Jet energy scale setting with ”γ + Jet” events at LHC energies. Selection of events with a clean ”γ + Jet” topology and $P_t^\gamma - P_t^{Jet}$ disbalance.

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Abstract

It is shown in the paper that $P_t$ activity limitation (modulus of the vector sum) of all particle beyond ”γ + Jet” system $P_t^\text{out}$ leads to the noticeable $P_t^\gamma$ and $P_t^{Jet}$ disbalance decreasing. On a simultaneous restriction of the cluster $P_t$ and $P_t^\text{out}$ from above it is possible to reach an acceptable balance between $P_t^\gamma$ and $P_t^{Jet}$ with a sufficient number of the ”γ + Jet” events for the jet energy scale setting and hadron calorimeter calibration of the CMS detector at LHC.
1. INTRODUCTION

Here we continue a detailed study of the $P_t^\gamma$ and $P_t^{\text{Jet}}$ disbalance and are planning to show how the calibration accuracy can be improved by simultaneous imposing both cuts $P_{\text{CUT}}^{\text{clus}}$ and $P_{\text{CUT}}^{\text{out}}$ as well as by introduction of jet isolation requirement.

2. DETAILS OF $P_t^\gamma$ AND $P_t^{\text{Jet}}$ DISBALANCE DEPENDENCE ON $P_{\text{CUT}}^{\text{clus}}$ AND $P_{\text{CUT}}^{\text{out}}$ PARAMETERS.

In the previous papers ([1, 2]) we introduced observables (variables) and discussed what cuts for them may lead to a decrease in the $P_t^\gamma$ and $P_t^{\text{Jet}}$ disbalance. Below we concentrate on three of them: a restriction of cluster $P_t$ ($P_{\text{CUT}}^{\text{clus}}$), limitation of the summed vector $P_t$ of all particles detectable in the $|\eta| < 5$ region out of the "$\gamma + \text{Jet}$" system ($P_{\text{CUT}}^{\text{out}}$), the cut for jet isolation ($e^{\text{jet}}$)\(^1\).

Figs. 1–7 can be considered as an illustration and a complement to the tables of Appendixes 1–4 of [3]. In Fig. 1 we show a dependence of the ratio \((P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma\) on the $P_{\text{CUT}}^{\text{clus}}$ value for the case of Selection 1 and two jetfinders LUCELL and UA1 for two $P_t^\gamma$ intervals $40 < P_t^\gamma < 50$ GeV/c and $300 < P_t^\gamma < 360$ GeV/c. An evident tendency of balance improvement with decreasing $P_{\text{CUT}}^{\text{clus}}$ is revealed for all three jetfinding algorithms and both $P_t^\gamma$ intervals. It is seen that we can essentially increase the accuracy by constraining $P_{\text{CUT}}^{\text{clus}}$ (without $P_{\text{CUT}}^{\text{out}}$ restriction) by 5 GeV/c. Thus, for the UA1 algorithm the mean and RMS values of $(P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma$ drop from 0.029 down to 0.021 and from 0.174 down to 0.105, respectively, in the first $P_t^\gamma$ interval. For the LUCELL algorithm the situation after such a strict cut becomes even better. In Figs. 2–5 the average values for the $(P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma$ variable and the number of events for $L_{\text{int}} = 3$ fb\(^{-1}\) are displayed for two types of Selections as a function of $P_{\text{CUT}}^{\text{clus}}$ for four $P_t^\gamma$ intervals and for all three jetfinders. Again, passing to Selection 2 we see that for all $P_t^\gamma$ intervals and for both jetfinders the balance gradually improves with restricting $P_{\text{CUT}}^{\text{clus}}$. After limiting $P_t$ activity in the ring around the jet (Figs. 4, 5) the disbalance drops to the 1% level for the $40 < P_t^\gamma < 50$ GeV/c interval and for $P_{\text{CUT}}^{\text{clus}} = 5$ GeV/c. The number of events in this case decreases by a factor of 5 as compared with Selection 1. It falls down to 30–50 thousand events at $L_{\text{int}} = 3$ fb\(^{-1}\), which seems to be still quite sufficient statistics for accurate determination of the jet scale and calibration. It should be noted that starting from $P_t^\gamma = 100$ GeV/c practically all events in the Selection 2 sample are comprised inside the 1% accuracy window. At the same time the number of events decreases by about twofold with respect to Selection 1.

Up to now we have been studying the influence of the $P_{\text{CUT}}^{\text{clus}}$ parameter on the balance. Let us see in analogy with Fig. 6 what effect is produced by the $P_{\text{CUT}}^{\text{out}}$ variation. If we constrain this variable by 5 GeV/c, keeping $P_{\text{CUT}}^{\text{clus}}$ weakly restricted by $P_{\text{CUT}}^{\text{clus}} = 30$ GeV/c (practically unbound), then, as can be seen from Fig. 6, the mean and RMS values of the $(P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma$ variable in the case of UA1 algorithm decrease from 3% down to 1.6% and from 17.4% down to 8.8%, respectively, for $40 < P_t^\gamma < 50$ GeV/c. For LUCELL jetfinder the $(P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma$ value is even less. At $300 < P_t^\gamma < 360$ GeV/c practically all events have the mean and RMS values of $(P_t^\gamma - P_t^{\text{Jet}})/P_t^\gamma$ less than 1.3% and 5%, respectively.

The influence of the $P_{\text{CUT}}^{\text{out}}$ variation (with the fixed value $P_{\text{CUT}}^{\text{clus}} = 10$ GeV/c)\(^1\)

\(^1\)For the detailed explanation of cuts used here we refer the reader to papers [1–3].
on the distribution of \((P_t^\gamma - P_t^J)/P_t^\gamma\) is shown in Fig. 7 for Selection 1. In this case the mean value drops from 2\% to 1.5\% for UA1 and to about 1\% for the LUCELL algorithm for \(40 < P_t^\gamma < 50 \text{ GeV/c}\) interval. At the same time RMS changes from 10 – 11\% to 8\% level for all algorithms.

3. SUMMARY

The new cuts introduced in [1] \(P_t^{\text{clust CUT}}\) and \(P_t^{\text{out CUT}}\) as well as introduction of a new object of isolated jet are found to be very efficient tools to improve the calibration accuracy. Their combined usage for this aim and for the background suppression will be shown in more details in paper [4].

4. ACKNOWLEDGMENTS

We are greatly thankful to D. Denegri for having offered this theme to study, fruitful discussions and permanent support and encouragement. It is a pleasure for us to express our recognition for helpful discussions to P. Aurenche, M. Dittmar, M. Fontannaz, J.Ph. Guillet, M.L. Mangano, E. Pilon, H. Rohringer, S. Tapprogge and J. Womersley.

References


Fig. 1: A dependence \( (P_{t\gamma} - P_{tJ})/P_{t\gamma} \) on \( P_{t\gamma}^{\text{CUT}} \) for LUCELL and UA1 jetfinding algorithms and two intervals of \( P_{t\gamma} \). The mean and RMS of the distributions are displayed on the figures. \( P_{t\gamma}^{\text{out}} \) is not limited. Selection 1
Fig. 2 (left): Selection 1. $\Delta \phi = 15^\circ$. Number of events (for $L_{int} = 3 fb^{-1}$) dependence on $P_{T_{\text{clust}}}^{\text{CUT}}$ in cases of LUCCELL and UA1 jetfinding algorithms. $P_{T_{\text{out}}}^*$ is not limited.

Fig. 3 (bottom): Selection 1. $\Delta \phi = 15^\circ$. $(P_{T\gamma} - P_{TJ})/P_{T\gamma}$ dependence on $P_{T_{\text{clust}}}^{\text{CUT}}$ in cases of UA1 and LUCCELL jetfinding algorithms. $P_{T_{\text{out}}}^*$ is not limited.
Fig. 4 (left): Selection 2. $\Delta \phi = 15^\circ$, $\varepsilon^{jet} < 2\%$.
Number of events (for $L_{int} = 3 fb^{-1}$) dependence on $P_t^{cut}$ in cases of LUELL and UA1 jetfinding algorithms. $P_t^{out}$ is not limited.

Fig. 5 (bottom): Selection 2. $\Delta \phi = 15^\circ$, $\varepsilon^{jet} < 2\%$. $(P_t^\gamma - P_t^J)/P_t^\gamma$ dependence on $P_t^{cut}$ in cases of LUELL and UA1 jetfinding algorithms. $P_t^{out}$ is not limited.
Fig. 6: A dependence \((P_t^\gamma - P_t^J)/P_t^\gamma\) on \(P_t^{\text{clust}}\) for LUCeLL and UA1 jetfinding algorithms and two intervals of \(P_t^\gamma\). The mean and RMS of the distributions are displayed on the figures. \(P_t^{\text{clust}} < 30 \text{ GeV/c}\). Selection 1
Fig. 7: A dependence $(Pt^\gamma - Pt^J)/Pt^\gamma$ on $P_{T}^{\gamma^{UT}}$ for LUCELL and UA1 jetfinding algorithms and two intervals of $P_{T}^{\gamma}$. The mean and RMS of the distributions are displayed on the figures. $P_{T}^{clus}<10$ GeV/c. Selection 1