Experimental Proposal

for FNAL 15 foot Bubble Chamber

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$\bar{p}p$ and K^-p Interactions at 100 GeV/c using FNAL 15 foot Bubble Chamber

Experimenters:

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I. Introduction

We propose to take 100,000 pictures of a negative beam at 100 GeV/c in FNAL 15 foot bubble chamber filled with hydrogen. We request to use the beam kicker magnet for controlling the number of beam tracks. Use of the mass tagging system is also requested to identify and to locate the $\bar{p}$ and K^- beams. The enriched $\bar{p}$ beam proposed by W. W. Neale[1] is also extremely desirable. If the run without the enriched $\bar{p}$ beam scheme comes earlier, we prefer the run without this scheme rather than waiting for this scheme. Because of the large fiducial volume available for the 15' BC, the experiment without the enriched $\bar{p}$ beam device is feasible considering the number of events estimated from the recent beam survey data.[2]

Strong interaction physics for $\bar{p}p$ and K^-p at this energy region has not been explored and any physics results obtained from this exposure will provide usefull information for understanding strong interaction physics. In this experiment, we study both inclusive and exclusive reactions in $\bar{p}p$ and K^-p interactions. In particular, we investigate the multiplicity distributions, and diffractive processes for $\bar{p}p$ and K^-p interactions and compare with those in low energy region.

Our scanning and measuring capability allows us to handle the data within 8 months after we finish taking the pictures.

II. Physics Interest

In this experiment, we study all $\bar{p}p$, K^-p and π^-p interactions at 100 GeV/c. Our particular interests are in both inclusive and exclusive reactions in $\bar{p}p$ interactions. Data for high energy $\bar{p}p$ interactions are very sparse and only the total cross sections have been measured.(3) Many studies(4) for $\bar{p}p$ interactions have been carried in the lower energy region. We have been studying $\bar{p}p$ interactions at 7 and 15 GeV/c.(5) Now we extend our study to the higher energy, 100 GeV/c.

(1). Multiplicity

The multiplicity distributions for $\bar{p}p$ interactions have so far measured up to 32 GeV/c.(4) We investigate the detail feature of multiplicity, the behaviour of $\langle n \rangle$ /D and the KNO scaling at 100 GeV/c. The prong counting for the 15' BC is easier comparing with that for the 30 inch bubble chamber. The multiplicity distribution for γ(or π^o) is also measured. The single γ detection efficiency is about 10% for the 15' chamber.

(2). Inclusive reactions

The inclusive reactions for neutral particles such as γ(or π^o), K^o, Λ^o are very interesting in the view of

the scaling behaviour. We measure the X (Feynman variable) distributions for :

$$\bar{p}p \longrightarrow \gamma(\text{or } \pi^0) + MM, \quad (1)$$
$$\longrightarrow K^0 + MM, \quad (2)$$
$$\longrightarrow \Lambda^0 + MM. \quad (3)$$

We emphasize the advantage of the large size bubble chamber to detect the neutral particles.

We also investigate the missing mass distributions from inclusive reactions for slow proton, Δ^{++} and vector mesons:

$$\bar{p}p \longrightarrow p + MM, \quad (4)$$
$$\longrightarrow \Delta^{++} + MM, \quad (5)$$
$$\longrightarrow \text{Vector meson} + MM, \quad (6)$$

where the charged particles emitted in backward hemi-sphere are measured. We attempt to use ionization information to identify slow particles.

The particle correlations for positive and negative tracks are also investigated.

(3). <u>Exclusive reactions</u>

We measure all two, four and six prong events and attempt

to measure the cross sections for the 4-C reactions:

$$\bar{p}p \longrightarrow \bar{p}p \quad , \qquad (7)$$

$$\longrightarrow \bar{p}p\pi^+\pi^- \quad , \qquad (8)$$

$$\longrightarrow \bar{p}p\pi^+\pi^-\pi^+\pi^- , \qquad (9)$$

The particular interests in these reactions are:

a) elastic scattering,

b) diffraction process, and

c) $\Delta^{++}(\overline{\Delta^{++}})$ production.

Study of elastic scattering is important to separate the inelastic from elastic scattering in the two prong events.

(4). <u>K^- physics</u>

The K^-p physics at high energy region is quite interesting. For a case when the enriched $\bar{p}$ beam device is not used, we are able to study K^-p interactions at 100 GeV/c in the very similar way as for $\bar{p}p$ physics. We study the multiplicity, inclusive reactions for neutral particle, and exclusive reactions with a particular emphasis on the K^-p diffractive processes.

III. Experiment

Schematic view of experimental arrangement is shown in Fig. 1. We require the following experimental set up.

a) Negative charged beam of 100 GeV/c ($\pm$ 1%) produced from the bombardment of 400 GeV/c primary proton (or the highest energy practically available) on the external target. If the enriched particle beam device suggested by Neale[1] is available at the time for this run, we prefer to use this device. The use of this device is expected to improve $\bar{p}$ flux in the beam by a factor of about 2.

b) The mass tagging identification using a set of gas Cerenkov counters for $\bar{p}$ and K^- with the array of wire chambers in front of the chamber to determine the beam position.

c). Beam kicker magnet. The maximum beam track number is set at about 7.

The reliable mass tagging is most essential for this experiment. The miss tagging rate for $\bar{p}$ is hoped to be less than 2%.

Using the latest beam survey measurement[2], we estimate the fractions of $\bar{p}$ and K^- particles in the beam at the chamber. The fractions for $\bar{p}$ and K^- at 100 GeV/c are respectively 0.035 and 0.025 for the primary proton momentum of 400 GeV/c. Without using the enriched $\bar{p}$ beam device, we expect 11,000 $\bar{p}p$ and 3,800

K^-p interactions from the 100,000 pictures assuming a fiducial volume of 300cm and 7 beam tracks per picture. If the device is used, the $\bar{p}p$ interactions increase by a factor of about two. Table I shows the fractions, the wanted particle numbers and the expected total interactions for the above two cases. Table II shows the expected topological cross sections and numbers of events for $\bar{p}p$ and K^-p interactions.

We send three persons for about one month for the period of this run. If it is advisable for us to participate with the preparation of this run, we consider to send one person for a few months before the run starts.

IV. Analysis

Ten versatile image plane digitizers with variable magnifications of 18 and 40 will be mainly used for both scanning and measuring. These digitizers have been used for the analysis of ANL 12' BC pictures. Other six conventional image plane digitizers will be also used for measurements. About 8 months is estimated to complete the measurements including the remeasurements and the data analysis.

Program, TVGP-SQUAW, for the ANL 12' BC has been in operation at Tohoku University. This will be modified to the FNAL 15' BC. If the FNAL program HYDRA is available at the time of the data analysis, we will also attempt to use the program.

The following computers are used for analysis;

a. TOSBAC 3400 model 51 (PDP 10 equivalent), full time use for only Tohoku bubble chamber group.

b. NEAC 2200 model 700 (Tohoku University Computer Center, CDC 6600 equivalent).

Manpower for this data analysis in the Tohoku University group is;

1 Professor

2 Associate Professors

5 Research Associates

3 Technicians

4 Graduate Students

24 Scanners (8 full time equivalent)

REFERENCES

1) Talks by W. W. Neale; Special beam workshop for 15' BC at FNAL (Feb. 15, 1974)

   W. W. Neale; FNAL Report, FN-259, 220(June 24, '74)

2) J. Lach and S. Pruss: TM-285, 2254.000, Hadron Beams in the Neutrino Area; W. F. Baker et al., NAL-Pub-74/13-Exp 7100.104.

3) A. S. Carroll et al.; NAL-Pub-74/75-Exp 7100.104

   A. S. Carroll et al.; NAL-Pub-74/76-Exp 7100.104

4) 15 GeV/c $\bar{p}p$

   F. T. Dao et al.; Int. Conf. on Elementary particles, Aix-en-Provence(1973); NAL-Pub-73/80-Exp(1974), NAL-Pub-73/81-Exp(1974), Physics Letters 45B 513(1973).

   32 GeV/c $\bar{p}p$:

   G. A. Akopdjanov et al.; CERN/D. Ph. II/Phys. 74-4.

5) H. Kichimi: Ph.D Thesis (Tohoku Univ.), 1973

   T. Kitagaki et al.: 4th International Symposium on $\bar{N}N$ Interactions, Liblice (1974).

Table I. $\bar{p}$ and K^- fraction and number of wanted interactions

		(a) mass tagging system	(b)* mass tagging system with enriched beam device
Fraction of wanted beam particles at 15' BC	$\bar{p}$	0.035	0.074
	K^-	0.025	0.0
Wanted incident tracks for 100 K pix	$\bar{p}$	24.4 K	51.8 K
	K^-	17.8 K	———
No. of expected total interactions in 300 cm fiducial volume for 100 K pix	$\bar{p}$	11.1 K	23.6 K
	K^-	3.8 K	———

* The values in column (b) are calculated using the $\bar{p}$ fraction estimated by W. W. Neale (See Ref. (1)).

Table II. Expected topological cross sections and the event numbers

Prong No.	Expected* topological cross section	(a) mass tagging system		(b) mass tagging system with enriched beam device
		$\bar{p}p$	K^-p	$\bar{p}p$
2	12.4 mb	3300	1100	7000
4	8.5	2300	780	4800
6	8.1	2100	740	4600
8	6.3	1700	570	3500
10	4.0	1100	360	2200
12	1.7	460	160	1000
14	0.67	180	60	400
16	0.23	60	20	130
18	0.05	14	5	30
20	0.017	4	2	10
total	42.0 mb	11.1 K	3.8 K	23.6 K

* The expected topological cross section for $\bar{p}p$ interactions, σ_n, is calculated assuming that σ_n is proportional to that for pp interactions at 100 GeV/c (PRL 31, 1563, 1973).

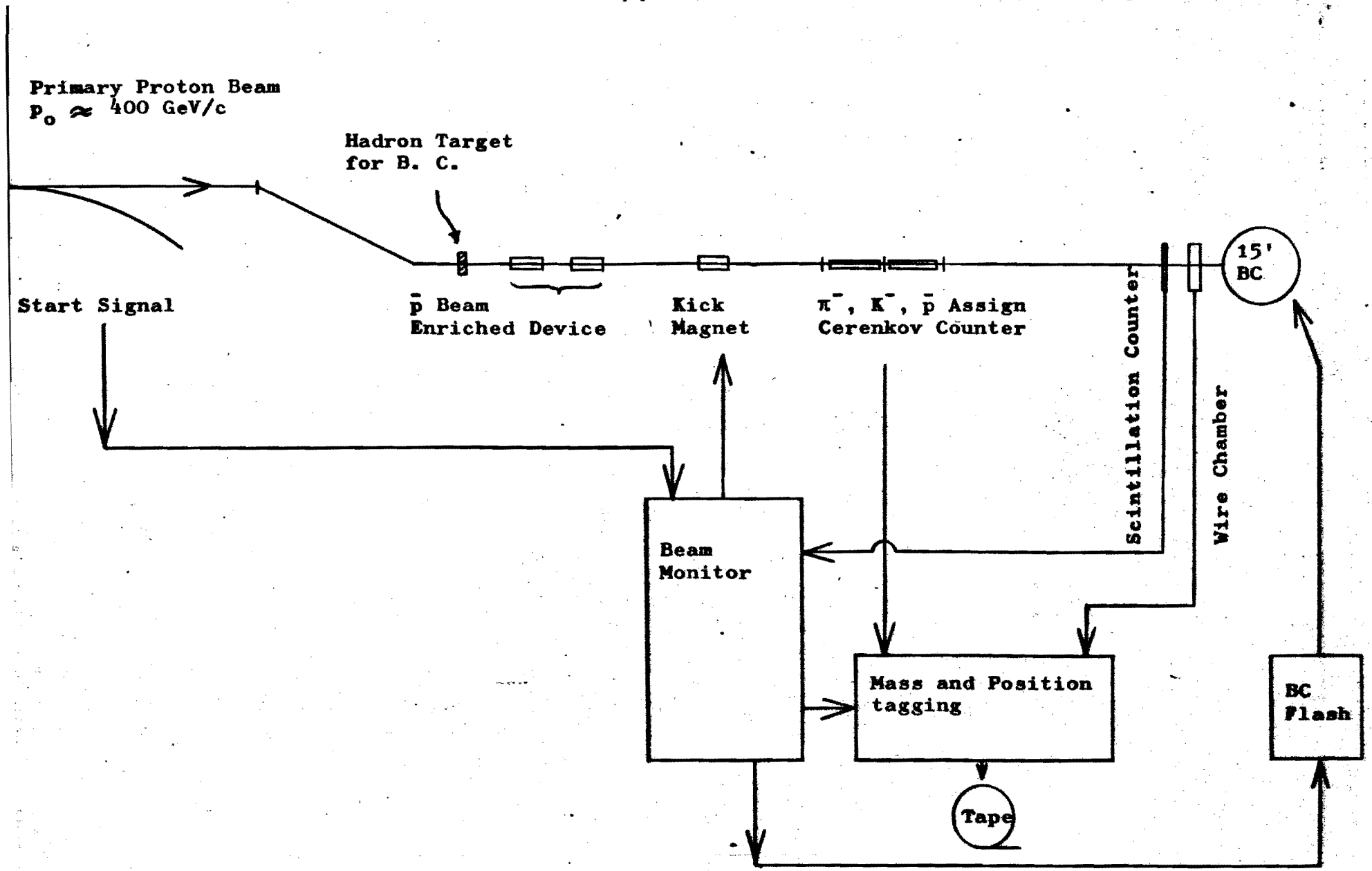

Fig. 1 Schematic diagram of experiment