Low temperature operation

Single electron charging energy

$E_C = e^2/C$, ($C=8e_re_oR$, disk)
$R = 10$ nm $\quad E_C = 30$ meV
$R = 100$ nm $\quad E_C = 3$ meV

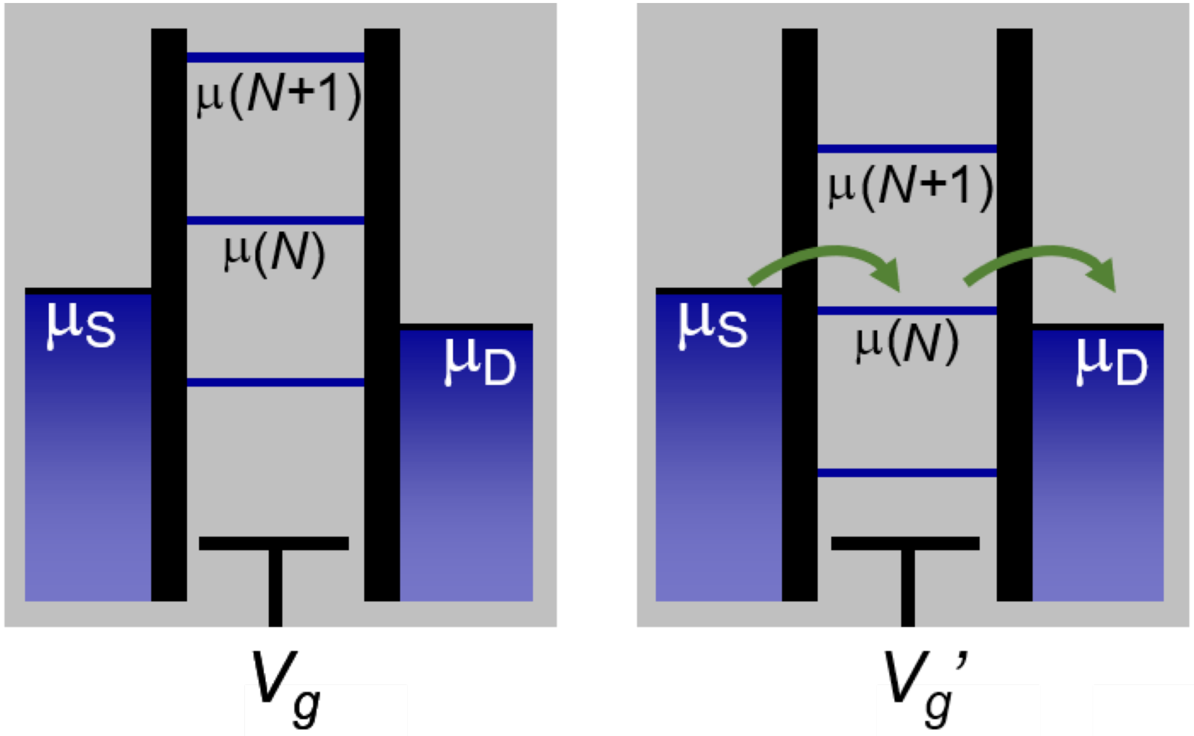
Thermal energy

$T = 300$ K $\quad k_BT \sim 26$ meV
$T = 4.2$ K $\quad k_BT \sim 0.35$ meV
$T = 30$ mK $\quad k_BT \sim 2.6$ ueV

Operation is at low temperatures

Dilution refrigerators reach temperatures below 10mk

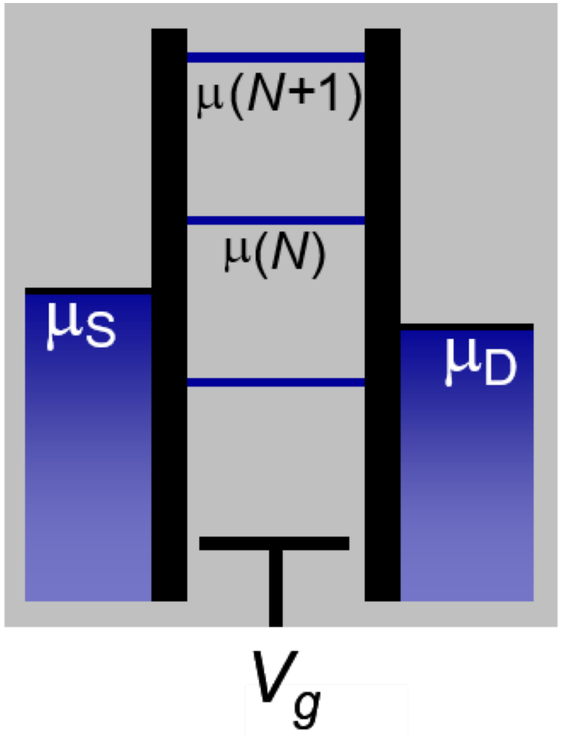
Quantum dots

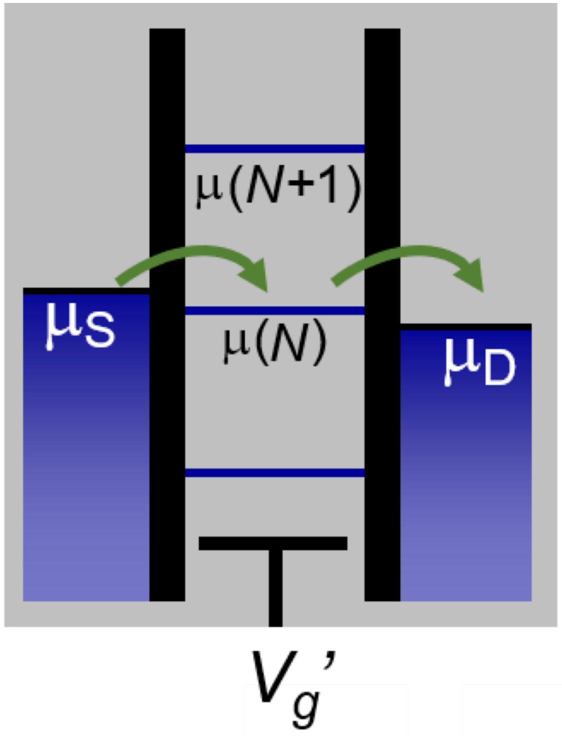


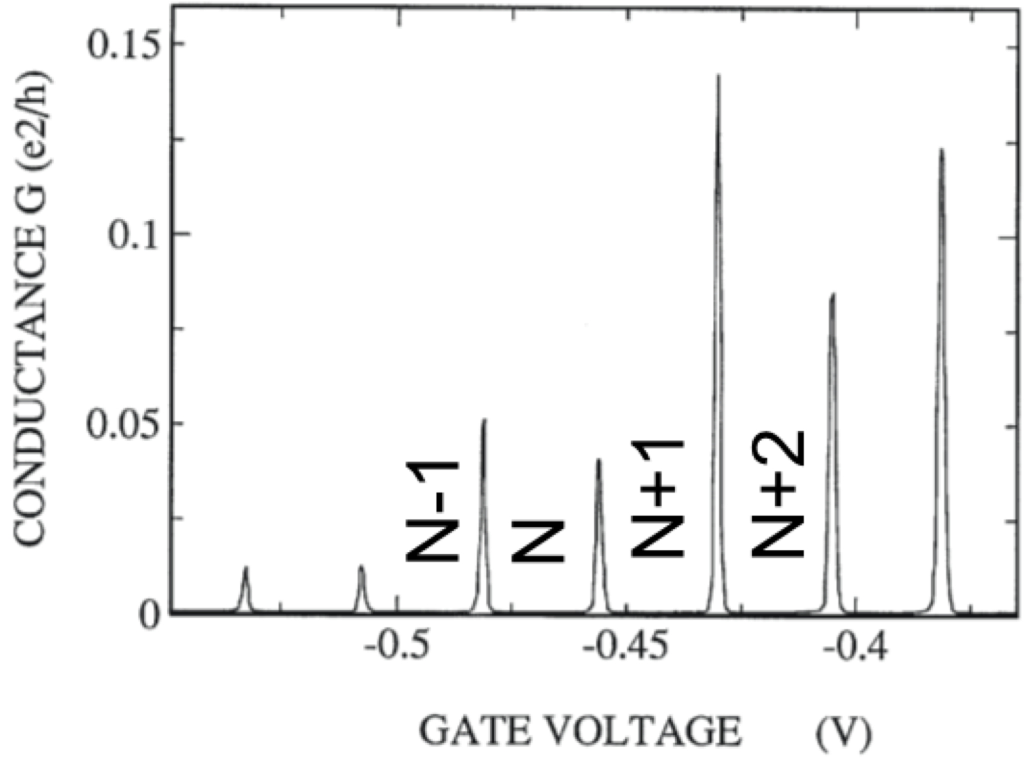
- Energy an electron needs to have in order to enter the dot.

$$m(n) = \mu(N) - \mu(N-1)$$

Quantum dots

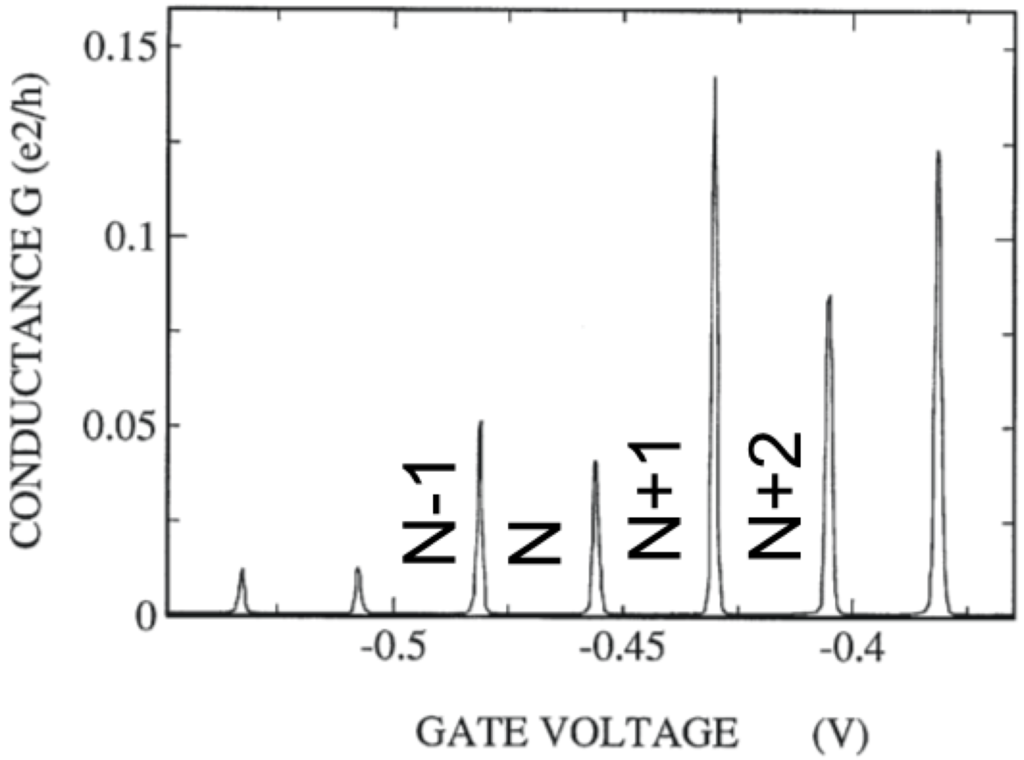




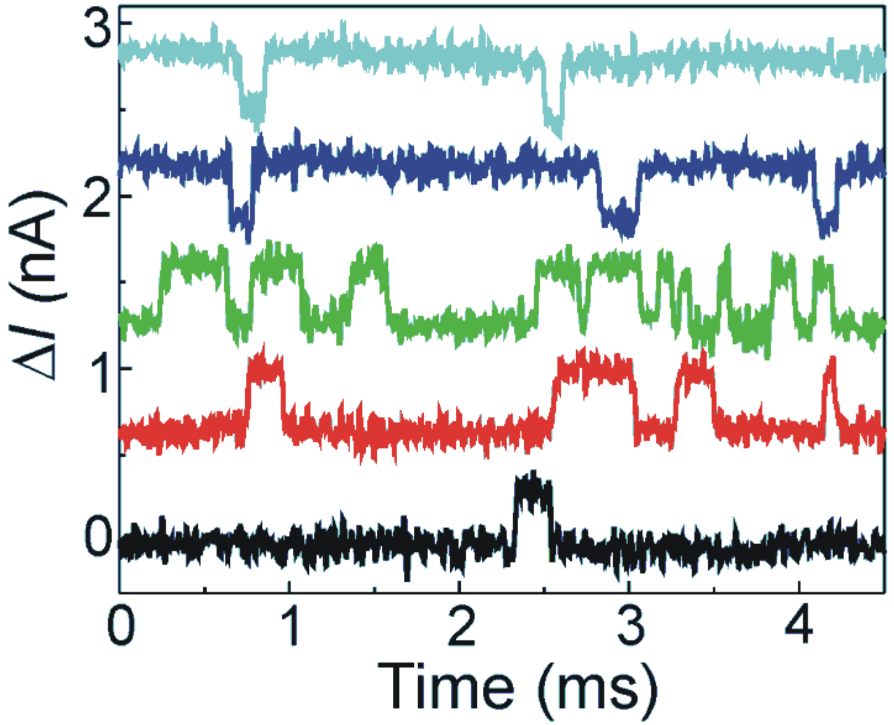


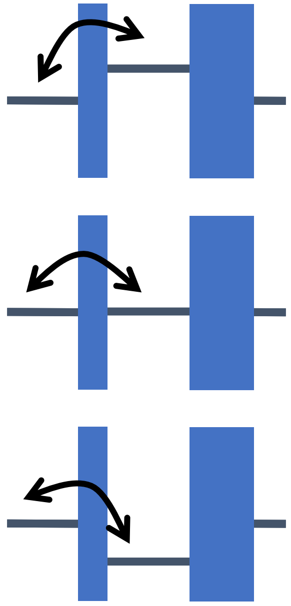
Charge sensing

- A quantum dot can also be a very sensitive electrometer.

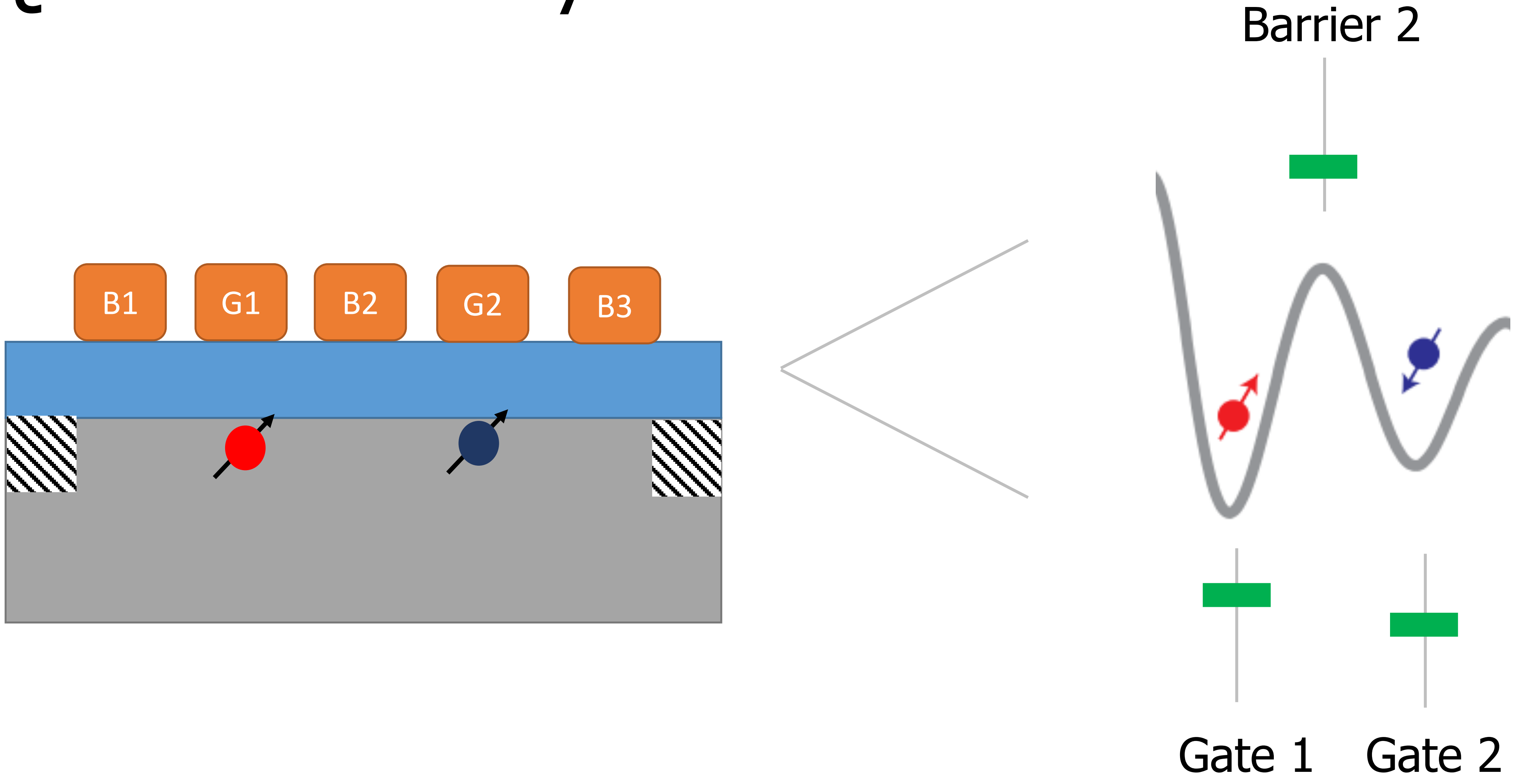


- See single electrons jump on/off in real time.

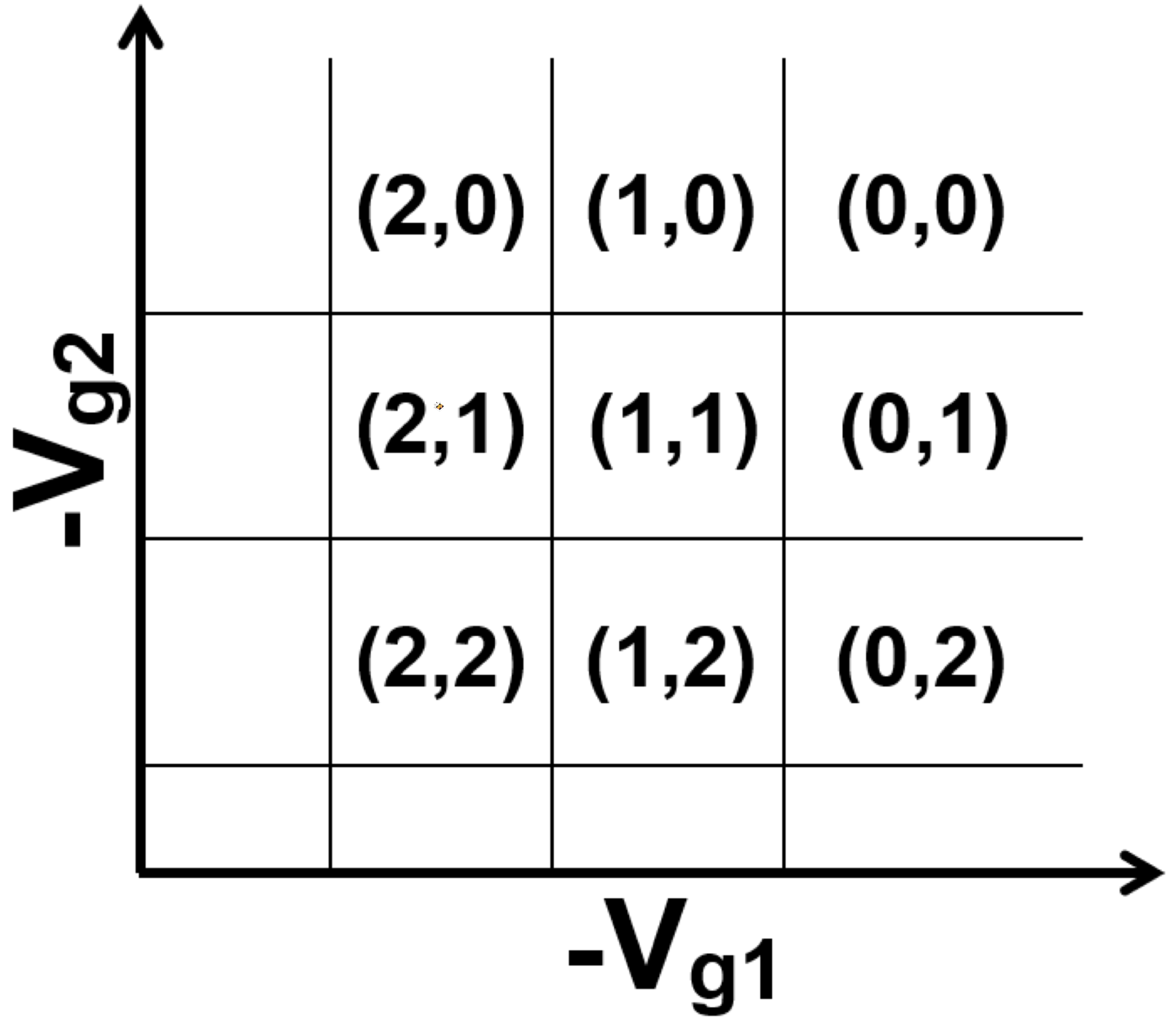


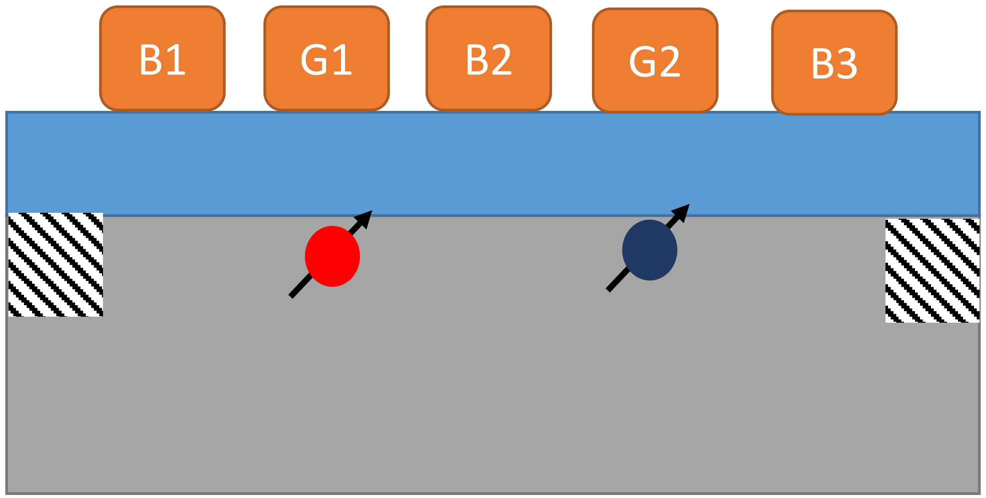


Quantum dot system

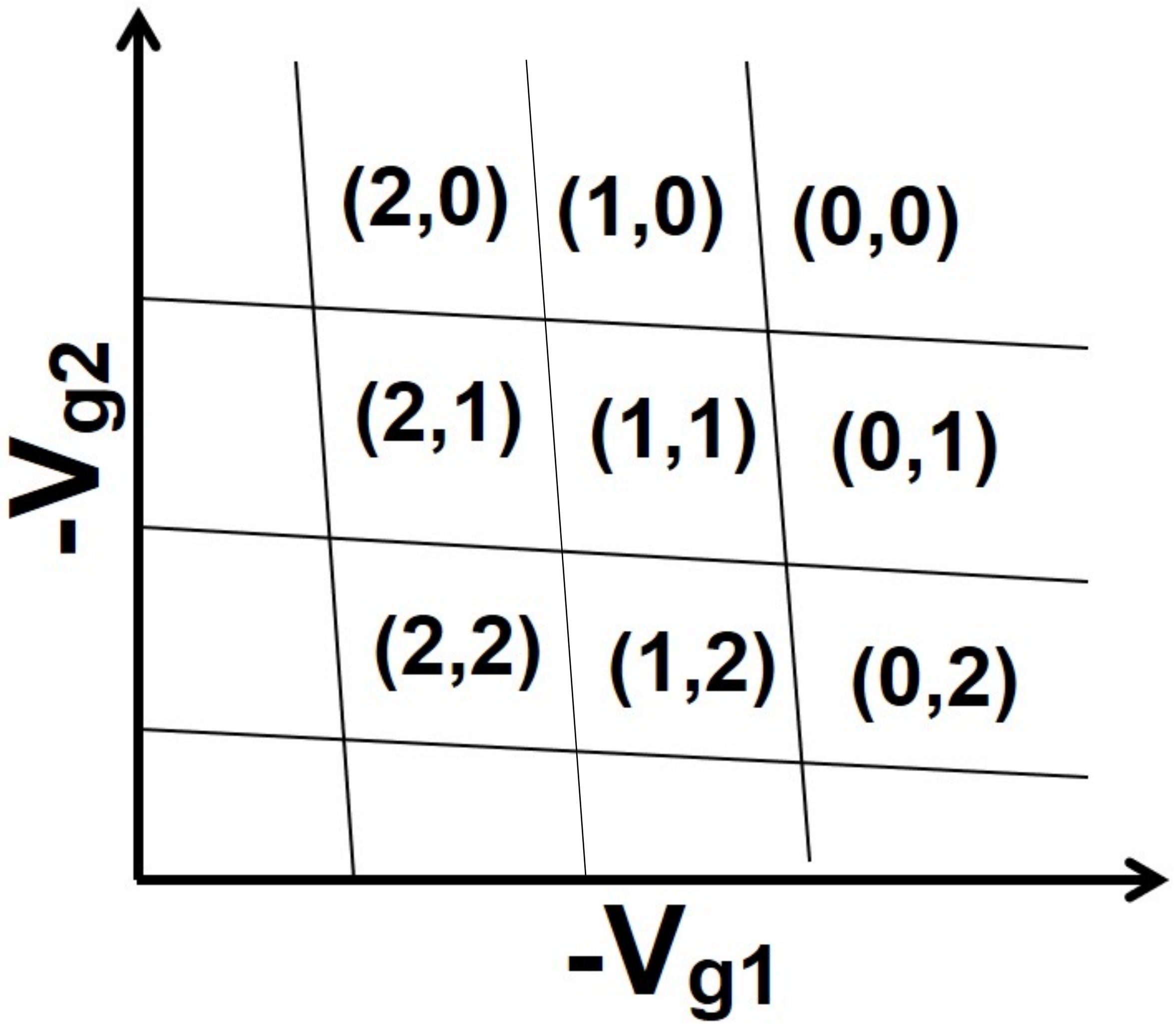


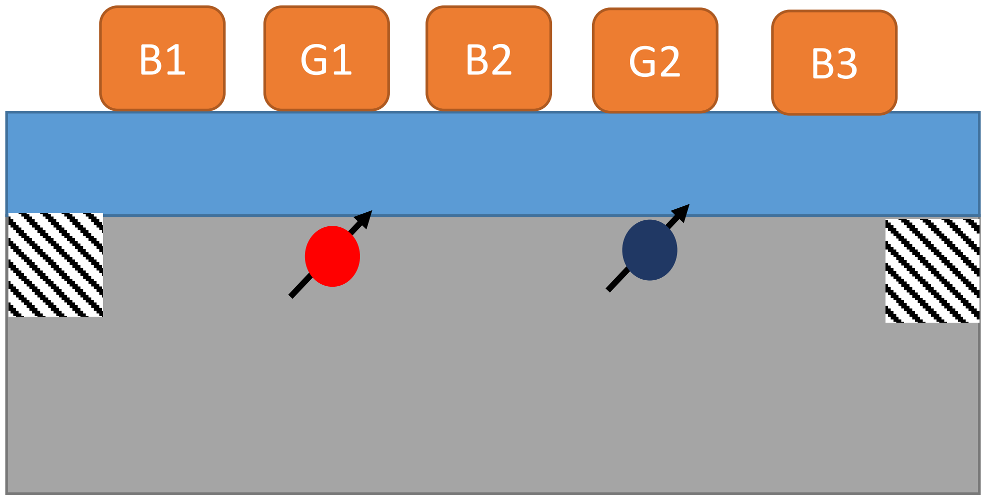
Two coupled quantum dots





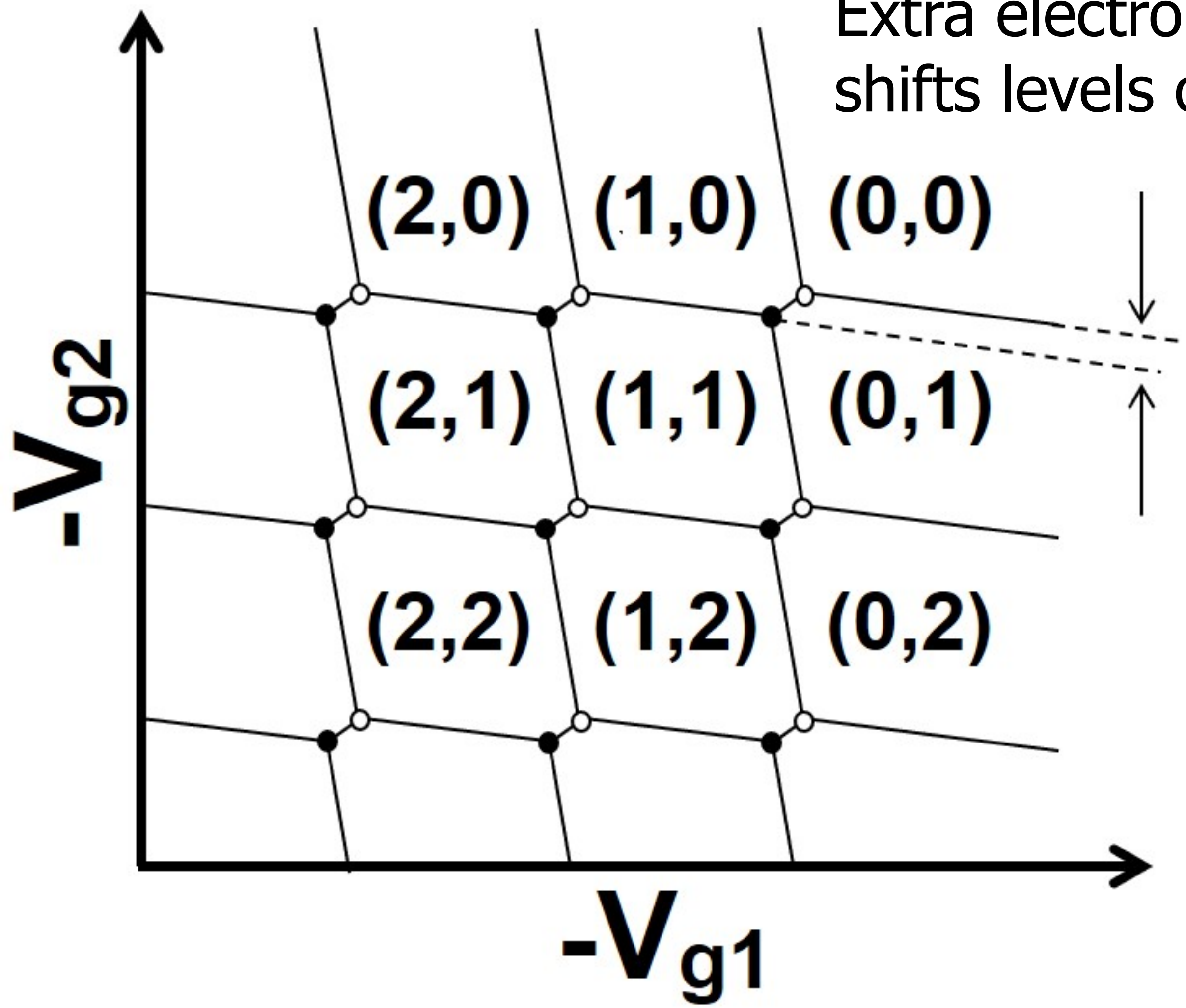
Two coupled quantum dots

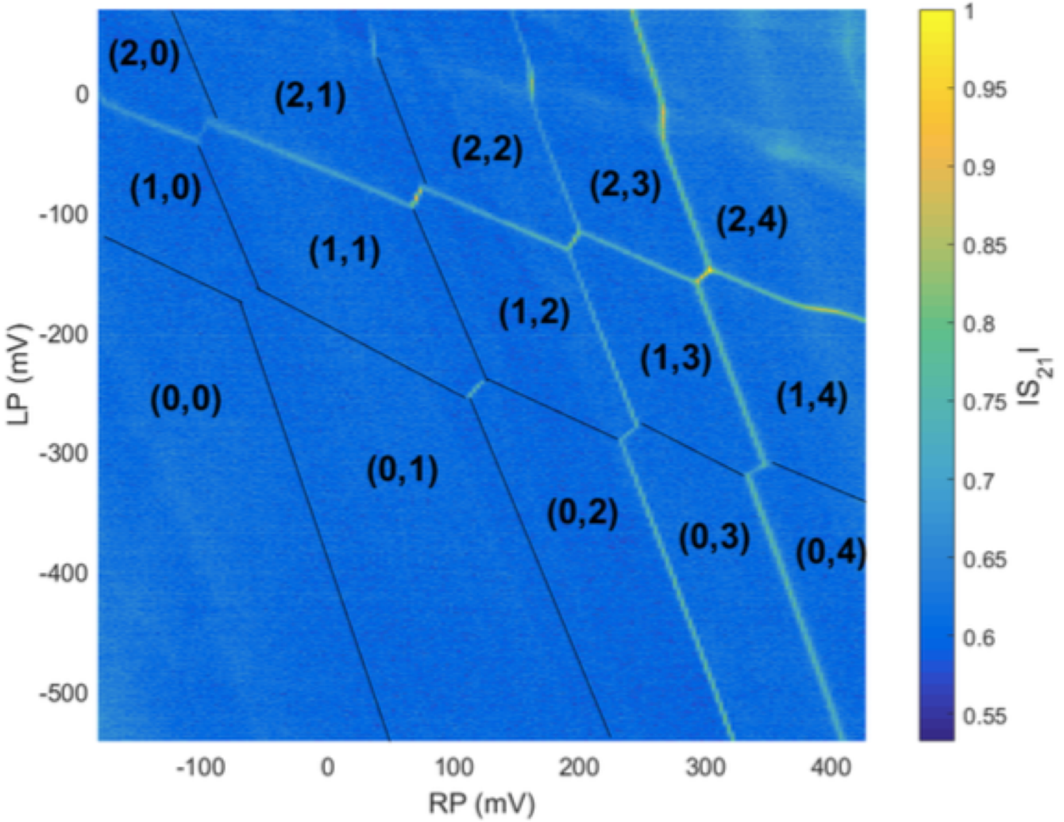




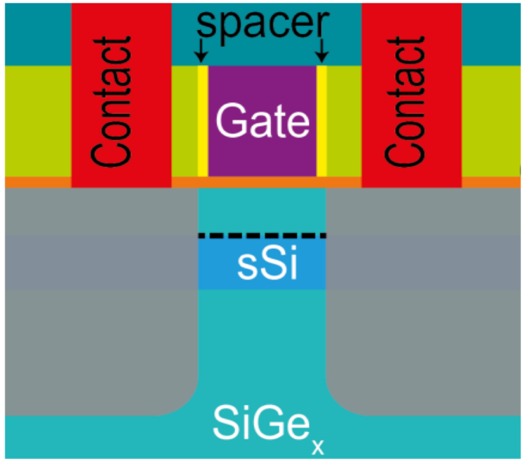
Two coupled quantum dots

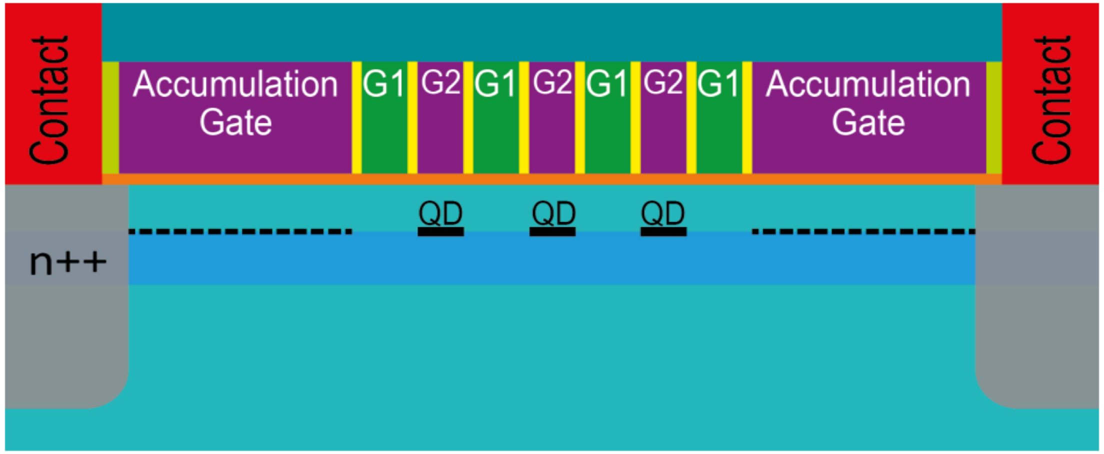
Extra electron in one dot shifts levels of other dot



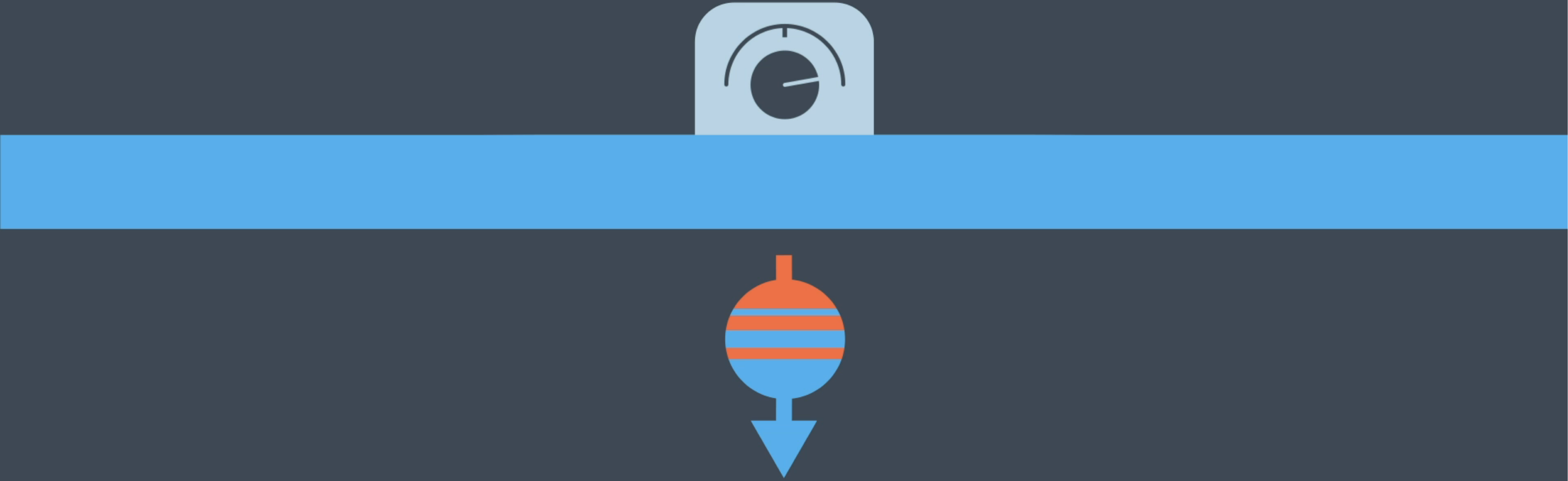


From transistors to many quantum dots





Industrial involvement



A quantum integrated circuit