D0Note No. 4028

Effects of Electronic Noise on Cone Jet Reconstruction

V.V. Zutshi

Northern Illinois University

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Abstract

INTRODUCTION

This note studies the effects of electronic noise on the reconstruction of jets with the Run II Cone Algorithm. The noise is simulated as a single gaussian in the 'pileup' package with a width given as a function of layer and ieta. Initial starting point for injecting noise were values close to the Run I measurements, referred to here as the default noise . The noise was then varied to two and three times this value putting it squarely in the range of values we are seeing in Run II. It is assumed that there is no non-linearity and only the sensitivity to noise is looked at. A QCD sample with $p_T^{min} > 40$ GeV is used for these studies. Official jet energy scale corrections are not used however the proper scaling is applied (such that the mean E/E$_gen = 1.0$) when comparing resolutions.

EVENT CHARACTERISTICS

Fig. 1 shows some of the gross characteristics of the event for the sample where no noise simulation has been done. This also implies that no zero-suppression threshold has been applied. Figs.2, 3,4 and 5,6,7 show the same plots for QCD events where noise with two and three times the default noise sigma has been overlayed respectively.

EXTRA JETS

With the current parameters the Run II cone algorithms give rise to extra jets which basically come from noise in the calorimeter for low zero-suppression values. The fact that these are spurious jets can be established by looking at their distance of closest match with a Monte Carlo generated jet (see Figs. 8-13). For comparison the minimum distance plot for QCD events with no noise simulation is also shown in Fig. 14.

JET PROPERTIES

Based on the δR_{min} plot we classify the jets into 'true' ($\delta R_{min} < 0.25$) and 'noise' jets ($\delta R_{min} > 0.6$). Figs. 15-21 provide a glimpse into the charecteristics of these two species of jets.

RESPONSE AND RESOLUTION

Response is defined as the ratio of the reconstructed to generated jet energy for matched ($\delta R_{min} < 0.25$) jets. Resolution is defined as the width of the E/E_{gen} distribution. The generated energy is unbinned at the higher end i.e. the point at X GeV refers to all jets between X and X + ∞. Fig. 22 shows the jet response as a function of the generated energy for QCD events injected with twice the default noise and then zero-suppressed at the 1.5, 2.0 and 2.5 σ levels. From this plot one can surmise that for true jets 1.5σ suppression leaves too much noise inside jets which can significantly skew the low energy jets. On the other hand 2.5σ seems to entail a higher response correction. In the resolution projection (see Fig. 23) too it appears that of the values considered 2σ suppression is the closest to the optimum point. Similar qualitative conclusions can be draw from the QCD sample with the higher (3 times the default) noise (see Figs. 24 and 25).

COMMENTS A.K.A. BULLSHIT

In a sense we are grappling with a dual problem here. On one hand we would like to raise threshold to kill spurious jets but on the other hand from the plots it looks like this will have the unintended consequence of biasing the true jets. A number of options, however, do exist:

(a) Include negative towers in the clustering

(b) Raise seed and precluster thresholds

(c) Layer-dependent zs threshold

(d) Some combination of the above

Each one of these options has its capabilities and limitations and they are preliminarily investigated in what follows.

JUST NOISE

To understand the generation of jets from noise, files with neutrino events were run through d0sim. This has the effect of producing 'just noise' files in which the only energy deposits in the calorimeter are those generated by the noise gaussian. Fig. 26 displays the total energy distribution for 1000 events. As expected the distribution is centered around zero. These events give rise to jets as can be seen in Figs.27 through 34. A possible reason for the generation of the numerous jets from noise can be the requirement of only including the positive E_T towers in the clustering. The cells belonging to a particular tower are summed vectorially and towers with a net positive E_T are kept. This requirement had been imposed in the past based on some energy resolution studies on events with large number of minbias overlap. Fig. 35 shows what happens when negative towers are also included in the clustering.

MORE ON NEGATIVE TOWERS

The exercise of including negative towers can be extended to the QCD sample (see Fig.36). As expected the inclusion of negative towers in the clustering process has a marked impact on the number of noise jets that get generated. Ofcourse, inclusion of negative towers during clustering means that true jets will also be built up using both positive and negative towers (see Figs37-39). Figs. 40 and 41 show the response and resolution for true jets when no restrictions are made on the E_T's of the towers participating in the clustering. They can be directly compared with Figs. 22 and 23 which use only positive E_T towers.

SEEDS AND PRECLUSTERS

The default Run II cone algorithm starts with a seed of 0.5 GeV. It then draws a 0.3 cone and demands that this precluster be atleast 1.0 GeV. In view of the high number of jets created by noise raising these thresholds might be a potential way of mitigating the problem. Care would have to be taken that the thresholds are not raised so much that they start affecting the reconstruction efficiency of true jets. As a test Fig. 42 shows the number of jets reconstructed if these thresholds are doubled (i.e. a seed threshold of 1.0 GeV and a precluster threshold 2.0 GeV). No significant decrease in efficiency was observed for true jets when using these thresholds.

FIGURES

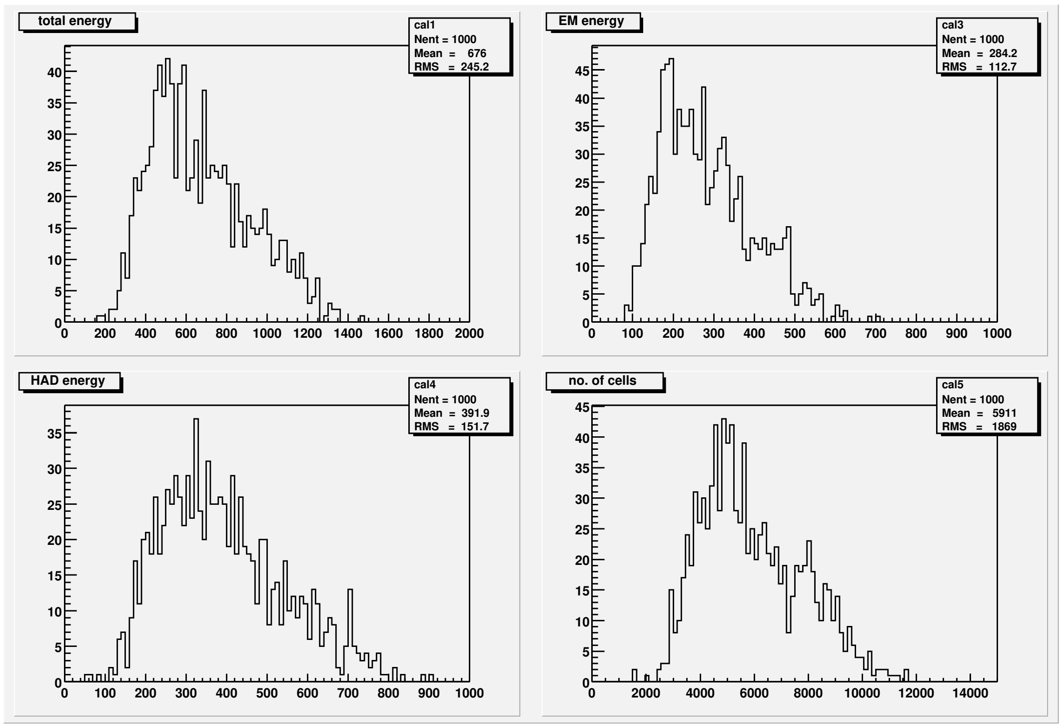

FIG. 1. QCD events with no noise simulation

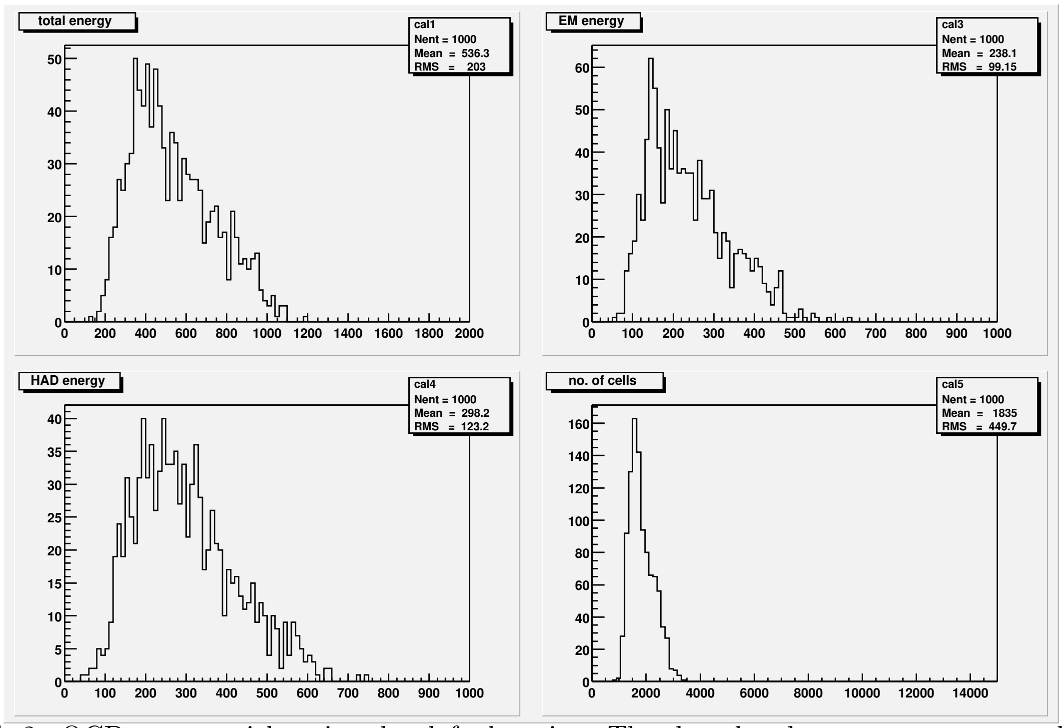

FIG. 2. QCD events with twice the default noise. The data has been zero- suppressed at the 2.5σ (scaled) level

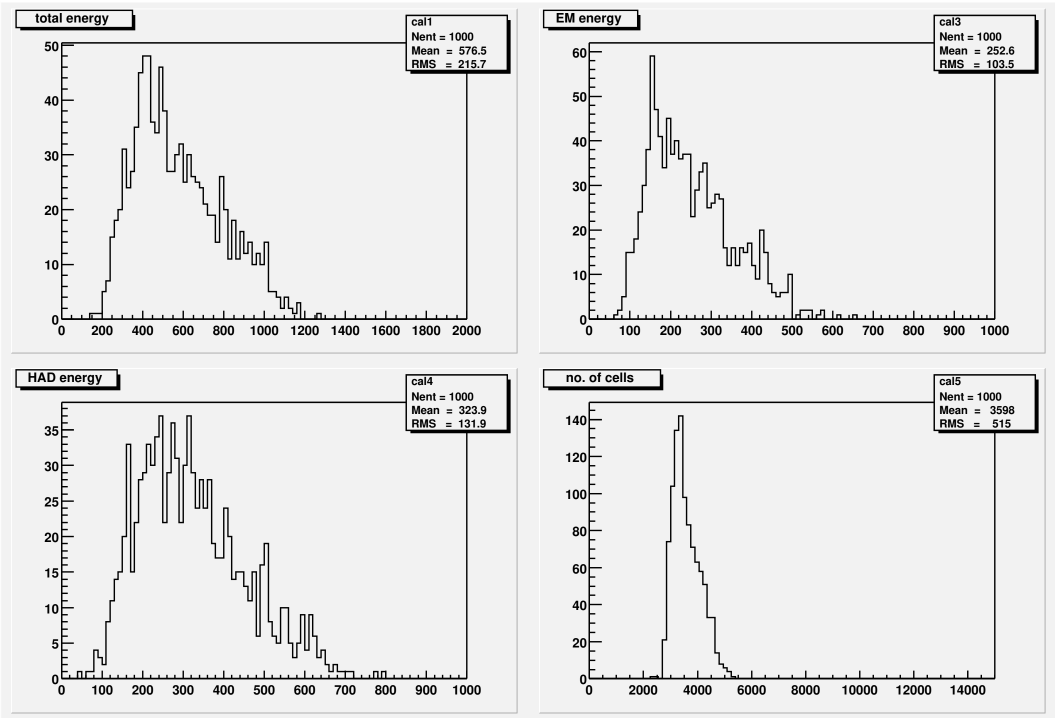

FIG. 3. QCD events with twice the default noise. The data has been zero- suppressed at the 2.0σ (scaled) level

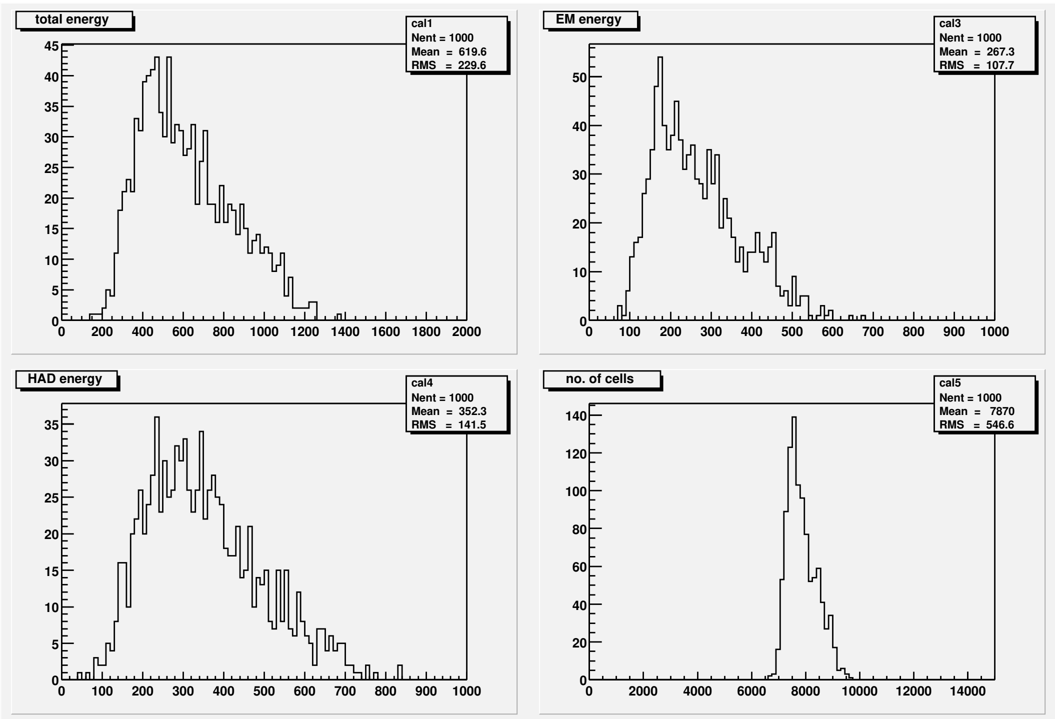

FIG. 4. QCD events with twice the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level

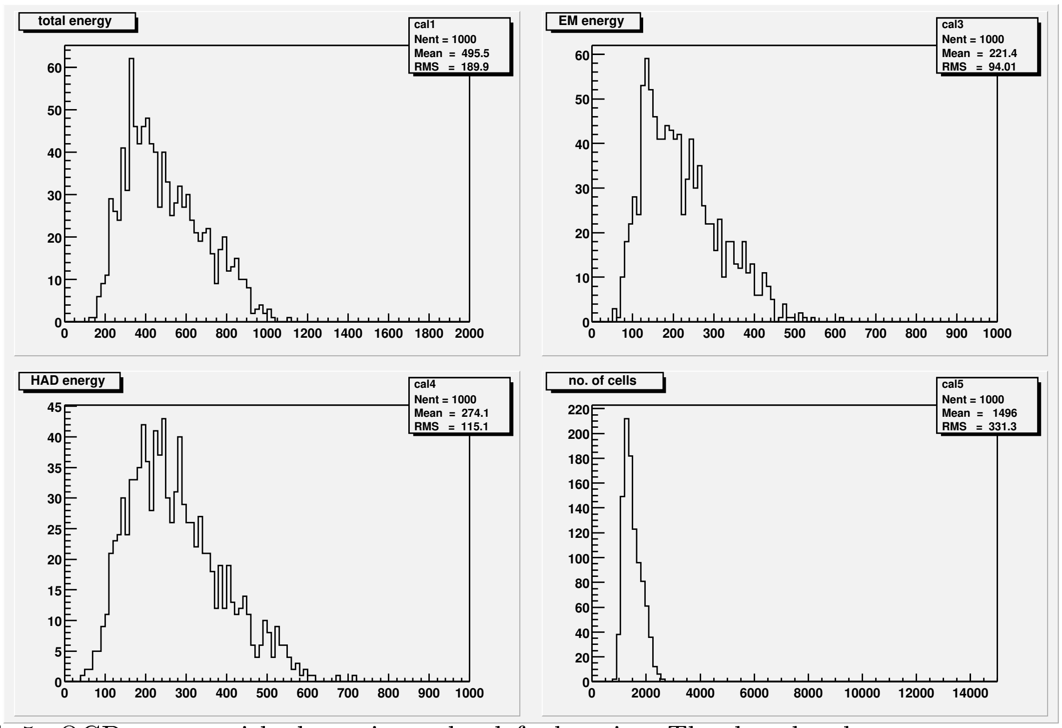

FIG. 5. QCD events with three times the default noise. The data has been zero- suppressed at the 2.5σ (scaled) level

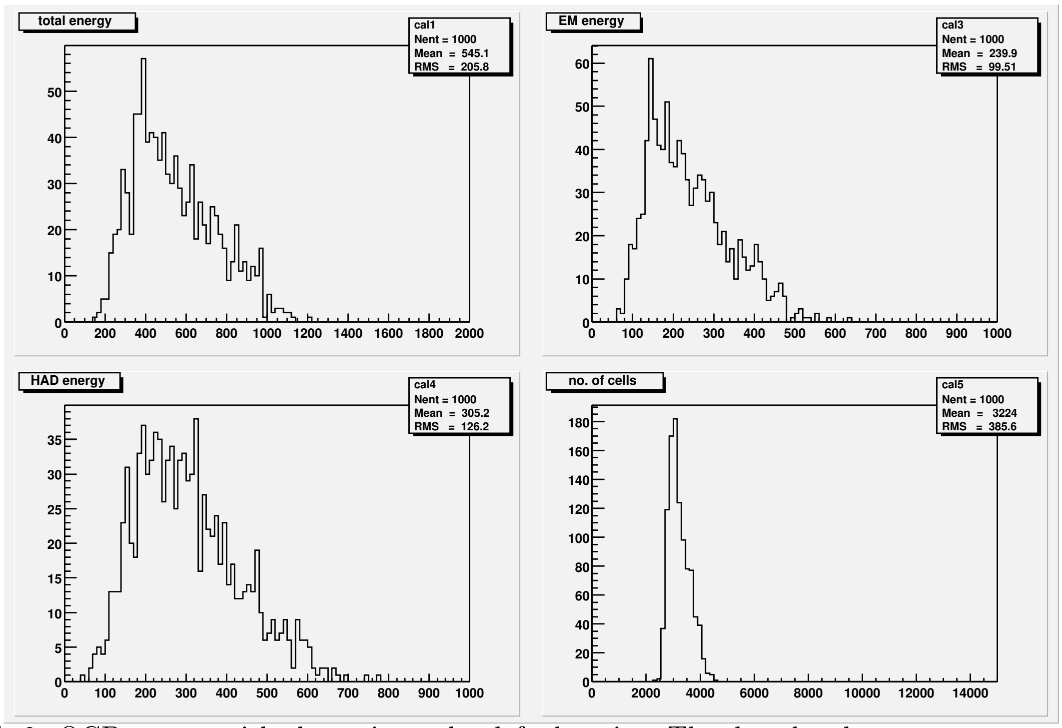

FIG. 6. QCD events with three times the default noise. The data has been zero- suppressed at the 2.0σ (scaled) level

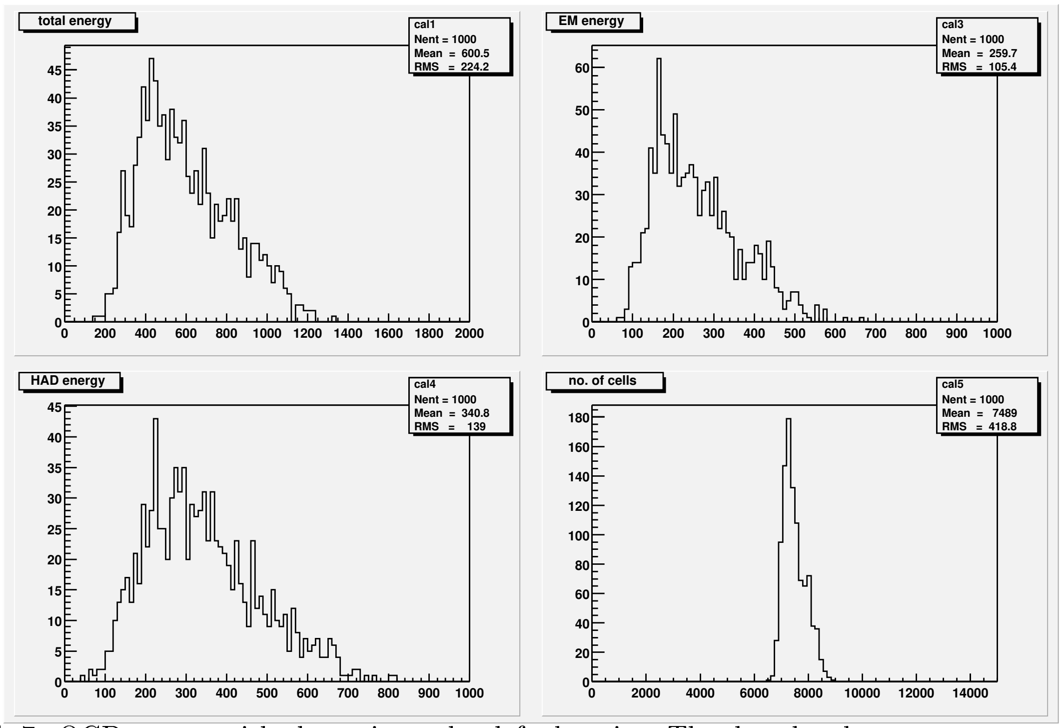

FIG. 7. QCD events with three times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level

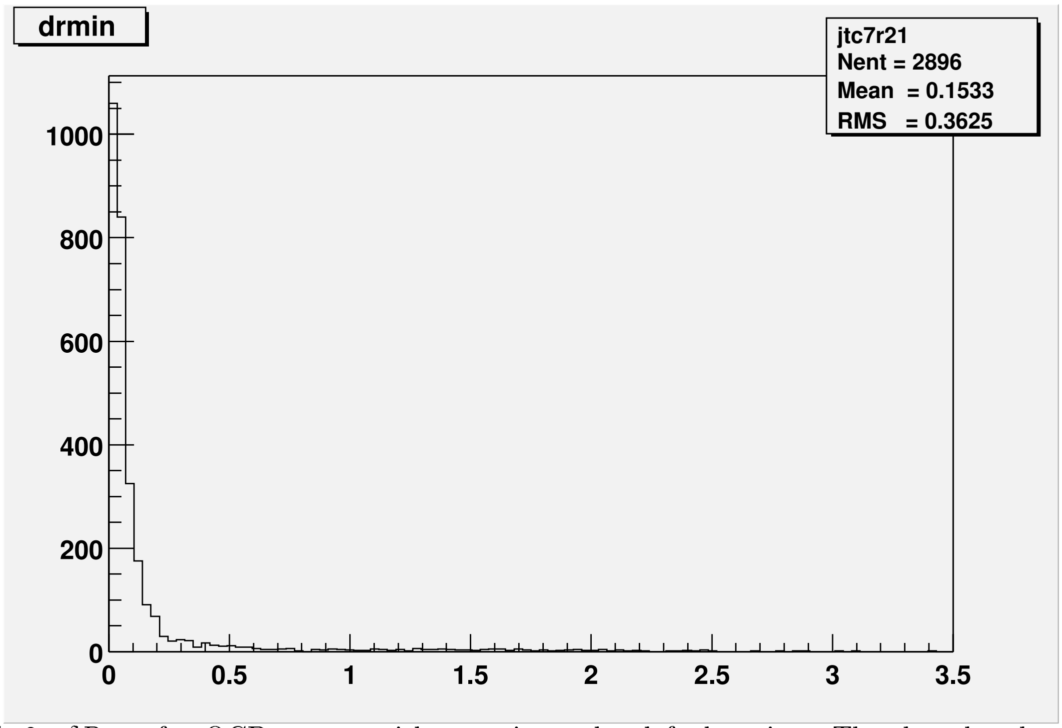

FIG. 8. δR_{min} for QCD events with two times the default noise. The data has been zero-suppressed at the 2.5σ (scaled) level

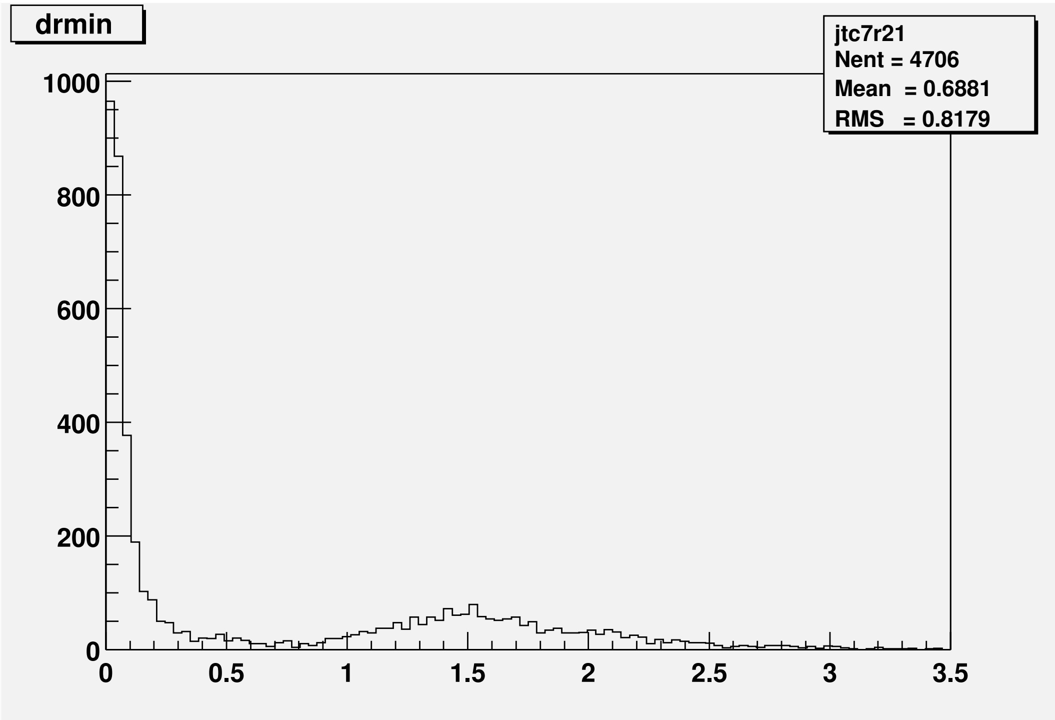

FIG. 9. δR_{min} for QCD events with two times the default noise. The data has been zero-suppressed at the 2.0σ (scaled) level

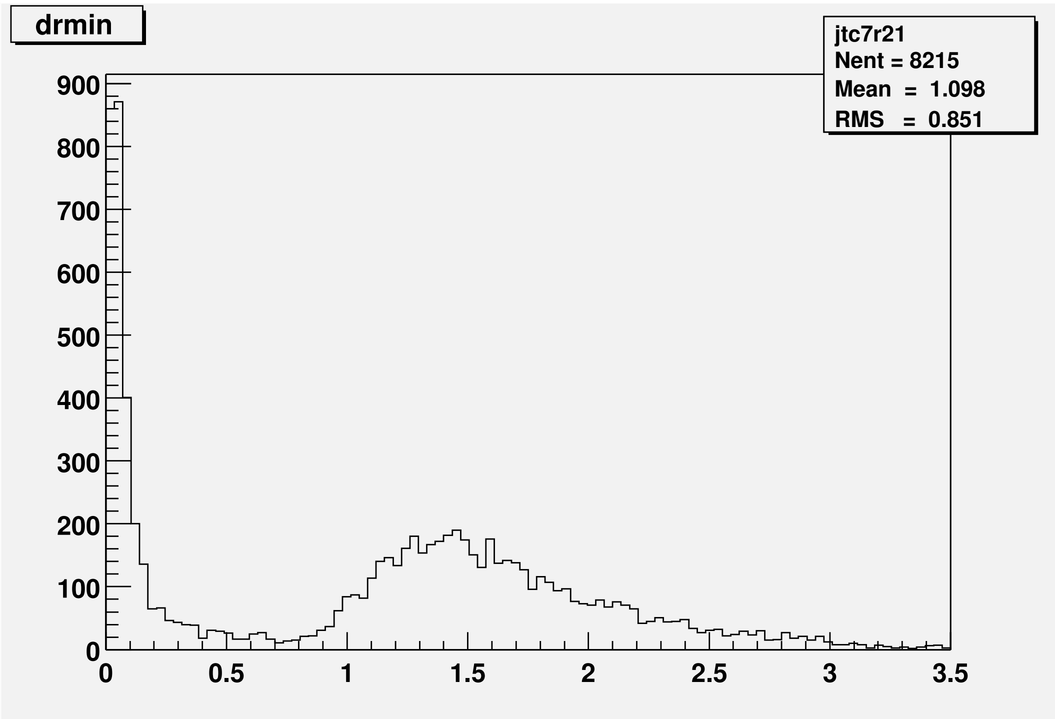

FIG. 10. δR_{min} for QCD events with two times the default noise. The data has been zero-suppressed at the 1.5σ (scaled) level

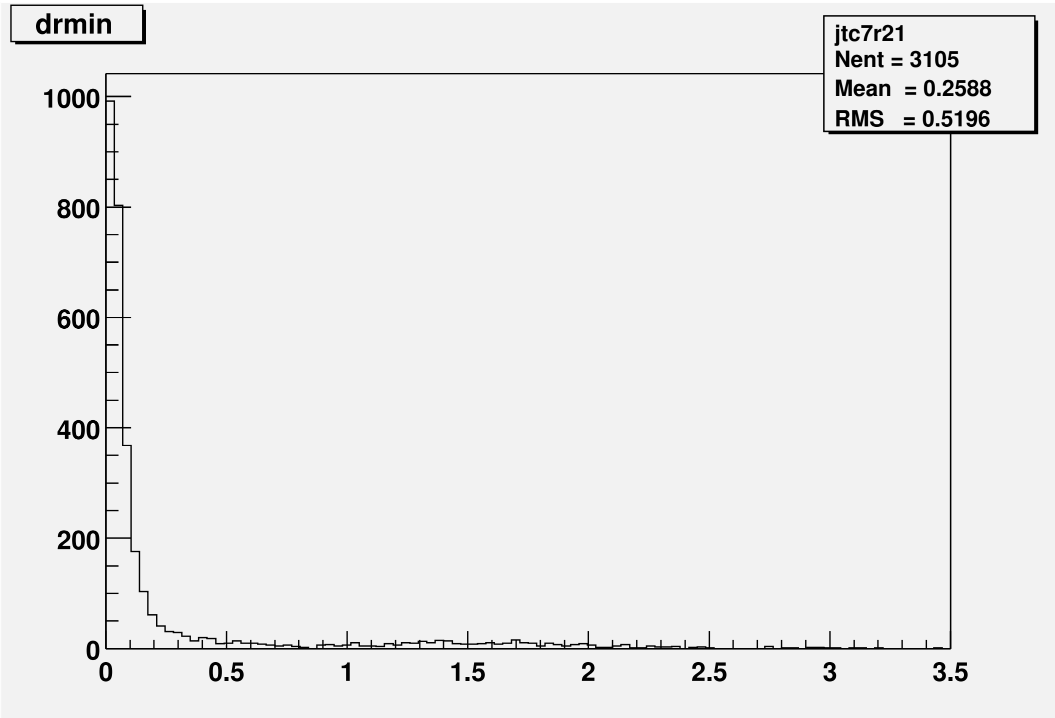

FIG. 11. δR_{min} for QCD events with three times the default noise. The data has been zero-suppressed at the 2.5σ (scaled) level

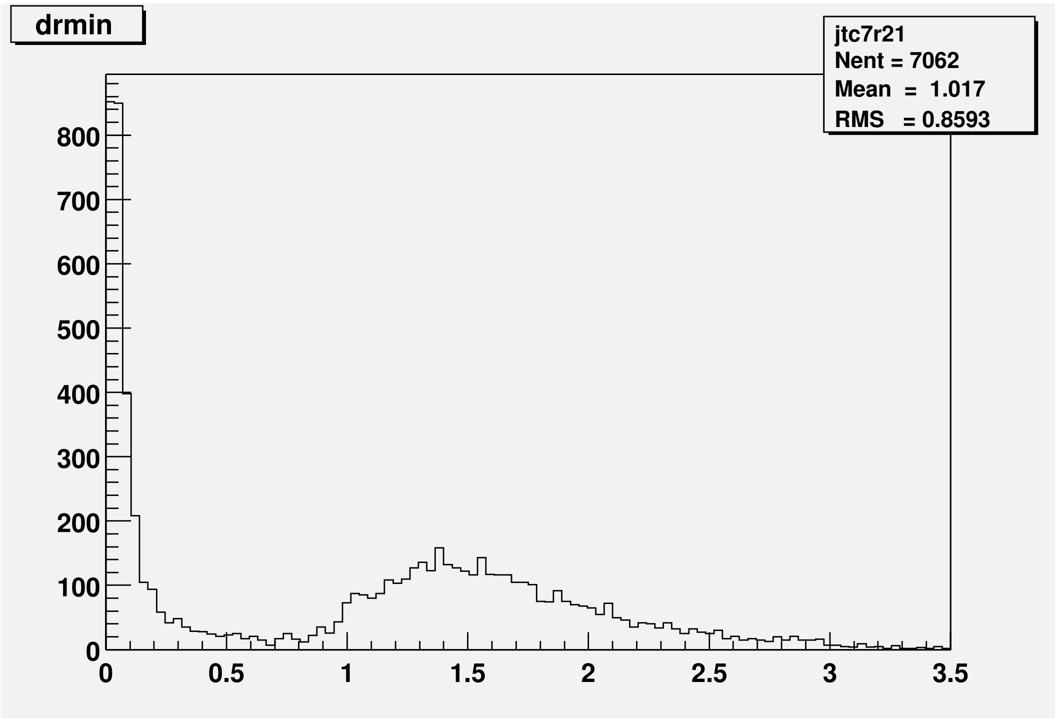

FIG. 12. δR_{min} for QCD events with three times the default noise. The data has been zero-suppressed at the 2.0σ (scaled) level

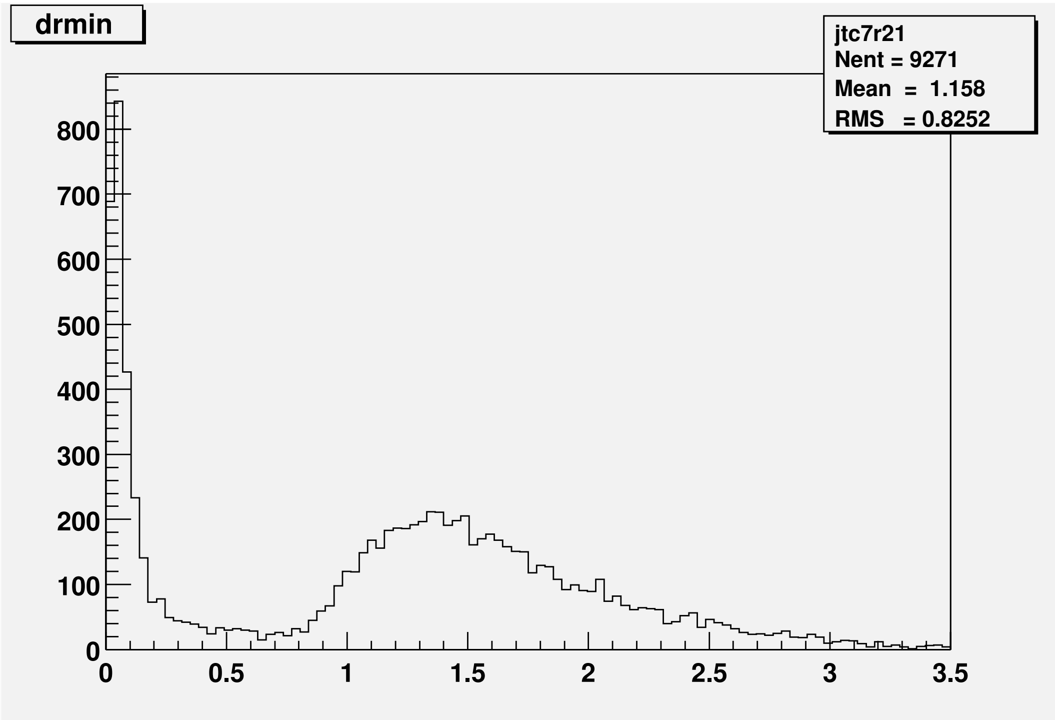

FIG. 13. δR_{min} for QCD events with three times the default noise. The data has been zero-suppressed at the 1.5σ (scaled) level

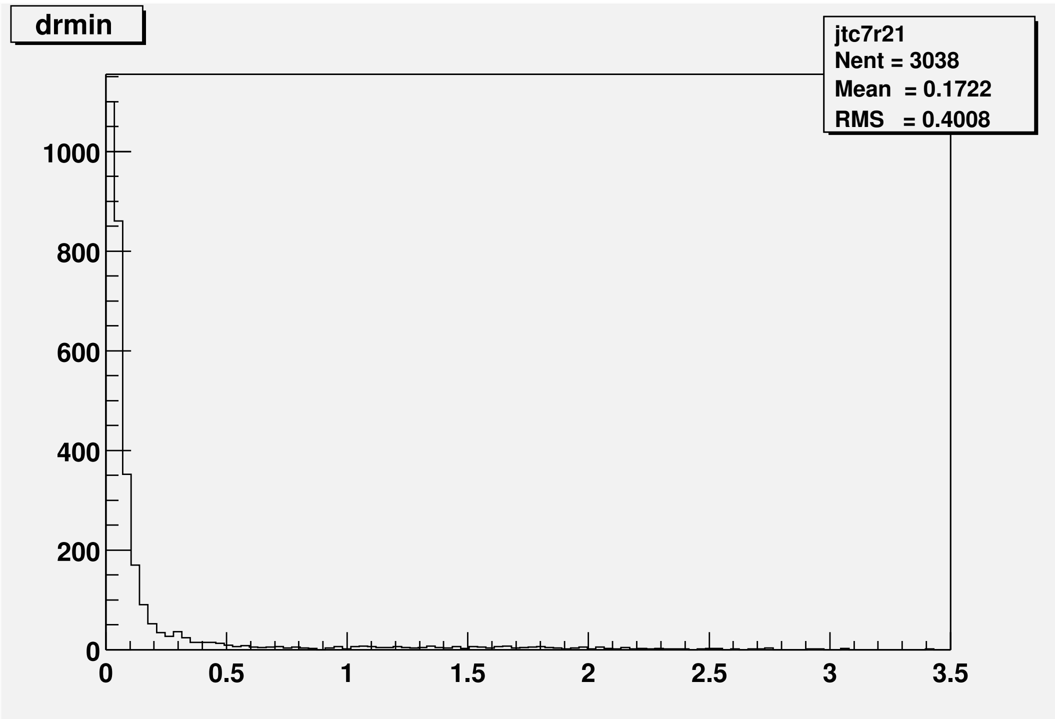

FIG. 14. δR_{min} for QCD events with no noise overlay

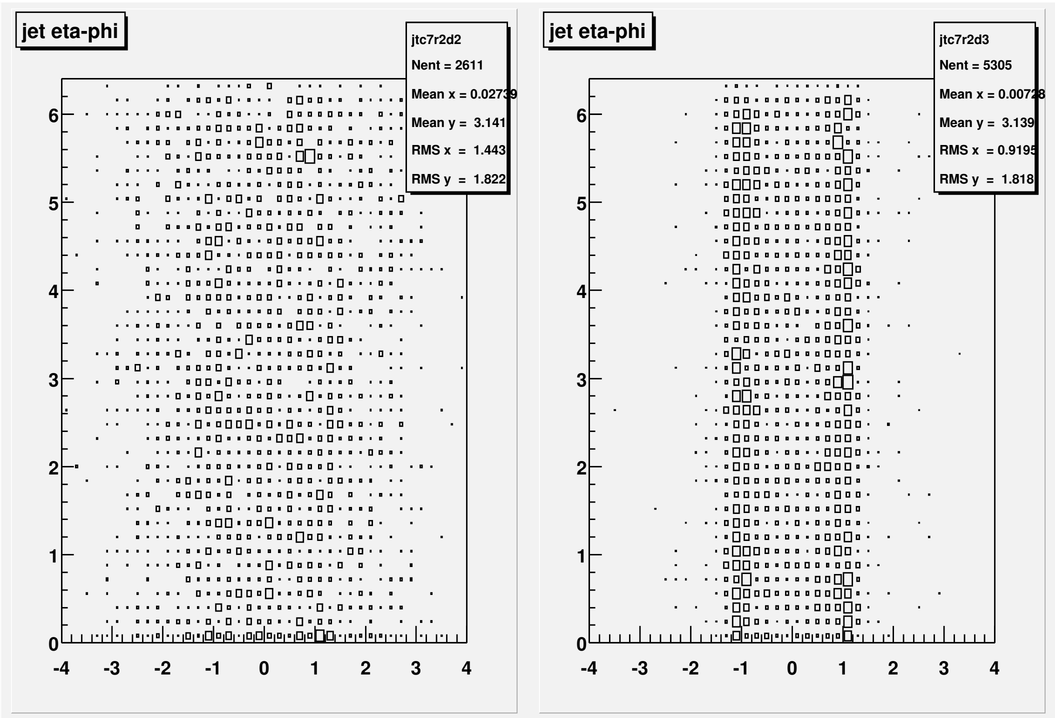

FIG. 15. True (left) and noise (right) jets in QCD events with two times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

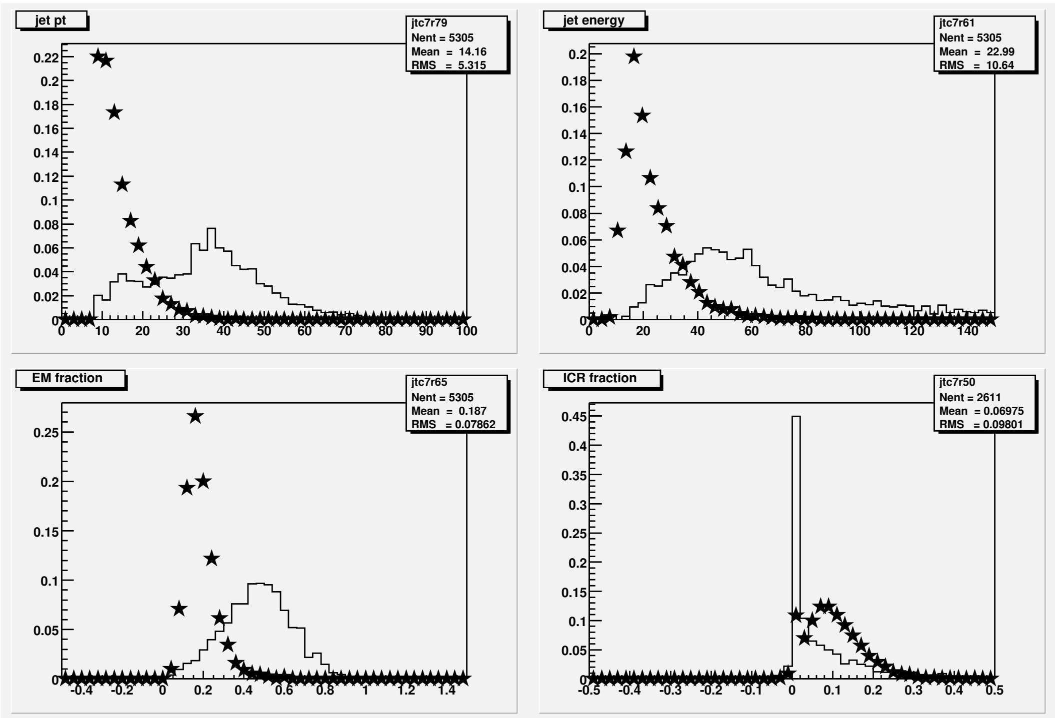

FIG. 16. True (histo) and noise (points) jets in QCD events with two times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

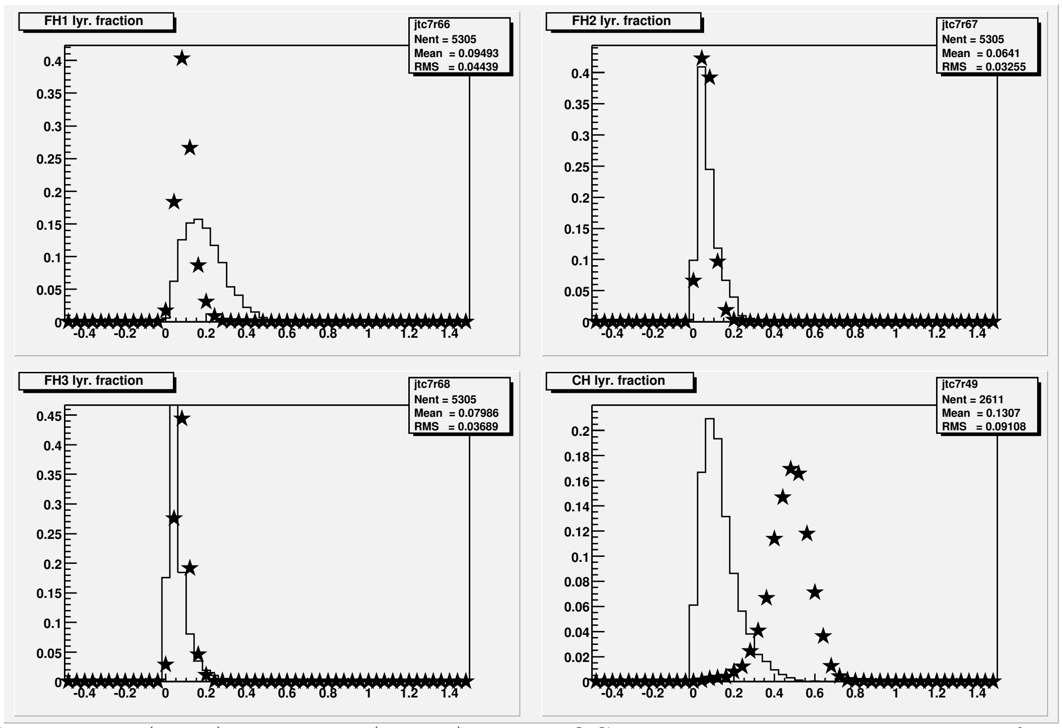

FIG. 17. True (histo) and noise (points) jets in QCD events with two times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

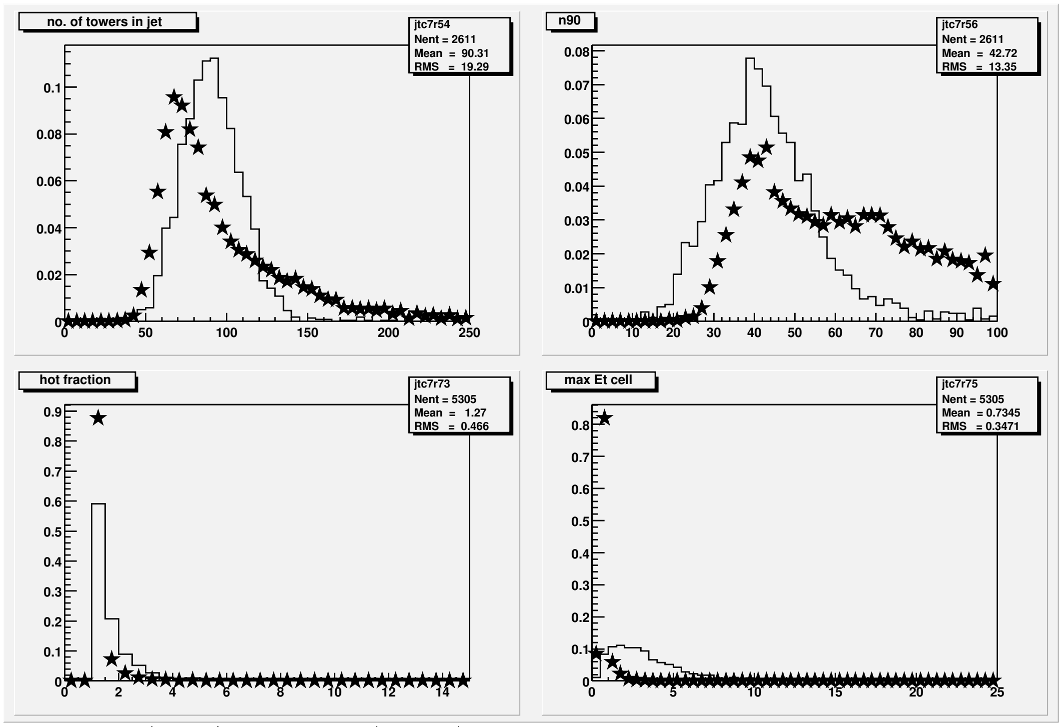

FIG. 18. True (histo) and noise (points) jets in QCD events with two times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

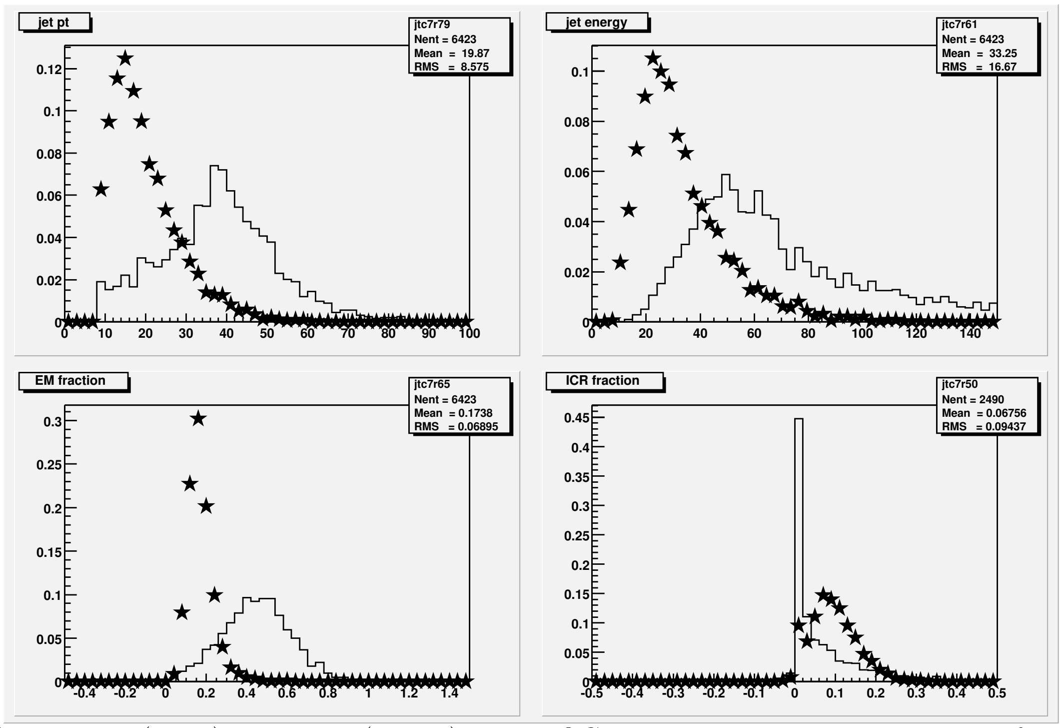

FIG. 19. True (histo) and noise (points) jets in QCD events with three times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

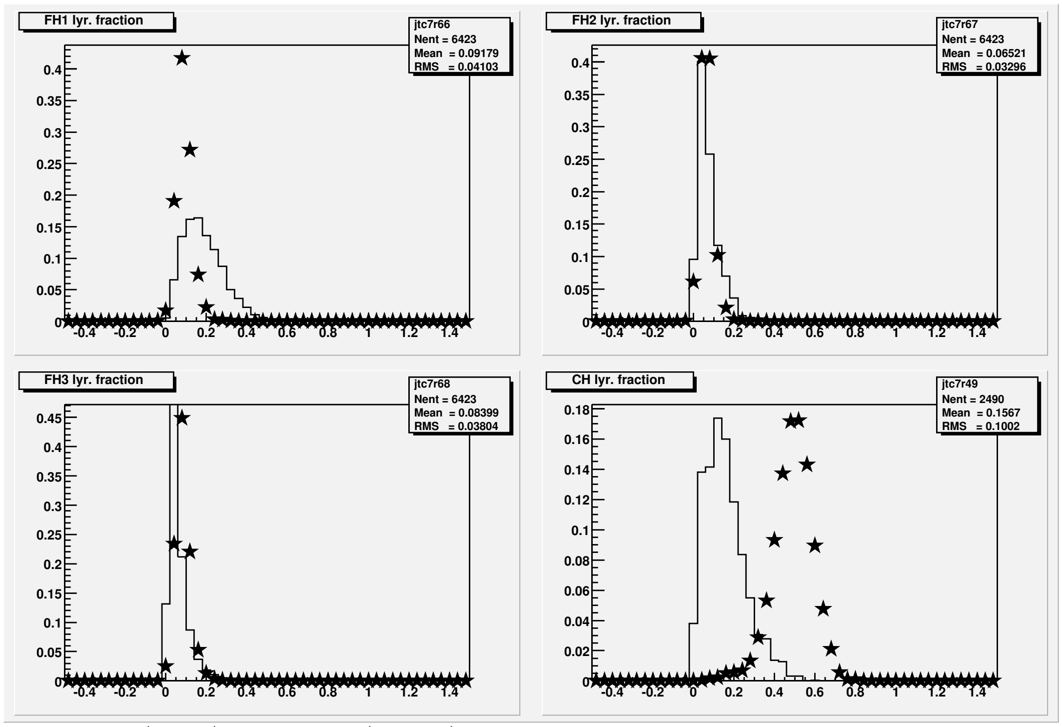

FIG. 20. True (histo) and noise (points) jets in QCD events with three times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

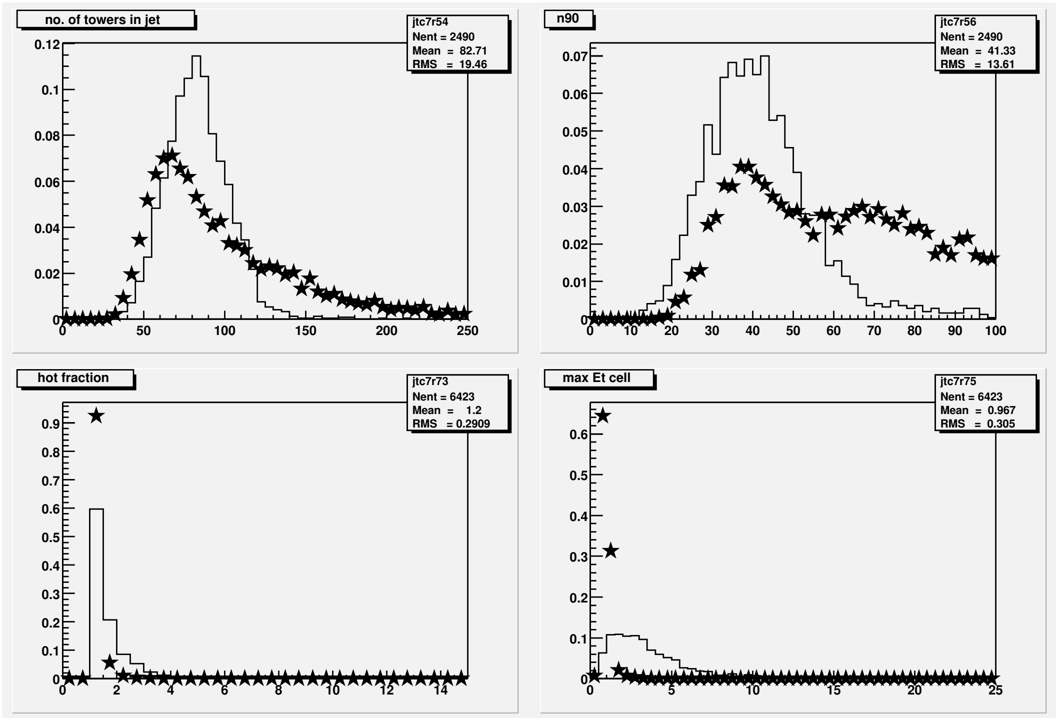

FIG. 21. True (histo) and noise (points) jets in QCD events with three times the default noise. The data has been zero- suppressed at the 1.5σ (scaled) level.

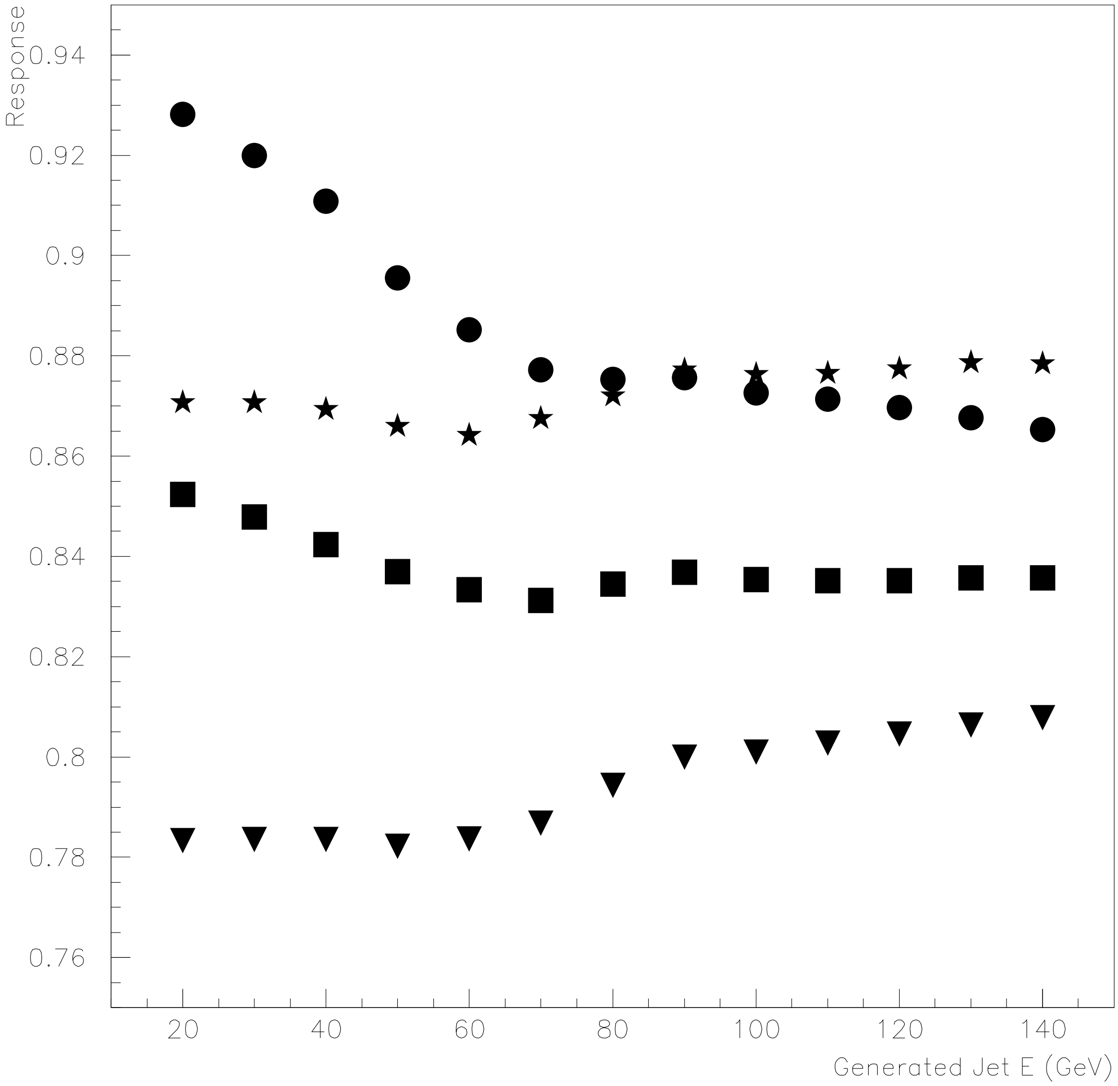

FIG. 22. Jet response as a function of the generated jet energy for QCD events with no noise (stars), twice the default noise with 1.5 (circles), 2.0 (squares) and 2.5 (triangles) σ zs

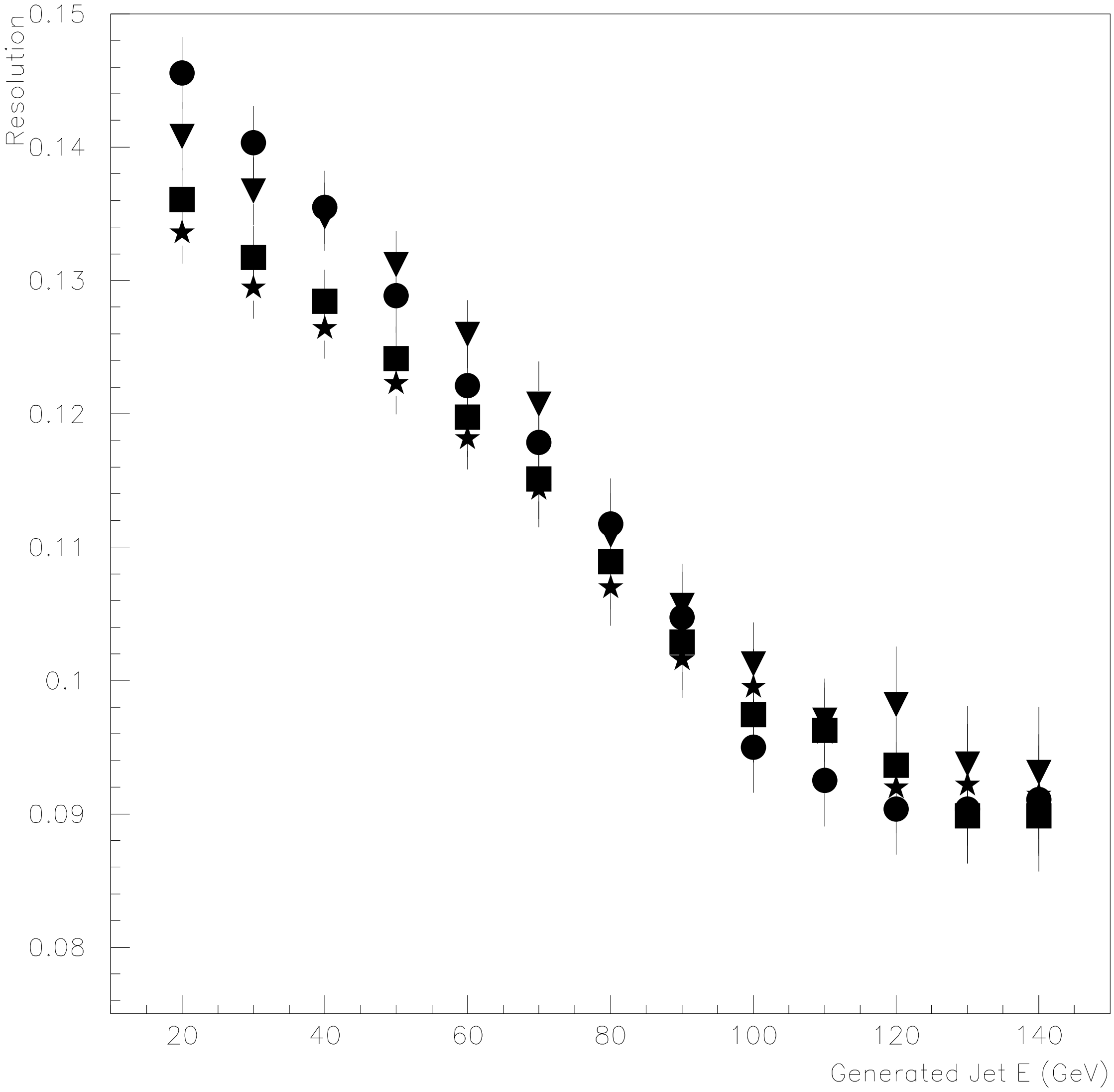

FIG. 23. Jet resolution as a function of the generated jet energy for QCD events with no noise (stars), twice the default noise with 1.5 (circles), 2.0 (squares) and 2.5 (triangles) σ zs

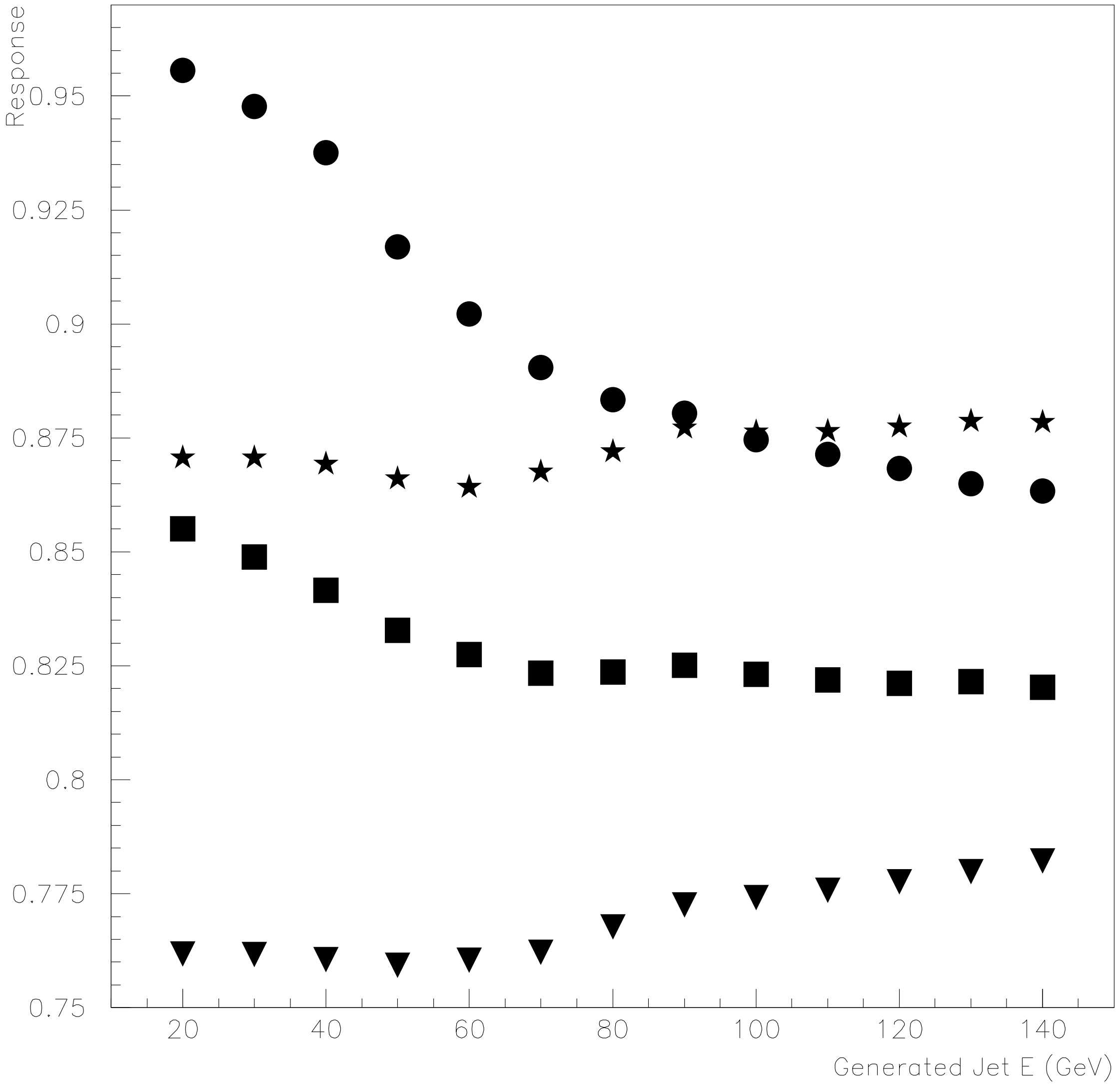

FIG. 24. Jet response as a function of the generated jet energy for QCD events with no noise (stars), three times the default noise with 1.5 (circles), 2.0 (squares) and 2.5 (triangles) σ zs

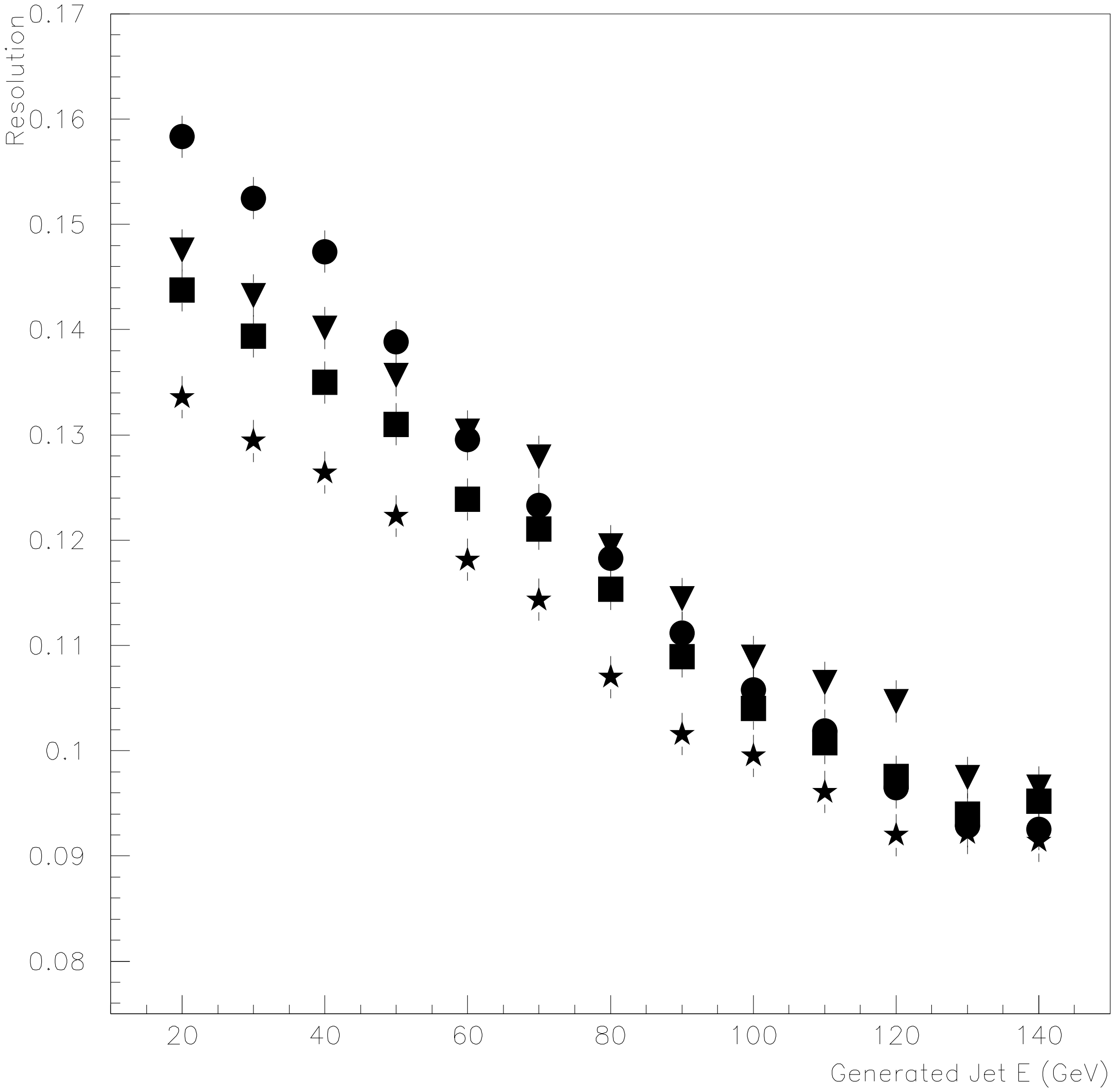

FIG. 25. Jet resolution as a function of the generated jet energy for QCD events with no noise (stars), three times the default noise with 1.5 (circles), 2.0 (squares) and 2.5 (triangles) σ zs

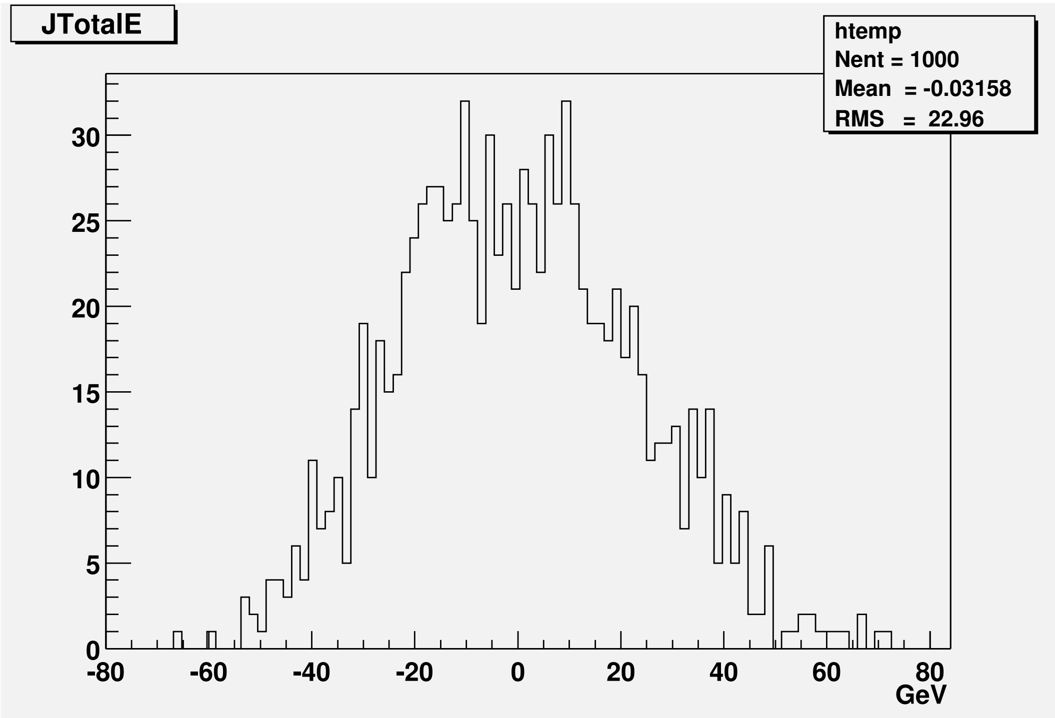

FIG. 26. Total energy distribution for 'just noise' events with three times the default noise and 1.5 σ zero-suppression

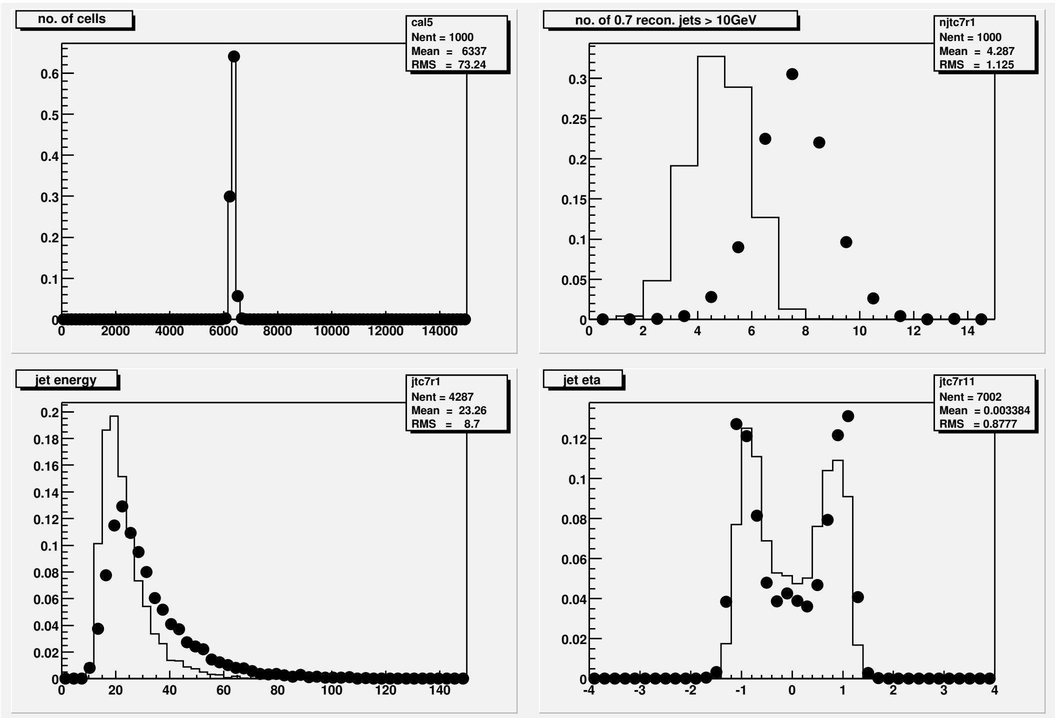

FIG. 27. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 1.5 σ zs

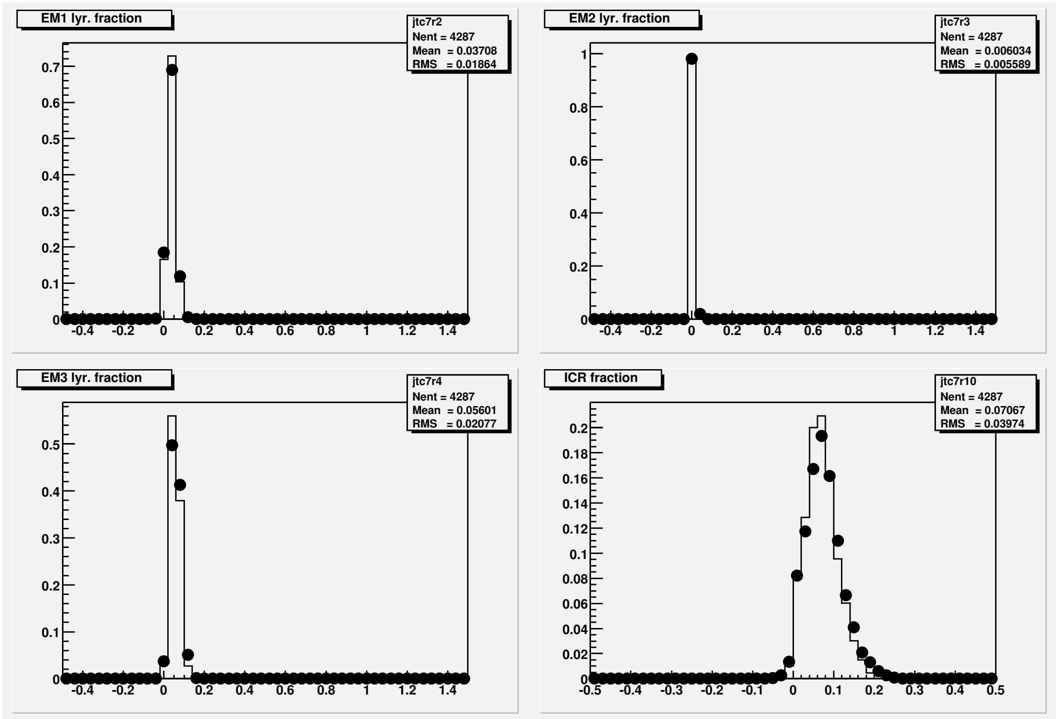

FIG. 28. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 1.5 σ zs

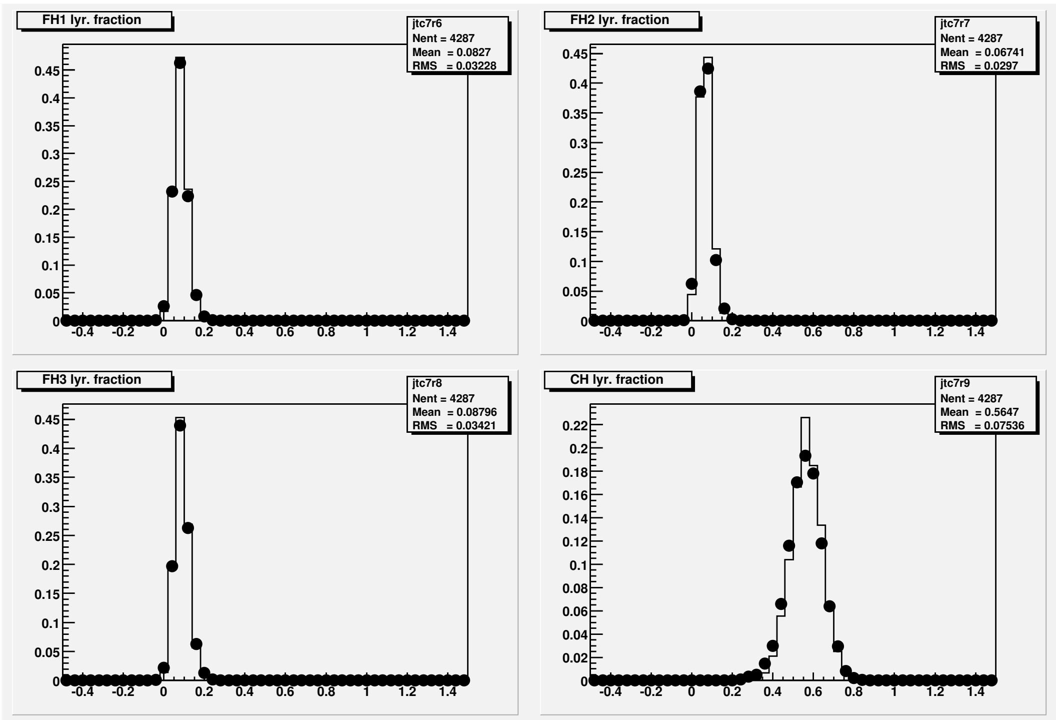

FIG. 29. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 1.5 σ zs

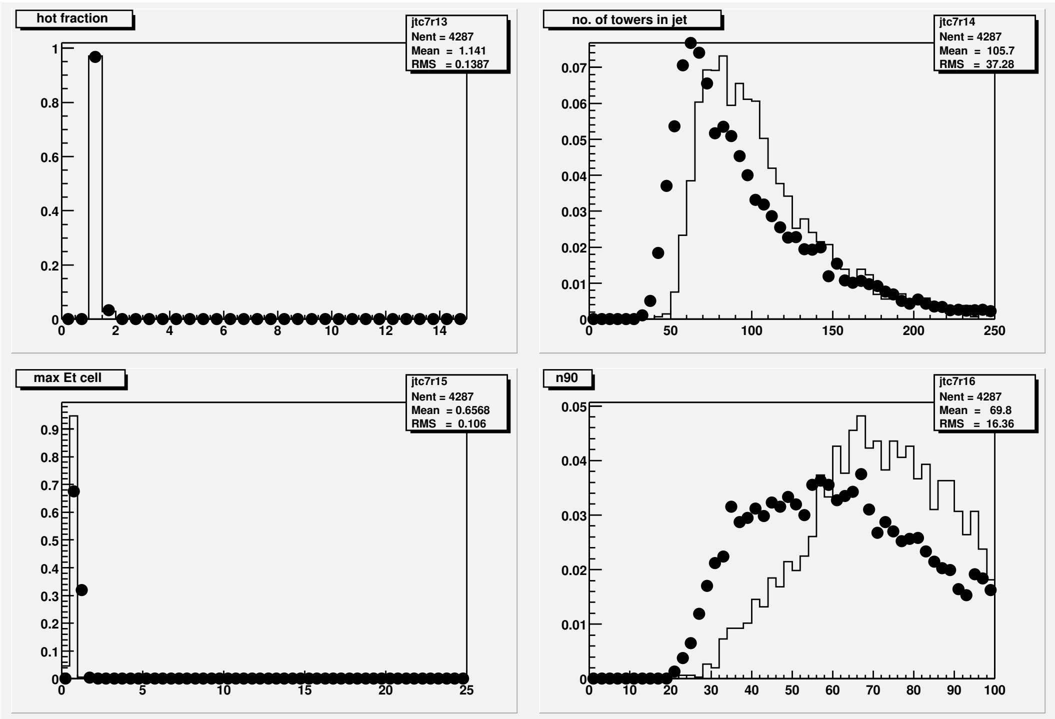

FIG. 30. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 1.5 σ zs

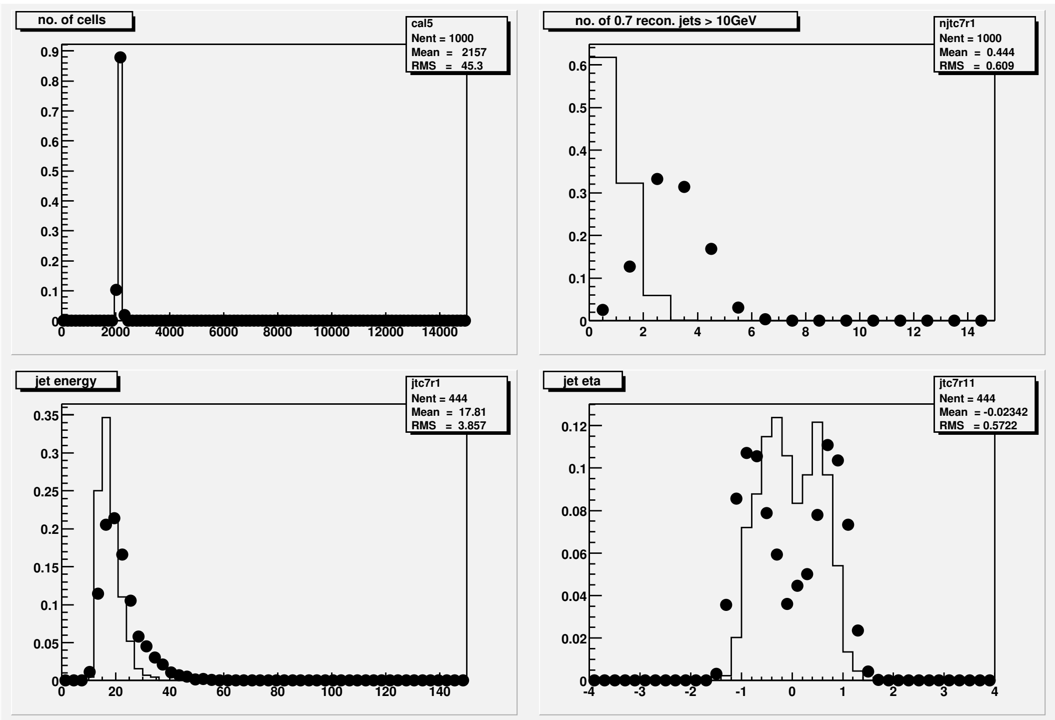

FIG. 31. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 2.0 σ zs

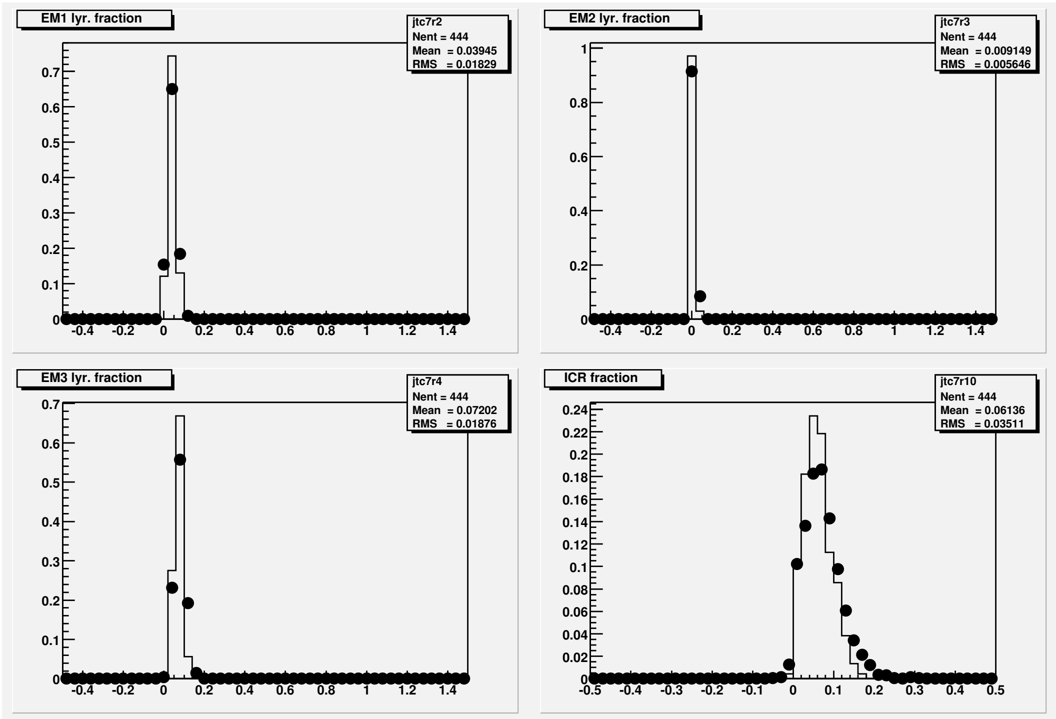

FIG. 32. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 2.0 σ zs

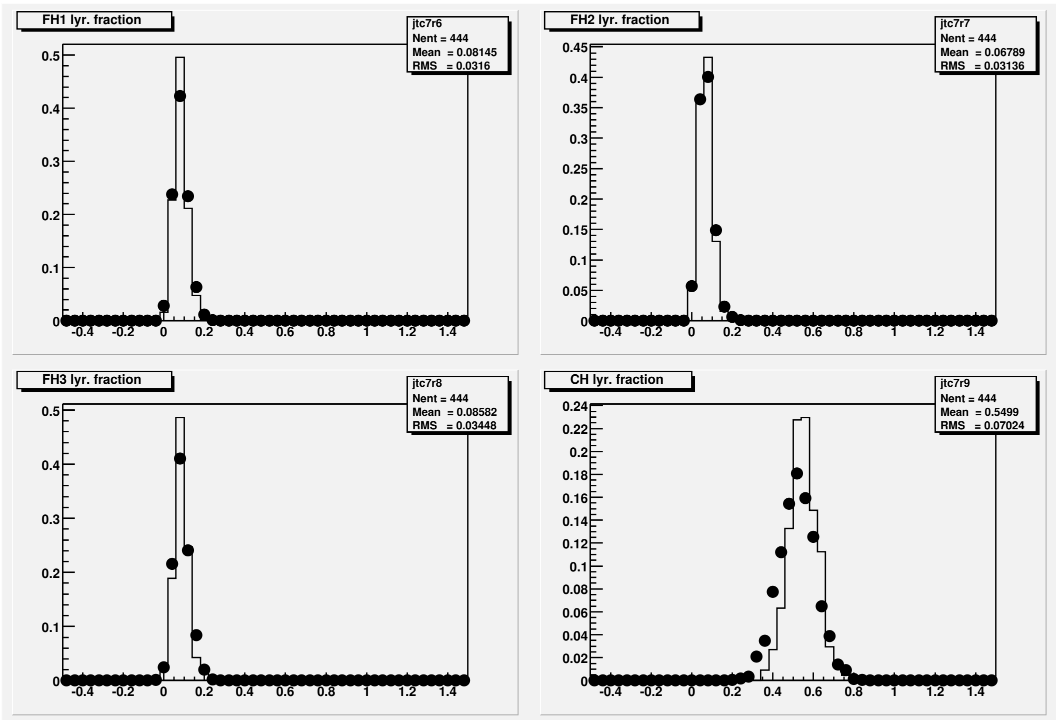

FIG. 33. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 2.0 σ zs

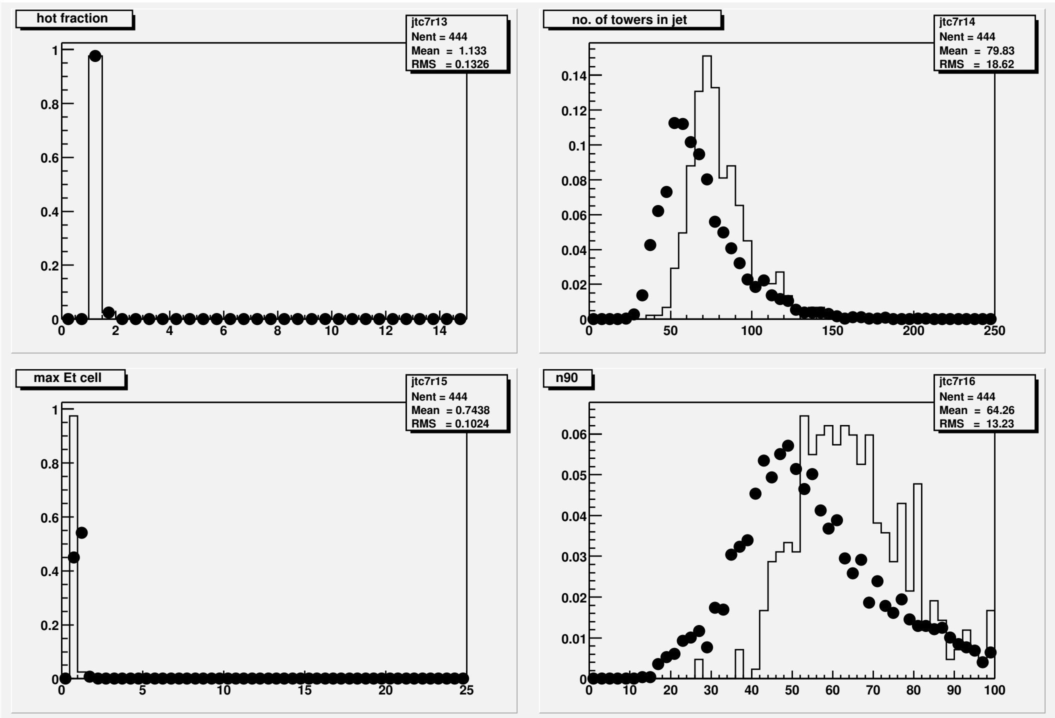

FIG. 34. Jets in 'just noise' events with two (histogram) and three (circles) times the default noise and 2.0 σ zs

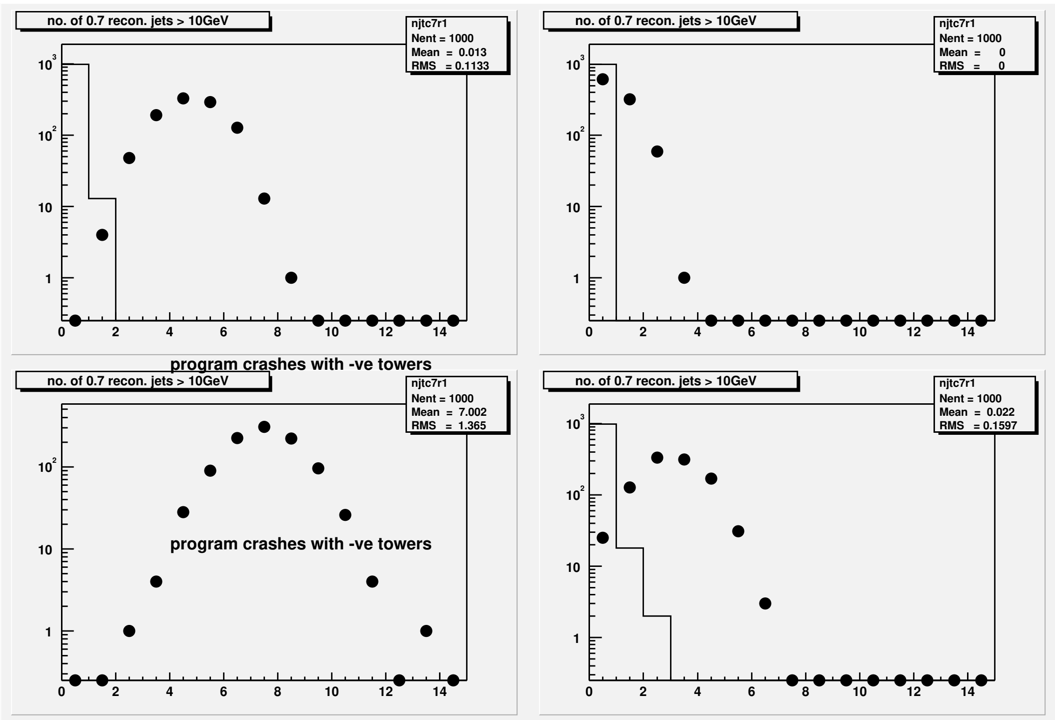

FIG. 35. Jets in 'just noise' events with two (upper row) and three (bottom row) times the default noise with 1.5 (left coulmn) and 2.0 (right column) σ zs. Clustering done with only +ve (circles) or with both +ve and -ve towers (histogram) is shown.

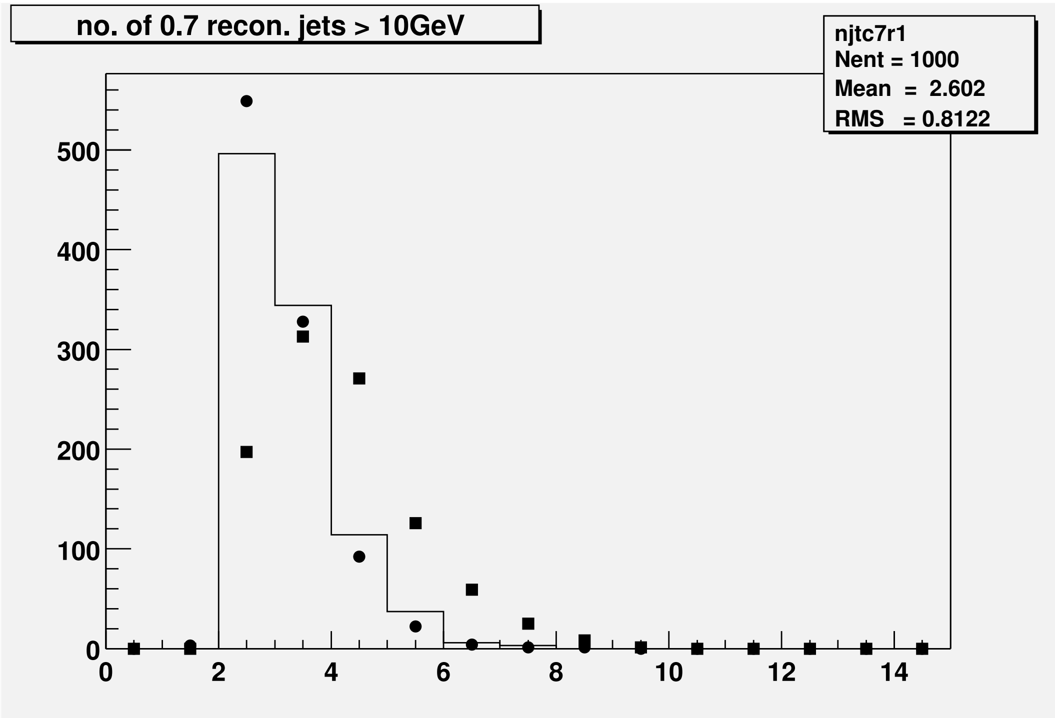

FIG. 36. Jets in QCD events with no noise (histogram) and two times the default noise with 2.0 σ zs. Clustering is done with all towers (circles) or only positive towers (squares) in the noise overlayed sample

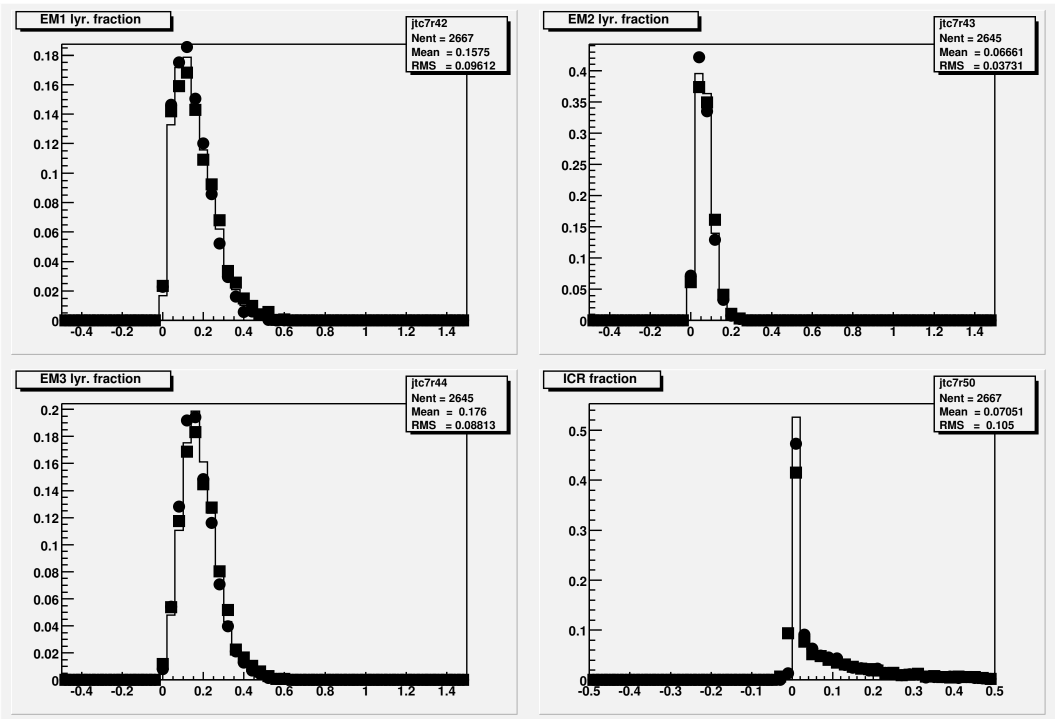

FIG. 37. Jets in QCD events with no noise (histogram) and two times the default noise with 2.0 σ zs. Clustering is done with all towers (squares) or only positive towers (circles) in the noise overlayed sample

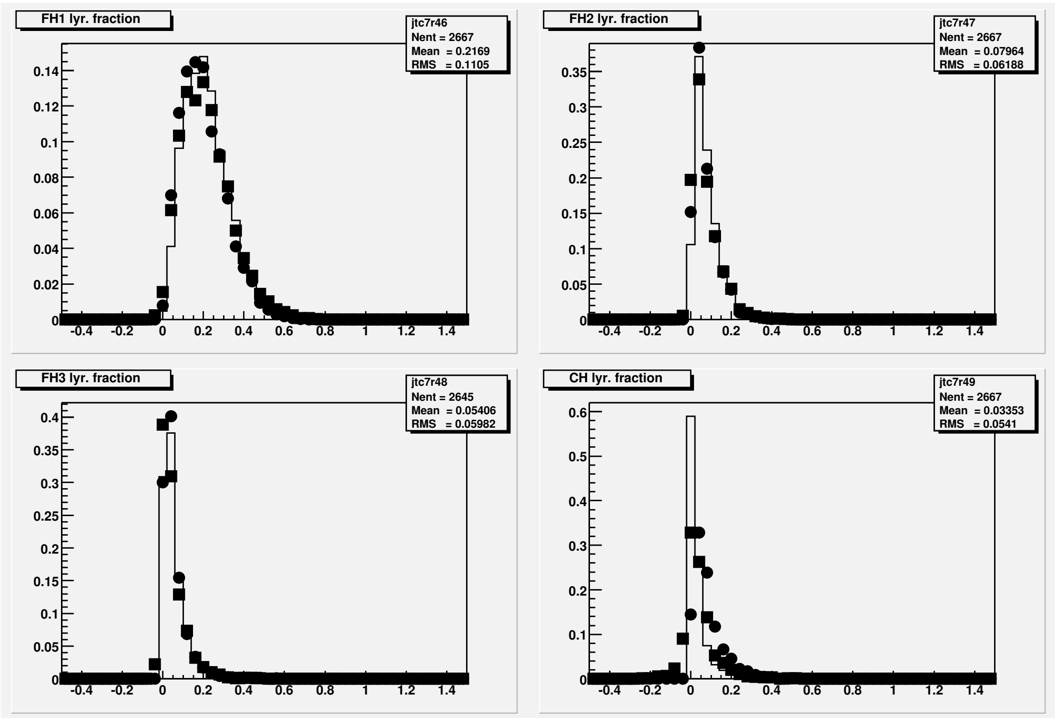

FIG. 38. Jets in QCD events with no noise (histogram) and two times the default noise with 2.0 σ zs. Clustering is done with all towers (squares) or only positive towers (circles) in the noise overlayed sample

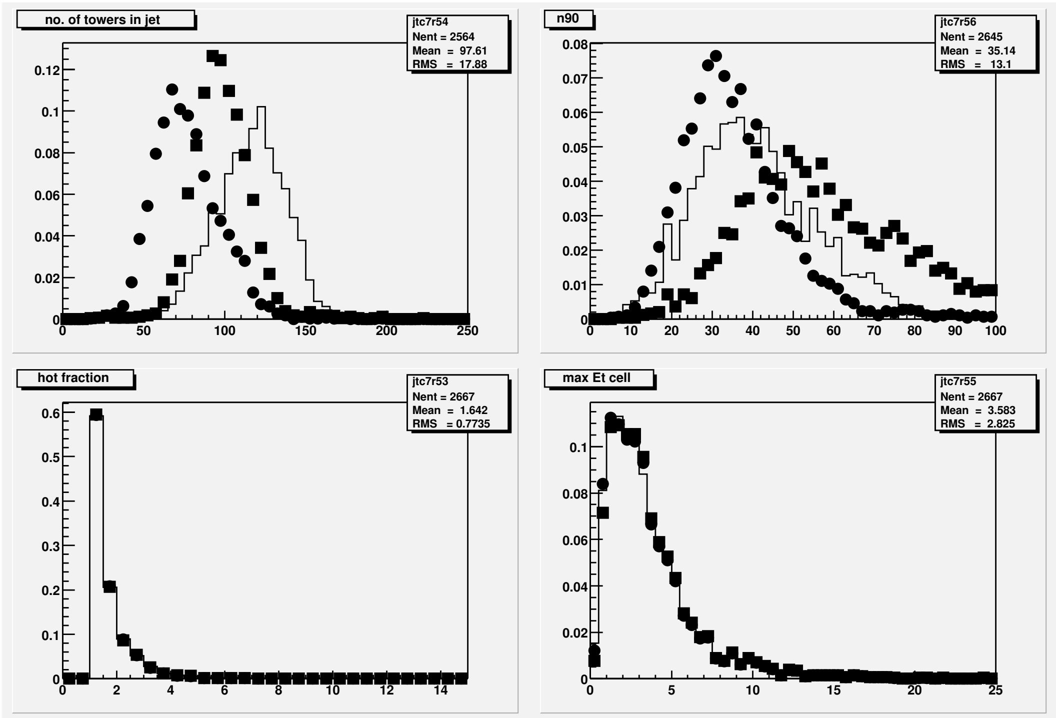

FIG. 39. Jets in QCD events with no noise (histogram) and two times the default noise with 2.0 σ zs. Clustering is done with all towers (squares) or only positive towers (circles) in the noise overlayed sample

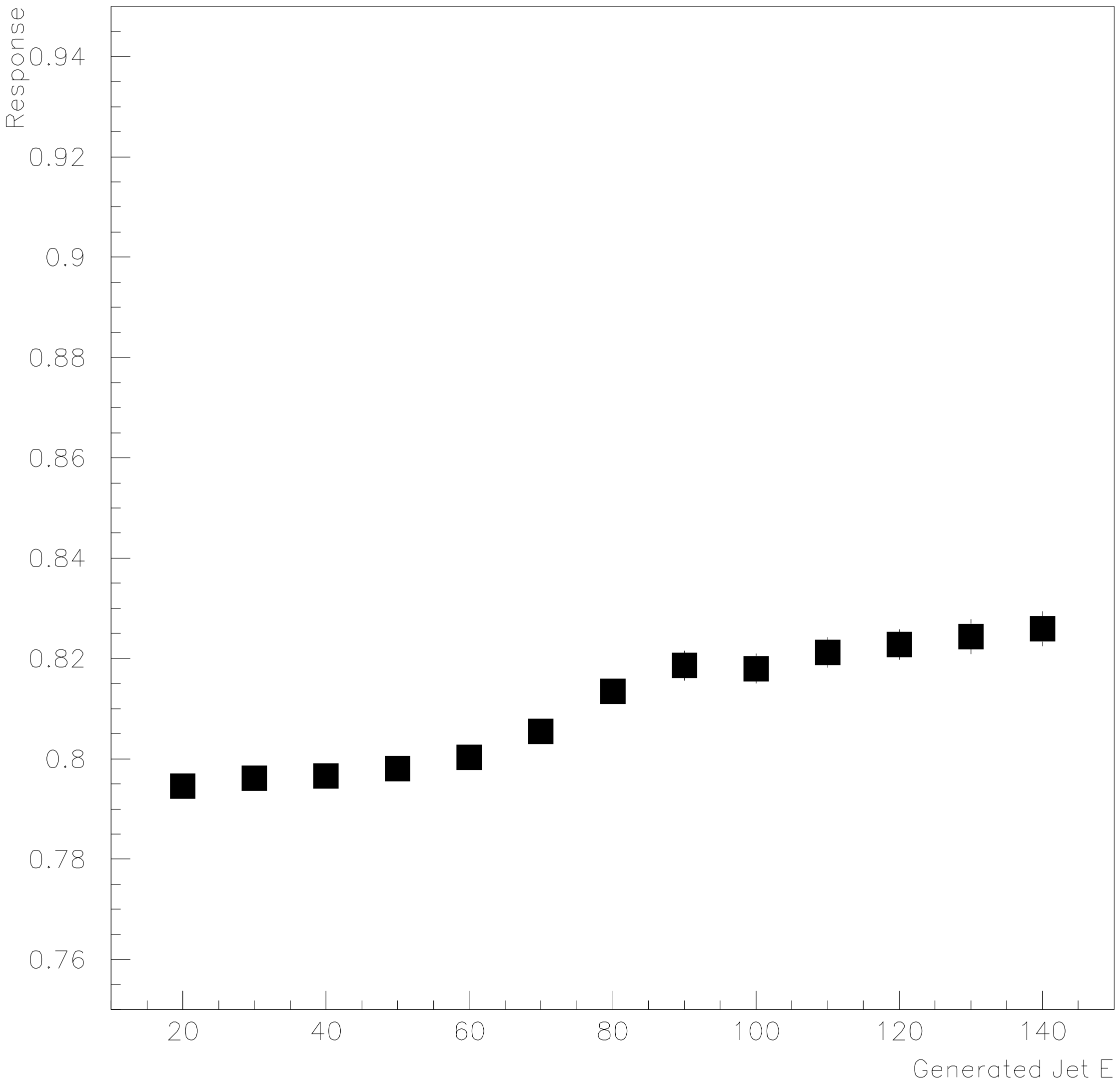

FIG. 40. Jet response for QCD jets with two times the default noise and 2.0 σ zs. All towers (+ve and -ve) have been clustered.

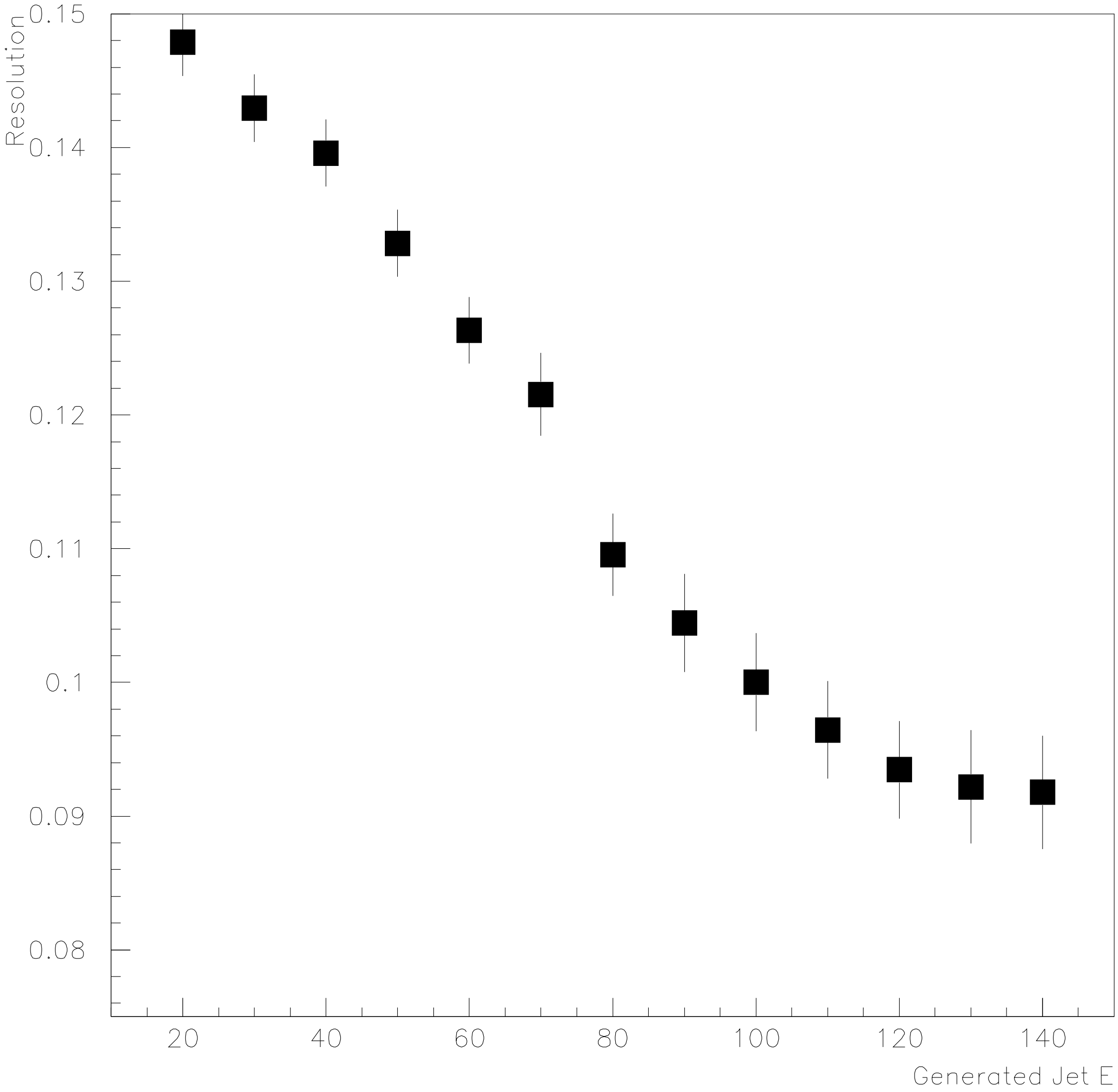

FIG. 41. Jet resolution for QCD jets with two times the default noise and 2.0 σ zs. All towers (+ve and -ve) have been clustered.

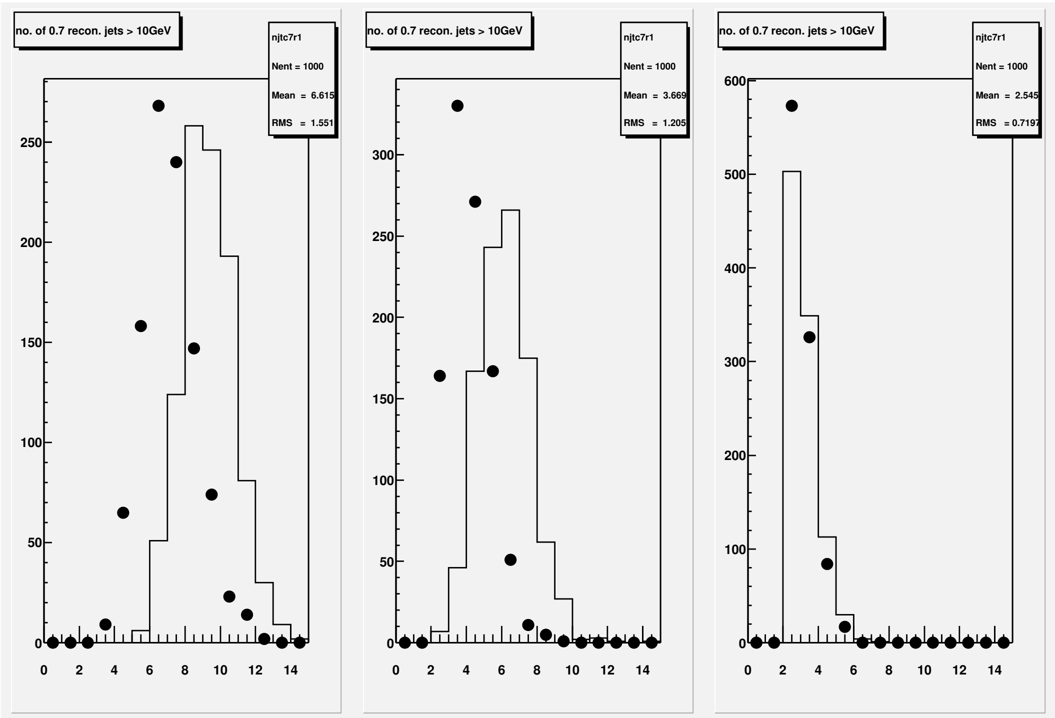

FIG. 42. Number of jets in QCD events overlayed with three times the default noise with default (histogram) and higher seed-precluster (circles) thresholds. The data has been suppressed at the 1.5 (left), 2.0 (center) and 2.5 (right) σ level.