Top Quark Mass Measurement From B-jet Energy Spectrum

Group 1

Facilitator: Junghwan John Goh / Geonmo Ryu

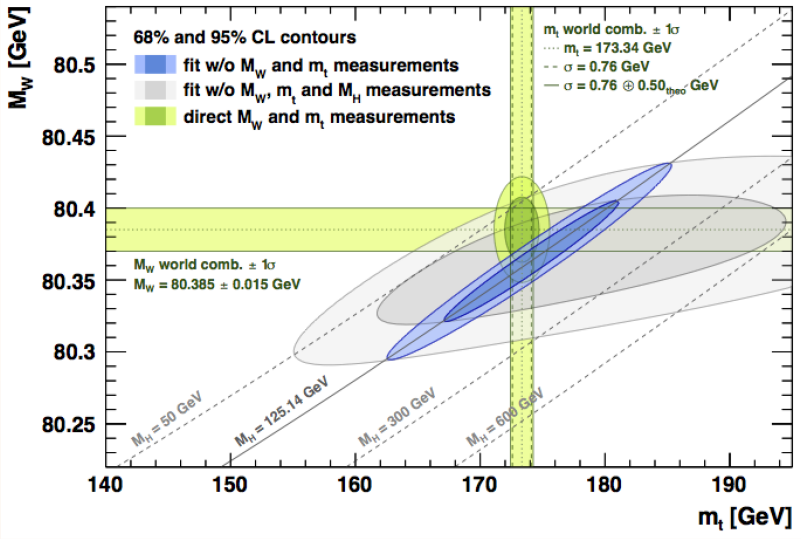
Ching-Wei Chen [National Central University]
Ji-Kong Huang [National Central University]
Yi-Jhih Yang [National Taiwan University] (TA)
Li Linwei [Peking University]
Yee Hsiung [National Taiwan University]

Group 1 part 1

- Introduction
- Event selection
- Eb fitting and MC calibration

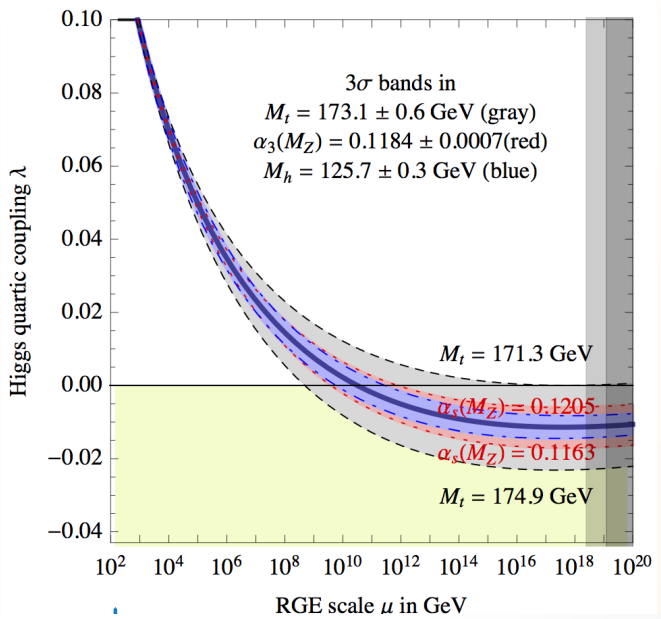
The electroweak fit and indirect measurement of M_W

EPJC 74(2014)3046



The electroweak vacuum stability

JHEP 1208(2012)098



Introduction

- In 2012: proton-proton collisions with $\sqrt{s} = 8$ TeV and $\mathcal{L} = (19.7 \pm 0.8)$ fb^{-1}
  - $\sigma_{t\bar{t}} = 246$ pb : $N_{t\bar{t}} \sim 4.9 \cdot 10^6$ top-pair events
  - $\sigma_t = 87$ pb : $N_t \sim 1.7 \cdot 10^6$ single-top events
- In 2015: proton-proton collisions with $\sqrt{s} = 13$ TeV and $\mathcal{L} = 2.44$ fb^{-1}
  - $\sigma_{t\bar{t}} = 832$ pb : $N_{t\bar{t}} \sim 2.0 \cdot 10^6$ top-pair events
  - $\sigma_t = 142$ pb : $N_t \sim 3.5 \cdot 10^5$ single-top events

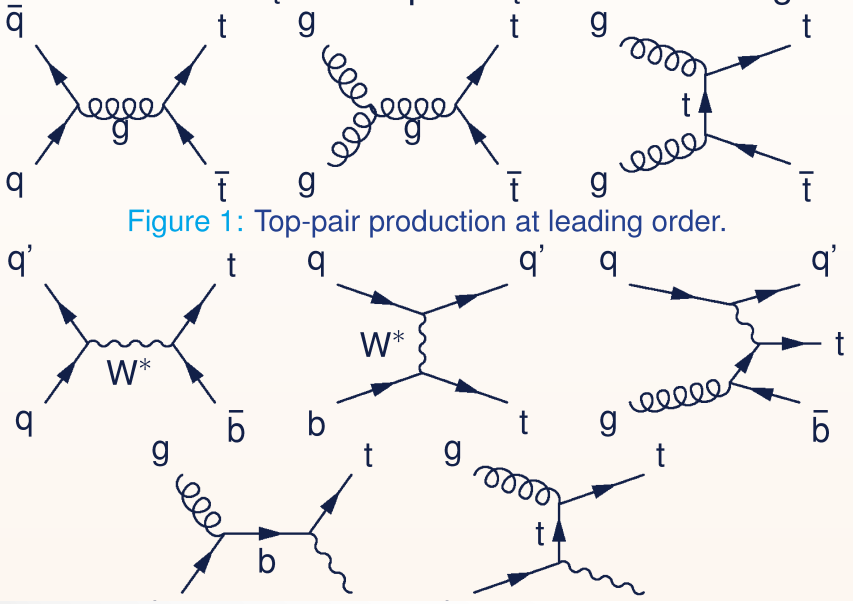
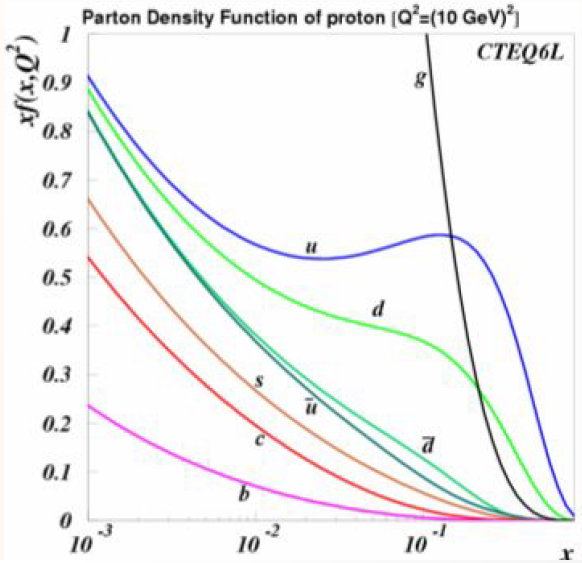


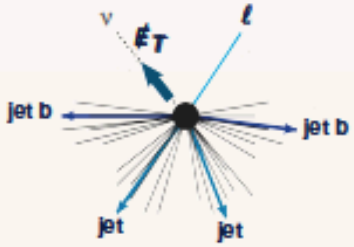
Figure 1: Top-pair production at leading order.



Reconstruction of a $t\bar{t}$ event

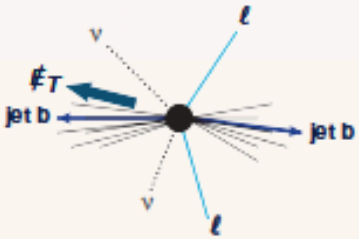
- *Particle-flow* algorithm:
  1. identification of 5 types of candidates from **all the tracks left** in the detector: electrons, muons, photons, neutral and charged hadrons
  2. identification and withdrawal of **isolated electrons and muons**
  3. subtraction of charged hadrons not coming from the primary vertex
  4. **jets** reconstruction with an anti-k_t 0.5 algorithm and estimation of $\not{E}_T$
- Jet/muon/electron energy corrections
- b-tagging

$t\bar{t}$ semi-leptonic



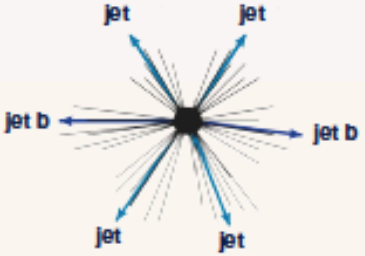
$BR \sim 45\%$

$t\bar{t}$ dileptonic



$BR \sim 9\%$

$t\bar{t}$ hadronic



$BR \sim 46\%$

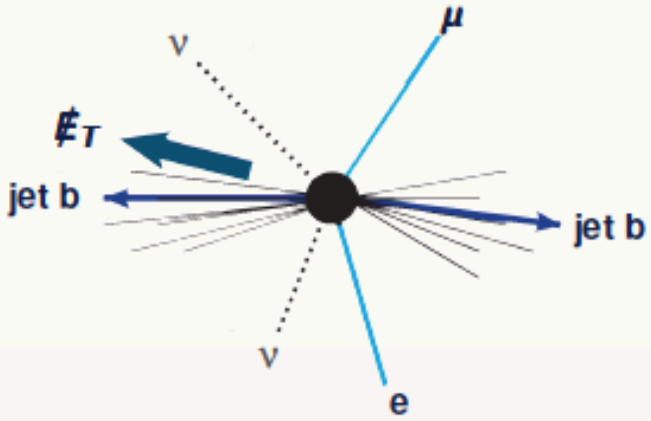
Selection of $e\mu$ events

Triggers

- Mu8_Ele17_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL
- Mu17_Ele8_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL

Leptons

- 1 isolated muon and 1 isolated electron
  - $p_T > 20$ GeV and $|\eta| \leq 2.4$
  - $I_{rel} < 0.15$ (0.12) in a cone of 0.3 (0.4)
- opposite charges
- $M_{e\mu} > 12$ GeV



Jets

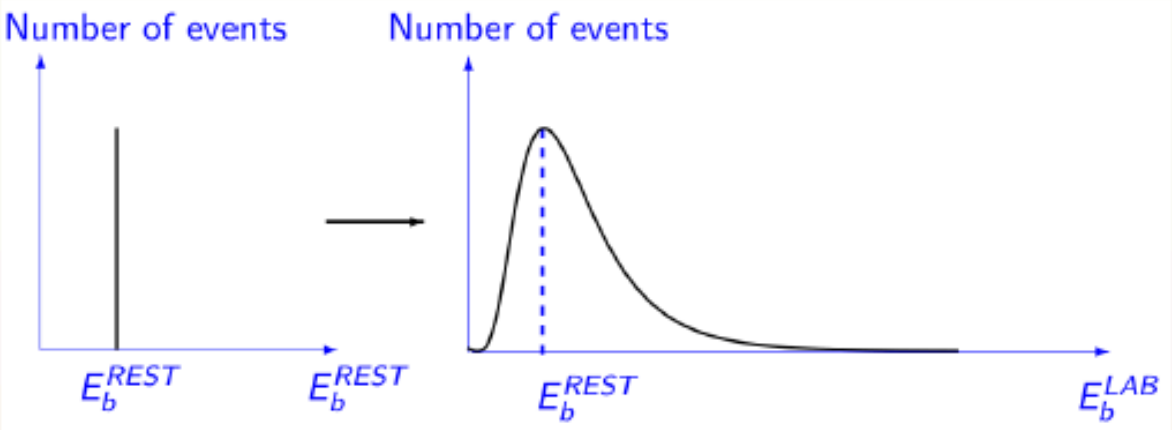
- ≥ 2 jets with $p_T > 30$ GeV and $|\eta| \leq 2.5$
- 1 or 2 b-tagged jets (CSV > 0.405)

No $\not{E}_T$ requirement

Total number of b-tagged jets in data: 51 372
Correctly identified b-jets in $t\bar{t}$ events: 93%

From the theory

- Kinematic of a 2-body decay in the top-quark rest frame:
  $M_t = E_b^{rest} + \sqrt{M_W^2 - M_b^2 + (E_b^{rest})^2}$
- After boosting the b-quark by β_t from the top-quark rest frame to the laboratory frame: $E_b^{lab} = E_b^{rest}\gamma_t(1 + \beta_t \cos\theta)$, where $\theta = (\vec{\beta}_t, \vec{p}_b)$



$\Rightarrow$ M_t can be inferred from the peak position of the E_b^{lab} spectrum:

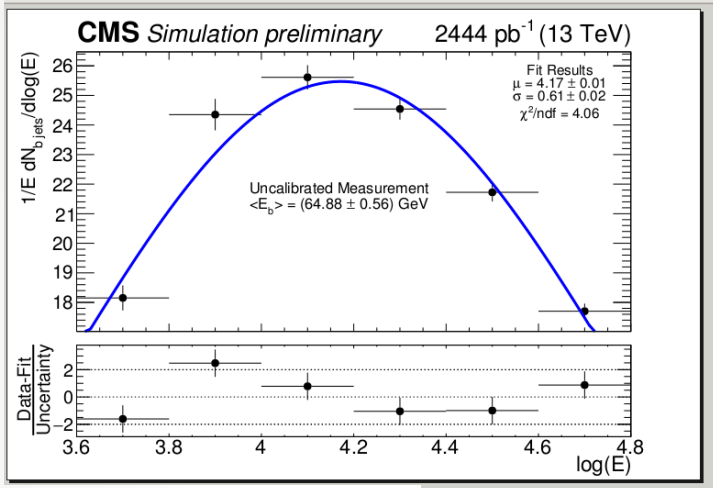
- purely kinematic, need of a precise reconstruction of **only 1** decay product
- **robust** wrt $\sqrt{s}$, β_t, and ISR variations

Event Yields

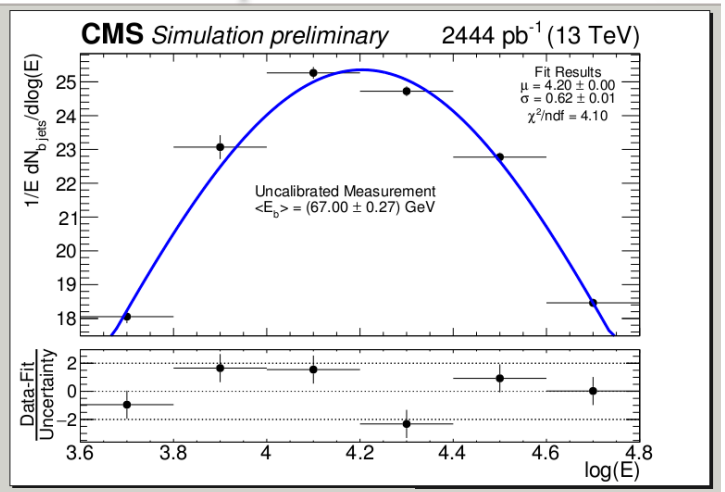
Process	Number of events
Diboson	789 ± 7
Single top	553 ± 10
$t\bar{t}$+V	20.1 ± 0.5
$t\bar{t}$	10845 ± 20
DY	316 ± 36
W	86 ± 39
Total from simulations	12611 ± 39
Data	14760

MC Eb fit

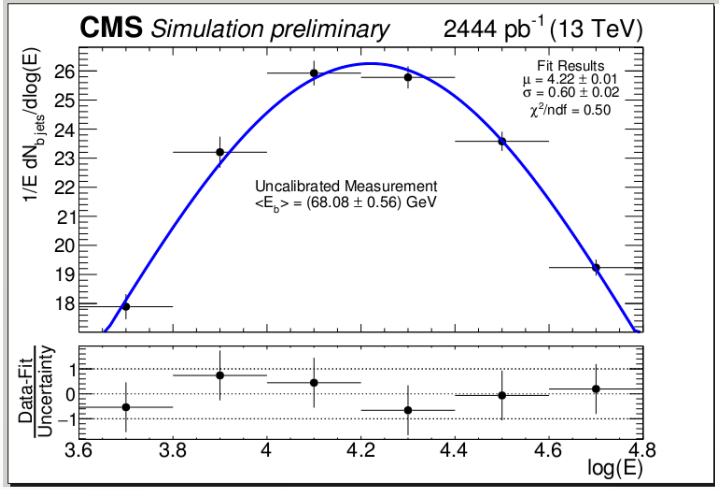
mtop=169.5 GeV



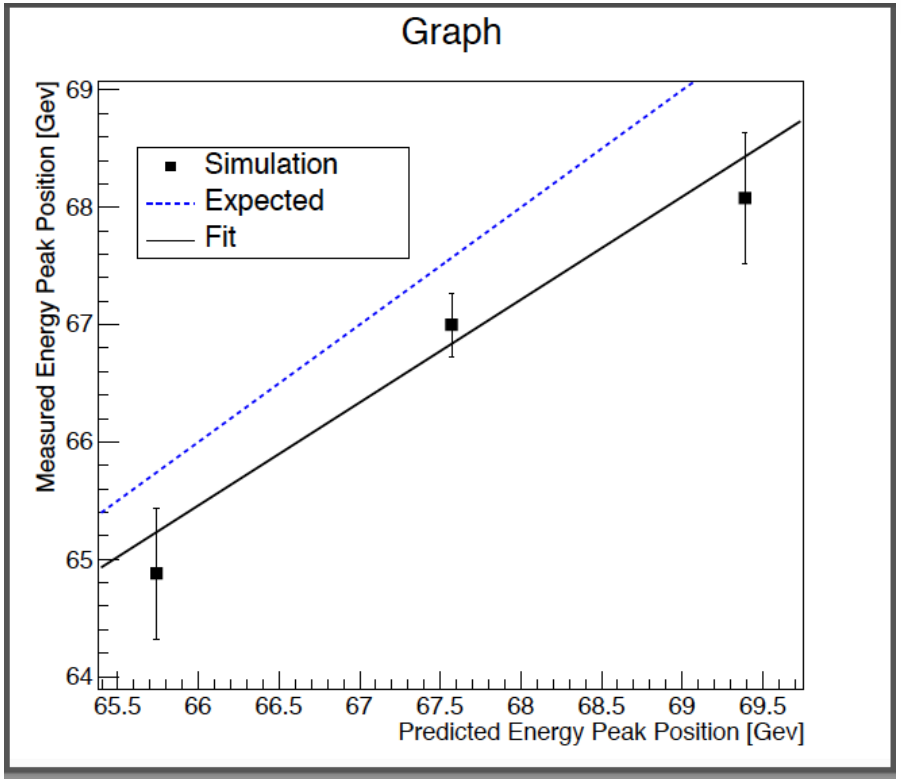
mtop=172.5 GeV



mtop=175.5 GeV



B-Jet Energy Spectrum Eb



$Y = bX + a$

a: 7.5612 +- 1.466

b: 0.877 +- 0.217

Mt (GeV)	MC Eb fit (GeV)	Exact Calculation Eb(GeV)
169.5	64.88 +- 0.56	65.74
172.5	67.00 +- 0.27	67.57
175.5	68.08 +- 0.56	69.37

Systematic Uncertainties

Systematic Uncertainties	**MC Eb fit (GeV)**
amcatnloFXFX_pythia	65.93 +- 0.76
amcatnloFXFX_herwig	65.03 +- 0.73
madgraphMLM	67.21 +- 0.52
Scale up	66.48 +- 0.60
Scale down	66.51 +- 0.66
Mtop = 172.5 GeV (nominal)	67.00 +- 0.27