# Meeting on P.S. Nuclear Physics

20.12.1957

**Present:** C.J.Bakker, J.B.Adams, W.Gentner, L.Kowarski, H.D.Bridge, F.Cerulus, G.von Dardel P.Germain, R.Hagedorn, B.Hedin, A.Lundby, A.W.Merrison, B.de Raad, L.Resegotti, C.Schmelzer, A.Schoch, A.Tollerstrup, V.Weiskopff.

## 1. Progress reports.

Cerulus reported on the progress of the calculation on the pion yield, using Fermi statistical theory. The calculations have two aims: the relative probability for production of n mesons, and the momentum spectrum of the pions when n mesons are produced. For the latter calculations one is especially interested in the high energy end, particularly for the case when only one, two or three mesons are produced. These cases will essentially determine the high energy tail of the meson spectra and will thus provide information on the maximum pion energy for which the intensity is adequate for experiments. Transformed to the laboratory system, the preliminary results indicate that 0,06 pions above 20 GeV are emitted per steradian in the forward direction for each proton interaction in the target. The data refer to the total production of positive, negative and neutral pions. The production in a particular charge state is about one third of the total cross section or slightly less for the negative pions, which cannot be produced singly in proton-proton collisions. A detailed report will be distributed shortly.

The uncertainty in the estimated cross section can easily be as large as a factor of 5, since the contribution of the three-meson spectrum has to be guessed. A more reliable calculation requires much computational work, either on an electronic computer or using the computing staff of for example NPL.

Bridge has suggested that experimental data on pion production in the Eurotron energy range should be relatively readily obtained from the Pic du Midi cloudchamber photographs. This possibility is to be investigated.

Weisskopf pointed out that Fermi statistical theory is expected to give too low cross section in the Eurotron energy range since there is not enough time for thermodynamical equilibrium to be established, and that this might lead to errors of 100 or so Hagedorn suggested that the agreement with experimental data indicated that the theory is not so bad after all, but Bridge felt that this experimental evidence was extremely scant to allow such conclusions.

von Dardel reviewed the results so far obtained in planning the experiment on pion proton interactions with counters (experiment 2), and sketched a preliminary layout of the analysing and focusing magnets needed. An experiment on the total cross section. seems to be quite feasible using gas Cerenkov counters before and after the sample. Intensity is also ample for this experiment. A more ambitious experiment to determine the differential scattering cross sections as a function of angle, momentum and identity of the scattered or secondary particle has been given some attention, but seems rather marginal both for intensity and for space in the experimental hall. One should consider to have facilities for taking out beams at the opposite side of the ring where experiments requiring more space than can be provided in the experimental hall may be performed in the open air.

de Raad and Resegotti have investigated a first version of the focusing lens and bending magnet providing the momentum analysis. The focusing lens will be quite close to the machine and will focus the beam on a slit through the concrete shield 15 m away. The bending magnet will bend 20 GeV/c particles through $5^{\circ}$ and the momentum accuracy at this momentum will be about 2 o/o. The angle of divergence accepted from the target is only $0^{\circ}5$. It is possible that this may be increased with a more expensive target channel, and the first version studied may not be the optimum for a good use of the machine.

The problem of the slit for momentum analysis of high energy particles undoubtedly is a problem which must be looked into. Similarly the comparatively large transparence of the concrete shield which only provides an attenuation of a factor 5000 for particles traversing it perpendicularly may create a high background in the experimental hall which in particular is disturbing for bubble chambers and other track instruments.

Peyrou reviewed the thinking on the use of bubble chamber at the machine as summarised by von Dardel in PS Nucl.Phys./5. An error should be corrected in this document, on p.2 line 7 from the bottom should read: "momentum determinations for tracks down to 50 cm..." He pointed out that this report was not concerned with the bubble chamber only with the pion-proton experiments in view but on a more general basis. He remarked that the conclusion that the bubble chamber will only be run a few weeks or days per year and the rest of the time is needed for analysing the results, however is only true for such experiments as the pion-proton experiment where the photographs are very rich in interesting events. Experiments on rare events which can be easily picked out from a large number of photographs in the preliminary scanning would need more exposure time to produce a sufficient number of events without thereby overloading the analysing facilities. It may also be that a big bubble chamber will have a long recovery time and will thereby need a lot of machine time to produce a certain number of pictures.

Kowarski considered that rather than to limit the machine time for the bubble chamber so as to allow the organisation for analysing the pictures to keep up with it, we should change our ideas on the scale of the analysing organisation. We might well consider to have 100 IEP instruments supplemented by 10 computers of the IBM 704 type.

Peyroud stressed that in addition to IEP which measures the geometry of the events we must have an organisation for the analysis of the events. This can only be done by physicists with a lavish use of electronic computers and data handling machines.

After these reports the meeting discussed the problems to be attacked next. Hagedorn suggested that the most efficient use of the machine in the initial stage may well be experiments of a qualitative kind, rather than the more quantitative experiments discussed up to now. Such experiments might involve bubble chambers or other track chambers. Tollestrup suggested that photographic plates exposed in a high magnetic field might be a useful technique. It was informed that Schluter, who has been working on such problems at MIT had expressed his desire to come to CERN for a year and that this would be possible on a Ford foundation fellowship. Hine pointed out however that the group had been set up to see what could be done with conventional techniques and what conventional instruments would be needed.

Adams suggested that the group should take on one more function namely to consider the distribution of work inside CERN on, for example IEP, photomultipliers, etc. since this work affects the programme of CERN as a whole.

After some discussion it was concluded that time had now come to shift part of the work to the study of other experiments and the two antiproton experiments (7 and 8 of the table at the end of PS Nucl.Phys.Group/1) were chosen. The work on the experimental arrangements for the pion experiments should however be pursued, aiming at a stage where a decision can be taken on what to order at the end of 1958.

2. Staff for the PS Nuclear Physics Group.

The group has up to now depended entirely on voluntary part-time work apart from von Dardel. Both Hine and Merrison will be unable to devote much time to the problems in the future due to other tasks. It is necessary to get more permanent staff for the group. Gentner mentioned that one of the fellows appointed by Switzerland who is joining Cern shortly would be suitable to work in the group since he has just come back after two years at Berkeley.

Yuan will spend a few months in CERN and will not be tied up with any experiment, and could contribute a lot to the group. Similarly Hofstetter will spend a year with CERN.

The group will in addition need computer effort and technicians.

Bubble Chamber.

Adams opened the discussion by stating the need for a large bubble chamber for the P.S. There is no staff foreseen for this chamber in 1958. Some staff could be put on the job in 1959 but it is hardly possible to have the chamber ready when the machine works. A cooperation with the British bubble chamber group might produce a chamber more rapidly. Should CERN rely on the British group or should we start our own programme, presumably by delaying or dropping some other programme?

Kowarski reviewed the present situation. 30 people are or will be engaged in the bubble chamber programme during 1958. Of these two thirds are engaged in the testing and use of the 10 cm chamber, and one third is ddsigning the 30 cm chamber. When the 10 cm chamber is completed one third of the staff will continue to study it and the remaining two thirds will concentrate on the 30 cm chamber which should be finished by the end of 1958.

The main problem is to divide the available effort between the 10 , 30 and 150 cm chambers. We have one man on the budget for 1958 to start thinking on the big chamber but this is obviously not enough. We have three possibilities: slow down the 30 cm chamber, go slow on the 150 cm chamber or hire more staff outside the budget. The present plan is to do some thinking in 1958 and a major budgetary effort in 1959.

Adams pointed out that in 1959 staff would start to become available in the P.S. division for doing other work, and he would be opposed to the idea of taking on staff from outside. Peyrou pointed out that a lot of time would be gained if a relatively modest effort, say one mechanical engineer, one magnet engineer and 3 draughtsmen could start work on the big chamber already in 1958 to produce realistic drawings even if the actual hardware would only come in 1959. Even if we put more staff on the project, for example by stopping the 30 cm chamber we would not produce more. In 1959 we could then see what effort is available within CERN. Whether the chamber can be ready in time for the machine will depend on how early in 1959 and to what extent staff will be available from the P.S.

Adams asked how such a plan would tie up with the British plans. If we can start only in 1959 to build our chamber we would expect that the British chamber should be ready 12 to 18 months before ours. On the other hand Peyrou's suggestion would leave us time to profit from experience in other laboratories e.g. Alvarez.

Merrison emphasized the need for a bubble chamber to do good physics with the machine. He considered it unlikely that the British chamber would be ready in time, so CERN must build a chamber itself and if necessary scrap the 30 cm chamber to provide staff.

Bridge pointed out that there are large risks connected with building a 150 cm chamber without first having the experience of a 30 cm chamber. No bigger chambers are in operation now.

Peyrou stated on a question by Adams that the largest chamber that could be built without the previous experience of a 30 cm chamber would be 80 to 100 cm. Such a chamber could be ready in time for the P.S. A big propane chamber could possibly be made with reserve for how the big pressure should be handled. He considered that to drop the 30 cm chamber now would be too drastic. Drawings are made and the magnet ordered and the big chamber would not be very much advanced by such a step. No Cern bubble chamber would then be available for the S.C. Two smaller chambers of say 30 cm do not in any way constitute a substitute for one big chamber.

Kowarski pointed out that it is a logical contradiction to start to develop experimental apparatus only when the machine is ready. The apparatus must be available when the machine starts and should be developed in parallel. For a further discussion of the bubble chamber programme and for final proposals see Appendix I.

3. Future meetings.

It was decided that the meetings of the working groups should go on as before. The meetings of the bigger committee should be replaced by occasional seminars with a wide participation.

G. von Dardel

## APPENDIX I

## MEMORANDUM

January 13, 1958

To: PS Research Group

From: L. Kowarski and C. Peyrou

### Bubble Chamber Programme 1958-1959

This memorandum sums up the conclusions we have drawn from the very interesting and useful meeting of the PS Research Group which took place on the 20th December.

It seems to be generally understood that the Bubble Chamber, and especially the liquid-hydrogen Bubble Chamber is expected to be one of the main experimental instruments to be used in connection with the PS. To fulfill any really useful role at all it must at least reach a certain minimum size; beyond that minimum, the bigger the bettdr with no limits seen at present other than those set by the available funds and skills.

Should we plan and start at once a "reasonably big" (say, 150 cm) Bubble Chamber project? Only if we do, can we hope to have one ready for the moment the PS beams are available, or not too much later. There are, however, several arguments against such an immediate start:

(a) No correspoinding resources exist in the 1958 budget. The budgetarily approved Bb. Ch. programme for 1958 expressly includes the use of the 10 cm chamber, the completion of the 30 cm chamber and "one man to think about a bigger chamber". Even if we stop all activities on smaller chambers, the resources thus released would not be sufficient.

(b) The immediate creation of a big Bb. Ch. Project with an adequate applied-physics and engineering staff, at a time when similar staff has to exert its greatest effort in the PS construction, would result in a temporary swelling of these categories of staff - difficult to achieve because of the European shortage of such staff, and difficult to bring down to an unswollen level once this temporary conjunction has passed. From this point of view alone it would be advisable to delay a big CERN Bb. Ch. project and not to aim at a <u>simultaneous</u> development of both the PS itself and of a <u>major</u> piece of equipment to be used with it. Such a delayed project, if finally accepted, would on the contrary provide a welcome continuity of employment offered by CERN to the staff categories in question.

(c) It would be prudent to wait for Alvarez' results.

(d) A big Bb. Ch. project has been started in Britain and their chamber might offer a temporary solution for CERN's most urgent needs.

(e) A really big Bb. Ch. might not be ready in time (end of 1960?) whereas a somewhat smaller chamber (see below), might.

In view of all these arguments taken together it seems difficult to advocate the immediate start-up of a big Bb. Ch. project in CERN. The rejection of this idea shifts however automatically the discussion on the desirability and feasibility of the next most useful project, one step down the size scale.

The extent of this downward step is subject to the minimum condition mentioned above, and to a maximum condition arising from the fact that experience available in CERN from the smaller projects (10 and 30 cm) cannot be extrapolated beyond a certain size. On these lines we arrive at the suggestion, voiced by Merrison, of a size of the order of 80-100 cm (say 90) which is neither too difficult to build in a reasonable time, nor useless as a PS-research tool. Such a project is obviously nearly free from all the objections listed above. It would, in addition, meet Prof. Blackett's argument in favour of pursuing at least two projects of PS-useful chambers (one in CERN, one in Britain) as an insurance against a major delay in one of them. We consider that it offers a very reasonable chance of having a useful chamber for that initial period when PS needs it most (visual techniques are particularly useful in the beginning, when intensities have not yet reached their full value), provided this particular aspect of urgency is recognized and resources are granted accordingly.

As soon as the basic decision is made, a preliminary study by a small group should be started. A very small provision has been made to that effect in the 1958 budget (one engineer's post); other almost immediate staff resources could be obtained from outside (we expect the arrival from Saclay of a development physicist paid by Saclay in 1958-59) or from the SC Division where some development staff is becoming available. A Ford fellow (Brenner) would either join the group, or replace another member of the STS staff who would then become available for the 90-cm planning. For the next 6 months or so there would hardly be any need for emergency additions to the budgetary staff. Later in 1958 and in 1959 extension of the staff assigned to the 90-cm project would become necessary. It has been suggested that the need for this extension could be minimized or even annulled by stopping the construction of the 30 cm chamber altogether and putting all its staff on the 90 cm chamber. After a careful consideration we arrived at the opinion that such a step cannot be recommended. The reasons are:

(a) The two projects are sufficiently out of phase to prevent any substantial benefit to the one accruing from the cancellation of the other - the stoppage of the construction of the 30 will not substantially advance the design of the 90, the testing of the 30 will not substantially interfere with the construction of the 90 and so on. Such gains to the 90 as remain probable do not seem big enough to justify the waste which would result from abandoning the 30 cm, already somewhat advanced.

(b) The 30 cm chamber is useful for SC research.

(c) The 30 cm chamber will afford a useful training step for the PS physicists.

(d) The design, making, testing and use of the 30 cm chamber will provide a useful (although not indispensable) information to those engaged in the corresponding steps of the 90 cm project.

All these arguments preclude the cancellation of the 30 cm project but do not totally exclude some measure of postponement of its completion. Such postponement may become unavoidable if the necessary expansion, late in 1958 and in 1959, of the 90 cm staff creates serious budgetary difficulties. In no case should the detailed design of the 30 cm (to be completed fairly soon), be slowed down.

To sum up, the CERN Bb.Ch. programme should comprise:

- As a necessary first step: the completion and use of the 10 cm chamber.
- The completion of the design of the 30 cm chamber; its construction and use with such speed as its staff allocation will allow.
- An immediate start of the 90 cm project, using at first no extensions of budgetary staff and later on (late 1958 and 1959) all possible resources, including those transferred (if necessary) from the 30 cm, and with a firm aim to have the 90 cm chamber ready for the beginning of the PS research.
- An understanding with the British Bb. Ch. project concerning the future use of this chamber by CERN.
- At a later date (as yet unspecified): discussions concerning the possible extensions of this programme towards bigger sizes.

Such a programme results from several compromises and we should be careful to avoid the pitfalls inherent in every compromise. If we want our chosen type to succeed fully enough to compensate for the restrictions suffered by other types, we have to make our choice without haste but also without delay. Otherwise CERN might well find itself one day in a situation where the importance of hydrogen Bb.Ch. has been emphasized by Alvarez' success; the British chamber is not yet available and no adequate CERN-made chamber is ready at a time when PS needs it most.

Concluding proposal

We propose that the following points should be submitted to a searching discussion within your Group:

1. No Bb.Ch. project beyond 100 cm should be started at present in CERN.

2. A project of about 90 cm should be declared urgent and started at once.

3. The following resources should be given to it in 1958:

(a) The embryo planning nucleus already foreseen in the budget.
(b) New non-budgetary resources such as personnel paid by outside agencies or applied-physics personnel made available by the SC Division.
(c) Resources possible made available by a decrease in urgency of the construction (not design) of the 30 cm chamber.
(d) If necessary, a very slight (one or two units) increase of the Bb.Chl staff foreseen in the budget, later in 1958.

4. The detailed design of the 30 cm chamber should not be slowed down and no orders already placed should be cancelled. The possibility of a redistribution of staff, which would result in some slowing down of the construction of this chamber should not be excluded.

Agreed opinions on these points would form a suitable basis for a policy recommendation by the Group of Directors, not later than mid-February.

20.1.1958

Enclosed find the minutes of the meeting on P.S. Nucl. Phys. of 20.12.1957. Note in particular the appendix on the bubble chamber programme by Kowarski-Peyrou which is based on the discussions at the meeting and later considerations. In order to expedite this matter without the need for an extra meeting would you please inform me of your comments on the bubble chamber programme.

G.von Dardel.

/jdw