PiTP: Introduction to Collider Physics

Practicum on Simulations

Assignment 7

(July 26 2005)

<u>Problem 1.</u> Higgs production at the Tevatron and LHC. Repeat problems 1 and 3 from Assignment 4:

(a) Calculate the cross-section for $p\bar{p} \to Wh$ at the Tevatron ($E_{CM} = 2$ TeV) as a function of the Higgs mass m_h, for $100 < m_h < 200$ GeV. Repeat for the case of Higgs production in vector-boson fusion at the LHC ($E_{CM} = 14$ TeV). *Hint: Refer to Sec. 8.5.1 for a description of light Higgs production in PYTHIA.*

(b) For a fixed value of the Higgs boson mass, say $m_h = 120$ GeV, investigate the accuracy of the result for the cross-section as a function of the number of events N_{ev} requested for generation. What do you think is the minimum number of events which would give a good estimate of the cross-section? For large N_{ev} the statistical error should scale as $1/\sqrt{N_{ev}}$. Is this consistent with your findings?

(c) The fortran code of the class exercise (`/home/pitp/PYTHIA/Matchev/example.f`) contains an example of turning off certain decay channels, for example all W decays except $W \to e\nu_e$. Activate this piece of code and check that the resulting cross-section is indeed smaller by the branching fraction $B(W \to e\nu_e)$.

<u>Problem 2.</u> $h \to \gamma\gamma$ discovery channel at the LHC: signal versus background. One of the main discovery channels for a light Higgs boson at the LHC is $pp \to h \to \gamma\gamma$. The purpose of this exercise is to compare signal to background and produce a plot analogous to the CMS plot shown in Fig. 1 (see next page). Use PYTHIA to simulate Higgs production in gluon fusion ($gg \to h$) with subsequent $h \to \gamma\gamma$ decays. Then simulate the main physics background $pp \to \gamma\gamma$ (see Sec. 8.4.1) and compare the diphoton invariant mass distribution for signal and background, for 100 fb^{-1} of data, as in the figure.

Hint: You may want to use the trick of Problem 1(c) and turn off the other Higgs decays, leaving only $h \to \gamma\gamma$.

<u>Problem 3.</u> $gg \to h \to b\bar{b}$ at the LHC. Repeat Problem 2, but for the case of the dominant Higgs production process ($gg \to h$) and the dominant Higgs decay mode ($h \to b\bar{b}$). Compare the $b\bar{b}$ invariant mass distribution for signal and background (see Sec. 8.2.2 for the relevant $b\bar{b}$ processes). Is this a good discovery channel?

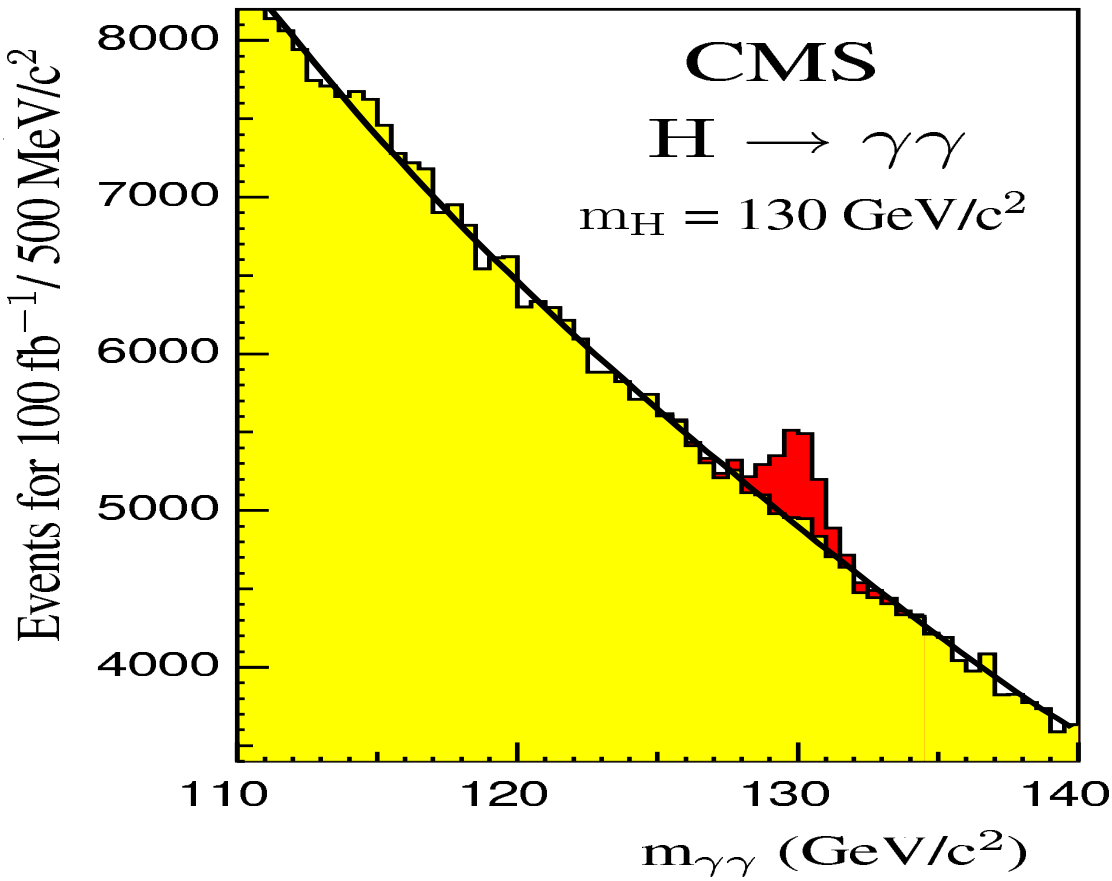

Figure 1: *CMS simulation of $h \to \gamma\gamma$ (from hep-ph/0405026).*