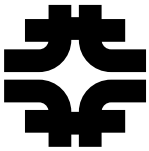

Fermi National Accelerator Laboratory

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A Measurement of non-EM Backgrounds in the Fermilab Wide Band e^+e^- Beam

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1 Abstract

Using an electromagnetic (EM) calorimeter and lead absorbers in the beam, the non-EM backgrounds (muons and hadrons) in the nominal 300 GeV e^- and e^+ beams were measured to be approximately 6 % and 37 % respectively.

2 Introduction

The Fermilab Wide Band Neutral Beam [1], [2] produces and simultaneously transports both e^- and e^+ beams [3] to a lead radiator where a photon beam is produced by bremsstrahlung.

Initially, the primary protons strike a target. The uninteracted protons and produced charged particles are swept away producing a zero degree neutral beam, consisting of γ (from decay of π^0), neutrons, Λ^0 (and $\overline{\Lambda^0}$), and K_L^0.

In a lead converter, the γ are converted into e^+e^- pairs which are collected by the beamline optics system and transported to the radiator.

At a moderate fraction of the incident proton momentum, typically $x \approx$ 0.30-0.45, charged particle backgrounds are produced mainly by interactions of neutrons in the convertor and decays of Λ^0 and K_L^0. Neutrons are pro-

duced in the primary proton interactions in the target as "leading particles" (triangular momentum spectrum peaked at $x \approx 0.8$) and protons produced in secondary neutron interactions in the photon converter are also "leading particles". Λ^0 produced in the primary interaction [4] have a fairly hard Feynman-x distribution, $x\ dN/dx$, which peaks at about $x = 0.5$ at zero degrees. Since the proton from the Λ decay takes most of the momenta, between 76-94 %, this, too, has the potential to produce hadronic backgrounds at moderate x. Note that for production of $\overline{\Lambda^0}$ at zero degrees, $x\ dN/dx \approx e^{-12x}$ indicating much lower typical $\overline{\Lambda^0}$ momenta, and an insignificant source of background for these e^+e^- momenta. The non-EM backgrounds from K_L^0 decay are symmetric with respect to beam polarity.

Early observation in the 1990 run with the "double-band" mode indicated a much larger non-EM background in the e^+ than in the e^- beam. This was mainly attributed to protons from the decays of the leading Λ^0. An additional dipole magnet was placed downstream of the beam stop/collimator in the target station and upstream of the lead converter. This magnet was briefly tested during the 1991 run (running in series with the beam collection quadrupole magnets) and indicated that the non-EM background could be reduced in this manner. For the 1996-97 E831/FOCUS run, this extra dipole was outfitted with its own power supply to provide additional sweeping by running at higher currents than the quadrupoles.

3 Technique

This analysis is based on the assumption that the shape of the response of the hadronic component of the non-EM backgrounds in an EM calorimeter placed at the end of the Wide Band beamline (at the end of the E831/FOCUS experiment) would be independent of the insertion of lead plates ($e^{\pm}$ absorbers, thickness = 2 inches) at the intermediate momentum dispersed focus of the beamline. Radiation and showering in these lead plates, of course, completely prevented the e^+ or e^- from making it through the second stage of the beam and reaching the calorimeter. Typical calorimeter response to these non-EM background beams is presented in Figure 1, showing a peak at $E_{BGM}/TGMOM = 0$ for muons and non-interacting hadrons, followed by a shoulder extending to $E_{BGM}/TGMOM \approx 0.8$ for hadrons interacting in the calorimeter.

The EM calorimeter (called BGM) was a novel design [5] based on alternating lead plates and fused silica optical cerenkov radiator plates (both 1/4" thick) read out via UVT lucite light collection system to a photomultiplier. The calorimeter was a total of 25 X_o deep to contain the EM shower. One can see from the peak at $E_{BGM}/TGMOM = 1$ in Figures 2. and 3. that the BGM resolution for electrons and positrons was $\sigma/\text{peak} \approx$ 2 % for the nominal 300 GeV beam (after deconvolution of the 2.2 % resolution for the incident beam momentum tagging).

4 Data

Data [6] were taken at the nominal 300 GeV e^+e^- beam settings (for 800 GeV primary protons), with stoppered-down collimator settings which reduced the beam rate to 3 % of the normal data rate. This was done to allow the e^+e^- beam to traverse the entire E831/FOCUS spectrometer, without damaging or rate-overloading the spectrometer, rather than being swept into their upstream beam stops after bremsstrahlung. This introduces a possible source of systematic error since the phase space for the normal data beam and the beam used in this study are different and therefore the relative backgrounds also might be different.

The trigger requirement was a coincidence of the TR2 counter array with the Tevatron RF signal indicating an incident charged beam particle which then initiated data readout. Events selected off-line were required to have a single reconstructed track in the beam momentum tagging spectrometer. There was no readout suppression of the ADC pedestal for the EM calorimeter. The data presented are raw ADC pulse height channels with pedestal subtracted, divided by the momentum measured in the beam tagging system. This gave the quantity $E_{BGM}/TGMOM$.

Figure 2. shows the $E_{BGM}/TGMOM$ distributions for the positive beam settings (beam stop inserted for negative beam arm) for the full beam (dashed histogram, e^+ absorber OUT) and for the beam with the lead absorber inserted (dotted histogram, e^+ absorber IN) for the positive particles. The dotted histogram (e^+ absorber IN) includes muons and hadrons, while the dashed histogram (e^+ absorber OUT) includes $\mu^+ + h^+ + e^+$. The dotted histogram for e^+ absorber IN data was normalized to optimize the fit (shown as solid histogram) to the e^+ absorber OUT histogram over the range 0.06

$\leq E_{BGM}/TGMOM \leq 0.50$ units. The region below 0.06 units is excluded from the fit since the μ^+ and h^+ background components could be affected relatively differently by the e^+ absorber. This allowed extrapolation of the hadronic background in the overlap region beyond 0.50 units indicating that an e^+ fraction of 63 % and $\mu^+ + h^+$ background of 37 % for the e^+ absorber OUT beam (minisucle statistical errors, dominated by systematic uncertainties).

Similarly, Figure 3. shows the same analysis for the negative beam (with beam stop inserted for the positive beam arm). In this case, the non-EM background is substantially smaller, about 6 %. In order to see this background component more easily, the negative beam data is also shown in a semi-logarithmic plot in Figure 4.

5 Summary and Discussion

At nominal 300 GeV settings, the non-EM backgrounds were approximately 37 % for the e^+ beam and 6 % for the e^- beam. These data were taken at very reduced collimator settings and should be repeated/checked at normal data rates and conditions in future Wide Band beam runs.

It is noted that these charged particle beams are not used directly for photoproduction experiments but produce neutral bremsstrahlung gamma ray beams. In this case, neutrons or K_L^0 produced in the photon radiator by hadronic backgrounds in the beam can interact in the experiment target producing backgrounds for the photoproduction data. We had previously attempted to measure such backgrounds in our photoproduction trigger rates using $\mu^{\pm}+h^{\pm}$ beams (lead $e^{\pm}$-absorbers IN) and found that these background trigger rates for E831/FOCUS were negligible (much too small to make the investment in beam-time to measure this background worthwhile).

file: peterg/background.tex

References

[1] J. Butler *et al.*, Design for a New Wide-Band Neutral Beam for the Tevatron, Fermilab TM-963 (1980, updated 1989), unpublished.

[2] P.L. Frabetti *et al.*, A wide band photon beam at the Fermilab Tevatron to study heavy flavors, Nucl. Instr. and Meth. A329(1993)62.

[3] P. Kasper *et al.*, Wide Band to 'Double Band' Upgrade, Fermilab TM-1552 (1988), unpublished.

[4] P. Skubic *et al.*, Phys. Rev. D18, 3115 (1978).

[5] The fused silica EM calorimetry for E831/FOCUS, to be published.

[6] E831/FOCUS Runs 14070-14073, August, 1997.

Figure 1: $E_{BGM}/TGMOM$ distribution for 300 GeV positive non-EM background beam (e^+ absorber IN).

Figure 2: $E_{BGM}/TGMOM$ distribution for 300 GeV positive beam. Dashed histogram is full beam (e^+ absorber OUT). Dotted histogram is for $\mu^+ + h^+$ background (e^+ absorber IN), normalized by fit over region 0.06-0.50 units (solid histogram).

Figure 3: $E_{BGM}/TGMOM$ distribution for 300 GeV negative beam. Dashed histogram is full beam (e^- absorber OUT). Dotted histogram is for $\mu^- + h^-$ backgrounds (e^- absorber IN), normalized by fit over region 0.06-0.50 units (solid hitogram).

Figure 4: Same 300 GeV negative beam data as in Figure 2. plotted on semi-logarithmic scale to more easily observe the background component.

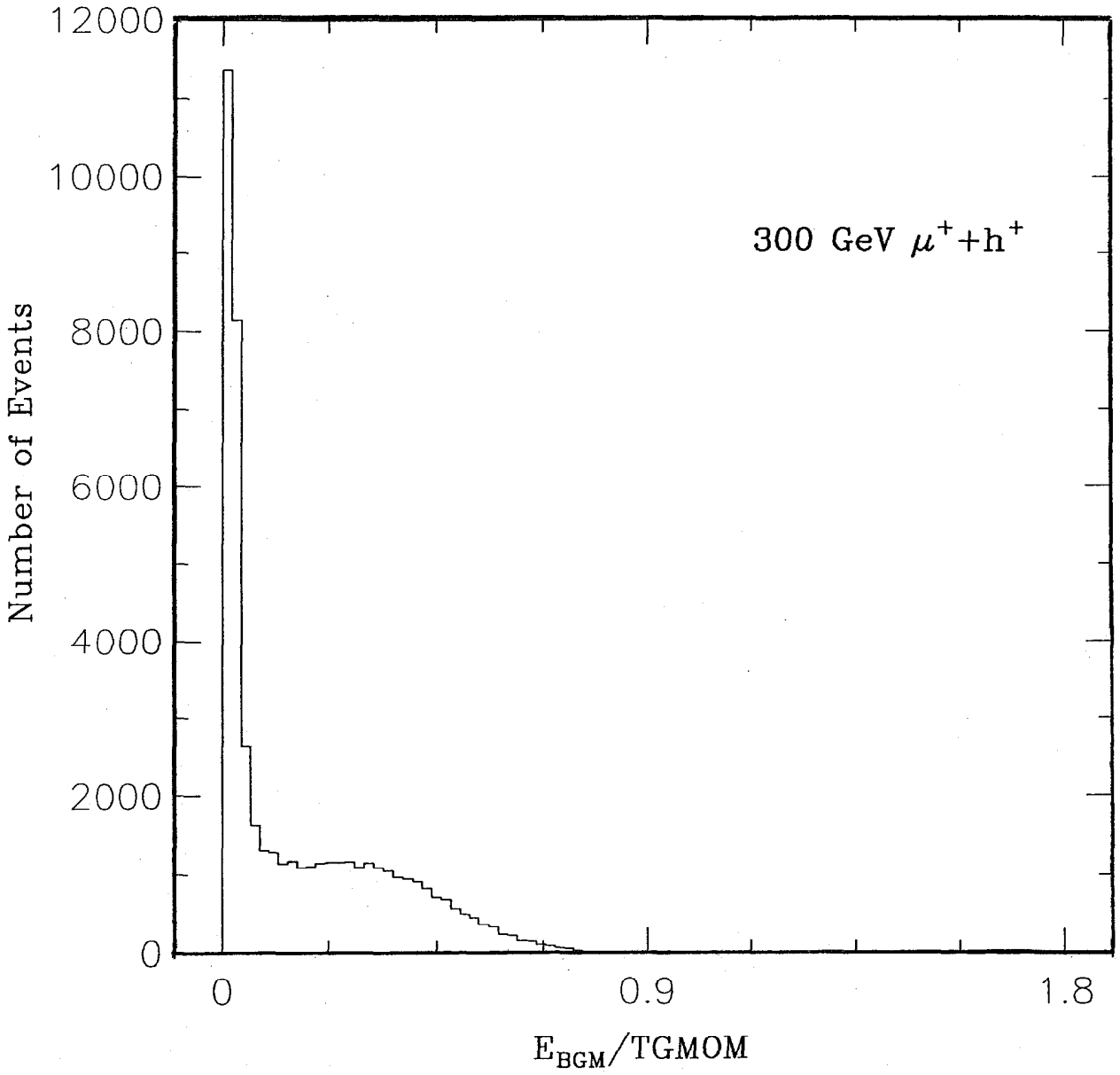


Figure 1: $E_{BGM}/TGMOM$ distribution for 300 GeV positive non-EM background beam (e^+ absorber IN).

Figure 2

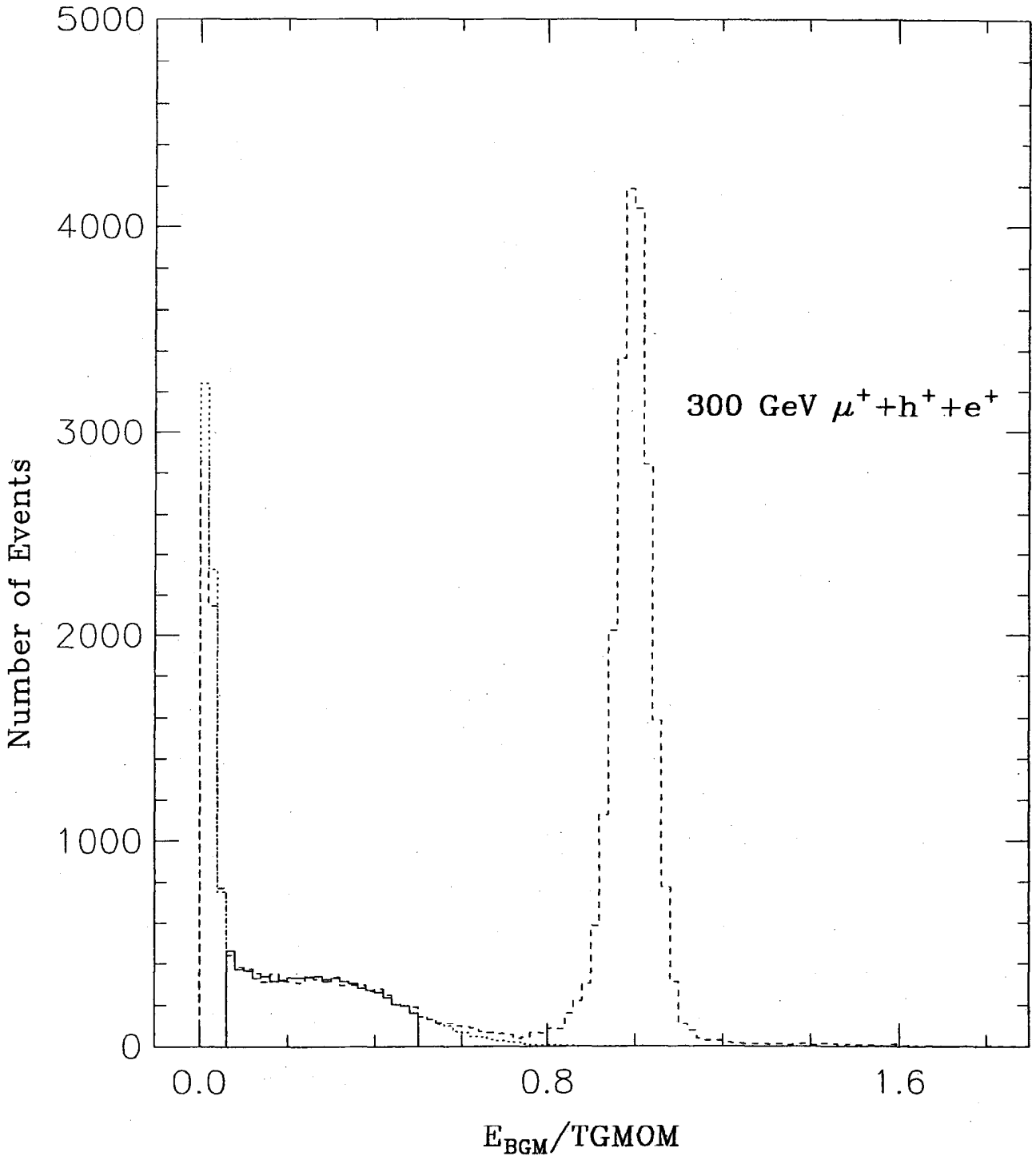


Figure 2: $E_{BGM}/TGMOM$ distribution for 300 GeV positive beam. Dashed histogram is full beam (e^+ absorber OUT). Dotted histogram is for $\mu^+ + h^+$ background (e^+ absorber IN), normalized by fit over region 0.06-0.50 units (solid histogram).

Figure 3

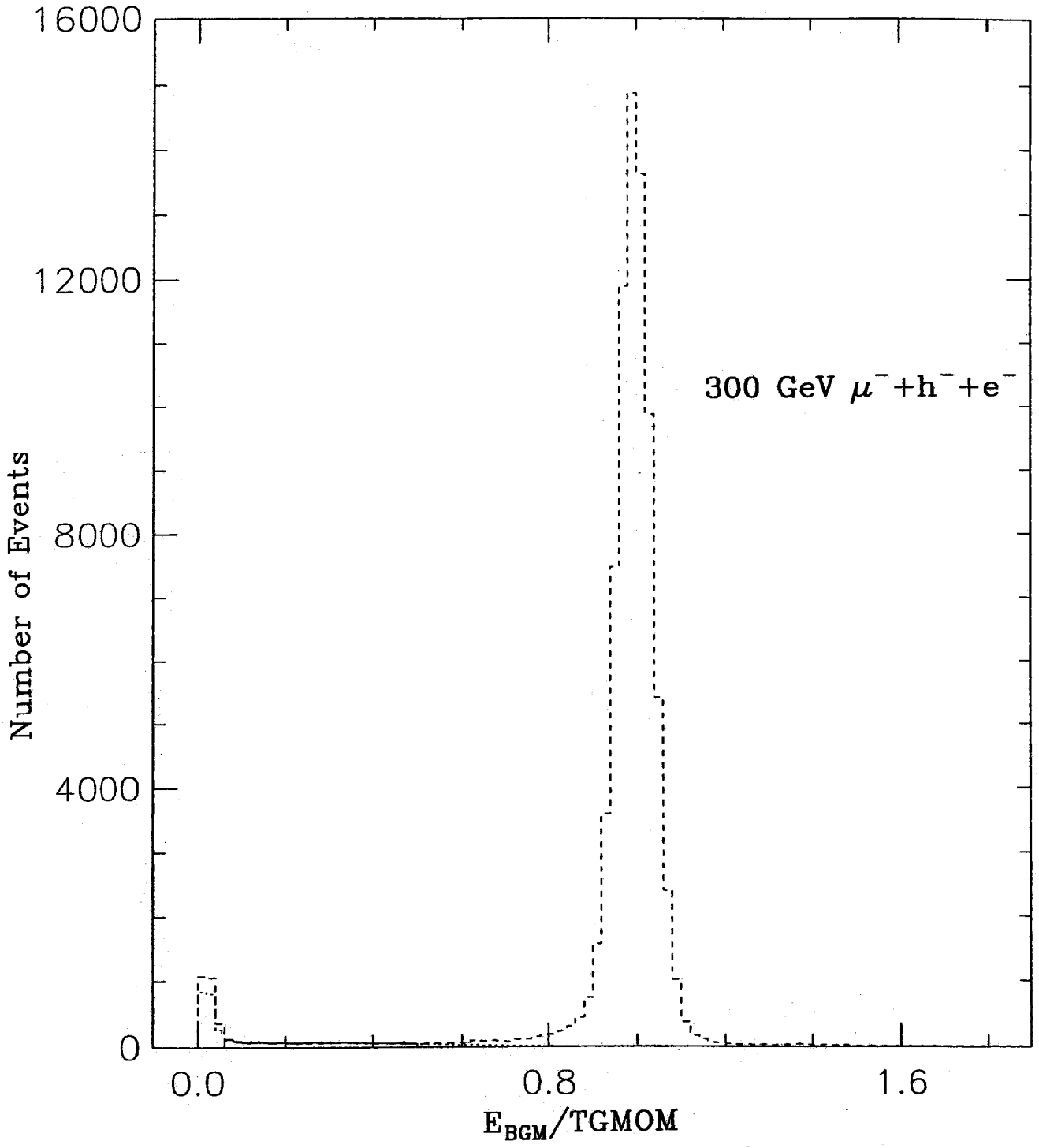
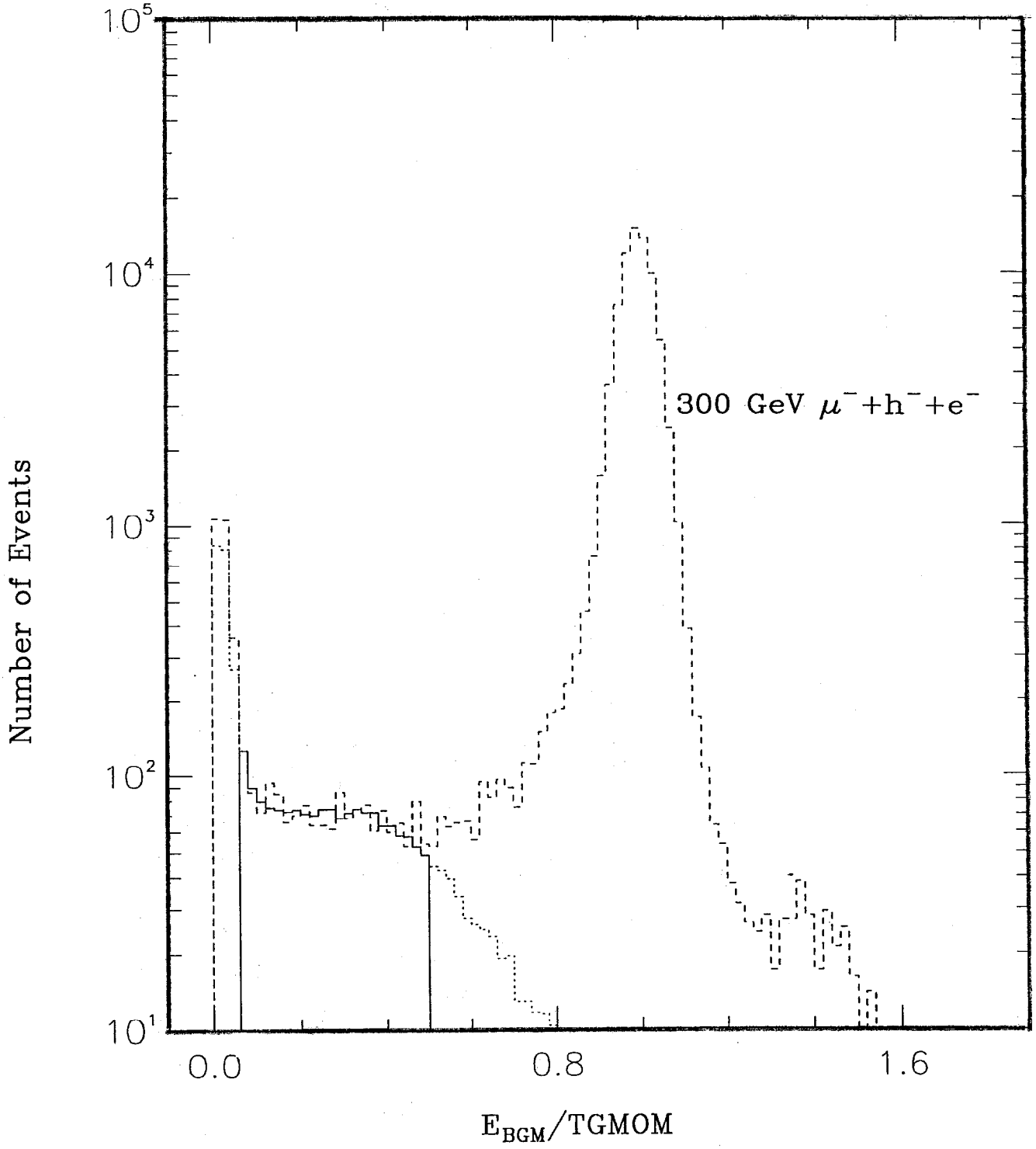


Figure 3: $E_{BGM}/TGMOM$ distribution for 300 GeV negative beam. Dashed histogram is full beam (e^- absorber OUT). Dotted histogram is for $\mu^- + h^-$ backgrounds (e^- absorber IN), normalized by fit over region 0.06-0.50 units (solid hitogram).



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