CalcHEP and HEPMDB

High Energy Physics Model Database

practical introduction and tutorial

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Southampton University & Rutherford Appleton LAB

OUTLINE

- **CalcHEP**
  - ***introduction/tutorial***
    - models and symbolic session
    - numerical session and kinematical distributions
    - event generation
    - automatic generation of the Feynman rules from the Lagrangian with LanHEP
  - ***CalcHEP Batch Interface and tutorial***
- **High Energy Physics Model Database (HEPMDB)**
  - ***Pre-History of HEPMDB and its idea***
  - ***HEPMD, present status and tutorial***
  - ***Future plans***

Practical points

- The WEB page of CalcHEP
  http://theory.npi.msu.su/~pukhov/calchep.html

- The WEB page of HEPMDB
  http://hepmdb.soton.ac.uk/

- e-mail for your questions/remarks
  calchep@googlegroups.com
  hepmdb@soton.ac.uk
  a.belyaev@soton.ac.uk,

- some useful Manuals
  http://www.hep.phys.soton.ac.uk/~belyaev/manual

Exercise#xx

- exercises
  for those who wants to practice and start using CalcHEP right-away

Practical points

HEP

CalcHEP and HEPMDB: practical introduction and tutorial

by Dr. Alexander Belyaev (University of Southampton & Rutherford Lab)

Friday, May 4, 2012 from **15:00** to **16:00** (Europe/Zurich)
at CERN (40-R-C10)
EVO link --- http://evo.caltech.edu/evoNext/koala.jnlp?meeting=MtM8Ma2t2aDuDu9D92Ds9t

Description The practical introduction into CalcHEP package and High Energy Physics Model database will be given together with the follow-up tutorial.

CalcHEP is a powerful tool for theoretical, phenomenological and experimental studies in High Energy Physics (HEP). CalcHEP allows users to automate the calculations and studies starting from the introduction of any user-defined model and ending by the realistic event simulation, kinematical distributions and analysis. In its present status CalcHEP can be considered is a ready setup for study of LHC physics within Standard Model and Beyond.
On the other hand HEPMDB is a convenient centralized storage environment for HEP models, and can accommodate, via web interface to the HPC cluster, the validation of models, evaluation of LHC predictions and event generation-simulation chain. The ultimate goal of HEPMDB is perform an effective LHC data interpretation isolating the most successful theory for explaining the LHC observations.

Material CalcHEP manual | External Links | HEPMDB contribution to Les Houches 2011

CalcHEP

was born as a CompHEP in 1989: MGU-89-63/140

- **Author(s)**
  - *Alexander Pukhov*

    (AB and Neil Christensen have joined the project in 2009)

    http://theory.npi.msu.su/~pukhov/calchep.html
- **Idea**
  - ***The effective study of HEP phenomenology passing at high level of automation from your favorite model to physical observables such as decay width, branching ratios, cross sections kinematic distributions, parton-level events, ...***
- **Analogous packages** **(matrix element generators)**

  http://www.ippp.dur.ac.uk/montecarlo/BSM/

  - ***CompHEP (Boos et al)***
  - ***MadGraph/MadEvent (Maltoni, Stelzer)***
  - ***Grace/Helas (Fujimoto et al)***
  - ***FeynArts/FeynCalc/FormCalc (Hahn et al)***
  - ***WHIZARD,O'mega (Moretti, Ohl, Reuter)***
  - ***Sherpa (Krauss et al)***

Features/Limitations of CalcHEP

- **Can evaluate any decay and scattering processes within any (user defined) model!**

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- **Tree-level processes**
- **Squared Matrix Element calculation**
  - *no spin information for outgoing particles – spin averaged amplitude*

Features/Limitations of CalcHEP

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- **Tree-level processes**
- **Squared Matrix Element calculation**
  - *no spin information for outgoing particles – spin averaged amplitude*
- **Limit on number of external legs (involved particles) and number of diagrams**
  - *official limit – 8 , unofficial – none*
  - *limit is set from the practical point of view:*
    - 2 → 6 (1→7) set the essential time/memory limit
    - number of diagrams ~ 500 set the disk space and the time limit

http://theory.npi.msu.su/~pukhov/calchep.html

CalcHEP - a package for calculation of Feynman diagrams and integration over multi-particle phase space.

Authors - Alexander Pukhov, Alexander Belyaev, Neil Christensen

The main idea in CalcHEP was to enable one to go directly from the Lagrangian to the cross sections and distributions effectively, with the high level of automation. The package can be compiled on any Unix platform.

General information

- Main facilities , Old Versions , Acknowledgments News&Bugs

Manual

- calchep_man_3.3.0.pdf (manual for version 3.3, March 23, 2012)
- HEP computer tools (Lecture by Alexander Belyaev)

See also: Dan Green, High Pt physics at hadron colliders (Cambrige University Press)

Codes download.

- Licence • Installation • References&Contributions

CalcHEP code for UNIX: • version 3.3.6 (April 27, 2012)

Models:

- MSSM(24.06.2011) • NMSSM23(07.05.2011) • CPVMSSM(03.05.2012) • LeptoQuarks

Universal Extra Dimension Models: • 5DSM • 6DSM SUSY models for CompHEP • By A.Semenov

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Relative packages on Web:

Packages for model generation: • LanHEP • FeynRules

RGE and spectrum calculation: • SuSpect • Isajet • SoftSUSY • SPheno • CPsuperH • NMHDecay

Particle widths in MSSM: • SDECAY • HDECAY

Parton showers: • PYTHIA

Email contact: **calchep@googlegroups.com**

- Main Page

http://theory.npi.msu.su/~pukhov/calchep.html

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Quick start with CalcHEP: practical notes on the installation

- **Download code, read manual and compile**
  http://theory.npi.msu.su/~pukhov/calchep.html
  - tar -zxvf calchep_3.*x.x*.tgz
  - cd calchep_3.*x.x*
  - make

  the current version is 3.*x.x* = 3.0
- **Create work directory**
  - From calchep_3.*x.x* directory:

  ./mkUsrDir *../calc_work*
- **Supported operating system**
  - Linux, IRIX, IRIX64, HP-UX, OSF1, SunOS, Darwin, CYGWIN (see *getFlags* file)

Exercise#1: Install CalcHEP

Starting CalcHEP

- **cd ../calc_work**

- **Files:**

bin -> .... /calchep_3.x.x/bin
calchep
calchep_batch
calchep.ini
models/
results/
tmp/

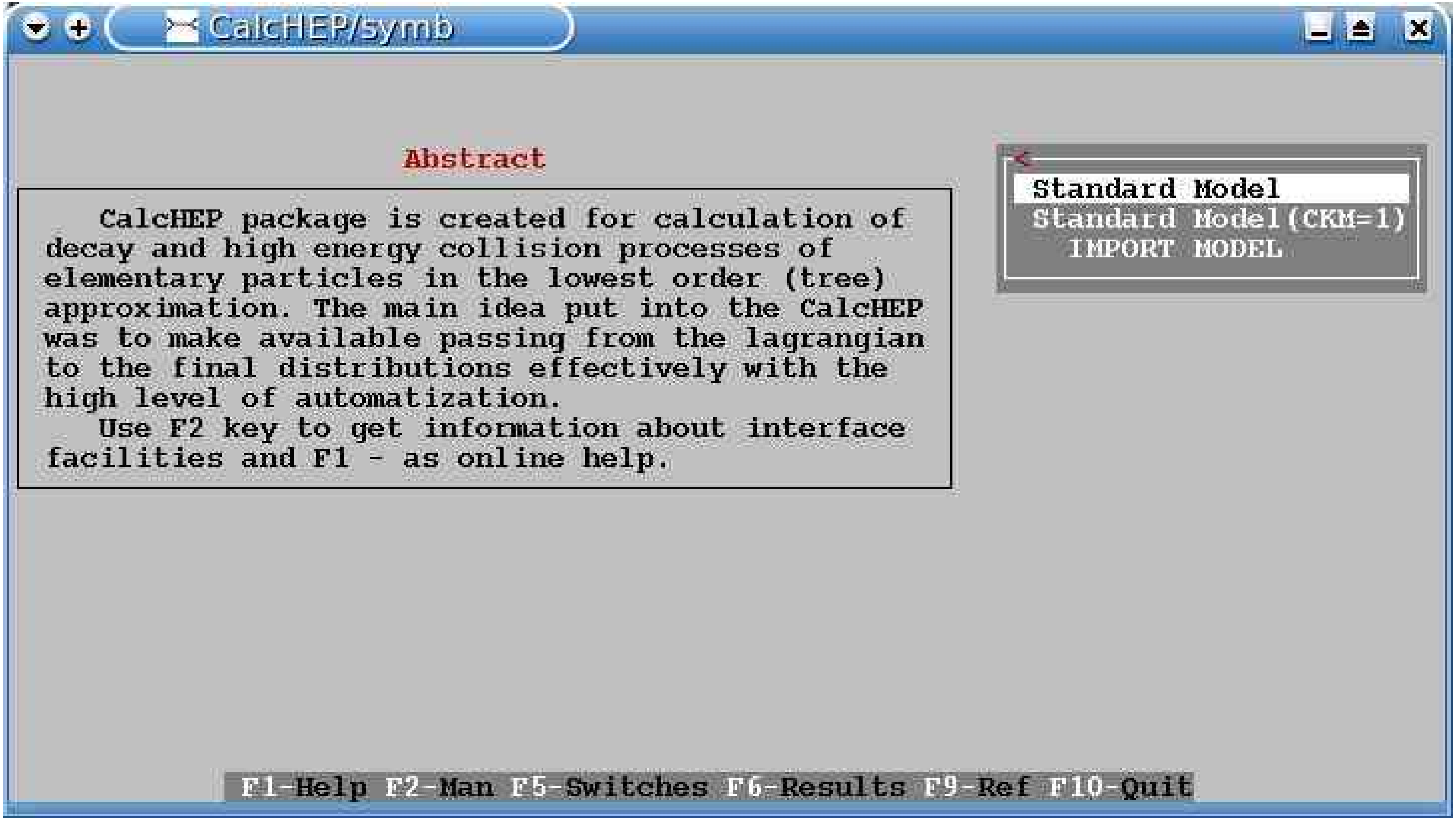
- **Start:**

./calchep

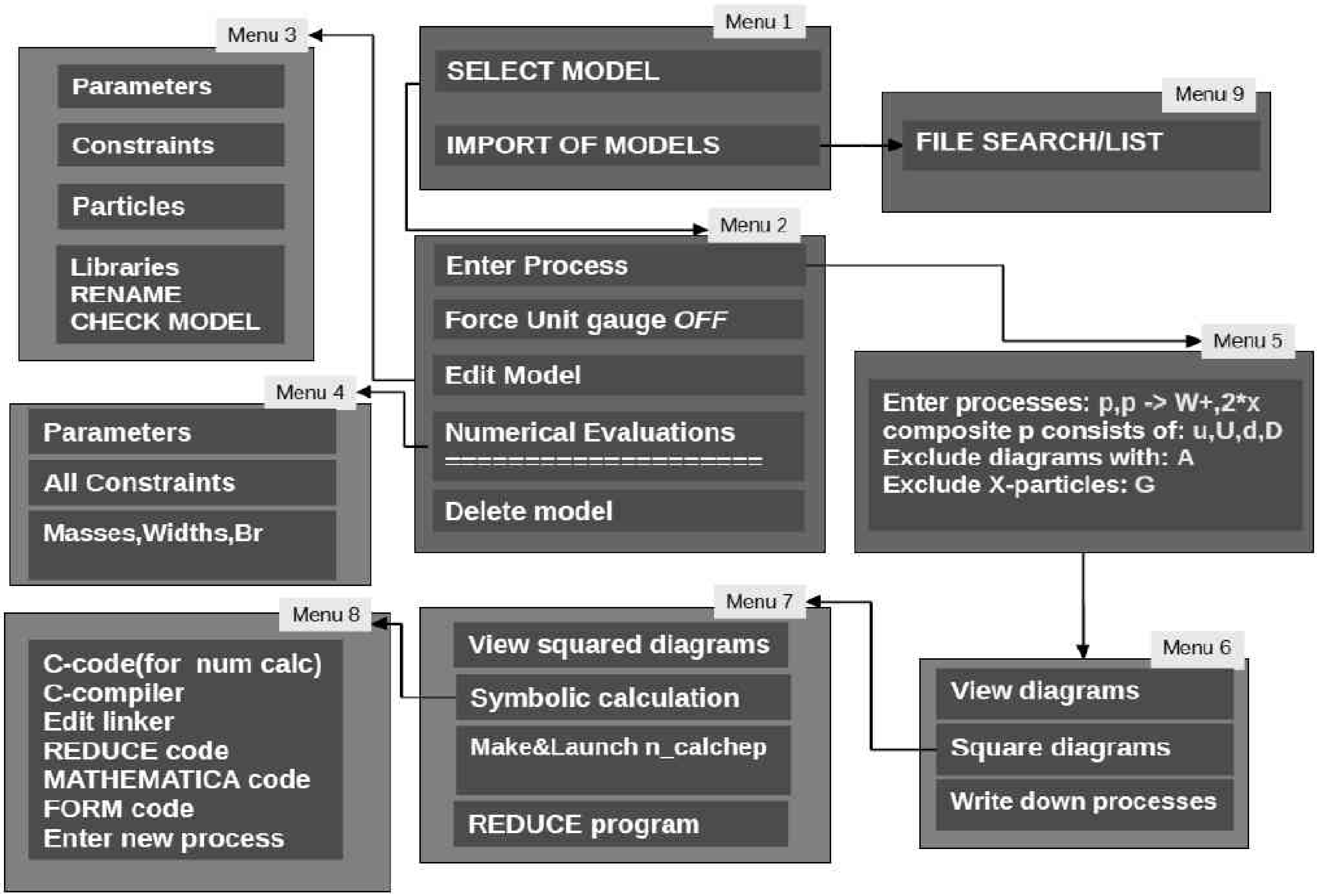
Starting CalcHEP

```
CalcHEP/symb

    CalcHEP - a package for Calculation in High Energy Physics
            Version 3.3.6:  Last correction April 27,2012


  Authors: Alexander Pukhov(Skobeltsyn Institute of Nuclear Physics,Moscow)
           Alexander Belyaev(University of Southampton)
           Neil Chistensen (University of Pittsburgh)

  For contacts:                email: <calchep@googlegroups.com>
                               http://theory.sinp.msu.ru/~pukhov/calchep.html


  The BSMs for CalcHEP were developed in collaboration with:
        G.Belanger,F.Boudjema,A.Semenov

  The package contains codes written by:
        M.Donckt,V.Edneral,V.Ilyin,D.Kovalenko,A.Kryukov,G.Lepage,A.Semenov

                     Press F9 or click the box below to get

                    References, Contributions, Acknowledgments

 This information is available during the session by means of the F9 key
```

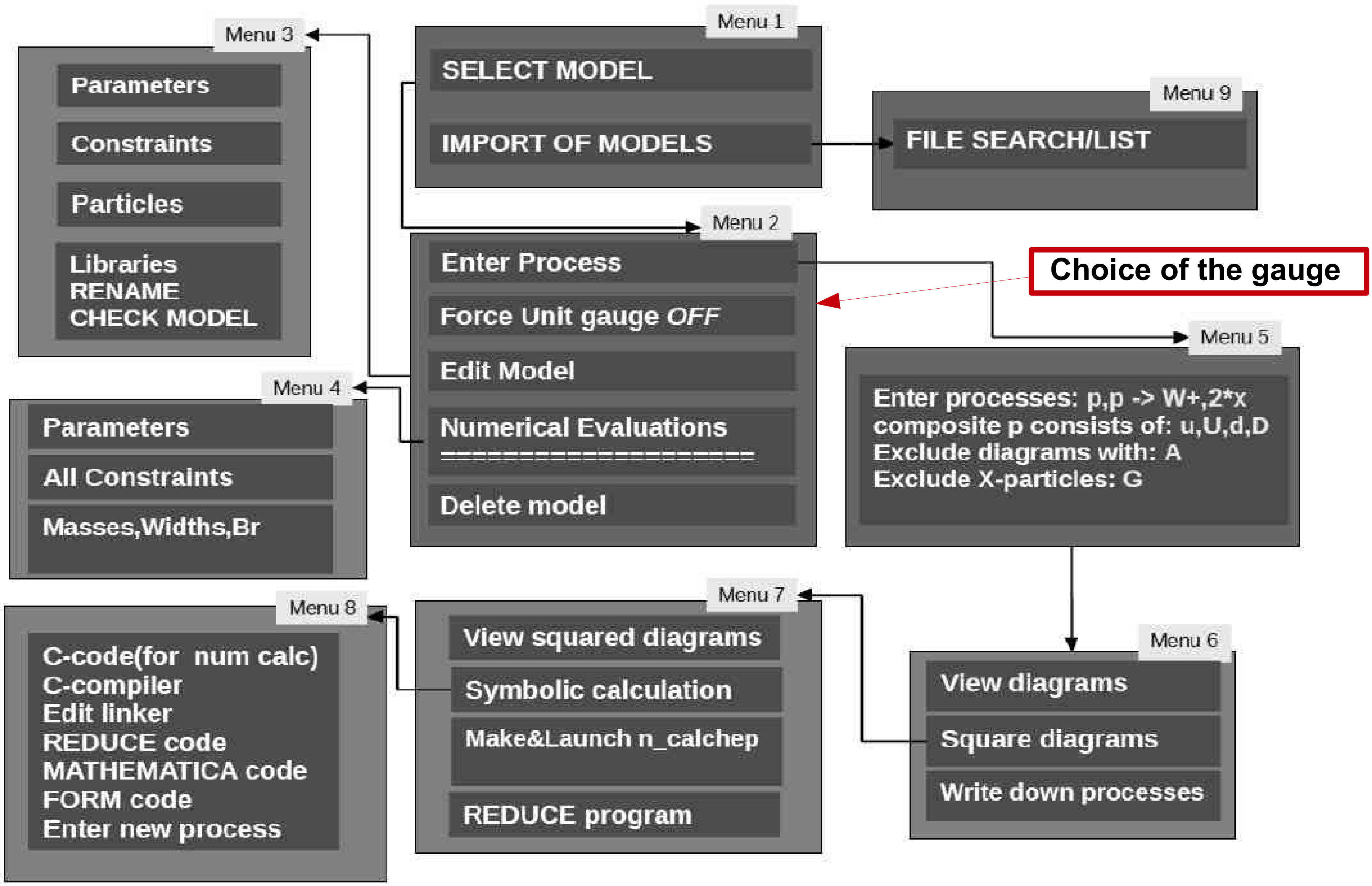
Starting CalcHEP



CalcHEP menu structure: symbolic part

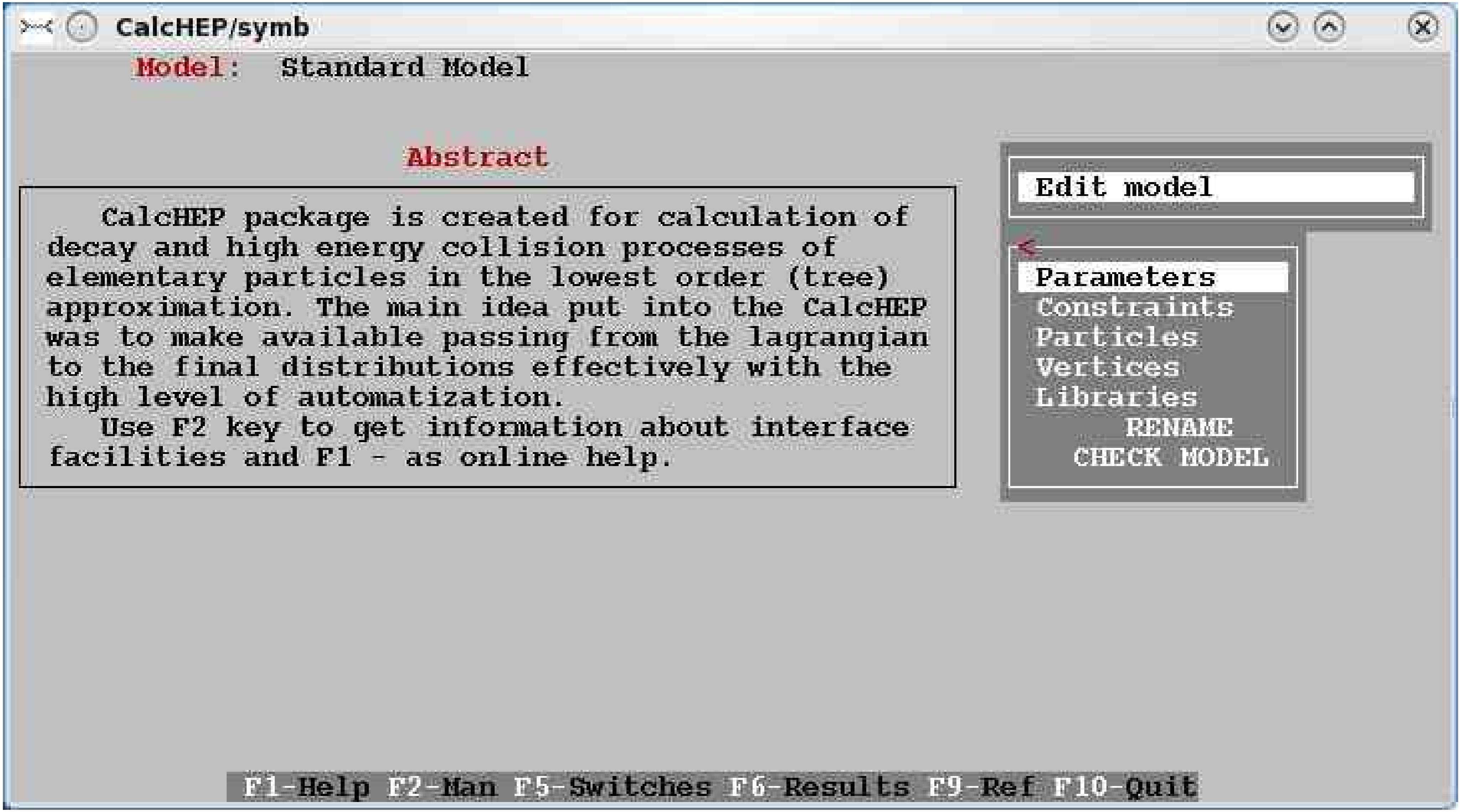


CalcHEP menu structure: symbolic part



Model Structure

Parameters **Constraints**
Particles **Vertices**



Particles: prtcl*xx*.mdl (spins 0,1/2,1,3/2,2)

CalcHEP/symb

Particles

Clr-Del-Size-Read-ErrMes

Full name	A	A+	number	2*spin	mass	width	color	aux	>LaTex(A)<	>LaTeX(A+) <
gluon	G	G	21	2	0	0	8	G	g	g
photon	A	A	22	2	0	0	1	G	\gamma	\gamma
Z-boson	Z	Z	23	2	MZ	wZ	1	G	Z	Z
W-boson	W+	W-	24	2	MW	wW	1	G	W^+	W^-
Higgs	h	h	25	0	Mh	!wh	1		h	h
electron	e	E	11	1	0	0	1		e^-	e^+
e-neutrino	ne	Ne	12	1	0	0	1	L	\nu_e	\bar{\nu}_e
muon	m	M	13	1	Mm	0	1		\mu^-	\mu^+
m-neutrino	nm	Nm	14	1	0	0	1	L	\nu_\mu	\bar{\nu}_\mu
tau-lepton	l	L	15	1	Ml	0	1		\tau^-	\tau^-
t-neutrino	nl	Nl	16	1	0	0	1	L	\nu_\tau	\bar{\nu}_\tau
d-quark	d	D	1	1	0	0	3		d	\bar{d}
u-quark	u	U	2	1	0	0	3		u	\bar{u}
s-quark	s	S	3	1	Ms	0	3		s	\bar{s}
c-quark	c	C	4	1	Mc	0	3		c	\bar{c}
b-quark	b	B	5	1	Mb	0	3		b	\bar{b}
t-quark	t	T	6	1	Mt	wt	3		t	\bar{t}

F1-F2-Xgoto-Ygoto-Find-Write

Particles: prtcl*xx*.mdl

CalcHEP/symb

Particles

Clr-Del-Size-Read-ErrMes

Full name	A	A+	number	2*spin	mass	width	color	aux	>LaTex(A)<	>LaTeX(A+)
gluon	G	G	21	2	0	0	8	G	g	g
photon	A	A	22	2	0	0	1	G	\gamma	\gamma
Z-boson	Z	Z	23	2	MZ	wZ	1	G	Z	Z
W-boson	W+	W-	24	2	MW	wW	1	G	W^+	W^-
Higgs	h	h	25	0	Mh	!wh	1		h	h
electron	e	E	11	1	0	0	1		e^-	e^+
e-neutrino	ne	Ne	12	1	0	0	1	L	\nu_e	\bar{\nu}_e
muon	m	M	13	1	Mm	0	1		\mu^-	\mu^+
m-neutrino	nm	Nm	14	1	0	0	1	L	\nu_\mu	\bar{\nu}_\mu
tau-lepton	l	L	15	1	Ml	0	1		\tau^-	\tau^-
t-neutrino	nl	Nl	16	1	0	0	1	L	\nu_\tau	\bar{\nu}_\tau
d-quark	d	D	1	1	0	0	3		d	\bar{d}
u-quark	u	U	2	1	0	0	3		u	\bar{u}
s-quark	s	S	3	1	Ms	0	3		s	\bar{s}
c-quark	c	C	4	1	Mc	0	3		c	\bar{c}
b-quark	b	B	5	1	Mb	0	3		b	\bar{b}
t-quark	t	T	6	1	Mt	wt	3		t	\bar{t}

Higgs boson width will be calculated `on the fly`

F1-F2-Xgoto-Ygoto-Find-Write

Independent parameters: vars*xx*.mdl

CalcHEP/symb

Parameters 1

Clr Del Size Read ErrMes

Name	Value	> Comment
alfEMZ	0.0078180608	MS-BAR electromagnetic alpha(MZ)
alfSMZ	0.1172	Srtong alpha(MZ) for running mass calculation
Q	100	scale for running mass calculation
GG	1.238	Running Strong coupling. The given value doesn't matter.
SW	0.481	MS-BAR sine of the electroweak mixing angle
s12	0.221	Parameter of C-K-M matrix (PDG96)
s23	0.041	Parameter of C-K-M matrix (PDG96)
s13	0.0035	Parameter of C-K-M matrix (PDG96)
Mm	0.1057	muon mass
Ml	1.777	tau-lepton mass
McMc	1.2	Mc(Mc)
Ms	0	s-quark mass (pole mass, PDG96)
MbMb	4.25	Mb(Mb)
Mtp	175	t-quark pole mass
MZ	91.187	Z-boson mass
Mh	120	higgs mass
wt	1.59	t-quark width (tree level 1->2x)
wZ	2.49444	Z-boson width (tree level 1->2x)
wW	2.08895	W-boson width (tree level 1->2x)

F1 F2 Xgoto Ygoto Find Write

Dependent parameters(constraints): func*xx*.mdl

```
CalcHEP/symb
                              Constraints
Clr-Del-Size-Read-ErrMes
 Name     |> Expression
EE        |sqrt(16*atan(1.)*alfEMZ)        % electromagnetic constant
CW        |sqrt(1-SW^ 2)                   % cos of the Weinberg angle
MW        |MZ*CW                           % W-boson  mass
c12       |sqrt(1-s12^ 2)                  % parameter  of C-K-M matrix
c23       |sqrt(1-s23^ 2)                  % parameter  of C-K-M matrix
c13       |sqrt(1-s13^ 2)                  % parameter  of C-K-M matrix
Vud       |c12*c13                         % C-K-M matrix element
Vus       |s12*c13                         % C-K-M matrix element
Vub       |s13                             % C-K-M matrix element
Vcd       |-s12*c23-c12*s23*s13            % C-K-M matrix element
Vcs       |c12*c23-s12*s23*s13             % C-K-M matrix element
Vcb       |s23*c13                         % C-K-M matrix element
Vtd       |s12*s23-c12*c23*s13             % C-K-M matrix element
Vts       |-c12*s23-s12*c23*s13            % C-K-M matrix element
Vtb       |c23*c13                         % C-K-M matrix element
qcdOk     |initQCD(alfSMZ,McMc,MbMb,Mtp)
 Mb       |MbEff(Q)*one(qcdOk)
 Mt       |MtEff(Q)*one(qcdOk)
 Mc       |McEff(Q)*one(qcdOk)

F1-F2-Xgoto-Ygoto-Find-Write
```

Dependent parameters(constraints): func*xx*.mdl

- **MSSM case**

```
CalcHEP/symb
Constraints
Clr Del Size Read ErrMes
  Name   |> Expression
 smOk    |saveSM(MbMb,Mtp,SW,alfSMZ,alfEMZ,MZ,Ml)*saveSLHA(1)
mssmOk   |suspectEwsbMSSMc(smOk,tb,MG1,MG2,MG3,Am,Al,At,Ab,MH3,mu,Ml2,Ml3,Mr2,Mr3,Mq2,Mq
%mssmOk|isajetEwsbMSSMc(smOk,tb,MG1,MG2,MG3,Am,Al,At,Ab,MH3,mu,Ml2,Ml3,Mr2,Mr3,Mq2,Mq3
%mssmOk|softSusyEwsbMSSMc(smOk,tb,MG1,MG2,MG3,Am,Al,At,Ab,MH3,mu,Ml2,Ml3,Mr2,Mr3,Mq2,M
%mssmOk|sphenoEwsbMSSMc(smOk,tb,MG1,MG2,MG3,Am,Al,At,Ab,MH3,mu,Ml2,Ml3,Mr2,Mr3,Mq2,Mq3
*drho    |deltarho(mssmOk)
*gmuon   |gmuon(mssmOk)
*bsgnlo|bsgnlo(mssmOk)
*bsmumu|bsmumu(mssmOk)
*LEPlim|masslimits(mssmOk)
 Mb      |MbEff(Q)*one(smOk)
 Mt      |MtEff(Q)*one(smOk)
*SC      |sqrt(alphaQCD(Q)/12.566371)*one(smOk)
 Mh      |Mh(mssmOk)
 MHH     |MHH(mssmOk)
 MHc     |MHc(mssmOk)
 alpha   |alpha(mssmOk)
 MNE1    |MNE1(mssmOk)
 MNE2    |MNE2(mssmOk)
 MNE3    |MNE3(mssmOk)
 MNE4    |MNE4(mssmOk)
 MC1     |MC1(mssmOk)
 MC2     |MC2(mssmOk)
 MSG     |MSG(mssmOk)
 MSne    |MSne(mssmOk)
```

Feynman rules: lgrng*xx*.mdl

CalcHEP/symb

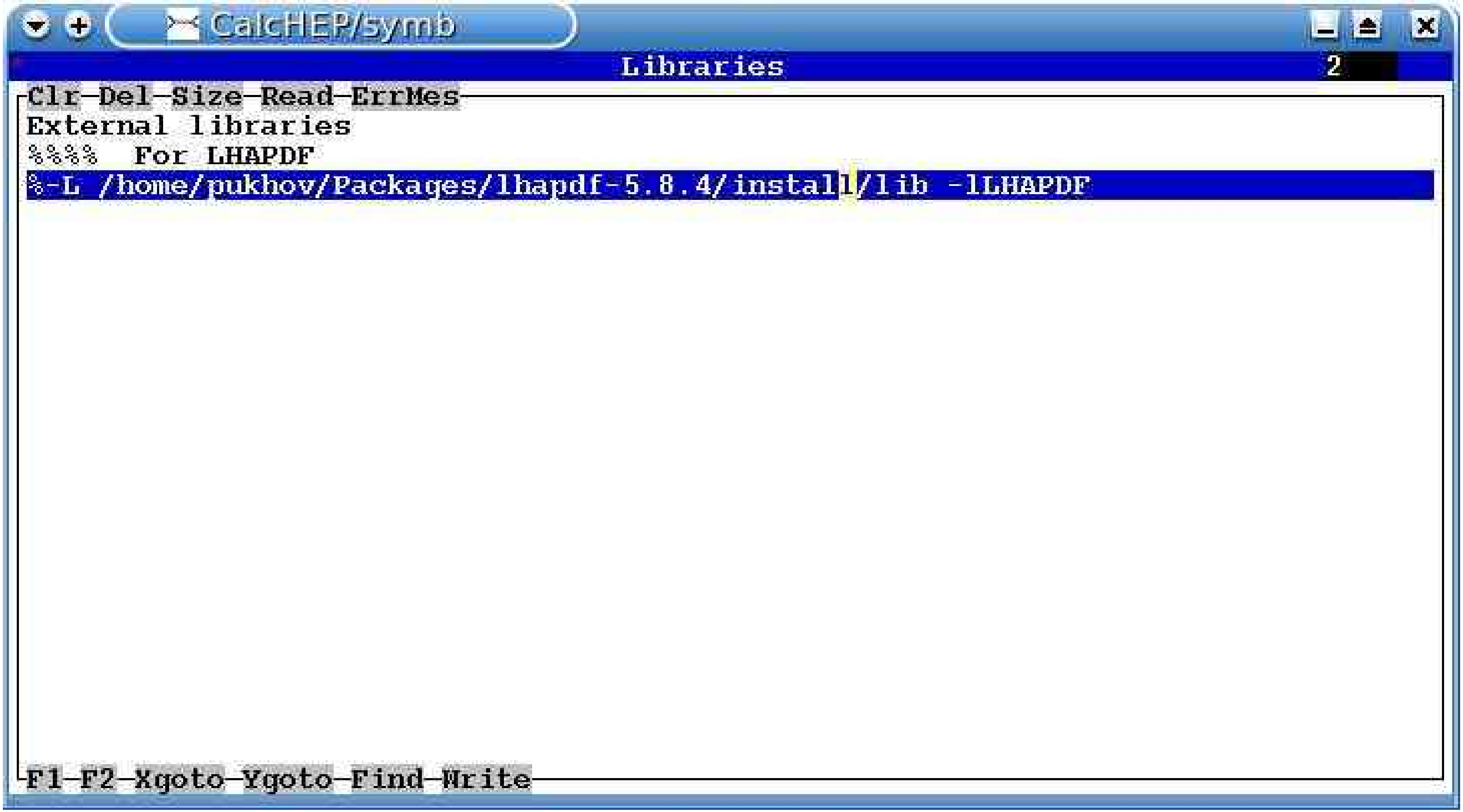
Vertices

Clr-Del-Size-Read-ErrMes

A1	A2	A3	A4	> Factor <|	> Lorentz part
h	W+	W-		EE*MW/SW	m2.m3
h	Z	Z		EE/(SW*CW^2)*MW	m2.m3
h	h	h		-(3/2)*EE*Mh^2/(MW*SW)	1
h	h	h	h	(-3/4)*(EE*Mh/(MW*SW))^2	1
h	h	Z	Z	(1/2)*(EE/(SW*CW))^2	m3.m4
h	h	W+	W-	(1/2)*(EE/SW)^2	m3.m4
M	m	h		-EE*Mm/(2*MW*SW)	1
L	l	h		-EE*Ml /(2*MW*SW)	1
C	c	h		-EE*Mc/(2*MW*SW)	1
S	s	h		-EE*Ms/(2*MW*SW)	1
B	b	h		-EE*Mb/(2*MW*SW)	1
T	t	h		-EE*Mt /(2*MW*SW)	1
E	e	A		-EE	G(m3)
M	m	A		-EE	G(m3)
L	l	A		-EE	G(m3)
Ne	e	W+		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)
Nm	m	W+		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)
Nl	l	W+		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)
E	ne	W-		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)
M	nm	W-		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)
L	nl	W-		EE/(2*Sqrt2*SW)	G(m3)*(1-G5)

F1-F2-Xgoto-Ygoto-Find-Write

External Libraries: extlib*xx*.mdl



Details of symbolic session

- *The syntax for the input is:* `P1[,P2] -> P3,P4 [,...,[N*x]]`
  'P1'..'P4' are particle names, N is a number of particles
- ***hadron/composite particle scattering***
  'p,p->W+,b,B'
  unknown particle are assumed to be composite:
  'p' consists of u,U,d,D,s,S,c,C,b,B,G
- ***wild cards/names for outgoing particles***
  'H -> 2*x'
- ***intermediate particles can be non-trivially excluded***
  'W+ > 2, A>1, Z>3'
- ***particle width can be calculated 'on-fly'***
  '!wtop' , i.e. '!' symbol should be used in the prt table
- ***particles spin***
  0, 1/2, 1, 3/2, 2

Exercise#2
calculate SM Higgs boson Decay width and branching ratios as a function of Higgs boson mass

Principle KEYS for CalcHEPs GUI

Enter menu selection (forward)

Exit menu selection (back)

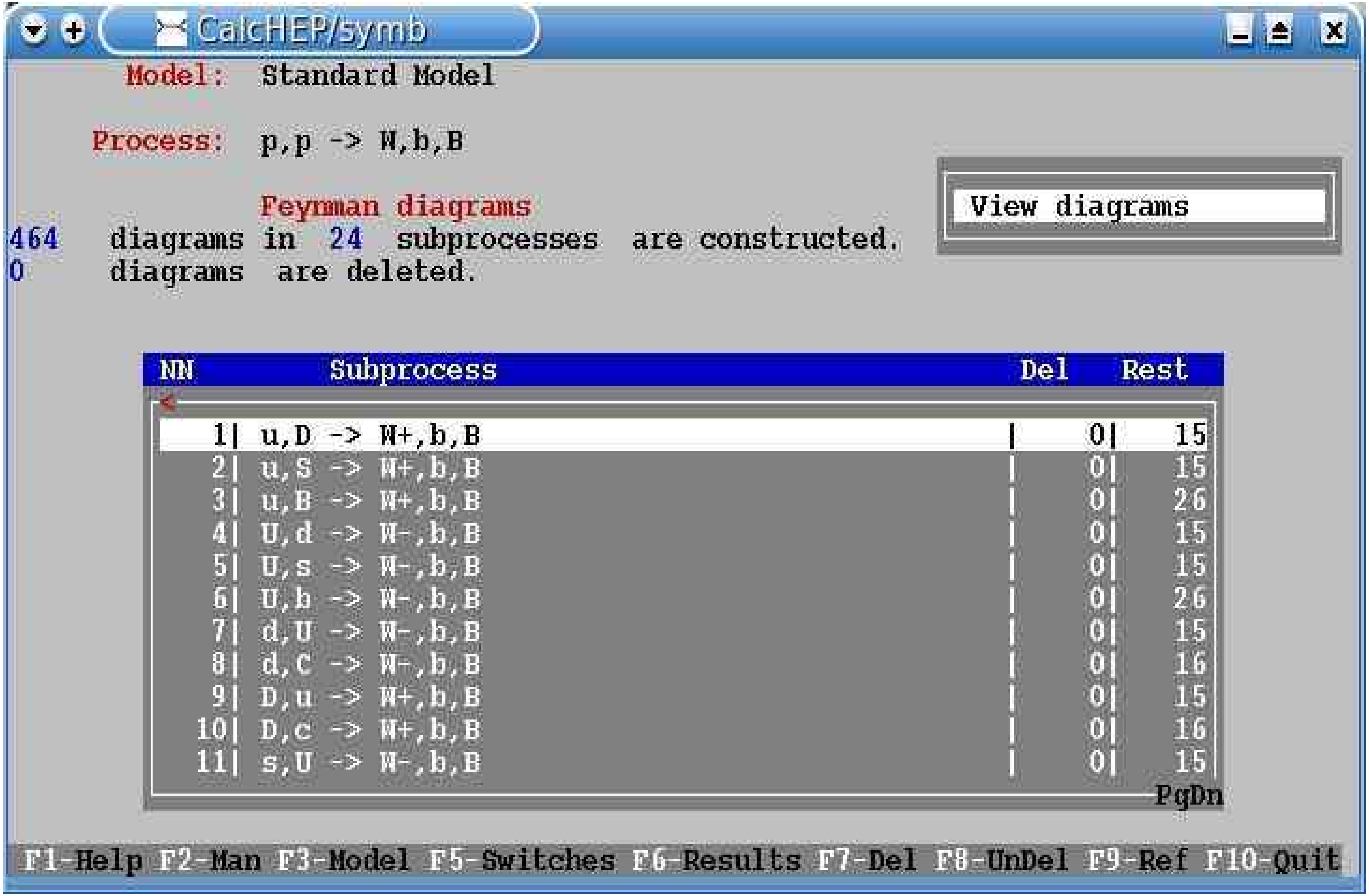
Help!

Example of the symbolic calculation

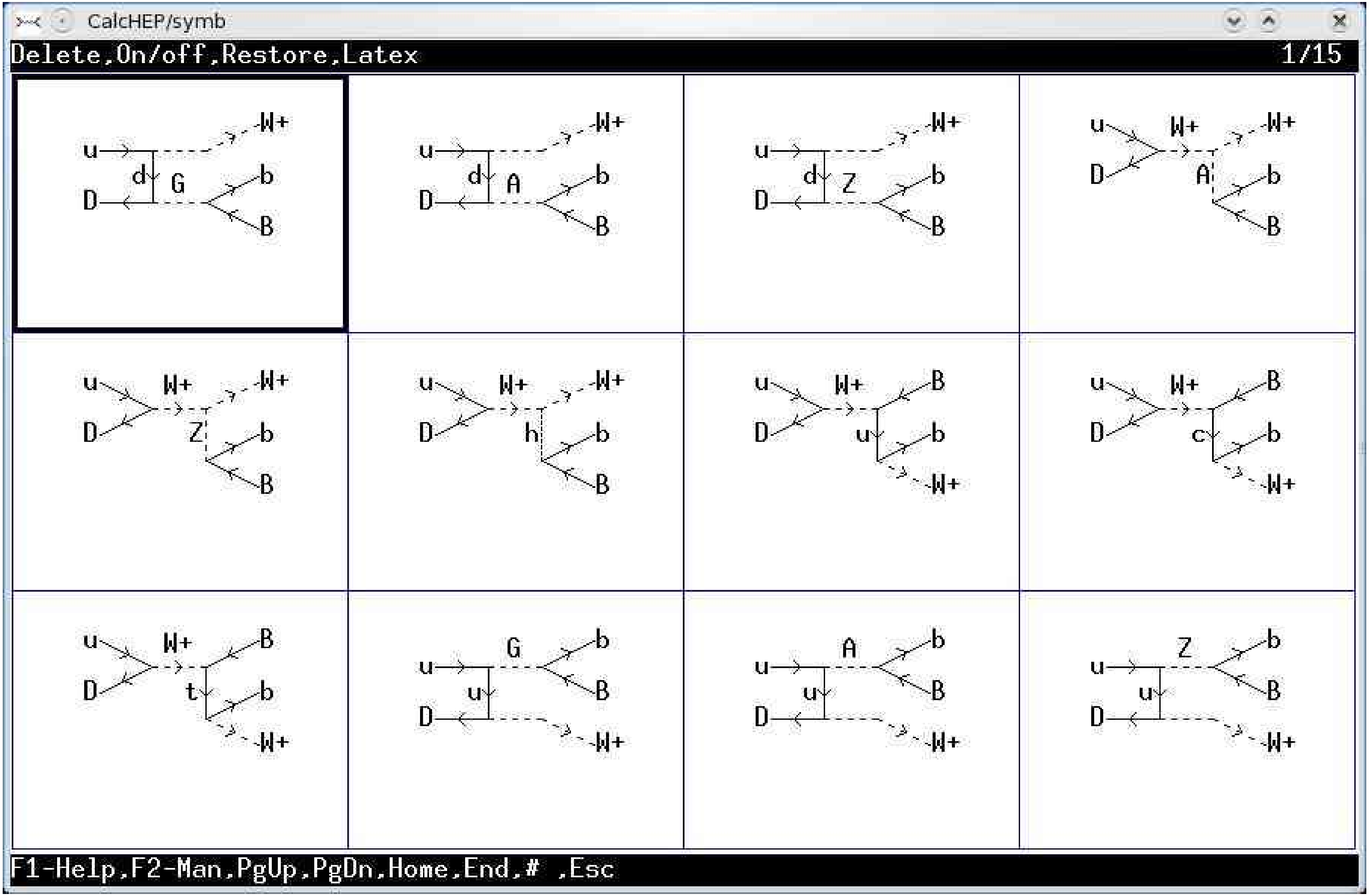
```
CalcHEP/symb
      Model:  Standard Model

              List of particles (antiparticles)

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

Enter  process: p,p -> W,b,B
composit 'p'  consists of: u,U,d,D,s,S,c,C,b,B,G
composit 'W'  consists of: W+,W-
Exclude diagrams with
```

Example of the symbolic calculation

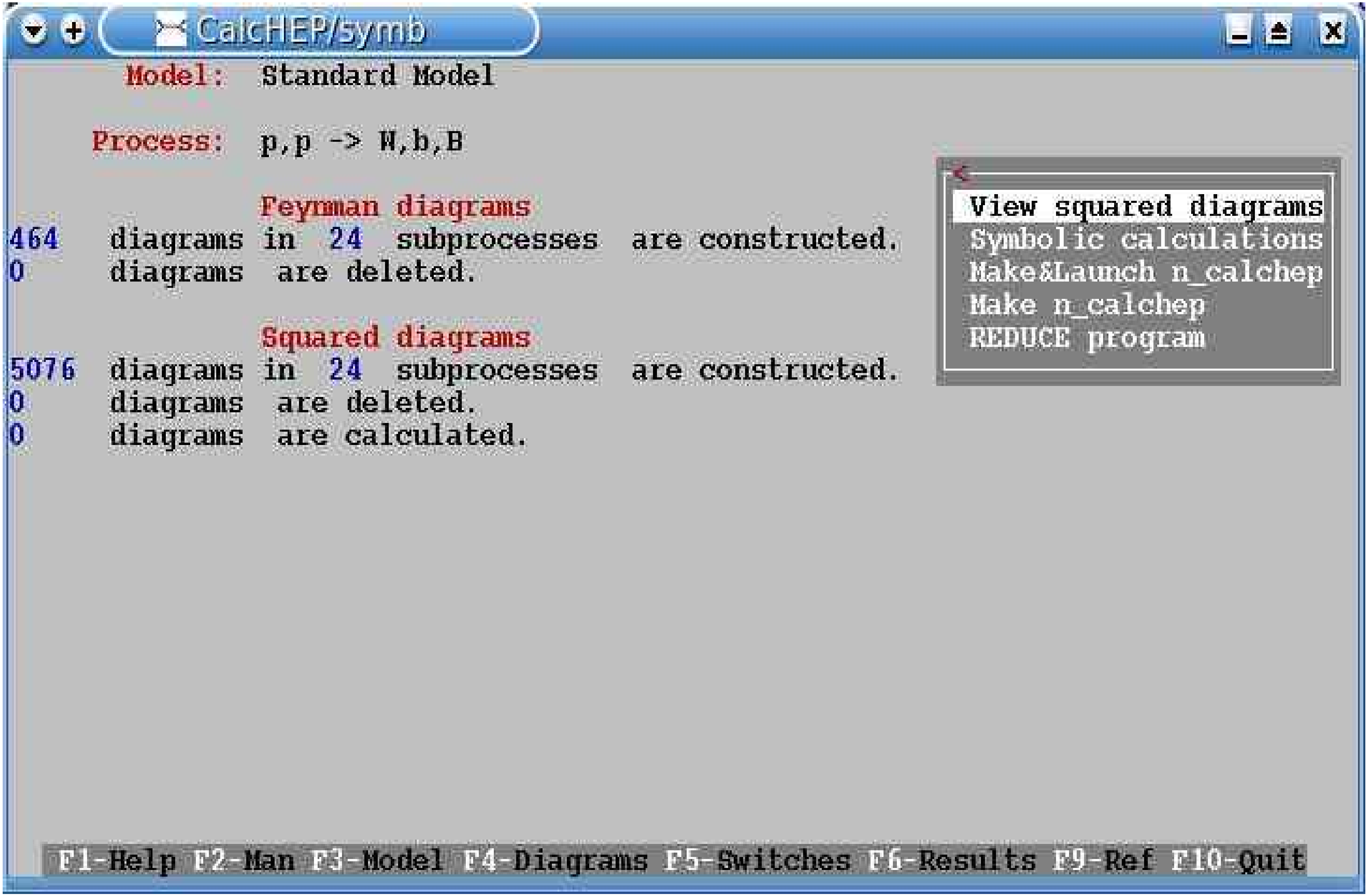
Example of the symbolic calculation



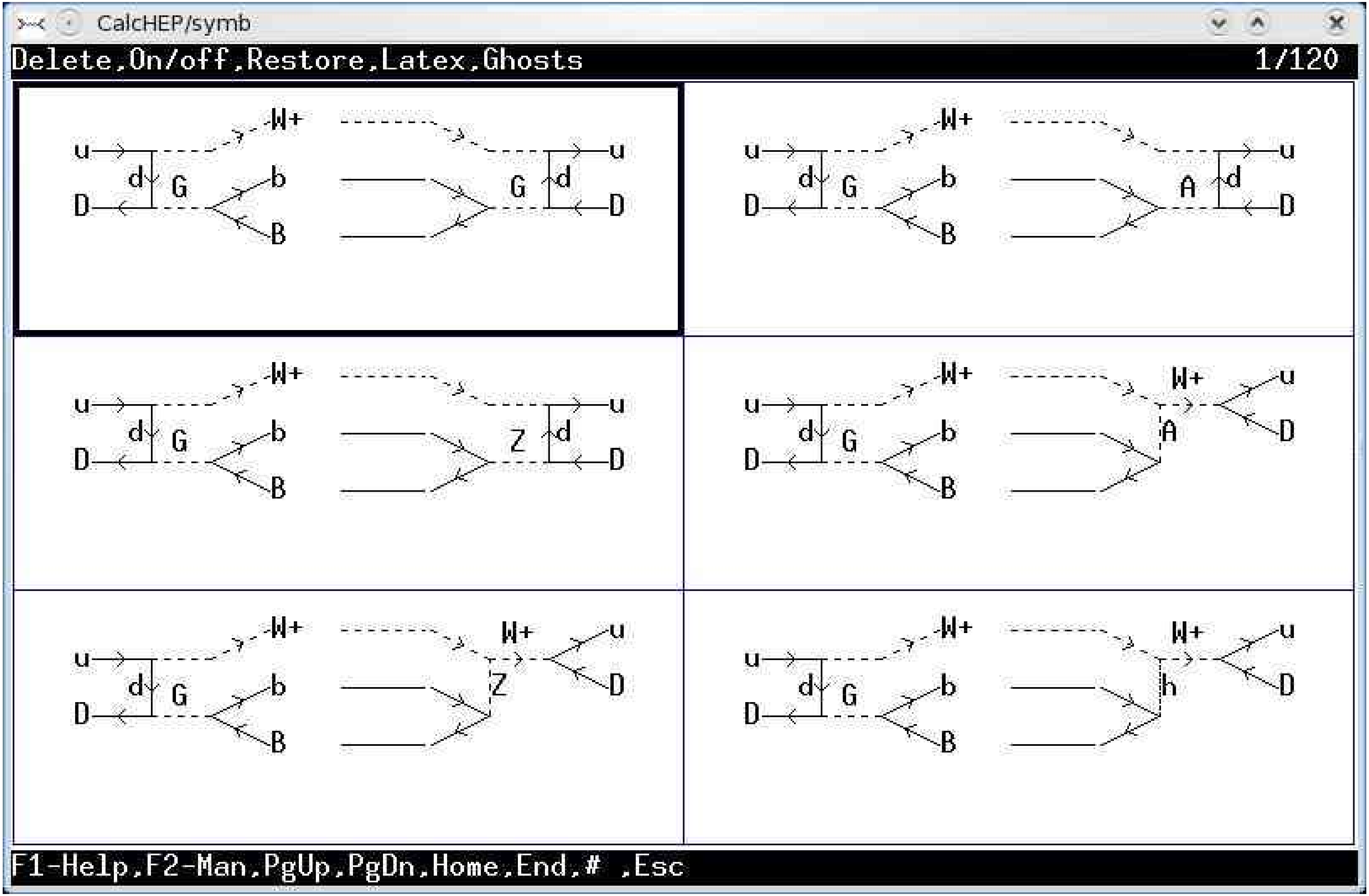
Example of the symbolic calculation



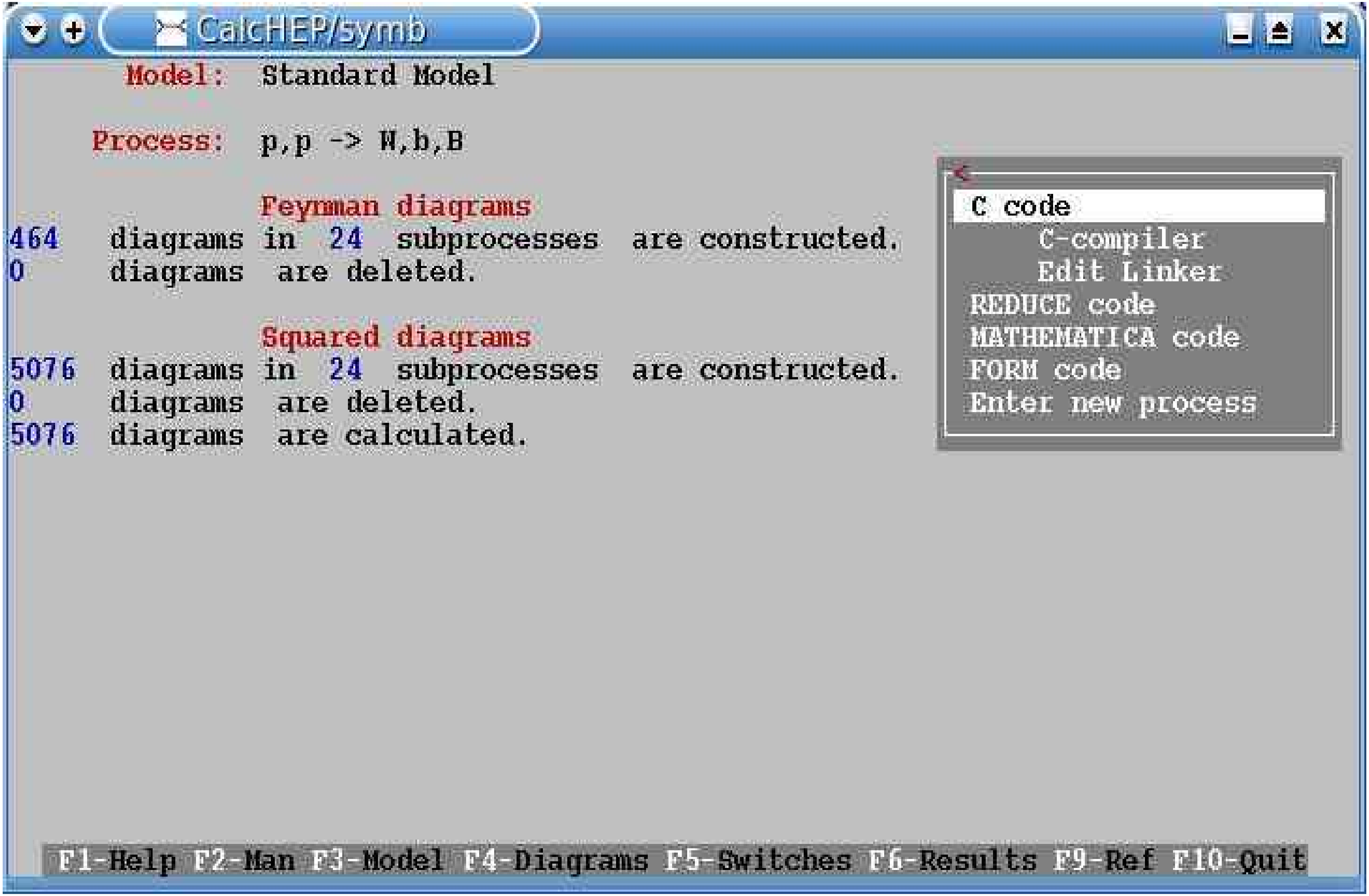
Example of the symbolic calculation



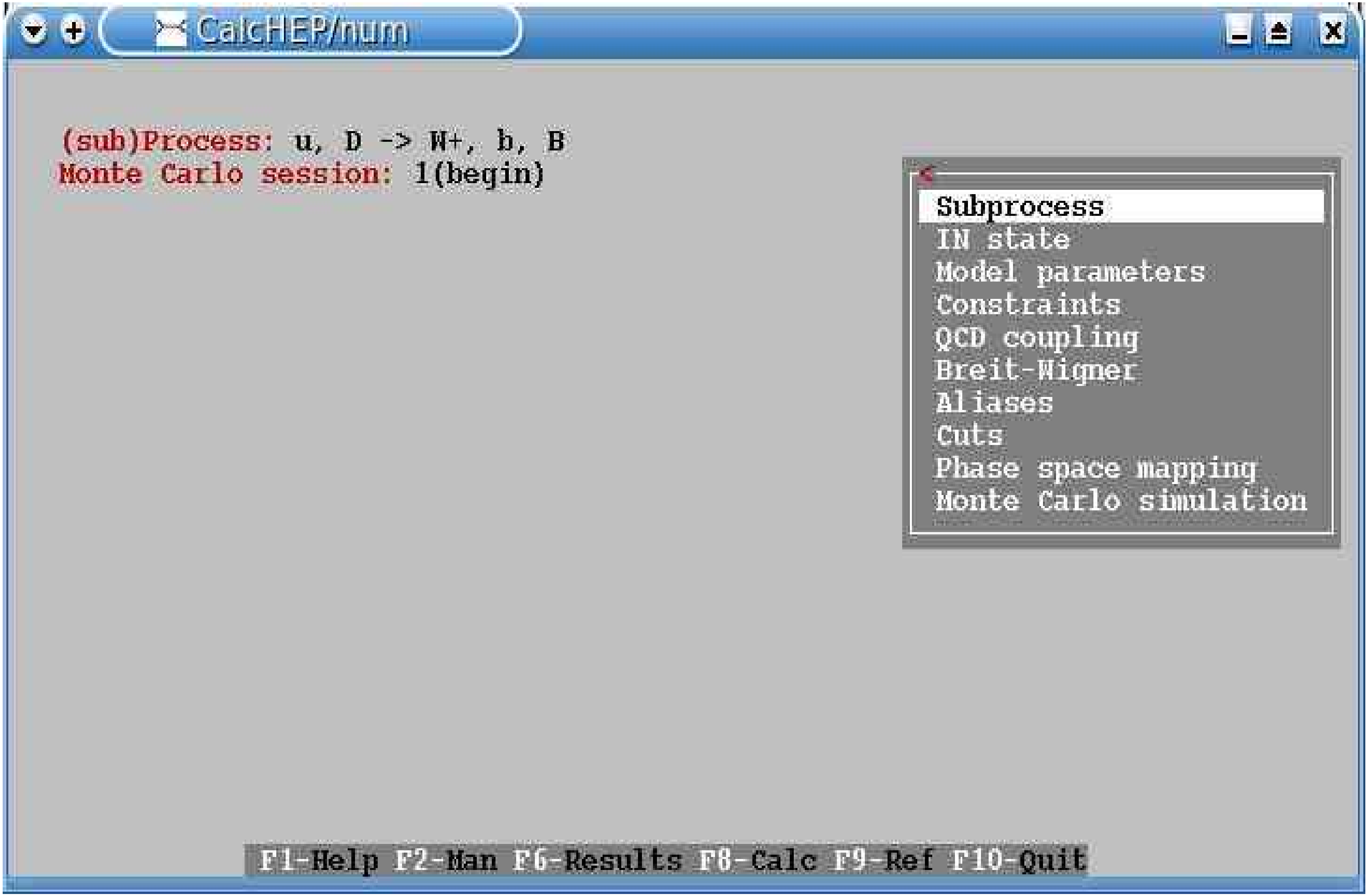
Example of the symbolic calculation



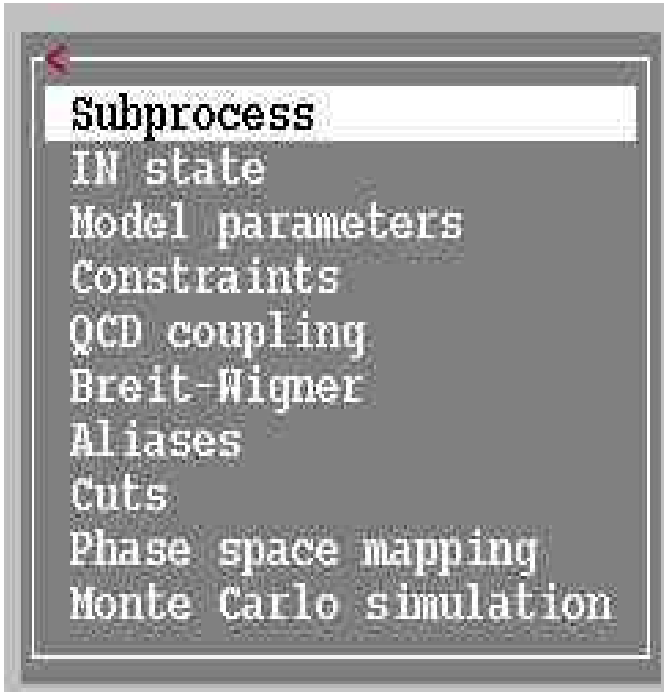
Example of the symbolic calculation

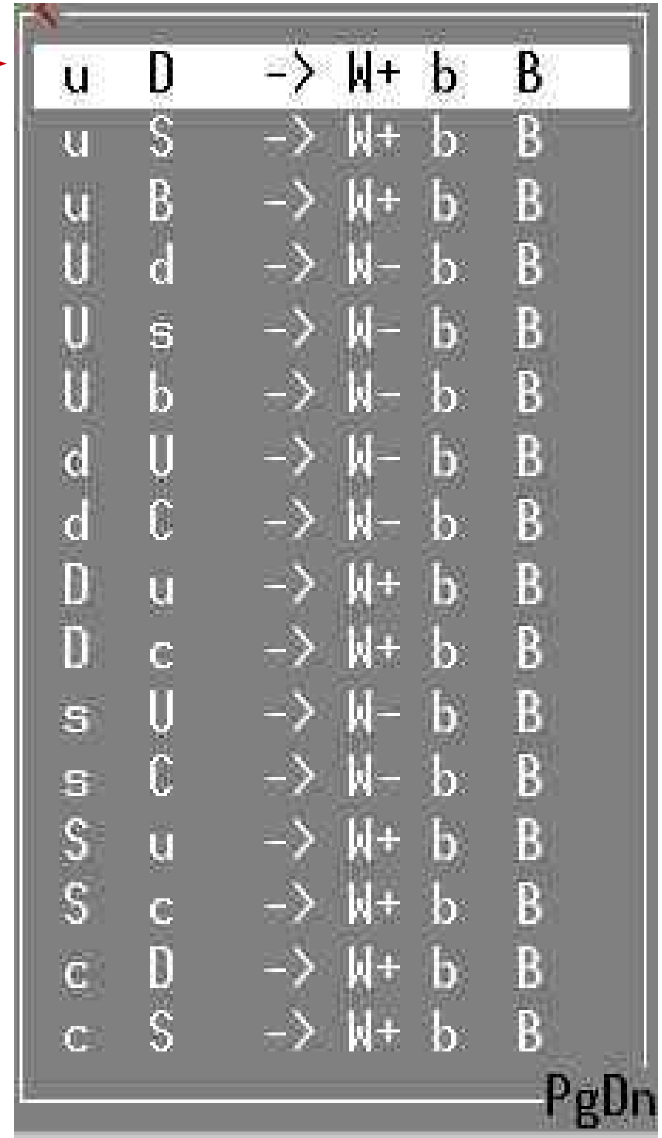


Numerical part of CalcHEP

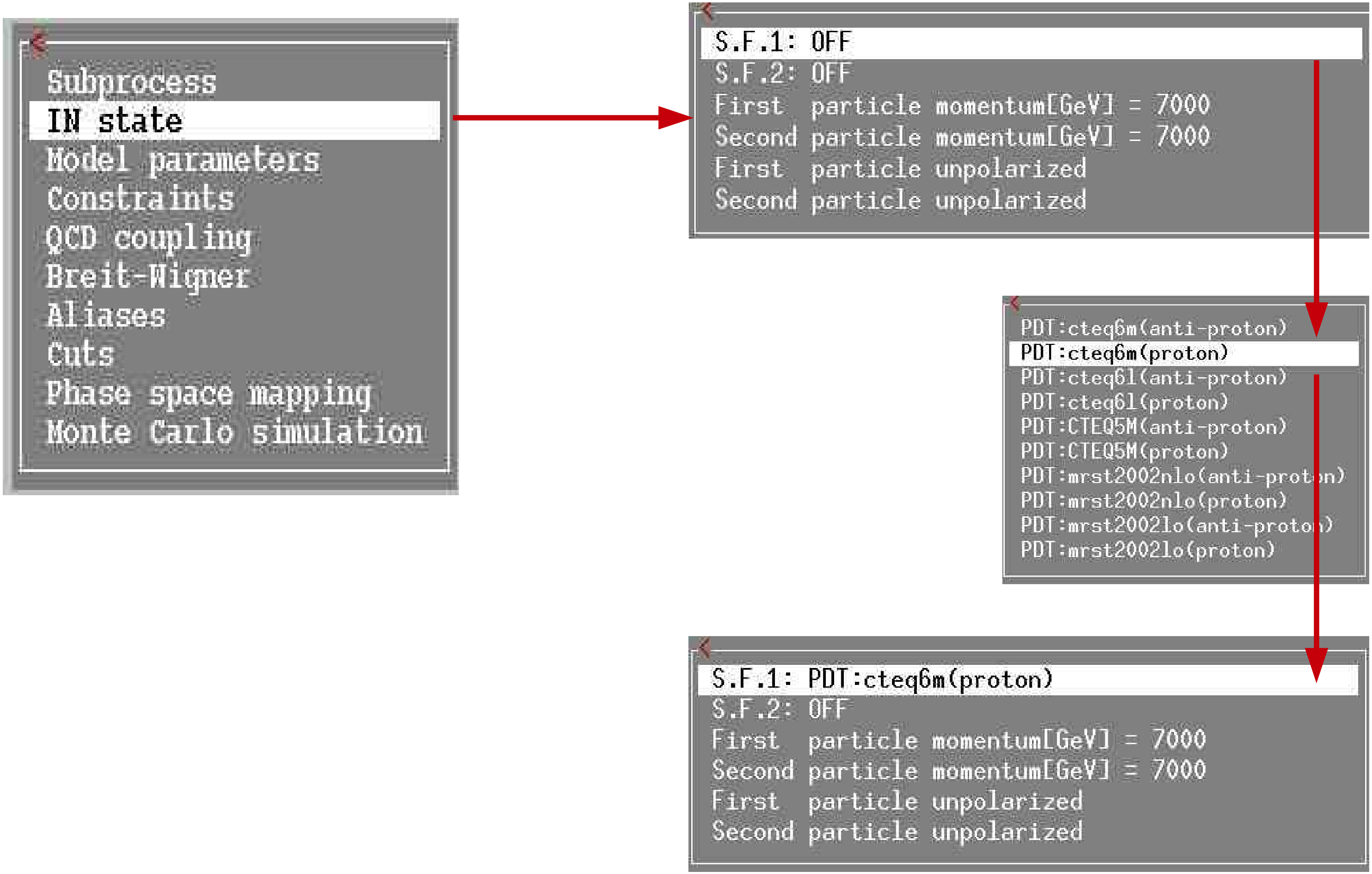


subprocess menu

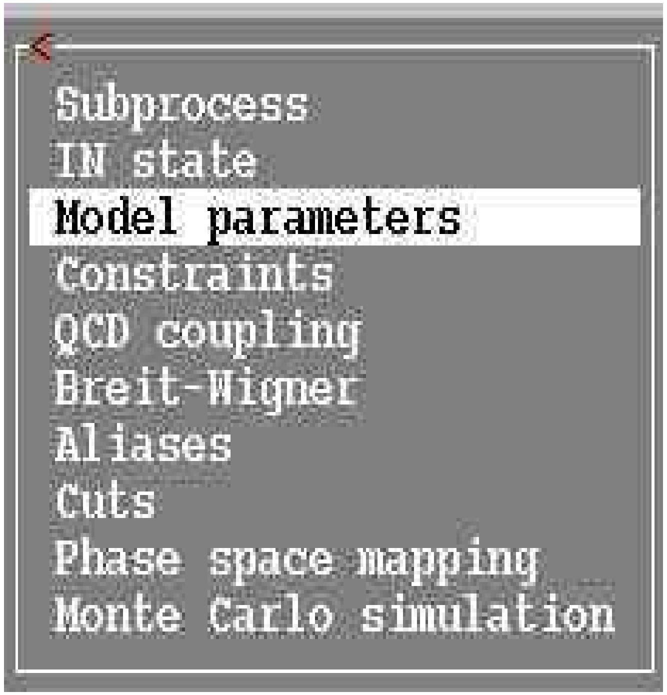


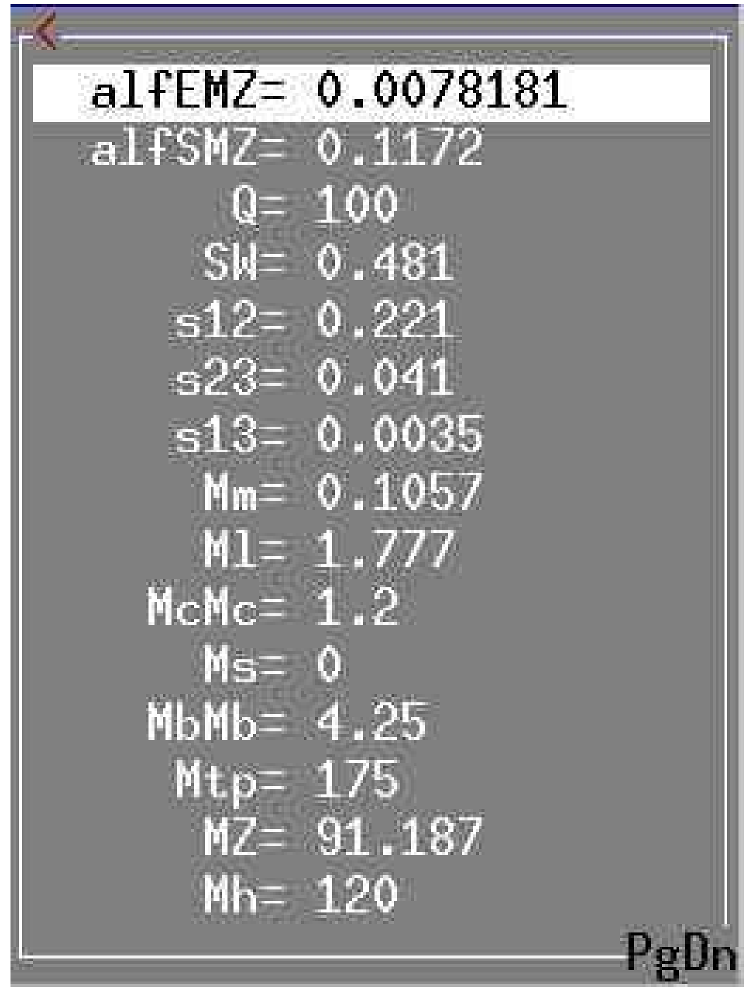


control of the initial states and parton density functions

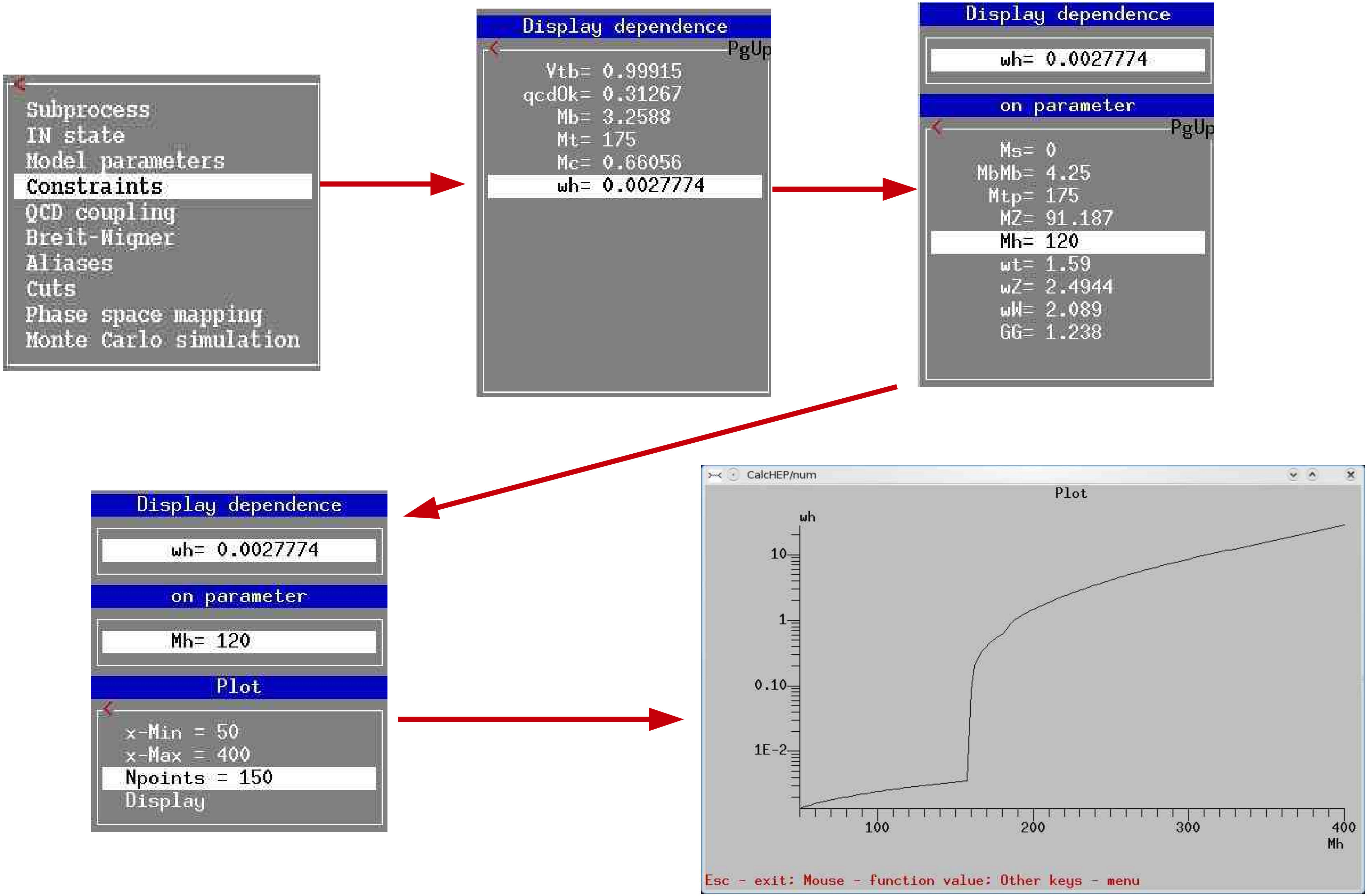


model parameters

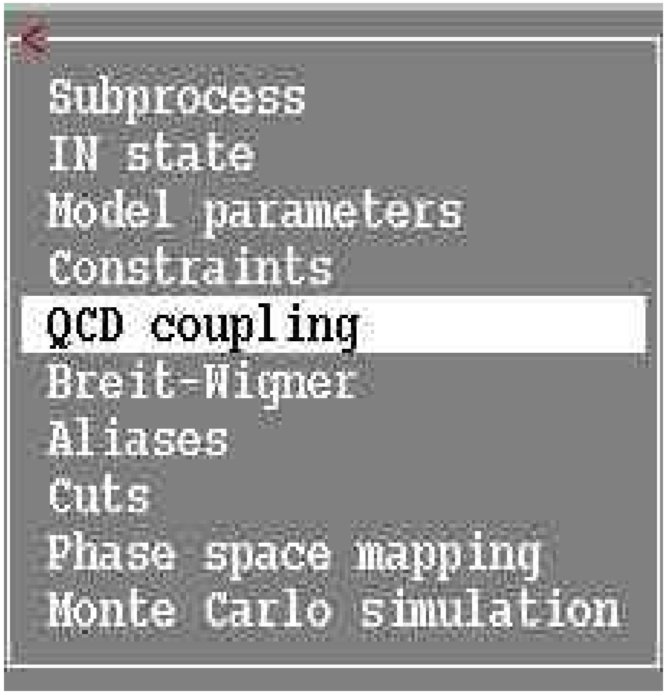


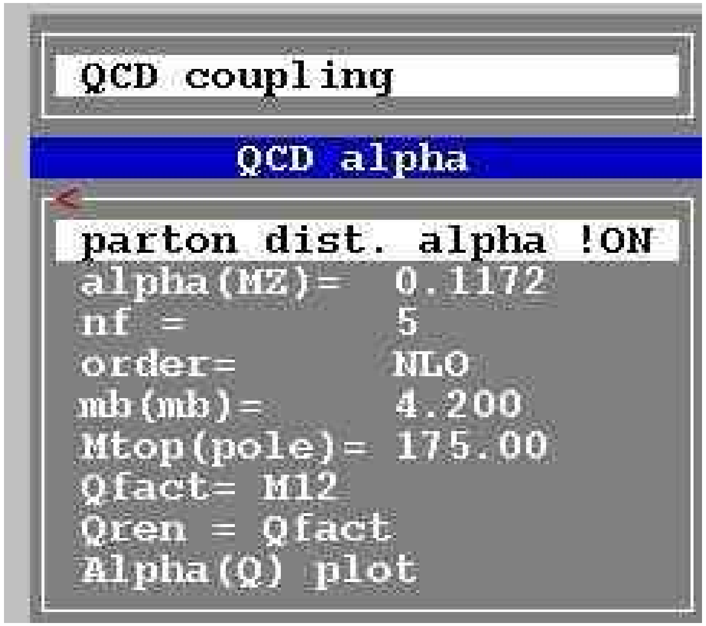


dependent parameters

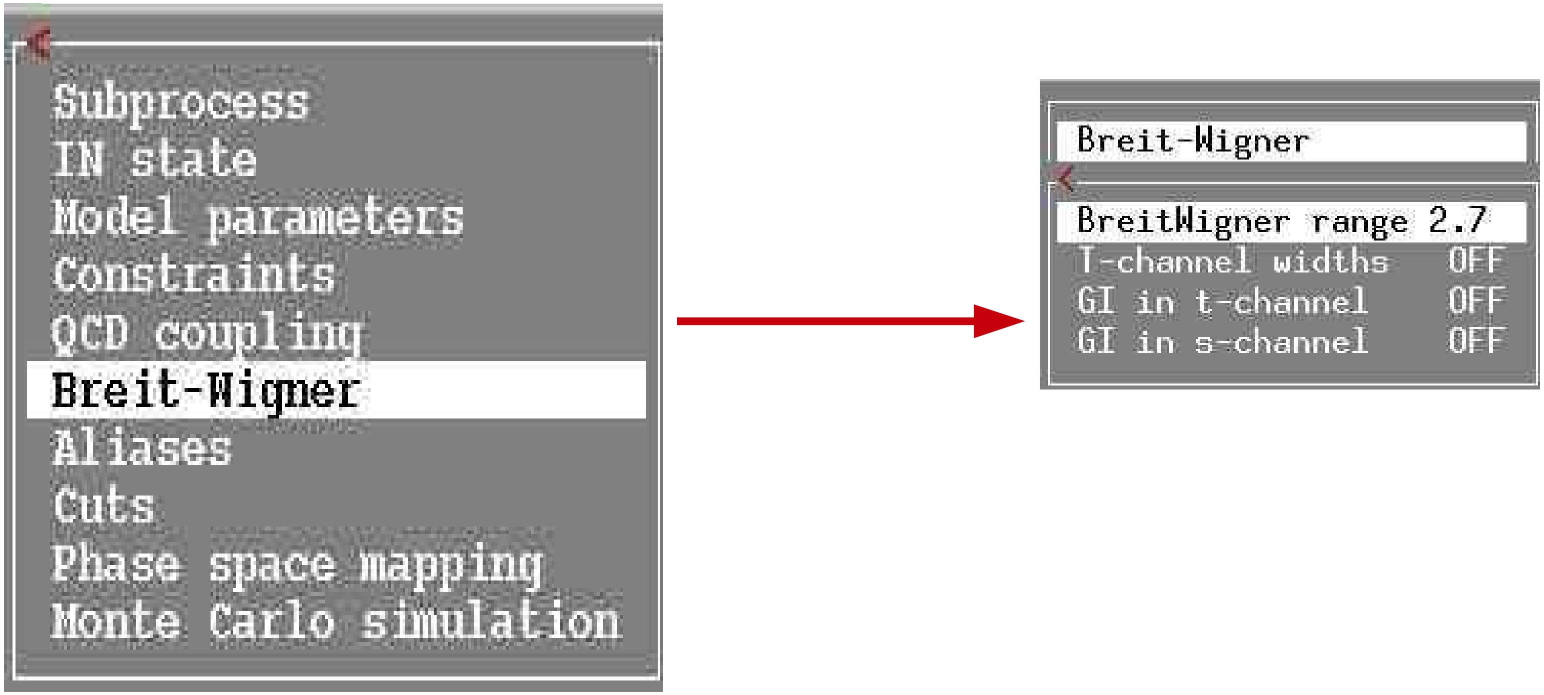


QCD coupling and the scale

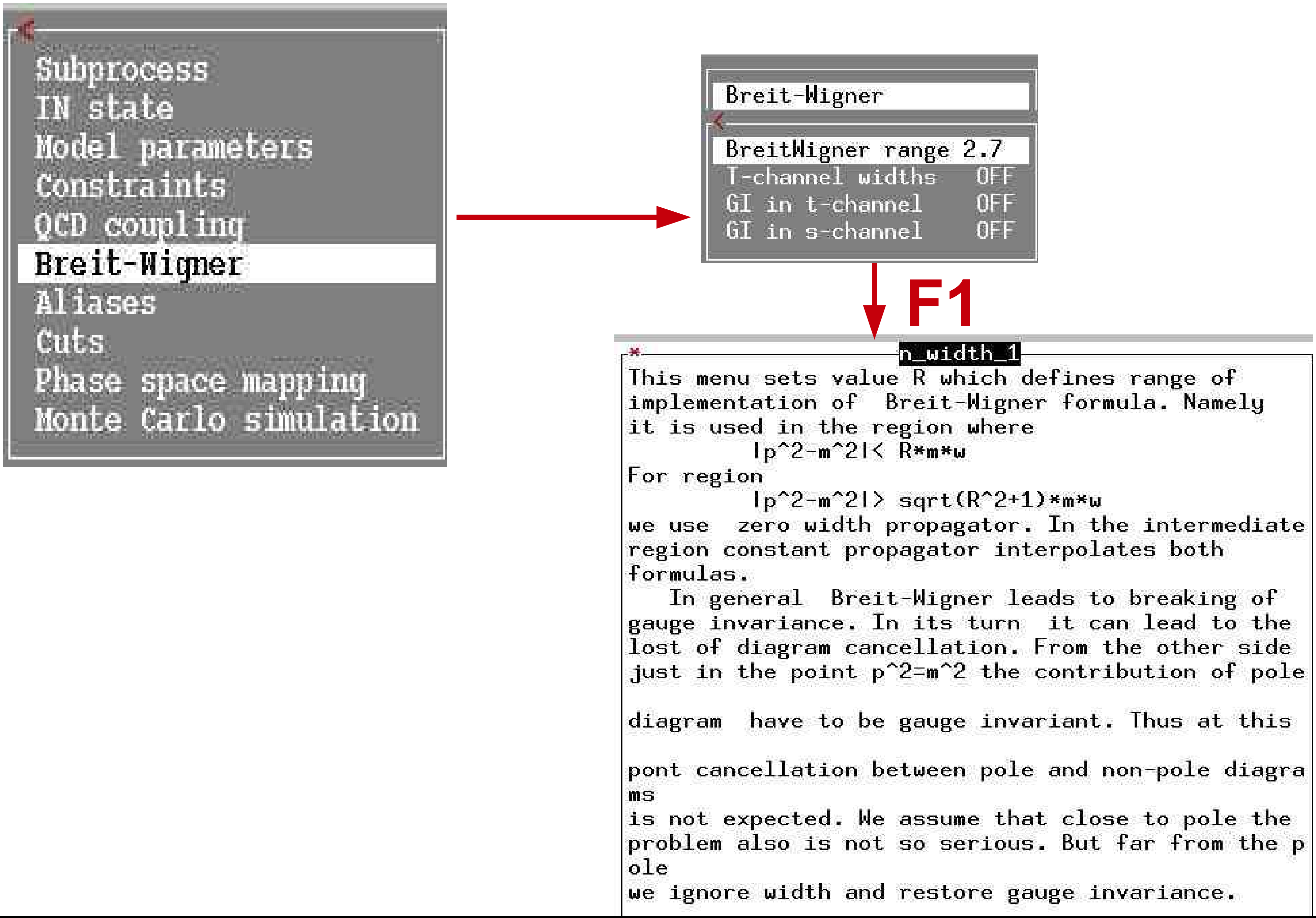




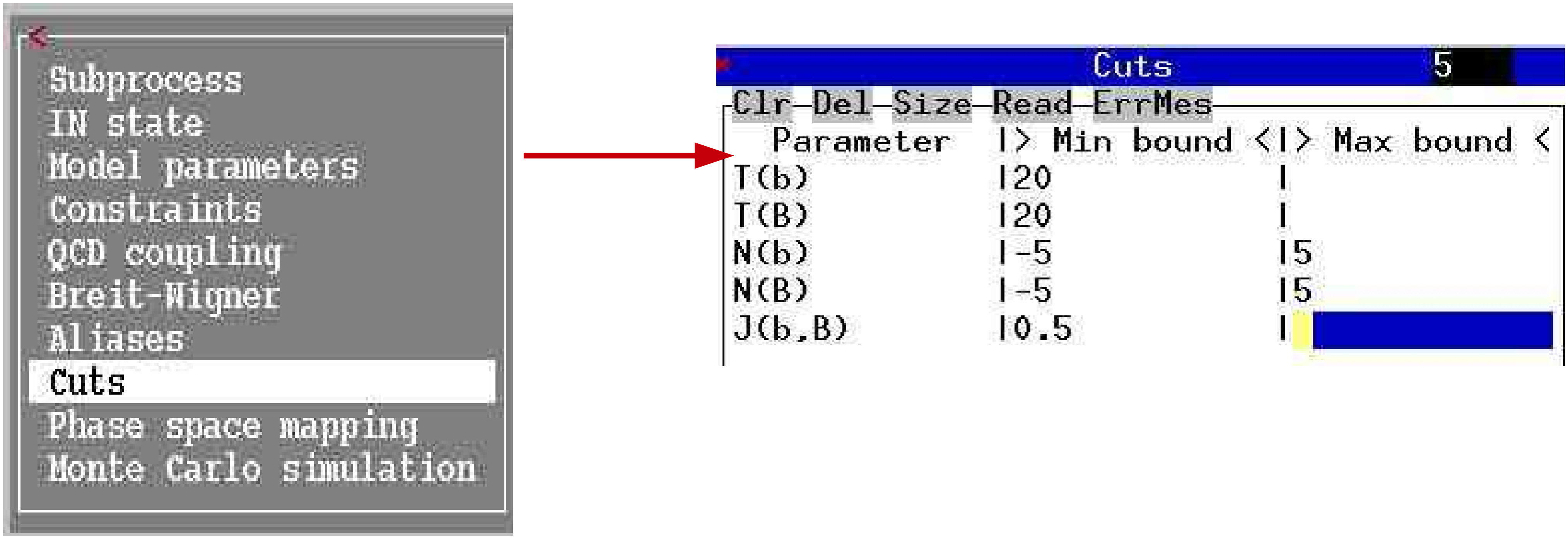
control of resonances



control of resonances



setting kinematical cuts



setting kinematical cuts

Subprocess
IN state
Model parameters
Constraints
QCD coupling
Breit-Wigner
Aliases
Cuts
Phase space mapping
Monte Carlo simulation

Cuts 0

Clr Del Size Read ErrMes

Parameter	Min bound	Max bound

F1

n_cut

This table apples cuts on the phase space. A phase space function is described in the first column. Its limits are defined and the second and the third columns. If one of these fields is empty then a one-side cut is applied.

The phase space function is defined by its name which characterize type of cut and a particle list for which the cut is applied.
For example, "T(u)" means transverse momentum of 'u'-quark;
T(u,D) means summary transverse momentum of quark pair.
The following cut functions are available:

A - Angle in degree units;
C - Cosine of angle;
J - Jet cone angle;
E - Energy of the particle set;
M - Mass of the particle set;
P - Cosine in the rest frame of pair;

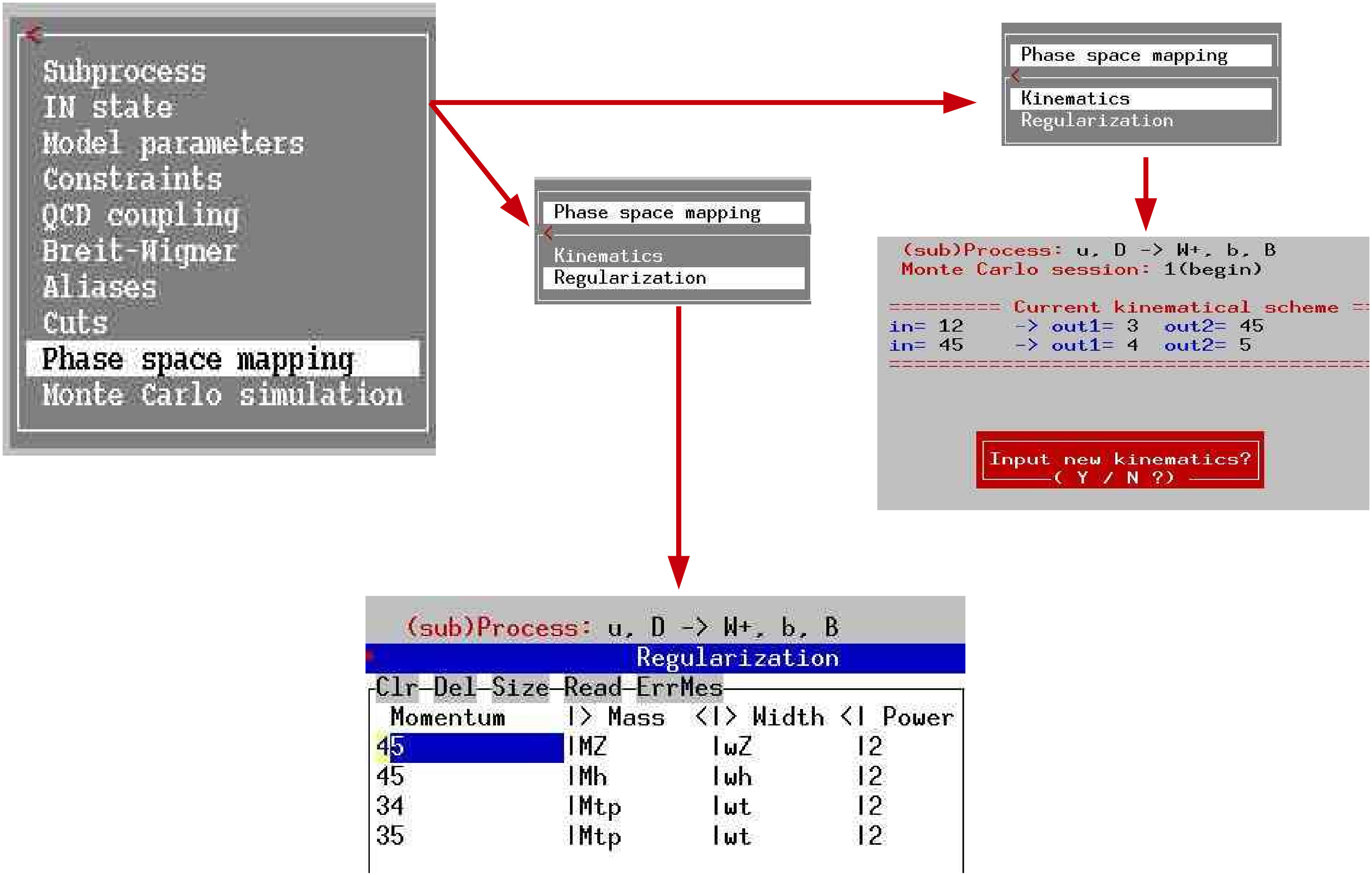
PgDn

Cuts 5

Clr Del Size Read ErrMes

Parameter	Min bound	Max bound
T(b)	20	
T(B)	20	
N(b)	-5	5
N(B)	-5	5
J(b,B)	0.5	

phase-space mapping



integration over the phase space

```
Subprocess
IN state
Model parameters
Constraints
QCD coupling
Breit-Wigner
Aliases
Cuts
Phase space mapping
Monte Carlo simulation
```

```
Monte Carlo simulation

nSess  = 5
nCalls = 10000
Set  Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid           OFF
Clear  grid
Event Cubes 10000
Generate Events
```

Distributions

Clr-Del-Size-Read-ErrMes

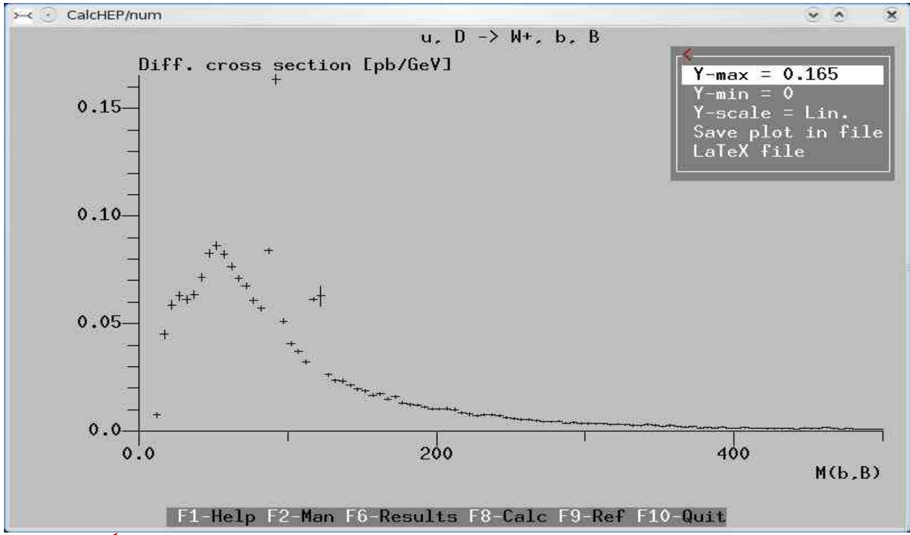
Parameter_1	Min_1	Max_1	Parameter_2	Min_2	Max_2
T(b)	0	200			
T(B)	0	200			
N(b)	-5	5			
N(B)	-5	5			
M(b,B)	0	500			
M(W+,b)	0	500			
T(b)	0	500	M(b,B)	0	500

```
Monte Carlo simulation

nSess  = 5
nCalls = 10000
Set  Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid           OFF
Clear  grid
Event Cubes 10000
Generate Events
```

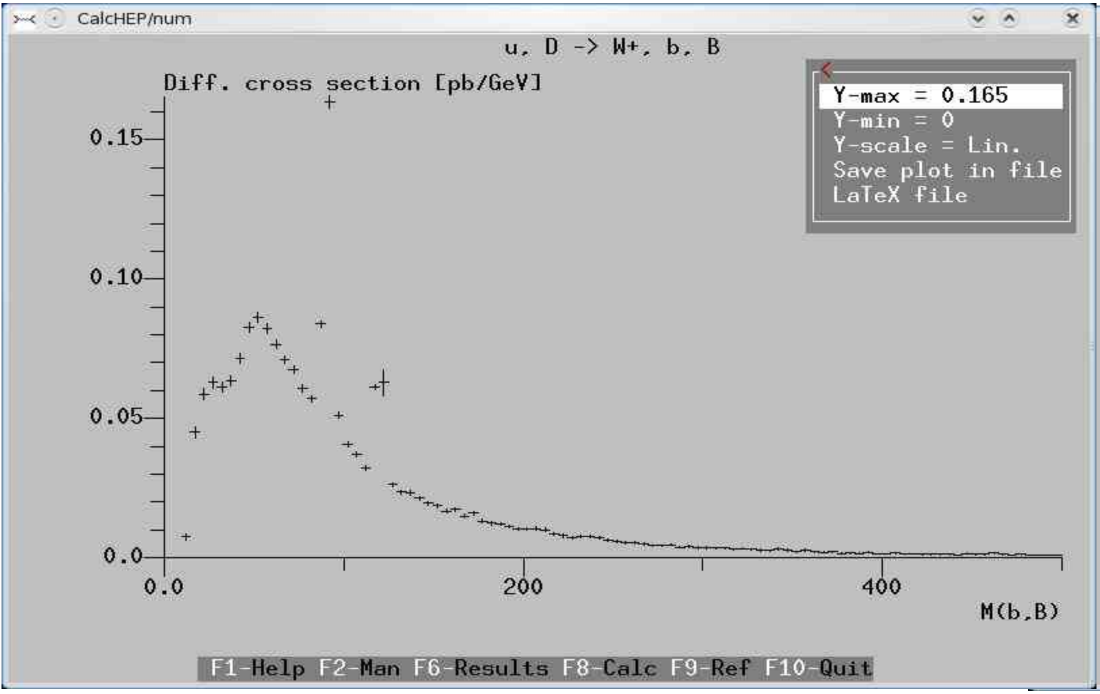
(sub)Process: u, D -> W+, b, B
Monte Carlo session: 2(continue)

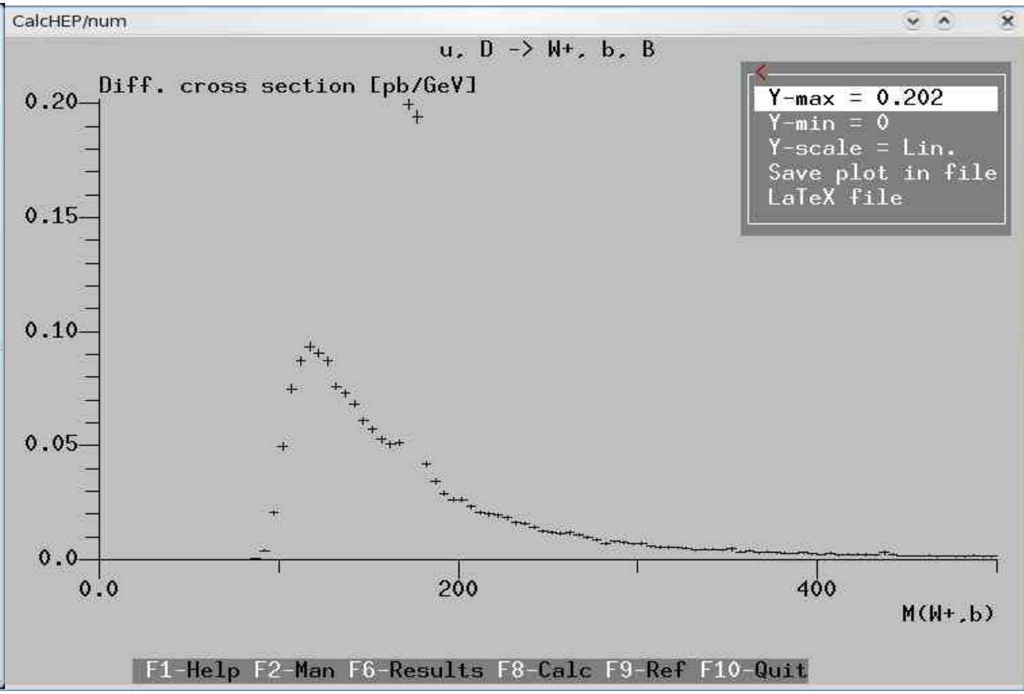
#IT	Cross section [pb]	Error %
6	9.5931E+00	7.10E-01
7	9.5686E+00	6.79E-01
8	9.5669E+00	6.82E-01
9	9.6892E+00	7.93E-01
10	9.6267E+00	7.51E-01
1	9.7757E+00	7.32E-01
clear statistics.		
2	9.6557E+00	6.82E-01
3	9.7464E+00	1.38E+00
4	9.6945E+00	1.05E+00
5	9.7032E+00	7.68E-01
< >	9.7095E+00	3.74E-01

```
Monte Carlo simulation

nSess  = 5
nCalls = 10000
Set  Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid           OFF
Clear  grid
Event Cubes 10000
Generate Events
```



Resulting M_{bb} and M_{Wtb} kinematical distributions



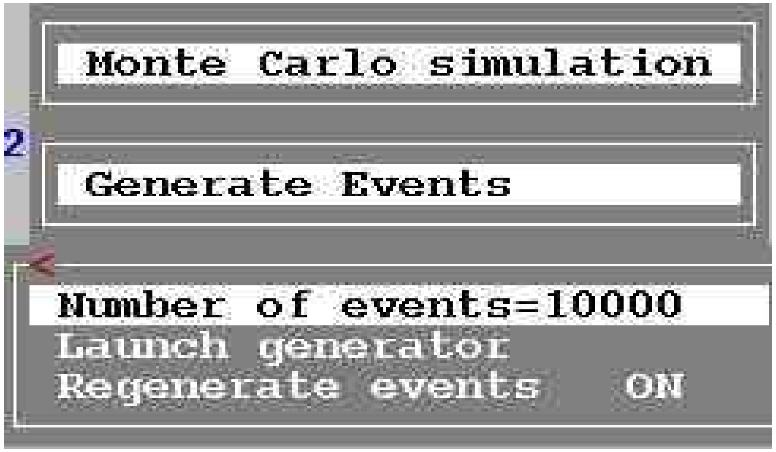


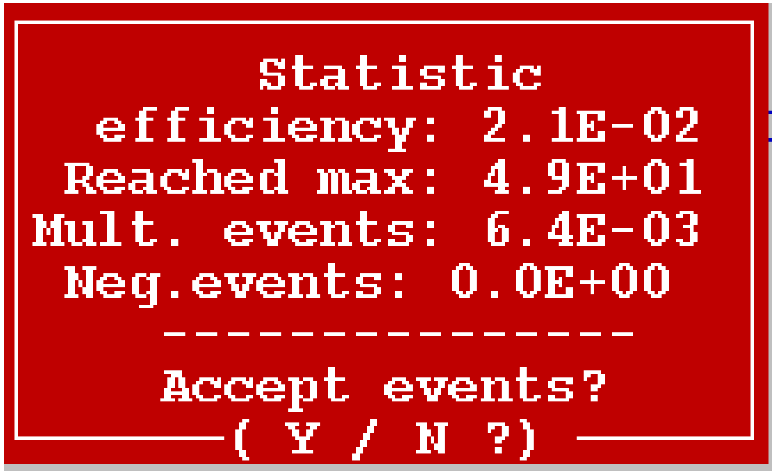
Exercise#3

1. Calculate WbB production rates at Tevatron and LHC for PT b-jet > 20 GeV, b-Jet separation > 0.5, max pseudorapidity < 3

2. Plot bb- and Wb invariant mass distributions for PT b-jet > 20 GeV and PT b-jet > 40 GeV

events generations





GUI gives user a full control of details of symbolic/numerical session. Is there automation of calculation involving many sub-processes?

there are several useful scripts which run various loops and aimed to make a calculation easy

- ***cycle over subprocesses***
  - ***exit from the numerical session***
  - **cd results**
  - **../bin/subproc_cycle *lumi nmax***

requires 2 parameters:

1. luminosity

2. max number of events per process

e.g.

../bin/subproc_cycle 1000 100000

running subproc_cycle for SM model

```
../bin/subproc_cycle 0 0
#Subprocess 1 ( u, D -> W+, b, B ) Cross section = 9.6364E+00 , 0 events
#Subprocess 2 ( u, S -> W+, b, B ) Cross section = 4.0808E-01 , 0 events
#Subprocess 3 ( u, B -> W+, b, B ) Cross section = 2.3490E-04 , 0 events
#Subprocess 4 ( U, d -> W-, b, B ) Cross section = 5.7795E+00 , 0 events
#Subprocess 5 ( U, s -> W-, b, B ) Cross section = 1.0253E-01 , 0 events
#Subprocess 6 ( U, b -> W-, b, B ) Cross section = 4.3181E-05 , 0 events
#Subprocess 7 ( d, U -> W-, b, B ) Cross section = 5.8270E+00 , 0 events
#Subprocess 8 ( d, C -> W-, b, B ) Cross section = 2.1421E-01 , 0 events
#Subprocess 9 ( D, u -> W+, b, B ) Cross section = 9.5470E+00 , 0 events
#Subprocess 10 ( D, c -> W+, b, B ) Cross section = 9.1056E-02 , 0 events
#Subprocess 11 ( s, U -> W-, b, B ) Cross section = 1.0383E-01 , 0 events
#Subprocess 12 ( s, C -> W-, b, B ) Cross section = 1.2694E+00 , 0 events
#Subprocess 13 ( S, u -> W+, b, B ) Cross section = 4.1026E-01 , 0 events
#Subprocess 14 ( S, c -> W+, b, B ) Cross section = 1.2333E+00 , 0 events
#Subprocess 15 ( c, D -> W+, b, B ) Cross section = 9.3773E-02 , 0 events
#Subprocess 16 ( c, S -> W+, b, B ) Cross section = 1.2480E+00 , 0 events
#Subprocess 17 ( c, B -> W+, b, B ) Cross section = 3.4475E-03 , 0 events
#Subprocess 18 ( C, d -> W-, b, B ) Cross section = 2.1469E-01 , 0 events
#Subprocess 19 ( C, s -> W-, b, B ) Cross section = 1.2651E+00 , 0 events
#Subprocess 20 ( C, b -> W-, b, B ) Cross section = 3.4542E-03 , 0 events
#Subprocess 21 ( b, U -> W-, b, B ) Cross section = 4.3722E-05 , 0 events
#Subprocess 22 ( b, C -> W-, b, B ) Cross section = 3.3992E-03 , 0 events
#Subprocess 23 ( B, u -> W+, b, B ) Cross section = 2.3111E-04 , 0 events
#Subprocess 24 ( B, c -> W+, b, B ) Cross section = 3.4543E-03 , 0 events
Sum of distributions is stored in file distr_7_30
Total Cross Section 37.45843711 [pb]
see details in prt_7 - prt_30 files
```

Accessing your results

- **results are stored in "results" directory**
- **output files:**
  - n_calchep *numerical module*
  - prt_*nn* *protocol*
  - distr_*nn*_*mm* *summed distributions*
  - distr_*nn* *individual distribution*
  - events_*nn.txt* *events file*
  - list_prc.txt *list of processes*
  - qnumbers *qnumbers – PYTHIA input with new prt definitions*
  - session.dat *current session status – format is similar to* prt_*nn* *one*
- **for every new process the "results" directory is offered to be renamed or removed**

protocol prt_*nn*

```
    CalcHEP kinematics module
 The session parameters:

#Subprocess 1 ( u, D -> W+, b, B )
#Session_number 1
#Initial_state  inP1=7.000000E+03  inP2=7.000000E+03
 Polarizations= { 0.000000E+00  0.000000E+00 }
  StrFun1="PDT:cteq6m(proton)" 2212
  StrFun2="PDT:cteq6m(proton)" 2212

#Physical_Parameters
    alfEMZ = 7.818060999999999E-03
    alfSMZ = 1.172000000000000E-01
............................................
............................................
#Cuts
*** Table ***
 Cuts
  Parameter    |> Min bound <|> Max bound <|
T(b)           |20           |
T(B)           |20           |
............................................
............................................
#Regularization
*** Table ***
 Regularization
 Momentum      |> Mass  <|> Width <| Power|
45             |MZ       |wZ       |2
45             |Mh       |wh       |2
............................................
............................................
#END
===================================
 #IT   Cross section [pb]  Error %    nCall   chi**2
  1      2.0373E+00       3.30E+01    20000
  2      8.6164E+00       2.86E+01    20000
............................................
............................................
```

useful scripts for numerical session

see calchep_3.x.x/bin/ directory and README file!

- **subproc_cycle** ../bin/subproc_cycle 1000 100000
- **sum_distr** ../bin/sum_distr distr_2 distr_3 > distr_sum
- **show_distr** ../bin/show_distr distr_sum
- **plot_view** ../bin/plot_view < tab_1.txt
- **events2tab**
- **gen_events**
- **name_cycle**
- **pcm_cycle**

Exercise#4
learn how to use:
1) gen_events
2) events2tab
3) plot_view

scripts for numerical session

- ## events2tab

Parameters:
1- name of variable,
2- minimum limit,
3- maximum limit,
4- number of bins(<=300).
File with events must be passed to input.

```
../bin/events2tab "T(b)" 1 100 200 < events_1.txt >tab.txt
../bin/tab_view < tab.txt
```

- ## name_cycle

1: Name of parameter
2: Initial value
3: Step
4: Number of steps

```
../bin/name_cycle Mh 100 10 11
```

scripts above became a part of calchep_batch interface – to be discussed in the following lecture(s)

Events generation with CalcHEP

```
~/proj/intro_to_hep_tools/calc_work_2.5.4/pp_wbb_ckm1>
../bin/subproc_cycle 1000 1000
#Subprocess 1 ( u, D -> W+, b, B ) Cross section = 9.7505E+00 , 1000 events
#Subprocess 2 ( U, d -> W-, b, B ) Cross section = 5.5019E+00 , 1000 events
#Subprocess 3 ( d, U -> W-, b, B ) Cross section = 5.5315E+00 , 1000 events
#Subprocess 4 ( D, u -> W+, b, B ) Cross section = 9.7105E+00 , 1000 events
#Subprocess 5 ( s, C -> W-, b, B ) Cross section = 1.5902E+00 , 1000 events
#Subprocess 6 ( S, c -> W+, b, B ) Cross section = 1.3525E+00 , 1000 events
#Subprocess 7 ( c, S -> W+, b, B ) Cross section = 1.3425E+00 , 1000 events
#Subprocess 8 ( C, s -> W-, b, B ) Cross section = 1.5716E+00 , 1000 events
Sum of distributions is stored in file distr_34_41
Total Cross Section 36.3512 [pb]

~/proj/intro_to_hep_tools/calc_work_2.5.4/w_decay>
../bin/subproc_cycle 1000
width(W+)=0.67001
#Subprocess 1 ( W+ -> E, ne ) width=2.2339E-01 Br=0.3334129341 Nevents= 334
#Subprocess 2 ( W+ -> M, nm ) width=2.2339E-01 Br=0.3334129341 Nevents= 334
#Subprocess 3 ( W+ -> L, nl ) width=2.2323E-01 Br=0.3331741317 Nevents= 334
width(W-)=0.67001
#Subprocess 4 ( W- -> e, Ne ) width=2.2339E-01 Br=0.3334129341 Nevents= 334
#Subprocess 5 ( W- -> m, Nm ) width=2.2339E-01 Br=0.3334129341 Nevents= 334
#Subprocess 6 ( W- -> l, Nl ) width=2.2323E-01 Br=0.3331741317 Nevents= 334
```

- Dirs are accessible at

http://www.hep.phys.soton.ac.uk/~belyaev/proj/intro_to_hep_tools/

Events generation with CalcHEP

- **bin/event_mixer nevents event_dirs**

mixes subprocesses and connects scattering and decay events

```
bin/event_mixer 1000 pp_wbb_ckm1 w_decay
total cross section 1.166E+01
Max number of events 3728
```

- **the output is event_mixer.lhe *file***

```
<LesHouchesEvents version="1.0">
<!--
File generated with CalcHEP-PYTHIA interface
-->
<header>
<slha>
</slha>
</header>
<init>
  2212  2212  7.00000006860E+03  7.00000006860E+03    -1    -1    -1    -1     3     1
  1.16593335502E+01  0.00000000000E+00  1.00000000000E+00   1
</init>
<event>
 7    1   1.0000000E+00   2.8420000E+02  -1.0000000E+00  -1.0000000E+00
       -3    -1     0     0     0   501  0.00000000000E+00  0.00000000000E+00  1.54424456520E+02
        4    -1     0     0   500     0  0.00000000000E+00  0.00000000000E+00 -1.30792414700E+02
       24     2     1     2     0     0 -9.99292465447E+01 -1.63668803915E+01 -6.48692987742E+01
        5     1     1     2   500     0  7.34149473360E+01  2.15593961832E+01  4.23390519202E+01
       -5     1     1     2     0   501  2.65142992097E+01 -5.19251579179E+00  4.61622886720E+01
      -11     1     3     3     0     0 -7.19345413730E+01  7.47572186340E-01 -8.03452022142E+01
       12     1     3     3     0     0 -2.79947051718E+01 -1.71144525779E+01  1.54759034400E+01
</event>
```

CalcHEP batch interface: results from CalcHEP in one shot

- calchep_batch batch_file

At .../~belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/batch_file

```
calchep_batch batch_file
Progress information can be found in the html directory.
Simply open the following link in your browser:
file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html
```

Main Features

- Batch file
- Process library
- Runs
- Combines decays
- Parallelization
- HTML progress

batch_file

```
Model:          Standard Model(CKM=1)
Model changed:  False
Gauge:          Feynman
```

```
Process:     p,p->W,b,B
Decay:       W->ll,nn

Composite:   p=u,U,d,D,s,S,c,C,b,B,G
Composite:   W=W+,W-
Composite:   ll=e,E,m,M,l,L
Composite:   nn=ne,Ne,nm,Nm,nl,Nl
```

CalcHEP batch interface: results from CalcHEP in one shot

file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html

Home
Symbolic Results
Numerical Results
Events Library
Process Library
Help

Thank you for using CalcHEP!
Please cite arXiv:0000.0000

CalcHEP Batch Details

Standard Model(CKM=1)

Done!

	Finished	Time(hr)
Symbolic	14/14	0.00
σ	1/1	0.03
Events	1/1	0.05

CalcHEP batch interface: results from CalcHEP in one shot

file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html

Symbolic Sessions

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Process Library
Help

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Please cite arXiv:0000.0000

Standard Model(CKM=1)

Processes	Lib	PID	Time(hr)
u,D->W+,b,B	✓		
U,d->W-,b,B	✓		
d,U->W-,b,B	✓		
D,u->W+,b,B	✓		
s,C->W-,b,B	✓		
S,c->W+,b,B	✓		
c,S->W+,b,B	✓		
C,s->W-,b,B	✓		
W+->E,ne	✓		
W+->M,nm	✓		
W+->L,nl	✓		
W-->e,Ne	✓		
W-->m,Nm	✓		
W-->l,Nl	✓		
Widths	✓		

CalcHEP batch interface: results from CalcHEP in one shot

file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html

Home
Symbolic Results
Numerical Results
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Help

Thank you for using CalcHEP!
Please cite arXiv:0000.0000

Numerical Sessions

Standard Model(CKM=1)

Done!

Runs	σ (fb)	Running	Finished	Time (hr)	N events
Single	12350	0/15	15/15	0.14	50000
				0.14	

CalcHEP batch interface: results from CalcHEP in one shot

file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html

Standard Model(CKM=1)

Done!

Home
Symbolic Results
Numerical Results
Events Library
Process Library
Help

Thank you for using CalcHEP!
Please cite arXiv:0000.0000

Processes	σ (fb)	PID	Time (hr)	N events	Details
u,D->W+,b,B	10047	27115	0.02	14910/14910	prt_1 session.dat
U,d->W-,b,B	5636.4	27125	0.01	8364/8364	prt_1 session.dat
d,U->W-,b,B	5567.9	27129	0.01	8263/8263	prt_1 session.dat
D,u->W+,b,B	9850.2	27145	0.02	14618/14618	prt_1 session.dat
s,C->W-,b,B	1609.9	27366	0.01	2389/2389	prt_1 session.dat
S,c->W+,b,B	1359.9	27370	0.01	2018/2018	prt_1 session.dat
c,S->W+,b,B	1374.5	27563	0.01	2039/2039	prt_1 session.dat
C,s->W-,b,B	1614.8	27581	0.01	2396/2396	prt_1 session.dat
Total	37061			54997/54997	

Decays	Γ (GeV)	PID	Time (hr)	N events	Details
W+->E,ne	0.22339	27583	0.01	255000/254999	prt_1 session.dat
W+->M,nm	0.22339	27586	0.01	255000/254999	prt_1 session.dat
W+->L,nl	0.22323	27891	0.01	255000/254999	prt_1 session.dat
W-->e,Ne	0.22339	27893	0.01	255000/254999	prt_1 session.dat
W-->m,Nm	0.22339	27896	0.01	255000/254999	prt_1 session.dat
W-->l,Nl	0.22323	27905	0.01	255000/254999	prt_1 session.dat

Widths		PID	Time (hr)		Details
Widths		28254	0.01		session.dat
Total	12350		0.14		

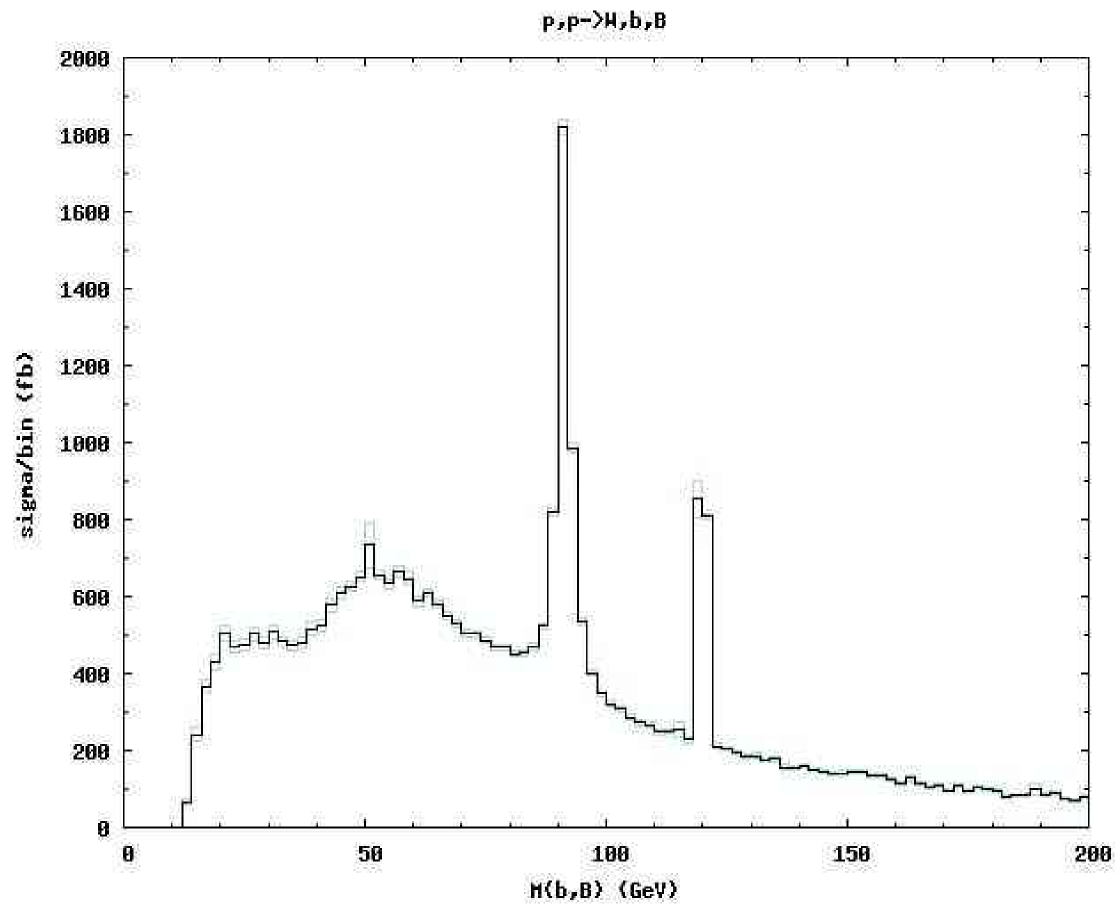
CalcHEP batch interface: results from CalcHEP in one shot

file:///home/belyaev/proj/intro_to_hep_tools/calc_work_2.5.4/html/index.html

Home
Symbolic Results
Numerical Results
Events Library
Process Library
Help

Thank you for using CalcHEP!
Please cite arXiv:0000.0000

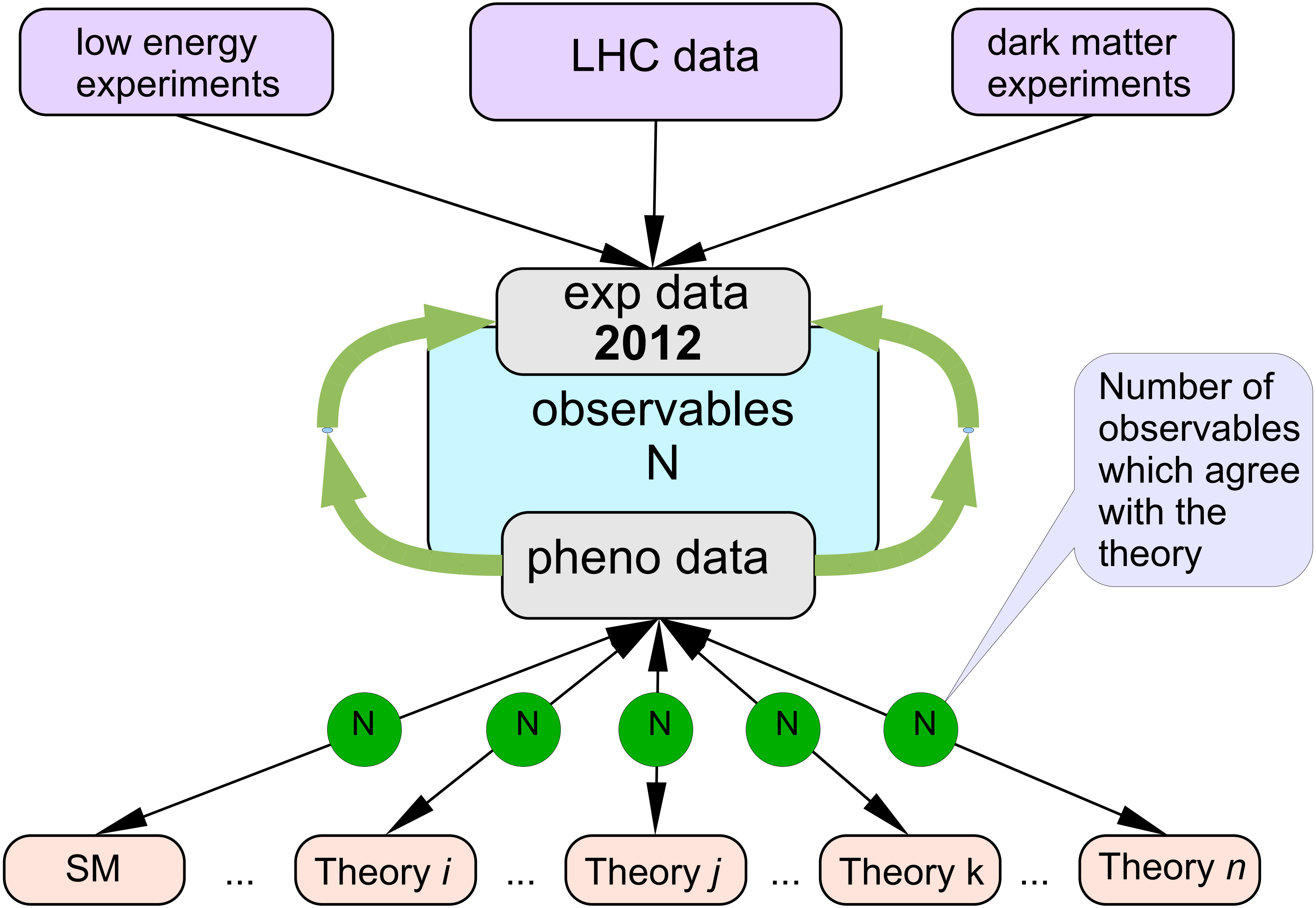
Distributions



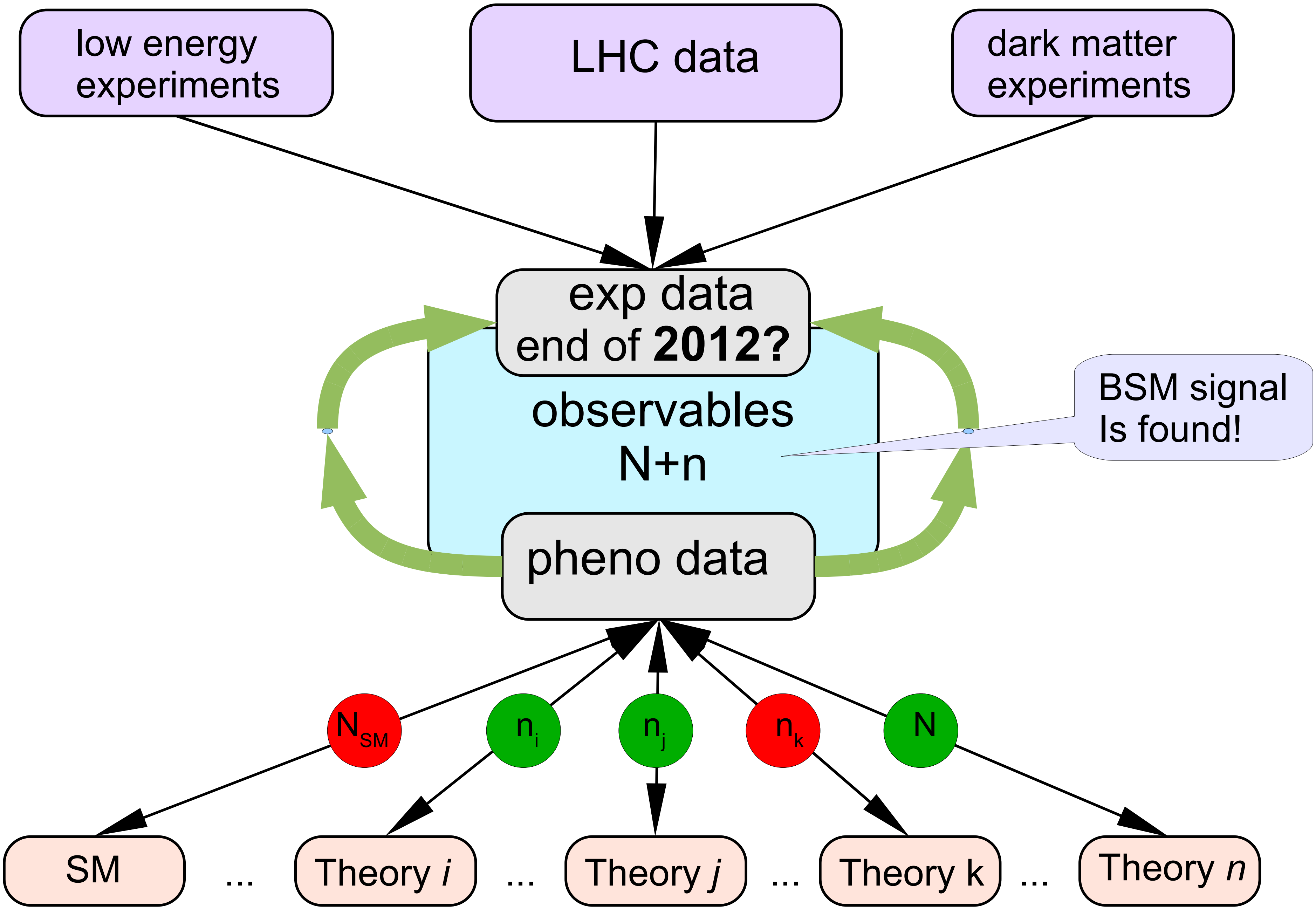
p,p->H,b,B

HEPMDB

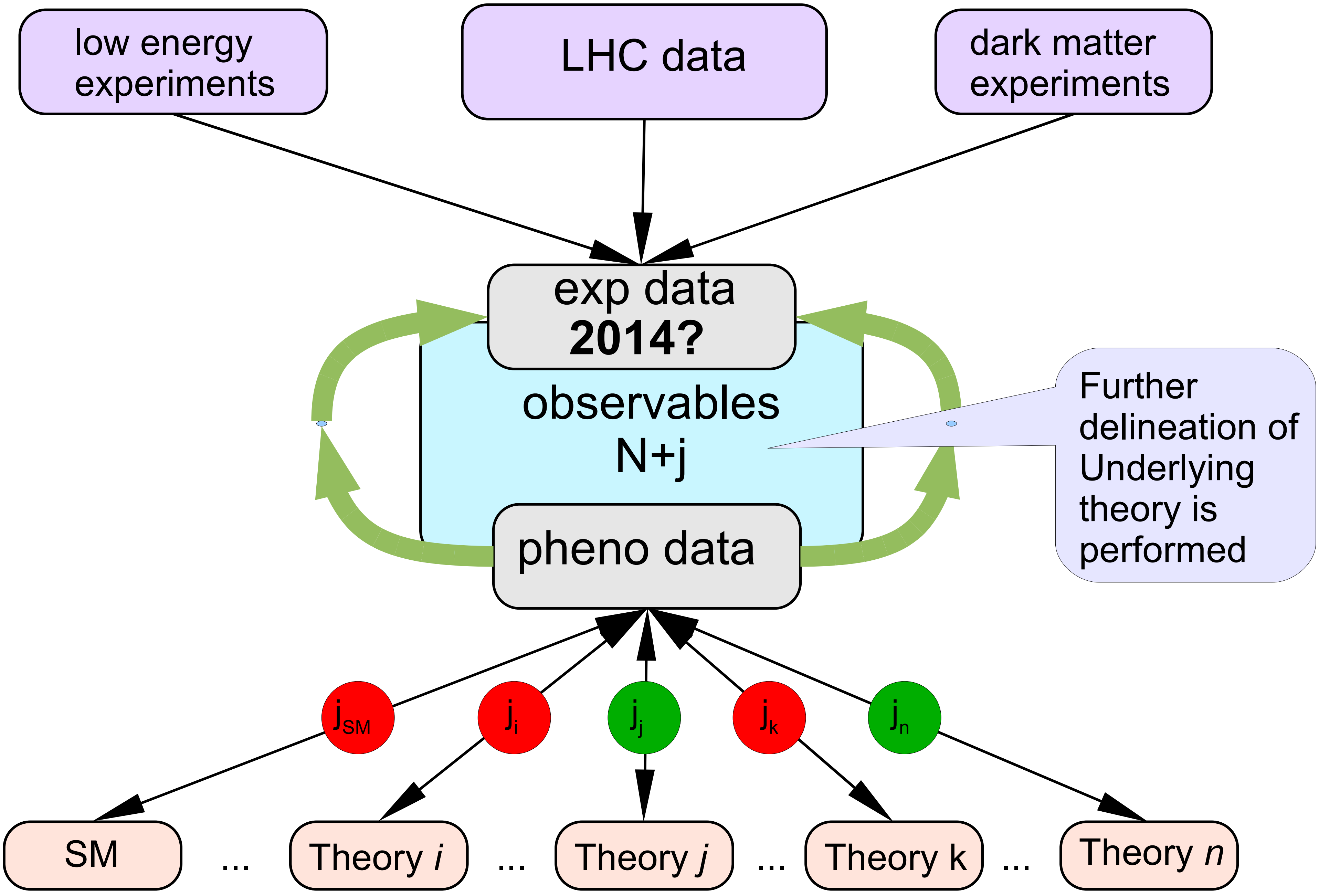
Possible scenario in the near future



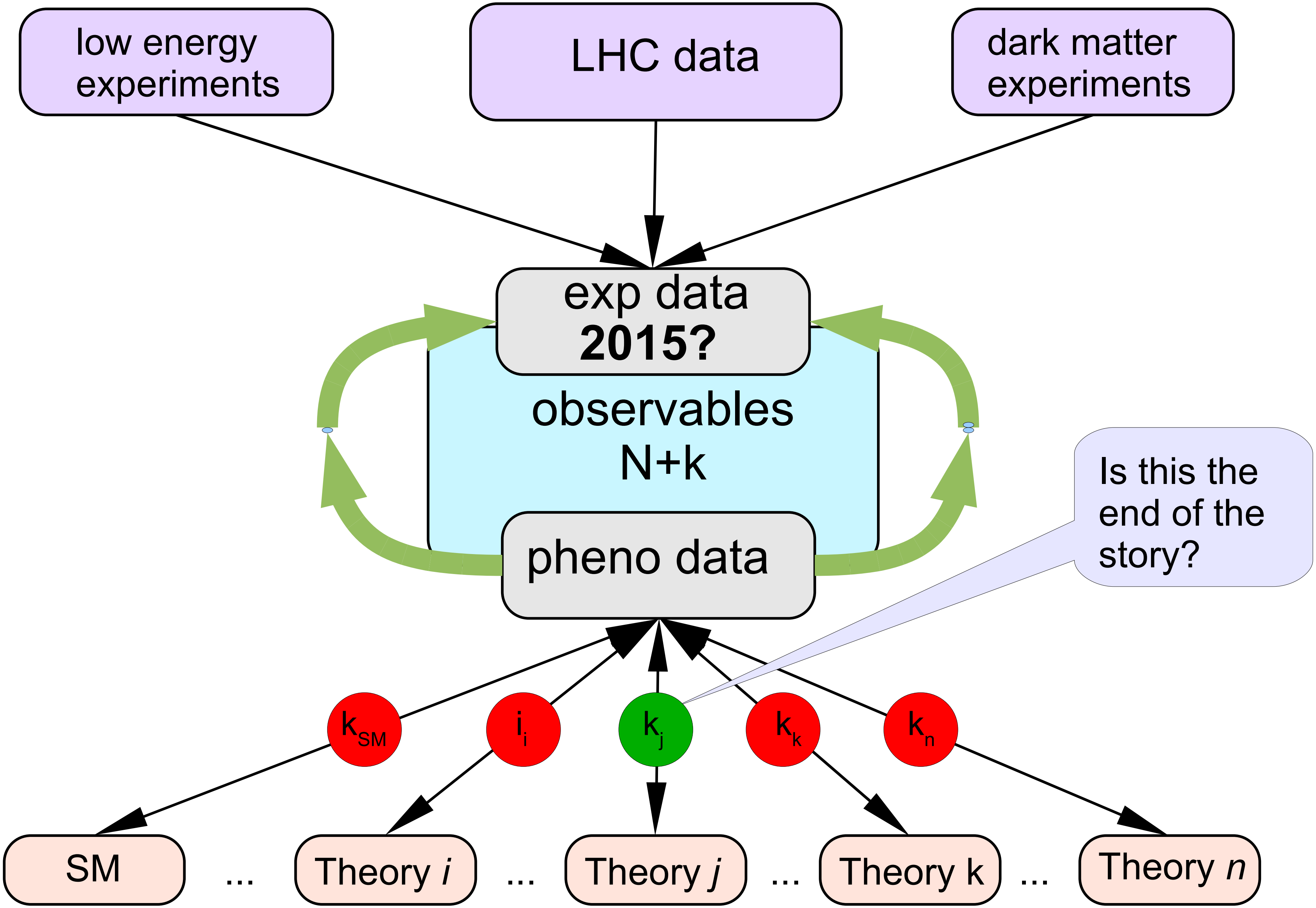
Possible scenario in the near future



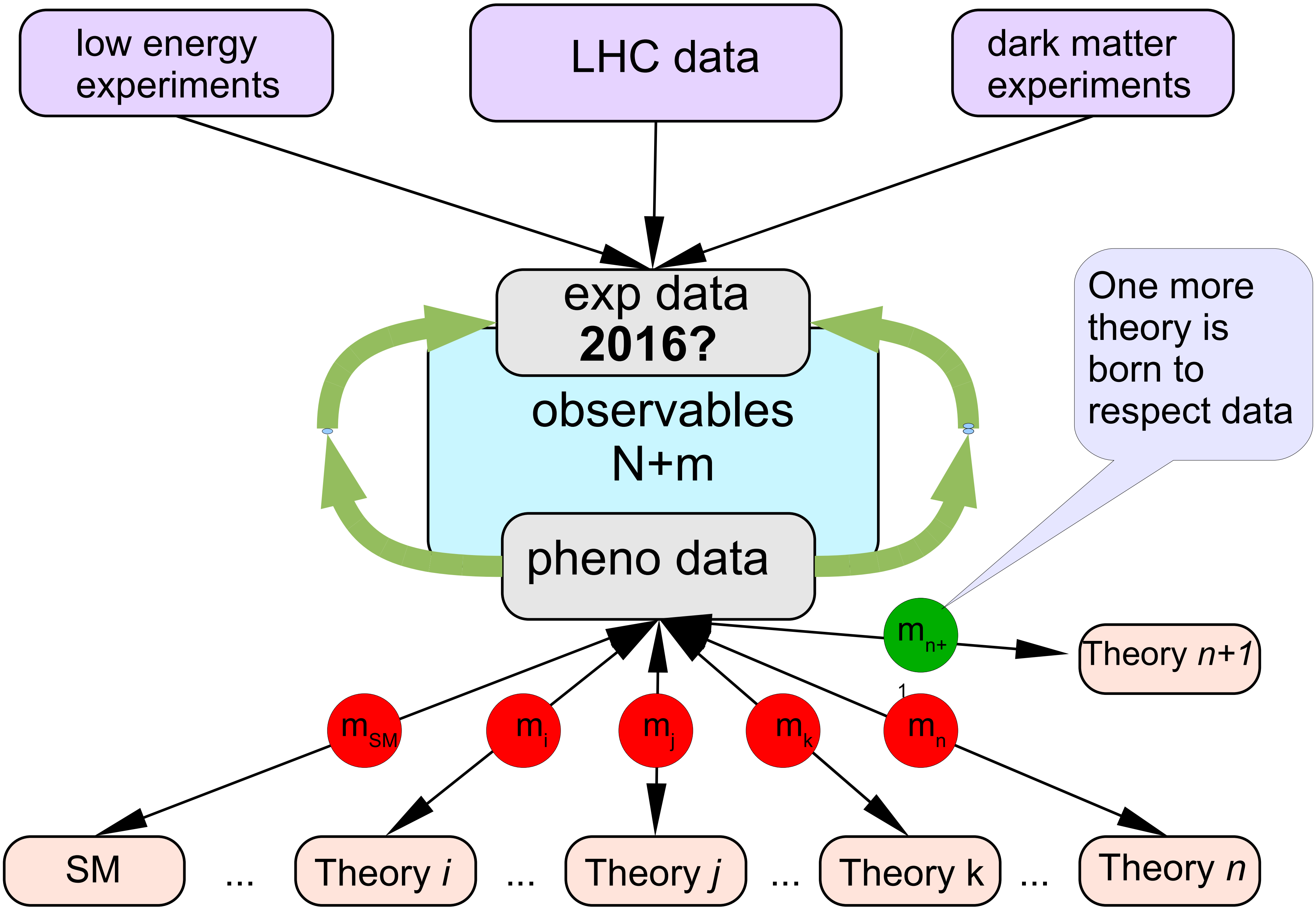
Possible scenario in the near future



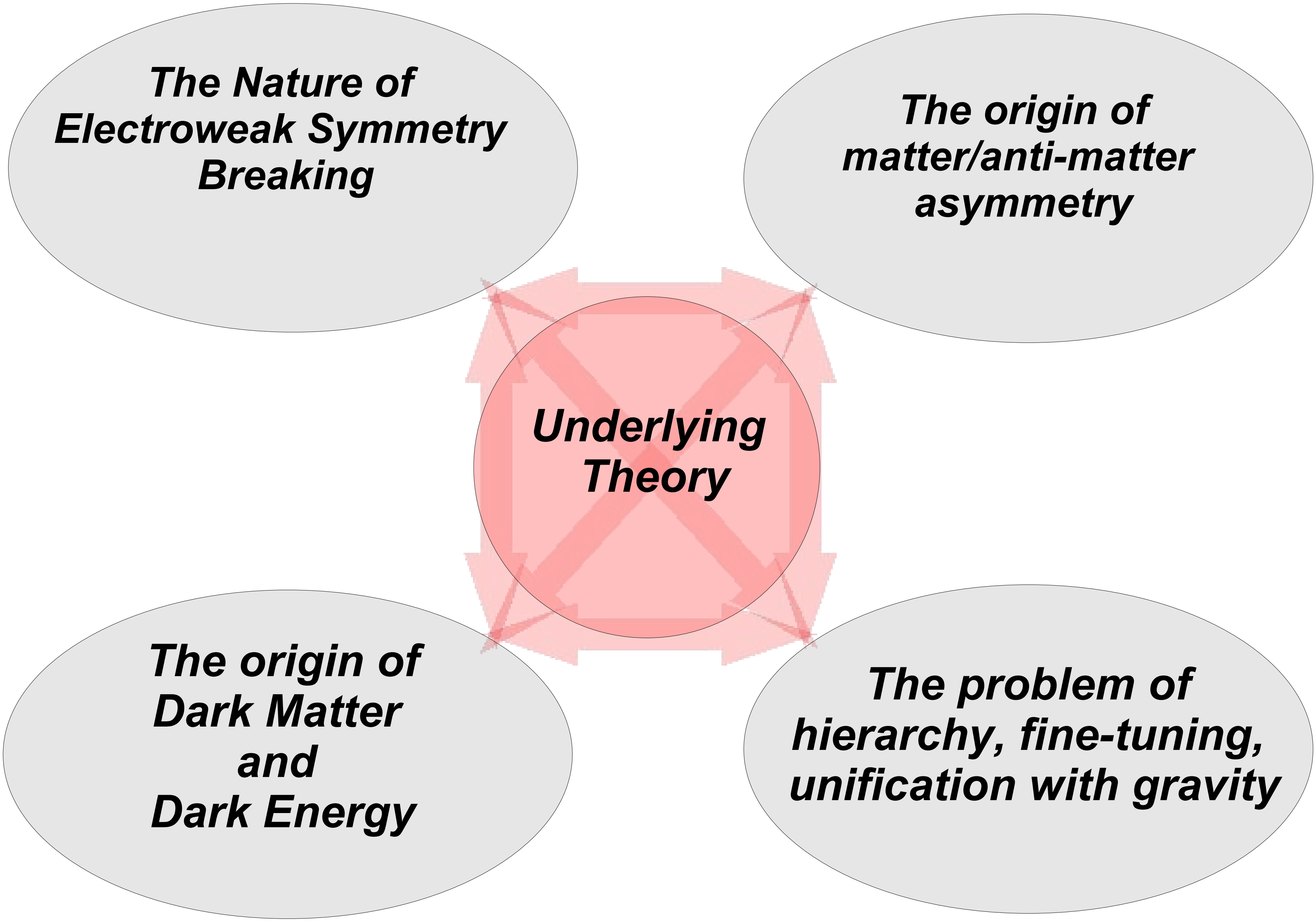
Possible scenario in the near future



Possible scenario in the near future



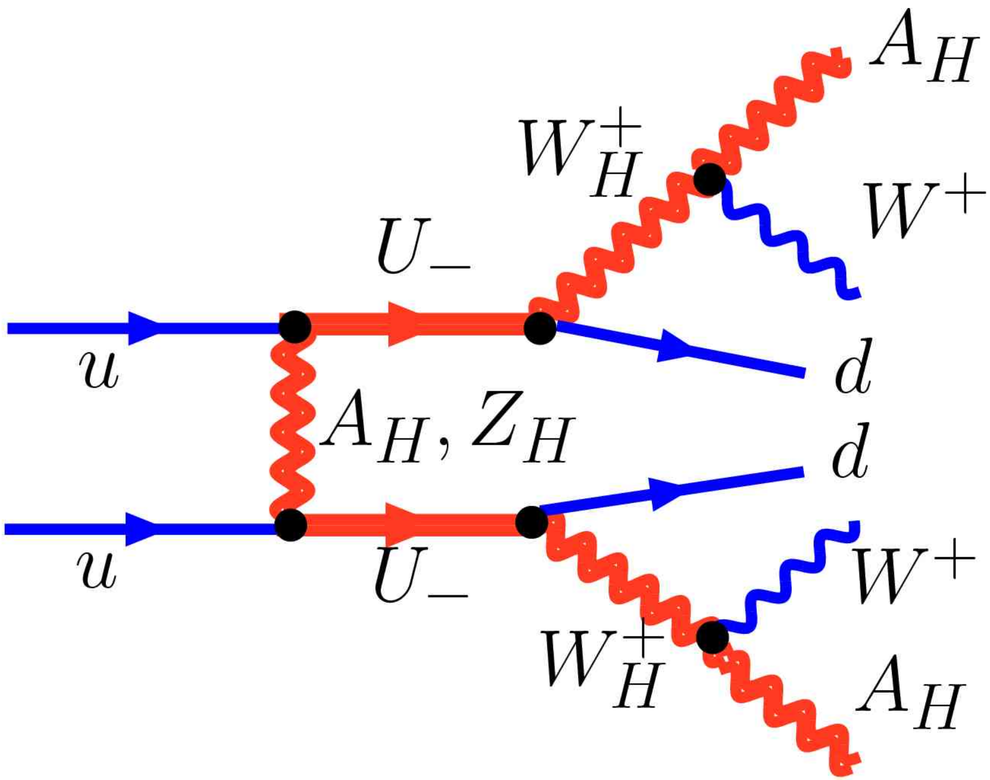
What underlying theory should explain?

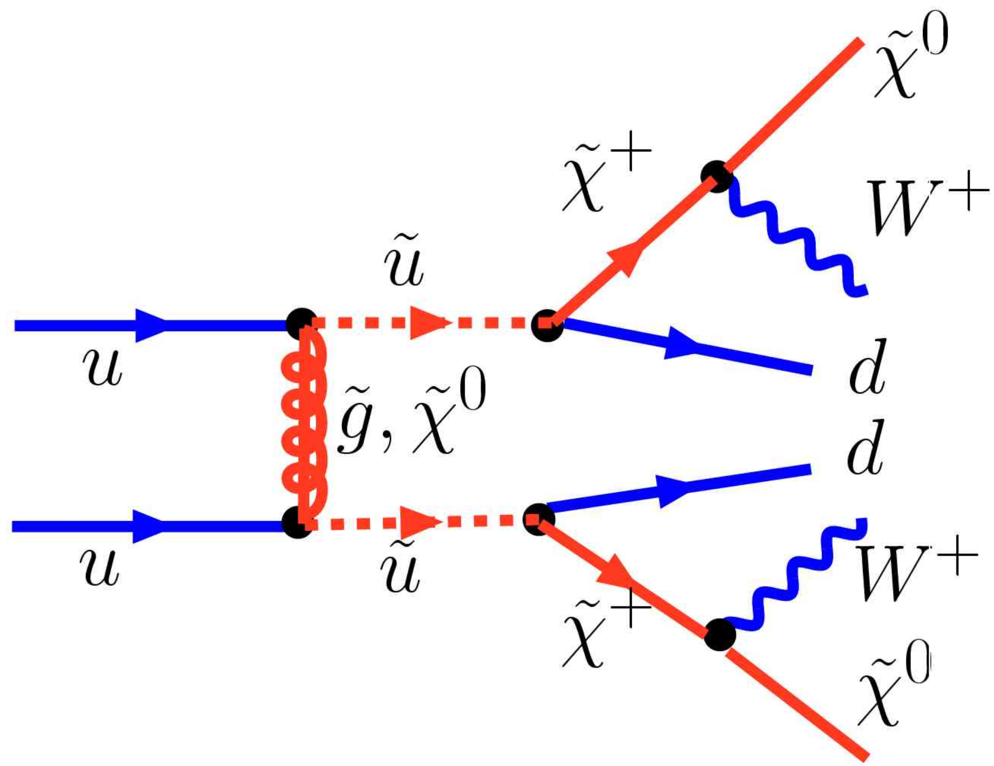


Promising candidates for underlying theory ...

- **Supersymmetry:**
  - *cMSSM, MSSM, NMSSM, E_6SSM, ...*
- **Walking Technicolor**
- **Little Higgs models with T-parity**
- **Extradimensional Models:**
  - *Universal and Warp extra dimensions*

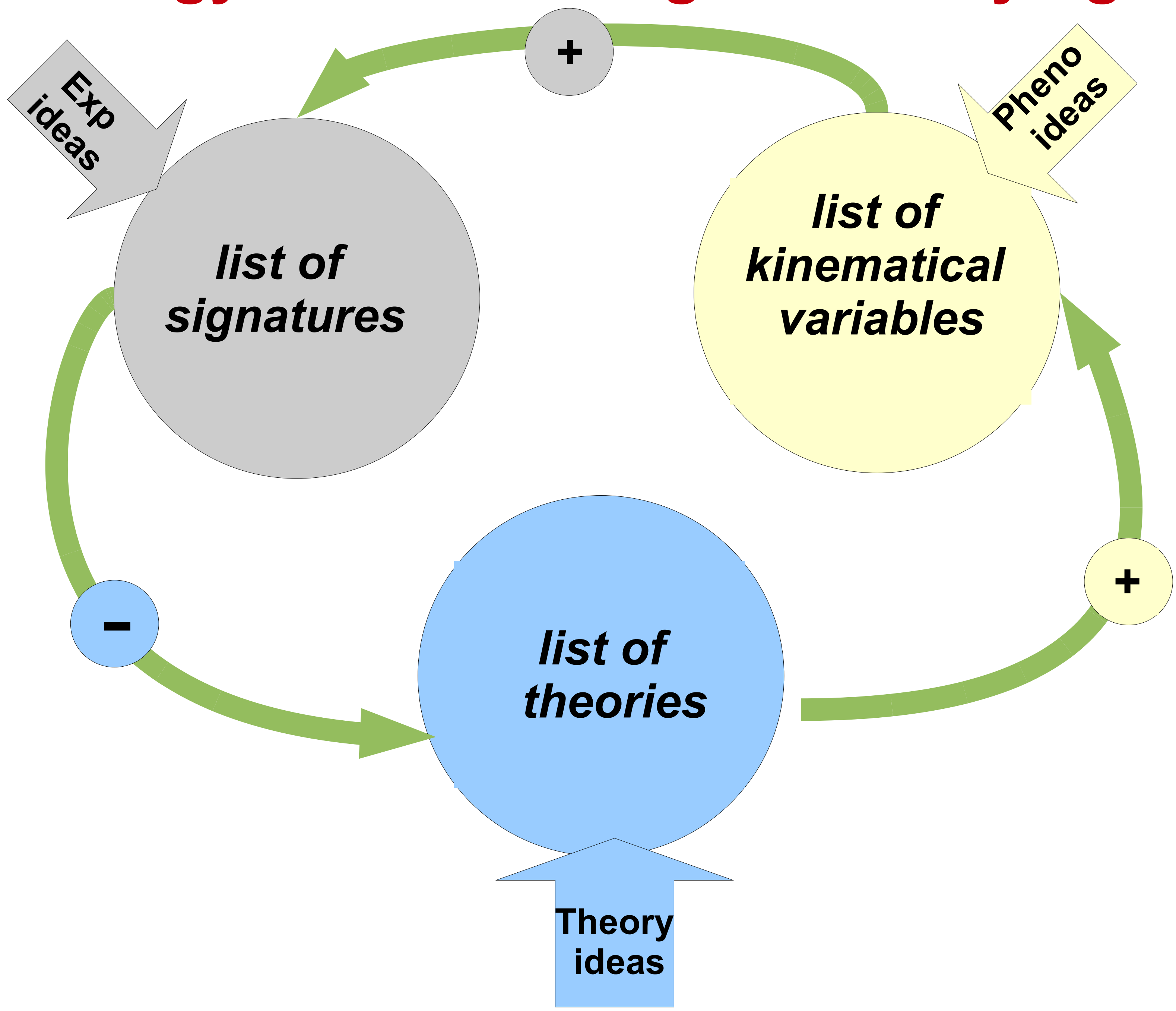
Signatures could look alike



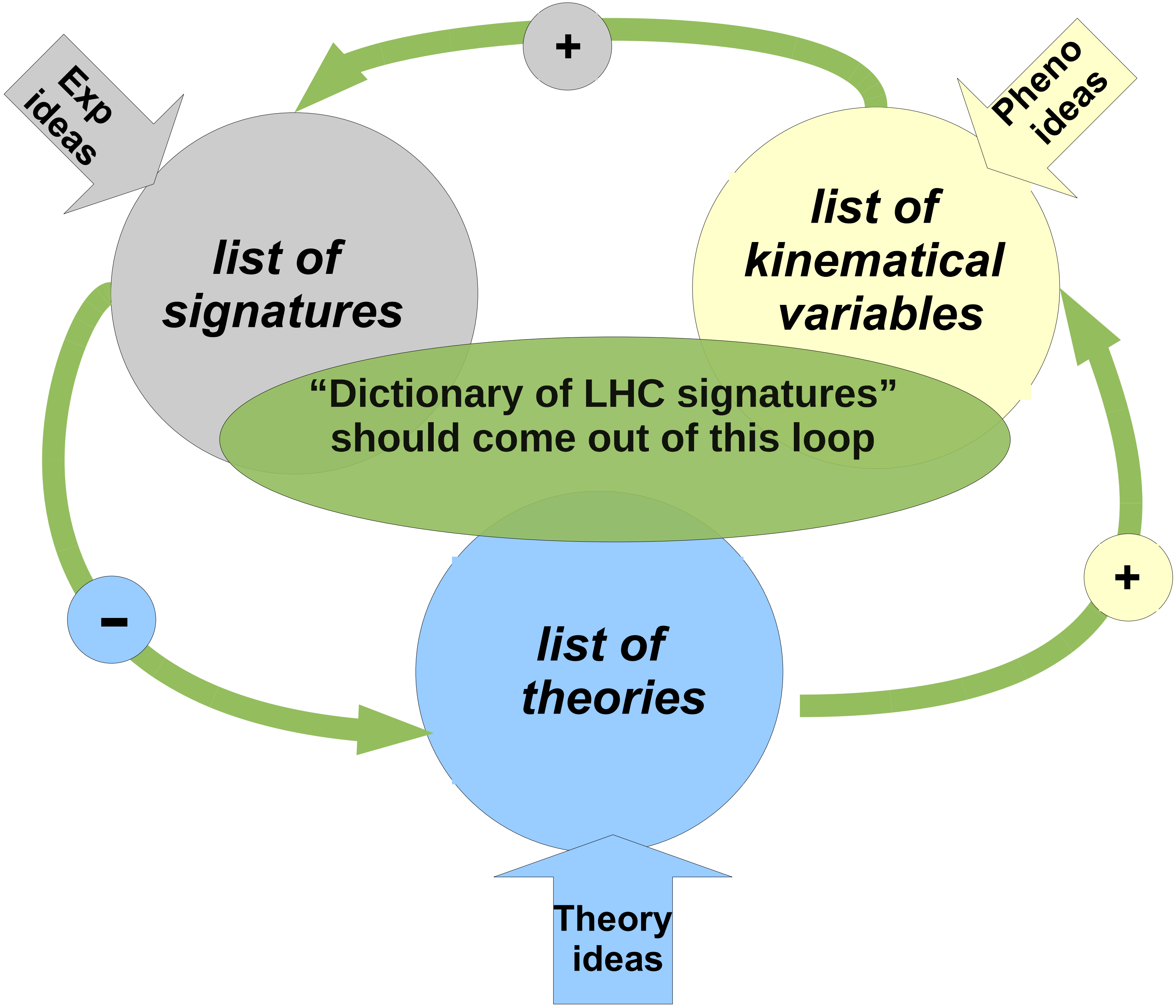


LHT **SUSY**

The strategy for delineating of underlying theory



The strategy for delineating of underlying theory



First Steps towards "Dictionary"

A.B., Asesh Datta, Rohini Godbole, Bruce Mellado, Andreas Nyffeler, Chara Petridou, D.P. Roy, Pramana 72:229-238,2009. e-Print: arXiv:0806.2838 [hep-ph]

Variables		SUSY (MSSM)	LHT	UED
Spin		heavy partners differ in spin by 1/2	heavy partners have the same spin, no heavy gluon	heavy partners have the same spin
Higher level modes		NO heavy partners	NO heavy partners	YES heavy partners
$N_{l^+l^+}/N_{l^-l^-}$		$R_{SUSY} < R_{LHT}$	R_{LHT}	$R_{UED} \simeq R_{LHT}$
SS leptons rates		from several channels: SS heavy fermions, Majorana fermions	only from SS heavy fermions	only from SS heavy fermions
$R = \frac{N(\not{E}_T + jets)}{N(l's + \not{E}_T + \text{jets})}$		$R_{\rm SUSY}$	$R_{\rm LHT} < R_{\rm SUSY}$	$R_{\rm UED}$ to be studied
b-jet multiplicity		enhanced (FP)	not enhanced	not enhanced
Single heavy top		NO	YES	YES via KK2 decay
polarization effects	$tt + \not{E}_T$	to be studied	to be studied	to be studied
	$\tau\tau + \not{E}_T$	to be studied	to be studied	to be studied
Direct DM detection rate		high (FP) low (coann)	low (Bino-like LTP)	typically low for γ_1(5D) DM [22] typically high for γ_H(6D) DM [22]

It was realised that "Dictionary of LHC Signatures" in the form of various tables is not enough to accommodate all models and their signatures

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We need dictionary in the form of the Model Database and their Signatures

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High Energy Physics Model Database [HEPMDB]

High Energy Physics Model Database

HEPMDB

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About HEPMDB

HEPMDB is created to facilitate the connection between High Energy theory and experiment, to store and validate theoretical models, to develop dictionary of the model signatures aimed to identify the fundamental theory responsible for signals expected at the LHC. HEPMDB is also designed for collecting different signatures for its models as well as respective experimental efficiencies. Using this information HEPMDB will be able to compare its BSM model predictions with LHC data which and would allow to discriminate an underlying theory. The database is in the development stage and your input in the 'Forum' section is highly appreciated. Database collects Particle Physics Models. These models are supposed to be public and represent themselves a set of Feynman Rules which can be in form of input for any of Matrix Element generators such as CalcHEP, CompHEP, FeynArts, Madgraph, SHERPA, WHIZARD. HEPMDB has an entrance for Model authors -- 'Authors' -- where Authors can test and validate their models. To become an 'Author', you should register in a 'Register' section. 'Authors' are welcomed to also upload LanHEP or FeynRules source of their models.

Validation

Test and model validation will be available in the nearest future and would include the computing of theoretical predictions for your model on our site via submitting jobs into the High Performance Computing Cluster (HPCC) at University site. It will also allow to run Feynman Rules generators -- LanHEP and FeynRules through the HPCC. You will learn news about this option in 'Forum' section. HEPMDB also collects signatures of Particle Physics Models, for which we suggest to use keywords which 'Authors' supposed to assign to their models. The database of signatures is in the permanent development and is available in the 'Signatures' section. Information and links on relevant packages, e.g. Matrix Element generators or Feynman Rules generator is located in the section 'Tools'.

News

New database is available

2011-06-07 20:21:27

A new database is available to download from our system. It is possible to validate this model on our system as well.
More »

IBM

2011-03-29 01:05:39

We now have confirmation from IBM that all the Iridis 3 racks will be arriving on the 26th September.
More »

Iridis 3

High Energy Physics Model Database

https://hepmdb.soton.ac.uk/

- **Developed at Southampton with support from IPPP, Durham**
  as a result of ideas discussed in the context of the “Dictionary of LHC signatures”, at the FeynRules workshop (April, 2010) and at the Mini-Workshop on Dynamical Symmetry Breaking models and tools (July 2010)
- **Further discussed at Les Hocuhes Workshop, June 201**

High Energy Physics Model Database – HEPMDB. Towards decoding of the underlying theory at the LHC.

Maksym Bondarenko[1], Alexander Belyaev[1,2], Lorenzo Basso[1,2,3], Edward Boos[4], Vyacheslav Bunichev[4], R. Sekhar Chivukula[5], Neil D. Christensen[6], Simon Cox[7], Albert De Roeck[8], Stefano Moretti[1,2], Alexander Pukhov[4], Sezen Sekmen[8], Andrei Semenov[9], Elizabeth H. Simmons[5], Claire Shepherd-Themistocleous[2], Christian Speckner[3]

Abstract

We present here the first stage of development of the High Energy Physics Model Data-Base (HEPMDB) which is already a convenient centralized storage environment for HEP models, and can accommodate, via web interface to the HPC cluster, the validation of models, evaluation of LHC predictions and event generation-simulation chain. The ultimate goal of HEPMDB is perform an effective LHC data interpretation isolating the most successful theory for explaining the LHC observations.

Functions of HEPMDB (1)

- collects HEP models for various multipurpose Matrix Element (ME) generators like CalcHEP, CompHEP, FeynArts, MadGraph/MadEvent, AMEGIC ++/COMIX within SHERPA and WHIZARD.
  Under "HEP models" we denote the set of particles, Feynman rules and parameters written in the format specific for a given package
- collects models' sources which can be used in the HEPMDB to generate HEP models for various ME generators using FeynRules or LanHEP which automate the process of generating Feynman Rules, particle spectra, etc..
  For the moment, FeynRules supports formats for CompHEP, CalcHEP, FeynArts, GoSam, MadGraph/MadEvent, SHERPA and WHIZARD Currently LanHEP works with CalcHEP, CompHEP, FeynArts and GoSam. Also, the latest LanHEP version 3.15 has an option under testing of outputting the model in UFO format which provides a way to interface it with MadGraph/MadEvent
- allows users to upload their models and perform evaluation of HEP processes and event generation for their own models using the full power of the High Performance Computing (HPC) cluster behind the HEPMDB
  This is one of the very powerful features of the HEPMDB: it provides a web interface to various ME generators which can then also be run directly on the HPC cluster. This way, users can preform calculations for any model from HEPMDB avoiding problems related to installing the actual software, which can sometimes be quite cumbersome

Functions of HEPMDB (2)

- allows to cross check and validate models for different ME generators.
  similar functionality is also provided by the FeynRules web validation framework, however, the FeynRules web validation is mainly geared towards comparing FeynRules models and can use its knowledge of the model format to provide a throughout and highly automatized test procedure for those, while HEPMDB works in a more generic way and will provide access to more model formats at the price of slightly less automatization.
- collect predictions and specific features of various models in the form of database of signatures and perform comparison of various model predictions with experimental data (to be developed)
  There are a lot of different aspects related to this problem. This task includes a comprehensive development of a database of signatures as well as development of the format of presentation of these signatures. This format will be consistent with the format which will be used by the experimentalists for the presentation of the LHC data, discussed in the context of the "Les Houches Recommendations for the Presentation of LHC Results" activity.
- allows to trace the history of the model modifications, and makes available all the versions of the model
  Through this application, we stress the importance of reproducibility of the results coming from HEPMDB or from a particular model downloaded from HEPMDB.

Sounding similar but qualitatively different related projects

- "Database of Numerical HEP scattering cross sections"
  http://durpdg.dur.ac.uk/HEPDATA/REAC
  collects various particle scattering process which are connected to experimental searches of different reactions

- "Signatures of New Physics at the LHC" web-site
  http://www.lhcnewphysics.org/
  collects various BSM signatures, their classification and related papers

- FeynRules and models database
  http://feynrules.irmp.ucl.ac.be
  collects various models implemented into FeynRules

- **HEPMDB can effectively collaborate with all projects above!**

The current status of HEPMDB (1)

- Allows to find and download an existing HEP mode. The search engine checks patterns in the fields: *Model, Authors, References, Abstract, Signatures and Information*

HEPMDB

High Energy Physics Models DataBase

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Search in HEPMDB | Show All Models

Search Models :: Results for [MSSM]

1. **MSSM** [2011-06-21 10:54:07] hepmdb:0611.0028

   CalcHEP/MicrOMEGAs groups

   We present MSSM with SUGRA and AMSB scenario as well as MSSM with low energy input. Read file INSTALLATION for model installation and file CITE for references on scientific publications which pre...

2. **MSSM (Whizard)** [2011-12-30 04:38:49] hepmdb:1211.0047

   Christian Speckner

   MSSM model for Whizard...

3. **RPV MSSM** [2012-02-17 18:30:58] hepmdb:0212.0049

   Uploaded by Metin Ata, created by Benjamin Fuks

   (taken from FeynRules web page) Our implementation keeps all the flavour-violating and helicity-mixing terms in the Lagrangian and also all the possible additional CP-violating phases. In order to de...

The current status of HEPMDB (2)

- one can upload a new model (upon user registration). The model can be uploaded in the format of any ME generator. Also, a user can upload the model source in FeynRules or LanHEP formats

Model : MSSM

http://hepmdb.soton.ac.uk/hepmdb:0611.0028

Authors

CalcHEP/MicrOMEGAs groups

Added By

Alexander Belyaev

References

G.~Belanger, F.~Boudjema, A.~Pukhov and A.~Semenov, Comput. Phys. Commun. 174, 577 (2006)[arXiv:hep-ph/0405253]
A.~Djouadi, J.~L.~Kneur and G.~Moultaka, arXiv:hep-ph/0211331

Abstract

Updated MSSM model for CalcHEP is uploaded (bug for SC constant in the file with dependences is corrected)

Information

We present MSSM with SUGRA and AMSB scenario as well as MSSM with low energy input. Read file INSTALLATION for model installation and file CITE for references on scientific publications which present realization of the model.

Tools

CalcHEP [model]

Model History

2011-12-02 15:01:19
2011-10-14 13:40:10

[Download Model File] [Validate Model on HPCx] [Edit Model]

Reviews

The current status of HEPMDB (3)

- allows to the evaluate cross sections for user-defined processes for the chosen model and produce a respective LHE file with generated parton-level events. This file is becomes available for download once the process is finished.
  Currently, the HEPMDB allows the user to perform these calculations (using the HPC) for CalcHEP, WHIZARD and MadGRAPH 5 (under testing) models only.
- produces ntuple files and allows to plot various kinematical distributions
- allows to update/add features and respective signatures specific to each model.
  These features and signatures can be used in the future to distinguish the model from others and connect it to the LHC signatures.
- keeps track of the model changes, providing reproducibility for the results obtained with previous versions of the models uploaded to HEPMDB
- allows to collect feedback/remarks on particular model from users in Review section

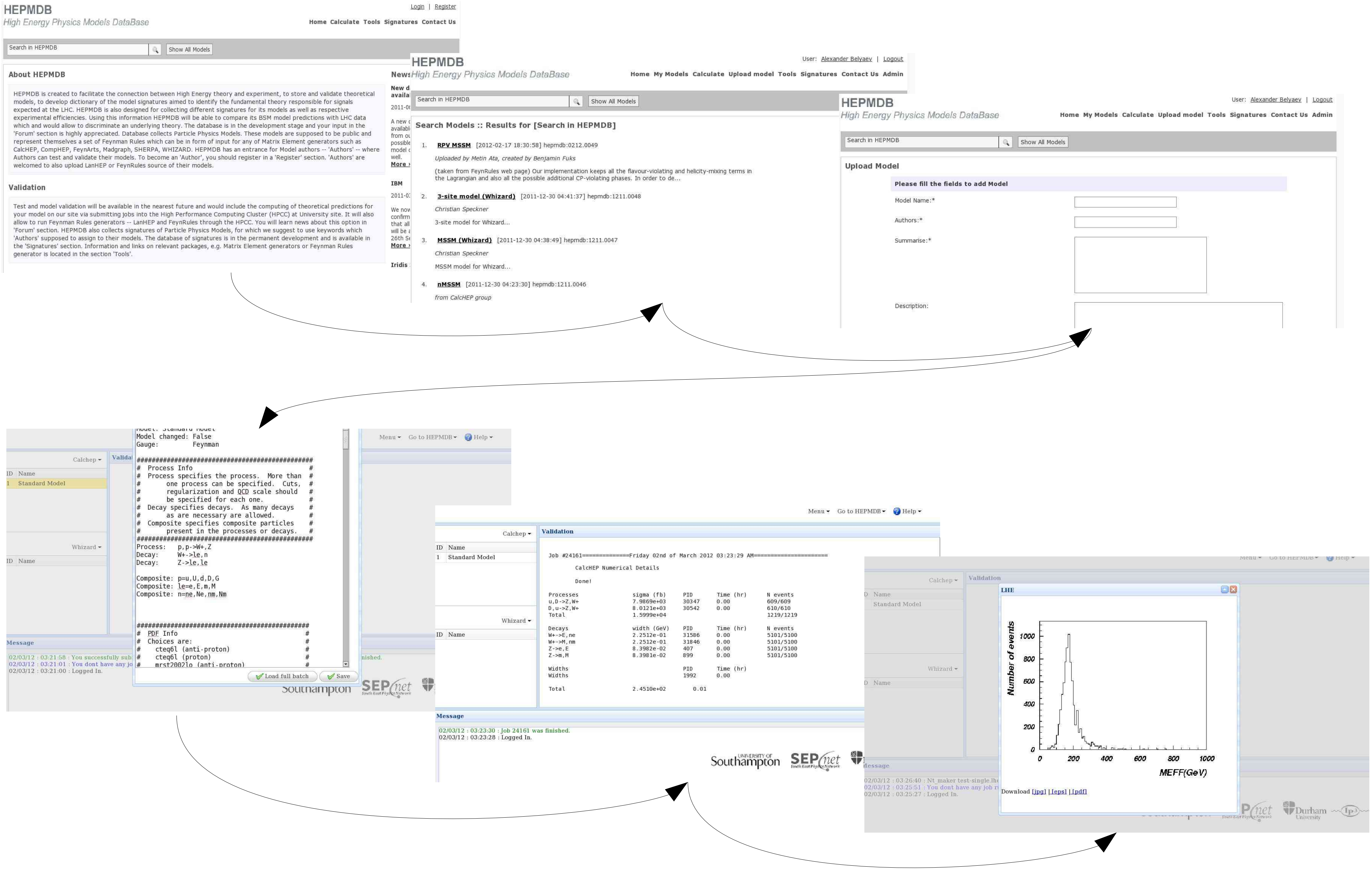
Future prospects for HEPMDB (months scale)

- The LanHEP and FeynRules packages will be added to provide model generation from model sources
- The MadGraph/MadEvent and CompHEP packages will be added.
- A systematic model validation process will be started and the respective pages will be added.
- The possibility to study events beyond the parton level will be carefully considered, up to detector simulation.
  One concrete possibility would be the chain
  LHE events -> HEPMC events -> FASTSIM events (ROOT format)
  For the FASTSIM package, Delphes seems a promising candidate.
- The structure of the database of signatures will be extended to deal with correlated signatures (i.e., whereby multiple signatures, or lacks thereof, must be accounted for simultaneously)

Future prospects for HEPMDB (~year time scale)

- we plan to install the MicrOMEGAs package for evaluation of the dark matter relic density as well as to provide a possibility for scans of various model parameter spaces.
- the format for model predictions consistent with the format for presentation of the LHC data by experimentalists is planned.
- The question about including automatic tools for NLO evaluations is under discussion and will be developed further at the later stages of HEPMDB development.

Tutorial



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RPV MSSM
3-site model (Whizard)
MSSM (Whizard)
nMSSM
Upload Model
Please fill the fields to add Model
Model Name:*
Authors:*
Summarise:*
Description:
Menu Go to HEPMDB Help
Calchep
Whizard
Validation
Message
Standard Model
Load full batch
Save
CalcHEP Numerical Details
LHE
Number of events
MEFF(GeV)
Download [jpg] [eps] [pdf]

Remarks on collecting models at HEPMDB

- **there are numerous model implementations exist on the market (FeynRules team, LanHEP/CalcHEP/CompHEP teams, private implementations)**
- **they are highly complementary and useful**
- **HEPMDB is the natural place to accommodate all of them (also allows to private upload)**

Example of models created for CalcHEP

- **SM + extensions**
  - SM
  - B-L symmetric Z' with heavy Majorana neutrinos
  - SM + Z'
  - general 2 Higgs doublet model
  - 4th generation
  - Excited fermions
  - Model with contact interactions
  - Standard Model + anomalous gauge boson couplings
  - Model of strongly int EW sector (5 & 6 dim operators involving Sigma field)
- **SUSY**
  - constraint MSSM
  - general MSSM, with 124 free parameters
  - NMSSM
  - RPVMSSM
  - left-right symmetric MSSM
  - MSSM with CP violation
  - E6MSSM
- **Extra dimensions**
  - 5D UED with 2KK layers
  - 6D UED with 2KK layers
  - ADD = ADD
  - RS = Randall Sundrum
- **Leptoquarks**
  - Complete LQ model SU(3)xSU(1)xU(1) vector&scalar
- **Technicolor & Higgsless**
  - Minimal walking technicolor
  - TC with DM
  - 3-site model
  - Hidden Local symmetry model
  - 4SM = general 4-site model
- **Little Higgs**
  - Littlest higss model with T-parity
  - LHT + T-parity violation

Models at FeynRules web-site

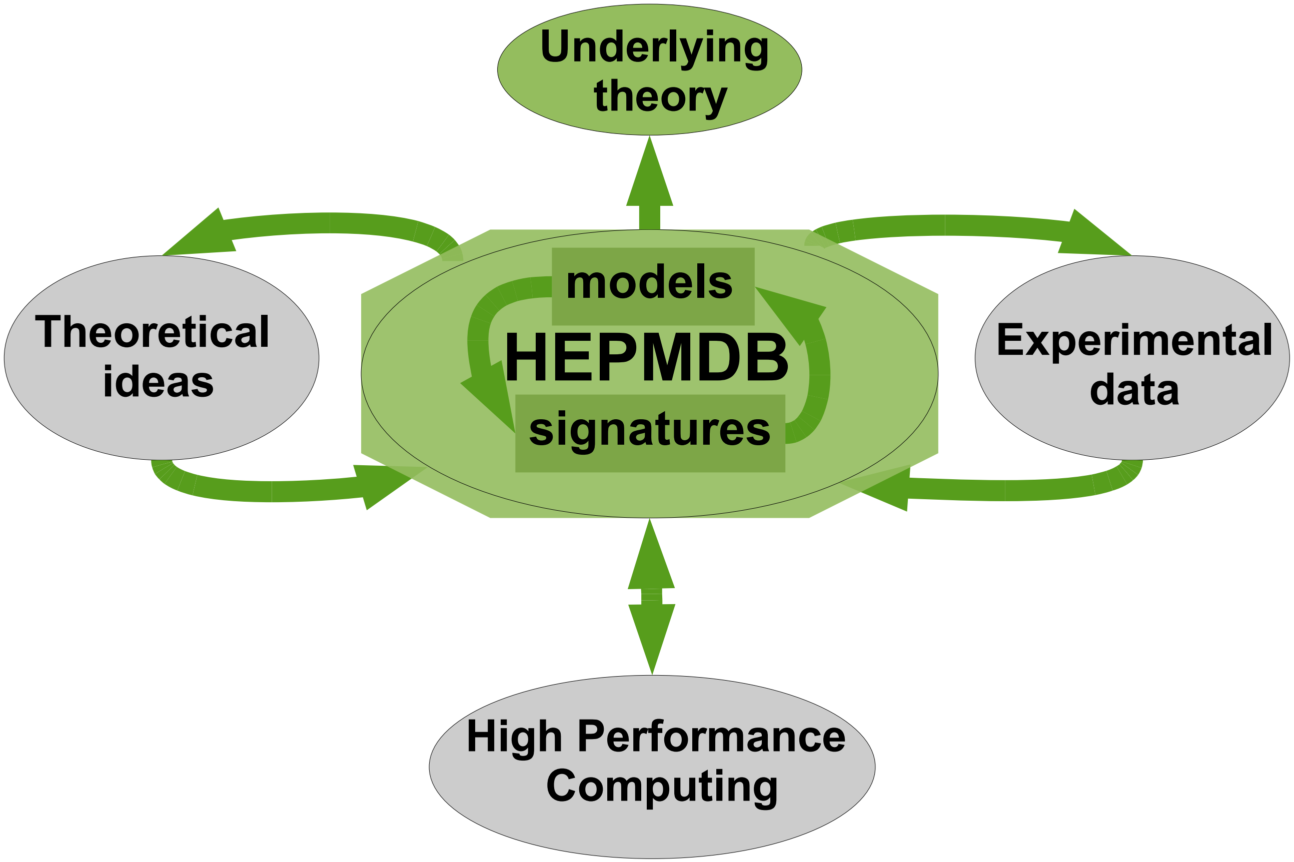
Standard Model	The SM implementation of FeynRules, included into the distribution of the FeynRules package.
Simple extensions of the SM (10)	Several models based on the SM that include one or more additional particles, like a 4th generation, a second Higgs doublet or additional colored scalars.
Supersymmetric Models (4)	Various supersymmetric extensions of the SM, including the MSSM, the NMSSM and many more.
Extra-dimensional Models (4)	Extensions of the SM including KK excitations of the SM particles.
Strongly coupled and effective field theories (4)	Including Technicolor, Little Higgs, as well as SM higher-dimensional operators.
Miscellaneous (0)	

Conclusions

- HEPMDB is already a convenient centralized storage environment for HEP models. Via web interface to the HPC cluster it allows to evaluate the LHC predictions and event generation-simulation chain

- we hope that starting from the present stage, HEPMDB development will be boosted further via involvement of the HEP community
  (via direct involvement into HEPMDB, via various projects involving HEPMDB, via numerous comments/requests for HEPMDB features)

- we think that in the near future the HEPMDB will also become a powerful tool for isolation of the most successful theory for explaining the LHC data


Underlying theory
Theoretical ideas
models
HEPMDB
signatures
Experimental data
High Performance Computing

THANK YOU!