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GARGAMELLE AND BEBC

HOW EUROPE'S LAST TWO GIANT BUBBLE CHAMBERS WERE CHOSEN

Dominique Pestre

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In the closing months of 1963, the debate in the United States was well under way on the large bubble chambers necessary for the 1970s and 1980s. At this time hydrogen chambers of about 2 metres were already being used at Berkeley and, for less than a year, at Brookhaven. The importance of neutrino physics, a domain in rapid expansion since 1961 and 1962, was the reason most often given by those supporting projects for new chambers. This was a physics which required the presence of very large volumes if one was to obtain an interaction rate which was not totally negligible. As a corollary those who used this argument insisted that the bubble chamber was still the detector par excellence, the detector which recorded all charged particles without a priori selection. It still was the "universal detector", to use an expression coined by Alvarez in 1957 when he tried to convince the physics community that his device would dominate electronic detectors in the future.

It was against this background that, in January 1964, R.P. Shutt, who was responsible for the 80-inch hydrogen chamber commissioned the previous year at Brookhaven, produced a report for the laboratory management. Surveying the studies made at Stanford and elsewhere on the East Coast during the preceding months, Shutt concluded that a "good compromise" would be to build a heavy liquid chamber of 10,000 litres or a hydrogen chamber of 40 m^3.[1]

1. Towards a First Choice for a Heavy Liquid Chamber, Gargamelle

1.1 *A snap-shot of events, January-June 1964*

The debate in Europe got under way in January/February 1964, essentially because the question was then at the top of the agenda in the United States and because it was impossible for Europe to lag behind these developments. Let us not forget that during these years it was still the Americans who fixed the rhythm of evolution for detectors in high-energy physics, both as regards technological innovations and as regards size.

The first report which appeared in Europe was written by André Lagarrigue, one of the three most important people at the Ecole Polytechnique in Paris and one of the leaders of heavy liquid chamber physics at CERN. Lagarrigue's report, dated 10 February 1964, proposed the construction of a common European heavy liquid chamber 8 metres long and 1.65 metres in diameter (i.e. of some 17,000 litres), a

[1] For these two paragraphs, *History of CERN*, vol. 2, chap. 8; *Note* by R. P. Shutt, 30/1/64 (DG 20569).

chamber to be built under the supervision of CERN.[2] European laboratories interested in it could contribute directly to the costs of construction but would not build their own. This attitude on the part of someone whom, we can be sure, envisaged playing a crucial role in the realisation and use of this new detector shows that the lessons of the years 1958-1961 had been learned. Since there was little room for too many heavy and relatively immobile detectors like bubble chambers around the giant accelerators at CERN or at BNL, it was indispensable to negotiate the number and the kind of such devices in advance. As far as heavy liquid chambers were concerned, this certainly meant that it was impossible to build and to instal at Geneva more than one single chamber. This explains why Lagarrigue envisaged a joint project with Franzinetti and the Italian groups (and possibly also with British groups), and that he accepted a "neutral" zone like CERN as the official centre for the project.

In March, with the American physicists apparently advancing rapidly, Lagarrigue and Franzinetti gathered together at Geneva the European heavy liquid specialists. Their aim was to ensure that they would not be forgotten at a moment when "the most serious competition to the heavy liquid chamber for neutrino physics", what looked "very much like the ultimate weapon for physics in the 10 GeV region" seemed to be "the very large (e.g. 40 m^3) hydrogen chamber such as proposed by Shutt". This fear of being marginalised had two consequences. Firstly — and this was the purpose of the meeting — the heavy liquid specialists felt that they had to react quickly. Secondly, they thought it best to capitalise on what were their strengths — i.e., that heavy liquid chambers were relatively cheap and simple to build and that it would be possible to have one operational *well in advance* of any (American or European) hydrogen chamber. They felt it was therefore essential not to lose a moment, to start immediately on studies, and if necessary to reduce the size of the chamber. This is what Lagarrigue proposed early in April, suggesting that its volume be reduced from 17 to 10 m^3.[3]

Two different attitudes emerged at the meeting held at CERN on 9 April 1964. The first one was that of the French and Italian physicists who wanted a very big heavy liquid chamber constructed rapidly. They disagreed, however, on the length of the chamber. While everyone understood Lagarrigue's reasons for reducing the

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[2] Letter Lagarrigue to Weisskopf, 14/2/64 (DG 20568); *Rapport sur un projet de chambre à liquides lourds* by Lagarrigue, Musset, Rousset, February 1964 (DG 20569); report by Fiorini, Guerriero, Mannelli, Negri, Scotoni, undated (DG 20567).

[3] Letter Lagarrigue to Hine, 3/4/64 (DG 20568); *Record of a meeting...*, 14/4/64 (DG 20568) from which these quotes are taken; SPC/182/Add., 20/4/64.

chamber length from 8 to 4-5 metres, opinions were divided as to the effect that this would have in the long term (the chamber risked becoming obsolete rather rapidly). It was thus suggested that the size question be reconsidered later. The second attitude was that of the CERN management. As expressed by Hine, it was that "since the budget for 1966 and the forecasts for 1967 and 1968 would not be fixed until December 1964, CERN could not make any commitment before then [...]". There was some truth in the argument, obviously, but one can also see in it a wish to be cautious on the part of an organisation which had always tried to have the best equipment possible. Clearly, CERN wanted to compare the respective advantages of a heavy liquid chamber and a hydrogen chamber before committing itself to anything.[4]

A decision of this nature (which was a decision to wait) could easily have slowed down the entire process — particularly since the Italian physicists led by Franzinetti apparently were not able to gather together the money needed for their participation. In the event this did not happen. This was because the French physicists in these years were rather rich, so that an agreement was rapidly reached between Francis Perrin, High Commissioner of the CEA, and Bernard Grégory, the director of research at CERN and in fact the most senior physicist at the Ecole Polytechnique. They decided that France would take overall responsibility for the chamber. The agreement reached at the end of June was that two-thirds of the construction costs would be borne by the CEA, that the remaining costs of the construction would be paid by the Ecole Polytechnique with a contribution from the Geneva laboratory, and that the costs of installation would be charged to CERN. Certainly no formal decision could be taken by CERN, for the reasons given by Mervyn Hine. However, it seems difficult to imagine that the European physicists would refuse such a gift and that they would not succeed, in due course, in having the necessary sums included in the organisation's budget. As for the construction, it was planned to do this at the CEA's laboratory at Saclay under the direction of R. Florent.[5]

In brief then a project crystalised in less than six months — Lagarrigue's final proposals regarding a chamber reduced in size being temporarily accepted. This first extremely rapid phase of the decision-making process calls for certain comments.

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[4] *Record of a meeting...*, 14/4/64 (DG 20568) from which the quote is taken.

[5] Letter Grégory to Rousset, 24/6/64 (DG 20568).

1.2 *How are we to understand a choice as rapid as this?*

Firstly, it is important to survey the set of circumstances which led to the "decision" to finance a heavy liquid chamber 4-5 metres long and 1.5 to 2 metres in diameter. The "trigger", if one can call it that, was the rapid progress in America during the last months of 1963, a development which stimulated in Europe a desire to follow the trend. This was the first reason put forward by the partisans of bubble chambers and it was accepted as completely legitimate by their colleagues.

The second factor accounting for the quick agreement was the importance which neutrino physics had in Europe. During the two previous years this research had been strongly supported by Victor Weisskopf and had become of central importance at CERN. Heavy liquid bubble chambers were detectors well adapted to it. Perhaps they were not the only kind of chamber suitable for this work, but neutrino physics was one of the areas in which they were known to perform extremely well.

The third reason why this "choice" was so quick was that only one group of protagonists was involved in this debate, that there was not really a competing project: in fact there was no choice in the usual sense of the word. Presenting the American studies led by Shutt as a menace for Europe, the heavy liquid specialists formulated a project which was naturally centred around their competence and their know-how. They did not envisage any other alternative. In a certain sense this point is very banal because it amounts to saying that Lagarrigue (or Franzinetti) were fighting for themselves and for their groups and that above all they sought to finance their projects and to have new resources at their disposal. It is worth mentioning all the same when one bears in mind the way in which this type of decision is often described.

The final element, and probably the most decisive, is related to Grégory's personality and to the position which he had in the French decision-making system. In particular one must not forget that Grégory was a specialist in bubble chambers, convinced of the potential of neutrino physics, and of the competence of the head of the project who would be Lagarrigue. Grégory knew that money could be obtained in France for high-energy physics, and he preferred to see such investments made in equipment for use at the centre of excellence that was CERN rather than going to a national accelerator which would necessarily be smaller. He thus persuaded Perrin to act quickly and he imposed his choice on the clan of the Polytechniciens.[6]

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[6] See in particular *History of CERN*, vol. 2, chap. 12. 5 and 12. 6.

Are we saying that there was nothing really at stake here, that there was no scientific debate around this decision, that the technical arguments used in the reports written throughout 1964 were only cosmetic, and that they were only there to create a good impression? No, to say this would be false, it would be to overlook an essential dimension of the process. At the same time it is important to appreciate the exact place and the effect of these reflections.

Certainly, in the debate at issue the protagonists spoke regularly of physics, particularly when they had to define the size or the shape of the chamber, or when they needed to justify its need vis-à-vis outsiders. These discussions were often lively and they took place regularly, but it would be mistaken to deduce from this that they determined the nature of the final proposal. Comparative judgments and opinions differed from one physicist to the next and experimentalists admitted openly, for example, that the theories they used to make their predictions would be obsolete within five or six years. Anyway, they all knew that it was essential to be pragmatic about money (who would pay and how much could be reasonably hoped for?) about time (what was the situation in the competition between America and Europe?) and about space (could several detectors be installed around the same accelerator?). In any big science decision then it is always a mix of very heterogeneous motivations which prevails, a cocktail which is always very specific and composed of quite different ingredients. And in this cocktail strictly scientific arguments often carry very little weight.[7]

2. The Emergence of Hydrogen Bubble Chamber Projects and Grégory's Proposal for a Tripartite Solution, September 1964-May 1965

As we have already mentioned, a hydrogen chamber is much more complex and sophisticated than a heavy liquid chamber, if only because one has to manipulate liquid hydrogen at a very low temperature. It is also a device which imposes extremely strict security requirements during its use (there are risks of an explosion of this vast mass of hydrogen) and of which the construction costs are several times those of an equivalent propane or benzine chamber. On the other hand, there are distinct advantages when it comes to interpreting the photographs taken with the device. Since the incident particles only interact with protons (the nuclei of hydrogen)

[7] This is developed in greater depth in Pestre (1989).

and not with the nuclei of complex molecules the events produced are "cleaner" and their interpretation is facilitated.[8]

2.1 *Converging on a single CERN-Franco-German project, Autumn 1964*

In contrast to Lagarrigue's project, no dominant centre appeared for the construction of a hydrogen chamber. On the contrary we find, in the space of a few months, three "groups" declaring their wish to construct or to participate in the construction of such a chamber. These projects were more spectacular and ambitious than a heavy liquid chamber, and they rapidly created a widespread interest in the entire community — and ultimately threatened to reduce seriously the need and the use of Lagarrigue's chamber!

It was once again a French proposal which got the process under way in September 1964. It was made by the group of André Berthelot, Director of LPCHE, the CEA's high-energy physics laboratory at Saclay. Berthelot was less integrated than other French groups in the activities at CERN and he wanted to retain a certain autonomy in the building of big chambers. He thus proposed that a large European hydrogen chamber be built from separate, independent modules. In his proposition in September he suggested two types of basic modules. One was 4 m^3 in volume (diameter 1.3 metres, length 3 metres), the other 8 m^3 (diameter 1.6 metres, length 4 metres). With the first, chambers of six or nine metres in length, and of 1.3 metres in diameter, could be installed. With the second, the chambers would be eight or twelve metres long and 1.6 metres in diameter. Berthelot thought that he could rapidly construct one module and use it as an independent chamber at the CEA's accelerator "Saturne" at Saclay, or at Serpukhov where he had contacts. At a later stage this chamber module could be assembled with other identical modules which would together comprise a big chamber for CERN. In this way Berthelot seems to have wanted to decentralize decision-making, to distribute the work among various builders, without hindering the construction of the big equipment necessary to compete with the United States.[9]

As one might imagine, the reaction of the CERN physicists (or of those who used Geneva as their central base) was not favourable. They pointed out that the technical structure proposed by Berthelot added an unnecessary degree of complexity,

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[8] *History of CERN*, vol. 2, chap. 8.4.1.

[9] Memorandum Peyrou to Grégory, 2/10/64 (DG20562); *Projet [...] présenté par le LPCHE...*, 16/10/64 (DG20562); letter Florent to Grégory, 16/10/64 (DG20562).

that the process of assembling the device would not be simple, that a number of undesirable effects would probably arise in the thermodynamic equilibrium of the whole, and that the total cost would probably increase considerably. And even if these were not mentioned, one can well imagine that political considerations were also in the back of everyone's minds. However that may be, the idea was very rapidly dismissed, the bubble chamber leaders (who controlled the Track Chamber Committee at CERN) preferring one single hydrogen chamber based on Shutt's new ideas.[10]

Although this proposition by the director of LPCHE was rejected, it had important consequences because it forced CERN to become involved in hydrogen chambers. CERN could not afford to leave the terrain free to Berthelot since he could obtain money from the CEA and in this way hinder the Geneva laboratory if it wanted to make a later request — after all, there is never an infinite amount of money available. Since France was one of the key players in the European bubble chamber lobby, Berthelot's initiative could not be overlooked and allowed to gather momentum.

The reaction of the CERN management in October and November was of two main kinds. On the one hand, the need "to give serious consideration to the construction of a [very big] liquid hydrogen bubble chamber" was included in the medium-term projects under consideration by the laboratory, notably the four-year PS improvement programme. In the document which he drafted for the SPC in mid-October, Hine wrote that this chamber "would be circular with a diameter of four to five metres and the useful volume would be about 25 m^3 of liquid hydrogen". He added that "metal plates would be mounted in the chamber". This in fact was word for word a description of Shutt's project at Brookhaven at the time. The first step taken by the CERN management was thus to confirm the need for a big hydrogen chamber and to encourage everyone to think along American lines.[11]

At the same time CERN's French director of research Bernard Grégory tried to bring the sheep that had strayed back into the fold. Classically, he convened a meeting of the Track Chamber Committee to which he invited Berthelot with the aim of "surveying the problem of the new generation of bubble chambers". The committee met on 18 November, and listened to three presentations. One was by Berthelot on his

[10] Letter Florent to Grégory, 16/10/64 (DG20562). See below for Shutt's new ideas.

[11] SPC/189, 13/10/64, for the quotes.

project, another was by Lagarrigue on Gargamelle (this being the name that the French had given to their heavy liquid chamber). The third presentation was by Charles Peyrou, the director of the hydrogen chamber division at CERN, who explained Shutt's ideas. On this occasion, the German physicists announced their intention of also constructing a large hydrogen chamber. A bubble chamber policy working group comprising the most senior Europeans in this domain was then set up. It held its first meeting in Geneva on 2 December 1964.[12]

The third initiative, alongside those of Berthelot and of CERN, was effectively taken in Germany. Towards the beginning of November six directors of physics institutes (Fucks and Faissner from Aachen, Paul from Bonn, Jentschke from Hamburg, Filthuth from Heidelberg and Heisenberg from Munich) wrote a long letter to the Minister of Research. They asked him to include in the agenda of the Ministerial Working Group on High-Energy Physics, which was to meet on 30 November 1964, a project for financing a very big hydrogen chamber. Their point of departure, the model on which they proposed to base their discussion, was also Shutt's project. Stating that such a chamber was indispensable for Germany — the field was dominated by the French and the British, according to the report — the signatories asked for the resources to study it in detail. The cost of construction was estimated to be 40 million Deutschmark (Shutt's estimate), and CERN was expected to provide 15-20 millions for installing the chamber in Geneva. Just as Lagarrigue had done, the authors of the letter suggested that the chamber should be paid for and built by Germany, and that it should then be transported to Geneva and used collectively by all Europeans. What the German physicists wanted to do then was to acquire a new expertise in the technology of hydrogen chambers, feeling that they were behind France and the CERN staff in this area.[13]

The meeting of the bubble chamber policy working group on 2 December 1964 reached agreement on two main points. Firstly, "the majority" — meaning everybody except Berthelot — recommended the construction of "a large HBC, similar in size to Shutt's proposal". The group added that "it is felt that it might not be justified to first construct an intermediate size chamber" — which amounted to a final rejection of Berthelot's proposal. Then, since Lagarrigue had not been forgotten, the text added that "supplementary projects like Gargamelle should be considered". This

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[12] Letter Grégory to Berthelot, 6/11/64 (DG20562).

[13] Report sent by six physicists to the Bundesministerium, 16/11/64 (DG 20822); Letter Gottstein to Weisskopf, 27/11/64 (DG 20822).

reference to the heavy liquid chamber was made with the qualification that the project should in no way impede the hydrogen chamber, which was the priority project.[14]

From this date onwards Weisskopf on the one hand, Grégory, Perrin and the senior members of the German physics community on the other,[15] seem to have focussed their minds on the idea of having a very big hydrogen chamber which would be built tripartitely by CERN, France and Germany. Unfortunately our documents are not particularly precise on this point.[16] What is certain, on the other hand, is that "certain official French and German quarters" agreed, by the end of December, to have a *feasibility study* prepared as soon as possible. Indeed, in the last days of December Grégory asked Florent to draft a working document which would summarise the discussions held until then. Florent submitted his report, entitled "Draft agreement for a feasibility study for a large European bubble chamber" on 5 January 1965. It stated that CERN, the French CEA, and a German organisation not yet decided (probably the Minister of Atomic Energy) "envisaged the joint construction" of a large bubble chamber estimated to cost 60 MSF, and that the project would be financed in "equal parts by the three participants". In the following days, Grégory tried to set up the political and technical infrastructure needed for this feasibility study.[17]

2.2 *Having the project endorsed by the European physics community, January-February 1965*

Two major problems now had to be solved by Grégory. It was important to associate the organised community of high-energy physicists with the project. This meant to have them approve it and declare that it was indispensable for European physics in the 1970s. It was also necessary to set up a tripartite (CERN, France, Germany) technical group which would be under the supervision of those who were paying. Its task would be to conceive a detailed and, if possible, innovative design of a viable chamber.

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[14] BCPW Group, First meeting, 14/12/64 (DG20562) from which the quotes are taken.

[15] Given the events of 1965, it is probable that Jentschke played a central role in this agreement, but we do not have any exact information for 1964.

[16] However, see *Résumé de la conversation du 9 décembre avec Berthelot*, 11/12/64 (DG20562); Council 15-16 12/64, Minutes, 48.

[17] BCPW Group, Second meeting, 5/1/65 (DG 20562); letter Florent to Grégory, 5/1/65 and *Projet d'accord...*, edited by Florent, 4/1/65 (DG20562).

The first problem required discussing carefully the "scientific value of the project — this to be judged by a fairly large number of people", to cite the formula used by Grégory in a letter of 15 January to his future French and German colleagues. Classically, this entailed passing through three successive phases. To begin with a report (a plea one could say) would have to be drafted by the partisans of bubble chambers. For this, Grégory approached the CERN Track Chamber Committee which was the "official representative" of this part of the community. Then it was necessary to have "the value of the instrument" recognised by "the physicists who are not involved in the technique". In other words, one had to neutralise that part of the community which worked with electronic means of detection, and which was separately organised. This was to be done by the Scientific Policy Committee, the usual body responsible for validating CERN's scientific projects. Finally, and strengthened by its unanimous recommendation — the proposals of the SPC were made in the name of all European physicists —, political representatives would be contacted. That meant the Council, as far as CERN was concerned, and administrators in the relevant agencies for France and Germany.

There were three aspects to the second problem which Grégory had to solve: have the money committed, appoint the men who would have to design and build the chamber, and draft the convention, i.e., the text which would regulate the relations between the three partners. Here Grégory proposed to be pragmatic and prudent, and not to look beyond the short term. To set the ball rolling, there was to be a meeting between Weisskopf, Perrin and Jentschke who "should agree on setting up for 1965 a study group [who would make a technical study of the chamber] with the oral agreement that if a proper convention can be found [...] the share of money from each country would be of the order of one-third each". Thereafter the money for the technical feasibility study was to be committed for a year or 18 months, and those who would manage the project were to be nominated. Finally, and in parallel, one should begin to think about the drafting of the convention. The actual construction ought to start, Grégory suggested, towards the end of 1965 or during 1966.[18]

The first months of 1965 were dedicated to finding a solution to the first problem: to associate the organised community of physicists with the project. On 10 February the Track Chamber Committee submitted its report entitled "Future of Bubble Chambers at CERN and in Europe".[19]

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[18] Letter Grégory to Teucher, 15/1/65, from which the quotes are taken (for the two preceding paragraphs).

[19] SPC/194, 10/2/65.

The TCC reaffirmed, firstly, that "physicists need an unbiased and universal instrument for the systematic study of high-energy collisions", insisting that bubble chambers were still the best detector for this purpose. In Europe bubble chambers had the additional function of "keeping the social peace" since they enabled universities to be directly associated with the advanced research done at CERN. The preparation of the runs with bubble chambers only required a limited investment in time and the analysis of photographs could be done at home — in contrast to electronic experiments which were more individualistic and idiosyncratic and which could really only be carried out by full-time researchers who were able to spend long periods based in Geneva.

The ideal chamber which the report described was of very large volume and took up again the ideas developed by Shutt's group. It was cylindrical in shape (useful volume of 25 m^3) but mounted vertically (4 to 5 metres in diameter and 2 to 3 metres high). The dimensions of its windows would be reduced thanks to the use of new optical and photographic techniques and of scotch-lite, a reflecting material which would line the inside surface of the chamber. Metal plates would also be added inside the chamber so as to enable a good detection of gamma rays and the determination of their energy.

The Track Chamber Committee's report then remarked that France had proposed building a heavy liquid chamber for use at CERN. Stressing that such a chamber would in no way serve as a replacement for a hydrogen chamber, the report insisted all the same that it would be extremely interested also to have this device at CERN. The heavy liquid chamber would be ready two years before the hydrogen chamber, and it would therefore allow "immediately an impressive progress in neutrino physics". Once the hydrogen chamber came on line the heavy liquid chamber would allow for a more balanced programme, and would help supply universities with photographs.

Director-General Victor Weisskopf introduced two important nuances when commenting on this report to the meeting of the SPC. Firstly he insisted that the design of the hydrogen chamber was not yet to be regarded as settled. Important sums of money were involved, and the chamber would have a central place in CERN's future programme. It was then important to be sure that there were not other scientifically interesting alternatives. Taking up a theme that was fashionable at the time, Weisskopf suggested for example the study "of a faster cycling bubble chamber

with spark chamber arrangements", i.e., a combination of the electronic and bubble chamber techniques.

The second nuance introduced by Weisskopf — and perhaps this was really more than simply a nuance — was that he gave clearer support to Gargamelle. He not only stressed the interest of having a chamber which could do neutrino physics two or three years before anyone else in the world. He also stressed "the very good arguments why national groups should remain active in building bubble chambers", the advantage in terms of experimental flexibility which the presence of two chambers would have for CERN in the 1970s, and the fact that it was an excellent deal since the costs for CERN would be negligible! From this Weisskopf concluded that if no decision could yet be taken on the hydrogen chamber — the design was not yet ready and CERN's budgets had not yet been fixed for the years to come — the same was not the case for Gargamelle. "Since time scale plays a major role in the arguments supporting that project", and since "our share in the Gargamelle project is [...] small", it was not inconceivable to arrive rapidly "at a decision in principle even if the budgets are not exactly known".[20]

Two days later, on 16 February, the SPC adopted the conclusions of these two reports and recommended to the Council "that a working party be set up to study in detail all the questions concerning the specifications of [the giant hydrogen chamber]". As for Gargamelle, it proposed that "a decision be taken at one of the next Council sessions, since its design is already well advanced and it could be built quickly".[21]

2.3 *Formalising the relations between the three partners. The agreement of 4 May 1965 between Jentschke, Perrin and Weisskopf*

Towards the end of February 1965 steps were taken to find a solution to the second problem, namely to set up a technical group who had to design the chamber under the supervision of the three fundgivers. Here the most delicate question was that of who should be in charge of the group doing the technical study. This was because, from the outset, Charles Peyrou and his division demanded to be responsible for almost the entire project. Their main argument was that they and they alone had the necessary

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[20] *Comments to the SPC...*, by the DG, SPC/195, 10/2/65, from which the quotes are taken (for the two preceding paragraphs).

[21] SPC/199/Draft, 26/4/65.

expertise, that most of the skills "were to be found already at CERN in terms of number of people, of experience with big chambers and industrial installation, and even of the spirit of invention". On the French (and German) sides feelings were obviously very different and, to the extent that the costs were shared, it seemed obvious that they ought to be associated in all aspects of the construction — if only in this way to acquire the know-how which was needed for this kind of task![22]

Grégory was asked to find a solution informally. With the agreement of Jentschke, Perrin and Weisskopf he opened negotiations with the principal protagonists, i.e., Florent for the French, Teucher for the Germans and Peyrou for the hydrogen chamber division at CERN. Without going into the details of the successive proposals which were put forward let us simply note that, from April onwards, people were thinking in terms of a double structure.[23]

At the head of the project a study committee would be set up. It would be comprised of six persons whose task it would be to make the important technological choices, to guide and to examine the proposals coming from the working groups, to establish the financial framework and to plan the overall realisation of the project. It would be formed of two representatives from CERN, namely Peyrou and Schmeissner, have two people from France, Grégory and Florent, and two German representatives, Filthuth and Teucher. In short, this study group would have five physicists and one builder (Florent) distributed equally between two nationalities. Although his existence was never clearly recognised in the documents, a British member of the CERN staff (Burger) also participated at all the meetings of the committee in 1965.[24]

Below the study committee a working group was envisaged. It was to be comprised of physicists, engineers and technicians from CERN and from the two countries involved and its task was to carry out the studies as such. Several ways of managing it were discussed. Initially there was the idea of having a single director,

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[22] Memo TC/ChP/sm, 20/1/61 (DG 20562).

[23] For the broad outline of the negotiations, letters Grégory to Jentschke, 9/3/65, Grégory to Teucher, 8/4/65 (DG20562), CERN/TC/StG 5000 65-1, 15/6/65 (DG20031), letter Weisskopf to Perrin, 25/5/65 (DG20562), CERN/TC/StG 5000 65-3 and 65-4, 16/6/65 et 22/7/65 (DG20031).

[24] See for example letter from Grégory to Perrin of 13/9/65 (DG20562), which gives the compositions of the study group (six names without Burger), or the note from Florent to Grégory of 8/11/65 (DG20561) which gives the list of the study group and asks: 'Should the name of its Chairman and Secretary appear, and that of Burger'. Burger was Peyrou's deputy at the head of the TC division.

namely Peyrou for the design phase and Florent for the construction phase. Then the idea was floated of having a two-headed management structure, Florent-Schmeissner, to be followed by Florent-Filthuth. This proved to be acceptable only in the short term and to the Franco-German group. Finally, the principle of a "non-integrated management" was adopted, i.e., a non-choice was made, and "those responsible for representing the three partners (Filthuth, Florent, Schmeissner) would each have authority over their staff" whom, as a matter of fact, were always paid in this early stage by the laboratories from which they came.[25]

This agreement, which was not easily reached, was confirmed at a meeting held on 4 May between Jentschke, Perrin and Weisskopf. The study committee met for the first time on 8 June in line with the rather informal practice initiated three months earlier.[26] The working group, for its part, was officially set up at the end of May, and it developed very rapidly. To anticipate a little, let us simply note that in December it comprised 21 people, 4 Germans (2 physicists, 2 engineers), 7 French (1 physicist, 4 engineers, 2 draftsmen) and 10 members of CERN (6 engineers and 4 draftsmen).[27]

What we find then is a tripartite arrangement sought for and supported by the members of the establishment but which encountered some difficulties when it came to setting it up in practice. As is so often the case it was rivalry between people and institutions which was at the base of the conflicts. In this particular case, the difficulties encountered were rigidified by national interests. Even if these were not at the root of the skirmishes, they were a supplementary "resource" to which actors could appeal to break or to reverse a decision which they did not like. It was for example possible to block the arrangement in which there was a single strong manager by appealing to national interest, an argument that was all the more weighty in this case since from the start it had been understood that there would be an equal distribution between the three participants. Weisskopf, Perrin and Jentschke were all

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[25] Schmeissner was a top CERN staff member and represented the organisation. In the previous scheme for a two-headed management (Florent-Schmeissner), the latter would have been '[taken] off the CERN pay-roll and [made] a pure German', according to Weisskopf's formulation in his letter to Jentschke, 15/4/65 (DG20822). The quote is from Florent, *Note...*, 9/12/65 (DG20562).

[26] Three non-official meetings were held in the presence of these six person and Burger on 24/3, 23/4 and 18/5, CERN/TC/StG 5000 65-1 and 65-3, 15/6/65 and 16/6/65 (DG20031); letter Weisskopf to Perrin, 25/5/65 (DG20562).

[27] *Note...*, drafted by Florent for the CEA, 9/12/65 (DG20562).

aware of this limit, but they felt that it would be difficult to reverse it in the short term. All the same, they hoped to overcome it during the construction phase.[28]

3. The Decision and the Construction of Gargamelle

As we have seen after the SPC meeting in February 1965 the trajectory of the decision for Gargamelle differed noticeably from that for the hydrogen chamber. Two of the main protagonists, Weisskopf and Grégory, effectively considered Gargamelle to be a simple case (the business was technically uncontroversial) and more or less arranged from the political point of view (since the chamber was "offered" by France and the costs to be borne by CERN were negligible). We have therefore decided to treat the two cases separately from this date onwards.

3.1 *The complications surrounding Gargamelle and the final solution, February-December 1965*

The most urgent thing to do in March and in April as far as Gargamelle was concerned was to finalise the drafting of the convention. A first version, suggested by the services of the CEA, was circulated at CERN at the beginning of February. The idea was to submit the text to the Finance Committee in May for a final decision by the Council in June. (Let us remember that it was the Finance Committee that first studied legal questions which were then passed up to the Council.) On 16 April, after a visit to Saclay by G. Hampton, CERN's Director of Administration, a new version of the text was sent to Geneva.[29]

Broadly speaking, this text stipulated that the construction of the chamber, which was the responsibility of the CEA and which would be done in France, would be supervised by a mixed committee in which the two partners (CERN and France) would be equally represented. It added that the costs of construction would be charged to the CEA, CERN contributing a capital sum of 5 MSF (distributed over four years). Finally it recognised that "CERN shall be solely responsible for [the]

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[28] The question of the rivalry between national groups has already been analysed in volume 2 with regard to the great debate in 1959 over bringing nationally constructed chambers to CERN (chaps. 8.2 and 8.3).

[29] *Gargamelle, Grandes lignes d'un projet de convention*, 2/2/65 (DA20257); letters Grégory to Perrin, 9/3/65 (DG20562); Hampton to Lévy-Mandel, 14/4/65 (DG20568); Goure (CEA) to Grégory, 16/4/65 (DG20568); Hampton to Goure, 26/4/65 (DA20257).

operation [of the chamber] under CERN regulations, in accordance with the scientific programmes defined by the Director-General".[30]

The Finance Committee was satisfied with these arrangements and, at its meeting on 3 and 4 May, it approved the principles underlying the text. The following day the SPC also gave its blessing to the operation, Bernardini declaring "that he considered the Gargamelle project to be an excellent example of co-operation". The Scientific Policy Committee even stated that "it would prefer to cut the [money for the construction of the experimental] East area rather than [for] Gargamelle" in the event that the reduction of the 1967 budget by 8 MSF demanded by the Finance Committee forced a choice between the two items.[31]

It only remained for the Council meeting in June to go along with this unanimous point of view once the provisional budgets for CERN for 1967 and 1968 had been voted on. Weisskopf was optimistic in a letter that he wrote to Perrin dated 25 May. CERN's final agreement would certainly be given during the summer, he said, and there was no need to interrupt the studies already under way regarding the site (i.e., where and in which experimental hall to instal the chamber) and the necessary equipment for analyzing the photographs taken by Gargamelle.[32]

As it so happened the hope that there would be a definite decision in June was not fulfilled. The budgetary crisis which had beset CERN for several months persisted, and was not resolved during this Council session. And without any budgetary provisions for the years to come, the Council refused to take any position on future investments. Somewhat unexpectedly then all was blocked, and there seemed little hope that the tendency would be reversed easily. Clearly, there were major problems which transcended the simple question of Gargamelle.[33]

Three months later, however, a very simple, and definite, solution was found by the organisation's management. As we have said no scientist wanted to delay a project which was ready, which was of limited cost, and which they judged to be scientifically important. Thus Weisskopf and Grégory decided to commit the money

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[30] *Broad outline of...*, FC/770, 23/4/65.

[31] SPC/203, 4/5/65; memo Grégory, 13/5/65 (DG20568).

[32] Letter Weisskopf to Perrin, 25/5/65 (DA20257).

[33] Council, 16-17/6/65, minutes.

themselves, within the normal framework of CERN budget, and without any concern for the final sum which the Council would vote for the forthcoming years. Believing that to manage was above all to exercise the art of choice (even when resources were uncertain), they were sure that they would find a way of installing the chamber in Geneva under suitable conditions and that they could pay the 5 MSF promised to the CEA. To simplify matters, the latter in fact offered a loan to CERN to cover the instalment due for 1966.

At the start of autumn the technical liaison between the groups at CERN, at the CEA and of Lagarrigue was thus normalised again. The final contract between the CEA and the CERN management was signed on 2 December 1965. For the first time in CERN's history an investment which was initially thought to require a decision at the level of the Council was approved by the Director-General using his existing executive authority.[34]

3.2 *The principle dates in the construction of Gargamelle*

Even though our study is not intended to cover the construction and the preparation of the experimental programmes for the chambers, we will give here some summary information on the more important events during these phases. Here they are for Gargamelle.

The design of the chamber did not undergo important changes between the end of 1965 and its commissioning at CERN in December 1970. (Annex 1 gives the principle parameters of Gargamelle.) There was however an important delay during the construction. While the contract foresaw that the chamber would first be assembled and tested at the Centre d'Etudes Nucléaires at Saclay, then dismounted and transported to CERN during the first months of 1969, the chamber was in fact directly assembled at Geneva, the first photographs were only taken in December 1970 and the first important run only occurred in March 1971.

This delay of about two years does not however appear to have been a major catastrophe, since the competing hydrogen chambers also suffered important delays. Since there is no "absolute time" for carrying out experimental work — what counts above all for the scientific community is to be the first and to succeed — it is the maintenance of a lead which really counts. In any event the chamber was the decisive element in the neutrino experiments at CERN which were done between 1971 and

[34] Letters Goure to CERN, 28/10/65, Fleischmann (CEA) to CERN, 2/12/65 (DA20257).

1974. These experiments provided the first evidence for weak neutral currents, certainly the first very important "discovery" made in the history of CERN.

It was realised at the CEA in January 1968 that a delay in the construction of Gargamelle might well occur. According to the work plan which had been adopted, the body of the chamber ought to have been delivered by industry in June 1968, and the tests should have occurred between July and November. The political events in France in May and June 1968, however, upset the initial plan and led Lagarrigue to suggest, in November 1968, that the chamber should perhaps not be assembled at Saclay. Rather, its body should be delivered directly to Geneva and the assembly done on the spot. Lagarrigue made the official proposal to Grégory on 27 January, who accepted it two months later. Everyone hoped then that the chamber body would be delivered in the summer of 1969.[35]

By October, this key component was still not delivered and the CEA made an official complaint to the supplier, the Compagnie des Ateliers et Forges de la Loire (the Creusot-Loire group). This was one of the best metallurgical industries in France and also the CEA's and CERN's normal supplier. The director of the company justified the delay by appealing to "social difficulties" in France since 1968 and the fact that they were dealing with "a very complex piece of equipment which was difficult to construct because of its tendency to lose its shape after having been welded". He promised to deliver the item at the end of March 1970. This time the delay was negligible and the chamber was subjected to its first tests at CERN before the end of the year.[36]

The preparation of the experimental programme raised two different kind of problems. The first, which was dealt with very early on, was that of the data handling facilities, notably the scanning tables necessary for reading Gargamelle's photographs. It was essential to rethink the procedure for treating the films, as well as the computer programmes associated with them, since the optics of the chamber was extremely complicated and involved the use of eight cameras. This issue was at the focus of

[35] Letters Lagarrigue to Grégory, 15/11/68 and 27/1/69 (DG20568 et DA20257), Lévy-Mandel to Grégory, 24/2/65, and reply, 19/3/69 (DG20257).

[36] Letters Pascal (CEA) to Malcor (CAFL), 3/10/69 (DA20257), Malcor to Grégory, 25/11/65 (DA20257), Hampton to Lévy-Mandel, 3/5/71 (DA20257).

many meetings at the European level from early 1966, and the matter was settled by building a new series of scanning tables.[37]

The second problem was the classical one of deciding what particle beams should be fired at the chamber and what experiments should be done first. The issue was first raised in a memorandum to the TCC drafted in common by Lagarrigue and by Ramm, who was responsible for heavy liquid chambers at CERN. It was then discussed regularly in the so-called Gargamelle Users Committee. This body was modelled on other experimental committees at CERN, and it met for the first time on 29 November 1967. Its task was to discuss proposals for experiments coming from different European groups and to elaborate a coordinated programme for Gargamelle which satisfied and reconciled as many users as possible.[38]

As we have already mentioned, the first important experiments done with the chamber were those with a neutrino beam. Their results were of fundamental importance, as is explained in more detail in other chapters of this book.

4. The Decision to Construct BEBC and the CERN-Franco-German Convention, Summer 1965-July 1967

Between summer 1965, when the study group was set up and the technical groups began to start working in Geneva, and February 1966, when a first report was submitted to the SPC, those responsible for the big hydrogen chamber were primarily concerned with scientific and technical matters. In the agreement reached between Jentschke, Perrin and Weisskopf on 4 May political questions had been provisionally resolved. Now the main objective was to define technically the ideal and multi-purpose detector which would be submitted to the member states for financing. The bubble chamber specialists were certainly convinced that the best chamber to build would be a classic one of the type that Shutt had proposed, and that it was this kind of chamber that should first be studied. At the same time they could not but listen to the views of Weisskopf and of the physicists doing electronic experiments and to compare their preferred option with other types of detectors.

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[37] See for example *Progress Report on the Data Handling Facilities Necessary for GARGAMELLE*, 29/8/1967 (DG 20569).

[38] On the establishment of the committee, see *Minutes of Gargamelle users meeting held on 29th Nov. 1967* (DA 20257) and Grégory's refinements, letter to Burhop, 21/12/1967 (DG 20568). The practical implementation differed very little from that described in volume 2, chap. 8.5 to 8.7, with regard to bubble chamber collaborations.

There were at least two reasons why they had to broaden their field of investigation. On the one hand, they did not really have a choice, we might say. They had to meet the demands coming from the rest of the community, even if only formally. Given the high costs of a very big hydrogen chamber it was essential that the specialists in electronic detection should at least not oppose the project in political circles. On the other hand, they had to reassure themselves, and to study closely alternatives which could improve the performance of the system. Granted the strong competition in the field, they would certainly be held responsible for any bad choices if other devices were in a better position to make important discoveries in the future. Rivals with better detectors could eventually steal their glory, fame, and recognition and as a consequence limit their means for continuing to do top-level research.

4.1 *Technical discussions around the various possibilities, June 1965-February 1966*

To get the technical work under way, the study group defined two major directions during its first meetings in June 1965. Firstly, and in the light of "information recently received from the United States", they opted for a superconducting magnet. As this was still a rather novel technique the CERN group needed to deal with rather basic questions like trying to establish whether it was better to have an iron yoke with the superconducting coils or not. Secondly, the study group defined a first set of parameters for its preferred option, a very big hydrogen chamber. On 8 June the committee fixed "for the moment, a diameter of 4.5 metres and a height of 3.3 meters, it being understood that [...] one would examine the economic implications for 4 and 5 meters". As for the interior of the chamber, it was still assumed that one would instal plates for detecting the π^0, though their thickness and orientation were still to be defined. The optics also had to be carefully studied ("can a large volume of hydrogen be photographed? Will photography through a large volume of hydrogen allow precise measurements?" etc.).[39]

In parallel and as a response to Weisskopf's remarks, the committee also considered the possibility of having mixed chambers with the same magnetic volume as the conventional chamber. Studies done at Saclay in 1964 on high repetition rate chambers were taken up again,[40] and two variants of the mixed chambers were

[39] CERN/TC/StG 5000 65-4, 22/7/65 (minutes of the meeting of 8/6/65) (+Peyrou, Sept.).

[40] The 'working speed' of a chamber is measured by the number of expansions it can make per second (each expansion is associated with a photographic exposure). In order to profit fully from the advantages the electronics offer it is essential to increase the chambers' repetition rate. Hence the reactivation of the French studies made the previous year (*Projet de chambre à haut taux de*

studied during the summer. One was a 3.5 m^3 hydrogen chamber linked to a spark chamber, the whole being placed inside a 5 meter magnet. The other comprised the same rapid cycling chamber this time associated with a circular spark chamber which was placed inside 2.5 meter superconducting coils. Spark chambers surrounded the whole. Initiated in July, these exploratory studies led in their turn to new variants whose details were presented during the months of November and December.[41]

The range and variety of questions which were still open for discussion during this period is clear from a reading of the documents produced for the end of the year. To vary our account and not to linger on mixed chambers, we can note for example that the position of the axis of the chamber — and we are now speaking of the classic Shutt type chamber — became in its turn an object of discussion. A variant with a horizontal axis, and with a vertical window 3.5 meters in diameter and weighing 7 tonnes, was chosen. Its advantages were that it required "classical" optics, that temperature control was "good", and that the relationship between the useful and the total volume was "favourable". On the other hand, the mechanical construction was "complex" because of the "asymmetry" arising from the fact that the piston was on a horizontal axis. In another "improved" version of the Shutt chamber with a vertical axis, the detector retained a "simple" mechanical structure and was fitted with "more conventional" optics. Here though the group feared that there would be temperature inhomogeneities in the chamber and that it would be difficult to protect it against cosmic rays. In January 1966 both variants were still being considered while in February a horizontal variant with a vertical piston was being envisaged.[42]

It was not only the technology of the chamber that was discussed during these eight months. In parallel, a number of questions relating to the physics that could be done with it were raised. What was needed was to compare the performance of different kinds of detection as regards specific questions in physics. Thus on 17 January the members of the committee and of the working group met in Geneva, along with physicists like Armenteros and Lagarrigue, to debate five or six essential points related to the practice of bubble chamber physics. Their discussions were informed by three preliminary reports prepared by the study group. A comparison

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répétition, mars 1964, DG20561). Add *Etudes sur [...] chambre mixte à heut taux de répétition*, 1/9/65 (DG20561).

[41] CERN/TC/StG 5000 65-5 to 65-10, 65-13, 66-3, resp. 28/7/65, 31/8/65, 22/9/65, 4/11/65, 18/11/65, 29/11/65, 23/12/65, 12/1/66 (DG20561).

[42] CERN/TC/BEBC 65-1 to 65-3, December 1965 (DG20561).

was drawn between three types of detectors: a classic 5 meter chamber with plates inserted, and two mixed chambers of different types and of 1.7 and 2.5 meters. These were studied in terms of their advantages for the detection of π^0s and of neutrons, for research with high statistics, for their precision in the measurement of trajectories, etc.[43]

Finally in 1966, partially because more money was available and partially because the study group had grown in size and had been divided into seven specialised sub-groups, a number of experimental studies began in conjunction with the more theoretical approaches. At this stage they were predominantly concerned with the optical properties of scotch-lite through varying depths of hydrogen and with the modes and the speed of bubble formation in the chambers.[44]

4.2 *The budget again and the drafting of the report on the big hydrogen chamber, February-October 1966*

This first phase came to an end towards the end of February 1966. The final recommendation was to abandon mixed chambers and to concentrate on a classical big hydrogen chamber. This is not to say that the studies had arrived at a "logical conclusion". We now know that this never happens, that there is never an inevitable conclusion because all studies are limited in their objectives and in their means. It was simply that the members of the committee and of the working group judged that the time had now come to reduce the number of possible alternatives, and that one system was more promising than the others. Of course it was true, as Peyrou put it in March after the second meeting on the physics aspects of the project, that "the opinion of physicists remained divided between two possible solutions", and that "the mixed system [...] would enable one to gain a factor of 4" from the point of view of statistics. All the same the classical chamber seemed to the bubble chamber physicists on the committee as the solution. As a result they decided that, unless there were unforeseen novelties, all studies henceforth and until September would concentrate on two variants of a big chamber without any electronics organically associated with it. One design would have a vertical axis and the other a horizontal axis with a vertical piston.[45]

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[43] CERN/TC/BEBC 66-12, 15/2/66 (DG20561).

[44] CERN/TC/BEBC 66-12, 15/2/66 (DG20561).

[45] SPC/218, 2/3/66; CERN/TC/BEBC 66-29, 13/4/66 (DG20561) from which the quotes attributed to Peyrou are taken. The fact that the bubble and electronic communities were deeply divided is

The second reason for devoting the resources available to one single solution was that it was essential not to delay the practical implementation of the project any longer. In May 1965 the study committee hoped to arrive at a clear result before the end of the year — a result which could be submitted to the Council and to the member states for their approval and financing. In autumn, as the number of options multiplied, this date had to be put back by six months. Now, in February 1966, it was deemed urgent to invert the rhythm and to arrive at a definite conclusion. As a result September 1966 was fixed as the target date. By this date, it was decided, the final report describing the technical and financial aspects of the project had to be submitted to the SPC, and to an international conference of experts which would meet in Heidelberg in October. In the interim the committee submitted an intermediate report to the SPC proposing the principle of a big chamber, which the committee approved.[46]

In March, the study committee drafted a note concerning the cost of the chamber. Translating the most recent figures from BNL into those appropriate for a European situation, it concluded that the costs had initially been underestimated. It was probably necessary, it said, to simplify the design if one wanted to remain within the order of magnitude put to governments fifteen months before. The use of large glass surfaces, for example, seemed to introduce a prohibitive cost overrun. Similarly, the plates which Shutt had proposed to introduce into the chamber to facilitate the detections of gammas and of neutral particles were costly, and they had disappeared from the most recent designs at Brookhaven.[47]

As far as the committee was concerned, these cost increases meant that the space in which they could manoeuvre was reduced and that thenceforth they necessarily had to associate technical designs and cost estimates more closely. As they were now moving to the last stage in the conception of the chamber there was no longer any sense in putting forward technical solutions without at the same time estimating their costs. As a result they proposed to restrict themselves to the study of a chamber of about 3.5 meters in diameter whose cost seemed to be about 72 MSF.

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eminently evident from this final decision. This point was already dealt with in volume 2, chapter 8.4

[46] *Note..., Considérations sur le coût du projet*, TC/RF/mk, 14/3/66 (DG20561); SPC/218, 2/3/66; CERN/TC/BEBC 66-29, 13/4/66 (DG20561).

[47] *Note..., Considérations sur le coût du projet*, TC/RF/mk, 14/3/66 (DG20561).

The choice of the figure 72 corresponded to the fact that there had been a "re-evaluation [in the light of inflation] of the initial cost" of 66 millions submitted in March 1965 to Weisskopf, Perrin, Jentschke and to political circles. And since scientists rarely restrict themselves when adopting solutions in the highly competitive field of high-energy physics, the committee recommended that all the same one should still examine the implications on the final cost of increasing the diameter of the chamber to 4.5 meters and to 5 meters.[48]

In the autumn 1966 the contours of the project that would be submitted to governments began to emerge. In October, the Study Group for a Large European Bubble Chamber produced a report of about 100 pages. Here it proposed a cylindrical chamber 3.5 meters in diameter and about 3 meters in height with a vertical axis, and a useful volume of 20 m3 (see figure 1). Its piston which was 2 meters in diameter was situated underneath the chamber and four cameras were placed on top of the cylinder to photograph the volume through lenses with an aperture of 105°. The magnetic field of 35 kGauss was produced by two liquid helium cooled superconducting coils. As for the much debated problem of the detection of gammas, the report did not propose a definite solution. Instead it suggested that various alternative solutions and their costs should be studied, "such as various metal plate arrangements and neon-hydrogen chamber fillings".[49]

As for planning, the report estimated that the chamber would be working in 1971 if the decision to build it was taken at the start of 1967. Financially, studies made in Europe with industries had led to the conclusion that the cost of construction would be high, and of the order of 84 MSF "which represents 27% more than the 66 foreseen [...]". As Charles Peyrou wrote, defending the project, "[it] is certainly not a preposterous increase between a superficial evaluation and a careful one", especially if one took inflation into account. All the same the most important thing to be done now by the protagonists of the project was to convince the German and French governments of this fact, as well as the scientific opponents who were looking closely at the project in the light of this last-minute cost increase. Providing his friends with arguments which they could use if they had to reply to those who "expressed doubts as to whether the chamber should be built at all", Peyrou suggested that one should

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[48] CERN/TC/BEBC 66-29, 13/4/66 (DG20561).

[49] CERN/TC/BEBC 66-75, 9/11/66 (DG20561); SPC/231 and 231/Add., Annex 2, for the meeting of 27/9/66; SPC/233, 18/11/66, describing the chamber and from which the quote is taken.

remember that "counter physics has also a long-range investment which is much bigger and is called storage rings".[50]

4.3 *Financing the chamber and its cost increase, drafting the convention, and setting up the group to construct it, October 1966-July 1967*

From the time of the SPC meeting in November 1966 it was clear that the most delicate question was the additional cost of the chamber. In the case of CERN, for example, the final budget provisions made for the years to come were based on an estimation of 66 MSF. To get around this problem Director-General Bernard Grégory[51] proposed to spread the construction of the chamber over an additional year. "Since the amount required for one year of construction was about the same as that necessary for one year's operation", he wrote, it was not even necessary to allocate additional funds for the device. The SPC, unhappy at the prospect of another complication, accepted Grégory's proposal, adding all the same that the size of the chamber should not be reduced.[52]

A final agreement between Grégory, Jentschke and Perrin was reached early in 1967. They accepted to share the cost of construction equally, and agreed that the time for building the chamber should be extended so as not to exceed the contributions foreseen for the first four years. In February the German minister for scientific research, Dr. Stoltenberg, was contacted for his final agreement, which was more easily given by the French CEA. The Study Group, confident that the project would now go ahead, decided to start designing the experimental equipment that was needed. The most important were a one-meter diameter model of the chamber and a test bank for superconducting strips. All that now remained in the weeks ahead was to finalise the text of the convention.[53]

The drafting of the convention between CERN, France and Germany got under way in the summer 1966. On 18 July, after a meeting of scientists held in Geneva, Peyrou drafted a first version which was sent to the CEA and to the

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[50] Add to the previous references Peyrou's report, SPC/236, prepared for the meeting of 29/11/66, and his letter to 'Dear Friends' of 27/10/66 (DG20562), from which the quotes are taken.

[51] Bernard Grégory was CERN Director-General from 1 January 1966.

[52] SPC/231 (meeting of 27/9/66); SPC/236 (meeting of 29/11/66), quote on page 7.

[53] Letter Grégory to Schulte-Meermann, 8/2/67 (DG20563); SPC/239 (meeting of 15-16/3/67); D. Ph.II/BEBC 67-13, 8/2/67.

Bundesministerium für Wissenschaftsforschung (BWF).[54] On 12 October 1966 this version was drastically modified after a meeting of legal experts. Here two major problems emerged, both connected to possible industrial spin-offs from the project. Both France and Germany wanted the convention to guarantee them a sort of "juste retour" (fair return) linked to their important financial contributions. Germany's main concern was industrial contracts.[55] It wanted the text of the convention to state clearly that these would be distributed equally between the partners — a point resisted by CERN and by all the member states bar Germany and France on the grounds that it violated the existing policy of awarding contracts competitively to the best bidder. For France, on the other hand, the main problem was the protection of the inventions which the project could generate. Here again, CERN was opposed on the grounds of the current practice which held that the organisation did not take out patents.[56]

After two additional meetings in February and March 1967, a text was agreed for submission to the Finance Committee and to the CERN Council. In substance the agreement stipulated that the chamber would be CERN's property from the very beginning and that it would be constructed by "a joint team from the three parties". The chamber's cost was officially fixed at 84 MSF in 1966 prices. This was a definitive price and no additional money could be claimed from France or from Germany. Any cost overrun would be paid for by CERN. The convention stipulated that if this cost overrun was below 10 per cent, "CERN would meet the extra cost" automatically, but if it was in excess of 10 per cent, the CERN Council was to be consulted about how best to handle the problem.

The management of the project was to be in the hands of a "Steering Committee consisting of a representative of each party", with CERN being represented by its Director-General. The Steering Committee, which would take its decisions by unanimity but would only meet several times a year, was to designate a Project Committee and to nominate a Project Leader. Its task was to approve the annual budget, to define a policy on patents if or when that became necessary, and to

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[54] In June 1966, the CEA had already circulated a first version. See letter CEA, Contracts Office, to CERN, 17/6/66 (DG20562). Add letter Peyrou to Goure (CEA), 18/7/66 (DG20562).

[55] An added German concern was the question of language. This was solved by drafting a text in three languages and agreeing to do the same for future texts linked to BEBC (CERN's official languages are English and French).

[56] Contract/letter no 8.424/r, 16/9/66 (DA20258); *Réunion au sujet de la convention..., 12/10/66; Projet de convention résultant des discussions...*, 12/10/66; letter Goure to Hampton, 5/12/66 (DA20258).

study the attribution of contracts worth more than 2 MSF. Contracts of a lower value would be dealt with by the Finance Committee and by CERN. The Project Committee, for its part, comprised two technical experts per partner. It was to monitor the technical aspects of the construction and to advise the Director-General on the organisation and the progress of the work. As for the distribution of contracts, and "in so far as is compatible with technical and economic requirements", the Director-General was to ensure that this was as equitable as possible. In short, a more or less clear commitment was taken to satisfy the specific demands made by France and by Germany, without formally questioning the overall policy of the organisation.[57]

The debates in May and in June in the FC and in the Council were rather difficult. There were two main reasons for this. Firstly and above all there was "the fact that CERN was committing itself to providing any extra funds necessary in the course of the construction", a fact which disturbed certain delegations who saw in it an open-ended commitment to building the chamber. Secondly there was the question of "the adjudication procedure for large contracts". Here it was the German delegation who insisted that it should be the Steering Committee who had the last word and not the CERN Finance Committee. We will not enter into the details of the subsequent negotiations here. It is simply worth noting that everyone wanted to arrive at a suitable solution as quickly as possible, and that the final agreement was ratified by the Council on 14 and 15 June 1967. Only minor changes were made to the text during this final phase, though certain delegations did openly express their reservations on some points. On 21 July Bernard Grégory, CERN's Director-General, Hans von Heppe, Secretary of State to the Federal Republic of Germany and Robert Hirsch, Administrateur Général of the CEA officially signed the agreement at CERN in Geneva.[58]

5. Some remarks about the construction of the BEBC, 1967-1972

The first meeting of the Steering Committee was held on 20 September 1967. It was composed of three well-known personalities, namely, Bernard Grégory, Wolfgang Paul and Francis Perrin, and it quickly confirmed a number of steps taken unofficially since the start of the year. The most important was the appointment of R. Florent as

[57] The text is in FC/943, 10/5/67.

[58] FC/951, 11/5/67, 5 for the quotes; FC/964, 13/6/67; Council, 14-15/6/67, minutes, 31-32; Press release, 21/7/67 (DA20259).

the sole head of the project — a decision that had been in the offing for quite some time to avoid the imbroglio of 1965. The second was the confirmation of the members of the Project Committee — Peyrou and Schmeissner for CERN, Teucher and Filthuth for Germany, Lévy-Mandel and Meyer for France — a list reflecting the wish for stability.[59]

Around this time about 50 people were in the team building the chamber (it would reach a maximum of 90 by 1971). Its main tasks were to test superconducting material and to construct a one-meter diameter model of the chamber. The latter was needed particularly to study the thermodynamics of the expansion system and the sources of optical distortion in the detector. In addition the group had to look into the characteristics of scotch-lite and of photography through several meters of liquid hydrogen — this work had been under way for over a year and was being done at Saclay and at DESY —, into magnetic shielding requirements — this work had also started the preceding year at Saclay —, and into the most suitable mixture of hydrogen and of neon, the aim here being to arrive at a means of detecting π^0s using a technique simpler than that of integrating plates into the body of the chamber.[60]

In December the Steering Committee accepted the final revision of the parameters of the system. A new idea put forward by Florent's group seemed to allow for an effective increase in the chamber diameter by 20 cm and so of its useful volume by about 10% without any significant increase in the cost. Towards the middle of 1968, a number of calls for tender were made, notably "for 45 km of stabilized superconducting material" for "the stainless steel vessels (350 tons of stainless steel)", the magnetic shielding and the cooling system. In parallel the construction works got under way on the site at CERN. As regards the one meter diameter model, which was working during the autumn, it led the designers to prefer a chamber having a piston made of fibre-glass epoxy.[61]

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[59] EBC/5, 12/10/67 (minutes of the meeting of 20/9). J. Meyer had replaced Grégory in the Study Committee as the latter had been nominated DG of CERN. R. Lévy-Mandel was in the CEA's Saturne Department.

[60] EBC/2, 5/9/67 (*Progress Report*). The idea was to replace the plates by a transparent hydrogen target in the mixture of neon and hydrogen. 'In this way, it was thought possible with the same photograph to observe the primary interactions in the target and, in the mixture, the electron pairs produced by conversion of gamma from π^0 decay' (EBC/2, 5/9/67, 4).

[61] EBC/STC/9, 4/12/67; EBC/12, 4/3/68; EBC/STC/14, 12/3/68; EBC/19, 29/5/68 EBC/22, 23/10/68. It is to be noted that this choice of a piston of fibre-glass epoxy would turn out to be disastrous in practice.

Towards the end of 1968 an important point of friction began to emerge. It was the fact that the contracts were rather badly distributed between the partners, notably to the disadvantage of Germany whose representatives claimed that the agreements were not being respected. The reasons for the disequilibrium, according to Teucher in a letter which he wrote in January 1969, was that "at present German industrial companies are not extremely eager to get orders for special equipment". Reporting to Grégory on the rather unhappy experiences he had had with the industrialists in his country, Teucher concluded that "it is sometimes really hard work".[62]

In summer 1969, with the situation not improving notably, a new argument was used to placate the German authorities.[63] It was pointed out that if one deducted the contracts of no technical interest, like those for the construction of the buildings or for the delivery of the shielding, the distribution passed from 53% to 37% for France, and it increased from 23.8% to 33.5% for Germany. The other participating states then received 29% of the contracts. It was also noted that a considerable effort had been taken by the builders vis-à-vis German firms. Florent thus stressed that it was often "necessary for us to insist strongly that the German prices become more competitive during second and third calls for tender", the calls being repeated to try to improve the distribution of the awards. He added that "if we had simply gone ahead and placed orders on the basis of the first call for tenders, the present global distribution would give 8.6% for Germany and 68.5% for France ...".[64]

From the end of 1969 onwards it became increasingly clear that a number of industries would not be able to respect their delivery dates. By the winter 1970/71 the overall delay was estimated to be more than one year and it was hoped "that commissioning would begin at the end of 1971 or at the beginning of 1972". Six months later it was financial considerations which further slowed down the BEBC completion programme. At the same time the initial experimental programme of the chamber was the object of repeated and extremely complex controversies because the accelerated rate of construction of the 300 GeV machine was interfering with the organisation of work in certain experimental zones on the site at CERN.[65]

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[62] EBC/29, 1/4/69; letter Teucher to Grégory, 3/1/69 (DG20563).

[63] Though it was accepted by the German delegates themselves. Cf EBC/35, 18/11/69, 10.

[64] EBC/STC/32, 11/6/69 and memo Florent, 18/6/69 from which the indicated figures and the quotes are taken.

[65] It is impossible to list the numerous sources used here. See for the construction EBC/47, 23/10/70; EBC/51, 12/3/70; EBC/56, 17/11/70; for the experimental programme, letters Rousset to Cresti,

Finally in the summer of 1972 (June and July) the first tests of the Big European Bubble Chamber got under way — operations being immediately halted by serious leaks in the vacuum tank and the magnet.

Tests got under way again in mid-January 1973. In about a dozen days the magnet was cooled down by 20,000 litres of helium, "and when operating temperatures were reached, current was fed to the superconductor increasing in steps towards the design level". The instrumentation and the expansion system were then tested, and a map of the magnetic field was drawn up. Around 23 and 24 February a current of 5000 Amps was reached and the field was 3.1 Tesla in the chamber. Now it was the turn of the chamber itself to be cooled. The helium cooling the magnets was temporarily decanted into the reserve dewars, the idea being that only one operation should be performed at a time. On 3 May 38,000 litres of liquid hydrogen were in the chamber and the first photographs of particles were taken. The final phase of testing ended by the simultaneous operation of the magnet and the bubble chamber.

After certain necessary modifications and repairs had been made, notably to the expansion system, new tests were undertaken in June and July and again in October 1973, after another shut-down. In December, a first run was made in which 25,000 photographs were taken in a K minus beam of 9 GeV/c. "Somewhat drastic surgery" was however felt necessary by January 1974 after some inexplicable phenomena had been observed during the charging and discharging of the magnet. Thus for the next ten months the chamber was once again dismounted and totally overhauled, with new tests getting under way in December 1974. It was only in the following six months that the chamber finally fully entered into operation and took more than 400,000 photographs. Its running-in was thus rather long and particularly laborious.[66]

6. Some words by way of conclusion

The first striking fact about these decisions is how much they differed from those taken towards the end of the 1950s for the first generation of bubble chambers at CERN. In those early years there was no collaboration between the CERN teams and those in the member states, and choices were made independently in France, in Great

1/7/71, Perkins to Dear colleagues, 8/7/71, to Jentschke, 9/7/71, Hine to Perkins, 19/7/71, Peyrou to Lehr, 23/8/71, to Jentschke, 2/9/71, etc.

[66] These three paragraphs are based on the CERN annual reports and the *Courrier CERN*.

Britain, in Italy and at CERN. Now the new chambers (Gargamelle and BEBC) were the subject of a European-wide discussion. This evolution is not surprising and reflects two things. Firstly, an increase in the size of bubble chambers. In the late 1950s European physicists were taking their first steps in this technology and each of them built average sized chambers — an approach that was demanded by their need to learn the technique. In 1964/65, on the other hand, the question was completely different. Now the task was to construct costly, technically complex and highly performing devices. More or less only one or two such detectors could be envisaged at a European level.

At the same time this development reflected a more important change in social practice. It was a symptom of the consolidation of the European bubble chamber community since the time when the 25 GeV PS was commissioned. In 1958/59 each national group was in fact independent and it constructed the chamber for which it had adequate financial and human resources. It was only after this had been done that the question of installing the detector, notably in Geneva, was raised. It was then that the national groups came up against the physicists at CERN, who themselves wanted to instal chambers in their laboratory and who were not particularly keen to collaborate, believing in their superiority and preferring to keep outsiders on the margins of experimental work at the PS. Hence the dialogue of the deaf which we described in volume 2, hence the false debates, hence the incomprehension. After several years of working together under the supervision of the "levelling" committee that was the Track Chamber Committee, and with everyone now satisfied with the functioning of the system of collaborations, attitudes were very different. And quite naturally the questions were posed in joint terms, and at the European level.

This remark leads to a second. Even if the senior members of the community were thinking about the problem at the European level and were determined to establish collaborative solutions from the very start, the fact remains that conflicts between ambitious individuals and between institutions were real once the phase of concrete realisation started. This competition on the ground is rather banal, however, since it is part of everyday life in all scientific work. We will simply add, then, that these oppositions were rather easily dealt with and that they did not lead at any moment to a questioning of the rights of access to CERN's heavy equipment, which was governed by rules established in the first years of the TCC. Both BEBC and Gargamelle, chosen and constructed communally, were thus declared CERN property from the beginning and nobody objected to their utilisation being organised by the CERN experimental committees. This was even though everyone knew from

experience that the builders would have certain *de facto* privileges during the definition of the first experimental programmes.

Similarly, the relation between bubble chamber specialists and specialists in electronic detection techniques was not affected by this decision-making process. In fact the two communities remained more or less separate from each other, each collecting its own resources and defining its own projects. Certainly Weisskopf and Grégory tried to interest the community in hybrid projects and to have mixed chambers studied, but as we have seen there was little enthusiasm for them. While it was "normal" for the director of a laboratory to see things globally and to try to facilitate cross-fertilisations which he thought would increase the efficiency of his laboratory, it was also only to be expected that the different professional and technical milieux would remain attached to their own fields of technical expertise. Nor should we be surprised by this mutual unwillingness of the two groups to mix with each other when we remember the important technical differences which separated the two traditions of detection, bubble chambers and visual modes of detection versus electronic apparatus and binary techniques.[67]

There is one important phenomenon which has not changed however: it is the attitude vis-à-vis the United States, an attitude which might be described as "imitative". By this we do not mean that the Europeans did nothing but copy or reproduce what the Americans were doing, nor do we mean that they showed no independence in the elaboration and the design of their equipment. It would be absolutely wrong to see things in this way, as we have already shown regarding the technical developments in the preceding period. The sense in which we can see the Europeans imitating what the Americans were doing is in their tendency towards the systematic increase in the size of the equipment. The Americans remained those who imposed the rhythm at which the field advanced in the spiral to ever higher energies.

This is true in all technical fields — think for example of the debate on CERN's second generation of accelerators in the 1960s. And it was indeed the developments around Shutt at Brookhaven that triggered European plans for giant bubble chambers. Of course there is no necessity, nothing inevitable, in this race towards ever bigger pieces of equipment. If it was the Americans and not the Europeans who imposed the rhythm in the post-war period it was because they now were the leaders in high-energy physics, it was because they defined the new rules of

[67] For the last two paragraphs, see *History of CERN, Volume 2*, chapter 8.

efficiency in knowledge-producing equipment, it was because they redefined what was to count as appropriate in the practice of physics. Europe had not entirely caught up twenty years after the war, and the rules of the new game had not yet been perfectly assimilated. As a result, Europeans still had the impression of being behind the Americans in that domain of big science par excellence which is high-energy physics. Fifteen years later the gap had been closed.

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STUDIES IN CERN HISTORY

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