IL NUOVO CIMENTO Vol. 33 C, N. 4 Luglio-Agosto 2010
DOI 10.1393/ncc/i2010-10687-8

Colloquia: TOP2010

Expectations for first single-top studies in CMS proton-proton collisions

A. O. M. Iorio on behalf of the CMS Collaboration
Università di Napoli "Federico II" and INFN, Sezione di Napoli - Napoli, Italy

(ricevuto il 14 Luglio 2010; approvato il 15 Luglio 2010; pubblicato online il 16 Novembre 2010)

Summary. — We report on the expectations for first single top studies at the LHC with the CMS experiment. The Standard Model predicts the production of single top quark through three electroweak processes at LHC, referred to as t, s and tW channels. The t-channel has the highest cross section and the most potential for early observation. We describe the search strategy for the t-channel applied on a Monte Carlo sample at 10 TeV p-p collision energy with an integrated luminosity of 200 pb^{-1} and on the expectations for the search of single top t-channel in the 7 TeV scenario.

PACS 14.65.Ha – Top quarks.

1. – Introduction

We report on the strategy for the search of single top in the t-channel at the Large Hadron Collider (LHC) with the Compact Muon Solenoid (CMS) experiment.

Section **2** describes the Standard Model single top physics. Section **3** describes the analysis strategy for the single top t-channel search at LHC. Section **4** reports our conclusions and the expectations for single top search at 7 TeV collision energy scenario.

2. – Single top production at LHC

The Standard Model predicts the production of single top through three different mechanisms [1, 2] in the hadron-hadron interaction. The processes are classified by the 4-momentum squared q^2 of the W boson involved in the process: the s-channel is mediated by a W boson with $q^2 > m_W^2$ (fig. 1(a)); in the tW-channel a W boson is produced with $q^2 = m_W^2$ (fig. 1(a)); t-channel is mediated by a W boson with $q^2 < 0$ (fig. 1(c)). The single top allows to investigate the electroweak sector of the top quark physics. All single top channels are related to the CKM matrix element V_{tb}, allowing a direct measurement of this parameter. It is possible to investigate the tWb vertex structure and FCNC couplings, in the production processes. In addition, single top topologies allow searches for anomalous couplings and s-channel resonances like W' bosons. The

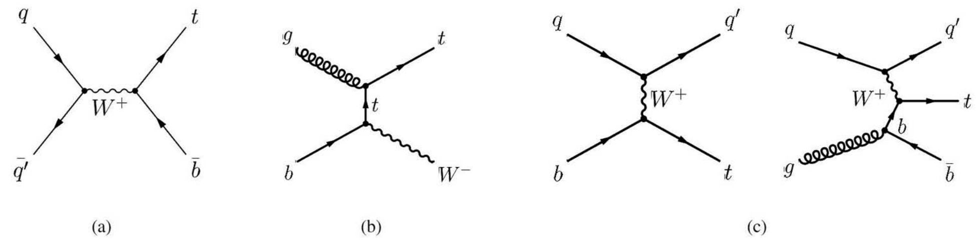

Fig. 1. – Single top production channels. a) s-channel; b) tW channel; c) t-channel.

dominant process at LHC will be the t-channel with a cross section of 124.5(63) pb at 10(7) TeV, followed by the tW with 32.7(10.6) pb at 10(7) TeV, and then the s channel with 6.6(4.6) pb at 10(7) TeV (cross sections from MCFM [3]).

3. – Search for single top at CMS

In this section we describe the strategy for the search of the single top t-channel at CMS. For this study only the muonic final states are considered (where $t \rightarrow W\bar{b} \rightarrow \bar{b}\mu\nu$). The s and tW channels are considered as background. This analysis refers to a Monte Carlo sample corresponding to an integrated luminosity of $200\,\text{pb}^{-1}$ at 10 TeV collision energy.

3·1. *Event selection.* – The topology of events searched for in the detector consists of a single muon, a jet identified as a b-tagged jet and a second jet stemming from the light quark. The contribution of signal events with 2 b-tagged jets is strongly suppressed because the second b-jet is likely not to pass the kinematic cuts for jets and/or to be out of the geometric acceptance of the b-tagging algorithm.

3·2. *Template fit.* – To extract the signal from data a fit is performed on $\cos\theta_{lj}$, defined as the angle between the light quark jet and the muon in the top quark rest frame. The angular disribution of the top quark decay products with respect to its spin axis, taken as the direction of the light quark jet, is [5]

$$\frac{\mathrm{d}\Gamma}{\Gamma\mathrm{d}\cos\theta} = \frac{1}{2}\cdot(1 + A\cdot\cos\theta), \tag{1}$$

with $A = 1$ for the lepton, -0.4 for the b quark, and -0.33 for the ν. The top momentum is reconstructed using the 4-momenta the muon, the b-tagged jet and the missing transverse energy (MET). Figure 2 shows the reconstructed top mass. Figure 3 shows the distribution of $\cos\theta_{lj}$. The fit is performed in the region $[-1, 0.75]$ of $\cos\theta_{lj}$ where the background distribution is approximately flat.

3·3. *Results.* – The statistical significance has been obtained generating 500000 pseudoexperiments. Figure 4 shows the sensitivity as a function of the integrated luminosity. The procedure yields a statistical cross section uncertainty of 35%, a luminosity uncertainty foreseen to be 10% plus the other systematic uncertainties that sum up to 14%.

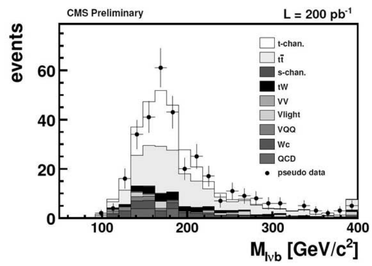

Fig. 2. – Invariant mass of the top quark reconstructed from the muon, the b-jet and the MET [4].

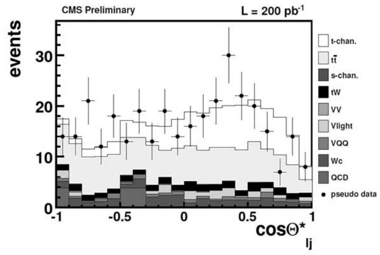

Fig. 3. – Distribution of the $\cos\theta_{lj}$ after full selection. The dots represent the sum of all channels for the equivalent of $200\,\mathrm{pb}^{-1}$ integrated luminosity.

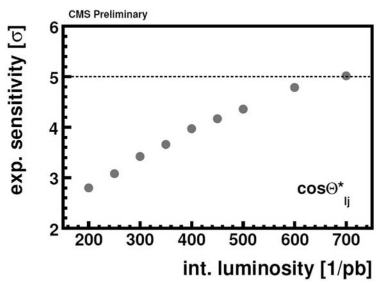

Fig. 4. – Evolution of the sensitivity of the analysis with respect to the luminosity. Sistematic uncertainties are not taken into account in this plot.

4. – Conclusions

We reported on the analysis strategy for the single top t-channel search with CMS at LHC in the 10 TeV collision energy scenario. A rescaling of the signal and background yields according to the cross-section ratio expected for 10 and 7 TeV collision energies, assuming the same selection shows that to get the same sensitivity as for the 10 TeV samples the integrated luminosity needed at 7 TeV is about double the one at 10 TeV.

REFERENCES

[1] Harris B. G. *et al.*, *Phys. Rev. D*, **66** (2002) 054024, arXiv:hep-ph/0207055.
[2] Campbell J. and Tramontano F., *Nucl. Phys. B*, **726** (2005) 109, arXiv:hep-ph/0506289.

[3] Campbell J. and Ellis R. K., *Monte Carlo for FeMtobarn processes*, available from World Wide Web: `http://mcfm.fnal.gov/`.
[4] The CMS Collaboration, *Prospects for the measurement of the single-top t-channel cross section in the muon channel with* $200\,\text{pb}^{-1}$ *of CMS data at* $10\,\text{TeV}$, CMS PAS TOP-09-005 (2009).
[5] Mahlon G. and Parke R., *Phys. Rev. D*, **55** (1997) 7294.