S42

September 21st 1965

Memorandum

To : The Members of the EEC and NPRC

From : L.W. Jones, B. Hyams, D. Potter, B. Zacharov, W. Koch, E. Lorenz, L. von Lindern, P. Weilhammer (U. Stierlin).

Re : A further Elaboration of the Experiment S 42 of Hyams et.al.

Since the original proposal of 18 November 1964 and subsequent addenda NP/2775/60, the status of this experiment has developed to the point where test running is now scheduled this autumn. Approval for purchase of a large magnet has been obtained, however, the magnet will not be available until well into 1966. The beam d 22 has been built and use of its extension, d 22a, is planned for this experiment, however, this beam presently runs only from 6 to 12 GeV/c.

In this memorandum we should like to request specific decisions to avoid confusion and misunderstanding in the future.

1) The proposal and its oral and written elaborations placed equal emphasis on strong and electromagnetic decays of resonances. In written reports of decisions by the NPRC and EEC only the electromagnetic decay case is discussed. As we have heard no criticism of the plans for the diboson aspect of the experiment, we should like to see its status clarified. We note that the test run this autumn only addresses the electromagnetic decays. The measurement of E.M. decay branching ratios already necessitates strong decay measurements.

2) The experiment is designed to utilize either the newly-designed "H" magnet or one of the "C" magnets to be delivered in October. Due to the delay in the "H" magnet project and the imminent arrival of the "C"s, we believe an early judgement on their availability for this experiment must be made soon.

3) The beam d 22 can be extended to 15 GeV/c by relatively minor component rearrangements. We reiterate our belief that it is exceedingly important to reach 20-18 GeV/c in the diboson portion of the experiment. We should like to see a specific schedule for such a major modification. In this, of course, we would surely desire that this be done compatible with the Saclay group and their program for the experiment S 35.

4) In order to fully realize the potential of this experiment, automatic processing of the data film is essential, and every effort is being made to see that the film is compatible with requirements of the HPD. Thus, we request agreement that data film can be handled through the CERN HPD system. The Munich group is building an HPD system also, and should this come into full, reliable operation soon enough, it will serve to aid in this analysis. However, the history of all such automatic film handling programs suggests that it would be exceedingly unwise to rely on the newer facility coming into prompt operation.

Supplement to the Proposal for Experiment S 42

on Strong Decays of Resonances

Lawrence W. Jones

As presented in the Letter of Intention of 9 February 1965, there are at least four somewhat separable areas which should be studied. Below is an elaboration of the earlier discussion.

(1) The low-mass region. The data from the 1962 dipion experiment, analyzed since the earlier memorandum, give good quantitative data on the s-wave π-π phase shift. Questions which are now accentuated include the behaviour of the P-wave phase shift below 600 MeV. The sign change of $\delta_1{}'$ in this region may suggest that the ρ^0 is an elementary particle (or a CDD pole) rather than a dynamical (Breit-Wigner) resonance (C. Lovelace, private discussions).

The new experiment will have greatly expanded and improved threshold Cerenkov counters for π-K discrimination. This will make possible clean studies of $\pi^+K^\pm$ and K^+K^- systems near threshold. In particular, the data should help in resolving the recurrent confusion over the kappa meson.

(2) The ρ^0 mass range is now seen to contain at least three phenomena; the J = I = 0 ϵ^0 resonance, and the $\omega^0 \rightarrow 2\pi$. The coherent - interference, as elucidated by Durand and Chiu, should now be studied with good statistics and resolution, and yet at a rather high energy where ω and ρ production are comparable. It is clear that the understanding of this mass region requires high statistics taken at different incident momenta, a range of 4-momentum transfers, and with good data on angular distributions.

The earlier diboson experiment was handicapped by the unavailability of a liquid hydrogen target. With a hydrogen target and anticoincidence counters we can separate the 2-body final state (ρ^0n) from the "inelastic" ρ production studied before. By quantitative measurements at 20 GeV/c, we should be able to study possible Reggeization of the exchanged pion. Thus, at $-t = 0.3$ (GeV/c)^2, the ρ^0 production should be less by x^2, relative to the one-pion-exchange model, as compared to production at 2.5 GeV/c and the same momentum transfer, if the pion Regge trajectory has a slope $d\alpha/dt = +1$.

The inelastic ρ production has shown qualitative features that bear on the nature of peripheral processes, in particular the one-pion-exchange model, and warrent further elucidation. The greater statistics and precision of this experiment together with the liquid hydrogen target, will permit this study.

(3) Higher-mass states. The discovery of a state at 1.67 GeV decaying into $\pi^+\pi^-$ has whetted our appetite for searching for higher-lying states. The importance of this search in the light of group theoretical models hardly requires discussion. We would emphasize, however, that high-mass status (masses from 1.5 - 3.0 GeV) should be studied at the highest possible production energy so that the peripheral model can be applied in the cleanest way to study their spin, the possible exchanged particles, and to avoid complication with final nucleon vertex states. The ability to distinguish pions from kaons is of course of paramount importance here.

(4) Three-particle final states. The arguments concerning searches for new states applies again here, however, our primary motivation here has been the study of the Ferreti process, e.g. the diffraction dissociation of a pion into three pions. Data from the Heavy Liquid Bubble Chamber indicated that the A_1 meson might be coherently produced at 16 GeV/c. Meanwhile other experiments and calculations continue to leave the role of the A_1 itself in considerable doubt. Experiments with good statistics at high energy are necessary to clarify this situation. It should be recalled that diffraction dissociation cross-sections increase with energy, while one pion exchange processes fall off as $1/p^2$.

Lead-plate spark chambers are included in our experimental design primarily in order to study ω^0 production at the energies where $\omega^0 \rightarrow \mu^\pm$ is studied. These chambers will make possible the study, of states such as $\pi^0\pi^+\pi^-$, $\pi^0K^+K^-$, and other states involving neutral plus strange particles.

Experimental Requirements

This program of study should include at least 250,000 events and consequently we should plan on taking at least 10^6 photographs of strong decays. The trigger efficiency is quite uncertain at this point, but will vary between 10% and 50% depending on dipion mass and incident momentum. The data could be taken using a decision-making spark chamber to select a diboson mass range (or alternatively 3-outgoing particles) based on the number and spacing of sparks. This would permit selective study of the mass ranges described above. It is our plan to use instead a "shotgun" approach, taking data over all mass ranges simultaneously. The different diboson mass areas will then be sorted in the process of the automatic, rapid data processing. Based on this data we will then have the option of using decision chambers for triggering in mass ranges of particular interest in the later phases of the experimental program.

The running time required for 10^6 pictures at 3 events/pulse is 15 to 30 days of continuous running. This should of course be broken into several intervals. We would emphasize that at least half of this run should be at beam energies of 18-20 GeV/c. We should also emphasize that the greatest productivity would be achieved if this experiment could remain in situ for many months, running off and on as scheduling permitted. This topology is admirably suited to exploration of a great many problems in particle physics in an energy range largely unexplored except for elastic scattering and total cross sections. We believe that this class of experiments exploits the PS in a manner which most fully realizes its potential at Europe's highest-energy accelerator.