RESEARCH PROPOSAL FOR

THE FERMI NATIONAL ACCELERATOR LABORATORY

PRODUCTION OF ELECTROMAGNETIC CASCADE SHOWERS BY SEVERAL HUNDRED GeV ELECTRONS IN EMULSION CHAMBERS

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SUMMARY

It is proposed to expose two different types of emulsion chambers in order to study the development of electromagnetic cascade showers. One chamber will be composed of a stack of pure nuclear emulsions wherein the showers can be studied in a uniform medium having a radiation length of about 2.9 cm. Comparison will be made with theory and cosmic ray studies.

Experiments will also be conducted with emulsion chambers consisting of a combination of lead sheets and nuclear emulsions of a design similar to those employed in cosmic ray experiments. Again comparison will be made with theory and the results of cosmic ray investigations.

It is proposed to expose the stacks to electrons of the highest practical energy; at least 100 GeV.

INTRODUCTION

Experiments on the study of high energy galactic electrons are most important from the point of view of the origin of cosmic rays and the nature of the interstellar medium. While the knowledge of electrons under 50 GeV is rather good, these lower energies do not appear, at this time, to allow very much to be said about their origin. On the other hand, the higher energy electrons (100 to 1,000 GeV) appear to be more closely associated with the high energy proton and heavy nuclei content of the cosmic radiation. It is quite important to obtain good data on the flux of galactic electrons to 1,000 GeV in order to be able to make detailed comparisons with the hadron component.

Groups in India, Japan, Chicago and Maryland have made measurements of the flux of galactic electrons over 100 GeV.

Unfortunately the observations lead to fluxes which differ by four to five times the statistical errors.

During the High Energy Cosmic Ray Nuclear Interaction Conference in Japan in the Fall of 1974, a working session of the Japanese and Indian groups went over their respective data and attempted to resolve differences. Comparisons were difficult since detectors were different but the main problem is connected with the callibration of energies as measured by the sizes of the electromagnetic showers produced by the electrons. Differences of about 30% exist as a consequence of applying theory to the very complex problem of shower development. While 30% doesn't appear to be much of a difference, it has a profound effect upon the evaluation of the flux when the energy spectrum of the electrons is quite steep,

$$\frac{dN}{dE} = kE^{-2.7} .$$

While good calibrations to 20 GeV have been obrained at SLAC, we have a desperate need for calibrations in the several hundred GeV region.

In addition to the need for a calibration of our cosmic ray instruments, by its own right, it would be of scintific value to carry out a detailed experimental check of shower theory at the higher energies available in the FNAL electron beam.

In order to carry out the objectives outlined above, we propose to prepare several emulsion chambers nearly identical in basic design to those used in current cosmic ray observations. The chambers would be exposed to about 1-10 electrons per cm^2

so that studies could be made on the development of showers produced by individual electrons. In addition several stacks would be exposed to much higher fluxes (1,000 to 200,000/cm^2) in order to look at the overall development of showers and the effect of nuclear electroproduction processes.

DESIGN PARAMETERS OF EMULSION CHAMBERS

A. Pure Emulsion Shower Detector

It is proposed to make up a stack of emulsions of cross sectional area 10 x 10 cm and a length corresponding to 8.1 radiation lengths (24 cm). The stack, as shown below would be made up of 390 Ilford pellicles, 600 microns in thickness. Most of the pellicles would be of old exposed emulsions from balloon flight disasters but 40 new pellicles (400 microns thick) would be placed at distances in radiation lengths as shown in Fig. 1.

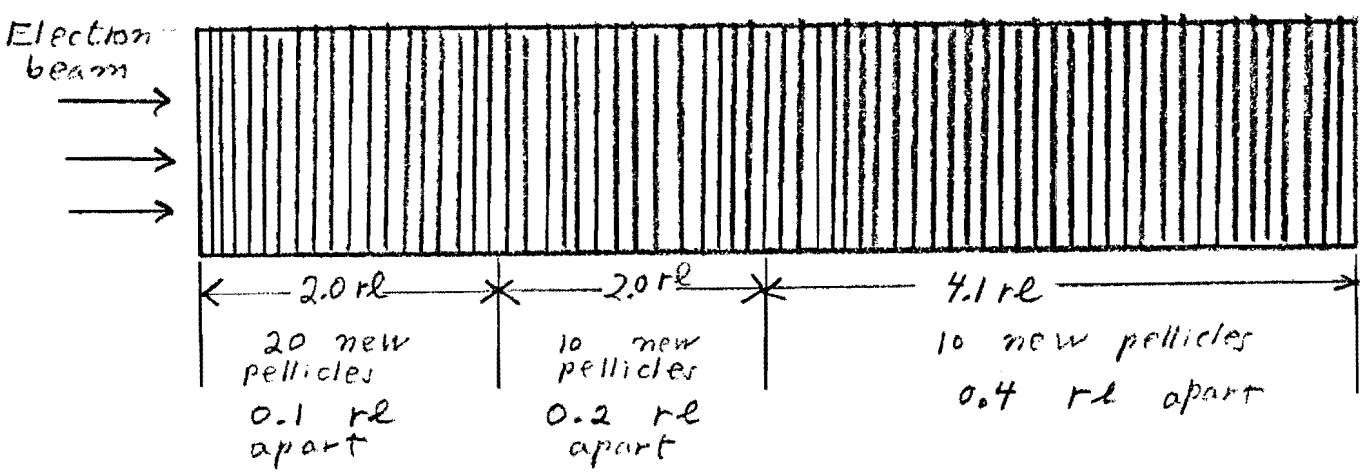


Fig. 1 DETECTOR A, Pure Emulsion Stack

B. Composite Emusion Chamber (emulsion and lead plates)

It is proposed to test a chamber of a type nearly identicla to one that will be used for the U. S. - Japan program to measure galactic electrons. The chamber is 8.2 radiation lengths in thickness and details of the design are shown in Fig. 2.

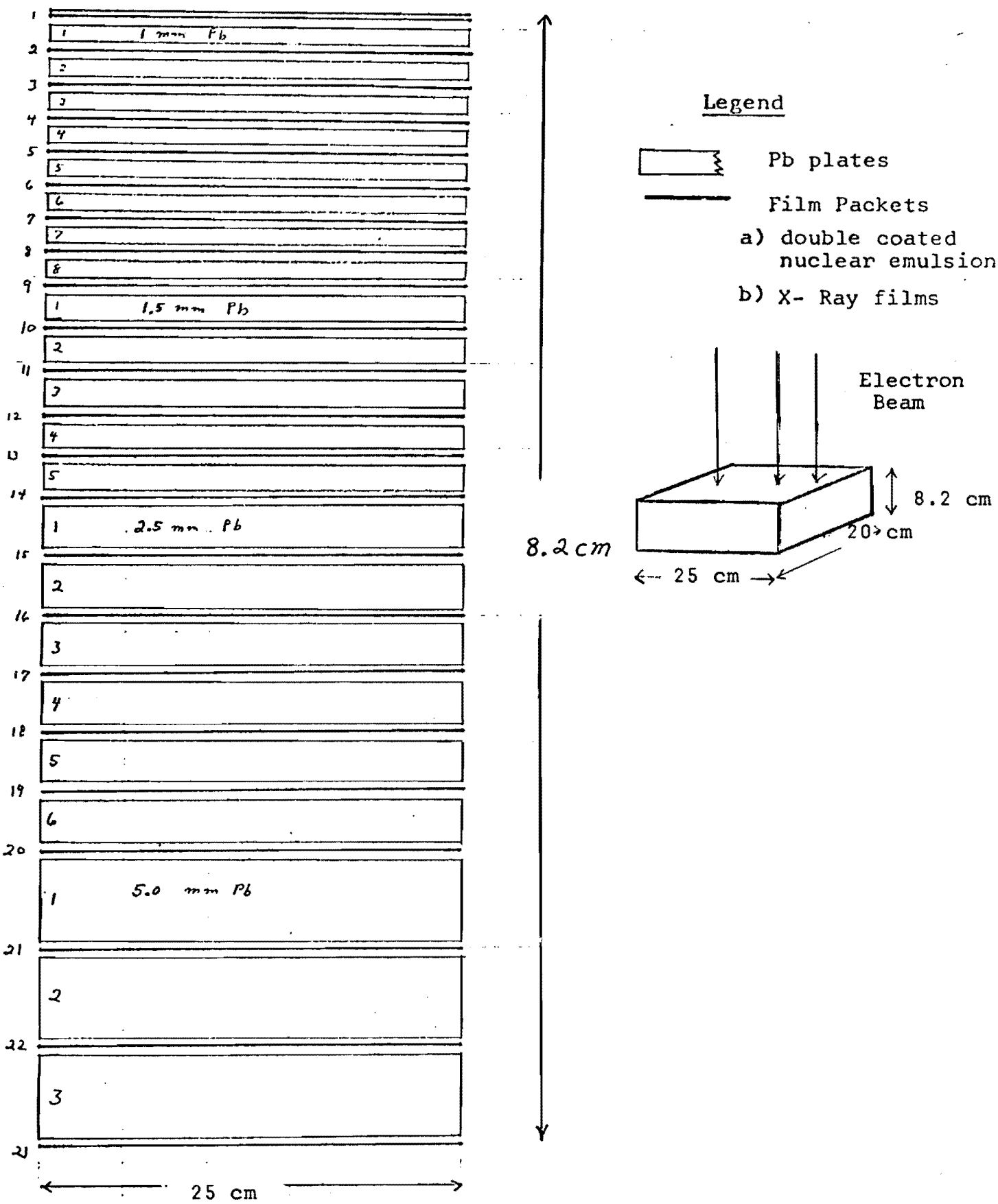
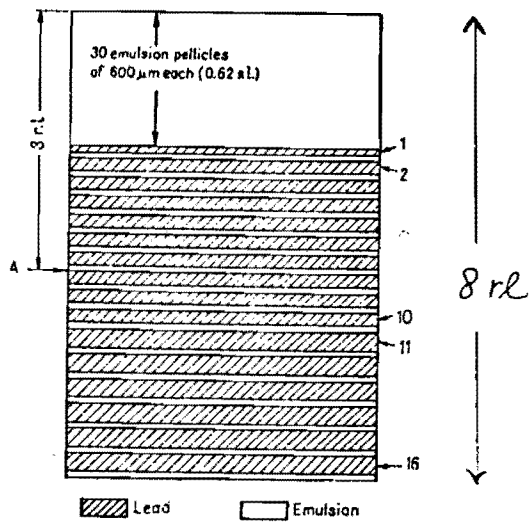


Fig. 2 COMPOSITE EMULSION CHAMBER Type B

C. Lead-Emulsion Sandwich (Tata-style)

Since differences in calibration of chambers might be dependent upon subtle geometry considerations, it would be desirable to test a chamber of the type employed by the Tata group. The chamber shown in Fig. 3 would be used for this purpose.

Electron
Beam



Details

a) Upper block of emulsion 1.8 cm thick (0.63 rl.)

b) One lead sheet 1 mm thic

c) Nine lead sheets 2 mm
Six lead sheets 3 mm

Fig. 3 Emulsion-Lead chamber of Tata style

D. Chamber to Study Overall Development of Showers and Effect of Nuclear Electroproduction Processes

After using the chamber in Fig. 1 for the study of the development of individual showers, the plates will be replaced and the detector subjected to electron fluxes from 1,000 to 200,000 /cm^2. The former flux will give good information on the average development of showers and the latter will provide information on the influence of nuclear electroproduction processes.

EXPOSURE AND FLUX REQUIREMENTS

A. ENERGY

It is desired to expose the emulsion stacks described above to electrons of an energy as high as practical but certainly over 100 GeV.

B. Dimensions of Stacks

Stack	Type of Detector	Dimensions	Flux electrons/cm^2
1.	Pure emulsion Fig. 1	10 cm x 10 cm 24 cm long	10
2.	Composite Chamber Fig. 2	20 cm x 25 cm 8.2 cm long	10
3.	Lead-Emulsion Sandwich Fig. 3	10 cm x 10 cm 8 cm long	10
5.	Shower Development and Electroproduction	10 cm x 10 cm 24 cm long	1,000
6.	Shower Development and Electroproduction	20 cm x 25 cm 5 cm long	200,000