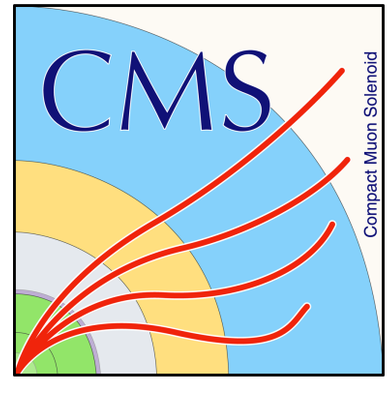

JET ENERGY UNCERTAINTIES

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EDITED

OUTLINE:

- Application of Recommended JEC uncertainties

SELECTION CRITERIA

Electrons

- EGamma POG Tight selection

Muons

- Muon POG Tight selection

Jets

- JetMET POG Loose selection
- Pt > 30

b-jets

- csv mid cut (0.8484)
- Pt > 20

Preselection and Rf selection

- Preselection: Z peak cut; BJet rejection
- Rf selection: Preselection + cuts on the random forest outputs (.96 Drell Yan and .6 Top)

RANDOM FOREST INPUTS

Top

- recoil
- **HT**
- jet1_csv
- qT
- **numb_jets**
- **metMod**
- **dPhiLLJet**
- dPhiLLMET
- **dPhiMETJet**

DY

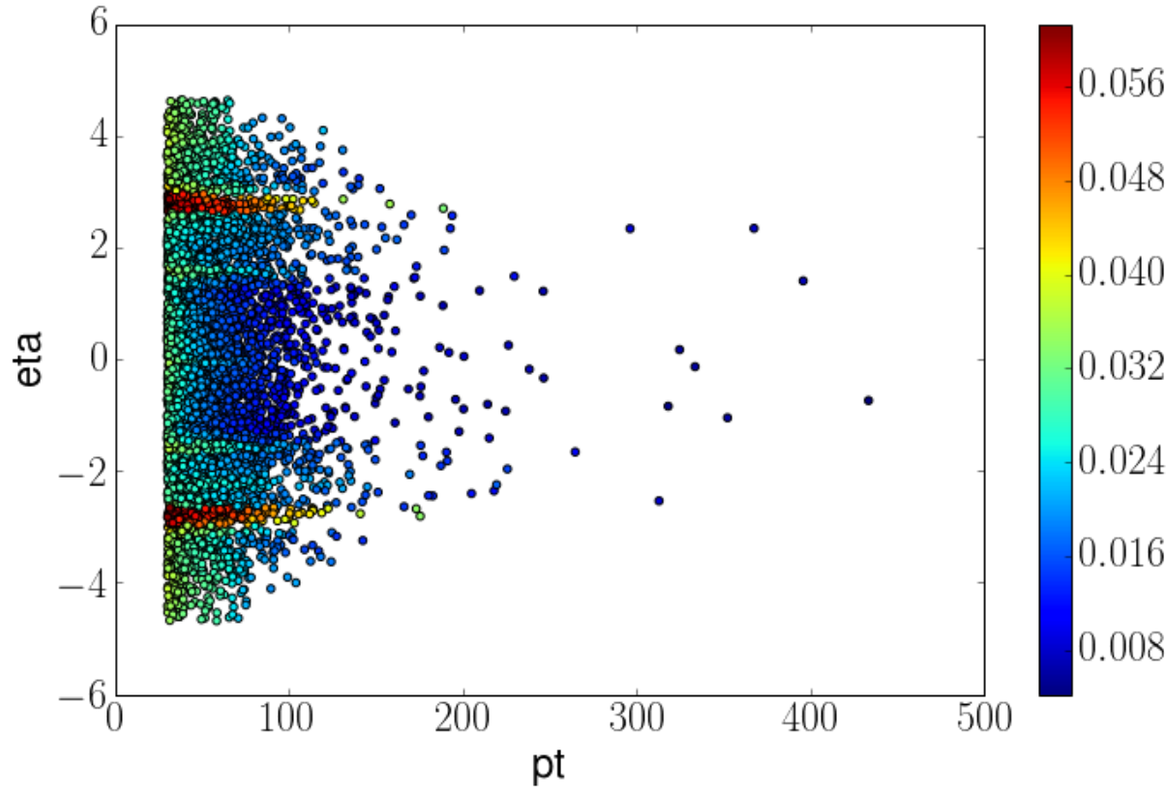
- lep_Type
- **metMod**
- **METProj**
- qT
- mllMET
- dPhiLL
- mll
- **dPhiLLMET**
- lep2_pt
- recoil

JEC UNCERTAINTIES

- Twiki: https://twiki.cern.ch/twiki/bin/viewauth/CMS/JECUncertaintySources
- Source code: https://github.com/miquork/jecsys/tree/Summer16_23Sep2016V4
- JECDataBase: https://github.com/cms-jet/JECDatabase/tree/master/tarballs (Summer16_03Feb2017*)
- L2 residuals: https://indico.cern.ch/event/641882/

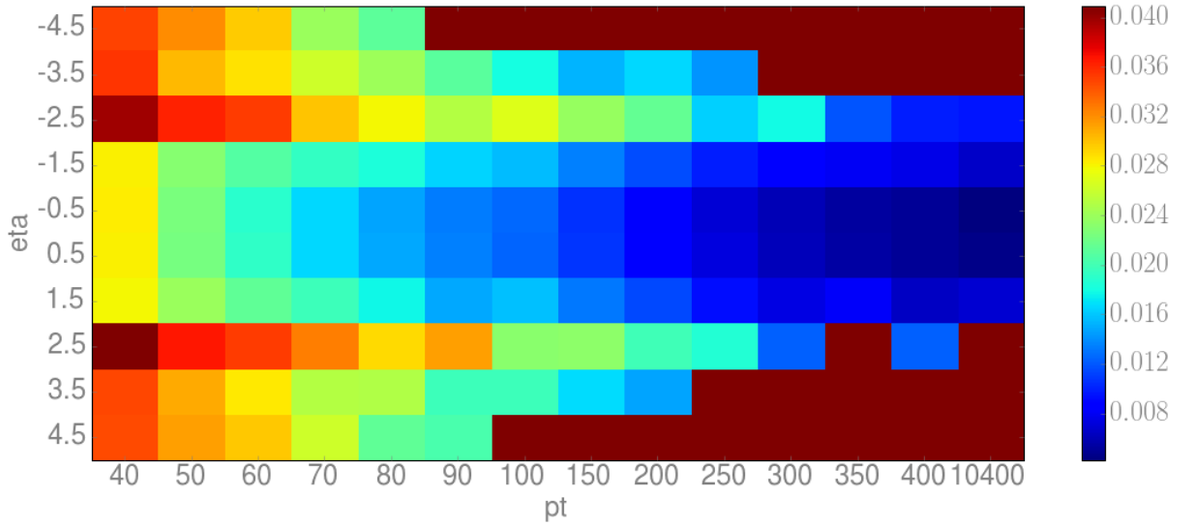
Methodology:

+JEC uncertainty module takes jet pt and jet eta and returns an uncertainty.



JEC UNCERTAINTIES

Applying the uncertainty:
+We take a sample of 5000 events with atleast one jet. and bin that sample in pt and eta.
+We calculate the average the uncertainty for each bin.
+We apply this average uncertainty to monte carlo jets that fall with in the respective pt, eta bins.



- pt binning(GeV): [30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400, 10400]
- eta binning: [-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5]
- bins with no events are set to the highest uncertainty(0.0409)

JEC UNCERTAINTIES

Recalculating Jet pt and associated features

Jet pt: $p_n = p_n(1 \pm \sigma_n)$

Number of Jets: that pass our pt cut

HT: Sum the new Jet Pt

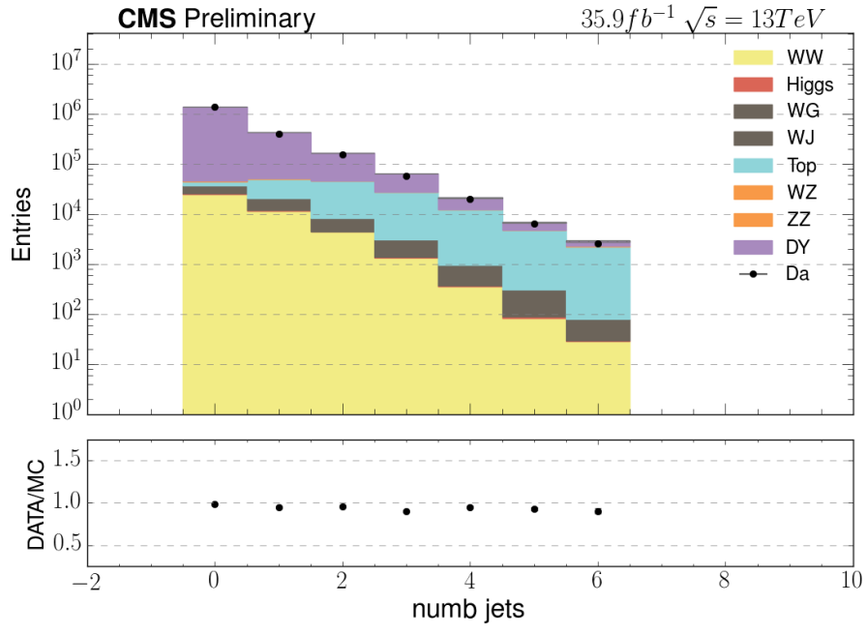
MET: Original MET - Change in HT

recoil: Recalcuate the with new MET

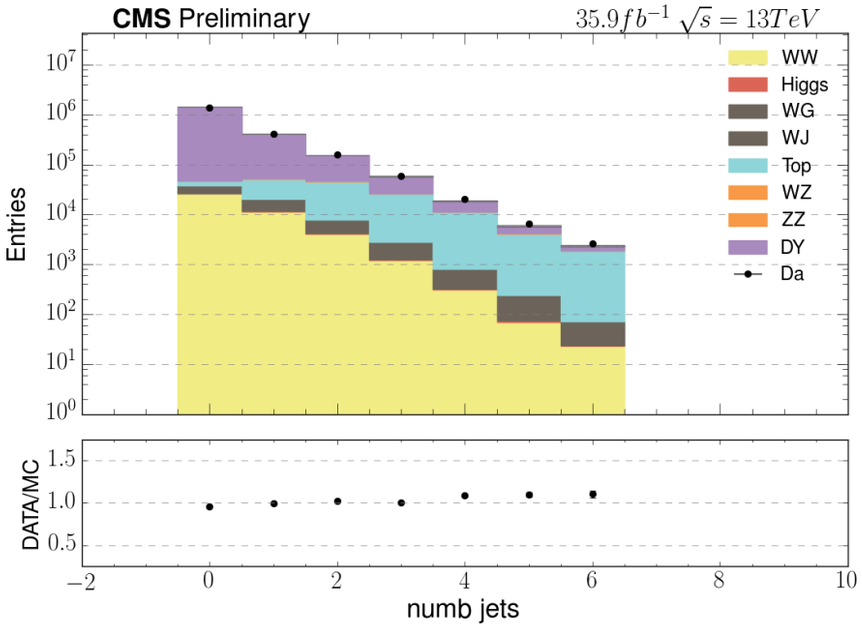
dPhiLLJET, dPhiMETJet: Set to -1 if the number of jets is zero

All jets are scaled in the same direction by σ_n, a function of pt and eta.

- Up



- Down



PRE SELECTION MONTE CARLO YIELDS AFTER RECOMMENDED

	% Difference(Number of Jets)				
Process	**0**	**1**	**2**	**3**	**4**
DY	1.83	1.53	6.58	0.26	0.01
Top	7.03	3.27	3.96	0.14	0.01
WW	1.68	1.31	6.22	0.27	0

RF SELECTION MONTE CARLO YIELDS AFTER RECOMMENDED

	% Difference (Number of Jets)				
Process	0	1	2	3	4
DY	2.44	3.3068	0	50	nan
Top	5.36	4.70	5.09	2.5	0
WW	1.23	7.14	4.80	6.59	2.77

CROSS-SECTIONS

```
Cross-section calcs
up: +0.05
down: -0.038
Average delta: 0.044
% delta: 1.167
```

WW COMPONENT

```
Recommended shift
   epsilon   bar epsilon   N jets
Low:   0.358244786357 0.0210972941394 [67156.0, 7893.0, 421.0, 78.0]
High:  0.356669511572 0.0166073228082 [65746.0, 8097.0, 467.0, 89.0]
Orig:  0.350842949456 0.0 [66454.0, 8622.0, 469.0, 91.0]
Tot jet scale unc:  1.88523084738
```

BACKUPS

- /DYJetsToLL_M-10to50_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6[,_ext1,]-[v1,v1,v2]/MINIAODSIM
- /DYJetsToLL_M-50_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6_ext2-v1/MINIAODSIM
- /WWTo2L2Nu_13TeV-powheg/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /TTToSemilepton_TuneCUETP8M2_ttHtranche3_13TeV-powheg-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /TTTo2L2Nu_TuneCUETP8M2_ttHtranche3_13TeV-powheg-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ST_s-channel_4f_leptonDecays_13TeV-amcatnlo-pythia8_TuneCUETP8M1/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ST_t-channel_antitop_4f_inclusiveDecays_TuneCUETP8M2T4_13TeV-powhegV2-madspin/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ST_t-channel_top_4f_inclusiveDecays_TuneCUETP8M2T4_13TeV-powhegV2-madspin/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ST_tW_antitop_5f_inclusiveDecays_13TeV-powheg-pythia8_TuneCUETP8M2T4/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ST_tW_top_5f_inclusiveDecays_13TeV-powheg-pythia8_TuneCUETP8M2T4/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /WZTo3LNu_TuneCUETP8M1_13TeV-powheg-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /WZTo2L2Q_13TeV_amcatnloFXFX_madspin_pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ZZTo2L2Nu_13TeV_powheg_pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /ZZTo2L2Q_13TeV_amcatnloFXFX_madspin_pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM
- /W*JetsToLNu_TuneCUETP8M1_13TeV-madgraphMLM-pythia8/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v1/MINIAODSIM

Pre selection Monte Carlo yields after Recommended

```
  process           type                                                njets
0      DY  official_orig  [648055, 273550, 114968, 34461, 8536, 2056, 657]
1      DY    official_up  [639989, 276325, 120259, 34461, 8536, 2056, 657]
2      DY  official_down  [663724, 267914, 105120, 34278, 8534, 2056, 657]
delta [ 11867.5   4205.5   7569.5     91.5      1.       0.       0. ]
% delta [ 1.83124889  1.53737891  6.58400598  0.26551754  0.01171509  0.          0.        ]
  process           type                              njets
```

```
  process           type                                                 njets
0     Top  official_orig  [194609, 733984, 931643, 577418, 261414, 98262...
1     Top    official_up  [185652, 717413, 957171, 577418, 261414, 98262...
2     Top  official_down  [213004, 765421, 883447, 575812, 261386, 98260...
delta [ 13676.  24004.  36862.    803.     14.      1.      0.]
% delta [ 7.02742422  3.27037102  3.9566658   0.13906737  0.00535549  0.00101769
  0.        ]
```

```
  process           type                                              njets
0      WW  official_orig  [116566, 54031, 19871, 6028, 1602, 361, 130]
1      WW    official_up  [115228, 54489, 20751, 6028, 1602, 361, 130]
2      WW  official_down  [119144, 53077, 18280, 5995, 1602, 361, 130]
delta [ 1958.    706.   1235.5    16.5     0.      0.      0. ]
% delta [ 1.67973509  1.30665729  6.21760354  0.27372263  0.          0.          0.        ]
```

Rf selection Monte Carlo yields after Recommended

```
  process              type                          njets
0      DY  official_orig_rf  [1268, 378, 5, 1, 0, 0, 0]
1      DY    official_up_rf  [1228, 374, 5, 1, 0, 0, 0]
2      DY  official_down_rf  [1290, 357, 5, 0, 0, 0, 0]
delta [ 31.   12.5   0.    0.5   0.    0.    0. ]
% delta [  2.44479495   3.30687831   0.          50.                  nan
          nan          nan]
```

```
  process              type                                  njets
0     Top  official_orig_rf   [99417, 22653, 993, 220, 45, 19, 1]
1     Top    official_up_rf  [95252, 22017, 1039, 226, 45, 20, 2]
2     Top  official_down_rf  [105910, 24148, 938, 215, 45, 18, 1]
delta [ 5329.   1065.5    50.5     5.5     0.      1.      0.5]
% delta [  5.36025026   4.70357127   5.08559919   2.5          0.          5.26315789
  50.        ]
```

```
  process              type                                  njets
0      WW  official_orig_rf  [66454, 8622, 469, 91, 18, 6, 1]
1      WW    official_up_rf  [65746, 8116, 474, 91, 19, 6, 1]
2      WW  official_down_rf  [67375, 7897, 429, 79, 18, 6, 1]
delta [ 814.5  615.5   22.5    6.     0.5    0.     0. ]
% delta [ 1.22565985  7.13871492  4.79744136  6.59340659  2.77777778  0.          0.        ]
```

Pre selection Monte Carlo yields after FLAT

```
  process       type                                                  njets
0      DY  flat_orig  [648055, 273550, 114968, 34461, 8536, 2056, 657]
1      DY    flat_up  [639989, 276325, 117949, 36056, 9023, 2240, 701]
2      DY  flat_down  [660098, 269426, 110415, 32141, 7771, 1862, 570]
delta [ 10054.5   3449.5   3767.    1957.5    626.     189.      65.5]
% delta [ 1.55148869  1.26101261  3.27656391  5.68033429  7.33364574  9.192607
  9.9695586 ]
```

```
  process       type                                                   njets
0     Top  flat_orig  [194609, 733984, 931643, 577418, 261414, 98262...
1     Top    flat_up  [185652, 717413, 930232, 587781, 269958, 10320...
2     Top  flat_down  [208845, 759658, 932389, 561237, 248310, 91202...
delta [ 11596.5  21122.5   1078.5  13272.   10824.    5999.    3702.5]
% delta [ 5.95887138  2.87778753  0.11576323  2.29850819  4.14055865  6.10510676
  8.01771368]
```

```
  process       type                                                njets
0      WW  flat_orig  [116566, 54031, 19871, 6028, 1602, 361, 130]
1      WW    flat_up  [115228, 54489, 20382, 6296, 1670, 388, 136]
2      WW  flat_down  [118499, 53314, 19192, 5662, 1477, 329, 116]
delta [ 1635.5   587.5   595.    317.     96.5    29.5    10. ]
% delta [ 1.40306779  1.08733875  2.99431332  5.2587923   6.02372035  8.17174515
  7.69230769]
```

Rf selection Monte Carlo yields after FLAT

```
  process          type                          njets
0      DY  flat_orig_rf  [1268, 378, 5, 1, 0, 0, 0]
1      DY    flat_up_rf  [1228, 377, 3, 0, 0, 0, 0]
2      DY  flat_down_rf  [1334, 365, 7, 0, 0, 0, 0]
delta [ 53.   7.   2.   1.   0.   0.   0.]
% delta [   4.17981073    1.85185185   40.          100.                    nan
           nan           nan]
```

```
  process          type                                  njets
0     Top  flat_orig_rf    [99417, 22653, 993, 220, 45, 19, 1]
1     Top    flat_up_rf    [95252, 24039, 746, 167, 28, 11, 1]
2     Top  flat_down_rf  [106007, 23307, 1266, 291, 52, 22, 0]
delta [ 5377.5  1020.    260.     62.     12.      5.5     0.5]
% delta [  5.40903467   4.50271487  26.18328298  28.18181818  26.66666667
  28.94736842  50.        ]
```

```
  process          type                                 njets
0      WW  flat_orig_rf   [66454, 8622, 469, 91, 18, 6, 1]
1      WW    flat_up_rf   [65746, 8407, 340, 63, 14, 5, 0]
2      WW  flat_down_rf  [67447, 7969, 520, 102, 25, 2, 0]
delta [ 850.5  434.    90.    19.5    5.5    2.5    1. ]
% delta [   1.27983267    5.03363489   19.18976546   21.42857143   30.55555556
   41.66666667  100.        ]
```

WW COMPONENT

```
Recommended shift
   epsilon   bar epsilon   N jets
Low:   0.358244786357 0.0210972941394 [67156.0, 7893.0, 421.0, 78.0]
High:  0.356669511572 0.0166073228082 [65746.0, 8097.0, 467.0, 89.0]
Orig:  0.350842949456 0.0 [66454.0, 8622.0, 469.0, 91.0]
Tot jet scale unc:  1.88523084738

Flat shift
   epsilon   bar epsilon   N jets
Low:   0.357550416962 0.0188853512971 [67447.0, 7969.0, 520.0, 102.0]
High:  0.357144498897 0.0177286361863 [65746.0, 8176.0, 339.0, 63.0]
Orig:  0.350923110737 0.0 [66454.0, 8622.0, 469.0, 91.0]
Tot jet scale unc:  1.83069937417
```