Measurement of $\mathrm{R} = \mathrm{B}(\mathrm{t} \to \mathrm{Wb})/\mathrm{B}(\mathrm{t} \to \mathrm{Wq})$ using b-tagging in the l+jets channel

on behalf of the DØ collaboration

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Introduction

- In the SM, the ratio $R = B(t \to Wb)/B(t \to Wq)$, can be expressed in terms of the CKM matrix elements:

$$R = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2} = |V_{tb}|^2$$

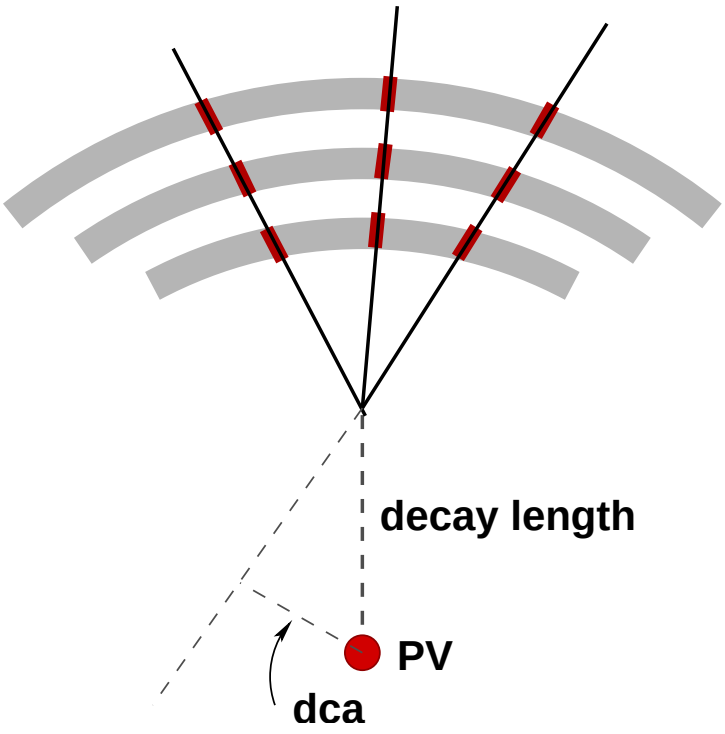
- Under two assumptions:
  - Exactly three generations of coupling quarks.
  - The CKM matrix is unitary.

  the value of $|V_{tb}|$ is restricted to $0.9990 < |V_{tb}| < 0.9992$.
- Since $|V_{tb}| \sim 1$ in the SM, it is usually assumed that the branching fraction $B(t \to Wb)$ is 100%.
- The measurement of the single top production cross-section will provide a powerful constraint on $|V_{tb}|$.

- This analysis is an extension of the cross-section analysis with b-tagging in the l+jets channel.
- The exact same dataset was used, corresponding to an integrated luminosity of:
  - $160\ \mathrm{pb}^{-1}$ in the μ+jets channel.
  - $170\ \mathrm{pb}^{-1}$ in the e+jets channel.
- The number of $t\bar{t}$ events with one and two b-tags is determined by the probability to b-tag a jet from a top decay and the fraction of events with 0, 1 and 2 b-quarks.
- The most likely value of R is deduced from the number of double tagged and single tagged events.
- The capability to distinguish between light jets and b-jets is crucial for this measurement.

b-tagging algorithms

- This analysis was done using two separate algorithms:
  - SVT (explicit reconstruction of secondary vertices).
  - CSIP (impact parameter significance based).
- Algorithms perform well:
  - Probability for tagging a b-jet $\sim 35\%$.
  - Probability for tagging a l-jet $< 0.5\%$.
- Performance measured in data and parametrized vs E_T and η of the jets.



Tagging efficiency for $t\bar{t}$

- When not requiring $B(t \to Wb)$ to be 100%, the probability to single tag a top event becomes:

$$P(tt) = R^2 P(tt \to bb) + 2R(1-R)P(tt \to bq_l) + (1-R)^2 P(tt \to q_l q_l)$$

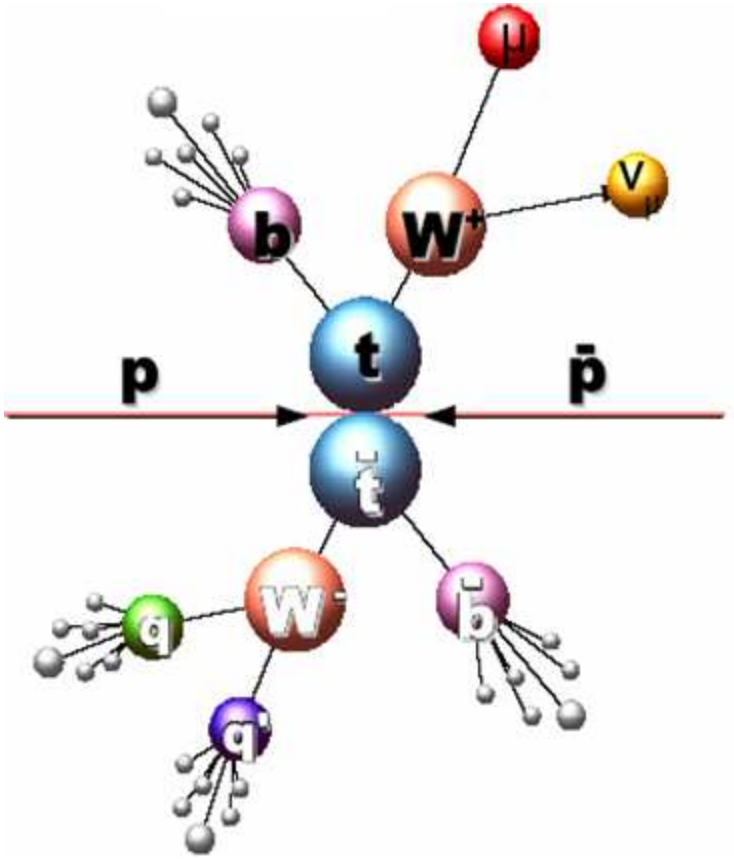
where P denotes the tagging probability and $q_l = (s, d)$.

	e+jets		μ+jets	
Single Tags	3 jets	≥ 4 jets	3 jets	≥ 4 jets
$t\bar{t} \to WbWb$ (SVT)	43.1±0.2	45.1±0.1	43.0±0.2	44.7±0.1
$t\bar{t} \to WbWq_l$ (SVT)	32.0±0.3	36.3±0.2	32.4±0.3	35.7±0.2
$t\bar{t} \to Wq_lWq_l$ (SVT)	5.6±0.2	7.6±0.2	5.6±0.2	7.8±0.2
$t\bar{t} \to WbWb$ (CSIP)	44.7±1.0	45.9±0.8	44.4±1.0	45.6±0.8
$t\bar{t} \to WbWq_l$ (CSIP)	32.2±0.7	35.6±0.6	32.2±0.7	35.0±0.6
$t\bar{t} \to Wq_lq_l$ (CSIP)	6.4±0.1	7.5±0.1	6.6±0.2	7.7±0.1

Preselection

All events are required to have:

- passed the signal trigger.
- a tight isolated 20 GeV electron or muon.
- large $\not\!\!E_T$, at least 20 (17) GeV in the e (μ) channel.
- no second high p_T isolated lepton.
- a reconstructed PV with at least 3 tracks, within $|z| < 60$ cm.

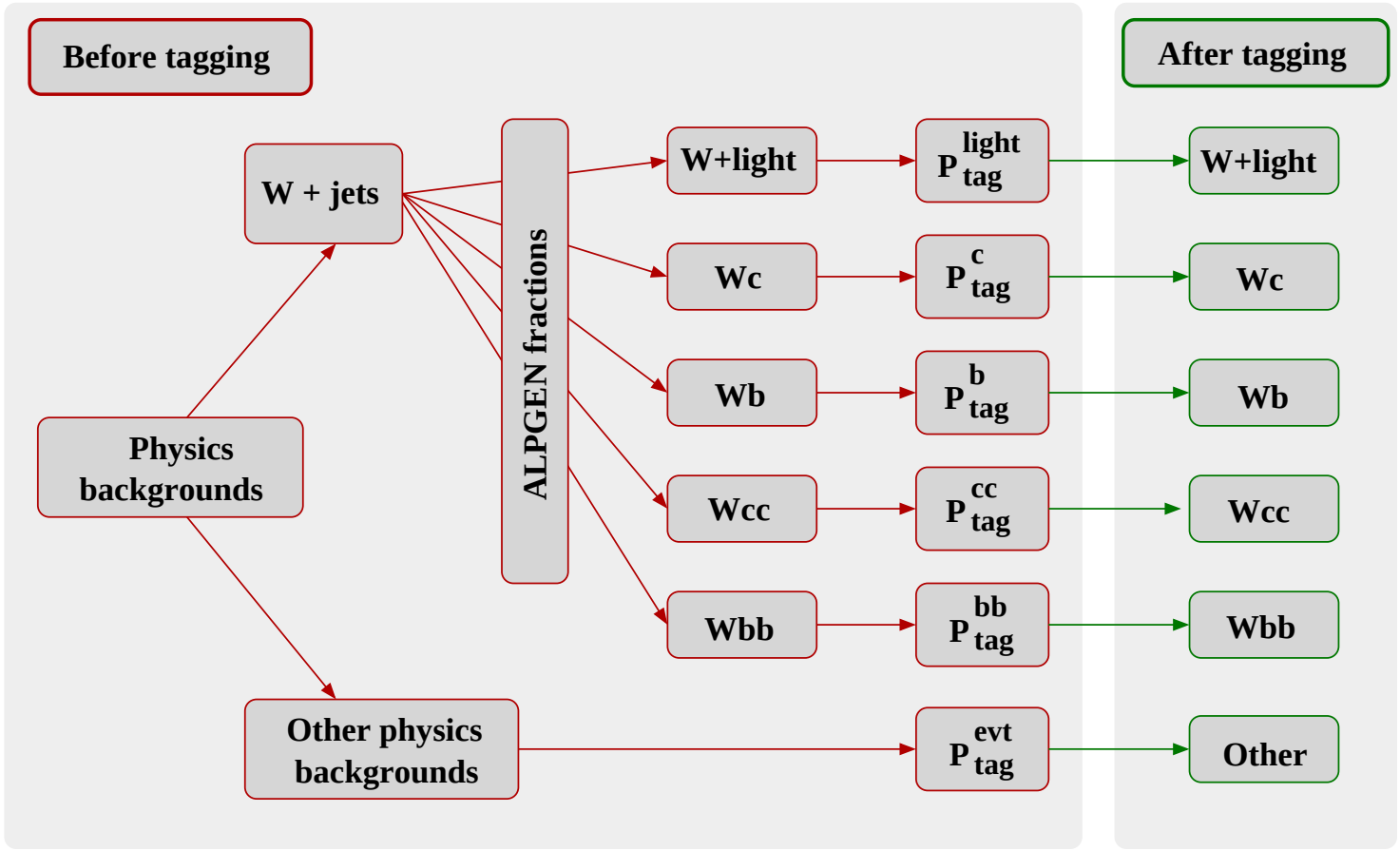


Background calculation

- The expected number of tagged background events is calculated exactly like in the cross-section analysis.
- The preselected sample is first split into:
  - Physics backgrounds: Events with a real lepton.
  - Multijet QCD events with a fake lepton.
- The dominant background is W+jets.
- The event tagging probability, P_{QCD}^{tag}, for multijet QCD events is obtained in an independent data sample.

$$N_{QCD}^{tag} = P_{QCD}^{tag} * N_{QCD}^{presel}$$

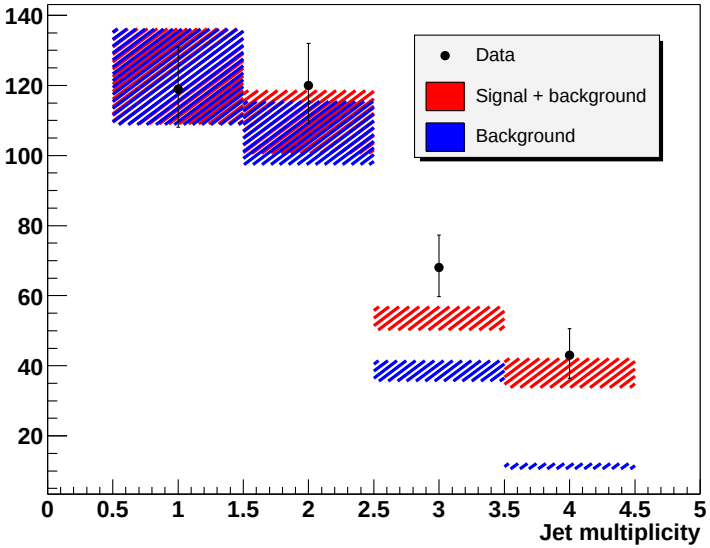
Physics backgrounds



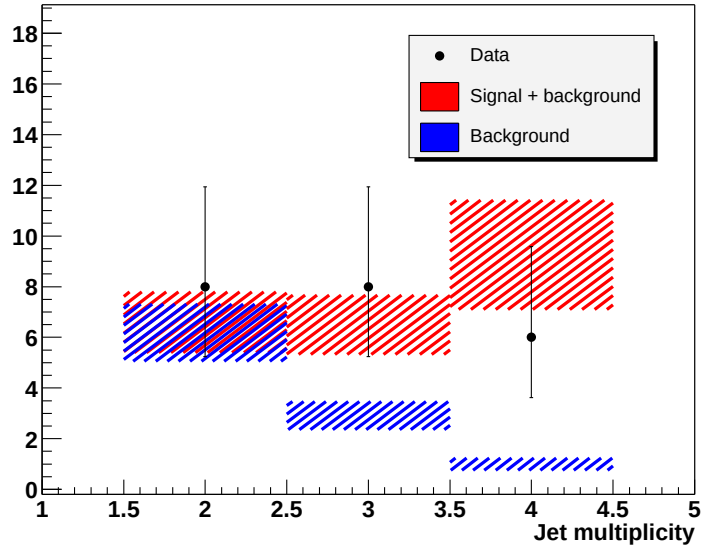
- Other physics backgrounds include single top production and diboson (WW, WZ and ZZ) production.

Observed events (SVT)

- The boxes represent the predicted number of tagged events including all statistical and systematic errors.



Single tagged events

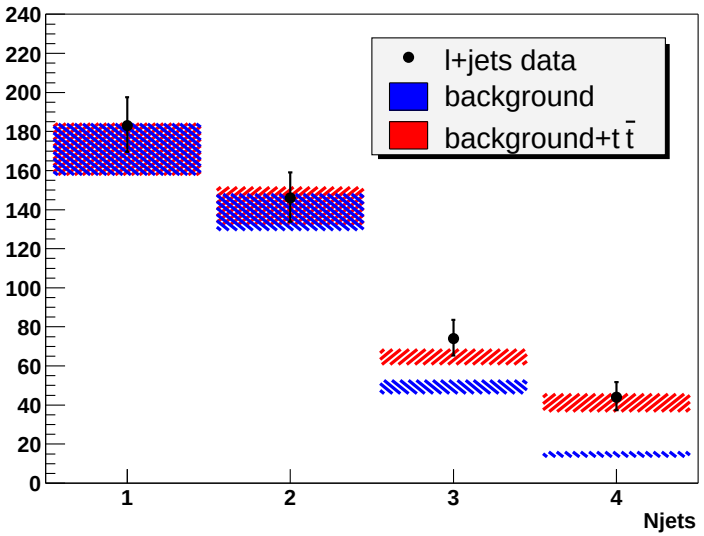


Double tagged events

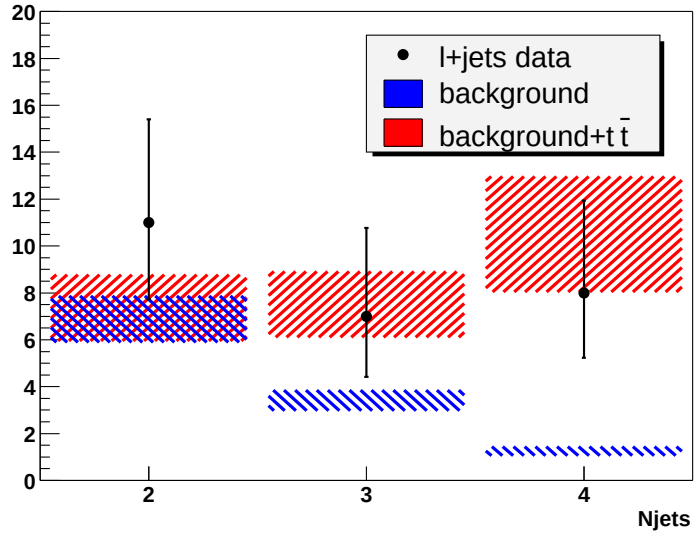
- In these plots a 7 pb cross-section is assumed for $t\bar{t}$.

Observed events (CSIP)

- The boxes represent the predicted number of tagged events including all statistical and systematic errors.



Single tagged events

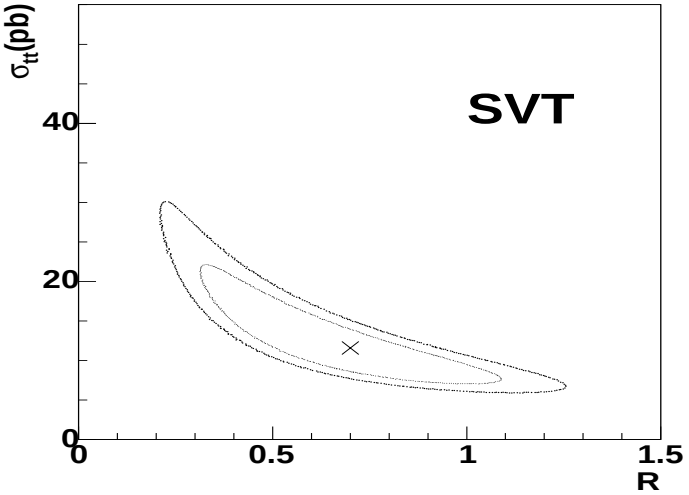


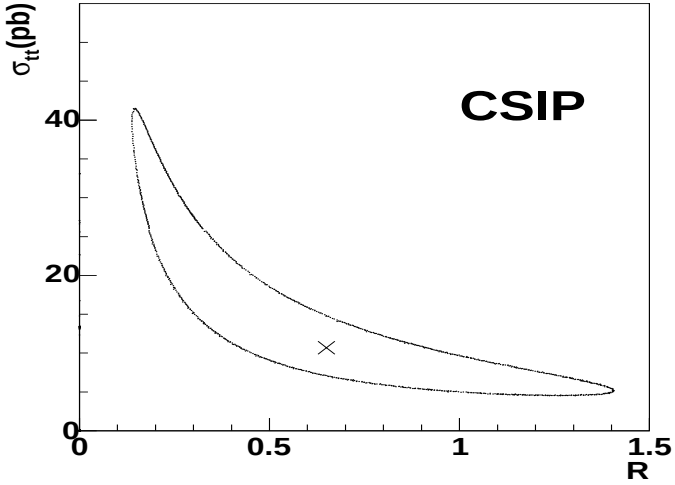
Double tagged events

- In these plots a 7 pb cross-section is assumed for $t\bar{t}$.

Result

- The cross-section, $\sigma_{t\bar{t}}$, and the ratio R are fitted together using a maximum likelihood function.

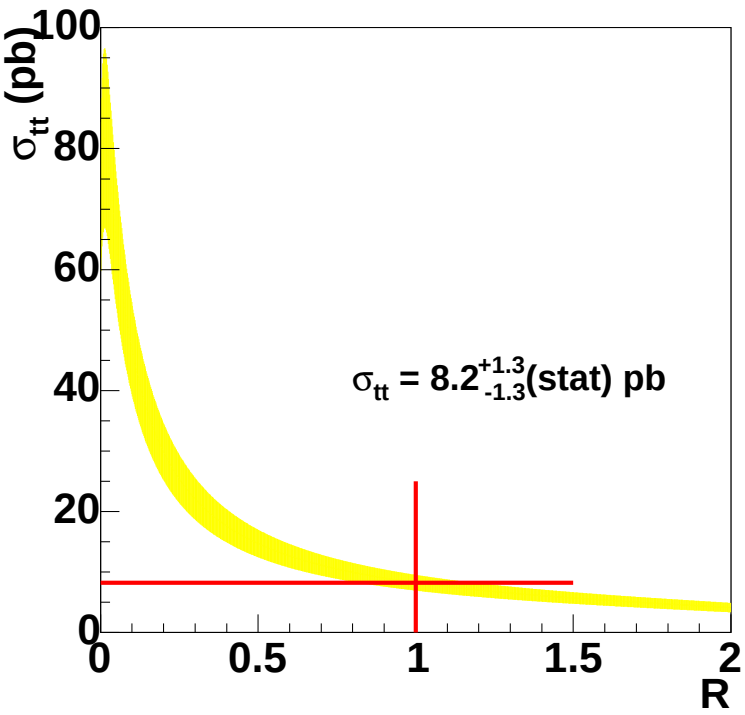




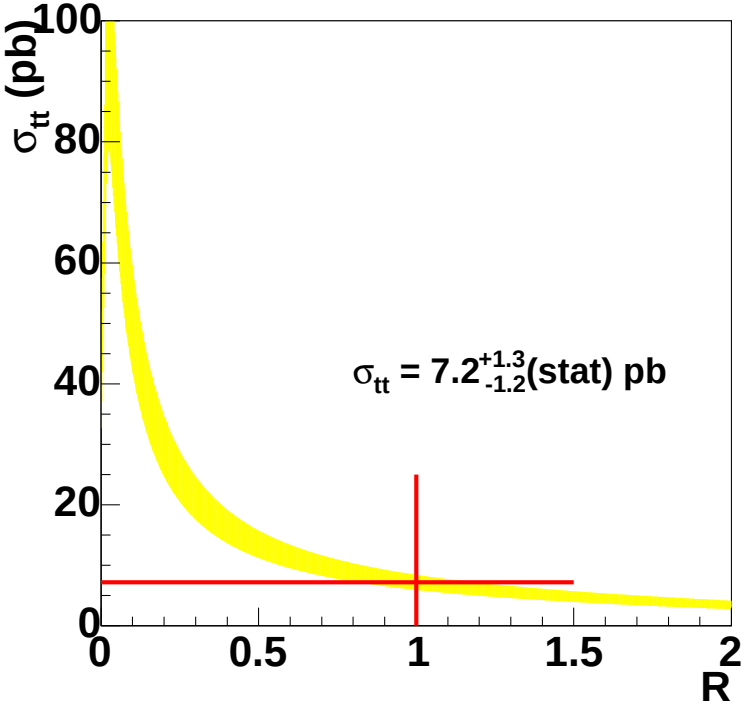
$$SVT \quad : \quad R = 0.70^{+0.27}_{-0.24}(stat)^{+0.11}_{-0.10}(syst) \qquad \sigma_{t\bar{t}} = 11.6^{+5.6}_{-3.2}(stat)\text{pb}$$

$$CSIP \quad : \quad R = 0.65^{+0.34}_{-0.30}(stat)^{+0.17}_{-0.12}(syst) \qquad \sigma_{t\bar{t}} = 10.7^{+8.2}_{-3.7}(stat)\text{pb}$$

Cross-section as a function of R



SVT



CSIP

- The fitted $\sigma_{t\bar{t}}$ for a given value of R, when R is known with infinite precision. Also shown is $\sigma_{t\bar{t}}$ for the value $R = 1$.

Conclusion

- New physics, like a fourth quark generation, could lead to a deviation from the predicted value for R.
- The most likely value of R is found to be:

$$SVT \quad : \quad R = 0.70^{+0.27}_{-0.24}(stat)^{+0.11}_{-0.10}(syst)$$
$$CSIP \quad : \quad R = 0.65^{+0.34}_{-0.30}(stat)^{+0.17}_{-0.12}(syst)$$

- The dominant systematic errors are b-tagging efficiency measurements in data, and the uncertainty on the JES.
- The result presented above is in good agreement with the Standard Model expectation of $R \sim 1$.