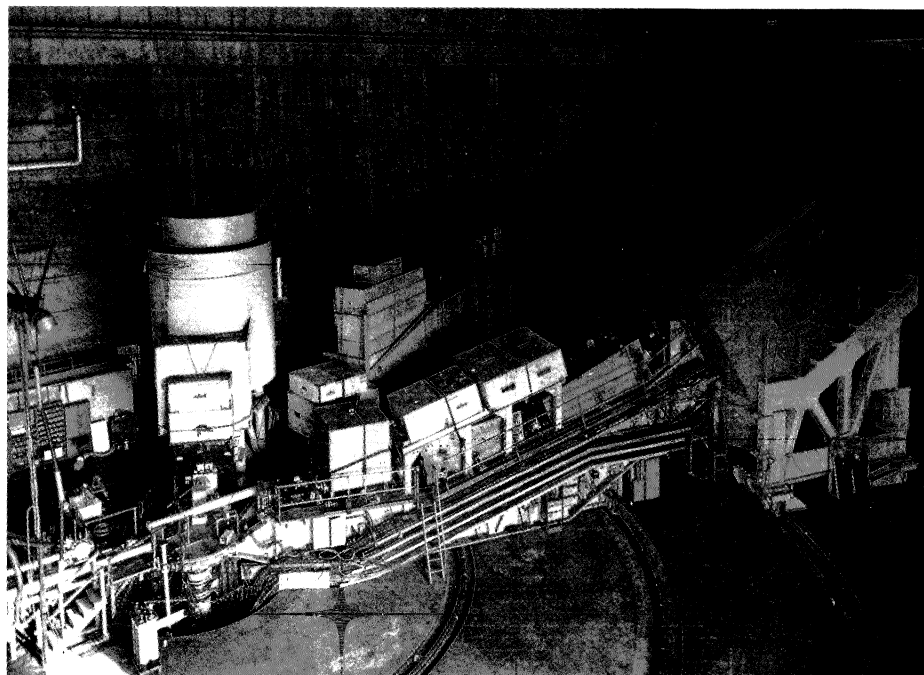


The same detectors almost two decades later, still soldiering on.



hulks have wrought in the minds of men and women – in the way we now perceive our entire Universe. Occasionally a bird flies past the massive open doors and into this vast concrete cavern, diving and screeching above, as if laughing at my futile efforts.

How is it possible to be so sentimental about mere artifacts – lifeless configurations of concrete and steel, lead, plastic, and glass? How can a scientist be so unscientific? Were he alive today, a famous American general, hero of World War II, would probably understand my feelings for these aged veterans. 'Old soldiers never die,' he said when relieved of his command during the Korean War; 'They just fade away.'

The pion's pioneers

In 1946, a band of intrepid physicists took a batch of a new kind of photographic emulsion up the Pic du Midi in the French Pyrenees to expose them to cosmic rays. After analysing the results at Bristol, C. M. G. Lattes, H. Muirhead, G. P. S. Occhialini and C. F. Powell were able to announce early the following year that they had seen the long-awaited pi meson, or pion, postulated by Yukawa in 1935 as the carrier of the strong nuclear force. This landmark discovery quickly revitalized particle physics after all its wartime upheavals.

At the end of July, the H. H. Wills Physics Laboratory at Bristol was the scene of an unusual and memorable international conference to mark the 40th anniversary of this discovery.

40 years ago, Lattes was a young research worker brought to

England from Brazil by Occhialini, also recently arrived from that country at the instigation of P. M. S. Blackett, with whom he had worked in the Cavendish Laboratory in the early 1930s developing the counter-controlled cloud chamber technique. Muirhead was a young research student who had graduated at Bristol in 1946 while Powell, then a Reader in Physics in the Wills Laboratory, had spent many years perfecting the nuclear emulsion technique.

What these workers observed in new Ilford nuclear research emulsions exposed to the cosmic radiation at mountain altitudes were clear-cut examples of the decay of a heavy meson (about three hundred times heavier than an electron) to a lighter meson (about two hundred times the electron mass) of unique energy – a two-body

Peter Fowler recounted the pion discovery at the Bristol 40th anniversary meeting. Fowler, whose association with Bristol stretches over a comparable span, is a grandson of Rutherford. His father, Ralph Fowler, a key theorist at the Cavendish Laboratory in Cambridge, was married to Rutherford's only daughter Eileen.



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It was Cesare Lattes (left) and Hugh Muirhead who, together with G. P. S. Occhialini and Cecil Powell, discovered the pion at Bristol in 1947. The two met again at Bristol in July at the meeting to mark the 40th anniversary of the epic discovery.

decay process. At the very same time and quite independently R. Marshak and H. Bethe announced their two meson hypothesis to account for the apparent failure of the meson normally observed in cosmic rays to behave like Yukawa's particle.

Both Lattes and Muirhead were present at the meeting but Occhialini, who is living in retirement in Italy, was unable to come although he sent a message by his wife, Connie Dilworth, who attended one of the sessions. Cecil Powell died in 1969 but his wife Isobel was present throughout the Conference.

The list of about 100 participants included some of the famous names in cosmic ray and particle physics, many of them now retired; E. Amaldi, Sir Clifford Butler, M. Conversi, R. H. Dalitz, P. H. Fowler, Sir Charles Frank, H. Fröhlich, W. Jentschke, N. Kemmer, R. E. Marshak, Sir Rudolf Peierls, D. H. Perkins, J. Pniewski, G. D. Rochester, R. D. Sard and V. L. Telegdi, to name but a few. The Chancellor of the University, Dorothy Hodgkin, was also present.

The first invited paper was from Marcello Conversi – 'From the discovery of the "mesotron" to that of its leptonic nature.' He recalled the early work on muons carried out in Rome under the German occupation by Pancini, Piccioni and himself, and how to escape Allied bombs they had to move their apparatus through the blacked-out streets of the city to sanctuary near the Vatican. Then N. Kemmer ('Waiting for the Pion') reviewed the theory of the 1930s, including his famous 1938 paper formulating a meson theory with positive, negative and neutral mesons giving exchange forces between nucleons



independent of their electric charge.

Peter Fowler described the actual pion discovery in the early months of 1947. He stressed that the discovery was made possible by the development by Ilford Ltd (and later Kodak) of special nuclear research emulsions, under contracts placed by the UK Ministry of Supply as soon as the war had ended as part of the UK effort to restart pure science. The university physicists improved the processing methods so that it became possible to develop thicker emulsions, greatly improving the technique.

These new emulsions, only 50 microns thick and 2×1 cm in area, were taken by Occhialini to the Pic du Midi in 1946. When developed and examined in Bristol, Powell later recalled in his autobiography 'it was as if, suddenly, we had broken into a walled orchard,

where protected trees had flourished and all exotic fruits had ripened in great profusion'. Powell and his co-workers soon saw examples of slow mesons captured by nuclei and causing a disintegration, as did Don Perkins, then at Imperial College, in emulsions he had exposed in an aeroplane. However, it was Lattes, Muirhead, Occhialini and Powell (or rather Marietta Kurz and Irene Roberts – wife of the late Max Roberts of CERN's EP Division) who had the good fortune to find within a few days two examples of the now well known decay of a pion into a muon. Since the mass difference between the two particles is relatively small, the muon only had an energy of about 4 MeV, corresponding to a range of about 600 microns in emulsion. If it had been much greater the muon would have escaped the thin emulsions initially

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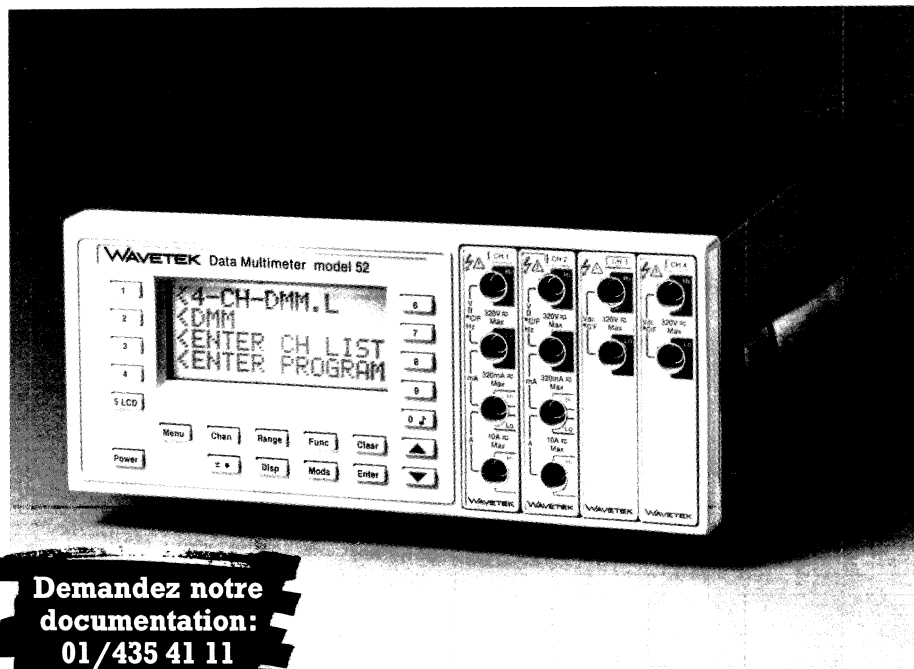
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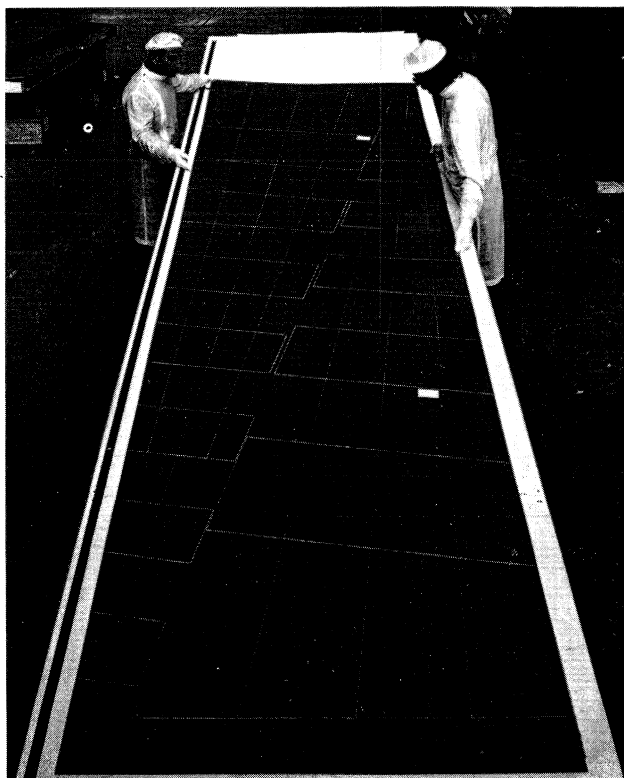
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Cecil Powell's research group at Bristol in 1949. Rear row, left to right; A. R. Gattiker, Mary Cole, Mrs. M. L. Andrews, Mary Merritt, Alex Cole, Peggy Ford, Miss P. Dyer, June Cowie, Grace Hussey, Mrs. B. Moore, Mrs. J. Van der Merwe, Mary Jones, Margaret Stott. Middle row; W. O. Lock, J. H. Davies*, D. T. King*, H. Heitler, S. O. C. Sorensen*, Mrs. I. Powell*, C. F. Powell. Front row; T. Coor, H. Muirhead*, U. Camerini, C. Franzinetti, N. Tobin, P. H. Fowler*. (Those indicated with an asterisk were present at the Bristol meeting this year.)*

(Photo University of Bristol)

used and the event would not have been recognized.

Fowler recalled that in order to get more events by exposing emulsions at higher mountain altitudes, Lattes travelled to Mount Chacaltaya in Bolivia, where there was a meteorological station at 5300 metres. The then Head of the Department, A. M. Tyndall, suggested that he should fly British – BOAC as it then was – to Rio de Janeiro but Lattes preferred the Brazilian airline Varig which not only had a new type of plane – a Constellation – but also served thick steaks. A wise choice as the BOAC plane crashed at Dakar with no survivors.

In the discussion following Fowler's paper, Lattes was able to correct a story which has been current for forty years. It was often said that artificially produced pions were only seen in emulsions exposed at the Berkeley Cyclotron when Lattes arrived there early in 1948 and showed how to correctly develop the emulsions. In fact Lattes said that at the time Gardner (who was making the exposures) was not well and did not have time to scan the emulsions systematically. Lattes had the time and knew exactly where to look, which is why he found the first examples of artificially produced pions.

One of the persons all emulsion physicists present at the Conference were pleased to see was C. Waller, for many years Chief Chemist at Ilford and together with the late M. A. Vincent the man largely responsible for the production of the Ilford Nuclear Research Emulsions, and especially the electron-sensitive G5 type. One highlight of the Conference was Waller's short talk, including a practical demonstration of the preparation of nuclear emulsion, frequently



stopping his delivery to give the emulsion mixture a stir or two in a large glass jar!

Electron-sensitive emulsions (sensitive to particles of minimum ionization) became commercially available in 1948 first from Kodak as NT4 and then early in 1949 as Ilford G5. Owen Lock described how the Bristol group exposed the new emulsions first on the Jungfrau-joch (Switzerland) and then higher up in the atmosphere by means of free balloons.

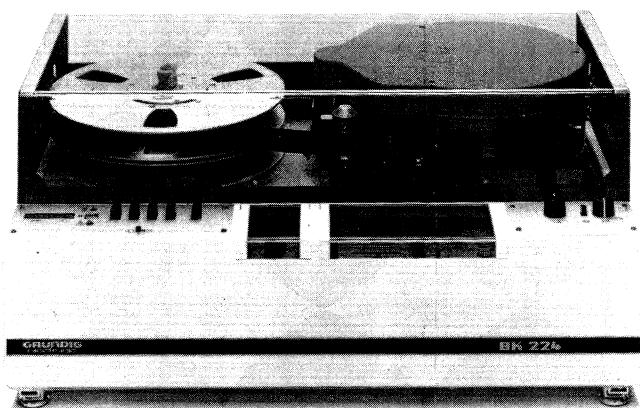
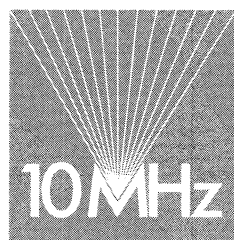
Almost at once the first example was found of a heavy meson decay into three charged pions (later called the tau-meson and finally reidentified as a kaon) while the analysis of the events found in emulsions flown on a single balloon flight at 70 000 feet for 90 minutes provided enough material for a series of now classic papers published in the Philosophical Magazine in the years 1949 to 1951. In these studies the production and interaction properties of the charged pions were established and evidence also obtained for the

creation of neutral pions, with even an estimate of their lifetime at less than 5×10^{-14} seconds, a remarkable achievement, made possible by the micron resolution obtainable in the emulsion.

Don Davis followed with a comprehensive survey of the subsequent use of emulsion for the study of hyperfragment physics, the determination of the magnetic moments of the lambda and sigma hyperons and more recently for charm and beauty searches.

The year 1947 also saw the discovery in cloud chamber pictures of the charged and neutral kaons – then called V-particles – by Rochester and Butler at Manchester. The second day of the Conference began with two historical talks by the pair. George Rochester, still sprightly despite his advancing years, gave an excellent account of the early cosmic ray work at Manchester which led up to the discovery of the V-particles in a small cloud chamber operated at sea level. As with the first 'tau-meson', no further examples

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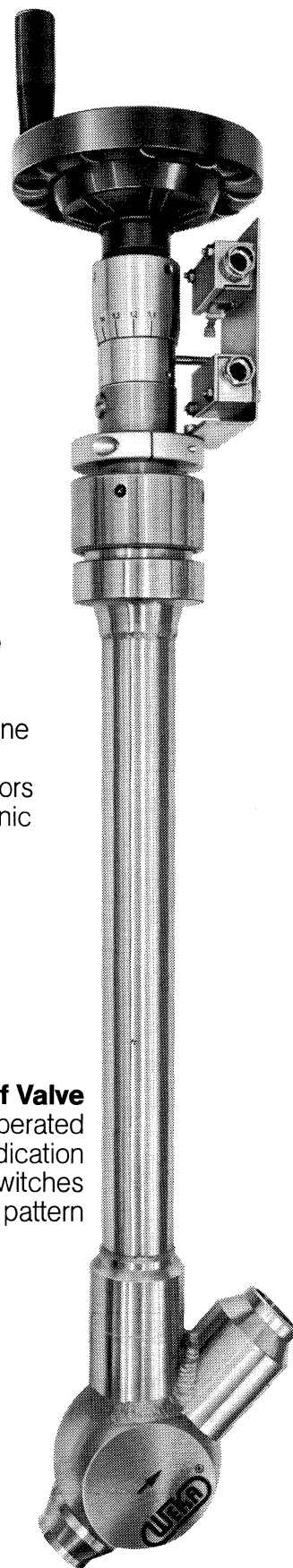
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Particle physics research in the late 1940s. Owen Lock (right) and Max Roberts prepare a balloon for launching.

of these new and strange events were found for more than two years, which unnerved the authors (both in Bristol and in Manchester)!

It was soon realized that more events might be obtained by moving the apparatus to the mountains, easy and even essential for emulsions, but difficult for a cloud chamber and its large magnet. In those days there was no telepherique to the top of the Pic du Midi in France while the facilities on the Jungfraujoch could not handle the 3-ton magnet base plate. In his 'Physics on the Mountaintops' talk Clifford Butler described how Occhialini persuaded his old friend and colleague Blackett to transport the so-called Blackett magnet of the Manchester cloud chamber to the Pyrenees in 1949. The Manchester contingent there was soon joined by a group from Leprince-Ringuet's Ecole Polytechnique in Paris with Armenteros, Astier, Gregory, Lagarrigue, Muller, Peyrou and others. A little later a new cloud chamber and magnet from Manchester was installed on the Jungfraujoch by the late J. A. Newth and others and the operation of this facility was later turned over to CERN – hence the

reference to cosmic rays in the CERN Convention.

The Conference concluded with a masterly theoretical survey of the whole field of pion physics by Dick Dalitz and with concluding remarks from Don Perkins. Earlier, at the Conference dinner, Edoardo Amaldi spoke on 'The beginnings of particle physics – from cosmic rays to CERN'. As a suitable finale Peter Fowler showed a series of short films of some of the balloon launches of emulsion stacks in the various expeditions to Italy in the 1950s.

The highly successful Conference brought together many of those active in the cosmic ray field in the immediate post-war years, who were able to record their recollections for the benefit of historians of particle physics and all those interested in the development of the subject. Many friends and colleagues from those exciting pioneer years met once again, in many cases for the first time in twenty or more years and in a few cases for the first time in thirty-five years! Old friendships were taken up as if they had never been interrupted. The only regret of the participants was that they did not

have more time to talk to each other.

The efficient Organizing Committee was chaired by Peter Fowler, with Brian Foster as Organizing Secretary. Sponsors were the UK Science and Engineering Research Council and the Institute of Physics, together with Bristol University. The Proceedings will be published by Adam Hilger as the publishing house of the UK Institute of Physics. In addition to the papers and subsequent discussion, selected reprints of seminal papers will be included. In the near future the University of Bristol will republish the fragment of autobiography on which Cecil Powell was working at the time of his death, together with some photographs from Mrs Isobel Powell and from the archives of his department. The booklet 'Cecil Powell: Fragments of Autobiography' is available from the Information Office, University of Bristol, 8 Priory Road, Bristol BS8 1T2, UK, price £ 2.50 (Cheques payable to 'University of Bristol').

The meeting came at a time when the support for pure science in the UK is being rethought. The pioneering cosmic ray work in the UK had a strong influence on the emergence of particle physics in Europe and many of the early international collaborations formed in those days helped to create the favourable atmosphere for the subsequent creation of CERN in the early 1950s. Those at Bristol took the opportunity to send an open letter to British Prime Minister Margaret Thatcher appealing to her to intervene personally to prevent a 'tragedy' that might befall British science if the United Kingdom pulled out of CERN.

By Owen Lock