Revised DRAFT
November 7, 1967

SCIENTIFIC JUSTIFICATION

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In the field of particle physics, the main objective has always been the quest of the fundamental understanding of the nature of matter. A deep understanding of all the facets of the nature of matter, the laws that govern it, and the language in which it should be described, is not only of essential importance in the advancement of science but also in the intellectual advancement of human culture and our civilization.

In the past two decades, particle physics research has made enormous strides toward this goal with the successful operation of the various high energy accelerators both in this country and abroad. These accelerators include the LRL 350 MeV Synchrocyclotron (1946), the Brookhaven 3 BeV Cosmotron (1952), the LRL 6 BeV Bevatron (1954), the CERN PS (28 BeV alternating gradient proton synchrotron, 1959), the Brookhaven AGS (33 BeV alternating gradient proton synchrotron, 1960), and the Stanford 20 BeV electron linear accelerator (1966).

Prior to the construction of some of the more recent accelerators, detailed justifications on scientific grounds were given for these projects. As is well known, not only were these justifications fulfilled as originally expected, but, in addition, far more rewarding results were obtained in unexpected quarters including a number of surprising insights of profound importance. In fact the importance of the unforeseen results outranks that of the initial scientific grounds used in justifying the need for such accelerators. We shall cite a few examples of such profoundly significant results:

(1) The so-called θ- τ puzzle which resulted from experimental findings at the Cosmotron and the Bevatron led to the bold suggestion that the long-held parity conservation law may not be valid in weak interactions. Subsequently, an experimental proof was provided by the CO^{60} β-decay experiment which verified the nonconservation of parity in weak interactions. This surprising finding opened up a new realm of understanding in the field of weak interactions which consequently led to many exciting speculations and experimental investigations of profound implications in many branches of physics.

(2) The finding of an apparent violation of invariance under time reversal transformation from experiments on the decay of neutral kaons. An interpretation that certain fundamental laws may not be invariant if the flow of time is reversed would certainly lead to important consequences in the weak as well as in the electromagnetic interactions. Many experiments on this subject have already been carried out and a number of investigations are still underway to try to clear up this extremely important question.

(3) The finding of two distinctly different neutrinos, one associated with muons and one associated with electrons.

(4) The discovery of a new class of "strange" particles that decay much more slowly than had been expected. The law of conservation of strangeness gives a classification of the strong and weak interactions of the particles and explains the rate of "strange" particle decay. This law has been confirmed by numerous experiments at the multi-BeV accelerators.

(5) The finding of the associated production of "strange" particles, and resonant states (approximately over 200) far exceeded the original concept of "elementary" particles which were viewed as fundamental building blocks

of matter and therefore very limited in number. Such an unexpected finding has thus led to a drastic revision of the original concept. On the other hand, a great amount of symmetry has been shown in the properties of these particles, and this has suggested grouping them into families. Such families consist of 10 or 8 particles (perhaps more in some cases), where the particles in each family have a close resemblance and the structure of the various families is either analogous or closely related. An appropriate type of grouping is known mathematically as the SU(3) symmetry; and when SU(3) group theory was applied to the grouping problem, it predicted a new particle, the Ω^-, in addition to the known particles existing then. The Ω^- was later discovered at the AGS and the SU(3) symmetry theory was greatly enhanced.

The above examples serve mainly to illustrate some of the outstanding "unexpected" contributions made as the result of the availability of the high energy accelerators. In addition, of course, most of the scientific justifications used for constructing accelerators have been realized. Among the many expected contributions from accelerators, the discovery of the antiproton is certainly an outstanding example. (The Bevatron was designed to have an energy high enough to produce antiprotons if they existed.)

If we turn now to the motivation for building a 200-400 BeV accelerator, we have many compelling arguments to support our desire to go to such high energies. A comprehensive list of these arguments has already been well documented,[1, 2, 3, 4, 5, 6, 7, 8] two or three years ago. However, it may well be emphasized here that these arguments still hold valid and two outstanding arguments can be cited which have become of even more particular

importance than they were known to be two years ago. The first one is that the number of particles now known is so large, and their properties are so diverse, that these particles are probably not the ultimate constituents of nature after all but rather the manifestations of some deeper structure which has not yet been penetrated. This structure can only be penetrated by higher energy investigations. Furthermore, the remarkable regularity of the mass spectra of the strongly interacting particles and the comparatively small mass differences between the particles suggests a convincing analogy between it and atomic spectra. Perhaps all of these particles are composite states of some fundamental massive triplets which have been suggested as the basic building blocks of nature. Energies considerably higher than those available in the existing accelerators are needed to produce these massive triplets if they do exist. The second important argument deals with the question concerning weak interactions. In analogy with the quanta of other interactions (the photons of the electromagnetic interaction and the meson of the nuclear interaction), one expects that there exists a field quantum, the "intermediate boson", which transmits the weak interaction. It is somewhat surprising that it has not so far been found, although it may just be that it has such a high mass that existing accelerators cannot produce it. Thus if it exists, its mass is probably large enough that considerably higher energy accelerators such as the proposed 200-400 BeV accelerator will be needed to produce it in abundance.

In spite of the introduction of all the strong arguments and compelling reasons based on foreseeable scientific ground, for the justification of building the proposed 200-400 BeV accelerator, it may very likely turn out that many more exciting and richer insights into the nature of matter are in store to surprise us. This has always been the case in the past when higher energy

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