Draft

Proposal for Northern Site for National Institute for Nuclear Physics.

1. The National Institute is providing a high energy accelerator at the Harwell site. It is understood that the paper on which the Government based its decision to proceed with the Institute contained the suggestion that a second accelerator might be built within about a 10 year period. Assuming that only about 50 scientists from the Universities can use the Harwell machine at the same time, there seems definitely to be a case for such a second machine if one takes into account all those Departments of Physics which are likely to be interested in high energy work.

If this were to be agreed, the question of siting would become important. (a) It is probably undesirable from a physical point of view to expand the Harwell Branch of the Institute further, because of the saturation of the area by Atomic Energy projects. (b) It would be a great advantage to the Universities if the work could be carried out within daily commuting distance, ~~A good commuting distance appears to be about 40 miles.~~ Harwell only satisfies this condition for the Universities of Oxford and Reading, but commuting from London would probably be possible, and Cambridge, Bristol and Birmingham are perhaps not too badly placed. (c) If this view is accepted, a very good place for the second site would be in the triangle Birmingham-Liverpool-Manchester. All of these three Universities have major interests in Nuclear Physics, and a site near Crewe would be excellent from the point of view of rail travel. The three professors consider that they could find 50 research workers for work with the machine in 5 years time. The use of the site would, of course, not be restricted to the three Universities, and it is thought that Crewe, with its excellent rail service, might be much more convenient than Harwell to a number of other Northern and Scottish Universities. Also, in due course, it would be possible to put other equipment, for example a research nuclear reactor, on the site. But it must be emphasised that Crewe is only a suggestion and that we have no particular site in mind.

2. During the past 18 months, an informal committee has held 4 meetings to consider the possibility of a second large accelerator in a Northern area. The group consists of :-

Professor H.W.B.Skinner	Liverpool.	Chairman.
Professor J.M.Cassels	"	
Mr.M.J.Moore	"	
Professor P.B.Moon	Birmingham	
Dr.L.Riddiford	"	
Professor S.Devons	Manchester	
Dr.B.Hyams	"	
Mr.D.W.Fry	Harwell	
Dr.T.G.Pickavance	"	
Mr.L.B.Mullett	"	
Dr.W.Walkinshaw	"	
Mr.J.D.Lawson	"	
Professor R.E.Peierls and	Birmingham	
Professor J.Diamond also attended some of the meetings.	Manchester	

The committee has considered the following types of accelerator. If required reports could be supplied, but the rough conclusions are indicated below :-

(1)	Electron linear accelerator, say 10 Gev.	Very expensive
(2)	Electron synchrotron, 6-8 Gev.	Possible
(3)	Very high energy accelerator, say more than 50 Gev.	Very expensive
(4)	900 Mev spiral ridge cyclotron	Not sufficiently attractive for its expense.
(5)	Gas discharge accelerators	Certainly not practicable for many years.
(6)	Colliding Beam accelerators	Not practicable at present.

In comparing (1) and (2) it was considered that though the linear accelerator would be excellent for electron diffraction experiments, its short pulse (1-3 μs) and small duty cycle (1 in 3000), which cannot be increased without great expense, would be a considerable disadvantage for many counter experiments. The price of the machine alone would be at least £6m, and the running expenses, on account of the need for replacement of the high powered klystrons, would be much in excess of those for a proton or electron synchrotron.

The group therefore came to the conclusion that the only machine which could be recommended at present would be the electron synchrotron. ~~It could not make any recommendation for any of the other machines considered.~~

3. A very suitable design for an electron synchrotron has, during the past few years, been evolved at the M.I.T. by Professor Livingston and his team. It is intended to erect this at Cambridge, Mass. for the use of Harvard University and the M.I.T. It is not known whether the American A.E.C. has actually provided the money but it is expected that it will.

Another machine, along very similar lines, is being planned by Professor Jentschke at Hamburg, and it is believed that he has got a promise of the money to go ahead. Sir John Cockcroft saw Professor Livingston in October 1957 and obtained the latest estimate of $6m for the machine plus $2m for the buildings. Professor Jentschke issued a report in mid-1956 from which we deduce figures of $5.3m for the machine and $2.8m for the buildings. The cost of the machine is therefore less than half that of the Harwell proton synchrotron.

If it were decided to proceed with such a machine, it can be assumed that Professor Livingston would give us access to all details of his machine, as he has done to Professor Jentschke. We should therefore not have to do any basic design work. This would very much ease the starting-up of the project. Assuming that we were not delayed by problems of site acquisition and development, we estimate that we could complete the work within about 4 years of the authority to go ahead. If the authority came within 1 year, we should not be much behind the American machine, and perhaps not behind the German one at all. But it must be emphasised that if there is substantial

delay in getting the authorisation, the project would become much less attractive.

We can roughly estimate the cost as follows :-

Site acquisition and development	£1.5 - 2.5m
Building for electron synchrotron	£1.4m
Electron synchrotron	£2.1m
	£3.8 - 4.3 m [4.6]

4. The following are types of work which might be done with the 6-8 Gev electron synchrotron.

The main purpose of building a 6-8 Gev electron synchrotron would be to investigate strange particles and antibaryons. It is well known that strong beams of these particles are better produced by proton accelerators such as the machine already being built at Harwell. However an electron machine would make it possible to study the photoproduction of the particles by the processes :-

Reaction	Threshold (Gev)
$\gamma + N \rightarrow \Lambda + K$	0.91
$\gamma + N \rightarrow \Sigma + K$	1.05
$\gamma + N \rightarrow N + K + \tilde{K}$	1.51
$\gamma + N \rightarrow \Xi + 2K$	2.37
$\gamma + N \rightarrow 2N + \tilde{N}$	3.74
$\gamma + N \rightarrow 2N + \tilde{\Lambda} + \tilde{K}$	5.95
$\gamma + N \rightarrow 2\Lambda + \tilde{\Xi}$	6.25

Because of the energy limitations on existing electron accelerators, only the first reaction has been observed so far. The remaining reactions offer a rich and attractive field of study, which cannot be attacked until the electron synchrotrons now planned in the U.S.A. and Germany come into operation in about 4 years time.

A study of these reactions, particularly near threshold, should offer results which are particularly easy to discuss from a theoretical point of view. A machine with maximum energy 6-8 Gev can be used to produce γ rays at any energy up to this maximum, and so would be very suitable for

all the above reactions. A particle process involving 'strong' reactions involves at least two 'vertices', where a particle is absorbed or created. In the simple ~~reactions listed, and in these alone~~ photoproduction, one of the 'vertices' involves a radiation process, which is thought to be well understood and easily handled by present-day field theoretical methods. This means that theoretical attention can be concentrated on the other ~~single~~ vertex involving the strange particles or anti-baryons. It is to be expected that specially clear evidence on the parities of the particles and on the couplings between them will result. It will also be of great interest to check that other photoproduction reactions, forbidden by strangeness selection rules, do not in fact occur.

A second class of experiments would aim at extending present-day studies of the scattering of electrons by nuclei, ~~with a view to~~ and the investigation of the structure of the nucleon down to very small radii. This sort of experiment requires a very 'clean' electron beam, and the problem of extracting such an electron beam from the synchrotron would require careful study.

5. ~~Since it is only informal, the committee is not entitled to make any definite application to the Governing Board of the Institute.~~ If the project were to be considered, the Universities concerned, ~~and perhaps the University Grants Committee~~, would have to be consulted. The ~~committee~~ group however, thinks that it ought to put to the National Institute the results of its work, in order to help in forming a policy ~~on the problem of the~~ for a second site. It feels that there are really only two alternatives (a) to proceed quickly with the 6-8 Gev electron synchrotron, (b) to hold up any discussion of a second site in abeyance for probably at least 5 years pending the results of preliminary work on new types of machine. The ~~committee~~ group ~~is in favour of the first alternative because its~~ review of new types of high energy machines, e.g. spiral ridge machines or gas discharge machines, does not give any ground for optimism about their success within a reasonable time.