**Problem 1.** Higgs production at the Tevatron and LHC. Repeat problems 1 and 3 from Homework Set 4:

(a) Calculate the cross-section for $p\bar{p} \rightarrow Wh$ 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 ($E_{CM} = 7$ 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 $m_h = 125$ 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 already contains an example of turning off certain decay channels, for example all $W$ decays except $W \rightarrow e\nu_e$. Activate this piece of code and check that the resulting cross-section is indeed smaller by the branching fraction $B(W \rightarrow e\nu_e)$.

**Problem 2.** $h \rightarrow \gamma\gamma$ discovery channel at the LHC: signal versus background. One of the main discovery channels for a light Higgs boson at the LHC is $pp \rightarrow h \rightarrow \gamma\gamma$. 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 ($gg \rightarrow h$) with subsequent $h \rightarrow \gamma\gamma$ decays. Then simulate the main physics background $pp \rightarrow \gamma\gamma$ (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 $h \rightarrow \gamma\gamma$.***
Figure 1: CMS simulation of $h \rightarrow \gamma\gamma$ ($m_H = 130$ GeV/c$^2$) (from hep-ph/0405026).