

Wikiprint Book

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Basics of QCD for the LHC, Cern School 2011

5 Lectures are given on QCD and MC's developments for the LHC.

The PDF of the lectures can be found here:

[QCD1 : Intro and QCD fundamentals?](#)

[QCD2: QCD in the final state?](#)

[QCD3: QCD in the initial state?](#)

[QCD4: From accurate QCD to useful QCD?](#)

[QCD5: Advanced QCD with applications to the LHC?](#)

The examples and exercises are related to physics at the LHC.

Basic aspects of QCD

Various Tests and exercises

A collection of test, exercises, and web applications on pQCD can be found in [QCD-exercises.pdf?](#).

Exercise on recursive relations

Think about the computation of $q \bar{q} + n \gamma$ in a recursive way, by trying not calculate the same quantities twice. Show that the complexity of the calculation goes from $n!$ (factorial) to $2^{(n-1)}$ (exponential).

Going NLO

1. $pp \rightarrow H$ at LO (1-loop): details of the calculation (Mathematica Notebook) [HiggsGG-LO-mtfinite.nb?](#)
2. $pp \rightarrow H$ at NLO: details of the calculation (Mathematica Notebook) [higgsGG-NLO.nb?](#)
3. $pp \rightarrow H$ at NLO: cross section evaluation for the LHC (Mathematica Notebook+PDF libraries to be compiled) [phenHiggs.tar.gz?](#).

A summary of the results can be found in [Higgs.pdf?](#).

Selected exercises on QCD that can be solved with a Matrix Element generator.

- [DeadCone:Radiation from heavy quarks]: the dead cone in $e^+e^- \rightarrow Q\bar{Q}g$.
- [GluonSpin:Spin of the gluon]: Vector vs scalar in the angular correlations of $e^+e^- \rightarrow 4$ jets.
- [2Jets:Jets] : Di-jet kinematics and rates in pp collisions.
- [3Jets:3 Jets] : Energy distributions in 3-jet events in pp collisions.
- [tt:top production] : $t\bar{t}$ production, Tevatron vs LHC.
- [WAsymm:Drell-Yan]: rapidity asymmetry at the Tevatron and LHC.
- [TopDecaySpinCorrelations: Spin correlations in top decay], by [?Bryan Webber](#).

Monte Carlo integration

A short introduction to the techniques of Monte Carlo integration. Exercises proposed during lecture are collected in this Mathematica Notebook: [mc101.nb?](#).

LHC Phenomenology

- [DiscoverTheHiggs:SM Higgs discovery at the LHC]: Three important channels
- [WarmingUpChallenge:Simple Black Boxes]: New gauge bosons

How to familiarize with Software.[MadGraph](#)

All exercises proposed can be "solved" or checked with Software.[MadGraph](#) / Software.[MadEvent](#). Here is how to familiarize with the code.

- Logon to the Software.[MadGraph](#) web site and register.

- Familiarize with the code by generating a few processes in QED and QCD trying to guess which diagrams appear. What is the minimum number of jets have to be asked for in e^+e^- collisions so that the triple gauge vertex appear?
- Look at the new physics models and check the particle and interactions content.
- Generate events for a few selected processes and look at the plots:
 - $t\bar{t}$ production with decays: $pp \rightarrow t\bar{t} \rightarrow b\bar{b}\mu^+e^- \nu\bar{\nu}$
 - VV production: $pp \rightarrow VV$; leptons, with $V=Z,W$.
 - Single top + Higgs: $pp \rightarrow tHj$ (QCD=0, QED=3, $j=gudsc, p=gudscb$). Show that there is a large negative interference between the diagrams

-- Main.FabioMaltoni - 2011-09-09