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Giuseppe Occhialini: the Florentine years

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Abstract: G.P.S. Occhialini, Beppo but also Beppino for some Florentine friend, graduated in physics from the University of Florence in 1929. Bruno Rossi was his supervisor and suggested the thesis topic, together with Augusto Occhialini, Beppo's father. The Institute of Physics in Florence, together with that of Rome, was then an advanced research centre. During the period in which Occhialini was a student - until his return to Florence in 1934 after three years at the Cavendish Laboratory - eminent physicists had worked in Florence. In addition, the Mathematical-Physical-Astrophysical Seminar, promoted by Giorgio Abetti, encouraged contacts with Italian and foreign scientists. On his return to Florence in 1934, Occhialini found an environment profoundly changed from a scientific point of view: Garbasso was dead, and Bruno Rossi had gone to Padua. Persico had already gone to Turin in 1930. The fascist regime, moreover, had made life increasingly difficult for researchers who did not respect imposed constraints. Despite these difficulties, Occhialini didn't rest on the laurels collected with Blackett in Cambridge and tried to project and realize, without success, a large cloud chamber. He studied how to use photographic plates instead of cloud chamber in the same period. At the same time, he carried out clandestine activities in opposition to the fascist regime. I will highlight contributions to the study of cosmic rays that he gave in the Florentine period when he was Garbasso's 2nd assistant between 1930 and 1931 and between 1934 and 1937, when he decided to move to Brazil invited by Gleb Wataghin.

Keywords: Giuseppe Occhialini, Physics, Florence

1. The formative period

> The formative period in Arcetri represents, from 1927 to 1931, one of the three important stages in his [Occhialini] existence; the other two are the periods at the Cavendish Laboratory in Cambridge and the period at the Wills Laboratory in Bristol (Occhialini, 1974, p. 10).

Such a classification influenced historiography. However, there are at least four more periods that deserve attention:

a) the formative period between 1930 and '31 in Florence;
b) the period from 1934 to '37 in Florence;
c) the Brazilian period from 1937 to 1945;
d) the Italian period first in Genoa between 1950 and '51 and then in Milan from the academic year 1951/'52 to his retirement.

In this contribution, I will limit myself to the Florentine period, namely to the formative period and to the period 1934-37. To highlight the main cultural and technical characteristics of the Arcetri Occhialini stressed the importance of two factors:

1. the Mathematical-Physical-Astrophysical Seminar;
2. the collegial reading of journals.

The first one, favouring contacts with Italian and foreign scientists, introduced the University of Florence to an International environment. The second was promoted by Enrico Persico (1900-1969), who had regular visits to Arcetri[1], engaged all the members of the small community of physicists: Gilberto Bernardini (1906-1995), Bruno Rossi (1905-1993), Daria Bocciarelli (1910-2006), Attilio Colacevich (1907-1953), Lorenzo Emo Capodilista (1909-1973), Giulio Racah (1909-1965), Guglielmo Righini (1908-1978), to keep up to date of the contents of the journals of the very rich library (Occhialini, 1974, p. 102). As Rossi would later recall, Persico "had undertaken to unravel for us the mysteries of wave mechanics" (Rossi, 1985, p. 53).

2. The Mathematical-Physical-Astrophysical Seminar

In 1987, on the Round Table organized in Arcetri in honour of Occhialini's eightieth birthday, Occhialini drew on the blackboard an equilateral triangle, "un triangolo mistico" [a mystical triangle]. At the vertices, he entered those who, in his opinion, had been the architects of what would later be called "The spirit of Arcetri" (Casalbuoni, Dominici & Mazzoni, 2021). In the upper vertex, there was Antonio Garbasso; in the other two vertices Giorgio Abetti (1882-1982) and Enrico Persico.

Abetti was the founder of the Mathematical-Physical-Astrophysical Seminar formally established in 1932, but whose activity had begun some years earlier when he had invited Edwin Hubble (1889-1953) in 1928. Students could also participate in the seminars, and Occhialini probably attended as a student in some of them. Students could also give lectures under the guidance of Faculty professors. The word "Seminary" was even unknown to Occhialini before Bernardini spoke of it (Occhialini, 2007, p. 77).

The Archives of the Astrophysical Observatory of Arcetri preserve a rich testimony of the birth and the working of the Seminary since its inception[2]. Dozens and dozens of scholars were invited by the tireless G. Abetti to participate in the activities of the Seminar. The lectures were addressed not only to astrophysicists or mathematicians but also chemists, biologists, and engineers. In addition, we find historians and philosophers of science among the invited lecturers (Sodi, 2010). The texts or abstracts of the conferences are not in the Archives, but from the titles, it's possible to understand that lecturers were invited to talk about topics to which they were experts.

In 1930-31 Occhialini held a conference on "La diffusione nucleare della radiazione molto dura" [The diffusion of very penetrating radiation]. In 1933-34 Giulio Racah held a conference entitled "L'Elettrone positivo". In 1933-34 Giulio Racah lectured on "Le teorie di Dirac sull'elettrone positivo" [Dirac's theories about positive electron]. In 1933-34 G. Gentile lectured on "Le teorie di Dirac sull'elettrone positivo". In 1935-36 Occhialini held the conference "I premi Nobel per la fisica e la chimica" [Nobel prizes in physics and chemistry] and the conference "Assorbimento anomalo dei raggi gamma" [Anomalous absorption of γ-rays]. In 1933-34 Gilberto Bernardini lectured on "Nuove scoperte fatte a Roma da E. Fermi e dai suoi collaboratori all'Istituto Fisico di quella Università" [New discoveries made in Rome by E. Fermi and his collaborators of the Physics Institute of that University]. A conference was held by A.W. Hull (1880-1966) who talked about the thyratron, a new electronic device that made it possible and easy to control the Wilson chamber in Cambridge (Weiner, 1971, Session IV, p. 29). B. Rossi held several conferences, some of them in 1930-31 "L'azione di un campo magnetico terrestre sui corpuscoli della radiazione penetrante dal punto di vista teorico e sperimentale" [The action of a terrestrial magnetic field on the corpuscles of penetrating radiation from a theoretical and experimental point of view], and again

[1] Arcetri is a hill not far from the Florentine centre. Galileo Galilei spent the last decade of his life there in the Villa Gioiello, from 1631 to '42. In 1872 the new Astronomical Observatory of Florence was established on the hill. Later, in 1921, the physics laboratory of the Istituto di Studi Superiori, Pratici e di Perfezionamento, located in via Gino Capponi, in the centre of Florence, moved to the hill. The Institute of Physics, which took up the inheritance of the Istituto di Studi Superiori etc. became, in 1924, an integral part of the newly established University of Florence, thanks also to Antonio Garbasso (1871-1933), his first Director as well as Mayor of Florence.

[2] The Section of the Archives dealing with the Seminar and with the International Astronomical Union (IAU) has been consulted and analyzed in a voluminous thesis that contains, in the Appendices, a register of the material (Sodi, 2010).

in the same academic year "Gli effetti di latitudine e di emissione secondaria della radiazione penetrante" [The effects of latitude and secondary emission of penetrating radiation]. In 1931-32 he held the conference "I risultati del Congresso di fisica nucleare tenuto a Roma nell'ottobre del 1931" [The results of the Congress of Nuclear Physics held in Rome in October 1931] (together with G. Bernardini) (Sodi, 2010).

3. Occhialini's thesis

Giuseppe Paolo Stanislao Occhialini (1907-1993) graduated in physics from the University of Florence[3] in November 1929. In the academic year 1929-30, in addition to Occhialini, also Attilio Colacevich, Laura Romani[4], Francesco Scandone (1909-1981) graduated. Rossi was the supervisor of Occhialini's thesis. The topic of Beppo's thesis dealt with cosmic rays and was inspired, in addition to Bruno Rossi, also by Beppo's father, who knew Millikan's theory[5]. His father Augusto personally knew Kolhörster, who was working with Bothe on the detection of cosmic rays with Geiger-Müller (GM) counters and a coincidence method (Geiger & Müller, 1928). In Beppo's thesis, an Appendix presented the results of Bothe and Kolhörster's research. The paper had just appeared in *Zeitschrift für Physik*. In it, they used the method of coincidences for the study of cosmic rays. Their experimental results questioned Millikan's theory (Bothe & Kolhörster, 1929).

4. Occhialini's first paper

In 1931 Occhialini published his first paper (Occhialini, 1931). The author used (GM) counters to measure the energy of β rays emitted by weakly radioactive sources. As Beppo recalled, his choice to do research in radioactivity and nuclear physics had been influenced by a conference that Corbino had held in Florence on 9 September 1929 at the eighteenth meeting of the Società Italiana per il Progresso delle Scienze [Italian Society for the Progress of Sciences][6] (Weiner, 1971, Session I, pp. 13-14).

The instrument consists of a cylindrical box A and a GM counter B located at the centre. The weakly radioactive sample of rubidium is applied to the internal part of the cylinder (Fig. 1a). The counter is located between the pole expansions of an electromagnet. As the magnetic field progressively increased, the β rays emitted by the sample were increasingly deflected until none of them could reach the counter (Fig. 1b). In the case of monochromatic radiation, rigidity H^{ρ} of the particles emitted by the sample will be expressed by

$$H^{\rho} = H^{E}\frac{D}{2}$$

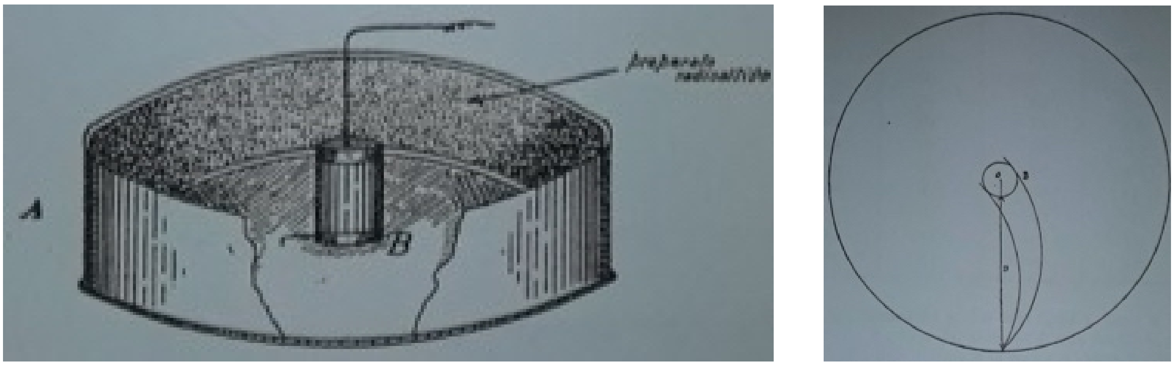
where H^{E} is the field relative to the cancellation point and D is the distance of the sample from the counter wall. More details of the apparatus were given by Bocciarelli (1931).

[3] The University of Florence started on 1^{st} October 1924 with four Faculties: Mathematical-Physical-Natural Sciences, Letters, Medicine and Law. The Faculty of Mathematical-Physical-Natural Sciences activated five degree courses: Chemistry, Physics, Mathematics, Physics and Mathematics, Natural Sciences. In 1925-26 the two-year preparatory course in Engineering was also activated Mandò 1986; L'Università degli Studi di Firenze 1924-2004; Schettino 2004; Bonetti & Mazzoni, 2007; Bianchi, Galli & Gasperini, 2013; Casalbuoni *et al*. 2016; Lucci, Salvadori & Selleri, 2019; Dominici, 2020; Casalbuoni, Dominici & Mazzoni, 2022.

[4] Little is known about Laura Romani Abigaille. Floriana Tagliabue (Tagliabue, 2022) quotes her as "Romani Abigaille, Villani Flora" among the graduates in Physics in 1929/30. Presumably, she dedicated herself to teaching mathematics and physics in secondary schools.

[5] On the influence of his father on the choice of Beppo's thesis topic there is the testimony of Livio Scarsi to whom Beppo had told that his father Augusto, having spent the summer months at the laboratory of Bothe and Kolhörster, had reported on their experiments on cosmic radiation. According to this testimony, Beppo had proposed "Cosmic rays" as a thesis topic to Bruno Rossi (Gariboldi & Tucci, 2006, p. XIV).

[6] In it, Corbino claimed that the modification of the nucleus of the atom was the only possibility of new great discoveries in physics (Corbino, 1930, p. 164).



(a) **(b)**

Fig. 1

The paper is important for many reasons:

1. Occhialini projected a spectrograph suggested by Bruno Rossi who, however, didn't want to sign the paper;
2. Daria Bocciarelli used for the potassium the same instrument Occhialini had used for rubidium. Her paper was published on *Nature* (Bocciarelli, 1931);
3. Occhialini's paper highlighted the ability of Rossi's group to build GM counters.

About points 1) and 2) Occhialini said to Weiner:

> So, I was the first pupil of Bruno Rossi... and I produced the first counter for the spectrum of rubidium. This is called the magnetic spectrum... The idea was of Bruno Rossi. He refused to sign it... it has been afterwards copied by Libby (Weiner, 1971, Session I, p. 2).

Occhialini, in the interview, cited Libby who, together with Lee, published 1939 a paper (Libby & Lee, 1939) in which an instrument very similar to that one proposed by Occhialini was described (Fig. 2). Libby used the instrument to get energies of the Soft Beta-Radiations of Rb^{37}, Na^{22}, S^{35}, and Au^{198}. Afterwards, Libby found a system for dating ancient fossils and archaeological relics based on the slightly radioactive isotope ^{14}C. Libby had become aware of the instrument and the method of using it in Bocciarelli's paper, quoted in Libby & Lee's paper of 1939.

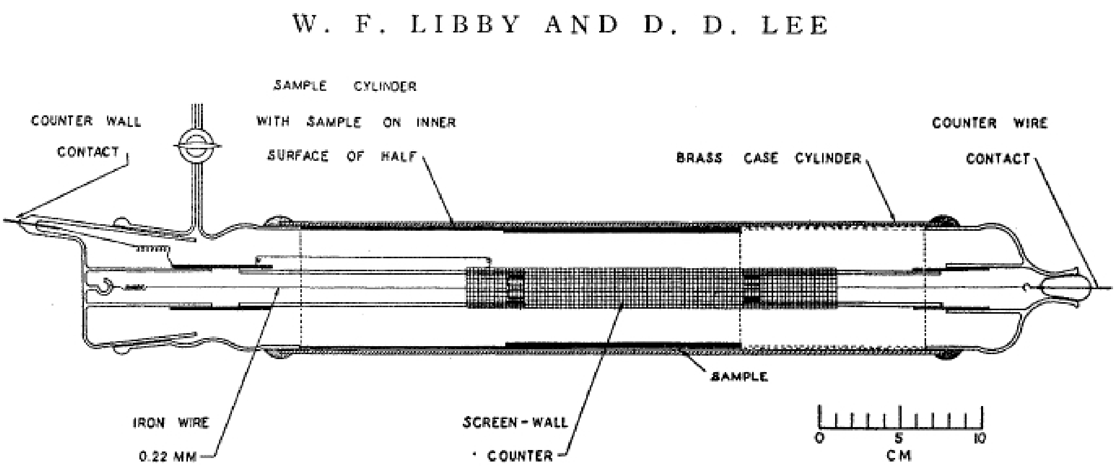


Fig. 2

5. Bruno Rossi in Charlottenburg

In the summer of 1930, Bruno Rossi attended the Physikalisch-Technische Reichsanstalt in Charlottenburg (Berlin) with a CNR scholarship. There he perfected his experimental methods on cosmic rays and the use of GM counters. The use of a simple and inexpensive instrument such as GM counters allowed the implementation of a new research program whose low cost was a very important requirement for the incipient Arcetri School. As Occhialini reported in 1971

> He [Bruno Rossi] did understand that the tube counter of Geiger-Müller was the great equalizer that would allow a very poor lad to work without the possibility of great apparatus or of buying material, most of all without radioactive sources (Weiner, 1971, Session I, p. 3).

On 7 February 1930, Rossi sent a paper to *Nature* (Rossi, 1930) in which he proposed the circuit that allowed the simultaneous detection of the discharge of several meters (multiple coincidences), thus making a marked improvement over the circuit proposed by Bothe.

Once Rossi had oriented the research group towards the study of cosmic rays and once he had acquired a great mastery of the construction and use of GM counters, Rossi turned his attention to the cloud chambers that allowed the visualization of the tracks left by cosmic rays.

Had someone in Rossi's group acquired knowledge and skills in using the cloud chamber then Rossi's idea of coincidence circuits could have been realized. The choice fell on Bernardini who, at that time, had the obligation of military service. So, it was Beppo who went there with a CNR scholarship lasting three months.

Germany would have been the other place to go, but Rossi enthusiastically reported on Blackett and his wife. Based on the report, Beppo decided that Cambridge would be the right place for him. Bernardini wrote to him:

> Look here, shall I tell you that I wish you good luck, for these three months, which you are going to pass near Rutherford, - believe me that it is a bit like to wish you happiness for all the rest of your life (Weiner, 1971, Session I, p. 38).

6. Occhialini in Cambridge and discovery of positron

When Occhialini went in July 1931 to the Cavendish Laboratory in Cambridge (UK) Blackett was one of the few people who had a complete knowledge of Wilson's chamber. However, no coincidence circuit was envisaged in the Wilson chamber, and GM counters were rarely used, an attitude that Occhialini had never understood. Rutherford's scorn for the technique was perhaps at the origin of his lack of interest in GM meters: "He seemed to have an almost religious despise for people like Geiger, Wilson, Blackett..." (Occhialini & Dilworth, 2023, p. 3). Blackett's first experience in the Cavendish reflected this attitude although he was certainly aware of the works of Bothe & Kolhörster (1929), Bothe (1930), Rossi (1930). When Occhialini arrived at Cambridge Blackett understood that the Cavendish had to change to keep up with the proposed innovations.

Blackett and Occhialini developed a cloud chamber whose expansion was triggered by a Rossi coincidence circuit realized with counters placed above and below the chamber. Integration of the GM counters with the cloud chamber and with a system that allowed particles "to take their own cloud photographs" (Blackett & Occhialini, 1933, p. 699) led Blackett and Occhialini to announce the discovery of particles of high energy, uncertain whether they were electrons or protons (Blackett & Occhialini, 1933). In 1933 the authors considered that the new phenomenon could be explained by Dirac's theory (Blackett

& Occhialini, 1933, p. 713) according to which the positron was the anti-electron whose destiny was to annihilate with an electron producing one or more photons[7].

In a letter written to Augusto Occhialini in 1948, Blackett claimed that Beppo's arrival at Cambridge prompted him to study cosmic rays, a research field he had never abandoned. The novelty of Blackett and Occhialini's work did not derive from the discovery of the positron, which had already been identified by Anderson (Anderson, 1932). The novelty of their work derived:

a) from the application, for the first time, of the Rossi coincidence circuit to the Wilson camera;
b) from the interpretation given by Blackett and Occhialini in terms of Dirac's theory[8];
c) from having designed and built an automatic system for the photograph of particles that left traces of themselves in Wilson's camera.

Points a) and b) were part of Occhialini's knowledge before he went to Cambridge. Occhialini had heard of Dirac's theory from Persico in Florence[9]. As Occhialini recounted

> He [Persico] called us one day in his studio, explained... what was the theory of Dirac, about holes and so on. And this again was of tremendous importance, for having been introduced in this way I was one of the few people in the world who knew that there was such a Dirac theory. In every textbook by now, you'll read that it was absolutely evident that the Dirac theory was the positron (Weiner, 1971, Session I, p. 26).

In the 1933 paper, the authors showed how the positive electron reacted with a negative electron emitting low-energy γ photons. This mechanism was given by Dirac's theory of electrons (Blackett & Occhialini 1933, p. 714).

Blackett had spoken with Dirac before the announcement of the new phenomenon at the Royal Society and "showed surprise at Dirac's common sense and understanding of experimental phenomena (Occhialini & Dilworth, 2023, p. 5)." According to Blackett, it was better to accept Dirac's theory than no theory at all (Weiner, 1971, Session I p. 50). Although Dirac worked at the Cavendish Laboratory, he was not held in high esteem by Rutherford. As Occhialini recalled in his Memoirs, Rutherford, speaking of Dirac, said: "When Dirac, who has already greatly improved, will know some physics" (Occhialini & Dilworth, 2023, p. 2).

Blackett in his Nobel Lecture claimed:

> The fate of the positrons was discussed in relation to Dirac's theory of holes. On this theory a positive electron was envisaged as a "hole" in a sea consisting of an infinite number of negative electrons in states of negative kinetic energy. Dirac's theory predicted that a positive electron would disappear by uniting with a negative electron to form one or more quanta. Occhialini and I suggested that the anomalous absorption of hard gamma rays by nuclei might be a result of the process of pair production, and that the

[7] In 1962 John L. Heilbron tried to interview Blackett who, however, would neither let Heilbron use the recorder, nor take any notes. So, we have only what Heilbron recalled about the conversation. According to Blackett, Bohr was initially unconvinced by Anderson's evidence, but persuaded by the extensive evidence offered by the photographs of Blackett and Occhialini. Dirac worked very closely with them; in fact, he was often at the laboratory. When asked how long they had known about Dirac's theory, Blackett replied he wasn't quite certain, but that it didn't matter anyway because nobody took Dirac's theory seriously. Thus, although Dirac's theory involved such a difficulty, it was hardly evidence enough for a convincing demonstration of the existence of a new particle. Dirac himself at first identified the negative energy particles with protons (Heilbron, 1962).

[8] "Anderson realized that there was a connection between his work and the research of Dirac *after* reading the paper of Blackett and Occhialini" (Hanson, 1961, pp. 311-312). On the contribution of Blackett and Occhialini to the 'discovery' of the positron, Leone and Robotti have written several papers. In them, they rightly stressed that Blackett and Occhialini weren't driven in designing their experimental apparatus by Dirac's theory, although both were aware of its contents (Leone & Robotti, 2012, p. 540).

[9] Before Occhialini went to Cambridge, Dirac had published four papers: (Dirac, 1928a, 1928b, 1930b, 1930c, 1931). From their analysis, it can be deduced that the author himself had several doubts and in one of them, as well as in the first edition of the *Principles of Quantum Mechanics* of 1930 (Dirac, 1930a, p. 248), he thought that the new particle (yet to be discovered) was the proton, as Blackett noted in 1962 (Heilbron, 1962). However, all doubts disappeared in Dirac's Nobel lecture of 1933: "On this view the positron is just a mirror-image of the electron, having exactly the same mass and opposite charge" (Dirac, 1965). The same happened at the seventh Solvay conference in Brussels in 1933 (Dirac, 1934, p. 205).

> observed re-emission of softer radiation might represent the emission of two 0.5 MeV quanta resulting from the annihilation of a positive and negative electron. Subsequent work has confirmed this suggestion (Blackett, 1964, p. 106).

In his Memoirs, Occhialini reported that Dirac's theory wasn't acknowledged by Rutherford and Chadwick, unlike Rome's group who sent to Occhialini a telegram based on his love of caving: "Congratulations for explanation of Dirac hole" (Occhialini & Dilworth, 2023, p. 8).

About point c) an interesting testimony is given by Occhialini in the interview given in 1971. In 1970 Rossi sent to Occhialini a text of a lecture he had to do on the radio. In it, Rossi also inserted the point of view of Occhialini, who reacted by saying that his views had been distorted. Rossi had written that Occhialini had left Florence so that he could put counters in the experiment with a cloud chamber. According to Occhialini that was not true as when he arrived in Cambridge Blackett had proposed to put together two different techniques: the one Rossi had taught Occhialini, namely the use of GM counters to activate the cloud chamber and the technique which "this undiscussed[10] master" (Weiner, 1971, Session III, p. 11) used to produce cosmic rays, i.e. Blackett's deep knowledge of the cloud chamber (Weiner, 1971, Session III, p. 18). When Rossi stressed only the technique he had invented, he made a mistake.

A third one must be added to these two techniques: that of activating the photo-camera to take photos of the phenomena that occurred in the cloud chamber. Both Blackett and Occhialini made a significant contribution to this technique (Blackett, 1934).

In a private conversation with Hanson H. Bethe said: "Nobody took 'experimental' positive electrons before 1933 seriously, nor did Dirac make the connection in 1931" (Hanson, 1961, p. 198).

7. Occhialini in Florence between 1934 and 1937: a new cloud Chamber

Occhialini returned to Florence in March 1934 after three years at Cavendish Laboratory instead of the three scheduled months. In Cambridge, he had been persecuted by letters from his Florentine friends who urged him:

> to leave England and to try to make peace with the University authorities and the fascist Party. Under these conditions I could only work like a madman in the hope that my luck would turn (Occhialini & Dilworth, 2023, p. 12).

When in August 1933 he went to Zurich for a meeting, he decided not to go to Italy. "I had the depression of being jobless and very bitter from misunderstandings" (Weiner, 1971, Session III, p. 20). But after a few months, Occhialini returned to Italy due to his mother's deteriorating health. He also went to Florence to dispel some rumours that ran about his person; he had the impression that his Florentine colleagues accused him that he was giving himself airs and that he was going to get a job in England. He spoke with Bernardini who, citing what some newspapers have written, told him that he should have talked about Florence. It was on that occasion that Occhialini thought that perhaps it was better to work in the Rome Group (Weiner, 1971, Session III, pp. 47-48).

In 1934 Occhialini definitively came back to Florence. He found great changes: Garbasso died in 1933, Rossi had won the chair and moved to Padua in 1932 and in 1930 Persico went to Turin on the chair of Higher Physics. Moreover, the fascist regime had further strengthened its presence in society and institutions.

In Florence, he started planning a cloud chamber, the largest ever. On this, he had been thinking during the last month in Cambridge. But, as he said in his interview, "I mucked it completely" (Weiner, 1971,

[10] In Weiner, 1971, which holds the transcription of the recorded interview, instead of 'undiscussed' there is the word 'undisclosed'. The transcription was not checked by Occhialini.

Session IV p. 6). The problem was the magnetic field (20.000 gauss); he had completely underestimated the problem of the lack of funding to have enough electrical power.

Moreover, the workshop did not exist, the technical staff was missing, and the students were not interested. From a general point of view, there was only one certainty: sooner or later, war would break out, and everything would be blocked.

> every night when I was going to bed, I was kneeling near my bed, asking, "let me for once be right, let me for once be right" (Weiner, 1971, Session IV p. 6).

Bernardini suggested he contact Marconi, then President of the CNR and an influential politician. But the only result that Occhialini got was a letter on Marconi's letterhead, given to him by Marconi's secretary. Marconi (or maybe his secretary) wrote "what Dr. Occhialini wants to do is worthy of help." The sentence of Laureto Tieri (1879-1952), Garbasso's successor, was unequivocal: "This letter doesn't mean absolutely anything" (Weiner, 1971, Session IV p. 14). The letter was never used. Occhialini turned to Officina Galileo for financial support, but the result was once again negative.

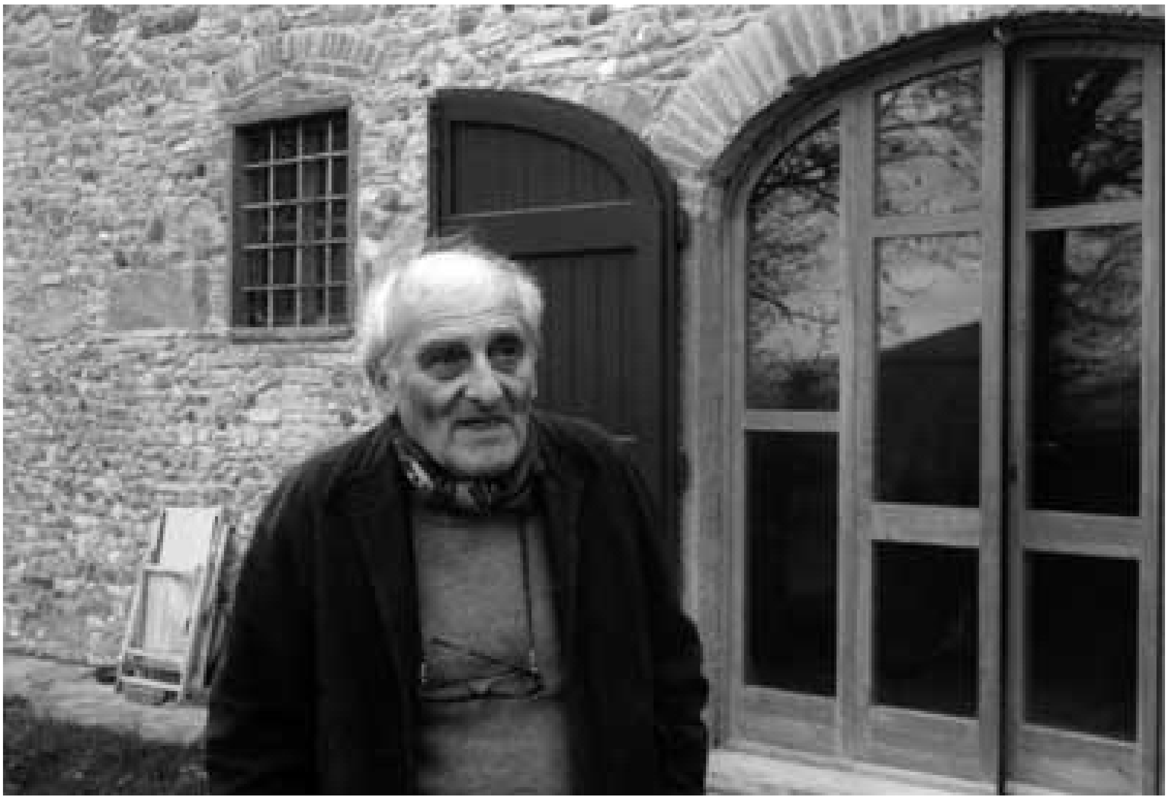


Fig. 3: Giuseppe Paolo Stanislao Occhialini (1907-1993) in front of the country house in Marcialla (Florence) where together with his wife Constance Dilworth moved in 1985.

8. Occhialini in Florence between 1934 and 1937: photographic detection of particles

To my knowledge, Occhialini mentioned the attempt in 1936 to replace the cloud chamber with a photographic plate in the interview. At one point in the conversation, the interviewer, Charles Weiner, asked him whether he had received any material from his old friends in Cambridge. Occhialini replied that when he was in Florence he was interested in the photographic detection of particles and added: "I thought that this was the chief thing... It was the kind of things that was at this moment starting" (Weiner, 1971, Session IV p. 51). Blackett sent him two boxes of infrared halftone plates. Occhialini bombarded them with α particles but when he went to develop them, they were black. Afterwards, he used a polonium beryllium source to get neutrons and could start investigating neutron tracks. But when he developed them, he realized that in this case the flop was also complete.

He deduced that there was some problem with the plates and not with the procedure he had imagined. Beppo resumed his old project in Bristol when he worked with Powell.

9. Conclusions

The figure of Occhialini (Fig. 3), despite the extensive documentation available, including his publications, remains full of contradictions. Many scientific events that characterized his research are difficult to reconstruct. To avoid getting involved in psychological problems that I would not be able to manage, I would like to underline some points regarding his scientific achievements. What was his contribution in the collaboration with Blackett in the rediscovery of the positron and the interpretation of the experimental results according to Dirac's electron theory? As we have seen, Occhialini knew Dirac's theory of the electron because Persico had talked about it in Florence. And Dirac worked at the Cavendish, as did Blackett. In the discovery of the muon and the pion in Bristol in 1947, what was his contribution beyond the suggestion to Ilford of concentrated emulsions?

Occhialini had a complex relationship with Florence: while on the one hand Garbasso, Abetti, Persico, and Rossi had influenced or even determined his scientific culture before going to Cambridge, on the other, on his return to Florence in 1934, he felt that world had dissolved: Garbasso was dead, Persico and Rossi had gone to Padua and Turin respectively. Only Bernardini remained who, however, in 1937 left Florence for Camerino. In the same year, Racah went to Pisa. Daria Bocciarelli was leaving for the Istituto Superiore di Sanità in Rome where she arrived in 1938. Finally, with the enactment of the racial laws, starting in 1938, the Italian University was deprived of professors of Jewish origin. When he was in Cambridge, Occhialini considered himself a barbarian although he was aware of his roots in the Marche and Tuscany, cradles of the Renaissance. This is how one of his colleagues described him: "he holds his listeners spellbound when he talked about... the beauty of Tuscany and Umbria landscape" (Tagliaferri, 1994). When, in 1937, Occhialini decided to go to Brazil leaving the Florence "paradise", where he came back only in passing several years later, he realized that something profound was happening in his life: "at the moment in which I was leaving Florence I had a very clear idea that I was closing the door of my youth and that I would not be young anymore" (Weiner, 1971, Session IV, p. 33).

Afterwards, Occhialini expressed high esteem for Blackett, unlike what he had said and written about Powell. But this did not prevent the wise and mature Occhialini from dedicating a commemorative plaque on a bench to Powell at the Capanna Vittoria mountain refuge, on Alpe Giumello, in Valsassina where Powell had died during a walk on 9 August 1969.

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