Exercises for Advanced Particle Physics - Winter term 2013/14

Exercise sheet No. VI

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The solutions have to be returned to mail box no. 1
in the foyer of the Gustav-Mie-House before **Monday, December 9th, 12:00h**.

Simulation and study of few QCD processes

The goal of these exercises is to be able to simulate high energy collisions taking into account simple transition amplitudes due to QCD interactions. After simulation, we propose to analyse these collisions by looking at different distributions, as it is done in LHC experiments.

Exercise No. 1: Download and run examples **(2 points)**

All the file needed to perform the study are accessible on the following link: http://rmadar.web.cern.ch/rmadar/Teaching/Pyhtia/QCD/

1. Copy the files `GenerationQCDprocess.cc` and `Makefile` in the directory `examples` of Pythia. Compile and execute the program (warning will appear at the compilation). Check that you obtain a rootfile `PythiaOutput.root` containing a tree.

2. Download the files `ProcessAnalysis.C` and `ProcessAnalysis.h`. In root, write the following:
```
.L ProcessAnalysis.C+
ProcessAnalysis MyAnalysis
MyAnalysis.Loop()
```
Check that you have a rootfile `MyAnalysisResult.root` containing (for now!) only one histogram. Search on Particle Data Group website, the meaning ot the "PDG id".

Exercise No. 2: Study of simple QCD processes **(8 points)**

Now, we want to modify the example files to look at different properties of the two processes:

$$qg \to qg \quad \text{and} \quad \mathrm{gg} \to \mathrm{q\bar{q}} \tag{1}$$

1. Simulate the process $qg \to qg$. Check that the energy, the momentum and the electric charge are conserved during the collision, using `ProcessAnalysis.C`.

2. Plot the distribution of the center-of-mass energy of the process. Is the laboratory frame always the rest frame of the out-coming $\{q, g\}$ system?

3. Is the fraction of in-coming quark and anti-quark equal?

4. Check the initial state of the collision in `GenerationQCDprocess.cc` and explain the two previous questions.

5. Draw the Feynman diagrams of $qg \to qg$ and discuss which channels are involved (s, t and u). In `ProcessAnalysis.C`, compute the angle θ^* between the out-coming quark and the z-axis, in the rest frame of the out-coming $\{q, g\}$ system. Comment the result.

6. Simulate the process $gg \to q\bar{q}$ and answer the previous question for this process.