



# <http://theory.sinp.msu.ru/~pukhov/calchep.html>

**Authors - Alexander Pukhov, Alexander Belyaev, Neil Christensen**

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

## General information

[Main features](#), [Acknowledgments](#) [News&Bugs](#) [Publications&Lectures](#) [Contributions](#)

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## Manual

[calchep\\_man\\_3.3.6.pdf](#) (manual for version 3.3.6, July 19, 2012)

[HEP computer tools](#) (Lecture by Alexander Belyaev)

See also: [Dan Green, High Pt physics at hadron colliders](#) (Cambridge University Press)

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## Code download.

[Licence](#) [Installation](#) [Curent version 3.4.7](#) (27.05.2014) [Old Versions](#),

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## Models:

[MSSM\(24.06.2011\)](#) [NMSSM23\(07.05.2011\)](#) [CPVMSSM\(11.06.2013\)](#) [SUSY models By A.Semenov](#) [LeptoQuarks](#) [5DSM](#) [6DSM](#)

Model database [HEPMDB](#)

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## Related packages on Web:

Packages for model generation: [LanHEP](#) [FeynRules](#) [SARAH](#)

RGE and spectrum calculation: [SuSpect](#) [Isajet](#) [SoftSUSY](#) [SPHeno](#) [CPsuperH](#) [NMSSMTools](#)

Particle widths in MSSM: [SUSY-HIT](#) [HDECAY](#)

Parton showers: [PYTHIA](#)

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## Contacts

Email: [calchep@googlegroups.com](mailto:calchep@googlegroups.com)

Launchpad service: [Ask a question](#) [File a bug](#)

# Kurulum

- **tar zxvf calchep\_3.4.x.tgz**
- **cd calchep\_3.4.x**
- **make**
- **./mkWORKdir ../calcworkcpc (istenilen bir isim verilebilir, bende calcworkcpc)**
- **cd ..**
- **cd calcworkcpc**

# Bu program ile ne yapabiliriz?

## **Calculate High Energy Physics**

- ◆ Dallanma Oranı Hesaplayabiliriz 😊
- ◆ Ađeç Seviyesinde Tesir Kesiti Hesaplayabiliriz 😊
- ◆ Feynman Çizimleri Yapabiliriz 😊
- ◆ Olay Üretimi 😊
- ◆ Yeni süreç girebiliriz 😊

**Not: En çok kullanacağınız tuş: esc tuşu**



```
iturk — bash — 80x24
Last login: Fri Aug 1 19:35:30 on ttys000
user-MacBook-Pro-3:~ iturk$ cd calchep
calchep/      calchep3.4.cpc/
user-MacBook-Pro-3:~ iturk$ cd calchep3.4.cpc/calc
calchep_3.4.cpc/  calchep_3.4.cpc.tar  calcworkcpc/
user-MacBook-Pro-3:~ iturk$ cd calchep3.4.cpc/calcworkcpc/
```

```
calcworkcpc — bash — 80x24
Last login: Fri Aug 1 19:35:30 on ttys000
user-MacBook-Pro-3:~ iturk$ cd calchep
calchep/      calchep3.4.cpc/
user-MacBook-Pro-3:~ iturk$ cd calchep3.4.cpc/calc
calchep_3.4.cpc/  calchep_3.4.cpc.tar  calcworkcpc/
user-MacBook-Pro-3:~ iturk$ cd calchep3.4.cpc/calcworkcpc/
user-MacBook-Pro-3:calcworkcpc iturk$ ./calchep
```

# Çalışma Sırası – 1

1- Bir parçacık seçelim.

2- Bozunma genişliğini

hesaplayalım.

3- Dallanma oranını

hesaplayalım.

```
CalcHEP_3.4.cpc/symb
CalcHEP - a package for Calculation in High Energy Physics
Version 3.4.cpc: Last correction April 8, 2013

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

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                Questions  : https://answers.launchpad.net/calchep
                Bugs       : https://bugs.launchpad.net/calchep
                Code&Models: 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
```

## Abstract

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization. Use F2 key to get information about interface facilities and F1 - as online help. **Questions:** <https://answers.launchpad.net/calchep> **Bugs:** <https://bugs.launchpad.net/calchep>

```
Standard Model
Standard Model (CKM=1)
SM(CKM=1 with hGG/AA)
IMPORT MODEL
```

```
CalcHEP_3.4.cpc/symb
Model: Standard Model

Abstract

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization. Use F2 key to get information about interface facilities and F1 - as online help. Questions: https://answers.launchpad.net/calchep Bugs: https://bugs.launchpad.net/calchep

Enter Process
Force Unit.Gauge= OFF
Edit model
Numerical Evaluation
=====
Delete model
```

CalcHEP\_3.4.cpc/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	

CalcHEP\_3.4.cpc/symb

Model: Standard Model

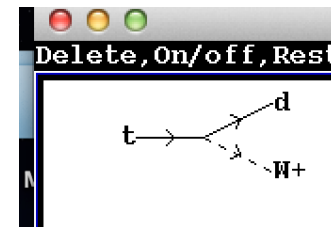
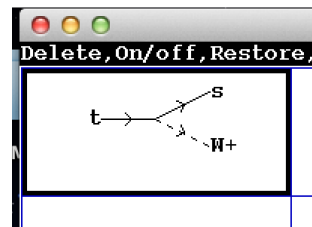
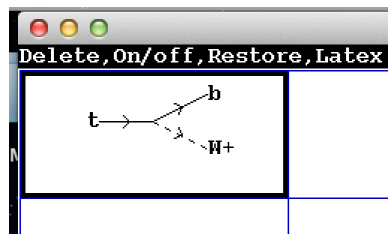
Process: t->2\*x

Enter process: t->2\*x

Feynman diagrams

3 diagrams in 3 subprocesses are constructed.  
0 diagrams are deleted.

NN	Subprocess	Del	Rest
1	t -> W+, b	0	1
2	t -> W+, s	0	1
3	t -> W+, d	0	1



CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:** t->2\*x

**Feynman diagrams**  
diagrams in 3 subprocesses are constructed.  
diagrams are deleted.

- View diagrams
- Square diagrams**
- Write down processes

CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:** t->2\*x

**Feynman diagrams**  
diagrams in 3 subprocesses are constructed.  
diagrams are deleted.

**Squared diagrams**

- View squared diagrams
- Symbolic calculations**
- Make&Launch n\_calchep
- Make n\_calchep
- REDUCE program

CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:** t->2\*x

**Feynman diagrams**  
diagrams in 3 subprocesses are constructed.  
diagrams are deleted.

- C code**
- C-compiler
- Edit Linker

CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:** t->2\*x

**Feynman diagrams**  
diagrams in 3 subprocesses are constructed.  
diagrams are deleted.

**Squared diagrams**  
diagrams in 3 subprocesses are constructed.  
diagrams are deleted.  
diagrams are calculated.

- C code**
- C-compiler**
- Edit Linker
- REDUCE code
- MATHEMATICA code
- FORM code
- Enter new process

```
CalcHEP_3.4.cpc/num
(sub)Process: t -> W+, b
Monte Carlo session: 1(begin)
Subprocess
IN state
Model parameters
Constraints
QCD coupling
Breit-Wigner
Aliases
Cuts
Phase space mapping
Monte Carlo simulation
Total width
```

Bozunma Genişliği

Dallanma Oranı

```
CalcHEP_3.4.cpc/num
Decay t -> 2*x
Total width : 1.527E+00 GeV
Modes and fractions :
W+  b - 9.99E+01%
W+  s - 5.04E-02%
W+  d - 3.20E-03%
Incoming particle
Show Branchings
QCD Scale Q= M1
Model parameters
Constraints
Parameter dependence
```

# Çalışma Sırası – 2

- 1) Bir model seçelim.  
Örneğin Standart Model seçilir.**
- 2) Bir süreç seçelim.  
İstenmeyen alt süreçler atılabilir.**
- 3) Feynman çizimlerinin karesini alıp sonucu “C” dilinde yazdıralım.  
Çizimler mutlaka inceleyelim.**
- 4) “C” programını derleyip sayısal inceleme yapalım.  
Sonuçlar burada elde edebiliriz.**
- 5) Hızlandırıcı da burada seçelim.**
- 6) Tesir kesitlerini elde edelim.  
a)ISR ve BS etkileri dahil olmadan b) dahil ederek**



```
CalcHEP_3.4.cpc/symb

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**Abstract**

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface facilities and F1 - as online help.

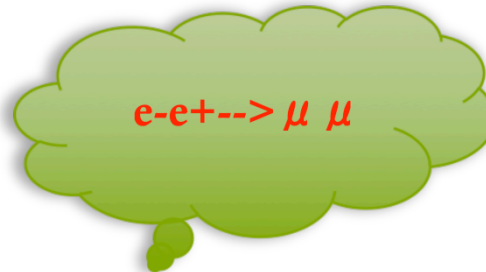
Questions <https://answers.launchpad.net/calchep>  
Bugs <https://bugs.launchpad.net/calchep>

**Standard Model**  
Standard Model (CKM=1)  
SM (CKM=1 with hGG/AA)  
IMPORT MODEL

## Model Seçimi

SUSY, SM, QED ile ilgili modelleri bulabilir.

**Temel Bir Süreç elektron+pozitron-->muon+antimüon**



# Temel Bir Süreç elektron+pozitron-->muon+antimuon

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

Model: Standard Model

**Abstract**

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface facilities and F1 - as online help.

**Questions:** <https://answers.launchpad.net/calchep>

**Bugs:** <https://bugs.launchpad.net/calchep>

**Enter Process**

Force Unit.Gauge= OFF  
Edit model  
Numerical Evaluation  
-----  
Delete model

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

## List of particles (antiparticles)

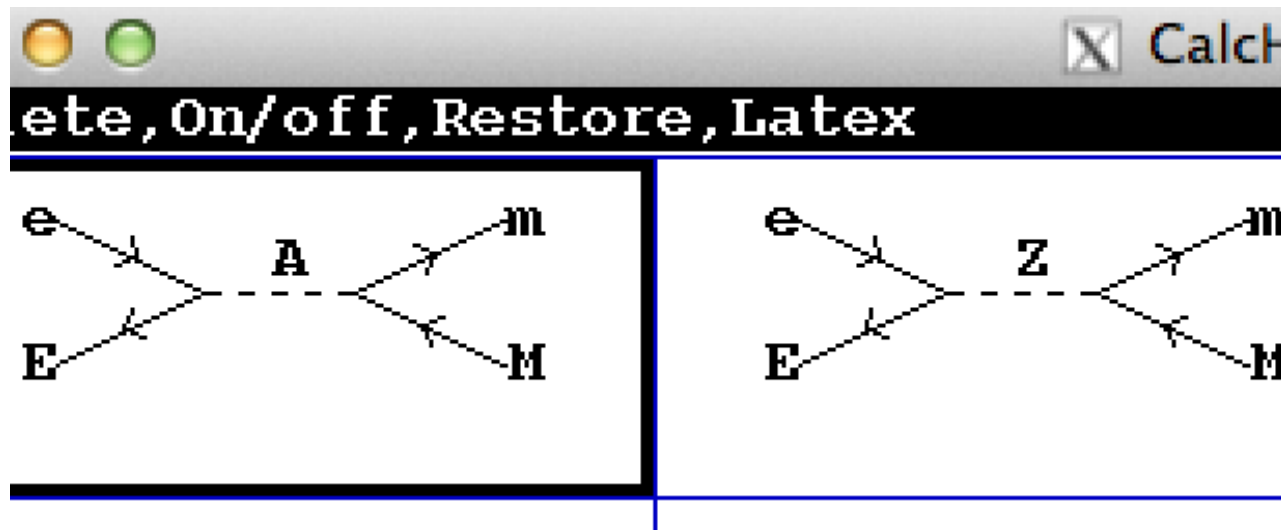
G(G )- gluon	A(A )- photon	Z(Z )- Z-boson
W+(W- )- W-boson	h(h )- Higgs	e(E )- electron
ne(Ne )- e-neutrino	m(M )- muon	mm(Nm )- m-neutrino
l(L )- tau-lepton	nl(Nl )- t-neutrino	d(D )- d-quark
u(U )- u-quark	s(S )- s-quark	c(C )- c-quark
b(B )- b-quark	t(T )- t-quark	

Enter process: e,E -> m,M  
Exclude diagrams with

İstemediğimiz altsüreç varsa ilgili parçacık yazılır. Örneğin: Z ara parçacıklı altsüreci istemiyorsak Z yazılır

```
CalcHEP_3.4.cpc/symb
Model: Standard Model
Process: e,E -> m,M
Feynman diagrams
2 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.
```

< View diagrams  
Square diagrams  
Write down processes



CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:**  $e, E \rightarrow m, M$

**Feynman diagrams**  
 2 diagrams in 1 subprocesses are constructed.  
 0 diagrams are deleted.

<

View diagrams

**Square diagrams**

Write down processes

CalcHEP\_3.4.cpc/symb

**Model:** Standard Model

**Process:**  $e, E \rightarrow m, M$

**Feynman diagrams**  
 2 diagrams in 1 subprocesses are constructed.  
 0 diagrams are deleted.

**Squared diagrams**  
 3 diagrams in 1 subprocesses are constructed.  
 0 diagrams are deleted.  
 0 diagrams are calculated.

<

**View squared diagrams**

Symbolic calculations

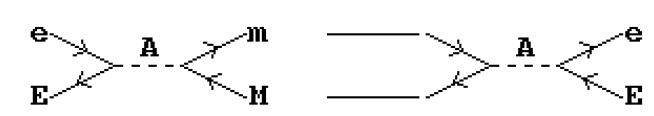
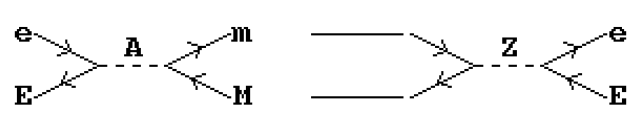
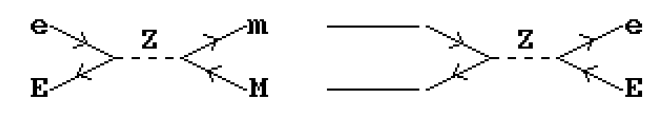
Make&Launch n\_calchep

Make n\_calchep

REDUCE program

CalcHEP\_3.4.cpc/symb

Delete, On/off, Restore, Latex, Ghosts 1/3

 <p>CALC</p>	 <p>CALC</p>
 <p>CALC</p>	

```
CalcHEP_3.4.cpc/symb
Model: Standard Model
Process: e,E -> m,M

Feynman diagrams
2 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.

Squared diagrams
3 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.
3 diagrams are calculated.
```

- View squared diagrams
- Symbolic calculations**
- Make&Launch n\_calchep
- Make n\_calchep
- REDUCE program

```
CalcHEP_3.4.cpc/symb
Model: Standard Model
Process: e,E -> m,M

Feynman diagrams
2 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.

Squared diagrams
3 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.
3 diagrams are calculated.
```

- C code**
- C-compiler
- Edit Linker
- REDUCE code
- MATHEMATICA code
- FORM code
- Enter new process

```
CalcHEP_3.4.cpc/symb
Model: Standard Model
Process: e,E -> m,M

Feynman diagrams
2 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.

Squared diagrams
3 diagrams in 1 subprocesses are constructed.
0 diagrams are deleted.
3 diagrams are calculated.
```

- C code
- C-compiler**
- Edit Linker
- REDUCE code
- MATHEMATICA code
- FORM code
- Enter new process

CalcHEP\_3.4.cpc/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 1(begin)

<

**Subprocess**

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

CalcHEP\_3.4.cpc/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 1(begin)

<

Subprocess

**IN state**

Model parameters  
Constraints  
QCD coupling  
Breit-Wigner  
Aliases  
Cuts

CalcHEP\_3.4.7/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 2

**IN state**

#IT Cross section[pb] E <

**S.F.1: OFF**

S.F.2: OFF

First particle momentum[GeV] = 500

Second particle momentum[GeV] = 500

First particle unpolarized

Second particle unpolarized



CalcHEP\_3.4.cpc/num

```
(sub)Process: e, E -> m, M
Monte Carlo session: 1(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
```

Subprocess  
IN state  
Model parameters  
Constraints  
QCD coupling  
Breit-Wigner  
Aliases  
Cuts  
Phase space mapping  
**Monte Carlo simulation**  
1D intergration

CalcHEP\_3.4.cpc/num

```
(sub)Process: e, E -> m, M
Monte Carlo session: 1(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Monte Carlo simulation

nSess = 5

Enter new value 50

CalcHEP\_3.4.cpc/num

```
(sub)Process: e, E -> m, M
Monte Carlo session: 1(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Monte Carlo simulation

nCalls = 20000

Enter new value 20000

```
CalcHEP_3.4.cpc/num
(sub)Process: e, E -> m, M
Monte Carlo session: 1(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Monte Carlo simulation

nSess = 50  
nCalls = 20000  
Set Distributions  
**\*Start integration**  
Display Distributions  
Clear statistic  
Freeze grid OFF  
Clear grid  
Event Cubes 10000  
Generate Events

```
CalcHEP_3.4.7/num
(sub)Process: e, E -> m, M
Monte Carlo session: 2(begin)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
46 1.1404E-01 1.00E-04 20000
47 1.1404E-01 1.00E-04 20000
48 1.1404E-01 1.00E-04 20000
49 1.1404E-01 1.00E-04 20000
50 1.1404E-01 1.00E-04 20000
< > 1.1404E-01 1.41E-05 100000 0.2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
38 1.1404E-01 1.00E-04 20000
39 1.1404E-01 1.00E-04 20000
40 1.1404E-01 1.00E-04 20000
41 1.1404E-01 1.00E-04 20000
```

Monte Carlo simulation

**\*Start integration**



Integration is over  
— Press any key —



## ISR&BS Etkisini (Hızlandırıcımıza Uygun Olarak) Göz Önüne Alalım

**ISR:** İlk ışımadan yayınlanan foton radyasyonu-KM enerjisini azaltabilir.

**BS:** Parçacıkların EM alanından dolayı enerji kaybediyor. Bu spektrum doğrusal çarpıştırıcının geometrisine (bunch x+y sizes), demetin boyutlarına (bunch length), demetdeki parçacık sayısına (bunch of particles), demet enerjisine göre değişim göstermektedir.

CalcHEP\_3.4.cpc/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 1(begin)

IN state

S.F.1: Qis

OFF

Qisr=1.00E0\*sqrtS, Beamstr: 560.0, 0.400, 2.

CalcHEP\_3.4.cpc/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 1(begin)

IN state

S.F.1: Qisr=1.00E0\*sqrtS, Beamstr: 560.0, 0.400, 2.0E+10

ISR scale = 1.00E+00\*sqrtS  
Beamstrahlung ON  
Bunch x+y sizes (mm) = 560.0  
Bunch length (mm) = 0.400  
Number of particles = 2.0e+10  
\* N\_gamma = 1.53  
\* Upsilon = 0.55  
Beamstrahlung F(x) plot  
Beamstrahlung F(x)^(1-x)^(2/3)

CalcHEP\_3.4.cpc/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 1(begin)

IN state

S.F.2: OFF

ISR scale = 1.00E+00\*sqrtS  
Beamstrahlung ON  
Bunch x+y sizes (mm) = 560.0  
Bunch length (mm) = 0.400

CalcHEP\_3.4.7/num

(sub)Process: e, E -> m, M  
Monte Carlo session: 2(continue)

IN state

#IT Cross section[ph] E  
46 1.1404E-01 1.  
47 1.1404E-01 1.  
48 1.1404E-01 1.  
49 1.1404E-01 1.  
50 1.1404E-01 1.  
< > 1.1404E-01 1.  
XXXXXXXXXXXXXXXXXXXXXXXXXXXX

S.F.1: Qisr=1.00E0\*sqrtS, Beamstr: 560.0, 0.400, 2.0E+10  
S.F.2: Qisr=1.00E0\*sqrtS, Beamstr: 560.0, 0.400, 2.0E+10  
First particle momentum[GeV] = 500  
Second particle momentum[GeV] = 500  
First particle unpolarized  
Second particle unpolarized

38 1.1404E-01 1.00E-04 20000  
39 1.1404E-01 1.00E-04 20000  
40 1.1404E-01 1.00E-04 20000

```
CalcHEP_3.4.cpc/num
(sub)Process: e, E -> m, M
Monte Carlo session: 1(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 9.5786E-03 1.20E+00 1940400
```

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

```
CalcHEP_3.4.cpc/num
(sub)Process: e, E -> m, M
Monte Carlo session: 1(continue)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

- Monte Carlo simulation
- nSess = 50
- nCalls = 20000
- Set Distributions
- \*Start integration
- Display Distributions
- Clear statistic
- Freeze grid OFF
- Clear grid
- Event Cubes 10000

```
CalcHEP_3.4.7/num
(sub)Process: e, E -> m, M
Monte Carlo session: 3(begin)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
149 3.9890E-01 5.14E-01 19404
150 4.0224E-01 5.14E-01 19404
< > 4.0354E-01 1.41E+00 2910600 1
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
138 3.9721E-01 4.89E-01 19404
139 3.9563E-01 4.90E-01 19404
140 3.9748E-01 4.99E-01 19404
141 3.9472E-01 5.21E-01 19404
142 3.9625E-01 5.03E-01 19404
```

- Monte Carlo simulation
- \*Start integration

Integration is over  
Press any key



Önceki sonuçla karşılaştırıldığında sonucun değiştiğini görüyoruz  
yani hızlandırıcı parametrelerinin tesir kesiti üzerindeki etkisini görüyoruz.

```

CalcHEP_3.4.7/num
(sub)Process: e, E -> m, M
Monte Carlo session: 3(begin)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
149 3.9890E-01 5.14E-01 19404
150 4.0224E-01 5.14E-01 19404
< > 4.0354E-01 1.41E+00 2910600 1
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
138 3.9721E-01 4.89E-01 19404
139 3.9563E-01 4.90E-01 19404
140 3.9748E-01 4.99E-01 19404
141 3.9472E-01 5.21E-01 19404
142 3.9625E-01 5.03E-01 19404
143 4.0065E-01 5.10E-01 19404
144 4.0149E-01 4.98E-01 19404
145 4.0099E-01 4.99E-01 19404
146 3.9903E-01 5.16E-01 19404
147 3.9893E-01 5.11E-01 19404

```

```

Monte Carlo simulation
nSess = 50
nCalls = 20000
Set Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid OFF
Clear grid
Event Cubes 10000
Generate Events

```

### F1 komutuna basılır

```

CalcHEP_3.4.cpc/num
(sub)Process: e, E -> m, M
Distributions 1
-Clr-Del-Size-Read-ErrMes
Parameter_1|> Min_1 <|> Max_1 <|> Parameter_2|> Min_2 <|> Max_2 <
M(m,M) |0 |500|

```

```

* n_distrib PgUp
quark pair.
There are 3 special parameters which allow to test incoming particle
distribution: 'E1', 'E2' - energies of first and second incoming
particles and M12 - total CMS energy.

For outgoing particles the available key names are:

A - Angle in degree unit
C - Cosine of angle
D - Jet separation min(pT1^2,pT2^2)*(cosh(d_Rapidity)-cos(d_AzimuthAngle))
J - Jet cone angle
E - Energy of the particle set
M - Mass of the particle set
P - Cosine of the angle between the first particle in the list and
the direction of boosting of the particle set into the rest
frame of the particles set
T - Transverse momentum (P_t) of the particle set
S - Squared mass
Y - Rapidity of the particle set
PgDn

```



(sub)Process: e, E -> m, M  
 Monte Carlo session: 3(begin)

Monte Carlo simulation

\*Start integration

#IT	Cross section[pb]	Error[%]	nCall	Eff.	chi^2
149	3.9890E-01	5.14E-01	19404		
150	4.0224E-01	5.14E-01	19404		
< >	4.0354E-01	1.41E+00			

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

138	3.9721E-01	4.89E-01			
139	3.9563E-01	4.90E-01			
140	3.9748E-01	4.99E-01			
141	3.9472E-01	5.21E-01			

(sub)Process: e, E -> m, M  
 Monte Carlo session: 3(continue)

Monte Carlo simulation

nSess = 50  
 nCalls = 20000  
 Set Distributions  
 \*Start integration  
 Display Distributions  
 Clear statistic  
 Freeze grid OFF

#IT	Cross section[pb]	Error[%]	nCall	Eff.	chi^2
193	3.9802E-01	4.47E-01	19404		
194	3.9823E-01	4.40E-01	19404		
195	3.9727E-01	4.55E-01	19404		
196	4.0011E-01	4.59E-01	19404		
197	4.0074E-01	4.63E-01	19404		
198	3.9801E-01	4.51E-01	19404		
199	4.0036E-01	4.72E-01	19404		
200	3.98				
< >	4.02				

XXXXXXXXXXXX

(sub)Process: e, E -> m, M  
 Monte Carlo session: 3(continue)

#IT	Cross section[pb]	Error[%]	nCall	Eff.	chi^2
193	3.9802E-01	4.47E-01	19404		
194	3.9823E-01	4.40E-01	19404		
195	3.9727E-01	4.55E-01	19404		
196	4.0011E-01	4.59E-01	19404		
197	4.0074E-01	4.63E-01	19404		
198	3.9801E-01	4.51E-01	19404		
199	4.0036E-01	4.72E-01	19404		
200	3.9869E-01	4.57E-01	19404		
< >	4.0229E-01	1.06E+00	3880800		1
188	3.9703E-01	4.47E-01	19404		
189	3.9648E-01	4.39E-01	19404		
190	3.9892E-01	4.44E-01	19404		
191	3.9923E-01	4.33E-01	19404		
192	3.9765E-01	4.42E-01	19404		

Monte Carlo simulation

Display Distributions  
 Distributions

M(m, M)

number of bins

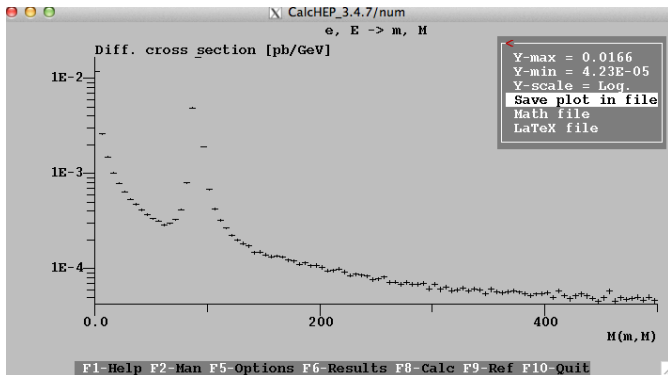
300  
 150  
 100  
 75  
 60  
 50  
 30  
 25

PgDn

➤ Çift- mu değişmez  
 (invariant) kütle dağılımı

➤ latex&text çıktı alınabilir

➤ log&lineer Y eksenini  
 kullanılabilir



## Çalışma Sırası-3 – PROTONLARDA

Aynı yollardan tesir kesitlerini ama bu sefer kesmeler (cutlar) koyarak hesaplayalım. Sonra da bol bol olay üretimi yapalım.  $pp \rightarrow bB$  sürecini inceleyelim.

Model: Standard Model/Unitary Gauge/

Abstract

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the Lagrangian to the high level.

Enter Process

Force Unit.Gauge= ON

Edit model

Numerical Evaluation

-----

Delete model

Model: Standard Model/Unitary Gauge/

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	mm(Mm )- 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	

Model: Standard Model/Unitary Gauge/

Process:  $p, p \rightarrow b, B$

Feynman diagrams

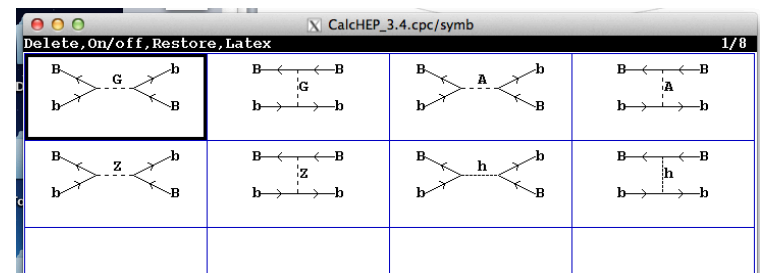
53 diagrams in 15 subprocesses are constructed.  
0 diagrams are deleted.

View diagrams

Enter process:  $p, p \rightarrow b, B$   
 composite 'p' consists of:  $u, U, c, C, d, D, s, S, b, B, G$

NN	Subprocess	Del	Rest
1	$u, U \rightarrow b, B$	0	4
2	$u, C \rightarrow b, B$	0	1
3	$U, u \rightarrow b, B$	0	4
4	$U, c \rightarrow b, B$	0	1
5	$c, U \rightarrow b, B$	0	1
6	$c, C \rightarrow b, B$	0	5
7	$C, u \rightarrow b, B$	0	1
8	$C, c \rightarrow b, B$	0	5
9	$d, D \rightarrow b, B$	0	3
10	$D, d \rightarrow b, B$	0	3
11	$s, S \rightarrow b, B$	0	3

PgDn



CalcHEP\_3.4.cpc/symb

Model: Standard Model/Unitary Gauge/  
Process: p,p->b,B

Feynman diagrams  
53 diagrams in 15 subprocesses are constructed.  
0 diagrams are deleted.

- View diagrams
- Square diagrams
- Write down processes

CalcHEP\_3.4.cpc/symb

Model: Standard Model/Unitary Gauge/  
Process: p,p->b,B

Feynman diagrams  
53 diagrams in 15 subprocesses are constructed.  
0 diagrams are deleted.

- View squared diagrams
- Symbolic calculations
- Make&Launch n\_calchep
- Make n\_calchep

CalcHEP\_3.4.cpc/symb

Model: Standard Model/Unitary Gauge/  
Process: p,p->b,B

Feynman diagrams  
53 diagrams in 15 subprocesses are constructed.

- C code
- C-compiler

CalcHEP\_3.4.cpc/symb

Model: Standard Model/Unitary Gauge/  
Process: p,p->b,B

Feynman diagrams  
53 diagrams in 15 subprocesses are constructed.  
0 diagrams are deleted.

- C code
- C-compiler
- Edit Linker
- REDUCE code

CalcHEP\_3.4.cpc/num

(sub)Process: b, B -> b, B  
Monte Carlo session: 1(begin)

- Subprocess
- IN state
- Model parameters
- Constraints
- QCD coupling
- Print names

CalcHEP\_3.4.cpc/num

(sub)Process: b, B -> b, B  
Monte Carlo session: 1(begin)

- S.F. 1: OFF
- IN state
- PDT:mrst2002nlo(anti-proton)
- PDT:mrst2002nlo(proton)
- PDT:mrst2002lo(anti-proton)
- PDT:mrst2002lo(proton)
- PDT:cteq6m(anti-proton)
- PDT:cteq6m(proton)
- PDT:cteq6l(anti-proton)
- PDT:cteq6l(proton)
- PDT:CTEQ5M(anti-proton)
- PDT:CTEQ5M(proton)

CalcHEP\_3.4.cpc/num

(sub)Process: b, B -> b, B  
Monte Carlo session: 1(begin)

- S.F. 2: PDT:cteq6l(p
- IN state
- PDT:mrst2002nlo(anti-proton)
- PDT:mrst2002nlo(proton)
- PDT:mrst2002lo(anti-proton)
- PDT:mrst2002lo(proton)
- PDT:cteq6m(anti-proton)
- PDT:cteq6m(proton)
- PDT:cteq6l(anti-proton)
- PDT:cteq6l(proton)
- PDT:CTEQ5M(anti-proton)
- PDT:CTEQ5M(proton)

```

CalcHEP_3.4.cpc/num
(sub)Process: b, B -> b, B
Monte Carlo session: 1(begin)
IN state
S.F. 1: PDT:cteq6l (proton)
S.F. 2: PDT:cteq6l (proton)
First particle momentum[GeV] = 4000
Second particle momentum[GeV] = 4000
First particle unpolarized
Second particle unpolarized

```

```

CalcHEP_3.4.cpc/num
(sub)Process: b, B -> b, B
Monte Carlo session: 1(begin)
Subprocess
IN state
Model parameters
Constraints
QCD coupling
Breit-Wigner
Aliases
Cuts
Phase space mapping
Monte Carlo simulation
ID integration

```

```

CalcHEP_3.4.cpc/num
(sub)Process: b, B -> b, B
Monte Carlo session: 1(begin)
Monte Carlo simulation
#IT Cross section[pb] Error[%] nCalls Eff. chi^2
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
nSess = 50
nCalls = 20000
Set Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid OFF
Clear grid
Event Cubes 10000
Generate Events

```

```

CalcHEP_3.4.cpc/num
(sub)Process: b, B -> b, B
Monte Carlo session: 1(begin)
Monte Carlo simulation
*Start integration
Integration is over
Press any key
#IT Cross section[pb] Error[%] nCalls Eff. chi^2
94 7.6681E+51 3.63E+01 19404
Bad Precision 1E+02%;
95 1.0716E+52 4.99E+01 19404
Bad Precision 1E+02%;
96 4.6702E+51 7.63E+01 19404
Bad Precision 1E+02%;
97 1.3864E+52 8.98E+01 19404
Bad Precision 1E+02%;
98 1.3164E+51 7.26E+01 19404
Bad Precision 1E+02%;
99 1.1121E+51 7.55E+01 19404
Bad Precision 1E+02%;
100 8.6143E+51 8.1E+01 19404
Bad Precision 1E+02%;
< > 1.7024E+52 1940400 2

```

Sonuçlar iyi değil ☹

Ne yapmalı ??

## ÇÖZÜM: Kesmeler (Cut) Konmalı

### Cuts

- T3
- T4
- N3
- N4 gibi

(sub)Process: b, B -> b, B  
Monte Carlo session: 1(continue)

#IT	Cross section[pb]	Error[%]	nCall	Eff.	chi^2
< >	1.7024E+52	1.22E+01	1940400		
95	1.0716E+52	4.99E+01	19404		
96	4.6702E+51	7.63E+01	19404		
97	1.3864E+52	8.98E+01	19404		
98	1.3164E+51	7.26E+01	19404		

Bad Precision 1E+02%;

Subprocess  
IN state  
Model parameters  
Constraints  
QCD coupling  
Breit-Wigner  
Aliases  
**Cuts**  
Phase space mapping  
Monte Carlo simulation  
1D intergration

konulabilir...

(sub)Process: b, B -> b, B

Clr	Del	Size	Read	ErrMes	Parameter	Min bound	Max bound

chi^2

2

F1-F2-Xgoto-Ygoto-Find-Write

(sub)Process: b, B -> b, B

Clr	Del	Size	Read	ErrMes	Parameter	Min bound	Max bound
					T(b)	200	
					T(B)	200	
					N(b)	-2.5	2.5
					N(B)	-2.5	2.5

chi^2

2

```

CalcHEP_3.4.cpc/num
(sub)Process: b, B -> b, B
Monte Carlo session: 2(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2

```

- Subprocess
- IN state
- Model parameters
- Constraints
- QCD coupling
- Breit-Wigner
- Aliases
- Cuts
- Phase space mapping
- Monte Carlo simulation
- 1D intergration

```

CalcHEP_3.4.cpc/num

(sub)Process: b, B -> b, B
Monte Carlo session: 1(begin)

#IT Cross section[pb] Error[%] nCalls Eff. chi^2
46 3.5111E-01 5.59E-01 19404
47 3.5007E-01 7.00E-01 19404
48 3.5255E-01 6.50E-01 19404
49 3.4944E-01 5.89E-01 19404
50 3.5743E-01 1.57E+00 19404
< > 3.5323E-01 6.47E-01 970200 0.4
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

```

Monte Carlo simulation

\*Start integration

Integration is over  
—Press any key—

Sadece bir alt süreç hesapladık, hepsini yani toplam tesir kesitini hesaplamak CalcHEP'den geri çıkılır.

Başka bir pencere açalım ve results dizinine girilerek session.dat dosyasından parametreler kontrol edilebilir.

```

user-MacBook-Pro-3:results iturk$ nano session.dat

```

```

results -- nano -- 80x24
GNU nano 2.0.6 File: session.dat

#Subprocess 1 ( b, B -> b, B )
#Session_number 1
#Initial_state inP1=4.000000E+03 inP2=4.000000E+03
Polarizations= { 0.000000E+00 0.000000E+00 }
StrFun1="PDT:cteq6l(proton)" 2212
StrFun2="PDT:cteq6l(proton)" 2212

#Physical_Parameters
EE = 3.1343000000000000E-01
alfSMZ = 1.1840000000000000E-01
Q = 1.0000000000000000E+02
s12 = 2.2100000000000000E-01
s23 = 4.1000000000000000E-02
s13 = 3.5000000000000000E-03
Mm = 1.0570000000000000E-01
ML = 1.7770000000000000E+00
McMc = 1.2000000000000000E+00
MbMb = 4.2500000000000000E+00

```



Yine results dizinine girilerek **../bin/subproc\_cycle 0 0** komutu yazılır.

```
user-MacBook-Pro-3:results iturk$ cd ..  
user-MacBook-Pro-3:calcworkcpc iturk$ cd results/  
user-MacBook-Pro-3:results iturk$ ../bin/subproc_cycle 0 0
```

```
user-MacBook-Pro-3:results iturk$ ../bin/subproc_cycle 0 0  
#Subprocess 1 ( b, B -> b, B ) Cross section = 3.5370E-01 , 0 events  
#Subprocess 2 ( B, b -> b, B ) Cross section = 3.5337E-01 , 0 events  
#Subprocess 3 ( u, U -> b, B ) Cross section = 2.1467E+00 , 0 events  
#Subprocess 4 ( u, C -> b, B ) Cross section = 1.1989E-08 , 0 events  
#Subprocess 5 ( U, u -> b, B ) Cross section = 2.1541E+00 , 0 events  
#Subprocess 6 ( U, c -> b, B ) Cross section = 1.0024E-09 , 0 events  
#Subprocess 7 ( c, U -> b, B ) Cross section = 1.0019E-09 , 0 events  
#Subprocess 8 ( c, C -> b, B ) Cross section = 4.3243E-02 , 0 events  
#Subprocess 9 ( C, u -> b, B ) Cross section = 1.1894E-08 , 0 events  
#Subprocess 10 ( C, c -> b, B ) Cross section = 4.3275E-02 , 0 events  
#Subprocess 11 ( d, D -> b, B ) Cross section = 1.2996E+00 , 0 events  
#Subprocess 12 ( D, d -> b, B ) Cross section = 1.3003E+00 , 0 events  
#Subprocess 13 ( s, S -> b, B ) Cross section = 1.2834E-01 , 0 events  
#Subprocess 14 ( S, s -> b, B ) Cross section = 1.2796E-01 , 0 events  
#Subprocess 15 ( G, G -> b, B ) Cross section = 2.3688E+01 , 0 events  
Total Cross Section 31.63858803 [pb]  
see details in prt_1 - prt_15 files
```

**Tüm alt süreçlerin tesir kesitlerini hesaplamış olduk 😊**

# OLAY ÜRETİMİ

```
user-MacBook-Pro-3:results iturk$ ./n_calchep
```

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

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

./n\_calchep komutu ile CalcHEP ekranına direk dönülebilir.

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

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

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

Monte Carlo simulation
nSess = 50
nCalls = 20000
Set Distributions
*Start integration
Display Distributions
Clear statistic
Freeze grid ON
Clear grid
Event Cubes 10000
Generate Events
```

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

Monte Carlo simulation
Generate Events
Number of events=10000
Launch generator
Allow weighted events OFF
```

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

Monte Carlo simulation
Generate Events
Number of events=10000
Launch generator
Allow weighted events OFF
```

```
CalcHEP_3.4.cpc/num

(sub)Process: G, G -> b, B
Monte Carlo session: 30(continue)

#IT Cross section[pb] Error[%] nCall Eff. chi^2
< > 2.3631E+01 3.44E-01 49130 6.2E-01

Monte Carlo simulation
Generate Events
Launch generator

Statistic
Events generated: 10000
efficiency: 5.6E-01
Max event multiplicity: 3
Multiple events(total): 25
Negative weight events: 0
-----
Accept events?
(Y / N ?)
```

Y harfine basarak olay dosyalarını results dizininde elde edebiliriz. Her bir alt süreç için bu işlem yapılmalıdır.

Peki bunun bir kısa yolu var mıdır???

# KISA YOL

```
user-MacBook-Pro-3:results iturk$ ./bin/subproc_cycle 100 1000
```

```
user-MacBook-Pro-3:results iturk$ ls
EXTLIBsh      events_27.txt  prt_13         prt_23         prt_6
VandP.cc      events_28.txt  prt_14         prt_24         prt_7
autoprot.h    events_29.txt  prt_15         prt_25         prt_8
aux           events_30.txt  prt_16         prt_26         prt_9
events_16.txt n_calchep      prt_17         prt_27         scale.c
events_17.txt n_calchep.dSYM prt_18         prt_28         scale.so
events_18.txt proclib_0.a    prt_19         prt_29         scale.so.dSYM
events_20.txt  prt_1          prt_2          prt_3          session.dat
events_23.txt  prt_10         prt_20         prt_30
events_25.txt  prt_11         prt_21         prt_4
user-MacBook-Pro-3:results iturk$ ./bin/subproc_cycle 100 1000+
```

Sonuçta olay dosyaları oluşur (alt süreç sayısı kadar oluşmadı) neden???

#Number_of_events	1000												
#Events	P1_3 [Gev]	P2_3 [Gev]	P3_1 [Gev]	P3_2 [Gev]	P3_3 [Gev]	P4_1 [Gev]	P4_2 [Gev]	P4_3 [Gev]	Q_factor	alpha_QCD	Color chains		
1	3.2895054289E+02	-1.4273472973E+02	1.9629887833E+02	8.6897259478E+01	1.2521481368E+02	-1.9629887833E+02	-8.6897259478E+01	6.1000999474E+01	4.334E+02	9.563E-02	(1 2)(4 3)		
1	8.8786555372E+01	-6.3873345889E+02	1.2634770740E+02	1.6409697244E+02	-4.5460894754E+02	-1.2634770740E+02	-1.6409697244E+02	-9.5337955974E+01	4.764E+02	9.455E-02	(1 2)(4 3)		
1	1.9317462109E+02	-3.3253896668E+02	-2.0930947481E+02	-1.4211154184E+02	-8.5503843259E+01	2.0930947481E+02	1.4211154184E+02	-5.3860502327E+01	5.069E+02	9.385E-02	(1 2)(4 3)		
1	2.9170277693E+02	-5.3210134311E+02	-2.4362108426E+02	-8.8182849265E+01	1.9010366506E+02	2.4362108426E+02	8.8182849265E+01	-4.3050223125E+02	7.880E+02	8.918E-02	(1 2)(4 3)		
1	1.3891215695E+02	-8.2014563610E+02	1.3816447729E+01	2.1177937626E+02	3.2273061168E+01	-1.3816447729E+01	-2.1177937626E+02	-7.1350654031E+02	6.751E+02	9.075E-02	(1 2)(4 3)		
1	3.3604721942E+02	-2.7312314428E+02	1.1902827653E+02	2.3251316233E+02	1.8575482353E+02	-1.1902827653E+02	-2.3251316233E+02	-1.2283074639E+02	6.059E+02	9.189E-02	(1 2)(4 3)		
1	3.7581600984E+02	-1.5057375977E+02	7.0323322615E+01	1.9019263149E+02	2.5023943681E+02	-7.0323322615E+01	-1.9019263149E+02	-2.4997186738E+01	4.758E+02	9.456E-02	(1 2)(4 3)		
1	3.0351583115E+02	-2.6369400137E+02	1.9235030154E+02	-2.0335734650E+02	-2.1208911670E+01	-1.9235030154E+02	2.0335734650E+02	6.1030741458E+01	5.658E+02	9.263E-02	(1 2)(4 3)		
1	3.2915954153E+02	-3.0194635681E+02	-2.2015352121E+02	1.0100474125E+02	2.1558395739E+02	2.2015352121E+02	-1.0100474125E+02	-1.883077266E+02	6.306E+02	9.146E-02	(1 2)(4 3)		
1	6.4071160706E+02	-1.6146656323E+02	2.6628951195E+02	1.2641319173E+02	4.0013295783E+02	-2.6628951195E+02	-1.2641319173E+02	7.9112085999E+01	6.433E+02	9.125E-02	(1 2)(4 3)		
1	2.3383605770E+02	-2.5899803135E+02	5.6033812326E+01	2.3402342884E+02	3.9026123563E+01	-5.6033812326E+01	-2.3402342884E+02	-6.4188097213E+01	4.922E+02	9.418E-02	(1 2)(4 3)		
1	3.3660828956E+02	-2.1820069023E+02	6.9322348697E+01	2.6182235591E+02	6.9028475355E+01	-6.9322348697E+01	-2.6182235591E+02	4.9379123982E+01	5.421E+02	9.310E-02	(1 2)(4 3)		
1	3.4449554994E+02	-1.3817903714E+02	1.7822332712E+02	-1.2381517783E+02	1.2815401541E+02	-1.7822332712E+02	1.2381517783E+02	7.8162497391E+01	4.364E+02	9.555E-02	(1 3)(4 2)		
1	8.175561785E+02	-6.1698506250E+01	-2.0281994024E+02	8.0532287079E+01	4.8240215295E+02	2.0281994024E+02	-8.0532287079E+01	2.7345495865E+02	4.494E+02	9.522E-02	(1 2)(4 3)		
1	2.5790971576E+02	-1.9774384515E+02	1.0584692601E+01	-2.0528545734E+02	1.2442939890E+02	-1.0584692601E+01	2.0528545734E+02	-6.4263528289E+01	4.517E+02	9.516E-02	(1 2)(4 3)		
1	4.8805542520E+02	-2.7685696558E+02	-5.3697574560E+01	-2.8947798424E+02	3.3459459955E+02	5.3697574560E+01	2.8947798424E+02	-1.2339613992E+02	7.352E+02	8.988E-02	(1 2)(4 3)		
1	2.5437084137E+02	-1.8754336225E+02	1.8761745436E+01	2.1725850523E+02	2.0919066769E+01	-1.8761745436E+01	-2.1725850523E+02	4.5908412343E+01	4.369E+02	9.554E-02	(1 2)(4 3)		
1	1.4290638553E+02	-8.5384698865E+02	2.2012136052E+02	1.4030266037E+02	-2.4272112111E+01	-2.2012136052E+02	-1.4030266037E+02	-6.8666849101E+02	6.987E+02	9.040E-02	(1 2)(4 3)		
1	2.9138193985E+02	-5.7837403544E+02	2.1733916861E+02	-2.6209778066E+01	2.2439066019E+02	-2.1733916861E+02	2.6209778066E+01	-5.1138275577E+02	8.211E+02	8.877E-02	(1 2)(4 3)		
1	2.6595042899E+02	-6.0562307507E+02	-4.0274686670E+01	2.4203169116E+02	1.7502364194E+02	4.0274686670E+01	-2.4203169116E+02	-5.1469628802E+02	8.027E+02	8.900E-02	(1 2)(4 3)		
1	4.7435749712E+02	-1.1020114337E+02	-5.5126157291E+01	-2.0458987892E+02	2.9193172339E+02	5.5126157291E+01	2.0458987892E+02	7.2224630369E+01	4.573E+02	9.501E-02	(1 2)(4 3)		

# Sonuçta olay dosyalarını birbirine harmanlayalım....

```
user-MacBook-Pro-3:results iturk$ ../bin/event_mixer
../bin/event_mixer needs arguments: Luminosity[1/fb] nEvents event_directories ...
user-MacBook-Pro-3:results iturk$ ../bin/event_mixer 100 1000 .
? 150E+01 total cross section[fb]
```

İşmlük

Olay sayısı

```
user-MacBook-Pro-3:results iturk$ nano event_mixer.lhe
```

```
GNU nano 2.0.6 File: event_mixer.lhe
<!--
File generated with CalcHEP-PYTHIA interface
-->
<header>
<hepm1>
<samples xmlns="http://mcdb.cern.ch/hepm1/0.2/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://mcdb.cern.ch/hepm1/0.2/ http://mcdb.cern.ch/hepm1/0.2/hepm1.xsd">
  <files>
    <file>
      <eventsNumber> 1000 </eventsNumber>
      <crossSection unit="pb">31.502904</crossSection>
      <fileSize> 682506 </fileSize>
      <comments></comments>
      <location>
        <path/>
      </location>
    </file>
  </files>
</samples>
```

```
results -- nano -- 154x21
GNU nano 2.0.6 File: event_mixer.lhe Modified
21 -1 0 0 500 502 0.0000000000E+00 0.0000000000E+00 4.04769194600E+02 4.04769194600E+02 0.0000000000E+00 0.0000E+00 9.0
21 -1 0 0 501 500 0.0000000000E+00 0.0000000000E+00 -1.56808369800E+02 1.56808369800E+02 0.0000000000E+00 0.0000E+00 9.0
5 1 1 2 501 0 1.44599812290E+02 1.60959034800E+02 -1.98058234600E+01 2.17300929661E+02 3.24141395780E+00 0.0000E+00 9.0
-5 1 1 2 0 502 -1.44599812290E+02 -1.60959034800E+02 2.67766648210E+02 3.44276634818E+02 3.24141395780E+00 0.0000E+00 9.0
</event>
<event>
4 1 1.00000000E+00 6.80900000E+02 -1.00000000E+00 9.06000000E-02
1 -1 0 0 500 0 0.0000000000E+00 0.0000000000E+00 6.70265151070E+02 6.70265151070E+02 0.0000000000E+00 0.0000E+00 9.0
-1 -1 0 0 0 501 0.0000000000E+00 0.0000000000E+00 -1.72916265410E+02 1.72916265410E+02 0.0000000000E+00 0.0000E+00 9.0
5 1 1 2 500 0 -1.26624959070E+02 2.99387584110E+02 1.23467921570E+02 3.47737890084E+02 3.24141395780E+00 0.0000E+00 9.0
-5 1 1 2 0 501 1.26624959070E+02 -2.99387584110E+02 3.73880964090E+02 4.95443526400E+02 3.24141395780E+00 0.0000E+00 9.0
</event>
<event>
4 1 1.00000000E+00 4.79200000E+02 -1.00000000E+00 9.44800000E-02
21 -1 0 0 500 501 0.0000000000E+00 0.0000000000E+00 2.91459881240E+02 2.91459881240E+02 0.0000000000E+00 0.0000E+00 9.0
21 -1 0 0 501 502 0.0000000000E+00 0.0000000000E+00 -1.96975955610E+02 1.96975955610E+02 0.0000000000E+00 0.0000E+00 9.0
Get Help WriteOut Read File Prev Page Cut Text Cur Pos
Exit Justify Where Is Next Page UnCut Text To Spell
```

# YENİ MODEL OLUŞTURMA

pp->Ht

CalcHEP\_3.4.7/symb

**Abstract**

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface facilities and F1 - as online help.

Questions: <https://answers.launchpad.net/calchep>  
Bugs: <https://bugs.launchpad.net/calchep>

Standard Model  
Standard Model (CKM=1)  
SM (CKM=1 with hGG/AA)  
HeavyQuarkFCNC  
HeavyQuarkFCNCDynamic  
H-tB\_Model1  
H-tB\_Model2  
WWV-dogru

**IMPORT MODEL**

CalcHEP\_3.4.7/symb

**IMPORT MODEL**

**Choose a model**

Download all models

Standard Model	1.mdl
H-tB_Model1	10.mdl
Standard Model (CKM=1)	2.mdl
SM (CKM=1 with hGG/AA)	3.mdl
HeavyQuarkFCNC	4.mdl
HeavyQuarkFCNCDynamic	5.mdl
H-tB_Model1	6.mdl
H-tB_Model2	7.mdl
WWV-dogru	8.mdl

PgDn

CalcHEP\_3.4.7/symb

File Search: `$CALCHEP/./calwork/Models`

**IMPORT MODEL**

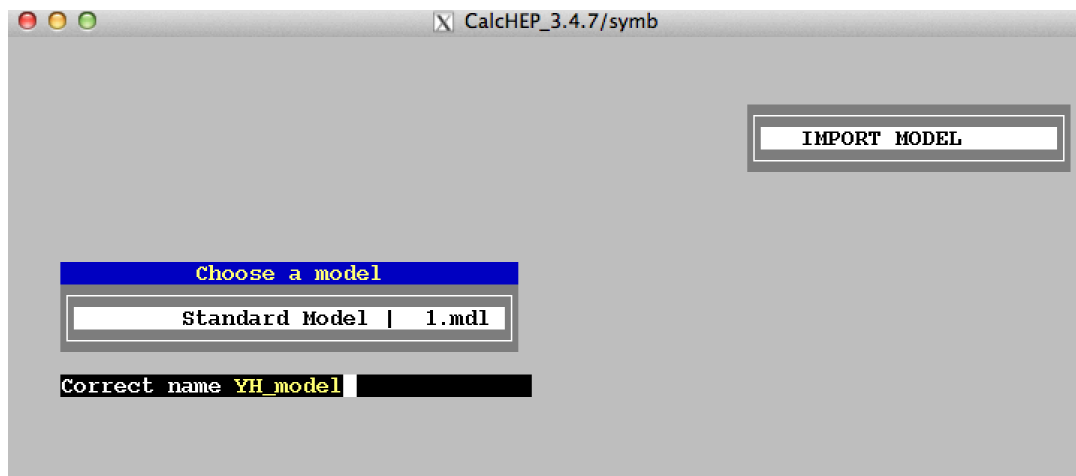
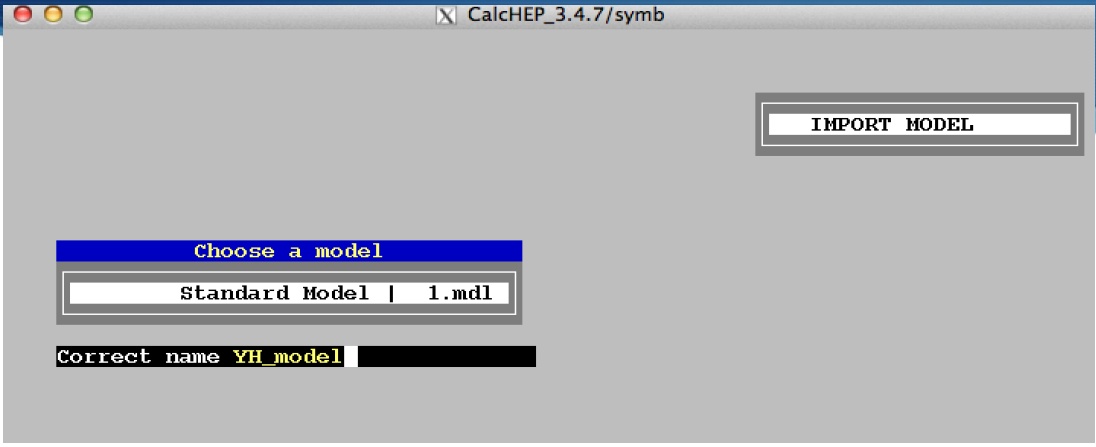
CalcHEP\_3.4.7/symb

**IMPORT MODEL**

**Choose a model**

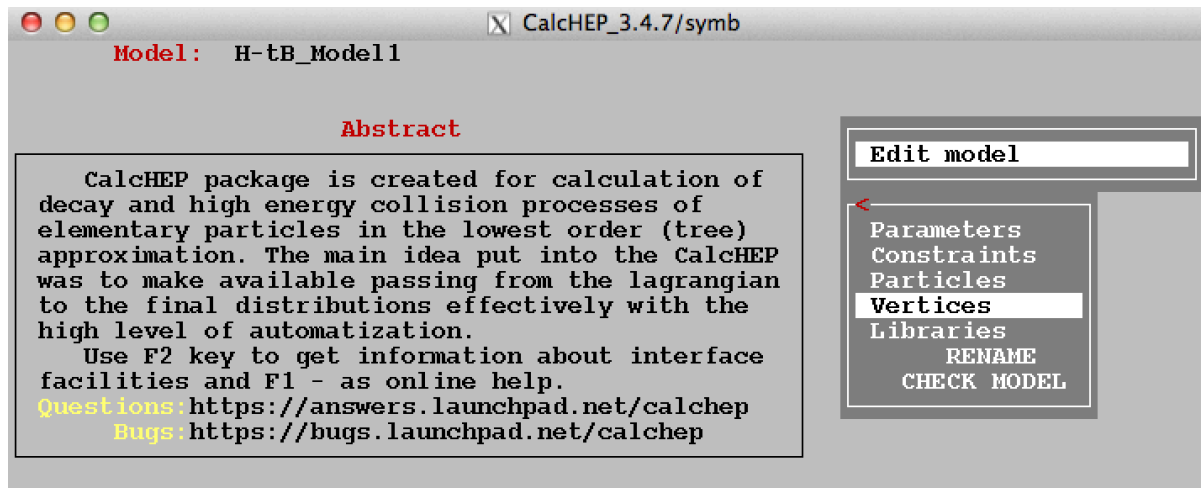
Standard Model	1.mdl
----------------	-------

Correct name `YH_model`



## Değişiklik yapılacak yerler:

- \* Vertices
- \* Parameters
- \* Constraints
- \* Particles



$$g_{H-t\bar{b}} = \frac{g}{2\sqrt{2}m_W} [m_t \cot \beta(1 + \gamma_5) + m_b \tan \beta(1 - \gamma_5)].$$



B	t	H-	$-\frac{EE^*V_{tb}}{2\sqrt{2}SW^*MW}$	$M_t \cot \beta (1 + G_5) + M_b \tan \beta (1 - G_5)$
T	b	H+	$-\frac{EE^*V_{tb}}{2\sqrt{2}SW^*MW}$	$M_t \cot \beta (1 - G_5) + M_b \tan \beta (1 + G_5)$



Model: YH\_model

**Abstract**

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface

Edit model

Parameters

Constraints  
 Particles  
 Vertices  
 Libraries

RENAME

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Name	Value	Comment
EE	0.31343	elecromagnetic constant
alFSMZ	0.1184	Srtong alpha(MZ) for running mass calculation
Q	100	scale for running mass calculation
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)
MbMb	4.25	Mb(Mb)
Mtp	172.5	t-quark pole mass
MZ	91.188	Z-boson mass
MW	80.385	W-boson mass
Mh	125	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)
MHx	900.0	Mass of H-/H+
tanb	1.0	tanb



## Abstract

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface

Edit model

Parameters

Constraints

Particles

Vertices

Libraries

RENAME

X CalcHEP\_3.4.7/sy

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Qu

Constraints

20

Name	Expression	
CW	MW/MZ	% on-shell cos of the Weinberg angle
SW	sqrt(1-CW^2)	% sin of the Weinberg angle
GF	EE^2/(2*SW*MW)^2/Sqrt2	% Fermi constant (not used below)
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
LamQCD	initQCD5(al fSMZ, McMc, MbMb, Mtp)	
Mb	MbEff(Q)	
Mt	MtEff(Q)	
Mc	McEff(Q)	
coth	1/tanb	

Model: YH\_model

**Abstract**

CalcHEP package is created for calculation of decay and high energy collision processes of elementary particles in the lowest order (tree) approximation. The main idea put into the CalcHEP was to make available passing from the lagrangian to the final distributions effectively with the high level of automatization.

Use F2 key to get information about interface

Edit model

Parameters

Constraints

**Particles**

Vertices

Libraries

RENAME

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CalcHEP\_3.4.7/symb

Particles 18

Full name	A	A	PDG	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 <sup>+</sup>	W <sup>-</sup>
Higgs	h	h	25	0	Mh	!wh	1		h	h
electron	e	E	11	1	0	0	1		e <sup>-</sup>	e <sup>+</sup>
e-neutrino	ne	Ne	12	1	0	0	1	L	\nu_e	\bar{\nu}_e
muon	m	M	13	1	Mm	0	1		\mu <sup>-</sup>	\mu <sup>+</sup>
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 <sup>-</sup>	\tau <sup>+</sup>
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	0	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}
HiggsH+-	H+	H-	37	0	MHx	!wHx	1		H <sup>+</sup>	H <sup>-</sup>

```
Model: YH_model/Unitary Gauge/

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           mm(Mm )- 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       H+(H- )- HiggsH+-

Enter process: p, p->H-, t
composite 'p' consists of: u, d, s, c, b, U, C, D, S, B, G
Exclude diagrams with
```

Süreç girilir ve önceki adımlar takip edilirse  
tesir kesiti elde edilir...

```
user-MacBook-Pro-3:results iturk$ ../bin/subproc_cycle 0 0
#Subprocess 1 ( b, G -> t, H- ) Cross section = 1.8399E-04 , 0 events
#Subprocess 2 ( G, b -> t, H- ) Cross section = 1.8421E-04 , 0 events
Total Cross Section 0.0003682 [pb]
see details in prt_1 - prt_2 files
user-MacBook-Pro-3:results iturk$
```

## Kaynaklar

HPFBU Kars Kış Okulu notları (G. Ünel)

Program kılavuzu

CalcHEP-from model building down to collider phenomenology  
(A. Belyaev)

## **ÖDEV**

\*  $p,p \rightarrow W^+, b, \bar{b}$  sürecini kütle merkezi enerjisi 14 TeV için toplam tesir kesitini hesaplayınız.