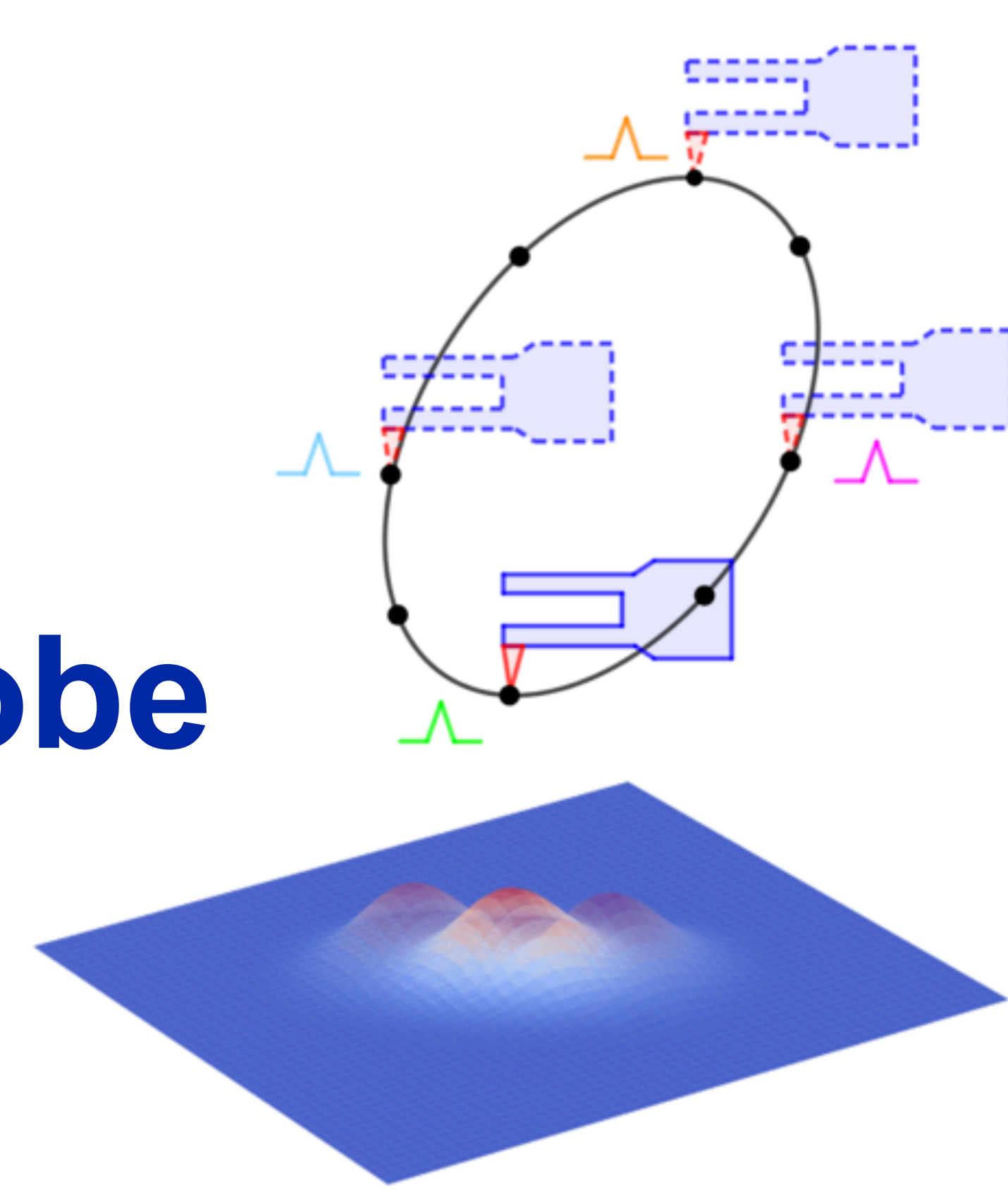


Tracking the tip trajectory of a Scanning Probe Microscope

Lorena Niggli, Fabian Natterer,

Department of Physics, University of Zurich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland



1. Reversed Microscope

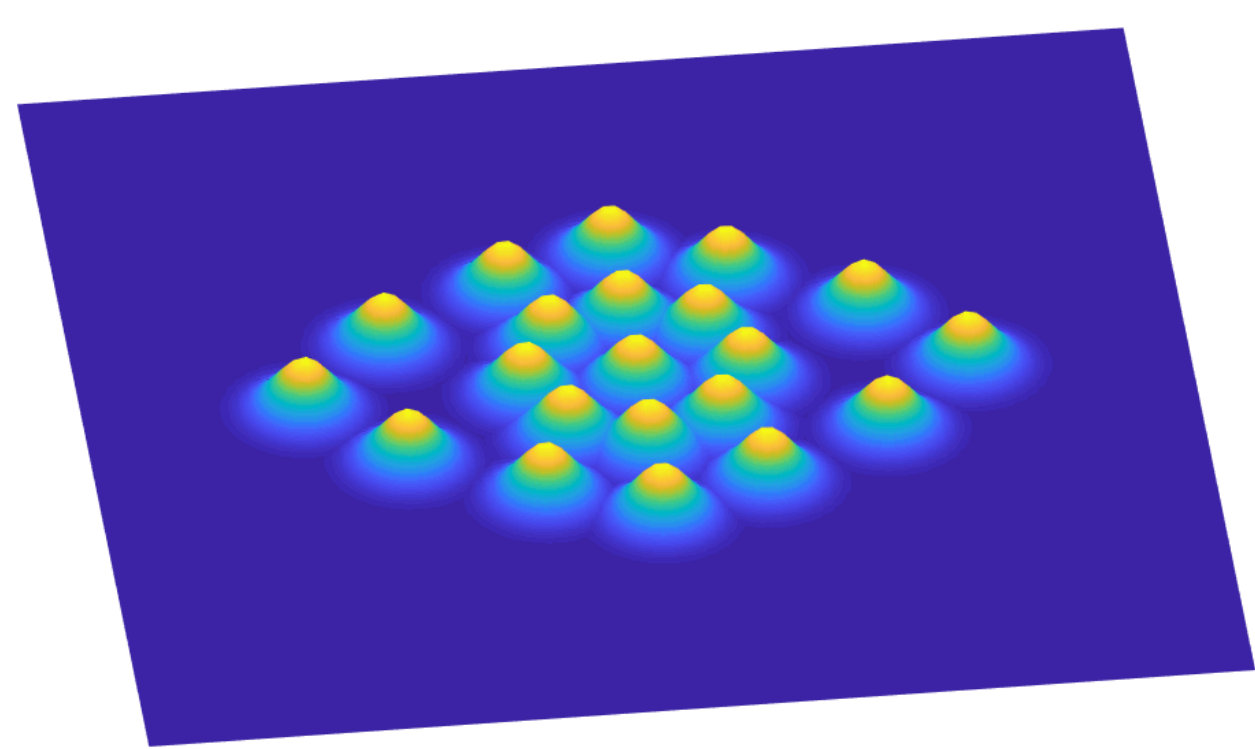


Fig.1: Array of atoms on a substrate

- Sample investigates the movement of the tip
- Tip is 50% of the measurement
- Quantization of the tilting of a molecule attached to the tip

2. Reconstruction of the trajectory

- x and y coordinate

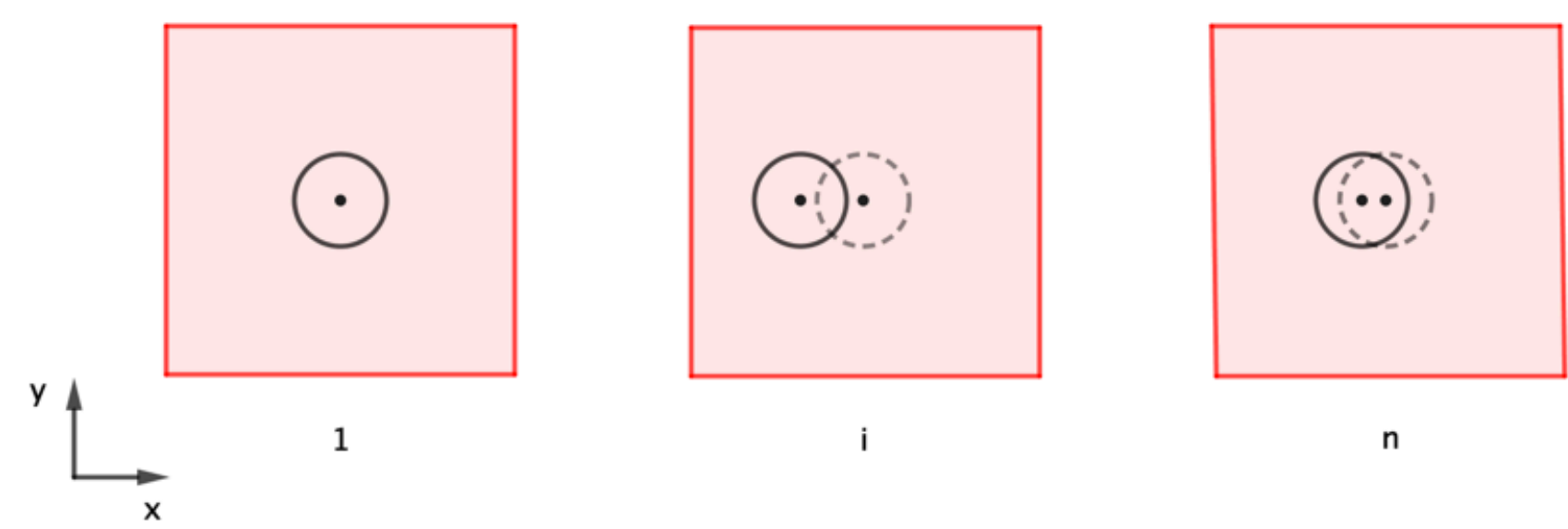


Fig.2: Shift of the atom's position yields x and y coordinates of the tip

- z coordinate

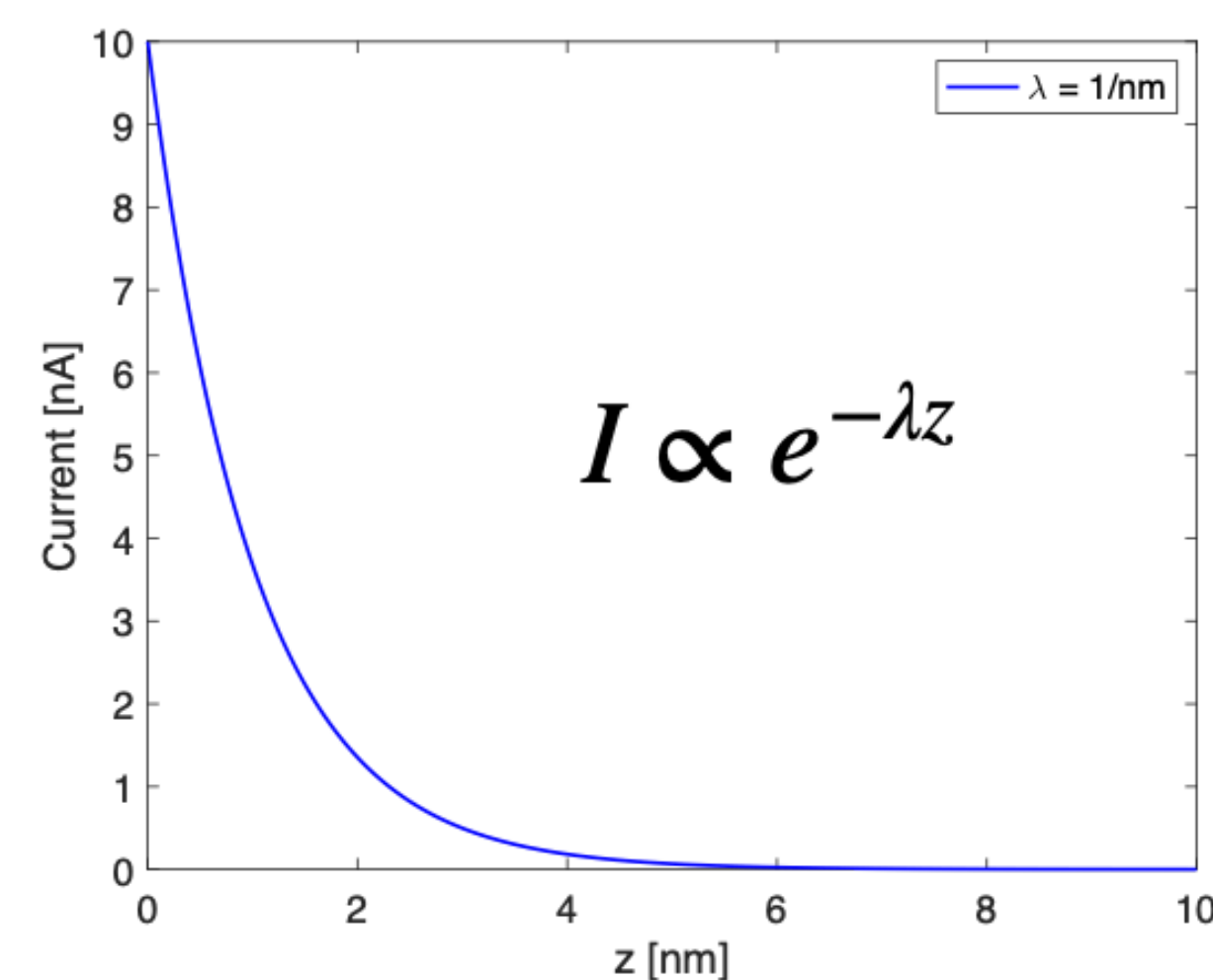


Fig.3: Measured current of an AFM combined with an STM has an exponential dependency on the tip-sample distance

- Constant height I -measurements
- Shifting of atom's position in x - y plane
- Tip-sample distance dependent current [1]
- I - z spectroscopy to determine decay constant

3. Method illustrated on the example of an elliptic trajectory

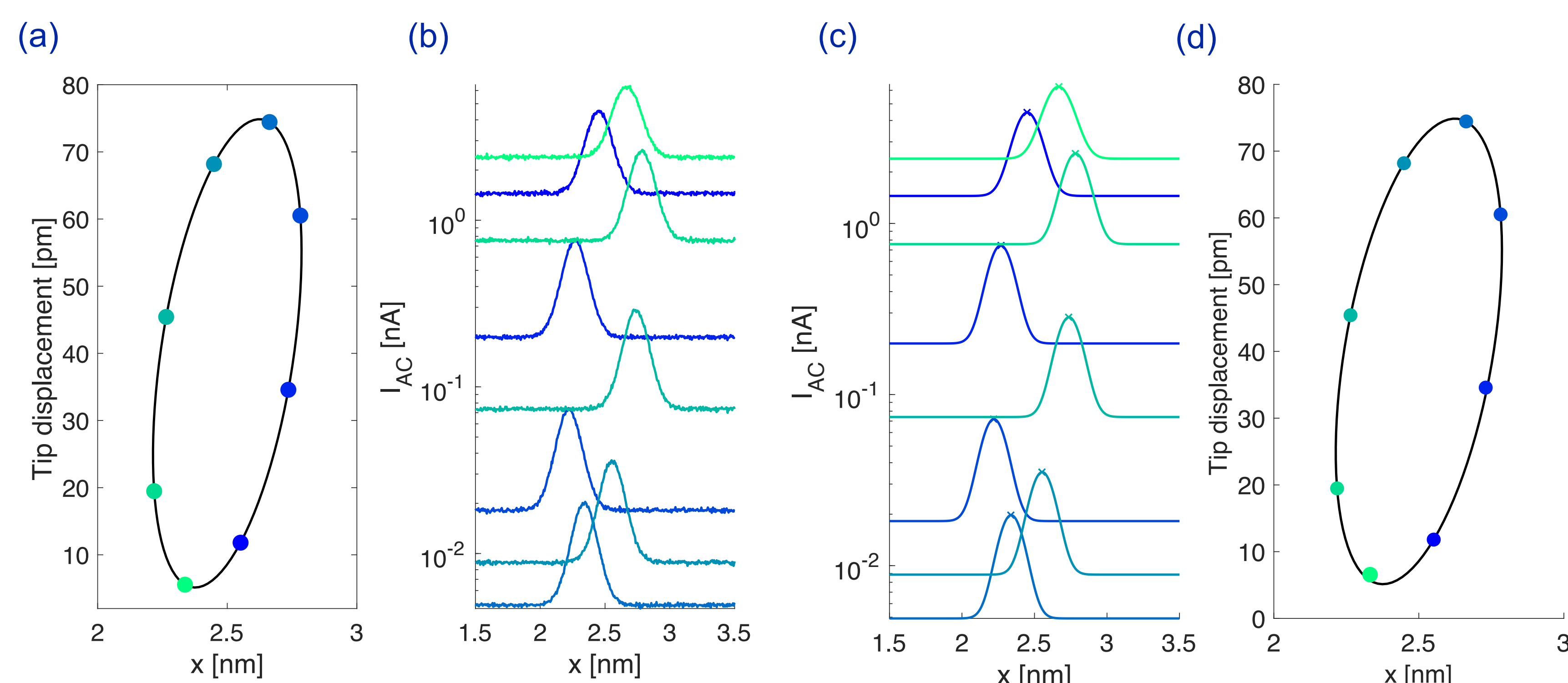


Fig.4: (a) Ansatz elliptic trajectory, (b) simulated constant height measurement, (c) Gaussian fit to the data and (d) reconstruction of tip trajectory

4. Functionalized tip: tilting of the molecule

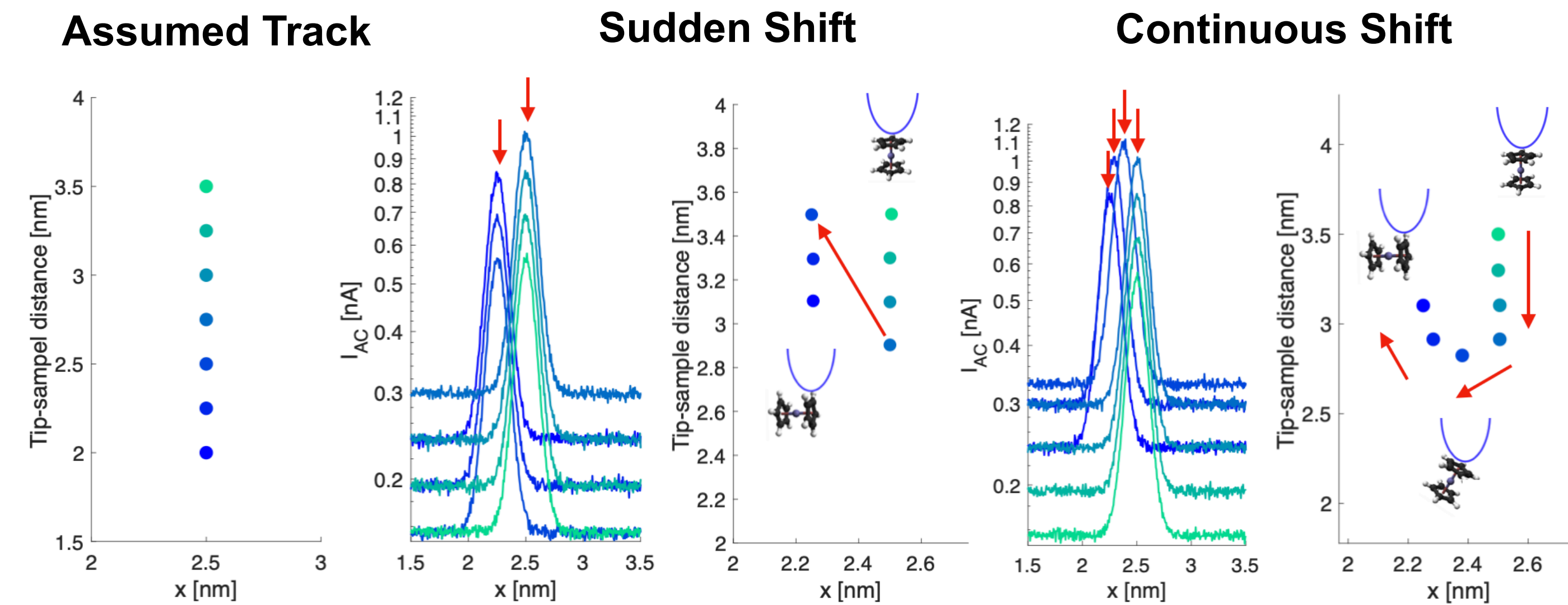


Fig.5: Quantification of the tilting of a tip terminated by a nickelocene molecule

5. Experimental Setup

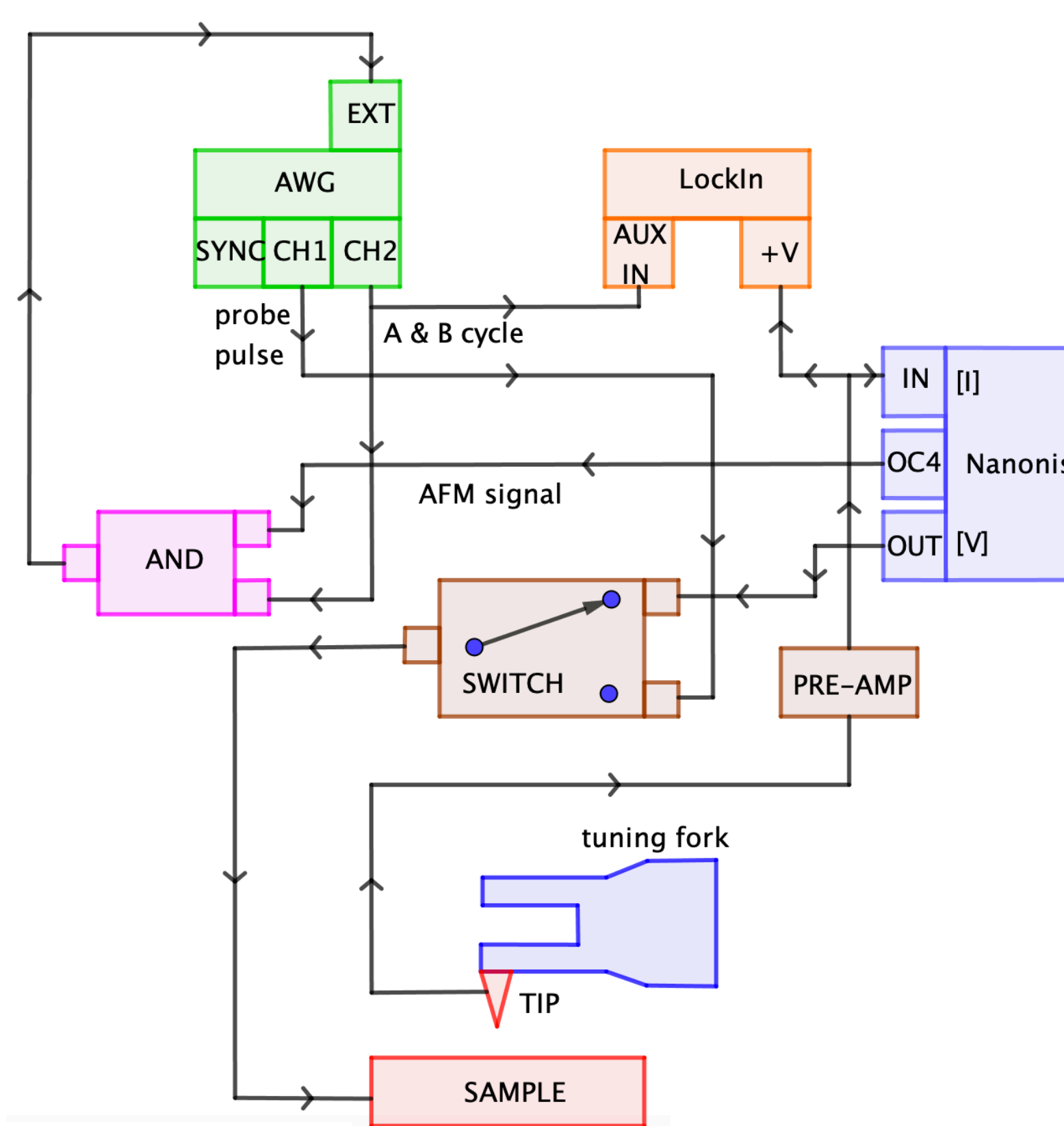


Fig.6: Setup to measure the tip trajectory of an AFM with a switch between the normal operation and the modified one

5.1 Working principle of the AND gate

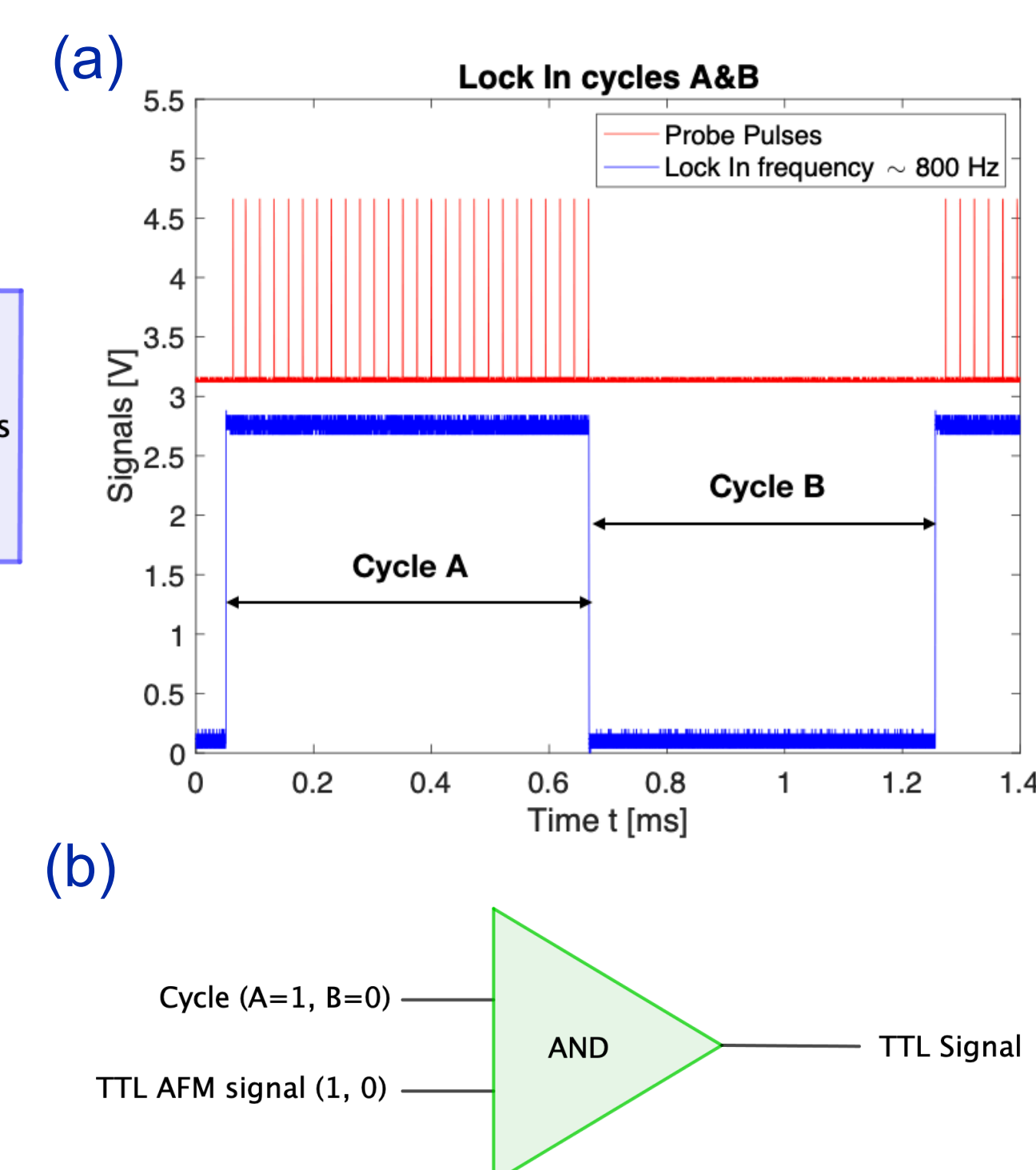


Fig.7: (a) Lock In cycles A&B with generated probe pulses, (b) schematic AND gate

6. Current measurement at specific points of the tip's oscillation

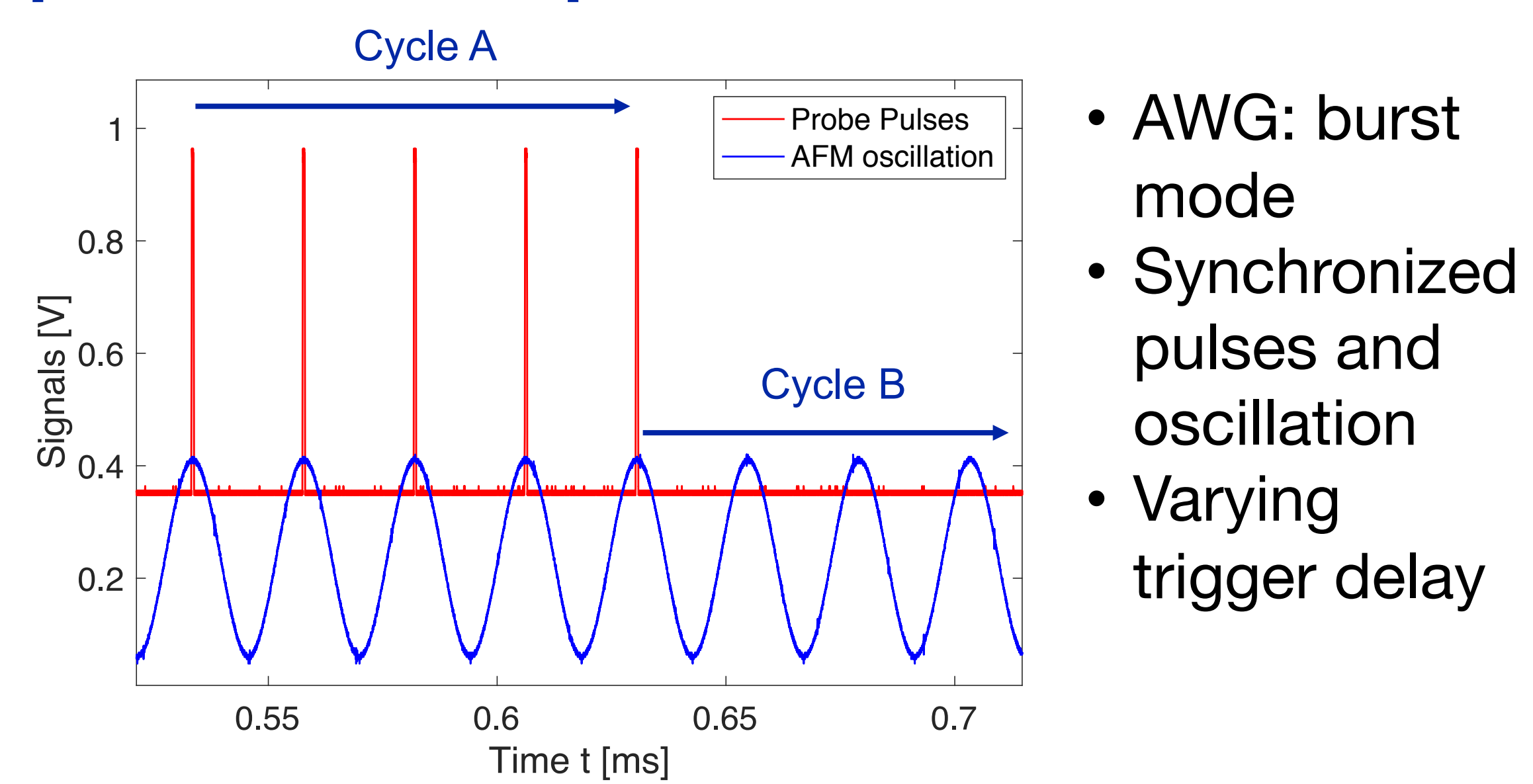


Fig.8: Synchronized probe pulses (red) and the AFM oscillation signal (blue)

7. References

- [1] Franz Giessibl, Rev. Mod. Phys 75, 949 (2003)

Conclusion

- Apply probe pulses at exactly the same position in the tip's oscillation
- Lock-In measurement to enhance signal to noise ratio
- Method to reconstruct the tip trajectory is applicable to any AFM/STM systems

Outlook

- Distinction of contributions in spectroscopy experiments
- Exploit flipping of the molecule as a Lock-In measurement
- Time-resolved measurements combined with atomic force microscopy
- Combine AFM and ESR
- New high resolution imaging modes

Contact

Lorena Niggli
lorena.niggli@uzh.ch