CompHEP, specialized package for automatic calculations of elementary particle decays and collisions.

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At present time when a new generation of TeV colliders are beginning to operate one needs to calculate cross sections for a great number of various reactions. Such calculations are united in the framework of the collider physical program, providing predictions how to detect the signatures of the new physics. The CompHEP package was created for calculation of decays and high energy collisions of elementary particles in tree approximation. The main idea put into the CompHEP was to make available passing from the Lagrangian to the final distributions with the high level of automatization.

Key words: collision physics; feynman diagrams; symbolic calculations; code generation; optimization; Monte-Carlo.

CompHEP project was started in 1989 by physicists and programmers from the Institute of Nuclear Physics of Moscow St. University [1]. The package is written on C language and the installation on any UNIX workstation is possible. The code is available at http://theory.npi.msu.su/∼pukhov/comphep.html. This talk describes a general structure of the version 3.3.

CompHEP is a menu-driven system with context HELP. The notations are very similar to those used in particle physics. It contains built-in models of particle interactions including the Standard Model. A creation of a new model is available. CompHEP allows to

- select process by specifying *in*- and *out*- particles for decays of $1 \to 2, \ldots, 1 \to 5$ types and collisions of $2 \to 2, \ldots, 2 \to 4$ types;
- generate and display tree-like Feynman diagrams, as well as squared ones;
- derive analytical expressions corresponding to squared diagrams with the help of the fast built-in symbolic calculator;
- save analytical results in the REDUCE, MATHEMATICA and FORM codes;
- generate the optimized C codes for the squared matrix elements in order to make further numerical calculations.
- switch on the convolution with structure functions for in-states;
- choose phase space kinematical variables;
- introduce kinematical cuts;
- make regularization to remove sharp peaks from the integrand;
- calculate distributions, cross sections (widths) by the Monte-Carlo method.

Menu system is represented in Fig. and consists of the following menus.

Menu 1: In starting menu the user selects a model of elementary particle interaction or creates a new model.

Menu 2: Enter process is an option for entering the process. If the input is correct the corresponding Feynman diagrams are constructed and the user gets to Menu 4. Edit model leads to the Menu 3.

Delete changes removes models created by the user or restores original version for built-in models.

Menu 3: A physical model in CompHEP consists of four files: Parameters, Constraints, Particles and Lagrangian. This menu allows to the user insert changes in the model. After the changes CompHEP checks the new model. In the case of mistakes the error message appears.

Menu 4: View diagrams displays Feynman diagrams. The LATEX output can be generated. Squaring generates diagrams for squared matrix element.

Menu 5: The user can View squared diagrams. Symbolic calculations of the squared diagrams are performed by means of the built-in symbolic manipulation module, for testing it the REDUCE program can be used.

Menu 6: Here the user can View squared diagrams again. One can Write results for squared diagrams on the disk in different formats (see Menu 7 in Fig.). C-code is used for the further numerical calculations. Numerical calculation is used to compile the produced C-code, and then call Menu 8.

Menu 8: Monte-Carlo simulation passes the user to the Menu 9. Other positions call the menus for setting physical parameters and phase space parameterization. By IN state the user sets the structure functions for in-particles (see Menu 10 in Fig.), the CMS energy and rapidity. Model parameters allows to change physical parameters. Kinematics is used to define variables in the most proper way for the further integration over phase space. An algorithm of this parameterization is given in [2]. Cuts introduces kinematical cuts. Regularization is used to transform integration variables for representing the integrand as a smooth function in the case of sharp peaks (see [2]).

Menu 9: The fist position starts Monte-Carlo integration by VEGAS [3] with parameters: Itms - number of iterations, and nCall - the number of calls per iteration. Clear statistic is used to restart the integration process. Set histogram allows the user to define the list of histograms to fill during the Monte-Carlo session. Display histogram provides the user with the possibility to display and save in a file the histograms filled.

Menu 11: Finite width can be implemented by two ways, one keeps gauge invariance and another does not. The width can be defined as a parameter or as a function with dependence on the invariant mass of decay products.

Menu 12: For calculations of processes with strong interaction the user can change Λ_{QCD} and Q^2 scales. The latter can be taken as some combination of the particle momenta squared to provide running Q^2 scale. The value of Λ_{QCD} displayed corresponds to $N_f = 5$. For evaluating α_s two-loop formula is used at Q^2 and $\Lambda^{(5)}_{QCD}$ defined by the user and with matching Λ_{QCD} scale with the number of flavors.

In [4] one can find a review of physical results obtained by means of CompHEP.

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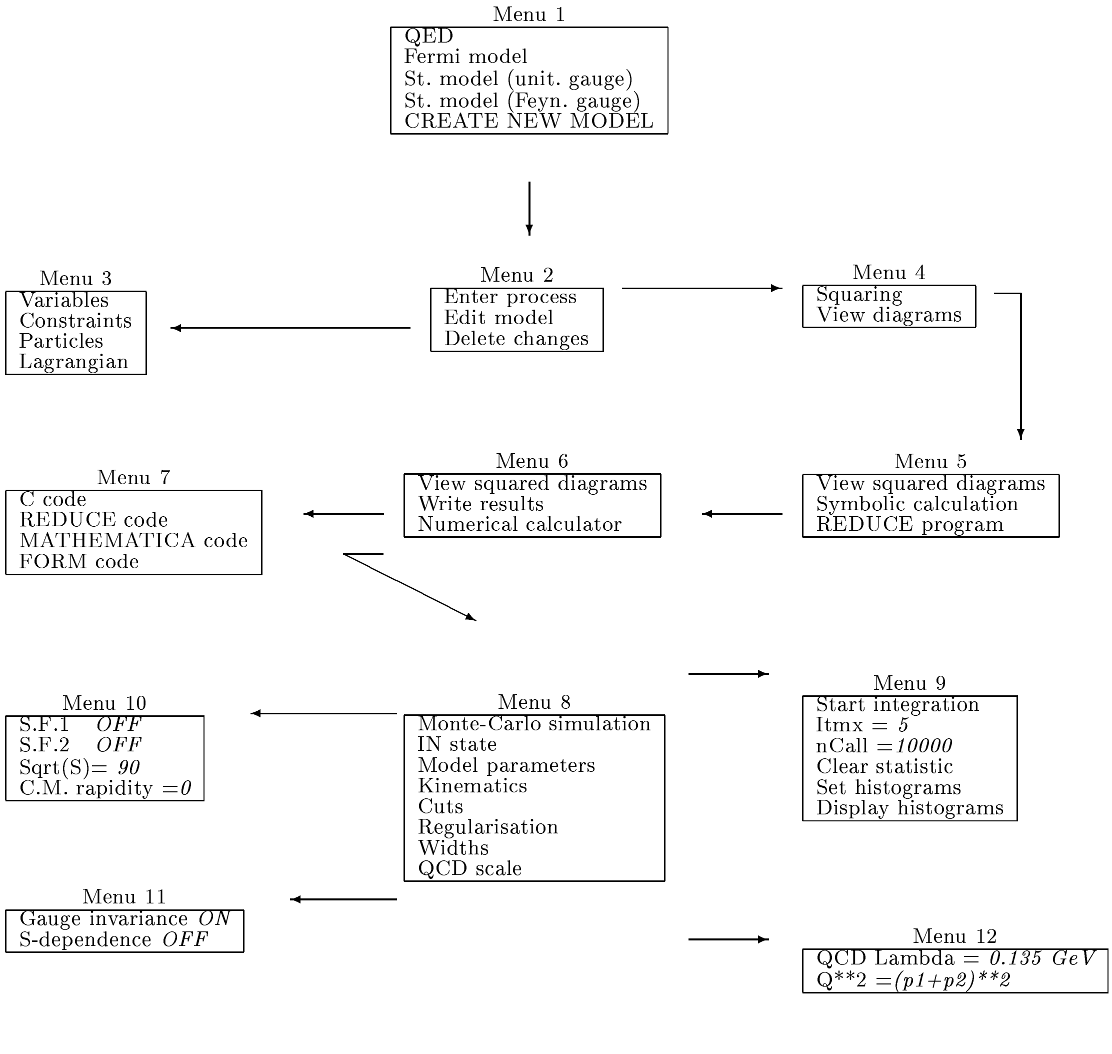

Fig. 1. CompHEP menu system.