MINISTRY OF SUPPLY,

Atomic Energy Research
Establishment,

HARWELL, DIDCOT,
BERKS.

12th August, 1952.

Sir James Chadwick, F.R.S.,
The Lodge,
Gonville and Caius College,
Cambridge.

Dear Sir James,

I hope that you will not mind my putting before you some of my views on the proposed European Laboratory. I have come to believe that the United Kingdom would be well advised to participate fully in the scheme, and consequently I am alarmed at our continued reluctance to join. I know that there would be economic and political difficulties, and I can understand that the Foreign Office may have well founded objections to our participation. This is not the time to discuss political matters, but I am prepared to risk a statement of views on some of the objections which might be raised by the Treasury. However, we must first agree on the scientific aspects of the project. It would be irregular for me, as a Civil Servant, to claim to represent the views of any official group at Harwell, and the opinions which I express are my own, but there is a considerable body of unofficial opinion along similar lines among physicists at Harwell and in the universities.

It is frequently said that high energy machines are now too costly to be justifiable in view of the remarkable success of cosmic ray research in recent years, and that future British efforts in the physics of very high energies should therefore be concentrated on cosmic rays. I have heard Powell express this opinion, but on the other hand, Blackett has recently said that he is now in favour of building machines in the 10-20 GeV range.

It seems to me that the principal role of cosmic ray research is still to make preliminary explorations of the very high energy field, leaving to the machines most of the task of making detailed studies of the new phenomena which appear. In particular the new particles are discovered in cosmic rays, and their detailed properties and interactions with other particles are investigated in planned laboratory experiments using accelerators. The progress of work on the π - mesons provides an example. The charged π's were discovered in cosmic rays, but the study of their properties soon passed almost entirely into the hands of those physicists who had access to machines. Experiments at Berkeley, Columbia, Rochester and Chicago established the spin and parity and the type of field interaction of π - mesons with nucleons, and also provided accurate values of the mass and lifetime and much additional information about the excitation of nuclei by π - mesons. Experiments with machines provided evidence for the existence of π^0 mesons which would have been difficult or impossible to obtain from cosmic ray research. The advantages of intensity and controllability coupled with the accessibility in the laboratory of apparatus such as analysing magnets and cloud chambers with magnetic fields, have been decisive. These advantages will continue to be available in the 10-20 GeV energy range with proton synchrotrons, and the gain in intensity over cosmic rays in this region is estimated to be a factor about 10^{10}. The experience with π - mesons may be expected to be repeated in investigations of the new range of heavier particles already discovered in cosmic rays.

These considerations were discussed at greater length at the Buckland conference, and have also been summarised by Cassels in a report which you will have seen.

Cosmic ray research will continue to yield important results for a very long time, particularly with the help of the powerful techniques developed by Powell's school, and the two fields of work are complementary.

We shall presumably have to rely on cosmic rays alone for studies of the very highest energies, since accelerators become too expensive to contemplate at energies far below the highest available in cosmic rays. The proposed accelerators are already sufficiently expensive to make it legitimate to consider whether this stage has not already been reached on this side of the Atlantic. Many people think that the economic limit of accelerators has not yet been reached, either for us or for the Americans, and I share this belief. We already know from the cosmic ray results on the new mesons that a big field of work is accessible at 10-20 GeV and is likely to be of great importance to nuclear physics. We also know, from preliminary studies of the Brookhaven experience, that a proton synchrotron for 10-20 GeV would be entirely practicable and that its reliability, performance and engineering soundness could be guaranteed if adequate staff and facilities were provided. I am certain that the necessary scientific, technical and industrial effort is available in Western Europe, where Western Germany's recovery and her temporary freedom from rearmament loading are of great value, and I believe that the necessary effort could be made available in Great Britain alone, though this would be more difficult and would be subject to delays in obtaining raw materials. The question of relating the scientific merits and the engineering practicability of the project to a specific sum of money is more difficult. I shall make some observations on this, but at this point I wish to emphasize that a project of this kind should be accepted, or rejected, in two stages. The first is concerned solely with the scientific soundness and value of the scheme, and the project should meet with the approval of the greatest number of working scientists on its scientific merits. Money hardly enters into this consideration, except insofar as the cost may be obviously so high that scientific discussions would be a waste of time. I think that we ought to complete the scientific consideration of the accelerator project even though we may fear serious opposition on economic and political grounds; the scientific value of the scheme may turn out to be so great, and the consequences of inaction demonstrably so serious for physics in Britain, that we shall have a strong case in the economic and political discussions. The recent conference at Buckland was remarkable for the degree of agreement reached on the scientific aspects of high energy accelerators between experienced physicists of varied interests. I believe that I am right in saying that Sir George Thomson's was the only dissenting voice in a lively discussion which covered not only the proton synchrotron but also our proposed linear proton accelerator.

The effects of our failure to enter the really high energy field with machines would go far beyond the specialised subject of high energy nuclear physics. The absence of a British effort, in what seems to many young physicists and to most students to be the most exciting field of work, could eventually exert a sterilising influence on the whole of nuclear physics in this country and, through this, on many fields of technology which have no direct relation to high energy physics. I think that these effects would reach most damaging proportions if the Europeans were to go ahead successfully without us and to provide themselves with a large proton synchrotron. The European Laboratory would then exert on our better experimentalists a similar attraction to that which already draws theorists towards Princeton and other American institutions. There are no visa difficulties in Europe, and the attractions of Europe are stronger than those of the U.S.A. for many Englishmen. It would be better for our physicists to work at the European Laboratory on leave from posts in this country, as official British representatives sharing the direction of the work, and eventually to return here. We need not worry overmuch about having to take second place to a prosperous and powerful country like the U.S.A., but many people would become dispirited if we appeared to come eleventh, behind Yugoslavia, in high energy physics.

It is true that the European scheme may founder on account of political difficulties, but the European physicists, at least, have apparently produced a reasonable degree of co-operation and have laid down a programme which, on technical grounds, gives good hope of success. Bakker's synchro-cyclotron group is particularly impressive. Many people believe that the idea of a European Laboratory, containing machines, is a good one and should not be allowed to founder; I believe that the scheme could go through if it were backed by Britain and that it would have a fair chance of success even without British support.

It is difficult to decide how much expenditure on accelerators can be justified, since the normal economic rules cannot be applied to future pure research. Most people have relied in the past on a general argument, namely that pure research should be supported by the community as a cultural and creative activity desirable in itself and that the community is occasionally rewarded by a new practical application. The sums involved in modern accelerators are so large that a more specific justification is required. I believe that the probable effect of this project upon the larger fields of nuclear physics provides this justification, especially in view of the importance in the public mind of all work which is in any way associated with atomic energy. National prestige is an important consideration for this country at the present moment.

The total cost of a proton synchrotron of adequate size would be about £5,000,000, and the cost of full British participation in the European Laboratory would be £285,000 per annum. For comparison the present direct expenditure from Government funds on civil scientific research is £16,000,000 per annum, the expenditure of the D.S.I.R. is about £30,000,000 and the Ministry of Supply vote for research and development is £100,000,000. The total cost of the proton synchrotron is appreciable, even on this scale, but the cost of participation in the European Laboratory represents about 1.8% of the funds expended on direct support of civil research, or less than 0.3% of the research and development expenditure of the Ministry of Supply.

It is often argued that Great Britain has already spent enough money on nuclear physics, but I suggest that we have not received value for money in the post-war accelerator programme. The accelerator programme was badly planned from a national point of view, despite the efforts of those responsible for its co-ordination. As an example to illustrate my meaning I shall quote first the case of the large cyclotrons. The Harwell cyclotron was built in good time and to good engineering standards, and has been operating very reliably for over 2½ years. A useful programme of research has been conducted showing that we can still put accelerators to good use when we get them, but the machine is too small and an additional expenditure representing a fraction of the total cost would have enabled this country to enter the artificial meson field in good time. The Liverpool cyclotron is exceedingly well engineered and is of adequate size, but will enter the field at least 5 years after Berkeley, at a time when much of the cream will have been skimmed. Most of the remainder of the machine programme has been even less satisfactory. The troubles experienced with the 1 MeV rectifier sets, the Van de Graaff machines, the Birmingham project and the Glasgow and Oxford synchrotrons may be cited. We must all share some responsibility for these shortcomings, not all of which can be attributed to industrial difficulties or to the absence of information about the nuclear physics of high energies in 1946. We are now in a much better position; it is now possible to decide on suitable types and sizes of machines from considerations of engineering and nuclear physics and we can recognise our former errors. We can still reach the 10-20 GeV range in good time, since the Berkeley machine will produce only 6.4 GeV and a larger Brookhaven machine has only reached the talking stage.

It has been said that our economic difficulties would prevent our participation in the European scheme because we are in deficit with the European Payments Union, and payments have to be made in gold. I think that the Europeans would appreciate these difficulties, which we hope are temporary, and would accept payments in kind as the major British contribution. We should have to pay the subsistence allowances of our staff in hard currency, but this is already done on a larger scale for businessmen and official representatives. We could supply a complete injector system (a linear accelerator, which we are especially well equipped to produce), some of the component parts of the machine, and a steady supply of electronics equipment for nuclear physics. These would be "unrequited exports", but the entire accelerator would be an unrequited export, along with everything else which we consume at home, if we were to build it in this country.

The difficulties which would be experienced by the Foreign Office and other Government agencies, in joining fully into the scheme and allowing substantial numbers of British physicists to remain abroad for fairly long periods, might

perhaps be very serious. Possibly the idea of having the European Laboratory in this country should be considered as a last resort. The Europeans would not like this but they might be willing to accept it as the only means of bringing Britain into the scheme. If we are to take any positive action we must make up our minds very quickly, particularly if we wish to have the laboratory in this country.

Yours sincerely,

T.G. PICKAVANCE.