NAL PROPOSAL No. 287

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STREAMER CHAMBER STUDY OF LARGE P_T INTERACTIONS

Collaboration

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SUMMARY

Recent results in hadronic interactions suggest that a fertile field of experimental study may be the interactions leading to one or more final state particles with large total transverse momentum. In this proposed experiment, we wish to study interactions in which there is at least one such particle which serves as the trigger. All of the charged particles produced in the interaction are observed in a Streamer Chamber which is placed in a magnetic field. This arrangement allows us to measure the complete rapidity (y) distributions for all charged particles. We propose to use a small solid target placed inside the Streamer Chamber, thereby allowing us to observe all (even very low momentum) charged particles which are emitted in coincidence with the large transverse momentum trigger particles. For the backward hemisphere, the momenta of the charged particles would be measured for all triggering events. In addition, neutral strange particles such as Λ's and K's can be detected with good efficiency for momenta up to 30 GeV/c for Λ's and 10 GeV/c for K's using 70 cm of decay path in the Streamer Chamber (the Λ's are of particular interest with respect to the question of parity violation in high-P_T events). This experiment proposes to use the existing apparatus of Experiment E-86A, which consists of a Streamer Chamber and an MWPC hodoscope downstream, and to add to it some counters and a simple calorimeter to trigger on high-P_T events. Events with at least one charged particle having transverse momentum greater than 2.0 GeV will be collected at the rate of approximately one per pulse at $\sim 5 \times 10^5$ π's per pulse; thus, 30,000 triggers would require only 20 hours of data taking at full efficiency. Such a sample of data would be more than enough to give an overall view of what is going on in high $p_\perp$ interactions. It is anticipated that 60 hours of tuneup time will be required. The trigger of Experiment 86A has already been designed to exclude upstream interactions, which are one of the biggest sources of background in high $p_\perp$ experiments.

PHYSICS JUSTIFICATION

In this experiment we are proposing to study in some detail the particles emitted in coincidence with $P_T > 2$ GeV/c events. The trigger allows us to select events in which the large P_T is carried by either one or more charged particles, neutrals alone, or a combination of charged and neutral particles. Since the experiment will be performed in a Streamer Chamber, all of the charged particles which are emitted will be observed. The production angles and the momenta of these charged particles will be obtained. We thus obtain full rapidity distributions for particles emitted in coincidence with $P_T > 2$ GeV particles. In addition, the Streamer Chamber gives us the ability to measure Λ's and/or K's which decay in the Streamer Chamber volume. Such events serve to test for parity violation in large P_T interactions.

Experimental studies of high p_T interactions have been carried out at both NAL and the ISR. These experiments have given information about the power law dependence. Recently at ISR rapidity and multiplicity distributions of the charged particles associated with high p_T, triggers have been obtained[1]. The ISR results have taught us that the associated multiplicity of charged particles is larger (~18) than that obtained for all interactions. Also the data associated with triggers at 90° indicate that the large p_T is balanced locally in rapidity. In this experiment, by triggering at 90° and 60° in the CMS (which is a ~1 unit shift of rapidity) we should be able to determine whether the balancing occurs in the same or opposite hemisphere. In addition, triggering on neutral particles gives us information which extends the recent ISR measurements because the magnetic field allows us to separate positive and negative particles. The detailed study of associated multiplicity for π induced interactions will compliment and extend the recent ISR results.

The theory of high-P_T interactions is in a rapidly evolving state. A number of models have been proposed which discuss the power law behavior of the P_T distribution as well as more subtle details. However, it is important to stress that these models are still evolving and therefore we do not base this experiment on a specific model but argue that its importance lies in the fact that it gives information about the structure of high-P_T events which otherwise would not be obtained in the current round of experiments. This experiment is therefore complementary to those which have been approved at NAL and the ISR.

To summarize, the purpose of this experiment is:

1) To obtain information on all the charged particles which are emitted in high-P_T events. This includes momenta for all charged particles within the backward hemisphere, as well as production angles for all charged particles, and +/- ratios.
2) To obtain information on the Λ's below 30 GeV and K^o's below 10 GeV which occur in high P_T events.

APPARATUS NEEDED

The experiment is to be performed using the Streamer Chamber and magnet of E-86A followed by a momentum selecting telescope and a calorimeter (see Fig. 1). No magnet, other than the one already in place in the Meson Lab, is required. Since the target for this experiment is to be inside the Streamer Chamber, the Streamer Chamber magnet is the analyzer of secondary particle momenta. A simple counter telescope and calorimeter will select a range of momenta and production angles corresponding to transverse momenta above a chosen value. The greatest source of false triggers would be slow particles which could be bent into the trigger telescope by the magnet and these are eliminated by the calorimeter.

The E-86 magnet bends particles in a vertical plane. The calorimeter will be placed so that the production plane, defined by the incident beam and the secondary particles, is horizontal and therefore perpendicular to the bend plane. This arrangement insures that the triggering particles all have large and similar production angles(60^{o}, 90^{o} CMS) regardless of their momenta. Thus, P_T is proportional to the calorimeter pulse height in all cases, and the Streamer Chamber may be triggered on any value of P_T above some minimum.

The trigger will be rather general in that single particles or showers, charged or neutral, can be accepted simultaneously and separated later. The Streamer Chamber will measure the number and momenta of the charged particles entering the calorimeter. Depending on the rates, the trigger may also be adjusted to favor or inhibit either charged or neutral particles by means of Pb convertors and scintillators in various combinations of coincidence or anti-coincidence. No matter what the triggering particles are, however, the observation of complete events in the chamber when the momentum transfer is very large should be quite interesting. Upstream interactions are vetoed by E-86A anti-counters in front of the Streamer Chamber.

The calorimeter itself will consist of plastic scintillator sheets interleaved between iron and/or other plates. A cross section of 60 cm x 60 cm will be sufficient to eliminate edge effects and provide the desired solid angle (80°-100° cms). A total of 20 plates of 4 cm thickness of iron will give, according to Engler et al.[2], a resolution of $\pm$ 15% at our lowest desired momentum of 25 GeV/c (see Fig. 2). This design would certainly be adequate for a charged-particle-only trigger. The admission into the trigger of photons accompanying the charged particles requires the entrance section of the calorimeter to be composed of Pb sheets and scintillators, with a separate output signal for this section. The final design may differ from this description, but it is clear that a calorimeter can be built that will provide a resolution adequate to select a sample of genuine high-P_T events.

E-86A is set up in beam line M1 in the Meson Lab. This beam can provide π^- mesons of up to 250 GeV/c momentum. The Streamer Chamber can handle $\sim 5 \times 10^5$ particles per second, and we would want a flux of $\sim 5 \times 10^5$ π^- per pulse, depending on the duty cycle. The beam spot should be small. A diameter of a few mm has been obtained in beam studies to date, and this size would be quite adequate.

SCOPE OF THE EXPERIMENT

Event rates given in Table I are computed using the data of Cronin et al.[3] for incident protons, since no pion beam data are available. It is assumed that the high-P_T events from the pion reactions will constitute the same fraction of the total cross section as do the proton high-P_T events for the total pp cross section. Thus, the cross sections of Cronin et al. have been scaled by 23/40 for these calculations.

TABLE I. Events detected per 20-hour day with P_T greater than the value in the first row assuming 5×10^5 pions at 200 GeV/c incident on a one-tenth-interaction-length target. The angular acceptance is from 80°-100° in the cms and 20° in azimuth.

P_T GeV/c	2.0	2.5	3.0	3.5	4.0
Rate per 20 hours	31,000	3,800	530	84	13

A realistic beam spill equivalent to 0.5 seconds at 100% duty cycle would reduce these rates by a factor of two.

We are requesting a two-week period of running in order to accumulate a (conservatively estimated) few thousand events. We believe that this experiment will serve as the test of the Streamer Chamber apparatus for Experiment 86A. In E-86A, we require a test in order to get the beam into the Streamer Chamber and to determine that our trigger is properly working. We would anticipate

the high-P_T run to serve as this test; we do not anticipate asking any time in addition to that already approved for Experiment 86A, but rather to be given the permission to take data on high-P_T events. The difference between E-86A apparatus and that which we would make for this test would be the addition of the downstream telescope and calorimeter which would be provided by the Davis group. We would also run this experiment with neon gas in the chamber since it simplifies the operation of the Streamer Chamber. The space already assigned to E-86A in the Meson Detecting Building will suffice for the needs of this experiment, and no additional space is requested.

REFERENCES

[1] M. Jacob "Large Transverse Momentum Phenomena" - ISR Discussion Meeting No. 7 - Dec. 1973 - CERN Internal Note.

[2] J. Engler et al., Nuclear Inst. and Meth. 106, 189 (1973).

[3] J. W. Cronin et al., Phys. Rev. Lett. 31, 1426 (1973).

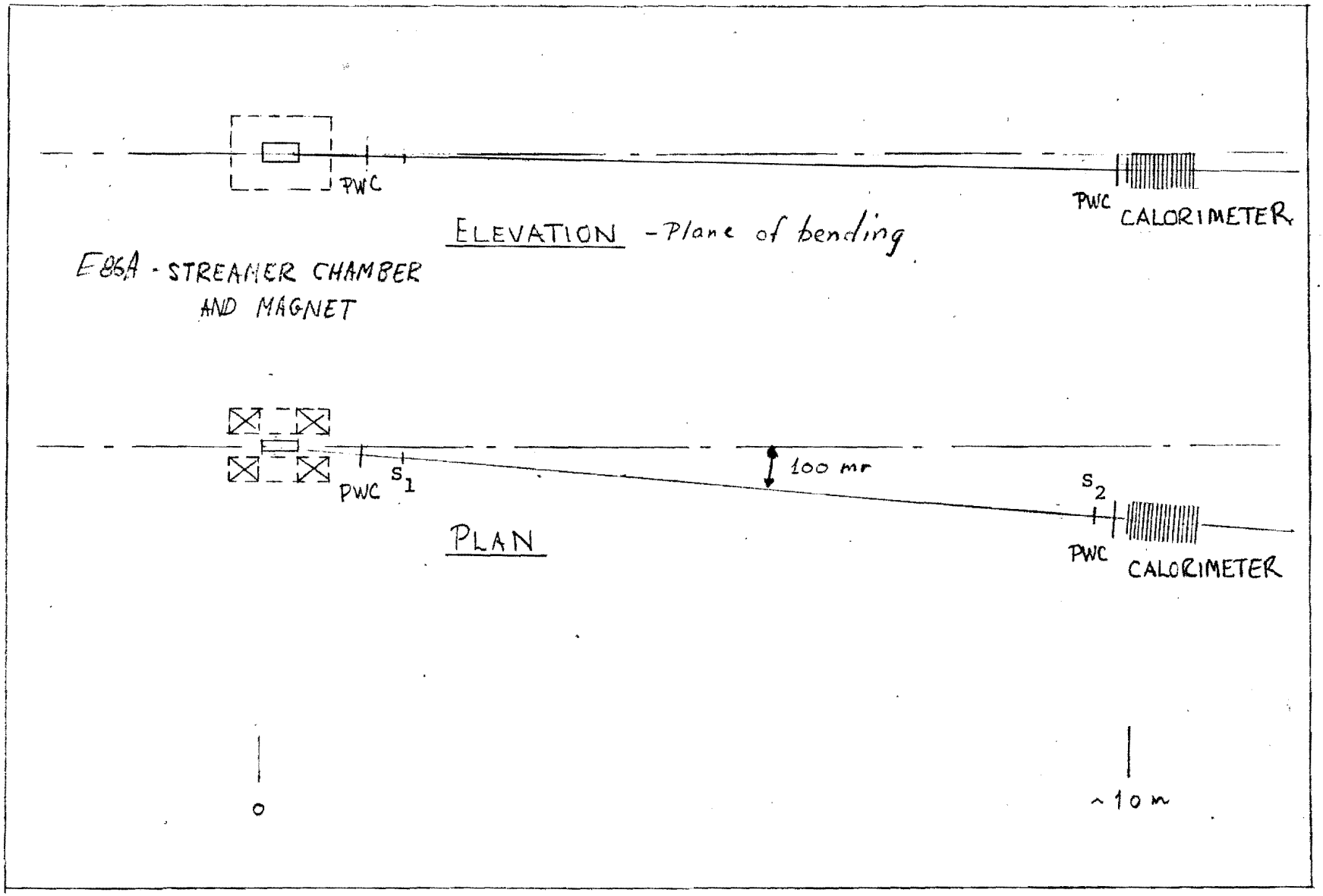

Fig. 1 Layout of high-P_T trigger (100 mr selects events at 90° CMS for 200 GeV incident pions).

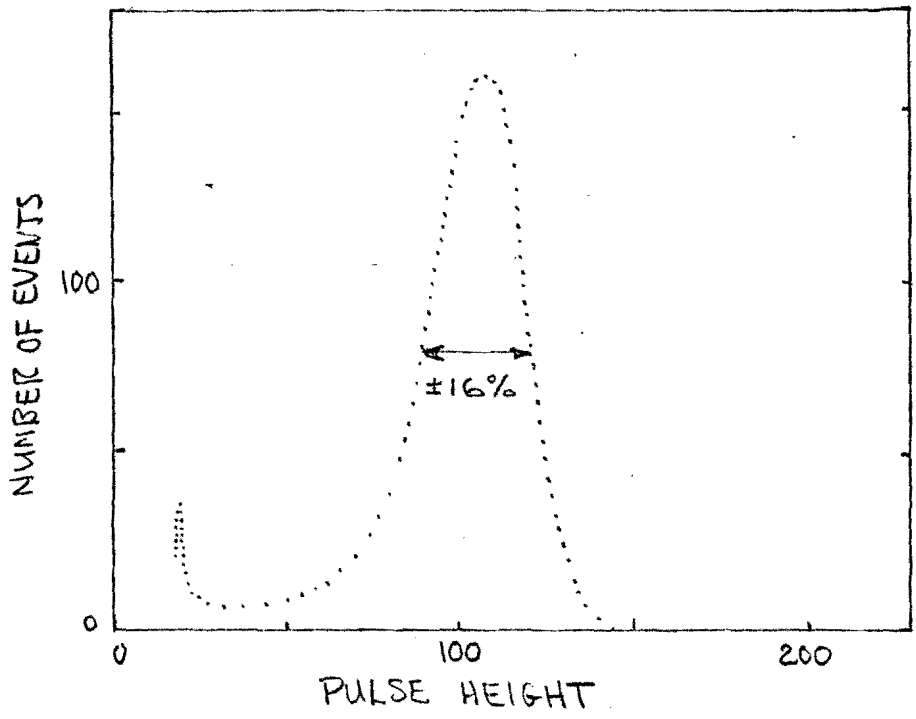

Fig. 2 Data from Fig. 3 of Ref. 1 for 23.5 GeV/c protons incident on calorimeter consisting of 60 cm of iron interleaved uniformly among 20 plastic scintillators.