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CalcHEP Part 1: Calculate a simple Standard Model cross section

Two exercise sessions are foreseen as project work to calculate cross sections of proton proton collisions with the CalcHEP package.

User installation and start of the CalcHEP session

The CalcHEP root directory is not intended to start a session. For this purpose the user has to prepare a special working directory. The user working directory is prepared by the command

```
> /opt/calchep_2.3.6/mkUsrDir dir_Name
```

launched from the CalcHEP root directory, for example

```
> /opt/calchep_2.3.6/mkUsrDir ~/WORK
```

(You do not have to create the directory `~/WORK` by hand.) As a result the following subdirectories and files should appear in your `WORK` directory:

```
models/   tmp/   results/   bin/   calchep   calchep.ini
```

The directory `models/` is used for files which describe models of particle interactions. The directory `tmp/` is created for temporal files. The directory `results/` is assigned for a CalcHEP output. `bin/` is a symbolic link to CalcHEP executables. To start a CalcHEP session type the command

```
> ./calchep
```

Elements of the user interface

There are the following elements of the user interface in the CalcHEP package: On-line Help, Menu, Message, String Editor, Table Editor, Diagram Viewer and Plot Viewer. You

can control them using the Arrows keys, Enter, Esc, Backspace, PgUp/PgDn keys and the mouse click. CalcHEP is sensitive to the left mouse button release.

The menu program displays a list of functions. Use the arrow keys or a mouse click to highlight a desired function. Press the Enter key or click on the highlighted function to activate it. In order to get back to the previous menu level press the Esc key or click the asterisk in the top-left corner of the menu border. The menu program is also sensitive to the functional keys F1, F2, ..,F10. The list of active functional keys depends on the program point and is displayed on the bottom line of the screen.

1 Numerical calculation by CalcHEP

Two functions of the menu of the CalcHEP screen launch integration programs. One of them is the ordinary Simpson integration routine which can operate only for the $2 \to 2$ reactions. The other one is the Monte Carlo program *Vegas* which gives the cross sections for $2 \to 2$,..., $2 \to 4$ type processes.

Calculate a standard model process

Choose the option "Standard Model" and execute the following exercises of part 1 of the CalcHEP session:

1.1 Create all 12 diagrams of the process $pp \to e^-\bar{\nu}_e$ (type `p,p->e,Ne` and enter the composition of 'p'. There is no parton density function for the top or anti–top in the proton.

1.2 Choose the subprocess $\bar{u}d \to e^-\bar{\nu}_e$ and calculate its cross section at a center–of–mass energy of 14 GeV with *Vegas*. (First choose in "IN state" for "S.F.1" and "S.F.2" "cteq61 (proton)" as parton density function (PDF). In *Vegas*, set "nCalls" to 50000.)

1.3 Choose the subprocess $\bar{u}d \to e^-\bar{\nu}_e$ and calculate its cross section in dependence of the center–of–mass energy (1 TeV - 14 TeV) with "easy $2 \to 2$" (for this you have to switch off the parton density function again).

1.4 Choose the subprocess $\bar{u}d \to e^-\bar{\nu}_e$ and calculate its angular dependence at 14 TeV CMS (you can leave the number of points as they are).

1.5 Choose the subprocess $\bar{u}d \to e^-\bar{\nu}_e$ and calculate its cross section at 14 TeV CMS for $E(e^-) > 5$ GeV (Cuts) (with PDF's).

1.6 Display the branching ratios of the W boson's 2 body decays (choose the process $W^- \to 2 * x$ in the symbolic part of CalcHEP).

(In order to create the *Latex* outputs, type "l" and go to "LaTeX".)