EasyNData[1]: A simple tool to extract numerical values from published plots.

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Abstract

The comparison of numerical data with published plots is a frequently occurring task. In this article I present a short computer program written in Java$^{\mathrm{TM}}$ helping in those cases where someone wants to get the numbers out of a plot but is not able to read the plot with a decent accuracy and cannot contact the author of the plot directly for whatever reason. The accuracy reached by this method depends on many factors. For the examples illustrated in this paper a precision at the level of a few per mille could be reached. The tool might help in improving the quality of future publications.

I. Introduction

The comparison with published results which are only presented in form of plots is a frequently occuring task. Usually one proceeds by first looking at the plot and guessing whether the numbers might be the same as those one has calculated. While this is sufficient for a rough estimate it is clear that at a certain point one might want to make a more detailed comparison. In that case the first thing to try is clearly to contact the author of the plot and ask him politely for the raw data. Unfortunately in many cases this does not work. It might be due to the fact that the person who did the plot left physics, or that simply the data files are somehow lost or that people just don't like to talk to each other. In these cases one has to resort to other techniques. In the old days a good technique was to print out the plot as large as possible, and then equiped with a ruler to measure individual points which were afterwards transformed using a calculator to get the value itself. While in principle nothing is wrong with this technique it is tedious and error prone and somehow does not qualify as a technique for the new millenium. The uncertainty of points extracted in this way depends on the size of the plot and on the ability to measure individual points. Using a large format together with a ruler equiped with a magnifying glass a decent accuracy can be reached. It should be clear that there is an intrinsic limitation of the method due to the quality of the plot and the line thickness. The obvious improvement of the method described above is to first

[1] The program is available from http://puwer.web.cern.ch/puwer/EasyNData/

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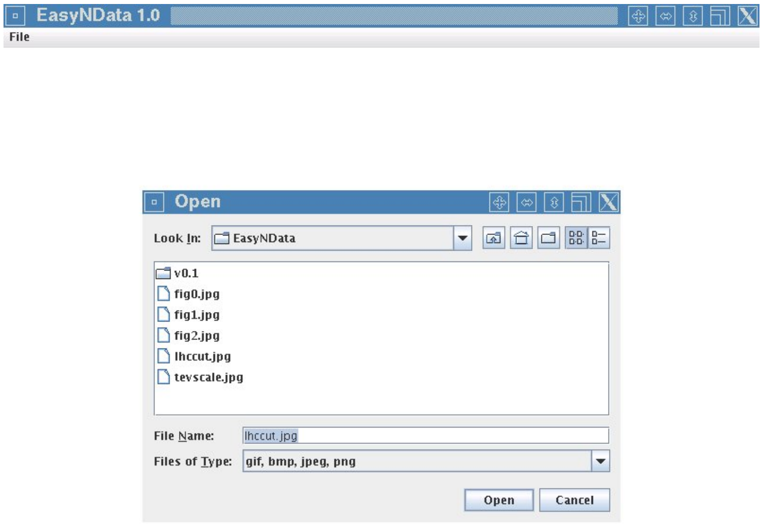
obtain a representation of the plot which can be displayed on the screen and then using the mouse to read off individual data points. After having calibrated once the mouse coordinates are translated automatically into the plot coordinates by a short program.

II. Program description

The above mentioned method has been coded in a Java$^{\text{TM}}$ program called EasyNData. Most of it could be recycled from a much more complicated program Map2GPS I wrote some time ago in which points from scanned maps were translated to Universal Transverse Mercator (UTM) coordinates using the world geodetic system of the year 1984 (WGS84). (The combination of the ellipsoid WGS84 together with coordinate system UTM is used in most of the modern GPS devices.) Having made this as a side remark I shall came back to the description of the program EasyNData presented in this article. The program is best described by a simple example. Suppose we want to compare the data shown in Fig. 4 of ref. [1] because we did a second calculation and we do not want to contact the authors directly[3]. Using EasyNData the procedure is as



Look In: EasyNData

v0.1
fig0.jpg
fig1.jpg
fig2.jpg
lhccut.jpg
tevscale.jpg

File Name: lhccut.jpg

Files of Type: gif, bmp, jpeg, png

Figure II.1: File chooser to load the desired JPEG file.

[3] It is probably fair to say that a table with concrete values would have improved ref. [1]. Apparently this was somehow forgotten during the write-up.

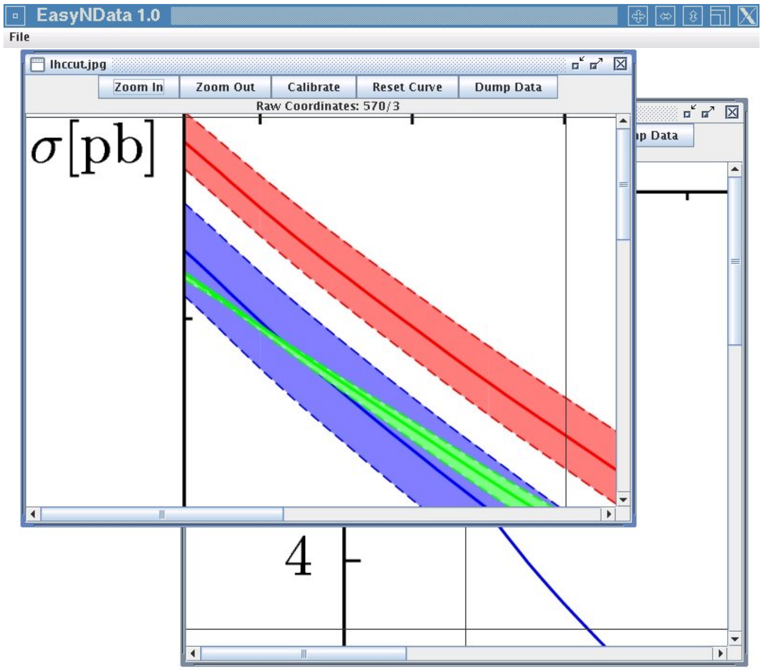
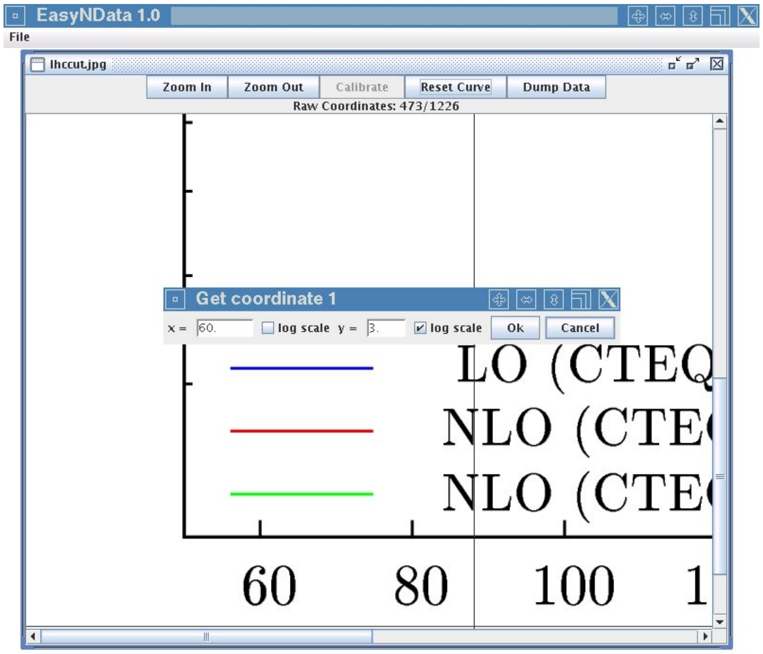


Figure II.2: Loaded plot is displayed in EasyNData.



Raw Coordinates: 473/1226

x = 60. ☐ log scale y = 3. ☑ log scale

Figure II.3: Calibration procedure.

follows:

1. Convert the plot to JPEG format. This can be done for example by a screen shot or by retrieving the Postscript file of the plot from `http://arxiv.org/` and converting it to JPEG format using publicly available tools. In principle a scanner could also do the job. (This might be useful in cases where the plot is only available from a journal.) It pays off to create a large format to reach good accuracy.

2. Start EasyNData by calling `java -jar EasyNData.jar` Open the JPEG file using the file menu (Fig. II.1). Now one should see the figure inside the window (see Fig. II.2). Note that you can load several plots at the same time.

3. Press the button ”Calibrate” to start the calibration procedure. One should chose a point in the plot where it is easy to read off the coordinates. After clicking on the point a new window opens where the coordinates in units used in the plot have to be entered (Fig. II.3). If the corresponding axis has a logarithmic scale the check box log scale must be selected.

4. This step has to be repeated with a second point. Having done that the calibration is finished. In the first line ”Raw Coordinates” of the plot window should now appear replaced by ”Calibrated Coordinates”. To check that nothing went wrong one may try a few points where an easy extraction is possible. Note that the calibration procedure can be redone at any time.

5. Place the crosshair cursor where ever you like to get the data. The corresponding values are displayed on the fly.

Update v1.0:
Saving points directly to a file:
The functionality to save extracted points directly to a file has been added. This is done in the following way:

1. First calibrate the plot as described above.

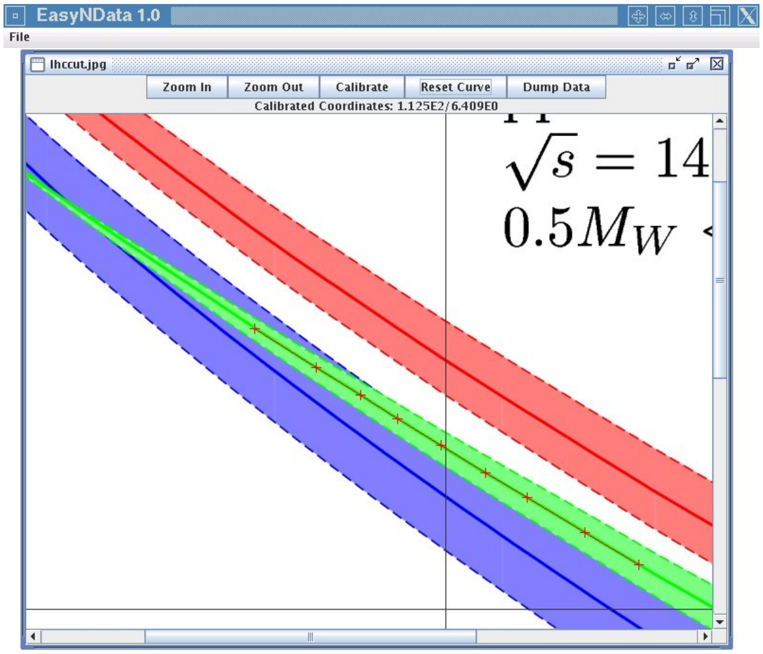
2. Then use the left mouse button to put sampling points on the curve you want to extract. The points next to each other are connected by a straight line. Note that only the points are extracted, the line is for illustrative purpose only (cf. Fig. II.4).

3. At any time a point already set can be *dragged-and-dropped* with the left mouse button. This is used to move the point in case that it was not well placed initially.

4. The last point can always be removed by clicking the right mouse button.

5. When you are done with a curve dumping the corresponding data points to a file is as easy as clicking on the ”Dump Data” button.

6. To clear all the points and start a new curve just click on ”Reset Curve”.



Calibrated Coordinates: 1.125E2/6.409E0

Figure II.4: Extraction of multiple points

Use keyboard to navigate the mouse pointer:
Since version 1.0 the cross hair pointer can also be moved via the keyboard. Using “shift-arrow” moves the pointer pixel wise in the corresponding direction. A point can be selected with “shift-enter”. The last point set can be removed via “shift-delete”. Note that the internal frame needs to have the ”focus” to allow the use of the keyboard. This is usually reached by clicking on the upper part of the frame.

Supported image formats:
As java supports also PNG, BMP and GIF without loading any additional class, this formats can also be used when a plot is loaded as a bitmap.

Requirements: The program should run on every platform where a recent runtime version of the Java^{TM} virtual machine is available. Note however that due to major incompatibilities between java versions > 1.5 and earlier ones the version has to be at least 1.5. In the example described below the version used was (output from `java -version`):

```
java version "1.5.0_08"
Java(TM) 2 Runtime Environment, Standard Edition (build 1.5.0_08-b03)
Java HotSpot(TM) 64-Bit Server VM (build 1.5.0_08-b03, mixed mode)
```

The program was also sucessfully tested under 32bit linux and Microsoft® Windows Vista^{TM}. Note that the program is delivered as jar-file. No compilation is necessary.

III. Examples

Using EasyNData I find for the upper blue line in Fig. 4 of ref. [1] the results shown in table 1. (The upper line was chosen because of its steepness—any uncertainty in the *x* determination adds as an important uncertainty to the *y* determination. So the steeper the more difficult is the extraction.) Two remarks are in order.

scale μ/m_w	value obtained using EasyNData	original data [1]
0.1	5.480	5.50573...
1.0	2.293	2.30282...
3.1622	1.650	1.65366...
10.0	1.239	1.24081...

Table 1: Extraction of data from Fig. 4 of ref. [1]

1. Although the numbers in the last column are given to 6 digits it is not claimed that the cross section is known with that precision. I just quoted the numbers as they were obtained from a numerical phase space integration and used in the preparation of the plots.

2. In fact the extraction of the plot data consists of two informations. The *x*- as well as the *y*-axis have to be extracted. In the example the *x* values were chosen such to match the sampling points used in the numerics. In case of the value 3.1622 it was not possible to exactly hit this point with the mouse due to the discret sampling of the mouse position. This could be solved by further increasing the bitmap or switching to a screen with a higher resolution. (The example was run on a notebook with XGA resolution that is 1024x758.)

One might argue that this was an easy example because the *y*-axis is linear. So let's do a second example and take the middle line of the red band shown in the lower plot of Fig.6 of ref. [1]. The results are shown in table 2. Although the accuracy is not as good as in the first example it is still better than a 1%. Given that the uncertainty of the original data points due to the numerical integration is probably of the same size the extracted data would still allow what I would call a detailed comparison.

cut	value obtained using EasyNData	original data [1]
50	31.78	31.9544...
100	14.65	14.7153...
200	4.490	4.48797...

Table 2: Extraction of data from Fig.6 of ref. [1]

The JPEG files used in the example were created from the plots available on `http://arxiv.org/`. They are bundled together with the program so that everybody can repeat the example.

IV. Known limitations and possible extensions

It seems to be that zooming into an already large image creates a runtime exception caused by insufficient memory of the java virtual machine. This is not a severe problem because in any case one will not gain anything from further zooming. The main purpose of the zoom-in button is to undo a previous zoom-out action. It might be as well that this problem could be avoid by attributing more memory to the virtual machine when the program is launched. Using more than 2 points to calibrate the plot could further improve the quality. It might also be useful to store the information about the calibration so that this could be reused when the plot is accessed a second time. In addition one could also think to sample a given curve completely automatically after the plot has been calibrated.

Please note that no warranty for the correctness of the program is given and that every user is using the program on its own risk.

V. Conclusions

In this article a short Java^{TM} tool is described to extract numerical data from published plots. Depending on the quality of the plots an accuracy at a few per mille level can be reached. Given that in many cases the numerical data is not more precise this is sufficient for many detailed comparisons. I believe that statements as made for example in ref. [2] footnote 1 on page 2 are not state of the art, given that the main question is whether one agrees or not on the prediction for measurable quantities. This is in particular true taken into account that we all know that the tricky part of one-loop corrections for the LHC is to get it right in the entire relevant phase space (in a finite time!) and not just in one point.

Acknowledgment:
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References

[1] S. Dittmaier, S.Kallweit, P.Uwer, *NLO QCD corrections to WW+jet production at hadron colliders*, [arXiv:0710.1577],

[2] J. Campbell, R.K.Ellis, G. Zanderighi, *Next-to-leading order predictions for WW + 1 jet distributions at the LHC*, [arXiv:0710.1832]