Exercises for Tutorial 3

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1 Fraction of 3-jet events v. centre-of-mass energy

Get the directory for tutorial 3. If you cloned it with previously, do

```
git stash
git pull
```

and then go to the directory `tutorial-3/pythia-example-3`. Otherwise download a fresh zip file, unpack it and edit the `Makefile` in the above directory so that the path to Pythia points to where you built it previously.

The example here (yet again called `main01`!) is almost the same as from tutorial 2, but it is set up to calculate the 3-jet rate (i.e. the last part of tutorial 2). As usual, look at the program to make sure that you understand what it's doing.

You can build and run the code as follows

```
make
./main01 -Q 100.0 -nev 1000
```

and by changing the value of the "`-Q`" ("`-nev`") option you can change the centre-of-mass energy (number of events). Look in the file and you'll see various kinds of information being output.

Each run with a separate centre-of-mass energy will generate a separate output file. Run a few Q values, e.g. from $Q = 20\,\text{GeV}$ to $100\,\text{TeV}$. You'll probably want to use greater statistics than above, e.g. 10^4 events per run.

The three jet rate should go as $c\alpha_s(Q)$ with c some fixed coefficient. Recall the formula for $\alpha_s(Q)$ from the lectures and check whether the expectation is satisfied.

2 The JADE jet algorithms

The first sequential recombination jet algorithm that was used was called the JADE algorithm It was similar to the e^+e^- k_t algorithm, but used a distance measure that was

similar to an invariant mass

$$y_{ij} = 2\frac{E_i E_j}{Q^2}(1 - \cos\theta_{ij})\,, \tag{1}$$

which at first sight seems like a natural physical choice.

Imagine an event with

- two almost back-to-back hard particles a and b and energies $Q/2$.
- and two soft particles, 1 and 2, each with energy $\epsilon Q/2$, $\epsilon \ll 1$

Let $\theta_{a1} = \theta_{b2} \ll 1$.

Physically, one would expect that a good jet algorithm will always recombine particles that are very close in angle, i.e. 1 with a and 2 with b. Does the JADE algorithm do this?