



22 October 2021
maria.adriana.sabia@cern.ch

Search for Supersymmetry in compressed scenarios

Maria Adriana Sabia
CERN, CH-1211 Geneva, Switzerland

Summary

The present analysis is focused on the search for direct pair production of the lightest top squark ($\tilde{t}_1$) in final states with two leptons of opposite electric charge, jets and missing transverse momentum, with $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) \leq m(W) + m(b)$, discussed in the paper [1]. The effect of the selection cuts on the data at truth and reconstruction level are investigated by studying the distributions of some variables of interest. In the small Δm region, the quality of the analysis might be strongly improved by reconstruction techniques targeting electrons and muons of low transverse momentum. However, also in this case, the distributions would be severely affected by the cut on the two leptons invariant mass, thus requiring further studies and a redefinition of the small Δm analysis cuts.

Contents

1	Supersymmetry	3
2	Four body analysis	3
3	Study of the distributions	4
3.1	Variables of interest	4
3.2	Analysis	6
3.3	Truth level data sample	8
3.3.1	Efficiency and mean values	8

3.4	Reconstruction level data sample	11
3.4.1	Efficiency and mean values	11
4	Conclusion	13
A	Truth level data	14
A.1	Efficiency	14
A.2	Truth level peaks	14
A.3	2D distributions	25
B	Reco level data	36
B.1	Efficiency	36
B.2	Reco level peaks	36
B.3	Reconstruction level 2D plots	47
B.3.1	2D distributions	47

1 Supersymmetry

So far, the Standard Model (SM) of particle physics has been extremely successful in describing all particles and their interactions but many questions remain unanswered and pave the path for new physics searches beyond the Standard Model (bSM).

One of the most compelling scenarios for physics bSM is supersymmetry, a space-time symmetry that, for each SM particle, postulates the existence of a supersymmetric partner, with the same property as its SM counterpart except for the spin which differs by 1/2 unit.

Furthermore, R-parity, defined as $R = (-1)^{3(B-L)+2S}$, where B and L stand for baryonic and lepton number respectively, is assumed to be conserved in order to avoid B and L violation.

SUSY particles production happens in pairs, hence, the lightest supersymmetric particle (LSP) must be stable and provides a viable Dark Matter (DM) candidate. In the following, a generic R-parity-conserving Minimal Supersymmetric Standard Model (MSSM) is assumed to be valid. In this context, the right-handed and left-handed supersymmetric scalar partner of quarks (squarks), $\tilde{q}_R$ and $\tilde{q}_L$, can mix and give rise to two mass eigenstates $\tilde{q}_1$ (the lightest one) and $\tilde{q}_2$ (the heaviest one). In particular, in the top squark sector, large mass mixing can produce a $\tilde{t}_1$ which happens to be significantly lighter than the other squarks and can couple with SM particles.

The super-partners of the electroweak gauge bosons and of the Higgs are called *bino*, *winos* and *higgsinos*, respectively and can mix producing *charginos* and *neutralinos*, whose mass eigenstates are indicated as $\tilde{\chi}_i^\pm$ ($i = 1, 2$) and $\tilde{\chi}_j^0$ ($j = 1, 2, 3, 4$). Among these states, the lightest neutralino $\tilde{\chi}_1^0$ is considered a DM candidate [1].

2 Four body analysis

We look for direct pair production of the lightest top squark and DM particles in final states with two leptons (electrons or muons) of opposite electric charge, jets and missing transverse momentum. The mass difference Δm between the top squark and the neutralino $\tilde{\chi}_1^0$, determines which decay modes are relevant.

In the following the situation in which $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) \leq m(W) + m(b)$ is considered. In this kinematic region, the relevant decay mode is the four body decay channel, defined as $\tilde{t}_1 \rightarrow b f f' \tilde{\chi}_1^0$, where f and f' are fermions coming from the virtual W^* decay (see figure 1).

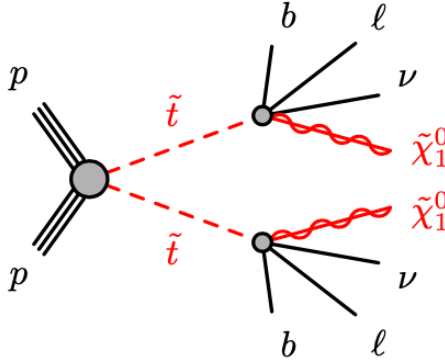


Figure 1: Four-body decay channel $\tilde{t} \rightarrow b f \bar{f}' \tilde{\chi}_1^0$, where the two top squark both decay into a top quark and a neutralino. The top quark decays then into a b quark and a virtual W, which in turn decays into two fermions f and f'.

A dedicated event selection for this decay mode has been performed to maximise the sensitivity ([1]). The selection addresses two different Δm regions, defined as small Δm and large Δm signal regions ($SR_{\text{small}\Delta m}^{4 \text{ body}}$ and $SR_{\text{large}\Delta m}^{4 \text{ body}}$). These two regions are expected to be orthogonal since for small Δm we require that the momenta of the leading ($p(\ell_1)$) and subleading ($p(\ell_2)$) leptons are respectively below 25 GeV and 10 GeV, whereas for large Δm we require $p(\ell_2) \geq 10$ GeV. No excess is observed in the data relative to the expected background.

Moreover, limits for simplified models in which the $\tilde{t}_1$ decays into t and $\tilde{\chi}_1^0$ with $BR = 100\%$ have been set in the plane $\tilde{t}-\tilde{\chi}_1^0$. For what concerns the 4-body decay mode, top squark masses are excluded up to 540 GeV for $\Delta m(\tilde{t}_1, \tilde{\chi}_1^0) = 40$ GeV (figure 2).

3 Study of the distributions

The goal of this work is to analyse the distributions of some variables of interest and to study the detector acceptance in the small Δm region.

3.1 Variables of interest

The variables of interest in this analysis are listed below:

- **lep1_4b** $\rightarrow$ transverse momentum of the leading lepton;

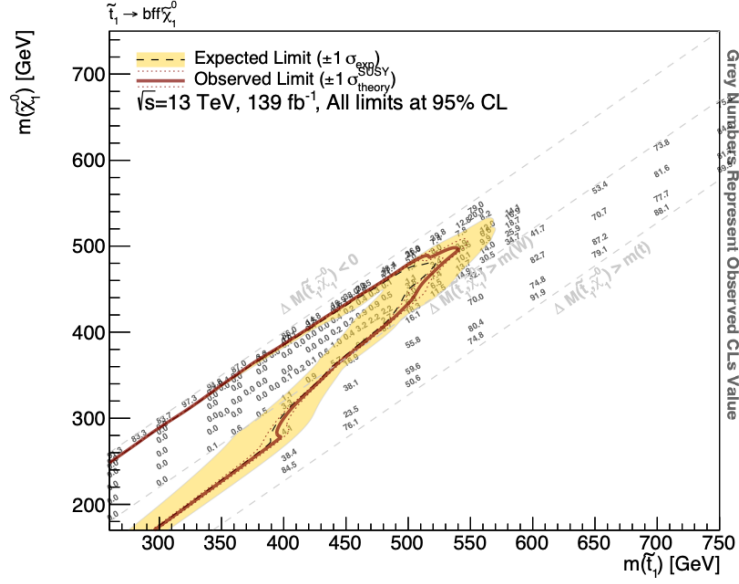


Figure 2: Exclusion limit contour (95% CL) in the plane $\tilde{t}-\tilde{\chi}_1^0$ for a simplified model in which the $\tilde{t}$ decays into t^* and $\tilde{\chi}_1^0$ with $\text{BR} = 100\%$ ([2]).

- lep2_4b $\rightarrow$ transverse momentum of the subleading lepton;
- ptJet1_4b $\rightarrow$ transverse momentum of the leading jet;
- ptJet2_4b $\rightarrow$ transverse momentum of the subleading jet;
- MET $\rightarrow$ missing transverse energy, also indicated with E_T^{miss} ;
- METsig $\rightarrow$ missing transverse energy significance, defined as

$$E_T^{\text{miss}} = \frac{|\mathbf{p}_T^{\text{miss}}|}{\sqrt{\sigma_L^2(1 - \rho_{LT}^2)}} \quad (1)$$

where $\mathbf{p}_T^{\text{miss}}$ is the negative vector sum of the transverse momenta for all baseline electrons, photons, muons and jets, σ_L is the (longitudinal) component parallel to the $\mathbf{p}_T^{\text{miss}}$ of the total transverse momentum resolution for all objects in the event and ρ_{LT} is the correlation factor between the parallel and perpendicular components of the transverse momentum resolution for each object [1];

- m11_4b $\rightarrow$ invariant mass of the first two leptons;

- **R2l_4b** $\rightarrow$ missing transverse energy divided by the scalar sum of the transverse momenta of the two leptons;

$$\frac{E_T^{\text{miss}}}{(p_T(\ell_1) + p_T(\ell_2))} \quad (2)$$

- **R2l4j_4b** $\rightarrow$ missing transverse energy divided by the scalar sum of the transverse momenta of the two leptons and the first four jets, defined as

$$\frac{E_T^{\text{miss}}}{E_T^{\text{miss}} + p_T(\ell_1) + p_T(\ell_2) + \sum_{i=1, \dots, N \leq 4} p_T(j_i)} \quad (3)$$

- **pb1l_TLV_4b** $\rightarrow$ absolute value of the vector sum of the missing transverse momentum and the transverse momenta of the two leptons, whose absolute value can be interpreted as the magnitude of all the hadronic activity in the event;
- **minDRL2Jets** $\rightarrow$ minimum angular distance between the subleading lepton and the jets in the event;

3.2 Analysis

The following analysis is based on two different simulated data samples for the signal discussed in section 2. The first one simulates background and signal data at truth level, while the second one is obtained applying the reconstruction cuts and the detector smearing in order to reproduce ATLAS Run 2 reconstruction performances. All the data are taken at pre-selection level, which means that the cuts that define the two signal regions (Sec. 2) have not been fully applied. The cuts which have been used in the present analysis are listed below:

First sequence (with **m1l_4b** cut):

- '**nlep4b** > 0' ;
- '**nlep4b**==2 && !**isSS_4b** && **m1l_4b** >10. && **MET** > 250.' ;
- '**lep1_4b** < 100.' ;
- '**lep2_4b** < 100.' ;
- '**ptJet1_4b** > 150 & **ptJet2_4b** > 0' ;

- 'minDRL2Jets > 1.'

Second sequence (without m11_4b cut):

- 'nlep4b > 0' ;

- 'nlep4b==2 && !isSS_4b && MET > 250.' ;

- 'lep1_4b < 100.' ;

- 'lep2_4b < 100.' ;

- 'ptJet1_4b > 150 & ptJet2_4b > 0' ;

- 'minDRL2Jets > 1.'

For each sequence, the cuts are progressively applied in order to study how they affect the distributions of the variables of interest. First of all, I computed the cumulative efficiency of the selection cuts when they are applied in sequence. This corresponds to the ratio between the number of events after each one of the cuts and the total number of events which were in the sample before applying the reconstruction cuts. Second of all, for each one of the variables listed in section 3.1 and for each Δm , I found the peak of the distribution, performed a gaussian fit and plotted the 2D distributions of the signal. Subsequently, I exploited these plots to study the effects of the analysis cuts on the peak values and on the shape of the distributions.

The algorithm to find the mean and standard deviation of the distributions is built as follows:

1. **Find the maximum:** find the maximum of the distribution and compute the projections of the FWHM on the x-axis;
2. **Find the mean:** perform a gaussian fit in the interval found in step 1. and find the mean of the distribution;
3. **Find the left standard deviation:** start from the maximum and integrate the distribution to the left until the value corresponding to 33% of the total integral is reached;
4. **Find the right standard deviation:** start from the value found in 3 and integrate the distribution to the right until the value corresponding to 68% of the total integral is reached.

This algorithm has been chosen in order to give an estimate of the shape of the distributions, by including the bulk of each histogram within the uncertainties. An example of this analysis is shown in figure 3.

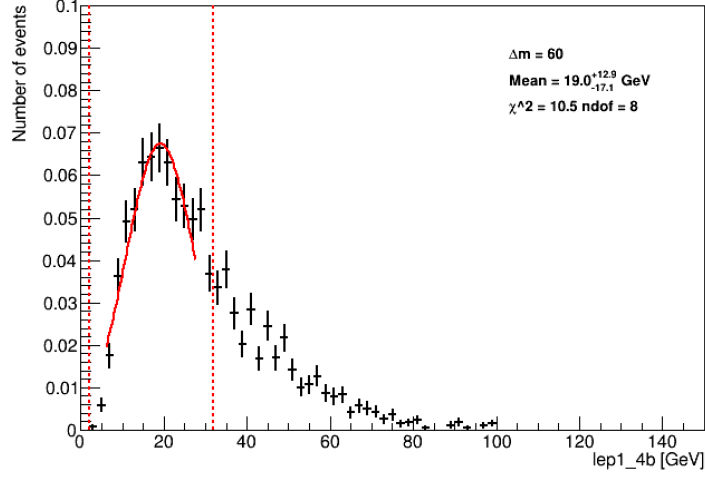


Figure 3: Example of the procedure used to find the mean and standard deviation of the distributions.

3.3 Truth level data sample

In the following section, the results of the study performed on the truth level data are presented. As an example, the variables `lep1_4b`, `lep2_4b`, `MET` and `METsig` are shown, while the same plots for the distributions listed in section 3 can be found in the appendix A.

3.3.1 Efficiency and mean values

In this section, two different situations are compared: the first one is a sequence of cuts including the cut on the invariant mass of the two leptons (`m11_4b > 10 GeV`) and the second is the same sequence of cuts without the invariant mass cut. This has been done because a net effect on the peaks and the shapes of the distributions has been observed when applying the invariant mass cut, especially in the small Δm region.

One can notice that, when the cut on the invariant mass is included, the efficiency decreases dramatically from 19.37 %, when the cut is not applied, to 0.29 %, when the cut is applied. In addition, the efficiency decreases in both cases when the cuts '`ptJet1_4b > 150 & ptJet2_4b > 0`' and '`minDRL2Jets > 1.`' are applied. The results of the computation are summarized in the tables (1 and 2).

Then, I applied the algorithm described in section 3.2 in order to find the peaks

and the left/right standard deviations of the distributions for each one of the variables listed in Sec. 3 and for each Δm . As an example, some of them are shown below. Figures 4a, 4b, 4c and 4d show the peaks of the distributions as a function of the variable of interest (`lep1_4b`, `lep2_4b`, `MET` and `METsig`) in GeV with three different selections cuts: `'nlep4b==2 && !isSS_4b && MET > 250.'`, the complete sequence with `mll_cut`, namely `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.'` + `'lep1_4b < 100.'` + `'lep2_4b < 100.'` + `'ptJet1_4b > 150. && ptJet2_4b > 0.'` + `'minDRL2Jets > 1.'` (3.2) and the complete sequence without `mll_cut`, namely `nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.'` + `'lep1_4b < 100. + lep2_4b < 100.'` + `'ptJet1_4b > 150. && ptJet2_4b > 0.'` + `'minDRL2Jets > 1.'` (3.2).

It can be noticed that, in all the four distributions, the cut on the invariant mass of the two leptons modifies the value of the peak and mainly affects the small Δm signal regions (especially 8 and 13 GeV). The plots of the peaks for each one of the selection cuts applied in sequence are located in the appendix 4.

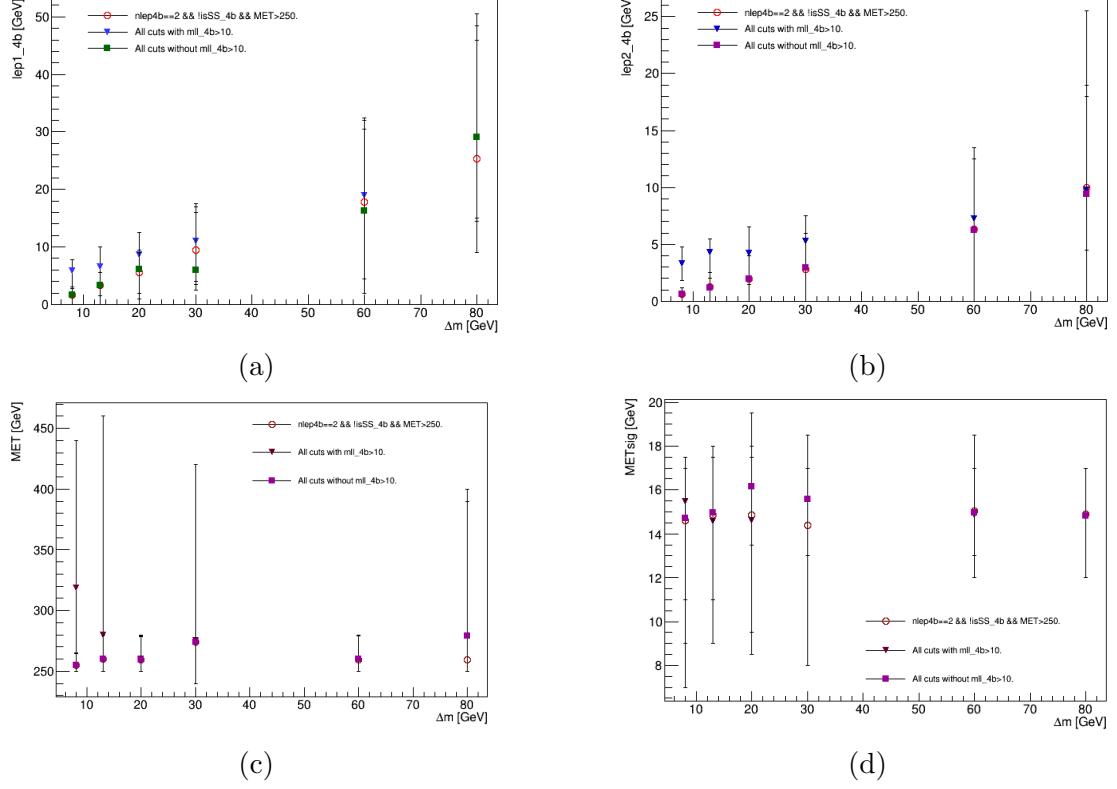


Figure 4: Peaks of the distributions at truth level of **lep1_4b** [GeV] (Fig. 4a), peaks of the distributions at truth level of **lep2_4b** [GeV] (Fig. 4b), peaks of the distributions at truth level of **MET** [GeV] (Fig. 4c) and peaks of the distributions at truth level of **METsig** [GeV] (Fig. 4d) when 3 sequences of selection cuts are applied: 'nlep4b==2 && !isSS_4b && MET > 250.', the complete sequence with mll_cut, namely 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' + 'minDRL2Jets > 1.' and the complete sequence without mll_cut, namely nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' + 'lep1_4b < 100. + lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' + 'minDRL2Jets > 1.'. The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

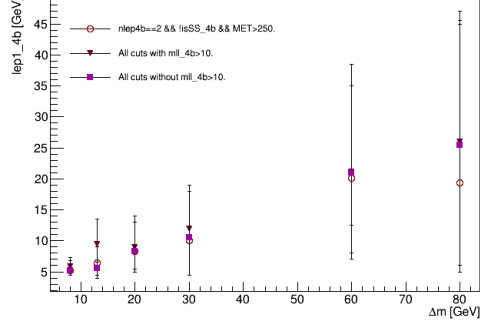
3.4 Reconstruction level data sample

In the following section, the results of the study performed on the reconstruction level data are presented. As an example, the variables `lep1_4b`, `lep2_4b`, `MET` and `METsig` are shown, while the same plots for the distributions listed in section 3 can be found in the appendix B.

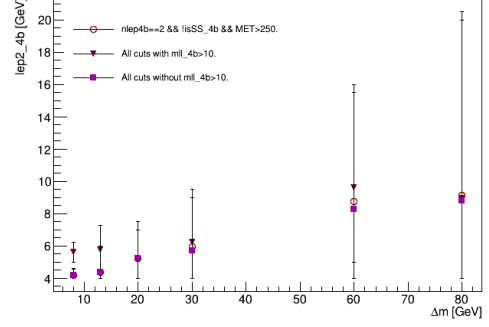
3.4.1 Efficiency and mean values

For what concerns the reconstruction level data, I performed the same kind of analysis discussed in section 3.3. The efficiency of the selection cuts is computed also in this case for the two complete selection sequences (with and without the cut on the invariant mass of the two leptons) and the results are shown in table 3 and 4.

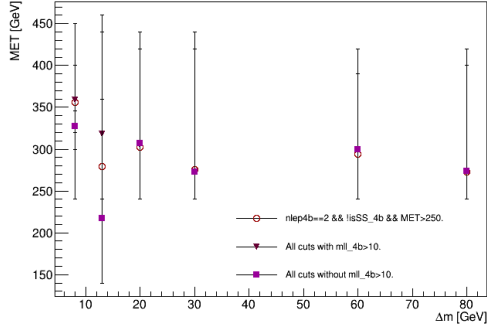
In this case, the cut on the invariant mass has a milder effect on the acceptance. This is because the current reconstruction sensitivity in ATLAS does not allow for the effect to be observed. However, if the current reconstruction is extended to lower P_t -leptons, the impact of the invariant mass cut must be taken into account. The following plots (figures 5a, 5b, 5c and 5d) show the peaks and the left/right standard deviations of the distributions for each one of the variables listed in Sec. 3 and for each Δm as a function of the variables [GeV].



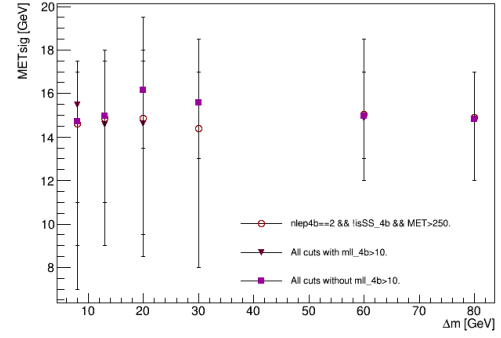
(a)



(b)



(c)



(d)

Figure 5: Peaks of the distributions at reco level of lep1_4b [GeV] (Fig. 5a), peaks of the distributions at reco level of lep2_4b [GeV] (Fig. 5b), peaks of the distributions at reco level of MET [GeV] (Fig. 5c) and peaks of the distributions at reco level of METsig [GeV] (Fig. 5d) when 3 sequences of selection cuts are applied: 'nlep4b==2 && !isSS_4b && MET > 250.', the complete sequence with mll_cut, namely 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' + 'minDRL2Jets > 1.' and the complete sequence without 'mll_cut', namely 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' + 'lep1_4b < 100. + lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' + 'minDRL2Jets > 1.'. The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

4 Conclusion

A study of the effect of the preselection cuts applied in the analysis [1] was performed, considering the truth and smeared distributions and comparing the results. First of all, it has been observed that the larger discrepancies between truth and reconstructed distributions are visible in the small Δm region (especially for $\Delta m = 8$ and 13 GeV). Second of all, the cut which affects the distributions the most is the one in which the invariant mass of the two leptons is required to be > 10 GeV at truth level, whereas the effect is negligible when reconstruction level data are considered.

However, the current sensitivity does not allow to explore the region in which the invariant mass cut becomes important. For this reason, if the sensitivity is increased, an accurate study of the small Δm region will be pivotal to any further analysis. In particular, since the current analysis software reconstructs electrons and muons with p_T greater than 4.5 GeV and 3 GeV respectively, new reconstruction techniques should be applied/developed in order to lower the p_T -threshold of the leptons and thus have access to the low- Δm signal model.

A Truth level data

A.1 Efficiency

Cuts	$\Delta m = 8 \text{ GeV}$	$\Delta m = 13 \text{ GeV}$	$\Delta m = 20 \text{ GeV}$	$\Delta m = 30 \text{ GeV}$	$\Delta m = 60 \text{ GeV}$	$\Delta m = 80 \text{ GeV}$
cut0	78.04%	61.12%	52.84%	55.82%	50.55%	50.50%
cut1	0.29%	2.53%	9.19%	6.11%	11.68%	11.12%
cut2	0.29%	2.53%	9.19%	6.11%	11.58%	10.77%
cut3	0.29%	2.53%	9.19%	6.11%	11.58%	10.77%
cut4	0.20%	1.80%	7.08%	4.55%	10.02%	9.41%
cut5	0.16%	1.36%	5.07%	3.37%	6.69%	6.15%

Table 1: Cumulative efficiency of the selection cuts, where cut0 = 'nlep4b > 0', cut1 = 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.', cut2 = 'lep1_4b < 100.', cut3 = 'lep2_4b < 100.', cut4 = 'ptJet1_4b > 150 & ptJet2_4b > 0' and cut5 = 'minDRL2Jets > 1.'. All the cuts are applied in sequence.

Cuts	$\Delta m = 8 \text{ GeV}$	$\Delta m = 13 \text{ GeV}$	$\Delta m = 20 \text{ GeV}$	$\Delta m = 30 \text{ GeV}$	$\Delta m = 60 \text{ GeV}$	$\Delta m = 80 \text{ GeV}$
cut0	78.04%	61.12%	52.84%	55.82%	50.55%	50.50%
cut1	19.37%	17.76%	14.80%	15.79%	13.46%	12.10%
cut2	19.37%	17.76%	14.79 %	15.79%	13.36%	11.74 %
cut3	19.37%	17.76%	14.79 %	15.79%	13.36%	11.74 %
cut4	13.48%	12.65%	11.40 %	11.65%	11.57 %	10.26%
cut5	11.01%	10.07%	8.75%	9.00%	7.77 %	6.73%

Table 2: Cumulative efficiency of the selection cuts, where cut0 = 'nlep4b > 0', cut1 = 'nlep4b==2 && !isSS_4b && MET > 250.', cut2 = 'lep1_4b < 100.', cut3 = 'lep2_4b < 100.', cut4 = 'ptJet1_4b > 150 & ptJet2_4b > 0' and cut5 = 'minDRL2Jets > 1.'. All the cuts are applied in sequence.

A.2 Truth level peaks

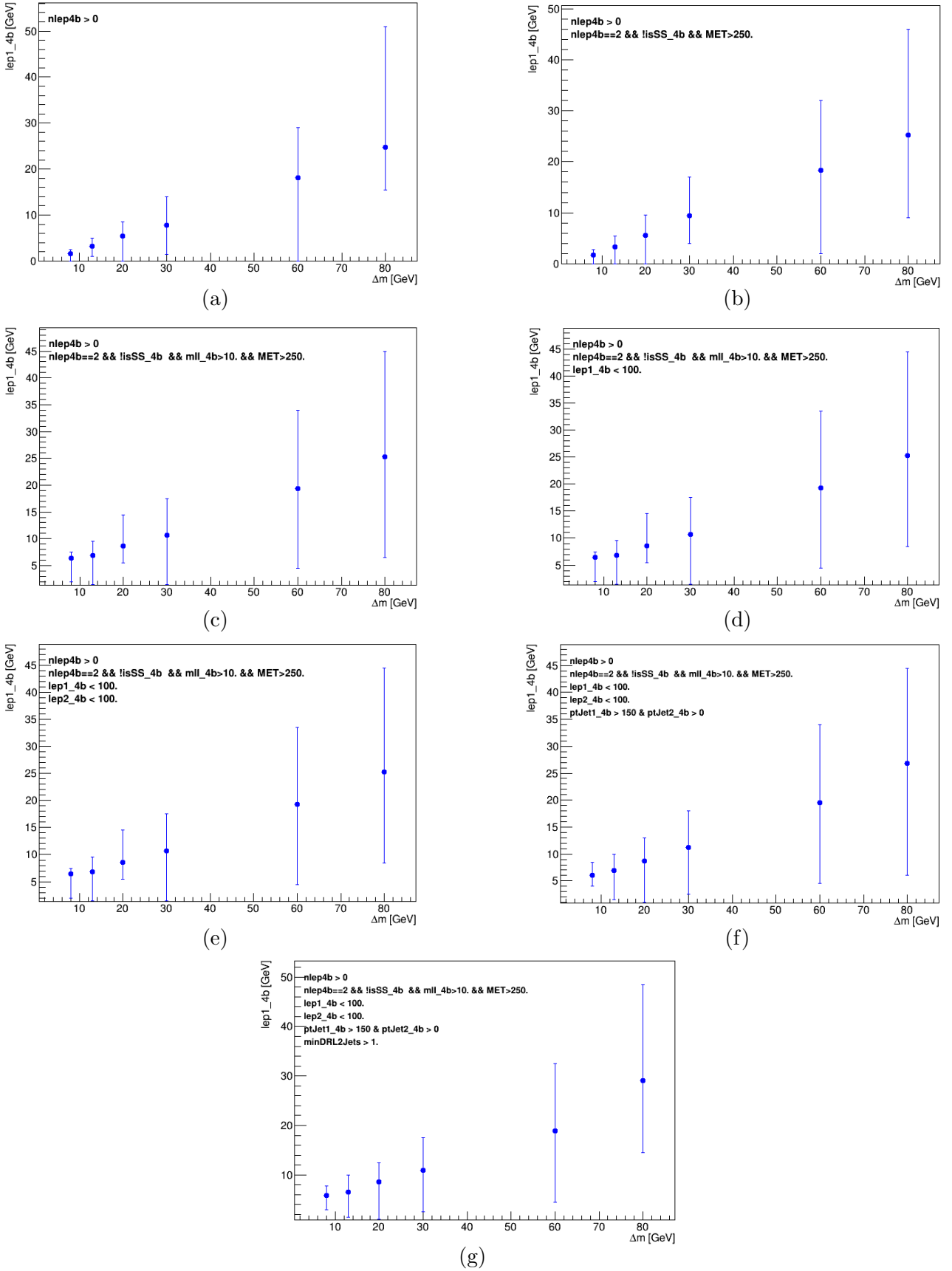


Figure 6: Peaks of the distributions of lep1_4b [GeV] vs Δm [GeV] at truth level. Applied cuts: ' $\text{nlep4b} > 0$ ' (Fig. 6a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{MET} > 250.$ ' (Fig. 6b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' (Fig. 6c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' (Fig. 6d), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 6e), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 6f), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 6g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

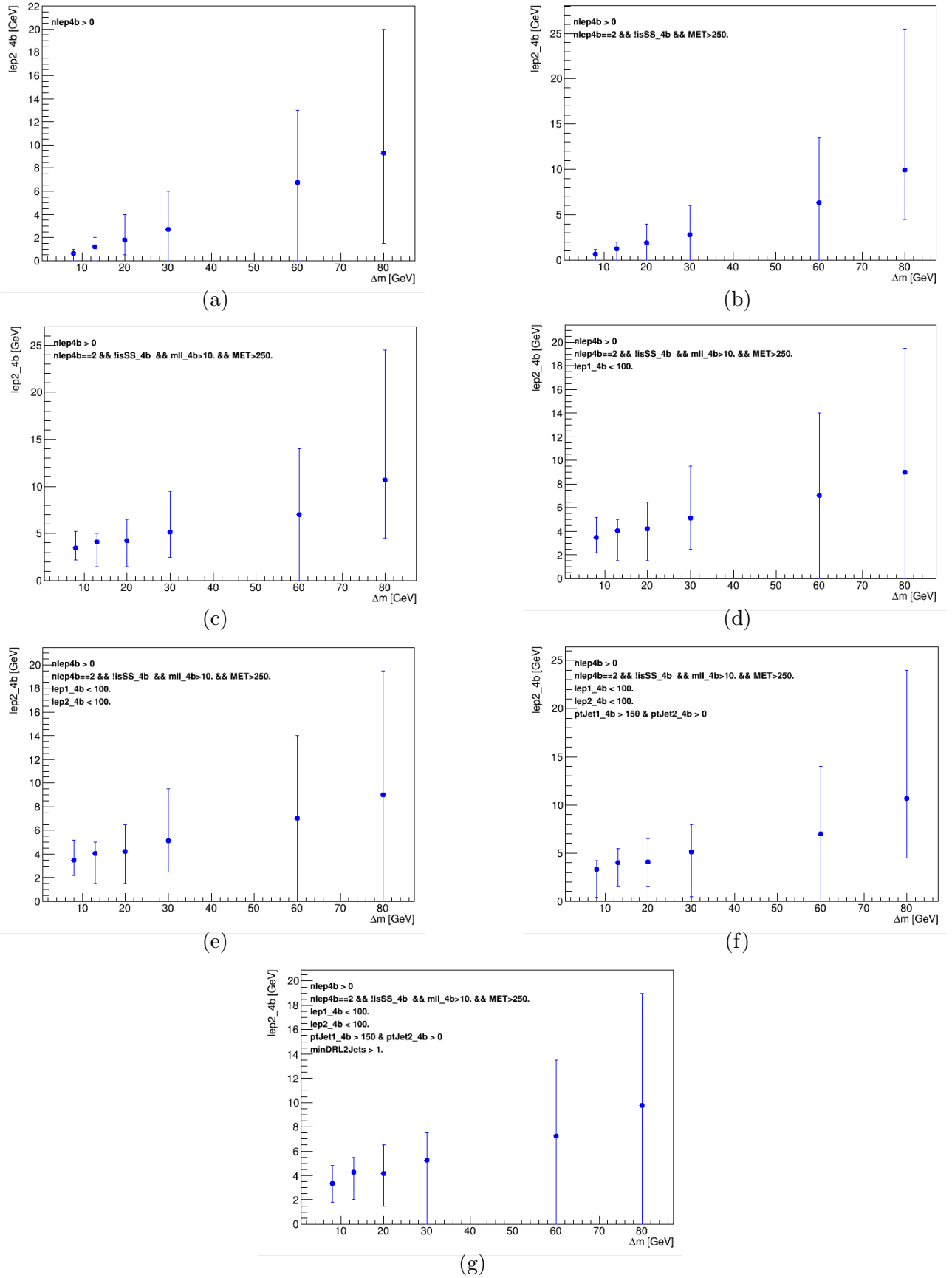
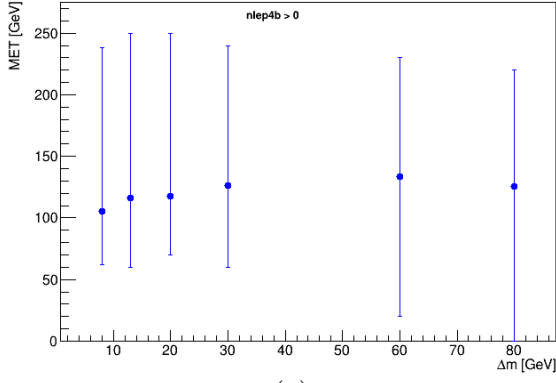
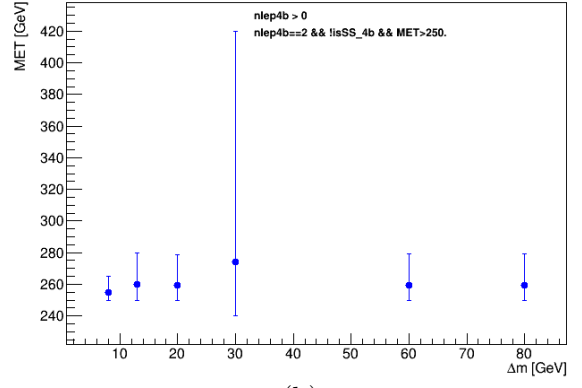


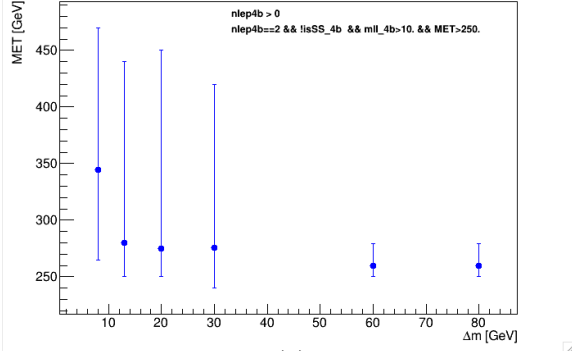
Figure 7: Peaks of the distributions of lep2_4b [GeV] vs Δm [GeV] at truth level. Applied cuts: ' $\text{lep2_4b} > 0$ ' (Fig. 7a), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{MET} > 250.$ ' (Fig. 7b), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' (Fig. 7c), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' (Fig. 7d), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 7e), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 7f), ' $\text{lep2_4b} > 0$ ' + ' $\text{lep2_4b} = 2 \ \&\& \ ! \text{isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 7g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



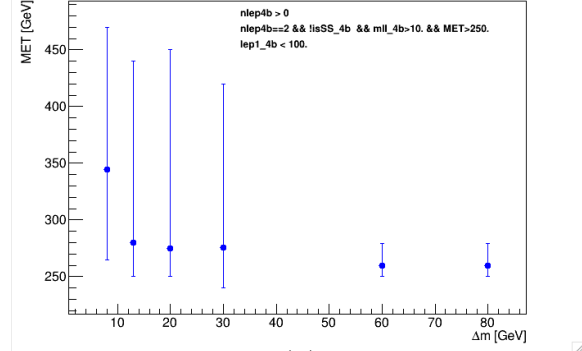
(a)



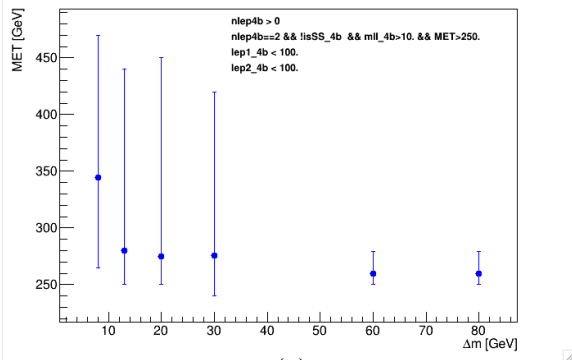
(b)



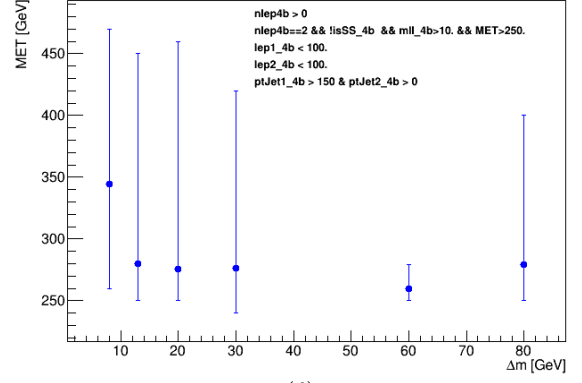
(c)



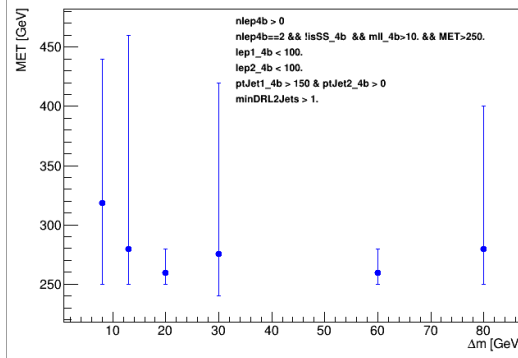
(d)



(e)



(f)



(g)

Figure 8: Peaks of the distributions of MET [GeV] vs Δm [GeV] at truth level. Applied cuts: 'nlep4b > 0' (Fig. 8a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 8b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 8c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 8d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 8e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 8f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 8g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

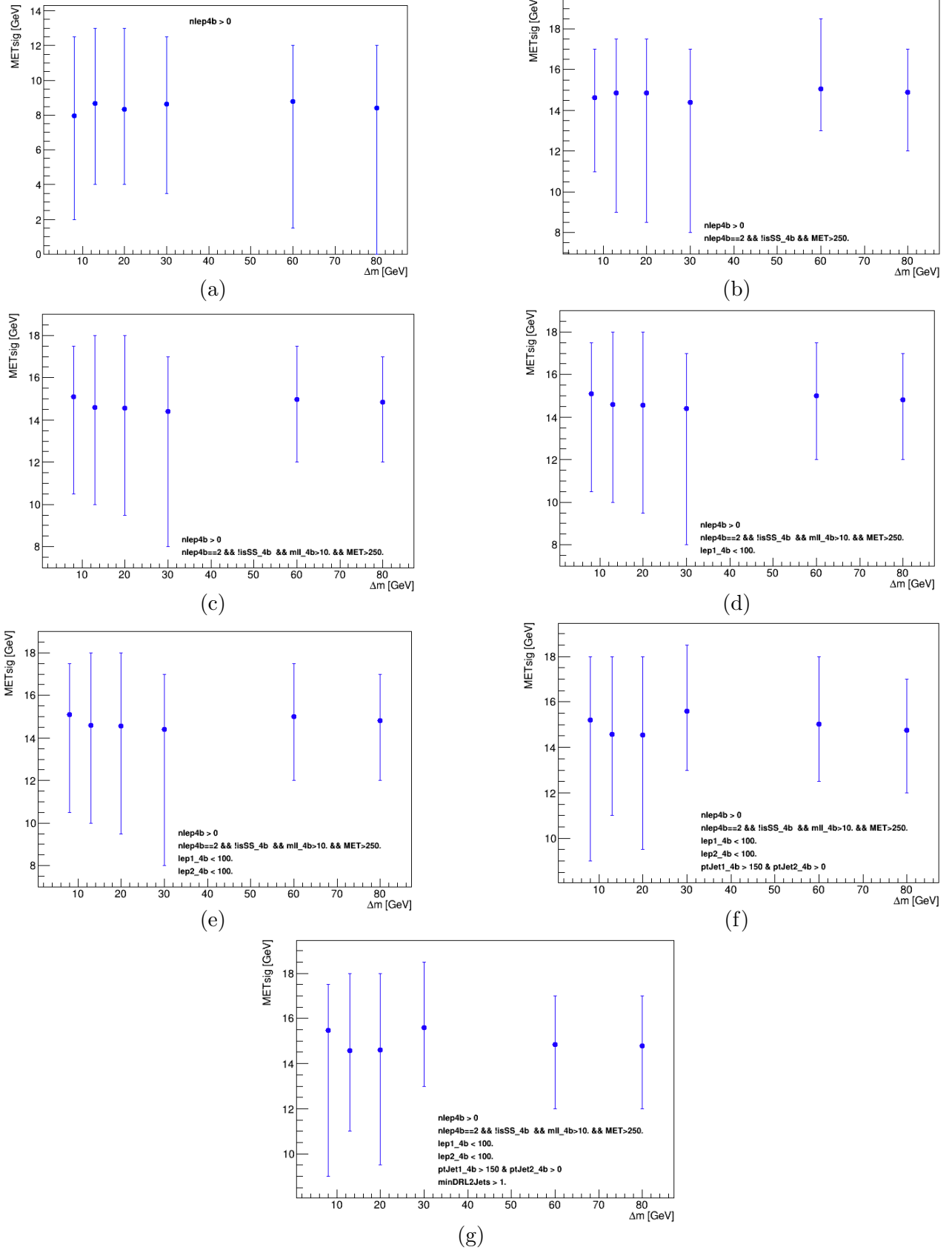


Figure 9: Peaks of the distributions of METsig [GeV] vs Δm [GeV] at truth level. Applied cuts: 'nlep4b > 0' (Fig. 9a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 9b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 9c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 9d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 9e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 9f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 9g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

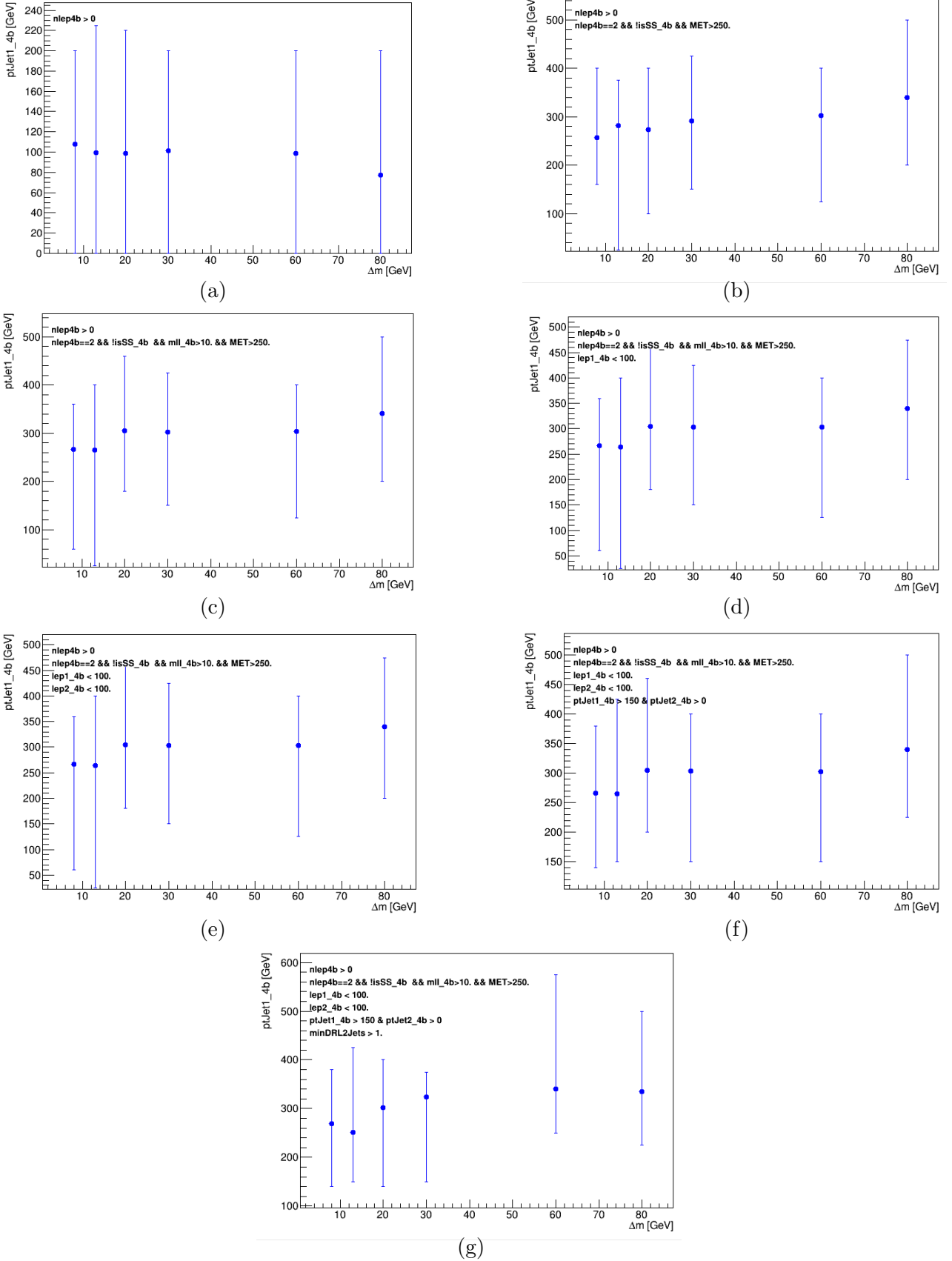
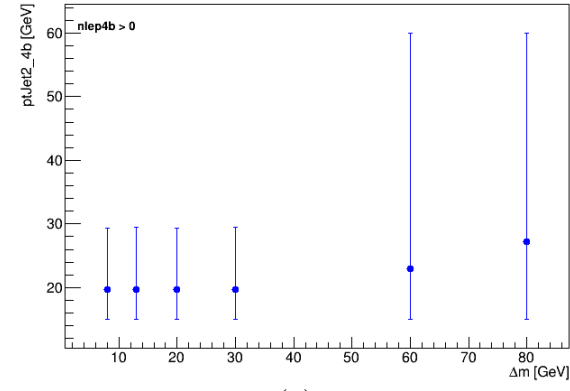
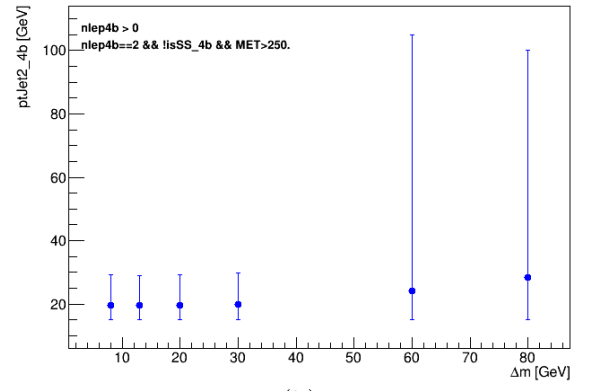


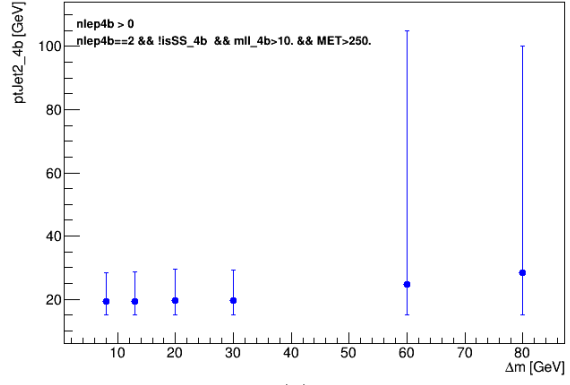
Figure 10: Peaks of the distributions of pt_{Jet1_4b} [GeV] vs Δm [GeV] at truth level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 10a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 10b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 10c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 10d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 10e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 10f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 10g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



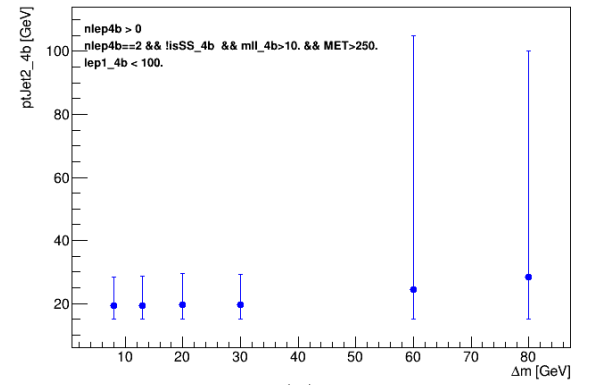
(a)



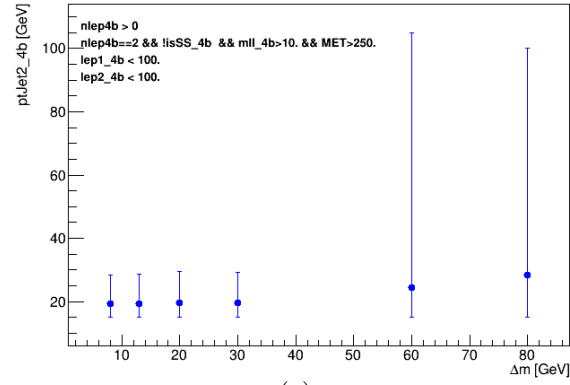
(b)



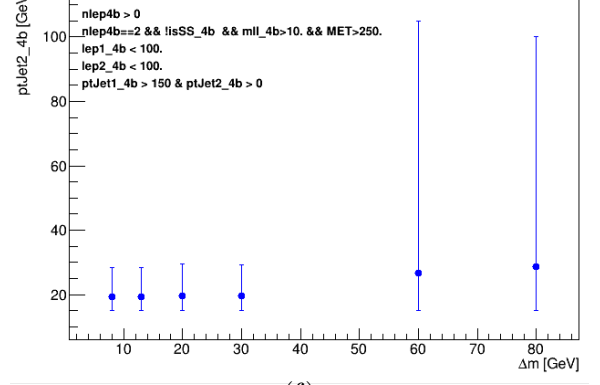
(c)



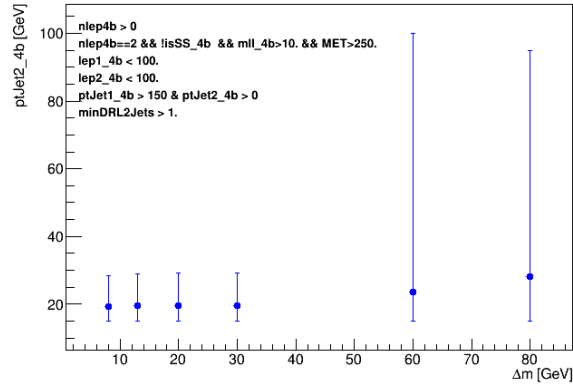
(d)



(e)

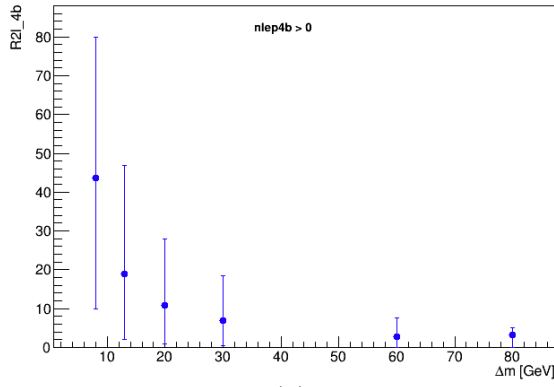


(f)

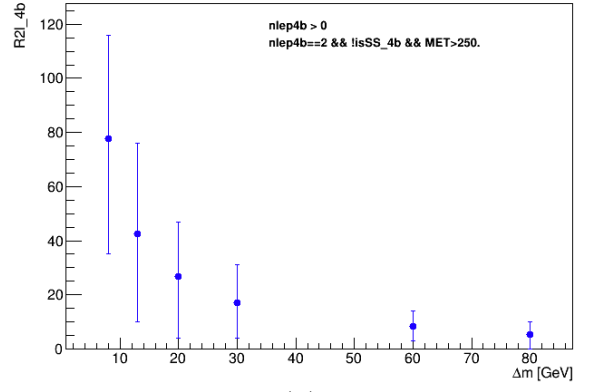


(g)

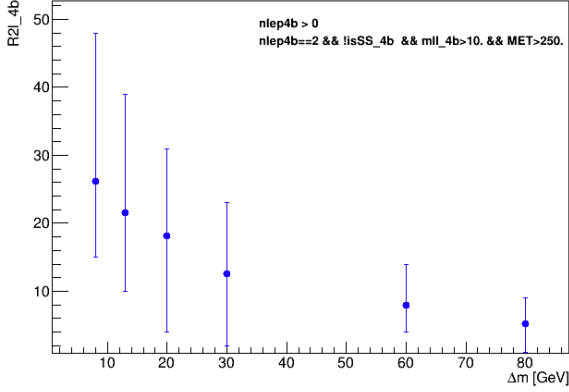
Figure 11: Peaks of the distributions of $ptJet2.4b$ [GeV] vs Δm [GeV] at truth level. Applied cuts: 'nlep4b > 0' (Fig. 11a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 11b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 11c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 11d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 11e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 11f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 11g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



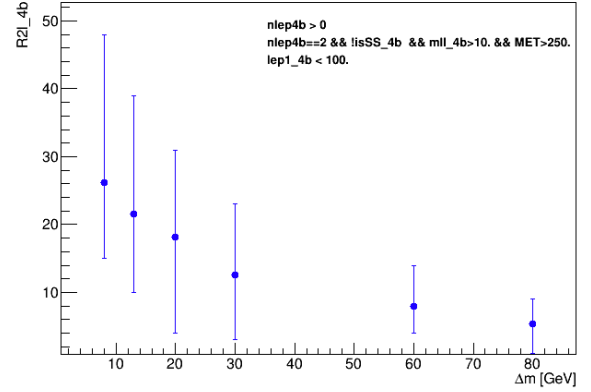
(a)



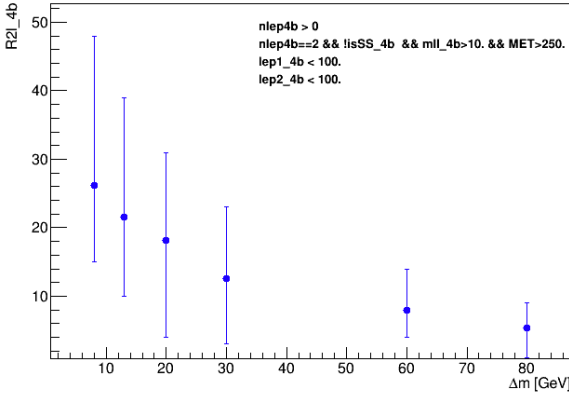
(b)



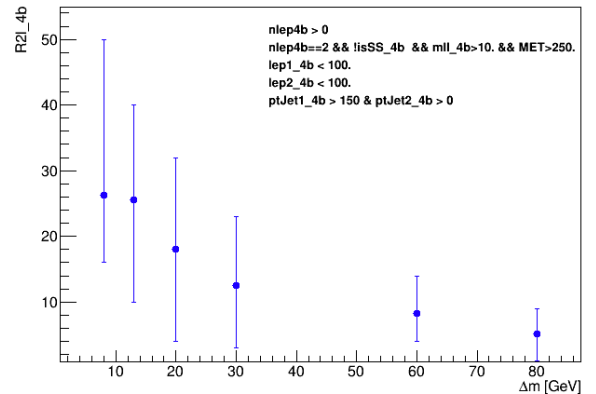
(c)



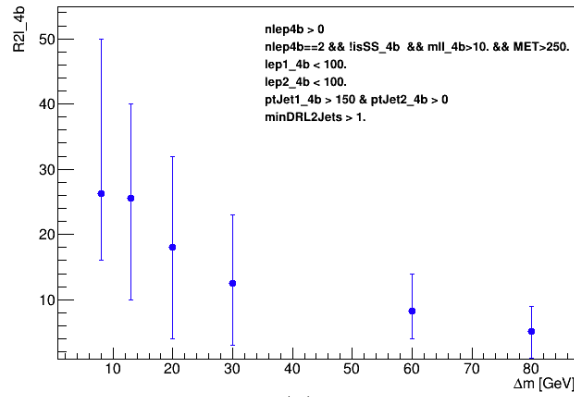
(d)



(e)



(f)



(g)

Figure 12: Peaks of the distributions of $R2L_{4b}$ [GeV] vs Δm [GeV] at truth level. Applied cuts: 'nlep4b > 0' (Fig. 12a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 12b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 12c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 12d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 12e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 12f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 12g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

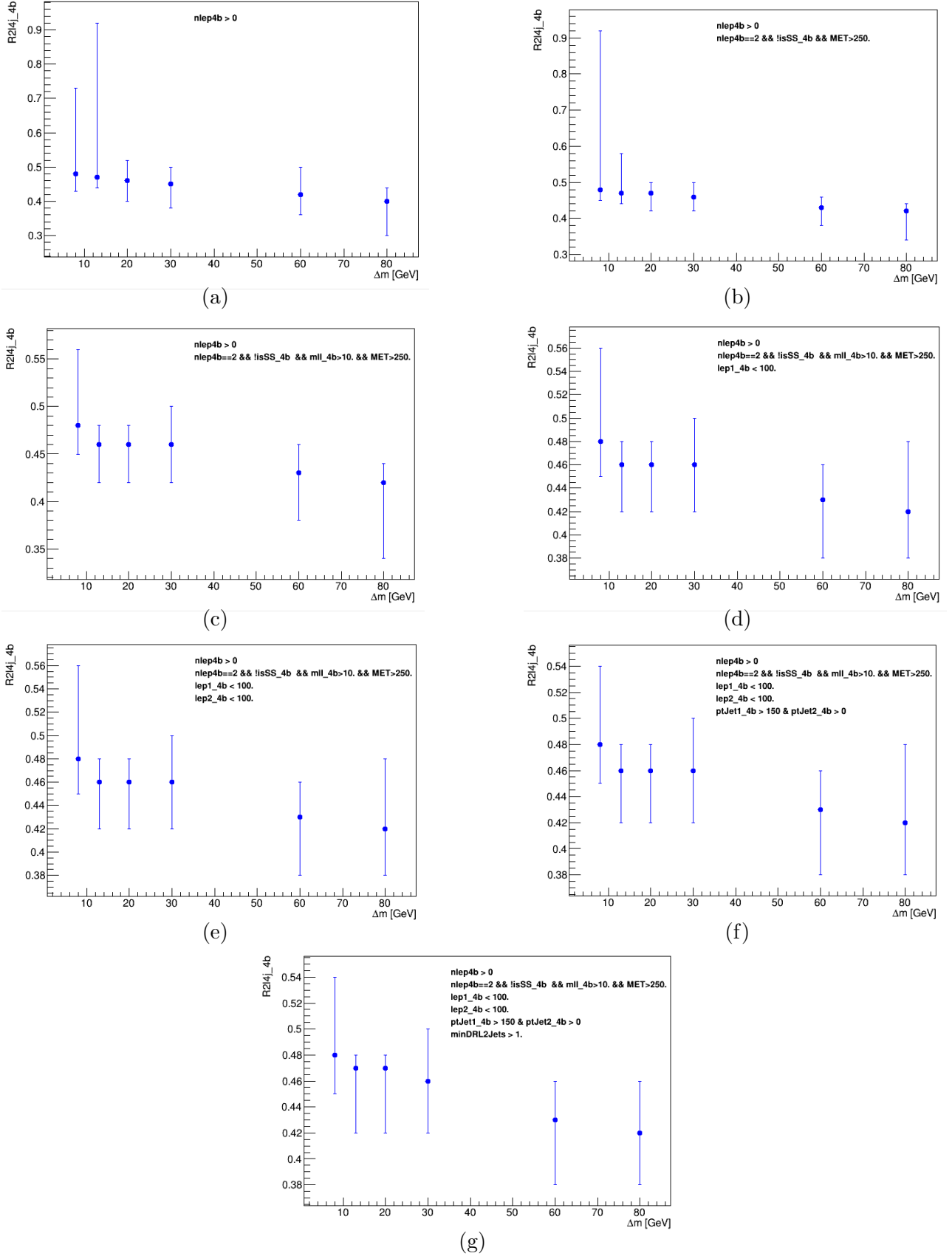


Figure 13: Peaks of the distributions of $R2l4j_4b$ [GeV] vs Δm [GeV] at truth level. Applied cuts: 'nlep4b > 0' (Fig. 13a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 13b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 13c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 13d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 13e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' (Fig. 13f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. && ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 13g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

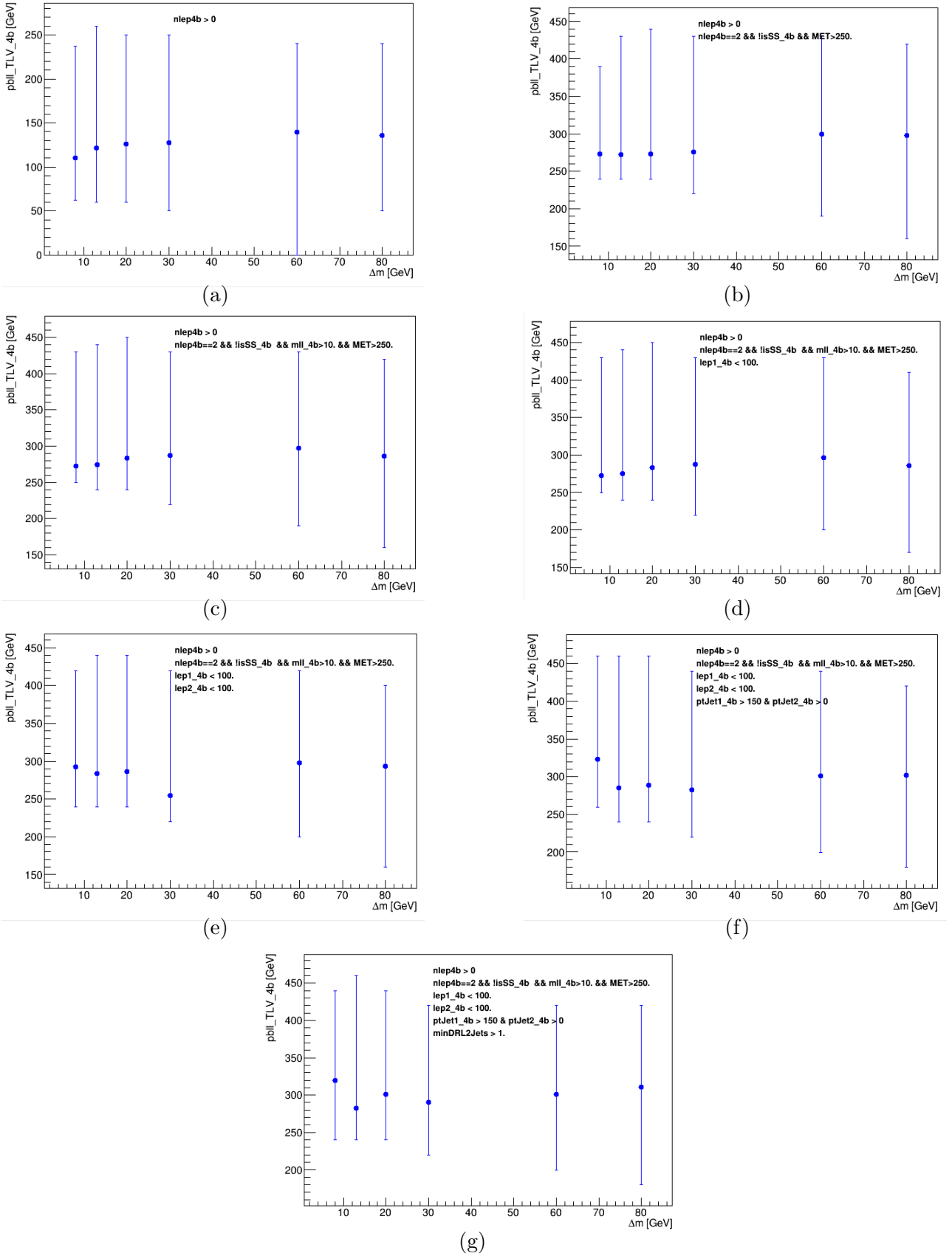


Figure 14: Peaks of the distributions of $pbll.TLV.4b$ [GeV] vs Δm [GeV] at truth level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 14a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ MET > 250.$ ' (Fig. 14b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ mll.4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 14c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ mll.4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' (Fig. 14d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ mll.4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' (Fig. 14e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ mll.4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' + ' $ptJet1.4b > 150. \ \& \ ptJet2.4b > 0.$ ' (Fig. 14f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS.4b \ \&\& \ mll.4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' + ' $ptJet1.4b > 150. \ \& \ ptJet2.4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 14g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

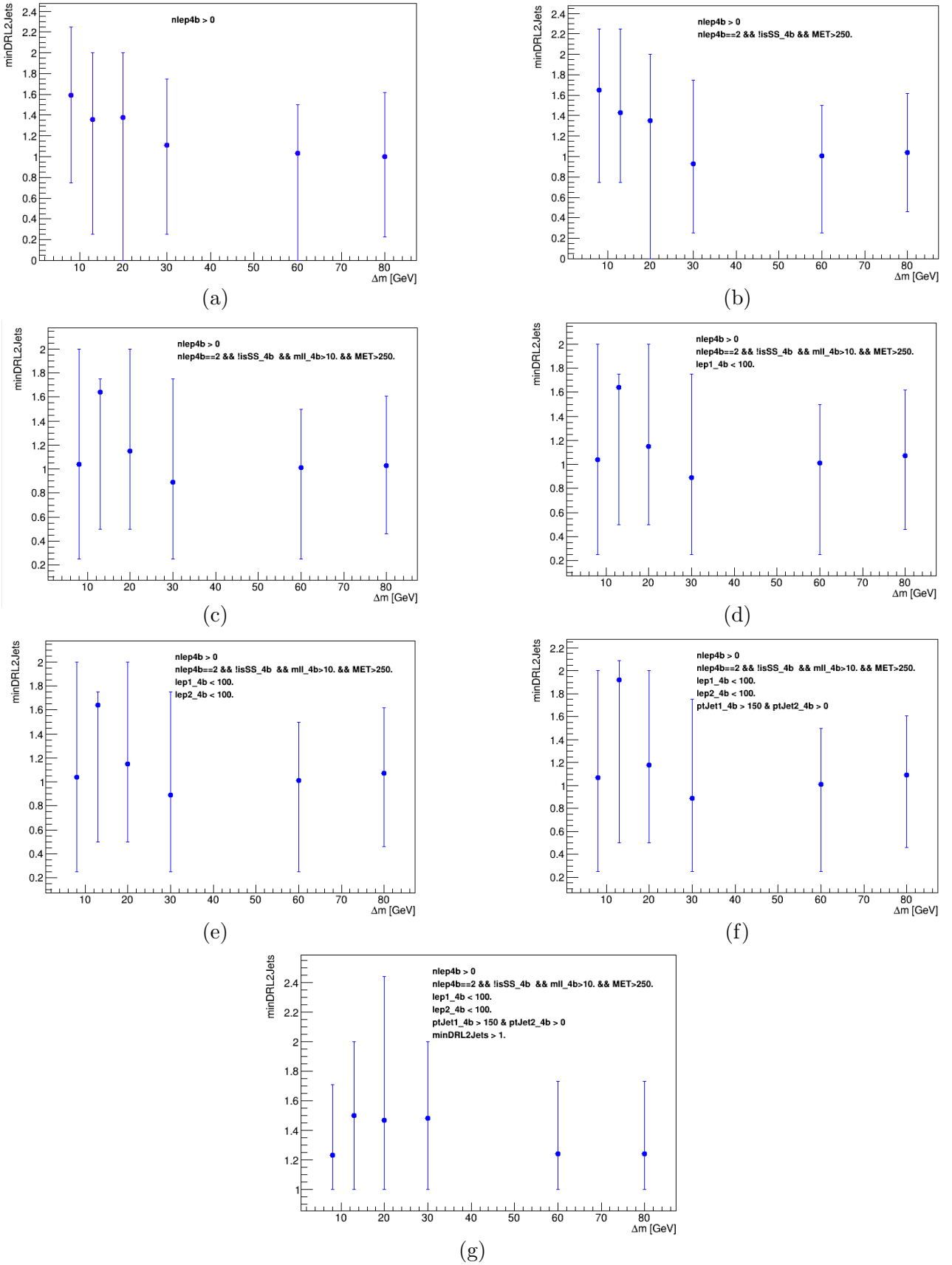
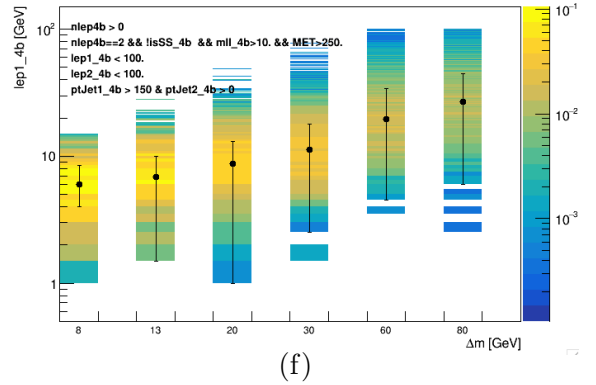
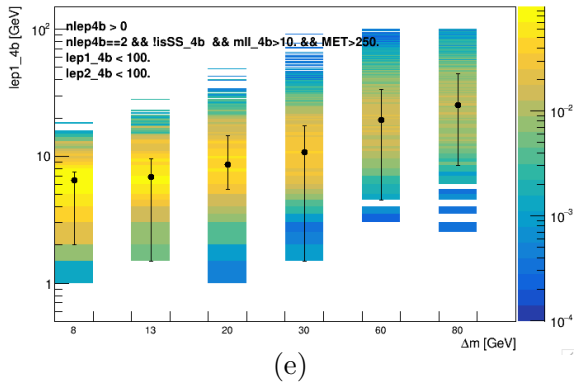
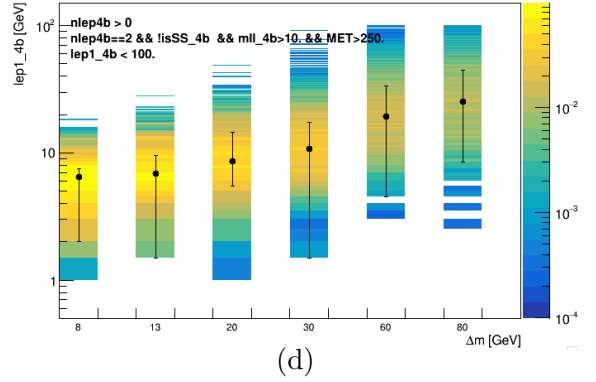
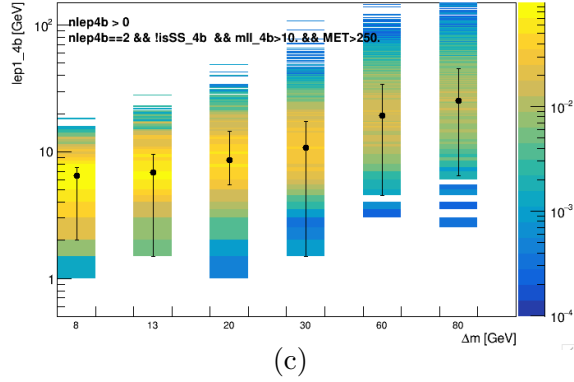
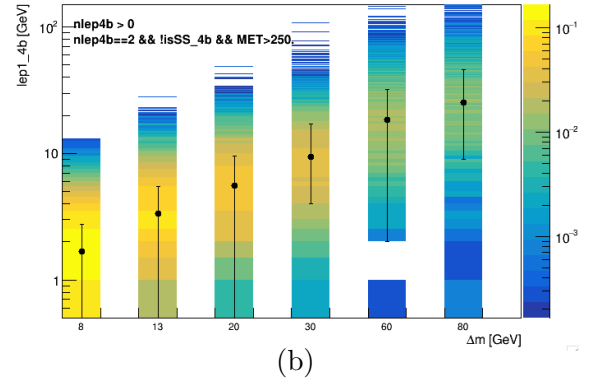
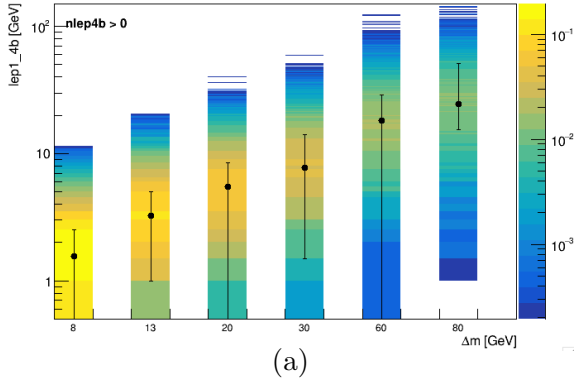


Figure 15: Peaks of the distributions of minDRL2Jets [GeV] vs Δm [GeV] at truth level. Applied cuts: ' $\text{nlep4b} > 0$ ' (Fig. 15a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{MET} > 250.$ ' (Fig. 15b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' (Fig. 15c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' (Fig. 15d), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 15e), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \text{ptJet2_4b} > 0.$ ' (Fig. 15f), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \text{!isSS_4b} \ \&\& \text{mll_4b} > 10. \ \&\& \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 15g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

A.3 2D distributions

In order to check the correctness of the previous analysis, we show the bidimensional correlation plots of the distributions vs Δm [GeV]. Once the variable is fixed, each value of Δm corresponds to a properly normalized distribution. The plots show that the peaks and the left/right standard deviations describe exactly the region where the bulk of the distributions is situated and thus the analysis of the peaks, discussed in Sec. 3.3.1, accounts well for the shape of the distributions. As an example, some of the correlation plots are shown below, both for the first selection cut sequence (Figures 16a, 16b, 16c, 16e, 16f, 17a) and for second selection cut sequence (Figures 18a, 18b, 18c, 18d). Also in this case, one can point out that the position of the peak, and thus of the bulk of the distribution, is strongly affected by the cut on the invariant mass of the two leptons.



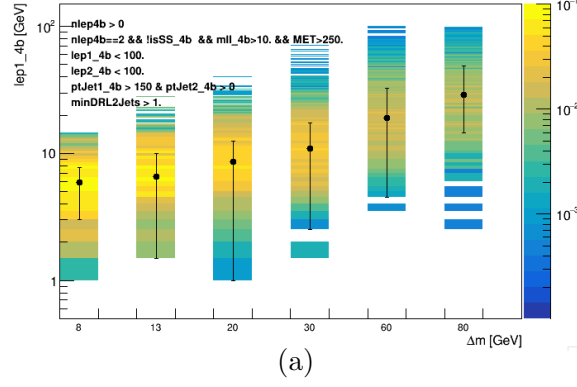


Figure 17: 2D distribution of lep1_4b vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: ' $\text{nlep4b} > 0$ ' (Fig. 16a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' (Fig. 16b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' (Fig. 16c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' (Fig. 16d), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 16e), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 16f), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 17a). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

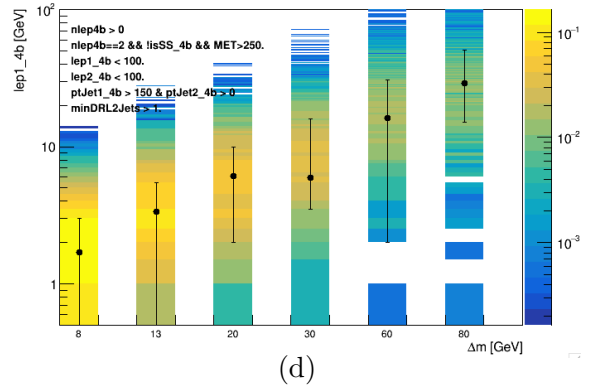
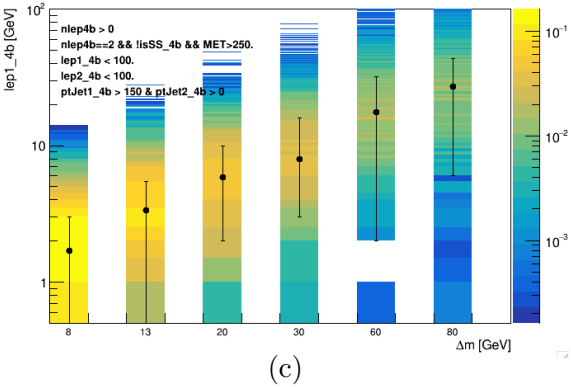
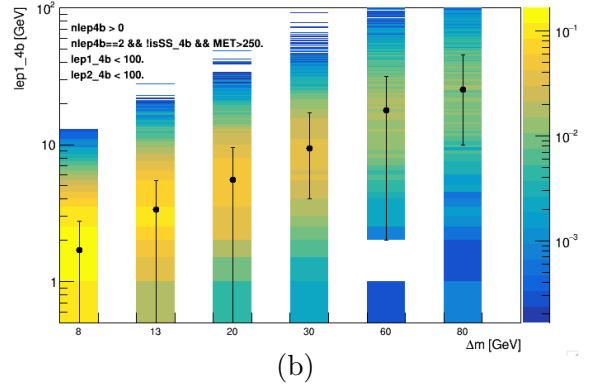
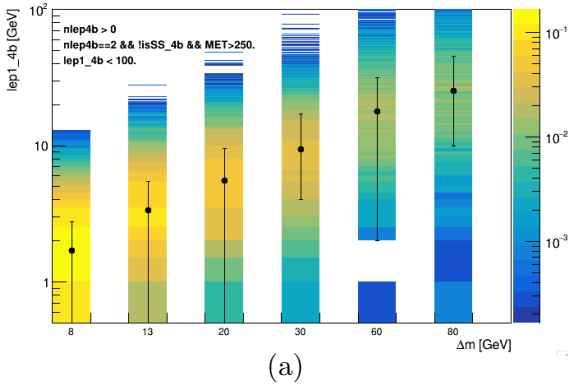


Figure 18: 2D distributions of lep1_4b [GeV] vs Δm [GeV] at truth level without invariant mass cut. Applied cuts: ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + (Fig. 18a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 18b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 18c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 18d). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

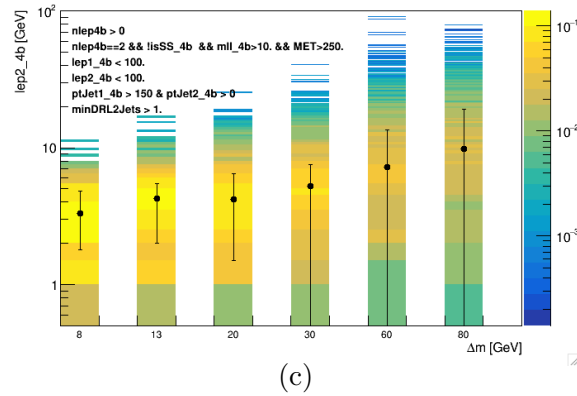
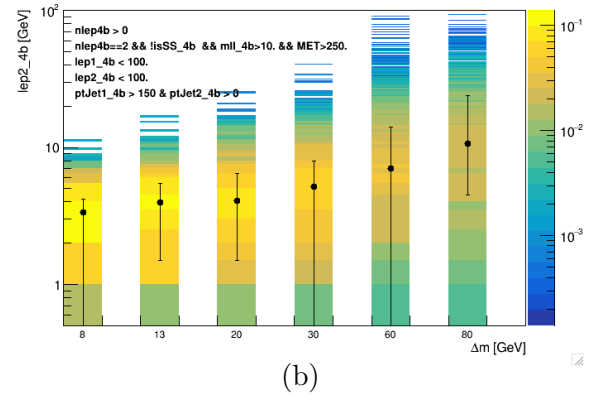
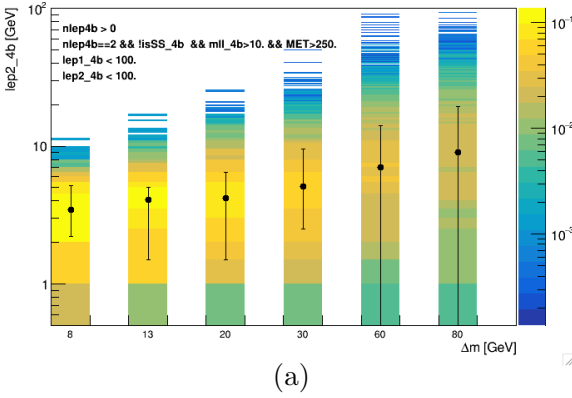
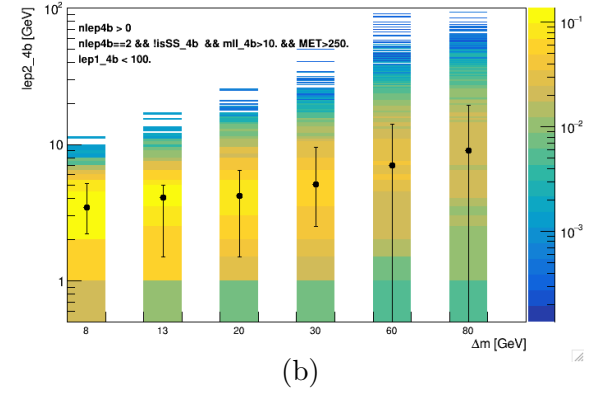
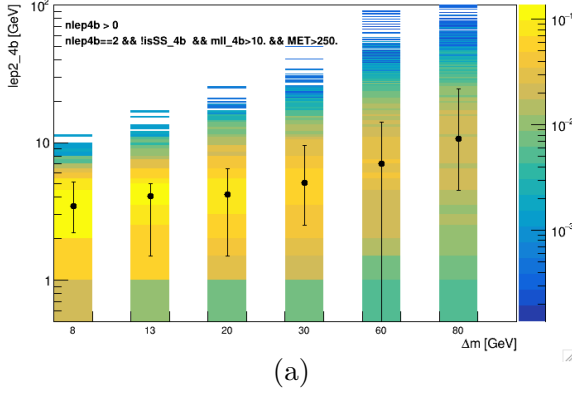
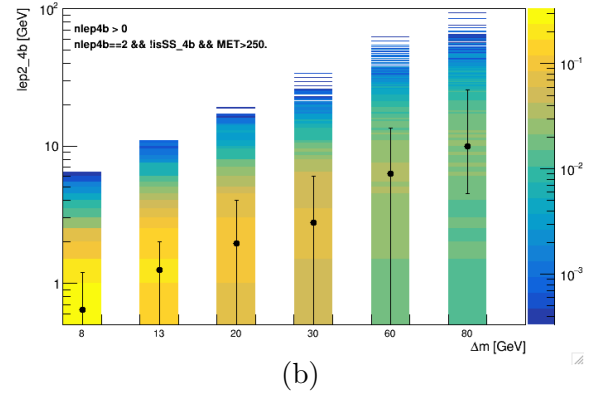
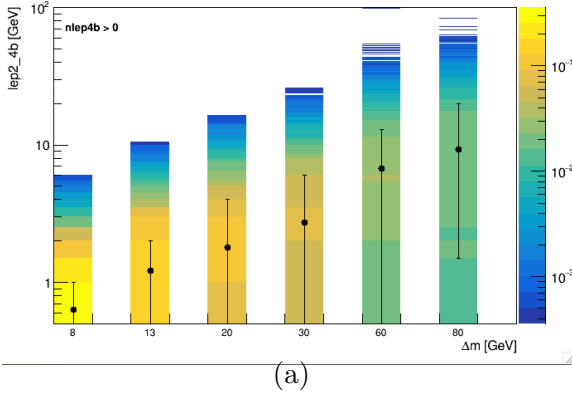


Figure 21: 2D distribution of lep2_{4b} vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: ' $\text{nlep4b} > 0$ ' (Fig. 19a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{MET} > 250.$ ' (Fig. 19b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{mll}_{4b} > 10. \ \&\& \ \text{MET} > 250.$ ' (Fig. 20a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{mll}_{4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1}_{4b} < 100.$ ' (Fig. 20b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{mll}_{4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1}_{4b} < 100.$ ' + ' $\text{lep2}_{4b} < 100.$ ' (Fig. 21a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{mll}_{4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1}_{4b} < 100.$ ' + ' $\text{lep2}_{4b} < 100.$ ' + ' $\text{ptJet1}_{4b} > 150 \ \&\& \ \text{ptJet2}_{4b} > 0.$ ' (Fig. 21b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} == 2 \ \&\& \ !\text{isSS}_{4b} \ \&\& \ \text{mll}_{4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1}_{4b} < 100.$ ' + ' $\text{lep2}_{4b} < 100.$ ' + ' $\text{ptJet1}_{4b} > 150. \ \&\& \ \text{ptJet2}_{4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 21c). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

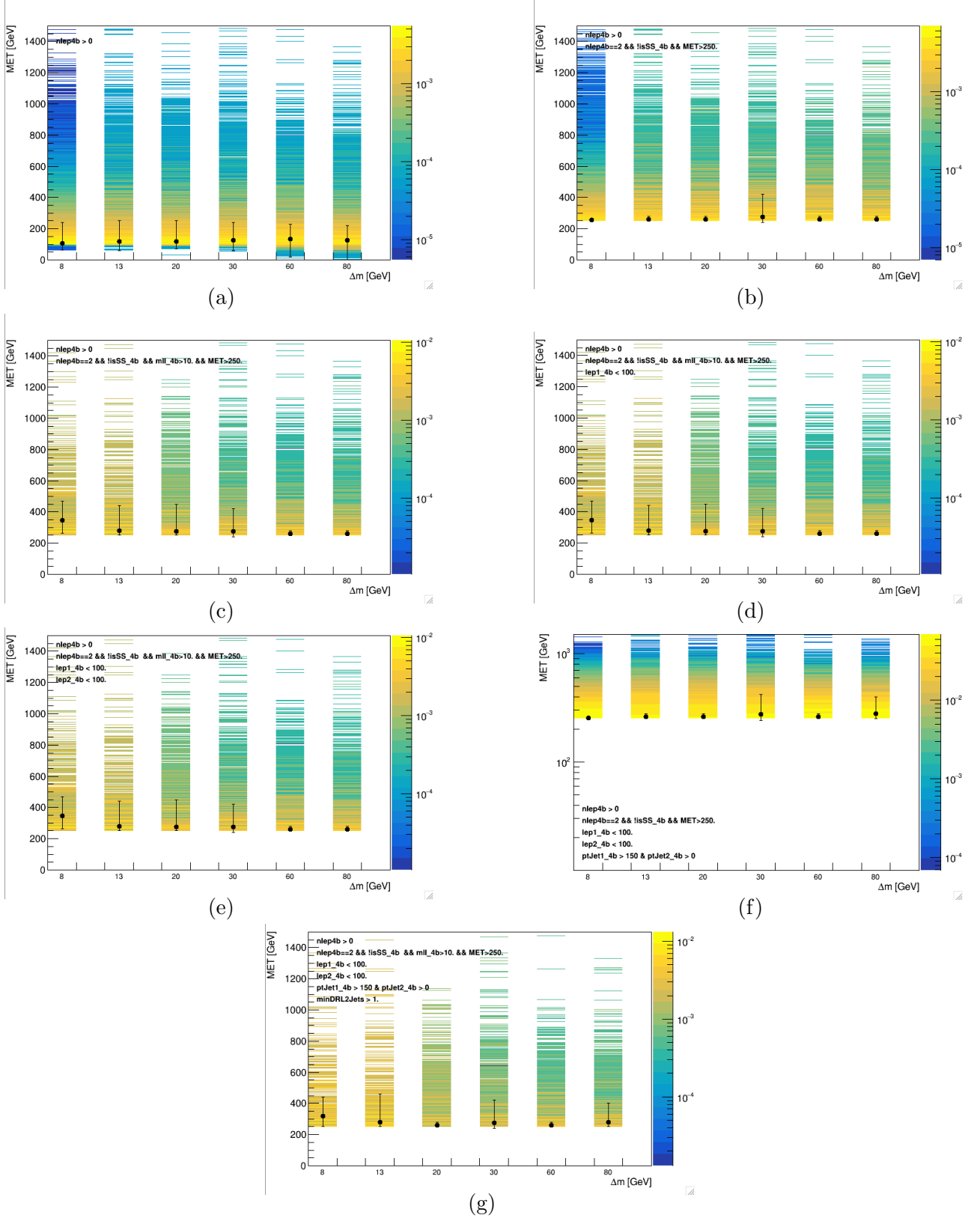


Figure 22: 2D distribution of MET vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 22a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 22b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 22c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 22d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 22e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 22f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 22g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

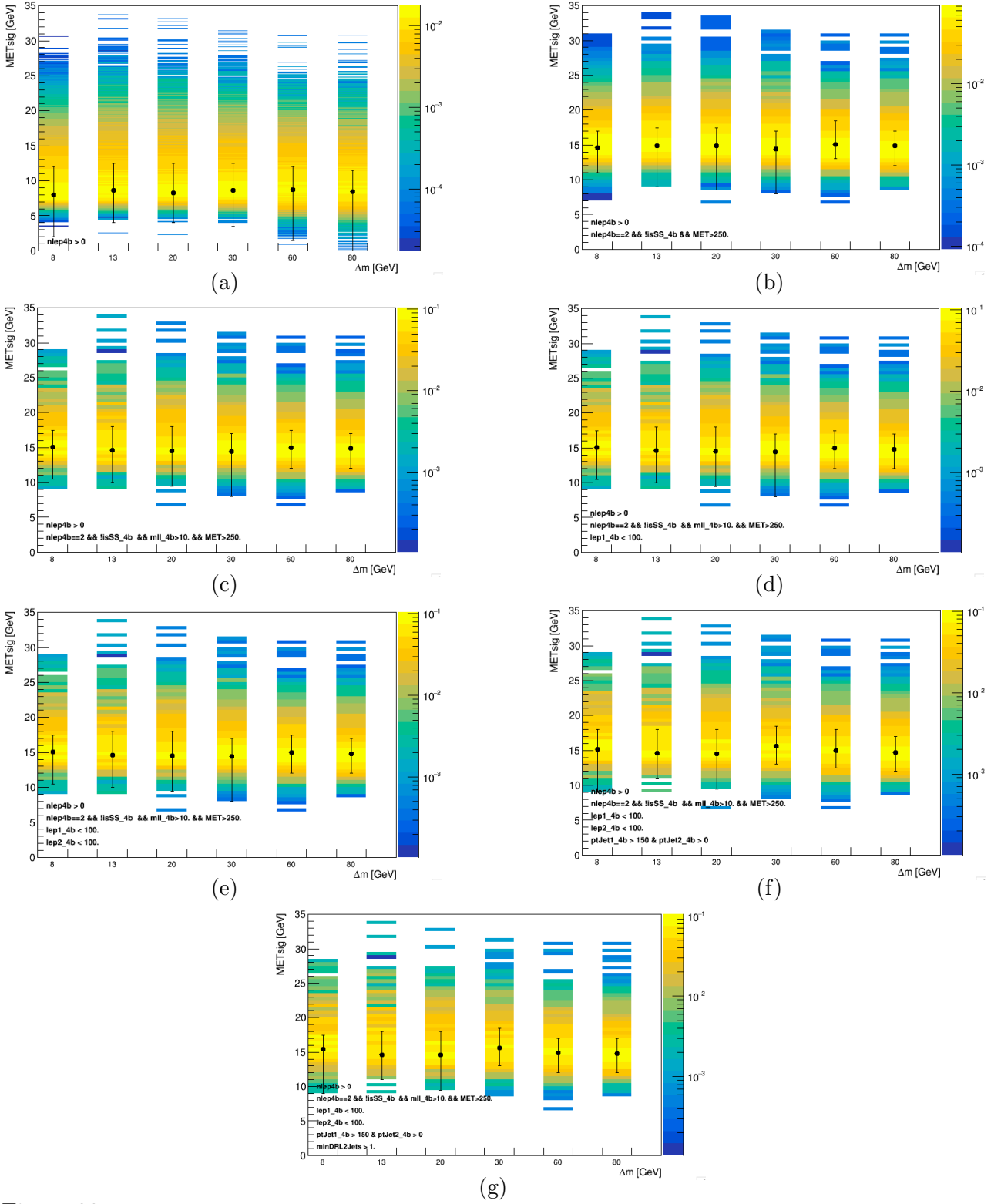
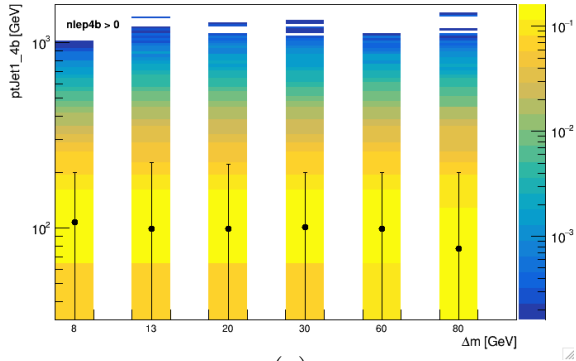
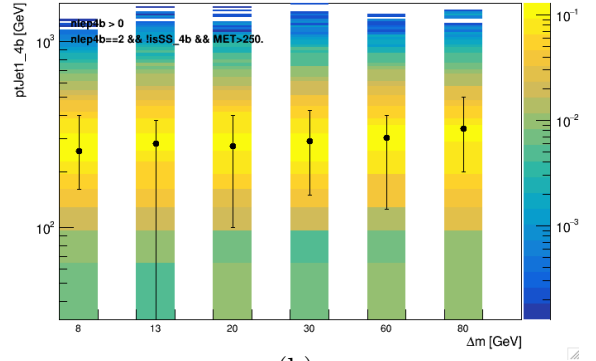


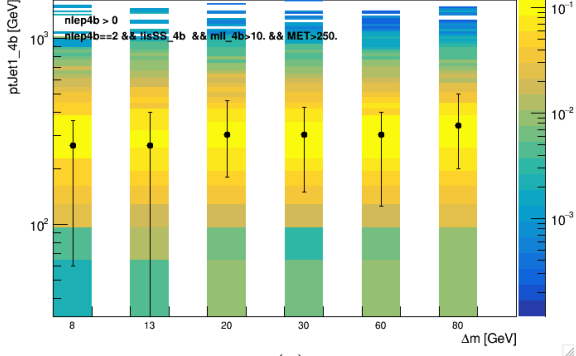
Figure 23: 2D distribution of METsig vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 23a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 23b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 23c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 23d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 23e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 23f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150 & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 23g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



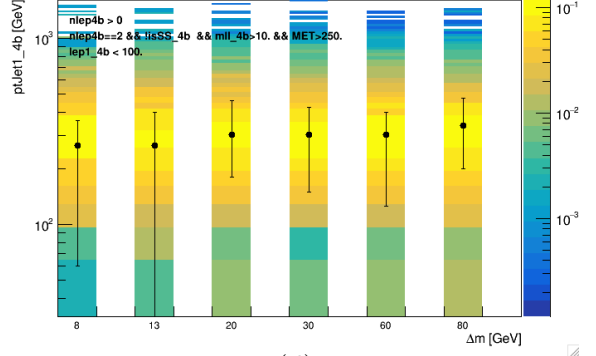
(a)



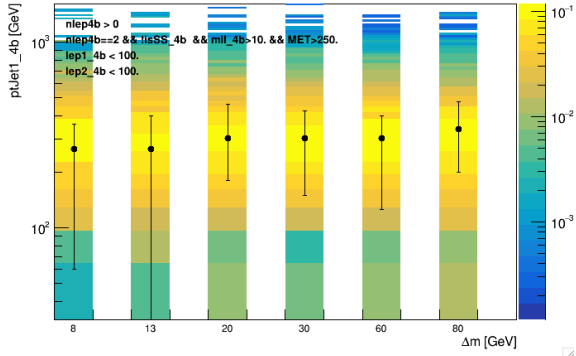
(b)



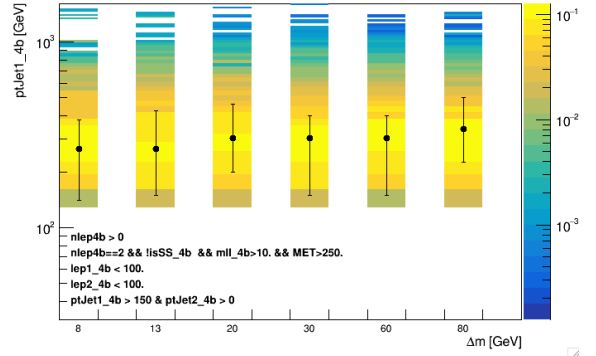
(c)



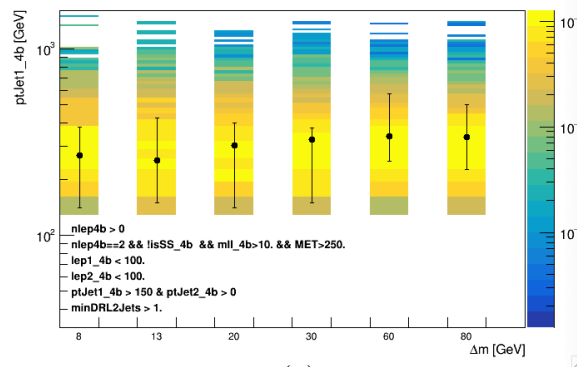
(d)



(e)



(f)



(g)

Figure 24: 2D distribution of $pt_{Jet1.4b}$ vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: ' $nlep4b > 0$ ' (Fig. 24a), ' $nlep4b > 0$ ' + ' $nlep4b > 0$ ' + ' $nlep4b == 2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 24b), ' $nlep4b > 0$ ' + ' $nlep4b == 2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 24c), ' $nlep4b > 0$ ' + ' $nlep4b == 2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 24e), ' $nlep4b > 0$ ' + ' $nlep4b == 2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150 \ \& \ ptJet2_4b > 0$ ' (Fig. 24f), ' $nlep4b > 0$ ' + ' $nlep4b == 2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 24g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

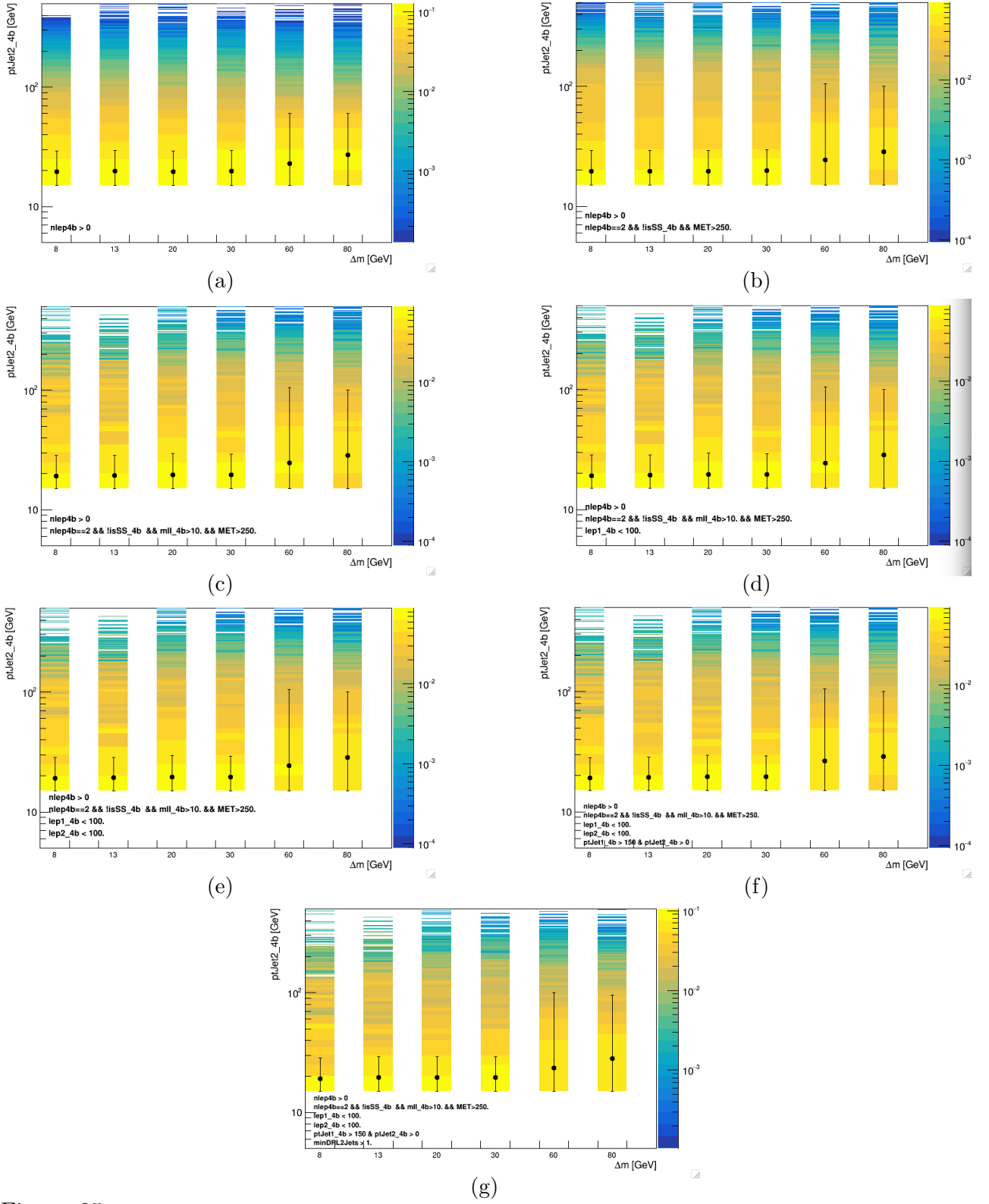


Figure 25: 2D distribution of $pt_{Jet2.4b}$ vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 25a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 25b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 25c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 25d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 25e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' (Fig. 25f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' + 'minDRL2Jets > 1.' (Fig. 25g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

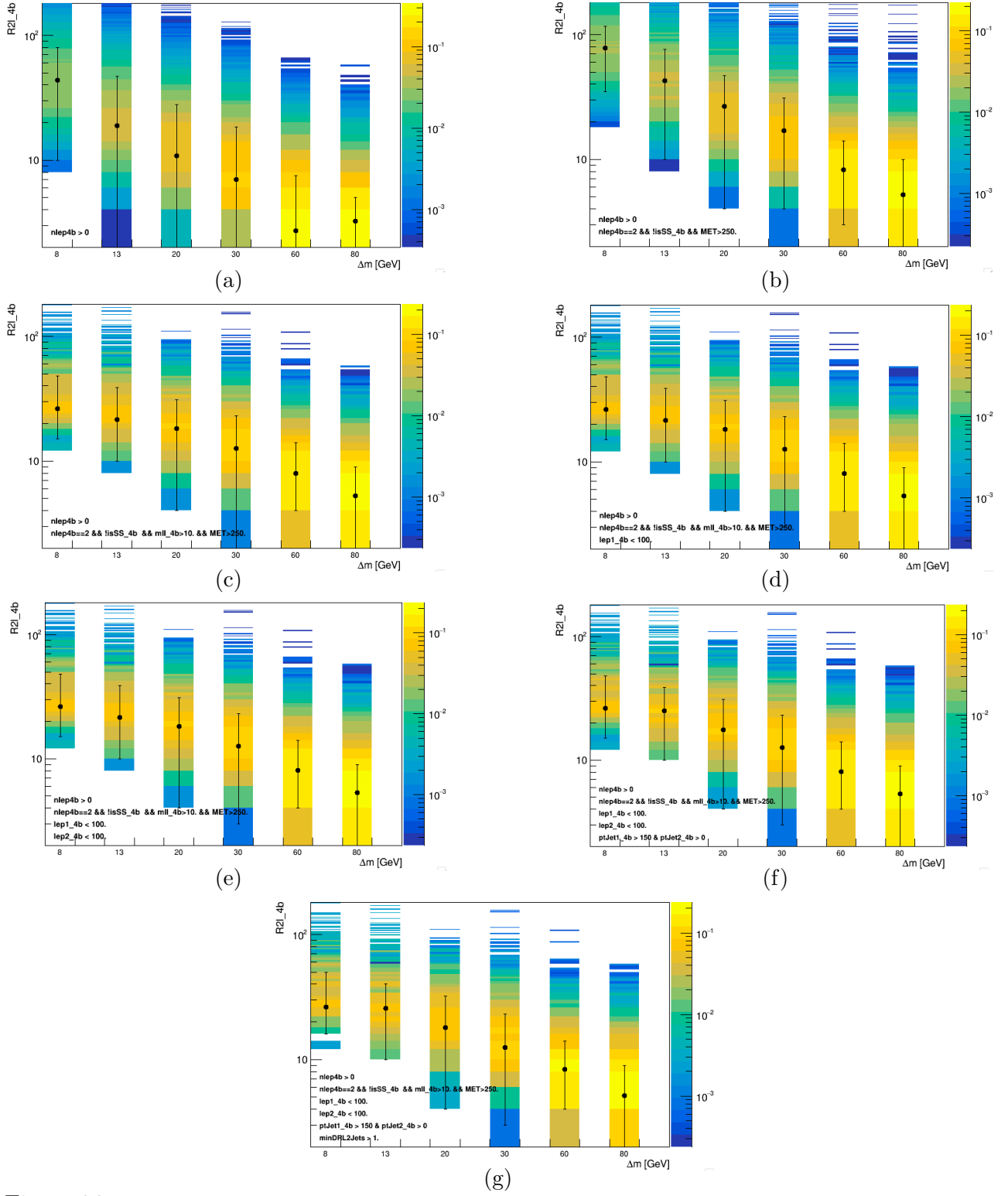


Figure 26: 2D distribution of $R_{2l,4b}$ vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 26a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 26b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 26c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 26d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 26e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 26f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 26g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

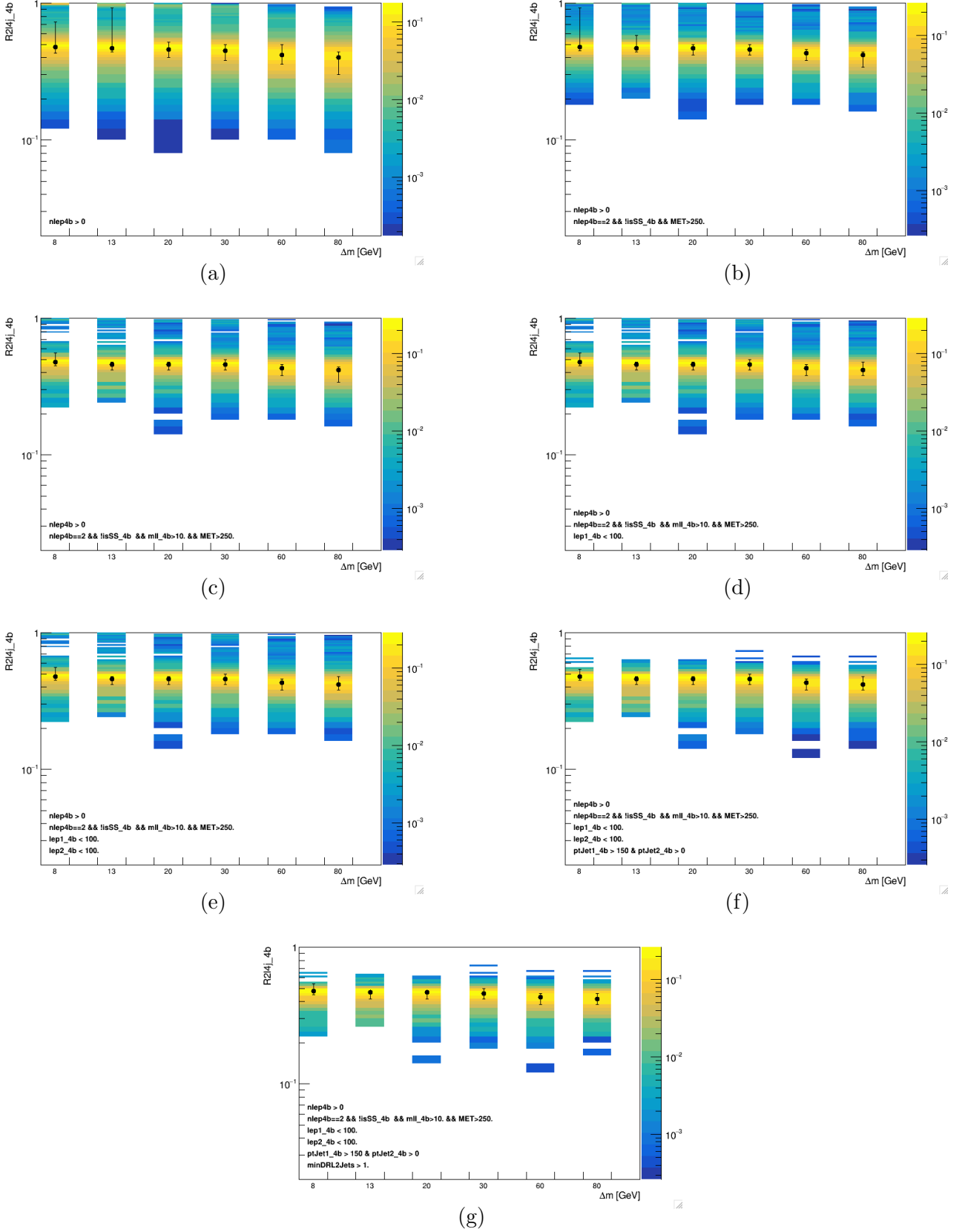


Figure 27: 2D distribution of $R2l4j_4b$ vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 27a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 27b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 27c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 27d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 27e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 27f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 27g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

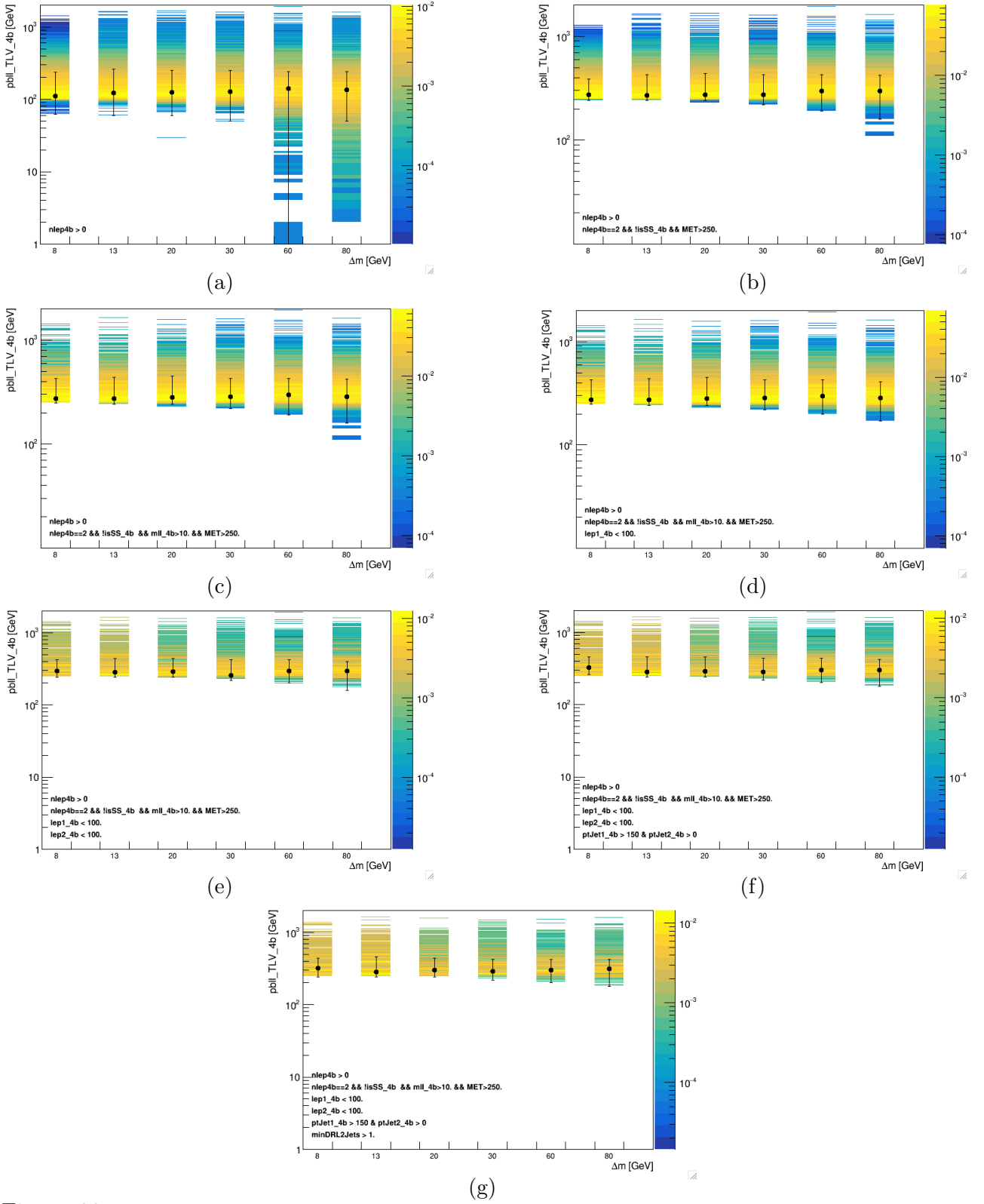


Figure 28: 2D distribution of pbll_TLV_4b vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 28a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 28b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 28c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 28d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 28e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 28f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 28g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

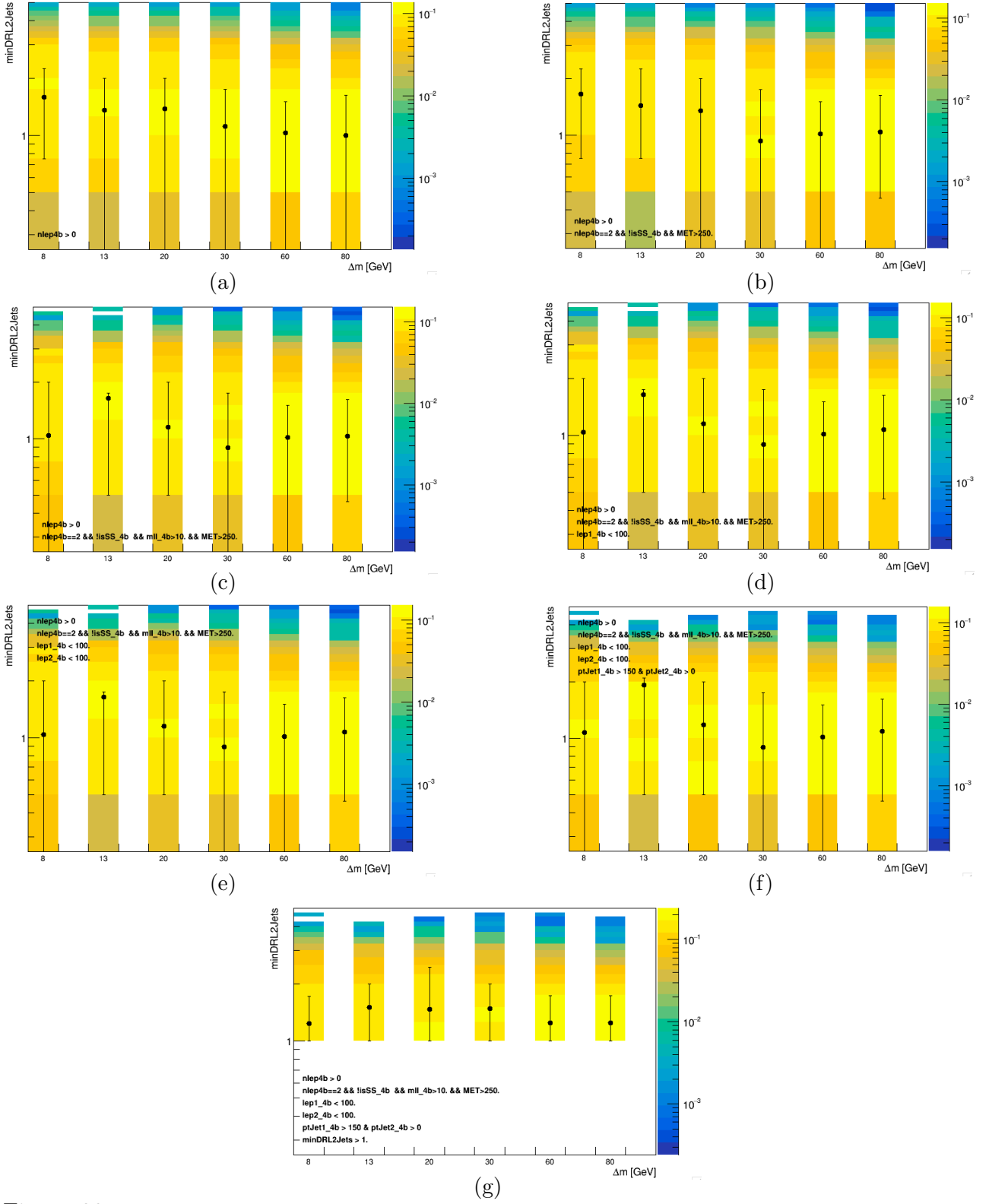


Figure 29: 2D distribution of minDRL2Jets vs Δm [GeV] at truth level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 29a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && MET > 250.' (Fig. 29b), 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && mll.4b > 10. && MET > 250.' (Fig. 29c), 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && mll.4b > 10. && MET > 250.' + 'lep1.4b < 100.' (Fig. 29d), 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && mll.4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.' (Fig. 29e), 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && mll.4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' (Fig. 29f), 'nlep4b > 0' + 'nlep4b==2 && !isSS.4b && mll.4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' + 'minDRL2Jets > 1.' (Fig. 29g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

B Reco level data

B.1 Efficiency

Cuts	$\Delta m = 8 \text{ GeV}$	$\Delta m = 13 \text{ GeV}$	$\Delta m = 20 \text{ GeV}$	$\Delta m = 30 \text{ GeV}$	$\Delta m = 60 \text{ GeV}$	$\Delta m = 80 \text{ GeV}$
cut0	0.13%	2.54%	18.55%	10.11%	29.98%	33.28%
cut1	0.03%	0.67%	4.72%	2.55%	7.39%	8.45%
cut2	0.03%	0.67%	4.72%	2.55%	7.30%	8.15%
cut3	0.03%	0.67%	4.72%	2.55%	7.30%	8.15%
cut4	0.01%	0.44%	3.24%	1.72%	5.78%	6.60%
cut5	0.01%	0.34%	2.45%	1.35%	3.91	%4.64%

Table 3: Cumulative efficiency of the selection cuts, where cut0 = 'nlep4b > 0' , cut1 = 'nlep4b==2 && !isSS_4b && mll_4b >10. && MET > 250.', cut2 = 'lep1_4b < 100.', cut3 = 'lep2_4b < 100.' , cut4 = 'ptJet1_4b > 150 & ptJet2_4b > 0' and cut5 = 'minDRL2Jets > 1.'. All the cuts are applied in sequence.

Cuts	$\Delta m = 8 \text{ GeV}$	$\Delta m = 13 \text{ GeV}$	$\Delta m = 20 \text{ GeV}$	$\Delta m = 30 \text{ GeV}$	$\Delta m = 60 \text{ GeV}$	$\Delta m = 80 \text{ GeV}$
cut0	0.13%	2.54%	18.55%	10.11%	29.98%	33.28%
cut1	0.05%	0.96%	5.50%	3.26%	7.95%	8.74 %
cut2	0.05%	0.96%	5.50%	3.26%	7.86%	8.44 %
cut3	0.05%	0.96%	5.50%	3.26%	7.86%	8.44 %
cut4	0.03%	0.65%	3.79%	2.17%	6.21%	6.82%
cut5	0.02%	0.52%	2.91%	1.72%	4.19 %	4.79%

Table 4: Cumulative efficiency of the selection cuts, where cut0 = 'nlep4b > 0' , cut1 = 'nlep4b==2 && !isSS_4b && MET > 250.', cut2 = 'lep1_4b < 100.', cut3 = 'lep2_4b < 100.' , cut4 = 'ptJet1_4b > 150 & ptJet2_4b > 0' and cut5 = 'minDRL2Jets > 1.'. All the cuts are applied in sequence.

B.2 Reco level peaks

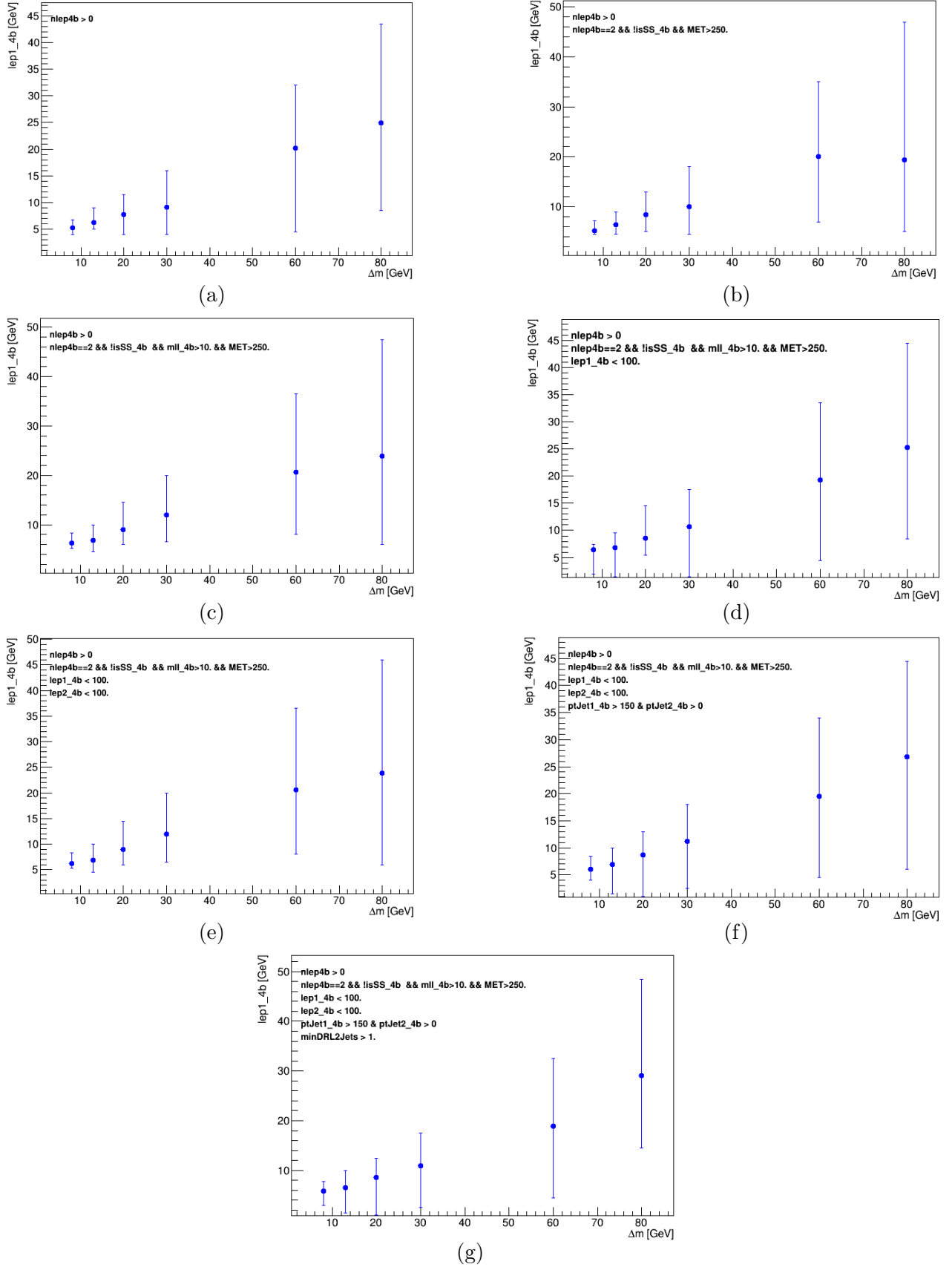
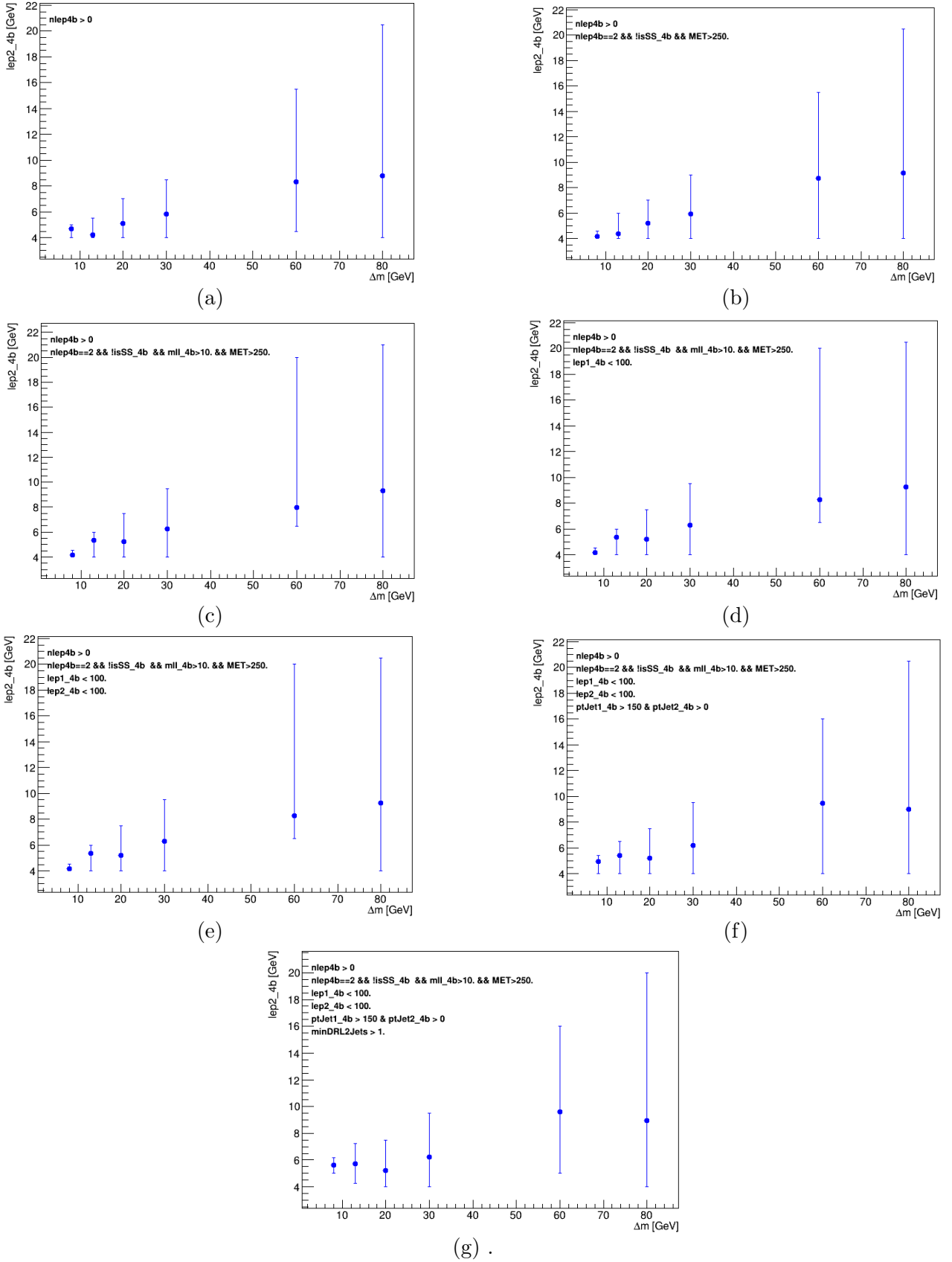


Figure 30: Peaks of the distributions of lep1_{4b} [GeV] vs Δm [GeV] at reco level. Applied cuts: 'nlep4b > 0' (Fig. 30a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 30b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 30c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 30d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 30e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 30f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 30g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



(g) .

Figure 31: Peaks of the distributions of `lep2.4b` [GeV] vs Δm [GeV] at reco level. Applied cuts: `'nlep4b > 0'` (Fig. 31a), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.'` (Fig. 31b), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.'` (Fig. 31c), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1.4b < 100.'` (Fig. 31d), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.'` (Fig. 31e), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.'` (Fig. 31f), `'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1.4b < 100.' + 'lep2.4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' + 'minDRL2Jets > 1.'` (Fig. 31g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

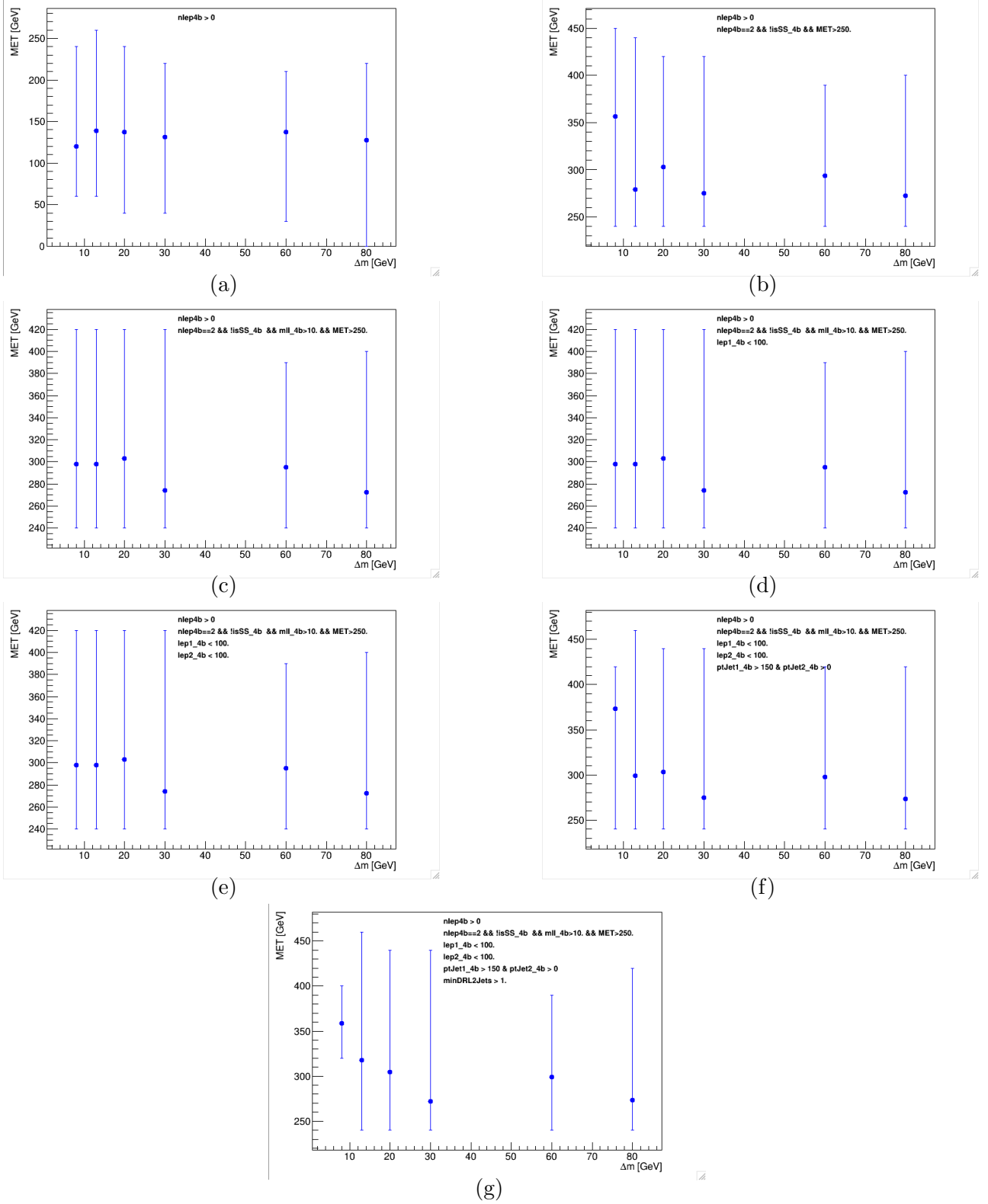


Figure 32: Peaks of the distributions of MET [GeV] vs Δm [GeV] at reco level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 32a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 32b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 32c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 32d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 32e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 32f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 32g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

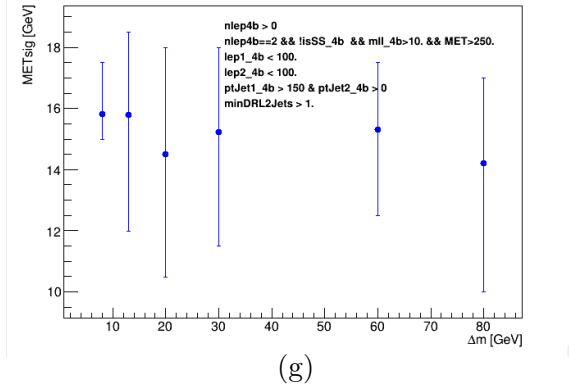
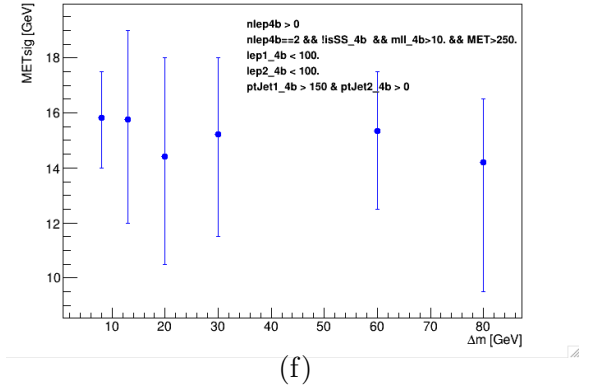
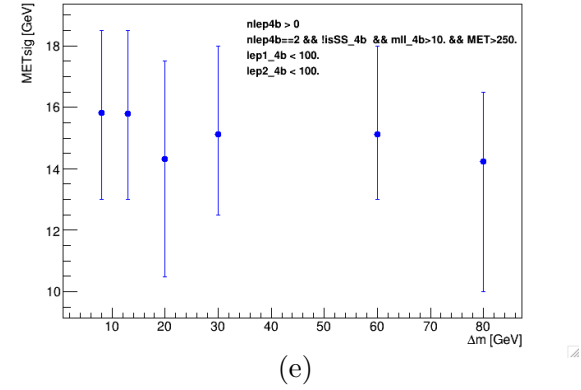
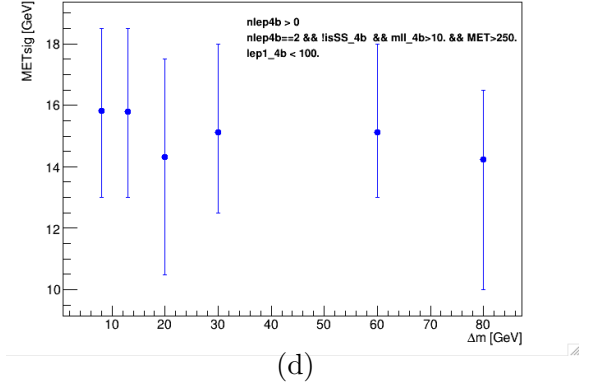
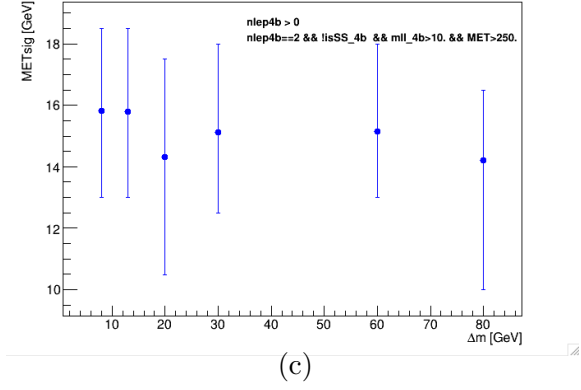
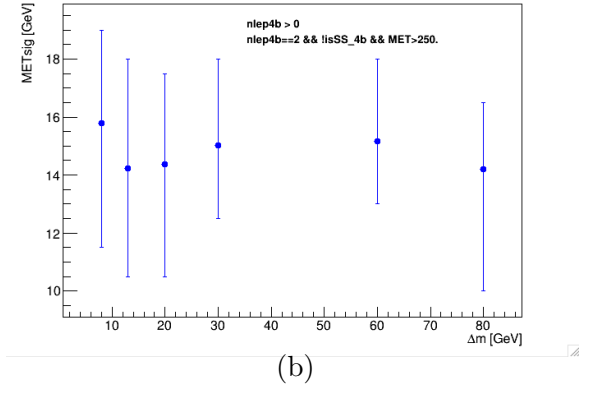
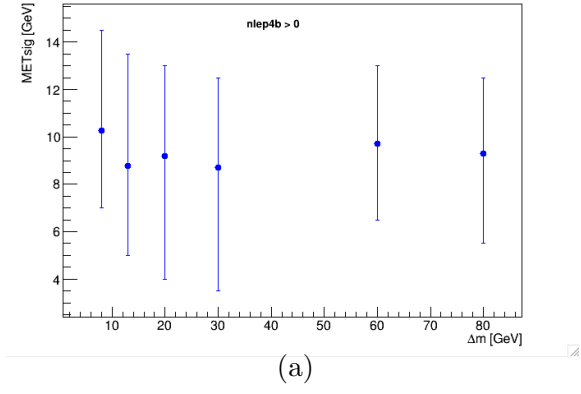


Figure 33: Peaks of the distributions of METsig [GeV] vs Δm [GeV] at reco level. Applied cuts: 'nlep4b > 0' (Fig. 33a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 33b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 45b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 33d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 33e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 33f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 33g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

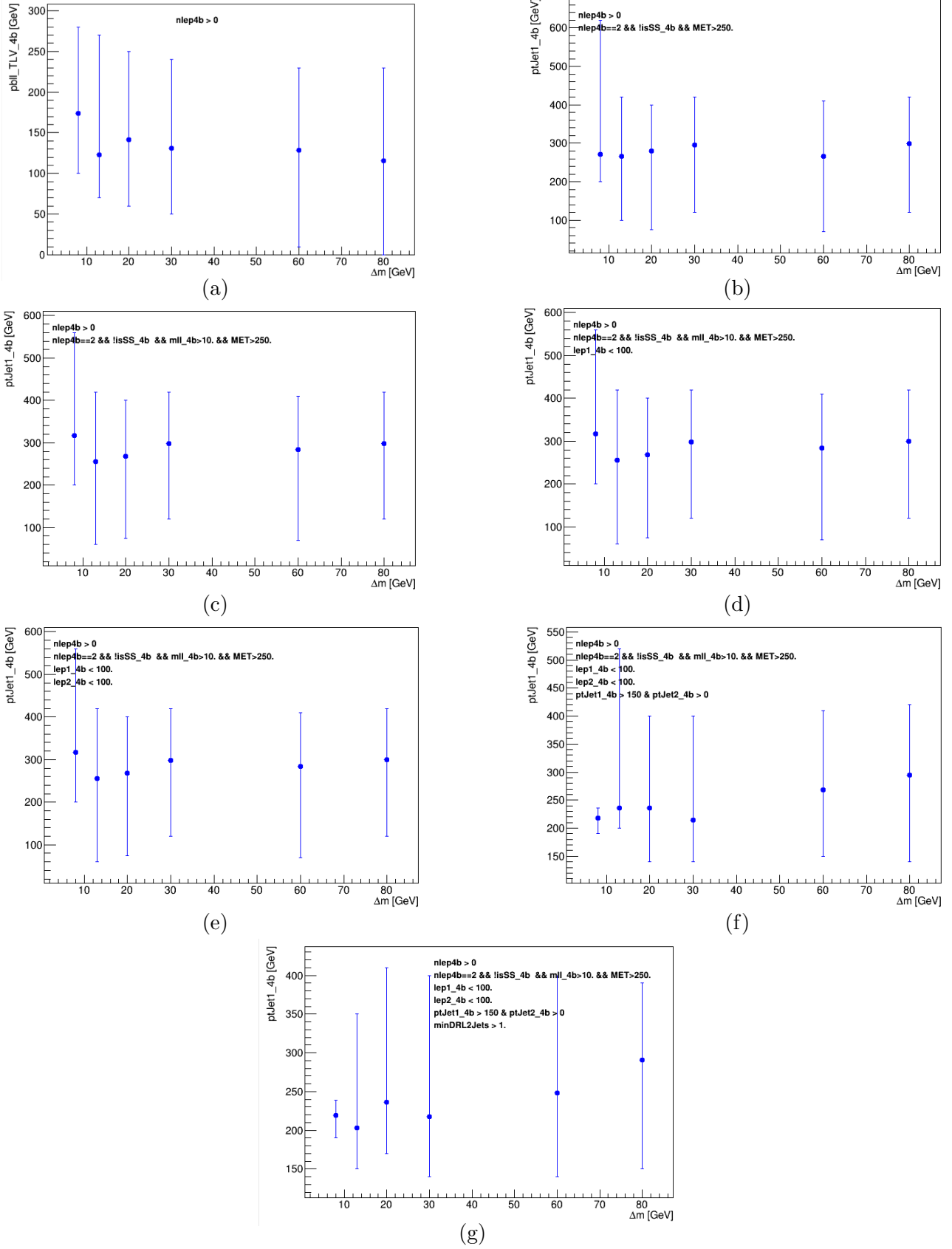


Figure 34: Peaks of the distributions of $ptJet1.4b$ [GeV] vs Δm [GeV] at reco level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 34a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 34b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 34c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' (Fig. 34d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' (Fig. 34e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' + ' $ptJet1.4b > 150. \ \& \ ptJet2.4b > 0.$ ' (Fig. 34f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1.4b < 100.$ ' + ' $lep2.4b < 100.$ ' + ' $ptJet1.4b > 150. \ \& \ ptJet2.4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 34g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

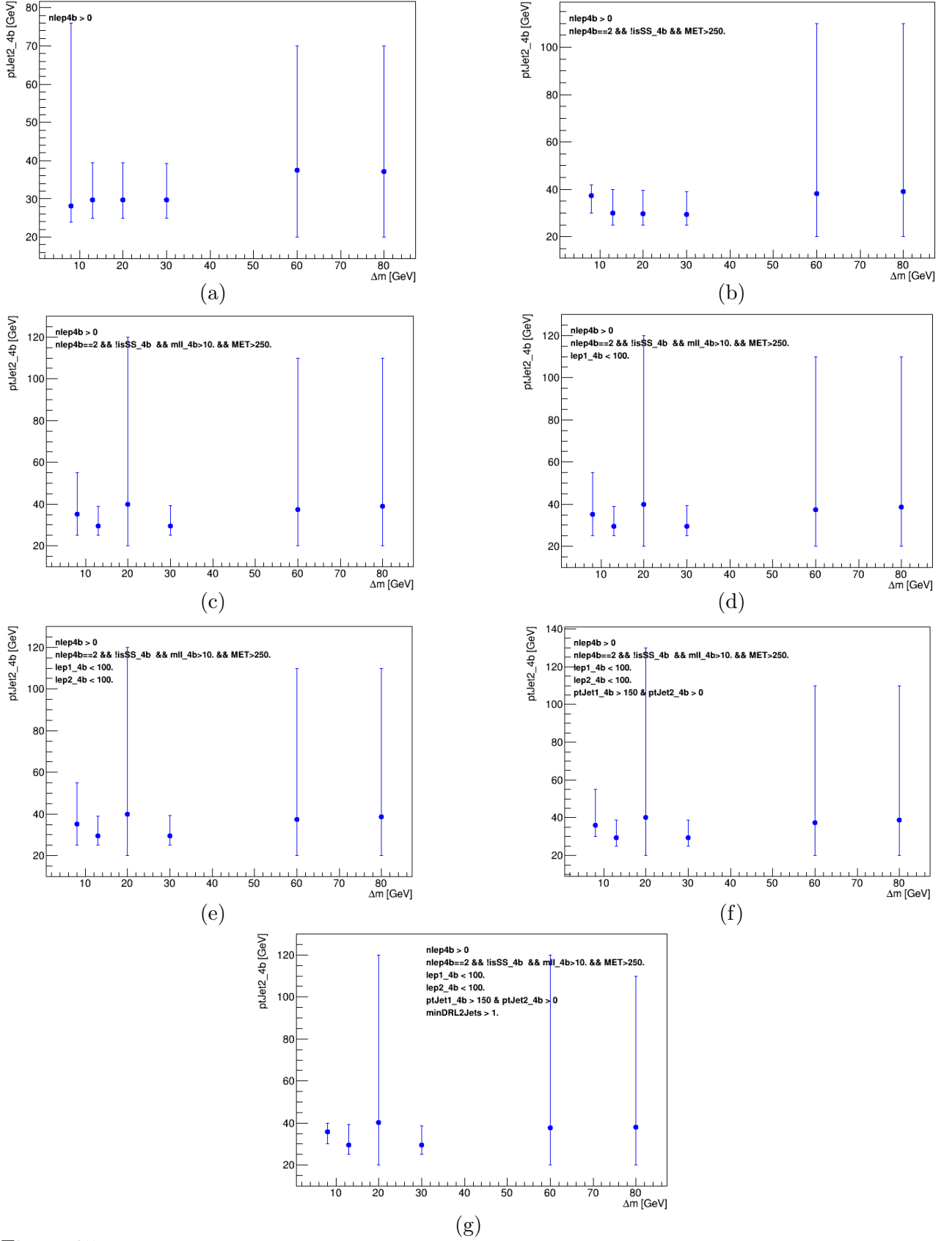
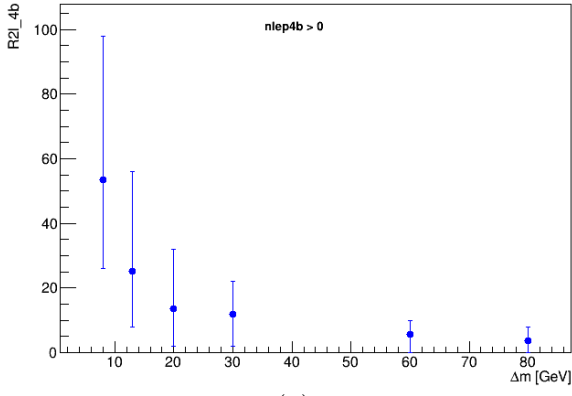
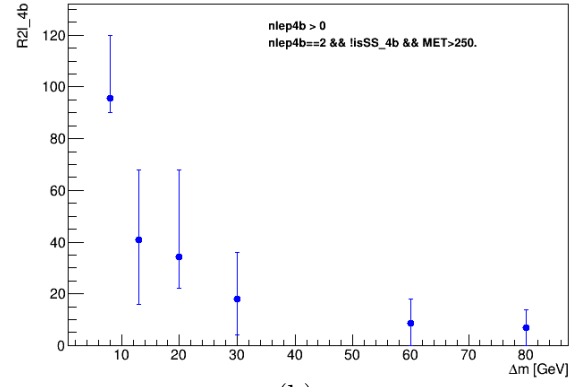


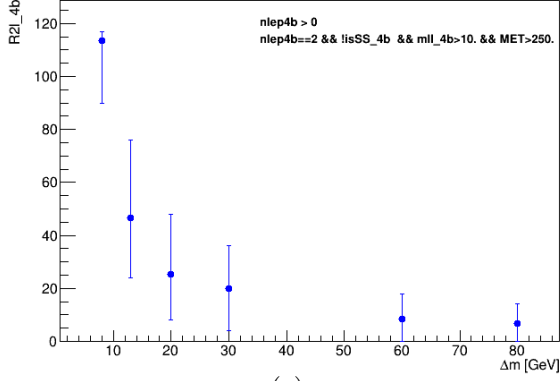
Figure 35: Peaks of the distributions of pt_{Jet2_4b} [GeV] vs Δm [GeV] at reco level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 35a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 35b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 35c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 35d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 35e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 35f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 35g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



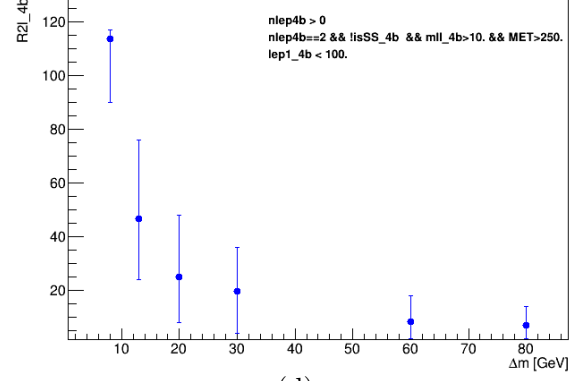
(a)



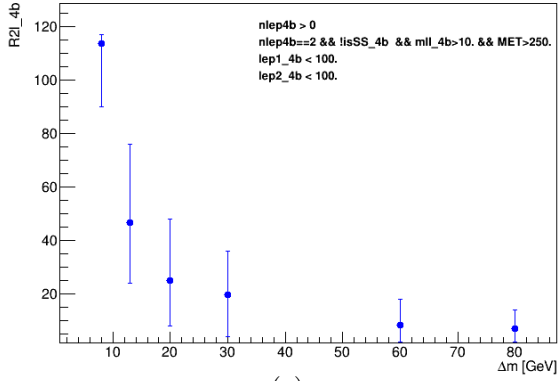
(b)



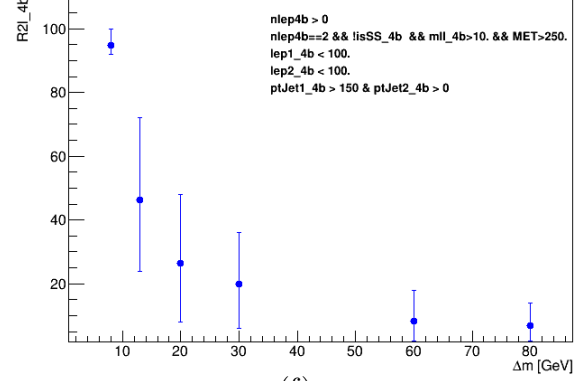
(c)



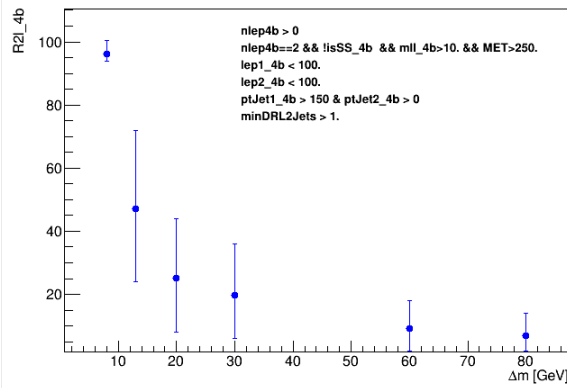
(d)



(e)



(f)



(g)

Figure 36: Peaks of the distributions of $R2l_{4b}$ [GeV] vs Δm [GeV] at reco level. Applied cuts: 'nlep4b > 0' (Fig. 36a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 36b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 36c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 36d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 36e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 36f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 36g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

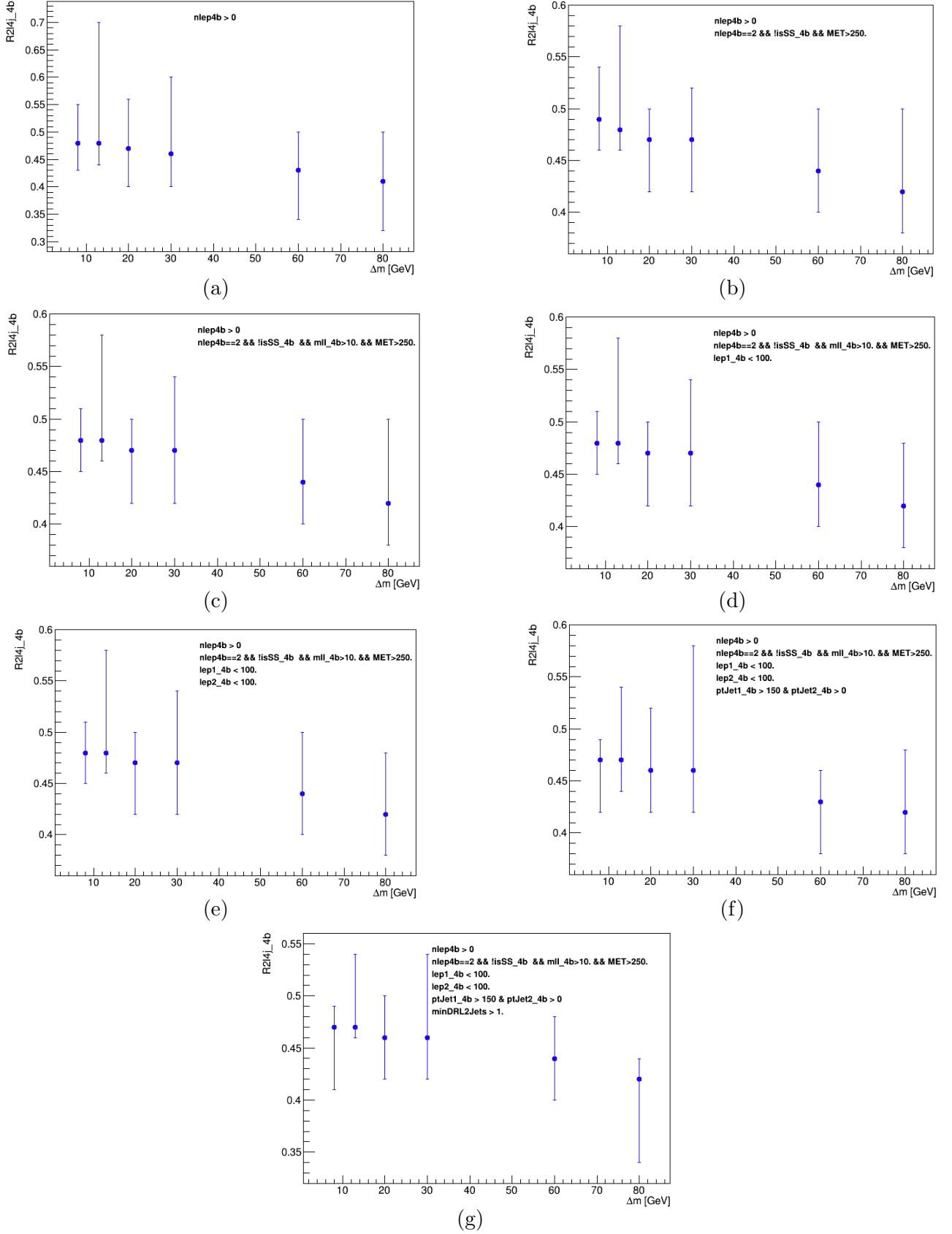


Figure 37: Peaks of the distributions of $R2l4j_4b$ [GeV] vs Δm [GeV] at reco level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 37a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 37b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 37c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 37d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 37e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 37f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 37g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

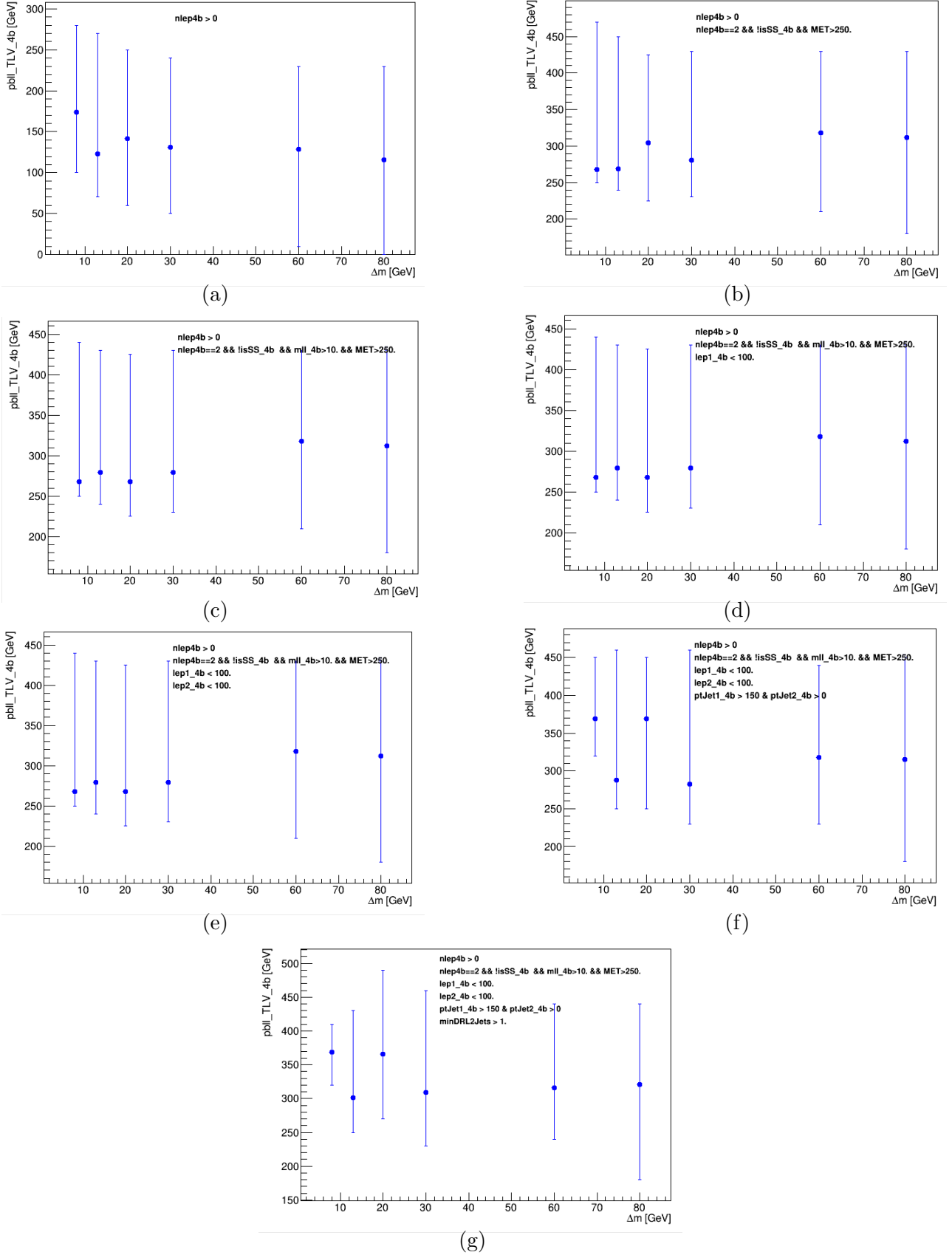
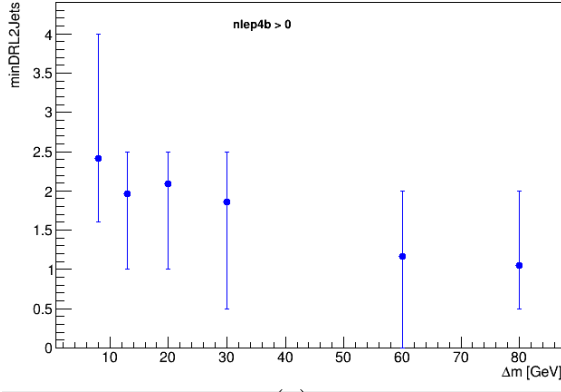
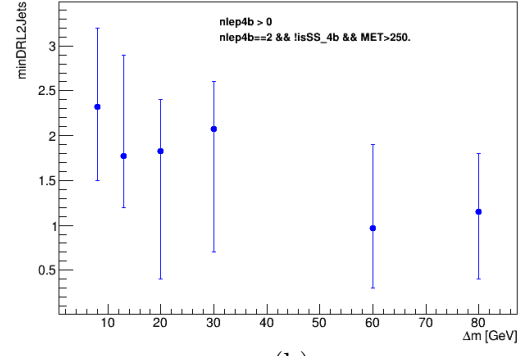


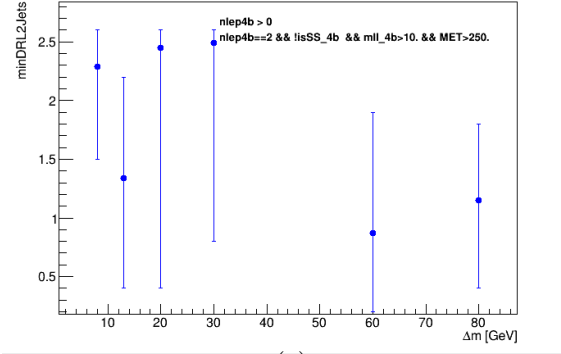
Figure 38: Peaks of the distributions of pbl_TLV_4b [GeV] vs Δm [GeV] at reco level. Applied cuts: ' $nlep4b > 0$ ' (Fig. 38a), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 38b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 38c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 38d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 38e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 38f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 38g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.



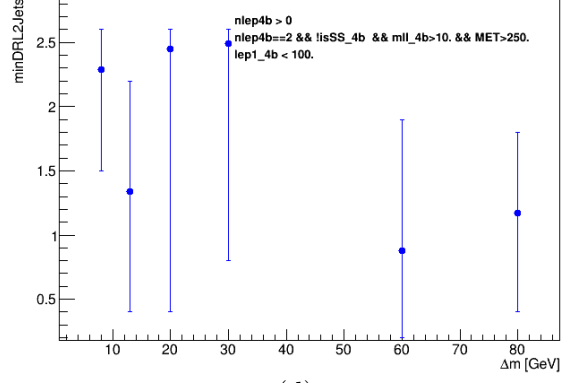
(a)



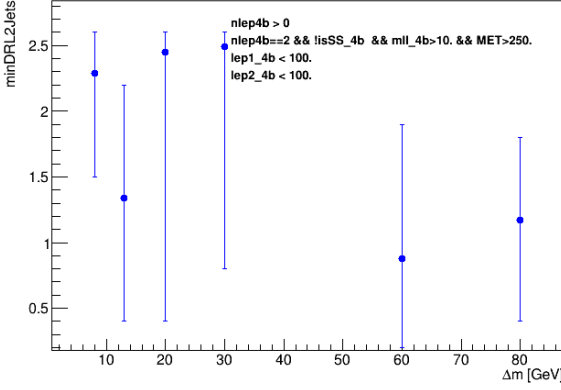
(b)



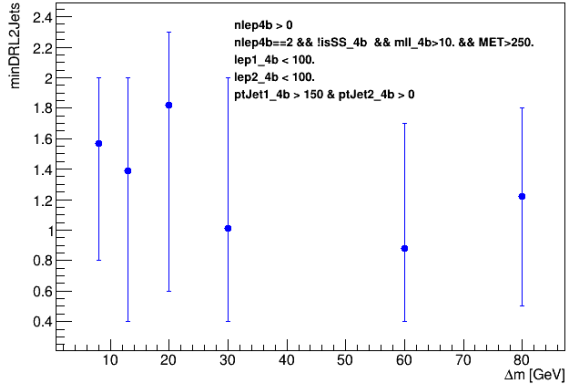
(c)



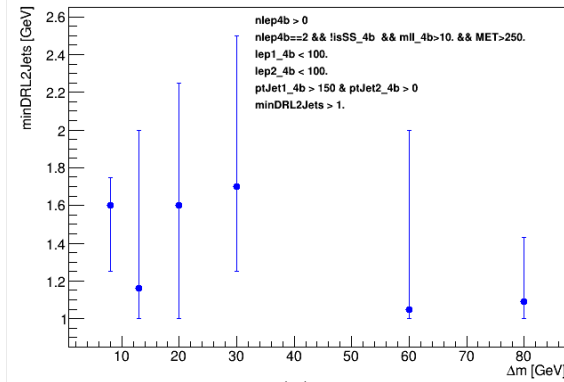
(d)



(e)



(f)



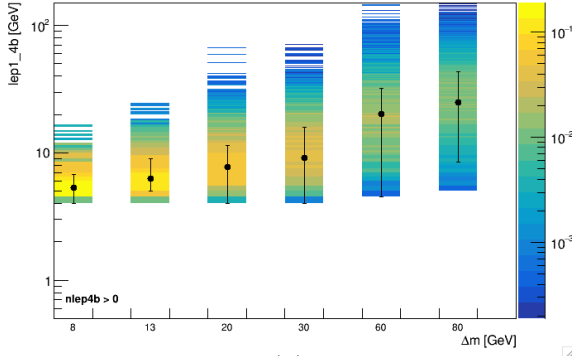
(g)

Figure 39: Peaks of the distributions of minDRL2Jets [GeV] vs Δm [GeV] at reco level. Applied cuts: 'nlep4b > 0' (Fig. 39a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 39b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 39c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 39d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 39e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 39f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 39g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

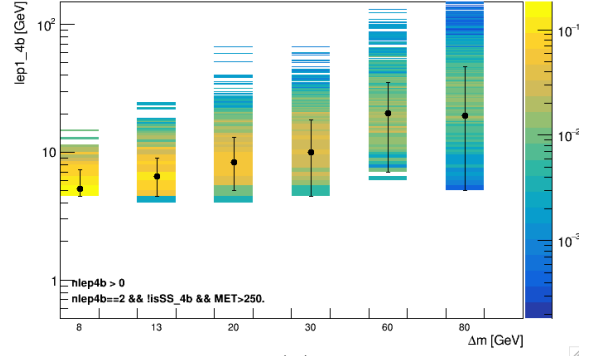
B.3 Reconstruction level 2D plots

B.3.1 2D distributions

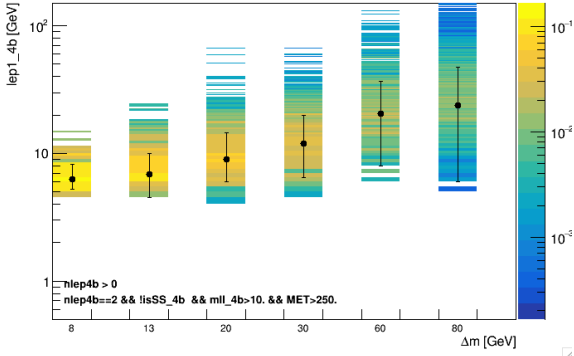
The bidimensional correlation plots of the distributions vs Δm [GeV] can provide a further confirmation of the correctness of the analysis. Figures 40a, 40b, 40c, 40e, 40f, 41a show the distributions for selection cut 1 and figures 42a, 42b, 42c, 42d for selection cut 2:



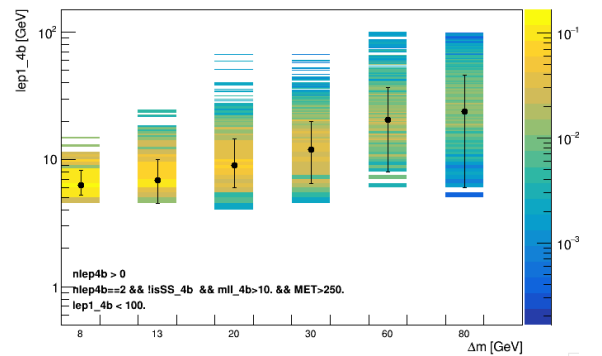
(a)



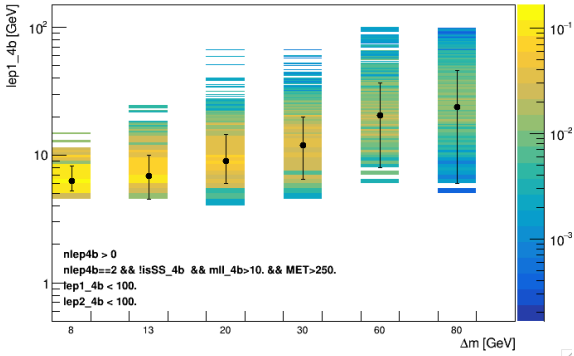
(b)



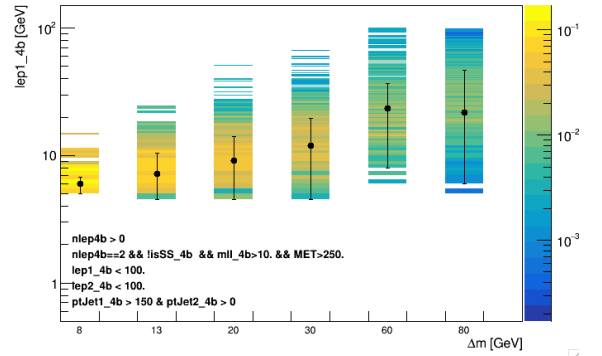
(c)



(d)



(e)



(f)

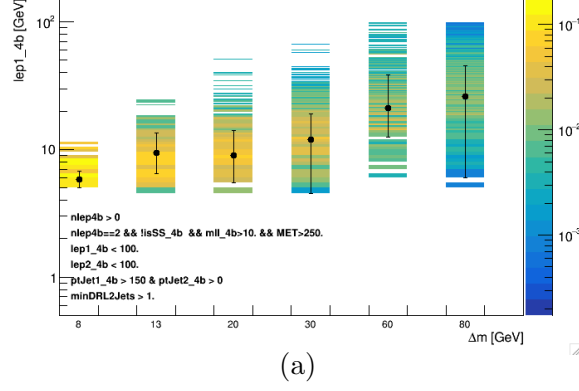


Figure 41: 2D distribution of lep1_4b vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: ' $\text{nlep4b} > 0$ ' (Fig. 40a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' (Fig. 40b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' (Fig. 40c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' (Fig. 40d), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 40e), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 40f), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{mll_4b} > 10. \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 41a). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

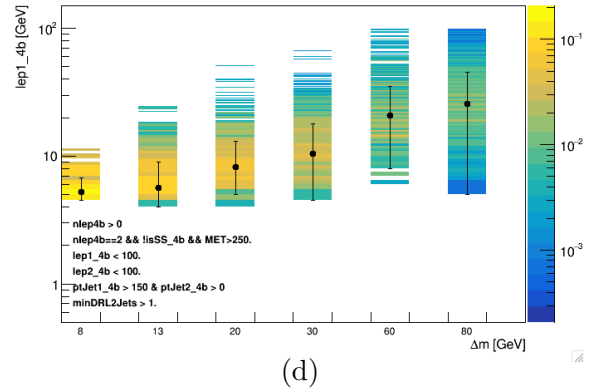
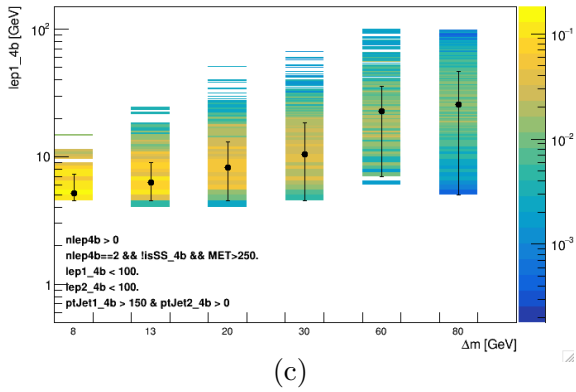
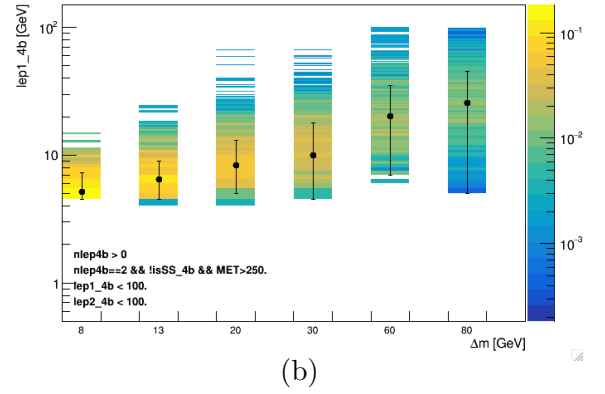
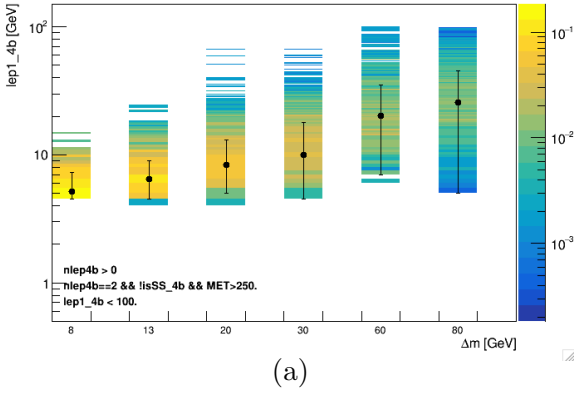


Figure 42: 2D distributions of lep1_4b [GeV] vs Δm [GeV] at reco level without invariant mass cut. Applied cuts: ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + (Fig. 42a), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' (Fig. 42b), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' (Fig. 42c), ' $\text{nlep4b} > 0$ ' + ' $\text{nlep4b}==2 \ \&\& \ !\text{isSS_4b} \ \&\& \ \text{MET} > 250.$ ' + ' $\text{lep1_4b} < 100.$ ' + ' $\text{lep2_4b} < 100.$ ' + ' $\text{ptJet1_4b} > 150. \ \& \ \text{ptJet2_4b} > 0.$ ' + ' $\text{minDRL2Jets} > 1.$ ' (Fig. 42d). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

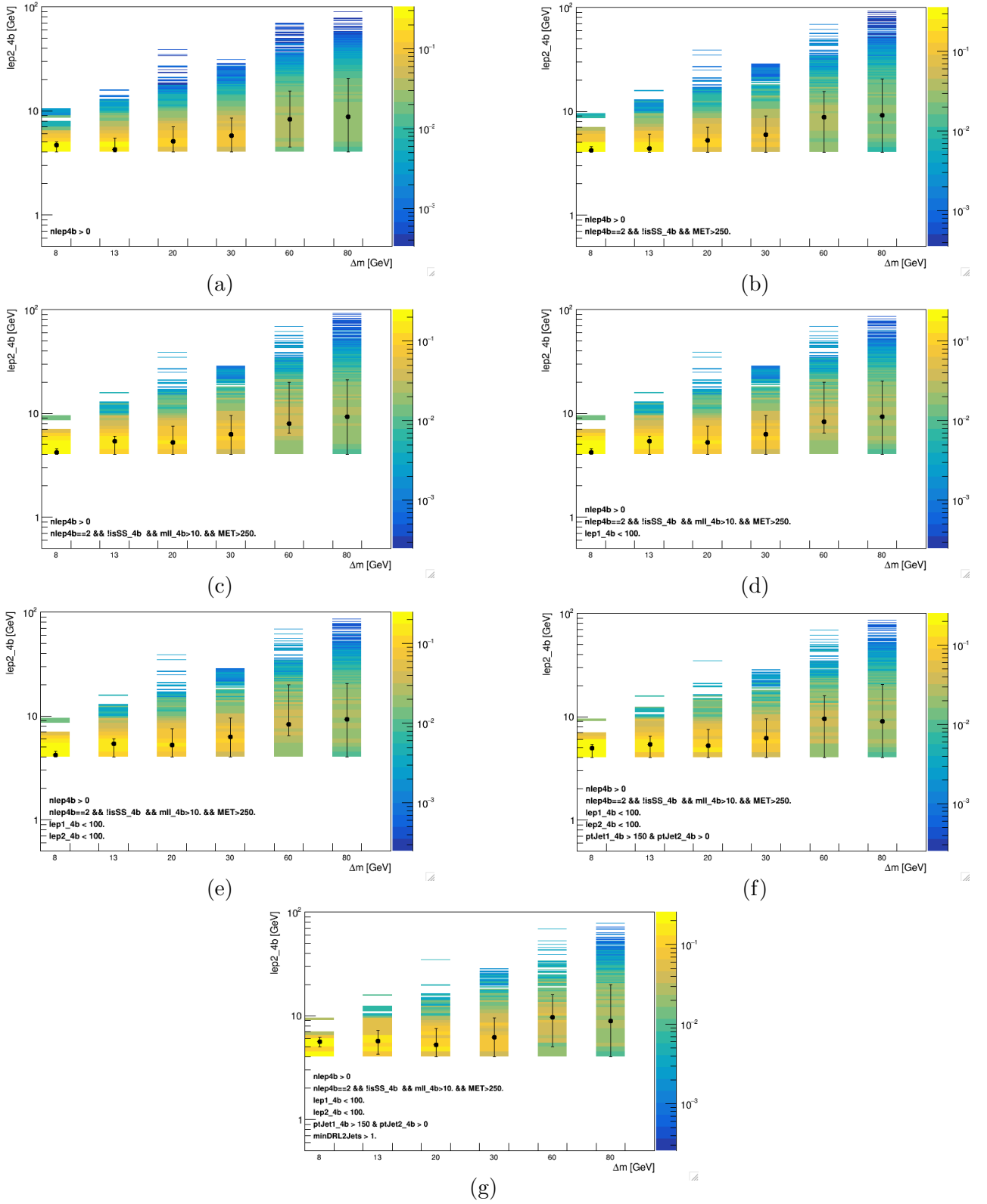


Figure 43: 2D distribution of $lep2_4b$ vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: ' $nlep4b > 0$ ' (Fig. 43a), ' $nlep4b > 0$ ' + ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 43b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 43c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 43d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 43e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 43f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 43g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

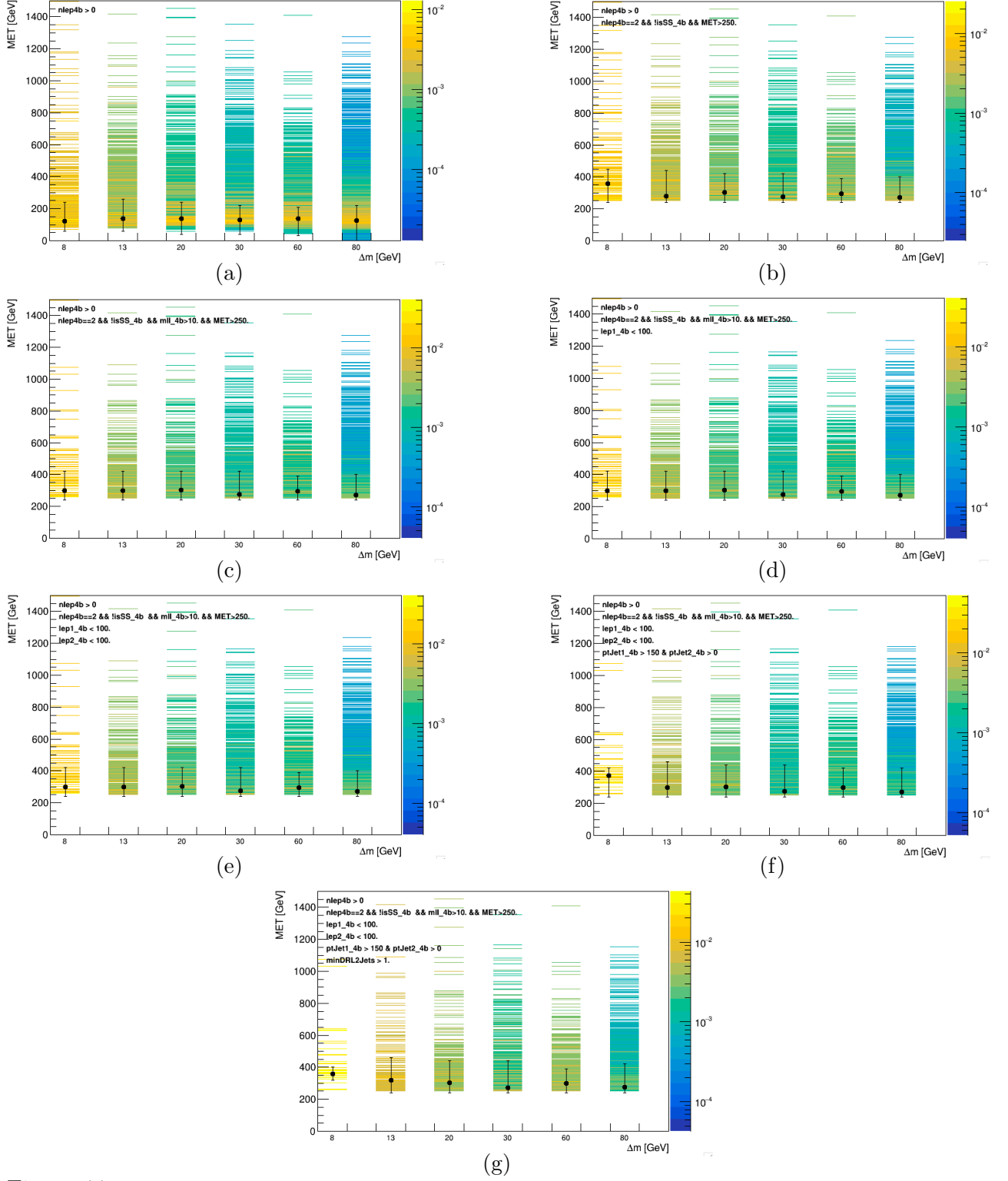


Figure 44: 2D distribution of MET vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 44a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 44b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 44c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 44d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 44e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 44f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 44g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

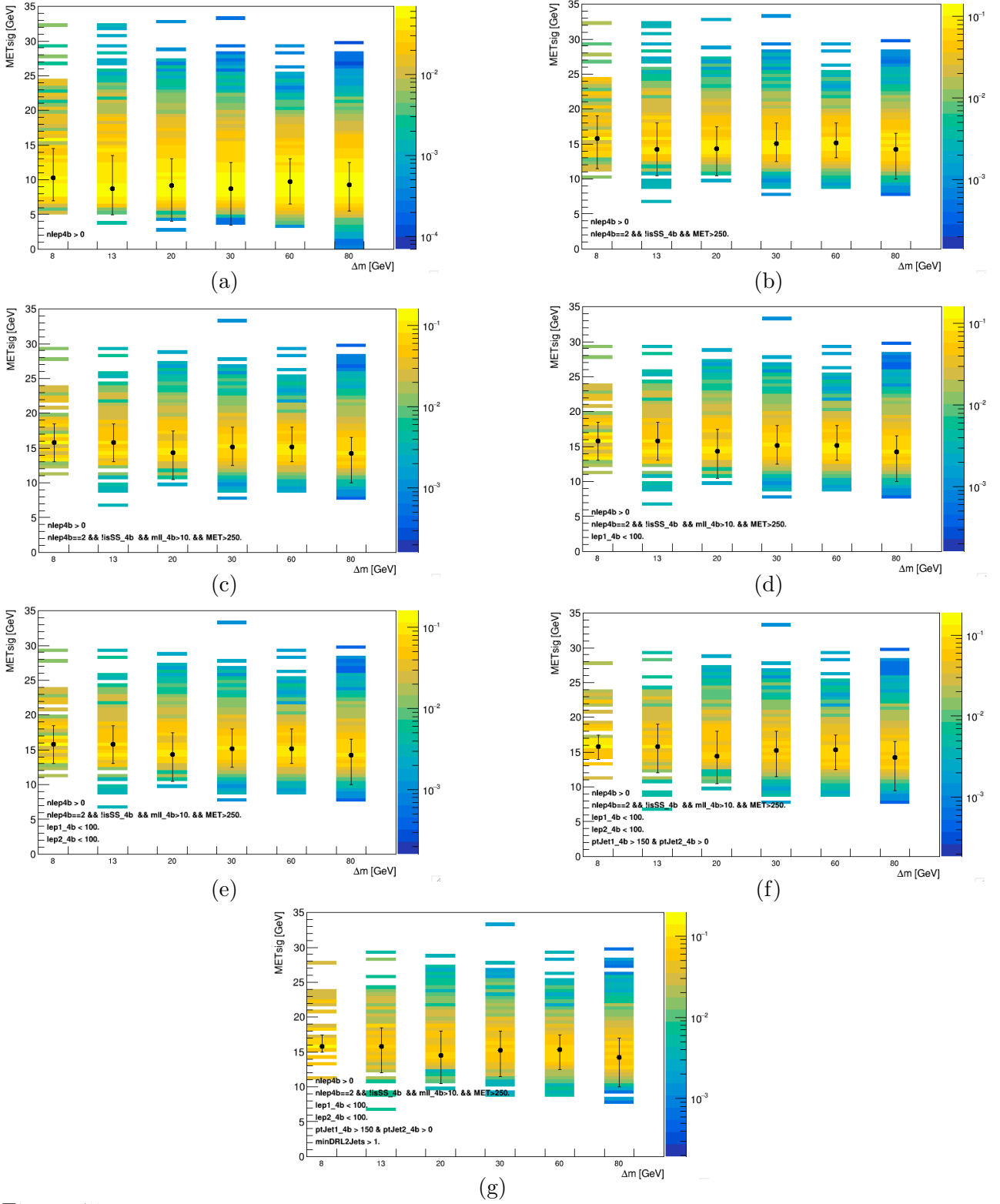


Figure 45: 2D distribution of METsig vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 45a), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 45b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 45c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 45d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 45e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 45f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 45g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

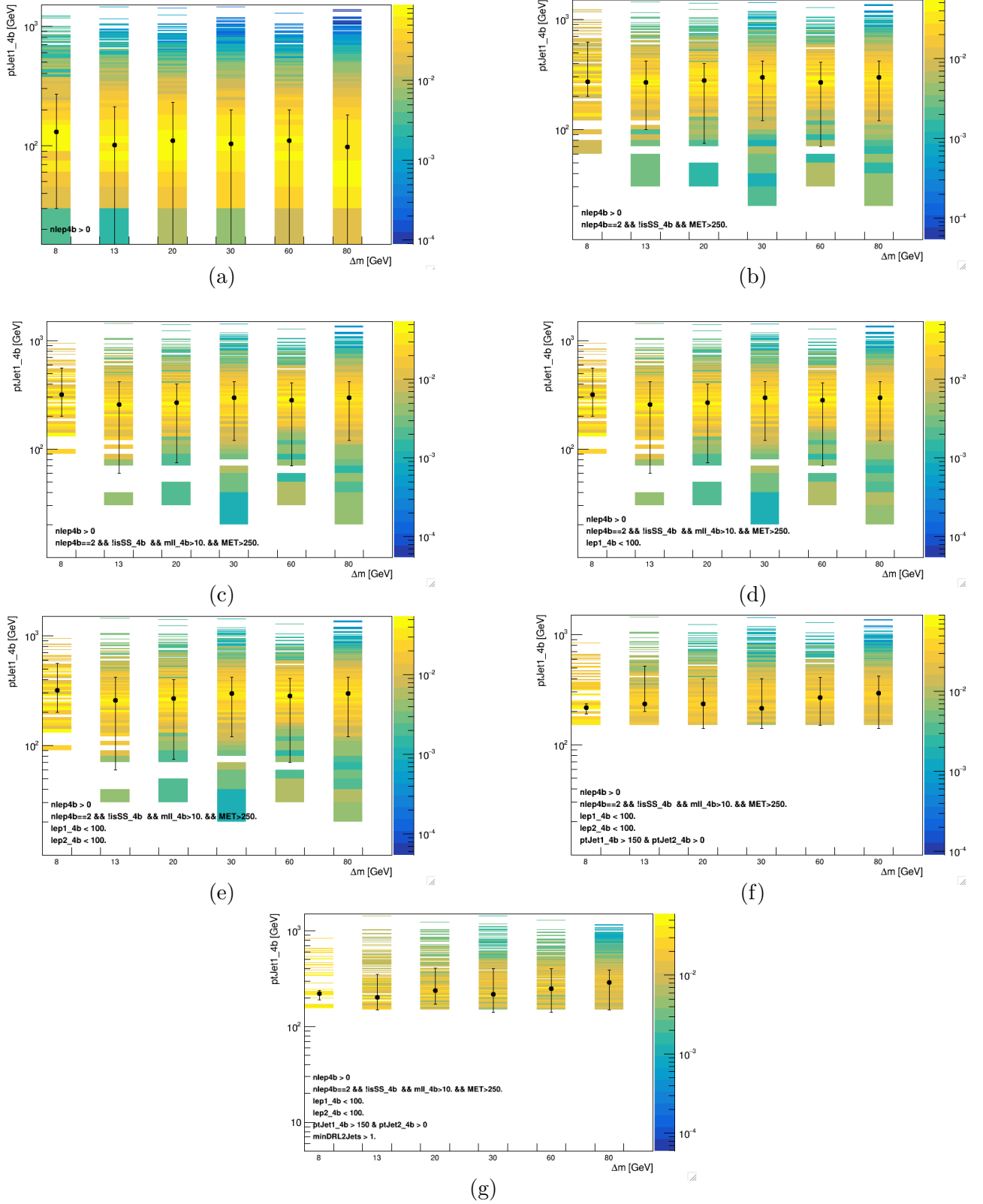


Figure 46: 2D distribution of $ptJet1_4b$ vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: ' $nlep4b > 0$ ' (Fig. 46a), ' $nlep4b > 0$ ' + ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ MET > 250.$ ' (Fig. 46b), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' (Fig. 46c), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' (Fig. 46d), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' (Fig. 46e), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' (Fig. 46f), ' $nlep4b > 0$ ' + ' $nlep4b==2 \ \&\& \ !isSS_4b \ \&\& \ mll_4b > 10. \ \&\& \ MET > 250.$ ' + ' $lep1_4b < 100.$ ' + ' $lep2_4b < 100.$ ' + ' $ptJet1_4b > 150. \ \& \ ptJet2_4b > 0.$ ' + ' $minDRL2Jets > 1.$ ' (Fig. 46g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

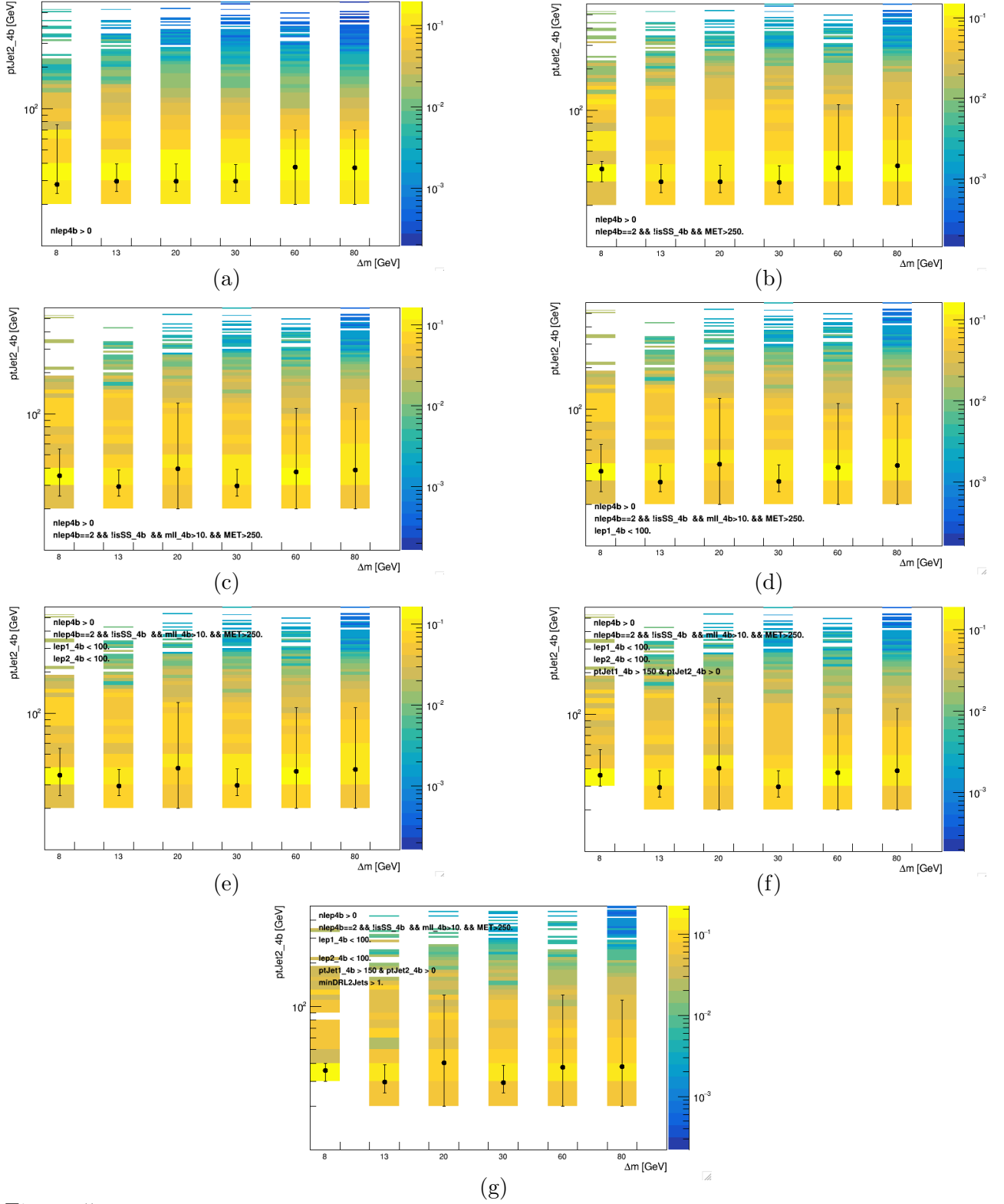


Figure 47: 2D distribution of $pt_{Jet2.4b}$ vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 47a), 'nlep4b > 0' + 'nlep4b == 0' + 'nlep4b == 2 && !isSS_4b && MET > 250.' (Fig. 47b), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 47c), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 47d), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 47e), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' (Fig. 47f), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1.4b > 150. & ptJet2.4b > 0.' + 'minDRL2Jets > 1.' (Fig. 47g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

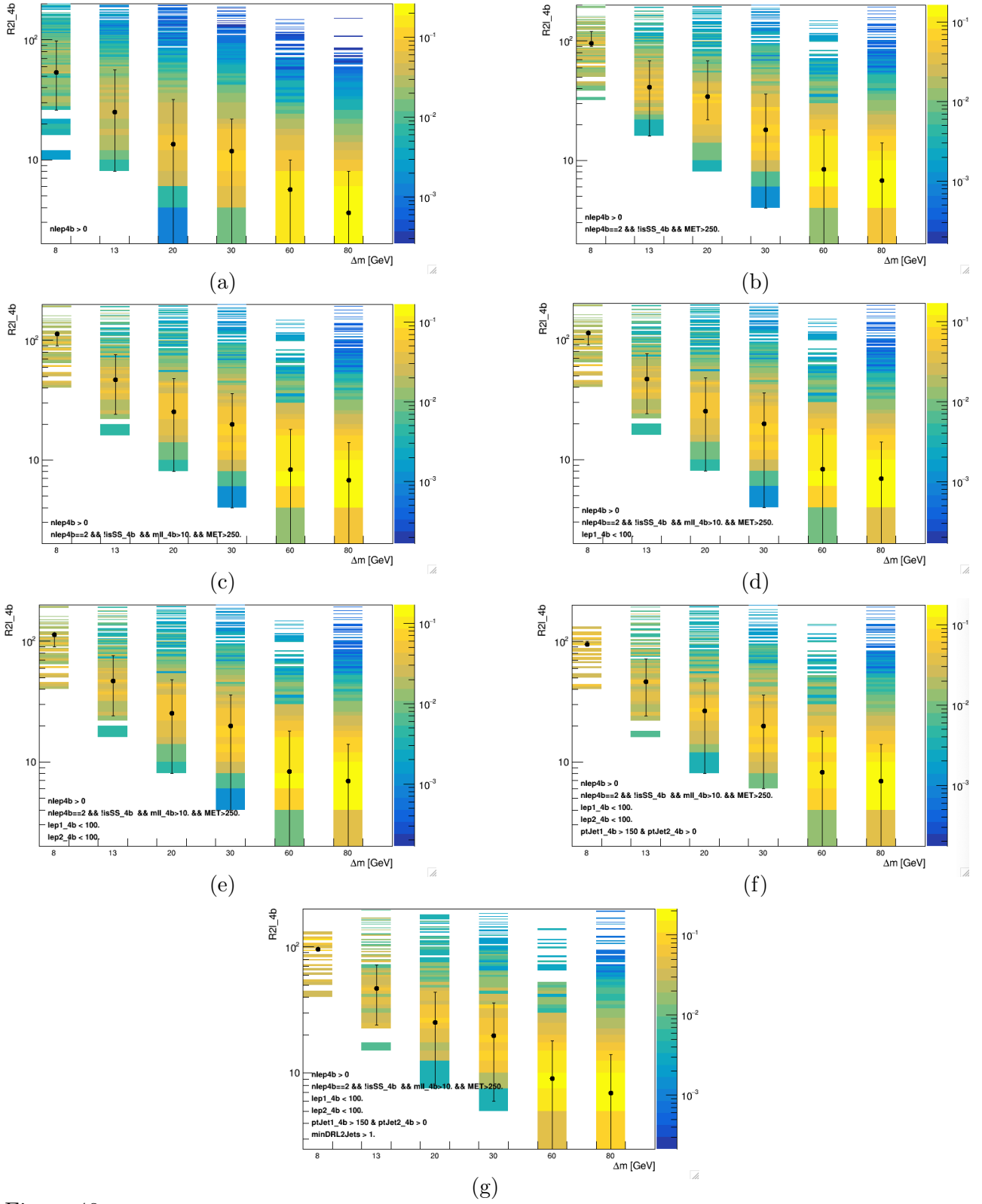


Figure 48: 2D distribution of $R21_{4b}$ vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 48a), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && MET > 250.' (Fig. 48b), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 48c), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 48d), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 48e), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 48f), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 48g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

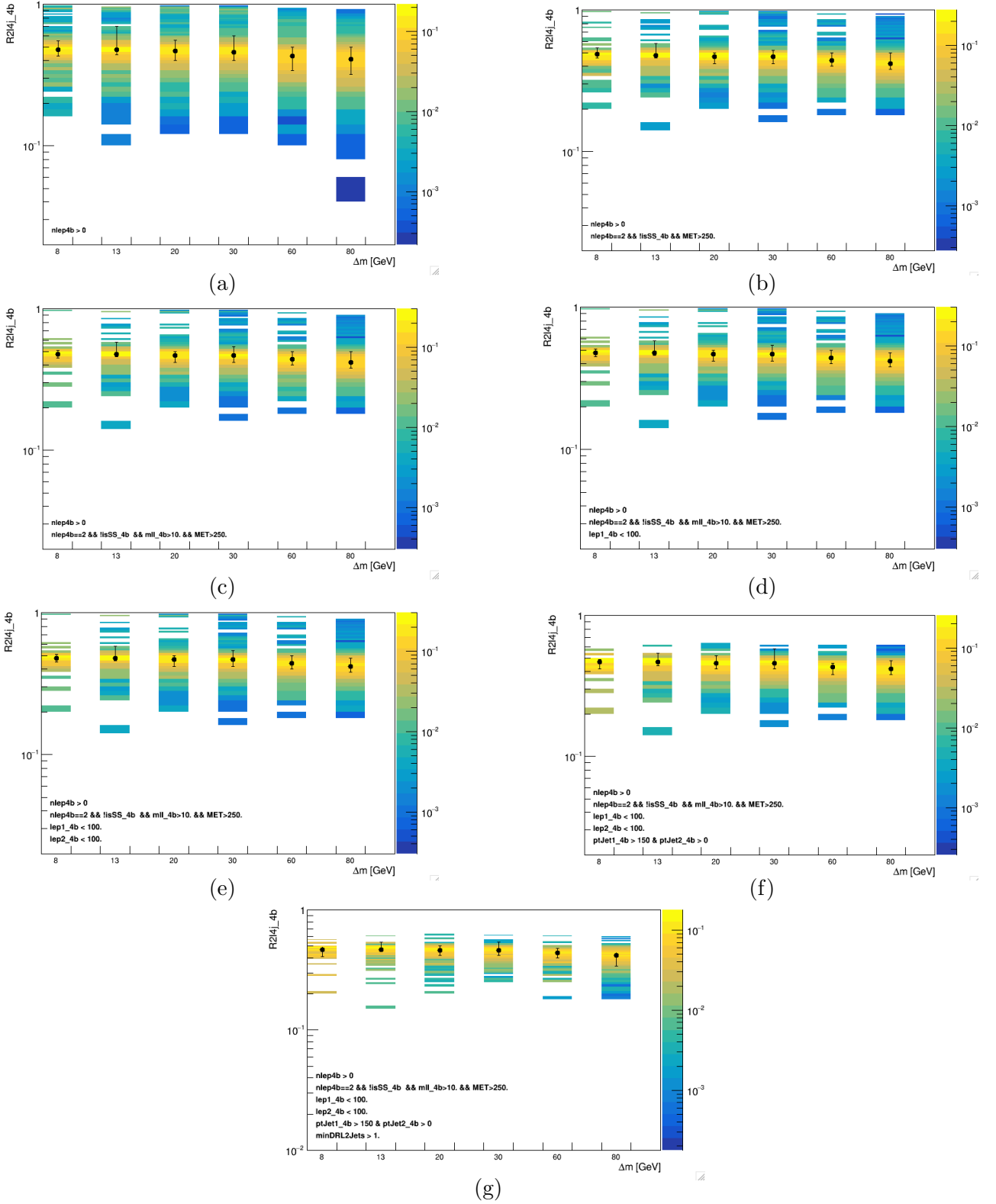


Figure 49: 2D distribution of $R214j_4b$ vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 49a), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && MET > 250.' (Fig. 27b), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 49c), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 49d), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 49e), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 49f), 'nlep4b > 0' + 'nlep4b == 2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 49g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

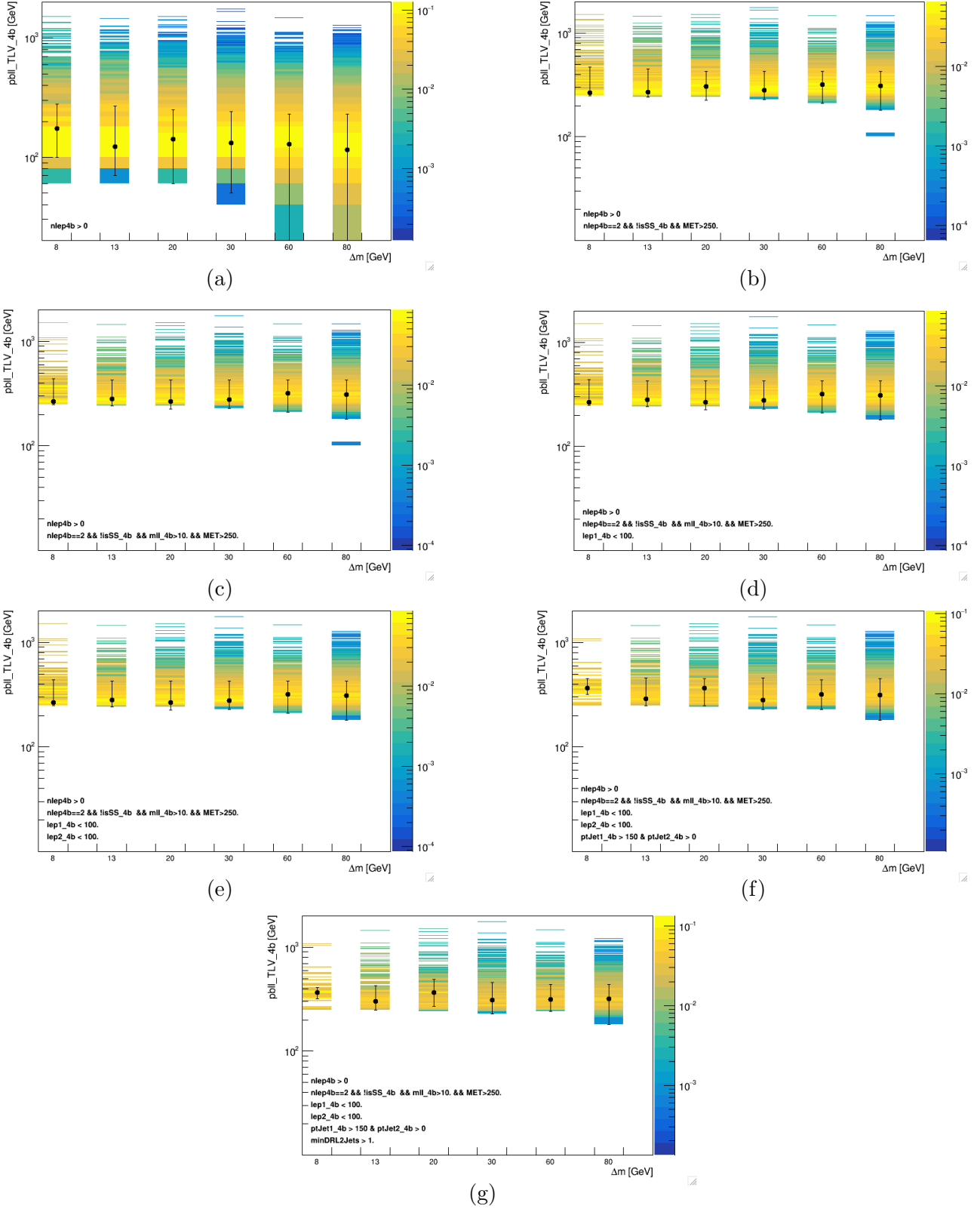


Figure 50: 2D distribution of pbl1_TLV_4b vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 50a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 50b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 50c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 50d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 50e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' (Fig. 50f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 50g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

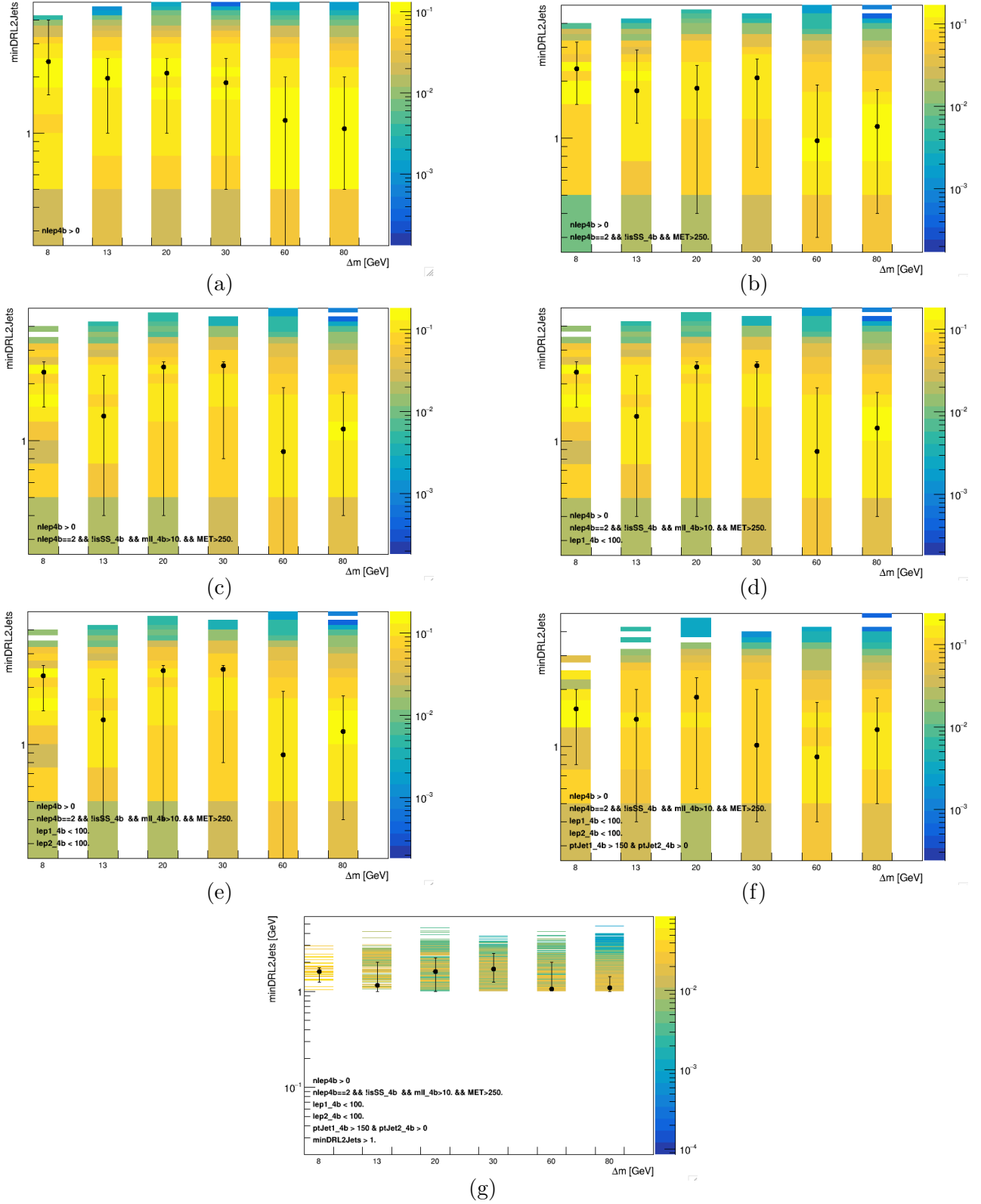


Figure 51: 2D distribution of minDRL2Jets vs Δm [GeV] at reco level. The black dots show the peaks of the same distributions. Applied cuts: 'nlep4b > 0' (Fig. 51a), 'nlep4b > 0' + 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && MET > 250.' (Fig. 51b), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' (Fig. 51c), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' (Fig. 51d), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' (Fig. 51e), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150 & ptJet2_4b > 0.' (Fig. 51f), 'nlep4b > 0' + 'nlep4b==2 && !isSS_4b && mll_4b > 10. && MET > 250.' + 'lep1_4b < 100.' + 'lep2_4b < 100.' + 'ptJet1_4b > 150. & ptJet2_4b > 0.' + 'minDRL2Jets > 1.' (Fig. 51g). The uncertainties are computed as the abscissa values corresponding to 68% of the total integral.

References

- [1] The ATLAS collaboration. “Search for new phenomena in events with two opposite-charge leptons, jets and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector..” In: *JHEP 04 (2021) 165* (2021). doi: [10.1007/JHEP04\(2021\)165](https://doi.org/10.1007/JHEP04(2021)165).
- [2] The ATLAS collaboration. “Search for pair produced top squarks and Dark Matter in final states with two leptons in pp collisions at $\sqrt{s} = 13$ TeV.” In: *ANA-SUSY-2018-08-INT1* (2020).