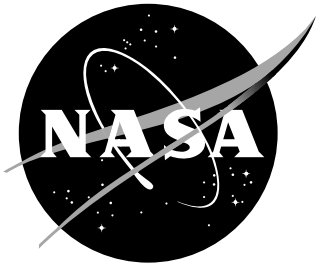
NASA/TM–2019–220395



NtGCM User's Manual: 1.1

(High Pressure High Temperature Laser based) Nanotube Growth Chamber Monitor

Godfrey Sauti, Cheol Park, Joseph W. Lee, Hoa H. Luong
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August 2019

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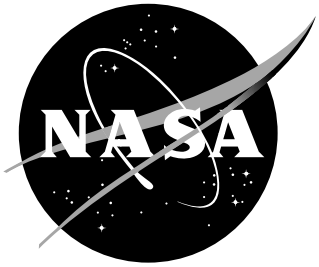

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Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

August 2019

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NtGCM utilizes modules from the GS Toolkit (GSTK) and CB Toolkit (CBTK). The GSTK was developed and is maintained by Godfrey Sauti. The CBTK was developed by Cameron Butler and Godfrey Sauti and is maintained by Godfrey Sauti. NtGCM software was developed and is maintained by Godfrey Sauti.

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Abstract

This manual describes the installation and use of NtGCM software. NtGCM is software designed for monitoring the growth of nanotubes in a high temperature and high pressure chamber using a laser*. NtGCM software monitors a dozen different parameters that are important to understanding the growth of the nanomaterials including the laser input power, the temperature at eight separate locations inside and outside the growth chamber, as well as the pressure and flow rate of the gaseous media that control the environment in the chamber. The measurements are all made in real time. The program features a robust user account management layer and a rich data display manager that allows plotted data, displayed units and other parameters to be changed on the fly for the operator's convenience.

*For more details on nanotube growth using lasers see for example M. W. Smith, K. C. Jordan, C. Park, J.-W. Kim, P. T. Lillehei, R. Crooks, J. S. Harrison, "Very long single- and few-walled boron nitride nanotubes via the pressurized vapor/condenser method" Nanotechnology **20** 505604 (2009).

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Contents

1 About this document

This manual is intended primarily to help guide the user through installation and running of the software described. In addition to helping an existing user to be able to more effectively utilize the software, this manual also provides an avenue for a potential new user to understand the capabilities of the software. Finally, the software described is built in a modular manner, with common tasks such as the graphing of data and user management handled by dedicated modules that can be inserted into a new project. This manual also provides program developers an application example demonstrating the use of these modules for possible integration into their work.

1.1 Disclaimer

While every effort has been made to ensure the smooth operation of the software and accuracy of this manual, it must be noted that the program is intended to be used for research purposes only. The authors, developer, copyright holders and/or other parties provide the program and this manual "AS IS" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of fitness for a particular purpose. The developer also offer no warranty that the data format of future versions of the program will be compatible with that of this development version. The entire risk as to the quality and performance of the program and the security of data rests with the user. Any suggestions on improvements to the program or this manual may be communicated to the developer for consideration. The modules that carry out data management, user account management and other tasks in this software are available from the developer upon request.

2 Getting started

2.1 Terminology and notation

Back to the table of contents

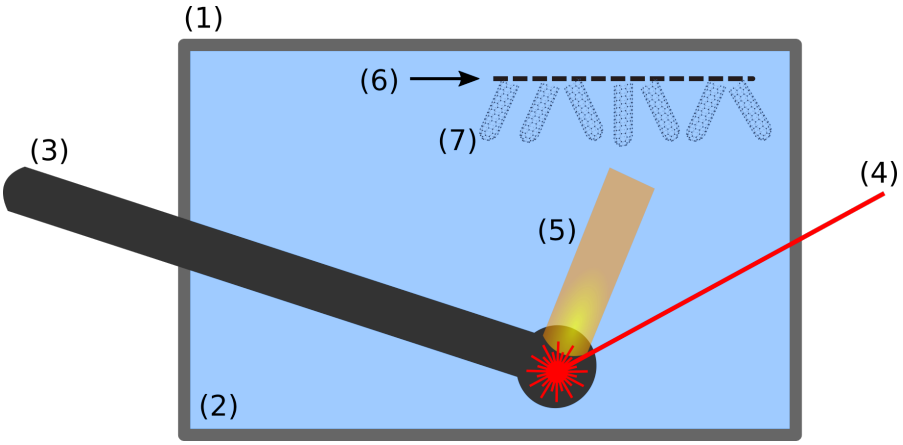


Figure 1: A highly simplified schematic of the high pressure high temperature growth of boron nitride nanotubes using a laser. The components labeled in the schematic are described in the text.

Figure 1 shows a highly simplified schematic of the high temperature high pressure laser growth of boron nitride nanotubes. The schematic is aimed only at helping understand the terminology used in this manual. For a fuller description of the growth process, the reader is referred to Smith et al. [1] The elements of the growth system are:

1. High pressure chamber
2. A gaseous medium that includes nitrogen or nitrogen containing compounds
3. A feedstock containing boron
4. The laser which heats up and vaporizes the feedstock
5. A plume in which elemental boron reacts with nitrogen
6. A condensation/collector mesh
7. Nanotubes accumulating on the collector mesh

In this manual, the terms *measurement*, *monitoring* and *test* will be used interchangeably to refer to an instance when nanotubes are being grown in the pressure chamber and  is tracking and recording one or more processing variables. Note also the use of *timestamp/Timestamp* and *Time Stamp* when referring to time signatures that are included in the measurement data. Whenever possible the single word *timestamp* will be used in the text but *Time Stamp* may also be used when there

[1] M. W. Smith, K. C. Jordan, C. Park, J.-W. Kim, P. T. Lillehei, R. Crooks, J. S. Harrison, "Very long single- and few-walled boron nitride nanotubes via the pressurized vapor/condenser method" Nanotechnology **20** 505604 (2009).

is a need for consistency with the notation utilized in the program code. Section, subsection and description headers will be in normal case except for cases where the header refers to a named application window or function. In that case, first letter capitalization may be used.

Note: While the information displayed in the screenshots from running instances of the application is only meant as an illustration to the user of the program features and is scaled to fit the page layout, in the electronic version of this document, it is possible to zoom in to that sample content for a closer look.

2.2 Requirements

Back to the table of contents

- **Minimum (tested) hardware**
  Pentium III/Celeron 866 MHz or higher; 256 MB RAM; 700 MB disk space
- **Operating System**
  Microsoft Windows XP and above. Tested on MS Windows XP, 7 and 8.
- **National Instruments (NI) LabVIEW Run-Time Engine**
  On computers that do not have a working installation of NI LabVIEW, NtGCM requires the installation of the NI Run-Time environment. Use Run-Time engine 2013 or newer. The 32 and 64 bit Windows Run-Time engines for LabVIEW 2014 may be obtained from National Instruments
  http://www.ni.com/download/labview-run-time-engine-2014/4887/en/ and
  http://www.ni.com/download/labview-run-time-engine-2014/4889/en/.
- **Measurement Computing (MC) DAQ Drivers & *Insta*Cal**
  NtGCM requires the installation of Measurement Computing drivers for the USB-TC thermocouple DAQ. The selection of the thermocouple to be used can only be done in Measurement Computing ***Insta*Cal** software. The thermocouple selection in NtGCM is only to ensure that the correct description is included in the measurement data files. NtGCM **DOES NOT CONFIGURE THE THERMOCOUPLE.**
  Measurement Computing software may be obtained from www.mccdaq.com.
- **Instrument settings file**
  Instrument settings are read from `NtGCM_Instrument_Settings.cfg` which must be in the NtGCM installation folder.
- **Notepad**
  In order to be able access the read-only views of the Logbook, (program) Error Log, Measurement Log and Messages Log, a text editor such as MS Notepad must be installed on the computer running NtGCM.
- **Adobe Reader**
  To access NtGCM (*.pdf) help files, Adobe Reader should be installed. Adobe Reader can be obtained from www.adobe.com.
- **Image viewer**
  To view the screen shots generated by NtGCM a photo browser that displays *.png image files must be installed.

While every effort has been made to test functionality of 3rd *party tools, the final responsibility for compatibility of third party software settings and* NtGCM *rests with the user.*

3 NtGCM overview

3.1 Start up

Back to the table of contents

On starting up,  loads a number of settings from configuration files located in the installation directory and the application directory (Fig. 2). The location of these files, on a particular host system, is determined at installation time by the software. The settings in the files include information that the application will need to communicate with instruments as well as details on the currently registered users. If no file with user settings is found, it will be assumed that this is the first running of the software on a particular host and therefore a new one will be created.

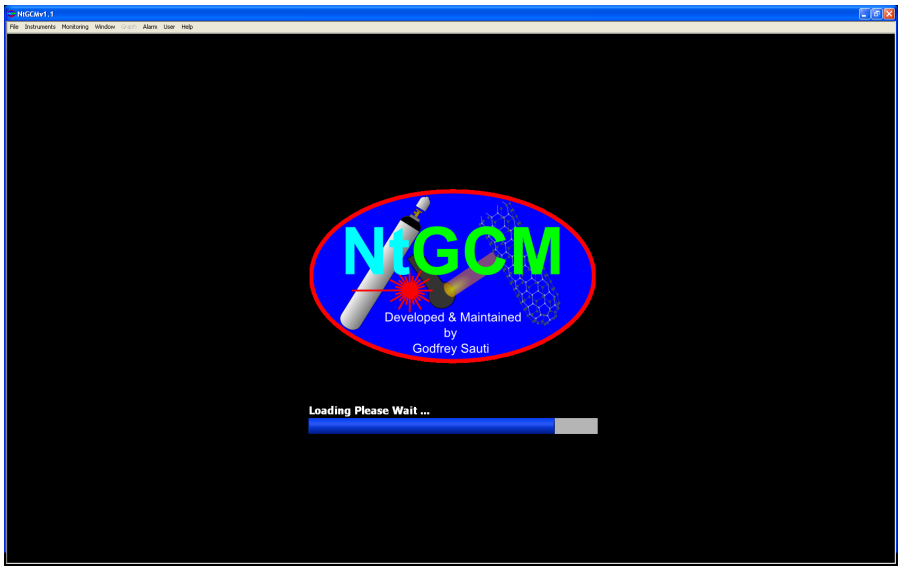


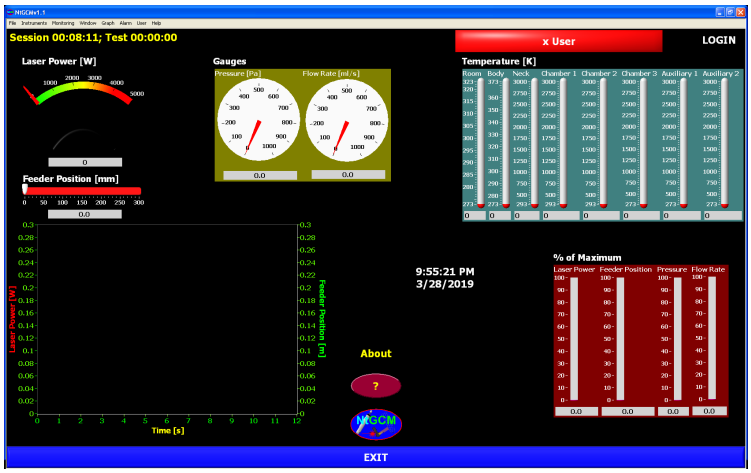
Figure 2: **NtGCM** loads settings from configuration files located in the installation directory as well as the application directory. These settings include instrument configurations and information on the registered users.

(a) Start up screen when no users registered (LOGIN button disabled)

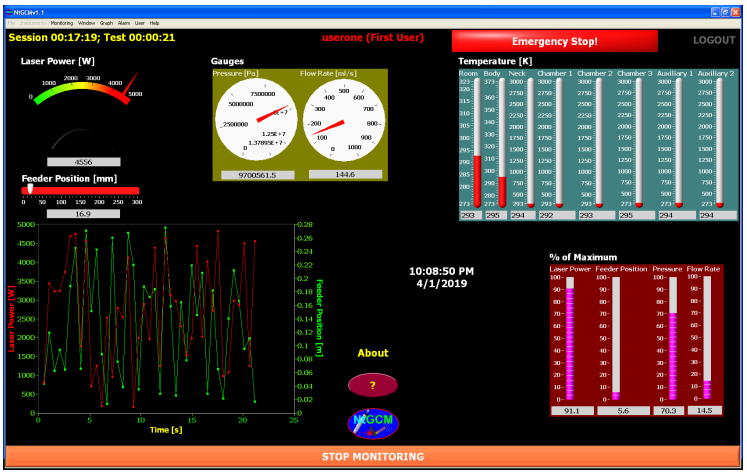
(b) One or more users registered (LOGIN button enabled)

Figure 3: The windows that display when **NtGCM** launches

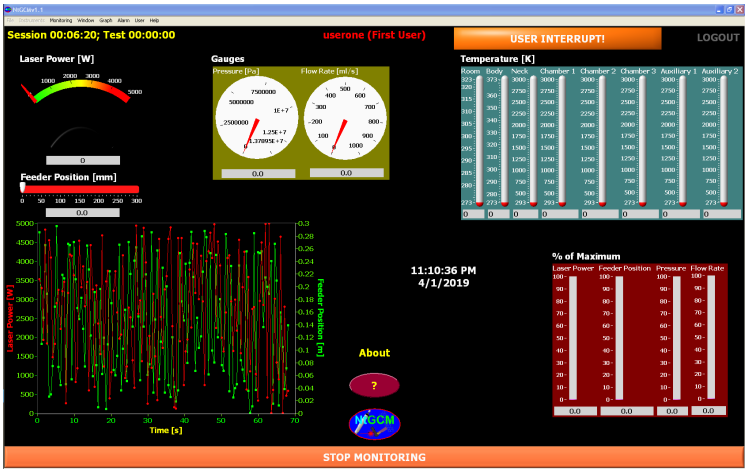
Figures 3 and 4 show some screenshots. Figure 3 shows the startup screen before (3(a)) and after (3(b)) the first user has been registered (user administration will be discussed in more detail in Section 5). Figure 4 shows the **Primary Measurement Window** which is described in detail in Section 4.3.1.



(a) Before measurement



(b) Measurement running



(c) Measurement stopped

Figure 4: The **Primary Measurement Window** (a) before, (b) during and (c) after a measurement

Features of the program include:

1. **The big picture**
   (a) is intended to make the user experience in setting up and running of the measurement the same irrespective of the instruments in use. The user only deals with one interface and the program handles instrument specific settings.
   (b) monitors/can monitor and record (depending on the physical hardware present and user settings) the variables listed below with their (typically SI) units:
      i. Time [s] (From the start of the measurement to when the data point is captured)
      ii. Timestamp (Recorded internally as the time in seconds since 01/01/1904 00:00:00.00 UTC)
      iii. Laser power [W]
      iv. (Boron feedstock) Feeder position [m]
      v. (Chamber gas) Pressure [Pa]
      vi. (Gas) Flow rate [m^3/s]
      vii. 8 Temperatures:
         A. Room
         B. Chamber neck
         C. Chamber wall
         D. Interior of chamber location 1
         E. Interior of chamber location 2
         F. Interior of chamber location 3
         G. A temperature at a location that is specified by the user in the test notes
         H. Another temperature at a location that is specified by the user in the test notes
      viii. (Boron source) Feed rate (Change in feeder position divided by elapsed time) [m/s]
      ix. Proportional Indicators [%]:
      These record certain values in proportion to some predefined maxima (typically device/safety limits). The values recorded are...
         A. Laser power
         B. Feeder position
         C. (Chamber) pressure
         D. (Gas) flow rate
2. **User management**
   (a) features a **User Manager** to control access to experiment settings
   (b) The **User Manager** allows different measurement settings and preferences to be saved for each authorized user. These settings are loaded whenever the associated user logs in.
   (c) User account types are:

Standard user Can carry out measurements but not add or remove users

Advanced user Can carry out measurements, and add but not remove users

Administrator Can carry out measurements and add or remove users

(d) The **User Manager** features a logbook that registers various events including user login/logout and the start of measurements. User comments can also be entered into the logbook. All users are able to open a read-only snapshot of the logbook. Snapshots of the logbook are compressed and archived periodically (automatically or at the user's request).

3. **Instruments**
   (a) offers of a choice of suitable instruments for each measurement. The user must ensure that the instruments chosen to run the measurement are correctly connected and configured. The program then handles communicating with the instruments and using them during testing.
   (b) Instrument settings are read from the file `NtGCM_Instrument_Settings.cfg` which must always be available in the parent directory.
4. **Measurement files**
   (a) All filenames are specified before the start of a test, allowing the program to save each data point immediately upon measurement. This prevents the loss of data should anything interrupt the system during a measurement.
   (b) The program can automatically generate unique filenames that are timestamped. This is convenient when the user needs to set up a measurement quickly. It is however highly recommended that files be given more descriptive names or easy future reference.
5. **Setting up and running a measurement**
   (a) will not start a test until various critical settings have been configured. A test status display guides the user in identifying any outstanding issues.
   (b) The program also selectively enables and disables access to menu items to guide the user in setting up measurements or otherwise using the application. Only those menu functions that are compatible with the current settings or are appropriate for the current stage in the set up process are enabled.
   (c) A test profile feature allows the user to preview and verify the parameters of a test before it is run. A clock counts from the start of a test, allowing the user to keep track of its progress.
   (d) Various warnings and alarms may be set up to alert the user of special conditions during a measurement. Alarms and warnings

can be set for the following variables:

i. Laser power
ii. Feeder position
iii. Pressure
iv. Flow rate
v. All temperatures except room temperature
vi. Feed rate

Conditions that can trigger an alarm/warning include:

- Value rises above a set limit
- Value drops below a set limit
- Value drops a by a certain (user entered) (%)
- The value of a continuously monitored variable drops a user defined (%) below the maximum measured value. This is achieved by continuously recalculating the maximum as data is monitored.

Additional settings are available but will most likely not be very relevant in the usage of  .

6. **Graph and front panel controls**
   (a) The user may change any graph or front panel controls even when a measurement is running
   (b) The user can display the data in any appropriate units that they are comfortable with
   (c) The analysis graphs allow for the overlay of multiple measurements
   (d) The graphs allow the user to place the legend information in an unobtrusive location
   (e) Menu and mouse access to various features
   (f) At any time, a user may take a snapshot of a graph window or the front panel controls. The *.png image file generated is automatically named (including date and time) and stored in the user's working directory.
7. **Help**
   (a) Multiple help files including instrument manuals and this manual are available within the program in *.pdf format and accessible through the menu or front panel controls.

The above and other features will be described in more detail in the remainder of this manual.

3.2 Accessing help

Back to the table of contents

features a number of help tools that can be accessed though the front panel controls or from the main menu. Included in the help section is information about the program, this manual as well as the manuals of the instruments that can control (Fig. 5).

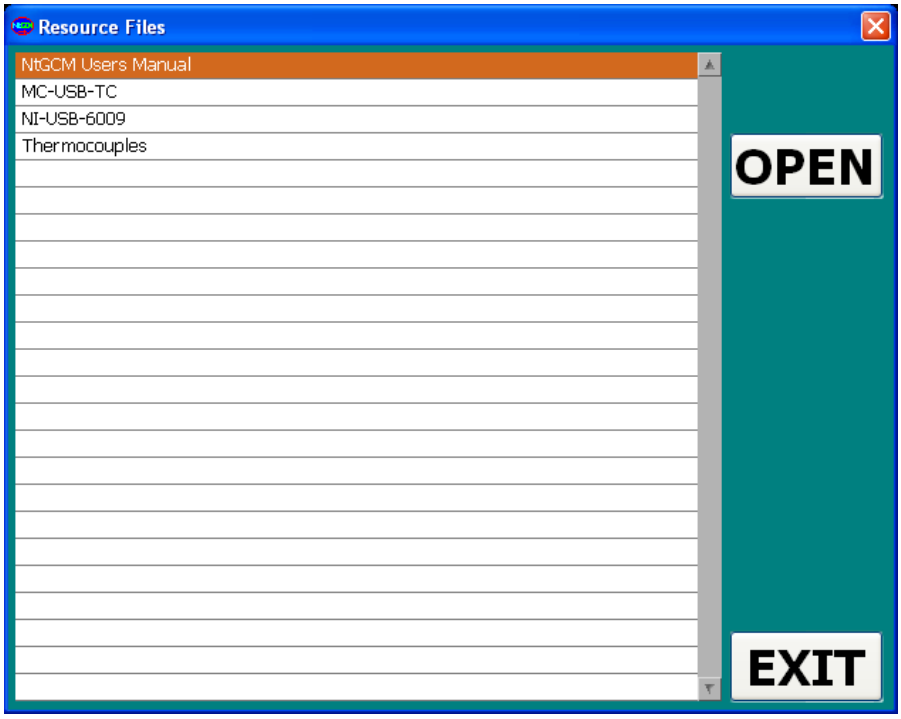


Figure 5: A list of the all the help files accessible through **NtGCM**. These files can be opened by the system's *.pdf reader.

3.3 NtGCM files

Back to the table of contents

During measurements, data is written to three files. The Measurement Data File (*.res) contains all information about the measurement. This data is structured for read-back by the program but is in a format that is human readable. A select set of data is written to the Measurement Log (*.log) which contains tabular text. Messages generated by the program during the measurement are written, in plain text, to the measurement Messages Log (*.msg). Note that the program starts to write to the messages log as soon as a new filename is entered and not at the start of the measurement. This allows for messages that may come up during measurement set up or between measurements to also be recorded. These messages could be useful in troubleshooting.

4 The user interface

4.1 Front panel controls

Back to the table of contents

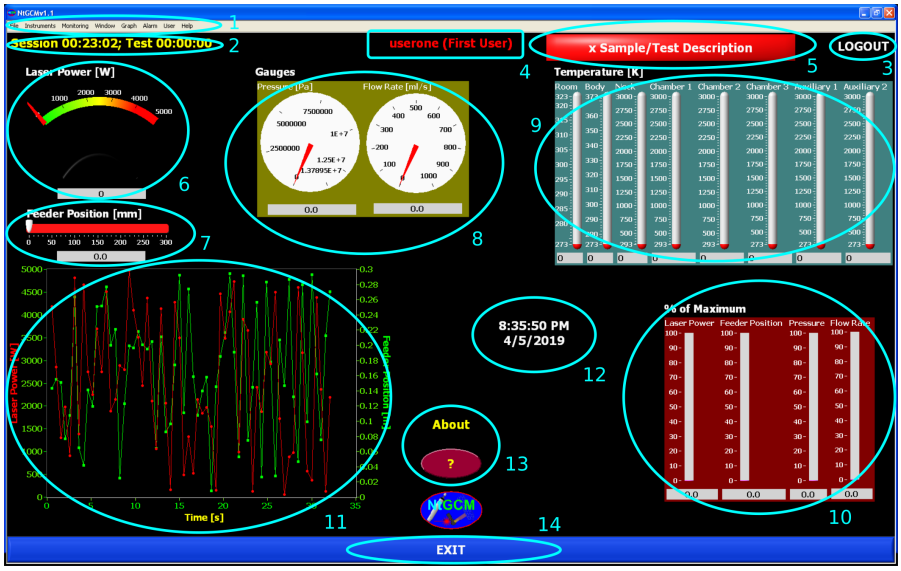


Figure 6: Controls and indicators in the **Primary Measurement Window**

Below is a description of the controls and indicators in the **Primary Measurement Window**. Note that in NIGCM notation **Primary Measurement Window** actually refers to the graph (11) in Fig. 6. In this manual, **Primary Measurement Window** will be used to refer both to the graph as well as to the full front panel featuring the graph and the additional controls depending on the context.

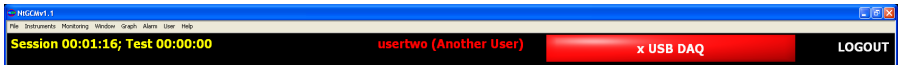
1. **Main menu**: This is where most user actions and measurement setup will occur. Some but not all of the menu actions are mirrored with controls on the front panel. The menu will be discussed in detail in Section 4.2.
2. **Clocks**: The clocks are the pulse of the system. The **session timer** shows how much time has passed since the currently running instance of the program was started. Any internal error state that may freeze the operation of the program's measurement engine is often first seen by a stopping of this timer. The **test timer** starts counting once a measurement begins. This clock will continue to update periodically until the measurement is completed.
3. LOGIN/LOGOUT: User login and logout button.
4. **Logged in user name**: Name of the currently logged in user.
5. Test Readiness Indicator: This indicator shows whether or not the minimum setup to start a measurement has been met. If not,

it indicates, sequentially, the settings that need to be addressed before the start of a measurement. Additional states of the Test Readiness Indicator are shown in Fig. 7.

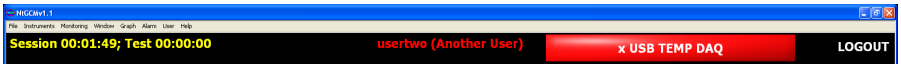
6. **Laser power**: Laser power indicator.
7. **Feeder position**: Feedstock position indicator.
8. **Pressure and flow rate**: Chamber pressure and gas flow rate indicators.
9. **Temperature**: Temperature indicators for various zones inside and outside of the pressure chamber.
10. **Proportional indicators**: This shows a selection of the variables compared to some preset maxima. The maximum values of the variables are set in the instrument configuration file `NtGCM_Instrument_Settings.cfg`
11. **Primary Measurement Window** (Graph): This is one of three graph windows generated by . Data from the running measurement is shown in this window. The plotted quantities and their units can be changed at any time during or after the measurement. The other two graph windows are the **Auxiliary Measurement Window** and **Analysis (2D) Window** which are full screen windows.
12. **Clock**: This shows the current date and time as reported by the Operating System (OS). The clock's timestamp will be added to the measurement data recorded by to help synchronize with measurements from other instruments that are not being read through . This assumes that these measurements are on the same computer or one whose time has been synced with that running . If the timestamp is incorrect, this can be fixed by adjusting the system time using the OS's clock tools.
13. **About** and **?**: Quick access to the help items.
14. EXIT / STOP MONITORING button: This provides another option for stopping a measurement or exiting the program. When a measurement is running, this button transforms to a STOP MONITORING button. The measurement *must* be in the stopped state before exiting the program. During a measurement, the Test Readiness indicator becomes the Emergency Stop! button. This provides yet another way to quickly stop the measurement while ensuring that measurement files are properly terminated and communications with instruments safely closed.

(a) No users registered

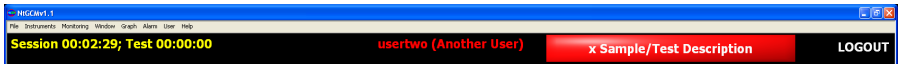
(b) No user logged in



(c) Primary DAQ not selected

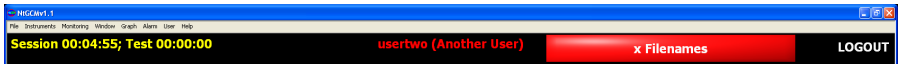


(d) Temperature monitor no selected



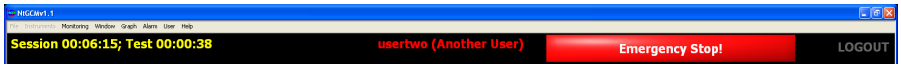
(e) Invalid test description

(f) Invalid test environment



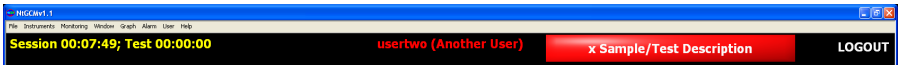
(g) Measurement filenames not set

(h) Measurement ready to start



(i) Measurement running

(j) Measurement stopped by user



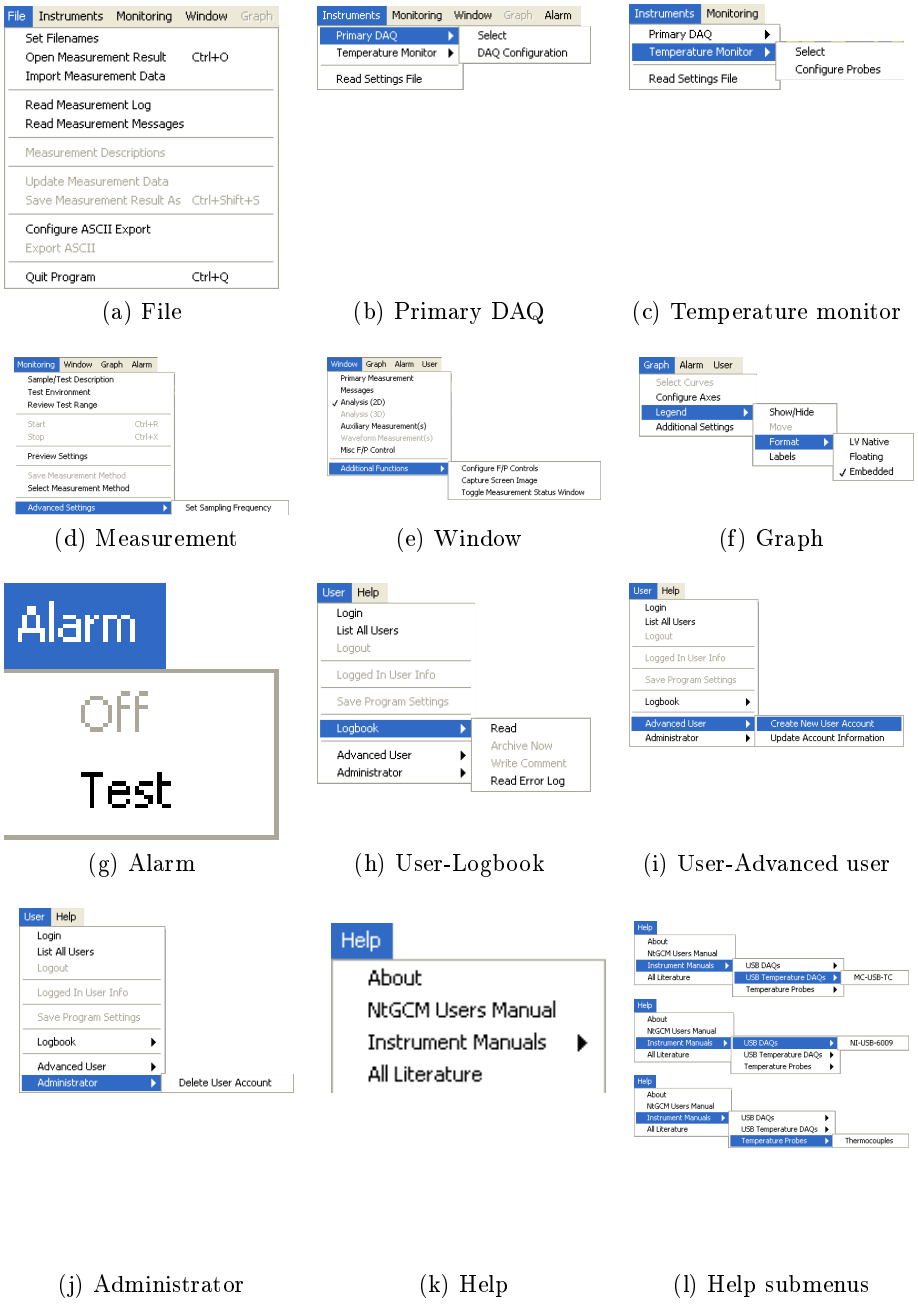
(k) Post measurement (waiting for setup of the next measurement)

Figure 7: **NtGCM** guides the user through the steps of setting up and running a measurement through the Test Readiness Indicator

4.2 The main menu

Back to the table of contents

Fig. 8 shows the menu.



(a) File (b) Primary DAQ (c) Temperature monitor

(d) Measurement (e) Window (f) Graph

(g) Alarm (h) User-Logbook (i) User-Advanced user

(j) Administrator (k) Help (l) Help submenus

Figure 8: The **NtGCM** menu

A full listing of the menu items is shown below:

1. **File**
   - Set Filenames
   - Open Measurement Result (Ctrl+O)
   - Import Measurement Data
   - Read Measurement Log
   - Read Measurement Messages
   - Measurement Descriptions
   - Update Measurement Data
   - Save Measurement Result As (Ctrl+Shift+S)
   - Configure ASCII Export
   - Export ASCII
   - Quit Program (Ctrl+Q)
2. **Instruments**
   - Primary DAQ
     - Select
     - DAQ Configuration
   - Temperature Monitor
     - Select
     - Configure Probes
   - Read Settings File
3. **Monitoring**
   - Sample/Test Description
   - Test Environment
   - Review Test Range
   - Start (Ctrl+R)
   - Stop (Ctrl+X)
   - Preview Settings
   - Save Measurement Method
   - Select Measurement Method
   - Advanced Settings
     - Set Sampling Frequency
4. **Window**
   - Primary Measurement
   - Auxiliary Measurement
   - Messages
   - Analysis (2D)
   - Analysis (3D) (Disabled)
   - Misc F/P Control
   - Additional Functions
     - Configure F/P Controls
     - Capture Screen Image
     - Toggle Measurement Status Window
5. **Graph**
   - Select Curves
   - Configure Axes
   - Legend
     - Show/Hide
     - Move
     - Format
       - LV Native
       - Floating
       - Embedded
     - Labels
   - Additional Settings
6. **Alarm**
   - Off
   - Test
7. **User**
   - Login
   - List All Users
   - Logout
   - Logged In User Info
   - Save Program Settings
   - Logbook
     - Read
     - Archive Now
     - Write Comment
     - Read Error Log
   - Advanced User
     - Create New User Account
     - Update Account Information
   - Administrator
     - Delete User Account
8. **Help**
   - About
   - NtGCM Users Manual
   - Instrument Manuals
     - Primary DAQ
       - NI-USB-6009
     - USB Temperature DAQs
       - MC-USB-TC
   - All Literature

4.3 Graph and Messages windows

Back to the table of contents

A variety of plotting options, for the data collected, are available through the window and graph menus. At any point during or after a measurement, the plotted quantities, for the currently running or loaded measurements, may be changed by selecting Graph→Configure Axes from the menu. The interface for doing so will be covered after the descriptions for each of the available plotting windows.

4.3.1 Primary Measurement Window (Graph)

In NIGCM the **Primary Measurement Window** (Fig. 9) consists of a graph also known as the **Primary Measurement Window** as well as some additional numerical indicators. The most recently collected measurement data in the current session will be displayed in the **Primary Measurement Window** graph and those indicators. During a measurement, this graph and the indicators will update as data points are collected.

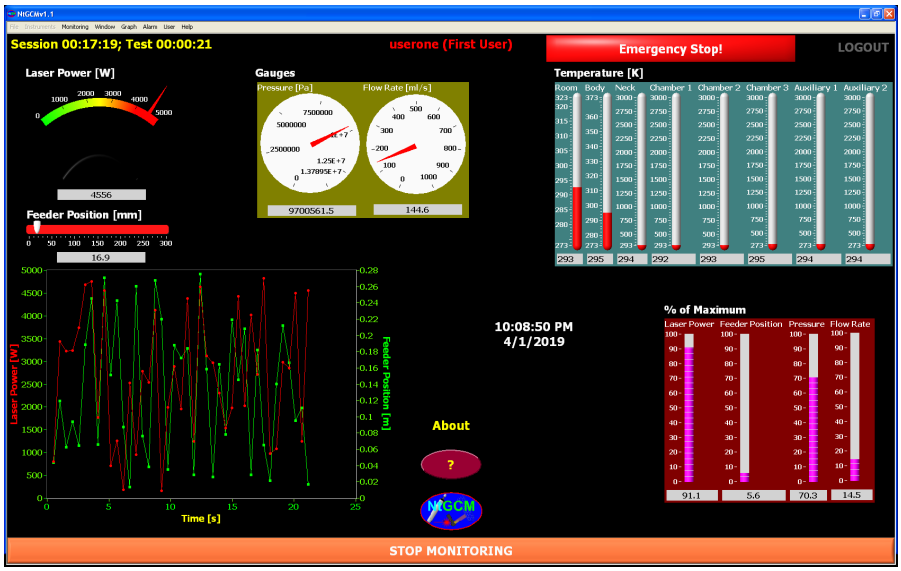
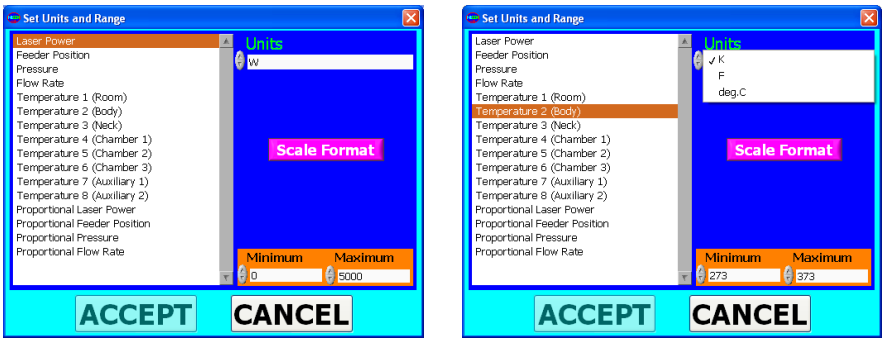


Figure 9: The **Primary Measurement Window** when a measurement is running

4.3.2 Configuring the front panel indicators

The display units and range of the front panel controls can be changed by double-clicking on any one of these controls. The dialog shown in Fig. 10 is brought up. Note that while the range of each of the temperature controls can be set in any units that the user is comfortable with in the setup dialog, all the temperatures will be displayed to the units selected for the first (RT) indicator. The units being used are included as part of the control caption as shown in Fig. 11. All the other ranges will be automatically converted to the units of the first control.



(a) Front panel control units (b) Options are available for the units

Figure 10: Setting the units and display ranges of the front panel controls

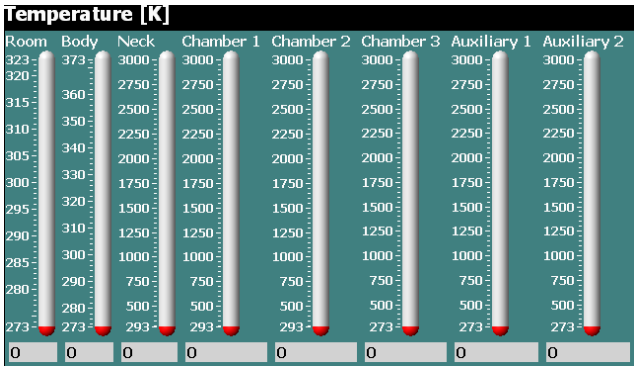


Figure 11: Note that *all* the temperature controls will display values to the units selected for the first control (**Room** temperature). Individual ranges can be set for the different indicators.

4.3.3 Messages window

Clicking Window→Messages in the menu heading will cause the screen in Fig. 12 to appear.

This **Measurement Messages Window** displays certain measurement related messages. These include the time at which a measurement starts or ends, information on the measurement settings and the status of communications with the instruments. When troubleshooting any measurement anomaly, this should be the first place to look. The information displayed in the **Measurement Messages Window** is written to the Messages Log file. Note that writing to a Messages Log starts (and ends) when a new filename is entered and so the messages recorded will include information generated at set up time before a measurement or after one has finished.

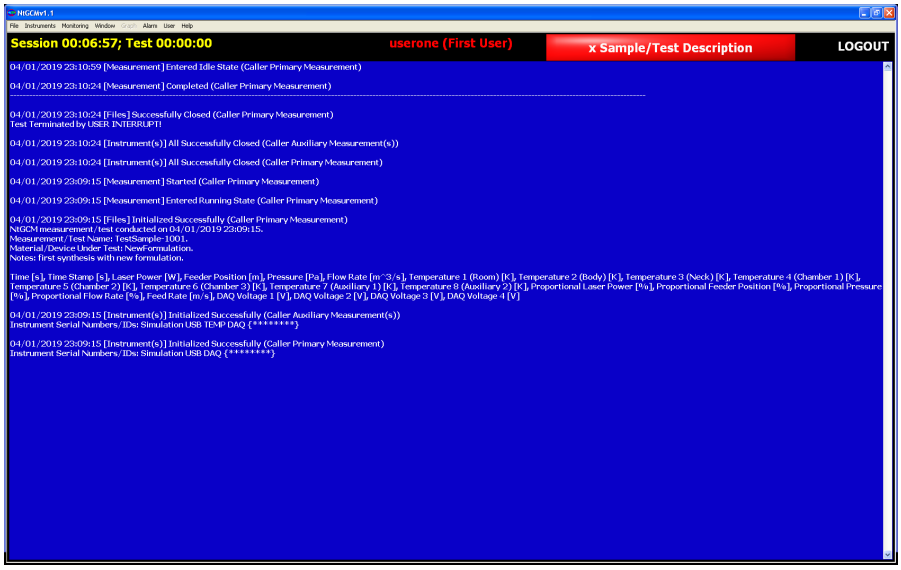
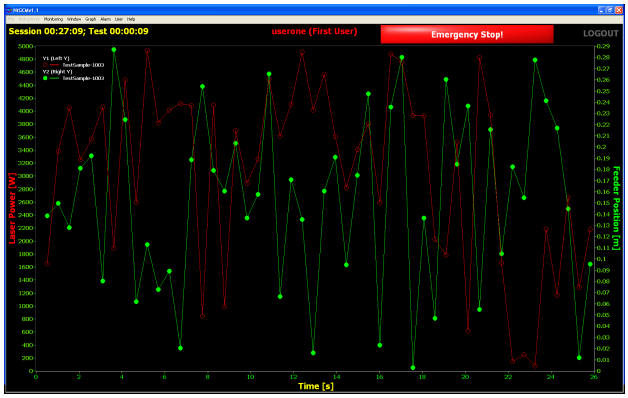


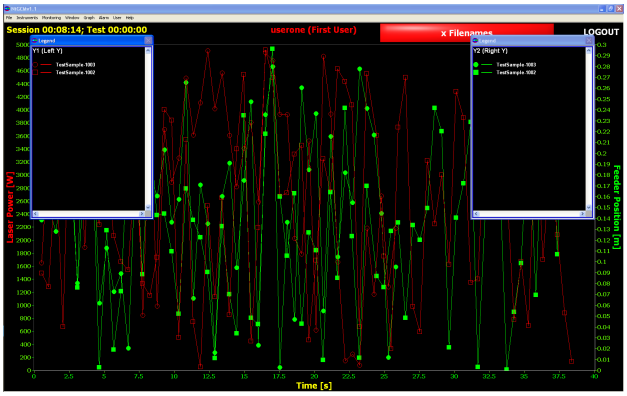
Figure 12: The **Measurement Messages Window** showing a snapshot of typical messages displayed during a run. These messages will change depending on the communications between the program and the instruments. **Note: In the electronic version of this manual, it is possible to zoom in and read the messages displayed in this test instance.**

4.3.4 Auxiliary Measurement Window

The measurement data can also be plotted on a full screen graph in the **Auxiliary Measurement Window** (Fig. 13). As with the **Primary Measurement Window**, the data will be plotted in real-time as it is acquired. By default, the **Auxiliary Measurement Window** automatically loads the first measurement in the session. If there are additional measurements, those will need to be selected for plotting in the **Auxiliary Measurement Window**. If the currently running measurement is one of those selected for display then the data is updated automatically. The **Auxiliary Measurement Window** supports plotting multiple curves and so the currently running measurement as well as any loaded measurement results can be plotted together. Information on the plots is provided through legends that can be displayed in various formats.



(a) Single curve ("embedded" legend)



(b) Multiple curves ("floating" legend)

Figure 13: Data plotted in the **Auxiliary Measurement Window**. If the current measurement is one of the selected plots in the **Auxiliary Measurement Window** then the data is updated as the measurement runs. The **Auxiliary Measurement Window** allows stacking of multiple plots (b) so measured results from different runs can be compared. Various legend formats are supported.

4.3.5 2D analysis graph window

In this window, users may plot results from multiple measurements for comparison and any additional analysis (Fig. 14). The user must have collected, opened or imported at least one set of data during the current session. Procedures for opening and importing data are covered in Section 8. Once there is data available to the **Analysis (2D) Window**, the user may use Graph→Select Curves to select which curves to display from the available data (Section 4.3.8).

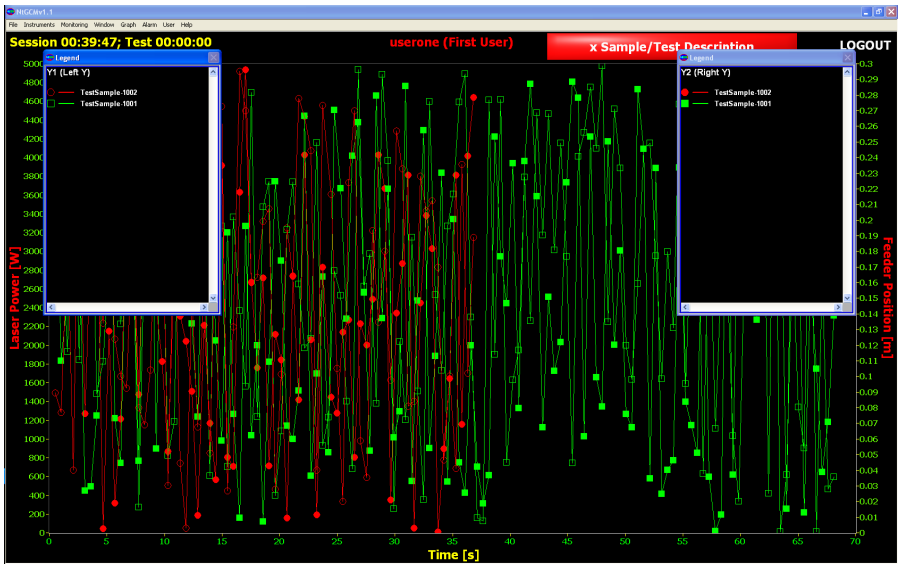


Figure 14: The **Analysis (2D) Window** showing multiple plots

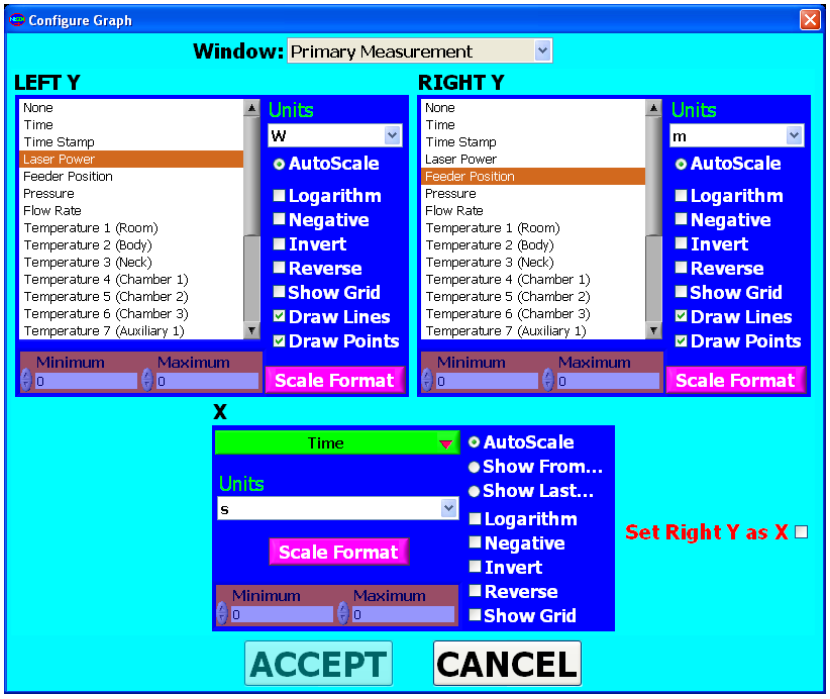
4.3.6 Configuring graph axes

In order to configure the graph axes select Graph→Configure Axes from the menu which will bring up the dialog shown in Fig. 15. The dialog will come up for the currently displayed graph window. The dialog can also be brought up by double-clicking with the mouse on the graph axes. To set what quantity is being displayed on either Y-axis, simply click on the desired quantity from the list of available options. The units may be changed by either clicking on the up and down arrows next to the units box or by clicking the units box and then selecting the desired units from the list that appears.

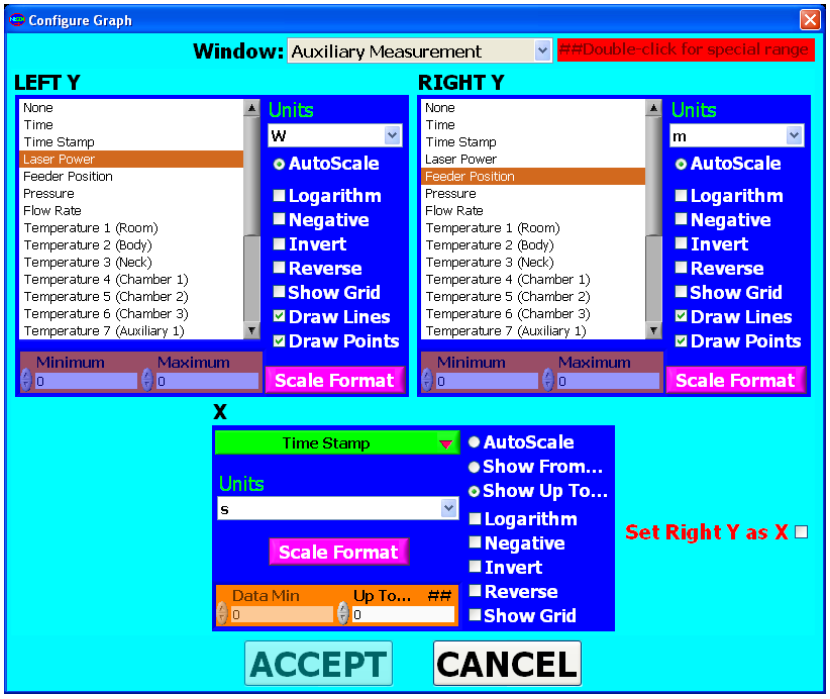
For each axis, there are a number of selectable options for managing the display of data. The are as follows:

- **AutoScale**: This option is checked by default. If it is not desirable for the axis scale to automatically adjust as new data is collected, then this item should be unchecked and a minimum and maximum value for the scale should be provided in the appropriate input controls.
- **Show From..., Show Last..., Show Up To**: These allow setting a rolling scale that shows part of the range (X-axis *Time* and *Time Stamp* only). These special ranges are set using the dialogs shown in Fig. 16.
- **Logarithm**: Checking this will cause the scale to be put into a logarithmic format.
- **Negative**: When this option is selected, the data displayed will be multiplied by negative one (-1).
- **Invert**: This option will display the inverse of the data $(1/x)$.
- **Reverse**: This option will flip the scale of the axis to go from a high value to a lower one.
- **Show Grid**: Choosing this option will cause grid lines to be drawn along the axis for which the option is selected. Horizontal lines will appear on the chart for a Y-axis and vertical lines for an X-axis.
- **Join Points**: Selecting this will draw straight line segments between the data points.
- **Hide Points**: This option toggles the visibility of data points. If *Join Points* is checked, then the lines will still appear on the chart.

The quantity plotted on the X-axis can also be changed in one of two ways. Firstly, the user can select the variable to be plotted from the drop-down menu. In some cases, it is desirable to plot data that would typically be on a Y-axis as the X value. This is done by using Set Right Y as X option and will automatically set the X-axis to be whatever quantity was being plotted on the right Y-axis. In this mode, the right Y-axis will then no longer be displayed. As with the other settings, the user can readily go back to the conventional display of the axes by de-selecting Set Right Y as X.

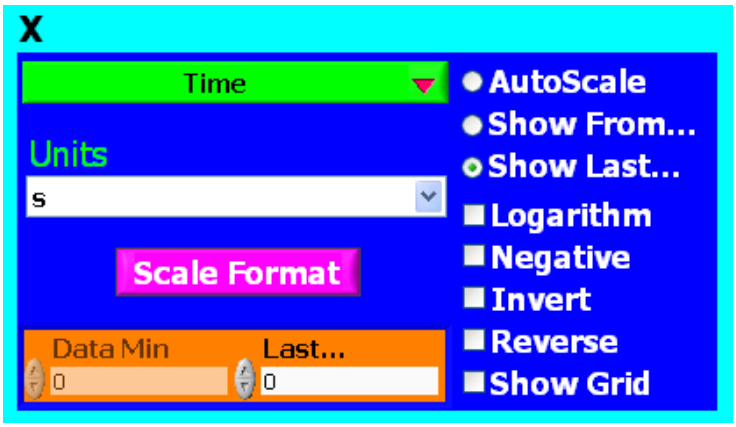


(a) Configuring plots displayed in the **Primary Measurement Window**

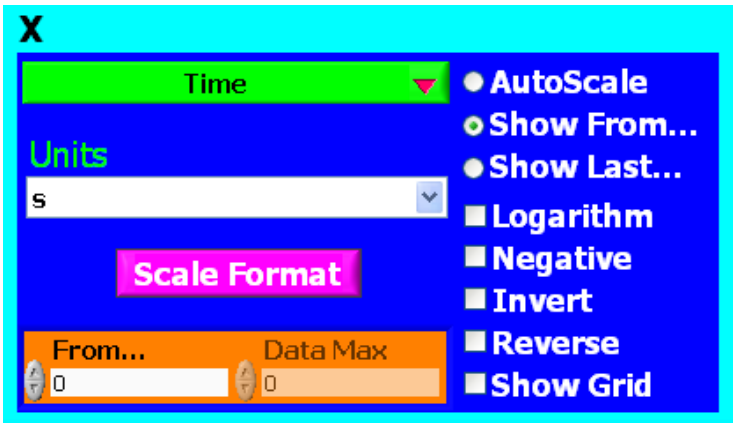


(b) Setting up a "special range" for data in the **Auxiliary Measurement Window**

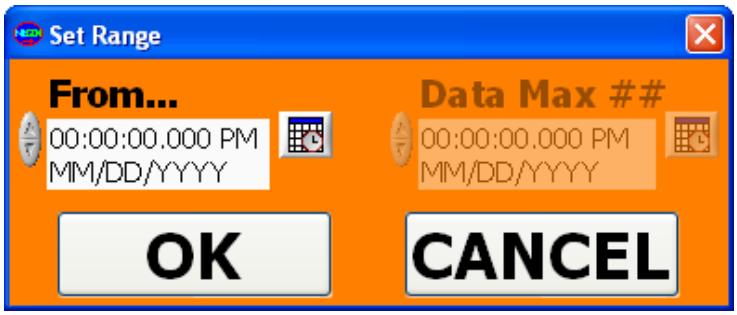
Figure 15: Configuring the axes and plot of a 2D graph in the (a) **Primary Measurement Window** and (b) **Auxiliary Measurement Window**). For "special" variables such as the **Time Stamp** additional tools are available when setting the range manually.



(a) Show Last...



(b) Show From...



(c) Special range for the **Time Stamp**

Figure 16: X-Axis **Time** and **Time Stamp** have additional ranges that are available for manual selection

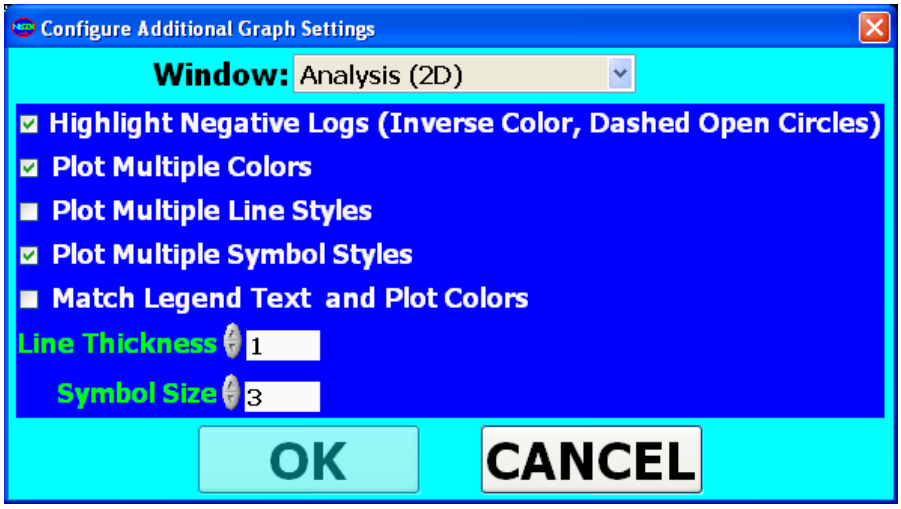


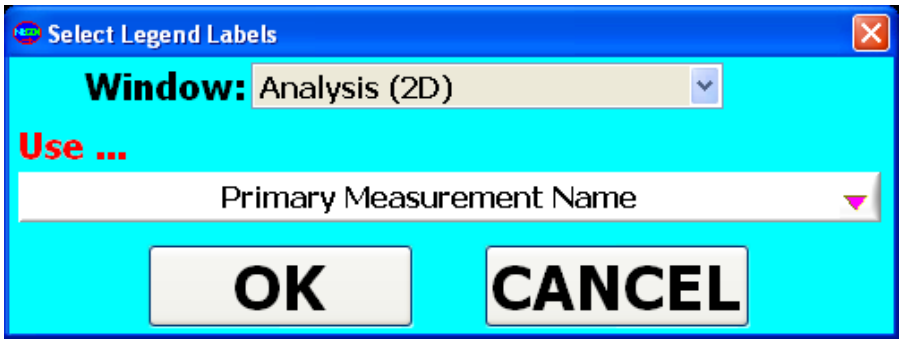
Figure 17: Some additional graph settings

There are some additional plot attributes that can also be set for each of the graphs through the dialog shown in Fig. 17. The dialog may be obtained from the menu selection Graph→Additional Settings. The settings accessible include:

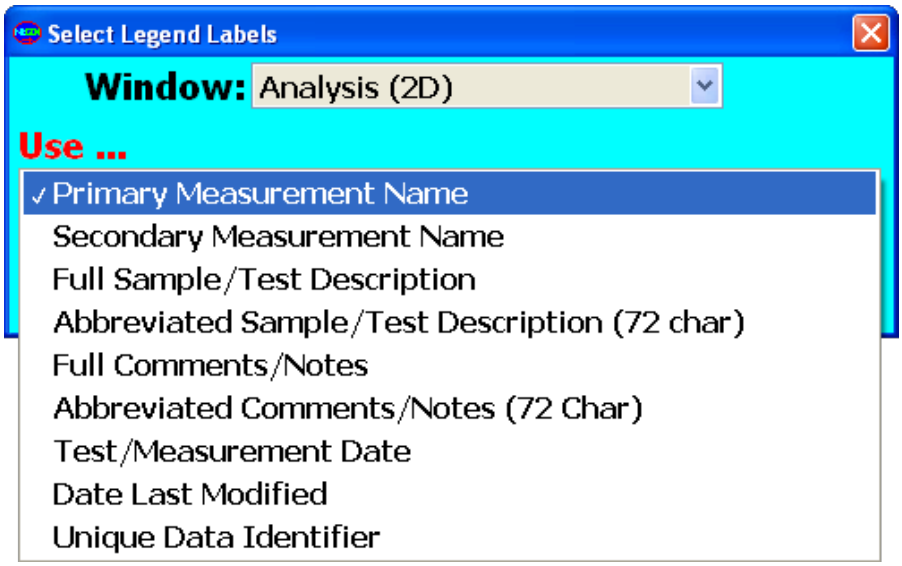
- **Highlight Negative Logs** Whenever the *Logarithm* option is selected, in the graph format in Fig. 15, plots the log of the absolute value of the number to protect against numerical errors (Logs of negative numbers are not defined in the real plane). In some cases, the data whose value is being plotted is actually negative, it is possible for to show this.
- **Plot Multiple Colors** Because has to deal with different graph content possibly on both the left and right axes and with the possibility of having to highlight negative logs, it has been left to the user to determine, for the presentation of a particular data set, whether or not to try and use multiple colors.
- **Plot Multiple Line Styles** and **Plot Multiple Symbol Styles** As with the line colors, the options are provided to use multiple line and symbol styles. The user is encouraged to try out combinations of these settings to see what works best for their particular data.
- **Match Legend Text and Plot Colors** will either have all the legend text in one color or can match the text color to the plot color. Again the user is encouraged to use the settings that best fit their requirements.
- **Line Thickness** and **Symbol Size** can vary the thickness of the graph lines as well as the sign of the symbols used.

4.3.7 Graph legends

gives a number of options for the information that can be displayed in the legend Fig. 18.



(a) Selecting legend labels



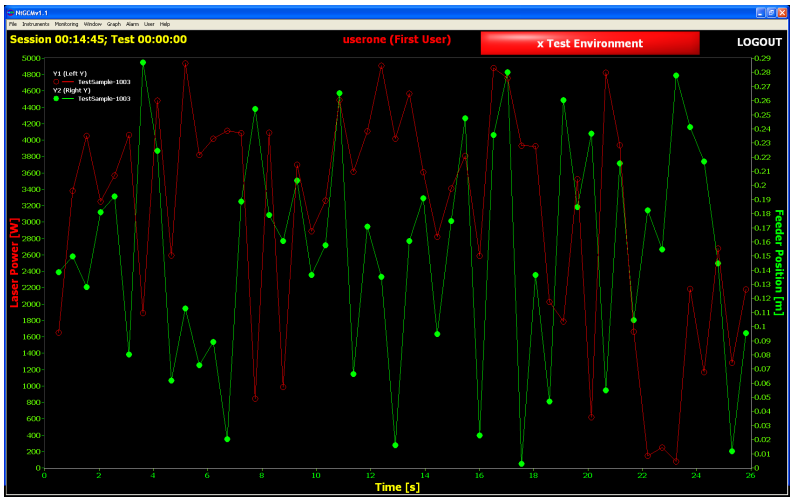
(b) Options for labeling the plots

Figure 18: Selecting information to display in the graph legend

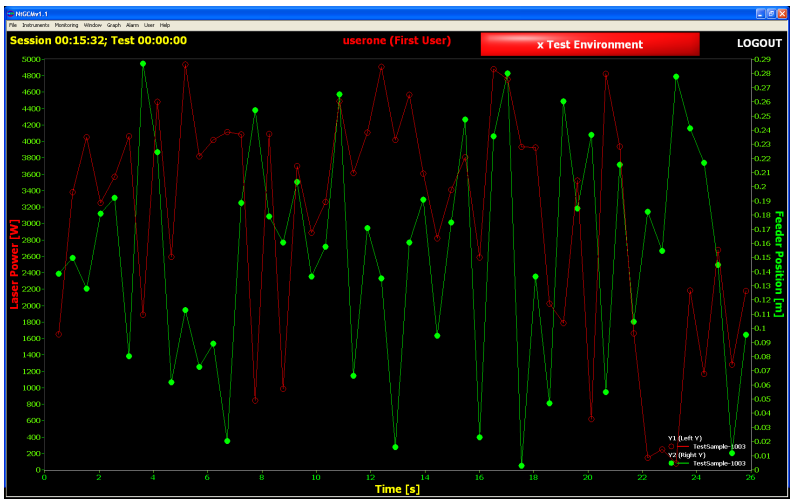
The plotting windows in can display legends in various forms. The following legend configuration options are available from the menu:

- Show/Hide Legend (in the **Auxiliary Measurement Window** and **Analysis (2D) Window** this is also achieved by double-clicking anywhere in the plot, away from the axes. Clicking in the region of the axes brings up the axes settings dialogs.)
- Change the format of the legend
- Change the information that is displayed in the legend
- Change the location of the legend

The *LV Native* and *Embedded* legends are drawn on the graph canvas while the *Floating* legends are displayed in specialized "floating "windows.



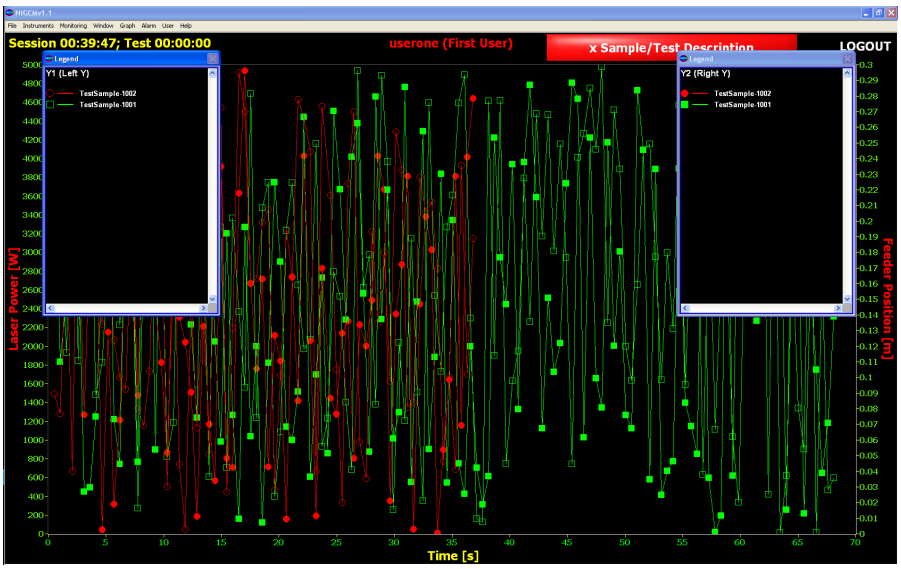
(a) "Embedded" legend positioned in the top left corner



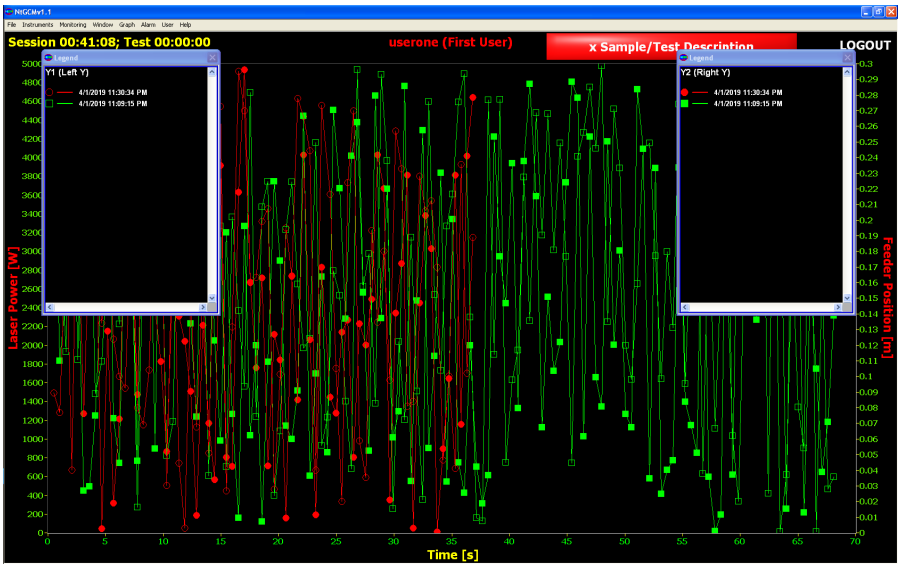
(b) "Embedded" legend positioned in the bottom right corner

Figure 19: *Embedded* legends showing different placement options

The position of the *LV Native* and *Embedded* legends on the canvas can be changed by double-clicking somewhere in the graph window (not on the axes labels) or through the Graph→Legend→Move menu item. The positions available range from top-left to bottom-right (Figs. 19(a) and 19(b)). It is up to the user to pick a location for the legend that does not (substantially) interfere with the reading of the plotted data. The *Floating* legends offer a more flexible option that can be moved to any place on the screen. Two options for the test descriptions are shown in are shown in use in Figs. 20(a) and 20(b), the test name and test date respectively. Note that for user settable test descriptors, the data for a specific option may not be available if the user did not enter that information when the test was carried out.



(a) "Floating" legend (plots labeled by test/sample name)

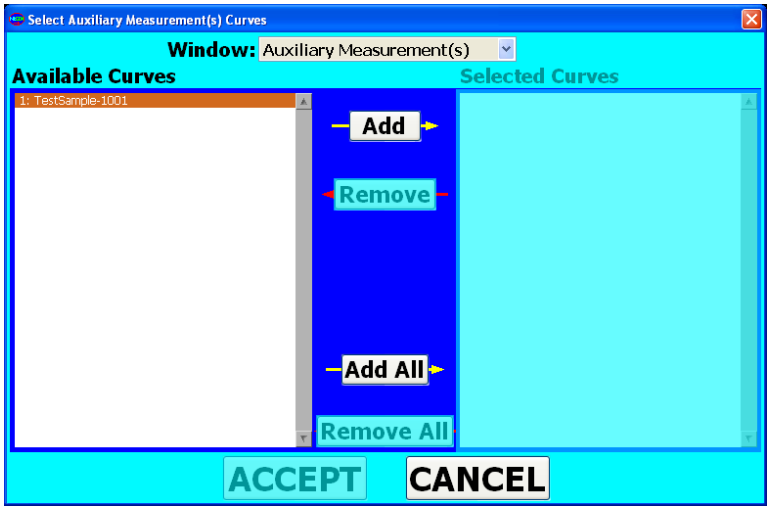


(b) "Floating" legend (plots labeled by test date)

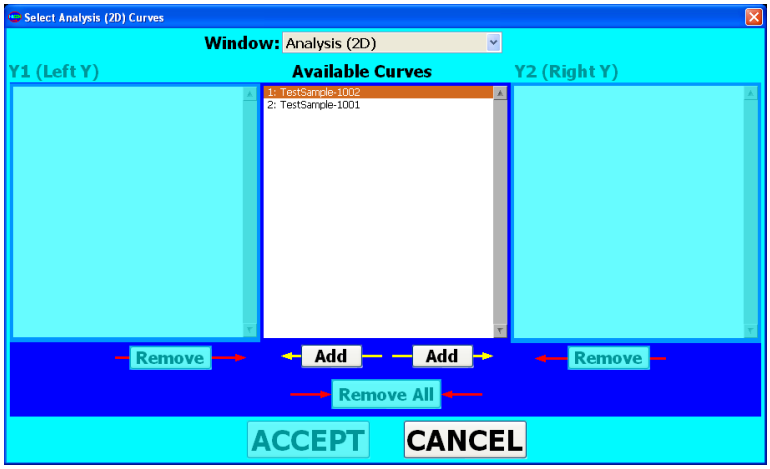
Figure 20: *Floating* legends showing information display options

4.3.8 Selecting curves

The option Graph→Select Curves is available only for the **Auxiliary Measurement Window** and **Analysis (2D) Window** which are capable of plotting multiple curves. This allows the user to choose what data to have displayed in these graphs to make them more readable or to compare different measurements. Figure 21 shows the dialogs for selecting curves for the **Auxiliary Measurement Window** (21(a)) and the **Analysis (2D) Window** (21(b)). The difference in the two is that the **Analysis (2D) Window** allows for the independent selection of data sets for the left and right axes while in the case of the **Auxiliary Measurement Window**, the same data sets are used for both axes. With each data set, different columns can be selected for plotting (Section 4.3.6).



(a) Selecting curves to plot in **Auxiliary Measurement Window**



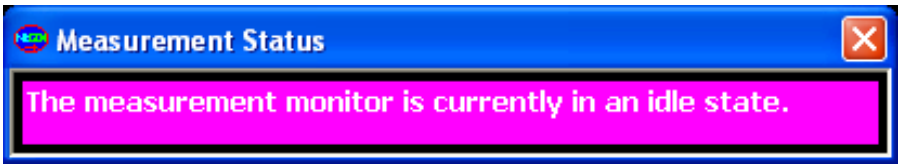
(b) Selecting left and right y-axis data for the **Analysis (2D) Window**

Figure 21: Selecting the curves to display in the (a) **Auxiliary Measurement Window** and (b) **Analysis (2D) Window**

To select a curve for plotting in the **Auxiliary Measurement Window**, click on it in the ***Available Curves*** column and then the Add button. This will add the data associated with the selected curve to the plot. For the **Analysis (2D) Window**, the curve highlighted in the ***Available Curves*** column can be added to either the ***Y1 (Left Y)*** or ***Y2 (Right Y)*** axis independently. This is done by using the Add button pointing to the desired axis column. To remove data from an axis, click on the curve listing in the appropriate column and then click the single Remove button in the case of the **Auxiliary Measurement Window** or the button under the column for the **Analysis (2D) Window**. The buttons Add All and Remove All can also be used to add or remove all the available plots.

4.3.9 Measurement Status Window

A floating window to show the status of the measurement can be displayed (or hidden) using the menu selection Window→Additional Settings→Toggle Measurement Messages or by double-clicking with the mouse in the center of the graph in the **Primary Measurement Window**. Selecting to display the messages brings up a text dialog similar to those shown in Fig. 22. The dialog can be closed by double-clicking anywhere in the main window or through the close button.



(a) Measurement status dialog when test is idle

(b) Measurement status dialog when a test is running

(c) Measurement status dialog after a test is completed

Figure 22: The **Measurement Status Window** showing messages that are typically displayed at various stages of a measurement

5 User account management

runs a user account management system that controls user access to functions as well as allowing each user to have their own preferred settings. The settings include measurement parameters and the configurations of the various graphs and controls, such as the units, file paths etc. On logging into the application, the program looks to see if there is a valid user settings file, which it reads in, otherwise default settings are loaded.
NOTE! Only users that are ***registered*** and ***logged in*** can run measurements while all others are able to recall measurements and browse the settings.
allows for three types of user accounts:

1. **Standard User** Can run measurements but cannot create or delete user accounts
2. **Advanced User** Can create user accounts but cannot delete an existing account
3. **Administrator** Can create and delete user accounts

When there is no user logged in it is still possible to open and plot saved measurement results as well as read the logbook but not to set up or run a measurement.

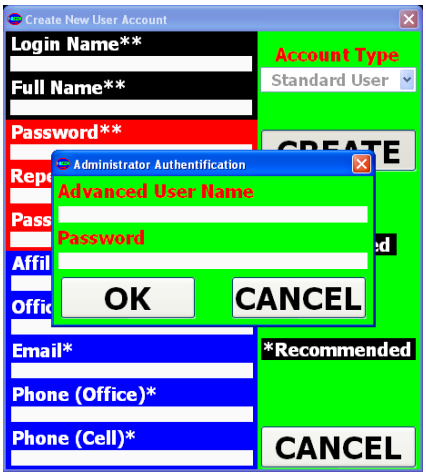
5.1 First-time user/creating new accounts

Back to the table of contents

The first time any user wishes to make a measurement, an account must be created for them. The first account created on the computer will be an Administrator account Fig. 23(a). In order to create an account, go to the User→Advanced User→Create New User Account option from the menu. Note that creating an account requires *Administrator* or *Advanced User* authentication credentials (Fig. 23(b)). The dialog box in Fig. 23(c) will appear for creating an account. There are several options for the level of access that the new user should have, the administrator/account creator may select any one of these that is available.
NOTE! Only an *Administrator* can create an account with administrator privileges.

Once an account is created, it is possible to modify the account information. A *Standard User* or *Advanced User* can only update his/her own account information. An *Administrator* can update the information of any user, including resetting user account passwords for the other users. To modify an existing user account, the dialogs in Fig. 24 should be invoked through the menu selection User→Advanced User→Update Account Information.

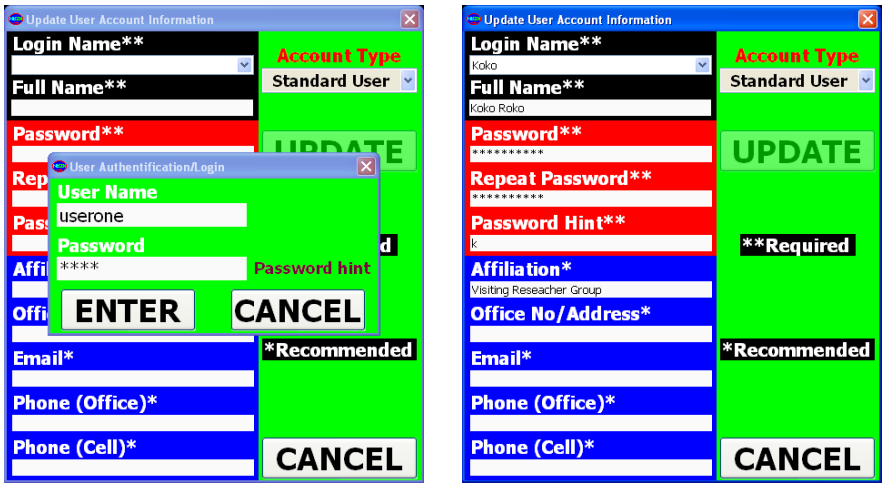
(a) Creating the first user account



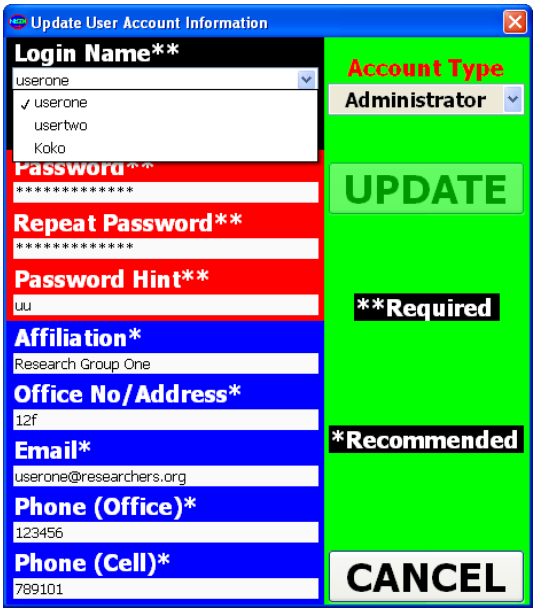
(b) Administrator authentication

(c) User account types

Figure 23: **NtGCM** offers a number of user account types. (a)The first user registered is automatically assigned an *Administrator* account. (b) The subsequent addition of users requires *Administrator* (or *Advanced User*) authentication. (c) These added users can have *Standard User*, *Advanced User* or *Administrator* level credentials. An *Advanced User* can add additional *Standard* or *Advanced* but not *Administrators* privileges.



(a) Authentication (b) *Standard User* information update



(c) Administrators can update other users' accounts

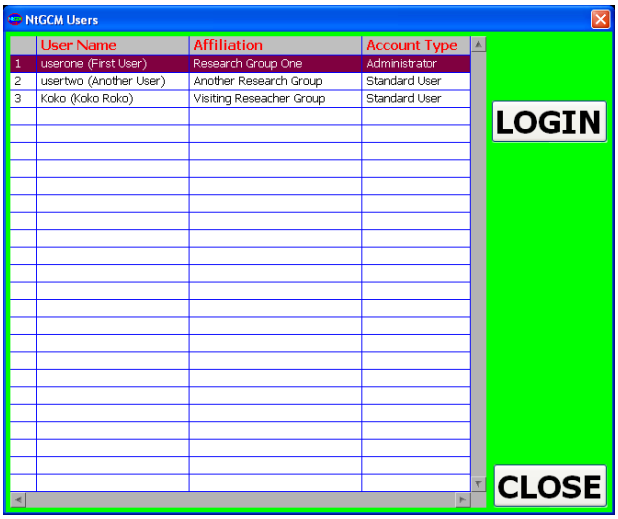
Figure 24: Some user account information can be updated after the account has been created. (a) In order to update information, authentication is required. (b) A *Standard User* can only update their own information, while (c) an administrator can also modify the information of other users.

5.2 Logging in

Back to the table of contents

There are three ways to access the user login dialog (Fig. 25(a)). The first is the LOGIN button at the top right hand of the front panel (3) in Fig. 6. The menu selection User→Login will also bring up the login dialog. For the two options above, once the login dialog is displayed, the user must enter the correct login name and password. The third option is through the menu selection User→List All Users. This will cause a dialog to appear with all registered users listed Fig. 25(b). From there, if there is no user currently logged in, they can select the user account to be logged in to and click the LOGIN button. This will bring the up the login dialog in Fig. 25(a) with the user name field pre-populated. The user must then enter the correct password to login. A password hint is also available if one was set up during the account creation process.

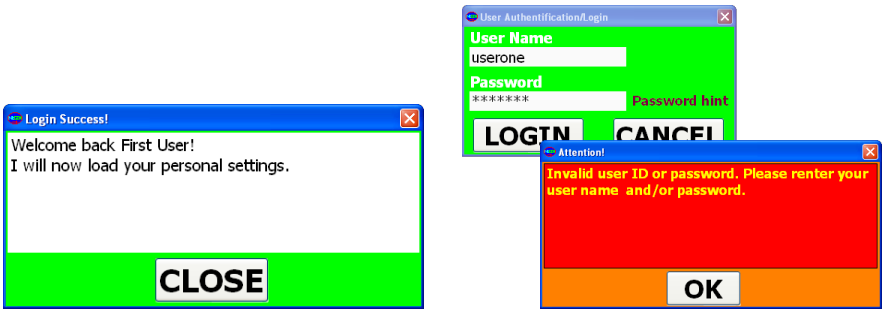
(a) The user login dialog



(b) List of all registered users

Figure 25: User logging in can be achieved by (a) directly calling the login dialog from the main menu or front panel login button and then entering the user (login) name and password. Alternatively, (a) a list of all registered users can be brought up and used to pre-populate the name field in the login dialog.

After the user has successfully logged in, user specific settings are loaded as shown in Fig. 26(a). User login requirements are strictly enforced and incorrect information leads to login failure Fig. 26(b).



(a) Login success (b) Login failure

Figure 26: Login success and failure

If a user is already logged in, then the selection and login functions of the *List All Users* dialog are disabled (Fig. 27).

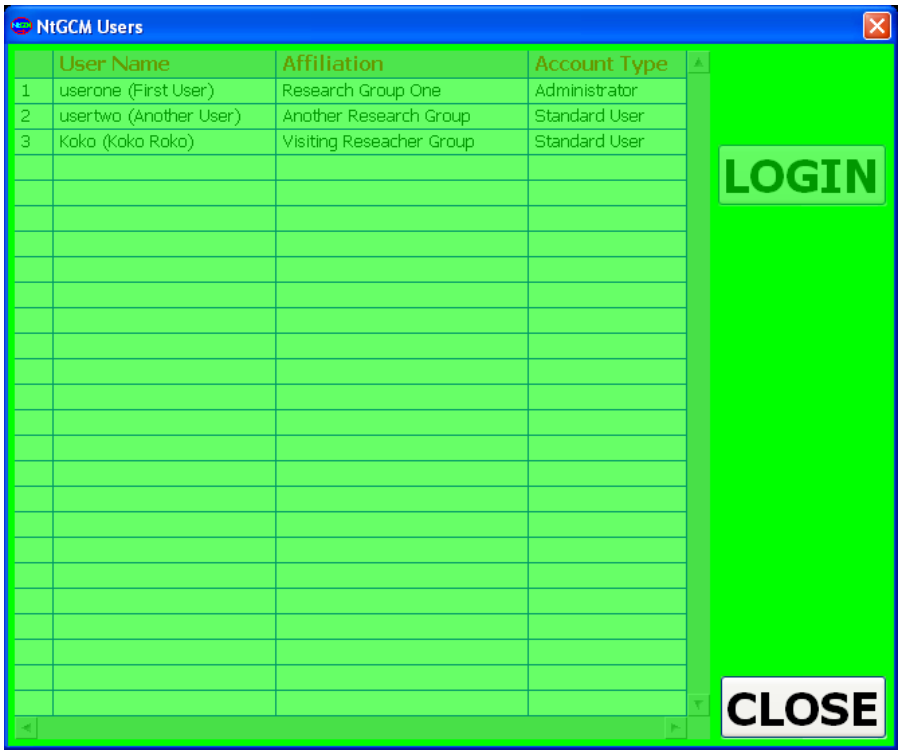
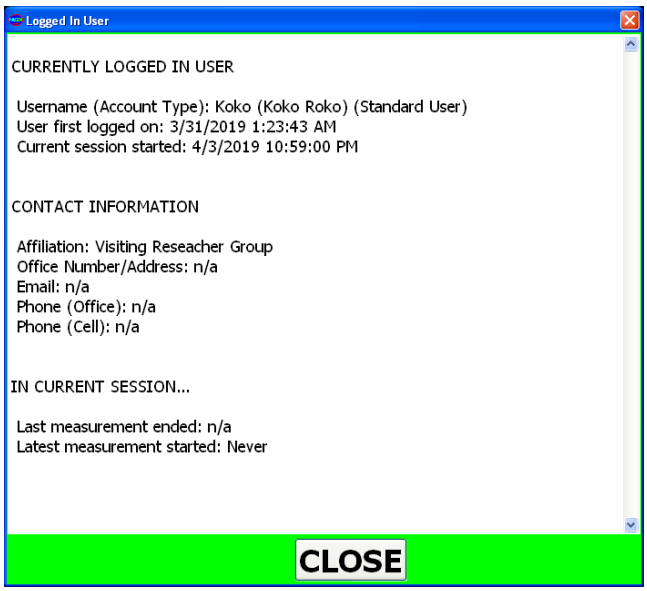
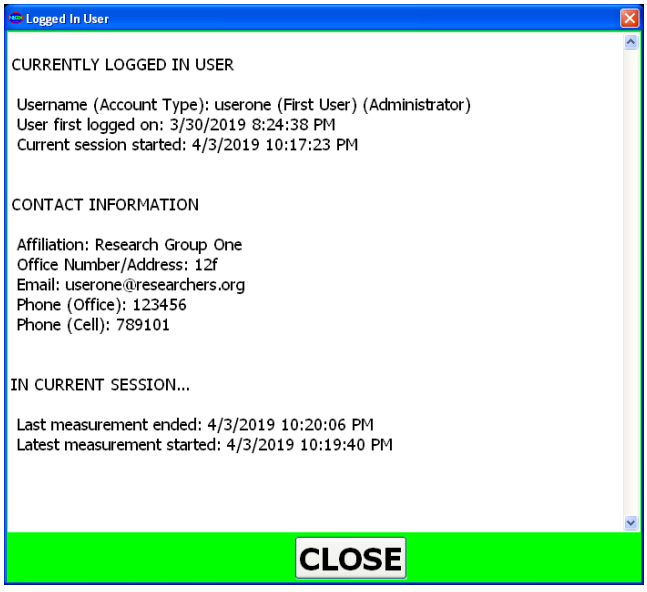


Figure 27: *List All Users* dialog when there is a user already logged in. New user selection and login functions are disabled

At anytime, it is possible to request some information about the currently logged in user, Fig. 28. The information provided includes the contact information of the user, if that was included in the account settings, when they logged in as well as when they last ran a measurement.



(a) Logged in user Information with partial contact details



(b) User information including full contact details and timing of the latest measurements in the current session

Figure 28: Accessing information about the currently logged in user, including contact details if they are available, as well as information on when they last ran a measurement

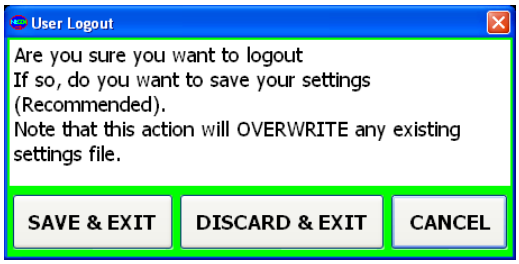
5.3 Logging out/saving settings

Back to the table of contents

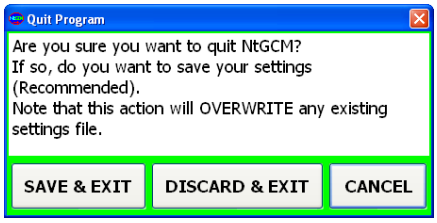
Making the User→Logout menu selection, using the LOGOUT button on the Front Panel or the EXIT button (14 in Fig. 6) will bring up the logout dialogs Fig. 29. The program will ask the user if they would like to save their settings as they logout Fig. 29. Saved settings are available to the user upon logging in again and make setting up and getting ready to run a measurement quicker. The settings that are saved by  include all of the following:

- Test description (except for the test/sample name)
- Selected instruments
- Front panel control units and ranges
- Graph axes configurations
- ASCII data export settings

Note! Settings can also be saved while logged in by selecting User→Save Program Settings in the menu. This action is recommended after a major change to the settings which the user wishes to preserve, such as configuring a number of instruments. It helps protect the new settings should the session not terminate cleanly.



(a) User logout dialog



(b) Quit program (user logged in)

(c) Quit program (no user logged in)

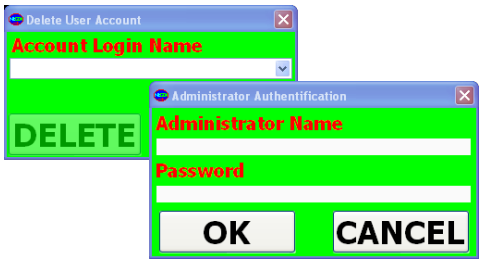
Figure 29: Dialogs that appear on (a) user logout and (b) & (c) quitting the program

5.4 Deleting user accounts (Administrator ONLY)

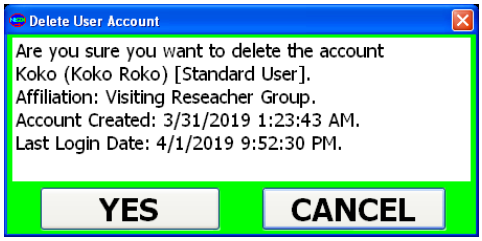
Back to the table of contents

By selecting User→Administrator→Delete User Account in the menu, an administrator may remove a user account. Administrator authentication is through the dialog in Fig. 30(a).

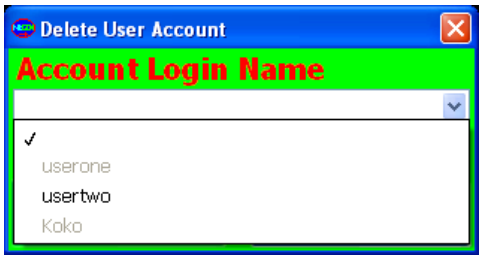
Note! Account deletion is NOT reversible. A warning is issued before the deletion of the user account Fig. 30(b). The accounts of a user that is currently logged in or the administrator that is attempting to delete the account (unless they are the last remaining user) cannot be deleted Fig. 30(c). Deleting a user account in  will erase settings but not any measurement data.



(a) Administrator authentication



(b) Delete confirmation



(c) Some accounts may be non-deletable with current settings

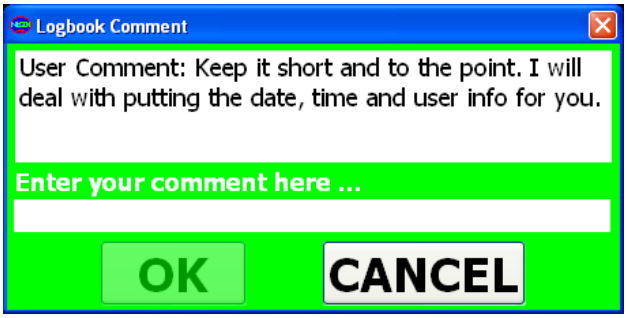
Figure 30: (a) Deleting a user account requires *Administrator* credentials. (b) **NtGCM** will give a series of warnings before deleting a user account. (c) Note that it is not possible to delete the account of a user that is currently logged in or the administrator that is attempting to delete the account unless they are the last registered user.

5.5 Logbook

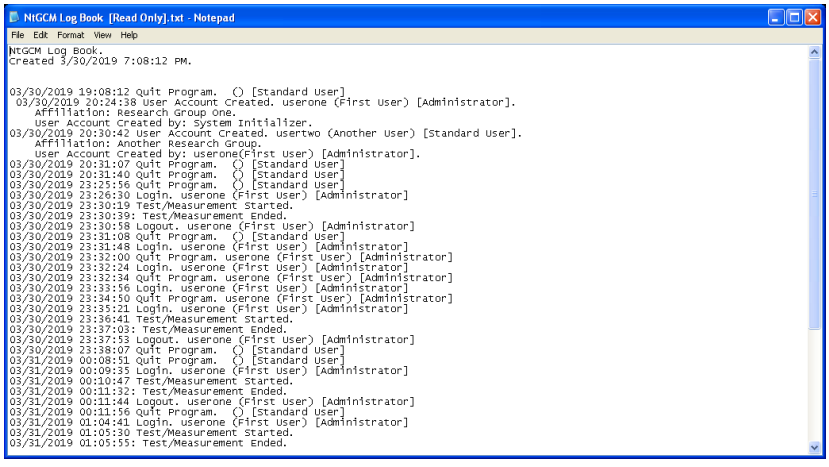
Back to the table of contents

maintains a logbook that contains various information on program execution events. The logbook can be accessed by the User→Logbook→Read menu selection. The logbook displays any information regarding when users have logged on or off and when any measurements have been run (Fig. 31(b)). Additionally, it will display any comments written by previous users. A user may write a comment by clicking User→Logbook→Write Comment in the user menu to get the dialog in Fig. 31(a). Simply entering the desired commentary into the resulting dialog box is sufficient, as the logbook will automatically add a time and date to the comment.

The program also maintains an error log. The error log (Fig. 32) can also be accessed from the user menu. As its name implies, this log is a running record of any errors that have occurred while the program was running. These notes are mainly aimed for developer/maintainer user and may be requested during program troubleshooting.



(a) Writing a user comment



(b) Read-only view of the logbook

Figure 31: A logged in user may write a brief comment into the logbook. Any user can access a read-only view of the logbook

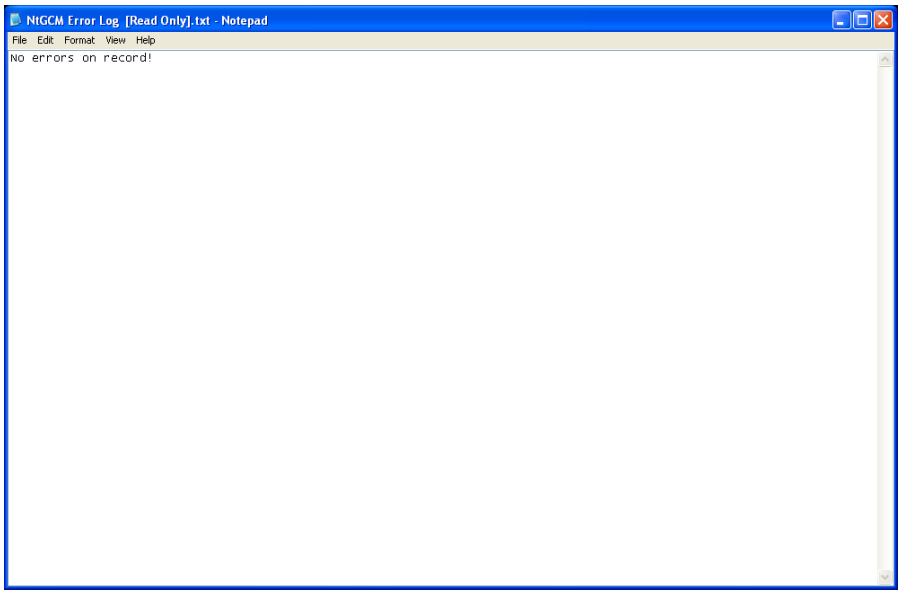


Figure 32: **NtGCM** also maintains an error log. Again the user is able to access a read-only view of the log. The errors logged may be communicated to the developer for possible fixes in later releases of the software.

IMPORTANT! Note that the logbook and error log are only intended for tracking program performance. It is up to the user to maintain proper records and notes of their experiments.

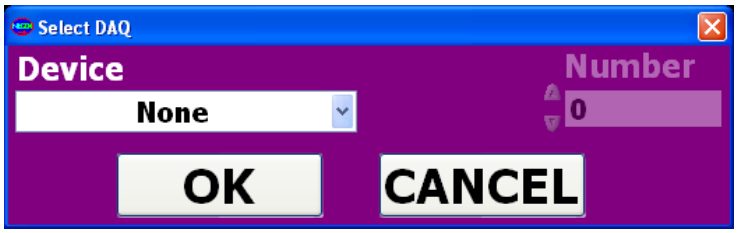
6 Setting up a measurement

The software will not allow a measurement to be started until various settings have been correctly configured. These are described in this section. Incomplete or non-compliant settings will be highlighted in the Test Readiness Indicator.

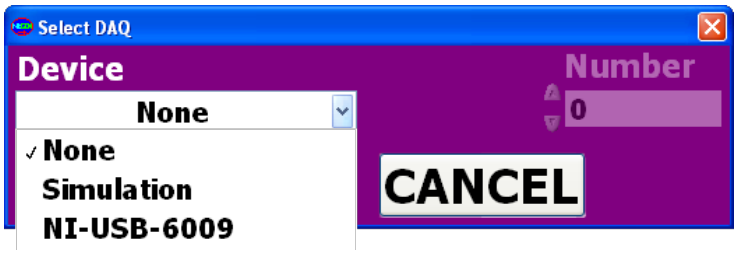
6.1 Selecting instruments

Back to the table of contents

The "Primary" DAQ, which reads all the test variables except for the temperatures, can be selected through Instruments→Primary DAQ→Select. The dialog box in Fig. 33 will be brought up. The device to be used can then be selected from the pull-down menu. A device number allows the instrument to be identified on the host system's USB bus.



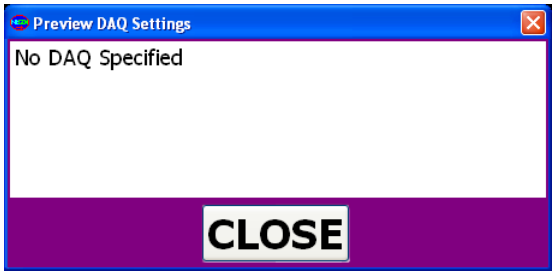
(a) Primary DAQ selection window



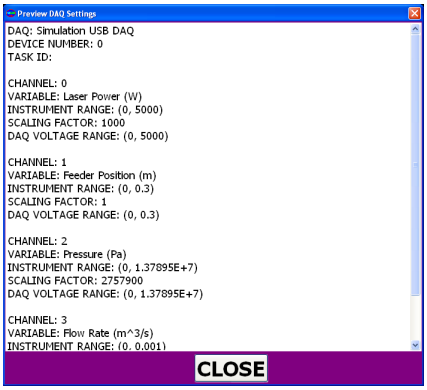
(b) The DAQs available for selection

Figure 33: Selecting the primary DAQ. The device to be used can be chosen in the pull-down menu listing all the devices that **NtGCM** supports. A device number is used by the system to address the specific hardware being used.

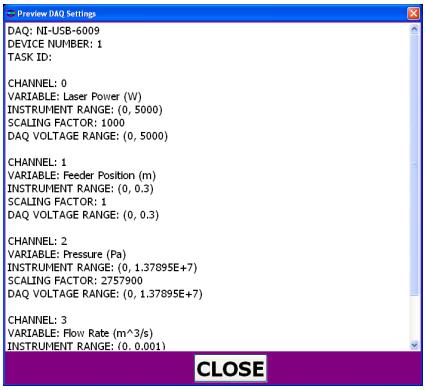
The configuration of the primary DAQ that is currently selected can be accessed by going to Instruments→Primary DAQ→Configure in the menu to get one of the dialogs in Fig. 34. These settings, which cannot be altered from within , are shown for information only.



(a) No DAQ selected



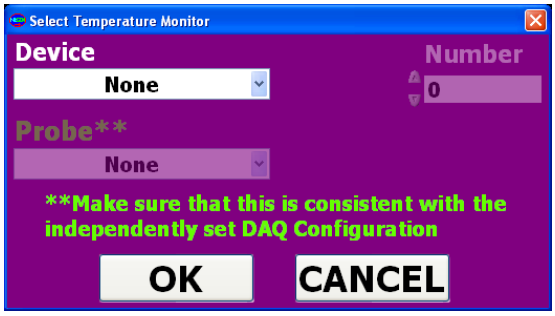
(b) Simulation DAQ settings



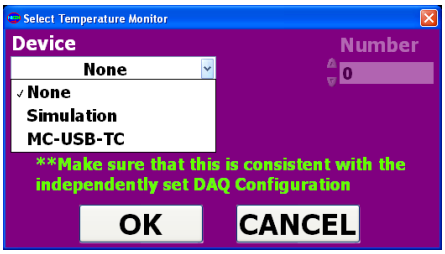
(c) NI USB 6009 DAQ settings

Figure 34: Primary DAQ configuration settings. These are read in from a file which is located in the **NtGCM** installation directory

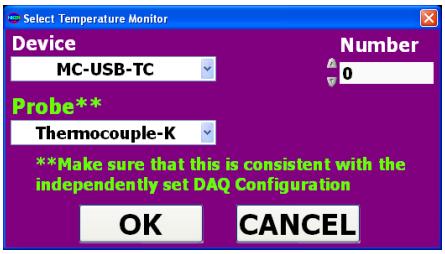
uses a separate (from the "Primary") DAQ to read the temperature probes. This DAQ can be selected by navigating to Instruments→Temperature Monitor→Select in the menu. The dialog box in Fig. 35 will appear. The user must select both the DAQ device and the (temperature reading) probe type. A device number must also be set and is used by the system to address the hardware.



(a) The temperature reading DAQ selection dialog



(b) Available DAQs



(c) Selected DAQ and probe type

Figure 35: Dialogs for selecting the temperature probe reading DAQ. The user must select both the DAQ device and probe type that is being used.

The probe selection dialog allows for a large number of options. (Fig. 36). Not all of these will be in use for a particular instance in which is being used, nor would all the temperature ranges be compatible with the experiments managed by the software. Do note that the selection in must match the hardware that is being used for the information saved in the measurement files to be useful in setting up future experiments.

REMINDER! The temperature probe selection in is only for reference purposes and ensuring that the correct information is added to the measurement results files. Configuring of the probe that will actually be used by the software is done external to (Section B.2)

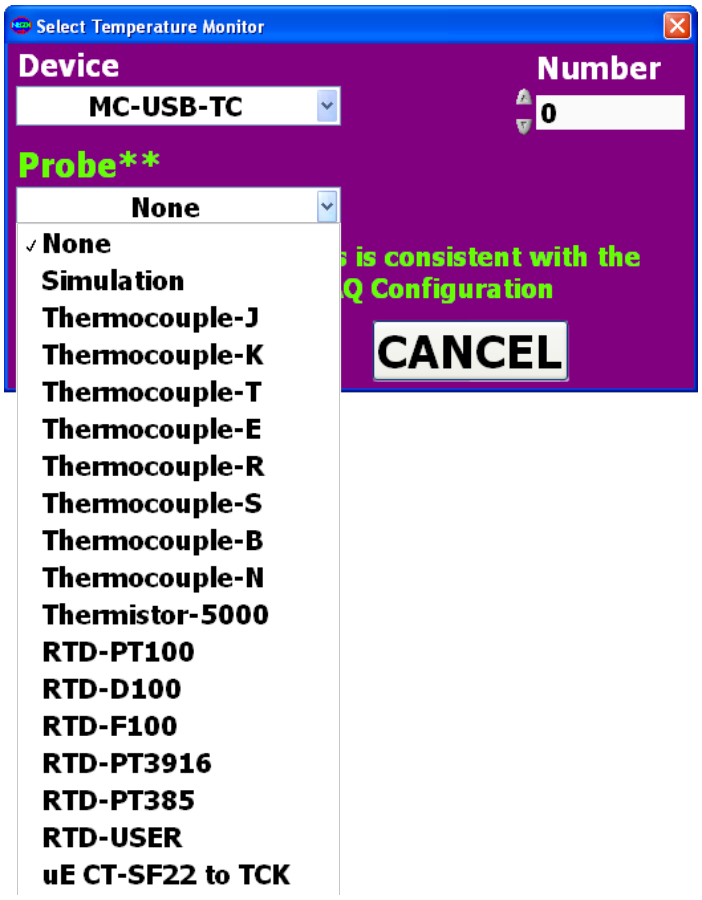


Figure 36: Selecting the temperature probe. Note that in **NtGCM**, the probe selection is only for reference purposes and inclusion in the measurement file description fields. The actual probe used will be determined by the settings in ***Insta*Cal**. It is highly recommended though that the **NtGCM** settings match the ***Insta*Cal** settings so that the data in the measurement files will include the correct details on the experiment.

The temperature probe locations can seen by going to Instruments→Temperature Monitor→Configure Probes which brings up the dialog shown in Fig. 37. These settings cannot be changed by the user and again are shown for information only. However, there are two "Auxiliary" temperature probes that the user can locate at their discretion. Information on the location of these probes may be added to the test notes (Section 6.2).

Figure 37: Temperature probe locations. Note that these settings cannot be changed by the user. However, there are two "Auxiliary" temperature probe channels that the user can assign as they find necessary. Notes on the location of these probes may be added to the test settings notes or otherwise recorded by the user.

The complete "Primary"and temperature reading DAQs configuration information is read in from the file `NtGCM_Instrument_Settings.cfg`. The contents of this file can be shown to the user following the menu selection Instruments→Read Settings File. A dialog such as that shown in Fig. 38 will be displayed. These developer level settings cannot be modified by the user are are only shown for information purposes.

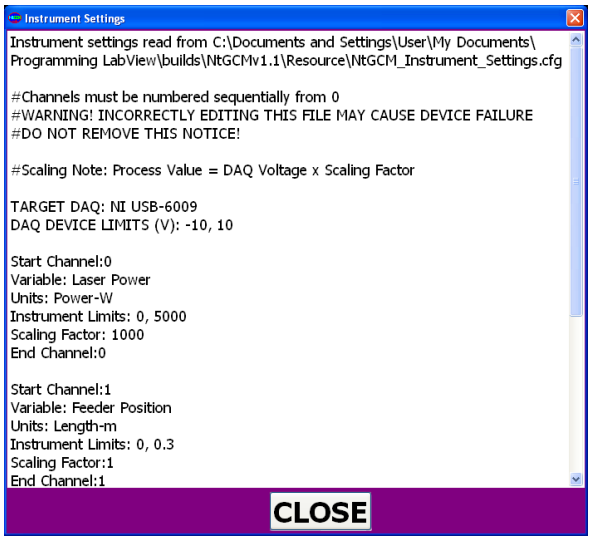
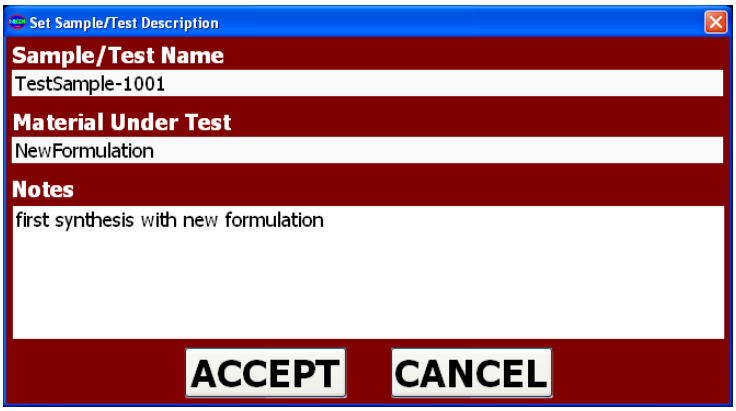


Figure 38: Snapshot of the contents of the settings file that **NtGCM** uses and which is located in the installation directory. It is possible to view but not to change these settings in the application.

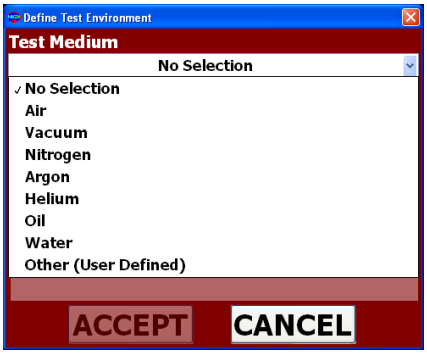
6.2 Setting the test description and test environment

Back to the table of contents

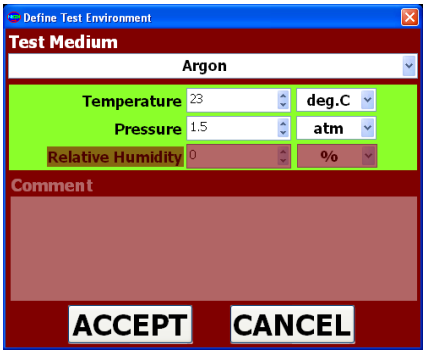
The dialogs in Fig. 39 are used to specify settings of the test. A description of the test, including a sample/test identifier, the material under test and any additional notes that the user may wish to add are entered using the dialog shown in Fig. 39(a). The ***Sample/Test Name*** is a required field that must be filled in before a measurement can begin. As the test/sample description may be used in legend labels it is recommended to keep it short and concise. Additional information on the test can always be added in the notes. A valid test environment must also be entered using the dialog in Fig. 39(c). There are a number of predefined templates for setting the test environment Fig. 39(b) as well as the ability to enter settings for a fully user defined environment.



(a) Test/sample description



(b) Picking templates for setting the test environment



(c) Details of a test environment

Figure 39: Setting the test/sample description as well as the test environment

6.3 Reviewing the test range and setting alarms

Back to the table of contents

The *Review Test Range* dialog (Fig. 40) allows the user to set alarms and other actions for those variables that allow it. The dialog is accessed by the menu selection Monitoring→Review Test Range. A summary of some key test variables is presented, as well as, warning and alarms that the user may have set.

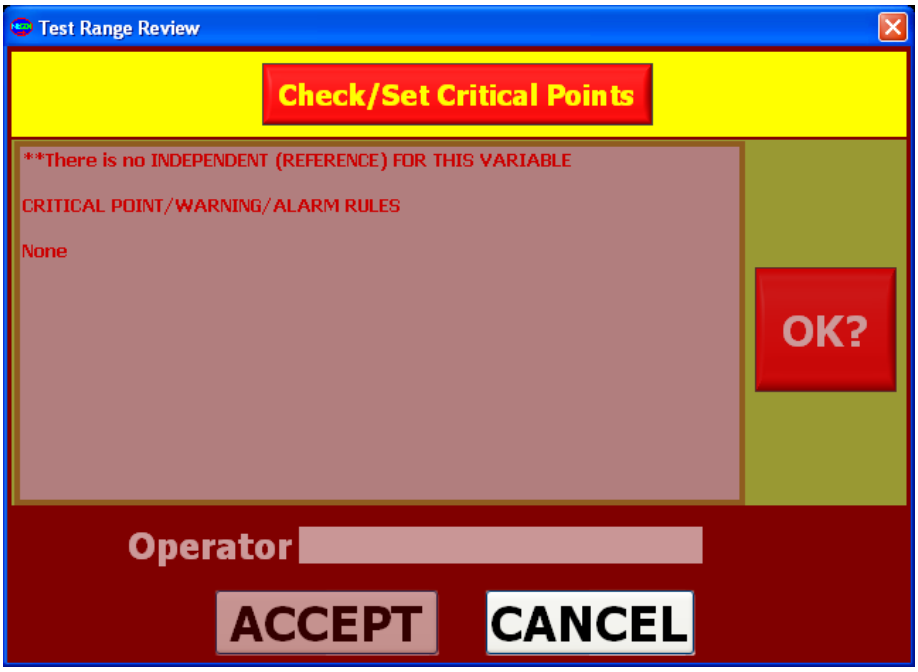
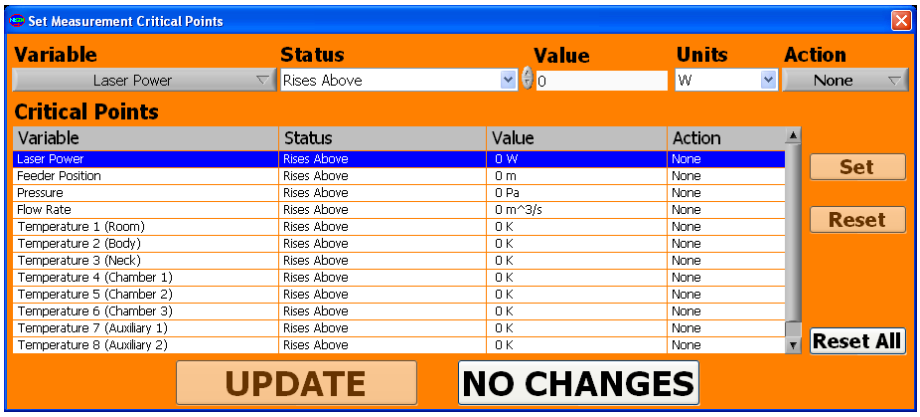
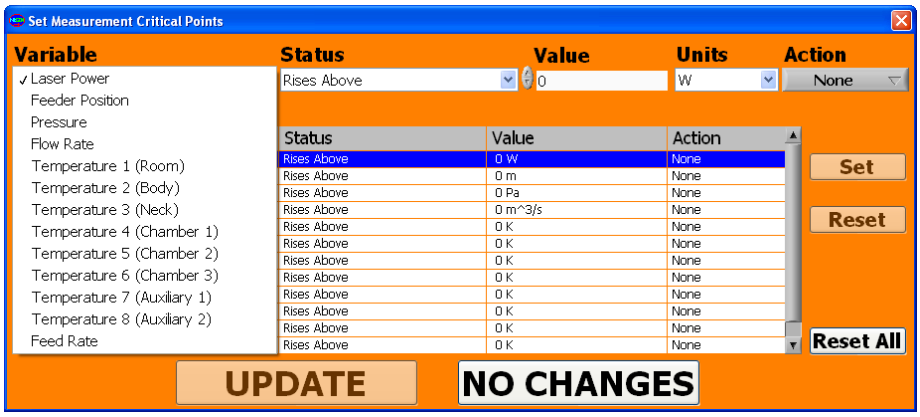


Figure 40: Before the test, the user can review the range of values that various variables are expected to lie in and set actions to be carried out if the values reach some critical points during a run. Note that because **NtGCM** is a monitoring (and not a measurement controlling) application, the operator signature is not a strict requirement to start a measurement.

allows alarms and other actions to be set for a number of the measurement variables. Entering of the set-points for alarms and other actions is initiated by clicking the Check/Set Critical Points button on the test range review dialog. This brings up the additional dialogs in Figs. 41 and 42. Figure 41(a) shows a summary of the settings while Figs. 41(b), 42(a) and 42(b) show some of the variables that allow for setting of critical points, the status of the variables that can trigger critical point actions 42(a) and the actions that can be triggered 42(b).

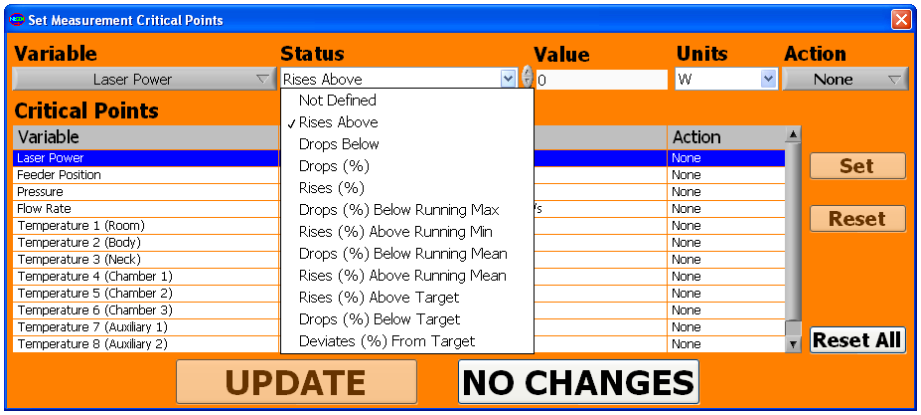


(a) Settings to define the critical points and actions to be triggered

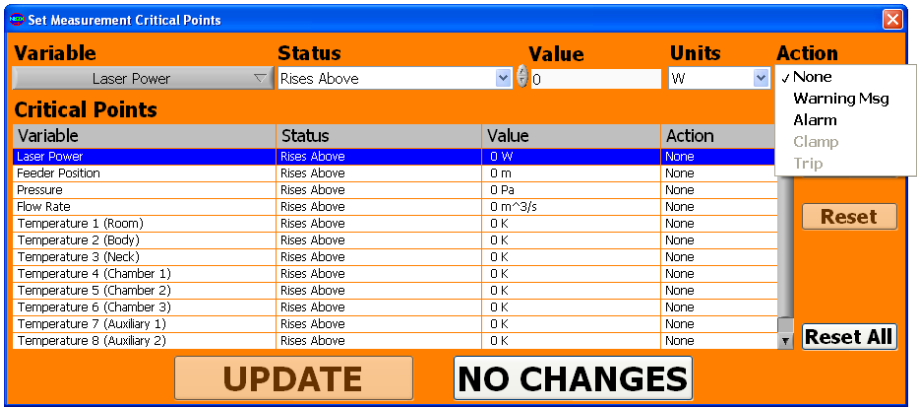


(b) The variables for which critical point actions can be set

Figure 41: Various actions can be set to be triggered should some variables exceed preset bounds during a measurement



(a) Variable status that trigger critical points



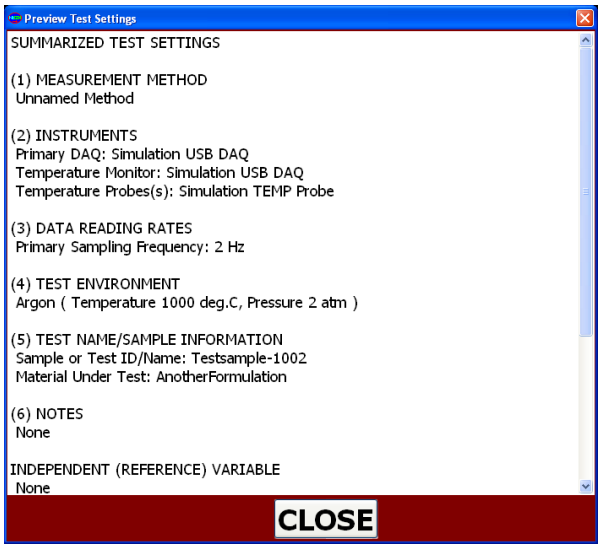
(b) Actions to be taken on reaching a critical point

Figure 42: (a)Measurement variable status that trigger critical point actions and (b) the actions that are triggered

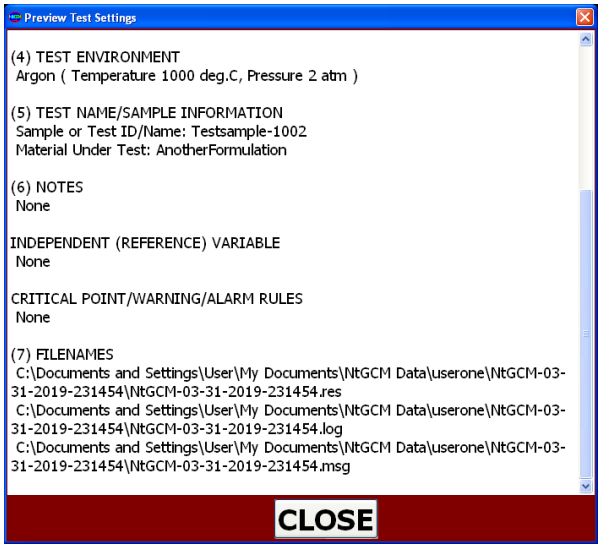
6.4 Previewing test settings

Back to the table of contents

At any moment before or during a measurement, the user can see a summary of the current test settings. Monitoring→Preview Settings will bring up the dialog in Fig. 43.



(a) Previewing test settings



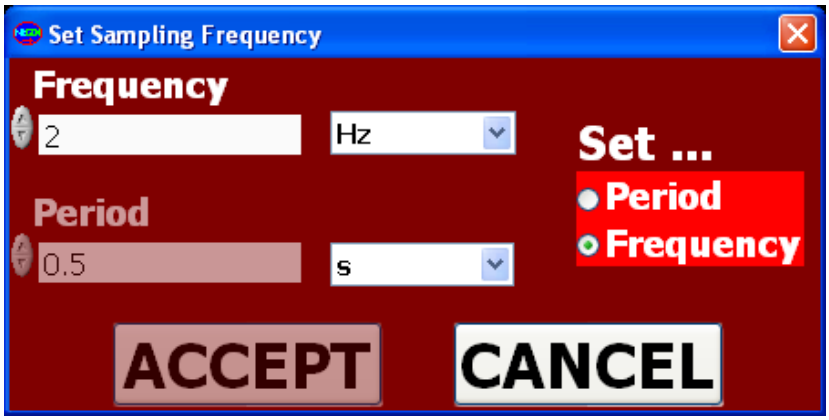
(b) Preview test settings (continued)

Figure 43: At any time before or during a measurement, it is possible to view a summary of the current test settings

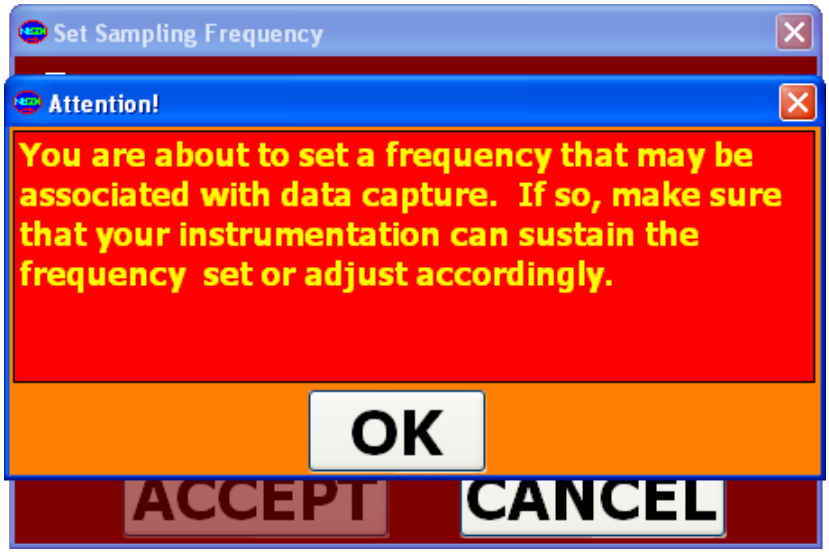
6.5 Advanced measurement settings: Sampling frequency

Back to the table of contents

The user can set a data capture rate using the dialog shown in Fig. 44. This dialog is invoked though the menu selection Monitoring→Advanced Settings→Set Sampling Frequency. It is important to make sure that this data capture rate is supported by the hardware being used Fig. 44(a). A warning is issued to the user before setting this value to make them aware of the importance of ensuring that the settings chosen are compatible with the hardware in use Fig. 44(b).



(a) Setting the sampling frequency



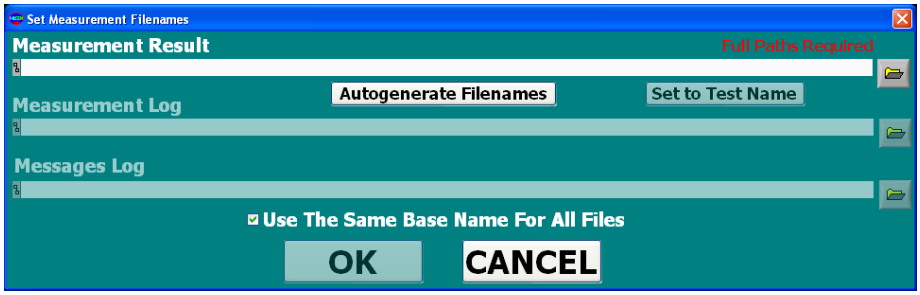
(b) Sample frequency warning

Figure 44: **NtGCM** allows the user to set a (maximum) sampling/instrument reading rate to be used in the measurement. It should be noted that the actual frequency at which data is gathered will depend on the hardware response.

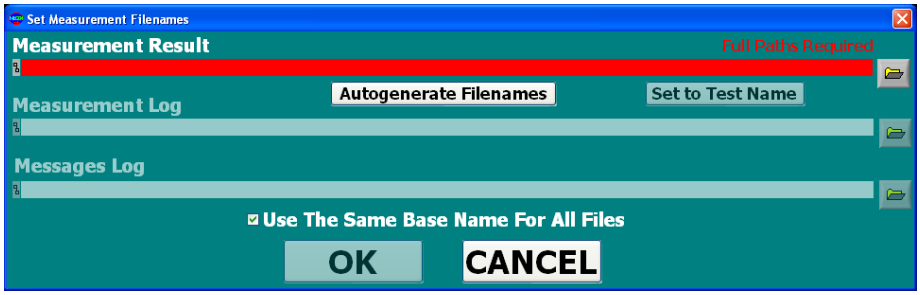
6.6 Setting filenames

Back to the table of contents

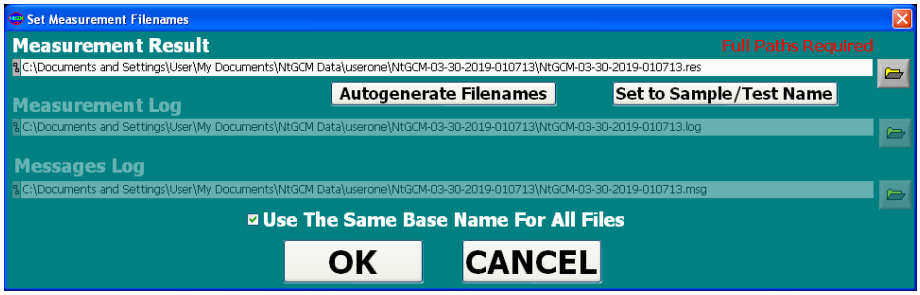
Before beginning a measurement, the files to which the data should be written must be specified through the dialogs in Fig. 45. NtGCM writes to three files during the measurement (Fig. 45(a)). These are the Measurement Data (*.res), Measurement Log (*.log) and Messages Log (*.msg) files. Each of the three files is **required** and if not set correctly will be highlighted Fig. 45(b). The Use the Same Base Name For All Files option



(a) The dialog for setting up measurement filenames



(b) Highlighting of a missing **required** file



(c) Auto-generated filenames (also using the same base name)

Figure 45: Setting the measurement filenames. **NtGCM** writes measurement data to three files. The names of the files can be independent, have the same base, be auto-generated or derive from the sample/test name. The user must enter the full path for the files. In the case of the auto-generated and test/sample name derived filenames, the path points to the current working directory.

may be selected to ensure all files are saved in the same folder with the same base name and different extensions. This eliminates the need to type each name individually and keeps the data and logs filenames consistent. If using the same base name is enabled, then the user need only enter a value in the ***Measurement Result*** input.

Pressing the Autogenerate Filenames button allows all the filename inputs to be populated with automatically generated names. The format for the automatically generated filenames which includes the current name of the program and the date and time of the measurement is shown in Fig. 45(c). Filenames are generated pointing to the current working directory which is usually the user's assigned directory. Filenames may also be derived from the sample/test names. Note that in this case it is up to the user to make sure that the appropriate test name has been set before using the Set to Test Name button. will read the current settings and propose a filename which is displayed to the user. The name will not be automatically updated if a user were to go and change the measurement settings and not come back to the filename set up dialog. This protects the filename settings from characters in a test/sample description that may not be compatible with the host system's file naming rules.

6.7 Saving and loading measurement methods

Back to the table of contents

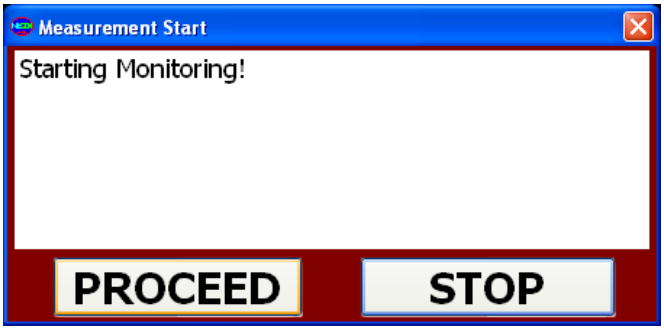
measurement settings are typically saved and loaded as part of the user login/logout process. In this case, there is one set of settings for the user. There may be cases where the user might want to be able to save and quickly access more than one experiment configuration or when the same settings need to accessed by multiple users. Save/load measurement method provides this functionality. The measurement method includes instrument selections and data export settings. Saving a measurement method is through the menu selection Monitoring→Save Measurement Method. A method can be loaded by selecting Monitoring→Load Measurement Method. The loaded method will override any settings that the user may have configured in the currently running session.

7 Running the measurement

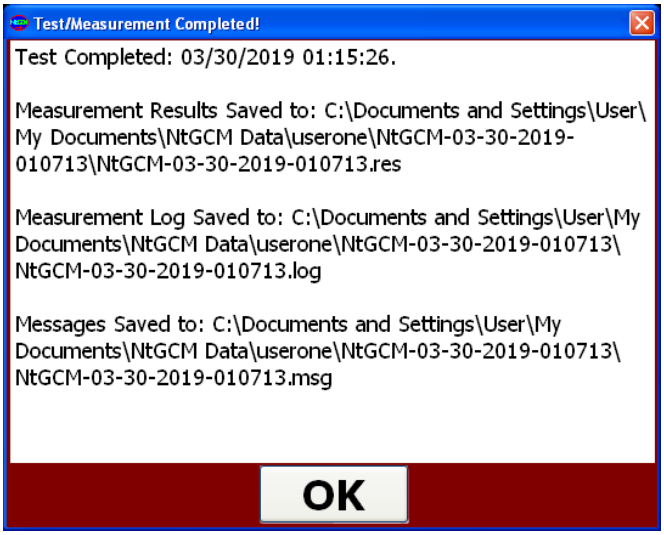
Data acquisition is started through the main menu selection Monitoring→Start. This brings up the user prompt dialog in Fig. 46(a). Once data acquisition has begun, the measurements will run until stopped by the user. The Test Readiness Indicator button on the the front panel highlights that the measurement is running and the EXIT button at the bottom of the Front Panel changes to STOP MONITORING state.

To stop monitoring, either the button on the front panel (14) in Fig. 6 can be used or the menu selection selection Monitoring→Stop made.

Once data acquisition is completed, a dialog box will appear listing the locations to which the measurement results as well as measurement and messages logs were saved (Fig. 46(b)).



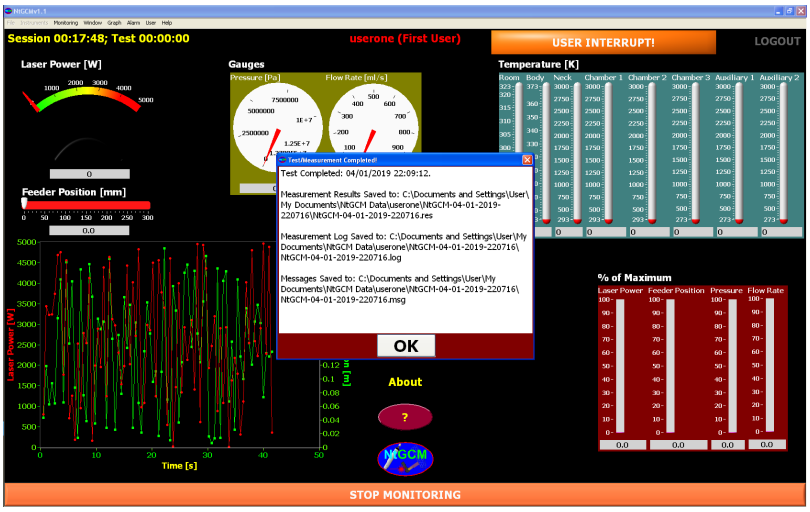
(a) Measurement startup prompt



(b) Measurement completion message

Figure 46: Measurement start and completed messages. The measurement completion message includes a listing of the full paths of the measurement files.

After the measurement is completed, the test name is reset while other settings are maintained to make it easier to set up the next measurement. As experiments are typically run with different settings, NTGCM will prompt the user to confirm some variables before the start of the next test even if they are to remain the same.



(a) Measurement interrupt by the user

(b) Post measurement view of front panel controls

Figure 47: **Primary Measurement Window** when a measurement is stopped and afterwards. Note that after a test is completed, the user must confirm a number of parameters such as the *Test Description* even if it is intended to use the same settings as before.

8 Working with measurement results files

provides a variety of tools to work with measurement data. This section gives an overview of the different functions that can be used to manipulate data files in the program. All of these functions may be found under the File menu.

8.1 Opening a measurement result

Back to the table of contents

allows the user to not only load results from previous measurement for display and analysis in the **Auxiliary Measurement Window** and **Analysis (2D) Window**, but also to easily access and reuse the settings of those measurements. When a measurement result is opened, it will bring the data as well as all the measurement settings associated with that data into the program's workspace, automatically overwriting any previous measurement settings the user may have entered. All this is done through a dialog box which prompts the user to enter or browse for the desired data file (Fig. 48).

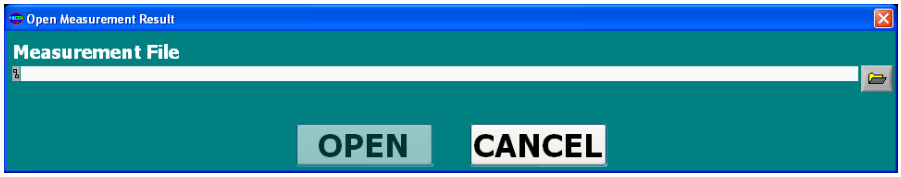


Figure 48: The dialog to open a measurement result file

8.2 Importing measurement data

Back to the table of contents

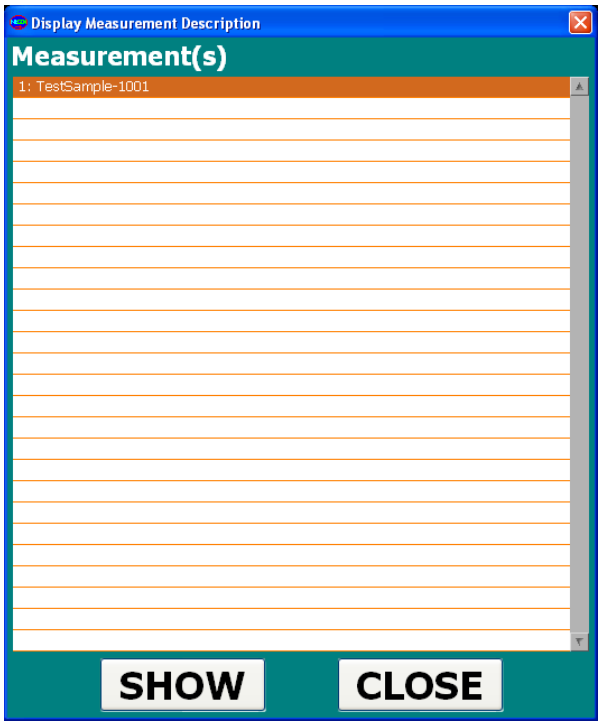
Importing differs from opening a measurement result file in that the settings from the loaded measurement file are not used to reset the current measurement environment. This makes importing ideal when the data is desired purely for display/analysis purposes. Opening a measurement result is more suited when it is intended to display data from the previous measurement as well as setting up a new test using settings similar to the one that has been opened.

8.3 Accessing measurement descriptions

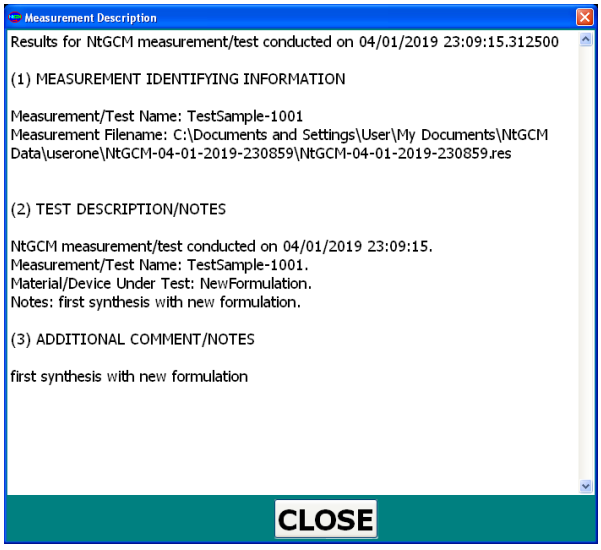
Back to the table of contents

When saves test data, there is additional information describing the measurement that is also saved. The data, which is available for the measurements conducted in or loaded into the session, can be accessed through the File→Measurement Descriptions menu selection. This brings up the dialog in Fig. 49(a) allowing the user to browse and

select from the available measurements. Once a measurement is selected, information such as that shown in Fig. 49(b) is displayed.



(a) Selecting a measurement whose description to display



(b) Description of the measurement

Figure 49: **NtGCM** can display the description of the current measurement or other measurements loaded into the current session. (a) The user can select the measurement whose description they wish to see and (b) get the information that is available on that measurement.

8.4 Saving measurement result as new file

Back to the table of contents

Although the program will automatically save data acquired during a run to the filenames specified at measurement set up, it is sometimes necessary to save data under a new filename. This is particularly the case for example if the user wants to replace an automatically generated filename with something that is easier to remember. The menu selection File→Save Measurement Result As will open a dialog that allows the user to set a new file path to which the data will be saved. The function creates a copy of the data and does not erase the previous file. If the user wishes to erase that file, they may use the host system's file management tools. This should only be done after making certain of the location and validity of the replacement file.

Figure 50: The dialog to save a measurement result under a new filename

8.5 Modifying and (re)saving measurement data

will allow certain aspects of already measured data to be modified and the measurement saved, preferably under a new name. This feature allows the user to, for example, fix an incorrect sample description. Note that none of these changes have any effect on the experimentally measured data. A note on the changes is added to a new measurement messages file which is created when the modified data is saved. Only the most recently completed or opened (not imported) measurement can be modified. Modification of the measurement data is achieved by going to the appropriate measurement configuration dialog (Section 6). The user must explicitly request for the change to the data to be completed (File→Update Measurement Data) upon which a dialog warning about what the action is issued (Fig. 51). Should the user continue with the changes, the data is then modified. Measurement data can be saved under the existing filename or a new filename (preferred) by calling the *Save Measurement Result As...* dialog (Fig. 50).

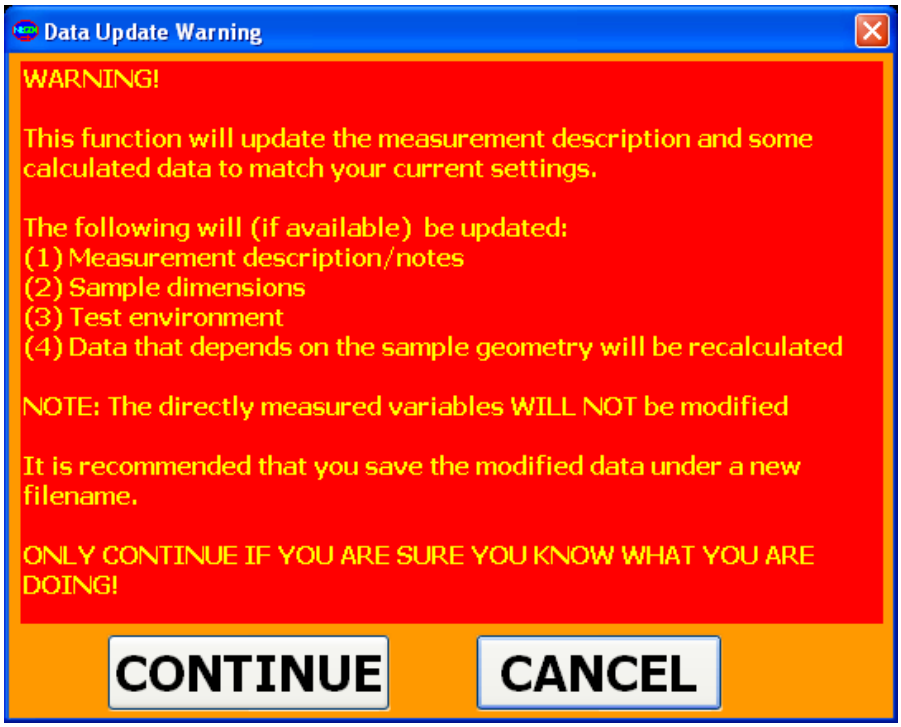


Figure 51: Warning about what is and (more importantly) is not possible when updating measurement data

8.6 Exporting measurement data

Back to the table of contents

Any measurement results collected can be exported in ASCII format. The first step in doing so is to select File→Configure ASCII Export in the menu, which will cause the dialog in Fig. 52 to appear. To add a data column to the exported file, click on the desired quantity in the ***Functions Available*** list and then the Add button. There is no limit to the number of columns that are exported beyond the number of measured values but each available column may only be exported once. The ordering of the exported columns may be changed by selecting one from the ***Export Data Column(s)*** list using the Move Up and Move Down buttons.

The units used for a given column can also be changed by selecting it in the ***Export Data Column(s)*** list and then selection the desired unit from the ***Units*** column. Set SI Units for All will affect all exported data columns and change their units to SI.

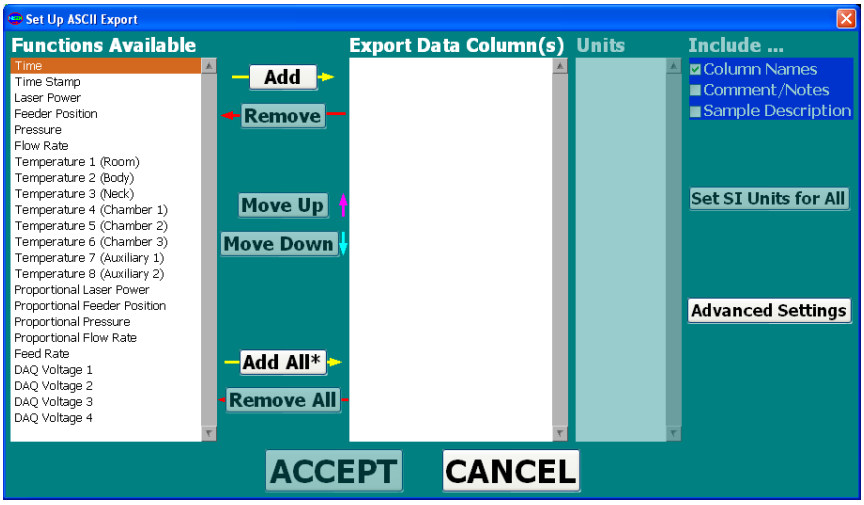


Figure 52: Configuring data export involves picking which columns from all the available data to export, the ordering of those columns as well the the units to use. Additional header information may also be included in the export file.

The user may also opt to include column names, comments made in the sample description dialog and/or the sample description itself in the exported data file. Note that if comments and/or a sample description are included in the export, this additional information may affect the way some spreadsheet programs will load/import the exported data.

Additional control of the formating of the numeric data that is exported is possible and invoked using the Advanced Settings button. This brings up the dialog in Fig. 53. Some formatting choices may make the data easier to display or import into other software.

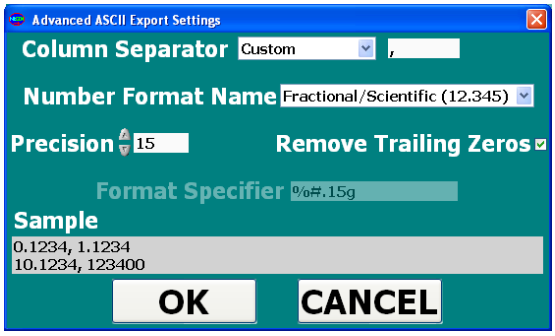


Figure 53: Detailed control of the formatting of the exported data is also supported

After the export is configured, the user must use the menu selection File→Export ASCII in order to actually export data. This will bring up a dialog with a list of all datasets collected or opened during the current session (Fig. 54). Highlighting a dataset to be exported and choosing the SELECT button will bring up the dialog in Fig. 55(a). If it is desired to export all the available datasets, then the SELECT ALL option can be used. When exporting multiple datasets at once, there are a number of options offered for setting the export filenames (Figs. 55(b), 55(c)) or saving all the exported datasets to a single file (Fig. 55(d)).

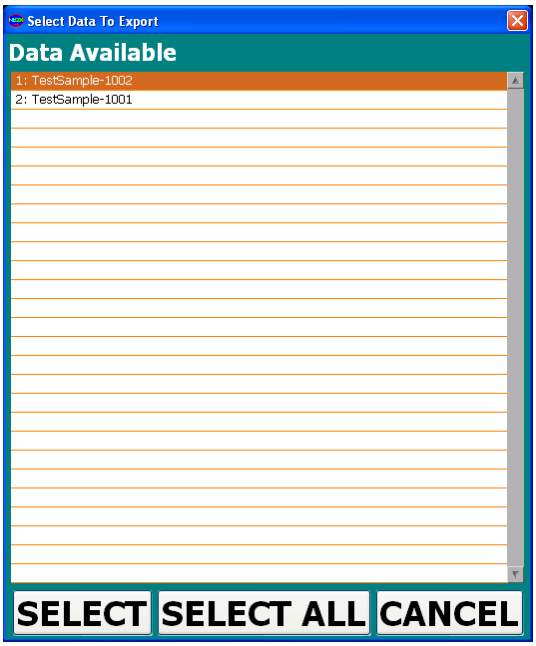
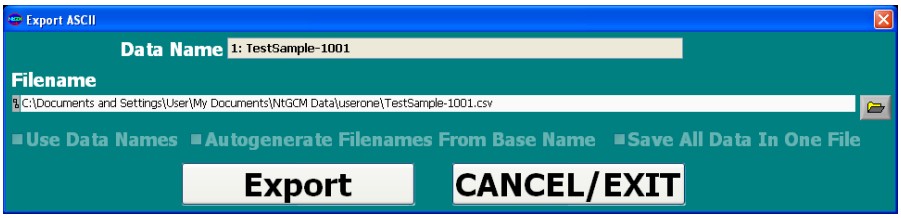
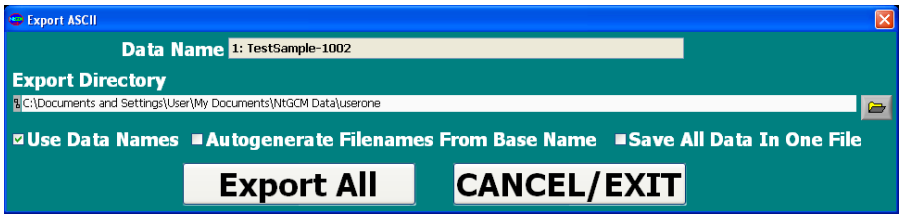


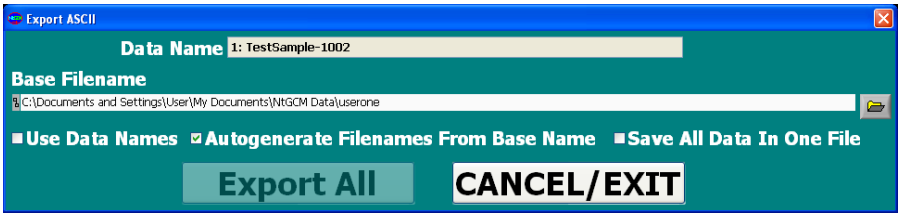
Figure 54: Selecting the data to export. It is possible to select a single or multiple datasets and to save that data in one or multiple files.



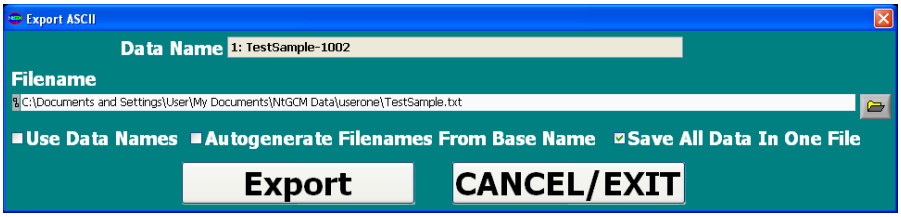
(a) Exporting a single dataset



(b) Using data name to generate filenames when exporting for multiple datasets



(c) Filenames for multiple datasets can be generated from a user input base name



(d) Data from multiple measurements can also be exported to a single file

Figure 55: Dialogs for exporting data for (a) a single dataset, as well as (b), (c) options for naming files that **NtGCM** offers when exporting multiple datasets. (d) Multiple datasets may also be exported to a single file. In that case, the data columns will be concatenated.

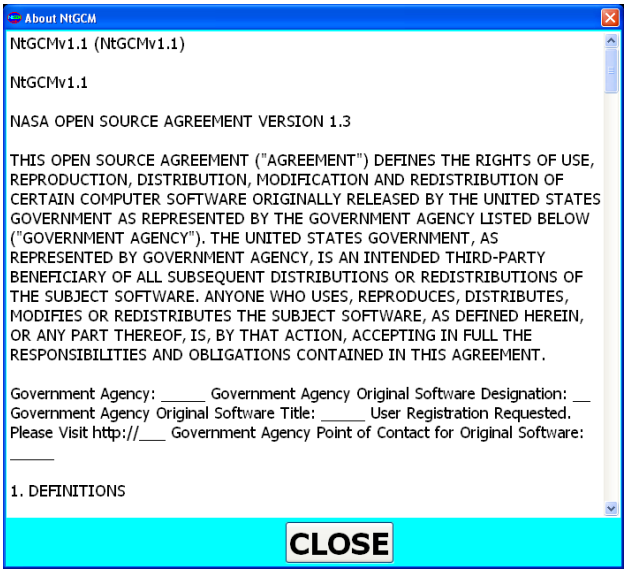
8.7 Reading measurement and messages logs

Back to the table of contents

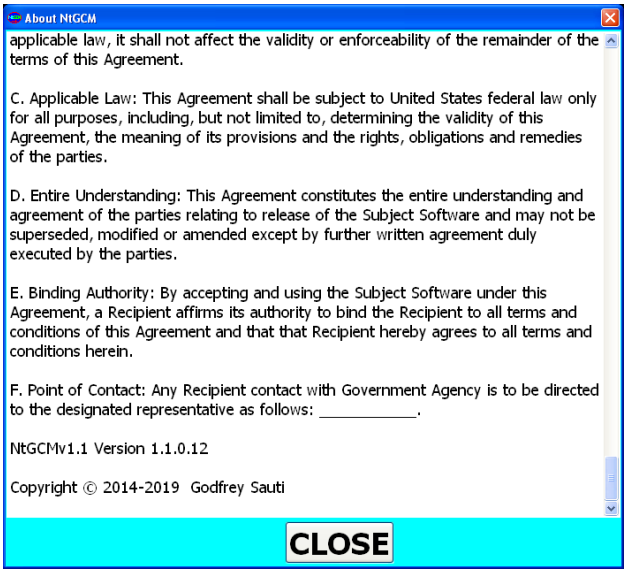
can open saved measurement and messages logs in read-only mode using the host system's text editor. This function can be accessed from the menu through File→Read Measurement Log and File→Read Messages Log.

9 Getting help

features a help interface that includes access to this manual as well as instrument manuals. The manuals and other documentation are in ***.pdf** format and therefore reading them requires a working installation of a suitable reader to be available on the host computer. Information about the program, including the version number be be accessed through the menu selection Help→About. This brings up the dialog shown in Fig. 56.



(a) Information about the program



(b) Information about the program (cont)

Figure 56: Information about **NtGCM**

This manual can be accessed through the menu selection Help→NtGCM Users Manual. Individual instrument manuals are accessed through the menu selection Help→(..the instrument..). It is also possible to access all the literature in the program data store through the option Help→All Literature.This brings up the dialog shown in Fig. 57.

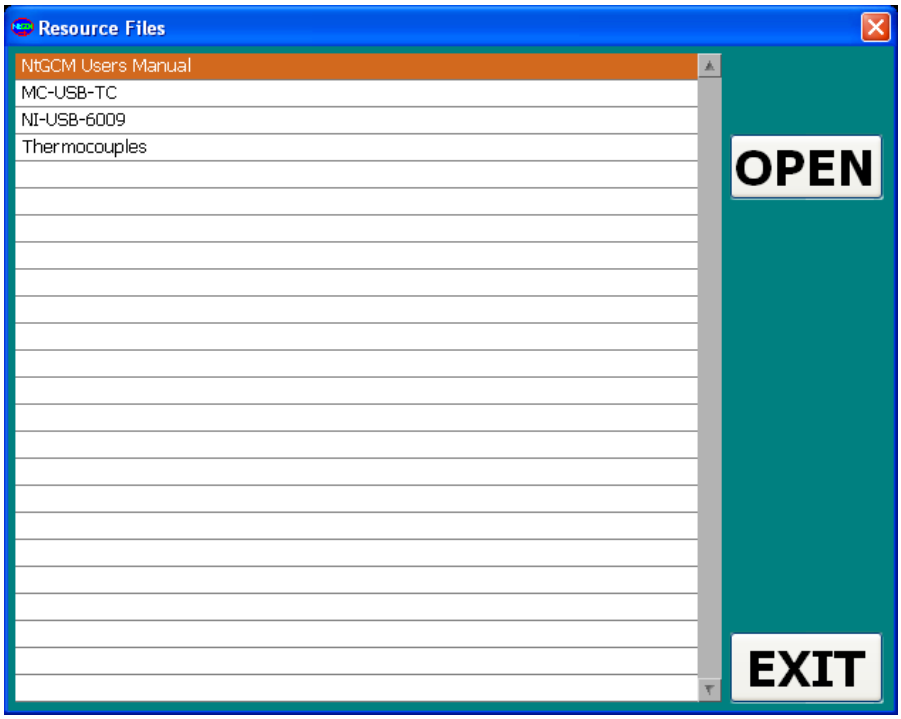


Figure 57: A listing of all the available resource files

Appendix A

Supported hardware

This software supports the use of any of the hardware described in this appendix for data acquisition.

A.1 USB DAQs ("Primary" DAQs)

Back to the table of contents

supports the DAQs below as the "Primary" device for reading most of the test data with the exception of the temperature probes which are read through a dedicated DAQ.

- **National Instruments NI USB 6009** This is a multifunction DAQ device with eight (8) analog in (AI) (14-bit, 48 kS/s), two (2) analog out (AO) (150 Hz) and thirteen (13) digital I/O channels.

A.2 Temperature DAQs

Back to the table of contents

uses a dedicated temperature reading DAQ that supports multiple probes.

1. **Measurement Computing USB-TC** (MC USB-TC) The MC USB-TC will support up to eight (8) thermocouples.

A.3 Temperature probes

Back to the table of contents

1. The MC-USB-TC supports type J, K, R, S, T, N, E, and B thermocouples.

IMPORTANT! For configuring the MC USB-TC, the temperature probes (thermocouples) to be used have to be specified in the Measurement Computing provided and separately installed ***Insta*Cal** software. The corresponding setting in is only used for reference purposes and DOES NOT affect the actual hardware used. It is up to the user to make sure that the correct temperature probe is being used and that the readings are being interpreted correctly.

Appendix B

Setting up the USB DAQs

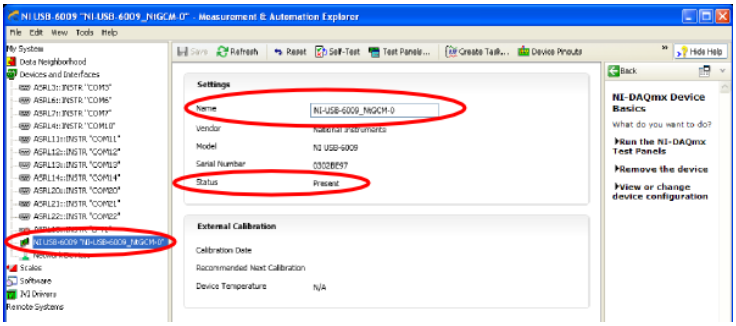
Back to the table of contents

Note that the following information includes settings in 3rd party software. The Developers and maintainers of NtGCM make no claims as to the accuracy of the information which is only intended to help the user get started. For more up to date and accurate information, the user is strongly advised to consult the documentation for the 3rd party tools.

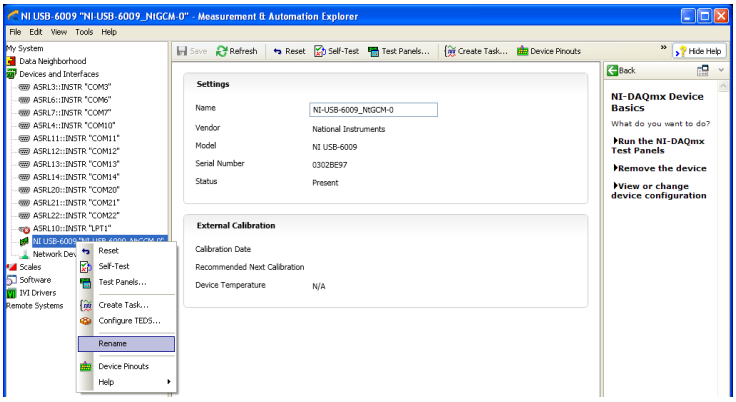
B.1 Setting up the NI-USB-6009 in NI MAX and NtGCM

1. Make sure that the device is connected to the computer and that the status indicator LED is ON.
2. Open National Instruments Measurement and Automation Explorer (NI MAX). **NtGCM** was compiled with the Version of MAX shown in Fig. B58(a).
3. In NI MAX, under **Devices and Interfaces** find your device (NI-USB-6009). Information about the device will be displayed under **Settings**. Key are the **Name** and **Status** (Fig. B58(b)). The device name must correspond to the setting in **NtGCM** and the device status must be ***Present*** for it to be accessed by NtGCM.
4. To rename a device, in the left hand panel, right-click on the selected device and select *Rename* then enter the new name (Fig. B58(c))
5. For USB devices, NtGCM using the naming convention ***Device***`_NtGCM-`***Number*** is used. Device and Number should be as shown in the select device dialog (Fig. B59).
6. A restart of NtGCM and or the computer may be required to make the settings take effect.

(a) NI MAX Version used in **NtGCM** compilation



(b) Key settings for the NI USB-6009 DAQ



(c) Renaming the device

Figure B58: Configuring the USB DAQ in NI MAX

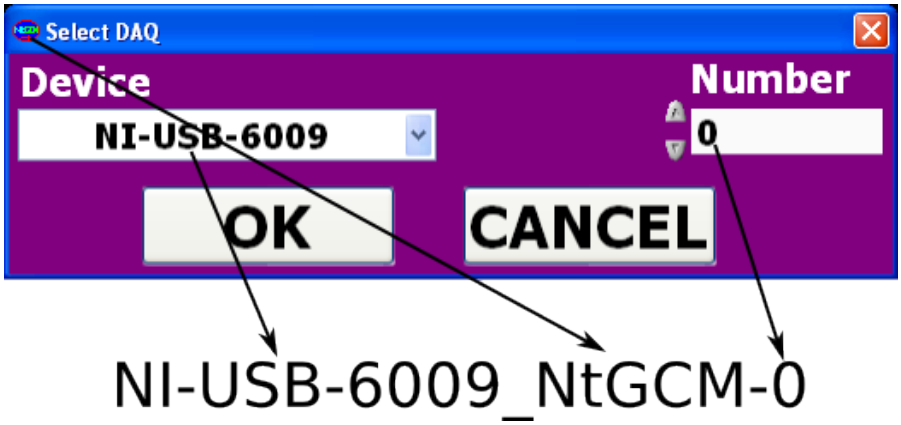
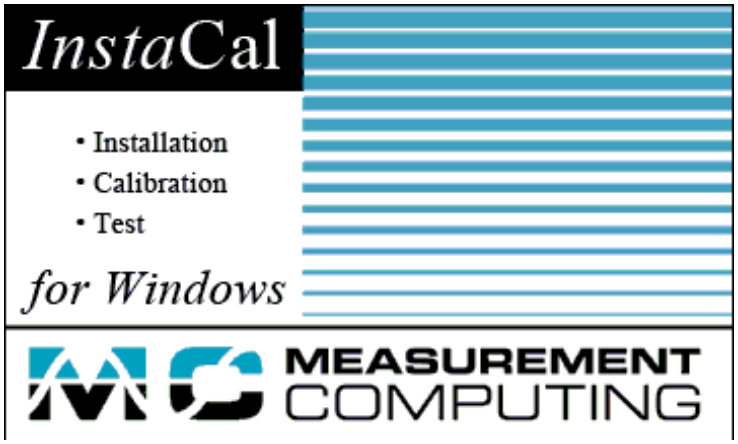


Figure B59: The convention for naming a USB DAQ in **NtGCM**. The corresponding name must be entered in NI MAX in order for **NtGCM** to be able to communicate with the device.

B.2 Setting up the USB-TC in *Insta*Cal

The version of ***Insta*Cal** used to test NtGCM is show in Fig. B60. To use ***Insta*Cal**...

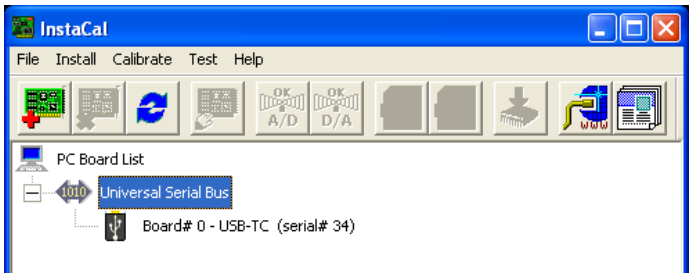
1. Make sure that the device is connected to the computer and that the status indicator LED is ON.
2. Open Measurement Computing ***Insta*Cal**. Information about the devices (Boards in ***Insta*Cal**notation) that are available should then be displayed as shown in Fig. B61(a). If there are more than one device attached, you may need to use ***Insta*Cal**'s blink feature to identify the board you intend to use with NtGCM.
3. If necessary, you can change the number of a board as shown in Figs. B61(b) and B61(b) to match what you intend to use in NtGCM. **In order for NtGCM to be able to communicate with the Device, the Board number must match the Device number in the NtGCM select temperature DAQ dialog.**
4. Select the type of thermocouple that you intend to use as shown in Fig. B62(a). **Note: This is the ONLY place you have to select the thermocouple that will be used. As stated elsewhere, the selection in NtGCM is only used for reference purposes**
5. Save the configuration as shown in Fig. B62(b).The naming convention for the configuration is ***Device*_NtGCM-*Number***. Device and Number should be as shown in the select device dialog (Fig. B63).
6. Make sure that the configuration that you intend to use has been sent to the device. A dialog to that effect appears when you save a configuration different from the current one.
7. A restart of the computer is recommended to make the settings take effect.
8. You may also need to plug and unplug the device if you have communicated with it using ***Insta*Cal**, before NtGCM can take proper control of it.



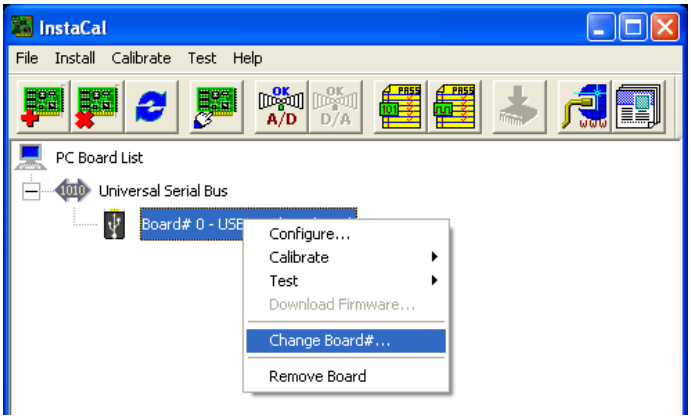
(a) The ***Insta*Cal** banner

(b) The ***Insta*Cal** version used to test **NtGCM**

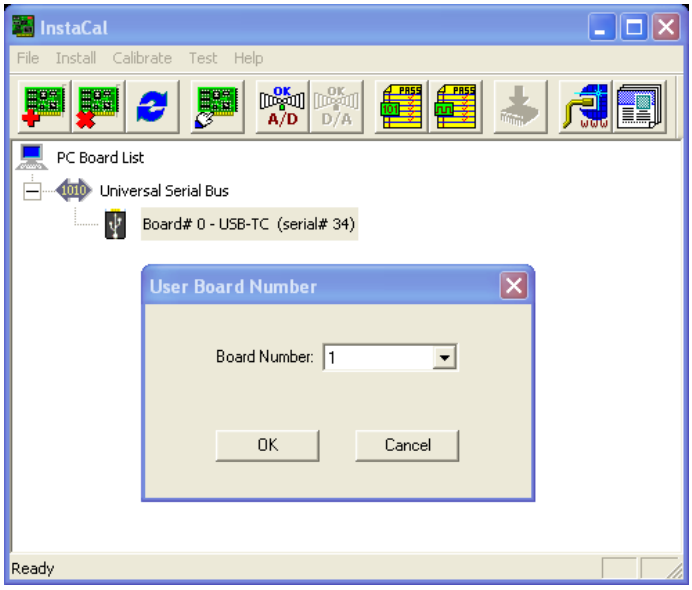
Figure B60: The version of ***Insta*Cal** used to test **NtGCM**



(a) The Boards available

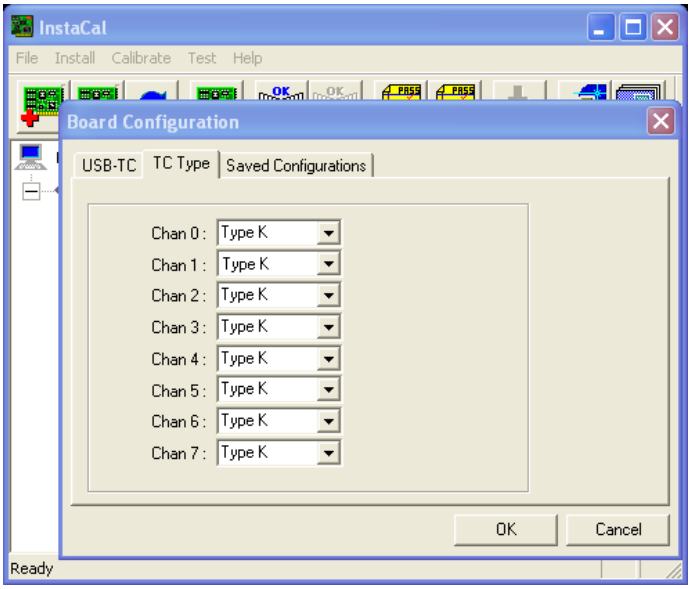


(b) Changing the Board Number

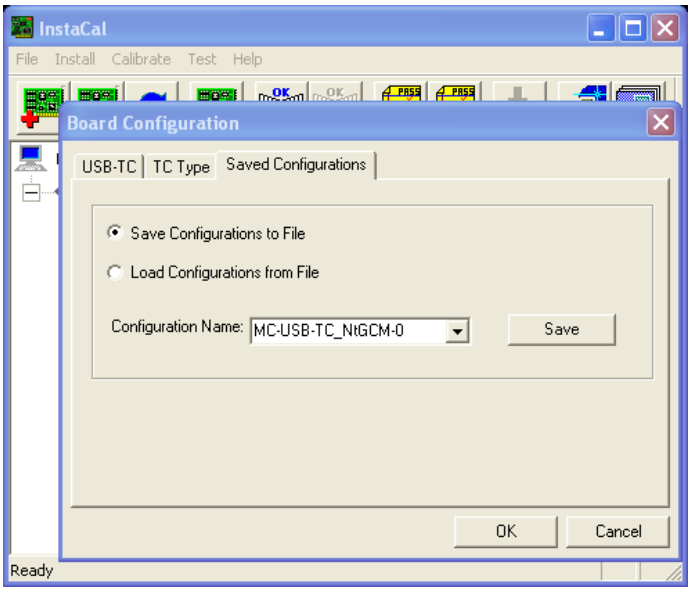


(c) Selecting the Board Number

Figure B61: Selecting a device and setting the Board Number in ***Insta*Cal**. The Board Number is equivalent to the Device Number in **NtGCM**.



(a) Selecting a thermocouple in ***Insta*Cal**



(b) Saving the configuration

Figure B62: Selecting the thermocouple and saving the configuration in ***Insta*Cal**. Note that while it may be possible to assign different thermocouple types to the different channels, **NtGCM** assumes a single type of thermocouple is being used for all the channels. Note that this limitation in **NtGCM** only affects the information written about the measurement and the user could use multiple thermocouple types as allowed by ***Insta*Cal** and add appropriate comments to the measurement notes.

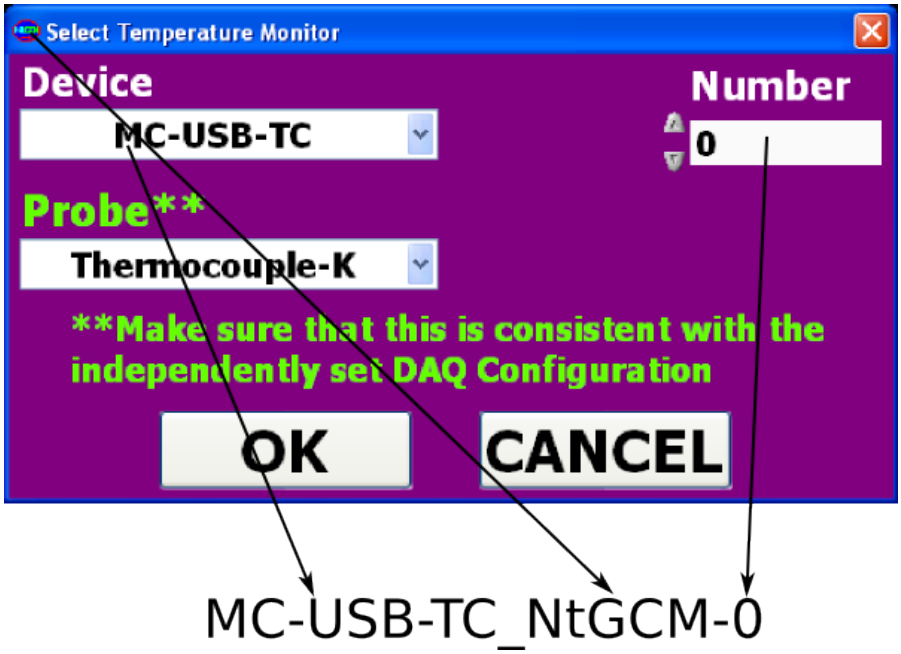


Figure B63: The convention for naming a temperature DAQ in **NtGCM**. The device number used in **NtGCM** must match the board number in ***Insta*Cal** in order for **NtGCM** to be able to communicate with the device.

Appendix C

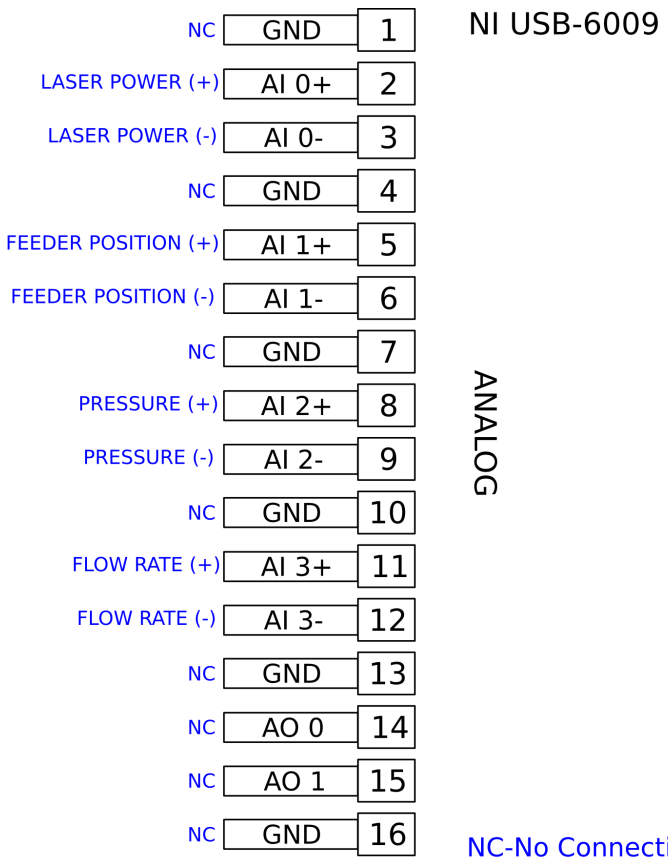
Troubleshooting the USB devices

Back to the table of contents

In the event of communications trouble with the USB devices, the user may try self-test and reset procedures using NI MAX for the NI USB-6009 and ***Insta*Cal** for the MC USB-TC. To access the interactive control of these devices follow the steps in Sections B.1 and B.2 to get the dialogs in figures B58, B60, B61, and B62. Additional information about these may be found in the appropriate instrument manuals.

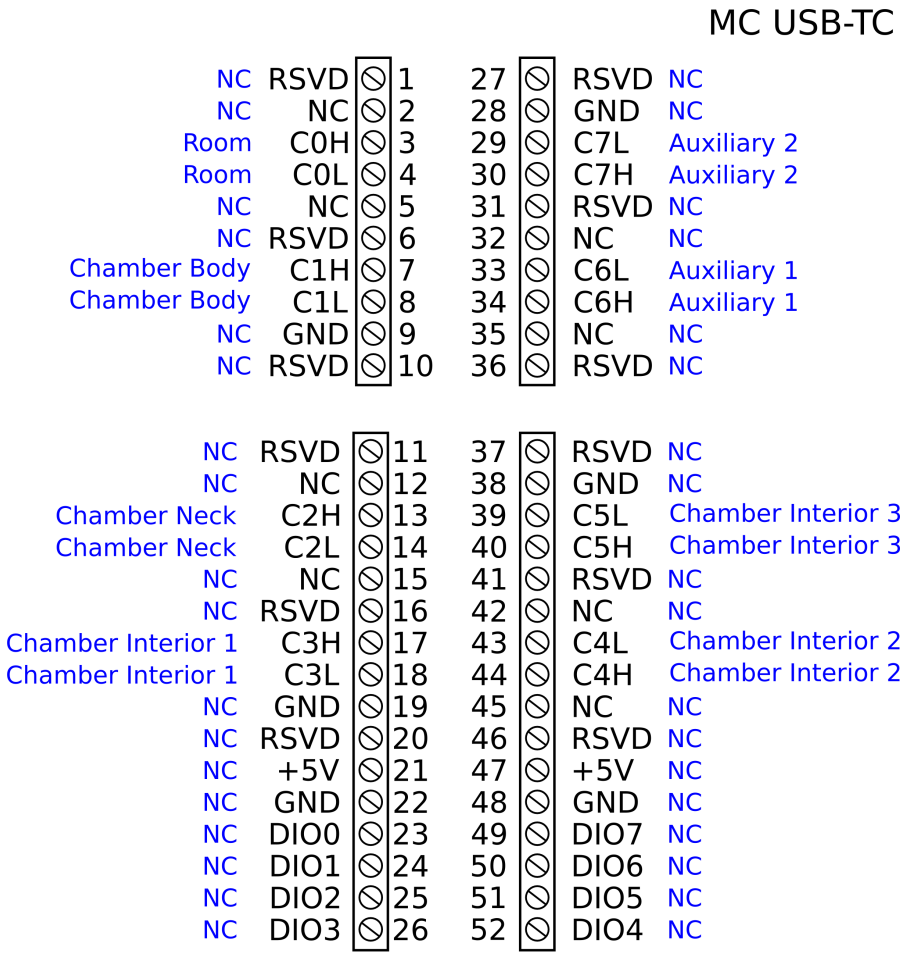
C.1 Wiring diagrams

Figures C64 and C65 are the recommended wiring diagrams for the NI USB-6009 and MC USB-TC. Note that the actual wiring used may differ from the recommendation if necessary but the user must make sure to make the appropriate changes in the instrument settings file for the NI USB-6009 or including them in the measurement notes for the MC USB-TC.



Default configuration. The above connections apply ONLY for the default configuration. Any changes to these must be matched by changes in the configuration file **NtGCM_Instrument_Settings.cfg**

Figure C64: Recommended wiring for the NI USB-6009



NC-No Connection

Recommended wiring. Any deviations from the above should be recorded in the measurement notes to enable the correct interpretation of the recorded data.

Figure C65: Recommended wiring for the MC USB-TC

REPORT DOCUMENTATION PAGE

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(High Pressure High Temperature Laser based) Nanotube Growth Chamber Monitor

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14. ABSTRACT

This manual describes the installation and use of NtGCM software. NtGCM is software designed for monitoring the growth of nanotubes in a high temperature and high pressure chamber using a laser*. NtGCM software monitors a dozen different parameters that are important to understanding the growth of the nanomaterials including the laser input power, the temperature at eight separate locations inside and outside the growth chamber, as well as the pressure and flow rate of the gaseous media that control the environment in the chamber. The measurements are all made in real time. The program features a robust user account management layer and a rich data display manager that allows plotted data, displayed units and other parameters to be changed on the fly for the operator's convenience.

15. SUBJECT TERMS
Laser Grown Nanotubes, Boron Nitride Nanotubes, High Pressure, High Temperature, LabVIEW Programming

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