

TT AFM “LongBeach” Procedures and Protocols

V2.1

1. Startup Procedure

1. Turn on PC: Allow to boot to Windows. Turn on monitor. Password is “afm”
2. Turn on second PC that controls the video camera.
3. Turn on EBox; all seven green lights should come on
4. Start Software (e.g. AFM Workshop 2.0.3.exe)
5. Remove dust sheet from AFM
6. Lower lab jack below wooden mass box, to enable the AFM to float freely, it’s recommended that you leave at least 1 cm clearance
7. Turn on video camera light source
8. Remove dust cap from video microscope
9. Start USB 2.0 Camera Software and click the “Play” button to show the live feed

2. Shutdown Procedure

1. Ensure disengaged from surface
2. Lift head ca. 1cm.
3. Exit Software (e.g. AFM Workshop 2.0.3.exe)¹
4. Turn off EBox
5. Shutdown PC and turn off monitor. Repeat for second PC, stopping software and shutting down.
6. Remove your sample, and probe if appropriate. If you might not be the next user of the AFM, remove the probe and return to the probe box.
7. Raise lab jack, to remove strain from elastic bungee cords
8. Turn off video camera light source
9. Fit dust cap to video microscope
10. Place dust sheet over AFM

¹ BUG ALERT: Some versions of the software do not shutdown if you use the red box with a cross in the upper right of the window. Instead exit with the “Exit” button on the Topo Scan Tab. If the software won’t close, use windows task manager to close it.)

3. Insert Probe and align

INSERT

1. Remove the probe holder cassette from the instrument and place it, upside-down on probe insertion base, see figure 1.

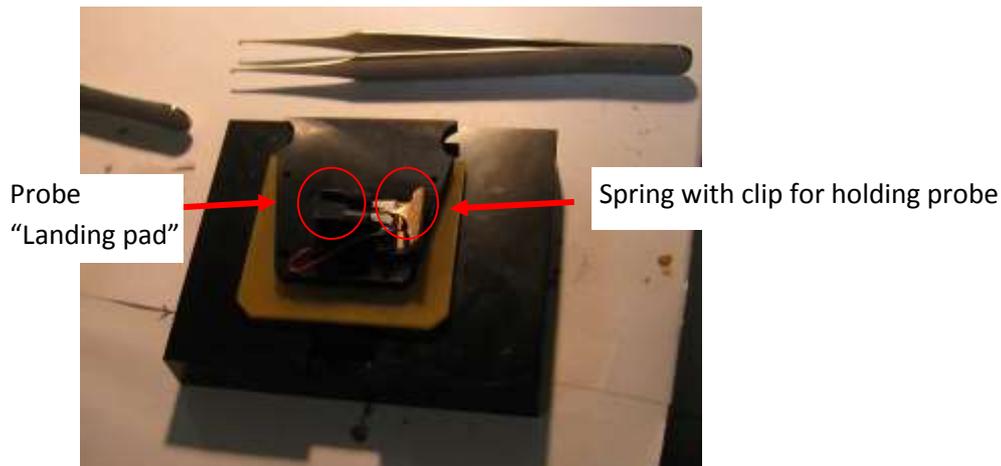


Figure 1: Probe holder cassette in Probe insertion base.

2. Open box with probes, next to probe insertion base.
3. Use probe tweezers to move probe to "landing pad" on probe insertion base.
4. With one hand, push down on cassette until brass spring rises a little (it moves less than one millimetre). With your other hand, use rubber brush to move probe under spring, and then release. Check probe is seated all the way back in the slot.
5. Lift probe cassette from probe insertion base, turn the right way up and slide into AFM instrument.

ALIGN

6. If using a reflective sample, insert it now as it makes alignment easier.
7. Start video microscope software, It may be called App300.exe or "USB 3 Mega pixels camera", it should be USB 2.0 Camera,
8. Push play button in video microscope software
9. Locate probe in video microscope. This may be as simple as moving the focal plane of the microscope up and down using the wheel on the side.

10. If laser is not on, turn it on in AFM Workshop software. Also check, that motor is responding.²
11. Align laser on probe using the two laser translation thumbscrews located at the top and front of the AFM head; see figure 2.

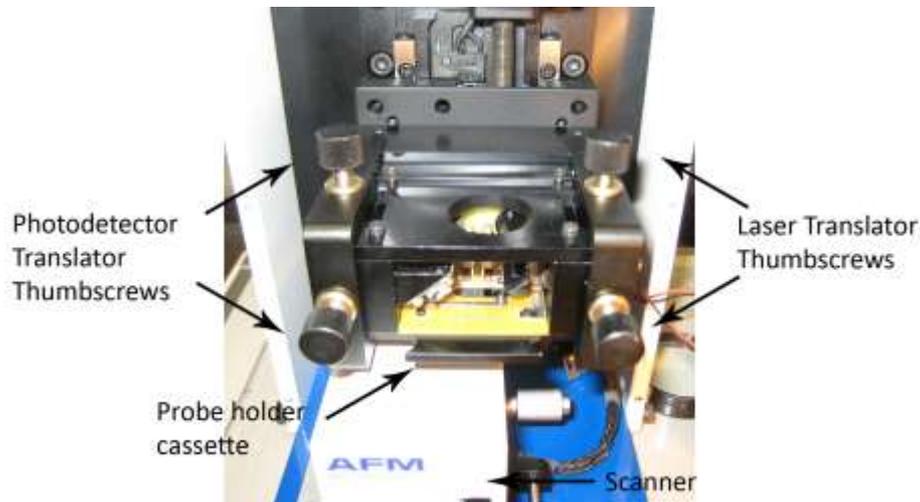


Figure 2: AFM Head, indicating location of thumbscrews for translation of laser and photodetector

12. For details on alignment of laser see page 89 of Eaton and West. Get the maximum signal. The laser may not look like a discreet spot, see figure 3.

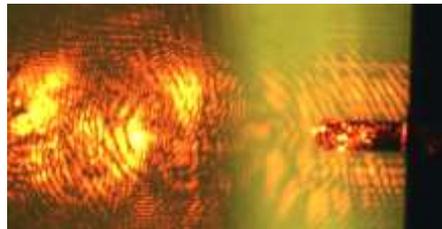


FIGURE 3: Laser alignment, often you get diffraction pattern instead of a visible spot

13. You may not be able to get the top-bottom(T-B) and left-right(L-R) signals to zero, without reducing the Top+Bottom, the important thing, is that they should change when you move the photodetector translation thumbscrews. Get the T-B and L-R signals as close to zero as you can (ideally within 0.1V), without jeopardising the T+B signal to do so.

² If either laser or motor does not respond, you need to turn off the software and ebox, wait for green lights to go out. Then turn on again the ebox, then the software back on.

4. Approach (contact Mode)

1. Select “Non-vibrating”
2. Ensure the Range Check is Complete (with green light) before approaching. DO range check with the probe somewhat close to the sample, so that you can see both sample and probe when range check is going on. During range check, the sample should translate around a square under the probe. If this does not happen, there is a problem.
3. Ensure you have aligned the laser on the probe, you need to have between 0.8 and 1.V in the Top-Bottom signal for approach to work.

Approach (Vibrating Mode)

Select “Vibrating”

Ensure the Range Check is Complete (with green light) before approaching. DO range check with the probe somewhat close to the sample, so that you can see both sample and probe when range check is going on. During range check, the sample should translate around a square under the probe. If this does not happen, there is a problem.

Moving the probe towards the sample is achieved with the Manual Z motor control buttons, “Up” and “Down”. It is recommended to use a speed less than half the maximum in this control. The best way to tell if the probe is approaching your sample, is to focus on the sample, and move the probe down until it is NEARLY in focus.

Laser should already be aligned on probe, the place of the red dot on the photodetector is not very important. Ideally, TB should be in the middle of its range. The “vibrating” option makes the “Tune Frequency” window active.

Use this window to find the resonant frequency of the probe, and set the correct amplitude:

You should know the range of possible values of the natural resonant frequency (R_f) of your probe, if not, look on the box. For AppNano ACT probes, it-s 200-400kHz.

Set “Lower” and “Upper” values accordingly to sweep this range. Note It won’t work if you have a “selected” value outside of the range.

An initial guess for the driving amplitude (“Amplitude V_{pp} ”), would be 0.2 V. You need at least 1 step per KHz, so for the above case, set steps to 200.

Press “Sweep”

You should see a sharp positive peak in the amplitude trace somewhere in that range (fig 4a). Move the green (lower), blue (selected) and red (upper)

lines to close in on the peak. Do this by putting the green line on the left of the peak, the blue on in the middle of it and the red one on the right of the peak. Reduce the number of steps. Typically 50 steps would be a good choice.

Repeat a sweep, with fewer steps (e.g. 50). Do this until the peak fills most to the windows as in figure 4b.

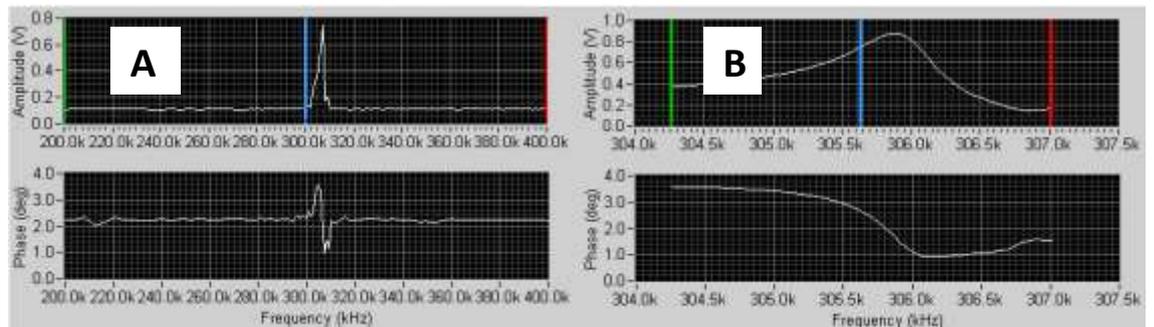


FIGURE 4 Tune window: A: Initial tune; B: Tune at scale suitable for selecting operating conditions.

When you can see the peak clearly as in figure 4b adjust the Driving Amplitude (Vpp) to achieve the desired peak amplitude in the window, for example 0.6V.

Now, the operating frequency should be chosen. Ideally, you will do this with the probe already close to the sample surface. If necessary, use “Down” button to achieve this, using the focus of the video microscope to help you get close.

This guide assumes you use software version 2.0.3. Other versions will be different in this part of the procedure. UPDATE: As of version 1.5.7, the curve is displayed in the correct place on the window.

Put the blue line on the highest point of the amplitude curve.

Ensure the “A” for advanced at the bottom is checked, which enables you to see the “Z amplitude value at the bottom of the screen. Look at the amplitude value, it should be oscillating a little in the decimal points. Note the value.

Move the blue line a little to the left. Check the amplitude value in system again. You want the amplitude to decrease by 2-5 % on moving left, compared to the maximum value. For example, if you have a maximum of 1.00V, look for a value of 0.95-0.98 V.

NOTE: This procedure is particularly confusing some old versions of the software, e.g. version 1.5.6, because of a bug in the software, which means the REAL amplitude curve is shifted to the left of the DISPLAYED amplitude curve by ca.100Hz.

Ideally, you should start with a maximum amplitude between 0.5 and 0.7 V.

Before automated tip approach you should get the probe as close to the sample as possible, without risking damage to the probe. You do this using the manual z motor controls (bottom left). Typically this is done while focusing on the sample, looking for the probe to become CLOSE to focus. Use the focus wheel to move focus between the sample, to the probe, and back to the sample, to check the distance, as necessary.

When ready to start automated approach (i.e. the probe is very close to the surface), press “start” in the “automated tip approach” box.

The approach occurs step by step, in the “woodpecker” method (see i)

Eventually, it should say feedback ON (green light). Ideally z drive should be in the centre of the range (0 V).

If not in centre, but not at the extremes, use the Jog Up and Jog Down buttons, to adjust the position. You will need to enter a distance in the box in the middle of these two buttons, before using them, e.g. 1 µm.

If something has gone wrong, it may press the tip HARD against the sample, so watch the video microscope while this is occurring. If you see cantilever bending, STOP, and raise the tip.

5. Scan (Vibrating Mode)

- a. Automated Tip approach should have finished with the yellow line in the middle of the range, in the Z drive display. If not, approach again. If this never works, ensure the sample is not moving, and try reselecting the operation frequency.
- b. Go to “topo scan” tab.
- c. The table below has some suggested initial operating parameters. Some of these may be inappropriate for your sample. For example, you may only be interested in larger or smaller scans than 15 µm.

Parameter	Suggested initial value
type	3d
Scan rate	0.5Hz
Scan lines	128
Scan size	15µm
Samples/pixel	20
Rotation	0 degrees

center	X and Y = 25 μm (when using 50 μm range), 7.5 and 7.5 for 15 μm range scanner.
Gain	2
Proportional	200
Integral	2000
Derivative	0
Left image, Right Image	Z_drive, Z_ampl

- d. Click “start” to begin scanning.
- e. If your images show NOTHING (except laser interference in the amplitude channel), there are several things to try: reduce setpoint, approach again, and / or increase amplitude in prescan (in this order). Typically, the initial setpoint will be too high, so a reduction of 10 to 20% maybe required. Be cautious, and do not reduce setpoint below 60% of its initial value.
- f. Adjust parameters (especially Scan Rate, Gain, Proportional, Integral and Setpoint) as required while scanning, watching the effect on the line scan and image. For more on this see chapter 4 of Eaton and West.

6. Open Saved Data File with Gwyddion – Raw Data

1. This procedure is to open files with the extension .wsf from the AFM Workshop software, with very old versions of Gwyddion. **With versions of gwyddion above 2.22 , this procedure is no longer necessary, simply open .wsf files with “automatically select” selected in the file->Open Dialog in Gwyddion.**
2. Use Gwyddion 2.20 or later
3. Click file ->open
4. Navigate to the directory. For 1.5.1, the files are located in a directory specified in Testdata_path in the parameter file.
5. Select File Type:Raw Data files, select the file and click open.
6. IN the information tab, select the resolution and physical dimensions as specified in the file name.
7. Under z scale the correct setting is normally 1.00 nm, for the left image, and 1.00 mV for the right images.

8. TO change the units click “change” and type the name of the unit you want to use. You may then need to click the drop down list of units to refine it (i.e. to change from mm to nm).
9. In the data format tab, select Text data, and start form line: 17. Leave row skip at 0 lines. Field delimiter should be set to “any whitespace”. It is a good idea to go into presets, and save this configuration under a name like “AFMWORKSHOP 1.5.1 128 pix”.
10. Click OK.
11. NOTE: Opening files like this takes a LONG TIME if they are of a high resolution..To give an idea, on the DELL inspiron5 with Sempron Processors, approximately the following times apply:

resolution	Data points	Time
128	16,384	3
256	65,536	29
512	262,144	480

7. Reducing Z gain (high resolution scanning).

For scanners with large z range, lower noise in z, and hence higher resolution can be attained by reducing the z gain. To do this:

1. Approach normally, ensure imaging is working.
2. Do a tip retract.
3. GO to system tab, reduce Z HV Gain Parameter, and tip approach motor jog.
4. The values to use depend on how low the noise needs to be, consult this table:

Z HV Gain Parameter	Z Range (nm)	Z Noise (nm)(Approx)	Suggested Tip Approach Motor Jog (um)
15 (default)	17000	0.85	5
14	15867	0.79	5
13	14733	0.74	5
12	13600	0.68	5
11	12467	0.62	5
10	11333	0.57	5

9	10200	0.51	5
8	9067	0.45	5
7	7933	0.4	5
6	6800	0.34	4
5	5667	0.28	4
4	4533	0.23	4
3	3400	0.17	4
2	2267	0.11	2
1	1133	0.06	1

CAUTION: The tip approach motor jog value must ALWAYS be smaller than the Z range in the above table! If this is not the case, tip approach will fail!

¹ Atomic Force Microscopy, Eaton and West, Chapter 2.