

CompHEP, version 4.5

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For CompHEP Collaboration:

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Outline

- **CompHEP overview**
- **New features in version 4.5**
- **Usage in D0, CMS, ILC**

History

CompHEP project
has started In 1989
in Moscow State University

The main purpose is
to make Calculations in HEP
Automatic and
Model independent



Motivations

Large number of Feynman diagrams and large number of subprocesses require automation

Goals:

- Automation of tree level diagram calculations
- “Unification” of symbolical and numerical calculation (in UI) – a full computational chain for phenomenologists
- Interfacing to other generators (for showering and hadronization) and further (full simulation)
- Interfacing to NLO codes: cross section calculators, mass spectrum calculators

Community projects: CompHEP, GRACE, MadGraph, AlpGen, Omega/WHIZARD, Sherpa/Amegic, etc.

CompHEP conception

- CompHEP constructs tree level Feynman diagrams for a given parton process
- Symbolical calculations of the Feynman diagrams squared
- Automated preparation of binary for numerical calculations by Monte-Carlo technique (based on C code): cross sections, distributions, events
- Model independence: Model description files are input for CompHEP. CompHEP can work with 0,1/2,1-spin particles, Majorana and Dirac spinors, 3- and 4- vertices with fields, derivatives of fields, functions of parameters
- “Universal”, build-in symbolic calculator: CompHEP can calculate N^2 tree level diagrams for any process $1, 2 \rightarrow M$. N and M are limited by computer resources only
- User-friendly interface: GUI for both symbolic and numerical parts, comprehensive build-in help (F1), batch scripts

CompHEP Model

CompHEP Model defines particles and their interactions.
Technically CompHEP model is a set of 5 text files (tables)

- A set of fundamental particles: names, mass/width, spin, charges
- Numerical model parameters: mass/width values, couplings, mixing parameters, etc.
- Constrains: relations between the parameters
- Lagrangian: a set of all interaction vertexes
- Composite particles: proton, artificial useful particle combinations

CompHEP SM Model

CompHEP version 4.5.0rc6

Variables

Clr	Rest	Del	Size	Name	Value	>	Comment	<
EE				Elementary charge (alpha=1/127.9, on-shell, MZ)	0.31345			
GG				Strong coupling constant (Z pnt, alp=0.1172pm0)	1.21358			
SW				sin of the Weinberg angle (MZ point -> MW=79.9)	0.48076			
s12				Parameter of C-K-M matrix (PDG2002)	0.2229			
s23				Parameter of C-K-M matrix (PDG2002)	0.0412			
s13				Parameter of C-K-M matrix (PDG2002)	0.0036			
MZ				mass of Z boson	91.1876			
wZ				width of Z boson	2.43631			
wW				width of W boson	2.02798			
Mm				mass of muon	0.10566			
Mtau				mass of tau-lepton	1.77699			
Mc				mass of c-quark	1.65			
Ms				mass of s-quark	0.117			
Mtop				mass of t-quark	174.3			
wtop				width of t-quark	1.54688			
Mb				mass of b-quark	4.85			
MH				mass of Higgs	115			
wH				width of Higgs	0.0061744			

F1 F2 Top Bottom GoTo Find Zoom ErrMes

CompHEP version 4.5.0rc6

Particles

Clr	Rest	Del	Size	Full name	P	aP	2*spin	mass	width	color	aux	>	LaTeX(A)	<
				gluon	G	G	2	0	0	8	G	G		G
				photon	A	A	2	0	0	1	G	A		A
				Z boson	Z	Z	2	MZ	wZ	1	G	Z		Z
				W boson	W+	W-	2	MW	wW	1	G	W+		W^
				neutrino	ne	Ne	1	0	0	1	L	\nu^e		\b
				electron	e	E	1	0	0	1		e		\b
				mu-neutrino	nm	Nm	1	0	0	1	L	\nu^\mu		\b
				muon	m	M	1	Mm	0	1		\mu		\b
				tau-neutrino	nl	Nl	1	0	0	1	L	\nu^\tau		\b
				tau-lepton	l	L	1	Mtau	0	1		\tau		\b
				u-quark	u	U	1	0	0	3		u		\b
				d-quark	d	D	1	0	0	3		d		\b
				c-quark	c	C	1	Mc	0	3		c		\b
				s-quark	s	S	1	Ms	0	3		s		\b
				t-quark	t	T	1	Mtop	wtop	3		t		\b
				b-quark	b	B	1	Mb	0	3		b		\b
				Higgs	H	H	0	MH	wH	1		H		H

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CompHEP version 4.5.0rc6

Constraints

Clr	Rest	Del	Size	Name	>	Expression	<
CW				$\sqrt{1-SW^2}$			
c12				$\sqrt{1-s12^2}$			
c23				$\sqrt{1-s23^2}$			
c13				$\sqrt{1-s13^2}$			
Vud				$c12*c13$			
Vus				$s12*c13$			
Vub				$s13$			
Vcd				$-s12*c23-c12*s23*s13$			
Vcs				$c12*c23-s12*s23*s13$			
Vcb				$s23*c13$			
Vtd				$s12*s23-c12*c23*s13$			
Vts				$-c12*s23-s12*c23*s13$			
Vtb				$c23*c13$			
MW				$MZ*CW$			

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CompHEP version 4.5.0rc6

Lagrangian

Clr	Rest	Del	Size	P1	P2	P3	P4	>	Factor	<
				P1	P2	P3	P4		Factor	d
				b	W+				$-EE*\sqrt{2}*Vcb/(4*SW)$	G(m)
				b	W+.f				$i*EE*\sqrt{2}*Vcb/(4*MW*SW)$	Mb*
				c	A				$-2*EE/3$	G(m)
				c	G				GG	G(m)
				c	H				$-EE*Mc/(2*MW*SW)$	1
				c	Z				$-EE/(12*CW*SW)$	(3-
				c	Z.f				$i*EE*Mc/(2*MW*SW)$	G5
				d	W+				$-EE*\sqrt{2}*Vcd/(4*SW)$	G(m)
				d	W+.f				$-i*EE*Mc*\sqrt{2}*Vcd/(4*MW*SW)$	(1-
				s	W+				$-EE*\sqrt{2}*Vcs/(4*SW)$	G(m)
				s	W+.f				$i*EE*\sqrt{2}*Vcs/(4*MW*SW)$	Ms*
				c	W-				$-EE*\sqrt{2}*Vcd/(4*SW)$	G(m)
				d	W-.f				$i*EE*Mc*\sqrt{2}*Vcd/(4*MW*SW)$	(1+
				d	A				EE/3	G(m)
				d	G				GG	G(m)
				d	Z				$-EE/(12*CW*SW)$	2*S
				t	W-				$-EE*\sqrt{2}*Vtd/(4*SW)$	G(m)
				t	W-.f				$i*EE*Mtop*\sqrt{2}*Vtd/(4*MW*SW)$	(1+
				u	W-				$-EE*\sqrt{2}*Vud/(4*SW)$	G(m)
				e	A				EE	G(m)
				e	Z				$EE/(4*CW*SW)$	(1-

F1 F2 Top Bottom GoTo Find Zoom ErrMes

Basic and user-defined CompHEP Models

- Simple training models: QED, Effective 4-fermion Fermi model
- SM in two different gauges: unitary gauge and t 'Hooft-Feynman gauge. Flavour simplified SM model (#-model)
- SUSY Models: unconstrained MSSM (again in two gauges); SUGRA model; GMSB model

New (user-defined) Models

- Simple way (if your model is relatively simple): add new particles/params/vertices
- For more complicated models: **LanHEP** – a program for generation of Feynman rules for user-defined model (**developed by A.Semenov**)
 - Works with super-multiplets and superpotential
 - Generates all needed files for CompHEP (also FeynArts and LaTeX format)
 - Several options for self-checking (charge conservation, BRST invariance, etc.)
 - Has been used for CompHEP SUSY models and many other BSM models

CompHEP BSM Lagrangians

- Complete Leptoquark model. Includes Yukawa couplings for all types of LQ, gauge couplings and anomalous gauge couplings for vector LQ (by request)
- Top quark Lagrangian with anomalous couplings as follows from the dimension 6 effective operators (by request)
- Excited fermion Model (by request)
- Complete two-Higgs-doublet Model with conserved or broken CP invariance (by request)
- RS1 model and effective 4 particle Lagrangian for RS below KK threshold
- UED model (Matchev et al.)
- Minimal Higgsless Model (Chivukula et al.)
- **Exotics:** Muonic photon; para-photon; E6 isosinglet quark; Z' , W' bosons; doubly charged Higgs, color octet pseudoscalars, Inert Douplet Model, etc.

Symbolic calculations

The image shows four windows of the CompHEP 4.5.0rc6 software interface. The top-left window displays the 'Abstract' section, which describes the package's purpose for calculating decay and collision processes. A menu is visible on the right with 'SM, Feynman gauge' selected. The top-right window shows the 'Model' set to 'SM, Feynman gauge' and a menu with 'Enter Decay Process' selected. The bottom-left window displays the 'List of structure functions' with a list of 18 items, including PDFs and ISR, and shows input for beam energies and PDF number. The bottom-right window shows the 'List of composite particles' with three entries (j1, j2, j3) and shows input for the final state 'e, E, m, M, j2'. All windows have a footer with function key shortcuts: F1-Help, F2-Man, F5-Switches, F6-Results, F9-Quit.

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.

- QED
- Effective 4-fermion
- SM, unitary gauge
- SM, Feynman gauge**
- MSSM, unitary gauge
- MSSM, Feynman gauge
- SUGRA, Feynman gauge
- GMSB, Feynman gauge
- _SM_ud
- _SM_qQ
- CREATE NEW MODEL

F1-Help F2-Man F5-Switches F6-Results F9-Quit

Model: SM, Feynman gauge

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.

- Enter Decay Process
- Enter Scattering Process**
- Edit Beams Table
- Edit Str. Functions Table
- Edit Model
- Delete Model

F1-Help F2-Man F5-Switches F6-Results F9-Quit

Model: SM, Feynman gauge

List of structure functions

- 0: OFF
- 1: WWA (m=0.000511 Ch=-1 Q=100)
- 2: Laser Photons
- 3: ISR(100 Beamstr.:OFF)
- 10: PDF:cteq6m(proton)
- 11: PDF:cteq6m(anti-proton)
- 12: PDF:cteq6l1(proton)
- 13: PDF:cteq6l1(anti-proton)
- 14: PDF:cteq6d(proton)
- 15: PDF:cteq6d(anti-proton)
- 16: PDF:cteq5m1(proton)
- 17: PDF:cteq5m1(anti-proton)

PgDn

Enter 1st Beam:

Enter 1st Beam Energy (GeV) : 7000.000000

Enter 2nd Beam:

Enter 2nd Beam Energy (GeV) : 7000.000000

Enter PDF number : 12

Model: SM, Feynman gauge

List of composite particles (switch to the particle list by F3)

- Name: j1 (u,U,d,D,G)
- Name: j2 (u,U,d,D,s,S,c,C,G)
- Name: j3 (u,U,d,D,s,S,c,C,b,B,G)

Enter Final State: p,p -> e,E,m,M,j2

Applications Places System Thu 30 Oct, 09:37 Alexander Sherstnev

Symbolic calculations (2)

CompHEP version 4.5.0rc6

Model: SM, Feynman gauge

List of (anti)particles

G(G)	gluon	A(A)	photon	Z(Z)	Z boson
W+(W-)	W boson	ne(Ne)	neutrino	e(E)	electron
nm(Nm)	mu-neutrino	m(M)	muon	nl(Nl)	tau-neutrino
l(L)	tau-lepton	u(U)	u-quark	d(D)	d-quark
c(C)	c-quark	s(S)	s-quark	t(T)	t-quark
b(B)	b-quark	H(H)	Higgs		

Enter Final State: p,p -> e,E,j1
 Exclude diagrams with H
 Keep diagrams with

CompHEP version 4.5.0rc6

Model: SM, Feynman gauge

Process: p,p -> e,E,j1

Feynman diagrams

64 diagrams in 16 subprocesses are constructed.
 0 diagrams are deleted.

NN	Subprocess	Del	Rest
1	u,U -> G,e,E	0	4
2	u,G -> e,E,u	0	4
3	d,D -> G,e,E	0	4
4	d,G -> e,E,d	0	4
5	U,u -> G,e,E	0	4
6	U,G -> e,E,U	0	4
7	D,d -> G,e,E	0	4
8	D,G -> e,E,D	0	4
9	s,S -> G,e,E	0	4
10	c,C -> G,e,E	0	4
11	S,s -> G,e,E	0	4
12	C,c -> G,e,E	0	4

PgDn

F1-Help F2-Man F3-Model F5-Switches F6-Results F7-Del F8-UnDel F9-Quit

CompHEP version 4.5.0rc6

Delete, On/off, Restore, Latex

F1-Help, F2-Man, PgUp, PgDn, Home, End, #, Esc

CompHEP version 4.5.0rc6

Model: SM, Feynman gauge

Process: p,p -> e,E,j1

Feynman diagrams

64 diagrams in 16 subprocesses are constructed.
 0 diagrams are deleted.

Squared diagrams

160 diagrams in 16 subprocesses are constructed.
 0 diagrams are deleted.
 160 diagrams are calculated.
 0 Out of memory

Write results
 C-compiler
 Enter new process

F1-Help F2-Man F3-Model F4-Diagrams F5-Switches F6-Results F9-Quit

Applications Places System Thu 30 Oct, 09:40 Alexander Sherstnev

Numerical calculations

- **Customize numerical MC generator:** The most complicated part: do proper phase space sampling (regularizations + kinematics), set necessary kinematic cuts, Q^2 , PDF set, etc. Main goals – to improve efficiency of MC calculation and describe physics task. User may change model parameters and set kinematic cuts
- **Calculate full cross section and distributions:** CompHEP uses an improved version of the adaptive VEGAS algorithm for MC calculations. User may order different variables (P_T , inv. mass, rapidity, etc.) for histogramming
- **Generate events:** As soon as CompHEP customized, events can be generated for the subprocess. User set a number of the events They are kept to text files.

If the process consists of some subprocesses, the procedure is applied to the each subprocess.

Numerical calculations (2)

The image displays four windows of the CompHEP version 4.5.0rc6 software, arranged in a 2x2 grid. Each window shows the configuration and execution of a Monte Carlo simulation for the process $p, p \rightarrow e, E, j1$ (16 subprocesses).

Top-Left Window: Shows the initial state configuration. A menu is open with "Initial state" selected.

Top-Right Window: Shows the beam particle configuration. A menu is open with "Beam particle 1: proton" selected. The configuration includes:
Beam particle 1: proton
Str.Fun.1: PDF:cteq611
Str.Fun.2: PDF:cteq611
1 particle momentum[GeV] = 7000
2 particle momentum[GeV] = 7000

Bottom-Left Window: Shows the model parameters configuration. A menu is open with "Model parameters" selected. The configuration includes:
Change parameter
EE= 0.31345
SW= 0.48076
MZ= 91.188
wZ= 2.4363
Mc= 1.65
Ms= 0.117
GG= 1.2136

Bottom-Right Window: Shows the QCD scale configuration. A menu is open with "QCD scale" selected. The configuration includes:
QCD alpha
QCD Lambda6= ???
Q(GeV) = m45
Alpha(Q) plot

Each window also displays the process information: $p, p \rightarrow e, E, j1$ (16 subprocesses), $(sub)Process: u, U \rightarrow G, e, E$, and Monte Carlo session: 1(begin) or 3(begin).

Numerical calculations (3)

Process: $p, p \rightarrow e, E, j1$ (16 subprocesses)
(sub)Process: $u, U \rightarrow G, e, E$

Cuts 3

Parameter	> Min bound	< > Max bound	<
t3	10		
y3	-5	5	
m45	10		

Process: $p, p \rightarrow e, E, j1$ (16 subprocesses)
(sub)Process: $u, U \rightarrow G, e, E$

Regularization 4

Momentum	> Mass	< > Width	< Power
45	0	0	1
45	MZ	wZ	2
13	0	0	2
14	0	0	2

Process: $p, p \rightarrow e, E, j1$ (16 subprocesses)
(sub)Process: $u, U \rightarrow G, e, E$
Monte Carlo session: 1(begin)

Numerical Session

#IT	Cross section [pb]	Error %	nCall	chi**2
1	1.1705E+02	1.81E+00	90720	
2	1.1432E+02	1.16E+00	90720	
3	1.1540E+02	7.58E-01	90720	
4	1.1572E+02	1.03E+00	90720	
>	1.1539E+02	5.18E-01	362880	0.4
1	1.1613E+02	8.32E-01	90720	
2	1.1553E+02	6.48E-01	90720	
3	1.1679E+02	5.87E-01	90720	
4	1.1806E+02	9.86E-01	90720	
>	1.1644E+02	3.59E-01	362880	1
5	1.1465E+02	7.81E-01	90720	
6	1.1644E+02	8.01E-01	90720	
7	1.1518E+02	6.64E-01	90720	
8	1.1580E+02	5.92E-01	90720	
>	1.1596E+02	2.49E-01	725760	1

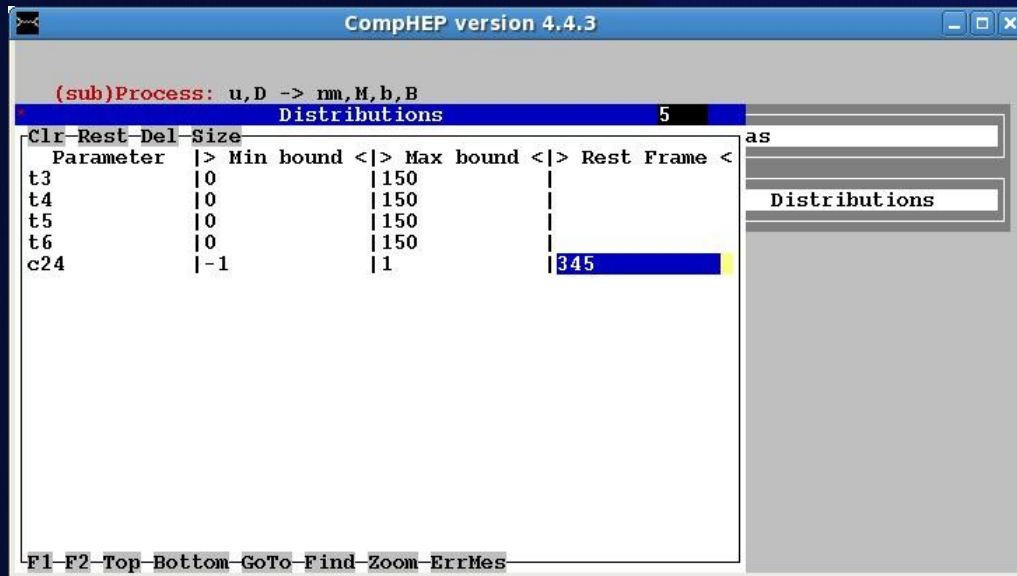
Process: $p, p \rightarrow e, E, j1$ (16 subprocesses)
(sub)Process: $u, U \rightarrow G, e, E$
Monte Carlo session: 3(begin)

Numerical Session

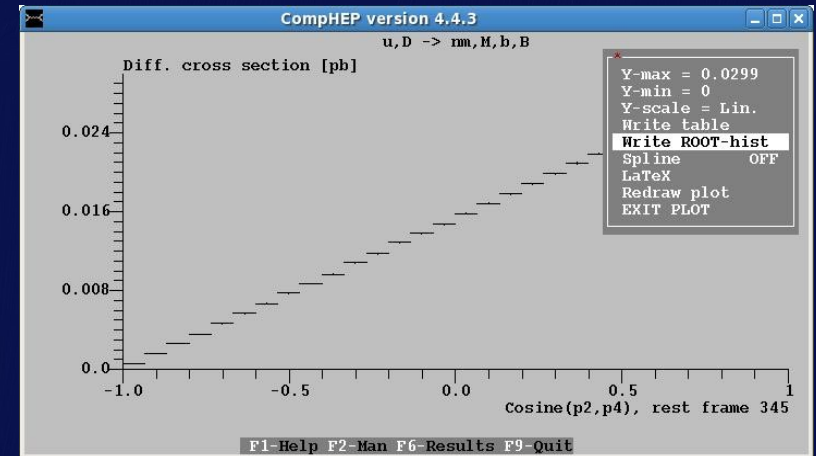
IT	Cross section [pb]	Error %	nCall	chi**2
1	1.1705E+02	1.81E+00	90720	
2	1.1432E+02	1.16E+00	90720	
3	1.1540E+02	7.58E-01	90720	
4	1.1572E+02	1.03E+00	90720	
>	1.1539E+02	5.18E-01	362880	0.4
1	1.1613E+02	8.32E-01	90720	
2	1.1553E+02	6.48E-01	90720	
3	1.1679E+02	5.87E-01	90720	
4	1.1806E+02	9.86E-01	90720	
>	1.1644E+02	3.59E-01	362880	1
5	1.1465E+02	7.81E-01	90720	
6	1.1644E+02	8.01E-01	90720	
7	1.1518E+02	6.64E-01	90720	
8	1.1580E+02	5.92E-01	90720	
>	1.1596E+02	2.49E-01	725760	1

Integration is over - Press any key

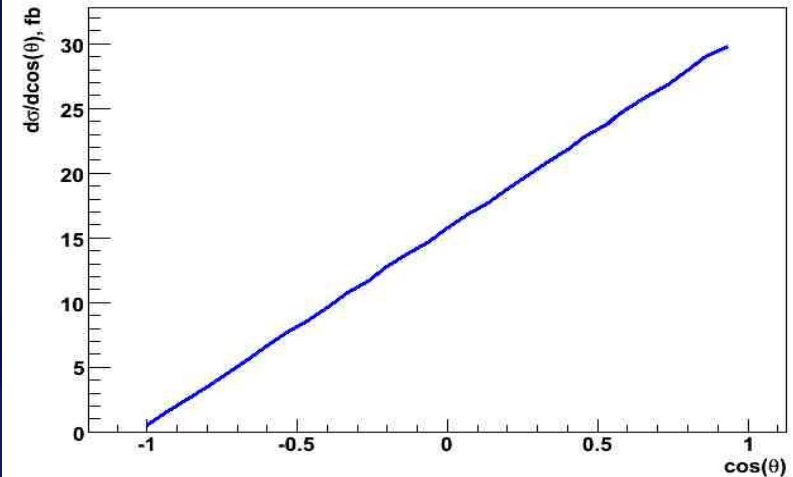
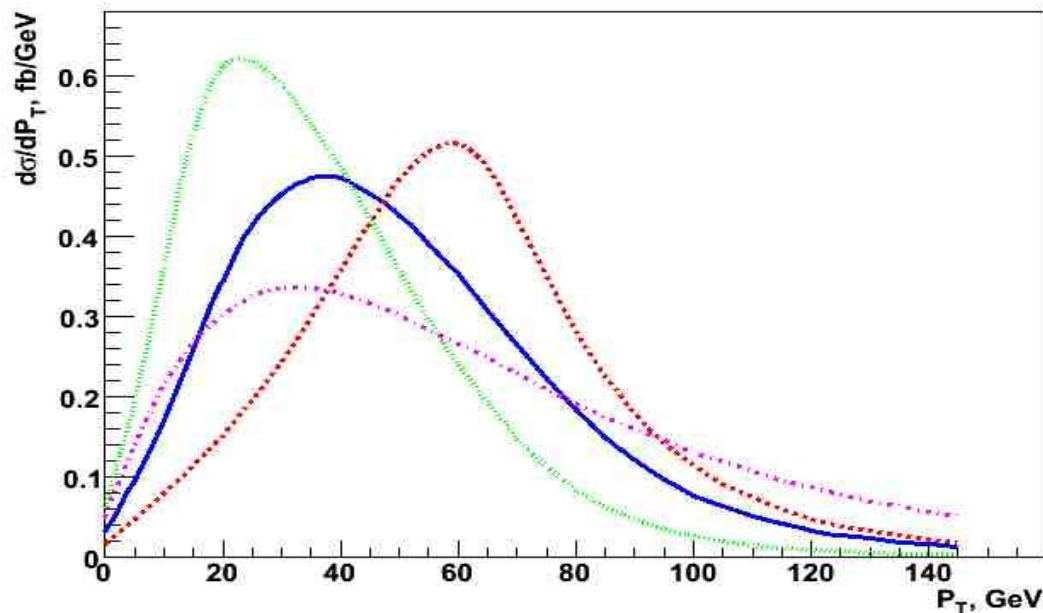
Distributions in CompHEP (ROOT interface)



New option in the numerical menu -
“write root histogram”



Pt distributions for all final particles



In “vegas” integration menu new submenu
“combine histograms” for superimposing
ROOT-histograms

Simulation of cascade decay in CompHEP

1. Generate production events

```
CompHEP version 4.5
#PEVLIB v.1.0 =====
#CompHEP version 4.5
#PROCESS u U -> m Nm b B H+
#Initial_state
  SQRT(S) 1.960000E+03
  Rapidity(c.m.s) 0.000000E+00
  StrFun1: PDF:cteq611(proton)
  StrFun2: PDF:cteq611(anti-proton)
#MASSES 0.000000000E+00 0.000000000E+00 0.000000000E+00 0.000000000E+00 0.620000000E+00 4.620000000E+00 1.5003506470E+02
#Cross_section(Width) 1.842239E-01
#Number_of_events 55266
-----
#CompHEP version 4.5
#PROCESS d D -> m Nm b B H+
#Initial_state
  SQRT(S) 1.960000E+03
  Rapidity(c.m.s) 0.000000E+00
  StrFun1: PDF:cteq611(proton)
  StrFun2: PDF:cteq611(anti-proton)
#MASSES 0.000000000E+00 0.000000000E+00 0.000000000E+00 0.000000000E+00 0.620000000E+00 4.620000000E+00 1.5003506470E+02
#Cross_section(Width) 3.316660E-02
#Number_of_events 9948
```

2. Generate decay events

```
CompHEP version 4.5
#CompHEP version 4.5
#PROCESS H+ -> E ne b B
#Initial_state
  SQRT(S) 0.000000E+00
  Rapidity(c.m.s) 0.000000E+00
  StrFun1: OFF
  StrFun2: OFF
#MASSES 1.5003506470E+02 0.000000000E+00 0.000000000E+00 4.620000000E+00 4.620000000E+00
#Cross_section(Width) 4.801043E-04
#Number_of_events 100000
-----
#Number_of_subprocesses = 1
#Total_cross_section(ph) = 4.801043E-04
#Events_mixed_and_randomized = 100000
#Nproc ===== Events =====
  1 -2.3466858060E+01 4.4298254788E+01 3.9019414884E+01 5.1245802995E+00 6.0883300482E+00 -2.8526782568E+01 5.1727835861E+00 -2.6188469731E+01 -1.0951522465E-01 1.3169494175E+01 -2.4198115105E+01 -1.0383117092E+01 9.119E+01 (5 4)
  1 -1.5191133328E+01 3.7733542463E+01 8.7906452501E+00 4.1632026402E+01 6.7928012131E+00 -2.6654965530E+01 -2.5675368818E+00 9.1008E+01 -7.6652434728E-01 -1.8592615690E+01 -7.0
```

3. Run command "cascade"

```
slava@slava:~/H+_2008/old_format/pp-mNbBH+
Файл Правка Вид Терминал Вкладки Справка
charged Higgs, tree: 156.467255
1-loop: 150.035065
-----
Delta rho total : 6.80672253E-05
-----
End of CompHEP numerical session.
[slava@slava pp-mNbBH+]$
[slava@slava pp-mNbBH+]$
[slava@slava pp-mNbBH+]$ ./cascade production.txt decay.txt
```

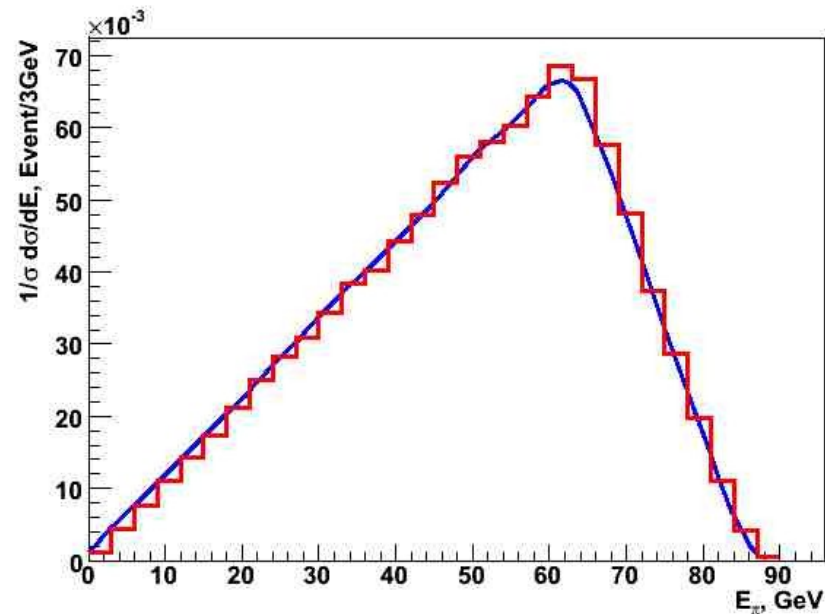
File with glued events

```
CompHEP version 4.5
#PEVLIB v.1.0 =====
#CompHEP version 4.5
#PROCESS u U -> m Nm b B E ne b B
#Initial_state
  SQRT(S) 1.960000e+03
  Rapidity(c.m.s) 0.000000e+00
  StrFun1:PDF:cteq611(proton)
  StrFun2:PDF:cteq611(anti-proton)
#MASSES 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 4.620000e+00 4.620000e+00 0.000000e+00 0.000000e+00 0.000000e+00 4.620000e+00 4.620000e+00
#Cross_section(Width) 1.842239e-01
#Number_of_events 55266
-----
#CompHEP version 4.5
#PROCESS d D -> m Nm b B E ne b B
#Initial_state
  SQRT(S) 1.960000e+03
  Rapidity(c.m.s) 0.000000e+00
  StrFun1:PDF:cteq611(proton)
  StrFun2:PDF:cteq611(anti-proton)
#MASSES 0.000000e+00 0.000000e+00 0.000000e+00 0.000000e+00 4.620000e+00 4.620000e+00 0.000000e+00 0.000000e+00 0.000000e+00 4.620000e+00 4.620000e+00
#Cross_section(Width) 3.316660e-02
#Number_of_events 9948
PgDn
```

Cascade processes with scalar

$$p\bar{p} \rightarrow t\bar{b} \rightarrow H^+ b\bar{b} \rightarrow \tau^+ \nu_\tau b\bar{b} \rightarrow \pi^+ \nu_\tau \bar{\nu}_\tau b\bar{b}$$

MSSM parameters : $\tan \beta = 0.5$, $M_{H^+} = 150$



Pion energy spectra in the top rest frame.

Smooth line for complete process 2-5 build from weighted events,
stepped line for cascade process (2-3)*(1-3) build from two unweighted events flow.

Batch system in CompHEP

Both symbolic & numerical parts have batch scripts:

Perl scripts: `symb_batch.pl` and `num_batch.pl`

Why the scripts are useful?

- Computations of many subprocesses – laborious task, can be significantly simplified especially for hadron colliders
- **Long/large-scale calculations:** GUI is not too handy
- **Support of parallel calculations:** very helpful for multi-CPU machines/computer clusters (pbs/lsf is available; grid in progress)
- **“Knowledge transfer”:** theorists/phenomenologists can prepare model/process.dat/batch.dat for further simulations by experimentalists

Symbolical batch: pp->m,Nm,b,B,H+ with t->b,H+ and T->m,Nm,B MSSM, tb=0.5, MH+=150GeV (H+->t*b->2f+bB dominates)

Prepare `process.dat` following toy example: all points well documented

`./symb_batch.pl -show diag` (to exclude several sub-leading diagrams)
27 diagrams in 9 subprocesses (54 sqr. diag.) (15 G,G->m,Nm,b,B,H+ diagrams)

`./symb_batch.pl -mp 2` calculate faster (2 times if you have 2*CPU machine)

```
#####
# Data file for symb_script.pl
# For the symb_batch script version 1.0
#####
# You have to set the model number, which you are going to
# The model number corresponds to the string number of the
# in the CompHEP model menu in the GUI mode..
model number: 6

# Beam names can be taken from a table of beams.
# (see CompHEP in the GUI regime). Energy unit is GeV
beam 1: p
beam 2: p
beam energy 1: 7000.0
beam energy 2: 7000.0

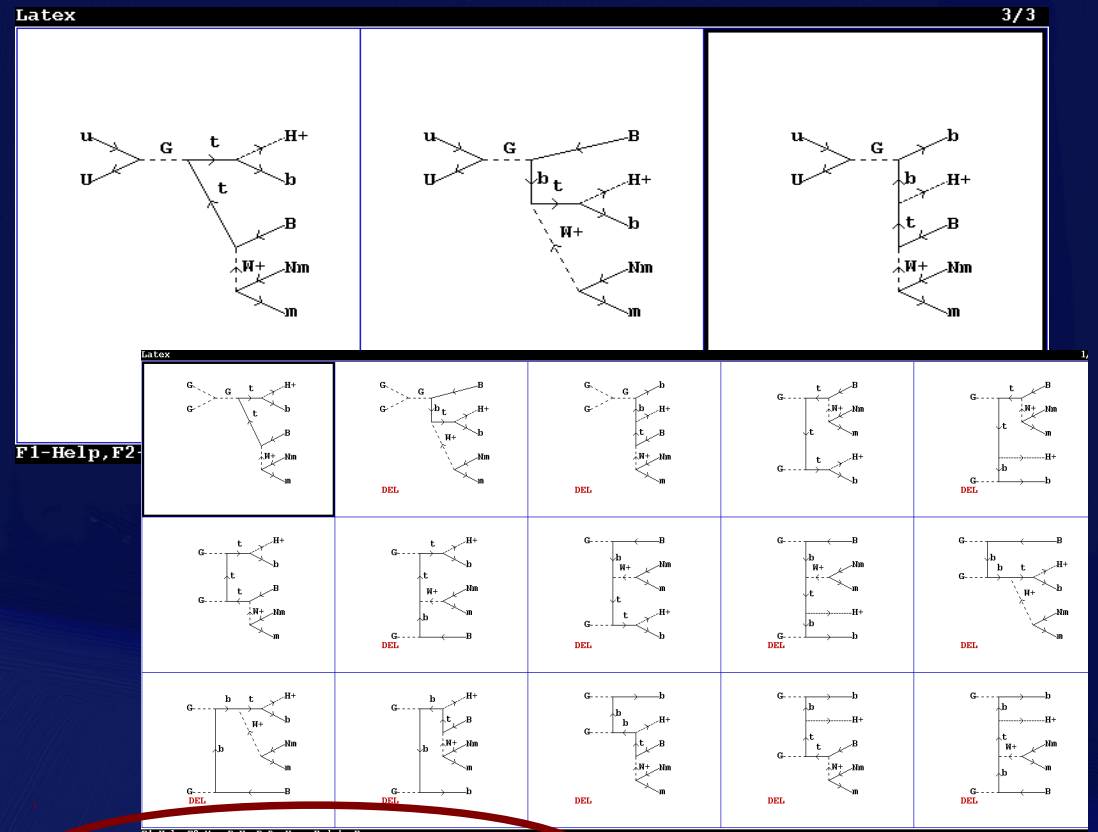
# This string defines the final state of your process. Mode
# particles and composite particles (see the corresponding
# can be used..
final state: m,Nm,b,B,H+

# If you'd like to exclude feynman diagrams with some model
# particles (in propagators!), enter the particles here]
exclude diagrams with: h,H,H3,u,d,c,s,A,Z

# If you'd like to keep feynman diagrams with some model
# particles (in propagators!), enter the particles here
# Examples:
#keep diagrams with: t,b,Z,A
keep diagrams with:

# If you enter no, s_comphep generates diagrams and does no
# do symbolic calculations.
make symbolic calculations(yes/no): yes

# If you enter no, comphep calculates all squared diagrams,
# but n_comphep will not be created.
make n_comphep generator(yes/no): yes
```



```
[note]$ ./symb_batch.pl -show stat
Diagram statistics: total = 54, calculated = 44, deleted = 0
[note]$ Old n_comphep is deleted!
End of CompHEP symbolical session.
*** n_comphep creation details have been written to symb_batch.log
```

Numerical batch: pp->m,Nm,b,B,H+ in MSSM

- Prepare **batch.dat**: customize first process via GUI and execute **./num_batch.pl**
- Customize differences in other subprocesses (if needed) via GUI and execute **./num_batch.pl -add -proc ...** for the necessary subprocesses
- Start numerical calculations with **./num_batch.pl -run ...**

```
#Subprocess 1 (u,U -> m,Nm,b,B,H+)
#Session_number 1
#Model_number 6
#Initial_state
  SQRT(S) 1.400000E+04
  Rapidity(c.m.s) 0.000000E+00
  StrFun1: PDF:cteq6l1(proton)
  StrFun2: PDF:cteq6l1(proton)

#Physical_Parameters
  EE = 3.1223000000000000E-01
  SW = 4.7300000000000000E-01
  MZ = 9.1188400000000000E+01
  Mtop = 1.7500000000000000E+02
  Mb = 4.6200000000000000E+00
  wtop = 1.7524000000000000E+00
  wW = 2.0889500000000000E+00
  mu = 1.0000000000000000E+03
  MG2 = 2.0000000000000000E+02
  MG3 = 3.0000000000000000E+02
  Mq3 = 1.0000000000000000E+03
  Mu3 = 1.0000000000000000E+03
  Md3 = 1.0000000000000000E+03
  Atop = 0.0000000000000000E+00
  Ab = 0.0000000000000000E+00
  MH3 = 1.3416000000000000E+02
  tb = 5.0000000000000000E-01
  GG = 1.216002374681738E+00

#Width_scheme 0

#Kinematical_scheme
12 -> 57 , 346
57 -> 5 , 7
346 -> 6 , 34
34 -> 3 , 4

#Cuts.
```

```
[note]$ ./num_batch.pl --show cs
List of available subprocesses:
Subprocess 1 (u,U -> m,Nm,b,B,H+): cross section [pb] = 6.2925e-01 +/- 1.30e-03 ( 2.06e-01 % )
Subprocess 2 (d,D -> m,Nm,b,B,H+): cross section [pb] = 3.8960e-01 +/- 8.15e-04 ( 2.09e-01 % )
Subprocess 3 (U,u -> m,Nm,b,B,H+): cross section [pb] = 6.2781e-01 +/- 1.55e-03 ( 2.47e-01 % )
Subprocess 4 (D,d -> m,Nm,b,B,H+): cross section [pb] = 3.8906e-01 +/- 9.31e-04 ( 2.39e-01 % )
Subprocess 5 (s,S -> m,Nm,b,B,H+): cross section [pb] = 6.6678e-02 +/- 1.43e-04 ( 2.14e-01 % )
Subprocess 6 (c,C -> m,Nm,b,B,H+): cross section [pb] = 3.0779e-02 +/- 6.58e-05 ( 2.14e-01 % )
Subprocess 7 (S,s -> m,Nm,b,B,H+): cross section [pb] = 6.6678e-02 +/- 1.43e-04 ( 2.14e-01 % )
Subprocess 8 (C,c -> m,Nm,b,B,H+): cross section [pb] = 3.0779e-02 +/- 6.58e-05 ( 2.14e-01 % )
Subprocess 9 (G,G -> m,Nm,b,B,H+): cross section [pb] = 1.4684e+01 +/- 3.59e-02 ( 2.44e-01 % )

Total CS [pb] = 1.6914e+01 +/- 3.60e-02 ( 2.13e-01 % )
```

```
#Regularization.
*** Table ***
Regularization
Momentum |> Mass <|> Width <| Power|
57 |Mtop |wtop |2.....
34 |MW |wW |2.....
346 |Mtop |wtop |2.....
=====
```

```
#QCD Lambda6 = 1.652000E-01 Scale = 175
#Vegas_calls 41472x5
#Vegas_integral 9.16788703338995469E+13 3.46369076228
#Distributions.
*** Table ***
Distributions
Parameter |> Min bound <|> Max bound <|> Rest Frame
=====
#Events 500 1 0.200000 2.000000 10000
#Random FA98C8AA370E
#VEGAS Grid Vegas grid: dim=12 size=50
```

Les Houches Agreements

LHEF, LHAPDF, SUSY LHA, BSM LHA

- **LHA I** is implemented in CompHEP-Interfaces
- **LHEF** - the format adopted by many developer groups (hep-ph/060917). Now CompHEP supports 3 event formats: cpyth-1, cpyth-2 (for experiments, where the formats are used), and 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. By default, the slhaScript file invokes SUSPECT
- **BSM LHA** is still being implemented

HepML

- Unified XML format of MC event files metadata
 - to keep comprehensive information on event
 - to store generator input parameters and setup
 - an effort to fix a unified extensible way of MC events description
 - the LHEF standard permits XML code in event file headers
- Main purposes:
 - to unify MC event files description (parton and particle levels of MC simulation)
 - to facilitate passing information from Matrix Element generators to Shower generators
 - to simplify MC generators tuning and testing
- Contributors
 - CEDAR <http://www.cedar.ac.uk>
 - LCG MCDB <http://mcdb.cern.ch>
- Homepage <https://twiki.cern.ch/twiki/bin/view/Main/HepML>

CompHEP can
generate
HepML code!

CompHEP-interfaces package

The CompHEP-Interfaces includes two interfaces for PYTHIA and HERWIG, These interfaces allow us to use processes computed by CompHEP as external processes in PYTHIA/HERWIG

Main goal: provide ISR/FSR, hadronization (jet fragmentation), and decays as it is done in PYTHIA/HERWIG

- CompHEP generates unweighted events (event files)
- The command *mix_flows* mixes several event files in one event file
- Some governing parameters (Event file name, the number of events and first event) are kept in the file **INPARM.DAT**
- A matching code for ME events and showers in PYTHIA are being developed in the package
- Simple routines for toy analysis are provided
- Program to translate data to ROOT file (record looks like LHA I)
- TAOLA interface available (by request)

MCDB — Knowledge Base

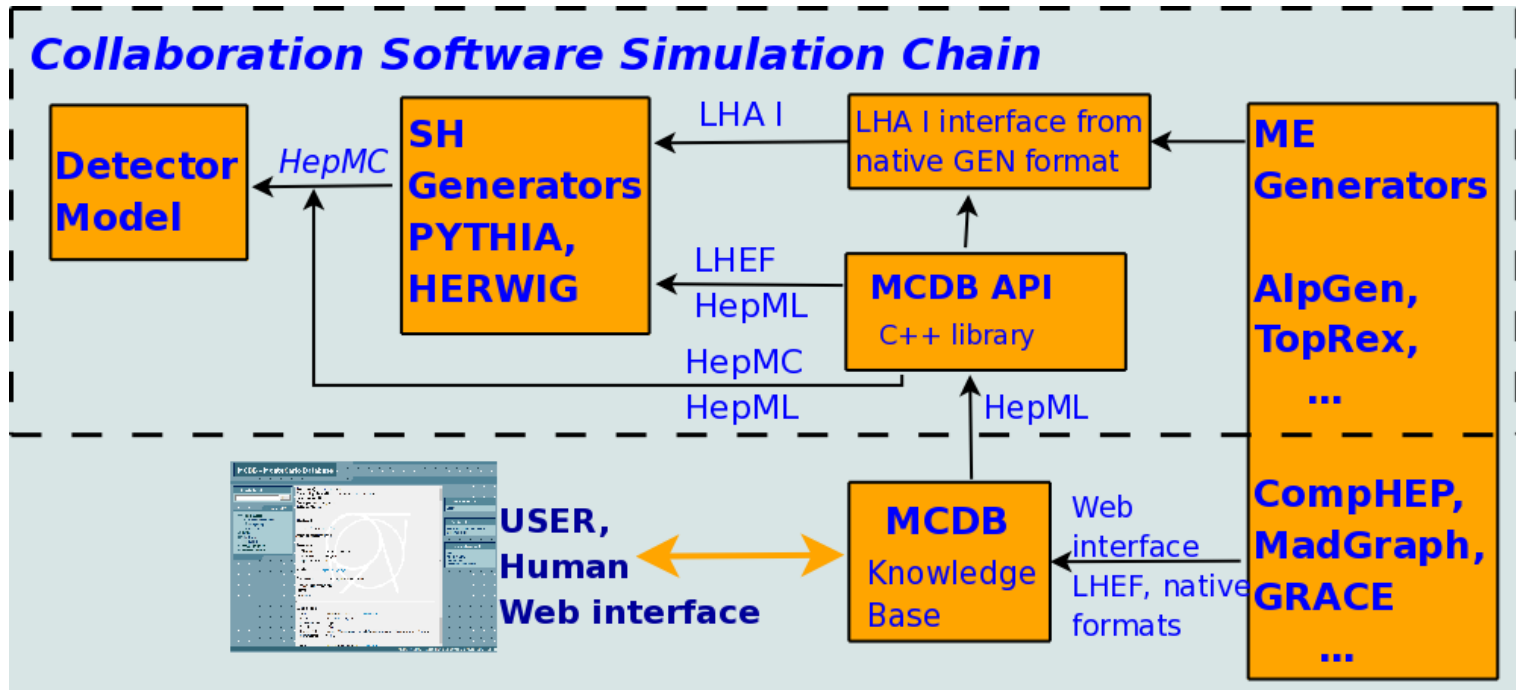
<http://mcdb.cern.ch>

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

The screenshot shows the MCDB website interface. At the top, there is a search bar and a navigation menu with categories like Top physics, QCD, Software, Requests, Higgs physics, and Gauge bosons. The main content area displays a search result for 't-channel single top events in HepMC format, effective NLO, generator SingleTop (CompHEP)'. The result includes author information (Lev Dudko, Dmitri Konstantinov), publication dates, categories, and a detailed abstract. The abstract describes the production of t-channel single top events using the SingleTop generator with an effective NLO technique. Below the abstract, there are sections for 'Author comments', 'Process' (Name: pp --> tq+tb->mu,nu,q,b,B; PDF set: CTEQ6M; QCD scale: 87.5 GeV), 'Model' (SM, Feynman gauge (Mtop=175)), 'Generator' (CompHEP, version: 4.4p3), and 'Other information' (no cuts). A 'Related papers' section lists 'EFFECTIVE-NLO EVENTS FOR THE T-CHANNEL SINGLE TOP PRODUCTION'. The footer of the page shows statistics of visits and copyright information for the Monte Carlo Generators group at CERN.

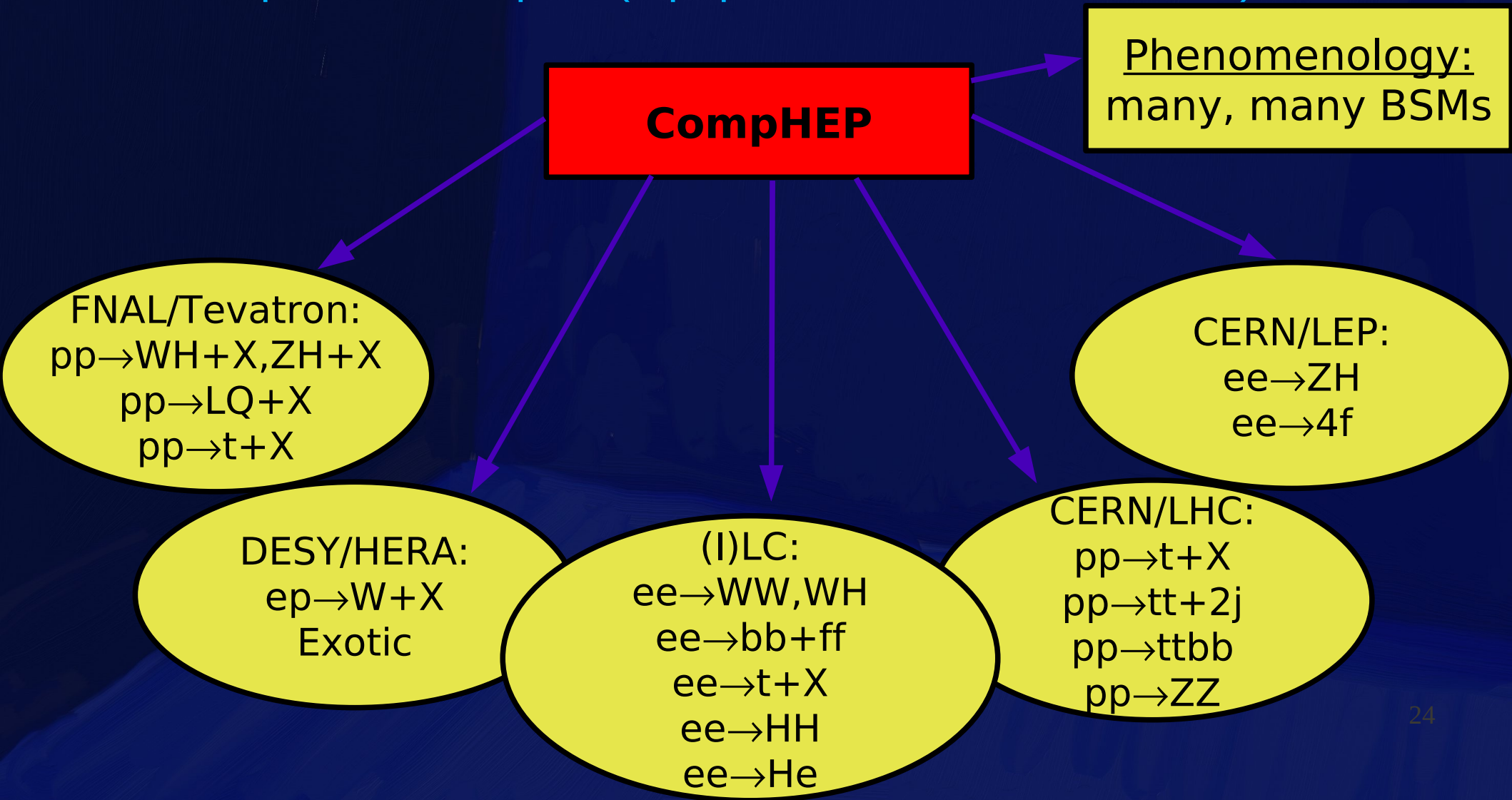
S.Belov, L.Dudko, A.Sherstnev et. al CPC178,222(2008)



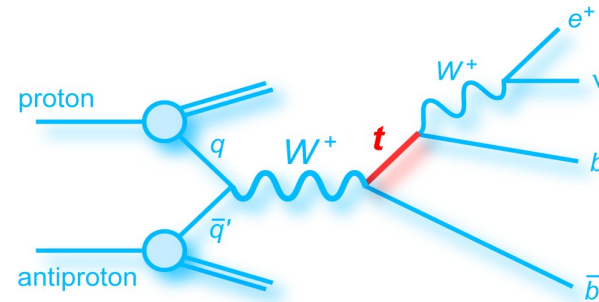
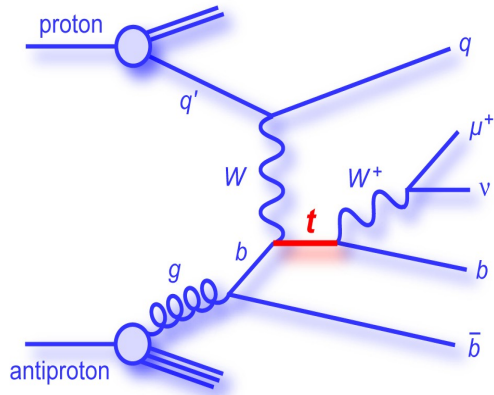
CompHEP

(Computation in High Energy Physics)

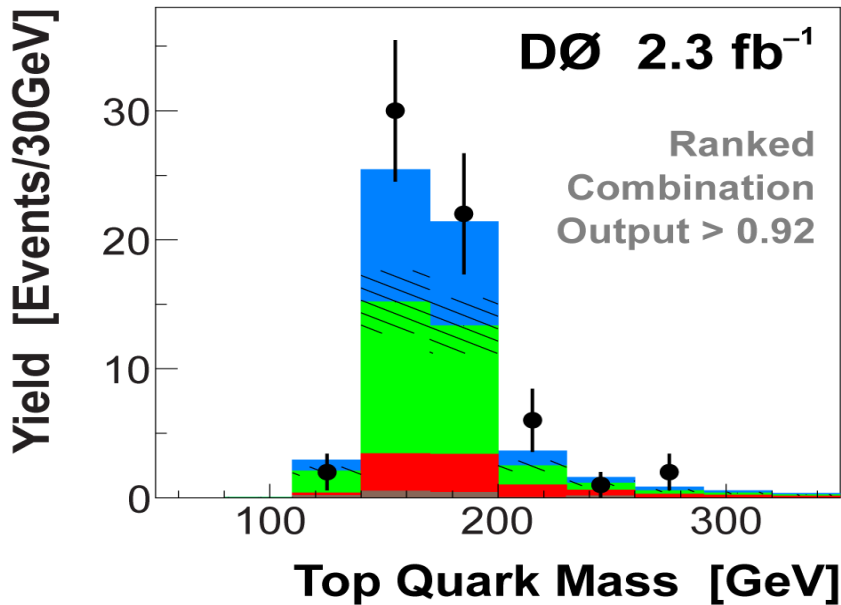
Incomplete list of processes simulated with CompHEP in the past (3 papers have ~1000 citations):



Observation of Single Top Quark Production

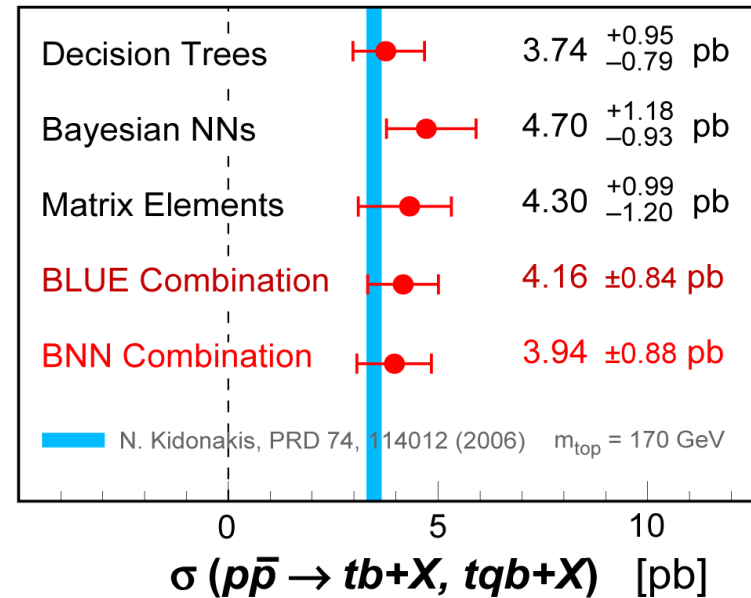


High Signal Region – m_{top}



DØ 2.3 fb⁻¹

March 2009



D0 Collaboration ([V.M. Abazov et al.](#)). **Phys.Rev.Lett.103:092001,2009.**

Search for anomalous top quark couplings with the D0 detector

$$\mathcal{L}_{tbW} = \frac{g}{\sqrt{2}} W_{\mu}^{-} \bar{b} \gamma^{\mu} (f_1^L P_L + f_1^R P_R) t$$

$$- \frac{g}{\sqrt{2} M_W} \partial_{\nu} W_{\mu}^{-} \bar{b} \sigma^{\mu\nu} (f_2^L P_L + f_2^R P_R) t + h.c.$$

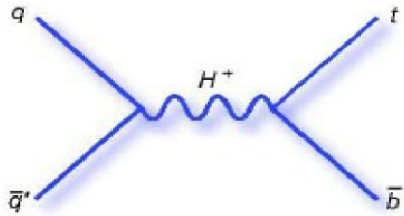
vector left and right couplings

tensor left and right couplings

$$P_{L,R} = 1/2 \cdot (1 \mp \gamma_5) \quad , \quad \sigma^{\mu\nu} = i/2 [\gamma^{\mu}, \gamma^{\nu}]$$

Scenario	Coupling	Coupling limit if $f_1^L = 1$
(L_1, R_1)	$ f_1^L ^2 = 1.27^{+0.57}_{-0.48}$	$ f_1^R ^2 < 1.01$
	$ f_1^R ^2 < 0.95$	
(L_1, L_2)	$ f_1^L ^2 = 1.27^{+0.60}_{-0.48}$	$ f_2^L ^2 < 0.28$
	$ f_2^L ^2 < 0.32$	
(L_1, R_2)	$ f_1^L ^2 = 1.04^{+0.55}_{-0.49}$	$ f_2^R ^2 < 0.23$
	$ f_2^R ^2 < 0.23$	

Search for charged Higgs bosons decaying to the top and bottom quarks in p anti-p collisions

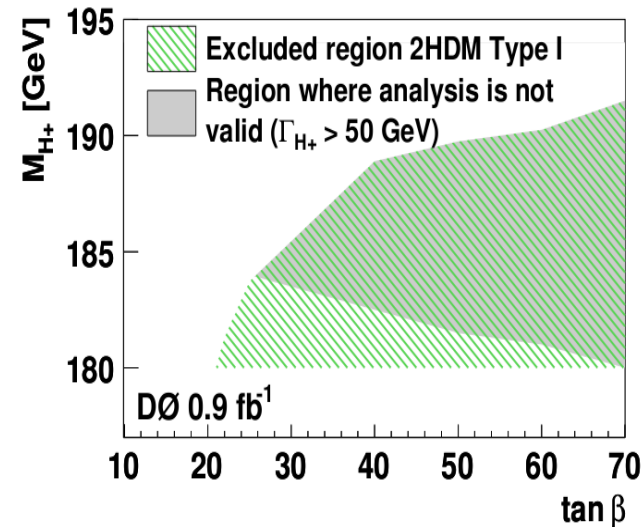
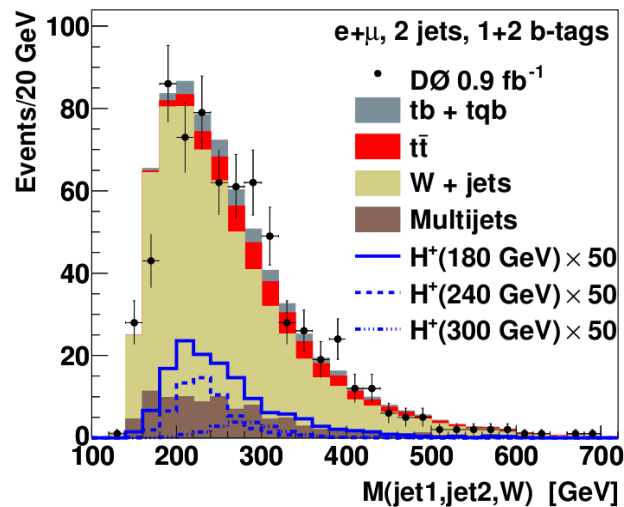


- General interaction of charged scalar to fermions:

$$\mathcal{L} = \frac{g_w V_{q_i q_j}}{2\sqrt{2}} H^+ \bar{q}_i (a_{q_i q_j}^L (1 - \gamma^5) + a_{q_i q_j}^R (1 + \gamma^5)) q_j + \text{H.c.}$$

- Squared ME for $u\bar{d} \rightarrow t\bar{b}$

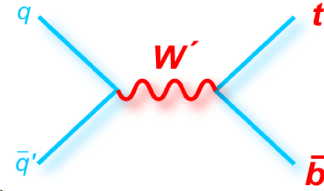
$$|M|^2 = g_w^4 V_{tb}^2 V_{ud}^2 (a_{ud}^L{}^2 + a_{ud}^R{}^2) \left[\frac{(a_{tb}^L{}^2 + a_{tb}^R{}^2)(p_u p_d)(p_t p_b) - 2M_t M_b a_{tb}^L a_{tb}^R (p_u p_d)}{(\hat{s} - M_{H^+}^2)^2 + \Gamma_{H^+}^2 M_{H^+}^2} \right]$$



Search for W-prime Boson Resonances Decaying to a Top Quark and a Bottom Quark.

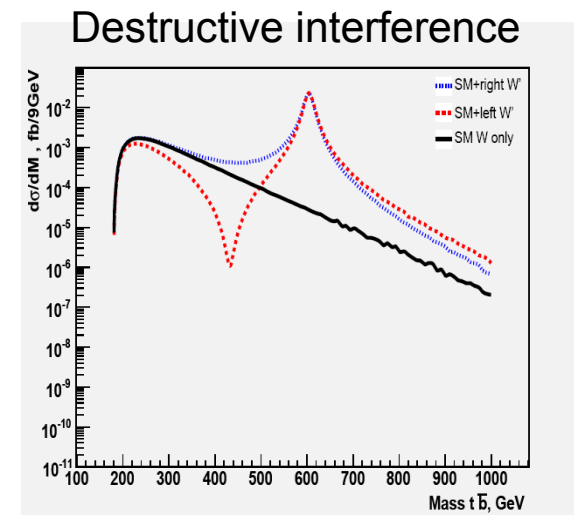
$$L = \frac{V_{q_i q_j}}{2\sqrt{2}} g_W \bar{q}_i \gamma_\mu [a_{q_i q_j}^R (1 + \gamma_5) + a_{q_i q_j}^L (1 - \gamma_5)] W' q_j + H.C.$$

$a_{q_i q_j}^R, a_{q_i q_j}^L$ - left and right couplings of W' to fermions

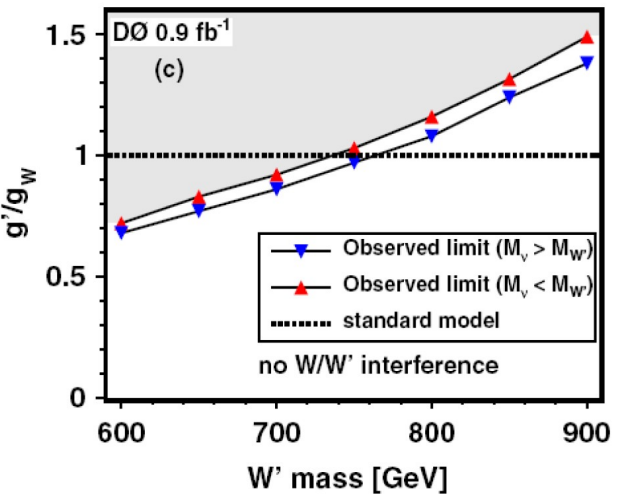
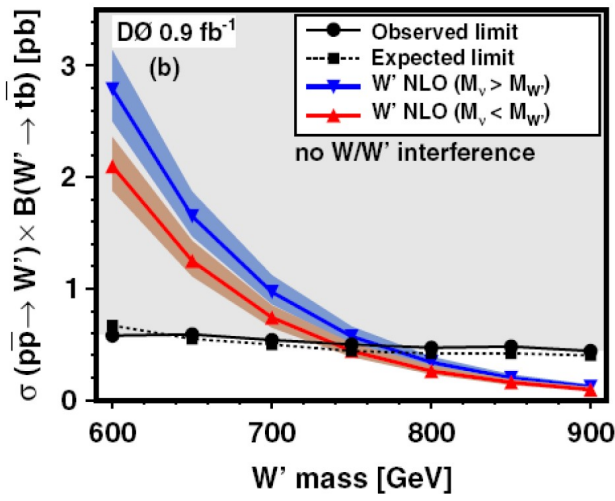
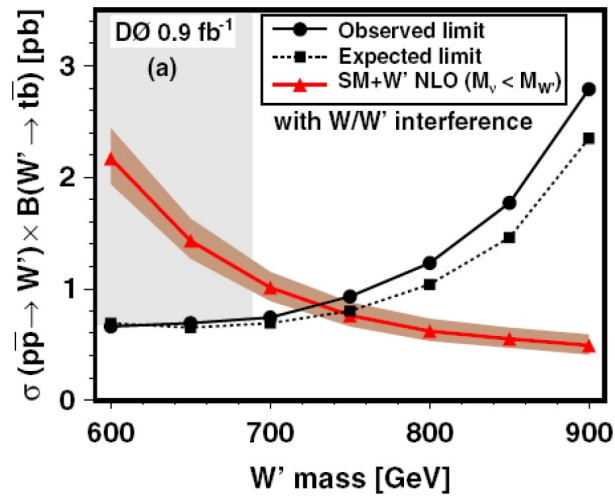


$$|M|^2 = SM + 2 \cdot a_{ud}^L \cdot a_{tb}^L \text{ (Interference of W and W')} +$$

$$+ [(a_{ud}^L)^2 (a_{tb}^L)^2 + (a_{ud}^R)^2 (a_{tb}^R)^2] W' + [(a_{ud}^L)^2 (a_{tb}^R)^2 + (a_{ud}^R)^2 (a_{tb}^L)^2] W'$$



$W' \rightarrow tb$ D0 results 0.9 fb^{-1}



Search for production of single top quarks via flavor-changing neutral currents at the Tevatron.

$$\frac{\kappa_f}{\Lambda} g_s \bar{f} \sigma^{\mu\nu} \frac{\lambda^a}{2} t G_{\mu\nu}^a + h.c.$$

f : u -quark, or c -quark

G : gauge field tensor of gluon

κ_f : strength of $\bar{t}ug$ or $\bar{t}cg$ couplings

Λ : scale of new physics

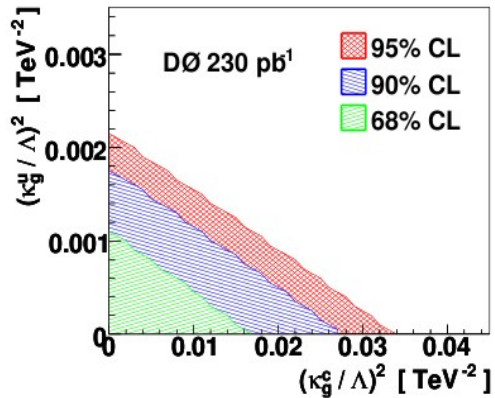
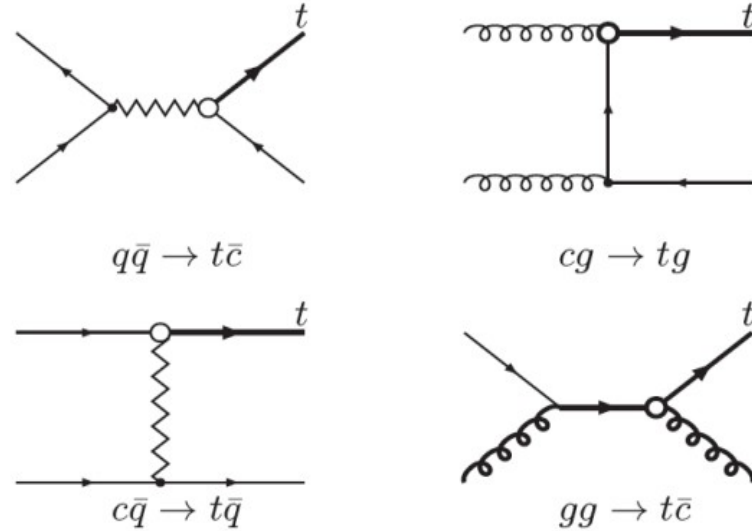


FIG. 2: Exclusion contours at various levels of confidence using 230 pb⁻¹ of D0 data in both the electron and muon channels (color online).

TABLE V: Upper limits on κ_g^c/Λ and κ_g^u/Λ , at 95% C.L.

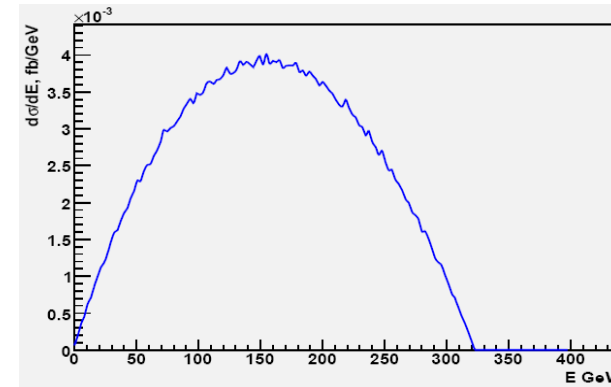
	Observed (expected) limits [TeV ⁻¹]	
	κ_g^c/Λ	κ_g^u/Λ
Electron channel	0.16 (0.19)	0.046 (0.052)
Muon channel	0.21 (0.21)	0.049 (0.050)
Combined	0.15 (0.16)	0.037 (0.041)

Prospects of a Search for a New Massless Neutral Gauge Boson at the ILC

$$\frac{1}{M^2} P_{\mu\nu} \left(\bar{q}_L \sigma^{\mu\nu} C_u \tilde{H} u_R + \bar{q}_L \sigma^{\mu\nu} C_d H d_R + \bar{l}_L \sigma^{\mu\nu} C_e H e_R + h.c \right)$$

The Feynman rules for the fermion-fermion- γ' vertices $\frac{c_f}{M^2} \cdot m_f \cdot p_\nu^{\gamma'} (\gamma^\nu \gamma^\mu - \gamma^\mu \gamma^\nu)$

The signal reaction $e^+ e^- \rightarrow t \bar{t} \gamma'$



γ' energy distribution

Background $e^+ e^- \rightarrow t \bar{t} \gamma$ $e^+ e^- \rightarrow t \bar{t} \nu \bar{\nu}$

Experimental limits for the paraphoton coupling parameter at 95% CL that may be reached at the ILC

$$ILC (\sqrt{s}=0.5 \text{ TeV}, L = 500 \text{ fb}^{-1}): \frac{M}{\sqrt{c_t}} = 0.33 \quad ILC (\sqrt{s}=1 \text{ TeV} L = 1000 \text{ fb}^{-1}): \frac{M}{\sqrt{c_t}} = 0.61$$

Prospects of mass measurements for neutral MSSM Higgs bosons in the intense-coupling regime at a linear collider.

$$\tan\beta = v_1/v_2 > 10, \quad M_h \sim M_A \sim M_H \sim 100-140 \text{ GeV.}$$

Mass measurements for CP-even h and H: $e^+e^- \rightarrow Z^0, h/H \rightarrow l^+l^-b\bar{b}$

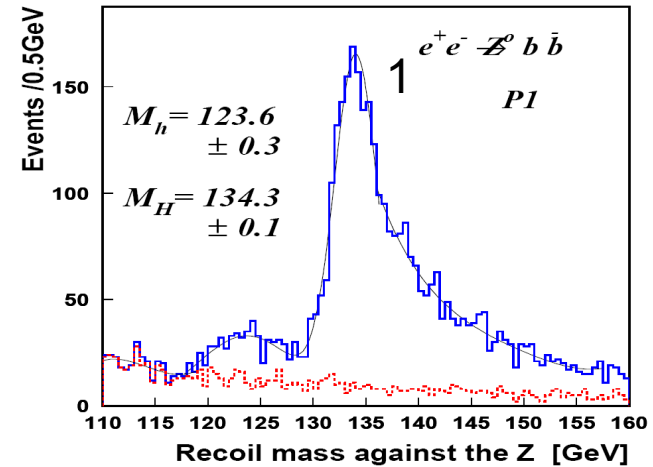
recoil mass method:

$$M_{h/H} = \hat{s} - 2\sqrt{\hat{s}}E_{Z^0} + M_{Z^0},$$

$$E_{Z^0} = E_{l^+} + E_{l^-}$$

Accuracy of h and H mass measurement:

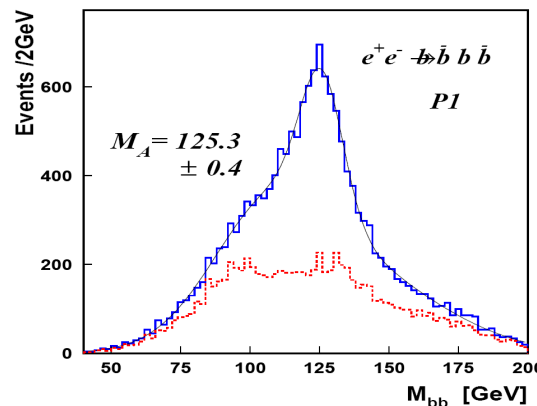
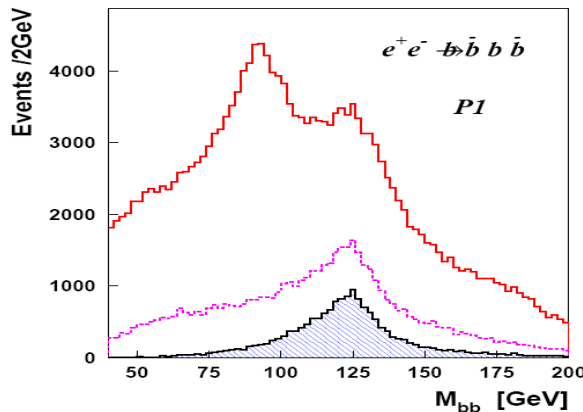
$\sim 100-300 \text{ MeV}$



Mass measurements for CP-odd A: $e^+e^- \rightarrow A + h/H \rightarrow b\bar{b}b\bar{b}$

Combinatorial bkgr.

Combinatorial mass-difference algorithm



accuracy of A mass measurement:

$\sim 300-500 \text{ MeV}$

Impact of tau polarization on the study of the MSSM charged Higgs bosons in top quark decays at the ILC

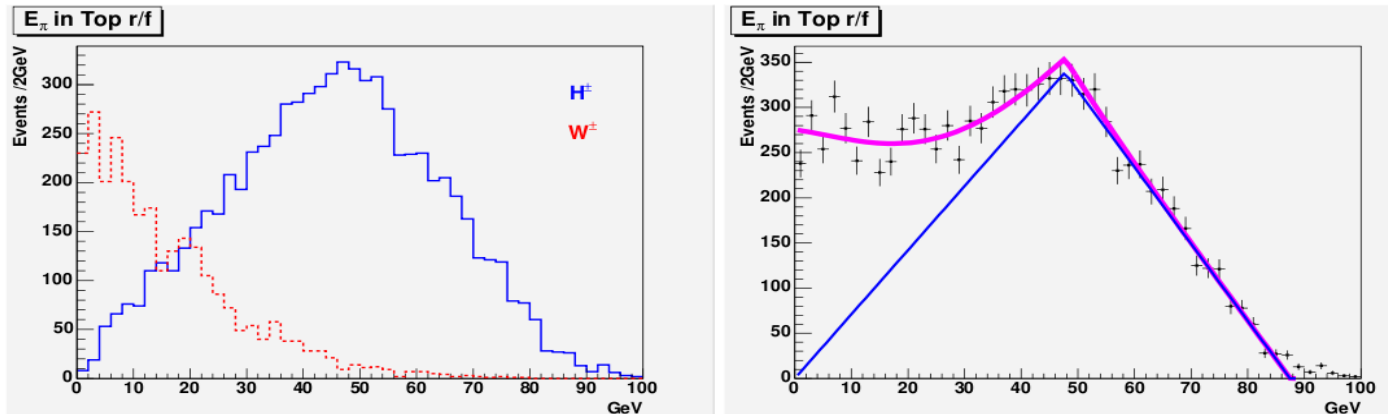
$$p\bar{p} \rightarrow t\bar{t} \rightarrow H^+ b W^- \bar{b}$$

tau-lepton polarization in decay: $H^+ \rightarrow \tau^+ \nu, \tau^+ \rightarrow \pi^+ \bar{\nu}$

$$\frac{1}{\Gamma} \frac{d\Gamma}{dy_\pi} = \frac{1}{x_{max} - x_{min}} \begin{cases} (1 - P_\tau) \log \frac{x_{max}}{x_{min}} + 2P_\tau y_\pi \left(\frac{1}{x_{min}} - \frac{1}{x_{max}} \right), & 0 < y_\pi < x_{min} \\ (1 - P_\tau) \log \frac{x_{max}}{y_\pi} + 2P_\tau \left(1 - \frac{y_\pi}{x_{max}} \right), & x_{min} < y_\pi \end{cases}$$

where $y_\pi = \frac{2E_\pi^{top}}{M_{top}}$, $x_{min} = \frac{2E_\tau^{min}}{M_{top}}$, $x_{max} = \frac{2E_\tau^{max}}{M_{top}}$, $E_\tau^{min} = \frac{M_R^2}{2M_{top}}$, $E_\tau^{max} = \frac{M_{top}}{2}$.

For the W boson, $P_\tau = -1$, and for the charged Higgs boson, $P_\tau = 1$.



fit of the shape of the pion energy spectrum yields the charged Higgs boson mass with an accuracy of about 1 GeV

Generated π^\pm energy spectra (left plots) and the fit (right plots)

Testing extra dimensions below the production threshold of Kaluza-Klein excitations.

Effective contact interaction KK gravitons and SM fields

$$L_{eff} = \left(\frac{0.91}{\Lambda_\pi^2 m_1^2} \right) T^{\mu\nu} \cdot \Delta_{\mu\nu,\rho\sigma} \cdot T^{\rho\sigma},$$

$$\Delta_{\mu\nu,\rho\sigma} = \frac{1}{2} \eta_{\mu\rho} \eta_{\nu\sigma} + \frac{1}{2} \eta_{\eta\sigma} \eta_{\nu\rho} - \left(\frac{1}{3} - \frac{\delta}{2} \right) \eta_{\eta\nu} \eta_{\rho\sigma}$$

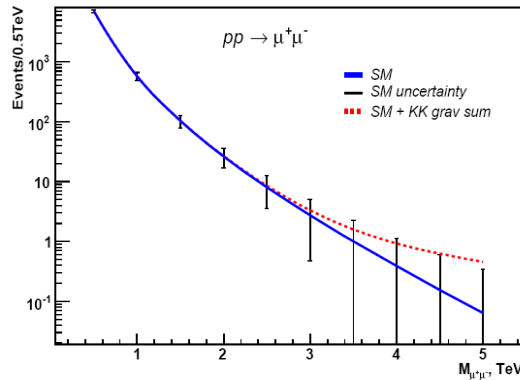
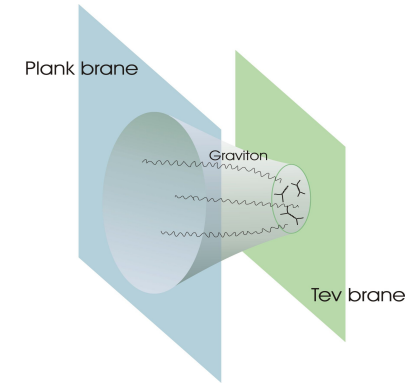
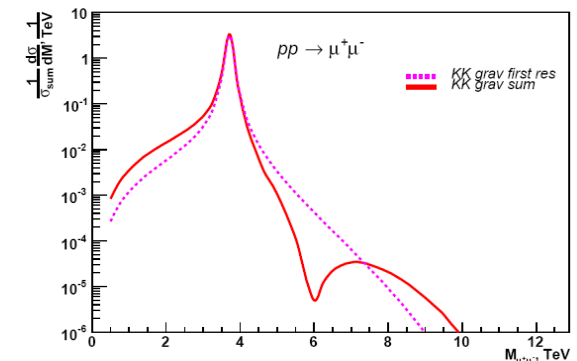


Table 1: Experimental limits for the coupling parameter at 95% CL that may be reached at the Tevatron and the LHC using Drell-Yan process for some values of integrated luminosity L .

TEVATRON ($\sqrt{s} = 1.96 \text{ TeV}$)		LHC ($\sqrt{s} = 14 \text{ TeV}$)	
$L, \text{ fb}^{-1}$	$\frac{0.91}{\Lambda_\pi^2 m_1^2}$ at 95% CL, TeV^{-4}	$L, \text{ fb}^{-1}$	$\frac{0.91}{\Lambda_\pi^2 m_1^2}$ at 95% CL, TeV^{-4}
1	1.185	10	$0.238 \cdot 10^{-2}$
2	0.995	20	$0.203 \cdot 10^{-2}$
3	0.900	30	$0.184 \cdot 10^{-2}$
5	0.790	50	$0.164 \cdot 10^{-2}$
10	0.664	100	$0.140 \cdot 10^{-2}$

interference between
the first KK mode and the rest KK tower

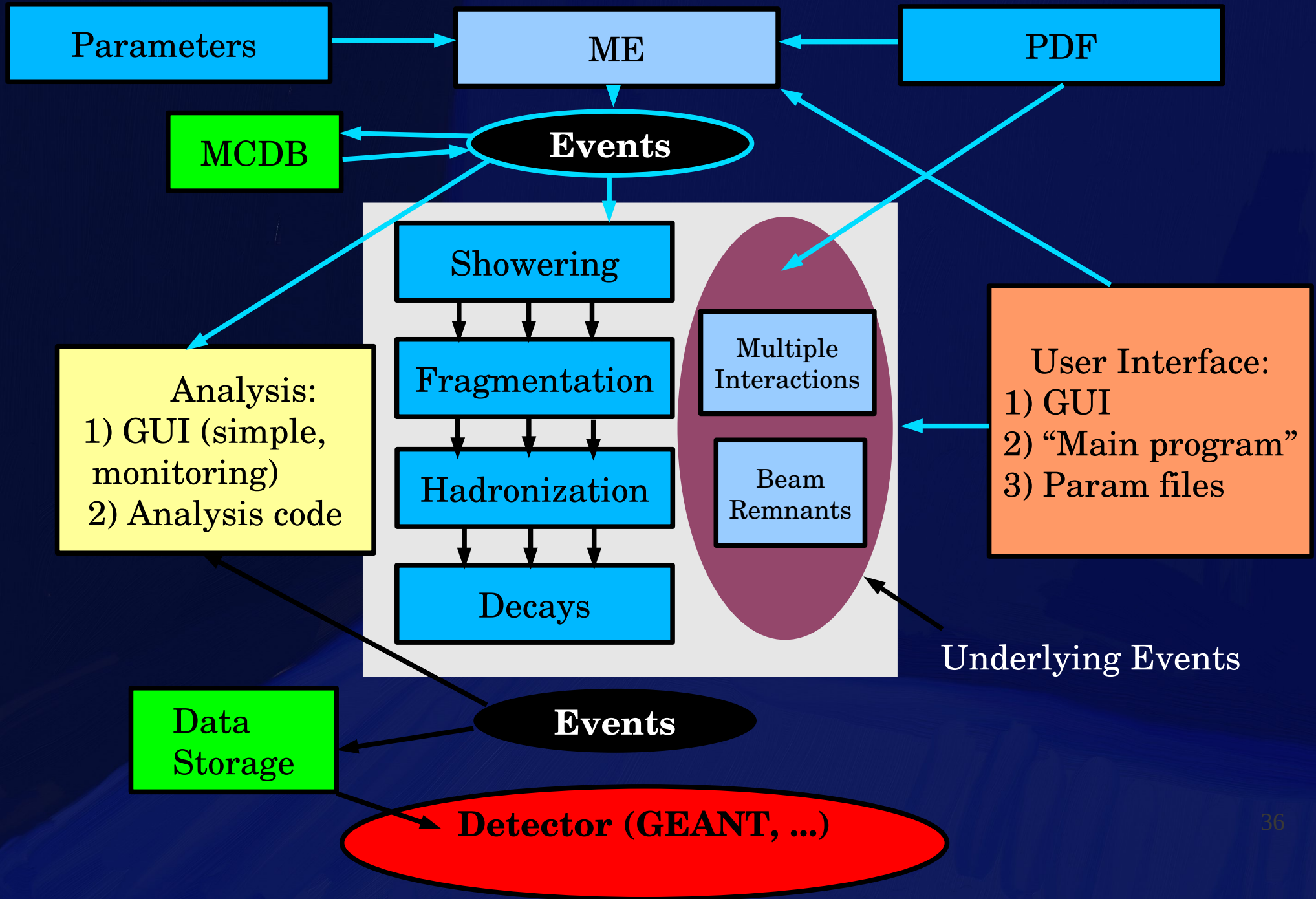


Concluding Remarks

- CompHEP with the interface to PYTHIA/HERWIG is a powerful tool for a simulation of SM/BSM physics at hadron and lepton colliders
- CompHEP can calculate cross sections, build different distributions, and generate un-weighted events
- CompHEP is compatible with all modern “Monte-Carlo industry” standards (Les Houches Accords 1, 2, 3, LHE). The CompHEP-Interfaces can be easily used and included to experimental environments
- Parallel computations both in symbolic and numerical modules are implemented as part of batch scripts
- CompHEP is integrated in D0 Environment and used in Run I and Run II
- More information on the new features in 4.5 is in arXiv:0901.4757

Backup slides

Modern Monte-Carlo Chain



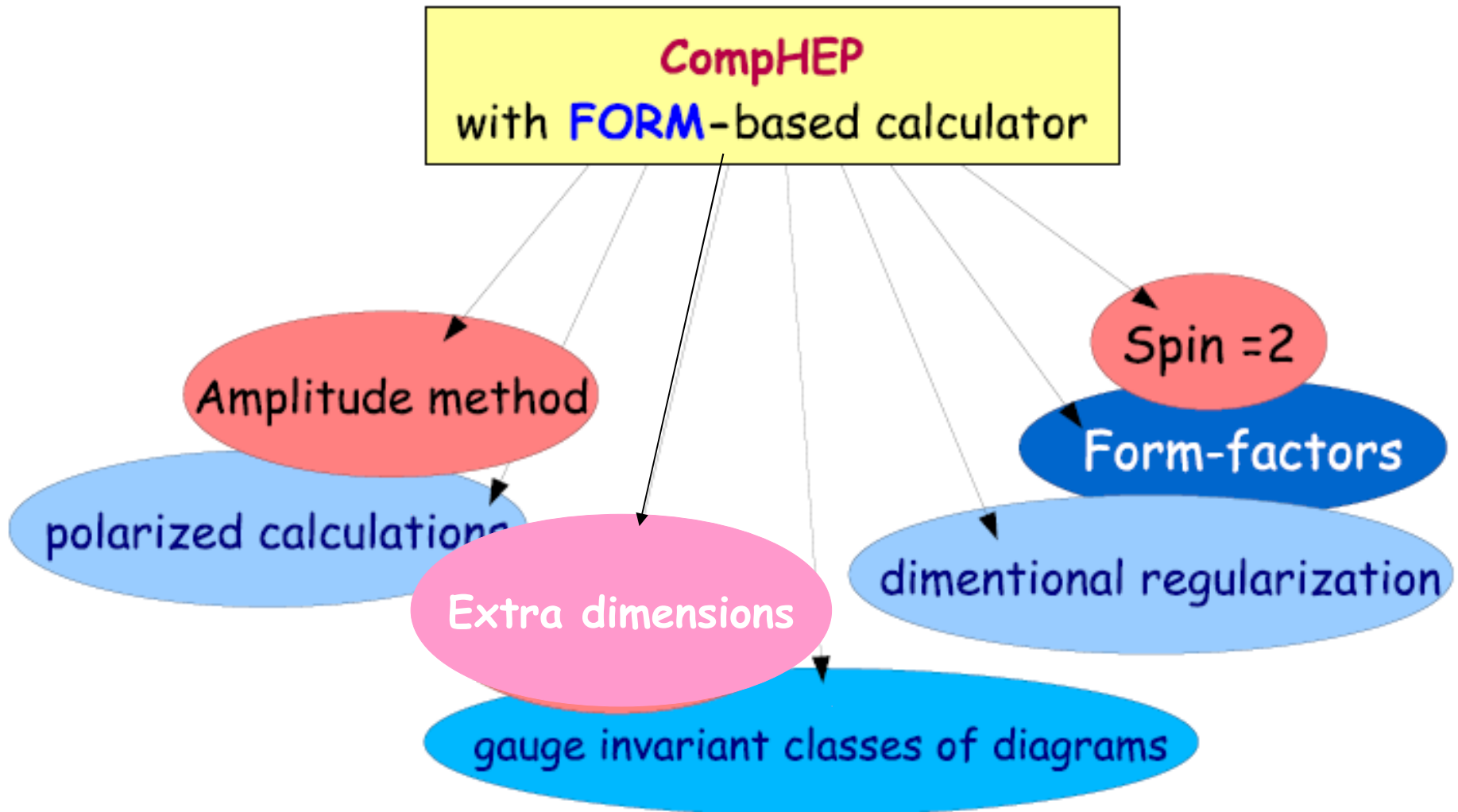
Les Houches Agreements

There are many MC generators with their own advantages and application areas. Often we are forced to use several generators for reliable calculations:

Problems:

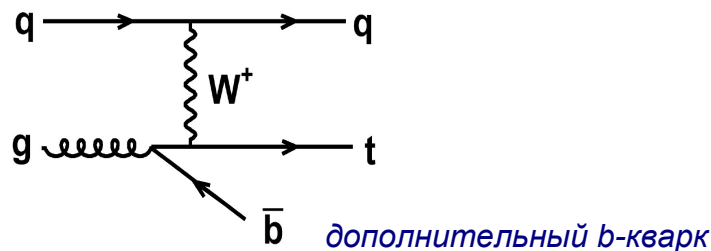
- Interfacing some MC codes (ME and SH generators): Les Houches Accord 1, Les Houches Event format
- Les Houches Accord 2: uniform interface to different PDF sets (LHAPDF package)
- Les Houches Accord 3: Interfacing SUSY codes to MC generators for parameters, spectrum, decays (SPA).
- BSM Les Houches Accord: fixing of parameter record for BSM
- Matching ME (LO/NLO) and SR(NL): CKKW, MC@NLO, Mrenna-Richardson, MLM, ...

Two symbolic passes in CompHEP: standard and FORM based



Монте-Карло генератор SingleTop. NLO (следующее за лидирующим) приближение.

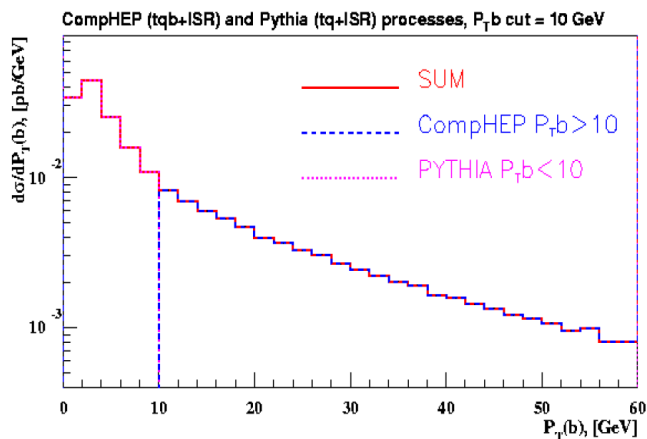
Лидирующий t -канальный процесс в NLO приближении:



События с $P_T(b) < P_T^0$ (жёсткая область) моделируются в пакете CompHEP.

События с $P_T(b) > P_T^0$ (мягкая область) моделируются в программе партонных ливней Pythia.

Комбинирование событий CompHEP и Pythia:



Относительные вклады процессов из Pythia и CompHEP определяются из условий нормировки к общему NLO сечению

$$\sigma_{NLO} = K \cdot \sigma_{Pythia} \Big|_{P_T(b) < P_T^0} + \sigma_{CompHEP} \Big|_{P_T(b) > P_T^0} \cdot$$

P_T^0 - некоторое значение поперечного импульса дополнительного b -кварка
 K -фактор подбирается из условия гладкости распределения $P_T(b)$

Генератор SingleTop адекватно моделирует NLO поправки.

Благодаря корректному алгоритму нормировки сечений и сшивки фазового пространства отсутствуют события с отрицательными весами и нет двойного учёта событий

General information and references

- CompHEP collaboration: E. Boos, V. Bunichev, M. Dubinin, L. Dudko, V. Ilyin, A. Kryukov, V. Edneral, V. Savrin (Moscow State), A. Semenov (JINR, Dubna), A.S. (Moscow State and Oxford University)
- CompHEP homepage: <http://comphep.sinp.msu.ru>
- References:
 - CompHEP 4.5 Status Report. E.Boos et al. arXiv:0901.4757
 - CompHEP: E. Boos et al., Nucl.Inst.Meth. A534:250 (2004) [hep-ph/0403123]
 - LanHEP: A. Semenov, Nucl.Inst.Meth. A393:293 (1997) [hep-ph/0403123]; 0805.0555 (hep-ph)
 - CompHEP-Interfaces: A.Belyaev et al., hep-ph/0101232
 - MCDB/HepML: S.Belov et al. Comput.Phys.Comm. 178:222 [hep-ph/0703287]

Event generation

- Events – phase space points, distributed according to $|M|^2$
- Monte-Carlo technique
- adaptive importance sampling method VEGAS
- For event generation: + stratified sampling
- Von Neumann (rejection) sampling:
 - If $g(x)$ – importance sampling function
 - $|M|^2 = f(x)$ – matrix element squared
 - Find $\omega_{\max}(x_0) = f(x_0)/g(x_0)$ and compare $\rho = \omega(x_i)/\omega_{\max} = \omega_i/\omega_{\max}$ and random number R
 - If $\rho > R$ – accept the point

Iterative Rejection sampling

- Usual efficiency in CompHEP – 0.1-1%.

What can we do with “waste”?

- Repeat the von Neumann procedure with the waste – rejected events!
- But importance sampling function is unknown...
- There is a way to calculate it

$$\omega_1 = \frac{N_{rej} \omega_0}{N_{tot} - N_{act} \omega_0 / I_{tot}}$$

- We can do several iterations, but should stop at some step.
- Stopping rule: $|I_0 - I_f| \geq \Delta I_0 + \Delta I_f$
- Real benefit: from 20% to 1000% of extra events **without** extra calculations of $|M|^2$

more details in 0807.2823

Symbolic parallel calculations

- Main idea:
 - symbolic calculation of one diagram is an independent task. The only unified point is the final binary data file.
 - Several calculation flows can be running at one time for several subsets of diagrams. The final point is to collect the binary data file
- Implemented in `./symb_batch.pl` with the option `-mp`
- 1st step! `./symb_batch.pl -help`
- Parallel calculations on one machine: `-mp N` means N symbolic calculations in parallel
- Batch system version (pbs/lsf) is being implemented
- Very easy to use!

Numerical parallel calculations

- Again, 1st step: `./num_batch.pl -help` (long and very detailed description). The script has lots of options (~30)!
- `n_compheap.exe` should be prepared! Main file is `batch.dat` in `/results` (based on `session.dat`). It can be edited by hand or via GUI and `./num_batch.pl -add` (customized subprocess added to `batch.dat`)
- Then `./num_batch.pl -run vegas` (cross section calculation for ALL subprocesses) and `./num_batch.pl -run max,evnt` (event generation)
- Parallel calculations available. Alone machine (useful for multi-CPU desktops): `-mp 3` (3 jobs are calculated simultaneously); computer clusters (with a batch system installed): `-lsf` and `-pbs`
- Many ways to present and monitor results and calculation process (see help)
- Very easy to use!

MCDB – Monte-Carlo events Data Base

Team: S.Belov, L. Dudko, A.Ribon, A.S. (JINR, MSU, CERN, Oxford)

Motivation:

- Verified MC simulation of complicated processes requires sophisticated expertise and expert knowledge
- A physics group in a collaboration requests experts and/or MC generator authors to create MC samples for the particular process
- The same physics processes are investigated by various physics groups, the same MC samples can be used in different analyses

The main motivation – to make MC event samples, prepared by experts, available for various physics groups

MCDB tasks:

- The database has to be available via the Web and Grid
- Using CASTOR/GRID technologies to keep/upload/download MC samples
- Simple and intuitive interface for events authors and end-users to find and manipulate event samples

MCDB: technical details

- Frontends: a Web site (mcdb.cern.ch) and API (via HepML) and Grid
- Backend: SQL for metadata and CASTOR for data
- Keep parton and particle level events with standard interface to the next level of simulation (PYTHIA/HERIWG, simu. software), based on LHA I
- Store detailed documentation for each set of event samples
- Provide communication between users and experts via MCDB web pages
- Direct programming interface of the collaboration software to LCG MCDB
- **Divided in two zones:**
 - **public area:** users can search for/browse the DB and download event files
 - **restricted area:** authors (experts) change MCDB content: upload and describe new event files, change the existed files and reply to user's comments

MCDB encourages end-users to cite event sample author's papers in case the events are used in physics analyses!

Paper: hep-ph/0703287