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SUMMARY OF DISCUSSION OF THE PHYSICAL INTEREST IN HIGHER INTENSITY

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ABSTRACT

A review of the kinds of experiments which become feasible as accelerator beam intensity is increased.

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INTRODUCTION

The preparation of this summary was greatly assisted by an internal Berkeley report[1] and by notes taken by Art Roberts[2] of a lengthy (sometimes multiple) discussion which from time to time included the following people: R. Adair, R. L. Cool, E. D. Courant, R. H. Dalitz, E. L. Goldwasser, R. H. Hildebrand, N. Horwitz, L. W. Jones, D. I. Meyer, T. R. Palfrey, B. Richter, A. Roberts, K. R. Symon, G. Tautfest K. Terwilliger, W. Walker, A. Wattenberg, T. Ypsilantis.

It was agreed that plans made now for experiments to be performed in six years are likely not to be very realistic. It also became apparent that when particles have energies above 5 Bev it is very difficult to identify the particles. Bubble chambers containing heavier liquids may be able to use momentum and scattering especially if high magnetic fields are available. Electronic techniques have not yet reached a perfection that one would like to see. The detection and identification techniques for energies above 5 Bev are clearly an important field for investigation.

The data on the yields of particle as a function of angle and impinging proton energy is either poor or doesn't exist, even on high energy π production. The lack of such data hampers our quantitatively specifying an optimum design for a machine which will yield secondary beams of fixed intensity and quality.

I. Experimental Utility of High Intensity Beams

It appears likely that the intensities of existing accelerators may reach roughly .3 μ amp time average beams. Therefore, for purposes of discussion we will define the "high-intensity" beams, under consideration here, as a factor of

100 higher; namely, 30 μ amp time average current. In order to justify construction of such an accelerator, it is obviously desirable to list new areas of research which such an accelerator would open to practical experimentation. This may be done by making a list of experiments of interest and pointing out those which require "high-intensity" and those which may be carried out with existing beams. We assume that an experiment, to be considered feasible, should require less than 30 days running time. It should be mentioned that, because of the limited time of the study group, we have made only crude estimates of the experimental practicality without designing detailed methods to carry out the experiments in question.

A. Strong Interactions

In the absence of any comprehensive theory of strongly interacting particles (e.g. π, K, N, Y, $\bar{N}$, $\bar{Y}$) it may be necessary to consider the interactions of all possible pairs of these particles. The measurements of interest would include total cross sections, elastic differential cross sections, polarization of the spin 1/2 particles in elastic scattering and finally the inelastic processes. The interpretation of the inelastic processes resulting in three particles in the final state is considerably simplified using the method of Chew and Low[3]. For example, consider the reactions

$$\pi + N \rightarrow \pi + \pi + N$$

$$K + N \rightarrow K + \pi + N$$

the first reaction may be related to the pion-pion ($\pi\pi$) interaction; the second to the K - π (Kπ) interaction. We will assume that such an interpretation is possible. For an estimate of the intensities required we refer to the appendix of the Berkeley report[1]. In Table I we summarize the intensities needed to measure total cross sections σ_t, elastic differential cross sections $\left(\frac{d\sigma}{d\Omega}\right)_{el}$ and

polarizations P. Finally it will be necessary to consider processes such as

$$\bar{N}\ N \longrightarrow \bar{Y}\ Y$$
$$\bar{N}\ N \longrightarrow \pi\ \pi$$
$$\bar{N}\ N \longrightarrow K\ K \quad ;$$

the first of these may possibly be measured with present beams; however, no events of this type have yet been seen (the cross section is likely to be in the micro-barn region). It seems not unreasonable that "high-intensity" machines will be required for a precision measurement of this process. The second and third of the above reactions represent two pion or two K annihilation and should be observable with existing machines. At the present time approximately 10^3 annihilation of antiprotons in hydrogen have not produced any events of this class, so it may be necessary to have higher intensities to investigate these processes in detail. The corresponding processes with hyperons

$$Y\ \bar{Y} \longrightarrow \pi\ \pi$$
$$Y\ \bar{Y} \longrightarrow K\ K$$

may conceivably be inferred from the inverse inelastic processes

$$\pi + N \longrightarrow Y + \bar{Y} + N$$
$$K + N \longrightarrow Y + \bar{Y} + Y$$

Experiments of this type require "high-intensity" beams if detailed information on these reactions is to be obtained.

TABLE I*

	σ_t	$\left(\frac{d\sigma}{d\Omega}\right)_{el}$	P
π N	E	E	E
K N	E	E	F
N N	E	E	E
Y N	E	E	F
$\bar{N}$ N	E	E	F
$\bar{Y}$ N	F	F	F
π Y	F	F	F
K Y	F	F	F
Y Y	F F	F F	F F
Y Y	F F	F F	F F
$\pi\pi$	E	E	-
π K	F	F	-
K K	F	F	-

*The symbols E, F, FF are defined as follows: E means it is measurable with existing accelerators, F means a future accelerator (30 μ amps) is required for the measurement and FF implies a far future accelerator (3000 μ amps) seems necessary unless yields are better than expected.

B. Weak Interactions

The general class of experiments involving the weak decays of hyperons and K-mesons appears to contain several processes of sufficiently low probability that they are not at present feasible. Some examples might include

$$\Sigma^0 \rightarrow \pi^- + p \qquad \theta^0 \rightarrow \pi^0 + \gamma + \gamma$$

$$\Sigma^0 \rightarrow \pi^0 + n$$

$$\Xi^0 \rightarrow \pi^- + p$$

$$\theta^0 \rightarrow e^+ + e^- \qquad \theta^0 \rightarrow 4\gamma$$

$$\Sigma^+ \rightarrow \mu^+ + n$$

$$\Lambda^0 \rightarrow \mu^- + p$$

comparison of three body decay modes of θ^0, and θ^0_2.

C. Unobserved Particles

Another class of experiments which could be pushed roughly two orders of magnitude further would be the search for rarely produced new particles. For example, a fermion of strangeness minus three or a boson of strangeness plus two.

D. Muon Experiments

A fifth class of experiments requires a higher intensity of high energy μ-mesons than is now possible. These could be used either to look for non-electromagnetic interactions of muons by comparison with the equivalent electron-proton interaction. They could also be used to probe nuclei at large momentum transfers. The radiative corrections are smaller than in the electron case.

In general, increasing machine energy increases only rather slowly the intensity of secondary particles (e.g. π-mesons) near the maximum machine energy. As a result, high intensity machines are more useful to obtain the high energy secondary beams which are required for many classes of research.

We want to stress the great importance of the duty cycle in high intensity machines. Experiments involving counter and scintillation chamber techniques require a beam duty cycle as close to 100% as possible. The desirable duty cycle for bubble chambers is quite different. They need the intensity in short duration bursts at infrequent intervals.

E. General Conclusion

At this point in the history of particle physics it is very clear that there is a strong need for a high intensity machine which can produce all known anti-particles.

REFERENCES

(1) Memorandum to E. M. McMillan from members of the informal "Future Accelerator Study Group".

(2) Notes from Art Roberts attached as an Appendix. (MURA-473).

(3) G. Chew and F. Low, UCRL Report No. 8427. See also G. Chew, UCRL Report No. 8670 and G. Chew, Physical Review 112,1380 (1958).