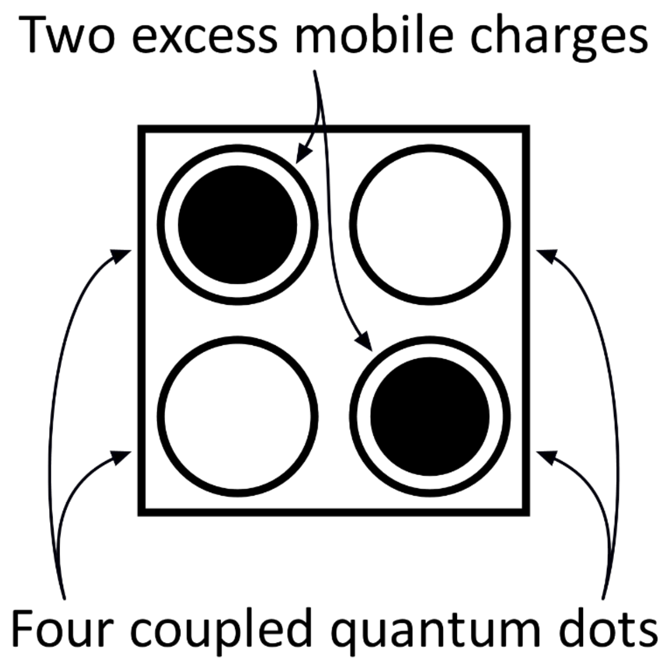
Single Electron Transistors for Molecular Computer Readout

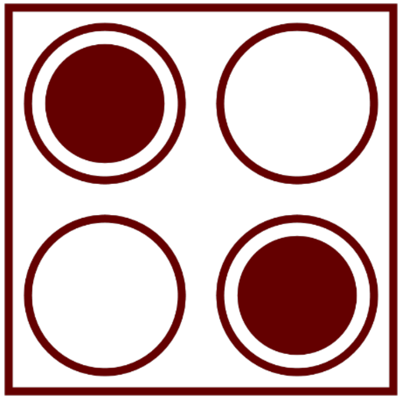
Matthew Filmer

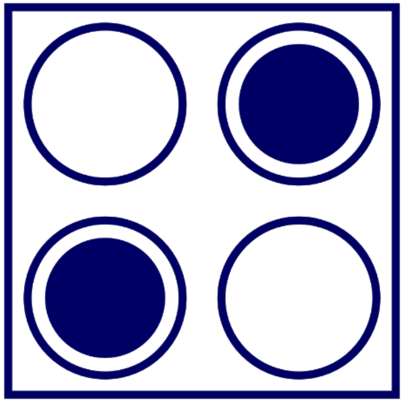
Quantum Dot Cellular Automata (QCA)



[1] Snider, 1999

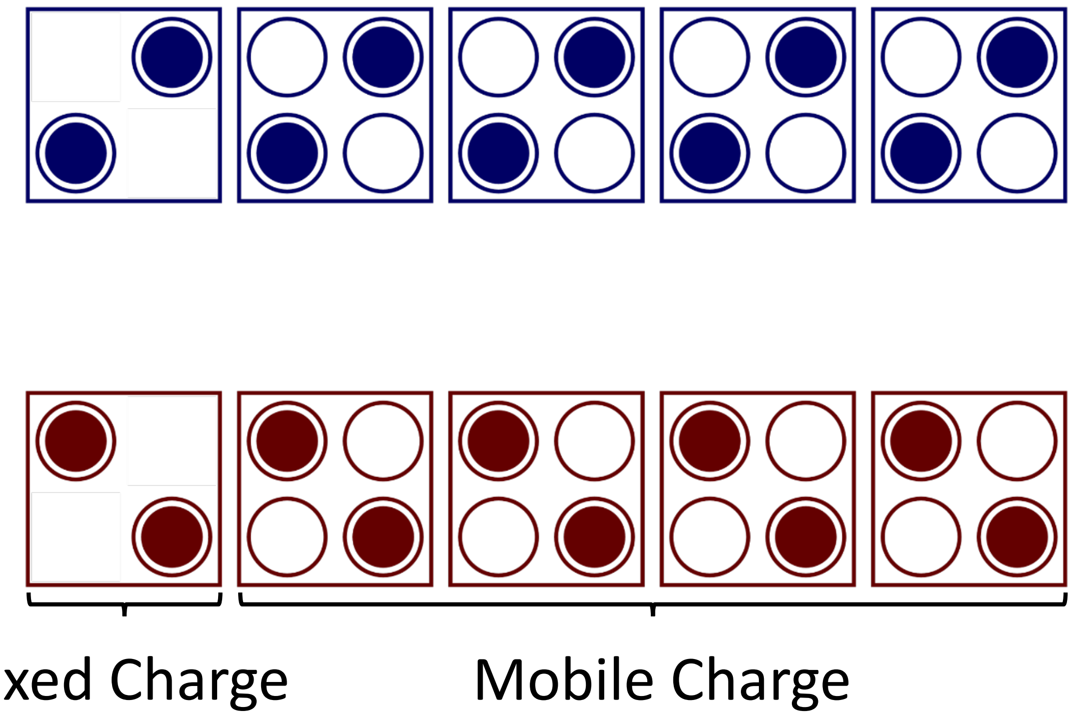
QCA States


0 State


1 State

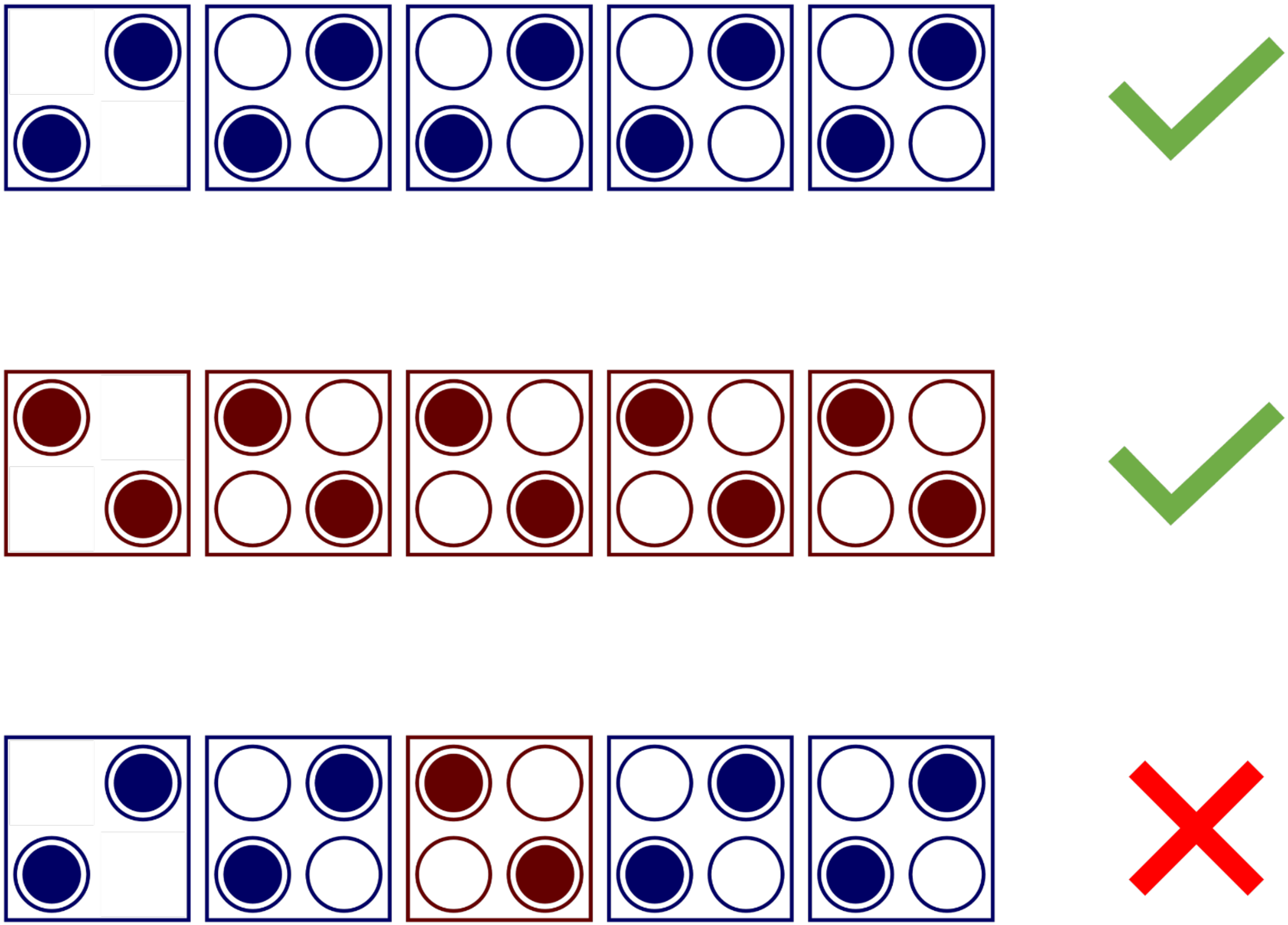
[1] Snider, 1999

QCA Wires



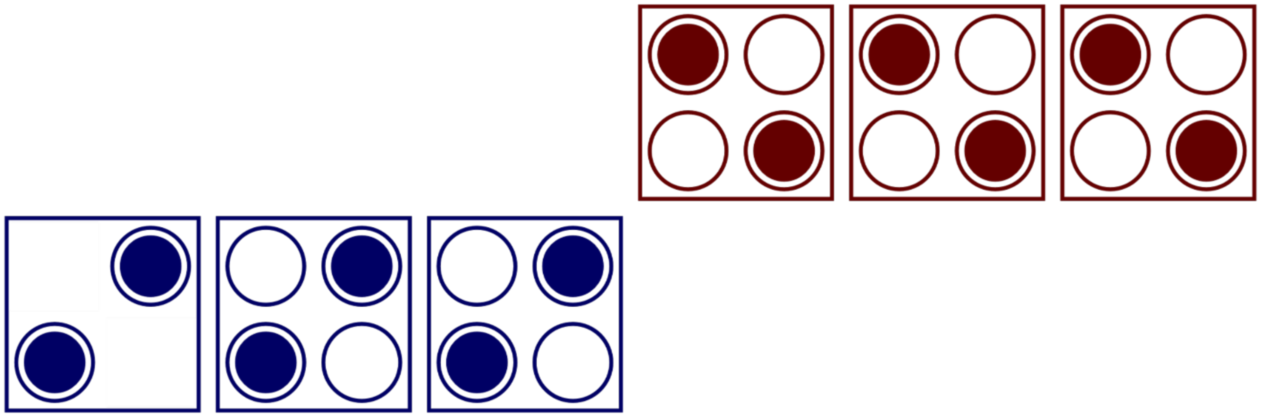
[1] Snider, 1999

QCA Wires



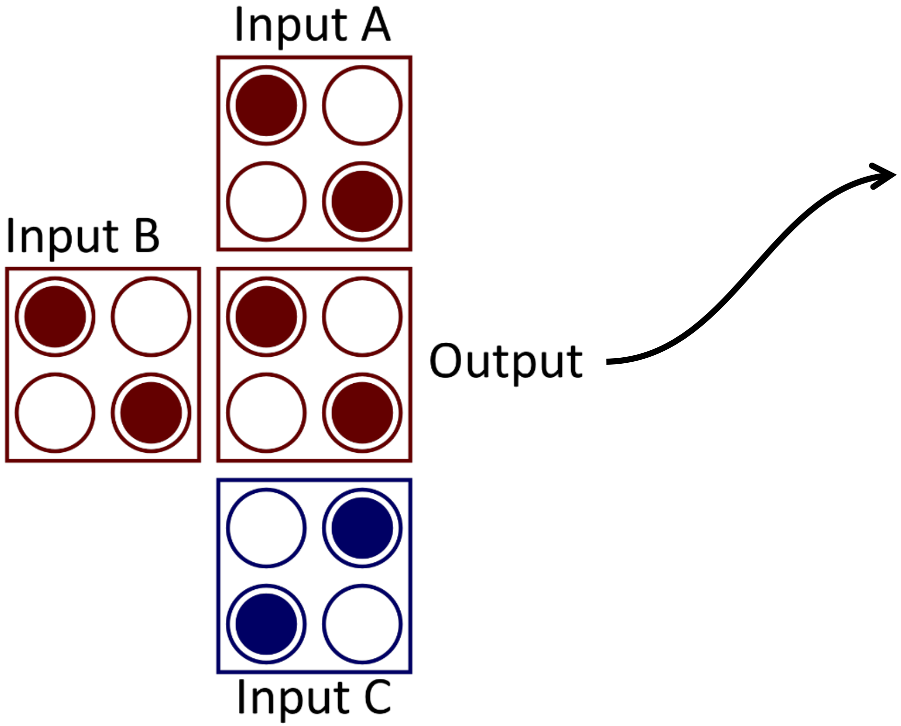
[1] Snider, 1999

QCA Inverter



[1] Snider, 1999

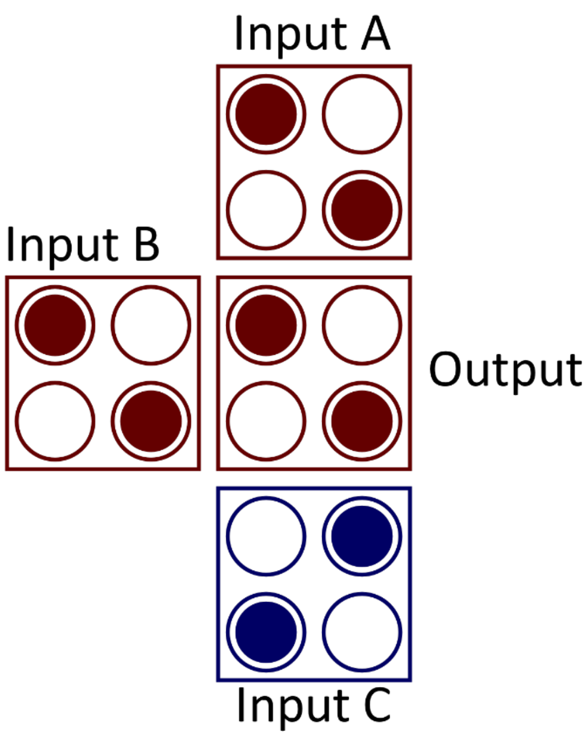
QCA Majority Gate



A	B	C	Out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

[1] Snider, 1999

QCA Majority Gate

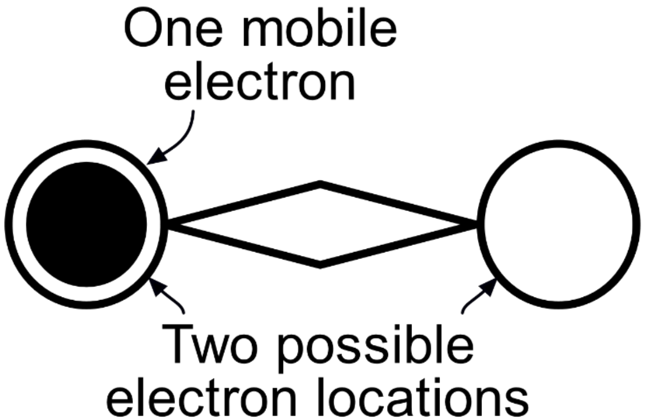


Program

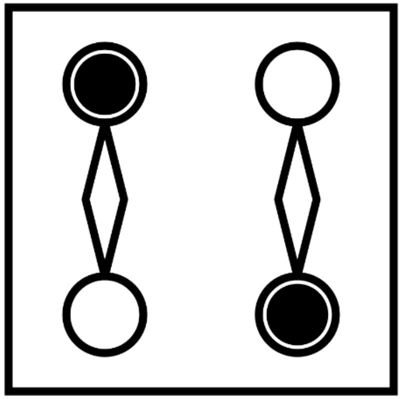
A	B	C	Out	
0	0	0	0	
0	0	1	0	AND
0	1	0	0	
0	1	1	1	
1	0	0	0	
1	0	1	1	OR
1	1	0	1	
1	1	1	1	

[1] Snider, 1999

Molecular Quantum Dot Cellular Automata



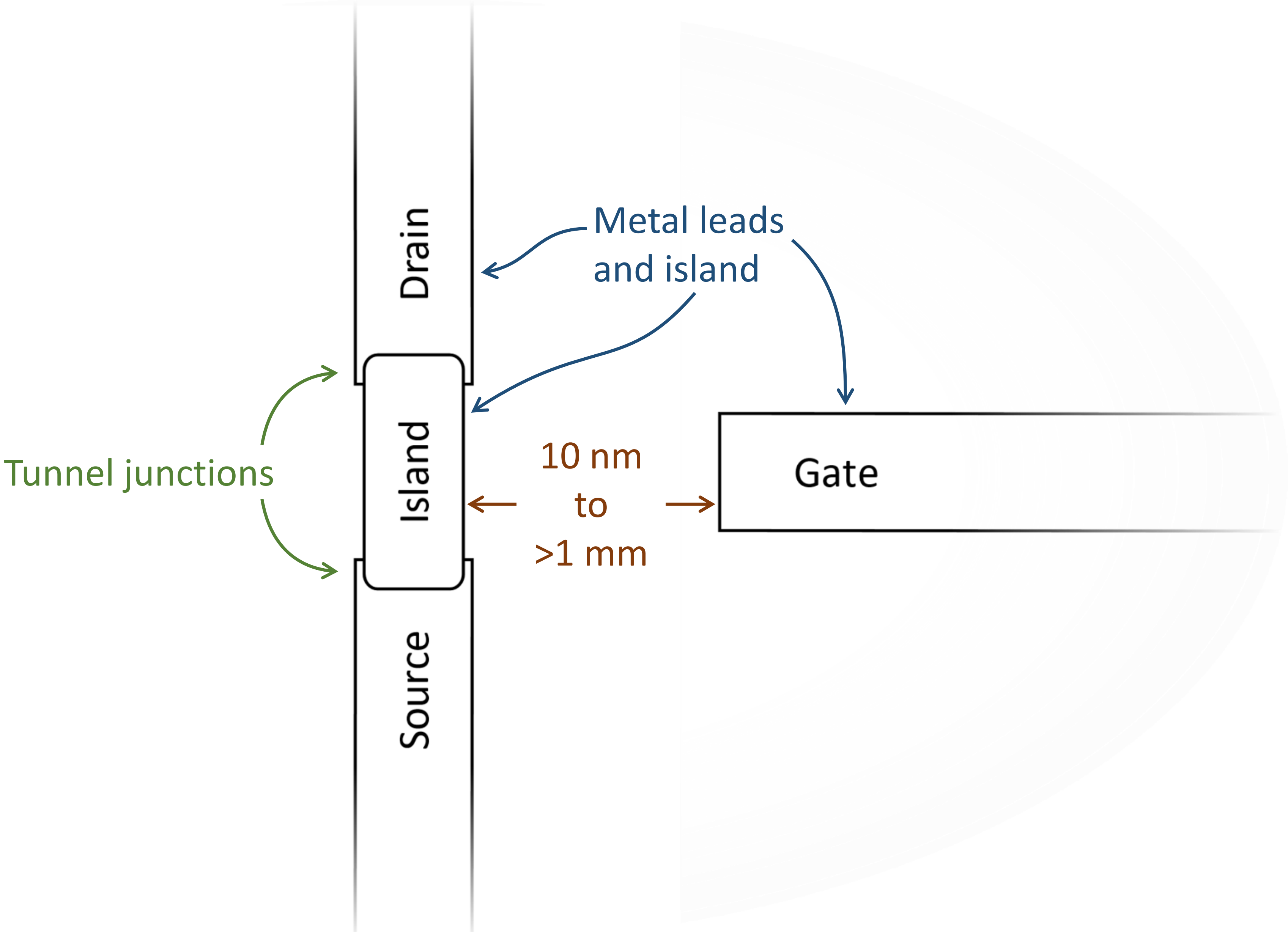
Mixed-Valence Molecule



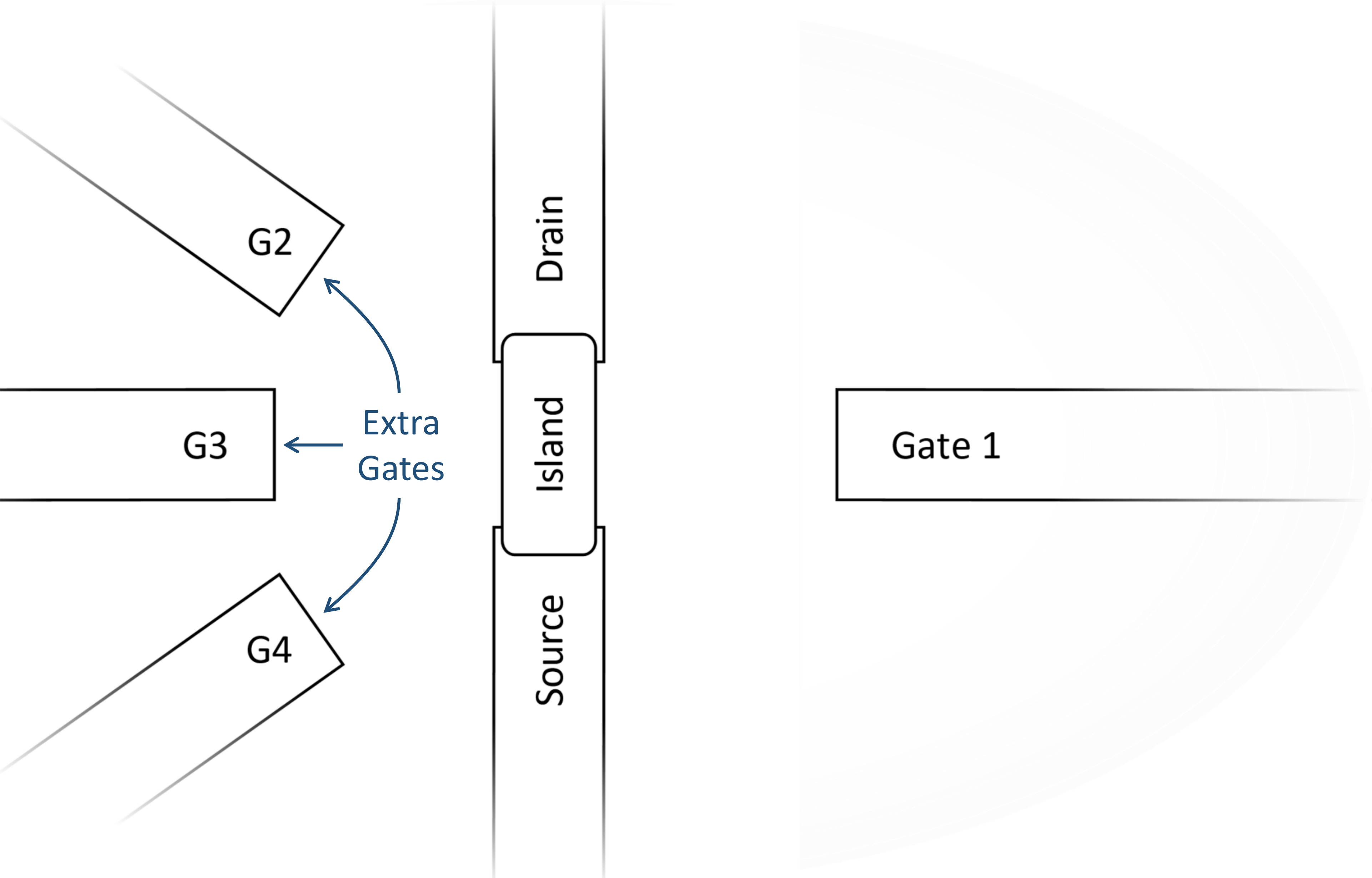
Two coupled
mixed-valence molecules

[2] Lent, 2002

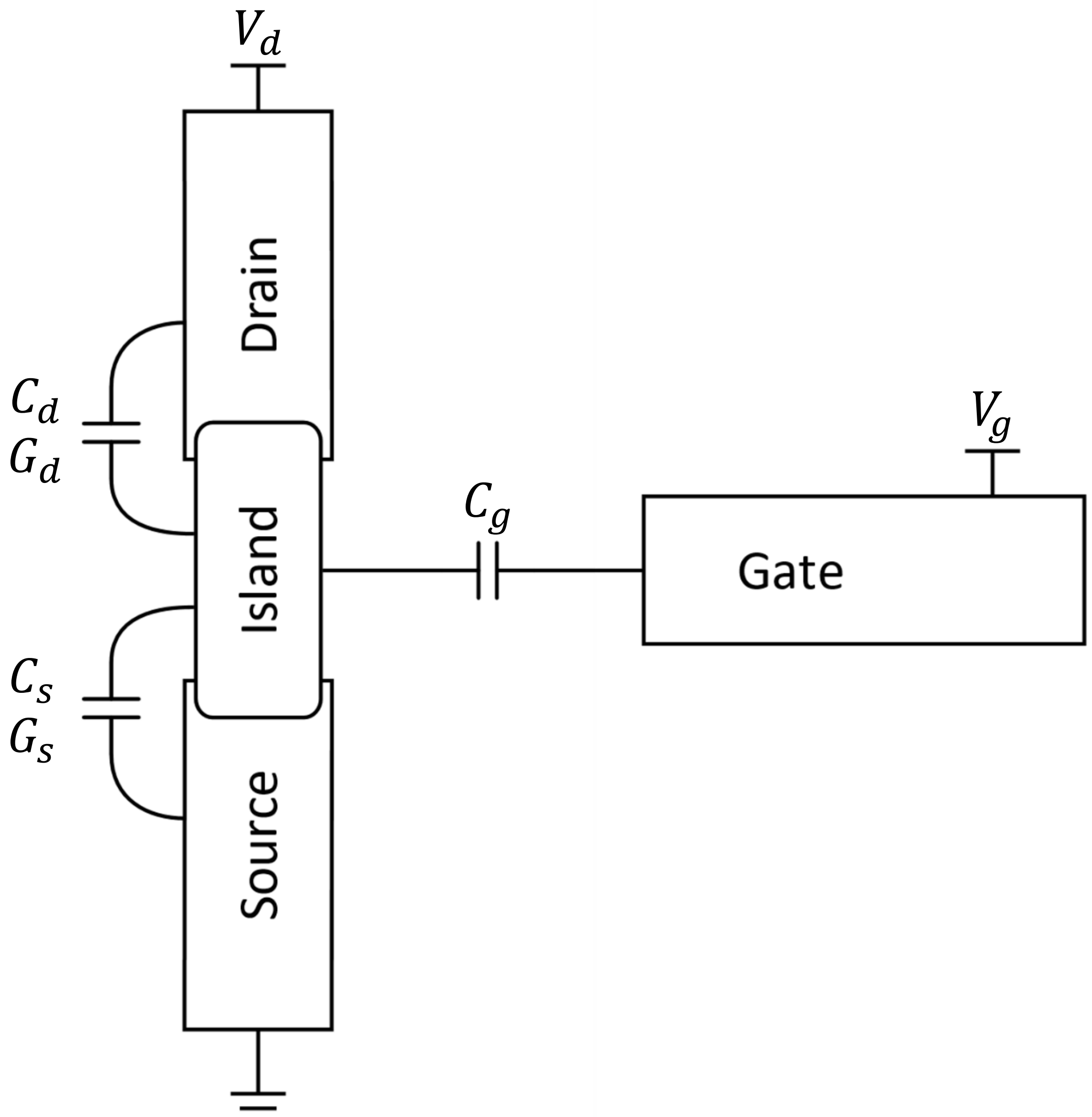
SET Structure



SET Structure



SET Structure



SET Island Potential

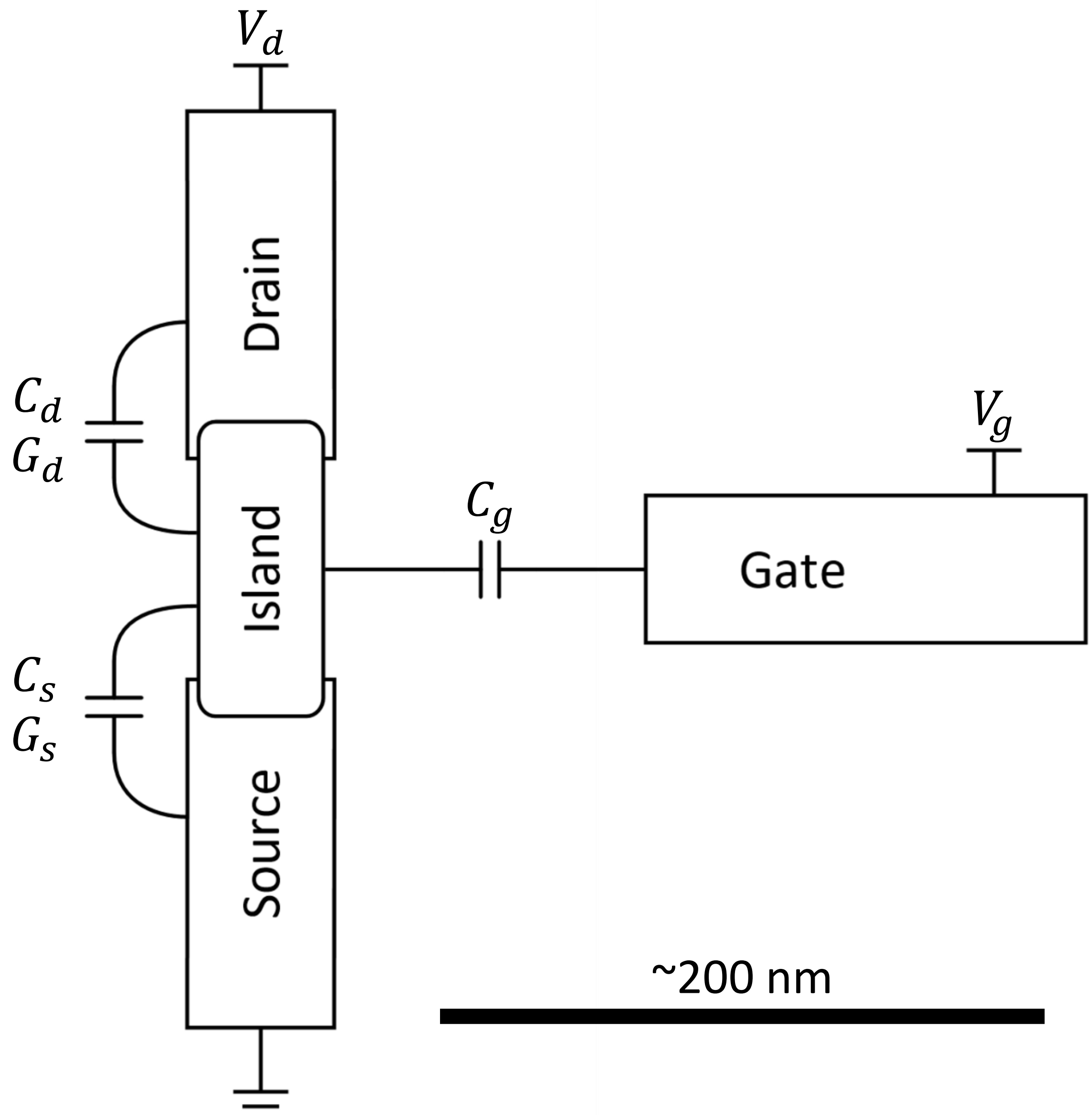
Total island capacitance

$$C_\Sigma = C_s + C_d + C_g$$

Electron charge

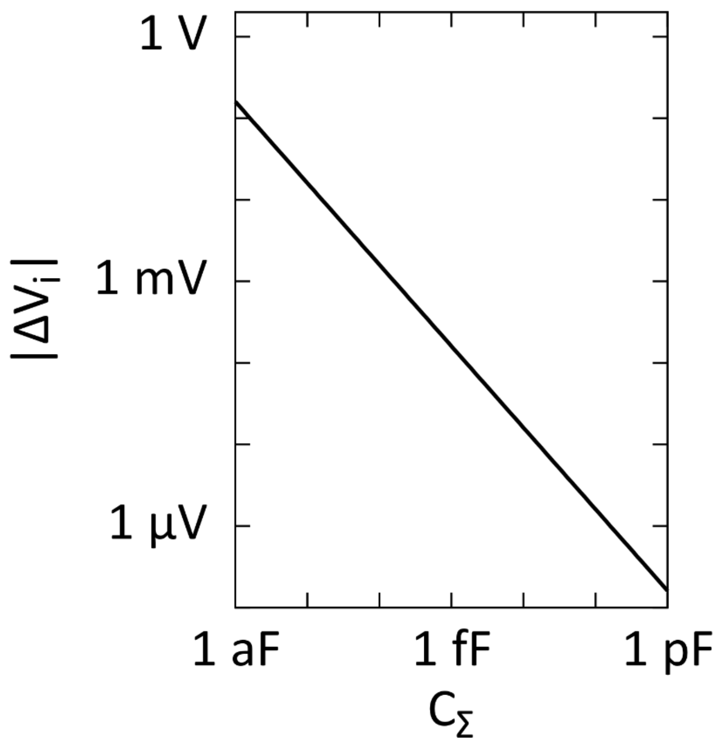
$$\Delta V_i = \frac{-e}{C_\Sigma}$$

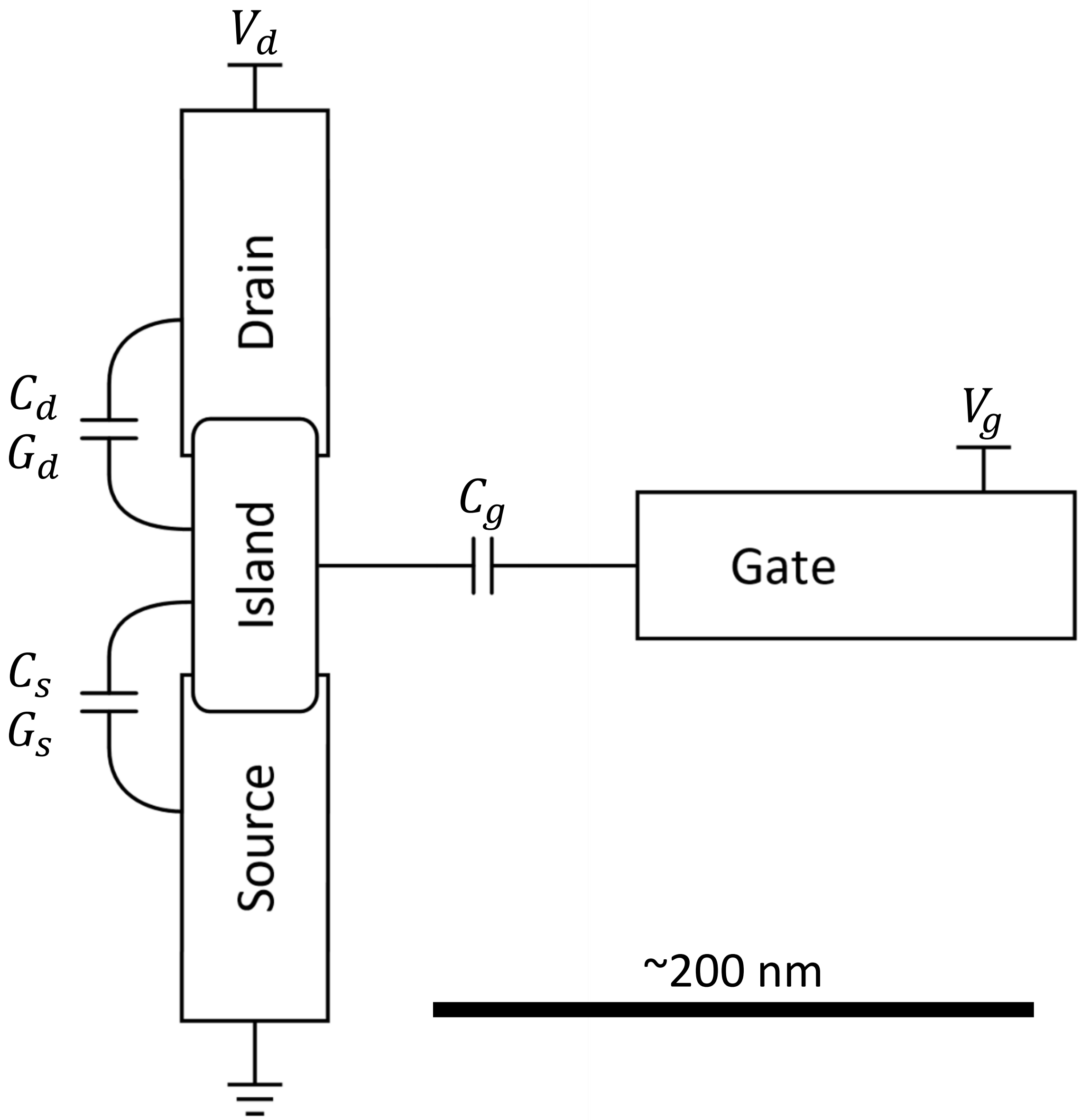
Change in island potential when an electron is added to the island



SET Island Potential

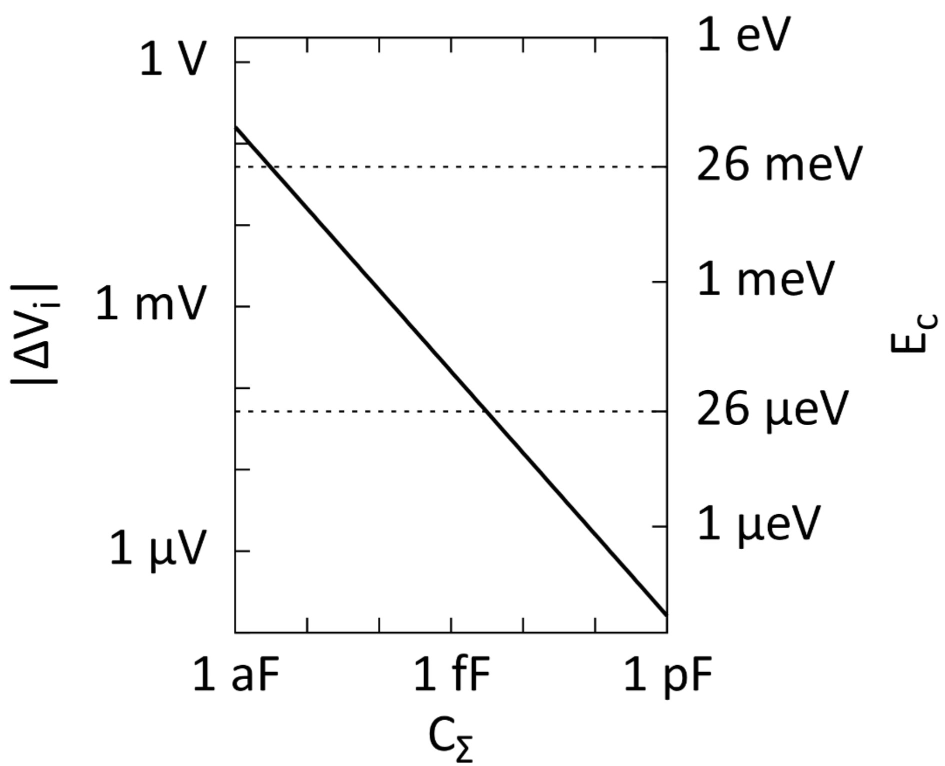
$$\Delta V_i = \frac{-e}{C_\Sigma}$$





SET Charging Energy

$$\Delta V_i = \frac{-e}{C_\Sigma}$$



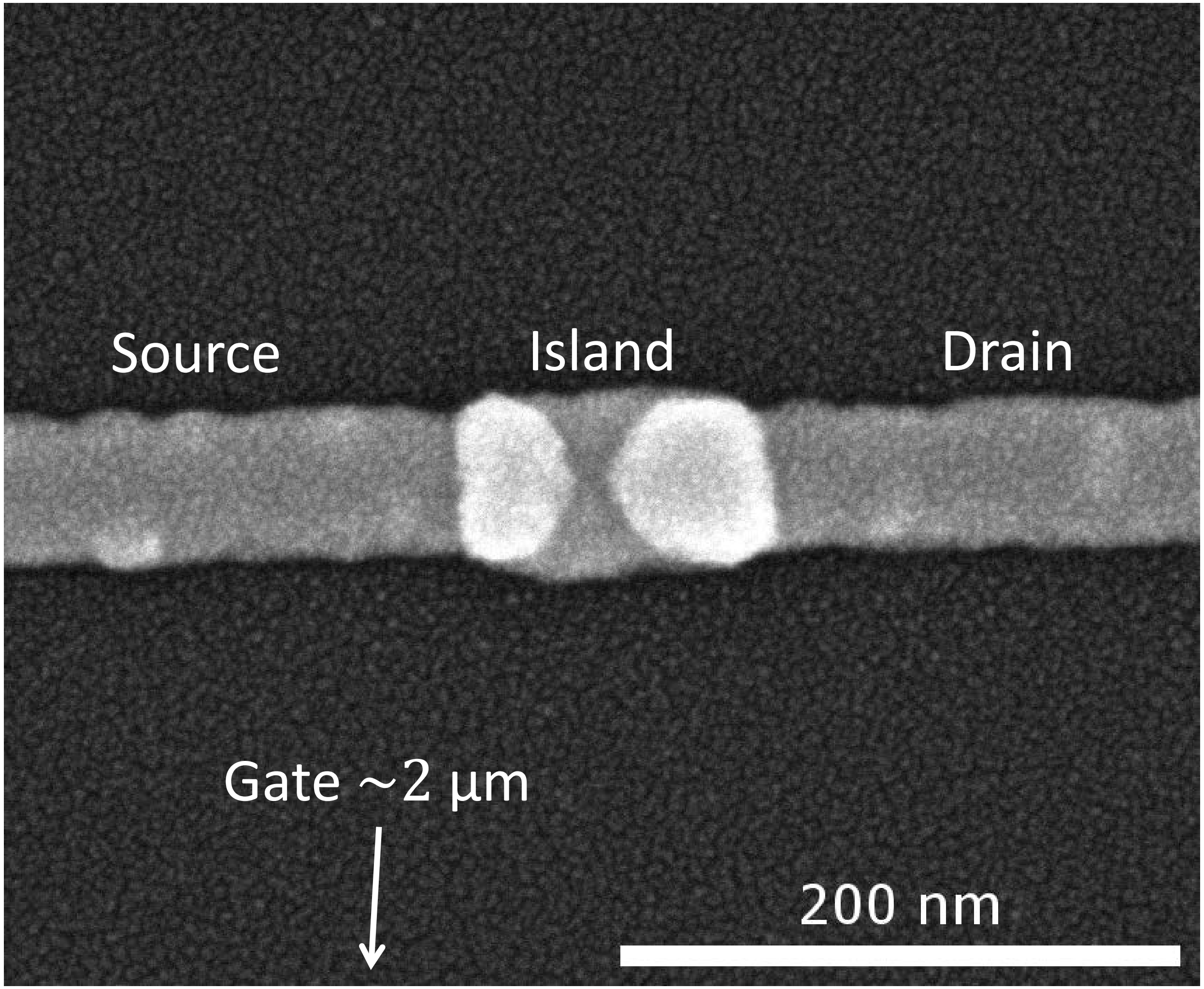
Energy stored in a capacitor

$$E_{cap} = \frac{1}{2} C V^2$$

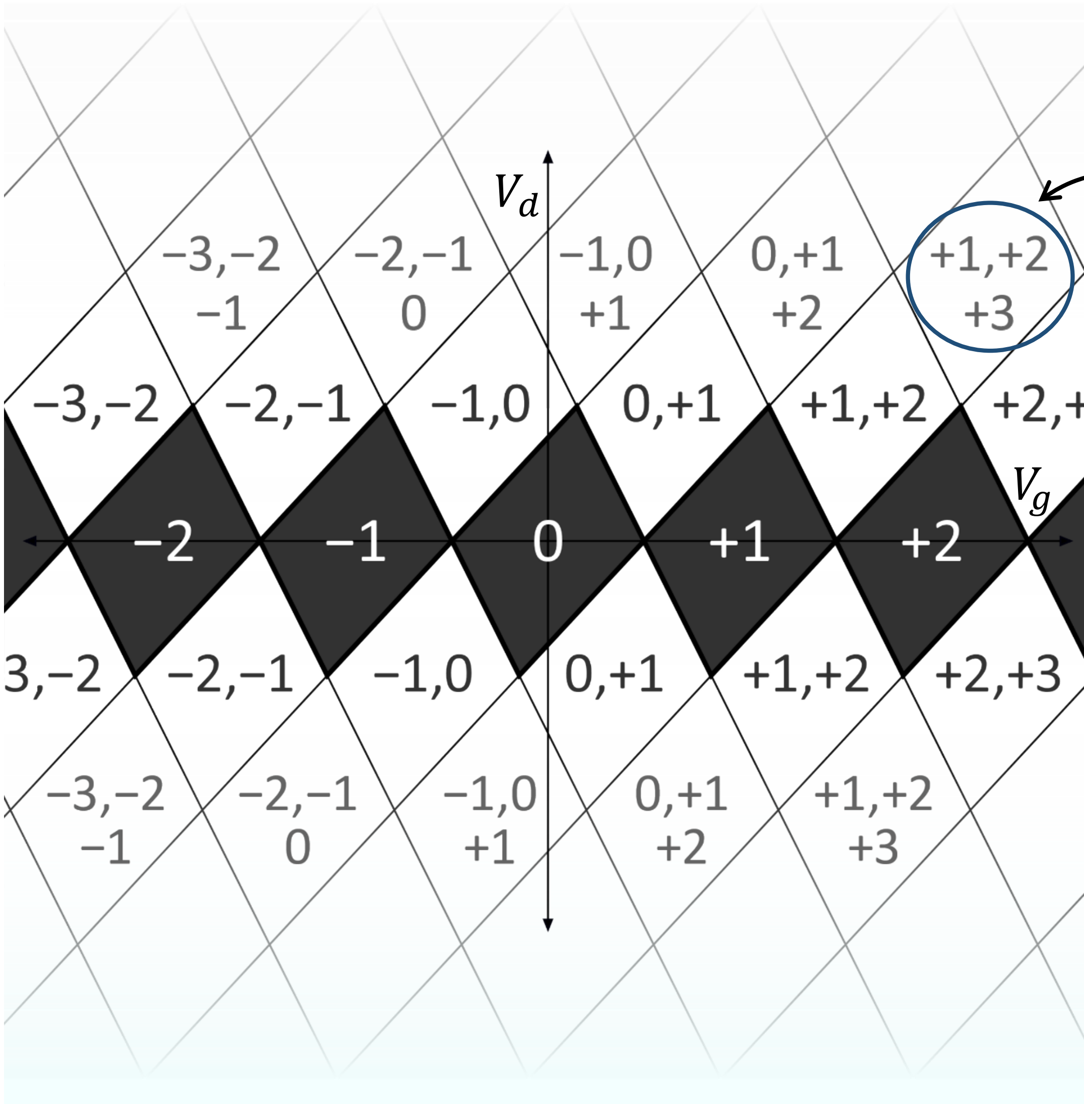
Charging energy of an SET

$$E_c = \frac{e^2}{2C_\Sigma}$$

SET Structure



Charging Diagram at 0 K

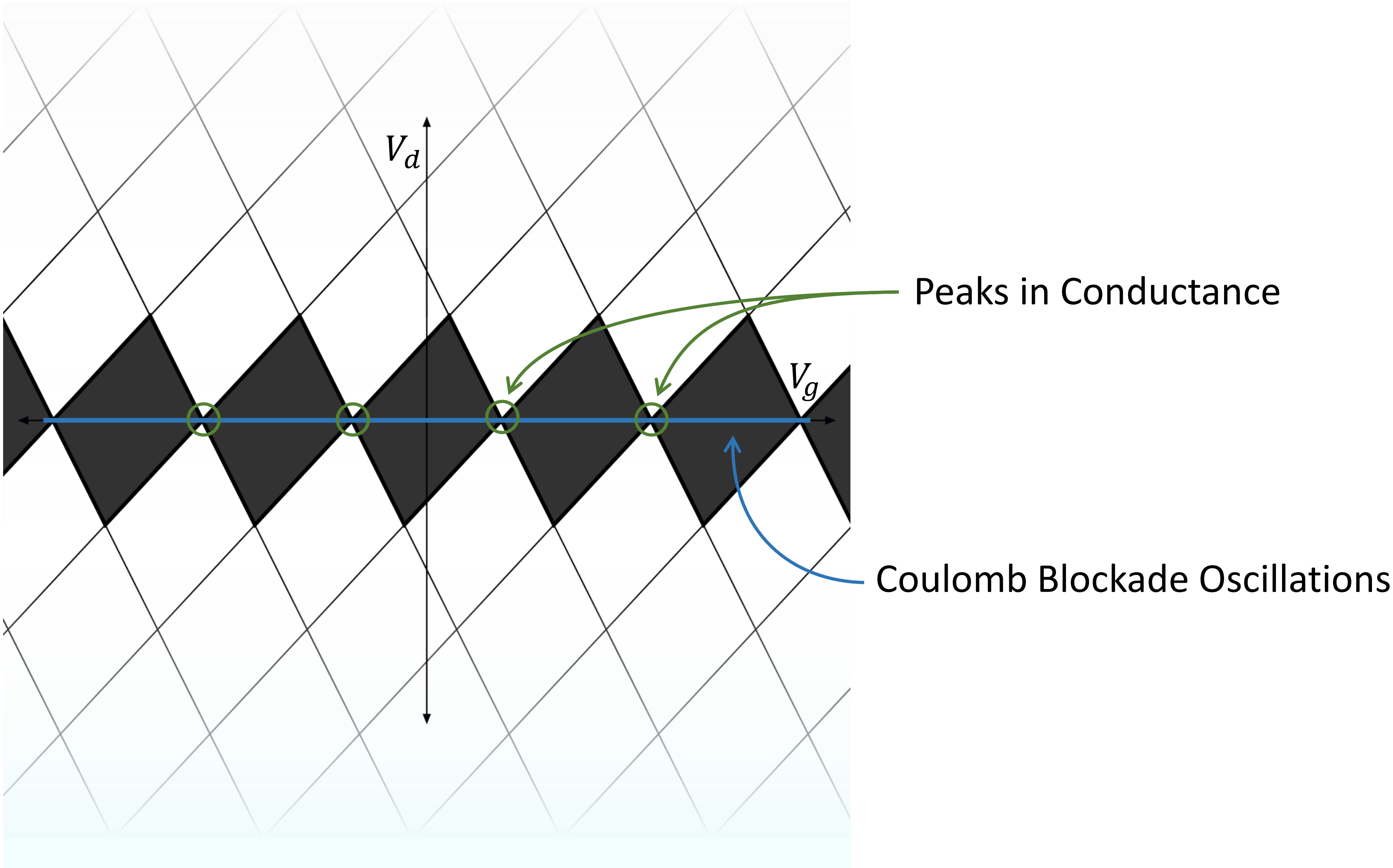


Allowed island charge

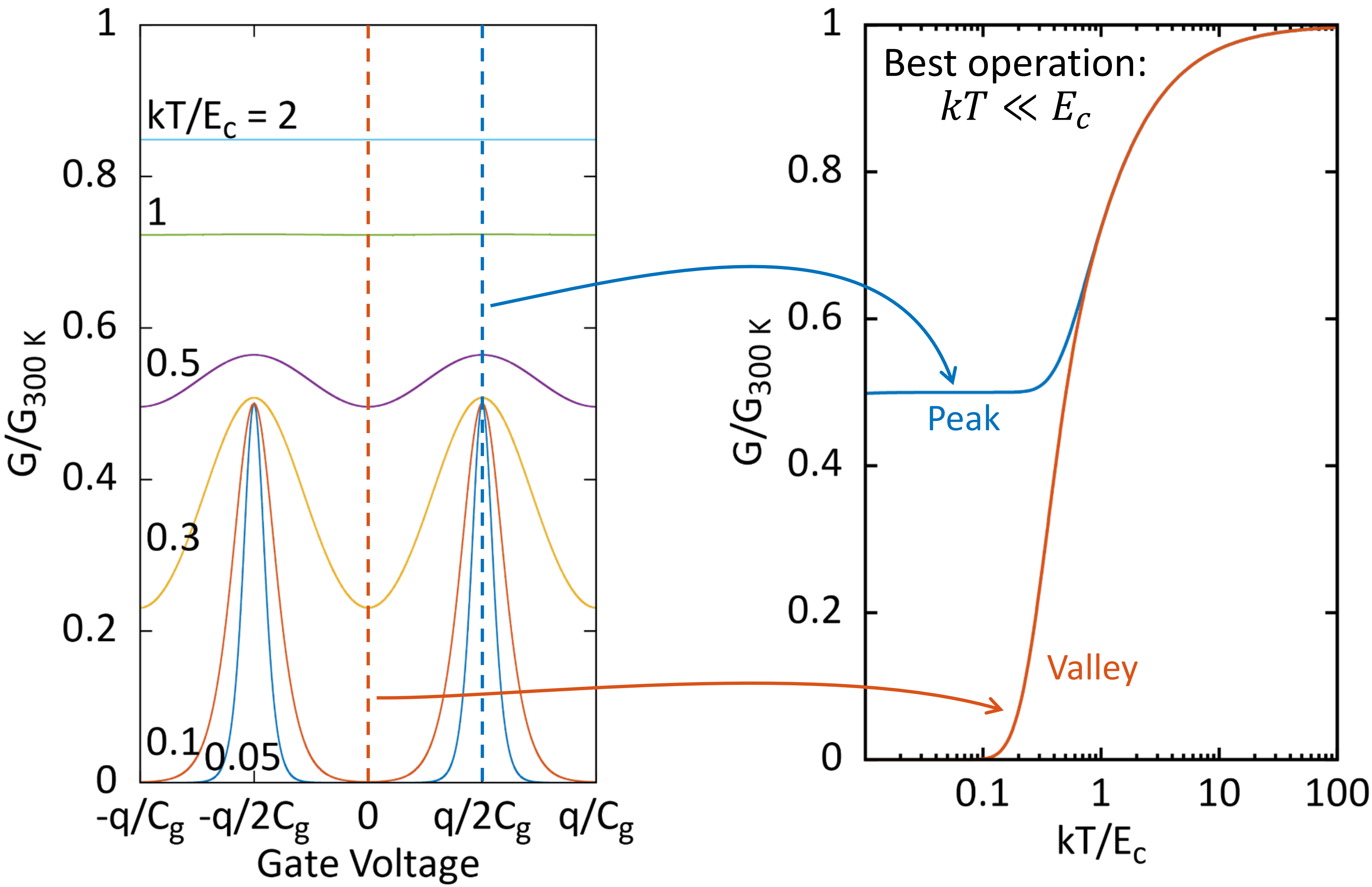
Single allowed charge

Multiple allowed charges

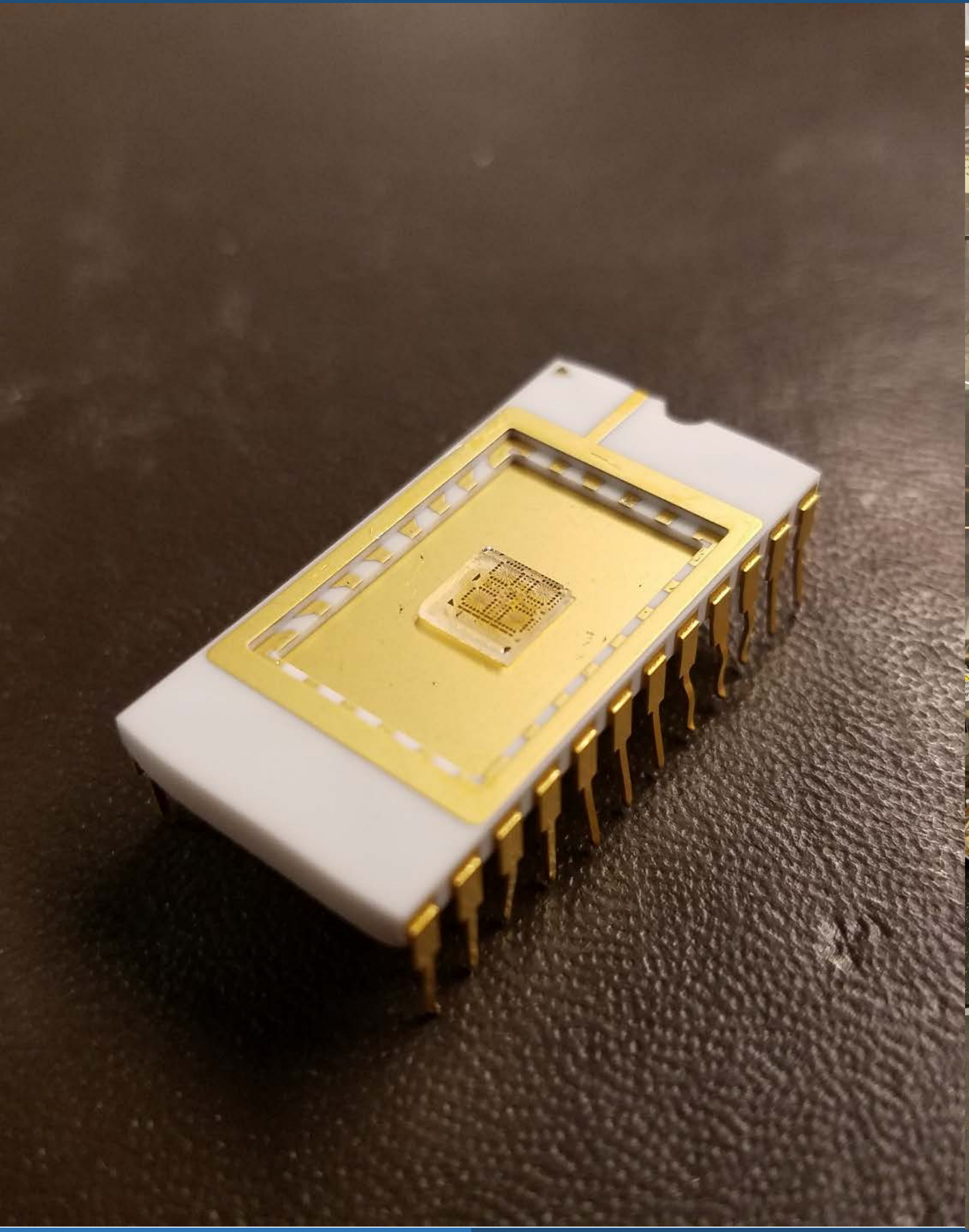
Charging Diagram at 0 K

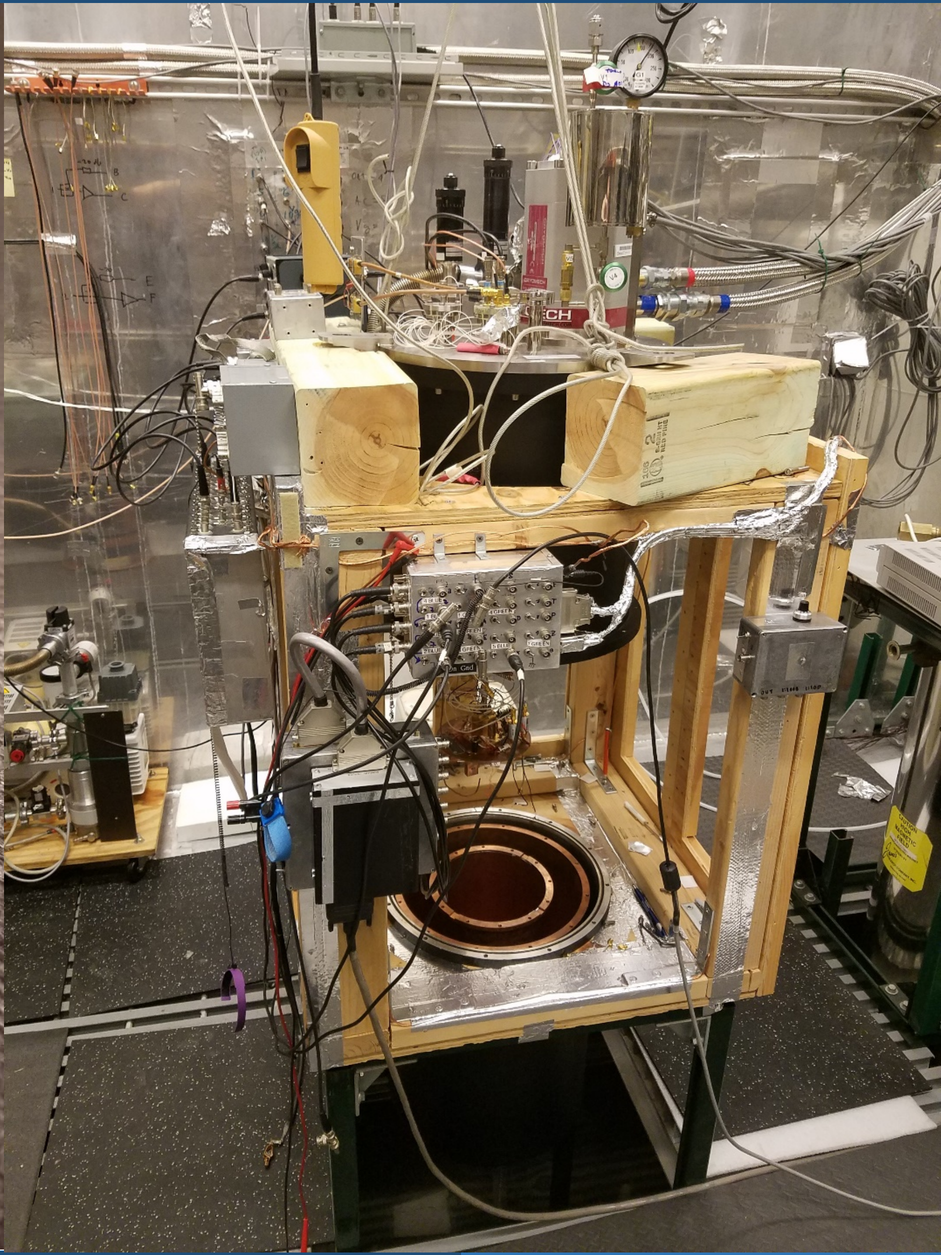


Coulomb Blockade Oscillations

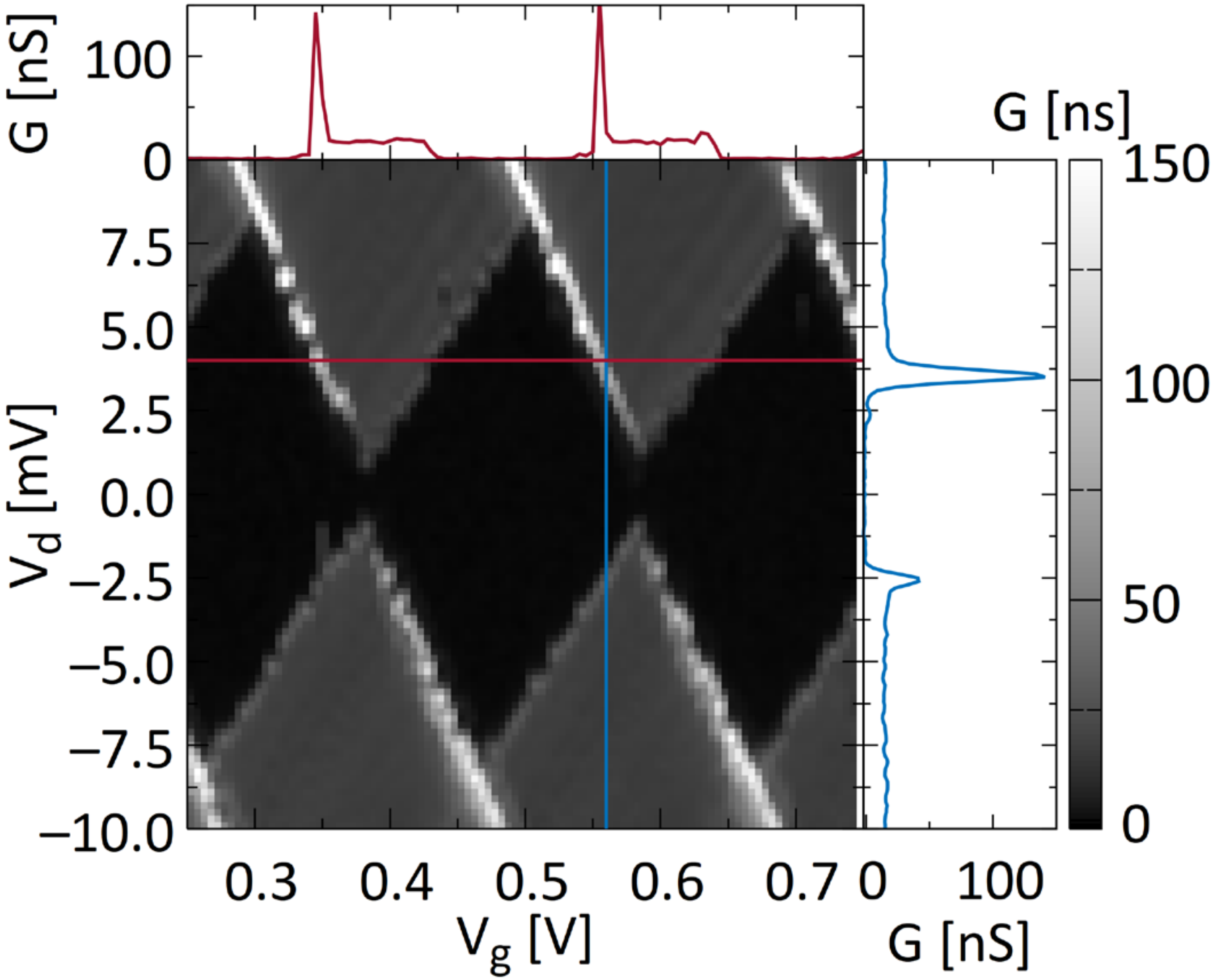


Measurement Setup

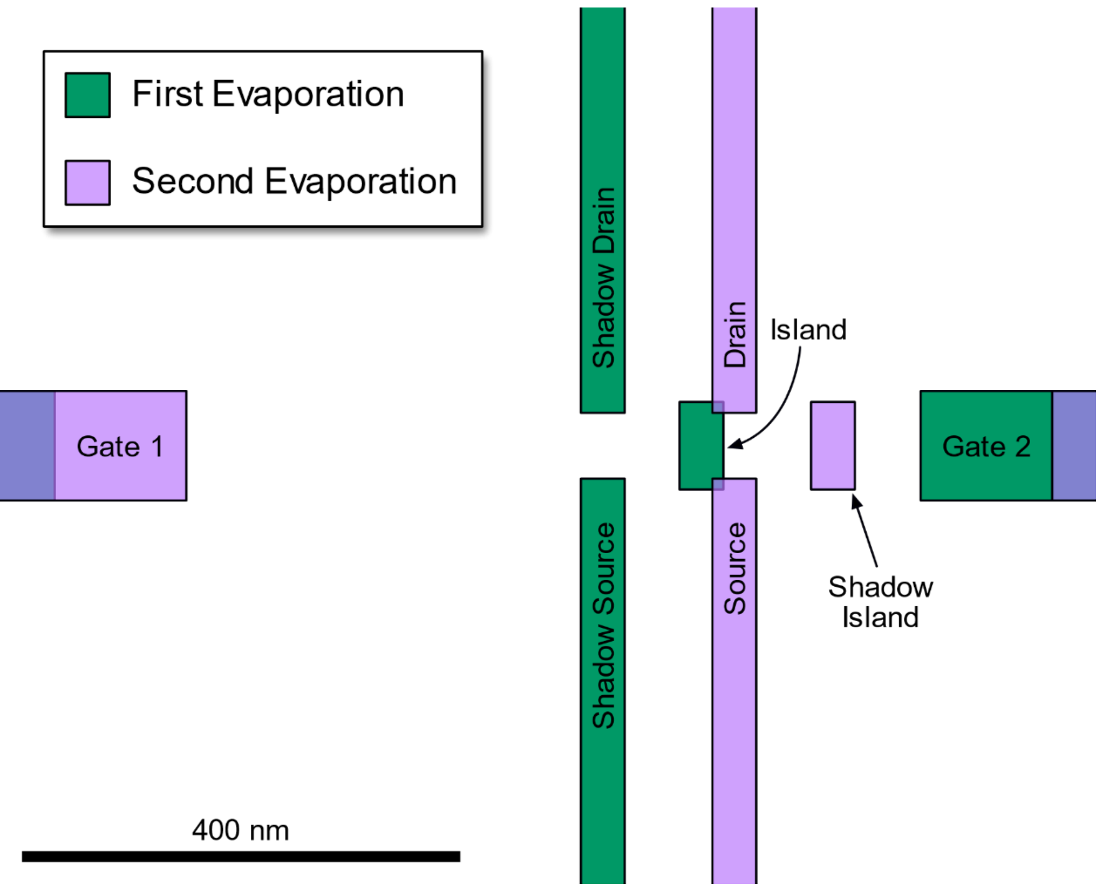


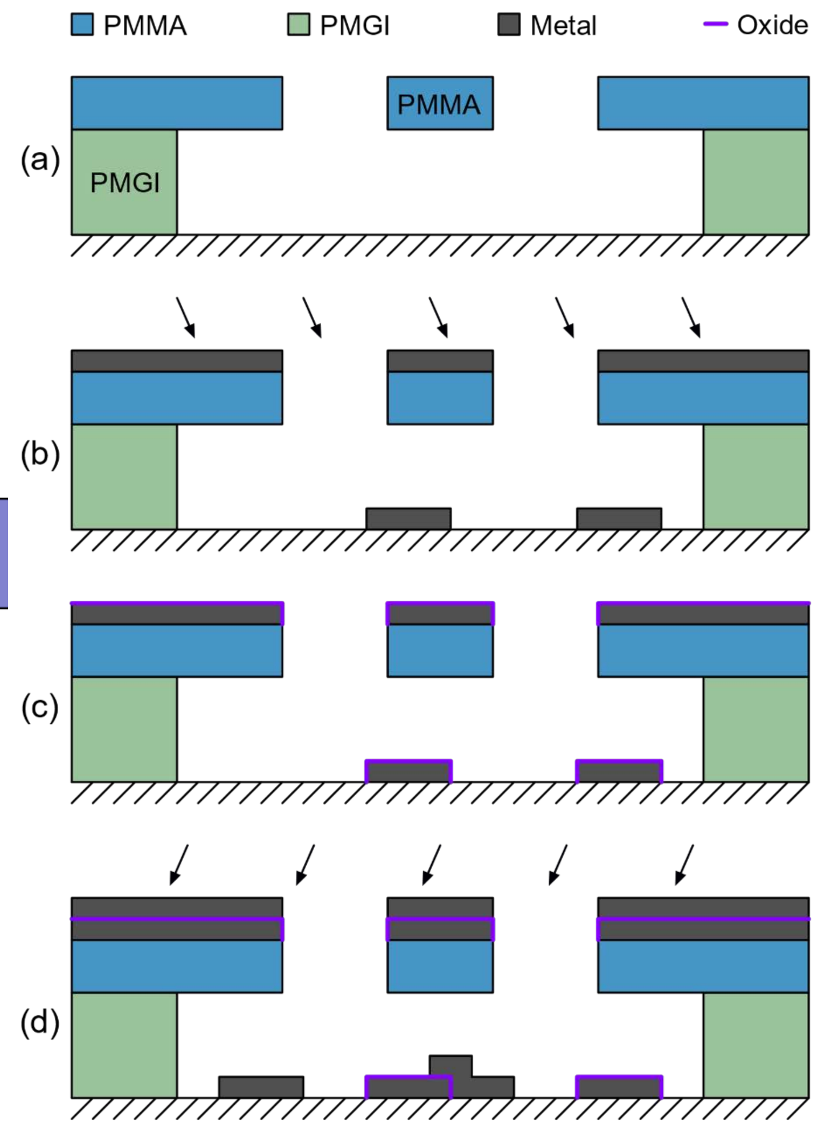


Measured SET at 300 mK

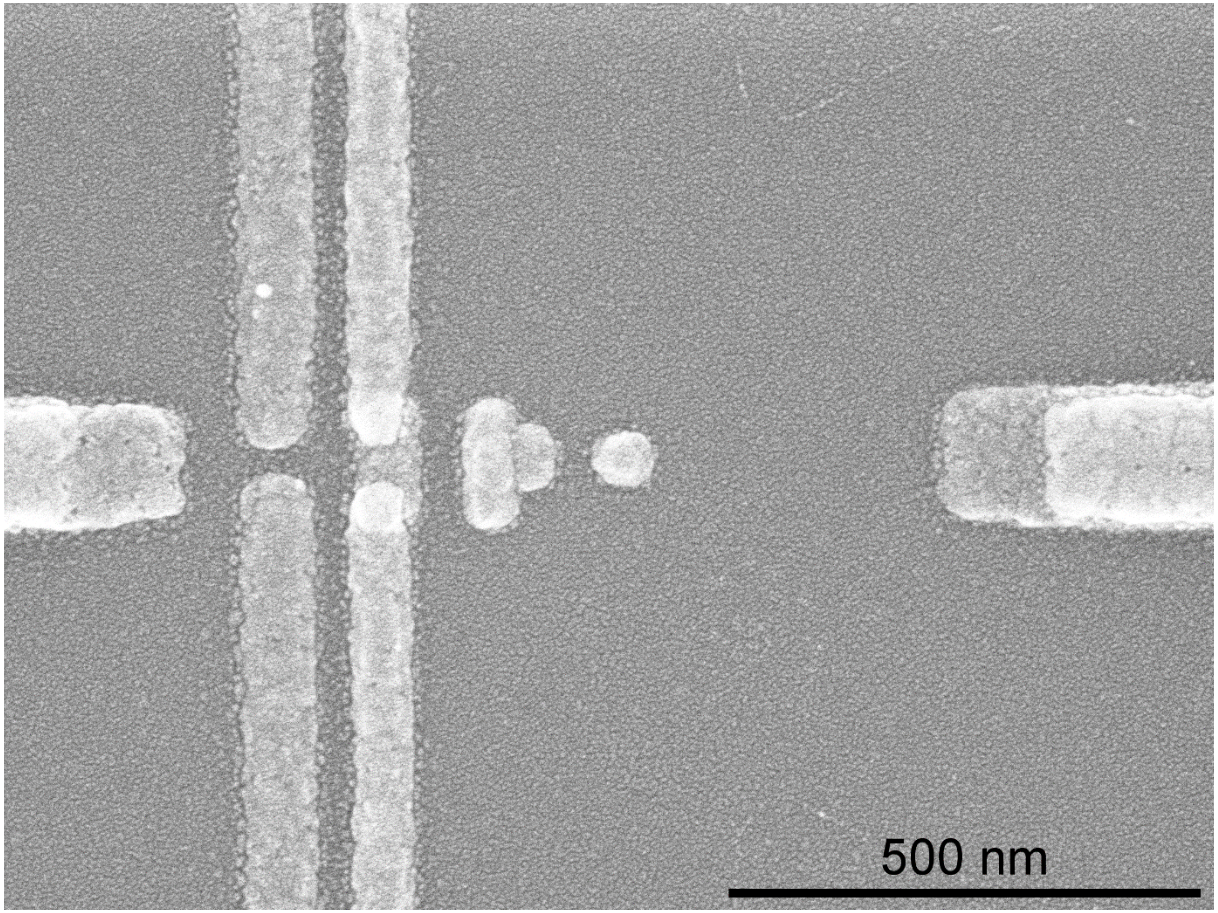


Dolan Bridge Process

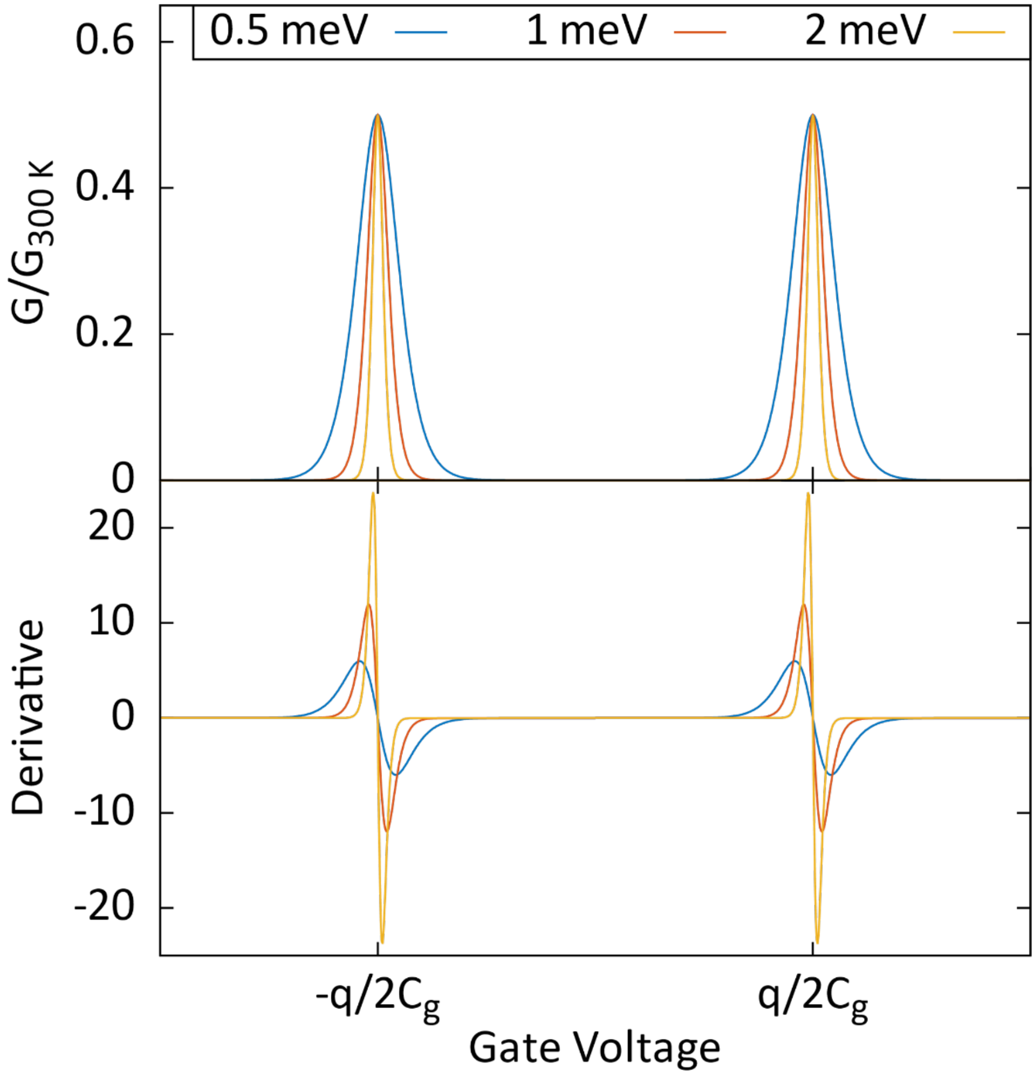




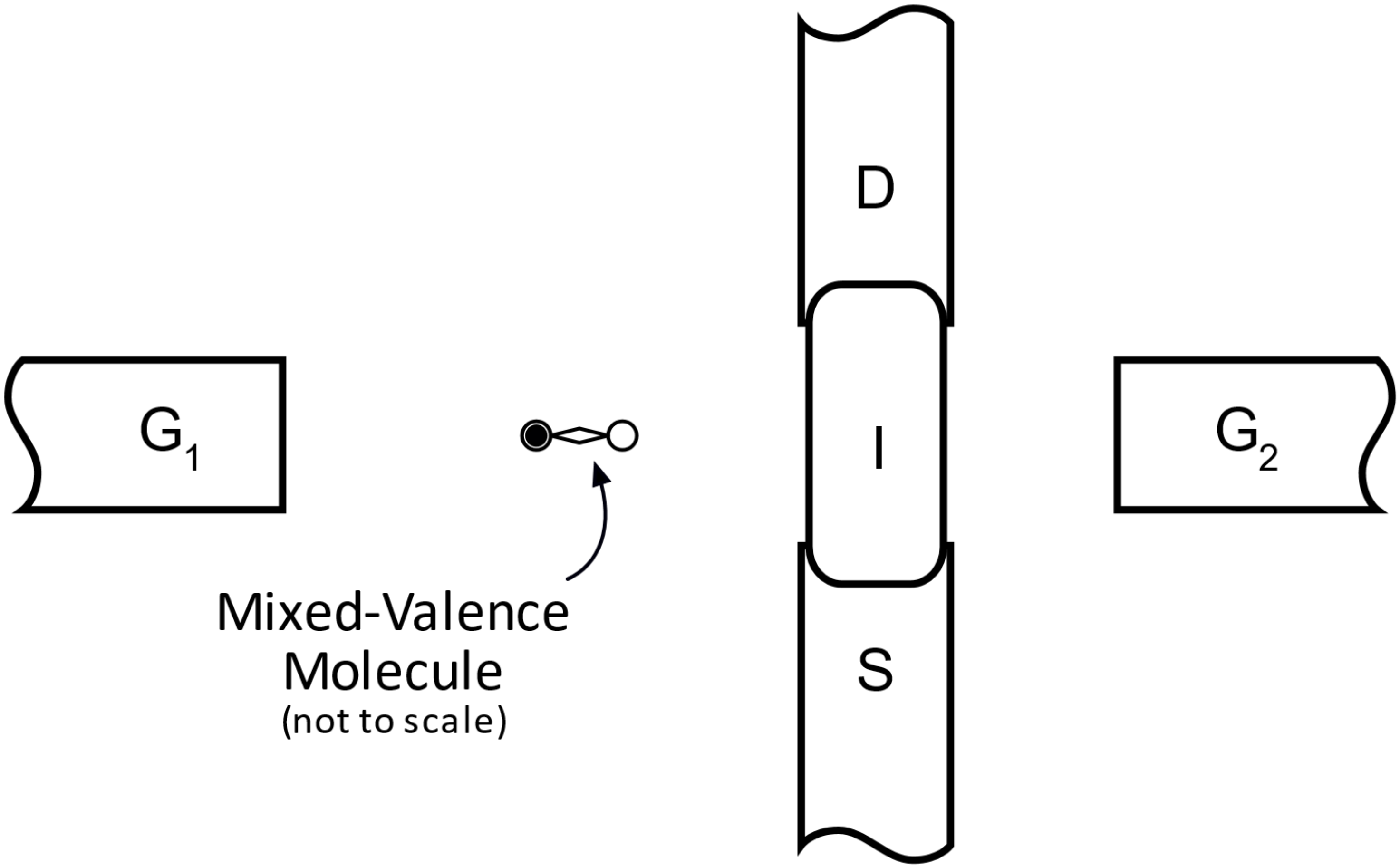
Dolan Bridge Process



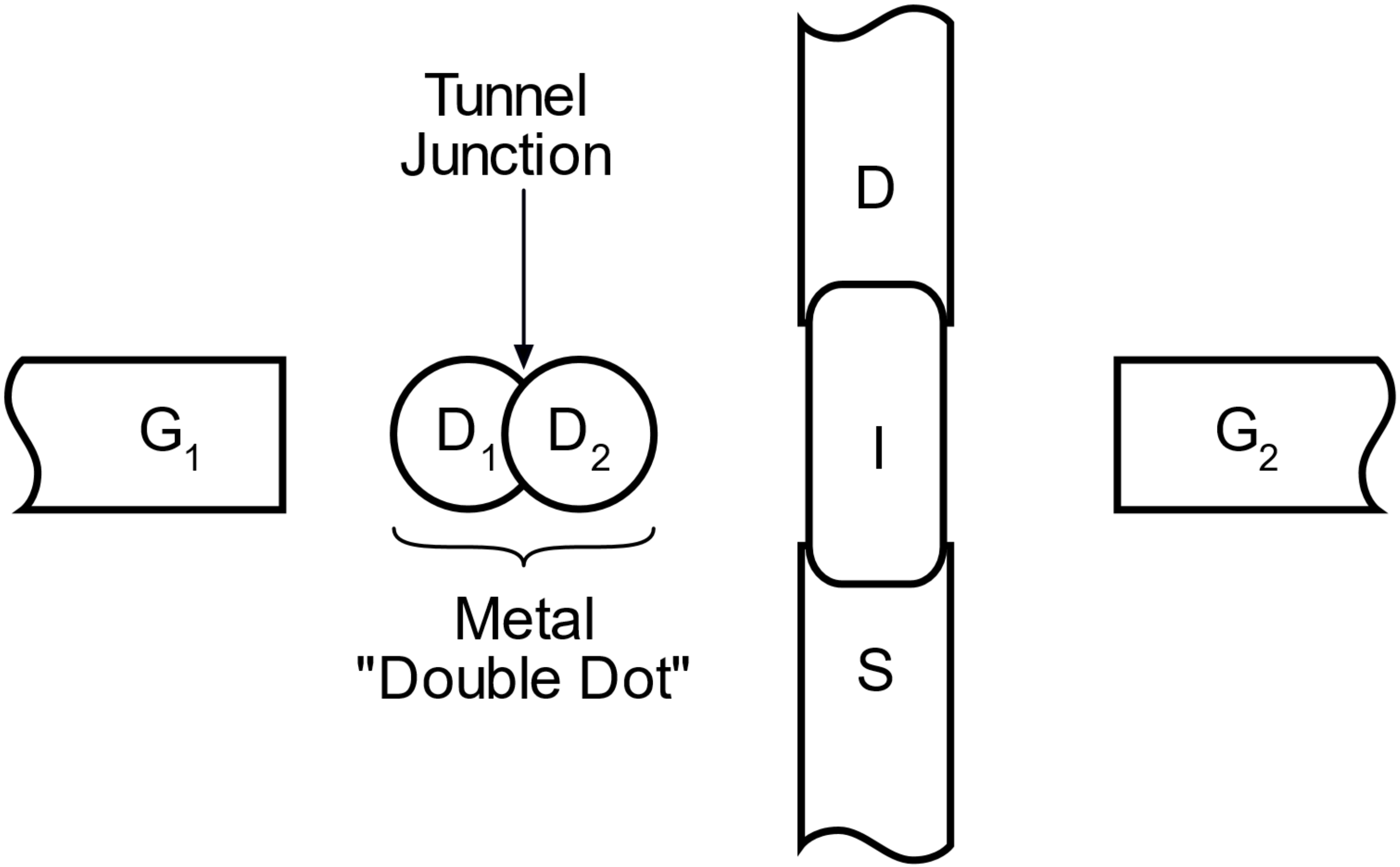
SET Charge Detector



SET Charge Detector

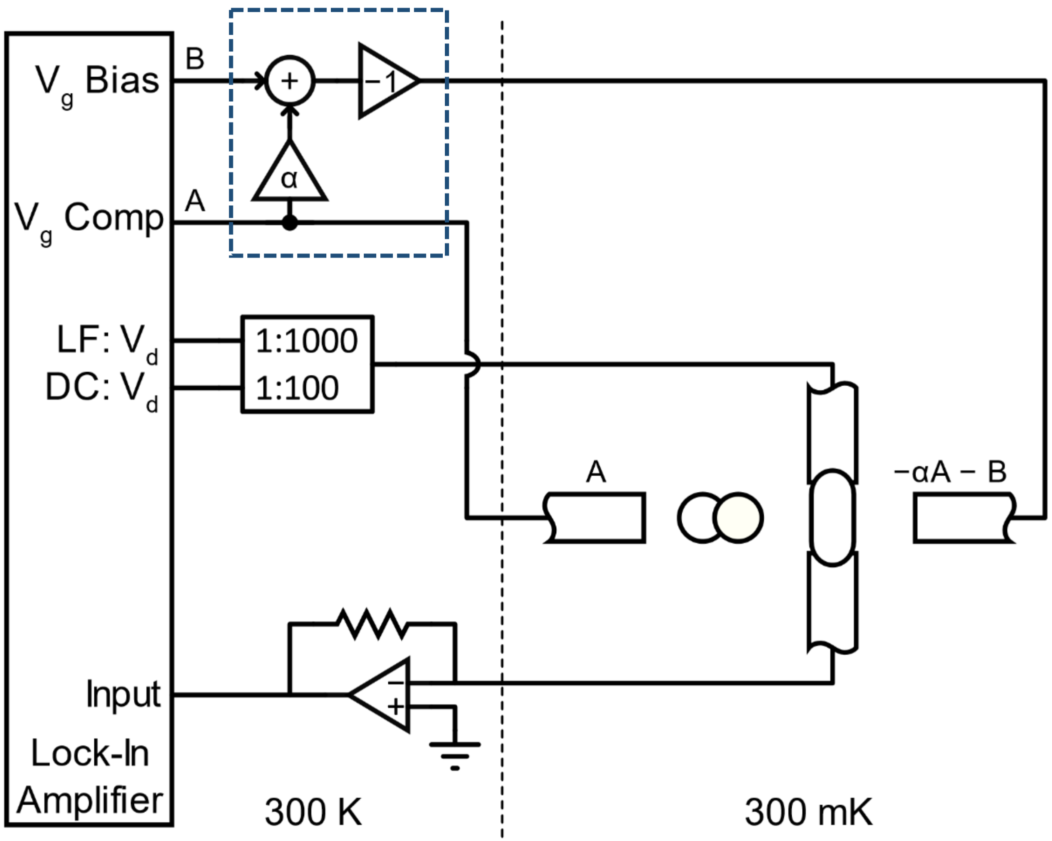


SET Charge Detector: Prototype Experiment

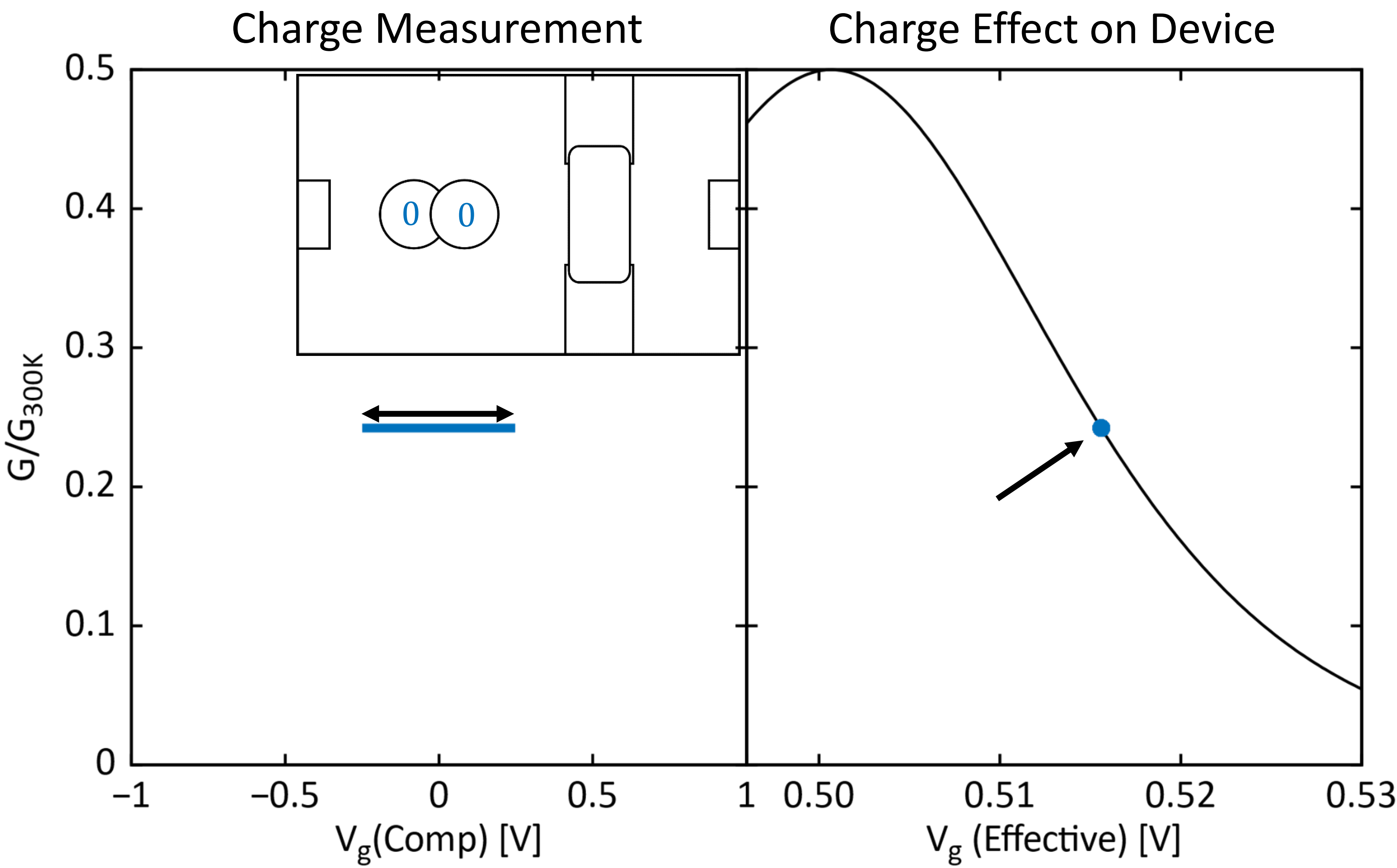


Compensated SET Measurement Setup

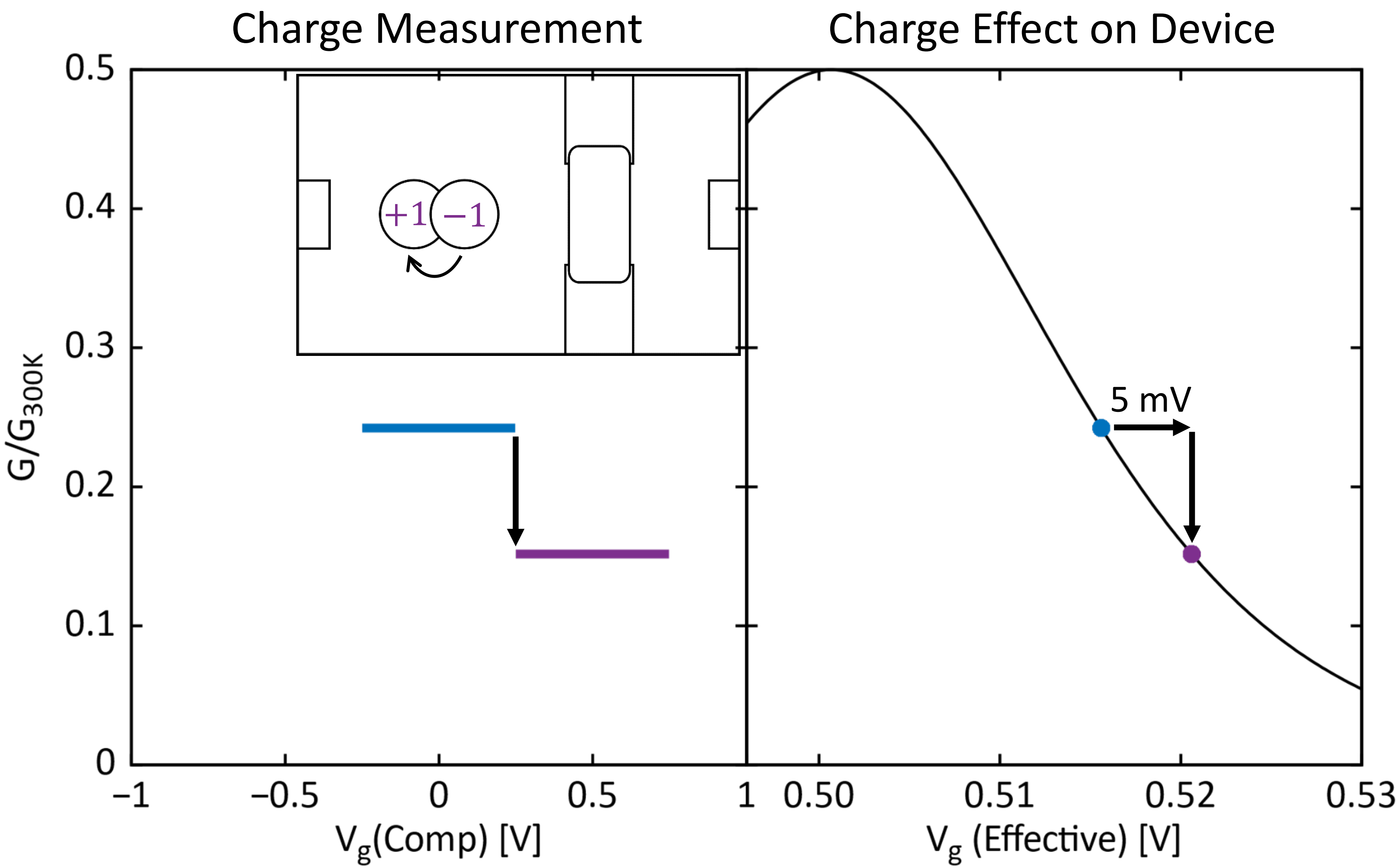
Gate Compensation



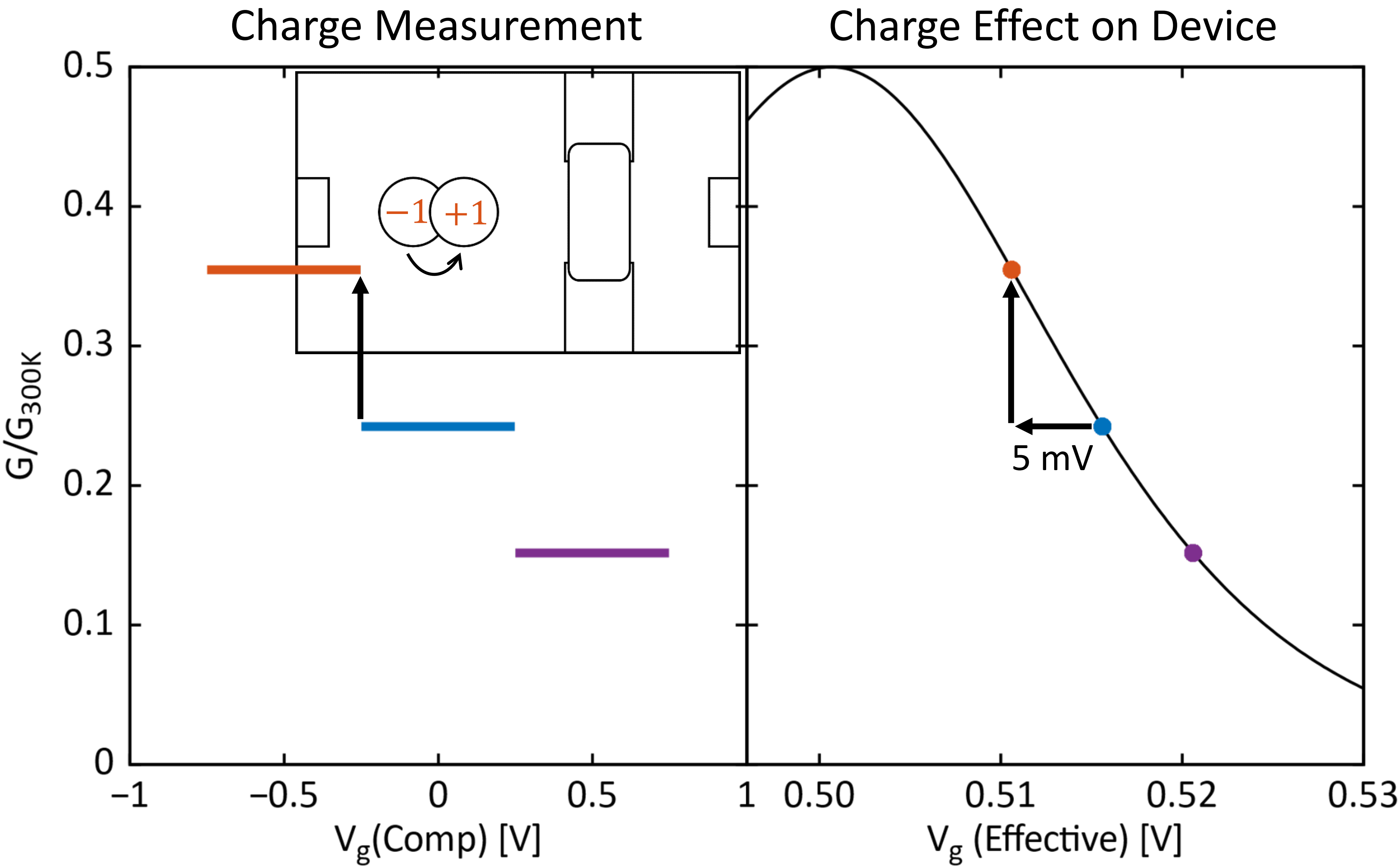
SET Charge Detector: 5 mV Signal



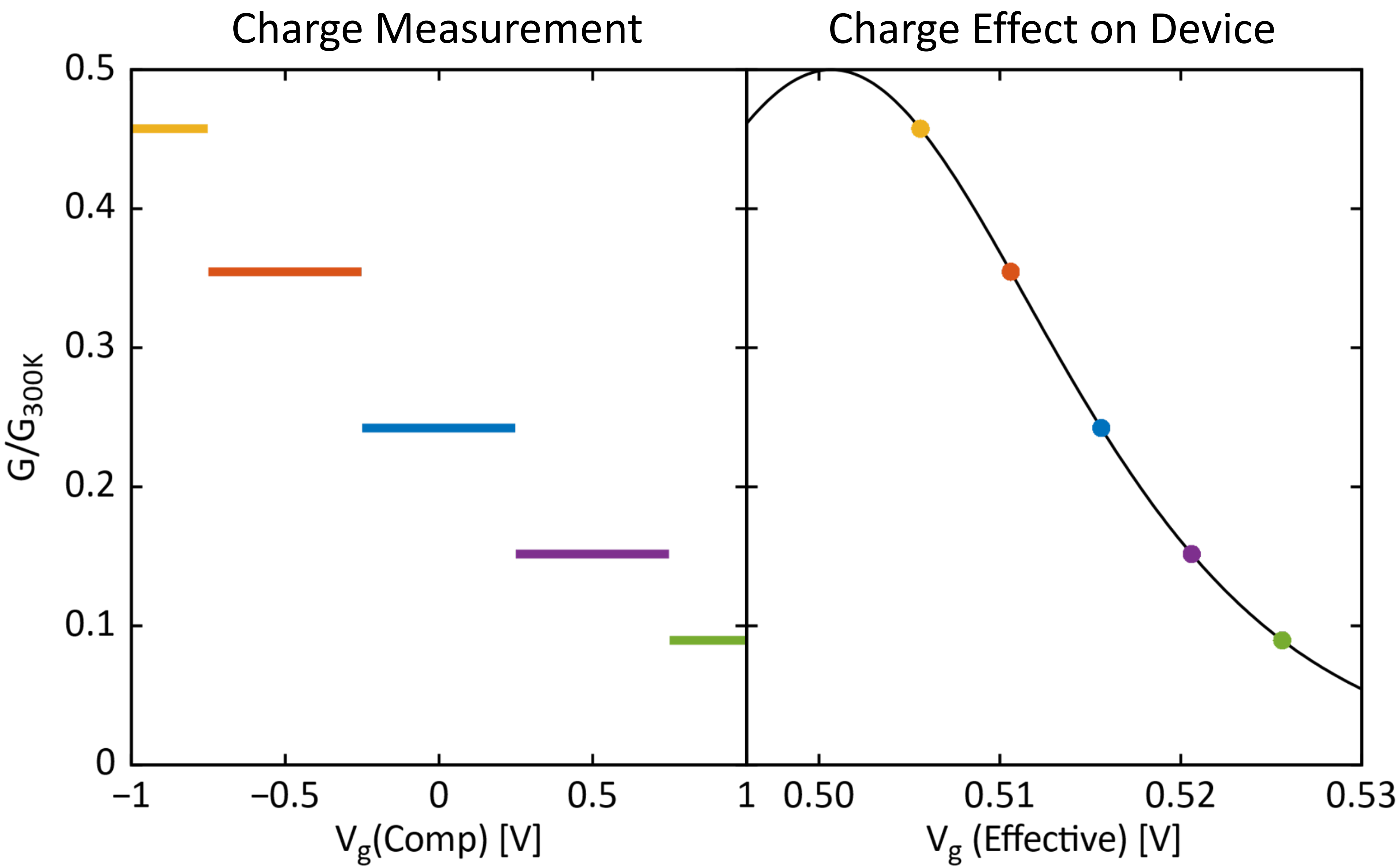
SET Charge Detector: 5 mV Signal



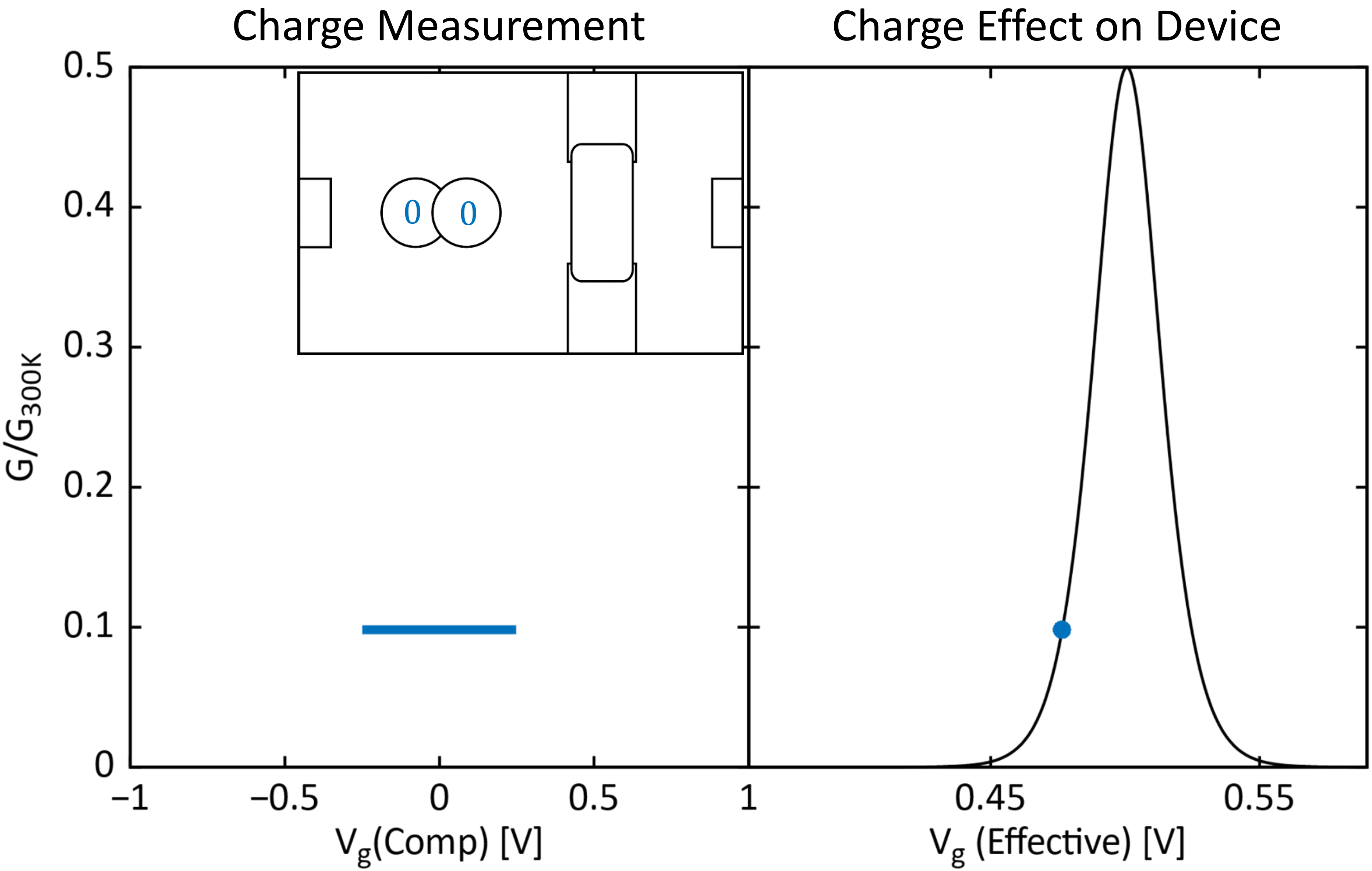
SET Charge Detector: 5 mV Signal



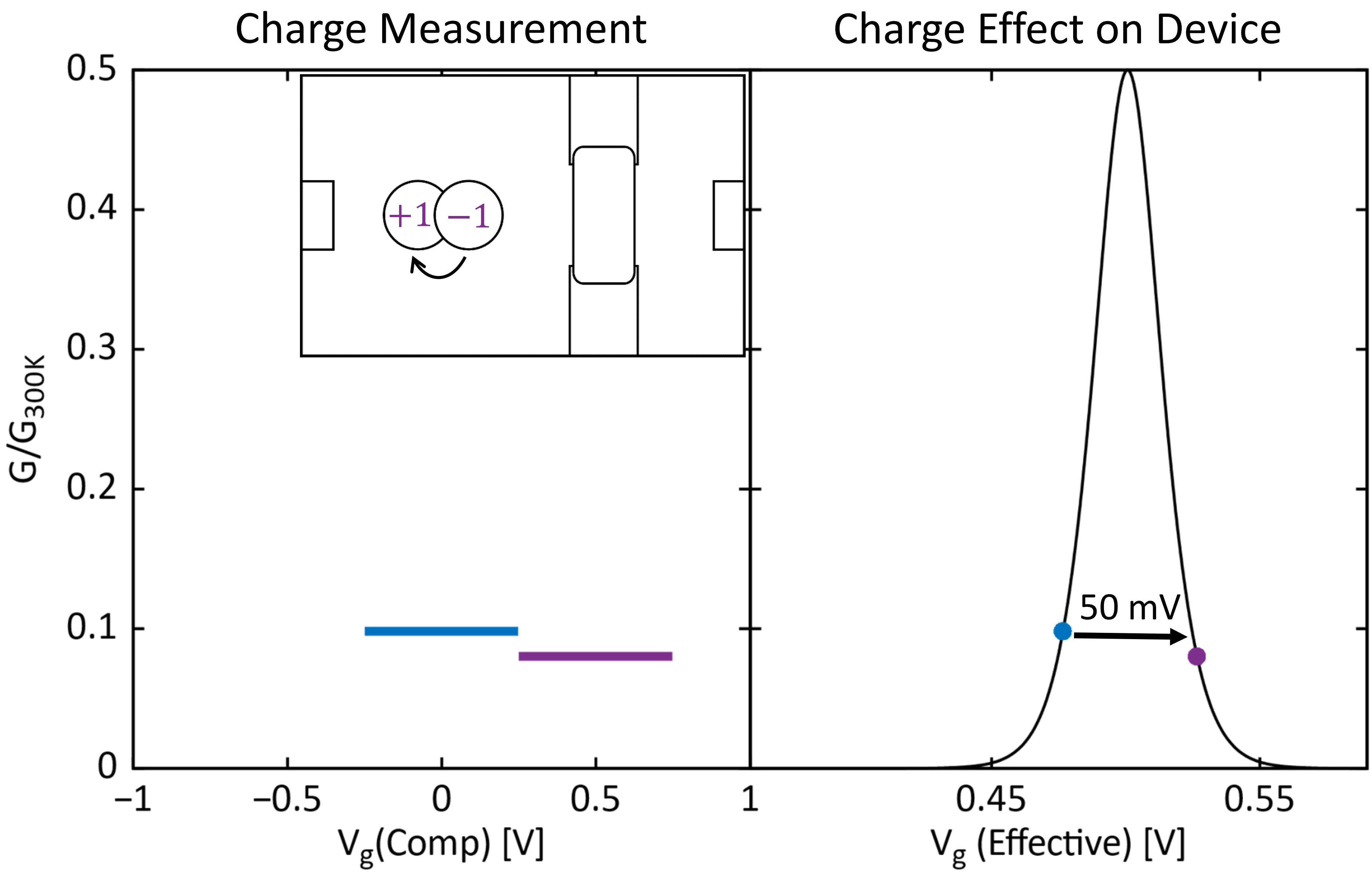
SET Charge Detector: 5 mV Signal



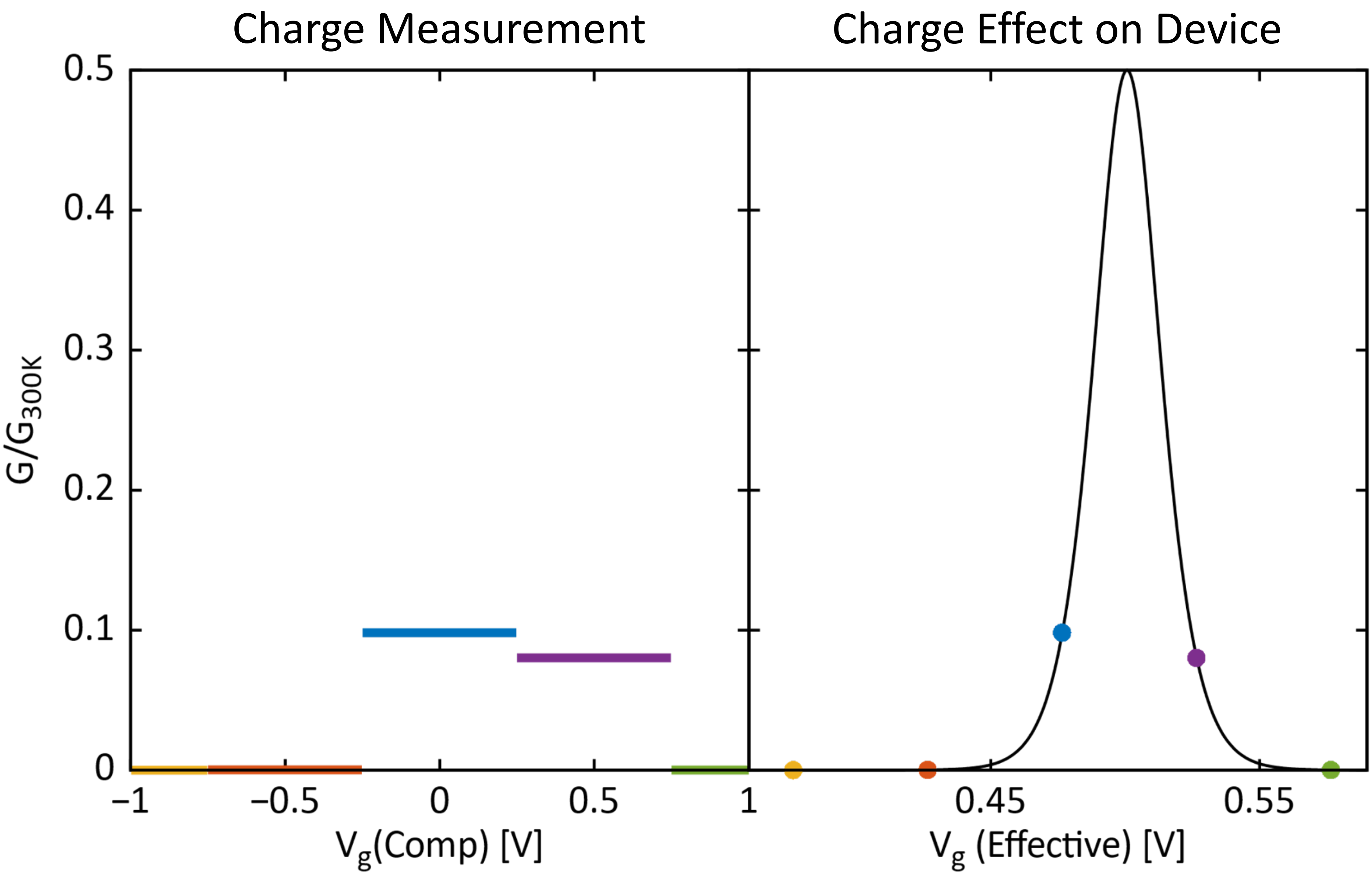
SET Charge Detector: 50 mV Signal



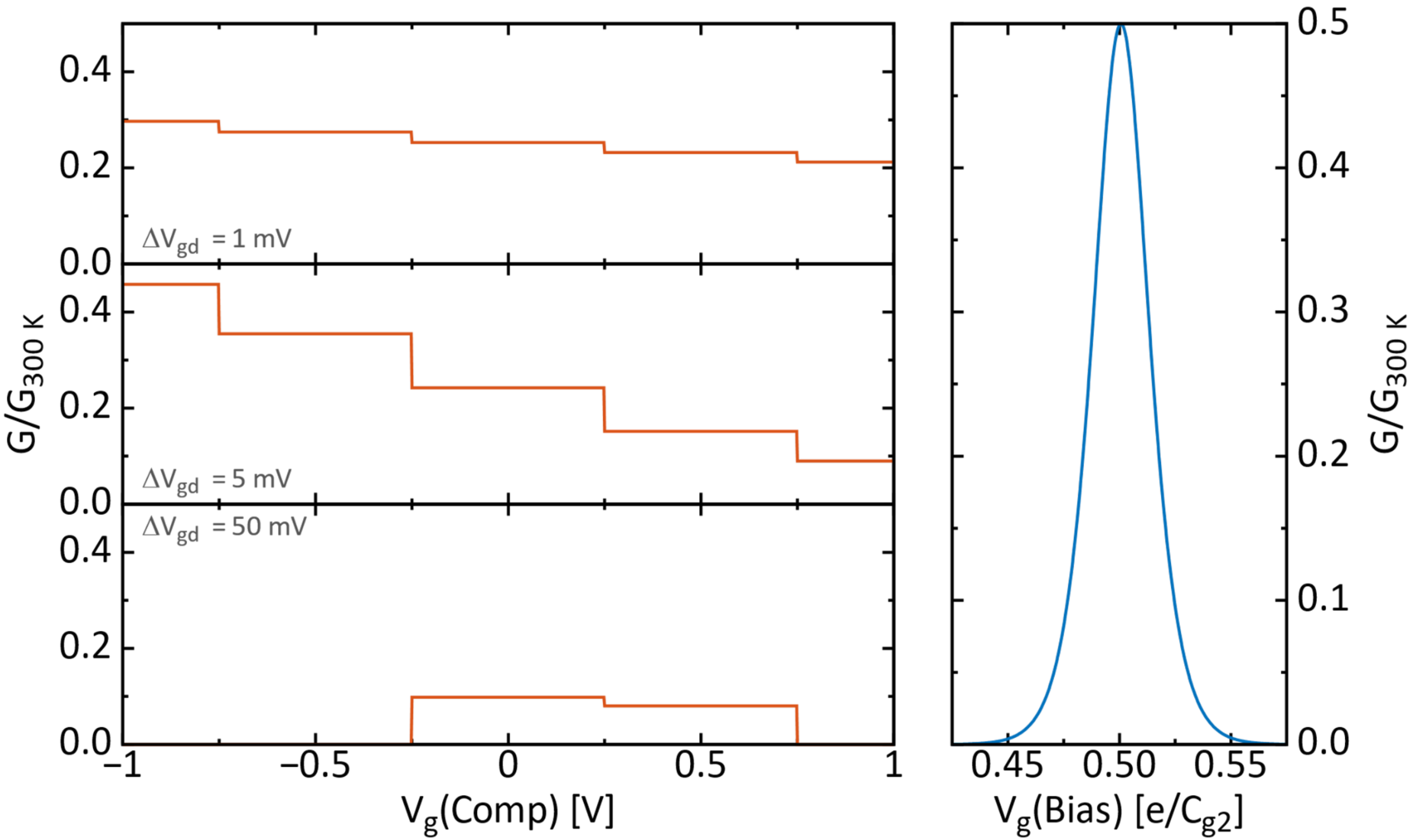
SET Charge Detector: 50 mV Signal



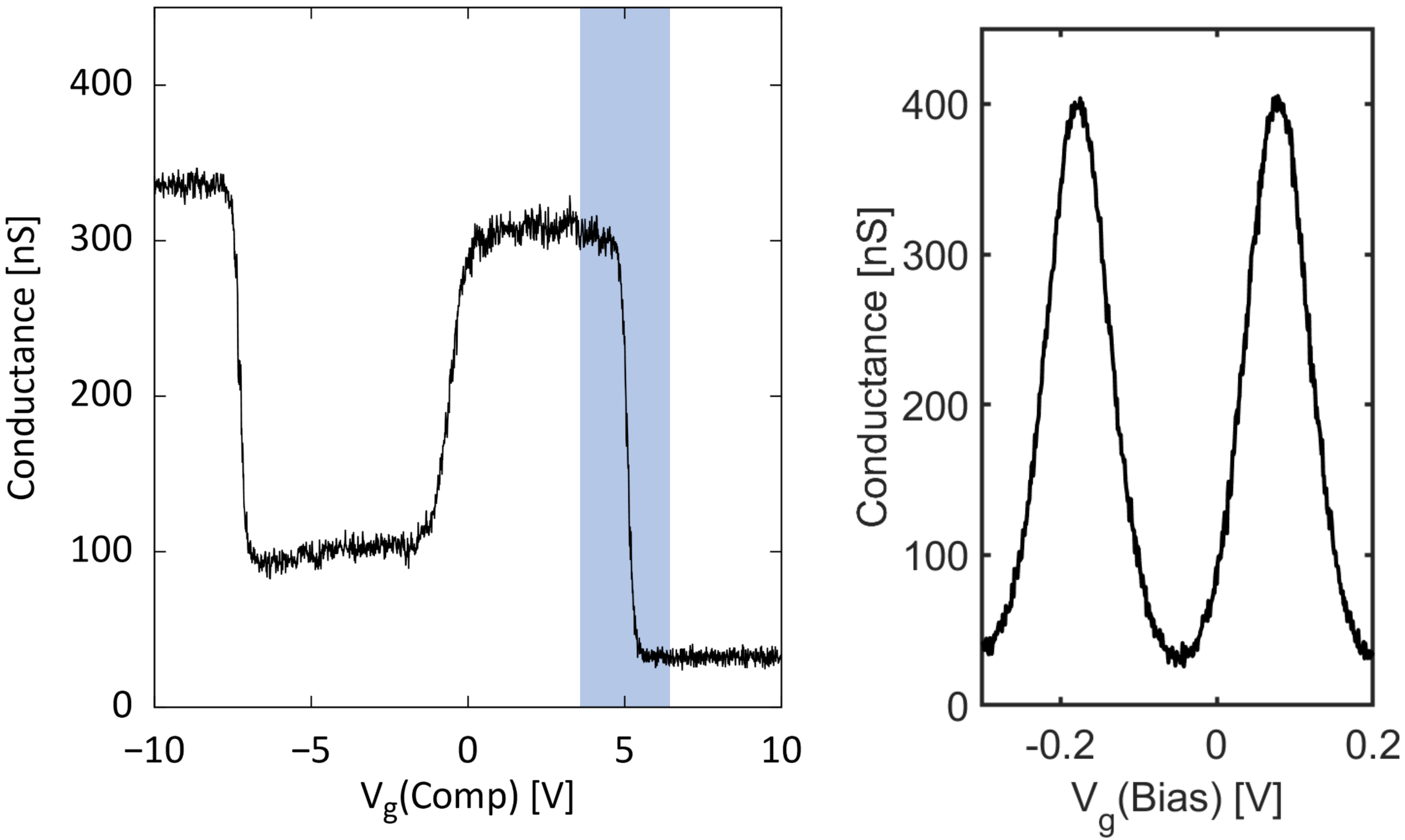
SET Charge Detector: 50 mV Signal



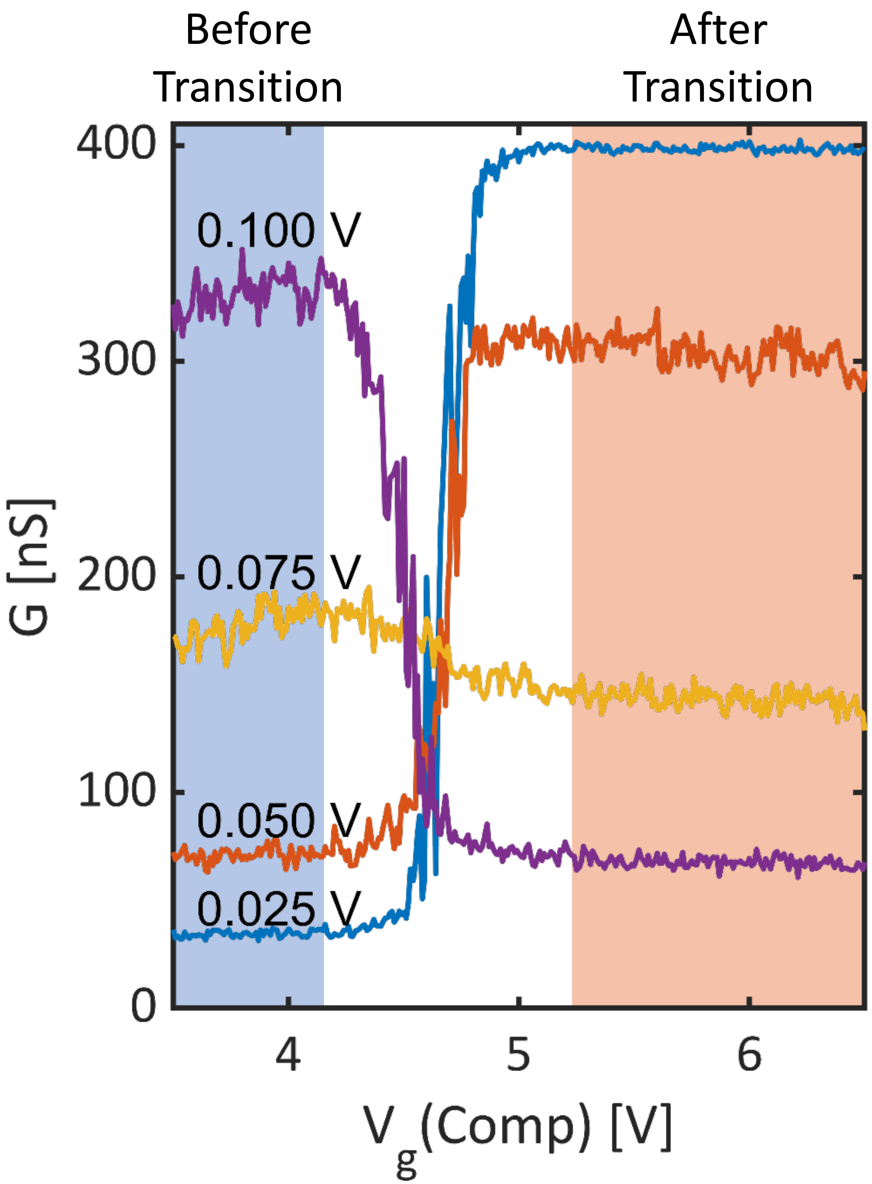
Compensated Measurement



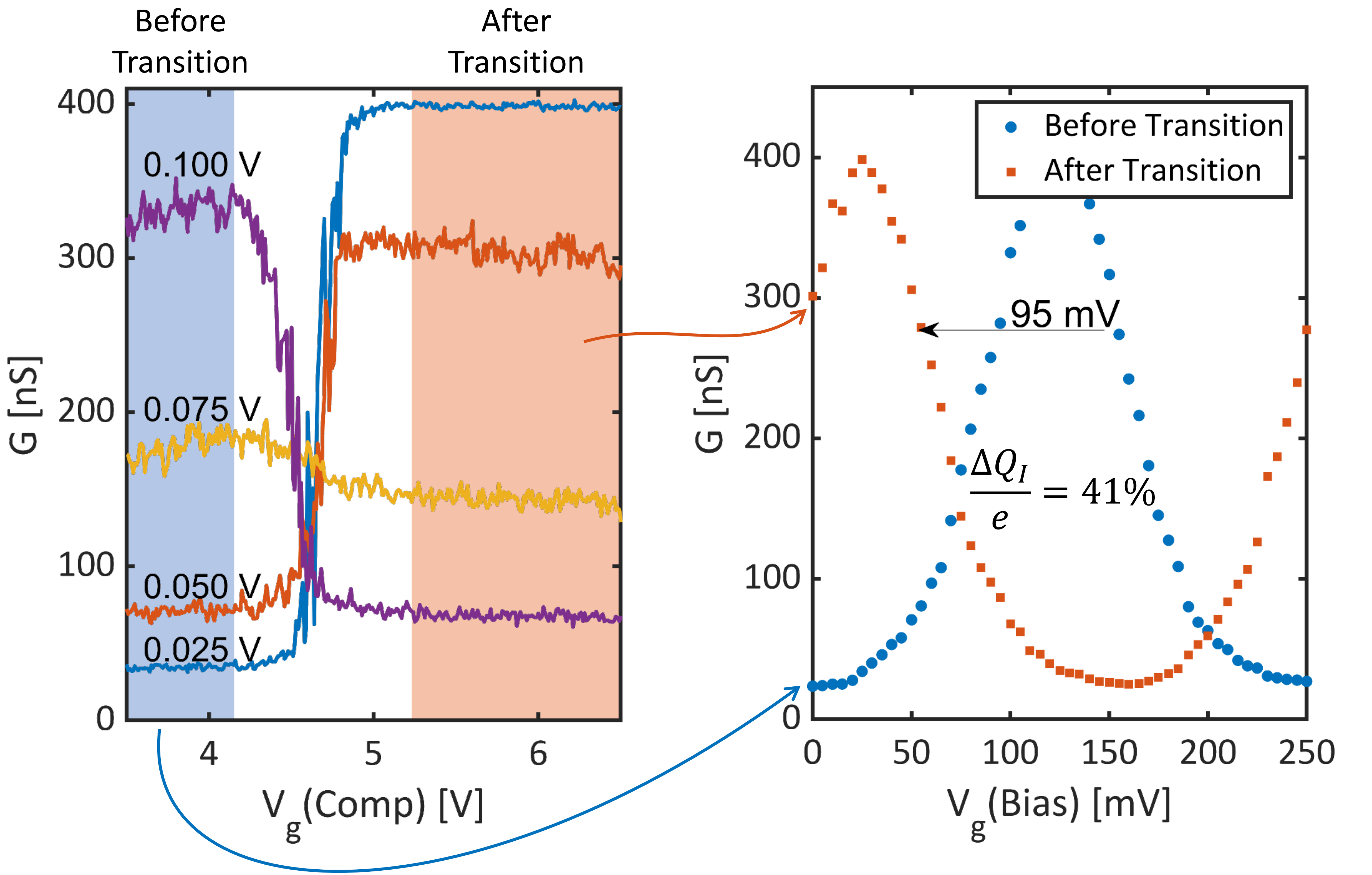
Measuring a Double Dot



Switching Analysis



Switching Analysis



References

[1] G. L. Snider, A. O. Orlov, I. Amlani, X. Zuo, G. H. Bernstein, C. S. Lent, J. L. Merz, and W. Porod, "Quantum-dot cellular automata: Review and recent experiments," Journal of Applied Physics, vol. 85, p. 4283, 1999.

[2] C. S. Lent, B. Isaksen, and M. Lieberman, "Molecular quantum-dot cellular automata," Journal of the American Chemical Society, vol. 125, pp. 1056-1063, JAN 29 2003.