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AOE Experimental Methods (AOE 3054)
Experiment 4: Particle Shadow Velocimetry using
DaVis 8.4.0 Software

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Particle Shadow Velocimetry Lab - Measurement Procedure

Please follow the instructions provided below.

- Open DaVis 8.4.0 from the desktop using the icon displayed in **Figure 1**, make sure that you received no error while the software loads. Otherwise, ask for help by alerting the GTA.

Figure 1: DaVis 8.4.0 Icon

- **IMPORTANT: ONLY CLICK ON WHAT YOU ARE INSTRUCTED TO CLICK ON, OTHERWISE YOU WILL CHANGE PARAMETERS THAT WILL RENDER YOUR DATA IRRELEVANT TO THE REQUIREMENTS OF YOUR EXPERIMENT!**

- Under "MyProjects" drop-down list select **JuniorLabsXXXX_YYYY**, where **XXXX** will be the year and **YYYY** the semester you are taking the course, e.g. *JuniorLabs2023_Spring* as shown in **Figure 2**.
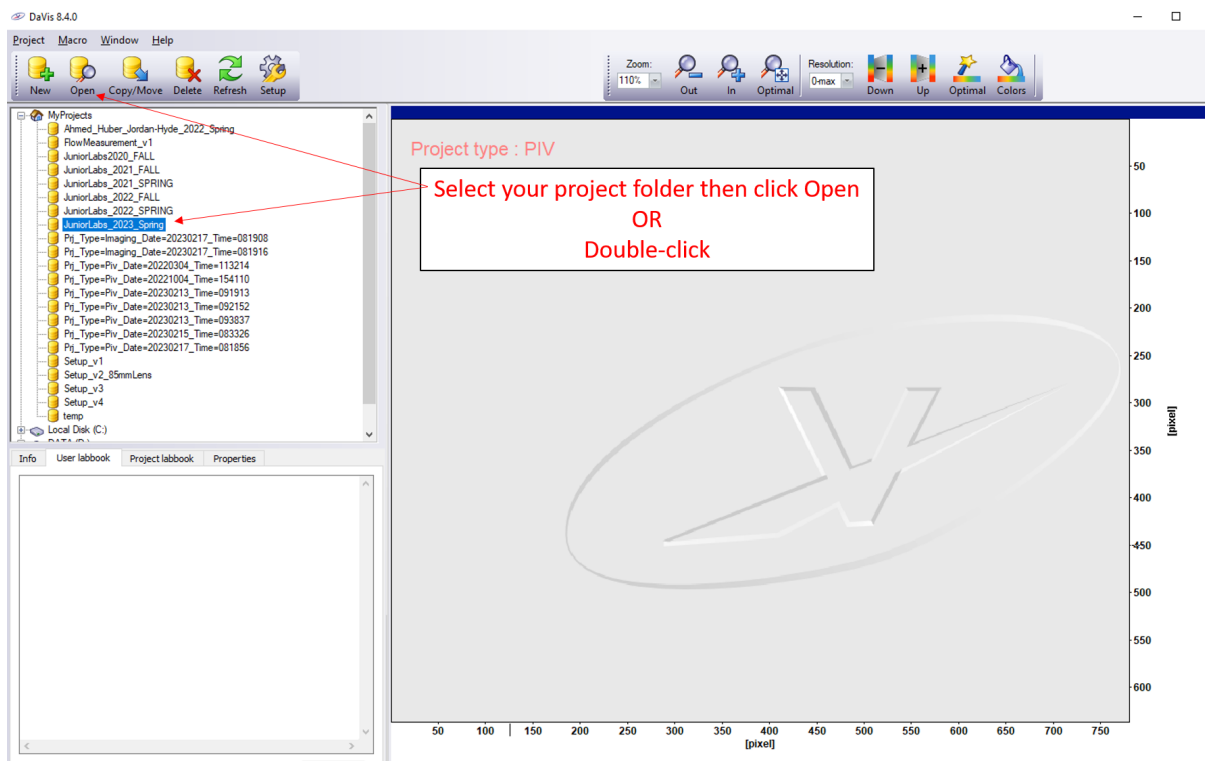

Figure 2: In the "MyProjects" drop-down list select the appropriate project for your semester
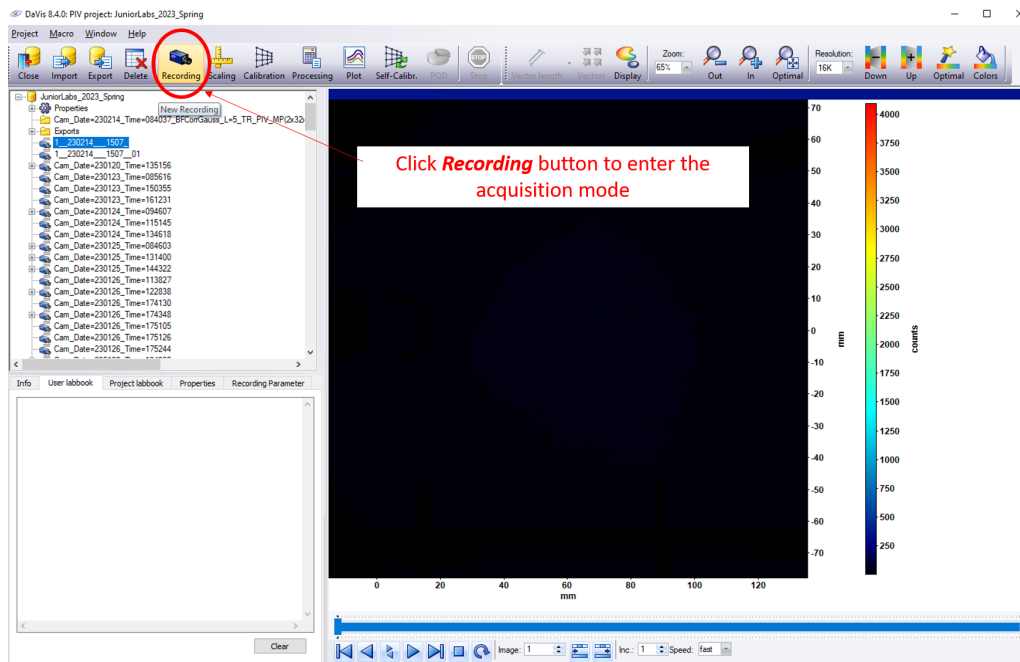
- Click "Recording", see **Figure 3**.

Figure 3: Enter acquisition mode with the "Recording" button

- In the new display, Click "Intensity Calibration" twice, each time wait until the process is completed, see **Figure 4**.
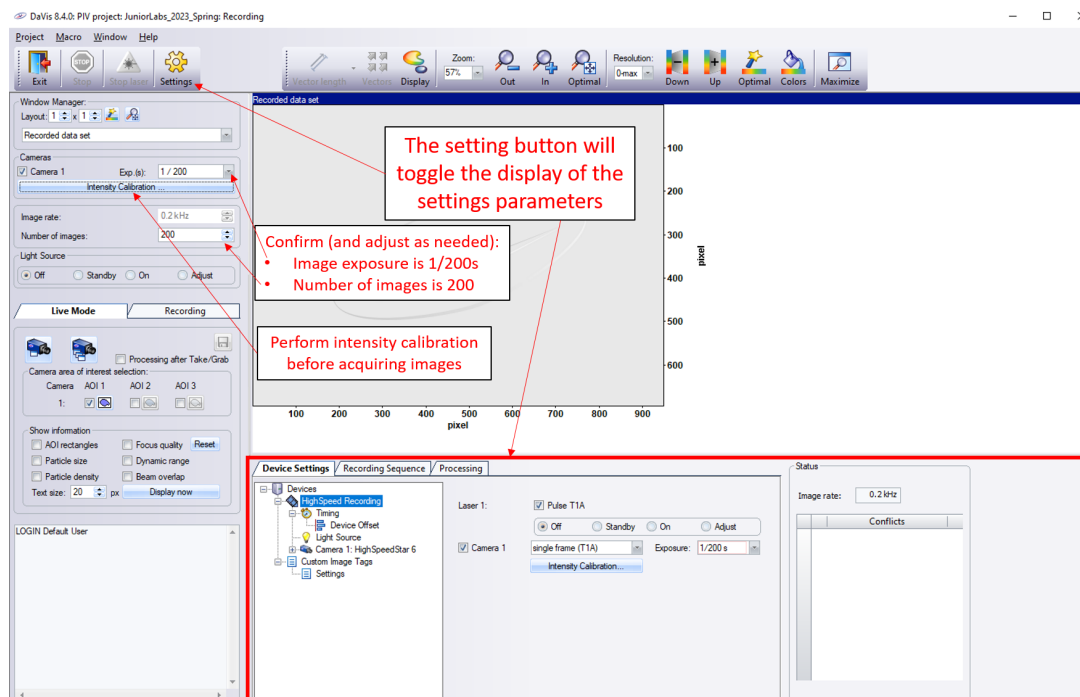

Figure 4: Perform "Intensity Calibration", update the number of images and image rate.

- Make sure that the number of images is set to 200 and image rate is 0.2 kHz, see **Figure 4**. This means that you will record *one second* of data.

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- Under Light Source, click "On", see **Figure 5**. This will enable the LED light source upon data acquisition. Try using "Adjust" and see on the live webcamera what happens with the light source? Once you are done, make sure to choose the "On" setting.
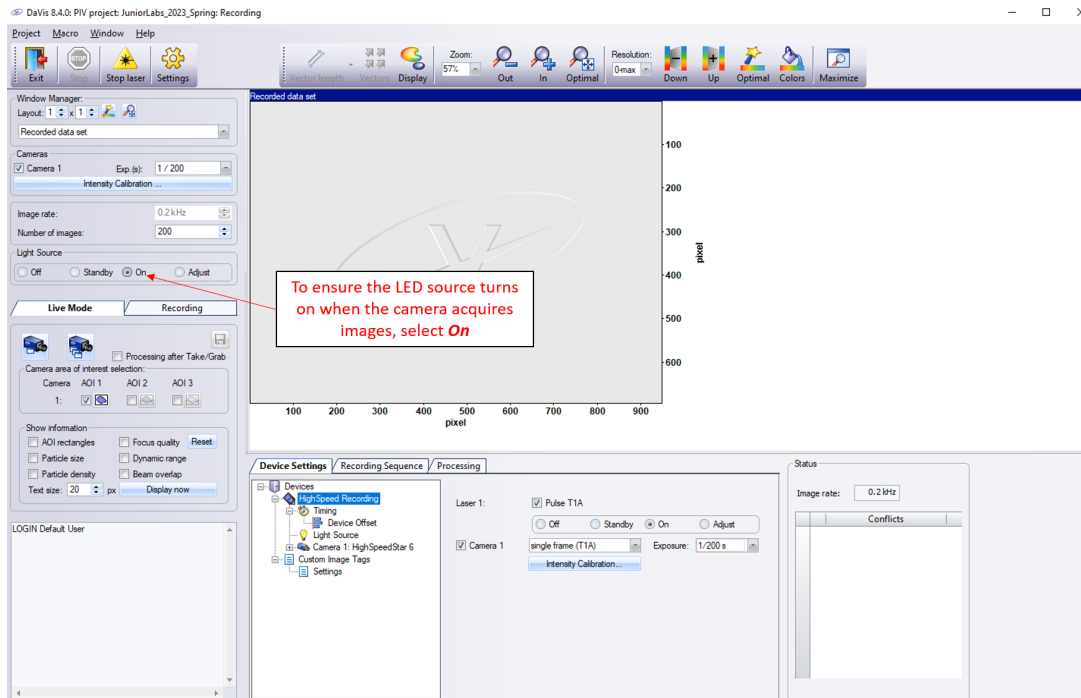

Figure 5: Light Source options setting for acquisition

- Click on the "HighSpeed Recording" settings at the botoom of the screen, see **Figure 6**. Make sure that the settings are as shown in **Figure 6**.
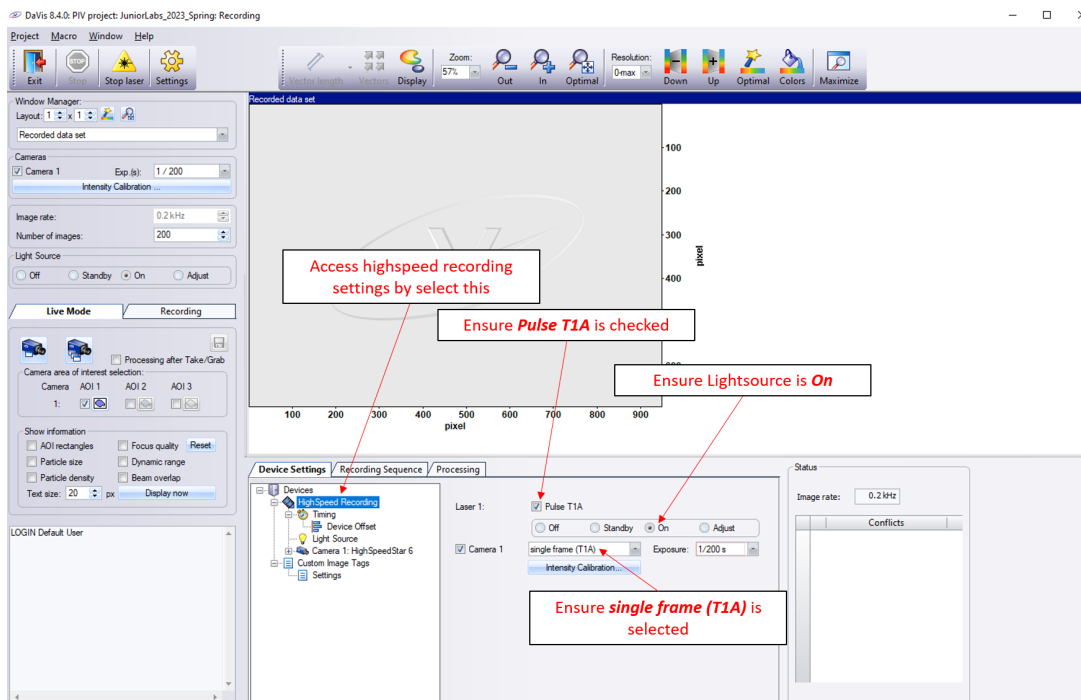

Figure 6: High Speed Recording Settings.

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- Click on the "Recording tab", as shown **Figure 7**, and then click on the Settings button at the top of the page to toggle the settings panel display and get a better view of the images that you are about to acquire.
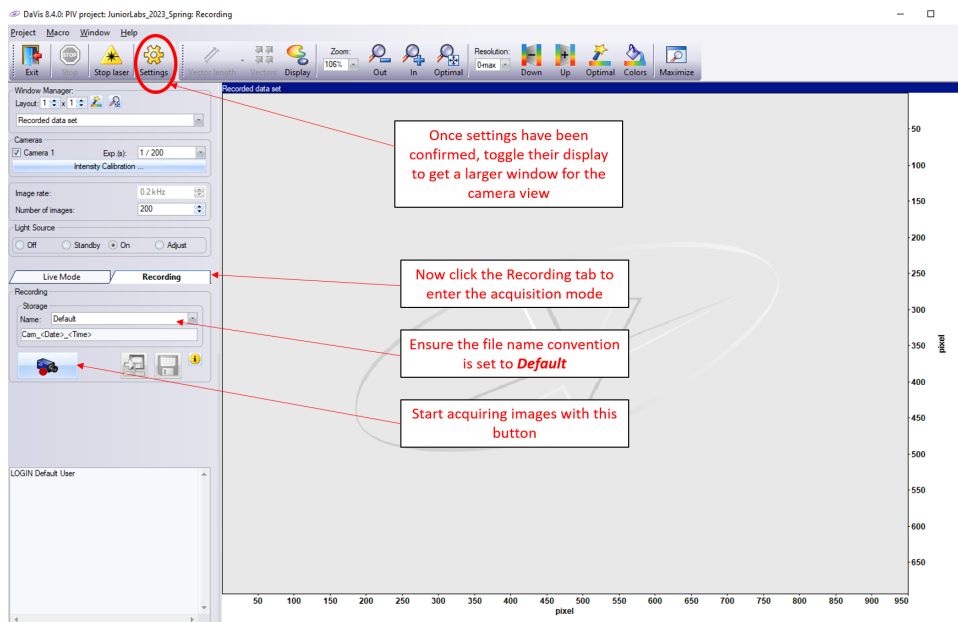

Figure 7: Recording Tab and Image Acquisition.

- We are about to acquire 200 images. The software will take care of the data acquisition, but the images will not be stored on the computer yet. They will remain in the internal storage of the camera for now. Before clicking the "Record Images" button, make sure that the naming of the recording is set to "Default", see **Figure 7**. Once everything looks good, go ahead and click on the "Record images" button. Make sure to keep an eye on the LED light source (or on the PTV camera feed) to see what is happening in the laboratory during that one second of data acquisition.
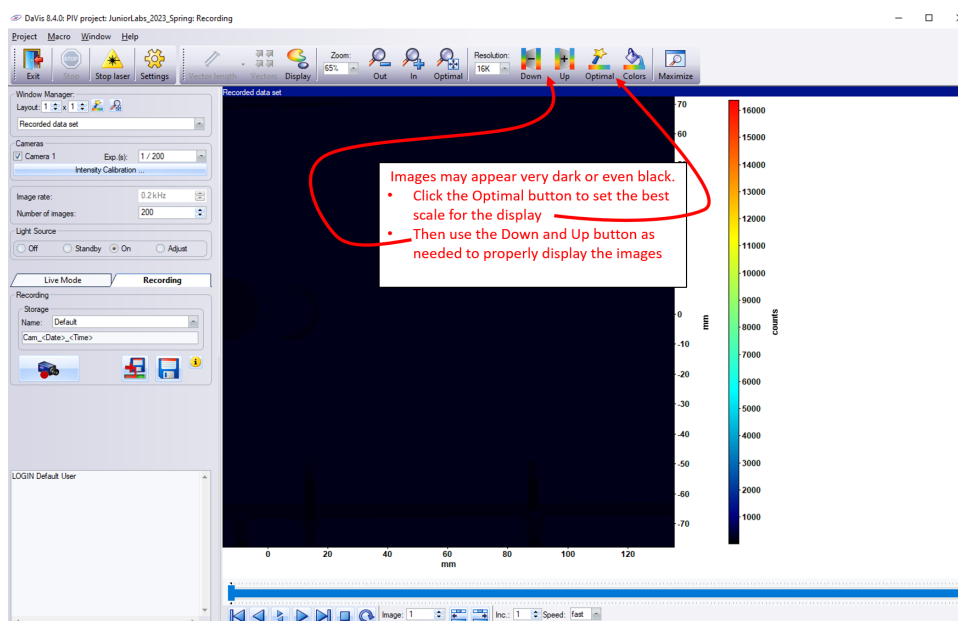

Figure 8: Initial image display and display controls.

- The status bar in the bottom left of the screen will say "Recording done" once the system finished taking images.

- To check the raw images you just acquired, click on the "Optimal" button (top toolbar), see **Figure 8**. Feel free to change the colormap by using the "Colors" button. Usually colormaps 1 and 2 are good choices for looking at the images. Adjust the range of the colorbar under the "Resolution" drop down menu. The option "0-max" will make the colormap span from zero to max value of the displayed data. The optio "+-max" will make the colormap span from min to max value of the displayed data. See which fits better to the displayed maps or images.

- Look for particles, check the background and surroundings. You might realize that the particles are rather hard to see and they are black dots or circles on a bright background, which is because we are looking at the shadow of the flow-seeding particles, hence the name of the method, Particle Shadow Velocimetry. These images will be converted during the processing step to ones that a Particle Image Velocimetry system would acquire. To do this, you will use a method called "Bright field correction".
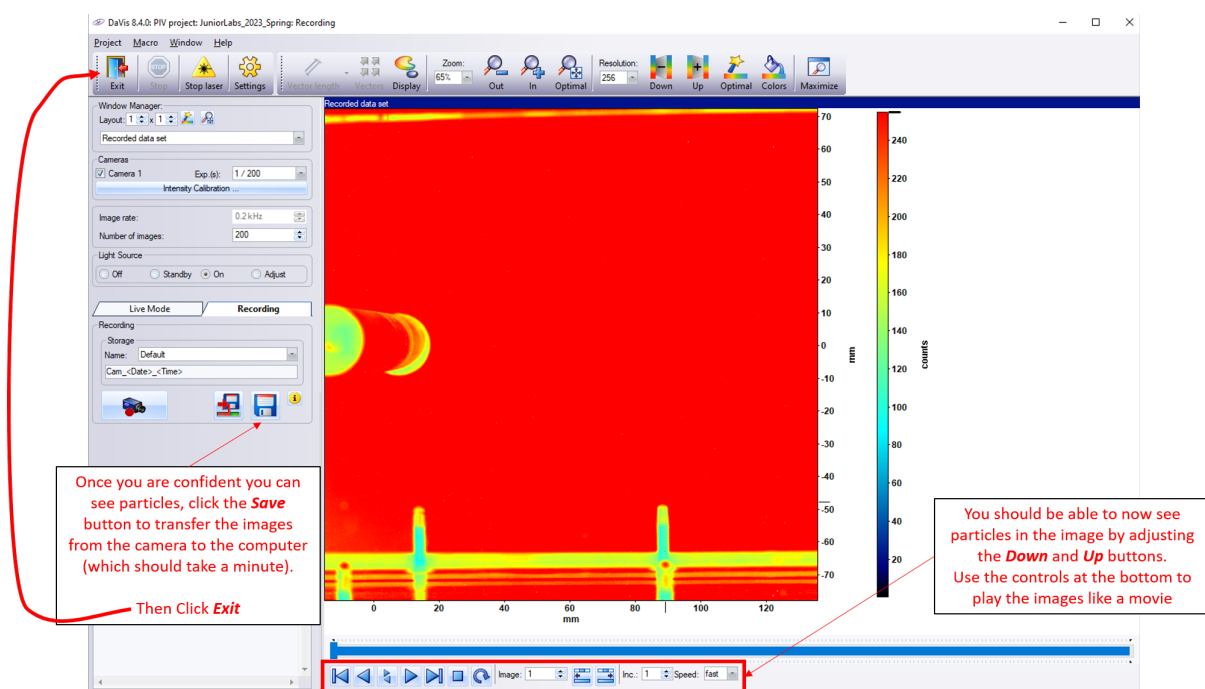

Figure 9: Saving images to the computer

- Under recording tab, click store all recorded images (blue floppy disk). This will take about 60 seconds, bottom left of screen will say "Done" once it is finished, see **Figure 9**.

- Click "Exit", see **Figure 9** to return to the main window.

- Right click on "Cam_Date=(Today's date) Time=(time of recording)". Under Cam_Date, the first two digits indicate year, the middle two digits indicate months and last two digits indicate the day. Under Time the first two digits indicate hours the middle two digits indicate minutes and last two digits indicate seconds, see **Figure 10**. *Make sure that you are processing the data you just recorded!*
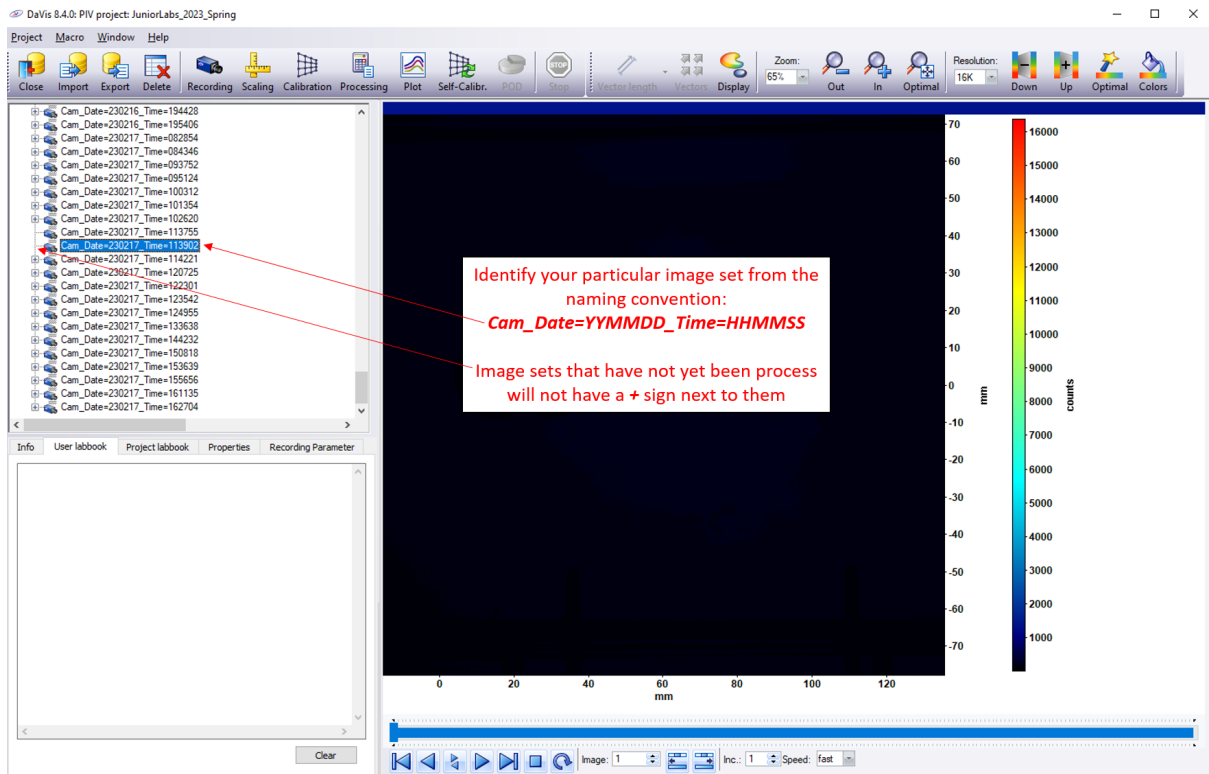
Figure 10: Identify **your** recording using the time and date stamps in the recording name.

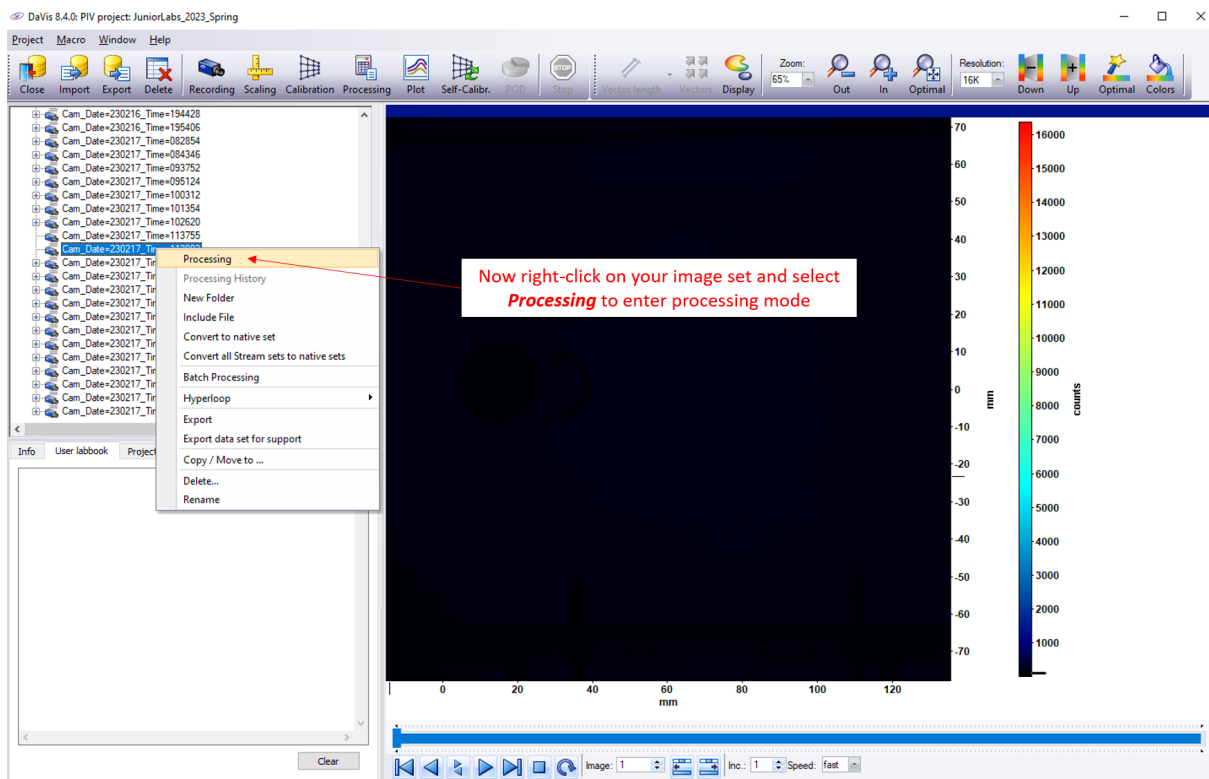- Under the drop-down list click right-click and select "Processing", see **Figure 11**.

Figure 11: How to enter the "Processing" module.

- Confirm operation list is:
  a. bright field correction
  b. PIV time-series
  c. vector statistics: scalar field result

- If the steps shown in the software are different (particularly if step c (vector statistics) shows **vector field** instead of **scalar field**), click Load icon from operation list, select **AOE 3054 Junior Lab PSV Processing** as shown in Figures 12 and 13. Make sure you click the "Load" button below the processing list once you selected it.
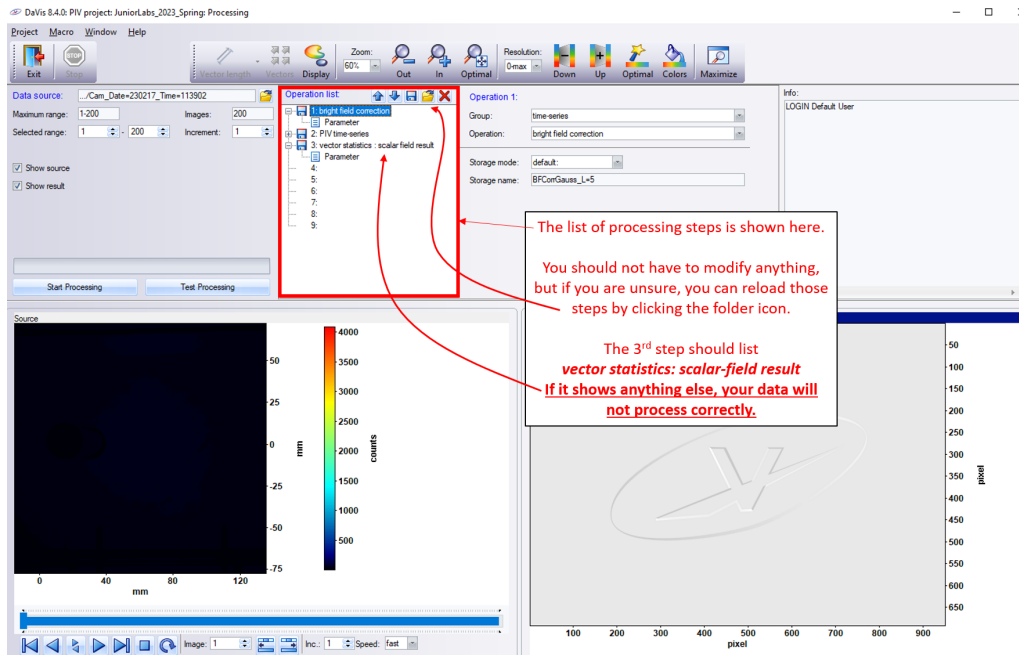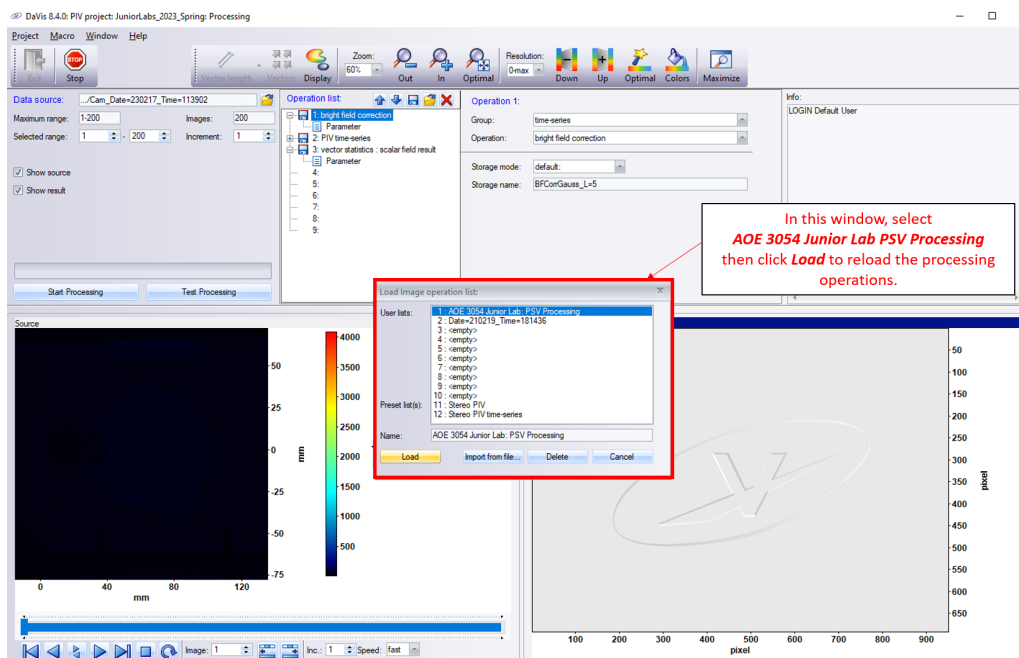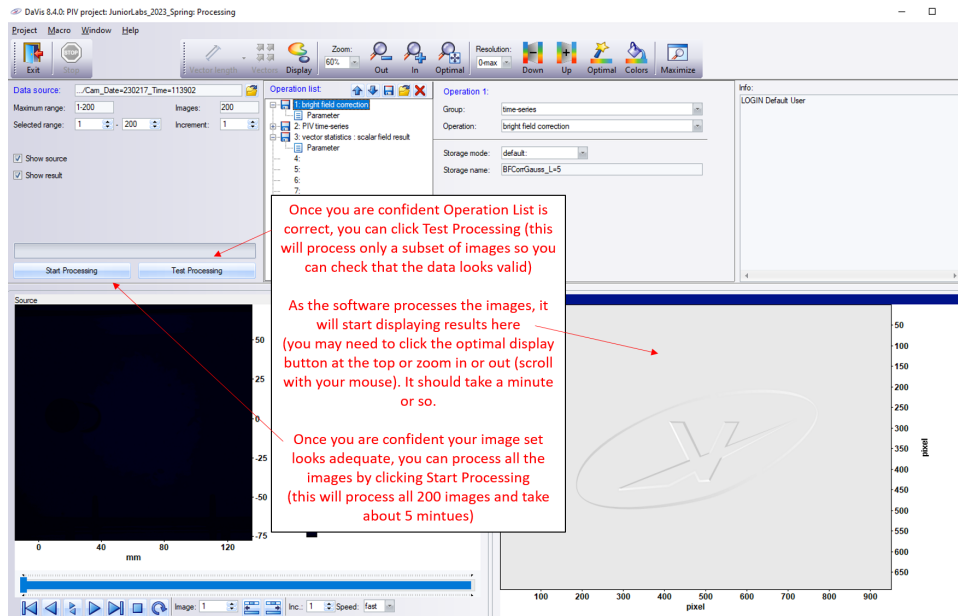

Figure 12: Processing module - Operation list.

Figure 13: Load Processing operation list.

Figure 14: Test and Full Processing.

- **For your first run**, click "Test Processing" (**Figure 14**). This will process a small subset of images and allow you to gauge the quality of the data.

- For processing your full image set, click "Start Processing" (**Figure 14**).

- Click "Optimal" 🎯 (top toolbar).

- Click "Optimal" 🎯 (top toolbar) again once picture changes to velocities.

- Wait for the processing to finish. It will take approximately 5-6 minutes. Until then, you can keep an eye on the process as the software will show you the results instantaneously.

- Click "Exit" 🚪

- Click on the "plus" sign next to your specific image set "Cam_Date=(Today's date) Time=(time of recording)" as shown in **Figure 15**a.

- <u>NOTE:</u> **If you set up the processing operation list properly, your image set tree should look like Figure 15a. If you only see Avg_Stdev (as in Figure 15b), the data was not processed correctly and you need to reload the operation list (Figure 13) and reprocess the data again.**

Figure 15: Available processed data if (a) the vector statistics results (see **Figure 12** are set properly and (b) if the vector statistics results are set **improperly**

- Click on "BFCorrGauss_L=5". Click "Optimal" 🔧 (top toolbar). Now you should see particles on a dark background. This is thanks to the Bright field correction step, which turns the raw images into a PIV-like results, see **Figure 16**b.

- Click "Optimal" 🔧 (top toolbar) to see the data better (and play around with the **Up** and **Down** button to fine tune the display.

- Click on the Play icon at the bottom to see the time-series of the recorded images.

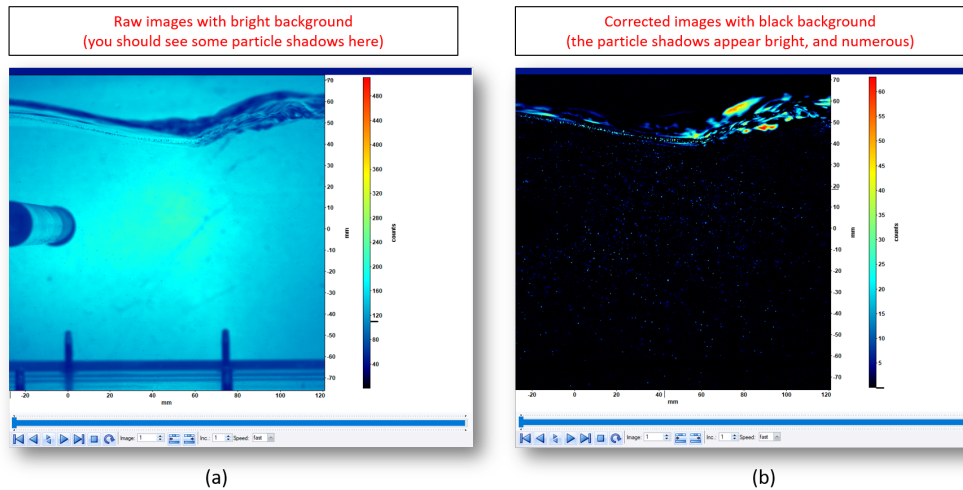Figure 16: RAW vs Bright field corrected images.

- If you now click on "TR_PIV_MP(3x32x32_75%ov)", you will be able to see the instantaneous velocity field results (through each of the 200 images). Again, display controls are at the top, and playing/pausing the sequence of images is done with the bottom control bar seen in **Figure 17** .
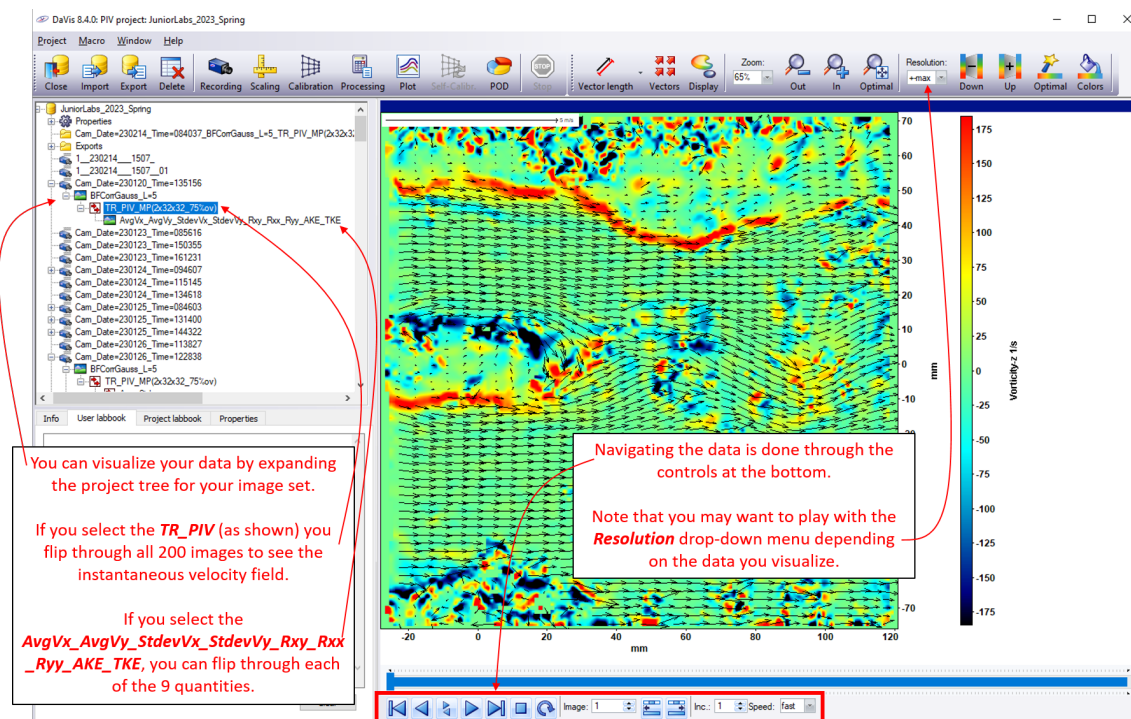

Figure 17: Post Processing, time-averaged vorticity magnitude.

- If you now click on "AvgVx_AvgVy_StdevVx _StdevVy_Rxy_Rxx_Ryy_AKE_TKE", you will be able to flip through the 9 average quantities obtaining from the statistics of the 200 images set.

- Click "Optimal" 🔧 (top toolbar) in each case to get a better view of the data.

- Click on the Play icon. You may need to bring the slider back to the left to play the images, see **Figure 17**.

- Click on the plus sign next to "TR_PIV_MP(3x32x32_75%ov)".

- Click on "AvgVx_AvgVy_StdevVx _StdevVy_Rxy_Rxx_Ryy_AKE_TKE".

- Click "Optimal" 🔧 (top toolbar)

- Click on the blue slider at the bottom to switch between average data and standard deviation, see **Figure 17**

- Next, you will Export your data.

- To export the *instantaneous velocity data*, right click "PIV_MP(3x32x32_75%ov)". To export the *time-averaged data*, right click on the third line ("AvgVx_AvgVy_StdevVx _StdevVy_Rxy_Rxx_Ryy_AKE_TKE").

- Under the drop-down list click "Export" as shown in **Figure 18**.

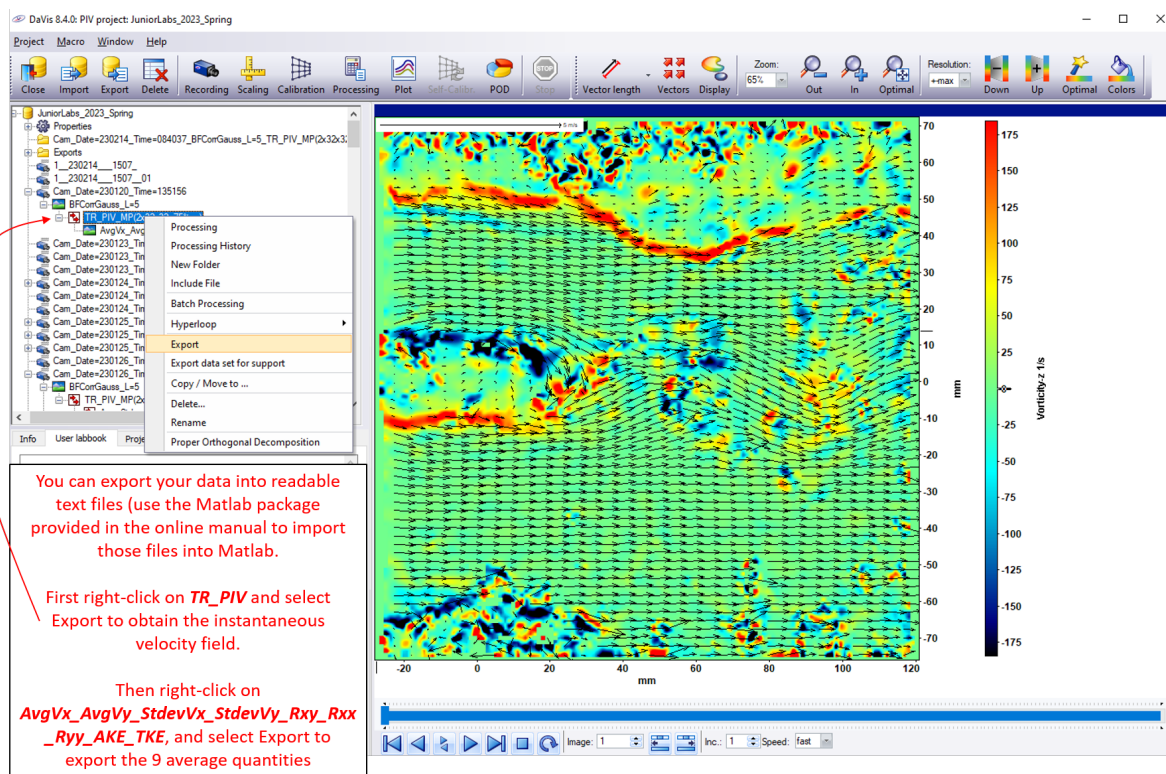Figure 18: Enter the "Export" module.

- Make sure that "File name" is set to "Default", and that your export type is Tecplot (DAT), as shown in **Figure 19**.

- Make sure you know where you have exported the data. The default location should be a folder under **D:/AOE3054 - XXXX YYYY Data/** where XXXX is the semester you are taking the course, and YYYY the year (e.g. *AOE3054 - Spring 2023 Data*).

- **You will need to upload your data to your own cloud storage (or use the jumpdrive provided) to access it from your own computer.**

- The instantaneous data set ("PIV_MP (3x32x32_75%ov)") will provide you x and y velocity components (V_x, V_y) at each point in the grid covering the imaging area (typically 128x128) and for each of the 200 frames. It will take up about 350 Mb of space.

- The time-averaged data set ("AvgVx_AvgVy_StdevVx_ StdevVy_Rxy _Rxx_Ryy_AKE_TKE") will give you x and y velocity components (V_x, V_y), their standard deviations $(Stdev(V_x), Stdev(V_y))$, Reynolds shear stresses (R_{xy}, R_{xx}, R_{yy}), average and total kinetic energies (AKE, TKE) and will require about 10 Mb of space.

- Once you are ready, click "Export" - see **Figure 19**.

- Open the files with a text editor (e.g. Notepad) to see their headers and to see what are the columns within each file correspond to.
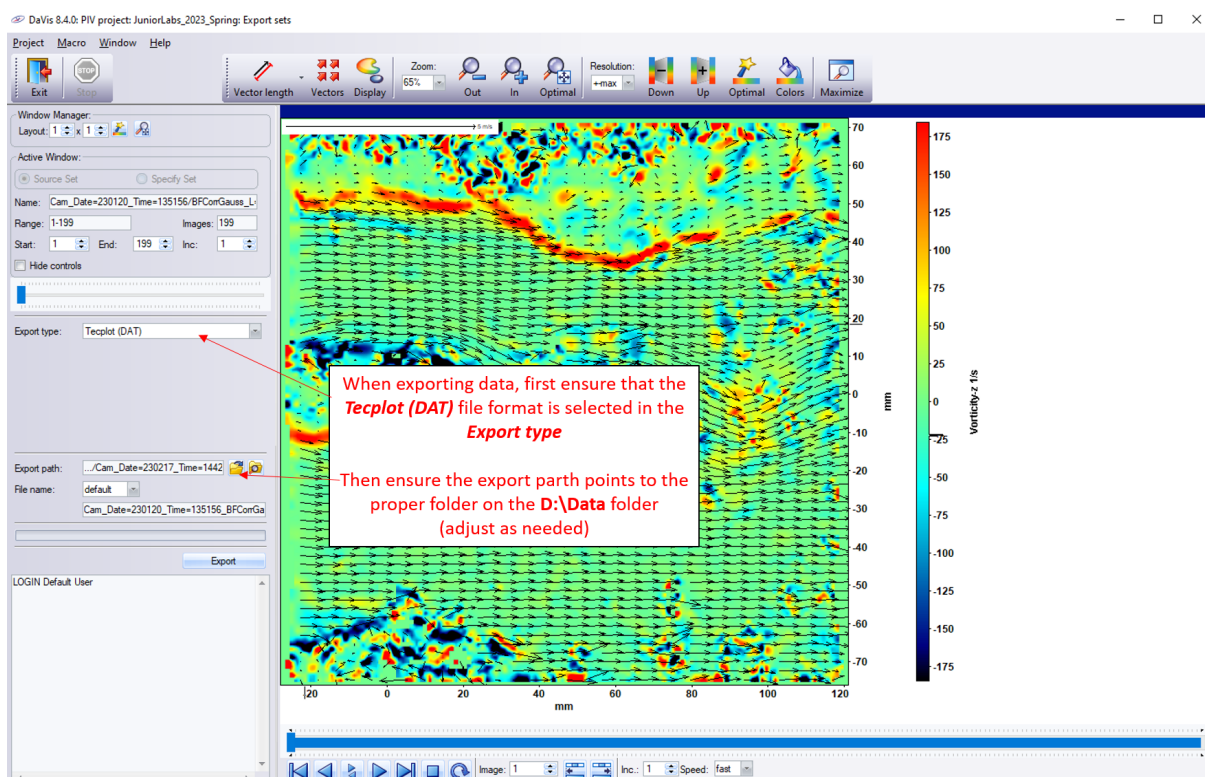

Figure 19: Exporting data.

- Click "Exit" when done

- Repeat the exporting process for whichever data set you need, such as various pump speeds, instantaneous velocity data or time-averaged data.

- **Make sure you transfer your files from the computer to cloud storage (or using the jumpdrive provided) regularly (you can start a second round of acquisition while analyzing your first data set). One entire data set could take up to 15 minutes to upload to the cloud, so plan accordingly.**

- Your data files should be under the following folders as .dat files:

  Instantaneous Velocity Field (199 files):

  "Cam_Date=(Today's date) Time=(time of recording)_BFCorrGauss_

  L=5_ PIV_MP(3x32x2_75%ov)=unknown"

  Averaged Quantities (9 files):

  "Cam_Date=(Today's date) Time=(time of recording)_BFCorrGauss_L=5_

  PIV_MP(3x32x2_75%ov)AvgVx_AvgVy_StdevVx_StdevVy_Rxy_Rxx_Ryy_AKE_TKE=unknown"

Each run will generate a series of 200 images and DaVis will export an associated set of 199 data files for the instantaneous velocity field and 9 files for the average quantities (Keep in mind that exporting data does take several minutes).

You can use a combination of exported data and screenshots from the DaVis results for your logbook, but keep in mind **you will need all your data files exported for the analysis in your report**.

Store your data (instantaneous and averaged) for each run in separate folders. You can then download this PIV Data Matlab Importing package - Updated 14 Sep 2021 to import the data from all your files (the 199 instantaneous and 9 averaged quantities) within a set and consolidate it in matrix form in Matlab. You can then use these MAT files and **write your own codes to perform further analysis and generate plots**.

Content of the AOE3054_PIV_Import_Rev1 Package:

- AOE3054_PIV_ImportInstant_2020.m: you will run this function on the 199 instantaneous velocity files to import that data into Matlab. The code will create a MAT file (whose name you will specify) with four variables:
  - X and Y are the streamwise and vertical coordinates of the measurement locations. The X and Y matrices have a size of MxM.
  - U and V are the velocity component matrices and will be MxMx199 matrices since you obtain components for each consecutive pair of the 200 images.
- AOE3054_PIV_ImportMean_2020.m: you will run this function on the 9 averaged quantity files to import that data into Matlab. The code will create a MAT file (whose name you will specify) with 12 variables:
  - X and Y are the streamwise and vertical coordinates of the measurement locations
  - U and V are the velocity components at those points
  - Umag is the velocity magnitude
  - stdU and stdV are the standard deviation at each point on the grid (computed over the 200 images)
  - AKE and TKE are the average and total kinetic energy
  - Rxx, Rxy, and Ryy are the Reynolds stresses
- Two folders containing a sample data set are provided in the ZIP file so you can test the import codes and debug your own plotting codes ahead of your experiment:
  - 20HzSampleData_Instantaneous: 199 instantaneous velocity files acquired at a pump speed of 20Hz.
  - 20HzSampleData_Averages: 9 averaged quantities acquired at a pump speed of 20Hz.