

# PiTP: Introduction to Collider Physics

## Practicum on Simulations

### Assignment 2

(July 19 2005)

**Recommended reading:** CompHEP manual<sup>1</sup>: Sections 3.1, 3.2 and 4.1.

**Problem 1. Definition of a physics model in CompHEP.** Start up a CompHEP session. The first thing you see is a menu with a choice of different models (see Sec. 3.2.1 from the manual for a description of the first few CompHEP menus). Let us agree to use the SM in unitary gauge, so select *SM, unitary gauge*. (Note: in CompHEP, you can always return to the previous step with the ESC key.) In the next menu we see several choices<sup>2</sup>. Before we do any calculations, let us first familiarize ourselves with the way a model is defined, so go directly to *Edit Model* (option No. 5) which will take us to the menu which defines a model. First, take a look at the *Particles* table which defines the different particles of the SM. See Sec. 4.1.3 of the manual for a description of the various fields in the Table. Now go back one step (ESC) and select *Variables*. These are the SM input parameters (see also Sec. 4.1.1 of the manual). Derived quantities are listed in *Constraints* (Sec. 4.1.2). Finally, *Lagrangian* contains the Feynman rules for the SM in the unitary gauge. For the CompHEP convention in defining the Feynman rules, see Sec. 4.1.5 of the manual. As an exercise, inspect the fermion gauge interactions.

**Problem 2. Higgs interactions in CompHEP.** Using your favourite source for the SM Feynman rules (e.g. textbook, lecture notes from the Field Theory class, etc.) check that the Higgs interactions in Table *Lagrangian* are programmed correctly. Check for both their structure and the prefactor.

**Problem 3. Input parameters in CompHEP.** Now let us critically review the values of the input parameters in the *Variables* table. Are there any inputs whose values need to be updated? If so, make a list of those, with their correct values.

**Problem 4. Higgs boson branching fractions.** For  $100 \text{ GeV} < m_h < 400 \text{ GeV}$ , plot:

- (a) the Higgs boson partial widths<sup>3</sup> to  $b\bar{b}, \tau^+\tau^-, c\bar{c}, W^+W^-, ZZ$  and  $t\bar{t}$ ;
- (b) the total Higgs boson width  $\Gamma_h$ ;
- (c) the branching fractions for the final states listed above<sup>4</sup>.
- (d) Based on the results from parts (a) and (b), justify qualitatively the result of part (c).
- (e) Do your results from (c) differ in any way from the real answer? If so, explain why.

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<sup>1</sup>Those of you who have installed CompHEP on their laptops, may use the updated version which comes with the CompHEP distribution: inside the CompHEP directory, go to the directory `doc/manual/` and latex the file `manual.tex`.

<sup>2</sup>Be careful to avoid choice No. 6, which deletes the model.

<sup>3</sup>Hint: In order to select all two body final states simultaneously, type `2 * x` for *Enter Final State*.

<sup>4</sup>Hint: Once you get to the stage shown in Fig. 9 of the manual, when you change the value of a parameter, the results for the total width and branching fractions are updated automatically.

**Problem 5. FORTRAN exercise: plotting with CompHEP.** In order to make plots (e.g. see the previous problem), you may use the plotting tool of CompHEP, save the result (use the *Write table* option, which saves the  $y$  values of the plot in your “results” directory) and then fill in the missing  $x$  values. Write a simple fortran program which will ask for the  $x$ -range of the plot (i.e. the minimum and maximum value of  $x$  and the number of points in between) then will read in the file with the  $y$  values and create a new file with both  $(x, y)$  present. You can then plot the latter with your favorite plotting package.