Karlsruhe Institute of Technology

CMS Germany

BMBF FSP-CMS

Current Status

Max Erhart | September 15, 2021

INSTITUTE OF EXPERIMENTAL PARTICLE PHYSICS (ETP)

Outline

Samples

Sample	σ [pb]
$t\bar{t}$ + jets	
/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	831.76 × 0.10706
/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	831.76 × 0.4411
/TTToHadronic_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	831.76 × 0.45441
DY + jets	
/DYJetsToLL_M-10to50_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	646.06
/DYJetsToLL_M-50_HT-70to100_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	211.21
/DYJetsToLL_M-50_HT-100to200_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	183.2
/DYJetsToLL_M-50_HT-200to400_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	55.29
/DYJetsToLL_M-50_HT-400to600_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	7.846
/DYJetsToLL_M-50_HT-600to800_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	1.933
/DYJetsToLL_M-50_HT-800to1200_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	0.831
/DYJetsToLL_M-50_HT-1200to2500_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	0.183
/DYJetsToLL_M-50_HT-2500toInf_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	0.004
Single top	
/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL18NanoAODv2	3.3633
/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	35.85
/ST_tW_top_5f_NoFullyHadronicDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	
/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv2	35.85
/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer19UL18NanoAODv2	136.02
/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer19UL18NanoAODv2	80.95
W + jets	
/WJetsToLNu_HT-70To100_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	1501.56
/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	1609.9
/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	475.0
/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	67.40
/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	16.75
/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	7.5
/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	1.66
/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	0.0391
/WJetsToLNu_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv2	61526.7
Diboson	
/WW_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv2	118.7
/WZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv2	47.13/65.5443?
/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv2	15.8274/16.523?
/ZZTo2L2Nu_TuneCP5_13TeV_powheg_pythia8/RunIISummer20UL18NanoAODv2	
$t\bar{t}$ + X	
/TTWJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8	0.2043
/TTWJetsToQQ_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8	0.4062
/TTZToLLNuNu_M-10_TuneCP5_13TeV-amcatnlo-pythia8	0.2529
/TTZToQQ_TuneCP5_13TeV-amcatnlo-pythia8	0.5297
/TTGJets_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8	3.697
/ttHTobb_M125_TuneCP5_13TeV-powheg-pythia8	
/ttHToNonbb_M125_TuneCP5_13TeV-powheg-pythia8	

Single lepton triggers

Table 3.1: Trigger paths of individual channels are connected via OR.

Channel	Trigger paths
electron	`HLT_Ele32_WPTight_Gsf`
	`HLT_Ele28_eta2p1_WPTight_Gsf_HT150`
muon	`HLT_IsoMu24`

Single lepton triggers

- Trigger SFs avalible for RunIISummer20UL18
  - Should also be applicable to RunIISummer19UL18
- Potential loss of events in low p_T region
- Recovery of dilepton events failing dilepton triggers

Channel	Trigger paths
double electron	require single electron trigger
double muon	required single muon trigger
electron-muon	required single electron or single muon trigger

Dilepton triggers as suggested by TOP PAG

- Lowest unprescaled triggers as suggested by TOP PAG[1]
- Trigger SFs not publically avalible (or not found)

Table 3.2: Trigger paths of individual channels are connected via OR.

Channel	Trigger paths
double electron	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL
	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_DZ
electron-muon	HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL
	HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Mu8_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ
double muon	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass3p8
	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass8

[1] https://twiki.cern.ch/twiki/bin/view/CMS/TopTriggerYear2018

Dilepton triggers used in recent dilepton $t\bar{t}+>1b$ analysis[2]

- Additional use of single leptron double lepton
- Recovery of double lepton events failing double lepton triggers
- Trigger SF not publically avalible

Channel	Trigger paths
double electron	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL
	HLT_Ele23_Ele12_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Ele32_WPTight_Gsf
electron-muon	HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL
	HLT_Mu23_TrkIsoVVL_Ele12_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Mu12_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Mu8_TrkIsoVVL_Ele23_CaloIdL_TrackIdL_IsoVL_DZ
	HLT_Ele32_WPTight_Gsf
	HLT_IsoMu24
double muon	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass3p8
	HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_DZ_Mass8
	HLT_IsoMu24

[2] https://twiki.cern.ch/twiki/bin/viewauth/CMS/TOP20009

Selections

Muons

- $p_T > 25\,\text{GeV}$
- $|\eta| < 2.4$
- `CutBasedIdTight`[3]
- `PFIsoLoose`

Electrons

- $p_T > 25\,\text{GeV}$
- $|\eta| < 2.4$
- Exclude barrel-endcap transition
  $1.4442 < |\eta| < 1.5660$
- `CutBasedIdTight`[4]

[3] `https://twiki.cern.ch/twiki/bin/view/CMS/SWGuideMuonIdRun2`

[4] `https://twiki.cern.ch/twiki/bin/viewauth/CMS/CutBasedElectronIdentificationRun2`

Selections

Jets

- AK4 jets
- $p_T > 30\,\text{GeV}$
- $|\eta| < 2.4$
- `TightLepVeto` jetId[5]
- Exclude jets with $\Delta R_{jl} < 0.4$

b jets

- DeepJet medium WP

[5] `https://twiki.cern.ch/twiki/bin/view/CMS/JetID13TeVRun2018`

Selections

Lepton pair

- 2 fully selected OC leptons
- $m_{ll} > 12\,\text{GeV}$
- Same lepton flavour exclude $76\,\text{GeV} < m_{ll} < 106\,\text{GeV}$

Vertex

- `PV_npvsGood`[6]

MET

- Same lepton flavour $|\vec{\not{E}}_{\text{T}}| > 30\,\text{GeV}$

[6] $ndof > 4$, $|\rho| < 2\,\text{cm}$ and $|z| < 24\,\text{cm}$

MET filter flags[8]

Filter Name	Data	MC
Flag_goodVertices	X	X
Flag_globalSuperTightHalo2016Filter	X	X
Flag_HBHENoiseFilter	X	X
Flag_HBHENoiseIsoFilter	X	X
Flag_EcalDeadCellTriggerPrimitiveFilter	X	X
Flag_BadPFMuonFilter	X	X
Flag_BadPFMuonDzFilter[7]	X	X
Flag_eeBadScFilter	X	X
Flag_ecalBadCalibFilter	X	X

[7] Not in nanoAODv2

[8] https://twiki.cern.ch/twiki/bin/view/CMS/MissingETOptionalFiltersRun2

Scale factors

- Single lepton trigger SFs
- Double lepton trigger SFs
- Electron ID, tracking SFs
- Muon ID, ISO SFs
- Fixed WP and iterative fit b-tagging SFs
- c-tagging SFs

Event reconstruction

- Assign jets stemming from $t\bar{t}$ or from additional jets
- Different approaches
  - χ^2
  - BDT
  - NN
- Possible use of existing jet assignment methods (JAN)
- Truth level jet assignment required between reconstructed jet and generator jet

Event classification

- Classify events according to flavour content of additional jets
  - $t\bar{t} + b\bar{b}$
  - $t\bar{t} + b$
  - $t\bar{t} + c\bar{c}$
  - $t\bar{t} + c$
  - $t\bar{t} + \text{light flavor}$
  - $t\bar{t} + \text{other}$
- Different MVA based approaches