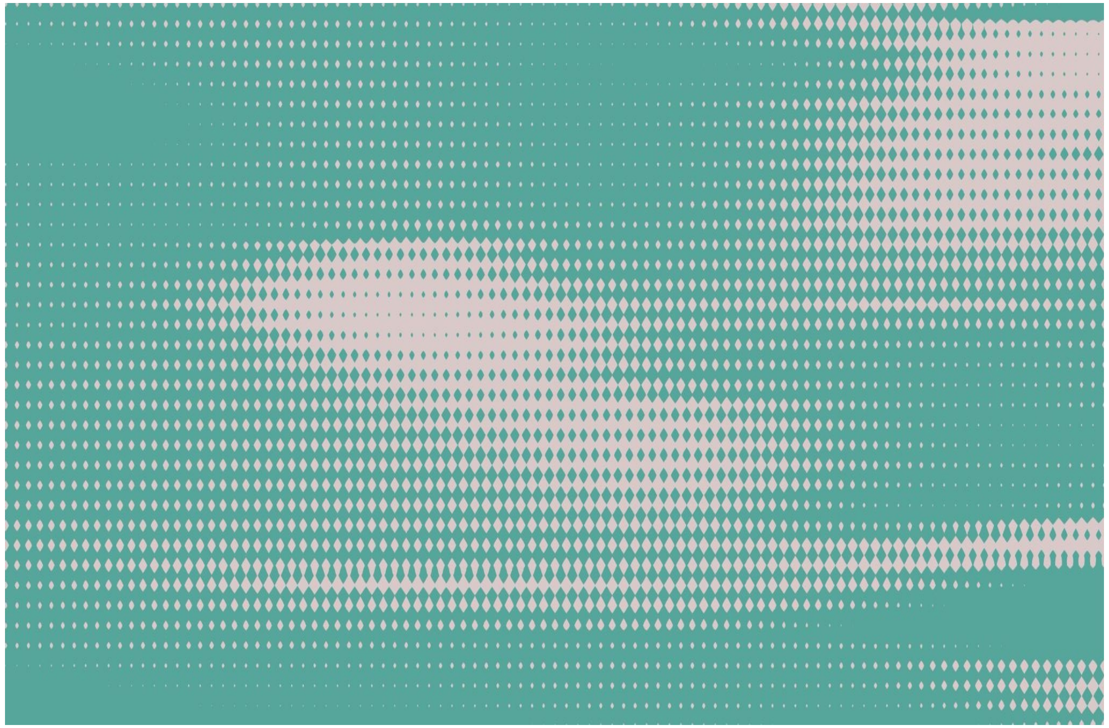
DNA SEQUENCING USING NANOPORES



PAU PUJOL DUQUE

SIMULACIÓ DE SISTEMES NANOMÈTRICS – FINAL PROJECT

CONTENTS

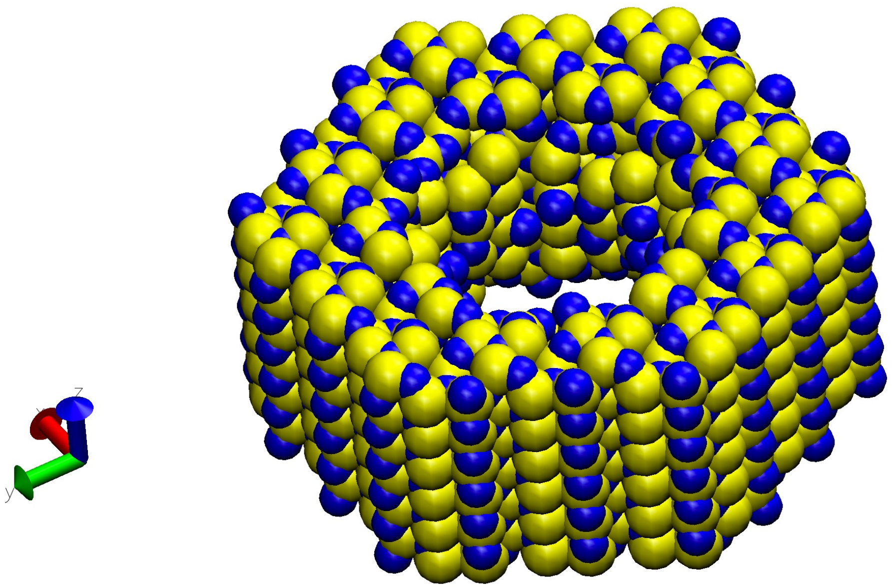
NANOPORE

Nanoscale holes that allow the passage of single molecules.

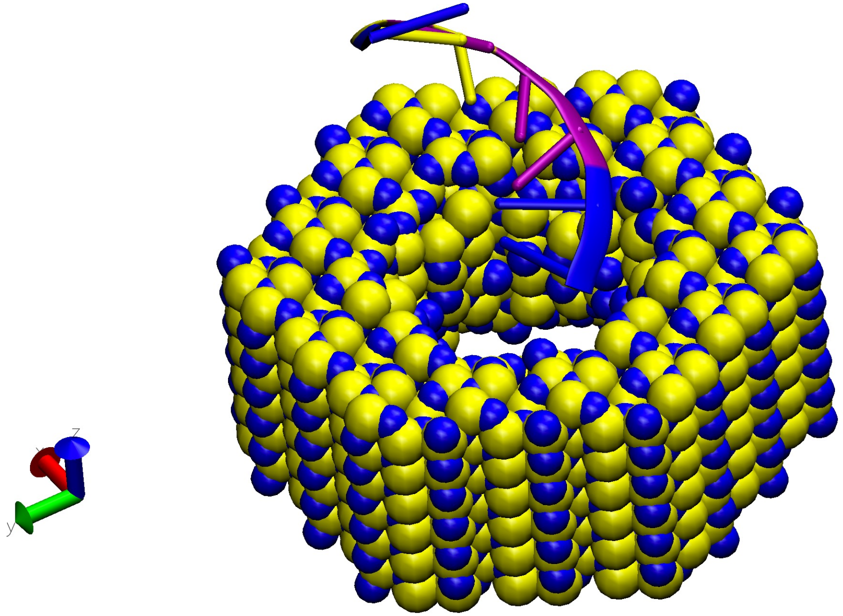
Valuable for their application in DNA sequencing.

Can be monitored by measuring the ionic current passing through it.

TWO SCENARIOS



Empty nanopore



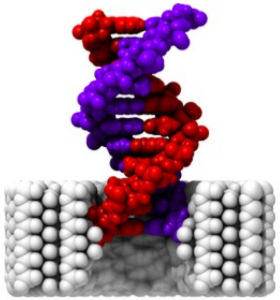
Nanopore with DNA chain

A-A-T-T-G-T-G-A

Files provided by Bionanotechnology Tutorial

University of Illinois at Urbana-Champaign
Beckman Institute for Advanced Science and Technology
Theoretical and Computational Biophysics Group
Computational Biophysics Workshop

Bionanotechnology Tutorial



Alek Aksimentiev

Jeffrey Comer

April 2011

A current version of this tutorial is available at
http://www.ks.uiuc.edu/Training/Tutorials/
Join the `tutorial-l@ks.uiuc.edu` mailing list for additional help.

INTRODUCTION

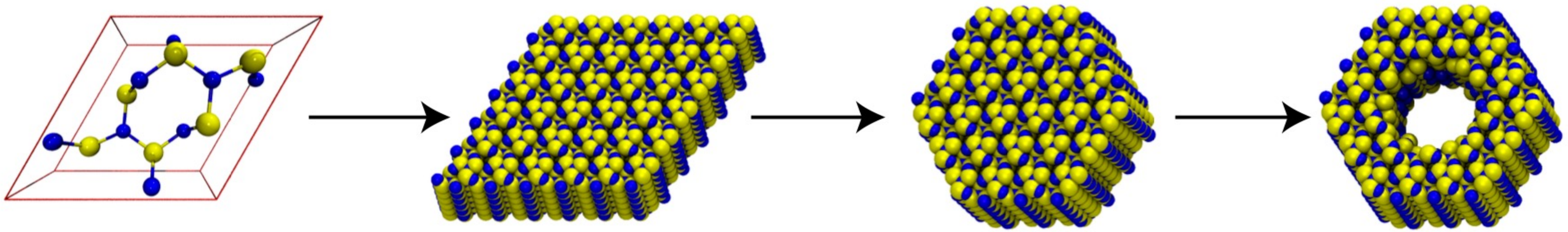
1. Material creation and pore drilling

2

3

4

5



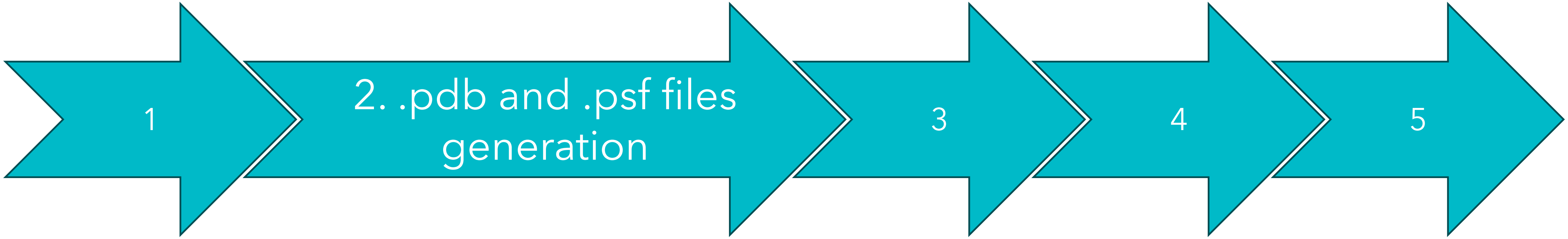
Si_3N_4 unit cell

Si_3N_4 membrane

Si_3N_4 hexagonal membrane

Si_3N_4 hexagonal membrane with nanopore

SIMULATION PARAMETERS



.pdb Coordinates file

.psf Structure file

Using topology parameters provided.

SIMULATION PARAMETERS

1 → 2 → 3. Calibrating the force field → 4 → 5

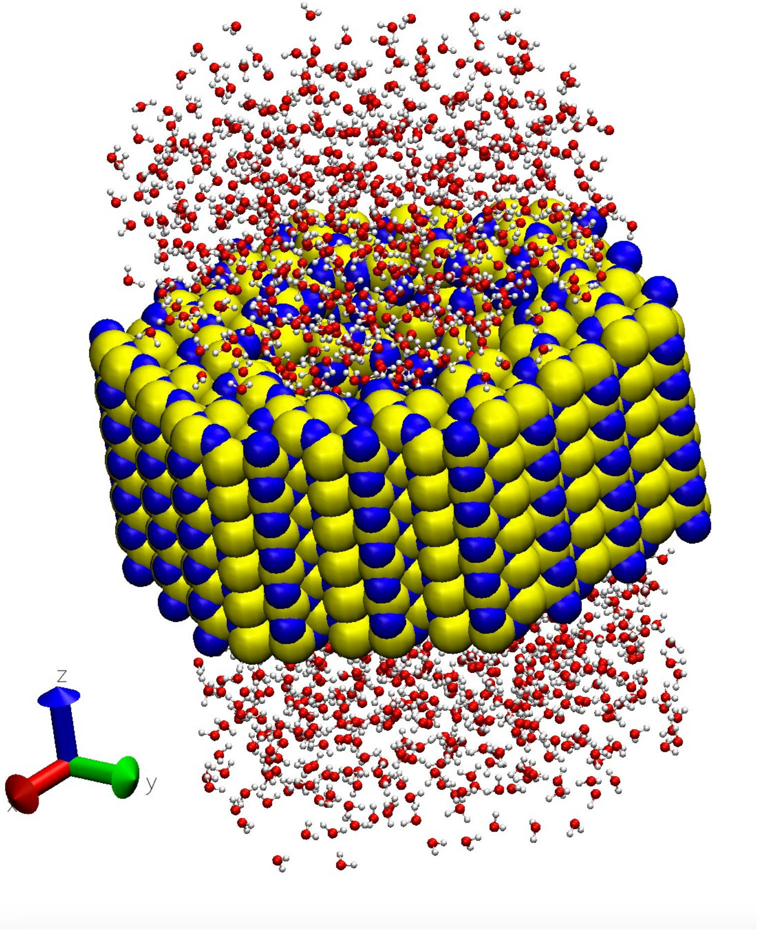
We apply an electric field to Si_3N_4 and measure the dipole moment. $\xrightarrow{\text{to obtain}}$ DIELECTRIC CONSTANT

SIMULATION PARAMETERS

1 → 2 → 3 → 4. Solvating the nanopore → 5

Adding:

- Solvation molecules
- Ions (KCl solution)



SIMULATION PARAMETERS

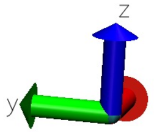
1 → 2 → 3 → 4 → 5. Adding DNA chain to nanopore

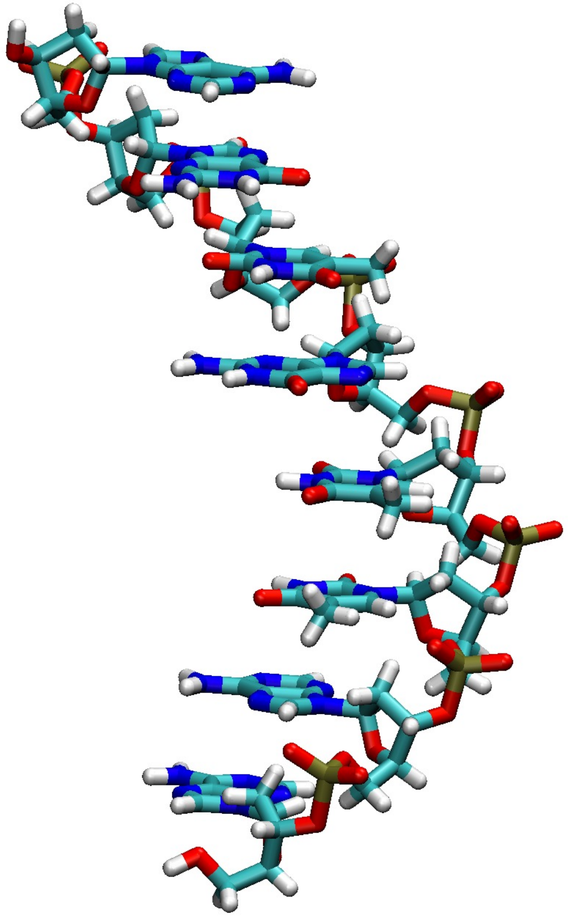
Previous steps:

- Strands separations (ssDNA)
- DNA strand bending

DNA CHAIN:

A-A-T-T-G-T-G-A

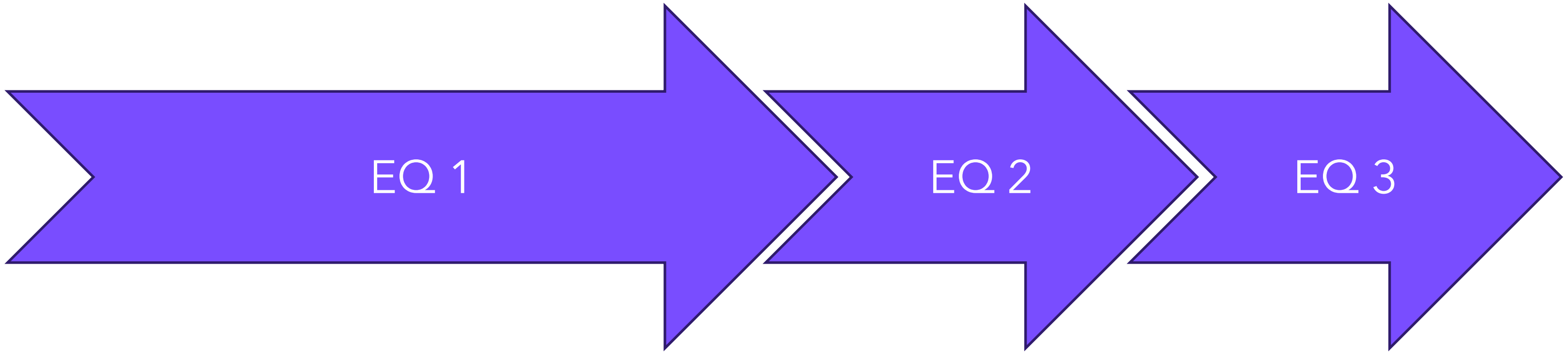




SIMULATION PARAMETERS

EQUATION 1 – Energy minimization

- 201 steps
- 1 fs of time step



SIMULATION EQUATIONS

EQUATION 1 – Energy minimization

- 201 steps
- 1 fs of time step

EQUATION 2 – Temp. Raise from 0 to 295k at cte. V

- 1000 steps
- 1 fs of time step

SIMULATION EQUATIONS

EQUATION 1 – Energy minimization

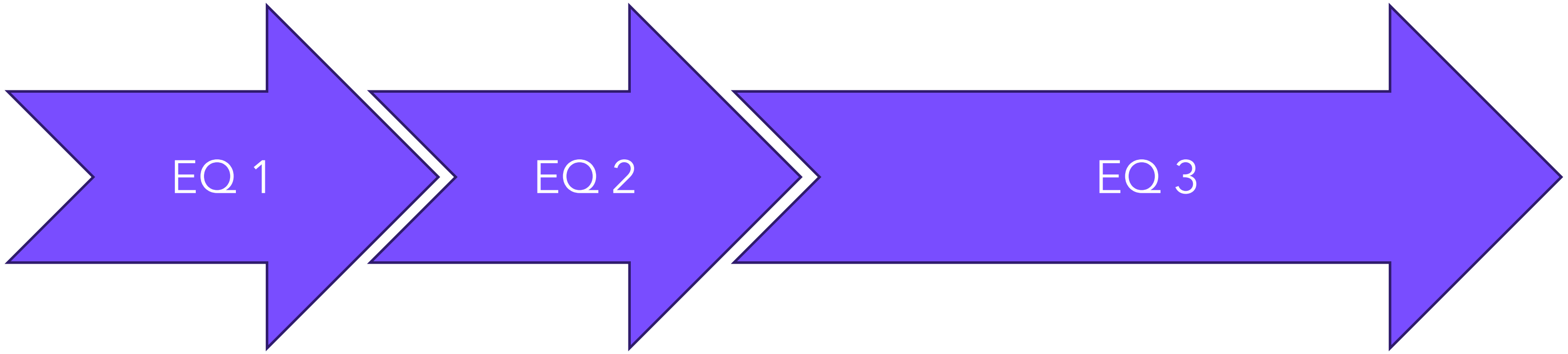
- 201 steps
- 1 fs of time step

EQUATION 2 – Temp. Raise from 0 to 295k at cte. V

- 1000 steps
- 1 fs of time step

EQUATION 3 – Equilibration at cte. p and Langevin thermostat

- 1000 steps
- 1 fs of time step



SIMULATION EQUATIONS

ELECTRIC FIELD

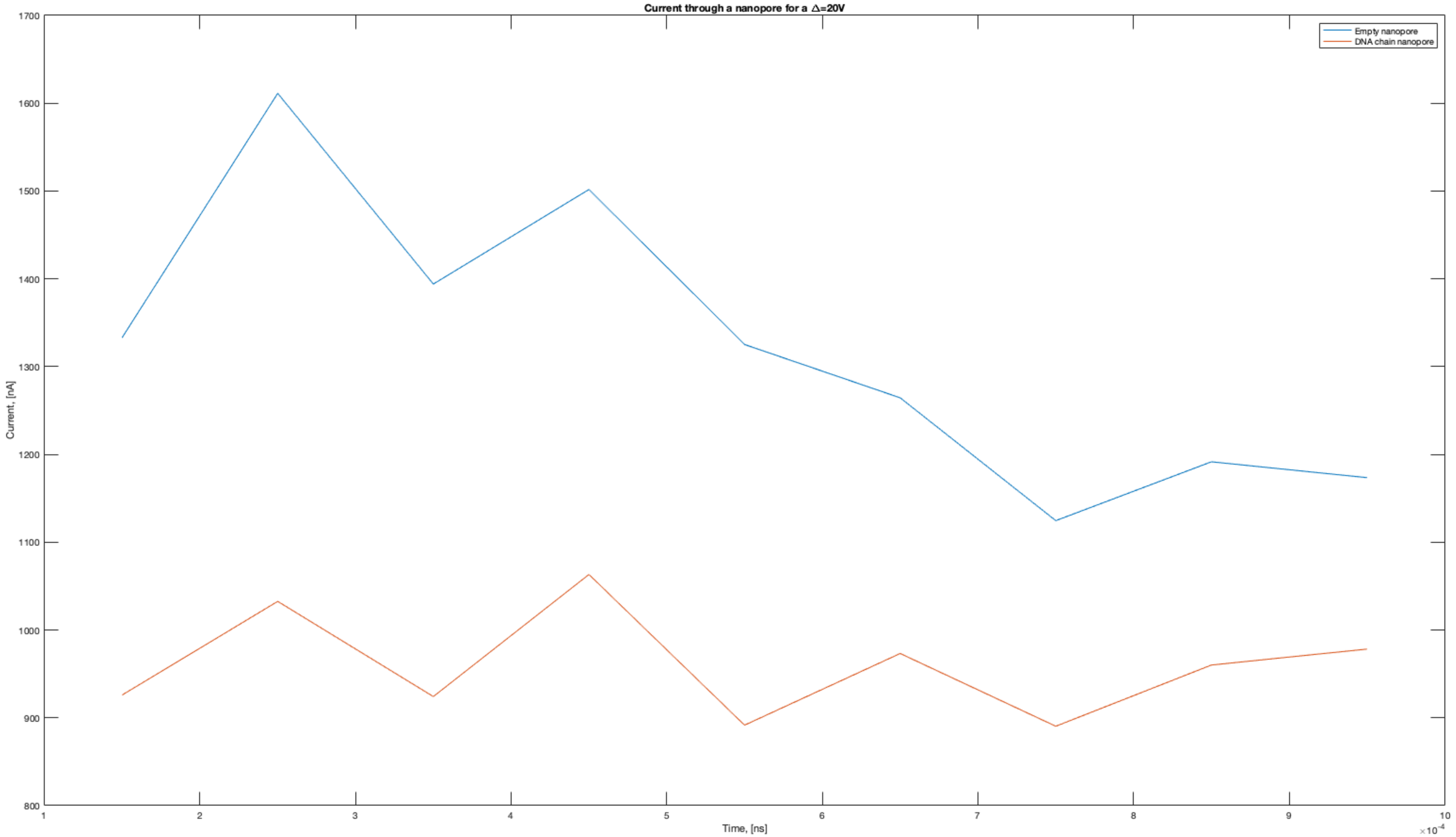
$$E_Z = -23{,}060549\frac{\Delta V}{l_z}$$

$$l_z = -c_z \begin{cases} l_z = -44{,}7598\ \text{Å} & \text{Empty nanopore} \\ l_z = -64{,}8282\ \text{Å} & \text{Nanopore with DNA} \end{cases}$$

$\Delta V, [V]$	EMPTY NANOPORE, $E_Z, [V/\text{Å}]$	NANOPORE WITH DNA, $E_Z, [V/\text{Å}]$
2	1,030	0,711
10	5,152	5,557
20	10,304	7,114

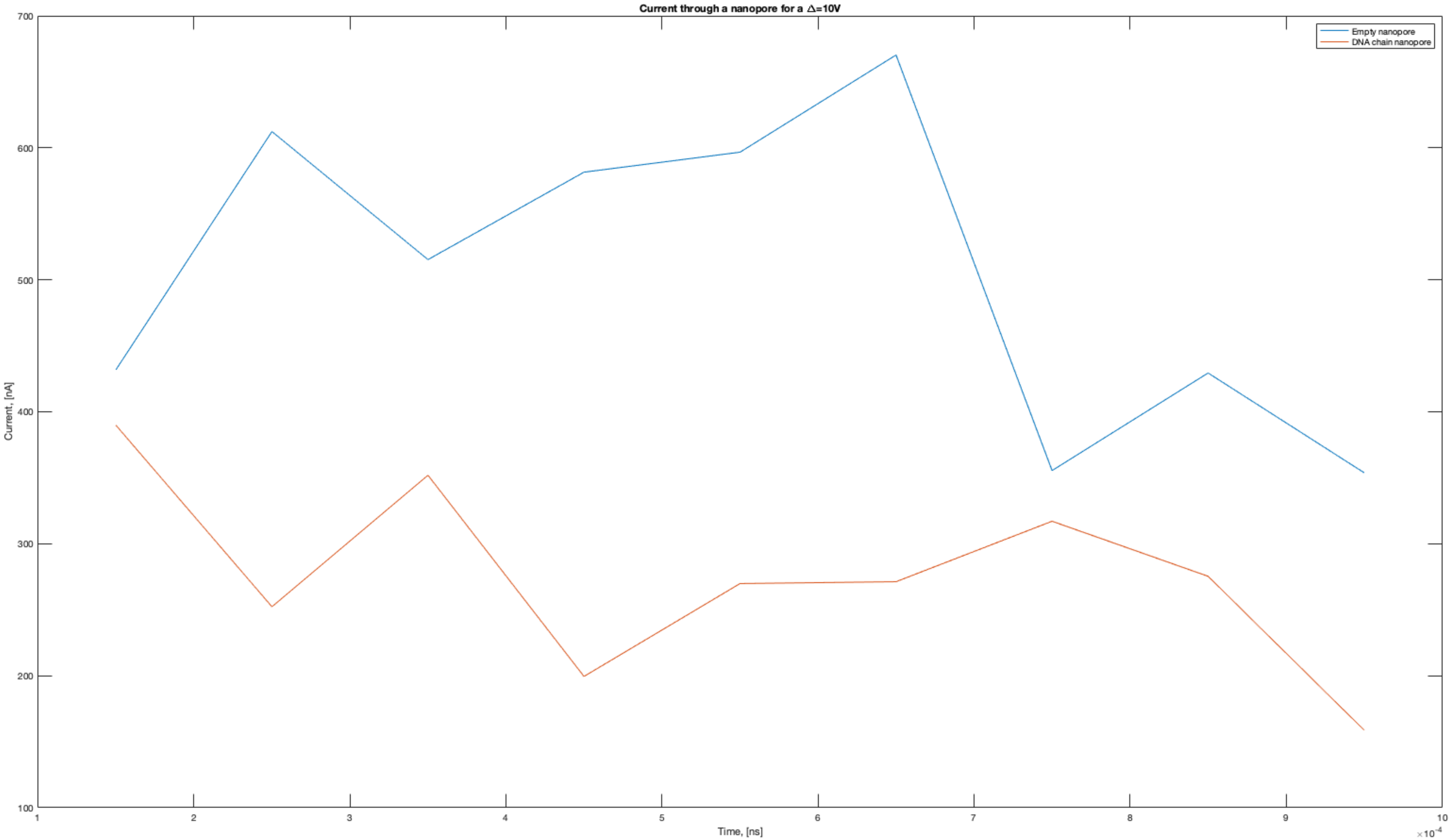
SIMULATION EQUATIONS

$\Delta V = 20V$



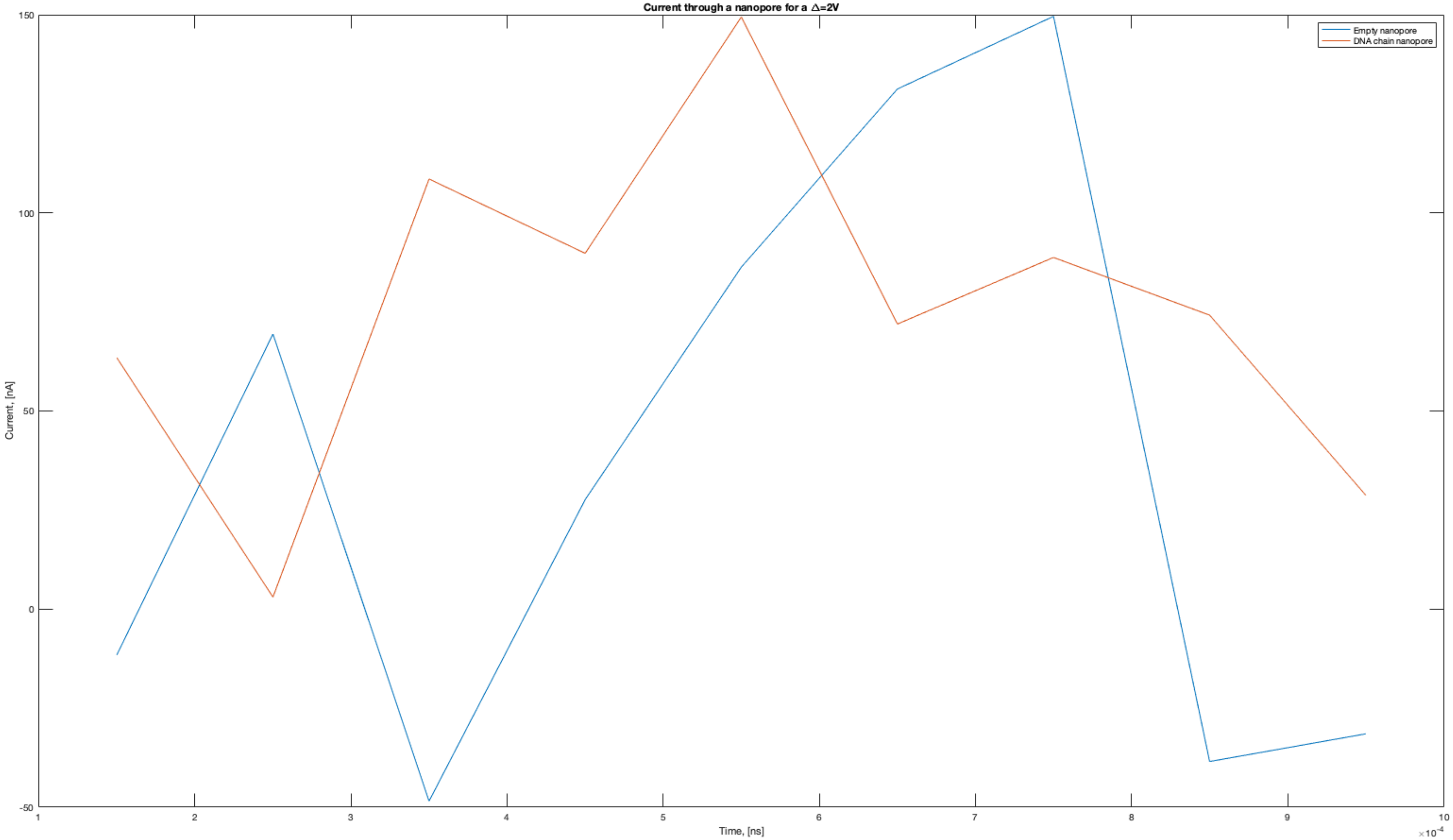
RESULTS

$\Delta V = 10V$



RESULTS

$\Delta V = 2V$

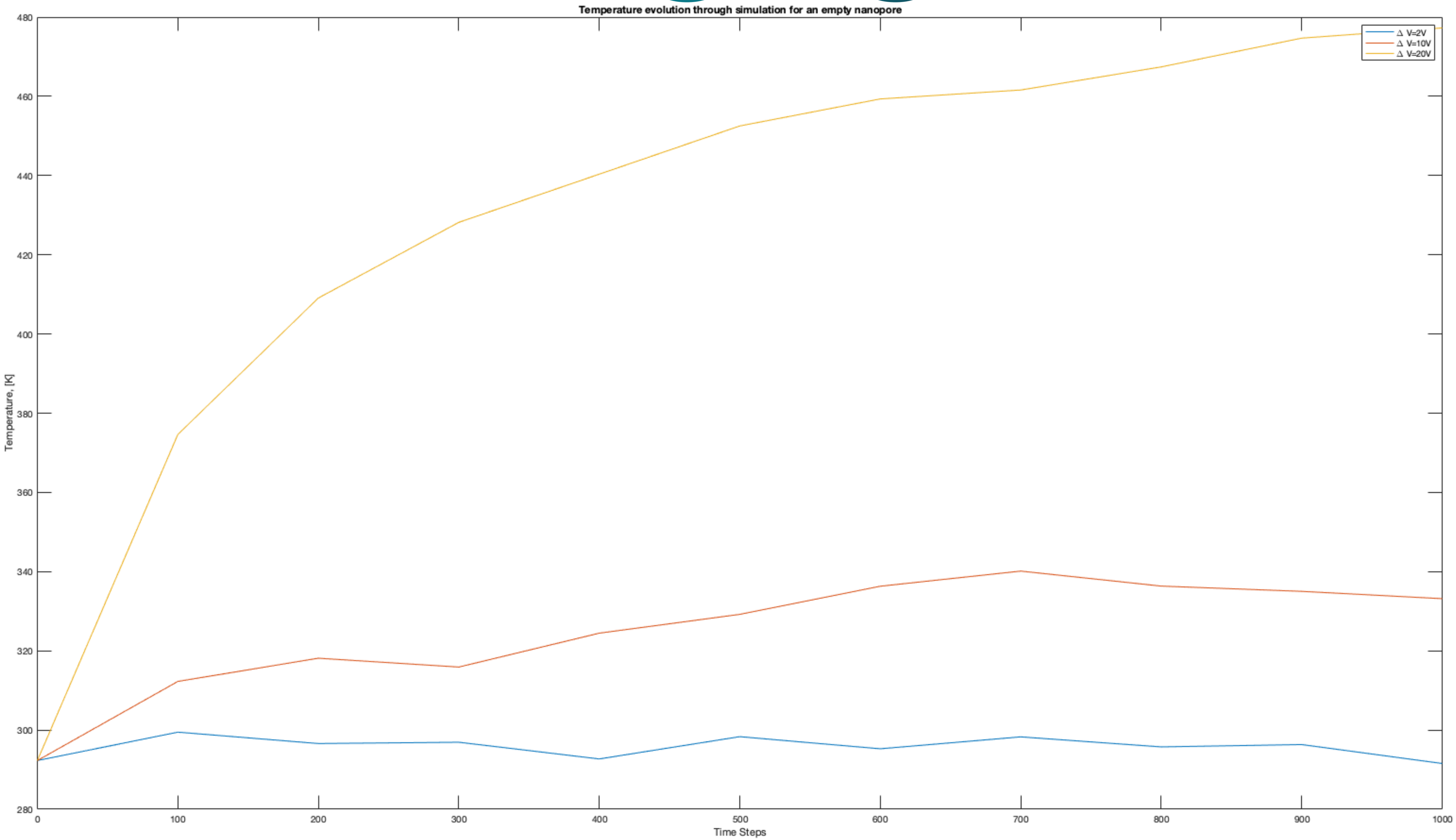


RESULTS

CURRENT

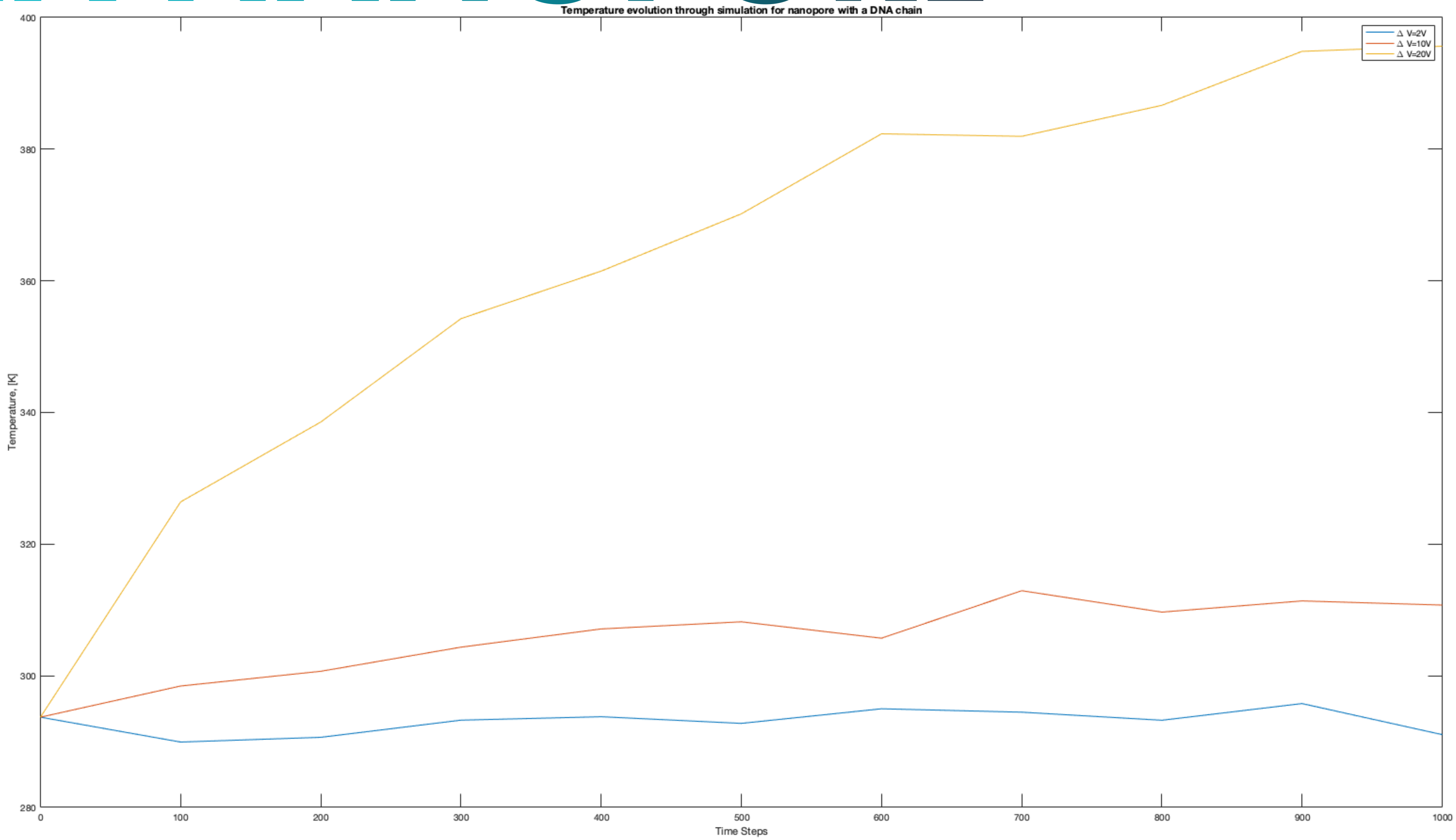
$\Delta V, [V]$	EMPTY MEAN CURRENT, $I_Z, [nA]$	DNA MEAN CURRENT, $I_Z, [nA]$
2	37,1	75,3
10	505,2	276,2
20	1324,4	959,9

EMPTY NANOPORE



RESULTS

DNA NANOPORE



RESULTS

CONCLUSIONS

- The current through a nanopore is higher when the nanopore is empty than when there is a DNA chain inside it.

- The temperature of the system, with or without the DNA chain on the nanopore, tends to be more constant when the potential difference is lower.

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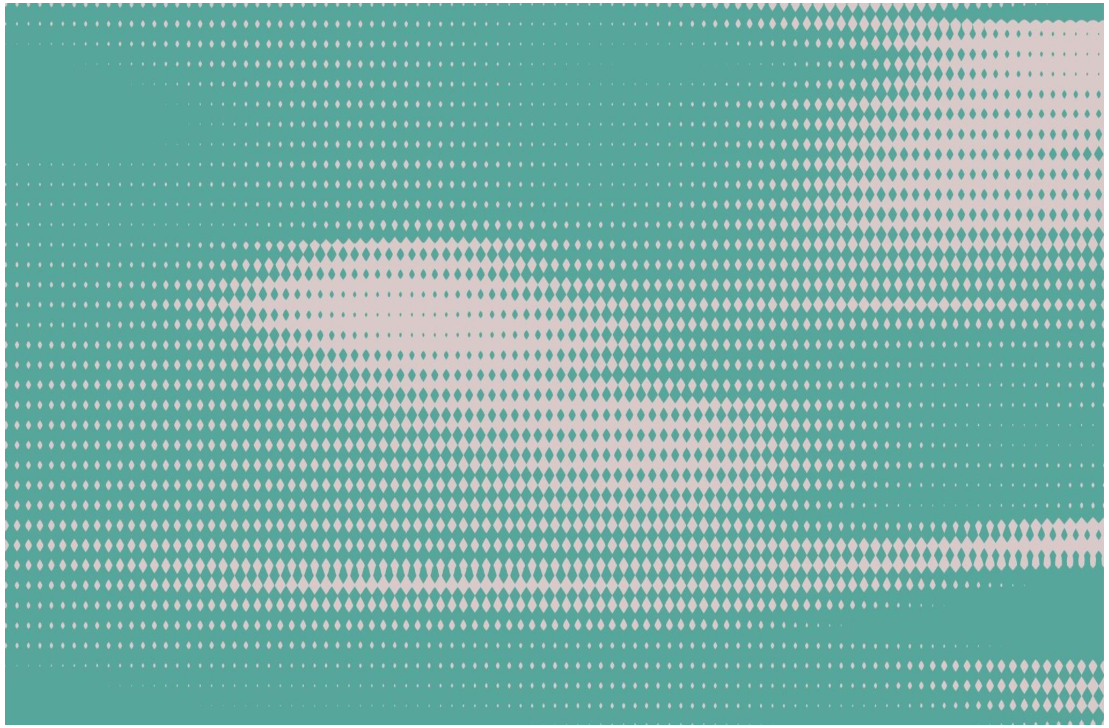

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