E1-2008-173

G. Bellettini[1], J. Budagov[2], G. Chlachidze[3], V. Glagolev[2],
A. Sissakian[2], I. Suslov[2], M. Trovato[1], G. Velev[3]
(on behalf of the CDF Collaboration)

TOP QUARK MASS MEASUREMENT IN THE 2.9 fb^{-1} TIGHT LEPTON AND ISOLATED TRACK SAMPLE USING NEUTRINO ϕ WEIGHTING METHOD

[1]INFN and Department of Physics, University of Pisa, Italy
[2]Joint Institute for Nuclear Research, Dubna
[3]FNAL, Batavia, USA

Беллеттини Дж. и др. (от коллаборации CDF) E1-2008-173

Измерение массы топ-кварка на статистике 2,9 фб$^{-1}$
в событиях «лептон–трек» с помощью метода взвешивания
по азимутальным углам нейтрино

Измерена масса топ-кварка в выборке $t\bar{t}$-событий, полученных коллаборацией CDF при $p\bar{p}$-столкновениях на тэватроне ($\sqrt{s}$ = 1,96 ТэВ). Для измерения использовались события, в которых регистрировался мюон (или электрон) и изолированный трек. На основе данных, соответствующих интегральной светимости 2,9 фб$^{-1}$, была получена выборка из 328 событий, удовлетворяющих критериям отбора. Проводилась реконструкция событий путем минимизации χ^2-функции, описывающей дилептонный канал распада $t\bar{t}$-событий. Проблема недостаточного числа кинематических связей для реконструкции решалась путем сканирования пространства возможных азимутальных углов обоих нейтрино. На основе результатов сканирования для каждого события строилась оценочная масса. Значение измеренной массы топ-кварка соответствует максимуму функции правдоподобия, описывающей вероятность наблюдения экспериментальной выборки на основе суперпозиции сигнальных и фоновых функций плотности вероятности оценочной массы. При ожидаемом числе фоновых событий $145{,}0 \pm 17{,}3$ значение измеренной массы топ-кварка составило $m_t = 165{,}5 \pm ^{3,4}_{3,3}$ (стат.) $\pm$ 3,1 (сист.) ГэВ/c^2.

Работа выполнена в Лаборатории ядерных проблем им. В. П. Джелепова ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 2008

Bellettini G. et al. (on behalf of the CDF Collaboration) E1-2008-173

Top Quark Mass Measurement in the 2.9 fb^{-1} Tight Lepton
and Isolated Track Sample Using Neutrino ϕ Weighting Method

We report on a measurement of the top quark mass with $t\bar{t}$ dilepton events produced in $p\bar{p}$ collisions at the Fermilab Tevatron ($\sqrt{s}$=1.96 TeV) and collected by the CDF II detector. Events with a charged muon or electron and an isolated track are searched for $t\bar{t}$ candidates. A sample of 328 events, corresponding to an integrated luminosity of 2.9 fb^{-1}, is obtained after all selection cuts. The top quark mass is reconstructed by minimizing a χ^2 function in the assumption of the $t\bar{t}$ dilepton hypothesis. The unconstrained kinematics of dilepton events is taken into account by the scan over the space of possibilities for the azimuthal angles of neutrinos, and a preferred mass is built for each event. In order to extract the top quark mass, a likelihood fit of the preferred mass distribution in data to a weighted sum of signal and background probability density functions is performed. Using the background constrained fit with 145.0±17.3 events expected from background we measure $m_t = 165.5 \pm ^{3.4}_{3.3}$ (stat.) GeV/c^2. The estimate of systematic error is 3.1 GeV/c^2.

The investigation has been performed at the Dzhelepov Laboratory of Nuclear Problems, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna, 2008

INTRODUCTION

One of the main physics goals of CDF [1] in Run II is the study of top quark properties. First observed by the CDF and DØ collaborations in 1995 [2], the top quark is very massive, more than 35 times heavier than b-quark. The top quark mass is one of the fundamental parameters of the Standard Model (SM). Within the SM its precise measurement together with W mass gives a constraint on the Higgs boson mass.

In the CDF Run II we study proton–antiproton collisions at a center-of-mass energy 1.96 TeV. Top quarks are mostly produced in pairs ($t\bar{t}$) from quark–antiquark annihilations ($\sim$85%) or from gluon–gluon fusion. According to the SM, both top quarks decay almost exclusively as $t \to Wb$. The channels of $t(\bar{t})$-decay are classified according to the decay modes of the W boson. The *dilepton* channel, when both W decay to leptons (e, μ), gets only 5% of decays, but has the best signal-to-background ratio. Near 30% of decays goes to the $lepton + jets$ channel, with one W producing an electron or a muon, and the other decaying into a quark pair and producing jets. The *all-hadronic* decay channel collects 46% of events, but has a large QCD background.

In this note we report on a measurement of the top quark mass in the dilepton channel using the lepton + track event selection to collect more events due to the relaxed cuts for one of the leptons.

1. DATA SAMPLE & EVENT SELECTION

In our analysis we used data collected between March 2002 and April 2008, corresponding to a total integrated luminosity of about 2.9 fb^{-1}. The data are collected with an inclusive lepton trigger that requires an electron with $E_T > 18$ GeV or a muon with $P_T > 18$ GeV/c. After full event recontruction we select events with a tight electron $E_T > 20$ GeV or muon with $P_T > 20$ GeV/c, an isolated track $P_T > 20$ GeV/c («track lepton» or «tl»), two or more jets $E_T > 20$ GeV, and significant missing transverse energy $\not{E}_T > 25$ GeV.

Tight electron candidates have a well-measured track pointing at an energy deposition in the calorimeter. In addition, the candidate's electromagnetic shower profile must be consistent with that expected for electrons. Tight muon candidates must have a well-measured track linked to hits in the muon chambers and a consistent energy deposition in the calorimeters with that expected for muons. Tight lepton has to be isolated that means that the total transverse energy within the cone of radius $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.4$, minus the candidate lepton E_T, is less than 10% of the candidate lepton E_T.

To count as the second lepton (track lepton) for our analysis a well-measured track must have $P_T > 20$ GeV/c, and pass a track isolation requirement. The track isolation is defined as the ratio of the transverse momentum of the candidate track to the sum of the transverse momenta of all tracks in a cone of radius $\Delta R = 0.4$ around it, including the candidate track itself. The track isolation value should be more than 0.9.

We require two (or more) jets with corrected $E_T > 20$ GeV and $|\eta| < 2.0$. The tight lepton and the track lepton have to be oppositely charged. Events with cosmic ray or conversion are eliminated.

Also, several topological vetoes are implemented in order to reduce the impact of backgrounds in the sample:

- Background contributions from Z boson decays yielding overestimated $\not{E}_T$ are removed by raising the $\not{E}_T$ requirement to 40 GeV for Z boson candidate. A Z boson candidate is identified when the invariant mass of the lepton pair is inside the Z mass window ([76, 106] GeV/c^2).
- Large azimuthal separations between $\overrightarrow{\not{E}_T}$ and jets ($\Delta\phi > 25°$), lepton ($\Delta\phi > 5°$), and track lepton ($\Delta\phi > 5°$, $\Delta\phi < 175°$) are required. The requirement of a minimum angle between jets and $\overrightarrow{\not{E}_T}$ is dropped if $\not{E}_T > 50$ GeV, since such large values of missing transverse energy are not expected to arise from jet mismeasurements.

After these selection cuts 328 events are left, which are reconstructed according to the $t\bar{t}$ hypothesis. The same cuts are applied to the Monte Carlo generated signal and background events.

2. TOP MASS RECONSTRUCTION

2.1. Brief Description of the Method. The estimated top mass value for each event is returned from a kinematic event reconstruction procedure [3]. In brief, event reconstruction is the result of minimization of the chi-squared function (χ^2) by the MINUIT routines. This chi-squared function has resolution terms related to the measured physical variables and constrained terms to take into account the kinematic equations. The formula for χ^2 we use is

$$\begin{aligned}
\chi^2 &= \chi^2_{\rm reso} + \chi^2_{\rm constr},\\
\chi^2_{\rm reso} &= \sum_{l=1}^{2} \frac{(P_T^l - \widetilde{P_T^l})^2}{{\sigma^l_{P_T}}^2} - 2\sum_{j=1}^{2} \ln\left(\mathscr{P}_{tf}(\widetilde{P_T^j}|P_T^j)\right) + \sum_{i=x,y} \frac{(UE^i - \widetilde{UE^i})^2}{{\sigma^i_{UE}}^2},\\
\chi^2_{\rm constr} &= -2\ln\left(\mathscr{P}_{\rm BW}(m_{\rm inv}^{l_1,\nu_1}|M_W,\Gamma_{M_W})\right) - \\
&\quad - 2\ln\left(\mathscr{P}_{\rm BW}(m_{\rm inv}^{l_2,\nu_2}|M_W,\Gamma_{M_W})\right) - \\
&\quad - 2\ln\left(\mathscr{P}_{\rm BW}(m_{\rm inv}^{l_1,\nu_1,j_1}|\widetilde{M}_t,\Gamma_{\widetilde{M}_t}\right) - 2\ln\left(\mathscr{P}_{\rm BW}(m_{\rm inv}^{l_2,\nu_2,j_2}|\widetilde{M}_t,\Gamma_{\widetilde{M}_t})\right).
\end{aligned} \tag{1}$$

The variables with a tilde sign refer to the output of the minimization procedure, whereas P_T and UE (unclustered energy) represent measured values corrected for known detector and physics effects. $\widetilde{M}_t$ is the fit parameter giving the reconstructed top mass. $\mathscr{P}_{tf}$ is the transfer functions between b-quark and jets: they express the probability of measuring a jet transverse momentum P_T^j from a given b-quark with transverse momentum $\widetilde{P_T^j}$. $\mathscr{P}_{\rm BW}(m_{\rm inv}; m, \Gamma) \equiv \dfrac{\Gamma^2 \cdot m^2}{(m_{\rm inv}^2 - m^2)^2 + m^2\Gamma^2}$ indicates the relativistic Breit–Wigner distribution function, which expresses the probability that an unstable particle of mass m and decay width Γ decay into a system of particles with invariant mass $m_{\rm inv}$. We insert the function $\Gamma_{M_t}(M_t)$ according to the standard model [4].

The first sum of $\chi^2_{\rm reso}$ runs over the primary lepton (tight lepton) and the track lepton. The second sum is over the two leading jets. The third sum runs over the transverse components of the unclustered energy (UE^x, UE^y), which is defined as the sum of the energy vectors from the towers not already associated with leptons or any leading jets. It also includes possible additional jets. For these jets the transverse energy is corrected for nonuniformities in the calorimeter response as a function of $|\eta|$, multiple $p\overline{p}$ interactions, and the hadronic jet energy scale of the calorimeter. The other term in formula (1), $\chi^2_{\rm constr}$, refers to the invariant masses of the couples lepton–neutrino and of the lepton–neutrino-leading jet system.

For the dilepton case due to the existence of two neutrinos we have a nonconstrained kinematics. The number of independent variables is one more than the number of kinematic constraints ($-1C$ kinematics). Obviously, it is impossible to pick up directly only one solution per event. We must assume some of the event parameters ($\mathbf{R}$) as known in order to constrain the kinematics and then vary $\mathbf{R}$ to determine a set of solutions. In addition, we attach a χ^2-dependent weight to each solution.

The minimal requirement in the case of $-1C$ kinematics to perform a minimization is to use a two-dimensional vector as $\mathbf{R}$. For our analysis we choose the azimuthal angles of the neutrino momenta $\mathbf{R} = (\phi_{\nu_1}, \phi_{\nu_2})$ and we create a net of solutions in the $(\phi_{\nu_1}, \phi_{\nu_2})$ plane. We need to cover full $(0 < \phi_{\nu_1} < 2\pi, 0 < \phi_{\nu_2} < 2\pi)$ plane by the net. Actually, taking into account the symmetry of the solutions for $\phi'_{\nu_1,\nu_2} = \phi_{\nu_1,\nu_2} + \pi$ it is enough to find the solutions in quadrant $(0 < \phi_{\nu_1} < \pi, 0 < \phi_{\nu_2} < \pi)$ and expand them over the whole $(0 < \phi_{\nu_1} < 2\pi, 0 < \phi_{\nu_2} < 2\pi)$ plane. As a result of Monte Carlo optimization [3], we choose to split the quadrant of $(0 < \phi_{\nu_1} < \pi, 0 < \phi_{\nu_2} < \pi)$ into 12×12 points.

For every point of the $(\phi_{\nu 1}, \phi_{\nu 2})$ plane we have 8 solutions. Double ambiguity corresponds to the two ways of associating the two charged leptons to the two leading jets (which are supposed to be b-jets). The four solutions are generated from the possibility for every neutrino to have two p_z momenta satisfying the $t\bar{t}$ kinematics.

Therefore, for each event, we perform 1152 minimizations, each of which returns a value of $M_{ijk}^{\rm reco}$ and χ^2_{ijk} $(i, j = 1, \ldots, 12; k = 1, \ldots, 8)$. We define $\chi'^2_{ijk} = \chi^2_{ijk} + 4 \cdot \ln(\Gamma_{M_t})$, which is obtained by using Eq. (1), where

$\mathscr{P}_{\rm BW}$ is substituted with $\dfrac{\Gamma \cdot m^2}{(m_{\rm inv}^2 - m^2)^2 + m^2\Gamma^2}$, and select the lowest χ'^2 solution for each point of the $(\phi_{\nu_1}, \phi_{\nu_2})$ grid, thereby reducing the number of obtained masses to 144. Each mass is next weighted according to

$$w_{ij} = \frac{\mathrm{e}^{-\chi'^2_{ij}/2}}{\sum\limits_{i=1}^{12}\sum\limits_{j=1}^{12} \mathrm{e}^{-\chi'^2_{ij}/2}}. \qquad (2)$$

A mass distribution is built and the most probable value (MPV) is identified. Masses below a threshold of 30% of the MPV bin content are discarded, and the remaining ones are averaged to compute the preferred top quark mass ($M_t^{\rm reco}$) for the event.

The final extraction of the top quark mass from a sample of lepton + track candidates is provided by the likelihood fit. The expected signal and background distributions (templates) are obtained using Monte Carlo samples with full detector simulation.

2.2. Monte Carlo Signal Templates. The official MC samples are used. The signal templates for input top masses in the 155–195 GeV/c^2 range are created with 2 GeV/c^2 steps. Then the obtained set of templates is parametrized by one Landau and two Gaussian functions:

$$f_s(M_t^{\rm reco}|M_{\rm top}) = \frac{p_7 p_6}{\sqrt{2\pi}\, p_2} \mathrm{e}^{-0.5(\frac{M_t^{\rm reco} - p_1}{p_2} + \mathrm{e}^{-\frac{M_t^{\rm reco} - p_1}{p_2}})} + \\ + \frac{p_7(1-p_6)}{\sqrt{2\pi}\, p_5} \mathrm{e}^{-0.5(\frac{M_t^{\rm reco} - p_4}{p_5})^2} + \frac{(1-p_7)}{\sqrt{2\pi}\, p_3} \mathrm{e}^{-0.5(\frac{M_t^{\rm reco} - p_8}{p_3})^2}. \qquad (3)$$

Notice that this parametrizing function is strongly dependent on the input top mass $M_{\rm top}$, or it is better to say that its parameters $p_1, \ldots, p_8$, are $M_{\rm top}$-dependent:

$$p_k = \alpha_k + \alpha_{k+8} \cdot M_{\rm top}. \qquad (4)$$

The examples of our templates are presented in Fig. 1.

2.3. Background Template. The main expected background processes in the dilepton sample are W+jets with a jet misidentified as a lepton («fakes»), Drell–Yan ($Z/\gamma^* \to e^+e^-, \mu^+\mu^-, \tau^+\tau^-$), and diboson ($WW$, WZ, ZZ) with additional jets. To take into account the contribution from background events we create background templates for each of the above-mentioned sources. In order to build general template for Drell–Yan events, the templates for each subprocess are combined using their cross sections and acceptances. Template for fake events is obtained by weighting the fakeable events from W+jets data sample according to the fake rate probability matrix.

The obtained templates (Fig. 2) for these processes are combined together according to the expected number of events, as derived by the $t\bar{t}$

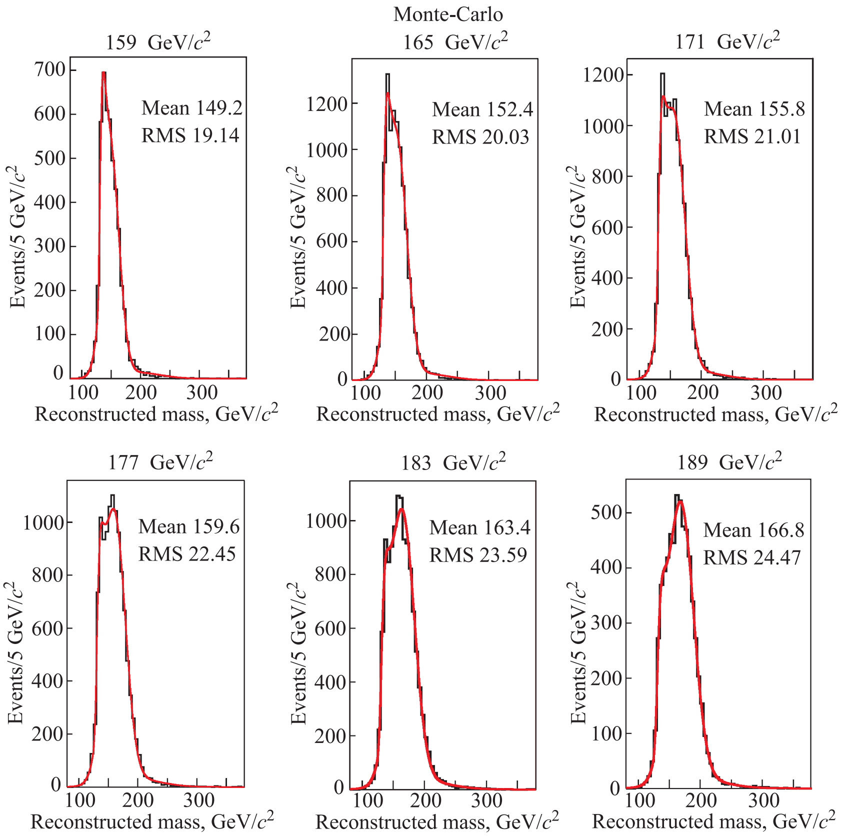

Fig. 1. The examples of the signal templates

cross-section group. The result for the combined background template is shown in Fig. 2, d.

The combined background template is fitted with a sum of two Landau and one Gaussian distribution functions, as:

$$f_b(M_t^{\rm reco}) = \frac{\beta_7\beta_6}{\sqrt{2\pi}\,\beta_2}{\rm e}^{-0.5(\frac{M_t^{\rm reco}-\beta_1}{\beta_2}+{\rm e}^{-\frac{M_t^{\rm reco}-\beta_1}{\beta_2}})}+$$
$$+\frac{\beta_7(1-\beta_6)}{\sqrt{2\pi}\,\beta_5}{\rm e}^{-0.5(\frac{M_t^{\rm reco}-\beta_4}{\beta_5})^2}+\frac{(1-\beta_7)}{\sqrt{2\pi}\,\beta_3}{\rm e}^{-0.5(\frac{M_t^{\rm reco}-\beta_8}{\beta_3}+{\rm e}^{-\frac{M_t^{\rm reco}-\beta_8}{\beta_3}})}, \quad (5)$$

where the fitted parameters $\beta_1 \cdots \beta_8$ are M_t-independent.

2.4. Likelihood. The likelihood function expresses the probability that a $M_t^{\rm reco}$ distribution from data is described by a mixture of background events and dilepton $t\bar{t}$ events with an assumed top quark mass.

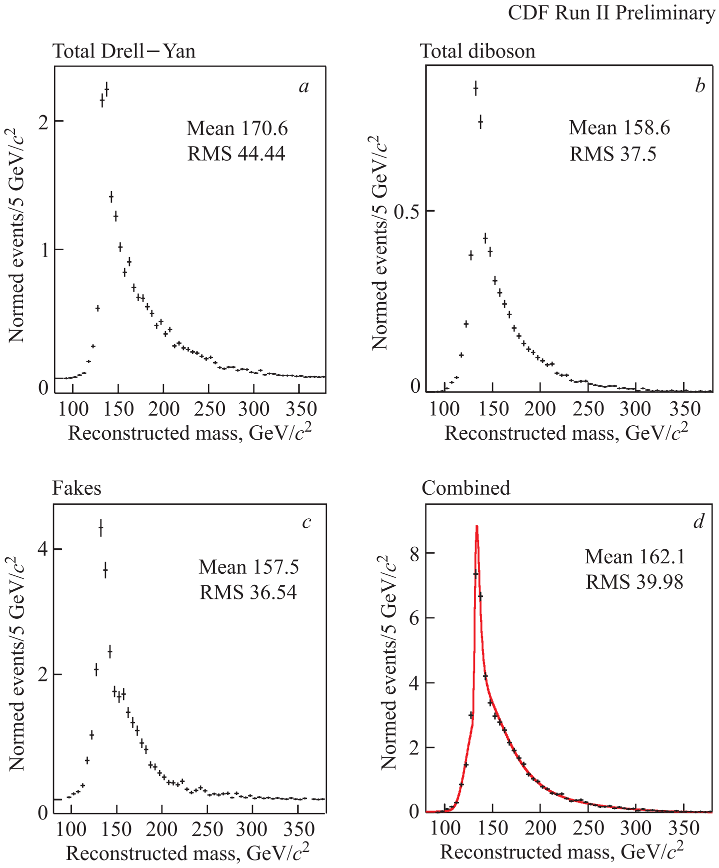

Fig. 2. Templates of background processes for Drell–Yan (a), diboson (b), «fake» (c) events. Plot d shows the combined background

Inputs for the likelihood are the reconstructed masses for N events in data sample ($m_n, n = 1, \cdots, N$), the parametrized signal and background p.d.f.'s (Eq. (3) and Eq. (5)) and the expected background number. The likelihood has the following form:

$$\mathscr{L} = \mathscr{L}_{\text{shape}} \cdot \mathscr{L}_{\text{backgr}} \cdot \mathscr{L}_{\text{param}}, \tag{6}$$

where

$$\mathscr{L}_{\text{shape}} = \frac{\mathrm{e}^{-(n_s+n_b)} \cdot (n_s+n_b)^N}{N!} \cdot \prod_{n=1}^{N} \frac{n_s \cdot f_s(m_n|M_{\text{top}}) + n_b \cdot f_b(m_n)}{n_s+n_b}. \tag{7}$$

Parameters n_s and n_b are the expected signal and background numbers in the lepton + track data sample. Also, the additional terms are added to constrain number of the background events and to constrain $\boldsymbol{\alpha}_0$, $\boldsymbol{\beta}_0$ parameters, obtained for the signal and background template parametrization:

$$\mathscr{L}_{\text{backgr}} = \exp\left(\frac{-(n_b - n_b^{\text{exp}})^2}{2\sigma_{n_b}^2}\right), \tag{8}$$

$$\mathscr{L}_{\text{param}} = \exp\{-0.5[(\boldsymbol{\alpha} - \boldsymbol{\alpha}_0)^T U^{-1}(\boldsymbol{\alpha} - \boldsymbol{\alpha}_0) + (\boldsymbol{\beta} - \boldsymbol{\beta}_0)^T V^{-1}(\boldsymbol{\beta} - \boldsymbol{\beta}_0)]\}. \tag{9}$$

Here U and V are the covariance matrices for the obtained parameters of the signal and background p.d.f.'s, respectively. A top quark mass (m_t) and its positive and negative statistical errors (σ^+ and σ^-) are returned by the fit.

3. RESULTS FROM PSEUDO-EXPERIMENTS

We check whether the fit with likelihood form (6) is able to return the correct mass by performing the «sanity check» pseudo-experiments (PE) for different input top mass values. The numbers of signal and background events in PE's are Poisson distributed with mean values as their expected numbers.

For each input top quark mass the median of the m_t distribution is chosen as the top quark mass estimate ($M_{\text{top}}^{\text{out}}$). $M_{\text{top}}^{\text{out}}$ versus input mass ($M_{\text{top}}^{\text{in}}$) and the bias, defined as $M_{\text{top}}^{\text{out}} - M_{\text{top}}^{\text{in}}$, are shown in Fig. 3. The error bars are determined by the limited statistics of the signal and background templates. Both fits in Fig. 3 are performed in the mass range 159–191 GeV/c^2: the slope of the straight line in plot a is consistent with one, while the average bias (horizontal line in plot b) is $-0.13 \pm \pm 0.10$ GeV/c^2. Although this value can be considered compatible with zero within uncertainties, we apply a shift of $+0.13$ GeV/c^2 to the result on data.

In order to check the bias on the statistical error, we use pulls. Pulls are defined as follows:

$$\frac{M_t^{\text{fit}} - M_t}{\sigma'}, \tag{10}$$

where $\sigma' = \begin{cases} \sigma^+, & \text{if } m_t < M_t \\ |\sigma^-|, & \text{if } m_t > M_t \end{cases}$. For each generated top quark mass, pull distributions are fitted by using Gaussian functions. The mean and width of the pull distributions versus generated top quark mass are shown in Fig. 4. Error bars account for the limited statistics of signal and background templates. The average width of pull distributions is 1.009 ± 0.005. A width larger than one indicates an underestimate of the statistical error. Accordingly, the statistical error obtained from data is rescaled by 1.009.

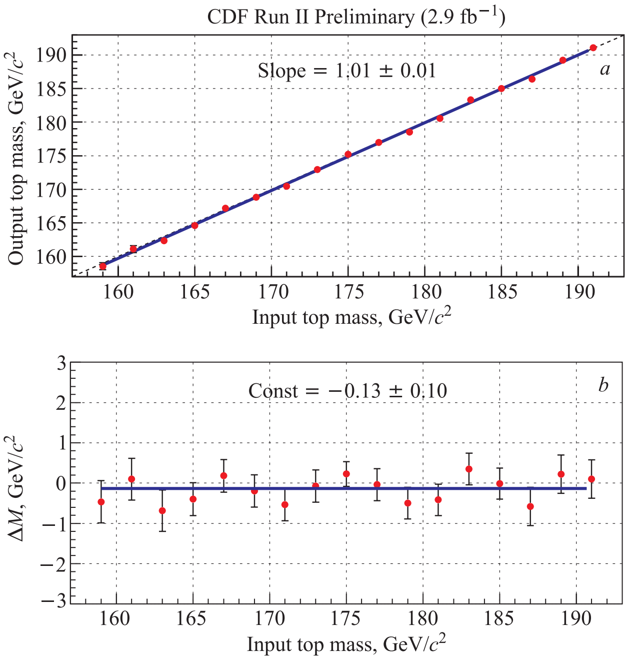

Fig. 3. The extracted top mass as a function of input mass (a). The result of a linear fit is also shown. Plot b shows the residuals (reconstructed − input top mass)

4. SYSTEMATIC UNCERTAINTIES

We consider the following sources of systematic uncertainties on the fitted mass value: a) jet energy scale, b) discrepancy between data and simulation luminosity profile (pile-up), c) amount of initial and final state radiation, d) shape of the background template, e) parton distribution functions, f) approximations made by Monte Carlo generators, and g) b-jet energy scale and lepton energy scale. The magnitudes of these uncertainties are estimated using large Monte Carlo samples generated only for the systematics study.

The procedure for estimating the systematic uncertainty is similar for all sources. For each source we vary the input value as appropriate (by 1σ, or changing PDF, etc.) and evaluate the impact on the returned top mass. This is done by simulating a large number (usually 10000 or more) of pseudo-experiments (PE) with the nominal assumption and with the alternate assumption. The reconstructed mass distribution from each PE is fitted with the same likelihood procedure as for the data. The obtained mass value enters an ensemble of results of simulated experiments. The systematic uncertainty assigned to our measurement is the difference

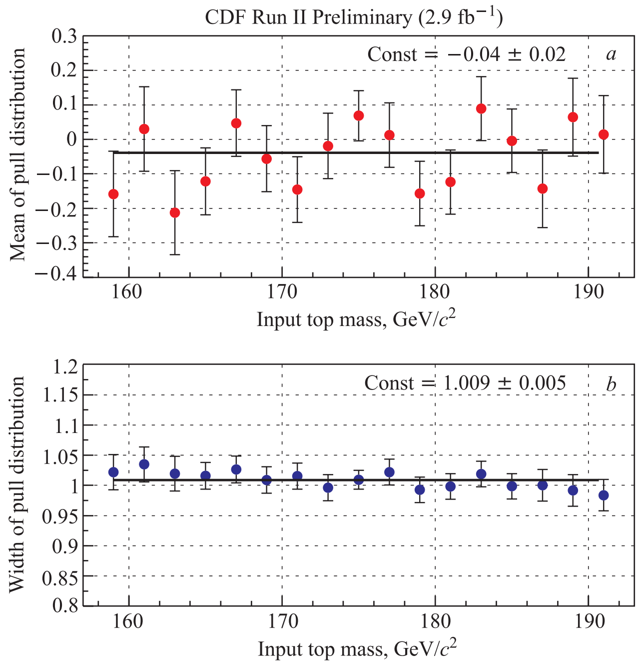

Fig. 4. Mean (a) and σ (b) of pull distributions determined from the pseudo-experiments as a function of input top mass

in the average of these result distributions for the nominal and shifted ensembles or half the difference between results obtained with $+\sigma$ and $-\sigma$ of the corresponding parameter change.

The largest contribution comes from the uncertainty in the jet energy measurement, which includes jet energy corrections for different calorimeter response (as a function of η), the absolute hadron energy scale, and jet fragmentation. Discrepancy in the data and MC luminosity profile is estimated by rescaling the top mass dependence on the number of interactions in the event by the difference in the number of interactions between data and MC. The initial and final state radiation (IFSR) uncertainties are estimated using the Pythia [5] Monte Carlo samples, in which QCD parameters for parton shower evolution in the initial and final states are varied simultaneously. The amount of variation is based on the CDF studies of Drell–Yan data. For the parton distribution functions (PDF) we consider two different groups of PDF (CTEQ and MRST), two sets of MRST for different $\Lambda_{\rm QCD}$ values, and 20 pairs of CTEQ6M uncertainty sets. The effect of using different top Monte Carlo generators is checked by comparing the nominal Pythia [5] with alternate Herwig [6] samples.

In order to estimate the effect on top mass from the uncertainty in background composition, we vary the contribution in combined background template of main sources (diboson, Drell–Yan and «fakes») by $\pm\sigma$. Contribution from another subsamples is corrected to maintain the total expected number of background events. We also study the effect from changing the shape of the main background contributors: Drell–Yan and «fakes».

Also, the additional uncertainty for the b-jet scale due to the heavy quark fragmentation, semileptonic b-jet branching ratio, and b-jet calorimeter response is taken into account. The effect on the top mass from the uncertainty on lepton energy scale is studied by applying $\pm 1\%$ shifts for lepton P_T.

The systematic uncertainties are summarized in the table. The total systematic uncertainty is estimated to be 3.1 GeV/c^2.

Summary of systematic uncertainties

CDF Run II Preliminary	
Source	Uncertainty, GeV/c^2
Jet energy scale	2.9
b-jet energy scale	0.4
Luminosity profile (pile-up)	0.2
Initial and final state radiations	0.3
Parton distribution functions	0.3
Monte Carlo generators	0.2
Background composition	0.5
Fakes shape	0.4
DY shape	0.3
Lepton energy scale	0.3
Total	**3.1**

5. RESULTS

The two-component background-constrained fit with $n_b^{\rm exp} = 145.0 \pm \pm 17.3$ expected background events for the obtained 328 lepton + track candidates returns $m_t = 165.35 \pm ^{3.35}_{3.22}$ GeV/c^2, with $181.4 \pm ^{21.9}_{21.3}$ signal events and $146.1 \pm ^{15.1}_{15.0}$ background events.

Figure 5, a shows the fitted mass distribution. The insert shows the mass dependence of the negative log-likelihood function. Plot b is the expected statistical errors from Monte Carlo sample, where the arrows indicate the errors returned by the fit to the data. The probability to have better accuracy than ours from data is 82%.

After the correction of the mean value increased on 0.13 GeV/c^2 and statistical errors multiplying by factor of 1.009 (see Sec. 3) our

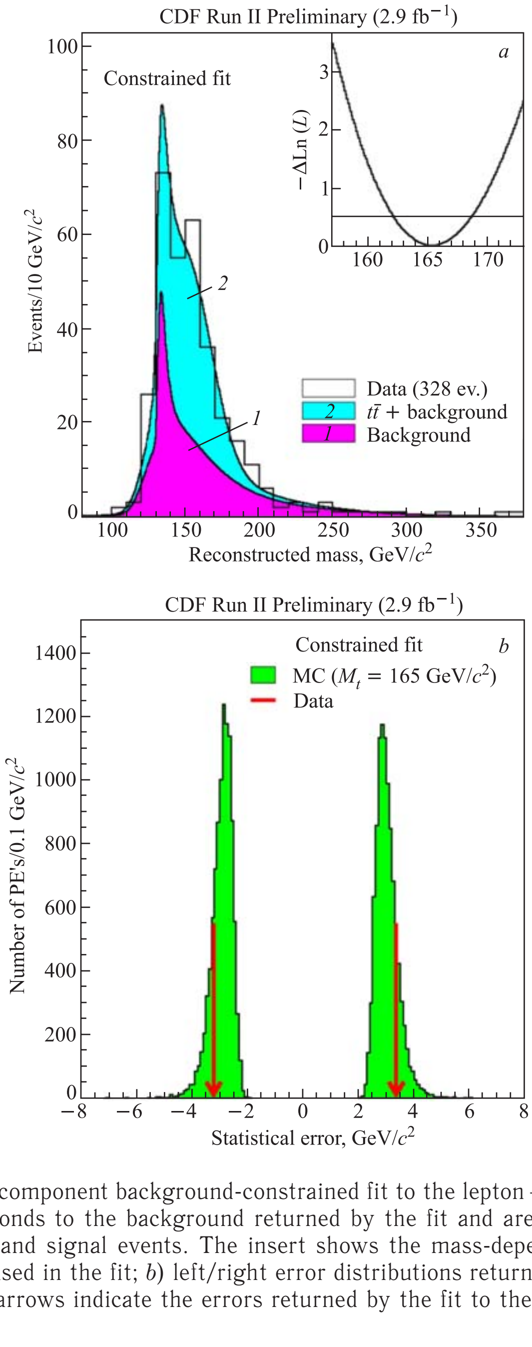

Fig. 5. *a*) Two-component background-constrained fit to the lepton + track sample. Area *1* corresponds to the background returned by the fit and area *2* is the sum of background and signal events. The insert shows the mass-dependent negative log-likelihood used in the fit; *b*) left/right error distributions returned by the PE's. The arrows indicate the errors returned by the fit to the data

preliminary result on the CDF data sample with the integrated luminosity of 2.9 fb^{-1} is

$$m_t = 165.5 \pm {}^{3.4}_{3.3}\ (\text{stat.}) \pm 3.1\ (\text{syst.})\ \text{GeV}/c^2.$$

We also performed a fit when the number of the background events is unconstrained. This fit returns $m_t = 165.33 \pm {}^{3.39}_{3.28}$ GeV/c^2, with $178.6 \pm {}^{30.9}_{31.1}$ signal events and $149.4 \pm {}^{31.6}_{29.5}$ background events.

CONCLUSION

A sample of 328 events, corresponding to an integrated luminosity of 2.9 fb^{-1}, is obtained from the CDF data sample after selection cuts. Using these events, our preliminary measurement of the top quark mass in the lepton+track sample is

$$m_t = 165.5 \pm {}^{3.4}_{3.3}\ (\text{stat.}) \pm 3.1\ (\text{syst.})\ \text{GeV}/c^2.$$

Acknowlegements. We thank the Fermilab staff and the technical staff of the participating institutions for their vital contributions. This work was supported by the U.S. Department of Energy and National Science Foundation; the Italian Istituto Nazionale di Fisica Nucleare; the Ministry of Education, Culture, Sports, Science and Technology of Japan; the Natural Sciences and Engineering Research Council of Canada; the National Science Council of the Republic of China; the Swiss National Science Foundation; the A.P. Sloan Foundation; the Bundesministerium für Bildung und Forschung, Germany; the Korean Science and Engineering Foundation and the Korean Research Foundation; the Science and Technology Facilities Council and the Royal Society, UK; the Institut National de Physique Nucleaire et Physique des Particules/CNRS; the Russian Foundation for Basic Research; the Comisión Interministerial de Ciencia y Tecnología, Spain; the European Community's Human Potential Programme; the Slovak R&D Agency; and the Academy of Finland.

References

1. The CDF II Detector Technical Design Report, Fermilab-Pub-96/390-E. 1996.
2. *Abe F. et al. (CDF Collaboration)* // Phys. Rev. Lett. 1995. V. 74. P. 2626; *Abachi S. et al. (CDF Collaboration)* // Ibid. P. 2632.
3. *Abulencia A. et al. (CDF Collaboration)* // Phys. Rev. D. 2006. V. 73. P. 112006.
4. *Beneke M. et al.* Top Quark Physics, arXiv:hep-ph/0003033.
5. *Sjostrand T. et al.* PYTHIA 6.216 // Comput. Phys. Commun. 2001. V. 135. P. 238.
6. *Marchesini G. et al.* // Comput. Phys. Commun. 1992. V. 67. P. 465.

Received on November 27, 2008.

Редактор *В. В. Булатова*

Подписано в печать 26.01.2009.
Формат $60 \times 90/16$. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,93. Уч.-изд. л. 1,26. Тираж 375 экз. Заказ № 56473.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.
E-mail: publish@jinr.ru
www.jinr.ru/publish/