Instrumentation
et mesure

User's guide

ISO SOFTWARE

TWO-PHASE FLOW STUDY

Summary

1 INTRODUCTION

The Interface Software for Optical probes, i.e. “ISO”, has been developed with the following two main objectives:

1. drive the RBI acquisition device, thus producing raw binary files,
2. process these raw files in order to get some quantitative information, through interactive menus and graphs.

The purpose of the following manual is to explain how to install, remove and use this software.

Warnings:

- *ISO software has been successfully tested with Windows 7. Malfunction has been demonstrated with Windows XP and Windows VISTA.*
- *ISO requires Microsoft .NET Framework client*

2 INSTALLATION

The installation procedure must follow 3 consecutive steps.

2.1 Install hardware first

Before using your acquisition board, you must plug it and install its driver. Without switching off your computer, please follow these steps:

1. plug the power supply into the acquisition device,
2. plug the USB cable into the acquisition device,
3. plug the USB cable into the computer,
4. since it is plug-and-play compliant, the new hardware device will be automatically detected by the operating system,
5. if you have an active internet connection, the driver will be automatically downloaded and installed,
6. if asked for the driver "USB Serial Converter", redirect to the local installation file `ftdibus.inf` located on the CD, in one of the *`<CD root>\Driver\Windows xx bits`* subfolders, to be chosen depending on which Windows version is operating (32 or 64 bits),
7. if asked for the driver "USB Serial Port", redirect to the local installation file `ftdiport.inf` located on the CD, in one of the *`<CD root>\Driver\Windows xx bits`* subfolders, to be chosen depending on which Windows version is operating (32 or 64 bits).

At this point, the acquisition driver is installed and will be loaded every time the acquisition board will be plugged to your computer.

2.2 Install National Instruments LabView runtime engine

ISO has been programmed in G-language using National Instruments development environment LabView. For easy distribution purposes, ISO has been compiled and an executable version is provided with the acquisition device.

Before operating ISO, the LabView runtime engine, distributed free of charge by National Instruments, must be installed on your computer. Adequate version of LabView runtime engine is located on the CD, in the *`<CD root>`*`\LabView RunTime Engine` directory. By running it, you can either install the runtime engine version in various languages.

You may be proposed to reboot your computer.

2.3 Install the ISO software

To properly install and operate ISO, ***YOU MUST HAVE ADMINISTRATOR PRIVILEGES***.

1. the installation program, called `ISO Installer.exe` , is located in the root directory of the CD,
2. run it as administrator (using right mouse button),
3. follow the instructions given by the installation wizard,
4. choose your language for installation,
5. select the directory where ISO will be installed; the default location proposed by the wizard is `C:\Program Files\Rbi`,
6. the installation wizard checks the consecutive actions (creation of directories, transfer of files, Registry initialisation…) and informs you whether the installation procedure succeeds or fails.

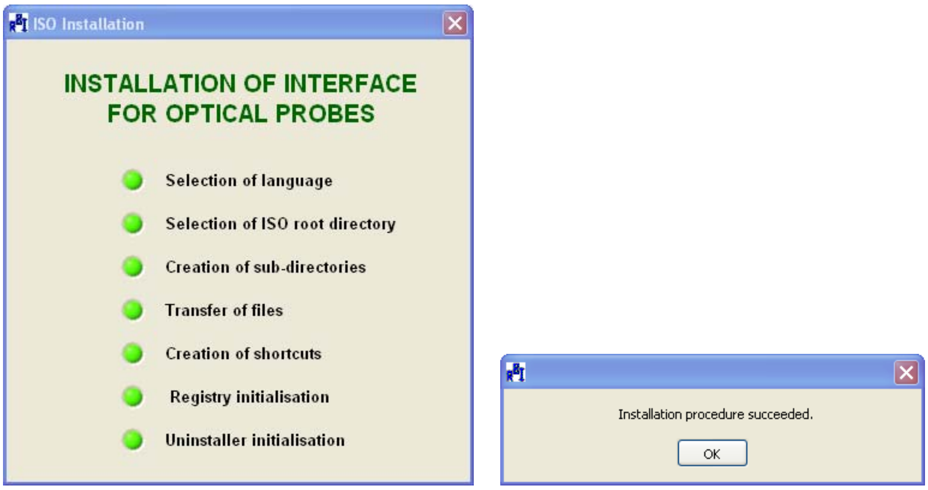

Figure 1: Installation wizard front panel

The installation wizard creates the following sub-directories:

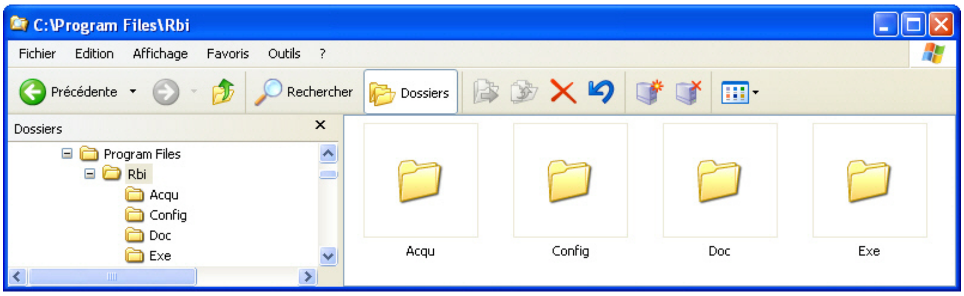

Figure 2: Directories required by ISO to operate

The installation wizard creates new keys and values in Windows Registry. Crucial operating parameters are stored in `HKEY_LOCAL_MACHINE\SOFTWARE`. This explains why you must have administrator privileges to access this Registry zone during installation.

3 REMOVAL

The removal procedure must follow 3 consecutive steps.

3.1 Uninstall the ISO software

To properly remove ISO, ***YOU MUST HAVE ADMINISTRATOR PRIVILEGES***.

1. run the uninstaller wizard through the Windows Control Panel,
2. follow the instructions given by the uninstallation wizard. It will check the consecutive actions (deletion of directories and files, Registry cleanup…) and informs you whether the removal procedure succeeds or fails.

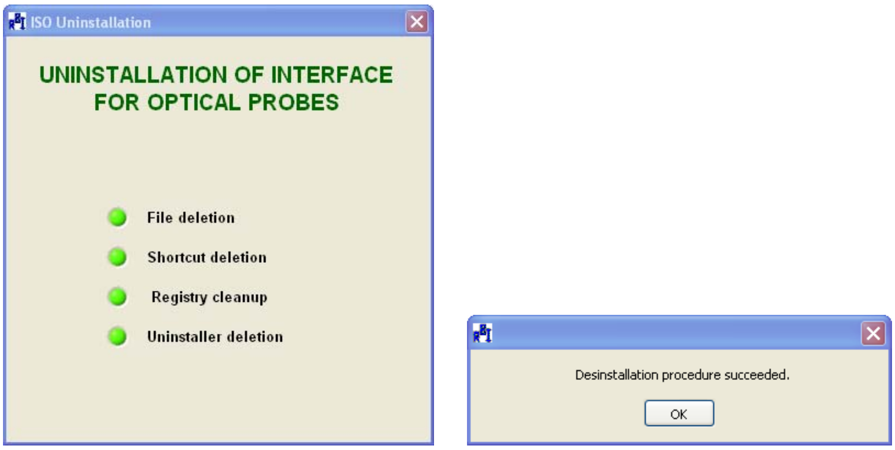

Figure 3: Removal wizard front panel

Notice all the folders and files located in ISO root directory are deleted by the removal procedure.

3.2 Uninstall National Instruments LabView runtime engine

Remove National Instruments LabView runtime engine through the Windows Control Panel.

3.3 Uninstall hardware driver

Remove the acquisition board driver through the Windows Control Panel.

4 STARTING ISO

The installation procedure places shortcuts on the Desktop and in the Start menu. Use these shortcuts to run ISO. Any user, even logged with restricted privileges, can operate ISO.

4.1 Introducing remark

The main objective of ISO is to perform acquisitions with multi-sensor optical probes, and to process the signals interactively. For that purpose, calculation results are, in most cases, presented by use of graphs and plots. The graphical user interface of ISO has been optimised for screen resolutions of 1280 x 1024 or higher. If ISO is used with lower screen resolutions, some front panels will be partially visible. Vertical scrolling will however be enabled by the presence of cursors beside the right border of windows.

4.2 Initialisation

When launched for the first time, ISO initialises the set of operating parameters to default values. These parameters are stored in the user's private Registry space `HKEY_CURRENT_USER\SOFTWARE`. In the same time, ISO creates several sub-directories in the user's private disk space. A first sub-directory, named `<My Files>\Rbi\Config`, is dedicated to the storage of probe characteristics. A second sub-directory, named `<My Files>\Rbi\Acqu`, is dedicated to the storage of data files created during signal acquisition. The initialisation procedure places some samples of such files in these folders. Once the initialisation is achieved, the following dialog-box is shown.

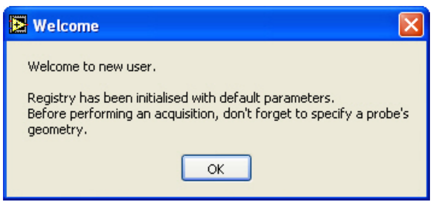

Figure 4: Dialog-box appearing after the initialisation procedure completes

4.3 Main menu

When started, ISO presents the main menu, as followed:

Figure 5: ISO main menu

4.3.1 Generalities

By pressing buttons, you have access to various tasks, such as:

- defining the geometry of a probe,
- performing an acquisition,

- processing stored acquisition files.

These buttons will be described in details further. But before performing these actions, you may wish to change some global working parameters.

4.3.2 Changing the working directories

As explained in § 4.2, the initialisation procedure creates some directories required by ISO to store various files. By default, these directories are located in the user's private disk space. The `Storage folders` item in ISO menu (see tag `2` in Figure 5) allows you to change some of these locations:

- *Configuration files*
  As it will be described later, you can store the geometrical characteristics of multi-sensor probes in archive files. By default, these files are stored in the `Config` sub-folder. You can designate another location by using the relevant menu or directly by pressing `Ctrl+G` key combination.

- *Acquisition results*
  After performing an acquisition, data are archived in binary files. By default, these files are stored in the `Acqu` sub-folder. You can designate another location by using the relevant menu or directly by pressing `Ctrl+A` key combination.

- *Temporary files*
  When processing archived acquisition files, ISO performs some calculations and generates intermediate files. By default, these files are stored in Windows temporary sub-folder. You can designate another location by using the relevant menu or directly by pressing `Ctrl+T` key combination.

Changes are immediate and permanent, which means that the specification of a new folder still remains valid after closing ISO.

4.3.3 Changing the language

As described previously, the installation procedure asks you to choose a language for installation (cf. § 0). By default, the same language is used by ISO. However, the `Language` item in ISO menu (see tag `3` in Figure 5) allows you to change the current language. You can also directly press `Ctrl+E` or `Ctrl+F` key combination to designate respectively English or French as the current language.

A change is not immediate. You must close ISO and start it again to read menus and texts in the newly specified language.

4.3.4 Getting help

The `Help` item in ISO menu (see tag `4` in Figure 5) gives you access to some helping information. You can also directly press `Ctrl+H` to open the present manual. The `Ctrl+?` key combination shows you which version of ISO is running.

4.3.5 Closing ISO

The `Exit` item in ISO menu (see tag `1` in Figure 5) or the button labelled `EXIT` (see tag `12` in Figure 5) closes ISO. You can also return to Windows by directly pressing `Ctrl+X` key combination.

5 CONFIGURATION OF A MULTI-SENSOR PROBE

You intend to use a multi-sensor probe to investigate a two-phase flow. For this purpose, you need to perform an acquisition of the signals delivered by the probe and to process them. The calculation of some characteristics of the flow (such as velocities, interfacial area, mean Sauter diameter…) requires the knowledge of the spacing between sensors and their orientation relatively to the flow.

It is important to know that, when performing an acquisition with ISO, these geometrical characteristics are embedded with the signals in the binary storage file, in order to give this file an autonomous feature for later processing. Consequently, information on the current probe geometry must be specified ***before*** performing any acquisition.

A dedicated interface gives you the ability to specify the spatial arrangement of the multi-sensor probes you are using. Pressing the button labelled `PROBE GEOMETRY & LOCATION` or the shortcut `F1` in ISO main menu (see tag 5 in Figure 5) activates this interface.

5.1 Geometry front panel

The following front-panel is presented:

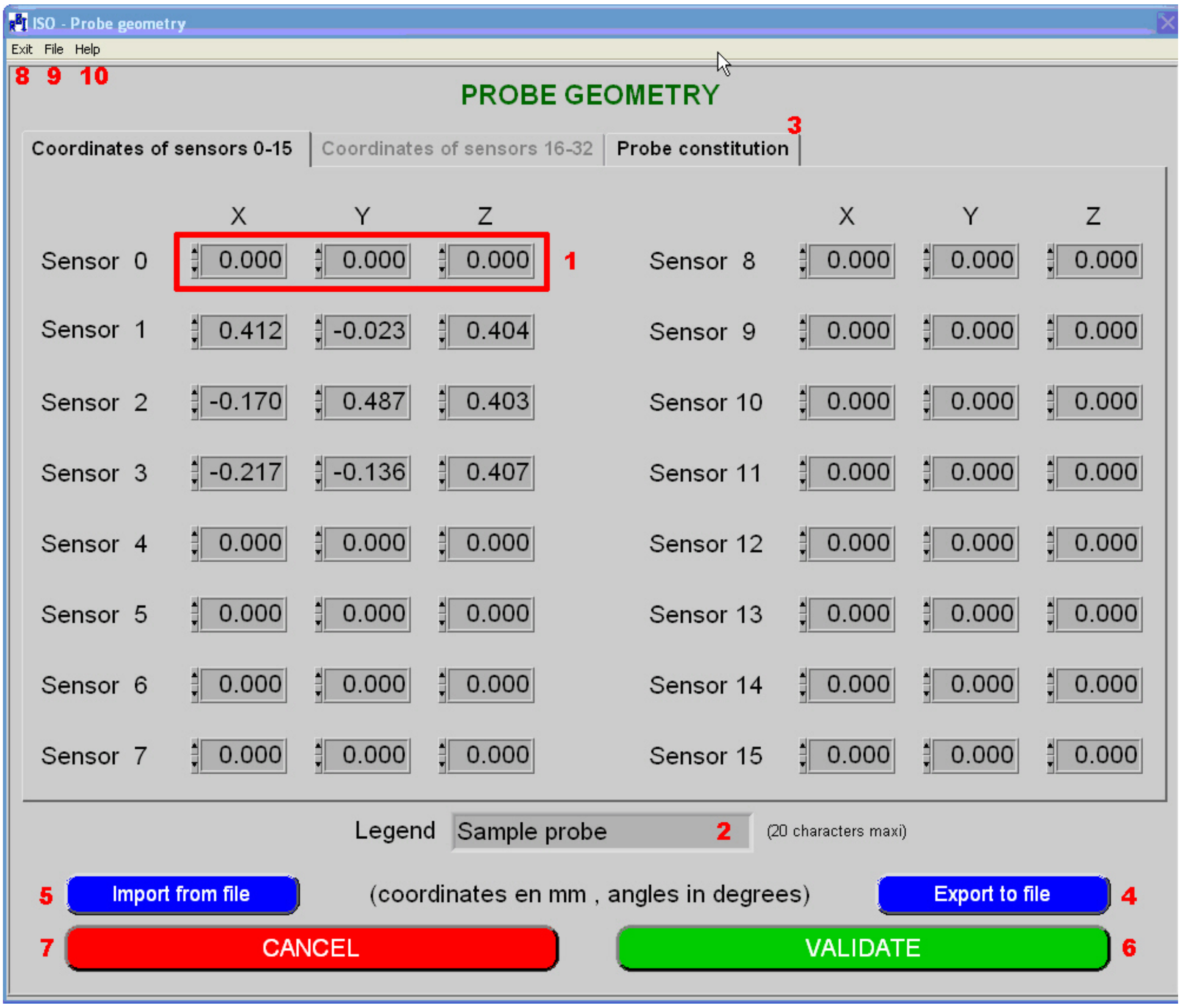

Figure 6: Front panel for specification of probe geometry

5.1.1 Setting the geometry characteristics

You must enter the coordinates (X,Y,Z) defining the spatial location of each tip of your multi-sensor probes (see tag 1 in Figure 6).

The Z-axis is oriented in the direction of the flow, as depicted in Figure 7.

All coordinates are captured in millimetres.

Each sensor number (from 0 to 15) corresponds to an input channel of the RBI acquisition board. Consequently, you can specify the coordinates of up to 16 sensors, which can belong to different probes.

You can identify the current set of coordinates by a legend, which is a string composed of, at most, 20 characters (see tag 2 in Figure 6). When processing data provided by a given probe, this legend appears on the interface, thus enabling an easy identification of the probe geometry.

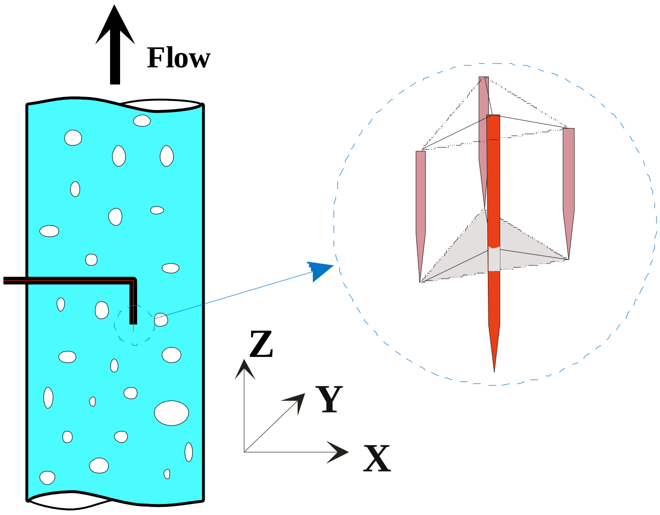

Figure 7: Convention for axis orientation

Other parameters can be specified on a complementary panel (see tag 3 in Figure 6). In particular, if a probe is inclined in the flow, you can simply enter the inclination angle (in degrees). Consequently, when processing data, the absolute position of each probe tip will be recalculated, taking automatically the inclination into account.

5.1.2 Managing archived settings

If you manage several probes, you can store the geometry settings of a probe in an archive file, by pressing the button labelled `Export to file` (see tag 4 in Figure 6), by using the dedicated menu (see tag 9 in Figure 6) or directly by pressing `Ctrl+E` key combination. You will be asked to provide the name of the archive file. By default, the directory proposed to store this file is the `Config` sub-folder, if not changed previously (cf. § 4.3.2).

At the opposite, you may wish to reload the geometry settings of a different probe, previously stored in an archive file. This importation can be performed by pressing the button labelled `Import from file` (see tag 5 in Figure 6), by using the dedicated menu (see tag 9 in Figure 6) or directly by pressing `Ctrl+I` key combination. You will be asked to provide the name of the archive file. By default, the directory proposed to locate this file is the `Config` sub-folder, if not changed previously (cf. § 4.3.2).

5.1.3 Validating or cancelling the settings

To use the information appearing on this geometry panel as the current settings, you must validate your capture and close the panel. This operation can be achieved by pressing the button labelled `VALIDATE` (see tag 6 in Figure 6), by using the dedicated menu (see tag 8 in Figure 6) or directly by pressing `Ctrl+S` key combination. The geometry settings will be stored in Windows Registry and used for later acquisitions.

If you want to cancel your capture and close the panel, press the button labelled `CANCEL` (see tag 7 in Figure 6), use the dedicated menu (see tag 8 in Figure 6) or directly pressing `Ctrl+X` key combination. The information appearing on the panel will be discarded and the current geometry settings stored in Windows Registry will not be modified.

5.1.4 Getting help

The `Help` item in menu (see tag 10 in Figure 6) gives you access to some helping information. You can also directly press `Ctrl+H` to open the present manual. The `Ctrl+?` key combination shows you which version of ISO is running.

6 PERFORMING AN ACQUISITION

6.1 Acquisition parameters

Before performing an acquisition, you must initialise several parameters. A dedicated interface gives you the ability to specify them. Pressing the button labelled `ACQUISITION PARAMETERS` or the shortcut `F2` in ISO main menu (see tag 6 in Figure 5) activates this interface.

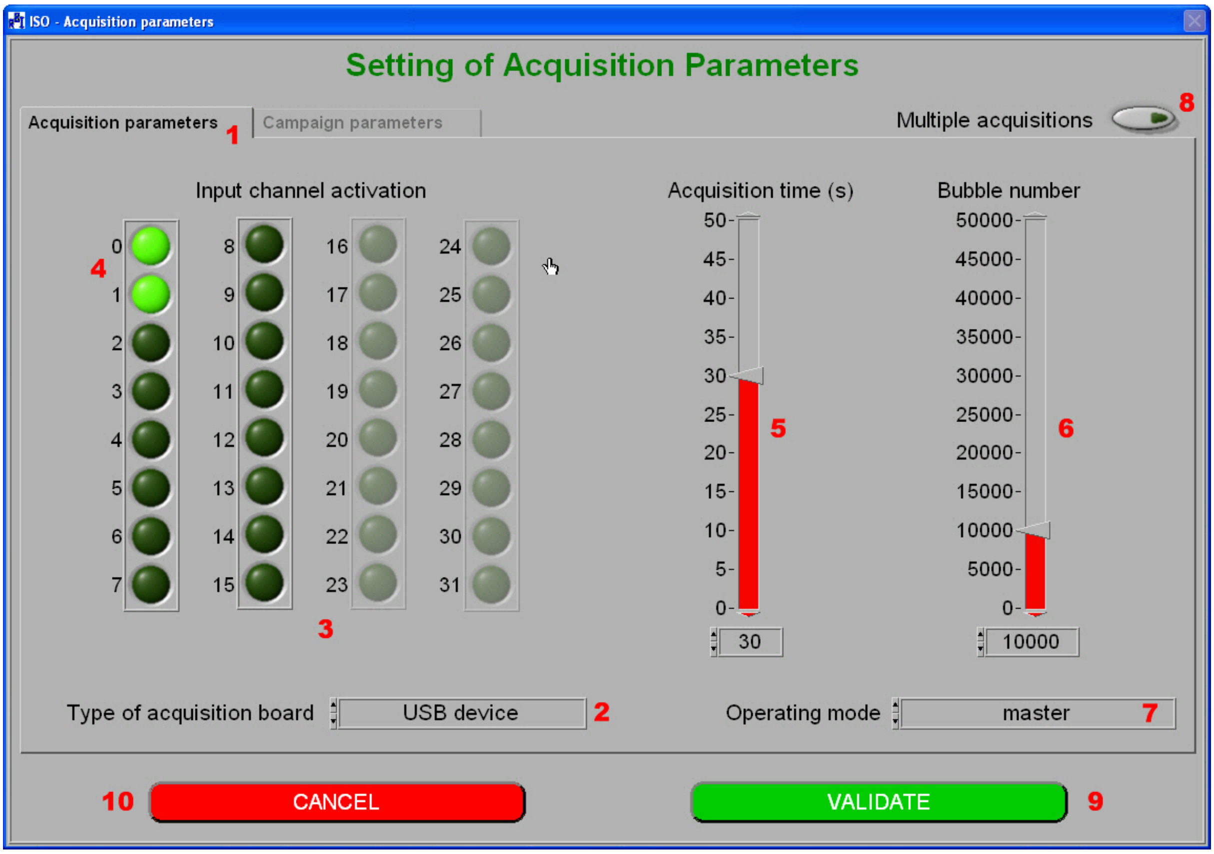

Figure 8: Front panel for specification of acquisition parameters

The main front panel is presented (see tag 1 in Figure 8), in which the main acquisition parameters can be specified.

6.1.1 *Selecting the acquisition board*

In the dedicated list (see tag 2 in Figure 8), you can select the type of acquisition board you intend to use. By default, the item `no device` is selected, which prevents from erroneously launching an acquisition if really no device is connected.

6.1.2 *Selecting the active input channels*

The maximum number of available input channels (see tag 3 in Figure 8) depends on the type of board which has been selected.

By clicking on the corresponding lights (see tag 4 in Figure 8), you can activate or inhibit individual input channels. A green light depicts an active channel, while a dark light indicates an inactive channel. The latter means that, even if a sensor is connected to this input channel, the incoming signal will be ignored by the acquisition board.

6.1.3 *Selecting the stopping criteria*

You must define when an acquisition will end. Two criteria can be taken into account:

- `Acquisition time` *criterion*

  With the relevant slider (see tag `5` in Figure 8), you can select the maximum acquisition time. When the board starts to operate, its internal clock is activated and the process stops after the specified duration expires.

- `Bubble number` *criterion*

  With the relevant slider (see tag `6` in Figure 8), you can select the maximum number of bubbles detected by the board. When the latter starts to operate, its internal counter is incremented as soon as a bubble is detected on one of the active input channels. The process stops after the counter value exceeds the specified maximum bubble number.

Both criteria have the same level of priority. This means that, in reality, the acquisition ends as soon as one of these two stopping criteria is satisfied.

6.1.4 *Selecting the operating mode*

In the relevant list (see tag `7` in Figure 8), you can select between 3 operating modes.

- `master` *mode*
  In this mode, the acquisition is launched interactively by the user and starts immediately (cf. § 6.3).

- `hardware synchronised` *mode*
  In this mode, the acquisition starting-up is triggered by the rising edge occurrence of an external TTL signal, provided to the board on the relevant connector. Independently from the TTL signal, the acquisition ends by itself when one of the stopping criteria is satisfied (cf. § 6.1.3).

- `hardware slave` *mode*
  In this mode, the acquisition is totally controlled by the external TTL signal provided to the board on the relevant connector. It means that the acquisition starts when a rising edge occurs, but is temporarily suspended when a falling edge occurs. Acquisition can continue if another rising edge occurs, and so on. The acquisition definitely ends when one of the stopping criteria is satisfied (cf. § 6.1.3).

- `software triggered` *mode*
  In this mode, the acquisition is launched interactively by the user but does not start immediately. A dedicated dialog box is proposed (cf. § 6.3) and the acquisition only starts when the dialog box is minimized, hidden or closed.

The `hardware synchronised` and `hardware slave` modes provide the opportunity to respectively trigger or control the acquisition by an external process. The `software triggered` mode provides the opportunity to trigger the acquisition by an external program.

6.1.5 *Selecting to perform a single acquisition*

When the push-button labelled `Multiple acquisitions` is off (see tag `8` in Figure 8), a single acquisition can be performed at a time.

6.1.6 *Validating or cancelling the settings*

To use the information appearing on this panel as the current parameters, you must validate your capture and close the panel. This operation can be achieved by pressing the button labelled `VALIDATE` (see tag `9` in Figure 8). The parameters will be stored in Windows Registry and used for later acquisitions.

If you want to cancel your capture and close the panel, press the button labelled `CANCEL` (see tag `10` in Figure 8). The information appearing on the panel will be discarded and the current acquisition parameters stored in Windows Registry will not be modified.

6.2 Multiple acquisition parameters

Instead of achieving a single acquisition, a sequence of multiple acquisitions can be automatically performed.

In the interface dedicated to acquisition parameters, when the push-button labelled `Multiple acquisitions` is high lightened (see tag 1 in Figure 9), a secondary panel labelled `CAMPAIGN PARAMETERS` is accessible (see tag 2 in Figure 9).

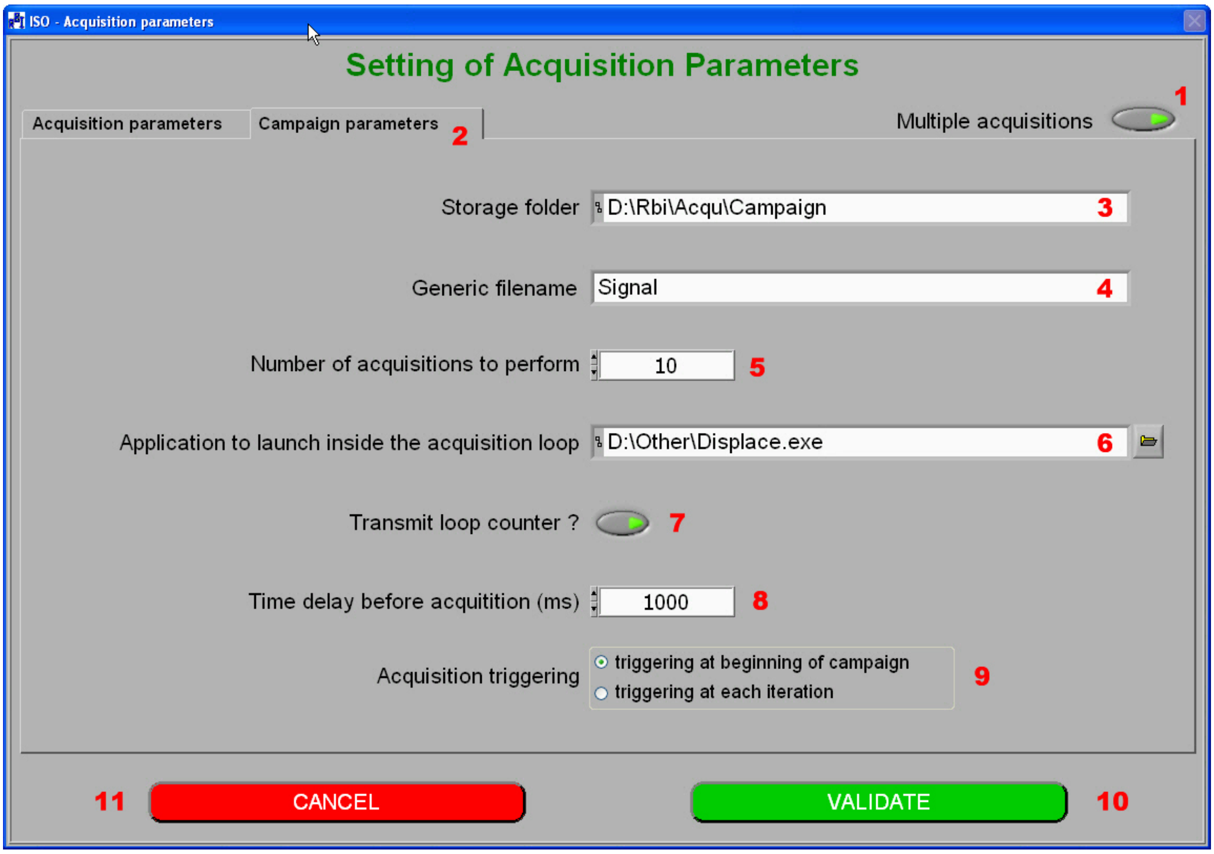

Figure 9: Front panel for specification of multiple acquisition parameters

6.2.1 *Defining the file storage syntax*

The first string capture field is used to define the directory where to store the acquisition files (see tag 3 in Figure 9).

The second string capture field is used to define the generic name of the files (see tag 4 in Figure 9).

At each iteration of the looped acquisition sequence, the absolute file path is composed by appending:

- the directory name
- the generic file name
- the value of the loop counter
- the generic extension `.rbi`

As an example, with the parameters specified in Figure 9, a series of files will be created, whose path is `D:\Rbi\Acqu\Campaign\Signal`*`ii`*`.rbi` where *`ii`* is replaced by the value of the loop counter.

6.2.2 *Defining the iteration number*

A numeric capture field is used to specify the number of acquisitions to perform (see tag 5 in Figure 9).

6.2.3 *Defining an additional iterative task to achieve*

At each iteration in the looped sequence, a command can be launched to perform an external task such as a displacement of the probe for instance.

A string capture field (see tag `6` in Figure 9) is used to specify the name of the program that must be run iteratively. This string must indicate the absolute path to an executable file (`.bat` or `.exe` type).

This external application can be launched with (or without) passing the value of the current loop counter as command-line argument. This possibility is activated (resp. inhibited) by using the dedicated push-button (see tag `7` in Figure 9).

It is important to mention that, at each iteration in the looped sequence, the external task is launched ***before*** performing an acquisition. A waiting time delay can be imposed between the end of the external task and the acquisition start-up (see tag `8` in Figure 9).

6.2.4 *Precising the operating mode*

When the `software triggered` operating mode is selected (cf. 6.1.4), the acquisition procedure is launched interactively by the user but does not start immediately. A dedicated dialog box is proposed (cf. § 6.3.1) and nothing happens until this dialog box is minimized, hidden or closed. The radio-buttons on the `CAMPAIGN PARAMETERS` panel (see tag `9` in Figure 9) are used to indicate if the triggering dialog box must be proposed once at the beginning of the campaign, or iteratively before the each acquisition of the campaign.

6.2.5 *Validating or cancelling the settings*

To use the information appearing on this panel as the current parameters, you must validate your capture and close the panel. This operation can be achieved by pressing the button labelled `VALIDATE` (see tag `10` in Figure 9). The parameters will be stored in Windows Registry and used for later acquisitions.

If you want to cancel your capture and close the panel, press the button labelled `CANCEL` (see tag `11` in Figure 9). The information appearing on the panel will be discarded and the current acquisition parameters stored in Windows Registry will not be modified.

6.3 Acquisition

Once the parameters have been set and stored in Windows Registry, you can perform one or several acquisitions by pressing the button labelled `ACQUISITION LAUNCHING` or the shortcut `F3` in ISO main menu (see tag `7` in Figure 5).

Depending on the parameters, this action will perform a single acquisition or begin a series of acquisitions.

In the case of a single acquisition, you will be asked to provide the name of the binary data file. By default, the directory proposed to store this file is the `Acqu` sub-folder, if not changed previously (cf. § 4.3.2).

If the acquisition fails, error code and message are reported. Some corresponding explanations and suggestions are provided in appendix.

6.3.1 *Software triggered acquisition*

When the `software triggered` operating mode is selected (cf. 6.1.4), the acquisition procedure is launched interactively by the user but does not start immediately. A dedicated dialog box (see Figure 10) is proposed and nothing happens until this dialog box is minimized, hidden or closed.

Figure 10: Dialog box used to trigger the acquisition

If the dialog box is minimized, hidden or closed externally by a third-party software or when the `Yes` button is pressed, the acquisition procedure is launched. If the `Cancel` button is pressed, the acquisition procedure is abandoned.

As an example, a triggering tool is provided with ISO during its installation. When executed, this program closes the dialog box if the latter has been previously opened. This program is named `ISO_External_Acquisition_Trigger.exe` and is located in the directory where ISO has been installed.

7 PERFORMING A DETAILED ANALYSIS

To access the interactive detailed data processing, you must press the button labelled `DETAILED ANALYSIS` or the shortcut `F4` in ISO main menu (see tag `8` in Figure 5). This action induces two steps:

1. you are asked to provide the name of the binary file to be processed. By default, the directory proposed to locate this file is the `Acqu` sub-folder, if not changed previously (cf. § 4.3.2),
2. the following sub-menu is presented:

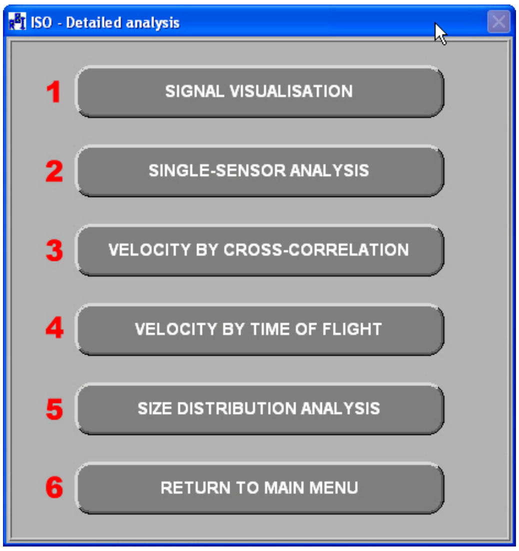

Figure 11: Detailed analysis sub-menu

It is important to know that, before presenting this sub-menu, ISO pre-processes the file you selected just before, and some intermediate results are stored in the temporary folder (cf. §4.1.2). In the case of a long acquisition (i.e. a large archive data file), these pre-processing calculations can last a few seconds.

7.1 Signal visualisation

Before processing a file and performing calculations, it may be useful to look at the raw signals. Pressing the button labelled `SIGNAL VISUALISATION` or the shortcut `F1` in the detailed analysis sub-menu (see tag `1` in Figure 11) activates this interface:

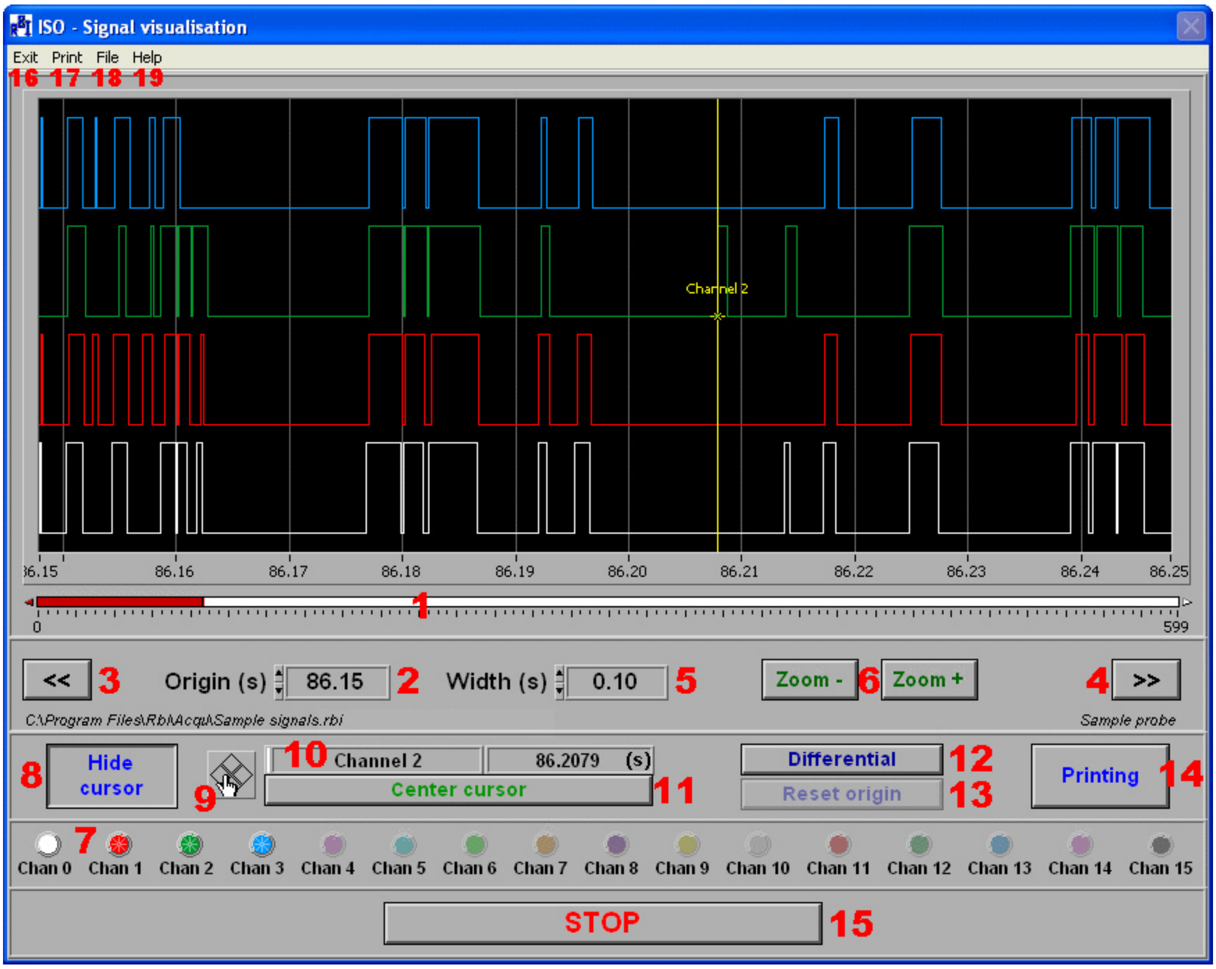

Figure 12: Front panel for signal visualisation

7.1.1 Defining the visualisation time-window

The interface provides the ability to visualise the signals in a window whose abscissa represents time. This window shows a portion of the acquisition total duration, which is represented by the ruler (see tag 1 in Figure 12).

The lower time limit of the plotted window can be precisely set (in seconds) with the capture field labelled `Origin` (see tag 2 in Figure 12). It can also be interactively changed by acting on the push-buttons labelled << and >> (see tags 3 and 4 in Figure 12), resulting in a translation of the window on the time axis.

The upper time limit of the plotted window can be precisely set (in seconds) relatively to the lower limit with the capture field labelled `Width` (see tag 5 in Figure 12). It can also be interactively changed by acting on the push-buttons labelled `Zoom +` and `Zoom -` (see tag 6 in Figure 12), resulting in a dilation or a contraction of the window on the time axis.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. §5.1.1).

7.1.2 Defining the plotted signals

The coloured lights (see tag 7 in Figure 12) show which signal is plotted or not. By clicking on the active lights, you can show or hide individual signals.

7.1.3 *Using the cursor*

A dedicated push-button (see tag 8 in Figure 12) enables to show or hide the cursor in the time-window.

This cursor is captive, which means that it remains attached to a signal. You can translate it on the time axis and select the signal it is attached to, by using the direction keypad (see tag 9 in Figure 12). The information zone (see tag 10 in Figure 12) indicates which signal the cursor is attached to, and the date of the event pointed by the cursor. If the cursor does not appear in the time-window, you can recall it by pressing the button labelled `Center cursor` (see tag 11 in Figure 12).

The cursor can be used in absolute or in differential mode. You can toggle between the two by pressing the dedicated button (see tag 12 in Figure 12). In absolute mode, acquisition start-up is considered as the time origin (t=0). This is useful to precisely determine the date of an event pointed by the cursor in the time window. In differential mode, the time origin is set to the current cursor location, when the user presses the button labelled `Reset origin` (see tag 13 in Figure 12). This is useful to precisely determine the time delay between two events in the time window.

7.1.4 *Printing the panel*

You can print the whole visualisation panel by pressing the dedicated button (see tag 14 in Figure 12), by using the dedicated menu (see tag 17 in Figure 12) or directly by pressing `Ctrl+P` key combination. If the button is pressed simultaneously with the `Shift` key, only the graph is printed

You will be asked to select the device driver before printing.

7.1.5 *Exporting the events*

Each signal is composed of events (rising and falling edges) occurring at succeeding dates. By using the dedicated menu (see tag 18 in Figure 12) or directly by pressing `Ctrl+E` key combination, you can export the chronological list of events, in an archive text file that can be processed by Microsoft Excel.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

7.1.6 *Closing the panel*

You can close the panel by pressing the button labelled `STOP` (see tag 15 in Figure 12), by using the dedicated menu (see tag 16 in Figure 12) or directly by pressing `Ctrl+X` key combination.

7.1.7 *Getting help*

The `Help` item in menu (see tag 19 in Figure 12) gives you access to some helping information. You can also directly press `Ctrl+H` to open the present manual. The `Ctrl+?` key combination shows you which version of ISO is running.

7.2 Single-sensor analysis

This paragraph is related to data processing requiring information from only one sensor, and thus concerning only one signal in a multi-sensor acquisition file. Pressing the button labelled `SINGLE-SENSOR ANALYSIS` or the shortcut `F2` in the detailed analysis sub-menu (see tag 2 in Figure 11) activates the following interface:

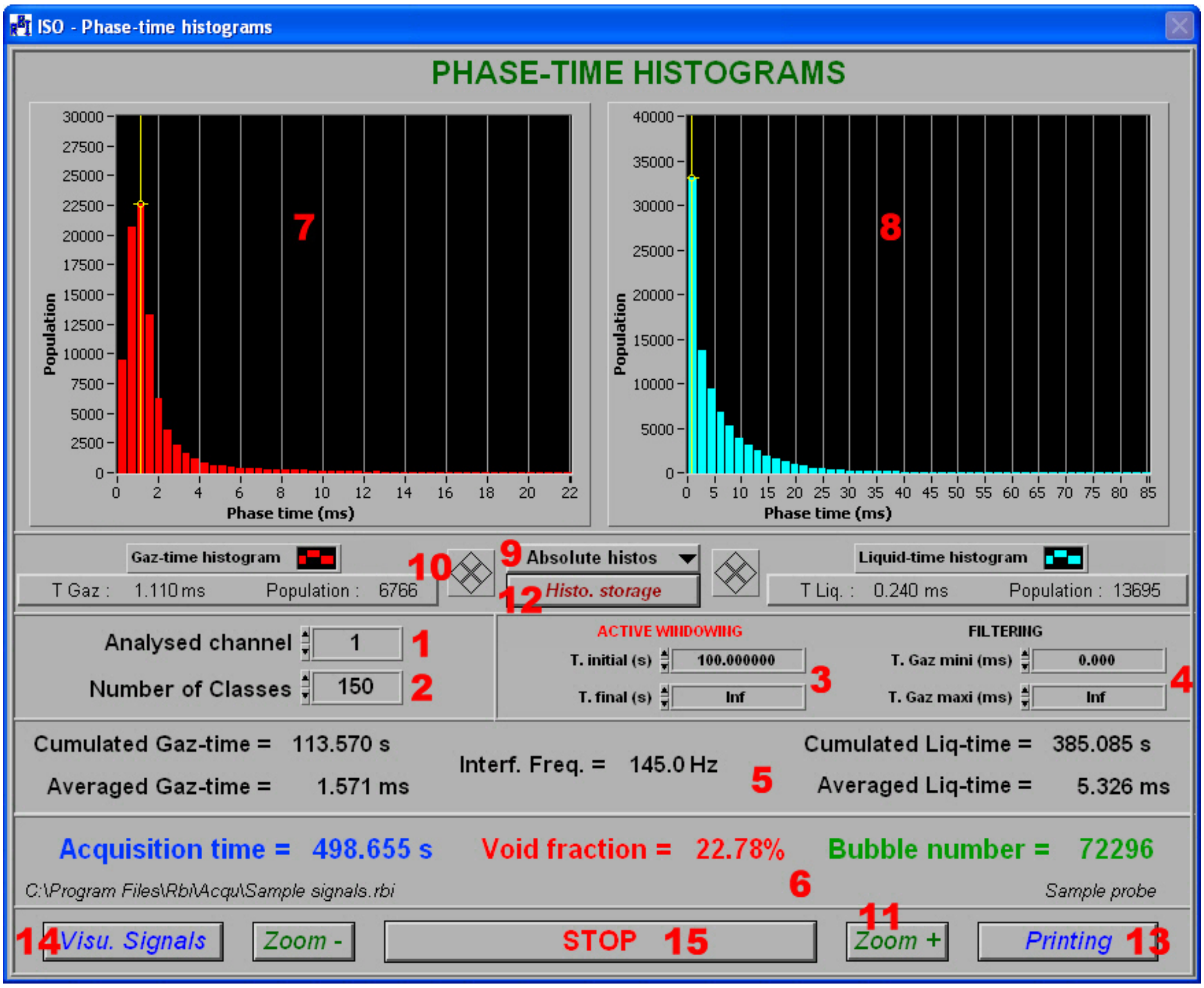

Figure 13: Front panel for single-sensor analysis

This panel provides quantitative information (such as acquisition time, number of bubbles, average phase-times…), and graphical information (phase-time histograms).

7.2.1 Selecting the main processing parameters

The calculation of the results presented in this panel only requires selecting the input channel to process (see tag 1 in Figure 13). You can notice that, even if the acquisition board can handle up to 16 signals, the list of channels that are available for selection when using this capture field is restricted to the number of signals really available in the archive file.

You must also define the number of points used to plot the curves presented on this panel. They are histograms, and this parameter (see tag 2 in Figure 13) represents the number of classes. Since the global number of bubbles is imposed by the signal content, choosing a large number of classes (abscissas) results in a low number of bubbles (ordinates) in these classes and the histograms will look “noisy”. At the opposite, choosing a low number of classes results in a large number of bubbles in these classes, and you will obtain curves with a few points. Your choice should be a compromise depending on the total amount of bubbles detected in the signal.

7.2.2 Selecting secondary processing parameters

By default, results and histograms are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 3 in Figure 13), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active (which is the case in Figure 13, where the window

extends from *t=100 s* until the end of the acquisition).

2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 4 in Figure 13), and bubbles whose gas-time is lower or greater than these values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active. This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

7.2.3 *Interpreting the quantitative results*

When processing the selected signal, ISO evaluates:

- the duration of the acquisition or the duration of the time window, if active (cf. § 7.2.2): T_{acq}
- the number of bubbles detected: N_b
- the cumulated and averaged gas-time: T_{gaz} and T_{gaz} / N_b
- the cumulated and averaged liquid-time: $T_{liq} = T_{acq} - T_{gaz}$ and T_{liq} / N_b
- the interference frequency: $f_{int} = N_b / T_{acq}$
- the void fraction: $\alpha = T_{gaz} / T_{acq}$

Times, frequency and void fraction are respectively expressed in seconds, Hertz and percent (see tags 5 and 6 in Figure 13).

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

7.2.4 *Interpreting the histograms*

As written above, the curves presented on this panel are the histograms of gas-times (see tag 7 in Figure 13) and liquid-times (see tag 8 in Figure 13). By use of a selector (see tag 9 in Figure 13), three kinds of representation are available:

- `Absolute histos`: the ordinate is the population of each class, i.e. the number of bubbles whose phase-time is within the range of the concerned class,
- `Relative histos`: the ordinate, expressed in percent, is the population of each class divided by the total number of bubbles in the signal,
- `Weighted histos`: the ordinate, expressed in seconds, is the population of each class multiplied by the value of the concerned class. This representation provides the opportunity to exhibit more clearly bi-modal histograms, which are characteristic of flows such as vertical slug flows, embedding a large quantity of small bubbles and a low quantity of large gas plugs.

A cursor appears on each plot. It is captive in the sense that, by use of arrows (see tag 10 in Figure 13 for the gas-time plot), it can be moved only from point to point on the curve. By default, it is located on the histogram peak, i.e. on the phase-time of the class containing the highest population. When moving the cursor, the phase-time (abscissa) and population (ordinate) of the class pointed by the cursor are presented.

In the same area of the panel, you can change some features of the curve: style, colour…

You can also enhance a portion of the curves, by acting on the push-buttons labelled `Zoom +` and `Zoom -` (see tag 11 in Figure 13), resulting in a dilation or a contraction of the plots on the phase-time axis.

7.2.5 Exporting the histograms

You may wish to plot or process the histograms outside ISO. When acting on the push-buttons labelled `Histos storage` (see tag 12 in Figure 13), an archive text file is generated, which can be processed by Microsoft Excel. The histograms are stored in 4 columns: gas-time class values, related population, liquid-time class values and related population.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

7.2.6 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag 13 in Figure 13). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

7.2.7 Viewing the signals

When interpreting the histograms, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag 14 in Figure 13) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the single-sensor analysis panel.

7.2.8 Closing the panel

You can close the single-sensor analysis panel by pressing the button labelled `STOP` (see tag 15 in Figure 13).

You will go back to the detailed analysis sub-menu (cf. Figure 11 in § 7).

7.3 Velocity analysis by cross-correlation

This paragraph is related to data processing requiring information from two sensors, and thus concerning two signals in a multi-sensor acquisition file. Pressing the button labelled `VELOCITY BY CROSS-CORRELATION` or the shortcut `F3` in the detailed analysis sub-menu (see tag 3 in Figure 11) activates the following interface:

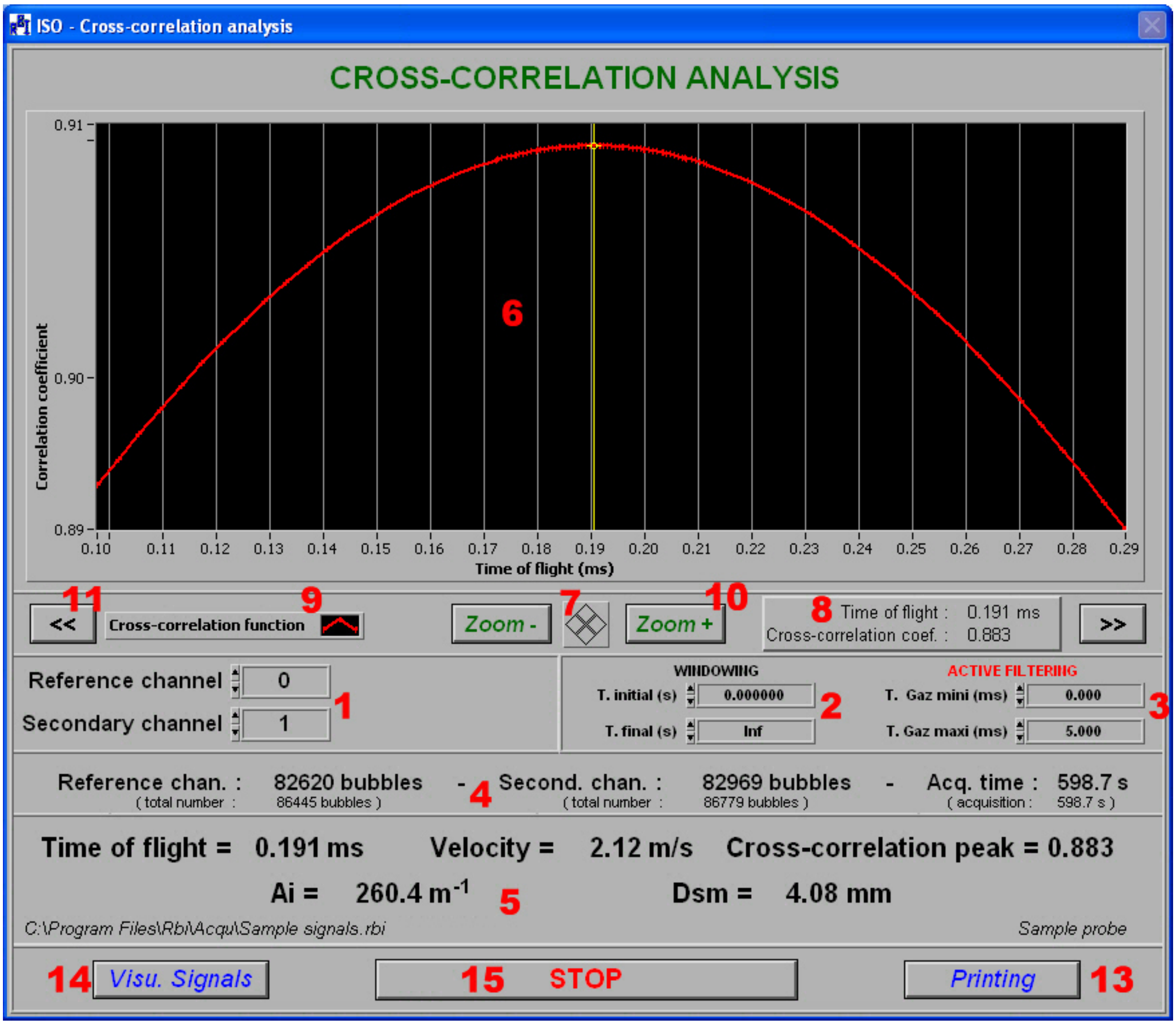

Figure 14: Front panel for cross-correlation function evaluation

This panel provides quantitative information (such as time of flight, velocity, interfacial area concentration…), and graphical information (cross-correlation function).

7.3.1 Selecting the main processing parameters

The calculation of the results presented in this panel only requires selecting two input channels to process: the reference and the secondary (see tag 1 in Figure 14). You can notice that, even if the acquisition board can handle up to 16 signals, the lists of channels that are available for selection when using these capture fields are restricted to the number of signals really available in the archive file.

To be significant, the cross-correlation function must be calculated between two different signals. Consequently, selecting the same sensor for both reference and secondary channel is forbidden.

7.3.2 Selecting secondary processing parameters

By default, results and cross-correlation are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 2 in Figure 14), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active.
2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 3 in Figure 14), and bubbles whose gas-time is lower or greater than these

values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active (which is the case in Figure 14, where the gas-time upper limit is 5 ms). This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

7.3.3 Interpreting the quantitative results

When processing the selected signals as single-sensors, ISO evaluates:

- the duration of the acquisition or the duration of the time window, if active (cf. § 7.3.2): T_{acq}
- the number of bubbles detected: N_b
- the interference frequency: $f_{int} = N_b / T_{acq}$
- the void fraction: $\alpha = T_{gaz} / T_{acq}$

Only the values T_{acq} and N_b (evaluated for the reference and the secondary channels) are presented on the panel. If a time-window or a phase-time filter is active, the values evaluated over both the restricted and the total populations are presented (see tag 4 in Figure 14).

When processing the selected signals together as coming from a two-sensor probe, ISO evaluates:

- the time of flight T_{flight} , which is an average transit time required by the bubbles to move from the reference sensor to the secondary sensor
- the average bubble velocity: $V_B = d / T_{flight}$, where d is the distance between the reference and the secondary sensors
- the interfacial area concentration: $A_i = 4 f_{int} / V_B$
- the mean Sauter diameter: $d_{32} = 6 \alpha / A_i$

Time of flight, bubble velocity, interfacial area concentration and mean Sauter diameter are respectively expressed in milliseconds, m/s, m^{-1} and mm (see tag 5 in Figure 14).

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

7.3.4 Interpreting the cross-correlation function

As written above, the curve presented on this panel is the correlation function between the time-signals collected on the reference and secondary input channels.

Cross-correlation analysis is based on the assumption that if a two-phase flow is “frozen” and translates with a uniform motion (i.e. if all interfaces are travelling with the same constant velocity and interfere with both sensors without any disturbance), then the two phase-indicating signals are identical and only shifted in time.

When translating in time the secondary signal with a given time-shift and correlating it with the reference one, a correlation value can be calculated. It evaluates the gas-time which is in common between the reference signal and the shifted secondary one. Comprised between 0 and 1, this correlation value reflects how the shifted secondary signal *“looks similar”* to the reference one.

When performing this calculation for a series of time-shift values, we obtain the cross-correlation function (see tag 6 in Figure 14). Time-shifts are abscissas (in milliseconds) and correlation values are ordinates. This function exhibits a correlation peak, for a given time shift. This value represents the “most frequently occurring” transit time between the reference and the secondary sensors, which can be associated with a “most probable” bubble velocity. This velocity value is then used to quantify the interfacial area concentration and mean Sauter diameter.

The sign convention used by ISO assumes that bubbles flowing in the positive direction interfere with the reference sensor first. Consequently, a ***positive velocity*** is obtained when the secondary signal is ***late*** with respect to the reference one.

A cursor appears on the plot. It is captive in the sense that, by use of arrows (see tag `7` in Figure 14), it can be moved only from point to point on the curve. By default, it is located on the correlation peak. When moving the cursor, the time-shift (abscissa) and associated correlation value (ordinate) are presented (see tag `8` in Figure 14).

In the same area of the panel (see tag `9` in Figure 14), you can change some features of the curve: style, colour…

You can also focus on a portion of the curve, by acting on the push-buttons labelled `Zoom +` and `Zoom -` (see tag `10` in Figure 14), resulting in a dilation or a contraction of the plot. When dilated, you can also translate the plot on the time-shift axis by acting on the push-buttons labelled `<<` and `>>` (see tag `11` in Figure 14).

7.3.5 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag `13` in Figure 14). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

7.3.6 Viewing the signals

When interpreting the cross-correlation function, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `14` in Figure 14) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the cross-correlation analysis panel.

7.3.7 Closing the panel

You can close the cross-correlation analysis panel by pressing the button labelled `STOP` (see tag `15` in Figure 14). You will go back to the detailed analysis sub-menu (cf. Figure 11 in § 7).

7.4 Velocity analysis by time of flight calculation

This paragraph is related to data processing requiring information from two sensors, and thus concerning two signals in a multi-sensor acquisition file. Pressing the button labelled `VELOCITY BY TIME OF FLIGHT` or the shortcut `F4` in the detailed analysis sub-menu (see tag `4` in Figure 11) activates the following interface:

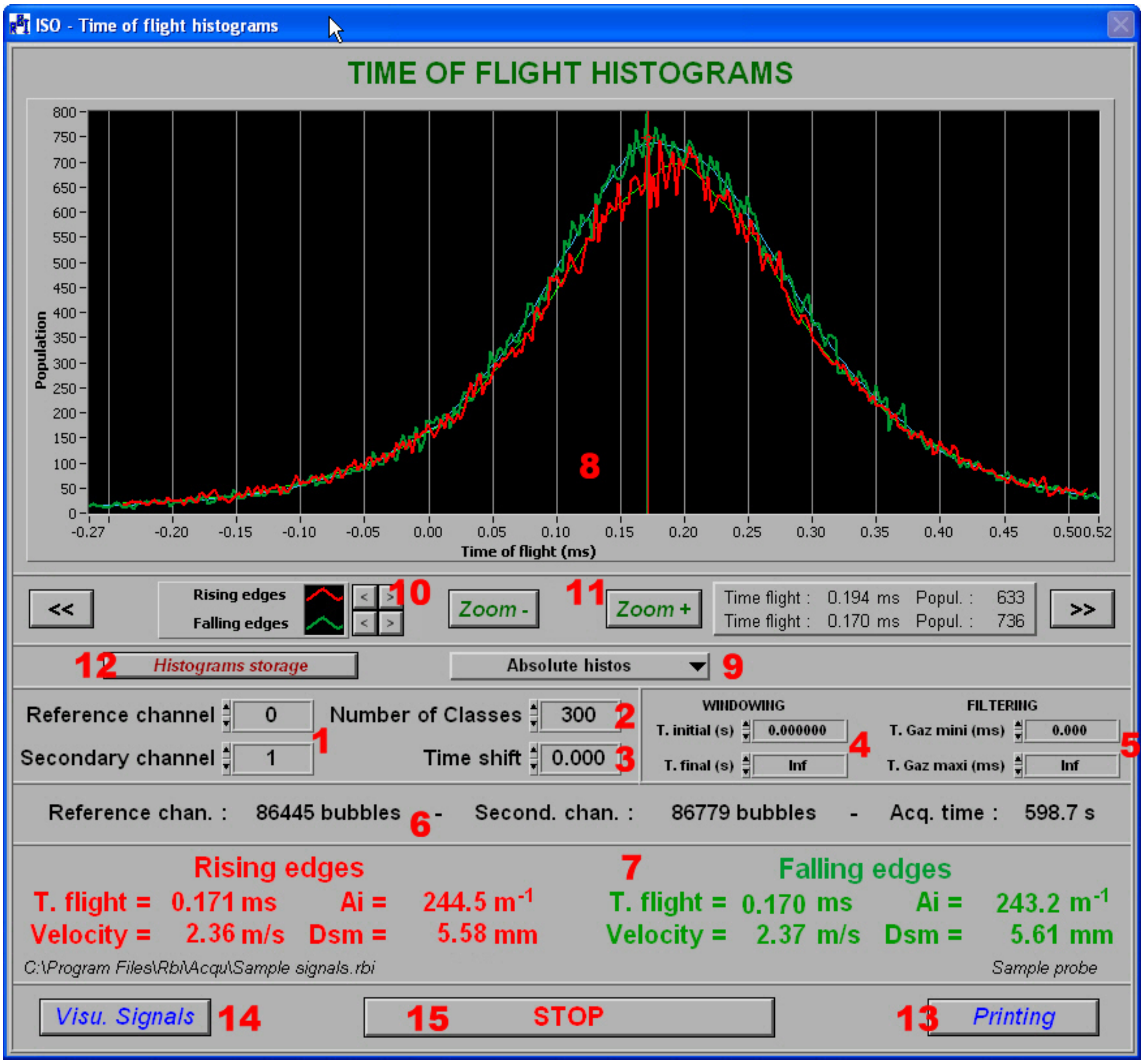

Figure 15: Front panel for time of flight histograms analysis

This panel provides quantitative information (such as times of flight, velocities, interfacial area concentrations…), and graphical information (time-of-flight histograms).

7.4.1 Selecting the main processing parameters

The calculation of the results presented in this panel requires selecting two input channels to process: the reference and the secondary (see tag 1 in Figure 15). You can notice that, even if the acquisition board can handle up to 16 signals, the lists of channels that are available for selection when using these capture fields are restricted to the number of signals really available in the archive file.

To be significant, the times of flight must be calculated between two different sensors. Consequently, selecting the same signal for both reference and secondary channel is forbidden.

You must also define the number of points used to plot the curves presented on this panel. They are histograms, and this parameter (see tag 2 in Figure 15) represents the number of classes. Since the global number of bubbles is imposed by the signals content, choosing a large number of classes (abscissas) results in a low number of time-of-flight values (ordinates) in these classes and the histograms will look “noisy”. At the opposite, choosing a low number of classes results in a large population in these classes, and you will obtain curves with a few points. Your choice should be a compromise depending on the total amount of bubbles detected in the signal.

If you know that the sensors are far apart, you can artificially translate the secondary signal on the time axis, with respect to the reference one. The time-shift is applied before performing the calculations, and its value must be specified with the dedicated capture field (see tag 3 in Figure 15).

7.4.2 Selecting secondary processing parameters

By default, results and histograms are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 4 in Figure 15), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active.
2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 5 in Figure 15), and bubbles whose gas-time is lower or greater than these values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active. This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

7.4.3 Interpreting the quantitative results

When processing the selected signals as single-sensors, ISO evaluates:

- the duration of the acquisition or the duration of the time window, if active (cf. § 7.4.2): T_{acq}
- the number of bubbles detected: N_b
- the interference frequency: $f_{int} = N_b / T_{acq}$
- the void fraction: $\alpha = T_{gaz} / T_{acq}$

Only the values T_{acq} and N_b (evaluated for the reference and the secondary channels) are presented on the panel. If a time-window or a phase-time filter is active, the values evaluated over both the restricted and the total populations are presented (see tag 6 in Figure 14).

When processing the selected signals together as coming from a two-sensor probe, ISO evaluates (either for liquid-to-gas and gas-to-liquid interfaces):

- a time of flight T_{flight} , which is an average transit time required by the interfaces to move from the reference sensor to the secondary sensor
- an average interface velocity: $V_B = d / T_{flight}$, where d is the distance between the reference and the secondary sensors
- an interfacial area concentration: $A_i = 4\, f_{int} / V_B$
- a mean Sauter diameter: $d_{32} = 6\, \alpha\, / A_i$

Times of flight, interface velocities, interfacial area concentrations and mean Sauter diameters are respectively expressed in milliseconds, m/s, m^{-1} and mm (see tag 7 in Figure 14).

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

7.4.4 Interpreting the histograms

As written above, the curves presented on this panel are time-of-flight histograms (see tag 8 in Figure 15). They are calculated either for liquid-to-gas and gas-to-liquid interfaces, which correspond respectively to rising edges and falling edges in the phase indicating signals.

When considering an event of a given type (rising or falling edge) in the reference signal, one can calculate the time delay between this event and *all* the events from the same type detected in the secondary signal. In this series of calculated values, only one delay corresponds to the transit time of a real interface between the two sensors. The calculation of this series of time delays can be repeated for each event in the reference signal. When we plot the histogram of these delays, a peak appears clearly. It corresponds to the "most probable time of flight" observed over all interfaces of the same type, and can be associated with a "most probable" interface velocity. For each type of interface (i.e. rising and falling edges), this velocity value is then used to quantify the interfacial area concentration and mean Sauter diameter.

The sign convention used by ISO assumes that interfaces flowing in the positive direction interfere with the reference sensor first. Consequently, a ***positive velocity*** is obtained when the events in the secondary signal are ***late*** with respect to the events in the reference one.

By use of a selector (see tag `9` in Figure 15), two kinds of representation are available:

- `Absolute histos`: the ordinate is the population of each class, i.e. the number of interfaces whose time of flight is within the range of the concerned class,
- `Relative histos`: the ordinate, expressed in percent, is the population of each class divided by the total number of combinations between interfaces detected in the concerned signals.

Two cursors appear on the graph. They are captive in the sense that, by use of arrows (see tag `10` in Figure 15), they can be moved only from point to point on their respective curve. By default, they are located on the histograms peak, i.e. on the time-of-flight of the class containing the highest population, for each type of interface (rising and falling edges). When moving a cursor, the time-of-flight (abscissa) and population (ordinate) of the class pointed by the cursor are presented.

In the same area of the panel, you can change some features of the curves: style, colour…

You can also enhance a portion of the curves, by acting on the push-buttons labelled `Zoom +` and `Zoom -` (see tag `11` in Figure 15), resulting in a dilation or a contraction of the plots on the time-of-flight axis. When dilated, you can also translate the plots on the time-of-flight axis by acting on the push-buttons labelled `<<` and `>>`.

7.4.5 Exporting the histograms

You may wish to plot or process the histograms outside ISO. When acting on the push-buttons labelled `Histograms storage` (see tag `12` in Figure 15), an archive text file is generated, which can be processed by Microsoft Excel. The histograms are stored in 4 columns: time-of flight class values and related population, for liquid-to-gas and gas-to-liquid interfaces.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

7.4.6 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag `13` in Figure 15). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

7.4.7 Viewing the signals

When interpreting the histograms, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `14` in Figure 15) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the time-of-flight analysis panel.

7.4.8 Closing the panel

You can close the time-of-flight analysis panel by pressing the button labelled `STOP` (see tag `15` in Figure 15). You will go back to the detailed analysis sub-menu (cf. Figure 11 in § 7).

7.5 Size distribution analysis

This paragraph is related to data processing requiring information from two sensors, and thus concerning two signals in a multi-sensor acquisition file. Pressing the button labelled `SIZE DISTRIBUTION ANALYSIS` or the shortcut `F5` in the detailed analysis sub-menu (see tag 5 in Figure 11) activates the following interface:

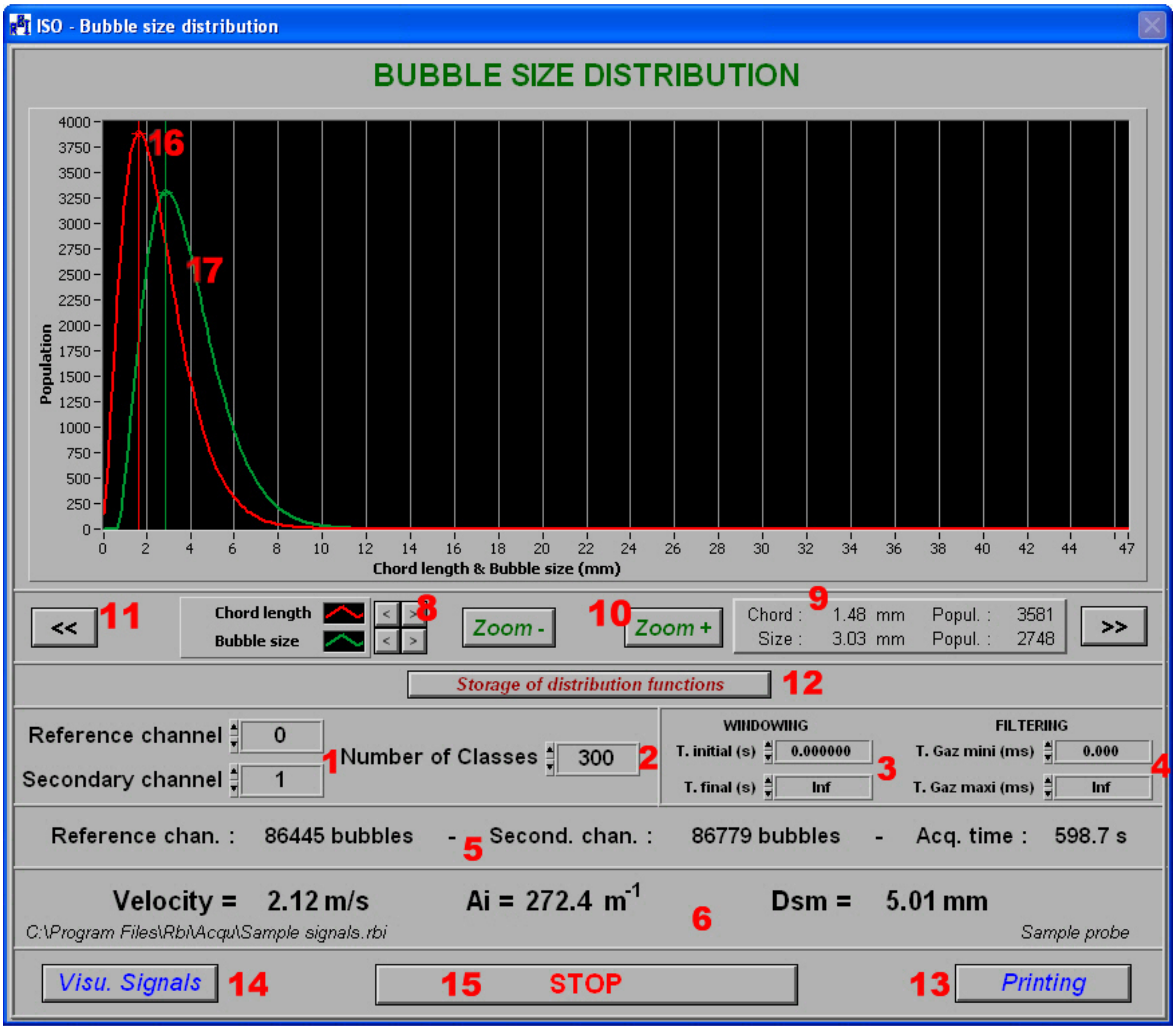

Figure 16: Front panel for size distribution analysis

This panel provides quantitative information (such as velocity, interfacial area concentration…), and graphical information (chord length and bubble size distributions).

7.5.1 Selecting the main processing parameters

The calculation of the results presented in this panel only requires selecting two input channels to process: the reference and the secondary (see tag 1 in Figure 16). You can notice that, even if the acquisition board can handle up to 16 signals, the lists of channels that are available for selection when using these capture fields are restricted to the number of signals really available in the archive file.

To be significant, the velocity (and related quantities) must be calculated between two different signals. Consequently, selecting the same sensor for both reference and secondary channel is forbidden.

You must also define the number of points used to plot the curves presented on this panel. They are histograms, and this parameter (see tag 2 in Figure 16) represents the number of classes. Since the global number of bubbles is imposed by the signal content, choosing a large number of classes (abscissas) results in a low number of bubbles (ordinates) in these classes and the histograms will look “noisy”. At the opposite, choosing a low number of classes results in a large number of bubbles in these classes, and you will obtain curves with a few points. Your choice should be a compromise depending on the total amount of bubbles detected in the signal.

7.5.2 *Selecting secondary processing parameters*

By default, results and distribution functions are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 3 in Figure 16), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active.
2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 4 in Figure 16), and bubbles whose gas-time is lower or greater than these values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active. This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

7.5.3 *Interpreting the quantitative results*

When processing the selected signals as single-sensors, ISO evaluates:

- the duration of the acquisition or the duration of the time window, if active (cf. § 7.5.2): T_{acq}
- the number of bubbles detected: N_b
- the interference frequency: $f_{int} = N_b / T_{acq}$
- the void fraction: $\alpha = T_{gaz} / T_{acq}$

Only the values T_{acq} and N_b (evaluated for the reference and the secondary channels) are presented on the panel. If a time-window or a phase-time filter is active, the values evaluated over both the restricted and the total populations are presented (see tag 5 in Figure 16).

When processing the selected signals together as coming from a two-sensor probe, ISO evaluates:

- the time of flight T_{flight} , which is an average transit time required by the bubbles to move from the reference sensor to the secondary sensor
- the average bubble velocity: $V_B = d / T_{flight}$, where d is the distance between the reference and the secondary sensors
- the interfacial area concentration: $A_i = 4 f_{int} / V_B$
- the mean Sauter diameter: $d_{32} = 6 \alpha / A_i$

Bubble velocity, interfacial area concentration and mean Sauter diameter are respectively expressed in m/s, m^{-1} and mm (see tag 6 in Figure 16).

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

7.5.4 *Interpreting the chord length and bubble size distributions*

As written above, the curves presented on this panel are the chord length and size distributions of the bubbles detected on the reference input channel. Their evaluation requires to process signals delivered by a reference and a secondary sensor.

A processing identical to what is described in § 7.2.4 provides the phase-time histogram for the signal issued from the reference sensor. A processing identical to what is described in § 7.3.3 provides an average bubble velocity. Multiplying each phase-time by the velocity leads to obtain the histogram of intercepted chord-lengths (see tag 16 in Figure 16).

By assuming that:

- the bubbles are spherical,
- they are evenly distributed throughout the analysed space,
- their motion is unidirectional,

stereological concepts enable to derive a bubble size distribution from the chord-length histogram (see tag `17` in Figure 16). Details of the calculation method can be found in Cubizolles (1996) and Garnier (1997).

Chord-lengths and bubble sizes are abscissas (in mm) and populations of the corresponding classes are ordinates. These distribution functions exhibit a peak, representing the “most frequently occurring” chord length and bubble size that has been intercepted by the reference sensor.

Cursors appear on the plots. They are captive in the sense that, by use of arrows (see tag `8` in Figure 16), they can be moved only from point to point on their curve. By default, they are located on the distribution peak. When moving the cursors, the chord-length and bubble size (abscissas) and associated populations (ordinates) are presented (see tag `9` in Figure 16).

In the same area of the panel, you can change some features of the curves: style, colour…

You can also focus on a portion of the curves, by acting on the push-buttons labelled `Zoom +` and `Zoom -` (see tag `10` in Figure 16), resulting in a dilation or a contraction of the plot. When dilated, you can also translate the plot on the abscissa axis by acting on the push-buttons labelled `<<` and `>>` (see tag `11` in Figure 16).

7.5.5 Exporting the distribution functions

You may wish to plot or process the histograms outside ISO. When acting on the push-buttons labelled `Storage of distribution functions` (see tag `12` in Figure 15), an archive text file is generated, which can be processed by Microsoft Excel. The distribution functions are stored in 6 columns: chord-length values and related population (raw and fitted), bubble size values and related population (absolute and normalized).

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

7.5.6 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag `13` in Figure 16). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

7.5.7 Viewing the signals

When interpreting the distribution functions, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `14` in Figure 16) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the size distribution analysis panel.

7.5.8 Closing the panel

You can close the size distribution analysis panel by pressing the button labelled `STOP` (see tag `15` in Figure 16). You will go back to the detailed analysis sub-menu (cf. Figure 11 in § 7).

7.6 Return to main menu

When desired detailed analysis have been performed, an action on the button labelled `RETURN TO MAIN MENU` in the detailed analysis sub-menu (see tag `6` in Figure 11) closes the sub-menu and gives the focus back to ISO main menu (cf. Figure 5 in § 4.1).

8 PERFORMING A TIME ANALYSIS

To access the interactive time evolution data processing, you must press the button labelled `TIME ANALYSIS` or the shortcut `F5` in ISO main menu (see tag `9` in Figure 5). This action induces two steps:

1. you are asked to provide the name of the binary file to be processed. By default, the directory proposed to locate this file is the `Acqu` sub-folder, if not changed previously (cf. § 4.3.2),
2. the following sub-menu is presented:

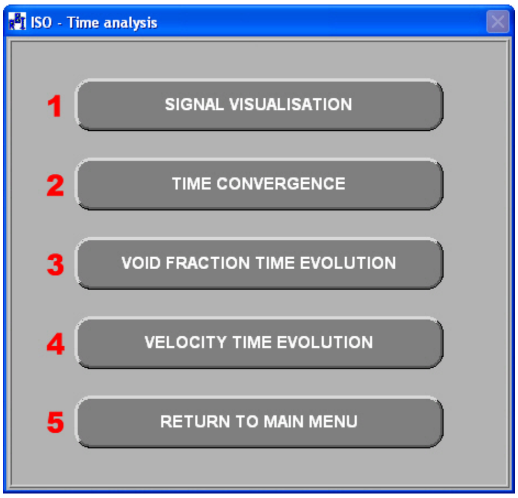

Figure 17: Time analysis sub-menu

It is important to know that, before presenting this sub-menu, ISO pre-processes the file you selected just before, and some intermediate results are stored in the temporary folder (cf. §4.1.2). In the case of a long acquisition (i.e. a large archive data file), these pre-processing calculations can last a few seconds. Notice that, if you select a file which has been processed just before (through a detailed analysis for instance), ISO will not pre-process this archive data file another time and will use the intermediate information that are still available in the temporary folder, thus saving some calculation time.

8.1 Signal visualisation

Before processing a file and performing calculations, it may be useful to look at the raw signals. Pressing the button labelled `SIGNAL VISUALISATION` or the shortcut `F1` in the detailed analysis sub-menu (see tag `1` in Figure 17) activates the same interface as described in § 7.1.

8.2 Time convergence

As described in § 6, you must define a set of working parameters before performing an acquisition. In particular, you have to determine the stopping criteria, and especially the acquisition duration. Consequently, the following question is asked: what is the minimum acquisition time that guarantees "reliable" results?

The objective of this paragraph is to provide the user a tool which helps in getting an answer to this question, which may become crucial if you have to perform sequences with several tens of acquisitions.

Quantities calculated by ISO through a detailed analysis (such as void fraction or interfacial area concentration for example) are averaged over a given time interval and the statistical convergence of such averages strongly depends on characteristics of the experimental facility and of the flow itself: amplitude of fluctuations, regulation of inlet conditions, involved two-phase flow phenomena and instabilities…

For these reasons, there is no universal answer to the question asked above, but a way of getting helpful information is to perform a long acquisition and to perform several calculations over time intervals with increasing width, and to determine the duration over which the averaged quantities do not evolve anymore.

In what follows, we deliberately focused the convergence analysis to void fraction. The related data processing requires information from only one sensor, and thus concerns only one signal in a multi-sensor acquisition file.

Pressing the button labelled `TIME CONVERGENCE` or the shortcut `F2` in the time analysis sub-menu (see tag 2 in Figure 17) activates the following interface:

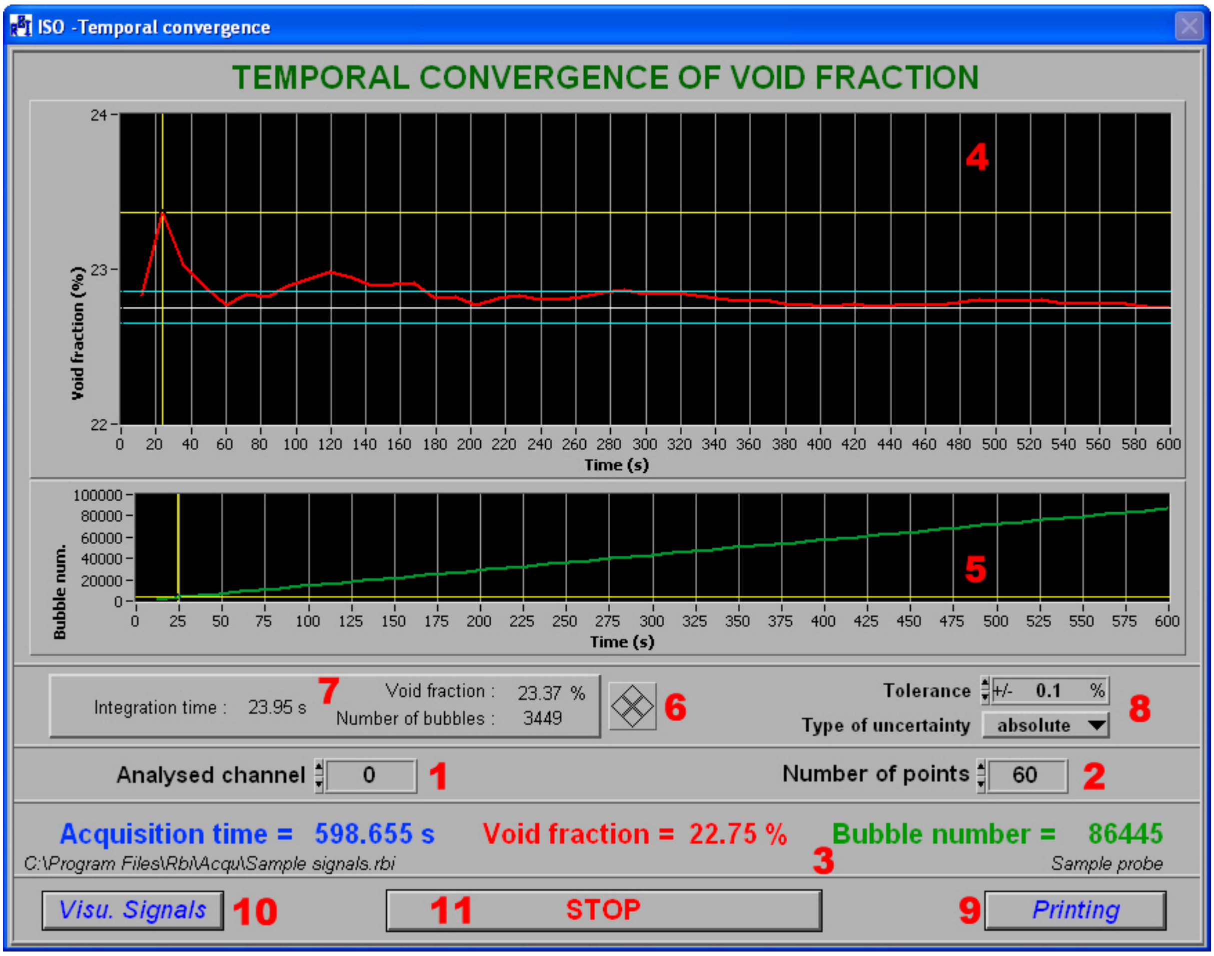

Figure 18: Front panel for time convergence analysis

This panel provides quantitative information (such as acquisition time, number of bubbles, void fraction…), and graphical information.

8.2.1 Selecting the main processing parameters

The calculation of the results presented in this panel only requires selecting the input channel to process (see tag 1 in Figure 18). You can notice that, even if the acquisition board can handle up to 16 signals, the list of channels that are available for selection when using this capture field is restricted to the number of signals really available in the archive file.

With this panel, ISO intends to exhibit the relation between the void fraction value and the width of the time interval used for averaging. The number of points used to plot the presented curves must be selected with the dedicated capture field (see tag 2 in Figure 18).

8.2.2 Interpreting the quantitative results

When processing the selected signal as a single-sensor, ISO evaluates and presents (see tag 3 in Figure 18):

- the total duration of the acquisition: T_{acq},
- the total number of bubbles detected,
- the void fraction evaluated over the total acquisition duration: α_{total}.

On this panel, times and durations are expressed in seconds.

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

8.2.3 Interpreting the time convergence

As written above, the time convergence can be analysed by varying the width of the time interval over which void fraction is evaluated.

If n is the number of points to plot (i.e. the number of void fraction calculations to perform), we evaluate the void fraction α_i on the time interval starting at $t = 0$ and ending at $t = i\ T_{acq} / n$. Notice that the last value α_n coincides with the void fraction value α_{total} calculated over the whole acquisition time (cf. § 8.2.2).

On the example presented above, the total acquisition was 600 s. Since we chose to build a convergence curve with 60 points, we evaluated the void fraction on intervals being 10s, 20s, 30s, … ,600s in width.

Two curves are plotted on the panel. The first curve (see tag `4` in Figure 18) exhibits the dependence of the void fraction on the width of the time interval over which it is evaluated. The second curve (see tag `5` in Figure 18) shows the number of bubbles detected in each corresponding time interval.

Cursors appear on the plots. They are captive in the sense that, by use of arrows (see tag `6` in Figure 18), they can be moved only from point to point on the curves (both cursors are moved simultaneously). When moving the cursors, the duration of the corresponding time interval (abscissa) is indicated (see tag `7` in Figure 18), with the corresponding void fraction value and bubble number (ordinates).

Three horizontal lines are superimposed on the first curve. The vertical location of the white line corresponds to the void fraction value α_{total} calculated over the total acquisition time. The blue lines are located apart from this value, and their location can be selected using the dedicated capture fields (see tag `8` in Figure 18). The numerical parameter defines the spacing between the blue lines and the white one. Selecting `absolute` means that this spacing is specified in term of void fraction. Selecting `relative` means that this spacing is specified in percent of the void fraction value α_{total}.

The blue lines define a kind of “tolerance band”, whose thickness is adjustable around the converged void fraction value α_{total} . The plot exhibits the minimal width of the time interval above which the void fraction curve remains bounded in this tolerance band.

On the example shown above, the value α_{total} equals 22.75%. An `absolute` tolerance value of 0.1% has been selected, which means that the blue lines are located at α = 22.65 % and α = 22.85 %. The first curve shows that it is necessary to perform acquisitions during more than 300 seconds to measure a void fraction value which is converged within a ±0.1% absolute tolerance interval. The second curve shows that, with the same flow conditions, more or less 42000 bubbles will be detected during such a 300s acquisition.

8.2.4 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag `9` in Figure 18). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

8.2.5 Viewing the signals

When interpreting the distribution functions, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `10` in Figure 18) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the size distribution analysis panel.

8.2.6 *Closing the panel*

You can close the size distribution analysis panel by pressing the button labelled `STOP` (see tag `11` in Figure 18). You will go back to the time analysis sub-menu (cf. Figure 17 in § 8).

8.3 Time evolution and single-sensor processing

Chapter 7.2 described how ISO processes data provided by a single sensor and what kind of averaged information can be extracted from a single signal.

In the case of a transient flow, it should be interesting to exhibit how the flow characteristics evolve in time. This is the purpose of the present paragraph.

Pressing the button labelled `VOID FRACTION TIME EVOLUTION` or the shortcut `F3` in the time analysis sub-menu (see tag `3` in Figure 17) activates the following interface:

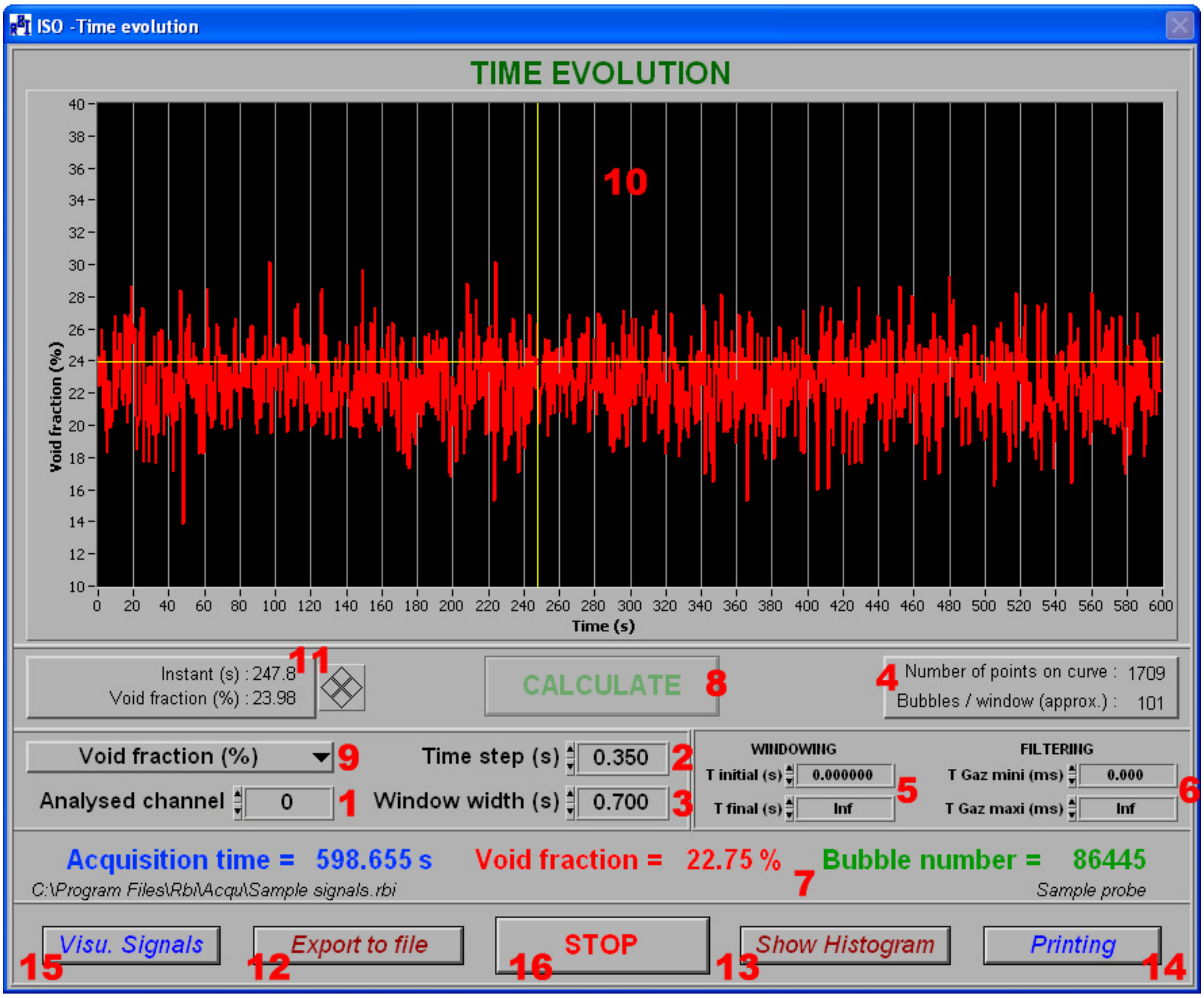

Figure 19: Front panel for void fraction time analysis

This panel provides quantitative information (such as acquisition time, number of bubbles, void fraction…), and graphical information.

8.3.1 *Selecting the main processing parameters*

The calculation of the results presented in this panel requires selecting the input channel to process (see tag `1` in Figure 19). You can notice that, even if the acquisition board can handle up to 16 signals, the list of channels that are available for selection when using this capture field is restricted to the number of signals really available in the archive file.

With this panel, ISO intends to exhibit the evolution in time of several quantities provided by the selected signal.

Instead of processing the entire signal (cf. § 7.2), the quantities of interest can be evaluated on a short time-window, which is translated along the time-axis in order to scan the total acquisition time. The width of the window and the translation time step must be defined with the appropriate capture fields (see respectively tags 2 and 3 in Figure 19). Values are specified in seconds.

Knowing the total number of bubbles and the total acquisition time, ISO is able to evaluate approximately the number of bubbles that could be detected in the translated window (see tag 4 in Figure 19). Identically, knowing the total acquisition time, the width of the window and the translation time step, ISO can evaluate the number of points on the resulting evolution curve. These orders of magnitude (which are automatically refreshed when changing the parameters) are helpful to select the optimal combination.

In the example shown in Figure 19, we notice that the window width is twice the time-step, which means that a time-window, located at a given instant, overlaps with half of the preceding window and half of the succeeding one.

8.3.2 Selecting secondary processing parameters

By default, results are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 5 in Figure 19), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active.
2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 6 in Figure 19), and bubbles whose gas-time is lower or greater than these values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active. This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

8.3.3 Interpreting the quantitative results

When processing the selected signal as a single-sensor, ISO evaluates and presents (see tag 7 in Figure 19):

- the total duration of the acquisition: T_{acq},
- the total number of bubbles detected,
- the void fraction evaluated over the total acquisition duration: α_{total}.

On this panel, times and durations are expressed in seconds.

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

8.3.4 Interpreting the time evolution

As explained before, time evolution is represented as a curve on the corresponding panel (see tag 10 in Figure 19).

Since the number of calculations can be important and, thus, require CPU time, the curve is not automatically refreshed as soon as one parameter is changed. A change in the selection activates a push-button labelled `CALCULATE`, which starts the calculations when pressed (see tag 8 in Figure 19). When achieved, different plots can be presented, depending on the selection in the list (see tag 9 in Figure 19). The quantities that are available for plot are:

- `Void fraction (%)`
- `Number of bubbles`
- `Interference freq. (Hz)`
- `Mean gas time (ms)`
- `Mean liquid time (ms)`

Since the calculation of these 5 quantities are performed at the same time, the plot is refreshed instantaneously when the selection changes.

A cursor appears on the graph. It is captive in the sense that, by use of arrows (see tag `11` in Figure 19), it can be moved only from point to point on the curve. By default, it is located on the 1st point of the curve. When moving the cursor, the time (abscissa) is presented, with the related value of the concerned variable.

In the same area of the panel, you can change some features of the curves: style, colour…

8.3.5 Exporting the curve

You may wish to plot or process the curves outside ISO. When acting on the push-buttons labelled `Export to file` (see tag `12` in Figure 19), an archive text file is generated, which can be processed by Microsoft Excel. The time evolution curves are stored in 6 columns: time values and the related values for void fraction, bubble number, interference frequency and phase-times.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

8.3.6 Plotting the histogram

You may wish to plot the histogram of the series of values plotted on the graph. An action on the push-button labelled `Show Histograms` (see tag `13` in Figure 19) splits the graph in two parts, revealing the desired histogram. Notice that the cursor also changes adequately.

The number of classes can be defined, and the type of representation can be selected in the following list:

- `Absolute histos`,
- `Relative histos`,
- `Weighted histos`.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

8.3.7 Printing the panel

You can print the whole visualisation panel by pressing the dedicated button (see tag `14` in Figure 19). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

8.3.8 Viewing the signals

When interpreting the time evolution curve, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `15` in Figure 19) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the time-evolution analysis panel.

8.3.9 Closing the panel

You can close the time-evolution analysis panel by pressing the button labelled `STOP` (see tag `16` in Figure 19). You will go back to the time analysis sub-menu (cf. Figure 17 in § 8).

8.4 Time evolution and double-sensor processing

Chapter 7.3 described how ISO processes data provided by a double sensor and the way of evaluating an average interface velocity by cross-correlating two signals.

In the case of a transient flow, it should be interesting to exhibit how this interface velocity evolves in time. This is the purpose of the present paragraph.

Pressing the button labelled `VELOCITY TIME EVOLUTION` or the shortcut `F4` in the time analysis sub-menu (see tag `4` in Figure 17) activates the following interface:

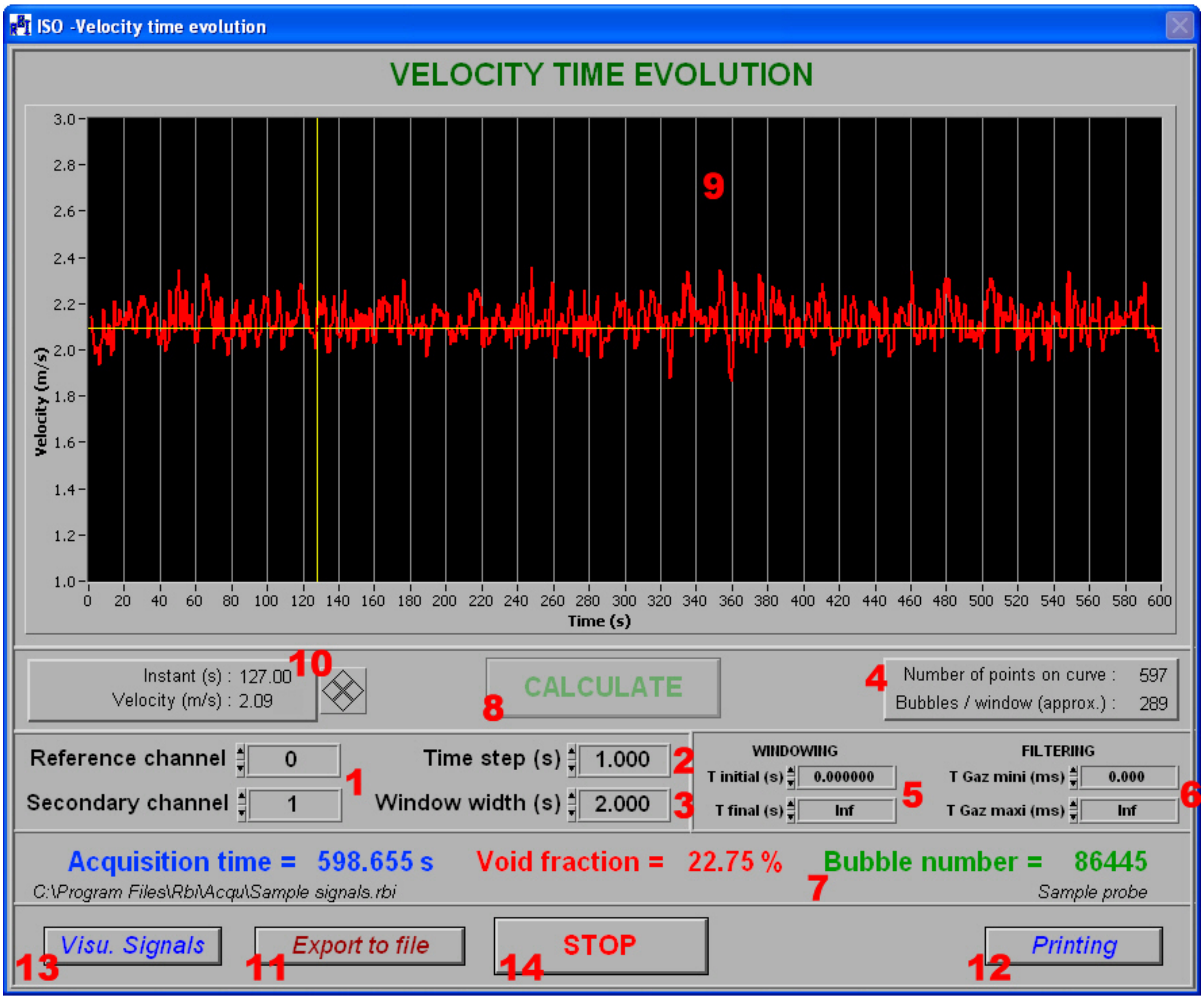

Figure 20: Front panel for velocity time analysis

This panel provides quantitative information (such as acquisition time, number of bubbles, void fraction…), and graphical information.

8.4.1 Selecting the main processing parameters

The calculation of the results presented in this panel requires selecting two input channels to process: the reference and the secondary (see tag `1` in Figure 20). You can notice that, even if the acquisition board can handle up to 16 signals, the lists of channels that are available for selection when using these capture fields are restricted to the number of signals really available in the archive file.

To be significant, the cross-correlation function must be calculated between two different signals. Consequently, selecting the same sensor for both reference and secondary channel is forbidden.

With this panel, ISO intends to exhibit the evolution in time of the interface velocity provided by the cross-correlation of the two selected signals. Instead of processing the entire signals (cf. § 7.2), the velocity of interest can be evaluated on a short time-window, which is translated along the time-axis in order to scan the total acquisition time. The width of the window and the translation time step must be defined with the appropriate capture fields (see respectively tags 2 and 3 in Figure 20). Values are specified in seconds.

Knowing the total number of bubbles and the total acquisition time, ISO is able to evaluate approximately the number of bubbles that could be detected in the translated window (see tag 4 in Figure 20). Identically, knowing the total acquisition time, the width of the window and the translation time step, ISO can evaluate the number of points on the resulting evolution curve. These orders of magnitude (which are automatically refreshed when changing the parameters) are helpful to select the optimal combination.

In the example shown in Figure 20, we notice that the window width is twice the time-step, which means that a time-window, located at a given instant, overlaps with half of the preceding window and half of the succeeding one.

8.4.2 Selecting secondary processing parameters

By default, results are evaluated upon all the bubbles detected in the whole signal. You can restrict these calculations to:

1. a time interval inside the acquisition duration. You must specify boundaries of this temporal window (see tag 5 in Figure 20), and bubbles detected before and after these limits will not be taken into account for data processing. Time boundaries must be expressed in seconds. A flag will change in colour, to indicate that a time-window is active.
2. a particular population of bubbles. You must specify the range of gas phase-time for the bubbles to be taken into account (see tag 6 in Figure 20), and bubbles whose gas-time is lower or greater than these values will be ignored during data processing. Phase-time boundaries must be expressed in milliseconds. A flag will change in colour, to indicate that a phase-time filter is active. This procedure may look as a size filter, even if the phase-time is not only depending on the bubble size.

8.4.3 Interpreting the quantitative results

When processing the selected signal as a single-sensor, ISO evaluates and presents (see tag 7 in Figure 20):

- the total duration of the acquisition: T_{acq},
- the total number of bubbles detected,
- the void fraction evaluated over the total acquisition duration: α_{total}.

On this panel, times and durations are expressed in seconds.

Notice that the values of these quantities are automatically refreshed when changing one of the processing parameters.

In the same region of the interface, two kinds of information are presented in italic:

- the name of the processed file,
- the legend of the geometry settings characterising the probe that has been used during the signal acquisition (cf. § 5.1.1).

8.4.4 Interpreting the time evolution

As explained before, time evolution is represented as a curve on the corresponding panel (see tag 9 in Figure 20).

Since the number of calculations can be important and, thus, require CPU time, the curve is not automatically refreshed as soon as one parameter is changed. A change in the selection activates a push-button labelled `CALCULATE`, which starts the calculations when pressed (see tag 8 in Figure 20).

A cursor appears on the graph. It is captive in the sense that, by use of arrows (see tag 10 in Figure 20), it can be moved only from point to point on the curve. By default, it is located on the 1st point of the curve. When moving the cursor, the time (abscissa) is presented, with the related value of the interface velocity (ordinate).

In the same area of the panel, you can change some features of the curves: style, colour…

8.4.5 *Exporting the curve*

You may wish to plot or process the curves outside ISO. When acting on the push-buttons labelled `Export to file` (see tag `11` in Figure 20), an archive text file is generated, which can be processed by Microsoft Excel. The velocity time evolution curve is stored in 2 columns: time values and the related values for velocity.

You will be asked to select the location of the archive file to create. By default, it is proposed to store it in the same directory as the original binary acquisition file.

8.4.6 *Printing the panel*

You can print the whole visualisation panel by pressing the dedicated button (see tag `12` in Figure 20). If the button is pressed simultaneously with the `Shift` key, only the graph is printed.

You will be asked to select the device driver before printing.

8.4.7 *Viewing the signals*

When interpreting the time evolution curve, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag `13` in Figure 20) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the time-evolution analysis panel.

8.4.8 *Closing the panel*

You can close the time-evolution analysis panel by pressing the button labelled `STOP` (see tag `14` in Figure 20). You will go back to the time analysis sub-menu (cf. Figure 17 in § 8).

8.5 Return to main menu

When desired time analysis have been performed, an action on the button labelled `RETURN TO MAIN MENU` in the time analysis sub-menu (see tag `5` in Figure 17) closes the sub-menu and gives the focus back to ISO main menu (cf. Figure 5 in § 4.1).

9 PERFORMING A SYNTHETIC ANALYSIS

As seen in chapter 7, ISO has the capabilities to process signals issued from acquisitions performed with single or double-sensor probes, and to quantify, over the whole (or a part of the) acquisition time, some parameters like bubble number, void fraction, interference frequency, bubble velocity, interfacial area concentration, mean Sauter diameter… Chapter 7 presented several interfaces, providing these quantities in a detailed and interactive way.

The first objective of the present chapter is to provide a synthetic presentation of the above mentioned quantities, with all the relevant values on the same interface.

The second objective is to describe that ISO is also capable of processing signals issued from acquisitions performed with four-sensor probes.

9.1 Processing parameters

Since all signal processings, in a synthetic presentation, are performed without interaction with the user, the calculation parameters must be selected before beginning.

A dedicated interface gives you the ability to specify these parameters. Pressing the button labelled `PROCESSING PARAMETERS` or the shortcut `F6` in ISO main menu (see tag `10` in Figure 5) activates this interface.

Pressing the button labelled `VELOCITY TIME EVOLUTION` in the time analysis sub-menu (see tag `4` in Figure 17) activates the following interface:

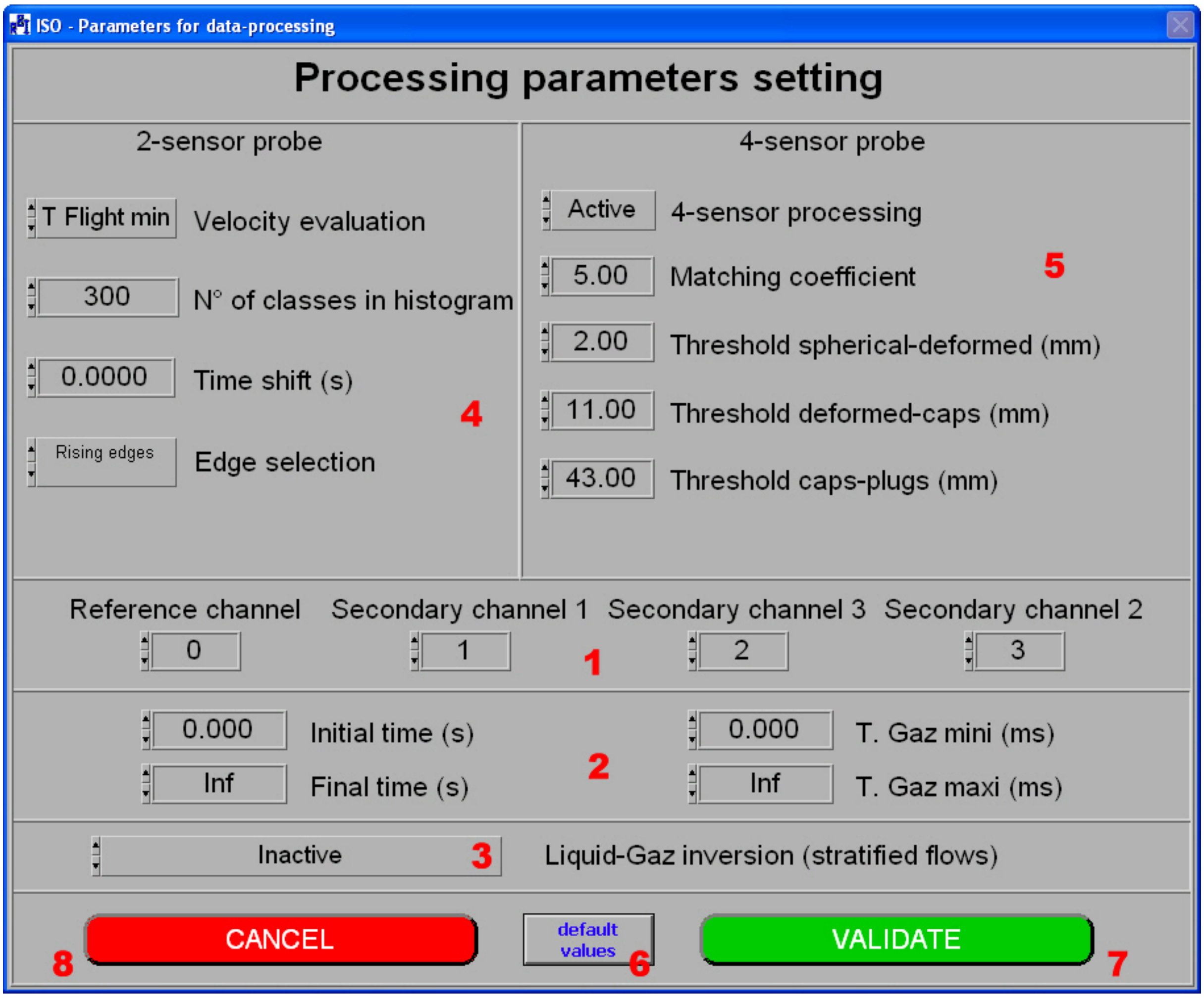

Figure 21: Front panel for selection of processing parameters

This panel provides only capture fields dedicated to the specification of the main and secondary processing parameters already described in chapter 7.

It is important to mention that at this point, the parameter selection ***anticipates*** the future processing of archived acquisition files. In other words, ***no verification is performed*** on, for example, which signals are available in the files to be processed. Such verifications are the user's responsibility.

9.1.1 Selecting the main processing parameters

The first parameters to set are the input channels to process. Since double-probe or 4-probe sensor processing will be achieved, 2 or 4 input channels must be initialised (see tag 1 in Figure 21).

9.1.2 Selecting the secondary parameters

As described in § 7.2 to § 7.5, results can be evaluated upon all the bubbles detected in the whole signal or restricted to a time interval inside the acquisition duration. In a similar way, analysis may focus on a particular population of bubbles.

In that purpose, the temporal boundaries and the range of gas phase-time for the bubbles to be taken into account can be specified (see tag 2 in Figure 21).

9.1.3 Focusing analysis on the gas or the liquid phase

By default, in all the preceding explanations, it was assumed that gas was the relevant phase of interest, in the sense that, like in a bubble flow, the inclusions to characterise (by void fraction, interfacial area…) are gaseous. In some applications, the events to characterise in the flow may be related to the liquid phase. This is the case of stratified flows for instance, where the analysis is focused on the waves.

In that objective, ISO provides the capability to “revert” the binary phase signals before processing them. This feature can be activated by pressing on the dedicated button (see tag 3 in Figure 21).

9.1.4 Selecting the parameters for double-sensor processing

One of the main purposes of using a double-sensor is to evaluate an average interface velocity. In chapter 7, two methods have been presented, related respectively to the calculation of the cross-correlation function (cf. § 7.3) and to the evaluation of the most probable time-of-flight (cf. § 7.37.4).

The selection between these two methods must be specified (see tag 4 in Figure 21) and the relevant parameters (also described in chapter 7) must also be defined.

9.1.5 Selecting the parameters for 4-sensor processing

The 4-sensor processing may active or non. It means that, even if an archive file contains 4 signals issued from a 4-sensor type, a processing typical of double-sensor can be performed. This can be specified using the dedicated selector (see tag 5 in Figure 21).

The second selector concerns the matching procedure applied to associate events in the 4 signals. The influence of this parameter on the processing efficiency will be discussed later.

A 4-sensor probe offers the capability to evaluate the size of individual inclusions, and thus to classify them into 4 groups, depending on their size: spherical bubble, ellipsoidal bubbles, caps and plugs. The boundaries separating these classes can be evaluated, based on fluid properties. Standard values, calculated for air and water at atmospheric pressure and ambient temperature are proposed.

9.1.6 Setting the parameters to default values

A set of default values can be applied to the processing parameters, by acting on the dedicated push-button (see tag 6 in Figure 21).

9.1.7 Validating or cancelling the settings

To use the information appearing on this panel for future processing, you must validate your capture and close the panel. This operation can be achieved by pressing the button labelled `VALIDATE` (see tag 7 in Figure 21). The settings will be stored in Windows Registry and used for later calculations.

If you want to cancel your capture and close the panel, press the button labelled `CANCEL` (see tag 8 in Figure 21). The information appearing on the panel will be discarded and the current settings stored in Windows Registry will not be modified.

9.2 Synthetic double-sensor processing

Once the processing parameters have been selected, the analysis of an archived acquisition file can be performed.

To access the synthetic results, you must press the button labelled `SYNTHETIC ANALYSIS` or the shortcut `F7` in ISO main menu (see tag 8 in Figure 5). This action induces two steps:

1. you are asked to provide the name of the binary file to be processed. By default, the directory proposed to locate this file is the `Acqu` sub-folder, if not changed previously (cf. § 4.3.2),
2. the calculations are performed.

If the 4-sensor processing has been disabled or if the file contains less than 4 signals, the following panel is presented:

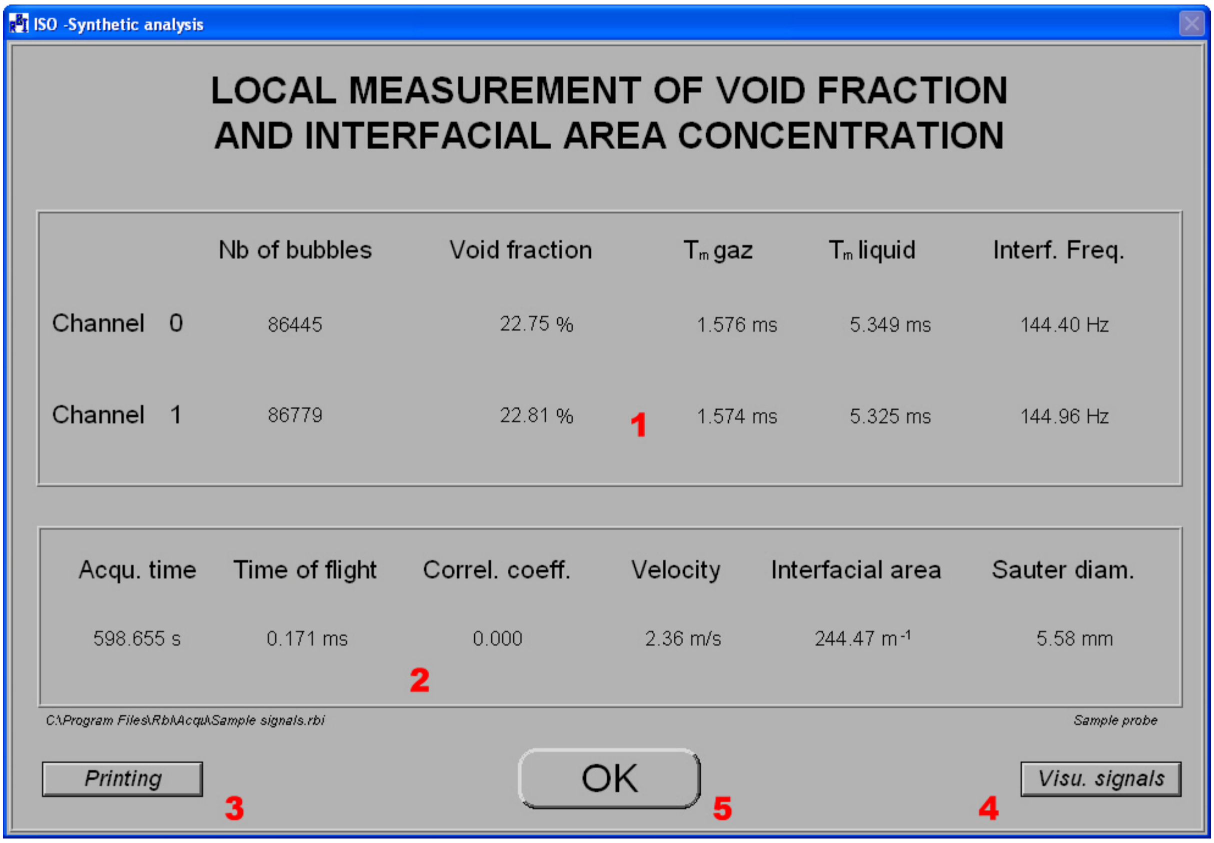

Figure 22: Front panel for synthetic double-sensor analysis

9.2.1 *Viewing the results*

This panel summarises the results of calculations achieved on each of the selected channels (see tag 1 in Figure 22), indicating the number of bubbles, the void fraction, the average phase-times and the interference frequency.

The panel also summarises the results of calculations achieved on the pair of selected channels (see tag 2 in Figure 22), indicating the time of flight, the cross-correlation coefficient (when cross-correlation function method is used), the average interface velocity, the interfacial area and the mean Sauter diameter.

9.2.2 *Printing the panel*

You can print the whole panel by pressing the dedicated button (see tag 3 in Figure 22).

You will be asked to select the device driver before printing.

9.2.3 *Viewing the signals*

When interpreting the results, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag 4 in Figure 22) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the synthetic analysis panel.

9.2.4 *Closing the panel*

You can close the time-evolution analysis panel by pressing the button labelled `OK` (see tag 5 in Figure 22). You will go back to ISO main menu (cf. Figure 5 in § 4.1).

9.3 Synthetic four-sensor processing

Once the processing parameters have been selected, the analysis of an archived acquisition file can be performed.

To access the synthetic results, you must press the button labelled `SYNTHETIC ANALYSIS` in ISO main menu (see tag 8 in Figure 5). This action induces two steps:

1. you are asked to provide the name of the binary file to be processed. By default, the directory proposed to locate this file is the `Acqu` sub-folder, if not changed previously (cf. § 4.3.2),
2. the calculations are performed.

If the 4-sensor processing has been enabled and if the file contains the 4 selected signals, the following panel is presented:

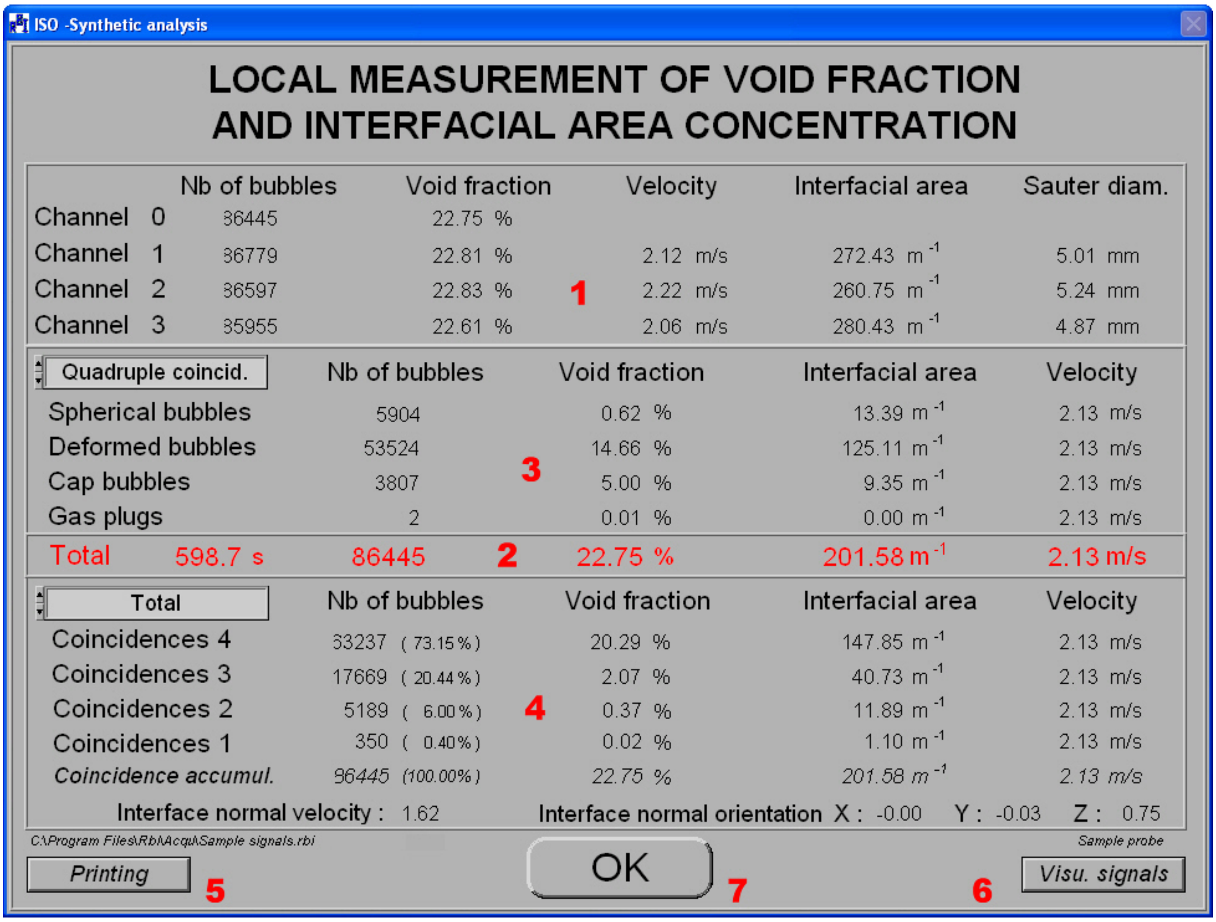

Figure 23: Front panel for synthetic four-sensor analysis

9.3.1 *Viewing the results*

This panel summarises the results of calculations achieved on the 3 double-sensors composed of the reference channel and each one of the secondary channels (see tag 1 in Figure 23), indicating the number of bubbles, the void fraction, the average interface velocity, the interfacial area and the mean Sauter diameter.

The results typical of the 4-sensor probe processing procedure are presented in details, for the whole bubble population (see tag 2 in Figure 23), for each class of inclusion (see tag 3 in Figure 23) and each class of event association (see tag 4 in Figure 23).

9.3.2 *Printing the panel*

You can print the whole panel by pressing the dedicated button (see tag 5 in Figure 23).

You will be asked to select the device driver before printing.

9.3.3 *Viewing the signals*

When interpreting the results, it may be useful to look at the raw signals. Pressing the button labelled `Visu. Signals` (see tag 6 in Figure 23) activates the signal viewing interface (cf. § 7.1). Closing this interface gives the focus back to the synthetic analysis panel.

In this case of 4-sensor probe, the signal visualisation panel offers the specific feature of exhibiting the association of events in the 4 signals.

9.3.4 *Closing the panel*

You can close the time-evolution analysis panel by pressing the button labelled `OK` (see tag 7 in Figure 23). You will go back to ISO main menu (cf. Figure 5 in § 4.1).

9.4 Multiple synthetic processing

Instead of processing an individual binary file, the user may perform the synthetic analysis of a series of archived files.

As explained above, after pressing the button labelled `SYNTHETIC ANALYSIS` or the shortcut `F7` in ISO main menu (see tag 8 in Figure 5), the user is asked to provide the name of the file to process. The latter may be a list of the files to be processed. To be recognized by ISO as a list of multiple processing, the extension of this file must be "`.lst`". Furthermore, it must be an ASCII text file containing several lines, each line indicating the full pathname (without bracket) of a valid data-file. When selecting such a list, ISO performs the analysis of each of the listed files, in an iterative loop. Instead of presenting the detailed front panel relevant to the type of analysis currently performed (Figure 22 or Figure 23), ISO shows a progression indicator.

The batch processing will produce an ASCII result-file, located in the same folder and having the same name as the list-file, but with the extention "`.xls`" allowing to be opened with Microsoft Excel. In this result-file, each line corresponds to the analysis of each of the individual files listed in the series.

10 CLOSING ISO

An action on the button labelled `EXIT` in ISO main menu (see tag 12 in Figure 5) closes ISO and returns back to Windows.

11 PERFORMING BATCH PROCESSING WITH ISO

ISO is capable to work in batch mode, to perform synthetic analysis on one (or several) archived file(s), which name has (have) to be passed to ISO as command-line argument(s).

ISO is also capable to work in batch mode, to perform synthetic analysis on a series of archived files. The list of the files to be processed must be an ASCII text file containing several lines, each line indicating the full pathname (without bracket) of a valid data-file. To be recognized by ISO as a list of batch processing, the extension of this list-file must be "`.lst`". This name has to be passed to ISO as a command-line argument.

The batch processing will produce an ASCII result-file, located in the same folder and having the same name as the list-file, but with the extention "`.xls`" allowing to be opened with Microsoft Excel. In this result-file, each line corresponds to the analysis of each of the individual files listed in the series.

12 APPENDIX 1: REFERENCES

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Garnier, J, 1997, Measurement of local flow pattern in boiling R12 simulating PWR conditions with multiple optical probes, OECD/CSNI Specialist meeting on advanced instrumentation and measurements techniques, Santa Barbara, CA, March 17-20.

13 APPENDIX 2: ERROR MESSAGES

Possible errors during execution of pgm « ISO.vi »

Numéro	Exécutant	Message	Commentaires
6111	[ACQU] - Preparation Acquisition VIN.vi	Unable to access Registry key "*HKCU\SOFTWARE\RBI Systems\Acquisition*"	The Registry base is not correctly initialised and does not contain the awaited keys. Initialise it again.
6112	[ACQU] - Preparation Acquisition VIN.vi	Unable to read values in Registry key "*HKCU\SOFTWARE\RBI Systems\Acquisition*"	The Registry base is not correctly initialised and does not contain the awaited values. Initialise it again.
6113	[ACQU] - Preparation Acquisition VIN.vi	Unable to access to folder "*xxxx*"	This folder is required to perform an acquisition. Verify its availability and access permissions.
6114	[ACQU] - Preparation Acquisition VIN.vi	Unable to create file "*xxxx*"	This file is required to perform an acquisition. Verify the total access permissions to the concerned folder.
6121	[ACQU] - Acquisition VIN2.vi	Impossible to access folder "*xxxx*"	This folder is required to perform an acquisition. Verify its availability and access permissions.
6122	[ACQU] - Acquisition VIN2.vi	Impossible to access file "*xxxx*"	This file is required to perform an acquisition. Verify its availability after preparing an acquisition.
6123	[ACQU] - Acquisition VIN2.vi	Impossible to run program "*sphere35.exe*"	The module driving the acquisition board cannot be launched. Verify its availability.
6124	[ACQU] - Acquisition VIN2.vi	Acquisition did not produce file "*xxxx*"	The module driving the acquisition board did not succeed. Verify the acquisition procedure in manual mode (DOS).
6131	[ACQU] - Acquisition VIN10.vi	Impossible to access folder "*xxxx*"	This folder is required to perform an acquisition. Verify its availability and access permissions.
6132	[ACQU] - Acquisition VIN10.vi	Impossible to access file "*xxxx*"	This file is required to perform an acquisition. Verify its availability after preparing an acquisition.
6133	[ACQU] - Acquisition VIN10.vi	Impossible to run program "*sphere10.exe*"	The module driving the acquisition board cannot be launched. Verify its availability.
6134	[ACQU] - Acquisition VIN10.vi	Acquisition did not produce file "*xxxx*"	The module driving the acquisition board did not succeed. Verify the acquisition procedure in manual mode (DOS).
6141	[ACQU] - Acquisition USB.vi	Unable to load dynamic library "*Sphere.dll*"	Verify the presence of the dll in Windows path.
6142	[ACQU] - Acquisition USB.vi	Unable to locate function "*Acq*" in dynamic library "*Sphere.dll*"	The dll controlling the acquisition board is corrupted.

6143	[ACQU] - Acquisition USB.vi	Unable to read the Registry key "*HKCU\SOFTWARE\RBI Systems\Acquisition*"	Registry is not initialised and do not contain the key where the acquisition parameters are stored.
6144	[ACQU] - Acquisition USB.vi	Unable to allocate enough memory to store events potentially detectable during acquisition	Verify available RAM.
6145	[ACQU] - Acquisition USB.vi	External trigger signal not detected before timeout	Verify external trigger source and cables.
6146	[ACQU] - Acquisition USB.vi	Maximum number of events reached, with buffer memory overflow	Perform the acquisition once again.
6147	[ACQU] - Acquisition USB.vi	Maximum acquisition time reached, with buffer memory overflow	Perform the acquisition once again.
6148	[ACQU] - Acquisition USB.vi	Unable to create storage file	Verify available disk space.
6149	[ACQU] - Acquisition USB.vi	Unable to store acquired events in PIF file	Verify available disk space.
6150	[ACQU] - Acquisition USB.vi	Unable to read file containing acquisition parameters	This file is required to perform an acquisition. Verify its availability and access permissions.
6151	[ACQU] - Acquisition USB.vi	Impossible to access folder "*xxxx*"	This folder is required to perform an acquisition. Verify its availability and access permissions.
6152	[ACQU] - Acquisition USB.vi	Acquisition did not produce file "*xxxx*"	The module driving the acquisition board did not succeed. Verify the acquisition procedure in manual mode (DOS).
6153	[ACQU] - Acquisition USB.vi	Failure occurred when running program "*sphere16.exe*"	The module driving the acquisition board did not succeed. Verify the acquisition procedure in manual mode (DOS).
6154	[ACQU] - Acquisition USB.vi	USB acquisition board is not detected	The acquisition board is not detected as an active USB peripheral. Verify its power supply and USB connection.
6156	[ACQU] - Acquisition Stop.vi	Acquisition has been interrupted by user	If a problem occurred during the acquisition, power off and on the USB acquisition black box.
6161	[ACQU] - Acquisition.vi	Impossible to create raw data file "*xxxx*"	Verify availability of the final destination.
6162	[ACQU] - Acquisition.vi	No acquisition board is installed	Do not try to perform acquisitions without any board, it will not succeed!!!
6163	[ACQU] - Acquisition.vi	External software trigger did not occur	When selecting the external software triggering mode, please close the dedicated dialog box with "OK" button to launch the acquisition.

Number	Procedure	Message	Comments
6171	Mak_Acq1_16_CIN	Argument containing the name of acquisition file is empty	Verify the value of arguments passed when calling the vi.
6172	Mak_Acq1_16_CIN	Unable to open the file “*xxxx*”	Verify the name of file passed as argument. Verify if the acquisition was successful.
6173	Mak_Acq1_16_CIN	Unable to open temporary storage file “*xxxx*”	Verify available storage place on disk.
6174	Mak_Acq1_16_CIN	Unable to allocate enough memory to store *nnn* events	Verify available RAM.
6175	Mak_Acq1_16_CIN	File reading interrupted (only *iii* events read from *nnn*)	Acquisition file is corrupted.
6176	Mak_Acq1_16_CIN	Date error on event *nnn*	Problem occurred during acquisition. Perform manual tests.
6177	Mak_Acq1_16_CIN	Buffer memory full on event *nnn*	Problem occurred during acquisition. Perform manual tests.
6178	Mak_Acq1_16_CIN	Unable to read value "*xxxx*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\yyy*"	Registry is not initialised and do not contain the awaited key.

Number	Procedure	Message	Comments
6201	Add_Geom_CIN	Argument containing the name of the PIF file to process is empty	Verify the value of arguments passed when calling the vi.
6202	Add_Geom_CIN	Argument containing the name of the geometry file to process is empty	Verify the value of arguments passed when calling the vi.
6203	Add _Geom_CIN	Unable to read value "*xxxx*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\Geometrie Sonde*"	Registry is not initialised and do not contain the key where the current probe geometry is stored.
6204	Add _Geom_CIN	Unable to open the file "*xxxx*"	The file which name is passed as argument does not exist.
6205	Add _Geom_CIN	The format of file "*xxxx*" is not compatible with Iso	The explored file is of unknown format.
6206	Add _Geom_CIN	The file "*xxxx*" seems to be from "*????*" type but its size does not match the awaited content	The first block of the explored file has been identified but the file size is not correct.
6207	Add _Geom_CIN	The file "*xxxx*" contains no geometry	The explored file does not contain the awaited geometry.
6208	Add _Geom_CIN	A problem occurred when reading the probe geometry in the file "*xxxx*"	The block containing the probe geometry in the explored file is uncompleted or corrupted.
6209	Add_Geom_CIN	The file "*xxxx*" already contains a probe geometry	Activate the adequate option if it is really necessary to replace the existing geometry by a new one.

Number	Procedure	Message	Comments
6252	Ext_Geom_CIN	Argument containing the name of the geometry file to process is empty	Verify the value of arguments passed when calling the vi.
6253	Ext_Geom_CIN	Unable to read value "*xxxx*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\Geometrie Sonde*"	Registry is not initialised and do not contain the key where the current probe geometry is stored.
6254	Ext_Geom_CIN	Unable to open the file "*xxxx*"	The file which name is passed as argument does not exist.
6255	Ext_Geom_CIN	The format of file "*xxxx*" is not compatible with Iso	The explored file is of unknown format.
6256	Ext_Geom_CIN	The file "*xxxx*" seems to be from "*????*" type but its size does not match the awaited content	The first block of the explored file has been identified but the file size is not correct.
6257	Ext_Geom_CIN	The file "*xxxx*" contains no geometry	The explored file does not contain the awaited geometry.
6258	Ext_Geom_CIN	A problem occurred when reading the probe geometry in the file "*xxxx*"	The block containing the probe geometry in the explored file is uncompleted or corrupted.

Number	Procedure	Message	Comments
6301	Lit_Acq_CIN	Argument containing the name of acquisition file is empty	Verify the value of arguments passed when calling the vi.
6302	Lit_Acq_CIN	Unable to open the PIF file “*xxxx*”	The file which name is passed as argument does not exist.
6303	Lit_Acq_CIN	The PIF file “*xxxx*” was not supplied by a referenced ISO acquisition board	The first block in the file does not correspond to any format characteristic of an ISO acquisition board.
6304	Lit_Acq_CIN	Unable to allocate enough memory to store *nnn* events	Verify available RAM.
6305	Lit_Acq_CIN	File reading interrupted (only *iii* events read from *nnn*)	Acquisition file is corrupted.
6306	Lit_Acq_CIN	Unable to allocate enough memory to store *nnn* events from PIF *i*	Verify available RAM.
6307	Lit_Acq_CIN	Unable to read value “*xxxx*” in the Registry key “*HKCU\SOFTWARE\RBI Systems\yyy*”	Registry is not initialised and do not contain the awaited key.
6308	Lit_Acq_CIN	Unable to store events in Ascii file “*xxxx*”	Verify available storage place on disk.
6309	Lit_Acq_CIN	Unable to store PIF *i* in file “*xxxx*”	Verify available storage place on disk.
6310	Lit_Acq_CIN	The file “*xxxx*” contains no event	Verify external trigger source, cables and signal levels.

Number	Procedure	Message	Comments
6401	Moyenne_CIN	Unable to read value “*Fips*” in the Registry key “*HKCU\SOFTWARE\RBI Systems\Repertoires*”	Registry is not initialised and do not contain the awaited key.
6402	Moyenne_CIN	Unable to open the PIF file “*xxxx*”	The file which name is passed as argument does not exist.
6403	Moyenne_CIN	No bubble found in PIF “*xxxx*”	The PIF file being read is empty. Before acquisition, verify if signal is present, check threshold levels on opto-electronics and activate at least 1 channel when setting acquisition parameters.
6404	Moyenne_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii*	Verify available RAM.
6405	Moyenne_CIN	Reading PIF file “*xxxx*” interrupted : only *iii* bubbles read from *nnn*	The PIF file being read is corrupted: the first block does not match with the whole content.
6406	Moyenne_CIN	No bubble found in PIF “*xxxx*” after windowing and filtering	The windowing and filtering parameters are too restrictive.
6407	Moyenne_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii* windowed and filtered	Verify available RAM.
6408	Moyenne_CIN	Unable to align return array containing results	Problem with interface between LabView and CIN.

Number	Procedure	Message	Comments
6501	Histos_CIN	Unable to read value “*Fips*” in the Registry key “*HKCU\SOFTWARE\RBI Systems\Repertoires*”	Registry is not initialised and do not contain the awaited key.
6502	Histos_CIN	Unable to open the PIF file “*xxxx*”	The file which name is passed as argument does not exist.
6503	Histos_CIN	No bubble found in PIF “*xxxx*”	The PIF file being read is empty. Before acquisition, verify if signal is present, check threshold levels on opto-electronics and activate at least 1 channel when setting acquisition parameters.
6504	Histos_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii*	Verify available RAM.
6505	Histos_CIN	Reading PIF file “*xxxx*” interrupted : only *iii* bubbles read from *nnn*	The PIF file being read is corrupted: the first block does not match with the whole content.
6506	Histos_CIN	No bubble found in PIF “*xxxx*” after windowing and filtering	The windowing and filtering parameters are too restrictive.
6507	Histos_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii* windowed and filtered	Verify available RAM.
6508	Histos_CIN	Unable to allocate enough memory to store classes/populations of Gas/Liquid time histogram	Verify available RAM.
6509	Histos_CIN	Unable to allocate enough memory to store intermediate lists	Verify available RAM.
6510	Histos_CIN	Unable to align return array containing classes/populations of Gas/Liquid time histogram	Problem with interface between LabView and CIN.

Number	Procedure	Message	Comments
6601	Cor_Rbi_CIN	Unable to read value "*Fips*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\Repertoires*"	Registry is not initialised and do not contain the awaited key.
6602	Cor_Rbi_CIN	Unable to open the PIF file "*xxxx*"	The file which name is passed as argument does not exist.
6603	Cor_Rbi_CIN	No bubble found in PIF "*xxxx*"	The PIF file being read is empty. Before acquisition, verify if signal is present, check threshold levels on opto-electronics and activate at least 1 channel when setting acquisition parameters.
6604	Cor_Rbi_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii*	Verify available RAM.
6605	Cor_Rbi_CIN	Reading PIF file "*xxxx*" interrupted : only *iii* bubbles read from *nnn*	The PIF file being read is corrupted: the first block does not match with the whole content.
6606	Cor_Rbi_CIN	No bubble found in PIF "*xxxx*" after windowing and filtering	The windowing and filtering parameters are too restrictive.
6607	Cor_Rbi_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii* windowed and filtered	Verify available RAM.
6608	Cor_Rbi_CIN	Unable to allocate enough memory to store correlation function	Verify available RAM.
6609	Cor_Rbi_CIN	Unable to allocate enough memory to store buffer arrays of correlation function	Verify available RAM.
6610	Cor_Rbi_CIN	Unable to allocate enough memory for intermediate storage of correlation function	Verify available RAM.
6611	Cor_Rbi_CIN	Unable to allocate enough memory for temporary storage of dates and durations of bubbles in reference/secondary PIF	Verify available RAM.
6612	Cor_Rbi_CIN	Unable to align return array containing abscissas/ordinates of correlation function	Problem with interface between LabView and CIN.

Number	Procedure	Message	Comments
6701	Histo_dt_CIN	Unable to read value "*Fips*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\Repertoires*"	Registry is not initialised and do not contain the awaited key.
6702	Histo_dt_CIN	Unable to open the PIF file "*xxxx*"	The file which name is passed as argument does not exist.
6703	Histo_dt_CIN	No bubble found in PIF "*xxxx*"	The PIF file being read is empty. Before acquisition, verify if signal is present, check threshold levels on opto-electronics and activate at least 1 channel when setting acquisition parameters.
6704	Histo_dt_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii*	Verify available RAM.
6705	Histo_dt_CIN	Reading PIF file "*xxxx*" interrupted : only *iii* bubbles read from *nnn*	The PIF file being read is corrupted: the first block does not match with the whole content.
6706	Histo_dt_CIN	No bubble found in PIF "*xxxx*" after windowing and filtering	The windowing and filtering parameters are too restrictive.
6707	Histo_dt_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii* windowed and filtered	Verify available RAM.
6708	Histo_dt_CIN	Unable to allocate enough memory to store classes/populations from time of flight histogram for rising/falling edges	Verify available RAM.
6709	Histo_dt_CIN	Unable to allocate enough memory to store dates from rising or falling edges of *iii* PIF	Verify available RAM.
6710	Histo_dt_CIN	Unable to allocate enough memory to store minimum times of flight	Verify available RAM.
6711	Histo_dt_CIN	Unable to allocate enough memory to store extreme classes from time of flight histogram	Verify available RAM.
6712	Histo_dt_CIN	Unable to align return array containing classes/populations from time of flight histogram for rising/falling edges	Problem with interface between LabView and CIN.

Number	Procedure	Message	Comments
6801	Quad_CIN	Unable to read value "*Fips*" in the Registry key "*HKCU\SOFTWARE\RBI Systems\Repertoires*"	Registry is not initialised and do not contain the awaited key.
6802	Quad_CIN	Unable to open the PIF file "*xxxx*"	The file which name is passed as argument does not exist.
6803	Quad_CIN	No bubble found in PIF "*xxxx*"	The PIF file being read is empty. Before acquisition, verify if signal is present, check threshold levels on opto-electronics and activate at least 1 channel when setting acquisition parameters.
6804	Quad_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii*	Verify available RAM.
6805	Quad_CIN	Reading PIF file "*xxxx*" interrupted : only *iii* bubbles read from *nnn*	The PIF file being read is corrupted : the first block does not match with the whole content.
6806	Quad_CIN	No bubble found in PIF "*xxxx*" after windowing and filtering	The windowing and filtering parameters are too restrictive.
6807	Quad_CIN	Unable to allocate enough memory to store *nnn* bubbles from PIF *iii* windowed and filtered	Verify available RAM.
6808	Quad_CIN	Unable to allocate enough memory to store event array	Verify available RAM.
6809	Quad_CIN	Unable to open the file "*xxxx*" to store the sorted events	Verify available disk space.
6810	Quad_CIN	Two tips have same coordinates, calculation is no more possible !	Verify the current probe’s geometry.
6811	Quad_CIN	Main determinant is null, calculation is no more possible !	Verify the current probe’s geometry.
6812	Quad_CIN	Unable to align return array containing results	Problem with interface between LabView and CIN.