBS), which was downtown in Geneva, and not at the more convenient seat that

Fig. 4. – This picture of Pontecorvo, Segrè and Amaldi was taken in September 1978 on the terrace of the Physics Department at La Sapienza (credit: Amaldi Archive, Department of Physics, Sapienza University, Rome).

UBS (*Union de Banques Suisses*) had on the CERN premises, because this was the bank with whom he had to do as Secretary General of the organization and he wanted to avoid any possible conflict of interest.

Emilio Segrè never forgave Pontecorvo for having caused the loss of such a large amount of money. This was clear when, twenty-five years later, Bruno was allowed to visit Italy on the occasion of the Conference held in Rome for celebrating Edoardo Amaldi's seventieth anniversary. I saw the cold exchange they had when they first met, even if in the picture shown in Fig. 4 both of them try to smile. In his autobiography Emilio Segrè wrote hard words against the State employees who treated the patent affair [6, p. 245]: "*The shenanigans used by the lawyers to obstruct and minimize the 'just compensation' ended by disgruntling Fermi to the extent that he declined reappointment to important government advisory boards* [...] *The treatment we received as inventors from the U.S. government reflects the mind-set of lawyers and bureaucrats, who believed that by squeezing the inventors as much as possible, they were properly serving the government.*"

3. – Charm

In 1978 I was working on an experiment mounted on the neutrino beam of the CERN Super Proton Synchrotron (SPS) by the CHARM (CERN- Hamburg- Amsterdam- Rome-Moscow) Collaboration, of which Klaus Winter was spokesperson. The detector was designed to perform three very different measurements. Winter wanted to study neutral current events and derive from them the proton structure functions. Guido Barbiellini had proposed to study the scattering of muon-neutrinos on electrons, a basic scattering phenomenon of which at the time only a handful of events had been recorded. I had envisaged in 1975 a novel measurement in the field of weak interactions: stop the positive

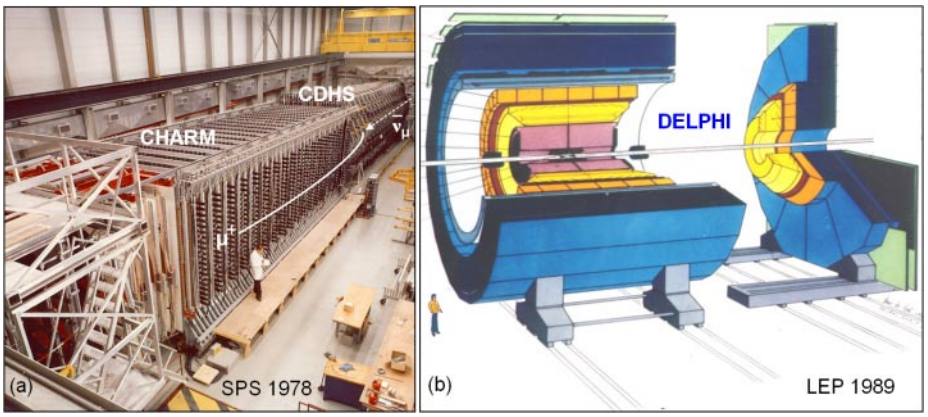


Fig. 5. – (a) The figure shows how the positive muons - produced by antineutrinos in the CDHS magnetized iron calorimeter - are focused towards the CHARM detector where they stopped. (b) The detector of the DELPHI collaboration was mounted in the Interaction Point 8 of LEP and collected more than 5 million events in ten years of data taking. (Credit: CERN Archives).

muons - produced by muon-antineutrinos in the many magnetized iron layers of the CERN-Dortmund-Heidelberg-Saclay (CDHS) calorimeter located in front of the CHARM detector – and measure their polarization by letting their spin precess in a weak vertical magnetic field. It would have been the first direct measurement of the properties of the charged weak interaction in a high-energy reaction. The spokesperson of CDHS was Jack Steinberger; it was not difficult to convince him and his collaboration that this was a worthwhile experiment [11].

The first two CHARM measurements needed a calorimeter made of a light material, in which the *hadronic* showers produced in neutral current events could be distinguished from the narrower and shorter *electromagnetic* showers due to the atomic electrons put in motion in the scattering of muons. For my proposal, instead, a target material was needed in which the muons at rest would not depolarize. After a series of preliminary measurements we decided to use as inert material 400 tons of Carrara marble, which is practically pure calcium carbonate and does not depolarize the muons since all its nuclei are even-even. The 10 cm slabs were interspersed with 4 metre long plastic scintillators and contained in square iron frames that provided the vertical magnetic field (Fig. 5a).

As I mentioned, that same year Bruno came back in Italy for the first time since he had emigrated to URSS, to participate in the Conference in honour of Edoardo Amaldi. Bruno was the true star of the event: a crowd of journalists waited for him at the airport and the Italian press and television had daily news on him and the reasons for which he had left the West for the Soviet Union. At the conference everybody wanted to meet him and I could talk to him only shortly. He was very pleased when he heard the idea – which had been put into practice – to measure the polarization of the muons (an old love of his) produced by muon-neutrinos (which he called "neutrettos"), in a reaction that he had himself proposed in 1943 to check whether a neutretto is really different from a neutrino. Moreover, Carrara – from where the marble used in CHARM came from – is only fifty kilometres from Pisa, Bruno's hometown...

In 1980 the CHARM Collaboration decided to perform a neutrino oscillation experiment and I became responsible for the construction of the close detector, i.e. of the

Fig. 6. – Guenakh Mitselmakher and Bruno Pontecorvo in 1978. (Credit: JINR, Dubna).

detector that was located much closer to the neutrino source than the CHARM detector of Fig. 5a [12,13]. I could describe this experiment to Bruno Pontecorvo only years later when I started to meet him more frequently, as I say in the next Section.

4. – DELPHI

In 1980 Guido Barbiellini and I decided to set-up a collaboration and propose a detector for the next CERN accelerator, the LEP (Large Electron Positron collider). DELPHI (DEtector with Lepton Photon and Hadron Identification) was approved by the LEP Committee in 1982 and built in the next seven years by a collaboration of twenty laboratories (Fig 5b); the group grew from three hundred physicists at the beginning of the construction phase up to about five hundreds during data taking. I was spokesperson for thirteen years.

The organization and the coordination of the DELPHI offered me the chance to meet Bruno Pontecorvo several times. From the beginning we wanted to have two groups of scientists from the USSR joining the Collaboration, following the very positive experience of the CHARM experiment, for which we had very successfully collaborated with the group of the *Moscow Institute for Theoretical and Experimental Physics*, lead by Vitali Kaftanov. The first team joining DELPHI was the one lead by Pavel Chliapnikov and based at the soviet Institute for High Energy Physics in Serpukhov. Quite naturally the second one had to come from the *Joint Institute for Nuclear Studies* (JINR), the international laboratory of the Eastern countries, which has since 1956 its seat in Dubna, a science town about 120 kilometres from Moscow.

However for months no conclusion was reached because too many group leaders, belonging to different Dubna laboratories, wanted to join us. With the help of Giuseppe Fidecaro, who was the chair of the CERN-USSR Committee, I had discussed with many colleagues but I was somewhat lost when finally I received from Bruno – who was since ever the JINR leading figure – a long letter. After tactfully describing the situation, he presented with very warm words Guenakh Mitselmakher, one of his best PhD students.

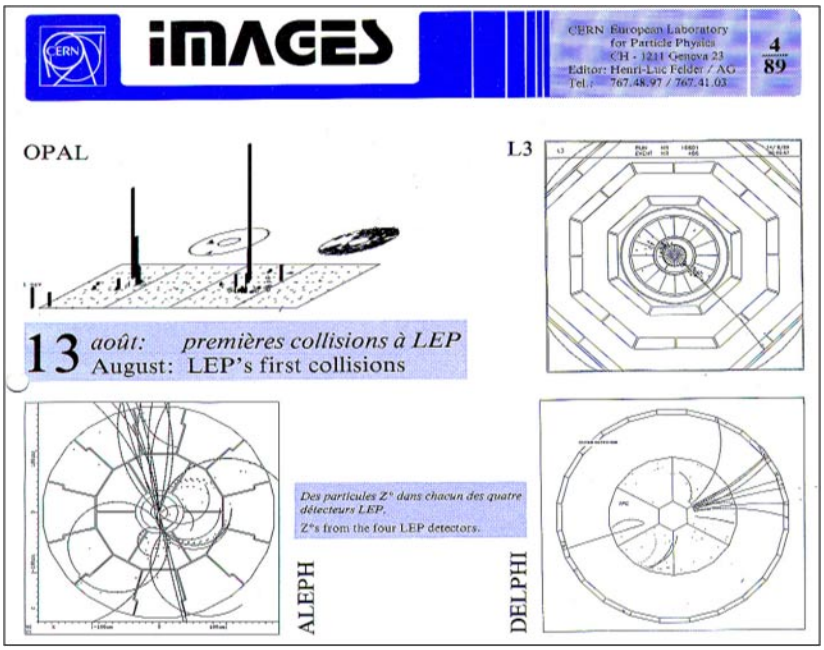


Fig. 7. – The first events recorded by the four detectors when LEP was switched on. (Credit: CERN Archives).

Eventually the Director of the Institute, the famous theoretician Nikolay Bogolyubov, decided that two groups, one lead by Mitselmakher and the other by Edward Tsyganov, would form the Dubna team of DELPHI. The overall leadership was given to Vladimir Kadyshevsky, a very capable theoretician who in 1988 followed Bogolyubov as Institute Director.

In the 80s I visited Dubna a few times and had various occasions to meet Bruno and

Fig. 8. – Giancarlo Wick and Bruno Pontecorvo visit DELPHI. (Credit: Ugo Amaldi).

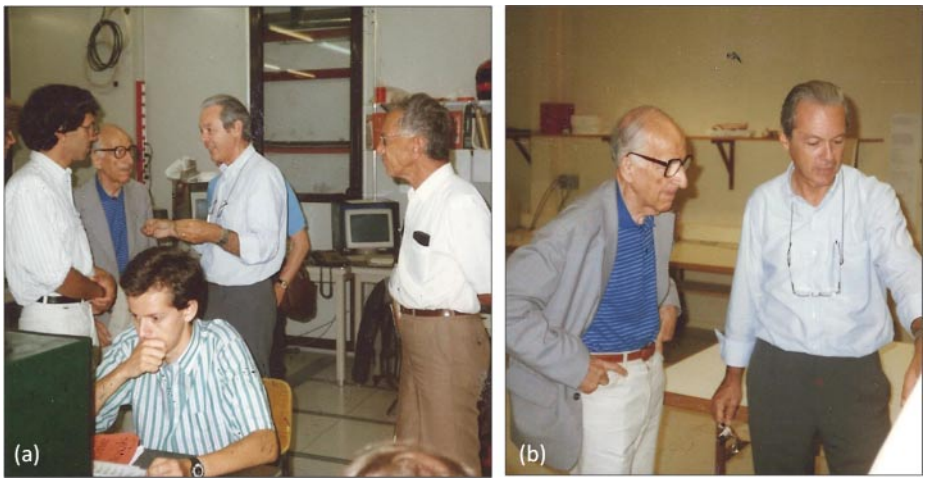


Fig. 9. – (a) In the DELPHI counting room I describe electron-positron collision to Alan Cocconi and Bruno, while Giuseppe Cocconi is listening from a short distance, on the right. (b) Bruno follows the description of the structure of the DELPHI detector. (Credit: Ugo Amaldi).

discuss many subjects with him. Here I recount four episodes.

The first time I talked to him in Dubna I asked why in 1950 he had left the West. His reply was concise and stopped any further discussion: "*Vedi, Ugo, per me il comunismo era come una religione*," "You see, Ugo, for me communism was kind of a religion."

On another occasion I visited him in his small house, hidden among trees covered by snow. The large dining table was cluttered with tea cups, sheets of papers covered by notes, newspapers, physics reports and old pens. Not far from the chair on which he used to sit there was a large open book. Approaching it, I told him my surprise. He answered: "*Io leggo sempre la Bibbia*", "*I always read the Bible.*"

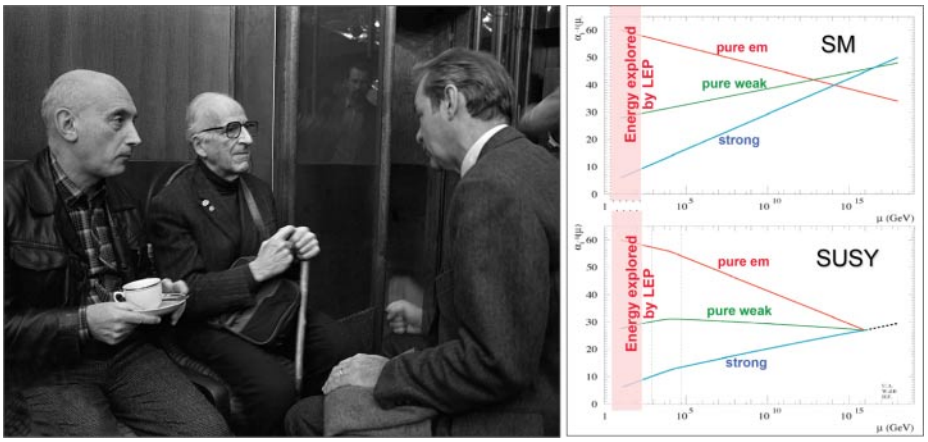


Fig. 10. – Samoil Bilenki, Bruno Pontecorvo and myself in 1991 in Dubna. (Credit: (a) JINR, Dubna; (b) Ugo Amaldi).

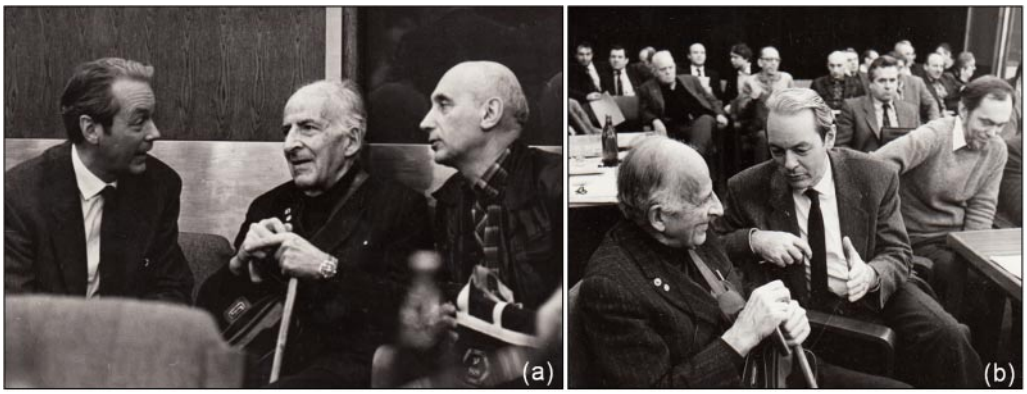


Fig. 11. – Two other pictures taken on the occasion of the meeting of the JINR Scientific Council. (Credit: JINR, Dubna).

Many of those who knew him told me that they never saw a Bible in Pontecorvo's house and myself I found this small episode at odds with Bruno's ideas. However, that day the Bible was on the table and Bruno told me exactly the words I have quoted.

The third episode happened while Andrei Sakharov and his wife Elena Bonner were exiled in Gorki. I had to go to JINR for DELPHI matters and my father – who was foreign member of the Soviet Academy – asked me to meet Bruno and tell him to pass a message to the higher levels of the Russian Academy. Thus I walked with Bruno among the Dubna trees, as we had done other times, and told him that Edoardo and the other members of the Italian Academy he knew well urged the Soviet Academy to oppose any action the Government would take against the Sakharovs and to act to free them from the Gorki exile. About one year later, when I went back to Dubna, Bruno told me: "*The day after I took a car and I went to Moscow to speak with Markov, then Academy President, who listened to me very attentively.*" Of course I cannot say whether this message had any influence on the liberation of the Sakharovs from the Gorki exile.

Finally, I mention the visit that Bruno Pontecorvo made to the DELPHI detector on August 25, 1989.

The LEP 'pilot' run lasted one week and ended on August 18, 1989. As shown in Fig. 7, one week before the CERN journal "Images" had reproduced the first events recorded by the four detectors: ALEPH (spokesperson: Jack Steinberger), DELPHI, L3 (spokesperson: Sam Ting) and OPAL (spokesperson: Aldo Michelini).

One week later I had the pleasure to show our detector and explain what we had done and what we hoped to do to three long time family friends: Bruno Pontecorvo, Giancarlo Wick and Giuseppe Cocconi, who was accompanied by his son Alan with his partner. I still remember the intellectual pleasure I had in explaining to these three great physicists and their relatives the structure of DELPHI and the first few events we had recorded during the pilot run.

Fig. 12. – The 1995 Bruno Pontecorvo Prize. (Credit: Ugo Amaldi).

5. – Scientific Council of the Joint Institute for Nuclear Research

In the 80s I was nominated member of the JINR Scientific Council together with Herwig Schopper – past CERN Director General. This gave me occasions to visit Dubna and meet Bruno about once a year even after I had resigned as DELPHI spokesperson at the end of 1993.

At the beginning of 1991 we had in Dubna the encounter I best remember.

With my colleague and friend Wim de Boer of Karlsruhe University and the PhD student Hermann Fürurstenau we had published a paper on the unification of the weak, electromagnetic and strong forces in which, by applying methods developed by others, we had shown that from the new LEP data one could deduce that the three coupling constants would unify at high energy if the minimal Supersymmetric (SUSY) Model was adopted, while this was not happening in the Standard Model (SM) [14].

This was the last time I met Bruno.

During the sessions of the Scientific Council I spent quite a lot of time discussing our paper and other physics subjects with Samoil Bilenki and Bruno. The pictures of Figs. 10 and Fig. 11 were taken on this occasion.

With the picture of Fig. 12 I conclude by recalling my joy when, in 1995, I received – for my contributions to the study of weak interactions and of the unification of the forces – the first Bruno Pontecorvo prize, which had been created the year before by the Joint Institute for Nuclear Research.

REFERENCES

[1] Fermi E., *Ric. Scient.*, **5**(1) (1934) 283; *Ibid.* **5**(1) (1934) 330.
[2] Amaldi E., D'Agostino O., Fermi E., Rasetti F., and Segrè E., *Ric. Scient.*, **5**(1) (1934) 452; *Ibid.*, **5**(1) (1934) 652; *Ibid.*, **5**(2) (1934) 21.
[3] Holton G., Fermi's Group and the Recapture of Italy's Place in Physics, in *The Scientific Imagination, Case Studies* (Cambridge University Press, Cambridge) 1978, Part 2, Section 5.
[4] Amaldi E., From the discovery of the neutron to the discovery of nuclear fission, *Physics Report* **111** (1-4) (1984) 152.

[5] De Gregorio A., Sulla scoperta della proprietà delle sostanze idrogenate di accrescere la radioattività indotta dai neutroni, *Nuovo Saggiatore*, **19** (Ott. 2003) 41.
[6] Segrè E., *A mind always in motion* (University of California Press, Berkeley-Los Angeles-Oxford) 1993, p. 95.
[7] Pontecorvo B., *Enrico Fermi* (Edizioni Studio Tesi, Pordenone) 1993, p. 82.
[8] Fermi L., *Atoms in the Family* (University of Chicago Press, Chicago) 1954, p. 100.
[9] Turchetti S., A contentious business: industrial patents and the production of isotopes 1930-1960, *Dynamis* **29** (2009) 191.
[10] Angela P., *Intervista sulla materia: dal nucleo alle galassie* (Laterza, Roma and Bari) 1980, p. 44.
[11] Jonker M. *et al.* (CHARM Collaboration), Measurements of the polarization of positive muons produced in high-energy anti-neutrinos interactions, *Z. Phys. C* **17** (1983) 211.
[12] Bergsma F. *et al.* (CHARM Collaboration), A search for oscillations of muon-neutrinos in an experiment with L/E, *Phys. Letters B* **142** (1984) 103.
[13] Bergsma F. *et al.* (CHARM Collaboration), A search for neutrino oscillations, *Z. Phys. C* **40** (1988) 171.
[14] U. Amaldi, de Boer W. and Furstenau H., Comparison of grand unified theories with electroweak and strong coupling constants measured at LEP, *Phys. Letters B*, **260** (1991) 447.