**Plotting an Invariant Mass Histogram with Excel**

In this tutorial, we are going to learn how to plot a histogram using Excel and open data sets from CMS Experiment at CERN. The file we use is "Jpsimumu.csv". This file can be obtained from the following link, in the Open Data Portal: http://opendata.cern.ch/record/545. It can also be accessed in the repository.

First, we are going to create a new Excel Spreadsheet and then we will import the file to this spreadsheet. In the data tab, select the option "From text/CSV". Locate where is the file in your computer and then click "import". A window like this one will appear:
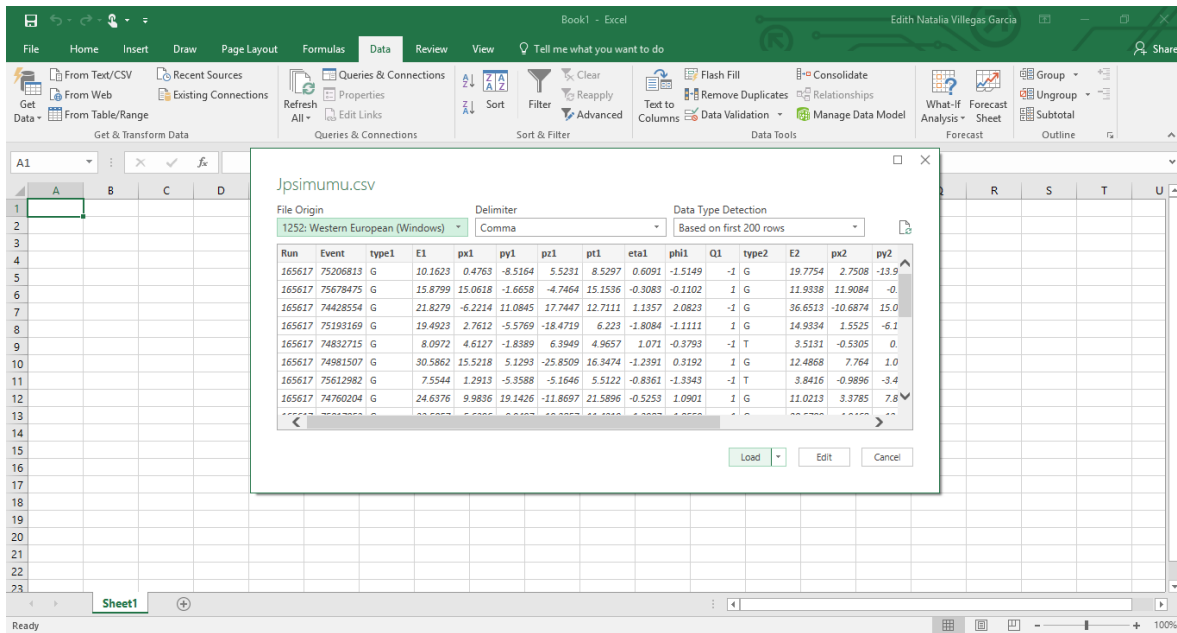

Verify that the selected delimiter is the comma and that the data structure is correctly recognized. Then click Load. The data should look something like this:
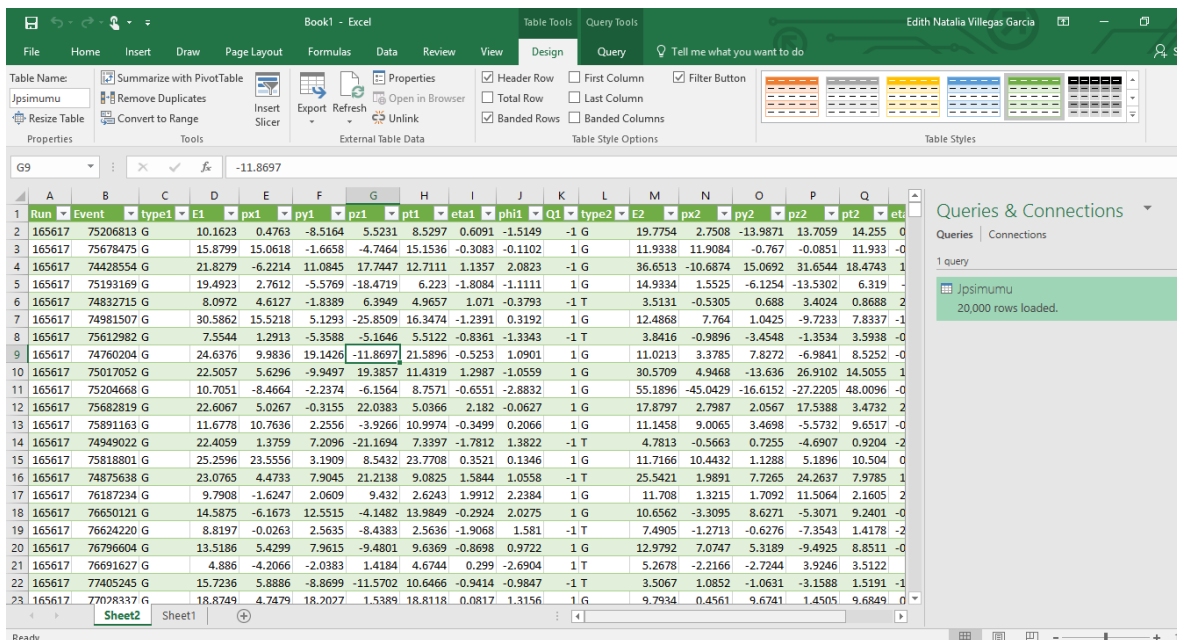
We are only going to use the mass data, so we can delete the rest of the columns by selecting them, right clicking on them and selecting the "delete" option of the menu.
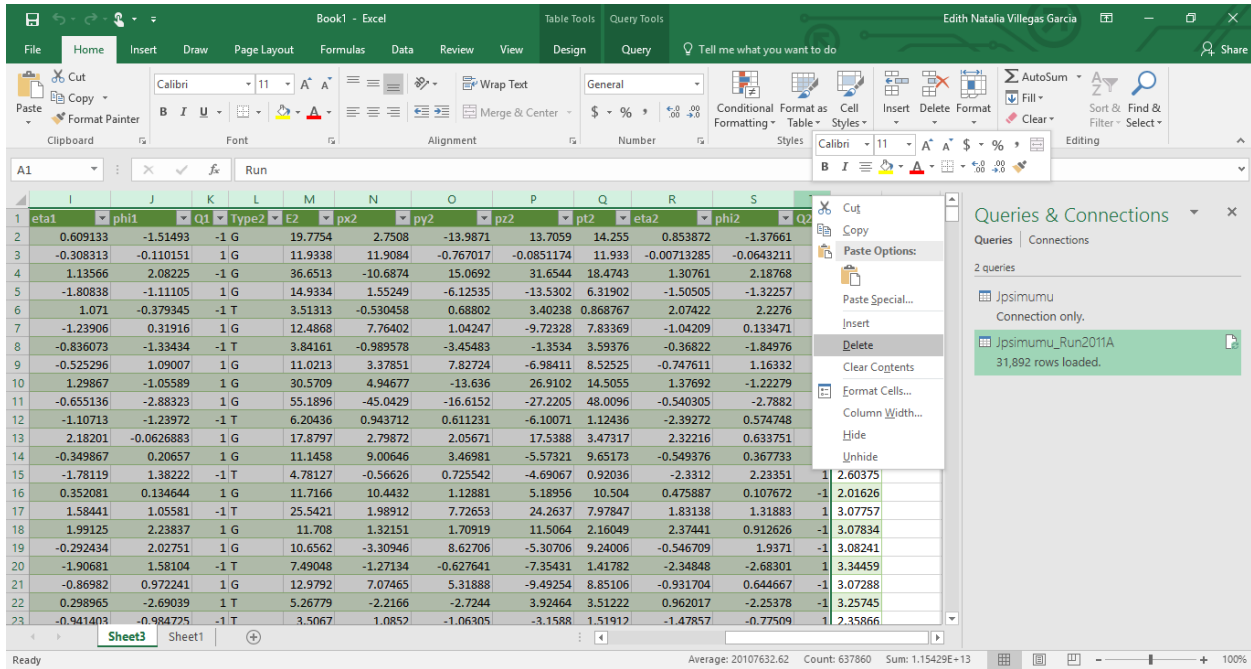

Next we can count how many values of mass we have in our file. We can do this by using the function COUNT( ). We write in the parenthesis the name of the first and last cells that contain our mass values, separated by :.
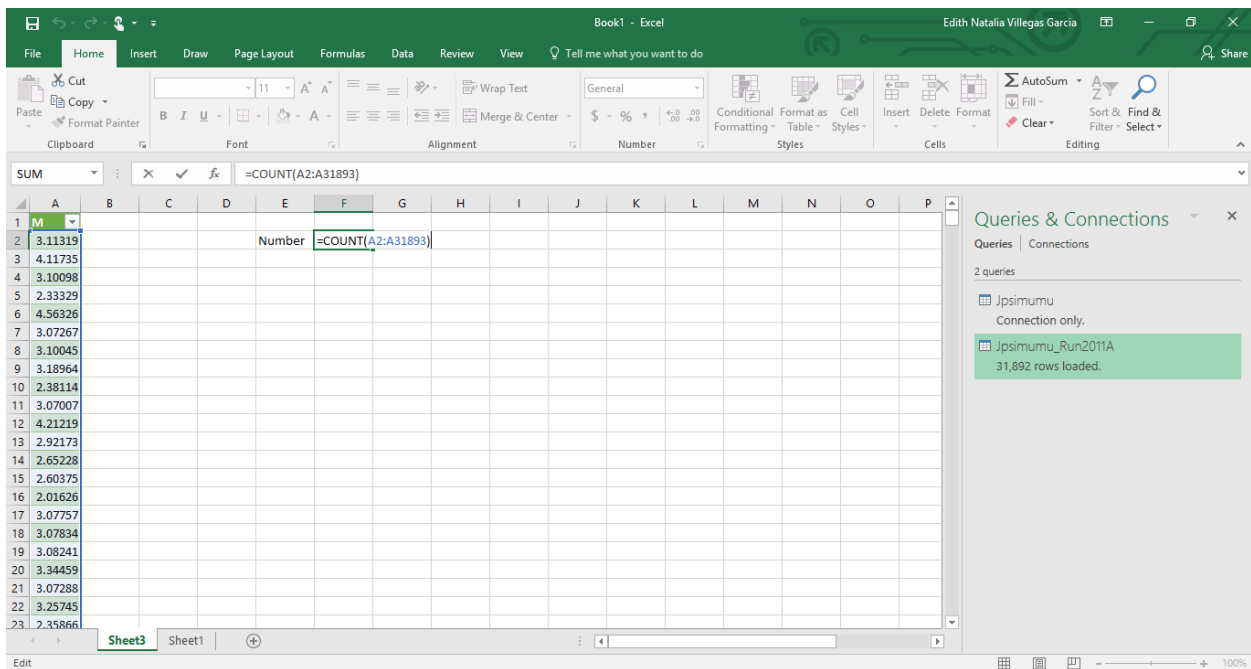
We can then calculate the maximum and minimum mass values using the functions MAX( ) and MIN( ), the same way we did with the COUNT( ) function. This gives us the range of our histogram. We can see from the result that our histogram's range will be 2.0 – 5.0 to cover all values.
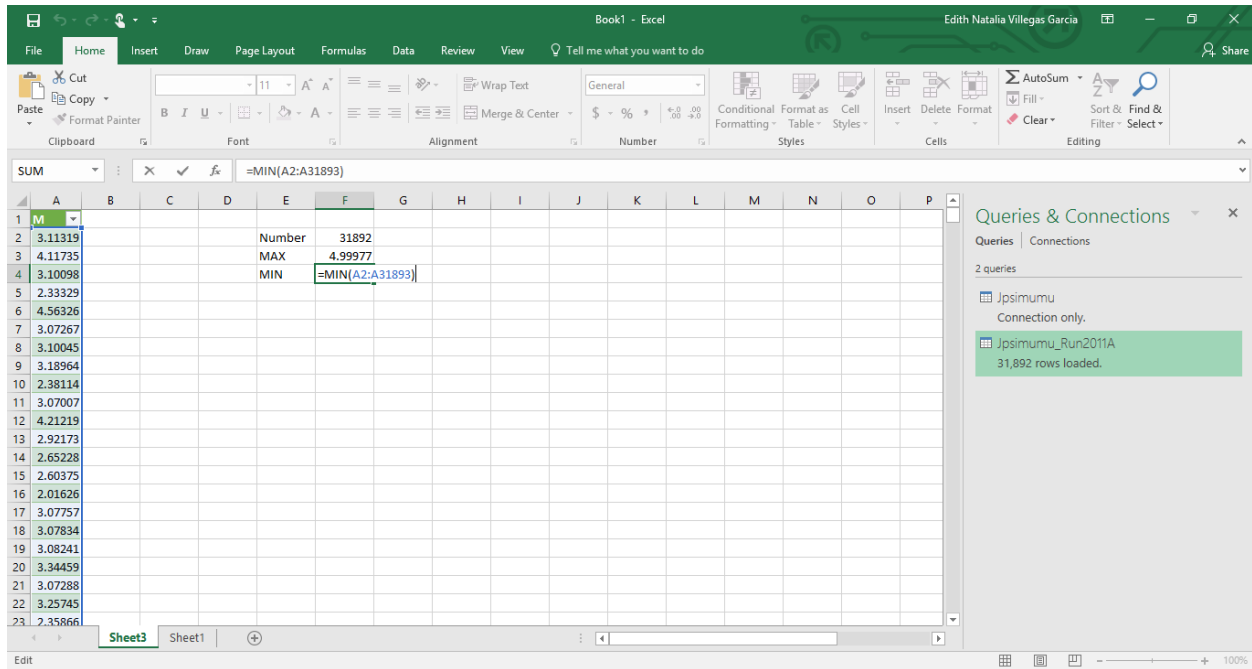

Now, let's create our classes for the histogram. We can go in steps of 0.01 GeV. In the column next to the mass column, write the first three numbers (2.00, 2.01, 2.02), then select them and slide them down from the right-bottom corner to create the rest of the numbers until you see a 5.00.
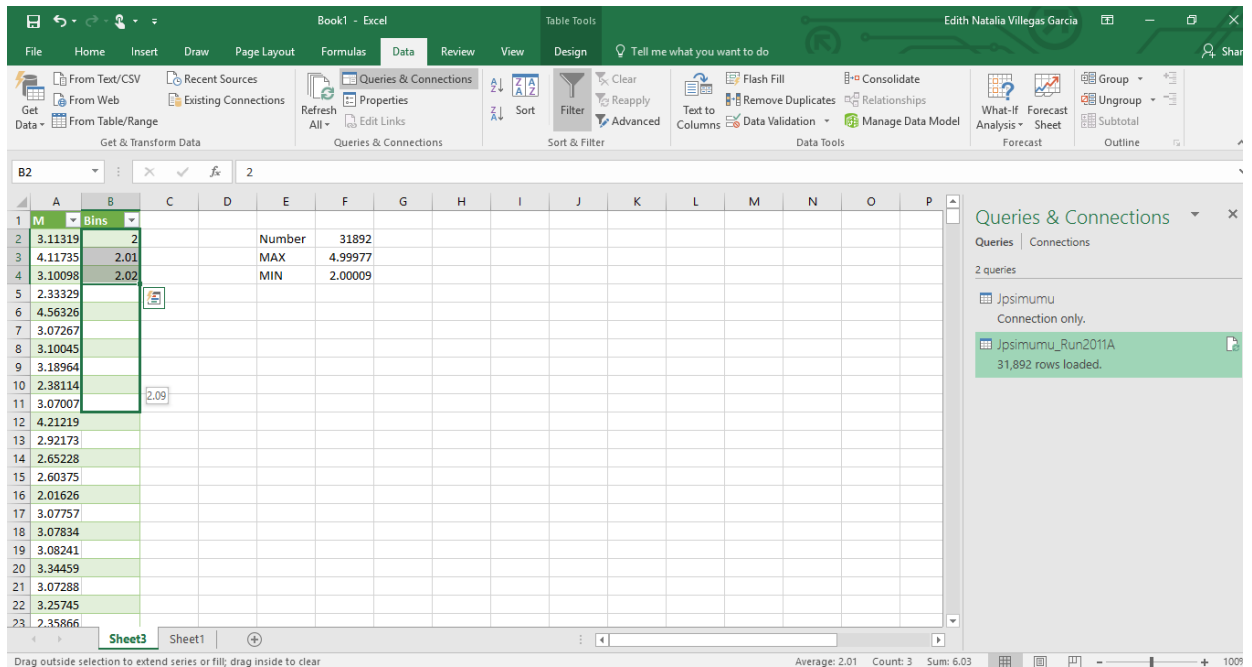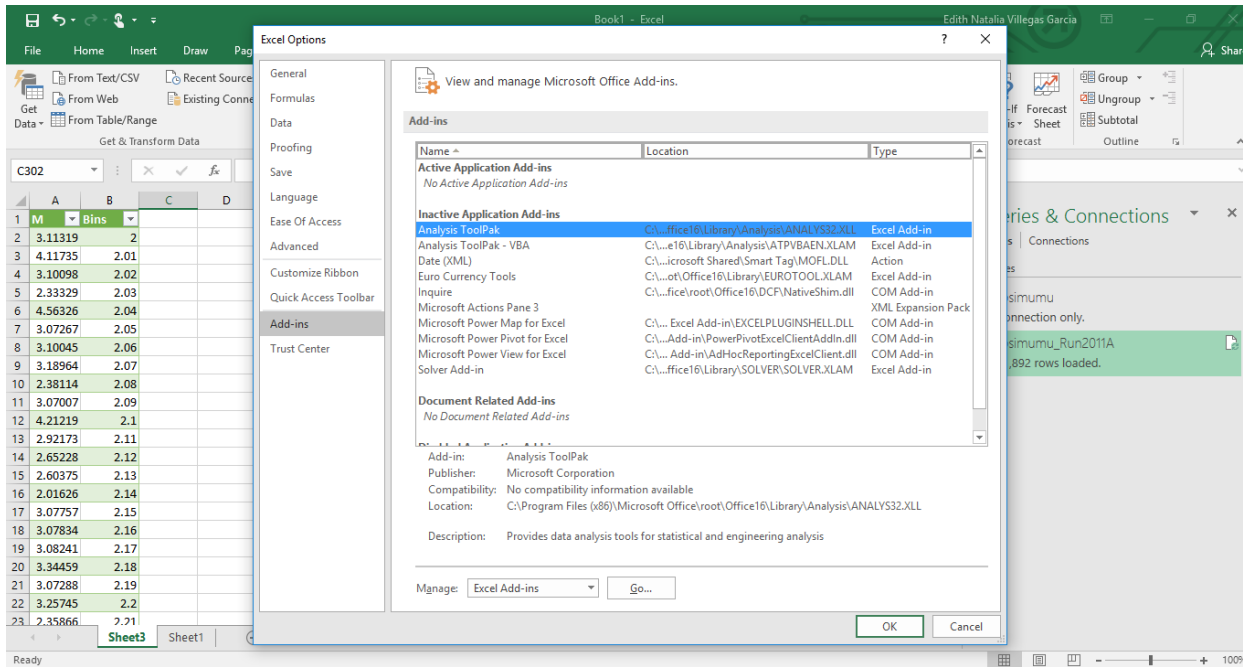
Now let's add the Analysis ToolPak add-in to Excel. On the file tab, click options.
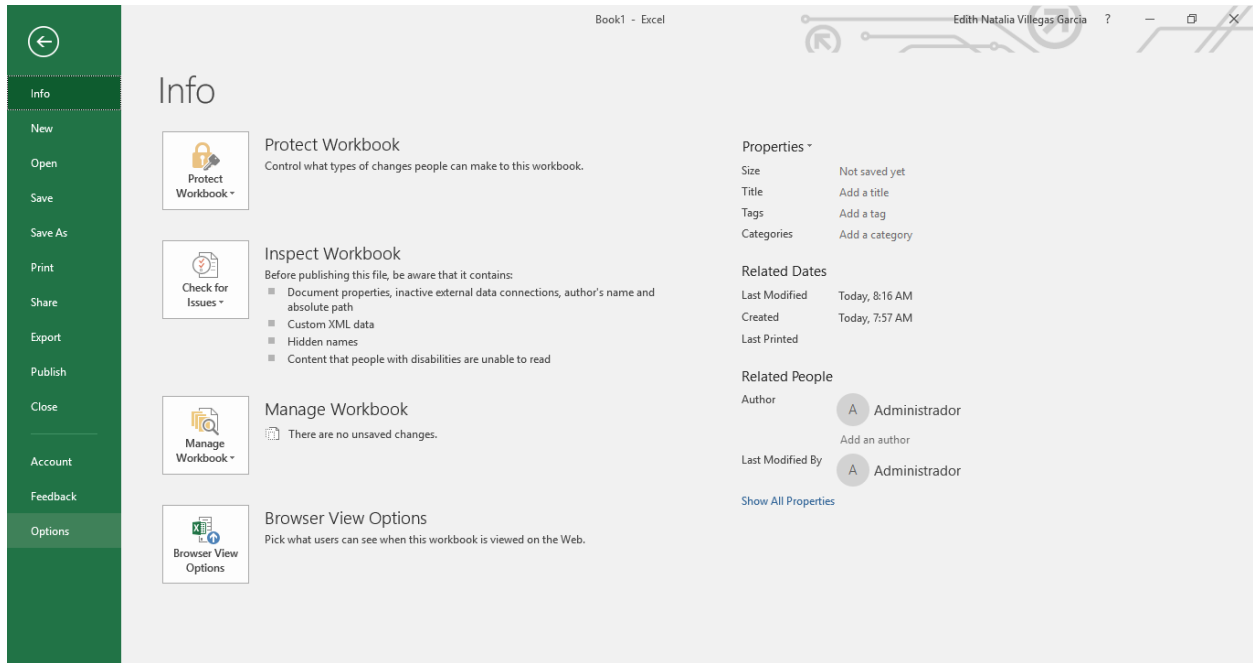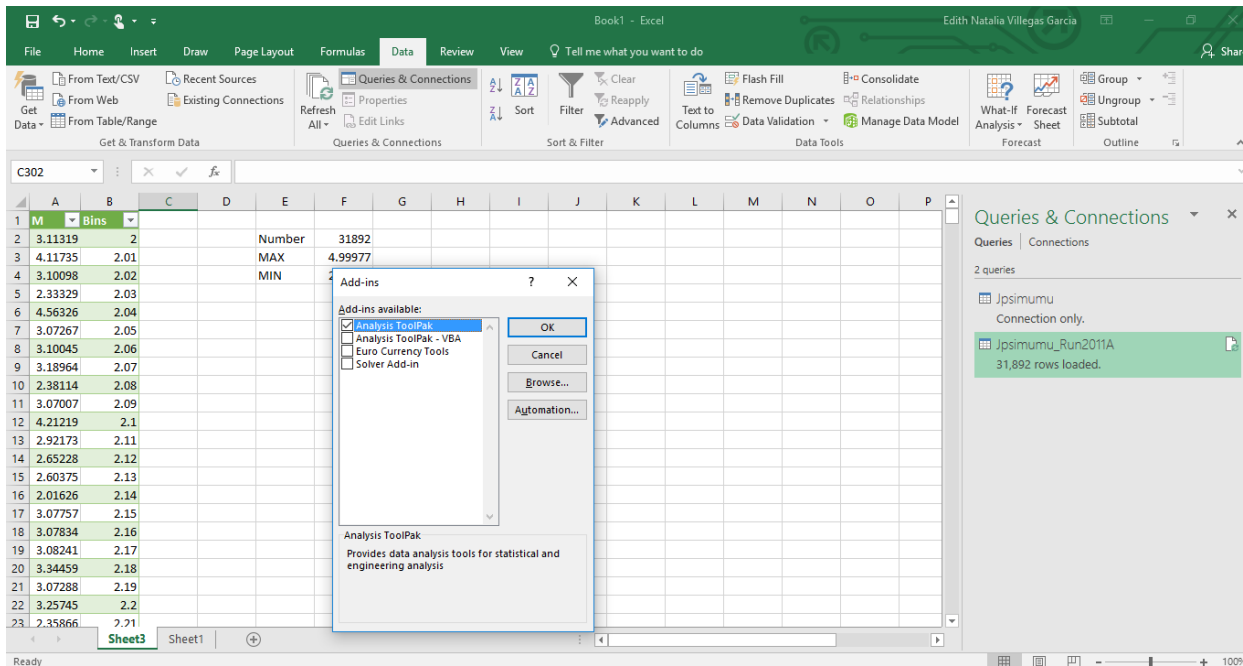
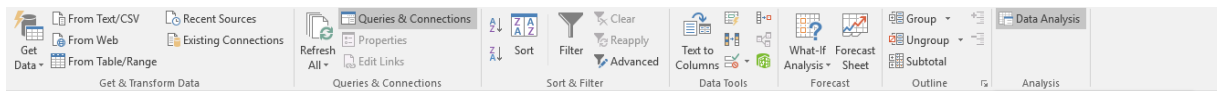

A window like this one will appear:
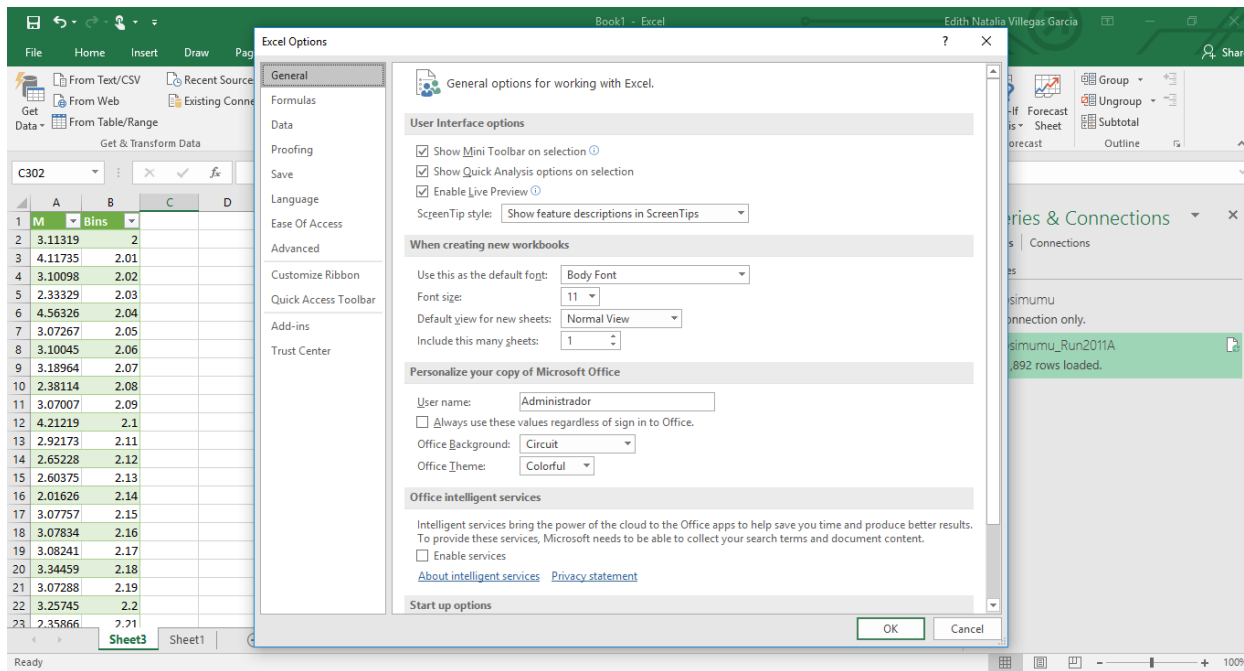
Now select Add-ins in the left panel, and something like this will appear:

Select the Analysis ToolPak and click Go. The next window will look like this:

Select Analysis ToolPak and click OK. The data analysis ToolPak is now activated. Now something like this will appear under the Data tab. Click Data Analysis.
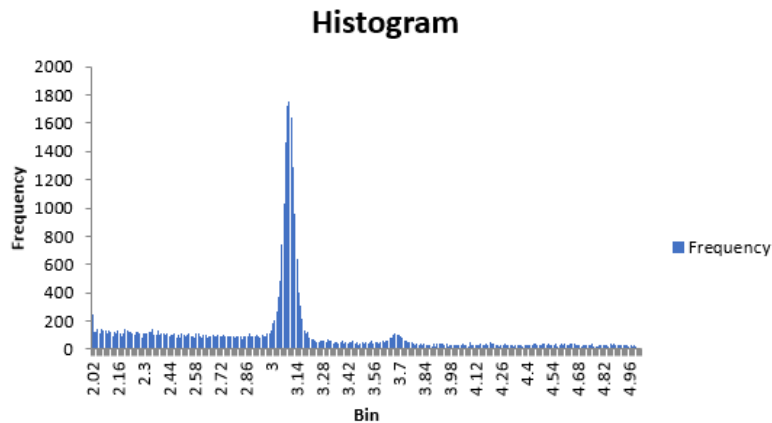
Now the next window will appear, select the option "Histogram" in the list and click OK.
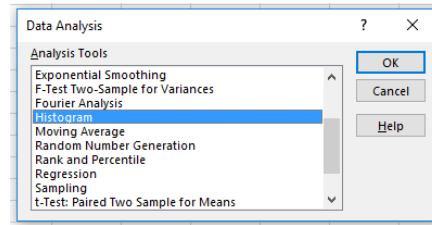
In the next window, in "Input Range" select all the values of the masses, on "Bin Range" all the values of the bins next to the masses and on "Output Range" select the cell next to the bins. Check the "Chart Output" option and click OK.
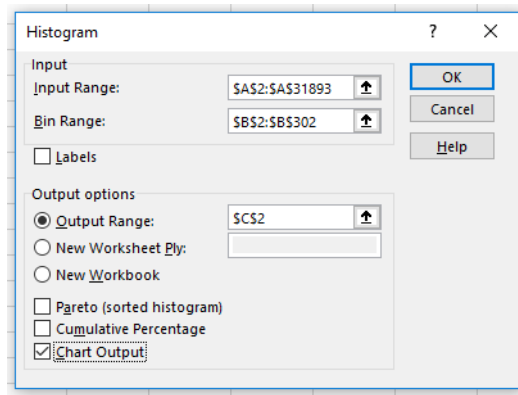
The result is a histogram like this:

You can clearly see a very big peak around 3.10 GeV and a smaller peak around 3.7 GeV. This two peaks correspond to two different particles that have those approximate mass values. Our file contains only events where exactly two muons were detected, so we can identify the particles with this information. Searching in the Particle Data Group website you can find that the two particles whose masses correspond to those values are the J/ψ meson and the ψ(2S) meson, respectively.

Exercise

You can find more data sets in CMS Open Data Website, plot the invariant mass histogram and see which particles you find in your plots.