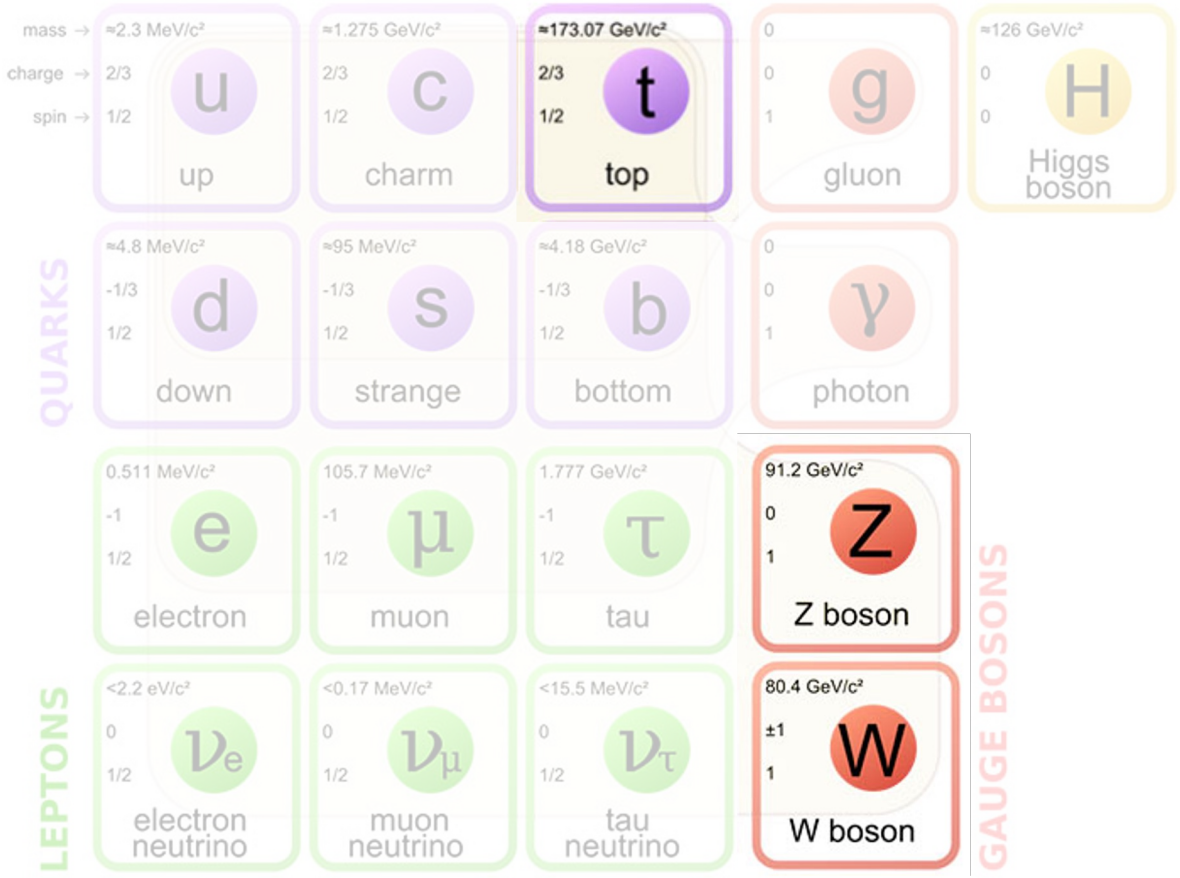
FACULTEIT WETENSCHAPPEN

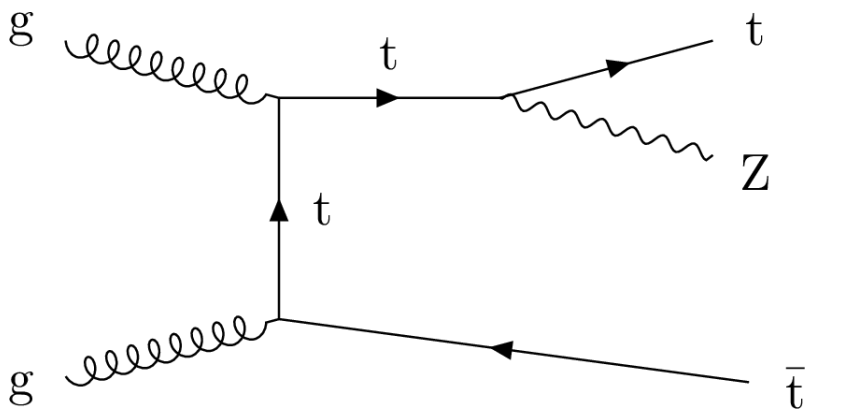
BOOSTED TOPOLOGIES IN ASSOCIATED TOP QUARK PRODUCTION WITH VECTOR BOSONS

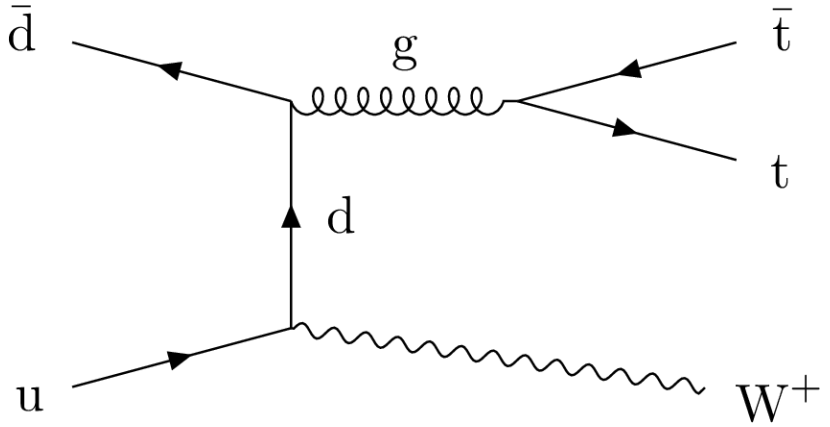
Amber Cauwels / 19-06-2024

UNIVERSITEIT GENT

WHY $t\bar{t} + V$?







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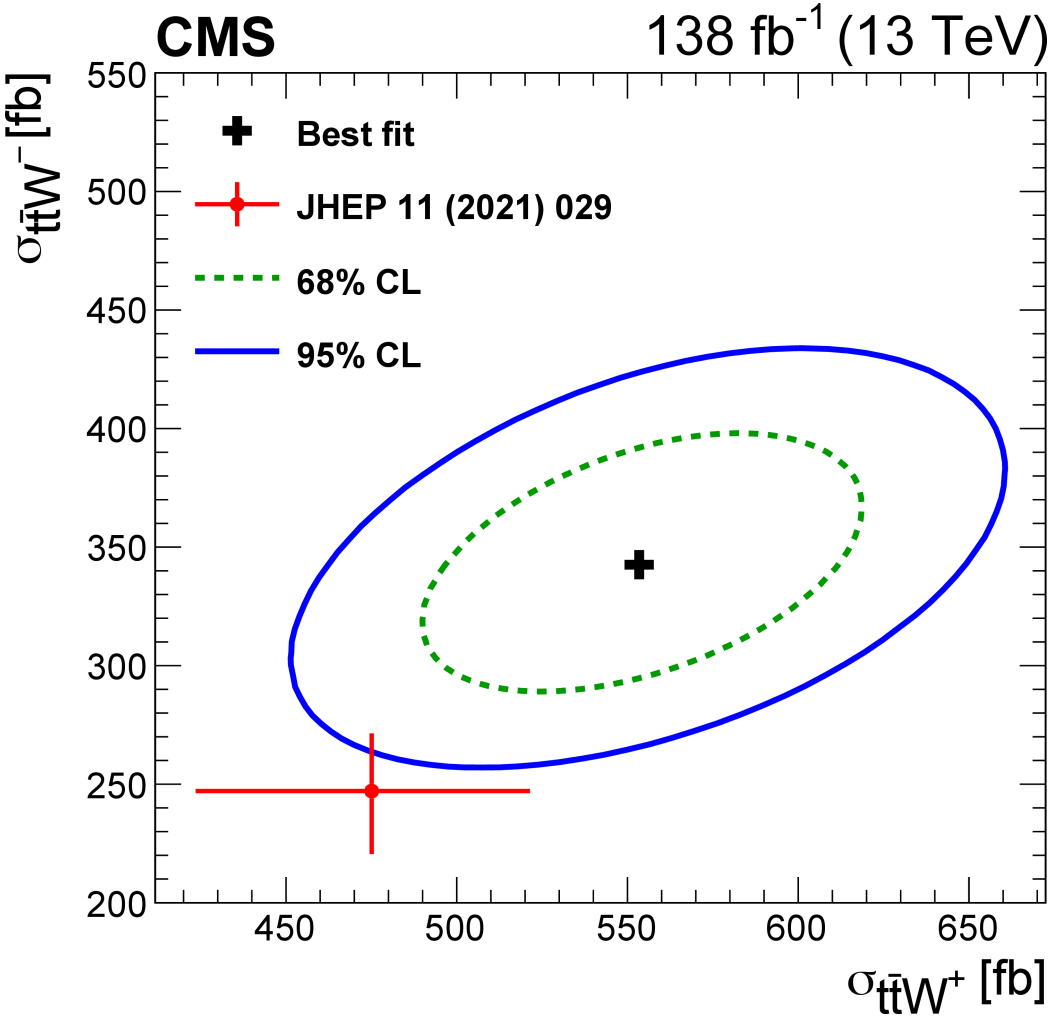
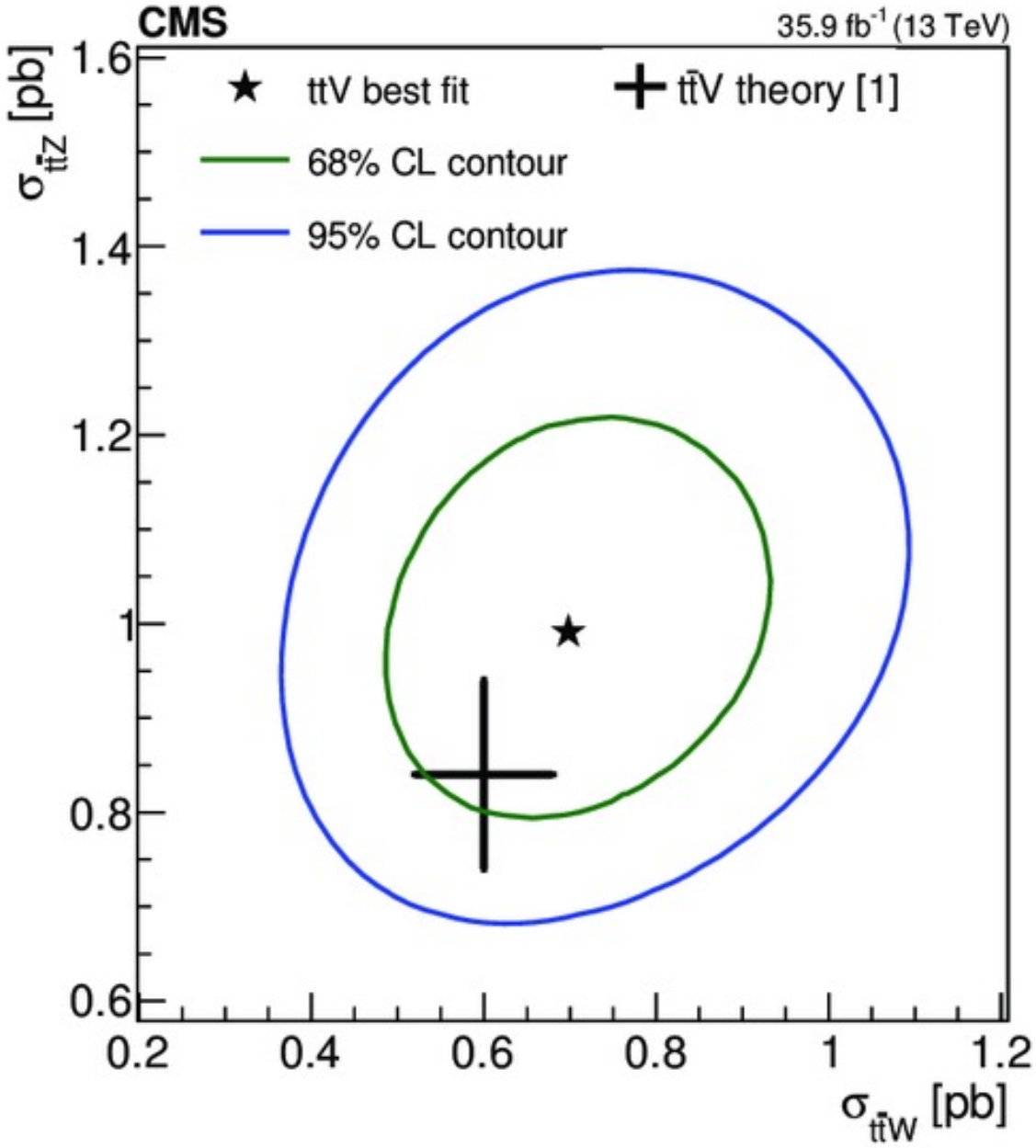
EARLIER $t\bar{t} + V$ RESULTS

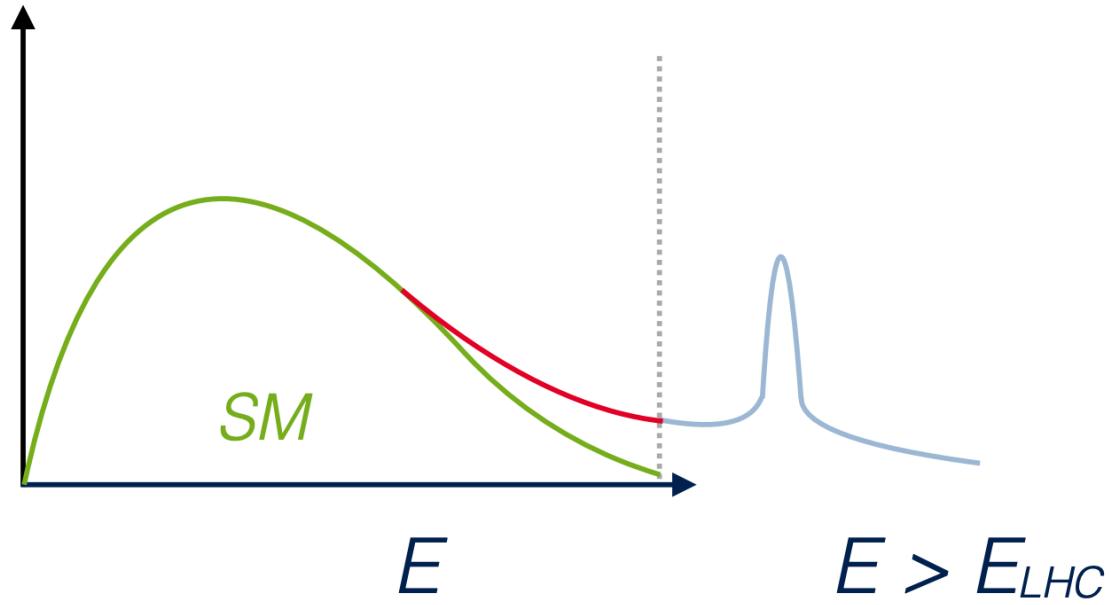


CMS-TOP-21-011

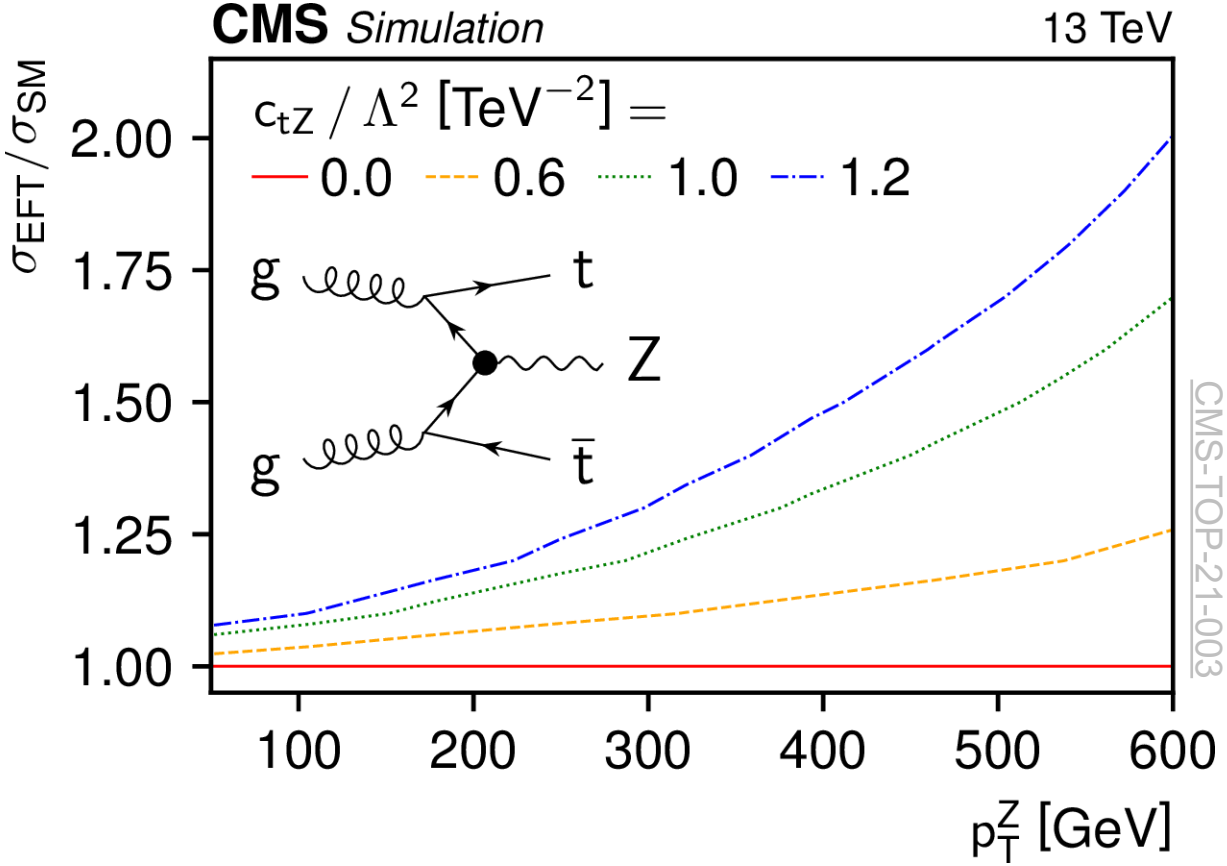


CMS-TOP-17-005

WHY $t\bar{t} + V$?



⇒ New physics is heavy



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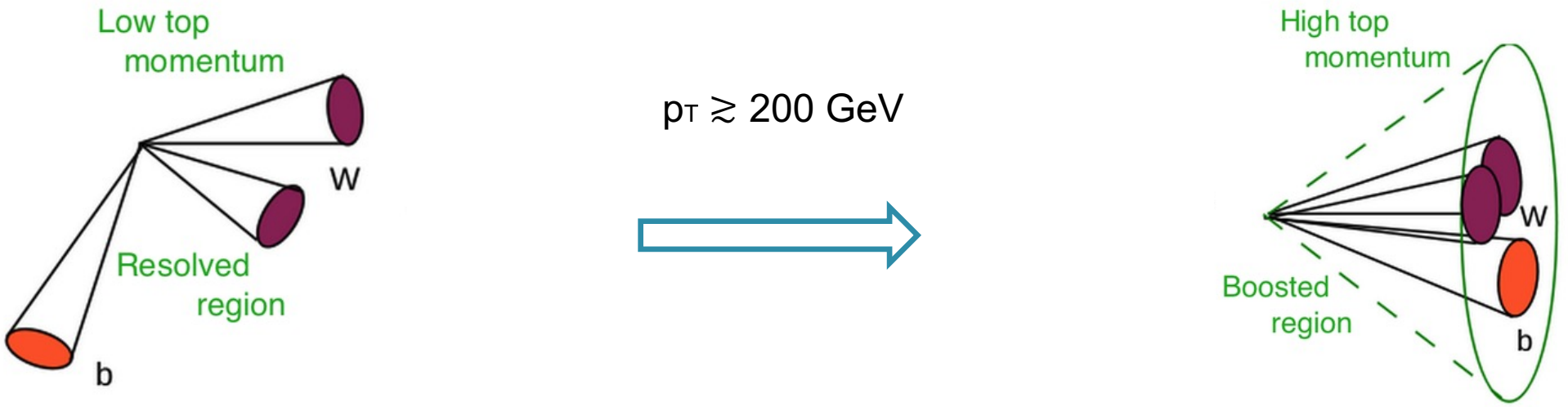
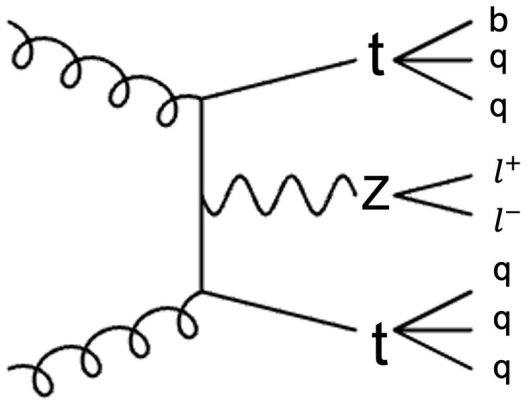
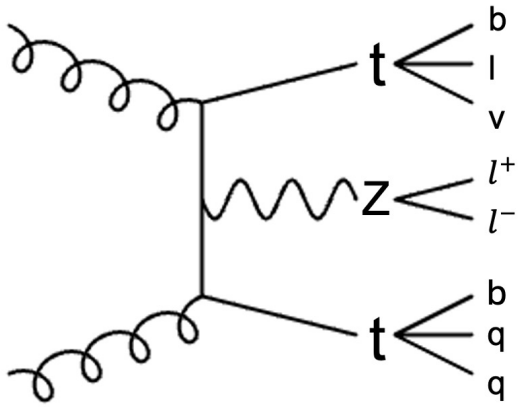
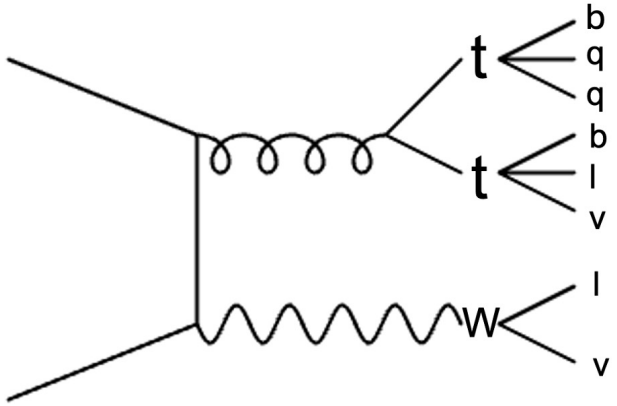
HADRONIC TOP QUARK DECAYS

$t \rightarrow bW \rightarrow bqq$

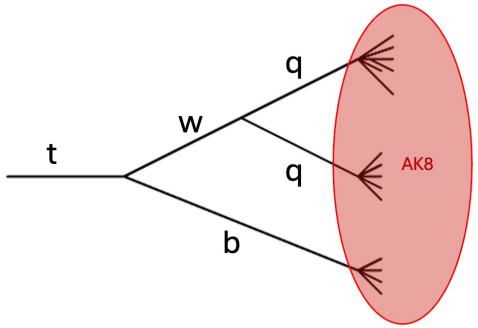


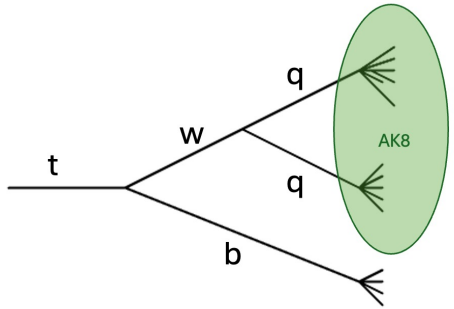
• 3 small jets • $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.4$ • 3 AK4-jets	• 1 big jet • $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.8$ • 1 AK8-jet

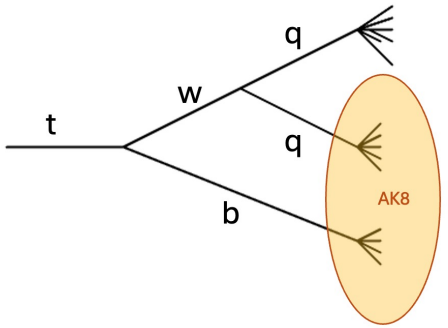
EVENT SELECTION

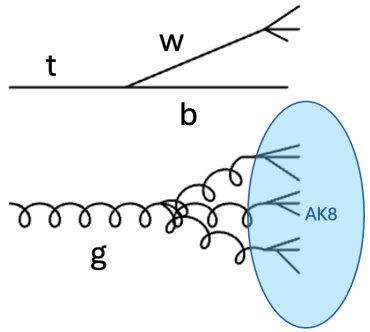
$t\bar{t}Z \rightarrow 2l$	$t\bar{t}Z \rightarrow \mathbf{3}l$	$t\bar{t}W \rightarrow 2l$
		
• = 2 leptons: OSSF • I m(ll) - m_Z I ≤ 10 GeV • ≥ 1 AK4-jet → b-tagged • ≥ 1 AK8-jet → t-tagged	• =3 leptons: OSSF • I m(ll) - m_Z I ≤ 10 GeV • ≥ 1 AK4-jet → b-tagged • ≥ 1 AK8-jet → t-tagged	• =2 leptons: SS • I m(ll) - m_Z I ≥ 15 GeV • Missing p_T > 30 GeV • ≥ 1 AK4-jet → b-tagged • ≥ 1 AK8-jet → t-tagged

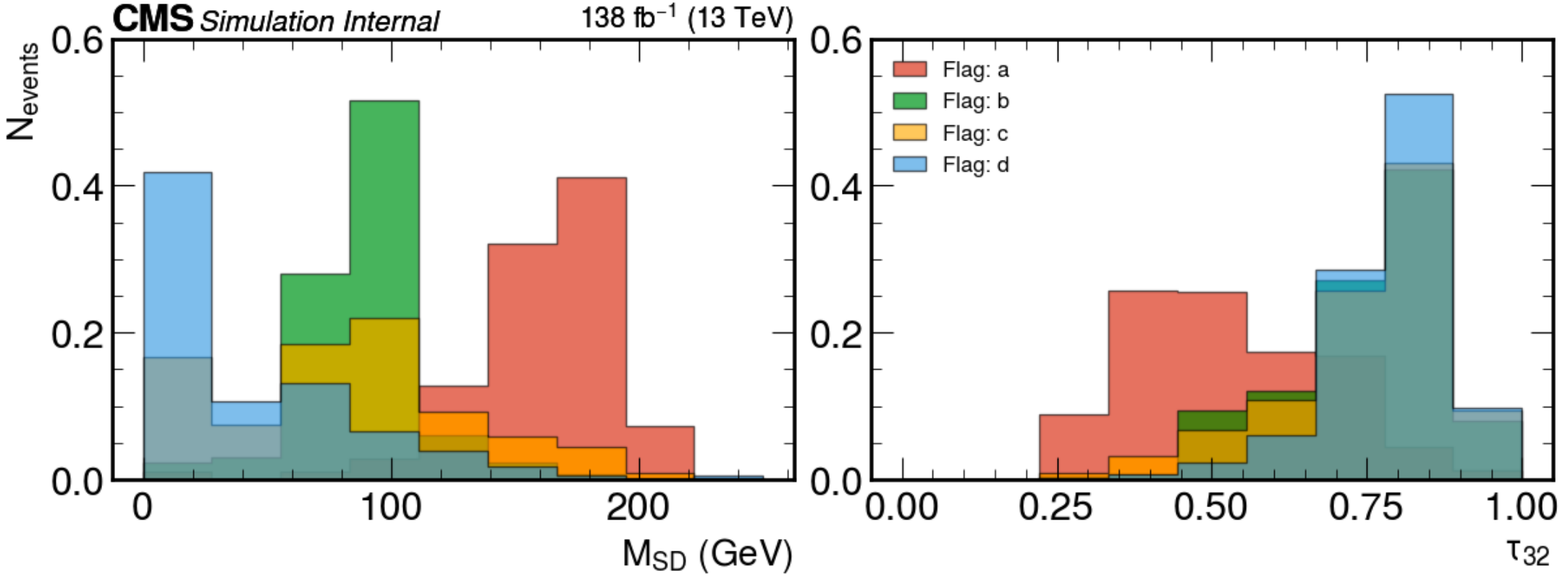
GENLEVEL STUDY OF AK8-JETS





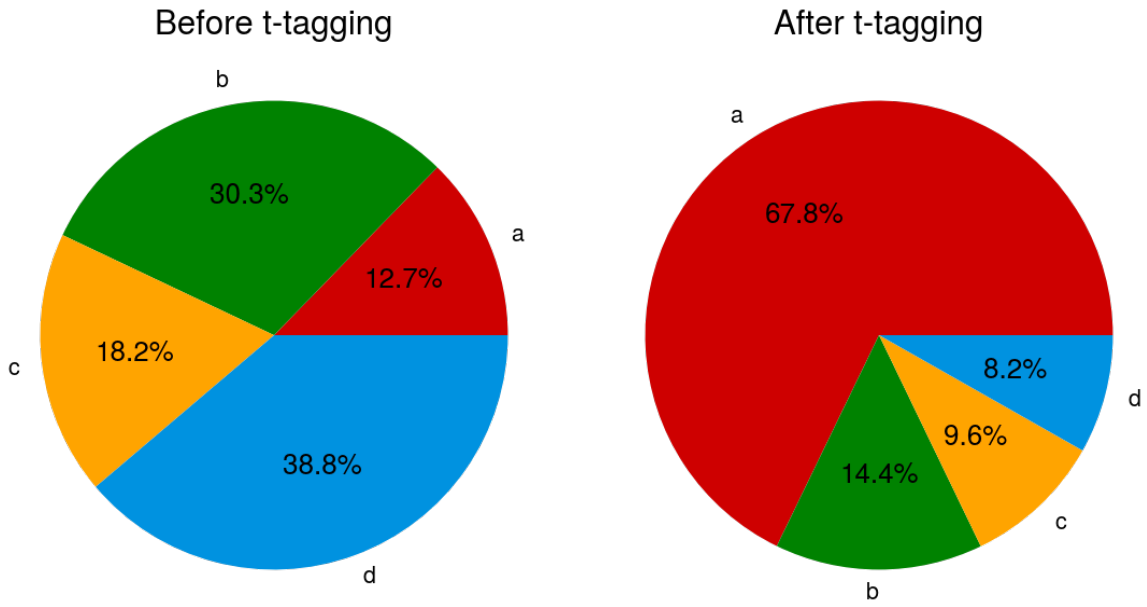


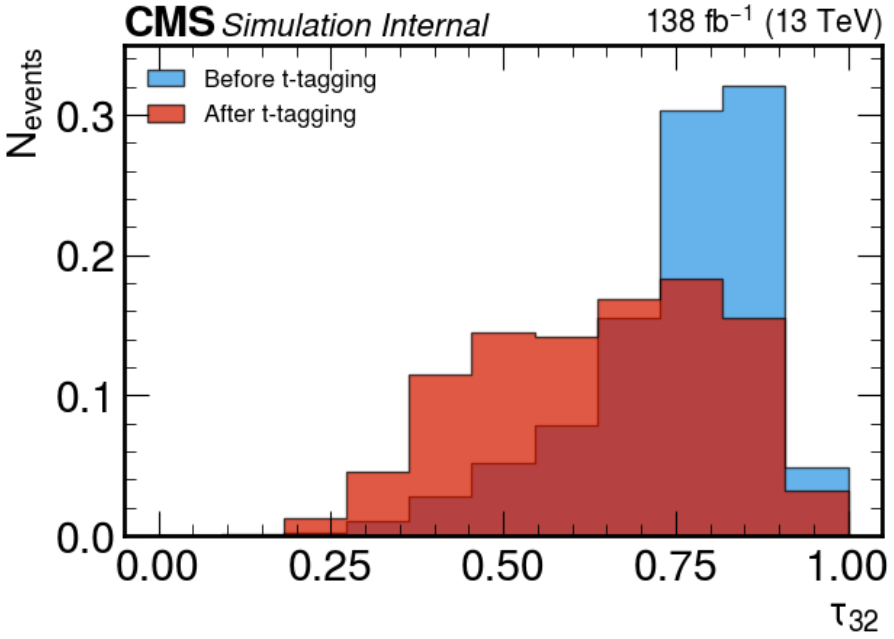


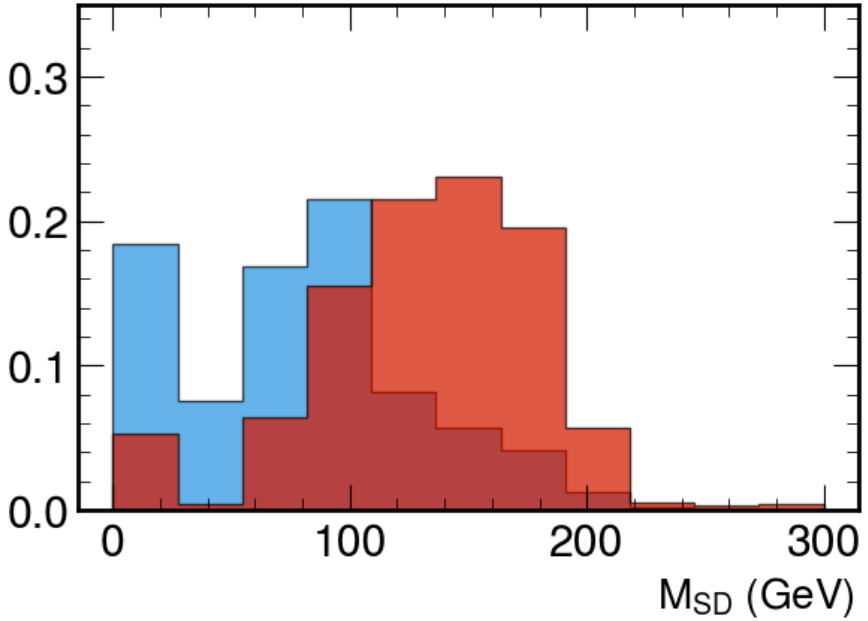


PARTICLENET

- GNN
- Represents Jets as ‘Particle Clouds’
- TvsQCD > 0.58





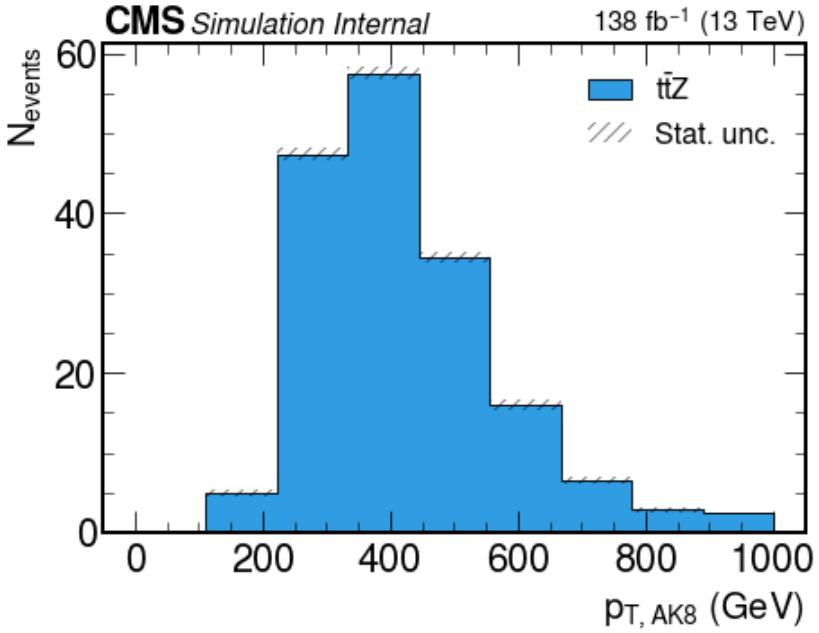


SIGNAL YIELDS

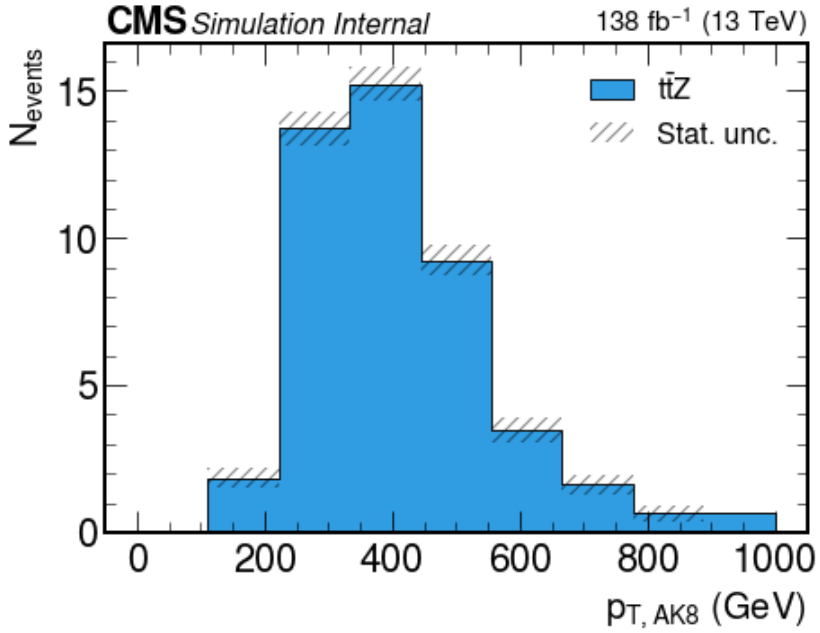
AK8-jets:

- p_T > 200 GeV
- η < 2.4
- ΔR with lep and AK4-jets > 0.8
- TvsQCD > 0.58 → LWP

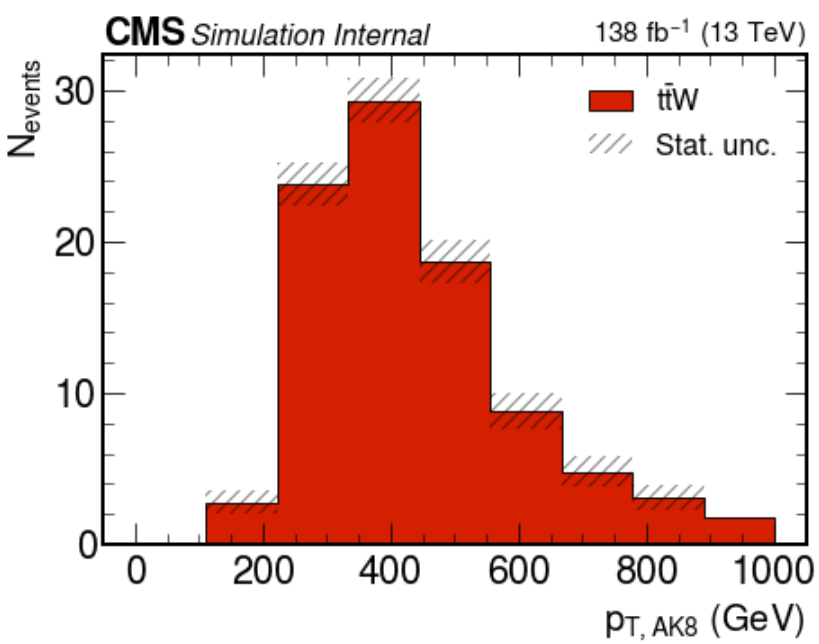
$t\bar{t}Z \rightarrow 2l$



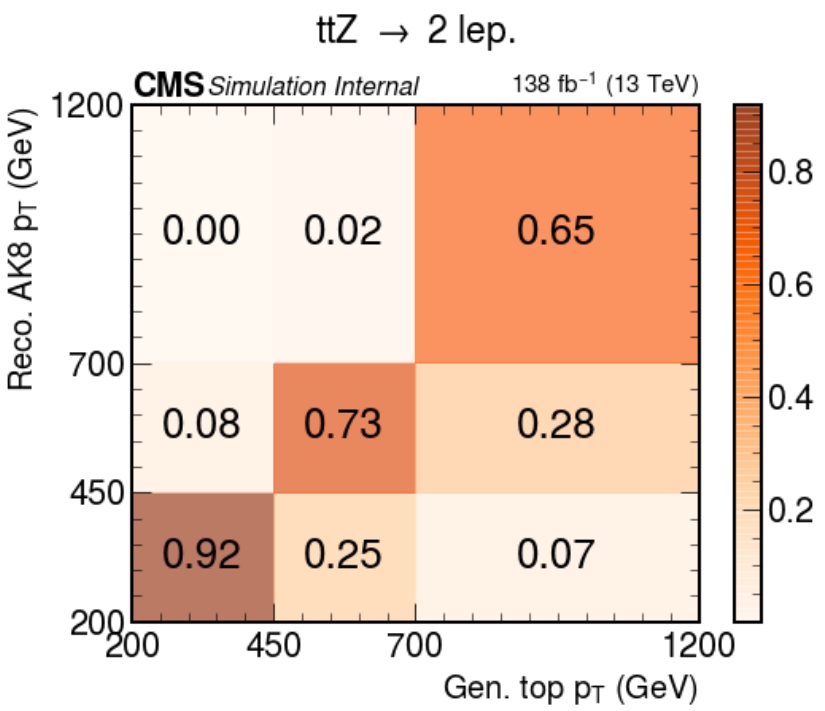
$t\bar{t}Z \rightarrow 3l$

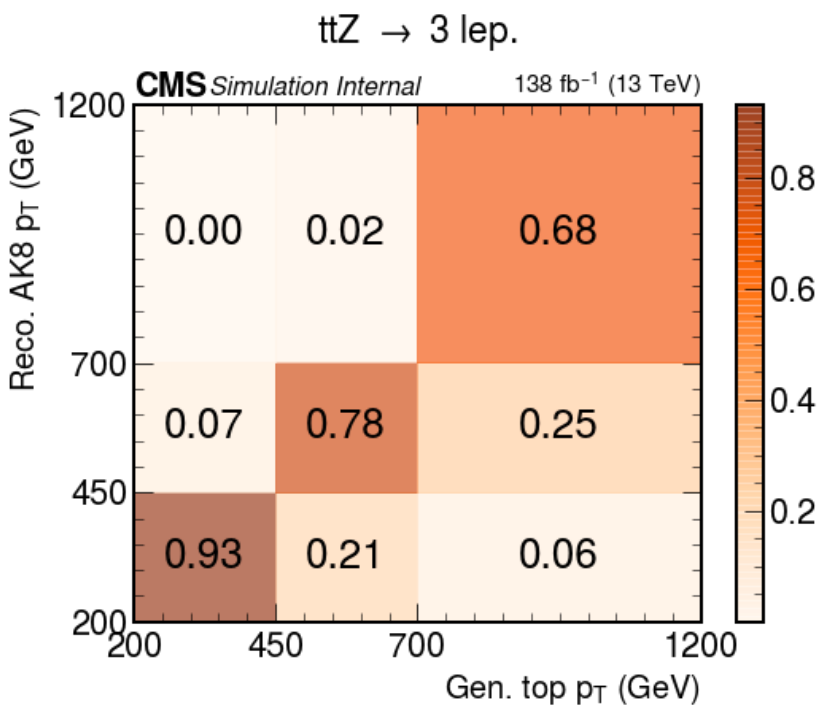


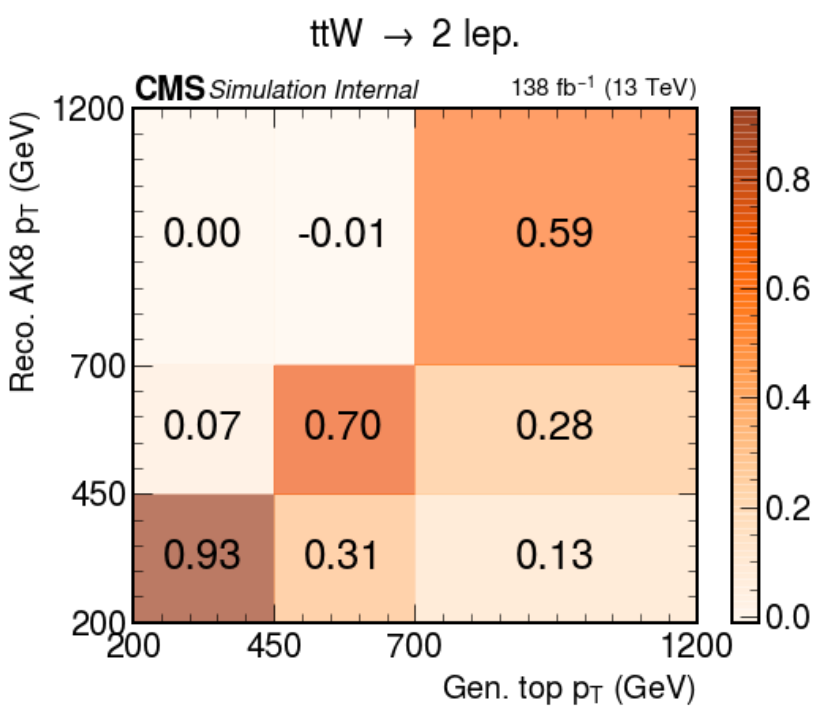
$t\bar{t}W \rightarrow 2l$



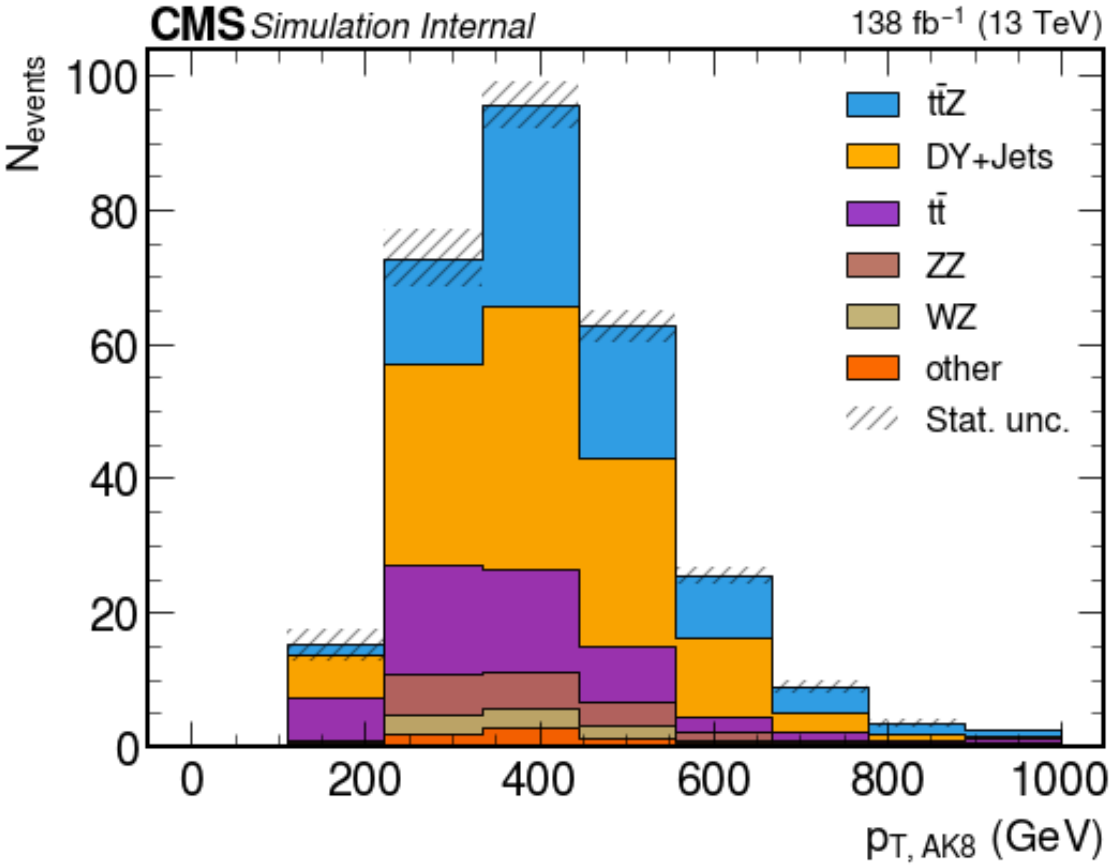
RESOLUTION MATRICES

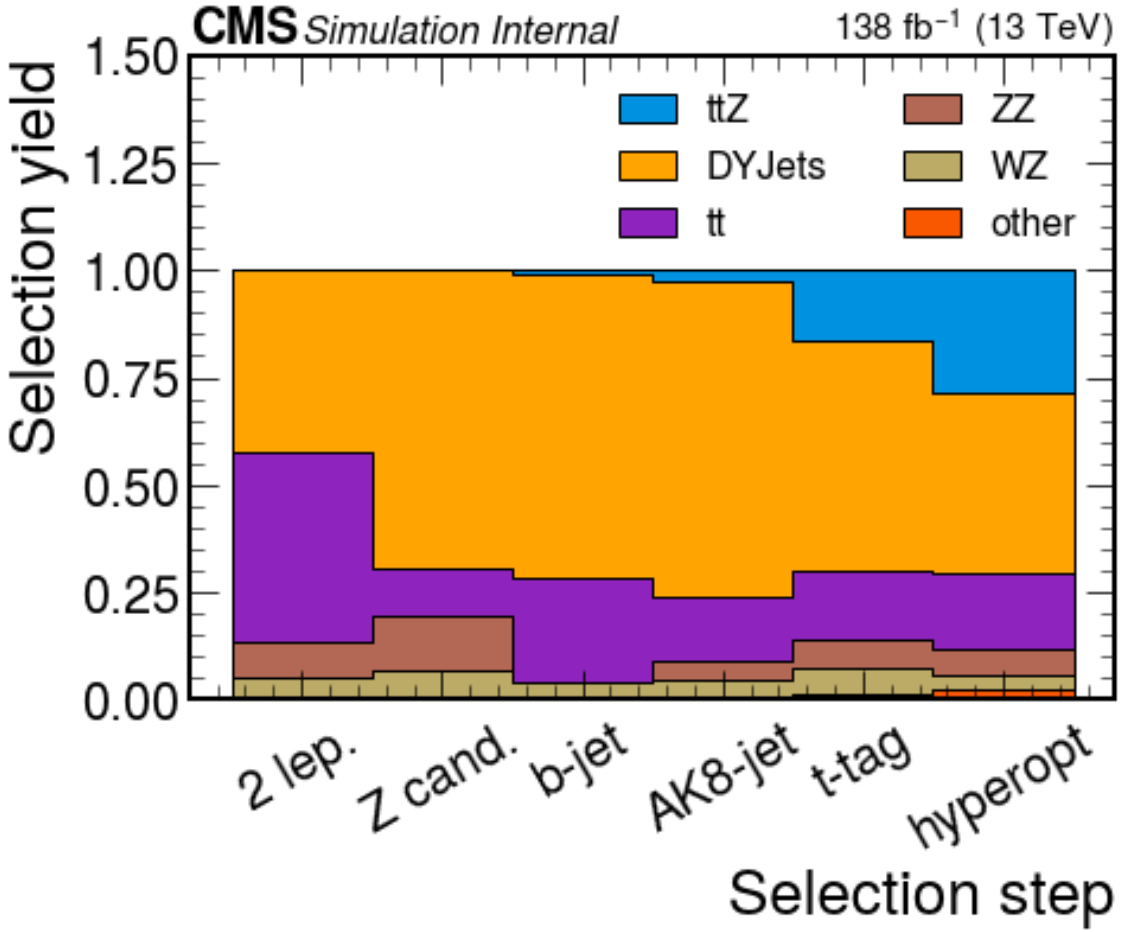






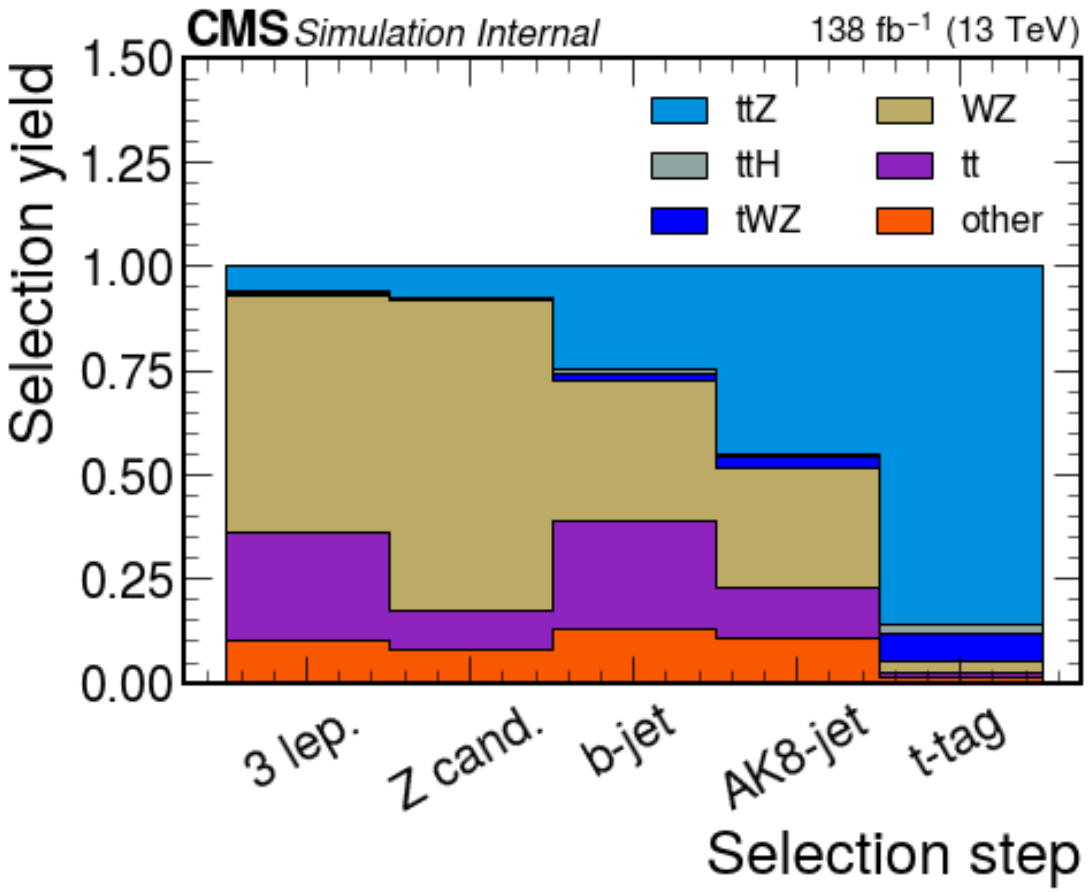
BACKGROUND PREDICTION $t\bar{t}Z \rightarrow 2l$

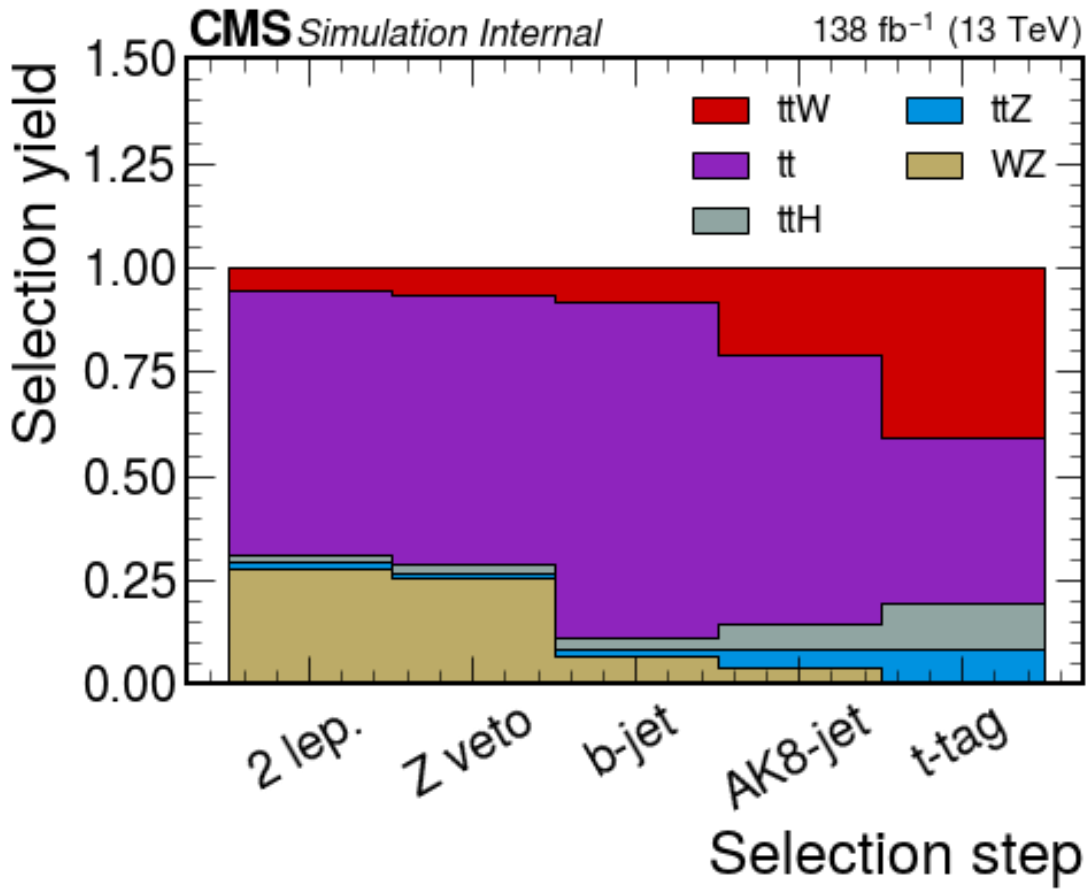




ttZ
tt̄
WZ
DYJets
ZZ
other: ttW, ttH, ttγ

BACKGROUND PREDICTION $t\bar{t}Z \rightarrow 3l$ & $t\bar{t}W \rightarrow 2l$





ttW ttH WZ tWZ

tt ttZ other: ttW, ttH, ttγ, tt, DYJets, ZZ

UNCERTAINTIES

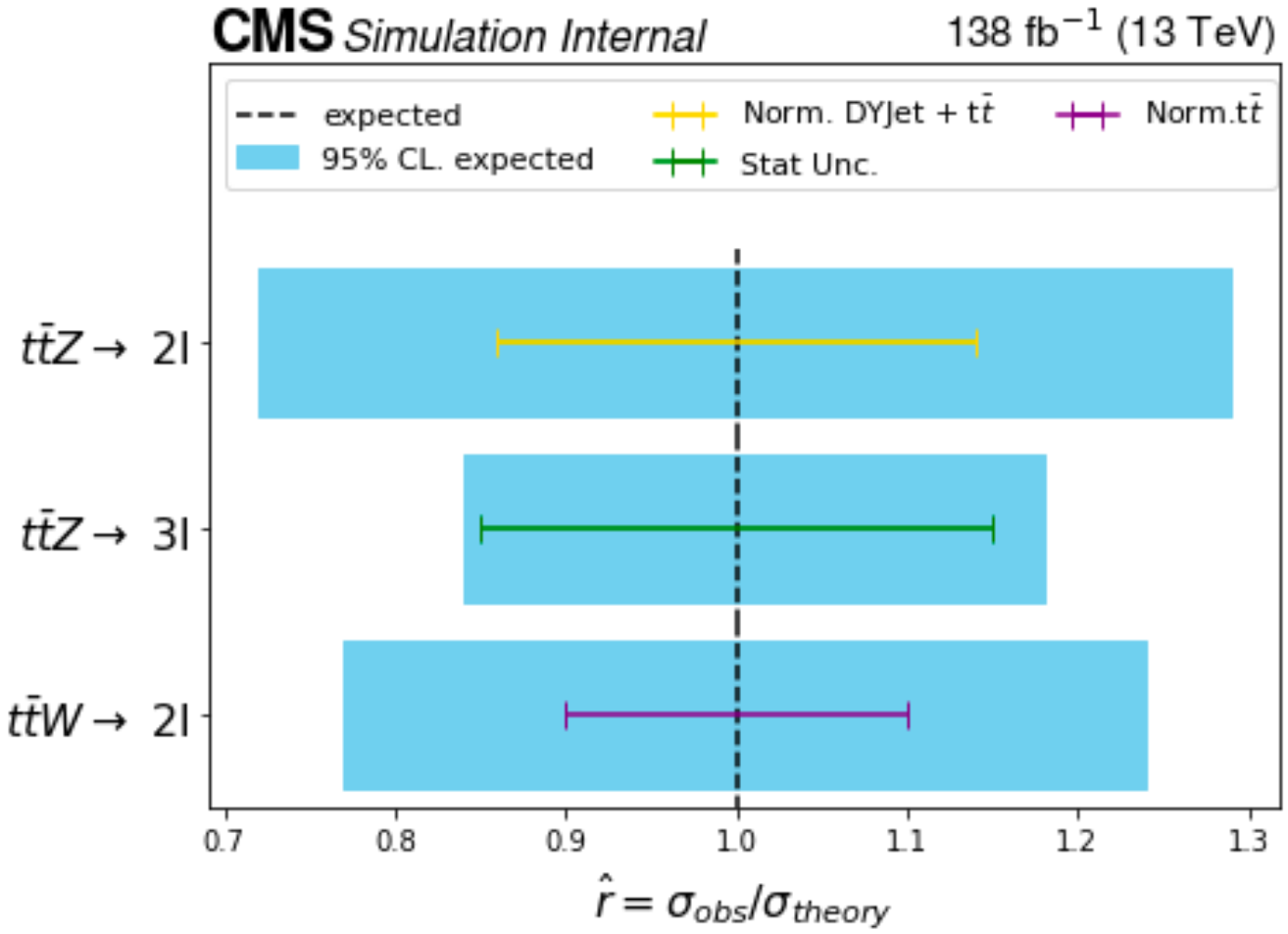
MC Statistics

Theoretical:

- μ_R, μ_F
- ISR, FSR

Normalisation BG:

- $DYJets$: extra QCD radiation
- $t\bar{t}$: non-prompt , badly modelled p_T



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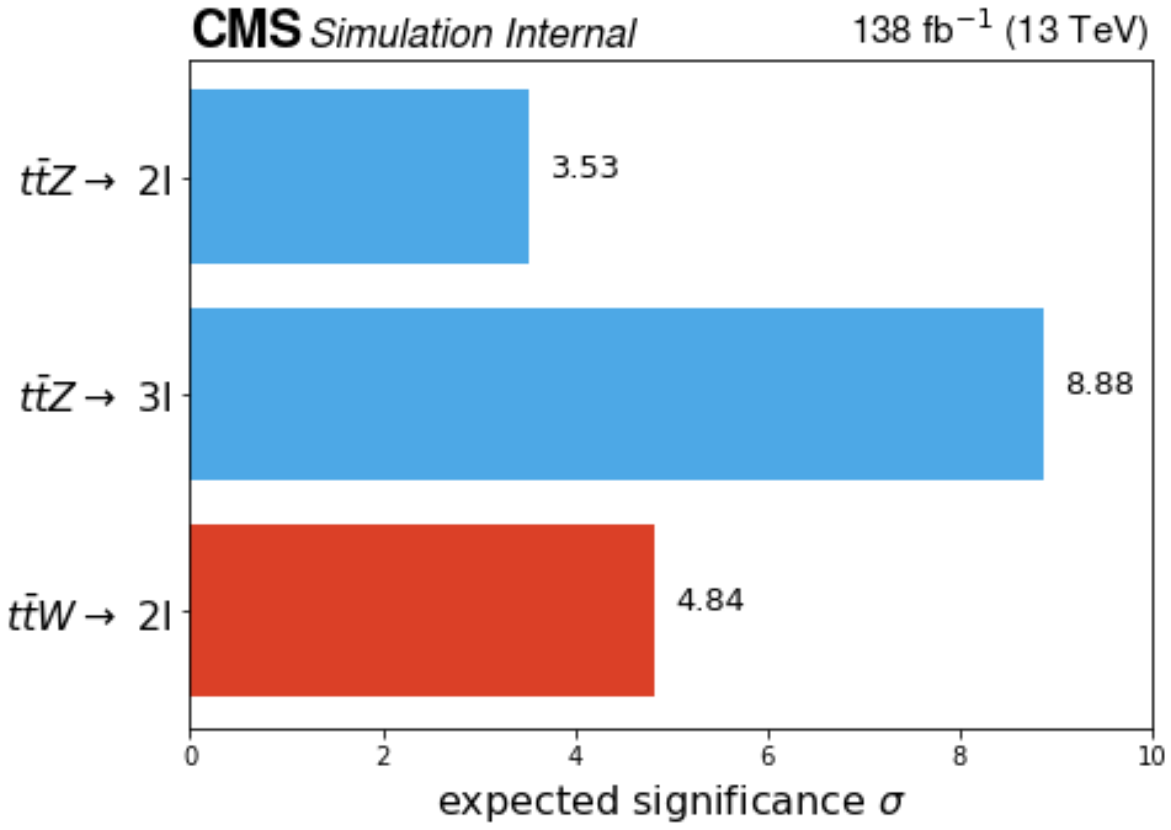
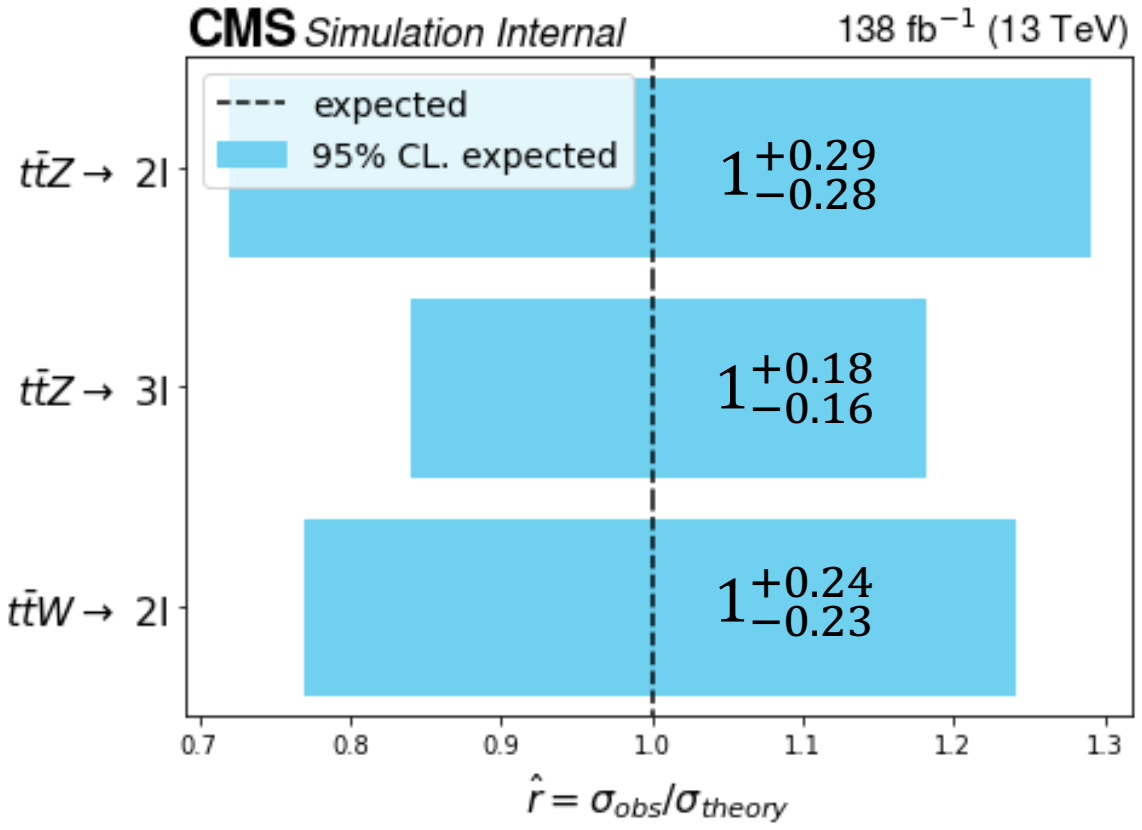
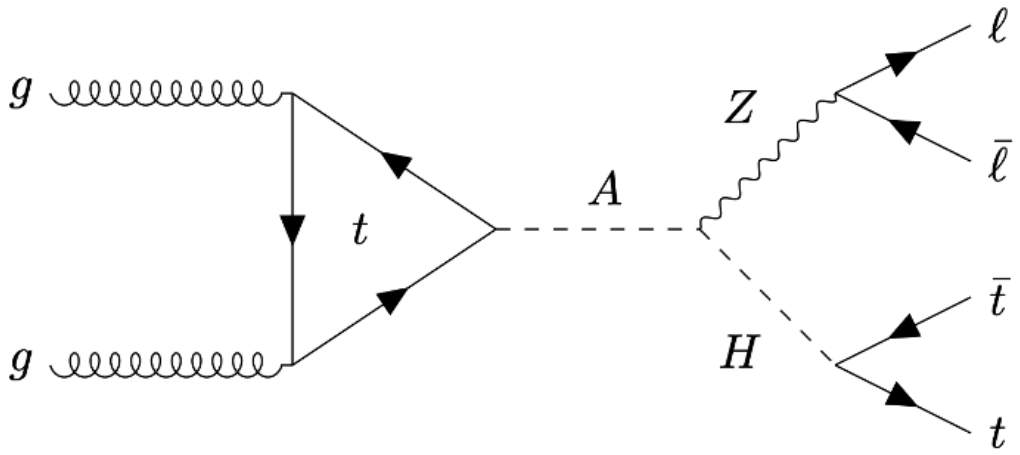
SIGNIFICANCE AND SIGNAL STRENGTH UNCERTAINTY

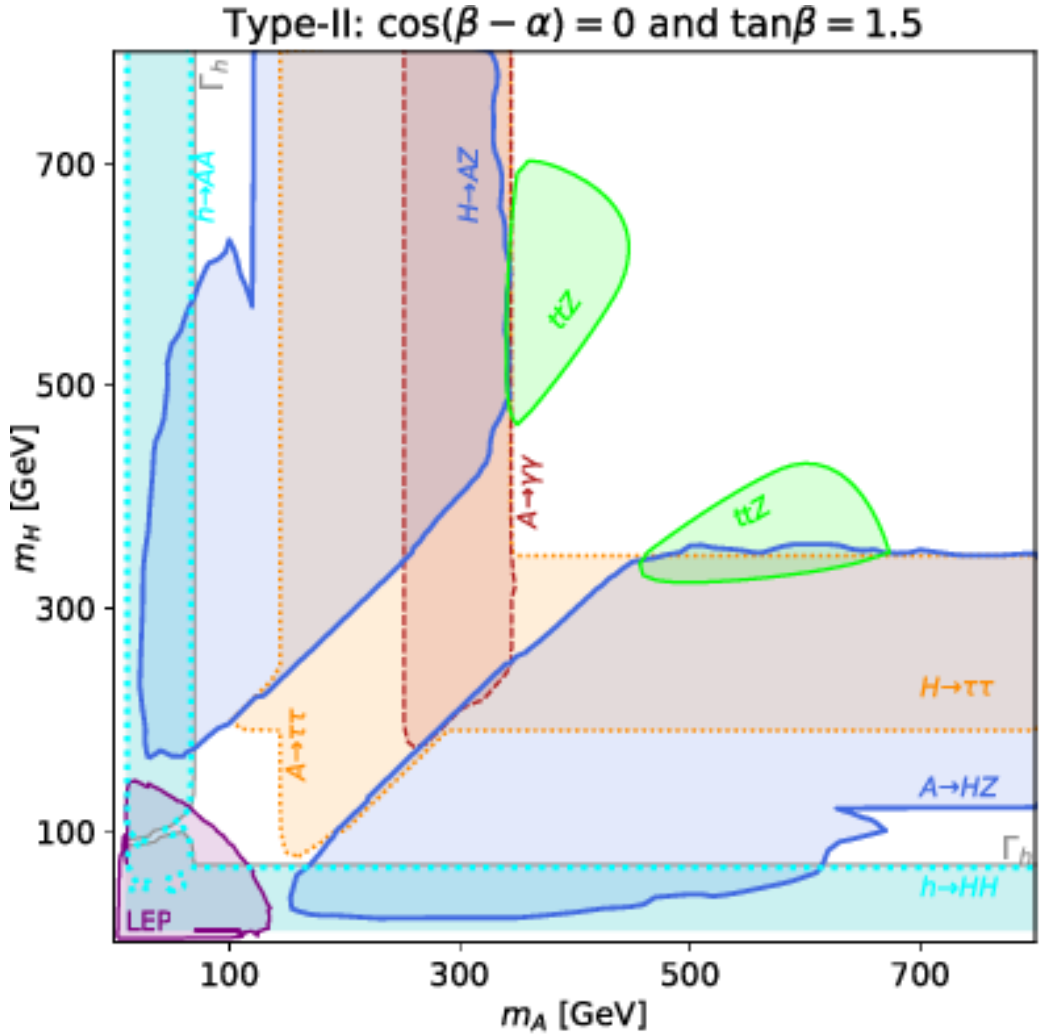




2HDM

- 2 doublets → 5 bosons
- $H,\ h,\ H^{\pm},\ A$
- $m_A,\ m_H,\ m_{H^{\pm}},\ tan\beta,\ \alpha$





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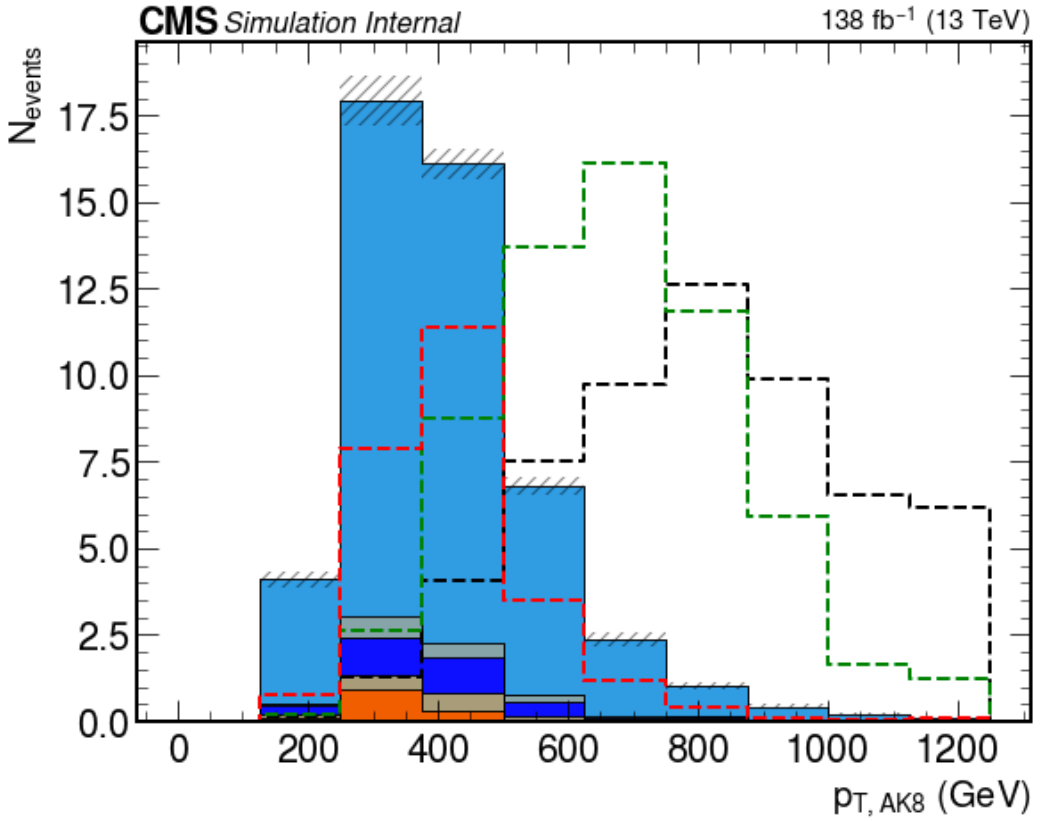
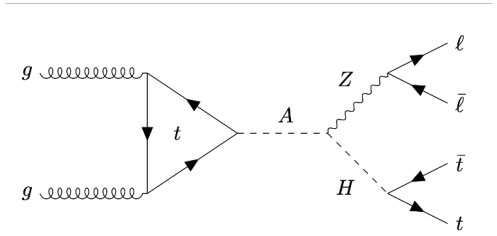
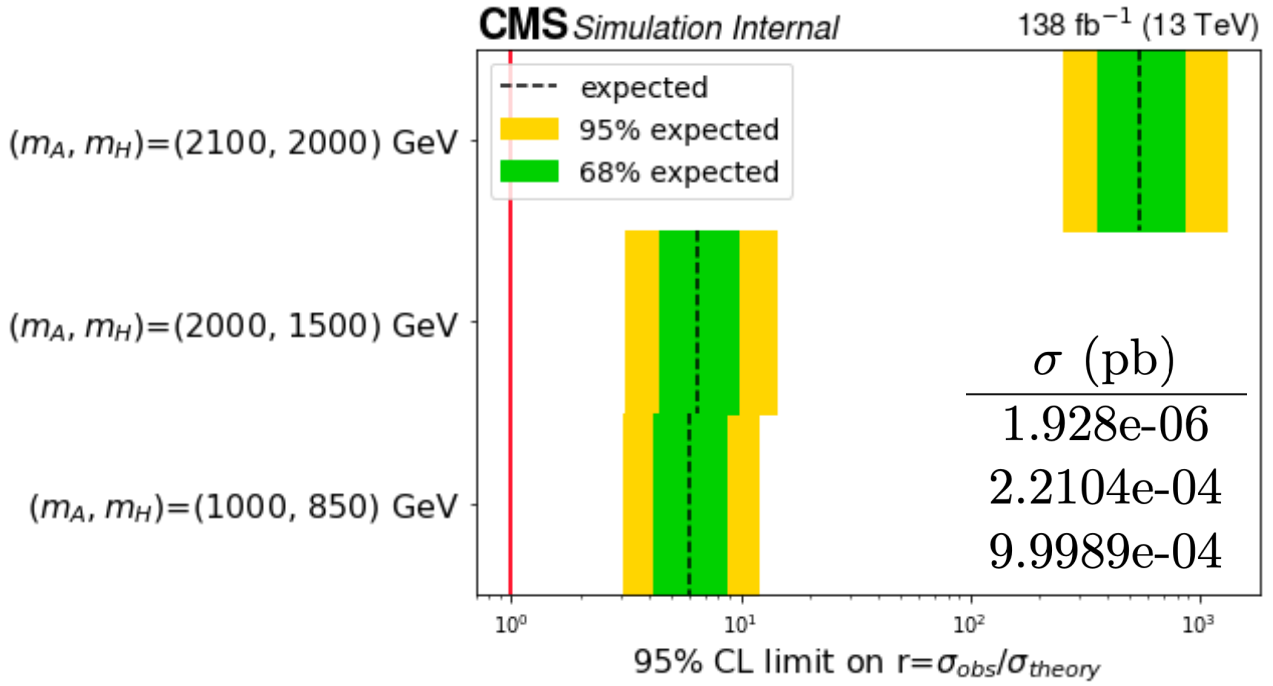
ASYMPTOTIC LIMIT







σ=100fb, (m_A, m_H)=(2100, 2000) GeV

σ=100fb, (m_A, m_H)=(2000, 1500) GeV

σ=100fb, (m_A, m_H)=(1000, 850) GeV

$t\bar{t}Z$ $t\bar{t}H$ tWZ WZ

other: $t\bar{t}W$, $t\bar{t}H$, $t\bar{t}\gamma$, $t\bar{t}$, DYJets, ZZ

CONCLUSIONS

Summary	What's next?
• Boosted $t\bar{t}Z$ and $t\bar{t}W$ measurements • $t\bar{t}Z \rightarrow 2l,\ t\bar{t}Z \rightarrow 3l,\ t\bar{t}W \rightarrow 2l$ • Investigated properties AK8-jets • Evaluated BG • Nuisance Parameter Impact • Expected significance and signal strength uncertainty • Sensitivity to 2HDM physics	• Further optimizing selection criteria • Understanding p_T discrepancy between gen-level t and reco-level AK8-jet • Refine BG estimation → CR • managing uncertainties • Compare to collision data • Increase sensitivity to 2HDM

FACULTEIT WETENSCHAPPEN

The End

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Academic Year: 2023-2024

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BACKUP

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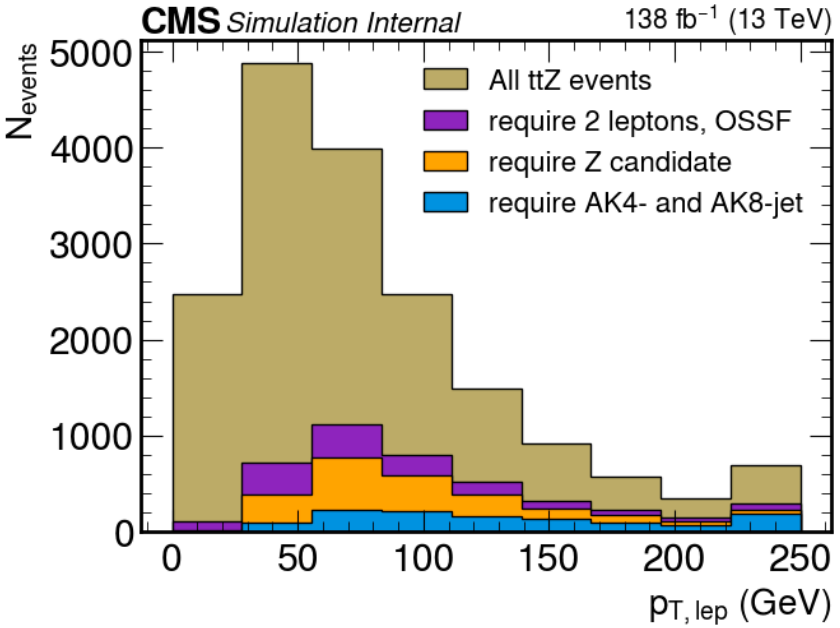
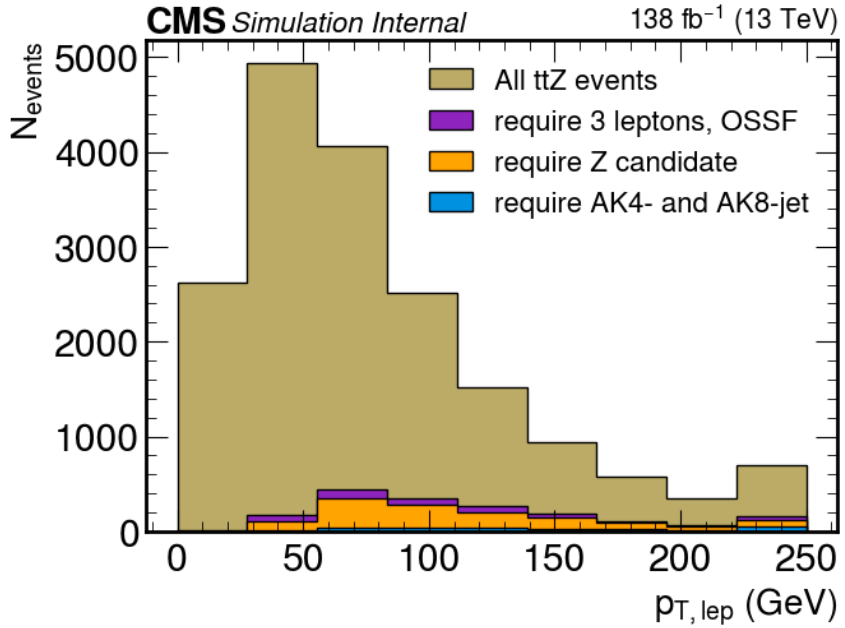
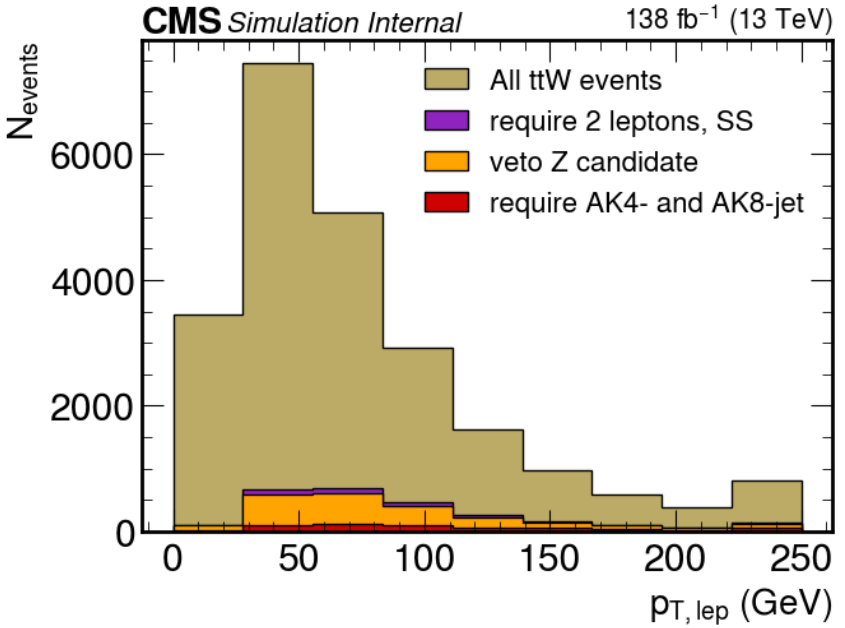
SIGNAL YIELD FOR SUBSEQUENT EVENT SELECTION STEPS







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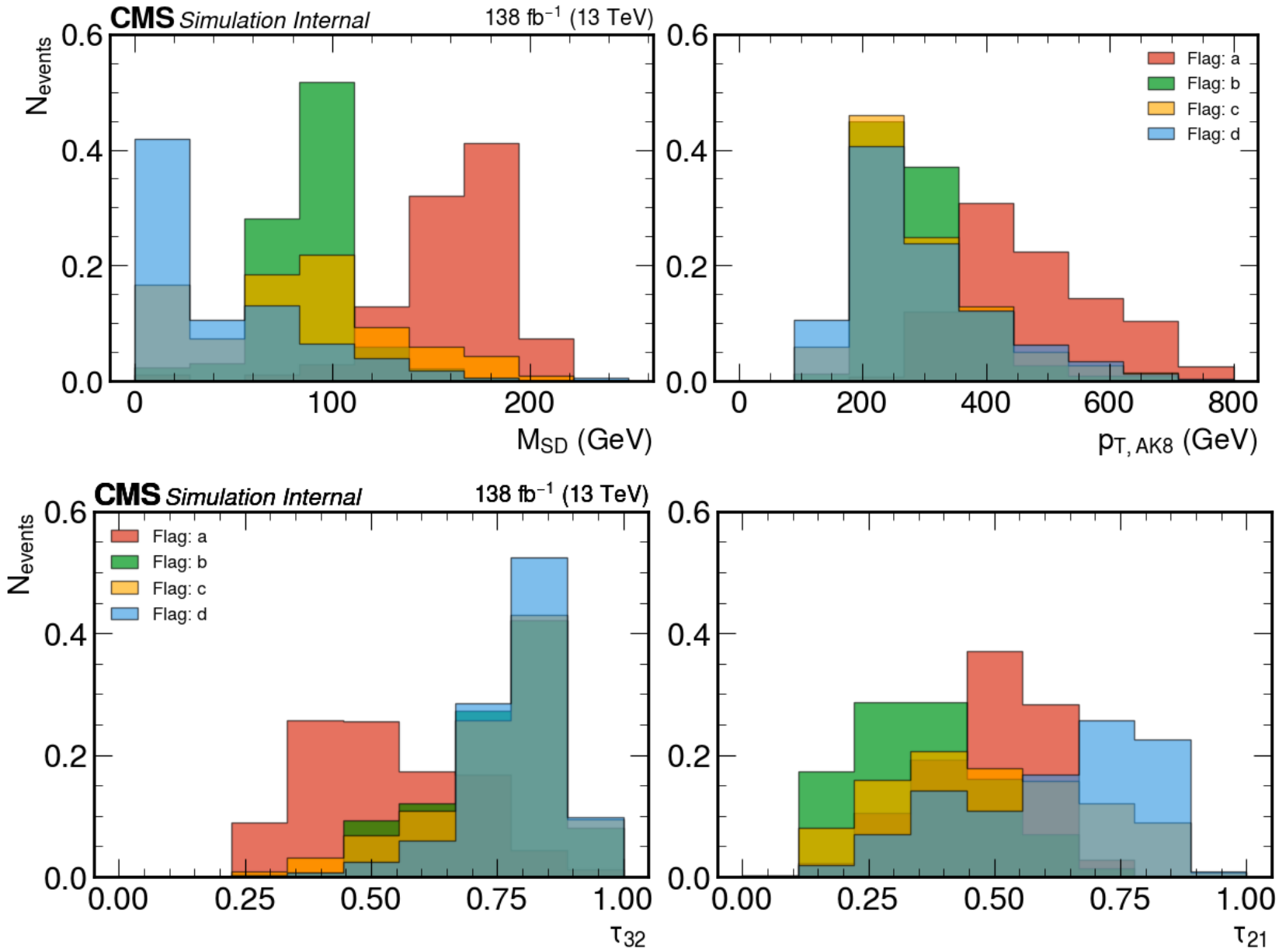
DISTRIBUTIONS FOR SEVERAL FLAGS



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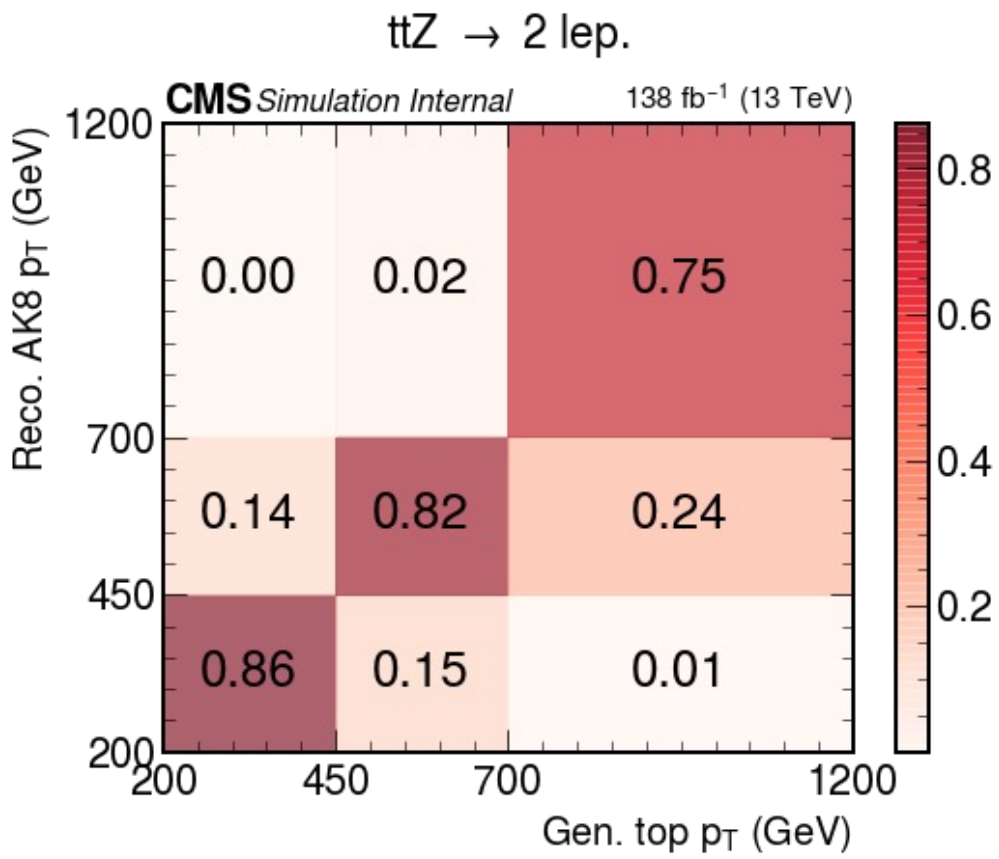
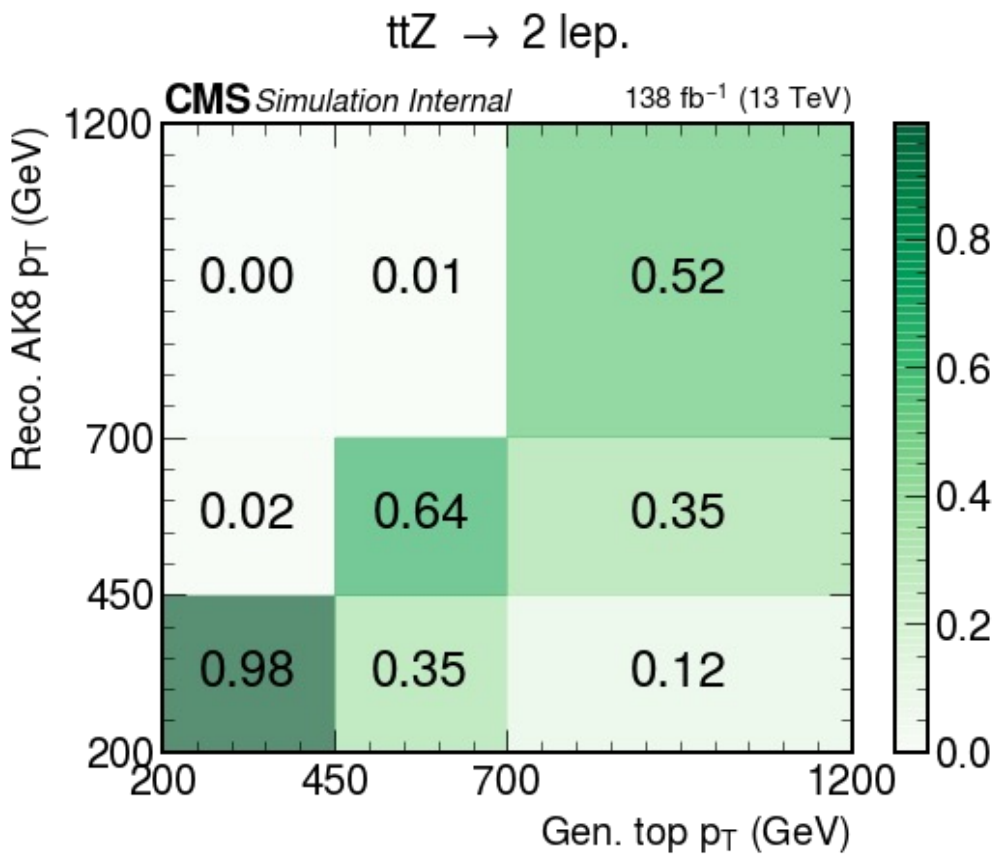
RESOLUTION MATRICES FOR DIFFERENT FLAGS





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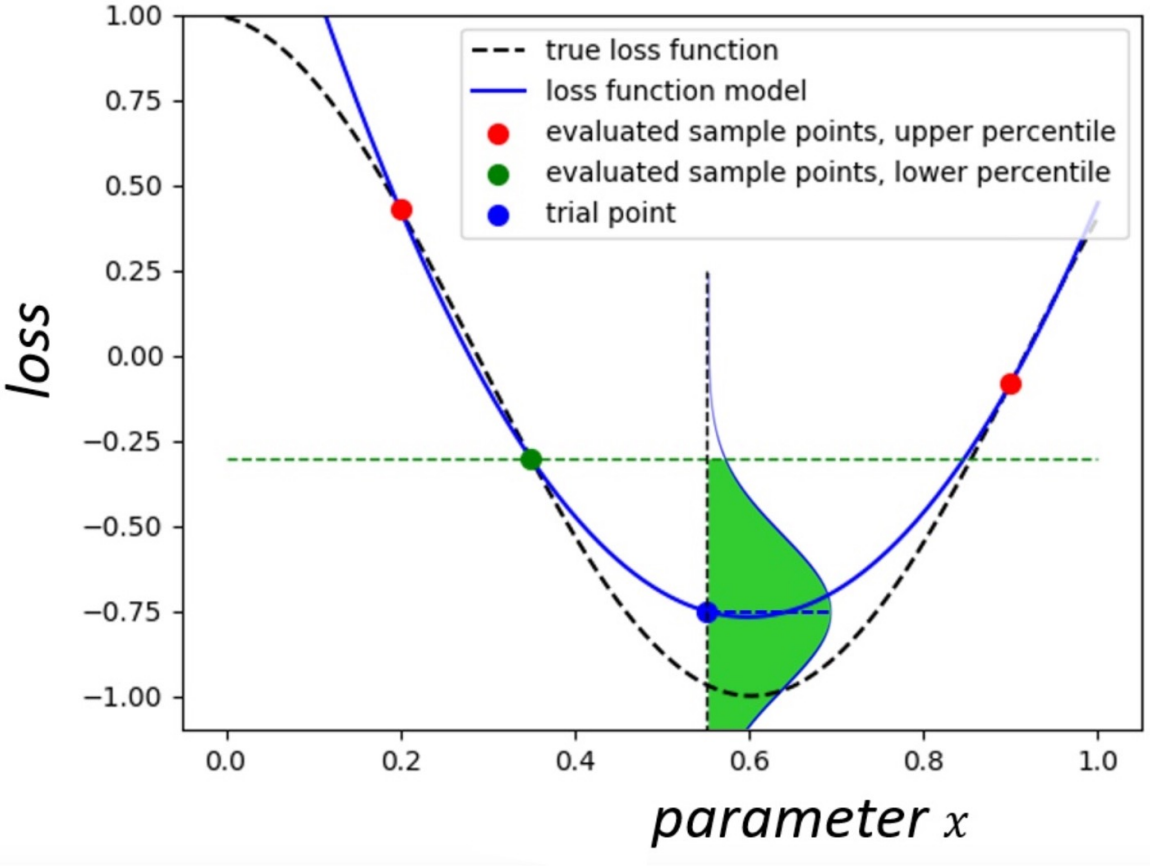
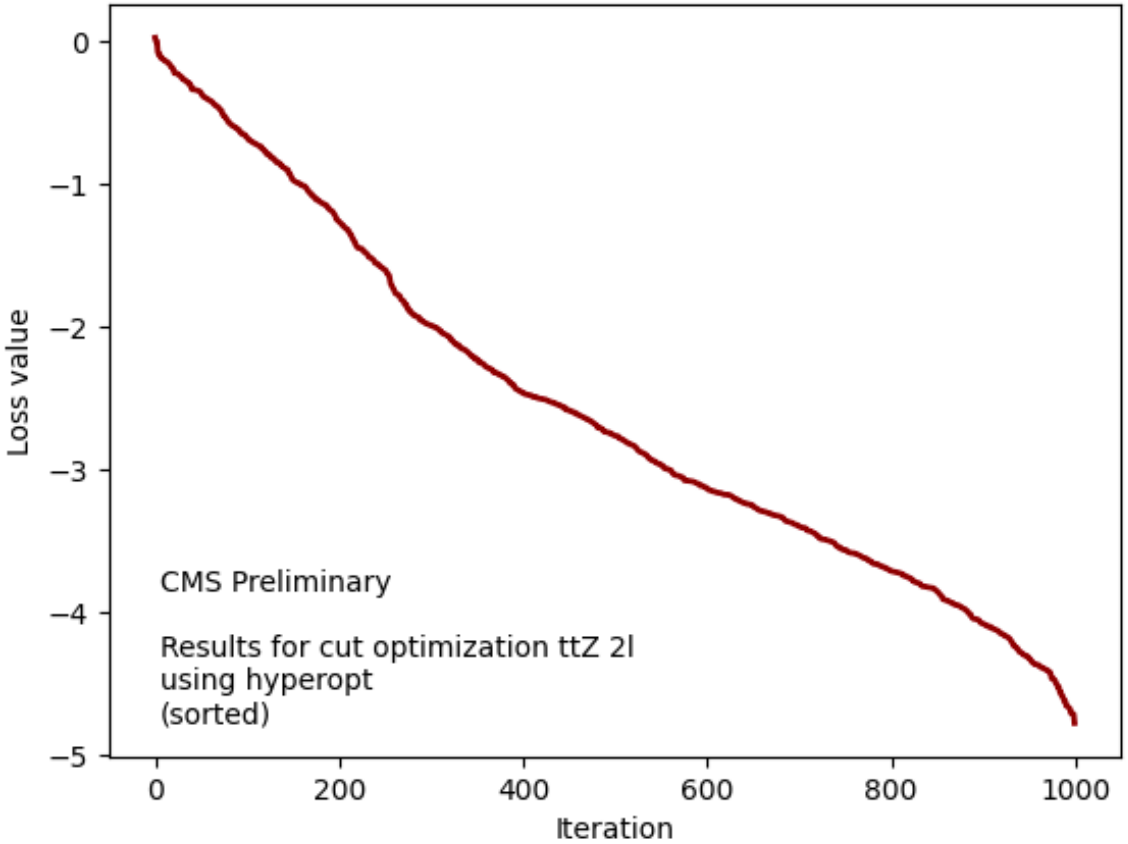
HYPEROPT





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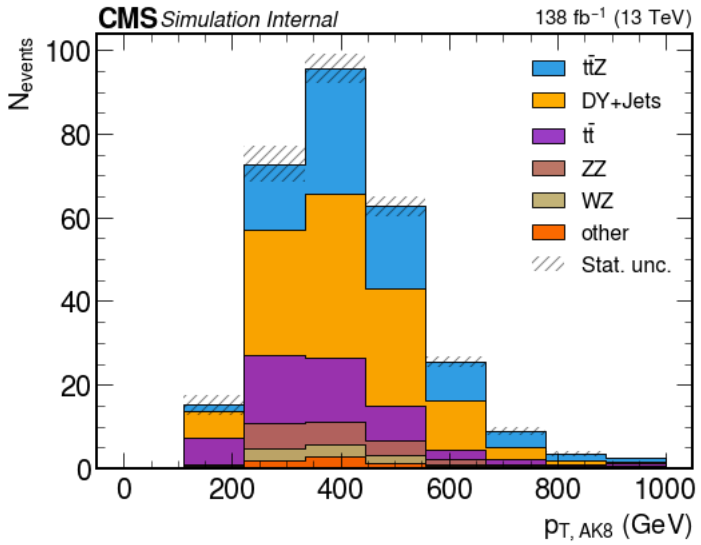
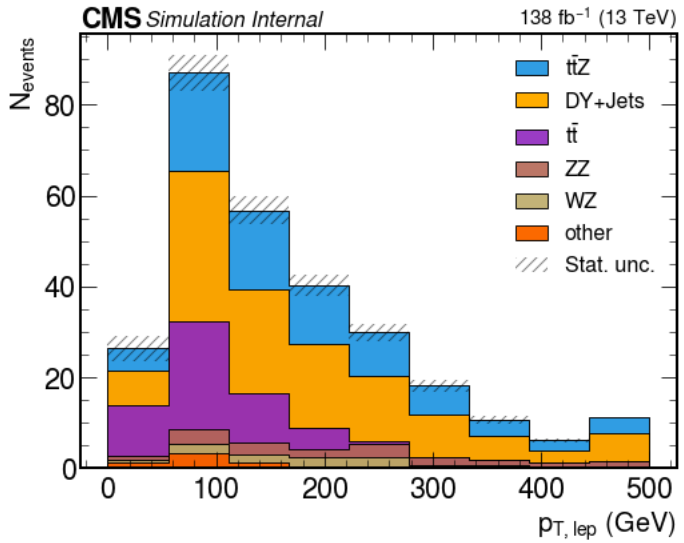
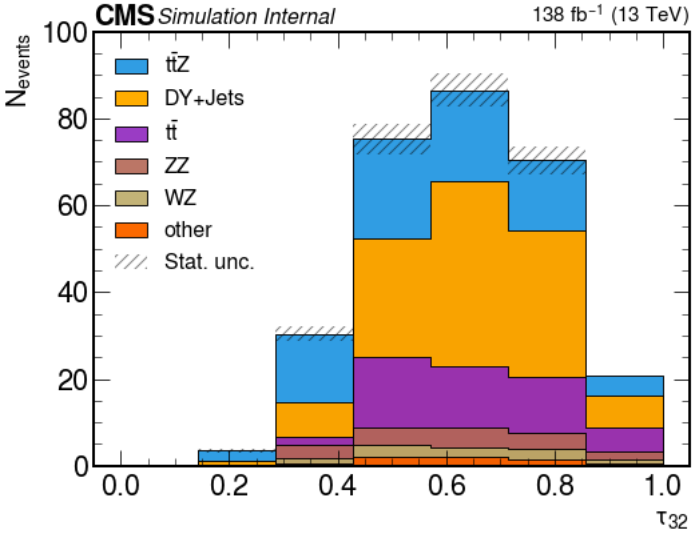
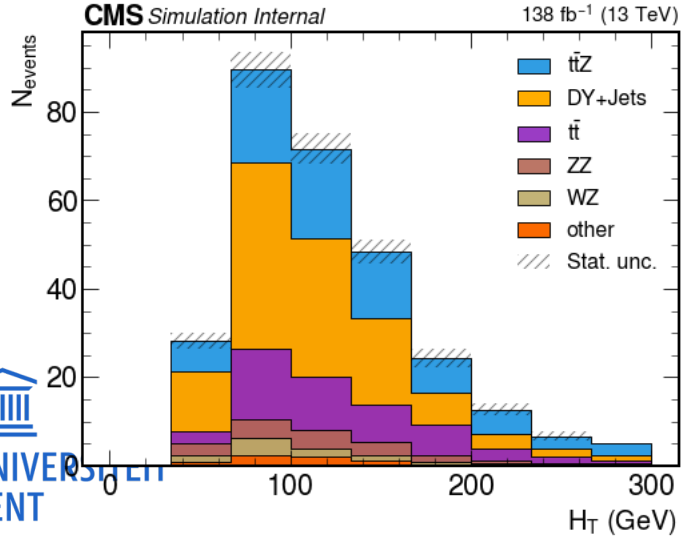
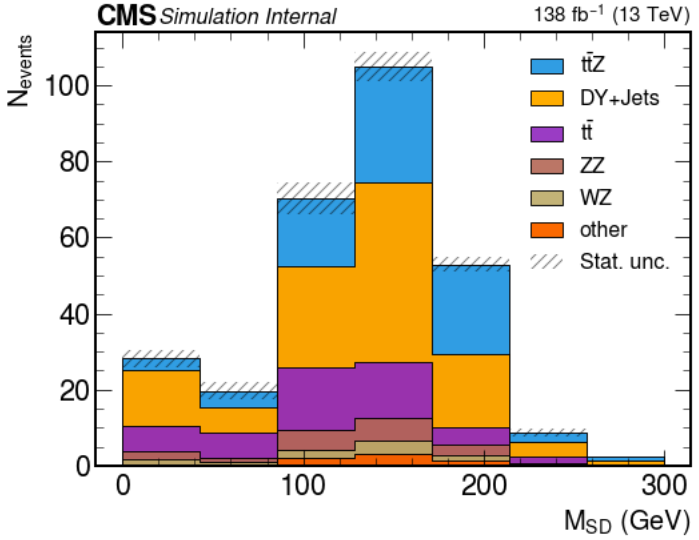
DISTRIBUTIONS FOR TTZ->2L











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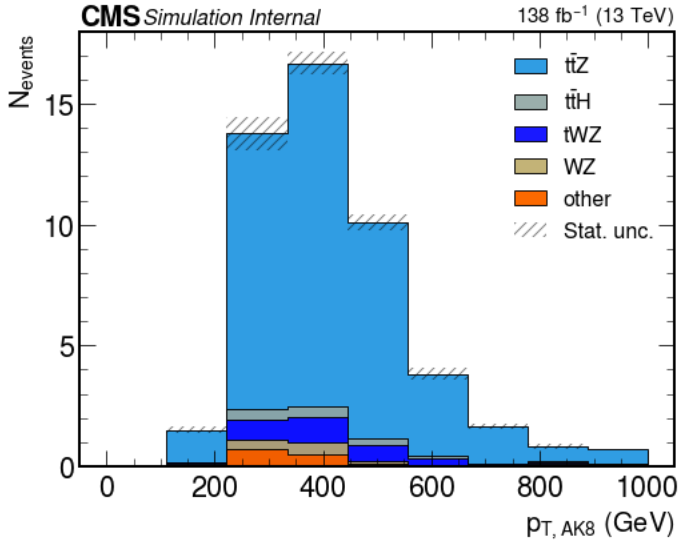
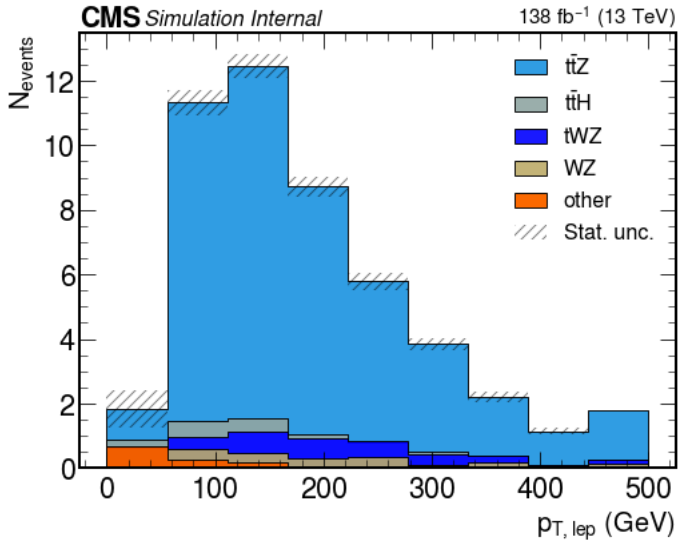
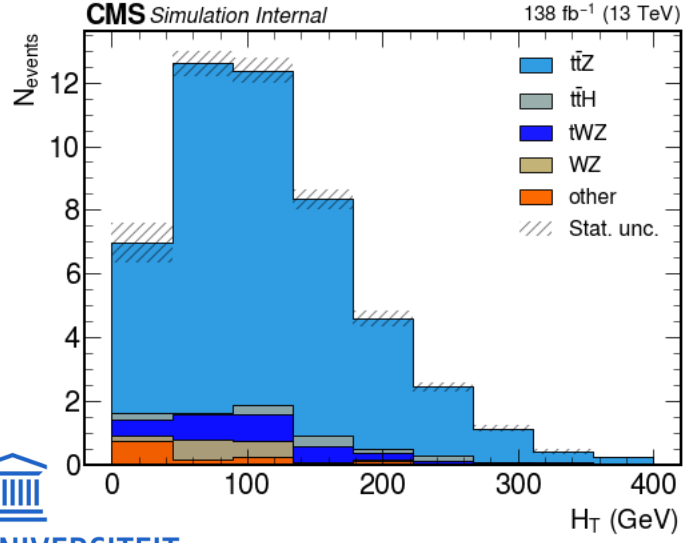
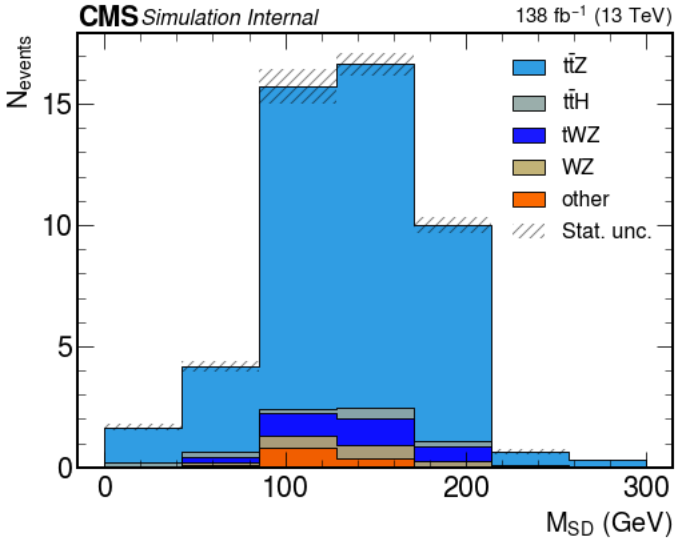
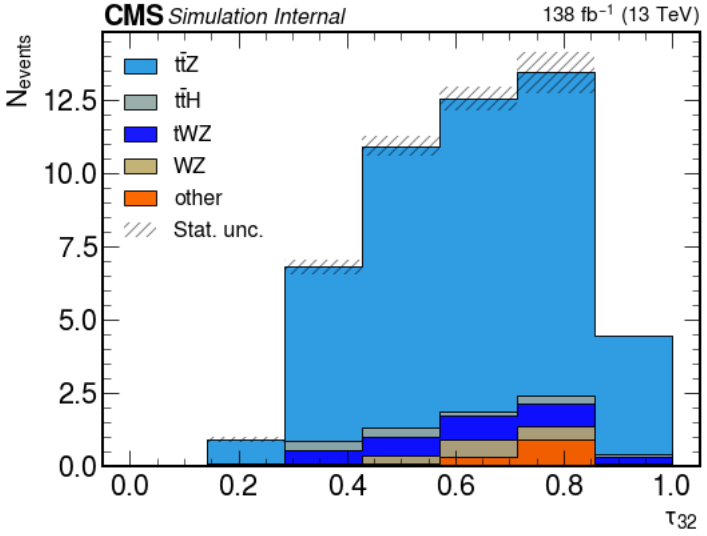
DISTRIBUTIONS FOR TTZ->3L











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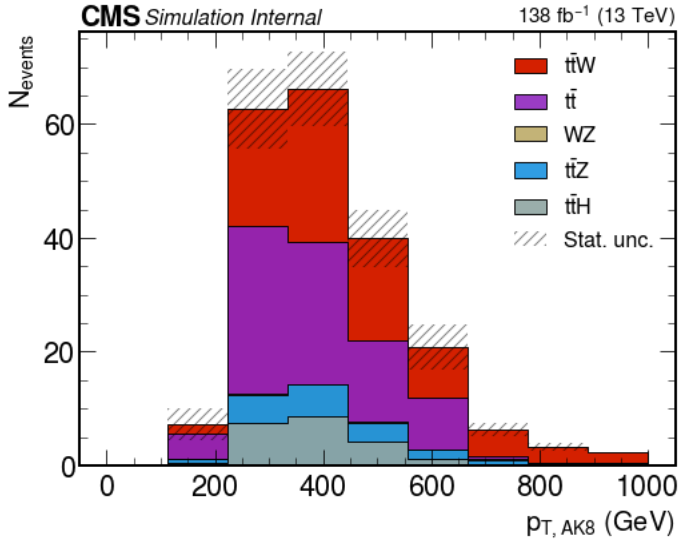

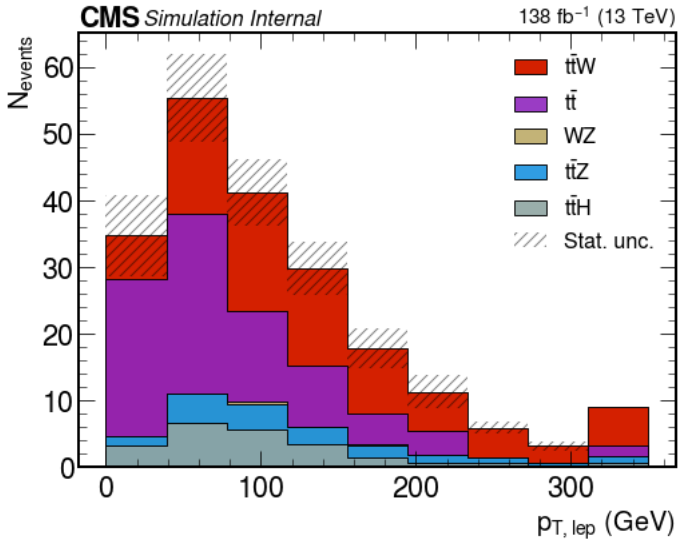

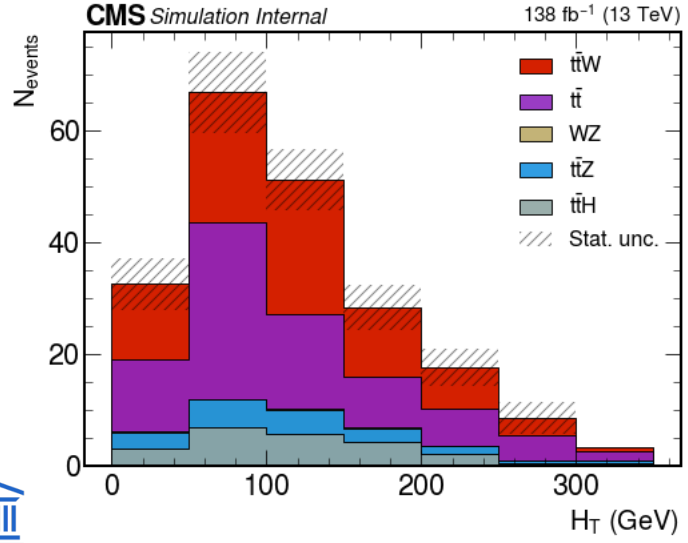

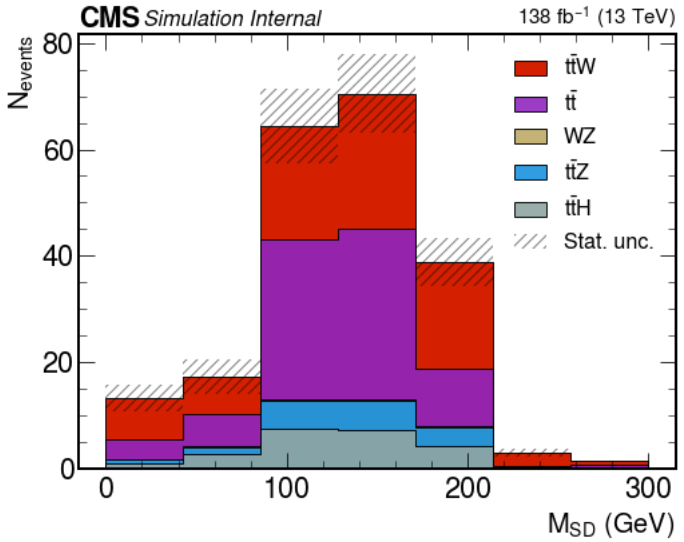

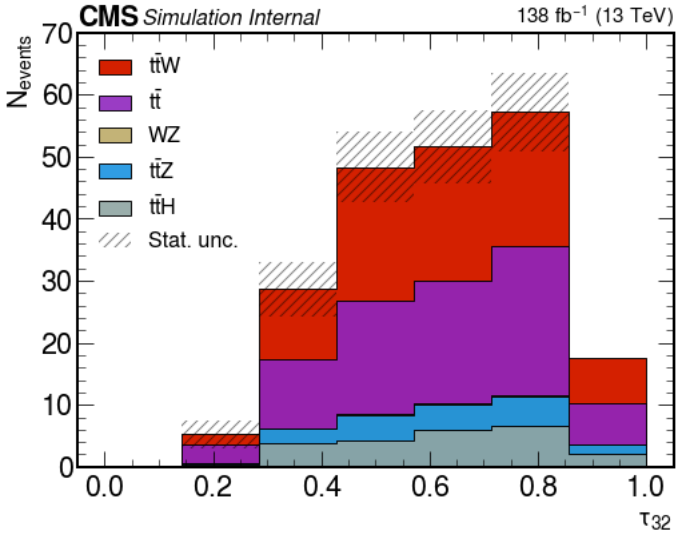

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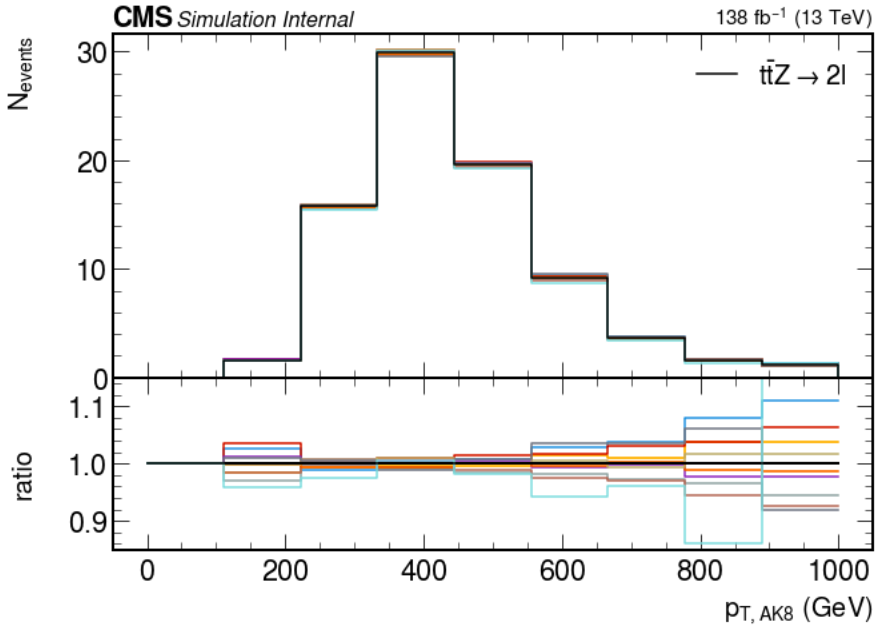
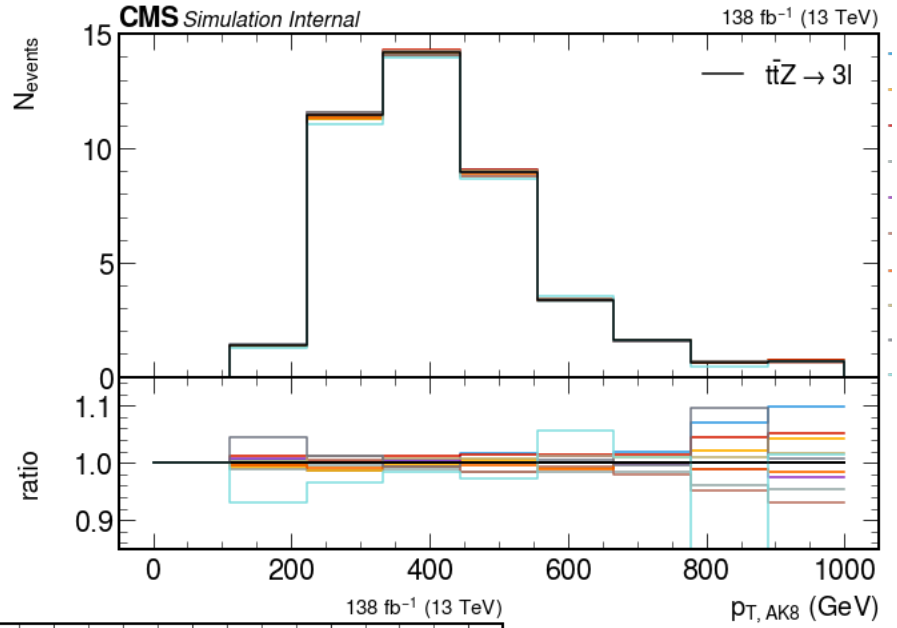
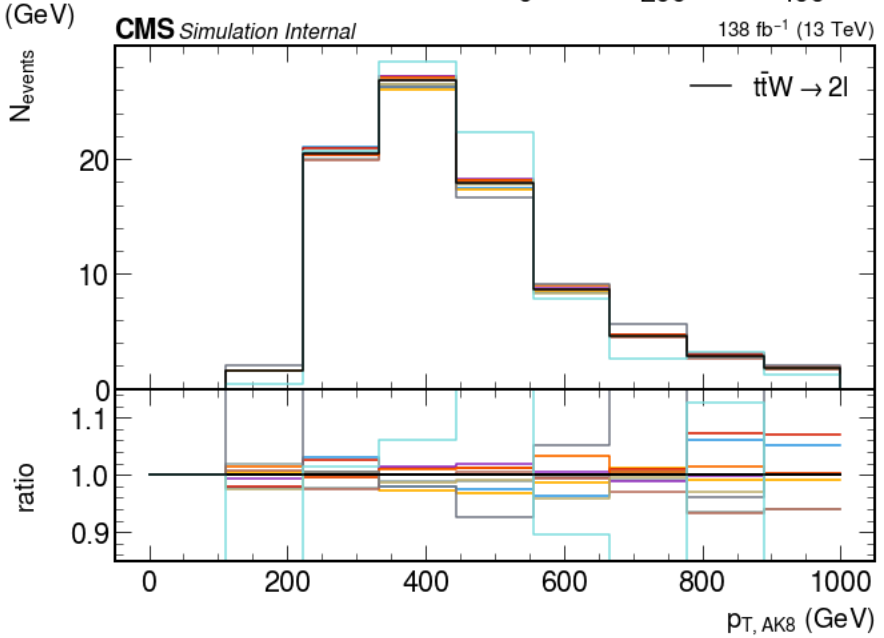
THEORETICAL UNCERTAINTIES







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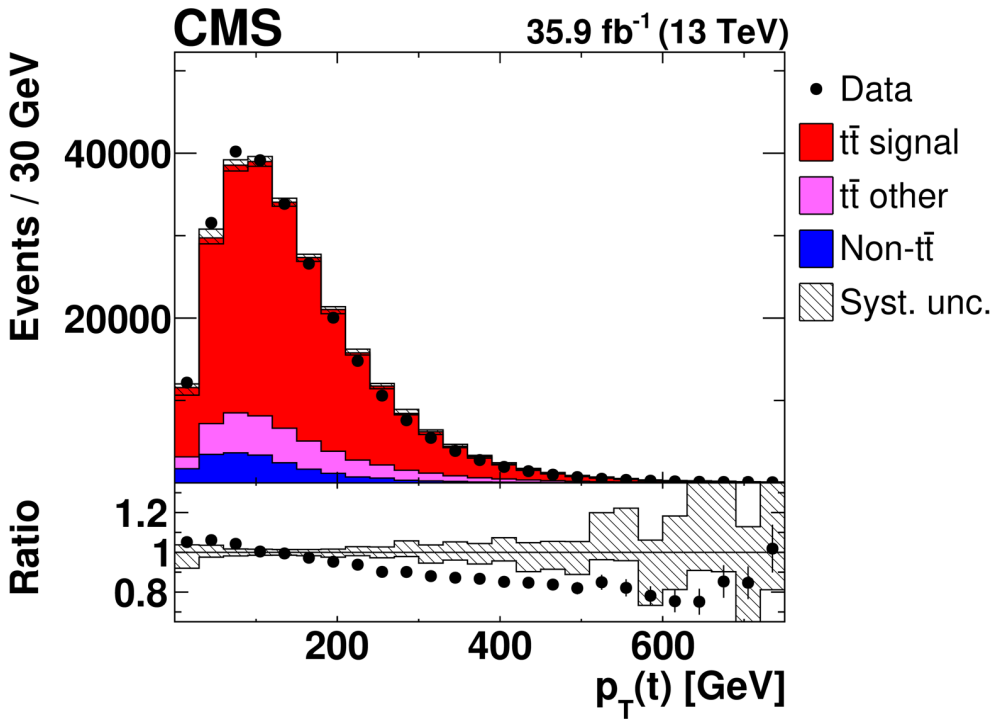
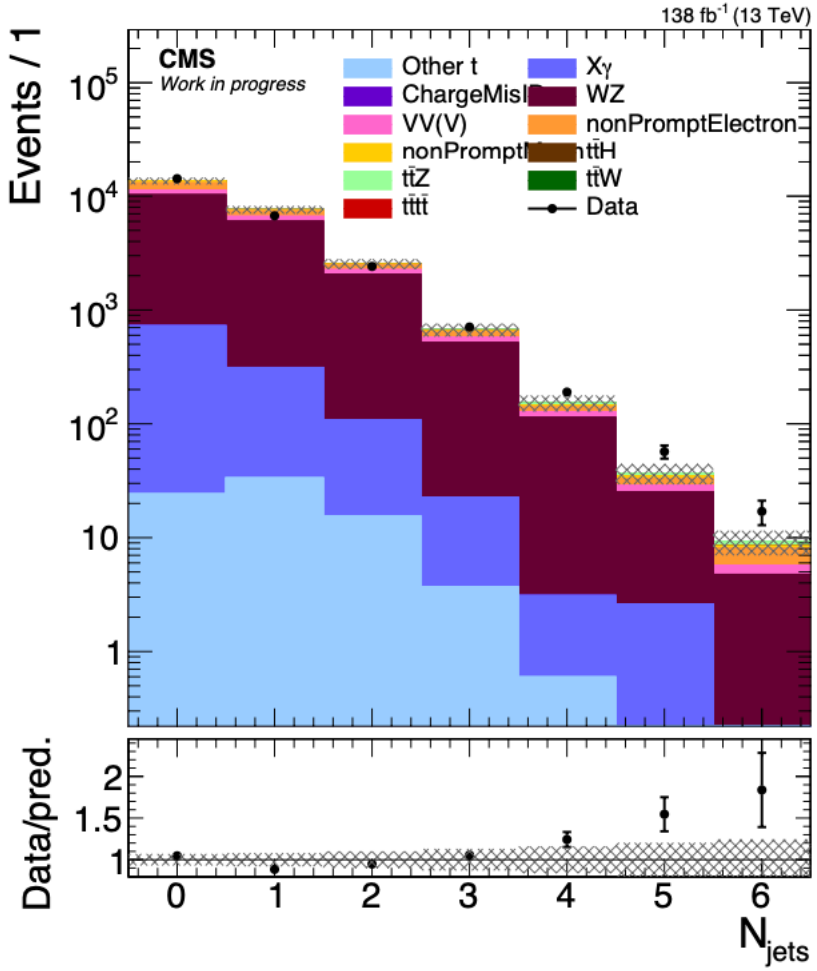
NORMALIZATION UNCERTAINTIES

Badly modelled p_T



Badly modelled extra QCD radiation



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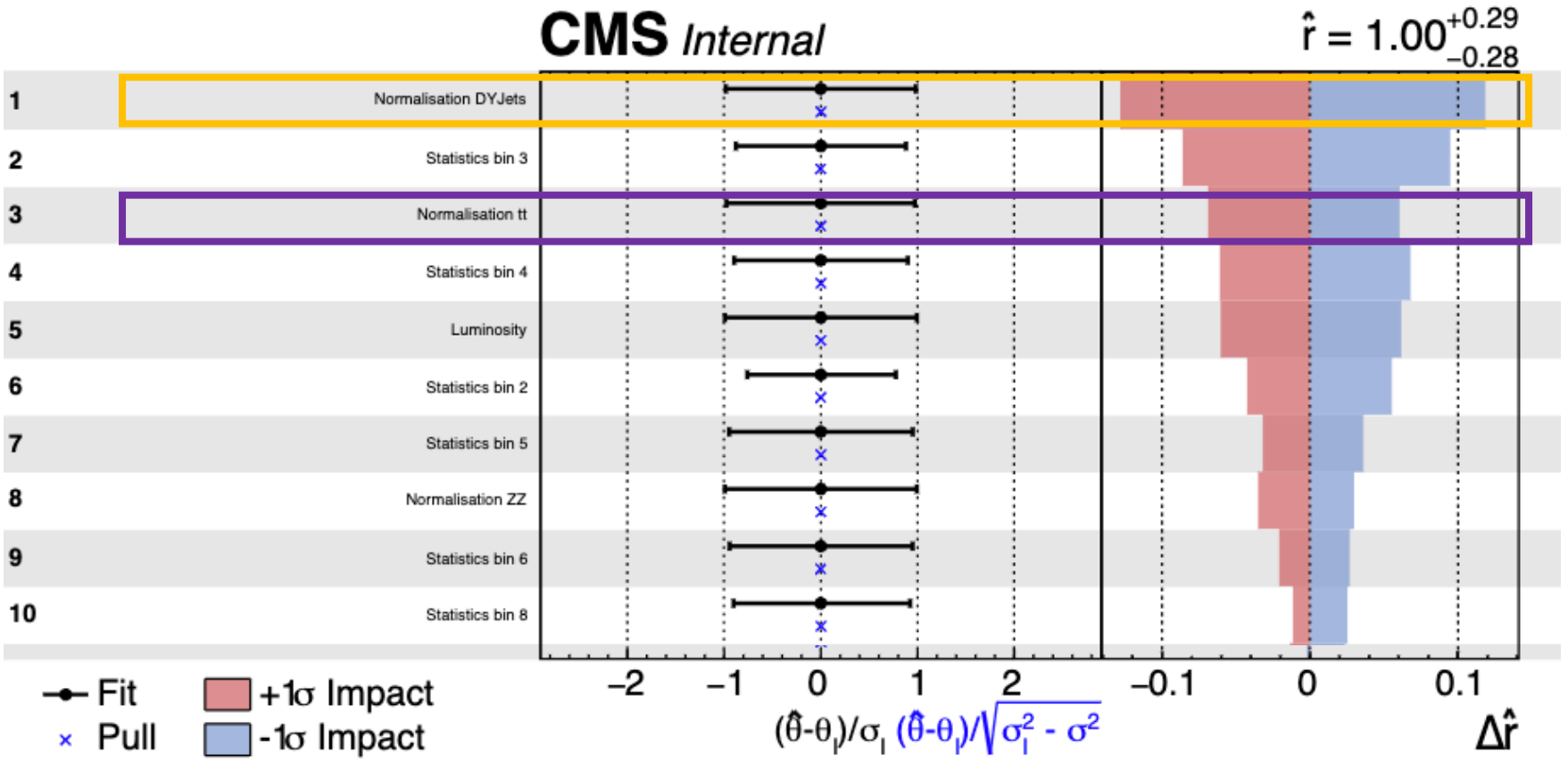
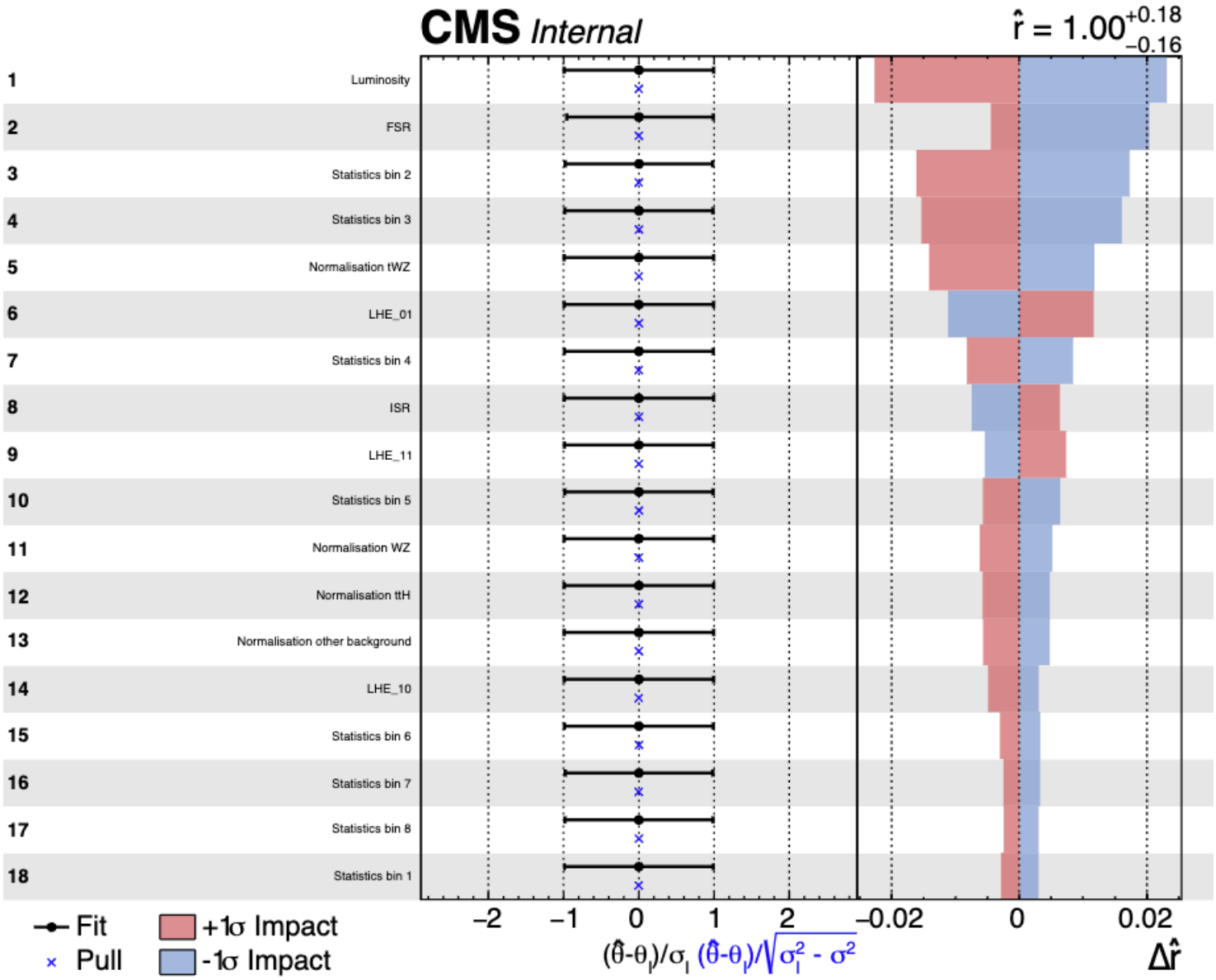
NUISANCE PARAMETER IMPACT: $t\bar{t}Z \rightarrow 2l$



Normalization uncertainties on $DYJets$

Normalization uncertainties on $t\bar{t}$

NUISANCE PARAMETER IMPACT TTZ->3L



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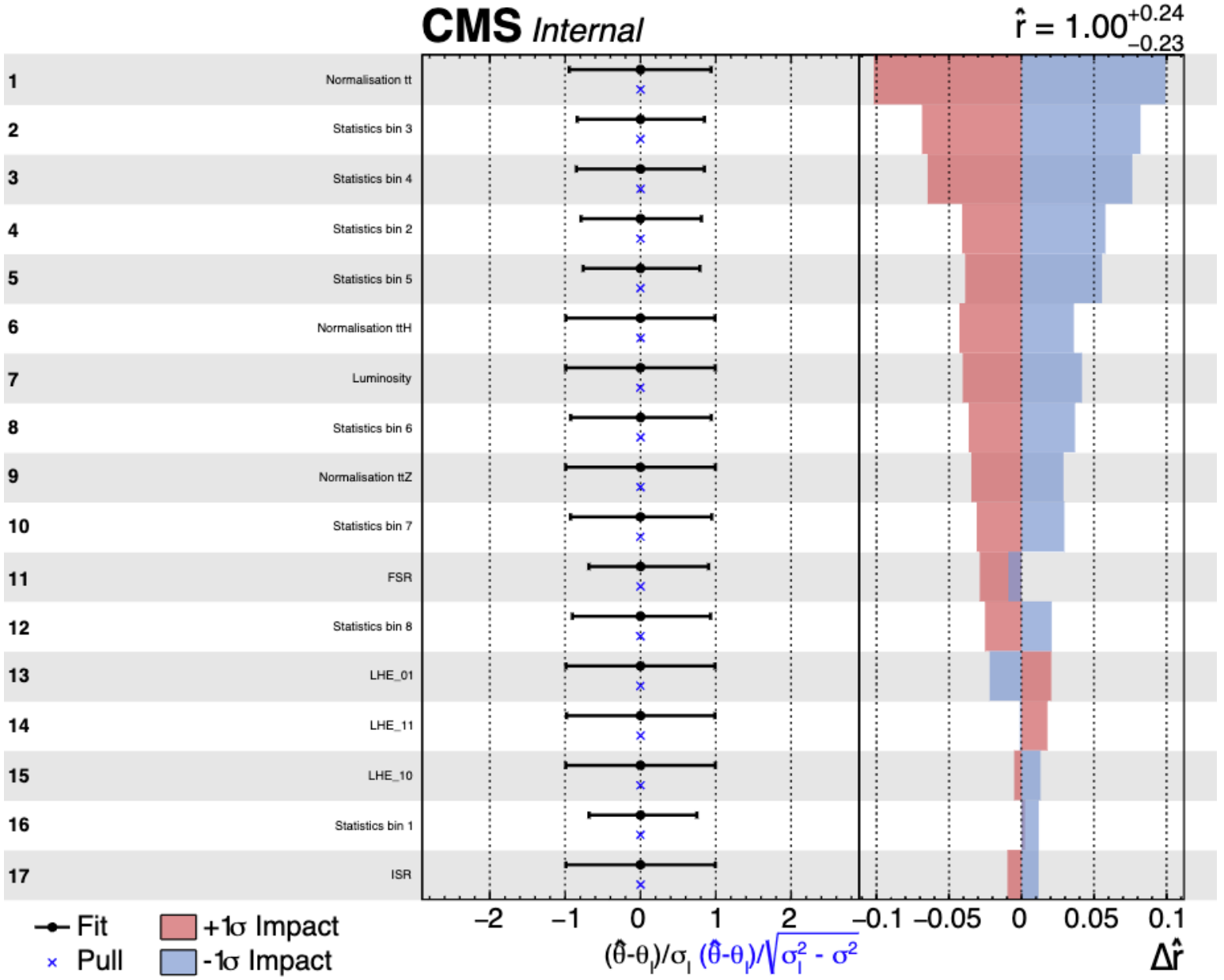

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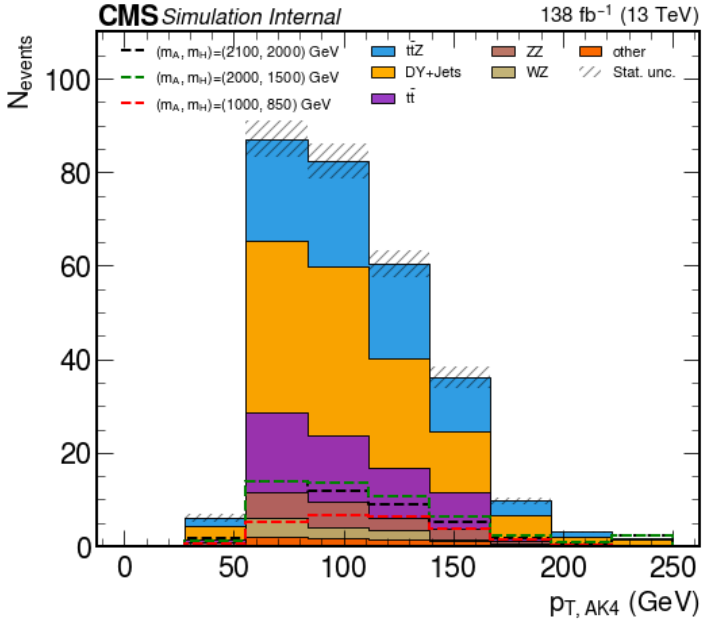
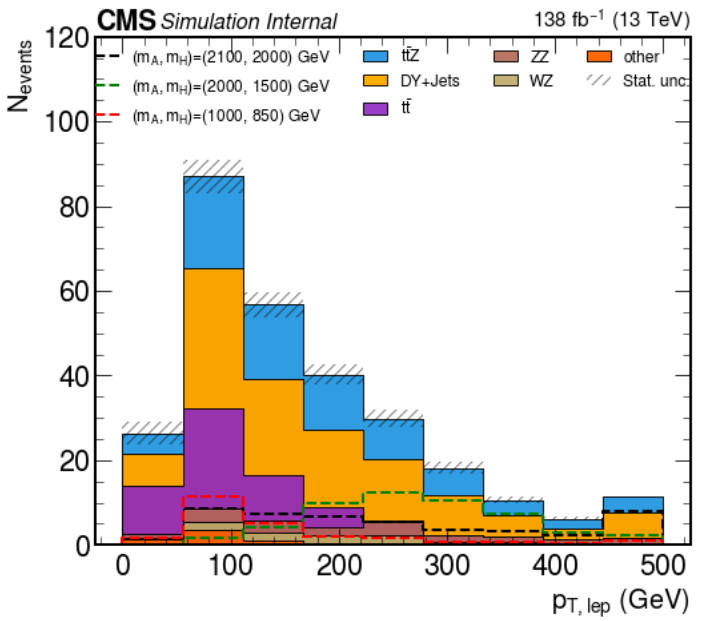
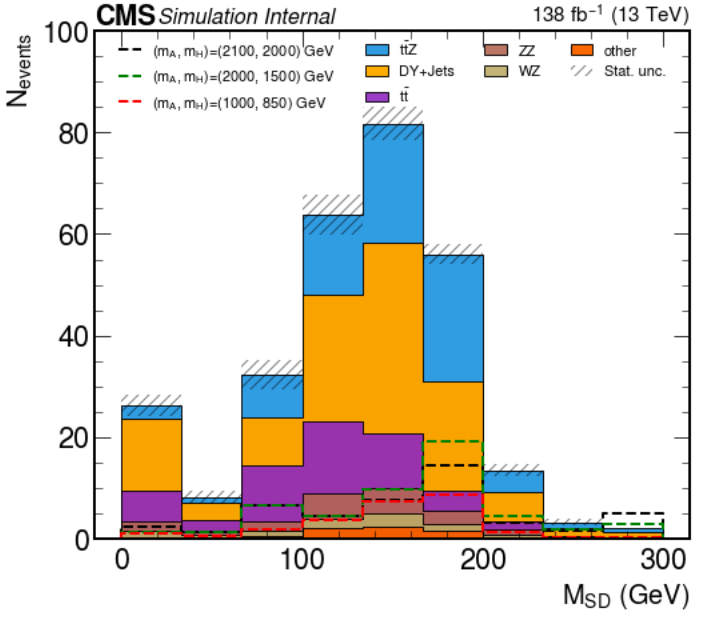
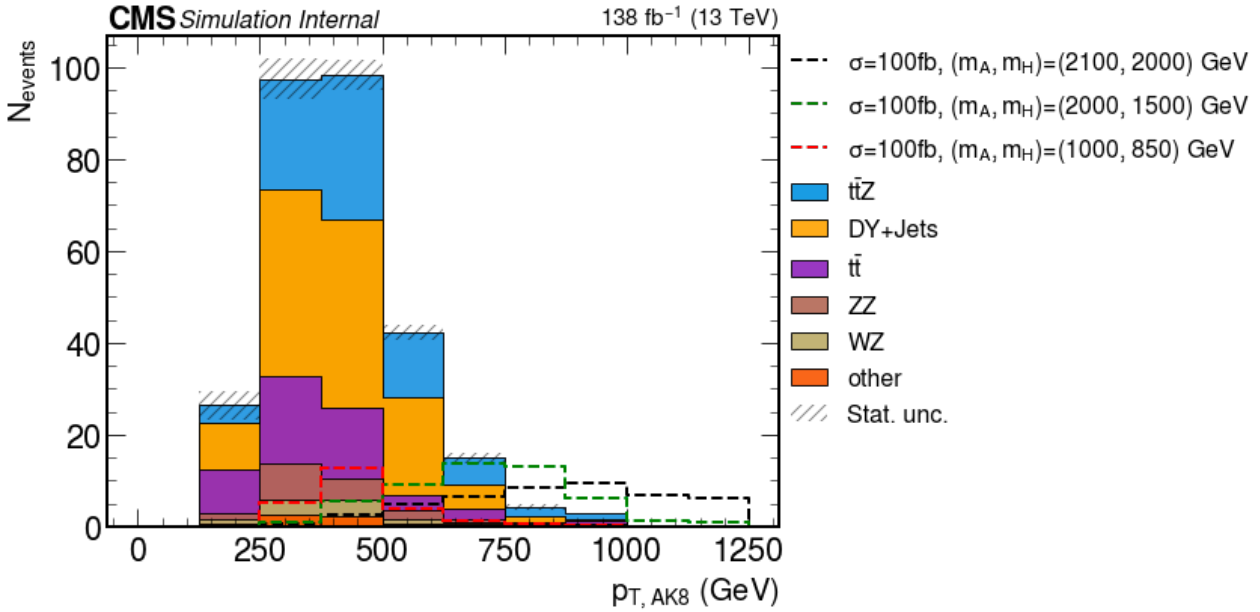
DISTRIBUTION 2HDM $t\bar{t}Z \rightarrow 2l$









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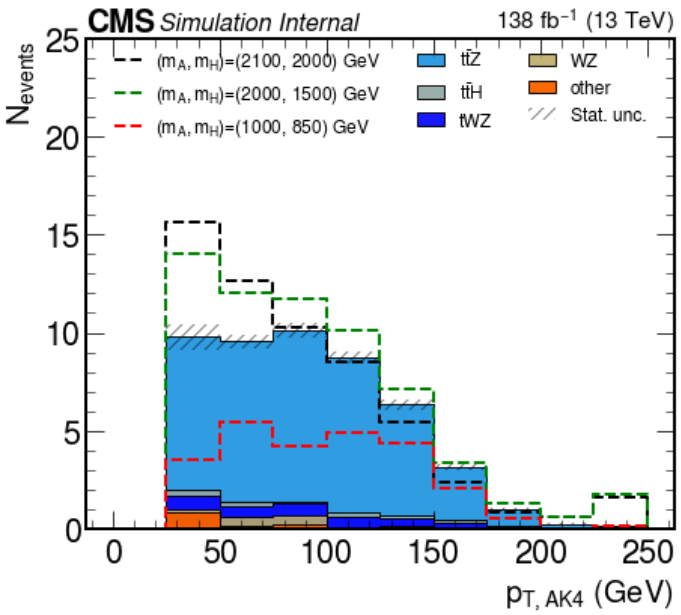
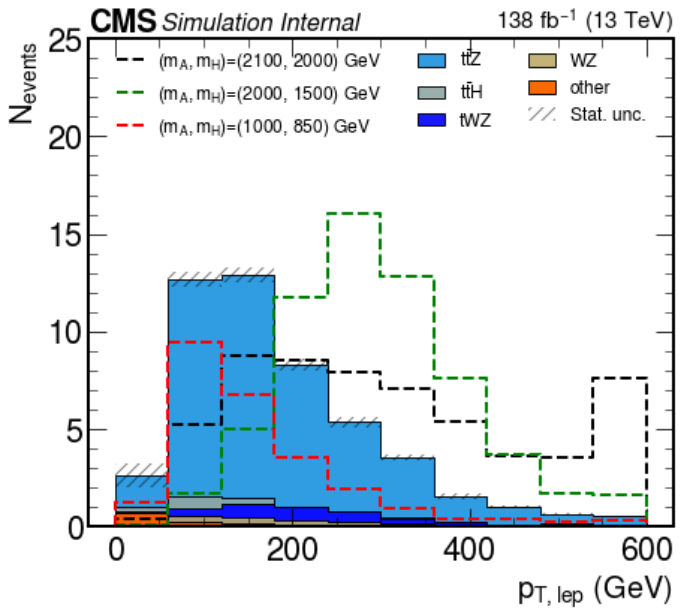
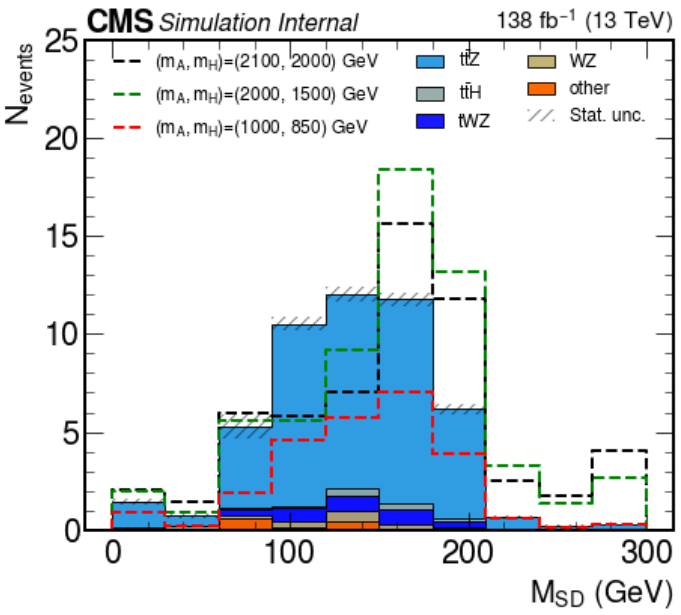
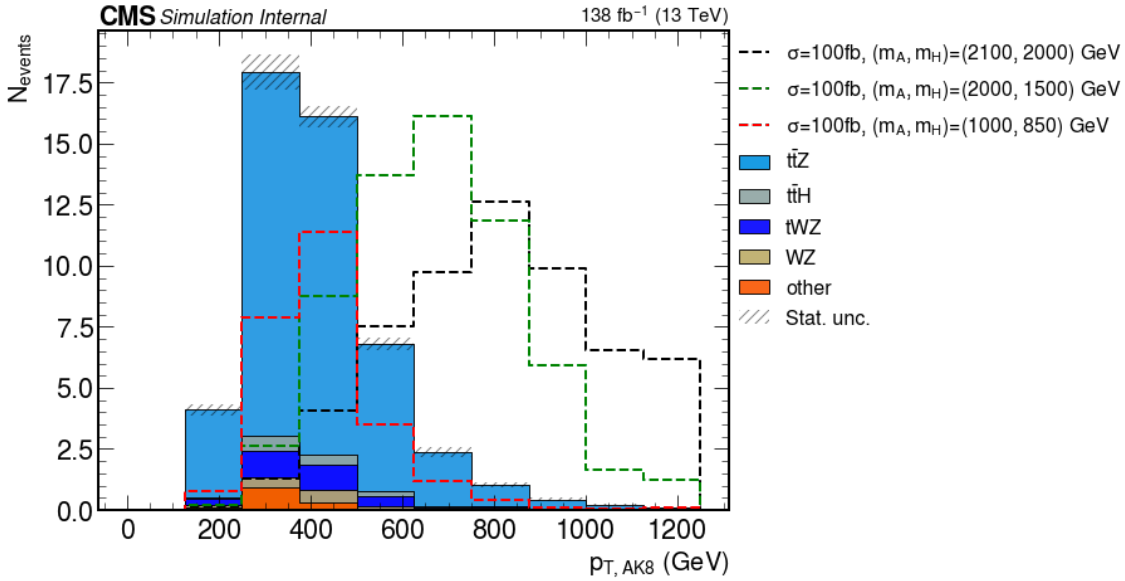
DISTRIBUTION 2HDM $t\bar{t}Z \rightarrow 3l$









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