

COPY

RESTRICTED

REPORT ON THE CONFERENCE ON HIGH ENERGY ACCELERATORS FOR
NUCLEAR RESEARCH

Buckland House, 7th June 1952

Edited by M. Snowden

CONTENTS

1. The purposes of the conference
- Sir John Cockcroft
2. The Theoretical Viewpoint on High Energy Research
- Professor R. E. Peierls
Discussion
3. The Experimental Viewpoint on High Energy Research
- Dr. J. M. Cassels
Discussion
4. Problems involved in constructing a Proton Linear Accelerator for 450 MeV.
- Mr. L. B. Mullett
Discussion
5. Dielectric loaded Linear Accelerators for High Energy Electrons
- Mr. R. B. R. S. Harvie
Discussion
6. Thoughts about a Proton Synchrotron
- Professor H. W. B. Skinner
Discussion
7. Problems involved in constructing a 15 BeV Proton Synchrotron
- Dr. T. G. Pickavance
Discussion
8. The Western European Nuclear Research Centre
 - a) The Organisation being built up
- Sir George Thomson
 - b) The Views of the Advisory Panel
- Mr. F. K. GowardDiscussion
9. Summing Up
- Sir John Cockcroft

THE PURPOSES OF THE CONFERENCE

By

Sir John Cockcroft

Sir John's opening remarks referred to the accelerator programme of the past five years. We were now seeing the completion of this programme in the cyclotron at Liverpool, the electron synchrotron at Glasgow and the proton synchrotron at Birmingham. Recently Cambridge had decided to build a 300 MeV linear electron accelerator and we at Harwell had been giving serious thought to the future of high energy accelerators here.

We had to consider the question of a machine giving high meson fluxes for doing work on meson absorption and scattering. This might be done by a machine of 500 MeV energy. Alternatively, there was the higher energy range in the BeV region where besides the high meson flux there might be other events. Also there was the dielectric loaded guide and its possibilities in the high energy field to be considered.

There was also the question of the European accelerator programme, our relationship to it and what facilities there would be available to us.

THE THEORETICAL VIEWPOINT ON HIGH ENERGY RESEARCH

By

Professor R. E. Peierls

Speaking for the theoretical physicists Professor Peierls said that in general terms they were very much in favour of high energy machines. When it came down to particulars it was difficult to judge the problem in all its aspects.

Considering the million volt energy range we were able to learn quite a lot about nuclei without having a complete theory of the nucleus. We were in a similar position to that which had confronted the chemists in the study of molecular structure, before the working out of the quantum theory.

Just as with atoms where electron energies of a few electron volts existed Rutherford, by using α -particles of several million volts energy, had been able to investigate atomic structure, so, in order to find out about the structure of the nucleus, we require energies much greater than those associated with the nucleons inside the nucleus.

The meson theory had now been shown to be much more complicated than that originally conceived by Yukawa. We wanted to know what was the basis of nuclear forces.

We wished to study the absorption and emission of mesons and to use the mesons themselves as a tool to explore the nucleus.

In any new energy range we would probably make discoveries which had not been predicted along with those expected by existing theory. Although we cannot say anything about the unpredictable events we should not ignore this aspect.

On the evidence to date we know that with energies in the 500 MeV range fast mesons are produced and these are providing a lot of information. The variation of meson cross sections with energy is quite important.

Beyond this energy range we should be able to produce V-particles and K meson. The picture here will be much more complex and more experiments will have to be done to sort out the information. The energies to produce Vs or Ks in the laboratory are not known. We must produce Vs either from an excited state of the nucleon or in pairs. In the former case less energy is required but it is probably necessary to produce a secondary particle. The threshold is not easily predictable but there is a possibility of producing V-particles at energies in excess of 1 BeV. Other particles may be produced at intermediate energies.

It is fairly certain that negative protons must exist but the mechanism of production is not known. Energies > 5 BeV would probably be involved, and the production would have to compete with other processes.

In cosmic rays we already have the energies as high as we want. How much better are artificial sources than cosmic ray sources? Besides the obvious question of intensity there is also the ability to control the timing of events with artificial sources.

The intensity required depends on the type of experiment and the sensitivity of the detector.

We must ensure that advances in machine development are paralleled by improvements in measuring instruments and experimental technique.

DISCUSSION

In reply to Sir John Cockcroft's question on the life time of the negative proton Professor Peierls said that in empty space the negative proton would be expected to be as stable as the positron. Sir George Thomson suggested that there might be barren gaps in the energy scale where few interesting results would be obtained. Professor Peierls thought this might be true if one was only interested in producing new particles but that in general in any energy

region, interesting and useful experiments could be performed. Professor Blackett did not think that many experiments on the properties of π -mesons could be made using cosmic ray sources. He thought that energies of the order of 10^{10} e.v. are required to produce V-particles but that, as many of them were found to be secondary events, energetic mesons themselves may be efficient in producing them.

Professor Peierls agreed with Professor Frisch that experiments with low energy mesons may provide data on multi-body forces.

Sir John then asked about the merits of high energy quanta and Professor Peierls replied that, because of the weaker interaction of quanta and the cross sections being down, he thought protons would be much more useful than electrons or γ -rays. In addition the background with quanta would be much higher. Professor Skinner pointed out that the γ -ray energy would have a continuous spectrum. Although the coincidence methods to define the γ -ray energy mentioned by Mr. Goward were possible and although as Dr. Shire remarked the electron beam intensity might be an order of magnitude greater than that for protons, Professor Massey thought the intensity for good experimental work would be too low. Dr. Cassels pointed out that in the BeV energy range protons were still more favourable, for very thick targets could be used. This could not be done with electrons or γ -rays, where even thinner targets were required because of the decrease of the interaction length with energy.

Dr. Shire asked if high electrons would not supply information unobtainable from other sources. Professor Peierls and Professor Blackett said that information on electrons themselves could be obtained, in particular electron-electron collisions where the distance of approach was near the classical radius. This might require energies of 5 BeV but Professor Massey felt that somewhere a machine for electrons of such an energy should be built.

Ed's Note

In the Bulletin of the American Phys. Soc. issue of May 1st the range of energy of particles producing V- particles is given as at least 5 BeV to greater than 25 BeV.

THE EXPERIMENTAL VIEWPOINT ON HIGH ENERGY RESEARCH

By

Dr. J. M. Cassels

Dr. Cassels, expressing the point of view of the experimental physicist at Harwell said that the time has come when we should like to construct a higher energy accelerator. The question was what kind of machine to build. We could divide the present field of experimental research at high energies into the four categories.

1. New Particles
2. Mesons
3. Nucleon - Nucleon Scattering
4. Electrodynamics

Of these 3 was adequately covered by existing machines and 4 by the Cambridge electron accelerator. Under 2 we had work on (a) production (b) absorption (c) scattering and (d) other properties. (a) and (b) were being covered by present machines but (c) and (d) require greater intensities of mesons than at present obtainable.

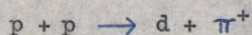
The alternatives are therefore a machine for

1. Intense Meson Fluxes
2. Energies in the 3-20 BeV range

Considering 1. First the following table lists the meson fluxes obtainable from different sources.

<u>Machine</u> (Output of 1 μ A assumed)	<u>Meson Flux</u> (Collimated with $\pm 2\frac{1}{2}$ MeV spread)	
	<u>+ ve</u>	<u>- ve</u>
1. 450 MeV cyclotron		
a) Internal target	50 (70 MeV)	50 (220 MeV)
b) External liquid H ₂ target Beam - 10^{-4} μ A.	35 (130 MeV)	-
2. 450 MeV linear accelerator for electrons	200 (180 MeV)	200 (189 MeV)
3. 450 MeV linear accelerator for protons		
a) C target	20,000 (220 MeV)	20,000 (220 MeV)
b) Liquid H ₂ target	400,000 (150 MeV)	

In the case of the cyclotron the meson beam is deflected out of the machine by the magnetic field - ve mesons coming off in the forward direction are used but only the backward moving + ve mesons are available externally; hence their lower energy. With external proton beams the



reaction is used and here the energy of the π^+ mesons is constant. Even when thick targets are used this is still approximately true for the protons and mesons lose energy at similar rates in the target.

It may be that an energy increase from 450 MeV - 600 MeV would be worth while. The cross section for meson scattering appears to increase with energy and then flatten off. 600 MeV enables us to continue exploration beyond the flattened region.

Considering the second alternative the position in the BeV range was much less clear. We had first to choose between protons and electrons. The energy available in the centre of mass system for various incident energies of proton or γ -ray is tabulated below.

<u>Energy of Proton or Electron</u> BeV	<u>Kinetic Energy Available in C. of M.</u>		
	<u>γ-Ray</u>	<u>BeV</u>	<u>Proton</u>
3	1.61		1.14
6	2.55		1.97
10	3.5		2.85
20	5.26		4.54

As the electron has first to be converted to a γ -ray, protons will prove a more effective source of reaction energy, the conversion of very high energy electrons into very high energy γ -rays being a rather inefficient process.

The new particles may be created by pair production by γ -rays, or through nuclear processes with either γ s or protons as primary particles. Considering the production of heavy mesons by direct pair production we would expect 1 μ A of electrons at 3 BeV to produce $2 \cdot 10^5$ mesons/sec. With each meson probably 10^7 soft shower particles would be present, so that this method is not attractive.

As far as nuclear production is concerned we know that in the 500 MeV range protons are 2000 times more efficient at producing mesons. At higher energies this factor will be even greater because of the target thickness effect. So even allowing any electron accelerator to have 10 or 100 times the beam current of the alternative proton accelerator the meson intensity will still be greater for the proton machine.

We turn now to the experimental techniques suitable for the sort of outputs delivered by high energy accelerators. Counting experiments will be very difficult with bevatron type accelerators because so many different kinds of particles will be present.

The diffusion cloud chamber should prove to be very satisfactory for use with bevatron and the low pulse rate of these machines suits the recovery time of this type of cloud chamber. About 10^{10} protons/pulse were available from the bevatron. The output required from a linear electron accelerator to give a comparable meson yield would be 10^{14} electrons. If we allow these to be spread over 10 millisecs the current is 1000 μ A.

The choice in Dr. Cassels opinion was either a proton linear accelerator for meson research or a bevatron in the energy range 10-20 BeV.

DISCUSSION

In answer to Dr. Shire's question about the feasibility of linear proton accelerators for the BeV range, Dr. Cassels said that the bevatron design was known to be satisfactory in this range, whereas the proton linear accelerator would be rather speculative. Professor Peierls agreed that it would be a good idea to go for an energy in excess of 450 MeV as this was thought to be the threshold for multiple meson production. Professor Devons pointed out that 7 BeV protons would only make available a similar amount of energy in the centre of mass system as 5 BeV γ rays. Dr. Cassels agreed but with Professor Oliphant emphasised that the inefficient production of high energy γ rays from high energy electrons more than outweighed this factor. Dr. Hereward told Sir John that Stanford's electron current was at least 10 μ A.

PROBLEMS INVOLVED IN CONSTRUCTING A PROTON LINEAR ACCELERATOR

FOR 450 MEV

By

Mr. L. B. Mullett

The design of a proton linear accelerator to deliver in the order of $1 \mu\text{A}$ of protons at 450 MeV was being studied. It was proposed to inject the protons at an energy between 0.5 and 4 MeV. and the duty cycle of the accelerator would be between $1/200$ and $1/100$. Starting with a source current of 10 mA the duty cycle would give a reduction to $100 \mu\text{A}$, the acceptance phase conditions to $10 \mu\text{A}$ and the focussing by foils or grids leave only $1 \mu\text{A}$ or so in the output beam. The Alvarez - type of accelerator had been considered and based on such a design the following figures would seem to be practicable with $\lambda = 150$ cms. 270 sections would be required and the total length would be about 200 metres. A peak power of 40 M.W. and a mean power of 400 K.W. for $1/100$ duty cycle would be necessary. However other guide structure which may make possible the use of π -mode operation should give an improved efficiency and a reduction in length to about 100 metres. π -mode operation with 2 gaps per wavelength is suggested and the stable phase angle would be 18° as against 45° for Alvarez accelerator. It might be possible to change to a travelling wave condition at the higher energies. Grid focussing on every other gap up to 45 MeV is required and then foil focussing on all remaining gaps.

Considering a reduction of wavelength, it would no longer be possible to use grid focussing but with foils λ might be as small as 25 cms. It was of interest to know that Alvarez was thinking along these lines for a proposed 500 MeV accelerator.

Other focussing systems had been considered such as centrifugal focussing using a helix as the accelerating electrode and a central wire at 100-200 KV D.C. to give the focussing conditions. The helix however is only practicable at low energies. A corrugated inner with the particles accelerated in the annular space between it and the outer also was only satisfactory at low energies. With corrugations on both inner and outer this drawback is removed but the system is very inefficient. The possibility of using an electron beam had also been considered and 1A of electrons in a beam of diameter 2 cms would be required from a supply of 70-100 KV.

The following costs had been estimated for an Alvarez type of accelerator working with λ between 75-150 cms.

Tetrode Valves 40-80 in number	£ 70,000
Modulators	£250,000
Waveguide	£ 60,000
Vacuum System	£ 20,000
Controls etc.	£ 10,000
	£400,000

This excluded the costs of the building to house the accelerator.

As far as scientific effort was concerned the present group would probably be adequate. About 18 months would be required to build the first experimental section and 6 months to test and finalise the design. A further $1\frac{1}{2}$ - 2 years would be required to complete the machine.

DISCUSSION

Dr. Bretscher asked about the line up of the waveguide sections. Mr. Mullett said that with the 3-4 cm. hole as designed there would not be much difficulty and Mr. Adams pointed out that to some extent the protons would follow the guide. Mr. Tozer asked about the possibility of cyclotron injection. This had been considered and is a possible alternative. Professor Oliphant suggested that the cost would be considerably reduced by using separate

resonators that Mr. Mullett said the efficiency would be reduced. Professor Skinner asked at what energy a travelling wave system would be possible. At 100-200 MeV it would be possible and the structure envisaged by Mullett would work for $v = 0.3 - 0.7c$.

DIELECTRIC LOADED LINEAR ACCELERATORS FOR HIGH ENERGY ELECTRONS

By

Mr. R. B. R. S. Harvie

Describing the present stage of development of dielectric loaded guides for accelerators Mr. Harvie said that a satisfactory dielectric material, titanium oxide had been developed. It had a Q of 8000 - 10,000 and a dielectric constant of 90.

Using this material the following shunt impedances were possible.

	<u>λ in cm</u>	<u>Z_s in Megohm/metre</u>
1. Simple Waveguide Structure Theoretical Value.	5	900
2. Practical estimate	5	400
3. Practical estimate	10	300
4. For comparison Stanford Metal Guide	10	40

Experiments on simple waveguide sections confirm the theoretical results except for unexpected losses occurring under vacuum condition and thought to be due to electron secondary emission from the surface of the dielectric. Coating of the surface to reduce this was to be tried.

An improved design of waveguide section to give higher Z_s was being developed for use with high energy accelerators. This eliminated the losses in the metal wall of the simple guide by replacing it with an open circuit $\lambda/4$ section of dielectric medium.

Referring to the costs of dielectric loaded accelerators relative to the ordinary metal walled type, Harvie thought the chief saving would be in R.F. power costs. The guide itself, the pumping system, and auxiliaries would be about the same. About $1/10$ of the R.F. power would be needed for $\lambda = 5$ cms. and $1/7.5$ for $\lambda = 10$ cms.

Further work was required on the development of the improved guide structure, the elimination of electron secondary emission and the design of valves on $\lambda = 5$ cms.

DISCUSSION

Sir John queried the advantage of 5 cms. and Harvie said the waveguide structure was simplified in going from 10 to 5 cms. Dr. Roaf was told that an electron beam had been passed down the dielectric guide and no charge build-up effects observed. In answer to Dr. Shire, Harvie said that the loading losses exceeded the guide losses and the former were removed when operating in air. Sir John asked how many klystrons/BeV would be required with the dielectric guide and Harvie thought 3/BeV as compared with 22/BeV at Stanford. The maximum volts/metre was limited by auto-emission in metal guides but Harvie could not give Professor Frisch a maximum value for the dielectric guide. Dr. Shire was told that the loading loss in db decrease as the power increased. In answer to Sir John Dr. Hereward said that about half the cost of a linear accelerator was in valves. The accuracy required for the dielectric guide was similar to that for the metal guide. Dr. Cassels asked the lowest particle velocity considered in dielectric loaded guide design and Harvie said no work had been done for $v < c$.

THOUGHTS ABOUT A PROTON SYNCHROTRON

By

Professor H. W. B. Skinner

Professor Skinner had recently visited Brookhaven and said that he had been very impressed by the systematic way in which they had tackled the problem of designing the 'Cosmotron' and the excellent engineering work that had gone into its construction. The machine was now working at 1.5 BeV and it was expected to be able to reach the design figure soon and probably push on to 3.5 BeV.

For the costs using the million dollar as a unit, 3.5 had been spent on contracts, 1.5 on salaries and 2.0 on the building, making a total of about 7. The Van de Graaff Injector had cost 0.5 the magnet 1.0 and the tube and R.F. supplies 2.0.

Berkeley had a machine under construction which would do 6 BeV.

Britain or Europe should have a machine in this energy range and preferable < 10 BeV. The Brookhaven results showed that a higher energy machine did not require a larger gap. That at Brookhaven was 9" and the Berkeley gap was being reduced from 4' to 1' in the light of this. The magnet cost should therefore be roughly proportional to E.

Professor Skinner closed by advocating that a Bevatron with E < 10 BeV be built in preference to the lower energy alternatives.

DISCUSSION

Professor Skinner told Dr. Bretscher that although 90 people had been employed on the Brookhaven project one could cut down this number for future projects because of the experience and design data now available.

PROBLEMS INVOLVED IN CONSTRUCTING A 15 BEV PROTON SYNCHROTRON

By

Dr. T. G. Pickavance

The Brookhaven machine was used as the basis for discussing the design of higher energy bevatrons. With this machine at 3 BeV and the Berkeley one at 6 BeV we ought to aim for something > 10 BeV. The range 10-20 BeV was therefore considered by extrapolating Brookhaven data. At Brookhaven the design energy was 3 BeV, the radius of the machine 30' and the weight of steel 1640 tons. The injection energy was 3.5 MeV from a Van de Graaff. 90 people had worked on the project for 4 years and total cost was approx. 6 million dollars.

Scaling this to 10 BeV we require a radius of 80'. By keeping the same gap dimensions we sacrifice intensity. At Brookhaven of 10^{12} protons injected in each pulse 10^{10} reach full energy. With 6 pulses/sec. This gives 10^9 protons/sec. The estimated yield of particles at 3 metres distance in 10^5 neutrons/cm²/sec and $10^5 \pi$ -mesons/cm²/sec.

We have to consider what intensity we require from higher energy machines, to do satisfactory experiments. Counters were unlikely to play a large role because of the unfavourable duty cycle. On the other hand the diffusion cloud chamber was ideally suitable. At Brookhaven the π -meson intensity is estimated at 1000/cm²/pulse and this compares with Chicago's 50/cm² in 10 pulses which are spread over a similar time interval to the Brookhaven pulse. For cloud chamber experiments these two figures can be directly compared and thus we can sacrifice considerable intensity in the bevatron design and still exceed the Berkeley figure. Also for experiments with the protons, we need deflect only 10^{-8} of the beam through a 1 cm² hole at 3 m in order to get the more than adequate intensity of 10 protons/cm²/pulse at 10 m.

In considering the design of bevatrons for energies in the 10-20 BeV range we could therefore be satisfied with an intensity some 50 times less than that obtained at Brookhaven. The following table lists intensities estimated by Adams and Goward for several possible designs.

	<u>Machine - Design</u> <u>Energy and other data</u>	<u>Magnet</u>		<u>Gas</u> <u>Scattering</u>	<u>Ratio of</u> <u>Output</u> <u>Intensity</u> <u>Relative to</u> <u>Brookhaven</u>
		<u>Weight</u> Tons	<u>Cost</u> 10 ⁶		
1.	3 BeV Brookhaven 3 MeV injector voltage	1,640	\$1.16	Negligible.	1
2.	10 BeV same gap as (1) 3 MeV inject.	4,300	\$0.86	20%	1/89
3.	10 BeV same gap as (1) 3 MeV inject dH/dt half in (1)	4,300	\$0.86	52%	1/50
4.	10 BeV same gap as (1) 10 MeV inject dH/dt as (3)	4,300	\$0.86	5%	1/9
5.	10 BeV twice gap in (1) 3 MeV inject dH/dt as (1)	17,200	\$3.5	Negligible	1/18
6.	20 BeV same gap as (1) 30 MeV inject dH/dt as (3)	9,000	\$1.8	3%	1/50

We see immediately that scaling the magnet gap in order to maintain intensity is very costly and that a far cheaper way is to increase the injection energy and current. As the gas scattering varied rapidly with operating pressure we should aim to keep the loss due to this down to about 5%. Reduction of dH/dt saved generator peak power. Both 10 BeV and 20 BeV machines were quite feasible the former with very good intensity and the latter with quite adequate intensity.

Turning now to the estimated costs for constructing these machines Dr. Pickavance drew up the following table.

<u>Item</u>	<u>Brookhaven</u>	<u>10 BeV</u>	<u>20 BeV</u>
Building	£/1.17 10 ⁶	£ 0.38 10 ⁶	£ 0.68 10 ⁶
Magnet	1.16	.86	1.8
Power Supplies	.55	.5	1.0
Injector	.53	.2	.4
R.F.	.09	.05	.1
Controls	.15	.04	.04
Vacuum System	.4	.4	.8
Shielding	.05	.04	.08
Overheads Admin. etc.	.4	.18	.2
Design Staff Salaries	1.2	.25	.25
	<u>£ 5.7 10⁶</u>	<u>£2.9 10⁶</u>	<u>£ 5.35 10⁶</u>

In ~~man~~ ^{man} power about 30 D/O + W/S staff would be required for 3 years and a design staff of 35.

DISCUSSION

Dr. Bretscher asked for an estimate of the total time to build such an accelerator and Dr. Pickavance thought 5 years a realistic figure. Professor Skinner questioned whether costs other than the magnet were linear with energy. Dr. Pickavance said that although some of his estimates were very approximate he thought the total figure reasonably good. Professor Peierls thought that 10 BeV was not a sufficient increase on the 6 BeV at Berkeley. Lord Cherwell asked Professor Peierls what the threshold for a proton pair would be. Professor Peierls answer of 5 BeV prompted Professor Skinner to say that the extra 4 BeV might therefore be well worth while.

THE WESTERN EUROPEAN NUCLEAR RESEARCH CENTRE

(a) THE ORGANISATION BEING BUILT UP

By

Sir George Thomson

Sir George recounted the history of the Western European N.R.C. since its original conception. At Florence in 1950 Rabi had suggested the need for a Western European centre for modern physics. In May 1951 at Paris Auger for U.N.E.S.C.O. called together a group of experts, Amaldi, Bakker, Dahl, Kowarski and Goward to put forward recommendations for the Research Centre. At Copenhagen in June 1951 these suggestions were criticised on the grounds of over emphasis of the experimental side and it was also thought that at this stage too definite plans should not be put forward. Bohr thought that the scheme would be more acceptable if more attention were paid to establishing co-operation between existing institutions and if the theoretical side of physics were included in any new centre being set up.

The United Kingdom were asked at Paris in December 1951 to clarify their attitude. Sir George as representative stated that no money would be given to the project but facilities for the use of the Liverpool cyclotron had been arranged. It was felt that the theoretical work at Copenhagen could be co-ordinated with the practical side at Liverpool. A draft scheme for the council of Representatives of European States for the Planning of an International Laboratory and the Organisation of Nuclear Research was drawn up. An intermediate planning stage was to last eighteen months during which plans for two accelerating machines were to be made.

The whole scheme was to be drawn up in a formal manner in order to impress the various governments concerned, and presented in the form of a treaty.

In February at Geneva and in May at Paris the countries concerned were asked to contribute a minimum of £ 100,000 to enable the Council to be set up and the various study groups to function. Study groups on 1. Theory, 2. Laboratories. 3. 500 MeV Synchrocyclotron. 4. Bevatron, were set up under Bohr, Kowarski, Bakker and Dahl respectively. Money to run such groups was to be supplied but only for design studies.

The British position at this stage was that the Treasury were not prepared to give the financial backing and the Foreign Office unwilling to allow signature of the treaty. However, although we have no official representative on the Council, a representative of the Royal Society (either Sir James Chadwick or Sir John Cockcroft) was invited to attend the next council meeting to be held in Copenhagen.

The Scandinavian countries emphasised the aspect of general co-operation between institutions and France and Italy emphasised the need for a centre for machines and Laboratories. The United Kingdom was wanted on the terms offered, namely no further financial obligations but use of the Liverpool cyclotron, but it was hoped that agreement establishing the council would receive signature.

THE WESTERN EUROPEAN NUCLEAR RESEARCH CENTRE

(b) THE VIEWS OF THE ADVISORY PANEL

By

Mr. F. K. Goward

Mr. Goward spoke as a member of the group of experts in accelerator design. With Bakker, Dahl, Kowarski and Alfven he felt that after the past year's study Europe was in a position to make a synchrocyclotron of about 500 MeV energy, and/or a bevatron in the higher energy range. However, the difficulty of obtaining money and the fact that no decision would be made for 18 months have to be considered. Also it would be difficult to get anyone to accept full time employment until the project was under way. Although there was general disappointment among the European enthusiasts that Britain would not fully co-operate or give financial aid, some members of the group felt that they could get along without help.

DISCUSSION

In the general discussion which followed the following points were brought out. It was questioned if construction of a bevatron in this country might prejudice the chances of a European Bevatron. Professor Blackett asked who had decided that we should not support the scheme and on what grounds the Treasury refusal had been made. Dr. Cassels asked that if we took no part in the construction of the European accelerators could we expect to be allowed to use them. Sir George Thomson thought the present offer of the use of the Liverpool cyclotron meant that the reciprocal facilities would be available to us on the European machine when completed. Professor Blackett thought that the Liverpool offer should stand on its own and not be balanced against any reciprocal offer. Professor Skinner agreed and there was considerable feeling that a positive contribution to the European effort was desirable. This might take the form of design effort at Harwell and possibly an offer to construct the European machine in this country.

It was questioned if the use of design effort at Harwell on the bevatron would detract from effort on the alternative Harwell project of a linear proton accelerator. Mr. Fry said inevitable this would be so and we might have to decide on one or the other. The general opinion was that it would be bad for Britain to have no bevatron of her own and also play no leading part in the construction of a European bevatron.

On the question of expense Lord Cherwell thought that it was not impossible to get a million pounds a year for a few years. The difficulty of obtaining 10,000 tons of steel was considerable and it was difficult to contribute to the European project as this would have to be in gold. It was suggested that Harwell should design a large Bevatron with the alternative objectives of either supplying the complete information for the European bevatron or building a bevatron in this country.

SUMMING UP

By

Sir John Cockcroft

Summing up the proceedings Sir John reminded us that Professor Peierls had said that energies greater than 6 BeV would probably be needed to produce V particles. Dr. Cassels had told us that an excellent flux for meson research could be produced by a 450 MeV proton linear accelerator. Mr. Mullett had described a design for such a machine and had estimated the cost at about £400,000. We could handle a project like this at Harwell. The linear accelerator at Cambridge would produce a reasonable meson flux and Mr. Harvie had spoken of the possibilities of the dielectric loaded guide for higher energy accelerators. Dr. Pickavance had put forward the case for a bevatron with energy not less than 10 BeV and such a project would cost at least three million pounds.

We had to view these possible alternatives in the light of the European plans for the Nuclear Research Centre described by Sir George Thomson and Mr. Goward.