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CMS

Top Mass Measurements of the Universität Hamburg

8th Annual Workshop of the Helmholtz Alliance

„Physics at the Terascale“

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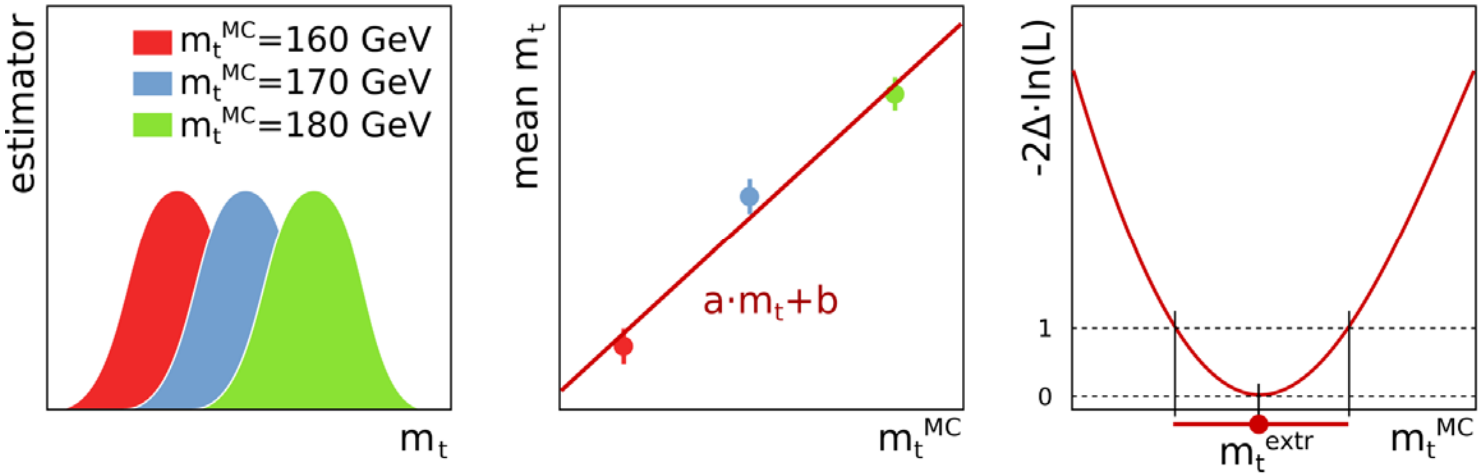
Hartmut Stadie, Eike Schlieckau, Markus Seidel
hartmut.stadie@desy.de, eike.schlieckau@desy.de, markus.seidel@desy.de

Overview

- Introduction
- Measurement Method
- Kinematic Fitting
- Ideogram Method
- All-Jets Analysis
- Lepton+Jets Analysis
- CMS Combination
- Summary

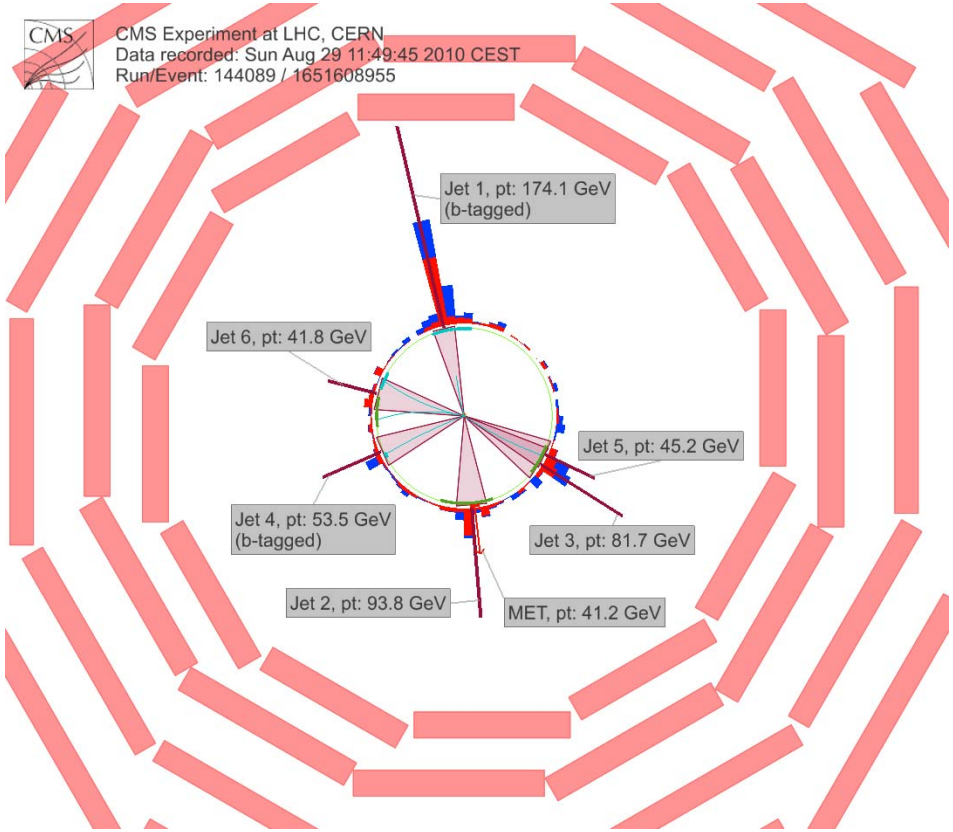
Measurement Method

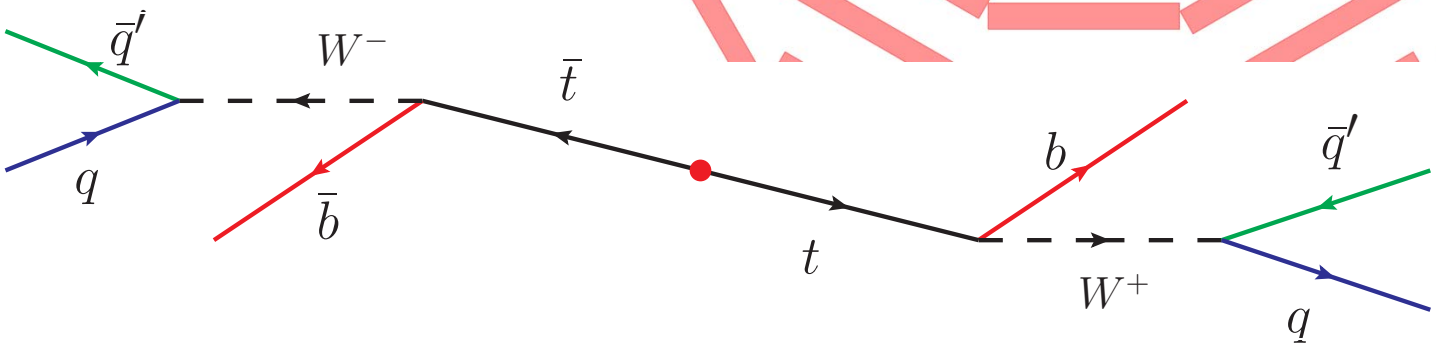
- Build estimator for m_t (invariant mass of decay products)
- Parametrize estimator as function of m_t^{MC} (and possible other parameters)
- Possible per event combination of multiple estimators
  - Ideogram method, CMS all-jets and l+jets
- Perform maximum likelihood fit to data



Kinematic Fitting

- Selected objects:
  - 4 untagged jets
  - 2 b-tagged jets





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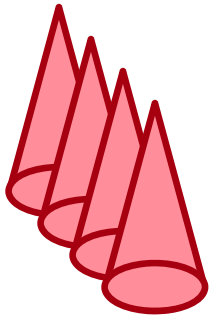
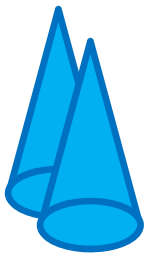
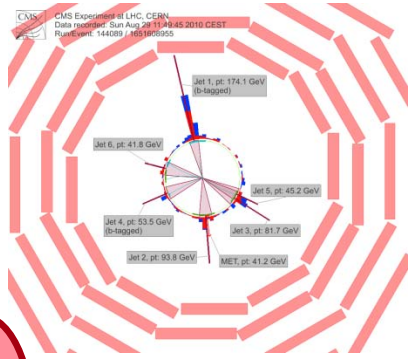
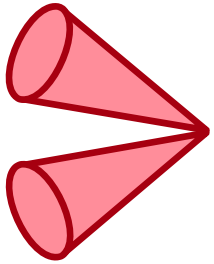


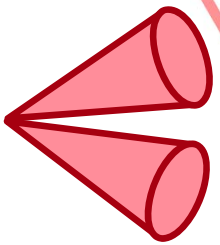




- Constraints:
  - 2x $m_{jj} = m_W$



= W boson &



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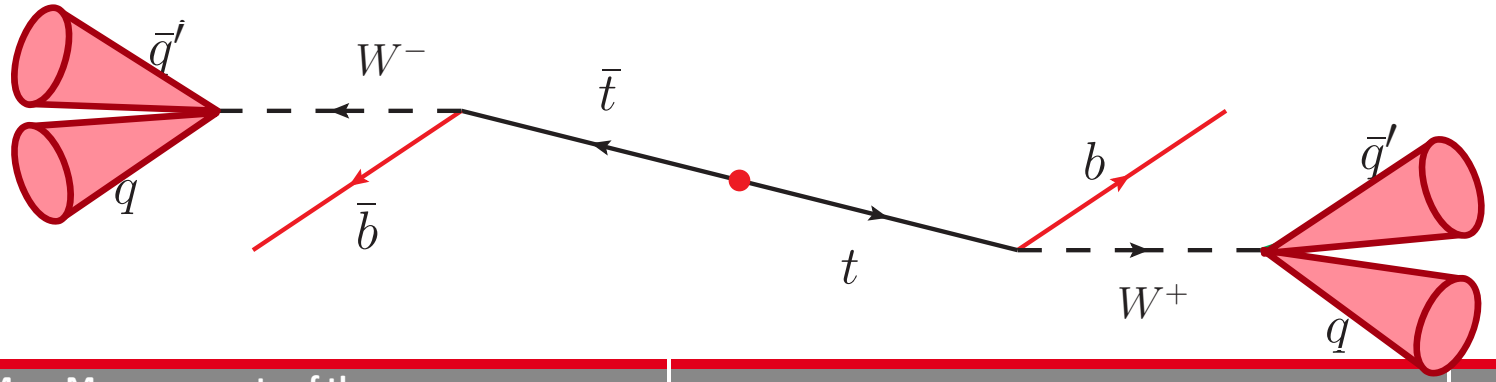

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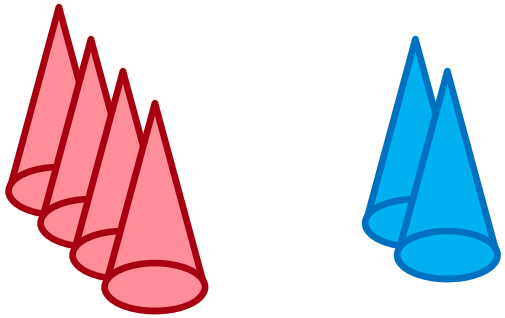

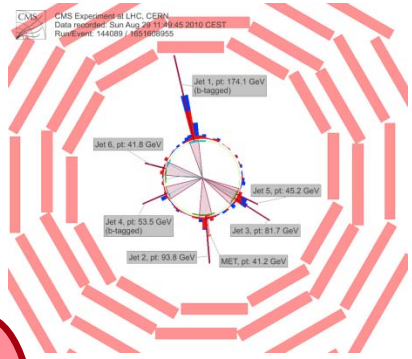

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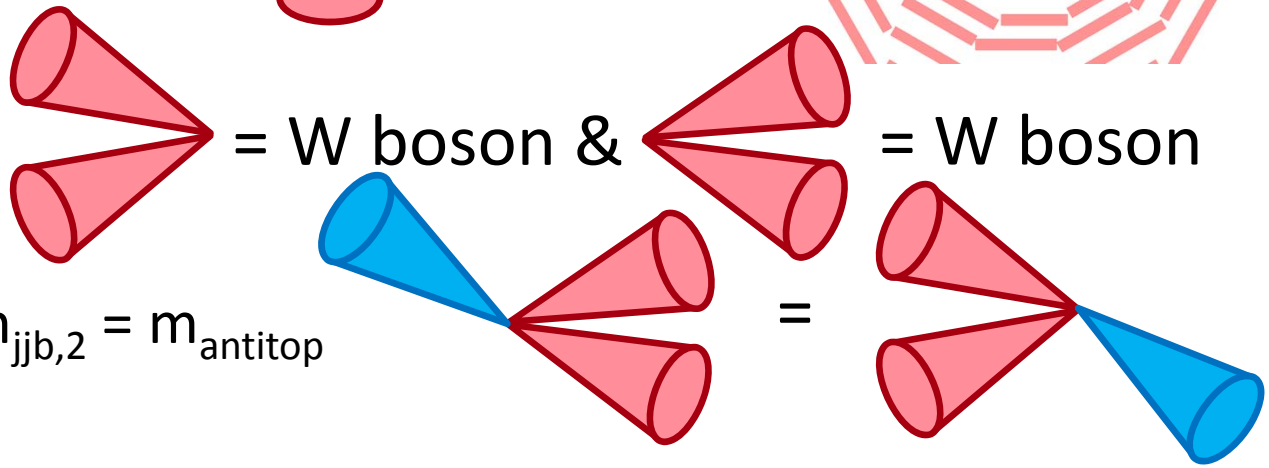
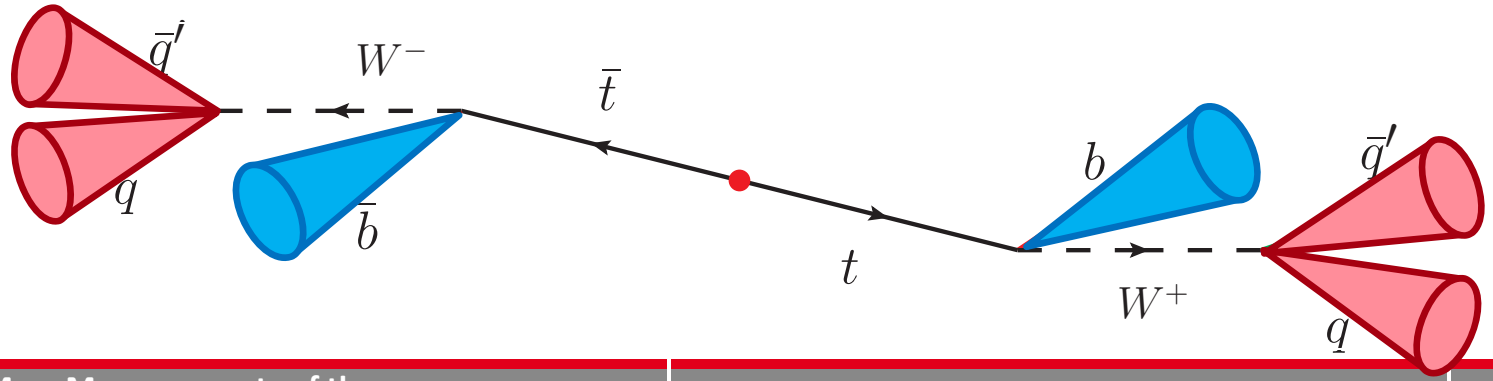
  - 2x $m_{jj} = m_W$
  - $m_{top} = m_{jjb,1} = m_{jjb,2} = m_{antitop}$





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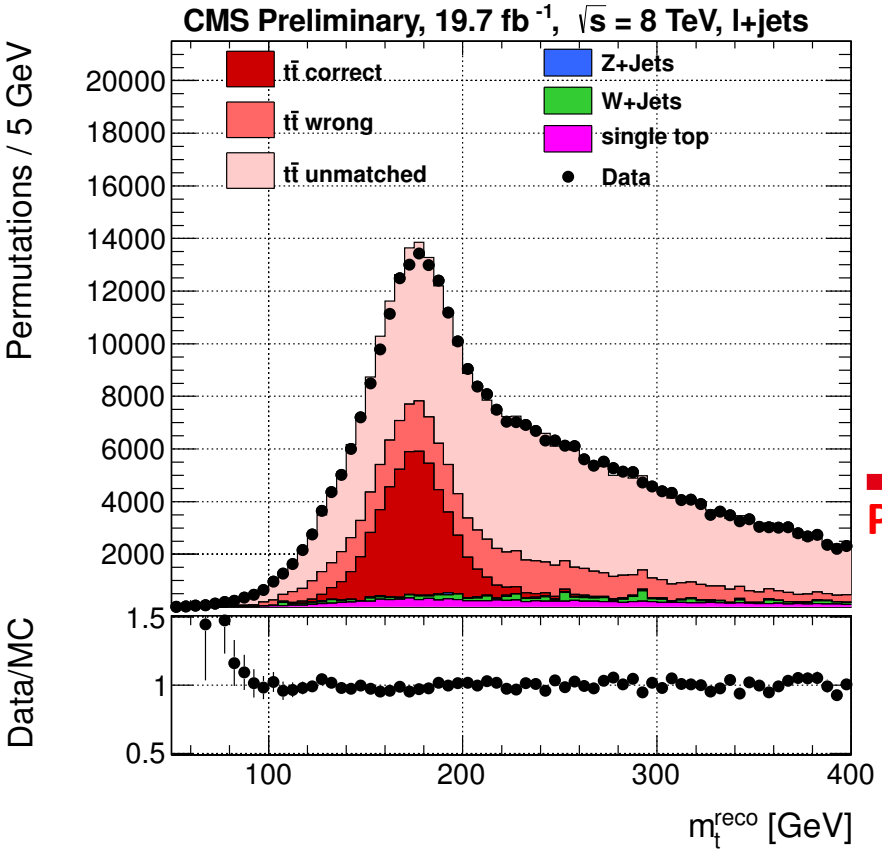
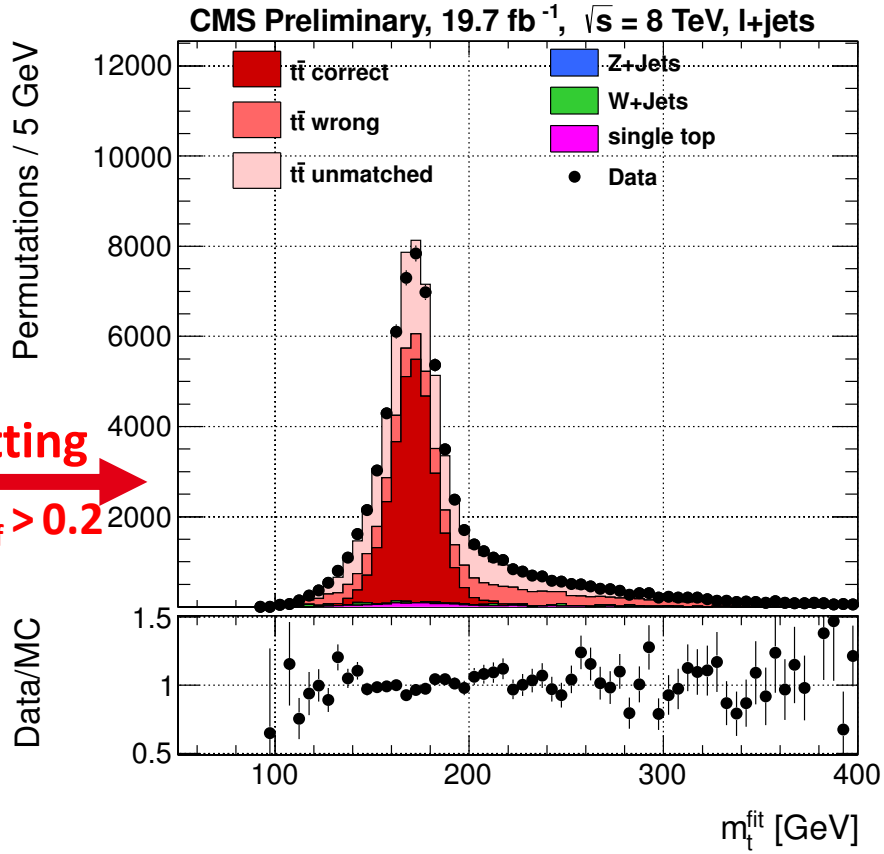


fitting

$P_{gof} > 0.2$



Ideogram Method

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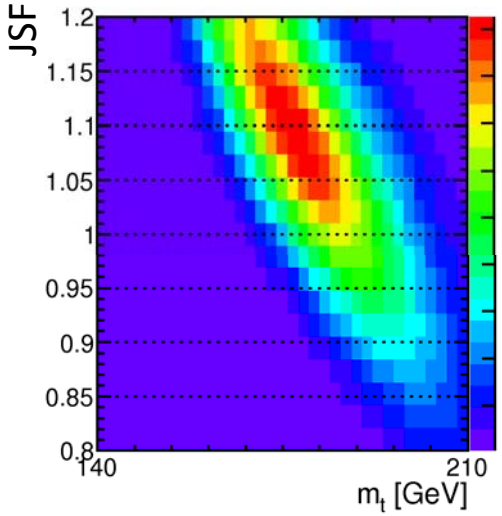
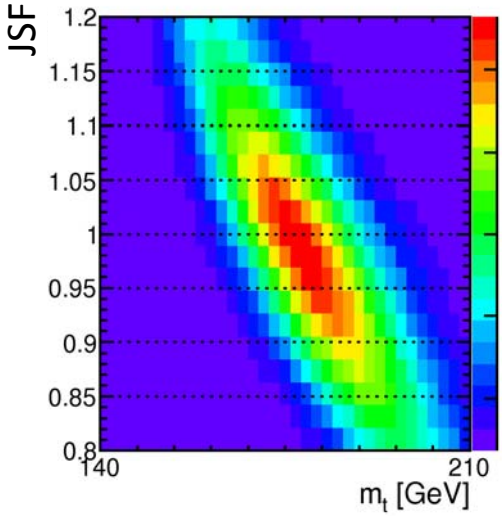


x



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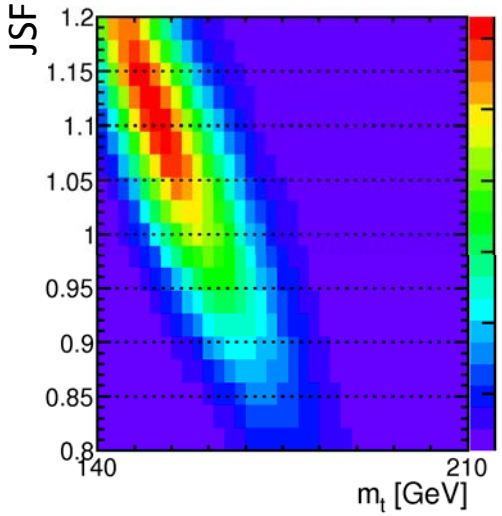

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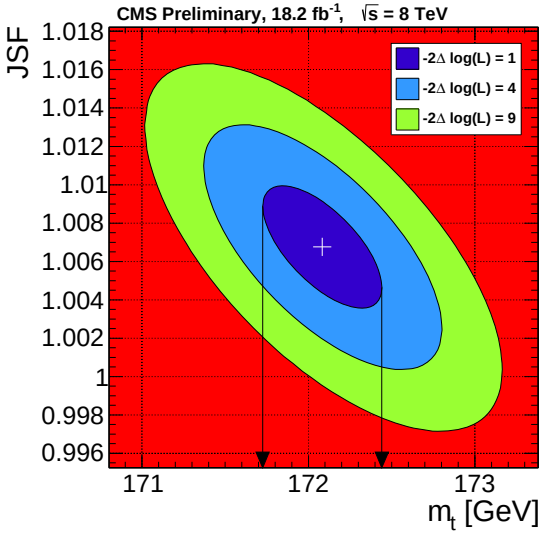


All-Jets – Event Selection

N_{data}

1. Trigger:

- QuadJet50
  - $p_T^{1-4} > 50$ GeV, based on calorimeter jets

490M

f_{sig} | ε_{sel}

2. Multi-Jet:

- p_T^4 (calo) > 60 GeV (confirm trigger)
  - Trigger efficiency > 99%
- Particle Flow, Anti-k_T (R=0.5), $|\eta| < 2.4$
- $p_T^{1-4} > 60$ GeV
- $p_T^{5-6} > 30$ GeV

1% | 4%

12M

3. B-Tagging:

- $N_{B\text{-}Tag}$ (CSVT) ≥ 2

16% | 1%

271k

4. Kinematic Fit:

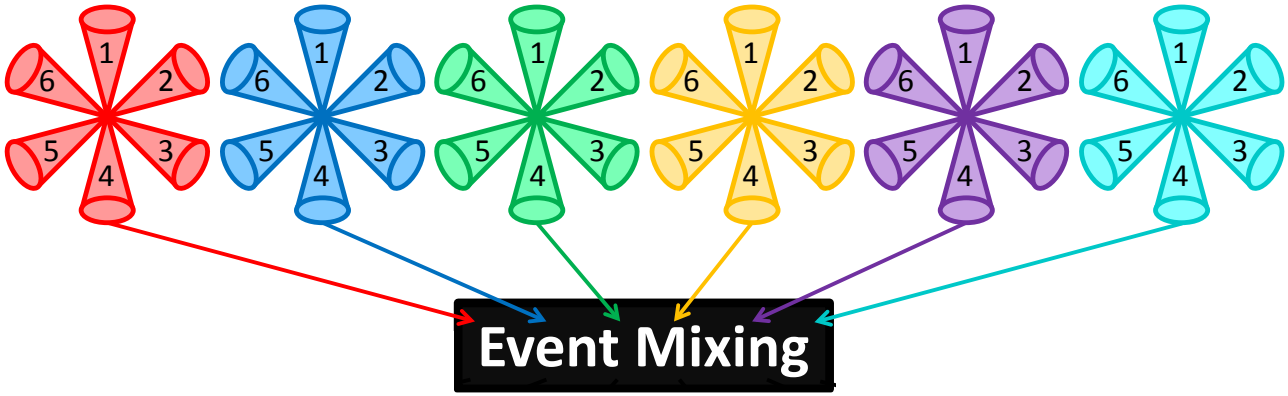
- Combine six leading jets using b-tag information
- Choose permutation with lowest χ^2
- P (χ^2) > 10% & $\Delta R_{bb} > 2.0$

78% | 0.1%

4356

Multijet Background Modeling

- Multijet background estimated using event mixing
  - Using all events after b-tagging requirement
    - 16% contamination of top-quark pair events
  - All jets in mixed events originate from different events



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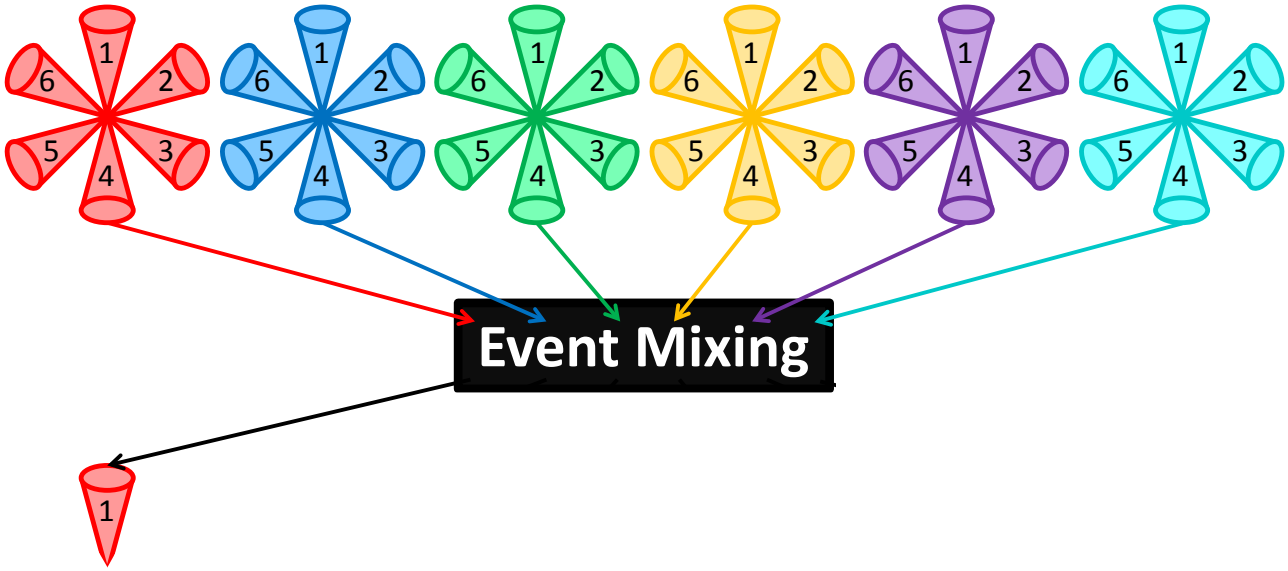

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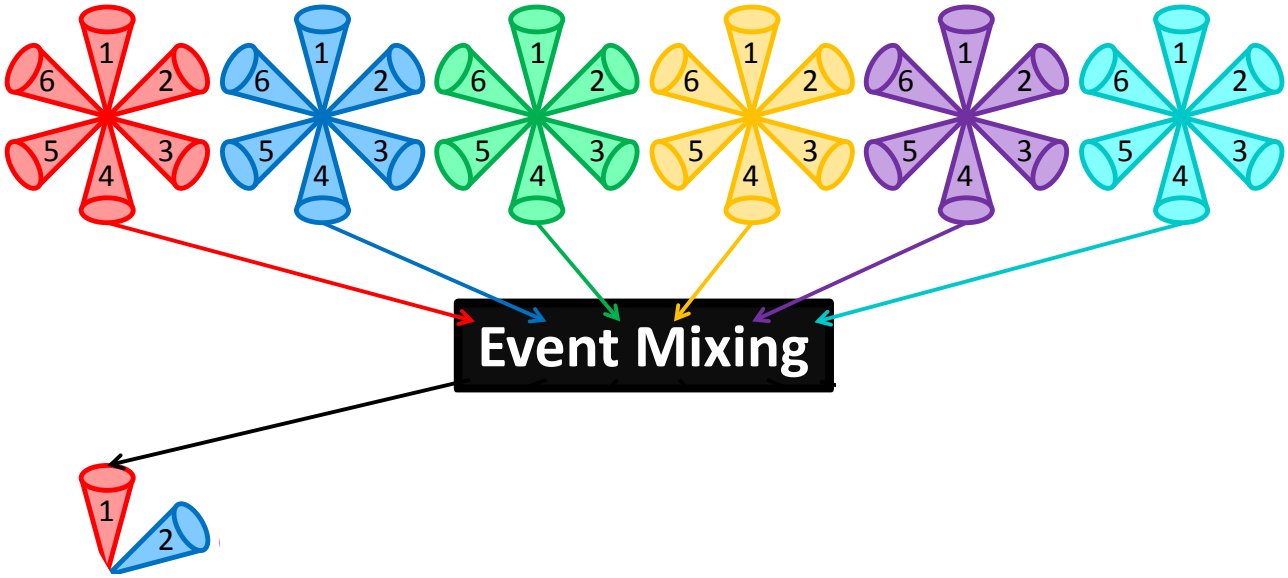

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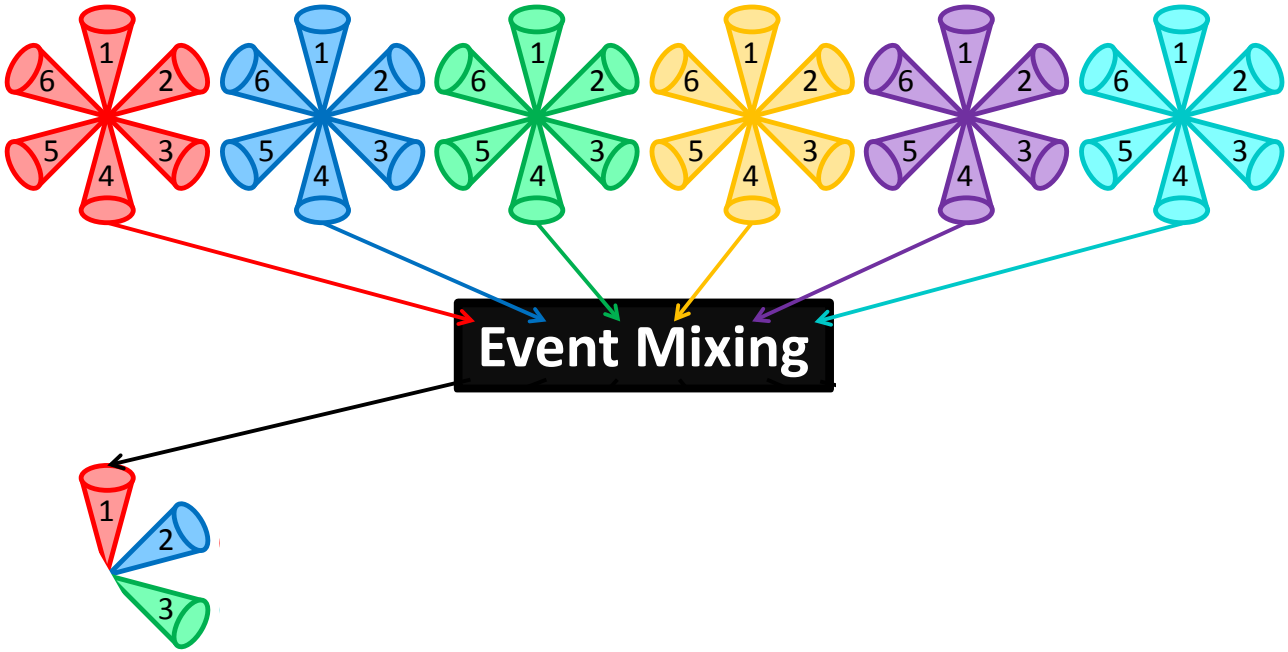

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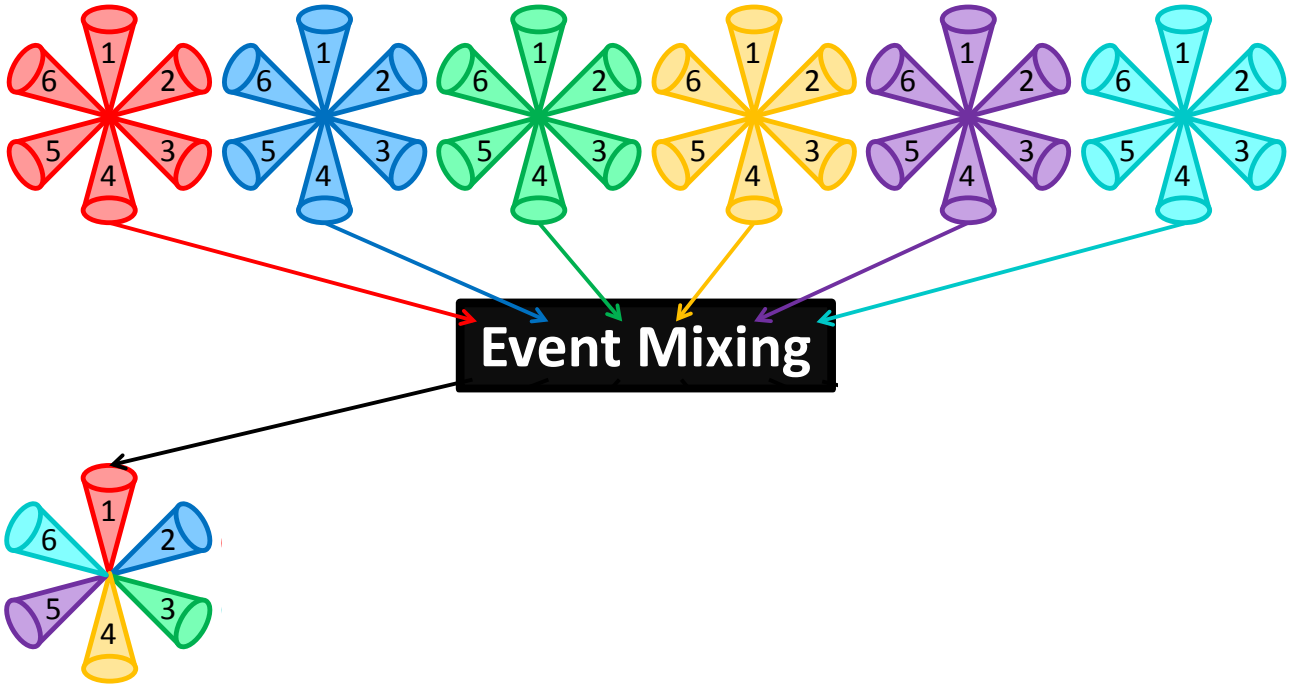

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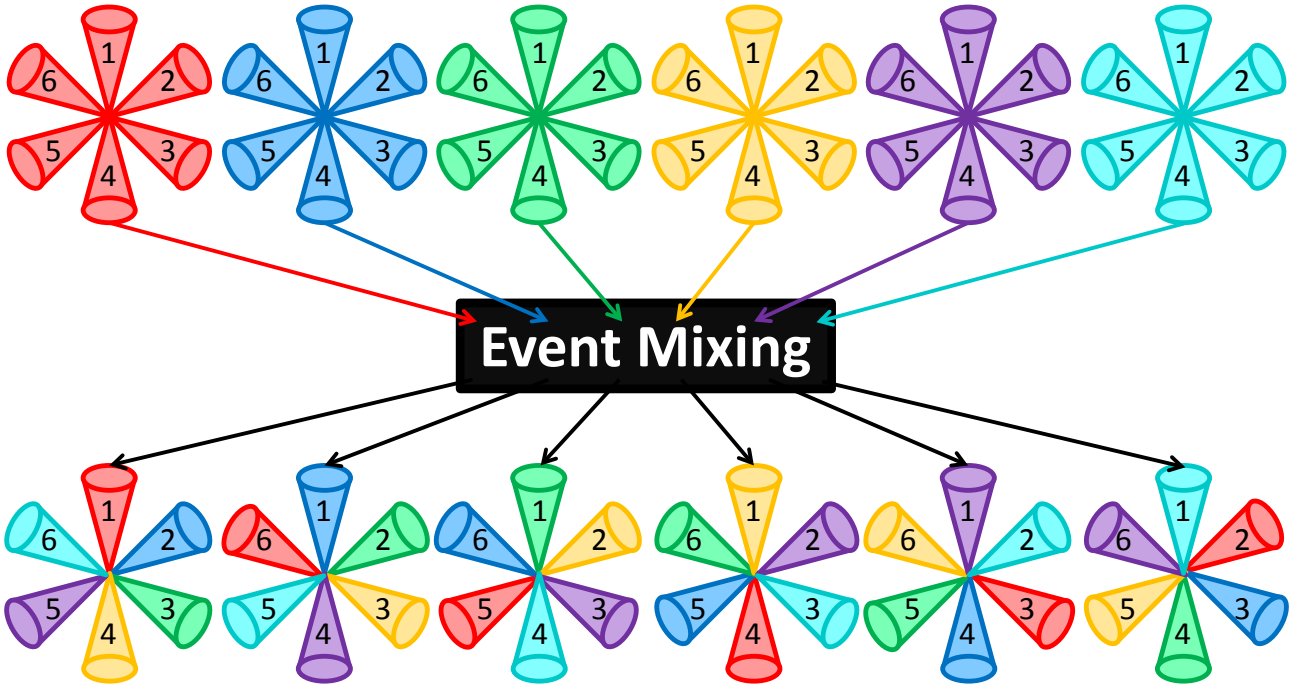
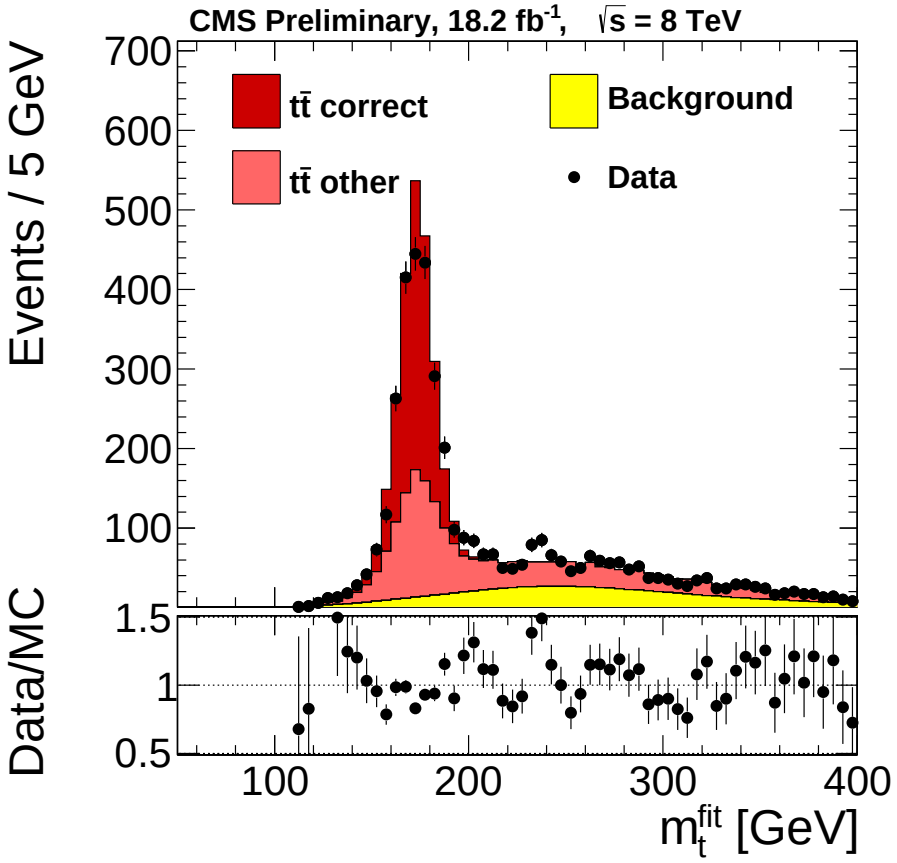
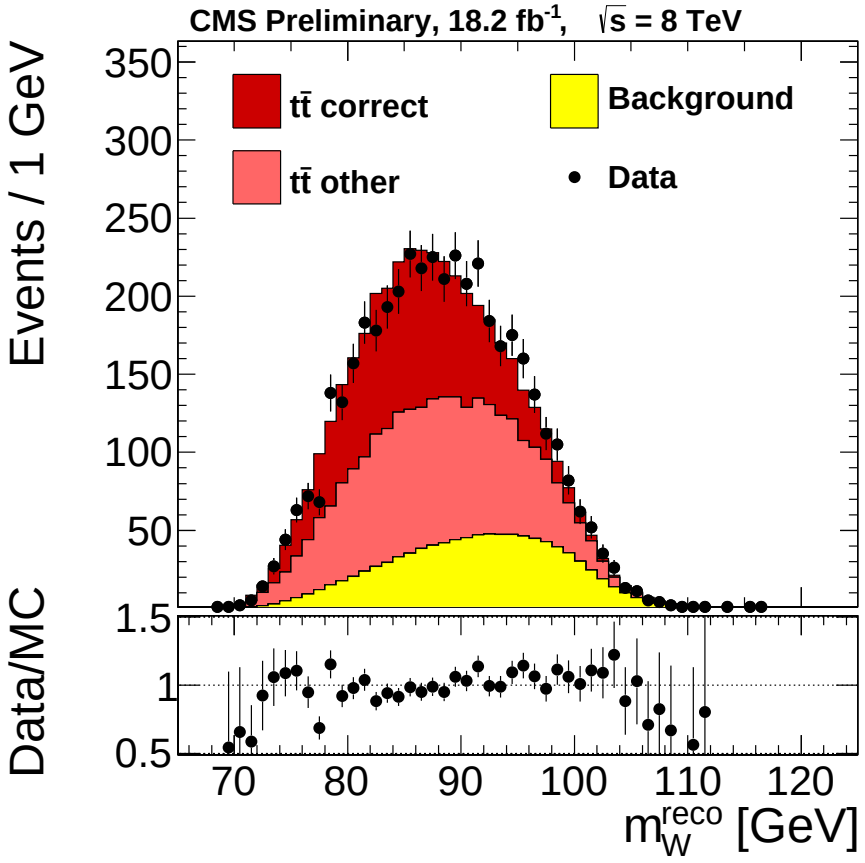


All-Jets – Distributions





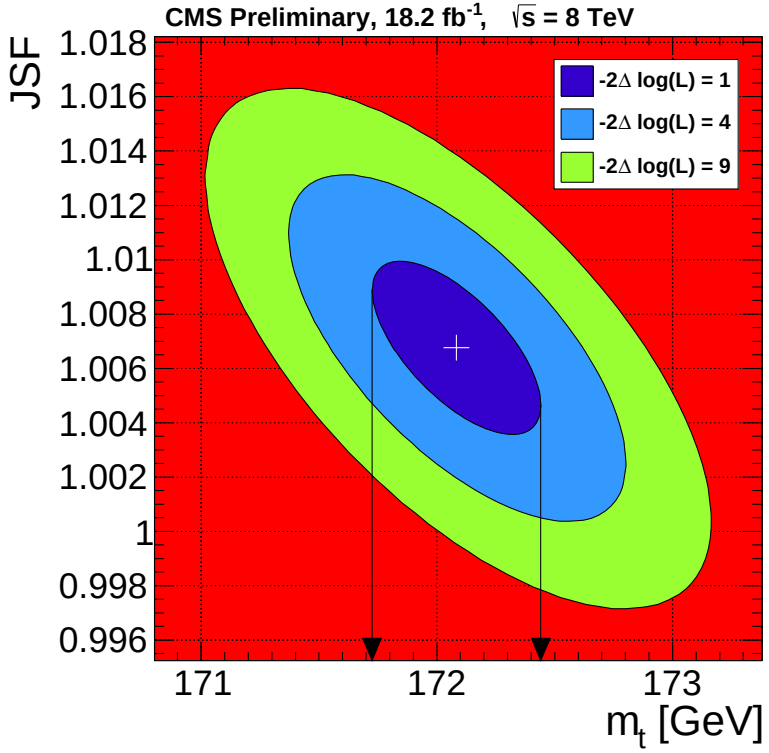
All-Jets Result at 8 TeV

CMS-PAS-TOP-14-002

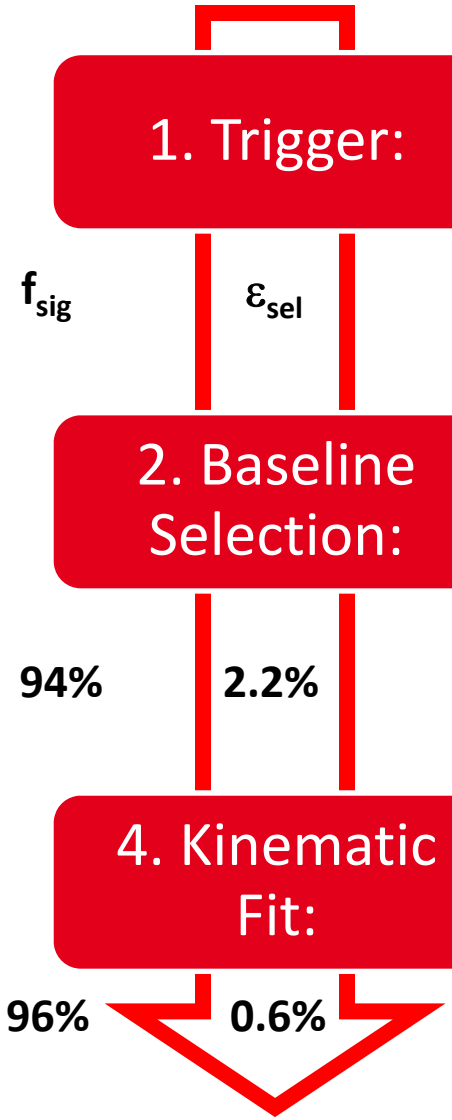
- Top-quark mass in all-jets final states:
  - m_t (2D) = 172.08 ± 0.36 (stat.+JSF) ± 0.83 (syst.) GeV
  - JSF = 1.007 ± 0.003 (stat.) ± 0.011 (syst.)
  - m_t (1D) = 172.59 ± 0.27 (stat.) ± 1.05 (syst.) GeV

JES+PU: 0.42
JSF: 0.24

Source	Unc. [GeV]
JES+PU+JSF	0.48
bJES+Had	0.39
Detector modelling	0.21
Signal modelling	0.52
Background	0.22
Method	0.06
Syst.	0.86
Stat. (m_t only)	0.27
Total	0.90



Lepton+Jets – Event Selection



- IsoMu24 or Ele27_WP80

N_{data}

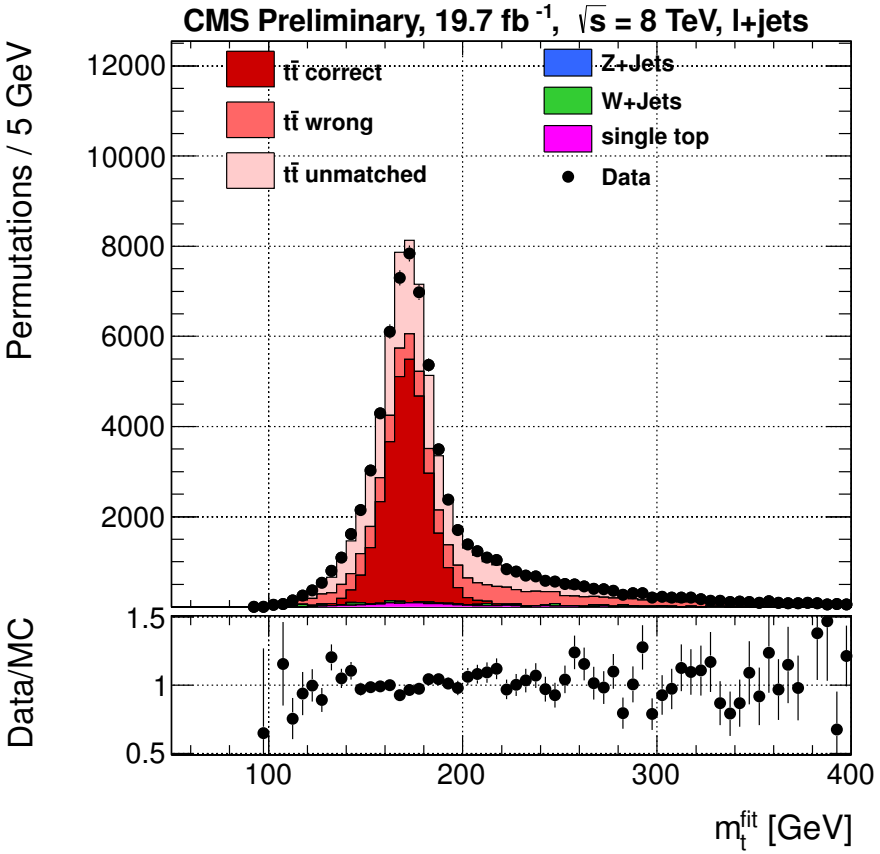
- 1 isolated lepton, $p_T > 33$ GeV and $|\eta| < 2.1$
- 4 PF jets, Anti-k_T (R=0.5), $|\eta| < 2.4$, $p_T > 30$ GeV
- $N_{B\text{-}Tag}$ (CSVM) = 2

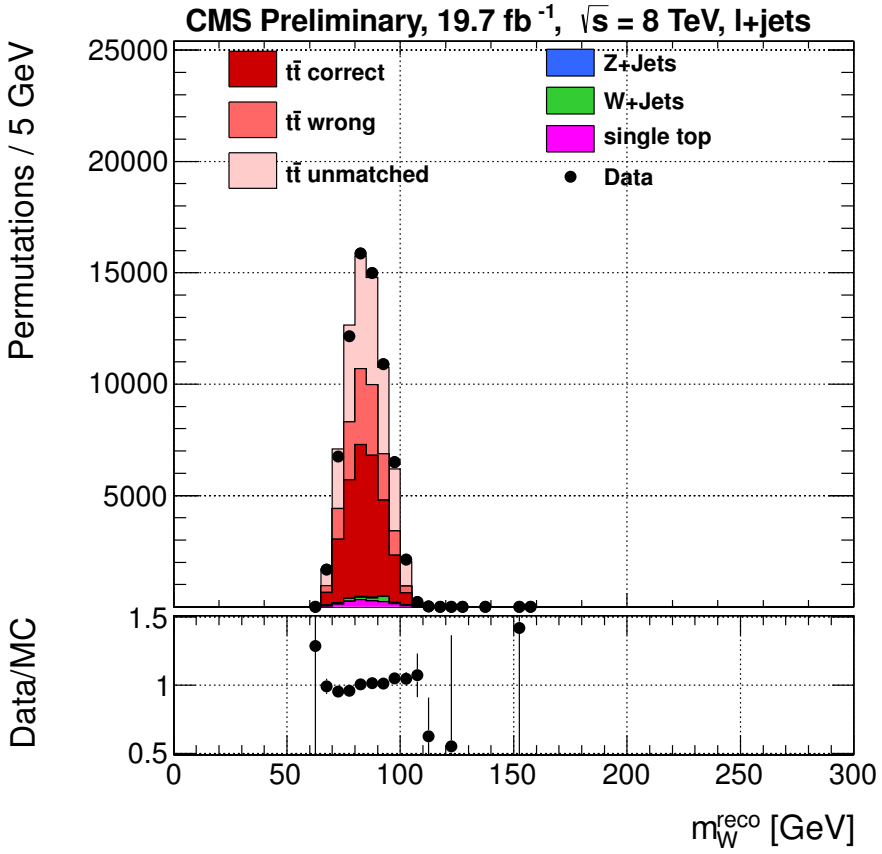
107k

- Combine four leading jets using b-tag information
- Take all permutations from kinematic fit
- P (χ^2) > 20%

28750

Lepton+Jets – Distributions





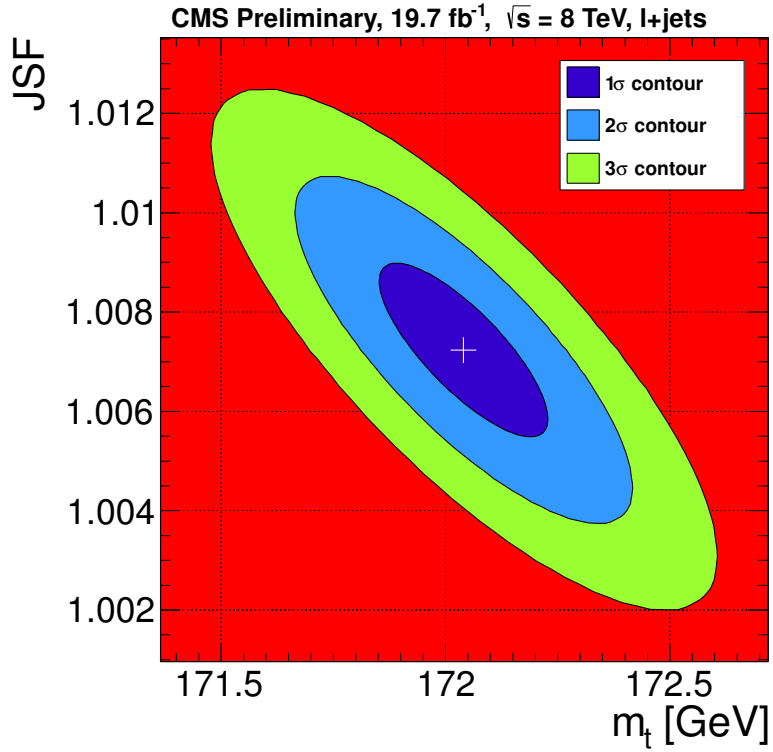
Lepton+Jets Results at 8 TeV

CMS-PAS-TOP-14-001

- Top-quark mass in lepton+jets final states:
  - m_t (2D) = 172.04 ± 0.19 (stat.+JSF) ± 0.75 (syst.) GeV
  - JSF = 1.007 ± 0.002 (stat.) ± 0.012 (syst.)
  - m_t (1D) = 172.66 ± 0.11 (stat.) ± 1.29 (syst.) GeV

JES+PU: 0.32
JSF: 0.15

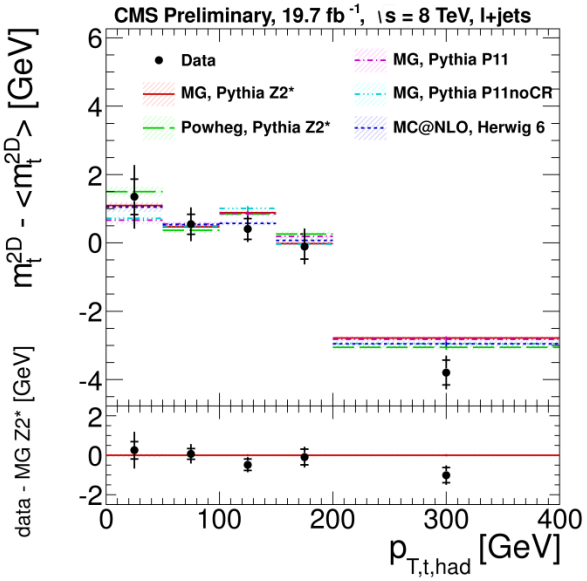
Source	Unc. [GeV]
JES+PU+JSF	0.36
bJES+Had	0.44
Detector modelling	0.28
Signal modelling	0.39
Background	0.11
Method	0.10
Syst.	0.76
Stat. (m_t only)	0.11
Total	0.77

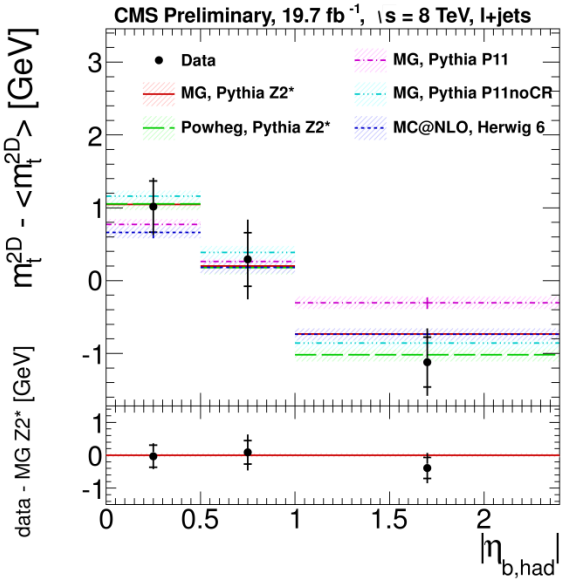


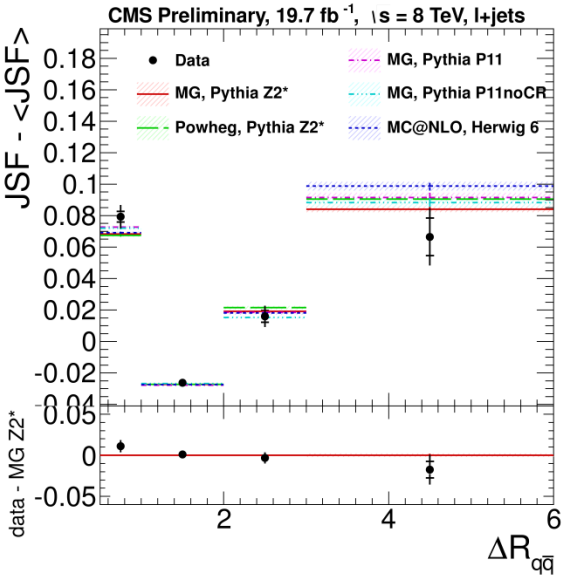
Lepton+Jets Results at 8 TeV

CMS-PAS-TOP-14-001

- Top mass vs. kinematic variables
- Data well-described
- χ^2 between data and MadGraph+Pythia Z2*
  - m_t: χ^2/ndf = 37/47 → P(χ^2,ndf) = 85%
  - JSF: χ^2/ndf = 61/47 → P(χ^2,ndf) = 8.3%







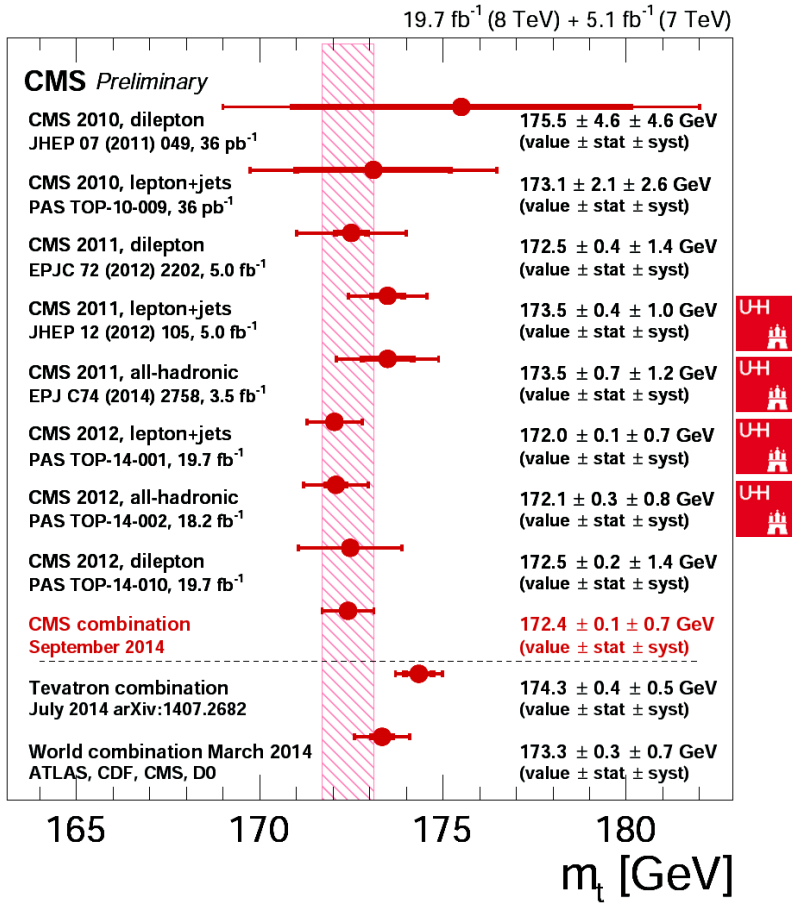
CMS Top-Mass Combination

- Combination of all standard CMS top-mass results
- Consistent between all decay channels

JES+PU: 0.25
JSF: 0.10

Source	Unc. [GeV]
JES+PU+JSF	0.27
bJES+Had	0.39
Detector modelling	0.19
Signal modelling	0.38
Background	0.09
Method	0.05
Syst.	0.65
Stat. (m_t only)	0.10
Total	0.65

CMS-PAS-TOP-14-015

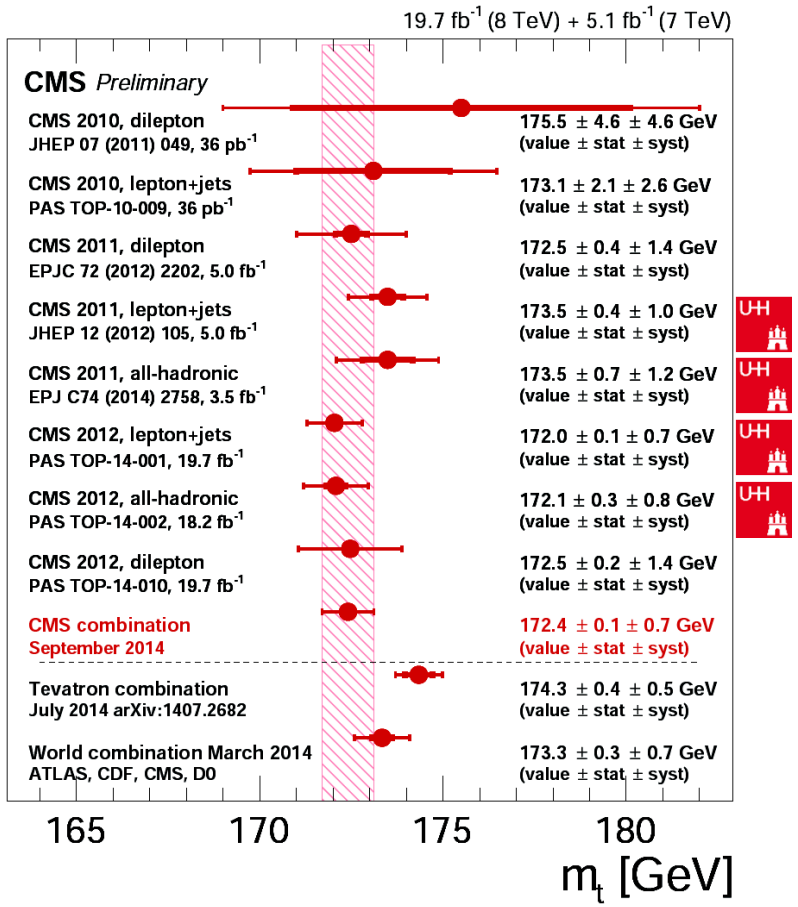


m_t = 172.38 ± 0.65 GeV (0.38%)

Summary

UHH mass analyses:

- Most precise analyses in all-jets and lepton+jets at LHC
- Both analyses (plus 7 TeV predecessors) drive the CMS combination, the most precise determination of the top-quark mass



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