Madgraph Tutorial

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Introduction

MadGraph is a framework that provides elements for the SM and BSM Phenomenology about the computation of cross-section, generations of events, Matrix Element and detector response, etc. For further information you can look into it. [1, MadGraph].

1 Download

You can download the latest version of Madgraph from it's website. [1, MadGraph]. Or you can simply download from this link `https://launchpad.net/mg5amcnlo/2.0/2.7.x/+download/MG5_aMC_v2.7.2.tar.gz`

2 Installation

Now, in order to install the madgraph open a terminal where you have download the madgraph .tar file. Once, you have open the terminal then follow the steps. Follow the Figure 1 Madgraph. For the installation of Madgraph we have the pre-requisite of the root cern and python2.7.

3 Madgraph tutorial

We have to look into it's tutorial.
Now, open the madgraph terminal follow the Figure 1 Madgraph.

3.1 Exploring the Model

By default the model is Standard model (SM). In order to see the particles in the current SM model write:
display particles
It's shows current model contains 17 particles. In this model all particles have the same name as the SM except of the photon it's symbol is **a** instead of γ.
In order to see the particles properties write following command like:
display particles h
It's shows the properties of Higgs like name, charge, spin, pdg_code, line etc. similarly, for the other particles just write **display particles particlename**.

3.2 Multiparticles

In order to define the multi-particles for saving the lot of typing in the channel. You can define the multiparticles like:
display multiparticles
It's shows the multi-particles like the jet, proton, leptons, lepton-neutrinos. You can define your own multiparticles like:
define v=w+ w- z a
It's define the multi-particle of electro-weak bosons.
Similarly, you can define the jets including the b-quarks in the jet. like:
define j=j b b∼

3.3 Interactions

In order to see the number of interaction or vertices in the current model. Type the command:
display interactions
This will show current model contains 56 interactions in SM model. In order to come out from this interactions view press **q** and press ENTER.

3.4 Generating a Process

To generate a collision process like PP collision goes to di-leptons:
generate p p > l+ l-
This is a Drell-Yan process in which di-leptons produce from a Z boson or photon decay. This process contains the 8 process with 16 diagrams. In order to display the diagrams of that process write the following command

and press ENTER.
display diagrams
In these diagrams you can see that there are two mediators photon (**a**) and Z boson. In order to exclude anyone of the mediator from the diagrams write the following command like:
generate p p > l+ l- /a
After this Write the command **display diagrams** and press ENTER. In these diagrams you can see that photon mediator are excluded from the diagrams, and only Z boson mediator is left.

3.5 Decay process

In order to generate a decay process there are a number of intermediate particles in the channel. Here, for the decaying particles we use the parenthesis in order to locate the decaying particles in the brackets.Like:
generate p p > z h , z > vl vl~ , (h > z l+ l- , z > l+ l-)
In above example, here higgs boson production associated with Z boson, where Z boson decays to neutrinos and Higgs boson decays to four leptons.

3.6 Packages Installation

After, the installation of the Madgraph we have to install other package inside the Madgraph on the terminal of Madgraph for the parton shower, detector response, and for events analysis, etc.Follow the Figure 2 Packages Installation. Packages:
install pythia8 [2]
install Delphes [3]
install pythia-pgs [4]
install MadAnalysis5 [5]
install ExRootAnalysis
After the installation of the packages it shows the successfully install in the directory of HEPTools in the Madgraph directory. In order to exit from the madgraph just enter exit and press.

4 Simulation of channels

In this section, we will see the simulation of different channels, calculate their cross-section, draw Feynman diagrams at a certain centre-of-mass energy at TeV scale.

5 tWZ Channel

In tWZ channel, here top quark is associated with di-boson. The final state contain three leptons along with one neutrino(MET) coming from the decays of top into W^+ boson along with b-jet, and from the decays of Z boson. Now write a decay channel on madgraph terminal. First open the madgraph terminal. Follow the Figure 1 Madgraph.
generate g b > t w- z , (t > b w+ , w+ > e+ ve), (z > e+ e-), (w- > u~ d)
Follow the Figure 3 for twz region.
When it's done now safe the output into a folder for that purpose do the following step and press Enter:
output regiontwz
It's save outputs in the folder name **regiontwz** in madgraph directory. Now, in order to launch process for parton shower and detector response and events reconstruction do the following step and press Enter:
launch regiontwz
There show a view like Figure 4 for packages. There are different packages pythia8, Delphes, MadAnalysis5, In order to enable package like for pythia8 for parton shower/hadronization **Press 1** and Enter. This will enable pythia8. For detector response we use the Delphes. In order to enable this **Press 2** and Enter. This will enable Delphes. And MadAnalysis5 use for analysis package it's already enabled. Now, finally **Press 0** and Enter. It will show the cards like run card, parameter,pythia8,Delphes and MadAnalysis5 Figure 5.Now to run this process you have to **Press 0** and Enter. The output will show on your default browser like Mozila FireFox. The competition of process will take time and output will show like Figure 6. You can see cross-section, collider energy, parton and hadron information are save in output.
In order to see output information you have to click on anyone MA5analysis1 and MA5analysis2_BasicReco. To see on madgraph terminal process is completed successfully.
You can see your outputs in your folder in which you have save your outputs, for this go back to the madgraph directory. And open **regiontwz** folder. You have to open file **crossx.html** in this file you can same information which you have seen in Mozila FireFox.Figure 7 crossx.html.

All outputs are save in folder **run_1** you can jump into this folder, from regiontwz/Events/run_1. Here you can see output about your channel.Figure 8 run_1.
Similarly, you can try other channels:
generate g g > t∼ t z, (z > e- e+), (t∼ > w- b∼ , w- > d u∼), (t > b w+, w+ > e+ ve)

5.1 Tutorials

I mentioned here, some useful links about madgraph tutorials. [6, Madgraph5], [7], [8]

References

[1] MadGraph, *https://launchpad.net/mg5amcnlo*

[2] An Introduction to PYTHIA 8.2, *https://arxiv.org/abs/1410.3012*

[3] DELPHES 3, A modular framework for fast simulation of a generic collider experiment, *https://arxiv.org/abs/1307.6346*

[4] PYTHIA 6.4 Physics and Manual, *https://arxiv.org/abs/hep-ph/0603175*

[5] MadAnalysis 5, a user-friendly framework for collider phenomenology, *https://arxiv.org/abs/1206.1599*

[6] MadGraph 5 : Going Beyond, *https://arxiv.org/abs/1106.0522*

[7] The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, *https://arxiv.org/abs/1405.0301*

[8] MadGrapg Twiki Pages, *https://twiki.cern.ch/twiki/bin/view/Main/UnitsHiggsTutorial2016*

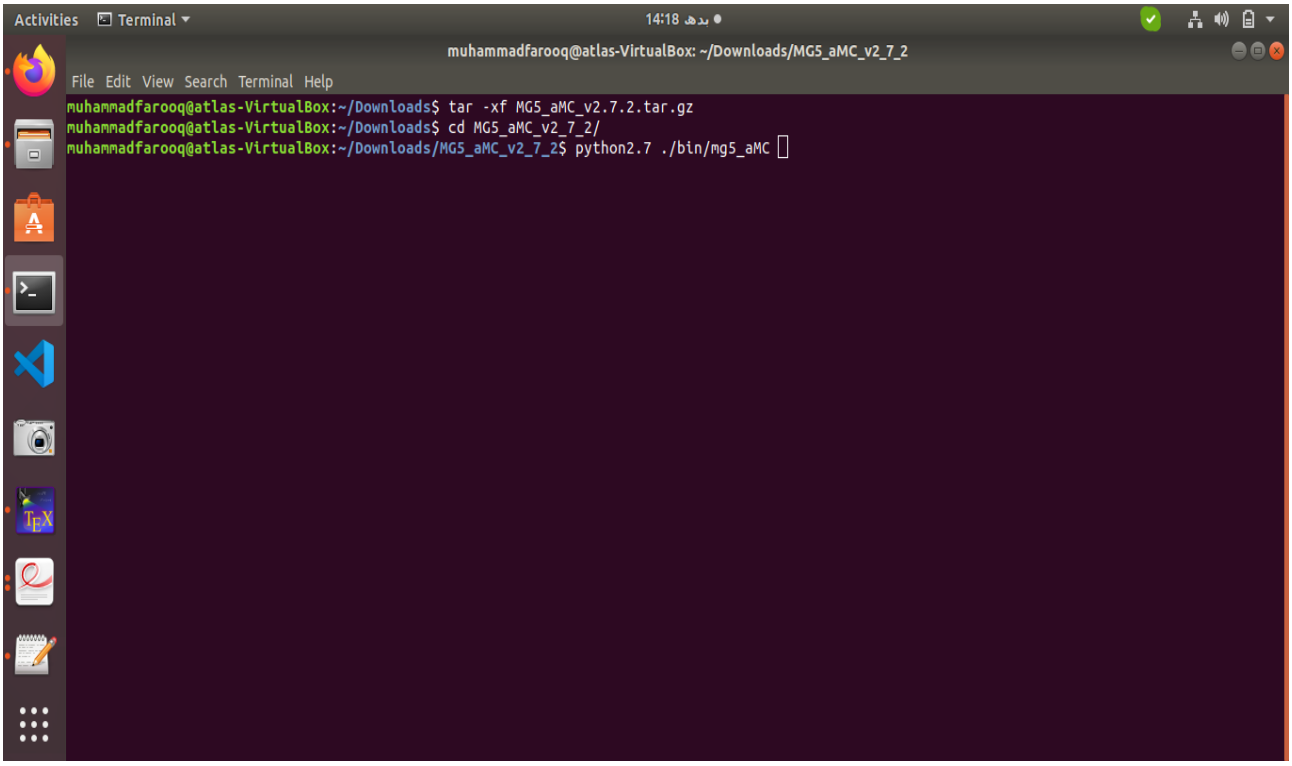

Figure 1: Madgraph installation

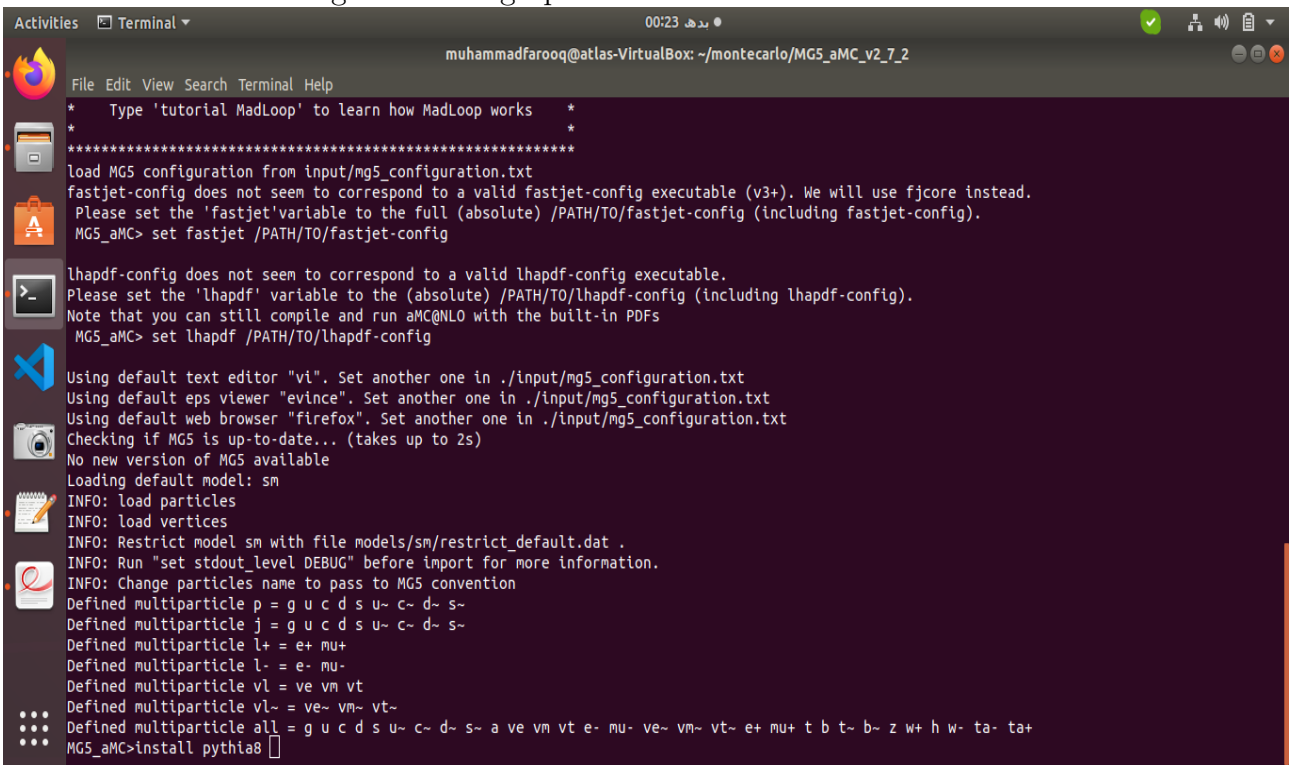

Figure 2: packages installation

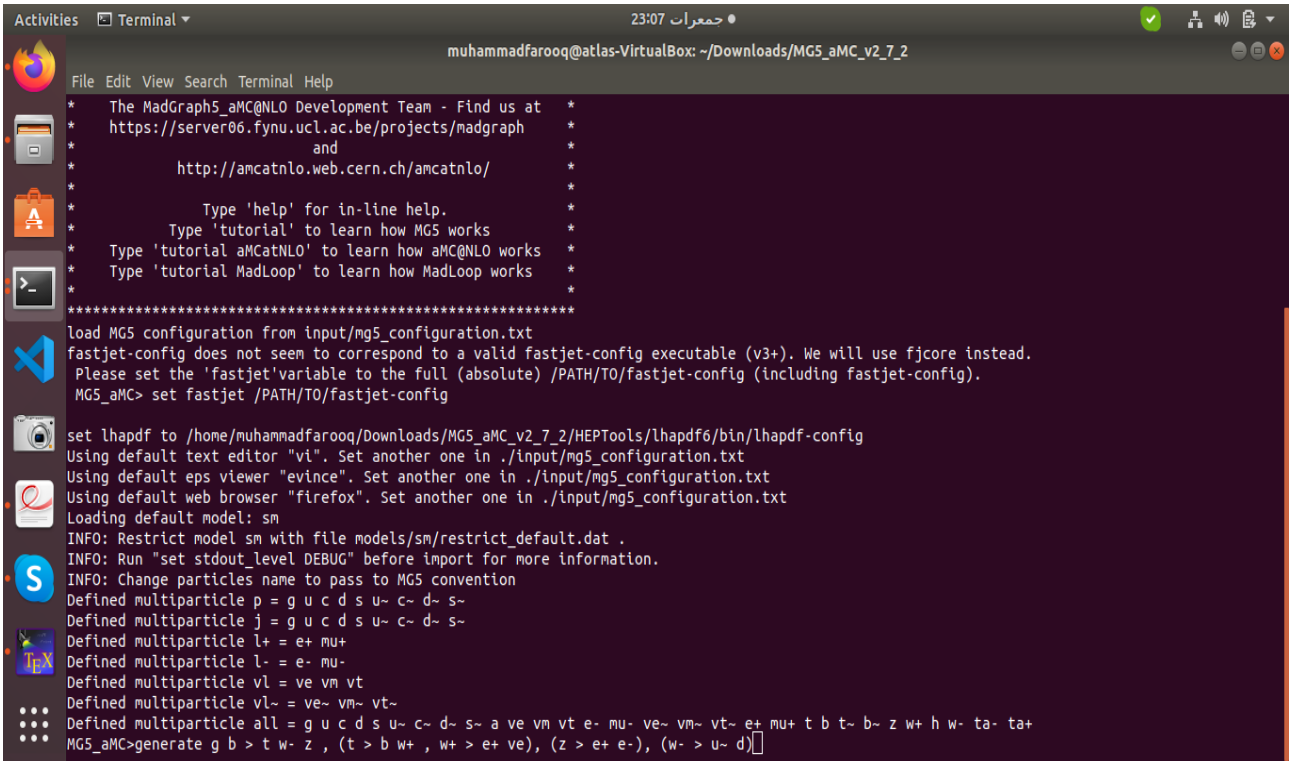

Figure 3: twz channel

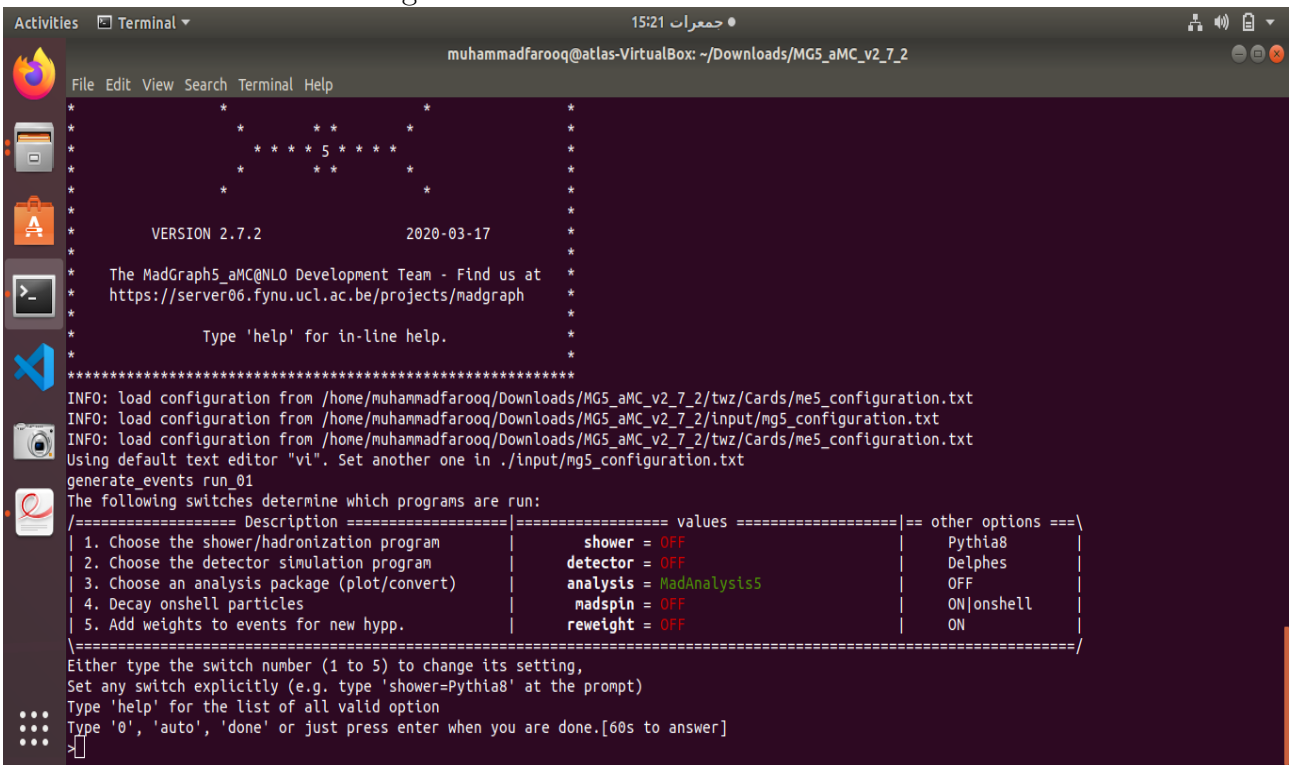

Figure 4: Packages selection

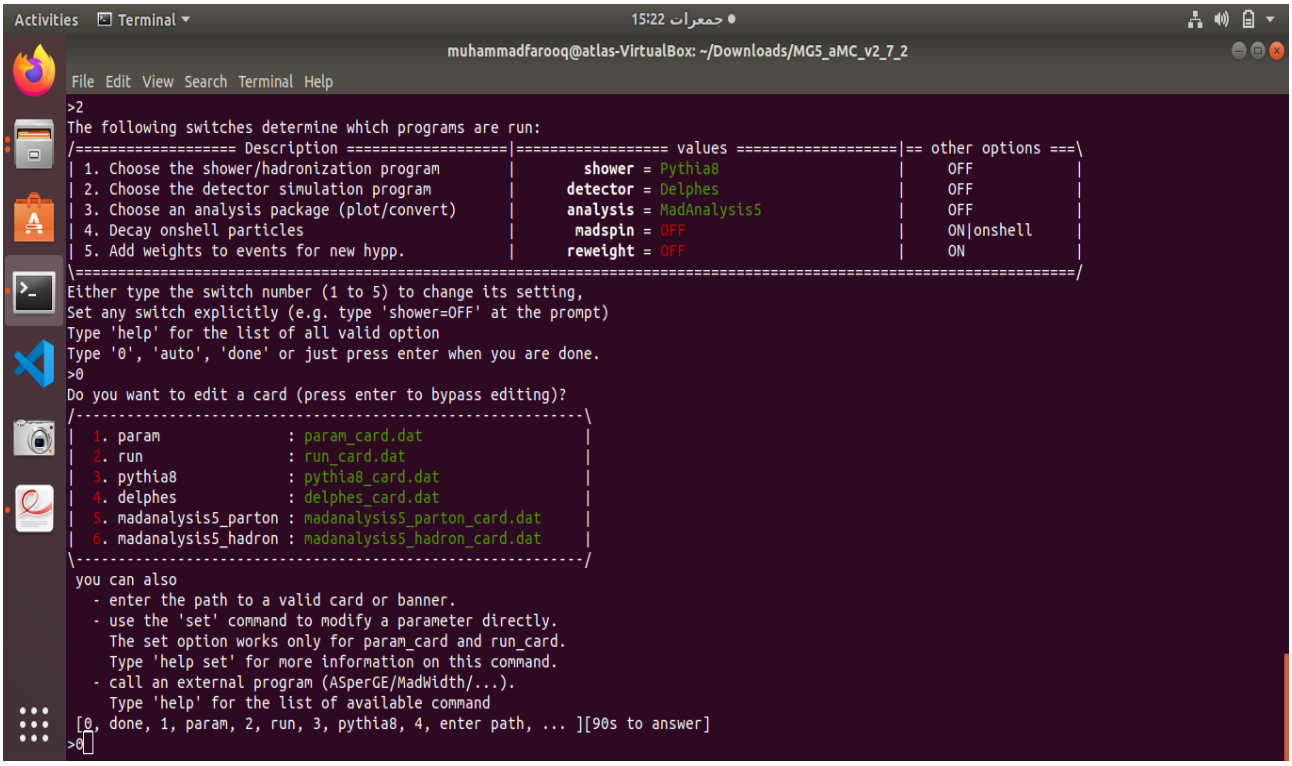

Figure 5: cards

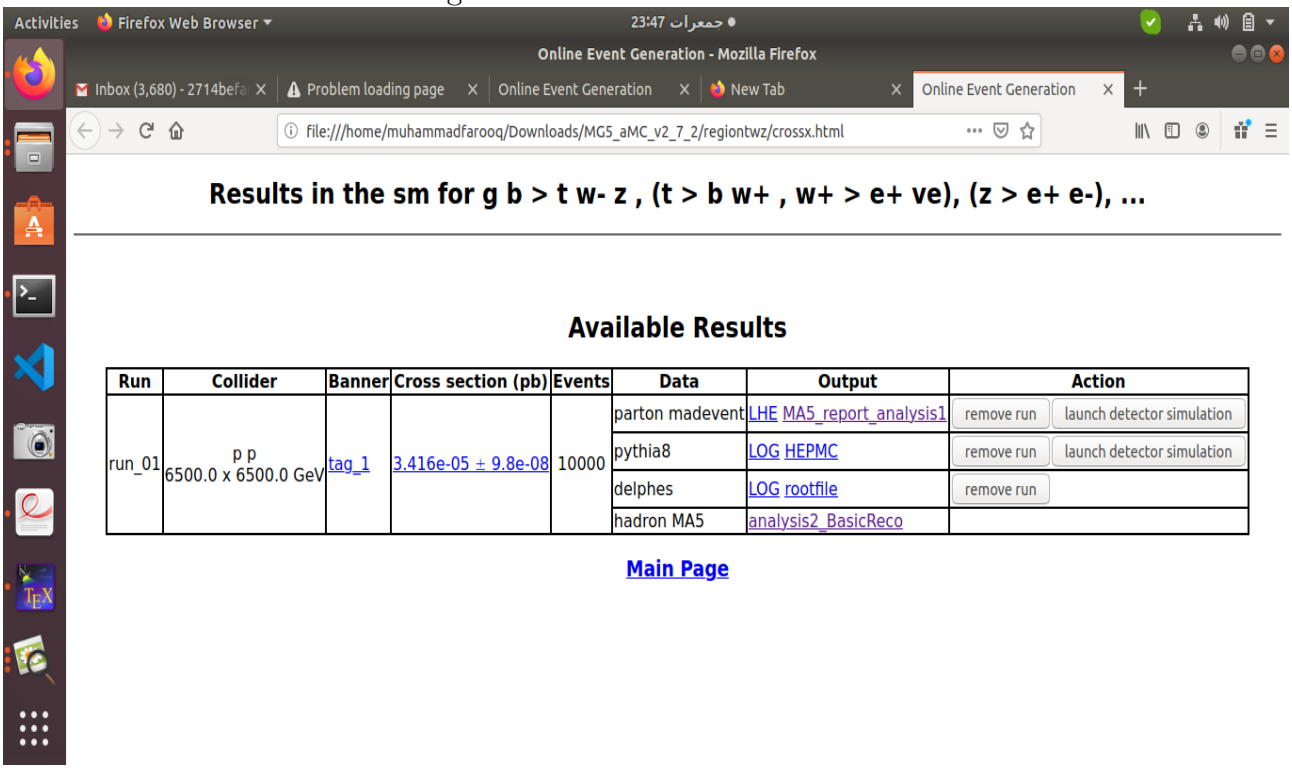

Figure 6: Main page

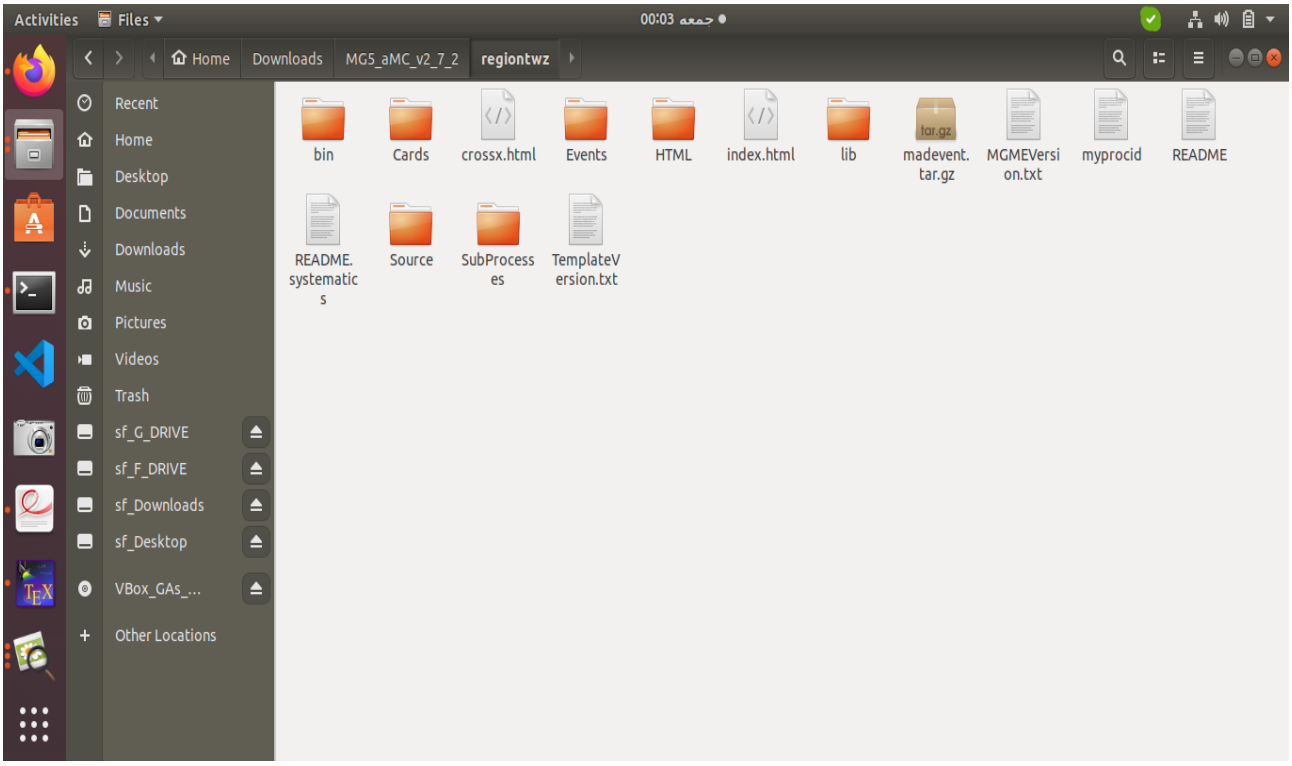

Figure 7: crossx.html

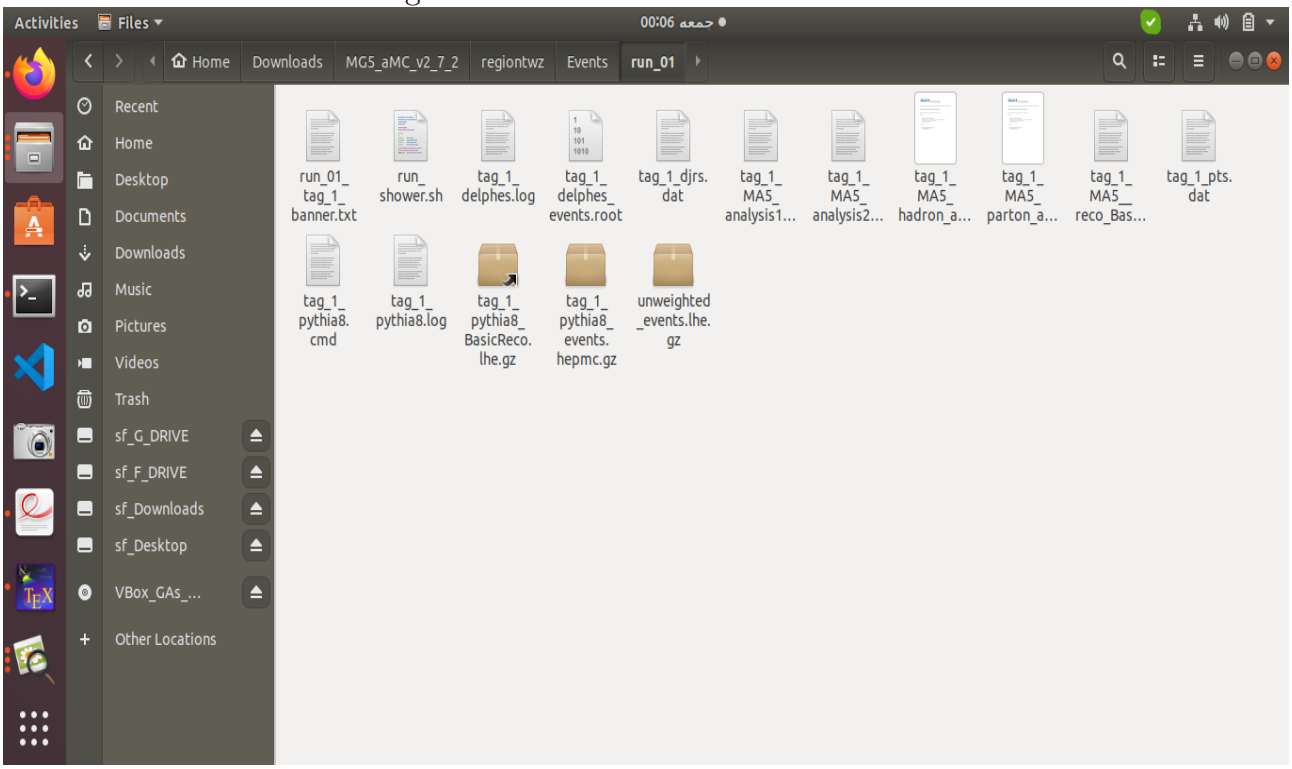

Figure 8: run_1