FERMILAB-CONF-85-186-E
Submitted to the 1985 SLAC
Summer Institute on Particle Physics

High Mass Dilepton and Hadron Production at $\sqrt{s}$ = 38.8 and 27.4 GeV

Fermilab Experiment 605

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We present preliminary results from Fermilab Experiment 605. Using our open-aperture data we present single hadron ratios from deuterium in the range $5 < p_T < 8$ GeV/c as well as a dielectron mass spectrum with resolution sufficient to separate the three T peaks. We also present ten percent of our closed-aperture dimuon data which shows a good sensitivity to possible new narrow resonances. The relative production ratios of the lowest three T states are determined.

Fermilab Experiment 605 was proposed in 1978 as primarily a dilepton resonance search. The intent was to make a significant improvement in sensitivity over an earlier experiment[1] which discovered the T family. The mass resolution in the earlier experiment ($\sigma_m/m = 0.02$) was dominated by multiple scattering in the beryllium absorber which was used to attenuate hadrons in the accepted aperture and thus to allow high luminosity dimuon measurements.

Figure 1 illustrates our initial approach. We attempted to remove the absorber completely, allowing our detectors to hide behind the primary beam dump from our luminous target. High transverse momentum (p_T) particles of interest were bent around the dump toward our detectors. Unwanted low p_T charged particles were swept away by the SM12 magnet (Fig. 2). Neutral particles originating in the target could not exit this magnet directly.

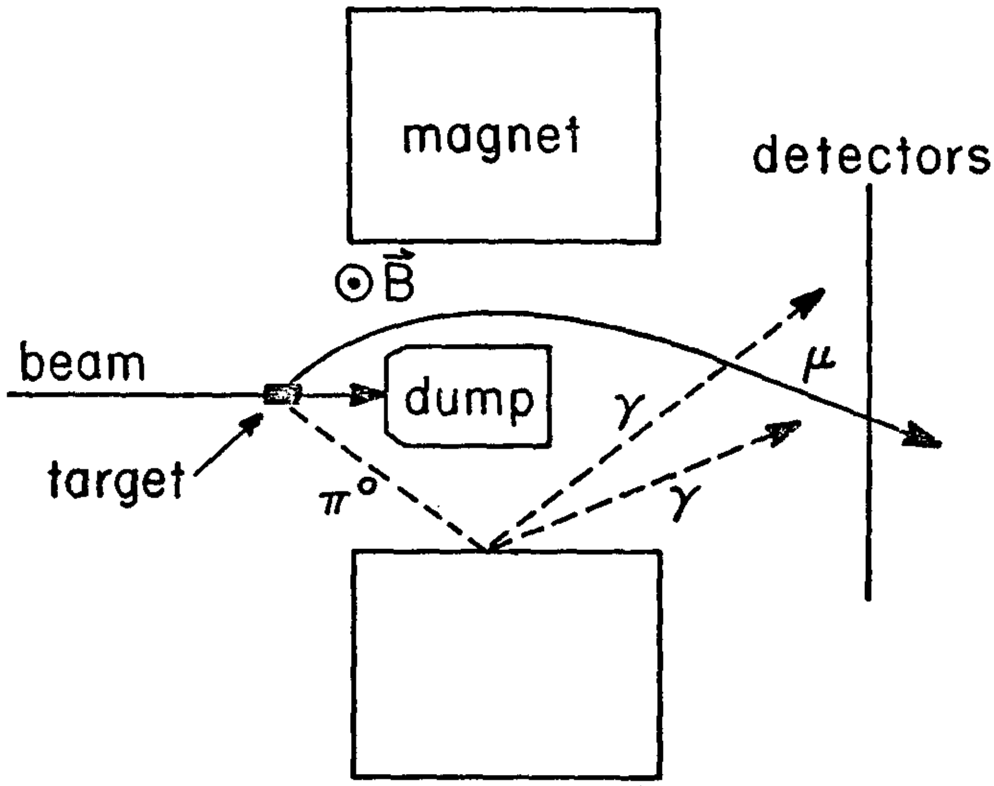

Figure 1. Schematic diagram of our open-aperture configuration (not to scale).

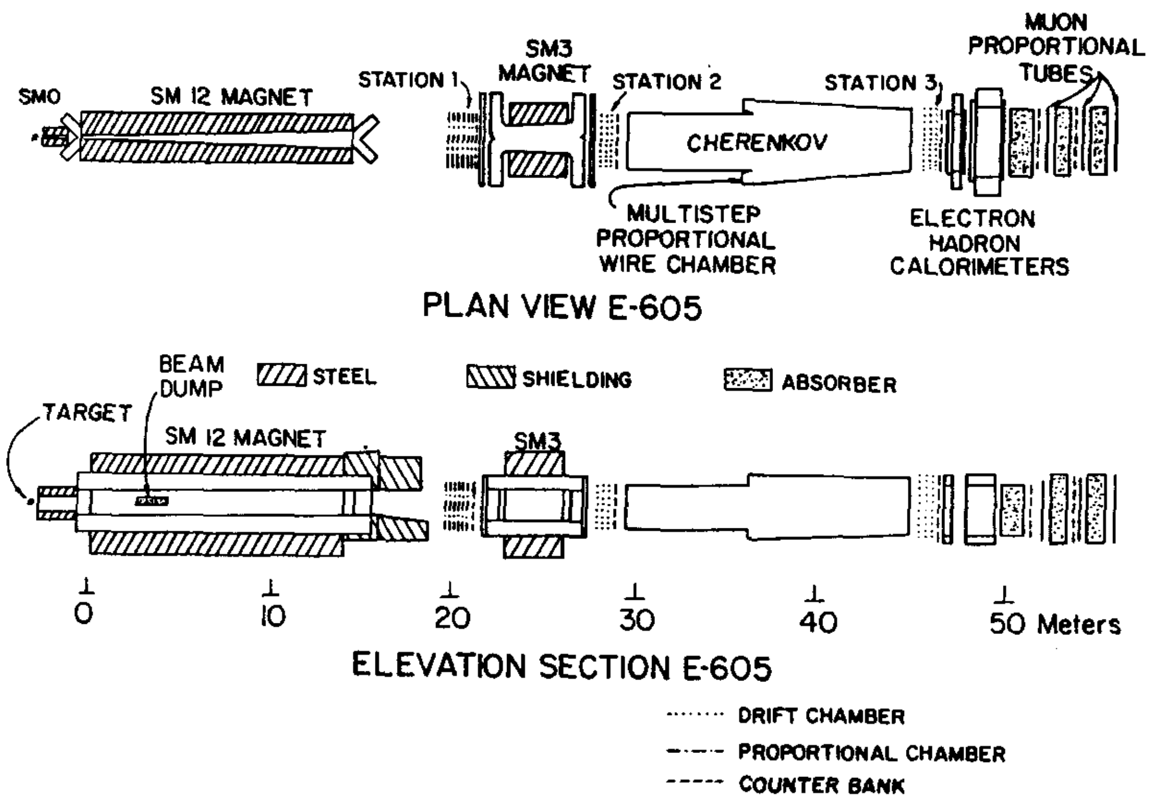

Figure 2. Layout of the apparatus

However, as Fig. 1 indicates, indirect neutrals were a problem. Our dominant background was due to low energy photons, presumably the products of π^o showers. Low energy neutrons produced in the dump were not a serious background.

It was recognized that open-aperture running, in addition to providing excellent mass resolution would allow simultaneous dielectron and hadron measurements in addition to dimuon measurements. Consequently we built a spectrometer (Fig. 2) equipped with complete particle identification. Hadron identification was carried out by a ring-imaging Cherenkov counter.[2] Our photon background (Fig. 1) limited our open-aperture luminosity to about $10^{35}cm^{-2}s^{-1}$ (with an aperture at high p_T of 0.5 center-of-momentum steradians). This luminosity was about a factor of 30 less than the closed-aperture luminosity discussed below.

In Table 1 we summarize our data recorded during the period 1982-1985. One paper[3] has recently been published showing that our 1982 data give support to the idea that constituent multiple scattering causes the A dependence of hadron production observed at high p_T. Our intent here is to display the scope of the remaining data and to present some preliminary results. Forthcoming theses[4] and future publications will present relevant experimental details.

Table 1. Data Recorded

integrated luminosity/nucleon (10^{39} cm^{-2})

target:	Be	Cu	W	LH_2	LD_2	$\sqrt{s}$ (GeV)	aperture
1982	0.2	0.3	0.3			27.4	open
1984	1.5	2.2	3.5	0.7	2.6	27.4	open
	12.9		2.2	0.8		38.8	open
1985		2800.				38.8	closed

In Figs. 3-6 we plot particle ratios from deuterium at $\sqrt{s}$ = 27.4 GeV in comparison to earlier results[5] from a Chicago-Princeton (CP) collaboration. (Our measurements cover the range $70° \lesssim \theta^* \lesssim 95°$ in center-of-momentum production angle. The CP measurements are at $\theta^* \approx 96°$). Efforts are currently underway to obtain predictions for these ratios using the LUND fragmentation model.[6] Here we simply note that the K^+/π^+ ratio is a fairly direct measure of the relative probability P(s)/P(u) of picking up a strange quark (compared to a u quark) during the fragmentation process. The value observed[7] for this relative probability in e^+e^- annihilation is 0.3, lower than the values we observe. Similar problems have been noted by two ISR experiments[8,9] (at lower values of $x_T = 2p_T/\sqrt{s}$).

The p/π^+ and $\bar{p}/\pi^-$ ratios provide information on the probability of picking up a diquark during the fragmentation process. Again, disagreements[10] with e^+e^- measurements have been found in hadronic production and our data should help illuminate the issues. We note that our data show good agreement with the CP data in the region of overlap except for the $\bar{p}/\pi^-$ ratio which appears to flatten out above p_T = 5 GeV/c in our data.

In Fig. 7 we show the e^+e^- mass spectrum observed in proton-beryllium collisions at $\sqrt{s}$ = 38.8 GeV. Efforts are underway to improve the mass resolution, but its present value ($\sigma_m \simeq$ 50 MeV) is sufficient to resolve the three Υ peaks. These measurements are used to check u-e universality below.

In 1985 we have added a 48 inch thick lead absorber (Fig. 8)

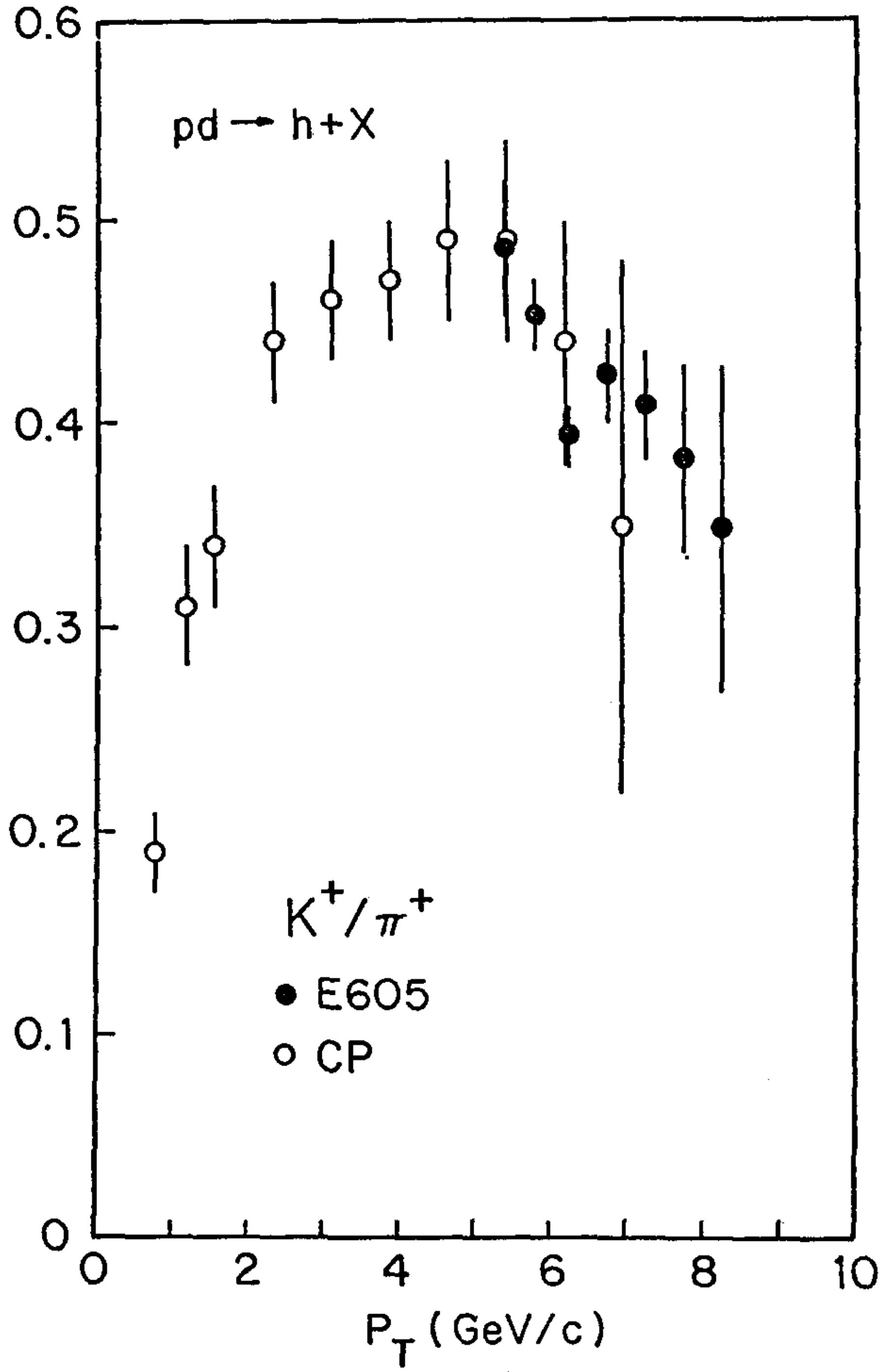

Figure 3. The ratio of K^+ to π^+ produced from deuterium at $\sqrt{s}$ = 27.4 GeV.

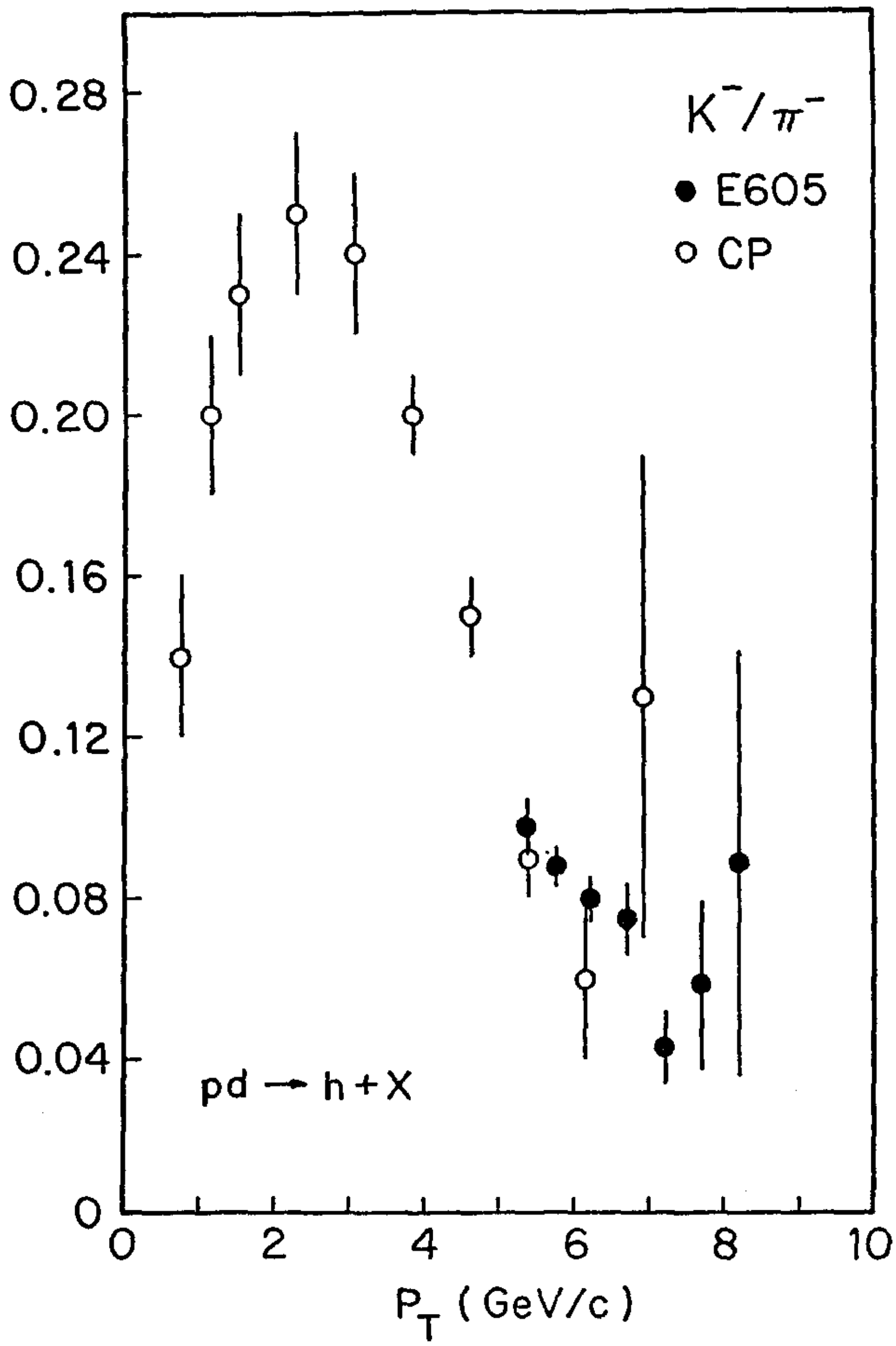

Figure 4. The ratio of K^- to π^- produced from deuterium at $\sqrt{s}$ = 27.4 GeV.

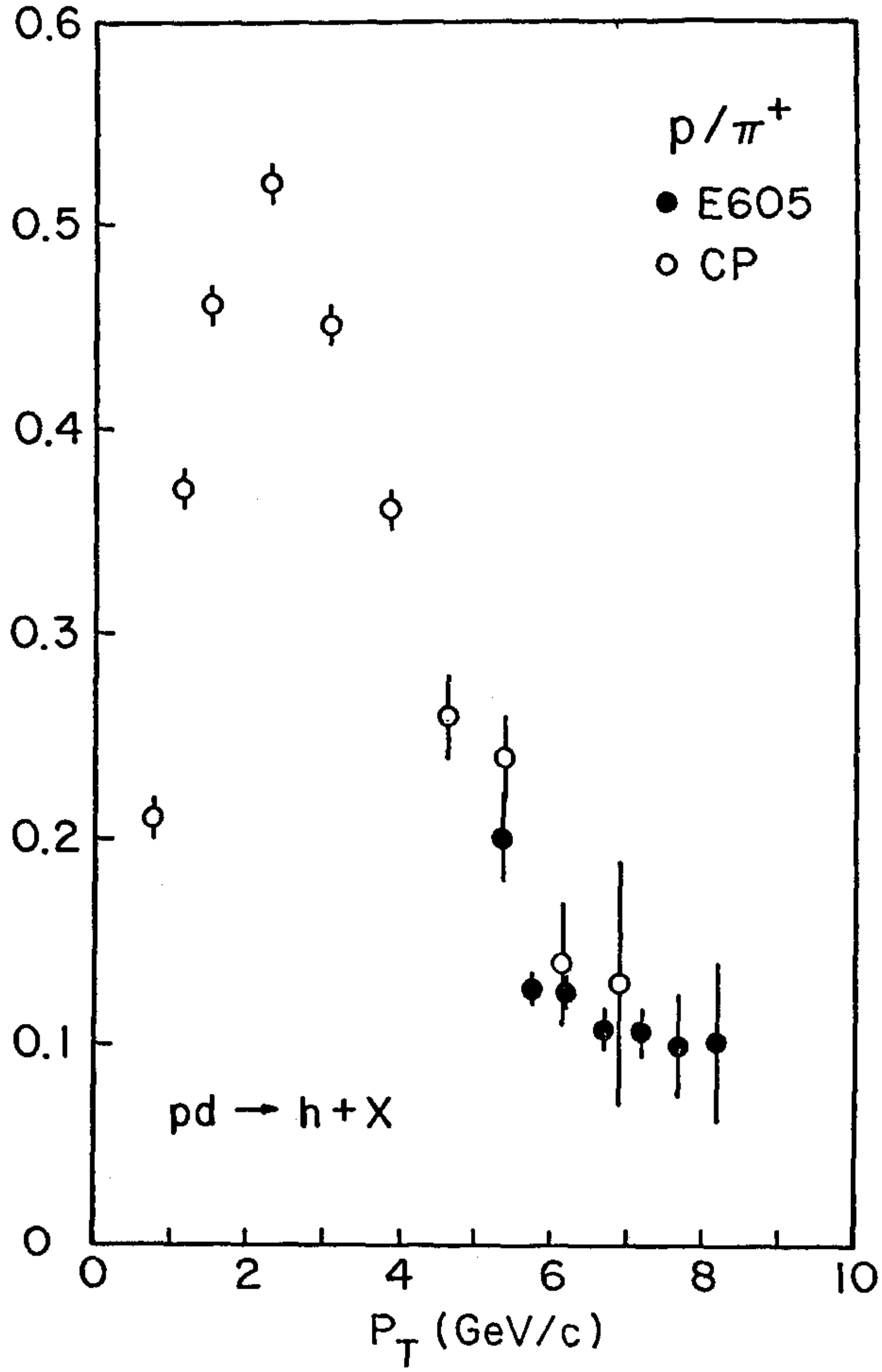

Figure 5. The ratio of p to π^+ produced from deuterium at $\sqrt{s}$ = 27.4 GeV.

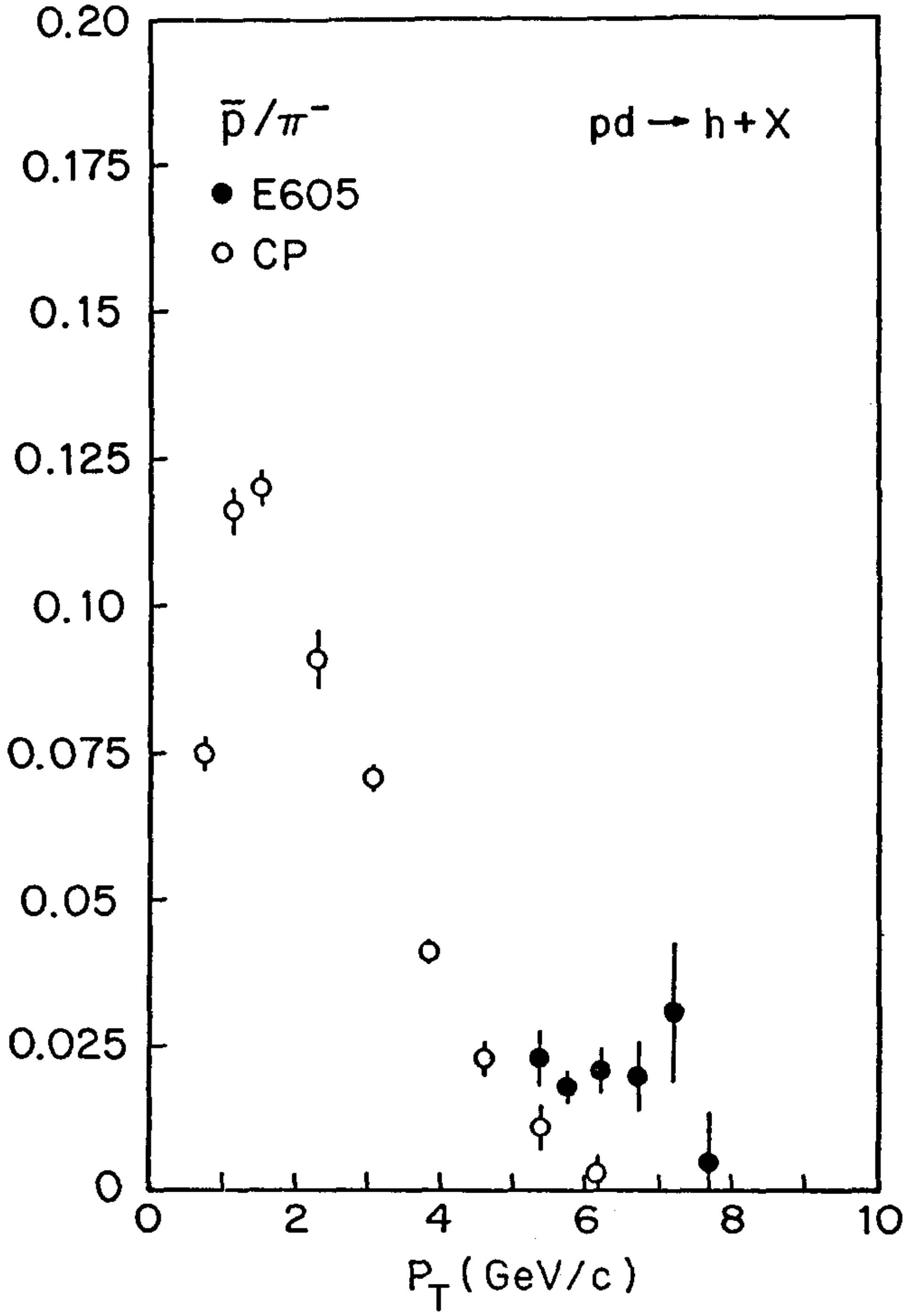

Figure 6. The ratio of $\bar{p}$ to π^- produced from deuterium at $\sqrt{s}$ = 27.4 GeV.

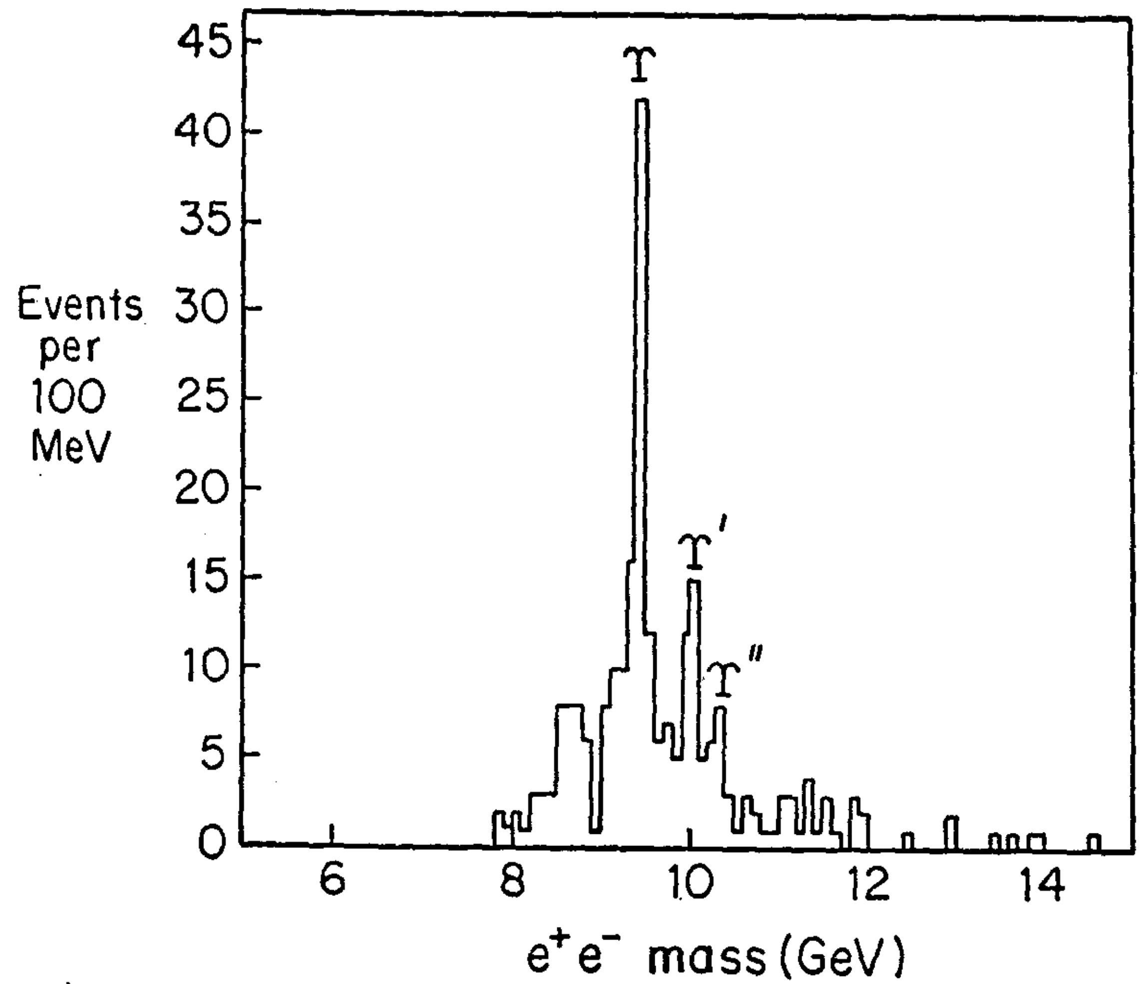

Figure 7. The e^+e^- mass spectrum observed in proton-beryllium collisions at $\sqrt{s}$ = 38.8 GeV.

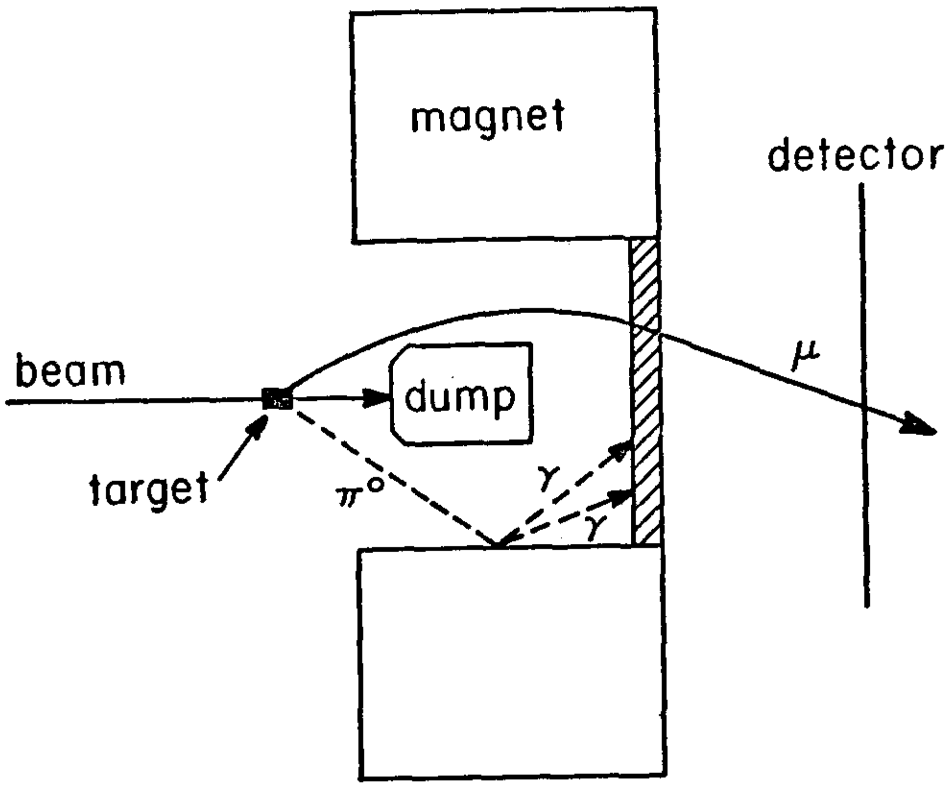

Figure 8. Schematic diagram of our closed-aperture configuration (not to scale).

at the downstream end of the SM12 magnet in order to eliminate our photon background. This absorber allowed us to increase our luminosity by a factor 30. Improvements in the reliability of our beam also helped to achieve the improvement in integrated luminosity for 1985 noted in Table 1. We retain good mass resolution in the presence of this relatively thin absorber by using our SM3 magnet to measure momenta. Production angles must still be measured by tracking particles through SM12. In Table 2 we show expected contributions to our mass resolution in our closed-aperture configuration.

In Fig. 9 we show 10% of our closed-aperture dimuon data. Our presently observed mass resolution $\sigma_m = 34$ MeV is about a factor of two worse than expected (Table 2). Present attempts to improve our resolution are focusing on a better understanding of our magnetic fields. However, good sensitivity to possible new narrow resonances is already evident in Fig. 9.

In Table 3 we show our preliminary values for the relative production ratios among the Υ states. We observe good agreement among our dielectron and dimuon ratios as well as the dimuon ratios from reference 1.

We gratefully acknowledge the dedicated assistance of many support staff from Fermilab and our home institutions. We thank the organizers of the SLAC Summer Institute for the opportunity to participate in this friendly, productive conference.

Table 2. Expected Contributions to Closed-Aperture Mass Resolution

Contribution	σ (MeV)
target size	6.3
dE/dx fluctuations	3.0
multiple scattering	
in target	9.4
in lead absorber	7.8
in detectors	6.5
in helium	3.7
chamber resolution	7.0
other	4.6
TOTAL	18.

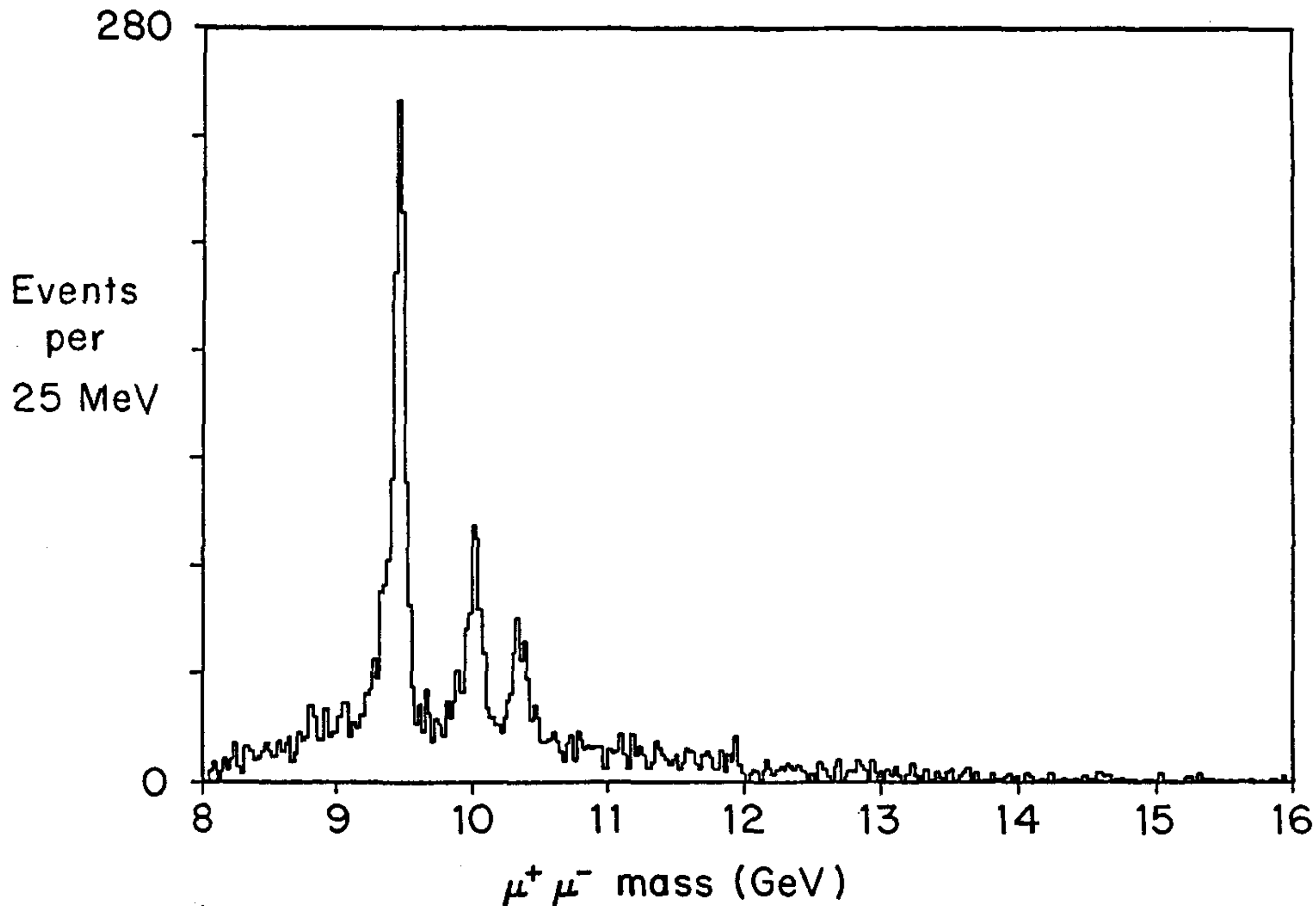

Figure 9. The $\mu^+ \mu^-$ mass spectrum observed in proton-copper collisions at $\sqrt{s} = 38.8$ GeV.

Table 3. Relative Production Ratios Among Υ States

Channel	Υ'/Υ	Υ''/Υ
dielectrons at $\sqrt{s}$ = 38.8 GeV	0.33±0.10	0.13±0.05
dimuons at $\sqrt{s}$ = 38.8 GeV	0.35±0.02	0.14±0.01
dimuons at $\sqrt{s}$ = 27.4 GeV (reference 1)	0.31±0.03	0.15±0.02

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