MURA-471 UC-28
TID-4500 (15 Edition)

MIDWESTERN UNIVERSITIES RESEARCH ASSOCIATION*

2203 University Avenue, Madison, Wisconsin

ENERGY CONSIDERATIONS FOR HIGH INTENSITY ACCELERATORS

W. D. Walker**

June 19, 1959

ABSTRACT

The choice of a desirable energy for a high intensity accelerator is discussed.

*AEC Research and Development Report. Research supported by the Atomic Energy Commission. Contract No. AEC AT(11-1)-384.

**University of Wisconsin

In choosing an energy there seems to be several areas of high energy physics at which one might aim.

1. π - μ Meson Physics.
2. K-Hyperon Physics.
3. Anti-Particles Physics.

π Meson Physics

The purpose of studies would be to try to understand in great detail the interactions of π mesons. At the present time, there seems to be structure in the π -P cross sections up to π energies of about 1.6 Bev.

In order to have high intensity beams of π's up to 1.6 Bev, it would be necessary to have a proton machine going up to perhaps 3.0 Bev. To do precision experiments on μ mesons, i. e., $(\mu + p \rightarrow \mu + p$
$\rightarrow \mu + \pi + p$ etc.)
would require a machine of at least 1000 times as great intensity as for the corresponding π meson machine.

K-Hyperon Physics

For doing K-meson physics one wants intense K beams of energies up to about 2 Bev/c. The K^+/π ratio goes from 1/200 at 3 Bev to $\sim$1/50 at about 6 Bev. The K^-/π ratio at 3 Bev is $\sim$1/1000 to 1/150 at 6 Bev. A reasonable proton energy would be 4 - 5 Bev.

Anti-Particle Physics

One would like to have a copious supply of anti-nucleons for studying such reactions as

$$\bar{N} + N \rightarrow \bar{\Lambda} + \Sigma$$
$$\rightarrow \bar{\Xi} + \Xi$$

or for using the reactions as a source of anti-hyperons.

The thresholds for such reactions are

	KE
$\bar{P} + P \longrightarrow \Lambda + \bar{\Lambda}^{\circ}$	770* MEV.
$\longrightarrow \Sigma + \bar{\Lambda}^{\circ}$	950*
$\longrightarrow \Sigma + \bar{\Sigma}$	1130
$\longrightarrow \Xi + \bar{\Xi}$	1840

(*The cross sections for these processes seems to be the order of 10^{-28} cm^2 close to the threshold.)

To determine the energy of a machine to give such beams is extremely difficult to estimate. The best one can do is to use phase space considerations.

$$\frac{dv}{dE} \sim \left(\frac{E_{cm}}{M} - 4 \right)^{7/2}$$

One can see this since the volume of a sphere in 12 dimensional space $\cong A p^{12}$; 4 constraints P, E_T; then we want the shell between E_T and $E_T + dE$.

$$\therefore \quad \frac{dv}{dE} \sim P^{12-5} \sim (KE)^{7/2}$$

K.E.	E_{cm}/M	$\left(\frac{E_{cm}}{M} - 4\right)^{7/2}$	σ_T	$\frac{d\sigma}{d\Omega\, dE}$
5.64	4.0	0		/Ster/Bev/c
6.0	4.1	3.1×10^{-4} (Fermi P takes up to 10^{-3})	$10^{-31} cm^2$	$\sim 10^{-30}$
9.4	4.90	.693	$10^{-28} cm^2$	$\sim 10^{-28}$
14.1	5.84	8.4	$10^{-27} cm^2$	

One would probably not expect the cross section for $\overline{P}$ production to get much above $\sim\left(\frac{\hbar}{M_p c}\right) \sim 10^{-27}\,cm^2$ at any energy. Consider now a 10 - 12 Bev machine. The effective increase over the bevatron would be only a factor $\sim$100. (This is because of a greater momentum and angular dispersion). The intensity this would give for an acceptance angle of .01 steradian/6 x 10^{23} targets/10^{10} proton/ 100 Mev/c = 600$\overline{p}$. For bubble chamber work this is fine if separation works.