Constraining systematic effects of top quark mass measurement from data

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20.09.18

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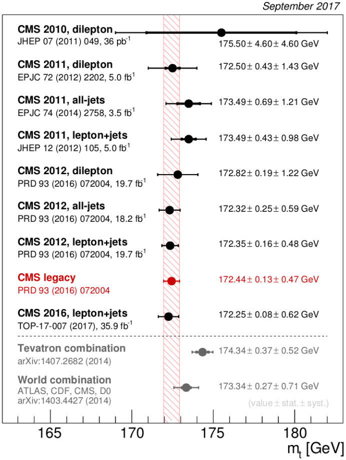
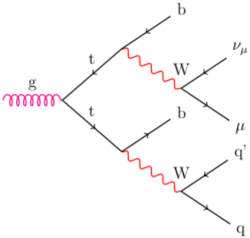
Introduction

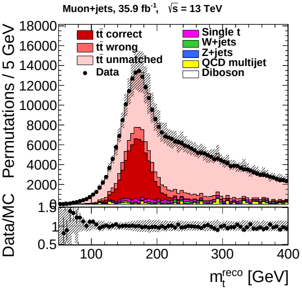
- Baseline is the 13TeV lepton+jets analysis using the ideogram method: CMS Top 17-007
- Major uncertainties in this analysis were:
  - Jet Energy Corrections (JEC)
  - JEC Flavor
  - Matrix element generator
  - Color reconnection modeling
- Measurement of the top mass and reduction of systematic uncertainties

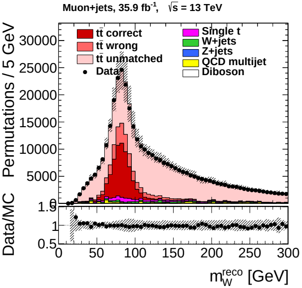


Event selection

- Possible channels:
  - lepton + jets channel
  - all jet channel
  - dilepton channel
- Here: Muon + jets channel
- One muon
  with $p_T > 26\text{GeV}$ and $|\eta| < 2.4$
- At least 4 jets
  with $p_T > 30\text{GeV}$ and $|\eta| < 2.4$
- 2 b-tagged jets

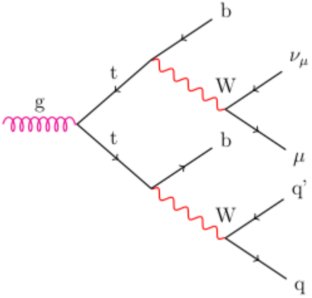


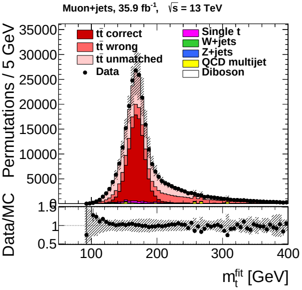


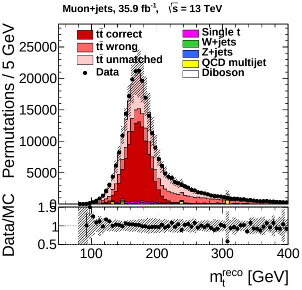


Kinematic Fit

- Used to improve resolution of reconstructed observables
- $m_t = m_{\bar{t}}$
- $m_W = 80.4$ GeV
- Missing E_T
- $P_{gof} = \exp(-\frac{1}{2}\chi^2) > 0.2$

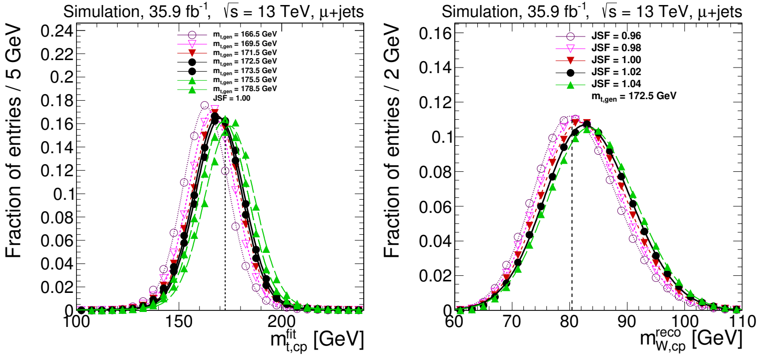






Previous mass extraction method

- Ideogram method using a likelihood fit
- Parameters of interest are m_t and JSF
- Derive $P(m_t^{Fit}, m_W^{Reco} | m_t, JSF)$ from multiple templates
- Estimation of systematic uncertainties with pseudo experiments

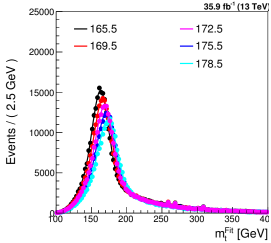


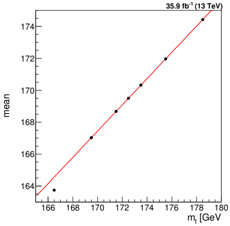
New analysis method

- Likelihood fit with systematic uncertainty sources as nuisance parameters $\theta_1, ..., \theta_n$
- Derive $P(m_t^{Fit}, m_W^{Reco} | m_t, \theta_1, ..., \theta_n)$
- Templates from variation of m_t and 1σ variation of 19 nuisance parameters
- Estimation of uncertainties directly from data

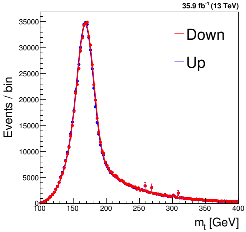
Template extraction

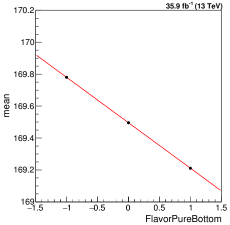
- Fit of observables with analytical functions
- $\mu = \mu_0 * (1 + s_{m_t}(m_t - 172.5)) * (1 + s_{\theta_1}\theta_1) * ... * (1 + s_{\theta_n}\theta_n)$
- Some systematics are externalized





Variation of input top mass

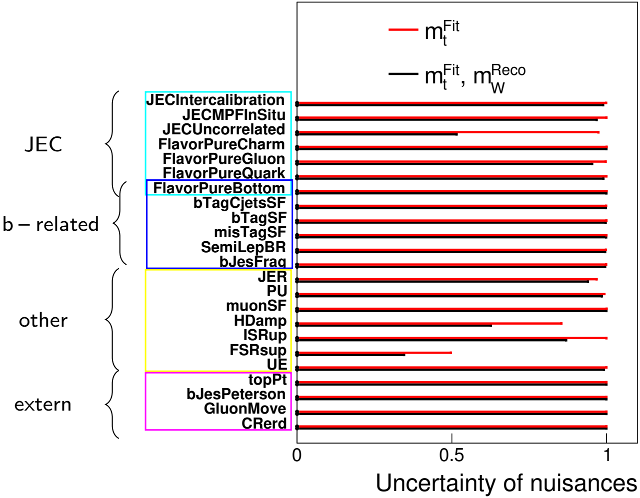




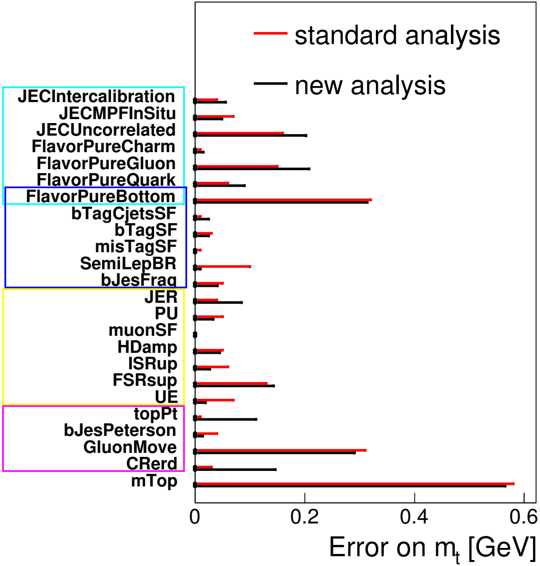
1σ variation of bottom jet energy scale

Calculation of nuisance parameters

- Gaussian constraints on systematics
- Fit $P(m_t^{Fit}, m_W^{Reco} | m_t, \theta_1, ..., \theta_n)$ to data

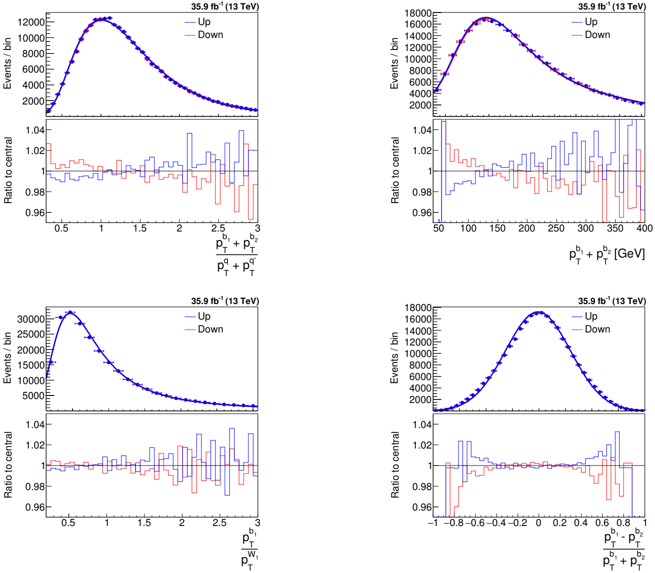


Comparison to standard analysis



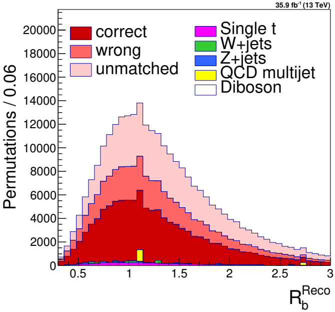
BJES dependent observable

- Observable should be sensitive to bottom jet energy scale
- 1σ variation of bottom jet energy scale

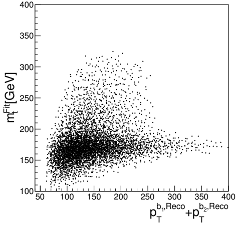


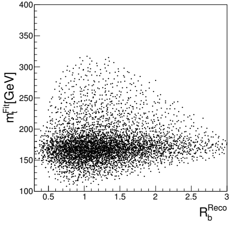
Observable comparison

Observable	Peak shift
$\frac{p_T^{b_1}+p_T^{b_2}}{p_T^{q}+p_T^{q'}}$	9.16σ
$p_T^{b_1} + p_T^{b_2}$	11.3σ
$\frac{p_T^{b_1}}{p_T^{W_1}}$	3.16σ
$\frac{p_T^{b_1}-p_T^{b_2}}{p_T^{b_1}+p_T^{b_2}}$	0.68σ



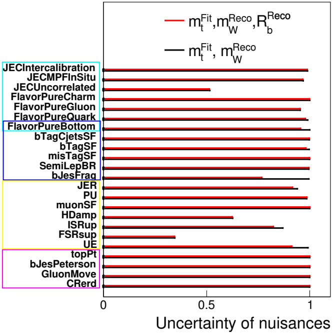
- Observable should be uncorrelated to m_t^{Fit} and m_W^{Reco}

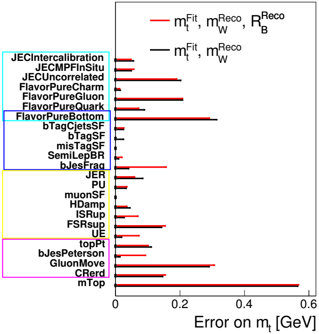




Effects of R_b on the measurement

- Some systematic uncertainties can be reduced
- External systematics provide a larger uncertainty
- Overall m_t uncertainty is approximately the same





Summary

- Nuisance parameter fit provides comparable results to standard analysis in Top-17-007
- Found observable to constrain flavor uncertainties
  - Some systematics are influenced in a negative way
  - No improvement in measurement
- Result:$m_t = 172.099 \pm 0.565$