

Lecture 13

ial Environment for dynamic AFM (VE
overview of capabilities; F-Z curve to

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Please go to www.nanohub.org and register for a free account.

OVERVIEW

What is VEDA?

Open-source simulator for AFM

Why do simulations?

Experiments

may involve unanticipated elements

expensive/time consuming

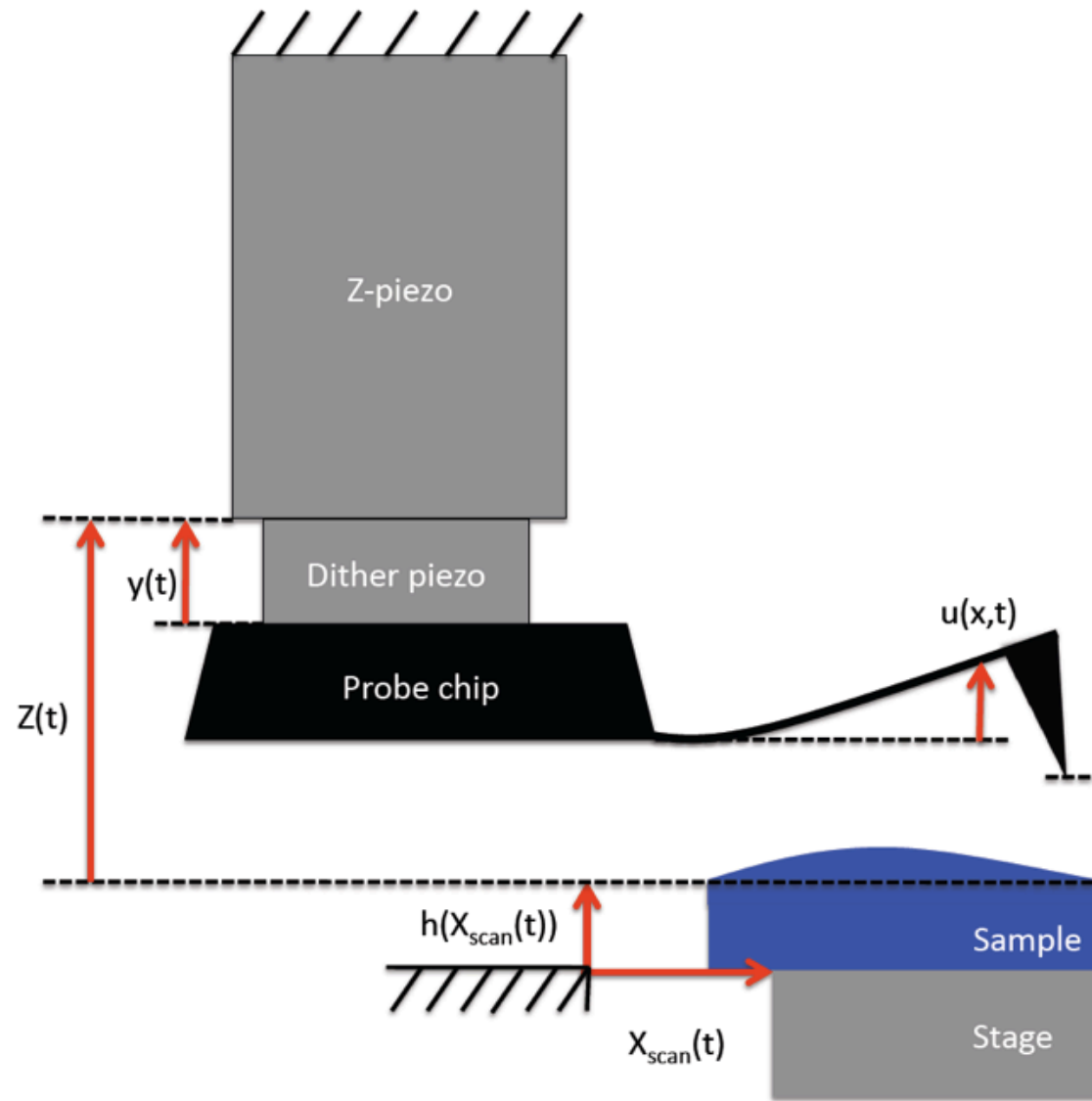
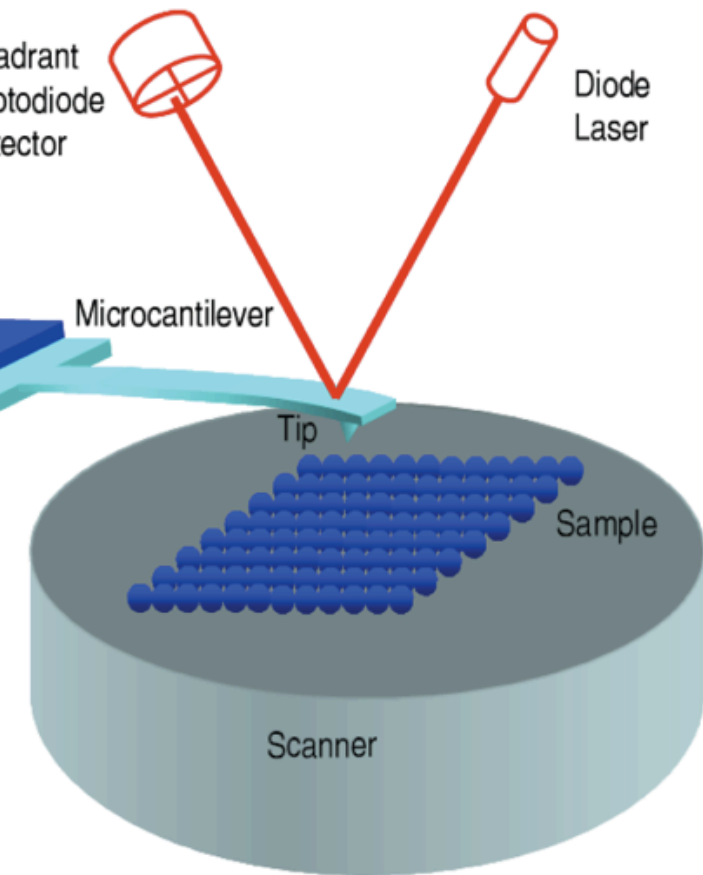
limited observables

simulations are useful because

the environment is controlled

in addition, simulation

Some preliminaries...





ONLINE SIMULATION AND MORE FOR NANOTECHNOLOGY

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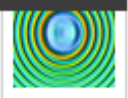
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FEATURED TOOL



Active Media FDTD Nanophotonic Device Simulator: Modeling and analysis of solid state, molecular or atomic semiconductor photonics media.

FEATURED ANIMATION



Nanomanufacturing: Top-Down and Bottom-Up: Martin presents an overview of nanomanufacturing techniques, explaining the difference between top-down and bottom-up approaches.

TOP TAGS

- ABACUS
- carbon nanotubes
- course lecture
- devices
- education/outreach
- Illinois
- material science
- molecular electro
- nano/bio
- nano electro-mechanical systems
- nanoelectronics
- nanomedicine
- nanophotonics
- nanotransistors
- quantum transport
- research semi

Resources: Tools

- ation undercooled anisotropy (2)
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- Resources Sort by: Title
- SUGARCube - Cantilever
 - VEDA 2.0 (Virtual Environment for ...)
 - VEDA: Amplitude Modulated Scanning
 - VEDA: Dynamic Approach Curves

Info

VEDA 2.0 (Virtual Environment for Dynamic AFM)

Comprehensive suite of dAFM simulators in air/liquid/vacuum on soft or hard samples [Learn more >](#)

Launch Tool →

7.6 RANKING

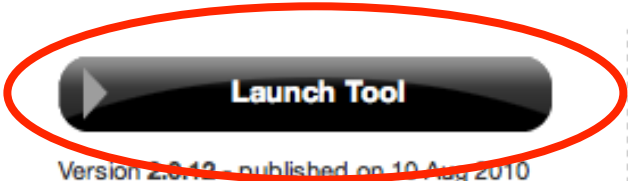
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- 0 questions (Ask a question)
- 0 review(s) (Review this)
- 0 wish(es) (Add a new wish)
- 0 citations

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Virtual Environment for Dynamic AFM)

John Melcher, Daniel Kiracofe, Laurene Tetard

Dynamic AFM simulators for air/liquid/vacuum on soft or hard samples



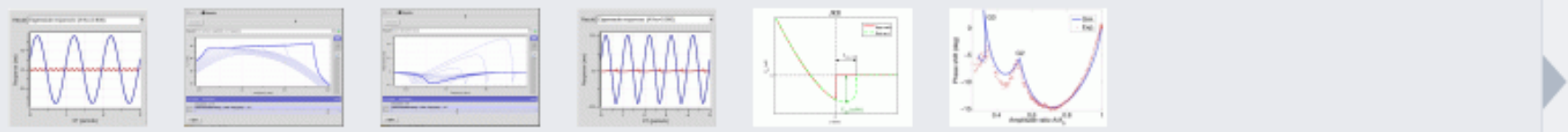
Version 2.0.12 published on 10 Aug 2010
DOI: 10.254/nanohub-r5349.14 cite this
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VEDA manual!

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VEDA is a suite of tools for simulating many different aspects of dynamic AFM under a range of operating modes and environments. VEDA consists of four tools:

Dynamic Approach Curves tool: accurately simulates an AFM cantilever excited at resonance and brought towards a sample surface. Two version are available: basic and advanced. The basic tool simulates oscillations of a single eigenmode of the cantilever, while the advanced tool simulates multiple eigenmodes and multiple excitation frequencies.

SEE ALSO

- Part of: NCN Simulation To...
- Part of: NCN Simulation To...

RECOMMENDATION

- Introduction to Environment t...
- VEDA: Amplitude Scanning
- VEDA: Dynam...

Tool

Questions?

About

Application:

Pick a tool here

- Pick a tool here
- Tip-sample force viewer
- Force Distance Curves
- Amplitude Modulated Approach Curves (basic)
- Amplitude Modulated Scanning (basic)
- Amplitude Modulated Approach Curves (advanced)
- Amplitude Modulated Scanning (advanced)
- Frequency Sweep (basic)
- Frequency Sweep (advanced)
- Frequency Modulated Approach Curves

Environment for Dynamic AFM) v2.0

Welcher, Daniel Kiracofe, Shuiqing Hu,
d Raman

Select a tool from the dropbox box to begin
(Note you can resize the window for optimal viewing
by dragging the handle at the bottom right. Once in
a tool, you can use the scrollbar on the right to access
more choices).



Tip-sample interaction force viewer tool

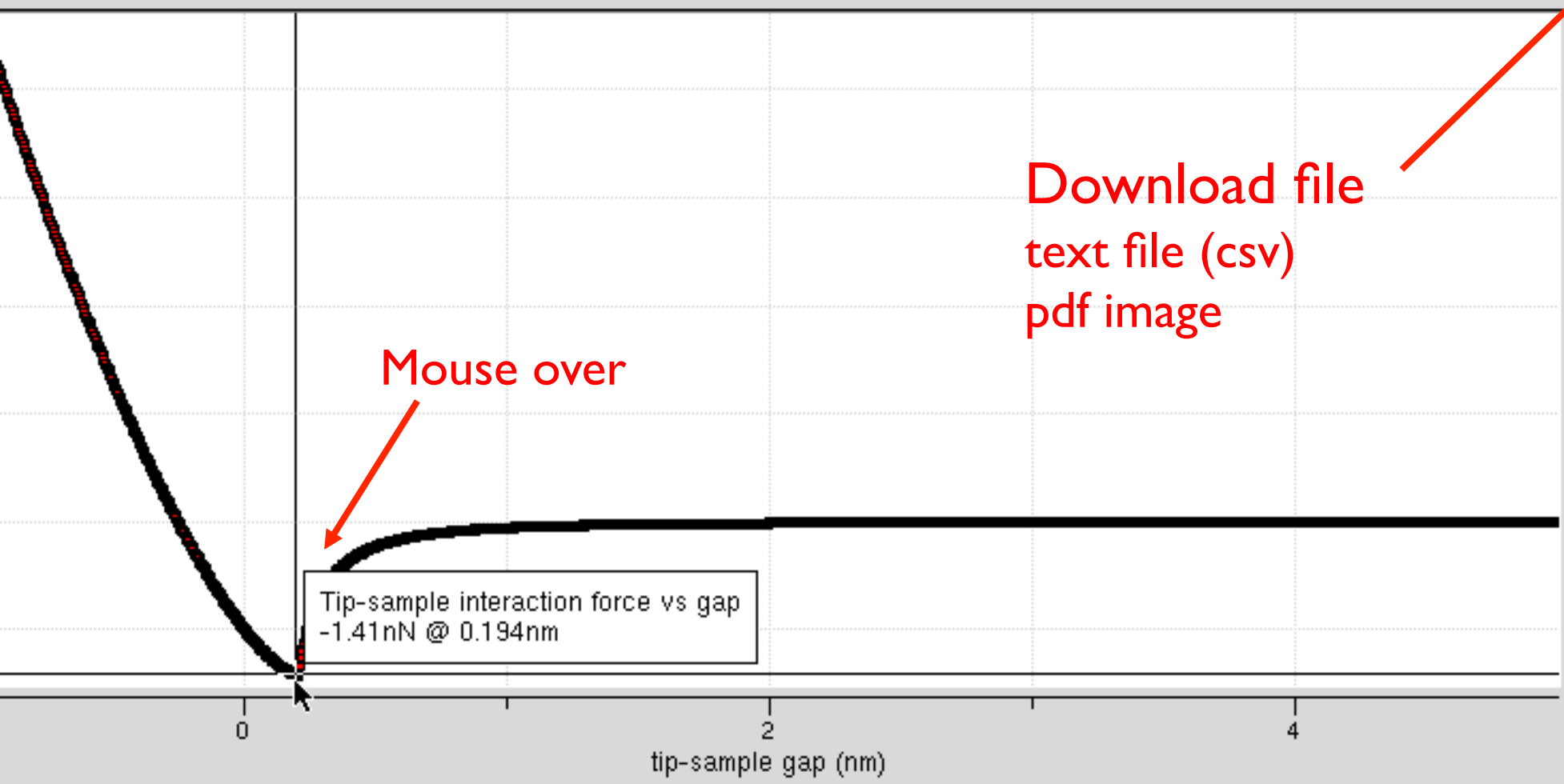
n:

Tip-sample interaction force viewer

→ **2 Simulate**

About this tool
Questions?

Tip-sample interaction force vs gap



Download file
text file (csv)
pdf image

Mouse over

Tip-sample interaction force vs gap
-1.41nN @ 0.194nm

Parameters...

Clear

Force Distance Curves

ation:

Distance Curves

Input → **2 Simulate**



About this
Questions

Sample loader: FZ Curves Example 1: Approaching and retracting from a sample modeled using DMT contact

Operating conditions and cantilever properties

Tip-sample interaction properties

Simulation parameters

Number of points plotted: **1000**


Resolution points per cycle: **1000**

Induts

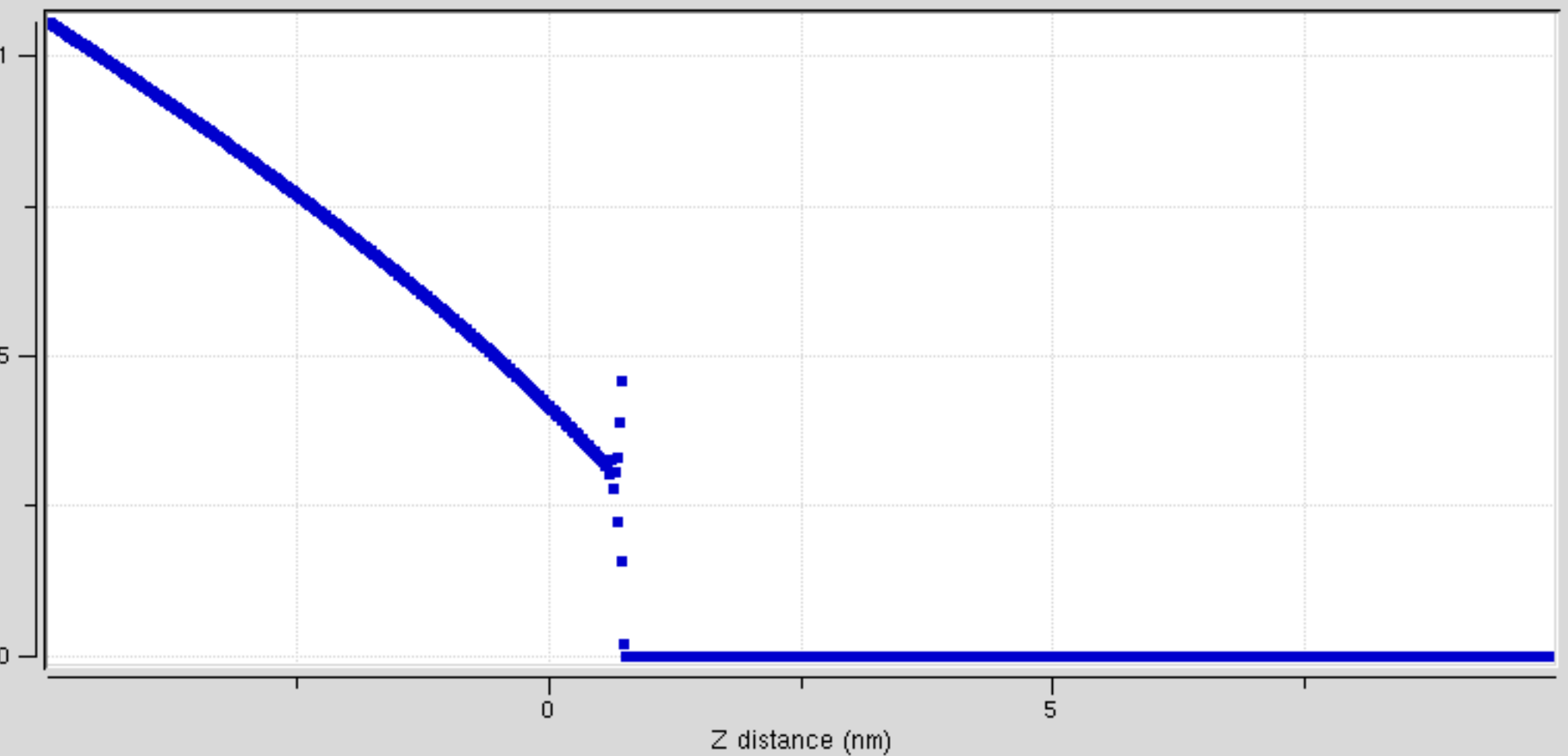
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Distance Curves

put → **2 Simulate**

 About this
Questions


ult: Indentation



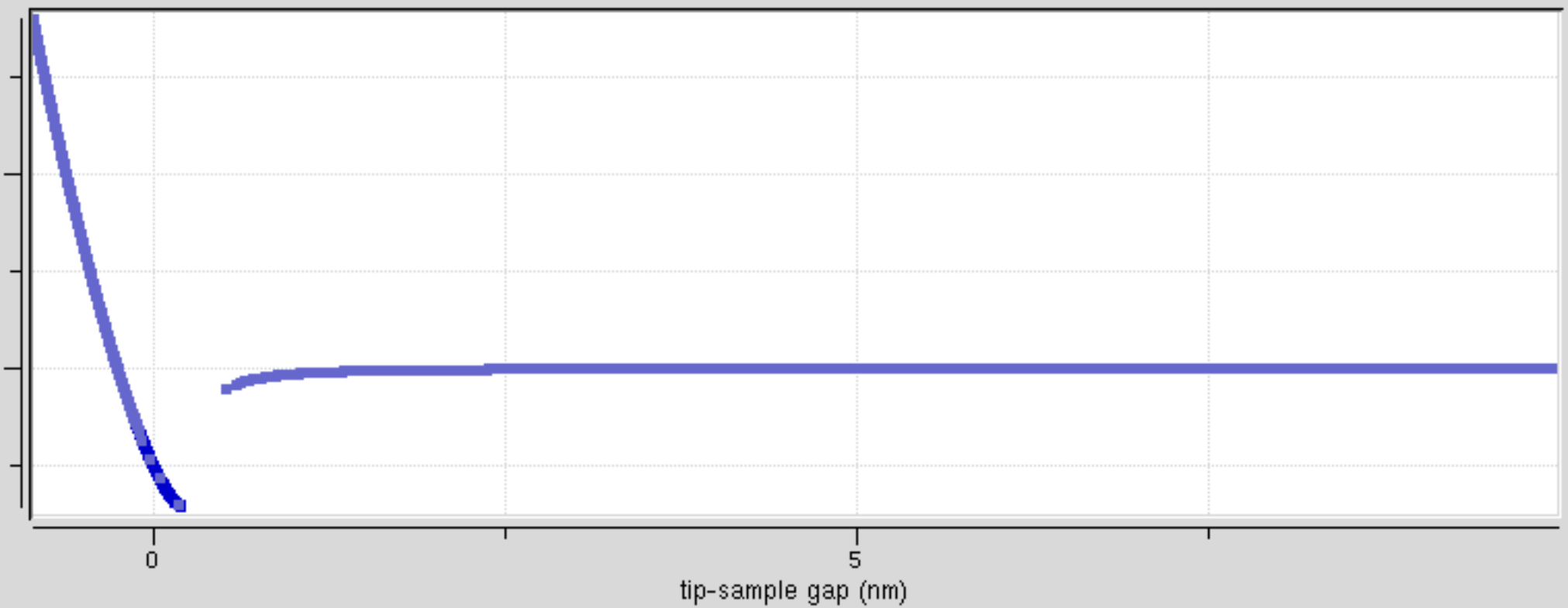
Inputs

ation: 
Distance Curves

Input → **2 Simulate**

 About this
Questions

Result: Tip-sample interaction force vs gap



Results Parameters...

Clear

► **Simulation** = #2

Initial Z separation (nm) = -5
Final Z separation (nm) = 10

PROBLEM 1

You are trying to determine the modulus of elasticity of a sample. You will be fitting an experimental “Tip-sample interaction force vs gap” (aka F-d curve) to a DMT model. You believe that your tip radius is 10 nm, but in actuality it is damaged and it is really 30 nm.

What will happen to your estimation of the elasticity?

Use all parameters from Example 1 except tip radius.

Take ~5 minutes to work through this and then we'll go over the answer.

Problem 1: Scitation

Location:

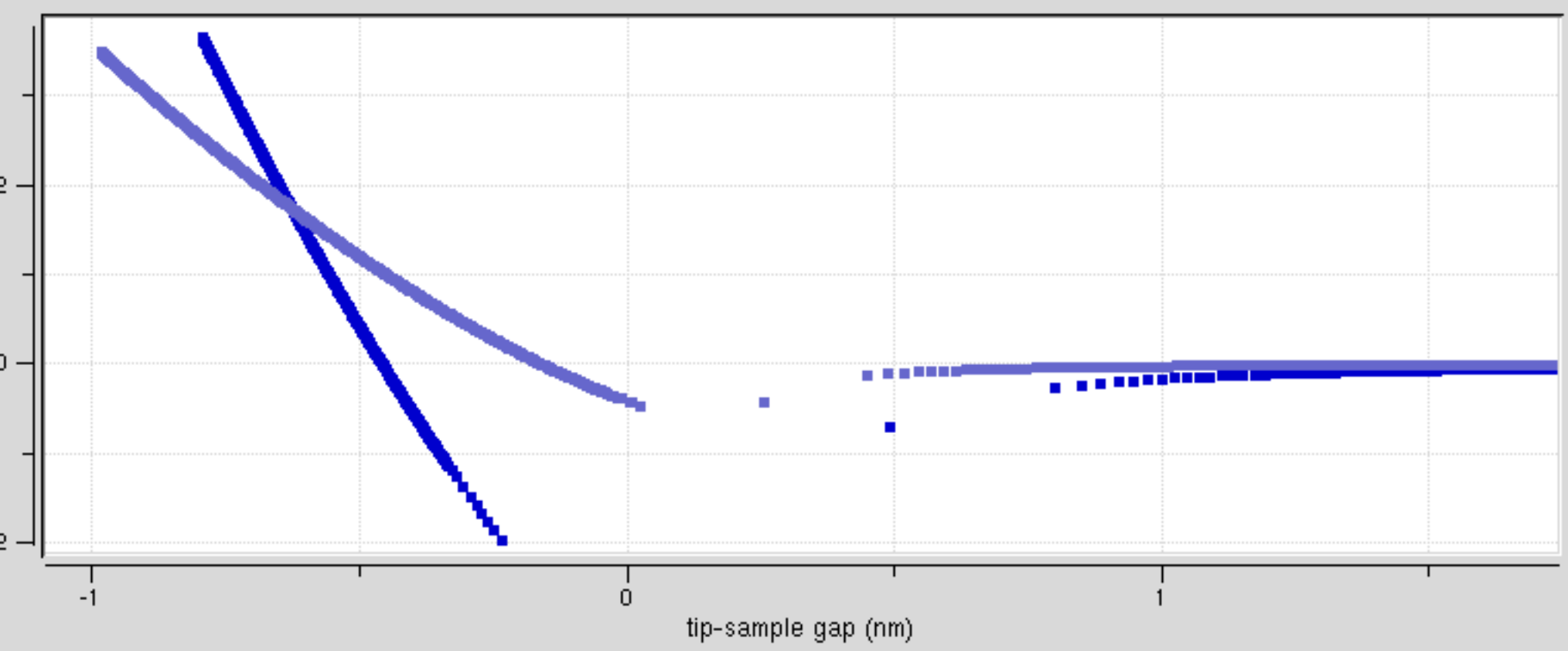
Distance Curves

Input → **2 Simulate**



About this
Questions

Result: Tip-sample interaction force vs gap



Results Parameters...

Clear

Simulation = #2
▶ **Tip radius (nm) = 30**



PROBLEM 2 - Cantilever Selection

You are trying to determine the stiffness of a soft biological sample. If you apply more than 200 pN force, you destroy the sample. Your cantilever choices are 0.1 N/m and 10 N/m. Which cantilever stiffness will be best?

Use linear contact tip-sample model, $k = 0.5 \text{ N/m}$

Hint 1: first determine the maximum Z you can apply for each stiffness.

Hint 2: think about possible experimental errors

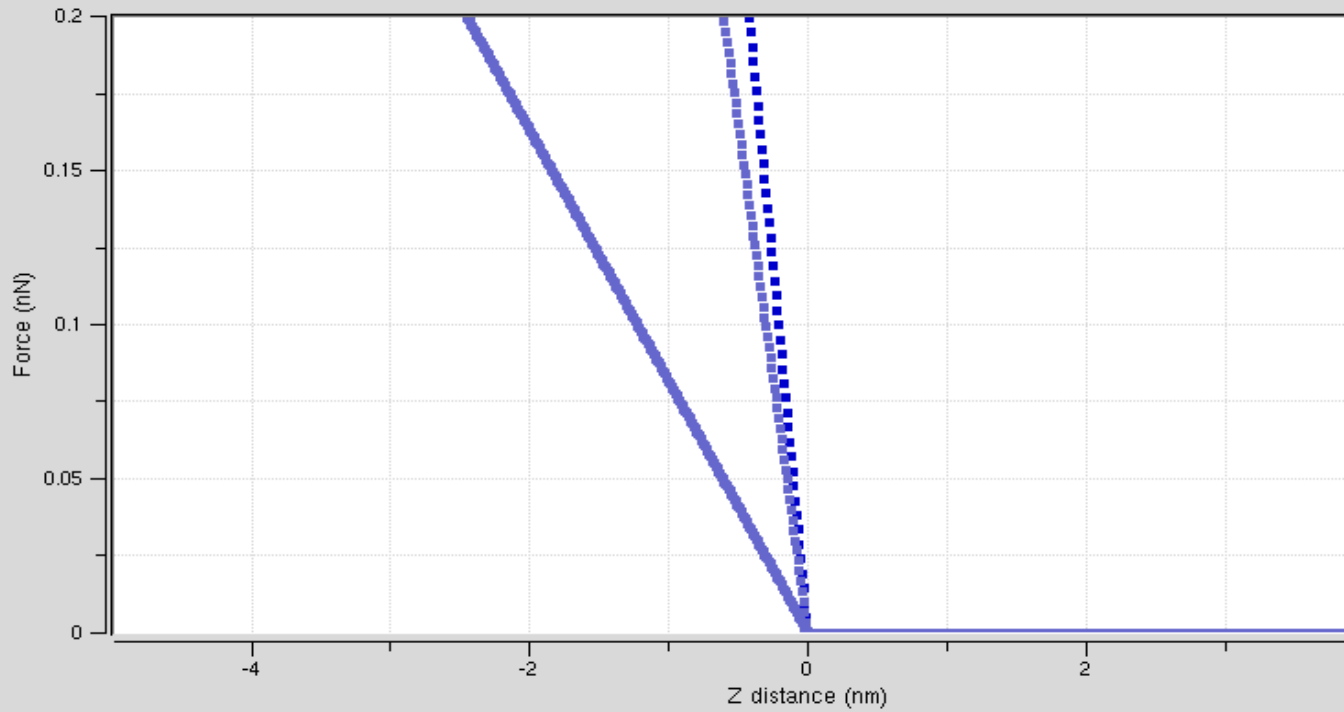
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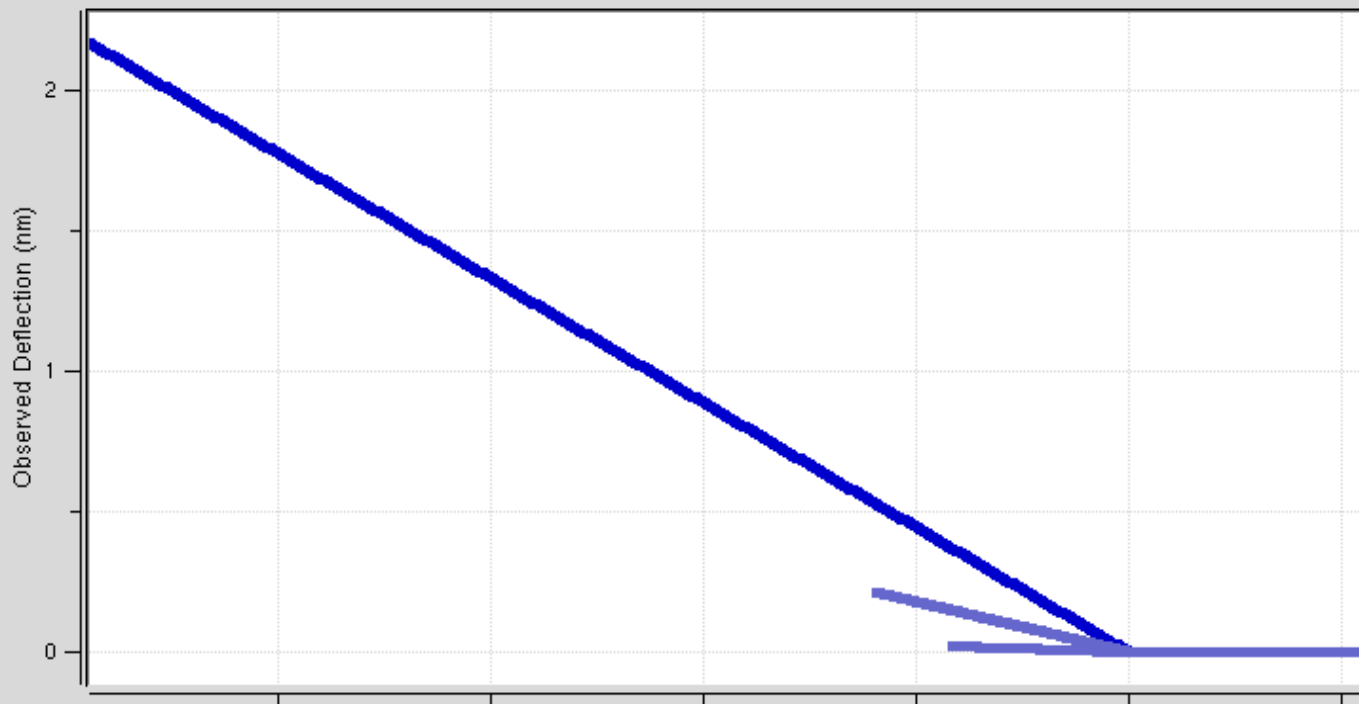
r

Result: Tip-sample interaction force vs Z distance



3 results Parameters...

Result: Observed cantilever deflection vs Z distance



are trying to determine the Young's modulus (i.e. stiffness) of a hard
The extension of the Z-piezo is limited to 10 nm beyond the point of
contact between the tip and sample. Your cantilever choices are 0.1 N/m, 1
10 N/m. Which cantilever is best and why?

the Hertz, $E = 60 \text{ GPa}$.

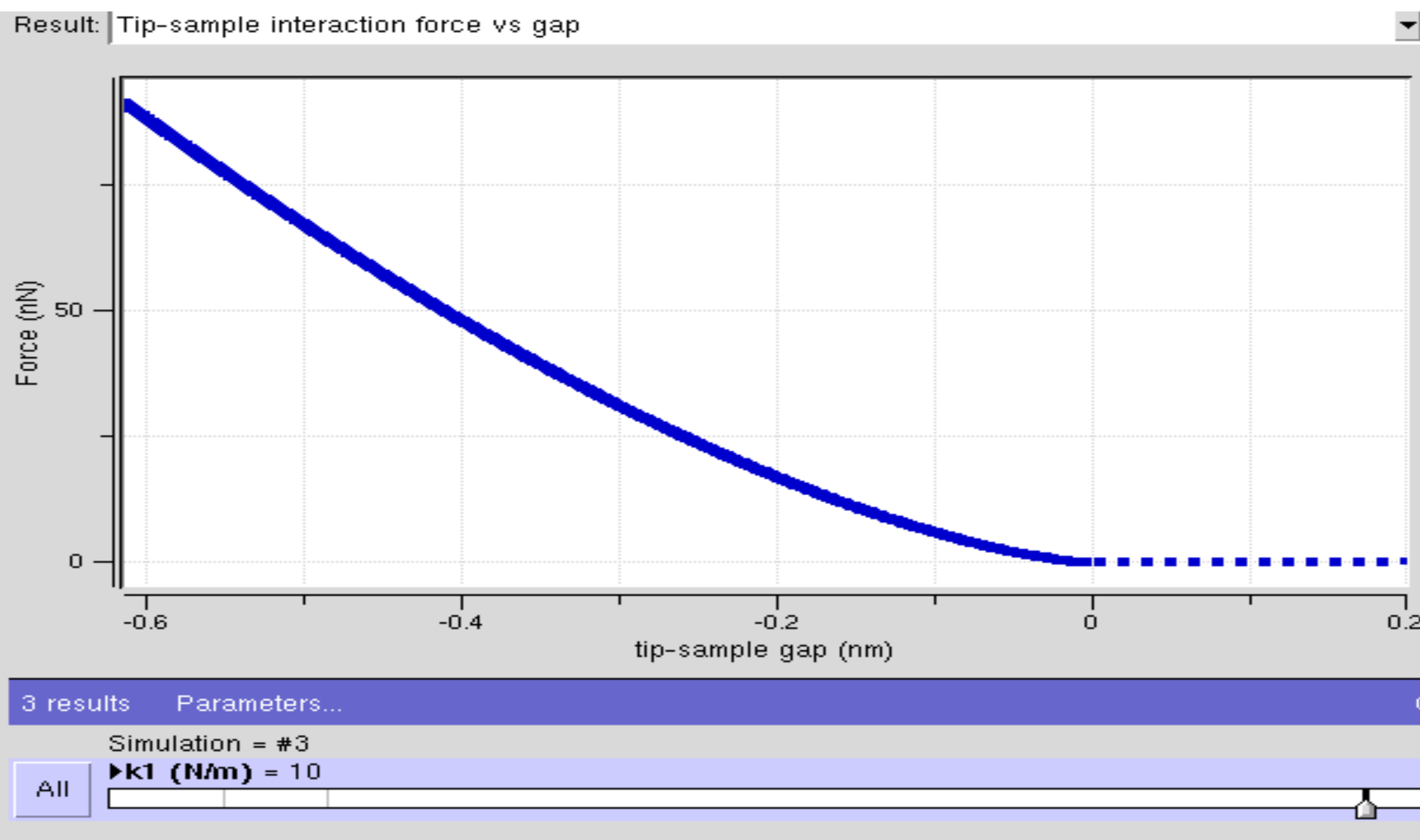
hint: use $Z_f = -10 \text{ nm}$

again, think about experimental errors

get done early, try downloading your problem 2 and 3 simulation
into Excel and applying experimental errors to the data.

random noise to observed deflection and Z motion, and then convert
force-gap (remember $\text{gap} = Z + \text{deflection}$, $\text{Force} = \text{deflection} * \text{stiffness}$)

Problem 3 solution



10 N/m cantilever will be best. Applies more force – more