CalcHEP and HEPMDB: High Energy Physics Model Database a practical introduction

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OUTLINE

• CalcHEP

- models and symbolic session
- numerical session and kinematical distributions
- event generation
- 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



Web pages & contacts

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

 The HEPMDB page http://hepmdb.soton.ac.uk

• e-mails

calchep@googlegroups.com hepmdb@soton.ac.uk a.belyaev@soton.ac.uk









"CalcHEP & HEPMDB"



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

• Author(s)

Alexander Pukhov, AB, Neil Christensen

(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)



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



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- Tree-level processes



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- Squared Matrix Element calculation
 - no spin information for outgoing particles spin averaged amplitude



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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
 - Iimit is set from the practical point of view:
 - 2 \rightarrow 6 (1 \rightarrow 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.



Email contact: calchep@googlegroups.com



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* = 3.3.6

- Create work directory
 - From calchep_3.x.x directory (e.g. ../calc_work)
 ./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





Principle KEYS for CalcHEPs GUI







Enter menu selection (forward) Exit menu selection (back)

Help!



Starting CalcHEP





CalcHEP menu structure: symbolic part



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CalcHEP menu structure: symbolic part





Model Structure

Parameters Particles Constraints Vertices

CalcHEP/symb me O \odot Model: Standard Model Abstract Edit model CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) Parameters approximation. The main idea put into the CalcHEP Constraints was to make available passing from the lagrangian Particles to the final distributions effectively with the Vertices high level of automatization. Libraries Use F2 key to get information about interface RENAME facilities and F1 - as online help. CHECK MODEL

F1-Help F2-Man F5-Switches F6-Results F9-Ref F10-Quit

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Particles: prtclxx.mdl (spins 0,1/2,1,3/2,2)

Full name g <mark>luon</mark>		10+	l number	12*sr			2.0 22.0	5.00	0202002 (2200 920200)	1370107872 <u></u>
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	1.002255	IG	121	12	10	10	18	IG	١g	g
photon	IA	IA	122	12	10	10	1	IG	l\gamma	l\gamma
Z-boson	1Z	1Z	123	12	IMZ	ΙwΖ	11	IG	IZ	IZ
W-boson	1 M+	1W-	124	12	I MW	l wW	11	IG	1W^+	1W^-
Higgs	lh	lh	125	10	1 Mh	l!wh	11	ļ.	lh	lh
electron	le	1E	111	11	10	10	11	<u>j</u> .	le^-	le^+
e-neutrino	Ine	INe	112	11	10	10	11	IL	l \nu_e	\bar{\nu}_e
muon	1 m	IM	113	11	l Mm	10	11	1	1 \mu^-	l\mu^+
m-neutrino	lnm	l Nm	114	11	10	10	11	IL	l\nu_\mu	\bar{\nu}_\mu
tau-lepton	11	1L	115	11	IM1	10	11	1	\tau^-	\tau^-
t-neutrino	Inl	IN1	116	11	10	10	11	IL	l\nu_\tau	\bar{\nu}_\ta
d-quark	ld	1D	11	11	10	10	13	Ť.	ld	l \bar{d}
u-quark	lu	IU	12	11	10	10	13	ĵ.	lu	l\bar{u}
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c-quark	lc	IC	14	11	1Mc	10	13	1	lc	\bar{c}
b-quark	lb	IB	15	11	1 Mb	10	13	Ű.	lb	l\bar{b}
t-quark	lt	II	16	11	IMt	lwt	13	1	lt	\bar{t}



Particles: prtclxx.mdl

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Higgs	lh	lh	125	10	1Mh	lwh	11	ĩ	lh	lh
electron	le	İE	111	iĩ	10	10	i1	8	le^-	le^+
e-neutrino	Ine	INe	112	11	10	10	11	ÎL.	l\nu_e	l\bar{\nu} e
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m-neutrino	Inm	l Nm	114	11	10	10	11	ÎL.	l\nu_\mu	l\bar{\nu}_\mu
tau-lepton	11	1L	115	i1	IMI	10	11	1	l\tau^-	l\tau^-
t-neutrino	Inl	IN1	116	11	10	10	11	ÎL-	l\nu_\tau	\bar{\nu}_\ta
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u-quark	lu	ÍŪ	12	11	10	10	13	- î	lu	l\bar{u}
s-quark	ls	15	13	11	IMs	10	13	8	ls	\bar{s}
c-quark	lc	IC	14	11	l Mc	10	13	- î	lc	l\bar{c}
b-quark	lb	IB	15	11	1 Mb	10	13	8	lb	l\bar{b}
t-quark	lt	11	16	11	IMt	lwt	13	- î	ĺt	\bar{t}
				Higg	gs bosol	n widt	th wil	l be d	calculated	`on the fly`



Independent parameters: varsxx.mdl

	cHEP/symb	Parameters 1
	1—Size—Read—Err	
mottoji beckerek	Value	1> Comment
	ZI0.1172	IMS-BAR electromagnetic alpha(MZ)
Q	1100	ISrtong alpha(MZ) for running mass calculation Iscale for running mass calculation
GG	11.238	IRunning Strong coupling. The given value doesn't matter
SM	10.481	IMS-BAR sine of the electroweak mixing angle
	10.221	IParameter of C-K-M matrix (PDG96)
s23	10.041	IParameter of C-K-M matrix (PDG96)
N3338533	10.0035	IParameter of C-K-M matrix (PDG96)
Mm	10.1057	Imuon mass
M1	11.777	Itau-lepton mass
McMc	11.2	IMc(Mc)
Ms	10	ls-quark mass (pole mass, PDG96)
MbMb	14.25	IMb(Mb)
Mtp	1175	lt-quark pole mass
MZ	191.187	IZ-boson mass
Mh	1120	lhiggs mass
ωt	11.59	It-quark width (tree level 1->2x)
ωZ	12.49444	IZ-boson width (tree level 1->2x)
ωW	12.08895	IW-boson width (tree level 1->2x)

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



Dependent parameters(constraints): funcxx.mdl

MARRINGARY HOURSDAY	Size Read ErrMes		
Name	Expression	٥.	
EE	<pre> sqrt(16*atan(1.)*alfEMZ)</pre>	2.2.46.00	electromagnetic constant
CW	$ \text{sqrt}(1-\text{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}) $	2 / Aug. 1	parameter of C-K-M matrix
c13	sqrt(1-s13^ 2)	125240	parameter of C-K-M matrix
Vud	c12*c13	2233	C-K-M matrix element
Vus	s12*c13	- 23	C-K-M matrix element
Vub	s13	8	C-K-M matrix element
Vcd	-s12*c23-c12*s23*s13	8	C-K-M matrix element
Vcs	c12*c23-s12*s23*s13	8	C-K-M matrix element
Vcb	s23*c13	8	C-K-M matrix element
Vtd	s12*s23-c12*c23*s13	8	C-K-M matrix element
Vts	-c12*s23-s12*c23*s13	8	C-K-M matrix element
Vtb	c23*c13	8	C-K-M matrix element
qcdOk	initQCD(alfSMZ,McMc,MbMb,Mtp)		
Mb	MbEff(Q)		
Mt	MtEff (Q)		
MC	McEff (Q)		



Feynman rules: lgrngxx.mdl

> CalcHEP/symb

			(Albino)		Vertices	
clr-	-Del-Si	ze-Rea	d-Errb	les		
A1	A2	A3	A4		Factor	<pre>< > Lorentz part</pre>
h	W+	M -		EE * MW/S	W	m2.m3 -
h	Z	Z		EE/(SW*	CW^ 2)*MW	m2.m3
h	h	h		-(3/2)*	EE*Mh^ 2/(MW*SW)	11
h	h	h	h	(-3/4)*	(EE*Mh/(MW*SW))^ 2	11
\mathbf{h}	h	2	Z	(1/2)*	(EE/(SW*CW))^ 2	m3.m4
h	$ \mathbf{h} $	W+	W-	(1/2)*	(EE/SW)^ 2	m3.m4
М	m	[h	32	-EE*Mm/	(2*MW*SW)	
I.	11	h		-EE*Ml	/ (2*MW*SW)	[]E
С	[C	h		I-EE*Mc/	(2*MW*SN)	11
S	s b	h		-EE*Ms/	(2*MW*SW)	Ĩ L
B	[b	h		-EE *Mb/	(2*MW*SW)	11
T E	t	h	i i	-EE*Mt	/(2*MW*SW)	11
E	le	A		I-EE		G(m3)
M	m	A		I-EE		G(m3)
L	<u>I</u> I	A		-EE		G(m3)
Ne	e	W+		EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
Mn	m	M+		EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
Nl	11	W+		EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
E	ne	W-		EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
M	rm	W-	i i	EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
L	nl	[W-	_3	EE/(2*S	qrt2*SW)	G(m3)*(1-G5)
F1-F	2-Xqot	o-Ygot	o-Find	l-Write	2000-00-00-00-00-00-00-00-00-00-00-00-00	AD MALE AND TAKEN AND ADDRESS COMMENDATION

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External Libraries: extlibxx.mdl

P ⊕ CatcHER/symb	
Libraries lr-Del-Size Read ErrMes	
xternal libraries	
888 For LHAPDF	
-L /home/pukhov/Packages/lhapdf-5.8.4/install/lib -lLH	APDF
'1-F2-Xgoto-Ygoto-Find-Write	



Details of symbolic session

- the input syntax: P1[,P2] → P3,P4 [,,...,[N*x]]
- 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'
 Exercise#2

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



Madal Chandend	fodal.	× 0
Model: Standard	loder	
List of par	ticles (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
1(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	
	🔁 u.U.d.D.s.S.c.C.b.B.G	
nter process: <mark>p.p -> W</mark> omposit 'p' consists o- omposit 'W' consists o- xclude diagrams with	🔁 u.U.d.D.s.S.c.C.b.B.G	



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CalcHEP/symb								•	
Model:	Standard Model								
Process:	p,p -> ₩,b,B						_		
	Eeunman diagrams		Vi	ем зац	ared	diagrams			
diagrams		are constructed.		cw squ					
	Squared diagrams								
	in 24 subprocesses	are constructed.							
diagrams	are calculated.								
NN Su	.bprocess		Del	Calc	Re	st			
↓	NH+ b B		T	01	01	120			
2022/2011 APP/2015/2022						K182 A 10 0 4 0 0 4			
			<u>î</u>	01	01	351			
41 U.d-	->Wb.B		Ť	01	01	120			
	->W-,b,B ->W-,b,B		Ť	01	01 01	120 136			
51 U.s [.]	->W-,b,B			01	01	136			
51 U.s 61 U.b	->Wb.B ->Wb.B			01 01	01 01	136 351			
51 U,s 61 U,b 71 d,U	->Wb.B ->Wb.B ->Wb.B		1 1 1 1	01 01 01	01 01 01	136 351 120			
51 U,s 61 U,b 71 d,U 81 d,C	->Wb.B ->Wb.B			01 01	01 01	136 351			
	Model: Process: diagrams diagrams diagrams diagrams diagrams NN Su ↓ 11 u,D- 21 u,S-	<pre>Model: Standard Model Process: p,p -> W,b,B diagrams in 24 subprocesses are deleted. Squared diagrams diagrams in 24 subprocesses are deleted. are deleted. are calculated.</pre>	<pre>Model: Standard Model Process: p,p -> W,b,B diagrams in 24 subprocesses are constructed. diagrams are deleted. diagrams in 24 subprocesses are constructed. diagrams are deleted. diagrams are calculated. NN Subprocess 11 u,D->W+,b,B 21 u,S->W+,b,B</pre>	Model: Standard Model Process: p.p> W.b.B Feynman diagrams Garams diagrams in 24 subprocesses are constructed. diagrams are deleted. Image: Squared diagrams diagrams in 24 subprocesses are constructed. diagrams are deleted. are constructed. diagrams are calculated. Del NN Subprocess Del 11 u.D->W+.b.B 1 21 u.S->W+.b.B 1	Model: Standard Model Process: p,p -> W,b,B Feynman diagrams iagrams in 24 subprocesses are constructed. diagrams are deleted. Squared diagrams diagrams in 24 subprocesses are constructed. Image: Squared diagrams diagrams are deleted. are constructed. diagrams are deleted. Image: Subprocesses are constructed. Model: Subprocess NN Subprocess I OI 21 u, D->W+,b,B Image: OI	Model: Standard Model Process: p.p> W.b.B View squared diagrams in 24 subprocesses are constructed. View squared diagrams are deleted. Squared diagrams are constructed. diagrams in 24 subprocesses are constructed. Del Calc Regime Model: NN Subprocess are constructed. 01 01 VI = W squared 1 01 01 01 01	Model: Standard Model Process: p.p> W.b.B View squared diagrams diagrams in 24 subprocesses are constructed. View squared diagrams diagrams in 24 subprocesses are constructed. Squared diagrams diagrams in 24 subprocesses are constructed. Del Calc Rest NN Subprocess Del Calc Rest 11 u,D->W+.b.B 1 01 01 120 21 u,S->W+.b.B 1 01 01 136	Model: Standard Model Process: p,p -> W,b,B View squared diagrams diagrams in 24 subprocesses are constructed. View squared diagrams diagrams in 24 subprocesses are constructed. View squared diagrams diagrams in 24 subprocesses are constructed. Squared diagrams diagrams are deleted. are constructed. diagrams are calculated. Del Calc Rest NN Subprocess I 01 01 120 21 u, D->W+,b,B I 01 01 136	Model: Standard Model Process: p,p -> W,b,B diagrams in 24 subprocesses are constructed. View squared diagrams diagrams are deleted. Squared diagrams diagrams in 24 subprocesses are constructed. Del Calc Rest MN Subprocess Del Calc Rest 11 u,D->W+,b,B 1 01 01 120 21 u,S->W+,b,B 1 01 01 136







× 🕤	CalcHEP/symb			20 3
	Model:	Standard Model		
	Process:	p,p → W,b,B		
72		Feynman diagrams in 24 subprocesses are deleted. Squared diagrams	are constructed.	View squared diagrams Symbolic calculations Make&Launch n_calchep Make n_calchep REDUCE program
208	diagrams	in 24 subprocesses are deleted. are calculated.	are constructed.	
1000-000		Man F3-Model F4-Diagram		

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CalcHEP/symb	۲	•	2
Model: Standard Model			
Process: p,p -> W,b,B			
	2		
Feynman diagrams C code			
2 diagrams in 24 subprocesses are constructed. C-compiler			
diagrams are deleted. Edit Linke	n:		
REDUCE code	-16-1		
Squared diagrams MATHEMATICA co 08 diagrams in 24 subprocesses are constructed. FORM code	ae		
diagrams are deleted.	ess		
08 diagrams are calculated.			
Out of memory			
	0.0		
F1-Help F2-Man F3-Model F4-Diagrams F5-Switches F6-Results F9-Ref F1	0-QUIT		



~ · ·	CalcHEP/symb			
	Model:	Standard Model		
	Process:	p,p -> ₩,b,B		
72		Feynman diagrams in 24 subprocesses	are constructed.	C code C-compiler Edit Linker
	Ģ	are deleted. Squared diagrams		REDUCE code MATHEMATICA code
208 208	diagrams diagrams	in 24 subprocesses are deleted. are calculated.	are constructed.	FORM code Enter new process
	Out of me	emory		

F1-Help F2-Man F3-Model F4-Diagrams F5-Switches F6-Results F9-Ref F10-Quit



Numerical part of CalcHEP

🖂 🕙 CalcHEP/num

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

Subprocess

IN state Model parameters Constraints QCD coupling Breit-Wigner Cuts Phase space mapping Vegas Generate events

V A

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F1-Help F2-Man F6-Results F8-Calc F9-Ref F10-Quit

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Menu structure of the numerical part




subprocess menu





control of the initial states and parton density functions



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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



- 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:



	Cuts		5
Clr-Del-Size	-Read-ErrMes-		
Parameter	<pre>I> Min bound</pre>	<i> Ma</i>	x bound <
T(b)	120	i anona seam	11958-116579-119019011 - 54
T (B)	120	Ĩ	
N(b)	1-5	15	
N(B)	1-5	15	
J(b,B)	10.5	1	



phase-space mapping





integration over the phase space



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







events generations

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	ON	
	the second second second second second second second second second second second second second second second se	r ibut ions

Monte Carlo simulation Generate Events Number of events=10000 Launch generator Regenerate events ON





GUI gives user a full control of details of symbolic/numerical session. To sum over the sub-processes one should use scripts

there are several scripts which run various loops to facilitate calculation

- 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

You should run it from results dir where the n_calchep binary is!



running subproc_cycle for SM model

/bin/subpr #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess	1 (u, 2 (u, 3 (u, 3 (U, 5 (U, 5 (U, 7 (d, 8 (d, 9 (D, 10 (D) 11 (s)	$\begin{array}{cccc} \mathbb{D} & -> & \mathbb{W} \\ \mathbb{S} & -> & \mathbb{W} \\ \mathbb{B} & -> & \mathbb{W} \\ \mathbb{d} & -> & \mathbb{W} \\ \mathbb{s} & -> & \mathbb{W} \end{array}$	+, b, B +, b, b, B -, b, b, B -, b, b, B -, b, b, b, b, b, b, b, b, b, b, b, b, b,)))))) B) B)	Cross Cross Cross Cross Cross Cross Cross Cross Cross Cross	section section section section section section section sectior sectior	$ \begin{array}{rcrr} = & 4 \\ = & 2 \\ = & 5 \\ = & 1 \\ = & 4 \\ = & 5 \\ = & 2 \\ = & 9 \\ 1 \\ = & 1 \\ \end{array} $	6364E+00 0808E-01 3490E-04 7795E+00 0253E-01 3181E-05 8270E+00 1421E-01 5470E+00 .1056E-0 .0383E-0 .2694E+0	, 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0	events events events events events events events events events events events events events
#Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess #Subprocess Sum of dist Total Cross see details	14 (S 15 (c 16 (c 17 (c 18 (C 20 (C 21 (b 22 (b 23 (B 24 (B cibutio Sectio	n 37.45	W+, b, W+, b, W+, b, W+, b, W-, b, W-, b, W-, b, W-, b, W+, b, tored i 843711	B) B) B) B) B) B) B B) B B B B B	Cross Cross Cross Cross Cross Cross Cross Cross Cross Cross ile di	section section section section section section section section section section	$ \begin{array}{rcrr} 1 &= 1 \\ 1 &= 9 \\ 1 &= 1 \\ 1 &= 3 \\ 1 &= 2 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1 &= 3 \\ 1$.1026E-0 .2333E+0 .3773E-0 .2480E+0 .4475E-0 .1469E-0 .2651E+0 .4542E-0 .3722E-0 .3992E-0 .3111E-0 .4543E-0	0,0 2,0 0,0 3,0 1,0 0,0 3,0 3,0 3,0 4,0	



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 \rightarrow 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)
            120
T(B)
             120
#Regularization
*** Table ***
Regularization
             |> Mass <|> Width <| Power|
Momentum
45
                       1wZ
                                 2
             | MZ
                                 2
45
             Mh
                       wh
#END
______
     Cross section [pb] Error % nCall
                                            chi**2
#IT
 1
      2.0373E+00
                         3.30E+01 20000
  2
        8.6164E+00
                         2.86E+01
                                     20000
```

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useful scripts for numerical session

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

- subproc_cycle
- sum_distr
- show_distr
- plot_view
- events2tab
- gen_events
- name_cycle
- pcm_cycle

../bin/subproc_cycle 1000 100000
../bin/sum_distr distr_2 distr_3 > distr_sum
../bin/show_distr distr_sum
../bin/plot_view < tab_1.txt</pre>

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 below



A tour to Monte Carlo

MC generators and CalcHEP batch interface

...because Einstein was wrong: God does throw dice! Quantum mechanics: amplitudes =→ probabilities Anything that possibly can happen, will! (but more or less often)





Incoming beams: parton densities

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Hard subprocess: described by matrix elements

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Resonance decays: correlated with hard subprocess

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Initial-state radiation: spacelike parton showers

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Final-state radiation: timelike parton showers

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Multiple parton-parton interactions ...



We need Events in LHE format to talk to MC generators!

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">
<1--
File generated with CalcHEP-PYTHIA interface
-->
<header>
<slha>
</slha>
</header>
<init>
            7.0000006860E+03 7.0000006860E+03
                                                                       -1
                                                                           3
                                                                                    1
  2212
       2212
                                                      -1
                                                            -1
                                                                  -1
  1.16593335502E+01 0.0000000000E+00 1.000000000E+00
                                                            1
</init>
<event>
          1.000000E+00
      1
                          2.8420000E+02
                                         -1.0000000E+00
                                                        -1.000000E+00
                              501
                  0
                                    0.0000000000E+00
       -3
            -1
                            0
                                                       0.0000000000E+00
                                                                          1.54424456520E+02
               -1
        4
                                 0
                                    0.0000000000E+00
                                                       0.0000000000E+00
                                                                        -1.30
                                                                              792414
       24
            2
                                  -9,99292465447E+01 -1,63668803915E+01
                                                                        -6.48692987742E+01
       5
            1
                                 0
                                                                            23390519202E+01
                                    7.34149473360E+01
                                                       2.15593961832E+01
       -5
            1
                              501
                                    2.65142992097E+01 -5.19251579179E+00
                                                                          4.61622886720E+01
      -11
            1
                                  -7.19345413730E+01
                                                       7.47572186340E-01
                                                                        -8.03452022142E+01
       12
             1
                                 0 -2.79947051718E+01 -1.71144525779E+01
                                                                         1.54759034400E+01
</event>
```

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Present Status of CalcHEP





calchep_batch 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 chang	ed: False
Gauge:	Feynman
Process:	p,p->₩,b,B
Decay:	₩->11,nn
Composite:	<pre>p=u,U,d,D,s,S,c,C,b,B,G</pre>
Composite:	W=W+,W-
Composite:	ll=e,E,m,M,l,L
Composite:	nn=ne,Ne,nm,Nm,nl,Nl



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



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

Symbolic Sessions

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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 1 W+->M,nm 1 W+->L,nl 1 W-->e.Ne 1 W-->m,Nm 1 W-->1.N1 1 Widths 1



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

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Numerical Sessions

Standard Model(CKM=1)

Done!

Runs σ (fb) Running Finished Time (hr) N events

Single 1235	0 0/15	15/15	0.14	50000
			0.14	



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

Standard Model(CKM=1)

Done!

Home						
Symbolic Results	Processes	σ (fb)	PID	Time (hr)	N events	Details
	u,D->W+,b,B	10047	27115	0.02	14910/14910	prt_1 session.da
Numerical Results	U,d->W-,b,B	5636.4	27125		8364/8364	prt_1 session.da
	d,U->W-,b,B	5567.9	27129		8263/8263	prt_1 session.da
Events Library	D,u->W+,b,B	9850.2	2010-00-010-010-010-010-0		14618/14618	prt_1 session.da
Process Library	s,C->W-,b,B	1609.9	27366		2389/2389	prt_1 session.da
	S,c->W+,b,B	1359.9	27370		2018/2018	prt_1 session.da
Help	c,S->W+,b,B	1374.5	27563		2039/2039	prt_1 session.da
TTATE D	C,s->W-,b,B	1614.8	27581	0.01	2396/2396	prt_1 session.da
	Total	37061			54997/54997	
Thank you for using	Decays	Г (GeV)	PID	Time (hr)	N events	Details
CalcHEP!	W+->E,ne	0.22339		0.01	255000/254999	prt 1 session.da
	W+->M,nm	0.22339	27586	0.01	255000/254999	prt_1 session.da
Please cite arXiv:0000.0000	W+->L,nl	0.22323	27891	0.01	255000/254999	prt_1 session.da
	W>e,Ne	0.22339	27893	0.01	255000/254999	prt_1 session.da
	W->m,Nm	0.22339	27896	0.01	255000/254999	prt_1 session.da
	W->l,Nl	0.22323	27905	0.01	255000/254999	prt_1 session.da
	Widths		PID	Time (hr)		Details
	Widths		28254	0.01		session.da
	Total	12350		0.14		

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



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Skeleton of the main program

```
IMPLICIT DOUBLE PRECISION(A-H, O-Z)
IMPLICIT INTEGER(I-N)
```

```
integer MSTP,MSTI
COMMON/PYPARS/MSTP(200),PARP(200),MSTI(200),PARI(200)
```

```
integer I,J,K,lun1,lun2,LHA
```

```
mstp(161)=lun2

mstp(162)=lun2

NEV=10

IMSS(21)=lun2
```

```
OPEN(lun2, FILE='lhe'file.lhe',STATUS='UNKNOWN',
& FORM='FORMATTED')
```

```
CALL PYINIT('USER',' ',' ',0d0)
DO 200 NVT=1,NEV
CALL PYEVNT
```

```
C... Insert your analysis here
```

```
200 CONTINUE
100 CALL PYSTAT(1)
CLOSE(lun2)
END
```



Examples of the CalcHEP application

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Dark matter relic density – IsaRed and MicrOmegas Neutralino relic density in mSUGRA

most of the parameter space is ruled out! $\Omega h^2 \gg 1$ special regions with high σ_A are required to get $0.094 < \Omega h^2 < 0.129$



W' 3-lepton signatures from 3-site Higgsless model

• CMS: W' 3-lepton signatures from 3-site Higgsless model





B-L extension of SM





Universal Extra Dimensions

In collaboration with M.Brown, J.M. Moreno, C. Papineau



Universal Extra Dimensions

Set up of the production and decay processes with the calchep batch

```
Process: p,p->u2,u2
                Process: p,p->y3,y3
                Process: p,p->y2,y3
                Decay: y1->2*x
                Decay: y2->2*x
                Decay: y3->2*x
                Decay: y4->2*x
                Decay: u5->2*x
                Decay: y6->2*x
                Decay: y7->2*x
                Decay: u8->2*x
                Composite: p=u,U,d,D,s,S,c,C,b,B,G
                Composite: u1=~G_1
                Composite: y2=~d1_1,~u1_1,~s1_1,~c1_1,~b1_1,~t1_1,~d2_1,~u2_1,~s2_1,~c2_1,~b2_1,~t2_1
                Composite: y3=~D1_1,~U1_1,~S1_1,~C1_1,~B1_1,~T1_1,~D2_1,~U2_1,~S2_1,~C2_1,~B2_1,~T2_1
                Composite: u4=Z,W+,W-,t,T,H
                Composite: y5="P_1,"V_1,"W+_1,"W-_1
                Composite: y6=~e1_1,~e2_1,~n1_1,~mu1_1,~mu2_1,~n2_1,~tau1_1,~tau2_1,~n3_1
                Composite: y7=~E1_1,~E2_1,~N1_1,~Mu1_1,~Mu2_1,~N2_1,~Tau1_1,~Tau2_1,~N3_1
                Composite: y8=~H_1.~a0_1.~a+_1.~a-_1
Scan in 2D space with the calchep batch
                              # Run Info
                             # Masses and Energies are in GeV
                             # More than one run can be specified at
                              #
                                   the same time.
                              Run parameter: invR
```

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Run begin:

Run begin:

Run n steps:

Run step size: 200

Run parameter: nL

Run step size: 10 Run n steps:

"CalcHEP & HEPMDB"

600

4

10

4

CalcHEP Batch Details

MUED-Chloe-2KK

Done!

	Finished	Time(hr)
Symbolic	6498/6498	0.00
σ	4/4	3.29
Events	4/4	7.30

Home Symbolic Results Numerical Results Events Library Process Library Help

Thank you for using CalcHEP! Please cite arXiv:0000.0000



Symbolic Sessions

MUED-Chloe-2KK

Processes	Lib PID Time(hr)
u,u->~u1_1,~u1_1	1
u,u->~u1_1,~u2_1	1
u,u->~u2_1,~u2_1	1
u,d->~d1_1,~u1_1	1
u,d->~d1_1,~c1_1	1
u,d->-d1_1,~t1_1	1
u,d->-d1_1,-u2_1	1
u,d->~d1_1,~c2_1	1
~ 6k subproc	esses
~a- 1->N1,~e2_1	1
~a1->N1,~e1_1	1
~a1->H,~W1	1
~a1->Z,~W1	1
~a1->A,~W1	1
~a1->W-,~V_1	1
~a1->W-,~P_1	1
Widths	1

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NE

Numerical Sessions

MUED-Chloe-2KK

Done!

Runs	σ (fb)	Running	Finished	Time (hr)	N events
invR=600 LR=40	5126	0/6499	6499/6499	20.68	50000
invR=800 LR=40	809.2	0/6499	6499/6499	28,52	50000
invR=1000 LR=40	151.2	0/6499	6499/6499	24.66	50000
invR=1200 LR=40	30.29	0/6499	6499/6499	21.86	50000
				95.72	

Home Symbolic Results Numerical Results Events Library Process Library Help

Thank you for using CalcHEP! Please cite arXiv:0000.0000



Numerical Sessions

MUED-Chloe-2KK

Done!

Help Thank you for	Processes	σ (fb)	PID	Time (hr)	N events		Details
using CalcHEP!	u,u->~u1 1,~u1 1	497.36	19766	0.00	5196/5196	prt 1	session.dat
Please cite	u,u->~u1 1,~u2 1	696.28	19769	0.00	7202/7202	prt 1	session.dat
arXiv:0000.0000	u,u->~u2 1,~u2 1	550.46	19775	0.00	5734/5734	prt 1	session.dat
	u,d->~d1_1,~u1_1	212.45	19781	0.00	2297/2297	prt 1	session.dat
		~ 6k s	subpr	oce	sses		
	~a1->N1,~e1_1	1.3688 $x10^{-14}$	14954	0.00	255000/254999	prt_1	session.dat
	~a- 1->H,~W- 1	0	14991	0.00	0/254999	prt 1	session.dat
	~a- 1->Z,~W- 1	0	15098	0.00	0/254999	prt 1	session.dat
	~a- 1->A,~W- 1	0 0 0	15172	0.00	0/254999	prt 1	session.dat
	~a- 1->W-,~V 1	0	18314	0.00	0/254999	prt 1	session.dat
	~a1->W-,~P_1	0	18320	0.00	0/254999	prt 1	session.dat
	Widths		PID	Time (hr)		ī	Details
	Widths		18342	0.00			session dat
	Total	5126		20.68			

Home Symbolic Results Numerical Results Events Library Process Library Help



CalcHEP Events Library

Home Symbolic Results Numerical Results Events Library Process Library

Date

Tue Mar 27 23:06:39 2012 Wed Mar 28 00:32:40 2012 Tue Mar 27 19:42:27 2012 Tue Mar 27 21:34:29 2012

LHE

0101 MH120 8tev-invR1000LR40.lhe

0101 MH120 8tev-invR1200LR40.lhe

Q1Q1 MH120 8tev-invR600LR40.lhe

0101 MH120 8tev-invR800LR40.lhe

plain Ntuple





Some highlights of the CalcHEP

- Convenient graphical interface
- Calculates particle widths 'on the fly'
- Allows to edit diagrams as well as squared diagrams important for the dedicated interference studies
- Easy to modify an existing model (GUI) or to implement the new one (LanHEP, FeynRules)
- Powerful batch interface connects numerous production and decay processes
- Allows to perform multidimensional scan of the the parameter space and produce LHE files in one run
- Adopted to HPC cluster
- Many more see an updated manual

Outlook

- ME matching: for 1,2,...3 jets ME's
- Connection production and decay without loss of the polarization info
- Helicity amplitude method is on the way
- Link to GoSam CalcHEP@NLO is under discussion



HEPMDB



What underlying theory should explain?





"CalcHEP & HEPMDB"

Promising candidates for underlying theory

- Supersymmetry:
 - CMSSM, MSSM, NMSSM, E₆SSM, ...
- Walking Technicolor
- Extradimensional Models:
 - Universal and Warp extra dimensions



Signatures could look alike





The strategy for delineating of underlying theory





The strategy for delineating of underlying theory





"CalcHEP & HEPMDB"

First Steps towards "Dictionary"

AB, Asesh Datta, A. De Roeck 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	NO	NO	YES	
modes	heavy partners	heavy partners	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	
$R = \frac{N(E_T + jets)}{N(l's + E_T + jets)}$	R _{SUSY}	$R_{\rm LHT} < R_{ m SUSY}$	$R_{\rm UED}$ to be studied	
b-jet multiplicity	enhanced (FP)	not enhanced	not enhanced	
Single heavy top	NO	YES	YES via KK2 decay	
polarization $tt + \not t$ effects $\tau\tau + \not t$		to be studied to be studied	to be studied to be studied	
Direct DM detection rate	high (FP) low (coann)	low (Bino-like LTP)	typically low for $\gamma_1(5D)$ DM [22] typically high fo $\gamma_H(6D)$ DM [22]	



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



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

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



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

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

High Energy Physics Model Database [HEPMDB]



High Energy Physics Model Database https://hepmdb.soton.ac.uk/

HEPMDB

High Energy Physics Models DataBase

Home News Calculate Tools Signatures Contact Us

Search in HEPMDB

Show All Models

0

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

News

CalcHEP and HEPMDB: practical introduction and tutorial

2012-05-03 23:13:13

CalcHEP and HEPMDB: practical introduction and tutorial will take place at CERN https://indico.cern.ch/conferenceDisplay.py?confId=189668 More >>

LHAPDF package is added

2012-03-25 12:55:34

LHAPDF is installed at HEPMDB and can be used now. To use LHAPDF installed at HEPMDB with CalcHEP models one should add -L\$HOME/lhapdf/lib/ -ILHAPDF line to your extlibN.mdl file. P.S. All news about HEPMDB like this one will be sent to all users registered at HEPMDB (they also should have an option not to receive these news if they want) More »

Miniworkshop on High Energy Physics Model Database (HEPMDB)

2012-05-03 23:15:00

Miniworkshop on High Energy Physics Model Database (HEPMDB). At IPPP at Durham we have a one-day mini-workshop on High Energy Physics Model Database (HEPMDB). The schedule and registration are available at http://indico.cern.ch/event/hepmdb



High Energy Physics Model Database

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 developed at the Les Houches Workshop, June 2011

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

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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.



Aims of the HEPMDB (1)

- to collect 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
- to collect 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

 to allows users 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



Aims of HEPMDB (2)

- to plot and document various kinematical distributions from generated events in the LHE format
- to allow to compare predictions from models generated from LanHEP and FeynRules
- to 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.

 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 and have an effective way to validate them

• HEPMDB can effectively collaborate with all projects above!



The current status of HEPMDB (1)

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

1000	PMDB Energy Physics Models DataBase	<u>Login Register</u> Home Calculate Tools Signatures Contact Us					
Sear	ch in HEPMDB Show All Models						
Sea	rch Models :: Results for [MSSM]						
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3.	RPV MSSM [2012-02-17 18:30:58] hepmdb:0212.0049 <i>Uploaded by Metin Ata, created by Benjamin Fuks</i> (taken from FeynRules web page) Our implementation keeps all the flavour-violating and helicity-mixing the Lagrangian and also all the possible additional CP-violating phases. In order to de	terms in					



"CalcHEP & HEPMDB"

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, allows to keep model privately!

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





"CalcHEP & HEPMDB"

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
- CompHEP package 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.
- Author of other packages/models are welcome to install/upload them
- 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.



MDB Show AI Models PDDB Screated to facilitate the connection between High Energy theory and experiment, to store and validate theoretical develop dictionary of the model signatures aimed to identify the fundamental theory responsible for signals if the LI-C. LEPMOB is also designed for collecting different signatures for its models as well as respective differences. Substrated high approximate, the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the start of the startow start the start of the startow start of the start of the sta	Image: Search in HEPMDB Search in HEPMDB Aready sould be an end of the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the search in the sear	or Whizard card) [2011-12-30_04:38:49] hepmdb:1211.004 <i>kner</i>	I Modes 1 the flavour-volating and helicity-mo hases. In order to de	te Upload model Tools Signature	HEPMDB High Energy Physics Models DataBase	Home My Models Calculate Upload n Show All Models	User: <u>Alexander Belvaex</u> Log model Tools Signatures Contact Us Add
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The star ad validation will be available in the neverst future and would include the computing of theoretical predictions on our site value site to the High Performance Computing Cluster (HSCC) at University site. It will also no experimental by Benerators - LankEP and FeynRules Models, for when we suggest to use expressions on our site value sources of batter models. Data our site value collects signatures of Particle Physics Models, for when we suggest to use keywords which upposed to assign to their models. The displays and signatures is in the permanent development and available in user's section. Information and links one for Models for Matrix Element generators were's section. Thermation and links one relevant packages of signatures is in the permanent development and elevands and the signation will be available in every section. Thermation and links one relevant packages of signatures is in the permanent development and is available in urge's section. 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HEPMDB

High Energy Physics Models DataBase

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Validation

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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

HEPMDB is created to facilitate the connection between High Energy theory and experiment, to store and validate theoretical

which and would allow to discriminate an underlying theory. The database is in the development stage and your input in the

represent themselves a set of Feynman Rules which can be in form of input for any of Matrix Element generators such as

Authors can test and validate their models. To become an 'Author', you should register in a 'Register' section, 'Authors' are

Test and model validation will be available in the nearest future and would include the computing of theoretical predictions for

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News

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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 »

Iridis 3

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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 »

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Alexander Belyaev

generator is located in the section 'Tools'.



welcomed to also upload LanHEP or FeynRules source of their models.

"CalcHEP & HEPMDB"

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Alexander Belyaev



"CalcHEP & HEPMDB"



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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)	



Remarks on collecting models at HEPMDB

- there are numerous model implementations exist (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 keep model privately, controlled by Public/Private option On/Off!)



Summary on HEPMDB

- HEPMDB is already a convenient centralized storage environment for HEP models. Via web interface to the HPC cluster (12 cores per user) 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 hope 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

