S1
S2

folder NPRC 4.2.62

MEMORANDUM 8.2.1962

To: The members of the Nuclear Physics Research Committee.

From: E. Bleuler, D.O. Caldwell, B. Elsner, D. Harting, L. Jones, W.C. Middelkoop, B. Zacharov.

Re: The high energy pion experiments S_1 and S_2.

At the NPRC meeting of 10th January 1962, it was decided to allocate 15 shifts with priority a to the high energy large angle pion-proton scattering experiment S_1, whereas the decision on time allocation for the experiment S_2, the dipion experiment, was left open.

We should like in this memorandum to summarize the current status of these two experiments and to report the decisions of the group on the experimental sequence which should be followed to make the most efficient use of the PS machine time.

Remarks on the status of the two experiments.

S_1 Large-angle pion-nucleon elastic scattering at 12 & 18 GeV.

This experiment will give important information on three aspects of the pion-nucleon problem. First, the experiment is designed to yield about 10^4 elastic events behind the diffraction peak if the cross section in this region is about 10 microbarns per steradian. The angular dependence, magnitude, and indeed the existence of this very large momentum-transfer part of the elastic scattering are completely open questions, both theoretically and experimentally. Second, data on the "tail" of the diffraction scattering are of great interest in connection with recent theories [1)2)], which suggest a narrowing of the diffraction peak at very high energies. Third, by comparing the backward scattering of $\pi^+ p$ with $\pi^- p$, the recent paper of Gell-Mann Frautschi, and Zachariasen[3)] suggests that direct information on the elementarity of the nucleon might be obtained.

Primarily for this third reason, we feel that it is essential to include a measurement of π^+ elastic scattering at 12 GeV in our programme. For technical reasons it is not possible, however, to have a π^+ beam of this energy available before the long shutdown of the PS in July.

S_2 The production of diboson systems in peripheral processes.

This experiment is, in fact, a continuation of the experiment S_o, to which the NPRC allocated machine time at the meeting of the 25 September 1961, with priority a. This experiment came to an untimely stop because of a major breakdown of the PS machine and the disappearance of the required beam immediately afterwards.

In spite of this, some data were taken, that have now been partly analysed. Events were found that fit the interpretation of a $\pi\ \pi$ system to be formed in a peripheral process and the mass of the dipion and the momentum transfer could be determined for each of these events. In this connection one may mention recent results obtained by Prof. Fretter concerning the interactions of 11 GeV pions in the Lagarrique bubble chamber[4]. At this energy the pion-nucleon interaction appears predominantly (perhaps for as much as 75%) to proceed through a one-pion exchange interaction and a cross-section of 1 to 3 mb is found for the formation of a final state containing only two charged pions at the peripheral vertex.

The physical basis for the experiment seems therefore firmly established. It should be emphasized that the experimental arrangement makes it possible to obtain data on $\pi\ \pi$, π K, and K K interactions in the same run.

Recent theoretical papers [3)5)] together with newer experimental[6] data continue to reveal further aspects of this problem. For example, the angular momentum of the diboson may be determined from the angular distribution of the diboson decay relative to the incoming pion[7]. Secondly, by determining the cross-section for a particular diboson channel versus momentum transfer, and repeating the measurements at two incident pion energies, information can be obtained on the term $S^{\alpha(t)}$ in the one boson exchange amplitude, and from this, possibly on the elementarity of the exchanged boson.

Conclusions regarding the experimental programme of our group.

In our request for PS machine time (see attached memorandum) we emphasized that a minimum programme for both experiments could be completed in 47 shifts, while 72 shifts would be required for a complete programme. In view of the considerations above, we could

not reconcile ourselves to attempt either experiment without completing the relevant measurements using the different incident pion beams required for the most interesting aspects of the analyses. Neither could we justify eliminating one experiment from our programme. Therefore we have chosen to commit ourselves to pursue both experiments through what we have defined as a complete programme.

Combining the facts that the π^+ beam will not be available until after July and that it would be technically difficult to switch back and forth between experiments S_1, and S_2, we have concluded that it is desirable to continue the diboson experiment as soon as the high energy pion beam is available. This experiment will be continued until sufficient data have been collected and 30 shifts of machine time will be needed for this.

The experimental apparatus can then be changed to the elastic scattering experiment in no less than two weeks. A major part of the apparatus, e.g. spark chambers and associated equipment, will be used in both experiments.

In view of the machine time available and considering the probable division of this machine time into separate periods, it is impossible to finish both experiments before the July shutdown, but 40 shifts (30 shifts for S_2 and 10 shifts for S_1) could be used very effectively.

For the completion of elastic scattering experiment(S_1) two requirements are then essential.

1) The high energy pion beam must be available in the period after September 1st.

2) About 30 shifts of machine time are allocated to this experiment between 1st September 1962 and 1st January 1963.

This would bring the total number of shifts to 70, which is very close to the 72 shifts originally requested for a full programme on both experiments.

We should like to emphasize that both experiments are directed at questions of the greatest current interest in high energy physics. They can collect data on these questions at a rate and with an accuracy not possible with other techniques; they are suited to the high energy

character of the PS and could not possibly be done on any accelerator of lower energy. Comparable experiments are neither planned nor in progress elsewhere.

REFERENCES

1) Lovelace, preprint (Imperial College, London) Diffraction scattering and Mandelstamm representation.

2) Chew and Frautschi. Phys.Rev. Letters 7 394 (1961).

3) Frautschi, Gell-Mann, and Zachariasen "Experimental Consequences of Regge Poler" (to be published).

4) W.B. Fretter "Interactions of 11.3 BeV Pions with Protons" H.E.P.S. No.17, 17 July 1961 Berkeley.

5) Chew and Frautschi. Phys.Rev.Letters 8, 41, (1962).

6) Button, et al. UCRL 9814.
(see appendix in this paper for detailed bibliography of further relevent theoretical papers).

7) Carmory and Van de Walle. UCRL 9932.