VariSphear

Variable Spherical Microphone Array

Quick Start Manual

Software Version R13-0109.C (Compiled)

Contents

1 Introduction and Installation

1.1 Welcome to VariSphear / VSA

Welcome to the VariSphear[1] system. VariSphear (VSA) is a spherical microphone array measurement system. This quick start manual helps you to set up the system and show you the most important steps to run a measurement session. The author expects you to have knowledge on audio and acoustic measurement techniques to understand and use the VariSphear system correctly.

VariSphear (VSA) was designed and developed in Germany during 2009-2011 at the Cologne University of Applied Sciences, the Technical University of Berlin, the Deutsche Telekom Laboratories in Berlin and the WDR (Westdeutscher Rundfunk) Köln.

For any further requests and/or technical support feel free to contact:
Benny Bernschütz, benjamin.bernschuetz@fh-koeln.de, +49 221 8275-2496 or
Prof. Dr.-Ing. C. Pörschmann, christoph.poerschmann@fh-koeln.de, +49 221 8275-2495

For software updates and further information visit:
→ **http://www.audiogroup.web.fh-koeln.de**

1.2 Required external components:

- Windows computer (XP/7)[2], min. resolution 1280x800px
- Ethernet network adapter
- Audio interface (Recommended: RME Fireface, HDSP, etc.)
- A microphone + microphone preamp

[1]VARIable SPHerical EAR
[2]Sorry, no support for Mac/Unix.

1.3 Unpacking and mounting the hardware

The VariSphear system comes in a professional touring case for secure transport and to enable a long lifetime of the components.

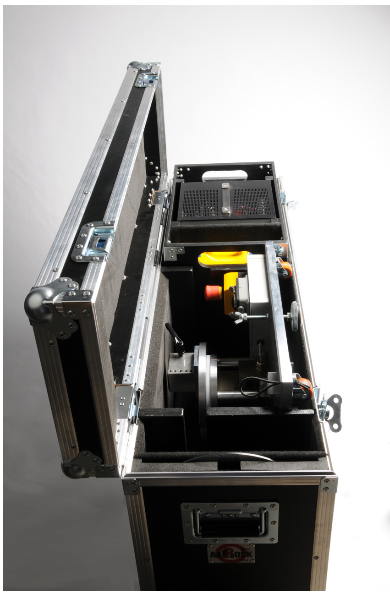

Figure 1.1: VariSphear transport box

All components including the array itself, PSU, cables, audio converters and other tools can be collocated inside. The case contains:

- VSA basement
- VSA robot arm
- Short microphone boom
- Long microphone boom
- 24V PSU
- Case with mountable laser sensor
- A small toolbox
- Basic cabling

Mounting the hardware is easy and takes only a few minutes. Insert the robot arm and fix it. Insert and fix the multi-pin connector. Insert the microphone boom and fix it. Now mount any microphone(s) of your choice to the boom's end(s) and connect the 5-PIN XLR audio plug. Connect the PSU, the audio signal outputs to your preamp /audio interface and the Ethernet port to your switch or directly to your computer. Mount the laser sensor (knurl screw) and connect it with the short 3.5mm stereo jack -> XLR 3PIN cable. (For audio measurements you should unmount the laser sensor because it influences the acoustic wave field -> scattering.) Finally the array should look more or less as follows:

Figure 1.2: VariSphear - completely mounted

As this is a scientific tool for laboratory use only, it is urgently necessary to think about every step you do. Misuse of the array can lead to damage of hardware or even persons! There are two very important things to do before starting any operation:

- Watch out for the boom length to fit all positions! (External obstacles and the lower end of the robot arm itself)
- Move the array to the park position[3] and fix the cable as shown in the following illustration:

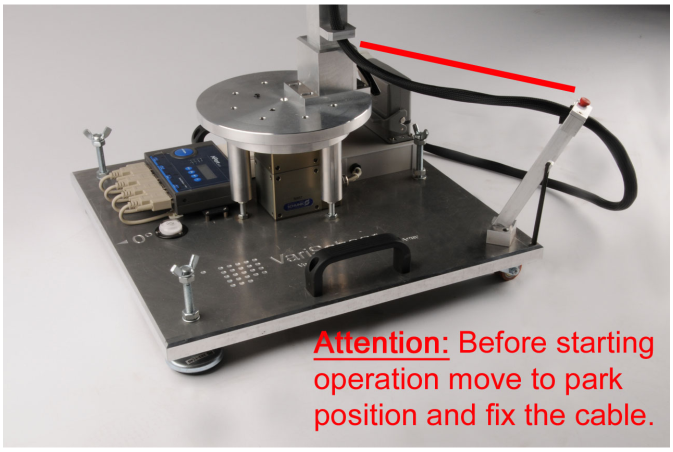

Figure 1.3: VariSphear - Remind to mount the cable in the correct position

Remember:
If you change the measurement height of the array, you have to repeat these steps!

If you don't mind these steps, operating the array can lead to serious damage of the hardware!

[3]This is an option you find in the VS wavecapture software.

1.4 Installation of the software

The VariSphear waveCapture software is written in MATLAB and uses some low level core routines written in C/C++. Since version R13-0109 it is not necessary anymore to have MATLAB installed on the computer to run the VariSphear software. The software has been 'compiled' using a MATLAB compiler. The required MCR (Matlab Compiler Runtime) is included in the installer package.

IMPORTANT: The VariSphear software needs to have permissions to write files to the hard disc during the runtime! If you experience lots of problems running the software it might be a simple permission issue.

The following screenshots guide through the installation process.

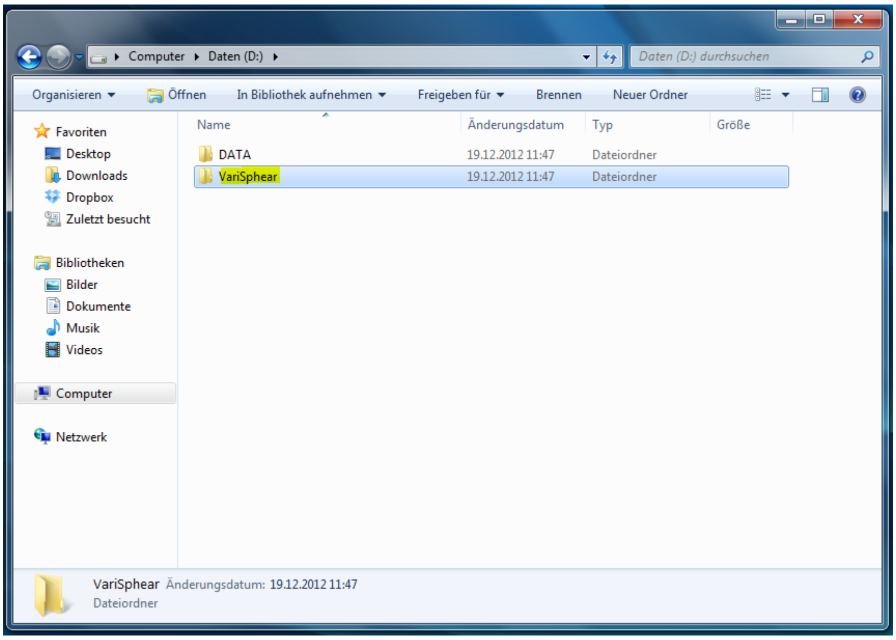

Figure 1.4: STEP 1: Make a new directory on the hard disc, e.g. named 'VariSphear'

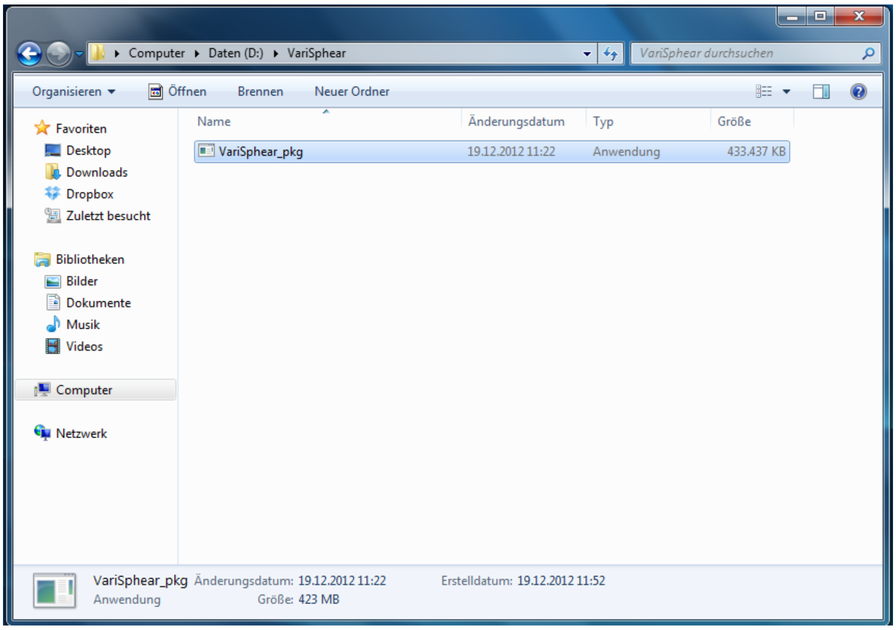

Figure 1.5: STEP 2: Copy the file: 'VariSphear_pkg.exe' to the new folder and execute it. This file is a self-inflating archive containing the software and the MCR (Matlab Compiler Runtime).

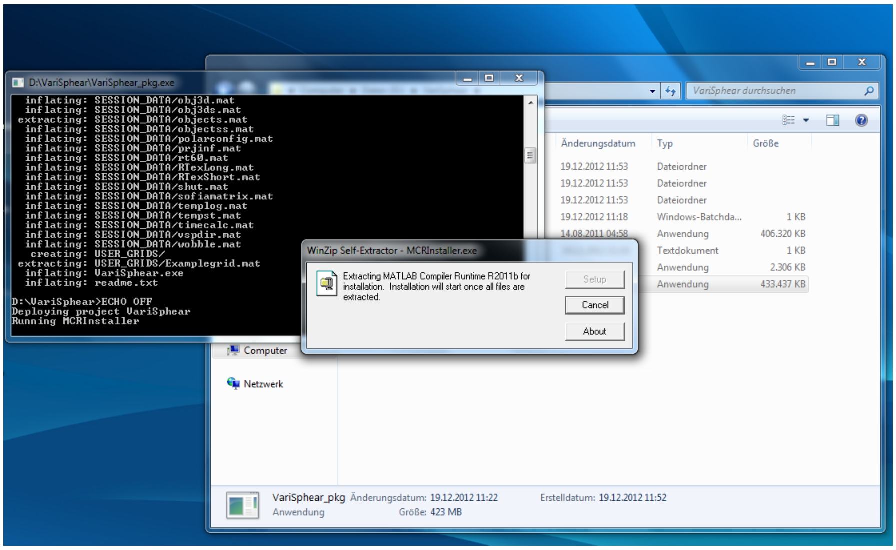

Figure 1.6: STEP 3: The archive is being extracted.

Figure 1.7: STEP 4: Start the installation of the MCR (Matlab Compiler Runtime)

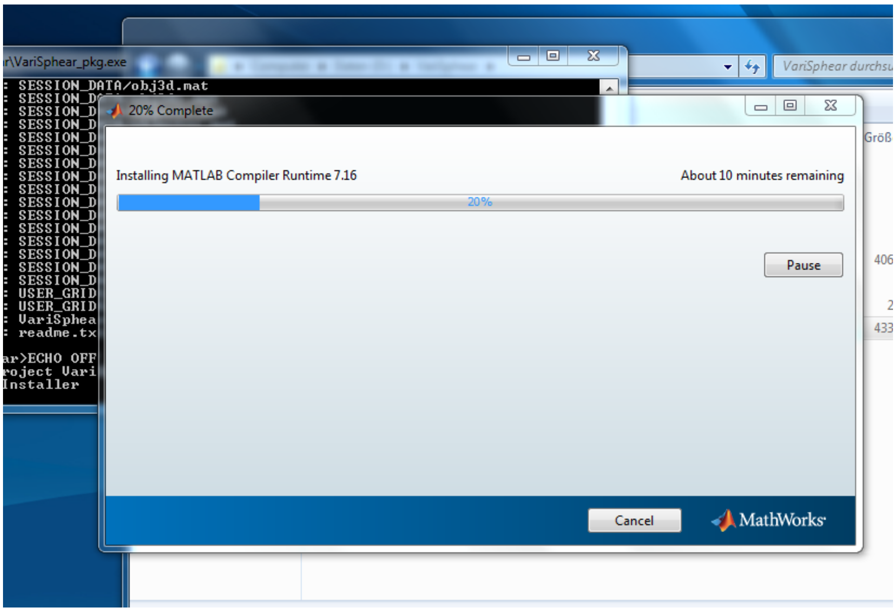

Figure 1.8: STEP 5: The MCR is installing... (This takes a few minutes)

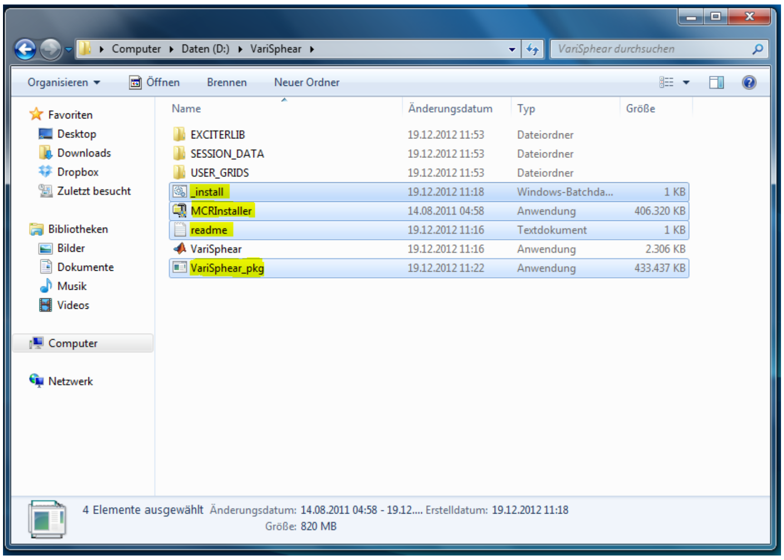

Figure 1.9: STEP 6: The files '_install.bat', 'MCRinstaller.exe', 'readme.txt' and 'VariSphear_pkg.exe' can now be deleted to save hard disc space.

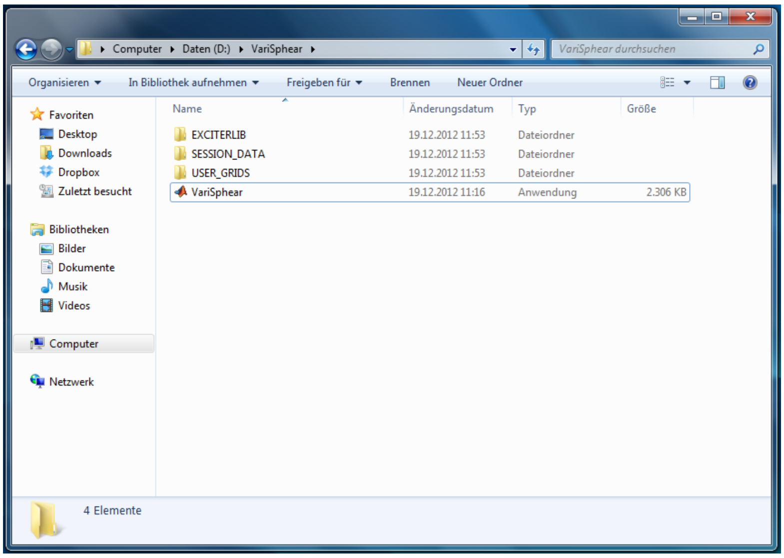

Figure 1.10: STEP 7: The program folder should look like this. The three folders 'EXCITERLIB', 'SESSION_DATA' and 'USER_GRIDS' are required by the software. After the first run, two files ('pathdef.mat', 'sessioncnt.mat') are added to this folder. These are written and required by the software.

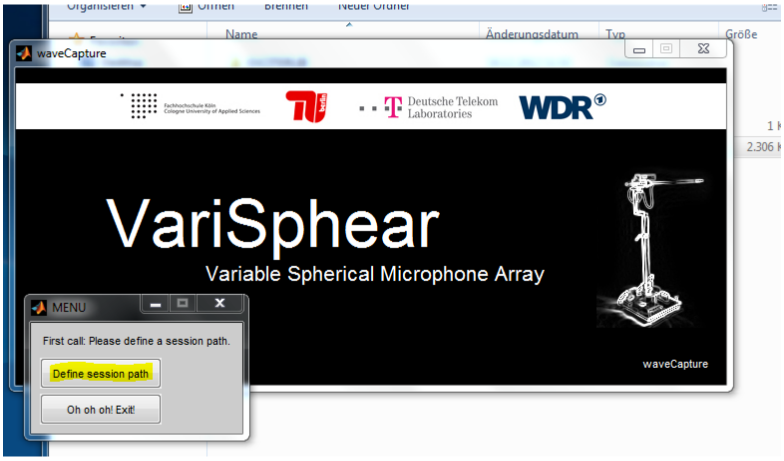

Figure 1.11: STEP 8: At the first run the software will ask to define a session path. The session path is used to save all measurement and project data.

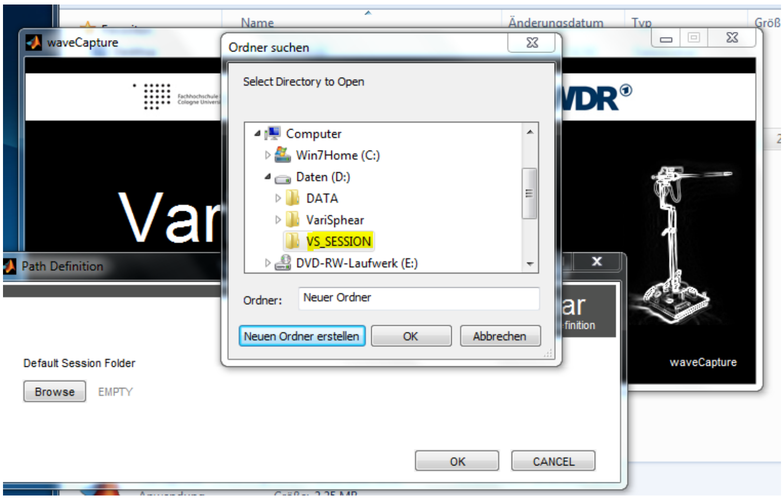

Figure 1.12: STEP 9: Create a new folder for the session path or use an existing session path from a previous VariSphear software.

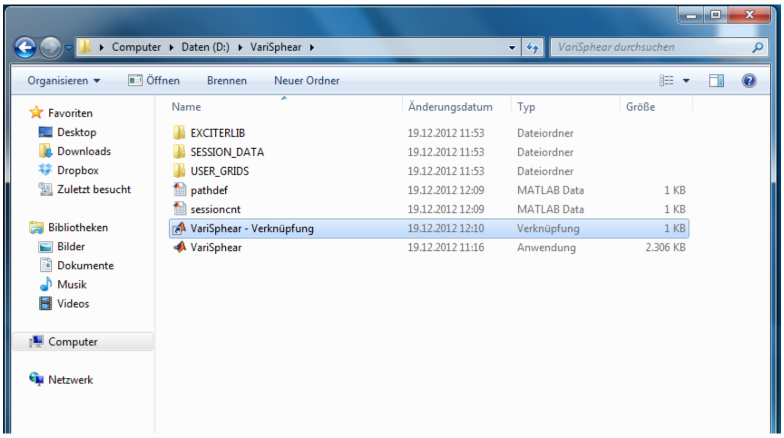

Figure 1.13: STEP 10: Create a shortcut of 'VariSphear.exe'

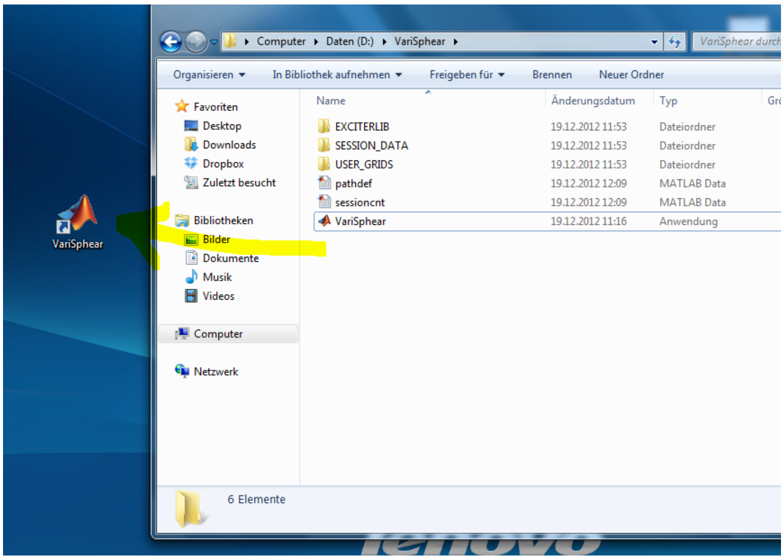

Figure 1.14: STEP 10: Rename and move the shortcut e.g. to the desktop.

1.5 Setting up the communication ports

The hardware is controlled via a Moxa NPort 5410 Device Server mounted on the VSA basement, which creates four virtual COM-ports on your system. The device server offers four RS232 Ports and 10/100MBit Ethernet connectivity. It can be integrated into any existing network or be driven by a direct connection between the computer and the VSA. It is possible and useful to set up a wireless LAN access point to operate the realCAD geometrix room CAD module. But you should always use a cable network for audio measurements and disable the wireless LAN connection on your computer as audio drivers and wireless LAN can lead to timing conflicts.
For more information on the serial device server NPort 5410 and actual driver download visit http://www.moxa.com/

Figure 1.15: Moxa NPort 5410 Serial Device Server

Set up the desired IP Adress of the port server using the unit's user interface. (IMPORTANT: Choose the same subnet your computer is assigned to!) Install the driver for the NPort 5410 server to your system (these can be found on the waveCapture disc). Search for NPORTs and map/activate the four virtual COM-Ports. The driver asks you to set the ports to real-com mode. (Don't care, the server is already set to real-com mode when shipped.)

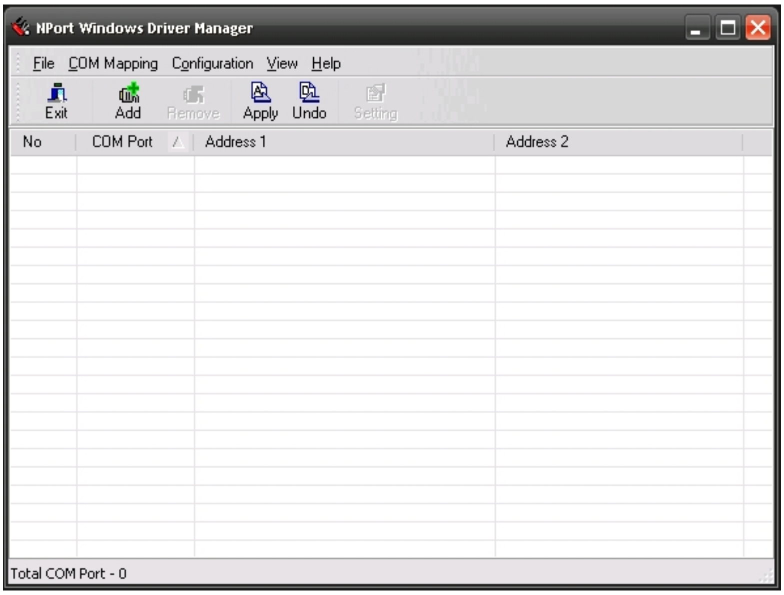

Figure 1.16: Moxa NPort Driver, Add device/ports

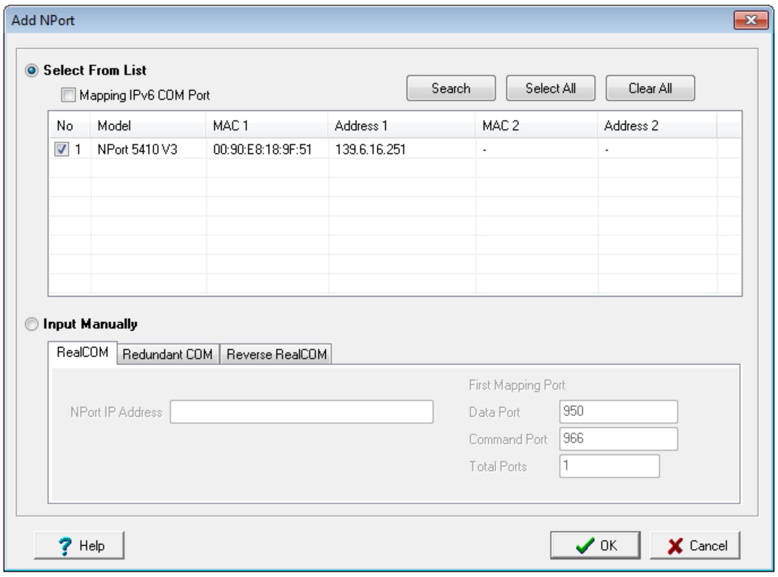

Figure 1.17: Moxa NPort Driver, Search Devices on the Network

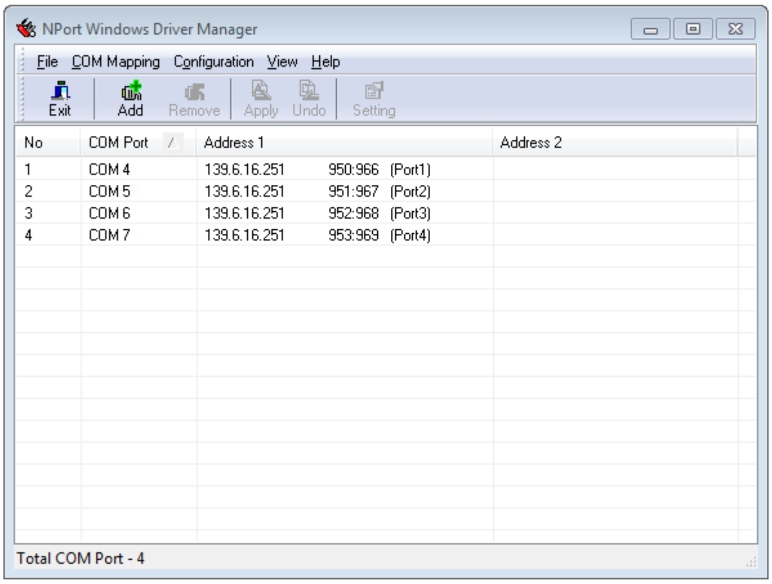

Figure 1.18: Moxa NPort Driver, COM Port Mapping

The server ports are connected to:

- Port 1: Azimuth Motor
- Port 2: Elevation Motor
- Port 3: Temperature Sensor
- Port 4: Laser Sensor

These ports are mapped e.g. to COM4, COM5, COM6, COM7 on your system (This always depends on the local existing ports). Do not change the basic settings for port speed, start/stop bits etc. The waveCapture drivers set up the correct port parameters automatically. Once the device server is set up you do not need to care about this topic anymore. Your system maps the COM-Ports on every system startup automatically.
Start waveCapture (»vs) and hit the **COM Set** button or press CTRL-O. Register the ports that have been created by the NPort driver, e.g. COM4. COM5, COM6, COM7.

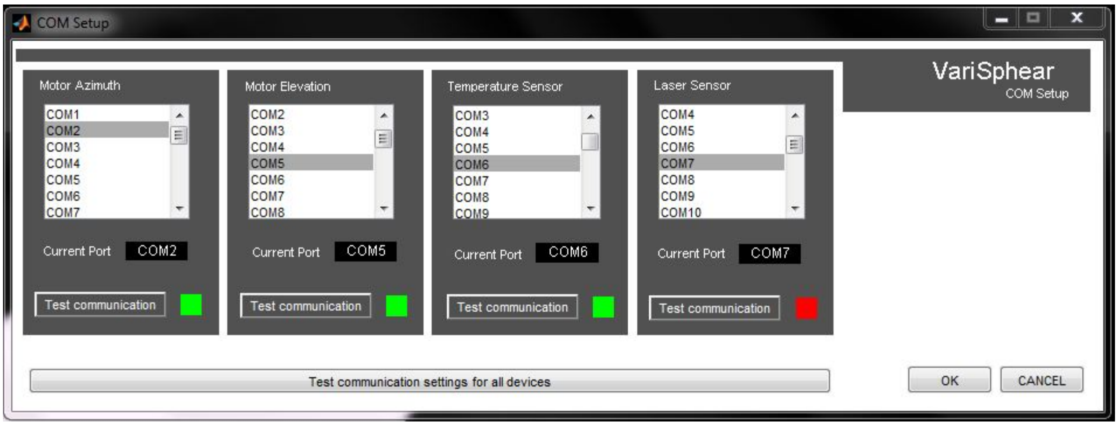

Figure 1.19: VariSphear wavecapture COM-Port Setup

Be sure to be connected to the VSA hardware and to have powered up all devices. Now the connectivity can be checked. This can be done seperately for a singular device or for all devices. The corresponding indicator lights turn green if the connection could be established and red if the device cannot be reached.

1.6 Audio interface and cabling

waveCapture uses a port audio binding for using ASIO audio device drivers. For testing purposes the Windows default record/audio device and driver can be used as a fallback solution. But this driver is not reliable (e.g. respecting latency[4]) and does only allow to connect 1 microphone.

The audiocapture module of the VSA always requires a hardware reference channel. There is no option to avoid this. For the reference channel you need to apply an analog[5] loop connection from the output to the input of your interface.

The interface and routing setup canbe found under 'VariSpear wavecapture => Audiocontrol => Audio Device/Driver', see chapter 2.3, page 23.

Using an ASIO driver the channel routing can be changed to use any inputs and outsputs of the connected device in the preferred order.

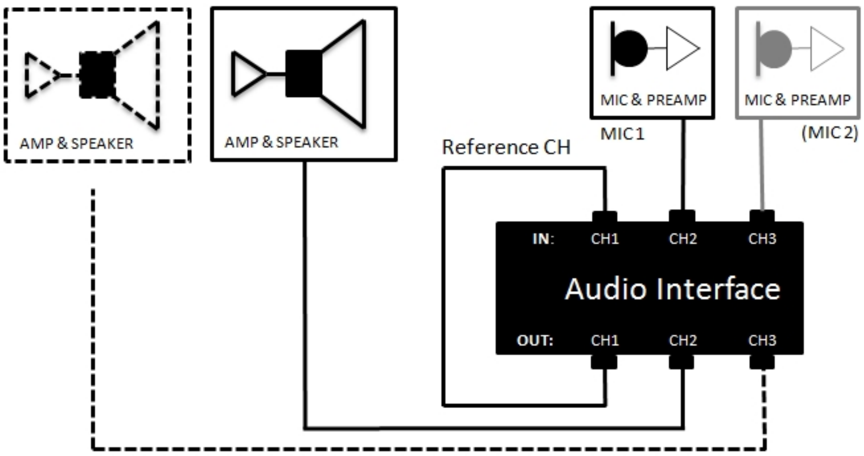

Figure 1.20: Example audio cabling for ASIO driver with reference and 1 or 2 Mics

The fallback solution using the windows default audio device does not offer free signal routing. For using this option please take care of setting up the sampling rate and bitdepth in the os system settings.

---

[4]Even if the system latency is automatically compensated by the audiocapture engine, the use of hardware with ASIO driver is recommended.

[5]NO digital loop via SPDIF or ADAT OPTICAL!

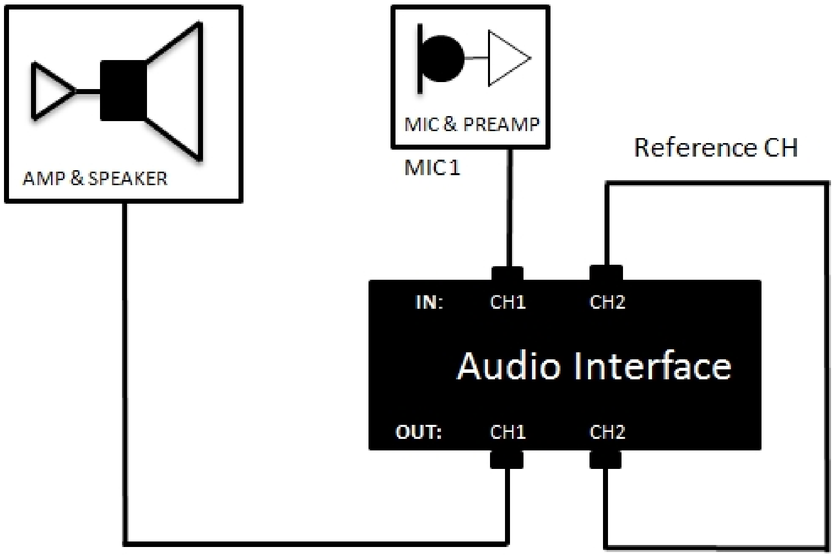

Figure 1.21: Audio cabling for using the Windows default audio device

1.7 VSA Laser Sensor for rCg

Here we go to set up the laser sensor[6] for using the realCAD geomterix (rCg) module. Mount the laser sensor to the VSA. Connect with the XLR 3-Pin to 3.5mm Stereo-Jack cable to the VSA head. Turn on power (press the big button). Hit the 'menu' button five times and you get to the important menu page.

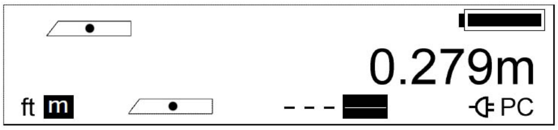

Figure 1.22: VariSphear Laser Sensor Menu

Set following parameters:

- Measures: METERS
- Reference: MIDDLE
- Beam: CONSTANT

On the last field there is a PC option. Hold down the corresponding key for around 3 seconds. Now you should be in remote mode and anything like V: 1.05 should appear on the display and on the upper side the BAUD rate (38400 BAUD). Down on the left button you can adjust the BAUD rate. Change it to 38400 BAUD if necessary - otherwise the sensor cannot communicate to the VSA.

The laser sensor works with 4xAA cells. So you also can use the sensor for manual measurement applications.

WARNING: Please be careful not to look directly into the laser beam while operating the VSA laser extension. This is a CLASS2 laser that can seriously harm your eyes.

[6] TOPCON EM-30 or Jenoptik LEM-30

2 VariSphear waveCapture

VariSphear waveCapture is the main control software for the VariSphear system. It is completely GUI based and designed for good handling and easy usage. It runs under Matlab. As this is a quick start manual, we give you a short introduction only. Most of the software should be self-explaining, just go ahead and try out for yourself before using the VariSphear system for any serious application. All important steps you do are written to the hard disk. In case of a system crash waveCapture remembers all important settings and you can directly go on working after system reboot.

After starting the VariSphear Software (»vs.m) you get to the main screen of waveCapture:

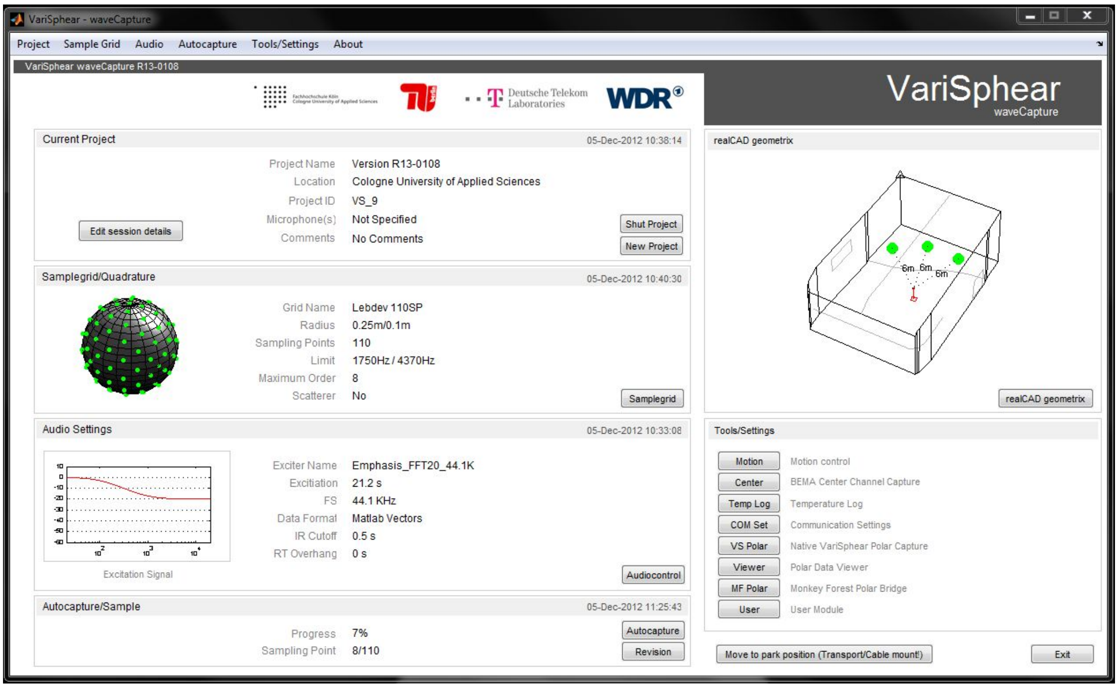

Figure 2.1: VariSphear waveCapture main window

The following pages give you a short introduction to waveCapture. Follow the chapters step by step and later you'll be ready to operate the VariSphear array on your own. The following steps assume that you mounted the hardware, installed the drivers and software. If not, return to Chapter 1. And again: Please take care of removing any obstacles arround the array and choosing an adequate array heigth according to the boom length! Take care of the right position for fixing the cable to avoid damage, see Fig.1.3, Page 6. The cable mount position can be reached in the waveCapture main window, see Fig.4.3, Page 46. Hit the button 'Move to park position'. This moves the array to a A90/E90 position. The short 'click' sound you hear from the motors is produced by the magnetic breaks that fix the positions.

2.1 Creating a new Project

First of all you have to create a new Project. Hit 'New Project' in the main window, see Fig.4.3, Page 46.

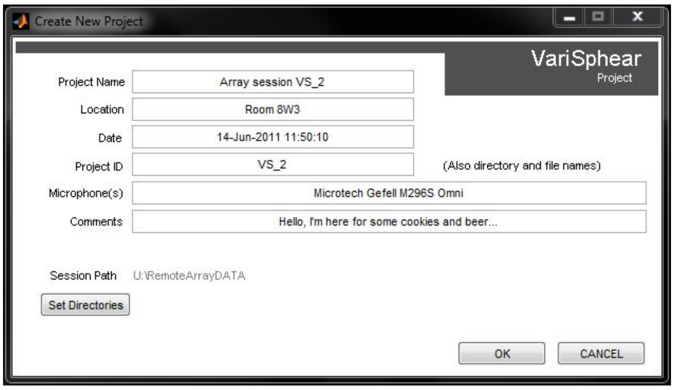

Figure 2.2: VariSphear Create new project

The project ID increments with every new project and defines the project names. If you don't like that, enter own names (Change the ID). The software creates a new project folder on your session path. Later on you find all the measurement data and project information of the actual session in that folder. Enter the measurment location and additional information and hit 'OK'. All details except the project ID can be changed later.

2.2 Sample Grid Section

Now select the sample grid. Hit 'Samplegrid'.

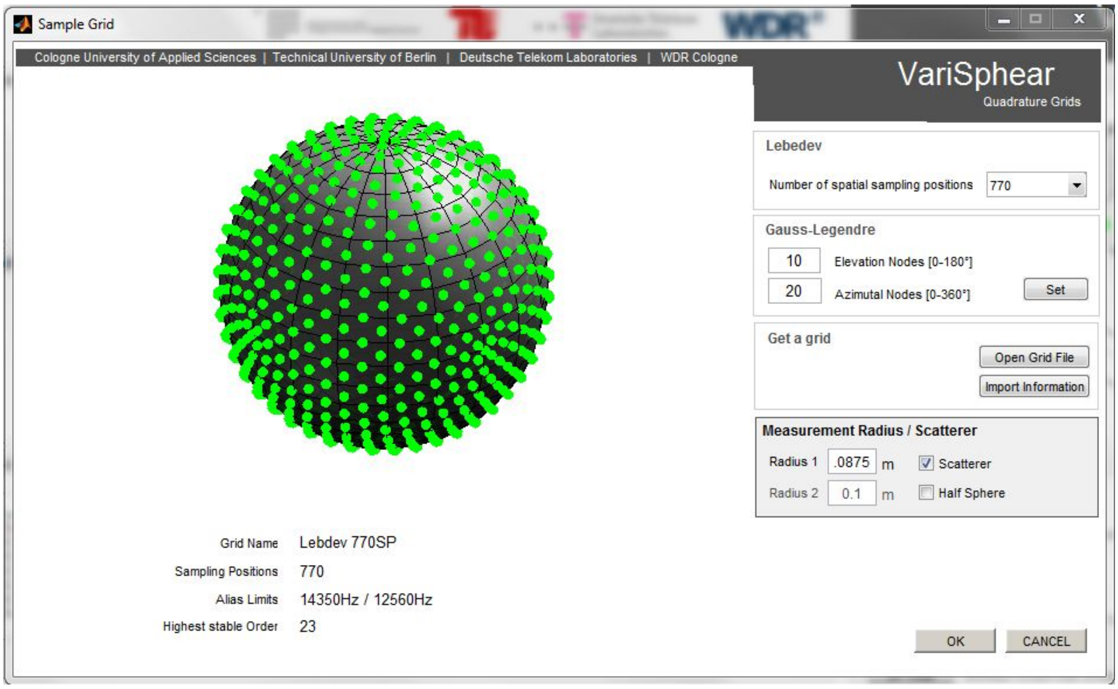

Figure 2.3: VariSphear Select Sample Grid

Lebedev and Gauss-Legendre quadrature grids are directly available an can be selected. But it is also possible to import arbitrary user grid (hit 'Open grid file')[1]. Hit 'OK' to accept the chosen settings. Get the radius/radii and enter the value to the corresponding field(s).

If you use a two-channel microphone boom with identical radii r1=r2 for symmetrical grids you can reduce the measurement duration for a full-sphere single-radius session by checkmarking the 'Half Sphere' option.

[1]For more information on importing grids hit 'Import Information'.

2.3 Audio Control

The audio control section (hit 'Audiocontrol' in the waveCapture main window) manages all the audio settings you need for running a measurement session.

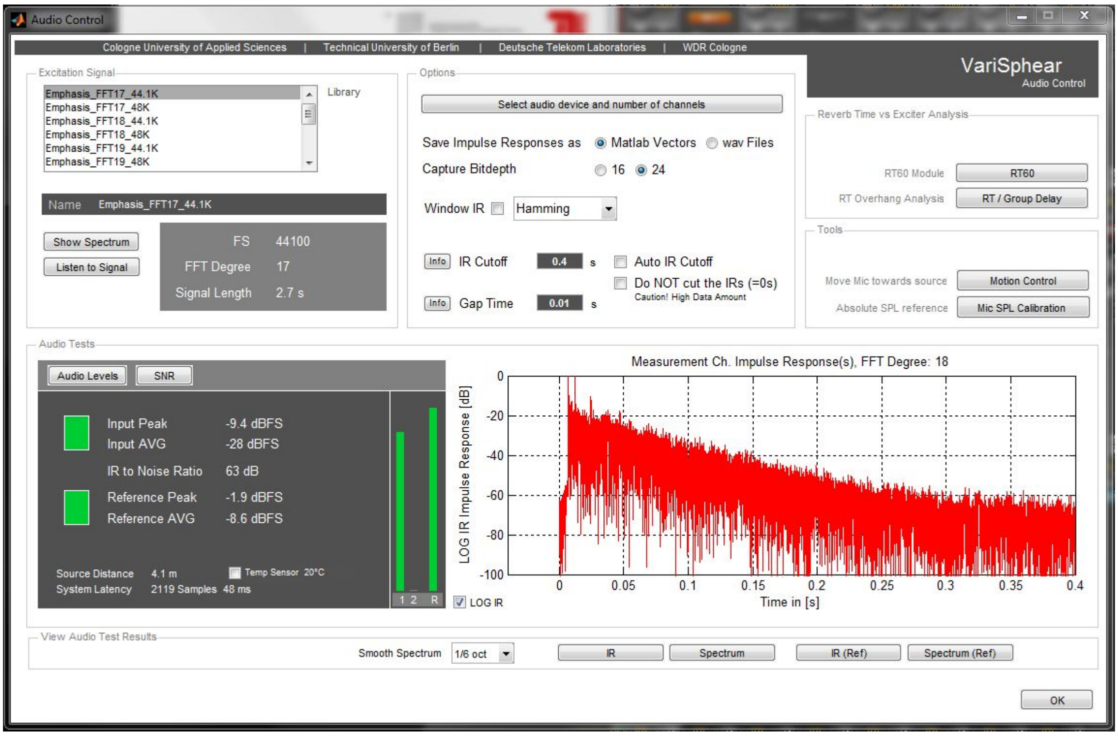

Figure 2.4: VariSphear Audio Control Section

First of all look to the upper section at the left hand side (Excitation Signal). The VSA system uses sine sweep signals for excitation. You find a library of useful and high quality sweep signals (Emphasis/Log) of different FFT degrees and for different sampling rates. The sampling rate for a measurement session is always locked to the selected excitation signal to avoid sample rate mismatches. So if you want to run e.g. a 96kHz session, just select any 96kHz exciter and all further processing is locked to this sampling rate. The signals from the library should cover most of the supposable measurement applications. You can load own exciters to the /EXCITERLIB folder or request custom exciters (contact benjamin.bernschuetz@fh-koeln.de).
There are buttons for listening to the signal or watching the spectrum in the excitation signal section. Additionally some basic information like signal name, FS, FFT Degree or

signal length are given.
At the lower left hand there are two basic audio test functions:

- **Audio Levels:** This function checks the audio levels and signal quality. If the levels are ok, the signal indicators for measurement channel and reference channel and the meters turn green. Adjust the levels and repeat this test until they do or until you think the levels are ok. The IR to Noise Ratio (INR) gives you a quality index. (You should move the array arm towards the exciter speaker during this measurement as this produces the highest SPL. Otherwise some samples could be clipped during the measurement process).

- **SNR:** A good input level does not always mean that everything is ok. Maybe the excitation signal coming out of your speaker does not produce enough SPL. In this case maybe you have good levels at your audio interface but bad measurement SNR. To avoid this problem do the SNR-Test. If the levels from the first test are ok but you have low SNR[2] at all Frequencies you should turn up the volume of your measurment speaker and reduce the gain of your mic preamp. If you do not get good SNR values (e.g. $>$ 50dB) your setup could be wrong or the distance of micarray and speaker is very large. Maybe you should use a more powerful speaker system.

In the upper middle section there are some project options. Select your audio device/driver here. You can use audio interfaces with ASIO driver or choose the Windows default audio playback/record device (only recomendet for testing the system!). For serious measurement application you have to use the ASIO driver. The VS audiocapture module needs a reference channel to compensate the total system latency from the analog outputs to the inputs. This way the offset of the resulting impulse responses directly coresponds to the runtime of the traveling wave from the sound source(s) to the microphones.

Important: If you use the Windows default driver take care to adjust the Sampling Rate and Bitdepth as used in the VS Measurement session. If you hear e.g. any presweeps or aliasing effects on listening to the excitation signal, your settings are wrong.

Click 'Audio Device/Driver' to set up the audio interface. For setting up the audio cabling read chapter 'Audio interface and cabling', 1.6 on page 17.

[2]Low SNR means e.g. around 30dB.

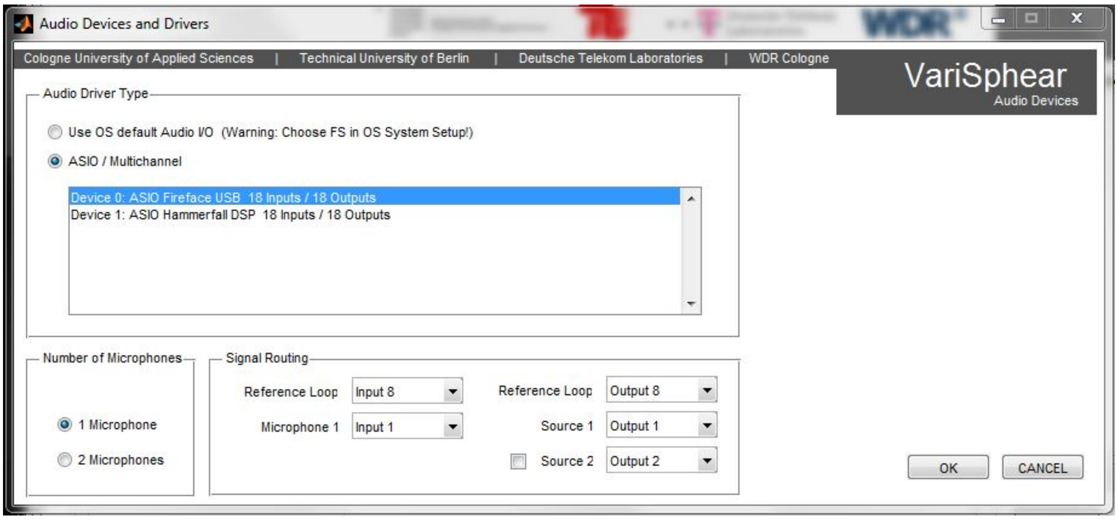

Figure 2.5: VariSphear audio interface, driver and routing

The impulse responses can be saved as WAV or MAT files. If you save the IRs as MAT files, autocapture appends the IR data to the information struct that is generated for each sample position. Otherwise you find WAV files[3] containing the IRs in the current project directory. If you do the post processing in MATLAB it is preferable using the MAT files option. Set the capture bitdepht to 16 or 24 bit. The ends of the output IRs can be windowed with a Hamming, Hann or Blackmann window. The window size is fitted automatically.

The IR Cutoff time defines the IR output length to be saved. As the internal audiocapture engine uses high resolution FFTs[4] the output IRs can result very long. This leads to lots of HD memory usage. Due to higher data amount the post processing needs more memory and CPU power. As most of the output IR data contains 'useless' headroom, you are able to cut the IRs off and to extract the significant periode only. This way you save lots of memory and processing power.

The IR Cutoff time can be acquired automatically during the audio levels test. The audiocapture engine calculates the overall -60dB decay time and adds a 25% of headroom. In most of the cases this leads to reasonable values for the gap time (RT Cutoff

[3]2 Files per sampling position if using two measurement channels. (No stereo sample)

[4]FFT Blocklenght = NextPowerOf2(2·Recordinglength)

time). Warning: This does hardly work in anechoic chambers. Observe the resulting IR: If you think that the automatically acquired value does not fit your requirements, set it manually. You should know that a value of **0s** means **NO CUTOFF!** Further you find the option to checkmark 'Do NOT cut IRs'. So all the returning IR data is saved to the HD. This option is definitely NOT recommended but if this meets your requirements do so.

In the upper right section you can start the RT60 module and do a RT vs. Group Delay test. Start the RT60 module first and do an 'Auto RT60' measurement. The array motors move to 6 different positions and take RT60 samples. Or you select the position radiobutton on the bottom menu and do manual RT60 measurement via 'One Position RT60'. Hit 'Average' and you see the RT60 Average for all checkmarked positions. (The RT60 data can be exported to MAT, RAW or XLS: The first row is the Frequency in Hz, Row 2-7 contain the RT60 data for positions 1-6 and row 8 is the averaged RT60 data). Finish with 'QUIT'.

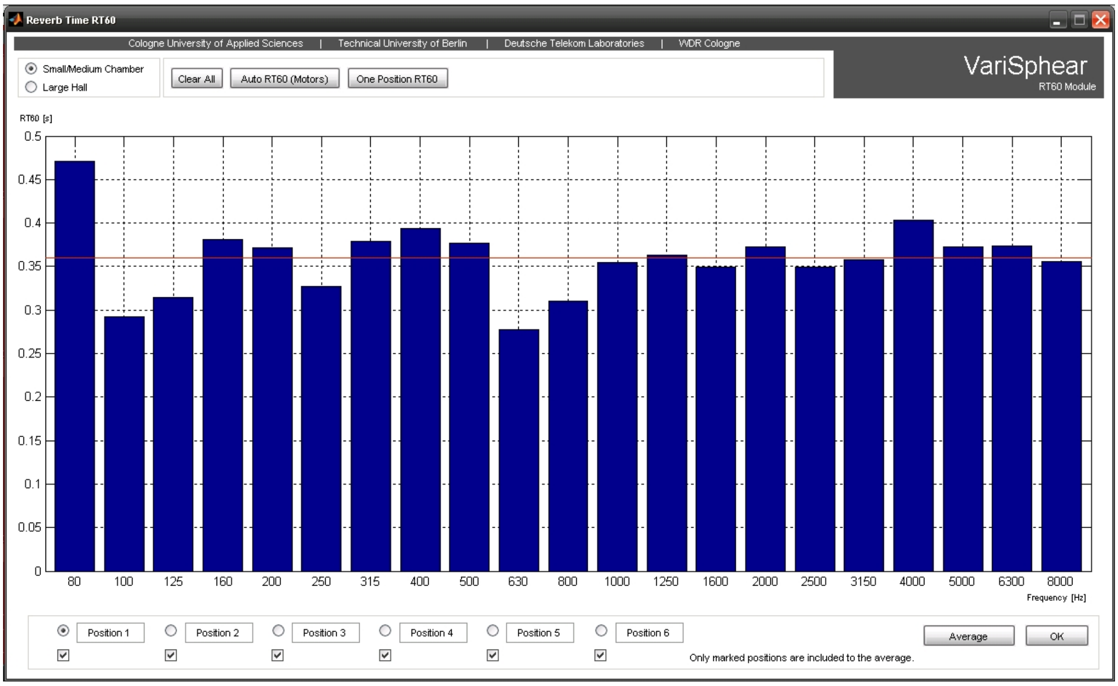

Figure 2.6: VariSphear RT60 Module

Once done this you are able to do a RT/GR analysis. This ensures that your record length during the audio measurement process is long enough and the reverb tail is not cut off. All green bars (negative, <0s) are good. If there appear any red ones (positiove, >=0s) or very short green ones, the value 'RT Overhang' is raised automatically. The record function goes on capturing for this time periode after playing the excitation signal to avoid cutting off the reverb slope of your room at higher frequencies. If you don't trust the RT vs GR result, set the RT overhang value manually as you like. This increases the measurement duration.

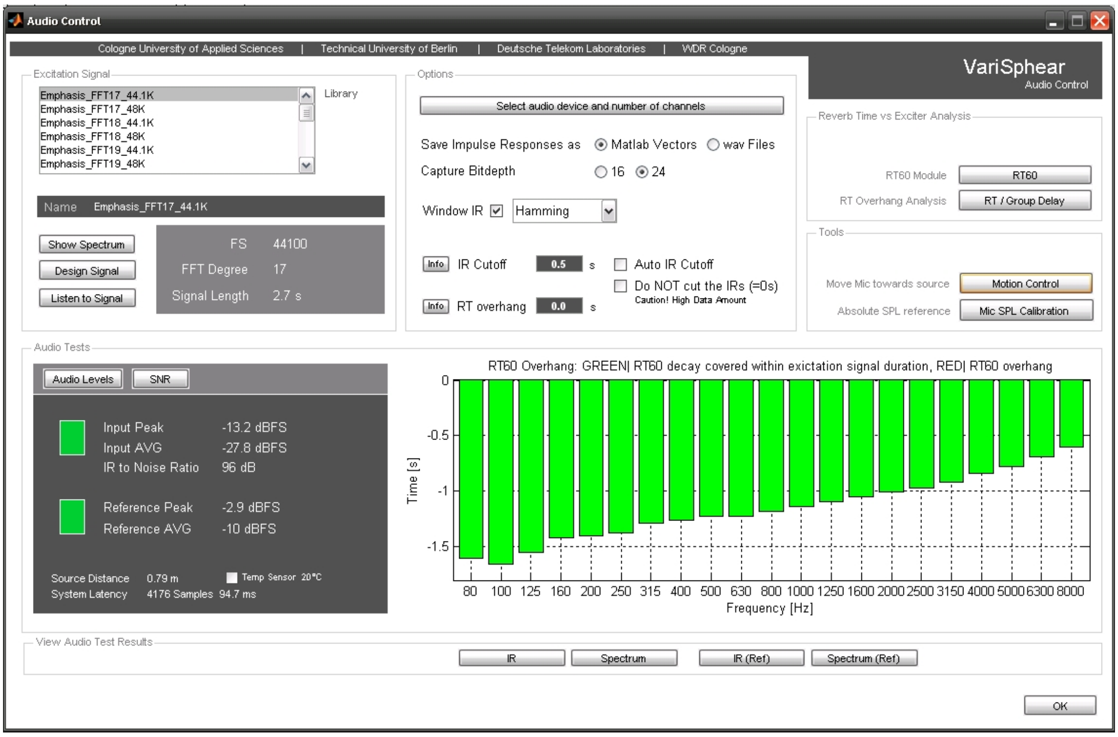

Figure 2.7: VariSphear Reverbtime/Group Delay (RT/GR) Analysis

2.4 Autocapture

The Autocapture Module does the automated IR measurement process including motion control, audio capture, error detection/correction etc.

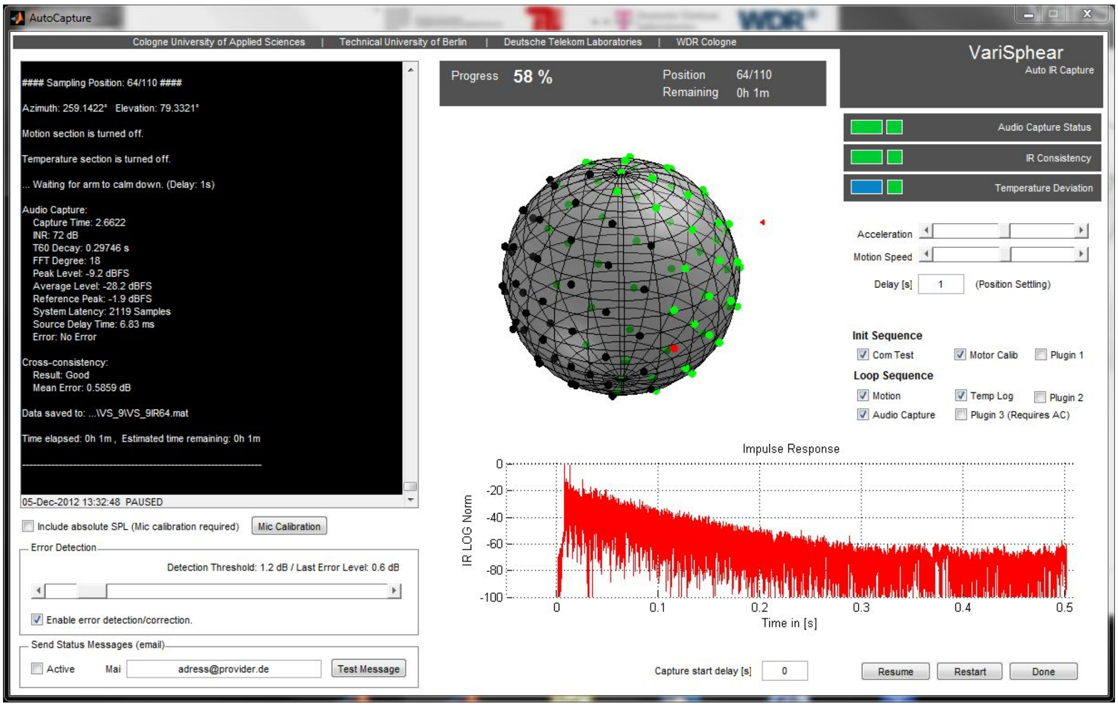

Figure 2.8: VariSphear Autocapture Module

At the left hand side there is the log-window. You find status messages and information during the automatic measurement process there. When shutting the project this log is written to a logfile in your session folder later on. In the middle section there is given some information on the session status like progress, remaining time etc. and you can watch the sampling positions in the globe plot. Black dots mean that the samples are still not acquired, green dots indicate that those positions are already done. The red dot indicates the actual sampling position.

Below you'll find a plot of the recently captured IR(s) and a Temperature plot. These plots toggle during the measurement process.

At the right hand side there is the control section. You can influence motion parameters (acceleration/speed) and set a delay (Motion settle time before starting audio capture).

Further you can enable or disable single blocks of the initialisation or loop sequences. At the bottom you find the 'machine control' buttons (go for it/pause/resume, cancel, restart, done). These buttons change, appear or disappear depending on the actual status. To start a measurement hit 'go for it'. Note: When hitting 'pause', the system is not directly going to stop. It finishes the current measurement position first to avoid inconsistent data. So be patient.

2.4.1 Error detection and correction

The Autocapture module brings up some error detection and correction to reduce the risk of (single) measurement errors. First of all the audio capture function itself reports errors e.g. in case the signal levels are poor etc. . Furthermore there is a consistency check function for the IRs. This function compares the current IR to the last one that was captured. It evaluates characteristic deviations in the noise floor. If the actual sample differs too much from the last one (called 'cross-consistency' here) there could be an error (e.g. if somebody enters the room, opens a door or if the mesaurement process itself fails etc.). The actual position is repeated in this case. If another error occurs, the Consistency Check changes to the 'auto-consistency' mode and compares two samples of the same position. It can be useful to compare two samples at the same spatial position ('auto-consistency/self-consistency') in these cases. Receiving an error the system does various retries until it moves to the next sampling position. If all of these retries fail, you get an error message for the current position but the system goes on to the next sampling position and will not stop working.

You can adjust the error threshold depending on the measurement environment. If the consistency check does produce many retries even if everything is ok, raise the thresholds. If it does not react even when you produce some noise (e.g. hand claps) the thresholds is set too high. There is a single sliders for the adjustment of the error detection threshold. If the error detection threshold is correctly adjusted, it is very likely that all of the recorded samples are quite good and you will not have any bad surprises evaluating the results later on. If you don't like the error detection/correction or it does not work good in your particular measurement situation, turn it off.

There are 3 error detection stages containing 6 indicator lights at the right hand side. These are:

- Audio Capture Status
- IR Consistency
- Temperature Deviation

The Audio Capture Status reports errors from the audio capture module itself (e.g. poor levels etc.), the IR Consistency has been explained above and the Temperature Deviation stage indicates strong and sudden changes of the air temperature (e.g. produced by airconditioners etc.) that may have influenced the measurement (Speed of sound). Additionally at the end of your measurement session you get the maximum temperature deviation during the Autcapture session. It's up to you to decide whether this deviation is critical or not.

The indicator lights work as follows: If an error occurs at the actual measurement position, the bigger left light turns red temporarily. It turns green again at the next positions or if the error is resolved automatically. If one of these lights turns red, the error correction always tries to solve the problem automatically. If the error correction does not resolve the problem successfully, the smaller red light at the right hand side turns red and stay red for the rest of the session. So if you leave the system alone during a measurement process, the small lights indicate any unresolved problems. If all the small indicators are green at the end of a session everything should be fine. If not, read the logfile and you find a problem description. The system later remembers bad samples and by using the 'Sample Browser' these positions can be repeated manually.

The last section is the Sequence control section. It is devided into Init Sequence and Loop Sequence. This section lets you enable or disable single steps of the Autocapture session (e.g. for testing).

2.4.2 Status Messages (email)

If your computer is connected to the internet, the VSA System is able to emit status messages via email. It reports the remain time every 20% as well as serious errors that require your personal attention immediately. Of course you also get a message on finishing

the session. If you own a mobile device that allows receiving emails you can go to have dinner or some drinks during a long-term measurement session :) Enjoy!
The function is quite easy to set up: Enter your email-adress[5] and send a test message. If this works just checkmark 'Active' in the Status Message field.

2.5 Revision/Sample Browser

The Sample Browser enables you to have a deeper look into the acquired measurement data. Additionally you can repeat single samples that failed during the autocapture process or samples that appear suspicious.

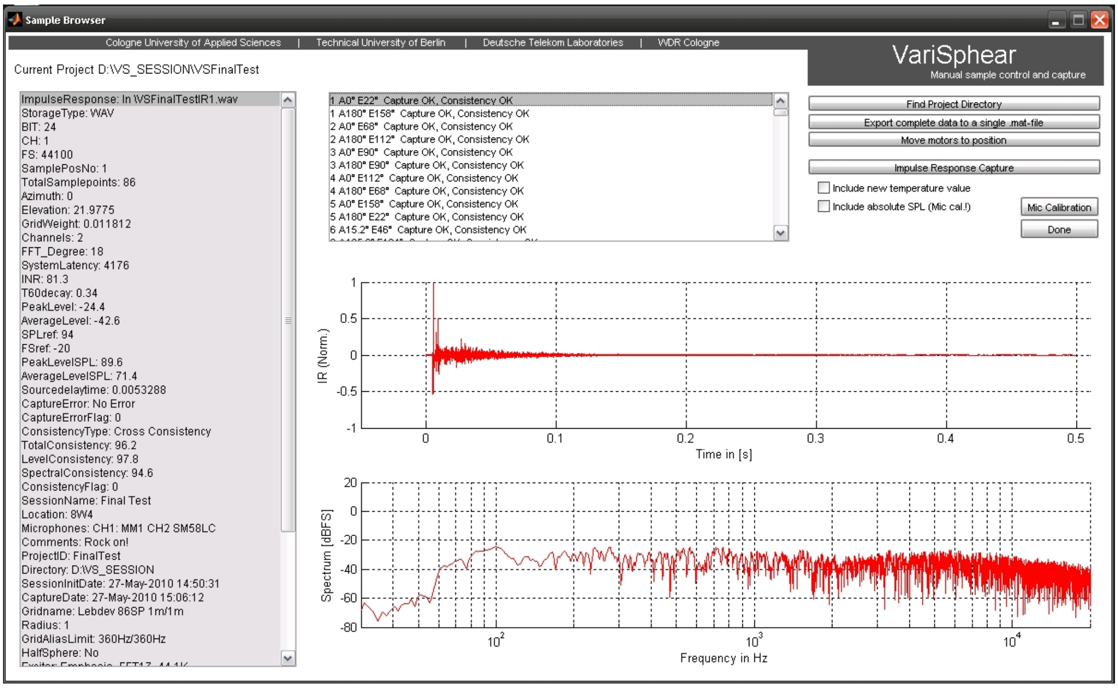

Figure 2.9: VariSphear Sample Browser

Entering the Sample Browser you are directly located in the current project folder. Hit 'Find Project Directory' to edit other projects. In the upper middle section there is a list of the single samples. If a sample contains errors, a warning is indicated. Click on a sample to view all details. At the left hand side you find the meta data of the selected

[5]For privacy reasons this email-adress ist not stored. You have to fill it in every time you start the autocapture module.

sample point. In the middle section the IR and the corresponding spectrum are shown. Hit 'Move Motors to position' and the VSA moves to the corresponding coordinates. Clicking 'Impulse Response Capture' lets you repeat the audio capture at this position (e.g. if any error was indicated). The original files are backuped in this case (\SAV*.*). If you prefer to have one complete data file instead of single files you can export all IRs and meta information hitting 'Export complete data to a single .mat file'.

2.6 Center Channel Capture

The Center Channel Capture (Located in the Main GUI, Tools/Settings) can be used to acquire a matched array center impulse response. A microphone must be manually placed at the physical array center. No motor motion is done. Then the number of repetitions (averaging) and the predelay are adjusted. The audiosettings follow the main global audio settings. The center IRs are then time aligned and matched to the array data. A new directory inside the project path is created where the center impulse responses are stored.

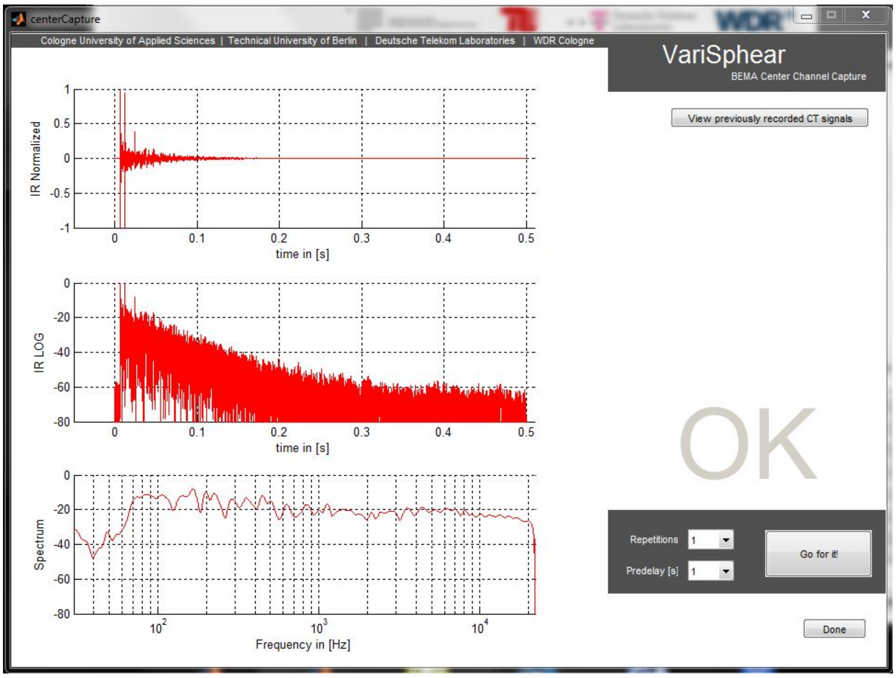

Figure 2.10: VariSphear Center Channel Capture

2.7 The Project is done

When you have finished your measurement session you must shut the project - hit 'Shut Project' in the main window. When you shut a project be sure you really have finished your work completely: The **session is locked** and you do not have access to change the project anymore. This is a write protection for your own safety. On shutting the project the logfile and a folder \SESSION_DATA is created. This folder contains all information to restore your measurement session if necessary[6]. The logfile is stored as a string to a .mat file and is dropped to the folder \LOGFILE.

[6]This has to be done manually, copy the content of the \SESSION_DATA folder to \VariSphear\SESSION_DATA. Try to avoid this operation and do this only in case of emergency.

3 realCAD geometrix

realCAD geometrix is an extension module for comfortable acquisition of room geometry. rCg includes basic CAD functions and requires the VSA laser sensor[1]. Please refer to chapter 1.7 on page 19 for setting up the laser sensor.

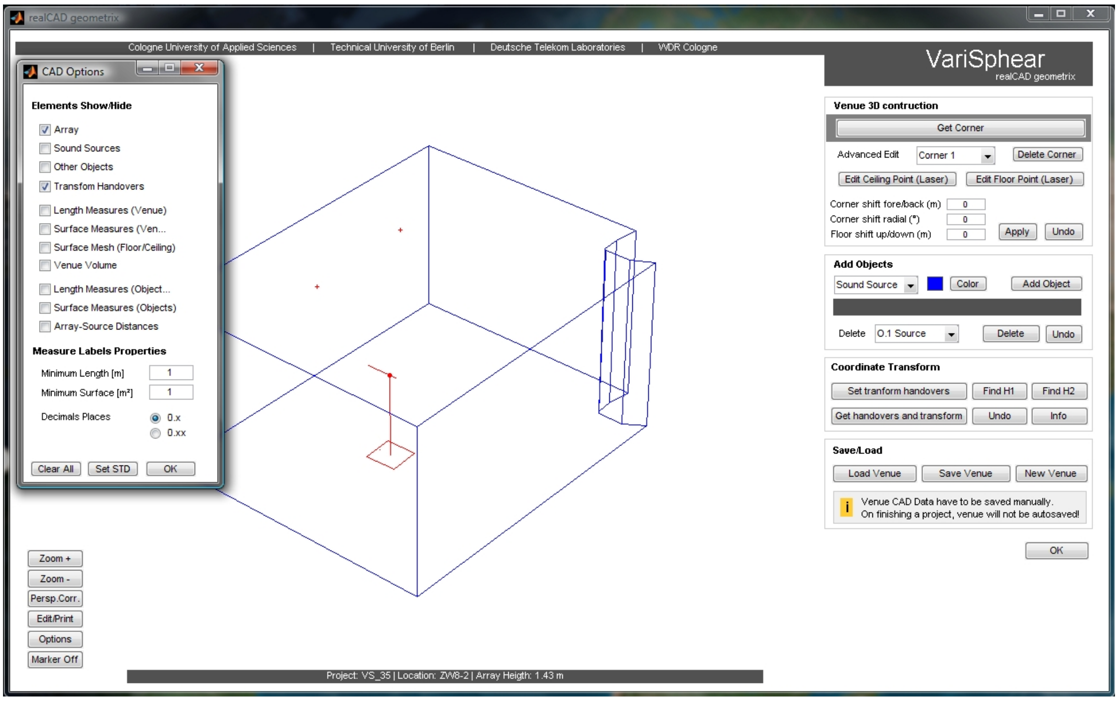

Figure 3.1: VariSphear realCAD geometrix

At the right hand side there is the construction section. The first block is for the basic room geometry acquisition. The next block lets you insert objects like sound sources or basic objects (Point/Line/Tri/Quad). The third block contains the coordinate transform section. This enables you to move the array to another position in the venue without

[1]TOPCON EM-30 or Jenoptik LEM-30

repeating all geomtric measurement. In the last block you can create a new project, load previous projects or save the current project.

3.1 Starting a rCg project

The VSA with laser sensor extension has to be mounted, powered and the laser sensor must be set to PC MODE before you start. Click 'New Venue'. The VSA elevation section starts to move and locate a point close to the base unit on the floor. Make sure there is a laser reflective floor surface at this position - if not, place a white sheet on the floor to enable the laser to triangulate the array heigth. If the operation finishes you see nothing more than the array itself on the construction screen. The array arm in the drawing always points to the 0 degree direction. You additionally find a small marker on the groundplane that indicates the 0 degree direction. Now we are ready to do the basic room geometry acquisition.

3.2 Acquisition of room geometry

Aquiring the room geometry is easy. You just have to locate all ceiling corners of the venue sequentially. Hit 'Get Corner' and the motion control opens up:

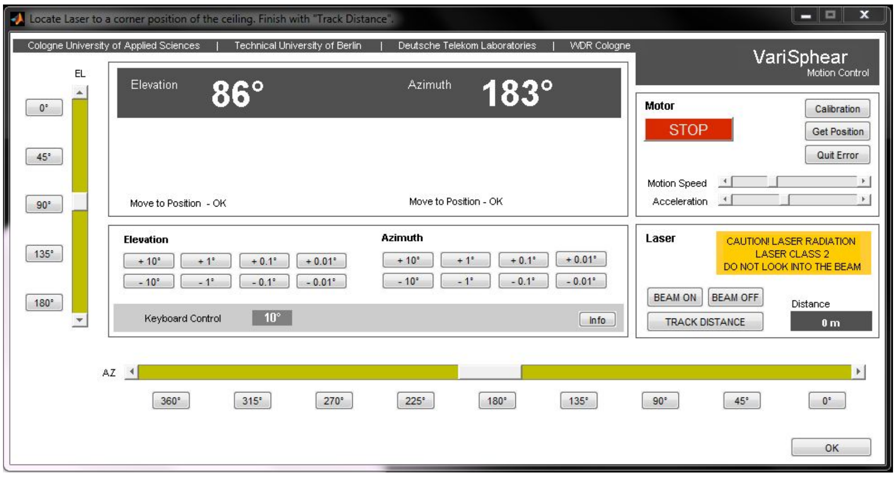

Figure 3.2: VariSphear rCg coordinate acquisition

The window frame information line of the motion control surface always states the current operation. Turn on the laser ('BEAM ON') and move the VSA arm towards a ceiling corner using the sliders, the differential position buttons, the absolute position buttons or activate the keyboard control and use the computer keyboard for motion control. When you located the ceiling corner finish with 'Track Distance'.

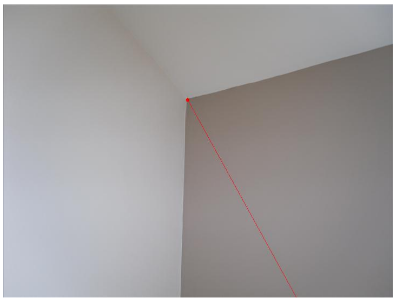

Figure 3.3: Locating a ceiling corner with the laser unit

The rGc geomtry engine calculates the corresponding floor corner coordinates supposing a plane floor in the whole venue and the array directly located on top. This works well for most of the basic cases. If you have more complex room geomteries you can later edit single points to adapt them to the real situation. After locating the first corner, you can observe this corner in the construction section.

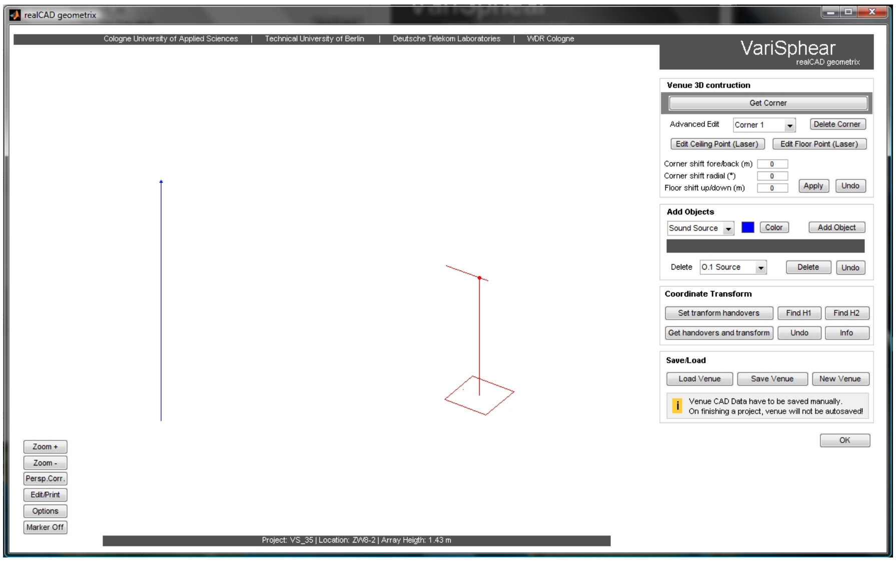

Figure 3.4: VariSphear rCg: First Room Corner

The first corner is always marked with a littel triangle on the upper side to ensure keeping an orientation during a 3D image rotation. Now repeat this process for the other room corners and the virtual venue takes shape in just a few minutes.

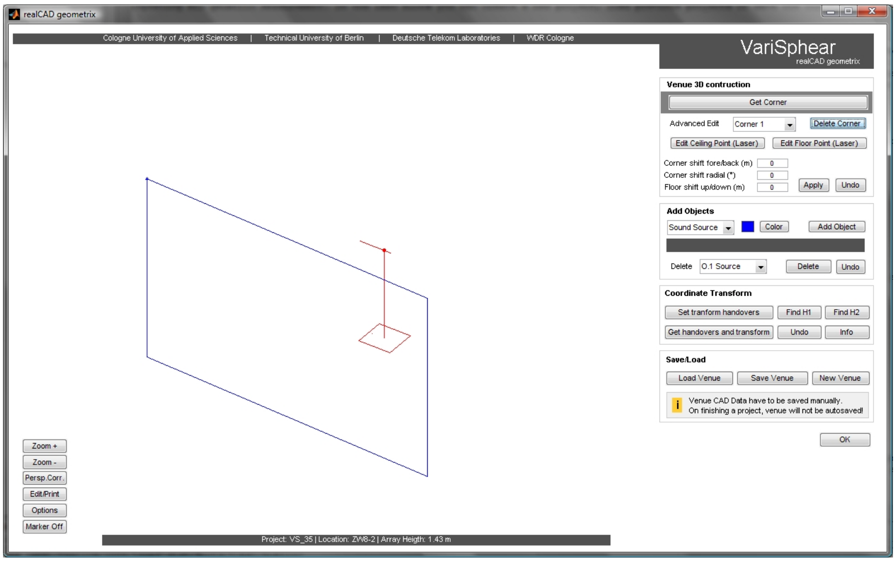

Figure 3.5: VariSphear rCg: Second Room Corner

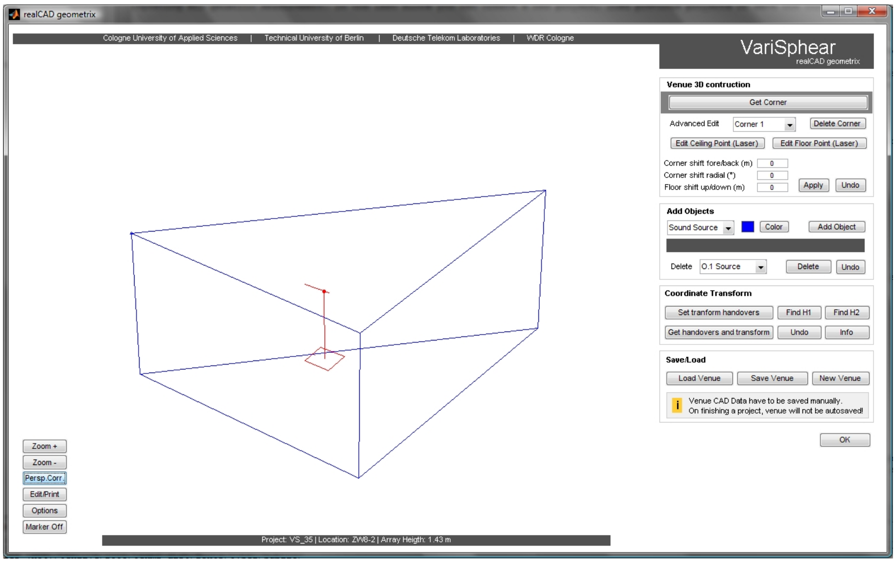

Figure 3.6: VariSphear rCg: Third Room Corner

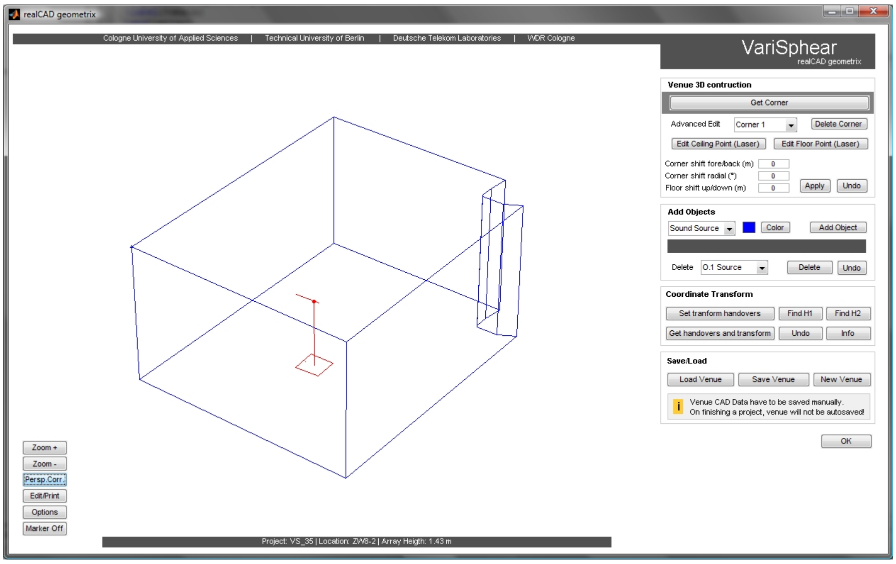

Figure 3.7: VariSphear rCg: More Room Corners...

The corners can be edited an deleted in the 'advaced edit' section. Select a corner and it is marked in the drawing. Now you have some options:

- Delete the entire corner
- Acquire new coordinates for the ceiling corner (laser based)
- Acquire new coordinates for the floor corner (laser based)
- Fore/Back shift of the entire corner
- Radial shift of the entire corner
- Shifting the floor corner up and down (z-axis)

With all of these options you should be able to adapt even complex rooms.

3.2.1 Construction Drawing and CAD Options

At the left bottom side there are located some buttons to incfluence the construction drawing. Zoom IN/OUT, Perspective Correction, Edit/Print, Options and Markers off.

- The perspective correction processes the image for a more realistic 3D view. Lines or Objects that are far away are drawn shorter/smaller. This corresponds to the real live visual peception. You can switch both views, the perspective corrected one for presentation purposes (nicer), the uncorrected view for construction. The uncorrected view is preferable for construction as parallel lines are drawn of the same size and you get a much better overview if everything is placed right.

- The Edit/Print option hands the drawing over to the matlab native graphics editor and you can add text or anything you like or print the drawing.

- The Markers Off button unmarks marked corners or objects.

- The options button opens up a new menu:

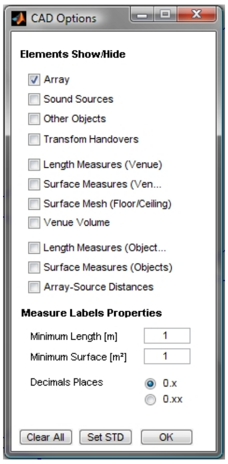

Figure 3.8: VariSphear rCg: CAD Options Menu

'Elements Show/Hide' enables you to make visible or unvisible the listed elements. The 'Measure Labels' Properties are to set minimum length and surface sizes that is plottet if length/surface measures is marked. This function helps you not to keep the drawing clear and not to overload it with labels. 'Decimal Places' lets you select the number of decimal places of the labels.

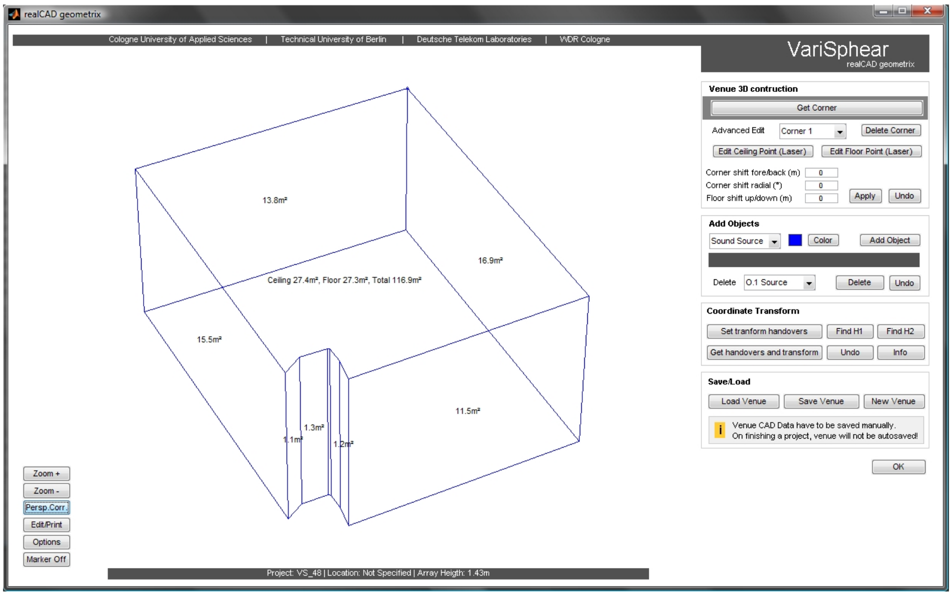

Figure 3.9: VariSphear rCg Example: Length Measures are shown

3.3 Add Sources and Objects

You can add sound sources and objects (Point/Line/Tri/Quad) to your drawing. Select the type (Pull down menu) and choose a color. Sources are shown as fat markers, points as smaller ones. The coordinates of the objects can acquired in the same way as the room corners. Hit 'Add Object', locate the laser on the target object and hit 'Track Distance'. Line, Tri and Quad require 2, 3 and 4 coordinates that have to be acquired sequentially.

3.4 Coordinate Transform

The coordinate transform enables you to move the array to arbitrary position inside the measurement venue without repeating the acquisition of room geometry and objects again. The coordinate transform engine needs two handover points (H1, H2). To do a coordinate transform proceed as follows:

1. Hit 'Set transform handovers' (The array has still to be placed at the **original** location).

2. The Motion Control opens up. Locate the laser on a room surface[2] (e.g. a wall). Hit 'Track Distance'. The array acquires the first handover (H1) coordinate, then moves to H1+30DEG (azim) and get H2. Now the handovers are set. If you selected 'Show Handovers' in the CAD options they are marked as two little red crosses in the drawing.

3. Hit 'Find H1'. The VSA laser points to the first handover. Place an exact marker to the H1 position on the surface. Press 'OK' to turn the laser beam off.

4. Hit 'Find H2'. The VSA laser points to the second handover. Place an exact marker to the H2 position on the surface. Press 'OK' to turn the laser beam off.

5. SAVE the actual venue for the first position! (Otherwise it is being lost after the transform).

6. Now you can move the array to another position, change the measurement height etc.

7. Press 'Get handovers and transform'.

8. The Motion Control opens up and you have to locate H1. Hit 'Track Distance'.

9. The Motion Control opens up again and you have to locate H2. Hit 'Track Distance'.

10. VSA triangulates the new array heigth.

11. The transformation engine now calculates all modified coordinates and the VSA is placed at the new position in the drawing.

12. Save the new venue choosing a different name.

3.5 Save/Open Venues

The rCa module works independently from the Autocapture module. If you shut a project in the main window, the venue CAD data is NOT saved automatically. You must save the venue CAD data manually, otherwise it gets lost. If you hit 'Save venue', you are located in your current project directory and the module creates a new folder called

[2]Be sure you can reach H1 and H2 (azim+30DEG) to paste markers and be sure you can locate H1 and H2 from your next array position!

\CAD_DATA. You should save your venues there to be sure having all data related to the current project in the same directory.
To load any venue file just click 'Load venue' and select the venue file. The venue files are stored in MAT format and contain venue and object vectors/coordinates.

4 Polar Data Acquisition

The VSA basement can be used as automated turntable for polar data acquisition. To acquire polar data you can use the native VSA Polar Capture module or the Monkey Forest Bridge[1].

4.1 VS Polar Capture

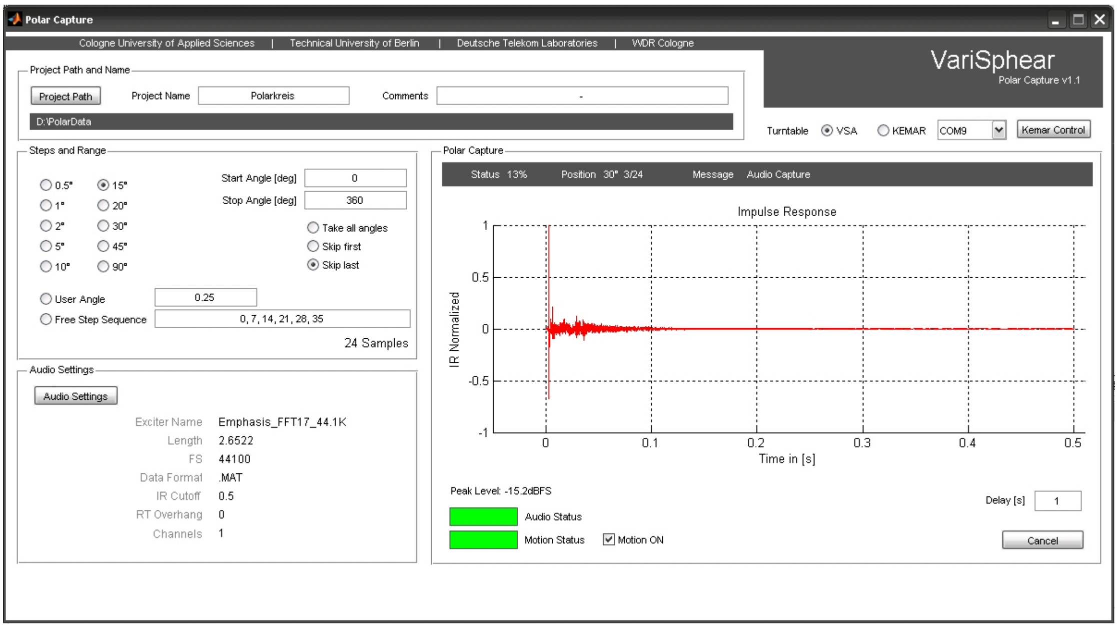

Figure 4.1: VariSphear Polar Capture v1.1

First of all choose the motion device: Select VSA if you use the basement as a turntable. If you use the modified KEMAR head (Deutsche Telekom Laboratories and University

[1] Monkey Forest Audio Measurement System (Four Audio, Germany) required.

of Rostock modified KEMAR Heads) choose the KEMAR option and select the corresponding COM-Port!
Set the project path and enter a project name. (PolarCapture creates a new directory for polar data within the project path.) It's time to select the step resolution and range. You have three options:

1. Use step angles from the predefined standard library (0.5DEG to 90DEG),
2. Enter your own step angle or
3. Define a free step sequence (delimiter: ',' or space).

Next define the range. Remember that the VSA basement motor is intentionally limited to angles from $0-360°$[2] by the software. Anyway you can enter any range you like as the motion section applies a modulo 360 operation on the requested angles. Hence crossing $> 360°$ the motors drive the other way around to the corresponding angles $< 360°$. You can take all angles or ignore either the first or the last angle. This way you can e.g. choose a range from $0 - 360°$ without having a double $0° = 360°$ value.
The audio setting calls the standard waveCapture audio-settings module. For more information return to section 2.3 on page 23. The IRs can be saved as .MAT vectors (recommended if you do the post-processing in Matlab) or (stereo) .WAV files.
As a matter of course the audiocapture process automatically waits for the motors to reach the desired angle. But if your mounted test item still oscillates for a while after the motion has stopped, you can add an additional delay to wait for the item to settle down before the audiocapture process starts (Default: 1s).
To start the session hit 'Go for it'.

[2] This is different for the modified KEMAR Head (T-Labs): The motion range is defined from $-180°$ to $+180°$.

4.2 VS Polar Viewer

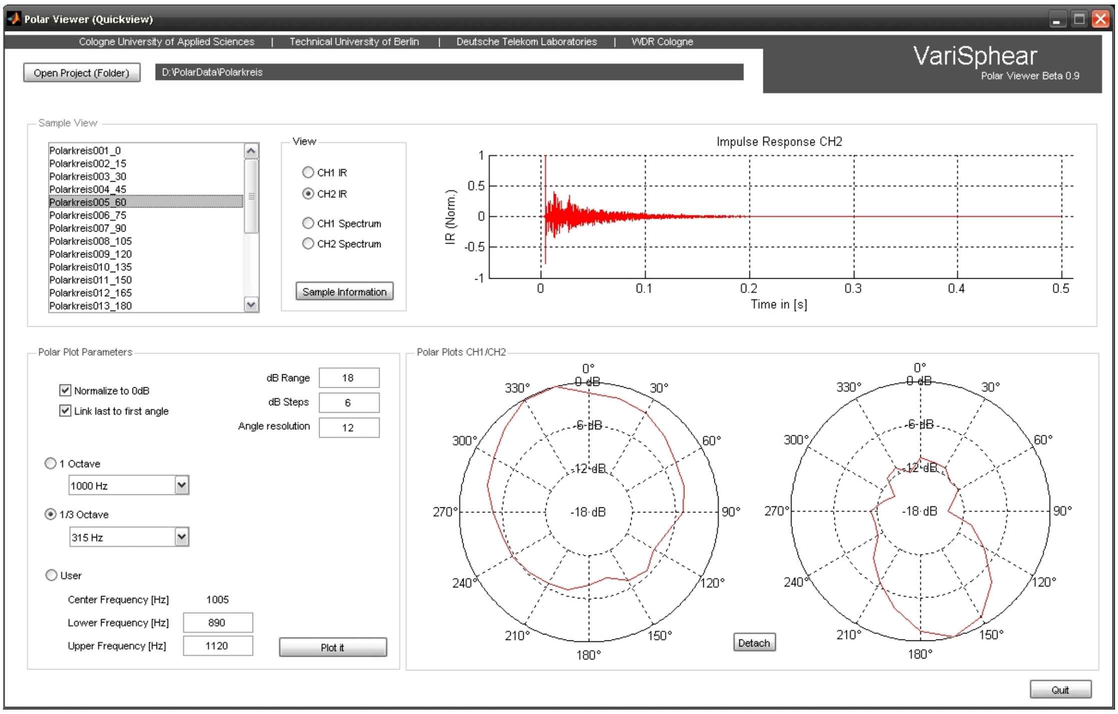

Figure 4.2: VariSphear Polar Capture v1.1

The Polar Viewer enables to watch or control the results of a polar acquisition session. Just open the desired project folder and you have access to single samples of the polar set in the upper section. Click on a sample in the listbox and you can observe the impulse responses or spectra. The lower section draws a polar plot. There are standard octave or 1/3 octave filters available to observe the directional behaviour of a sound source or microphone for a specific frequency band. You can also choose your own frequency range. The polar plots can be normalized to 0dB. The first and last angle can be auto-connected if necessary. Further you can adjust the dB range, the dB steps and the angle resolution of the polar plots. The 'detach' button lets you edit the figures[3]. (Advice: The polar plots can deliver strange results if you ran a session with a wild free step sequence as the plot function does not interprete free angle sequences on it's own.)

[3]The Polar Viewer is still in beta and improvements, in particular for the graphic presentation of the polar plots, will come up in a further version.

4.3 VSA - Monkey Forrest Bridge

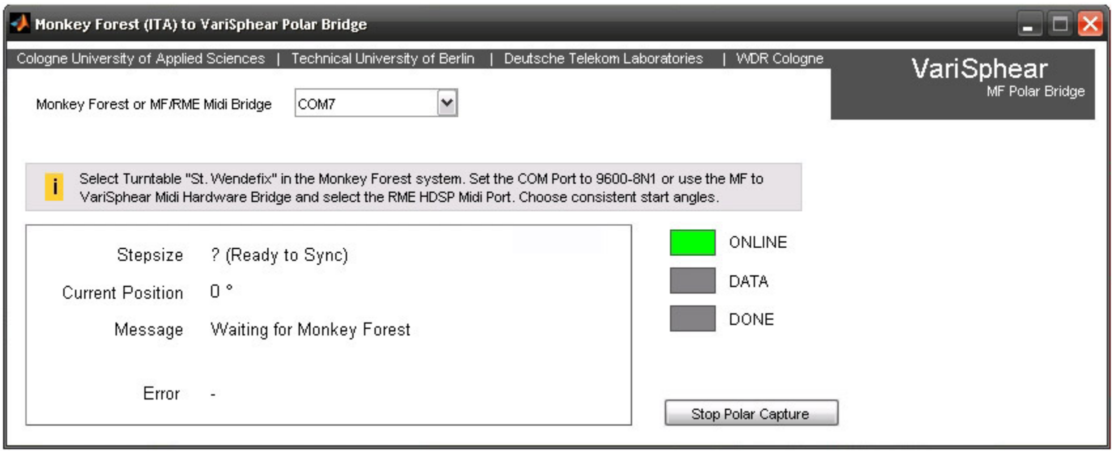

Figure 4.3: VariSphear Polar Capture v1.1

Connect the serial port of your MF computer to a serial port of the VSA computer. If your MF computer does not have any serial port, you additionally need the MF-VSA hardware bridge[4]. Select the ’St. Wendefix’ turntable in MF. Use a 9600-8-N-1 serial connection in MF. Choose the corresponding serial port in the bridge. Use a crossed serial cable (0-Modem). Initialize the Polar Session in MF. Assign the polar start angle from MF to the Bridge - this is important, because MF and VSA does an incremental angle sync only. Hit ’Go online’ in the MF-VSA Hardware Bridge. The array basement drives to the chosen polar start angle and wait for MF to sync. When you start the polar session in MF, the Bridge automatically syncs the VSA to the stepsize etc. If you have questions how to configure MF to work with the VSA please contact us.

[4] The harware bridge receives pseudo midi signals from the RME interface and distributes these signals to the VSA Computer (USB) and to the Robo-Frontend (ITA/Four Audio). For more information contact us.

5 Service

5.1 Internal Configuration of the PR070 Motor-Modules

The motors Schunk PR070 (Former AMTEC ROBOTICS) have to be configured before first operation. We have already done this for you before delivering the VSA units! But if anything does not work or you have to repeat this configuration: Use the software 'Schunk MTS'. Start the software, choose the desired COM-Port to open (depending on Azimuth or Elevation Motor)[1] and scan the bus for modules.
The following screenshots show you the correct settings for Azimuth and Elevation Motors. To enable the access to all parameters you have to change from 'user' to 'profi'-mode. Do this in Module>Change User. Enter the password 'Schunk' (case sensitive). Now you have access to all parameters. Be careful on changing settings, put **exactly** the parameters given in the graphics. Otherwise it is possible to lock yourself out and loose all communication to the motor! Surely this is not your intention.

[1]The Motors can also be driven with different IDs using the same RS232 port but we spent an own port for each EL/AZ motor to avoid bus conflicts. Therefore both modules use ID11 (default).

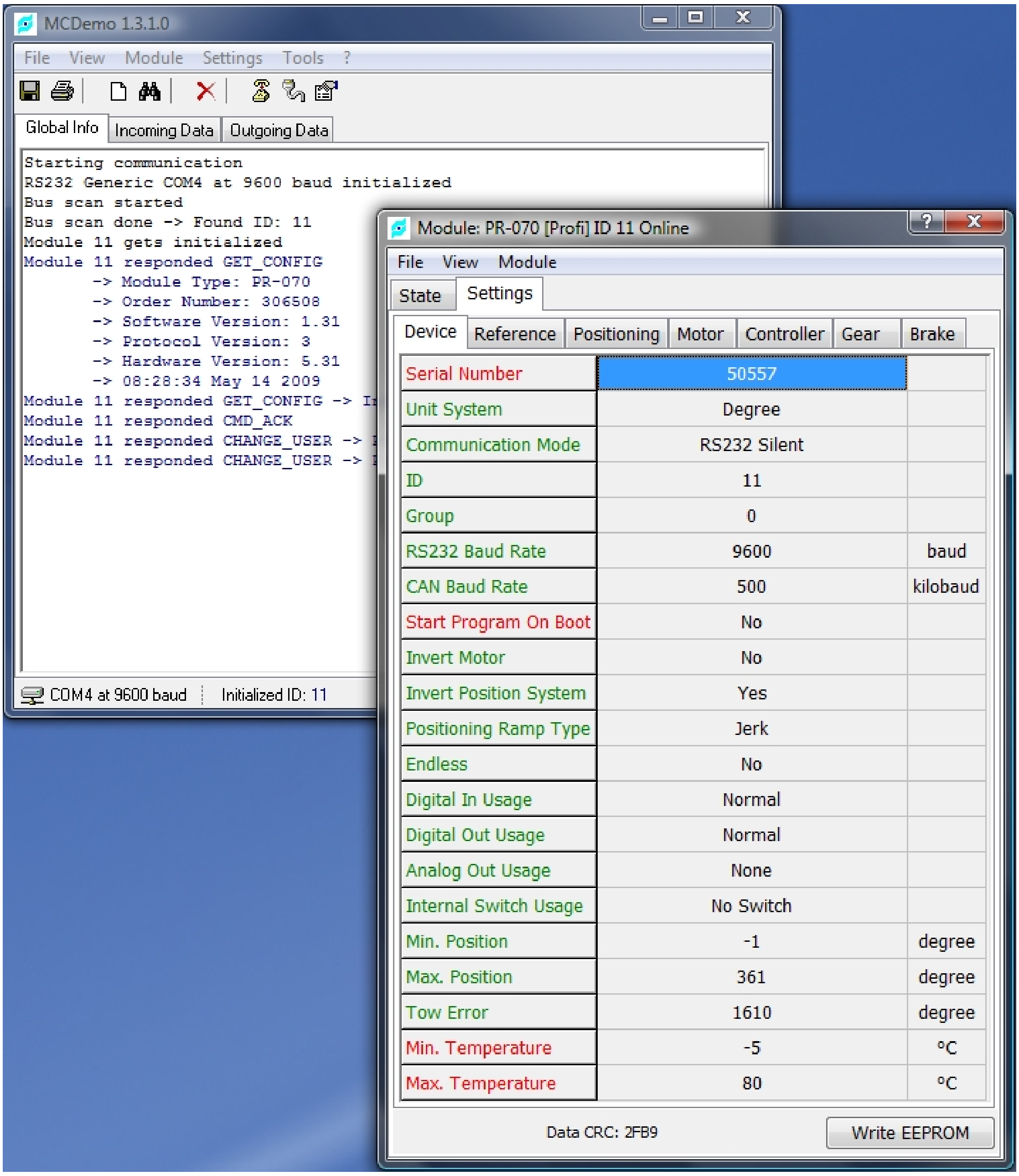

Figure 5.1: VariSphear AZIMUTH Motor Configuration in Profi-Mode

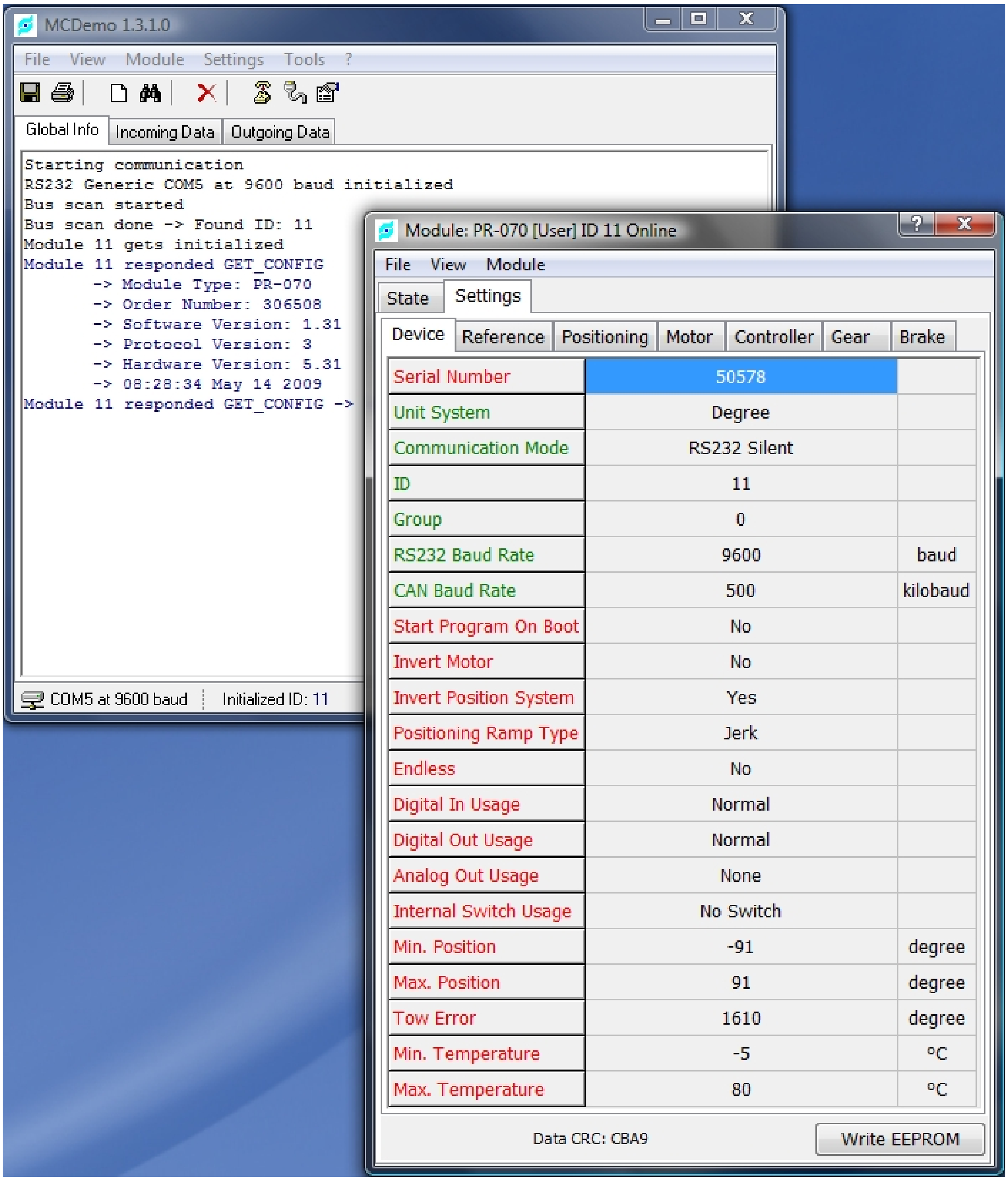

Figure 5.2: VariSphear ELEVATION Motor Configuration still in User-Mode

5.2 16-Pin Harting configuration

- PIN 1: PSU +24V
- PIN 2: PSU GND
- PIN 3: Temp Sens GND
- PIN 4: Temp Sens Data
- PIN 5: Temp Sens +5V
- PIN 6: Laser TX
- PIN 7: Laser RX
- PIN 8: Laser GND
- PIN 9: EL-Motor TX
- PIN 10: EL-Motor RX
- PIN 11: EL-Motor GND
- PIN 12: Audio 1 Hot(+)
- PIN 13: Audio 1 Cold(-)
- PIN 14: Audio GND
- PIN 15: Audio 2 Hot (+)
- PIN 16: Audio 2 Cold (-)

5.3 5-Pin Head Audio Connector

- PIN 1: Audio GND
- PIN 2: Audio 1 Hot(+)
- PIN 3: Audio 1 Cold(-)
- PIN 4: Audio 2 Hot (+)
- PIN 5: Audio 2 Cold (-)

5.4 4-Pin PSU Connector

- PIN 1: GND
- PIN 2: +24V
- PIN 3: n.c.
- PIN 4: n.c

6 Troubleshoot

This is a short troubleshoot guide. It contains the solutions to problems that could be observed during the development of the hard- and software. If you do not find a solution to your problem here, do not hesitate to contact us. If you experience any new problem and have a brilliant solution please let us know.

6.1 General Software Problems/Advices

Please remember: This is a non-commercial software tool. We did our best BUT not all possible scenarios are tested - not all errors are catched and treated. Please report any error you experience using waveCapture. Even if some error occurs don't loose your trust in that software. The core processes are well tested and accurately implemented. In Matlab you work far away from the machine and many of the possible problems or slow response issues are caused by the Matlab environment itself. It creates a considerable overhead.

6.1.1 The software crashes

The software crashes (or goes blind for a good while) when you try to communicate to any hardware device (motors, laser, temp sensor) while the NPort5410 is not connected, not powered or is set up wrong. Matlab talks to the NPort driver, but the driver cannot locate the ports. Try to avoid that.

- Connect, power up and if necessary adjust the settings of the NPort 5410 and its driver.

6.1.2 No access to the COM ports or no return messages

- Ethernet cable/wireless connection ok?

- Reconfigure the server. Delete the old COM ports and renew the ports. (Moxa NPort Driver) The COM ports have to be listed in your hardware manager as serial ports! In most of the cases this can solve your problem. Restart your computer if necessary.

6.1.3 Very slow reaction of the motion section and/or sensors

This delay can be up to 10 seconds.

- Are the network settings of the NPort5410 ok? Remember: Your computer and the server have to be subscribed to the SAME subnet. Otherwise there is no error but the ports react very slowly.
- Reconfigure the server. Delete the old COM ports and renew the ports. (Moxa NPort Driver) The COM ports have to be listed in your hardware manager as serial ports! In most of the cases this can solve your problem. Restart your computer if necessary.

6.1.4 Motors answer: "Move to position: ok" but they do NOT move

- This happens when the motors go to a saftey state due to an internal error. Go to the Motion GUI and hit "Quit Error". Now everything is rock'n'roll again.

6.2 Audio

6.2.1 Aliasing or presweep effects

This is a sample rate problem.

- If you use the Windows default audio device, you must set up the sample rate manually in the audio driver menu or in your OS! (Generally: Don't use this for serious applications, always use the ASIO driver!)
- If you are using the ASIO driver: Restart Matlab or if necessary restart your system. This should be solved.

6.2.2 There is ripple when doing a loop measurement

Apparently this is an ASIO driver communication problem that happens very rarely (using a RME HDSP inteface).

- Go to the hardware configuration and switch the buffer to another value.
- Do NOT use an audio buffer size of 8192 Samples. This can cause trouble sometimes. Choose anything in between 512 and 4096 Samples.
- Restart the system

6.2.3 There is more than one pulse in the IR view doing a loop measurement

Using a RME HDSP inteface with ASIO driver. (Maybe that also happens with other gear) Of course the spectrum looks awfully...

- Do NOT use an audio buffer size of 8192 Samples. This can cause trouble. Choose anything in between 512 and 4096 Samples and everything is rock'n'roll again.

7 Writing applications for the VSA

7.1 Plugins and User-Applications

Unfortunately the user-plugins and user application interfaces had to be dropped due to technical reasons (Matlab Compiler / MCR) since version R13-0109. Please use the VSA Device Drivers to implement own software.

7.2 VSA Device Drivers

The additional package 'VSADeviceDrivers' enables to control the motion section and to use the sensors of the VariSphear system within a Matlab script. The package contains the following files:

vs_motion.m (Motion control)
vs_temp.m (Temperature sensor)
vs_laser.m (Laser distance sensor)

Type "help vs_xxx.m" in Matlab to obtain documentation on these routines. The other files coming with package are used internally. Please do not edit or use them.

Download VSA Device Drivers:
→ **http://www.audiogroup.web.fh-koeln.de**

8 The End

This was an overview of the most important functions of the VariSphear hard- and software. You will explore more functions using the software. Try out.

If you find any bugs please report them. Please be appreciative of possible software bugs. As this is a non-comercial software tool, not all possible errors are catched and handled. If you have any ideas to improve the hard- or software please let us know.

We hope you enjoy using the VariSphear system!
For any support request, bug report, suggestion for improvement or more information contact:

Benny Bernschütz, benjamin.bernschuetz@fh-koeln.de, +49 221 8275-2496 or
Prof. Dr.-Ing. C. Pörschmann, christoph.poerschmann@fh-koeln.de, +49 221 8275-2495

For software updates and further information visit:
→ **http://www.audiogroup.web.fh-koeln.de**

Document: Software/Manual R13-0109 - Revision 1.1, 09th of January 2013