Radiating top quarks

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Citation for published version (APA):

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### A.1 Monte Carlo generators

Table A.1 lists all the Monte Carlo generators used throughout this thesis and their purpose. In case there are two version numbers mentioned, the first number refers to the version used for $\sqrt{s} = 14$ TeV studies in Chapter 5 and 6 (ATHENA release 12), and the second number to the version used for $\sqrt{s} = 10$ TeV studies in Chapter 7 (ATHENA release 14). Otherwise, the same version is used in either case.

<table>
<thead>
<tr>
<th>Generator</th>
<th>Version(s)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>HERWIG</td>
<td>6.510</td>
<td>General</td>
</tr>
<tr>
<td>JIMMY</td>
<td>4.0\textsuperscript{At}las 4.31</td>
<td>Underlying event</td>
</tr>
<tr>
<td>PYTHIA</td>
<td>6.403 6.418</td>
<td>General</td>
</tr>
<tr>
<td>MC@NLO</td>
<td>3.1 3.31</td>
<td>NLO ME</td>
</tr>
<tr>
<td>ALPGEN</td>
<td>2.06\textsuperscript{fix} 2.13</td>
<td>ME, MLM</td>
</tr>
<tr>
<td>ACERMC</td>
<td>3.2 3.5</td>
<td>ME</td>
</tr>
<tr>
<td>PHOTOS</td>
<td>2.15</td>
<td>QED corrections</td>
</tr>
<tr>
<td>TAUOLA</td>
<td>2.7</td>
<td>$\tau$ decays</td>
</tr>
<tr>
<td>ARIADNE</td>
<td>CVS</td>
<td>Dipole cascade, CKKW-L</td>
</tr>
<tr>
<td>MADGRAPH</td>
<td>4.4.19</td>
<td>ME</td>
</tr>
<tr>
<td>MCFM</td>
<td>5.5</td>
<td>NLO cross sections</td>
</tr>
</tbody>
</table>

Table A.1: List Monte Carlo generators used in this thesis.

### A.2 Samples for $\sqrt{s} = 14$ TeV

In Table A.2 the Monte Carlo samples are listed for the $\sqrt{s} = 14$ TeV analyses in Chapter 5 and 6. The samples are generated in ATHENA release 12. The reconstruction
Appendix A. List of MC generators and samples

of physics objects is carried out with both full and fast detector response simulation.

<table>
<thead>
<tr>
<th>$t\bar{t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>trig1_misal1_mc12.005200.T1_McAtNlo_Jimmy.recon.AOD.v12000601_tid006997</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005204.TTbar_FullHad_McAtNlo_Jimmy.recon.AOD.v12000601_tid006015</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005205.AcerMCttbar.recon.AOD.v12000601_tid006085</td>
</tr>
<tr>
<td>trig1_misal1_mc12.006250.AcerMCttbar.recon.AOD.v12000605_tid013579</td>
</tr>
<tr>
<td>trig1_misal1_mc12.006251.AcerMCttbar.recon.AOD.v12000605_tid013580</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>single $t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>trig1_misal1_mc12.005500.AcerMC_Wt.recon.AOD.v12000601_tid006192</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005500.AcerMC_Wt.recon.AOD.v12000601_tid006958</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005501.AcerMC_schan.recon.AOD.v12000601_tid006193</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005501.AcerMC_schan.recon.AOD.v12000601_tid006959</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005502.AcerMC_tchan.recon.AOD.v12000601_tid006194</td>
</tr>
<tr>
<td>trig1_misal1_mc12.005502.AcerMC_tchan.recon.AOD.v12000601_tid006960</td>
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</table>

<table>
<thead>
<tr>
<th>$W+\text{jets}$</th>
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</thead>
<tbody>
<tr>
<td>trig1_misal1_mc12.008240.AlpgenJimmyWenuNp2_pt20_filt3jet.recon.AOD.v12000601_tid006551</td>
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<tr>
<td>trig1_misal1_mc12.008241.AlpgenJimmyWenuNp3_pt20_filt3jet.recon.AOD.v12000601_tid006552</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008242.AlpgenJimmyWenuNp4_pt20_filt3jet.recon.AOD.v12000601_tid006553</td>
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<tr>
<td>trig1_misal1_mc12.008243.AlpgenJimmyWenuNp5_pt20_filt3jet.recon.AOD.v12000601_tid006554</td>
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<tr>
<td>trig1_misal1_mc12.008244.AlpgenJimmyWmunuNp2_pt20_filt3jet.recon.AOD.v12000601_tid006555</td>
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<tr>
<td>trig1_misal1_mc12.008245.AlpgenJimmyWmunuNp3_pt20_filt3jet.recon.AOD.v12000601_tid006556</td>
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<tr>
<td>trig1_misal1_mc12.008246.AlpgenJimmyWmunuNp4_pt20_filt3jet.recon.AOD.v12000601_tid006557</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008247.AlpgenJimmyWmunuNp5_pt20_filt3jet.recon.AOD.v12000601_tid006558</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008248.AlpgenJimmyWtaunuNp2_pt20_filt3jet.recon.AOD.v12000601_tid006559</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008249.AlpgenJimmyWtaunuNp3_pt20_filt3jet.recon.AOD.v12000601_tid006560</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008250.AlpgenJimmyWtaunuNp4_pt20_filt3jet.recon.AOD.v12000601_tid006561</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008251.AlpgenJimmyWtaunuNp5_pt20_filt3jet.recon.AOD.v12000601_tid006562</td>
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<table>
<thead>
<tr>
<th>$Z+\text{jets}$</th>
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</thead>
<tbody>
<tr>
<td>trig1_misal1_mc12.008131.AlpgenJimmyZeeNp1LooseCut.recon.AOD.v12000601_tid006603</td>
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<tr>
<td>trig1_misal1_mc12.008132.AlpgenJimmyZeeNp2LooseCut.recon.AOD.v12000601_tid006604</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008133.AlpgenJimmyZeeNp3LooseCut.recon.AOD.v12000601_tid006605</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008134.AlpgenJimmyZeeNp4LooseCut.recon.AOD.v12000601_tid006606</td>
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<tr>
<td>trig1_misal1_mc12.008135.AlpgenJimmyZeeNp5LooseCut.recon.AOD.v12000601_tid006607</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008143.AlpgenJimmyZmunuNp1LooseCut.recon.AOD.v12000601_tid006615</td>
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<tr>
<td>trig1_misal1_mc12.008144.AlpgenJimmyZmunuNp2LooseCut.recon.AOD.v12000601_tid006616</td>
</tr>
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<td>trig1_misal1_mc12.008145.AlpgenJimmyZmunuNp3LooseCut.recon.AOD.v12000601_tid006617</td>
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<td>trig1_misal1_mc12.008146.AlpgenJimmyZmunuNp4LooseCut.recon.AOD.v12000601_tid006618</td>
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<td>trig1_misal1_mc12.008147.AlpgenJimmyZtautauNp0LooseCut.recon.AOD.v12000601_tid006619</td>
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<td>trig1_misal1_mc12.008154.AlpgenJimmyZtautauNp1LooseCut.recon.AOD.v12000601_tid006626</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008155.AlpgenJimmyZtautauNp2LooseCut.recon.AOD.v12000601_tid006627</td>
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<tr>
<td>trig1_misal1_mc12.008156.AlpgenJimmyZtautauNp3LooseCut.recon.AOD.v12000601_tid006628</td>
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<tr>
<td>trig1_misal1_mc12.008157.AlpgenJimmyZtautauNp4LooseCut.recon.AOD.v12000601_tid006629</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008158.AlpgenJimmyZtautauNp0LooseCut.recon.AOD.v12000601_tid006630</td>
</tr>
<tr>
<td>trig1_misal1_mc12.008159.AlpgenJimmyZtautauNp5LooseCut.recon.AOD.v12000601_tid006631</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>$Wb\bar{b}$ + jets</th>
</tr>
</thead>
<tbody>
<tr>
<td>trig1_misal1_mc12.006280.AlpgenJimmyWbbNp0.recon.AOD.v12000605_tid015406</td>
</tr>
<tr>
<td>trig1_misal1_mc12.006281.AlpgenJimmyWbbNp1.recon.AOD.v12000605_tid015409</td>
</tr>
<tr>
<td>trig1_misal1_mc12.006282.AlpgenJimmyWbbNp2.recon.AOD.v12000605_tid015410</td>
</tr>
<tr>
<td>trig1_misal1_mc12.006283.AlpgenJimmyWbbNp3.recon.AOD.v12000605_tid015411</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$W^+W^-, W^\pm Z, ZZ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>trig1_misal1_csc1.005985.WW_Herwig.recon.AOD.v12000601_tid006070</td>
</tr>
<tr>
<td>trig1_misal1_csc1.005986.ZZ_Herwig.recon.AOD.v12000601_tid006068</td>
</tr>
<tr>
<td>trig1_misal1_csc1.005987.WZ_Herwig.recon.AOD.v12000601_tid006069</td>
</tr>
</tbody>
</table>

Table A.2: List of Monte Carlo samples for $\sqrt{s} = 14$ TeV used in Chapter 5 and 6.
A.2. Samples for $\sqrt{s} = 14$ TeV

In Table A.3 the Monte Carlo samples are listed for the $\sqrt{s} = 14$ TeV analysis in Chapter 6. The samples are generated in Athena release 12. The reconstruction of physics objects is carried out with fast detector response simulation only.

<table>
<thead>
<tr>
<th>Process</th>
<th>$\sigma$ (pb)</th>
<th>$K$-factor</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t\bar{t}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- semi- and di-leptonic</td>
<td>450.0</td>
<td>-</td>
<td>$\geq 1$ lepton</td>
</tr>
<tr>
<td>- fully hadronic</td>
<td>380.0</td>
<td>-</td>
<td>no lepton</td>
</tr>
<tr>
<td>single top:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- $W^\pm t$</td>
<td>26.7</td>
<td>-</td>
<td>one $W^\pm \rightarrow \ell^\pm \nu_\ell$, one $W^\pm \rightarrow jj$</td>
</tr>
<tr>
<td>- s-channel</td>
<td>3.3</td>
<td>-</td>
<td>$W^\pm \rightarrow \ell^\pm \nu_\ell$</td>
</tr>
<tr>
<td>- t-channel</td>
<td>81.3</td>
<td>-</td>
<td>$W^\pm \rightarrow \ell^\pm \nu_\ell$</td>
</tr>
<tr>
<td>$W^\pm (\rightarrow \ell^\pm \nu_\ell) +$ jets</td>
<td>912.0</td>
<td>1.15</td>
<td>$\geq 3$ jets: $p_T &gt; 30$ GeV, $</td>
</tr>
<tr>
<td>$Z(\rightarrow \ell^+\ell^-) +$ jets</td>
<td>896.1</td>
<td>1.15</td>
<td>$\geq 2$ $e, \mu$: $p_T &gt; 10$ GeV, $</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\geq 1$ jet: $p_T &gt; 20$ GeV, $</td>
</tr>
<tr>
<td>$W^\pm \bar{b}b +$ jets</td>
<td>19.9</td>
<td>2.57</td>
<td>$W^\pm \rightarrow \ell^\pm \nu_\ell$</td>
</tr>
<tr>
<td>$W^+W^-$</td>
<td>24.5</td>
<td>1.57</td>
<td>$\geq 1$ $e, \mu$: $p_T &gt; 10$ GeV, $</td>
</tr>
<tr>
<td>$W^\pm Z$</td>
<td>7.8</td>
<td>1.89</td>
<td>$\geq 1$ $e, \mu$: $p_T &gt; 10$ GeV, $</td>
</tr>
<tr>
<td>$ZZ$</td>
<td>2.1</td>
<td>1.29</td>
<td>$\geq 1$ $e, \mu$: $p_T &gt; 10$ GeV, $</td>
</tr>
</tbody>
</table>

Table A.3: List of Monte Carlo samples for $\sqrt{s} = 14$ TeV used in Chapter 6.

Cross sections

The cross sections and $K$-factors used for the Monte Carlo samples listed in Table A.2 are given in Table A.4. The cross sections are valid for $\sqrt{s} = 14$ TeV and include branching ratios and filter efficiencies for the requirements mentioned in the last column.

Table A.4: Cross sections and $K$-factors used for the samples in Table A.2.
Appendix A. List of MC generators and samples

The cross sections for the Monte Carlo samples listed in Table A.3 are given in Table A.5 and A.6. The cross sections are obtained with ALPGEN using MLM matching and are valid for $\sqrt{s} = 14$ TeV. For $t\bar{t}$ an additional $K$-factor of 2.02 was applied.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|}
\hline
process & sample & $\sigma_{\text{gen}}$ & $\epsilon_{\text{mlm}}$ & $\sigma_{\text{mlm}}$ \\
\hline
$t\bar{t} + 0p$ & 006264 & 197.61 & 0.263 & 51.97 pb \\
$t\bar{t} + 1p$ & 006265 & 250.83 & 0.240 & 60.20 pb \\
$t\bar{t} + 2p$ & 006266 & 186.65 & 0.217 & 40.50 pb \\
$t\bar{t} + 3p$ & 006267 & 103.17 & 0.298 & 30.74 pb \\
\hline
$t\bar{t}$ total & & & & 183.42 pb \\
\hline
\end{tabular}
\caption{Cross sections and MLM matching efficiencies for semi-leptonic $t\bar{t}$.}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
partons & $\sigma$ & $\mathcal{L}$ \\
\hline
2 & 17,778,800 pb & 0.051 pb$^{-1}$ \\
3 & 969,300 pb & 0.48 pb$^{-1}$ \\
4 & 108,204 pb & 1.6 pb$^{-1}$ \\
5+ & 14,040 pb & 9.1 pb$^{-1}$ \\
\hline
total & 18,870,344 pb & \\
\hline
\end{tabular}
\caption{Cross sections and luminosities of QCD multi-jet samples.}
\end{table}

A.3 Samples for $\sqrt{s} = 10$ TeV

In Table A.7 the Monte Carlo samples are listed for the $\sqrt{s} = 10$ TeV analysis in Chapter 7. The samples are generated in ATHENA release 14. The reconstruction of physics objects is carried out with both full and fast detector response simulation.

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
$W + $ jets \\
mc08.107690.1AlpgenJimmyWunuNp0_pt20.recon.AOD.e368_a68 \\
mc08.107691.1AlpgenJimmyWunuNp1_pt20.recon.AOD.e368_a68 \\
mc08.107692.1AlpgenJimmyWunuNp2_pt20.recon.AOD.e368_a68 \\
mc08.107693.1AlpgenJimmyWunuNp3_pt20.recon.AOD.e368_a68 \\
mc08.107694.1AlpgenJimmyWunuNp4_pt20.recon.AOD.e368_a68 \\
mc08.107695.1AlpgenJimmyWunuNp5_pt20.recon.AOD.e368_a68 \\
\hline
$Z + $ jets \\
mc08.107660.1AlpgenJimmyZunuNp0_pt20.recon.AOD.e376_a68 \\
mc08.107661.1AlpgenJimmyZunuNp1_pt20.recon.AOD.e376_a68 \\
mc08.107662.1AlpgenJimmyZunuNp2_pt20.recon.AOD.e376_a68 \\
mc08.107663.1AlpgenJimmyZunuNp3_pt20.recon.AOD.e376_a68 \\
mc08.107664.1AlpgenJimmyZunuNp4_pt20.recon.AOD.e376_a68 \\
mc08.107665.1AlpgenJimmyZunuNp5_pt20.recon.AOD.e376_a68 \\
\hline
\end{tabular}
\caption{List of Monte Carlo samples for $\sqrt{s} = 10$ TeV used in Chapter 7.}
\end{table}