Nanoprobe tomography alignment notes, John Provis, U.Melbourne, Aug 2009

Notes

- The two different frames of movement will be referred to as: '*moves the sample*' or '*moves the camera*'. These are the opposite of each other (antiparallel), and refer to the view on the screen – so if a button *moves the sample* to the right, the image of the sample on the screen moves to the right. If a button *moves the camera* to the right, the image of the sample on the screen moves to the left. This should be distinguished from the actual actions of the Sample x/y/z motors, which *move the stage*, or the m1/m2 motors, which *move the center of rotation*.
- The exact changeover between positive and negative angles (i.e. which direction m2 moves the sample) depends on the alignment between the axes of the two sets of motors. Currently this offset is ~10-15° (i.e. angles between 0 and about 15° behave as if they were negative angles), but this may change with hardware modifications in future and is worth keeping an eye on

Motor directions

- Sample x *moves the camera* left or right (i.e. clicking the left arrow moves the image of the sample closer to the right-hand side of the field of view)
- Sample y *moves the sample* up or down (i.e. clicking the up arrow moves the sample upwards in the field of view)
- Sample z moves the focus in or out
- The goniometer metrology rotation motor spins from $\theta = +90$ to -90°
- Attocube motors m1 and m2 change effective direction depending on θ:
    - At $\theta = 0°$, m1 runs parallel to Sample x (*moves the camera*), and m2 runs in the direction of Sample z. (Note: I haven't figured out which directions for the ones running in the z direction at each point, because it's not critical – depth of focus is more than the range through which the attocubes are likely to be moving in these steps)
    - At $\theta = +90°$, m1 runs antiparallel to Sample x (*moves the sample*), and m2 in the direction of Sample z
    - At $\theta = -90°$, m1 runs parallel to Sample x (*moves the camera*), and m2 in the direction of Sample z
    - When stepping towards ±90°, the motor directions approach the ±90° cases according to simple trigonometry – so larger steps in m2 are needed to see x-direction movement of the sample on the screen at low angles (e.g. 5°), because tan(5°) is a small number.

Sample alignment procedure

(1) Find the tip, step around in x & y using stage motors and mosaic scans to find a sample
(2) Focus the sample in z
(3) Record Sample x/y/z, m1 and m2
(4) Step gradually to -90°, adjusting m2 to keep the sample in view - initially 1° steps are usually necessary to keep the sample in the frame, then 5° steps can be used once the alignment improves
(5) Record m2
(6) Rotate back to 0° and return m2 to its original position
(7) Step gradually to +90°, similar to (4)
(8) Record m2
(9) *Move the center of rotation* by adjusting m2 to the average of its positions at ±90°
(10) *Move the stage* using Sample x, by the same amount that m2 moved as a first guess, although the angle offset in the axes will mean that a small additional adjustment is usually required to center the particle
(11) Rotate back to 0° and find the sample again. This can be done in a number of ways, from potentially fastest to slowest (but most reliable):
   a. Spin straight to 0° and find the sample with m1
   b. Spin straight to 0°, find the sample using horizontal (1x8) mosaic scans in Sample x, then calculate the change in Sample x that was applied to find the sample, add this value to m1, and return Sample x to its original position. This method can be nice if the m1 offset is large, but also introduces errors due to the axis angle mismatch.
   c. Step gradually from +90° back to 0° as was done in (4), but this time making the adjustments in m1. This is slow, but reliable, because the particle is always kept in view.
(12) The sample should now be at or near its center of rotation. However, it is rare that the alignment will be satisfactory at this point, further refinement is achieved by cycling through steps (4)-(12) - but usually without needing to step so gradually to keep the particle in frame as it should be close already.