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Top Studies

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Preliminary study of possible strategies in Top search in the framework of GEM detector is presented.

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ABSTRACT
Preliminary study of possible strategies in Top search in the framework of GEM detector is presented

Top quark is one of the two missing blocks needed in understanding of theoretical picture of elementary particle physics. For experiments at SSC it plays twofold role. If it will not be discovered at lower mass (around $150 GeV/c^2$) experiments at SSC should demonstrate ability to discover it at wide range of possible masses. Anyway it should be carefully studied because, it will represent background for another missing item – Higgs. Aim of this note is to provide some help to people working on TDR report on this subject for final tuning of parameters.

Response of GEM detector was simulated by GEMFAST simulation package (versions vII102 and vII202). Production of top was simulated by PYTHIA and mechanism of gluon gluon (quark anti quark) fusion for top anti top pair production was considered . In standard model heavy top (much heavier than W) decays with almost 100 % probability to W b. Therefore signatures of t $\bar{t}$ are connected to existence of at least two W and b-jet in the same event. Very clear signature consist of 3 leptons – 2 isolated and one inclusive muon (muon inside b-jet).

On the fig. 1 left column of figures represents response of GEM detector to muon from $W \rightarrow \mu\nu$ right to muon inside b-jet. In first row dependence of difference in transverse energy (measured in electromagnetic and hadronic calorimeters) in cone R=0.3 and R=0.1 ($R = \sqrt{(\delta\phi)^2 + (\delta\eta)^2}$) is presented. In second raw difference in pseudorapidity measured in muon system and in central tracker (matching with CT) is displayed. Because multiple scattering isn't simulated in GEMFAST it was incorporated here in simple small angle approximation. Last row represents ratio of momentum measured in CT to one measured in muon system (corrected for losses in calorimeter). These figures represent idealized picture when GEM detector responds to single W from top decay except that pileup and thermal noise in calorimeter are included. On fig.2 response to electrons from W decay is presented. Ratio of energy in 3x3 matrix around bump in electromagnetic calorimeter to 5x5 ,difference of transverse energy measured in calorimeter in cone 0.3 and electromagnetic calorimeter around cone 0.1, matching in ϕ, η and momentum between measurement in CT and electromagnetic calorimeter. These figures support selection of following cuts:

For isolated muons -

Cuts	efficiency
$P_{t\mu} > 25GeV/c$	83 %
$E_t^{ca}(R=0.3) - E_t^{ca}(R=0.1) < 2$	99 %
$\lvert\eta_{mu} - \eta_{ct}\rvert < 0.02$	97 %
$P_{ct}/P_{musys} \in (0.8, 1.2)$	85 %
track recons. efficiency in musys	87 %
track recons. efficiency in CT	$\sim$ 100%

For isolated electrons -

Cuts	efficiency
$E_t^{ca}(R=0.3) - E_t^{em}(R=0.1) < 6$	95 %
$EC33/EC55 > 0.9$	$\sim$ 100%
$\lvert\eta_{bump} - \eta_{ct}\rvert < 0.02$	$\sim$ 100%
$\lvert\phi_{bump} - \phi_{ct}\rvert < 0.02$	$\sim$ 100%
$P_{ct}/P_{m}usys \in (0.7, 1.2)$	74 %
track recons. efficiency in CT	$\sim$ 100%

For inclusive muons inside b-jet

Cuts	efficiency
$P_{t\mu} > 5GeV/c$	91 %
$E_t^{ca}(R=0.3) - E_t^{ca}(R=0.1) > 5$	66 %
$\lvert\eta_{mu} - \eta_{ct}\rvert < 0.04$	92 %
$P_{ct}/P_{musys} \in (0.85, 1.15)$	85 %
track recons. efficiency in musys	88 %
track recons. efficiency in CT	50-70 %

CT reconstruction efficiency of inclusive muon inside b-jet was estimated from GEM-FAST study using isolation criteria and also from full CT Monte Carlo study. On fig. 3 there are corresponding distributions as on fig.1 but now it represent response of GEM components to real t $\bar{t}$ event + pileup of on average 1.6 minimum biased events. Cuts are consecutively (from up down) applied. Fig 4. corresponds in same way to fig.2.
As was realized some time ago one can infer top mass from measurement of peak of effective mass of pair isolated lepton and inclusive muon. Leptons in combination should have different sign to correspond to leptons from the same top decay. On fig.5 above mentioned distribution for top mass = 200,250,300 GeV/c^2 are displayed. Peak values have been estimated from simple polynomial fit and corresponding numbers are 49,58,68 GeV/c^2 .
Most important background comes from production Z^0 + jet and from Z^0 + b $\bar{b}$. Cross section for these processes was estimated by PYTHIA and it is 222 nb and 4 nb respectively. By using as isolated lepton electron, background from this mode is suppressed to decay $Z^0 \rightarrow \tau\tau$ where one τ decays in $\tau \rightarrow e\nu\nu$ and other in $\tau \rightarrow \mu\nu\nu$ mode. P_t dependence of isolated leptons from this source is much softer then P_t distribution of isolated leptons from W and this background is largely suppressed by P_t cut. Estimated level for top mass = 200 GeV/c^2 is 4 % (in above conditions).
Direct measurement of top mass is possible when one is able to measure 3 jets from top decay. Our approach is following: We select isolated lepton and at least 3 jets in pseudorapidity region (-2.5,2.5) with P_t greater than 25 GeV/c. Two closest jets (in ϕ, η plane) with P_t of dijet greater than 180 GeV are selected. Distance in ϕ, η plane should be less than 1. Effective mass distribution is presented on fig. 6 (upper left). Candidate of b-jet associated with W from t decay is selected as closest jet to already selected dijet with distance less than 2 (phi, η plane). Effective mass distributions of three jets for top mass 200,250 and 300 GeV/c^2 fills rest of the figure 6. Extra condition was applied for top at mass=300 GeV/c^2. P_t of combination of b-jet candidate and isolated lepton should be greater than 180 GeV/c. Distributions are normalized to one SSC year. Above used selection criteria are good enough to find top mass peak in three jet effective mass distribution, but than different strategy should be adopted, depending on mass of the top. As most important background to this process is considered W + jets production. This

background was estimated also by PYTHIA and according to our estimate it contributes to 3 jets (selected as above) by the same order of magnitude as signal (for top mass = 200 GeV/c^2). Nevertheless it is not considered too dangerous because its effective mass dependence is quite different from signal.

I would like to thank Melin Huang who helped me a lot at the early stage of this work.

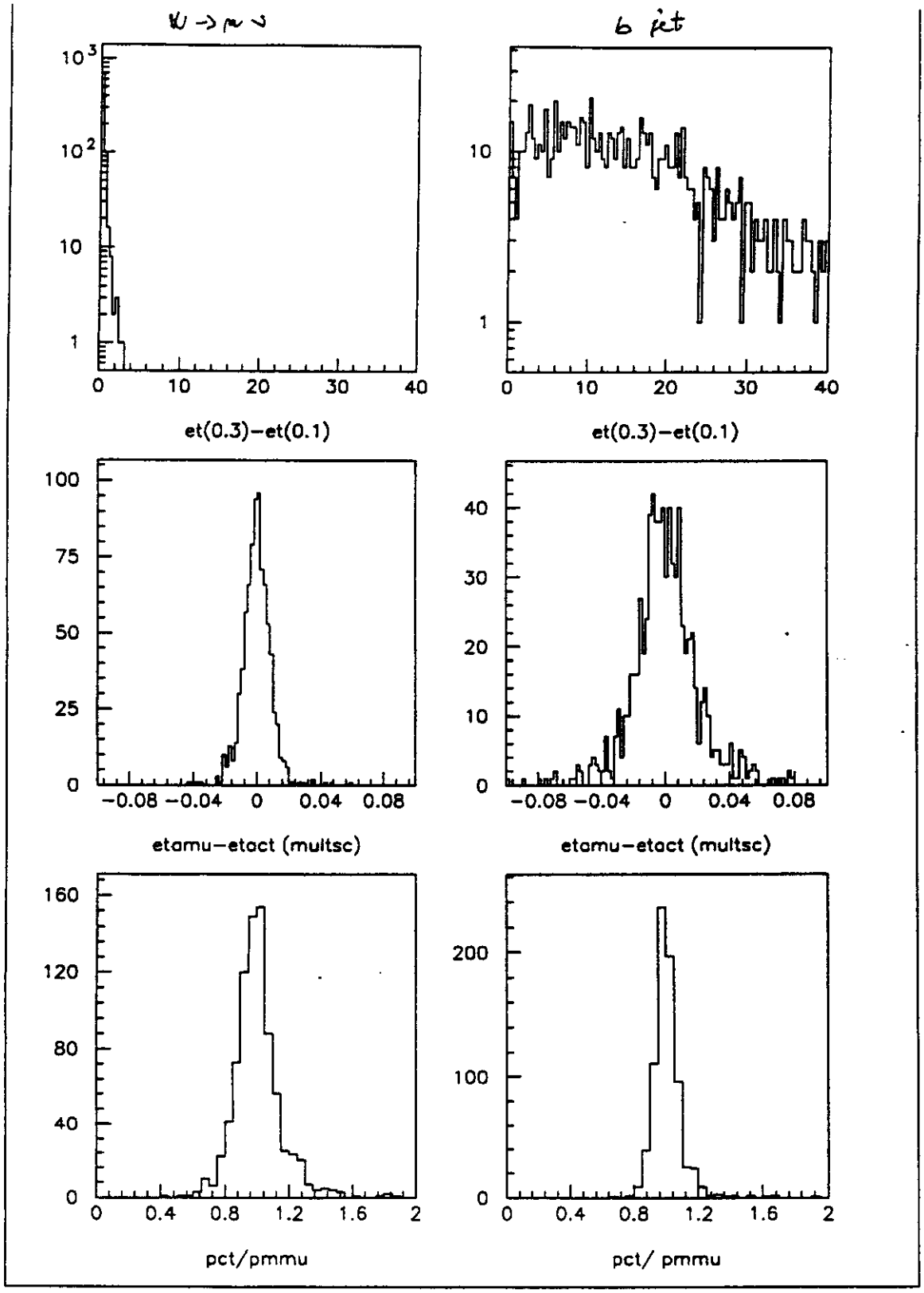
W -> μ ν
b jet
et(0.3)−et(0.1)
et(0.3)−et(0.1)
etamu−etact (multsc)
etamu−etact (multsc)
pct/pmmu
pct/ pmmu

Fig. 1

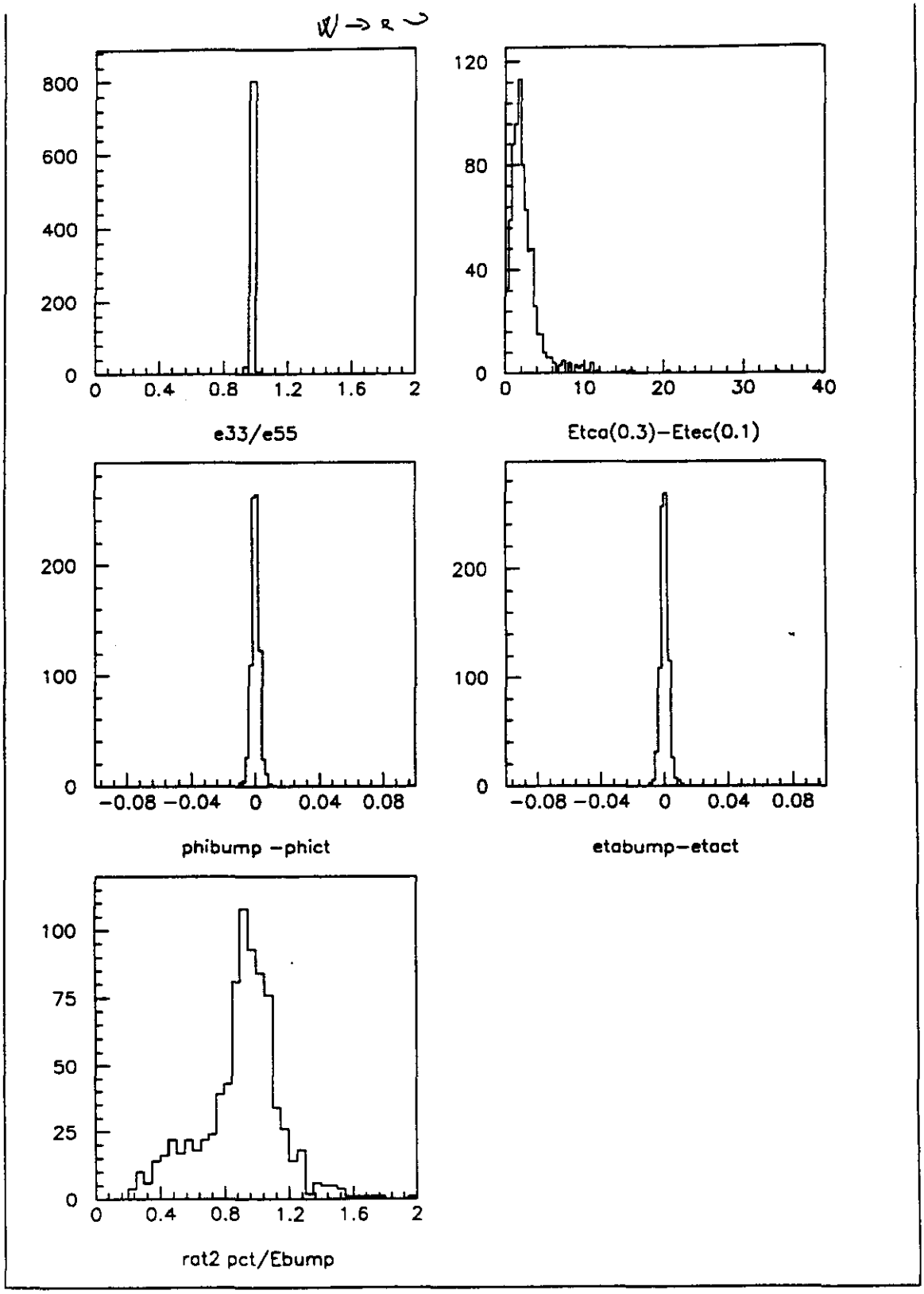
W → e ν
e33/e55
Etca(0.3)−Etec(0.1)
phibump −phict
etabump−etact
rat2 pct/Ebump

Fig 2.

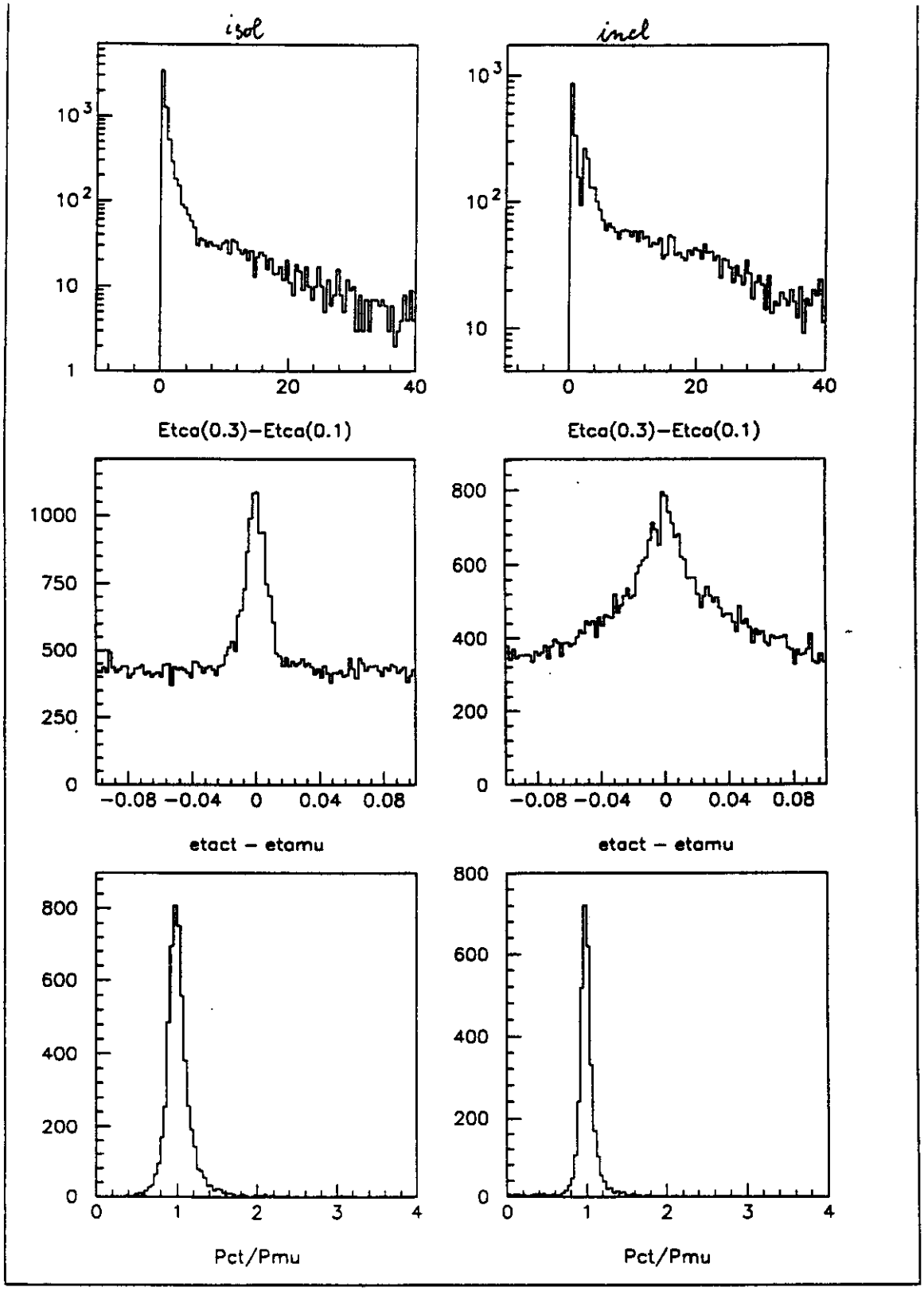
isol
incl
Etca(0.3)−Etca(0.1)
Etca(0.3)−Etca(0.1)
etact − etamu
etact − etamu
Pct/Pmu
Pct/Pmu

Fig. 3

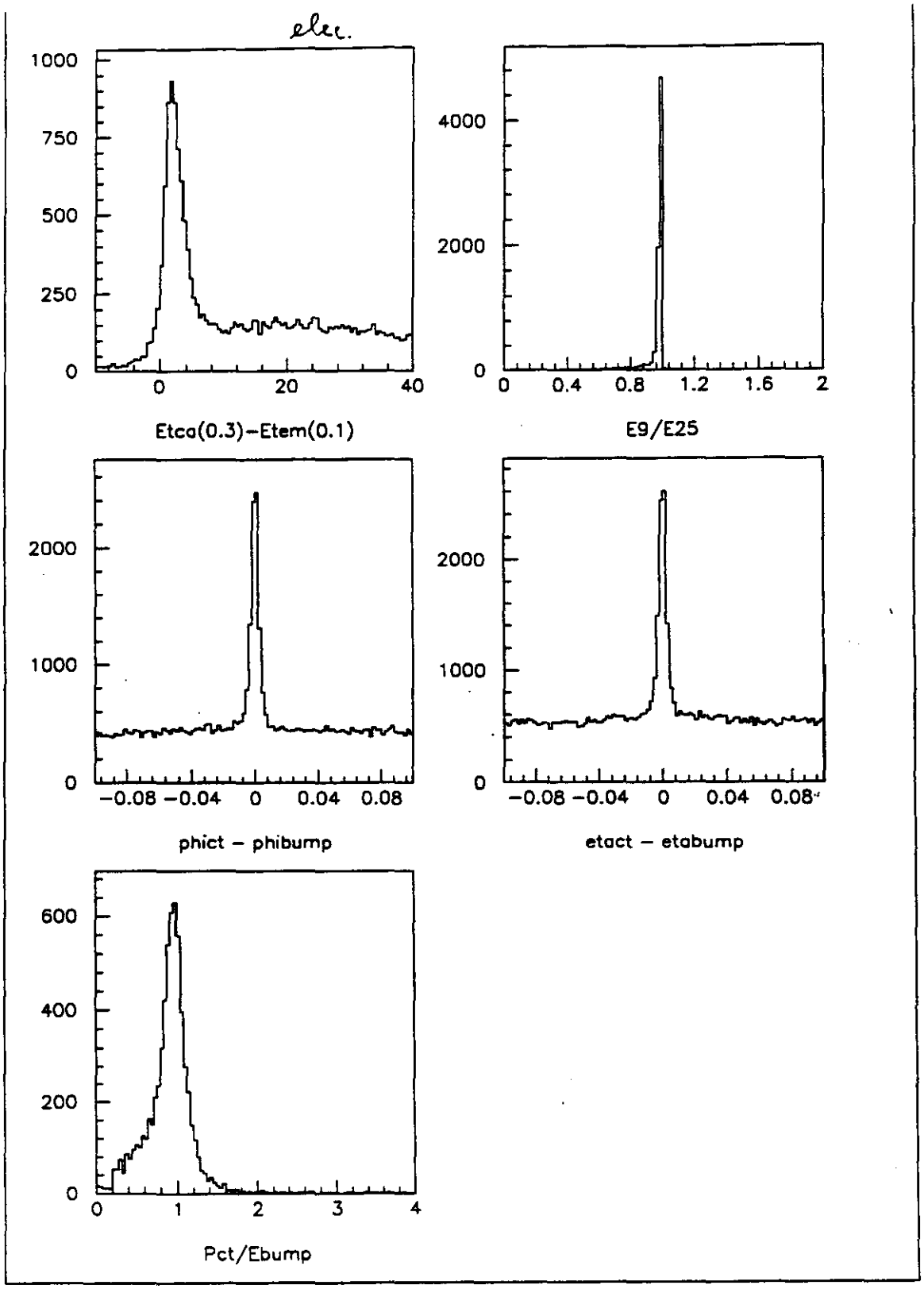
elec.
1000
750
500
250
0
0
20
40
Etca(0.3)−Etem(0.1)
4000
2000
0
0
0.4
0.8
1.2
1.6
2
E9/E25
2000
1000
0
−0.08 −0.04 0 0.04 0.08
phict − phibump
2000
1000
0
−0.08 −0.04 0 0.04 0.08
etact − etabump
600
400
200
0
0
1
2
3
4
Pct/Ebump

Fig. 4

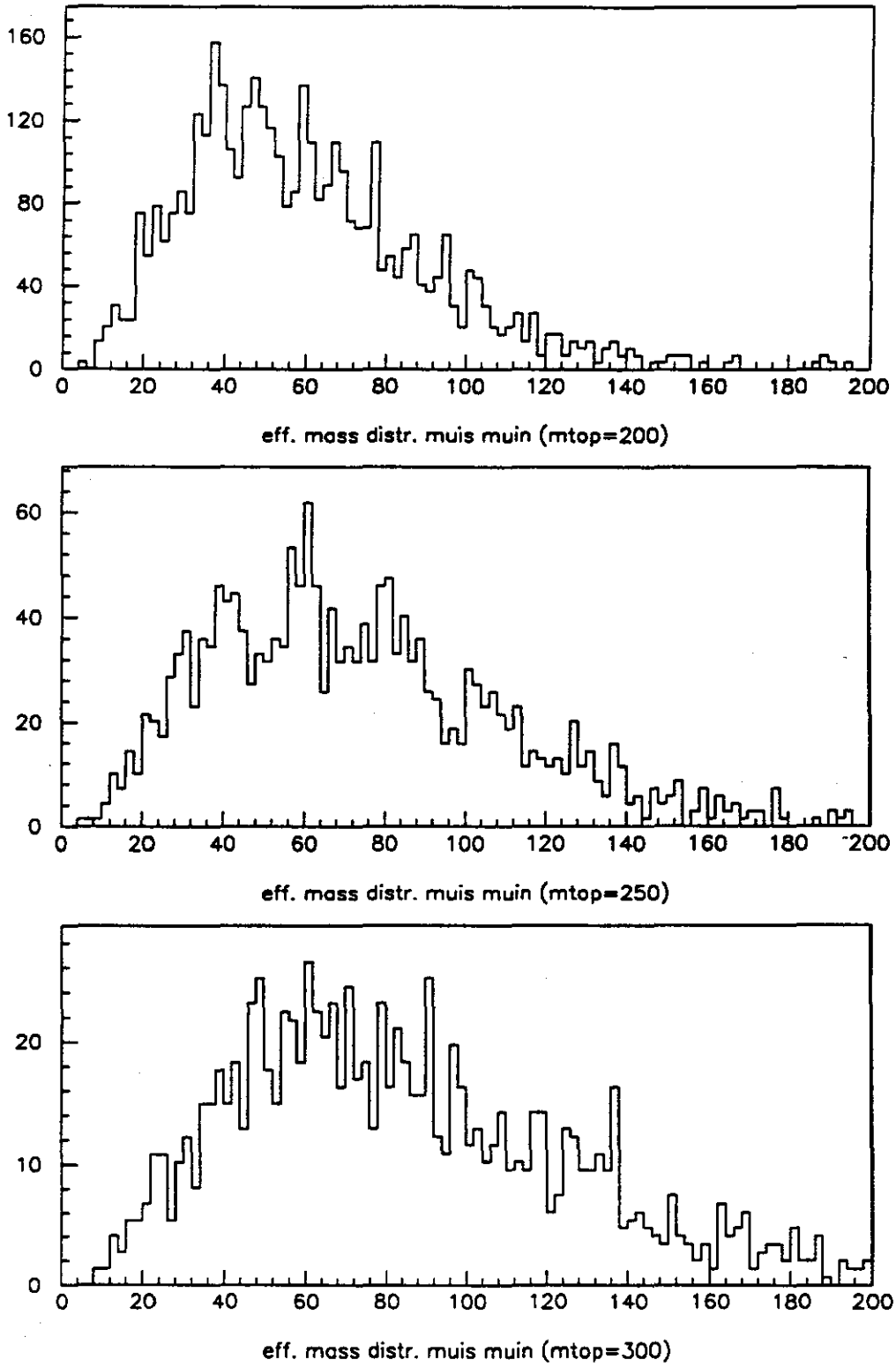
160
120
80
40
0
0 20 40 60 80 100 120 140 160 180 200
eff. mass distr. muis muin (mtop=200)
60
40
20
0
0 20 40 60 80 100 120 140 160 180 200
eff. mass distr. muis muin (mtop=250)
20
10
0
0 20 40 60 80 100 120 140 160 180 200
eff. mass distr. muis muin (mtop=300)

Fig-5

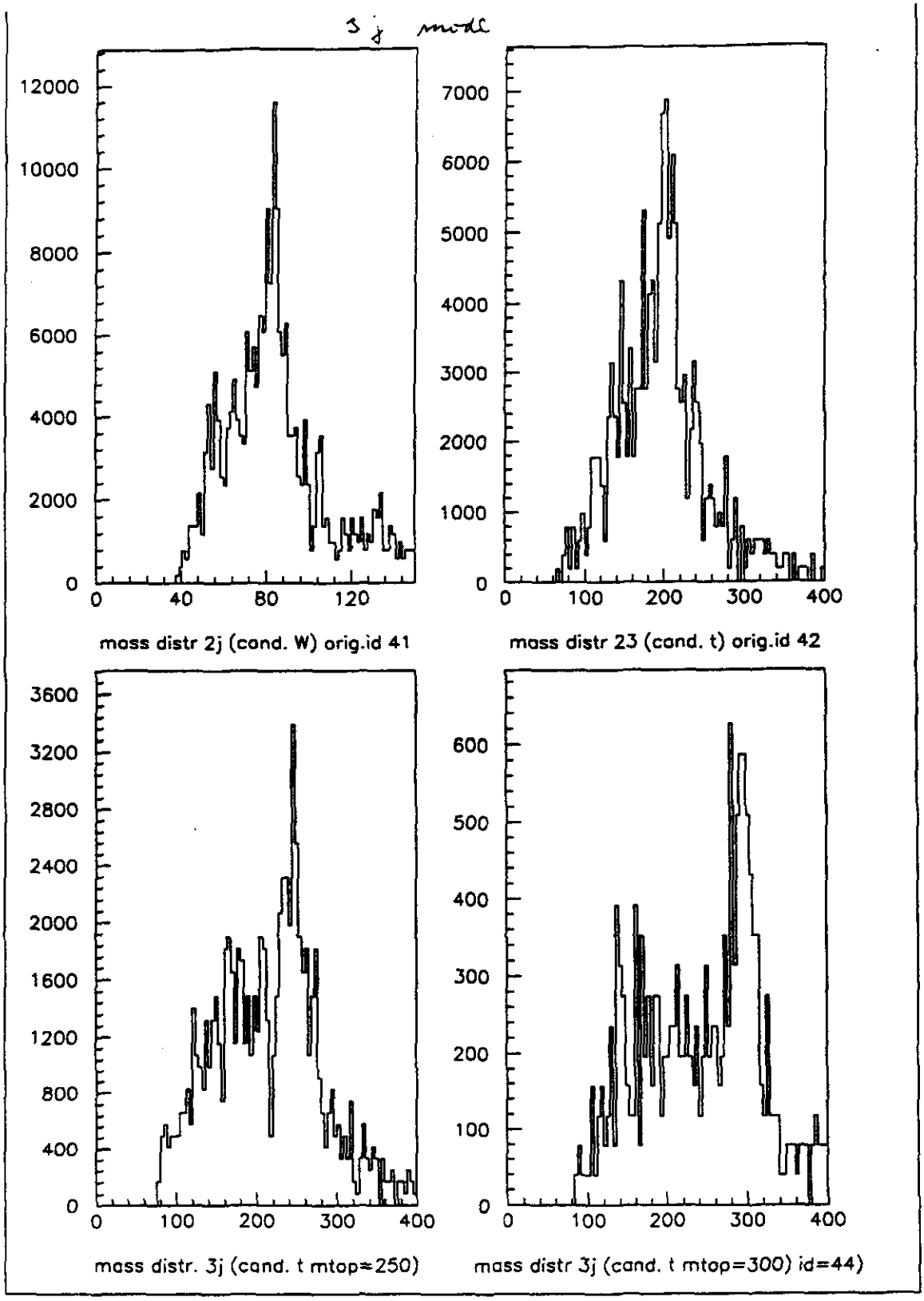
3 j mode
mass distr 2j (cond. W) orig.id 41
mass distr 23 (cond. t) orig.id 42
mass distr. 3j (cond. t mtop=250)
mass distr 3j (cond. t mtop=300) id=44)

Fig. 6