NAL Proposal No. 300

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STUDY OF PARTICLE PRODUCTION AT HIGH TRANSVERSE MOMENTA USING HYDROGEN AND DEUTERIUM TARGETS

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May 16, 1974

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ABSTRACT

We propose to study the particle constituents of a beam produced at 80 mrad lab angle (~ 90^{o} in the p-p c.m. system) by 200-500 GeV protons striking a liquid hydrogen/deuterium target. This work is basically an outgrowth of the investigation carried out in E-100 using targets of complex nuclei. The objectives of our proposed investigation with hydrogen/deuterium target are:

1. To unfold the hadron production cross section for p-p and p-n collisions;

2. To make a more precise determination of the s dependence of the cross section than can be done with complex nuclear targets due to the effects of Fermi momentum;

3. To establish without ambiguity that no complex nuclear effects are affecting the data sample acquired in E-100.

received JRS 4/18/74

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5630 ELLIS AVENUE

April 17, 1974

Dr. James R. Sanford
National Accelerator Laboratory
P. O. Box 500
Batavia, Illinois 60510

Dear Jim:

Thank you for your letter of March 7 concerning our forthcoming hydrogen run.

I think that your guess that we will need considerably more than 3 weeks to complete this run is a safe one, especially if 400 (and hopefully 500) GeV protons are available. Therefore, if you feel that this part of Experiment 100 should be given another number, please feel free to do so. The addendum concerning the hydrogen run can certainly be used as the proposal.

We have estimated the time necessary for the hydrogen deuterium running at 300 GeV. The estimate is broken down in the enclosed table. We would want to make these measurements for incident proton energies of 200, 300, 400, and if possible, 500 GeV. The time spent on each energy will be roughly the same : for 2×10^{12} protons/pulse on target, it would be approximately 3 weeks/energy .

Sincerely,

Jim

James W. Cronin

JWC:sk
enclosure

Estimates of Hydrogen/Deuterium Running Time Required
Estimates Made for 300 GeV, Both Polarity Secondaries

	Shifts	Protons
I. Initial tune-up and check-out of equipment and targets	6	----
II. 300 GeV Running		
1. Hydrogen cross-sections with Be normalization		
a) Low momentum runs (at low intensity)	2	
b) High momentum runs		$.8 \times 10^{17}$
2. Deuterium cross-sections with Be normalization		
a) Low momentum runs (at low intensity)	2	
b) High momentum runs		$.4 \times 10^{17}$
III. 400 GeV Running (same requirement as II.)	4	1.2×10^{17}
IV. 200 GeV Running (same requirement as II.)	4	1.2×10^{17}
V. 100 GeV Running (same requirement as II.)	4	1.2×10^{17}
VI. 500 GeV Running (same requirement as II.)	4	1.2×10^{17}
VII. Direct μ production from hydrogen at $p_\perp$ = 1.5, 2.25, 3.0 GeV/c at 300 GeV/c	___	2.6×10^{17}
TOTAL	26	8.6×10^{17}

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July 23, 1973

JUL 24 1973

Dr. James Sanford
National Accelerator Laboratory
P. O. Box 500
Batavia, Illinois 60510

Dear Jim,

Having gained enough experience with our spectrometer, we feel now is the time to formally submit the enclosed addendum regarding the installation of a hydrogen target. We would be glad to discuss it with you at your earliest convenience.

Sincerely yours,

Henry, Pierre

Henry Frisch, Pierre Piroué

HF:bb

Enclosure

Proposal File No. 100
Master
DO
JRS

Addendum to NAL Experiment 100

We propose to install a hydrogen target as the primary target for the production of high transverse momentum secondaries by 200 - 400 GeV protons.

The present targets used in Experiment 100 are made of Be, Ti, and W. With these targets we have measured, so far, the cross-sections for single particle production by 300 GeV protons at transverse momenta (P_T) of 1.1 to 7.5 GeV/c. We have also measured the particle constituents (π, K, p) at transverse momenta of 3.0 and 4.5 GeV/c. Figure 1 shows a Cerenkov counter pressure curve for a negative secondary beam of 40 GeV/c (P_T = 3 GeV/c). The invariant cross-section ($E \frac{d^3\sigma}{dp^3}$) for production of positive hadrons by 300 GeV protons striking a W target is displayed, in Figure 2, as a function of P_T. It is interesting to note that whereas our data agree quite well with ISR data at $P_T \lesssim 3$ GeV/c, there is a significant departure at $P_T \gtrsim 4$ GeV/c, which indicates a strong energy dependence at large P_T.

In light of these results, we should like to propose the installation of a hydrogen target, as mentioned in our original proposal. There are basically three reasons for doing this:

1. A hydrogen target, with the capability of being filled either with hydrogen or deuterium would enable us to unfold the hadron production cross-sections for p-p and p-n collisions. The many theoretical models (partons, etc.) which attempt to explain the "excess" of events at high transverse momenta have definite predictions for particle production in p-p and p-n collisions. Obviously, no p-n cross-sections can be measured at the ISR.

2. The hydrogen target eliminates the effects of Fermi motion which smears the available energy ($\sqrt{s}$) and the production angle in the proton-nucleon center-of-mass system. Hence, the s dependence of the cross-section can be measured more accurately.
3. Finally, the use of hydrogen as a target should establish without any ambiguity that no complex nuclear effects are affecting our data.

With a 1" in diameter and 6" long hydrogen target the secondary beam rate would drop by a factor of $\sim$20 with respect to our present Be target, which is quite acceptable. The target would be mounted directly on the 3C drawer in the Proton East target box, in place of the present target holder. The flask should probably be all metal to avoid radiation damage; it would be cooled to $\sim 20^{\circ}$ K by gaseous He in a surrounding cryostat. The instantaneous heat load due to energy loss amounts to $\sim$10 watts if one assumes a beam of 10^{12}protons per 100 msec of effective spill.

Because of the small volume of hydrogen involved no major problems of safety should arise.

Figure Captions

Figure 1. The Cerenkov Counter pressure curve for 40 GeV/c (P_T = 3 GeV/c) negative secondaries from collisions of 300 GeV protons with a W target. The graph shows both the 0 - 9 mr. and 9 - 30 mr. channels of the counter.

Figure 2. The invariant cross-section versus transverse momentum for positive secondaries produced in p-W collisions.

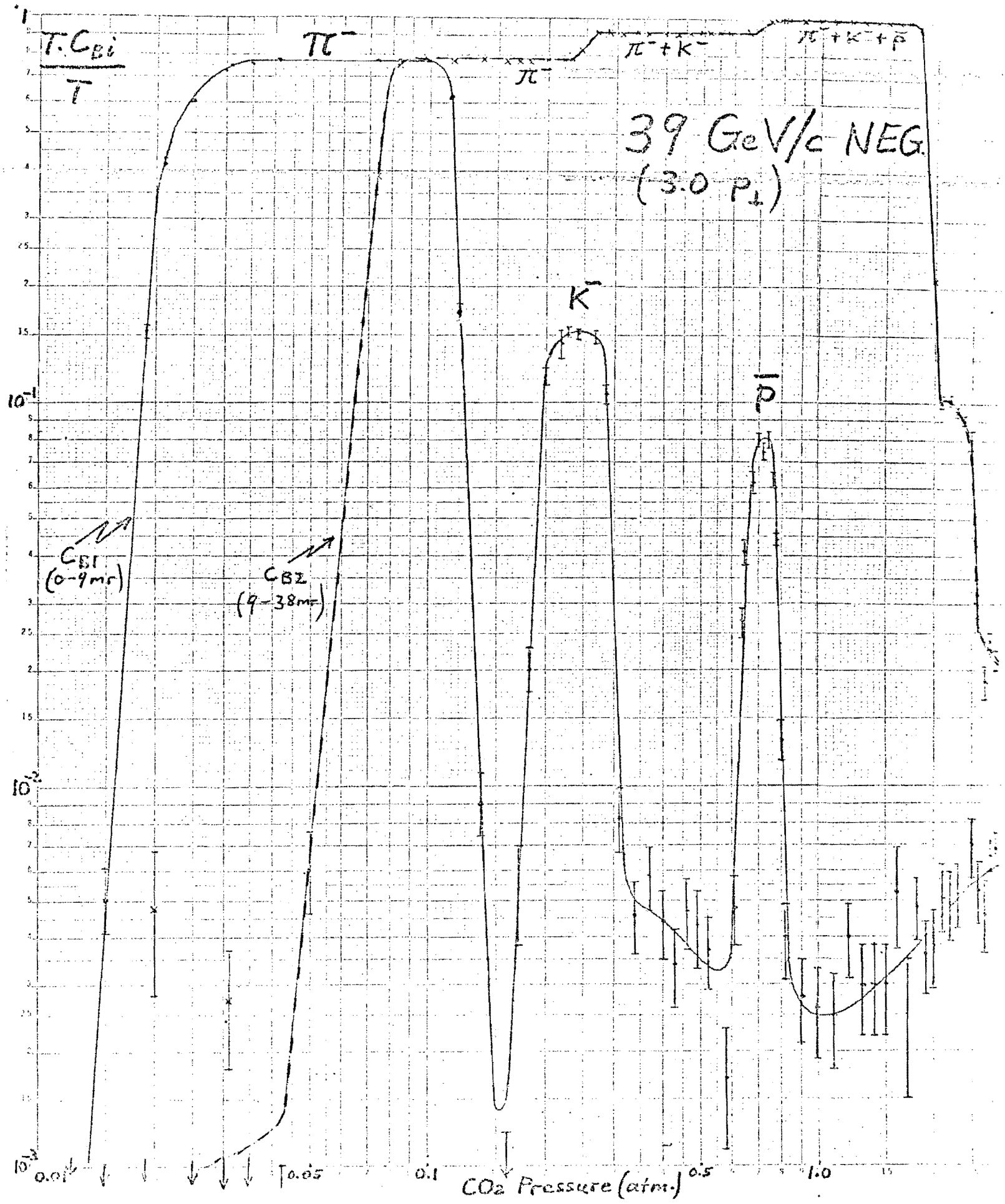
T·C_Bi / T
π⁻
π⁻ + K⁻
π⁻ + K⁻ + p̄
39 GeV/c NEG.
(3.0 P_L)
K⁻
p̄
C_B1 (0-9 mr)
C_B2 (9-38 mr)
1
10⁻¹
10⁻²
10⁻³
0.01
0.05
0.1
0.5
1.0
CO₂ Pressure (atm.)

Fig. 1

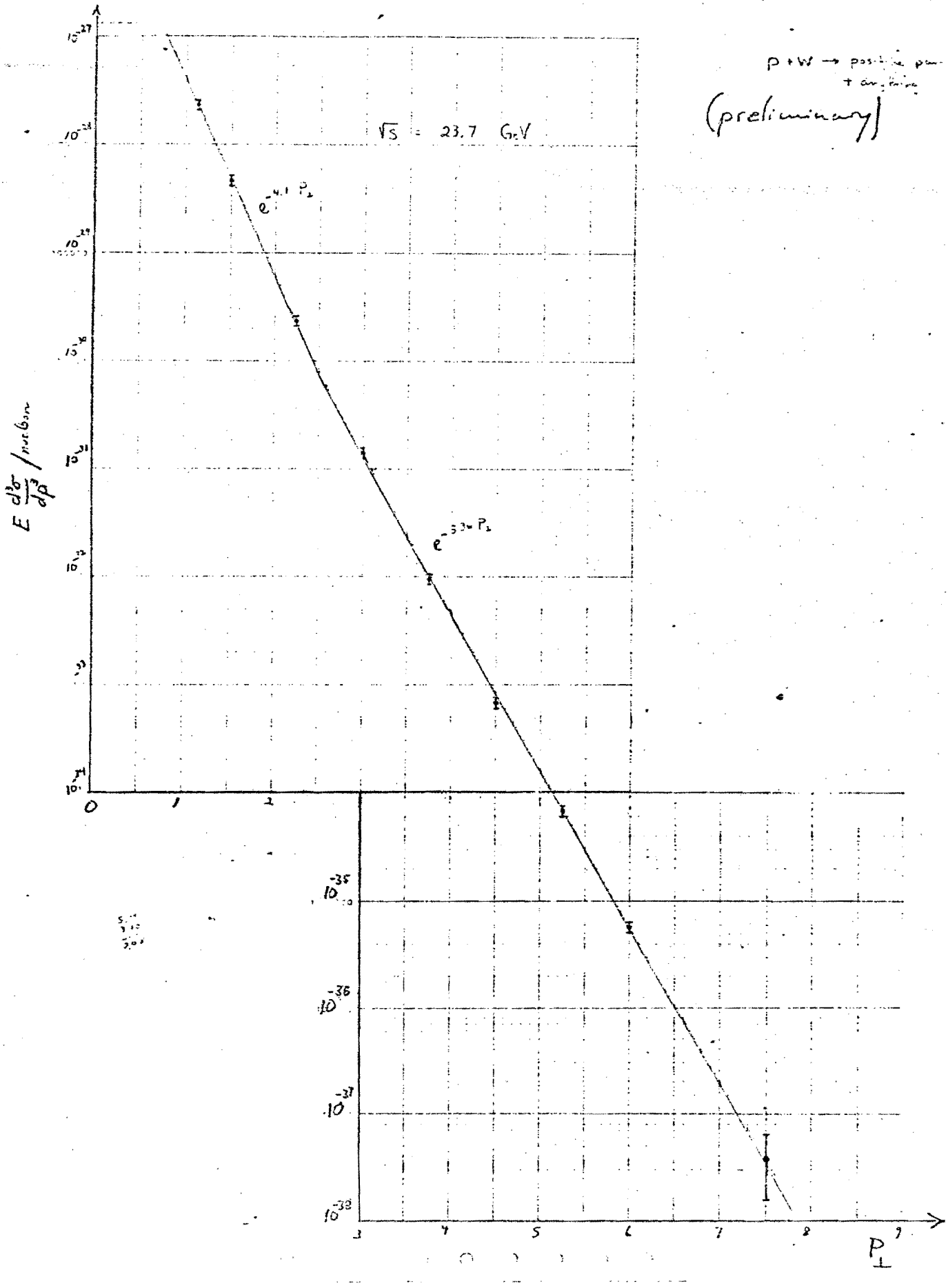
p + W → positive pion + anything
(preliminary)
√s = 23.7 GeV
$e^{-4.1 P_\perp}$
$e^{-5.3 P_\perp}$
$E \frac{d^3\sigma}{dp^3}$ / nucleon
$P_\perp$

Fig. 2