

Introduction to Data Analysis

IGOR Pro

WaveMetrics Igor Pro (6.1)
Based on slides by Adi Robinson

IGOR Pro 9 can be downloaded from the TWiki
To activate IGOR use the following information:
Serial Number: 84335
Activation Key: MVSY-MMJD-LDUP-MENY-PDYX-XANG-EJV

Introduction to Igor Pro

Igor Pro is an integrated program for visualizing, analyzing, transforming and presenting experimental data.

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Serial Number: 84335

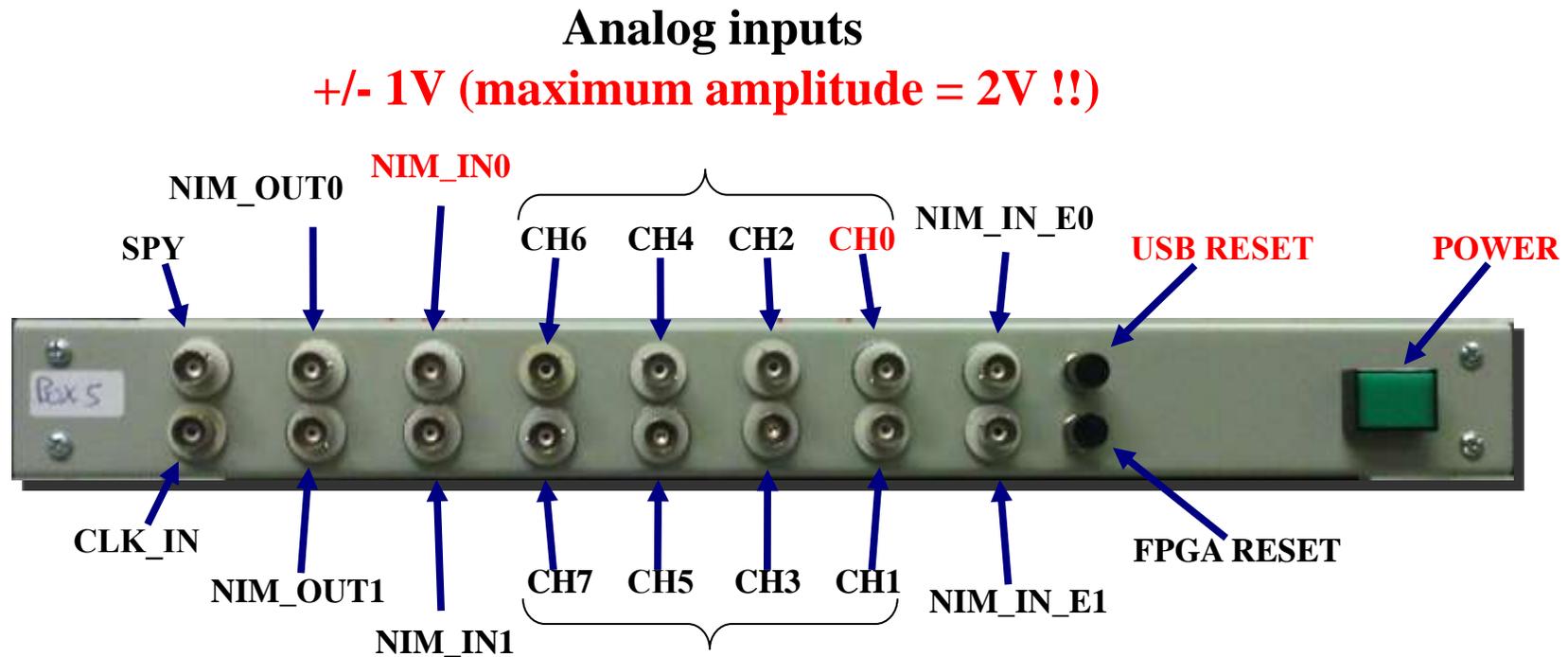
Activation Key: MVSY-MMJD-LDUP-MENY-PDYX-XANG-EJV

Igor Pro's features include:

- **Publication-quality graphics**
- High-speed data display
- **Ability to handle large event-by-event data sets**
- **Curve-fitting**, Fourier transforms, smoothing, **statistics**, and other data analysis algorithms
- Waveform arithmetic
- Image display and processing
- **Combination graphical and command-line user interface**
- Automation and data processing via a **built-in programming environment**
- Extensibility through modules written in the C and C++ languages

ANSEL Digital Data Source DDC-8 DSP

Detectors & electronics produce signal amplitude (energy) and time signals in up to 6 dimensions (≤ 6 signals per event).



Igor Pro - Waves

We use the term “wave” to describe an Igor object that contains an array of numbers. “Wave” is short for “waveform”, a term used in digital signal processing (DSP). The *wave* is the most important Igor concept.

In the context of ANSEL experiments, a typical wave consists of a sequence of numbers describing a series of “events,” for example, the stream of signal amplitudes generated by an operating radiation detector during some period of time.

Igor was originally designed to deal with waveform data. A waveform typically consists of hundreds to thousands of values measured at evenly spaced intervals of time. Such data are usually acquired from a digital oscilloscope, from a scientific instrument or from an analog-to-digital converter.

Igor Pro – Loading Waves

Most Igor users create “waves” by loading data from a file created by another program. In ANSEL, these original files are produced by the DDC8-Data Acquisition routines.

The process of *loading a file* reserves an array of computer cells and then stores data from the file in these cells.

The waves can contain numeric or text data.

Optionally, one can create a new wave or overwrite an already existing wave.

Igor provides routines for loading files with a number of different data types.

(There is no single universal file format for numeric or text data that all programs can read and write.)

Igor Pro – How to start

IGOR Pro

Manual

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Chapter I-2 — Guided Tour of Igor Pro

Guided Tour 1 - General Tour

In this exercise, we will generate data in three ways (typing, loading, and synthesizing) and we will generate graph, table, and page layout windows. We will jazz up a graph and a page layout with a little drawing and some text annotation. At the end we will explore some of the more advanced features of Igor Pro.

Launching Igor Pro

The Igor Pro application is typically installed in:

`/Applications/Igor Pro Folder (Macintosh)`

`C:\Program Files\WaveMetrics\Igor Pro Folder (Windows 32-bit)`

`C:\Program Files (x86)\WaveMetrics\Igor Pro Folder (Windows 64-bit)`

1. **Double-click the Igor Pro application file on your hard disk.**
On Windows you can also start Igor using the Start menu.
If Igor was already running, choose the File→New Experiment menu item.
2. **Use the Misc menu to turn preferences off.**
Turning preferences off ensures that the tour works the same for everyone.

Make a wave

Entering Data

1. If a table window is showing, click in it to bring it to the front.

When Igor starts up, it creates a new blank table unless this feature is turned off in the Miscellaneous Settings dialog. If the table is not showing, perform the following two steps:

- 1a. Choose the Windows→New Table menu item.

The New Table dialog appears.

- 1b. Click the Do It button.

A new blank table is created.

2. Type "0.1" and then press Return or Enter on your keyboard.

This creates a wave named "wave0" with 0.1 for the first point. Entering a value in the first row (point 0) of the first blank column automatically creates a new wave.

3. Type the following numbers, pressing Return or Enter after each one:

1.2

Your table should look like this:

1.9

2.6

4.5

5.1

5.8

7.8

8.3

9.7

Point	wave0
0	0.1
1	1.2
2	1.9
3	2.6
4	4.5
5	5.1
6	5.8
7	7.8
8	8.3
9	9.7
10	

4. Click in the first cell of the first blank column.

5. Enter the following numbers in the same way:

-0.12

-0.08

1.3

1

0.54

0.47

0.44

0.2

0.24

0.13

6. Choose Data→Rename.

7. Click "wave0" in the list and then click the arrow icon.

8. Replace "wave0" with "time".

Notice that you can't use the name "time" because it is the name of a apologize for usurping such a common name.

9. Change the name to "timeval".

10. Select "wave1" from the list, click the arrow icon, and type "yval".

11. Click Do It.

Plot a wave

Making a Graph

1. Choose the **Windows**→**New Graph** menu item.

The New Graph dialog will appear. This dialog comes in a simple form that most people will use and a more complex form that you can use to create complex multi-axis graphs in one step.

2. If you see a button labeled **Fewer Choices**, click it.

The button is initially labeled **More Choices** because the simpler form of the dialog is the default.

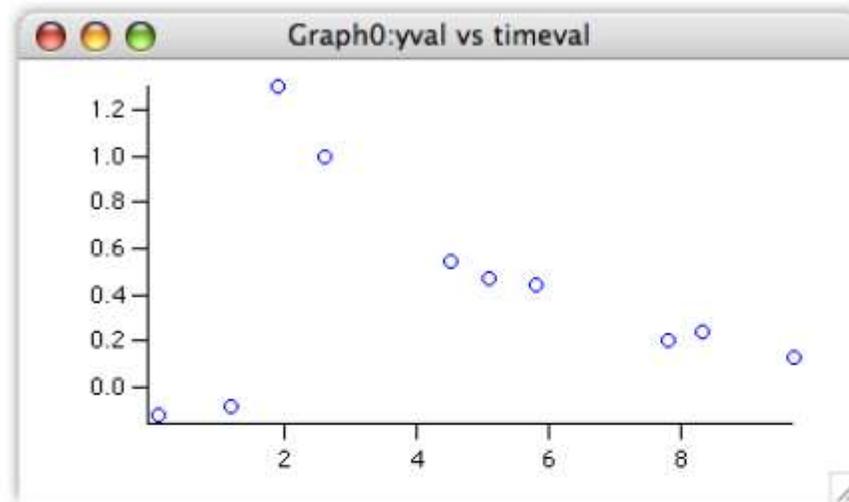
3. In the **Y Wave(s)** list, select **"yval"**.

4. In the **X Wave** list, select **"timeval"**.

5. **Click Do It.**

A simple graph is created.

Your graph should now look like this:



6. Position the cursor over the bottom axis line.

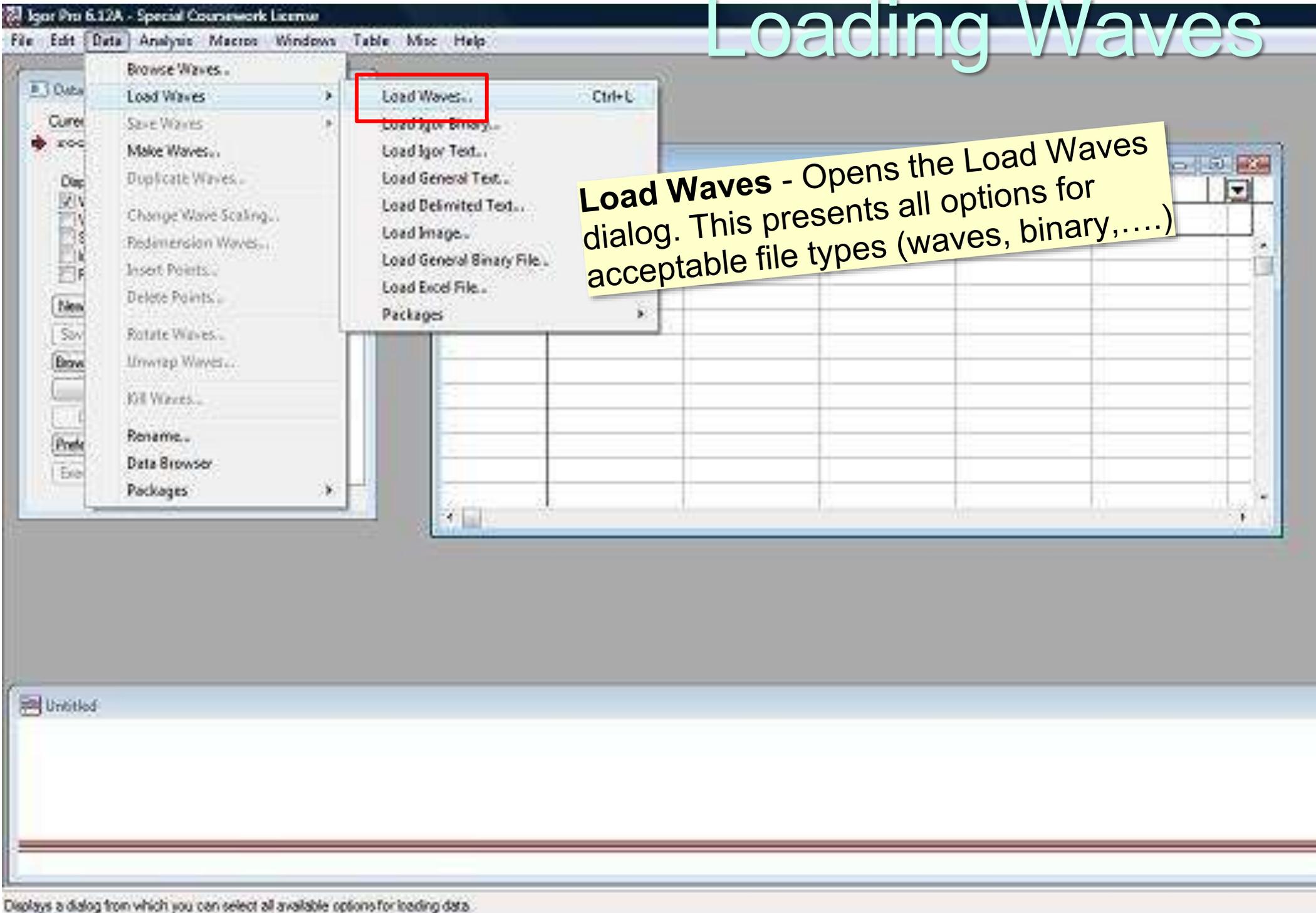
The cursor changes to this shape: . This indicates the cursor is over the axis and also that you can offset the axis (and the corresponding plot area edge) to a new position.

7. Double-click directly on the axis.

The **Modify Axis** dialog appears. If another dialog appears, click **cancel** and try again, making sure the  cursor is showing.

Note the **Live Update** checkbox in the top/right corner of the **Modify Axis** dialog. When it is checked, changes that you make in the dialog are immediately reflected in the graph. When it is unchecked, the changes appear only when you click **Do It**. The **Modify Axis** dialog is the only one with a **Live Update** checkbox.

Loading Waves



Loading Waves

Load Waves

Path

File Type: Delimited Text

File Type – Choose the type of file to be loaded

- Make table
- Read wave names
- Load from clipboard
- Overwrite existing waves

- Double precision
- Auto name and go

- none_
- Igor

Path (of file) – Choose the path of the loaded file

Load columns into matrix

Path:

File...

**Or type path explicitly,
Or browse computer for file**

Do It

To Cmd Line

To Clip

Tweaks...

Help

Cancel

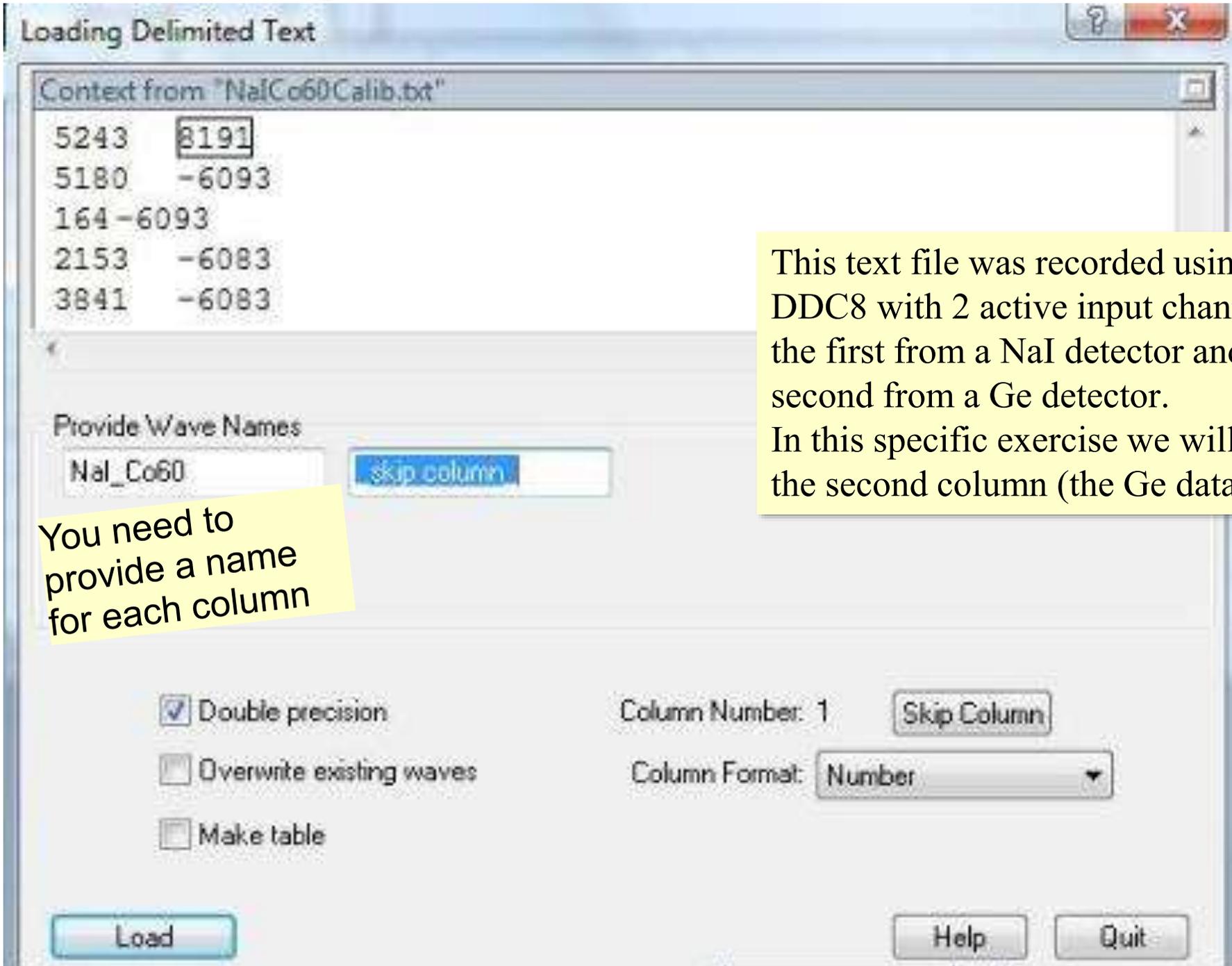
Loading Data

Summary: The basic sequence of actions to load 1D data, encoded as a delimited-text file, into IGOR

1. Bring up the ***Load Waves*** dialog.
2. Choose ***Delimited Text*** from the File Type pop-up menu.
3. Click the ***File*** button to select the file containing the data.
4. Click ***Do It***.

When you click *Do It*, the *Load Wave* operation runs. It executes the *Load Delimited Text* routine.

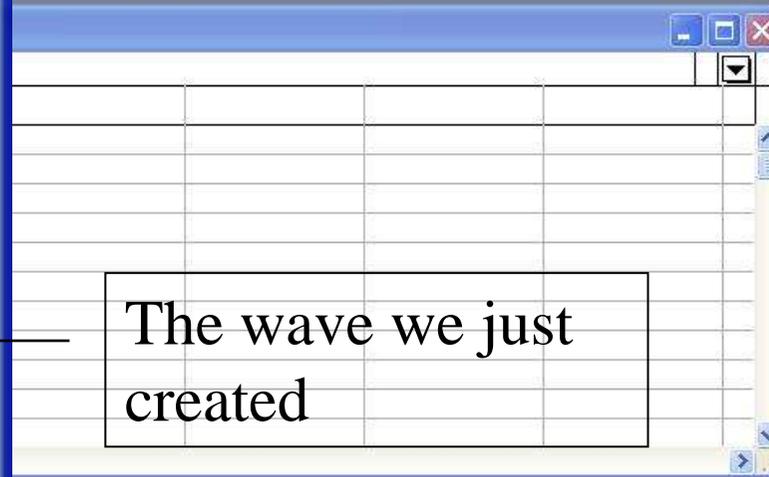
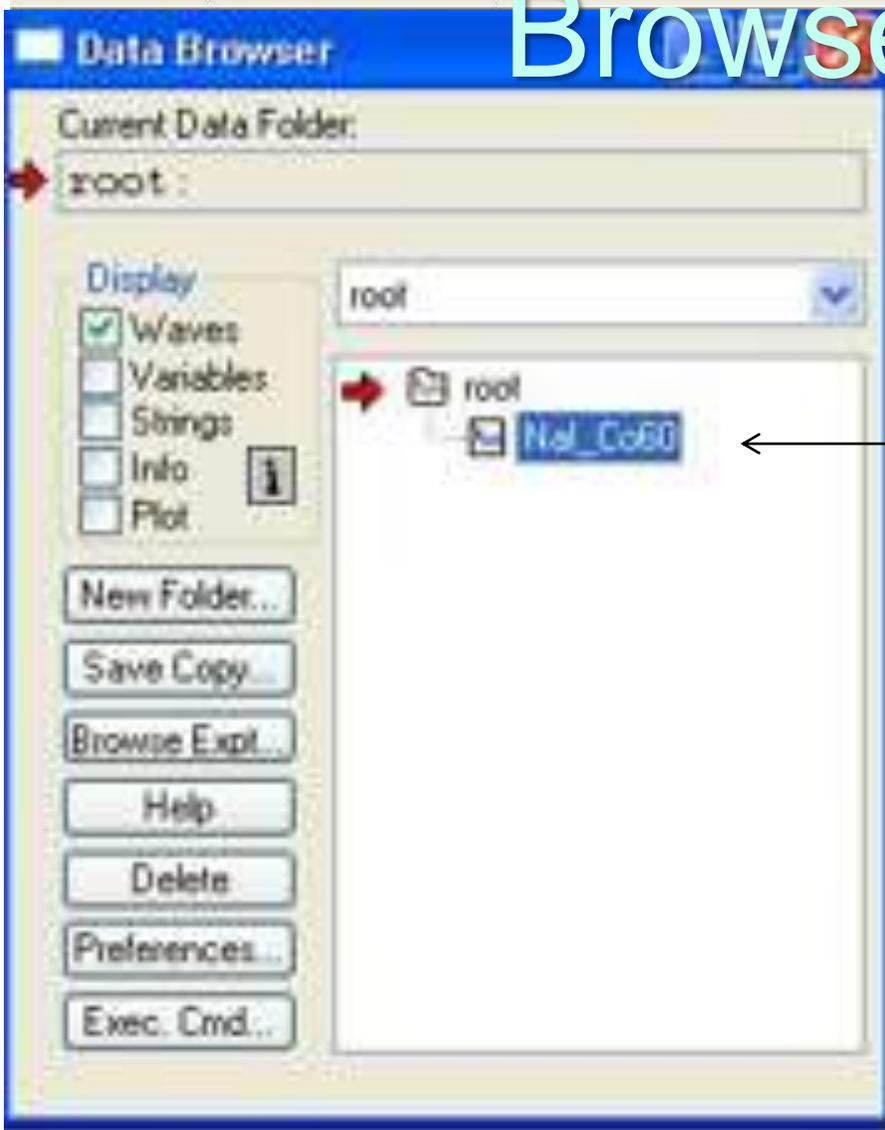
Loading Delimited-Text Files



You need to provide a name for each column

This text file was recorded using the DDC8 with 2 active input channels: the first from a NaI detector and a second from a Ge detector. In this specific exercise we will skip the second column (the Ge data).

Browse for Loaded Wave



The uploaded wave will appear in the Data Browser under the name you gave the column.



Histogram



Resort event data into a probability spectrum (“histogram”).
Go to Analysis and select Histogram



Histogram

Source Wave: Nal_Co60

Result: Output Wave: Auto

Where: Current Data Folder

Destination Bins: Manually set bins, Auto-set bin range, Set from destination wave, Auto-set bins: 1+log2(N), Auto-set bins: 3.49*Sdev*N^1/3

Number of Bins: 100

Bin Start: 0

Bin Width: 1

Output Options: Accumulate into Dest, Bin-Centered X Values, Cumulative, Normalize Result to Probability Density, Create Square Root(N) Wave

Display Output Wave

New Graph: Graph Layout: Output only

Make/N=100/O Nal_Co60_Hist;DelayUpdate Histogram/B={0,1,100} Nal_Co60,Nal_Co60_Hist

Do It To Cmd Line To Clip Help Cancel

Choose the wave to histogram under "**Source Wave.**"
Define sorting bins manually or have Igor set them.
Select **Display Output Wave** to display the histogram, once you click "**Do It**".

OR let IGOR do it via Auto-set

← 4096
← -32000
← 16

Displaying and Editing Histograms

- If you chose not to display the histogram from the histogram menu, you can **right-click the histogram name and click display.**
- Once a histogram is displayed you can edit the figure.
- Double clicking on one of the axes pops up the “Modify Axis” menu.
- You can set the range of each axis, label them and do other fancy things.
- **Right-clicking the middle of the figure pops** a menu that lets you append traces to the graph, add an annotation and edit other features of the figure.

Analysis – Fitting a Curve to Data

Curve Fitting

Function and Data | Data Options | Coefficients | Output Options

Function: gauss

Y Data: Nal_Co60

X Data: If you have only a Y wave, _calculated_

Data Options tab

From Target

Use Multiple Processors

Show:

Equation

Commands

$$y_0 + A \exp \left[- \left(\frac{x - x_0}{width} \right)^2 \right]$$

Do It | To Cmd Line | To Clip | No Error | Help | Cancel

0 1000 2000 3000 4000

- “Ctrl+I” pops up the *Cursor* sub menu.
- Drag both cursers to define the fit range for the peak.
- Go to “Analysis” → “Curve Fitting...”. → Function
- Choose fit function to apply to data.
- Choose the source of X and Y data.
- Here: Nal histogram = Y data, X data = calculated option
- Press **Data Options** tab and click the cursers button.
- Press **Do It!**

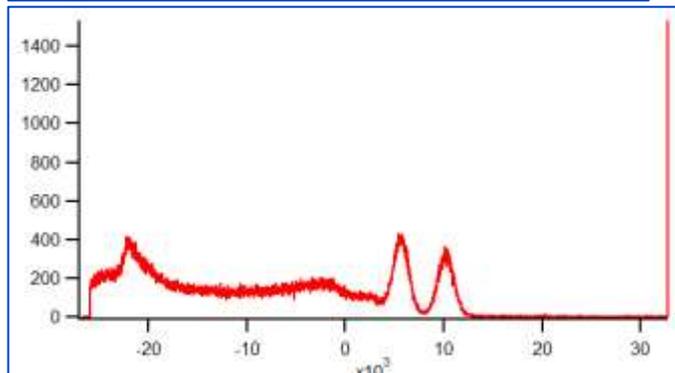
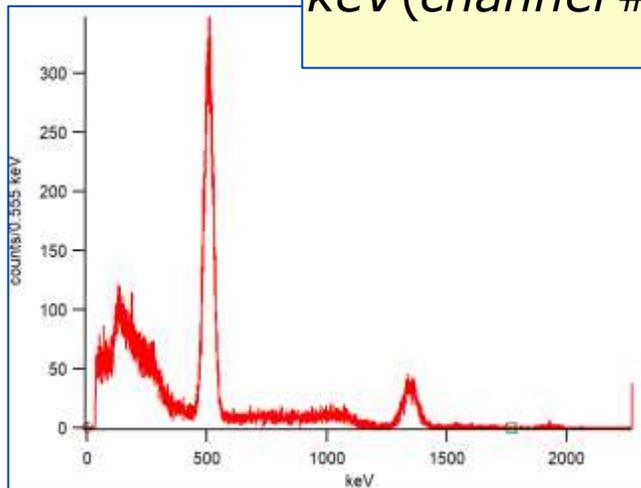
A fit trace should appear in the range between the cursers. The command box below shows values of each parameter and its error.

Perform an Energy Calibration of Detector

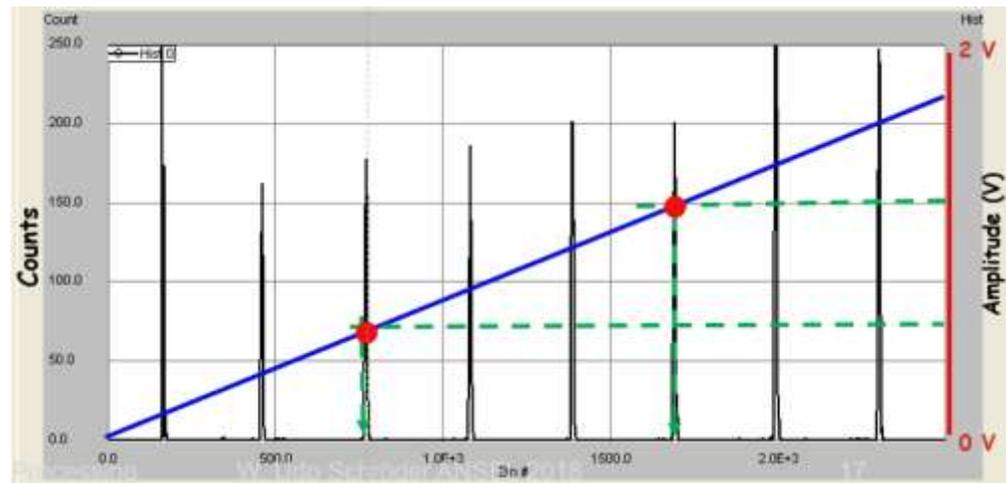
Measure spectra for various calibration sources with the same detector. If necessary, extend or interpolate gaps with normalized pulse generator (Pulser). **Fit relation between line channel #s and known line energies** → obtain linear calibration curve. Keep track of errors in calibration constants.

$$Energy = Energy(channel \#)$$

$$keV(channel \#) = offset(keV) + \left(\frac{keV}{channel \#} \right) \cdot channel \#$$



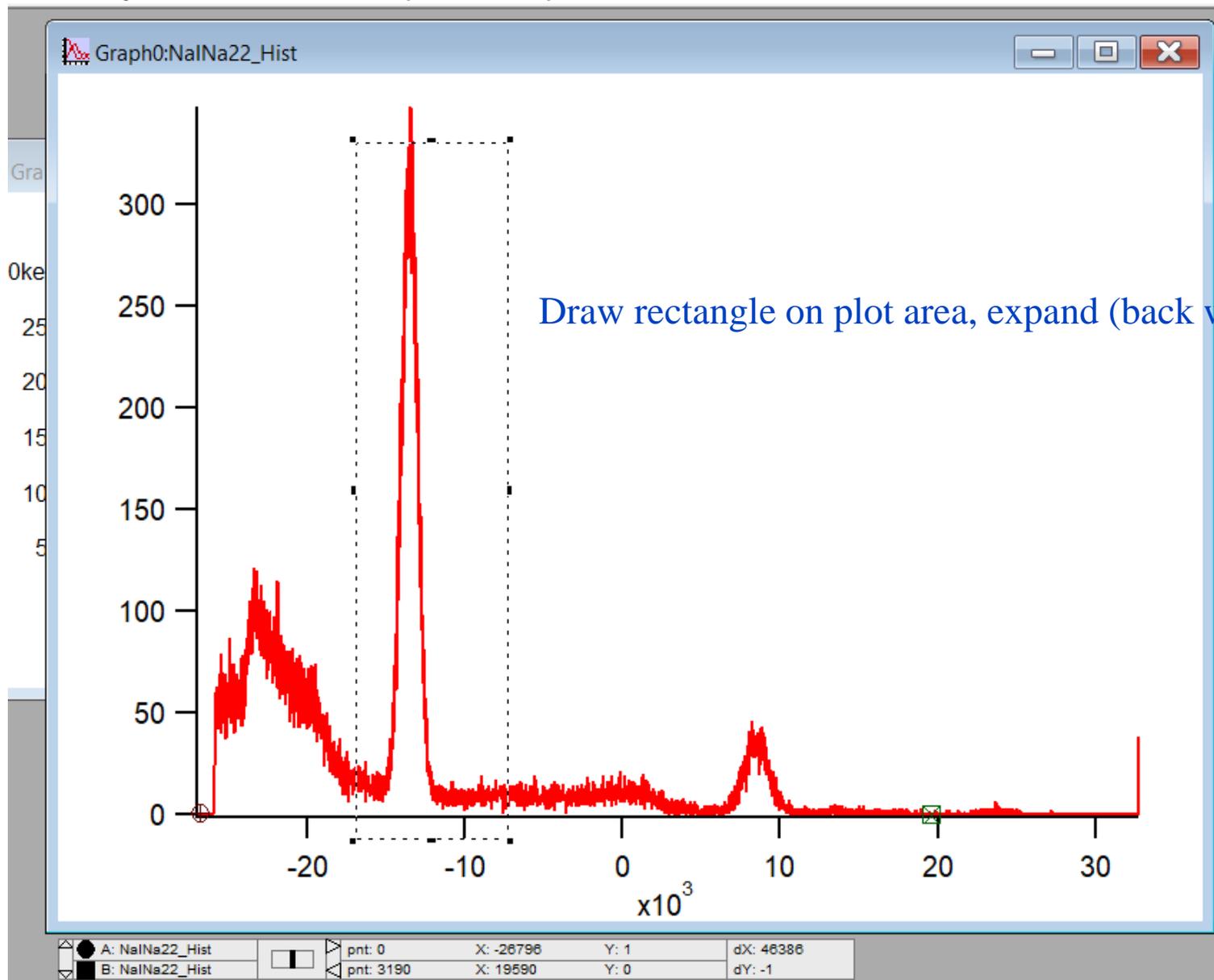
“Pulser Fence” calibrates abscissa of DAQ (Channel, Bin#) in Volts, MeV, etc.



Analysis-Gauss Fit to Na-22 Data

Na-22 spectrum has well separated lines: 511-keV γ line

Data Analysis Macros Windows Graph Misc Help



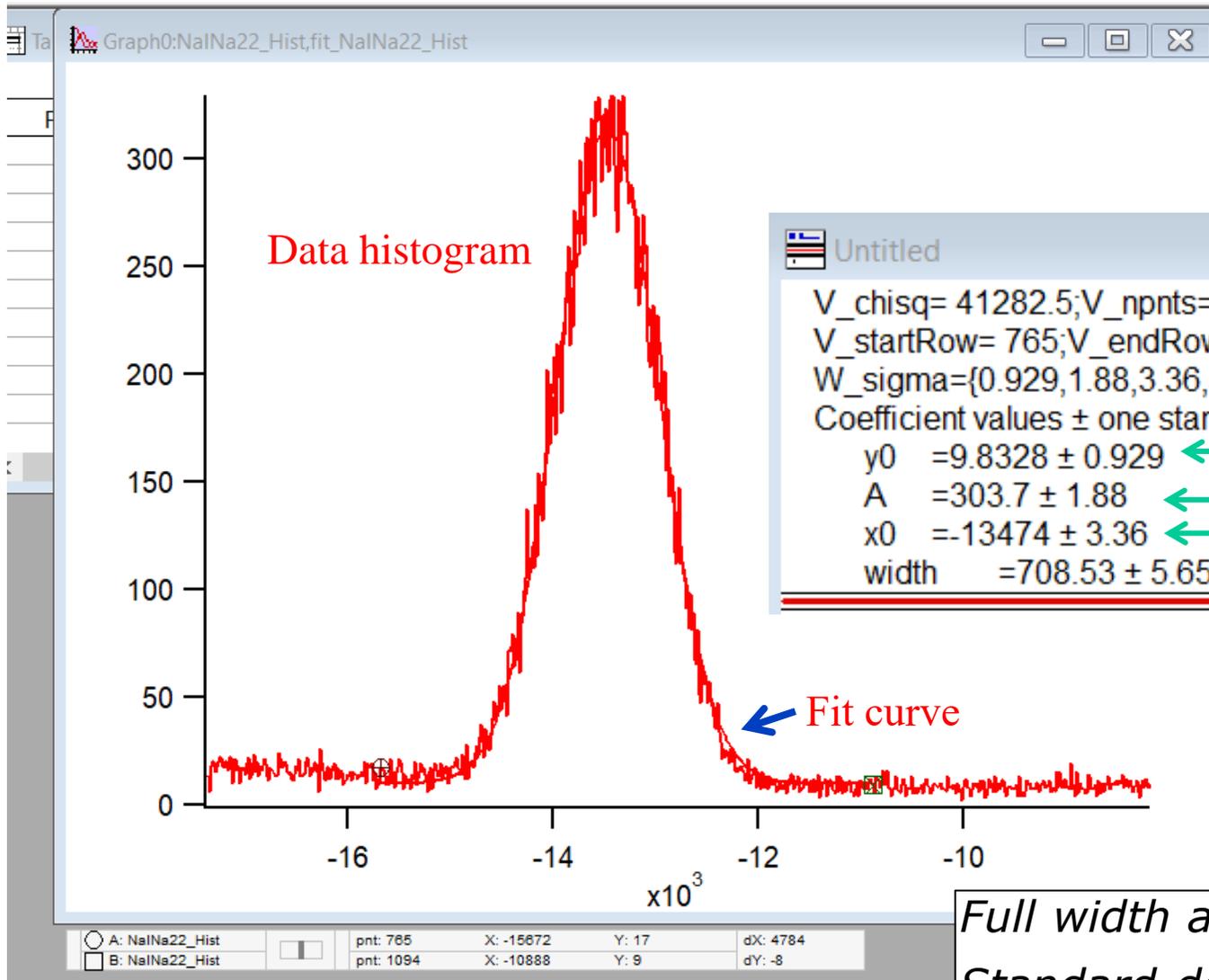
Analysis-Gauss Fit to Data

Na-22 spectrum, 511-keV γ line

Draw rectangle on plot area, expand (back with Ctrl=Z)

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File Edit Data Analysis Macros Windows Graph Misc Help



Full width at half maximum : Γ_{FWHM}
Standard deviation : $\sigma = \Gamma_{FWHM}/3.54$

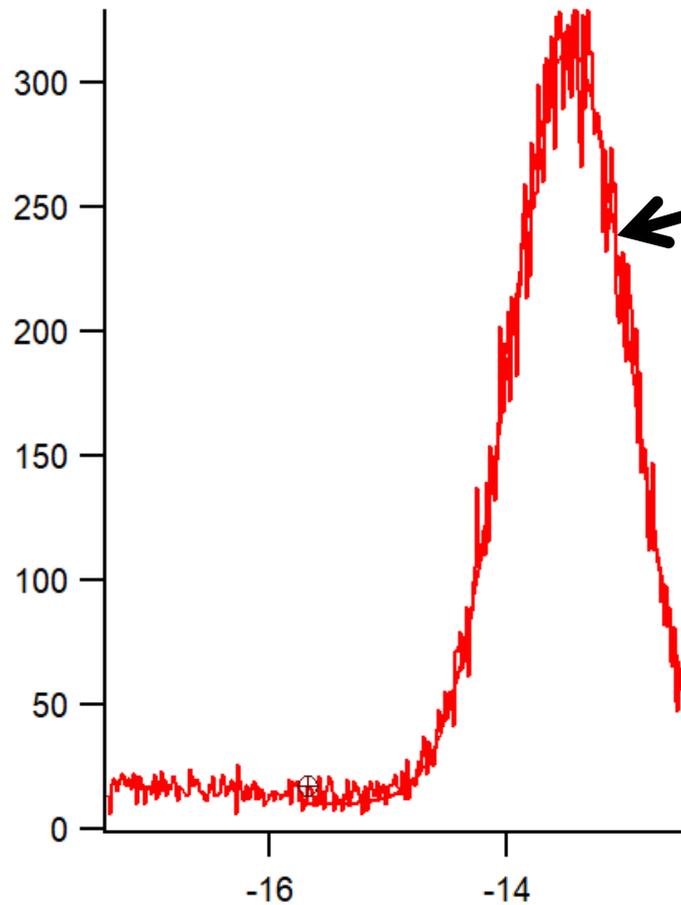
Analysis-Gauss Fit to Data

Na-22 spectrum, 511-keV γ line

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File Edit Data Analysis Macros Windows Graph Misc Help

Graph0:NaINa22_Hist,fit_NaINa22_Hist



Right-click on histogram, select

- Browse fit_NaINa22_Hist...
- Edit fit_NaINa22_Hist**
- Remove fit_NaINa22_Hist
- Duplicate Trace
- Replace Wave...
- Copy Display Command
- Modify fit_NaINa22_Hist...**

Modify Trace Appearance

Trace

- NaINa22_Hist
- fit_NaINa22_Hist**

Mode: Lines between points

Color: [Black]

Line Size: **400**

Style: 0

Grouping: None

Error bars... Gaps

Offset...

ModifyGraph lsize(fit_NaINa22_Hist)=4,rgb(fit_NaINa22_Hist)=(4352,4352,4352)

Do It To Cmd Line To Clip Help Cancel

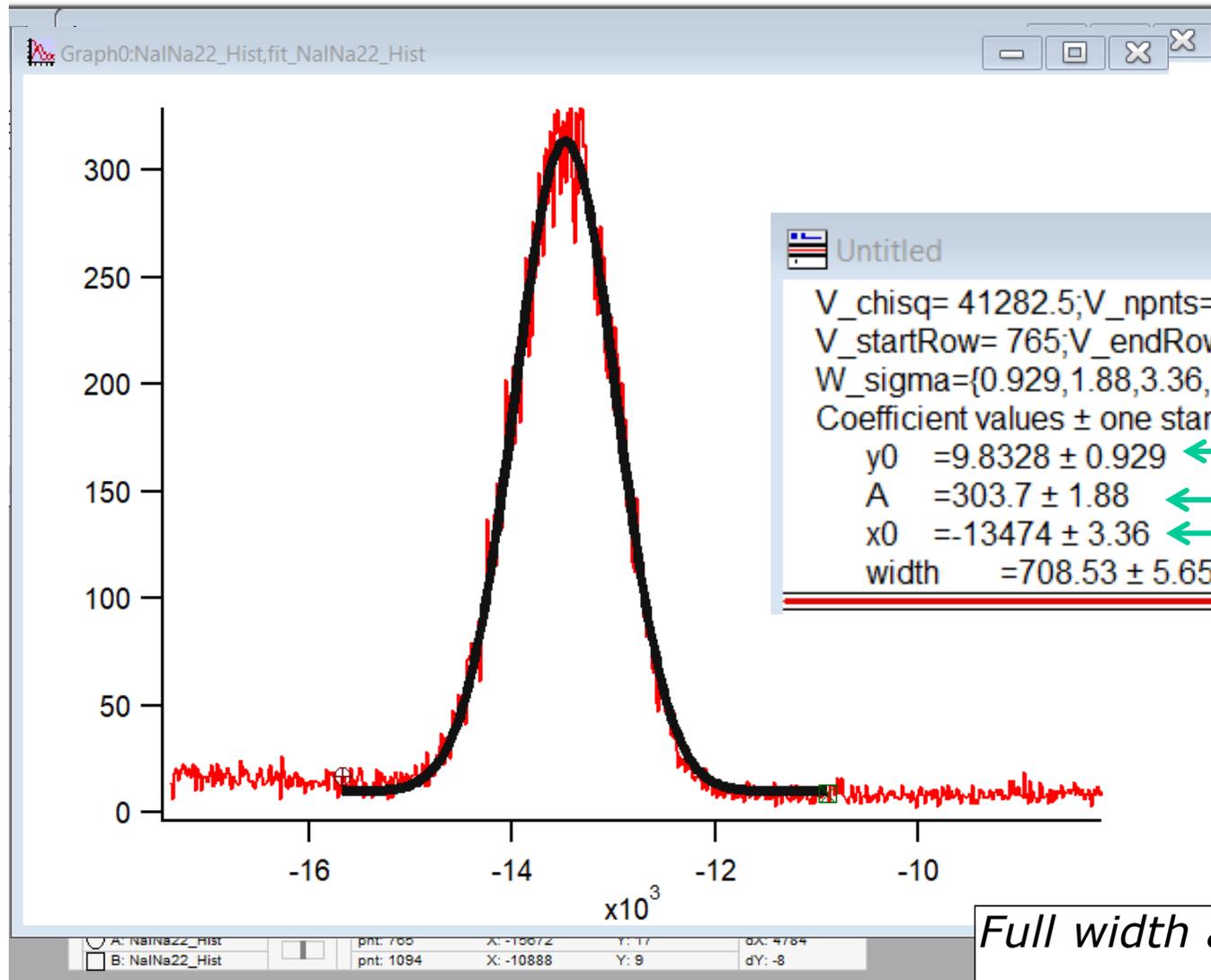
Select width of fit curve

Analysis-Gauss Fit to Data

Na-22 spectrum, 511-keV γ line

Draw rectangle on plot area, expand (back with Ctrl=Z)

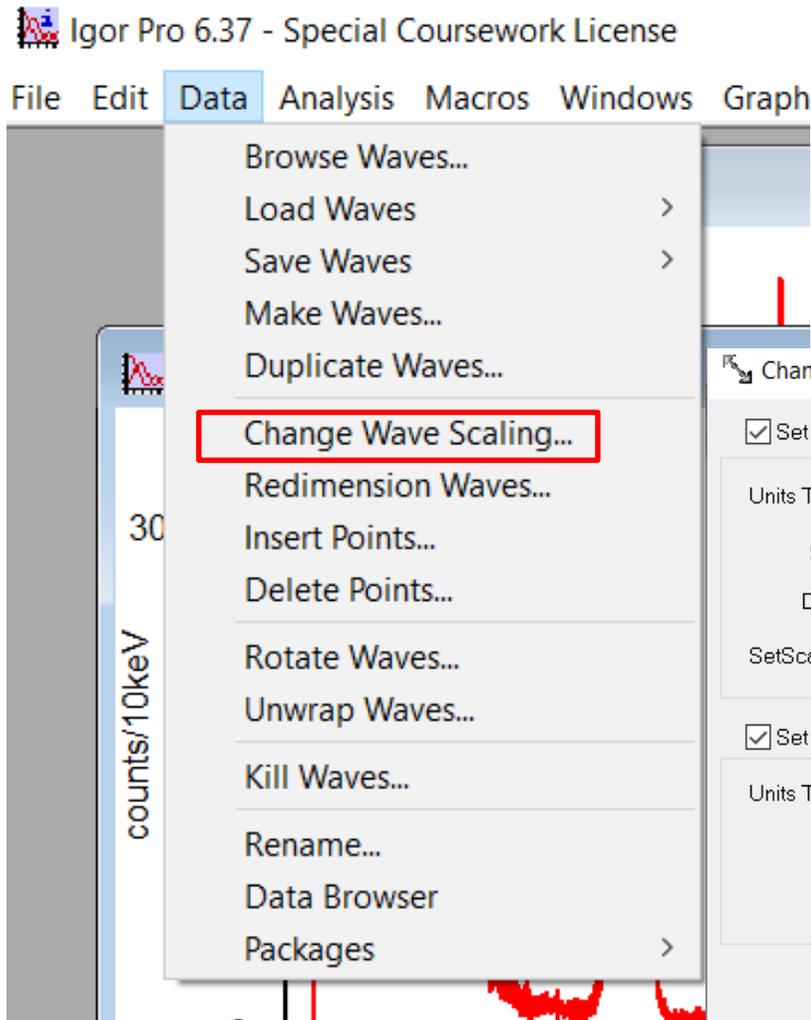
File Edit Data Analysis Macros Windows Graph Misc Help



Full width at half maximum : Γ_{FWHM}
Standard deviation : $\sigma = \Gamma_{FWHM}/3.54$

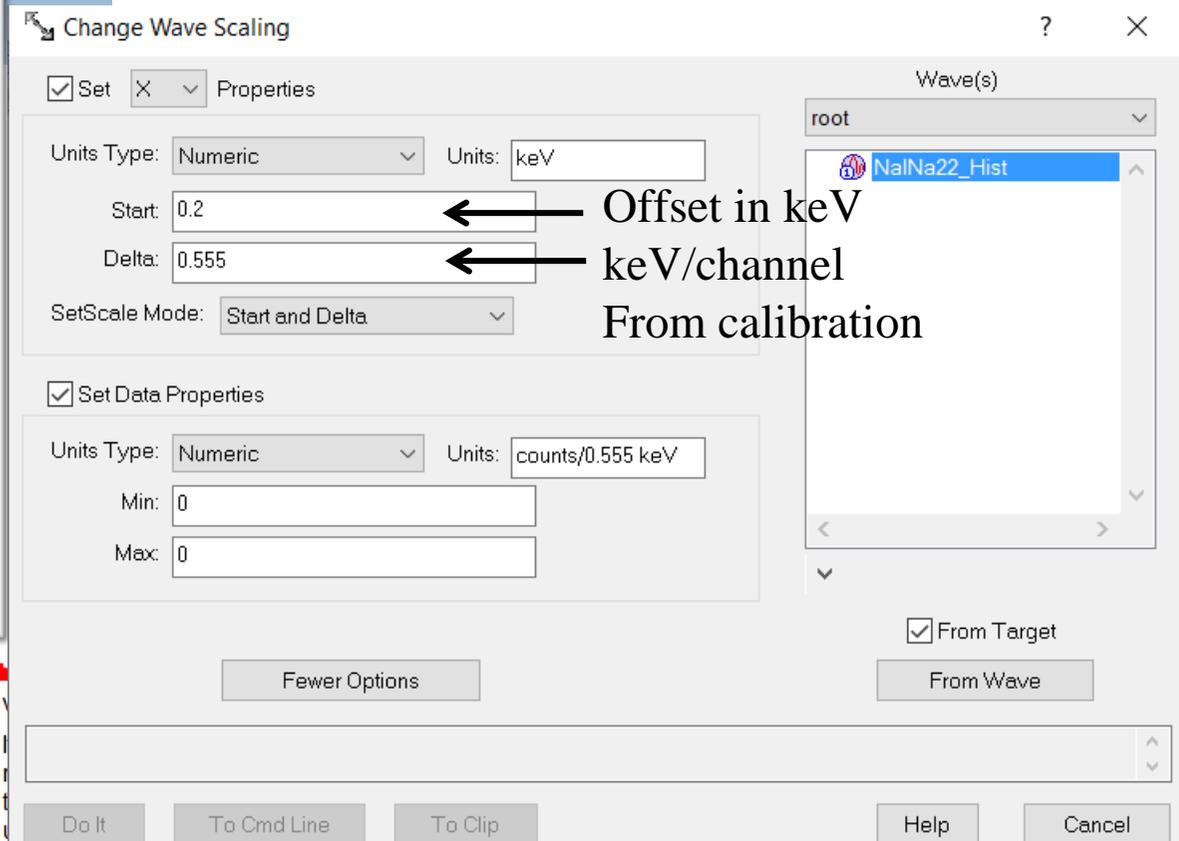
Analysis: Energy Calibrate Data

Na-22 spectrum, 511-keV γ line, following is a rough guess of energy scale of channel#s



Procedure window shows:

```
.SetScale/P*0.2,9,.555,"keV",NaINa22-dupl
```



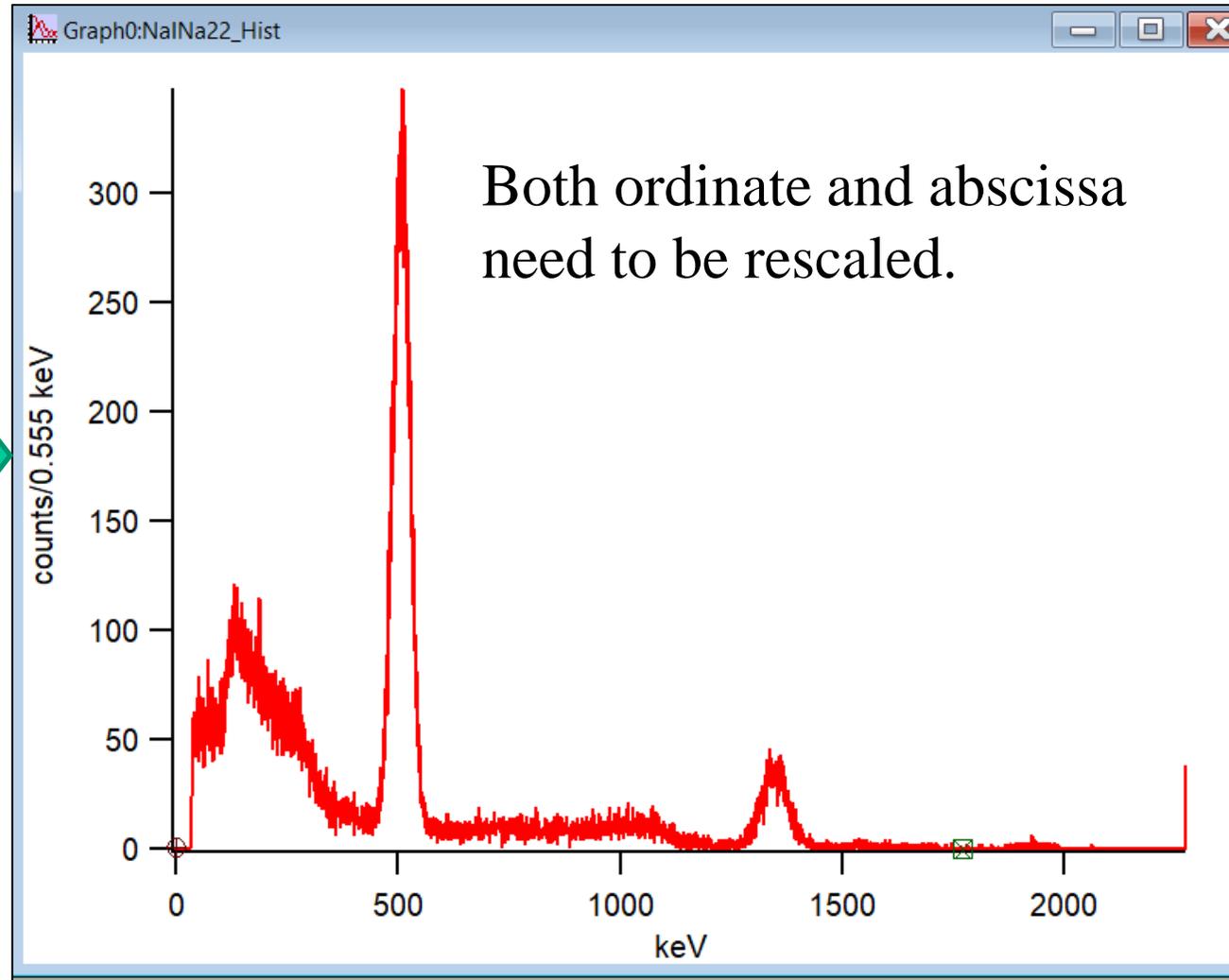
Analysis-Energy Calibrate Data

Na-22 spectrum, 511-keV γ line, following is a rough guess of energy scale of channel#s
1 channel=0.555keV

Number of
counts/channel is
now
counts/(channel
width in units of
keV).



Rescale to
counts/keV !



Changed scale to keV



(γ line is roughly at the correct energy, but not exactly)

User Defined Functions

A user-defined procedure is a routine written in Igor's built-in programming language by entering text in a procedure window. It can call upon built-in or external functions and operations, as well as other user-defined procedures, to manipulate Igor objects. Sets of procedures are stored in procedure files.

Igor uses a combination of the familiar graphical user interface and a command-line interface. This approach gives Igor both ease-of-use and programmability. The job of the user interface is to allow you to apply Igor's operations and functions to objects that you create. You can do this in three ways:

- Via menus and dialogs
- By typing Igor commands directly into the command line
- By writing Igor procedures

User Defined Functions - Example

Type in the procedure window the following:

```
FUNCTION FitGauss (wav, from,to)
VARIABLE from,to
WAVE wav
  CurveFit/Q gauss wav(from,to) /D
  VARIABLE PeakPos, sig, FWHM, PeakArea
  WAVE W_Coef = W_Coef
  PeakPos = W_Coef[2]
  FWHM = W_Coef[3]*2*sqrt(ln(2))
  sig = W_Coef[3] / sqrt(2)
  PRINT " pos, sigma, fwhm =", PeakPos, sig, FWHM, "
  DC pedestal=", W_Woef[0]
END
```

User Defined Gaussian Fit

- After compiling the user defined function, you can again place the cursers in the peak range you want to fit.
- Type "FitGauss (name of the fitted wave, xcsr(A), xcsr(B))" in the command bar in the command window.
- After you press enter the command window will process the fit and give you the position of the peak (pos), the width of the peak (sigma) and the full width at half maximum (FWHM).
- The user and create all sorts of function to assist him or hers analysis such as multiple gaussian fits, linear fits and more.