First measurement of B(t→Wb)/B(t→Wq)

in the dilepton channel

in pp collisions at $s^{1/2}$=7 TeV

CMS-PAS-TOP-11-029

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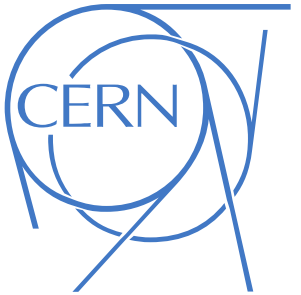
on behalf of the LIP/CMS group

Jornadas do LIP

21 Abril 2012

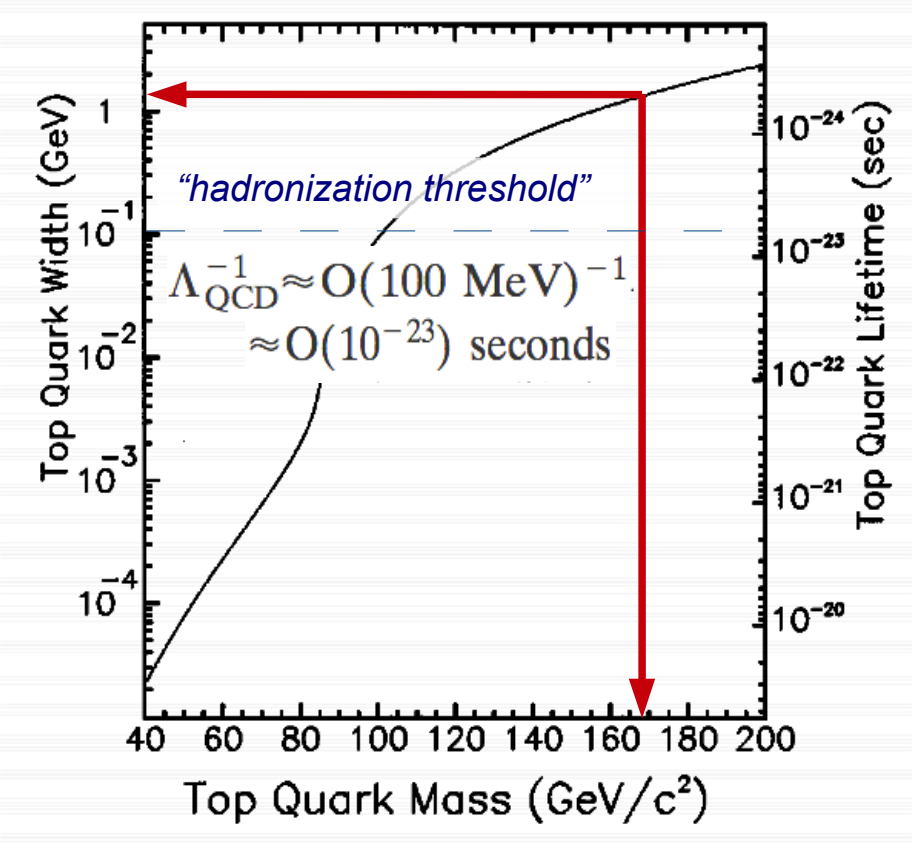


Introduction

- **Top decays promptly without hadronizing ►**
  - Lifetime too short to break colored strings connecting to proton remnants

- **t → Wb dominates**
  - Prompt decay → direct access to $\mathbf{V_{tb}}$
  - $|V_{ub}|$ and $|V_{cb}|$ measured to be very small (from B meson decays)
  - Unitarity + 3 generations imply that

$$\mathbf{|V_{tb}| = 0.998 \ @ \ 90\%CL}$$



- **With top pair events we measure R ►**
  - Generic quantity, relies on ability to identify jets from *b* hadronization
  - Latest measurements from Tevatron seem to indicate some tension with the SM prediction

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

$\mathcal{R} = 0.91 \pm 0.09\ (\text{stat} + \text{syst})$ CDF prelim. 7.5 fb^{-1}

$\mathcal{R} = 0.90 \pm 0.04\ (\text{stat} + \text{syst})$ D0 PRL 107, 121802 (2011)

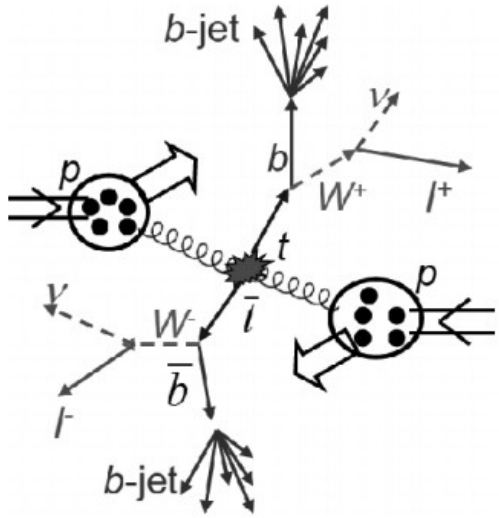
Sample used for the measurement

- We **use the dilepton channel**
  - Smallest branching ratio (~6.5%)
  - Lowest contamination from background

- **6263 evts** selected from **2.2 fb^{-1}** of data
  - ≥ 2 leptons p_T>20 GeV |η|<2.5
  - ≥ 2 jets p_T>30 GeV |η|<2.5
  - E_T^{miss}>30 GeV for same flavor channel
  - **Expect S/B=0.92** (0.70) for eμ (ee/μμ)

- Events are categorized according to the number of jets
  - What is the contamination from background?
  - **How many t → Wq decays did we reconstruct?**

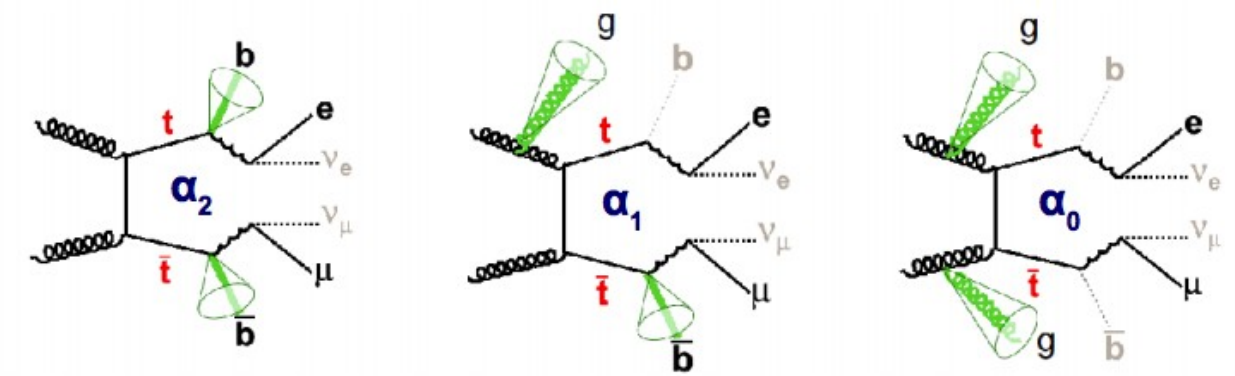
use data-driven estimates



Channel	*ee*	*μμ*	*eμ*
	2 jet		
Di-bosons	13 ± 3	15 ± 3	41 ± 8
Single top	34 ± 13	44 ± 16	113 ± 42
W+jets	10 ± 7		12 ± 7
$Z/\gamma^* \to \ell\ell$	323 ± 48	415 ± 67	160 ± 25
other $t\bar{t}$	5 ± 1	0.9 ± 0.4	8 ± 1
$t\bar{t}$ dileptons	544 ± 50	710 ± 100	1905 ± 179
Total expected	929 ± 71	1184 ± 122	2238 ± 186
data	907	1088	2424
	3 jet		
Di-bosons	2 ± 1	3 ± 1	7 ± 2
Single top	11 ± 4	13 ± 5	36 ± 14
W+jets	0.1 ± 0.1		
$Z/\gamma^* \to \ell\ell$	106 ± 16	136 ± 12	30 ± 5
other $t\bar{t}$	3 ± 1	2 ± 1	8 ± 1
$t\bar{t}$ dileptons	273 ± 25	349 ± 50	958 ± 90
Total expected	394 ± 30	504 ± 55	1040 ± 92
data	345	472	1027

Signal or background?

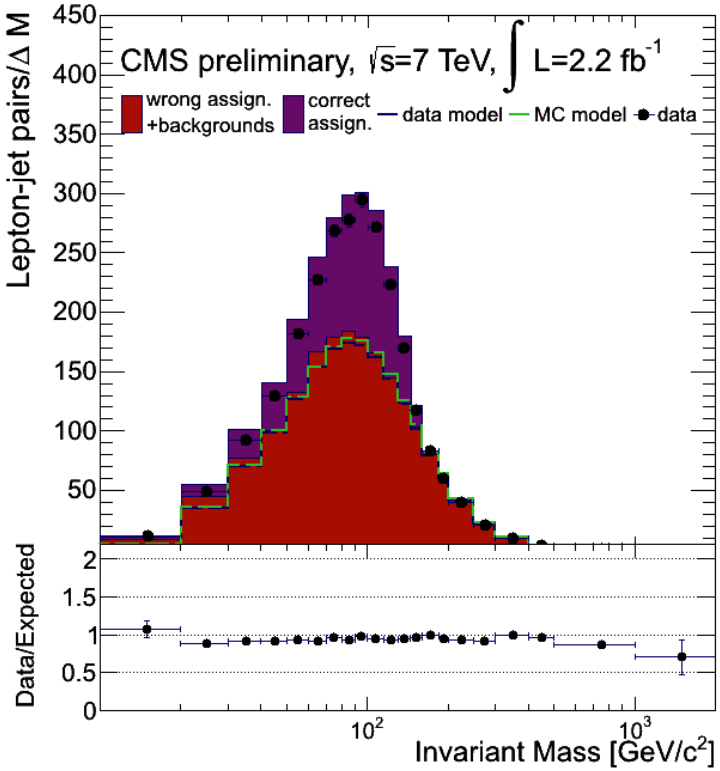
- **Background may mimic top quark decays / jets from top decays fails selection**
  - ISR, underlying event, multi-parton interactions, pileup contaminate the sample



- Experimental handle - the kinematics of the lepton-jet system from the same decay:

$$M_{\mathrm{lj}} \leq \sqrt{m_t^2 - m_W^2}$$

  - Wrong lepton-jet assignments are approximately combinatorial (model with event mixing techniques)
  - Wrong assignments dominate in the tails
  - Use the tails to normalize the misassignment contribution



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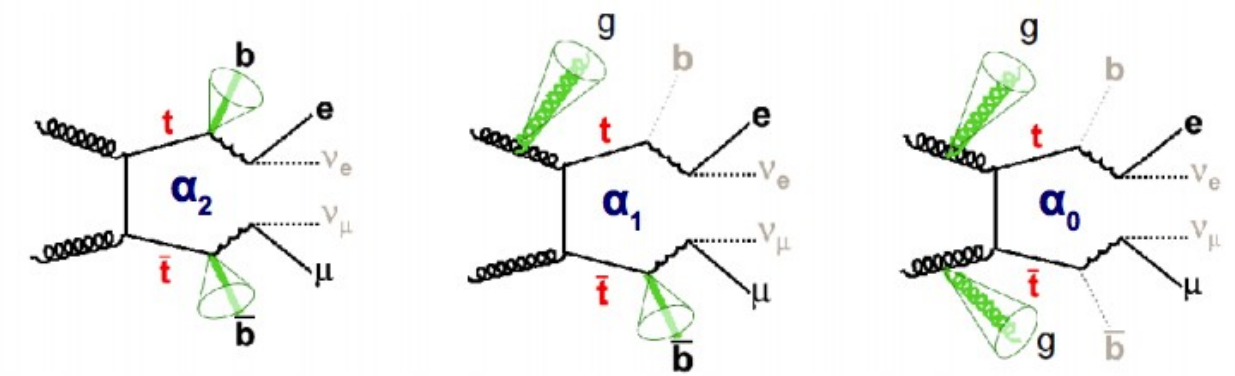

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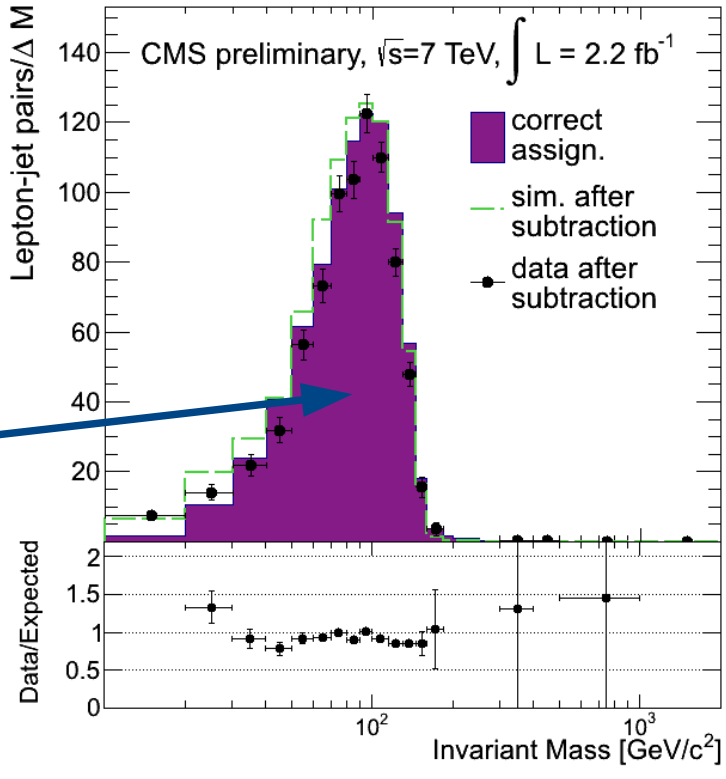
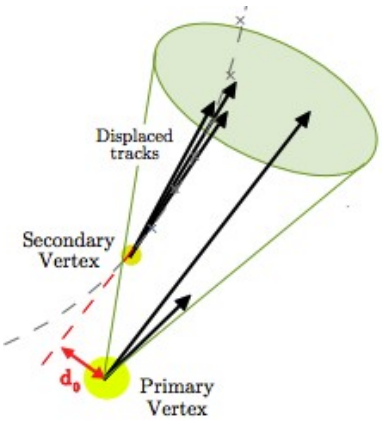
lepton-jet pair counting after subtraction measures N(t→Wq) reconstructed

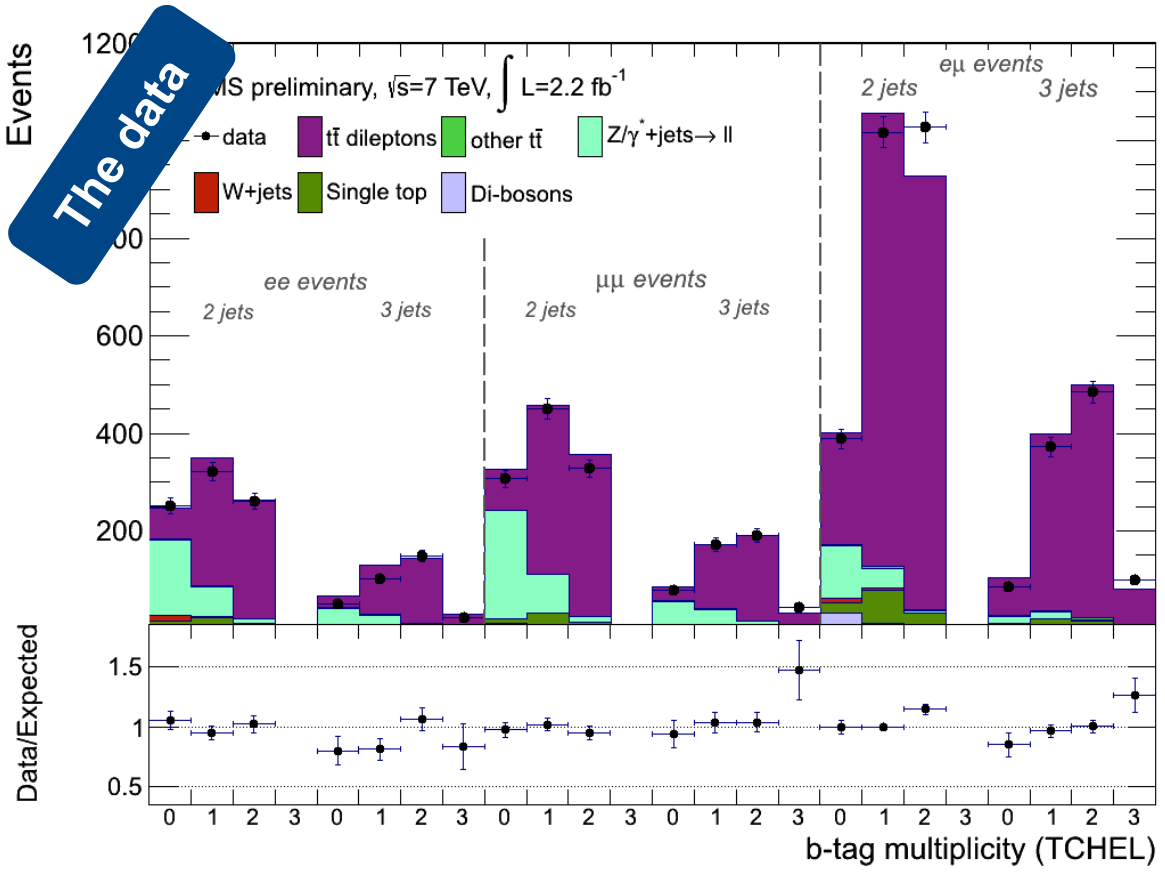


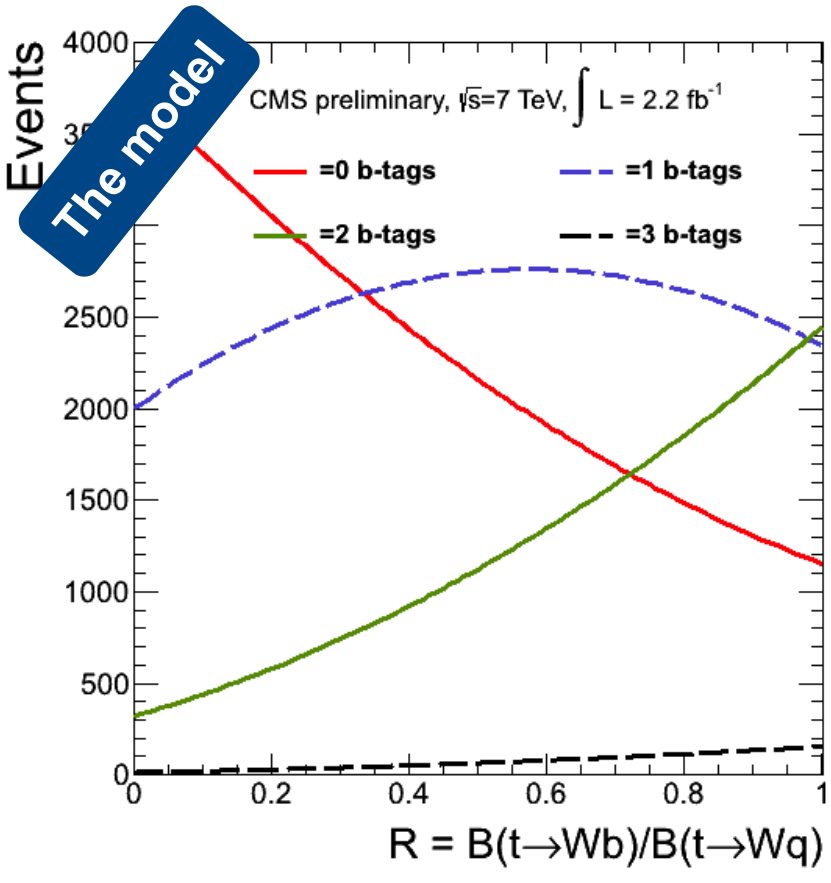
Measuring R in dilepton events

- Use a b-tagging discriminator algorithm
  - heavy flavor jets have displaced tracks, secondary vertices, soft leptons, ...
  - **count number of jets identified as *b* jets**
  - **compare with expectations** to measure 0, 1, 2, 3 b-tags



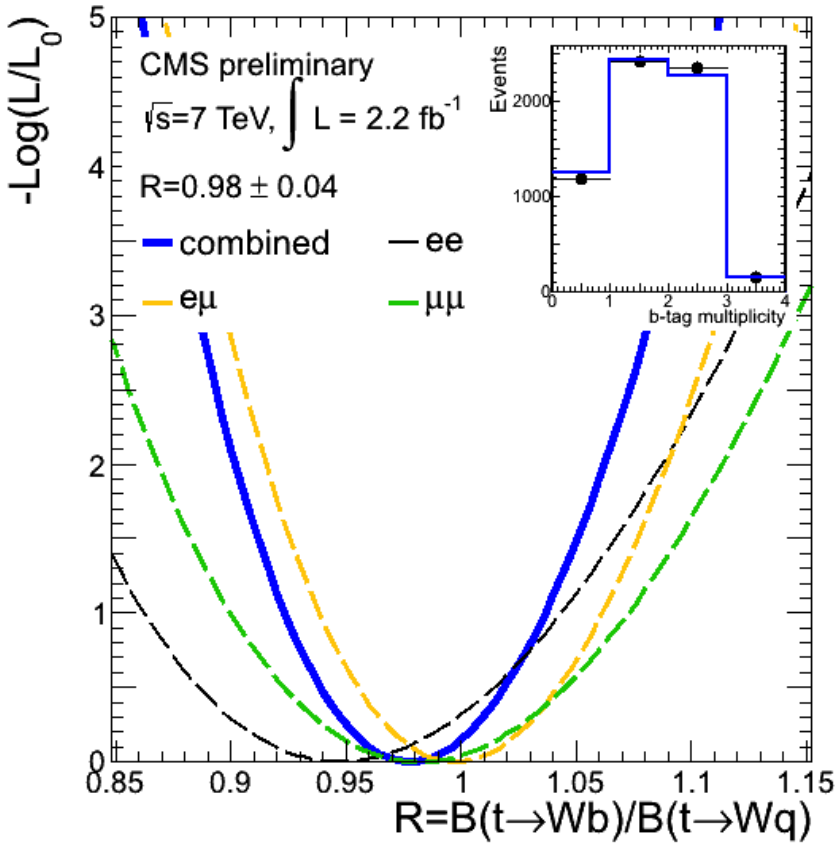
- Model based on R and data driven estimates of b-tag/mistag efficiencies (from dijet events), N(t→Wq) and background level (from selected sample)

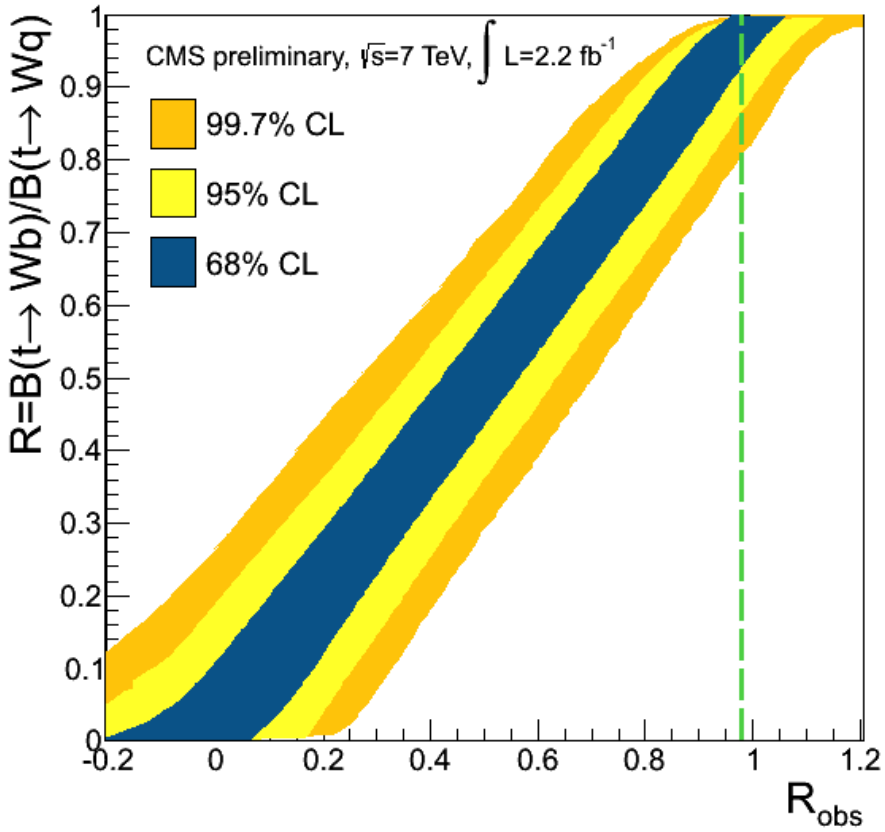




Results

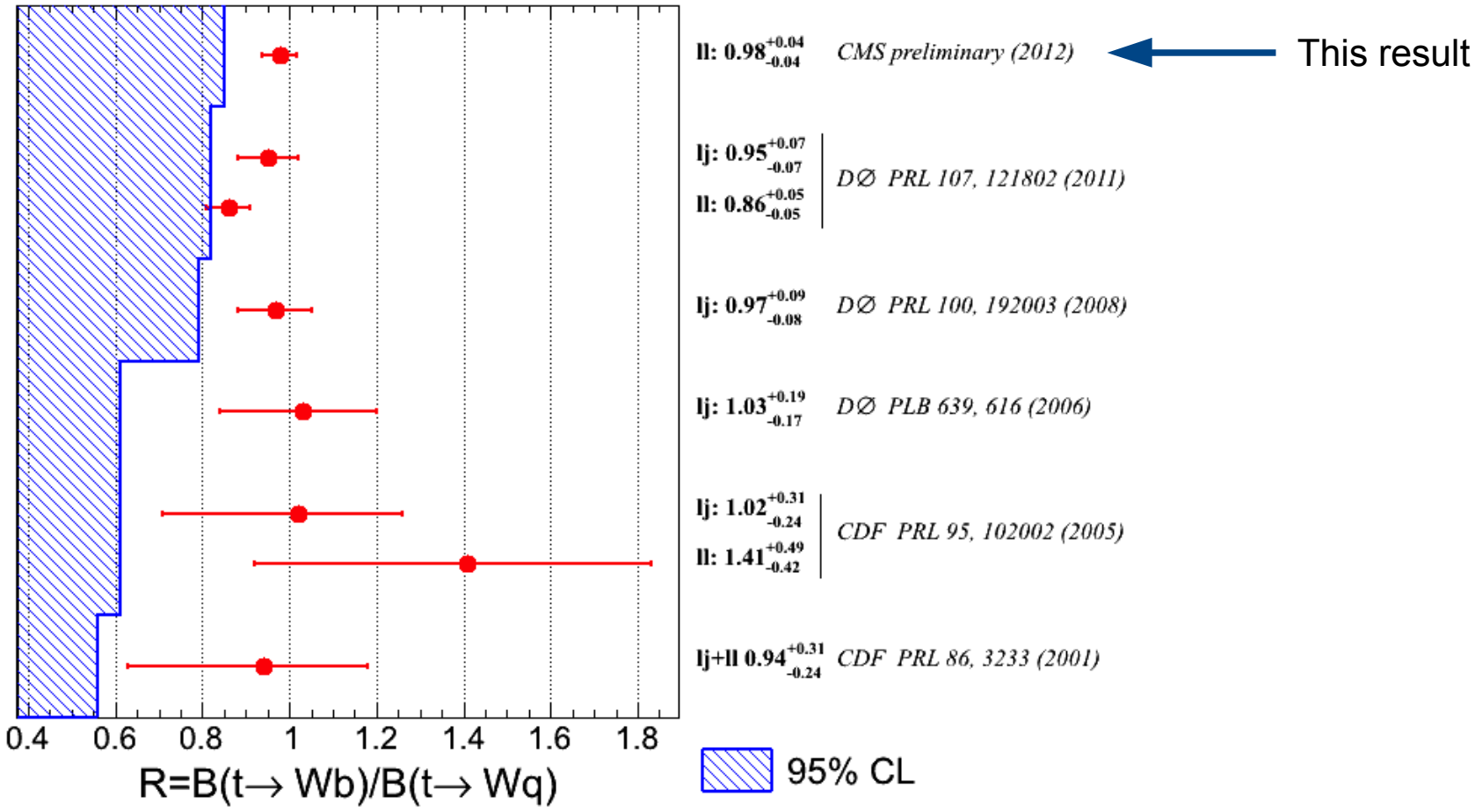
- From a profiled likelihood ratio fit **we measure**: $R = 0.98 \pm 0.04 \ (\text{stat} \oplus \text{syst})$
  - Consistent among different dilepton channels
  - Main uncertainties: b-tag uncertainty (3%) and fraction of correct assignments (2%)
- Imposing the physical bound (R≤1) with Feldman-Cousins approach **R>0.85 @ 95% CL**





Conclusions

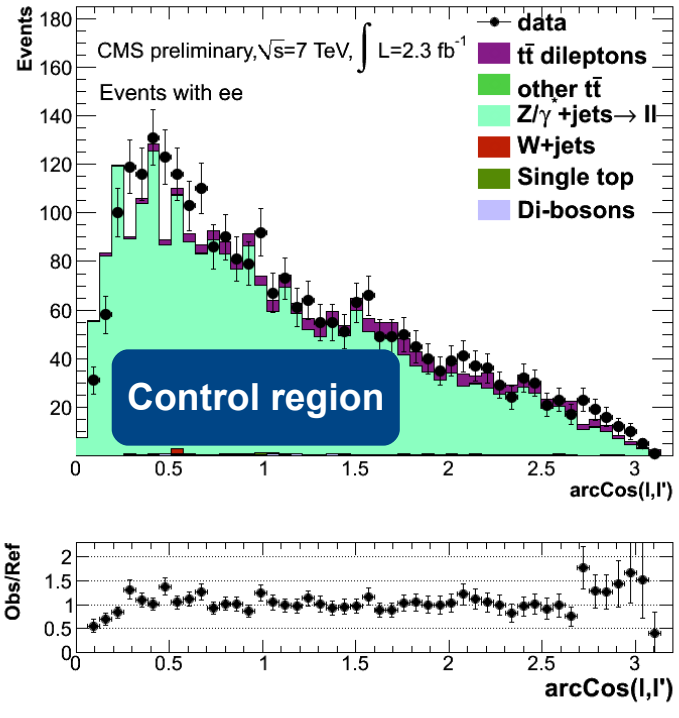
- **We are gaining knowledge on the nature of top decays at the LHC**
- First measurement of R at the LHC is the most precise so far
- Result is consistent with the SM predictions

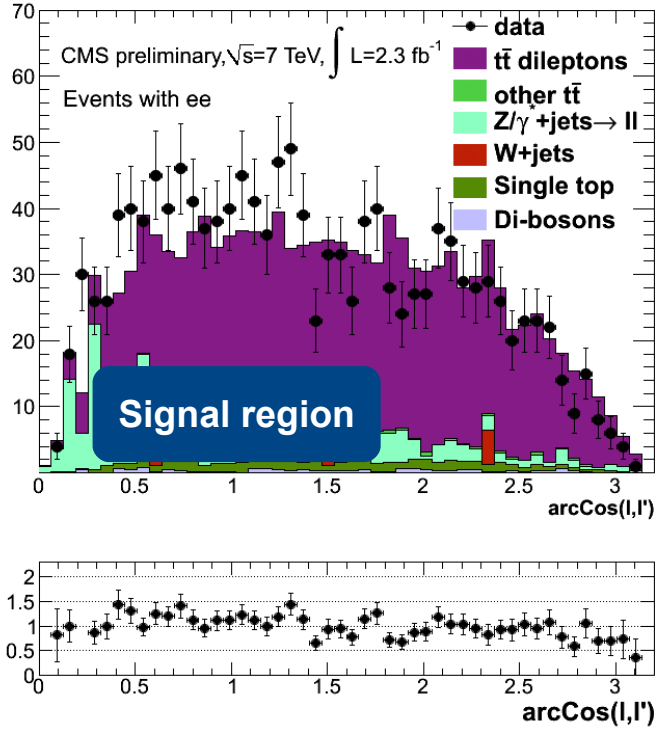


Backup

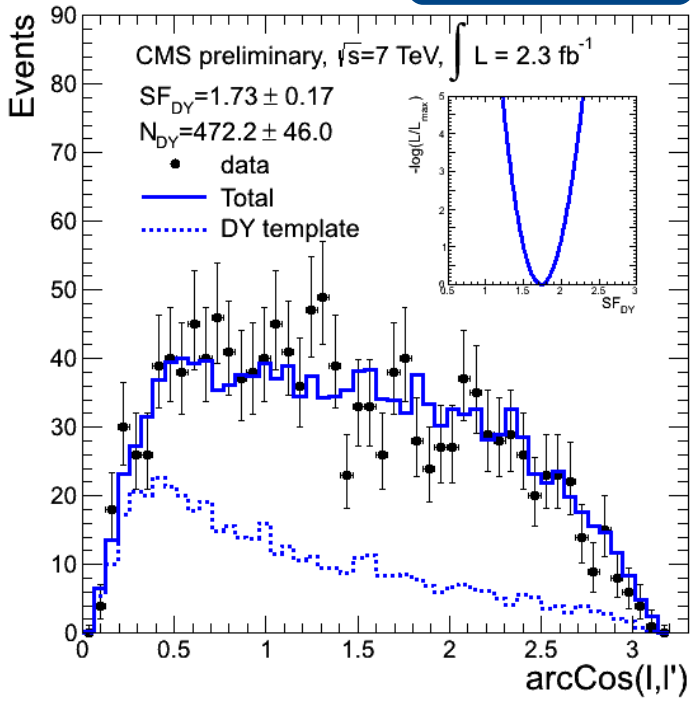
Data-driven estimation of Drell-Yan

- **Main background** in the same flavor channels
- Use the **angle between the two leptons**:
  - enough statistics in data to explore angular correlation in DY → ll decays
  - data-driven model for θ_{ll} from low E_T^{miss} region (<30 GeV)
- **Fit DY contribution in the final sample from binned likelihood fit**





Fit result



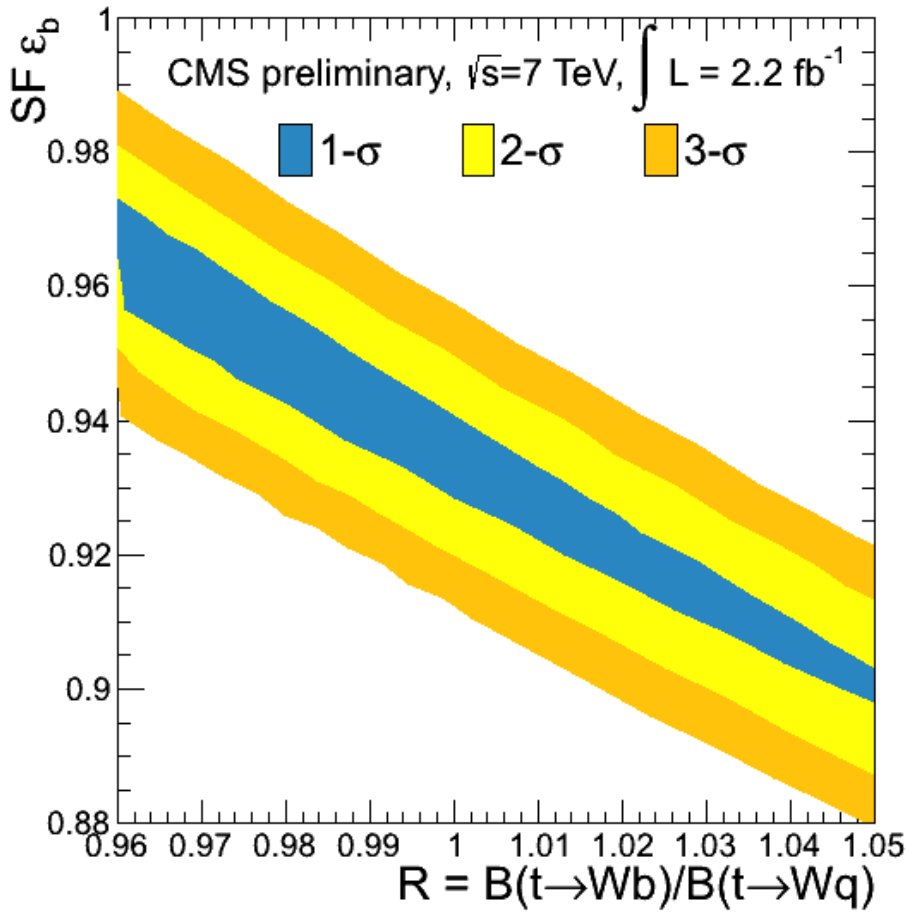
Systematics

Table 3: Summary of the systematic uncertainties affecting the measurement of R. The values for the uncertainties are absolute.

Source	Uncertainty
ε_b	0.031
ε_q	0.011
Jet energy scale	0.002
Jet energy resolution	0.004
Pile-up	0.006
Q^2	0.023
Jet-parton matching scale	0.011
DY contamination	0.012
$\bar{t}t$ contribution	0.002
Total	0.044

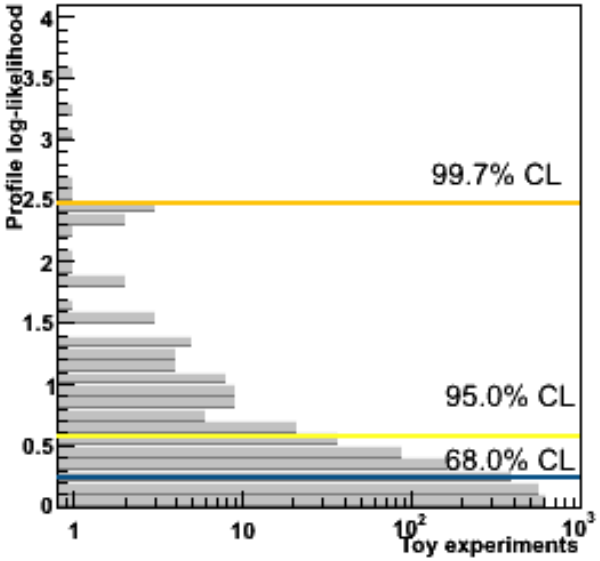
R and b-tag efficiency

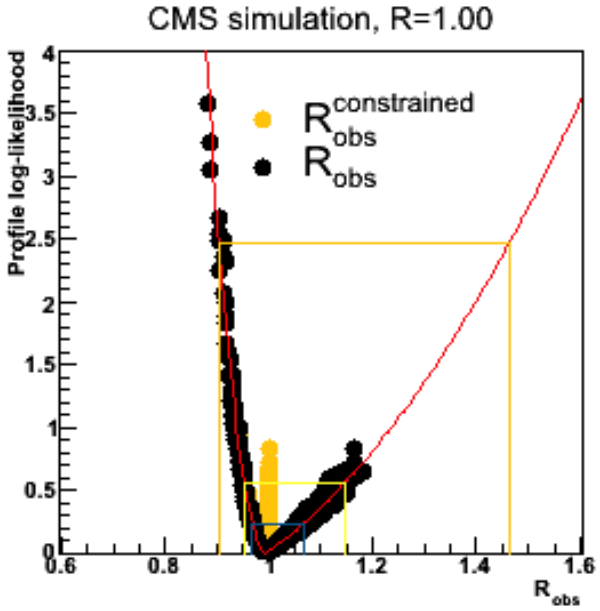
- Can't be measured simultaneously from data: 100% correlation
- Scan to find consistency between dijet based measurement of ε_b given as input



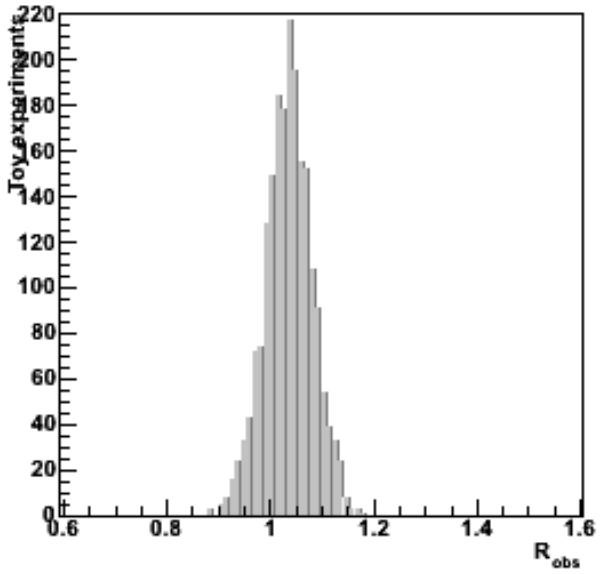
Statistical interpretation with Feldman-Cousins approach

- We use the Feldman-Cousins approach - cf. PRD 57 3873 (1998) to **impose the physical constraint at R≤1**





- We scan R in the range [0,1]
  - generate **toy experiments** (3×10^3) and compute the profile likelihood where all nuisance parameters are profiled to take systematics into account)
  - **Profile likelihood is used as test statistics** $t = 2 \log \frac{\mathcal{L}(y|R_{obs}, \hat{\hat{\vec{\nu}}})}{\mathcal{L}(y|R_{obs}, \hat{\vec{\nu}})}$
  - Define the upper acceptance given a CL from t distribution
    - If $t_{data} < t_{upper}$ the point is accepted in the F-C interval
    - inverting the function we find the corresponding R_{obs}



Final confidence interval on R

- The CI constructed by the F-C approach corresponds graphically to the intersection of the test statistics in data with the upper acceptance curves for a given value of R
- We obtain R>0.85 @ 95% CL (with a statistical uncertainty of 0.008)