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Colloquia: Pontecorvo100

Meeting Bruno Pontecorvo

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Summary. — Since 1947 the notion of weak interaction was Bruno's pet idea. I recall here a friendly meeting in Dubna, the visit to Italy in the late forties, the early work in the Russian environment.

1. – Dubna, 1989

I would like to thank the Organizers of the Pontecorvo100 Symposium for their kind invitation. It is an occasion for me to go back to the recollections on Bruno, published in 1997 [1], and to update my notes and contribution [2], while re-assessing my sources.

I had occasions to meet Pontecorvo in Italy a few times before he left for the Soviet Union in 1950, but I only made his acquaintance several years later, on the occasion of one of my visits to Dubna [2], in 1989. I do not remember how I happened to meet him in the Hall of the Dubna Hotel where I was staying. I had with me, for no special reason, a reprint of my talk *From Cosmic Rays to Physics with Accelerators* [3] given at the International Conference on *The restructuring of physical sciences in Europe and the United States, 1945-1960* held in Rome in September 1988. On seeing Bruno I suddenly decided to give him the reprint. We had never worked together. Bruno thanked me and I then left, convinced that all ended there. I was wrong.

In particular, at the Rome Conference I recalled that after the discovery of the Conversi-Pancini-Piccioni effect [4] Pontecorvo [5] was the first to notice *that the probability ($\sim 10^6\ s^{-1}$) of capture of a bound negative meson is of the order of the probability of ordinary K-capture processes (when allowance is made for the difference in the disintegration energy and the difference in the volumes of the muonic and electronic orbits).* Thus he called attention to the possible equality of the coupling constants of electrons and mesons to nucleons and essentially laid down the first two sides of the Puppi Triangle, namely the nuclear β-decay process and the inverse meson capture process, leading from the (N,P) pair to the (e,ν) and (μ,ν) pairs respectively. (The triangle representation was J.Tiomno's idea in 1949.)

I noticed that, if Fermi, Teller and Weisskopf [6] were the first to point out the existence of a 10^{10} – 10^{12} disagreement of the time of capture of mesons in carbon with previous estimates, Pontecorvo, in his paper published six months later [5], went into

Fig. 1. – B. Pontecorvo, V.P. Dzhelepov, V.I. Lushchikov, Dzh.B. Pontekorvo (1983).

more detail in the analysis of the consequences of the Rome experiment [4]) and discussed features of weak interactions with deep insight. Pontecorvo's idea in the following years developed through the work of other authors into the more general *Universal Fermi Interaction*: O. Klein (1948); G. Puppi (1948); J. Tiomno and J.A. Wheeler (1949); T.D. Lee, M. Rosenbluth, and C.N. Yang (1949); C.N. Yang and J. Tiomno (1950).

Next morning, at the same time and the same place I had met him the previous day, Bruno appeared. I was astonished ... Bruno was looking for me! I thought that he had appreciated the comparison with Fermi that I had made. I was glad to see his warm reaction, and it was my turn to get somewhat excited: his enthusiasm was also an acknowledgement of the CERN experiment [7] that about ten years later proved the validity of his *intuition*, as he called it in more recent times [8]. We recalled facts and anecdotes relating to his work and the CERN experiment. In the end Bruno took me to see the horses of his son Tito and we spent the whole morning together. After this friendly encounter we had frequent occasions to meet and talk, at Dubna, CERN and Rome. It was the start of friendship.

2. – Revisiting Bruno

My 1997 paper [2], together with the accompanying seminars, was an attempt to make the Bruno's scientific work known in an environment still dominated by other types of literature. Bruno's work in the Soviet Union had already been published in the Western World, but it was mainly known only by people with specific interests.

I chose to deal mainly with Bruno's work in the Western World (Italy, France, USA, Canada, UK). As to Bruno's work in 1951-55, done at a time nobody in the world knew where he and his family were, I summarized it briefly only in my 1997 seminar at Michigan and in my 1998 lectures at the *International Summer School on High Energy Physics in Memory of Bruno Pontecorvo*. I felt that I was lacking some piece of information. I'll return later to this point

The situation today, fifteen years later, is different. Two important Symposia are being held in Rome and Pisa on the occasion of Bruno's 100th birthday, and several brilliant colleagues have reported or are reporting their views of the different aspects of Bruno's work.

Thus, I have chosen to focus my attention here on Russian time. At the 2013 Rome International meeting I presented [9] a new look at the Bruno's inverse β process to detect neutrinos, after an older document came to light in 1996 at the Chalk River laboratory.

3. – Establishing the notion of Weak Interaction

In 1985 a Symposium was held at Fermilab on *Pions to quarks, Particle physics in the 1950s* and Bruno was invited to send a contribution. The Proceedings were only published in 1989. When I discovered the Bruno's contribution *Recollections on the Establishment of the Weak Interaction Notion* [10], I realized that it was the piece of information that I had been waiting for at an earlier time, and that I now recall briefly here.

Bruno introduced his contribution in the following way : *I shall cover mainly some Dubna work on new particles, performed in 1951–1955* [11, 12]*, in the context of the notion of weak interaction, a notion which was certainly not taken as granted in the early 50's, but since 1947 had become one of my pet ideas* [5].

He then continued: *... I shall limit myself to the evidence in favour of my 1947 idea, that the β-decay "is not alone". The processes, other than the β-decay, which pointed to some kind of universal behaviour concern first the muon and then strange particles. This story starts in 1947 and terminates in 1955.*

Indeed, after the discovery of particles copiously produced in cosmic rays that curiously decayed with a long lifetime Bruno [11] formulated independently of Pais [13] the idea of associate production of strange particles. Such an idea, however, was not well received, even contradicted by M. Schein [10] who claimed to have detected the production of isolated Λ^0 in the reaction $\pi^- + p \to \Lambda^0 + \pi^0$.

Then Bruno et al. [12], advantaged by the higher energy (670 MeV) of the Dubna synchro-cyclotron, with respect to the 450 MeV Chicago synchro-cyclotron used by Garwin [14], reached the conclusion that Λ^0 were produced in neither of the two processes $N + N \to N + \Lambda^0$ and $N + N \to \Lambda^0 + \Lambda^0$, in agreement with the idea of generation of two new particles together [11, 13].

As for the failure to observe the reaction $N + N \to \Lambda^0 + \Lambda^0$, the scheme figured out by Bruno, based on the conservation of the isotopic spin in the generation process (strong) and its non-conservation in the decay process (weak), led the authors [12] to conclude in favour of a 1/2 isospin heavy meson produced together with the Λ^0. Bruno's philosophy was correct, but his fertile imagination had missed for once the point.

Bruno acknowledged that the conservation of strangeness - M.Gell-Mann's idea - was equivalent to the conservation of the third component of the isotopic spin. However he recognized that the notion of strangeness was a very powerful tool without which physics could not have made the great steps ahead it did.

In Bruno's words, *at the Pisa conference of 1955, mainly as a result of the wonderful talk of M. Gell-Mann* [15]*, the notion of weak interaction, which was introduced in 1947* [5]*, became finally established.*

At the end of the eighties, while I was writing down some personal notes I was surprised to discover that the first time a session entirely devoted to *weak interactions*

had found its place in the Rochester Conference series only as late as in 1957. It is now clear why.

4. – Italy, the late forties

Bruno returned to Italy from Canada, for a short visit, in December 1947. He was the first to reappear in the country, out of the Italian physicists who had left before war. He spent a few days at the Institute of Physics of the University of Rome and on 17 December 1947 gave a seminar *Sulla Disintegrazione dei Mesoni ed i suoi Prodotti*.

Bruno came at a time when the echo of the Rome experiment [4], three months after the famous Shelter Island Conference, was still spreading out, and letters to *Nature* by the Bristol group in May and in October 1947 were bringing in compelling evidence of the production of a secondary meson, the μ-meson, from a primary one, the π-meson. I remember that the consequences of the discoveries were already being talked in Rome. Seen in the today optics the Bruno's seminar announced to be very interesting.

Bruno was already well involved in the renewal that was in the air. He had written in June 1947 his letter to Phys. Rev. [5] and was launching a series of cosmic ray experiments [16] to verify the possible consequences of his idea of a fundamental analogy between β-processes and processes of emission or absorption of charged mesons.

Most people at the Institute of Physics were engaged at that time in cosmic-ray experiments. As for theoretical physicists, like Gian Carlo Wick, Bruno Ferretti and Bruno Zumino, they were not there; Wick left for the US at the end of 1945, Ferretti for England in 1946, Zumino for the US also in 1946.

I was there when Bruno was around. I wish I'd attended Bruno's seminar. Unfortunately my family was waiting for me in the Abruzzi just on the eve of the Christmas holidays! Should anybody who attended that seminar in 1947 be alive, it would still be very interesting to hear from him.

Bruno returned to Italy in September 1949 from England, on the occasion of the Basel and Como International Conference on cosmic rays. On that occasion he visited the Olivetti factory in Ivrea and, on the way, the cosmic-ray laboratory at 3500 metres a.s.l. facing the Matterhorn, another sign of Bruno's new interest in cosmic-rays. (The laboratory was inaugurated in 1948; several physicists from various Italian universities carried out experiments there, including myself in 1952-54).

In Basel, Bruno presented a summary of the work done at Chalk River on proportional counters. I went to the conference section held in Como, but there Bruno remained silent, at least in public.

And then we get to the end of August 1950, when Mario Ageno and I met Bruno in Rome, at the Institute of Physics, as I reported in [2]. Quoting from there :

> "*On 1 September they (Bruno and his family) left by plane for Stockholm where they arrived before 9 p.m.. Next morning they proceeded to Helsinki, and then disappeared into thin air . . .*"

5. – Dubna, the first years

Before recalling Bruno's life in Dubna I should say that I had the privilege to profit of a direct knowledge of the Russian environment gained in the framework of the CERN-USSR collaboration.

The collaboration of CERN with USSR started soon after the establishment of the *Joint Institute for Nuclear Research* (JINR, Dubna) in 1956 (see O. W. Lock [20]. It was extended to the *Institute of High Energy Physics* (IHEP, Serpukov) in 1967 when the 70 GeV proton synchrotron started operation.

Already in 1992 it was known [8] how the Pontecorvo family reached Moscow: by sea to Helsinki from Stockholm, in two cars to Leningrad after traversing the USSR border, by train to Moscow. Though Bruno had to cross the border in the boot of the car, he was treated as a VIP all the way through, from the USSR border to Moscow. In Moscow they were lodged two months in a luxurious flat, in one of the best Moscow buildings in the very central Gorki street, that became their Moscow house for ever. They were submitted there to an intensive course of Russian.

During all their time in Moscow they were taken care of for everything, food and clothes. They, only didn't understand why they were not allowed going around Moscow unless accompanied by some kind of bodyguard *for their protection*.

At the end of their two month period in Moscow the whole family was moved to the area of the Bolshaya Volga settlement in a two store cottage like those where Dzhelepov and other leading personalities lived. There they started normal life. The Joint Institute for Nuclear Research did not exist yet.

Thus, on 1st November 1950 Pontecorvo joined the Hydro-Technical Laboratory, a secret laboratory of the USSR Academy of Sciences, equipped with a powerful synchro-cyclotron, as Head of the Experimental Physics Division. He was given an office and a secretary, Irina Grigorievna Pokrovskaya, who worked for him all along his life. Thanks to her a large number of documents on the early years of Pontecorvo were saved. Irina Grigorievna was among those who wrote about Bruno [21].

When Bruno arrived, in 1950, the laboratory had already a story [22, 23]. In August 1946, shortly after the discovery of the principle of phase stability by V.I. Veksler and E. McMillan, independently, the Russian Federation Government took up the initiative of I.V. Kurchatov to develop fundamental research in nuclear and high energy physics, and decided to create a new laboratory equipped with a powerful accelerator in a new location, in the area of the Bolshaya Volga settlement, on the bank of the Volga.

The general supervisor of the project and of the construction of the road and the railway line to Moscow was NKVD chief, Laurentij Beria, as I learned.

The new laboratory, a branch of the Moscow Institute of the Academy of Sciences led by I.V. Kurchatov, was named Hydro-Technical Laboratory, for reasons of secrecy. Everything concerning nuclear physics was top secret at that time. The construction of the synchro-cyclotron, designed to be the largest accelerator in the world (initially 460 MeV, 680 MeV later) started in 1947. Launched on 24 December 1949, the synchro-cyclotron (or "synchro-phasotron" as accelerators based on the phase stability principle were called at Dubna to honour Veksler and McMillan) started working in January 1950.

Since September 1948, M.G. Meshcheryakov and V.P. Dzhelepov had been appointed Director and vice-director of the laboratory, respectively, until 1956. Meshcheryakov had worked in the USA previously, in 1946-47, as an expert of the UN Atomic Committee. Dzhelepov had worked on the "uranium problem" in the forties under the direction of Kurchatov in Moscow. Nearly at the same time E.O. Lawrence at Berkeley used the 184-inch cyclotron magnet for studies that led to the development of the calutron.

In 1953 the Hydro-Technical laboratory was renamed "Institute of Nuclear Problems, Academy of Sciences" (INPAN). Another laboratory was established nearly at the same time in the same settlement, the "Electro-Physical Laboratory of the USSR Academy of Sciences" (EPhLAN) headed by Veksler.

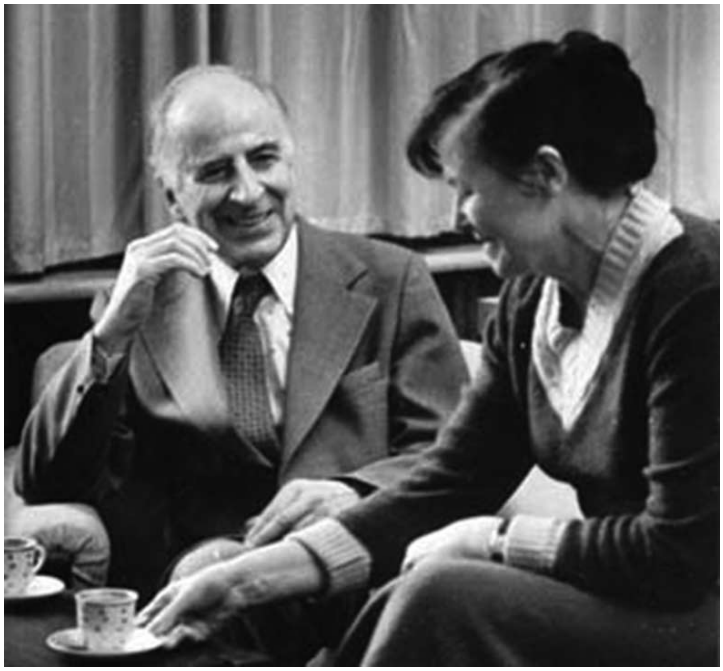

Fig. 2. – B. Pontecorvo, and Irina G. Prokovskaya (1983).

6. – 1955-1956, the opening

Around 1955 there was an opening in the West-East relationships. Bruno appeared in public for the first time giving a press conference on the occasion of some meeting for peace in Moscow. In August 1955 a first conference on Atoms for peace was held in Geneva to which a delegation from USSR including a number of scientists participated.

In 1956, the Joint Institute of Nuclear Research (JINR) was established on the basis of the first two Institutes, the INPAN and the EPhLAN, with I.D. Blokhintsev its first Director. At the same time the "Institute of Nuclear Problems, of Academy of Sciences" became the "JINR Laboratory of Nuclear Problems", with Dzhelepov as Director (until 1988), and Bruno Head of the Experimental Physics Division (until his death). The original Volga settlement became known under the name "Dubna – city of Sciences".

At the same time the scientific work previously recorded in internal reports was declassified and published in scientific Journals. English translations were published, mainly in the US. Numerous works, in particular all the work done at the synchro-cyclotron in the period 1950-1955, together with works done in other sectors of the Institute of Nuclear Problems and in other Russian laboratories, were reported by Meshcheryakov, Dzhelepov and other authors at the "CERN Symposium on High Energy Accelerators and Pion Physics" [17] held in Geneva on 13-23 June 1956. On that occasion the whole world learned that the USSR had the largest particle accelerator ever built.

That was the first time that a large delegation of Soviet scientists working in particle physics was taking part in a scientific conference in the Western World.

On the same occasion the world learned that Bruno Pontecorvo had had an active part in the scientific work with that machine and that on all that time, from 1st November

Fig. 3. – Dubna Synchro-cyclotron, initially 460 MeV, later 680 MeV.

1950 onwards, he had either been sitting in his office at B.Volga/Dubna for scientific work, or working on the floor at the Dubna synchro-cyclotron - never at the Lubyanka nor in atomic bomb laboratories.

Bruno was not present in Geneva. However a paper in collaboration with Dzehelepov, Meshcheryakov, et al. *High-Energy particle beams from the 6 Metre Synchrocyclotron and Their Utilization* was presented by Dzhelepov, and reported in Vol. 1 of [17].

Another paper, in collaboration with A.I. Mukhin et al., presented by Mukhin, *Positive Pion-Proton Scattering at the Energies 176, 200, 240, 270, 307 and 310 MeV* was reported in [17], Volume 2.

The results presented by Mukhin, together with pion production results from other experiments, created some embarrassment to the physics community interested in similar experiments at the CERN synchro-cyclotron. In 1956 the CERN SC was still in the stage of construction and the first acceleration tests were foreseen one year later. Pion beams for users were only foreseen in early 1958.

Fortunately nature was kind as by the end of the year weak interactions came on the front of the scene with the discovery of parity non-conservation.

Muhkin in 1962 was the first physicist from Dubna to visit CERN for a six month period as a *visitor* in an experiment at the synchro-cyclotron

Meshcheryakov later became Director of the JINR Laboratory of Computing Techniques and Automation. He died in 1994. To the very last he took active part in the discussions of the development of JINR, defending the freedom of scientific work.

The work of Bruno in those years, and in the following ones, is summarized by Dzhelepov in [23]. That article covers all the aspects of Bruno's life and gives a good idea of the wide range of his interests, scientific and non.

It was at the Conference in Geneva in June 1956 that Dzhelepov and I met the first

time. At the same time I met J.D. Prokoškin.

We met again at the 1958 Rochester conference [18], held in Geneva at the Institute of Physics of the University. On that occasion Dzhelepov visited the CERN synchro-cyclotron. The experiment that two months later detected the π-eν decay [7], the first experiment with a CERN accelerator, was already on the floor.

When in 1991 CERN held a Symposium [19] to celebrate the 33 years of life of the first CERN accelerator. Dzhelepov was there to read: *A Tribute from JINR Scientists* to the CERN scientists "whose SC experiments have enriched the world of science with results of the outmost importance".

7. – Keeping Bruno's memory alive

I happened to be in Protvino a few days before Bruno passed away, on September 24, 1993. I was shocked to hear of his sudden death in Dubna. I joined a three people delegation going to Dubna from Protvino for the funeral next day. Like others who knew Bruno I was invited to say a few words. Thus I had the privilege to give Bruno the last greetings from the country which had given him birth and had raised him as a physicist - together with Guido Piragino from Torino, who had an experiment at Dubna but had come primarily as scientific attaché to the Italian Embassy in Moscow.

Three years later, in September 1996, in the course of one of my visits to Dubna, Dzhelepov, then Honorary Director of the JINR Laboratory of Nuclear Problems, where Bruno, the same age as Dzhelepov, spent his full life since his arrival in 1950, asked me whether I could give a talk to remember Pontecorvo in the third anniversary of his death. Thus I prepared on the spot, writing by hand, my transparencies mainly recalling Bruno's life and work before his arrival in Dubna. The seminar was held on September 23, one day before Bruno's death three years earlier.

After the seminar Dzhelepov took me for dinner at his house, the same type of house as Bruno and other top scientists lived in. There was nobody in the house to help him and I was touched when I realized that he was going to cook for both of us. Unfortunately I could not help him. Our long conversation, showing how much he felt the passing away of Bruno, was moving. Dzhelepov died three years later, on 12 March 1999, aged 85.

As to the "B. Pontecorvo Selected Scientific Works" [1], as far as I know they were put together and published on the initiative of Dzhelepov and of Samoil M.Bilenky, a generation younger in respect to Bruno, who had been his main collaborator for neutrino physics in the last part of Bruno's life. It was the first time that I was meeting Samoil, although I had heard his name already at the 1956 CERN Symposium [17].

Samoil asked me to write my personal recollections for the book in preparation on the same occasion Dzhelepov had invited me to remember Bruno's early life. His invitation was followed by a rather long series of contacts and discussions with Samoil himself and with Misha G.Sapozhnikov. It was a pleasure to work and go through old documents with them: it was a fruitful time.

The Dubna seminar was the first of a series of lectures to remember Bruno in different countries. I remember particularly the lectures given in Canada where I was a guest of Geoffrey Hanna, a collaborator of Bruno. He drove me through the country and guided me around the Chalk River Laboratory and the residential city of Deep River, where I was introduced to other co-workers and friends of Bruno still alive. My visit to Canada, was very fruitful.

Much more is known today of Bruno. As to the old question [8], why did he *emigrate* to USSR, it remains open. Is that really important?

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