



# Extraction of CKM matrix elements in the single-top $t$ -channel events at 13 TeV with CMS

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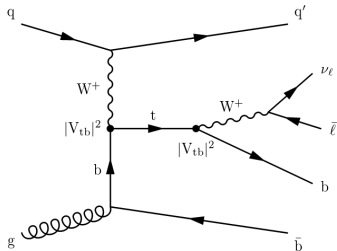
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on behalf of the CMS Collaboration

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# Single-top quark process

The top quark can be singly produced via electroweak interaction.



- light jets (high pseudorapidity)
- missing energy from  $\nu$
- isolated lepton
- b-jet from top quark
- b-jet from gluon splitting

Requirements: 2 or 3 jets (1 or 2 b jet)

- The single top  $t$ -channel production process is particularly indicated to measure the Cabibbo-Kobayashi-Maskawa elements  $|V_{tb}|^2$ ,  $|V_{ts}|^2$ , and  $|V_{td}|^2$ .
- The cross section and branching fraction can be written as:

$$\sigma_{t\text{-ch.,b}}\mathcal{B}(t \rightarrow Wb) + \sigma_{t\text{-ch.,b}}\mathcal{B}(t \rightarrow Wd,s) + \sigma_{t\text{-ch.,s,d}}\mathcal{B}(t \rightarrow Wb) + \mathcal{O}(|V_{td,s}|^4)$$

where:

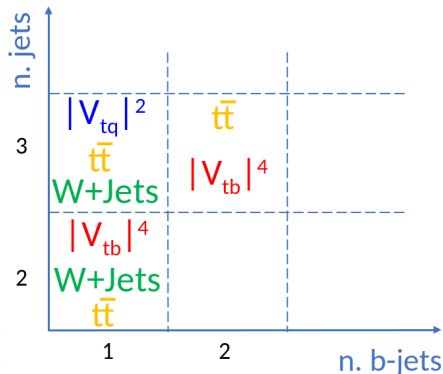
$$\sigma_{t\text{-ch.,q}} \propto |V_{tq}|^2$$

$$\mathcal{B}(t \rightarrow Wq) = |V_{tq}|^2 \tilde{\Gamma}_q \Gamma_{\text{top}}$$

# Analysis strategy

Several irreducible backgrounds  $\rightarrow$  control regions

- 2-jets–1-tag rich in  $t$ -channel  $|V_{tb}|^4$ ; main backgrounds:  $W + \text{jets}$  and  $t\bar{t}$
- 3-jets–1-tag rich in  $t$ -channel  $|V_{tq}|^2$ ; main bkg:  $W + \text{jets}$  and  $t\bar{t}$
- 3-jets–2-tags pure in  $|V_{tb}|^4$ ; main bkg:  $t\bar{t}$



QCD discrimination:

- Shape obtained from data (from region with anti-isolated lepton)
- Depleted by requiring W boson transverse mass  $> 50$  GeV

Signal to background discrimination:

- Several kinematic variables
- Use of Boosted Decision Trees discriminator
- simultaneous fit is performed: 6 categories (2 lepton flavour  $\times$  3 regions)

# Results

The absolute values of CKM matrix elements are extracted from the fit results[1]:

SM scenario:

$$|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2 = 1$$

Results:

$$|V_{tb}|^2 > 0.970$$

$$|V_{ts}|^2 + |V_{td}|^2 < 0.057$$

BSM model 1:

$$|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2 \neq 1$$

Results:

$$|V_{tb}|^2 = 0.988 \pm 0.051$$

$$|V_{ts}|^2 + |V_{td}|^2 = 0.06 \pm 0.06$$

BSM model 2:

$\Gamma_t$  allowed to vary due to decay in new particles

$$|V_{tb}|^2 = 0.988 \pm 0.024$$

$$|V_{ts}|^2 + |V_{td}|^2 = 0.06 \pm 0.06$$

$$\frac{\Gamma_t^{\text{obs}}}{\Gamma_t} = 0.99 \pm 0.42$$

No deviations observed from the SM

The results are more precise than the last measurement of  $|V_{tb}|$  performed by CMS[2] and than the ATLAS and CMS combination at  $\sqrt{s} = 7 - 8$  TeV [3]