Install and run the ETH particle tracking velocimetry (PTV) code under Microsoft Visual Studio 2005

- Download and install Active Tcl/Tk into C:\Program Files\Tcl (it is the things that make the GUI work if you don't have it go http://www.tcl.tk/ and install it).
- Decompress the self-extractable compressed file "PTV_VisualStudio2005.exe"- remember the folder you've chosen (e.g. E:\test).
- After decompression, you'll find a folder with the same name: PTV_VisualStudio2005 inside you find the ScanPTV.vcproj and double-click to open it with the Visual Studio 2005
- The file ptv.tcl is included; edit the second line (shown in **fig1**). For example, if you decompress it in E:\test then the second line should be E:\test\...... (don't touch the rest, plz)
- Set auto_path "E:/test/PTV_VisualStudio2005/Debug . $auto_path"
- That's it: Press the green arrow (or Debug -> Start Debugging or press F5) and that's it. all the rest is included in the proper order. If you want to change the Debug and make Release version, think :-)

After these steps you should be able to run the project that you see what is shown in **fig2**. If you don't see this contact Beat or Alex or Markus.

How to calibrate using a single plane?

In your "working folder" there are three folders called "img", "parameters", and "res". We are using the "Tu/e-Jet" test data. First a few preparations:

- In "Change parameters"->"Main parameters" for calibration you need to adapt 5 fields: 1) Number of cameras=4, "Refractive inices" 2) air=1.33, 3) glass=1.33, 4) water=1.33, thickness of glass=1. Yes, this is not very physical but there is a simple explanation: The "Tu/e-jet" setup uses prismas at the interface air water. The effect is that all the rays towards the camera cross the water/air interface at a very perpendicular angle. In the optical model we can treat this by lying to the code and by pretending that the entire experiment, including the cameras, is inside water.
- Copy the file "a_plane.txt" containing the true coordinates of your calibration plate into the "working folder". It has 25 points numbered from upper left to lower right. Plane "a" is 186mm away from the glass interface.
- Copy the calibration images "calib_<a>_cam<1-4>.tif" into the folder "img".
- Adjust the some setting under "Change Parameters"->"Change Calibration Parameters", as shown in **fig3**. You tell the program many things: Where it should look for the calibration images, where it should look for the files with your initial guess, where it should look where the points are located in real world, how big the pictures are (pixel * pixel), how large each pixel is, gray value threshold and stuff for point detection, and which 4 of the 25 possible calibration points you will manually click and thereby "teach" the program where the cameras are. The fields "Calibrate with different z-positions" and "Combine preprocessed plane" are set to zero, because here we are doing single target calibration.
- This is an important and 'easy to get wrong' step: Provide the four files with you initial guess of where the cameras are and how they are oriented. The easy way is: copy the files cal<1-4>.ori into the folder "working folder". The hard way is: Sit down

and figure them out yourself or verify, why cal<1-4>.ori are as they are. The first row is the camera position. The second row tells how the camera is rotated around x, y, and z-axis. Don't worry about the 3*3 matrix. Don't worry about the second last row. The last number is very important: it tells the 'focal distance'. How can it be guessed: In Our situation we have an ratio of "world image" to "Chip image" of 500mm to 65mm (384 pixels mal 17microns), e.g. 1:8. The distance fro lens to calibration target is about 800mm. Hence our focal distance is about 100mm. Don't continue if you don't understand this step. The situation of the setup is sketched in **fig4**. See **fig5** for an initial guess that works.

Now, we come to the actual calibration:

- In "Calibration" click "Show calib images".
- Then click detection. You should get 25 detections for each image. If you don't detect all it is still ok. The only requirement is that those points that are defined in "Point number for manual pre-orientation" are detected.
- Click "Manual orientation". You are then asked to click each of the four points of each image. Once you have successfully done this you can check your clicks with the menu "Orientation with file". It should look like **fig6**. Again if you are confused at this step do not continue, but think again or ask for help.
- To give you a feedback how good or bad your initial guess is you can use "Show initial guess". The yellow dots show where the dots from the calibration plane would end up on your images if the initial guess would be correct.
- To establish which detected point belongs to which calibration point click "Sortgrid". There is little you can do, but to check that the outcome looks like **fig7**.

Four files have been produced "raw<1-4>.ori" and they are next to your initial guesses. Have a look at them. Thee first six numbers are changed, i.e. camera position and orientation have been adapted. They will be used as starting values for the actual calibration in the next step.

- Click "Orientation". If all goes well you should get something like in **fig8**. You will find 8 new files created next to your calibration image files. There names are like your calibration images, but with .ori and .addpar appended. They contain the calibration your final result.

How to calibrate using multiple planes?

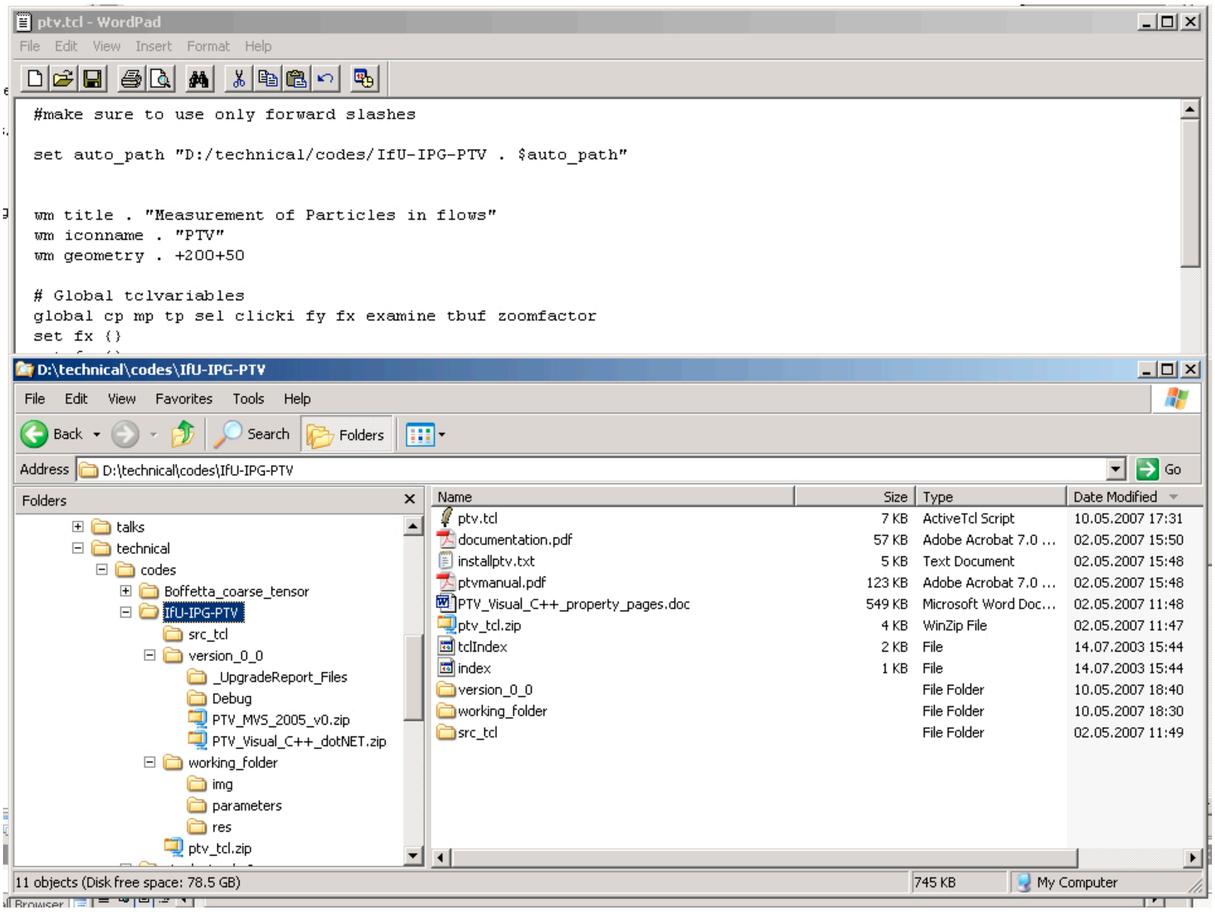
Don't do this before you have understood and done a single plane calibration. Basically, now you have to tell the code that you will do a multi plane calibration and then you perform one calibration per each plane plus a final calibration that combines it all.

- Under “Change calibration parameters” set the field of “Calibrate with different z-positions” to “1”.
- For each plane you have to: 1) adjust image file names, adjust “File of coordinates on Plate”, 2) perform sequence of steps “Show calib. images”, “Detection”, “Manual orientation” (use “Orientation with file” as a hint) , Sortgrid, and Orientation.
- Usually it is a good idea to restart the program after such a step.

You will see that after “Orientation” next to your calibration images 12 new files have been created. 4* .ori: never mind those. 4* .crd: they contain the metric image coordinates of the calibration dots for each camera. 4*.fix: they contain the corresponding real world coordinates of each image dot. The “crd” and “fix” files will be used of the program for the final step. Now, you tell the program that it is about to perform the last step, a combined calibration where the dots of all calibration planes will be jointly used.

- Create or change a file in the folder “parameter” that is called “multi_planes.par”. It defines 1) how many planes you use, and 2) what the base name of each plane is. Please have a look at **fig9**.
- In “Change calibration parameter” you have to change the image file names to something new, e.g. “img/calib_d_cam<1-4>.tif. “d” is reflecting that now from the previous planes a-c we will create a virtual target (**fig9**)
- Below you have to set the flag “Combine preprocessed planes?” to “1”, see **fig9**. In addition you can check the fields “xp” and “yp”. This allows for an image center that is offset to the centre optical axis.
- In addition you may choose to use more parameters for your calibration like “k1”, “k2” etc. However, usually these parameters don’t bring lot of gain and sometime lead to a crash of the operation “Orientation”.
- Restart the program, click “Show calib. images” and then immediately “Orientation”.

If all went well you are done. You should see something like in **fig10**. Next to you image files 8 new files (4 .ori and 4 .addpar) have been created. They contain your final multi-plane calibration. You may choose to experiment with different settings of calibration parameters (k1, k2, etc..) to further improve the quality.


ptv.tcl - WordPad
File Edit View Insert Format Help
#make sure to use only forward slashes
set auto_path "D:/technical/codes/IfU-IPG-PTV . $auto_path"
wm title . "Measurement of Particles in flows"
wm iconname . "PTV"
wm geometry . +200+50
Global tclvariables
global cp mp tp sel clicki fy fx examine tbuf zoomfactor
set fx ()
D:\technical\codes\IfU-IPG-PTV
File Edit View Favorites Tools Help
Back
Search
Folders
Address D:\technical\codes\IfU-IPG-PTV
Go
Folders
talks
technical
codes
Boffetta_coarse_tensor
IfU-IPG-PTV
src_tcl
version_0_0
_UpgradeReport_Files
Debug
PTV_MVS_2005_v0.zip
PTV_Visual_C++_dotNET.zip
working_folder
img
parameters
res
ptv_tcl.zip
Name
Size
Type
Date Modified
ptv.tcl 7 KB ActiveTcl Script 10.05.2007 17:31
documentation.pdf 57 KB Adobe Acrobat 7.0 ... 02.05.2007 15:50
installptv.txt 5 KB Text Document 02.05.2007 15:48
ptvmanual.pdf 123 KB Adobe Acrobat 7.0 ... 02.05.2007 15:48
PTV_Visual_C++_property_pages.doc 549 KB Microsoft Word Doc... 02.05.2007 11:48
ptv_tcl.zip 4 KB WinZip File 02.05.2007 11:47
tclIndex 2 KB File 14.07.2003 15:44
index 1 KB File 14.07.2003 15:44
version_0_0 File Folder 10.05.2007 18:40
working_folder File Folder 10.05.2007 18:30
src_tcl File Folder 02.05.2007 11:49
11 objects (Disk free space: 78.5 GB)
745 KB
My Computer
Figure 1

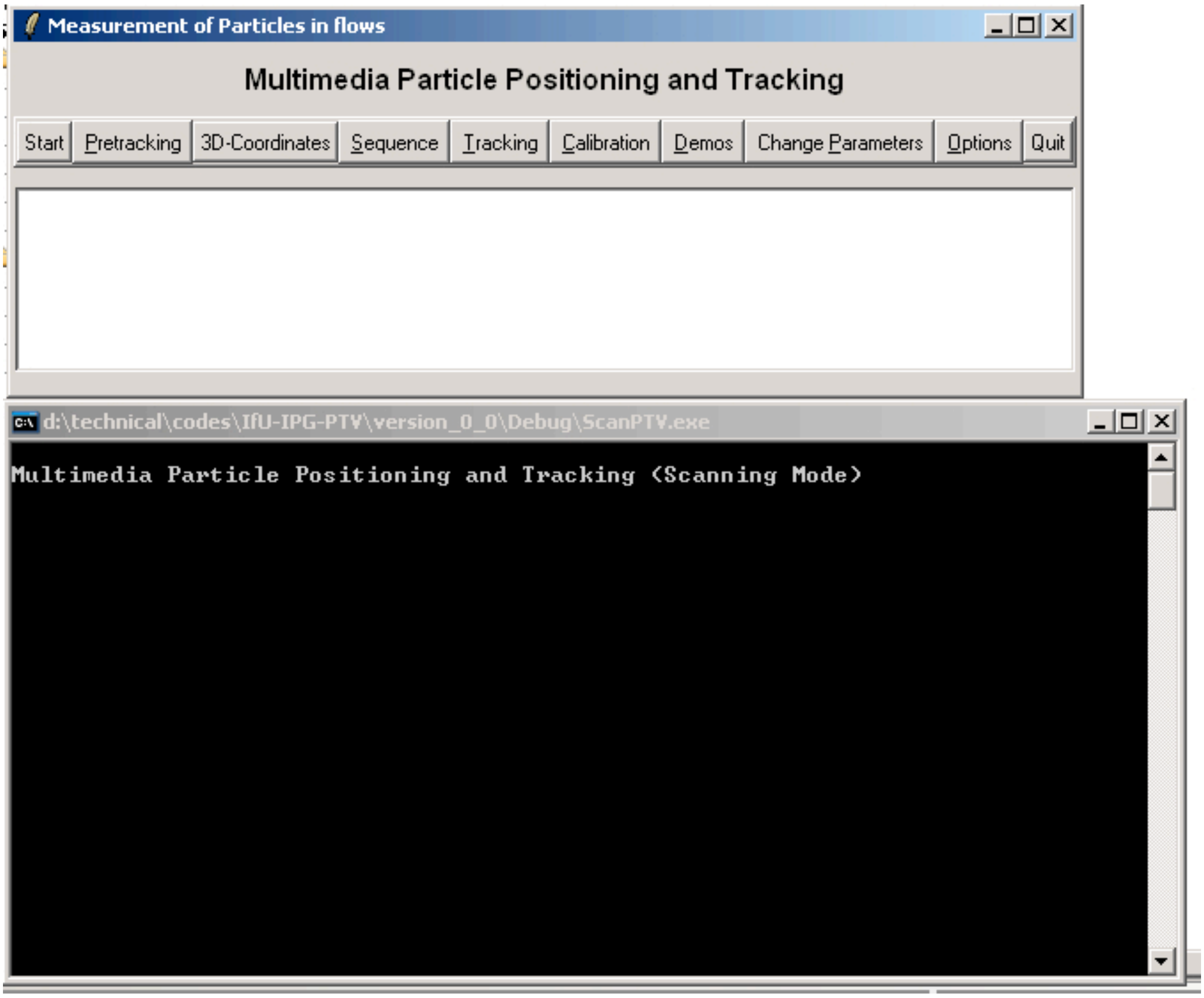

Measurement of Particles in flows
Multimedia Particle Positioning and Tracking
Start
Pretracking
3D-Coordinates
Sequence
Tracking
Calibration
Demos
Change Parameters
Options
Quit
d:\technical\codes\IfU-IPG-PTV\version_0_0\Debug\ScanPTV.exe
Multimedia Particle Positioning and Tracking (Scanning Mode)

Figure 2

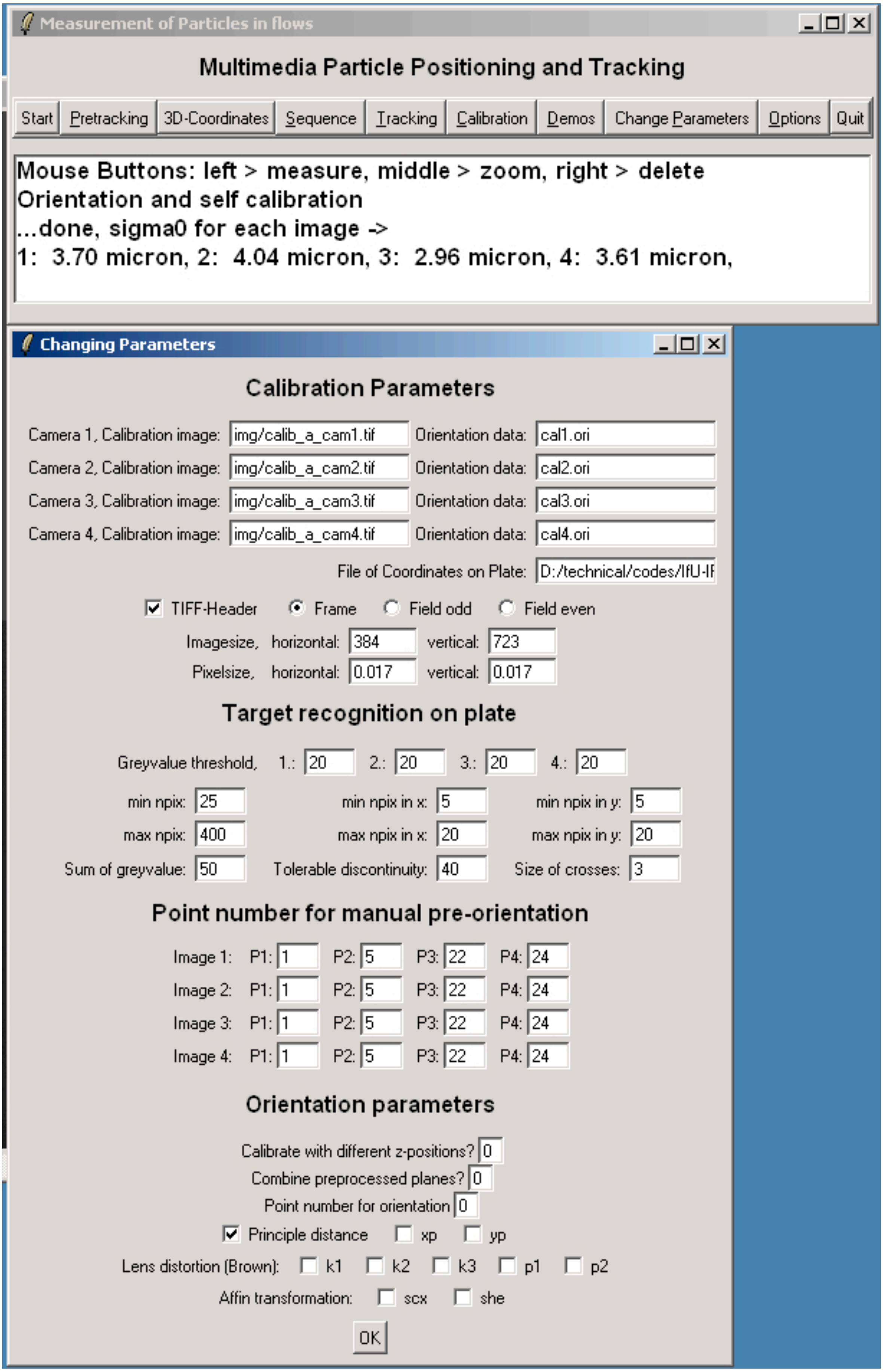

Measurement of Particles in flows
Multimedia Particle Positioning and Tracking
Start
Pretracking
3D-Coordinates
Sequence
Tracking
Calibration
Demos
Change Parameters
Options
Quit
Mouse Buttons: left > measure, middle > zoom, right > delete
Orientation and self calibration
...done, sigma0 for each image ->
1: 3.70 micron, 2: 4.04 micron, 3: 2.96 micron, 4: 3.61 micron,
Changing Parameters
Calibration Parameters
Camera 1, Calibration image: img/calib_a_cam1.tif Orientation data: cal1.ori
Camera 2, Calibration image: img/calib_a_cam2.tif Orientation data: cal2.ori
Camera 3, Calibration image: img/calib_a_cam3.tif Orientation data: cal3.ori
Camera 4, Calibration image: img/calib_a_cam4.tif Orientation data: cal4.ori
File of Coordinates on Plate: D:/technical/codes/IfU-IF
TIFF-Header
Frame
Field odd
Field even
Imagesize, horizontal: 384 vertical: 723
Pixelsize, horizontal: 0.017 vertical: 0.017
Target recognition on plate
Greyvalue threshold, 1.: 20 2.: 20 3.: 20 4.: 20
min npix: 25 min npix in x: 5 min npix in y: 5
max npix: 400 max npix in x: 20 max npix in y: 20
Sum of greyvalue: 50 Tolerable discontinuity: 40 Size of crosses: 3
Point number for manual pre-orientation
Image 1: P1: 1 P2: 5 P3: 22 P4: 24
Image 2: P1: 1 P2: 5 P3: 22 P4: 24
Image 3: P1: 1 P2: 5 P3: 22 P4: 24
Image 4: P1: 1 P2: 5 P3: 22 P4: 24
Orientation parameters
Calibrate with different z-positions? 0
Combine preprocessed planes? 0
Point number for orientation 0
Principle distance
xp
yp
Lens distortion (Brown): k1 k2 k3 p1 p2
Affin transformation: scx she
OK

Figure 3

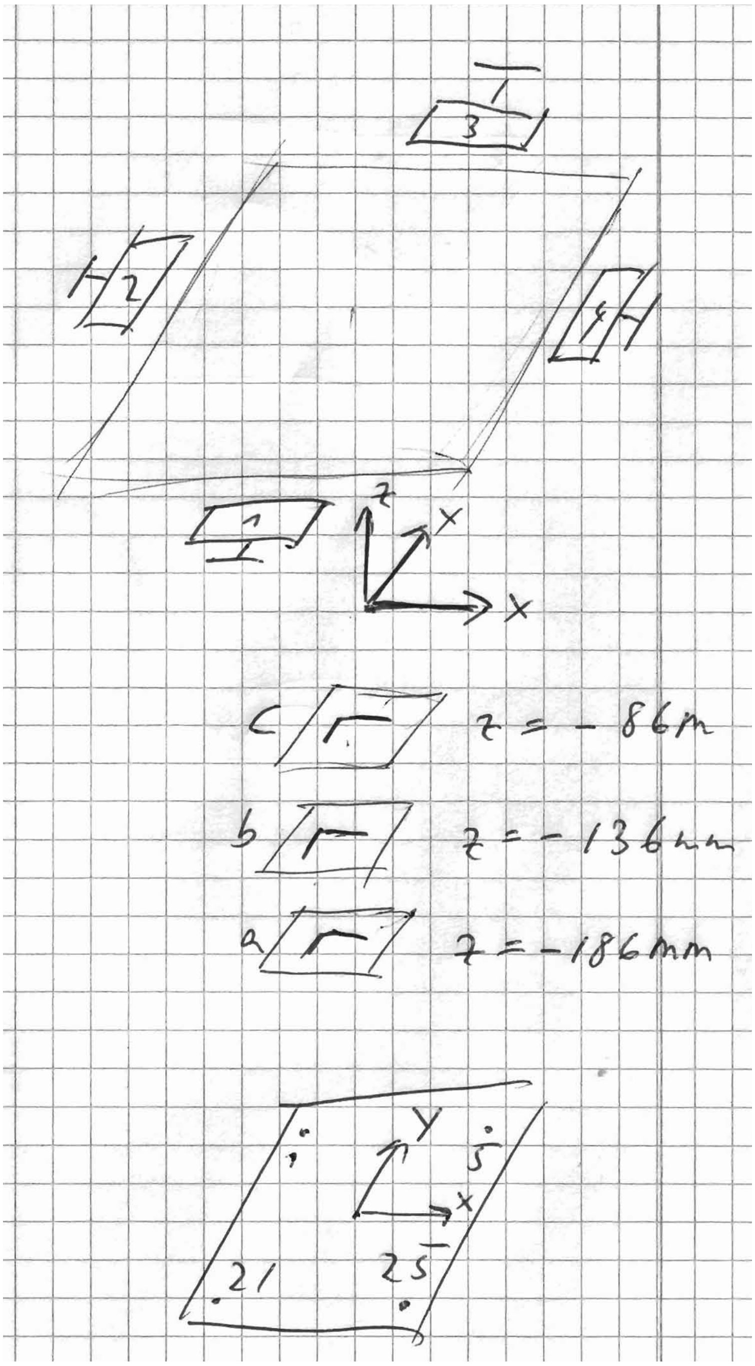


Figure 4

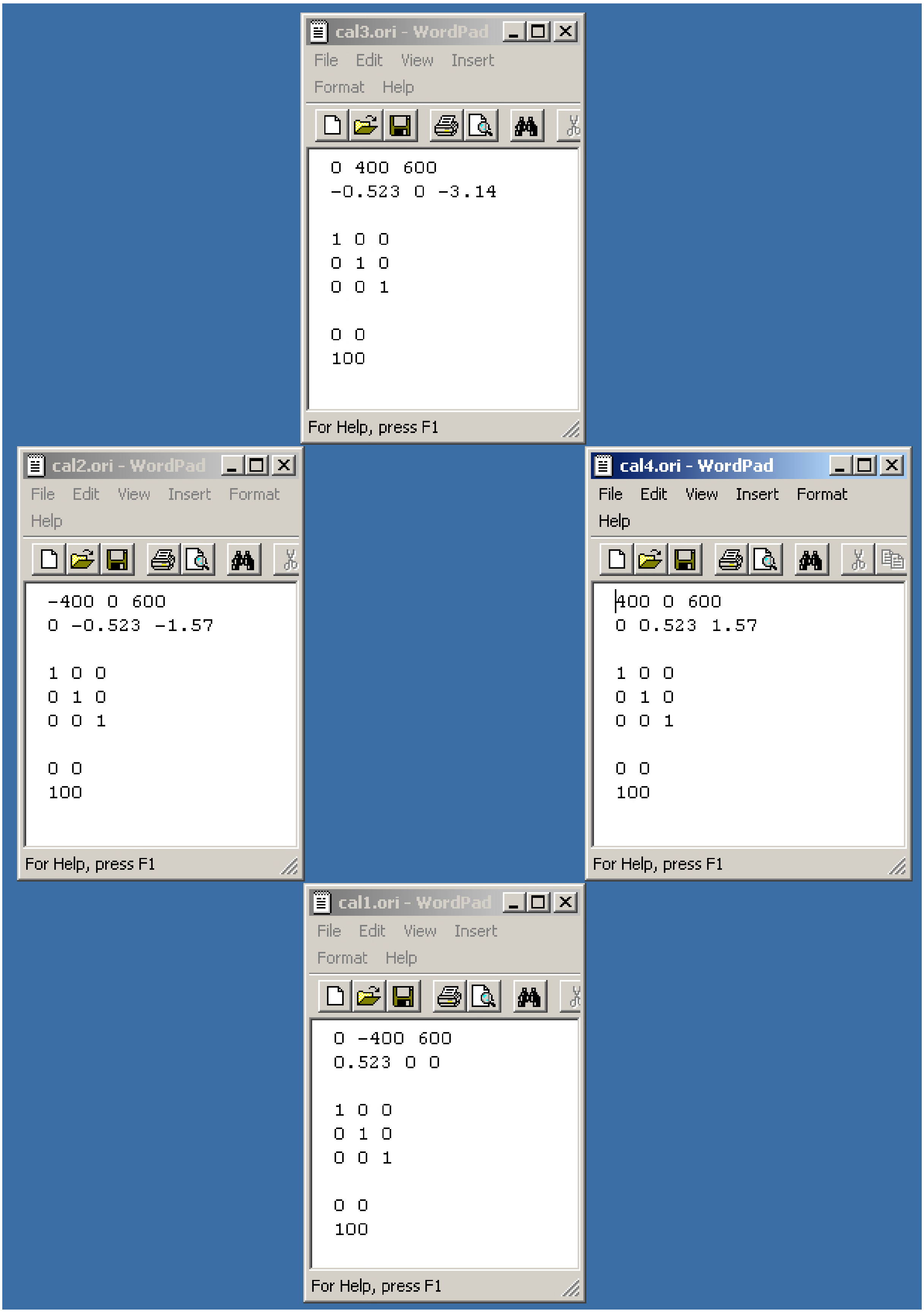

cal3.ori - WordPad
File Edit View Insert Format Help
0 400 600
-0.523 0 -3.14
1 0 0
0 1 0
0 0 1
0 0
100
For Help, press F1
cal2.ori - WordPad
File Edit View Insert Format Help
-400 0 600
0 -0.523 -1.57
1 0 0
0 1 0
0 0 1
0 0
100
For Help, press F1
cal4.ori - WordPad
File Edit View Insert Format Help
400 0 600
0 0.523 1.57
1 0 0
0 1 0
0 0 1
0 0
100
For Help, press F1
cal1.ori - WordPad
File Edit View Insert Format Help
0 -400 600
0.523 0 0
1 0 0
0 1 0
0 0 1
0 0
100
For Help, press F1

Figure 5

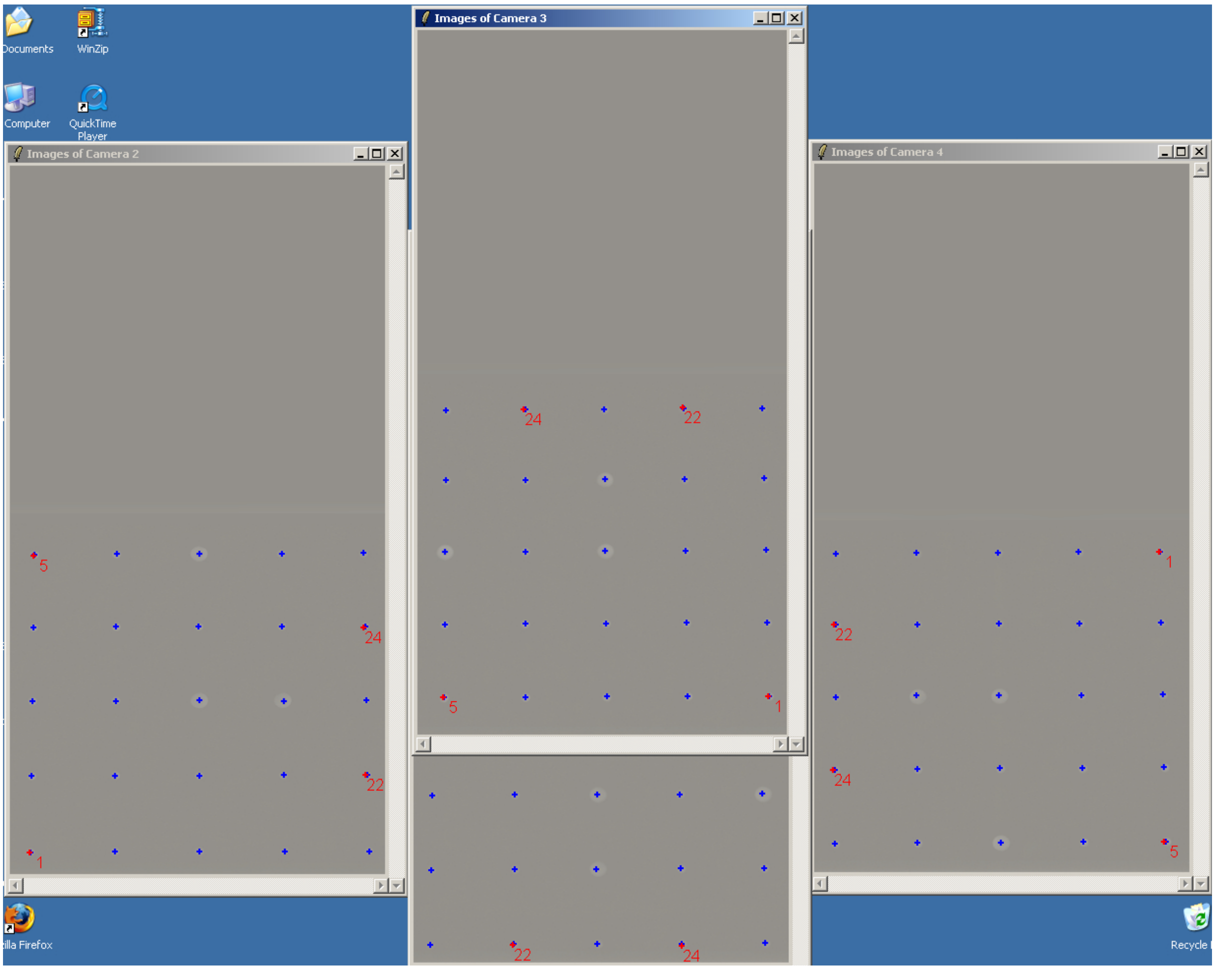

Documents
WinZip
Computer
QuickTime Player
Images of Camera 2
Images of Camera 3
Images of Camera 4
5
24
22
1
24
22
5
1
22
24
1
22
24
5
lla Firefox
Recycle

Figure 6

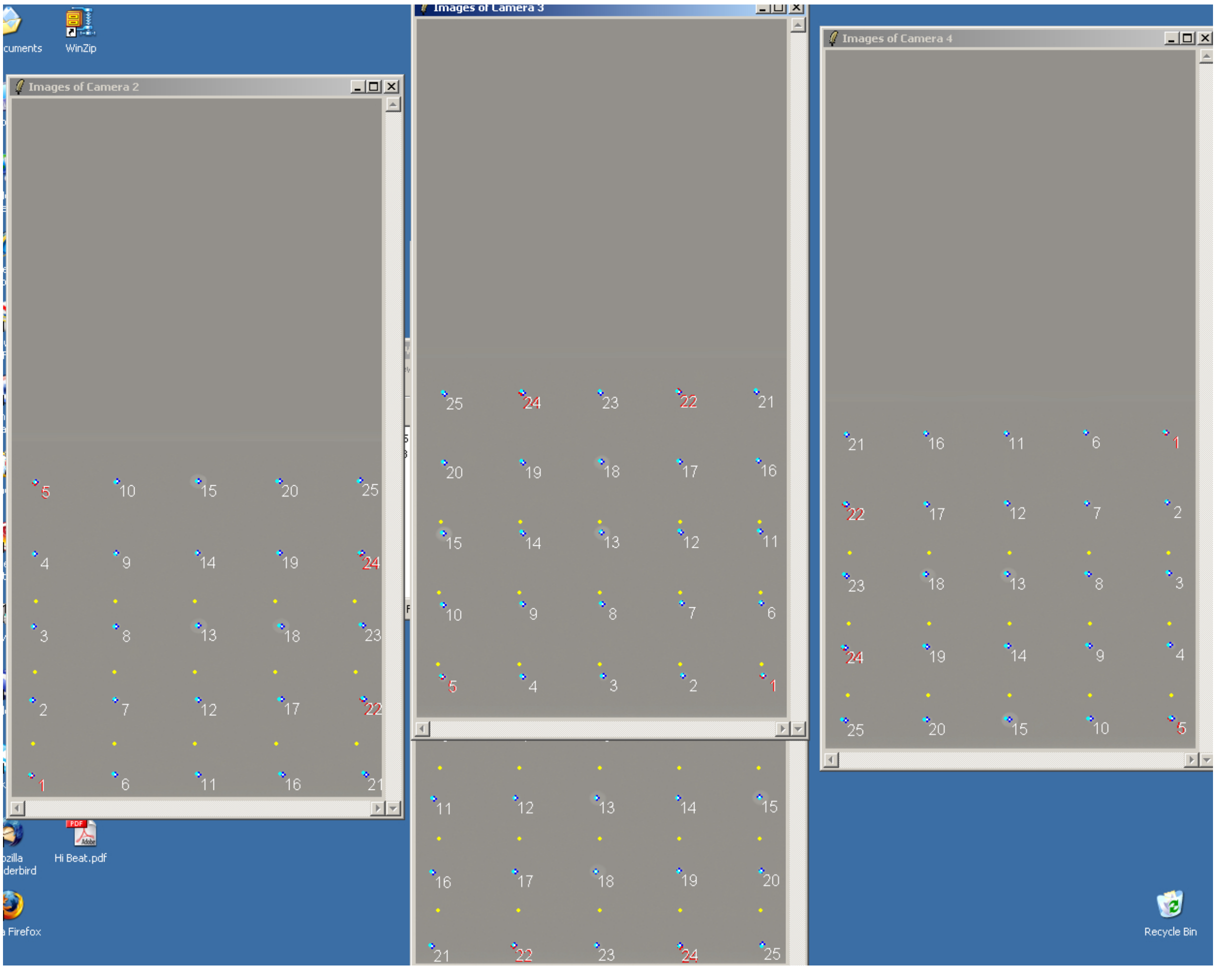

Images of Camera 2
Images of Camera 3
Images of Camera 4
WinZip
Hi Beat.pdf
Recycle Bin

Figure 7

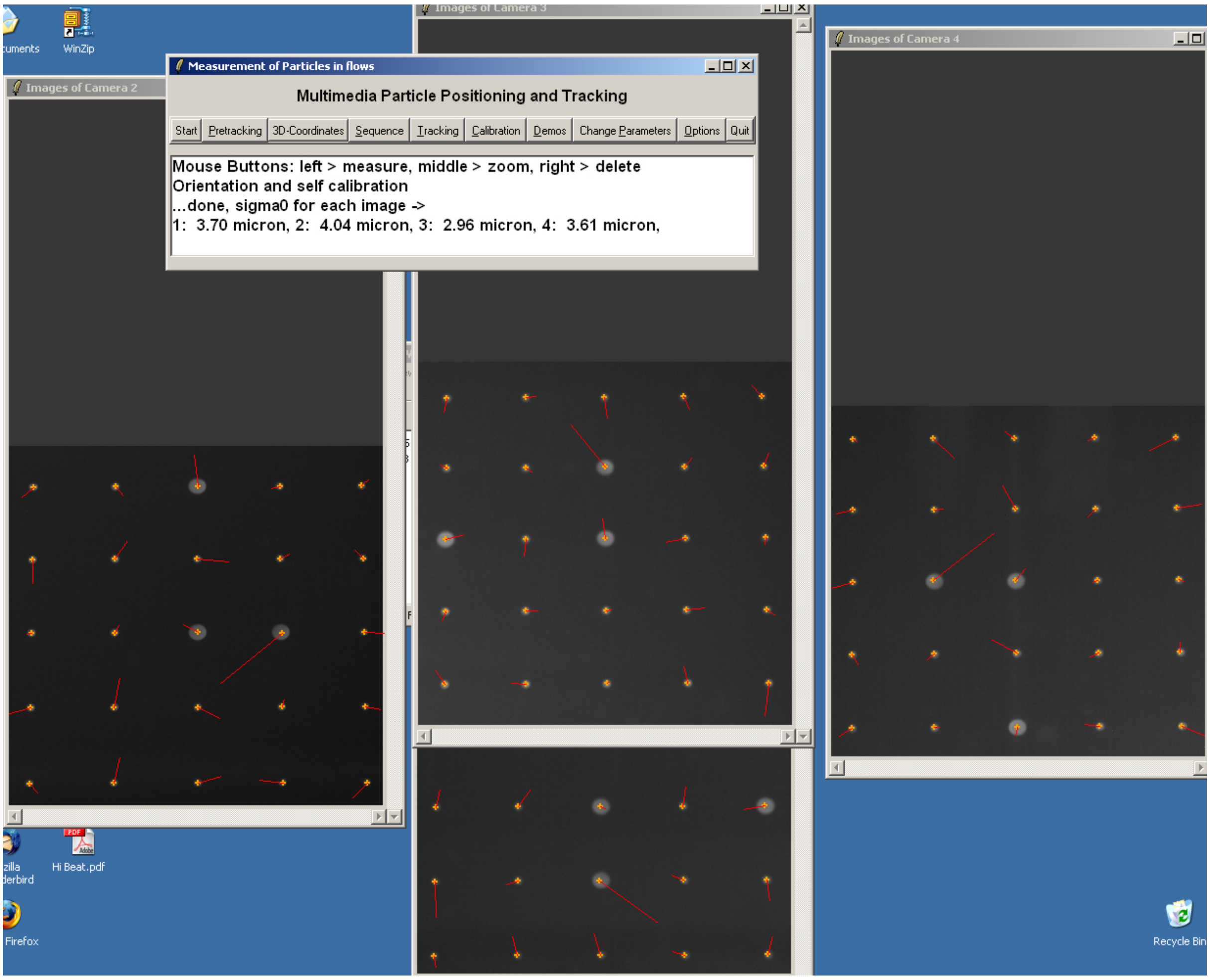

Measurement of Particles in flows
Multimedia Particle Positioning and Tracking
Start
Pretracking
3D-Coordinates
Sequence
Tracking
Calibration
Demos
Change Parameters
Options
Quit
Mouse Buttons: left > measure, middle > zoom, right > delete
Orientation and self calibration
...done, sigma0 for each image ->
1: 3.70 micron, 2: 4.04 micron, 3: 2.96 micron, 4: 3.61 micron,
Images of Camera 2
Images of Camera 3
Images of Camera 4
WinZip
Hi Beat.pdf
Firefox
Recycle Bin

Figure 8

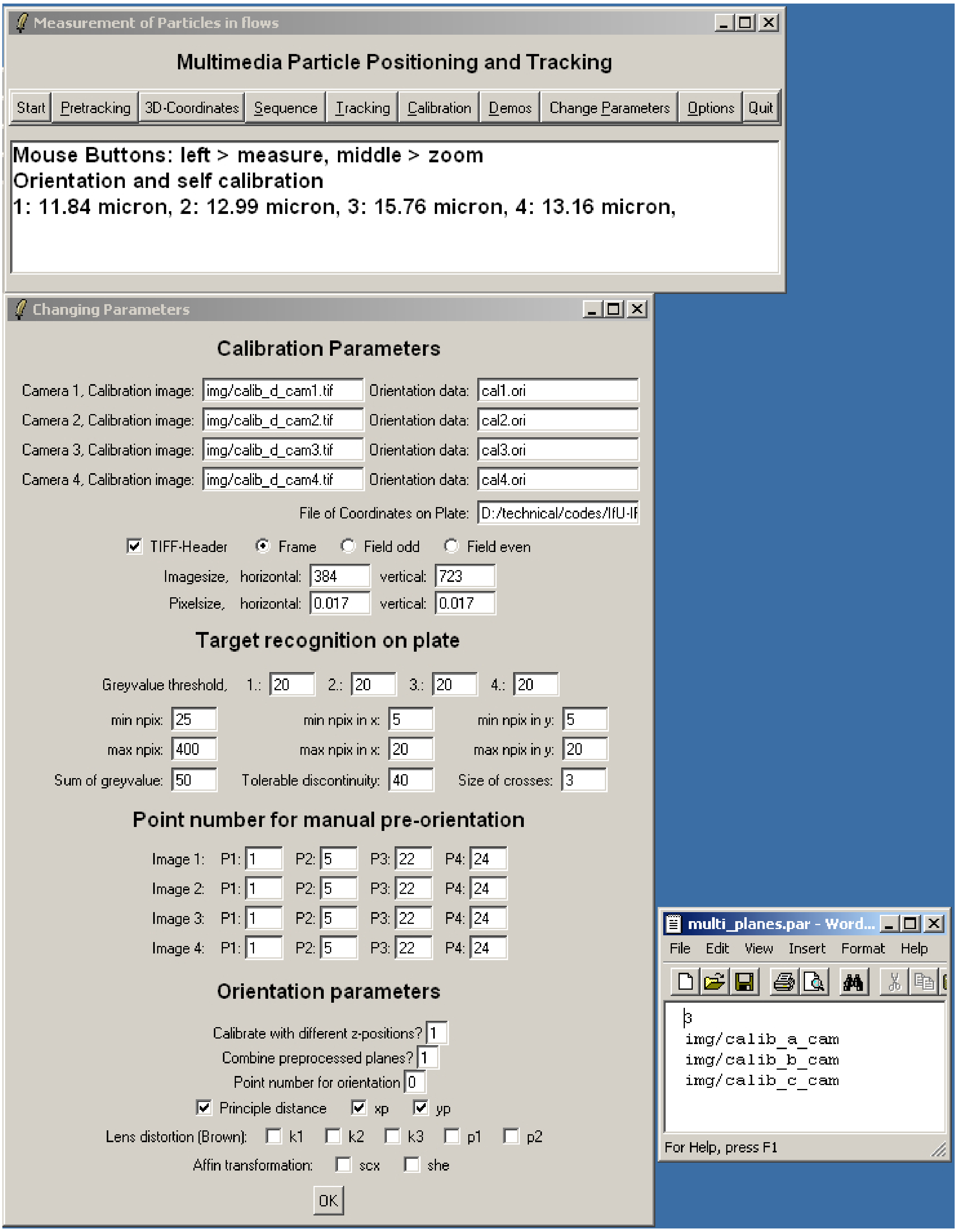

Measurement of Particles in flows
Multimedia Particle Positioning and Tracking
Start Pretracking 3D-Coordinates Sequence Tracking Calibration Demos Change Parameters Options Quit
Mouse Buttons: left > measure, middle > zoom
Orientation and self calibration
1: 11.84 micron, 2: 12.99 micron, 3: 15.76 micron, 4: 13.16 micron,
Changing Parameters
Calibration Parameters
Camera 1, Calibration image: img/calib_d_cam1.tif Orientation data: cal1.ori
Camera 2, Calibration image: img/calib_d_cam2.tif Orientation data: cal2.ori
Camera 3, Calibration image: img/calib_d_cam3.tif Orientation data: cal3.ori
Camera 4, Calibration image: img/calib_d_cam4.tif Orientation data: cal4.ori
File of Coordinates on Plate: D:/technical/codes/IfU-IF
TIFF-Header Frame Field odd Field even
Imagesize, horizontal: 384 vertical: 723
Pixelsize, horizontal: 0.017 vertical: 0.017
Target recognition on plate
Greyvalue threshold, 1.: 20 2.: 20 3.: 20 4.: 20
min npix: 25 min npix in x: 5 min npix in y: 5
max npix: 400 max npix in x: 20 max npix in y: 20
Sum of greyvalue: 50 Tolerable discontinuity: 40 Size of crosses: 3
Point number for manual pre-orientation
Image 1: P1: 1 P2: 5 P3: 22 P4: 24
Image 2: P1: 1 P2: 5 P3: 22 P4: 24
Image 3: P1: 1 P2: 5 P3: 22 P4: 24
Image 4: P1: 1 P2: 5 P3: 22 P4: 24
Orientation parameters
Calibrate with different z-positions? 1
Combine preprocessed planes? 1
Point number for orientation 0
Principle distance xp yp
Lens distortion (Brown): k1 k2 k3 p1 p2
Affin transformation: scx she
OK
multi_planes.par - Word...
File Edit View Insert Format Help
3
img/calib_a_cam
img/calib_b_cam
img/calib_c_cam
For Help, press F1

Figure 9

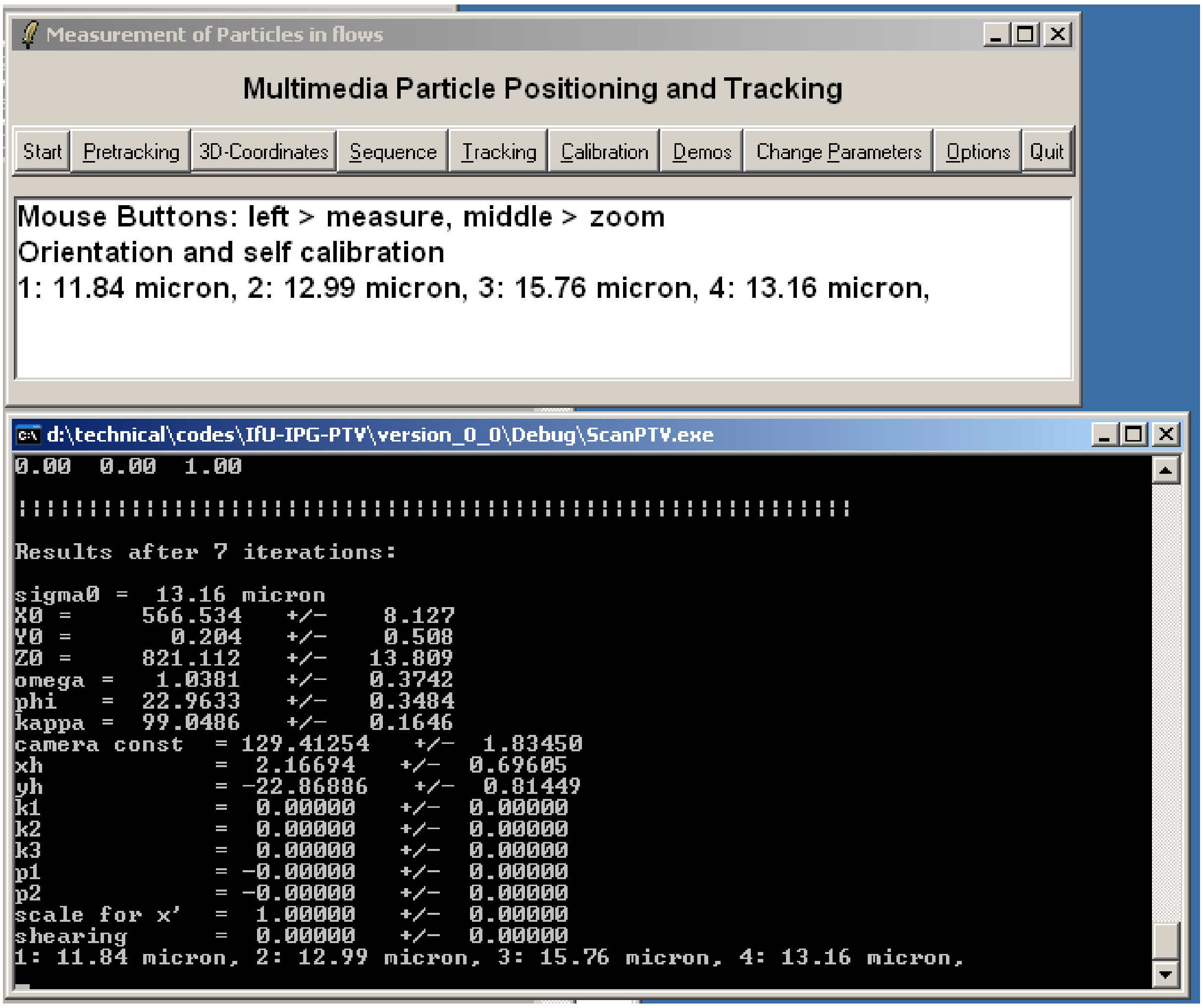

Measurement of Particles in flows
Multimedia Particle Positioning and Tracking
Start Pretracking 3D-Coordinates Sequence Tracking Calibration Demos Change Parameters Options Quit
Mouse Buttons: left > measure, middle > zoom
Orientation and self calibration
1: 11.84 micron, 2: 12.99 micron, 3: 15.76 micron, 4: 13.16 micron,
d:\technical\codes\IfU-IPG-PTV\version_0_0\Debug\ScanPTV.exe
0.00 0.00 1.00
Results after 7 iterations:
sigma0 = 13.16 micron
X0 = 566.534 +/- 8.127
Y0 = 0.204 +/- 0.508
Z0 = 821.112 +/- 13.809
omega = 1.0381 +/- 0.3742
phi = 22.9633 +/- 0.3484
kappa = 99.0486 +/- 0.1646
camera const = 129.41254 +/- 1.83450
xh = 2.16694 +/- 0.69605
yh = -22.86886 +/- 0.81449
k1 = 0.00000 +/- 0.00000
k2 = 0.00000 +/- 0.00000
k3 = 0.00000 +/- 0.00000
p1 = -0.00000 +/- 0.00000
p2 = -0.00000 +/- 0.00000
scale for x' = 1.00000 +/- 0.00000
shearing = 0.00000 +/- 0.00000
1: 11.84 micron, 2: 12.99 micron, 3: 15.76 micron, 4: 13.16 micron,

Figure 10