MadFKS v5 in a nutshell

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December 8, 2011

Abstract

An attempt for a MadFKS v5 manual. . .

1 What's MadFKS v5?

MadFKS v5 will be the new and public version of MadFKS, which implements the FKS subtraction (see Rik's lectures) using MadGraph v5. It generates the real emission process, the born, all the needed counterterms and the phase space to compute (hopefully) any total cross-section at NLO. The user will have "only" to provide the code for the virtual amplitude.

We managed to get a working alpha version for this school, and we will proudly show it to you.

2 Installation

Since MadFKS v5 has to be linked to FastJet, we recommend to install it inside the VM.
Steps:

1. Mount a shared directory on the VM (see README).
   We will install here MadFKS v5, so that it can avoid the VM disk space limit
2. Download the extraction script from `http://madgraph.cism.ucl.ac.be/AMCATNLOdata/extract_madfks5.sh.gz` (sorry not to have put it in the VM), unpack and execute it from the shared folder

   ```
   /bin/bash extract_madfks.sh
   ```

3. Go inside the madfks5 directory

   ```
   cd madfks5
   ```

4. If

   ```
   ./bin/mg5
   ```

   works, welcome to MadFKS v5!!!

3 Usage

If you managed to run MadFKS v5, you probably noticed that it has the same interface as MG5. The syntax to generate the code is the same as well. You need to generate the real emission process, i.e. the process with an extra parton/jet, and export it using the *fksreal* format.

```
> import model MYMODEL         # if you want to use a model other than sm
> generate p p > . . .         # real emission process!
> output fksreal MYFOLDERNAME  # where the code will be written
> quit
```

Then, if you go to *MYFOLDERNAME/SubProcesses*, you will find there all the various *P0_XXX_Y* directories, for all the possible FKS *i-j* pairings of the various partonic subprocesses. Before compiling the code, you need to extract the archive *virt.tar.gz*, which contains the code for the virtuals of some processes, and to compile it.

```
tar -xvf virt.tar.gz
cd virt
make
cp LesHouches.f .. # ******
cd ..
```

This compiles the virtuals for W boson, H boson production and decay, and for $t\bar{t}$ production.
Open the file *LesHouches.f* which contains the calls to the virtuals of the three processes, and uncomment the one you want.
Edit the *madfks_plot.f* file, choosing the plots you want to produce (look the examples in *Plot_Examples*.
Then you can compile MadFKS v5, from the *SubProcesses* directory, by typing

```
../bin/compile_madfks2.sh
```

giving as answers:

```
1 # compile and run link_fks
0 # do not compile and run tests
1 # compile and run gensym
1 # compile and run madevent
0 # do not use NLOComp
0 # do not compile only directories with nbodyonly
0 # local run
0 # VEGAS
1 # compile all dirs
1 # use 1 core to compile
```

Finally you can run it and get the results. To get the LO cross-section (faster, e.g to check if plots are corrects. . .):

```
 ./run.sh born0 none 0          # to compute the LO cross-section
 ./combine_results3.sh born0*   # to see the total cross-section
 ./combine_plots3.sh born0*     # to see the plots
```

To get the NLO cross-section:

```
 ./run.sh grid none 0         # to train the grid
 ./run.sh all grid 0          # to compute the total cross-section using the trained grid
 ./combine_results3.sh all*   # to see the total cross-section
 ./combine_plots3.sh all*     # to see the plots
```

In order to get smoother distributions, increase the number of points/iterations in *madin.all* and *madin.grid* files.
NOTE: All the informations concerning cuts in the run card are ignored!!! That's all folks!

4 Let's play!

4.1 W production in the Drell-Yan process

The first process we suggest, is the W production and leptonic decay into leptons.
NOTE: MadFKS does not support (yet) decay chains. Hence you should give as input the process with the final particles, specifying, if necessary, the coupling orders

```
> generate p p > e+ ve j
```

You can use

```
> display particles
```

to see the particle content of a model.

4.1.1 What is the W boson mass?

1. Study E_T^{miss}, $p_T^{e^+}$ distribution at LO. Use appropriate bounds and binning for histograms. Is there any information you can get from those distributions?
2. Study E_T^{miss}, $p_T^{e^+}$ distribution at NLO. What can you see with respect to LO?
3. Define the **transverse mass** as
$$m_T = \sqrt{E_T^{e^+} E_T^{miss} - 2 p_T^{e^+} \cdot p_T^{miss}}$$
Study the m_T distribution at LO and at NLO and comment which information you can extract

4.2 Higgs production in the effective theory and decay to 2τ or 2γ

For this process we need to import the model *heft*.
With the

```
> display interactions
```

command you can see which coupling (QED, QCD, HIG, HIW, ...) the various interactions correspond to. Try to figure out the correct couplings in order to have the desired process (i.e. for $h \to \gamma\gamma$ you **do not** want the photon to couple to quarks).

4.2.1 Missing something...

1. Suppose you are able to reconstruct the Higgs boson momentum catching both the τs or γs. Plot their invariant mass, p_t and rapidity distributions at LO and NLO. Are all those observables computed at NLO?
2. Suppose you miss one of the two τs (say, τ^-). Try to extract the Higgs boson mass from the τ^+ momentum, at LO and NLO.
3. Suppose you miss the γ with the smallest p_T. Try to extract the Higgs boson mass from the leading p_T photon. Comment and compare with the missed τ^- case.

4.3 $t\bar{t}$ production

4.3.1 LO or NLO (remember Rik's slide...)?

1. Plot the following distributions, and argue which one/ones correspond to a LO or to a NLO observables: P_T^t, $P_T^{t+\bar{t}}$, P_T^{jet}, $M^{t\bar{t}}$, $\Delta\phi^{t\bar{t}}$

4.3.2 Once upon a time the Tevatron was running...

And one of the most striking measurements it did was about the $t\bar{t}$ forward-backward asymmetry. The top quark is preferably (a some% effect) produced along the direction of the proton beam, while the anti-top preferably along the anti-proton.

1. Plot the distribution of $y_t - y_{\bar{t}}$, using a **linear** scale, setting the run card for the Tevatron. Can you see the small asymmetry of the NLO distribution?