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B-Jet Energy Correction for Top Mass Determination (II)
- as a Function of Top Mass -

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We derived energy correction for b-jets in $t\bar{t}$ events using HERWIG+QFL $t\bar{t}$ production simulation data for top masses of 140, 160, 170, 180, 200, 220 and 240 GeV/c^2 to determine top quark mass with top candidates events accurately.

The b-jet energy correction was obtained for dilepton +$\geq$2 jet events. We call this correction DLJSCO.

The magnitude of the correction depends on top quark mass. We parametrized the correction coefficients as a quadratic function of top quark mass. Using this parametrization, we obtained the top-mass-dependent b-jet energy correction function.

1 Reconstruction of simulated jets

In order to obtain the deviation of b-jet P_T from b-quark P_T, the following procedure was performed:

1. Find $b/\bar{b}$ quarks originating from $t/\bar{t}$ quark decay.
2. We use only $b/\bar{b}$ quark with $P_T > 5$ GeV/c.
3. Find a b-jet from JETS banks with a jet cone size of 0.4 in $\eta - \phi$ plane as follows: pick up all jets within a cone radius of 0.4 around a $b/\bar{b}$ quark. Apply the jet energy correction of QDJSCO[1] to the jets. Compare the ratio of b-quark P_T to jet P_T between the above jets. We identify a jet with the ratio closest to 1 as a b-jet.
4. Find soft lepton(e or μ) with $P_T > 2$ GeV/c within a cone radius of 0.4 around a $b/\bar{b}$ quark. If the b-jet has at least one soft lepton, the b-jet is tagged with soft lepton.

[1] In this note, QDJSCO means JTC90S and is always applied for a cone size of 0.4, with underlying event energy correction and with out-of-cone correction.

5. In the case of soft muon tagging, after we apply QDJSCO to the jet, we deal with the jet in two ways:
   (a) we do not apply any muon momentum correction.
   (b) we subtract muon energy deposit from the jet energy, and add muon momentum to the jet energy, where muon energy deposit is 2.2 GeV which is the average energy deposit in calorimeter by a minimum ionizing particle.

2 Jet energy correction factors

After the procedure of jet reconstruction described above, we obtained the ratio of b-quark P_T to b-jet P_T which we call R hereafter: $R = P_T^H / P_T^Q$, whereP_T^H is b-quark P_T and P_T^Q is the jet P_T corrected by QDJSCO. We made the distributions of R for 4 GeV/c bins of P_T^Q with $P_T^Q \geq 12$ GeV/c. The average value of R and its error are plotted as a function of the b-jet P_T for b jets

1. without lepton tagging (generic b jets),
2. with soft electron tagging,
3. with soft muon tagging and jet P_T not including muon momentum,
4. with soft muon tagging and jet P_T including muon momentum .

For each plot, we fitted it with a function $Y = exp(p1 + p2 \cdot P_T^Q) + p3$ in the same way as AAJSCO was obtained [2].

3 DLJSCO

This Monte Carlo data was generated with HERWIG, and simulated with QFL. We made 50,000 $t\bar{t}$ $\rightarrow$ dilepton + $\geq$ 2 jets events for each of top masses of 140, 160, 170, 180, 200, 220 and 240 GeV/c^2. Then we applied the following selection cuts of the top candidates:

- Number of leptons $\geq$ 2 with $E_T^e > 20$ GeV and $P_T^\mu > 20$ GeV/c,
- $\not{E}_T > 25$ GeV,

The distribution of b-quark P_T is shown for these simulation data in Fig. 1. We plotted the average value of R and its error as a function of the b-jet P_T and fitted it with a function $Y = exp(p1 + p2 \cdot P_T^Q) + p3$ as shown in Figs. 2 and 3. The absolute magnitude of the correction is 35% at b-jet P_T of 20 GeV/c and less than 5% at b-jet P_T above 40 GeV/c for b-jet without lepton tagging for a top mass of 170 GeV/c^2. We can obtain an overall correction by making the R distribution accumulated over all b-jet P_T as shown in Fig 4. The mean and RMS of R are 1.020$\pm$0.002 and 0.262, respectively, for generic b jets.

We compared DLJSCO for a top mass of 170 GeV/c^2 with DLJSCO for top masses of 140, 160, 180, 200, 220 and 240 GeV/c^2 in order to check the dependence of correction on top mass. as shown in Fig. 5. The difference in DLJSCO errors are also shown in Fig. 6. We parametrized the correction coefficients $p1, p2$ and $p3$ as a quadratic function of top mass, A + B$\cdot M_{top}$ + C$\cdot M_{top}^2$, to get the top-mass-dependent correction. The correction and its error thus obtained are consistent with the original DLJSCO for top masses of 140, 160, 180, 200, 220 and 240 GeV/c^2 within an error of 2% as shown in Figs. 7 and 8.

4 Conclusions

Energy correction DLJSCO for b-jets in $t\bar{t} \rightarrow$ dilepton events was derived using HERWIG+QFL $t\bar{t}$ production simulation data. The absolute magnitude of the energy correction is 35% at b-jet P_T of 20 GeV/c and less than 5% at b-jet P_T above 40 GeV/c for b-jet without lepton tagging for a top mass of 170 GeV/c^2.

As we have a large dependence of DLJSCO on a top mass between 140 GeV/c^2 and 240 GeV/c^2, we made the DLJSCO correction as a quadratic function of top mass. The correction and its error thus obtained were found to be consistent with the original DLJSCO for top masses of 140, 160, 170, 180, 200, 220 and 240 GeV/c^2 within an error of 2%.

References

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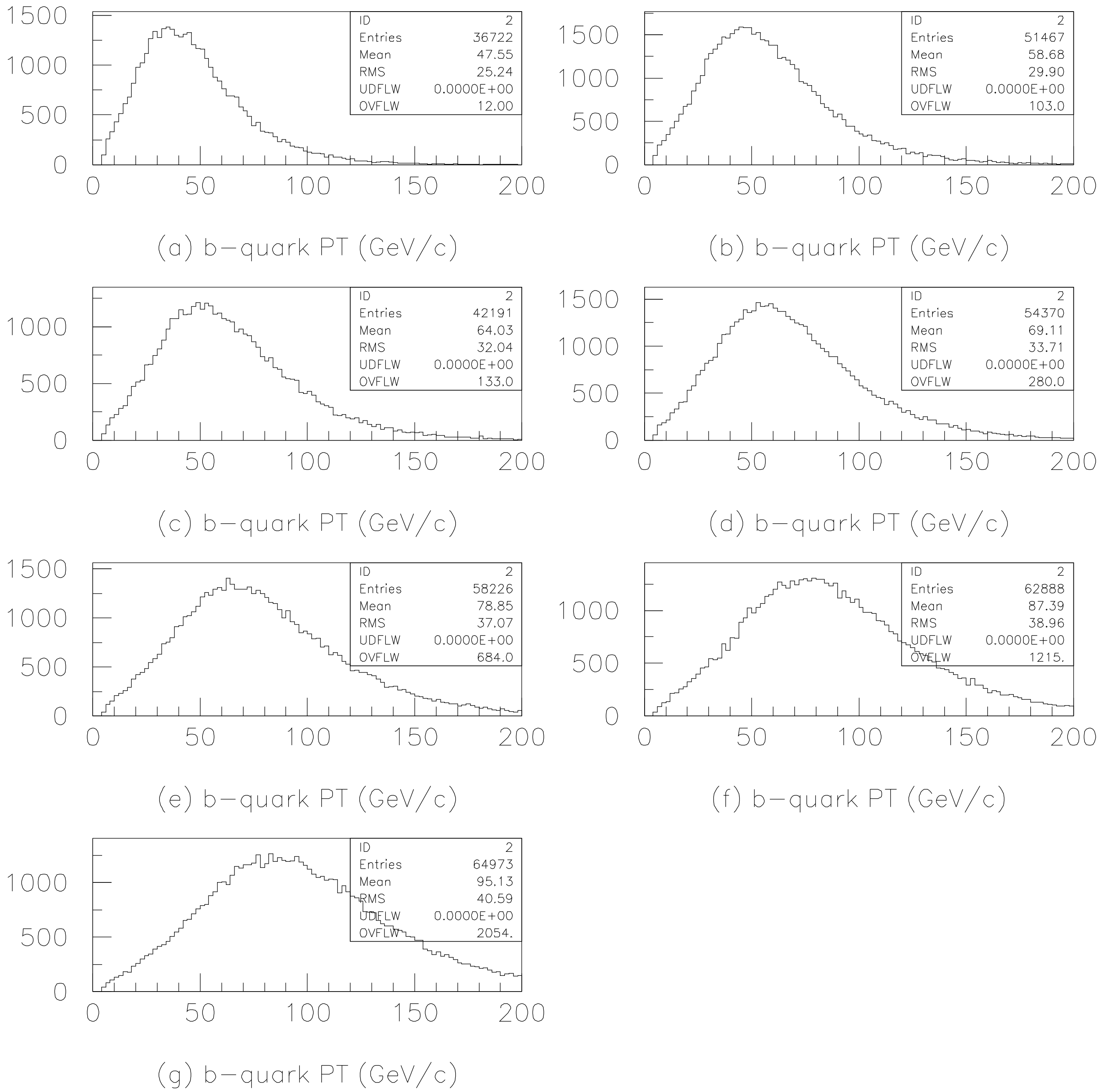

Figure 1: B-quark P_T for top quark masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 170 GeV/c^2, (d) 180 GeV/c^2, (e) 200 GeV/c^2, (f) 220 GeV/$c^2$and (g) 240 GeV/c^2.

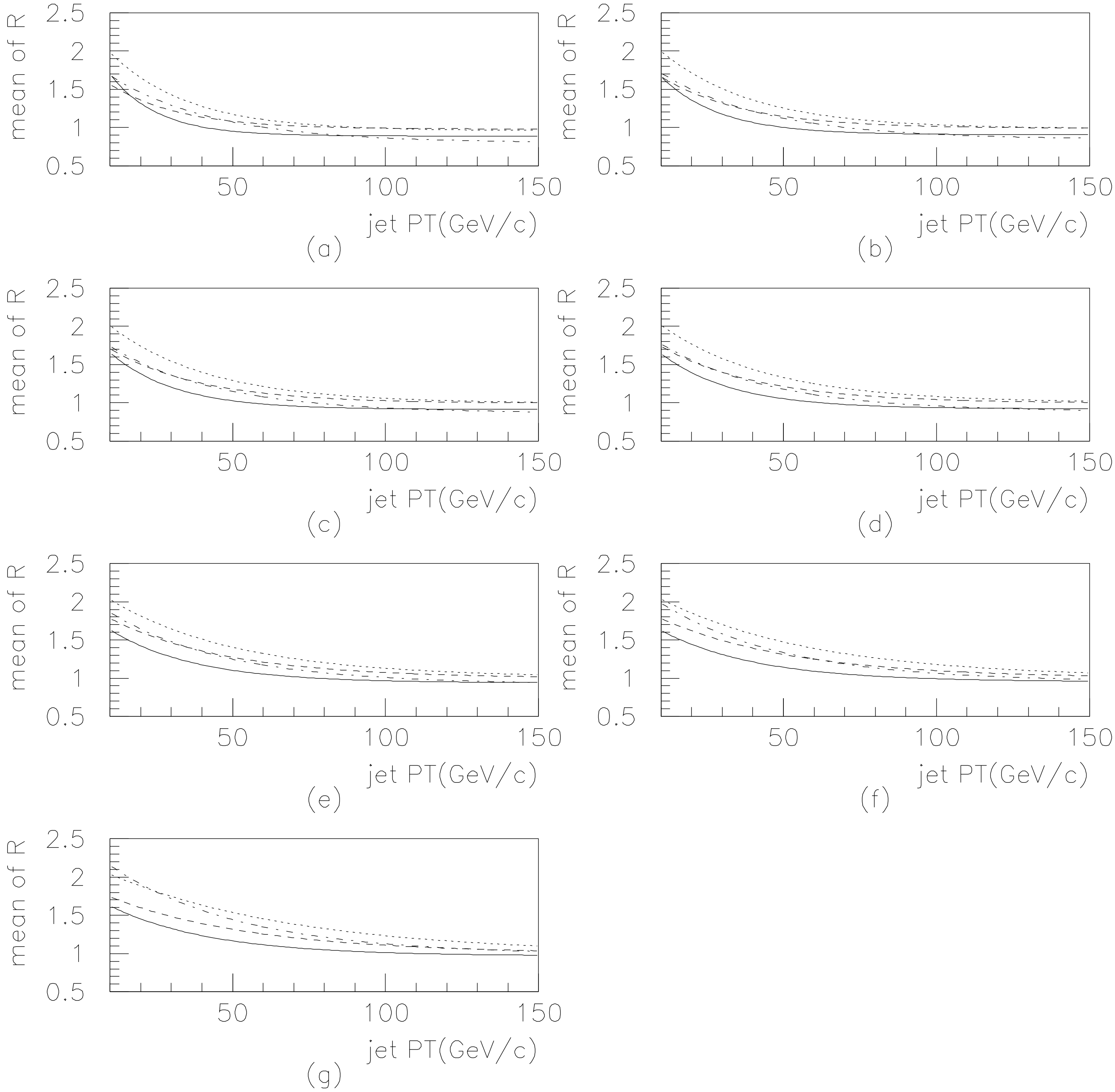

Figure 2: average of R vs. b-jet P_T for b-jets without soft lepton tagging (solid line), with soft electron tagging (dashed line), with soft muon tagging and jet P_T not including muon momentum (dotted line), and with soft muon tagging and jet P_T including muon momentum (dot-dashed line) in HERWIG+QFL $t\bar{t} \rightarrow$ dilepton + $\geq$ 2 jets events at top masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 170 GeV/c^2, (d) 180 GeV/c^2, (e) 200 GeV/c^2, (f) 220 GeV/c^2 and (f) 240 GeV/c^2 (DLJSCO).

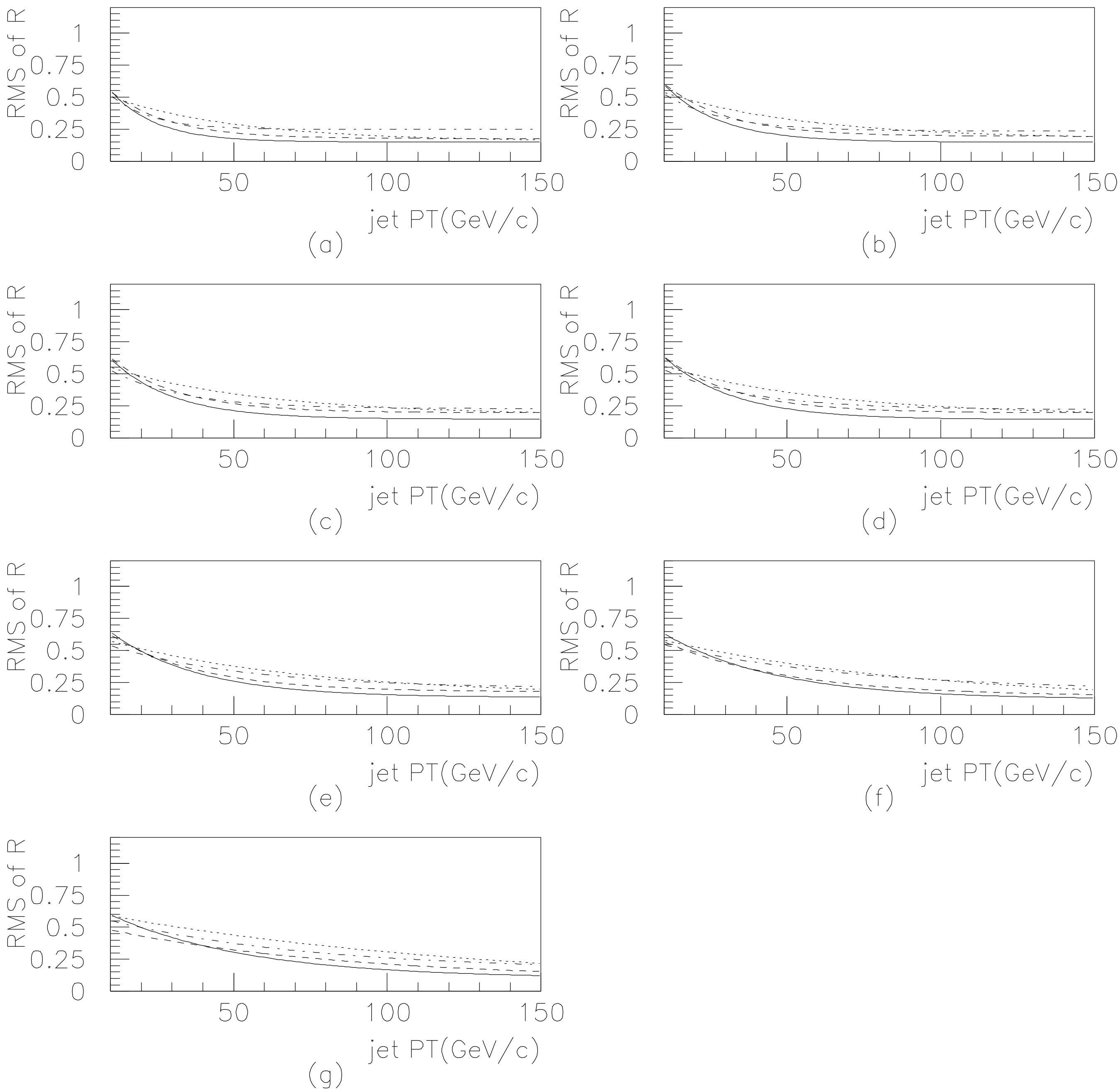

Figure 3: RMS of R vs. b-jet P_T for b-jets without soft lepton tagging (solid line), with soft electron tagging (dashed line), with soft muon tagging and jet P_T not including muon momentum (dotted line), and with soft muon tagging and jet P_T including muon momentum (dot-dashed line) in HERWIG+QFL $t\bar{t} \rightarrow$ dilepton + $\geq$ 2 jets events at top masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 170 GeV/c^2, (d) 180 GeV/c^2, (e) 200 GeV/c^2, (f) 220 GeV/c^2 and (f) 240 GeV/c^2 (DLJSCO).

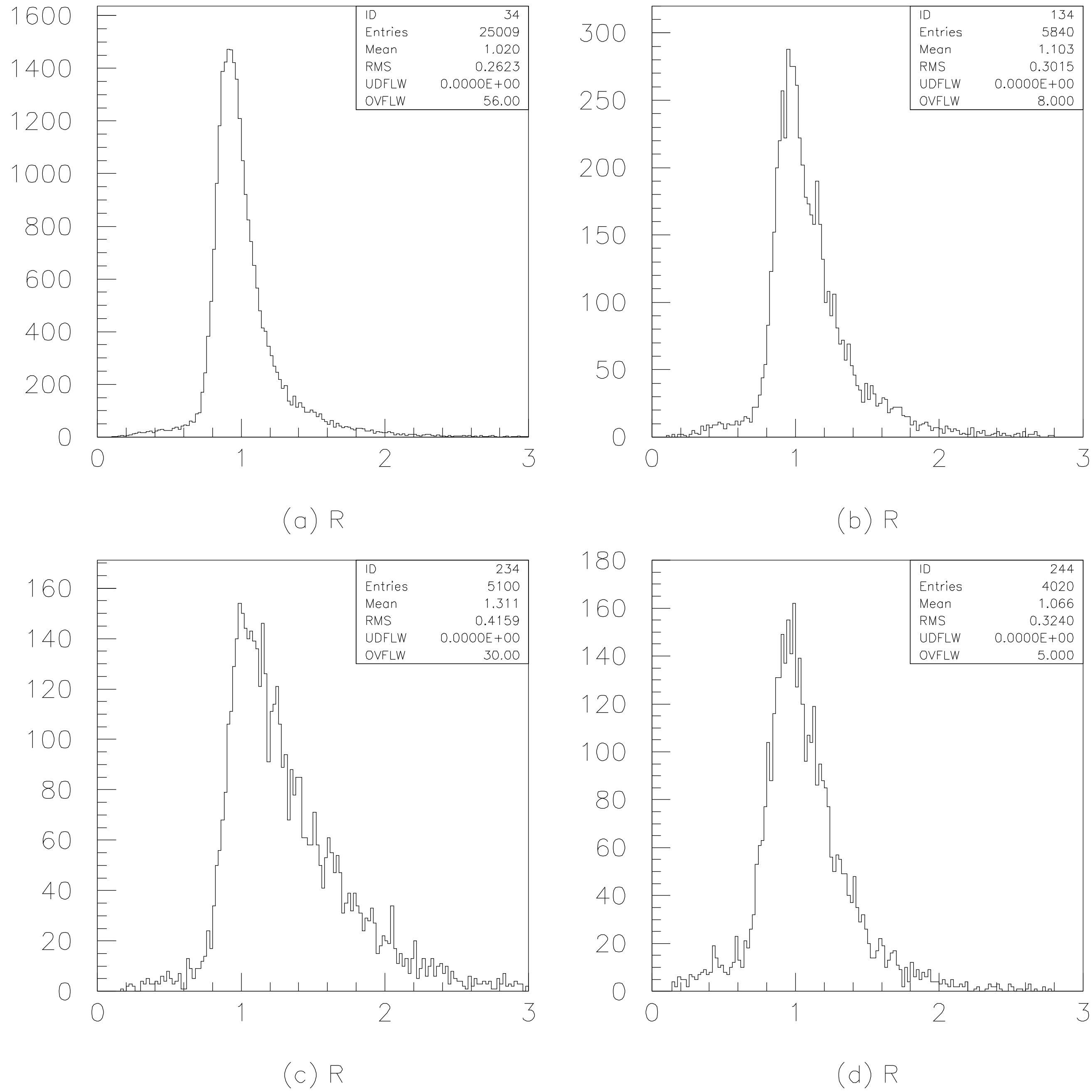

Figure 4: the R distribution accumulated over all b-jet P_T for b-jets (a) without soft lepton tagging, (b) with soft electron tagging, (c) with soft muon tagging and jet P_T not including muon momentum, and (d) with soft muon tagging and jet P_T including muon momentum in HERWIG+QFL $t\bar{t} \rightarrow$ dilepton + $\geq$ 2 jets events for a top quark mass of 170 GeV/c^2 (DLJSCO).

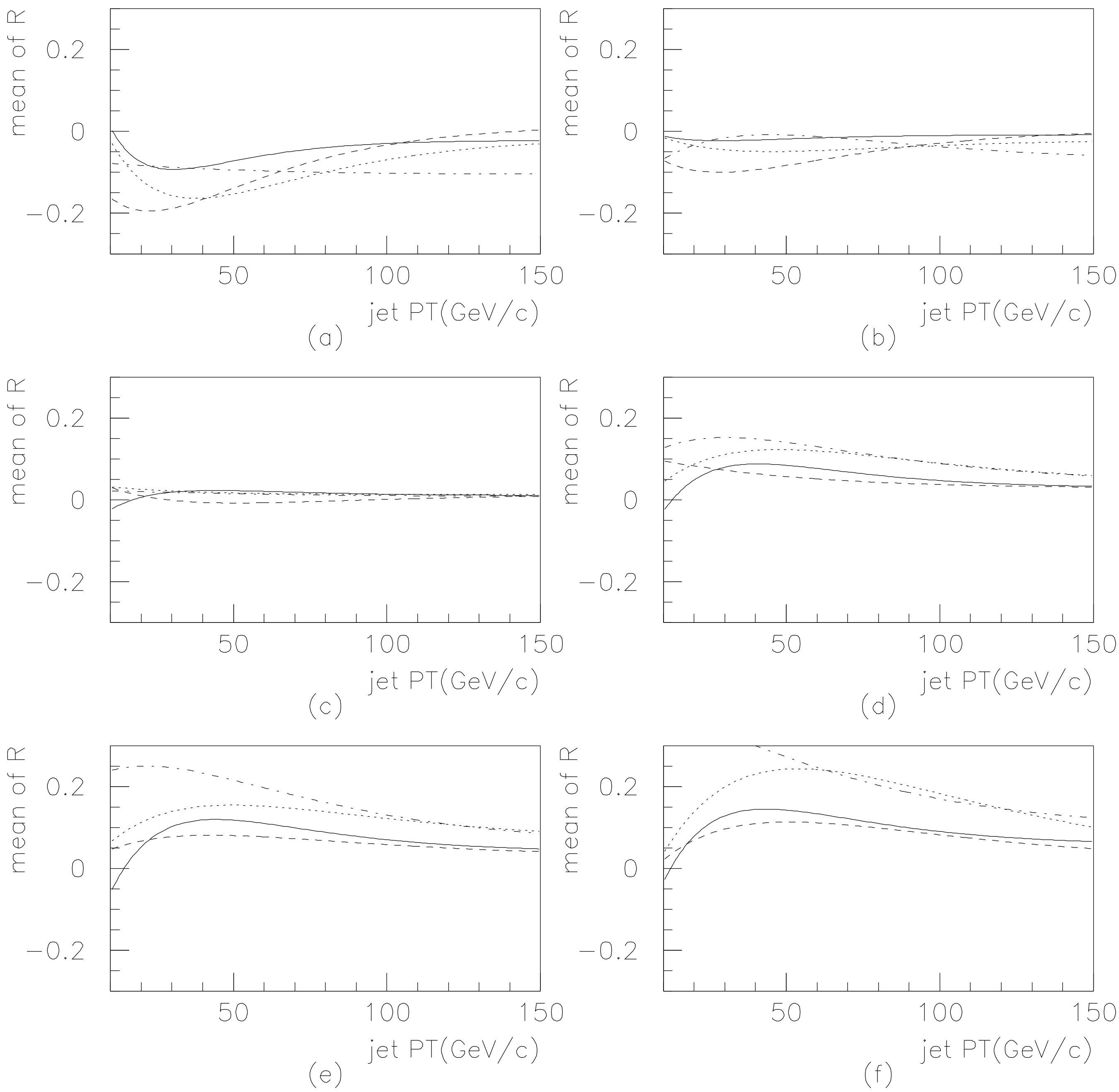

Figure 5: The difference between the DLJSCO at a top quark mass of 170 GeV/c^2 and the DLJSCO at other top quark masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 180 GeV/c^2, (d) 200 GeV/c^2, (e) 220 GeV/c^2 and (f) 240 GeV/c^2, DLJSCO(Mtop) − DLJSCO(170 GeV/c^2), as a function of b-jet P_T. Solid line shows b jets without soft lepton tagging, dashed line shows b jets with soft electron tagging, dotted line shows b jets with soft muon tagging and jet P_T not including muon momentum, and dot-dashed line shows with soft muon tagging and jet P_T including muon momentum.

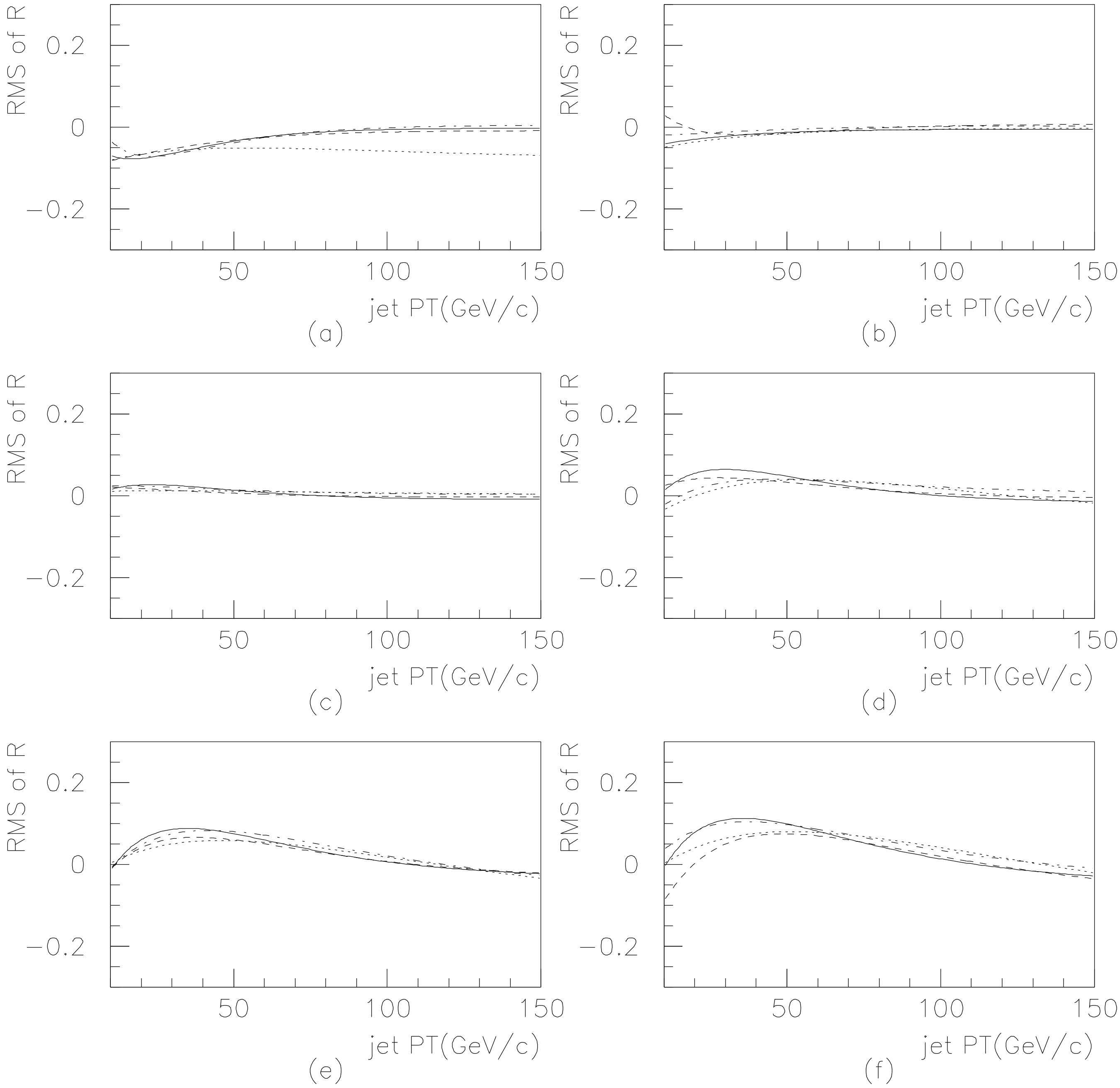

Figure 6: The difference between the DLJSCO error at a top quark mass of 170 GeV/c^2 and the DLJSCO error at other top quark masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 180 GeV/c^2, (d) 200 GeV/c^2, (e) 220 GeV/c^2 and (f) 240 GeV/c^2, DLJSCO(Mtop) − DLJSCO(170 GeV/c^2), as a function of b-jet P_T. Solid line shows b jets without soft lepton tagging, dashed line shows b jets with soft electron tagging, dotted line shows b jets with soft muon tagging and jet P_T not including muon momentum, and dot-dashed line shows with soft muon tagging and jet P_T including muon momentum.

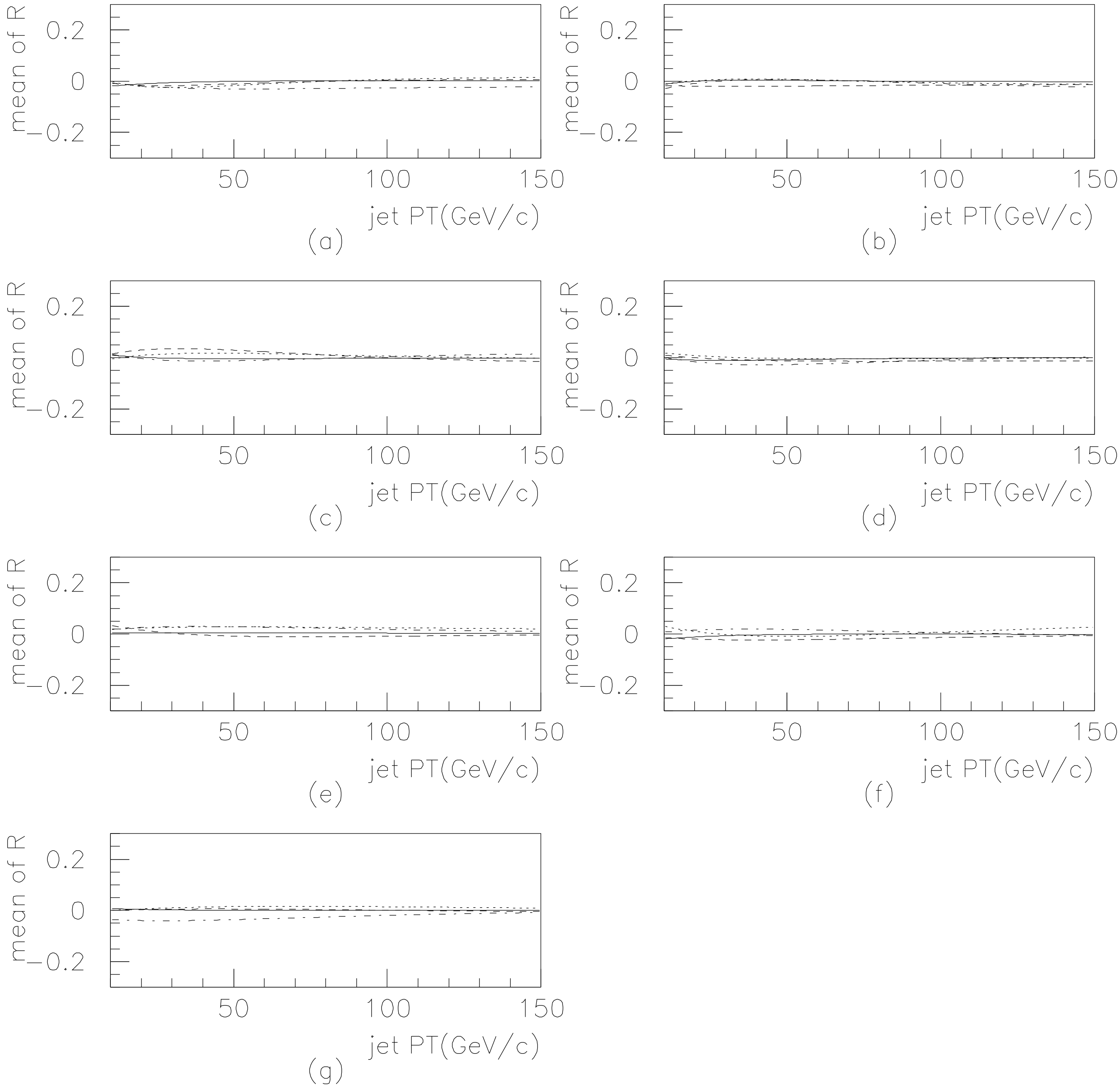

Figure 7: The difference between the two corrections, DLJSCO as a quadratic function of top masses − DLJSCO, as a function of b-jet P_T for b-jets without soft lepton tagging (solid line), with soft electron tagging (dashed line), with soft muon tagging and jet P_T not including muon momentum (dotted line), and with soft muon tagging and jet P_T including muon momentum (dot-dashed line) at top masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 170 GeV/c^2, (d) 180 GeV/c^2, (e) 200 GeV/c^2, (f) 220 GeV/c^2 and (f) 240 GeV/c^2.

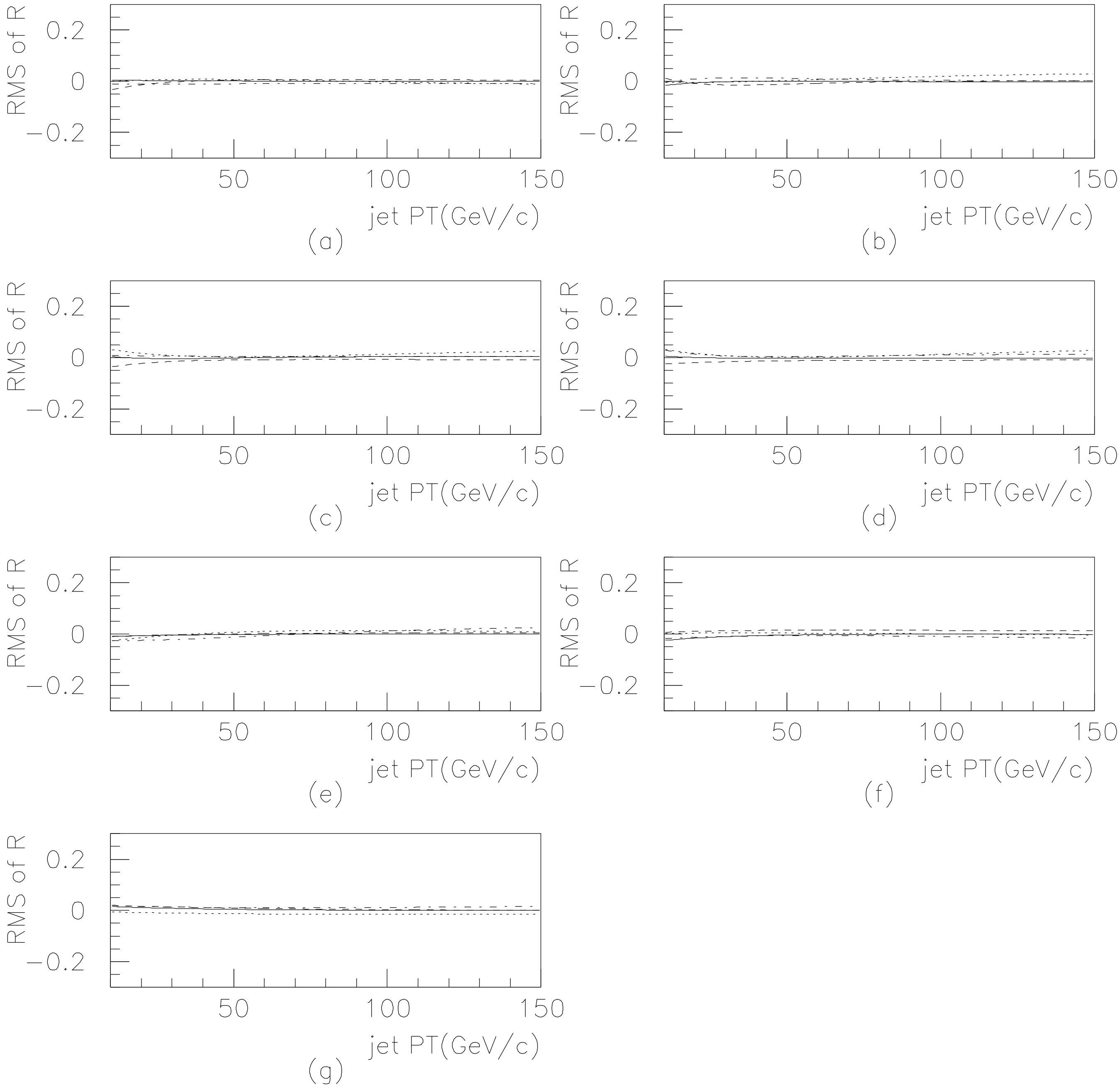

Figure 8: The difference between the two correction errors, DLJSCO as a quadratic function of top masses − DLJSCO, as a function of b-jet P_T for b-jets without soft lepton tagging (solid line), with soft electron tagging (dashed line), with soft muon tagging and jet P_T not including muon momentum (dotted line), and with soft muon tagging and jet P_T including muon momentum (dot-dashed line) at top masses of (a) 140 GeV/c^2, (b) 160 GeV/c^2, (c) 170 GeV/c^2, (d) 180 GeV/c^2, (e) 200 GeV/c^2, (f) 220 GeV/c^2 and (f) 240 GeV/c^2.