ACCELERATOR PROJECTS IN THE U.S.A.*

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ABSTRACT

A review was presented of operating, planned and high energy accelerators under construction in the U.S. It was pointed out that the program is broad based, addressing a variety of frontiers and encompassing many of most fruitful projectiles, intensities, and energy ranges. The U.S. program is also geographically diversified across the country in major research centers. The physics productivity over the past years has been excellent with a emphasis on the importance of sustaining the base program at least until the SSC is operating and possibly beyond.

ACCELERATOR CENTERS

This paper will focus on accelerator projects in the United States, concentrating on those that are operating, under construction or proposed. Such accelerators are located at the major centers for these activities and are at Brookhaven National Laboratory, Cornell, Fermilab and SLAC. The SSC endeavors which are of paramount importance are being extensively discussed by others at this meeting. Therefore, I will not make any comments on this subject, however for completeness, I will make a few remarks on the CEBAF Project.

I will begin by noting the different types of accelerators, fixed target and colliders, and the use of a variety of projectiles (e-,e+,p,\bar{p}, A) that are utilized to investigate the fundamental properties of matter. The electron e-, is the only particle that we know of that has no structure (is point like), is stable, and exists naturally. Its antiparticle the positron, (e+), is also stable in vacuum, however, it does not exist naturally and must be artificially produced, thereby somewhat limiting its intensity. The other naturally occurring stable particle is the proton. It is just hydrogen gas stripped of its electrons. We now know, however, that the proton is not fundamental, it is composed of smaller units called quarks and the gluons which hold the quarks together. In our present understanding of the dynamics of these quarks, they can never become free, as electrons do, but are forever destined to be entrapped inside the proton (or other hadrons such as neutrons, mesons, etc.). As such the energy of a proton (or its anti-particle the

*Work performed under the auspices of the U.S. DOE.
anti-proton) is distributed, in a continuous fashion, in the quarks and gluons. For completeness, we note a complex nucleus such as $^{16}_{28}S^{198}$ can be used as a projectile or a target, being viewed either as a collection of protons and neutrons or alternately as a large number of quarks or gluons.

With this assortment of possible projectiles $e^-, e^+, p, \bar{p}, A$ one can envisage all combinations but only a subset are considered to be useful. The two common types of interactions involve the so called fixed target mode where one projectile is very energetic, nearly always traveling close to the speed of light, hitting a stationary target; the second being the collider mode where two projectiles are made to collide head on. The former has the forte of yielding a high intensity and rate of interactions, but more limited in energy while the latter (collider) allows access to the highest energies but are more limited in intensity. Again among the colliders, as noted earlier, in an $e^-, e^+$ collider since these particles are point-like all the $e^-, e^+$ energy is available for the production process while in the pp or $p\bar{p}$ case, the $p$ or $p\bar{p}$ energy is distributed among the quarks and gluons and therefore only a fraction of the total energy is available for the fundamental quark or gluon interactions. Nevertheless, the energy available to these quarks and gluons can be substantial and greater than is in the $e^-, e^+$ case because, up to now, it has been possible to build much higher energy proton than electron machines (1,000 GeV vs. 100 GeV) due to the fact that electrons more readily radiate away their energy than protons. Below is listed the different types of machines and their locations.

Colliders:

- $e^-, e^+$: SLAC, Cornell
- $pp$: Fermilab
- $p\bar{p}$: SSC
- $AA$: BNL

Fixed Target:

- PA: BNL, Fermilab
- $eA$: SLAC, CEBAF

I now begin my survey of the activities at the major U.S. centers beginning with Fermilab. This laboratory near Chicago, houses an accelerator complex encompassing both fixed target and collider capability with protons and anti-protons as principle projectiles. A site overview is shown in Fig. 1. As in most hadron machines, the fixed target PA collision gives rise to a wide variety of intense secondary beams composed of $\pi$'s, $k$'s, $p$'s, $\nu$'s, etc. Over the years there has been extensive work on the detailed dynamics of $\pi N$, $p N$, $k N$ interactions as well as utilizing $\nu N$ interactions for the study of weak interactions and quark gluon energy distribution inside the nucleon. In addition, the relatively high energy available at the Tevatron accelerator at Fermilab has allowed for studies of charm particles and led to the discovery of the fifth quark, the $b$ quark.

In developing the collider mode, $p\bar{p}$, this laboratory built a machine utilizing superconducting magnets for the first time. A view of the tunnel with both the warm and cold magnets is shown in Fig. 2. At present both machines are running well with the collider achieving luminosities $10^{30}$/cm$^2$/sec, at spec, with two large detectors CDF which has been operational for several years, and D0 which should begin taking data next year. The CDF has been studying the highest energy collisions at any particle accelerator. This allows precision studies of well known