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NOTES ON THE SESSION ON THE EXPERIMENTAL USES OF HIGH INTENSITY ACCELERATORS

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ABSTRACT

Possible experimental uses of high intensity accelerators are discussed.

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Participants in the discussion on Tuesday, June 16, 1959, were R. H. Dalitz, R. Adair, E. L. Goldwasser, T. R. Palfrey, M. H. Blewett, N. Horwitz, R. H. Hildebrand, A. Roberts, B. Richter, D. L. Judd, R. L. Cool, A. Wattenberg, D. I. Meyer, A. C. Mitchell, G. Tautfest, and T. Ypsilantis.

I. General Considerations:

The session started by considering what types of experiments would be most interesting in a high intensity accelerator in the energy range from 10 to 15 Bev. By high intensity we mean the entire range from 1 microampere time average current up. There are obvious difficulties in such an analysis. Many of the experimental people here want to do experiments which require a beam increase by a factor of 10, or perhaps 100. Such increases in intensity may be anticipated in present accelerators and those now under construction. These experiments are therefore less relevant as a specification for new accelerators.

There was a certain amount of indecisive discussion concerning the relative usefulness of bubble chambers and counters in high intensity machines. The discussion was closed with the observation by Richter that a bubble chamber operating, with 50 incident particles per pulse will see 3000 events per year of operation, taking photographs every 5 seconds for a full year if the events occur once per 10^5 incident particles. Thus the study of rare events produces by copiously available particles requires equipment capable of accommodating high incident beam intersites.

It became apparent during the discussion that there was no very good method available for identifying particles of energies much above 5 Bev. The hydrogen bubble chamber cannot do so. Bubble

chambers containing heavier liquids may be able to use momentum and scattering; electronic techniques for identifying ultra-relativistic particles have not yet reached the stage of perfection one would like to see. This is clearly an important field for thorough investigation.

II. Experiments of Interest with High Energy Machines:

It was universally recognized that a discussion of the kind of experiments that might be done six or seven years from now, in an energy region not yet explored, is not likely to be very realistic.

With regard to the experiments that might be undertaken, we were assisted considerably by an internal Berkeley report which discusses the importance of building a machine of this general nature. The experiments listed in the Berkeley report are the following:

1. Measurements of total cross section and angular distribution of interactions produced by all possible particles over a wide energy range. In order to study the interactions produced by high energy π or K-mesons, one needs high-intensity primary beams, since the number of high-energy particles produced is not large.

2. Differential scattering and polarization experiments. This includes such experiments as measuring the polarization of protons scattered by π or K-mesons.

3. Experiments in which the equivalent of π or L-meson targets are utilized, according to the method outlined by Chew.

4. The procedure yielding the largest number of anti-hyperons seems to be the production of anti-hyperons by anti-protons. This requires high intensity beams. Not much is known about the yield of anti-protons as a function of energy. To obtain information on

anti-hyperons and hyperons needs advances in the technique of detection as well as strong sources.

5. The production of high intensity, high-energy μ and electron beams, especially the former. These require very high intensity. At the Cosomotron μ scattering in hydrogen could now be done with a frequency of about one event per day.

6. The electromagnetic structure of pions and muons, by bombarding electrons, that is to say, π-e and μ-e scattering at very high energies.

7. The study of the interactions between anti-nucleons and anti-hyperons by making pairs of anti-nucleons or anti-hyperons.

8. Studies of the static properties of anti-hyperons and anti-nucleons, such as the magnetic moments of anti-protons, and so on.

9. Studies of K-K interactions, by producing K pairs.

In addition to the above Berkeley experiments, most of which concern anti-particles and therefore require high energies, the following items were added:

In weak interactions we can at present with existing equipment study rare decay modes present to the order of 10^{-5}. It is likely that we can extend this another order or two of magnitude with existing accelerators. To get below abundances of the order of 10^{-7}, however, it will be necessary to obtain higher intensity hyperon and K-meson beams.

Dalitz pointed out that anti-particle interactions are important and must be studied extensively if adequate use is to be made of the dispersion relations.

One ought to look for the production of particles of higher

strangenesses and to investigate hypotheses like the one that strangeness is a multiplicative rather than an additive quantum number.

III. Energy Desirable:

After lunch the discussion concerned the question: should a high intensity machine be 10 or 15 Bev? It was considerably hampered by the fact that no adequate data exist on the yield of interesting particles as a function of energy or angle are available. For example, there are no data from the Cosmotron on the yield of π-mesons, as a function of angle and energy, from collisions of protons with either hydrogen or heavy nuclei. Nor are there any corresponding data on the yield of K-mesons or anti-nucleons, as a function of energy, which are adequate to determine the optimum energy of a machine designed to produce these particles. Such data are not available on the Bevatron either, and their lack has even hindered the proper design of beams for experiments at the Cosmotron and Bevatron.

To decide between 10 and 15 Bev, it would be very useful to have such data taken when the AGS machines come into operation. Such data will not be available for one to two years, at least. It is believed that the energy of a high intensity accelerator ought to be at least 10 Bev, in order to get an adequate yield of anti-protons and anti-hyperons; but we have no experimental data on which to decide between 10 and 15 Bev. If we had to make a decision at the moment, we might settle on a 12½ Bev as a compromise.

IV. Operating Characteristics:

The next point considered was the importance of various operating characteristics of the machine. This was necessary in order to guide designers to a choice among alternative machines. The following points were made and agreed on.

1. Repetition rate. Not all hydrogen bubble chamber users are agreed on the maximum repetition rate that can be expected from large hydrogen bubble chambers; but it appears that unless radical improvements in the hydrogen bubble chambers are made, one cycle per second will not be readily exceeded. It follows from this that the high repetition rate AGS is at a disadvantage relative to the FFAG machine insofar as the use of large hydrogen chambers are concerned.

Walker estimated that with propane or freon chambers, one might get reasonably large chambers up to 5 cycles per second. To get to 15 or 20 cycles per second, one will have to go to quite small chambers. Thus the obtaining of high intensities by rapid repetition rate is not well adapted to the purposes of bubble chambers. From the standpoint of bubble chambers what is more important is the number of microcoulombs in the beam that can be dumped on a target at one time.

2. A discussion on the duty cycle requirements. It was agreed that it would be very desirable to have variable duty cycles available. First, it is desirable to have available a short duty cycle, e.g., one turn ejection, for bubble chamber use. Second, it is desirable to have as long a duty cycle as possible for experiments using counters. It was pointed out that it is desirable to have these duty cycles available both for internal and external beams. Values less than 5% would be considered poor for counter use, especially with high intensity machines. In this connection Adair gave as his opinion that a major advantage of high intensity machines would be for counters and scintillation chambers rather than for bubble chambers.

However, the possibilities of improved beam selection for bubble chambers should not be discounted. In obtaining large duty cycles it is necessary to remember the rf structure of the beam, and to provide means for removing it.

3. Fast knock-out was possible on both kinds of machines and is desirable.

4. A considerable discussion was held on the importance of having variable maximum energy.

5. Among other desirable beam characteristics are good reproducibility of current, energy and position from pulse to pulse, easily controlled beam currents, very high density of the external beams in phase space, and the availability of high luminosity sources. It was considered of great importance in FFAG machines that the accelerating chamber be exposed to the experimental area over several intervals of 20 feet or more, so that beams could be brought out readily from internal targets; and also that it be possible in other parte of the machine to bring out beams through holes in the yoke.

In this connection it was not clear to the conferees just how beams of low energy positive particles were to be extracted from internal targets in FFAG machines. If this is not possible, then the extraction of a large fraction of the external beam with a long duty cycle becomes more important.

It was pointed out that the beam must be taken out at angles of less than 5 degrees to the incident proton beam in order to obtain full intensity, since it is known that pion and K-meson yields fall off rapidly at angles larger than this.