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CP VIOLATION IN CHARGED HIGGS PRODUCTION

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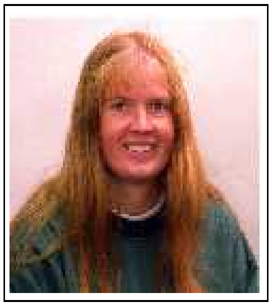

I present a study estimating the amount of CP violation present in the production of charged Higgs bosons due to the presence of complex trilinear scalar couplings. I compare the results of my study with previous results for the decay. I briefly comment on the possibility of observing this CP asymmetry at the LHC.

I have investigated the possibility of observing CP violation in the production and decay of MSSM charged Higgs bosons at the LHC. The CP violation arises from allowing the trilinear scalar couplings in the soft breaking Lagrangian to be complex, leading to complex phases. For the initial study I have chosen to investigate the effect of a complex A_t, keeping the other phases zero.

CP violation can occur at the $H^{\pm}tb$ vertex due to vertex corrections and Higgs self-energy diagrams containing supersymmetric particles. The decay process $H^{\pm} \rightarrow tb$ has already been studied [1]. I have investigated the production with a view to combining both the production and the decay to obtain a complete description. The amount of CP violation is given by the asymmetry

$$\mathcal{A}_{\rm CP} = \frac{\sigma(H^+) - \sigma(H^-)}{\sigma(H^+) + \sigma(H^-)}. \qquad (1)$$

1 The Decay

Initially I tried to reproduce the results for the decay to ensure that the production and decay studies would be consistent. While the sub-dominant loops agreed (such as the loops containing $\tilde{t}\tilde{b}\tilde{\chi}^0$ and $\tilde{\chi}^0\tilde{\chi}^{\pm}\tilde{t}/\tilde{b}$) there was a discrepancy in the dominant loop containing $\tilde{t}\tilde{b}\tilde{g}$. I discovered that this was due to a conjugation error in ref[1]. After correcting this, the two methods for calculating the decay asymmetry agree. The corrected asymmetry is less than that in the original study.

2 The Production

There are two main processes for charged Higgs production at the LHC, bottom – gluon fusion and gluon – gluon fusion. Care needs to be taken when combining them to avoid double counting. Bottom – gluon fusion is the dominant process and is the only one considered in this initial study.

The cross-section was calculated using FormCalc [2]. The parton level results are shown in Figure 1(a). The thresholds in partonic centre of mass energy, $\sqrt{\hat{s}}$, appear when different particles in the vertex correction can be produced as real particles, giving rise an imaginary part of the amplitude, which allows CP violation to be manifest.

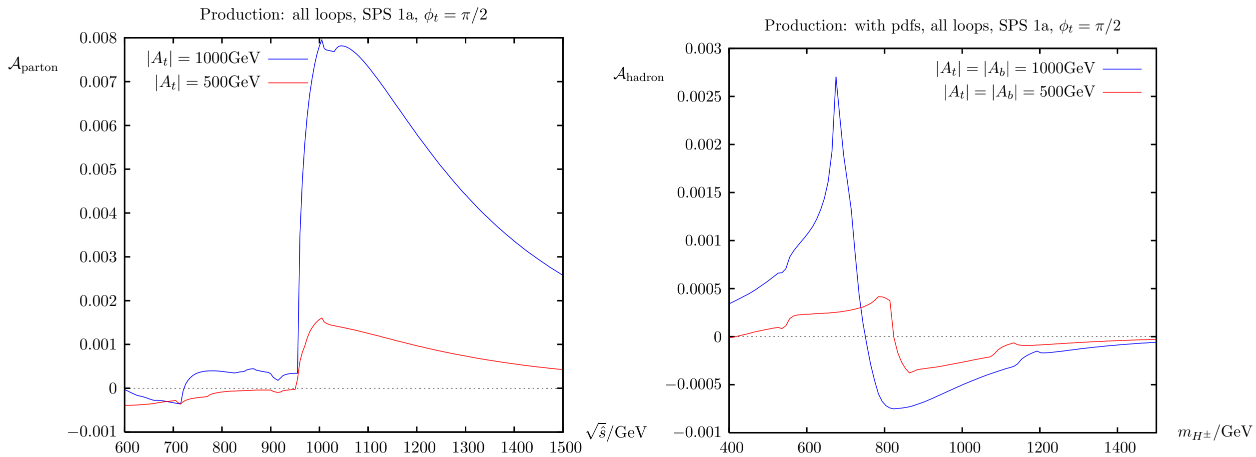

Figure 1: CP asymmetry in charged Higgs production (a) parton level. (b) hadron level.

Since the LHC is a proton – proton collider, it is necessary to include the parton distribution functions (pdfs) for the bottom quarks and gluons to obtain the CP asymmetry at the hadron level, Figure 1(b). Including the pdfs greatly reduces the asymmetry, making it very challenging to observe at the LHC.

3 Observing the Asymmetry at the LHC

The total cross-section is approximately 50 pb for low charged Higgs mass. For an integrated luminosity at the LHC of 100fb^{-1}, this would give a total of 5 000 charged Higgs events. Reducing this to take account of an acceptance of, say, 5%, gives only 250 events. It would not be possible to observe an asymmetry as small as that in Figure 1 with so few events and it is likely that it will be necessary to wait for the luminosity upgrade of the LHC to be able to observe this asymmetry.

Work which is being done to extend this initial study involves combining the production and decay asymmetries; including the gluon – gluon fusion production process; investigating other points in the MSSM parameter space; varying other parameters such as the phase of the trilinear couplings; investigating other loop processes such as box diagrams and exploring the possibilities of seeing the asymmetry at a future International Linear Collider which would provide a cleaner environment. This work forms part of ref [3].

References

1. E. Christova, H. Eberl, W. Majerotto and S. Kraml, *Nucl. Phys.* B **639**, 263 (2002)
2. T. Hahn and M. Perez-Victoria, *Comput. Phys. Commun.* **118**, 153 (1999)
3. J. Williams, "Phenomenology of CP Violation in Supersymmetric Models", Cambridge University PhD thesis, *in preparation*