PiTP: Introduction to Collider Physics

Practicum on Simulations

Assignment 8

(July 27 2005)

<u>Problem 1.</u> Supersymmetry. Start reading section 8.7 from the manual, up to and including section 8.7.5.

(a) Download the supersymmetry example from the PYTHIA website and then compile and link it with the main code. Keep the default input SUSY parameters.

(b) The example comes with a default MSUGRA parameter point: $M_{1/2} = 200$ GeV, $m_0 = 800$ GeV, $A_0 = 0$, $\tan\beta = 10$ and $\mu > 0$. Discuss the resulting spectrum.

(c) From the decay table, identify the dominant decay modes of the squarks and gluino. Draw a few sample cascades, following the decay of a squark (gluino) all the way to the LSP.

(d) Consider strong production of superpartners (`MSEL=40`) at the LHC. Identify the dominant production processes. How many squark/gluino events do we expect with 100 fb^{-1}?

(e) Repeat (d) for the Tevatron ($p\bar{p}, E = 2$ TeV$, 8$ fb^{-1}).

<u>Problem 2.</u> Slepton production at a Lepton Collider. Consider pair-production of the lightest smuon $\tilde{\mu}_1$ (of mass $M_{\tilde{\mu}_1}$) at a future Linear Collider of center-of-mass energy $E_{CM} > 2M_{\tilde{\mu}_1}$. Assume that the smuons decay directly to the LSP, which is the lightest neutralino $\tilde{\chi}_1^0$ of mass $M_{\tilde{\chi}_1^0}$. The diagram for this process is shown in Fig. 1.

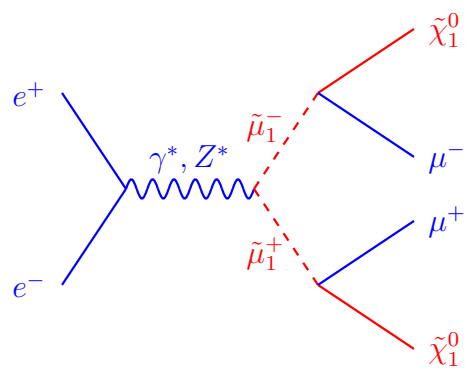

Figure 1: Smuon pair production and decay at an e^+e^- collider.

(a) Use PYTHIA to simulate the process of Fig. 1. Use $E_{CM} = 500$ GeV, and the following values of the MSUGRA parameters $M_{1/2} = 200$ GeV, $m_0 = 200$ GeV, $A_0 = 0$, $\tan\beta = 10$ and $\mu > 0$. (Basically these are the defaults from the sample file, except m_0 is reduced to 200 GeV.)

(b) Make a histogram of the muon energy distribution. Notice the box-like shape of the

distribution. Record the values of the two endpoints, E_{min} and E_{max}, of the muon energy distribution and use them to calculate the slepton and neutralino masses $M_{\tilde{\mu}_1}$ and $M_{\tilde{\chi}_1^0}$. How close did you get to the real answer?

<u>Problem 3.</u> Sparticle production at the LHC. Consider sparticle production at the LHC for the case of MSUGRA with default parameters as in the PYTHIA example (see Problem 1(b)).

(a) Plot the $\not{E}_T$ and H_T distributions resulting from strong production of superpartners (i.e. squarks and gluinos). H_T is the scalar sum of the p_T's of all reconstructed objects in the event (jets, leptons and photons) plus the $\not{E}_T$.

Hint: Which particles in the event listing will contribute to the missing energy measurement?

(b) Assume $t\bar{t}$ is the dominant SM background and plot the resulting $\not{E}_T$ and H_T distributions. Then compare signal and background on the same plot.

Hint: For part (b) you should be able to recycle the code from part (a) and simply change the process number to $t\bar{t}$.