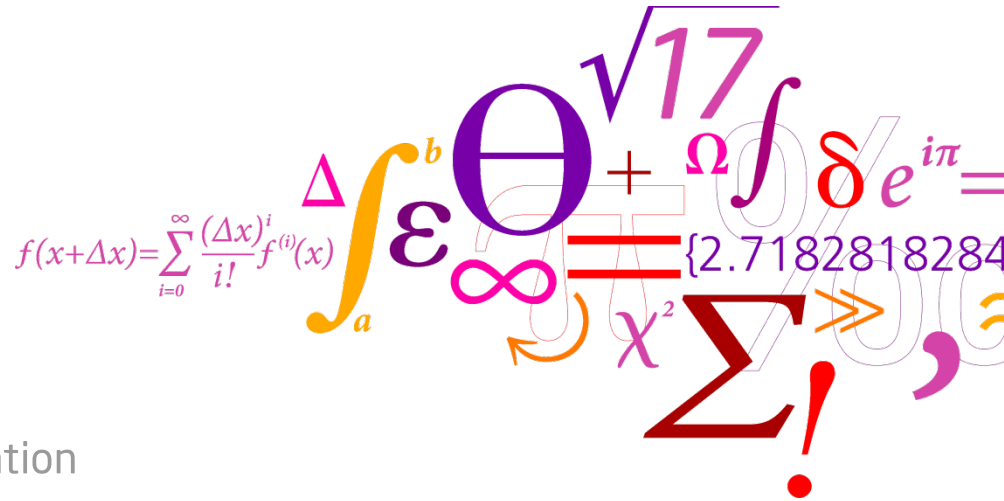
AFM Icon Re-training

Marts 26th 2015

April 15th 2015



DTU Danchip

National Center for Micro- and Nanofabrication

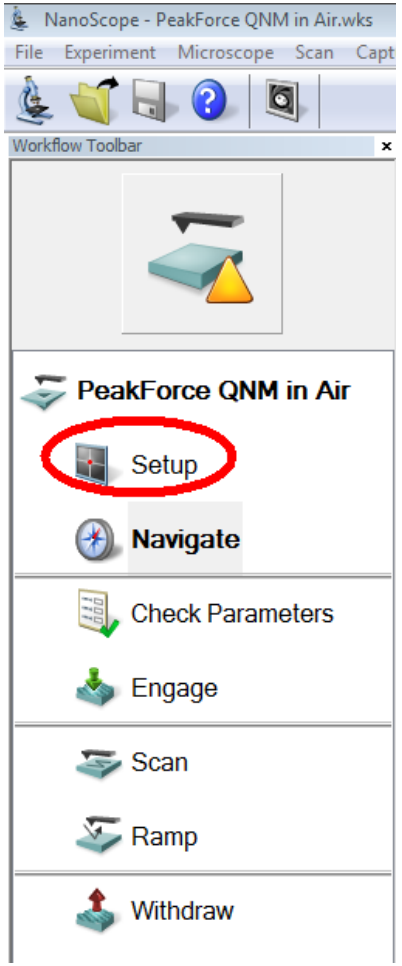
Agenda

- Change of Cantilever
- What experiment/workspace to use
- How to optimize your scan
- Change of standard probe?
- Booking rules
- High Aspect Ratio Scanning
- QNM
- How to get SPIP software

Change of Cantilever

- When changing cantilever – please remember to be in **setup**
- When do you need to change cantilever:
  - If the cantilever has broken off (please through it away)
  - If it does not help to adjust the scanning parameters and it does not help to clean* the tip. (Then please through it away)
  - If you can see that the tip shape is not good enough for your purpose. (please save it)

* Clean a tip by scanning on a carbon pad, mounted on a disc or a wafer. This only works in PeakForce tapping mode (or QNM).



What experiment / workspace to use

- For standard experiment we recommand:

  PeakForce QNM in air

  – This includes ScanAsyst

  – And mapping of

    - Youngs modulus
    - Adhesion
    - Deformation
    - Dissipation

  – And this experiment is set up with good engage settings.

- No change in recommandation when using tapping mode.

PeakForce Tapping – how to optimize scan

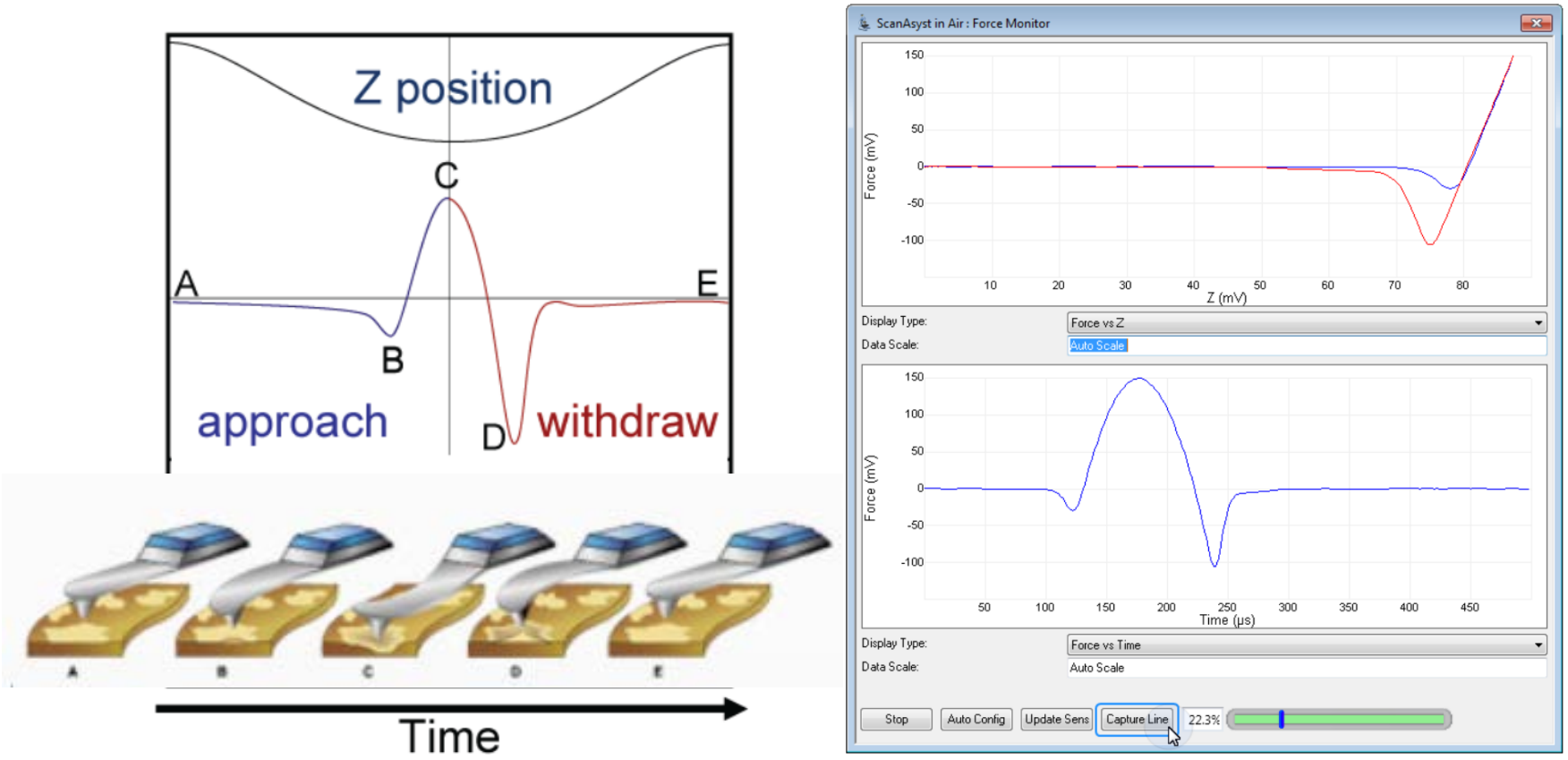
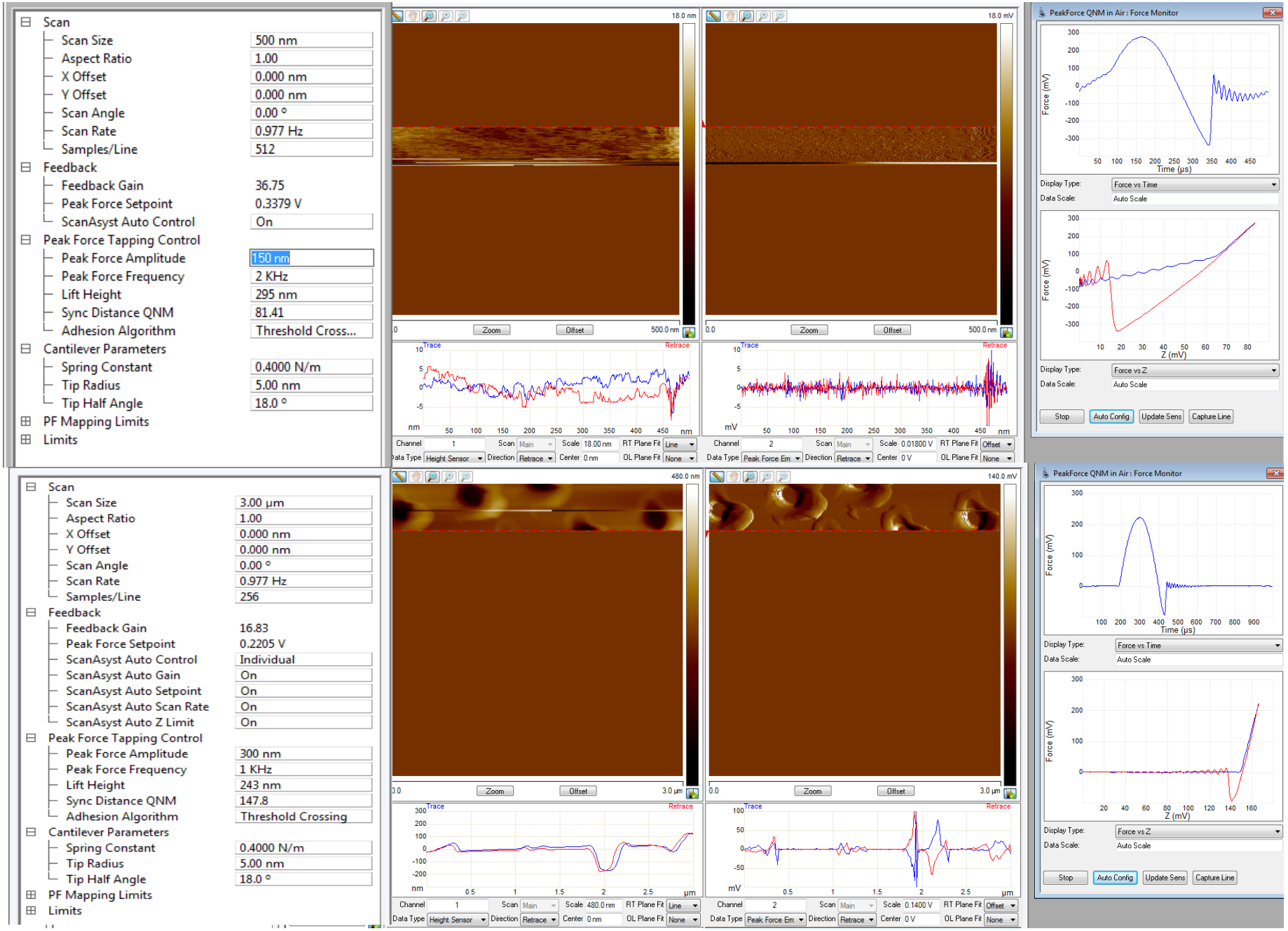
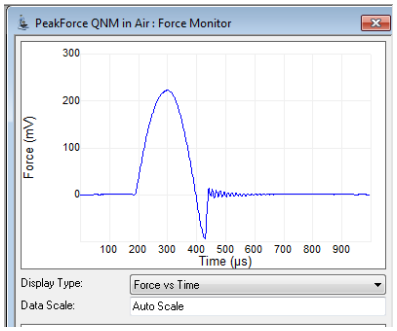


Figure 1: The "heartbeat." Z position, Force and Current as a function of time during one Peak Force Tapping cycle. Blue indicates approach while red indicates retract.


Scan
Scan Size 500 nm
Aspect Ratio 1.00
X Offset 0.000 nm
Y Offset 0.000 nm
Scan Angle 0.00 °
Scan Rate 0.977 Hz
Samples/Line 512
Feedback
Feedback Gain 36.75
Peak Force Setpoint 0.3379 V
ScanAsyst Auto Control On
Peak Force Tapping Control
Peak Force Amplitude 150 nm
Peak Force Frequency 2 KHz
Lift Height 295 nm
Sync Distance QNM 81.41
Adhesion Algorithm Threshold Cross...
Cantilever Parameters
Spring Constant 0.4000 N/m
Tip Radius 5.00 nm
Tip Half Angle 18.0 °
PF Mapping Limits
Limits
PeakForce QNM in Air : Force Monitor
Force (mV)
Time (µs)
Z (mV)
Display Type: Force vs Time
Data Scale: Auto Scale
Display Type: Force vs Z
Data Scale: Auto Scale
Stop
Auto Config
Update Sens
Capture Line
Scan
Scan Size 3.00 µm
Aspect Ratio 1.00
X Offset 0.000 nm
Y Offset 0.000 nm
Scan Angle 0.00 °
Scan Rate 0.977 Hz
Samples/Line 256
Feedback
Feedback Gain 16.83
Peak Force Setpoint 0.2205 V
ScanAsyst Auto Control Individual
ScanAsyst Auto Gain On
ScanAsyst Auto Setpoint On
ScanAsyst Auto Scan Rate On
ScanAsyst Auto Z Limit On
Peak Force Tapping Control
Peak Force Amplitude 300 nm
Peak Force Frequency 1 KHz
Lift Height 243 nm
Sync Distance QNM 147.8
Adhesion Algorithm Threshold Crossing
Cantilever Parameters
Spring Constant 0.4000 N/m
Tip Radius 5.00 nm
Tip Half Angle 18.0 °
PF Mapping Limits
Limits
PeakForce QNM in Air : Force Monitor
Force (mV)
Time (µs)
Z (mV)
Display Type: Force vs Time
Data Scale: Auto Scale
Display Type: Force vs Z
Data Scale: Auto Scale
Stop
Auto Config
Update Sens
Capture Line

How to optimize your scan

- Look at the **force curves** to make sure they look good.
- Adjust **Peak Force amplitude**. High value helps to release the tip from the surface.
- **Peak Force Frequency**: it some times help to set it down to 1KHz
- **Feedback gain:** Increasing the feedback gain can improve surface tracking; but too high a gain value will cause oscillation of the system and increase noise.
- **Peak Force Setpoint:** Increasing the Peak Force Setpoint will increase the interaction force between tip and sample which will result in good surface tracking but risks damaging the tip or the sample. It is generally desirable to reduce the Peak Force Setpoint to as small a value as possible.
- **Auto Config:** Press *Auto Config* if the force curve looks like this:



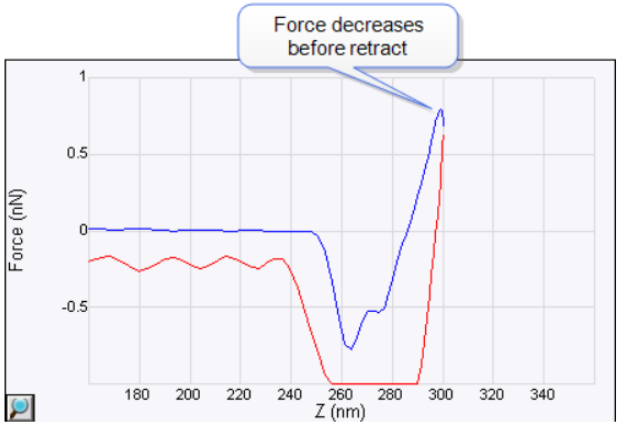


Figure 2: ScanAsyst Late Synch

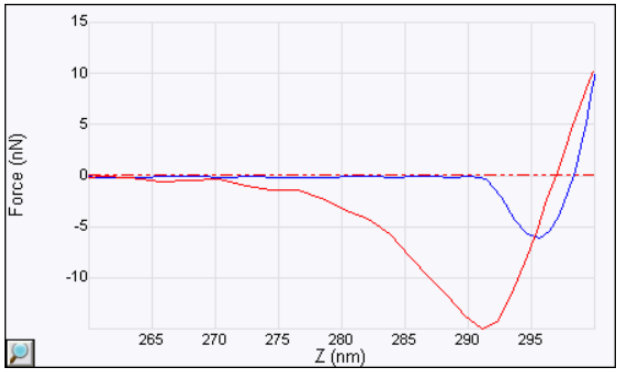
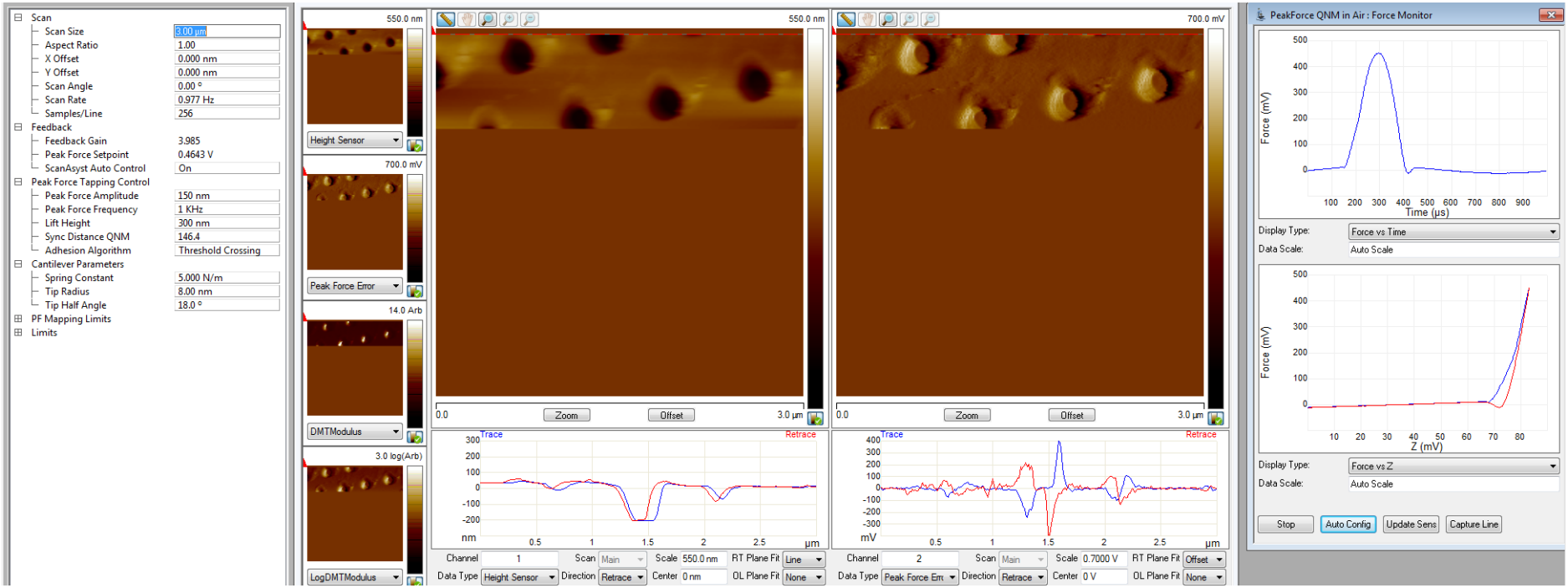


Figure 3: ScanAsyst Early Synch: the retract curve (red) should not be to the left of the (blue) approach curve.

Change of standard probe?



Here I used a stiffer probe: I have not adjusted any parameters (except scan size)

TAP150A: k=5N/m

ScanAsyst in air: k=0.4N/m

We are considering changing to this probe

Booking rules

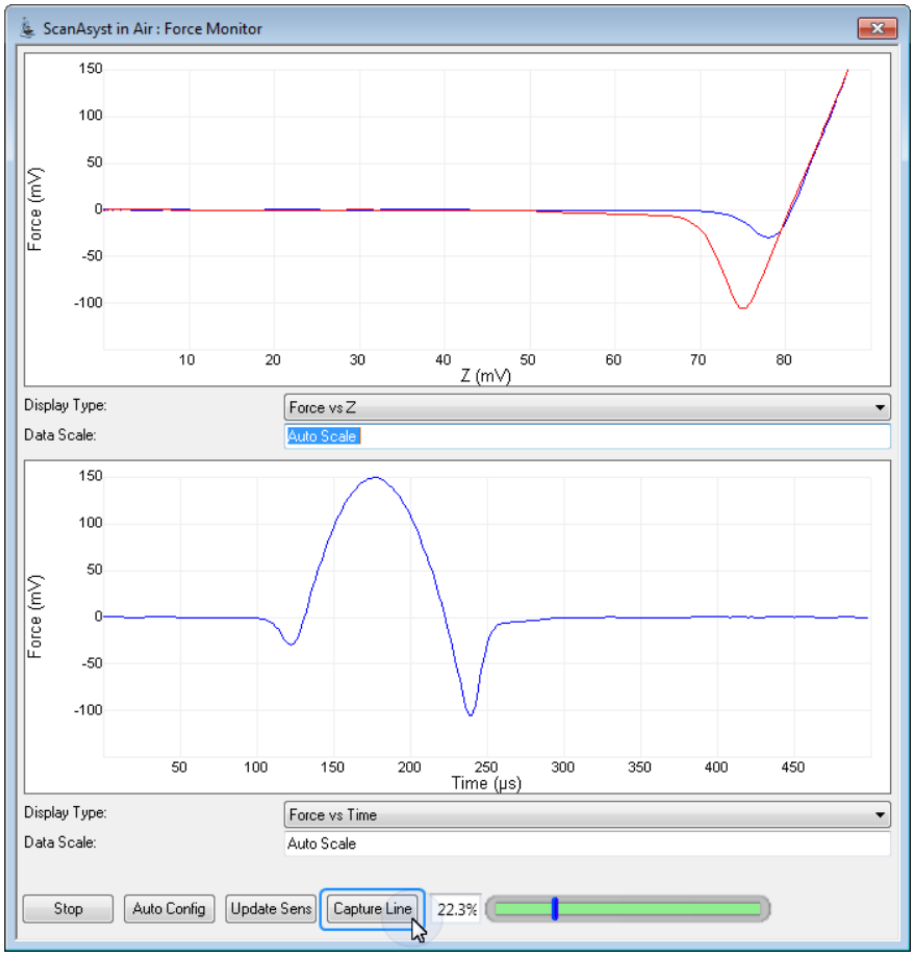
- We will keep the current booking rules: Monday to Friday between 8am and 4 pm
  - Maksimum 2 hours of booking per user.
  - 15min delay => your booking is lost

High Aspect Ratio (HAR) scanning

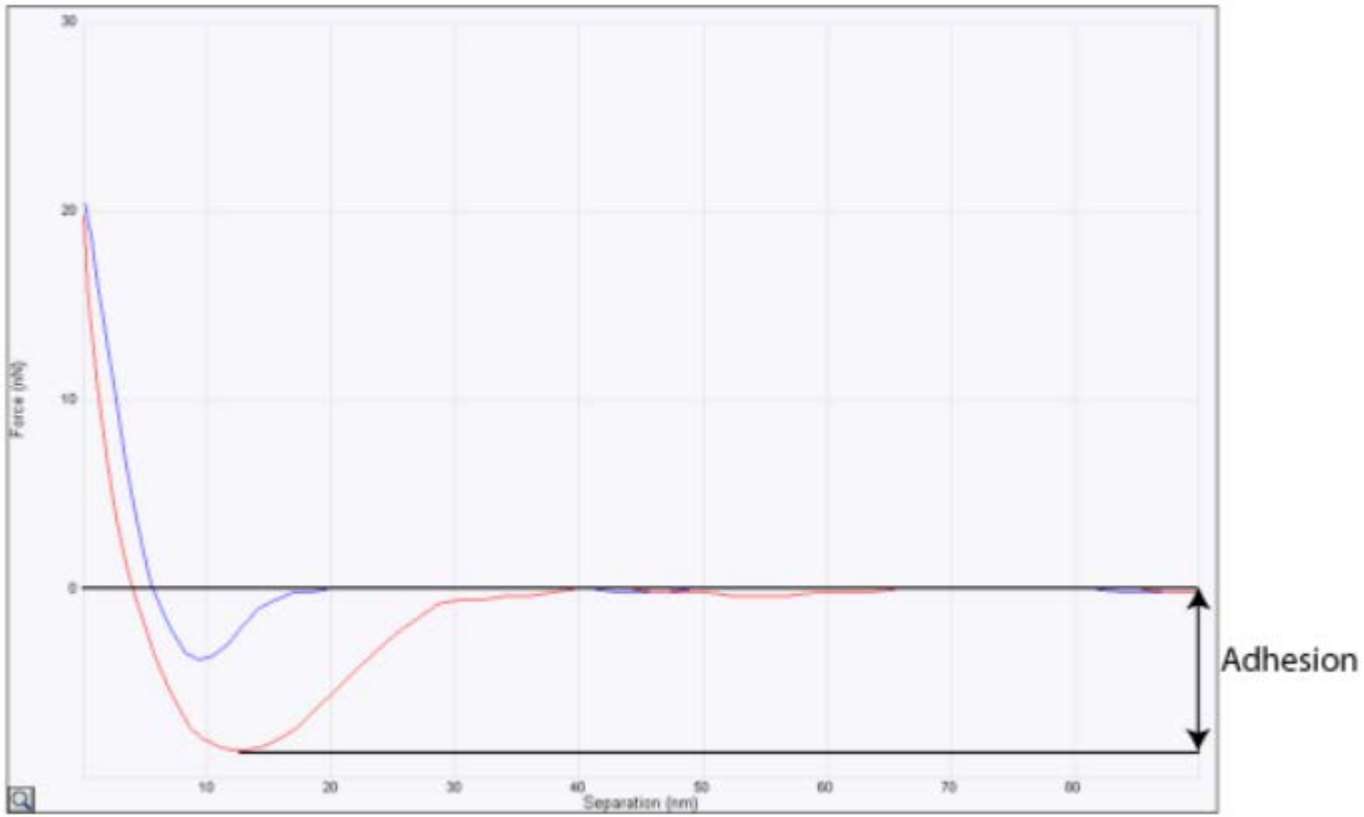
- Right now use dedicated Tapping mode experiments/workspaces
  - TappingMode 300nm trench (small step)
  - Tapping mode in air – 6µm Deep Trench (deep steps)
- Always engage with 0nm scan size and integral gain low (~0.5)
- Increase gain and scan size very slowly: 10nm->50nm->100nm->1µm
- If you get a false low depth you may have to decrease the amplitude setpoint a little.
- Using PeakForce tapping – maybe in the future

Quantitative Nanomechanical Mapping (QNM)

- Mapping of
  - Youngs Modulus
  - Adhesion
  - Deformation
  - Dissipation

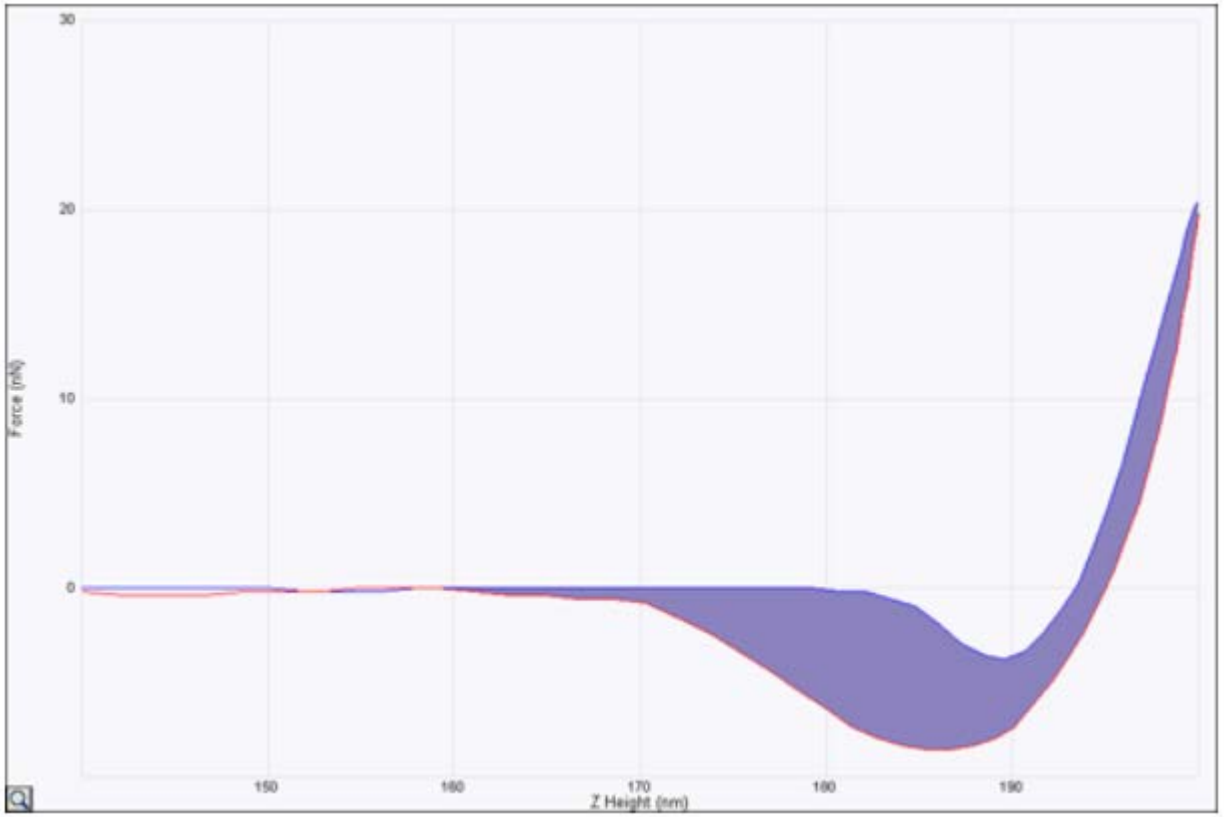


Adhesion

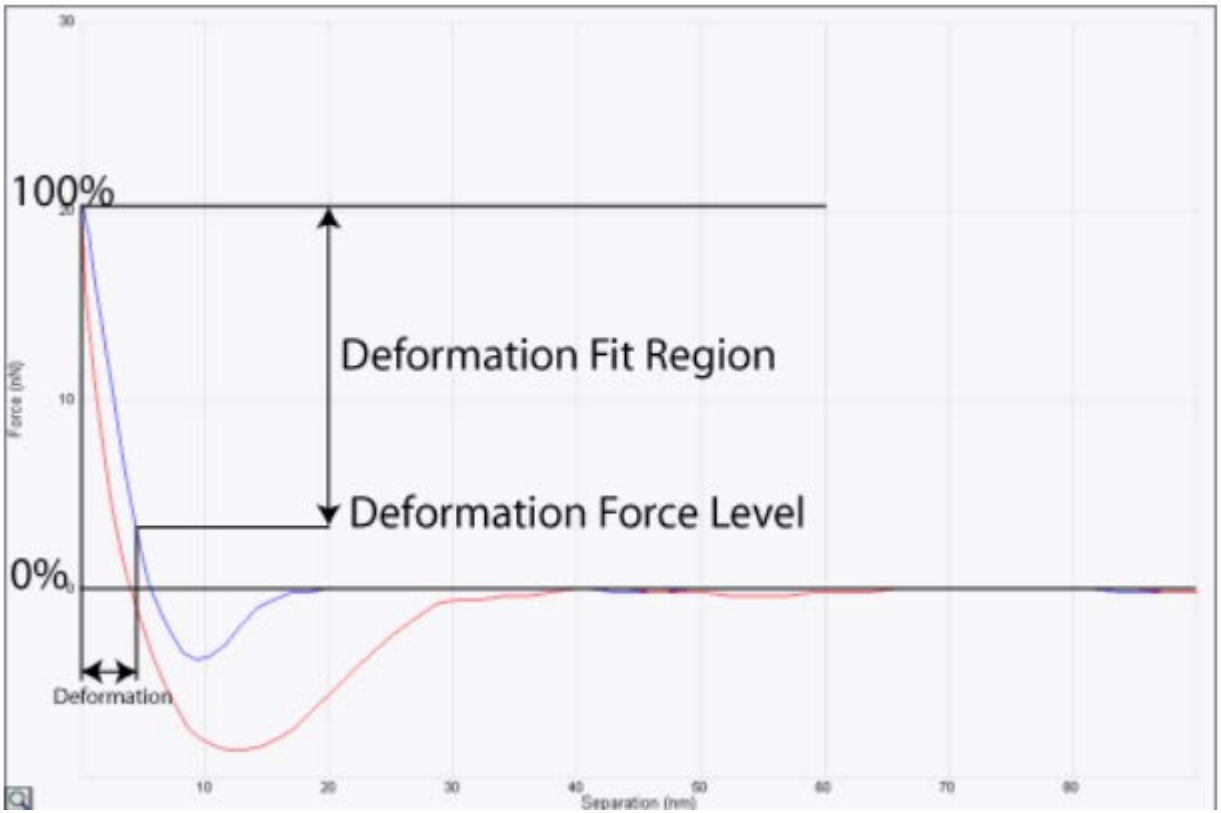

30
20
10
0
Force (nN)
10
20
30
40
50
60
70
80
Separation (nm)
Adhesion

Energy dissipation

- Mechanical energy loss pr. tapping cycle
- Elastic deformation has low dissipation



Deformation – maximum deformation of the sample (actually a little less)



The reduced Young's Modulus

- DMT Modulus for hard materials
- Sneddon Modulus for soft materials (like cells …)

The reduced Young's Modulus, E^*, is obtained by fitting the retract curve (green line in Figure 1) using the Derjaguin, Muller, Toropov (DMT)[1] model given by

$$F_{tip} = \frac{4}{3}E^* \sqrt{Rd^3} + F_{adh}$$

Where F_{tip} is the force on the tip, F_{adh} is the adhesion force, R is the tip end radius and d is the tip-sample separation.

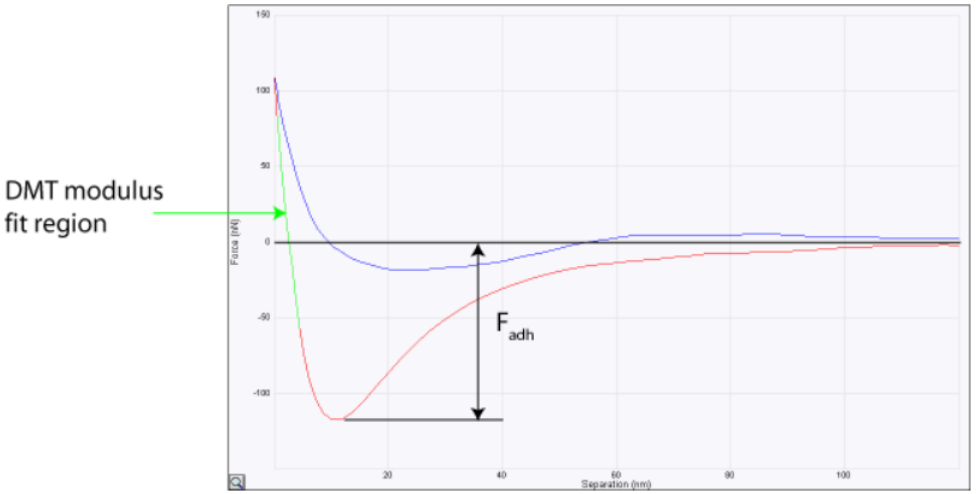


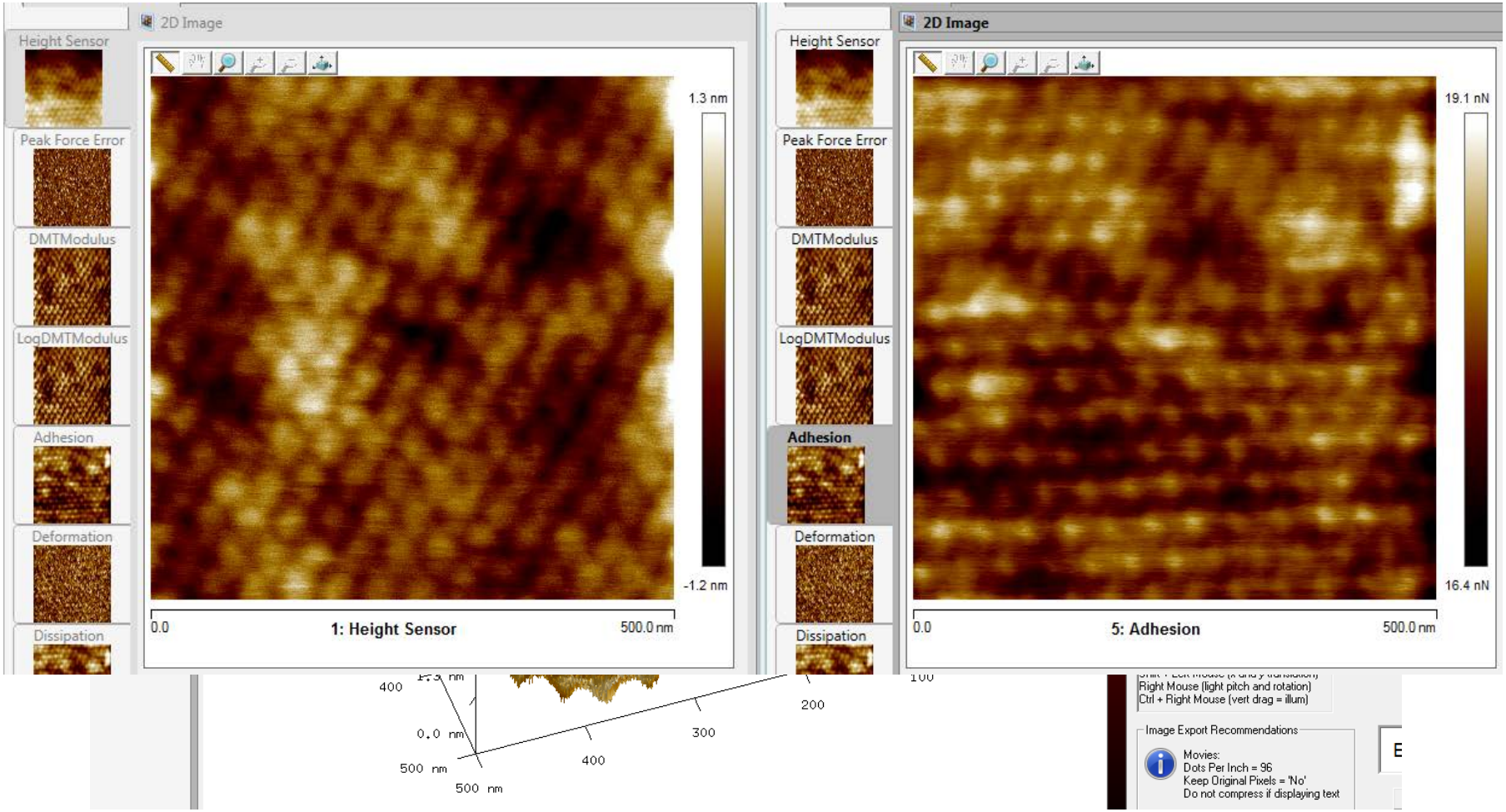
Figure 1: Force vs. Separation plot

How to use QNM

- By using the QNM workspace you get qualitatively mapping of *adhesion*, *dissipation*, *deformation* and *moduls*. That can give you a material contrast in the image that is not in the height data.

- For quantitative values for the *adheision*, *dissipation*, *deformation* and *moduls* you need to calibrate the system for the tip in use. We have a procedure for this, we have seen it once. Let us know if you want to do this and we can try it out together.

Example: mix of two different polymers with different adhesion. *By courtesy of Tao Li*



SPIP license

- DTU has a site licens – the following institutes have joined
  - Nanotech
  - Physics
  - Chemistry
  - Mechanics
  - CEN
  - Danchip
  - Energikonvertering
- To get it:
  - Contact John Tandrup Riedel JOTRI@ADM.DTU.DK
  - He needs name, email and institute

The End