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Momentum Resolution Criteria for the Central Tracker

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Abstract:

We present our calculation of the GEM central tracker resolution necessary for muon identification. The production of top quark pair and its background is analyzed

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We present our calculation of the GEM central tracker resolution necessary for muon identification. The production of top quark pair and its background is analyzed.

Momentum Resolution Criteria for the Central Tracker

Central tracking in a magnetic field will provide precision event vertex information as well as lepton momentum information to help identify the leptons and to reject the background. The GEM detector is designed to measure the electron energy and the muon momentum precisely in the EM calorimeter and the muon chambers out side of the calorimeters. The momentum information from the central tracker is needed for redundancy. The momentum resolution criteria is crucial for the central tracker design.

Considering the inclusive muon measurement, for example, $b \rightarrow \mu + X$, the major background will come from the hadron punchthroughs. The only efficient way to keep the signal acceptance and to reject the background is to match the muon measured inside (in central tracker) and outside (in muon chambers). We studied the $t\bar{t}$ decay events from the decay mode:

$$t\bar{t} \rightarrow W^+bW^-\bar{b} \rightarrow e^{\pm}\mu^{\mp} + \mu_{incl.} + X$$

and the background event from QCD two jet ($b\bar{b}$, gluons) events:

$$pp \rightarrow twojets(b, \bar{b}, gluons) \rightarrow e^{\pm}\mu^{\mp} + \mu_{incl.} + X$$

. The event selection criteria are listed below:

- $\mid \eta_{e,\mu} \mid < 2.5$;
- An isolated electron + an isolated muon, both with $p_T > 30\ GeV$;
- An inclusive muon (decay from $b - quark$) with $p_T > 5\ GeV$.

For ~~140~~ 250 GeV Top, we expect 20,000 events per SSC-year (10^7 sec.) at the standard luminosity. From QCD two jet events, we expect $\sim$ 12,500 events pass the above cuts. Table 1 lists the detailed information on two jet background calculations.

Table 1: $e^{\pm}\mu^{\mp} + \mu_{inclusive}$ **events from QCD**

N_{total} (M.C.)	N_{pass} (punchthrough)	p_T^{jet} range (GeV)	cross section (mb)	$N_{pass/year}$ $(10^{33}/cm^2/s)$
1000k	0	50 - 150		0
500k	0	150 - 300		0
200k	2	300 - 450	$0.7855E^{-4}$	7854
200k	5	450 - 600	$0.1117E^{-4}$	2790
200k	10	600 - 800	$0.2882E^{-5}$	1441
200k	8	800 - 1000	$0.6030E^{-6}$	241
200k	9	1000 - 1500	$0.2353E^{-6}$	106
100k	2	1500 - 2000	$0.2062E^{-7}$	4
5390k	31			12,526

In order to keep the shape of $e^{\pm}\mu^{\mp}$ mass spectra, which is needed to determine the Top mass, we must control the background contamination below 10%. This implies that we need reject 85% of the punchthrough background.

We used QCD $b\bar{b}$ two jet events to study the muon matching efficiency and the punchthrough rejection as the function of the central tracker momentum resolution. The following procedure was used in our simulation to find out the inside and outside muon matching efficiency:

- ISAJET generate events with TWOJET(Top is not included) process.
- For each prompt muon, we calculated the muon pass-through thickness of calorimetry material according to the incident angle. The energy loss is simulated by the energy loss spectrum obtained in GEANT simulation of muons that are closest in both momentum and incident angle. dE/dx energy loss is corrected according to the calorimetry thickness.

- For each charged pions and kaons, the following procedures were used to generate the punchthrough particles:

  1. We first check if the particle should generate punchthrough particles in the muon chambers. The punchthrough probability is calculated according to our GEANT simulation results.
  2. If there are charged punchthroughs in the muon chambers, the charged multiplicity was generated according to the distribution extrapolated from the distributions of the GEANT simulations.
  3. The energies and angular spread of the punchthrough particles are calculated according to the spectra from GEANT simulations.

- For charged particles measured in the out side muon chambers, we require their $p_T > 5\ GeV$, and must match with inner track. The following procedures were used for the matching:

  1. calculate total momentum resolution, $\delta_0 = \sqrt{\delta_V^2 + \delta_\mu^2}$, where δ_V is the central tracker momentum resolution, $\Delta p_V / p_V$; δ_μ is the muon chamber momentum resolution, $\Delta p_\mu / p_\mu$. according to the muon momentum measured in the muon chambers.
  2. calculate the multiple scattering angular spread, θ_0, based on the calorimeter thickness.
  3. Trace back the out side muon track to the central tracker, and select the all the charged particles within $5 \times \theta_0$ cone to find the best matching. We used minimize χ^2 method for the matching. The χ^2 is defined as

     $$\chi^2 = (\Delta p / \delta_0)^2 + (\Delta \theta / \theta_0)^2$$

     where $\Delta p = p_\mu + \Delta E - p_V$, p_μ is the momentum measured in out side muon chambers (assuming GEM muon chamber baseline design resolution) , ΔE is the muon energy loss in the calorimeter (assuming $\Delta E / E = 50\% / \sqrt{E} + 2\%$), and p_V is the momuntum measured in the

inner tracker (assuming $\Delta p/p^2 = C$, for $\mid \eta \mid < 1.5$, and $\Delta p/p^2 = C/sin\theta$, for $\mid \eta \mid > 1.5$, where C is a canstance. We have used C =0.001, 0.00125, 0.01, and 0.05 in our studies; $\Delta\theta$ is the angle between the out side muon track and the inner track measured in the central tracker.

- From the χ^2 distributions, shown in Fig. 1, we decide to cut the χ^2 at 10 to reject the background, and to keep the real muon acceptance.

We list our study results in the following, and then give a conclusion on the central tracker momuntum resolution criteria.

- The overall acceptance for muons is 85% if the χ^2 cut at 10; Selecting muons with $p_T > 5GeV$, the acceptance increases to 90%.
- 95% of the selected muons ($p_T > 5\ GeV$) match the correct tracks inside.
- The punchthrough rejections for different central tracker resolutions are listed in Table 2, which used $\chi^2 < 10$ cut for the matching. Fig. 2 shows the punchthrough particle p_T distributions before the cut and after the cut for different central tracker resolutions.

Table 2: **Punchthrough Rejection**

$\Delta p_V/p_V^2$	0.001	0.00125	0.01	0.05
Rejection:	80%	76%	35%	11%

We conclude that we need central tracker to provide momentum information for inclusive muon identification with the resolution of

$$\Delta p_V/p_V^2 \sim 1.0 \times 10^{-3}/GeV.$$

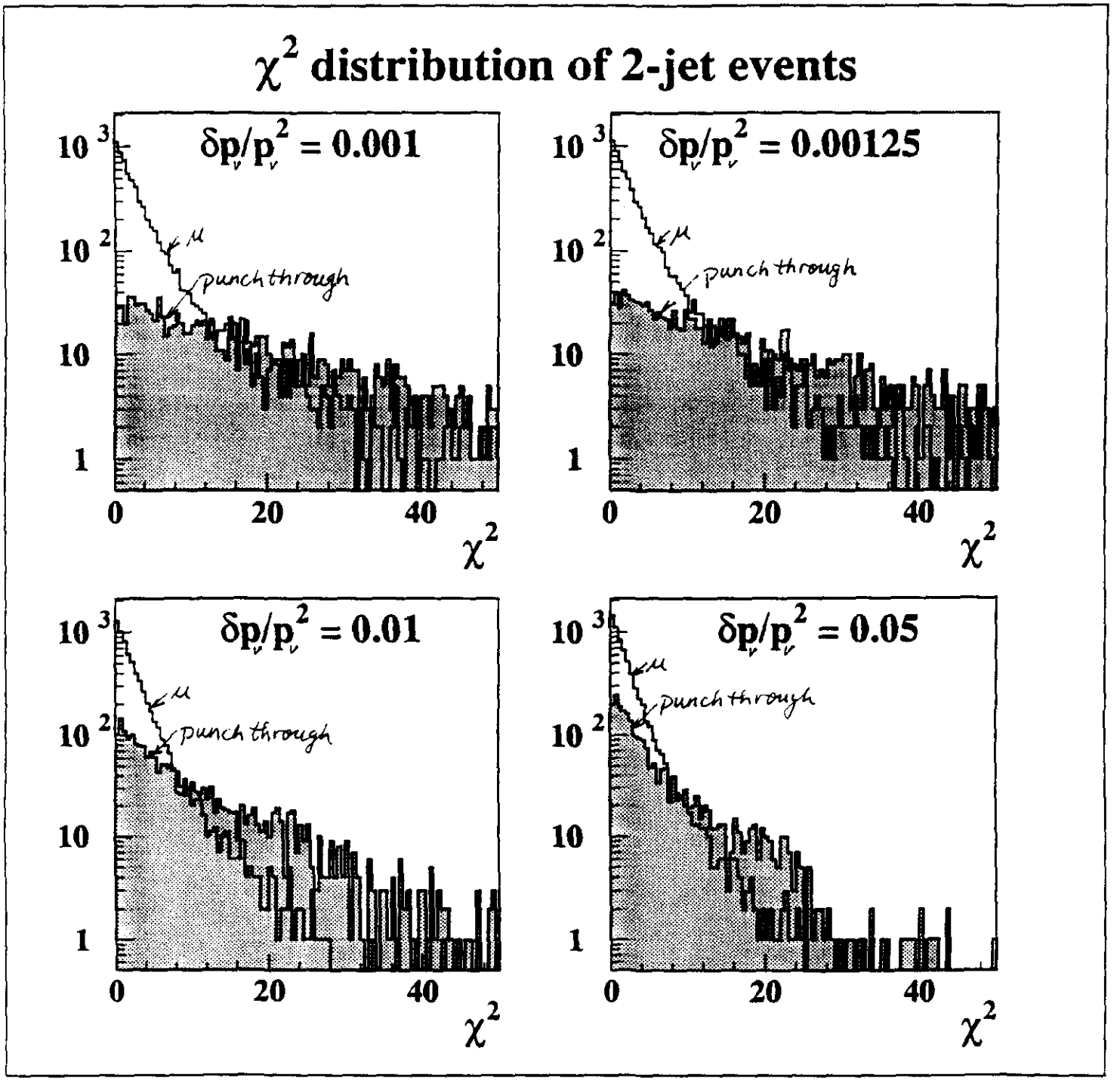
χ² distribution of 2-jet events
δp/p² = 0.001
δp/p² = 0.00125
δp/p² = 0.01
δp/p² = 0.05
μ
punch through
10³
10²
10
1
0
20
40
χ²

Fig. 1

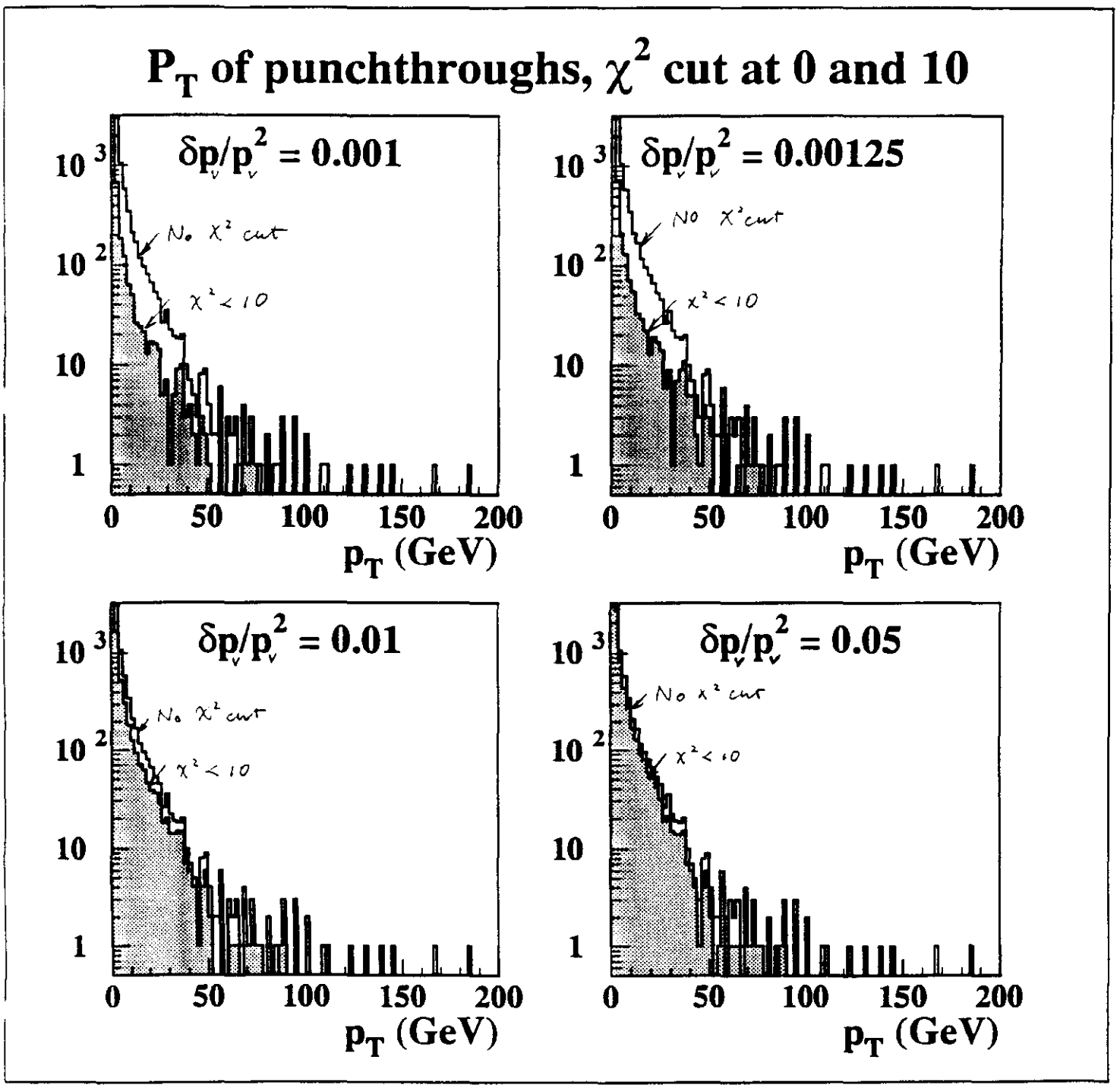
P_T of punchthroughs, χ^2 cut at 0 and 10
$\delta p_v/p_v^2 = 0.001$
$\delta p_v/p_v^2 = 0.00125$
$\delta p_v/p_v^2 = 0.01$
$\delta p_v/p_v^2 = 0.05$
No χ^2 cut
$\chi^2 < 10$
10^3
10^2
10
1
0
50
100
150
200
p_T (GeV)

Fig. 2