

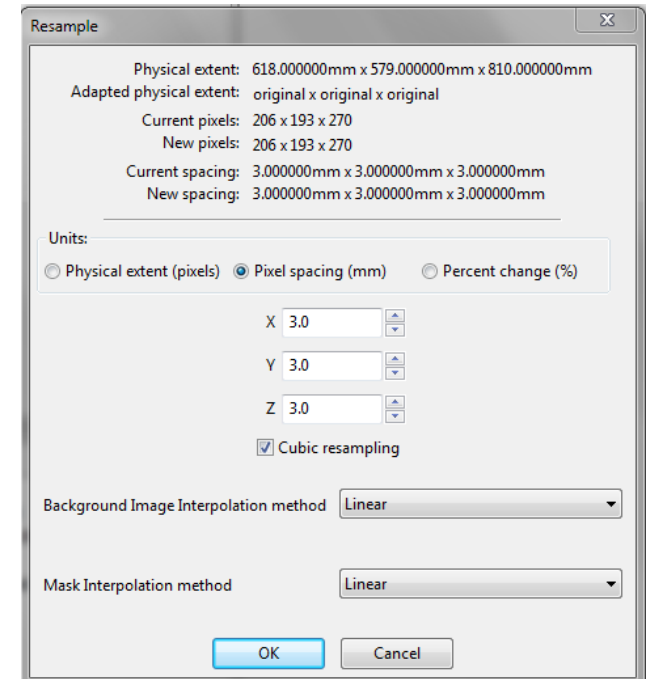
Segmentation and Meshing

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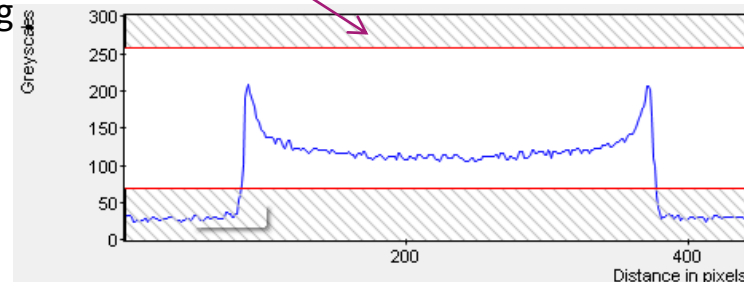
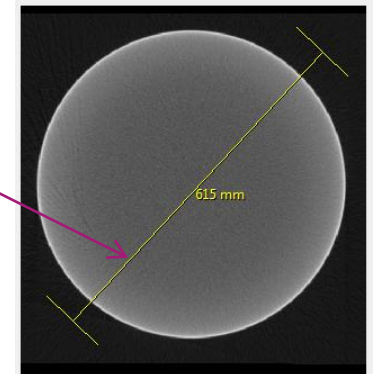
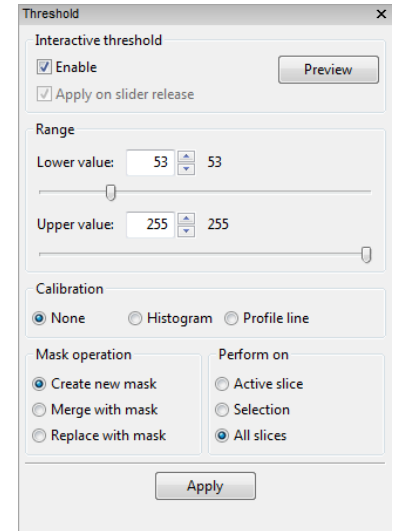
Resample

- High resolution scans may require resampling in order to be able to create a mesh and also dependent on computing hardware.
- Open 'Image processing' -> 'Resample'.
- Enter 3.0 as the new pixel spacing in X, and then tick the 'Cubic resampling' box to automatically set the Y and Z values to this spacing as well.
- The interpolation methods can be left as default.
- Click 'Apply' to resample the data.
- The image size has now been reduced by a factor of $(3^3)/(1^3) = 27$



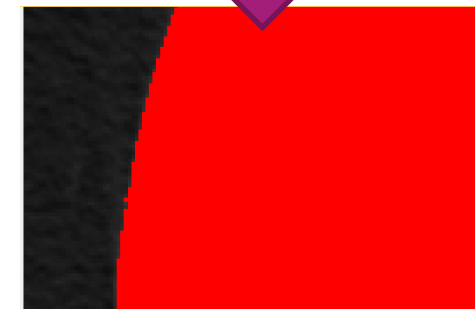
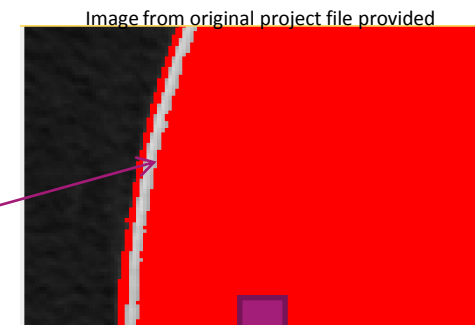
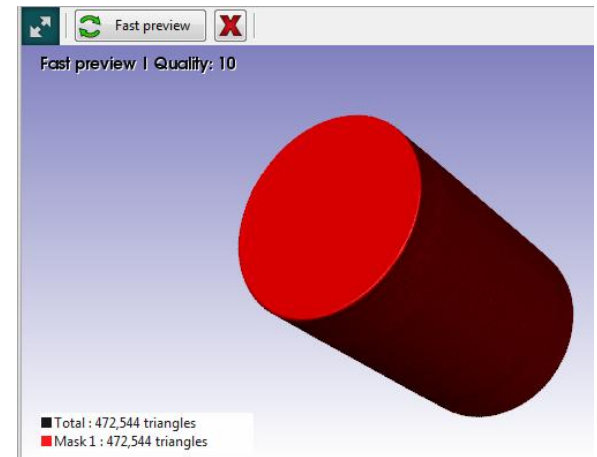
Segmentation 1: Threshold

- Often we start the segmentation process by applying a threshold.
- Open the threshold tool ('Image processing' -> 'Segmentation' -> 'Threshold') and check 'Enable' Interactive thresholding.
- We can click one of the  symbols to toggle maximising one of the 2D slice views.
- In the Threshold window, activate the 'Profile line' tool. We can then click twice on the 2D slice view to draw a line and obtain a histogram of the greyscale intensity along that line.
- The red horizontal lines in the histogram represent the threshold limits. These can be entered as values in the Threshold tool's window, or dragged in the profile line view.
- Interactive thresholding is enabled so the 2D slice will display the voxels that lie within the currently selected threshold limits whilst moving these in the profile line view.
- Assuming we want to segment the cylinder as a single homogenous object, threshold limits of 53-255 seem to perform well in this case.



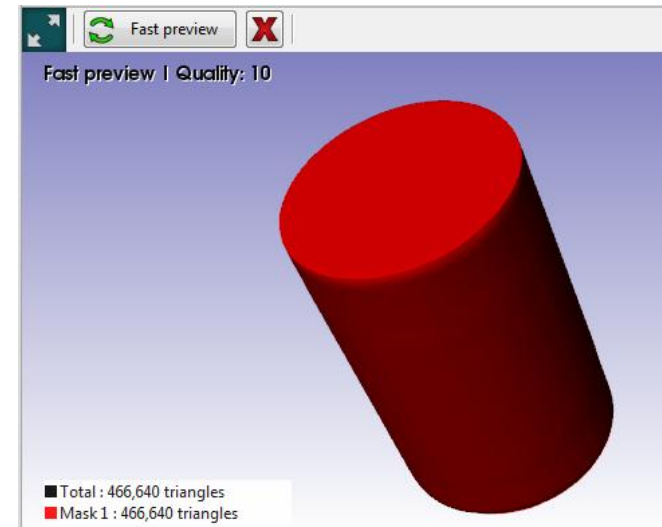
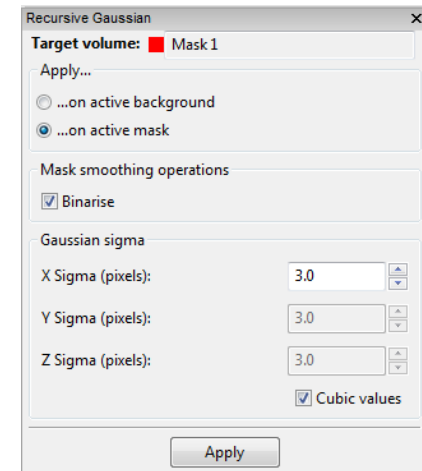
Segmentation 2: Cavity fill, Floodfill

- Ensure the threshold tool is set to 'Create new mask' on 'All slices' and click 'Apply' to create the mask.
- Click the 'Fast Preview' button to visualise the segmentation so far. A quick sketch of the model appears in the 3D view window.
- For this simple case the segmentation is already quite good, and we could go ahead and create an FE model now. For the sake of demonstration I will include some additional steps.
- In the test model that you sent, the surface of the cylinder had a very thin layer of voids. These can be seen on the zoomed in image on the right. This probably arose due to the Threshold settings used. Voids have not been created in this workflow, but we will perform a Cavity fill operations to fill these just in case. Go to 'Image processing' -> 'Additional' -> 'Cavity fill', and click 'Apply'.



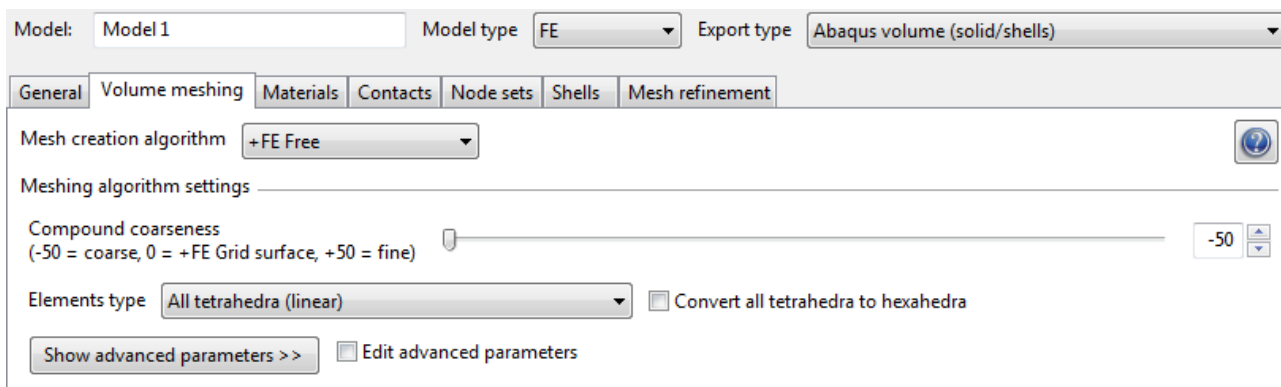
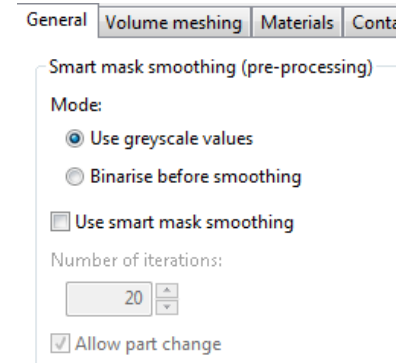
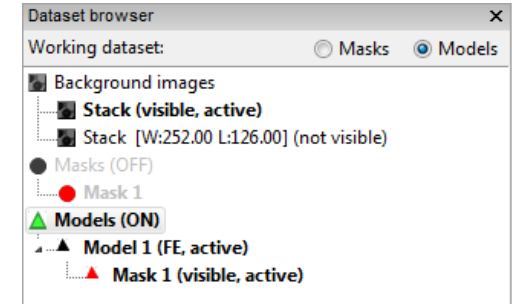
Segmentation 3: Smoothing

- The segmentation already has quite smooth surfaces. As an optional step, we can smooth these further.
- Open 'Image processing' -> 'Smoothing' -> 'Recursive Gaussian'. Make sure 'Binarise' is active, and apply smoothing of 3.0 pixels strength in X, Y, and Z.
- Refreshing the 3D view by pressing 'Fast Preview' again, we see the model with smooth outer surfaces.



Meshing 1

- To prepare a model for export, we right-click on 'Models' in the Dataset browser, and select 'Create new FE model'.
- Drag the mask we previously created into this new model.
- Right-click on the model and select 'Model configuration...' to setup model (alternatively select this via the FE model tab).
- Smoothing has already been applied, so here I have deselected smart mask smoothing.
- Make sure the export type is Abaqus.
- In the volume meshing tab: change the algorithm to '+FE Free'. We are greeting by the 'Compound coarseness' slider, which provides a simple way to easily control the relative density of our mesh. I have set the slider to -50 in this case, to produce a reasonably small mesh.



Meshing 2

- Close the 'Model configuration' dialog, and click 'Full model' in the 'FE model' tab.
- On my system, meshing took 1 min 34 s. It used a maximum of about 700 MB memory, and produced 53k tetrahedral elements.
- In the 'FE model' tab, we can select 'Quality inspection' to check for any poor quality elements. Users own quality metric targets can be defined. Using the default values, the resulting mesh is found to have no elements with errors or bad aspect ratios (i.e. 'Errors' and 'Warnings' zero).

