I. Contents

II. Calibrating the sensors with Cs5cal

A. Mounting the Circal

Fig.1: The Circal disc

Fig.2: After mounting

Fig.3: Note the notch

Get the Circal disc and put it into the hole of the Circal. Then screw it on by turning the white wheel of the Circal disc. Note the notch (Fig.3) which determines the mounting position.

Please do not fix the Circal too tightly. Just a notch beyond smooth turning of the Circal will suffice.

B. Mounting the sensors

Fig.4: The first magazine, front view …

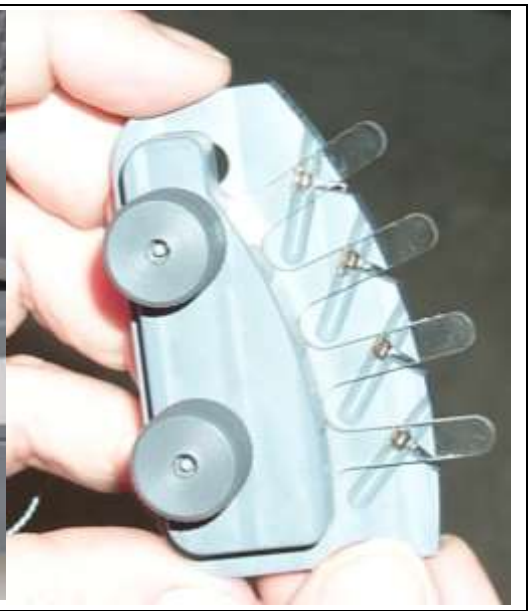


Fig.5: … top view

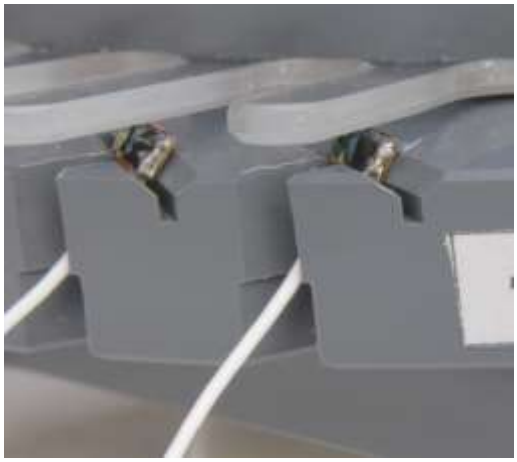


Fig.6: Close-up on the sensors

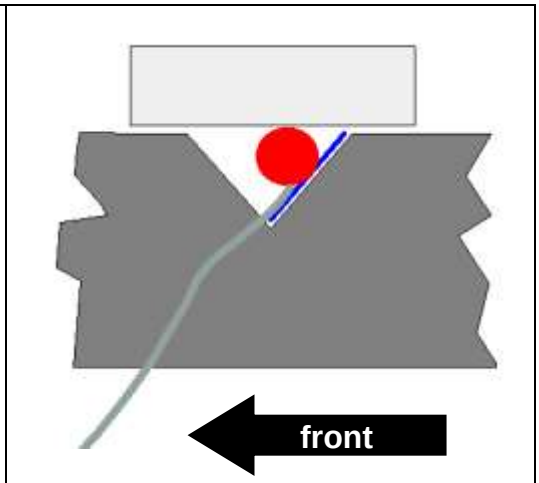


Fig.7: Alignment of the sensors

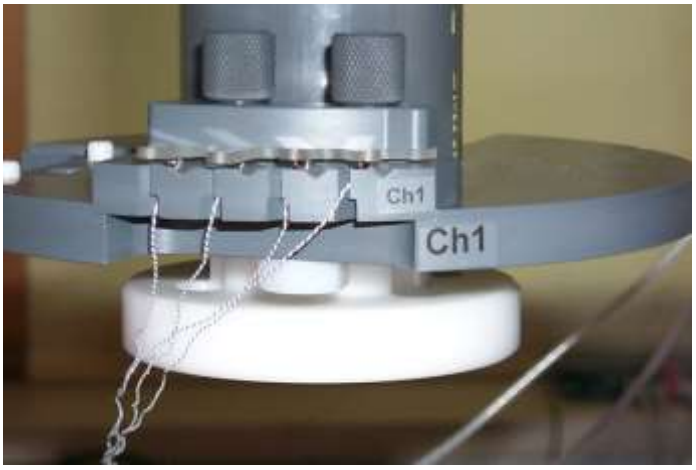
Loosen the two screws of the magazine and put in the sensors as shown in Fig.4 to Fig.7.

The first magazine holds sensor 1 to sensor 4, counted from right to left. The second magazine holds sensors 5 to 8, and the third magazine holds sensors 9 to 12.

Make sure that the location of each sensor corresponds to the channel it is connected to!

Tighten the screws of the magazine until the sensors stay steady in place without shaking. Do not put too much pressure on the sensors.

Fig.8:
Put the magazines in the corresponding gaps ….



C. Insert the sensor plugs

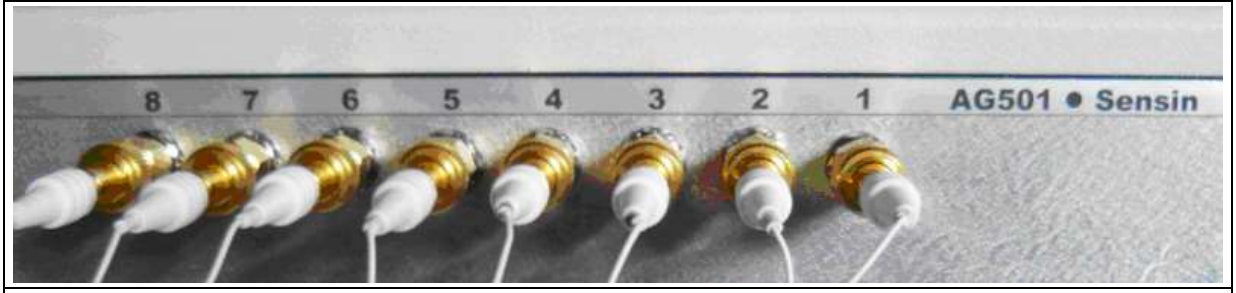


Fig.9: Connect the sensors

D. Starting cs5cal

1. Enter the name of the calibration set

You will be asked for the name of the calibration set. A folder with this name will be created (`/data/calibration/`). This folder becomes the calibration set. It will also contain a file with this name and the extension ".calset".

Enter a unique name. According to the common rules for file names, it must not contain any special characters.

Thus, `*#&$~\[]()` `` `<>|,.^"`. and spaces are not allowed.

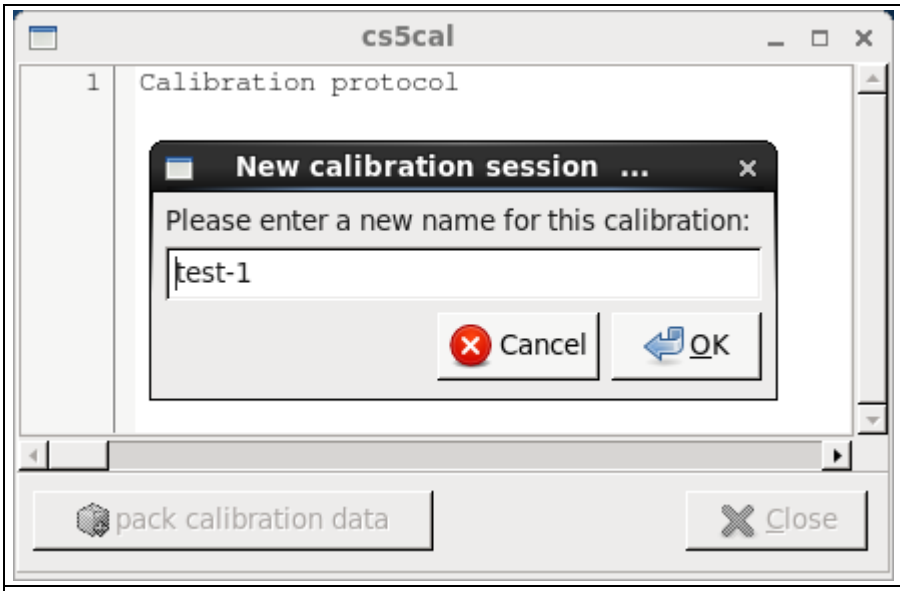


Fig.10: Enter the name for the calibration set

2. Location of the calibration data

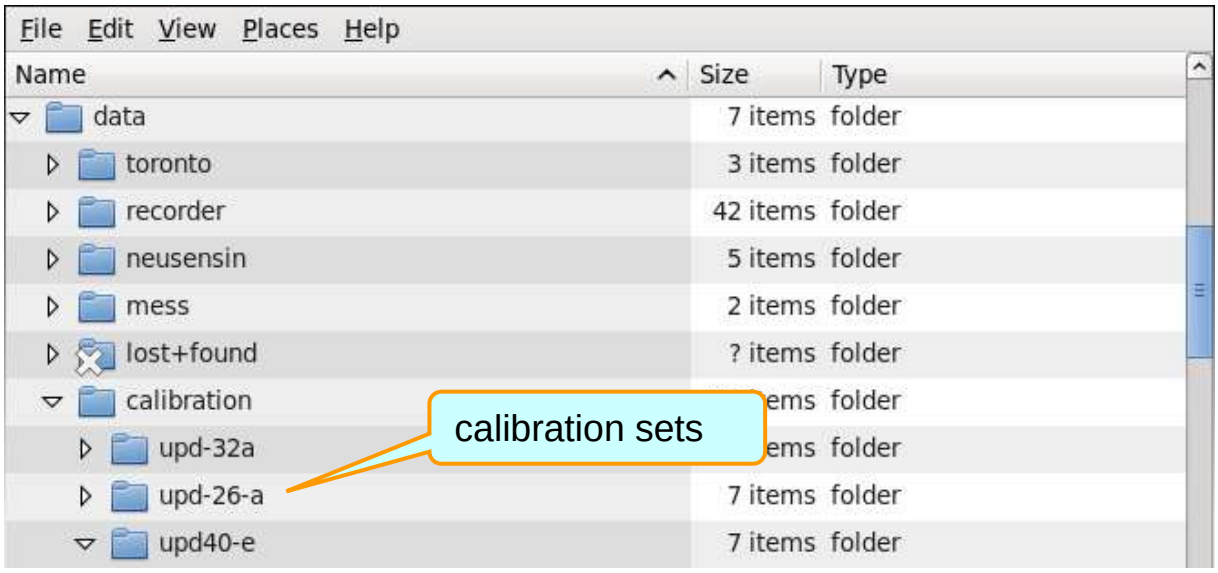


Fig.11: The calibration folders

The complete data from each calibration is stored in one subfolder of the "calibration" folder.

Fig.12: contents of a calibration set

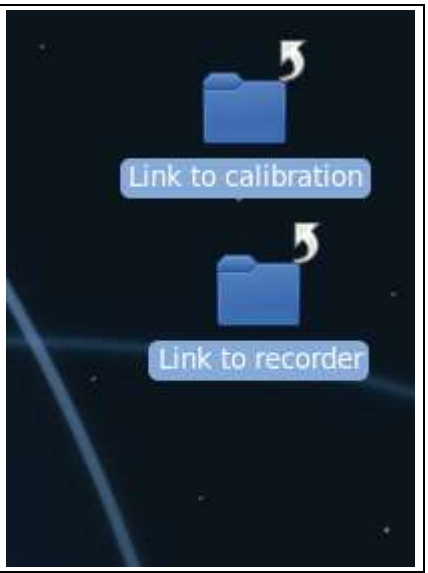


Fig.13: links on desktop

Additionally there is a subfolder TMP *.tmp that holds intermediate results.

3. Select the sensors to calibrate and start the calibration

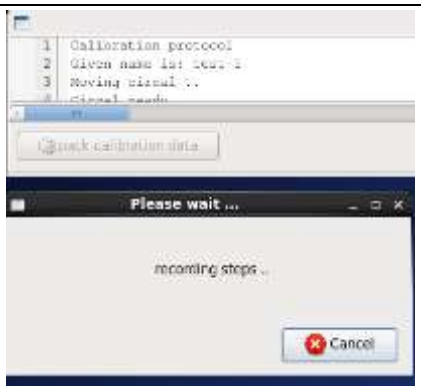
Fig.14: Select the magazines that contain sensors for calibration and check if all sensors are in their right position

Please note: As the calibration program calculates the relation between the four sensors in a magazine, it is recommended to completely fill the magazine – so it is proposed to calibrate 4, 8, 12 or 16 sensors (6, 12, 18 or 24 sensors for 24 channel systems respectively) – in each case four (or six) sensors in one magazine. Please make sure that the sensors are placed in the right order. Then click ‘OK’ to start the data recording.

4. Wait until the data recording is done

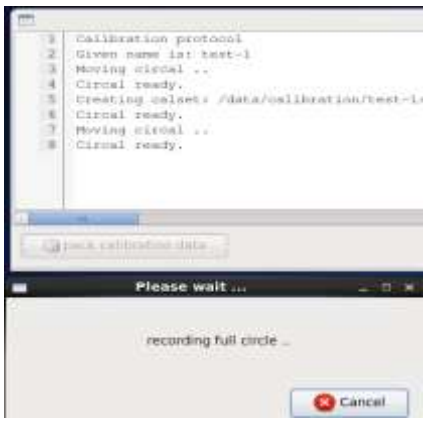
The calibration may take up to 20 minutes! The user is informed about its end by an info window.

Step 1



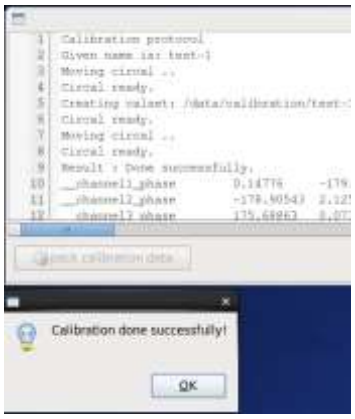
Step 2

Step 3



Step 4

Step 5



Wait until this window appears

5. Calibration has finished

In case of defective or missing sensors in a calibration, the concluding dialog informs about how many sensors were calibrated successfully, and for which sensors and why calibration failed (Fig. 15).

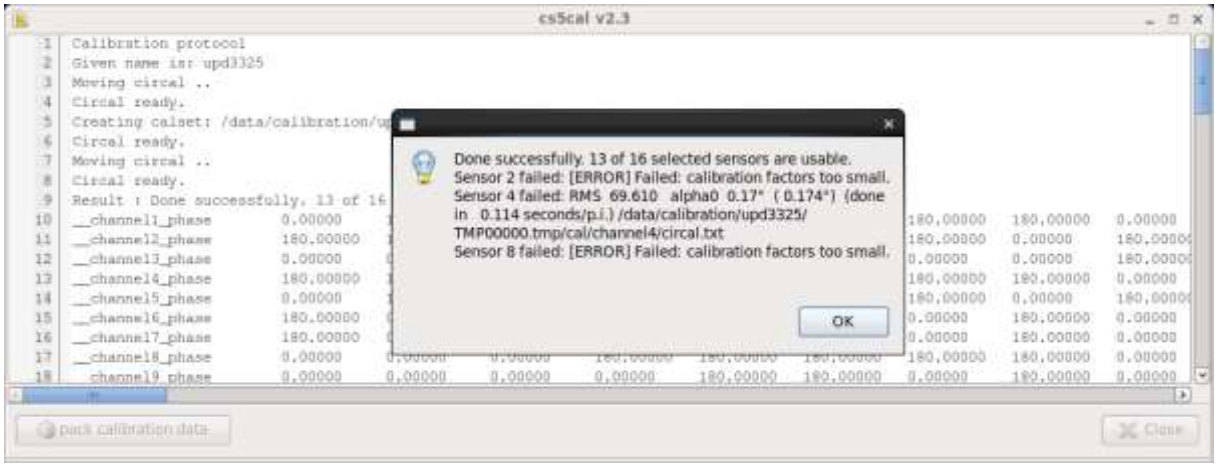


Fig.15: If applicable, the concluding dialog informs about defective or missing sensors

After closing the dialog you can find an overview of the calibration results in the cs5cal-window. Information on defective sensors is attached at the bottom of the calibration results (Fig. 16). The information is stored in the calibration protocol (see *Check the calibration result* II.D.7).

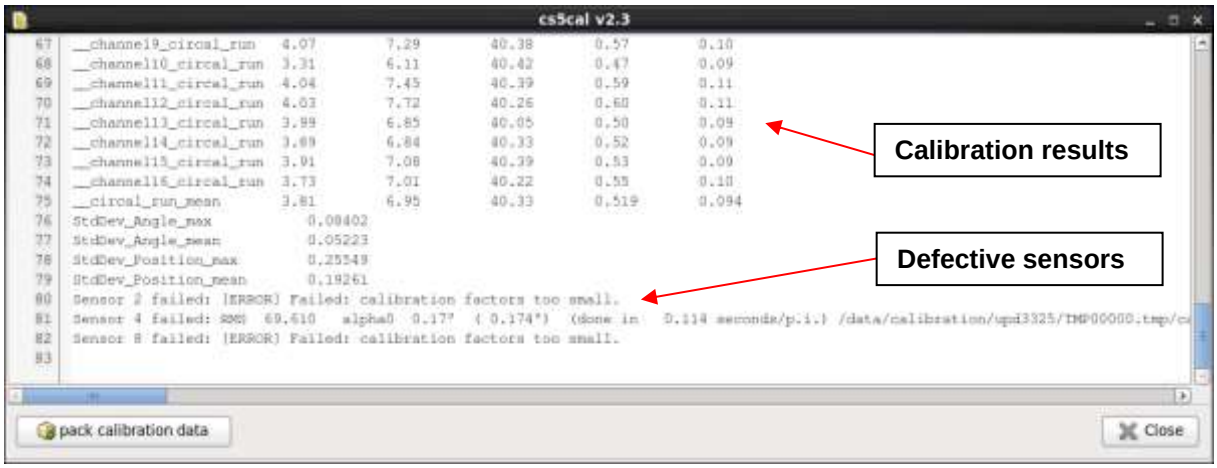


Fig.16: Calibration protocol with results and information on defective sensors

6. Pack the calibration data

If you want to send the calibration information for analysis purposes, please click the "pack calibration data" button (Fig. 17). Otherwise, click close and the calibration is finished.

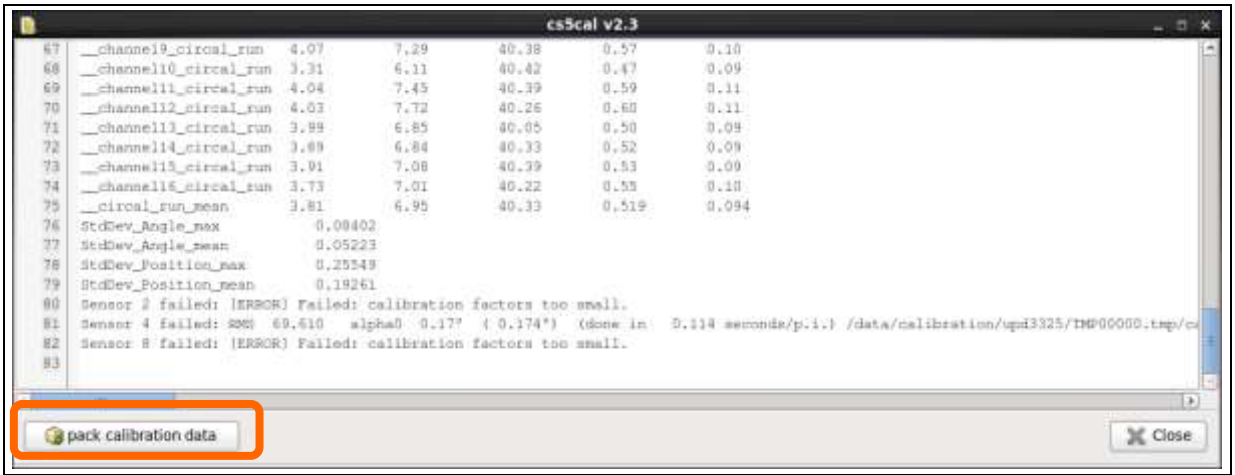


Fig. 17: Create an archive file (*.tbz) if desired...

The "pack calibration data" button will create an archive file (*.tbz) in the /data/calibration folder. The name of this archive is the same as the name of the calibration set with the extension *.tbz.

7. Check the calibration result

The important information that is needed in order to review the calibration results is in the calibration protocol file (*.txt) inside the calibration set sub folder.

a) An Example calibration protocol file:

To get a better overview, the data of channels 2 to 15 is omitted.

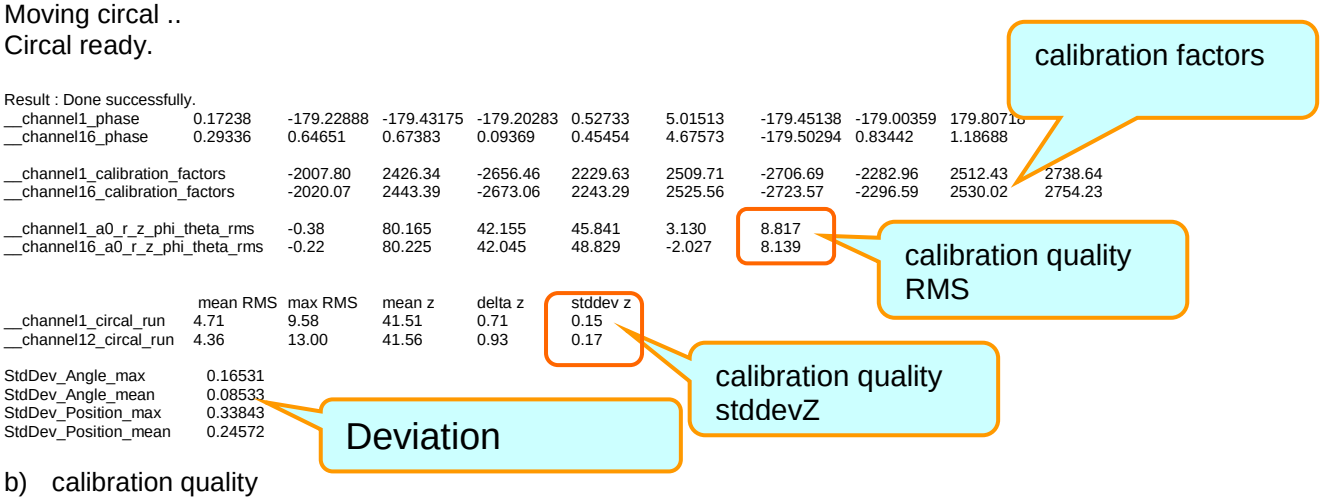
Calibration protocol
Given name is: test-1
Moving circal ..
Circal ready.
Creating calset: /data/calibration/test-1.calset
Circal ready.
Moving circal ..
Circal ready.

Result : Done successfully.

__channel1_phase	0.17238	-179.22888	-179.43175	-179.20283	0.52733	5.01513	-179.45138	-179.00359	179.80718
__channel16_phase	0.29336	0.64651	0.67383	0.09369	0.45454	4.67573	-179.50294	0.83442	1.18688
__channel1_calibration_factors		-2007.80	2426.34	-2656.46	2229.63	2509.71	-2706.69	-2282.96	2512.43	2738.64
__channel16_calibration_factors		-2020.07	2443.39	-2673.06	2243.29	2525.56	-2723.57	-2296.59	2530.02	2754.23
__channel1_a0_r_z_phi_theta_rms		-0.38	80.165	42.155	45.841	3.130	8.817			
__channel16_a0_r_z_phi_theta_rms		-0.22	80.225	42.045	48.829	-2.027	8.139			

	mean RMS	max RMS	mean z	delta z	stddev z
__channel1_circal_run	4.71	9.58	41.51	0.71	0.15
__channel12_circal_run	4.36	13.00	41.56	0.93	0.17

StdDev_Angle_max	0.16531
StdDev_Angle_mean	0.08533
StdDev_Position_max	0.33843
StdDev_Position_mean	0.24572



b) calibration quality

The line for each channel shows the parameters a0, r, z, phi, theta, and rms arranged from left to right.

a0 = alpha0 - the deviation from the expected zero position for this sensor on the Circal disk

r = the Radius described by this sensor during a Circal revolution (=80mm)

z = the averaged z – coordinate from this sensor during a Circal revolution

phi = the angle between the sensor's axis and a line to the circal's centre (=45°).

theta= the angle between the sensor's axis and the xy plane (elevation = 0°).

The value for a0 should be less than ±0.5°. If it is not, please check the "Circal Logic Zero position" in the "setup_circal.pdf" document.

The r, z, phi, and theta values depend on the Circal parameter. The parameters have a fix ideal value that can vary depending on the positioning of the sensor inside the magazine.

c) Circal run

The "delta z" shows the peak to peak deviation of the z-coordinates from each channel – during the Circal run. This is one criterion for the calibration quality (the smaller the better). In an ideal error free system, the delta z would be 0. The stddev Z should be less than 0.25 mm. The Circal run is stored in the following directory: /data/calibration/test-1/TMP00000.tmp/tests/rawpos/0001.pos. You will be able to display this data with Cs5view

d) Deviation summary

There are four lines showing the maximum and mean deviation in the Circal run and all extra recordings

The first line shows the maximum deviation that occurred between any two sensor axes.

The second line shows the mean of all measured changes of angle differences.

The third line shows the maximum deviation that occurred in the Euclidian distance between any two sensors.

The fourth line shows the mean of all measured changes of the Euclidian distance differences.

To get a more detailed analysis of the above differences, please find the file in the following directory: /data/calibration/test-1/TMP00000.tmp/tests/rawpos/distmatrix.txt.

E. Trouble shooting

While moving the initial circle of the calibration the software checks for low amplitudes and errors in the sensor sequence. The calibration process is halted if errors are detected.

1. Low amplitudes

Low amplitudes indicate broken sensors or a bad sensor connection. Please check sensors and sensor connections. If the error persists even after sensor replacement, the affected channels have to be tested for hardware errors.

2. Sequence error

During the initial circle the software checks the sequence of maximum amplitudes measured for all sensors. An error in the sensor sequence can have different causes.

1. Check if the sensors are accidentally swapped as indicated by the message (for example sensor 9 is connected to channel 10 and vice versa).
2. Check if the affected sensors are mounted correctly in the magazines (see Fig. 4-7). The maximum amplitude of a badly mounted sensor can deviate from the expected position.
3. Also broken sensors can lead to a sequence error.

3. Bad Calibration factors

In case of bad calibration factors or error messages

- check if the magazines are well placed
- check if the sensors are well placed
- check if there is no defective sensor in use

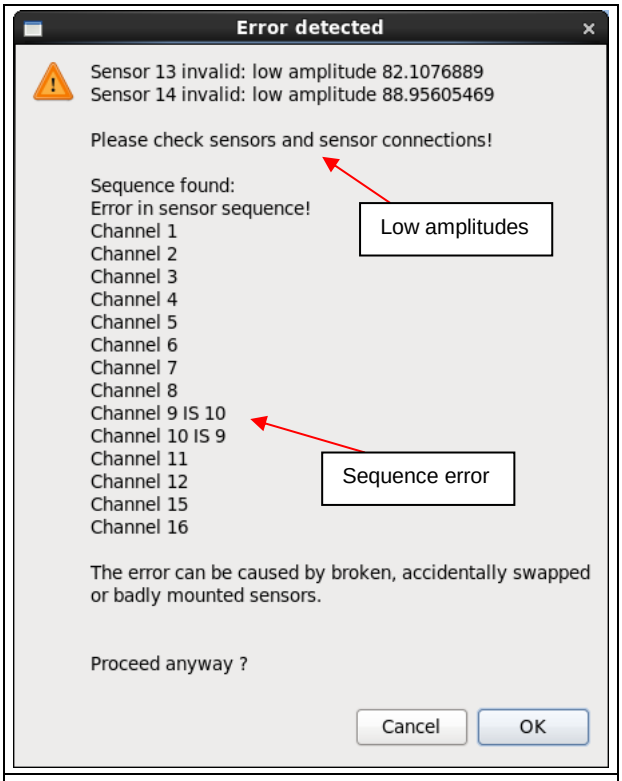


Fig. 18: Error messages during calibration

III. Revision history - cs5cal Sensor Calibration

Date	Revision	Annotation
June 11th, 2012	1	Initial Carstens Release
November 7th, 2012	2	
February 7th, 2013	3	Grammar & spelling, readability
February 25th, 2014	4	Identification of defective sensors without invalidating calibration
October 22nd, 2015	5	Updated trouble shooting