

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

and

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

JOINT CONSULTATIVE PANEL FOR NUCLEAR RESEARCH

Minutes of the Third Meeting held at Imperial College, London
on Wednesday, 6th March, 1963

Present: Sir John Cockcroft (Chairman)

Dr. J. B. Adams
Dr. A. Ashmore
Professor W. E. Burcham
Professor E. H. S. Burhop
Professor C. C. Butler
Professor G. F. Chew
Professor B. H. Flowers
Professor J. C. Gunn
Mr. G. Hubbard
Sir Harrie Massey
Professor P. T. Matthews
Sir Harry Melville
Professor A. W. Merrison
Mr. L. B. Mullett
Dr. T. G. Pickavance
Professor C. F. Powell
Professor A. Salam
Dr. G. H. Stafford
Mr. R. St. J. Walker

Mr. I. A. Learmouth } Joint Secretaries
Dr. J. A. V. Willis }

Apologies for absence were received from Professor Dee, Professor Cassels, Professor Peierls, Professor Paul, Professor Rochester, Professor Wilkinson and Dr. Green.

1. Sir John Cockcroft said that the purpose of the meeting was to consider the possible European high energy accelerator which was being proposed. The Advisory Council on Scientific Policy had asked for an appreciation of this proposal to be prepared, giving the scientific case for the machine, recommendations about its energy, an approximate estimate of the cost, estimates of the staff required in relation to the availability of physicists and recommendations concerning any consequential requirements for addition of support to nuclear physics in universities. The present meeting was a step in the preparation of the report, and he thought that a smaller working party should then be set up to go more closely into the detail. Sir Harry Melville said that the A.C.S.P. would have to weigh up the proposal in relation to other scientific needs, and make recommendations to the Government, and such a large proposal would then be a matter for Cabinet consideration rather than for the usual approach to the Treasury.
2. The timing of the report was discussed. It was stated that the C.E.R.N. Council expected to give preliminary consideration to the proposal in June, and that recommendations on energy from their Committee under Professor Amaldi would be available in April. It was agreed that our report ought to be ready by the end of April.

3. European discussions

3.1 Dr. Adams outlined some recent discussions of future high energy physics facilities, particularly in European countries. His notes, written in December, 1962, had been circulated to the Panel beforehand and indicated four main propositions:-

- (a) for C.E.R.N. to build a proton synchrotron of 100 GeV;
- and (b) to build storage rings for the present C.E.R.N. proton synchrotron;
- and (c) support for the home "pyramid" of high energy physics in European countries;
- and (d) to look towards a 300 to 1,000 GeV machine later in collaboration with the U.S.A. and perhaps U.S.S.R.

Dr. Adams said that the main change since these notes were written was that the energy contemplated for the new P.S. had crept up well above 100 GeV.

3.2 Discussion dealt first with Dr. Adams' reference to Professor Amaldi's statement that 0.2% of national income should be spent on pure research. The Gross National Product of the U.K. is £22,000M. £35M is spent on universities, and substantial further amounts on pure research elsewhere. However, differences in accounting conventions make comparisons between countries difficult. Also any standard such as that given by Professor Amaldi must be ephemeral, because expenditure on pure research is increasing faster than the Gross National Product.

3.3 On the question of support of the home "pyramid", there was some divergence of view as to whether this referred to high energy physics only or to nuclear structure research as well. It was strongly argued that a case for such large expenditure can apply only to the most fundamental work, and it was probably common ground that the "home pyramid" must be such as to provide really lively centres of fundamental work with a flow of people to and from the European laboratory. On the other hand, it was argued that nuclear structure research provided for good Ph.D. training.

4. The Usefulness to Physics of a very high energy machine

4.1 Professor Salam reviewed the case for a high energy machine from the theoretical point of view, and emphasised the extremely fundamental nature of the study of action at very short distances (10^{-14} cms). He discussed two extremely important ideas which just could not be studied with the present generation of accelerators:-

- (a) the asymptotic behaviour of cross-sections,
- and (b) the inter-relationship between strong, electro-magnetic and weak interactions, for a study of which weak form factors of elementary particles were as important as the electro-magnetic form factors.

None of the present accelerators could hope to provide neutrino beams of sufficient intensity and energy to study these weak form factors. If the new accelerator were considered only as a neutrino source, this would justify all its costs.

4.2 In discussion many members took up the point of the extremely fundamental nature of high energy physics, and it was emphasised that even many senior scientists in other fields of work did not appreciate its immense impact on a wide field of ideas. A quantitative point arose here:- Sir Harry Melville pointed out that if expenditure on high energy physics

were to rise to say £50M a year this would begin to be comparable with the estimated total of £200M spent in the country on industrial research, and said that it would then be hard to avoid direct judging between short-term research and pure research (which some people would call in this context "speculative" research). Professor Burhop said that he had estimated the U.K. expenditure on a European 300 BeV accelerator nine years after completion (at $\frac{1}{4}$ of the total) as £8M per year - but it was agreed that past experience must make us very cautious over estimates in this field. Better estimates will be available in April from the C.E.R.N. study.

5. The Choice of Energy

5.1 Professor Chew said that he would give a personal view, and one perhaps not widely popular. He thought that very likely there were no characteristic energy thresholds in the presently attainable energy range, above a few BeV, and that the energy transfer also seemed to be limited to a few BeV. However, in the case of strong interactions, he was convinced that the Regge pole expansion would be the key to progress for a long time, and the energy required to allow the effects of different poles to be separated was now becoming clear. The 30 GeV now available allowed hardly any such analysis, but an increase by a factor of 4 to 120 GeV would allow a very good test of the Regge pole expansion.

5.2 In discussion the results of a C.E.R.N. study were reported, showing that for energies over about 100 GeV it would be cheaper to build a machine with very high energy injection, perhaps from an intermediate synchrotron, than to build a scaled-up C.P.S. In addition, a ten-fold greater intensity could be expected. It was stated that the cost, and also the time of construction and particularly the capital expenditure per year, all rose rather slowly with increasing energy in the range 100-150 GeV. The general feeling of the Panel was that when making such a major effort one should above all try to avoid choosing too low an energy.

6. Main power

6.1 Dr. Pickavance discussed the numbers of high energy physicists and of accelerator physicists and engineers who might be available to work on a European accelerator. The present number of experimental physicists at Ph.D. level engaged in high energy physics research in this country was about 120. The number of applied physicists and fully qualified engineers engaged in development, construction and operation of the accelerators and equipment was also about 120. A survey by Professor Merrison had shown that the country's output of Ph.D's in experimental physics in 1955/60 averaged about 170 per year, of whom one third were in high energy physics (10%), low energy physics (16%) and cosmic ray physics (7%). 27% of these took university posts and a few others stayed in the subject by taking posts with bodies such as C.E.R.N. and N.I.R.N.S. From these figures, the prospective numbers available had been estimated on the following assumptions:-

- (a) an increase of 10% per annum in Ph.D's produced in physics over the next 10 years;
- (b) the total proportion in high energy, low energy and cosmic ray physics would remain at one third, there would be some reduction in the proportions in low energy and cosmic ray physics, balanced by a rise of the proportion in high energy physics from 10% to 15%;
- (c) the average high energy physicist who stayed in the subject would be active in research for 20 years;
- (d) the proportion of high energy physicists staying in the subject would be 40%.

Using the above assumptions, an estimate could be made of the numbers available for or requiring research facilities in the future, and the results were:-

	<u>Total</u>	<u>No. for machines existing or approved</u>	<u>Balance (for new machines)</u>
By Oct. 1967	180	180	-
By Oct. 1972	290	160	130

If assumption (d) were made more conservative and only 30% were assumed to stay in the subject, the numbers available from the country would still be 80. C.E.R.N. had estimated that they would require 100-130 Ph.D's by 1970-72 for high energy physics and data handling on the high energy accelerator. The figures suggested that we would be able to supply our share, which would be a quarter, with a balance for possible new national projects.

6.2 In discussion of these figures it was pointed out that the prospects depended upon high energy physics retaining its present attractions, which included the fact that so many of the professors were nuclear and high energy physicists. Also, very intensive use would have to be made of the facilities in the U.K. if all these men were to be trained.

6.3 Another point made in discussion was that to make full use of such a large European accelerator many administrative and organisational difficulties would need to be overcome - whereas in the immediate future the trend might be the other way, towards perhaps less use of C.E.R.N., as Nimrod and then Nina came into operation.

7. Storage Rings

7.1 Sir John Cockcroft asked what was the present view of storage rings at C.E.R.N. Professor Burhop said that while there was no question of preferring storage rings instead of a high energy synchrotron, C.E.R.N. were very interested in storage rings for the C.P.S. both for bubble chamber work (feeding the ring with say one pulse per minute, and taking protons out for each bubble chamber cycle) and for neutrino experiments (filling up the ring over a long period and taking the protons out in one burst). It seemed that C.E.R.N. would most like to be given approval say by the end of 1964 to go ahead with storage rings (requiring a maximum rate of expenditure of about 60 million Swiss Francs per year) and to get approval for a high energy proton synchrotron about a year later.

7.2 The Panel recognised a double danger in the possibility outlined in the previous paragraph. There was a danger that having approved the storage rings, Governments would then not approve the synchrotron, the more important need. Also, Governments would feel that they were being approached first with the thin end of a wedge. For both these reasons, the Panel would favour the presentation of both schemes together to Governments. A possible practical difficulty was that the synchrotron project would almost certainly require a new C.E.R.N. Convention, while the others might not, but the Panel thought that such considerations should if possible not be allowed to determine the presentation to the Government.

8. Consequences on the nuclear physics programme at home

Sir John Cockcroft said that the report to be prepared would need to include a discussion of the effect of the suggested European programme on the nuclear physics programme in universities at home. Sir Harrie Massey said that there would be some relevant information in the report of a panel

set up by the Nuclear Physics Sub-Committee of D.S.I.R. to consider the requirements for nuclear structure machines.

9. Further Action

The Panel agreed to set up a working party to draft a report before the end of April as requested by the A.C.S.P. (paragraph 1 above). It was agreed that a further meeting of the Panel would then be held if necessary, but the draft report would first be circulated to see whether members wanted such a further meeting. With the Panel's approval, the Chairman asked the following to make up the working party:

Professor Flowers (convenor)
Dr. Adams
Professor Butler
Professor Cassels
Sir Harrie Massey
Professor Merrison
Dr. Pickavance
Professor Powell
Professor Salam
Professor Wilkinson

It was agreed that the report ought not to duplicate the work of the C.E.R.N. report: it would be quite acceptable to append a copy of the C.E.R.N. report and refer to it. The report should aim at presenting the case for a new high energy machine in a form which would convince other scientists.

I. A. Learmouth)
J. A. V. Willis) Joint Secretaries