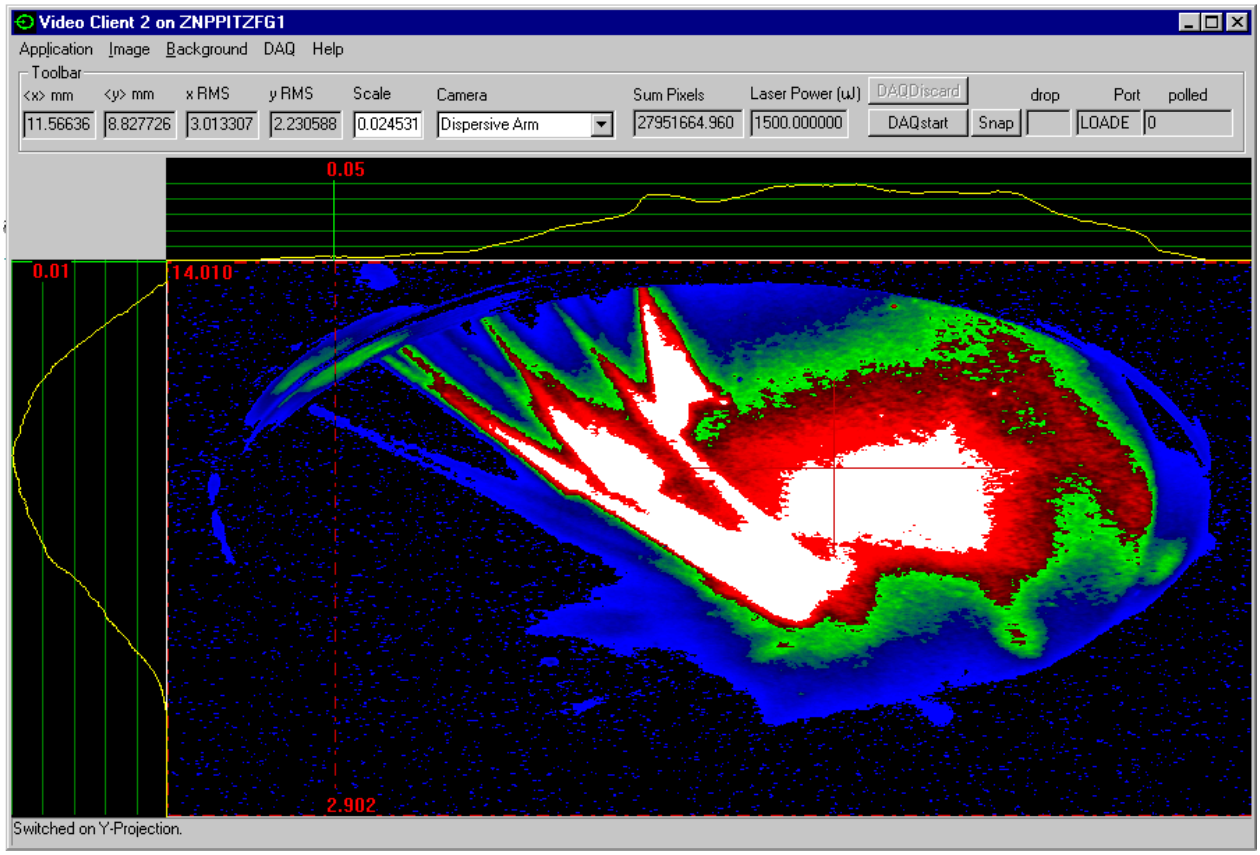
Video Client 2

For video data acquisition and analysis

User Documentation



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1. Introduction

The Video Client is a program to acquire and analyse video data. It was developed for the Photo Injector Test Facility at DESY Zeuthen (PITZ). The optimisation of an electron source is only possible with a diagnostics based on an advanced video system. The goal is to measure the electron beam position and the transverse profile of the beam at different locations along the beam line. The Video Client is a part of the PITZ video system. Other parts include a grabber server and a camera slow control tool.

Using this software one has different tools to analyse the beam. One can just poll some frames continuously to watch the beam or grab some frames to analyse them off-line. A background can be subtracted, e.g. to subtract dark current which is also visible on the screen. In addition one can normalize the image intensity, watch the X and Y projection of the video signal and calculate the beam position and size using different algorithms. An area of interest (rectangular and circular) can also be selected so that all calculations are done using only the video data belonging to this area and not the whole video frame. In addition, laser power can be calculated and data can be printed.

In grab mode, an image sequence can be acquired. The calculations are then averaged over all pictures. In addition, X-Rays can be filtered out of the picture.

2. Setting up the Environment

In this part of the documentation, everything is explained what has to be done in order to use the application on a new (and clean) computer.

The new computer must have a fast network connection (at least 100 MBit), otherwise there will be lots of frame drops. Although compression is used, a 10 MBit network connection is not sufficient. The data rate is 1 MB/s in average at 5 Hz. At 10 Hz the data rate is doubled. The peak transfer rate is 2.2 MB/s at 5 Hz and 4.4 MB/s at 10 Hz, so a 100 MBit network connection is really needed.

Secondly the TINE (Three-fold Integrated Network Environment) must be installed properly on the PC. The TINE install package is distributed via Netinstall service across DESY. One can make sure that TINE is installed by having the Instant Client, which is a TINE diagnosis application, running on the PC.

The program applies an optimised C++/ASSEMBLY code so that most of the calculations can be done in real time (up to 10Hz) on a fast PC. At least a Pentium III 1000 MHz is suggested. On a Pentium IV PC >1.8 GHz run two instances can be run simultaneously watching at different cameras. An even smaller PC is sufficient if all calculations and the projections are switched off while polling frames. But at least a Pentium II or comparable processor is required. Old versions of the program had problems with Hyper Threading of modern Pentium IV CPUs. This is fixed since V2.4 . Up to now the program was not tested on multi processor machines. Side effects could appear. For Fitting operation mode a really powerful PC is needed. The author recom-

mends at least Pentium IV 2.4 GHz. On slower machines fitting mode can be disabled in order not to overload the PC.

It has to be underlined that the ASSEMBLY language and the **M**ulti**m**edia E**x**tension (MMX) instructions are intensively used. So at least to run this program the processor must have the MMX instruction set built in. In addition, at least 128 MB RAM must be installed on the PC to enjoy working with the program.
For operating system one has the choice between Windows NT 4, Windows 2000 and Windows XP (all tested and verified). Old Windows systems like 98, 98SE and WinME should also work, but the program was not tested on these operating systems.

If all of these conditions are met, one can try to start the program. The whole program consists of an executable, a config file and some additional files. A proper preconfigured version can be found on DFS drive "S:\znp\pitz\Video System\Video Client 2\Precompiled\" . The program must be copied to the local harddisk or the home directory and run from there. In addition to copy the files to a proper drive, an environment variable must be set up in order for the program to work properly. The variable is called "ENSHOST" with the value "corvus:aquila".

After putting the files and setting up the variable the program can be started. If the program is successfully started and shows approximately the screen as it is shown on the cover sheet, it is time for the next chapter.

3. Configuring the Application at First Start-up

When the program is started the first time, it could happen that some error messages occur. One should first go into the Preferences dialog (Application->Preferences…) and set up the configuration. The following dialog is displayed:

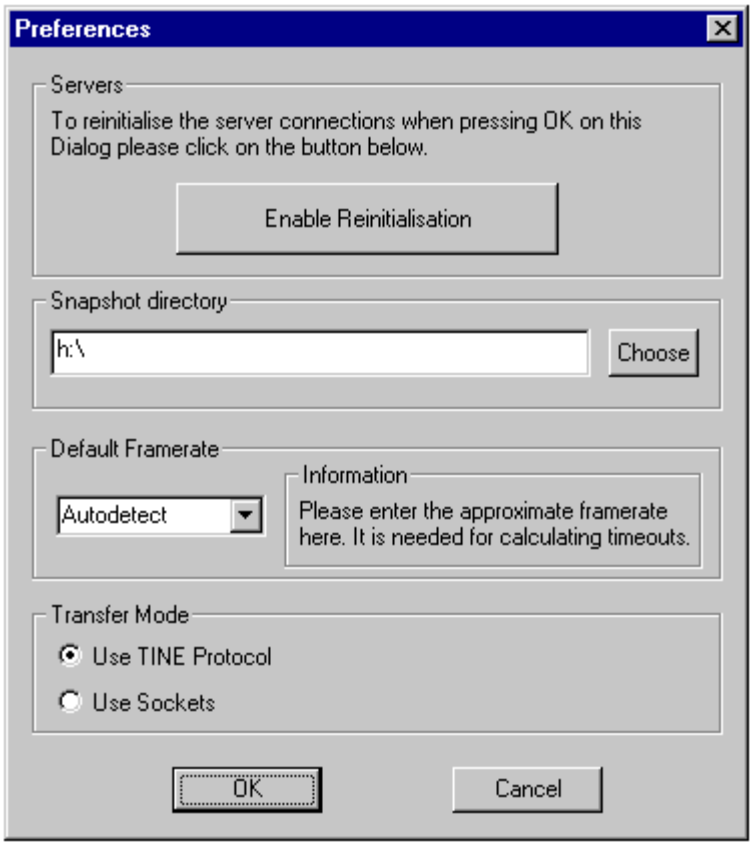

Fig. 1: Preferences Dialog

Servers

Using the button "Enable Reinitialization" one can force the program to reload the server configuration. This should be done if the user experiences a lot of errors when getting frames from the servers or changing the camera port. When reinitialising, the program checks whether the servers are properly running and it masks out the servers that are malfunctioning. If this reinitialisation does not help, one has to ask the responsible person for the Video System for help.

Snapshot Directory

In the middle of the “Preferences”- dialog, a snapshot directory can be entered. When running the application, one has the option to snap pictures (e.g. the user is watching live video and want to save a frame immediately). For proper use of this function, a directory in which the images will be saved has to be set up. This directory can be specified here. By pressing the 'Choose' button

and selecting a proper directory one sets up a directory for storing the snapshot images. A detailed description of snapping images can be found in the subsection 7.2.

Default Framerate

When grabbing frames, the Video Client checks for a timeout. It could be that the server is not grabbing and the user waits forever - the grabbing never completes. Because of this the program is doing a timeout check when grabbing frames. One just has to set the current grabbing frequency into the control on the preferences dialog and the timeout is calculated to a corresponding value. The frequency of the grabbing is equal to the frequency (repetition rate) of the RF system. The user has to make sure that the frequency entered matches the real frequency of the grabbing system.

It is also possible to use autodetection of the repetition rate. Then the Video Client 2 will try to autodetect the repetition rate of the system. But in case this autodetection fails one will wait for a long time before the timeout error message is displayed by the application. In this case, the proper repetition rate has to be set up manually.

Transfer mode

The user has two options on how the application acquires the frames from the server. The first one (preferred) is using the TINE protocol. Using this transfer mode the frames are transferred to the client using multicast, an operation mode which saves network bandwidth and server resources.

The second option is "Use Sockets". This transfer mode is more stable than TINE protocol, but wastes network bandwidth and server resources. It is not preferred. Socket mode should only be selected when a transfer using TINE protocol is not stable or a connection to the server is not possible.

When the application starts up, it checks whether the TINE protocol can be used for transferring the video frames. If it found out that TINE protocol is not possible, then it automatically reverts back to socket mode. When this is the case, the user has no options on this part of the dialog, both radio buttons are greyed out.

The transfer mode setting is not permanently remembered. Each time the application is started it must be set up again.

4. Checking the proper Operation of the Server Connections

One can check whether the server and the default selected camera is running by trying to grab a single frame ('Image->Grab->1 frame'). If no error message is displayed, the frame was successfully grabbed. One should switch to other cameras using the camera control on the toolbar and verify that these cameras also work. If there are no error messages, everything seems to run fine.

In case of errors like "Timeout" or "Server disconnected", one should check the timeout setting in the Preferences dialog or switch the transfer mode to sockets.

Once the server connections are working properly, poll mode can be started. In poll mode, the client continuously acquires frames. It is like watching television. When in poll mode, one can see the frames coming in by taking a look at the 'Frames polled' counter on the tool bar. This number should increase. If poll mode is switched on, and the number of frames does not increase, it is most likely that there is no camera connected on the camera port the application is grabbing from. It can also be that the camera is switched off. By trying to select another camera port one can see whether this port works. More information on grabbing problems can be found in the FAQ section.

5. The Toolbar on the Application Window

In this section, the toolbar on the main application window is explained and the controls that are located there are described.

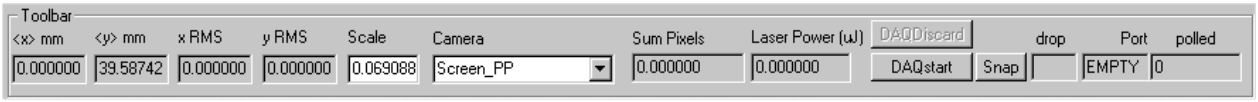

Fig. 2: Toolbar

On the left of the toolbar, four controls are displayed. These are the calculated spot size and centre position values. When *Statistics* mode is switched to *Straightforward* or *Fourier*, the four values <x>, <y>, x RMS and y RMS are calculated. The values <x> and <y> are the spot centre coordinates in x and y dimension. The values x RMS and y RMS are the calculated size of the spot. The yellow cross on the spot is drawn according to these four coordinates.

These four values are scaled values, which means based on the proper pixel-based values these values are scaled by the 'Scale' factor. If the scale factor is 1.0, 1 millimetre equals to 1 pixel. The scale factor can be changed at any time. The scale factor for the camera the application is grabbing or polling from is downloaded from the server.

After the four calculated numbers and the scale edit field, there is a combo box where one can select one of the camera ports of the servers the application is connected to. One can just select the camera port from which should be grabbed or polled. The camera can also be selected while poll mode is switched on. Please note that it could be that there is no camera connected to the port or it is switched off. In this case, polling or grabbing frames will fail. Poll mode does not generate an error message, but one can take a look at the 'Polled frames' counter. This number should increase periodically. In grab mode, there is an error message displayed that no frame could be grabbed. In this case, one should check the cabling and/or talk to the person responsible for the video system. It should be noted that by switching the camera port, the background is cleared, too. Under normal conditions it makes no sense to use the background of one camera port on another camera port.

To the right of the camera combo box, there are two fields showing the sum of the pixel intensities inside the area of interest and the calculated laser power (μJ) based on this sum of the pixels. The laser power is calculated using a lookup table which stores a curve. One can only calculate the laser power when the statistics are switched on.

After the laser power field there are two DAQ buttons. The lower one is called DAQstart. Using this button, data acquisition to file can be started for analysis with programs that can read Excel files. When the DAQstart button is pressed the first time, one has to set up a DAQ directory where the files are stored.

Inside such a DAQ file, the following data is stored:

- X mean, Y mean, X RMS, Y RMS
- Timestamp
- SP Voltage
- SP Phase
- Klystron Forward Power
- Gun Forward Power
- Gun Reflected Power
- Gun Gradient
- Current of Main Solenoid Imain
- Current of Bucking Ibuck

When the DAQ is finished, the user has the option to stop the DAQ and write the results to file or discard the data. Using the upper button "DAQdiscard", the data can be discarded. Nothing is written to file. When the data should be stored, the DAQstart-button must be pressed (which is then labelled DAQstop) and the data is written to file. On thing must be noted. The DAQ function was designed for short-time data acquisition. Especially at 10 Hz repetition rate, the DAQ should not be used for more than one hour.

To the right of the DAQ functions, there is a small button labelled 'Snap'. By pressing this button, a snapshot of what is shown in the video frame is written to disk. For further information please look at section 7.

After the snap button, there are see three control fields located. The first one is the dropped frames counter.
Monitoring this control on the tool bar, one can check whether the network is overloaded or a stable transmission takes place. When the network bandwidth is very low, frames are dropped. Frames could also be dropped if the server is overloaded, but that should not happen. Please note that if frames are dropped, there is no loss-less transmission from server to client. If the analysis is based on loss-less data (it means that all frames were taken one after another) it will be faulty.
It must be outlined that the dropped frames counter is only active when in poll mode. In grab mode, the user is warned by the application when not all frames were grabbed one after another.

Right beside the dropped frames counter is the 'Port' field. On this field, the origin of the displayed image is written. When in poll mode, this control writes the number of the camera port the frames are taken from. After frames were grabbed, this control shows the number of the port, too.

After loading some frames from a file, the control shows 'LOADED'. When a background is shown, then 'BCKGND' is written there. So when some data is displayed, the user immediately knows where it came from.

The rightmost control on the toolbar is the 'Frames polled' counter. This control tells how many frames have been polled up to now from the actually selected camera port. This control only increases in poll mode. By looking at this control one can check whether frames are really grabbed on the server. If this control does not increase periodically and poll mode is switched on, one can try to select another camera port to check whether the server is really grabbing and make sure that the camera is on. If no frames could be acquired (i.e. get the control to increase periodically), one should talk to the person responsible for the video system or look into the FAQ section.

6. The Menus - Basic Functionality

In this section, the basic functionality is described. When reading this section, it is assumed that grabbing and polling works and that some picture and not just a black video frame can be seen on screen.

When in poll mode, one can try to set up some configuration from the Application menu. For example the colour mode can be changed from greyscale images to false colour images. From the camera all pixels are greyscale (8 bit per pixel). If the image is rather black, one might not see anything although there is some information in the video frame. By switching to false colour mode by pressing F6 or selecting 'Application->Color mode->False color' from the menu, one ou should see a coloured image instead of a greyscale one. Blue colours encode dark areas, medium vivid areas are encoded by green and bright areas are encoded by red. The brightest pixel value is pure white. One can switch back any time by pressing F5 or selecting 'Application->Color mode ->Grayscale'. The colour modes are covered in detail in section 7.1 .

After selecting the colour mode, the most important part of the application is explained. This is the calculation of spot centre and spot *root-mean-square (RMS)* size. These calculations can be switched on by selecting one of the three main statistics modes (*Straightforward, Fourier* or *Fitting*). First of all, a brief explanation is given on how these three modes work.

In ***Straightforward*** **mode** the application employs the standard formulae for calculation of an weighted average of the beam size *(S_x , S_y)* and centre *(<X>,<Y>):*

$$\langle X\rangle = \frac{\sum w_i X_i}{\sum w_i} \qquad \langle Y\rangle = \frac{\sum w_i Y_i}{\sum w_i}$$

$$S_x = \sqrt{\frac{\sum w_i \left(X_i - < X >\right)^2}{\sum w_i}} \qquad S_y = \sqrt{\frac{\sum w_i \left(Y_i - < Y >\right)^2}{\sum w_i}}$$

In these expressions the sum is over the whole set of points composing the so-called **A**rea **O**f **I**nterest (AOI). The weight factors *{w_i}* represent the intensity values for each one of the points.

In ***Fourier* mode**, the calculations are preceded by expansion of the projected intensity (along *X*- and *Y-axes*) in a Fourier series (up to the $5^{\underline{th}}$ term). For this purpose we apply *Discrete Fourier Transformations* (DFT). The beam centre *(<X>,<Y>)* is then defined by the conditions:

$\max(I^{X}{}_{DFT}) = I^{X}{}_{DFT}(< X >)$ and
$\max(I^{Y}{}_{DFT}) = I^{Y}{}_{DFT}(< Y >)$
Here $I^{X}{}_{DFT}(\ )$ and $I^{Y}{}_{DFT}(\ )$ stand for the DFT-expanded intensities.

The *Fourier* mode implements a different concept for the beam position than the *Straightforward* mode. In fact the DFT performs a *low-pass* filter to the incoming video data. Therefore it is less sensitive to noise.
After the beam centre is found, the beam size is calculated using the standard formulae, applied to the non-filtered data.

In *Fitting* mode the beam center and RMS size are deduced by fitting the projected X and Y intensities to Gaussian functions with background offset:

$$I(x) = B + \frac{\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)}{\sigma\sqrt{2\pi}} \qquad (1)$$

Here $\boldsymbol{B}$ is the background offset, $\boldsymbol{\mu}$ the beam centre and $\boldsymbol{\sigma}$ the size. The fitting routine performs least square fit and implements the gradient descent algorithm for minimizing the sum of quadratic residuals.

The residual noise remaining after the background subtraction is filtered out and therefore this mode is supposed to be less sensitive to noise. On the other hand the initial shape of the intensity projection limits the accuracy of the method. In the cases when the distribution is not Gaussian like the fitted centre and sizes could deviate significantly from non-fitted ones.
In addition due to CPU power limitations not all of the projection points are taken into account in residuals calculation. This is only true for Poll (Live Video) mode, in Grab mode all projection points are taken into account in residuals calculation. The distribution is sampled at a given, uniformly distributed, number of points.

Depending on the working conditions, one can choose between Fourier mode, straightforward statistics, Fitting and statistics off. The following table outlines the differences.

Type	Description	Hotkey
Off	no statistics at all, also: **no** normalization	F4
Straightforward	standard statistics, fast, sensitive to noise	F3
Fourier	applies DFT, slower, insensitive to noise	F2
Fitting	fitting of projections, very slow, very insensitive to noise	

One can switch between the modes either by the hotkey that is written in the table or by selecting 'Application->Statistics mode' from the menu.

The Streakcamera mode

A special analysis mode was integrated in the last version of the Video Client 2. It is the *Streak camera* mode. It does calculation of the bunch length in picoseconds based on the Y projection of the video frame that is delivered from the Streak camera. A calibration was applied to have approximately the same result as the installed streak camera.

When the Streak camera mode is on, the estimated bunch length in picoseconds is written on the Y projection frame as well as in the toolbar. The RMS values on the toolbar change to picoseconds values which give the bunch length in x and y.

After selecting a proper analysis mode, a yellow cross can be seen somewhere on the screen. The cross is there where the program thinks the spot is located. The cross does not only show the centre position of the spot, but also the size of it.

In addition, there is another kind of cross when the mouse is moved over the video window. This one shows the actual mouse pointer and the coordinates of it inside the video frame scaled to millimetre values. Using the mouse pointer inside the video window, one can select an area of interest by moving the mouse to the starting position, press the left mouse button, move the mouse to the desired end position and release the left mouse button. It is just like selecting areas in a paint program. There are two modes for the area of interest which can be switched inside the application menu. One can switch between rectangular and circular area of interest. If the area of interest is properly selected, a yellow rectangle/circle is drawn around it. From now on, all statistical calculations as well as the normalization are only done inside the area of interest. To unselect an area of interest, the mouse should be dragged inside the video window and one should click on the left mouse button and do not move the mouse. After releasing the left mouse button, the area of interest is reset to the whole frame.

Another important part of the application is background subtraction. For example an image with a lot of dark current on it is shown. Later, when spots are visible, the dark current should be masked out. In order to do this, one can grab a background picture by using 'Background->Grab' or 'CTRL-G'. Now for every picture that is grabbed or polled, the background is subtracted before

it is analysed. When the spots are visible, one is not able to see the dark current because it is properly masked out. The background can be cleared at any time by selecting 'Background->Clear' from the menu or by pressing the hotkey 'CTRL-C'. If the background image should be displayed, one can press 'CTRL-S' or select 'Background->Show' to display the actual background image.

In poll mode, the video frames are continuously displayed as they are received from the server. The algorithm is like this:

- acquire one frame and subtract background
- apply x-ray filtering, if it is switched on
- normalize area of interest if normalization is switched on
- do statistical analysis on the area of interest if statistics are switched on
- display the frame

All the calculations are done once per frame. In grab mode it is a bit different. One can choose how many pictures to grab. After grabbing the pictures, the calculations are done for every picture and are then averaged. The displayed image is an average of all grabbed images. This applies for the calculation, too.

The algorithm is like this:

- acquire n frames
- apply x-ray filtering (if it is switched on) on each single frame
- subtract background on each single frame
- normalize area of interest if normalization is switched on
- do statistical calculation on the area of interest on each frame (if statistics are switched on)
- create average image over all n frames (using mean values)
- calculate average spot centre and size values over all n frames
- display average values and average video frame

The author suggests that the reader should play around a bit with the different algorithms and functions to get used to it.

7. The Menus - Advanced Functionality

In this section the advanced functionality is covered. The details of some features of the program are explained. After this, loading and saving frames or frame packs as well as loading and saving background images is explained. In addition, the background subtraction functionality is covered.

7.1. Features

Switching the Colour Palette

One can switch the colour palette at any time by using the hotkeys or the Application menu. In greyscale mode, the darkest pixel (black) has a value of 0, the brightest pixel (pure white) has a value of 255. In false colour mode, the darker areas have blue values, medium intensive areas have green values, bright areas have red colours and the brightest value (255) is mapped to pure white. In jet false colour mode the colours are the same as in Matlab when JET false colour table is used. By having the statistics off and thus no normalization takes place one can check whether the camera signal is saturated by entering false colour mode and check whether there are white areas. If white areas can be seen (value of 255), the image is saturated. If a lot of pure white areas are seen all over the video window, the frame is over saturated. Opening the Slow Control Client is suggested to adjust the gain of the camera.

Switching to Statistics Mode

When in poll mode and statistics mode is switched on, the effect will be seen immediately when the next frame is polled. It is automatically analysed according to the enabled statistics mode. When frames were grabbed in the past, or images have been loaded in, the effect of the new statistics will be seen just when reanalysing the image. This can be done via hotkey (ALT-A), via the Image menu or by reselecting the area of interest. Please note that when first statistics are switched on and then frames are grabbed, these frames will be automatically analysed due to the enabled statistics mode. But when some pictures are in the buffer, one has to analyse the image(s) again via the hotkey or the menu.

Projections

Another feature is the projection mode. In addition to the video window, there can be some space on the main window reserved to draw the x, the y or both projection(s) (as shown) of the video signal.

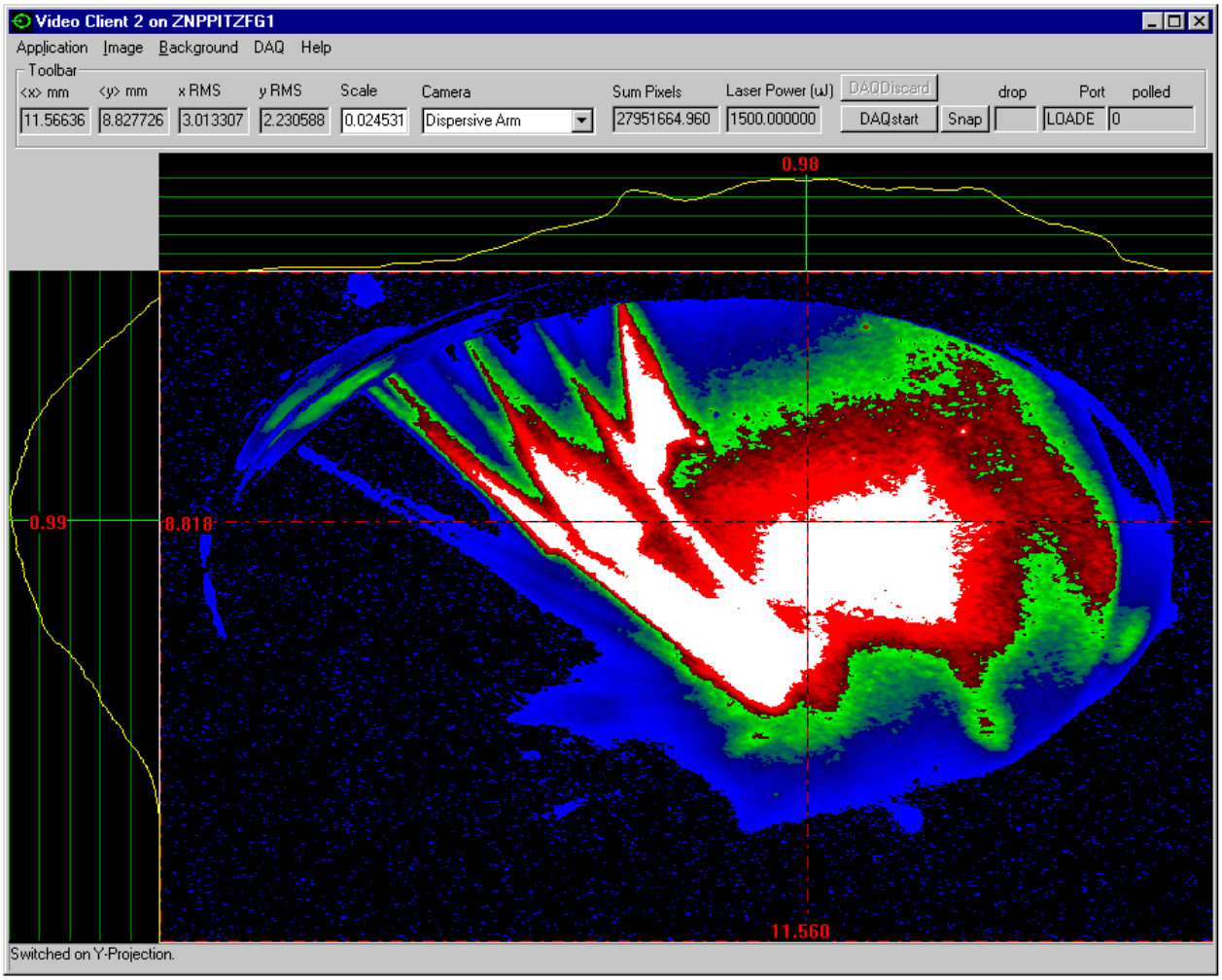

Fig. 3: Application window with X and Y projection

In the projection frame, one can look at the projection of the video signal. The projection can be either in X and Y (as displayed) or just X (top of the video frame) or Y (to the left of the video frame), according to the type of projection one has chosen from the 'Application->Projection Mode' menu. When in grab mode and more than one frame has been grabbed, the projection is also averaged over all frames. The projections are calculated together with the statistics (at least the straightforward statistics mode is based on the projections), so they are only calculated when the statistics is calculated. When the statistics mode is off, no projections are calculated. When in poll mode, the projections are automatically updated for every new frame that comes in. When poll mode is off, the statistics are only updated when frames are grabbed, or when Analyse from the Image menu is selected.

The yellow line inside the projection area is the projected intensity. When moving the mouse inside the video area, one is able to see a bright green line moving inside the projection area. This is the actual position inside the projection. Over the bright green line there is a number displayed. This is the value of the projected intensity at that position.

Please note that the projection array is normalized, so the biggest value is 1.0.
In addition to the bright green line, there are also 5 dark green lines. These are orientation lines. The first line is at 0.2, the second one at 0.4, the third one at 0.6, the fourth one at 0.8 and the last one at 1.0. Using these lines, one can easily estimate the value at a given point.

In Streak camera statistics mode inside the Y projection frame a estimated bunch length in y is written.

X-Ray Filtering

When grabbing frames during the real experiment, there exists a lot of radiation. The cameras are sensitive to X-rays, which show up in the video signal as peaks. Because these peaks can falsify calculations, there is a filter implemented into the video client. One can switch on X-ray filtering by selecting 'Application->X-Ray filtering'.

To illustrate what this filter does, here a short introduction: To filter out X-rays, one can apply the 'discard-single-peak' algorithm. The idea of this algorithm is to discard pixels of non-zero value that are surrounded by zero value (black coloured) pixels. In addition one can generalize this kind of logic and make all pixels which stick up by more than p=100% over their neighbours equal to the average of the surrounding pixels. The value of p is arbitrary and depends on the working conditions.
The above-described algorithm filters effectively X-ray peaks, as one can see on figures 4a-4b. The measurement corresponding to these figures is made on 08.02.02 and is one of the first measurements done with the new emittance measurement system (EMSY). Figure 4a shows a 3D profile of the beam at the position of EMSY. X-rays are observed as sharp randomly distributed peaks. Figure 4b shows the result of the filter, after application of the filtering procedure (p=100%).

As one can see, the signal is not changed by the filtering procedure, but the filter has effectively removed the X-ray noise.

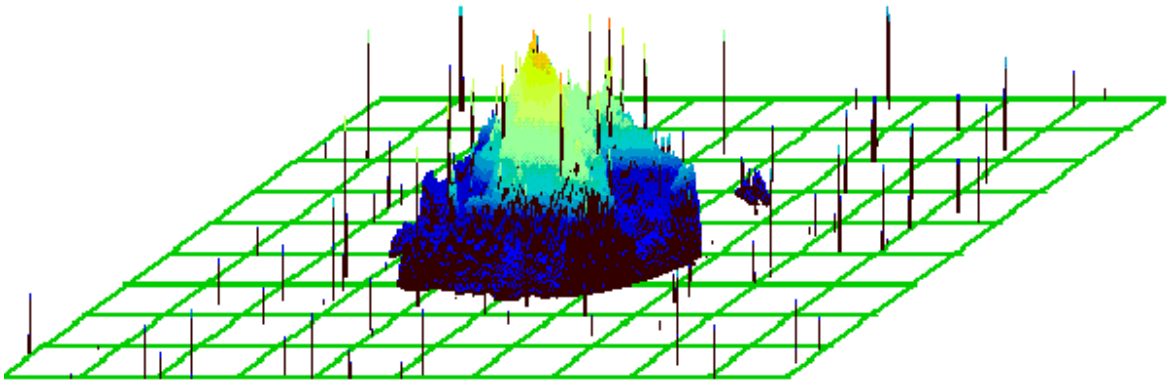

Fig. 4a: non-filtered 3d profile of the beam

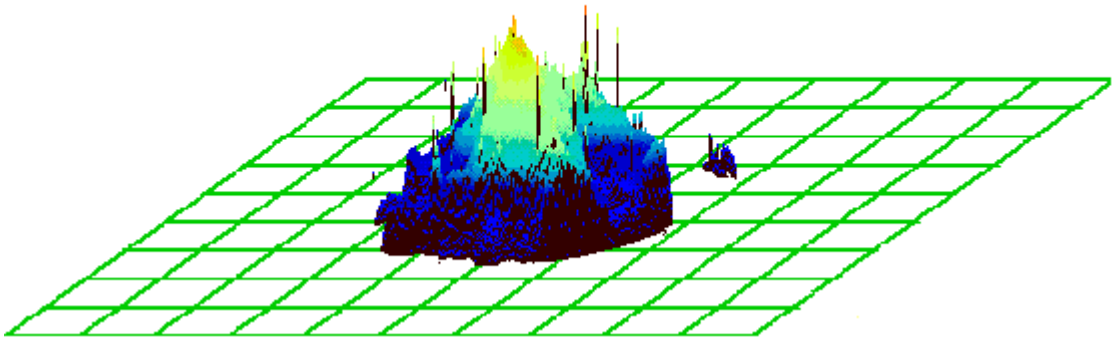

Fig. 4b: filtered 3d profile of the beam

From Video Client version 2 on, X-Ray filtering is not only active in grab mode, but in poll mode, too. When in poll mode, one has to be careful because X-Ray filtering takes a lot of CPU time. X-ray filtering is done together with the statistics and the projections. Even if the statistics is switched off, x-ray filtering will take place if it is switched on. So frames are automatically filtered if X-Ray filtering is switched on. X-ray filtering is applied if:

- frames are polled
- frames are grabbed
- images are loaded
- 'Image->Analyze' is selected or the hotkey 'ALT-A' is pressed

Grab and Poll Mode

In poll mode, images are continuously acquired by the Video Client and displayed on the video area. Before displaying, the data is processed in this order

- apply X-Ray filtering
- subtract the background
- normalize the area of interest
- calculate projections
- calculate statistics according to the selected statistics mode

When statistics is switched off, only the background is subtracted and the normalization is processed, depending whether it is switched on. No statistics calculation will take place. Poll mode consumes a lot of CPU time. Because of this, one has to be very careful when applying x-ray filtering in poll mode. Especially at 10 Hz it will overwhelm a Pentium III 1000 MHz PC. Please note that when poll mode is switched on, some functions of the application are not available because they would interfere with the poll mode. One has to switch poll mode off and is then able to use these disabled functions.

In grab mode, all of the features that are switched on are calculated. Grab mode is also CPU-intensive, but that does not really matter, because all calculations are done offline and not while receiving from the server. The frames are buffered before they are analysed. If one frame is grabbed, the data is processed just like in poll mode.
If more than one frame is grabbed, the calculations are done per frame and are then averaged. Also the displayed image is an average of all grabbed frames.

Grab And Save

In the Image menu one has a special functionality of the program, the so-called Grab and Save mode. This mode is meant for semi-automatic data taking with remote operation of the laser shutter. Using this mode, one can grab n frames

- enveloped background
- envelope frames
- averaged background
- average frames

semi-automatic with much less user interaction than it normally takes.

Before grabbing each background the laser shutter is closed. Before grabbing frames the laser shutter is opened. After a failure or after finishing the operation the laser shutter is reset to the condition where it was before issuing Grab and Save.

After successfully completing the grabbing stage, 8 files are stored to disk. Two files compose the envelope and average frames. These files are stored in IMC format in order not to eat up disk space too much. Another two files are stored for the single background images that are a result of enveloping and averaging the background frames. These files are stored as BKG files. The last two image files are the raw frames that compose the enveloped and averaged background. These files are saved as a slight abbreviation of the IMC file format, the so-called BKC file format. It contains the compressed background images. The last two files are text files and contain important experiment values while grabbing the frames. It can also contain hand-written additional information so that the person who analyses the images later one knows what can be seen on these images.

(Re-)Analysing an Image

Sometimes it happens that some frames were grabbed, but the user forgot to switch on statistics, or wants to apply x-ray filtering. One might have noticed that when statistics or x-ray filtering is switched on, the data is not recalculated. One has to reanalyse the image for the new settings to take effect. After selecting the desired mode from the menu (statistics, projection mode, x-ray filtering or grabbing a new background), one can just select 'Image->Analyze' from the menu or press the hotkey 'ALT-A' to reanalyse the picture. All of the modifications will be applied to the source data. This process can be repeated many times.

Printing

One can print either the video image as it is seen on screen or the whole application window including the toolbar, the projections etc.. This is done via "Application->Print image" or "Application->Print whole window" respectively. After selecting the proper function one can choose the favourite printer. This can be a real printer or e.g. the printer driver for the electronic logbook. The image will always be fitted to the size of half a page. Please note that switching the colour mode to greyscale produces better results on black and white printers. For colour printers, this adjustment is not needed.

Laser Power Measurement

If statistics are switched on, one can easily measure the laser power of the spot as it is seen on screen. This will be only valid for the Virtual Cathode camera. Based on a calibrated lookup-table the laser power in μJ is calculated. Please note that a very good background subtraction (nearly no background left) is needed in order to have a proper result.

Help

There is a small help function inside the Video Client 2. Inside the menu, one can select Help->Quick reference to see a small overview of the program. This function opens the default web browser and displays an html file that is located in the same directory as the executable.

7.2. Loading and Saving

Snapshots

During normal operation, it is important to save some frames that are seen, or store special background images to a file to load them in later. For saving frames, there are two options. Either one can save a snapshot on what is seen on the video screen by pressing F10 or by pressing the 'Snap' button on the toolbar. Using this mode, one gets information in the file exactly as it is seen on the screen (what you see is what you get). This means that the image data is background subtracted, normalized, colour coded and maybe x-ray filtered. The images are saved as BMP files in the directory that has been entered on the preferences dialog. The filename is a special one, it contains the actual date and time. For example if a snapshot was taken on **July 5th**, **2002** at **14:47:12** the filename would be: **snap05_07_2002__14_47_12.bmp** .

Saving Images

In comparison to the snapshot mode one can also save the raw images, as they were grabbed from the frame grabber. When in poll mode, there is 1 picture in the buffer. Using 'Image->Save' this image can be saved. If there were pictures grabbed, the number of pictures in the buffer depends on how many pictures have been grabbed. For example if 10 pictures were grabbed, these 10 pictures are also in the grab buffer and can be saved.

After opening the 'Image->Save' dialog, one can choose which picture format should be used for saving the data. One can either save in the native format of the application, which is IMM/IMC (**IM**age **M**edia, **I**mage **M**edia **C**ompressed) or save them as BMP files to import them into a picture-processing program. The following table outlines the differences:

BMP	IMM/IMC
- can be processed by other programs (e.g. picture processing programs) - colour coded - only one image per file - no scale value can be saved - uncompressed	- can save more than one image in one file - contains the scale value - proprietary - uncompressed (IMM) - approx. 10:1 loss-less compressed (IMC) - raw, unprocessed data

Please note that when BMP files are used, the scale setting is lost, which is saved only in an IMM/IMC file. Also there cannot be a pack of frames into the file (as it is possible to have 10 frames in an IMM/IMC file). Every BMP file just has 1 image in it. If 10 pictures are saved, 10 BMP files are written to disk.

When saving a buffer that has more than one image in it as BMP files, there is a string appended to each BMP file containing the number of the image. For example if a buffer that contains three images is saved and the base file name is 'test', the three images would be written as: test0.bmp, test1.bmp, test2.bmp .

In addition to the BMP images, the actual background is stored as 'test_bkg.bmp'. When saving an IMM file, the background is stored as a BKG file. For more information on BKG files, please look at the next section 'Saving Backgrounds'.

When writing images, the raw image and not the image that is seen on the screen is saved. The saved image is not processed in any kind. That means no background is subtracted, no area of interest is normalized and no x-rays are filtered. BMP files have 8 bit palletised colours and are uncompressed.

When saving images, it is possible to save a text file together with the image. This file contains the current settings of the experiment and some additional information one can enter on a special dialog. Just enter or modify the information to meet your requirements.

Saving Backgrounds

In addition to saving images, where the background is stored automatically together with the image, one can also save the background separately, using 'Background->Save' from the menu. As for saving images, one has the option between two file formats when saving backgrounds: BKG files and BMP files. The advance of the BMP file format is that these files can be loaded into a picture-processing program while the BKG format is proprietary. One should use BKG files if he background should be loaded in again into the video client. BMP files should be used to export the images to other applications. As pictures, backgrounds have the same characteristics. They have a varying width and height and each pixel has 8 bits resolution.

Loading Images

As for saving images, one has two file format choices when loading images. These two formats are BMP and IMM/IMC. Please note that saved BMP files, cannot be loaded in as a bunch. For example, if 10 pictures were saved out of the grab buffer as BMP files, it is **not** possible to load them in so that there are 10 images in the grab buffer. If these images should be loaded in a bunch, one has to use IMM or IMC files.

After opening the Image->Load dialog, one has to select the desired file format and the proper file. If there is some error while loading, the program will tell. The most common error is to load arbitrary BMP files. Please look into the subsection 'Loading Arbitrary Images' what to do if the image does not comply. Images must be uncompressed and use 8-bit colour depth.

Loading Background

As for saving backgrounds, one has two file format choices when loading backgrounds. These two formats are BKG and BMP. After opening the Background->Load dialog, one has to select the desired file format and the proper file to load. If there was an error while loading, the program will tell.

Loading Arbitrary Images

It is possible to load arbitrary images into the Video Client 2 in order to analyse them. But two conditions must be met when loading in BMP files. One has to make sure that the image uses 8 bits per pixel and that the image is uncompressed. Width and height of the image does not matter, one can load in whatever width and height the image might have.

If an compressed image or an image with a different colour depth should be loaded in, one should load the image into a picture processing program like Corel Photo Paint or Adobe Photoshop and modify the image properties to meet the requirements. After modification, the image should be saved as BMP and loaded into the Video Client.

7.3. The Background

In this subsection, some information on the background subtraction functionality is given. Please note that loading and saving of backgrounds is discussed in subsection 6.2 .

Grab a Background

Sometimes during grabbing or polling frames, it would be good to subtract a background from the image. Background subtraction is a common method to eliminate static noise from the video signal. A known source of static noise is dark current or reflections of the diagnostic devices.

When poll mode is switched off, one can easily grab a background. The grabbed background is then shown on the video window. The port control 'Port' signals that there is a background shown by showing 'BCKGND'. After grabbing a background, the background is subtracted from all images that come from the server or are loaded in. If one wants to throw away the background, it can be cleared. (see subsection 'Clear Background')

Add a Background

One can not only grab a background, but also add a background image to the current background image. One might want to create a combination of two background images. This can be done with the Background->Add menu entry. The grabbed background will be added to the current background.

Get a Background (Envelope and Average)

The result of the 'Get Background' process is the same as when grabbing a background. One will get one background image which will be subtracted from all images that come from the server or are loaded in. But the process how the background is created is a bit different.

For the 'Average' method, five, ten or more backgrounds are taken one after another. The real background image is the result of averaging all taken background images.

The 'Envelope' method is a bit different. Just like in the 'Average' method, five, ten or more backgrounds are grabbed. Then the algorithm looks for each pixel which of the taken background images has the maximum pixel value. This maximum value is stored into the appropriate pixel field of the resulting background image.

Both methods work better than just grabbing a single background when one wants to eliminate static noise from the video signal. In practice, the 'Envelope' method is significantly better than the 'Average' method.

For nearly perfect background subtraction the author recommends the 'Envelope' method using 10 or more pictures as basis.

Show a Background

The current background can be shown by selecting 'Background->Show' from the menu. Please note that showing the background is only possible when poll mode is switched off. The port control signals that there is a background shown by showing 'BCKGND'. One can continue with the analysis after inspecting the background. Nothing of the internal data buffer is changed. On the next operation that updates the video frame, the background is replaced by an analysed picture.

Clear a Background

When the current background is not needed any more, one can clear it at any time by selecting 'Background->Clear' from the menu. The background is then reset to pure black, which results in no background being subtracted in subsequent analysis. One can even clear the background while in poll mode. It should be noted that the current background is cleared if the camera port is switched by hand. Under normal conditions it makes no sense to use the background taken on one camera port on another camera port.

8. Keystrokes and Mouse

Using the application, one can not only use the mouse to access the functions. Some actions are mapped to accelerator keys. The following table shows the hotkeys of this application.

Hotkey	Description
F2	Switches statistics mode to Fourier statistics
F3	Switches statistics mode to straightforward statistics
F4	Switches all statistics off, also: no normalization takes place
F5	Switches the color palette to grayscale
F6	Switches the color palette to false colors
F10	Take a snapshot from what is seen inside the video frame
ALT-A	(Re-)Analyse the current frame buffer (can be loaded, grabbed or the last polled frame(s))
ALT-P	Switch poll mode on/off
CTRL-G	Grabs a background and shows it on the video frame
CTRL-S	Shows the actual background on the video frame
CTRL-C	Clears the background image (no background subtraction)

The mouse can be used for three special operations inside the video window. By applying a right-click inside the video window, one can start and respectively stop poll mode. By issuing a left click inside the video window without moving the mouse one can reset back the area of interest to the whole video window and can trigger reanalysis of the current image in the buffer. By doing a left click inside the video window and dragging the mouse (click and drag) one can set up the area of interest.

9. Frequently Asked Questions (FAQ)

1. *The Program keeps saying that it could not load the camera names from any server. In addition, the camera control on the toolbar is greyed out. What is wrong?*

   This can have more than one reason. In most cases, the TINE protocol is not functioning correctly. This can be either due to not correctly installed TINE distribution on your PC or that the TINE ENS (Equipment Nameserver) on Corvus is not running as it should be. Another possibility is that all grabber servers are not running.

   At first you should check whether the TINE (**T**hree-fold **I**ntegrated **N**etwork **E**nvironment) distribution is installed properly on your PC. If this is true, you should ask the responsible person for the Video System why the grabber server(s) is/are not running.

2. *On start up, the program complains that some (not all) video servers could not be contacted. What is wrong ?*

   This is mostly the case that some servers are just switched off due to maintenance or other reasons. After the program has started successfully, one should check whether all cameras one needs are listed in the camera control on the toolbar. If this is the case, no further action is necessary. If this is not the case, one should contact the person responsible for the video system.

3. *I am trying to start the program, but it refuses to start or complains that there is some dll missing.*

   Please double check whether the TINE (**T**hree-fold **I**ntegrated **N**etwork **E**nvironment) distribution is installed on your PC. If it is installed, it is most likely that it is not installed properly. Please reinstall it. If it is not installed, please install it and all problems should disappear.

   Another possibility could be that TINE is installed (you can check that by having an Instant Client application running on the PC), but the TINE ActiveX control (ACOP) the Video Client needs is not registered properly. You can recognize this by double clicking on the Video Client icon. If nothing happens and the program does not show up in the Task Manager, it is most likely that the ACOP control is not registered properly. To register it, open a command line, go to <WINDOWS HOME DIR>\system32\ and execute "regsvr32.exe ACOP.ocx". After executing this, the Video Client should start up without problems.

   If it still does not work, you should check whether the three DOOCS DLLs needed for reading out variables like Klystron Forward Power are located in the Video Client's directory. These three DLLs are DoocsAPI.dll, EqClient.dll and sunrpc.dll. If any of the files is not located in the program's directory, you should copy the DLLs from S:\znp\pitz\Video System\Video Client 2\Precompiled\Normal Version\ .

4. *I am polling from the server, but no image is displayed on the screen and the 'Frames polled' control does not increment. What is wrong?*

   Maybe there is no camera connected on the port you have chosen. It can also mean that the camera is switched off. Another possible problem could be that there is no trigger signal on the camera or that the camera is not configured properly. The easiest way is to select another camera port. If there are still no frames polled you should talk to the person responsible for the video system.

5. *The DAQ function is not working. Well, it is working but there are no proper values written to the file. What is wrong?*

   In most cases the DOOCS control system client library is not working as expected. This could be due to a missing/wrong ENSHOST environment variable pointing to none or missing ENS (Equipment Name Server). Another reason, if only some of the properties are missing are that the responsible DOOCS servers are just switched off (mainly in shutdown periods). Mostly this problem cannot be solved by users of the Video Client 2. One should contact the people responsible for the control system or the person responsible for the video system.