Fermilab Proposal No 576
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500 GeV Proton Interactions in Nuclear Emulsion.

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500 GeV proton interactions in nuclear emulsion.

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In previous experiments (project NAL # 116, 233 and) we have studied the interactions of 200, 300 and 400 GeV protons in nuclear emulsion. From these investigations we have published results about charged particle multiplicities and angular distributions. The publications are listed in enclosure 1.

In the proposed experiment we extend this work to be interactions of 500 GeV protons in nuclear emulsion. The aim is to compare the parameters (N_h, n_s, $\eta = \ln \operatorname{tg} \theta/2$) with those of the interactions of protons in nuclear emulsion at lower energy.

The main features of this experiment will be:

1. Measure the average charged particle multiplicity.
2. Compare the yield of secondaries in proton-nucleus collisions to the known ones from proton-proton collisions, in particular with regard to the correlation to the nuclear fragmentation.
3. Measure the angular distribution of the shower particles.
4. Look for any subtle differences between proton-nucleus reactions at 500 GeV and reactions at lower energy.
5. In particular very high multiplicity events correlated to strong nuclear fragmentation will be investigated.
6. Study the two particle correlation.

Emulsion stacks preparation and processing.

Ilford K5 emulsion will be used. The preparation and milling of the stacks will be done in Strasbourg. After exposure, the horizontally exposed stacks will be processed in Lund and in Strasbourg.

everywhere essentially linear. The correlation function exhibits also some strong variation with N_h[3]. Work on the detailed correlations between the angular distributions of N_h as the shower particle tracks will be initiated in the collaboration.

An investigation of the leading particle properties seem to imply an average inelasticity which is larger than expected[4]. We would like to mention that counter studies of the shower--particle distributions for different values of A, the atomic number, does not imply the regularities observed for fixed N_h.

Except for these features we would like to mention the existence of a small number of events (the number grows with the energy of the projectile) with a very strong "crowding" of the center of phase space which may imply the onset of some new phenomena. These events are also characterised by large values of N_h. Similar features have been observed in events from cosmic ray-physics and we would also like to mention the existence of some component producing small $P_\perp$-particles in the center of rapidity space with strong energy growth over the ISR-range[5].

In the proposal, P 568, we have suggested an investigation of π^--emulsion in order to test the corresponding dependence of the shower particle distributions on the projectile. In light of our recent experences from the analysis of the 400 GeV/n proton-emulsion exposure we feel that the investigation of larger projectile-energies may be of more imminent interest, in particular the gathering of more material on the large multiplicity events mentional above. The correlation between these events and the fragmentation of the nucleus makes emulsion studies a useful technique.

Emulsion dimensions and flux requirements.

Flux ~ 3×10^4 (particles/cm²).
3 stacks of 40 pellicles ($7.5 \times 10 \times 0.06$ cm³).

Beam characteristics.

The beam should be as flat as possible over the central region where the measurements will be made. One could expect this region to extend over 2 to 3 cm. Energy of the protons 500 GeV.

Scientific motivation of the experiment.

Hadron-nucleus collisions are expected to provide tests of the space-time structure of the dynamics in hadron-nucleon collisions and the experimental results have indeed meant severe constraints on several exisiting models and also stimulated the construction of new schemes[1)].

The International Emulsion Collaboration have from earlier exposures at FNAL at 200 GeV/c, 300 GeV/c and 400 GeV/c provided experimental results in particular on the correlation between the nuclear fragmentation parameters and the shower particle distributions (see list of publications given in enclosure 1).

From these results we conclude that some of the main features of the production process are essentially energy-independent provided the nuclear fragmentation is kept fixed[2)]. In particular we find (as reported in detail in a forthcoming paper) that for all the above-mentioned energies (and some lower energy results obtained from earlier work) there are for a fixed value of the number of heavy prongs N_h two fragmentation regions in pseudo-rapidity-space ($\eta = -\ln \text{tg}\, \theta$), a backward (target fragmentation) region strongly dependent upon N_h and a forward (projectile fragmentation) region (moving forward with ~ ln (s) as expected from kinematical considerations) essentially uncorrelated to all other experimental parameters. The remainder of phase-space, the central region, exhibits for a fixed moderate N_h an energy-independent mean density of particles per unit pseudorapidity. Depending upon the value of η there is a more or less strong growth with N_h but the rise is

Enclosure 1.

<u>Publications</u> from the 200-400 GeV emulsion experiments performed by the Barcelona-Batavia-Belgrade-Bucharest-Lund-Lyon-Montreal-Nancy-Ottawa-Paris-Rome-Strasbourg-Valencia collaboration.

1. 200 GeV proton interactions in nuclear emulsion (collaboratio AIP Conference Proceedings Number 12, 131 (1973).

2. Study of nuclear interactions of 200 GeV protons in emulsion. (collaboration). Proceedings of Fifth International Conferen on High-Energy Physics and Nuclear Structure June 1973, Uppsala, p.427.

3. Nuclear interactions of 200 GeV protons in emulsion. (collaboration). Phys. Lett. <u>488</u>, 467 (1974).

4. Multiplicity, Multiplicity Moments and Angular Distributions in Proton-Nucleus Interactions at Very High Energy. Proceedings of the ICTP Topical Meeting on High Energy Collisions Involving Nuclei, Trieste, 1974 (invited talk I. Otterlund).

5. Multiplicity correlations in Multihadron Reaction (B. Andersson, I. Otterlund) Nucl. Phys. <u>B88</u>, 349 (1975).

6. Nuclear Interactions of 200 GeV and 300 GeV Protons in Emulsion. (collaboration). Paper presented at VI Int. Conf. on High-Energy Physics and Nuclear Structure, Santa Fe and Los Alamos, 1975.

7. Some Trends in High-Energy Proton-Nucleus Interactions in Nuclear Emulsions. (collaboration). Proceeding of the 14th Int. Cosmic Ray Conf. Vol. 7, He session, p.2248 (1975), Munich.

8. On the Correlation between the number of heavy prongs and the number of shower particles in proton-nucleus collisions. B. Andersson, I. Otterlund, Nucl. Phys. <u>B99</u>, 425 (1975).

References.

1. K. Gottfried, Review talk at the Uppsala Conference (1973). W. Busza, Review talk at the Sante Fe Conference (1975) and the Multiparticle Conference at Intsing, Germany (1976). B. Andersson, Review talk at the Multiparticle Conference at Intsing, Germany (1976).

2. Belgrade-Lund-Lyon-Nancy-Ottawa-Paris-Rome-Santander-Valencia collaboration. Proceeding of the 15th Int. Cosmic Ray Conf. Plovdiv, Bulgaria, 1977.

3. Baroni et al., Nucl. Phys. B103, 213 (1976) and Rome Preprint (1977).

4. B. Andersson, G. Nilsson, I. Otterlund and E. Friedlander, Preprint LU TP 77-6 to be published.

9. The angular distributions of secondaries in proton-nucleus interactions at 200 and 300 GeV.
B. Andersson, I. Otterlund, Nucl. Phys. B102, 238 (1976).

10. Two-particle Rapidity Correlations in Proton-Nucleus interactions at 300 GeV.
(collaboration). Nucl. Phys. B103, 213 (1976).

11. Inclusive production in emulsion with accelerator beams. Proceedings of Topical Meeting on Multiparticle Production at Very High Energy, Trieste 1976 (invited talk I. Otterlund) 1976.

12. Energy dependence of two particle rapidity correlations in proton-nucleus interaction.
G. Baroni et al. Lettere Nuovo Cimento 18, 352 (1977).

13. The A-dependence of the ratio R_A for charged particle production in p-nucleus interactions.
(J. Hébert, H. Areti and C.J.D. Hébert).
Can. J. Phys.

14. Nuclear Emulsion Experiments on Particle Production at High Energies. Invited talk at the XVI Cracow School of Theoretical Physics, Zakopane, 1976. Acta Physica Polonica B8, 119 (1977).

15. An estimation of the mass of the "slow bodies" emitted in p-nucleus interactions at 200 and 300 GeV.
(collaboration).
Can. J. Phys. 55, 528 (1977).

16. Nuclear interactions of 300 GeV protons in emulsion.
J. Hébert, et al. Phys. Rev. D15, 1867 (1977).

17. Emulsion stars of 200, 300 and 400 GeV Protons.
(collaboration).
Nuo. Cim. Lett. 1977.

18. Study of Nuclear interaction of 400 GeV proton in emulsion (collaboration).
Proceeding of the 15th Int. Cosmic Ray Conf. Plovdiv, Bulgaria, 1977.

19. Properties of the Leading Particle in Proton-Nucleus Interactions.
B. Andersson, G. Nilsson, I. Otterlund and E. Friedlander, Lund Preprint 1977. To be published in Nuclear Physics.

20. Nuclear Interaction produced by 400 GeV protons, 1977.
To be published.

21. Scaling of multiplicity distributions from p-nucleus collisions in emulsion at energies between 6.2 and 300 GeV.
V.H. Areti, C.J.D. Hébert, and J. Hébert.
Physical Review D. Volume 15, Number 7, 874, 1977.