NAL PROPOSAL No. 205-A

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PHENOMENOLOGICAL STUDY OF MUON-NUCLEON COLLISION AT ENERGY MORE THAN 100 GeV IN EMULSION

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Addendum No. 1

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In addition to the exposure of the ordinary emulsion stack of the proposal 205, we propose the exposure of some sandwich stacks as preliminary run. The purpose of this experiment is to examine the A dependence of particle production induced by the muon-nucleus collision from light element (near carbon) to tungsten, where A is the mass number of the target nucleus. The features of the distributions for multiplicity and emission angles of produced charged particles are mainly examined. These results are compared with those obtained by the proton-nucleus collision at about the same energy and, then, any proper feature of particle production by virtual photon or any specific nuclear structure, for example, the parton-like structure, is probed.

The stack employed is composed of some amount of metal foil and plate-backing emulsion. One metal foil and one emulsion plate are alternatively piled up. Al, Fe and W of 10 cm x 12.5 cm and 200 or 250 micron thick are used as metal foil. Methacrylic plate of 10 cm x 12.5 cm and 800 micron thick is used as backing-plate, both side of which have the 50 micron thick ET7A emulsion. This emulsion has a high grain density, say, 35 to 40 grains per 100 micron in ordinary processing condition. This both-side emulsion-coated plate gives us the best information for the track direction, since the track direction is determined from the two bottom points in the both side where the emulsion is free from distortion at the processing stage. Methacrylic plate also serves as the target of light nuclei. Three kinds of metal-foil-sandwiched stacks are made to assure the muon inducing events in each kind of foil of about 10^3 under the exposed condition of 10^5 muons/cm^2. The energy of the impinging muon is hoped as 190 GeV, since we have already the ordinary and similar sandwich stacks exposed to the proton with the energy of 200 GeV.

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We propose an emulsion experiment to study the phenomenological features of the particle production induced by the muon-nucleon interaction in the energy available at NAL. The purpose of this experiment is to examine the hadron-side of the interaction for q^2 value of the order of 10^{-3} to several $(GeV/c)^2$ and for s value up to 100 GeV^2 or more, where q^2 is the squared 4-momentum transfer of the muon and s is the squared mass of the produced hadron system. The events with such large s values are only obtainable at NAL.

To investigate the behavior of final state hadrons of lepton-nucleon interaction over the wide range of q^2 and s is now very important subject in view of deeper understanding of virtual photon[1,2]. In this experiment, the following features of charged hadrons are examined as a function of q^2 and/or s over the ranges described above.

1. multiplicity
2. emission angles (rapidities) with direction of incident muon or virtual photon
3. behavior of slow proton
4. production rate of strange particles
5. new particle with short life time or short conversion length.

Whether the multiplicity distribution at large s, say, beyond the resonance region is Poissonian or not, how the mean multiplicity depends upon q^2 and/or s, how the angular distribution of the emitted charged hadrons with the direction of virtual photon or incident muon[3] is different at different ranges of q^2 or s, how these distributions are different from the case of the hadron-hadron collision, and so on will give us the

important information to probe any proper feature of particle production of virtual photon[1,2].

The angular and momentum distribution of the slow proton will offer us at least whether the hadron production of the virtual photon has the diffractive nature[4] or not. For particles emitted backward in the muon-nucleon center-of-mass system, the production rate of strange particles is investigated. If any feature of the production rate as a function of q^2 is observed, this will afford us the new aspect of the nucleon structure. Any new particle with short life time or short conversion length is inspected in the measuring stage on emission angles and momenta of produced particles. The emulsion has an unique advantage of this kind of new particle hunting because of its high resolution of space.

Experimental Procedure

A stack of nuclear emulsion of about 500 cm^3 is exposed to the muon beam of energy 100 GeV or more which is now available at NAL with a beam density of 5×10^5 muons/cm^2. The number of events induced by the incident muon is expected to be about 10^4 events, if the total cross section for the muon-nucleon interaction at an energy of muon of 150 GeV is taken as 20 microbarn.

The event required is mainly detected by the area scanning. By this method we can detect easily at least the events with one gray or one black track. Among about 10^4 events induced in the emulsion, the pure muon-nucleon events, that is, those expected not to leave any excitation into the nucleus are estimated to be about one-third.

In the analysis, the track with the highest momentum among the emitted particles in each collision is assumed as the outgoing muon. This estimation is done using the relative scattering measurement. The q^2 and s are approximately evaluated from the momentum of the assumed outgoing muon or by summing up the energies of produced hadrons where in most cases hadrons are assumed as pions and then the charge independence is taken into account.

At NAL, the extensive studies including the search of the aforementioned features are proceeded using analysing magnets and counter arrays. Though emulsion experiment has really considerable defect in statistics and accuracy in comparison with those counter experiments, this experiment has still the merit in the points that the interaction vertex is directly examined and there is no ambiguity to talk about the number of the charged hadrons and their emitted angles.

Summay of Exposure

1. Beam: muon of energy more than 100 GeV.
2. Pion contamination: as low as possible, say, less than 10^{-6}.
3. Intensity: 5×10^5 muons/cm^2.
4. Emulsion: Ilford K-5 pellicle of 7.5×15 cm^2, 600 micron thick. 75 sheets. Beam parallel to the 15.5 cm side.
5. Parallelity of beam itself and beam to emulsion: as good as possible in attainable range, say, less than 10 mrad.

References

1) H. Harari, Proceedings 1971 International Symposium on Electron and Photon Interactions at High Energies edited by M. B. Mistry, 299p. J. Bjorken, ibid. 281p., K. Berkelman, ibid. 263p., H. Kendal, ibid. 247p.

2) J. Bjorken, Proceedings of the 4th Hawaii Topical Conference in Particle Physics (1971) edited by D. E. Yount and P. N. Dobson, 187p.

3) For fast particles, that is, for the particles emitted forward, the information of the rapidity distribution will be obtained by the angular distribution.

4) H. Harari, Phys. Rev. Letters, 22 1078 (1969).