PiTP: Introduction to Collider Physics

Practicum on Simulations

Assignment 4

(July 21 2005)

Recommended reading: CompHEP manual: Section 3.3.

<u>Problem 1.</u> Higgs production at the Tevatron. The main production process used for a discovery of a light ($m_h < 140$ GeV) Higgs boson at the Tevatron is $p\bar{p} \to Wh$. In this exercise we shall calculate its cross-section using CompHEP.

(a) Start up CompHEP and generate the diagrams for $p\bar{p} \to W^+h$ and $p\bar{p} \to W^-h$. Without doing any calculations, try to guess and rank the first few dominant subprocesses according to their importance.

(b) Calculate the cross-section for $p\bar{p} \to W^\pm h$ at the Tevatron ($E_{CM} = 2$ TeV) as a function of the Higgs mass m_h, for $100 < m_h < 200$ GeV. *Hint: The cross-section is a slowly varying function of m_h, so you will only need to compute it at 3-4 points.*

(c) Check your guesses from (a) against the numerical results from (b).

<u>Problem 2.</u> Higgs production at the Tevatron: signal versus background. For a Higgs discovery in $p\bar{p} \to Wh$ at the Tevatron, one makes use of the decays $W \to \ell\nu$ and $h \to b\bar{b}$. The final state signature is therefore $\ell\nu b\bar{b}$. The main background is $Wb\bar{b}$ production, where the b's were produced through a gluon, photon or a Z. On the same plot, show the $b\bar{b}$ invariant mass distribution $M_{b\bar{b}}$ for the Wh signal and the $Wb\bar{b}$ background. Notice that because of the very small Higgs width Γ_h, the signal will peak very sharply at $M_{b\bar{b}} = m_h$. In reality, however, the energy of the b-jets is not perfectly measured, which results in an uncertainty in $M_{b\bar{b}}$ of order 10%. An easy way to account for the poor mass resolution and thus make our plot more "realistic", is to simply inflate the Higgs width Γ_h to $0.1m_h \sim 12$ GeV.

Hint: You may need to use the option "regularization" to constrain $M_{b\bar{b}}$ near the s-channel gluon, photon, Z or H resonances.

<u>Problem 3.</u> Higgs production at the LHC. Repeat Exercise 1, but for the case of Higgs production in vector-boson fusion at the LHC (pp collider, $E_{CM} = 14$ TeV).