ICS2023 Tutorial; requirements

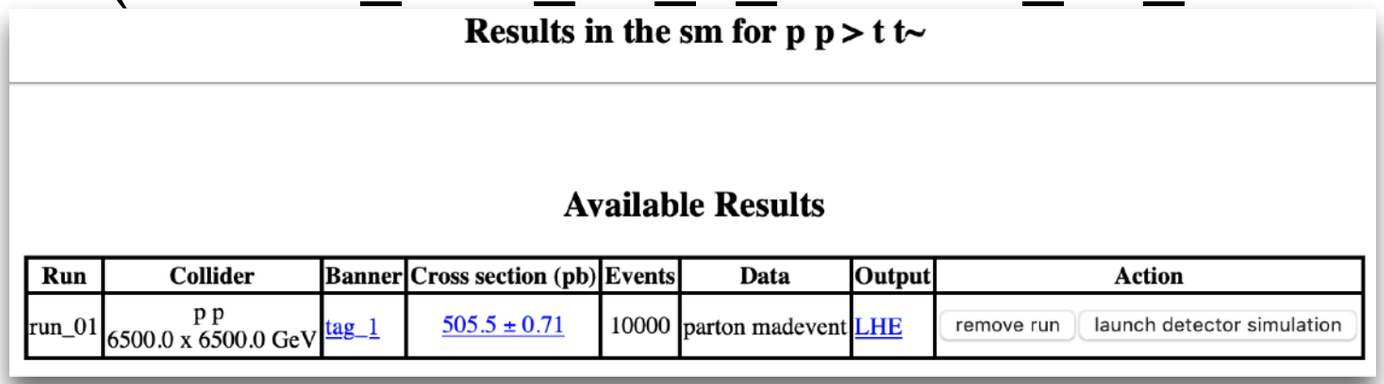
- Laptop PC (with internet connection)
- Terminal (for shell operation)
- Basic knowledge of shell commands;
  e.g. pwd, mkdir, cd, cp, mv, rm, tar, less, more, …
- python 2.7 or 3.7 (or higher)
- gfortran/gcc 4.6 or higher
- matplotlib (or ROOT) [for MadAnalysis5]
- Mathematica [only for those who want to learn FeynRules]

MadGraph5_aMC@NLO; start-up

- Download MG5_aMC_X.Y.Z.tar.gz (LTS_2.9.14) from the MadGraph5_aMC@NLO launchpad: https://launchpad.net/mg5amcnlo
- At your working directory in a terminal, untar:
  $ tar zxvf MG5_aMC_X.Y.Z.tar.gz
- Go into the MG5aMC directory:
  $ cd MG5_aMC_vX_Y_Z/
- Start MG5aMC:
  $ ./bin/mg5_aMC

MG5aMC; first try

- After the MG5aMC logo, your terminal should have MG5_aMC> prompt. Please try:
  - MG5_aMC> generate p p > t t~
  - MG5_aMC> output
  - MG5_aMC> launch
- Please ignore a few questions from MG5aMC by just pushing the "Enter" key, then after a few minutes, you should get in your browser (…/MG5_aMC_vX_Y_Z/PROC_sm_0/crossx.html) like



Results in the sm for p p > t t~

Available Results

Run	Collider	Banner	Cross section (pb)	Events	Data	Output	Action
run_01	p p 6500.0 x 6500.0 GeV	tag_1	505.5 ± 0.71	10000	parton madevent	LHE	remove run / launch detector simulation

- Now you are ready to do some simulations for the LHC and ILC!

MG5aMC; install other tools

Please also try to install other tools as

- For plots:
  MG5_aMC> install MadAnalysis5
- For parton-shower and hadronization:
  MG5_aMC> install pythia8

MG5aMC; main 4 steps

- MG5_aMC> import model MODEL (e.g. 2HDM)
- MG5_aMC> generate PROCESS (e.g. p p > t t~)
- MG5_aMC> output (myprocess)
- MG5_aMC> launch
- MG5_aMC> launch
- MG5_aMC> ...

MG5aMC; tips

- Use auto-completion by "tab (tab)".
- MG5_aMC> help
- MG5_aMC> help COMMAND (e.g. generate)
- MG5_aMC> tutorial

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Kentarou Mawatari (kentarou-mawatari) • Log Out

MadGraph5_aMC@NLO

ations Answers

that aims at providing all
M phenomenology, such as
e generation of hard events
ors, and the use of a variety
n and analysis. Processes can
er-defined Lagrangian, an the
t support this kind of
are QCD and EW corrections
e tree- and one-loop-level

sion of both MadGraph5 and
lines of development of
family. It therefore
rsions and all the beta

he code is: J. Alwall et al,
evel and next-to-leading
heir matching to parton
hep-ph]. In addition to that,
sions and/or of NLO
(eg NLO EW) require the
nation of next-to-leading
1804.10017 [hep-ph]. A more
nd here: http://amcatnlo.

package (see the right of this page)

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- Register a blueprint
- Help translate

Downloads

Latest version is 2.6.x

MG5_aMC_v2.6.7.tar.gz

MG5aMC_3.0.1_beta.ta

released on 2017-08-15

All downloads

Announcements

answers.launchpad.net

Kentarou Mawatari (kentarou-mawatari) • Log Out

MadGraph5_aMC@NLO

Overview Code Bugs Blueprints Translations **Answers**

Ask a question

Please enter a short description (at least 4 words) in the language of your choice, that describes your problem. We will use it to look for similar questions that may already exist.

Change your preferred languages to modify the list of languages available for writing the question.

Language:

English (en) *

The language in which this question is written. The languages marked with a star (*) are the languages spoken by at least one answer contact in the community.

Summary:

A one-line summary of the issue or problem.

Continue or Cancel

One can directly communicate with the developers via Launchpad (ask questions, report bugs, etc).

launchpad • Take the tour • Read the guide

https://launchpad.net/mg5amcnlo

EX-1; change parameters

- Semi-leptonic decays in top-pair production at the LHC:
  MG5_aMC> generate p p > t t~, t > b l- vl~, t~ > b~ j j
- How can we change?
  - top mass
  - top width
  - W mass
  - beam energy
  - pT cut on leptons

edit param_card.dat and/or run_card.dat in Cards/.

or

use the "set" command.

Solution

EX-1; change parameters

- Semi-leptonic decays in top-pair production at the LHC:
  MG5_aMC> generate p p > t t~, t > b l- vl~, t~ > b~ j j
- How can we change?
  - top mass
  - top width

  edit Cards/param_card.dat
  - W mass

  In the default SM, the W mass cannot be changed because it is an internal parameter.
  - beam energy
  - pT cut on leptons

  edit Cards/run_card.dat

EX-2; process generation (coupling order)

- What is the difference?

1. > generate p p > t t~

Check the Feynman diagrams !

2. > generate p p > t t~ QCD=0

3. > generate p p > t t~ QED=0

4. > generate p p > t t~ QED<=99

- Compare the cross sections.

Solution

EX-2; process generation (coupling order)

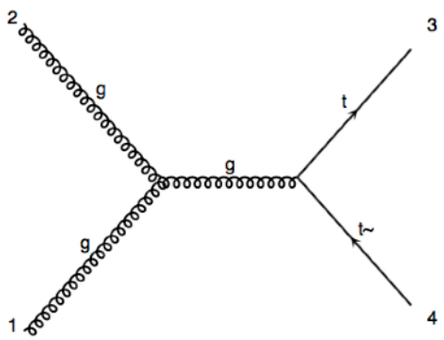


diagram 1 QCD=2, QED=0

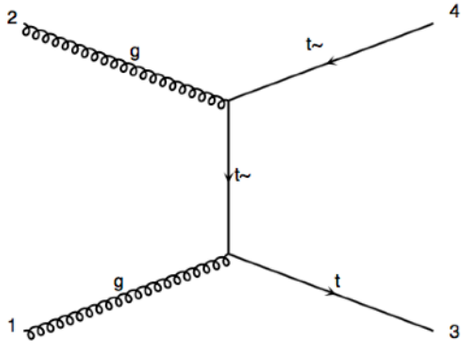


diagram 2 QCD=2, QED=0

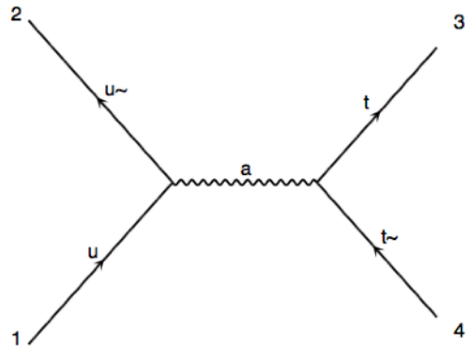


diagram 1 QCD=0, QED=2

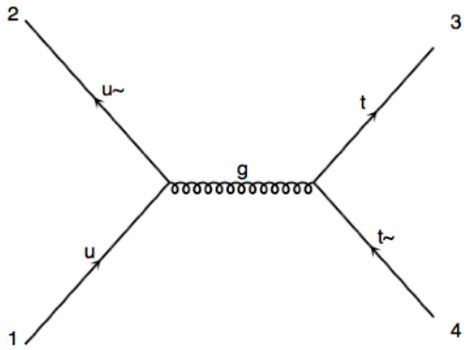


diagram 2 QCD=2, QED=0

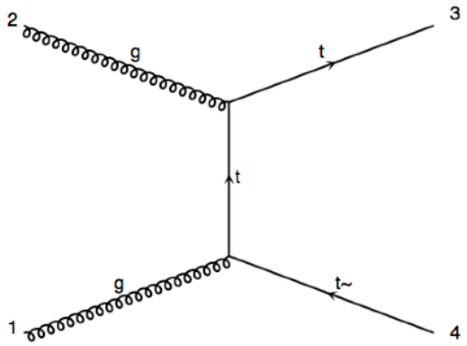


diagram 3 QCD=2, QED=0

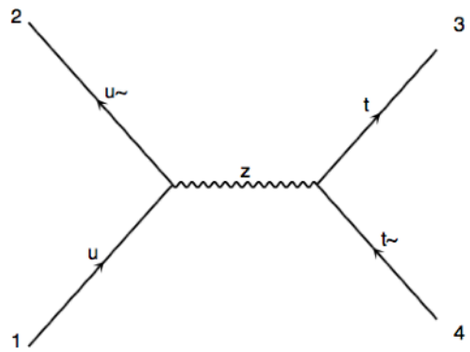


diagram 3 QCD=0, QED=2

QCD only

	Cross-Section ↓
/P1_gg_ttx	441.7
/P1_qq_ttx	64.04

QCD + QED

	Cross-Section ↓
/P1_gg_ttx	441.7
/P1_qq_ttx	64.06

EX-3; cross sections (param scan; root-S)

- Reproduce the red curve.

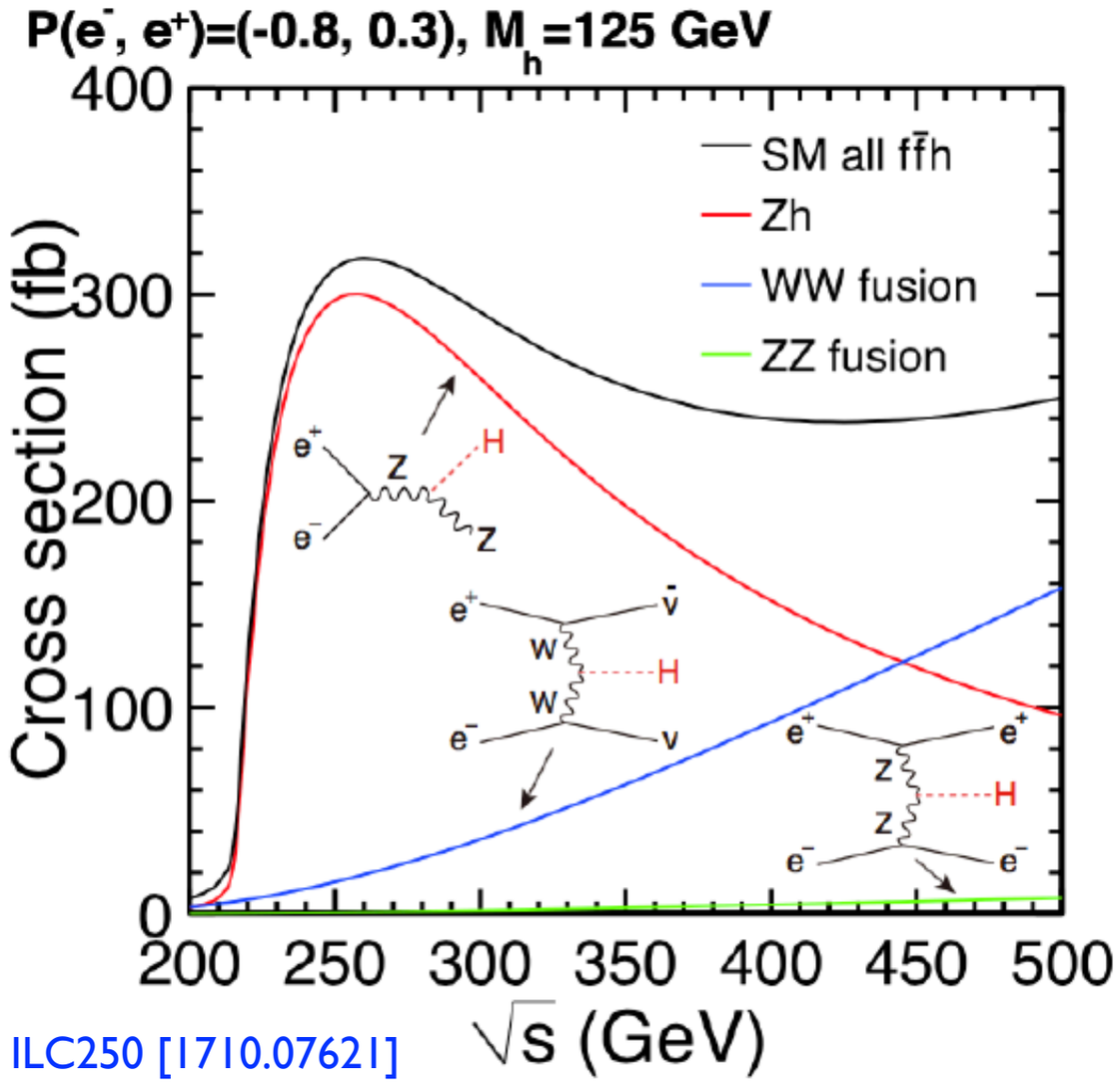


Fig.3 in ILC250 [1710.07621]

Edit myprocess/Cards/run_card.dat,
> launch -n rs200
Edit myprocess/Cards/run_card.dat,
> launch -n rs250
…

Write a MG5 script file.

Solution

EX-3; cross sections (param scan; root-S)

Run MG5aMC with a script file;

```
$ ./bin/mg5_aMC test_eehz.mg5
```

Make a data file;

```
$ cd Proc_eehz
$ ./bin/madevent
Proc_eehz> print_results --format=short --path=xsec.dat
```

test_eehz.mg5

```
generate e+ e- > h z
output Proc_eehz
#
launch -n 230
analysis = OFF
0
set polbeam1 30
set polbeam2 -80
set nevents 1
set ebeam 115
0
#
launch -n 240
0
set ebeam 120
0
#
launch -n 250
0
set ebeam 125
0
#
…
```

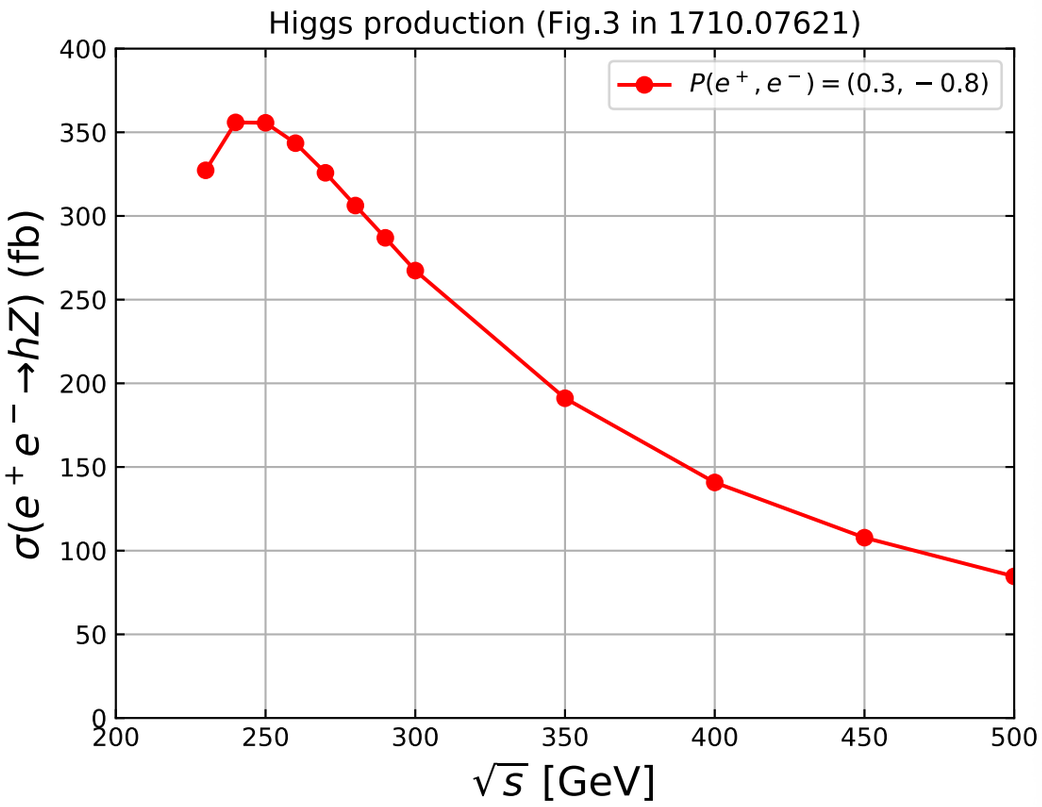
xsec.dat

```
# run_name tag cross error Nb_event cross_after_matching nb_event_after matching
230 tag_1 0.32727 0.00010604 1
240 tag_1 0.3559 0.00013049 1
250 tag_1 0.35566 0.00017036 1
260 tag_1 0.34348 0.00018299 1
270 tag_1 0.32577 0.00020246 1
280 tag_1 0.30622 0.0002151 1
290 tag_1 0.28693 0.00021947 1
300 tag_1 0.26736 0.00024268 1
350 tag_1 0.19108 0.00023025 1
400 tag_1 0.14076 0.0002094 1
450 tag_1 0.10777 0.00018119 1
500 tag_1 0.084641 0.00027909 1
```

Solution

EX-3; cross sections (param scan; root-S)

Make a plot (e.g. by matplotlib);
$ python xsec.py



xsec.py

```
import numpy as np
import matplotlib.pyplot as plt

## import data files
data = np.loadtxt('xsec.dat', skiprows=1, usecols=(0,2))

## define the variables for the x and y axes
roots=data[:,0]
xsec=data[:,1]

## setup a plot
plt.plot(roots,xsec*1000,'-or',label='$P(e^+,e^-)=(0.3,-0.8)$')
xlab=r'$\sqrt{s}$ [GeV]'
ylab=r'$\sigma(e^+e^-\to hZ)$ (fb)'
xlimrange=[200,500]
ylimrange=[0,400]
savepdf='xsec.pdf'

## setup the details
plt.xlim(xlimrange)
plt.ylim(ylimrange)
plt.title("Higgs production (Fig.3 in 1710.07621)")
plt.xlabel(xlab, fontsize=16)
plt.ylabel(ylab, fontsize=16)
plt.legend()
plt.grid()
plt.gca().xaxis.set_tick_params(which='both', direction='in',bottom=True, top=True, left=True, right=True)
plt.gca().yaxis.set_tick_params(which='both', direction='in',bottom=True, top=True, left=True, right=True)

## output
plt.savefig(savepdf, format='pdf', bbox_inches='tight')
plt.show()
```

EX-4; cross sections (param scan; masses)

- Reproduce the black curves.

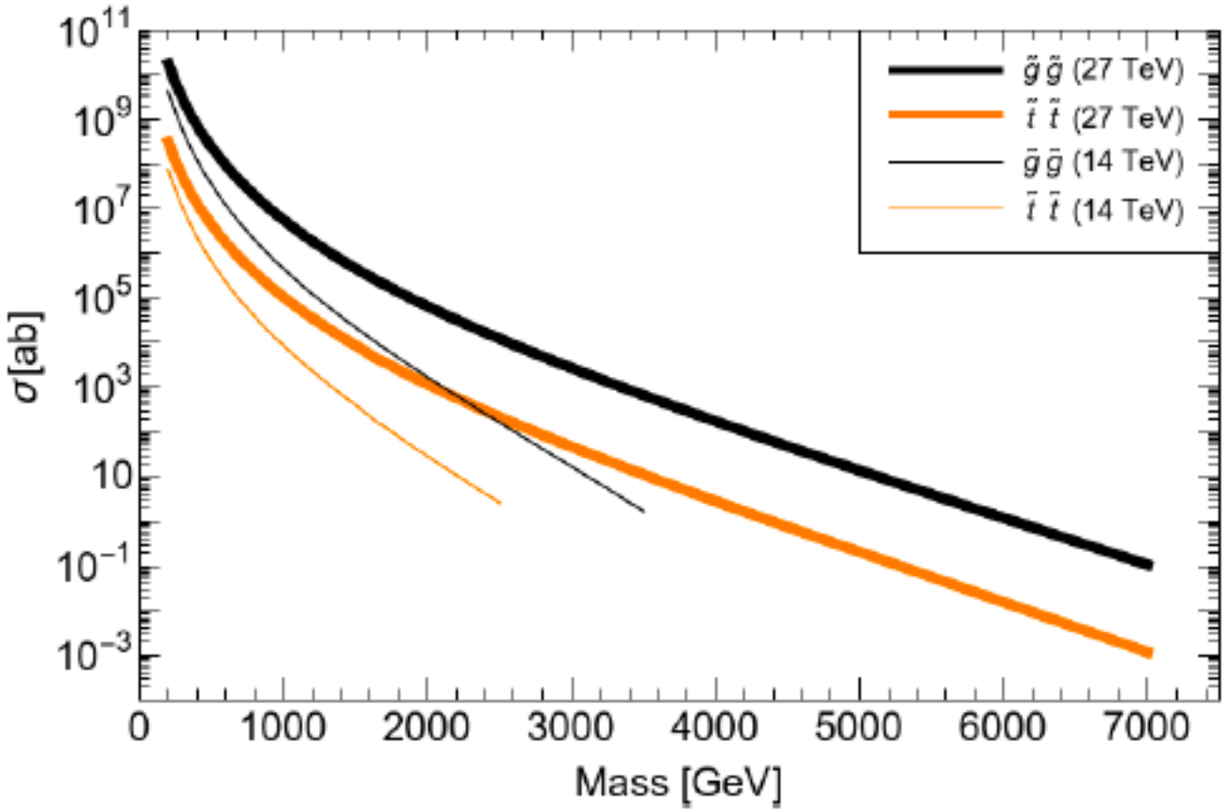


Fig.2.1(left) in HL-LHC/HE-LHC [1812.07831]

Edit myprocess/Cards/param_card.dat,
> launch -n m1000
Edit myprocess/Cards/param_card.dat,
> launch -n m2000
…

Use a scan command in param_card.dat.

Solution

EX-4; cross sections (param scan; masses)

```
$ ./bin/mg5_aMC
> import model MSSM_SLHA2
> generate p p > go go
> output Proc_gluinopair
> launch -n mgo27TeV
> analysis = OFF
> 0
> set nevents 1
> set ebeam 13500
> set mgo scan:[1000*i for i in range (1,8)]
> 0
```

Check the scan results;

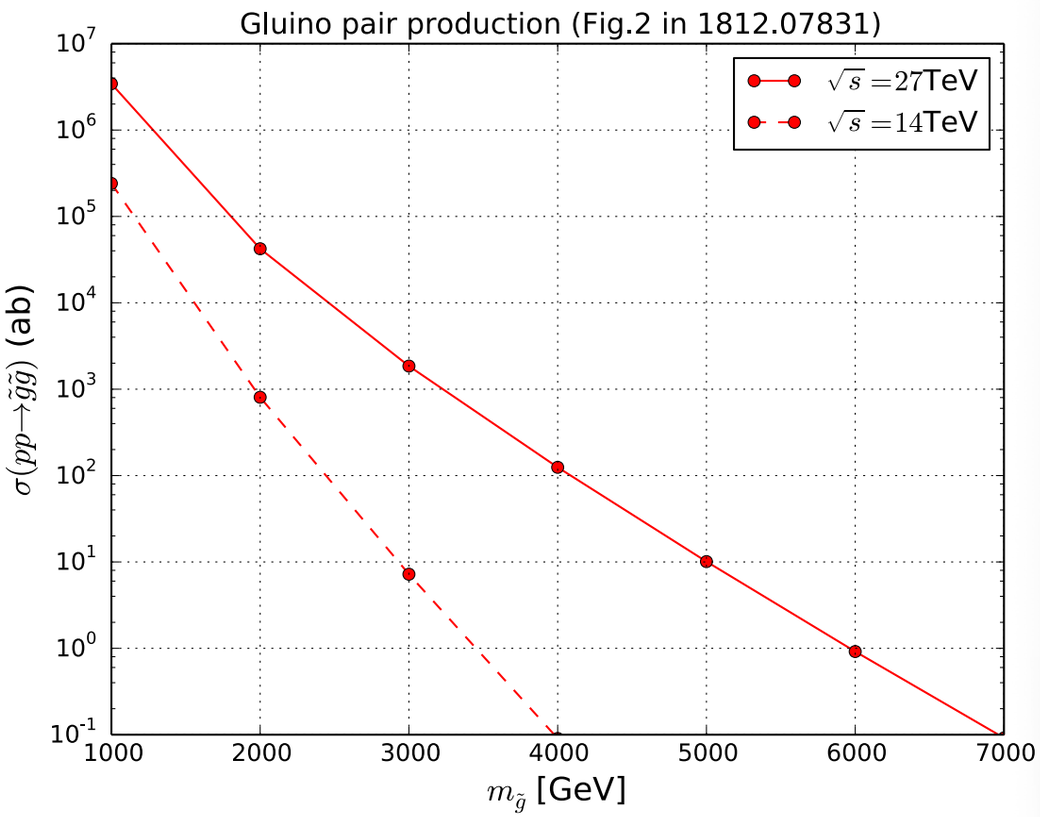
```
$ cd Proc_gluinopair/Events/
$ more scan_mgo27TeV[-_scan_07].txt
```

#run_name	mass#1000021	cross
mgo27TeV	1.000000e+03	3.404119e+00
mgo27TeV_scan_02	2.000000e+03	4.243611e-02
mgo27TeV_scan_03	3.000000e+03	1.852129e-03
mgo27TeV_scan_04	4.000000e+03	1.246744e-04
mgo27TeV_scan_05	5.000000e+03	1.017567e-05
mgo27TeV_scan_06	6.000000e+03	9.133868e-07
mgo27TeV_scan_07	7.000000e+03	9.263558e-08

Solution

EX-4; cross sections (param scan; masses)

Make a plot (e.g. by matplotlib);
$ python xsec.py



xsec_gluinopair.py

```
import numpy as np
import matplotlib.pyplot as plt

## import data files
data1 = np.loadtxt('scan_mgo27TeV[-_scan_07].txt', skiprows=1, usecols=(1,2))
data2 = np.loadtxt('scan_mgo14TeV[-_scan_07].txt', skiprows=1, usecols=(1,2))

## define the variables for the x and y axes
mgo=data1[:,0]
xsec1=data1[:,1]
xsec2=data2[:,1]

## setup a plot
plt.plot(mgo,xsec1*10**6,'-or',label='$\sqrt{s}=27$TeV')
plt.plot(mgo,xsec2*10**6,'--or',label='$\sqrt{s}=14$TeV')

xlab=r'$m_{\tilde g}$ [GeV]'
ylab=r'$\sigma(pp\to \tilde g\tilde g)$ (ab)'
xlimrange=[1000,7000]
ylimrange=[10**-1,10**7]
savepdf='xsec_gluinopair.pdf'

## setup the details
plt.yscale('log')
plt.xlim(xlimrange)
plt.ylim(ylimrange)
plt.title("Gluino pair production (Fig.2 in 1812.07831)")
plt.xlabel(xlab, fontsize=16)
plt.ylabel(ylab, fontsize=16)
plt.legend()
plt.grid()
plt.gca().xaxis.set_tick_params(which='both', direction='in',bottom=True, top=True, left=True, right=True)
plt.gca().yaxis.set_tick_params(which='both', direction='in',bottom=True, top=True, left=True, right=True)

## output
plt.savefig(savepdf, format='pdf', bbox_inches='tight')
plt.show()
```

EX-5; process generation (syntax)

- What is the difference?

1. > generate p p > e+ e-
2. > generate p p > z > e+ e-
3. > generate p p > z, z > e+ e-
4. > generate p p > e+ e- $ z
5. > generate p p > e+ e- $$ z
6. > generate p p > e+ e- / z

Edit myprocess/Cards/madanalysis5_parton_card.dat to refine bins of plots.

Run MA5 later;
$ cd myprocess/
$ ./bin/madevent
myprocess> madanalysis5_parton

- Compare the distributions of the lepton-pair invariant mass.

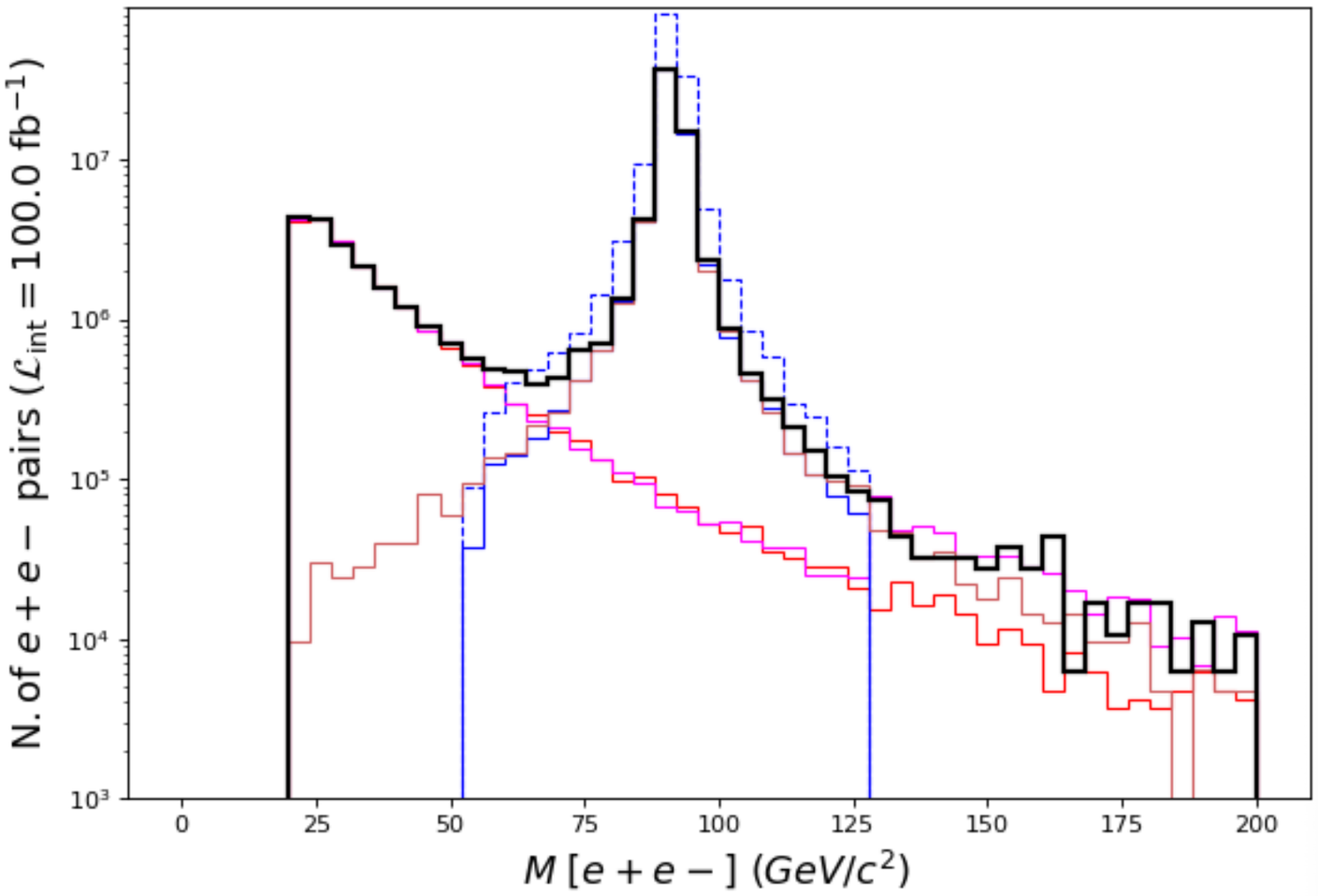
Run MA5 standalone;
$ MG5_aMC_vX_Y_Z/HEPTools/madanalysis5/madanalysis5/bin/ma5

Solution

EX-5; process generation (syntax)

Run MA5 standalone;

$ …HEPTools/madanalysis5/madanalysis5/bin/ma5 test.ma5



Check cut_decays in run_card.dat.

test.ma5

```
import ProcDY1/Events/run_02/unweighted_events.lhe.gz as DY1
import ProcDY2/Events/run_02/unweighted_events.lhe.gz as DY2
import ProcDY3/Events/run_02/unweighted_events.lhe.gz as DY3
import ProcDY3/Events/run_03/unweighted_events.lhe.gz as DY3_cutdecayT
import ProcDY4/Events/run_02/unweighted_events.lhe.gz as DY4
import ProcDY5/Events/run_02/unweighted_events.lhe.gz as DY5
#import ProcDY6/Events/run_02/unweighted_events.lhe.gz as DY6
#
set main.stacking_method = superimpose
set main.lumi = 100
set DY1.linecolor = black
set DY1.linewidth = 2
set DY3.linecolor = blue
set DY3.linestyle = dashed
set DY3_cutdecayT.linecolor = blue
#
plot M(e+ e-) 50 0 200 [logY]
set selection[1].ymin = 1000
submit MA5plot
```