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NEW MONOCHROMATOR AND SONAR SYSTEM USER MANUAL

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Abstract

In this note, we report the features of the RICH Gas Monitoring System. A dedicated system has been designed to handle the delicate radiator gas operations for COMPASS RICH-1. The gas analysis system consists of two components the monochromator system and the sonar system. The monochromator system allows a wavelength-dependent determination of the transparency of the gas in the interesting wavelength range and can indicate the presence of contaminants. The sonar system can determine the composition of a binary gas mixture to a percent level accuracy.

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CHAPTER 1:

CHAPTER 2:

CHAPTER 3:

CHAPTER 4:

CHAPTER 5:

CHAPTER 6:

APPENDICES

CHAPTER 1:

The RICH Monochromator System and The RICH Sonar System

1.1 - Introduction:

The COMPASS RICH-1 is a large-size Ring Imaging Cherenkov detector which performs hadron identification. Its large-volume vessel is filled with C4F10 , a heavy fluorocarbon.
Cherenkov photons emitted in the gas are reflected by two spherical mirror surfaces. The photons are converted to electrons by the CsI photon cathodes of eight Multi-Wire Proportional Chambers (MWPC), which amplify the single photoelectrons and allowing to detect them [1]. In the central region MWPCs have been replaced by multianode photomultiplier tubes (MAPMT) within the RICH-1 upgrade project, in operation since 2006[2].
The quest for sufficient number of Cherenkov photons for this gas determines the overall length of the radiator vessel to be of about 3 m. The RICH-1 large acceptance geometry results in a photon detector surface of 5.6m^2.
A dedicated system has been designed to handle the delicate radiator gas operations for RICH-1 detector due to several stringent constraints for the gas pressure and purity[3].
Whenever it is necessary to analyze the radiator gas, a sample is passed to the gas analysis system.
The gas analysis system[3] consists of two components the MONOCHROMATOR SYSTEM and the SONAR SYSTEM .

The monochromator system allows a wavelength-dependent determination of the transparency of the gas in the interesting wavelength range and can indicate the presence of contaminants.
The sonar system is used to measure the fraction of nitrogen present in the radiator gas, sampled in series with the gas flow through the monochromator. This system can determine the composition of a binary gas mixture to a percent level accuracy.
The sonar is also used when the RICH vessel is being filled with C4F10 or this gas is recovered as well.
The composition of the binary mixture N2/C4F10 is an important parameter, as it is related to the refractive index of the mixture, which determines the Cherenkov threshold and angle.

1.2 - The setup of the monochromator system

Figure 1.1 gives a schematic view of the setup used to measure gas transparency [3]. The light from UV lamp is filtered by the monochromator, so to select a wavelength with a bandwidth of about 1 nm. It transits along a path formed by the two orthogonal pipes flushed with the radiator gas. At the end of the horizontal section of the gas tube the monochromatic light beam is split by a CaF2 beam splitter. Part of the light goes directly to the lower photomultiplier tube PMT2 used as reference; the rest traverses the 2 meters (1957 mm exactly) long vertical part, and is detected by the upper photomultiplier, PMT1 [3].
When C4F10 flows through the tube, the transparency over these 2 meters can be determined measuring the anode current of the PMTs, I1 and I2:

$$T(\lambda) = G(\lambda)^{-1} \times \left[\frac{I_1(\lambda) - I_{1,dark}}{I_2(\lambda) - I_{2,dark}} \right]$$

Formula 1.1: Transparency

Where the dark currents are the measured anode currents of the PMT's with no stimulus at the photo-cathode.
The function $G(\lambda)$ is obtained performing a reference measurement. The reference measurement is performed flushing pure nitrogen, which is known to be transparent. During this measurement the currents of PMT's are measured using the same transparency calculation.

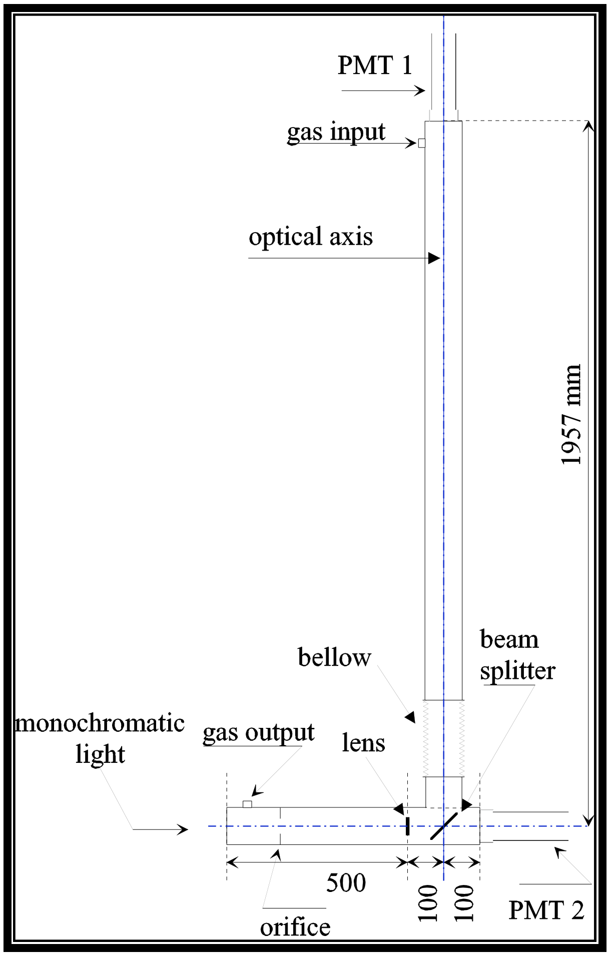

Figure 1.1 The monochromator gas tube

To generate a beam of monochromatic VUV light, a monochromator McPherson model 234/302 [4] is used. A picture of the monochromator internal setup is shown in the figure 1.1. This monochromator is based on a so-called constant deviation setup, where the total opening angle is constant, and the grating is rotated to scan the spectrum. The grating is optimized for the range 100–300 nm wavelength.

The entrance and exit slits are 0.1 mm wide. The light source used is an L2D2 deuterium lamp by Hamamatsu, powered by its dedicated C1518 power supply.

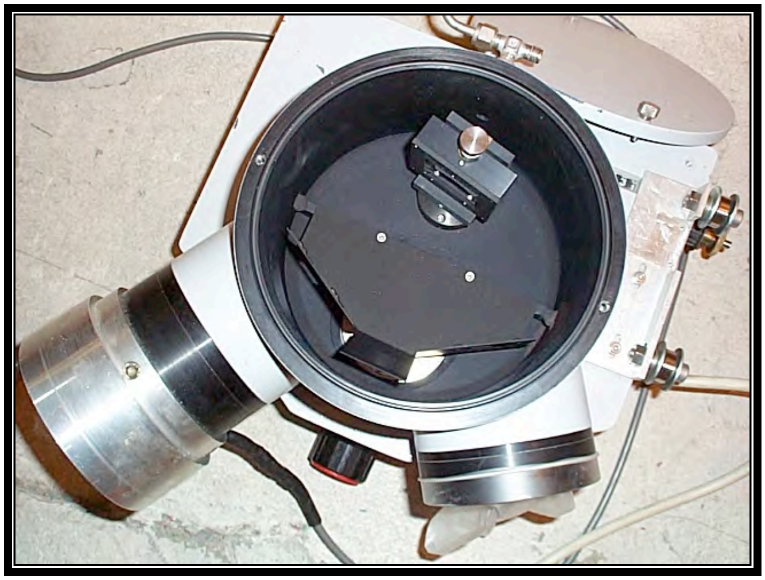

Figure 1.2 McPherson model 234/302 monochromator

Figure. 1.3 shows the mechanical arrangement involved to turn the grating with the required accuracy. The screw-threads axis is driven by a stepper motor.

1.3 The monochromator system read out

The whole setup is remotely controlled and read out by the RICH Gas System Computer. Three PCI NI data acquisition electronics cards are plugged in this computer to perform the read out and the control of the monochromator system.
An encoder is used to keep correctly track of the stepper motor position.
The monochromator stepper motor is steered by a motion control card (NI Motion 7342) connected to the power drive (National Instrument MID 7602) that also reads out the monochromator encoder.

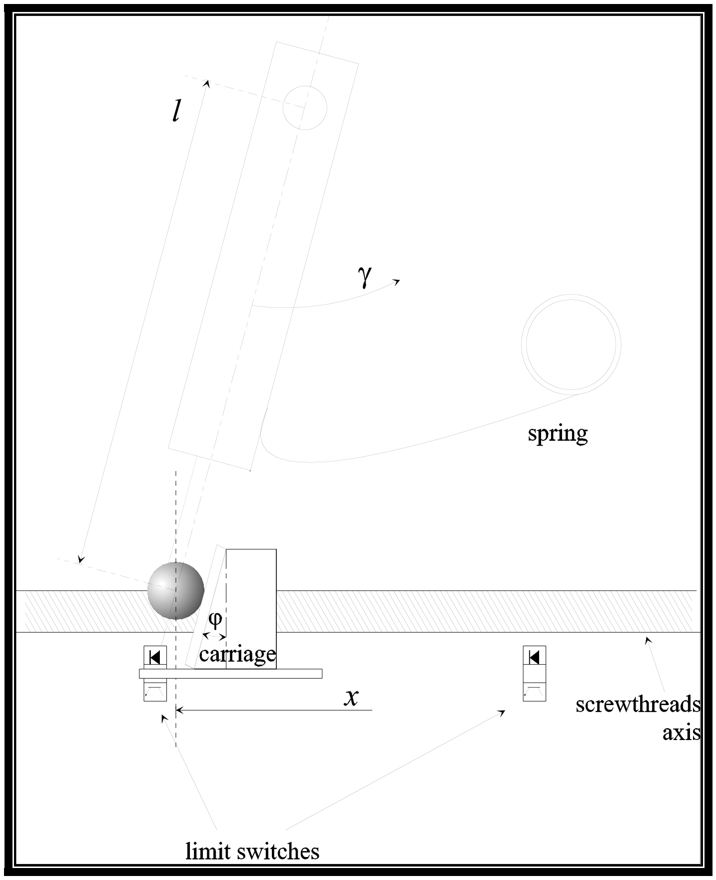

Figure. 1.3 The mechanical arrangement to steer the monochromator.

A multifunction digital and analog input board[6] (NI PCI 6289) reads out the state of the limit switches indicated in figure 1.3 using two analog input channels. The same card reads also two analog channels of a nA-meter, which measure the anode currents of the PMT's.

The high tension values applied to the PMT's is one of the two pre-set levels V0 and V1of the CAEN power supply module model N478, the selection is obtained applying logic level from a digital output channel of the NI PCI 6289 multifunction board.

V0 is a low value selected when the system is inactive; V1 is the work value during the measurement.

This same multifunction board controls all the other steering and read-out functions including a digital output to switch ON and OFF the power supply of the deuterium lamp.

Figure. 1.4 RIGB: The Gas System Box

The RICH Gas system Box (RIGB) is a custom cabling system, built in the electronics laboratory of INFN Trieste.

The three NI boards of the system are connected to this box using the dedicated NI cables.
Inside the RIGB there are three NI connector blocks, one for each board. They connects the input output channels coming from the cards and the specific components of this complex read out system as shown in figure 1.4.
The RIGB also houses the sonar box, described in details in the next section.

IMPORTANT:
The complete list of the analog and digital channels of the system is described in the Appendix B of this User Manual.

The application program is written in Labview 8.55, and is an update of a previous version in Labview 6 built using new NI DAQ-MX libraries, and newly written subroutines to control the stepper motor and relative encoder.
The program allows performing reference and transparency measurements, calculating and propagating the measurement errors. These data are stored in files in ASCII format, in the specific folders as it is described in the chapter 4.

The application program has an option to perform a wavelength calibration as well. In this routine, the spectrum is scanned searching for an intensity maximum at 160 nm, this is a property of the deuterium lamp.
The system formed by the D2 lamp and the PMTs equipped with wavelength shifter exhibits a pronounced maximum at 160 nm: this makes the absolute calibration possible.
More details about the monochromator program are described in the Chapter 3 of this Manual and the “Algorithms description” document [11].

1.4 - The sonar system

In series with the gas flow through the monochromator described in the previous section there is the sonar system. To monitor the composition of the binary mixture N2/C4F10, the sonar system measures the speed of sound in the gas[3].

1.4.1 - The sonar system setup and the sonar read out

In a binary gas mixture the sound velocity depends on the speed in the atmospheres formed by the single components, their relative concentration and the temperature.
Temperature changes have to be taken into account during series of measurements.
The SONAR SYSTEM device, shown in figure 1.6 consists of a closed stainless steel tube, long 648.5 mm filled with the gas to be analyzed. At a terminal end of the tube, there is an electrostatic transducer, which acts as a speaker in the transmit mode and as a microphone in the receive mode.

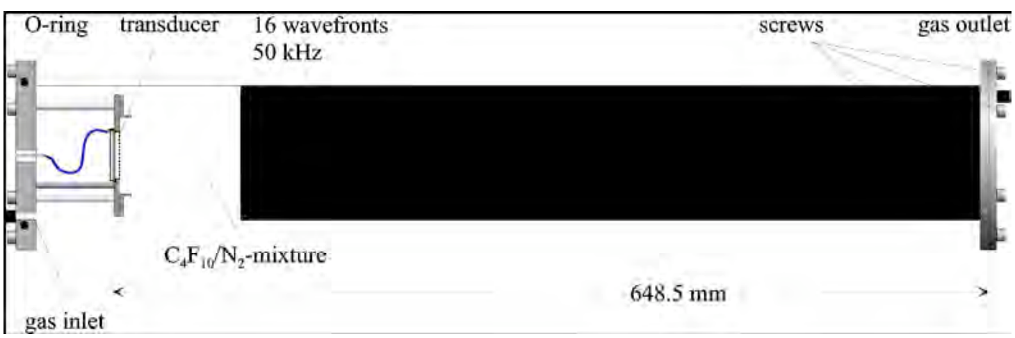

Figure. 1.6 The Sonar System Setup

The transducer generates a train of 16 pulses at a frequency of 50 KHz, while the back wall of the tube is used as a reflector of the sound. The transducer also collects the reflected waves. The transducer of the system is controlled by an external sonar driver.
The figure 1.7 is a zoom-in of the left end of figure 1.6. The transducer used is an electrostatic ultrasonic SensComp, series 600 based on a parallel plate capacitor of 42 mm diameter; it consists of a gold-plated metallised foil stretched over a concentrically grooved metal plate.

The metal plate is grounded while the foil is connected to a wire. The mobile element of the transducer is the foil that converts electrical energy into sound and converts back the echo in electrical energy.

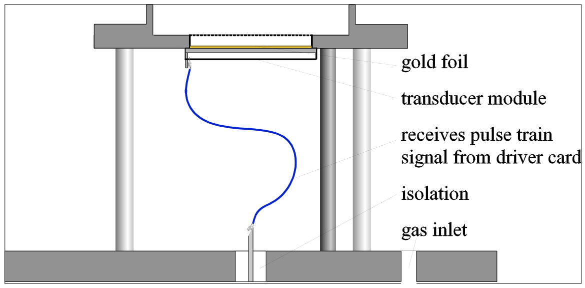

Figure. 1.7 The Sonar System Setup

The electronics board that controls the transducer is “SensComp 6500 Ranging Module” by Tecnosens, a sonar ranging board of the type that is used in auto focus systems of Polaroid cameras and is the heart of the system where the wave fronts signals emitted by the transducer are generated.
Figure 1.8 gives a detailed view of the electronics board mounted inside of the sonar box.

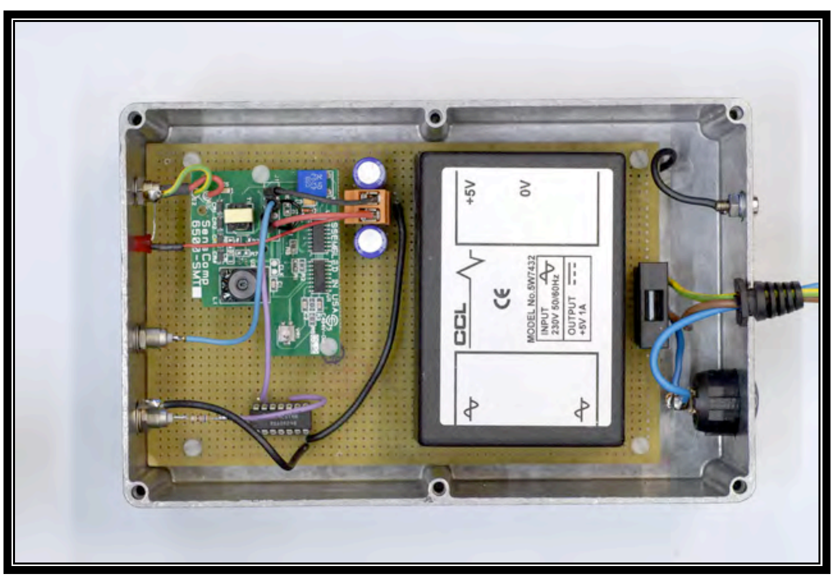

Figure. 1.8 The Sonar Box with the electronics board

At the beginning of a measurement, the transducer is excited by an adequate oscillating signal ranging from 0 to 400 V resulting in 16 pulses at a frequency of 50 KHz.
After the pulse train is generated, a dead time of 2.38 ms, internal blanking signal (BLNK) of the sonar board[5], is used to exclude false echo inputs (see figure 1.9).
Then the sonar driver card switches to microphone mode, and the potential of the plate is set to 200 V, to operate as a condenser microphone.
The sequence to initialize the transducer driver, sending and receiving the pulse train, is the INIT signal of the sonar ranging card.

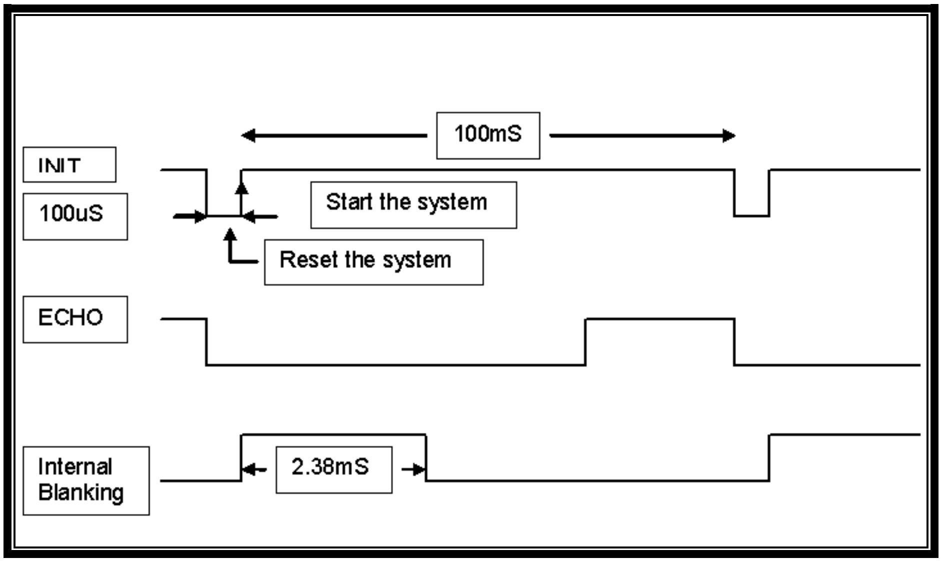

Figure. 1.9 Sonar signal timing

Figure 1.9 presents a detailed view of the signals timing.
The elapsed time between the transmission and the echo detection is a function of the distance to the target. The speed of sound is:

$$v = \frac{2x0.6485}{\text{t\_stop - (t\_start + t\_delay)}}$$

Where 0.6485 is the length of the tube, t_start is the start signal (INIT signal of the sonar board), t_stop is the time when the ECHO is detected, of the sonar board and t_delay is the sum of the delay from the ECHO signal goes up (end of reception).

The Counter timer digital input output board (NI PCI 6602) card of National Instruments does all the control and read-out of the INIT and ECHO signals. This card, shown in figure 1.10, is connected to the RIGB as well.

Figure. 1.10 The Sonar control board NI PCI 6602

CHAPTER 2:

The RICH Monochromator System Base Software

In this chapter the Monochromator software installed in the RICH Gas System Computer is described as well as the procedures needed to configure it.

2.1- Base Software Installed on the Gas System Control computer

The operating system installed in the RICH Gas System Computer is Windows XP.

The operating system was updated to the latest service pack and all security patches have been applied.

2.1.1- Other base software:

The versions of the different software packages are:

LabView Version: 8.5
MAX Version 4.2.0.3001
Motion Assistant 2.0.0
NI-Motion Device Driver 7.4.0.3002 and NI-Motion 7.6. to Upgrade to PCI NI Motion 7342
Firmware of the NI Motion: Version 68331
NI-DAQmx Device Driver 8.5.0f3

2.1.2.- Firmware Versions in NI Motion 7.6

The following table lists the firmware versions installed with NI-Motion 7.6. This allows using the software of the NI motion control library with the PCI NI Motion 7342 board that controls the stepper motor and the connected encoder.

Firmware Board	**Version Number NI 7342**
68331	7.40.3001
DSP	7.30.3001
FPGA1	7.00.3001
FPGA2	7.00.3001

Table 2.1: NI Motion 7342 board firmware versions

2.2. Measurement & Automation Explorer (MAX):

National Instruments provides a graphical user interface (GUI): the MAX. This user friendly application allows performing the following operations:

1. Configure your National Instruments hardware and software
2. Back up or replicate configuration data
3. Create and edit channels, tasks, interfaces, scales, and virtual instruments
4. Execute system diagnostics
5. View devices and instruments connected to your system
6. Update your National Instruments software

The most important operations for us are points 1, 3 and 5 described above.

For the developer, the most important operation is the configuration of the National Instruments hardware. For the user, it could be necessary to check the configuration and some times it could be useful to activate the Interactive system diagnostics of MAX as described in the following sections.

2.2.1 - MAX settings in the Gas System

In the gas system application program the major part of the channels of the three boards are configured inside the application by the dedicated initialization routines. Only for the NI Motion board and the monochromator encoder the settings are done via MAX, is essential that the three boards appear as shown in figure 2.2.

2.2.1.1- How to launch MAX:

To start MAX select the following Icon in the control panel:

Figure 2.1: MAX icon

The configuration panel Devices will list the NI Hardware and Software components installed in the PC, as shown in figure 2.2.

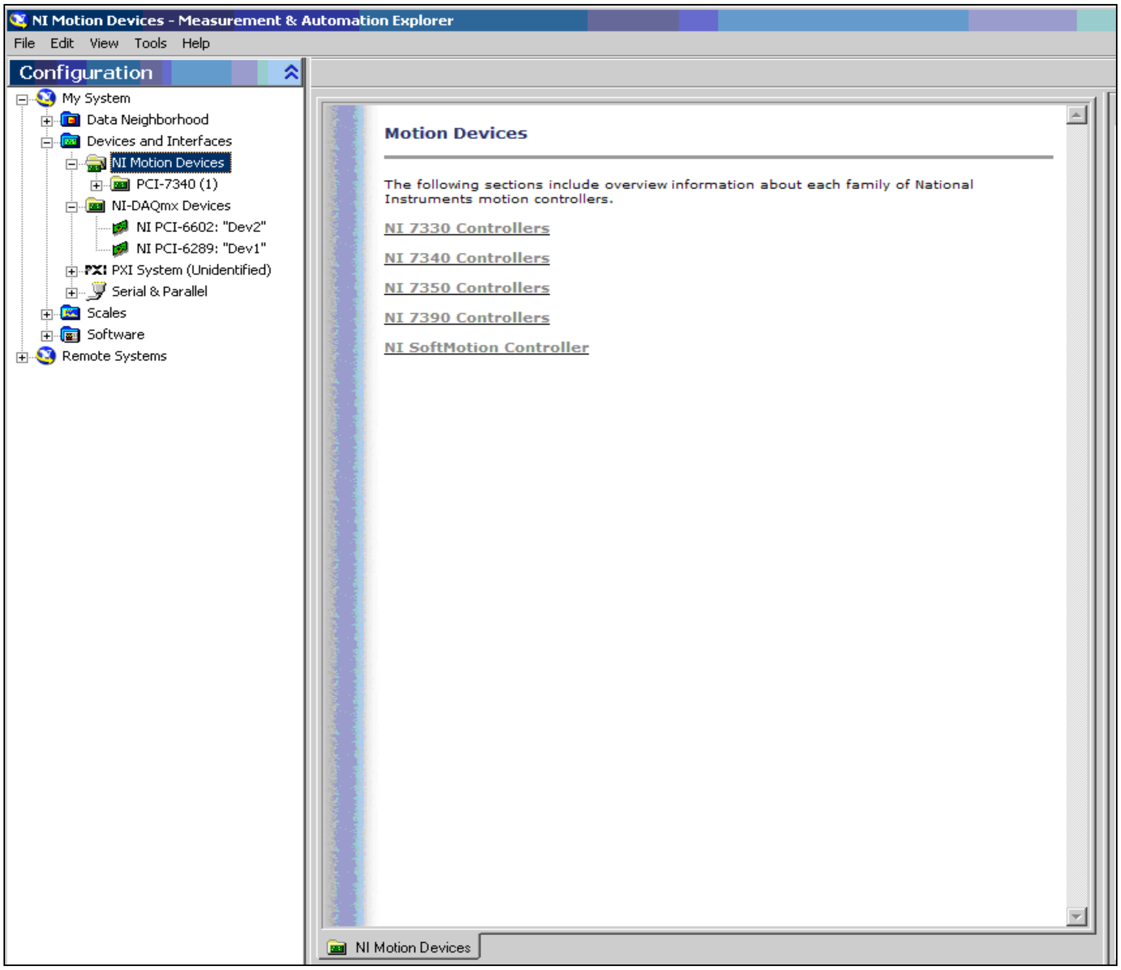

Figure 2.2: Main menu of MAX

2.2.2.- How to configure the NI Motion NI 7342 in MAX:

The NI Motion board of the RICH Gas System is a PCI 7342 board which is responsible for the control of the stepper motor and the encoder of the system. In the MAX menu you will find it as NI 7340, as shown in figure 2.3. This difference is due to fact that the spare board we have is a different version of the same family of NI Motion boards and LabView identifies them by the generic name PCI 7340.

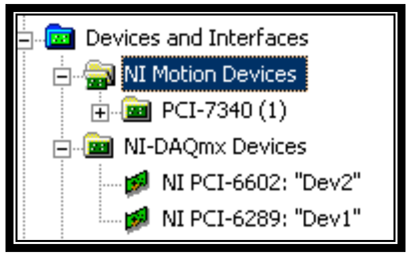

Figure 2.3: MAX menu of Devices and interfaces available and installed in the system

2.2.2.1 NI Motion 7340 family compatibility

The configuration saved for the system in MAX and the firmware versions on board described in table 2.1 allow working with both boards PCI 7340 and PCI 7342. The differences are handled internally.

The system is described in next section and in the additional document [10]. The correct settings for the NI Motion devices will be described step by step.

2.2.3. - How to configure the NI-Motion board settings in MAX:

1. Check the **Axis configuration** setting of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller: Expand NI Motion Devices **>>**
    4. Select PCI-7340(1) **>>** Default 7340 Settings **>>** Axis 1 **>>** Axis configuration
    5. Select the tag **Axis Configuration**
    6. Select the following settings:
    7. Type : *Stepper*
    8. Enabled: *Enabled*
    9. Feedback **>>** *Type of Feedback: Encoder*

2. Check the **Stepper settings** of the Axis configuration of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller : Expand NI Motion Devices >> PCI-7340 (1)
    4. Select Default 7342 Settings >> Axis 1 >> Axis configuration
    5. Select the tag **Stepper Settings**
    6. Select the following settings:
    7. Stepper steps per revolution: *2000*
    8. Stepper Loop Mode: *Closed Loop*
    9. Stepper Polarity: Active *Low*
    10. Stepper Output Mode: *Step & Direction*
    11. Stepper Pull In Moves>> *Pull In Window : (value): 1*
    12. Stepper Pull In Moves>> *Pull In Tries: 3*
    13. Feedback >> *Type of Feedback: Encoder*

3. Check the **Motion I/O** Settings of the NI 7340 controller:
    1. Launch MAX.
    2. Expand Devices and Interfaces.
    3. Select the appropriate motion controller: Expand NI Motion Devices >> PCI-7340(1)
    4. Select Default 7342 Settings >> Axis 1 >> Motion I/O Settings
    5. Select the following settings:
    6. Home & Limit Switch Settings >> Limit Filters: *Enabled*
    7. Fordward Limit Switch: *Enabled* ; Active Low Polarity: *Enabled*;
    8. Reverse Limit Switch: Enabled; Active Low Polarity: Enabled;
    9. Home Switch: *Enabled*; Active Low Polarity: *Enabled*;
    10. Inhibit Output Settings: Enabled; Active Low Polarity: *Enabled*;
    11. **The rest of the settings: *Disabled.***

4. Check the **Trajectory Settings** of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller: Expand NI Motion Devices >> PCI-7340(1) >>
    4. Select Default 7340 Settings >> Axis 1 >> Trajectory Settings
    5. Select the tag **Trajectory Settings**
    6. Units: *steps.*

7. Move Status Settings >> Following Error: *800 Counts*
8. Move Status Settings >> Velocity Threshold: *2000000 steps/s*
9. Run/Stop Threshold: *1 step/sample*
10. Velocity Filter Settings >> Filter Time: *10 milliseconds*
11. Velocity Filter Settings >> Filter Distance: *100 milliseconds*
12. **The rest of the Settings: *Not selected***

5. Check the **Trajectory Settings, Move constraints** of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller: Expand NI Motion Devices >> PCI-7340(1)
    4. Select Default 7340 Settings >> Axis 1 >> Trajectory Settings
    5. Select the tag **Move constraints**
    6. Units: *steps*
    7. Velocity: *4000 steps/s*
    8. Acceleration: *4000 steps/s^2*
    9. Deceleration: *4000 steps/s^2*
    10. S Curve Time: *1 sample periods*

6. Check the **Control Loop Settings** of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller: Expand NI Motion Devices >> PCI-7340(1)
    4. Select Default 7340 Settings >> Axis 1 >> Control Loop Settings
    5. Select the tag **Torque Limits & Offsets**
    6. Load Torque Limits & Offsets in: Volts
    7. Primary DAC Output
    8. Positive Torque Limit : *10 Volts*
    9. Negative Torque Limit : *10 Volts*
    10. Torque Offset: *0 Volts*
    11. Secondary DAC Output
    12. Positive Torque Limit : *10 Volts*
    13. Negative Torque Limit : *10 Volts*
    14. Torque Offset*: 0 Volts*
    15. Torque Offset: *0 Volts*

7. Check the **Encoder Settings** of the NI 7340 controller:
    1. Launch MAX.
    2. Expand **Devices and Interfaces.**
    3. Select the appropriate motion controller: Expand NI Motion Devices **>>** PCI-7340(1)
    4. Expand Default 7340 Settings **>>** Axis 1 **>>** Encoder Settings
    5. Select Encoder1
    6. Encoder Counts per revolution: *800*
    7. Filter frequency: *1.6 MHz*
    8. Select Polarities:
    9. Line State: *A, B* and Index: *Active High*
    10. Index Reference Criteria:
    11. Set A and B: *Inactive*

IMPORTANT:

1. After you complete the settings, select 

2. The Digital Input Output Settings channels of this board are not used in the Gas System configuration, and their configuration can be skipped.

2.3 - How to initialize the Motion board using the MAX:

The MAX settings must be loaded in the internal processor of the NI-Motion board.

To perform this, use the Interactive menu as shown in figure 2.4. Press “Initialize” from the upper menu bar, a time progress bar will be shown, up to the “Initialization Successful” message.

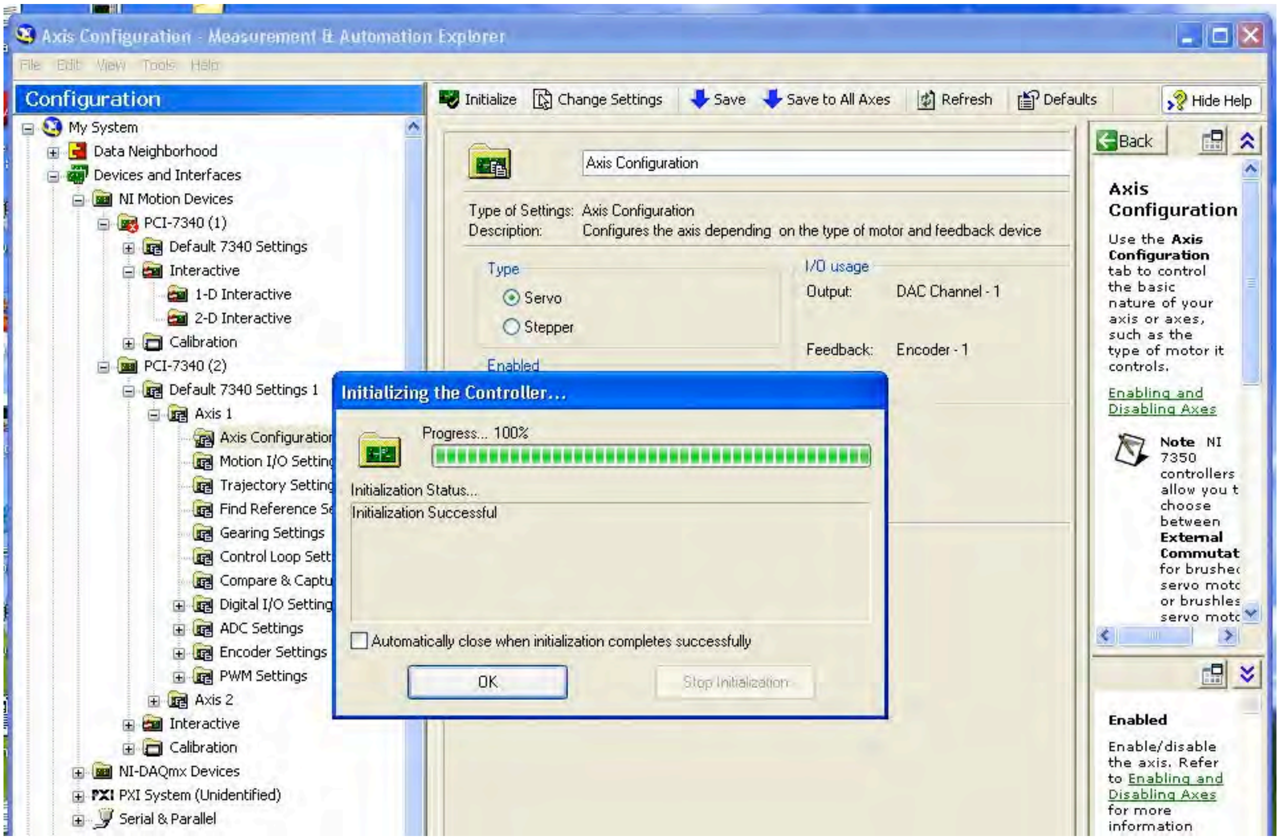

Figure 2.4: Initialization using MAX of NI MOTION controller

For more information about the stepper motor and encoder setting in MAX used in the Gas System see the document " COMPASS RICH-1 Gas System Max Settings" [10].

CHAPTER 3:

THE GAS SYSTEM COMPUTER CONTROLLER AND HOW TO OPERATE

3.1 The Gas System Computer

As described in chapter 1, the whole setup is controlled and read out by the Gas System computer. The program that controls the systems, written in LabView 8.55, allows performing reference and transparency measurements, calculating and propagating errors. The Gas System Computer is an Elonex Prosentia PC.

The original computer power supply was changed due to its inadequate performance during the test at the end of August 2007. The hardware system configuration details and the characteristics of the new computer power supply are described in ***Appendix C***.

3.2 - How to Operate the RICH Gas System

IMPORTANT:

Several hardware configurations and status indications must be respected to have the system in running mode and able to perform the measurements.

Before using the RICH gas system, check the following settings:

3.2.1. - Status of the RIGB:

The Gas System box must be **ON**.

3.2.2. - Status of the MID Power drive:

The MID 7602 driver status front panel LEDs should be as shown in figure 3.3 :

Power:	ON
+5V LED:	ON
Enable:	ON

Figure 3.3: .- MID 7602 driver status

All the other six status LEDs must be **OFF.**

3.2.3. - Front Set Up of the MID 7602 Power drive:

The National Instruments MID 7602 integrated stepper motor power drive provides reliable, easy-to-connect 2-axis drive solutions for National Instruments motion controllers.
The MID 7602 front panel has a detachable metal plate which when removed, gives access to two 10-position DIP switch banks. The stepper motor is connected to axis 1, which is configured by the left bank.
The configuration of the switches is shown in figure 3.4.

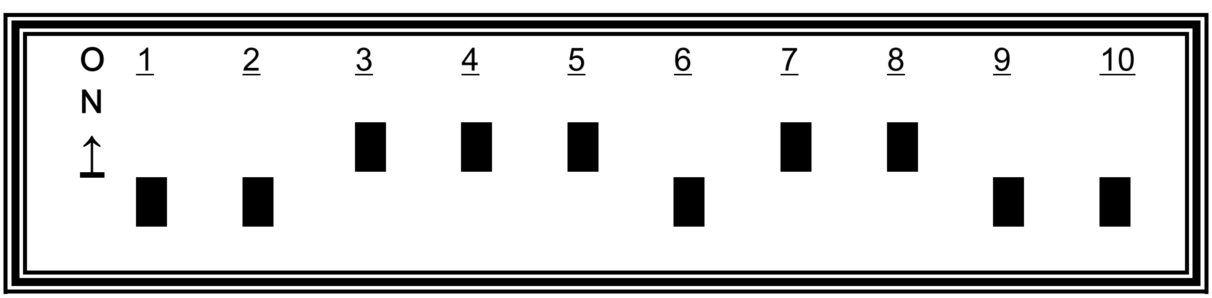

Figure 3.4: .- Front Panel Switches of the MID 7602 power drive

For more information about the stepper motor driver and power setting see the MID 7602 User Manual [9].

3.3.- The monochromator lamp:
The monochromator lamp is the box on shelf close to the sonar as shown in figure 3.5, must be **ON**.

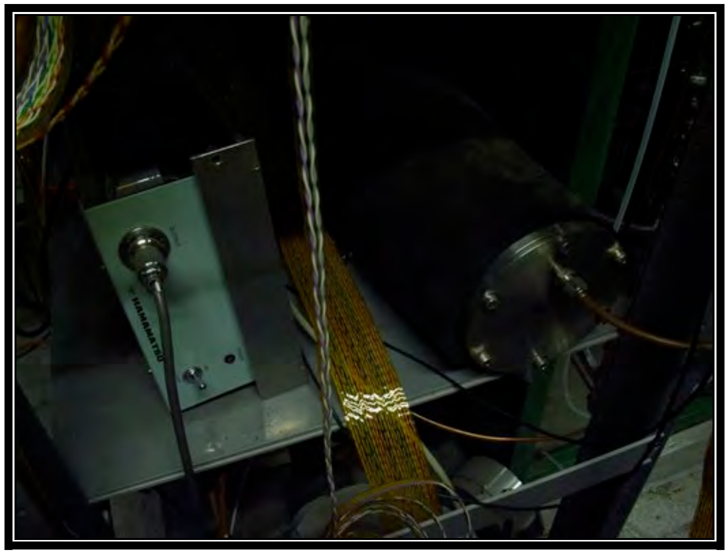

Figure 3.5: .- Monochromator Lamp power supply

3.4.- How to turn ON the CAEN Module

Just in case of power cut of the NIM crate housing the CAEN HV Module, it must be reprogrammed.

- To switch ON the PMT's to 200 Volts (they will ramp up only during the measurement); you must program channels 2 and 3 of the module:

1. Press < F > < 0 > < # >
2. Press < 2 > < # >
3. Press < F > < 10 > < # >
4. Press < F > < 0 > < # >
5. Press < 3 > < # >
6. Press < F > < 10 > < # >

3.5.- Login on the system

User: Gas-System

Password: Mono&Sonar@

3.6.- Check the Gas System Application programs before starting:
The Gas System Application programs are a set of LabView routines allowing to control the RICH Gas System.

This set of routines is installed in the Gas System Computer according to the "Installation instructions" described in chapter 4 section 4.1.1.

Another important requirement is maintaining the expected structure of disk files and folders.
The Application programs read parameters and configuration settings from a set of source files and save the measurement files in the destination folders.
The configuration folder should be as follow:

C:\Monochromator\sources\Transparency_last
C:\Monochromator\sources\TestingTools
C:\Monochromator\Configuration
C:\Monochromator\measurements
C:\Monochromator\Gas_System_Docs

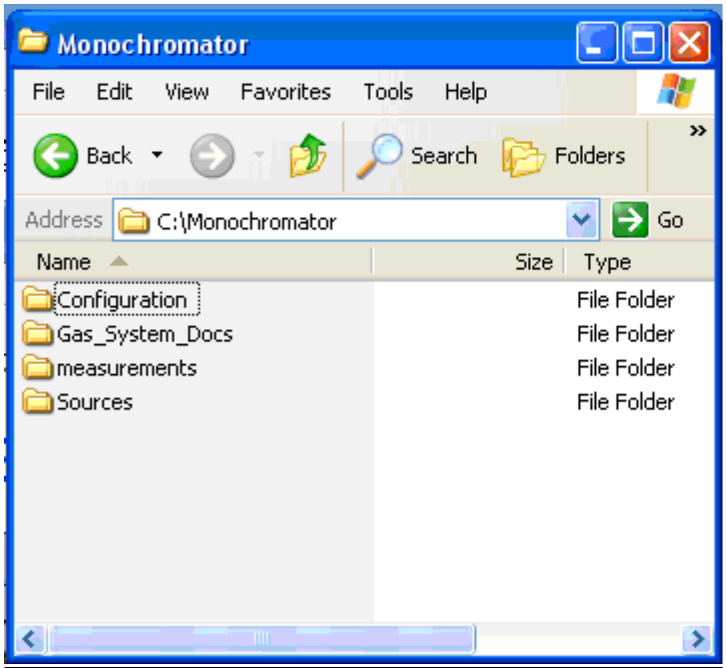

Figure 3.6: .- Monochromator folder configuration in the main host disk of the Gas System Computer

Figure 3.6 shows the configuration folder of the system. The specification of each folder is detailed in the next chapter. If one of these folders is not present as shown, refer to next chapter section 4.1.1 "Installation Instructions".

CHAPTER 4:

MAIN USER APPLICATION AND THE MEASUREMENTS

4.1.- The Main User Application

The COMPASS Rich Gas System User Application program, written in LabView Version 8.50 controls the Monochromator and Sonar Systems and allows to perform the measurements of the system.

4.1.1 Installation Instructions

The source program is already installed in the disk C: of the Gas System computer in the monochromator\sources\Transparency_last folder as described in the previous chapter section 3.3.6. In case of necessary re-installation of the system there is a CD with the complete version of the software the instruction in the next section.

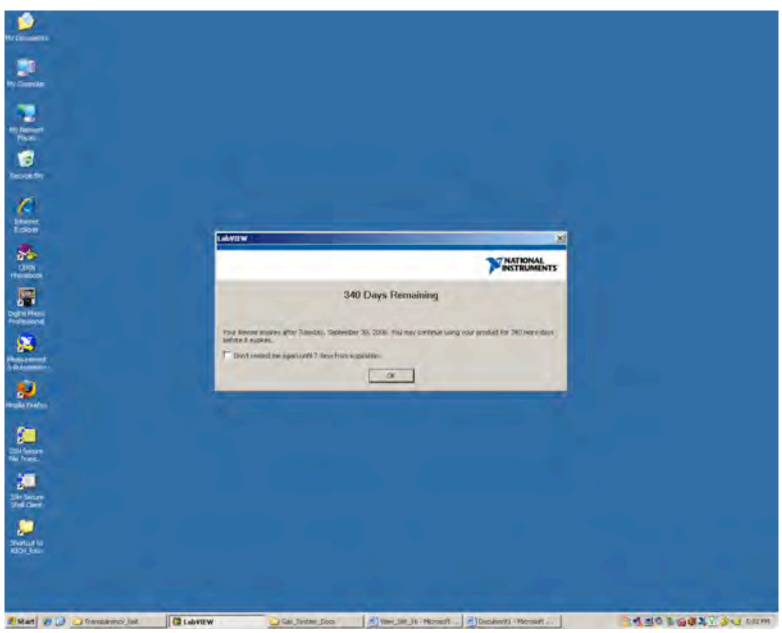

Figure 4.0: LabView License standalone control

The Program has a shortcut in the desktop is **New_Trasparency_2007_Final.vi.**

When the program starts the first time a window message opens with the LabView License standalone checking due to CERN License constrains as is possible to see in the figure 4.0.
Just press OK in the dialog confirmation window and follow the instruction of the next section.

4.2.- To operate the Monochromator system:

1.- Open the program.

2.- Set the parameters of the measurement as are described in the following sections.

3.- Press the START green button of the monochromator dialog window as is shown in the left part of the main window application in figure 4.1.

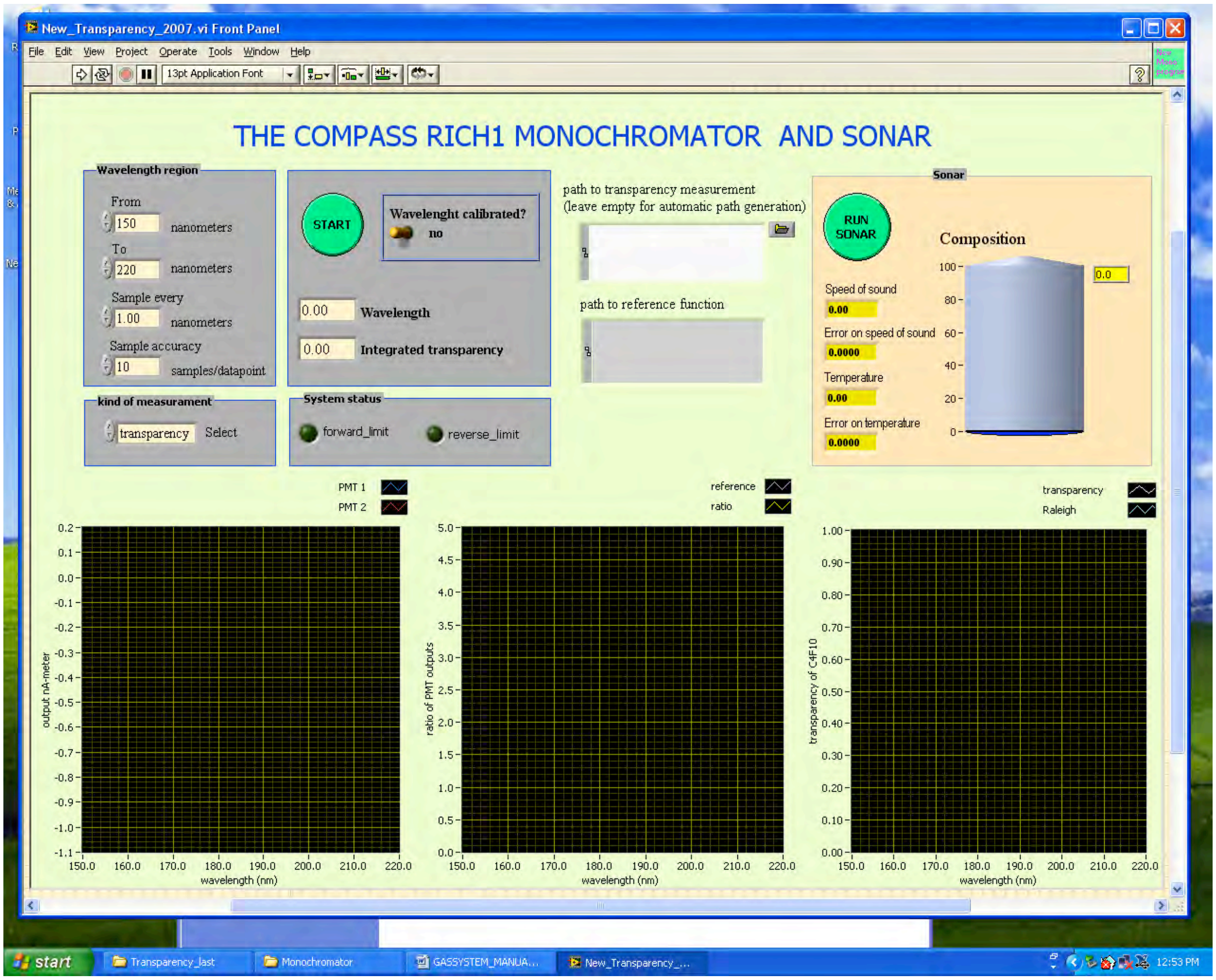

Figure 4.1: Main Monochromator and Sonar Application Program

The figure 4.1, shows the view of the Main Application Program Interface (API) that control both Systems. The Monochromator System on the left of the screen where is possible to set the parameters for the measurement and to the right side there is a display of the values reported for the Sonar System.
The lower part of the main API has three Plots windows displaying the behavior of the Monochromator system during the measurements.

4.3.- Configuration Files:

There is a set of special files that allows the program to have the standard behavior and the characterization of the System at such the index of refraction of materials, study the properties of the optical components. This files are classified as main configuration files, the list is:

RALEIGH.TXT

RICH_efficiency.txt

RICH_efficiency_norm.txt

These files are installed in the c:\Monochromator\configuration folder and the main program expects them from that location.

4.4.- Parameters of the Monochromator measurement

The values of the measurement units are:

4.4.1- Wavelength region: This setting allows the configuration of the scanning range of the monochromator expressed in nanometers. The lower and upper standard limits are reported below and can be changed, as shown in figure 4.2.

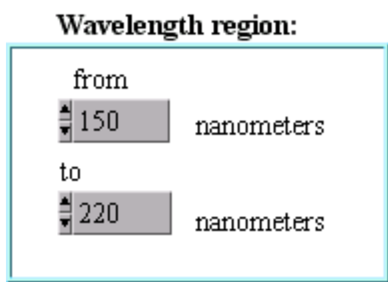

Fig 4.2: Standard limits of the Wavelength region.

4.4.2- Sample settings:
This option allows to set:

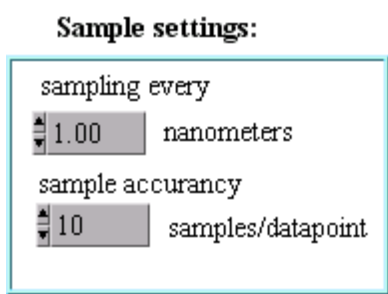

Fig 4.3: Monochromator measurement sample settings

a)- *Sampling every:* The number of nanometers between samplings in the measurement.

b)- The *sample accuracy:* How many samples per channel are read for each data point while the measurement is performed. When a data point is acquired, at a certain wavelength a certain number of samples is taken of the anode currents of both PMTs. The mean of these samples is used for calculating the transparency.

The fig. 4.3 shows the dialog window with the two parameters settings

IMPORTANT:

The following values are used in the New System:

1 sampling every nanometer and 50000 samples per data point. This is due to the features of the new board and the performance of the system.

4.5.- Monochromator Measurements

4.5.1 Type of measurements:

It's possible to perform two kinds of measurements, depending of the gas which is used.

4.5.1.1 Reference measurement:

The N2 gas is used to perform the reference measurement. This special procedure integrates the sigma value of the gas. The measurement values of PMT1 and PMT2 are plotted in the main interface and saved in a disc file (see section 4.5). The Figure. 4.4 gives a view of the results of a standard reference measurement of the system using N2 gas. The peak at 160 nm is shown in the first plot.

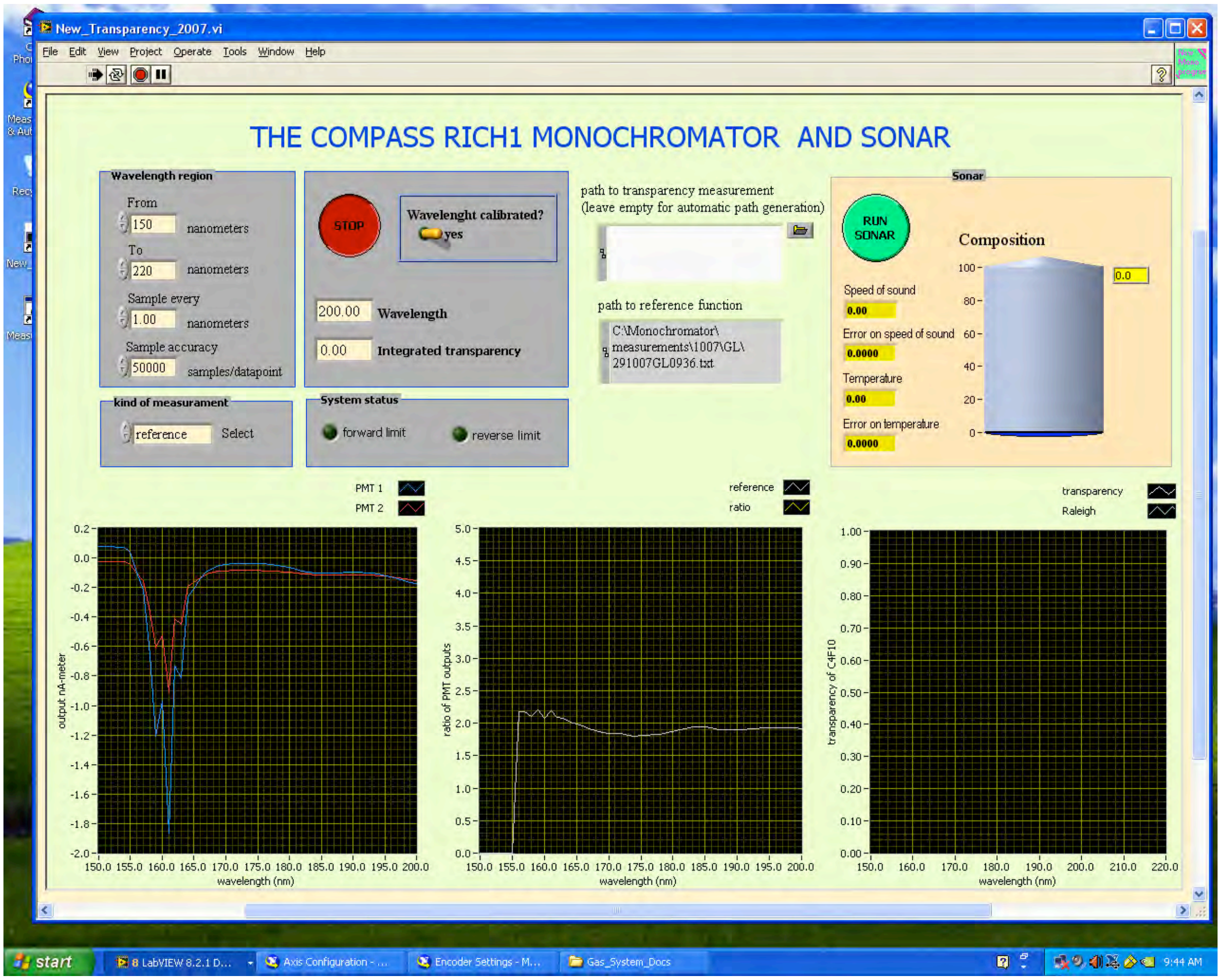

Figure 4.4: Reference measurement of the Monochromator System.

4.5.1.2. Transparency measurement:

The C4F10 gas is used to perform the transparency measurement.

During a transparency measurement, the transparency in the 150–220nm wavelength region is integrated over the total efficiency of the RICH-1 (see the curve in Figure 4.5).

The PMT1 and PMT2 ratio value is calculated and compared with the reference value.

The threshold values is 2.5 sigma of the reference and is used as the standard behavior of the transparency measurement with C4F10.

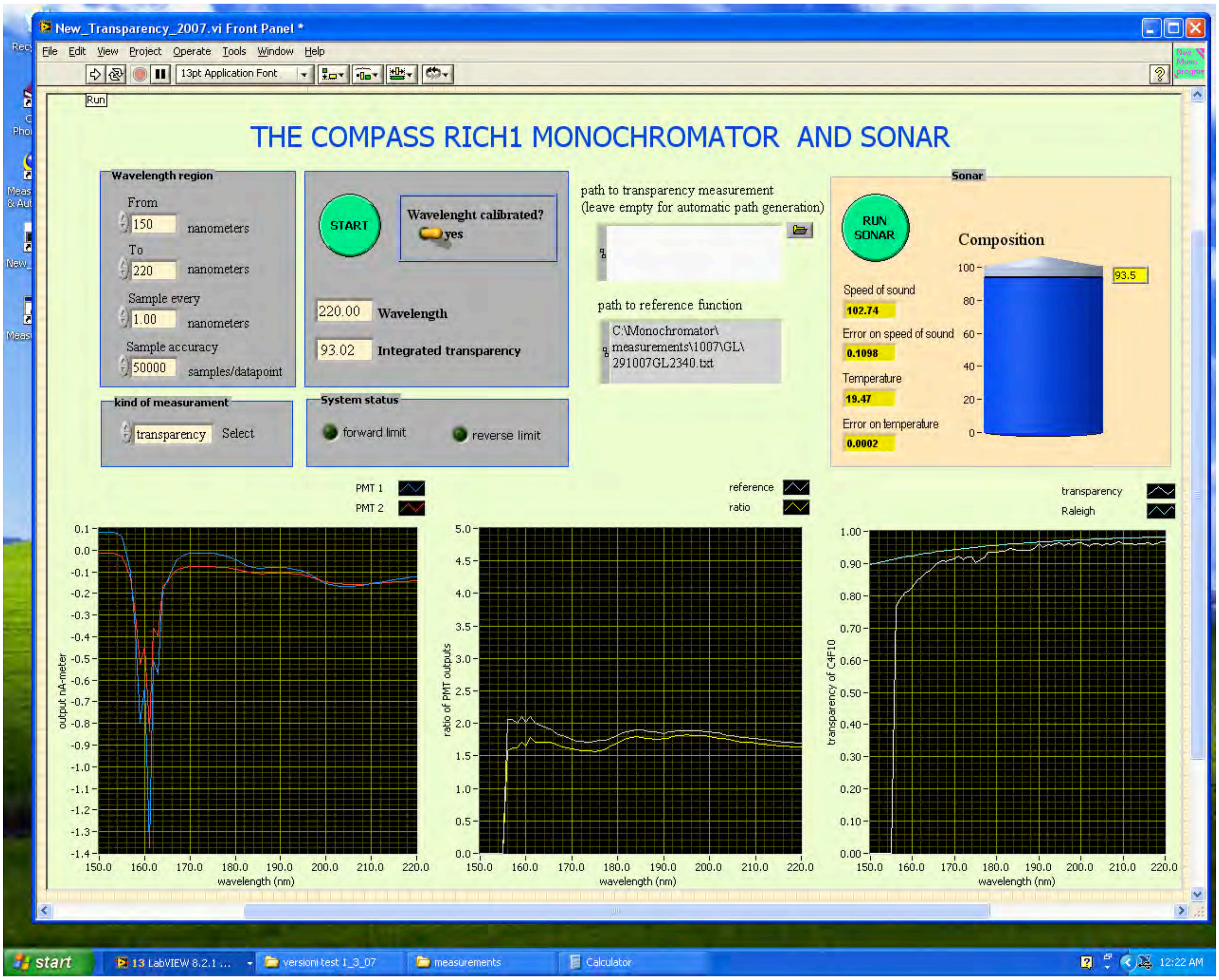

Figure 4.5: Transparency measurement of the Monochromator System and Sonar system measurement.

4.6.- How the measurement values are saved:
These values generated during the measurement are saved in ASCII files format. These files are stored in one special folder C:\Monochromator\measurements. In this folder there are a set of subfolders which are labeled by the name of the month and year in which the measurement has been performed. For instance: C:\Monochromator\measurements\GL\0407 contains the files generated by the reference measurements performed in April 2007.

The reference files are GL files, one example is:

060307GL1033.txt
This file was written on March 6Th at 10:33 a.m. Its complete path, as you see in the dialog window in figure 4.4 is:
C:\Monochromator\measurements\GL\0307\060307GL1033.txt

The transparence files are TL files, one example is:

080307TL1506.txt

The complete path is:

C:\Monochromator\measurements\TL\0306\080307TL1506.txt

4.7.- The Calibration of the Monochromator

This procedure is preliminary to the transparency measurement and allows finding the position of the peak at 160nm and defines it as the reference, absolute zero position of the monochromator stepper motor. The measurement starts searching the reverse limit switch of the rotating grid of the monochromator, going to negative values.
This determines the starting point of the calibration procedure. The procedure performs the scanning in a fixed angle range relative to the starting point, where the peak is known to be found.
In this routine, the spectrum is scanned for an intensity maximum at 160 nm, this is a property of the deuterium lamp.
There is a switch to put ON or OFF the possibility of calibrate the monochormator. At the startup the Application program has the calibration option set OFF (set **“NO”** in the dialog) by default as is shown in figure 4.1.
When the program finish the calibration procedure, automatically the switch is turned ON and the dialog set “YES” as is shown in figure 4.6.

Figure 4.6: Calibration option in the Monochromator System.

Important Note: Please perform this measurement if the monochromator was off or not used for a long period. Just put **“NO”** in the dialog option before to start.

4.8.- Interruption of the Measurement:

In case of necessity to interrupt the reference or transparency measurement before the end of the procedure:

4.8.1 To stop the measurement:

1.- press the red **STOP** button of the application program as is shown in figure 4.4

2.- wait the application program will move the stepper motor putting the monochromator allowing the system to arrive to a secure position.

3.- Check the mechanical counter position. Should be in te position: **0 1 2 2 2**

4.- At the end of this procedure the main application will change color of the **START** button as is shown in figure 4.1 just continue working normally.

4.9.- Sonar measurement:

The sonar system has been described in the chapter 1, the window application is shown in the figure 4.7.

The setup of the system used to measure the speed of sound is shown on the left side of the sonar window and shows the speed of sound in the gas medium and the error of the measurement.
The right side of the sonar window application shows a gas tank graphically and allows following visually the percentage of C4F10 gas in the filling procedure at that moment.

4. 10.- To operate the Sonar system:

1.- Open the program.

2.- Press the **RUN SONAR** green button of the sonar dialog window as is shown in the right side of the main window application in figure 4.7.

3.- Wait while the measurement is performed and the green button is:

As one single measurement by the sonar takes so little time, that the steering program takes 50 measurements and returns the mean.

4.- The values of the temperature, Speed of sound and the corresponding errors are shown in the display window is shown in figure 4.8.

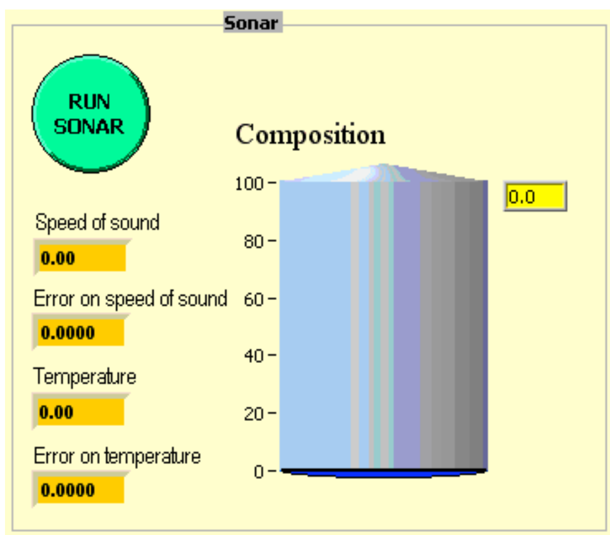

Figure 4.7: The Sonar System.

In the figure 4.5 is possible to visualize the application during the filling procedure with a 95 percent of tank filling.

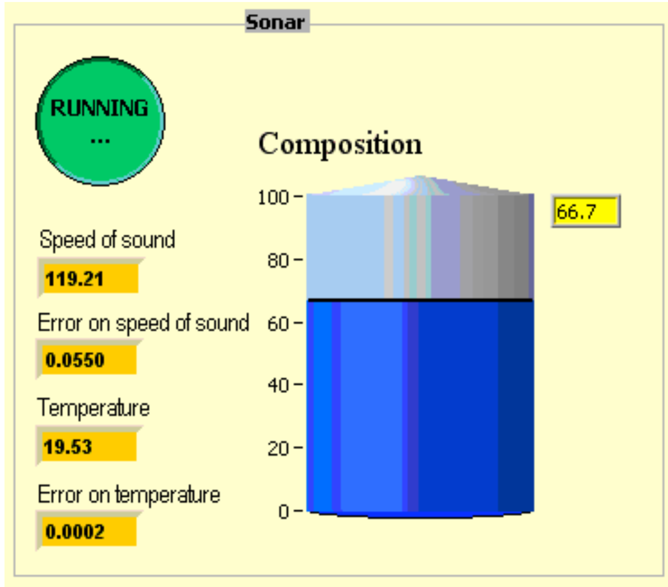

Figure 4.8: The Sonar System while running with 66.7 % of C4F10.

At the end of the measurement procedure as is shown in the display window is shown in figure 4.8. In this case the tank filling show 66.7 percent of filling.

CHAPTER 5:

TROUBLESHOOTING OF THE SYSTEM

This chapter gives some technical recommendation to follow in case of failure of some components during the measurements processes. Each problem is explained in detail and the resolution explained step by step.

5.1.- Solving problems with the MID 7602

In case of having problems in the system with the monochromator stepper motor or if the measurement stopped with no apparent reasons, it will be necessary to check the status of the MID 7602 box that performs the power control and driver of the stepper motor.

5.1.1.- In case of having some problems with the front panel configuration settings perform the follow steps:

1.- Turn OFF the MID 7602 module.

2.- Set the DIP switches as the settings in the chapter 3 section 3.3.3

5.1.2.- In case of having some problems with the status LEDs

1.- Turn OFF the MID 7602 module.

2.- Turn ON the MID 7602 module and Check again.

5.1.3.- If with the INHIBIT status LED is ON meaning there are some problems with the control of the stepper motor or encoder of the system.

1.- Turn OFF the MID 7602 module.

2.- Check the chapter 2 section Setting of the configuration of the NI Motion board.

3.- Open the NI MAX and check the settings of the Motion board.

4.- Replace the wrong settings in the NI MAX.

5.- Turn ON the MID 7602 module.

6.- Reprogram the board following step by step the instructions of the chapter 2 section 2.3 - How to program the Motion Board using the MAX.

7.- If all the instructions were followed correctly the MID 7602 LEDs status should be as shown in the specifications of the section 3.3.2. in this chapter before.

5.2.- Solving problems with the measurements

In case of problems during the execution, power cuts or missing files errors perform the follow steps:

1.- Copy the complete Monochromator directory files and directories from the Installation disk to directory c:\Monochromator.

2.- Choose **Replace** option when asking you about the existing file or folder.

3.- Check the structure of the directories copied to the destination c:\Monochromator directory; is should be as described in section 4.1.1 (Installation Instructions)

5.3.- Solving problems with the configuration files

If you have some problems during the measurement initialization like the normalized or configuration files are not found.

In case of the errors: "problems loading the configuration files" do:

1.- Close the Main program New_Trasparency_2007_Final.vi

2.- Copy the files from the BackUp folder to c:\Monochromator\configuration folder.

3.- Open the Main program New_Trasparency_2007_Final.vi and continue working normally

CHAPTER 6:

MONOCHROMATOR AUXILIARY TOOLS AND THE GAS SYSTEM SECURITY TOOLS. VEGA AND PLC SOFTWARE.

During the development stage of the gas system a set of “Testing Programs” has been developed in order to allow testing the operation of several modules of the system.
One complete recovery procedure in case of crash of the system has been programmed and inside this packet there is an Automatic Backup tool.
Another two software packages VEGA and PLC are present in the Gas System Computer as well.

6.1.- Automatic Backup Procedure

In the desktop you will find a backup script that you have to execute after each measurement.
All the measurements files will be copied to the data disk (disk D). The directory structure is the same as the structure of the system disk (disk C)

6.1.1 To perform the Backup:

1.- press double click in the script icon: GSMeasurement_BackUP present in the desktop

2.- wait the application program will be show the start message

3.- Press any key to continue.

4.- If the destination measurement directory (C:\Monochromator\measurements) does not exist you have to press D (to specify that is a directory)

5.- The BackUp script will show you the list of the files and directories data as shown in figure 5.2. This feature allow to control it.

6.- The procedure checks for each file If there is a file that already exist you can select to replace anyway. If not the files will be not copied.

The figure 6.1 shows the GSMeasurement_BackUP tool in execution with the first bat command.

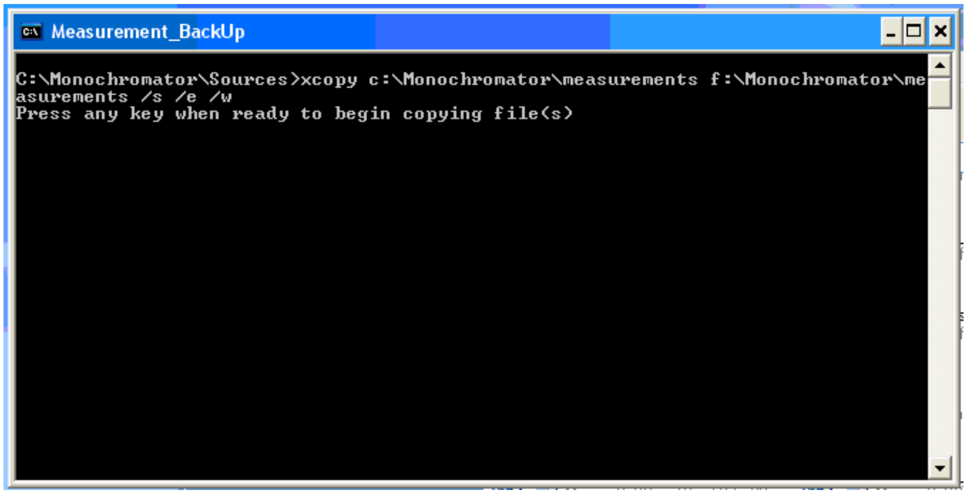

Figure 6.1: The automatic backup tool in execution

The directory checking procedure is shown in figure 6.2 and allows the user to check the target directory.

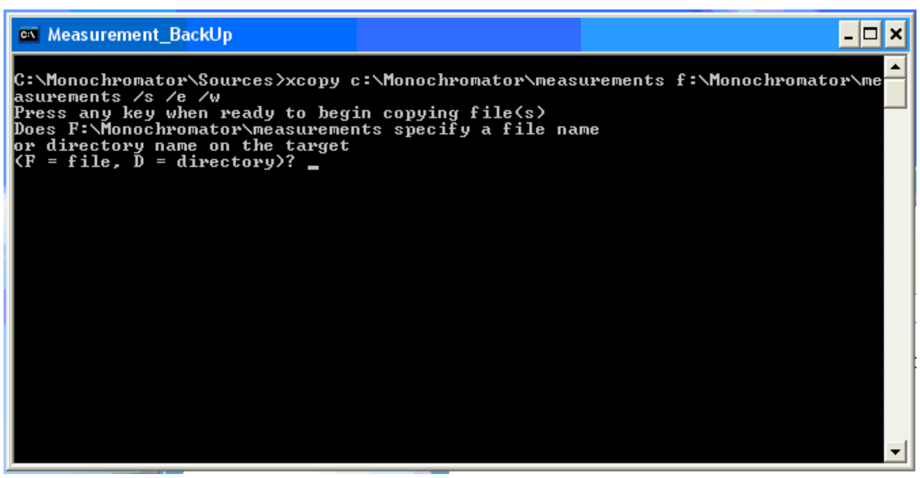

Figure 6.2: The automatic backup during the directory checking procedure

6.2.- Gas System Testing Programs

There is a set of programs to check and control the correct operation of the stepper motor and encoder. The set of program are in the folder c:\Monochromator\source\TestingTools

The more important testing programs are shown on the table 6.1. Each program has a description of the specific function that is able to perform.

Program	Function
New_StepperInit_2007_1.vi	This program performs the initialization of the stepper board NI control.
MotorREAD_2007.vi	This program reads the position of the encoder and the position of the stepper motor.
MotorMoveTest2_2007.vi	This program move the stepper motor from the Position StartCM position to TargetCM position. Where both positions are CM refers to Mechanical Counter of the stepper motor.

Table 6.1: List of the more important monochromator testing programs

The most complete program is MotorMoveTest2_2007 allows to perform the movement of the stepper motor.
The operator read the mechanical position and uses this value as an input parameter. The program perform internally the counts calculation of the number of count per steps are necessary to move the motor from StartCM to reach the TargetCM and move the stepper motor. Where StartCM is the initial position of the Monochromator mechanical counter and TargetCM is the final position of the mechanical counter.

The input parameters of the programs are the initial position of the mechanical counter and the destination target position and It's possible to set the ID of the Board as is shown in figure 6.3.
It's possible to have as output the status NI Motion position, the encoder position, the motor position and the error control as well.

IMPORTANT:

Before to start the execution of this program is necessary to execute the Initialization of the NI Motion Board using the New_StepperInit_2007_1.vi program.

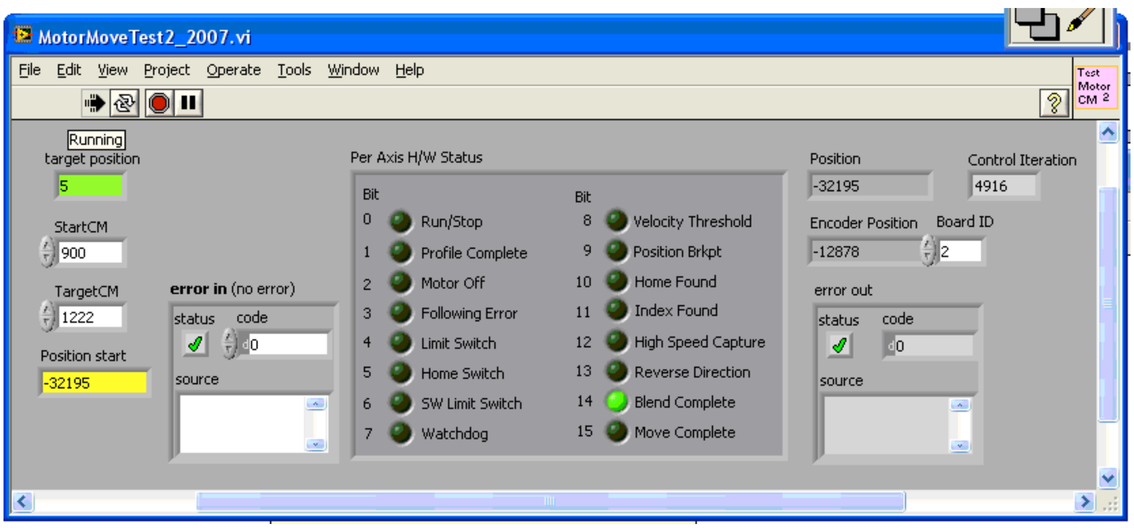

Figure 6.3: The MotorMoveTest2_2007, the more complete Monochromator test program

The other test programs are shown in the table 6.2. Each program has a help online that explain the specific function of the program, the input and output parameters as well.

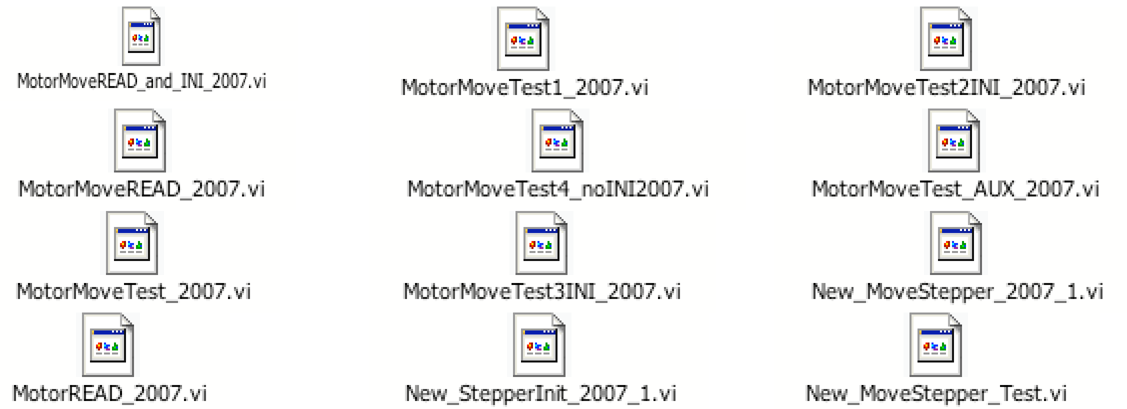

Table 6.2: List of the complete monochromator testing programs

6.3.- The Gas System package of security

One important aspect of the system is the recovery in case of crash during the run period of the COMPASS experiment.
In order to allow a fast intervention there is a list of every component of the system available in the Gas System Web Page [10].
The point in the Index "**7.-How to re start the system in case of crash**" of the system and a set of four documents describe the list of components of the system and the procedure to re-start the Gas system in a few minutes.
One back-Up computer was prepared as well. This computer (RICH Gas System Back-Up computer) has inside the spares of the electronics boards necessary the re-start the system just in case of Gas System computer crash.

6.3.1- Recovering from the Rich Gas System Main Hard Disk

In case of crash or read error of the disk C, a backup disk have been made and the data are saved continuously using the BackUp procedure described in the section 6.1.

6.3.1.1 To perform the Hard Disk recovery procedure:

1.- Open the Rich Gas System Computer case.

2.- Disconnect the SATA disk connector from the volume C: labeled "Boot disk " (damaged disk).

3.- Remove the damaged disk.

4.- Disconnect the SATA disk connector of the volume D: and connect the SATA disk connector from the Main disk (C:) to the volume D: labeled BackUp disk.

5.- Take the disk labeled "Rich Gas System Backup" from the Rich Barrack and install it in the position of the BackUp Hard Disk and Connect the power connector of the volume.

6.- Re start the computer.

7.- Execute the automatic BackUp

IMPORTANT:

The point number 7 is executable only if the point 5 was performed and the second disk is available again in the Rich Gas System computer. If It was not possible complete all the steps of the Hard Disk recovery procedure running with only one disk does not give the total security in case of a new disk crash.

6.3.2 Rich Gas System Computer crash recovery procedure:

The Rich Gas System Computer BackUp is ready in the RICH barrack. To replace the damaged one perform the procedure described in the next section.

6.3.2.1 To restore a system due to a computer crash:

1.- Power off the damaged computer and the RIGB.

2.- Replace the damaged computer with the backup computer, disconnecting the connector from the Rich Gas System Computer to the RIGB.

3.- Copy the directory :\Monochromator\measurements\ from the backup of the last measurements in the disk C: of the BackUp computer.

3.- Start the computer. Use the main Transparency program and work normally.

6.4.- The VEGA SYSTEM and PLC Software

6.4.1.- VEGA SYSTEM:

The VEGA Software performs the measurement of the liquid Gas in the tank of the system.

The main VEGA application program VVO832.EXE is installed in the folder C:\VEGA and is accessible to the user in the All Programs entry in the Start menu of the Rich Gas System computer.

There is a help online to follow the procedure of the configuration and working modes of the program.

6.4.2.- PLC Software

Is a set of programs that control the complete set of electrovalves and the rest components of the complete gas system of the RICH. This control is performed online and report errors using alarms on case the problems in the Gas System to the RICH Gas Experts and to the COMPASS DCS system as well.

The main software is PL7 pro of **SCHNEIDER** and “STEP & PRO” of **SIEMENS** that is used to perform the pre-cleaning procedure.

Acknowledgments

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Thanks to Benigno Gobbo who have contributed in the preparation of the back-up system; Elena Rocco, Jaroslav Polak and Giulia Pesaro who have with dedication contributed to the test of several layers of the System.
We wish to express our greatest appreciation to S. Duarte Pinto and O. Ullaland from the previous project. Thanks to G. Menon, L Rinaldi and M Gregori for their technical support on the RICH Gas System computer and the Backup computer.
I would like to thank Prof. Pino Furlan director of “Italian Labs” (TRIL - Training and Research in Italian Laboratories Programme) and my advisor Prof. Franco Bradamante, both gave me the framework and total support to participate in this project.

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[6] National Instrument, PCI 6289 DAQ Multifunction board User Manual for PCI or PXI Bus Systems, http://www.ni.com/pdf/manuals/

[7] National Instrument, 6602 User Manual High-Speed Counter/Timer for PCI or PXI Bus Systems, http://www.ni.com/pdf/manuals/322137b.pdf.

[8] National Instrument, Motion Control NI PCI-7342 Hardware User Manual, http://www.ni.com/pdf/manuals/373454a.pdf

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APPENDIX A:

RICH GAS SYSTEM COMPUTER CONFIGURATION

Description of the hardware RICH GAS SYSTEM Computer Configuration:

The computer is a Elonex 3000/ENG_P
Main-board: Intel D915PGN – C64142
BIOS: 0039
CPU: P4 630 LGA 775 FSB: 800
Serial Number: CH571-625-41
MAC Address: 00-13-20-A3-CA-09

Memory:
RAM DDR 400 SDRAMM-DIMM PC 1GB x 2 modules.

Extensions:
Internal DVD-RW Burner
HDU
Boot Disk
SATA DISK, 80GB, :

Combo CDR/DVD: Samsung IDE
VGA: PNY Quadro FX1400 – PCI-Express 16x

APPENDIX B:

GAS SYSTEM CHANNEL MAPPING

PCI NI-6289

HV (on/off) Dev1/port0/line1 connections on wire collector (CB-68LPR)
pin 17 out pin 18 Gnd (board NI-6289)

D2 (on/off) Dev1/port0/line0 connections on wire collector (CB-68LPR)
pin 52 out pin 18 Gnd (board NI-6289)

PM1 (read) Deav1/AI4 (use AI4 and AI12 in differential mode) connections on wire collector (CB-68LPR) pin 28 +AI4 and pin 61 -AI12 (board NI-6289)

PM2 (read) Deav1/AI5 (use AI5 and AI13 in differential mode) connections on wire collector (CB-68LPR) pin 60 +AI5 and pin 26 -AI13 (board NI-6289)

L.S. Forward (read) Deav1/AI2 (use AI2 and AI10 in differential mode) connections on wire collector (CB-68LPR) pin 65 +AI2 and pin 31 -AI10 (board NI-6289)

L.S. Reverse (read) Deav1/AI3 (use AI3 and AI11 in differential mode) connections on wire collector (CB-68LPR) pin 30 +AI3 and pin 63 -AI11 (board NI-6289)

TEMP2 (read) Dev3/AI0 connections on wire collector (CB-68LPR)
pin 68 input pin 67 Gnd (Used in RSE MODE board NI-6289)

PCI NI-6602

PULSE INIT (out) Dev2/CTR0 connections on wire collector (CB-68LPR)
pin 5 PFI 36/CTR0 OUT and pin 39 DGND (NI 6602)

READ ECHO (read) Dev2/CTR7 connections on wire collector (CB-68LPR)
pin 51 PFI 10/PO.10/CTR7 GATE and pin 50 DGND (NI 6602)

APPENDIX C

GAS SYSTEM COMPUTER AND CONTROLLER COMPUTER POWER SUPPLY

1. The Gas System Computer is a Elonex Prosentia. The hardware system configuration is:

Power Supply	**Changed**		
Main board	**Intel**	**D915PGN**	
BIOS	**0039**		
CPU	**P4 630**	**LGA775**	**FSB 800**
HDU	**SATA**	**80 GB**	**BOOT DISK**
HDU	**SATA**	**250 GB**	**DATA DISK**
HDU	**SATA**	**250 GB**	**BACKUP DISK**
Combo CDR/DVD	**SAMSUNG**	**IDE**	
RAM	**DDR (PC 400)**	**1024 MB**	**TWO MODULES**
NIC	**On-board**	**INTEL**	**Pro 100VE 10/100 Mb RJ45**

Table c.1: .- Hardware description of the RICH Gas System Computer

2.- Identification of the Hardware:

PC SERIAL NUMBER CH571-625-41
MAC ADDRESS: 00-13-20-A3-CA-09 (NEW MOTHER BOARD)
VGA P260CA019136001FK
CDR/DVD N6776RFYB92960

Table c.2: .- Hardware components identification of the RICH Gas System Computer

2.1.- The Power Supply:

The original computer power supply was changed at end of September due to problems in the functioning of the system during the test at the end of August.

New power supply is: Model ATRIX 500T, 640 W continuous.

The complete set of features shown in the table c.3 is used.

● Model:Atrix-500T

AC Input (wide range /Universal)	AC Input	95-250VAC	PFC Type
	Frequency	47-63Hz	PF-value
	Fuse Current	6.3A(slow-blow)	Efficiency
	Inrush Current	60A/200ms	Consumption
DC Output Max.Current Load *Note: Ipeak current is limited to total duration of 60s from PWR_OK driven true	Voutput	Output Load	Theor.Max.Of each rail
	DC rail	Imax(Ipeak*)	
	+3.3VDC	30A(40A)	(99W)
	+5VDC	30A(30A)	(150W)
	+12VDC	24A(25A)	(288W)
	-12VDC	0.8A(1A)	9.6W
	-5VDC	0.5A(0.8A)	2.5W
	+5VSB	2.5A(2.5A)	10W

Table c.3: .- RICH Gas System Computer Power supply configuration.