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Measurement Manual for OBACHT

Lea Steder*

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Abstract

OBACHT is an instrument developed for optical inspection of SRF cavities. This manual contains the description of a complete measurement cycle with OBACHT in section 2. The user shall be enabled to take pictures of welding seams at cavity equators and irides. In addition, beforehand needed cavity installation (cf. section 1) and calibration work (cf. section 2.3) is described as well as further information about the steering GUIs in section 3. Afterwards the safety components light tower and light curtain are shortly mentioned, while section 5 describes possible occurring errors and hopefully their elimination. The last part is only meant for experts and includes information for additional features of the system.

*DESY, Hamburg, Germany

1 Cavity Mounting

Correlated to the measurement procedure of a cavity inspection, is the installation of a cavity atop OBACHT. Such an installation should always be performed in the presence of an expert. Nevertheless, the whole procedure is described here and illustrated in figure 1.
Needed is the cavity lifter, visible in figure 1(a) and the gripper adapter, whose installation is shown in figure 1(b) and (c). The splint pin from (b) has to be placed again after the mounting of the gripper. The thick splint pins on the clamp of the gripper have to be adjusted in the open position (picture 1(d)), before gently grabbing the cavity as in figure 1(e). Be aware, that the cavity itself is never touched with blank hands, gloves have to be used. Then both splint pins are moved back in order to pick the cavity safely (cf. figure 1(f)).
For a proper mounting of the cavity onto OBACHT, an alignment of short (picture 1(g)) and long end group (picture 1(h) and (i)) to the holding fixtures has to be performed. The correct position is reached, when all four rollers have contact to the flange, as visible in figure 1(k). Is this not the case as in picture 1(j), the cavity has to be pressed down gently. In the end the the holding clamp of the OBACHT bench has to be screwed (cf. figure 1(l)) and the clamps of the gripper removed with help of the thick splint pins.

2 Measurement Procedure

This chapter is most important for an user performing an optical cavity inspection. Here is a full cycle of optical inspection of cavities with OBACHT described step by step. Including hard- and software starting procedures, calibration of coordinate systems of cavity and motors, the measurement itself via motor and camera GUI and in the end, the shutdown procedure.

2.1 Start Hardware

1. In case a cavity is already mounted on the bench: the sled has to be shifted carefully by hand over the camera tube in order to check, that motor movements won't harm the cavity.

2. Check of mirror position, both arrows visible in picture 2 have to be aligned.

3. Control cabinet panel: switch 24 V on with key
   → left ('24 V on') and middle ('chain closed') light shines green. After a while, the right button ('operational') indicates with green light the readiness of the system.
   → the light tower shows only the green light on the lowest position (cf. table 1 on page 15).

4. Control cabinet panel: switch 400 V with green 'I' button on
   → green light below the button shines

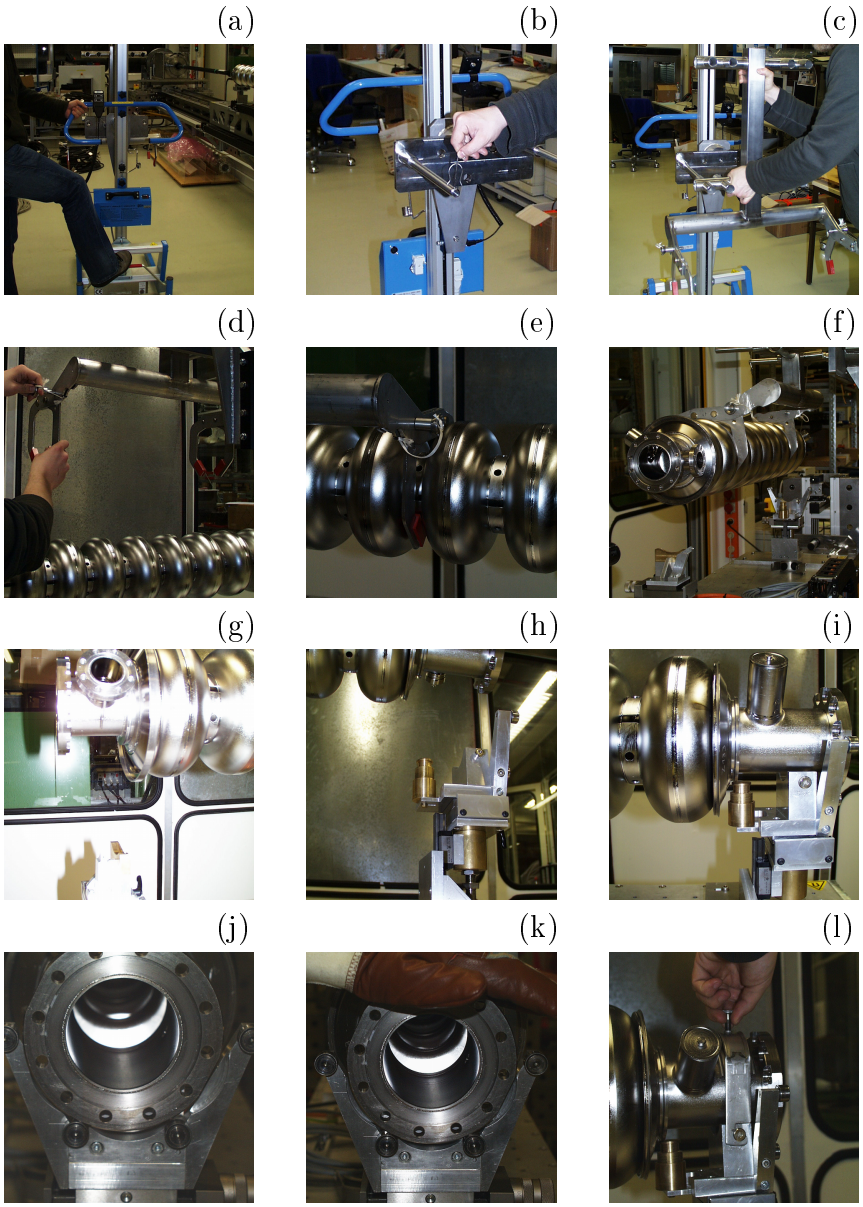

Figure 1: Installation of cavity onto OBACHT

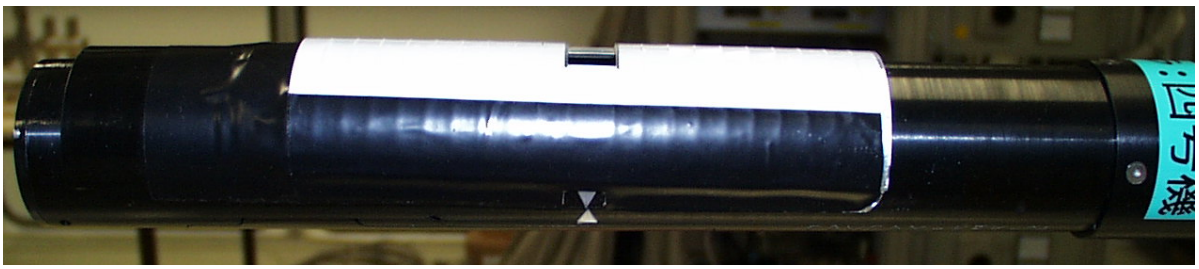

Figure 2: Camera tube with marker for mirror position. The white arrows on the bottom have to be aligned – here not exactly done

→ light tower shows in addition a red light on second position (cf. table 1 on page 15).

5. Switch box for step motor – steering the camera focus – on. The box is labeled as 'Controller No1' on a green sticker and is at the moment positioned atop the right PC on the desk.

6. Switch box for lighting steering ('CYLINDER ILLUMINATION CONTROLLER') on. This is not made via a button, but with the connector on the backside, which has to be plugged in.

2.2 Start Software

1. Start both PCs on desk with user `cavicam`. The password will be given to you by an expert.
   The left PC (PC2L) is used for the camera and everything connected to it, as well as the data storage and handling. The right PC (PC1R) steers the motor system, where as first action with a new cavity a coordinate calibration has to be performed. All these duties are done via LabVIEW VIs.

2. Open the camera, calibration and motor VIs:
   All VI's are started with the LabVIEW 'run' button (top line of window: black arrow).

   a) PC2L: start `1_OBACHT_TCPIP_camera.vi` in directory `Desktop/OBACHT_camera`, the resulting GUI can be seen in figure 3. Push the button 'files will stay locally' until it is green and shows 'move files to AFS'

   b) PC1R: open the `1_opt_inspection.lvproj` in directory `Desktop/optical_inspection`, then double click on `set_references.vi` in order to open the calibration tool, which is needed to adjust motor coordinates to the coordinates of the very cavity. The usage is described in the next section

c) PC1R: double click on
`2_opt_inspection_main` in `1_opt_inspection.lvproj`, the resulting motor GUI can be seen in figure 4, start it only after calibration.
As very first action the 'inspection type' has to be defined (can be found in central box on the right hand side – cf. picture 4). Default position of the button is 'special file', for a 'full inspection' (about 3000 pictures) it has to be switched. For testing purposes the ASCII file with the positions to be inspected has to be loaded in the box 'special file name' on the right hand side – cf. picture 4

3. An online status tool for measurement control can be found under:
http://www.desy.de/fla/steder/cavity_pic_check.php
Shown are the pictures in the afs directory as in figure 5. Red boxes indicate not existing pictures, orange appears an existing picture, which is not processed up to now, while green shows after the successful analysis of the picture. Moving over the boxes yields the appearance of the coordinate information of the picture.
In case the actual measured cavity is not listed, contact Lea Steder.

2.3 Calibration

The user interface for calibration looks like shown in figure 6. It may be, that single pushes on buttons of this tool do not work, just push again!

1. After starting the VI, a pop-up menu asking for Cavity ID and Inspection Number will appear.

2. Press the 'START' button ⇒ endswitches are tested and motors are calibrated (light tower shows a red blinking and a second red light). Afterwards the cavity mounting has to be confirmed in the pop-up menu.

3. Press 'TORQUE CALIB' and adjust the picture to the center of the power coupler (has to be done by eye at the moment). Confirm the position via the 'tqe' button on the lower right of the GUI.

4. For the calibration of the linear motor press 'LINEAR CALIB', bring the welding seam in the picture center via the cross pattern buttons and confirm the adjustment via the '0°' knob in the upper right quadrant of the GUI (cf. figure 6). Push 'NEXT' for the next angle setting and redo the procedure for all four.

5. After all four angles are calibrated write the adjustments to the corresponding equator via pressing knob '#1' in the column on the right hand side (below the angle buttons). Afterwards the same has to be done for all other equators.

6. In case one angle value was forgotten, press 'NEXT' until the right box is reached to catch up the calibration. If on the other hand, a whole equator setting was

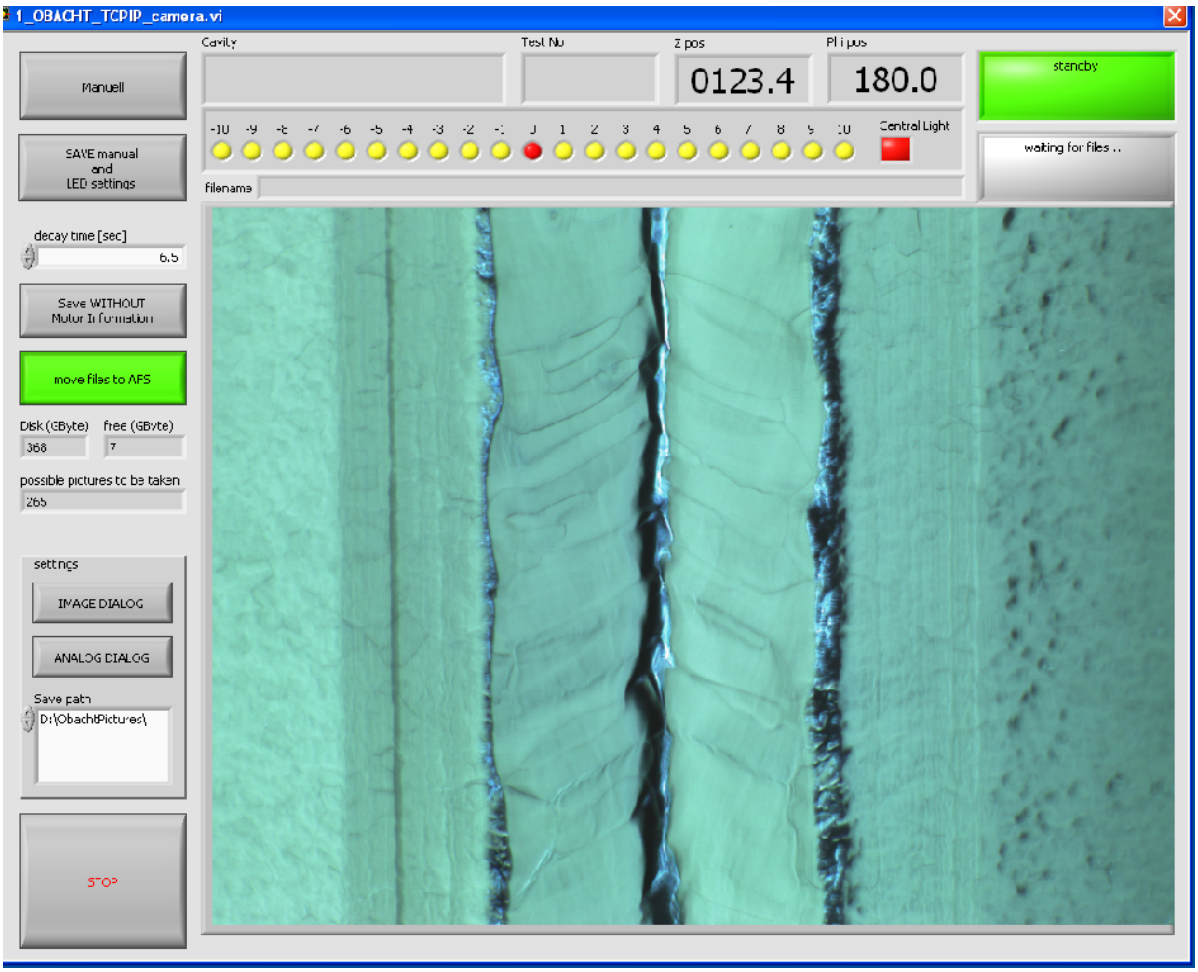

Figure 3: Screen shot of camera GUI

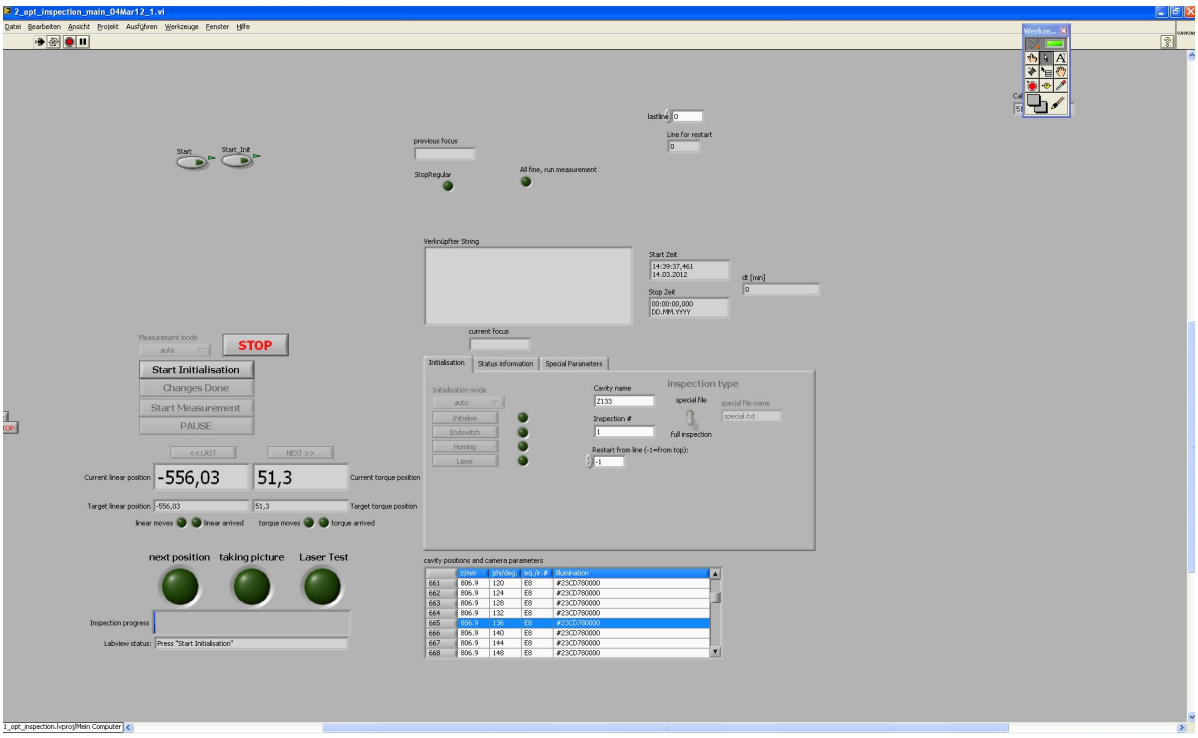

Figure 4: Screen shot of motor GUI in default view

missed, the position of the equator can be written to the left input box (for the z position) in the center of the GUI.

7. After calibrating everything, the values have to be saved via the 'SAVE CAL' button on the left. As a consequence all the values are written in a calibration file, which will be used in the motor steering.

8. The program can be closed with the help of the 'DONE' button.

In case of an already calibrated cavity, the referencing has to be performed via pressing the 'START' button and afterwards the 'LOAD CAL' button can be pressed to chose a calibration file, which shall be used for the very cavity.

2.4 Measurement

1. PC1R, motor GUI: default settings are 'automatic' for initialization and measurement mode

   a) after starting the VI, write cavity ID in the corresponding box, the inspection number is given automatically but can be changed manually

   b) press 'check name' button (warning if inspection number already exists) and click 'OK'

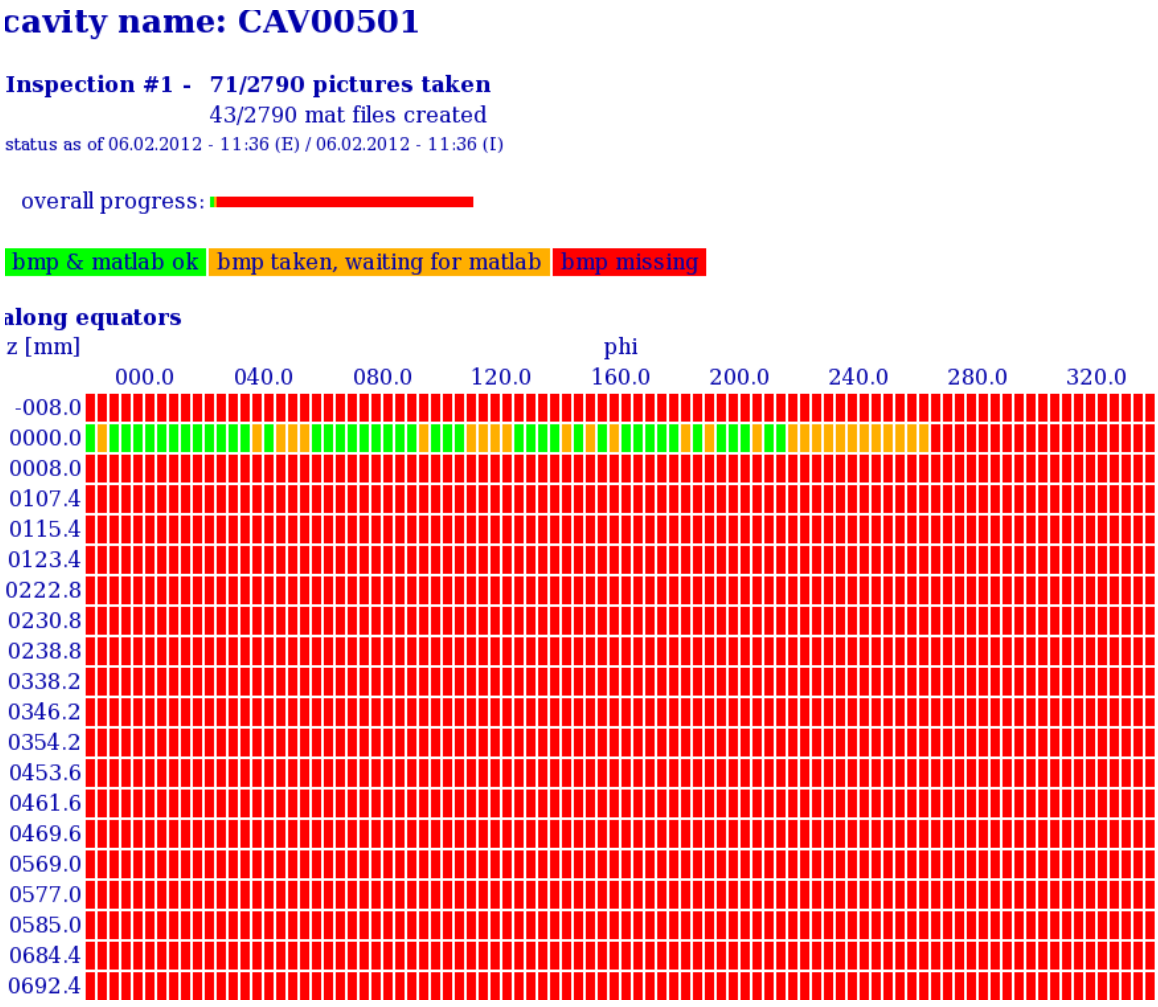

Figure 5: Screen shot of tool for online picture existence control

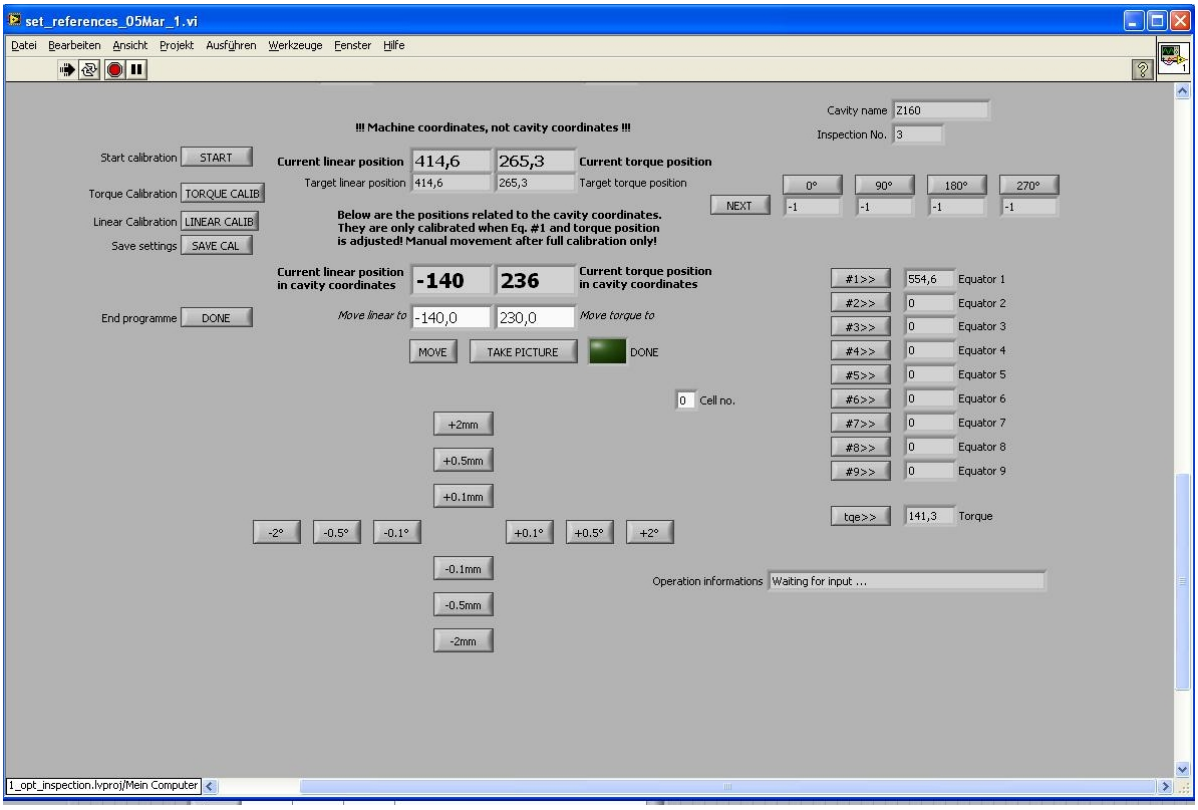

Figure 6: Screen shot of tool for motor coordinate calibration – `start_references.vi`

c) a pop-up menu is asking for the calibration file, the path has to be given as shown in figure 7

d) press button 'Start Initialisation'
⇒ sled approaches end switches, movement for not existing laser test is performed → yellow blinking light tower
In case the motors are still referenced, a pop-up menu asks, if the initialization can be skipped. Choose 'YES, I know what to do' only if the referencing is not needed again. If this is true, the 'Changes Done' button has to be pressed to proceed.

e) when, the referencing is performed again via choosing 'NO, do it again', a pop-up menu: 'Check if cavity is mounted and aligned properly' appears
here, the 400 V are switched off for cavity mounting → green light

f) mount cavity as described in section 1, if not already done → click 'everything ok!' on pop-up menu ⇒ light curtain is switched into operation

g) change inspection type, if needed. In this case the 'Changes Done' button has to be pressed before 'Start Measurement' can be used → click 'Start Measurement' button ⇒ sled approaches start position

h) measurement starts with first position (or pop-up menu asks for affirmation for continuing a halted/paused inspection)

i) if z position is changed during measurement, a pop-up menu with the following text will appear 'Focal plane changed! Check Focus' After adjusting the focus, the 'Done' button can be used to restart the procedure – focus setting can be done via remote control with arrow buttons on the small box

2. PC2L, camera GUI: saving of actual picture has to be approved. Included is also the possibility to log the actual position, in case of an eye-catching feature/defect in the picture. Hence, four buttons are given to chose as it can be seen in figure 8. In case a picture is conspicuous, the position is written into a table in the picture directory on afs (/afs/desy.de/group/fla/cavity/cavity_pictures). This table can then be used for a re-inspection of the cavity.

a) if a defect is observed press 'YES and logging' or alternatively use the 'left arrow' button of the keyboard instead of clicking via mouse

b) in case of a "clean" picture press 'YES, but no logging' or the 'right arrow'

c) choosing 'NO' button, skips actual picture
⇒ procedure is continued with next picture

d) choosing 'Automatic mode': no further action needed, can be withdrawn via 'Auto' button on top left corner of GUI, it will then be changed to 'Manuell'

e) in case of a difference between manually chosen and software LED settings a pop-up menu will appear as in figure 9. This shall prevent, that lighting settings are overwritten by manually (on the box) and unintentionally changed LED schemes

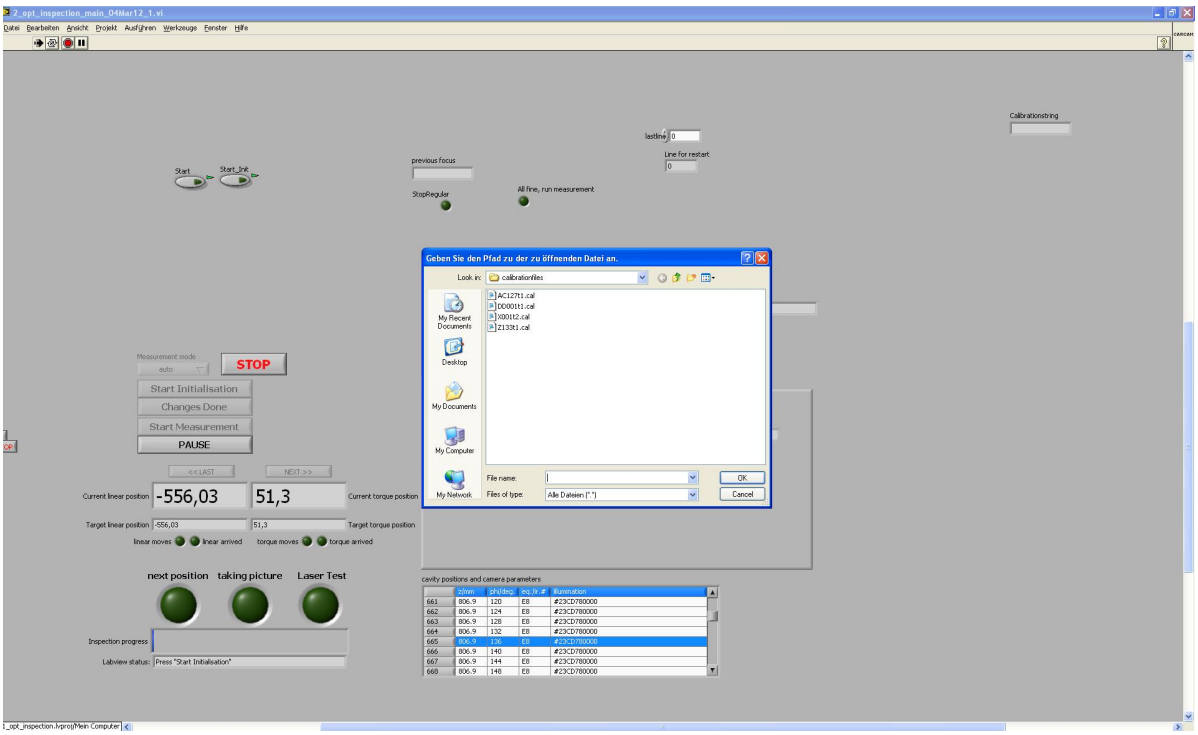

Figure 7: Screen shot of motor GUI – calibration file definition

3. After execution of the full measurement table in the motor GUI, motors are stopped automatically. The motor GUI will show pop-up menu 'Equator/Iris changed??, Check Focus', after affirmation motor GUI will tell: 'inspection done'

4. A control via the online tool (http://www.desy.de/fla/steder/cavity_pic_check.php), whether all pictures showed up in the afs directory is mandatory, since sometimes single pictures are missing. Re-measuring individual pictures is described in section 6.

For pausing a running measurement, the 'PAUSE' button in the motor GUI can be pressed. A possibility in the pop-up menu of the camera GUI asking for the file saving has to be chosen in addition. To restart press the 'CONTINUE' button in the motor GUI.

2.5 Shutdown Procedure

In order to end a measurement with OBACHT, the following steps have to be performed in arbitrary order.

- close VIs
- log off from PCs

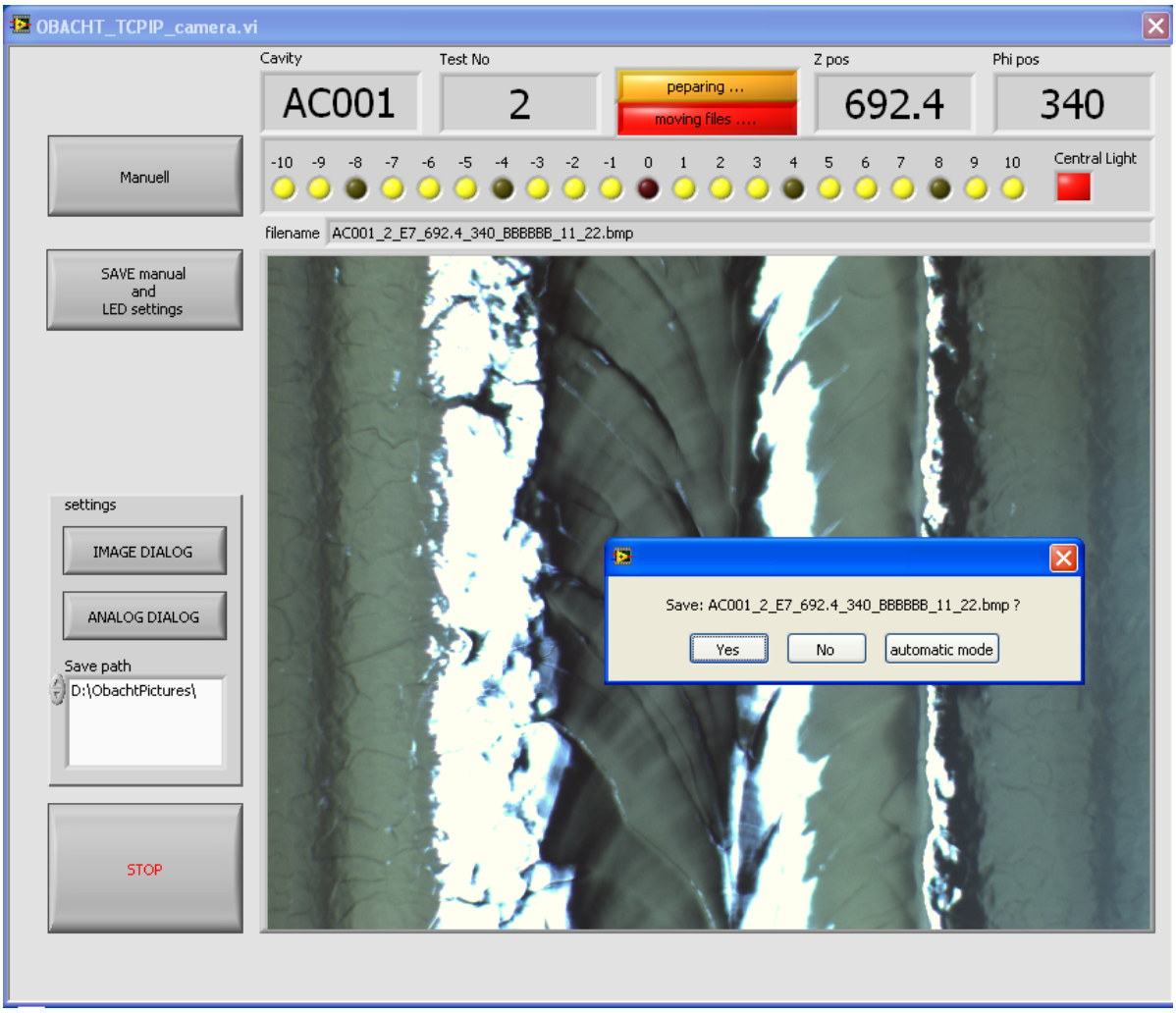

Figure 8: Screen shot of camera GUI with pop-up menu for picture saving

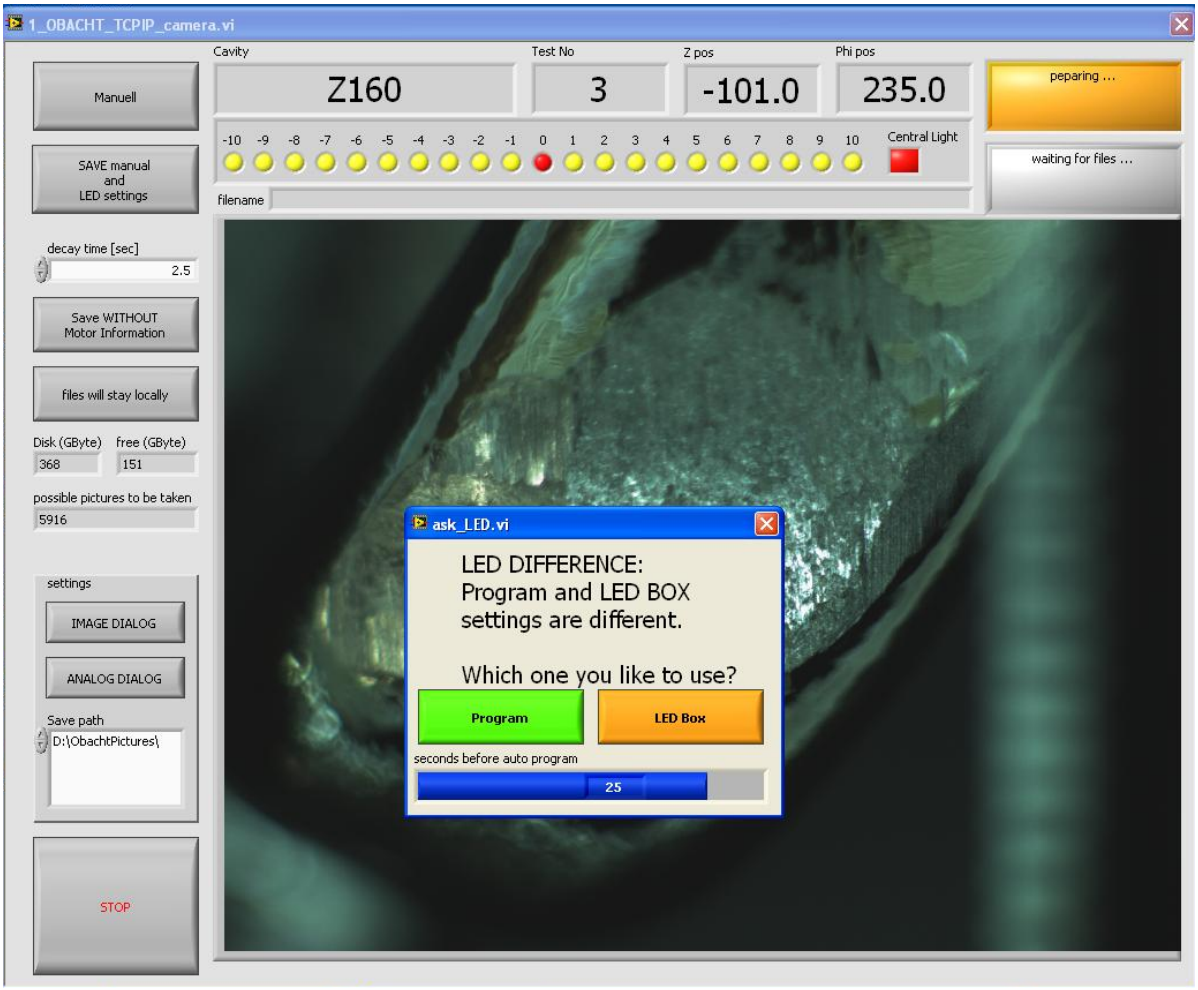

Figure 9: Screen shot of camera GUI with pop-up menu for LED settings

- switch off lighting control via unplugging the power supply on the multiple socket on the PC desk
- switch off box for focus adjustments (atop PC1R)
- switch off 400 V and 24 V on the control cabinet

3 LabVIEW GUIs

Important for users is the appearance of the graphical user interfaces (GUIs) of the steering programs. Here follows a description of the needed GUIs with all available features. The standard functionality for the measurement in automatic mode were described in section 2.4.

3.1 Reference GUI

This tool is needed to adjust the motor coordinates to the cavity system. For each cavity the calibration has to be done at least once in order to avoid confusion of coordinates. The motor GUI asks for the calibration file, if it is not available.
In addition this reference tool can be used to take single pictures. Therefore, the torque calibration and a calibration for the first equator have to be performed. Afterwards, the position which shall be investigated can be accessed via the input boxes in the center of the GUI.

3.2 Motor GUI

Its graphical user interface runs on the right PC on the desk - PC1R and can be seen in figure 4. It is started via the program `1_opt_inspection_main` as described in section 2.2 and controls the movement of linear and torque motor.
Additional information, for example status information of the PLC can be found on the tab on the right hand side. As well as the 'Special Parameters' tab, which is described in the expert section 6.
The 'PAUSE' button can be used to pause the measurement (picture saving pop-up menu of camera GUI awaits choosing of option) and continue it later.

3.3 Camera GUI

Here are some more information about additional buttons, like the status display - in the middle and top of the window (in between the cavity ID and the position information displays).

- 'standby' shines, while waiting for data from motor VI
- 'preparing' means waiting for fading of camera and motor movements, as well as saving of picture (on hard disc D:ObachtPictures)

- Buttons 'IMAGE DIALOG', 'ANALOG DIALOG' and 'Save path' input are **only meant for experts**, cf. section 6

4 Light Tower and Light Curtain

The light tower atop the OBACHT bench and the surrounding light curtain are part of the safety system. They shall indicate the system status at one glimpse and protect humans against danger caused by the moving motors.

4.1 Light Tower

The light tower is indicating the status of OBACHT. The systematic is chosen such, that red light denotes danger. The particular meanings are given in table 1.

light tower signification		
position	color	meaning
4	green	PLC on, only 24 V
4 + 1	green + red	PLC on with 400 V, motors off
1	only red	motors on
3	yellow blinking	laser procedure
2	red blinking	motor movement

Table 1: Flash light table, four lights are existing and are enumerated from the top.

4.2 Light Curtain

A light curtain is used as interlock system. It becomes armed in the moment, the motors are switched on. Switching on 400 V is not enough to enable the curtain as interlock, since movements in the area can still be made without danger.

5 Error Elimination

All known occurring errors are listed here with a description of steps to reset the system and continue the inspection. Please report every not listed error!

- 400 V are switched off at start of motor GUI
  1. Push button 'STOP' in motor GUI (includes reset of PLC)
  2. Switch 400 V on control cabinet panel on
  3. Next escalation step: move linear motor by hand a short way and restart everything

- black picture in camera GUI
  1. Press 'PAUSE' in motor GUI (PC1R)
  2. Press 'Stop' in camera GUI (PC2L)
  3. Unplug and plug again the lowermost black USB connector on PC2L
  4. Press LabVIEW 'run' button (arrow)
  5. Continue measurement via motor GUI 'CONTINUE' button
- picture not sharp
  1. Press 'PAUSE' button in motor GUI
  2. Use remote control, see section 6
  3. Push 'CONTINUE' in motor GUI
- light curtain triggered → green light on light tower, 400 V off
  1. Stop motor GUI via the LabVIEW 'Stop-Sign' button ('Status information' tab shows error number of PLC)
  2. Press 'STOP' in motor GUI
  3. Switch 400 V on control cabinet on
  4. Continue measurement
- online tool shows no progress, although measurements are done
  1. Check whether the camera GUI shows on the left a green button with 'move files to AFS' If 'files stay locally' can be read, push this button.
  2. Still not working? - Contact Lea Steder (5680 or lea.steder@desy.de).

6 Expert Modes

The different components have more functionality as described up to here. Hence, a short list of expert modes with only some describing keywords are given in the following.

PC1R, motor GUI:

- initialization mode manually
  1. Push 'Initialise' ⇒ motors are started
  2. Push 'Endswitch' ⇒ end switches are approached by the sled
  3. Push 'Homing' ⇒ reference position is approached
- if measurement mode 'step-by-step' (meant for restart after crash of VI): push 'NEXT' or 'LAST' until wished position is reached.

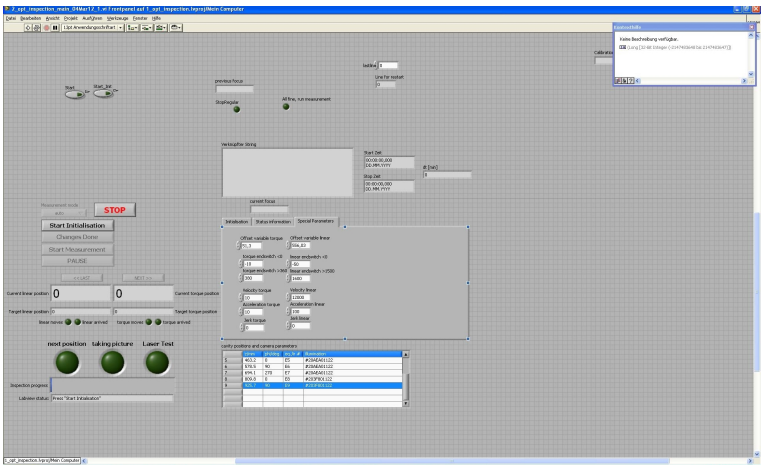

Figure 10: Screen shot of special parameter tab in motor GUI

- 'Special Parameters': in this tab – visible in picture 10 – the conversion of motor coordinates to cavity coordinates are made. This is only meant for experts and may have to be adjusted, when switching from a cavity with tank to a naked one ore vice versa.
  In addition the velocity, acceleration and the jerk settings of the motor movements are defined here. Default values are $1, 1, 0$ for the torque motor and $12000, 100, 0$ for the linear motor.

- redo measurement of individual pictures via new look-up table: write a fitting .txt file and load it via the 'special file' button in the motor GUI as described in section 2.2. The format of the .txt file can be given by an expert.

PC2L, camera GUI:

The fine tuning of image filters and analog color settings have to be defined by the experts according to the needs of the analysis framework.

- 'IMAGE DIALOG' can be seen in figure 12

- 'ANALOG DIALOG' visible in figure 11

- 'Save path' input: direct storage to AFS is possible here, but not recommended (AFS is mounted under G:)

Camera Focus Remote Control
As well as for the camera color settings, the focus adjustment has to be defined as first step by the picture experts, while the second step should include analysis mechanisms and an optimization for it.

- up/down arrow buttons: for focussing

- left/right arrow buttons: for tilting of mirror

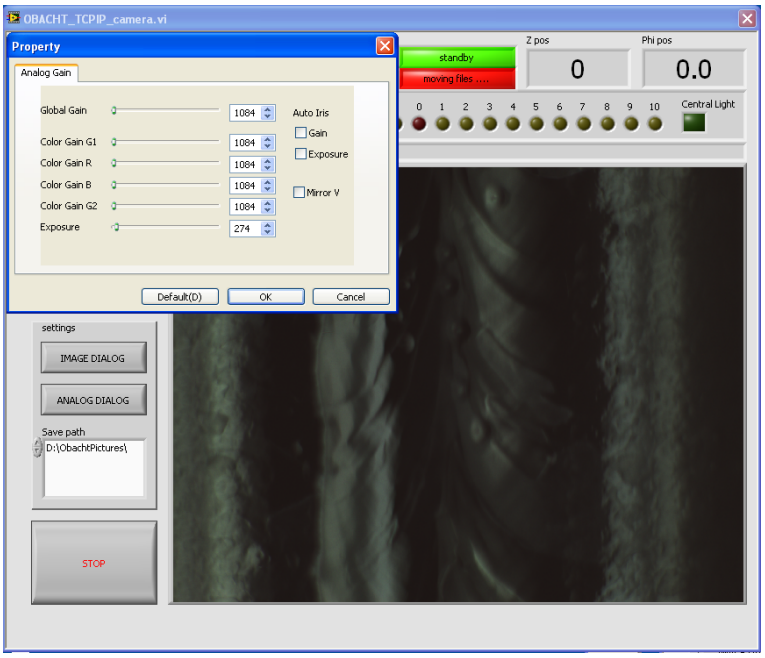

Figure 11: Screen shot of camera GUI – 'ANALOG DIALOG'

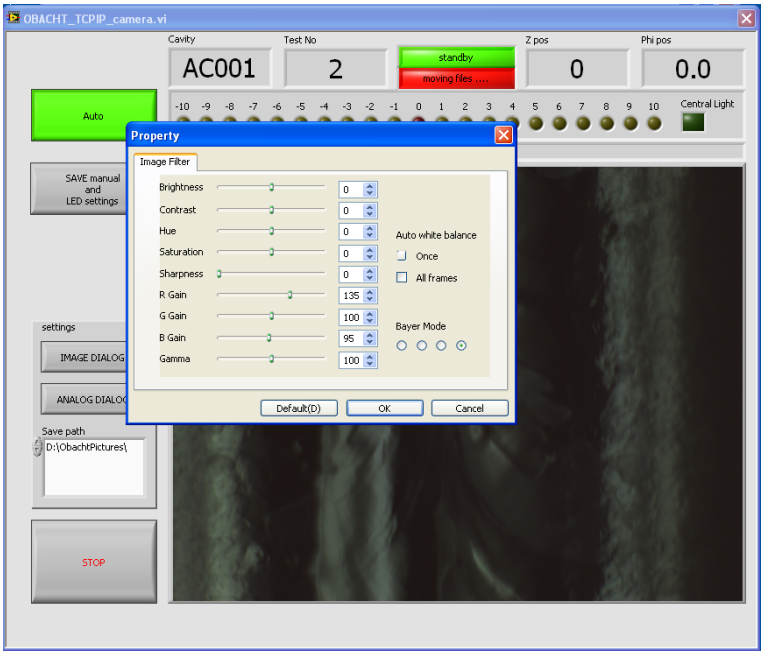

Figure 12: Screen shot of camera GUI – 'IMAGE DIALOG'

7 File Name Scheme

With the help of one single picture, the file name scheme shall be described here:
AC116_1_E1_0000.0_328.0_20AEA0_00_00.bmp
The underscores are used as delimiters.

- AC116_ → Cavity ID. In case one just needs to play and the picture shall not be processed. Write a leading X in front of the name.
- 1_ → inspection number
- E1_ → equator/cell or iris number (E,C,I), only for better legibility, position information make pictures uniquely
- 0000.0_ → z position
- 328.0_ → ϕ position
- 20AEA0_ → lighting adjustments
- 00_00 → shall later contain information about lighting intensity, at the moment only place holder

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