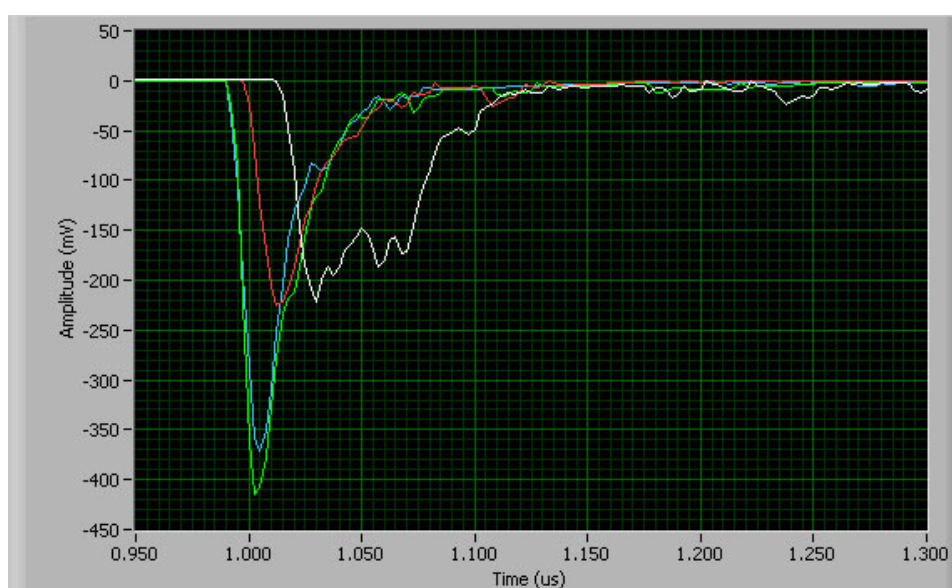


HiSPARC II Software User Guide

Version 2.1.1

Jeroen van Leerdam
May 28, 2008



For information about the HiSPARC project, visit:

<http://www.hisparc.nl>

This user guide, the *HiSPARC II* software and other *HiSPARC II* information can be found on:

<http://www.nikhef.nl/~jleerdam>

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Chapter 1

Introduction

The HiSPARC project measures muons from cosmic rays on the earth's surface with scintillator detectors. The signals from these scintillators are converted into electrical signals by Photomultiplier Tubes (PMTs). HiSPARC electronics are used in combination with a (personal) computer to read the PMTs out. In the original setup, the HiSPARC electronics consisted of multiple components and the settings had to be entered with dials and buttons on the hardware. All the PC had to do, was read out the (digitised) data and send it to the database.

The components of the HiSPARC electronics are now merged into a single device. This *HiSPARCII* device is still read out by a PC, but in the new setup, the electronics are also controlled by the PC. The settings can be entered in the LabVIEW software, that sends them to the *HiSPARCII* device. One device reads out two PMTs and the *HiSPARCII* software can handle two devices at a time (a *Master* and a *Slave*), so we can build detectors with four scintillators.

In this user guide, we describe how to install the *HiSPARCII* hardware and software (Chapters 2, 3 and 4) and how to use the software (Chapter 5). It is assumed that the rest of the detector is already installed—i.e., the scintillators, PMTs, high voltage cables, signal cables, GPS antenna and antenna cable are there and are ready to use.

Chapter 2

Getting Started

This chapter describes how to install and initialise the *HiSPARC II* hardware and software. The procedures for initialisation of the GPS receiver and calibration of the detector are explained in more detail in Chapters 3 and 4, respectively. The *HiSPARC II* program can be used with either one or two *HiSPARC II* devices. With one device you can use two channels/scintillators and with two devices you can use four. The installation procedure is the same for both options.

Note: To install the LabVIEW program and device drivers, you must have administrator rights in Windows.

2.1 Hardware

To use the *HiSPARC II* hardware, you need:

- a *HiSPARC II Master* device with power and USB cables
- a *HiSPARC II Slave* device with power and USB cables (optional)
- two short UTP cables to connect *Master* and *Slave* (optional, only if *Slave* is used)
- an extra USB cable for the GPS receiver (in the *Master*)
- a GPS antenna with cable
- a PC with *Microsoft Windows XP* installed

If you use two *HiSPARC II* devices, make sure that one of them is a *Master* device and the other one is a *Slave*. The electronics and the software will not work properly with two *Master* devices or two *Slave* devices. The difference between them is a GPS receiver: The *Master* has one and the *Slave* hasn't. The GPS antenna connection (Figure 2.2) should not be there on a *Slave* device.

2.2 Software

To control and read out the *HiSPARCII* hardware, you need the following software, that is all included in the *HiSPARCII* software package:

- the *HiSPARCII* LabVIEW program
- the *DSP GPS Timing Monitor* software
- FTDI USB drivers

2.3 Software Installation

To install the LabVIEW software (or actually the LabVIEW runtime engine), unzip the *HiSPARCII* software and go to the **Installer** directory. Execute **setup.exe** and follow the instructions. You have to enter the installation directory for the software here. After installation, you can start the *HiSPARCII* program by executing **HISPARCII_x_y_z.exe** in the installation directory (where **x**, **y** and **z** are the version numbers). The installer creates a link to this file in the *Start Menu*.

Note: To use the HiSPARCII software properly, the user that runs the program must have write permissions for the files in the installation directory and files in the GPS subdirectory. The administrator must either install the program in a directory where this is the case, or give the user these permissions in another directory.

2.4 Databases

Data from a *HiSPARCII* detector can be stored in two different databases. There is a *Central Database* that is located on the Nikhef institute and it is possible to have a *Local Database* at the location of the detector, although the latter is optional. If a *Local Database* is used, it is recommended to install it on a machine different from the detector's. Data from all HiSPARC detectors in the *Central Database* can be accessed through the HiSPARC website. The *Local Database* is only locally accessible. In general, data from the devices is sent to both the *Local* and the *Central Database*. As an intermediate step, it is stored in a *Buffer Database*, that is located on the same PC as the LabVIEW program. From there it is sent to the other databases.

To enable LabVIEW to write to this *Buffer Database*, *MySQL* must be installed on the PC to act as a database server and the database should be created, along with an *ODBC Data Source* that directs to it. In the future, all this will be done by the *HiSPARCII* installer, but for the moment it has to be done manually. In the rest of this guide, we will assume that the

connection with the *Buffer Database* is there, although this is not necessary to run the program and read out the detectors without storing the data.

2.5 Devices

Important: Never plug or unplug the Module I/O USB cables that connect the HiSPARCII devices to the PC with the device power on. This causes errors in the operating system USB drivers that Windows cannot handle. First connect the cables and wait until Windows has started and then switch the device power on. Switch the power off before unplugging the cables again. For the USB cable to the GPS receiver, it is the other way around. This cable must be connected with power on and disconnected before switching off the Master device.

The following has to be done to install the *HiSPARCII* devices (see also Figures 2.1 and 2.2):

1. If you are using two devices, connect them with the two small UTP cables: One cable from *Master LVDS Data Out* to *Slave LVDS Data In* and the other cable from *Slave LVDS Data Out* to *Master LVDS Data In*.
2. Connect the *Module I/O* USB port on the device with a USB cable to the PC. If you are using two devices, connect both.
3. Connect the cable from the GPS antenna to the *Master* device.
4. Switch the device(s) on: Wait until Windows has started and connect the power cable from the adaptor to *Power In* on the device.
5. Connect the *GPS Receiver* USB port on the *Master* with a USB cable to the PC.
6. After the ADC calibration (see Chapter 4), connect the PMT signal cables to the *PMT Inputs* on the front of the device: PMT 1 to *Master* input 1, PMT 2 to *Master* input 2 and if you are using a *Slave* device, PMT 3 to *Slave* input 1 and PMT 4 to *Slave* input 2.
7. After the ADC calibration and *step 6*, connect the PMT control cables to the *PMT Controls*.

2.6 USB Drivers

When the devices are used for the first time and the USB cables are connected, Windows will notice and starts a wizard to install the device. If this wizard asks for a location of the driver files, enter the directory where



Figure 2.1: The front of a *HiSPARC II* (*Master*) device



Figure 2.2: The back of a *HiSPARC II* (*Master*) device

the FTDI USB drivers are located (the `USB_drivers` directory of the *HiSPARCII* software).

2.7 GPS

If the *HiSPARCII* hardware is used for the first time, the GPS receiver needs to be configured. This process is described in Chapter 3. After this, every time the *Master* device is switched on, the GPS receiver needs some time to track the available satellites and calculate UTC time. You can watch the status of this process with the *DSP GPS Timing Monitor* software (see Figure 2.3). For this you should have connected the GPS receiver port of the *Master* device to the PC (as described in Section 2.5). To start the program, execute `GPS\DSPMon.exe` in the installation directory. After installation of the LabVIEW software, there should be a link in the *Start Menu*. The monitoring program needs the number of the GPS receiver COM port. You can change this number by clicking the right mouse button in the lower right corner of the window (`COM6 9600 8-0-1` in Figure 2.3).

The LabVIEW program only receives the right GPS information if:

- all *Status* lights are green
- the *Time* is *UTC*
- the *Rcvr Mode* in *GPS Status* is *(γ) Overdet Clock (Time)*
- at least four of the satellite (*SV*) numbers in *Signal Levels* are green (more is recommended)

Make sure you check this every time you restart the Master device and before you start the LabVIEW program to take data. The GPS information is not needed for the calibration procedure, so you don't have to check this before starting the calibration process.

2.8 Calibration

Before a *HiSPARCII* device can be used, it needs to be calibrated. The calibration procedure is described in Chapter 4.

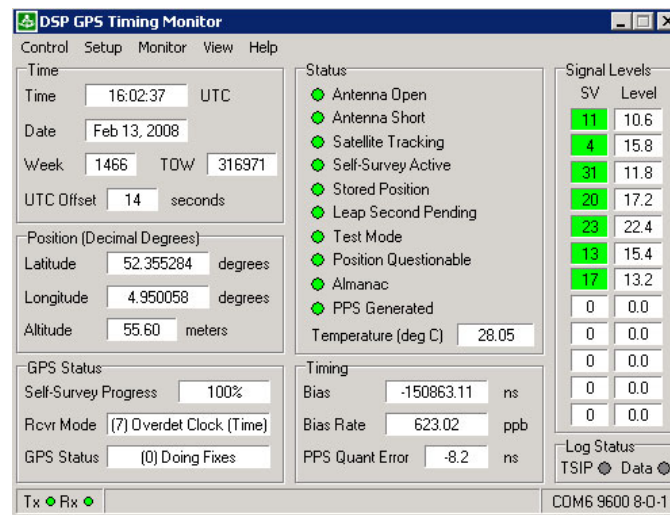


Figure 2.3: The DSP GPS Timing Monitor

Chapter 3

GPS settings

For comparison between detectors, each event is given a time stamp by the *HiSPARCII* hardware. To ensure that each event receives a correct time stamp, the *Global Positioning System* is used for synchronisation of the detector clocks. Each *Master* device has a GPS receiver to communicate with the GPS satellites. In this chapter we describe how to configure this receiver.

It is assumed that the installation, as described in Chapter 2, is done. We will use the information from Sections 2.3 and 2.7 in particular.

To change the GPS receiver settings, both the *HiSPARCII* LabVIEW software and the *DSP GPS Timing Monitor* are needed. The LabVIEW program runs immediately after the executable is started. A dialog box appears, in which you can select the mode for this session. This should be *Expert Mode*. You are prompted for a password, but if there is no password set yet, you can just click *OK* here. After the GPS configuration is done, you can exit the program by clicking the *Stop Program* button (see Figures 5.1 and 5.2 on pages 22 and 23). Do not save settings at exit. See Chapter 2, Section 2.3 and Chapter 5 for more information about the LabVIEW program and Chapter 2, Section 2.7 for the *DSP GPS Timing Monitor*.

Changes in the GPS settings can be made by pushing the *Enable writing to GPS receiver* and the *Apply Settings* buttons on the *Expert Settings* page in the *HiSPARCII* LabVIEW program (Figure 5.2). The GPS settings can now be written with the GPS monitoring program.

Set the *GPS Receiver*, *Timing Outputs*, *Self-Survey*, *Position* and *Packet Masks and Options* settings in the *Setup* menu (Figure 3.1) to the values indicated in Figures 3.2 to 3.6. If you change any values (most of the default values should be correct), do not forget to push the save buttons (*Set SV*, *Set Receiver*, *Set PPS*, *Set Qualifier*, ...). When this is done, save the settings with *Save Configuration* in the *Setup* menu.

In the *Position* settings, we did not set an *Accurate Position*. This position must be determined by the receiver in a self-survey. If the receiver has never been used before, a self-survey is started automatically if the *Master*

device is switched on. Because we changed the self-survey parameters, the process has to be restarted by clicking *Restart Self-Survey* in the *Control* menu. After the self-survey process, that takes one hour if the *Survey-Length* is set to *3600 fixes* (see Figure 3.4), the determined position will be stored. If for some reason a position is already stored (in this case, the *Stored Position* light in *Status* is green instead of yellow), this old position should be deleted with *Delete Pos* in the *Position* settings (Figure 3.5). The GPS receiver will now start a self-survey.

Note: It is very important that the position stored in the GPS receiver is correct. If the coordinates are wrong, the timestamps given to the events are off by an unknown amount of time. However, this is not immediately noticed, because the error is only a fraction of a second. Every time the GPS antenna is moved or a different GPS receiver/Master device is used with the antenna, a self-survey should be performed.

The GPS monitor should look like Figure 2.3 now, except if there still is a self-survey in progress. In that case the *GPS Status* indicates the progress of the self-survey and the *Rcvr Mode* is *Full Position (3D)*. This receiver mode will return to the saved value after the self-survey has finished.

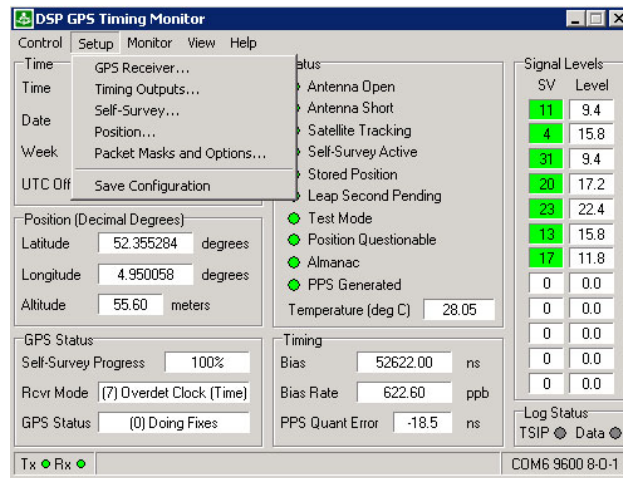
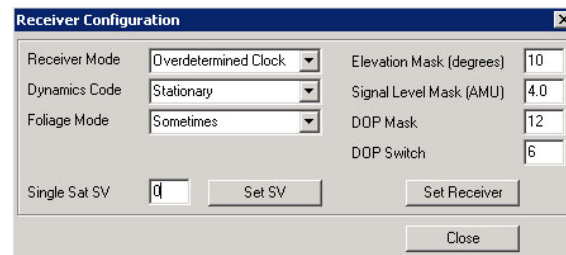
Figure 3.1: The *Setup* menu in the *GPS monitor*

Figure 3.2: GPS Receiver settings

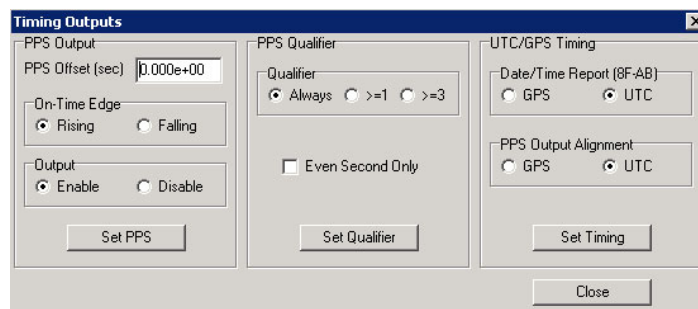


Figure 3.3: Timing Outputs

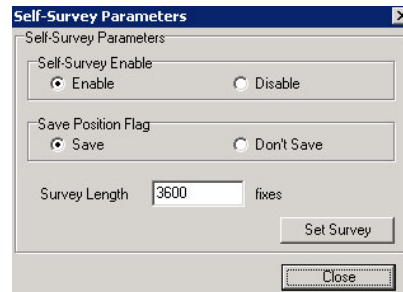


Figure 3.4: Self Survey settings

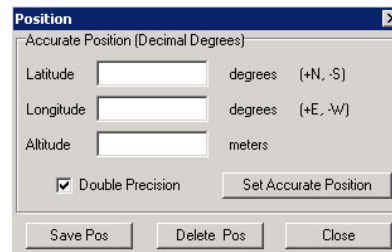


Figure 3.5: Position settings

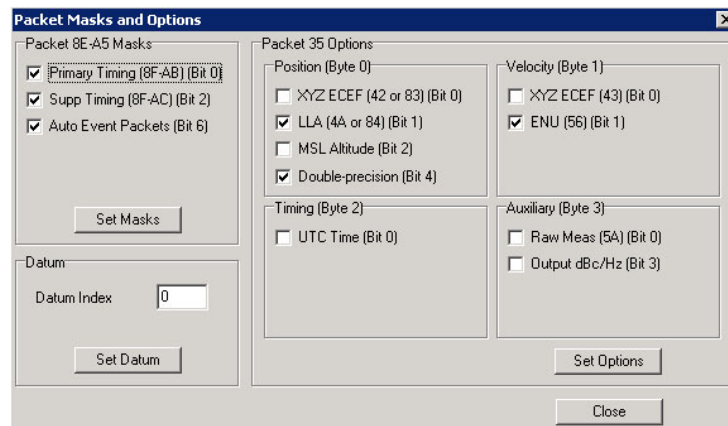


Figure 3.6: Packet Masks and Options

Chapter 4

Calibration

To send the signal on the analog inputs of a device to the computer, it needs to be digitised. This is done with four 12-bit ADCs (two per channel), that measure voltages from approximately 0 to 2 V¹. To make sure all ADCs give the same digital value for a certain voltage applied to the inputs and to determine what that particular value is, the device needs to be calibrated. This has to be done for both the *Master* and the *Slave* device (if you are using one). After the calibration is completed, it is necessary to make sure that all the scintillator/PMT combinations give the same response for a given particle that goes through the detector. This is done by adjusting the PMT high voltages.

To get the best results, the PMT calibration (Section 4.3) should be performed after the ADC alignment (Section 4.1), with the default values for the ADC calibration (Section 4.2). Then, after the device(s) has (have) been taking data for several hours (without writing to the database), the full ADC calibration should be done and the PMT calibration should be done again. This makes sure that the whole detector is on “operation temperature” during calibration. In this chapter it is again assumed that the installation as described in Chapter 2 has been completed.

4.1 ADC Alignment

To make sure that all the ADCs (in one device) have the same scale and give the same value for a given voltage, they have to be aligned. This alignment can be performed with the *HiSPARCII* LabVIEW program. When the program is started, it runs immediately and a dialog box appears, in which the user can select the mode to run in. This mode should be *Expert Mode* for the calibration procedure. You are now prompted for a password, but if no password is set yet, you can just click *OK* here. After the calibration,

¹The signal from the PMTs is actually a negative voltage, but before it is digitised, it is converted to a positive voltage. -1 V at the analog input corresponds to $+1\text{ V}$ at the ADC.

you can exit the program with the *Stop Program* button (see Figures 5.1 and 5.2 on pages 22 and 23).

Now first make sure that nothing is connected to the analog inputs of the devices (the PMT Inputs in Figure 2.1 on page 10). Go to the *Calibration* tab page of the program (Figure 5.18 on page 37) and push the *Start Calibration* button. The alignment process is now started and the calibration parameters in the lower left and lower right corners of the screen should be changing. (Obviously, if only a *Master* is used, only the *Master* values change.) The alignment is performed in six steps, so it finishes when the *Calibration Steps* in the upper right corner of the screen reach seven. Select *Yes* (save calibration settings) in the dialog box that appears.

Note: the settings are not saved to the device, but on the PC hard disk. If you use another device with the same PC, the calibration procedure must be repeated.

4.2 ADC Calibration

After the alignment process, one has to determine the scale and offset of the ADCs. These quantities are represented by the *Gain for ADC values* and *Offset for ADC values* controls on the *Calibration* tabs on the *Expert Settings* tabpage (see Figure 5.2 on page 23 and Figure 5.13 on page 32). These controls have to be set for each channel (so two times for each device). After alignment the values should be approximately -0.57 mV and 114 mV , respectively, which are the default values. The voltage on the analog input on the device is calculated with:

$$\text{Voltage} = \text{ADC Gain} \cdot \text{ADC value} + \text{ADC Offset} \quad (4.1)$$

The *Gain for ADC values* and *Offset for ADC values* should be set correctly on the *Calibration* tab pages, because the *HiSPARCII* program uses these values to calculate other device settings and to display events. If it is for some reason impossible to perform the calibration procedure described in this section, you can use the default values (after aligning with the *HiSPARCII* program), although this is not recommended.

The ADC calibration values can be determined by applying a (known) voltage to the analog inputs of the device and reading off the corresponding ADC value from the output of the *HiSPARCII* program. After (a minimum of) two of these measurements (at different voltages), the *Gain for ADC values* and the *Offset for ADC values* can be calculated with Equation 4.1.

For the voltage-ADC measurements, the *Gain for ADC values* should be temporarily set to 1.0000 and the *Offset for ADC values* to 0.0. To do this, enter the values in the controls and push the *Apply Settings* button (see Figure 5.2 on page 23 and Figure 5.3 on page 25). For these settings, the voltage that is displayed in the graphs on the *Events/Settings* tab and

the *Expert Settings* tab is equal in value to the ADC output. If a DC voltage is applied to the inputs, this will appear in the graphs as a line at a certain ADC value. The device(s) should be triggered to show this line in *events*. To do this, set the *Trigger Condition* on the *Events/Settings–Trigger Settings* tab page (Figures 5.1 and 5.4 on pages 22 and 26) to *Use only the external trigger* and push the *Apply Settings* button again. Now apply a positive pulse between 0 and 3 V and a length in the order of microseconds to the *Ext. Trig. In* input at the back of the *Master* device (see Figure 2.2 on page 10). Repeat the pulse every second or so. Each time this trigger is given, an event should appear on the screen and the ADC value can be read off. Use values for the DC voltage of $\approx -30\text{ mV}$ and $\approx -2000\text{ mV}$ and if you want more measurements, values in between. After calculating the ADC calibration values, do not forget to enter them on the *Expert Settings* tab page (and to push the *Apply Settings* button). The settings can be saved by pushing the *Save Settings* button.

4.3 PMT Calibration

Now that the devices are calibrated, we can take a look at the signals from the scintillators/PMTs. We have to calibrate this part of the detector as well, because each PMT behaves differently for a given high voltage applied to it. When a muon goes through a scintillator plate, it causes a pulse at the output of the PMT. For the calibration we will assume that this pulse is completely characterised by the maximum height it reaches (or actually the maximum depth, because the PMT's pulses are negative). Because we deal with statistical processes and this pulse height depends on the energy of the muon, the signal will be different for each particle that goes through the detector. However, a histogram of pulse heights over a long enough time, should always be the same. In approximation, these histograms only depend on the high voltage applied to the PMT; the higher the voltage, the more “high pulses” we get and the more the histogram shifts to the right. What we want to do now is making sure that we get the same histogram for all the PMTs.

If we would count the number of pulses that exceed a certain threshold pulse height in a given amount of time, we are actually measuring the surface of the pulse height histogram to the right of this threshold. If we make sure that the count/surface for a given threshold is the same for each PMT, the pulse height histograms are the same. We can adjust the count/surface by adjusting the PMT high voltage. The higher the voltage, the more counts we get.

Connect the cables from the PMTs to the front of the device(s), as described in Chapter 2, Section 2.5. Set the trigger to *Use only the external trigger* again (as in Section 4.2). We can set our threshold pulse height

on the *Events/Settings–Thresholds* tab pages (Figure 5.6 on page 28). The program uses two thresholds: a low one and a high one. Set the low threshold to 250 mV and the high threshold to 300 mV . (You can enter these values in the boxes to the right of the slide controls.) Do this for each channel (so two times for each device). Now go to the *Events/Settings–Photomultiplier Tube* tabs (Figure 5.8 on page 28) and set the *PMT High Voltage Adjusts* to 800 mV (this corresponds to approximately 800 V at the PMT). Push the *Apply Settings* button to send these values to the device(s).

On the *Statistics* tab page (Figure 5.17 on page 36) you can count the number of times each channel went over the thresholds. The grey panels at the bottom of the page show in the left column the number of times the signal went over the thresholds in the last second. If you push the *Start Counting* button in the middle, the middle column shows the total number of counts and the right column the average per second. You can set the number of seconds to count with the *Time to count* control.

Count for about 30 seconds and check the averages. For the low thresholds (250 mV) this should be between 50 and 60 counts/s and for the high thresholds (300 mV) between 30 and 40 counts/s . If this is not the case, adjust the *PMT High Voltage Adjusts* (do not forget the *Apply Settings* button) and repeat the measurement until all averages are within the given range. Now count again for 300 seconds and check if the averages are still right.

When the calibration is finished, push the *Save Settings* button to save all settings to the hard disk. You can exit the program by pushing the *Stop Program* button. Check the values for the high voltage again when the program is taking data: If the trigger is set to *At least 2 low signals* or *At least 2 high signals* (4 low and 4 high if you are using two devices), the *Pulse Height Histograms* on the *Statistics* page should be the same for all the channels and have a peak at $\approx 400\text{ counts}$ ($\approx 230\text{ mV}$). You can find an example of the *Pulse Height Histograms* in Figure 5.17, although this is for a different trigger condition, so the *Master–Channel 2* histogram is not the same as the histograms for the other channels.

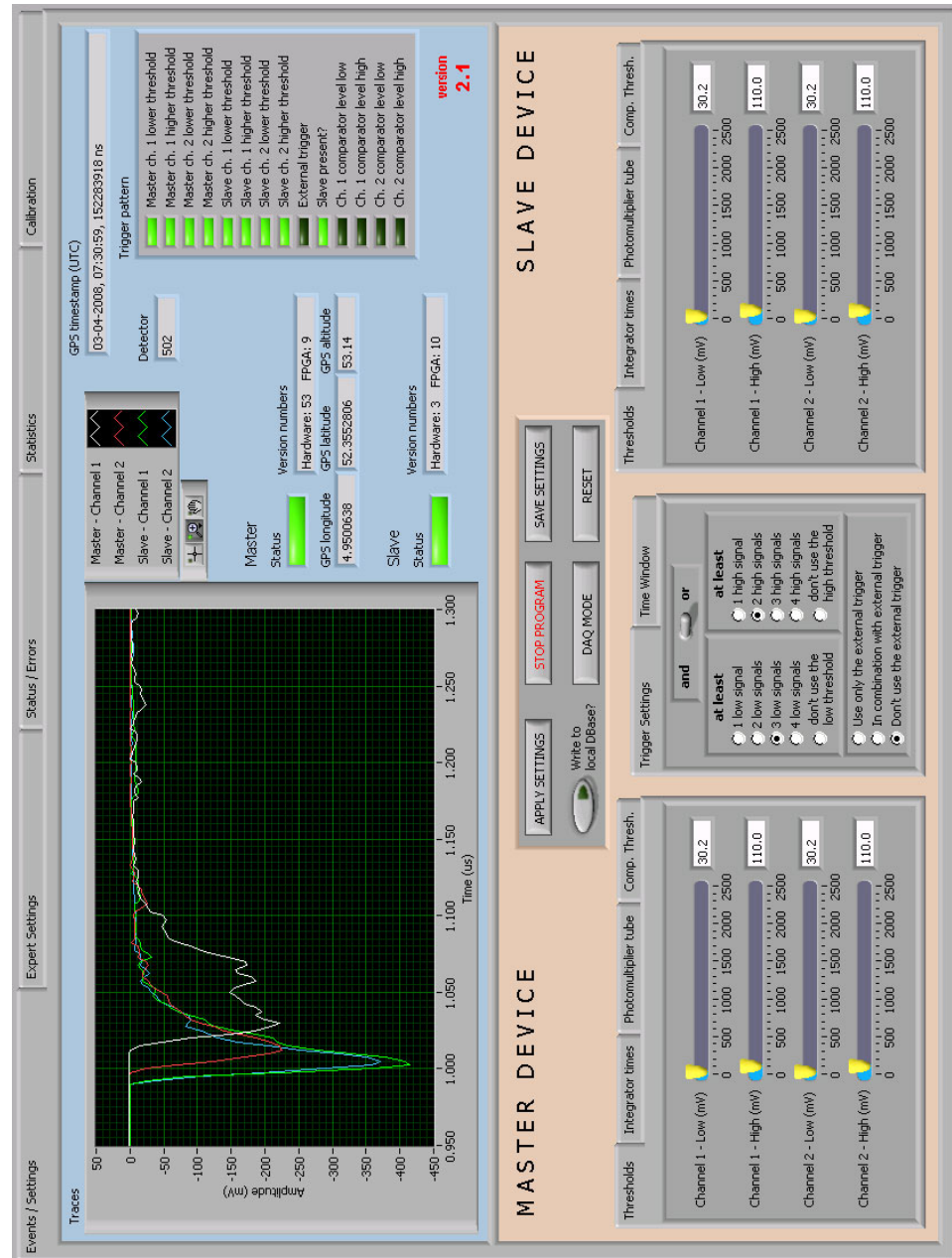
Chapter 5

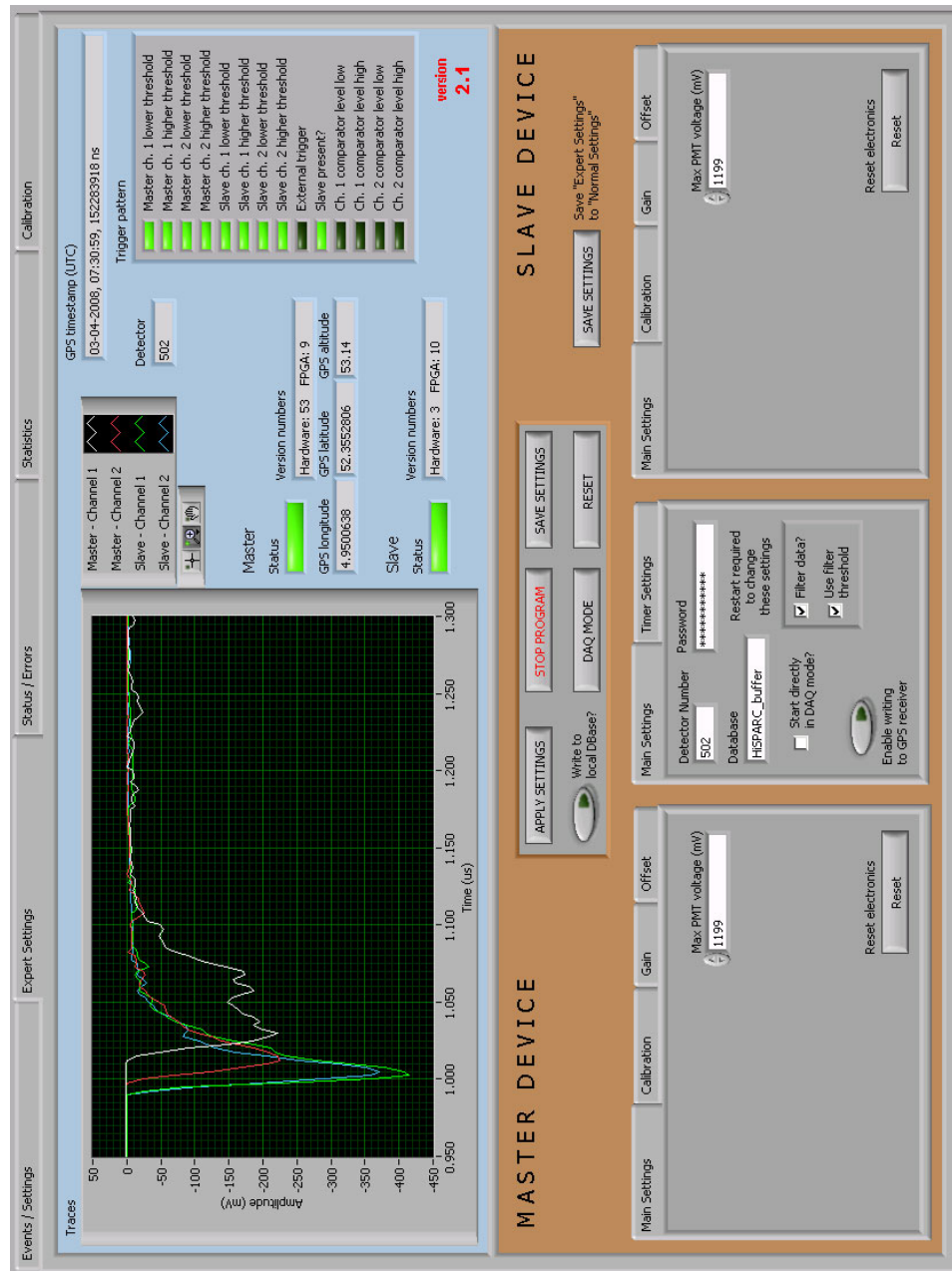
The HiSPARC II Program

The *HiSPARCII* LabVIEW program is used to control and read out the *HiSPARCII* devices and to send the data from the detectors to the database. It needs to be installed on the detector's PC and before usage, the detector should be calibrated as described in the previous chapters. In this chapter, all the program settings are explained and it is shown how to use the software. The program can be started by executing `HISPARCII_x_y_z.exe` in the installation directory (where *x*, *y* and *z* stand for the version numbers). In the installation process, a link to this file was created in the *Start Menu*. When the program starts, it runs immediately and the user is asked to select a mode to run in. These modes are explained in Section 5.1. For the *Expert Mode* a password is required, but this is set to an empty string by default, so just click *OK* if there is no password set yet. You can exit the program by pushing the *Stop Program* button (see Figure 5.1). After the exit, the program window is still open and it can be restarted by clicking the “run arrow” in the left upper corner.

5.1 Modes

The *HiSPARCII* program can run in *Normal Mode*, *Expert Mode* or *Data Acquisition Mode (DAQ Mode)*. After starting the LabVIEW program (or clicking the “run arrow”) you have to choose between the *Normal Mode* and the *Expert Mode*. When you select a version, the program will start running (after it gives a warning if only one device is or no devices are connected). In the *Normal* version, you can set all the settings for data taking, like thresholds, trigger settings and PMT settings and write events taken with these settings to the *Local Database*. In *Normal Mode* you cannot change any settings for the *DAQ Mode* and you do not have access to the settings on the *Expert Settings* tab page, like the calibration settings. The *Expert Mode* runs the same as the *Normal Mode*, but is password protected and now you have access to all settings. The *Expert* password can be set on the *Expert Settings–Main Settings* tab page (see Section 5.4.2). Finally, the

Figure 5.1: The *Events/Settings* tab

Figure 5.2: The *Expert Settings* tab

DAQ Mode is for long term data taking. In this mode the events are written to both the *Central* and the *Local Database* (if there is one) and it is not possible to change any settings while the program is in *DAQ Mode*.

The *Normal Mode* and the *Expert Mode* each have their own settings file on the hard disk to which settings can be saved. When the *Save Settings* button is pushed, it depends on the mode the program runs in to which file the settings are saved. The *Expert*, however, is able to write to the *Normal* file as well (see also Section 5.2). When the program starts, it loads the settings of the mode it is started in. The *DAQ Mode* uses the *Expert Settings*.

5.2 Buttons

In Figures 5.1 and 5.2 the *Settings* tabs of the program are shown. In the middle you can see a panel with six buttons. (Figure 5.3) This panel is visible at all the tabs and contains the main controls of the program.

Stop Program This button stops the running of the program. After pushing it, a dialog is shown in which you can choose to run again or to exit the program.

DAQ Mode After pushing this button, the program will restart and go into *DAQ Mode*. Data will be written to all databases. Pushing the *DAQ Mode* button while the program is in *DAQ Mode* will result in a restart to the “select mode dialog”.

Apply Settings All settings values (with the exception of the *Write to local DBase* button) can be changed without having immediate effect. Only after pushing *Apply Settings*, the new settings are processed and sent to the device(s).

Save Settings Pushing this button will save all current settings to the hard disk. When you restart after saving, the saved settings are restored. *Save Settings* writes the settings as they were at the last time that *Apply Settings* was pushed, so always *apply* first and then *save*.

Reset This button restores the default factory settings. Pushing it results in loss of all current settings. (This only affects the settings of the mode you are in.)

Write to local DBase? If this button is pushed and the light is on, all measured and processed data is written to the *Local Database*. Pushing this button has immediate effect, so there is no need to push the *Apply Settings* button, except if you want to save the *Write to local DBase* setting (see also *Save Settings*).



Figure 5.3: Buttons

On the *Expert Settings* tab page (Figure 5.2) there is another *Save Settings* button, to the right of the main six:

Save Settings (to Normal Settings) This second *Save Settings* button, that is only on the *Expert Settings* page, saves the current *Expert Settings* to the *Normal Settings*. This has no effect on the saved *Expert Settings*, but the old *Normal Settings* will be lost.

5.3 Events

Every time there has been a trigger and the device recorded the input signals for a number of microseconds (see also Section 5.4.1), an *event* is shown on the *Events/Settings* and *Expert Settings* tab pages and is written to the database (if the program is in *DAQ Mode* or if it is writing to the *Local Database*). An event consists of two or four traces (dependent on whether you are using two devices or not), a GPS time stamp, a trigger pattern and a detector number.

The *Traces* contain the measured ADC data and this is plotted on the screen. The *GPS timestamp* shows the date and time of the event. The *Trigger pattern* shows over which thresholds the input signal went at the time of the trigger and whether there was a *Slave* device present or not. The *Detector* number is the unique number set on the *Expert Settings–Detector Settings* tab. On the *Events* panels the current *Status*, the hardware and software *Version numbers* and the coordinates of the GPS antenna are shown as well.

5.4 Settings

Besides displaying recorded events, the *Events/Settings* and *Expert Settings* tabs also contain the controls for all the settings of the device(s). There are two types of settings: general settings and device settings. You can set the same settings on the *Slave* device as you can set on the *Master*, but the values can be different. The general settings apply to both the *Master* and the *Slave* device, or only to the *HiSPARC II* program itself. You can change the settings on the *Events/Settings* tab in both the *Normal Mode* as

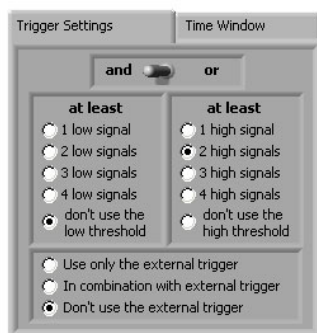


Figure 5.4: Trigger Settings

the *Expert Mode* and the settings on the *Expert Settings* tab only in *Expert Mode*.

5.4.1 Events/Settings

General Settings

Trigger Settings If a signal at the analog input exceeds its threshold value (see the *Thresholds* tab), a signal is sent to the trigger system, which decides whether to record an event or not. At this tab you can set under which condition this happens. You can use the internal (thresholds) system, the external trigger (an input on the devices) or both. For the internal trigger you can set the minimum number of high and low over-threshold signals there must be before the device starts taking data. If you use only a master device the maximum number of signals you can get is obviously two. With the *and/or switch* you can set whether you want at least n low signals *and* m high signals or at least n low signals *or* at least m high signals.

Time Window If there is a trigger, the device starts recording the input signals for a specified time. On this tab you can set the time it records before the time of the trigger (*Pre Coincidence Time*), the time within which all over-threshold signals must come to cause a trigger (*Coincidence Time* or *Trigger Window*) and the time it measures after the *Coincidence* timewindow (*Post Coincidence Time*). The *Coincidence Time* also counts for the total measuring time, so the total time is the sum of these three. The *Pre Coincidence Time* can be set from 0 to $2\mu\text{s}$, the *Coincidence Time* from 0 to $5\mu\text{s}$ and the *Post Coincidence Time* from 0 to $8\mu\text{s}$. The total time cannot be more than $10\mu\text{s}$. Although it is possible to use a *Pre Coincidence Time* down to zero, this is not recommended. If the *Pre Time* is smaller than $0.125\mu\text{s}$, the

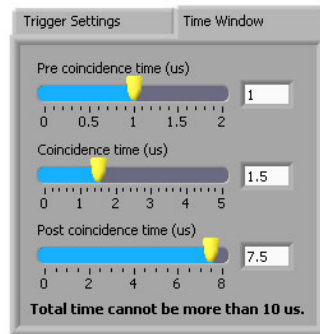


Figure 5.5: Time Windows

baseline of the signal cannot be determined and the histograms on the *Statistics* page will not be filled (see also Section 5.6).

Device Settings

Thresholds The thresholds give the values above which (or actually below which, because all voltages are negative) the signals on the analog inputs of the device(s) cause a signal in the trigger system. The trigger system then decides whether the device starts recording data or not. Each channel has its own threshold values and you can set both a low value and a high value. (See *Trigger Settings* for more information about the low and high values.) The *Statistics* tab page (Section 5.6 and Figure 5.17) shows how many times the input signal was above the threshold in the last second.

Warning: The threshold values are set in mV, but this is only correct if the device is calibrated and the right gain and offset values are set on the Expert Settings–Calibration tabs (see Chapter 4 for calibration).

Integrator Times Here the RC time constant of the integrator circuit at the analog inputs can be set. The controls can be set from 0 to 255, where 0 corresponds to a large RC time and 255 to a short RC time.

Photomultiplier Tube On the photomultiplier tube page the high voltage that is applied to the tube can be set. The voltage supplied by the *HiSPARC II* device is set in *mV* and transformed at the tube to a high voltage. The factor between the voltage at the device and the high voltage is approximately 1000. The voltage can vary from 300 *mV* to 1500 *mV*, but the maximum voltage you can apply is set on the *Expert Settings–Main Settings* tab. This tab also shows the supply current for each tube.

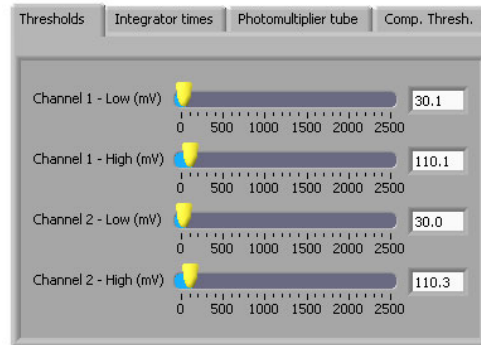


Figure 5.6: Thresholds

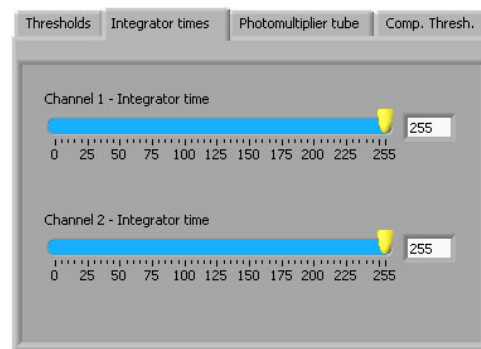


Figure 5.7: Integrator Times

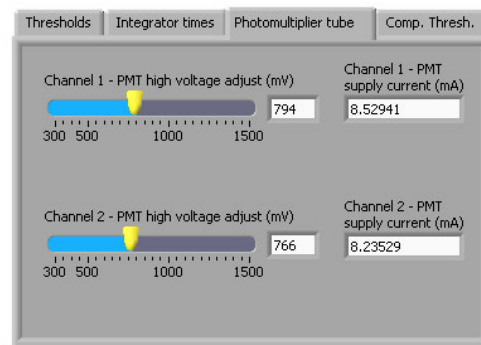


Figure 5.8: Photomultiplier Tube

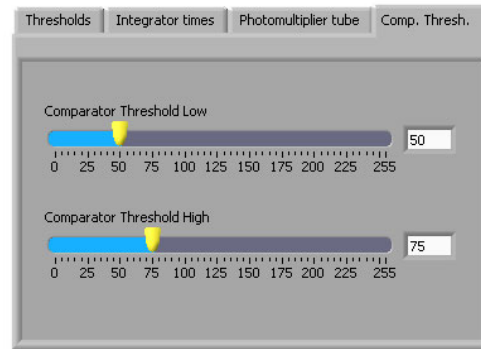


Figure 5.9: Comparator Thresholds

Comparator Thresholds Apart from two at the ADCs, the devices have two extra thresholds, which show whether the input signal was above a voltage that you can set on this tab. These voltages are set from 0 to 255. For the low threshold, this corresponds to approximately -2 V to -7 V , respectively. For the high threshold, this is -2 V and -11 V . For each event, you can see whether the signal went over these thresholds in the *Trigger Pattern* on the *Events/Settings* or the *Expert Settings* tab.

5.4.2 Expert Settings

General Settings

Main Settings On the *Main Settings* tab page, you can set several program parameters. To make changes on this tab page effective, a restart of the program is required (in addition to pushing the *Apply Settings* button and with the exception of *Enable writing to GPS receiver*).

The *Detector Number* is the unique number assigned to the detector. This number is used in the databases for identification and must be correct to enable the *Buffer Database* to send events to the *Central Database*.

The *Password* is required to enter the *Expert Mode* of the program. This password is not necessarily the same as the password required to send events to the *Central Database*. The default value is an empty string.

The program uses the value of the *Database* control to send events to the *Buffer Database*. This value should be the *Data Source Name (DSN)* of the *ODBC Data Source* that directs to the *Buffer Database*.

If *Start directly in DAQ mode* is set, the program will go to *DAQ Mode*

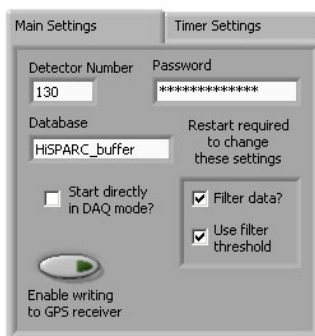


Figure 5.10: Main Settings (general)

as soon as it is started and skips the dialogs that usually appear. You can use this setting if the PC is configured to automatically logon to Windows and to start the *HiSPARCII* program at logon. This way, the program will automatically resume taking data after a restart of the PC. This is often desirable for long term data taking, as Windows has a habit of forcing a reboot after an automatic update. If the PC can also be configured to automatically power up after a power failure, only a crash can stop the data acquisition.

The *Filter data?* and *Use filter threshold* checkboxes control the filtering of the digital signals in the *HiSPARCII* software. Filtering is necessary for a number of *HiSPARCII* devices that have a flaw in the electronics. This flaw causes an oscillation in the analog input signal that is filtered out if *Filter data?* is set. Because the filtering has not the desired effect for large fluctuations of the input signal, a filter threshold is used. This threshold is controlled by the *Use filter threshold* checkbox. The software stops filtering if the fluctuation in the signal exceeds the threshold. If a device with the flaw is used, the filter should be used with a threshold, i.e.—both boxes should be checked. For devices without the flaw, the filter should not be used.

Enable writing to GPS receiver is the only control for which a change is effective immediately after pushing the *Apply Settings* button. This control enables or disables writing the GPS receiver settings (see Chapter 3). If you are not adjusting these settings, writing should be disabled (light on the button *off*).

Timer Settings On this tab page you can set the minimum time between *Screen Updates*, between *Device Checks* (both in seconds) and between *PC Clock Error Updates* (in minutes). The screen is only updated if there are new events or new *Second Messages* from the device, which contain the *Singles* information on the *Statistics* tab page (see Sec-

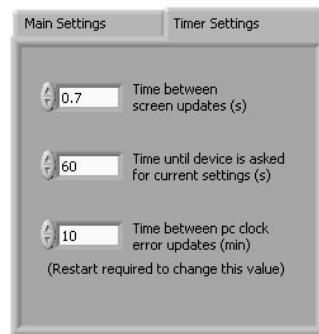


Figure 5.11: Timer Settings

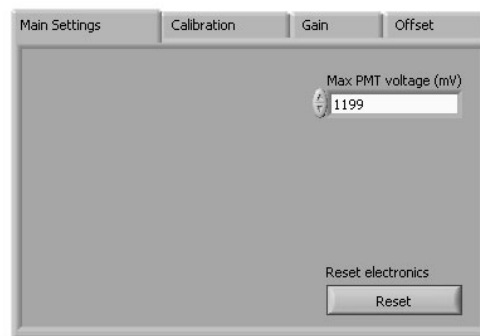


Figure 5.12: Main Settings (device)

tion 5.6). In a *Device Check*, the device is asked for its current settings and it is checked whether they correspond to the settings of the program or not. The *PC Clock Error Update* writes the difference between the time on the PC clock and UTC to a file. This difference is used by other *HiSPARCII* applications.

Device Settings

Main Settings If the *Reset* button on this page is pushed, the device will be reset. The program restarts with the saved settings. The *Max. PMT voltage* control sets the maximum PMT voltage that can be set with the *Photomultiplier tube* controls (see Section 5.4.1).

Calibration With the *Common offset* you can shift the ADC scale up or down. For a higher *Common offset* value, the ADCs will give higher values (or lower if you consider negative values). The *Common Offset* is determined in the calibration process (see Chapter 4).

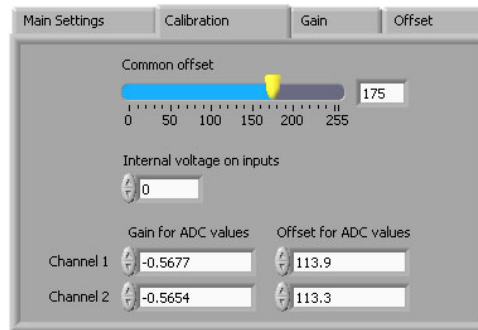


Figure 5.13: Calibration Settings



Figure 5.14: Gains

The *Internal voltage on inputs* control is used by the *HiSPARC II* program in the calibration process. For normal usage of the program this control can be ignored.

With the *Gain for ADC values* and the *Offset for ADC values*, you can calibrate the device further after the calibration procedure. This must be done to make sure that the program converts voltages and ADC values the right way. The voltage for a given ADC value is calculated with:

$$\text{Voltage} = \text{ADC Gain} \cdot \text{ADC value} + \text{ADC Offset}$$

Gain and Offset The *Gain* and *Offset* values determine with the *Common Offset* the value that the ADC gives for a certain voltage applied on the analog input. You can set a gain and an offset for each ADC (so two per channel). These values are determined in the calibration process (see Chapter 4).

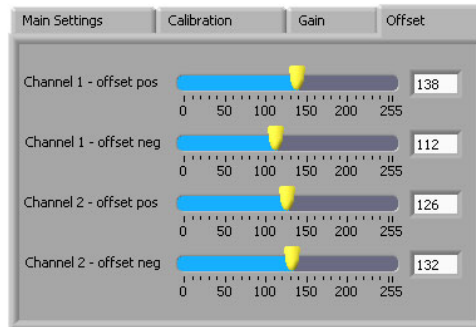


Figure 5.15: Offsets

5.5 Status/Errors

Figure 5.16 shows the *Status/Errors* tab page. Messages from all errors that occur are displayed here. This page also shows information about the *HiSPARC II* devices. You can see here whether a *Master* and a *Slave* device are connected or not, what the status of the devices is, whether the device has a GPS receiver or not and whether the device has detected a connection to a *Slave* device or not. For the *Master* device, its temperature is shown as well. This temperature is measured on the GPS receiver.

The status of the device is set to “bad” (a red *Status* light on this page) if the program did not receive any data from the device for more than two seconds or if the device does not respond to the request to send its settings in a device check. If the status is “bad” the program will try to restore a normal connection to the devices. If this process times out after ten seconds, the connection to the device is terminated (the *Connected?* light switches off) and there will be no further communication with the device until the program is restarted. If the *Master* device is disconnected, the *Slave* will be as well.

5.6 Statistics

If an event is shown on the *Events/Settings* and *Expert Settings* pages, values of a few important quantities calculated for each channel by the *HiSPARC II* program are added to the histograms on the *Statistics* tab page (Figure 5.17). These quantities are the *Number of Peaks*, the *Pulse Height* and the *Integral* of a recorded signal. The *Histogram number of peaks* counts the number of peaks in the recorded signal. Only peaks higher than 60 ADC counts ($\approx 35\text{ mV}$) are taken into account, where the height is the difference between the highest and the lowest point of the peak and not the height relative to a fixed point. The *Pulse Height* is the maximum (or actually

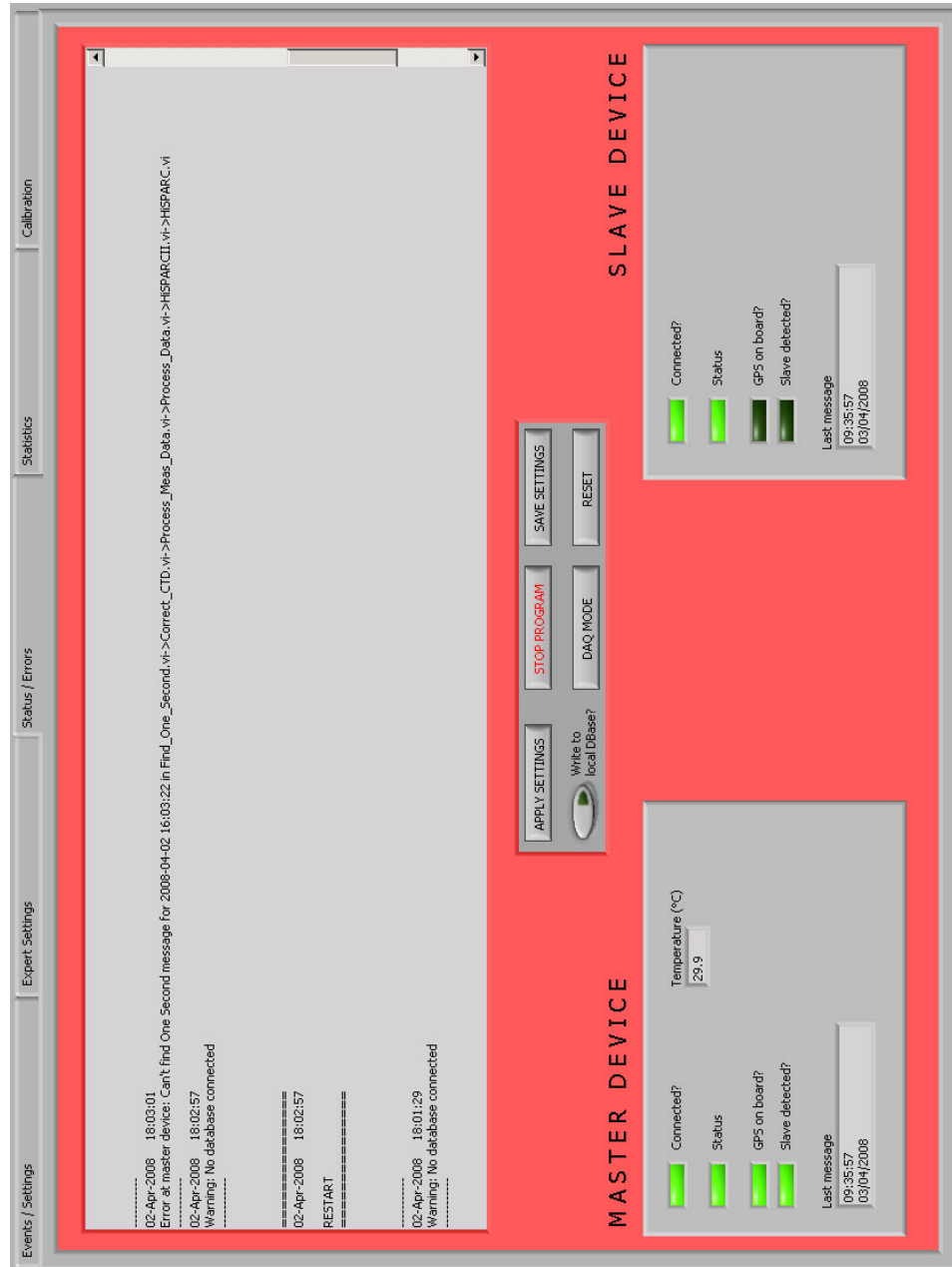
minimum) of the signal in the full recorded time. This value is calculated relative to a baseline, that is determined by taking the average of the first data points, where the PMT still is at its base voltage. The third histogram shows the values of the *Integral* of the recorded signal. This integral is the sum of the heights of the signal relative to the baseline, for each point where this height is larger than four ADC counts ($\approx 2\text{ mV}$). All the histograms have a maximum value, above which entries are no longer plotted. The number of entries above this maximum is shown in the counters below the histograms.

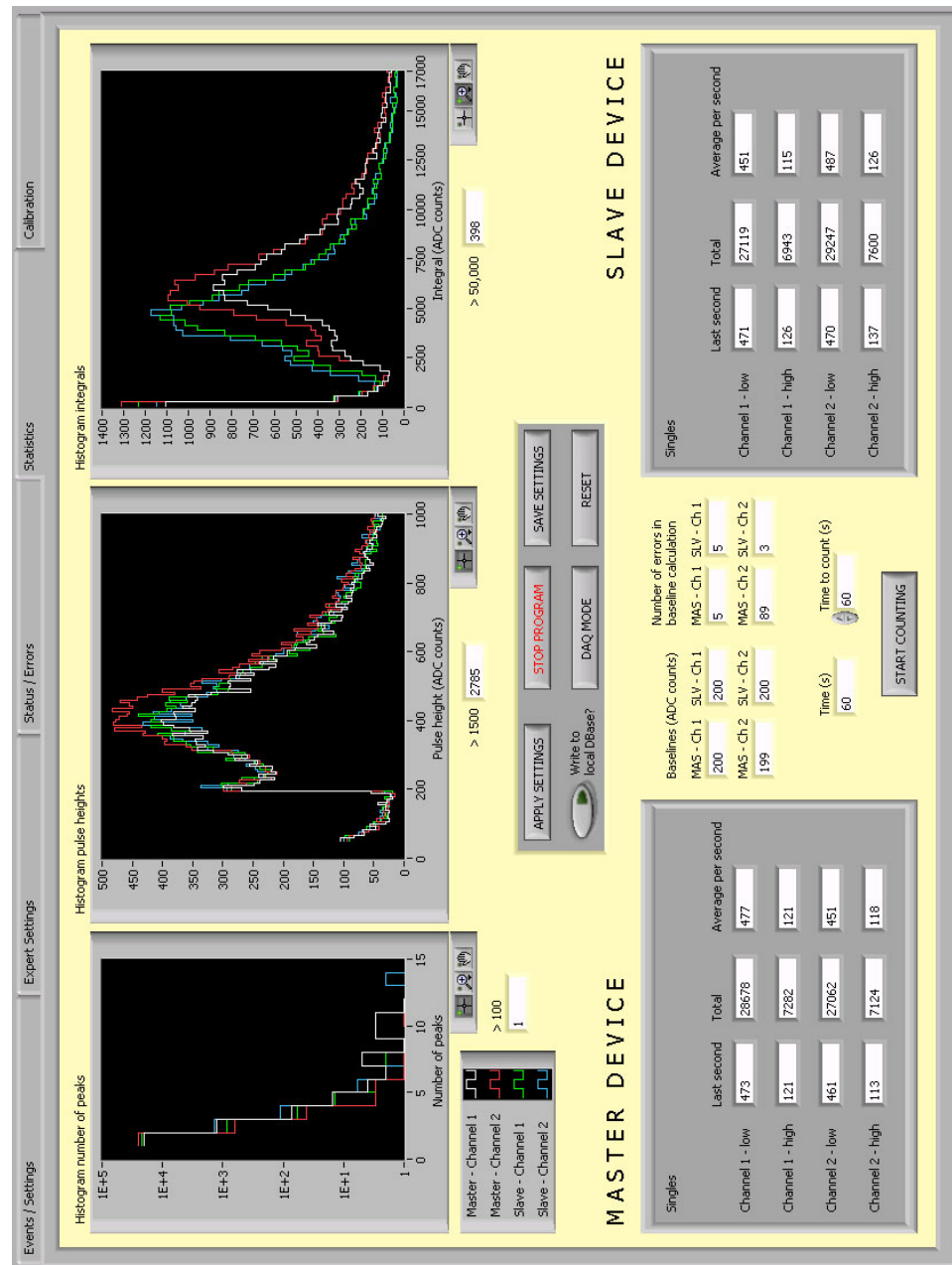
The baselines are also shown on the *Statistics* page for each event. These values should be around 200 ADC counts after the calibration procedure. If the signal already varies too much in the first data points, the program can't calculate a proper baseline. In that case, it tries again at the end of the recorded signal. If this doesn't work either, the values for the histograms cannot be calculated and the program gives an error for the baseline (-999). The number of errors for each channel is shown to the right of the baselines.

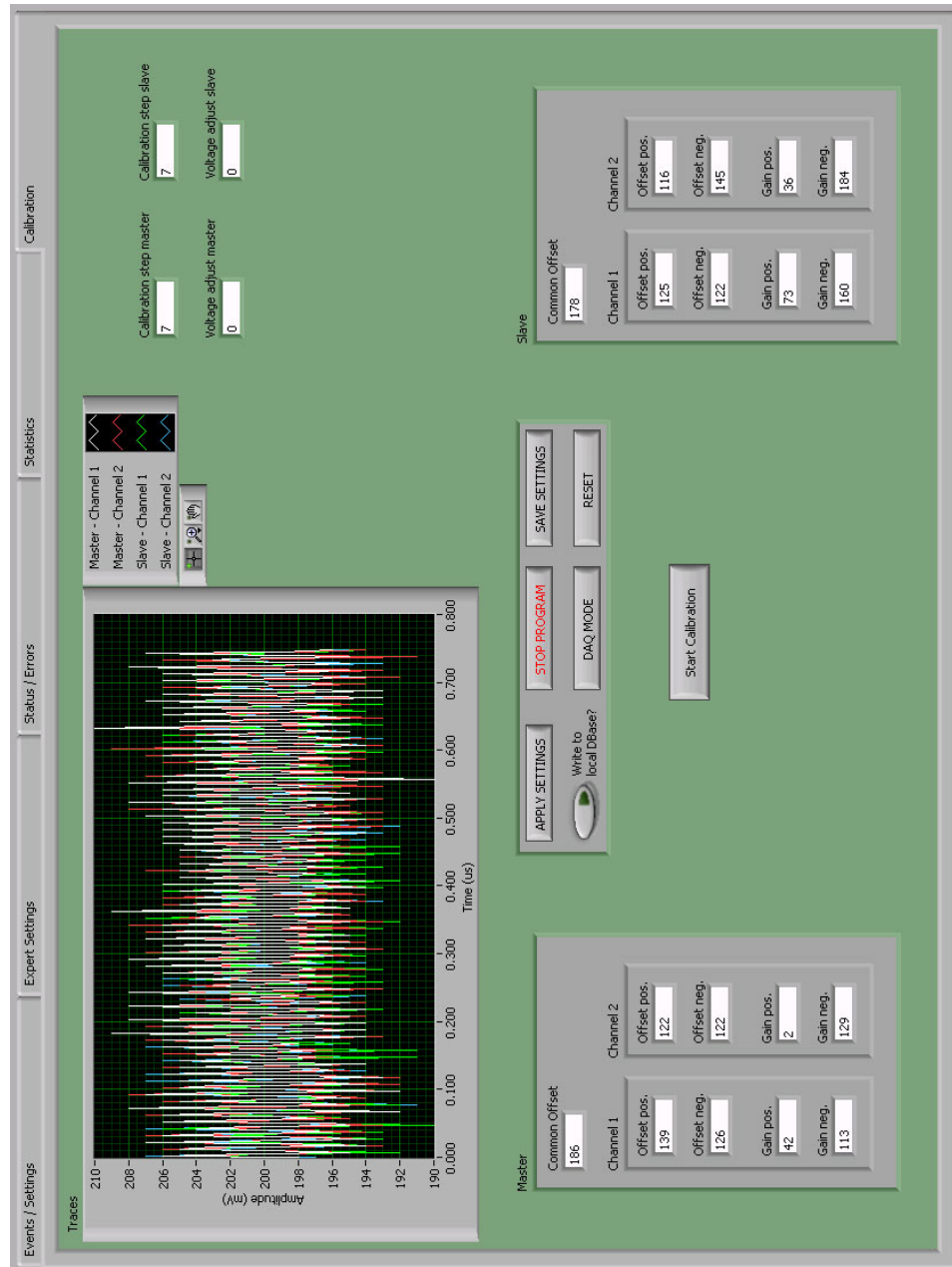
On the *Statistics* page you can also see the *Singles* for each threshold. This is the number of times the signal on the analog inputs exceeds the threshold. In the left column on the *Singles* panel, the number of singles in the last second is shown. If the *Start Counting* button is pushed, the program counts the singles for a longer period of time. In the middle column, you can see the total number of singles over this period and in the right column the average per second. You can set maximum time to count with the *Time to count* control, but the counting can always be stopped by pushing the *Counting* button again.

5.7 Calibration

In Figure 5.18, the *Calibration* tab page is shown. For information about the calibration process, see Chapter 4.

Figure 5.16: The *Status/Errors* tab

Figure 5.17: The *Statistics* tab

Figure 5.18: The *Calibration* tab