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IMPLEMENTATION OF THE CMS-SUS-19-006 ANALYSIS IN THE MADANALYSIS5 FRAMEWORK

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We present the MADANALYSIS5 implementation and validation of the search *Search for supersymmetry in proton-proton collisions at 13 TeV in final states with jets and missing transverse momentum* (CMS-SUS-19-006). The search targets models with at least two jets and large missing transverse momentum in the all-hadronic final state. The analyzed luminosity is 137 inverse femtobarns, corresponding to the Run 2 proton-proton data set recorded by the CMS detector at 13 TeV. This implementation has been validated in a variety of simplified models, by comparing derived cut flow tables and histograms with information provided by the CMS collaboration, using events generated using Pythia8 and MadGraph/amc@NLO. The validation is found reproduce the signal acceptance in most cases.

1. Introduction

Proton-proton collisions (events) that feature significant hadronic activity in combination with large missing transverse momentum $H_{\mathrm{T}}^{\mathrm{miss}}$ in the final state can act as a probe for a general class of beyond the Standard Model (BSM) candidate models. In particular, models of R-parity conserving supersymmetry that feature TeV-scale squarks or gluinos often have these attributes as hallmark signal event characteristics. Therefore, the data analyzed in the all-hadronic multi-jet channel [5] provide an important constraint on generic dark matter models and strong-production SUSY.

A MADANALYSIS5 implementation of [5] has been carried out for the purpose of recasting. This note provides supporting documentation for the implementation and details steps taken to validate the work using information made public by CMS. This information pertains to the efficiency and acceptance of signal events of benchmark points within the simplified models denoted T1qqqq, T1tttt, T1bbbb, T5qqqqVV (gluino pair production), and T2qq, T2tt, and T2bb (squark pair production).

2. Description of the analysis

The analysis strategy is to use a multitude of signal regions to target a variety of final states. The region definitions are based on selection criteria placed on the $H_{\mathrm{T}}^{\mathrm{miss}}$, H_{T} , jet- and b-jet multiplicity. The lower multiplicity regions probe squark pair production models where large multiplicities are more sensitive to gluinos. Categories with large b-jet multiplicity help target scenarios with kinematically accessible third-generation squarks, while the 0-b bins increase sensitivity on the margin. Larger and smaller $H_{\mathrm{T}}^{\mathrm{miss}}$ and H_{T} regions respectively target the compressed and uncompressed mass spectra.

2.1. *Object definitions*

The primary objects used in the CMS analysis are particle flow jets, obtained by a clustering of all reconstructed particles with trajectories pointing to the primary vertex using the anti-k_{T} jet algorithm with a cone size parameter of 0.4. Jets are required to have

- $p_{\mathrm{T}} > 30$ GeV and
- $|\eta| < 5.0$.

Because Particle Flow jets are the basis of the calculation of $E_{\mathrm{T}}^{\mathrm{miss}}$, they are inclusive with respect to all reconstructed energy in an event. This differs slightly from the default `Jet` collection in `Delphes` where jet clustering ignores energy deposited by particles that were not individually reconstructed and identified. Because of the less-than-1 reconstruction efficiency of charged and neutral hadrons, this leads to a scenario in which the $H_{\mathrm{T}}^{\mathrm{miss}}$ is frequently no longer a good proxy for the $E_{\mathrm{T}}^{\mathrm{miss}}$, as large amounts of energy are often neglected. To correct for this, the `Delphes` card was modified to set the efficiency of hadron reconstruction to 1:

```
for (int i=0; i<iterations;i++)
{
some nice delphes card code
}
```

Detector smearing of hadron energy is kept as default. The `MA5-tune` of `Delphes` also removes jets which are identified as originating from τ lepton decays from the `Jet` collection. These jets are added back in to the jet collection in the implementation code.

Leptons which point to the primary vertex are identified if they are isolated and satisfy

- p_{T} >10 GeV and
- $|\eta| < 2.5$ (2.4) for electrons (muons).

We implement a standard isolation definition, where when applied to a lepton candidate i, is given by

- $\sum_{j\neq i}^{n} p_{Tj}/p_{Ti} < 0.2$.

Here, the sum runs over all particles j with a cone of variable radius around the candidate lepton. The radius corresponds to that of the "mini-isolation" definition, given by

$$Idon'twanttowritethisagain. \tag{1}$$

Photons are identified if they have

- p_{T} >100 GeV and
- $|\eta| < 2.5$,

and if they satisfy the same isolation criterion applied to electrons. The analysis also applies a veto based on the presence of isolated tracks which were not identified as a lepton, aimed at further suppressing backgrounds from W+Jets and $t\bar{t}$ processes. Slightly different object criteria are placed on isolated tracks attributed to electrons, muons, and pions, and are summarized as

- p_{T} >5 GeV,
- $|\eta| < 2.4$,
- $m_{\mathrm{T}}(\mathrm{track}, H_{\mathrm{T}}^{\mathrm{miss}}) < 100$ GeV, and
- $I < 0.2$ (0.1) for electron and muon (pion) tracks,

where I is the isolation as defined above, but strictly with respect to other tracks within a constant-size cone of radius 0.3 around the candidate track.

2.2. *Event selection*

The baseline selection is as follows:

- $H_{\mathrm{T}}^{\mathrm{miss}} = |\vec{H}_{\mathrm{T}}^{\mathrm{miss}}| > 300$ GeV, where $\vec{H}_{\mathrm{T}}^{\mathrm{miss}}$ is the negative vector sum of jets;
- $H_{\mathrm{T}} > 300$ GeV, where H_{T} is the scalar sum of the p_{T} of jets within $|\eta| < 2.4$;
- $H_{\mathrm{T}} > H_{\mathrm{T}}^{\mathrm{miss}}$;
- $n_j > 1$, where n_j is the number of jets within $|\eta| < 2.4$;
- $n_e = n_\mu = n_\gamma = 0$;
- $\Delta\phi(\vec{j}_{1,2,3,4}, \vec{H}_{\mathrm{T}}^{\mathrm{miss}}) > 0.5, 0.5, 0.3, 0.3$, where $\{j_i\}$ is the p_{T}-ordered list of jets in a given event.

Events passing the baseline selection are further categorized into 174 orthogonal signal regions defined by ranges of $H_{\mathrm{T}}^{\mathrm{miss}}$, H_{T}, n_j, and n_b. These regions are not listed here but are provided in Tables 3-7 of [5]. An alternative, smaller set of aggregate signal regions is also defined in Table 9; we note there is considerable overlap among the aggregate regions.

3. Validation

3.1. *Event generation*

Events have been simulated for a host of benchmark signal model points for which information has been made available by CMS. These include..... events have been generated two-fold, once with LO Pythia8 used for generation and hadronization, and once using MadGraph MC@NLO for the generation and Pythia8 for the hadronization. In both cases a standard Delphes implementation with a modified detector card has been used to simulated the response of the CMS detector to these events.

Give information on how the event samples relevant for the validation of the analysis have been generated. Provide details about the generators that have been used, their versions, the model files, etc.

3.2. *Comparison with the official results*

In this section, you should put all the comparisons you have made. Cutflows in which you compare the MA5 numbers to the official ATLAS/CMS ones, distributions if any. Put here as much material as possible. Of course this depends on the pieces of information available in the analysis. Assess the level of agreement, why you think it is correct, etc.

Table 1. Pre-selection cutflow for the T1qqqq-1300-100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T > 300$	99.9	100.0	100.0	0.1	0.0	0.1	0.0	0.0
$H_T^{miss} > 300$	68.1	76.1	77.1	11.67	1.3	31.8	23.9	22.9
$H_T > H_T^{miss}$	68.0	76.0	77.0	11.69	1.3	0.1	0.1	0.1
NoIsoMuons	68.0	76.0	76.9	11.57	1.17	0.0	0.0	0.1
NoMuonsTracks	67.9	75.8	76.8	11.59	1.3	0.1	0.2	0.1
NoIsoElectrons	67.9	75.8	76.5	11.24	0.92	0.0	0.0	0.3
NoElectronsTracks	67.8	75.8	76.1	10.91	0.39	0.1	0.0	0.4
NoIsoTracks	67.5	75.5	75.3	10.36	-0.27	0.3	0.3	0.8
NoIsoPhotons	67.2	75.3	72.5	7.31	-3.86	0.3	0.2	2.8
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	66.5	73.4	71.2	6.6	-3.09	0.7	1.9	1.3
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	60.2	65.9	64.5	6.67	-2.17	6.3	7.5	6.7
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	55.4	61.3	59.6	7.05	-2.85	4.8	4.6	4.9
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	51.4	57.2	54.9	6.38	-4.19	4.0	4.1	4.7

Table 2. Signal yield in the aggregated signal regions for the T1qqqq-1300-100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	1085.58	1659.12	121.16	-795.99	-1269.36
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	104.41	278.9	57.3	-82.22	-386.74
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	492.73	922.53	60.23	-718.08	-1431.68
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	153.76	414.78	21.9	-602.1	-1793.97
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	2.86	0.0	1.96	-45.92	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	129.44	157.33	7.41	-1646.83	-2023.21
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	43.62	64.36	5.01	-770.66	-1184.63
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	77.24	107.27	5.26	-1368.44	-1939.35
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	43.62	64.36	4.97	-777.67	-1194.97
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	7.15	14.3	0.37	-1832.43	-3764.86
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	132.3	236.0	21.88	-504.66	-978.61
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.03	100.0	100.0

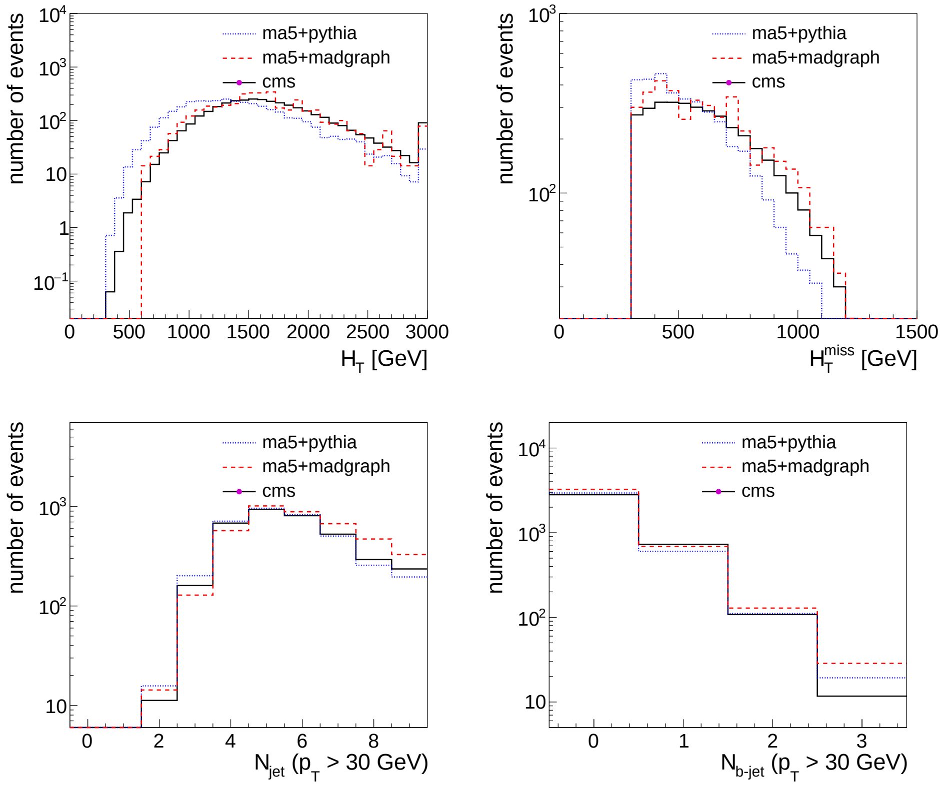

Fig. 1. Kinematic distributions for the T1qqqq-1300-100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 3. Pre-selection cutflow for the T1qqqq-1200-1000 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	93.3	99.4	99.6	6.33	0.2	6.7	0.6	0.4
$H_T > 300$	70.3	85.0	82.0	14.27	-3.66	23.0	14.4	17.6
$H_T^{miss} > 300$	32.7	23.2	21.2	-54.25	-9.43	37.6	61.8	60.8
$H_T > H_T^{miss}$	32.3	23.0	20.9	-54.55	-10.05	0.4	0.2	0.3
NoIsoMuons	32.3	23.0	20.8	-55.29	-10.58	0.0	0.0	0.1
NoMuonsTracks	32.2	23.0	20.8	-54.81	-10.58	0.1	0.0	0.0
NoIsoElectrons	32.2	23.0	20.7	-55.56	-11.11	0.0	0.0	0.1
NoElectronsTracks	32.2	23.0	20.6	-56.31	-11.65	0.0	0.0	0.1
NoIsoTracks	31.7	23.0	20.1	-57.71	-14.43	0.5	0.0	0.5
NoIsoPhotons	31.6	22.8	19.5	-62.05	-16.92	0.1	0.2	0.6
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	31.5	22.7	19.5	-61.54	-16.41	0.1	0.1	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	29.5	20.8	17.9	-64.8	-16.2	2.0	1.9	1.6
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	27.6	20.0	16.9	-63.31	-18.34	1.9	0.8	1.0
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	26.0	19.2	15.9	-63.52	-20.75	1.6	0.8	1.0

Table 4. Signal yield in the aggregated signal regions for the T1qqqq-1200-1000 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	476.36	251.45	193.14	-146.64	-30.19
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	22.94	13.97	13.84	-65.75	-0.94
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	186.22	167.63	111.28	-67.34	-50.64
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	53.98	55.88	46.1	-17.09	-21.21
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	2.7	0.0	1.53	-76.47	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	71.52	69.85	44.8	-59.64	-55.92
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	16.19	13.97	8.58	-88.69	-62.82
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	32.39	27.94	24.44	-32.53	-14.32
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	16.19	13.97	8.48	-90.92	-64.74
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	4.05	0.0	1.59	-154.72	100.0
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	49.93	41.91	40.23	-24.11	-4.18
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.07	100.0	100.0

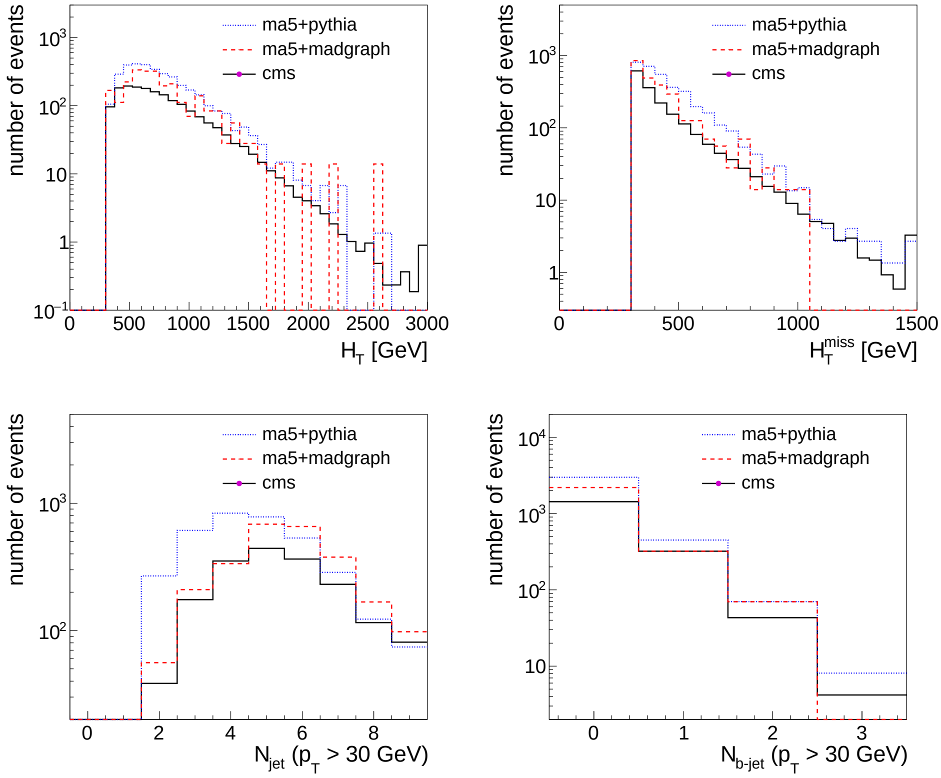

Fig. 2. Kinematic distributions for the T1qqqq-1200-1000 simplified model for the madanalysis5 implementation and those provided by CMS

Table 5. Pre-selection cutflow for the T1bbbb-1300-1100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	93.3	99.4	99.3	6.04	-0.1	6.7	0.6	0.7
$H_T > 300$	70.0	83.3	74.8	6.42	-11.36	23.3	16.1	24.5
$H_T^{miss} > 300$	31.3	24.3	19.9	-57.29	-22.11	38.7	59.0	54.9
$H_T > H_T^{miss}$	31.0	24.1	19.5	-58.97	-23.59	0.3	0.2	0.4
NoIsoMuons	31.0	24.0	19.2	-61.46	-25.0	0.0	0.1	0.3
NoMuonsTracks	30.7	23.9	18.9	-62.43	-26.46	0.3	0.1	0.3
NoIsoElectrons	30.7	23.9	18.8	-63.3	-27.13	0.0	0.0	0.1
NoElectronsTracks	30.3	23.6	18.4	-64.67	-28.26	0.4	0.3	0.4
NoIsoTracks	30.1	23.4	18.2	-65.38	-28.57	0.2	0.2	0.2
NoIsoPhotons	30.1	23.4	17.8	-69.1	-31.46	0.0	0.0	0.4
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	30.0	23.4	17.7	-69.49	-32.2	0.1	0.0	0.1
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	27.9	21.5	16.2	-72.22	-32.72	2.1	1.9	1.5
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	26.3	19.6	15.1	-74.17	-29.8	1.6	1.9	1.1
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	24.8	18.5	14.2	-74.65	-30.28	1.5	1.1	0.9

Table 6. Signal yield in the aggregated signal regions for the T1bbbb-1300-1100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	27.18	17.46	4.85	-460.41	-260.0
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	1.43	0.0	0.32	-346.87	100.0
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	7.87	13.97	1.68	-368.45	-731.55
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	5.72	17.46	3.21	-78.19	-443.93
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.0	0.0	0.1	100.0	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	953.28	939.32	589.39	-61.74	-59.37
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	201.67	171.1	105.43	-91.28	-62.29
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	317.52	464.42	236.98	-33.99	-95.97
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	181.65	160.63	102.58	-77.08	-56.59
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	45.77	108.25	51.73	11.52	-109.26
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	108.7	143.17	76.83	-41.48	-86.35
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	1.43	0.0	1.07	-33.64	100.0

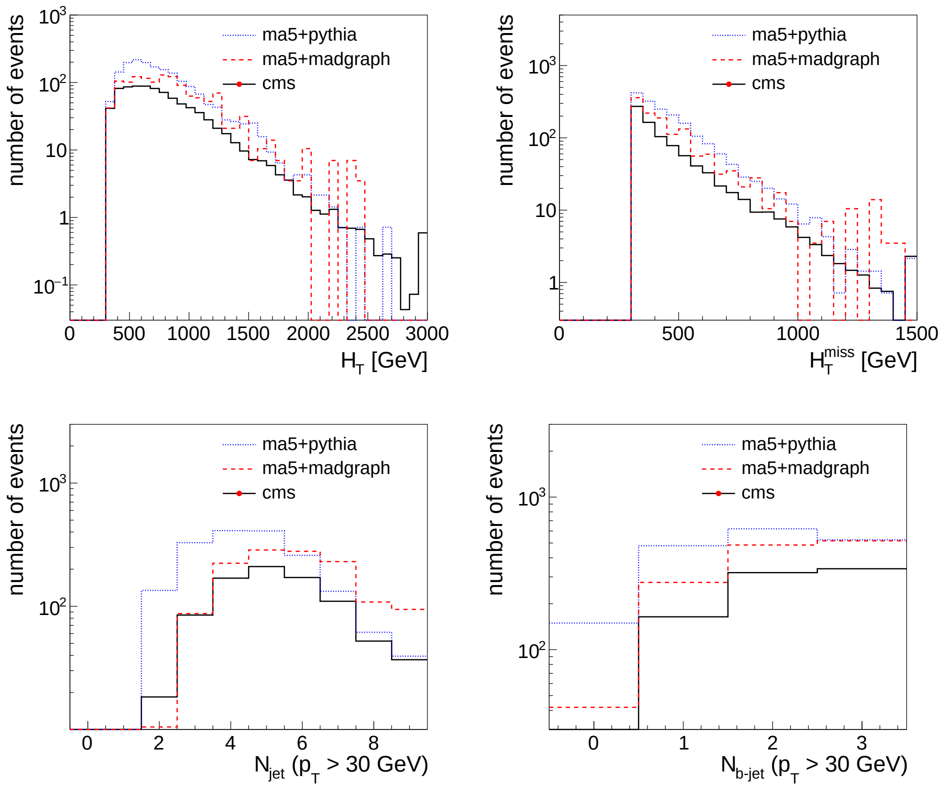

Fig. 3. Kinematic distributions for the T1bbbb-1300-1100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 7. Pre-selection cutflow for the T1bbbb-1800-200 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T > 300$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T^{miss} > 300$	80.4	85.5	86.9	7.48	1.61	19.6	14.5	13.1
$H_T > H_T^{miss}$	80.4	85.5	86.8	7.37	1.5	0.0	0.0	0.1
NoIsoMuons	80.4	85.5	86.0	6.51	0.58	0.0	0.0	0.8
NoMuonsTracks	80.2	85.4	85.8	6.53	0.47	0.2	0.1	0.2
NoIsoElectrons	80.2	85.3	85.4	6.09	0.12	0.0	0.1	0.4
NoElectronsTracks	80.0	85.2	85.0	5.88	-0.24	0.2	0.1	0.4
NoIsoTracks	79.8	85.0	84.4	5.45	-0.71	0.2	0.2	0.6
NoIsoPhotons	79.6	84.5	81.6	2.45	-3.55	0.2	0.5	2.8
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	78.3	82.1	80.1	2.25	-2.5	1.3	2.4	1.5
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	71.3	75.0	71.9	0.83	-4.31	7.0	7.1	8.2
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	65.8	68.2	66.5	1.05	-2.56	5.5	6.8	5.4
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	60.7	63.2	61.2	0.82	-3.27	5.1	5.0	5.3

Table 8. Signal yield in the aggregated signal regions for the T1bbbb-1800-200 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	5.06	5.29	11.88	57.41	55.47
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	1.32	1.82	4.95	73.33	63.23
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	1.89	2.01	4.77	60.38	57.86
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	2.41	4.38	5.68	57.57	22.89
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.24	0.36	0.43	44.19	16.28
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	193.12	201.43	143.99	-34.12	-39.89
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	108.78	133.74	100.49	-8.25	-33.09
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	100.99	127.72	79.3	-27.35	-61.06
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	105.57	129.73	97.83	-7.91	-32.61
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	21.68	34.48	12.97	-67.15	-165.84
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	66.96	98.53	74.87	10.56	-31.6
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.76	2.19	0.86	11.63	-154.65

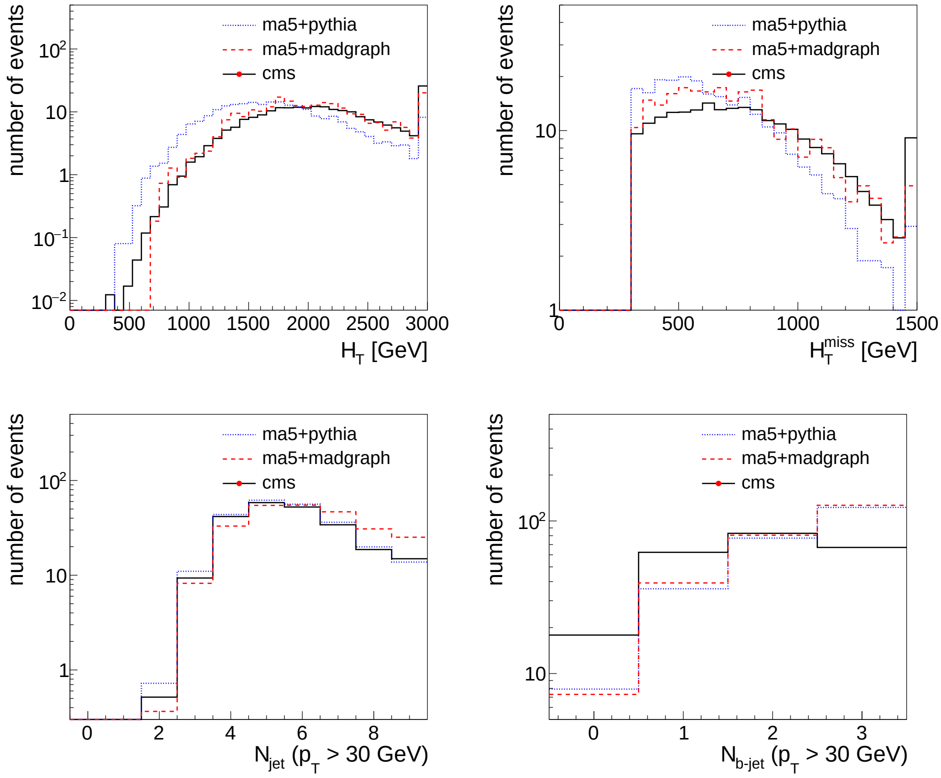

Fig. 4. Kinematic distributions for the T1bbbb-1800-200 simplified model for the madanalysis5 implementation and those provided by CMS

Table 9. Pre-selection cutflow for the T1tttt-1900-200 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T > 300$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T^{miss} > 300$	78.3	83.5	85.5	8.42	2.34	21.7	16.5	14.5
$H_T > H_T^{miss}$	78.3	83.5	85.5	8.42	2.34	0.0	0.0	0.0
NoIsoMuons	61.8	69.0	53.5	-15.51	-28.97	16.5	14.5	32.0
NoMuonsTracks	60.8	68.1	52.8	-15.15	-28.98	1.0	0.9	0.7
NoIsoElectrons	50.9	58.6	34.5	-47.54	-69.86	9.9	9.5	18.3
NoElectronsTracks	49.8	57.6	33.6	-48.21	-71.43	1.1	1.0	0.9
NoIsoTracks	48.8	56.6	32.2	-51.55	-75.78	1.0	1.0	1.4
NoIsoPhotons	48.4	56.3	30.4	-59.21	-85.2	0.4	0.3	1.8
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	47.5	54.8	29.8	-59.4	-83.89	0.9	1.5	0.6
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	42.9	49.9	26.8	-60.07	-86.19	4.6	4.9	3.0
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	40.1	47.0	25.1	-59.76	-87.25	2.8	2.9	1.7
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	37.5	44.5	23.5	-59.57	-89.36	2.6	2.5	1.6

Table 10. Signal yield in the aggregated signal regions for the T1tttt-1900-200 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	0.94	2.08	1.43	34.27	-45.45
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	0.23	0.73	0.68	66.18	-7.35
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	0.89	1.77	1.3	31.54	-36.15
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	4.47	8.52	5.12	12.7	-66.41
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.49	1.97	0.98	50.0	-101.02
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	74.64	88.14	39.89	-87.11	-120.96
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	39.76	57.89	27.13	-46.55	-113.38
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	67.49	82.11	37.52	-79.88	-118.84
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	39.76	57.89	27.13	-46.55	-113.38
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	41.35	50.3	19.32	-114.03	-160.35
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	44.84	66.93	32.65	-37.34	-104.99
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	4.62	10.81	3.69	-25.2	-192.95

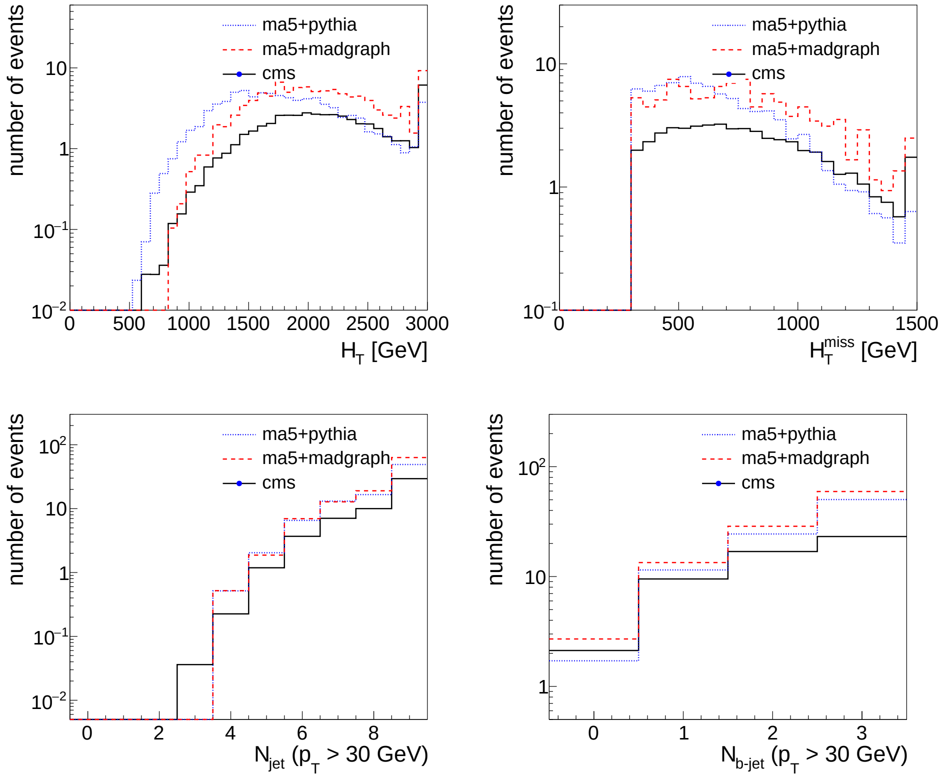

Fig. 5. Kinematic distributions for the T1tttt-1900-200 simplified model for the madanalysis5 implementation and those provided by CMS

Table 11. Pre-selection cutflow for the T1tttt-1300-1000 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	99.8	99.8	100.0	0.2	0.2	0.2	0.2	0.0
$H_T > 300$	89.7	99.7	90.1	0.44	-10.65	10.1	0.1	9.9
$H_T^{miss} > 300$	25.9	16.7	13.8	-87.68	-21.01	63.8	83.0	76.3
$H_T > H_T^{miss}$	25.8	16.7	13.8	-86.96	-21.01	0.1	0.0	0.0
NoIsoMuons	20.4	16.7	8.8	-131.82	-89.77	5.4	0.0	5.0
NoMuonsTracks	19.6	16.7	8.5	-130.59	-96.47	0.8	0.0	0.3
NoIsoElectrons	16.3	16.7	5.8	-181.03	-187.93	3.3	0.0	2.7
NoElectronsTracks	15.5	16.7	5.4	-187.04	-209.26	0.8	0.0	0.4
NoIsoTracks	14.7	16.2	5.0	-194.0	-224.0	0.8	0.5	0.4
NoIsoPhotons	14.6	15.7	4.9	-197.96	-220.41	0.1	0.5	0.1
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	14.5	15.0	4.9	-195.92	-206.12	0.1	0.7	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	13.3	10.5	4.1	-224.39	-156.1	1.2	4.5	0.8
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	12.3	6.5	3.5	-251.43	-85.71	1.0	4.0	0.6
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	11.2	3.1	3.1	-261.29	0.0	1.1	3.4	0.4

Table 12. Signal yield in the aggregated signal regions for the T1tttt-1300-1000 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	7.87	89.55	2.86	-175.17	-3031.12
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	0.72	40.7	0.43	-67.44	-9365.12
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	7.15	24.42	2.73	-161.9	-794.51
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	21.45	4.07	8.58	-150.0	52.56
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	2.86	0.0	0.77	-271.43	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	529.2	4.07	102.74	-415.09	96.04
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	74.37	0.0	18.52	-301.57	100.0
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	364.01	4.07	74.45	-388.93	94.53
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	74.37	0.0	18.52	-301.57	100.0
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	202.38	4.07	36.26	-458.14	88.78
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	99.4	4.07	27.2	-265.44	85.04
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	2.15	0.0	1.26	-70.63	100.0

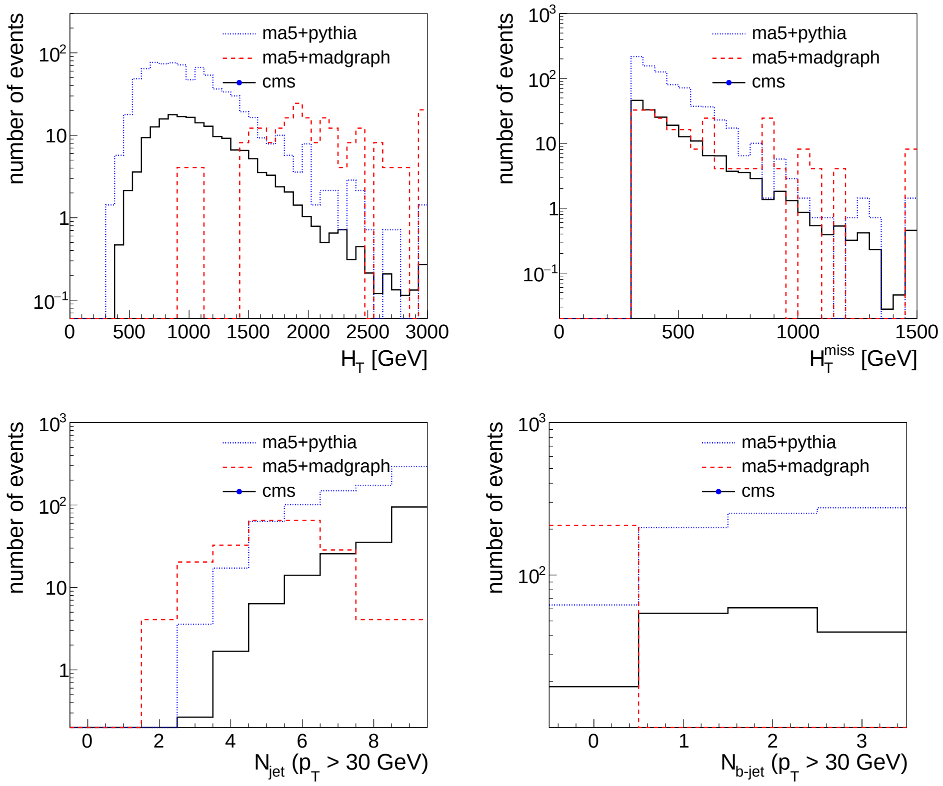

Fig. 6. Kinematic distributions for the T1tttt-1300-1000 simplified model for the madanalysis5 implementation and those provided by CMS

Table 13. Pre-selection cutflow for the T5qqqqVV-1800-100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
$H_T > 300$	99.9	100.0	100.0	0.1	0.0	0.1	0.0	0.0
$H_T^{miss} > 300$	79.8	79.7	83.0	3.86	3.98	20.1	20.3	17.0
$H_T > H_T^{miss}$	79.7	79.7	83.0	3.98	3.98	0.1	0.0	0.0
NoIsoMuons	69.5	75.0	68.6	-1.31	-9.33	10.2	4.7	14.4
NoMuonsTracks	69.4	74.7	68.3	-1.61	-9.37	0.1	0.3	0.3
NoIsoElectrons	62.1	70.2	56.2	-10.5	-24.91	7.3	4.5	12.1
NoElectronsTracks	61.8	70.1	55.6	-11.15	-26.08	0.3	0.1	0.6
NoIsoTracks	60.9	69.6	54.0	-12.78	-28.89	0.9	0.5	1.6
NoIsoPhotons	60.1	68.6	50.8	-18.31	-35.04	0.8	1.0	3.2
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	59.0	67.6	49.3	-19.68	-37.12	1.1	1.0	1.5
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	54.0	62.7	44.6	-21.08	-40.58	5.0	4.9	4.7
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	50.5	58.5	41.8	-20.81	-39.95	3.5	4.2	2.8
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	46.4	55.6	38.8	-19.59	-43.3	4.1	2.9	3.0

Table 14. Signal yield in the aggregated signal regions for the T5qqqqVV-1800-100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	69.36	81.46	51.62	-34.37	-57.81
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	17.46	20.15	19.93	12.39	-1.1
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	56.44	63.4	45.81	-23.2	-38.4
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	39.5	38.21	38.69	-2.09	1.24
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	4.25	2.1	4.77	10.9	55.97
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	15.65	29.81	15.94	1.82	-87.01
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	8.83	16.38	9.87	10.54	-65.96
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	13.61	27.71	14.43	5.68	-92.03
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	8.83	16.38	9.86	10.45	-66.13
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	2.01	5.46	2.09	3.83	-161.24
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	31.11	47.03	34.51	9.85	-36.28
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.2	0.84	0.27	25.93	-211.11

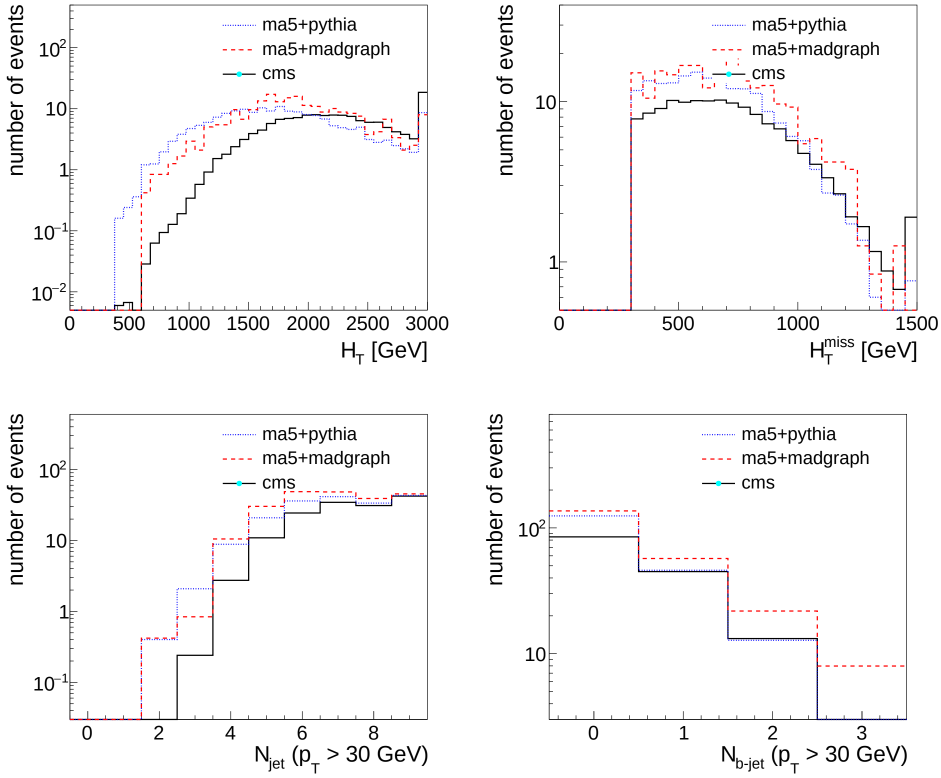

Fig. 7. Kinematic distributions for the T5qqqqVV-1800-100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 15. Pre-selection cutflow for the T5qqqqVV-1400-1100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	99.5	100.0	100.0	0.5	0.0	0.5	0.0	0.0
$H_T > 300$	91.4	89.5	94.6	3.38	5.39	8.1	10.5	5.4
$H_T^{miss} > 300$	35.0	12.6	22.2	-57.66	43.24	56.4	76.9	72.4
$H_T > H_T^{miss}$	34.9	11.8	22.1	-57.92	46.61	0.1	0.8	0.1
NoIsoMuons	30.8	10.2	18.5	-66.49	44.86	4.1	1.6	3.6
NoMuonsTracks	30.6	9.9	18.3	-67.21	45.9	0.2	0.3	0.2
NoIsoElectrons	27.6	8.9	15.5	-78.06	42.58	3.0	1.0	2.8
NoElectronsTracks	27.3	8.8	15.1	-80.79	41.72	0.3	0.1	0.4
NoIsoTracks	26.4	8.8	14.4	-83.33	38.89	0.9	0.0	0.7
NoIsoPhotons	26.3	8.8	14.0	-87.86	37.14	0.1	0.0	0.4
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	26.1	8.8	14.0	-86.43	37.14	0.2	0.0	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	24.2	8.2	12.8	-89.06	35.94	1.9	0.6	1.2
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	22.6	7.6	12.0	-88.33	36.67	1.6	0.6	0.8
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	21.0	7.2	11.2	-87.5	35.71	1.6	0.4	0.8

Table 16. Signal yield in the aggregated signal regions for the T5qqqqVV-1400-1100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	90.27	4.41	29.59	-205.07	85.1
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	10.51	0.0	2.9	-262.41	100.0
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	70.03	4.41	25.83	-171.12	82.93
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	41.24	0.0	21.91	-88.22	100.0
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	3.89	0.0	1.24	-213.71	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	66.14	35.25	28.72	-130.29	-22.74
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	9.73	0.0	4.34	-124.19	100.0
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	43.19	22.03	18.77	-130.1	-17.37
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	9.73	0.0	4.34	-124.19	100.0
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	7.0	4.41	3.05	-129.51	-44.59
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	29.96	0.0	16.04	-86.78	100.0
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.39	0.0	0.1	-290.0	100.0

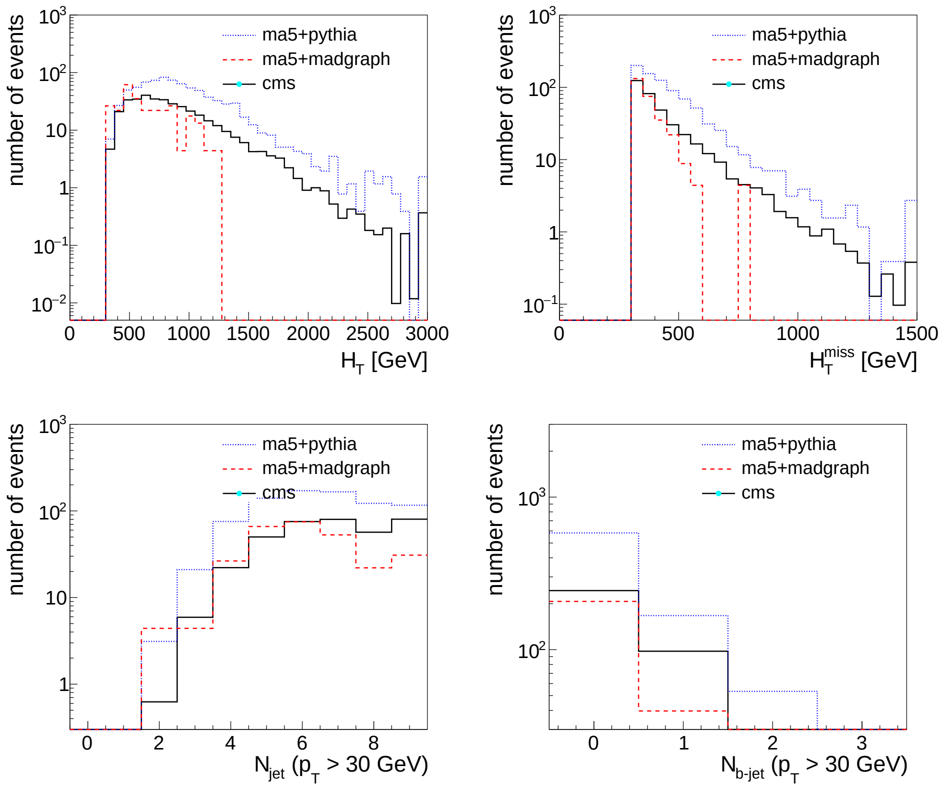

Fig. 8. Kinematic distributions for the T5qqqqVV-1400-1100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 17. Pre-selection cutflow for the T2qq-1400-200 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	99.1	99.7	99.1	0.0	-0.61	0.9	0.3	0.9
$H_T > 300$	98.9	99.6	99.0	0.1	-0.61	0.2	0.1	0.1
$H_T^{miss} > 300$	88.0	87.6	88.1	0.11	0.57	10.9	12.0	10.9
$H_T > H_T^{miss}$	87.0	86.3	86.9	-0.12	0.69	1.0	1.3	1.2
NoIsoMuons	87.0	86.3	86.8	-0.23	0.58	0.0	0.0	0.1
NoMuonsTracks	87.0	86.3	86.7	-0.35	0.46	0.0	0.0	0.1
NoIsoElectrons	86.9	86.3	86.4	-0.58	0.12	0.1	0.0	0.3
NoElectronsTracks	86.9	86.3	86.2	-0.81	-0.12	0.0	0.0	0.2
NoIsoTracks	86.8	86.1	85.6	-1.4	-0.58	0.1	0.2	0.6
NoIsoPhotons	86.0	85.5	83.7	-2.75	-2.15	0.8	0.6	1.9
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	85.8	85.2	83.5	-2.75	-2.04	0.2	0.3	0.2
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	81.7	80.6	78.7	-3.81	-2.41	4.1	4.6	4.8
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	77.6	76.5	74.4	-4.3	-2.82	4.1	4.1	4.3
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	74.8	73.3	71.4	-4.76	-2.66	2.8	3.2	3.0

Table 18. Signal yield in the aggregated signal regions for the T2qq-1400-200 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	268.09	233.19	285.27	6.02	18.26
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	44.23	44.39	35.93	-23.1	-23.55
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	28.18	39.43	33.64	16.23	-17.21
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	5.49	10.18	7.19	23.64	-41.59
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.26	0.52	0.4	35.0	-30.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	4.29	11.23	5.17	17.02	-117.21
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	3.87	9.66	4.55	14.95	-112.31
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	2.09	6.79	2.38	12.18	-185.29
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	3.5	9.14	3.72	5.91	-145.7
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	0.16	0.0	0.12	-33.33	100.0
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	5.8	14.1	10.6	45.28	-33.02
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.02	100.0	100.0

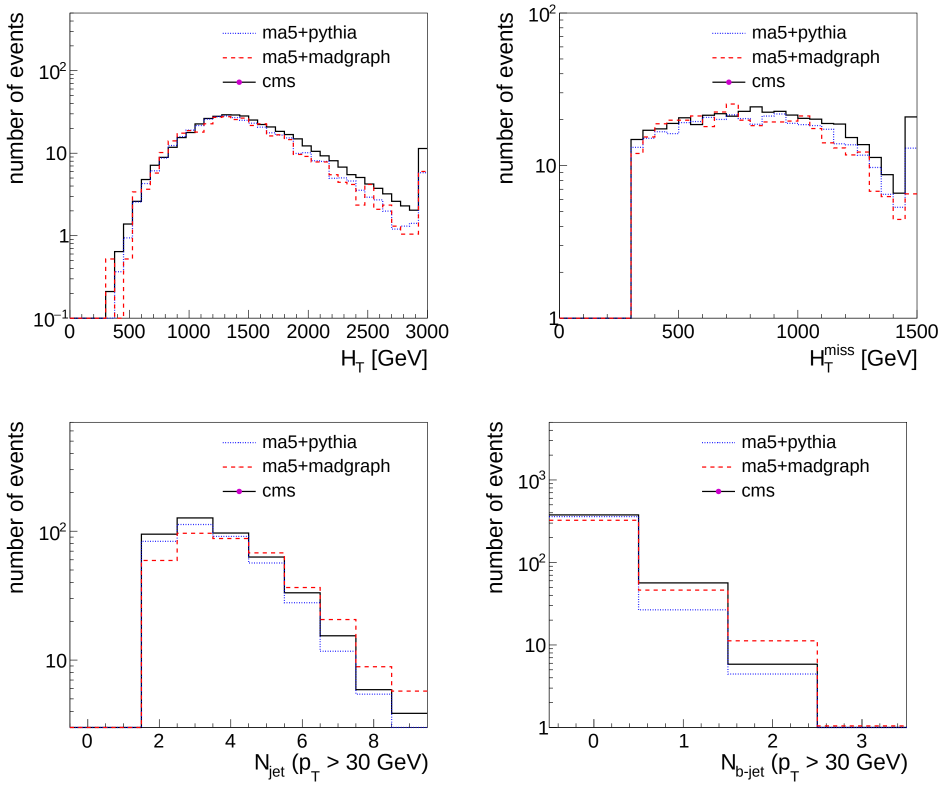

Fig. 9. Kinematic distributions for the T2qq-1400-200 simplified model for the madanalysis5 implementation and those provided by CMS

Table 19. Pre-selection cutflow for the T2qq-1000-800 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	96.1	97.5	97.8	1.74	0.31	3.9	2.5	2.2
$H_T > 300$	77.9	84.2	83.0	6.14	-1.45	18.2	13.3	14.8
$H_T^{miss} > 300$	30.1	31.4	31.3	3.83	-0.32	47.8	52.8	51.7
$H_T > H_T^{miss}$	29.4	30.6	30.2	2.65	-1.32	0.7	0.8	1.1
NoIsoMuons	29.4	30.6	30.2	2.65	-1.32	0.0	0.0	0.0
NoMuonsTracks	29.4	30.6	30.1	2.33	-1.66	0.0	0.0	0.1
NoIsoElectrons	29.4	30.6	30.0	2.0	-2.0	0.0	0.0	0.1
NoElectronsTracks	29.4	30.6	29.9	1.67	-2.34	0.0	0.0	0.1
NoIsoTracks	29.3	30.6	29.6	1.01	-3.38	0.1	0.0	0.3
NoIsoPhotons	29.2	30.4	28.8	-1.39	-5.56	0.1	0.2	0.8
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	29.2	30.4	28.8	-1.39	-5.56	0.0	0.0	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	27.6	29.0	27.1	-1.85	-7.01	1.6	1.4	1.7
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	26.7	27.9	26.1	-2.3	-6.9	0.9	1.1	1.0
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	26.0	27.2	25.2	-3.17	-7.94	0.7	0.7	0.9

Table 20. Signal yield in the aggregated signal regions for the T2qq-1000-800 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	177.2	219.05	188.65	6.07	-16.11
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	11.31	18.56	10.1	-11.98	-83.76
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	27.9	48.27	48.21	42.13	-0.12
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	4.52	7.43	11.76	61.56	36.82
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.75	0.0	0.34	-120.59	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	8.29	29.7	23.23	64.31	-27.85
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	1.51	0.0	4.57	66.96	100.0
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	3.02	7.43	8.68	65.21	14.4
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	1.51	0.0	4.23	64.3	100.0
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	0.0	0.0	0.36	100.0	100.0
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	4.52	14.85	14.65	69.15	-1.37
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.0	nan	nan

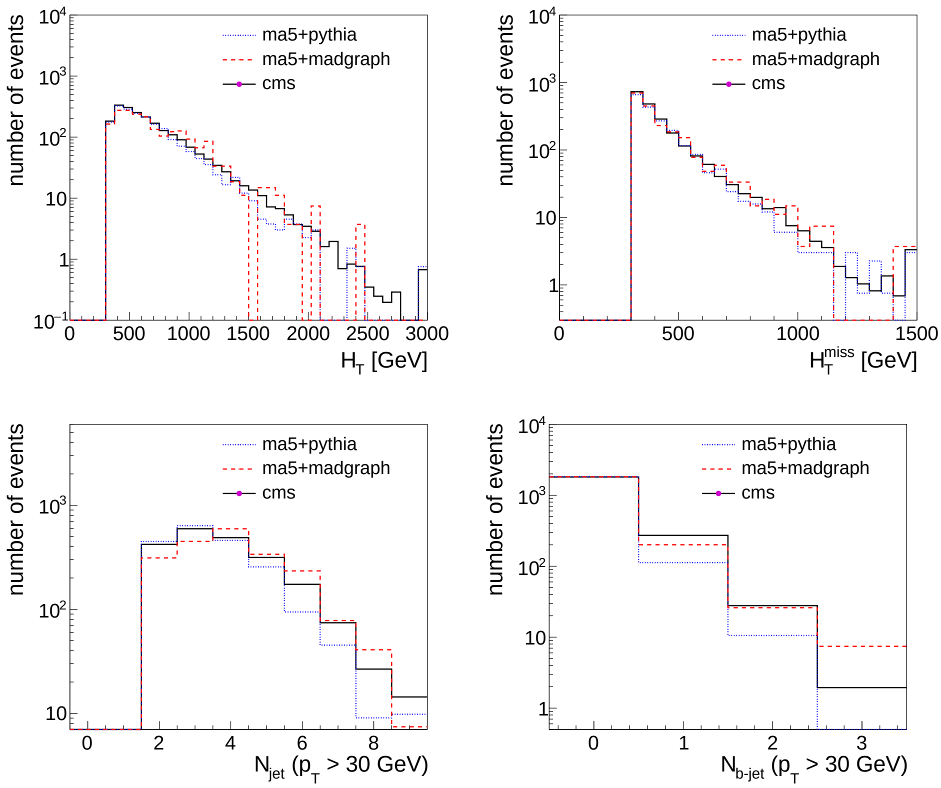

Fig. 10. Kinematic distributions for the T2qq-1000-800 simplified model for the madanalysis5 implementation and those provided by CMS

Table 21. Pre-selection cutflow for the T2bb-1000-100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	98.7	99.2	98.8	0.1	-0.4	1.3	0.8	1.2
$H_T > 300$	98.2	98.9	98.3	0.1	-0.61	0.5	0.3	0.5
$H_T^{miss} > 300$	78.9	76.9	79.5	0.75	3.27	19.3	22.0	18.8
$H_T > H_T^{miss}$	77.8	75.9	78.2	0.51	2.94	1.1	1.0	1.3
NoIsoMuons	77.8	75.9	77.8	0.0	2.44	0.0	0.0	0.4
NoMuonsTracks	77.7	75.8	77.7	0.0	2.45	0.1	0.1	0.1
NoIsoElectrons	77.7	75.8	77.5	-0.26	2.19	0.0	0.0	0.2
NoElectronsTracks	77.6	75.6	77.3	-0.39	2.2	0.1	0.2	0.2
NoIsoTracks	77.5	75.5	76.8	-0.91	1.69	0.1	0.1	0.5
NoIsoPhotons	77.2	75.1	75.2	-2.66	0.13	0.3	0.4	1.6
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	77.0	75.0	75.1	-2.53	0.13	0.2	0.1	0.1
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	73.0	70.7	70.6	-3.4	-0.14	4.0	4.3	4.5
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	69.3	67.2	66.9	-3.59	-0.45	3.7	3.5	3.7
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	66.7	63.9	64.5	-3.41	0.93	2.6	3.3	2.4

Table 22. Signal yield in the aggregated signal regions for the T2bb-1000-100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	53.99	48.77	81.08	33.41	39.85
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	1.87	2.73	3.24	42.28	15.74
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	3.65	5.47	7.38	50.54	25.88
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	1.68	3.19	3.38	50.3	5.62
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.0	0.0	0.11	100.0	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	149.99	168.64	84.14	-78.26	-100.43
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	141.95	130.35	76.83	-84.76	-69.66
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	36.49	48.31	23.03	-58.45	-109.77
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	79.91	83.86	43.57	-83.41	-92.47
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	2.81	4.1	1.01	-178.22	-305.94
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	33.12	46.03	29.97	-10.51	-53.59
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.09	0.46	0.04	-125.0	-1050.0

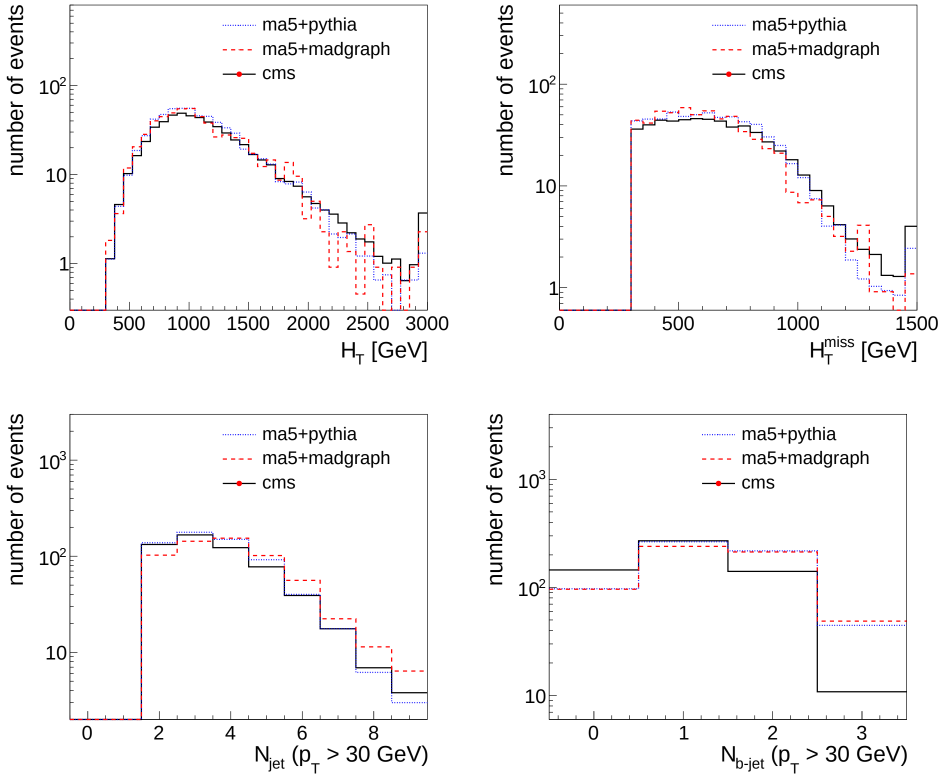

Fig. 11. Kinematic distributions for the T2bb-1000-100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 23. Pre-selection cutflow for the T2bb-600-450 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	95.2	95.3	95.4	0.21	0.1	4.8	4.7	4.6
$H_T > 300$	56.1	60.8	58.2	3.61	-4.47	39.1	34.5	37.2
$H_T^{miss} > 300$	12.0	12.9	13.6	11.76	5.15	44.1	47.9	44.6
$H_T > H_T^{miss}$	11.7	12.6	13.2	11.36	4.55	0.3	0.3	0.4
NoIsoMuons	11.7	12.6	13.1	10.69	3.82	0.0	0.0	0.1
NoMuonsTracks	11.7	12.5	13.1	10.69	4.58	0.0	0.1	0.0
NoIsoElectrons	11.7	12.5	13.0	10.0	3.85	0.0	0.0	0.1
NoElectronsTracks	11.7	12.5	12.9	9.3	3.1	0.0	0.0	0.1
NoIsoTracks	11.7	12.5	12.8	8.59	2.34	0.0	0.0	0.1
NoIsoPhotons	11.6	12.4	12.5	7.2	0.8	0.1	0.1	0.3
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	11.6	12.4	12.5	7.2	0.8	0.0	0.0	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	10.6	10.8	11.3	6.19	4.42	1.0	1.6	1.2
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	10.1	10.1	10.7	5.61	5.61	0.5	0.7	0.6
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	9.8	9.7	10.2	3.92	4.9	0.3	0.4	0.5

Table 24. Signal yield in the aggregated signal regions for the T2bb-600-450 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	25.28	51.72	30.02	15.79	-72.29
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	0.0	0.0	0.84	100.0	100.0
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	5.62	12.93	6.0	6.33	-115.5
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0 - 1$ $H_T > 600$ $H_T^{miss} > 600$	5.62	12.93	4.93	-14.0	-162.27
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0 - 1$ $H_T > 1700$ $H_T^{miss} > 850$	0.0	0.0	0.15	100.0	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	707.74	762.9	682.87	-3.64	-11.72
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	73.02	51.72	90.18	19.03	42.65
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	143.23	142.24	143.37	0.1	0.79
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	61.79	51.72	74.32	16.86	30.41
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	2.81	0.0	6.33	55.61	100.0
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	42.13	90.51	51.75	18.59	-74.9
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.07	100.0	100.0

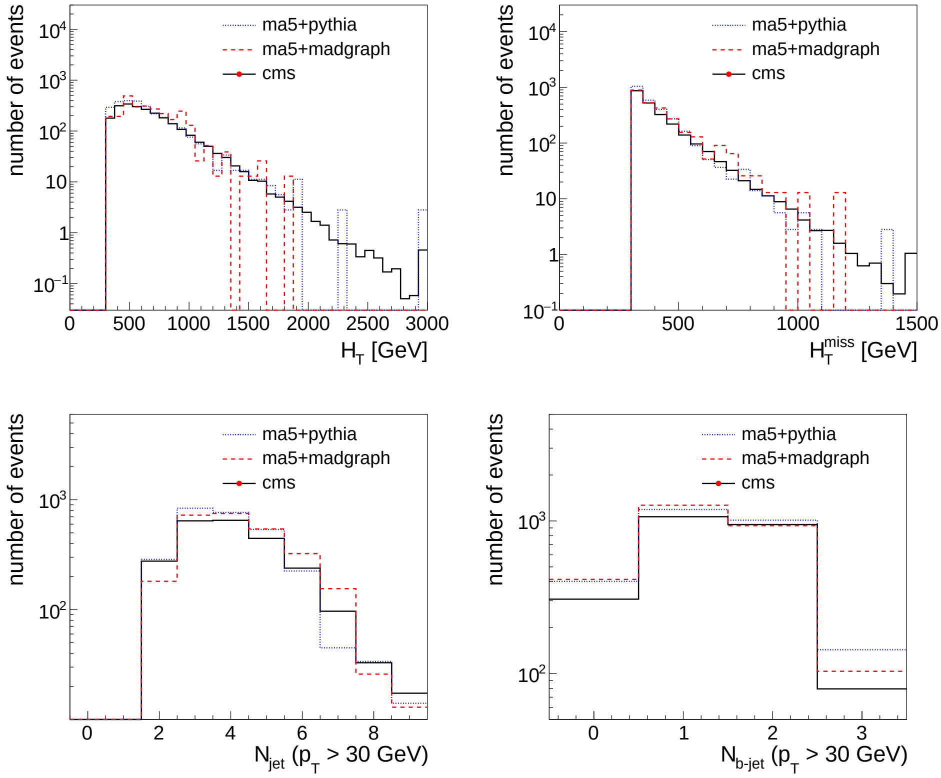

Fig. 12. Kinematic distributions for the T2bb-600-450 simplified model for the madanalysis5 implementation and those provided by CMS

Table 25. Pre-selection cutflow for the T2tt-950-100 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	99.8	100.0	99.9	0.1	-0.1	0.2	0.0	0.1
$H_T > 300$	98.3	99.0	98.6	0.3	-0.41	1.5	1.0	1.3
$H_T^{miss} > 300$	72.9	73.8	74.5	2.15	0.94	25.4	25.2	24.1
$H_T > H_T^{miss}$	72.1	73.2	73.6	2.04	0.54	0.8	0.6	0.9
NoIsoMuons	63.4	65.6	58.7	-8.01	-11.75	8.7	7.6	14.9
NoMuonsTracks	63.0	64.9	58.2	-8.25	-11.51	0.4	0.7	0.5
NoIsoElectrons	56.9	59.0	47.1	-20.81	-25.27	6.1	5.9	11.1
NoElectronsTracks	56.3	58.9	46.4	-21.34	-26.94	0.6	0.1	0.7
NoIsoTracks	55.7	58.5	45.5	-22.42	-28.57	0.6	0.4	0.9
NoIsoPhotons	55.2	58.2	43.8	-26.03	-32.88	0.5	0.3	1.7
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	55.1	58.1	43.7	-26.09	-32.95	0.1	0.1	0.1
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	52.2	54.7	41.1	-27.01	-33.09	2.9	3.4	2.6
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	50.6	52.7	39.8	-27.14	-32.41	1.6	2.0	1.3
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	49.0	51.0	38.5	-27.27	-32.47	1.6	1.7	1.3

Table 26. Signal yield in the aggregated signal regions for the T2tt-950-100 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	41.82	39.89	40.94	-2.15	2.56
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	1.9	2.03	1.56	-21.79	-30.13
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	14.66	16.23	13.38	-9.57	-21.3
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	13.31	18.26	12.77	-4.23	-42.99
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.27	0.0	0.28	3.57	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	276.56	292.76	181.57	-52.32	-61.24
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	123.14	116.97	87.22	-41.18	-34.11
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	138.08	162.27	96.21	-43.52	-68.66
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	114.86	111.56	81.86	-40.31	-36.28
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	13.44	20.96	7.36	-82.61	-184.78
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	105.63	117.65	88.82	-18.93	-32.46
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.54	0.0	0.19	-184.21	100.0

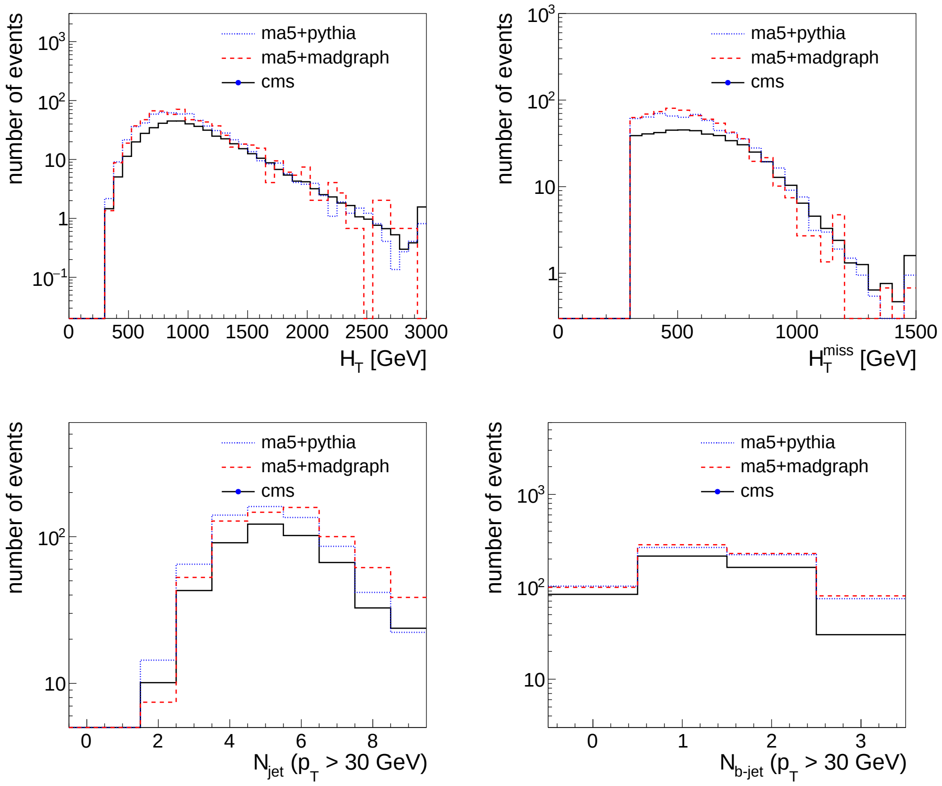

Fig. 13. Kinematic distributions for the T2tt-950-100 simplified model for the madanalysis5 implementation and those provided by CMS

Table 27. Pre-selection cutflow for the T2tt-600-400 simplified model.

Cut	MA5 pythia	MA5 madgraph	CMS	MA5 pythia diff [%]	MA5 madgraph diff [%]	MA5 pythia drop [%]	MA5 madgraph drop [%]	CMS drop [%]
$N_{jet} \geq 2$	99.5	99.4	99.6	0.1	0.2	0.5	0.6	0.4
$H_T > 300$	77.5	71.7	72.2	-7.34	0.69	22.0	27.7	27.4
$H_T^{miss} > 300$	13.7	9.5	9.2	-48.91	-3.26	63.8	62.2	63.0
$H_T > H_T^{miss}$	13.6	9.5	9.1	-49.45	-4.4	0.1	0.0	0.1
NoIsoMuons	11.7	7.9	7.0	-67.14	-12.86	1.9	1.6	2.1
NoMuonsTracks	11.6	7.8	6.9	-68.12	-13.04	0.1	0.1	0.1
NoIsoElectrons	10.1	6.8	5.4	-87.04	-25.93	1.5	1.0	1.5
NoElectronsTracks	9.9	6.7	5.2	-90.38	-28.85	0.2	0.1	0.2
NoIsoTracks	9.5	6.3	4.8	-97.92	-31.25	0.4	0.4	0.4
NoIsoPhotons	9.5	6.3	4.7	-102.13	-34.04	0.0	0.0	0.1
$\Delta\Phi_{H_T^{miss},j1} > 0.5$	9.5	6.3	4.7	-102.13	-34.04	0.0	0.0	0.0
$\Delta\Phi_{H_T^{miss},j2} > 0.5$	8.6	5.4	3.9	-120.51	-38.46	0.9	0.9	0.8
$\Delta\Phi_{H_T^{miss},j3} > 0.3$	8.0	4.8	3.4	-135.29	-41.18	0.6	0.6	0.5
$\Delta\Phi_{H_T^{miss},j4} > 0.3$	7.4	4.3	3.0	-146.67	-43.33	0.6	0.5	0.4

Table 28. Signal yield in the aggregated signal regions for the T2tt-600-400 simplified model.

Agg SR	MA5 pythia yield	MA5 madgraph yield	CMS yield	MA5 pythia diff [%]	MA5 madgraph diff [%]
SR1 $N_{jet} \geq 2$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	22.47	13.06	7.51	-199.2	-73.9
SR2 $N_{jet} \geq 4$ $N_{bjet} = 0$ $H_T > 1700$ $H_T^{miss} > 850$	2.81	0.0	0.32	-778.13	100.0
SR3 $N_{jet} \geq 6$ $N_{bjet} = 0$ $H_T > 600$ $H_T^{miss} > 600$	19.66	13.06	4.53	-334.0	-188.3
SR4 $N_{jet} \geq 8$ $N_{bjet} = 0-1$ $H_T > 600$ $H_T^{miss} > 600$	11.23	13.06	8.71	-28.93	-49.94
SR5 $N_{jet} \geq 10$ $N_{bjet} = 0-1$ $H_T > 1700$ $H_T^{miss} > 850$	0.0	0.0	0.23	100.0	100.0
SR6 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 300$ $H_T^{miss} > 300$	850.98	483.32	254.99	-233.73	-89.54
SR7 $N_{jet} \geq 2$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	44.94	26.13	19.85	-126.4	-31.64
SR8 $N_{jet} \geq 6$ $N_{bjet} \geq 2$ $H_T > 350$ $H_T^{miss} > 350$	342.64	326.57	130.96	-161.64	-149.37
SR9 $N_{jet} \geq 4$ $N_{bjet} \geq 2$ $H_T > 600$ $H_T^{miss} > 600$	39.32	26.13	19.67	-99.9	-32.84
SR10 $N_{jet} \geq 8$ $N_{bjet} \geq 3$ $H_T > 300$ $H_T^{miss} > 300$	42.13	52.25	20.36	-106.93	-156.63
SR11 $N_{jet} \geq 6$ $N_{bjet} \geq 1$ $H_T > 600$ $H_T^{miss} > 600$	61.79	39.19	30.97	-99.52	-26.54
SR12 $N_{jet} \geq 10$ $N_{bjet} \geq 3$ $H_T > 850$ $H_T^{miss} > 850$	0.0	0.0	0.09	100.0	100.0

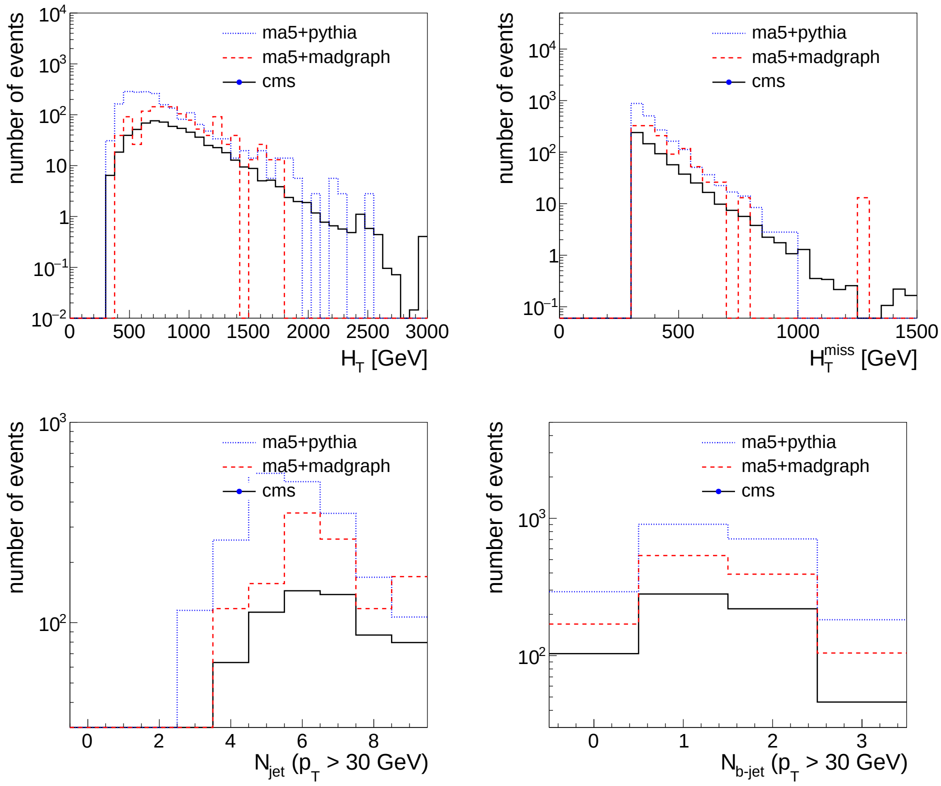

Fig. 14. Kinematic distributions for the T2tt-600-400 simplified model for the madanalysis5 implementation and those provided by CMS

4. Conclusions

Summarize your work here.

Acknowledgments

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