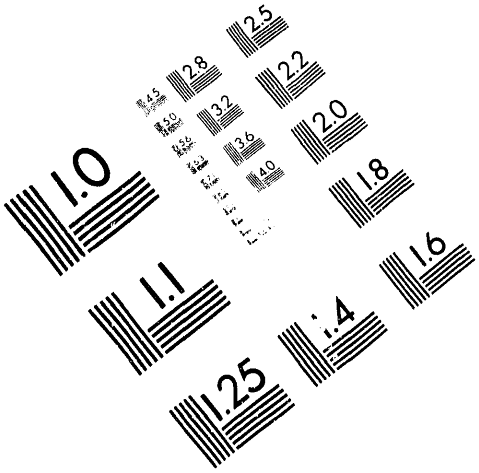

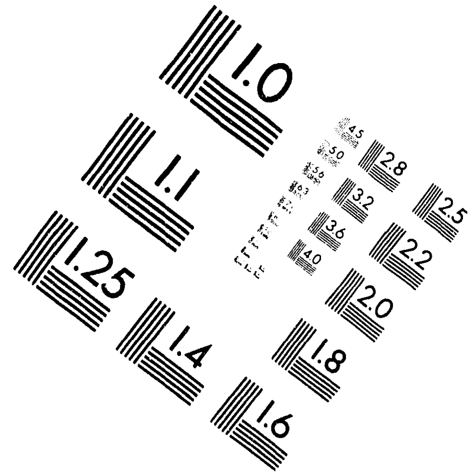

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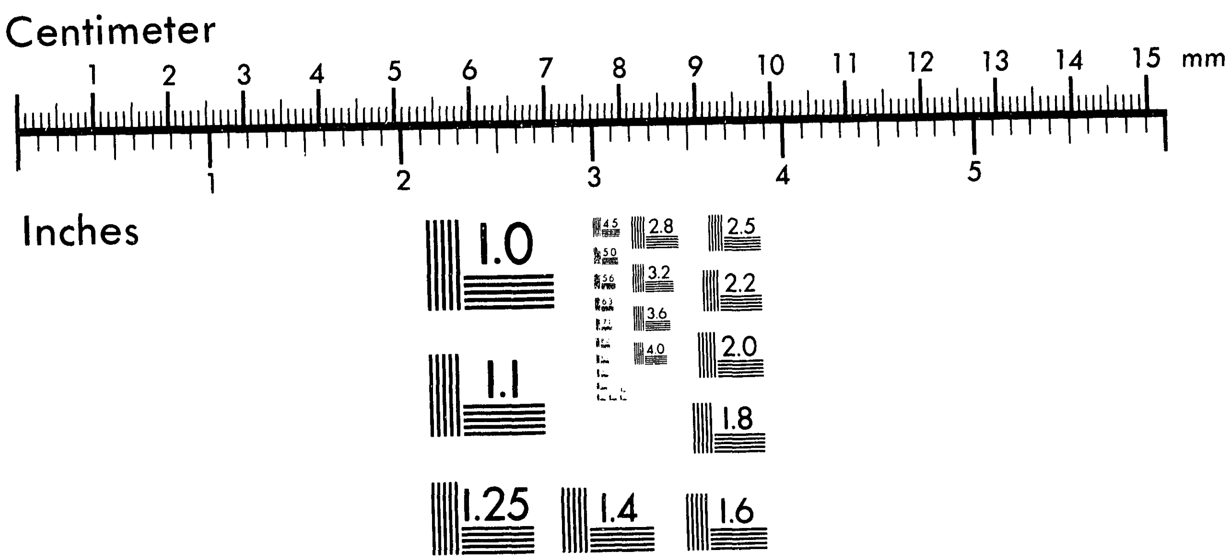

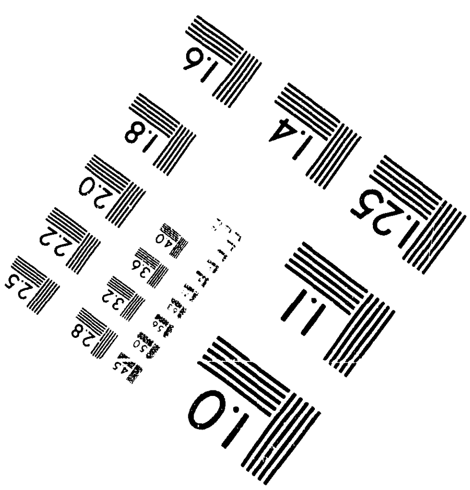

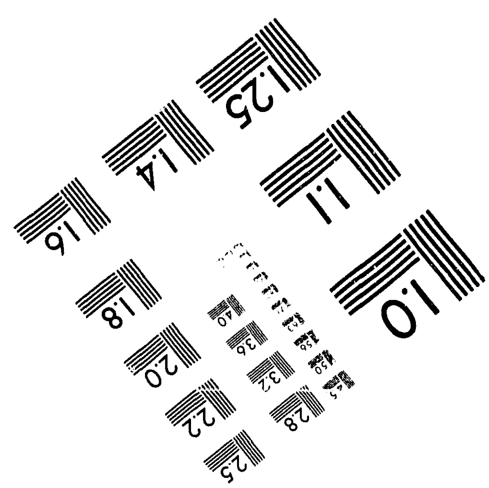

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Abstract

Experiment 789 is a fixed-target experiment at Fermilab designed to study low-multiplicity decays of charm and beauty. During the 1991 run, E789 collected $\approx 10^9$ events using an 800 GeV proton beam incident upon gold and beryllium targets. Analyses of these data include searches for $b \rightarrow J/\psi + X$ decays and A-dependence measurements of neutral D meson production. Preliminary results from the 1991 run are presented in this paper.

1 Introduction

Experiment 789 at Fermilab was designed to measure low-multiplicity decays of B and D mesons produced in a high-rate fixed-target environment. The existing E605/E772 spectrometer, used in previous experiments to detect hadron and lepton pairs, was significantly upgraded for E789 (Figure 1). In particular, a silicon microstrip vertex spectrometer and a vertex trigger processor were installed. The main physics goals of experiment 789 are 1) to measure $\sigma(b\bar{b})$ at 800 GeV via the detection of $b \rightarrow J/\psi + X$ inclusive decays, 2) to set branching-ratio limits for charmless dihadron decay modes of B mesons (such as $B \rightarrow \pi^+\pi^-, K\pi, K^+K^-, p\bar{p}$), and 3) measure the A-dependence of neutral D meson production. Preliminary results from analysis of data obtained by E789 during the 1991 fixed-target run are presented in this paper.

2 Summary of the 1991 Run

During the 1991 run, an 800 GeV proton beam was incident upon thin wire targets, 0.1 mm to 0.2 mm high and 0.8 mm to 3 mm thick, constructed of gold or beryllium. Sixteen silicon microstrip detectors were positioned 40 - 115 cm downstream of the target and covered the angular range 20 - 60 mr above and below the beam axis. The silicon detectors, type 'B' from Micron Semiconductor, had 5×5 cm^2 area, 300 μm thickness, and 50 μm pitch. They were oriented to measure either the Y (vertical) or the U,V coordinates ($\pm 5°$ stereo angles). Signals from 8,544 silicon strips were individually read out via Fermilab 128-channel amplifier cards [1] and LBL discriminators [2] synchronized to the accelerator RF. The discriminated signals were transmitted through $\approx$ 400 ns of multiconductor cable to coincidence registers. A vertex processor, which found tracks in the silicon detectors and selected events with decay vertices downstream of the target. was also implemented [3]. The thin target localized the primary interaction vertex and greatly simplified the design of the vertex processor which only needed to determine the position of the decay vertex.

The magnetic field of the SM12 magnet was varied in order to optimize the acceptance for either charm or beauty decays. For the charm data, the current of the SM12 magnet was set

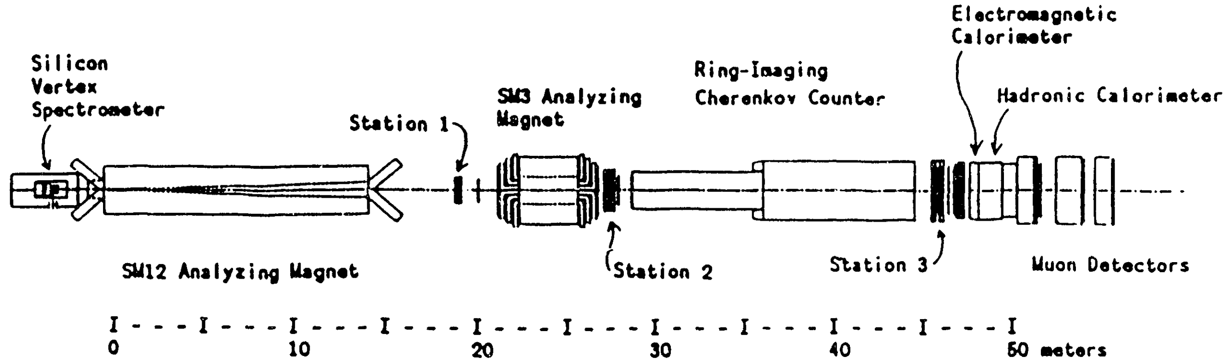

Figure 1: E789 apparatus (plan view).

at 1000 and 900 amps. Data were taken at 1×10^{10} protons per spill on 1.5 mm thick targets constructed of gold and beryllium in sequential, but separate, running periods. The charm running also served to check the performance of the silicon microstrip detectors and the vertex trigger processor. Approximately 380 million events were written onto 240 8-mm tapes during the charm running period.

For the beauty data, the current of the SM12 magnet was set to 1500 amps. In this configuration, the spectrometer had acceptance for both $B \rightarrow J/\psi + X$ and $B \rightarrow h^+h^-$ decays. Data were taken at 5×10^{10} protons per spill on a 3 mm thick gold target giving a 50 MHz interaction rate. The vertex trigger processor was not used for collecting beauty data since it gave a poor rejection factor when the multiplicity of tracks passing through the silicon detectors was large. Approximately 860 million events were written onto 700 8-mm tapes during the beauty running period.

3 Preliminary Results from E789

Figure 2 shows the dihadron invariant mass spectra obtained from an analysis of the charm data sample. The various target materials and SM12 magnetic field currents used to obtain the data are indicated in the caption. To reject the dihadron background originating from the target, we cut on the variable τ/σ where τ is the proper lifetime of the dihadron and σ is the calculated error on τ. For the data shown in Figure 2 we require $\tau/\sigma > 6$.

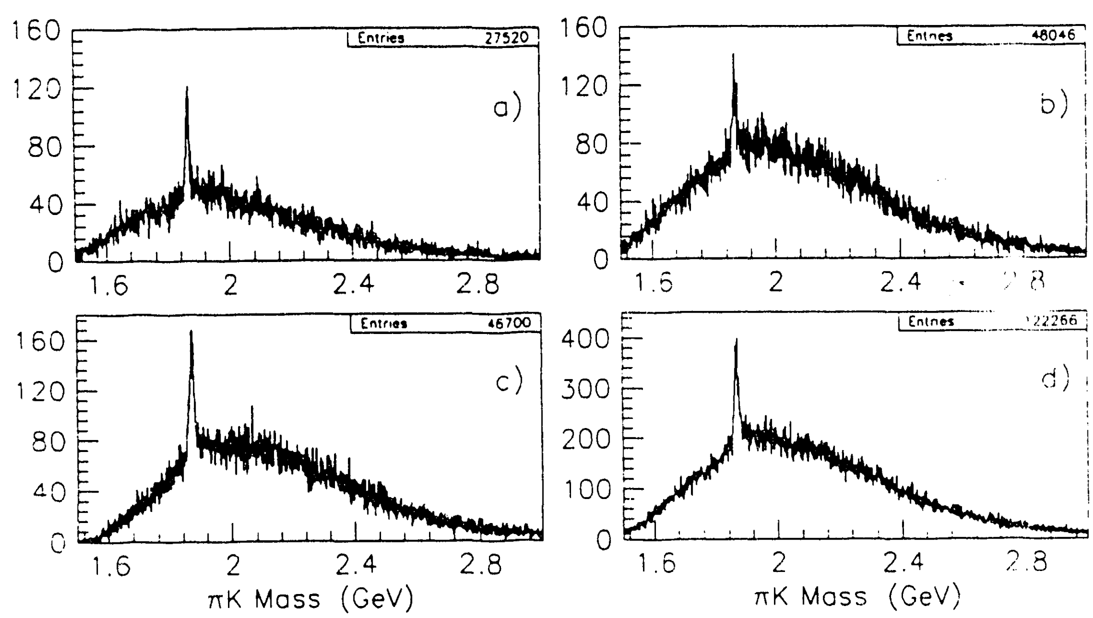

Figure 2: Dihadron invariant mass spectra: a) Be target, 900 Amps, b) Au target, 900 Amps, c) Au target, 1000 Amps, d) Entire data sample.

Cherenkov π/K particle identification has not been used for the plots shown in Figure 2. All of the plots shown in Figure 2 contain two entries per event, one for the π^+K^- and the other for the $\pi^- K^+$ particle assignments. Pion and kaon masses are assumed for each track and both invariant mass combinations are entries in the histograms. The correct particle assignment gives a sharp peak, corresponding to either the D^0 or $\overline{D^0}$ with a width $\sigma \approx 6$ MeV. The wrong particle assignment gives a much broader peak with a width $\sigma \approx 50$ MeV. The D^0 and $\overline{D^0}$ yields are determined by performing a "double-constrained" fit which takes into account the wrong mass combination background.

Figure 3 shows the J/ψ A-dependence as a function of x_F. The high x_F data were obtained using the E789 beam dump [4] and the low x_F data were obtained during the 1990 test run. The data obtained by E772 have previously been described [5]. Preliminary analysis of the beryllium and gold data described above results in $\alpha = 0.90 \pm 0.04$ for the A-dependence of neutral D meson production. This value is indicated in Figure 3 and is approximately equal to that for the J/ψ.

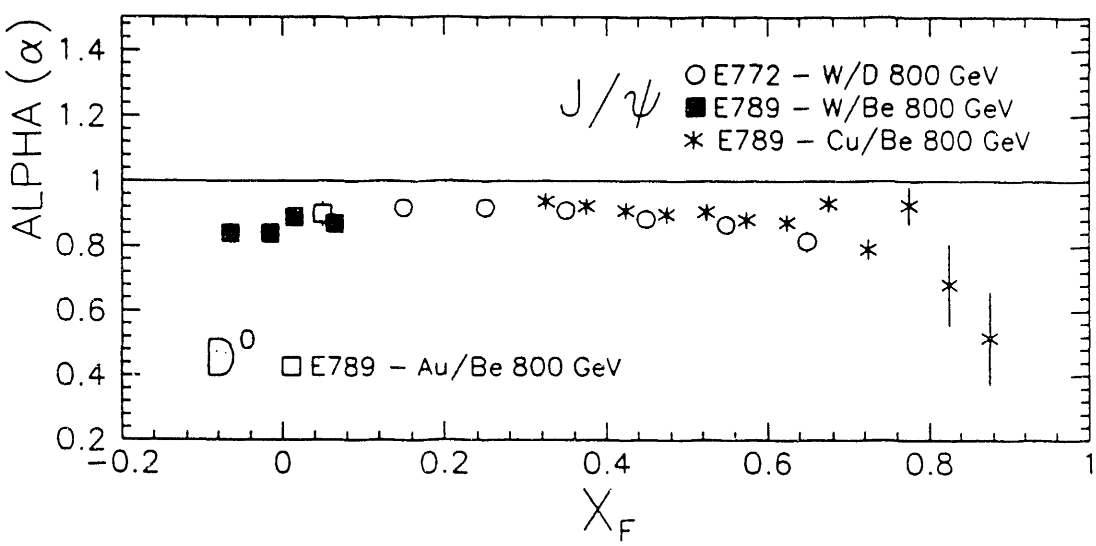

Figure 3: J/ψ A-dependence as a function of x_F. The neutral D meson value of α, obtained using the E789 charm data described in this paper, is also indicated in the figure.

Figure 4 shows the variation in the dihadron mass spectra, for the charm data sample, as a function of our vertex cut. Using our loosest vertex cut $\tau/\sigma > 3.9$, the data contains almost 3700 neutral D mesons. Preliminary analysis of the Be data results in an inclusive production cross section $\sigma_{pN}(D^0/\overline{D^0})(\alpha = 0.9) = (32 \pm 7)\mu$b which is consistent with previous measurements reported by E653 and E743 [6]. Systematic uncertainties for the charm results are being studied.

The dimuon invariant mass spectrum from a preliminary analysis of $\approx 50\%$ of the beauty data is shown in Figure 5a. For events shown in Figure 5a, good silicon tracks are required and vertex cuts have not yet been imposed. Approximately 39,000 J/ψ and 700 ψ' events are observed. To search for $b \rightarrow J/\psi + X$ events contained in this event sample, impact parameter and $Z_{\mathbf{vertex}}$ cuts are applied. Figure 5b shows the dimuon invariant mass spectrum for events in which both muon tracks have target impact parameters greater than 150μm and the event has

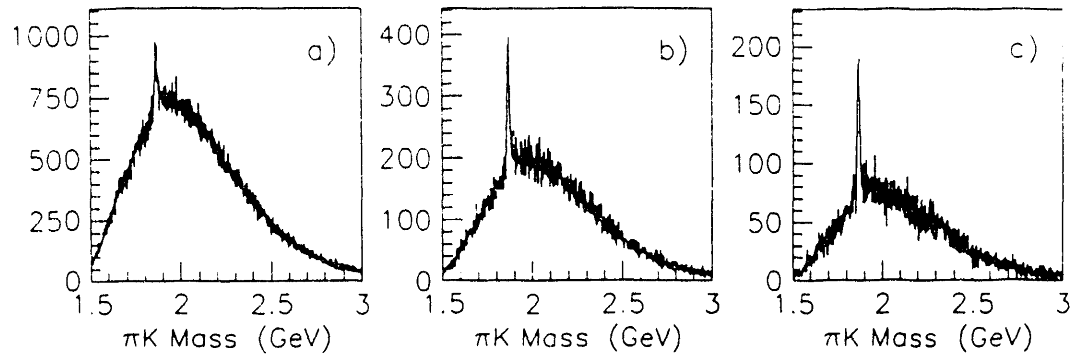

Figure 4: Dihadron invariant mass spectra as a function of our vertex cut: a) $\tau/\sigma > 3.9$, b) $\tau/\sigma > 6$, c) $\tau/\sigma > 7.9$.

a decay vertex at least 7 mm downstream of the target (7 mm < Z_{vertex} < 5 cm). Twenty-two events are seen in the J/ψ peak and these events are candidates for $b \rightarrow J/\psi + X$ decays. To estimate the background which might be caused by silicon tracking errors or from the tails of the target distribution, we also select events with decay vertices upstream of the target. Figure 5c shows the dimuon invariant mass for events with -5 cm < Z_{vertex} < -7 mm. This figure contains no events near the J/ψ region.

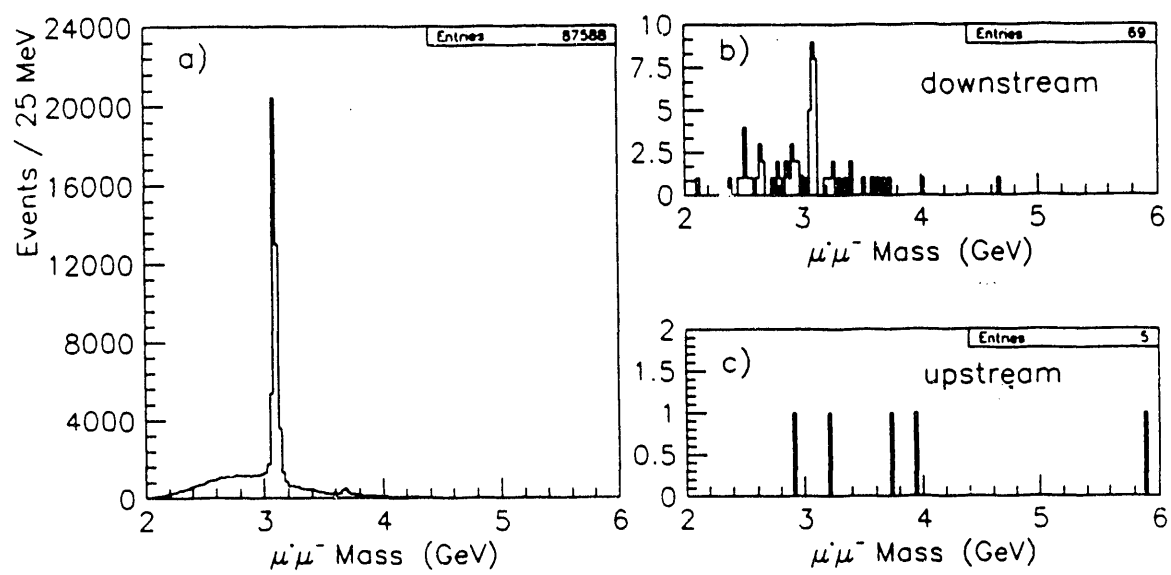

Figure 5: Dimuon invariant mass spectra.

Figure 6 shows the dimuon invariant mass spectrum for events with either upstream or downstream vertices. For each pair of plots, symmetric Z_{vertex} and impact parameter cuts are applied. The target Z_{vertex} distribution has upstream and downstream tails which can dominate with a loose set of vertex cuts (Figures 6a,b). As tighter cuts are applied, the tails are suppressed as is shown by the reduction in the number of events with upstream vertices (Figures 6c,e). Semileptonic decays of $b\bar{b}$ pairs give the J/ψ background seen in Figure 6f.

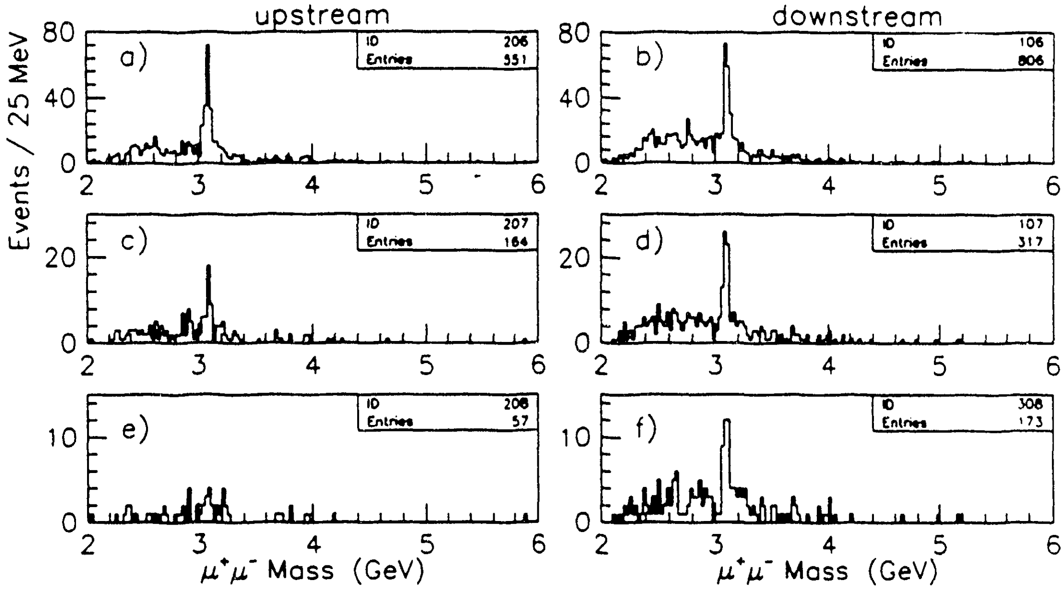

Figure 6: Dimuon invariant mass spectra for events with upstream and downstream vertices. Z_{vertex} a) < -3 mm, b) > 3 mm, c) < -4 mm, d) > 4 mm, e) < -5 mm, f) > 5 mm.

4 Summary

Experiment 789 explores the feasibility of studying beauty and charm physics in a high-rate fixed-target environment. Over 3000 neutral $D \to \pi K$ events have been observed from gold and beryllium targets. A preliminary analysis of the neutral D meson A-dependence gives $\alpha = 0.90 \pm 0.04$ approximately equal to that for the J/ψ as reported by experiment E772 [5]. A preliminary analysis of $\approx 50\%$ the dimuon beauty data yields 39,000 J/ψ events. Twenty-two of these J/ψ events have decay vertices more than 7 mm downstream of the target and are candidates for $b \to J/\psi + X$ decays. Analysis is underway to determine $\sigma(b\bar{b})$ at 800 GeV which will be compared to the theoretical predictions by Mangano e. *al* [7]. Analysis of the dihadron beauty data and $J/\psi \to e^+e^-$ data is in progress.

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