CompHEP
developments and applications

CompHEP collaboration:

E.Boos, V.Bunichev, M.Dubinin, L.Dudko, V.Edneral, V.Ilyin, A.Kryukov, V.Savrin, A.Semenov, A.Sherstnev

Institute of Nuclear Physics, Moscow State University

НИИЯФ
МГУ

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CompHEP - COMPUTER SYSTEM FOR CALCULATIONS OF PARTICLE COLLISION CHARACTERISTICS AT HIGH ENERGIES

MOSCOW 1989

Precision calculations of exclusive final states either in the SM or for the signals of new physics are necessary at LEP2, HERA, Tevatron, LHC, ILC. The number of final particles (fermions) in most interesting channels is usually 4, 5, 6 or 8. Production of fermions can be assoiciated with hard photons and/or jets.

- **ZZ, W+W-, HZ production - 4 fermions**
  M(e+ e- → e+ e- e+ e-) amplitude includes 144 diagrams
- **tt pair production - 8 fermions**
- **Single t-quark production in the gW mode - 5 fermions**
- **Higgs boson production in the ttH channel - 8 fermions**
- **Higgs boson production in the channel pp -> q q W+ W- - 6 fermions**

Two classes of event generators for collideres can be sorted out:
(1) operate with software libraries for a set of processes. Libraries includemainly 2➔2 and 1➔2 amplitudes squared
(2) operate with a set of Feynman rules or a set of elementary helicity amplitudes for a class of gauge models. Calculate automatically any desirable cross sections. With respect to (1) they are «generators of generators» (or «meta-generators»).

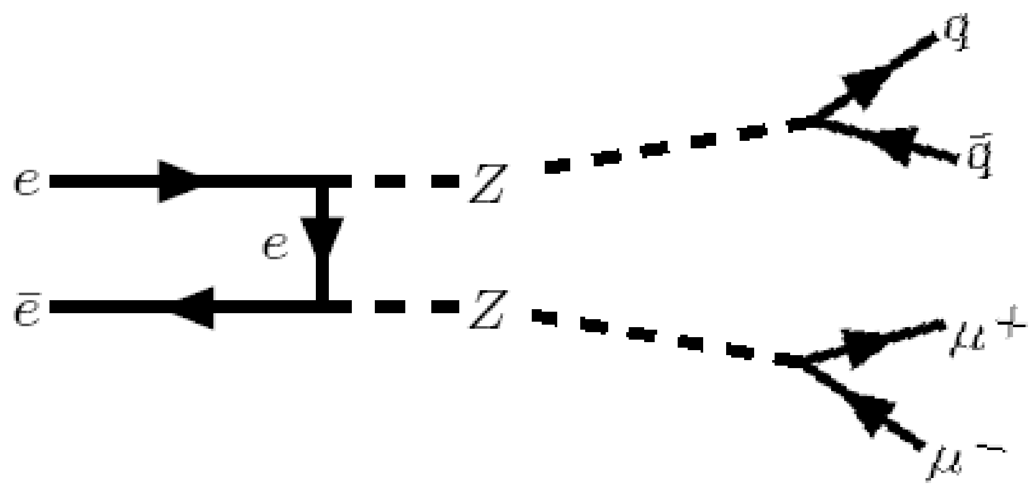
- **Generators of the classs (1) (based on libraries):**
  PYTHIA, HERWIG, ALPGEN, MC@NLO, TopREX, TAUOLA, WPHACT/PHASE, SANC, HDECAY...
- **Generators of the class (2) (based on Feynman rules:**
  CompHEP, GRACE, MadGraph, CalcHEP, O'MEGA/WHIZARD, SHERPA, ALPHA, HELAC

Outline

- **CompHEP for SM processes at LEP2, Tevatron, HERA и LHC. Complete tree-level sets of diagrams, gauge invariance and unitary behaviour. Multichannel Monte Carlo integration and regularization of amplitudes. Some examples.**
- **Lagrangians in CompHEP format. Generation of nonstandard models. LanHEP package.**
- **Applications to the BSM physics. Some examples.**
- **Applications of CompHEP for the LHC project: FORM core for symbolic calculations, interfaces to PYTHIA 6, HERWIG 6, Monte Carlo events database for the LHC (MCDB), noninteractive modes (batch modes) for multiprocessor machines, universal formats Les Houches Accord (LHA), interfaces to the LHC detector simulation packages, etc.**
- **Intermediate results**

CompHEP operates with complete gauge invariant tree-level sets of diagrams. Standard approximations like production $\times$ decay (or infinitely small width approximation: PYTHIA, HERWIG, ...) are not used.

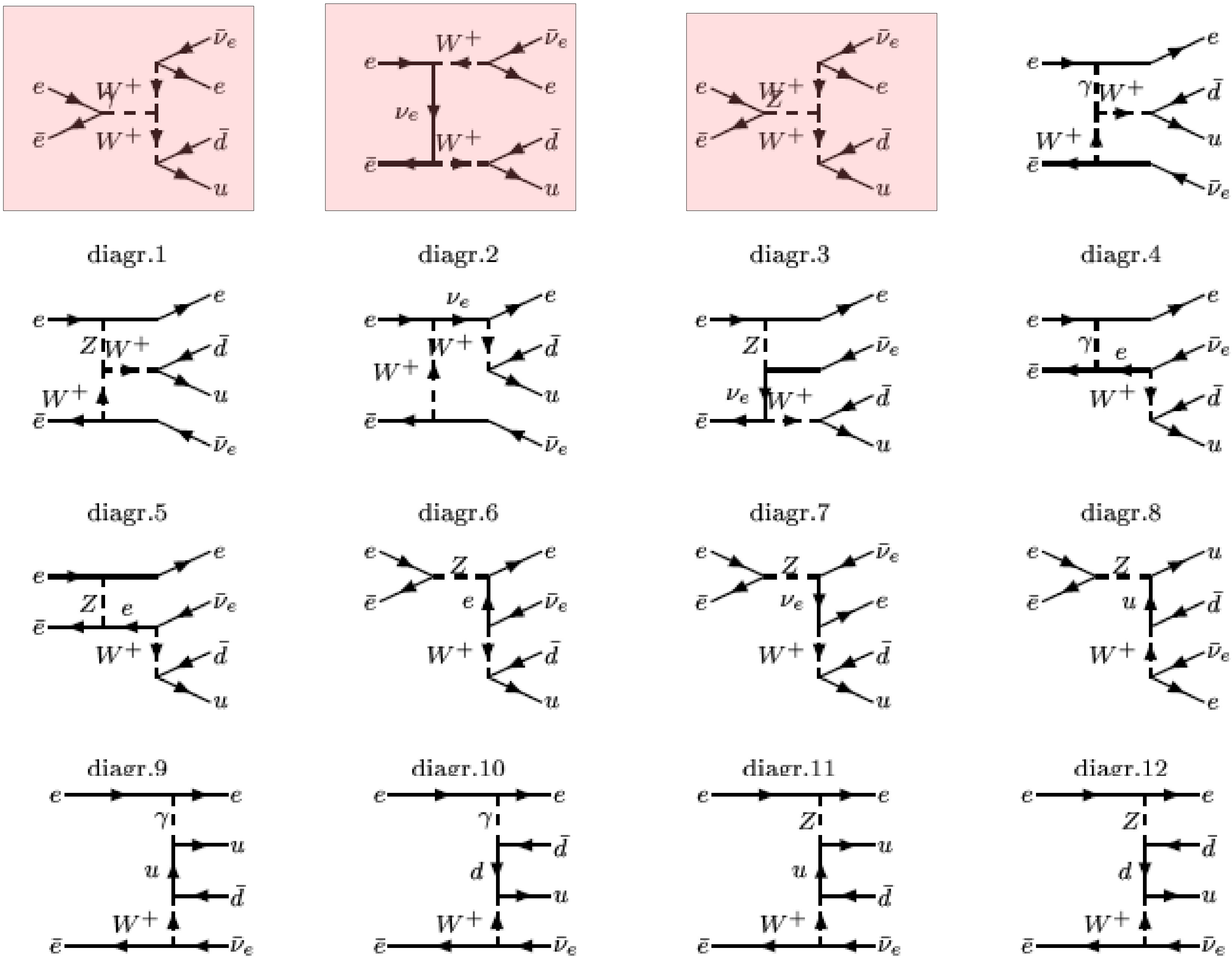
Four fermion production, LEP2: **e+, e- → μ+ μ- q q, e ν_e u d**



$$\frac{1}{(q^2 - m^2)^2 + m^2\Gamma^2} \Rightarrow \frac{\pi}{m\Gamma}\delta(q^2 - m^2)$$

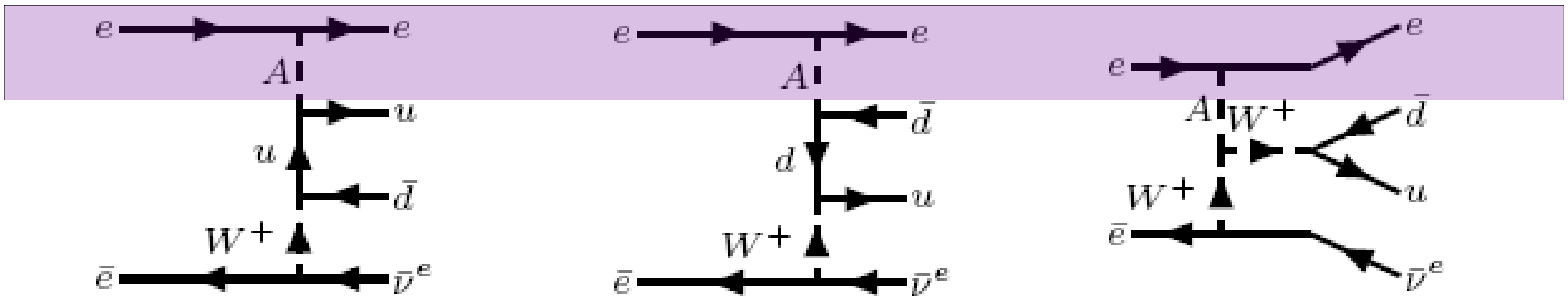
Good precision only in the resonance region. Ireducible background diagrams are not accounted for.

Example: **single W -boson production, LEP2**
e+ e- → e- ν_e u d, W+W- pair production in rose, other diagrams – single W and «ladder» (multiperipheral)



Exact (Breit-Wiegner) propagators may violate the cancellation of double poles in the squared amplitude (gauge U(1)$_{em}$ cancellations), leadind to the nonunitary growth of σ

Example: diagrams with t-channel photons (A≡γ)



$$t_{max} = -m_e^2 \left(\frac{M^2}{s}\right)^2, \qquad M^2 = (p_u+p_d+p_{\nu_e})^2, \qquad m_e = 0.511\,\mathrm{MeV},\ \sqrt{s} = 200\ \mathrm{GeV}$$

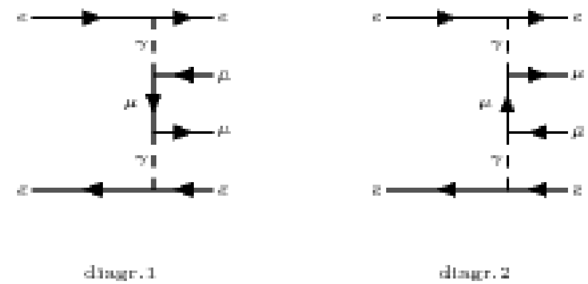
$$\sigma(s) = \int_{-s}^{t_{max}} \boxed{\frac{dt}{t^2}} \sim s^2/M^4. \qquad \text{Nonunitary}$$

$$\sigma(s) = \int_{-s}^{t_{max}} \boxed{\frac{dt}{t}} \sim \log(s/M^2) \qquad \text{OK}$$

Calculation of ladder with two photons in the t-channel

J.A.M. Vermaseren, Nucl.Phys. B229 (1983) 347

$e^+ e^- \rightarrow e^+ e^- \mu^+ \mu^-$



$\sqrt{s}$ = 30 GeV σ_{tot} = 119.5 nb no phase space cuts

m_e = 0.511 MeV

CompHEP version 3 FORTRAN quadruple precision

INTEGRATION BY VEGAS NCALL= 130000

IT	CURRENT RESULTS Cross section [pb]	Error %	ACCUMULATED RESULTS Cross section [pb]	Error %	CHI**2
1	1.273288D+05	15.70	1.273288D+05	15.70	.00
2	1.177421D+05	2.26	1.179097D+05	2.24	.23
3	1.193450D+05	.82	1.191731D+05	.77	.24
4	1.198106D+05	.83	1.194666D+05	.56	.24
5	1.188802D+05	.55	1.191650D+05	.39	.28

Regularization of CompHEP squared amplitudes is performed by means of the phase space factorization $dR_n = \int dR_{n-2}\, dR_2\, ds$ with the following replacements of variables corresponding to the singularities of an amplitude. This particular operation is not done automatically and requires some experience of the user.

Allows to reach the precision of cross section calculation at the level of 0.1 % and the efficiency of unweighted events generation for singular amplitudes of the order of 1 % at the LHC energy √s=14 TeV.

$$F(x) = f(x)\,(g_1(x) + \ldots + g_n(x)) = f(x) \sum_{i=1}^{n} g_i(x),$$

$$\int_a^b F(x)\,dx = \int_0^1 F(G^{-1}(y))\, J^x_{\{g\}}(y)\,dy,$$

$$J^x_{\{g\}}(y) = \frac{1}{\sum_{i=1}^n g_i(x(y))}(G(b) - G(a)).$$

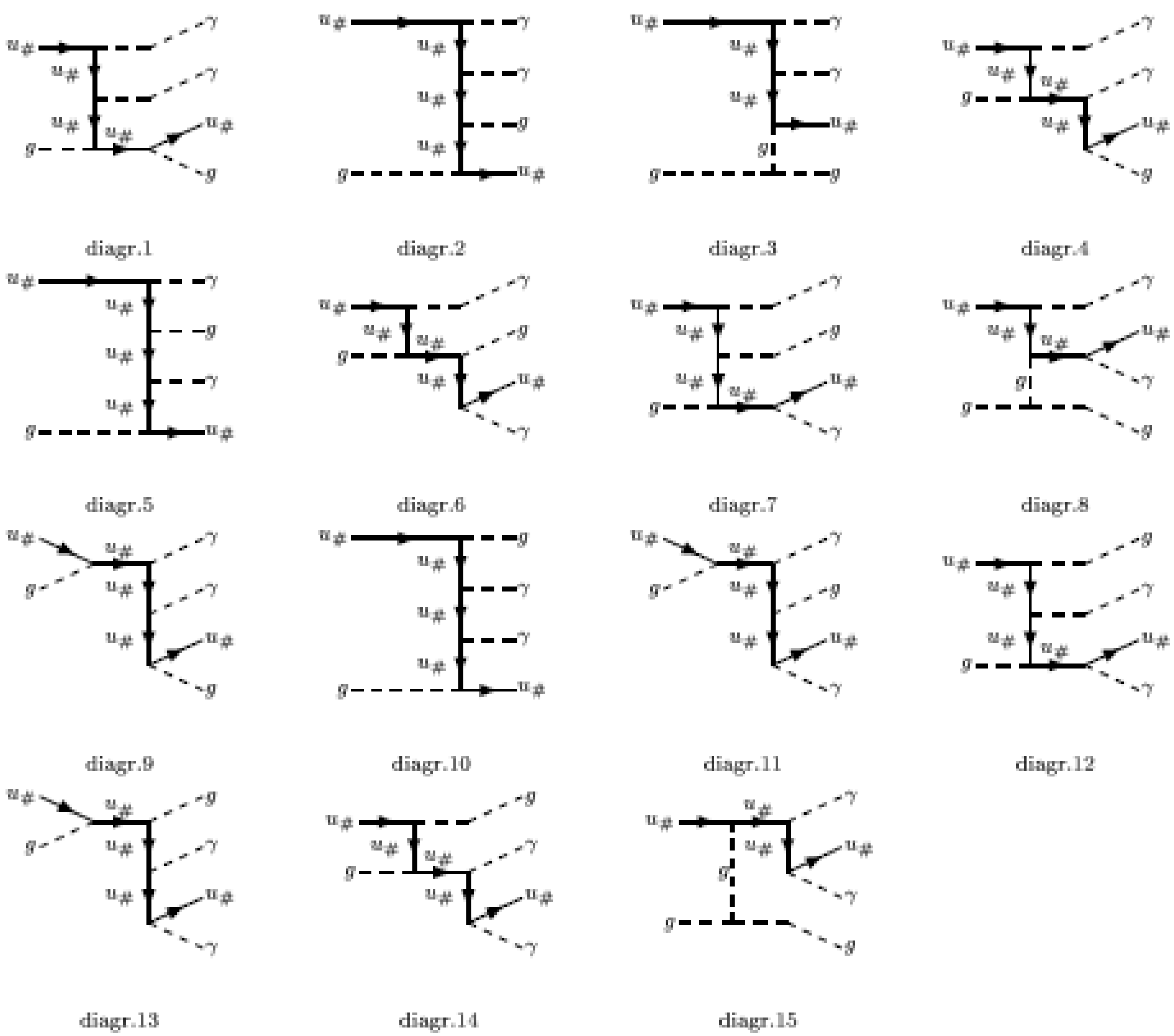
$$dx = \frac{1}{\sum_{i=1}^n g_i(x(\tilde{y}))}\,d\tilde{y},$$

$$\tilde{y}(x) = \sum_{i=1}^{n} G_i(x) \equiv G(x),$$

$$g_i(s_k) = \frac{1}{(s_k - S_0)^2 + \varepsilon^2}$$

$$G_i(s_k) = \frac{1}{\varepsilon} \arctan\left(\frac{s_k - S_0}{\varepsilon}\right).$$

Example: regularization of the amplitude pp → $\gamma\,\gamma$ + 2 jet (irreducible QCD background to the light Higgs boson signal at the LHC in the channel $\gamma\gamma$ + jets). 36 partonic subprocesses in the «hash-model» format, each of them includes 15-20 diagrams with 10-20 singularities.



Regularization

Momentum	|> Mass	<|> Width	<| Power|
13	|0	|0	|1
14	|0	|0	|1
15	|0	|0	|1
25	|0	|0	|1
26	|0	|0	|1
134	|0	|0	|2
135	|0	|0	|2
145	|0	|0	|2
256	|0	|0	|2
236	|0	|0	|2
246	|0	|0	|2
36	|0	|0	|1
46	|0	|0	|1
56	|0	|0	|1
356	|0	|0	|1
456	|0	|0	|1
346	|0	|0	|1
12	|0	|0	|2

==

Example: regularization of the amplitude pp → γ + 3 jet (QCD misidentification (or fake) background [jet ⇨ γ] to the light Higgs boson signal at the LHC in the channel $\gamma\gamma$+ jets). 50 partonic subprocesses in the «hash-model» format, each of them includes 30-40 diagrams with 10-20 singularities. Total number of QCD diagrams about 2000

	subprocess	σ, [pb]	$\frac{\sigma}{\sigma_{max}}$
1	u#,u# → A,G,u#,u#	514.1	0.36
2	u#,U# → A,G,u#,U#	123.2	0.09
3	u#,U# → A,G,d#,D#	0.3	0
4	u#,U# → A,G,G,G	2.4	0
5	u#,d# → A,G,u#,d#	208.1	0.15
6	u#,D# → A,G,u#,D#	101.4	0.07
7	u#,G → A,u#,u#,U#	52.5	0.04
8	U#,G → A,u#,d#,D#	30.3	0.02
9	u#,G → A,G,G,u#	1397.7	1
10	U#,u# → A,G,u#,U#	125.7	0.09
11	U#,u# → A,G,d#,D#	0.3	0
12	U#,u# → A,G,G,G	2.4	0
13	U#,U# → A,G,U#,U#	19.1	0.01
14	U#,d# → A,G,U#,d#	41.9	0.03
15	U#,D# → A,G,U#,D#	17.2	0.01
16	U#,G → A,u#,U#,U#	8.5	0.01
17	U#,G → A,U#,d#,D#	4.5	0
18	U#,G → A,G,G,U#	196.5	0.14
19	d#,u# → A,G,u#,d#	206.9	0.15
20	d#,U# → A,G,U#,d#	41.9	0.03
21	d#,d# → A,G,d d#	49.7	0.03
22	d#,D# → A,G,u#,U#	0.1	0
23	d#,D# → A,G,d#,D#	23.3	0.02
24	d#,D# → A,G,G,G	0.4	0
25	d#,G → A,u#,U#,d#	23.9	0.02

d#,G → A,d#,d#,D#	8.0	0
d#,G → A,G,G,d#	195.2	0.14
D#,u# → A,G,u#,D#	98.7	0.07
D#,U# → A,G,U#,D#	17.6	0.01
D#,d# → A,G,u#,U#	0.1	0
D#,d# → A,G,d#,D#	23.2	0.02
D#,d# → A,G,G,G	0.4	0
D#,D# → A,G,D#,D#	9.0	0
D#,G → A,u#,U#,D#	9.6	0
D#,G → A,d#,D#,D#	2.8	0
D#,G → A,G,G,D#	69.1	0.05
G,u# → A,u#,u#,U#	53.3	0.04
G,u# → A,u#,d#,D#	29.7	0.02
G,u# → A,G,G,u#	1400.0	1
G,U# → A,u#,U#,U#	9.5	0
G,U# → A,U#,d#,D#	4.5	0
G,U# → A,G,G,U#	198.6	0.14
G,d# → A,u#,U#,d#	23.8	0.02
G,d# → A,d#,d#,D#	7.7	0
G,d# → A,G,G,d#	190.9	0.13
G,D# → A,u#,U#,D#	9.9	0
G,D# → A,G,G,D#	2.9	0
G,D# → A,G,G,D#	68.8	0.05
G,G → A,G,u#,U#	277.9	0.20
G,G → A,G,d#,D#	69.5	0.05
pp → A,j,j,j	5970.4	

LanHEP: generates Feynman rules in CompHEP format

Some SM Lagrangian terms in the LanHEP model input file for generation of charged and neutral current vertices LanHEP

```
% left fermion interaction with gauge fields


lterm   anti(psi)*gamma*(1-g5)/2*(i*deriv-g*taupm*WW/2-Y*g1*B1)*psi
                where
                        psi=l1,  Y=-1/2;
                        psi=l2,  Y=-1/2;
                        psi=l3,  Y=-1/2;
                        psi=q1a, Y= 1/6;
                        psi=q2a, Y= 1/6;
                        psi=q3a, Y= 1/6.

% right fermion interaction with gauge fields

lterm   anti(psi)*gamma*(1+g5)/2*(i*deriv - Y*g1*B1)*psi
                where
                        psi=e1,Y= -1;
                        psi=e2,Y= -1;
                        psi=e3,Y= -1;
                        psi=u, Y=  2/3;
                        psi=c, Y=  2/3;
                        psi=t, Y=  2/3;
                        psi=d, Y= -1/3;
                        psi=s, Y= -1/3;
                        psi=b, Y= -1/3.


% quark-gluon interaction

lterm  GG*anti(psi)*lambda*gamma*G*psi where
        psi=q1; psi=q2; psi=q3.
```

W,Z – quarks sector in the CompHEP model file

```
SM, unitary gauge
 Lagrangian
P1   |P2   |P3   |P4   |>   Factor                                          <|> dLagrangian/ dA(p1) dA(p2) dA(p3)
A    |W+   |W-   |     |-EE                                                  |m3.p2*m1.m2-m1.p2*m2.m3-m2.p3*m1.m3+m1.p3*m2.m3+m2.p1*m1.m3-m3.p1*m1.m
B    |b    |A    |     |EE/3                                                 |G(m3)
B    |b    |G    |     |GG                                                   |G(m3)
B    |b    |H    |     |-EE*Mb/(2*MW*SW)                                     |1
B    |b    |Z    |     |-EE/(12*CW*SW)                                       |2*SW^2*G(m3)*(1+G5)-(3-2*SW^2)*G(m3)*(1-G5)
B    |c    |W-   |     |-EE*Sqrt2*Vcb/(4*SW)                                 |G(m3)*(1-G5)
B    |t    |W-   |     |-EE*Sqrt2*Vtb/(4*SW)                                 |G(m3)*(1-G5)
B    |u    |W-   |     |-EE*Sqrt2*Vub/(4*SW)                                 |G(m3)*(1-G5)
C    |b    |W+   |     |-EE*Sqrt2*Vcb/(4*SW)                                 |G(m3)*(1-G5)
C    |c    |A    |     |-2*EE/3                                              |G(m3)
C    |c    |G    |     |GG                                                   |G(m3)
C    |c    |H    |     |-EE*Mc/(2*MW*SW)                                     |1
C    |c    |Z    |     |-EE/(12*CW*SW)                                       |(3-4*SW^2)*G(m3)*(1-G5)-4*SW^2*G(m3)*(1+G5)
C    |d    |W+   |     |-EE*Sqrt2*Vcd/(4*SW)                                 |G(m3)*(1-G5)
C    |s    |W+   |     |-EE*Sqrt2*Vcs/(4*SW)                                 |G(m3)*(1-G5)
D    |c    |W-   |     |-EE*Sqrt2*Vcd/(4*SW)                                 |G(m3)*(1-G5)
D    |d    |A    |     |EE/3                                                 |G(m3)
D    |d    |G    |     |GG                                                   |G(m3)
D    |d    |Z    |     |-EE/(12*CW*SW)                                       |2*SW^2*G(m3)*(1+G5)-(3-2*SW^2)*G(m3)*(1-G5)
D    |t    |W-   |     |-EE*Sqrt2*Vtd/(4*SW)                                 |G(m3)*(1-G5)
D    |u    |W-   |     |-EE*Sqrt2*Vud/(4*SW)                                 |G(m3)*(1-G5)
E    |e    |A    |     |EE                                                   |G(m3)
E    |e    |Z    |     |EE/(4*CW*SW)                                         |(1-2*SW^2)*G(m3)*(1-G5)-2*SW^2*G(m3)*(1+G5)
E    |ne   |W-   |     |-EE*Sqrt2/(4*SW)                                     |G(m3)*(1-G5)
G    |G    |G    |     |GG                                                   |m2.p3*m1.m3-m1.p3*m2.m3+m3.p1*m1.m2-m2.p1*m1.m3-m3.p2*m1.m2+m1.p2*m2.m
G.C  |G.c  |G    |     |GG                                                   |m3.p2
H    |H    |H    |     |-3*EE*MH^2/(2*MW*SW)                                 |1
H    |W+   |W-   |     |EE*MW/SW                                             |m2.m3
H    |Z    |Z    |     |EE*MW/(CW^2*SW)                                      |m2.m3
```

General instruction

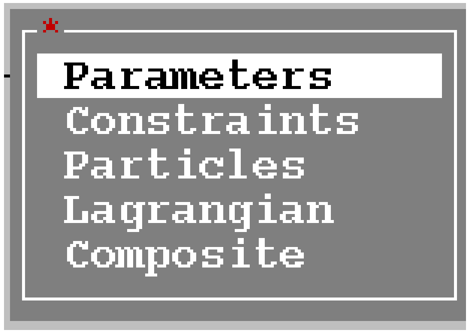
- Modify SM Feynman rules or write your own set. If too complicated,
- Install LanHEP

  http://theory.sinp.msu.ru/~semenov/lanhep.html

- Print Lagrangian in LanHEP file modelBSM.mdl
- Type the command lanhep modelBSM.mdl
- Check the output Feynman rules, constraints, etc. in

vars.mdl
func.mdl.
prtcls.mdl
lgrng.mdl

⇔

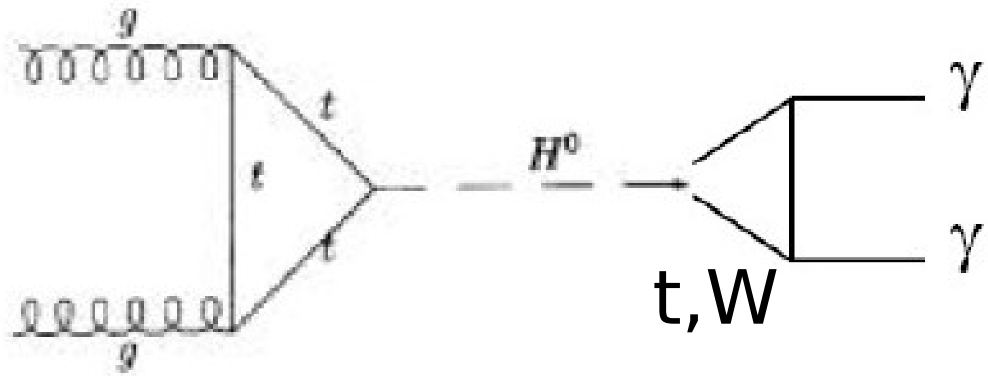


- Install CompHEP. Move *.mdl files to user/models dir

  http://theory.sinp.msu.ru/comphep

- Open new model. Input physical process of interest.   Generate unweighted events.

Simple example: how to implement gg→$\gamma\gamma$ at the one-loop to CompHEP model (Higgs bosoon at LHC, inclusive mode)



The effective Lagrangian $\mathcal{L}^{eff}_{\gamma\gamma H} = -\frac{\lambda_{\gamma\gamma H}}{4} F_{\mu\nu} F^{\mu\nu} H$

The effective vertex $\Gamma^{\mu\nu}_{\gamma\gamma H/\gamma Z H}(k_1, k_2) = \lambda_{\gamma\gamma H/\gamma Z H}[(k_1 k_2) g^{\mu\nu} - k_1^{\nu} k_2^{\mu}]$

where $$\lambda_{\gamma\gamma H} = 8\sqrt{\frac{\pi}{m_H^3}\Gamma^{tot} Br(H \to \gamma\gamma)}$$

find using HDECAY (Djouadi, Kalinowski, Spira, CPC 108(1998)56) or other loop package (e.g. FeynHiggs)

add `lterm` to LanHEP model file `model_FFH.mdl`

```
% effective lagrangian term FFH

parameter lambda_ggH=1e-5.

lterm   - lambda_ggH/4
        *(deriv^mu*A^nu-deriv^nu*A^mu)
        *(deriv^mu*A^nu-deriv^nu*A^mu)*H.
```

and generate `lgrng.mdl` in CompHEP format

```
Stand. Model+VVH (un. gauge)
 Lagrangian
P1   |P2   |P3   |P4   |>   Factor              <|> dLagrangian/ dA(p1) dA(p2) dA(p3)
A    |A    |H    |     |lambda_ggH               |p1.p2*m1.m2-m2.p1*m1.p2
A    |W+   |W-   |     |-EE                      |m3.p2*m1.m2-m1.p2*m2.m3-m2.p3*m1.m3+m1.p3*m2.m3+m2.p1*m1.m3-m3.p1*
B    |b    |A    |     |EE/3                     |G(m3)
B    |b    |G    |     |GG                       |G(m3)
B    |b    |H    |     |-EE*Mb/(2*MW*SW)         |1
B    |b    |Z    |     |-EE/(12*CW*SW)           |2*SW**2*G(m3)*(1+G5)-(3-2*SW**2)*G(m3)*(1-G5)
B    |c    |W-   |     |-EE*Sqrt2*Vcb/(4*SW)     |G(m3)*(1-G5)
B    |t    |W-   |     |-EE*Sqrt2*Vtb/(4*SW)     |G(m3)*(1-G5)
B    |u    |W-   |     |-EE*Sqrt2*Vub/(4*SW)     |G(m3)*(1-G5)
C    |b    |W+   |     |-EE*Sqrt2*Vcb/(4*SW)     |G(m3)*(1-G5)
C    |c    |A    |     |-2*EE/3                  |G(m3)
C    |c    |G    |     |GG                       |G(m3)
C    |c    |H    |     |-EE*Mc/(2*MW*SW)         |1
C    |c    |Z    |     |-EE/(12*CW*SW)           |(3-4*SW**2)*G(m3)*(1-G5)-4*SW**2*G(m3)*(1+G5)
```

Beyond the SM with CompHEP: main fields of interest (theory)

Effective operators of higher dimensions (ndim>4)

- anomalous triple $\gamma W+W-$, Z W+W- couplings
- anomalous quartic Z,W± couplings
- anomalous t-quark (Wtb) couplings
- anomalous Higgs self-couplings ndim=6
- contact 4-fermion interactions

SUSY particles

- chargino, neutralino and sfermion production
- MSSM without R-parity, NMSSM

SUSY Higgs bosons

- h, H, A and H± production
- intense coupling regime in the Higgs sector
- explicit CP violation in the Higgs sector

Quantum gravity and extra dimensions

- universal extra dimensions;
- RS1 and effective 4-particle Lagrangian for RS1
- neutral gauge boson from extra dimensions
- Higgs signals in large extra dimensions
- graviton production in KK with large extra dimensions
- relic density of KK dark matter

Extensions of SM (other than SUSY) and exotica

- Leptoquarks, scalar and vector
- excited quarks and leptons
- extra generations and heavy neutrino
- $SU(2)L\times SU(2)R\times U(1)$ model, W' and Z'
- $SU(3)L\times U(1)$ model, W' and Z', Higgs bosons
- lepton flavor violation, FCNC

Muonic photon
Paraphoton
E6 isosinglet quark
Heavy Dirac and Majorana neutrinos
little Higgs models with T-parity
doubly charged Higgs bosons
....

The list of topics is based on the analysis of more than 1000 papers quoting CompHEP.

Published experimental analyses beyond the SM quoting CompHEP

DELPHI	'98	chargino, neutralino, gravitino at	LEP2
ALEPH	'98	SUSY in γ+miss ET,	LEP2
DELPHI	'99	H in events with isolated γ	LEP2
D0	'01	leptoquark pairs –› 玶+jets	Tevatron
H1	'02	excited 玶	HERA
H1	'03	e and μ with miss PT	HERA
ZEUS	'03	single top production	HERA
D0,CDF	'03	single top production	Tevatron
OPAL	'03	single production of H++, H--	LEP2
D0	'04	three and four body stop decays	Tevatron
CDF	'05	excited and exotic lepton –› eγ	Tevatron
CMS	'05	discovery of SUSY with μμ	LHC
H1	'05	doubly charged Higgs bosons	HERA
H1	'05	search for monopole	HERA
D0	'08	single top discovery	Tevatron

List is not full. A number of CMS and Tevatron studies '09-'10 in progress or not yet appeared.

Example: Anomalous interactions of the top-quark

$$L_{eff} = L_{SM} + \frac{1}{\Lambda^2}\sum_i C_i O_i + O(\frac{1}{\Lambda^4})$$

Seven SU(2)⊗U(1) invariant effective operators of dimension six contributing to the Wtb vertex

$$\begin{aligned}
O_{tW\Phi} &= [(\bar{q}_L \sigma^{\mu\nu}\tau^I t_R)\Phi + \Phi^+(\bar{t}_R \sigma^{\mu\nu}\tau^I q_L)]W^I_{\mu\nu} \\
O_{bW\Phi} &= [(\bar{q}_L \sigma^{\mu\nu}\tau^I b_R)\Phi + \Phi^+(\bar{b}_R \sigma^{\mu\nu}\tau^I q_L)]W^I_{\mu\nu} \\
O_{t3} &= i[(\Phi^+ D_\mu \Phi)(\bar{t}_R \gamma_\mu b_R) - (D_\mu \Phi)^+ \Phi(\bar{b}_R \gamma_\mu t_R)] \\
O_{Dt} &= (q_L D_\mu t_R) D^\mu \Phi + (D^\mu \Phi)^+ (\overline{D_\mu t_R} q_L) \\
O_{qW} &= [\bar{q}_L \gamma^\mu \tau^I D^\nu q_L + \overline{D^\nu q_L}\gamma^\mu \tau^I q_L] W^I_{\mu\nu} \\
O^3_{\Phi q} &= i[\Phi^+ \tau^I D_\mu \Phi - (D_\mu \Phi)^+ \tau^I \Phi]\bar{q}_L \gamma_\mu \tau^I q_L \\
O_{Db} &= (q_L D_\mu b_R) D^\mu \Phi + (D_\mu \Phi)^+ (\overline{D_\mu b_R} q_L)
\end{aligned}$$

$$q_L = \begin{pmatrix} t_L \\ b_L \end{pmatrix}, \qquad W^I_{\mu\nu} = \partial_\mu W^I_\nu - \partial_\nu W^I_\mu + g\epsilon_{IJK} W^J_\mu W^K_\nu$$

O_tWΦ and O_bWΦ give the effective Lagrangian

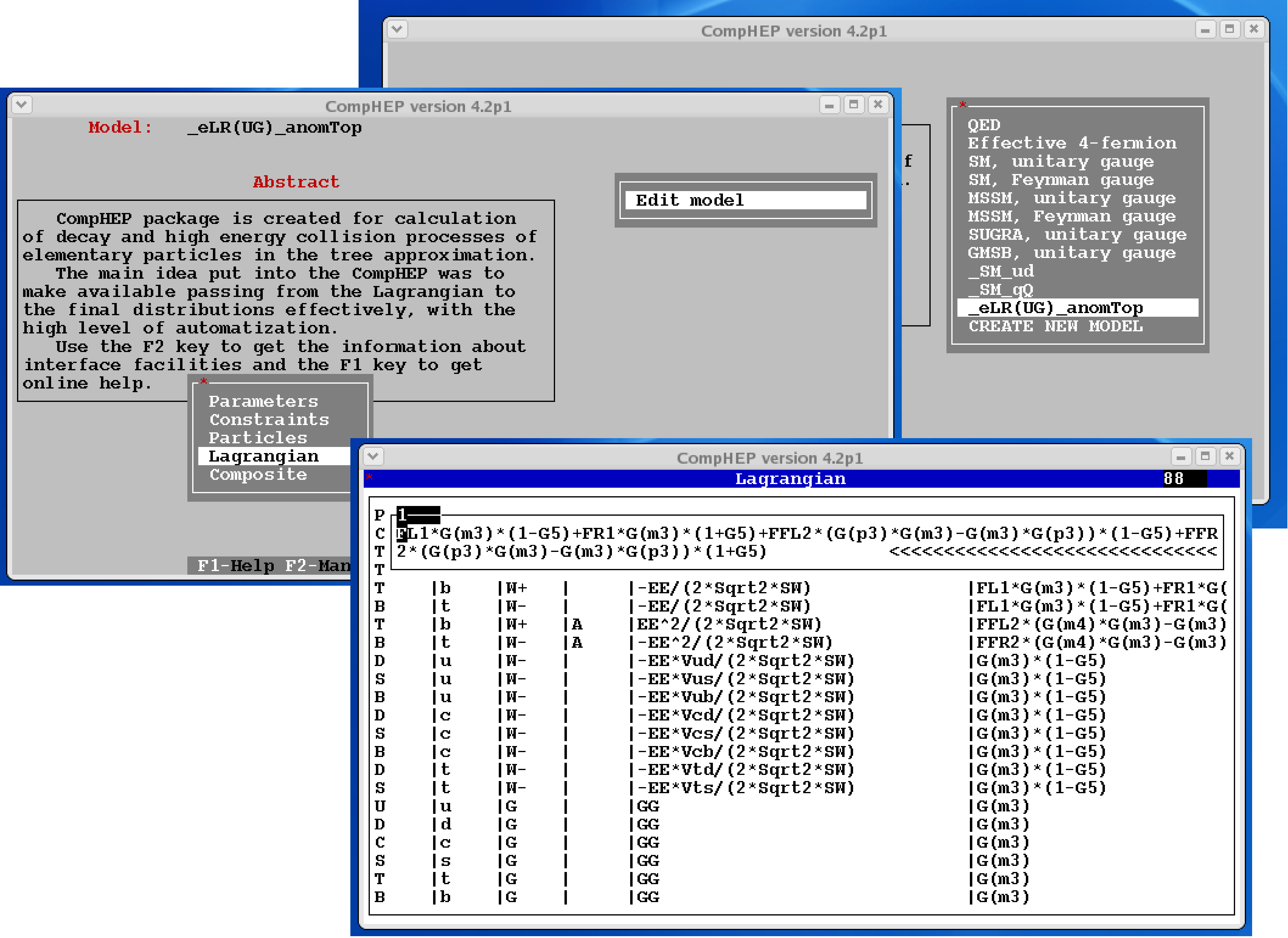
$$\mathcal{L} = \frac{g}{\sqrt{2}} \frac{1}{2m_W} W_{\mu\nu} \bar{t} \sigma^{\mu\nu} (f_{2R} P_L + f_{2L} P_R) b + \mathrm{h.c.}$$

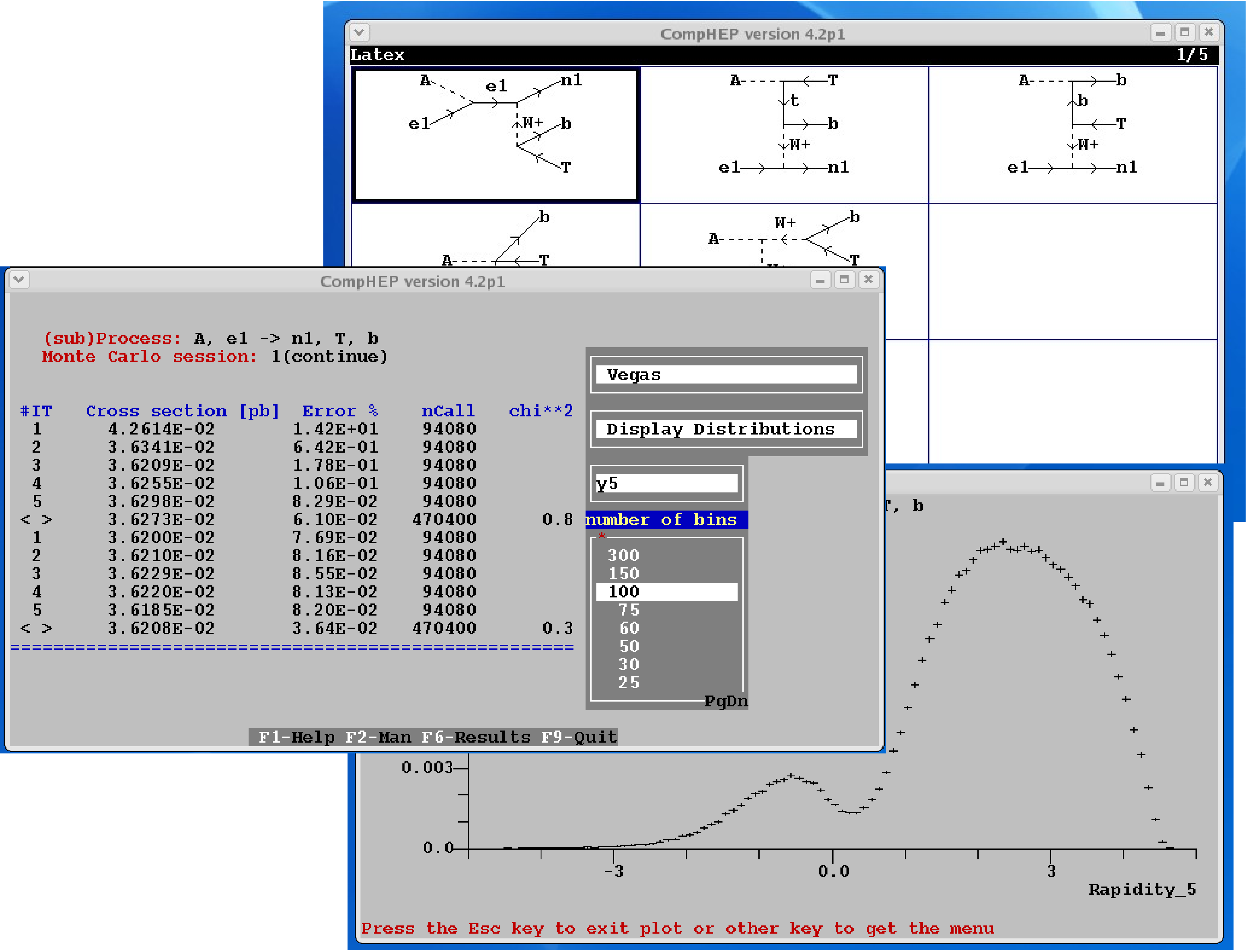
where f_2L and f_2R are the Wtb anomalous couplings

$$f_{2L} = \frac{C_{tW\Phi}}{\Lambda^2} \frac{v\sqrt{2}\, m_W}{g}, \quad f_{2R} = \frac{C_{bW\Phi}}{\Lambda^2} \frac{v\sqrt{2}\, m_W}{g}$$

$$W_{\mu\nu} = D_\mu W_\nu - D_\nu W_\mu, \qquad D_\mu = \partial_\mu - ieA_\mu$$
$$P_{R,L} = \frac{1}{2}(1 \pm \gamma_5), \qquad \sigma_{\mu\nu} = \frac{i}{2}(\gamma_\mu \gamma_\nu - \gamma_\nu \gamma_\mu)$$

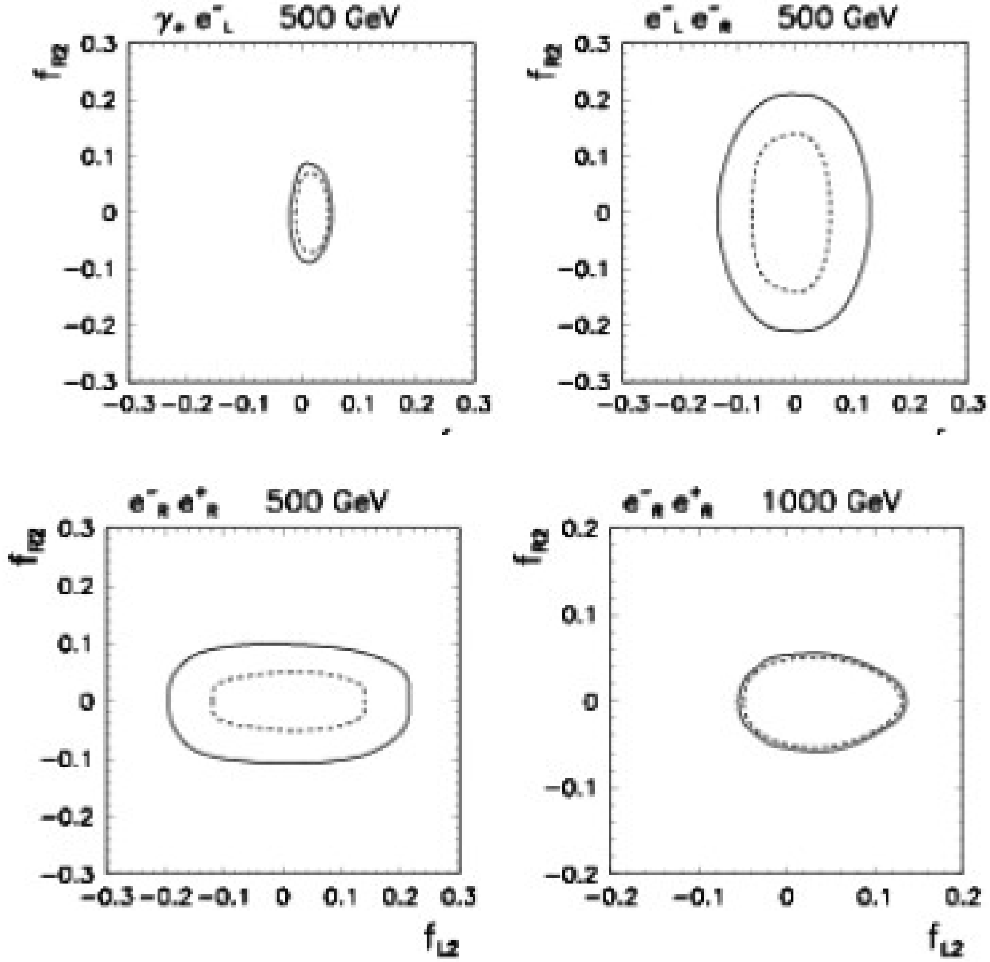
E.Boos, L.Dudko, M.D., T.Ohl, A.Pukhov, M.Sachwitz, H.Schreiber
EPJC 21(2001) 81, EPJC C16(2000)269, EPJC C11(1999)473


CompHEP version 4.2p1
Model: _eLR(UG)_anomTop
Abstract
CompHEP package is created for calculation of decay and high energy collision processes of elementary particles in the tree approximation.
The main idea put into the CompHEP was to make available passing from the Lagrangian to the final distributions effectively, with the high level of automatization.
Use the F2 key to get the information about interface facilities and the F1 key to get online help.
Edit model
Parameters
Constraints
Particles
Lagrangian
Composite
F1-Help F2-Man
CompHEP version 4.2p1
QED
Effective 4-fermion
SM, unitary gauge
SM, Feynman gauge
MSSM, unitary gauge
MSSM, Feynman gauge
SUGRA, unitary gauge
GMSB, unitary gauge
_SM_ud
_SM_qQ
_eLR(UG)_anomTop
CREATE NEW MODEL
CompHEP version 4.2p1
Lagrangian
88
FL1*G(m3)*(1-G5)+FR1*G(m3)*(1+G5)+FFL2*(G(p3)*G(m3)-G(m3)*G(p3))*(1-G5)+FFR
2*(G(p3)*G(m3)-G(m3)*G(p3))*(1+G5) <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
T |b |W+ | |-EE/(2*Sqrt2*SW) |FL1*G(m3)*(1-G5)+FR1*G(
B |t |W- | |-EE/(2*Sqrt2*SW) |FL1*G(m3)*(1-G5)+FR1*G(
T |b |W+ |A |EE^2/(2*Sqrt2*SW) |FFL2*(G(m4)*G(m3)-G(m3)
B |t |W- |A |-EE^2/(2*Sqrt2*SW) |FFR2*(G(m4)*G(m3)-G(m3)
D |u |W- | |-EE*Vud/(2*Sqrt2*SW) |G(m3)*(1-G5)
S |u |W- | |-EE*Vus/(2*Sqrt2*SW) |G(m3)*(1-G5)
B |u |W- | |-EE*Vub/(2*Sqrt2*SW) |G(m3)*(1-G5)
D |c |W- | |-EE*Vcd/(2*Sqrt2*SW) |G(m3)*(1-G5)
S |c |W- | |-EE*Vcs/(2*Sqrt2*SW) |G(m3)*(1-G5)
B |c |W- | |-EE*Vcb/(2*Sqrt2*SW) |G(m3)*(1-G5)
D |t |W- | |-EE*Vtd/(2*Sqrt2*SW) |G(m3)*(1-G5)
S |t |W- | |-EE*Vts/(2*Sqrt2*SW) |G(m3)*(1-G5)
U |u |G | |GG |G(m3)
D |d |G | |GG |G(m3)
C |c |G | |GG |G(m3)
S |s |G | |GG |G(m3)
T |t |G | |GG |G(m3)
B |b |G | |GG |G(m3)



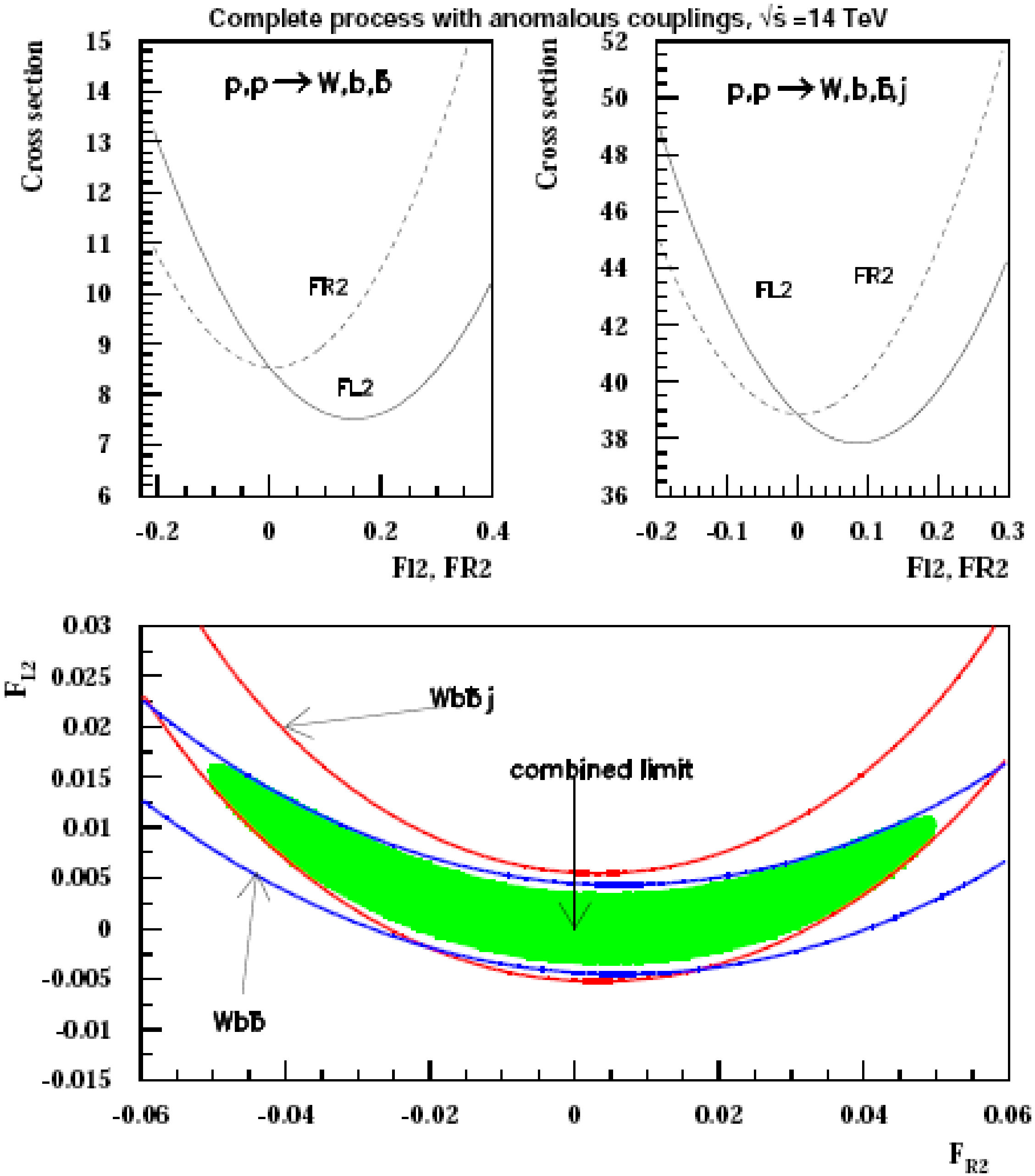
CompHEP version 4.2p1
Latex
1/5
A
e1
n1
W+
b
T
t
CompHEP version 4.2p1
(sub)Process: A, e1 -> n1, T, b
Monte Carlo session: 1(continue)
#IT Cross section [pb] Error % nCall chi**2
1 4.2614E-02 1.42E+01 94080
2 3.6341E-02 6.42E-01 94080
3 3.6209E-02 1.78E-01 94080
4 3.6255E-02 1.06E-01 94080
5 3.6298E-02 8.29E-02 94080
< > 3.6273E-02 6.10E-02 470400 0.8
1 3.6200E-02 7.69E-02 94080
2 3.6210E-02 8.16E-02 94080
3 3.6229E-02 8.55E-02 94080
4 3.6220E-02 8.13E-02 94080
5 3.6185E-02 8.20E-02 94080
< > 3.6208E-02 3.64E-02 470400 0.3
Vegas
Display Distributions
y5
number of bins
300
150
100
75
60
50
30
25
PgDn
F1-Help F2-Man F6-Results F9-Quit
T, b
0.003
0.0
-3
0.0
3
Rapidity_5
Press the Esc key to exit plot or other key to get the menu

Anomalous top couplings: tt and single t production, NLC



2σ bounds on the anomalous couplings f_{2L} and f_{2R} from the reactions $\gamma_+ e^-_L \to \nu_e \bar{t} b$, $e^-_L e^-_R \to e^- \nu_e \bar{t} b$ and $e^-_R e^+_R \to e^- \bar{\nu}_e t \bar{b}$ at $\sqrt{s}$ =0.5 TeV and 1.0 TeV, for integrated luminosities of 100 fb^{-1} (solid lines) and 500 fb^{-1} (dashed lines).

Anomalous top couplings: single top production, LHC



New Features in CompHEP 4.4 (Interfaces)

- CompHEP->PYTHIA (CPYTH) (ready)
- CompHEP->PYTHIA-TAUOLA (ready)
- CompHEP->HERWIG (ready)
- CompHEP->HERWIG++ (in progress)
- Interfaced to Exp. Collaboration SW:
  SIMDET(ILC), CMKIN(CMS), ATHENA(ATLAS) and D0 (Tevatron) Run II software.
- Macros of interface to ROOT graphics (in progress)
- Output Events are ready for LCG MCDB Data Base

Batch Modes in CompHEP 4.5

Both parts (symbolic & numerical) have batch regimes:

Perl scripts: symb_batch.pl and num_batch.pl

Why the scripts are useful?

Computations of many subprocesses – laborious task, can be significantly simplified

Long/large-scale calculations: GUI is not handy

Support of parallel calculations: very helpful for N*CPU machines/computer clusters (pbs/lsf is available; grid in progress)

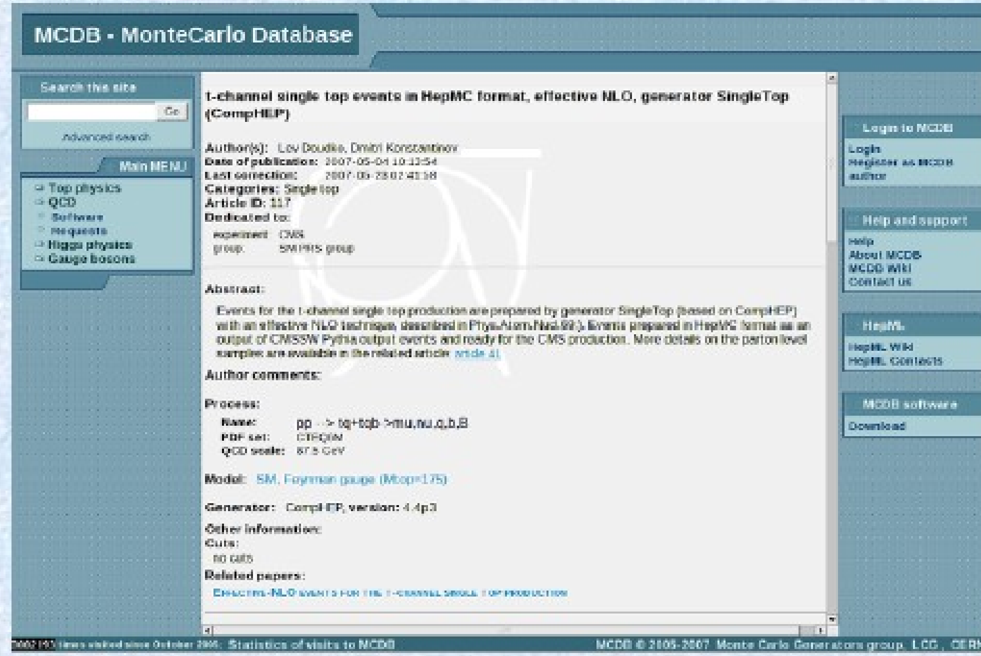
"Knowledge transfer": theorists/phenomenoligists can prepare model/process.dat/batch.dat for further simulations by experimentalists

MCDB — Knowledge Base

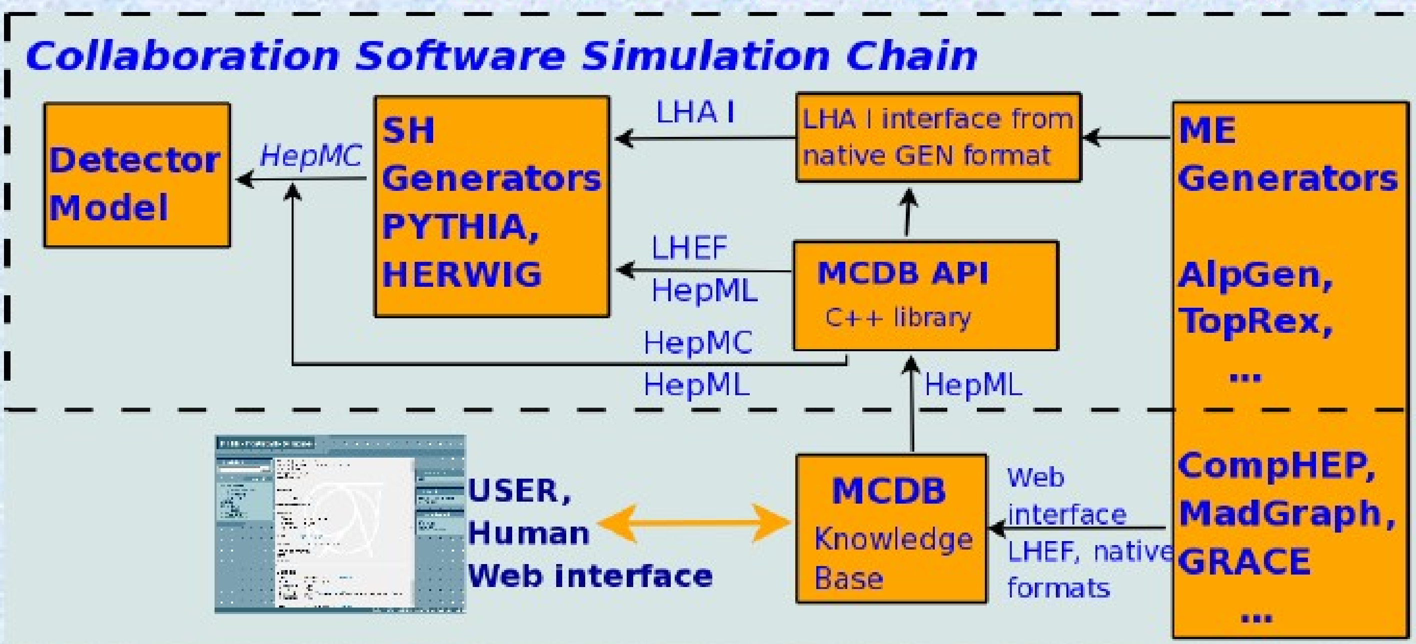
http://mcdb.cern.ch

Database of sophisticate MC simulated events and their description. It is Integrated with CMS software already

CompHEP group uses this project to distribute and document CompHEP events for LHC community



S.Belov, L.Dudko, A.Sherstnev et. al CPC178,222(2008)



LHEF, LHAPDF, SUSY LHA

LHEF - the format adopted by almost all developer groups

hep-ph/060917

Now CompHEP supports 3 formats:

cpyth-1, cpyth-2 (for experiments, where the formats are used),
LHEF with HepML header .

There is a special option -- Generator (LHEF format) -- in the event menu in n_comphep.

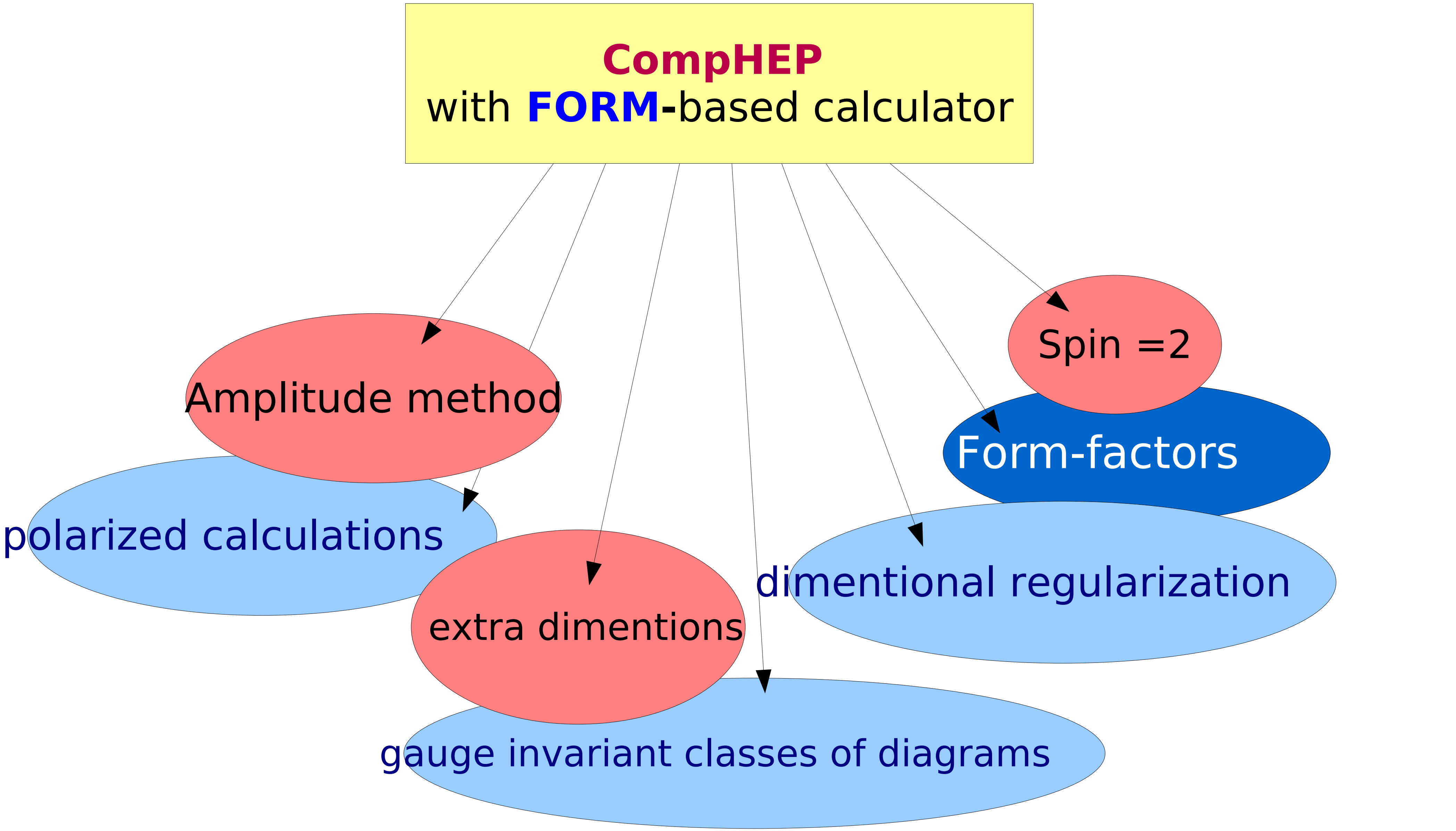
All modern PDFs are available via LHAPDF: CTEQ, MRST, Alekhin PDF, etc.

Both options, LHAPDF and internal PDF, are available in CompHEP 4.5
with the same functionality in both regimes

SUSY LHA

The SLHA interface is implemented in SUGRA and GMSB models of CompHEP
(instead of ISASUSY in the previous versions)
By default the slhaScript file invokes suSpect

New features of parallel version of CompHEP, based on FORM language



Conclusions

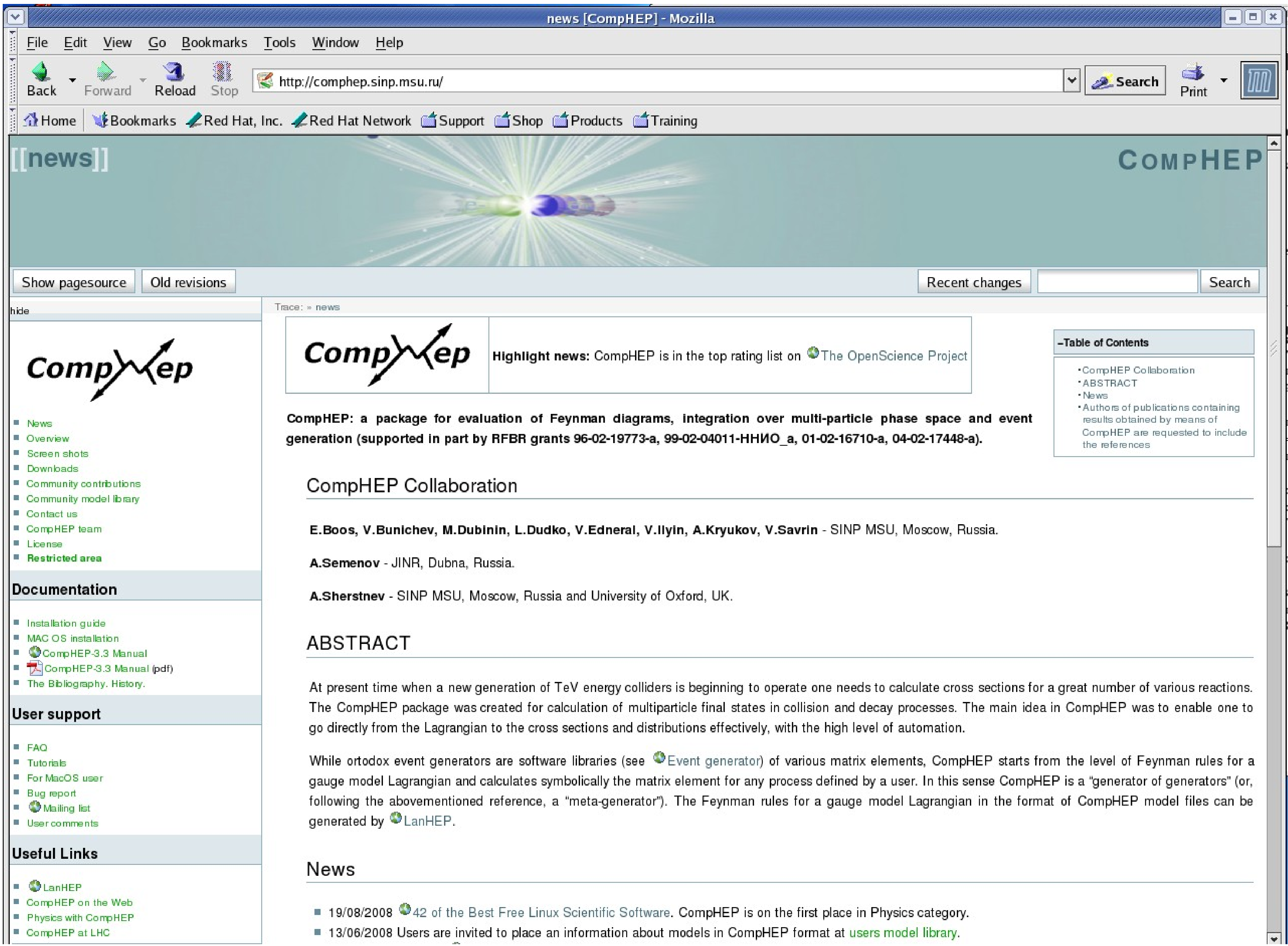
Why CompHEP is a convenient tool for collider phenomenology:

It is automated and has a developed user interface

- LanHEP generates Feynman rules in CompHEP format from the Lagrangian in coordinate space
- Once the Feynman rules are defined, any (up to 6-body) final state can be calculated at complete tree level set of diagrams. Spin correlations and irreducible backgrounds are included.

Experimentalists are familiar with the package

- The package generates unweighted events
- Interfaced to PYTHIA and HERWIG for showering and hadronization.
- Interfaced to full detector simulation packages CMSSW (CMS), ATHENA (ATLAS), D0 and CDF software ('mass production' can start from HEP CW Ntuples directly)
- Optimized and tested for simulation of large event samples at LHC, ILC and Tevatron, corresponding to realistic luminosities (10 inv. fb $\Leftrightarrow$ up to 10 million events)


news [CompHEP] - Mozilla
File Edit View Go Bookmarks Tools Window Help
Back Forward Reload Stop
http://comphep.sinp.msu.ru/
Search
Print
Home Bookmarks Red Hat, Inc. Red Hat Network Support Shop Products Training
[[news]]
CompHEP
Show pagesource Old revisions
Recent changes Search
hide
Trace: » news
CompHep
News
Overview
Screen shots
Downloads
Community contributions
Community model library
Contact us
CompHEP team
License
Restricted area
Documentation
Installation guide
MAC OS installation
CompHEP-3.3 Manual
CompHEP-3.3 Manual (pdf)
The Bibliography. History.
User support
FAQ
Tutorials
For MacOS user
Bug report
Mailing list
User comments
Useful Links
LanHEP
CompHEP on the Web
Physics with CompHEP
CompHEP at LHC
CompHep
Highlight news: CompHEP is in the top rating list on The OpenScience Project
CompHEP: a package for evaluation of Feynman diagrams, integration over multi-particle phase space and event generation (supported in part by RFBR grants 96-02-19773-a, 99-02-04011-ННИО_a, 01-02-16710-a, 04-02-17448-a).
–Table of Contents
CompHEP Collaboration
ABSTRACT
News
Authors of publications containing results obtained by means of CompHEP are requested to include the references
CompHEP Collaboration
E.Boos, V.Bunichev, M.Dubinin, L.Dudko, V.Edneral, V.Ilyin, A.Kryukov, V.Savrin - SINP MSU, Moscow, Russia.
A.Semenov - JINR, Dubna, Russia.
A.Sherstnev - SINP MSU, Moscow, Russia and University of Oxford, UK.
ABSTRACT
At present time when a new generation of TeV energy colliders is beginning to operate one needs to calculate cross sections for a great number of various reactions. The CompHEP package was created for calculation of multiparticle final states in collision and decay processes. The main idea in CompHEP was to enable one to go directly from the Lagrangian to the cross sections and distributions effectively, with the high level of automation.
While ortodox event generators are software libraries (see Event generator) of various matrix elements, CompHEP starts from the level of Feynman rules for a gauge model Lagrangian and calculates symbolically the matrix element for any process defined by a user. In this sense CompHEP is a "generator of generators" (or, following the abovementioned reference, a "meta-generator"). The Feynman rules for a gauge model Lagrangian in the format of CompHEP model files can be generated by LanHEP.
News
19/08/2008 42 of the Best Free Linux Scientific Software. CompHEP is on the first place in Physics category.
13/06/2008 Users are invited to place an information about models in CompHEP format at users model library.

CompHEP can be downloaded from the web page
http://comphep.sinp.msu.ru
(registration is required). Size of packed source codes 1.9 Mb.
Website statistics

- **2250 registered users**
- **From 5 to 15 downloads of the package every day**
- **600 visits from «unique hosts» every month**

Users manual, FAQ and other useful information can be found there.

Section «Tutorials» contains links to lecture courses on CompHEP by
D.Green (US CMS, LHC Physics Center), K.Matchev (Florida U), J.Richman (UC Santa Barbara)
and other instructive materials.

First in the Open Science Project, category «Highest rated software»
First in the «42 of the Best Free Linux Scientific Software», category «Physics»