Summary of 'Measurement of R = $\mathcal{B}(t \to Wb)/\mathcal{B}(t \to Wq)$ in Top–quark–pair Decays using Lepton+jets Events and the Full CDF Run II Data set'

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This paper presents a simultaneous measurement of R and the $t\bar{t}$production cross section $\sigma_{t\bar{t}}$. R describes the fraction of the branching ratio with

$$R = \frac{\mathcal{B}(t \to Wb)}{\mathcal{B}(t \to Wq)} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2}$$

and is therefore also related to the elements of the Cabibbo-Kobayashi-Maskawa (CKM) matrix for the bottom like quarks with the top quark ($|W_{tq}|, q = d, s, b$). By using constrains on the CKM elements, V_{ts} and V_{td} the value for the $|V_{tb}|$ matrix element is close to one. Consequently, any deviation of R close to one would indicate an influence of new beyond Standard Model physics like additional quarks or non SM top quark production. Since the $\sigma_{t\bar{t}}$ in other measurements is often calculated with $R = 1$, $\sigma_{t\bar{t}}$ and R are measured simultaneously, in order to avoid any bias.

The dataset is provided by the CDF II detector at the Fermilab Tevatron Collider and corresponds to an integrated luminosity of $8.7\,\mathrm{fb}^{-1}$. The events are produced with $p\overline{p}$ collisions at a center of mass energy of $\sqrt{s} = 1.96\,\mathrm{TeV}$.

In order to reproduce the $t\bar{t}$ signature the lepton + multiple jets decay channel is considered. One of the W bosons decays hadronically and one leponically into either a electron or muon. Therefore, the topology of the analyzed channel consists of one lepton (electron or muon), one neutrino inducing missing transverse energy E_T^{miss} and four jets of which two originate from the hadronization of b quarks.

According to this topology the event selection is chosen to require one isolated lepton (e or μ) with transverse energy $E_T > 20\,\mathrm{GeV}$, $E_T^{\text{miss}} > 20\,\mathrm{GeV}$ and at least three jets. The jets are required to have an E_T greater then $30\,\mathrm{GeV}$, $25\,\mathrm{GeV}$ and $20\,\mathrm{GeV}$ for either the leading, subleading or any additional jet respectively. Furthermore, one or two identified b jets are required to be found. In order to have a better reconstruction of the event, a selection criteria for the W boson transverse mass greater then $20\,\mathrm{GeV}$ is added.

The remaining background contributions after the event selection are W boson + heavy-flavor jets (c,b), W + light-flavor jets, QCD multijet + leptons, diboson production, single-top-quark production and Z boson + jets. These backgrounds are estimated using either data based techniques, simulation based techniques or both (REF 10).

For the main analysis a simultaneous fit in 18 subsamples is performed. These subsamples are created by separating the sample into their lepton category (electron, central or forward muon), the number of jets (3,4,$\geq$5) and the number of b tagged jets (2 b-tag, 3 b-tag). It is noticeable that the number of b-tag jets is the most sensitive to changes in R, due to its influence in the number of decaying top quarks into b quarks. Assuming a maximum efficiency for the b-tagging algorithm, the expected number of events with two b-tags would be proportional to R^2 , whereas, the number of events with one b-tag is proportional to $2R(1 - R)$. The total expected number of events $\mu_{\text{exp}}^{i,j}$ is determined using the expression

$$\mu_{\text{exp}}^{i,j} = \mu_{t\bar{t}}^{i,j} + N_B^{i,j} = \mathcal{L}^j \epsilon_{\text{evt}}^{i,j} \sigma_{t\bar{t}} \epsilon_{\text{tag}}^i(R) + N_B^{i,j},$$

where i indicating the jet bin with either one or two b-tagged jets and j indicating the lep-

ton category. $N_B^{i,j}$ is the expected number of background events, $\mathcal{L}^i$ the integrated luminosity, $\epsilon_{\mathrm{evt}}^{i,j}$ the trigger and lepton identification efficiencies and $\epsilon_{\mathrm{tag}}^i(R)$ is the event tagging efficiency. In order to account for the monte carlo sample assuming $|V_{tb}| = 1$ in the event generation, the matched parton level quarks are reassigned in their flavor if a random generated number P_b is lower then the value chosen for R. This creates a sample with an R fraction of top quarks decaying into bottom quarks and a $(R-1)$ fraction decaying differently.
Having extracted the expected yields for the number of events a likelihood fit can be performed. The used likelihood function is

$$\mathcal{L} = \prod_{i,j} \mathcal{P}\left(\mu_{exp}^{i,j}(R, \sigma_{t\bar{t}}, x_a)|N_{obs}^{i,j}\right) \prod_a G\left(x_a|0,1\right),$$

which includes a Poission probability $\mathcal{P}\left(\mu_{exp}^{i,j}(R, \sigma_{t\bar{t}}, x_a)|N_{obs}^{i,j}\right)$ to observe $N_{obs}^{i,j}$ events with an expected number of $\mu_{exp}^{i,j}$. The Gaussian functions $G\left(x_a|0,1\right)$ run over the nuisance parameters x_a allowing to include sources of systematic uncertainties. Since not all systematic uncertainties can be implemented as nuisance parameters, the analysis is executed by varying some uncertainties to determine their influence on the uncertainties on R and $\sigma_{t\bar{t}}$.
The resulting values of the simultaneous fit in all the subsamples are $R = 0.94 \pm 0.09$ and $\sigma_{t\bar{t}} = (7.5 \pm 1.5)$ pb with a correlation of $\rho = -0.434$. This result can be seen in fig. 1 which

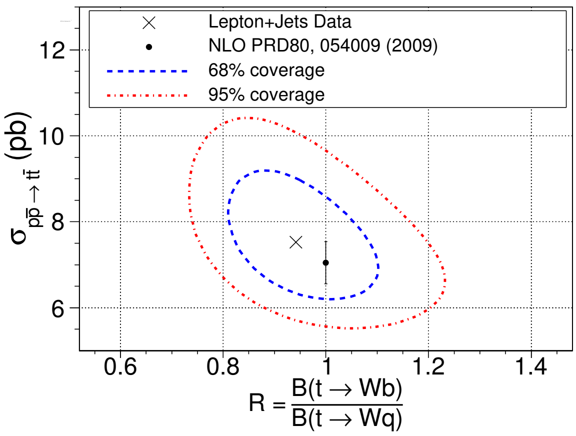

Figure 1: The fit results for R and $\sigma_{t\bar{t}}$ with its 68 % and 95 % confidence regions. The point corresponds to the theory NLO calculations.

References

[1] ATLAS Collaboration, Measurement of R $= \mathcal{B}\left(t \to Wb\right)/\mathcal{B}\left(t \to Wq\right)$ in Top–quark–pair Decays using Lepton+jets Events and the Full CDF Run II Data set, Phys. Rev. D 87 (2013) 111101.