02FUJS: Jet physics -- worksheet

This is a worksheet for the hands-on exercise here: https://www.github.com/matonoli/fujs-pythia-jets

* Required

* This form will record your name, please fill your name.

Jet radius dependence

You will now study how changing the jet definition parameters (radius) affects the number of reconstructed jets and their pT.
Follow the instructions provided to:
1) Compile the jet-generation code (makeTree.cc) by typing **make** in the terminal
2) Run the simulation by typing **./makeTree 30 50 2000** . This will generate 2000 events with produced jets with the default settings:

- Jet radius R = 0.4
- Jet algorithm = anti-kT
- pTHat range = 30–50 GeV (this is the pT exchanged in the 2->2 parton-parton scattering and defines the energy scale of the event)

3) This will create a file similar to: *jets_ptHat_30_50_jetR0.4.root*
4) Run the provided ROOT macro (anaTree.C) on this file by typing **root -l -b -q 'anaTree.cpp("jets_ptHat_30_50_jetR0.4.root")'**
5) Double-click the root file to view the histograms

1. What is the mean number of jets per event? (Look in the top right corner of the displayed hNJetsPerEvent in the statistics box) *

2. What is the mean jet pT? (Look at the hJetPt histogram) *

3. Now generate new data with a smaller radius. You will have to modify the makeTree.cc file from

   const double jetRadius = 0.4;

   to

   const double jetRadius = 0.2;

   Then recompile and rerun again, with all other settings unchanged, and analyse the new simulated data with:
   root -l -b -q
   'anaTree.cpp("jets_ptHat_30_50_jetR0.2.root")'

   How did the mean number of jets change? *

   - ◯ It is now smaller
   - ◯ It is now larger
   - ◯ It is the same

4. And how did the mean jet pT change? *

   - ◯ It is now smaller
   - ◯ It is now larger
   - ◯ It is the same

5. Please try to briefly explain with your own words why changing the radius changed the two quantities. *

Jet algorithm dependence

Let's now have a look at why the choice of different clustering algorithms matters.
1) Switch the jet radius parameter back to the default value of 0.4 in makeTree.cc
2) In the first step, we will focus on the anti-kt algorithm, which was the default. You already generated the data in Section 1.
3) Analyse again this data with **root -l -b -q 'anaTree.cpp("jets_ptHat_30_50_jetR0.4.root")'**

6. What is the mean jet area for the anti-kt algorithm? (Look at hJetArea) *

7. Can you guess why it's exactly this value? (Hint: if unsure, try to look at the file with R=0.2 and see how the mean area depends on R) *

8. Now, in the makeTree.cc file, modify the algorithm selection.

   fastjet::JetDefinition jetDefinition(fastjet::antikt_algorithm, jetRadius);

   to

   fastjet::JetDefinition jetDefinition(fastjet::cambridge_aachen_algorithm, jetRadius);

   Then, recompile the code, re-create the simulated data (with all other parameters kept the same), and re-analyse.

   Look at the jet area distribution and compare with the previous.
   The Cambridge/Aachen algorithm... *

   - ◯ also has a narrow peak, but the mean is noticably smaller.
   - ◯ also has a narrow peak, but the mean is noticably larger
   - ◯ doesn't have a narrow peak

9. Look at the class presentation about jets, specifically slide comparing different jet algorithms in the phi-y space. Can you use that to explain what happened? *

Dijet structure

10. 1) Using the last generated data (with pThat interval 30-50 GeV/c), look at the azimuthal correlation distribution between two jets produced in a single event (hDeltaPhi)

    2) Please upload a picture of the hDeltaPhi histogram

    (you can click the camera in the bottom left corner when viewing the histogram to save it as canvas.png / alternatively, screenshots or taking a picture with your phone is also perfectly fine). *

    Upload file

    File number limit: 1 Single file size limit: 10MB Allowed file types: Word, Excel, PPT, PDF, Image, Video, Audio

11. Do you understand this structure? What leads to it? *

12. Now generate the data with a different pThat interval, 80-100 GeV/c. This will simulate events with much more energetic jets.
To do that, you don't need to re-compile, simply re-run with:

./makeTree 80 100 2000

and then analyse with

root -l -b -q 'anaTree.cpp("jets_ptHat_80_100_jetR0.4.root")'

How does the correlation change from the previous? *

- ◯ The peak is broader
- ◯ The peak is narrower
- ◯ Something else

13. Can you guess why? (This is about physics, not jet definition) *

Summary

14. What does this exercise show about the concept of a "jet" in experimental particle physics? *

- ◯ A jet is uniquely determined by the underlying parton, independent of how it is reconstructed.
- ◯ A jet is a well-defined theoretical quantity that does not depend on experimental choices.
- ◯ A jet is an operationally defined object whose reconstructed properties depend on the jet algorithm, jet radius, and momentum thresholds.
- ◯ A jet cannot be defined in any precise or reproducible way.