The Review of KEK-PS Physics Activities in 1980's

The experiment program carried out in the 1980's at the KEK-PS covers a large variety of physics problems in both particle and nuclear physics. The total number of experiments performed is as large as 80. We have tried to review and evaluate carefully the PS physics activities based on the many published papers as well as oral presentations made at the Review Committee Meeting in November, 1990 at KEK. It is hard for us to evaluate in detail the outcome of such a large number of experiments and to appreciate physics context in which each of the experimental programs were planned and initiated. Consequently we expect that we might have failed to mention some important achievements in this report.

First we would like to state that the PS group has managed to maintain interesting programs by carefully identifying opportunities and effectively focussing their efforts to exploit them. This has enabled them to make important contributions of high quality to a wide area of physics in spite of severe competition with experiments using higher energy accelerators such as the AGS at BNL and the PS at CERN. Among the physics output there are results which were the world's highest quality data at the time or gave important partial answers to topical problems in the 1980's. Also we should mention some of the programs such as the study of hypernuclei by use of K-mesons at rest are indeed quite original and have proved to be promising for the future. In summary, we are very much impressed by the high quality and diversity of the overall program.

We divide PS research areas into several ones and evaluate activities in each of them in the following;

1) Weak Interactions

The study of rare decays of K-mesons is important for determining the parameters in the standard model of elementary particles, finding possible indications for need of a new model of particle physics beyond the standard one, and obtaining a new insight for understanding basic problems such as the origin of CP violation. It has been one of the most topical problems in particle physics in the 80's and will remain to be so in the next decade too.

In KEK-PS experiments such as E10 and E137, extensive studies of rare decays of K-mesons have been done with significant results such as the determination of the upper limits for the strength of flavour changing neutral currents and the limits on the magnitude of neutrino mixing. These results supplied us the world's best data at the time and made significant contributions to the better understanding of the standard model. For example, we note a large number of citations for the E10 paper as a good indication of the high quality of PS data.

Because of the topical nature of the study of rare decays of K-mesons, the PS experiments have to be very competitive with experiments such as those of BNL-AGS. Furthermore, in our present knowledge, the required sensitivity for the values of decay rates should be several order of magnitudes better than the previous ones in order to determine unambiguously the values of parameters in the standard model or obtain any indication for a need for new, non-standard model of physics. Therefore, we doubt whether the study of rare K-meson decays at KEK-PS could play an important roll in the 90's unless some unexpected breakthrough take place.

There have been some other decay experiments which are not extremely rate limited and perhaps less topical compared to rare decays of K-mesons. These are the study of μ-meson polarization in $K \rightarrow \mu\nu$ decays searching for the right-handed current and the study of $\Sigma^+ \rightarrow P\gamma$ decays. These experiments are outstanding in their high quality and the new experimental methods employed there seem to be promising. We hope further progress will be made in these types of experiments, but again the competition for

right handed current search with equivalent experiments at the HERA eP collider, which are sensitive to similar effects, will be expected to be severe.

2) Hadron Spectroscope

The existence of several barionium states had been reported in the late 70's and early 80's and the study of possible barionium states was one of the important topical problems in hadron spectroscopy. Experimental results coming from BNL and CERN were mutually contradictory and the physics situation was unclear. Very careful studies of barionium states by PS experiments such as E74, E131, and E68 have clearly denied the existence of the reported barionium states, thus settling the issue. We evaluate this achievement as one of the important contributions of KEK-PS experiments.

We also admire the study of $q\text{-}\bar{q}$ meson resonances using Benkei spectrometer, which is an extensive, productive, and well planned study of orbital and radial excitations of $q\text{-}\bar{q}$ system. The identification of radially excited states of η and η', the study of possible candidates of exotic states such as the iota (1460) and the E(1420), and many new informations on the $q\text{-}\bar{q}$ resonances have contributed for a better understanding of hadron spectroscopy in the context of the quark model. On the other hand we feel that a still more systematic and coordinated study is needed for an unambiguous determination of the properties of each of the meson resonances, unambiguous identification of each of the exotic states, and a definitive study of the $q\text{-}\bar{q}$ meson spectroscopy. Whether a further study in this direction at KEK-PS should be promoted and encouraged should be carefully considered.

3) Hadron-Nucleus Interactions

Studies of the momentum and angular distributions of various secondary particles and polarization of Λ produced in hadron-nucleus collisions and the study of two nucleon correlations observed in pion absorption by nuclei have been performed. They have supplied us high quality data in its energy range and these will remain as very useful data for understanding the mechanism of hadron-nucleus interactions in the intermediate energy range for years to come.

The idea of investigating the space-time development of the interactions of high energy particles in heavy nuclei is rather original, and powerful methods have been developed. If such an ambitious project is to yield definitive and convincing answers, however, it will be necessary to bring to bear all the possible tools to investigate the interactions. This would require the coordination of a larger variety of different types of measurements.

4) Hypernuclei

The study of production mechanism and spectroscopy of hypernuclei by use of K-mesons at rest and (π, K) reactions has been very productive and the results obtained are remarkable. These experiments have not only supplied us informative and fruitful data in the study of hypernuclei but also proved that the use of K- mesons at rest for production of hypernuclei is very effective, contrary to earlier ideas. With a new experimental hall built and a new spectrometer implemented, we believe that the study of hypernuclei at the KEK-PS will probably continue to be of world-class for some years to come.

The very remarkable work of E176 in discovering doubly strange hypernuclei, after many years of world -wide efforts, is a high-light of the KEK-PS experiments in the 80's. This observation has serious implications for the H-particle search, which is one of the most highly topical current problems. We hope the further study of doubly strange hypernuclei and H-particle (E176 and E127) by use of hybrid detector systems with nuclear emulsion will be successful.

We have just presented our evaluation of KEK-PS experiments in the 80's, which are classified into four major categories of physics. We also appreciate that the KEK-PS has been used for experiments covering a broad range of research areas including radio-chemical studies using stopped pions, thus showing the broad capability and usefulness of the PS.

Now we shall present two general and critical comments on the KEK-PS programs and experimental output;

1) Particle physics away from the energy frontier demands careful and well conceived programs of measurements in order to produce results of lasting significance. There should necessarily be follow-up experiments on the problem with more powerful detectors that exploit the latest technology. We feel that most of the particle physics work at the PS in the 80's has consisted of topical but "one-shot" type of experiments rather than systematic and programmatic experiments with subsequent follow-up efforts. In the area of experimental technology, most of the KEK-PS experiments adopted what might be classified as standard techniques and methods with, perhaps, the addition of occasional improvements. These improvements are relatively small but, in retrospect, played an important role in each of experiments. However, we recognized some research areas where the introduction of new technology at an early time might have lead to results with better quality and larger physics impact.

Specifically some of the committee members were dismayed by the limited use of new detection techniques, such as silicon-strip detectors and inorganic oxide-compound scintillators, which were developed by Japanese industry in the 80's.

2) In spite of our high evaluation of the KEK-PS physics activities in the 80's, the PS program does not seem to get the international visibility and appreciation that the quality of the work deserves. This is probably due in part to the manner of participation and presentation of the work of KEK-PS researchers at international conferences. Wider participation and more aggressive attitudes in presenting results at international conferences, and hosting more international meetings at KEK would improve the situation. Another route to better visibility would be to encourage more international participation in the KEK-PS program, for example by well publicized junior fellowship and senior visitor programs, and individual recruitment of groups from university groups abroad.

As we stated in the beginning of this report we give high ratings to the achievement of the KEK-PS programs in the 80's. The identification of doubly strange hypernulei, the spectroscopic study of hypernuclei by use of a new method, the accumulation of high quality data in hadron spectroscopy, the determination of upper limits for the decay rates of rare decays of K-mesons, and the study of hadron-nucleus collision mechanisms have lead to fruitful results. These contributions together with the important role of the KEK-PS in training young researchers in the field of particle and nuclear physics in Japan have shown that the KEK-PS will continue to be an extremely useful machine for years to come.

Finally we would like to make two recommendations for the future use of the KEK-PS based on our evaluation of PS physics activities in the 80's.

Recommendations;

1) The PS community should maintain the flexibility to pursue topical experiments when opportunities arise in order to test new theoretical predictions and new experimental approaches. Preparation for those experiments should be completed in adequately short time periods.

2) The PS community should develop a small number of well focussed and selected projects and pursue them with the necessary implementation of detector systems taking full advantage of new technology.

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