PROCEEDINGS OF SCIENCE

Single top production at LHC : a complete one-loop calculation in the MSSM.

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The calculation of the complete one-loop electroweak supersymmetric contributions to the two dominant processes (t-channel, associated tW production) of single top production at LHC is shortly reviewed .In the Minimal Supersymmetric Standard Model with mSUGRA symmetry breaking scheme the effects for a wide set of benchmark points are systematically of the order of a relative few percent.

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1. Introduction

A rather peculiar feature of the potential LHC outcomes is that of being able to provide from proton-proton collisions a relevant information on the charged weak current interactions of the top quark. This information will be offered by the study of the process of single top production.
A full and exhaustive illustration can be found in the very recent paper [1]. One usually defines three types of "single top" production processes (Fig.1): t-channel (a), s-channel (b) and tW associated production (c), (d).

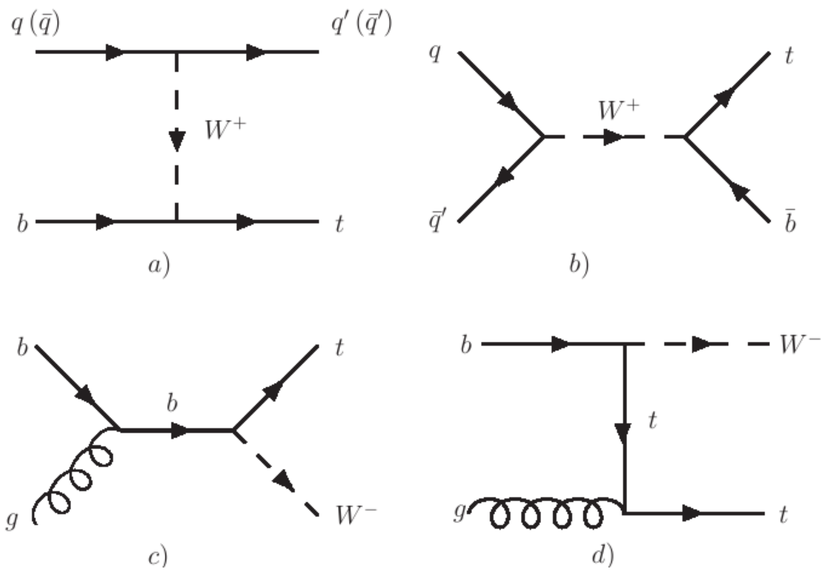

Figure 1: Feynman diagrams for single top production at LHC

2. t-channel

Usually, one calls single top t-channel process the sum of the two processes of single top and single antitop production. Eight processes give the expectedly dominant contributions. The t-channel production has the largest rate: roughly, 240 pb, not much less than the $t\bar{t}$ one (about 830 pb). Note that the single top rate (about 150 pb) is different at LHC (proton-proton) from the antitop one (about 90 pb). The tW production has a rate of about 65 pb (top=antitop rate). The s-channel has a $(t+\bar{t})$ rate of approximately 10 pb [2].
Why is the single top production interesting? Because it provides a unique (first) way of measuring the Wtb CKM coupling V_{tb}, since clearly e.g. the 3 total rates will all be proportional (Born level) to $|V_{tb}|^2$. This is the only poorly measured SM parameter of the CKM matrix. Assuming unitarity and 3 families, it should be very close to one (0.999...). From very recent CDF results [3] of t- and s-channels, one gets $|V_{tb}| > 0.66$ at 95 C.L.
The available predictions give also an estimate of the various theoretical uncertainties. These come from scale uncertainties, PDF uncertainties, m_t uncertainty. Roughly, one expects for the total rates:

1 t-channel: $240 \pm 10^{(th)}$

2 tW: $65 \pm 7^{(th)}$

3 s-channel: $10 \pm 1^{(th)}$.

Several estimates exist of the expected experimental accuracies. In general, they depend on the assumed integrated luminosity and vary with the process. It appears [4] that the most favourable situation corresponds to the t-channel, the worst one to the s-channel. For 1 fb^{-1}, one expects an overall uncertainty of a relative 20% (t-channel), 50% (tW), 90% (s-channel). For 10 fb^{1} the uncertainties are roughly halved. Experimental goal for the t-channel: "to reach a precision at the few percent level" [4].
It appears in conclusion that the t-channel process has an optimal (theory+experiment) uncertainty situation, possibly at the few percent level. Incidentally, NLO QCD effects are rather modest, at the five percent level. At this level of accuracy, a natural question that arises is: what is the size of the NLO electroweak effects? Could they be at a visible (say, more than five percent) level?
A priori, this possibility cannot be excluded. From a partial analysis performed for the dominant t-channel process in the MSSM it was found that for "asymptotic" accelerator energies large negative effects on the rate , of order ten percent (or more) were generated by the supposedly leading negative double Sudakov weak logarithms produced by a subset of weak one-loop diagrams [5]. A more complete one-loop calculation is however nowadays requested. The long calculation was performed in a recent paper (all details there) [6]. It was performed in the MSSM, mSugra symmetry breaking scheme, for a choice of twelve typical SUSY benchmark points. All one loop electroweak effects from self-energies, vertices, boxes, QED soft and hard radiation, SUSY QCD were computed (killing divergences of every kind).
The results of our calculation (8 processes) are shown in the Fig. 2. They can be summarized by the (sad?) statement: the complete one-loop electroweak effect is modest, at the (-two) percent level in the total rate, (also in the invariant mass distribution), both in the SM and in the MSSM, mSUGRA . Typical SUSY effects for SU6 are shown in Fig 3. SUSY alone remains below the one percent level (SUSY QCD at the permille level, agrees with [7].) A possible explanation of the vanishing effect is the cancellation between a negative term of Sudakov kind and a positive QED enhancement.
Consequence: the electroweak one-loop effects can be neglected at LHC for the t-channel process in the SM and in the mSUGRA MSSM; Born + NLO SM QCD is enough. But for different SUSY models still no investigation exists: it could be interesting to look for visible effects in other schemes.

3. tW production and s-channel

What about tW production? An identical prejudice exists of a partial sizeable negative one-loop asymptotic Sudakov effect [5]. The complete one-loop calculation has been performed in the mSUGRA MSSM [8]. Briefly, one finds for the rate a slightly larger effect (roughly, 6% SM , with an extra 6% from SUSY QCD [7], but the expected experimental "error" is much larger and the size of the rate is much smaller: the one loop electroweak is again modest (again, valid

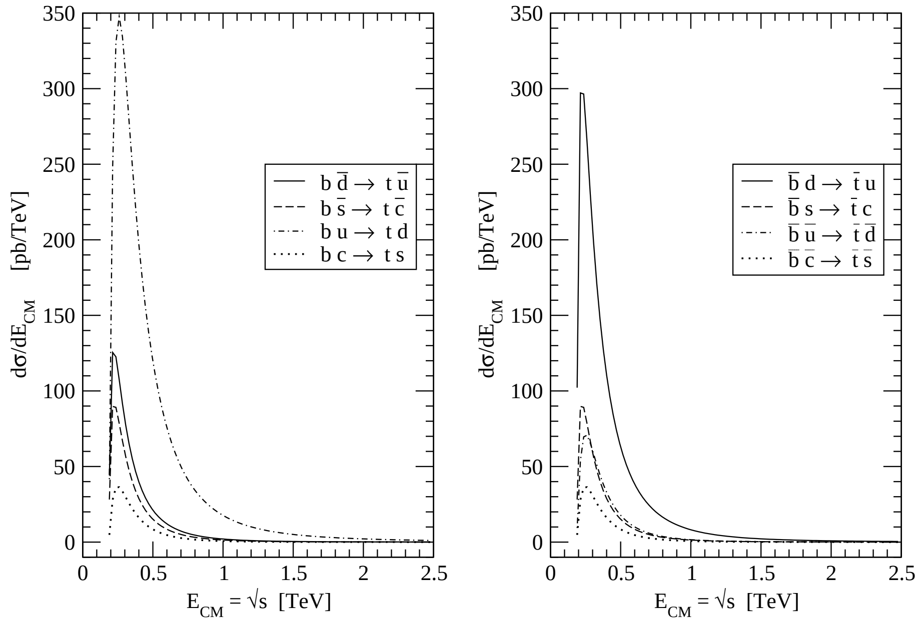

Figure 2: Differential distribution $d\sigma/dE_{\rm CM}$ for the 4+4 partonic processes of single t or $\bar{t}$ quark production.

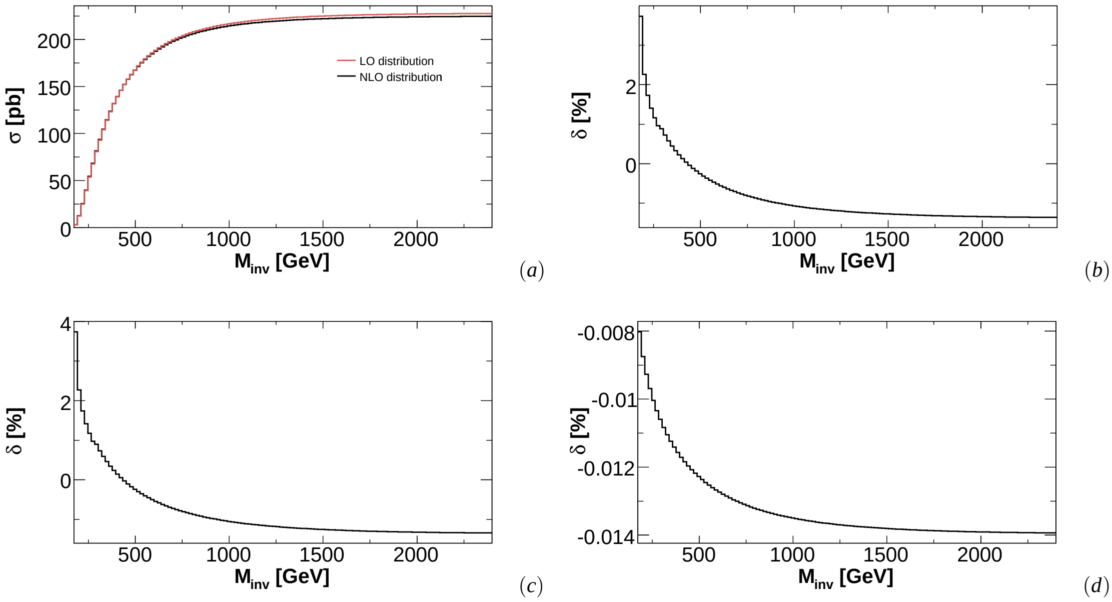

Figure 3: (a) LO and NLO corrections to the cumulative invariant mass distribution, (b) percentage contribution of the $\mathcal{O}(\alpha^3)$ plus SUSY QCD, (c) percentage contribution of the $\mathcal{O}(\alpha^3)$ corrections and (d) percentage contribution of the SUSY QCD.

in mSUGRA MSSM). For the *s*-channel the (Born) rate is so small that a one-loop electroweak calculation appears to be purely accademic.

4. Conclusions

The overall one-loop electroweak effect has been computed for single top production in the dominant t-channel and tW production cases in the SM and in the mSUGRA MSSM. At the expected LHC accuracy, the effect is quite small. For the derivation of V_{tb}, the theoretical description in these models appears therefore simple: the rate only depends on $|V_{tb}|$. A determination at the few percent level appears thus realistically experimentally performable.

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