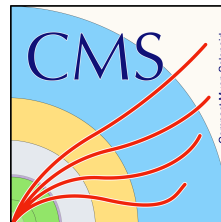# ttbar Analysis Status
NTUA
9/9/2020

George Bakas

Introduction

- B tagging Scale Factors
    - We had to apply the b-tagging sf's on all years
    - Re-do most of the work
    - The outcome is promising

- Neural Network
    - Giannis managed to run the NN successfully
    - MLP, 2 hidden layers→ N+10, N-3
    - Needs almost a month (!!) to run the NN for all years
    - not enough computing power from lxplus → had to train with all the events
        - Managed to find a way to include less events: Much faster (~ 2h)
    - Interesting result: Maybe we do not need to use it (more from giannis)

- Analysis Note:
    - Started writing the AN (AN-20-156)

- Systematics:
    - Giannis has already put a production for variations of our nominal MC files
    - 2017 and 2018 files: PS (parton Shower) weights are within the nominal files
        - New production because we did not save these weights

- ttX presentation on 16th of September

Signal Selection

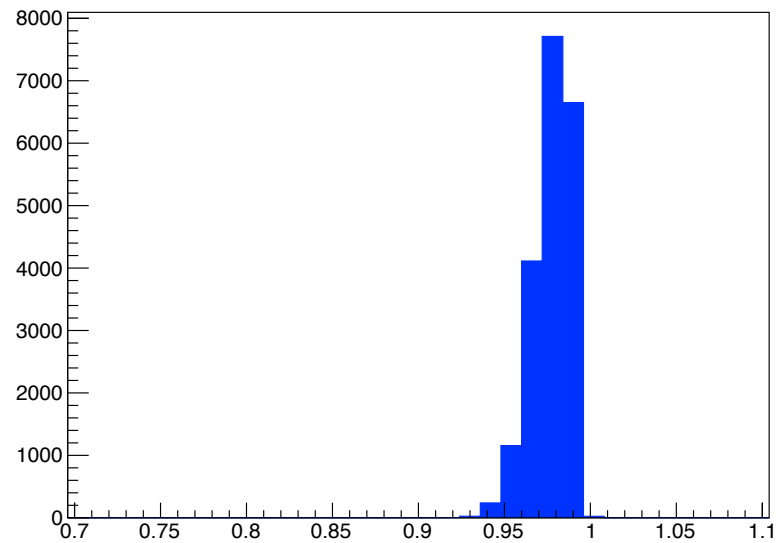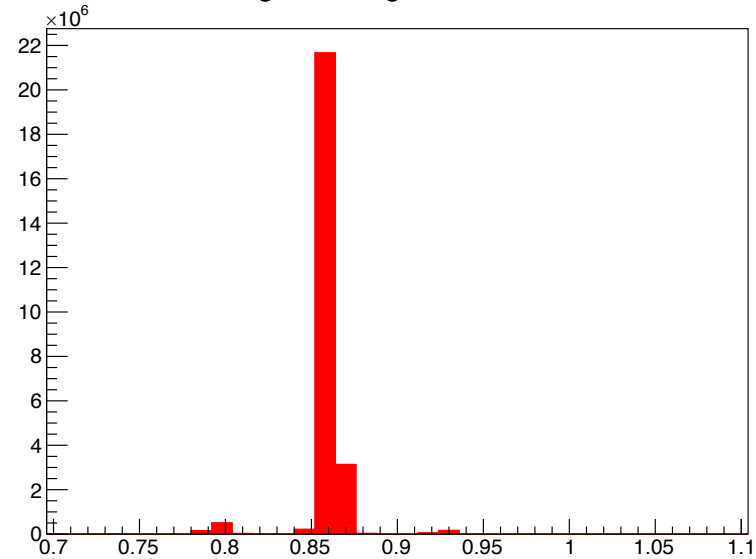| Variables	Selected Cut
pT (both leading jets)	> 400 GeV
Njets	> 1
N leptons	= 0
|eta| (both leading jets)	< 2.4
mJJ	> 1000 GeV
jetMassSoftDrop (only for fit)	(50,300) GeV
Top Tagger	> 0.2, 0, 0.1
B tagging (2 btagged jets)	> Medium WP
Signal Trigger	

Control Region Selection

Variables	Selected Cut
pT (both leading jets)	> 400 GeV
Njets	> 1
N leptons	= 0
|eta| (both leading jets)	< 2.4
mJJ	> 1000 GeV
jetMassSoftDrop (only for fit)	(50,300) GeV
Top Tagger	> 0.2, 0, 0.1
B tagging (0 btagged jets)	< Medium WP
Control Trigger	
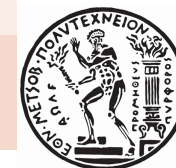
bTagging Scale Factor distributions in Signal Region
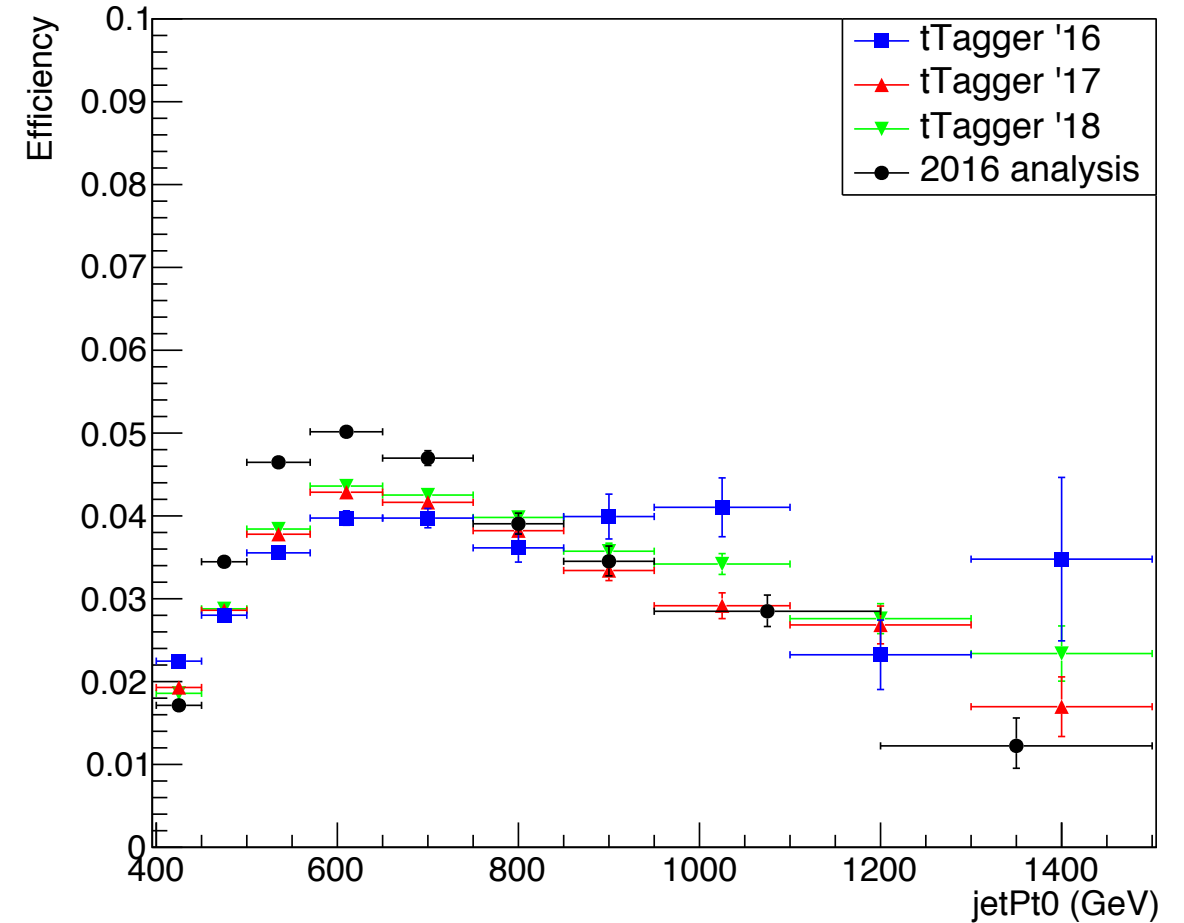
Efficiency and Acceptance Plots

b tagging SF's

without b tagging SF's

Parton Efficiency '16,'17,'18 NominalMC

Parton Efficiency '16,'17,'18 NominalMC
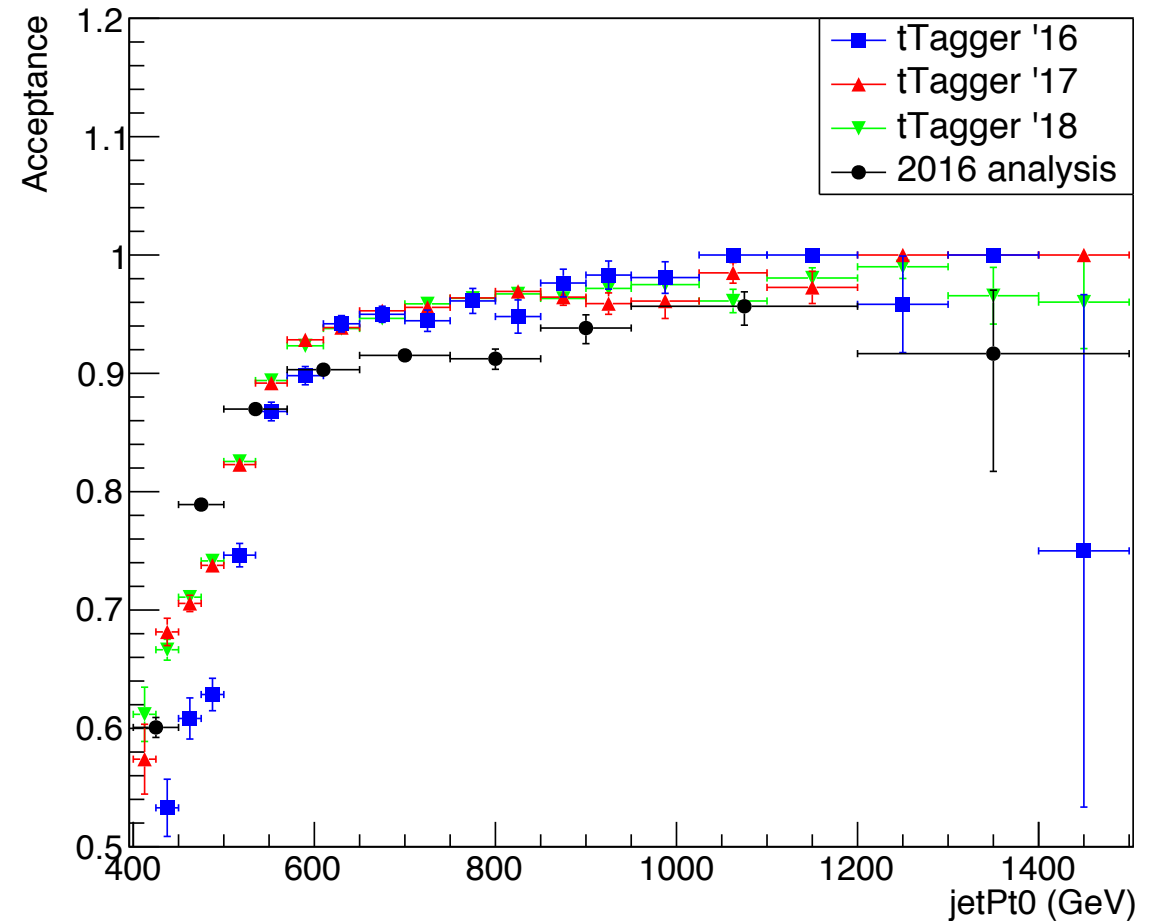
Efficiency and Acceptance Plots

b tagging SF's

without b tagging SF's

Parton Acceptance '16,'17,'18 NominalMC

Parton Acceptance '16,'17,'18 NominalMC
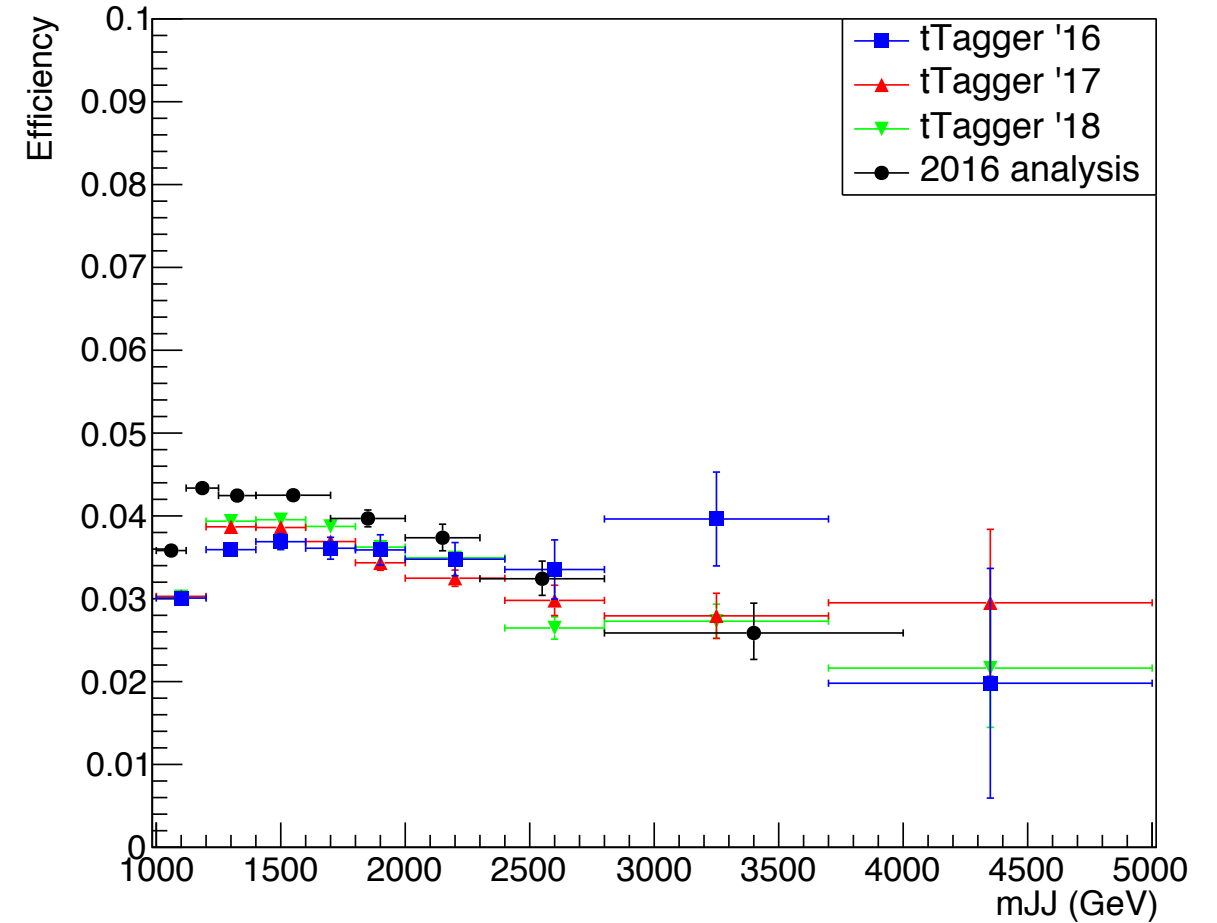
Efficiency and Acceptance Plots

b tagging SF's

without b tagging SF's

Parton Efficiency '16,'17,'18 NominalMC

Parton Efficiency '16,'17,'18 NominalMC
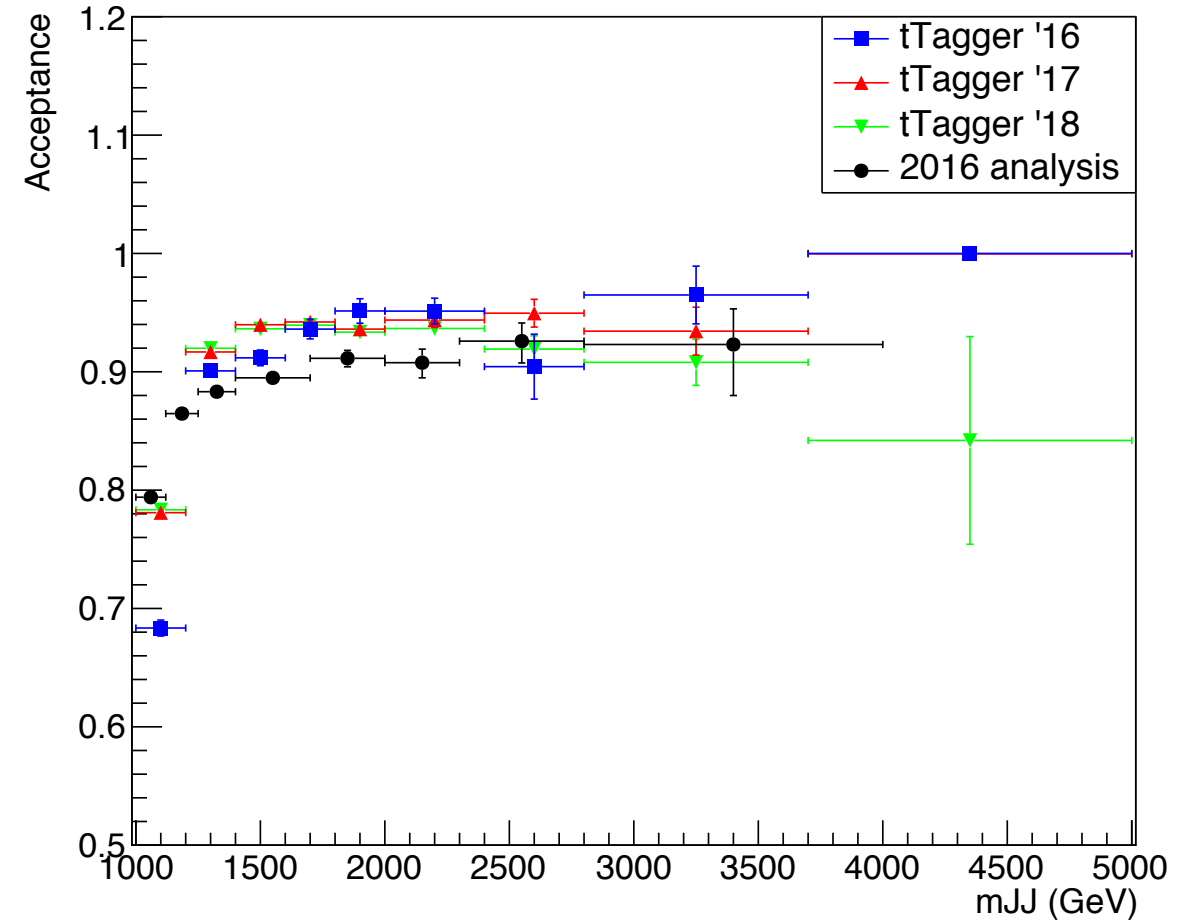
Efficiency and Acceptance Plots

b tagging SF's

without b tagging SF's

Parton Acceptance '16,'17,'18 NominalMC

Parton Acceptance '16,'17,'18 NominalMC
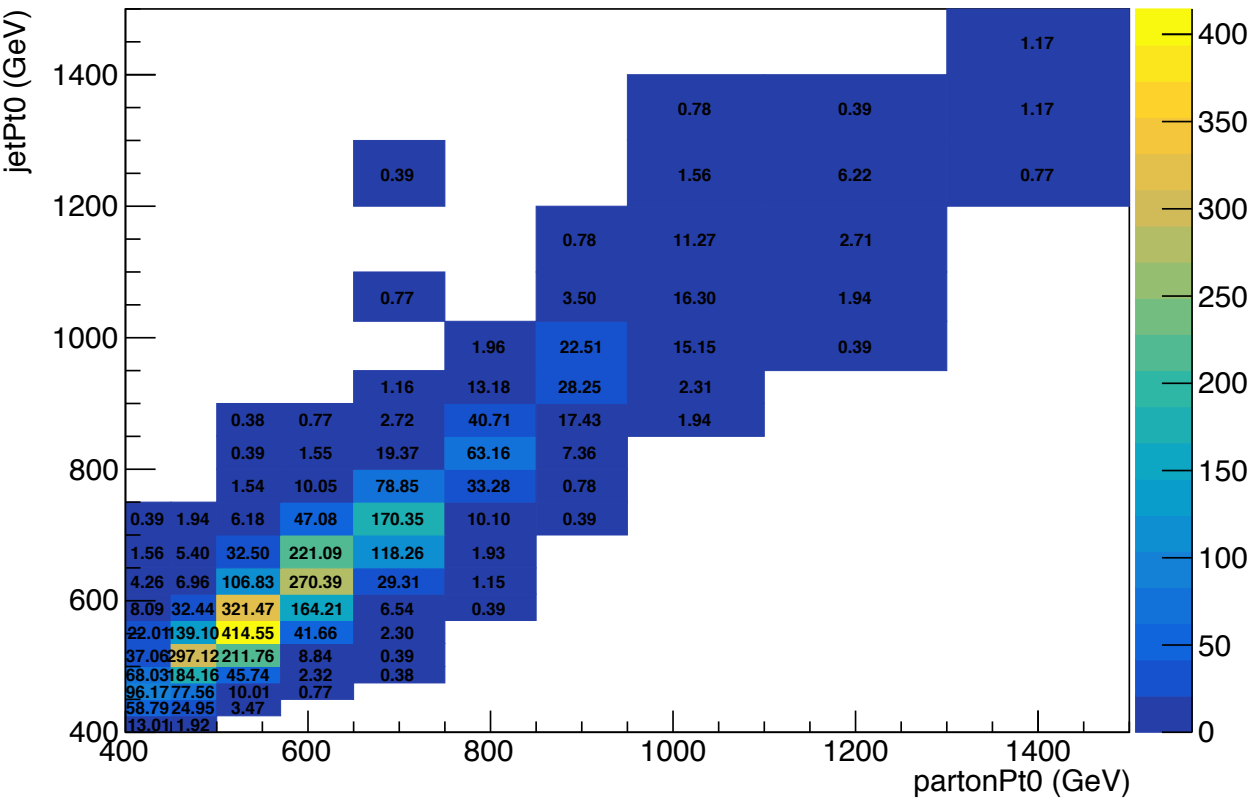
Response Matrices 2016
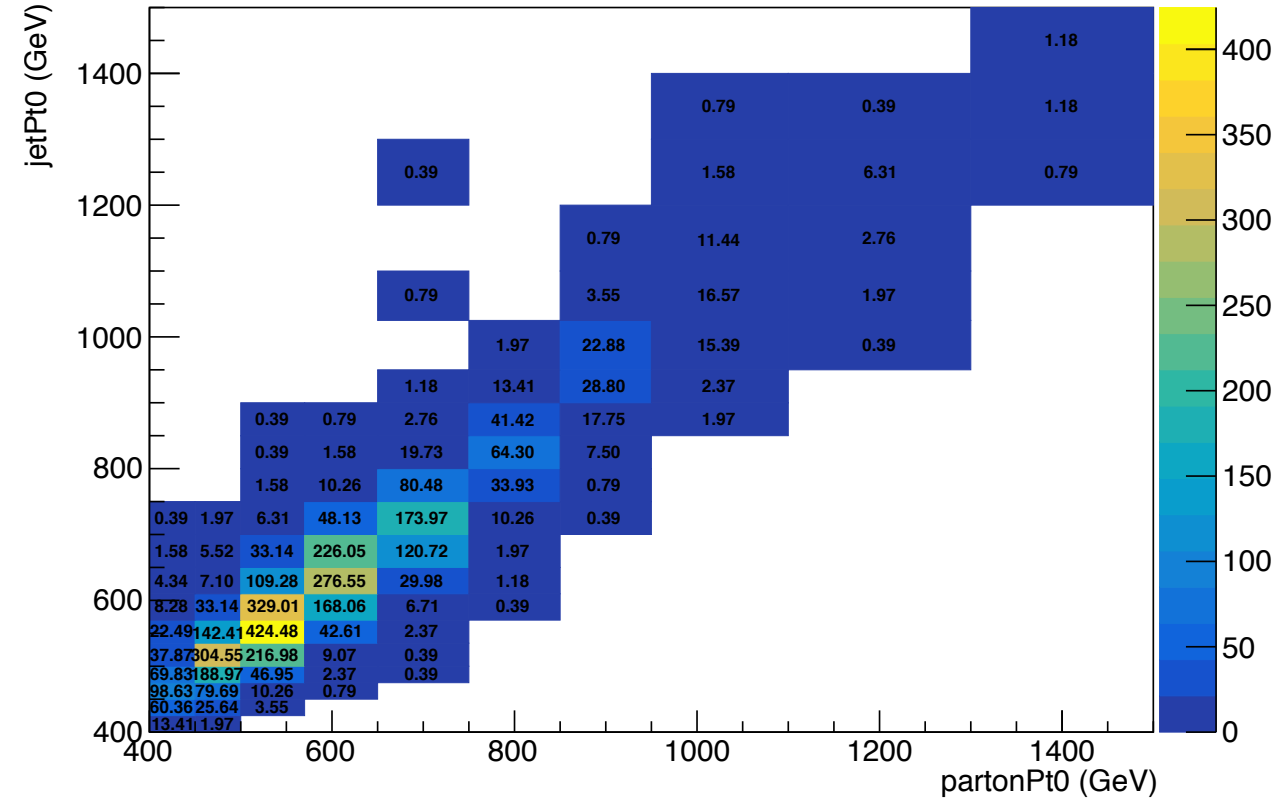
b tagging SF's   without b tagging SF's

Response Reco-Parton jetPt0 2016 NominalMC

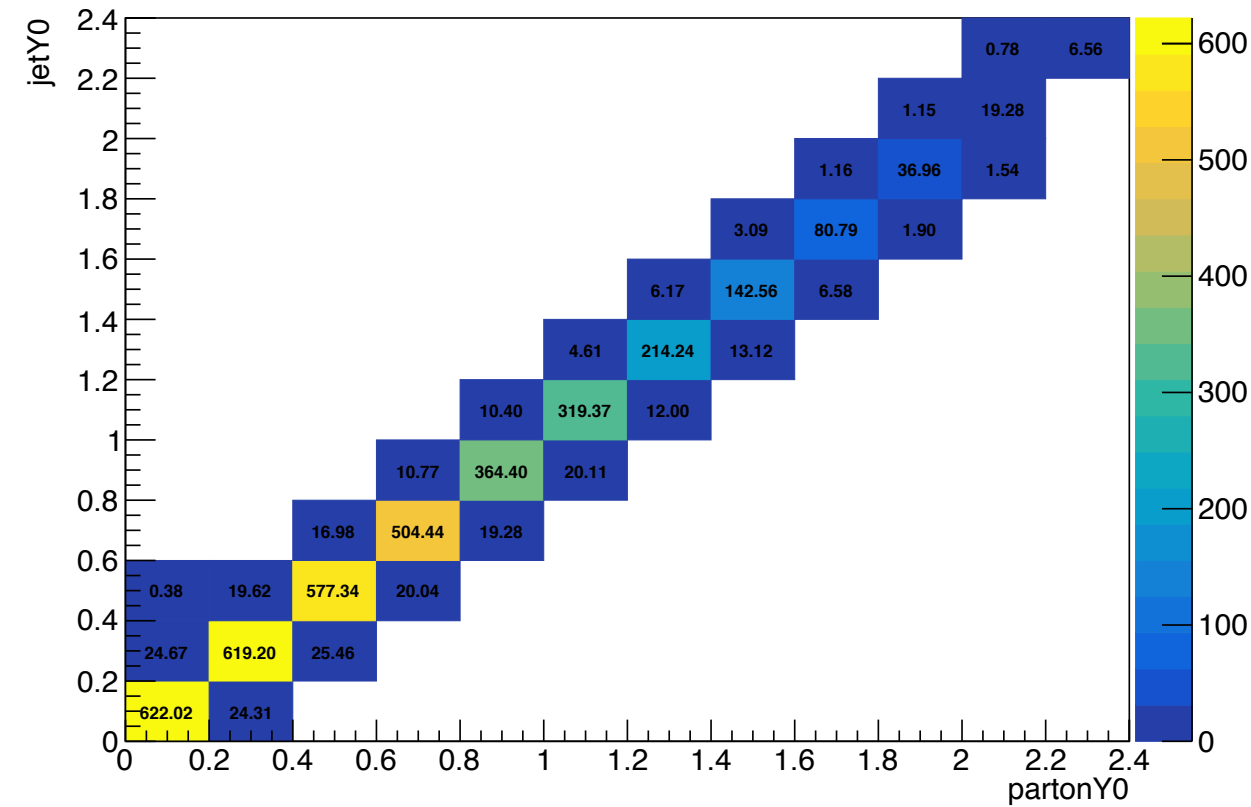Response Reco-Parton jetPt0 2016 NominalMC

Response Matrices 2016

b tagging SF's

without b tagging SF's

Response Reco-Parton jetY0 2016 NominalMC

Response Reco-Parton jetY0 2016 NominalMC

Response Matrices 2017

b tagging SF's

without b tagging SF's

Response Reco-Parton jetPt0 2017 NominalMC

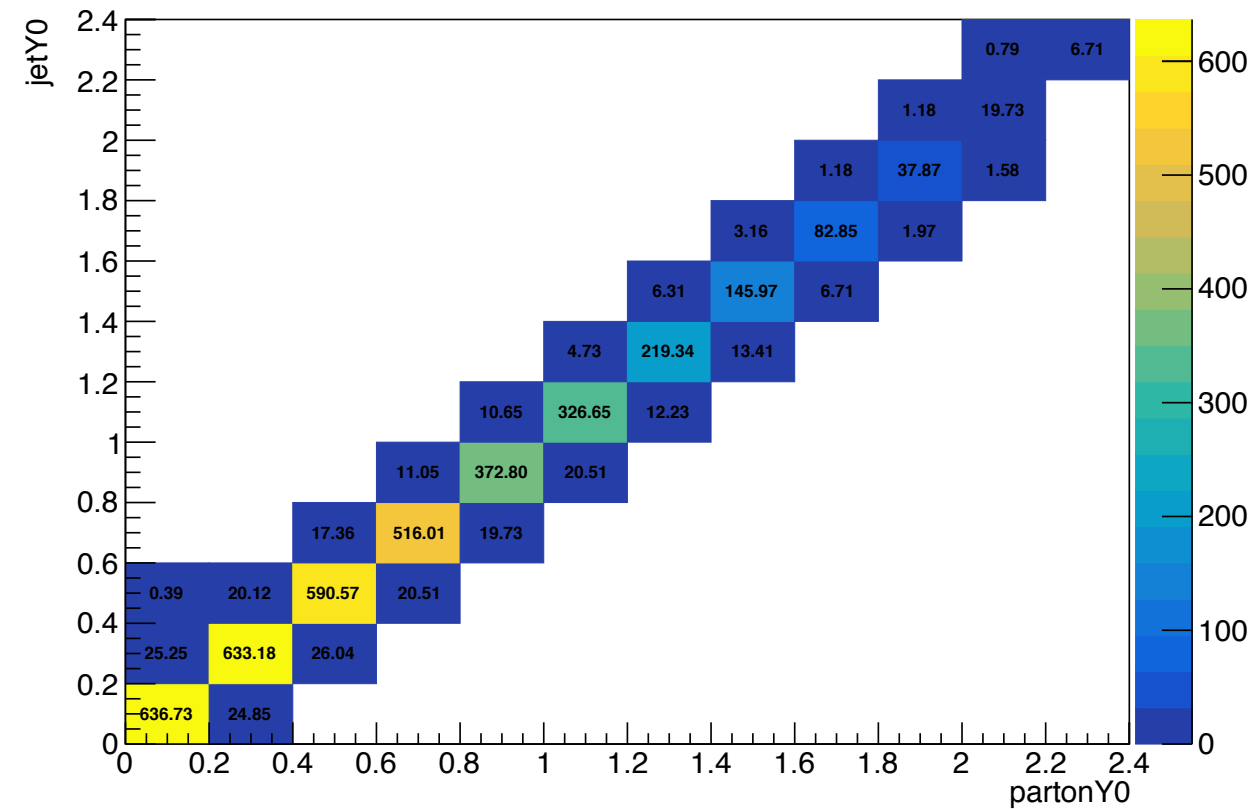Response Reco-Parton jetPt0 2017 NominalMC

Response Matrices 2017

b tagging SF's

without b tagging SF's

Response Reco-Parton jetY0 2017 NominalMC

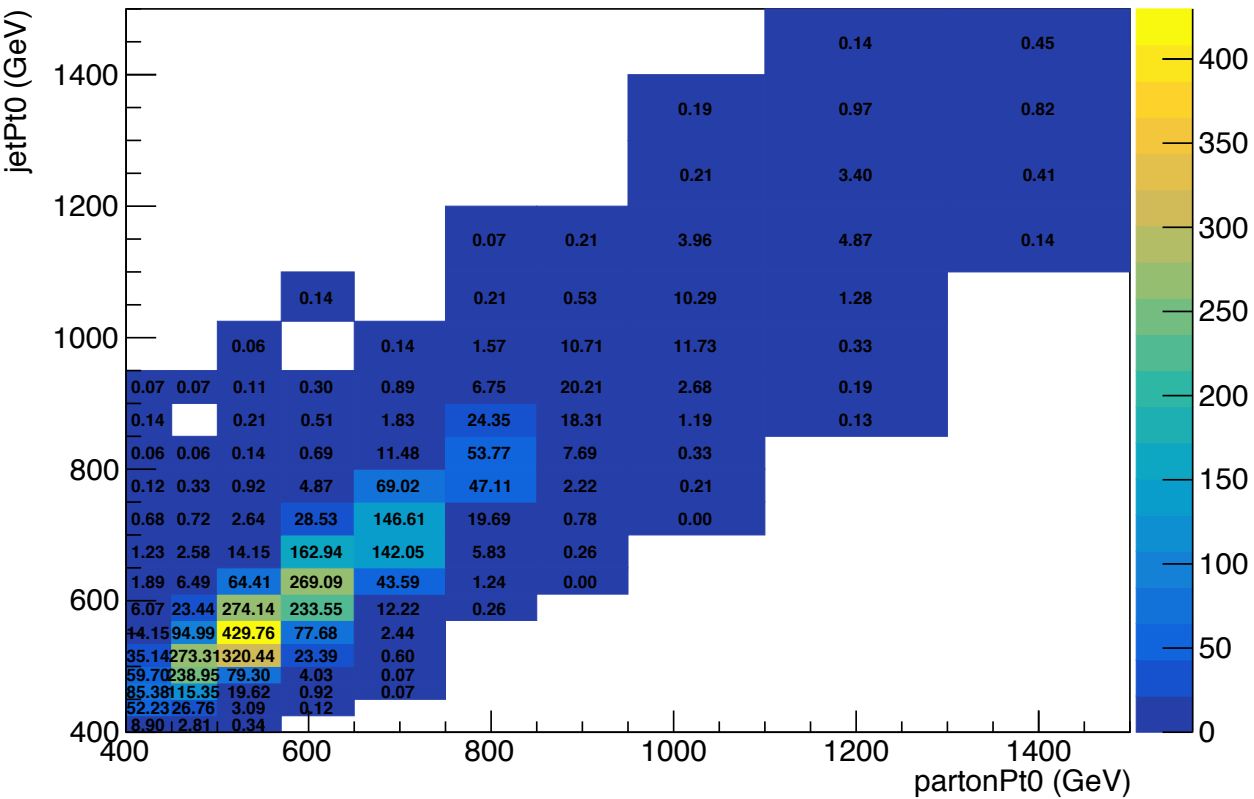

Response Reco-Parton jetY0 2017 NominalMC
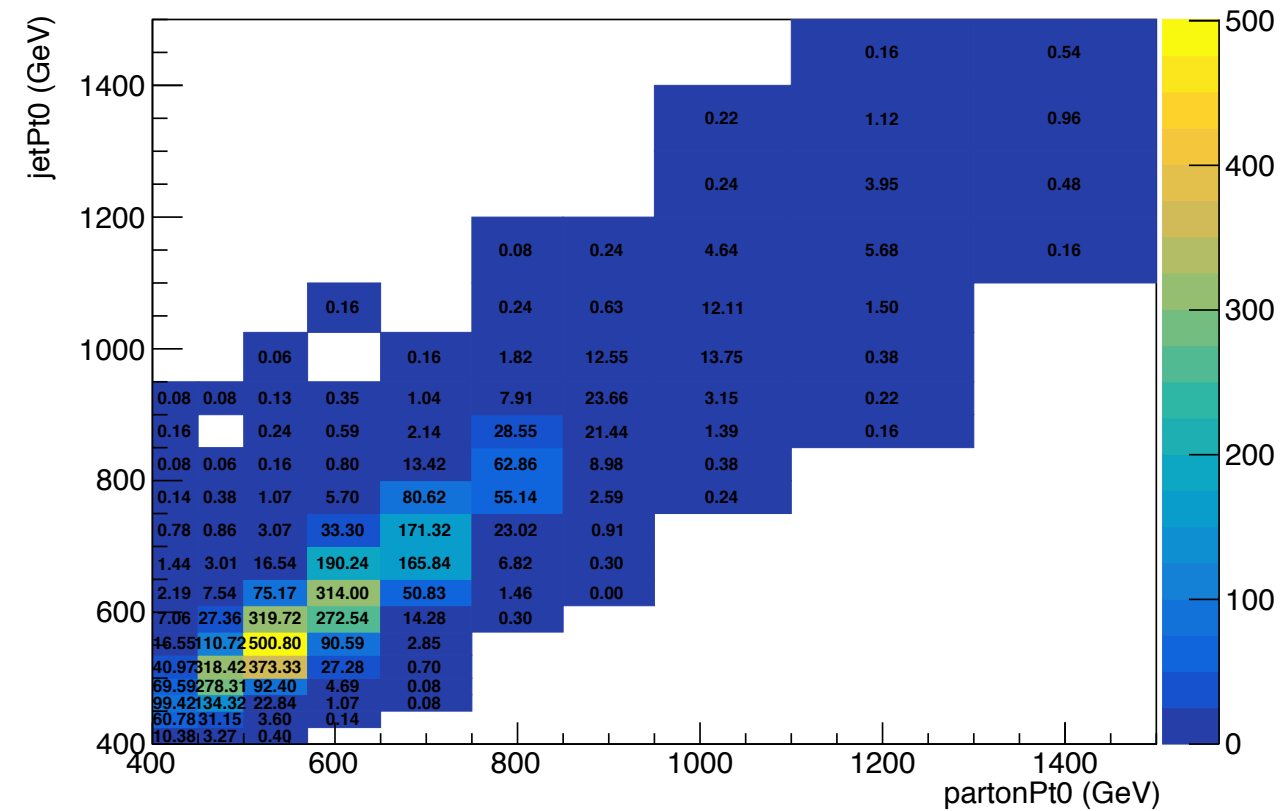
Response Matrices 2018

b tagging SF's

without b tagging SF's

Response Reco-Parton jetPt0 2018 NominalMC
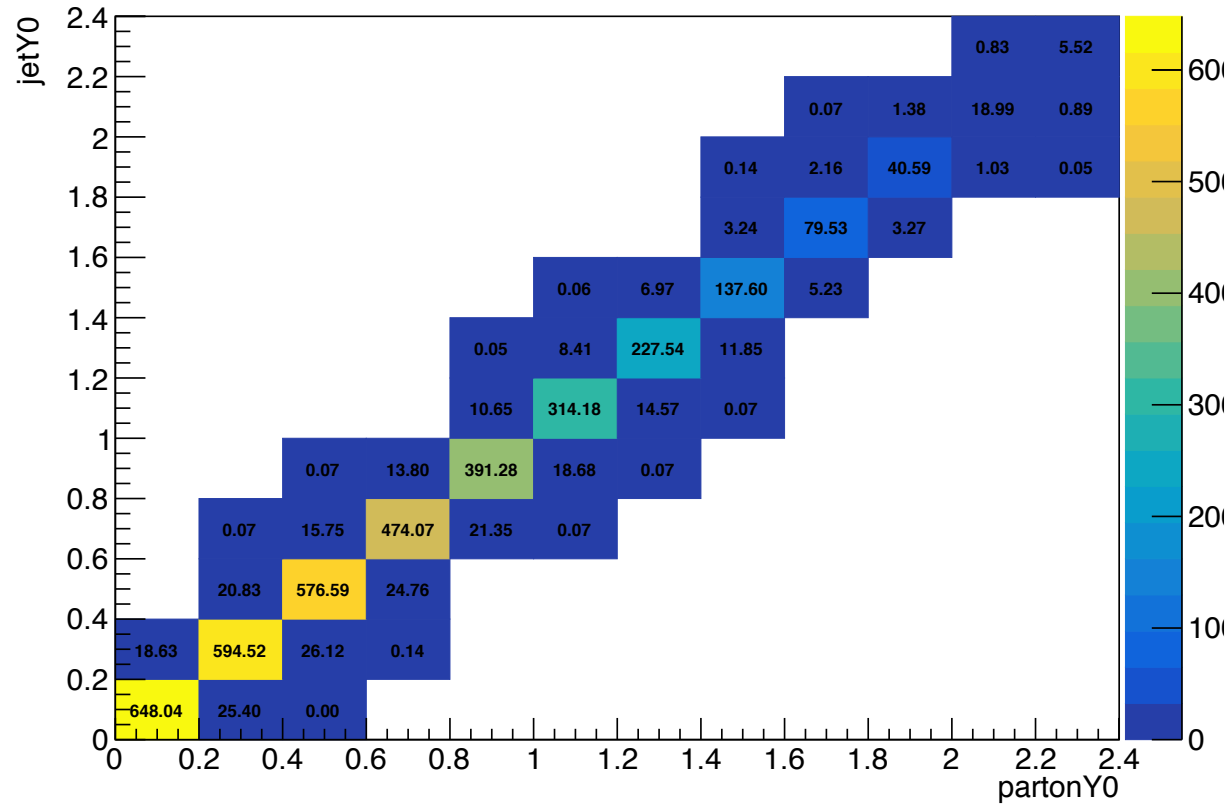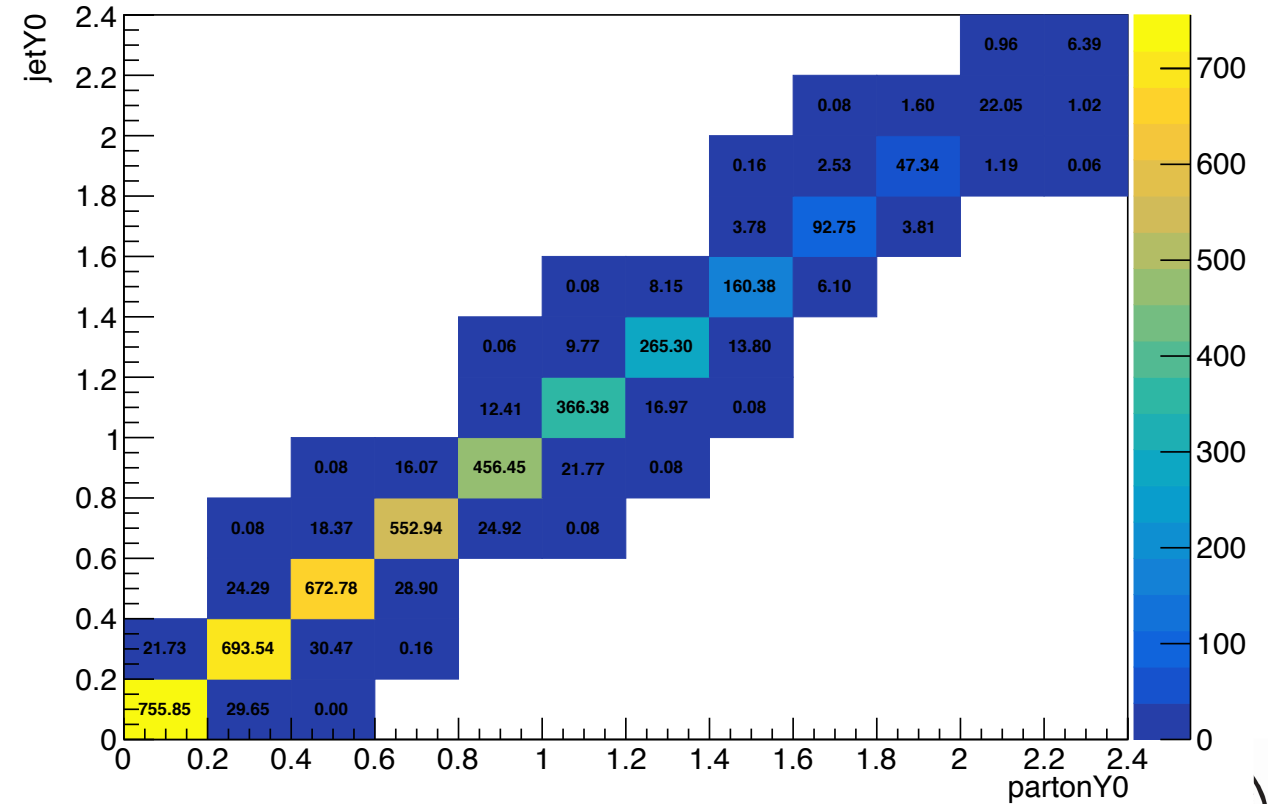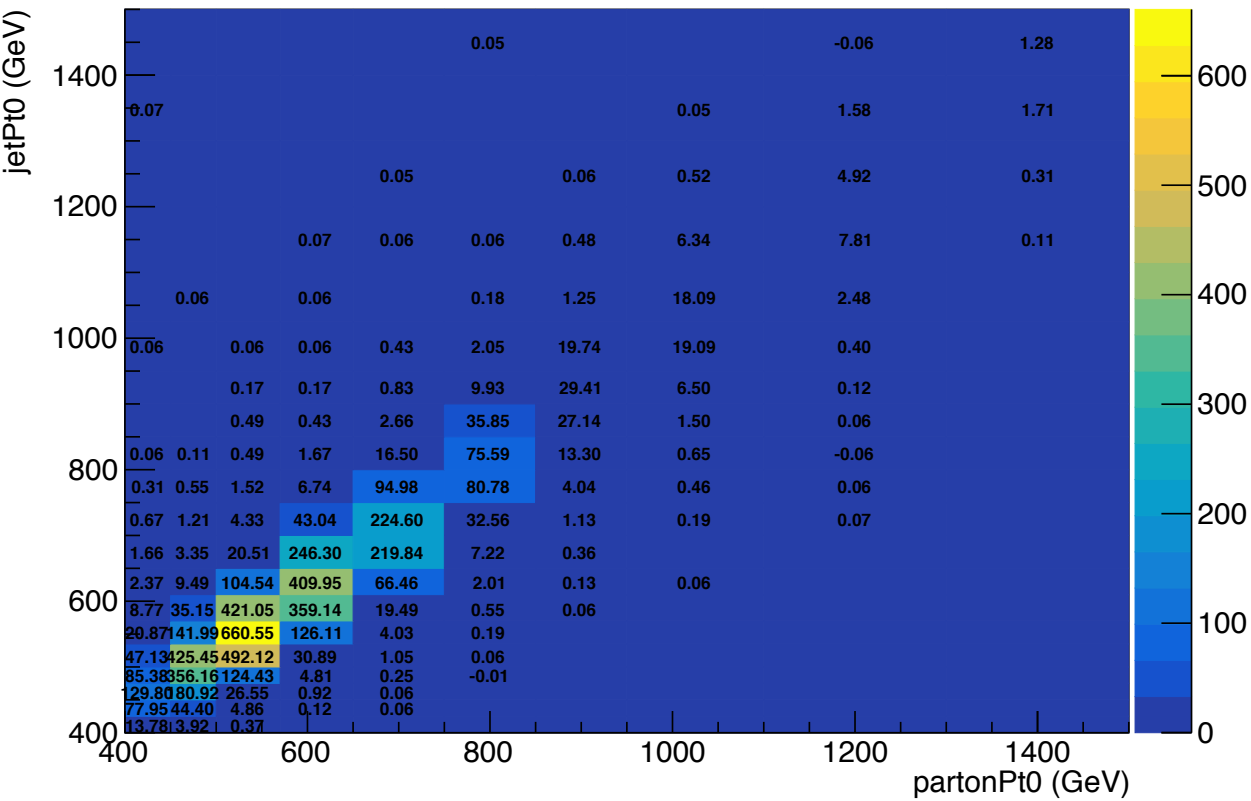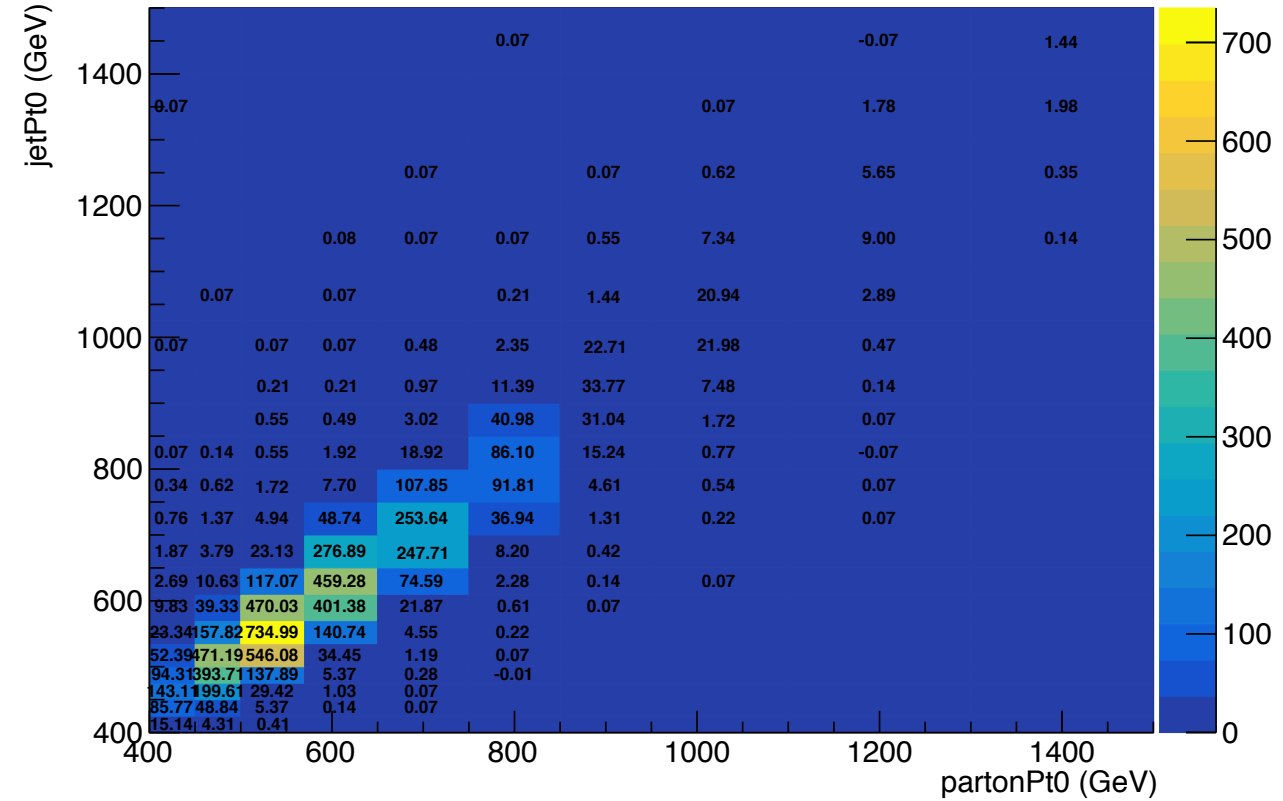

Response Reco-Parton jetPt0 2018 NominalMC

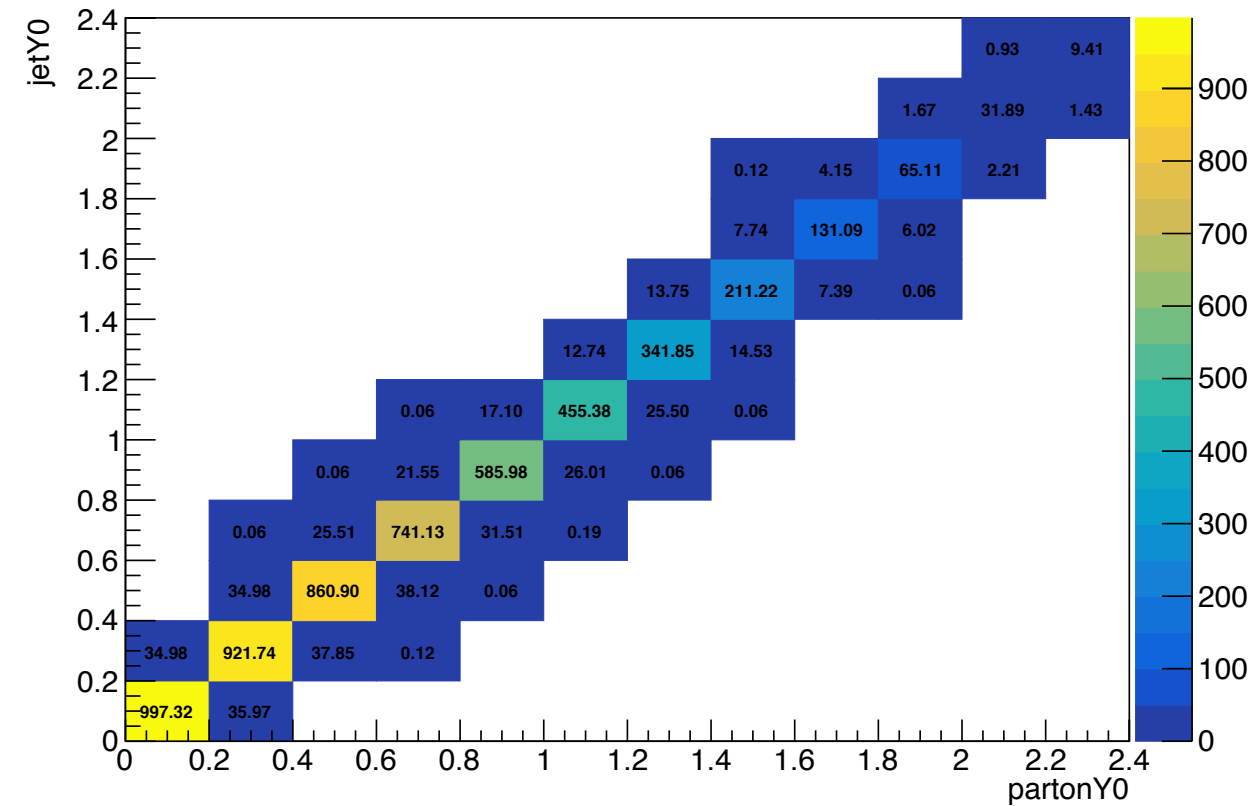# Response Matrices 2018

b tagging SF's

without b tagging SF's

Response Reco-Parton jetY0 2018 NominalMC

Response Reco-Parton jetY0 2018 NominalMC

Contamination Plots Medium WP (CR) 2016

b tagging SF's
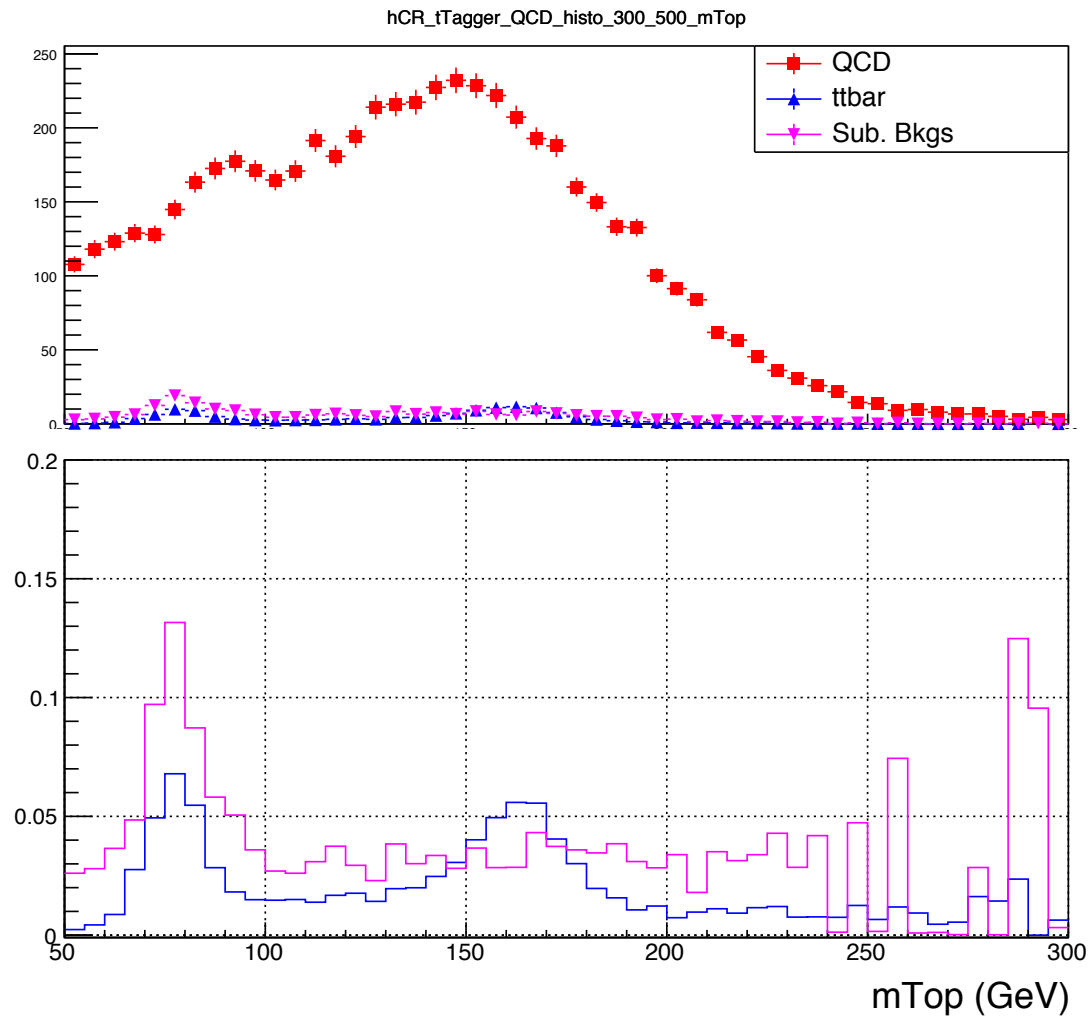
without b tagging SF's

Contamination Plots Medium WP (CR) 2017

b tagging SF's

without b tagging SF's

Contamination Plots Medium WP (CR) 2018

b tagging SF's

without b tagging SF's

Contamination Plots Medium WP (CR, SR) 2018

Comment

Shapes and in general contamination is NOT affected by btagging by Scale factors

- Both SR and Control Region use the Medium btag WP.
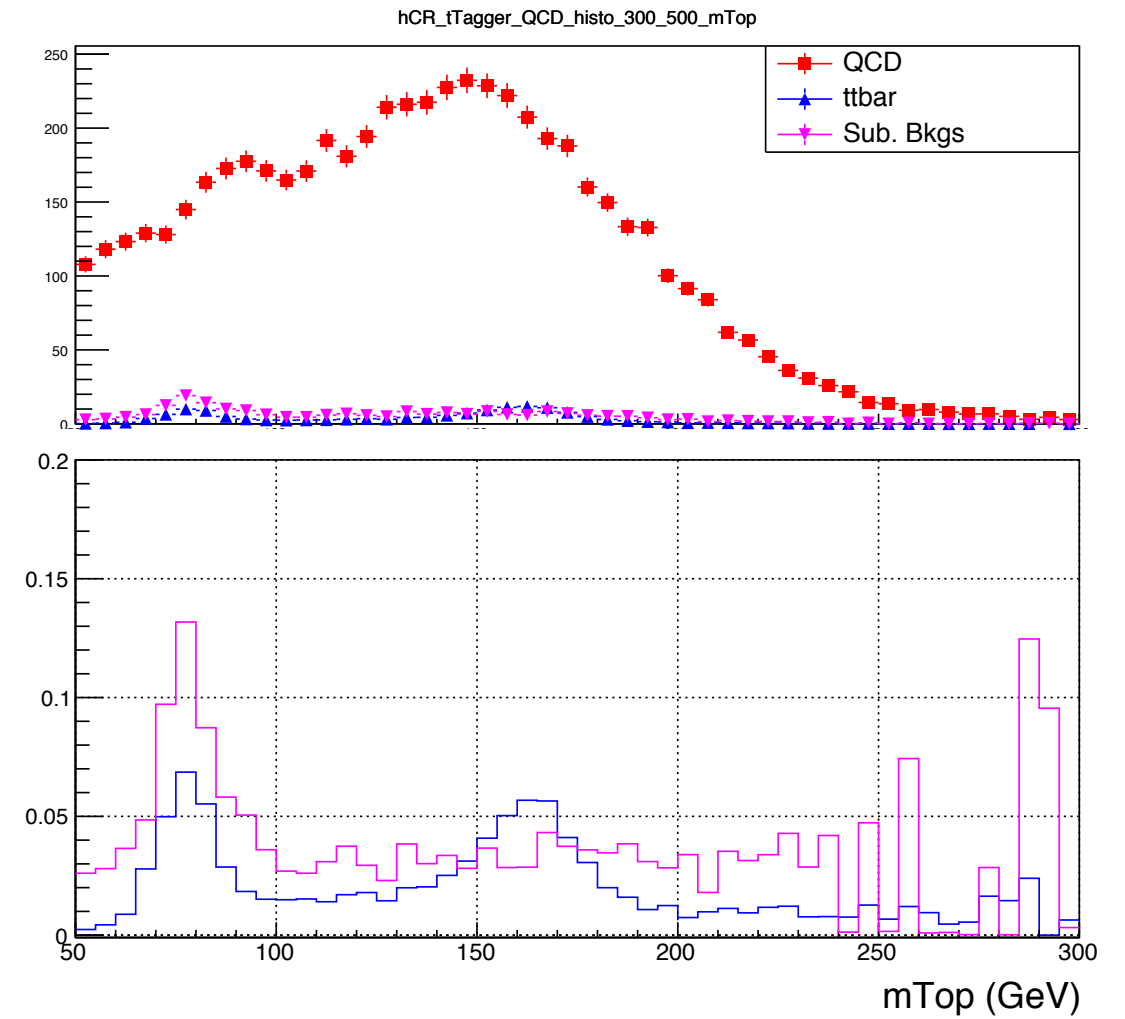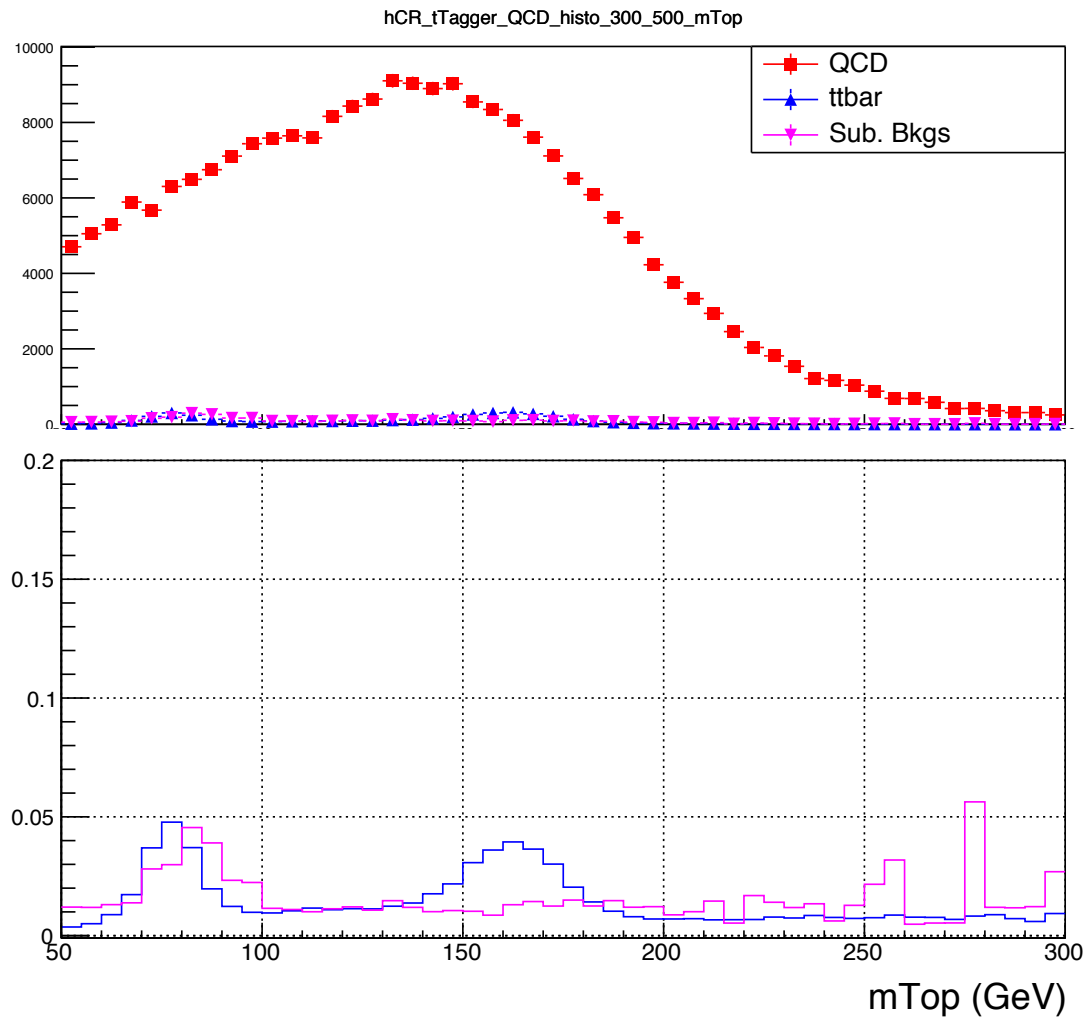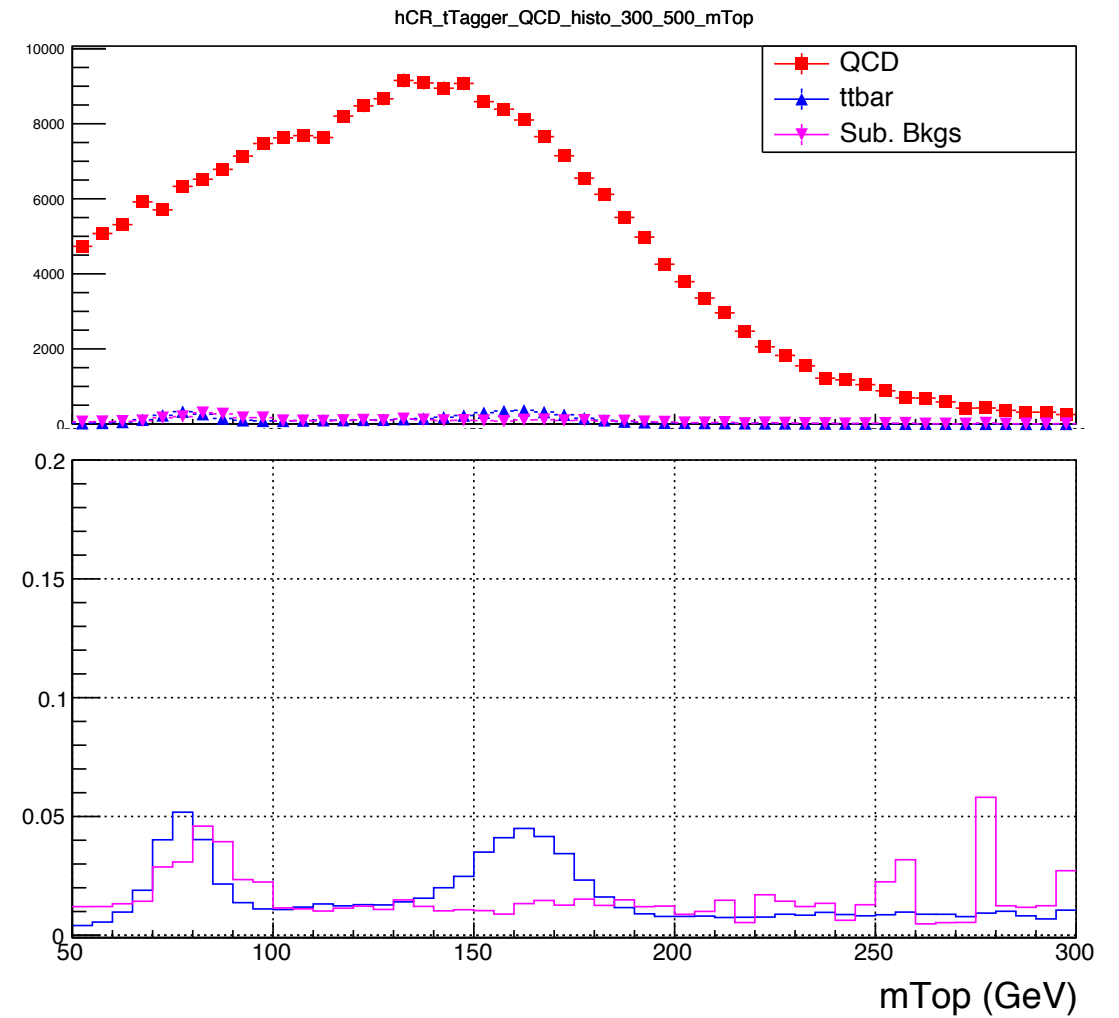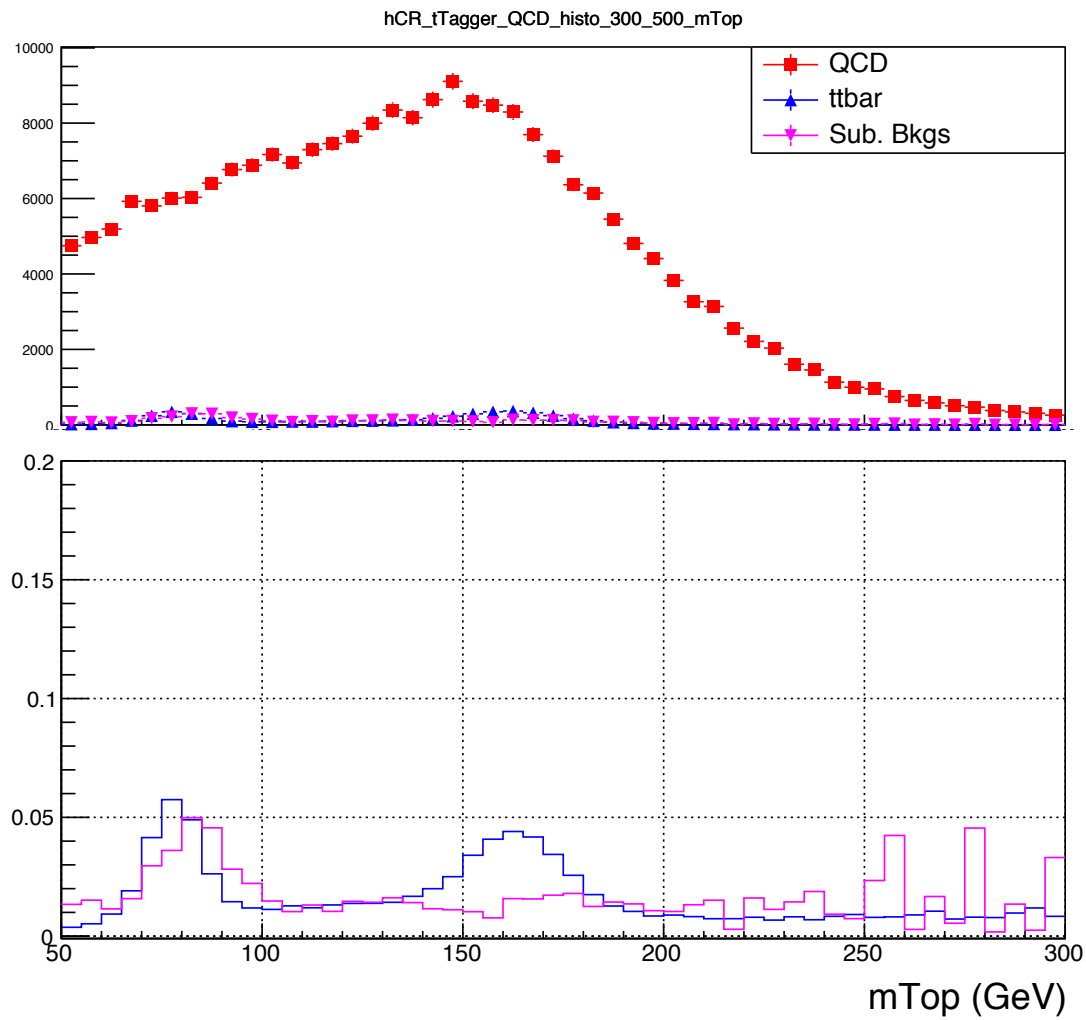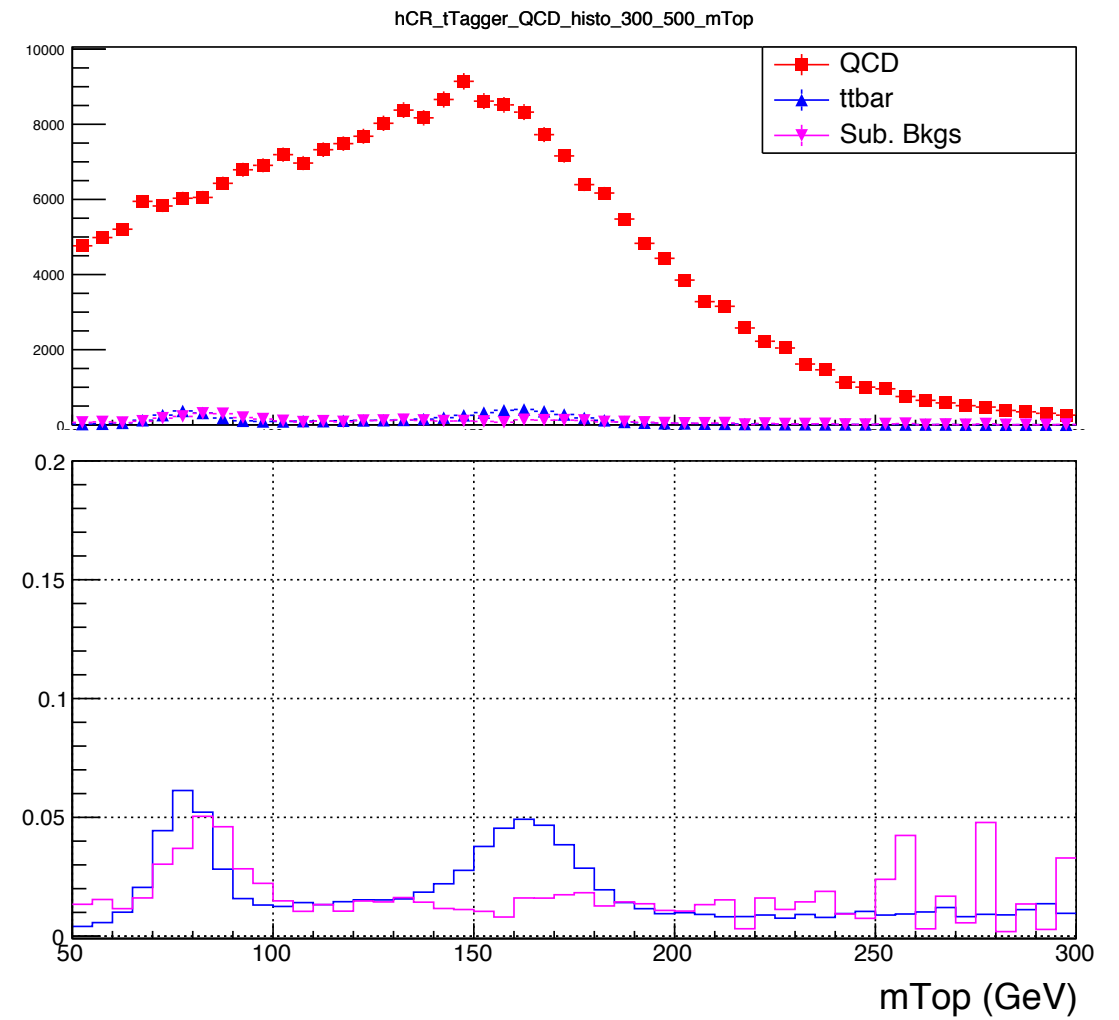- Intuition is to remove the ttbar and subdominant bkg contribution from the data Control Region

$$QCD_0(m^t) = D_0(m^t) - T_0(m^t) - Sub_0(m^t)$$

A RooPlot of "mTop"

Without tag SF:

Floating Parameter	FinalValue +/-	Error
kMassResol	9.2245e-01 +/-	2.72e-02
kMassScale	9.9906e-01 +/-	2.01e-03
kQCD_2b	6.8926e-02 +/-	5.06e-02
nFitBkg_2b	2.5236e+02 +/-	1.44e+02
nFitQCD_2b	2.9886e+03 +/-	1.73e+02
nFitSig2b	5.2694e+03 +/-	1.65e+02

Signal strength: r = 0.671244 ± 0.0252439 (old)

With b tag sf:

Floating Parameter	FinalValue +/-	Error
kMassResol	9.2251e-01 +/-	2.73e-02
kMassScale	9.9891e-01 +/-	2.01e-03
kQCD_2b	6.9753e-02 +/-	5.26e-02
nFitBkg_2b	2.4472e+02 +/-	1.47e+02
nFitQCD_2b	2.9890e+03 +/-	1.74e+02
nFitSig2b	5.2763e+03 +/-	1.67e+02

Signal strength: r = 0.686668 ± 0.0263103 (new)
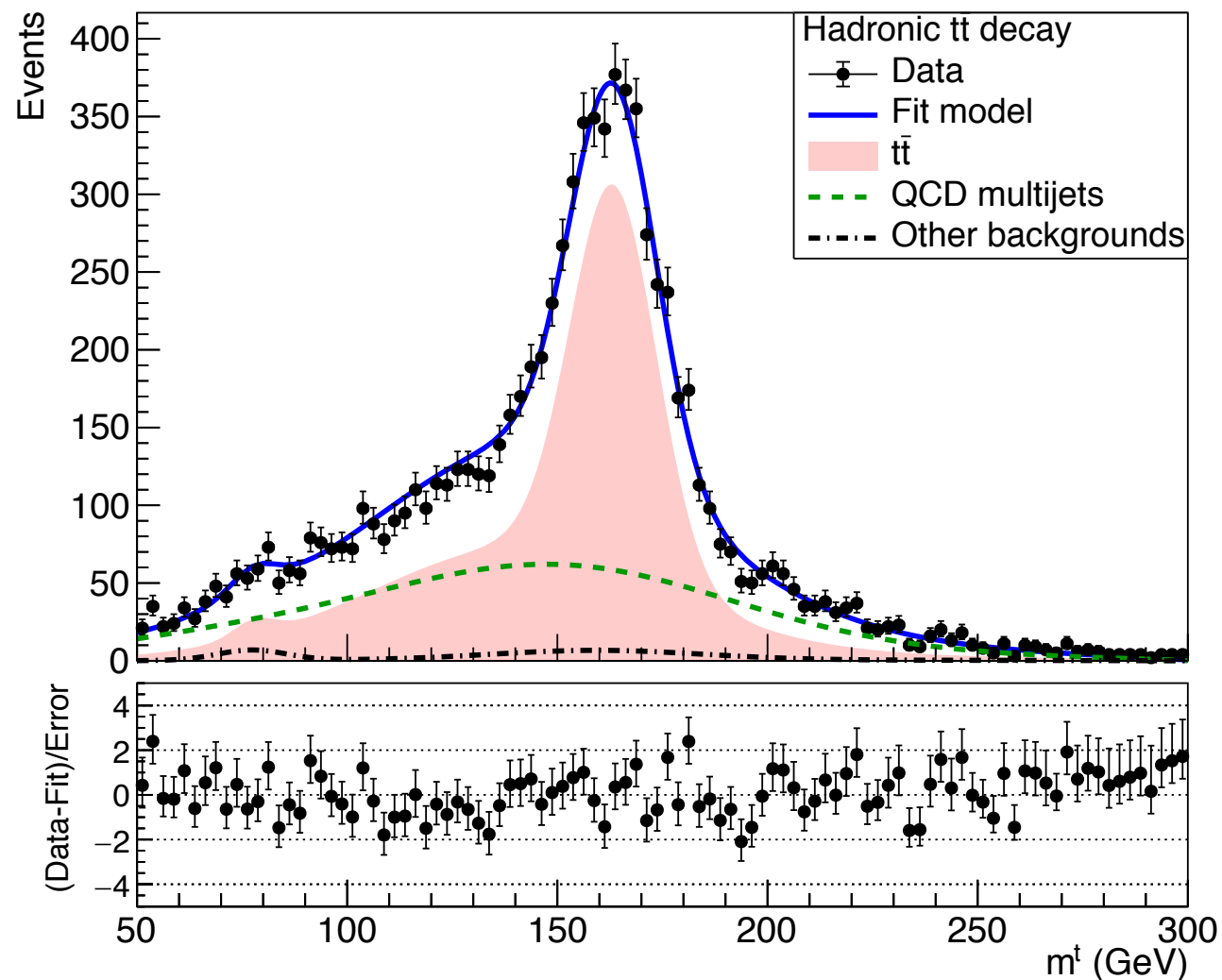
Simple Mass Fit 2017

Without b tag SF:

```
  Floating Parameter    FinalValue +/-   Error
  ------------------    -----------------------
       kMassResol       1.0990e+00 +/-  4.05e-02
       kMassScale       9.8328e-01 +/-  2.64e-03
          kQCD_2b       1.6702e-02 +/-  7.79e-03
       nFitBkg_2b       6.3994e+02 +/-  2.81e+02
       nFitQCD_2b       2.0219e+03 +/-  3.23e+02
        nFitSig2b       4.8080e+03 +/-  1.51e+02
```
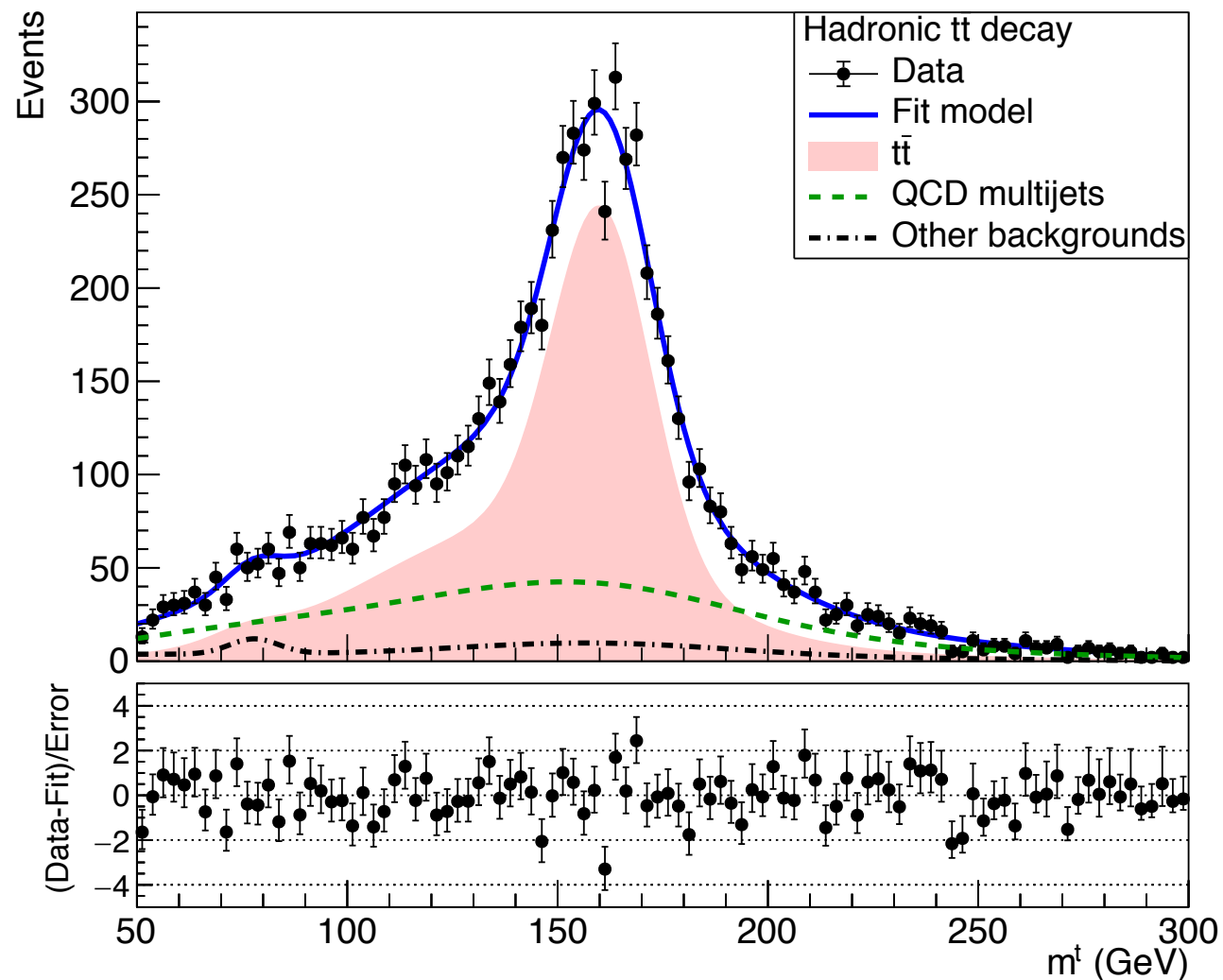
Signal strength: r = 0.553099 ± 0.0198563 (old)

With b tag SF:

```
  Floating Parameter    FinalValue +/-   Error
  ------------------    -----------------------
       kMassResol       1.0998e+00 +/-  4.02e-02
       kMassScale       9.8340e-01 +/-  2.66e-03
          kQCD_2b       1.6593e-02 +/-  7.44e-03
       nFitBkg_2b       4.9791e+02 +/-  2.68e+02
       nFitQCD_2b       2.1662e+03 +/-  3.11e+02
        nFitSig2b       4.8059e+03 +/-  1.50e+02
```

Signal strength: r = 0.644361 ± 0.023851 (new)

A RooPlot of "mTop"

Simple Mass Fit 2018

A RooPlot of "mTop"

Without b tag SF:

| Floating Parameter	FinalValue +/-	Error
kMassResol	1.0171e+00 +/-	2.87e-02
kMassScale	9.8961e-01 +/-	1.92e-03
kQCD_2b	1.3178e-02 +/-	3.01e-03
nFitBkg_2b	3.0164e+02 +/-	2.73e+02
nFitQCD_2b	4.7747e+03 +/-	3.04e+02
nFitSig2b	7.7140e+03 +/-	1.85e+02

Signal strength: r = 0.615816 ± 0.017298 (old)

With b tag SF:

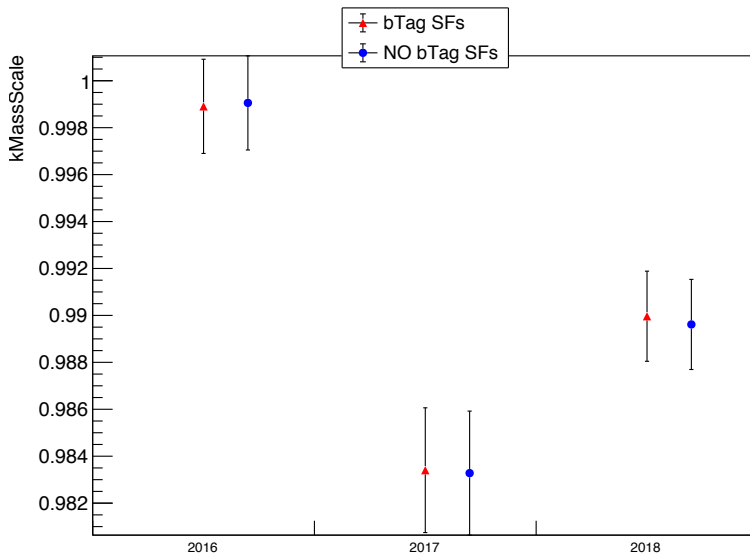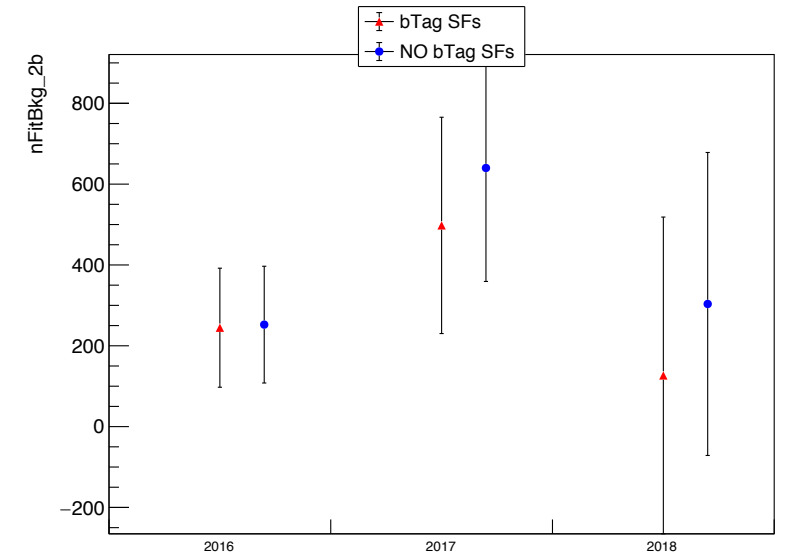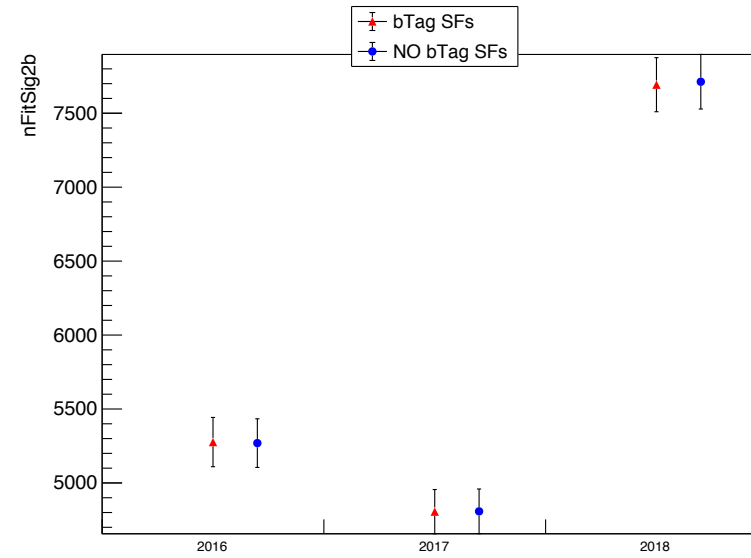| Floating Parameter	FinalValue +/-	Error
kMassResol	1.0153e+00 +/-	2.83e-02
kMassScale	9.8997e-01 +/-	1.92e-03
kQCD_2b	1.2803e-02 +/-	2.82e-03
nFitBkg_2b	1.2661e+02 +/-	3.92e+02
nFitQCD_2b	4.9706e+03 +/-	2.95e+02
nFitSig2b	7.6928e+03 +/-	1.83e+02

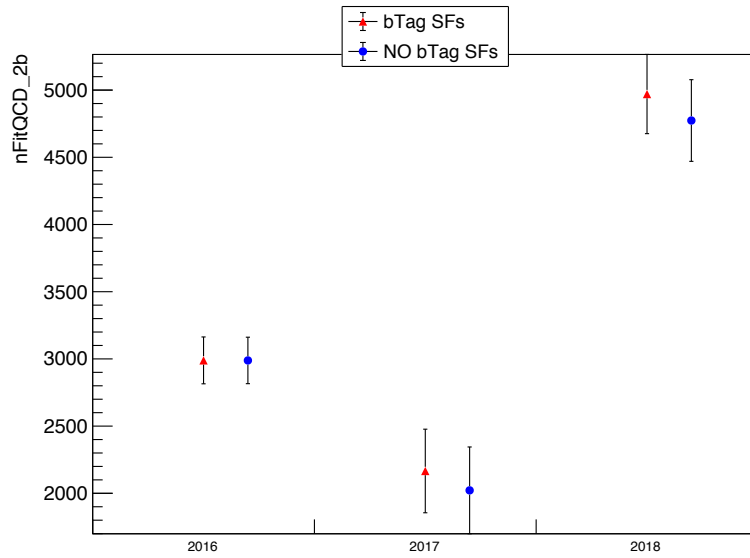**Signal strength: r = 0.686214 ± 0.019771**
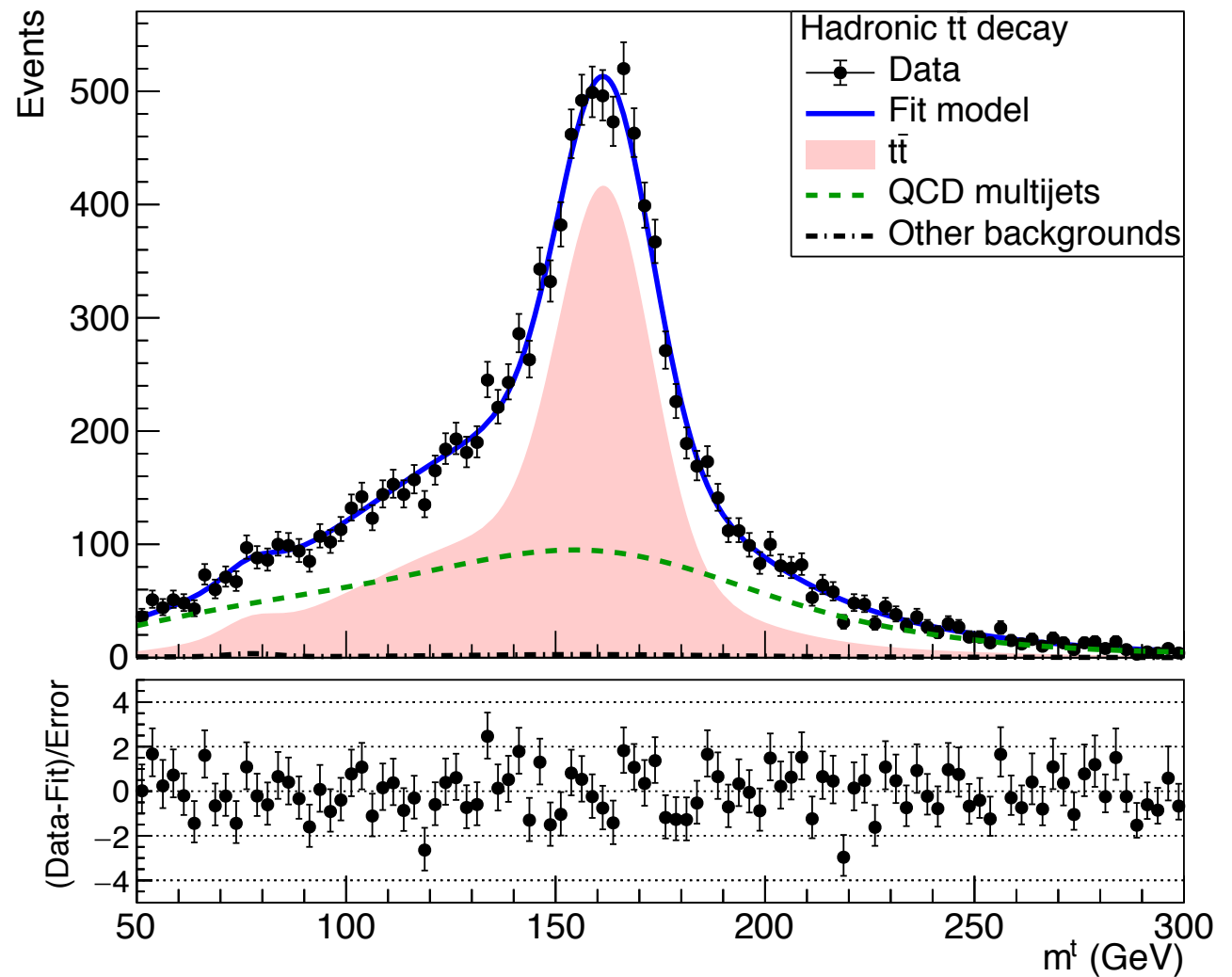
Signal Strength Results
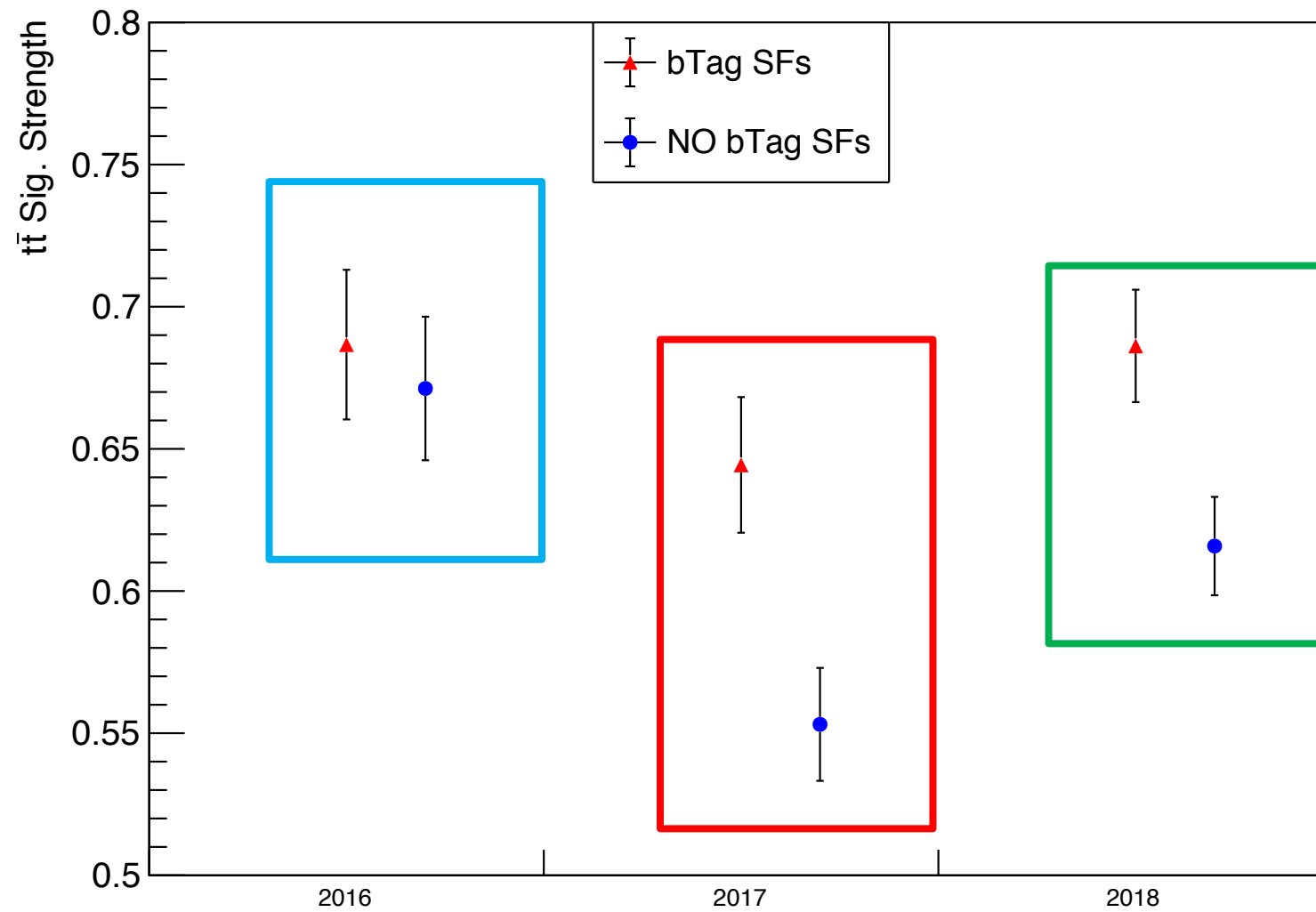
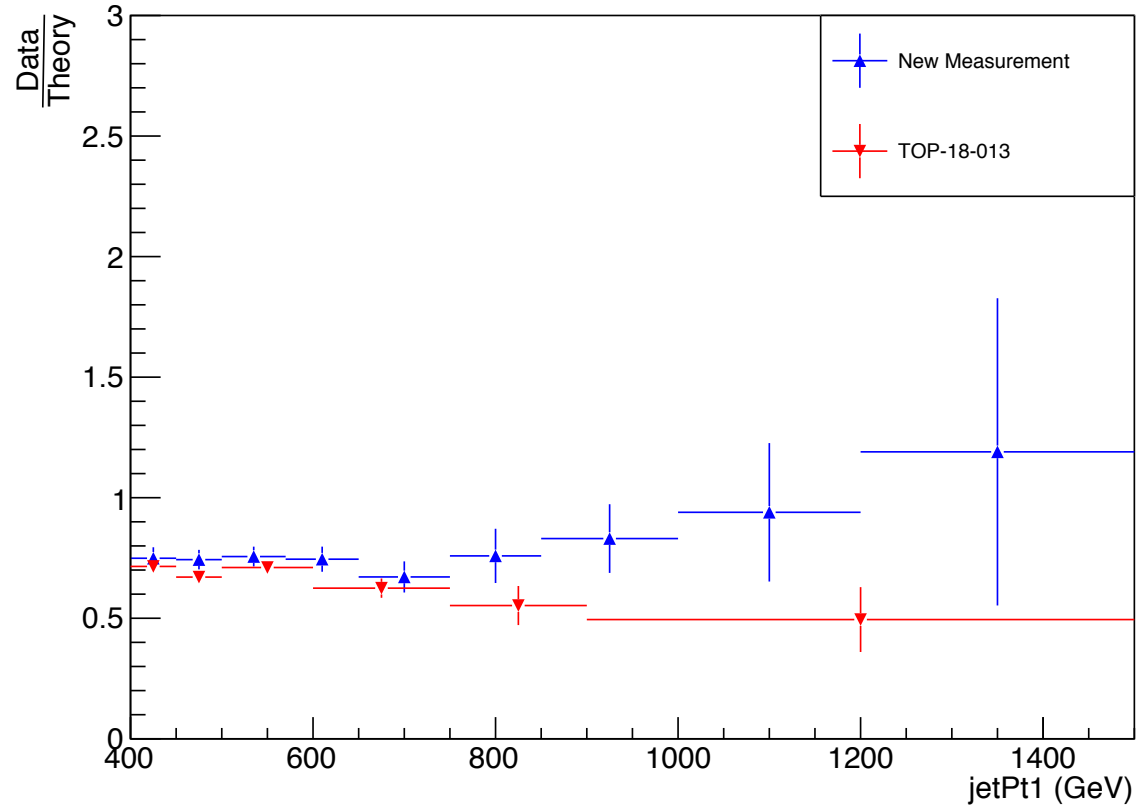# Fit Params Results Comparison
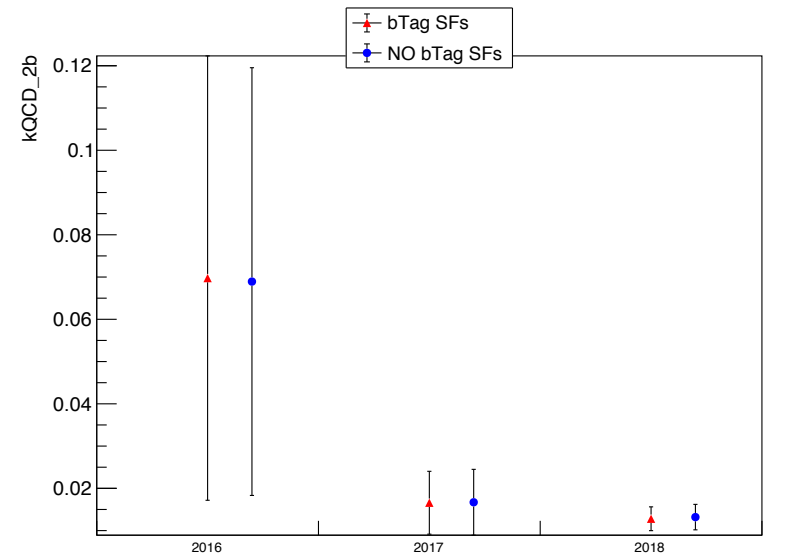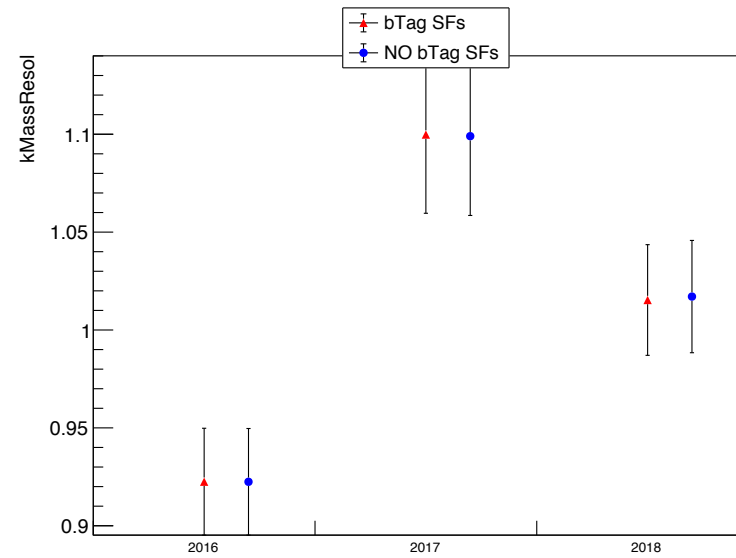
Signal Extraction 2016

b tagging SF's

without b tagging SF's

Fiducial DataOverMC ratio (2016, TOP18013)

Fiducial DataOverMC ratio (2016, TOP18013)

Signal Extraction 2016

b tagging SF's   without b tagging SF's
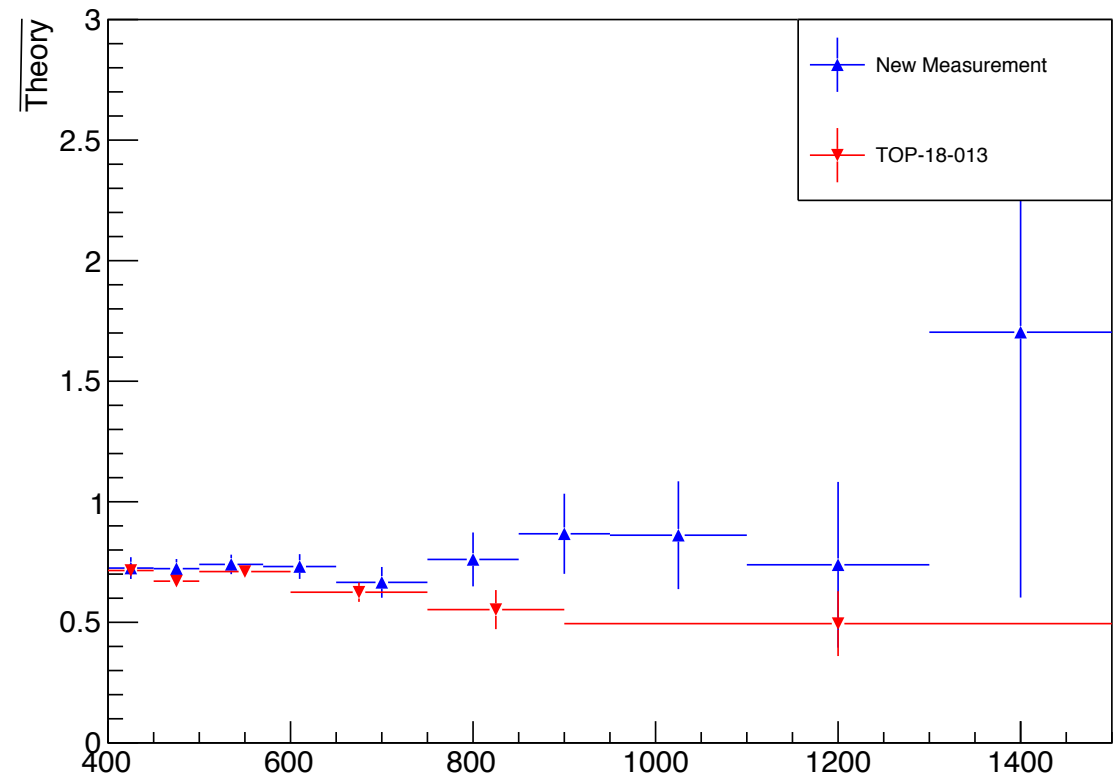
Fiducial DataOverMC ratio (2016, TOP18013)   Fiducial DataOverMC ratio (2016, TOP18013)
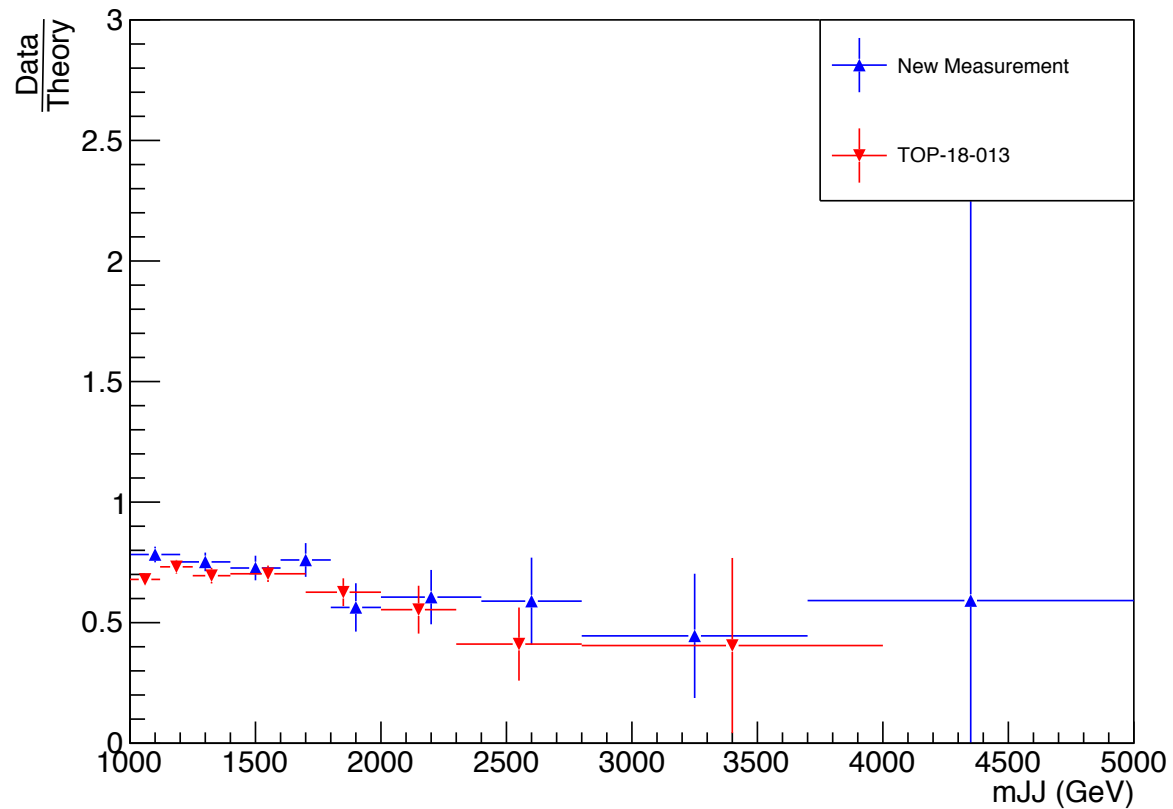
Signal Extraction 2017

b tagging SF's

without b tagging SF's

Signal Extraction 2017

b tagging SF's

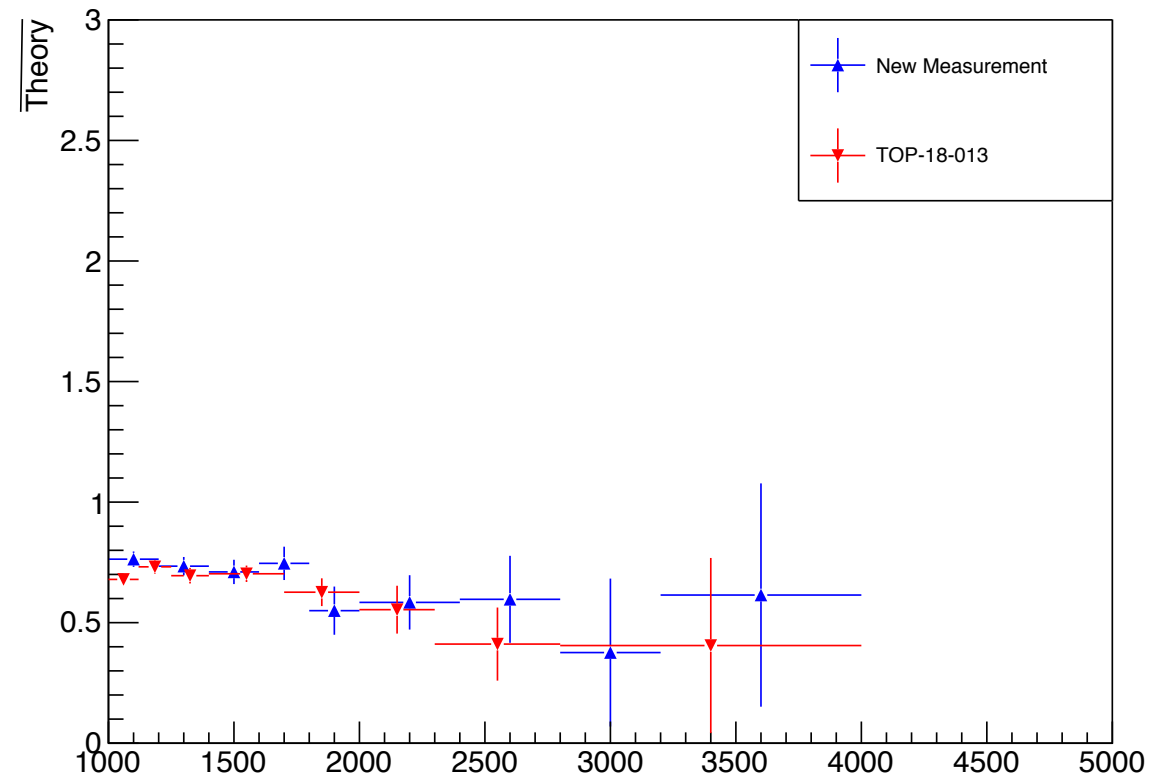without b tagging SF's

Fiducial DataOverMC ratio (2017, TOP18013)
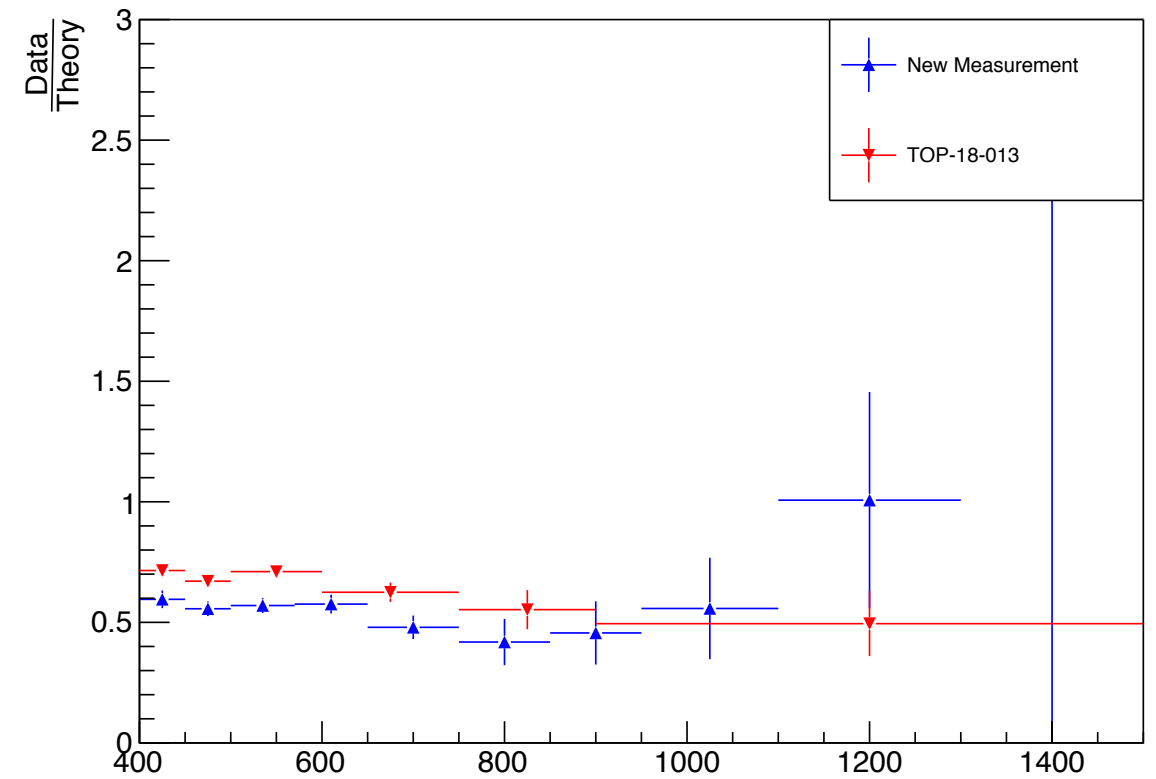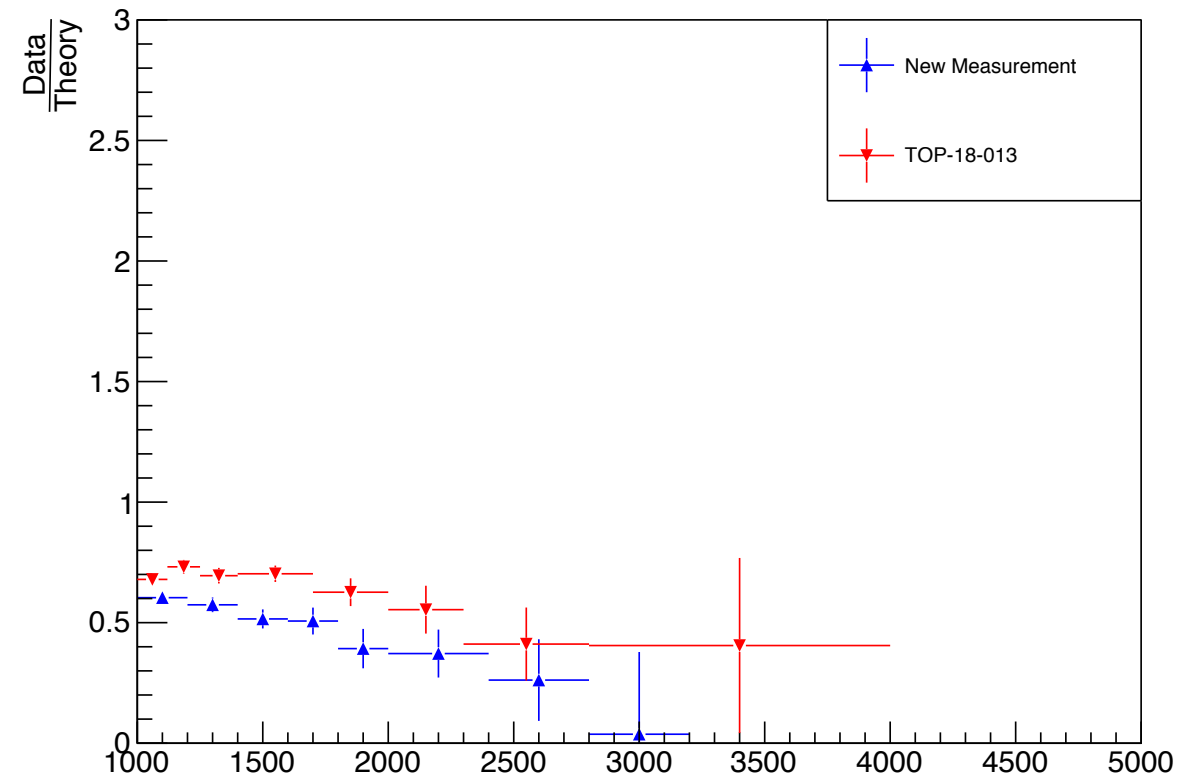
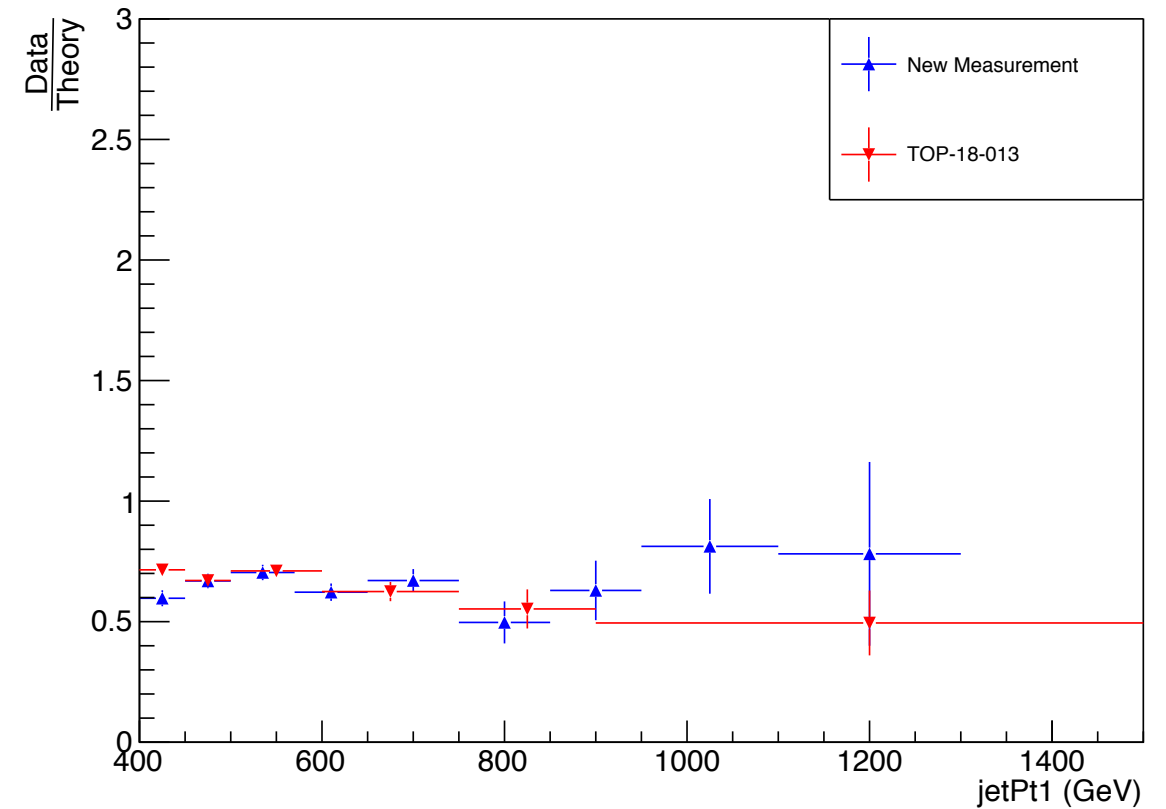Fiducial DataOverMC ratio (2017, TOP18013)

Signal Extraction 2018
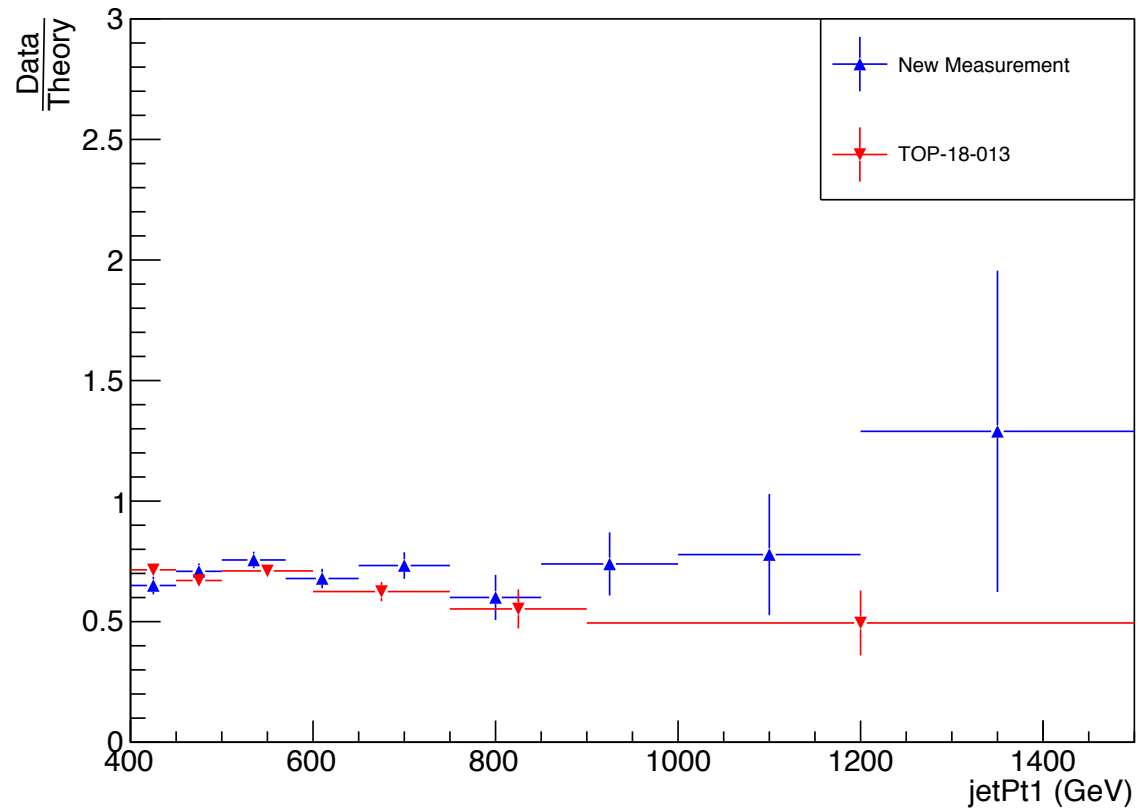
b tagging SF's

without b tagging SF's

Signal Extraction 2018

b tagging SF's

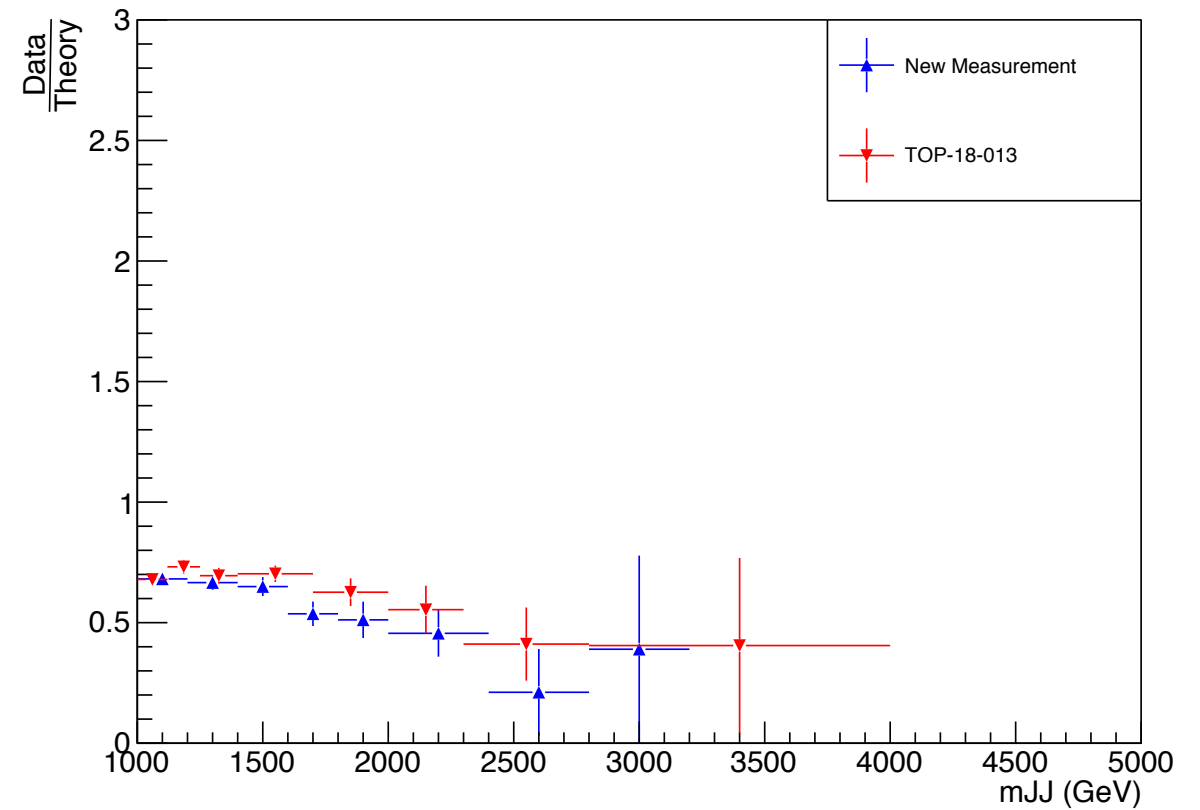without b tagging SF's

Fiducial DataOverMC ratio (2018, TOP18013)
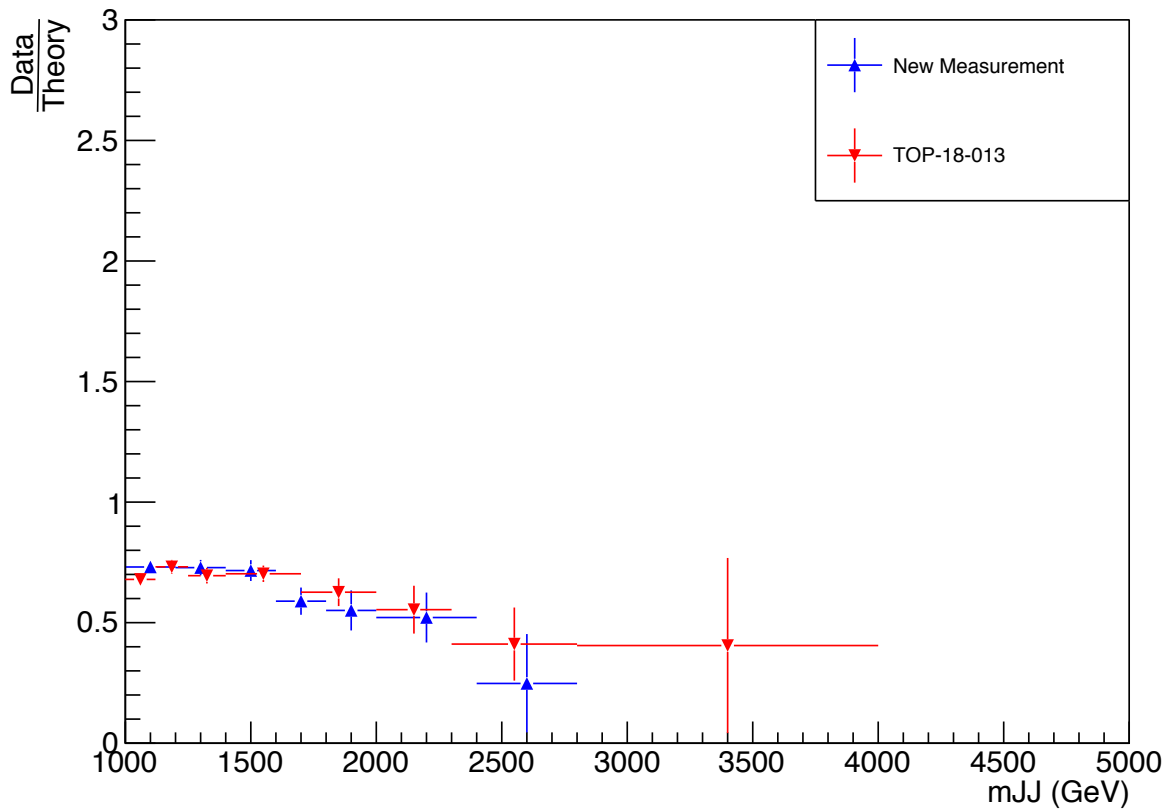
Fiducial DataOverMC ratio (2018, TOP18013)

Tag And Probe

- <u>Top Tagger Scale Factors</u>
  - Tag and Probe: Data and MC don't show inconsistency
  - Data is subtracted QCD and Subdominant bkgs (MC) so that the data sample is pure

$$efficiency = \frac{\#\ (1\ jet\ pass\ baseline + Tight\ TopTagger\ Cut\ AND\ 1\ jet\ pass\ SR)}{\#\ (1\ jet\ pass\ baseline + Tight\ TopTagger\ Cut\ AND\ 1\ jet\ pass\ only\ baseline)}$$

  - Randomization (check random jet) to fill histogram to avoid pT bias
  - mTop candidate distributions for Numerator and Denominator of efficiency
    - To scale the ttbar → fit the mTop in each of these regions (ttbar compatible ~ with SR)
  - Divide the phase space into pT regions: [400-600] GeV, [600-800] GeV, [800-Inf] GeV
    - Again no inconsistencies

Tag And Probe Calculations 2016

b tagging SF's   without b tagging SF's

Efficiency--with btagging SF's   Efficiency--without btagging SF's
eff data: 0.781 ± 0.038   eff data: 0.782 ± 0.039
eff ttbar: 0.772 ± 0.014   eff ttbar: 0.772 ± 0.014
-----------   -----------
Efficiency per Pt region   Efficiency per Pt region
eff data pT[400-600]: 0.761 ± 0.042   eff data pT[400-600]: 0.762 ± 0.043
eff ttbar pT[400-600]: 0.778 ± 0.016   eff ttbar pT[400-600]: 0.778 ± 0.016
-----------   -----------
eff data pT[600-800]: 0.851 ± 0.100   eff data pT[600-800]: 0.854 ± 0.103
eff ttbar pT[600-800]: 0.748 ± 0.031   eff ttbar pT[600-800]: 0.748 ± 0.031
-----------   -----------
eff data pT[800-Inf]: 0.886 ± 0.160   eff data pT[800-Inf]: 0.888 ± 0.161
eff ttbar pT[800-Inf]: 0.775 ± 0.063   eff ttbar pT[800-Inf]: 0.775 ± 0.064

Tight TopTagger + SR TopTagger
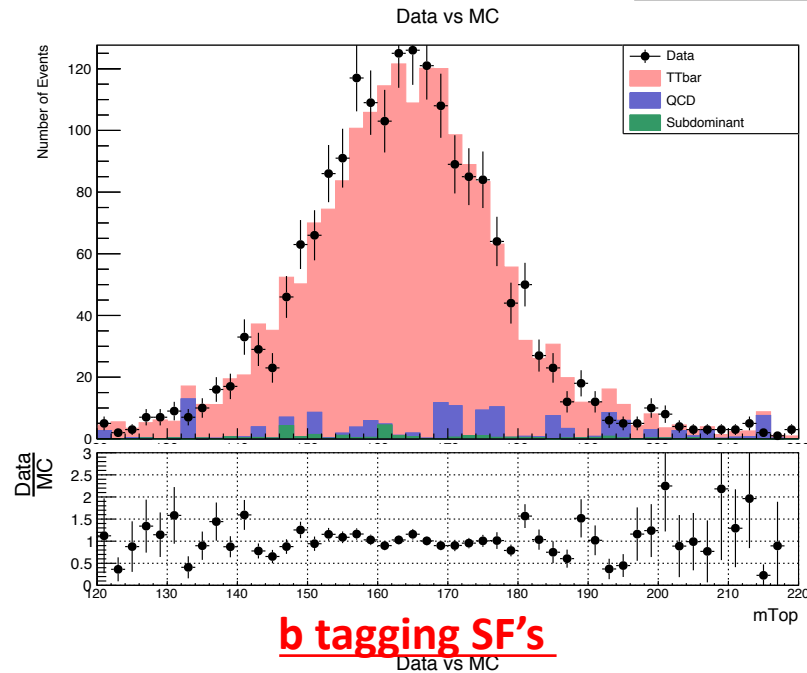
b tagging SF's
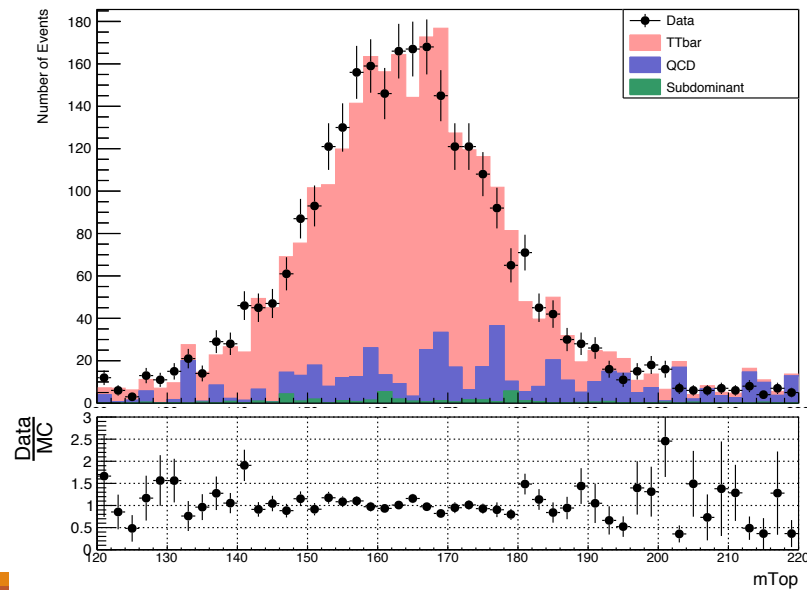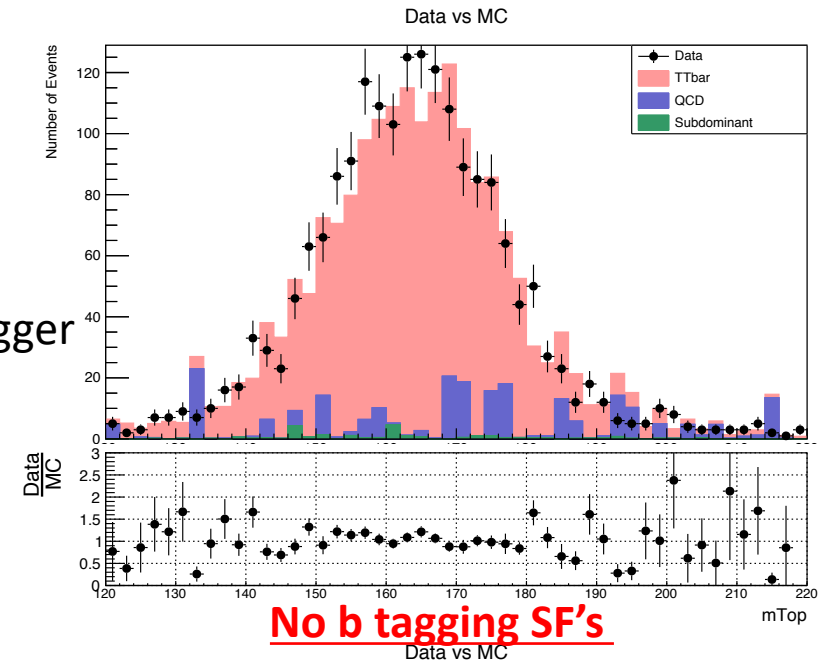
No b tagging SF's

Tight TopTagger + Probe
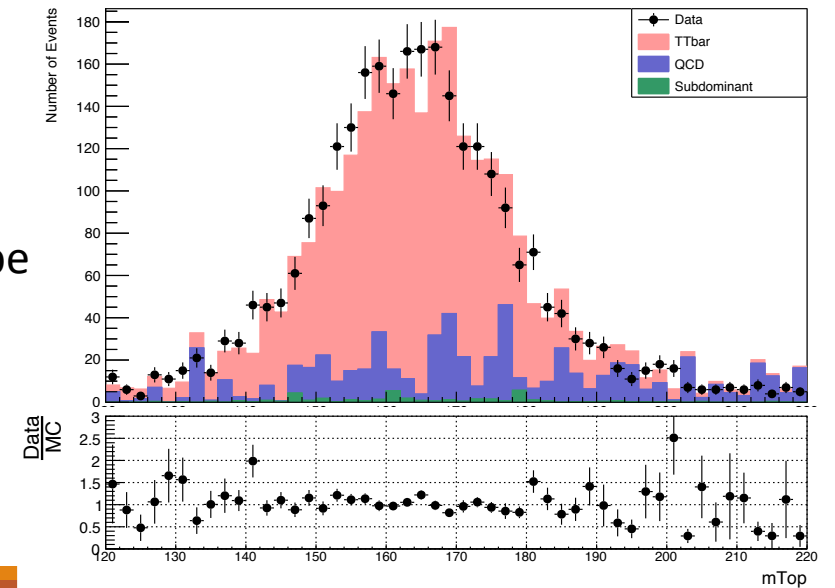
Tag And Probe Calculations 2017

b tagging SF's

Efficiency-- with btagging SF's
eff data: 0.857 ± 0.040
eff ttbar: 0.875 ± 0.0072

Efficiency per Pt region
eff data pT[400-600]: 0.872 ± 0.047
eff ttbar pT[400-600]: 0.874 ± 0.008
----
eff data pT[600-800]: 0.795 ± 0.088
eff ttbar pT[600-800]: 0.876 ± 0.018
----
eff data pT[800-Inf]: 0.797 ± 0.186
eff ttbar pT[800-Inf]: 0.899 ± 0.045

without b tagging SF's

Efficiency-- without btagging SF's
eff data: 0.864 ± 0.043
eff ttbar: 0.875 ± 0.007

Efficiency per Pt region
eff data pT[400-600]: 0.880 ± 0.049
eff ttbar pT[400-600]: 0.874 ± 0.008

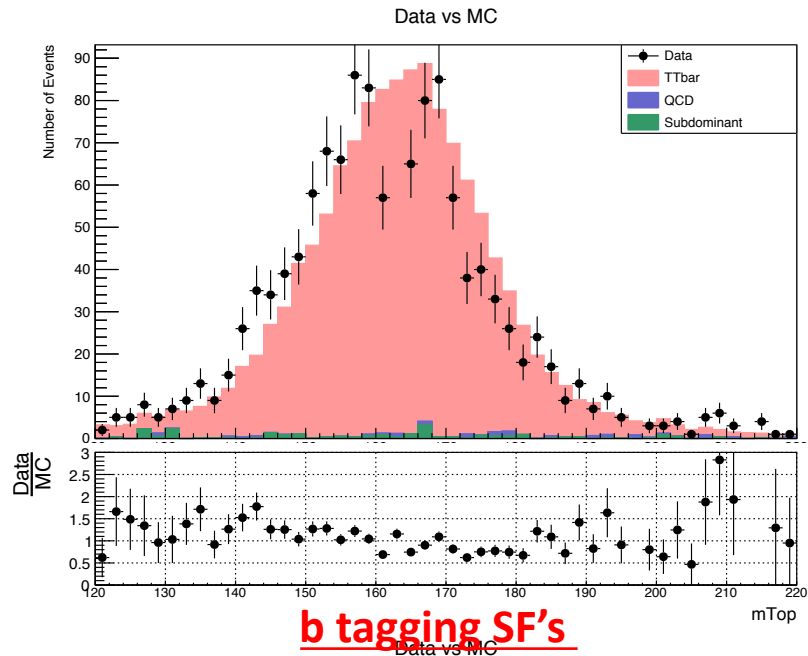eff data pT[600-800]: 0.8 ± 0.091
eff ttbar pT[600-800]: 0.876 ± 0.018
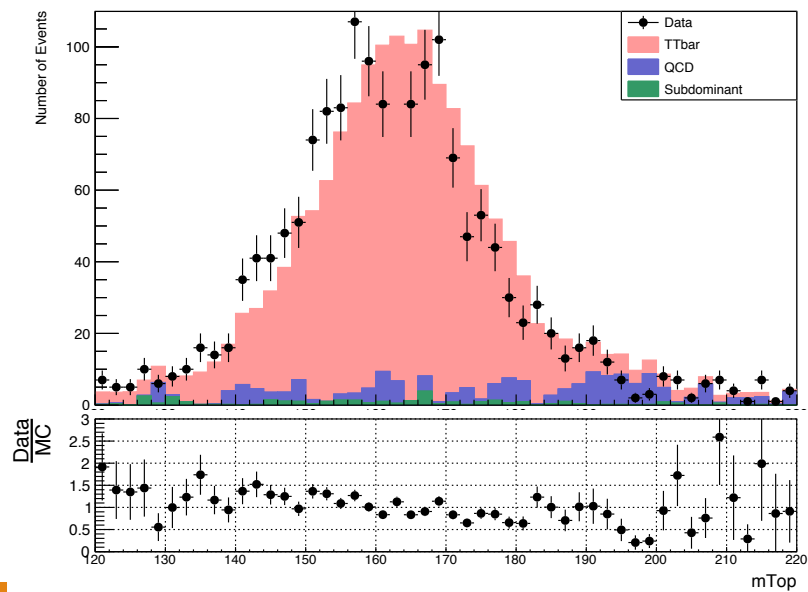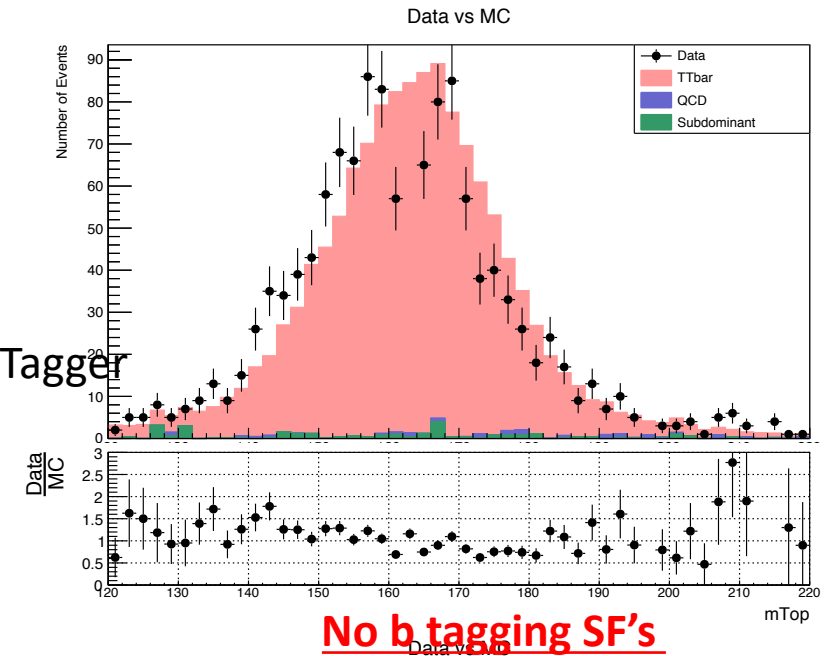----------
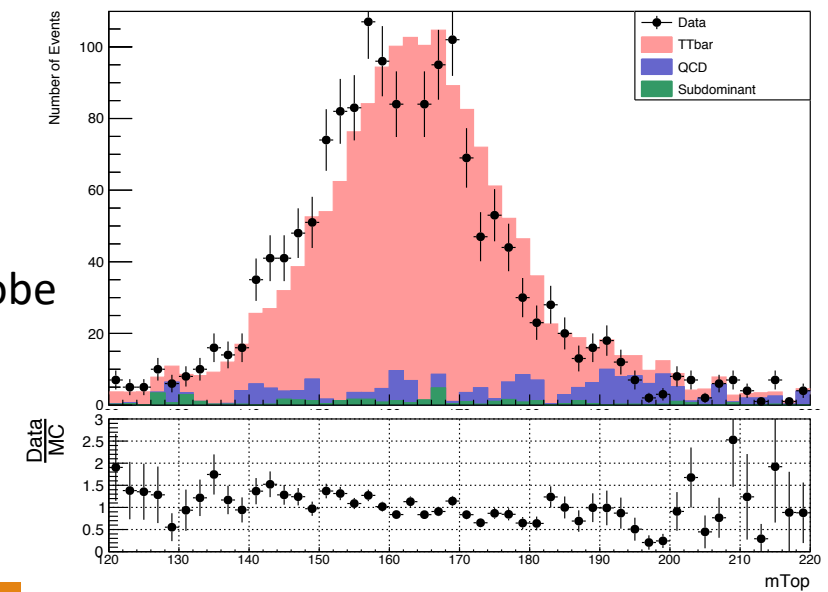eff data pT[800-Inf]: 0.796 ± 0.2
eff ttbar pT[800-Inf]: 0.898 ± 0.045

TagAndProbe Efficiency (2017)

Tight TopTagger + SR TopTagger

b tagging SF's   **No b tagging SF's**

Tight TopTagger + Probe

Tag And Probe Calculations 2018

<u>b tagging SF's</u>   <u>without b tagging SF's</u>

Efficiency-- with tag SF's   Efficiency-- without tag sf's
eff data: 0.816 ± 0.032   eff data: 0.822 ± 0.034
eff ttbar: 0.839 ± 0.005   eff ttbar: 0.839 ± 0.005
-----------   -----------
Efficiency per Pt region   Efficiency per Pt region
eff data pT[400-600]: 0.8176 ± 0.038   eff data pT[400-600]: 0.824 ± 0.039
eff ttbar pT[400-600]: 0.837 ± 0.006   eff ttbar pT[400-600]: 0.837 ± 0.006
-----------   -----------
eff data pT[600-800]: 0.809 ± 0.063   eff data pT[600-800]: 0.819 ± 0.066
eff ttbar pT[600-800]: 0.847 ± 0.013   eff ttbar pT[600-800]: 0.847 ± 0.013
-----------   -----------
eff data pT[800-Inf]: 0.772 ± 0.132   eff data pT[800-Inf]: 0.789 ± 0.141
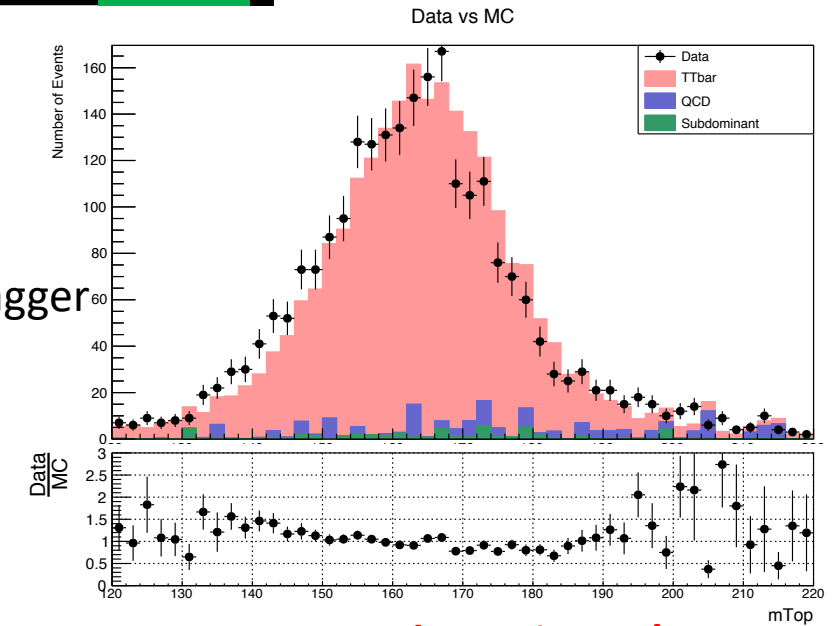eff ttbar pT[800-Inf]: 0.868 ± 0.032   eff ttbar pT[800-Inf]: 0.868 ± 0.032

TagAndProbe Efficiency (2018)
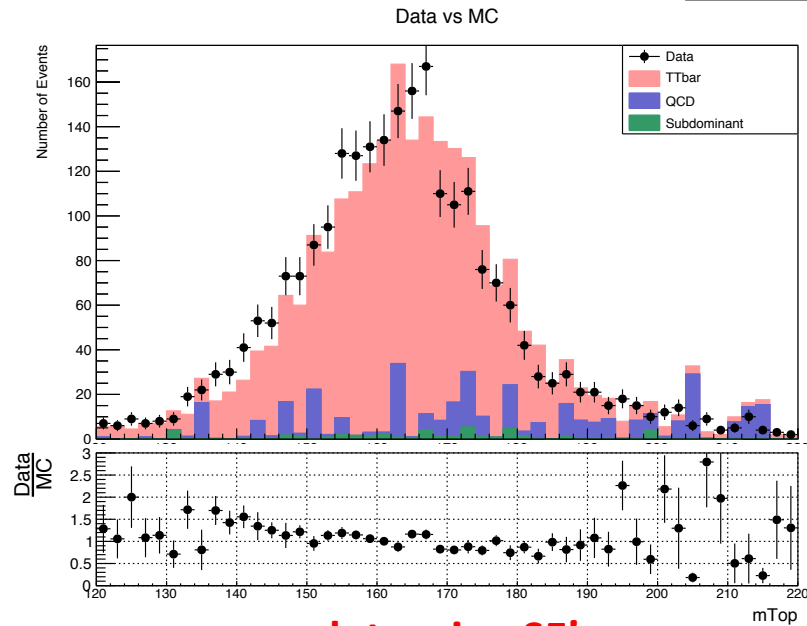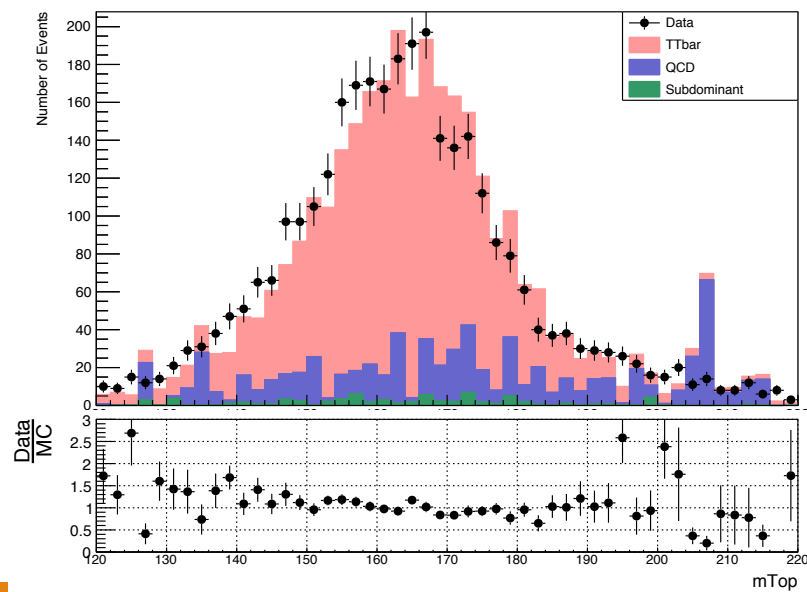
Tight TopTagger + SR TopTagger

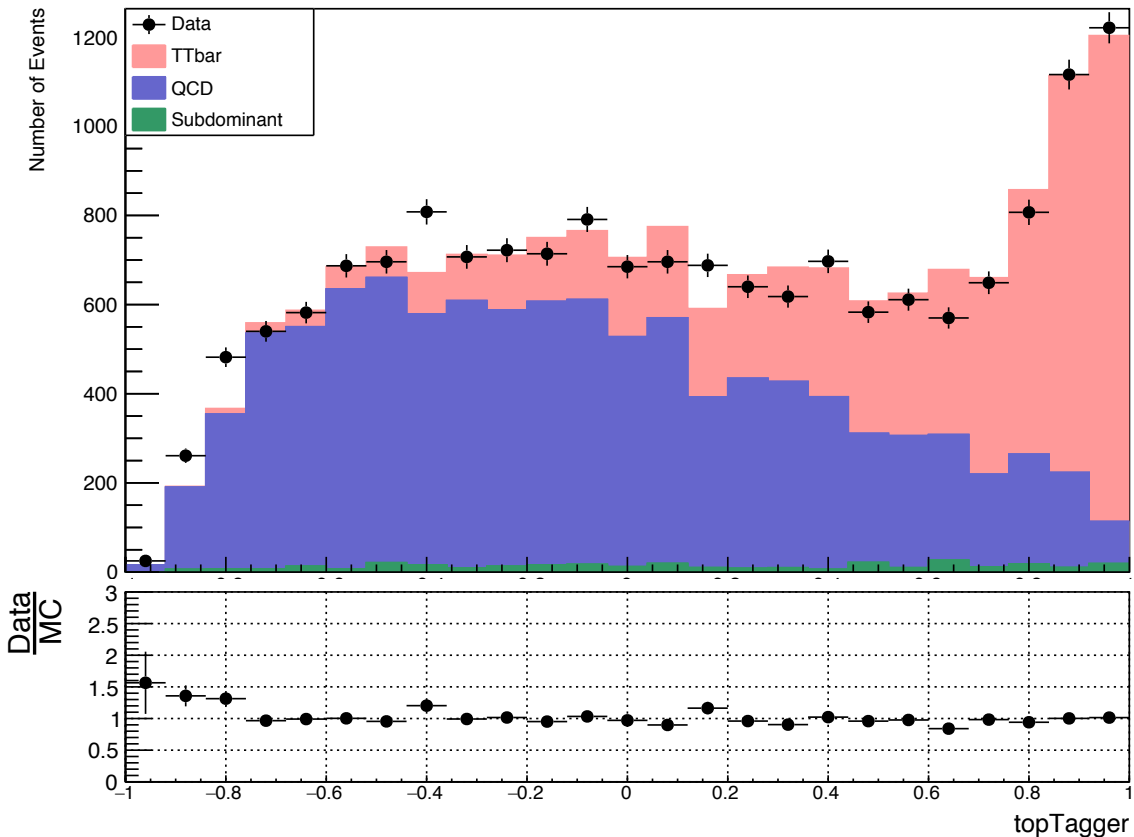**b tagging SF's**

No b tagging SF's

Tight TopTagger + Probe
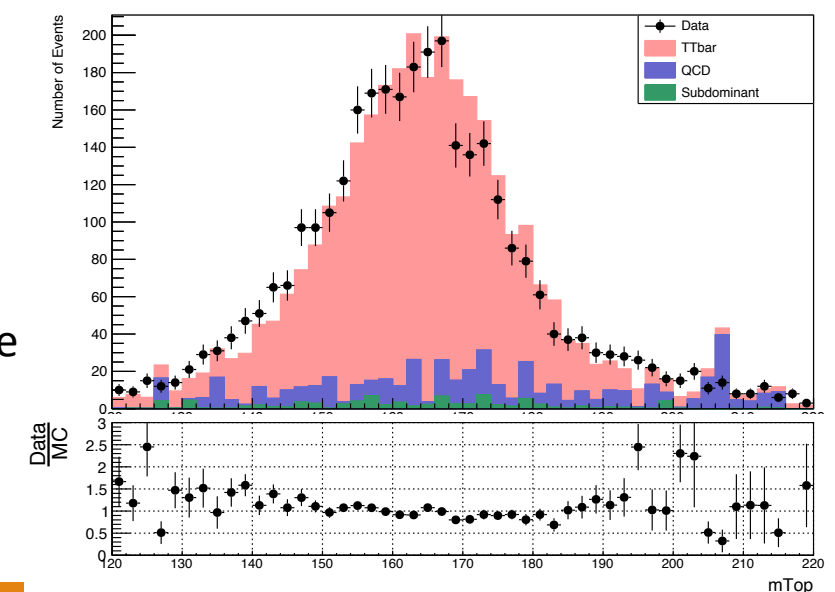
Data Vs MC Stacks for BDT output 2016

- BDT Output scores SR$_B$
  - SR$_B$: Baseline selection + tight Mass Cut (120,220) GeV, no TopTagger Selection
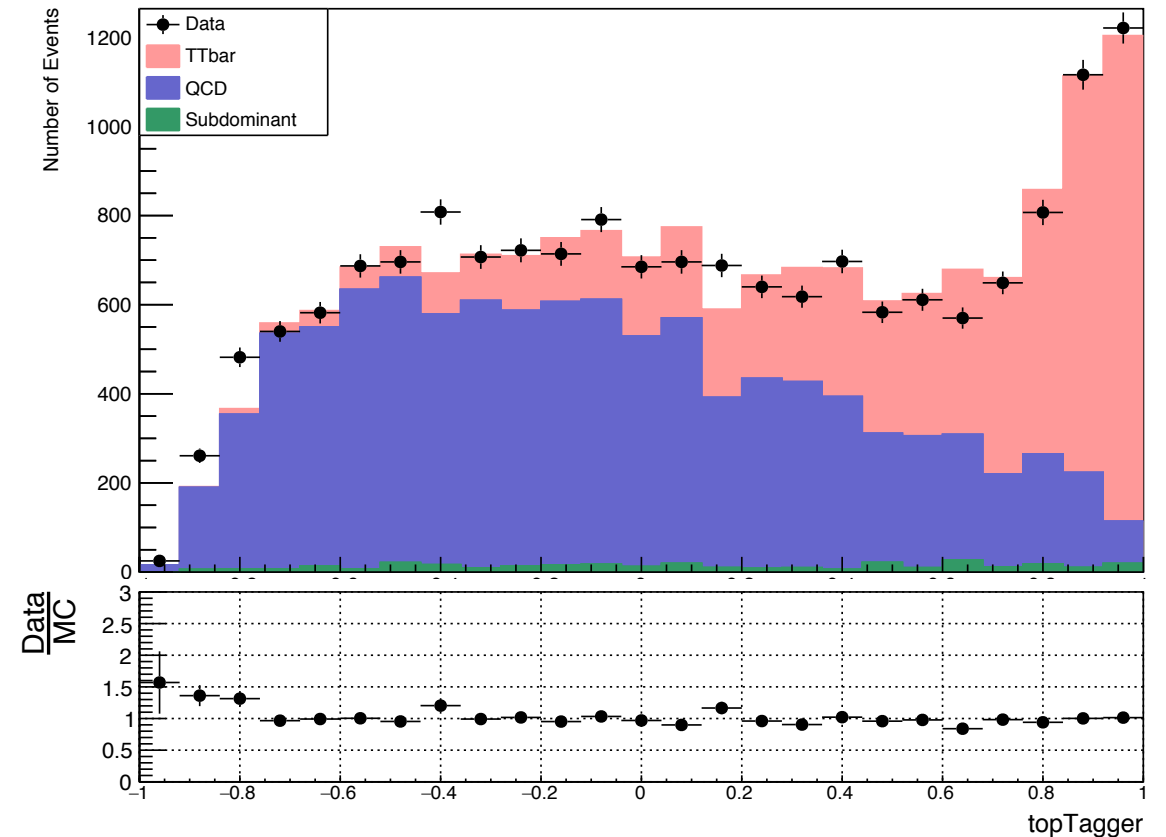 - QCD scaled to data (k-factor)

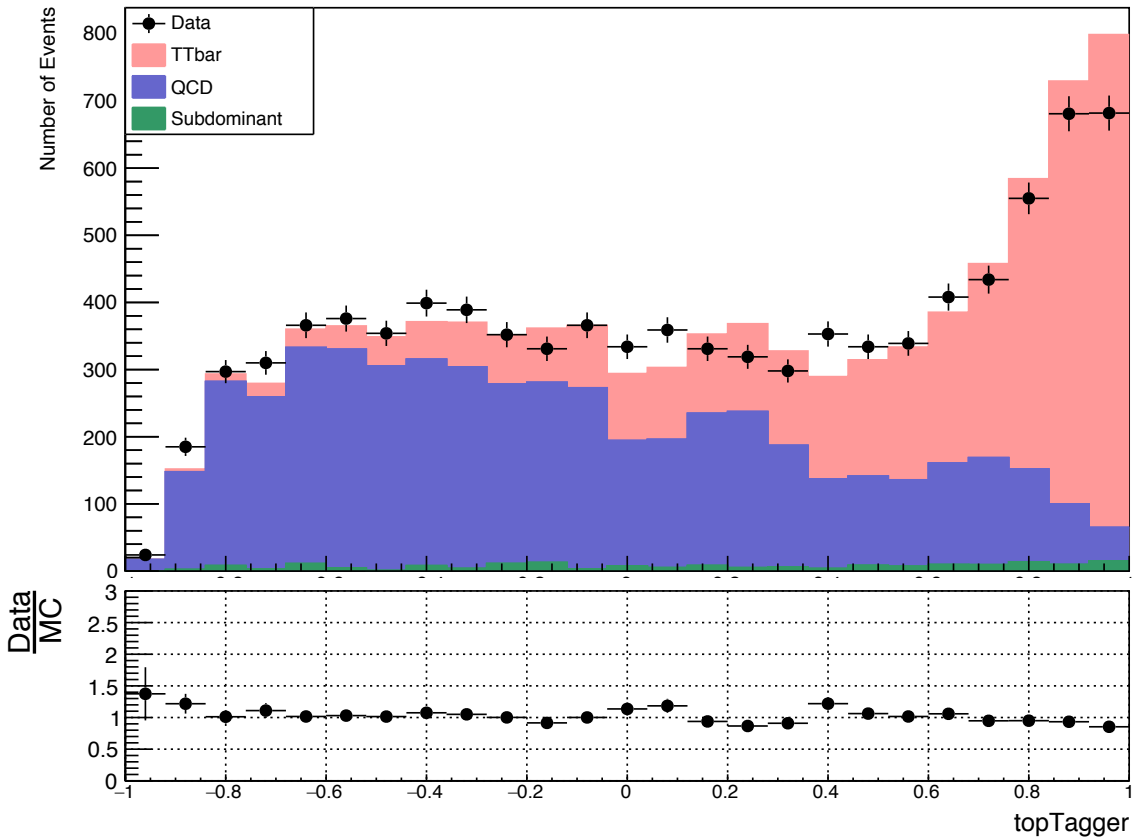b tagging SF's   without b tagging SF's
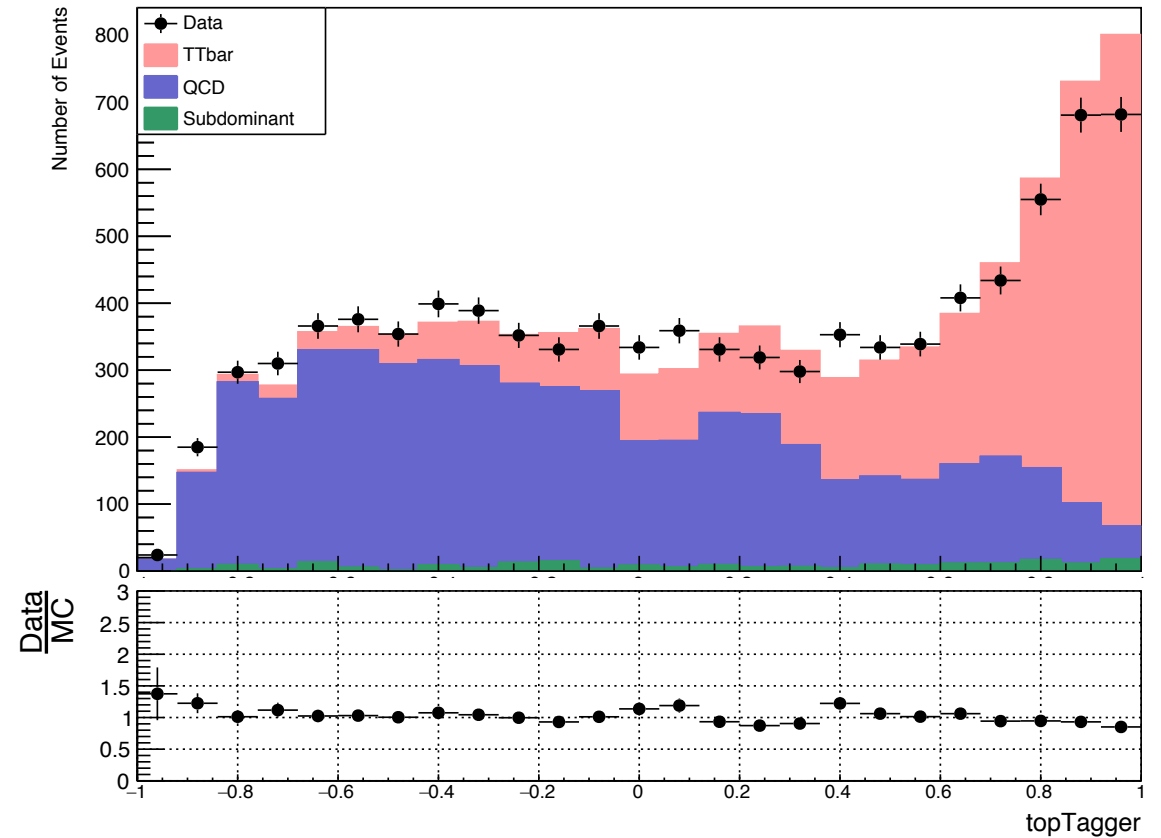
Data Vs MC Stacks for BDT output 2017

b tagging SF's

without b tagging SF's
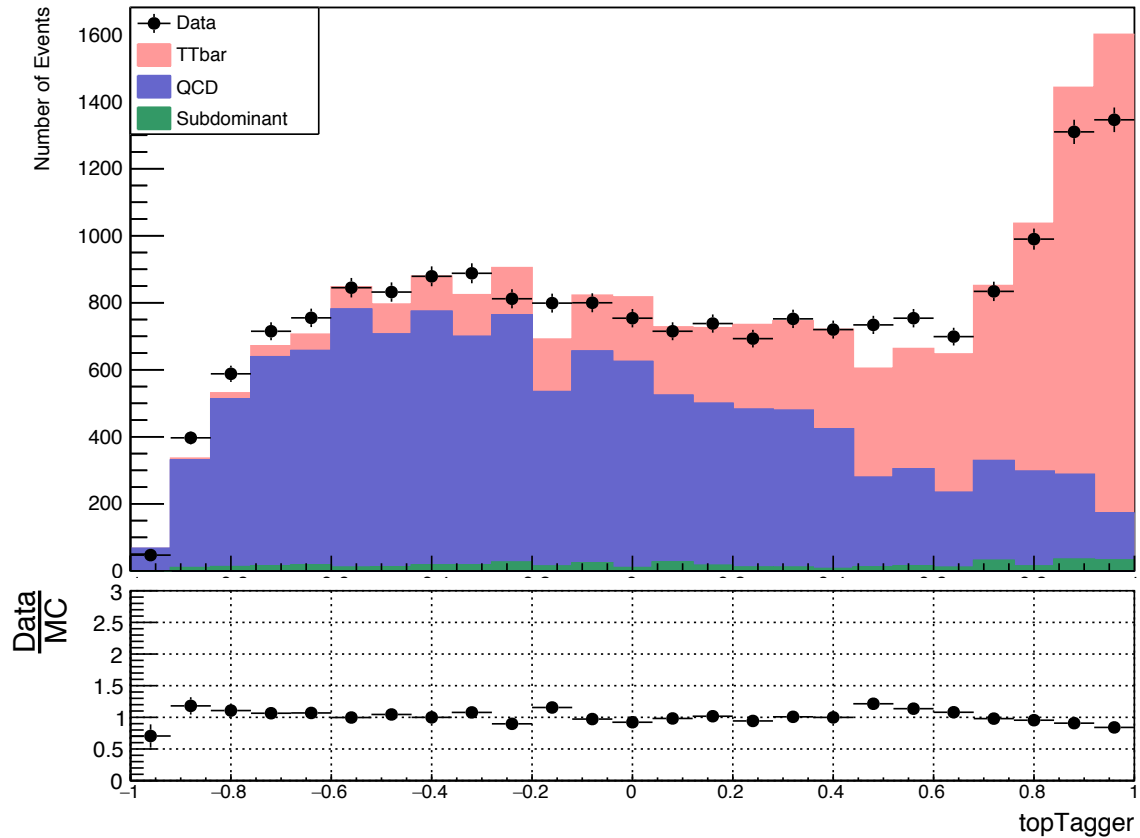
Data Vs MC Stacks for BDT output 2018
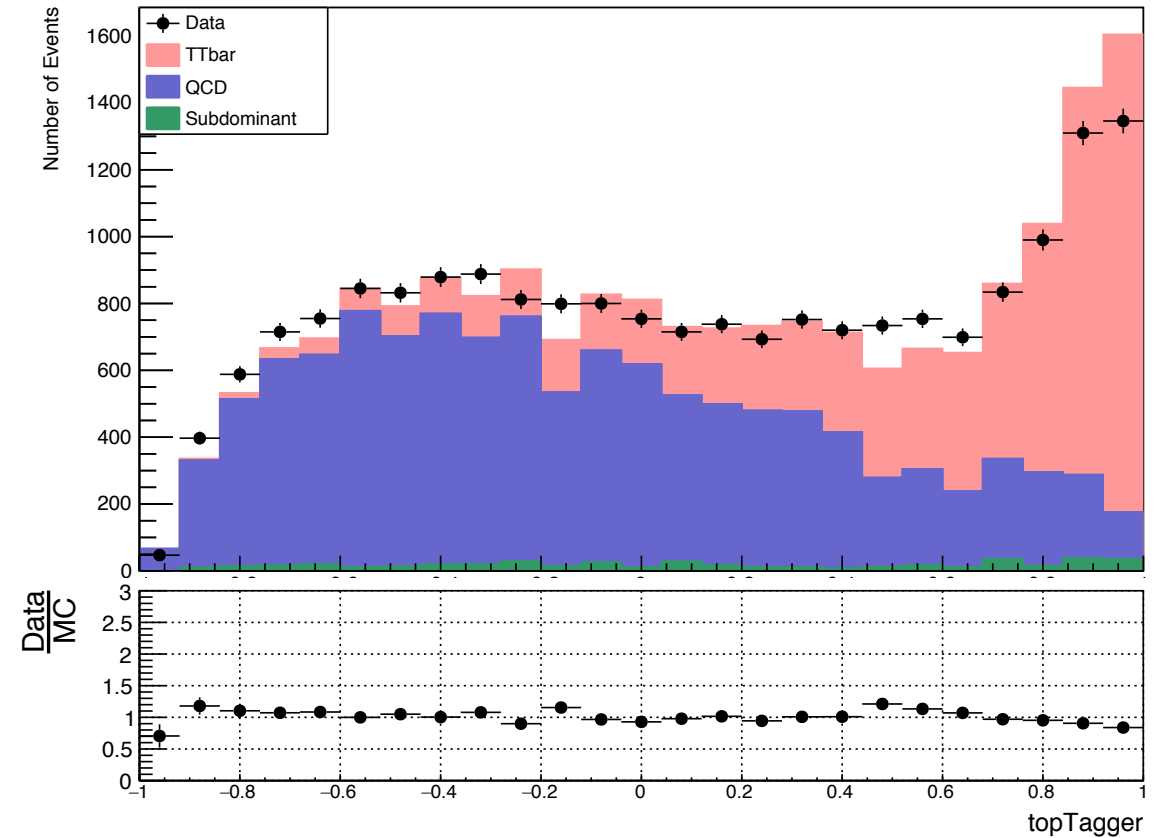
b tagging SF's   without b tagging SF's
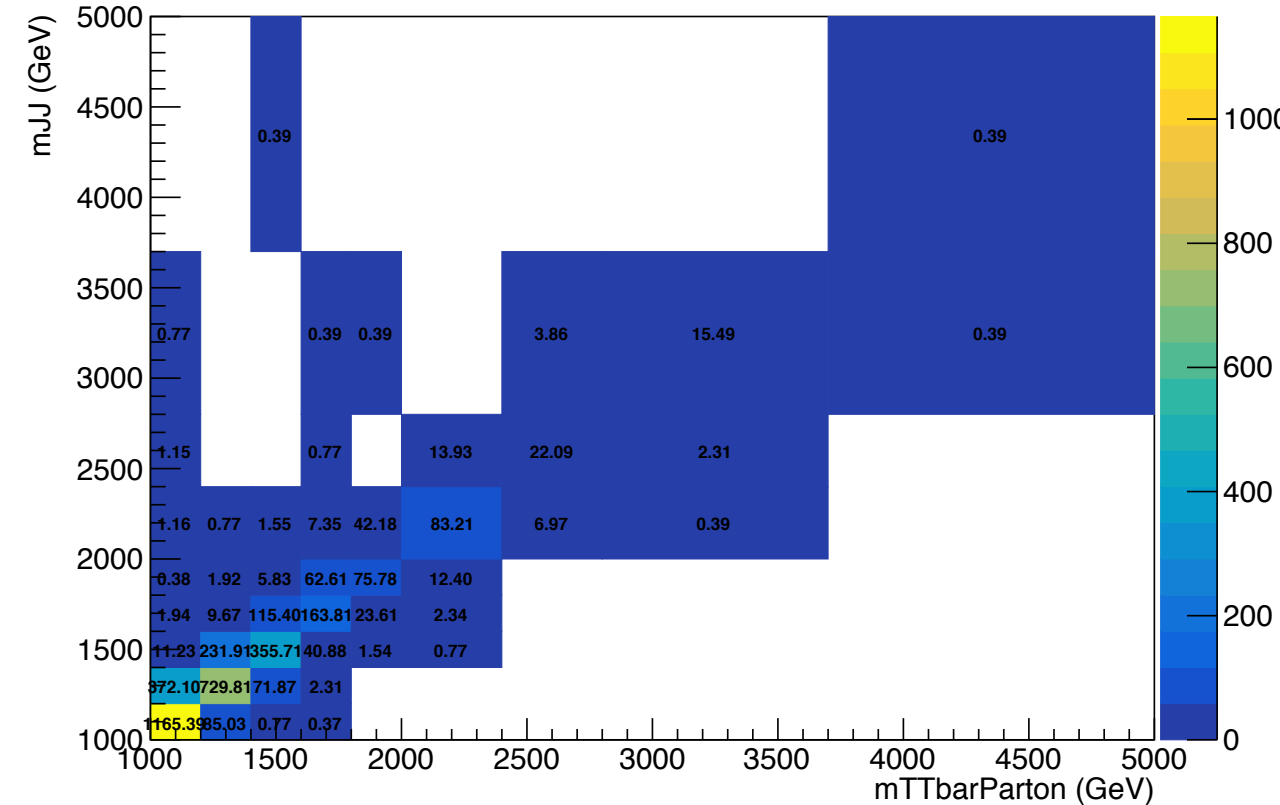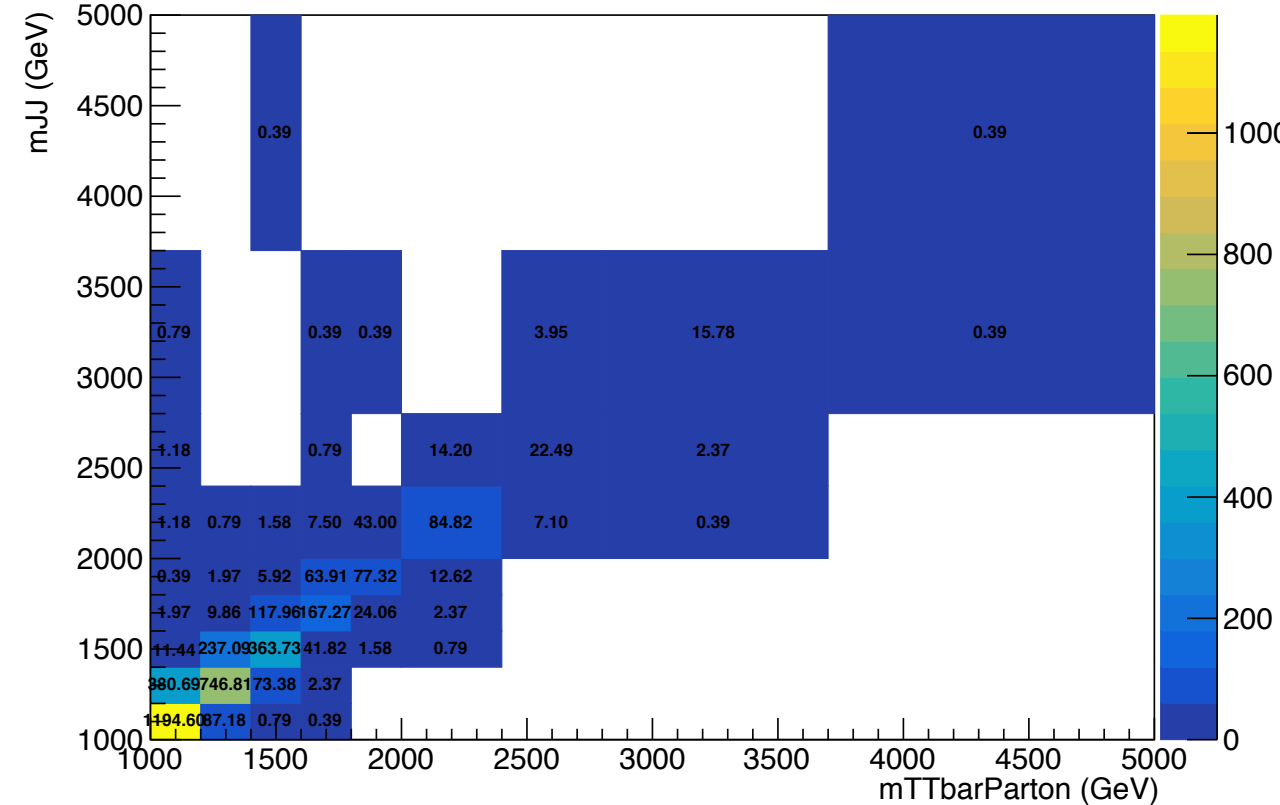
BACKUP SLIDES

Response Matrices 2016

b tagging SF's

without b tagging SF's

Response Reco-Parton mJJ 2016 NominalMC

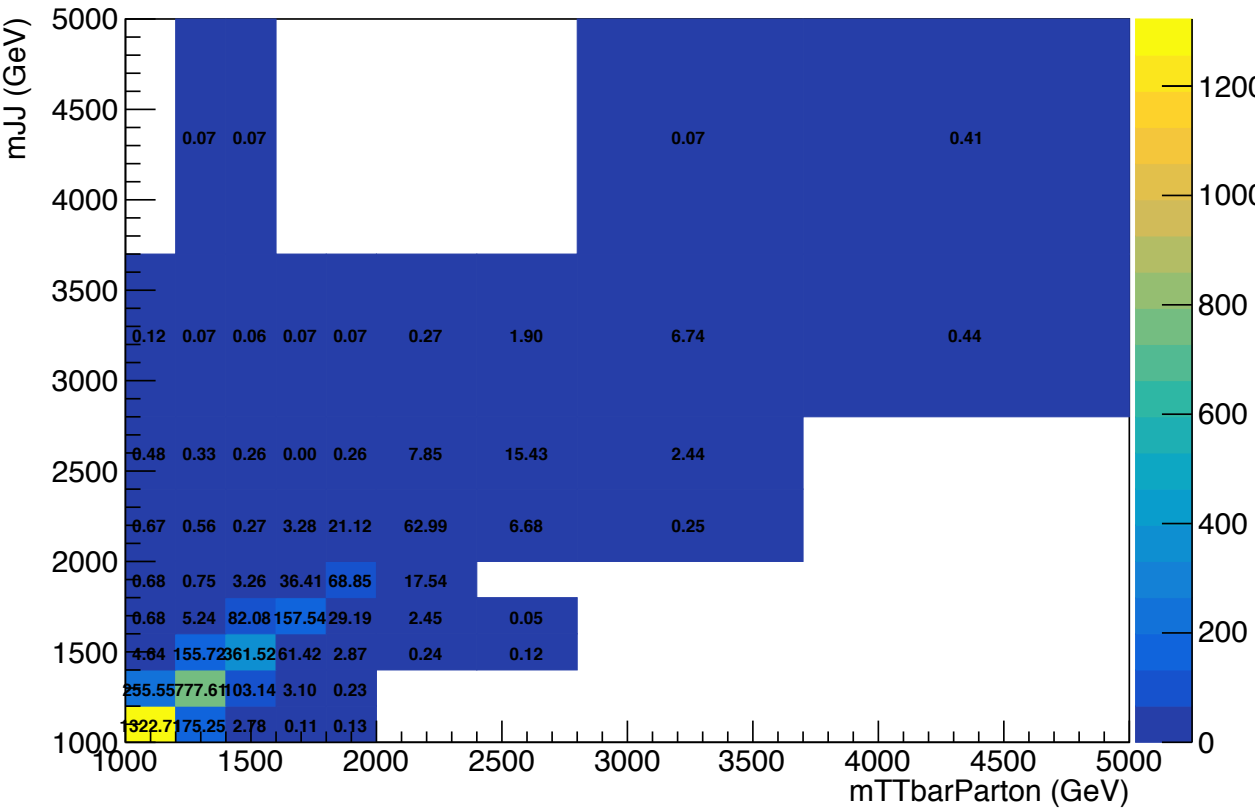Response Reco-Parton mJJ 2016 NominalMC
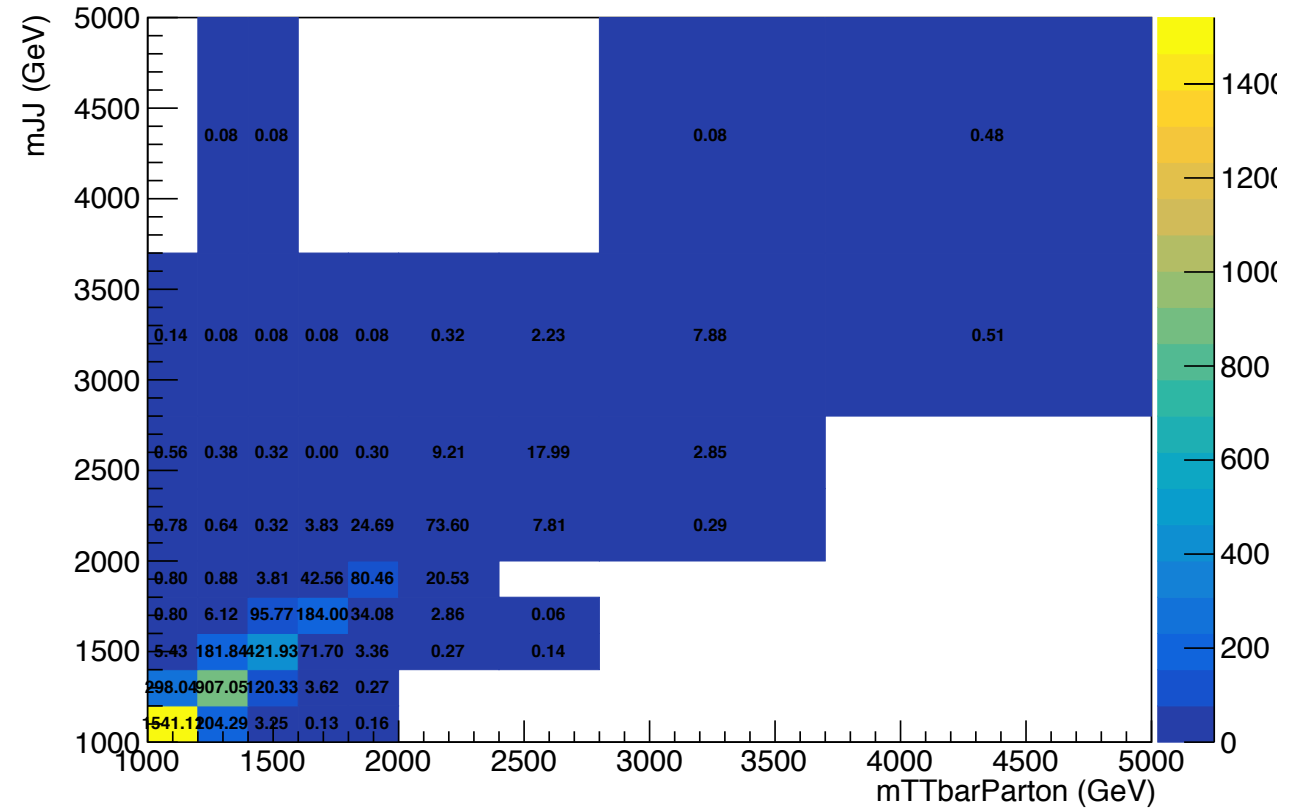
Response Matrices 2017

b tagging SF's

without b tagging SF's

Response Reco-Parton mJJ 2017 NominalMC

Response Reco-Parton mJJ 2017 NominalMC
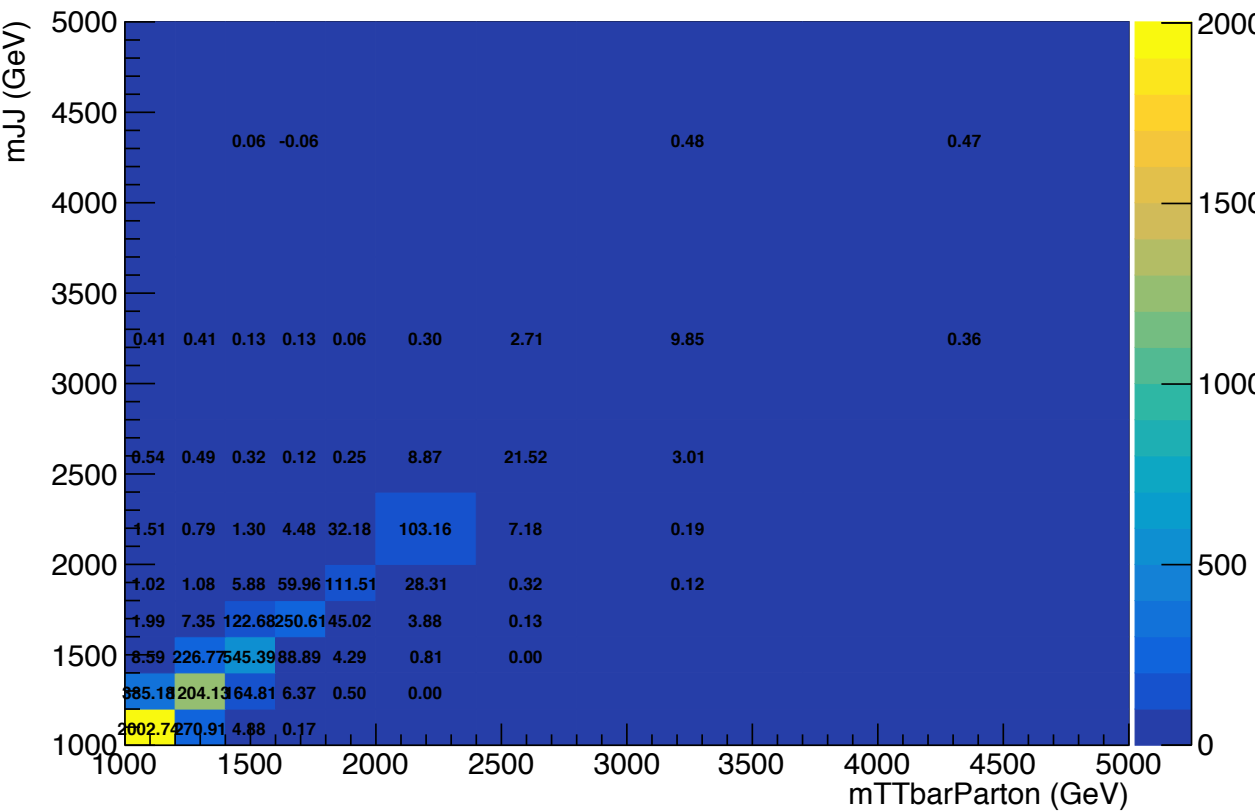
Response Matrices 2018

b tagging SF's   without b tagging SF's

Response Reco-Parton mJJ 2018 NominalMC

Response Reco-Parton mJJ 2018 NominalMC