SLIDE 1 *Nimrod Magnet*

This is just a picture of the many of Nimrod which I want you to register for a moment, and then we will compare it with the size of the magnet shown here (this is of course during the Nimrod installation), with that of the magnets of the present CERN 28 GeV machine, which I will refer to all the time as the CERN PS.

SLIDE 2 *Cern PS Magnet*

This is the corresponding magnet size of the CERN PS. There are about 100 units of the kind you can see in this picture around the ring of the machine which ~~is~~ has 200 m diameter.

Q. ? mass of steel.

A. The CERN PS is half the Nimrod magnet which is 7000 tons and this is about 3,200.

SLIDE 3 *Site Layout*

Shows the project as a whole. This illustrates the ring. The outer of those 2 beams you can see like a railway track, is the position of the machine which as one would expect, is buried in the ground for convenience in shielding. One needs about 30 feet of natural rock around all sides of the machine in order to shield it adequately ...
This ring diameter is about 2.4 km. You will notice a little ring up here in the corner. That is the machine of about the diameter of the present CERN PS, about 200 m which is part of the injection system and it has associated with it a 200 MeV linear accel. which is a prior stage of the injection system.

These are obviously laboratories, office buildings and so on. You will also see some experimental areas or experimental regions shown which are some distance from the accel. This distance here is everal kms, perhaps 3 or 4. The length of the beams that one gets from a machine like this are very long indeed. I will have more to say about this later.

That picture down there (the inset) shows to scale the CERN site ~~before~~ as it was before the bit went on up here for the ISR which are in France.

SLIDE 4 *Projection of 300 GeV Ring on R.L.*

Rutherford Lab. site. There is the R.L. site and there is that wing we just saw superimposed on top to show the scale.

SLIDE 5 Parameter Table

Top line here gives energies. 300 GeV machine energy variable is between 50 and 300. This is a little misleading as the CERN PS of course is variable. I have put 25 there as the particular figures underneath are related to 25 GeV operation.

The max. intensity pulse design for the European machine is $3.3\ 10^{13}$ so combined with the repetition rate of 1 every .3 sec, one can get a mean intensity of 10^{13} p.s. Corresponding figures for the CERN PS are round about 10^{12} p.p. and about 4.2 p.s. The figures in brackets are what they will be in the CERN PS improvement programme when it is completed in a few years time. It will then be 10^{13} p.s. and p.p. ~~1.3 x 10^12~~ Nimrod over here is up to 1.3×10^{12} p.s and the pulse a little under half that p.s. Here are the diameters and we have already referred to those.

I want you to look at the straight section lengths on here. Perhaps at this stage it is convenient to pointout that this machine is not just a scaled up CERN PS. The diameter is roughly scaled up to make sure we work it out to the higher momentum, but we look
just is not true.

If you look for example at these straight section lengths. Straight section lengths, i.e. lengths in which there is no component, no banding going on in the orbit, important for injection extraction and the positioning of the accelerator cavities. One needs rather straight section lengths to achieve a proportion of this in the case of the smaller ones. The longest length of the CPS is 3 m and if one was to just scale that machine up to 300 GeV then one would get 10 m; in fact the straight section length for the 300 GeV will be another 60 m.

A vital parameter to look at here is the vacuum chamber inside dimensions because that is the thing that determines the size of the magnet cross-section and it is the figure that affects overall cost of the magnet power supply. The CPS is 140 mm radial x 70 mm vertical, 14 cm x 7 cm. Nimrod is over there just for comparison and is about 1000 mm x 200 mm, but because one knows much more about the behaviour of the protons, how confident one can be in achieving the necessary alignment and so on, one can reduce the aperture in the 300 GeV machine below that of the CPS and will be coming down here to 100 m radial x 60 m vertical. You see that immediately reflected in the weight of steel - 3,200 tons for the CPS, 25,000 tons for the GeV. That figure there would be 140,000 tons reasonably scaled-up.

Of course the injection system is nothing like scaled up. The injector for the CPS is simply a 50 MeV linear accelerator. For the 300 GeV, the present design will involve a 200 MeV with the accelerator followed by a rapid cyclosynchrotron which will itself take the energy of the protons up to ?80 MeV before injecting them into the main ring.

It will inject 12 bursts into the main ring for each accelerator burst. They will be stored there during injection period and then accelerated up to the 300 GeV energy so that the intensity per pulse on this booster synchrotron ~~which will itself take the energy of the protons up to~~ is about 12 (you can see it obviously up there).

A lot of thought goes on in the design of the injection system. Several alternatives are under consideration and it is difficult tomake a clear choice between them.

They involve a higher energy linear accelerator than 200 MeV. This to be otherwise the same. This now seems to be a ?feature because a lot is understood about methods of making the r.f. cycle structure for the linear accelerator which suggests one could sufficiently extend the linac energy to 300 MeV with a crossbar structure which Alan Carne and his lads have had quite a lot to do.

Another system under consideration is one which would use only a 60 MeV linear accelerator and have a further stage of synchrotron-type of acceleration after that, before the beams are introduced into this booster synchrotron. That particular scheme which is known as the TART or the Triple Accelerator Ring Transfer involves the use of 3 synchrotrons which have some common components in them. They are interleaved in a rather special way. This is found to yield dividends in the amounts of protons one can accelerate without difficulty due to space charge effects. I do not want to say too much about them today, except to point out the obvious that if you have a very high density of charge particles together, that you are trying to hold together (they are trying to move apart from one another just under their natural repulsion) and there are certain limits to the number that you can retain in a given sited vauum vessel and so the injection system which is the area in which the greatest difficulty is encountered with the space charge effect has had some very special attention devoted to it.

There is a third scheme under consideration for injection which I'll just mention which means this booster synchrotron which is here, a 200 MeV diameter machine, is in fact split into 2 again, each of 100 m diam. and that again has the effect of alleviating the space charge difficulty making it more certain if we are going to be able to accelerate the numbers of protons one wants.

I think I mentioned something about injector beams earlier. I said that one would want to extract about 90% of the circulating beam; one might lose the remaining 10% or one might use it for internal targets in much the same way that we do on Nimrod and the CPS today.

SLIDE 6 *Magnet Block*

Cross section of the magnet blocks. This vertical dimension is about 80 cm x about 70 cm. You can see the whole thing makes something which in cross sections is rather less than 1 m square. Each block in the system would be about 20 m in length, and there are about 1000 of those in the whole ring.

SLIDE 7 *30° Sector*

This is 1/12 of the ring showing all its magnet blocks one after the other. It is a structure which repeats itself regularly all the way around. There are various places in which correction magnets, correction lenses have got to be put. There is a batch here, another here, and a whole lot of other things here which have to be related up for special purposes, e.g. pick up electrodes, special steering magnets for injection and so on.

At each 30° sector on each end of that is a long straight section.

These straight sections are quite short, just a few m in length but separating these 30^o sectors are 12 long straight sections, the ones in which the r.f. acceleration occurs and from which the beams are ejected.

SLIDE 8 *Main ring tunnel*

This just shows (a rough drawing) the magnet sitting in the main machine tunnel. The tunnel is about 5 m wide.

SLIDE 9

This is just to compare the normal spacing in the magnet lattice which is made up of 4 of these 6 m long magnet blocks with the arrangement in the long straight section which contains 2 quadrupoles. They will be a CD and CF otherwise the space in this field is free.

SLIDE 10 *Disposition (for survey)*

You see here an arrangement of the magnets. There are the 4 survey monuments which are used to align the whole system, which is done by measuring distances with stretched in-bar wires. This technique has been developed to quite a high degree of accuracy; individual measurements can be made in ~~a~~ hundreds of mm and it seems fairly definite ina lot of tests that have been taken that the whole system on the $2\frac{1}{2}$ km diam. ring can be aligned to the ~~vari~~ required degree of accuracy in this way.

The various dotted lines you see all round show various dimensions which would be measured. All of this requires the use of a modern computer to work out the position to the magnets. That is whythis technique would not work at the time the PS was being built. Of course a lot of computers would not perhaps be available.

SLIDE 11 *Magnet - pulse - injection*

This just shows the magnet cycle. This is the cycle of current. It actually says magnet power there. The current is not the current of the magnet, but somewhat similar. I think that is caught up onto the top of the picture. The injection occurs over this period. It is quite long - about .5 or .6 p.s. but at least 12 injected into the ~~accelerator~~ injector here. Then they are accelerated in here. I did not mention the power supply earlier for this system. It would be about half as big again as the present Nimrod power supply, so it is not a tremendously unusual thing. There are possible alternatives for the use of rotation in which there would no ~~change~~ rotation in equipment at all. This static type of power supply is being investigated by John Fox. The Laboratory is doing quite a bit on that.

~~NEXT~~ SLIDE 12 - site layout One of the activities of ECFA which Dr. Stafford mentioned at the beginning was to study the way in which this machine could be used, not to say that it had not been done for some in the CERN Study of 1964, but it was important to check estimates of cost of the numbers of people which the facility might support, see what special ~~arrange~~ developments might be required in technology in order to exploit the machine, whether any special requirements would be there for detectors and so on. This study was undertaken towards the end of last year and early this year with the help of about 60 physicists throughout Europe, many of whom came from the U.K.

This study was extremely successful, not only in that a lot of work was achieved. The outcome was very gratifying because it confirmed in a large degree the previous much broader estimates which had been made by the CERN Study group; it also brought a lot of people together to think about this project, people who are going to be concerned vitally with its utilization, and maybe them feel they understood because it really was their own thing they were talking about.

Now the outcome of this work as far as utilization in experimental areas are concerned ~~ine~~ is summarized in this picture. It was advocated finally by the EuropeanCommittee after studying the conclusions of the various Working Parties which came together, that we should initially plan on a thing that would have 2 main experimental areas. One down here which would be mainly used by counter experiments. They are very large by present day standards. This thing darkly outlined in the middle is an experimental ahll about 600 m long. This is about 6 times the size of Hall 3 and about 60 m wide, a little wider than Hall 3 and it has around it an apron whose full extent is of the order of 1 km in which beams can be extended from outside to inside the main area under some form of temporary shelter. It is rather expensive to build a building of this size in an area which you do not want to restrict all the time to a certain pattern of operation.

Another area up here, in which a number of this region down the back shows the area in which there will be detectors of the track cha. variety, bubble chas. or the developments therefrom and spark chas. Several possibilities for devices of this kind in this area were considered. Amongst them, very, very large bubble chas. which I will show you in a picture in a moment, one possible proposal, chas. whose working volume will be 100s, possibly 1000 times the working volume of bubble chas. today. The largest volume chamber in use is probably around a cubic metre. There are proposals here which involve many hundreds of cubic metres with the hydrogen possibly, even thousands of cubic metres. It is not at all certain how bubble cha. physics is going to develop in matters of this size. It is quite a long way ahead. It may well be that bubble chas. revert to the rôle of a relatively small system with counter arrangements around about, combining counters arranged around them. We thought it desirable for considering these proposals to include some sums of money for very large scale systems. I think there was £8M put in the estimates at the end for a very large b.c. system which might be 300 m^3 in volume and also for a very large magnetic spark cha. of volume 100 m. I think we put in about £3M for that. Both of these devices were promoted by people from this Laboratory.

I should say before we go from here the region you can see between detectors and the position about here, the region in which the secondary beams would be placed. They could be very long beams, up to 1 km in length. You see other possible areas of development in these other straight sections in which there are not these r.f. accelerator cavities placed.

SLIDE 13 Area I

This is a scale drawing, at least, of the exp. hall itself for the central area I which will be devoted for counter work. This region down the middle is a region of three target stations and series, beams coming from the left and at each target station, there are several ?2 high momentum beams shown here, each of which could be independently variable momentum by a special arrangement of magnets inside the target blockhouse, and in the case of this last target station the measurement of the particles will not be so

. These beams would not be of independently variable momentum. They are of a kind you get carrying out at the end. In each of these target stations it is estimated about 10% of the primary beam would be interacting. This is about as much as you can cope with.

SLIDE 14 Area I

This shows that target station area in a very exhorted scale in which the widths are 10 times as big as they ought to be relevant to lengths. You can see arrangements of magnets in somewhat more detail. This area was particularly worked on by J. Thresher and G. Manning and several others, and the target stations by E. Wilson and N.M. King.

Most of the steel in between these target stations is required for stopping muons produced in these targets. With a high energy ~~momen~~ machine muons become much more difficult to get red of than they are in machines like Nimrod and the CERN PS at the moment. This has to be about 15,000 tons of steel. It is all v. costly, weighs a lot, and has undesirable effects in that it produces reflections of the beams just from the sheer loading of the ground. This is one of the factors that has to be taken into account with the design of the experimental area, or more important, in the selection of the site.

SLIDE 15 Area II

This is the possible arrangement for Area II, again in an exhorted scale. That factor 10 is wrong. It is 5 times should be angles magnified by a factor of 5 of the radius. Vertical scale is 5 times the horizontal scale. You see diagrammatically shown here, a Heavy Liquid B.C., Magnet Spark C., Hydrogen B.C. being fed by various beams. The ones here at the bottom have got a 150 r.f. separated beam; other separated beams at the top here are for lower momenta and then the possibility of a neutrino beam, a muon beam and along here it will be possible to have some counters arranged around these beams as well. Probably initially the bubble chambers used in this area will be borrowed from other Laboratories. The H.L.B.C. might be from Gargamelle: the large H.L.C. at present under consideration - Hydrogen B.C. might well be the H.F.B.C. which is proposed to be b uilt at the R.L. Most of these beam lines would be underground for convenience in obtaining the necessary shielding, either by building tunnels if the ground is suitable, or by digging a trench and then putting it in afterwards.

SLIDE 16 Thomas B.C.

I promised I would say something about the large b.c. This is a picture of the so called Thomas chamber, a very large chamber. This one is perhaps much larger than one would want to build initially; it is 25 m diam., has 200 tons of liquid hydrogen in it; a huge 2000 ton weight sitting on top; lots of technical problems and lots of advantages. It is buried underground effectively. The forces observed by these superconducting coils which must have the requirement necessary for the magnetic field to operate in, are transferred to the ground round about. There are special arrangements here for photographs, probably this device would be used with some kind of computer system for recording the data it produces larger beams to provide the usual reference marks on the film.. typically everything that you think of every possible way we can bring techniques to bear.

SLIDE 17 Utiliz. Programme + Cost

This is a programme which was developed at the end of these U.S. It just shows what might be done by the end of three phases of operation. Phase I is up to the end of Year 0, i.e. end of machine construction; Phase II, 2 years later and Phase III, 4 years after construction. We consider it would be possible to develop from an initial arrangement in which 6 counter experiments are installed and where finally one could have 15 experiments on the floor simultaneously, i.e. in that first Area I, I mentioned. Similarly in Area II there is a progressive development here of the large track chamber detectors beginning from the initial situation whereone borrows chambers and later on where one has chambers available, especially built for the machine.

Costs

The total cost of providing this equipment up to the end of construction of the machine was estimated to cost $\sim$ 335 MSF (a bit under £30M), and somewhat smaller amounts are involved in getting to Phase II and Phase III. These are compared with the figures aboutthis part of the work of the Lab. in the initial CERN Design Study. We come to the conclusion that were not too far out in these sums which were near enough to being equal in the estimated errors, and in this Phase III one looks to have some money over to do something else with.

We also looked at the number of physicists this degree of activity might support on site and it was concluded that one would need initially about 104 people involved on those experiments and 2 years later this figure of 230, and later on a bit over 300. These figures again were in reasonable agreement with the figures suggested in the CERN Design Study proposal of 1964.

SLIDE 18 Bypass

This shows a possible development. I mention it just because it is connected with utilization. It is a v. late development which might be added to the machine. It has been working a good many years. It shows how one might be able to divert the beam after acceleration to cut across a part of the arc. In fact this picture shows it cutting across 2 of the straight sections. This just means a bypass and by building in here, a superconducting magnet storage ring for 300 GeV, or possibly a smaller conventional storage ring, one could arrange to obtain the kind of physics one does in these intersecting beam machines, feeding these rings either from the main accelerator or from the booster. This has been studied and looks feasible.

Siting

Sites offered

Sites for this facility were looked for in Europe about 4 or 5 years ago to see if it was possible to consider it. I have not perhaps stressed enough that the accuracy in the alignment in the magnets required - about .5 mm has got to be maintained over long periods so that one does not have to realign the machine - perhaps as long as 1 year. It is felt that the best way to do this is to get ground which is of average stability so that one can simply in effect put the components straight onto the surface. Therefore particular possible sites have been looked at in Europe superficially, i.e. measurements have been made on their surfaces. A chalk, a limestone and sandstone site have each been investigated and found at at least in that complexity the desired stability can be attained. These are measurements made out of overall lengths of about 300 m, which is the kind of length over which one has to achieve this .5 mm stability.

The next thing to do was to invite Member States of CERN to submit possible sites for consideration. The area required for the whole Laboratory allowing for some extensions is 30 sq.km, about 8 sq. m. The ground has to have this stability characteristic that I mentioned; also be reasonably incompressible so that as one moves very heavy shielding loads around experimental areas, the neighbouring beams already installed and aligned, are not going to be disturbed too much.

There must be adequate primary services, electricity and water. The site has got to be reaso~~n~~nably accessible to people from various parts of Europe and for equipment and there have to be a number of human amenities of various kinds. One has got to have schools, good medical services if one wants people to live there, to want to go there and work. At least 150 places have been looked at in some degree since this work began, although only 22 of them were finally submitted for serious consideration and this number is now 9.

SLIDE 19

1022 Sites: Most of the ones shown in circles are the ones under consideration. I will just enumerate them:

There are many statistics being collected on all these sites. All the things which we imagine relevant are related to travel, housing, the availability of staff in the area to support ______ industry. All these things are being looked at and this work is still going on. I might mention at this stage that it is felt there is a very important advantage to the host country in getting the machine on his own site, perhaps 40% of the budget of the Lab. will be spent in the host country, so one is obviously going to get one's own contribution back and a lot more. We will look a little now at the UK site itself.

SLIDE 20 Site projected on RL/AREE vicinity.

Just to show the local area that we know and some well known land-marks. The dotted line shows an approx. rectangular area which is the maximum requirement. In fact you could not build the machine on this site very readily around there, even if there were no existing laboratories taking up the space.

SLIDE 21 London – Mundford

Mundford is the square. It seemed a good idea to have Stansted airport on here. In fact, if it does come off it will certainly help a great deal to get to this site quickly. There are also some very useful Channel ports. You probably know places like Felixstowe are being built up and because they were old ports, not used very much, it is now possible to go straight in to modern techniques of transport without having to worry about how to get these modern methods of packaging and so on accepted by people.

SLIDE 22 Mundford Environs

Assoc. towns around the Mundford site with which you may be familiar.

SLIDE 23 Mundford Layout

U.K. Site. It is nearly all pine trees. Most of the land is owned by the Forestry Commission. There are a few _____ farmers with shooting ?tenders on it ..... These lines radiating off here are the lines one would be probably using if operating at Mundford.

SLIDE 24 Mundf. Beam Sections

Now these sections are important. They show the topography.around the ring. There are some areas hatched in here where it would be necessary to provide some fill as the surrounding ground is insufficient for shielding.
The lines along here show sections along the possible beam tunnels. They give some idea of the extent - 4 km in straight section and there are possibly some even longer than that. Longer beams may be required some day. You will also see in most cases there is a good bit of cover available in natural ground so that one does not need to find extra chalk - it is all chalk at Mundford -
1090 to pile on top of the tunnel.

SLIDE 25 Aerial View of part Mundford

Aerial view of only a very small part of the site showing some of the land used for growing .

SLIDE 26 Road through Site

This picture was taken recently by John Milne and shows one of the roads within the site, mostly pine trees. It is very flat, about 50-60 ft. variation in height.

SLIDE 27 Water Tank Test

I mentioned earlier the importance of compressibility of the ground. Mundford is one of the softest sites under consideration, at least superficially it is true to say that. Chalk is rather more compressible than granite and limestone which figured quite highly in some of the other sites, but depending on the degree of fissuring of the chalk and the amount of soft material in the fissures, it is quite probable that it will be adequately hard. One cannot be certain of this without doing a loading test on the site and the loading test has got to be done on a very large scale, to ~~s~~timulate the effect of some 10,000 tons of steel being moved about. This loading test is being done by the Building Research Station on behalf of the S.R.C. This is a 60'diam. x 60' high tank (actually we are using oil tank techniques) and is being built on the site for this purpose and will be filled with water and the flexes are going to be measured in shafts and tunnels in the ground below 80 radial, several hundred feet out and will be going on for several months. Several people from this Lab. are helping in this work, namely J. Milne, H. Lane and R. Forbes.

I have finished really most of what I want to say about the technical aspects of the project as compared with the situation when the CERN PS was first built. This machine is almost conventional; it really does not involve very much in the way of new technology in order to build it. It is certainly going to place more stringent demands on the geology of the site, and on the performance of industry, but nevertheless everything that one wants seems to be possible, although ~~there are~~ some technology and techniques are going to be stretched, but in all cases it seems reasonable to suppose that this can be done.

SLIDE 28 Programme

I want to indicate the main features of it. It illustrates the programme assuming a decision to build this device is taken sometime this year, or not too late next year and shows the machine being completed around about the end of 1976

This region 67/68 is concerned with the choice of site and the decision to be made of the new Lab.group, further studies of the site itself and finally starting to move to the site around about here, building machine tunnels and other civil engineering which could all be completed in this period up here.

We see here the programme for model studies on the accelerator components and later on on the utilization components, then magnets, quadrupoles and so on. Over this side the delivery, design test and installation.

SLIDE 29 Item costs

This shows the main part of the machine.

Machine proper: This is the accelerator without the utilization facilities and without the Lab. general facilities - 1,000 MSF (say £18M). Preparation for high energy research; the building of experimental equipment - £30M and the whole lot adding up to very nearly £150M.

SLIDE 30 Annual Budgets

Annual budgets:

This shows a very slight build up initially, ending up very nearly to

£25M p.a. U.K. contribution is £ ______________

Estimates of course have been made at the start and are all part and parcel of the timescale and costs, and they go beyond the stage of construction being completed after 1976 towards 5 years later in 1981 (about 5 years in 2 operations).

Personnel Estimates

Total on site: You can see at the end of construction about 2,500 people on site, building up perhaps later to some 4,000. Notice the number of experimental physicists in 1976 — 140, 210 two years later and 365 around 1981. These are composed of resident staff, experimenters and visitors which of course in turn are only just part of the total no. of people who can depend on the Lab.

These numbers have been looked at by ECFA in quite some detail and they have satisfied themselves that they are not unreasonable, and in fact I am satisfied myself they are v. reasonable, some of them may even be on the tight side. It is interesting to look particularly at the numbers of service personnel involved in administration, workshops and so on, site operations generally. These numbers as compared with the total no. of people on site doing this sort of indirect support of the programme itself ... The ratios of these numbers of total service personnel turn out to be reasonably close to those at the R.L., so we have some confidence that they are well founded.

Promotion of the project so far

Dr. Stafford said technical interest in this thing went back to the early 60's. There were similar studies going on in America at Berkeley and Brookhaven for rather different energy machines. The ECFA in 1963 recommended that a machine of about 300 GeV energy should be built and a decision should be taken to build it by the end of 1965. If it was not taken by then, one should look again and in fact the decision was not taken by then, and that was why ECFA was reconvened early last year. Now it is reported. in CERN ECFA REPORT 1967.

If you look at the back of this document you will find the names of about 30 people from the UK who were involved in one way or another either on the ECFA Committee or on the various Study Groups which were formed during the recent period I mentioned, and it was particularly in the Utilizatinn Studies that the UK contingent made a dominant contribution and one in which these utilization studies would certainlynot have been brought to a successful conclusion. It also had the very important effect of demonstrating how important a national programme is, something which brings people together, which makes them operational, workmanlike and understanding what is involved in a facility of this kind.

The CERN Council is the only official body which is dealing with the policy for this machine on behalf of the MemberStates. It began by consent doing this, without commitment because initially no country would just agree to go and build this thing, but it was agreed it should be studied and it authorized such studies and the search for possible sites, and also more recently the CERN Convention had got to be amended in order to allow that organization if it so wished, to extend its activities to the creation of a major new laboratory, particularly one which would become a dominant laboratory in the 80's and for the rest of this century.

At the end of last year Member States of CERN were asked would they formally agree to a new convention being drawn up for consideration during this year, and one hopes for agreement as a possible basis for constructing a new Laboratory.

Also towards the end of this year, it is intended that the number of sites under consideration will be narrowed down, perhaps to 3 in the first instance, perhaps going straight on to 1. It is possible of course that this decision of the sites will not be reached this year. Nevertheless, it is hoped that the countries essantial to the pursuit of this project, will have agreed to go ahead by the end of this year, if not before. I think it is important myself, that this particular decision is taken before a site is chosen, for the decision of a site could well drag on. There may be problems of course in finding the money to start off the project at the rate which is at present proposed, but that does not seem any reason for against, saying that one is going to adopt the project within the next year or two. It also enables people who have to plan this ~~hhing~~ to get ahead and plan it ~~is~~ in a sensible way. If they know that it is going to be supported they can do it with that much more confidence, and then finally, it is important politically to have the particularly important countries commit themselves to the project before a site is chosen, so that they cannot later on make conditions about going into the project if it is on their own territory, for example.

I now want to look at the overall programme of Europe briefly.

SLIDE 32 Present finance distribution – national – international

This shows budgets in high energy physics both national and international throughout Europe. Let us not worry too much about the countries other than the big four. They are all in millions of francs and we will mainly be comparing ratios, but just to us, we can look at the UK national high energy budget - say £10M. We would want to look then at the basic CERN contribution which from the UK is this figure 32.

Note that this is about 1/3 of the actual money being spent - about ¼ of the money being spent in the national high energy budgst of the UK. We havea particularly fairly high ratio of our total national budget to the CERN total contribution which is given over here - 3.3 if you take the figure 38 which is the total of the CERN contribution.

Recently it has been recognized that every country spends a certain amount of money at home, as part of its national programme in direct support of the CERN programme in addition to its basic CERN contribution, and it is clear looking at the average of the money being spent by the Member States that thus sum of money is a very important fraction of the actual CERN contribution. The average figure is .57. A figure equal to .6 of the basic CERN contribution is spent on the average by the main Member States of CERN as part of their national programme, helping to do the work at CERN. Notice the huge disparity between the amount of money being spent by France or their ratio 1.21 times the basic CERN contribution, compared to the UK which is only .22. On the average, we are perhaps balancing each other out, but it means France is getting a lot more out of CERN at the moment, than we are.

Undoubtedly this is connected with the fact we have an important major successful national facility already working in this country, whereas France is not really in high energy physics with Saturne at the moment. This picture will change radically if France goes ahead with its own present plans for its intended high energy machine.

GHS I think that in fact a lot of the French contribution must be in building bubble chambers.

LCWH This is important to say. This is any money at all spent for the international programme. It may not be spent ~~for~~ doing counter experiments in the Laboratory; it may well be spent building equipment to take there, and surely the French are spending a lot of money on things like that.

SLIDE 323 Physicists in HEP

These are the no. of people ECFA discovered could be said to be in the counter ~~ex~~ physics field. These are the numbers in the bubble chamber field. The numbers not in brackets are the total numbers in those countries in high energy physics in those fields - counters and b.c. The numbers in brackets are the numbers said to be wholly dependent on CERN for their experimental material. You can see for the UK it is believed we have 5 counter experiments wholly dependent on CERN - not people working at CERN or paid by CERN, but paid by the UK in some way. You will notice how much more this figure is with other countries involved. We are much more comparable in the b.c. field. If you go right across here you see that about, of the total big 4 population, 1135 people in HEP, 519 are wholly dependent on CERN for their experimental data, either in the form of film or including experiments at CERN.

The total HEP European population in the CERN estimates including everybody at the moment is believed to be 1436.

1765 SLIDE 334 Future Programme Model

1779 This slide was developed in an attempt to illustrate the essential conclusions of the possible hypothetical programme for the whole of Europe running ih to the 80's. It is proposed that the present PS at CERN ISR are operating but the PS particularly at some reduced scale in 1981 although the ISR programme is assumed to have grown considerably over that period. This is what is known as the international programme. Then one has the national and regional programmes and this is concerned with people and money, so we have this as part I, that part of the national and regional programme which is concerned with getting something out of the international facility and it is estimated that by '81 there will be a total of 1500 physicists at home as it were, outside CERN who are concerned with getting material out of the international laboratories and about 850 is not very much larger than the present totals of people dependent on their national income.

The important things to notice are the growth in the numbers from about 1500 to 2500 over that period which is about 15 years and in money around about a factor of 3. The growth in manpower is on the average about 4½% over this period. It is less than the growth of HEP in the past and it is less than the growth of most other sciences and it is felt therefore that advocsting the acceptance of this project, the approval by Member States is not basing the argument on maintaining the present rate of growth of high energy physicists or indeed even expecting to grow as other fields would grow, but rather a reduced rate of growth. The amount of money represents a fair amount of capital investment in terms of general exploitation of facilities apart from the capital investment which is a fairly standard growth rate of the kind people have got used to living with about 7 or 8%.

Continue on p. 23.

I want to conclude by (thank you for bearing with me so long) giving something of the scientific justification of this and a sort of affirmation about it. Everyone wants to know what practical application all this work has, which is going to be of direct benefit to mankind, and one must always come back to saying that, whilst it will be surprising if there is no direct application of all this activity some day, it is not possible to make any predictions. It is always a contradiction in terms of seeking to construct a facility which is designed to extend knowledge to ask what knowledge is going to be obtained. The only real justification is in this extension of knowledge. However if you want to console yourself in any way, ~~that~~ there will be probably some application of all this some day, perhaps a millennium away.

You may recall the researches of Faraday into electromagnetism which really form the basis of all electrical engineering today; you may think of Maxwell in electromagnetic theory and its development in radio communications, radar and television; one can think of quantum mechanics which today pervades nearly all the modern sciences; electronics, which depends on solid state physics and the application ofquantum mechanics there; physical chemistry, molecular biology; you can think of ? Rudkin looking at x-rays; I can think of all the atomic energy fields with which we are much more familiar in the application of radioactivity, and nuclear fission in power production.

All these things ~~people~~ began simply because curious people wanted to know the answers to questions which occured to them and they were always amongst the most brilliant people of their times. High energh physics is not any exception to this, and there is no question that it is one of the 2 or 3 most challenging of all such fields today. So this is why one can say it will be surprising if there will not be some application, but this is just not the justification for going ahead. One knows of course that countries or cultures which do not contribute to the most advanced sciences are definitely outside the main stream of human development with serious consequences to their intellectual life and their productive power. This is why we have always placed so much emphasis in the R.L. on the very close connection with university teaching and research.

Prof. Matthews explained something in the first talk of this series of the states of HEP today and the urge to go on to the new energy regions to seek to understand more, and perhaps confirm what is known today of the fundamental particle relations, the symmetry properties to which he referred, as well of course ~~to~~ so looking possibly at entirely new phenomena.

In purely technical terms, both strong and weak interaction physics need~~s~~ a step of the kind that would be provided by this machine, to make a worthwhile advance. Fortunately it seems to be financially within the resources of Europe. The construction period is not unacceptably long provided one gets an early decision to proceed.

You will recall that after the last War Europe was left behind in this field. The creation of CERN and national facilities like the R.L. here narrowed, and eventually eliminated the gap between Europe and the U.S. The brain drain has been reversed but the gap must not be allowed to recur. Europe is at a crossroads again now.

Fortunately it seems to recognize this. European physicists collectively support this project; the UK scientists are quite unanimous in their view almost in an unprecedented way. They support, they have expressed themselves in committee meetings, in chronicles and cloisters and many of them have demonstrated their enthusiasm for a lot of very hard work recently. It also seems that many politicians look sympathetically on the proposal. Britain has established a pre-eminent position in HEP amongst the countries of Europe and it is no doubt by building in the period between now and when this facility will be available, e.g. by putting to rights this exploitation of CERN as it is at the moment, we are poised to exploit, I think, with unique advantage this new facility wherever it happens to be built. I hope that we will officially say an unequivocal yes when the time comes later this year, if not before. I am not sure one should say "oui" but after all both French and English are official langugages of the European Organization for Research in Nuclear Science, so perhaps ~~we~~ it will not matter if we say "yes" or "oui".
