Fixed ST corrections for ttbar backgrounds update

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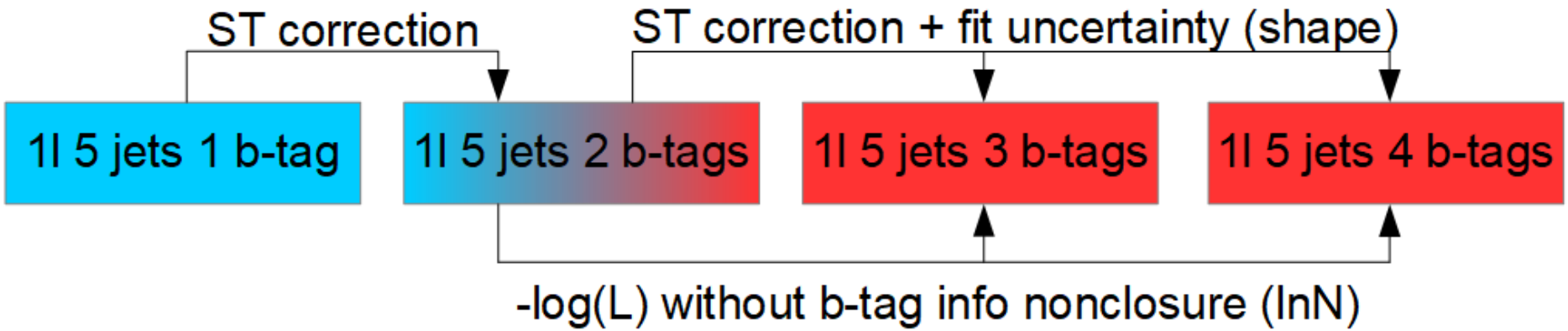
Changes since last update

- Region assignments (number of leptons, jets, and b-tagged jets) could be faulty when one of the objects didn't pass a further ID, like the jet PU ID $\rightarrow$ fixed
- HEM issue in 2018, we veto such events, has an appropriate reweighting by integrated luminosity affected
- 2016apv had a program error at the skimming step causing weird discrepancies
- Plotting macro in pyROOT with CMS CAT style calculated the wrong ratios when scaling by bin width (not understood, but fixed...)

Short recap of the $t\bar{t}$ STMET correction scheme

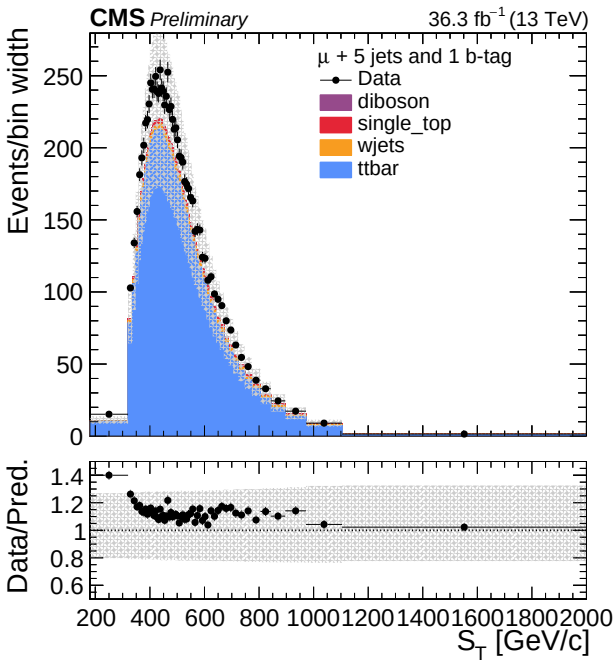


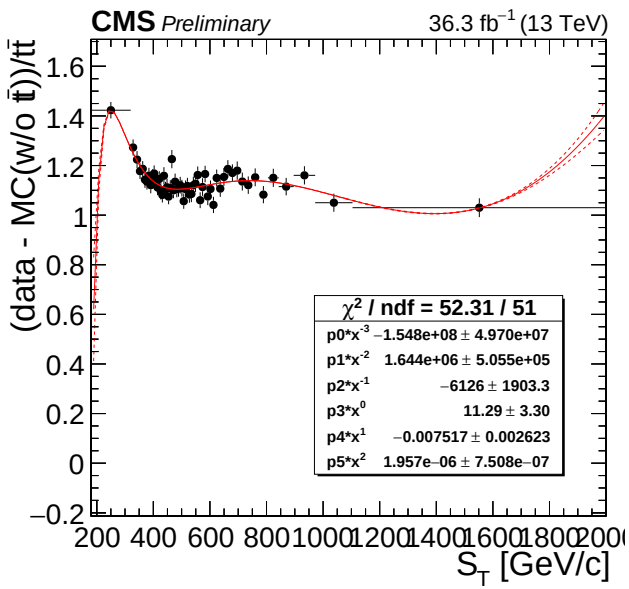
- The boost of the $t\bar{t}$ system isn't well-described in simulation
- We effectively look at events with such boosts $\rightarrow$ we do not consider normal semi-leptonic $t\bar{t}$ events with 4 jets, but events with 5/6 jets
- So we correct for boost effects by using STMET (we call this ST throughout) as a parametrization
- The extraction variables are H_{T} and m_{fit}, both of which require some cut on a kinematic fitter's probability output which we calibrate for each mass hypothesis separately
- The actual correction is derived on the 2b regions and applied to 3b and 4b of the same lepton type and jet multiplicity, separate by data-taking year

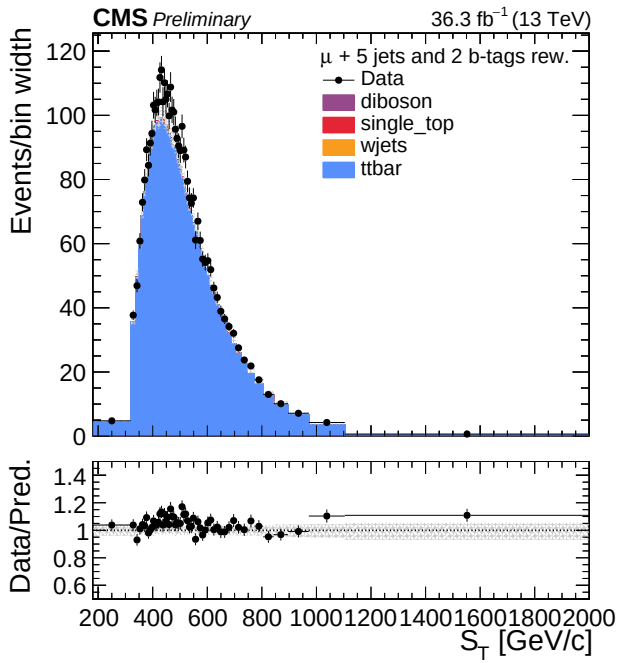
ST plots with fixed error bars in 2b reweighted regions

- Please keep in mind that the negative log likelihood (NLL) nonclosure uncertainties are not included in the reweighted 2b plot error bands (we could do that, by reading them from the general cards without cutting)
- The typical sizes of this normalization uncertainty on $t\bar{t}$ are 5–11% in 2016, 3–6% in 2017, and 4–7% in 2018 before taking into account cuts on the NLL are not yet taken into account and can change the actual uncertainties for the slicing method substantially

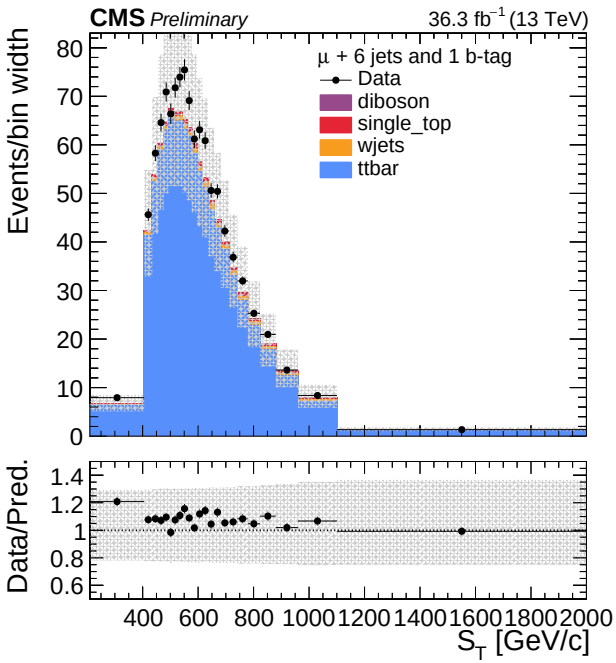
μ 5 jets 2016

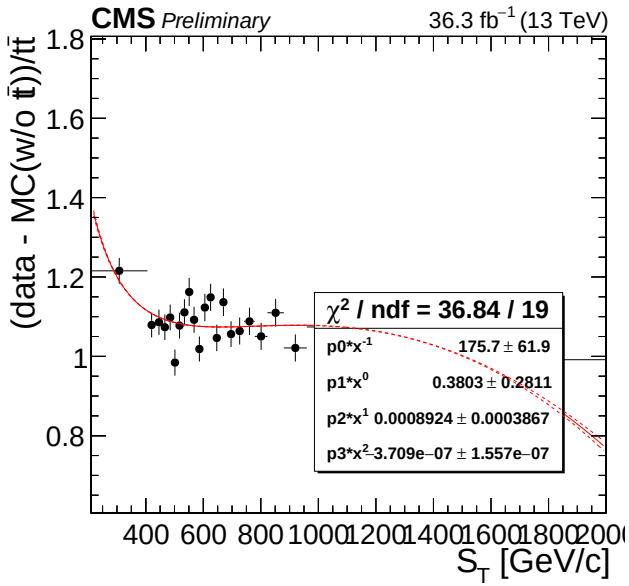


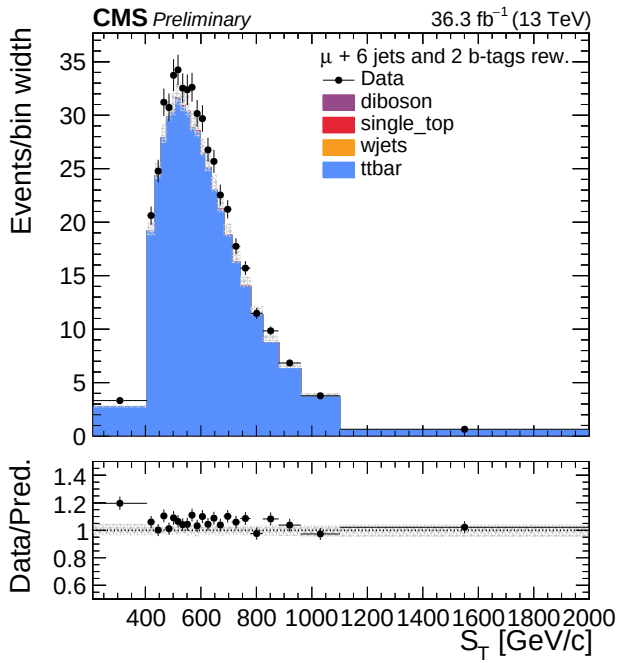




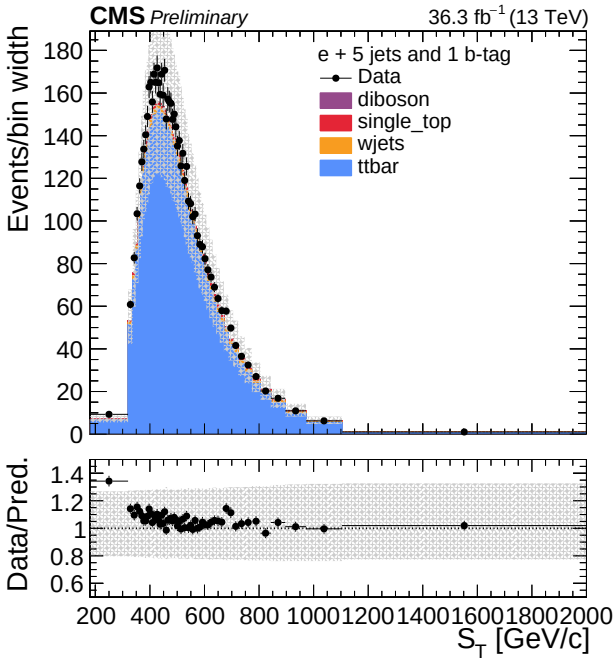
μ 6 jets 2016

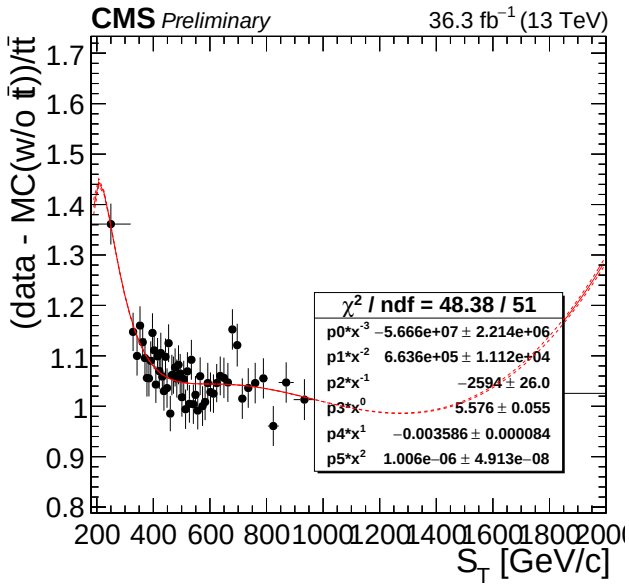


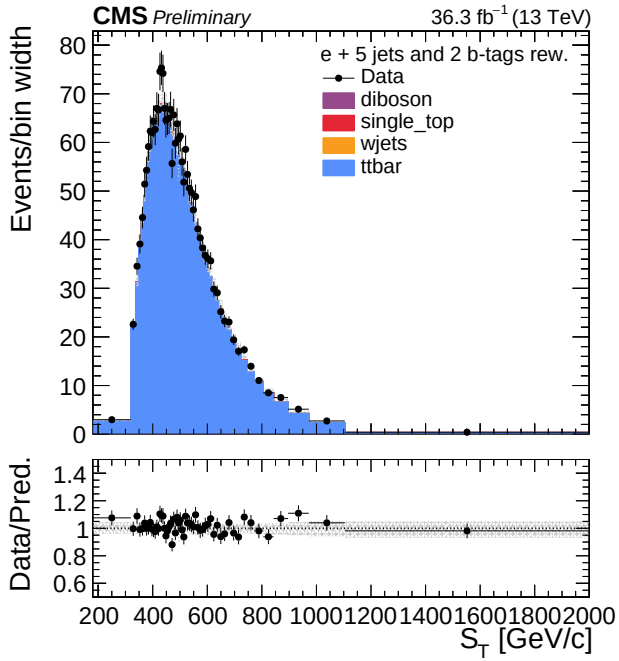




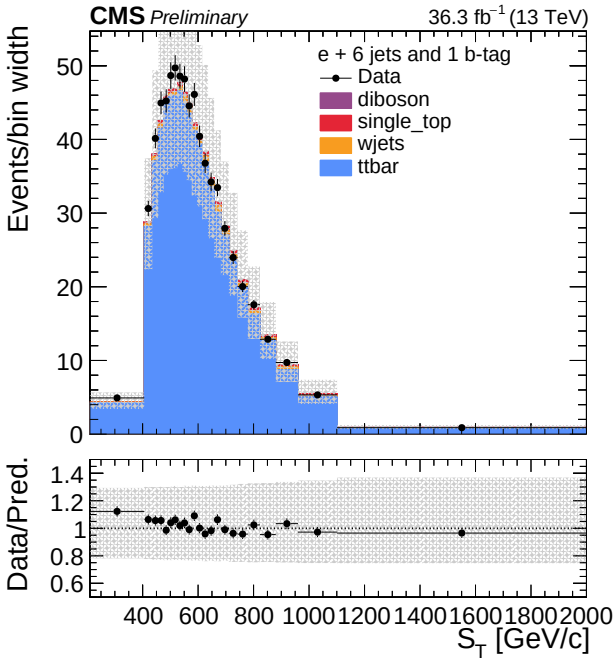
e 5 jets 2016


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 5 jets and 1 b-tag
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]


CMS Preliminary
36.3 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 48.38 / 51
p0*x^{-3} −5.666e+07 ± 2.214e+06
p1*x^{-2} 6.636e+05 ± 1.112e+04
p2*x^{-1} −2594 ± 26.0
p3*x^{0} 5.576 ± 0.055
p4*x^{1} −0.003586 ± 0.000084
p5*x^{2} 1.006e−06 ± 4.913e−08
S_T [GeV/c]


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

e 6 jets 2016


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 6 jets and 1 b-tag
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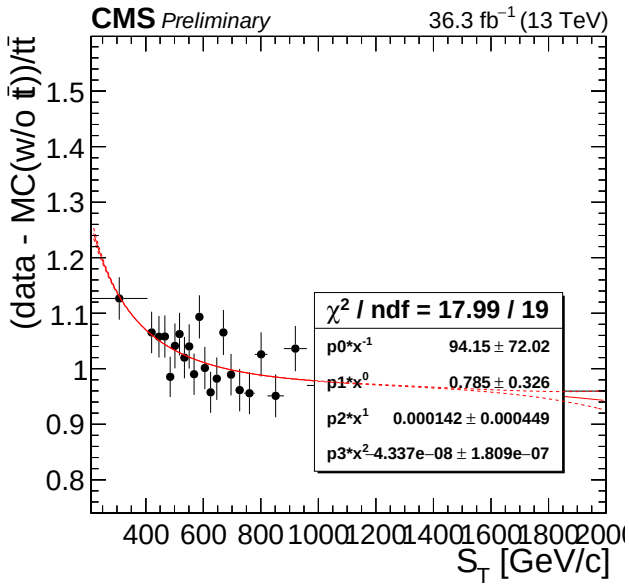
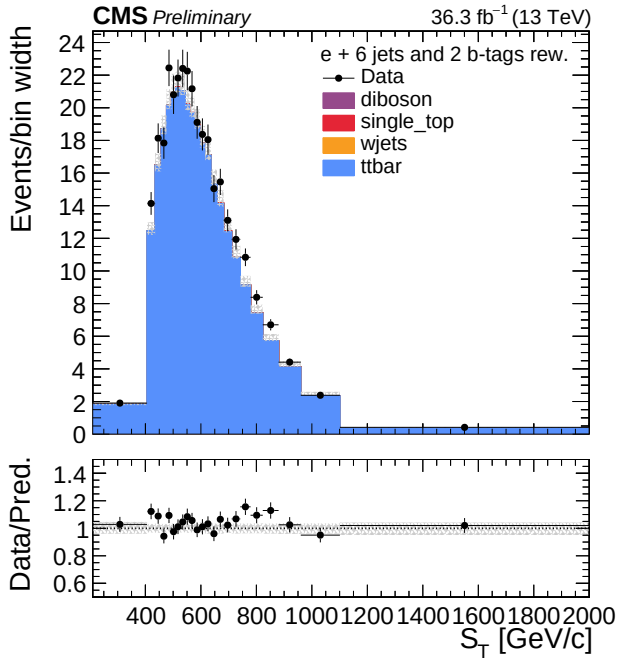
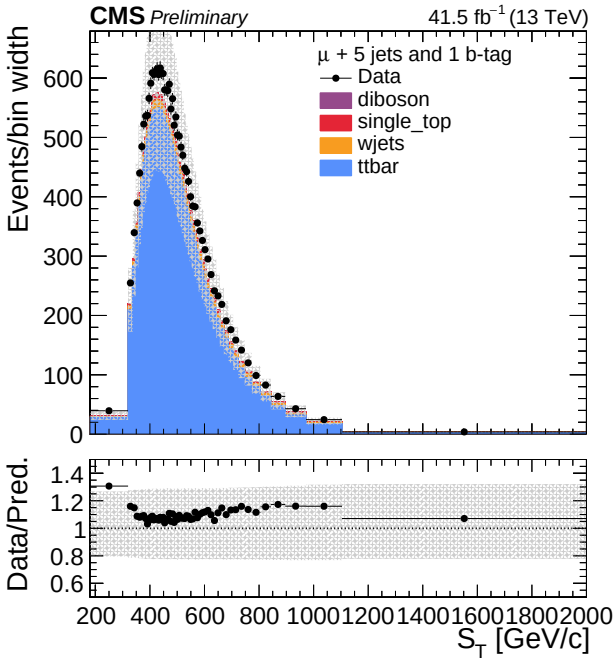
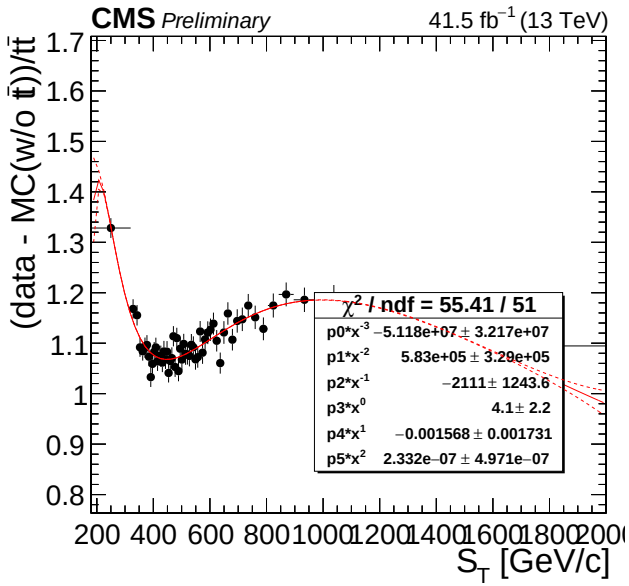
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

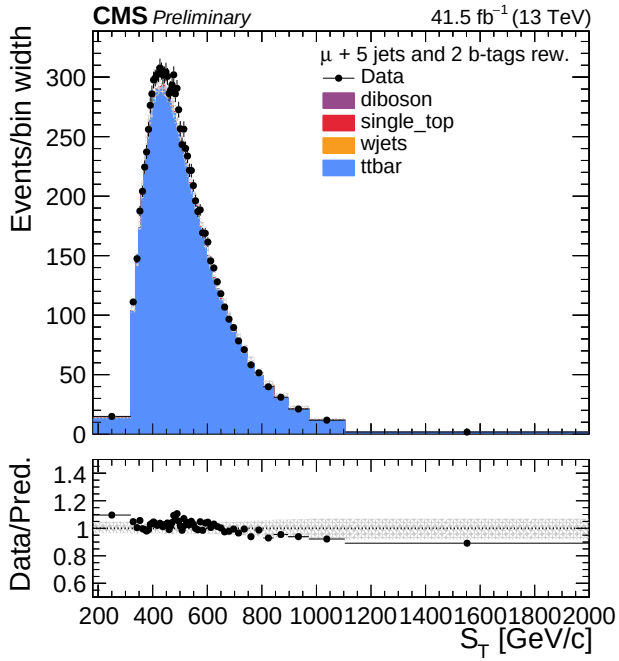

CMS Preliminary
36.3 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 17.99 / 19
p0*x^{-1} 94.15 ± 72.02
p1*x^{0} 0.785 ± 0.326
p2*x^{1} 0.000142 ± 0.000449
p3*x^{2} -4.337e-08 ± 1.809e-07
S_T [GeV/c]


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

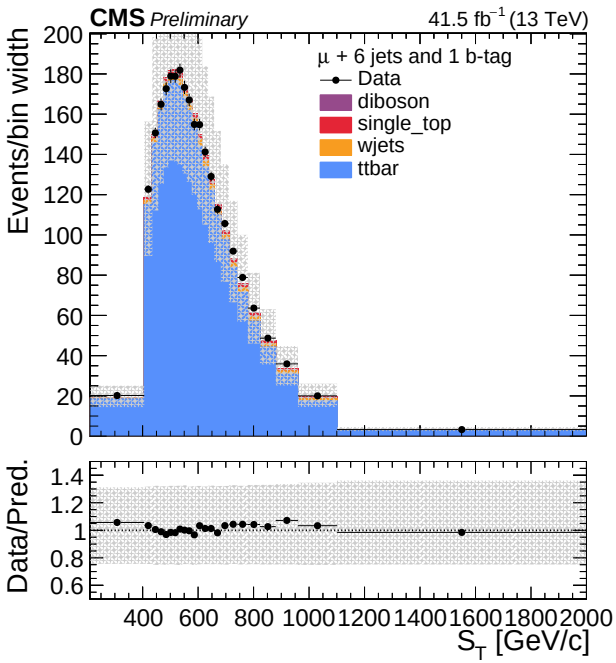
μ 5 jets 2017

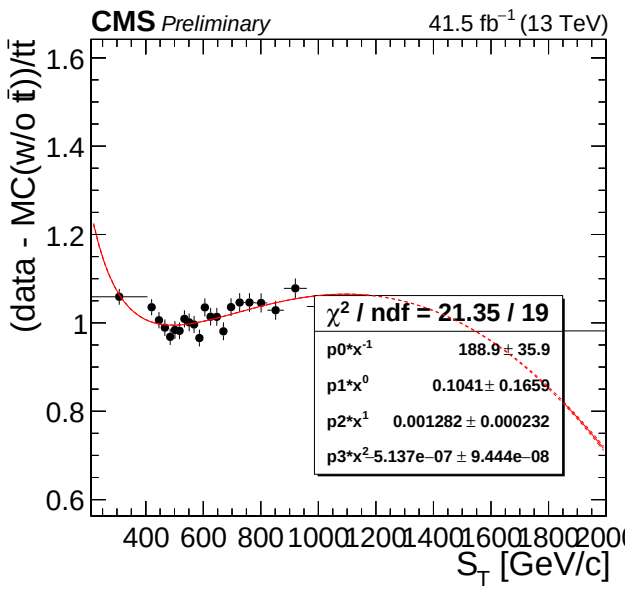


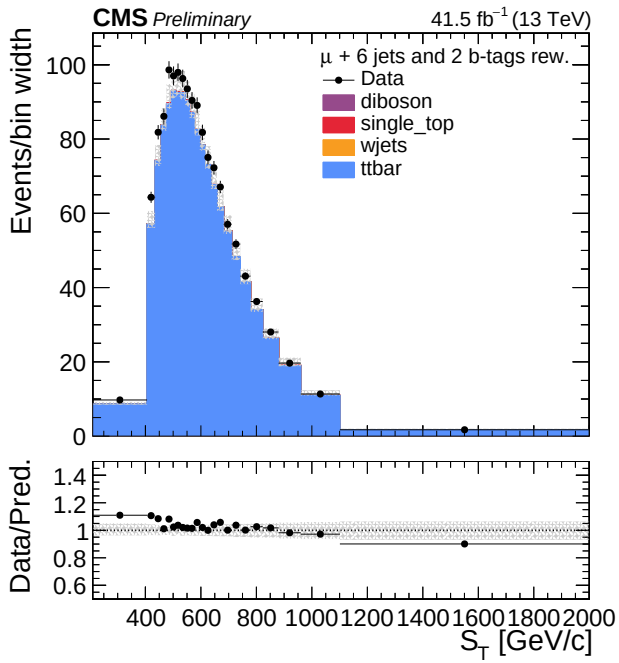




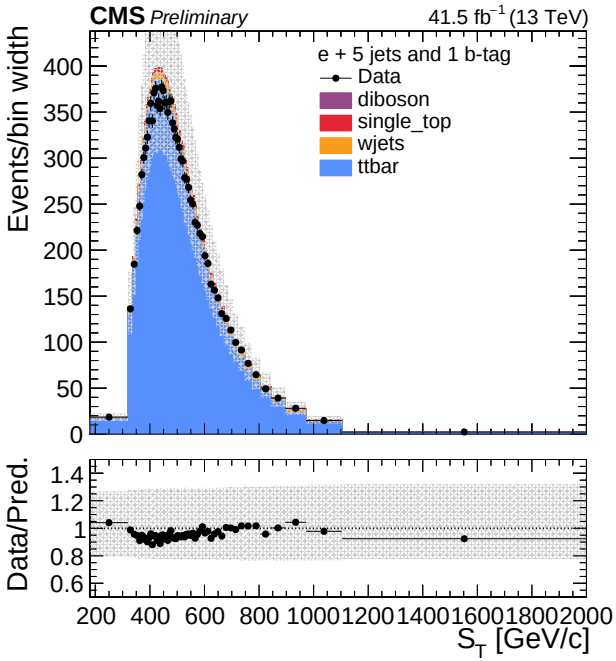
μ 6 jets 2017

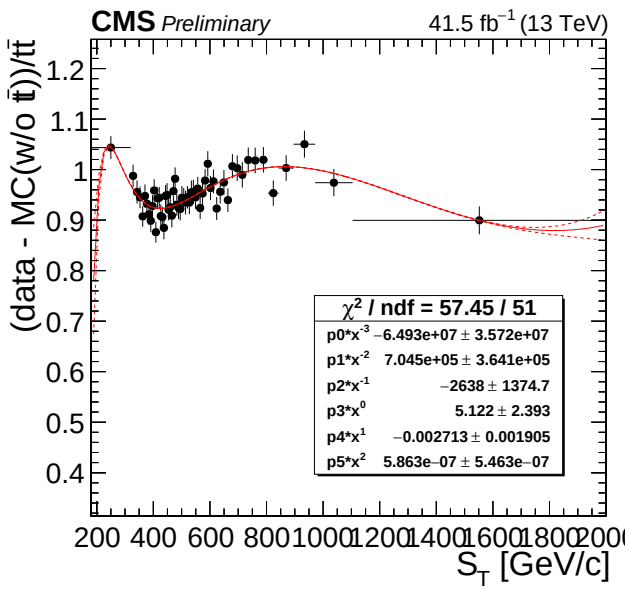


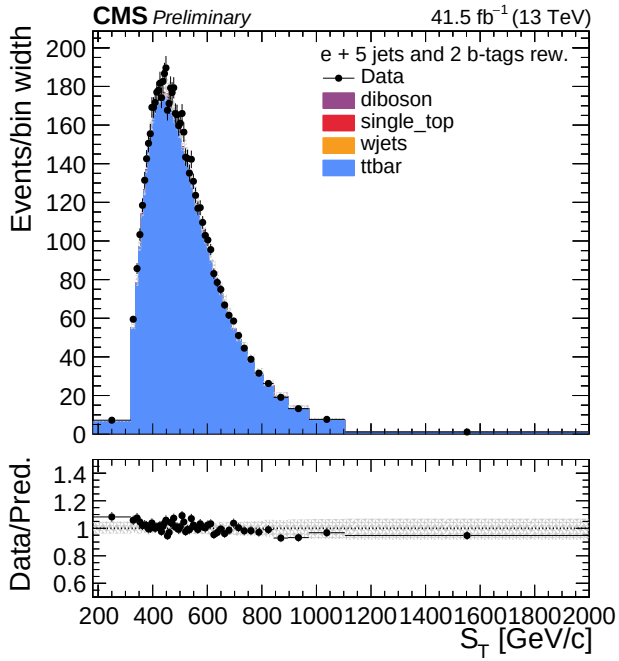




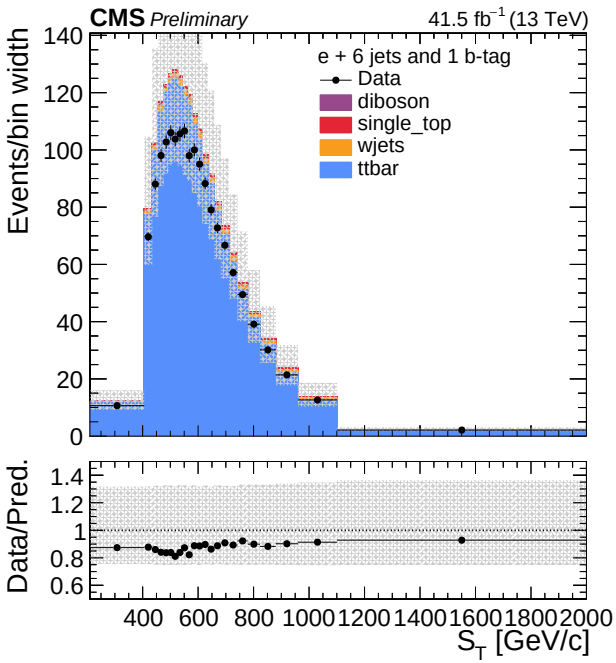
e 5 jets 2017


CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 5 jets and 1 b-tag
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]


CMS Preliminary
41.5 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 57.45 / 51
p0*x^{-3} −6.493e+07 ± 3.572e+07
p1*x^{-2} 7.045e+05 ± 3.641e+05
p2*x^{-1} −2638 ± 1374.7
p3*x^{0} 5.122 ± 2.393
p4*x^{1} −0.002713 ± 0.001905
p5*x^{2} 5.863e−07 ± 5.463e−07
S_T [GeV/c]


CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

e 6 jets 2017


CMS Preliminary
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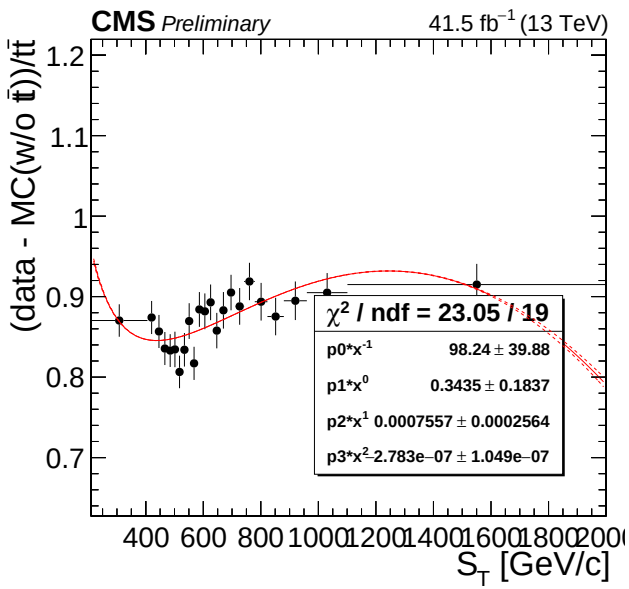
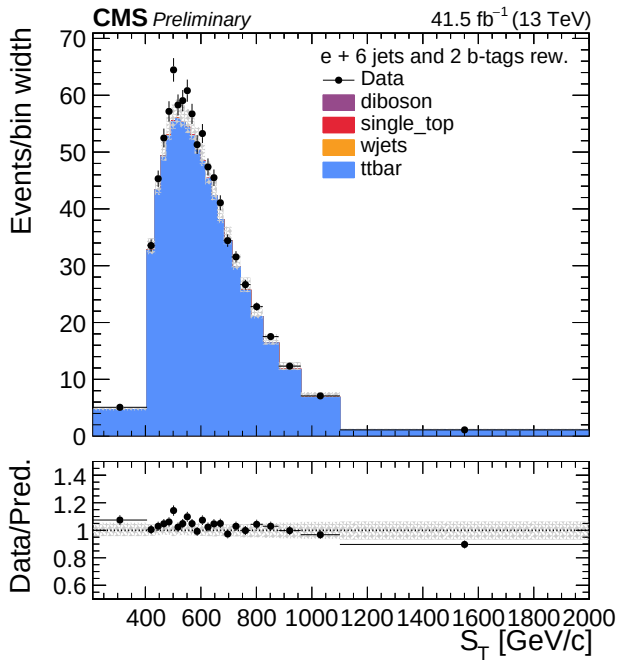
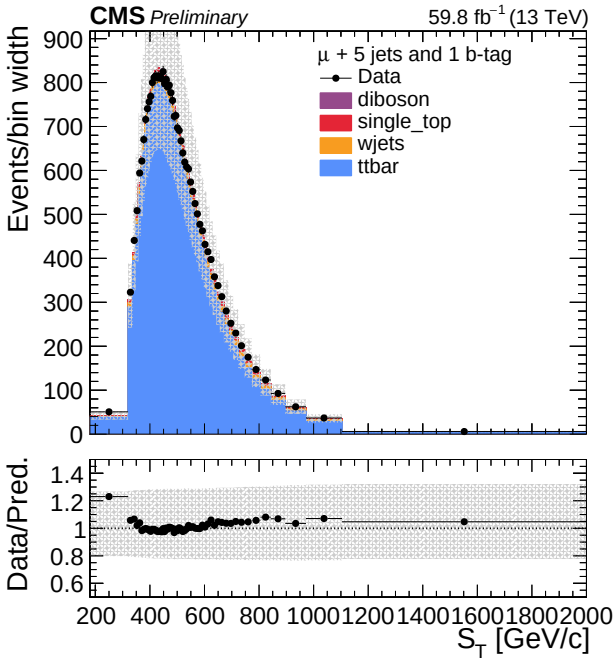
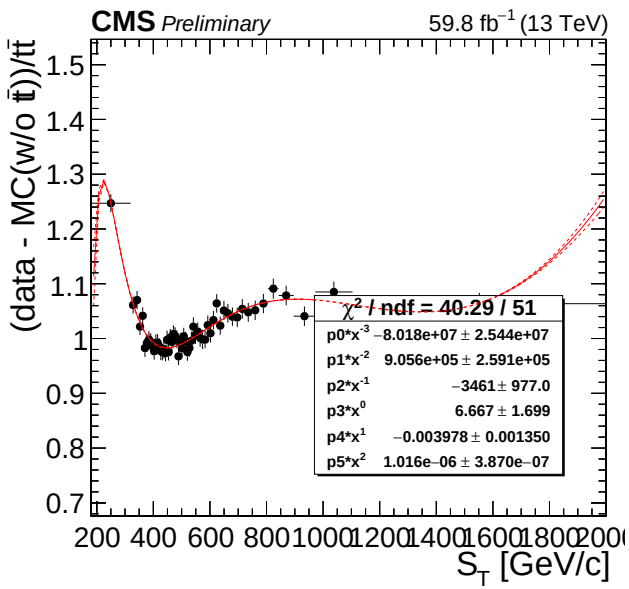
e + 6 jets and 1 b-tag
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

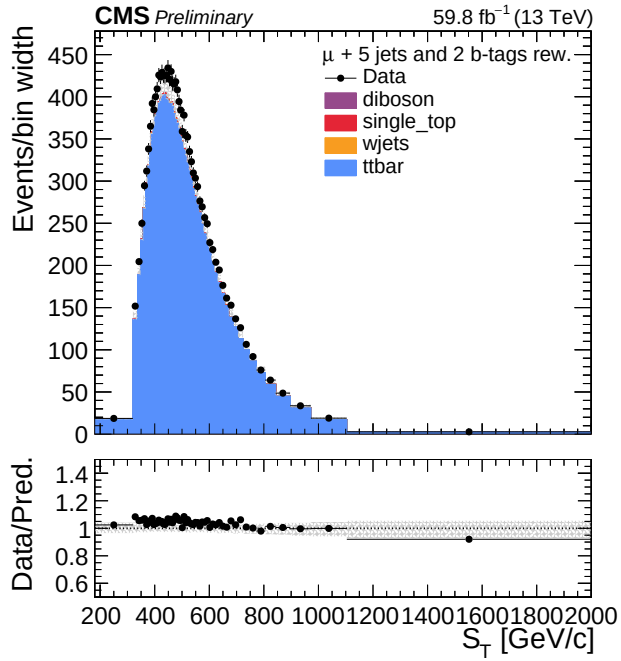

CMS Preliminary
41.5 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 23.05 / 19
p0*x^{-1} 98.24 ± 39.88
p1*x^{0} 0.3435 ± 0.1837
p2*x^{1} 0.0007557 ± 0.0002564
p3*x^{2} -2.783e-07 ± 1.049e-07
S_T [GeV/c]


CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

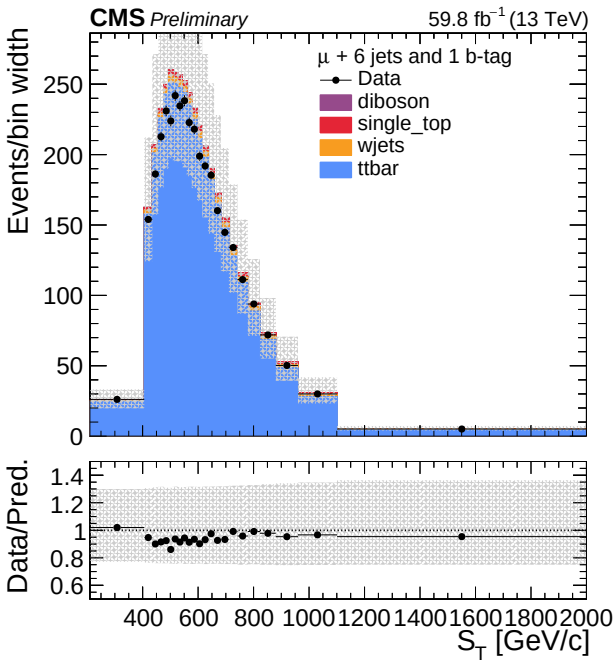
μ 5 jets 2018

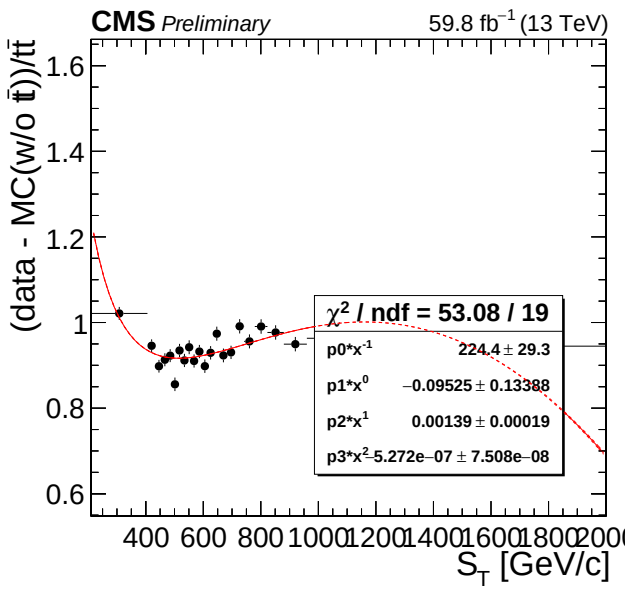


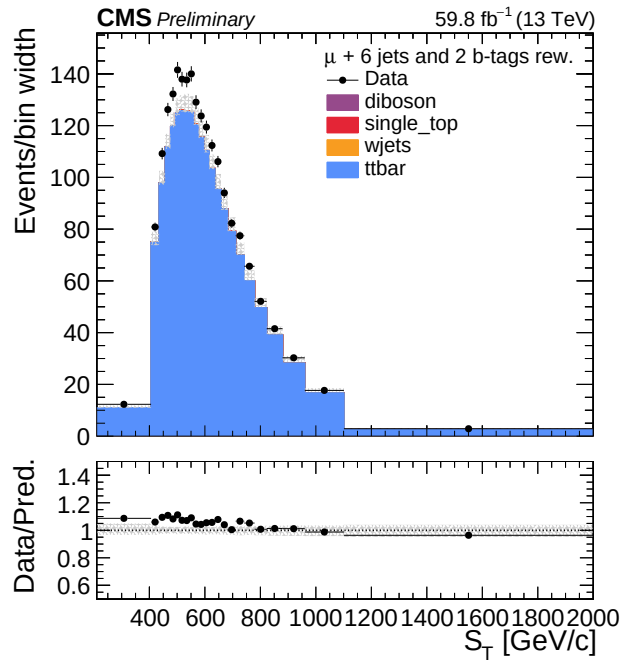




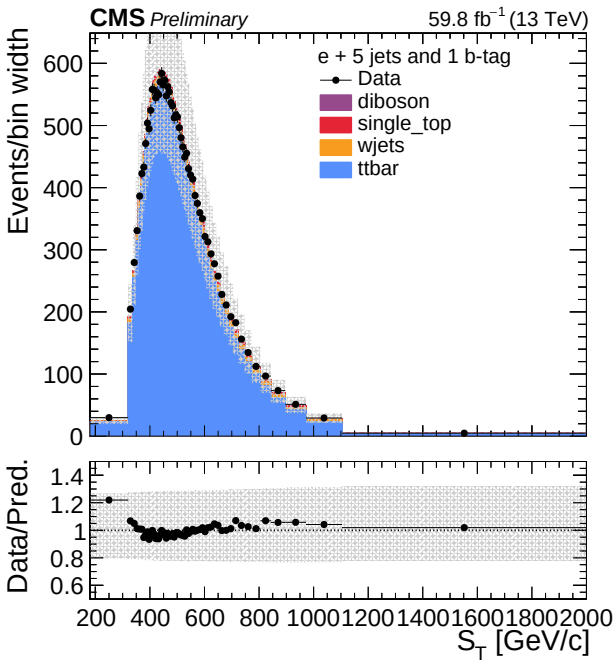
μ 6 jets 2018

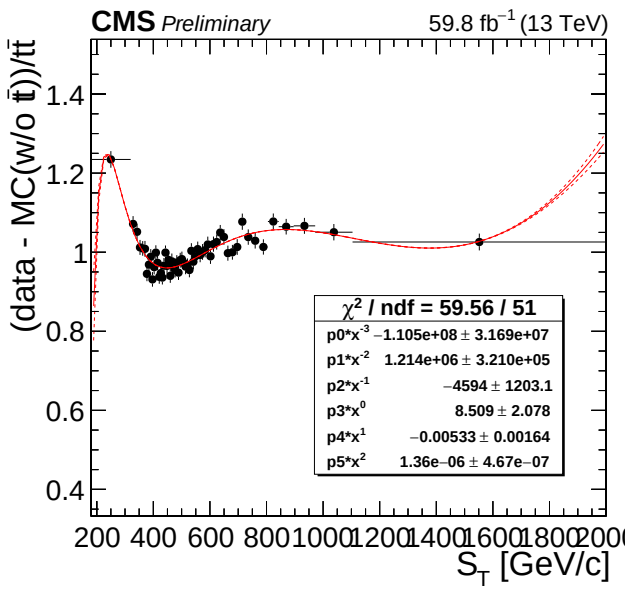


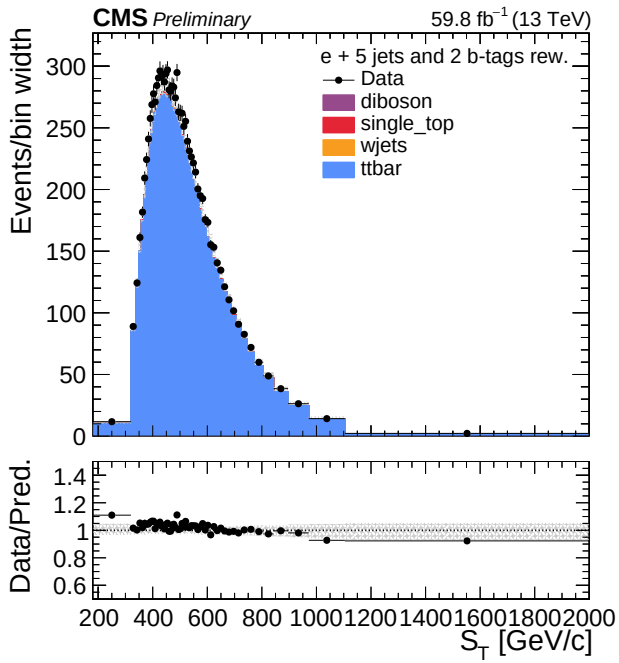




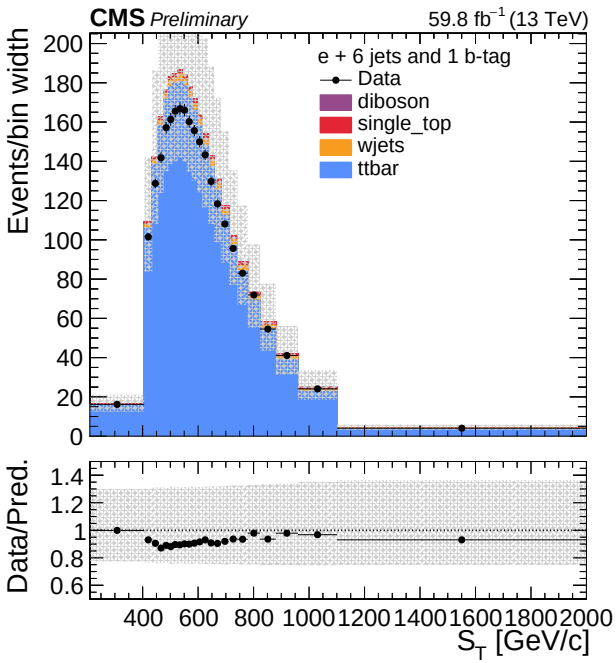
e 5 jets 2018


CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 5 jets and 1 b-tag
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]


CMS Preliminary
59.8 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 59.56 / 51
p0*x^{-3} −1.105e+08 ± 3.169e+07
p1*x^{-2} 1.214e+06 ± 3.210e+05
p2*x^{-1} −4594 ± 1203.1
p3*x^{0} 8.509 ± 2.078
p4*x^{1} −0.00533 ± 0.00164
p5*x^{2} 1.36e−06 ± 4.67e−07
S_T [GeV/c]


CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

e 6 jets 2018


CMS Preliminary
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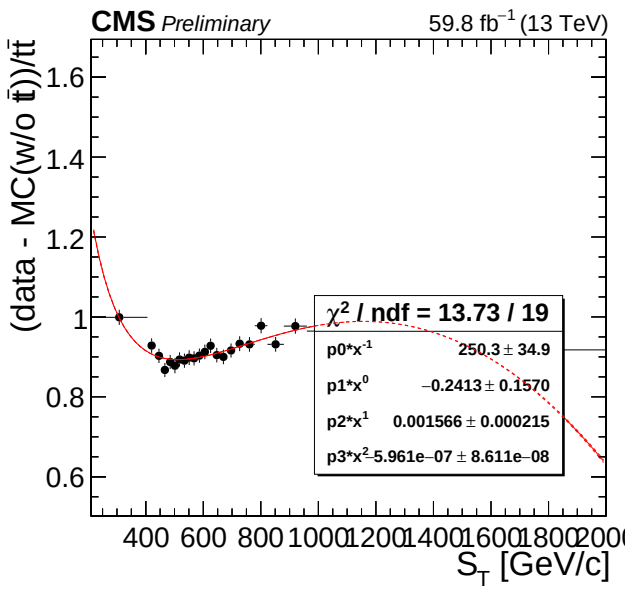
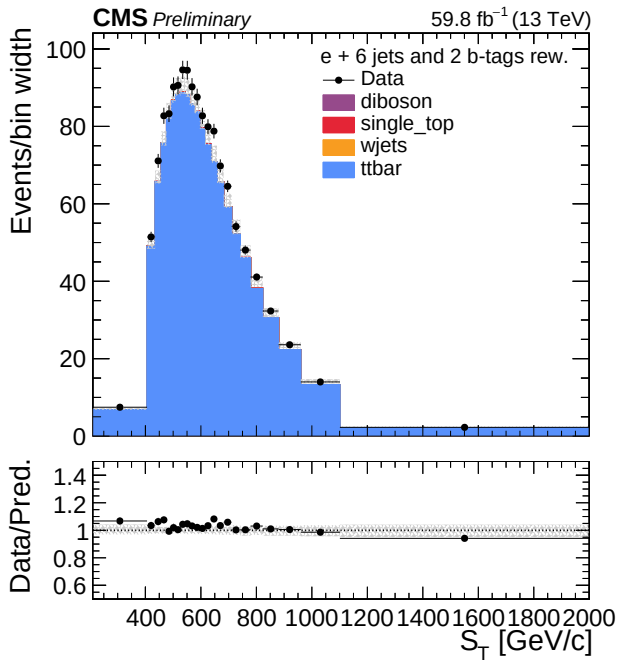
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

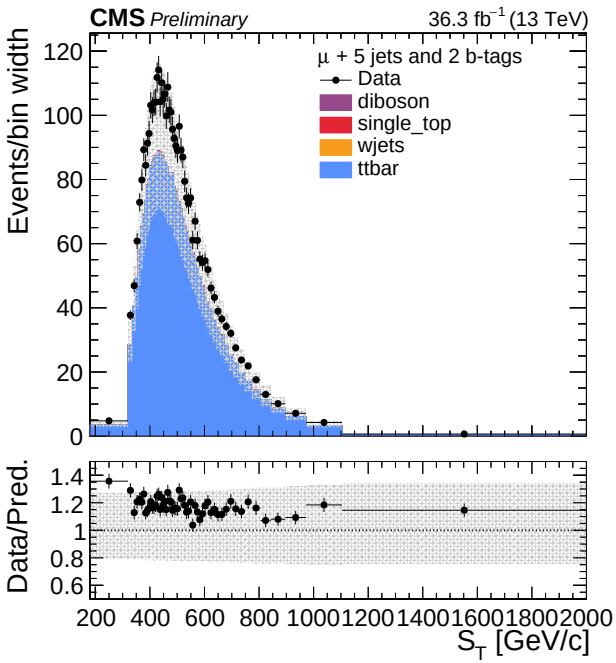

CMS Preliminary
59.8 fb^{-1} (13 TeV)
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
χ^2 / ndf = 13.73 / 19
p0*x^{-1} 250.3 ± 34.9
p1*x^{0} −0.2413 ± 0.1570
p2*x^{1} 0.001566 ± 0.000215
p3*x^{2} -5.961e−07 ± 8.611e−08
S_T [GeV/c]

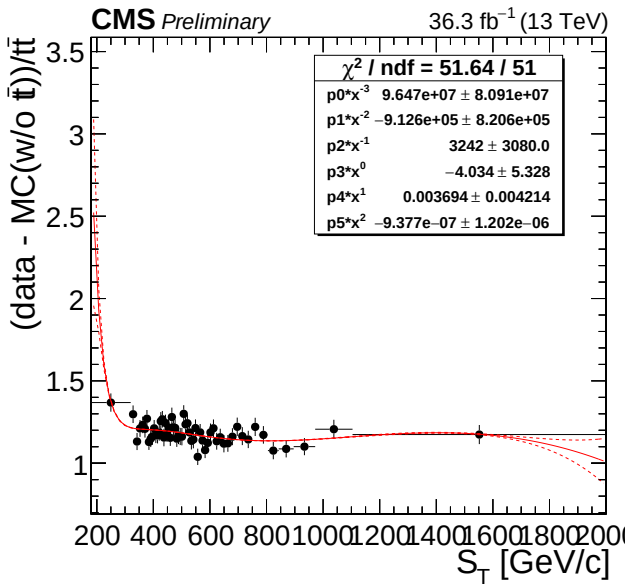

CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags rew.
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

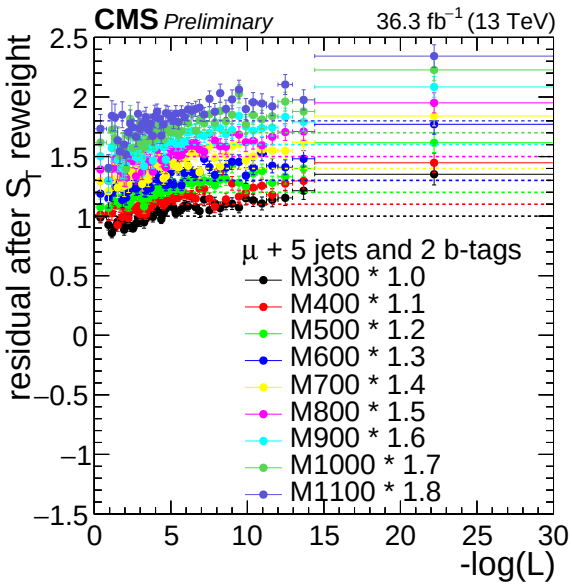
new plots

- raw uncorrected ST in the 2 b-tag region is shown on the left
- the middle has the ST fit from the uncorrected 2 b-tag region
- on the right, there's a spaced version of the resulting NLL nonclosures for all mass scenarios considered

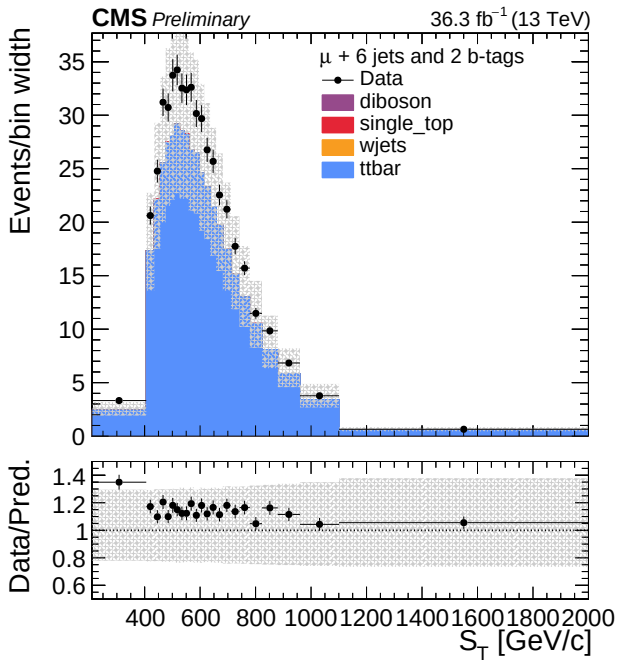
μ 5 jets 2016

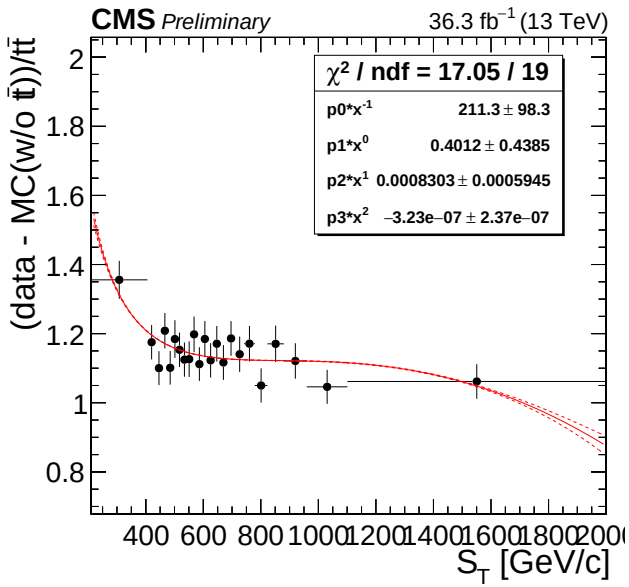


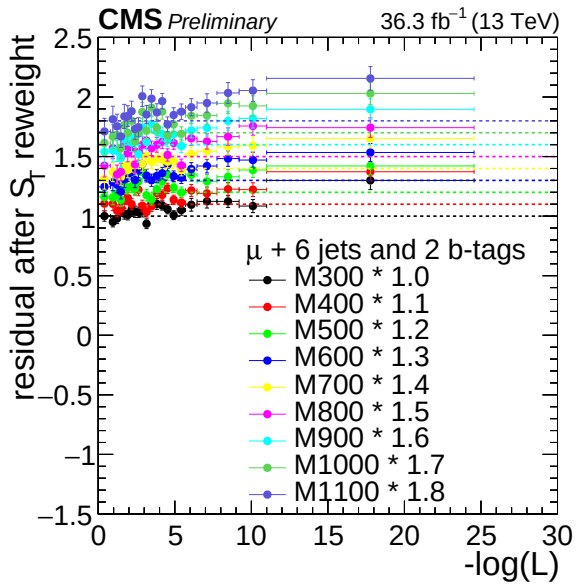




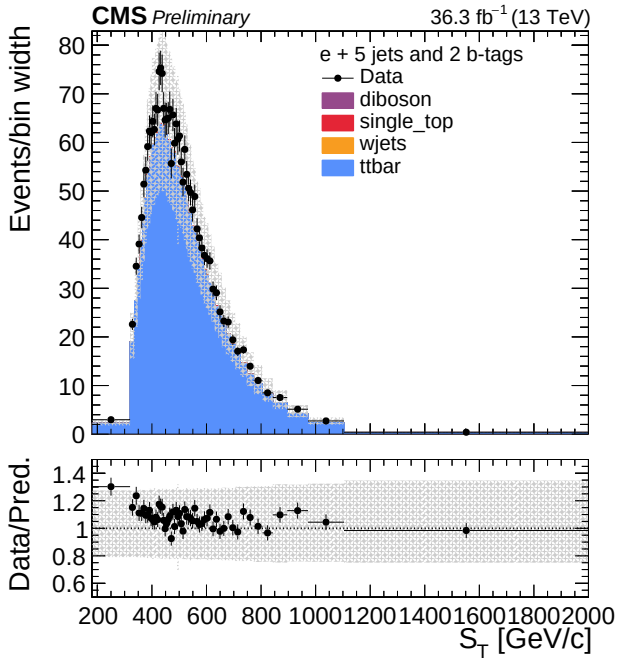
μ 6 jets 2016

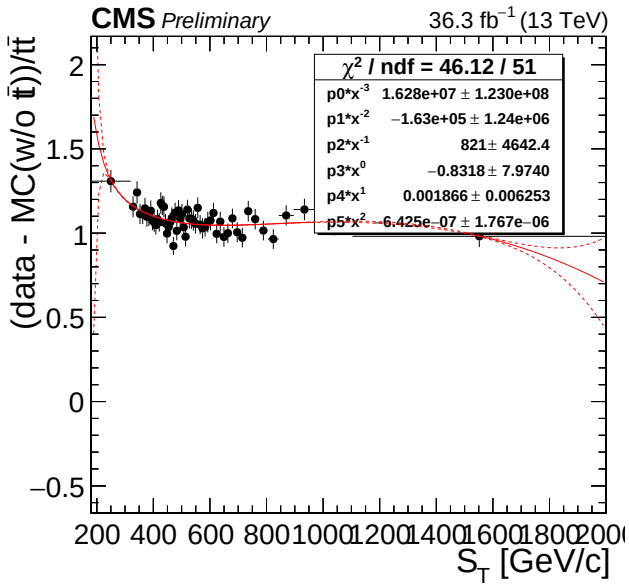


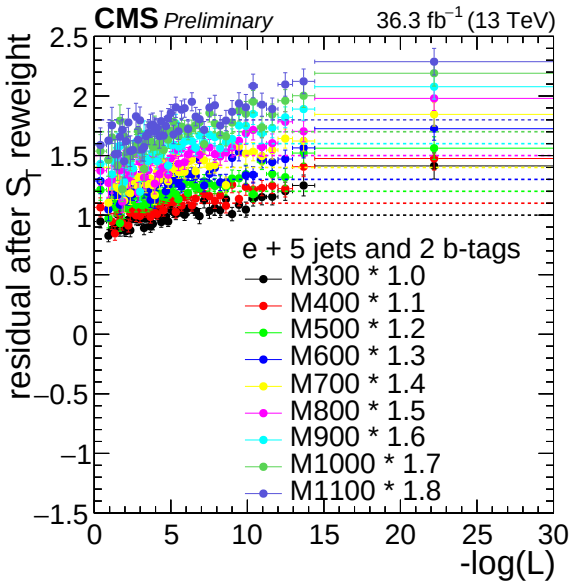




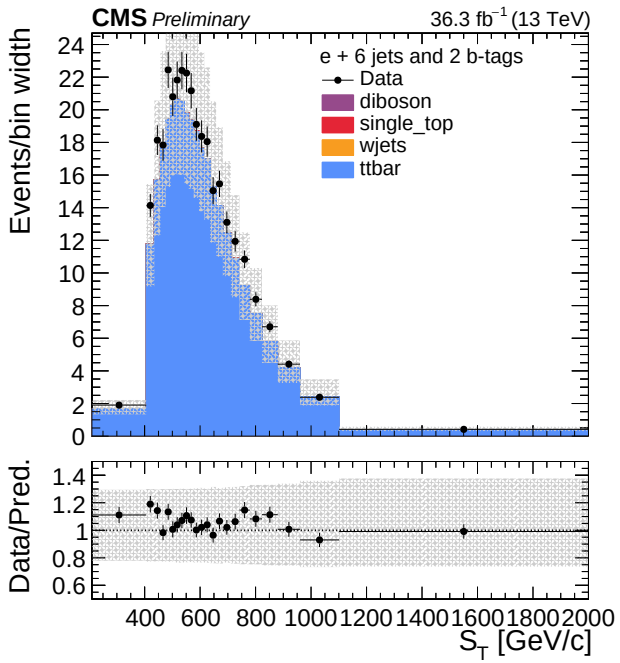
e 5 jets 2016

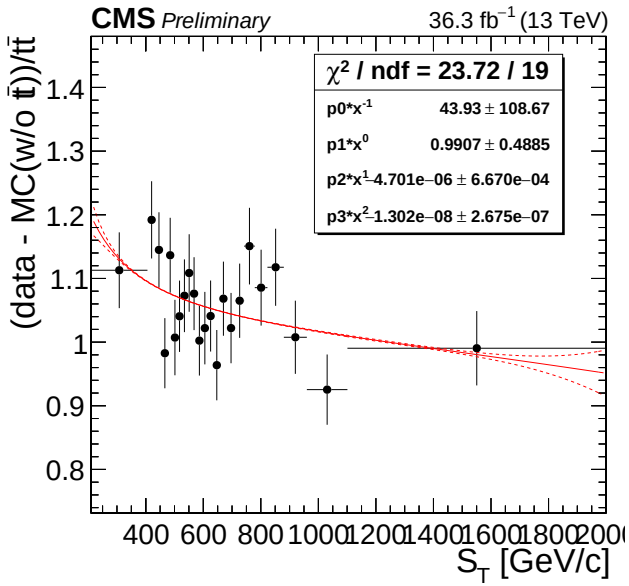

CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

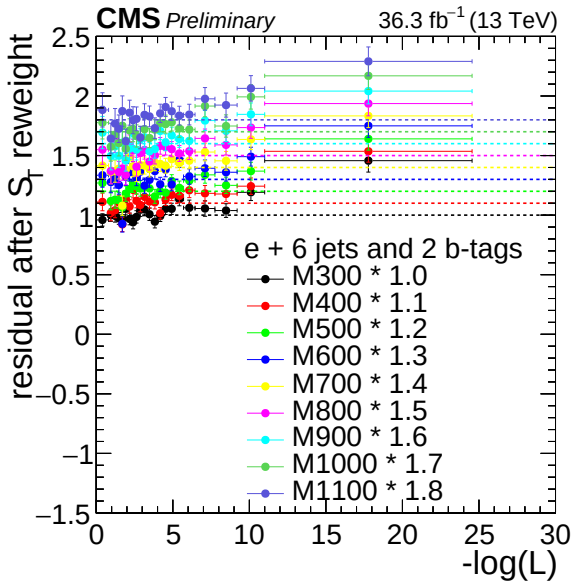

CMS Preliminary
36.3 fb^{-1} (13 TeV)
χ^2 / ndf = 46.12 / 51
p0*x^{-3} 1.628e+07 ± 1.230e+08
p1*x^{-2} −1.63e+05 ± 1.24e+06
p2*x^{-1} 821 ± 4642.4
p3*x^{0} −0.8318 ± 7.9740
p4*x^{1} 0.001866 ± 0.006253
p5*x^{2} −6.425e−07 ± 1.767e−06
(data - MC(w/o $\bar{t}t$))/$\bar{t}t$
S_T [GeV/c]


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

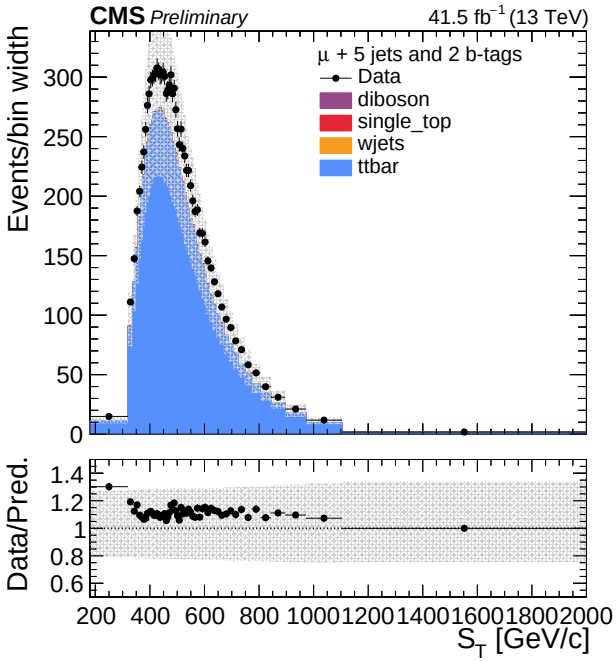
e 6 jets 2016

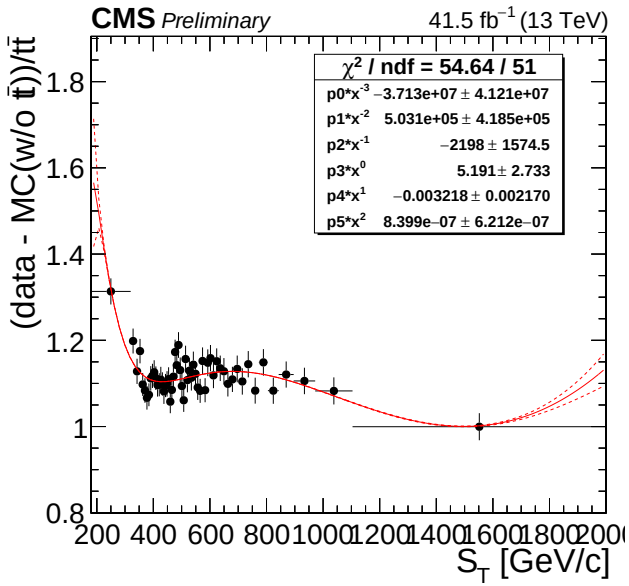

CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

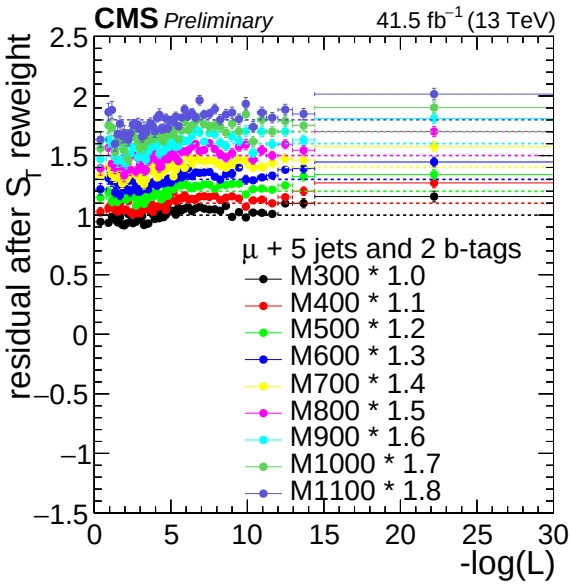

CMS Preliminary
36.3 fb^{-1} (13 TeV)
χ^2 / ndf = 23.72 / 19
p0*x^{-1} 43.93 ± 108.67
p1*x^{0} 0.9907 ± 0.4885
p2*x^{1} −4.701e−06 ± 6.670e−04
p3*x^{2} −1.302e−08 ± 2.675e−07
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
S_T [GeV/c]


CMS Preliminary
36.3 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

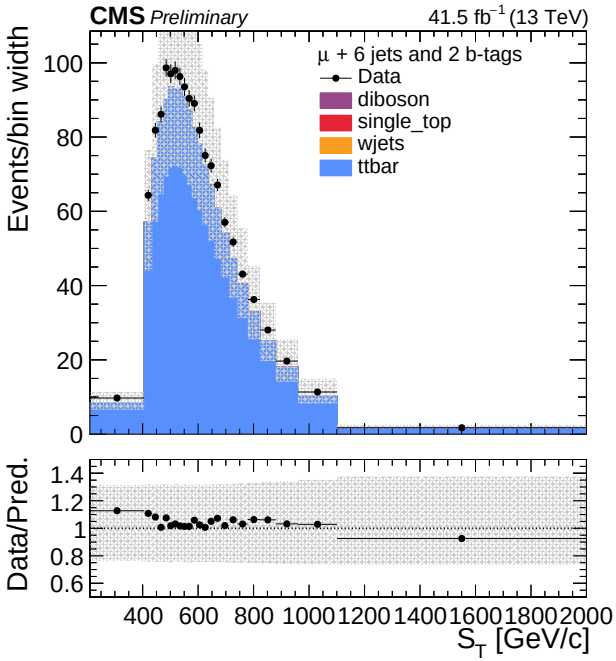
μ 5 jets 2017

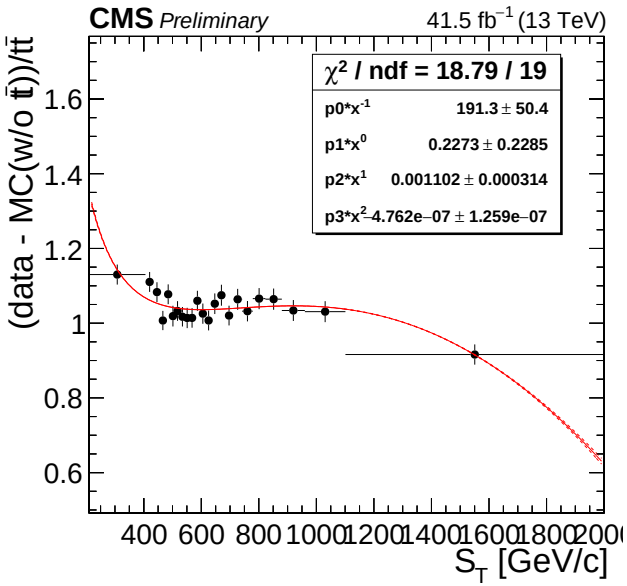


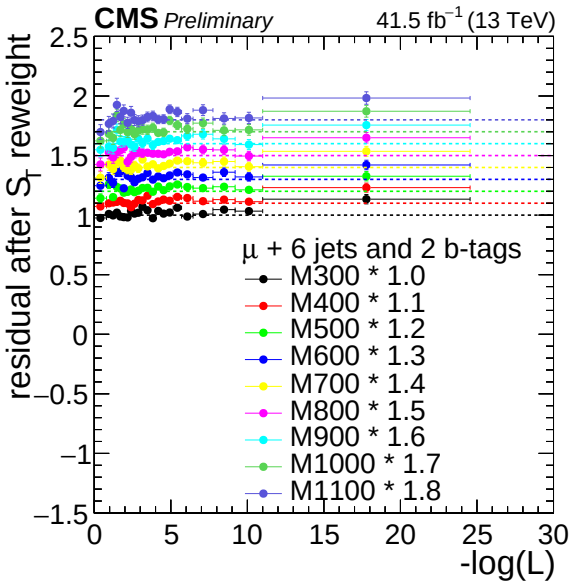




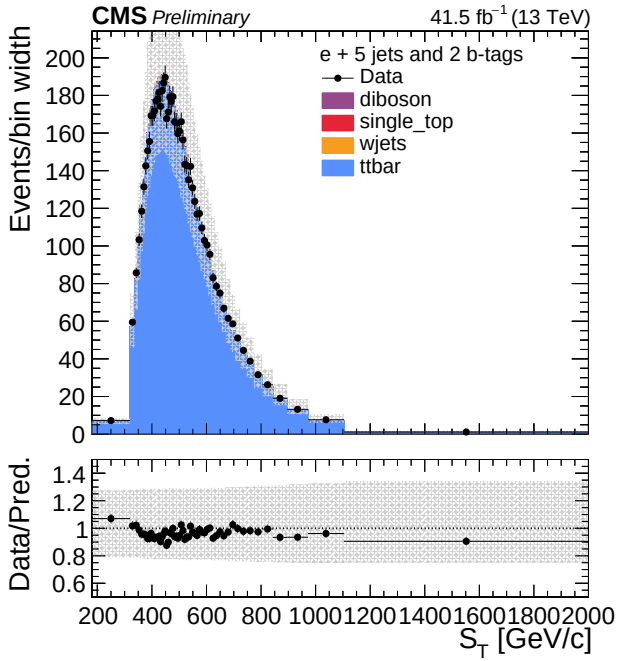
μ 6 jets 2017

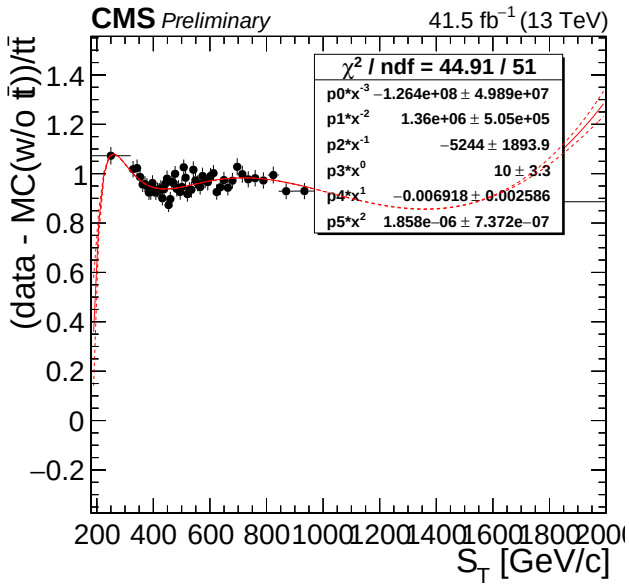


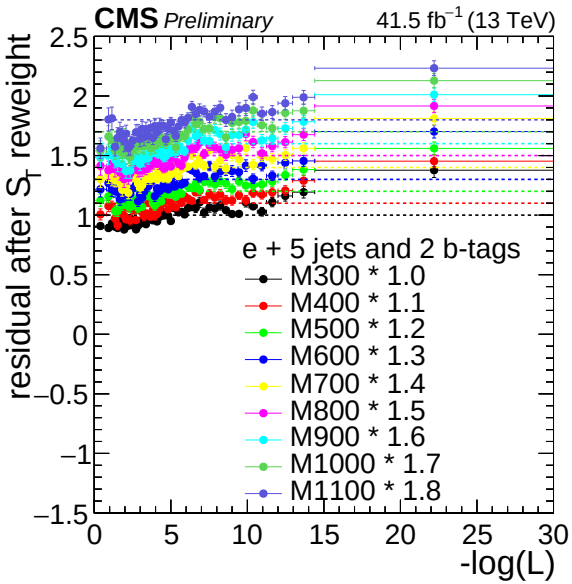




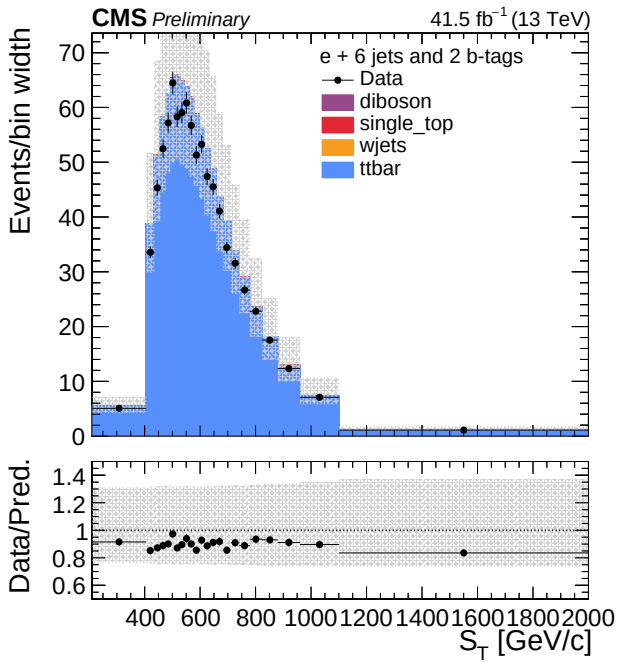
e 5 jets 2017

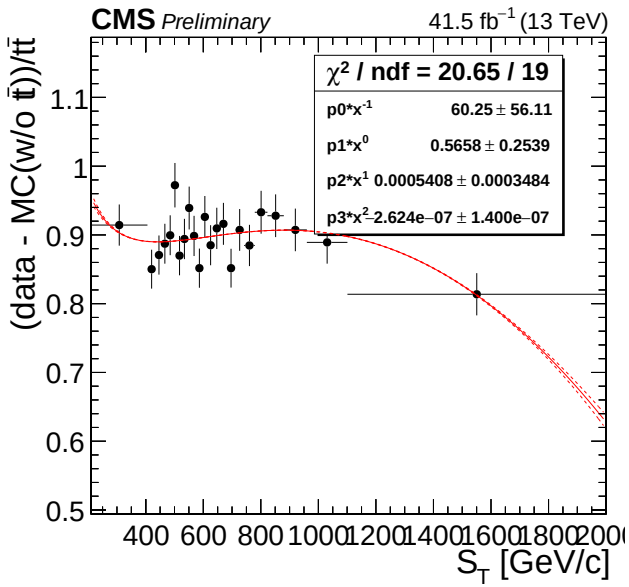

CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

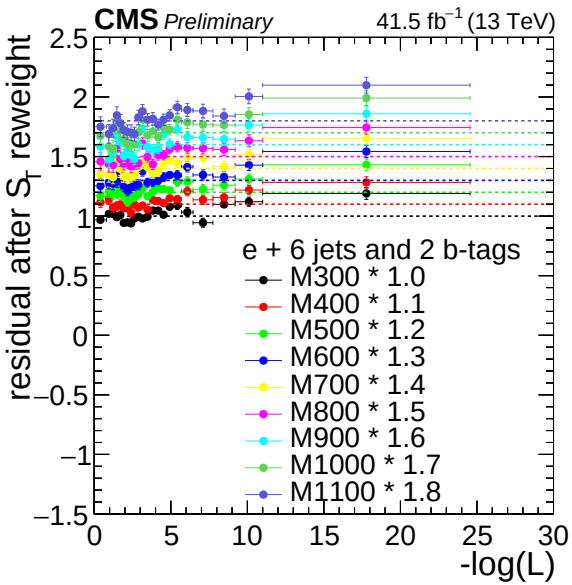

CMS Preliminary
41.5 fb^{-1} (13 TeV)
χ^2 / ndf = 44.91 / 51
p0*x^{-3} −1.264e+08 ± 4.989e+07
p1*x^{-2} 1.36e+06 ± 5.05e+05
p2*x^{-1} −5244 ± 1893.9
p3*x^{0} 10 ± 3.3
p4*x^{1} −0.006918 ± 0.002586
p5*x^{2} 1.858e−06 ± 7.372e−07
(data - MC(w/o $\bar{t}$t))/$\bar{t}$t
S_T [GeV/c]


CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

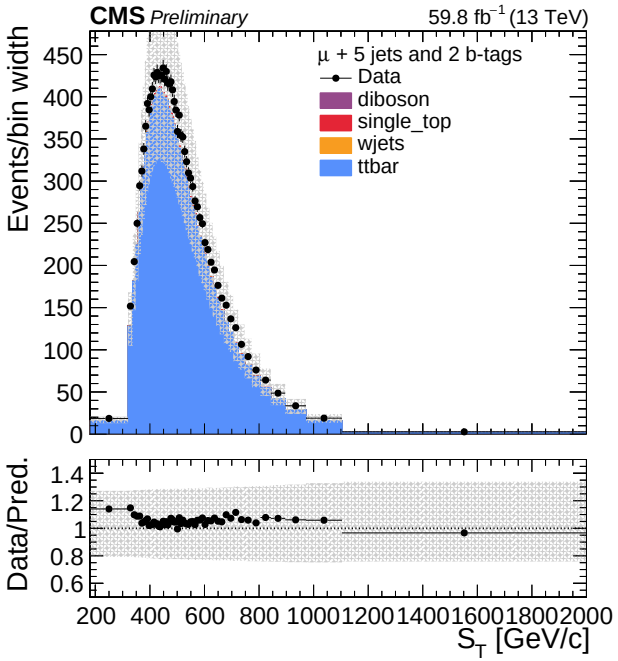
e 6 jets 2017

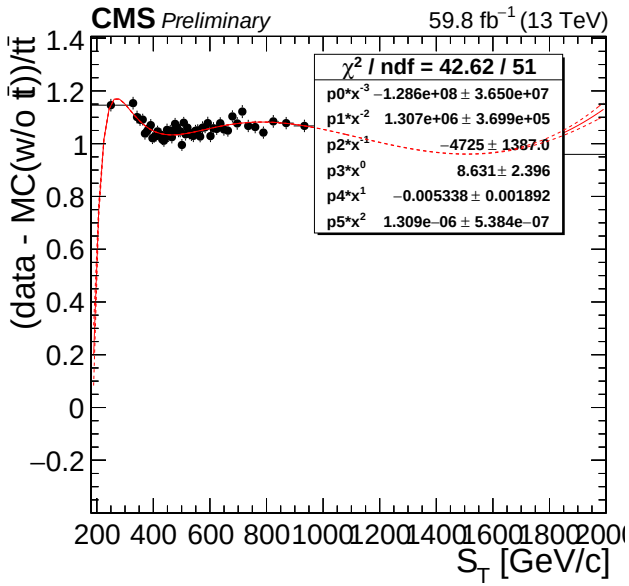

CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

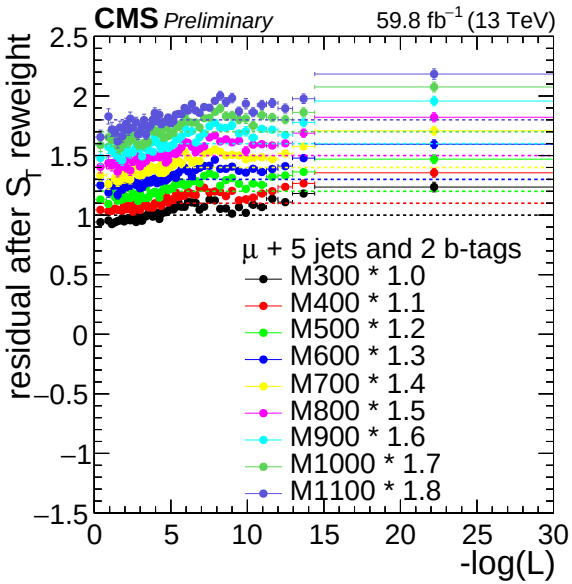

CMS Preliminary
41.5 fb^{-1} (13 TeV)
χ^2 / ndf = 20.65 / 19
p0*x^{-1} 60.25 ± 56.11
p1*x^{0} 0.5658 ± 0.2539
p2*x^{1} 0.0005408 ± 0.0003484
p3*x^{2} -2.624e-07 ± 1.400e-07
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
S_T [GeV/c]


CMS Preliminary
41.5 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

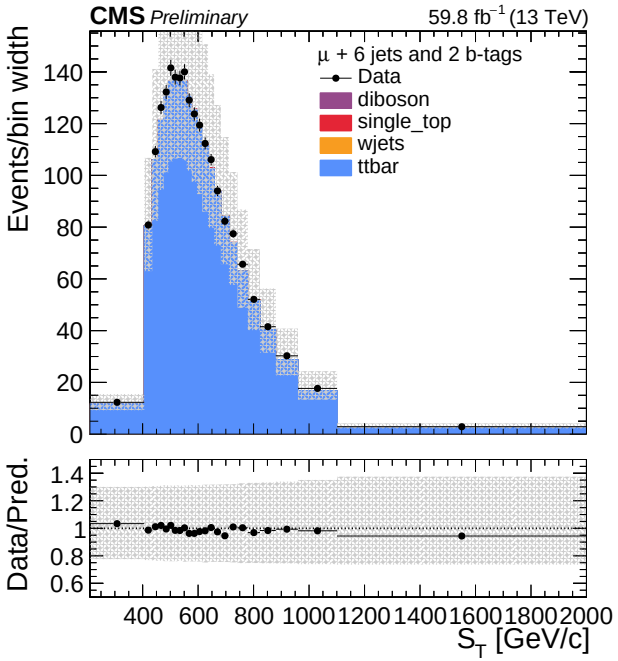
μ 5 jets 2018

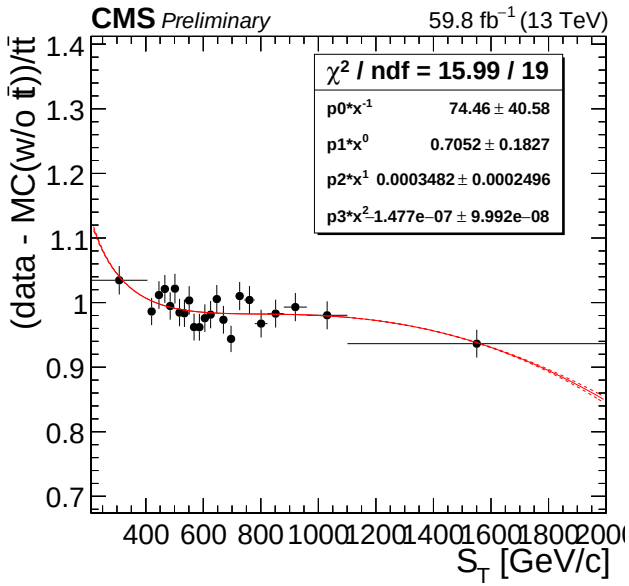


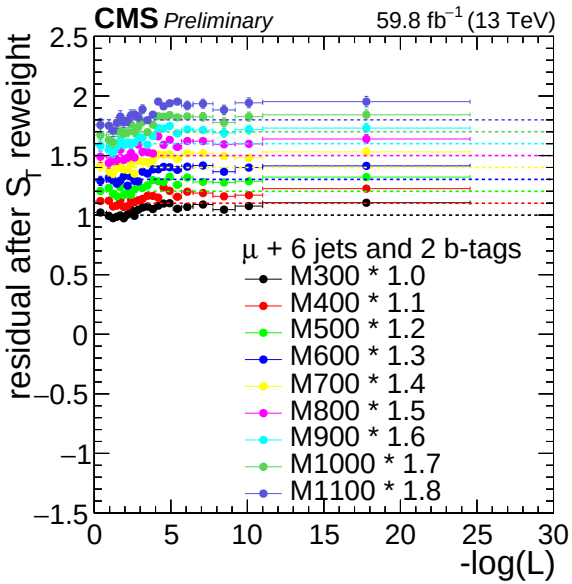




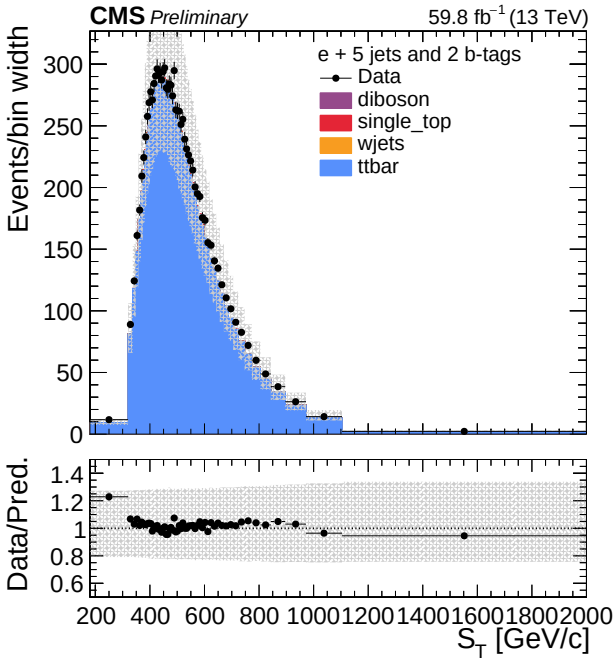
μ 6 jets 2018

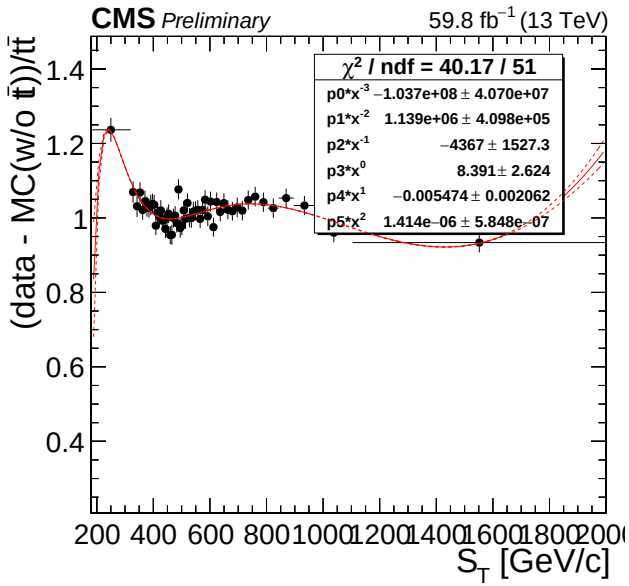


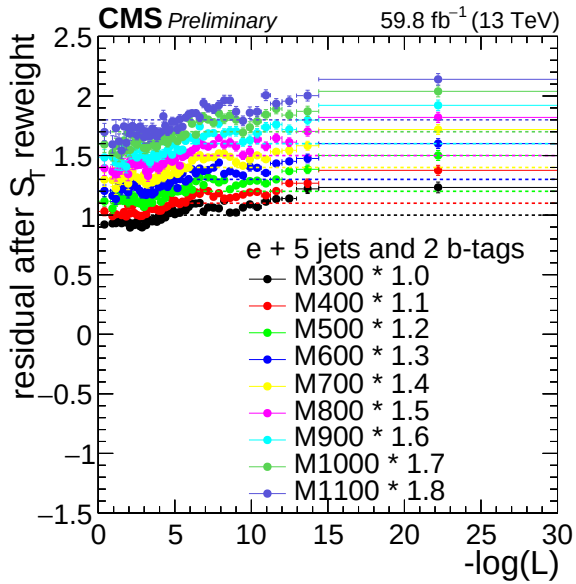




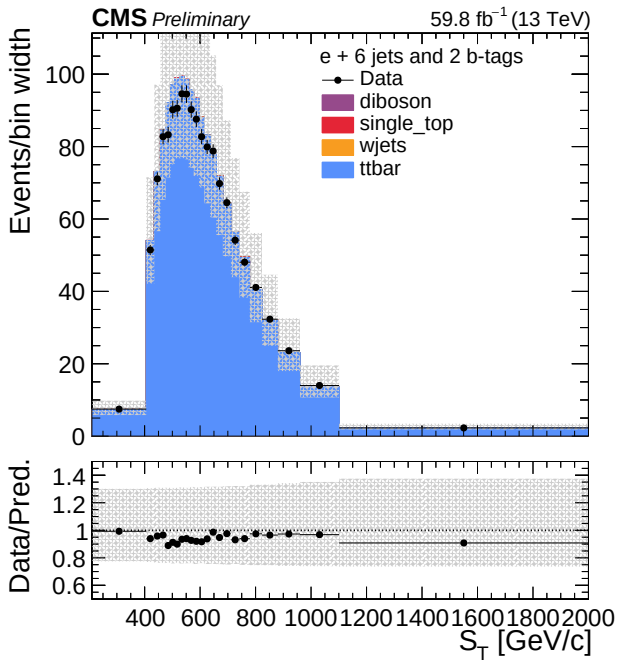
e 5 jets 2018

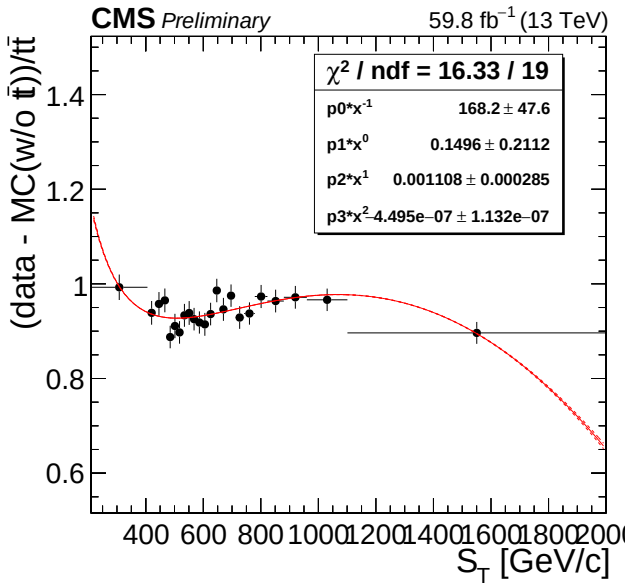

CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]

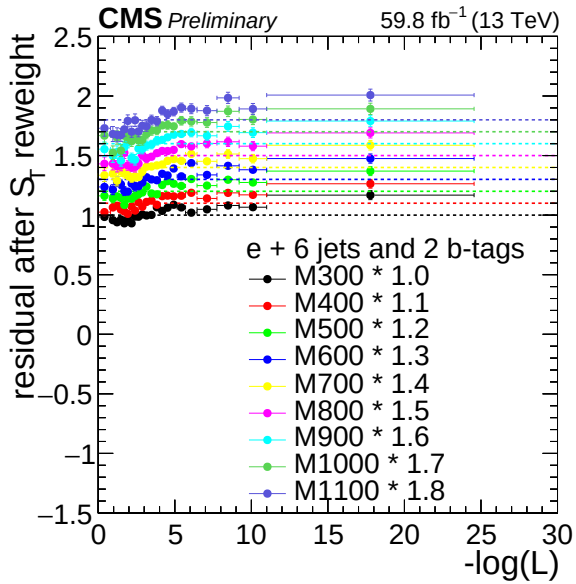

CMS Preliminary
59.8 fb^{-1} (13 TeV)
χ^2 / ndf = 40.17 / 51
p0*x^{-3} −1.037e+08 ± 4.070e+07
p1*x^{-2} 1.139e+06 ± 4.098e+05
p2*x^{-1} −4367 ± 1527.3
p3*x^{0} 8.391 ± 2.624
p4*x^{1} −0.005474 ± 0.002062
p5*x^{2} 1.414e−06 ± 5.848e−07
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
S_T [GeV/c]


CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 5 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

e 6 jets 2018


CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
Data
diboson
single_top
wjets
ttbar
Events/bin width
Data/Pred.
S_T [GeV/c]


CMS Preliminary
59.8 fb^{-1} (13 TeV)
χ^2 / ndf = 16.33 / 19
p0*x^{-1} 168.2 ± 47.6
p1*x^{0} 0.1496 ± 0.2112
p2*x^{1} 0.001108 ± 0.000285
p3*x^{2} -4.495e-07 ± 1.132e-07
(data - MC(w/o $t\bar{t}$))/$t\bar{t}$
S_T [GeV/c]


CMS Preliminary
59.8 fb^{-1} (13 TeV)
e + 6 jets and 2 b-tags
M300 * 1.0
M400 * 1.1
M500 * 1.2
M600 * 1.3
M700 * 1.4
M800 * 1.5
M900 * 1.6
M1000 * 1.7
M1100 * 1.8
residual after S_T reweight
-log(L)

WIP

- We are reoptimizing the cuts on the NLL for the different optimizations in the mass-dependent steps, now
- Dumping all the plots into an AN draft
- Plan is to send the conveners the draft, once all plots, tables, and cards are done