NAL PROPOSAL No. 39

Correspondent: W. D. Walker
Department of Physics
University of Wisconsin
Madison, Wisc. 53706

FTS/Commercial 608-262-5878

PROPOSAL FOR THE USE OF A RAPID CYCLING BUBBLE CHAMBER AT NAL

W. D. Walker, A. R. Erwin, M. A. Thompson, C. Mistretta
University of Wisconsin

J. D. Prentice, T. S. Yoon, E. C. West
University of Toronto

D. Carpenter, L. Fortney, C. Rose, M. Binkley
Duke University

June, 1970

Proposal for the Use of a
Rapid Cycling Bubble Chamber
at N. A. L.

University of Wisconsin

W. D. Walker, A. R. Erwin, M. A. Thompson, C. Mistretta

University of Toronto

J. D. Prentice, T. S. Yoon, E. C. West

Duke University

D. Carpenter, L. Fortney, C. Rose, M. Binkley

ABSTRACT

We outline the possible uses of a rapid cycling bubble chamber at NAL. We propose some survey experiments.

I. Description of the Wisconsin Rapid Cycling Bubble Chamber

This chamber is in the process of assembly at the present time. A schematic of the chamber is shown in figure 1. The diameter of the chamber is 14" and the chamber is 7" deep. It is expanded hydraulically. The resonant frequency of the chamber and expansion system should be 50 - 70 cps.

The chamber will be illuminated by a retrodirective dark-field system, somewhat similar to a coathanger system. The cycle rate could be as high as 50 - 70 cps for periods as long as 1/2 second. The chamber is refrigerated by means of a He refrigerator. The hydrogen inventory will thus be quite small, only the amount contained in the chamber itself.

The cycle rate will depend on the particular experiment since it is likely that chamber distortion will be proportional to cycle rate.

The chamber has an easily transportable magnet which can give the order of 25 Kg for 2 Megawatts.

Spatial resolution is an important aspect of bubble chamber use. We would propose to increase the spatial resolution of this chamber by using 4 views. Two of the views would be run in the conventional way using $\sim$ 10X demagnification and high F stop (16). The downstream pair would photograph the downstream part of the chamber with smaller demagnification at a lower F stop. We would hope to attain 20 - 30 μ space resolution in the region of the beam in this fashion.

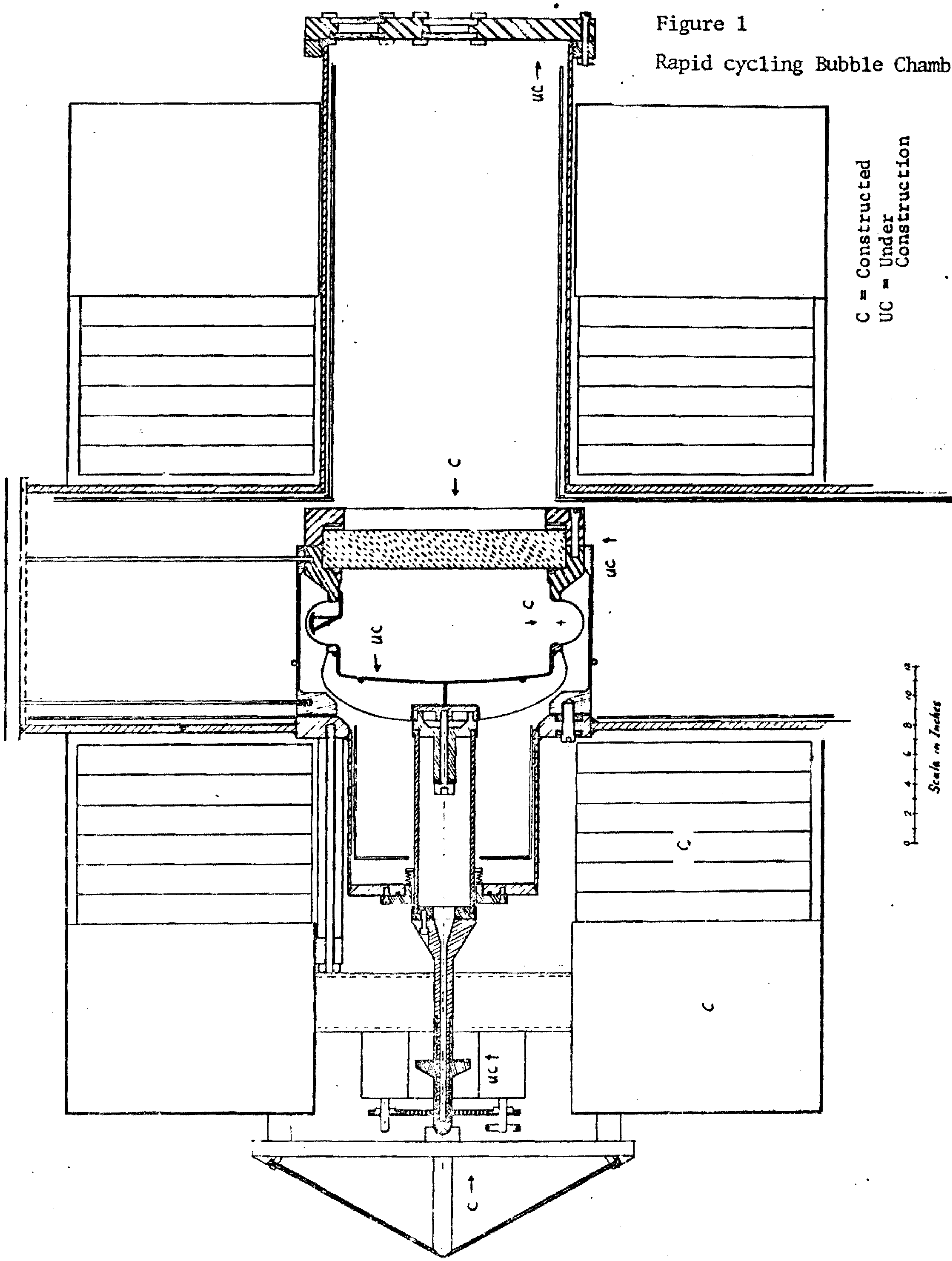
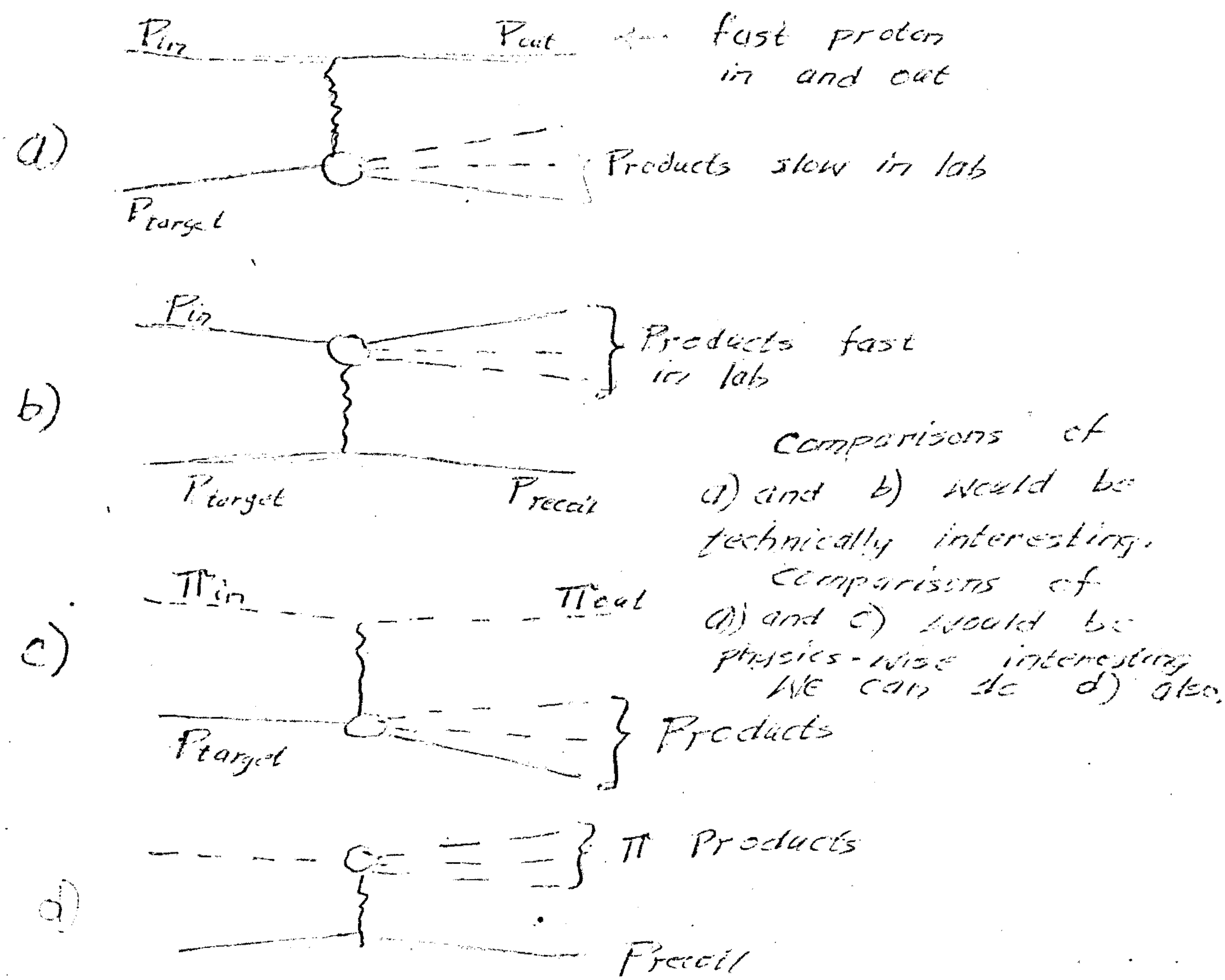


Figure 1

Rapid cycling Bubble Chamber

II. Possible Experiments

There are many possible experiments that one can consider for this chamber. We would propose to do the simplest of experiments first. This would be diffraction dissociation of the target nucleon. This requires the simplest spectrometer downstream. We would first propose to study diffraction dissociation by 100 and 200 BeV protons and 100 BeV $\pi^{\pm}$. This would also allow for a calibration of the spectrometer as a missing mass spectrometer. That is as follows.



We can also study the symmetric reaction in which we determine the mass of the fast particle by means of the recoiling nucleon in the bubble chamber. This technique should give reasonable resolution for the 2 - 4 BeV/c^2 mass range. The bubble chamber can readily measure momenta up to 1.5 BeV/c inside the chamber. Thus it would give good mass resolution in the 1 - 3 BeV/c^2 mass region in the lab system. The proton work would provide a useful calibration of both the chamber and the spectrometer. We would then propose to run π^+ or π^- at 100 BeV. The protons and π^+ could be run simultaneously in an unseparated + beam. We would propose to tag the π^+ by means of 1 or 2 Cerenkov counters. In this work we would propose to run the chamber with no more than one or 2 tracks per expansion. We would initially propose a very loose good - geometry trigger. i.e., A track slightly outside the beam spot would give a trigger. The beam would be within a 5-10 mm band in the bubble chamber. The spot size due to multiple scattering at a distance of 10 meters from the chamber would be a fraction of a millimeter.

The study of nucleon dissociation and the cross checks available should make it possible to, at least, begin a mass spectrum survey for $\pi + p \rightarrow \pi^* + p$. The mass of π^* can be determined modestly well in the 2 - 5 BeV/c^2 mass range by looking at the momentum of the recoiling proton. Some fitting can be done by means of the measurements obtained from the downstream spectrometer.

Requirements for the Chamber

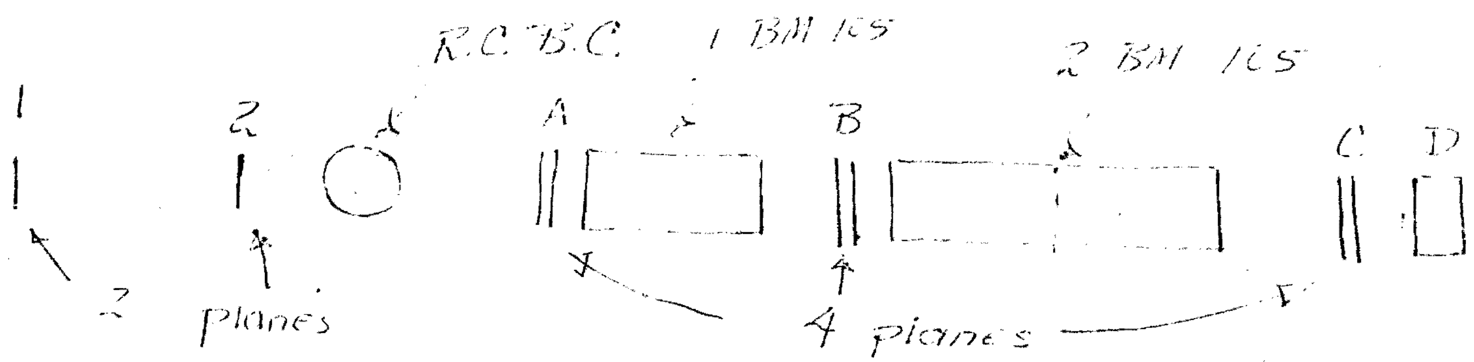
The chamber as planned would be pulsed for 10 or 15 times in a 1/2 second flat-top. We need to have an average of 1 particle/millisecond through the bubble chamber. This would mean a beam intensity of ∿ 500 - 1000 particles per pulse. We would like to have the order of 10^5 interactions for each exposure. This would mean the order of 10^6 expansions for 100, 200 BeV p's and 100 BeV π^+. In an 8 hour shift, one could take the order of 10^5 expansions. Thus the order of 10 shifts would be required for each energy allowing for no down-time. If one assumed a 30% efficiency for accelerator plus bubble chamber about 30 shifts would be required for each energy.

Background

The chamber is relatively small and we use a small part of the chamber so far as beam is concerned. (∿ 1/2 cm. swath across the chamber). We could tolerate 10X our beam intensity in stray tracks in the chamber so long as they were uniformly distributed in angle and position over the chamber. The automatic measuring machines would probably be disturbed by ~~terribly~~ many more stray tracks.

Spectrometer

It is very obvious that the chamber is very small. We propose to do as follows so far as momentum measurements are concerned. Tracks with momenta of 2.0 BeV/c or less are well measured inside the bubble chamber. Tracks with 2 - 6 BeV are measured in the bubble chamber magnet with its fringe field by putting 4 wire planes about 2 meters from the center of the chamber. Tracks with 6 - 30 BeV are measured in the next magnet segment which consists of an Argonne type BM 105 magnet - 6" x 18" x 72" x 18 Kg. magnet. This part of the spectrometer has a relatively large acceptance. (100 mr. x 33 mr.). The high momentum tracks are measured in the first and second bending magnet. We would propose using two BM 105 magnets with 4 wire planes.



plane A is used to measure intermediate momenta in the bubble chamber magnet.

D - possible γ detector.

This last part of the spectrometer will have about 1/3 the angular acceptance of the previous parts.

We would probably require 2 pairs of wire planes 5 meters apart on the up-stream side of the chamber to define the beam to .1 mr..

Scope of Physics

We can probably analyze 2, 4, 6 prong interactions with this system. We clearly don't search in a completely broad spectrum way but we believe that we can do a modest survey.

The comparison of p - p and π - p interactions at 100 BeV would be quite interesting. We can do fitted studies of diffraction dissociation quite well up to 3 BeV/c^2 in the laboratory system and up to 5 BeV/c^2 in the projectile system.

Quark Searches, etc.

If there were massive objects produced which decayed in 10^{-12} - 10^{-13} seconds they would conceivably be visible close to the interaction vertex unless they were always produced in highly multiple reactions. Since we would look at $\sim 10^5$ interactions for each energy and particle we could see things which are produced at the level of $10^{-30}cm^2$ if they gave a clear signature. Triadic quarks might show as events with odd numbers of prongs. We could also determine that the tracks have less than the usual "minimum" of ionization. Automatic measuring makes ionization measurements easy to do automatically.

Missing Mass Search

We can rapidly determine the missing mass spectrum by measuring the recoil nucleons or isobars in the laboratory system. Thus,

$$\text{a)}\quad \pi^{+} + p \rightarrow \pi^{*+} + p$$

$$\text{b)}\quad \rightarrow (\quad)^{\circ} + \underbrace{p + \pi^{+}}_{\Delta^{++}}$$

Reaction a) will be dominated by diffraction dissociation of the pion while the neutral objects from reaction 2 will be produced by pion exchange or other processes. In the case of both incident π's and nucleons, we can search up to 5 - 6 BeV/c^2 in missing mass.

In general the average of median momentum of a particle produced in these high energy collisions is quite low. We can scale up results from our 25 BeV experiment. The result is that at 100 BeV the median of the energy of the pion produced will be something like 2.5 BeV/c and at 200 BeV the median will be 3.5 BeV/c. Thus the bubble chamber itself, will be adequate to measure nearly 50% of the particles coming from the interactions. The arguments are given by figures 2 and 3, taken from our 25 BeV π^- work.

25 GeV/c $\pi^- P$

CENTER OF MASS SYSTEM LONGITUDINAL MOMENTUM SPECTRUM OF NEGATIVE TRACKS

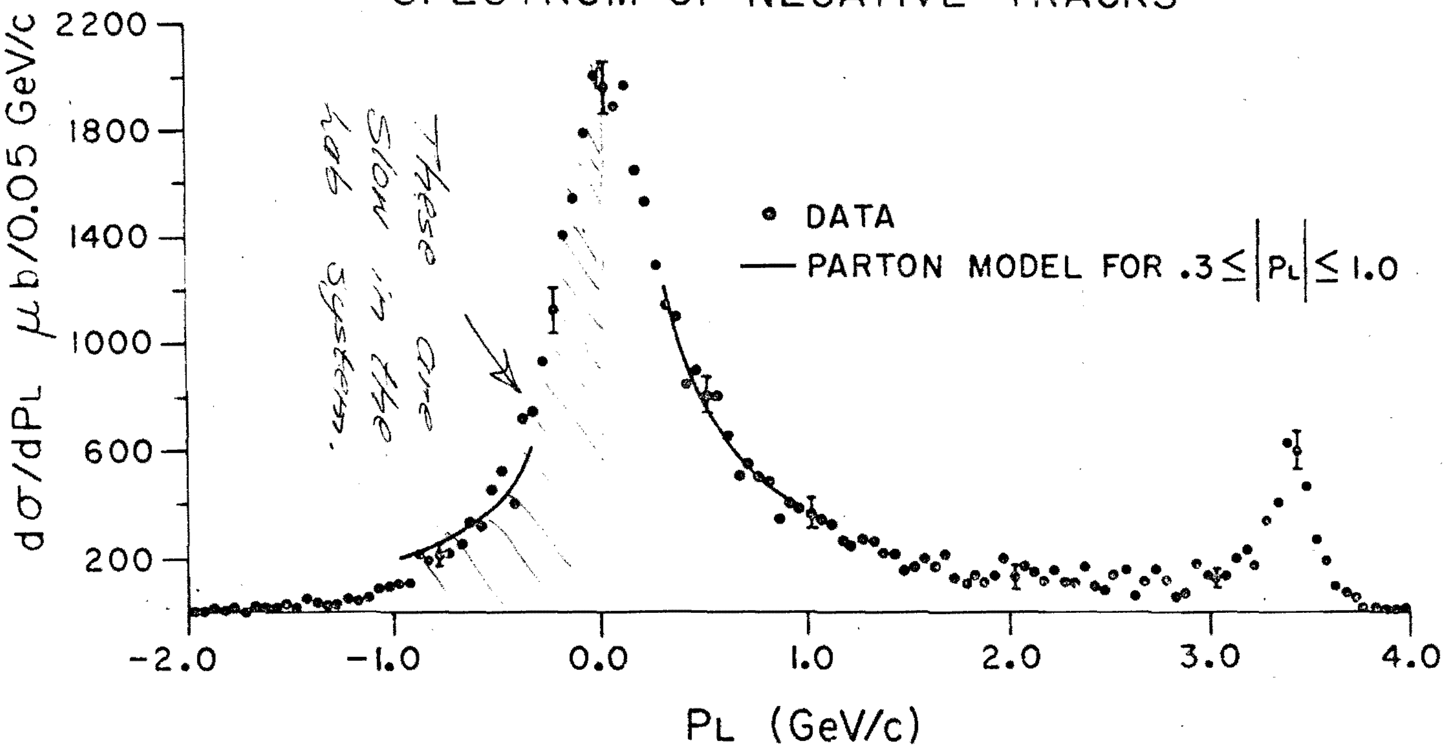


FIG. 13 (2)

Transform this distribution to Lab system using γ_c associated with 100 or 200 GeV protons.

25 GeV/c $\pi^- p$

LABORATORY LONGITUDINAL MOMENTUM DISTRIBUTION

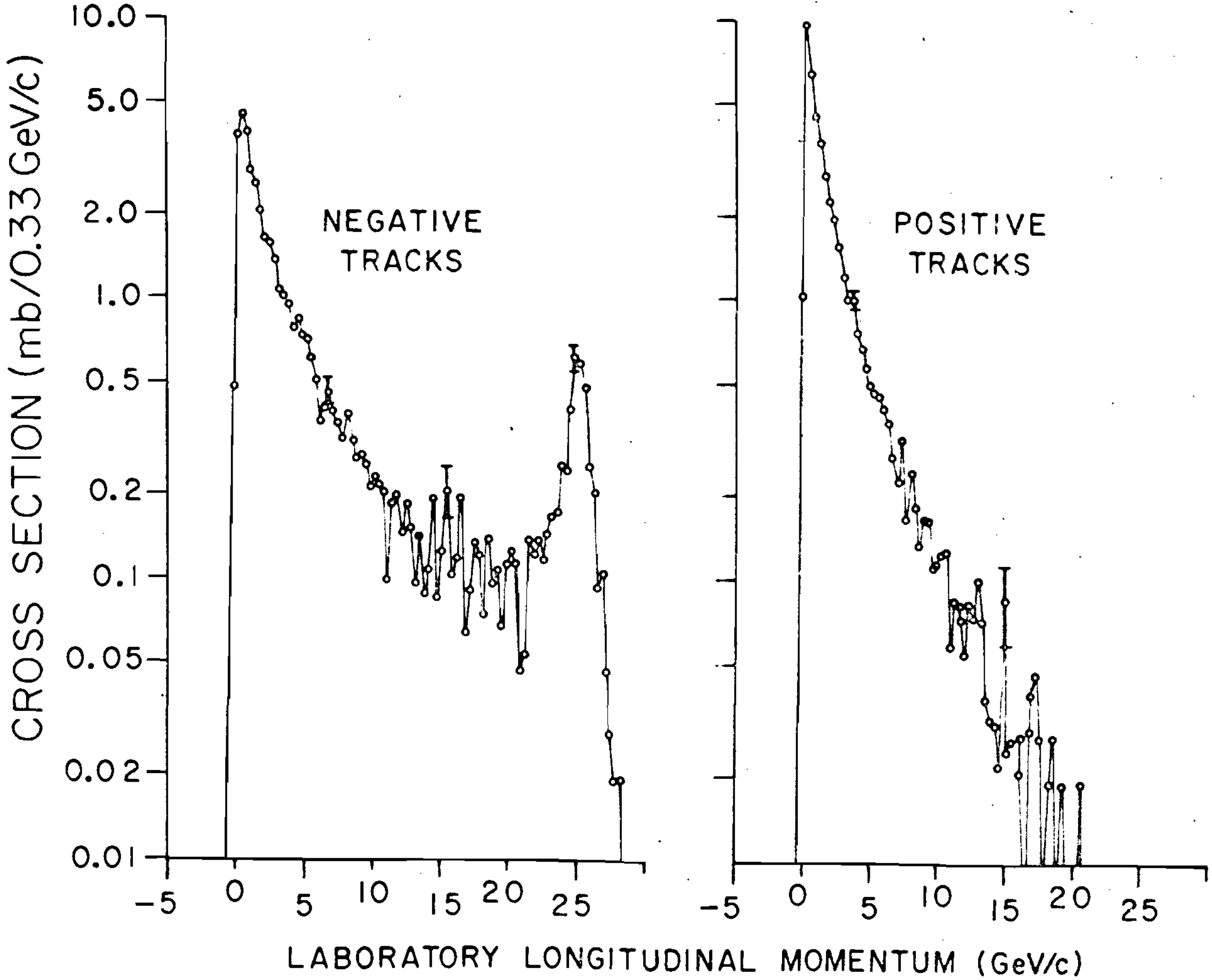


FIG. 14