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The Mediterranean flights and the G-Stack collaboration (1952–1955): A first example of European collaboration in particle physics

(1) Introduction

From summer 1952 a series of international balloon flights for the study of K-mesons was undertaken by a pioneering collaboration of several European laboratories, and concluded with the G-Stack collaboration in autumn 1954. The balloon, launched from Novi Ligure (Italy), was loaded with 15 litres of nuclear emulsions and reached an altitude between 23 and 30 km for six hours. The paper discussing the results of the flight, (*Nuovo Cimento*, November 1955) is usually referred to as the first paper with the first page fully filled with the authors' names (more than 30 physicists from 8 laboratories, coordinated by the Bristol, Milan and Padua groups).

The aim of this work is to show how the Mediterranean flights and the G-Stack collaboration were the first important example of Europeisation of physics research during the post-war years. Among the many facets of the flights which can be analysed — first of all their scientific value —, I will point out the importance of the flights as a pioneering, successful and highly cooperative enterprise.

The work is based on different kinds of sources (primary and secondary literature); among them, the documents collected in C.F. Powell Archives (Bristol), P.H. Fowler Archives (Bristol), E. Amaldi Archive (Rome) and G.P.S. Occhialini papers (Milan) were fundamental for the historical reconstruction.

(2) The birth of a collaboration

In December 1951, the cosmic-ray Bristol group, led by the Nobel laureate Cecil Powell, organized a meeting on *V-particles and heavy mesons* in order to *discuss the best method of collaborating in the attack on the problem presented by the heavy mesons and V-particles*;[1] the congress joined more than seventy physicists from all the laboratories interested in the problem of strange particles at the time.[2] Powell's remarks presented at the Bristol conference, clearly show the reasons which led him to promote the international Sardinian flights:

> The results of the work on the heavy mesons, had emphasized the importance of studying high energy disintegrations. In such experiments, it is a great advantage if the tracks of particles of lower energy can be eliminated from the detecting apparatus, for they provide an unwanted background against which, the heavy mesons and the high energy events have to be distinguished. These considerations suggest that the most favourable conditions would be provided by exposures at great altitudes near the magnetic equator.[3]

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[1] Belloni, Lanfranco; Dilworth, Constance (1988): "From little to big. A story of European postwar collaboration with nuclear emulsions", in: De Maria, Michelangelo; Grilli, Mario; Sebastiani, Fabio (eds.) (1988): *The restructuring of Physical Sciences in Europe and the United States 1945–1960* (World Scientific, 1988), pp. 732–744, here p. 736.

[2] Dallaporta, Nicola (1988). "Researches on high energy physics in Padova in the period 1945–1960" in: De Maria, Michelangelo; Grilli, Mario; Sebastiani, Fabio (eds.) (1988), *The restructuring of Physical Sciences in Europe and the United States 1945-1960* (World Scientific, 1988), pp.532–547, here p. 539.

[3] "Report of a conference on V-particles and heavy mesons" (Bristol, December 1951).

At the meeting, Powell's proposal was soon welcomed by the great part of the conference members.[4] As a consequence, an association with the aim of exposing bunches of emulsion plates at very high altitudes using polyethylene balloons (concerning which, Bristol had already acquired a large experience) was made up.

Two years later, many of the scientists who had contributed to the success of the Bristol Conference, participated to the Bagnères-de-Bigorre Conference (July 1953), where the cosmic ray community faced up with new scientific puzzles concerning the decay modes of heavy charged mesons. Like in Bristol, an innovative cooperative experiment was urged and the G-Stack, a flight with a great balloon loaded with a giant (G-) stack, was planned for the following year.

During these conferences, both very important in the history of post-war international balloon flights and cosmic ray physics, the cooperative effort of the participants was evident. Edoardo Amaldi, one of the leading Italian physicists at the time remembered that:

> In order to regain a first rank position in nuclear science, it was necessary to make a common effort. In fact, it was clear that in many European countries, still suffering from the very serious damages of the recent war, the problem of reconstructing their capacity and of developing their efficiency in the field of nuclear sciences could find adequate solution from both the financial aspect and from the point of view of technical and scientific personnel through a collaboration among the European countries.[5]

The joint of several laboratories made them able to collect enough economical and human resources to afford significant enterprises. A shared experiment among many groups could reduce the expense of the flight and the hazards of the enterprise.[6] Moreover, a collaborative and coordinated work of analysis was requested in order to obtain results with a great statistical value in a short time, a very important reason that led to establishing great collaboration in the field of particle physics:[7]

> The second reason for the collaboration was that the investigation of the resulting photographic material under the microscope was very arduous. A serious effort to discover new elementary particles and their properties, which the new experimental material made possible, could only be made if people in a number of laboratories joined together in a common effort.[8]

Besides the actual reasons that led to the constitution of a large network of scientists, the „ideal" aspect cannot be forgotten in order to understand the whole story. Among all the physicists who strongly contributed to the international flights, Powell — who can be considered the main actor of the flights — believed greatly in the importance of scientific collaboration as *the great transforming force* of his days.[9] According to Powell:

> But there are also important reasons why the bonds of international scientific collaboration should be made much stronger than they have ever been before because of the immensely greater significance of science for the whole of social life. But while we aspire to make science truly international in the sense that its results shall be freely available to all men, there are now important reasons for greatly extending international scientific collaboration: international science is strong because of the variety of resources

[4] Grilli, Mario; Sebastiani, Fabio (2002): "Collaborations among nuclear emulsion groups in Europe during the 1950s" *Rivista di Storia della Scienza* 1996, *4 (1),* pp. 181–206, here p. 184.

[5] Amaldi, Edoardo (1955). "CERN, the European Council for Nuclear Research", *Supplemento al Nuovo Cimento* 1955, II (X), p. 347.

[6] "International scientific collaboration (speech to W.S.F.W., Berlin, September)", *Powell papers* (Bristol archives) DM517/V/128.

[7] Comitato nazionale per le ricerche nucleari (1958): *Un piano quinquennale per lo sviluppo delle ricerche nucleari in Italia* (Roma, 1958), p. 380.

[8] "International scientific collaboration (speech to W.S.F.W., Berlin, September)", Powell papers (Bristol archives) DM517/V/128.

[9] *Ibidem.*

> which can be brought to bear on common problems by the representatives of different scientific traditions.[10]

The birth of a European collaboration in post-war years was the result of a fruitful mix of ideal, economical, technical and strictly scientific reasons, which were discussed and approved during international conferences joint by the most important laboratories interested in cosmic ray physics and in the unknown behaviour of heavy charged mesons.

(3) The members of the collaboration

One of the first initiatives undertaken by the Italian physics communities in order to reconstruct an advanced physics research, was the supporting of abroad training of young brilliant graduates — highly motivated but lacking in specific knowledge after the forced pause of the war — who, once returned home could start self-standing physics activities in their laboratories. A great attention was paid to the constitution of an Italian network too, able to organize national research and financial supports. The words of Nicola Dallaporta, an Italian physicist, are very explicit in this way:

> The wisest thing to do in order of rapidly progressing in using these several techniques was to get in touch with laboratories having already acquired a wide experience with such tools. So, three scientific connections very important for us were established with three cosmic ray research centres in Great Britain and Belgium: that is with Powell's laboratory in Bristol, and Occhialini's one in Brussels, for the nuclear emulsion technique; and with Blackett's one in Manchester.[11]

Strongly linked to the aim of reconstructing Italian physics, another fallout of the researchers' exchanges was the creation of a solid international network, of a highly motivated *comunnautè des savants* after the division of the war.[12]

> The mountain laboratories in Switzerland, France, and Italy, and, even more, the nuclear-emulsion laboratories of the universities of Bristol and Brussels, led, respectively, by Powell by Occhialini, had become in those years points of encounter for young physicists from many countries. The collaborations in mountain huts and the coordination of the experiments planned by different groups paved the way to the idea of wider and more ambitious collaborations, which were indeed arising in various places in Europe.[13]

Hence, the post-war international balloon flights represent a very interesting example of circulation of knowledge from a local to a global context and vice-versa. First, several young Italian researchers from different Italian university were sent abroad to learn new techniques and collaborated to find new technical and scientific solutions to the topics of the forefront particle physics in the important laboratories of Bristol, Brussels and Paris (from local to global). Then, once returned in Italy, they developed their own laboratories, trained new scientists in their turn (from global to local) and established huge collaborations with the abroad groups they previously collaborated with (from local to global again), creating a circulation of knowledge across Europe. Thus, the particle physics became a European-wide research, and, thanks to a common effort, quickly developed and obtained results which a single laboratory could not have reached by itself.

Moreover, the international flights contributed to the Europeisation of Italian physics, that at the end of the war had to be re-built almost entirely and that, thanks to the Italian leading role played during the international flights, less than 10 years after the end of the war, had reached an important position in the international particle physics scenario. Italy had strongly contributed to the development

[10] *Ibidem.*

[11] Dallaporta (1988). *Op. cit.*, p. 536.

[12] Russo, Arturo (2000): *Le reti dei fisici* (Pavia: La Goliardica pavese, 2000), p. 259.

[13] Amaldi, Edoardo (1989): "The history of CERN during the early 1950s" in: Brown, Laurie; Dresden, Max; Hoddeson, Lillian; (eds) (1989), *Pions to quarks. Particle Physics in the 1950s* (Cambridge: Cambridge University Press, 1989) , pp. 508–519, here p. 510.

of European post-war particle physics and, in its turn, Europe played an important role in the re-building of the Italian physics communities.

Eventually, the European collaboration on flying large plastic balloons was formally launched as a result of a meeting in Rome hosted by Edoardo Amaldi in 1952.[14] Soon, the newborn idea became real thanks to the efforts of Powell, Amaldi and other senior scientists; it represented a pioneering trial to organize a huge collaborative experiment, whose success would depend not only on scientific elements but also on the well-working of an international cooperation. The first campaign was undertaken in summer 1952, the following year another series of balloon was launched, and in 1954 the famous G-Stack was performed. Between May and July 1952, 11 balloons were launched from the airport of Elmas, Cagliari, Sardinia. Teams for the launching of balloons, made up of physicists and technicians, were drawn from Italian laboratories: Genoa, Rome, Milan, Padua, Turin; and European ones: Bristol, Brussels, Lund, Gottingen (Max Planck), London (Imperial College). Besides them, the groups of Glasgow, Paris (Ecole Polytechnique) and Cagliari participated to the flights, that means the full collaboration was made up of 13 groups, six of them from Italy.[15] In 1953, the extent of the collaboration had increased so that 23 laboratories, mostly from Western Europe, were involved in the Sardinian flights. The whole cooperation was made up of 6 Italian groups, 16 European groups and an Australian one.[16]

The following year, the groups involved in the G-Stack were reduced to the leading ones, Bristol, Milan and Padua: the members of these three laboratories (led by Cecil Powell, Giuseppe Occhialini and Michelangelo Merlin respectively) had created a network of friendship and scientific collaboration from the end of the Forties. At the end of 1954 the collaboration had been extended to include other university groups from Ireland and Denmark in order to obtain scientific results of greater statistical weight. The total group was eventually made up of 6 laboratories from 4 European countries, composed by more than 30 physicists and scanners. There were some advantages to extend the collaboration to other groups as in the Sardinian flights, but the organizers considered that the management would have been too difficult: the objects of the chase, the particles tracks, had to be frequently followed from one emulsion plate to another, that is from a laboratory to another, that is from a country to another of those involved.[17] Differently from the previous campaigns, the launch of the G-Stack was held on October 12th 1954, from Novi Ligure, in Piemonte, Northern Italy.

(4) A successful collaboration

From a scientific point of view, the success of the flights increased from the 1952 ones — almost a failure from a strictly scientific point of view — to the very successful G-Stack of 1954. In 1952 just 4 blocks of emulsions on 11 flights, were recovered; during 1953, 12 flights on 25 were successful: a lot of data about new decays modes (like the τ', K_μ, K_β) were collected and more than 40 articles were published on international journals from the European groups which analysed the data. Eventually, the G-Stack provided a homogeneous statistics and so many useful data that it gave a fundamental contribute to solve the puzzle concerning the mass of the heavy charged mesons and the relative frequencies of occurrence of the modes of decay, that is, it stated that there was just one particle (the K meson) decaying in six different modes.

[14] Perkins, Donald (2005): "From Pions to Proton Decay: Tales of the Unexpected", *Annual review of nuclear and particle science* 2005, *55*, pp. 1–26, here p. 14.

[15] CERN (1952): *Report on the expedition to the central Mediterranean for the study of cosmic radiation* (CERN/16, Rome, 30/9/52).

[16] Bern (Switzerland), Bristol (Great Britain), Brussels (Belgium), Caen (France), Catania (Italy), Copenhagen (Denmark), Dublin (University College) (Ireland), Dublin (Institute of Advanced Studies) (Ireland), Genoa (Italy), Gottingen, London (Great Britain), Lund (Sweden), Milan (Italy), Oslo (Norway), Padua (Italy), Paris (Ecole Polytechnique) (France), Paris (Ecole Normale) (France), Rome (Italy), Sydney (Australia), Turin (Italy), Trondheim (Norway), Uppsala (Sweden), Warsaw (Poland).

[17] "There are of course difficulties in establishing a successful collaboration. It takes time for standard procedures to be worked out, and to be put into general use", in: "International scientific collaboration (speech to W.S.F.W., Berlin, September)", *Powell papers.* DM517/V/128.

Besides their scientific value, which I have just briefly summed up, the flights marked a fundamental passage in the progress of knowledge of particle physics in the Fifties, because of their innovative value as a cooperative experiment. In this context, I will focus on their importance as a first example of European collaboration.

According to Powell:

> I think it would be generally agreed that these expeditions have played a valuable part in contributing to the discovery of new forms of matter, the mesons and hyperons, and the elucidations of their properties. This contribution could not have been made, or would have been much less effective, without a successful collaboration.[18]

The Mediterranean flights were the first strong answer to the need of establishing an international collaboration among European countries in the field of elementary physics, the only possible way to perform an expensive, in financial and human terms, research at the forefront of physics after Second World War.

The proper characteristics of the enterprises, made up of long periods of shared life, tension during a launch, joy of a success, delusion of a failure, created a solid collaboration, where the personal relationships played a major role. There was a strong collaboration among senior scientists, enthusiasts of the flights, the younger, who worked a lot in the technical, managerial and scientific aspects of the experiments, and the rest of the crew, made up of technicians, sailors, soldiers.

In the words of Powell:

> The collaboration was therefore established in response to a real need, and enabled us to attack problems which without it we could hardly have approached. The second feature of the collaboration was the advantages which, followed from it. There was firstly, of course, the great increase of power, brought about by mere members alone. But a more important point was that, through collaboration, we were able to bear upon a common problem the capacities, the skills, the scientific traditions of scientists from many different countries.[19]

According to Constance Dilworth (Milan group), the most important legacy of the G-Stack was *its demonstration of the feasibility of large inter-group collaborations*,[20] and for Donald Perkins, one of the collaborators of Cecil Powell, *these early collaborative efforts were the greatest achievement of the emulsion technique*.[21]

The knowledge transfer from the Bristol group to the Italians was one of the most important result of the expedition, highly whished by Powell, both because of ideal and technical consideration: the G-Stack definitely showed the importance of Italian physics research in Europe and of the European one in the World. With the G-Stack, at the middle of the Fifties, the years of the physics reconstruction were concluded in Italy; [22] thanks to the farsighted political choices of the senior scientists, Italy participated to the G-Stack and could afford the forefront of physics research.

Moreover, the comparison with other groups engaged in the same research but with different devices was greatly persecuted.

Eventually, after the G-Stack and the Pisa Conference (1955, when the results of the G-Stack were extensively presented), the accelerators, a source of high energy particles, took over, putting an end to the glorious years of particle physics research performed with cosmic rays. Namely, the Mediterranean flights represented a breaking-point in the history of particle physics because they were the last significant example of a kind of physics that was ending, mainly characterised from cheapness. The Mediterranean flights were organized during a crucial period of the European physics research, when new forms of research organization were emerging. The flights marked the passage from a local physics to a European-wide research, due first to the personal relationships among scientists which

[18] *Ibidem*.

[19] *Ibidem.*

[20] Belloni (1988). *Op. cit.*, p. 741.

[21] Perkins (2005). *Op. cit.*, p. 11.

[22] Amaldi, Edoardo (1979). „Gli anni della ricostruzione", *Giornale di Fisica* 1979, *20*, pp. 186–225.

formed an essential background to the setting up of large international laboratories like CERN, [23] a major happening in the history of European science. In the international flights (1952–55), it is easy to recognize the roots of a European awareness that led to its birth.

> The big scientific 20-plus laboratory collaborations of the early 50s were in Western Europe, using emulsions and cosmic rays — and they really worked, with enormous success. They had no small impact in the setting up of large scientific collaborative ventures like CERN" collaborations, because the creation process had yet begun due to necessity of having large machines.[24]

It is noteworthy that the expedition of 1952 was planned under the auspices of CERN, the new European centre for the study of nuclear and particle physics.

> The study of new instable particles, or other unfrequent events in cosmic rays, requires financial and human support that goes on the possibility of one or few laboratories. This is the same consideration that even before, and on a larger scale, took to the creation of CERN. Hence, the new initiative was planned under the auspices of CERN itself and developed thanks to its direction board.[25]

The newborn CERN had not yet any big machine working; however it needed to support both the European spirit of collaboration that stood at the basis of its creation, and the laboratories interested in particles physics. For this purpose, the Council agreed to support the research on cosmic radiation in the high atmosphere using balloons: thus, the Mediterranean flights were the first European collaboration undertaken under the CERN patronage.

The years which followed the G-Stack flight and the Pisa Conference in 1955 were characterized by the urgency of finding new kinds of research, after the big issue of the positive charged K-mesons had been almost solved, and, mainly, after the advent of accelerators. Many important experiences (such as the K-collaboration, the international flights of the Sixties, more sophisticated theoretical researches, …) stemmed from the Mediterranean flights and the G-Stack collaboration which, though marking the end of an epoch, contributed to start up new highly innovative kinds of research, first of all strongly cooperative and international campaigns in particle physics.

(5) Conclusion

In this paper, I pointed out the importance of the Mediterranean flights and the G-Stack collaboration as a pioneering example of international collaboration in particle physics during the early Fifties. Though a full comprehension of these flights cannot forget the analysis of their scientific success, in this context I focused on the cooperative facet of the enterprise as a strongly innovative characteristic in the contemporaneous history of physics. The reasons which led to establish such huge collaborations can be summed up in four different but related aspects: an economical reason due to the meagre resources of European laboratories at the end of the war; a scientific reason due to the enormous amount of data collected during the flights which had to be analysed as soon as possible; an ideal reason due to the faith that Powell had in scientific internationalism as a great transforming force of his time; a human reason due to the strong relationships born during the abroad visits of young researchers, mainly Italians.

The choice of collaboration, though expensive in management terms, was eventually successful. First of all because the data collected strongly contributed to solve the problem of the uniqueness of the K-meson in a very short time. Then, because the flights contributed to the circulation of knowledge of particle physics in the European context. The Mediterranean flights are an important example of how a research started from a local context became global, thus contributing to the Europeisation of the Italian physics; in the mid of the Fifties, the years of "physics" reconstruction were terminated in

[23] Donald Perkins in: Lock (1990). *Op. cit.*, p. 194.

[24] Donald Perkins in: Lock (1990). *Op. cit.*, p. 199.

[25] Rostagni, Antonio (1954). "Introduction", *Supplemento al Nuovo Cimento* 1954 *XII (IX)*, pp. 167–9, here p. 168.

Italy. Moreover, highly cooperative projects became the ordinary approach in particle physics, mainly after the birth of CERN, under whose patronage the first flights were organised.

The 1952–55 balloon flights marked the beginning of a new epoch of international collaborations, one of the main aspect of a new kind of scientific organization, the so-called big science. That is, among the several results achieved from these flights, there is also the contribution to the passage to a new stage in history of physics, due to a new form of collaboration.