
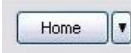

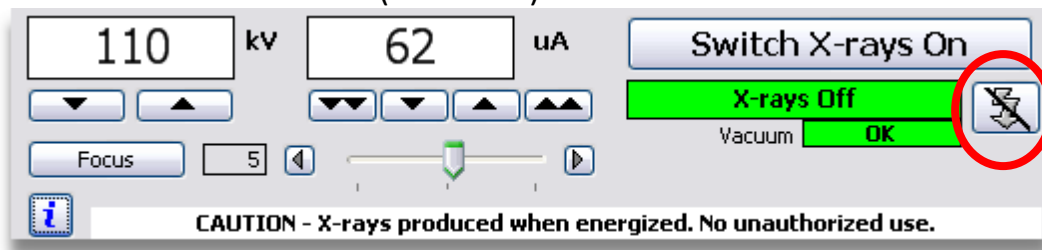


Operating Procedures for MICROCT1 Nikon XTH 225 ST

Ensuring System is Ready (go through to ensure all windows and tasks below have been completed – either by you or someone else – prior to mounting and scanning your sample)

- Log usage into the SMIF web site
- Ensure “X-ray On” light is not currently lighted on the front of the cabinet
- Ensure key interlock on control station is set to “on”
- Run **Inspect-X** program
 - Load wanted configuration i.e. Reflection-Front
 - Enter password **hp23.4jx**
 - Click **Yes** to login as “Supervisor”
 - Screen should have properties icon  if logged in correctly
- Home** axis before anything is placed in chamber
 - To **Home**, click down-arrow next to  and select **Mag**
 - Mag axis will then initialize, once it’s finished move stage all the way forward
 - Then, click down-arrow next to  and select **All Axes**
 - Stage will then initialize all axes and **Absolute** coordinates will go from red to black when stage is ready
- If you are the first user of MICROCT1 today, you must follow these steps otherwise continue onto next section:**

- Click the circled button (red circle) below from the main screen



- On the menu that pops-up (Intelligent Auto-Conditioning), click **start**
- Monitor “**Time stable at maximum kV**”, when greater than **15:00** -> **Switch X-rays Off**
- If conditioning takes longer than 1hr. or value of vacuum is higher than 40 for long periods of time, please **STOP** conditioning and contact SMIF staff

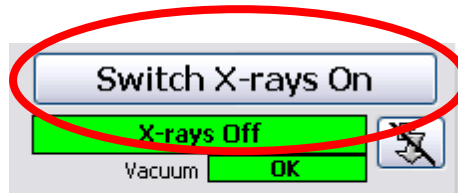
Mounting Specimen

- 1) Secure sample in appropriate material of minimal attenuation (i.e. florist foam, batting, light/non-thick plastic, etc) while ensuring rigidity

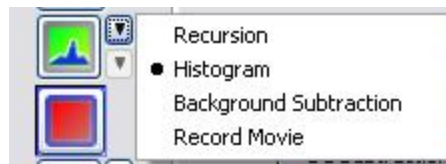
- 2) Ensure sample or region of interest in sample is placed along a vertical axis (center of rotation) within container to promote best resolution
- 3) Place sample and container onto turntable with region of interest placed as directly over center of rotation as possible
- 4) If known or needed, insert filter
- 5) Close door and ensure interlock is engaged
- 6) Continue onto next section


CT Scan Setup (Do For Every New Scan, See Appendix A for Batch Scanning)

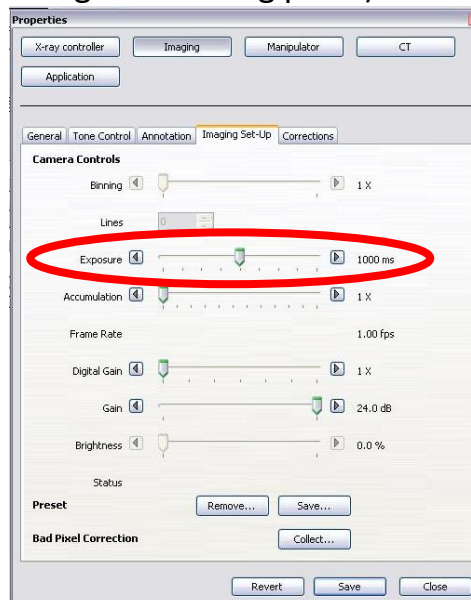
- 1) In Inspect-X software, **Set kV & W** to reasonable values (**130kV** and **12W**) are good starting points for most samples)
- 2) **Switch X-rays On**



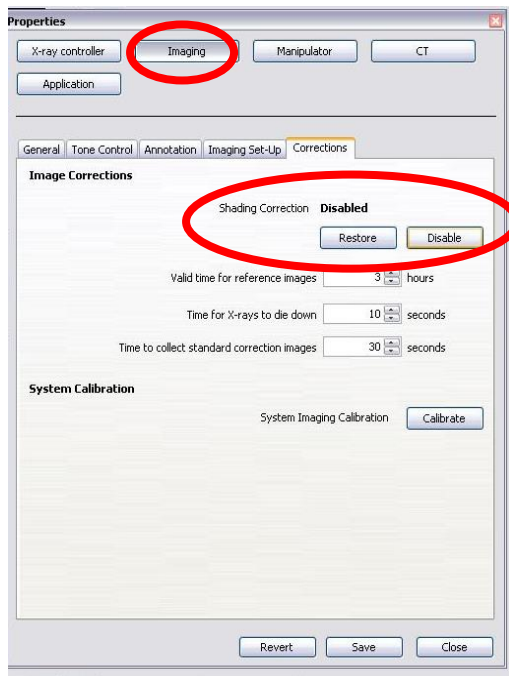
- 3) **Live Image On** with **Histogram** selected



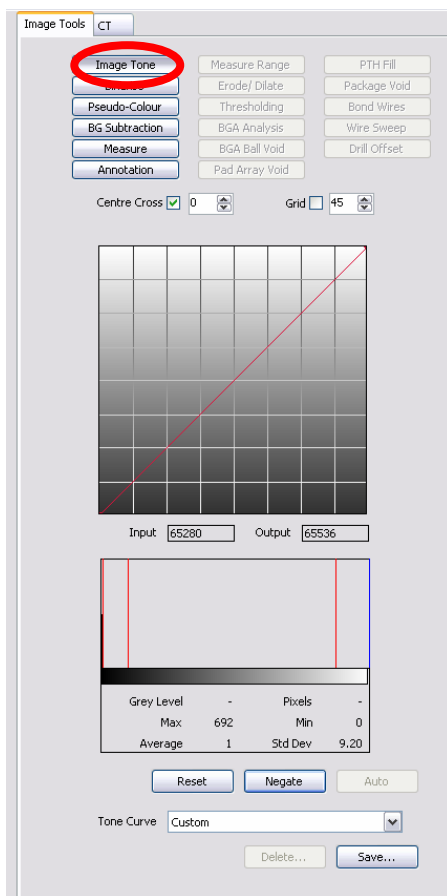
- 4)  **(Properties) -> Imaging Tab -> Imaging Set-Up** and change **Exposure** to desired value, **Save** (354ms or 500ms is a good starting point)



5) **Corrections** tab of **Properties->Imaging** window, Shading Correction -> **Disable**, **Save** and close window

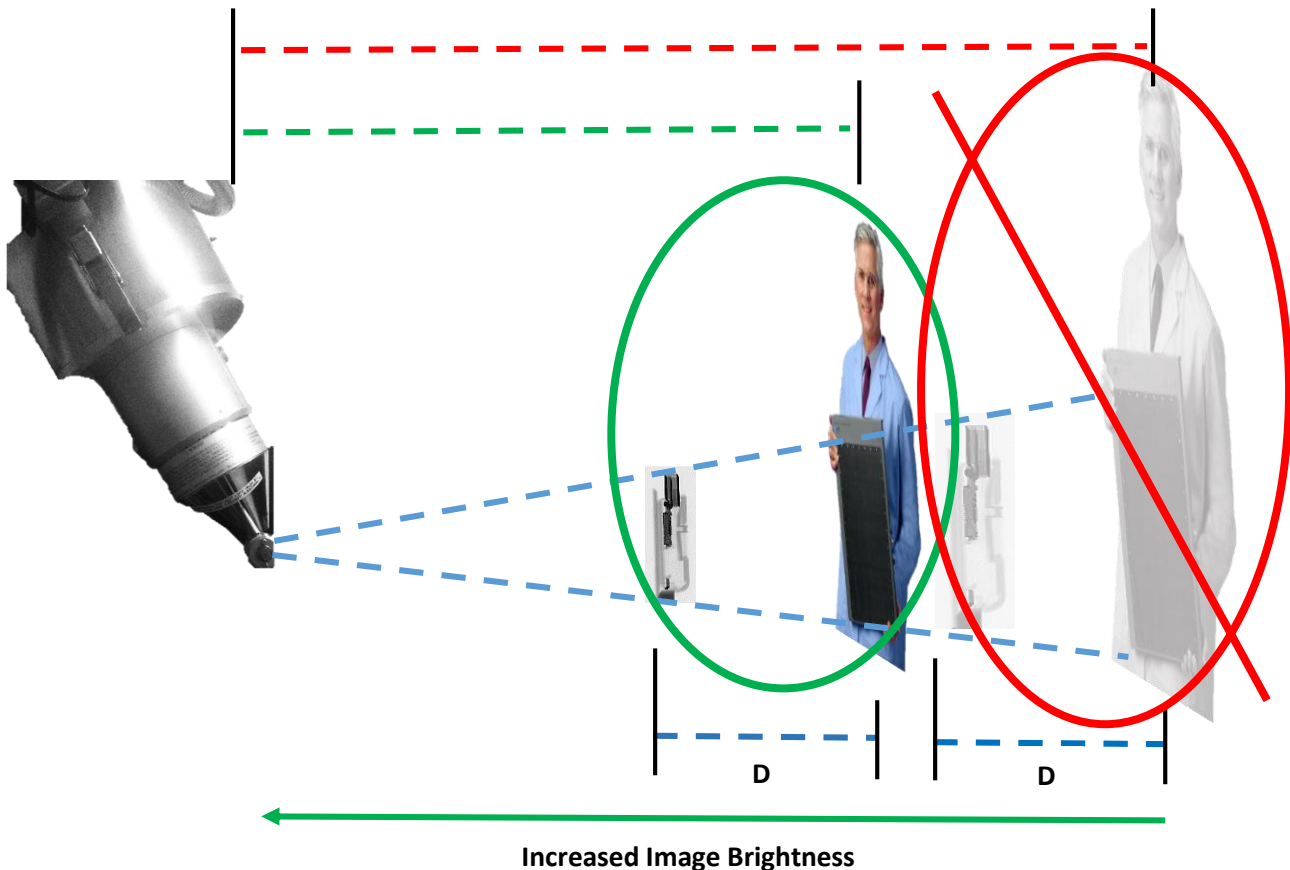


6) Make sure you are on the **Image Tools -> Image Tone Tab**
a. See below image



7) Set **X coordinate** -> **0** and position sample for optimal resolution and detector to source distance (see image below) using digital joysticks in GUI. Remember, sample must fit within FOV across all angles of stage rotation

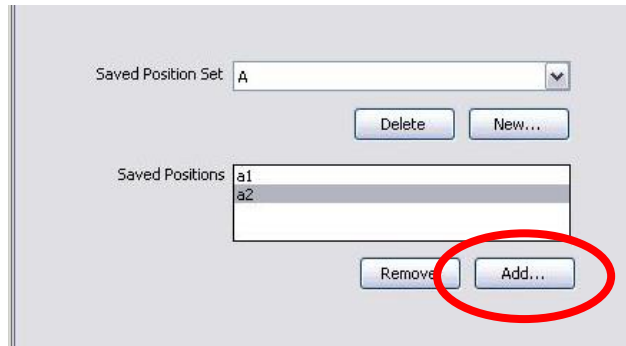
- When detector is closer to the source, images are brighter and sharper
- When detector is too close to the source, maximum resolution for sample may not be achieved or sample may not fit into FOV of the detector
- When detector is too close to the source the image may oversaturate and so detector exposure or source current/watts can be reduced
- Best practice is to optimize above for resolution vs. image clarity vs. scan time



D is the length which defines magnification (resolution of scan). The greater distance D between your sample and the detector, the smaller the voxel size your scan will have (i.e. higher resolution). This image shows that the same resolution can be achieved by moving both sample and detector closer to the source while maintaining their respective distance, D. Therefore, the green circle would be a quicker scan, sharper, and brighter image than that of the red-crossed circle while maintaining the resolution.

- 8) **Rotate to 0 and save position(s)** by clicking **Add** under the **Saved Position** menu and labelling appropriately
- a. For Batch Scan, repeat 7, saving all batch positions at Rotate = 0

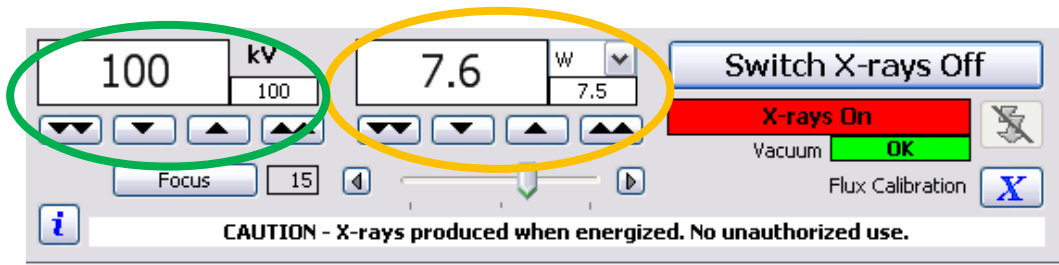
- b. Note, if scanning 1 continuous item across multiple scans, make sure the only coordinate that changes value b/w the scans is Y, otherwise scans will not be able to be seamlessly combined



- 9) **Reset** Image Tone and **Delete All** measurements, then rotate sample to darkest image
 - a. Darkest Image = The angle at which the sample is deepest/thickest in the image

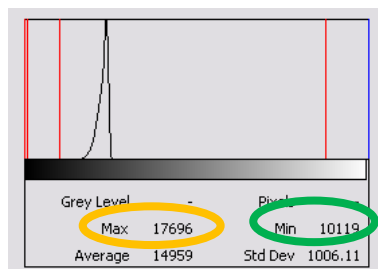
- 10) **Adjust kV** and **W** until **max gray value = 60000** at brightest projection

- a. Higher kV helps to penetrate denser areas, but reduces contrast in low density areas and can blur sample edges
- b. Higher W helps to heighten dynamic range, lower scan time and deafen noise, but can cause image blurriness and over-saturation if set to high



- 11) Now, **optimize width of histogram** by **adjusting W & Detector Exposure**

- a. Ensure image is not over-saturated and gray values are **b/w 10,000 min and 60,000 max**
- b. Above 15W and the source will auto-defocus which doesn't affect image sharpness for voxel sizes above 30um but may for smaller sizes
- c. The difference b/w Max and Min gray values will be the dynamic range of your image(s) and data
- d. The image blurs as a function of **W**. As a rule, keep **W** smaller than the voxel size (W to um).



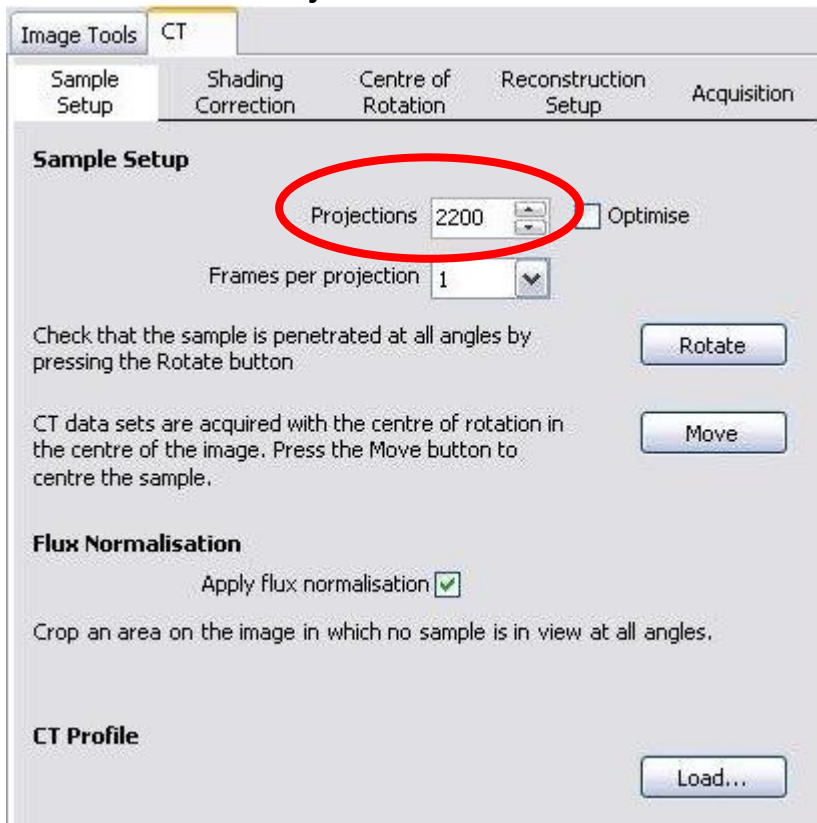
- 12) **Check** all projection angles for over-saturation

- a. Rotate the sample 360° ensuring **Max** gray value doesn't exceed 62,000

13) Go to **CT Tab**

14) **Sample Setup** -> enter number of projections needed based on how much your sample fills the screen from left to right as your rotate it about a full circle

- a. A sample that spans the image requires 1800 projections
- b. A sample which is very narrow would require ~1200projections
- c. For something of moderate width, estimate between 1200-1800 based on how wide it is
- d. Enter number of **Projections** into the field shown below



15) Set **Frames per Projection** according to image noise level and amount of dark areas in sample. 1-10 is a reasonable range of values

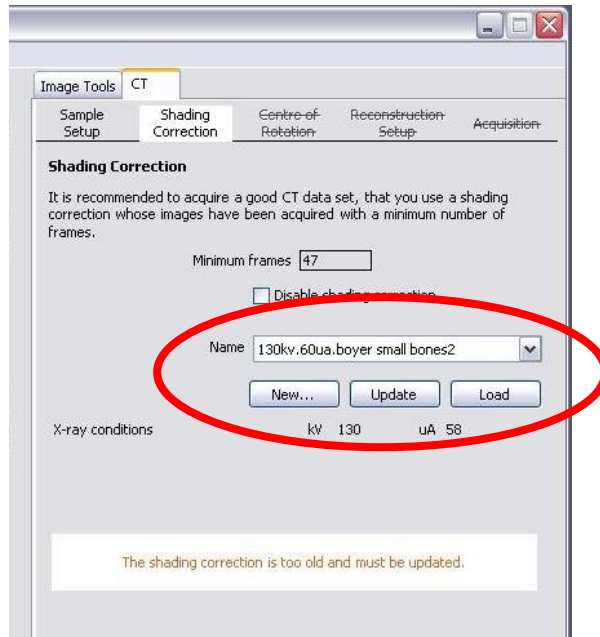
- a. More frames will multiply scan time by value used i.e. 4 = 4x longer scan
- b. For weak attenuating material, it is better to have higher Frames per projection than a longer exposure time
- c. For dense, metallic or samples with beam-hardening prone pockets, it is also better to increase the Frames per projection and keep the exposure time shorter

16) Ensure **Flux Normalization** is unchecked

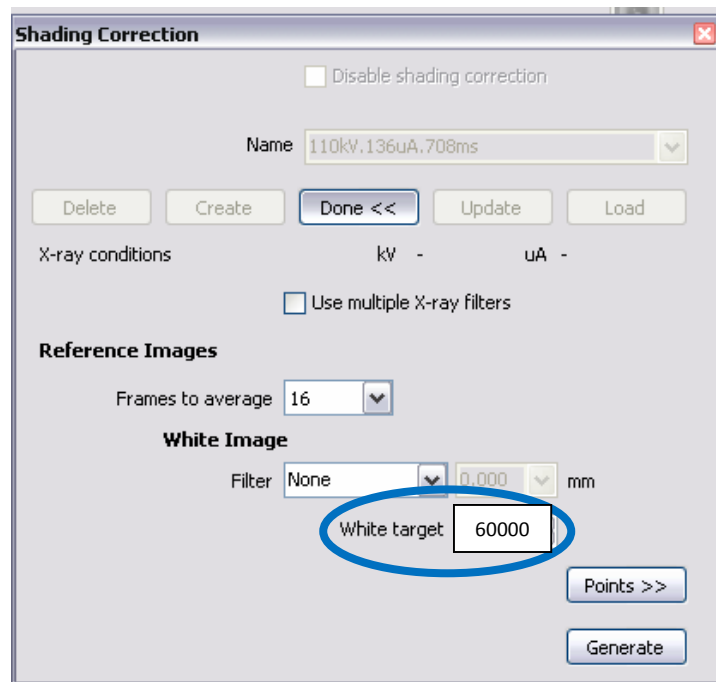
17) **Shading Correction** tab

- a. Click **New**

b. Enter **name 1,2,3,etc** for name



- c. If shown, select **Current** for exposure time as opposed to **Previous**
- d. **Create**
- e. **Move** sample out of field of view using digital joysticks



- f. **Change White Value to 60,000 (Blue Circle)**
- g. **Click Generate**
 - i. Filters can be left in despite the message.
 - ii. Errors of oversaturation of the detector may occur if the image was set up with a filter and it was removed prior to the calibration

h. **Number of reference images** should be left at **3** -> Click **Ok**



i. Wait for corrections to finish (can take multiple minutes)

18) For automated reconstruction, **Centre of Rotation** tab-> **Calculate automatically** -> Checked -> **Acquire** otherwise skip to **step 17**

a. Ensure resultant line on left image crosses through a portion of the sample

19) For automated reconstruction, **Reconstruction Setup** tab and enter information you would like used

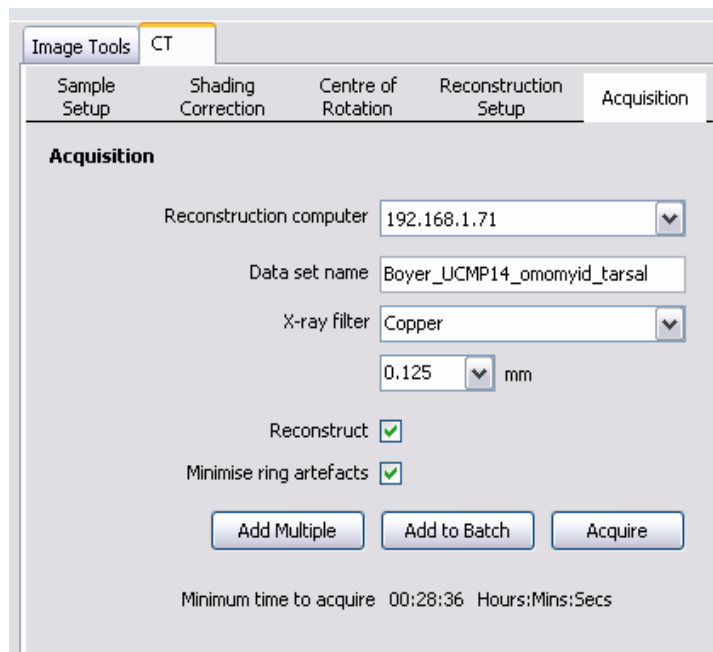
a. Leave **Reconstruction quality** at **100%** and enter known number preset for **Beam hardening** and **Noise reduction**

b. Under **Volume of Interest** click **Acquire**

c. Drag red box edges to crop out unwanted material on resultant 2 images on the left monitor – leave a good amount of space from sample edge

d. Note the changes in file size under **Disk space for volume**

20) **Acquisition** tab



21) Select appropriate Reconstruction computer (.71 = RECO1, .72 = RECO2) for saving

a. Ensure there is sufficient space on that computer

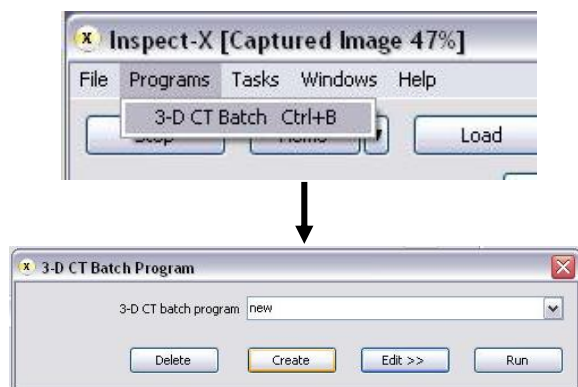
22) Fill in Dataset name beginning with your last name (surname or family name) and separate words with underscores “_” rather than spaces

a. See image above for example

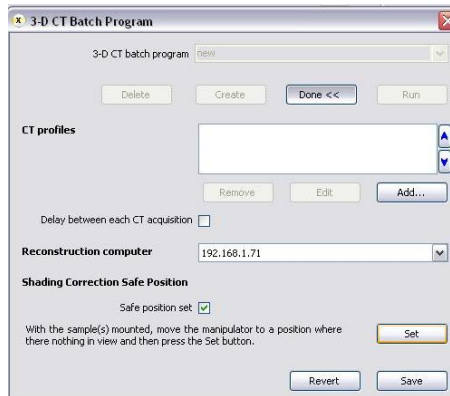
- 23) Select appropriate filter type under **X-ray filter** and **select** appropriate known **thickness** just below, otherwise select **None**
 - a. See image above for example
- 24) If wanting to have destination computer automatically reconstruct scan upon completion, make sure **Reconstruct** is checked and that steps in **18-19** were followed
 - a. If not automating a reconstruction, uncheck this box
- 25) **Minimize ring artifacts** can be selected but will extend scan time significantly
 - a. Most scans are fine when this option is not selected
 - b. Disables perpetual movement of stage rotation during scan to reduce angular smearing which causes ring artifacts in reconstructions
- 26) Click **Acquire**, UNLESS you are collecting a BATCH SCAN, then first follow directions in **Batch Scan Appendix** and at this step select **Add to Batch**
- 27) Scan will begin, note projected scan duration from pop-up
 - a. Do not leave before seeing a displayed time estimate as the scan may never begin
- 28) See **RECO Operating Procedure** for reconstruction of **MICROCT1** data

Appendix A: Batch Scan

- 1) Ensure steps **7-8** under **CT Scan Setup** were completed in full and that all regions/positions of interest were saved
- 2) **Programs** menu -> Give program a name -> **Create**



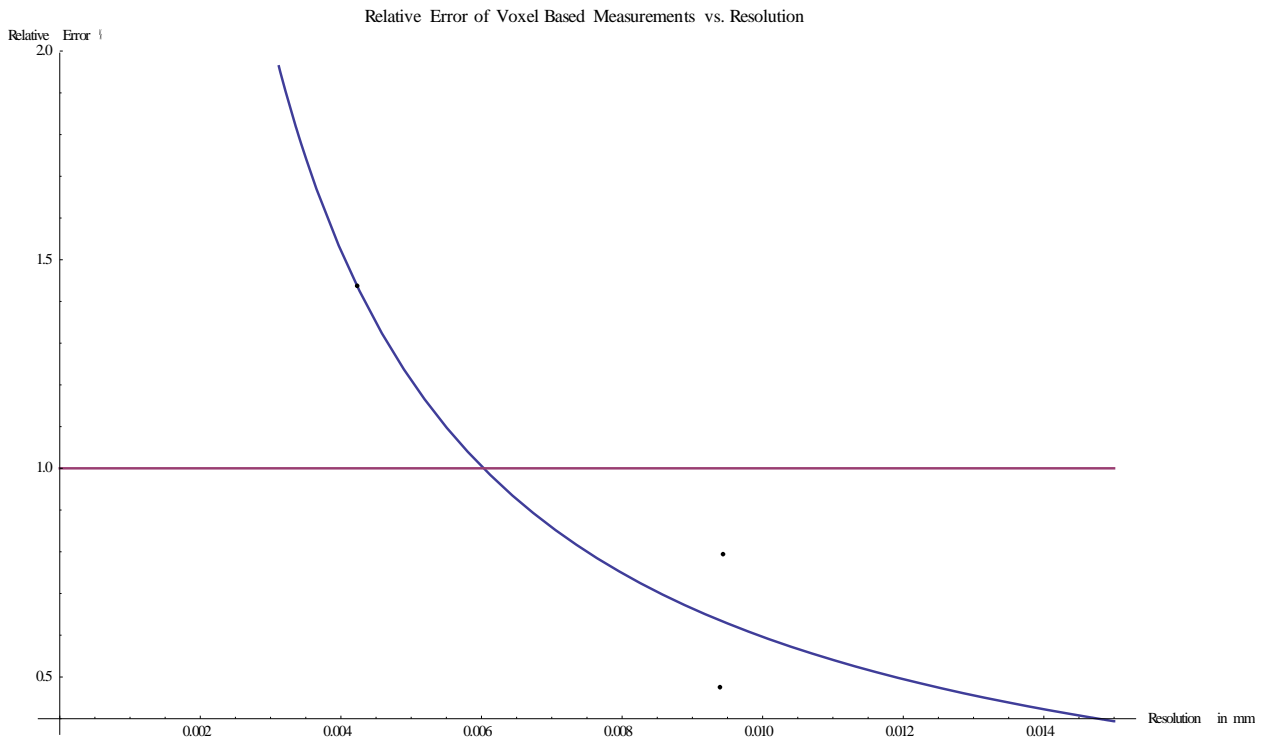
- 3) If batch will run longer than 5 hrs, a shading correction safe position will need to be set
 - a. Make sure to check **Safe position set**
 - b. Move sample out of view then click **Set** and **Save**



- 4) Leave above window open and **repeat steps 14-26** in (CT Scan Set-Up) selecting **Add to Batch** when reaching **step 26** until each scan in your batch appears in the **CT profiles** dialogue
- 5) When Done, **Save -> Done<< -> Run**
- 6) Batch should begin
- 7) Note projected run time under progress bar from pop-up window

Appendix B: Metrology

- 1) Measurements made on MicroCT become prone to higher error at higher resolutions (see plot below)
 - a. Use of SMIF approved standard or use of a known landmark in the scan to correlate measurements is highly recommended
 - b. For measurements made on samples scanned at resolutions below 15um, error might be >1% and sometimes as great as 25%**
 - c. You can choose to scan a standard with your specimen or after your specimen so long as it is done at the same resolution and detector distance
 - i. The y and x stage positions are irrelevant
 - d. Standards scanned alone can be collected at very short exposure time (286ms) and low average (1-2) with needed projections set to 800.
 - i. This scan usually takes 5 minutes



- 2) Once the standard has been scanned at the same resolution as your sample, you will need to open the reconstructed scan data in Volume Graphics VG Studio MAX 2.2 and measure the known dimension in software for correlation between measured vs. actual
 - a. You can use other software as well if you know how to edit the resolution settings of your imported data
- 3) You will then scale the voxel size of your scan by multiplying the ratio produced by $\frac{MEASURED}{ACTUAL}$ of your standard times the voxel size of your scan
 - a. The voxel size of the scanned standard and your sample MUST be the same
 - b. Please speak to Jimmy about this as he has an XLS which makes this very simple
- 4) Measurements now made on your scan data should have a relative error $<\sim 0.1\%$
- 5) For actual procedure to correct data using VG Studio MAX 2.2, see RECO Operating Procedure