Fermilab Proposal No. 385

Scientific Spokesman:

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PROPOSAL FOR EXPOSURE OF A STACK OF NUCLEAR EMULSIONS TO PROTONS OF 400 GeV/c

Chandigarh-Delhi-Jaipur-Jammu Collaboration

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INDIA.

1. INTRODUCTION :

Recently, there had been a revival of interest in hadron-nucleon and hadron-nucleus collisions. These studies have gained importance with the energies available at the ISR and the NAL. The extrapolations of experimental and theoretical ideas have led to definite framework with which phenomena of high energy colisions in the asymptotic energy region can be viewed. The experimental data from the ISR have indicated the usefulness of such framework. However, much more data at the accelerator energies is called for.

Experimentally, the study of multiplicities of secondary particles, their angular distributions, rapidity distributions, two or more particle correlations and fluctuations etc. are of great interest to differentiate between different models of multiparticle productions. Apart from the fact that the success of such techniques as the Glauber model has made analysis of nuclear effects more tractable, there are different models (such as statistical model, multiperipheral model, energy flux model, hypothesis of limiting fragmentation, parton model etc.) for multiple particle productions in high energy collisions and the predictions of these

theoretical ideas are to be continuously tested with the experimental data at different energies.

2. HADRON-NUCLEUS COLLISIONS :

Inspite of the complexity of process of hardon-nucleus (proton-nucleus) collisions, the experimental data upto 200 Gev/C are available at present. For such studies, nuclear Emulsion still offers excellent scope because of its unique spatial resolution and possibility of precise ionization and other measurements. The main results of proton-nucleus collisions at 200 Gev/C [1,2,3] and some of their conclusions are summarized below.

(i) The average shower particle multiplicity $\langle n_s \rangle$ changes from 5 to 13 when the energy increases from 20 - 200 Gev/C, whereas the average number of heavily ionising particles emitted, $\langle n_h \rangle$ remains constant at about 7.

This suggests that pions produced in the collision do not increase the excitation of the struck nucleus beyond a certain limit, i.e. most of the pions would appear to escape from the nucleus without appreciable cascading. This is not in accordance with the intranuclear cascade model.

It is indicated [3] that average shower multiplicity in porton-nucleus collisions at 200 Gev/C varies

1. Barcelona ..... Collaboration. Phys. Letts. 48B, 467 (1974)
2. Babecki et al - Phys. Letts. 47B, 268 (1973)
3. Bombay-Chandigarh-Jammu Collaboration. Phys. Letts. 50B, 391 (1974)

linearly with N_h; viz. $\langle n_s \rangle = a\ N_h + b$ with $a = .63 \pm .04$ and $b = 8.5 \pm .2$

(ii) The multiplicity depends on the mass of the target nucleus. Emulsion nuclei fall into two well separated mass groups. Thus, one finds

$$\langle n_s \rangle_{CNO} = 10.7 \pm 0.5$$

$$\langle n_s \rangle_{AgBr} = 14.7 \pm 0.5$$

The observed multiplicity in proton-nucleus interactions is lower than the expected value.

(iii) The angular distribution of the shower particles in the C.M. system depends on the value of N_h, for low values, $N_h = 0$ and 1, there being a pronounced anisotropy in the forward direction. This result when combined with that of 'p-p' interactions suggests that excessive emission of shower particles in the forward hemisphere is due to diffractive processes. Of course, excessive emission of shower particles for $N_h \geqslant 5$, in the backward direction in the CM system suggests that secondary reactions are important.

(iv) The parameter $R_{em} = \langle n_s \rangle / \langle n_{eh} \rangle$ is the ratio of the multiplicities in proton-nucleus and proton-nucleon collisions. It exhibits a slow increase in the range 10-70 Gev/C and attains a roughly constant value of 1.7 in the region of 200-8000 Gev/C. This also implies an A dependence of the type $A^{0.13}$ which is very slow.

The value of R_{em}=1.7 seems to be in good agreement with the predictions of the diffractive excitation model. However, one notes that this model fails to explain the charged multiplicity distribution and the observed energy dependence of $\langle n_{ch} \rangle$/D in p-p collision [4].

For 200 Gev/C proton-nucleus collisions, the value of R_{em} is in fairly good agreement with the predictions of Gottfried's energy flux cascade model [5]. This model also seems to explain some other features of proton-nucleaus interactions at 200 Gev/C; e.g. low $\langle n_h \rangle$, A independence of inelasticity etc.

3. OBJECTS OF THE STUDY OF PROTON-NUCLEUS COLLISIONS AT 400 Gev/C.

The results of the studies of proton-nucleus collisions upto 200 Gev/C indicate that no single model of multiparticle production seem to explain all the observed features of the interactions. At least one can say that hadron-nucleus collisions seem to favour at this stage those models in which the production takes place through a double step mechanism (e.g. diffractive excitation and energy cascade model) rather than the models which envisage instantaneous production (e.g. multiperipheral model).

It is therefore worth while that all the features of proton-nucleus interactions at energies higher than 200 Gev/C be studied. This includes the study of

4. S.N.Ganguli & P.K.Malhotra - Phys. Letts. 42B, 88 (1972)
5. K.Gottfried - Cornell Univ. pre print, CLNS - 260 (1974)

multiplicity of charged particles, Angular distribution of charged secondaries, Rapidity distributions of shower particles, particle correlations and fluctuation etc.

Further, according to fire ball and multi fire ball models, the average number of balls possibly follows a regularity $\langle N_f \rangle \sim \lg(E_L/200 \text{ Gev})$ where E_L is the laboratory energy of the hadron [6]. This would also bear investigation. Rapidity correlation data should provide valuable qualitative insight into the mechanism of cluster formation. In particular, rapidity spectra of events where P_T are large and where tracks are labelled by their azimuthal angle, might reveal the clustering pattern.

A commonly observed feature of high energy collisions is the low transverse momentum (P_T) of secondary particles. Measurements of transverse momentum are exceedingly tedious but we do hope to study a small number of events.

4. DETAILS OF EXPOSURE :

We propose to expose a stack of $\approx$ 50, K5 emulsion pellicles, each of size 6"x4"x600 μm and would like a flux of about 5×10^4 particles/cm^2. It would be desirable to have these in 4 shots. A special featu-re of the exposure we propose, would be to include 10 pellicles with double the normal gelatin content. This would facilitate

6. E.L.Feinberg - Phys. Reports 5C, 237 (1972).

a study of the differences in interactions with light and heavy nuclei.

5. STAFF & COLLABORATION :

This work would be a collaboration of Departments of Physics of four Universities. We give below their names and composition :

UNIVERSITY	No. of Physicists (Staff members)	Leader
Chandigarh	2	I.S.Mittra
Delhi	2	B.Bhowmik
Jaipur	2	S.Lokanathan
Jammu	2	Y. Prakash

In addition, some eight research scholars will work with the team. Each institution has the necessary equipment in the form of scanning and measuring microscope and other laboratory facilities. In addition, the University of Delhi has an excellent computer facility.

The leaders are all senior physicists with many years of experience particularly in emulsion work with several publications to their credit.

It is hoped that a major part of the study would be completed in about a year from the time of exposure.

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(Signed on behalf of the Collaboration)