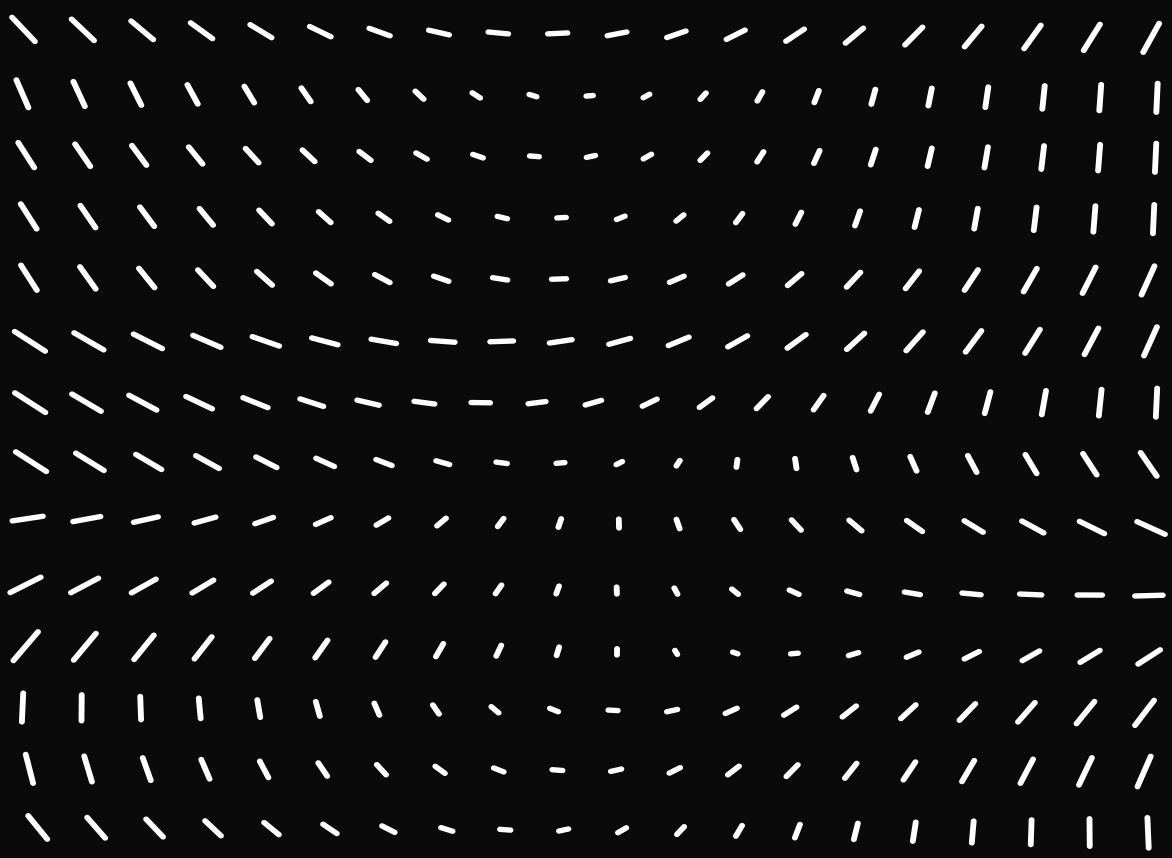
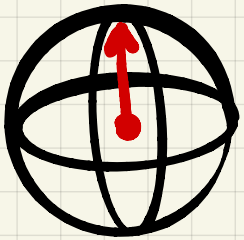
MARCH 26th, 2020

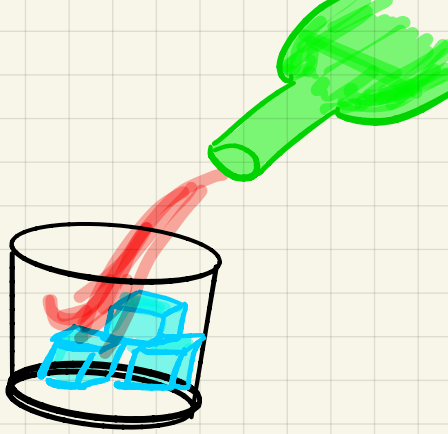
VIRTUAL - SPIN MEETING

MJC, HANSON et al.



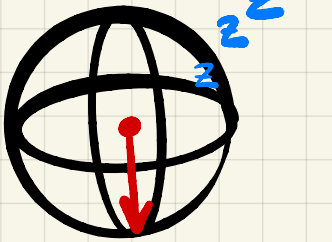
DiVincenzo Criteria

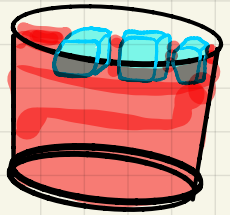
1 Initialize 

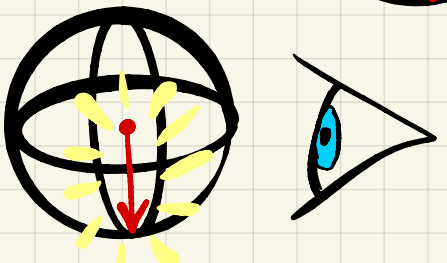
Prepare 

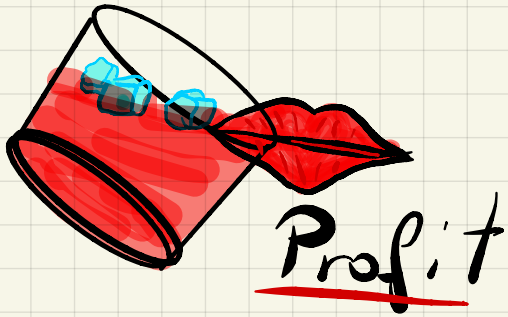
2 1 & 2 Qubit Operations 

Mix 

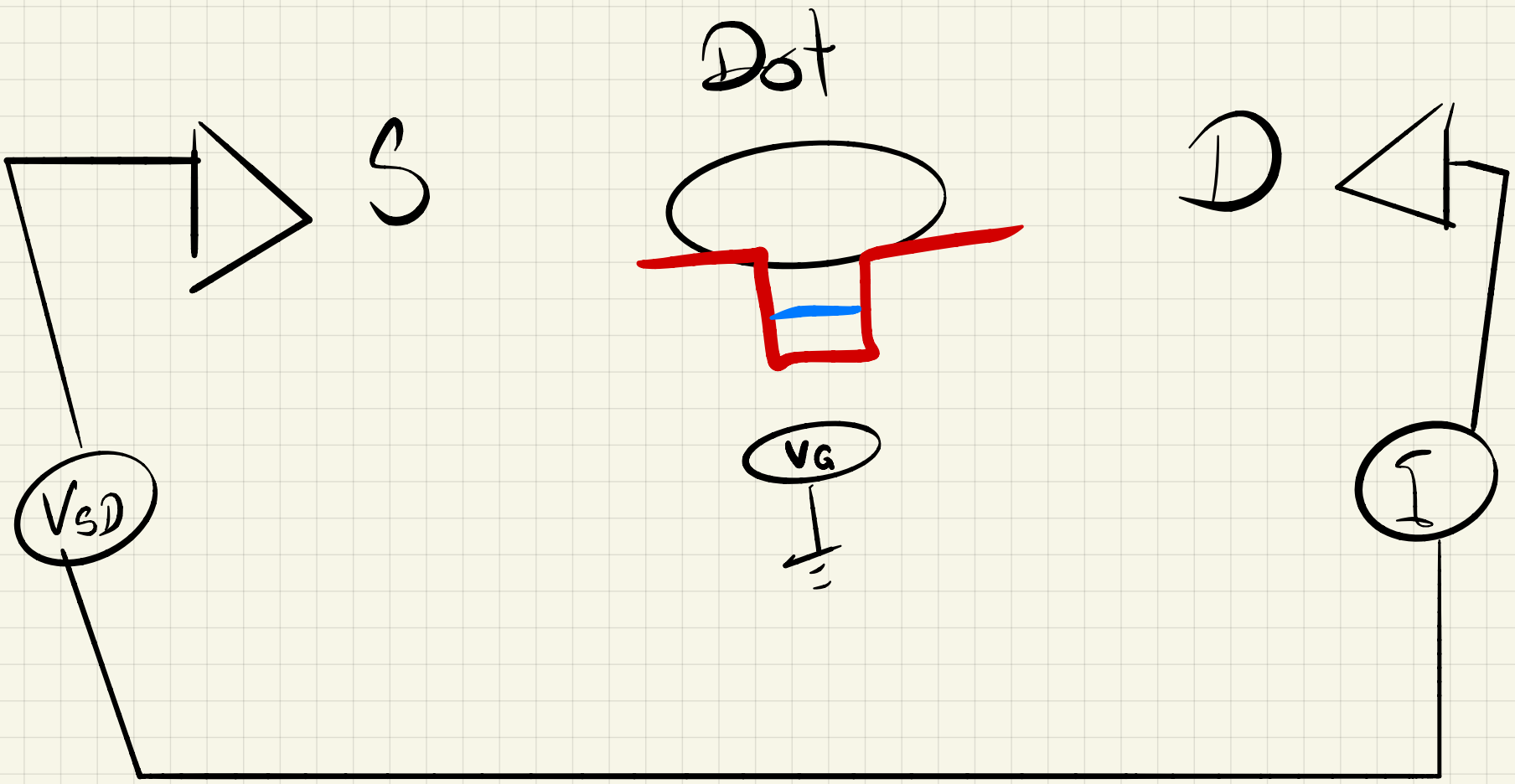
3 Long Coherence Times 

Chill 

4 Readout 

Profit 

Charges in Dots



Describe Levels in C.I. Model

- Describe Coulomb Interaction by single C

$$C = C_S + C_D + C_G = \text{const.}$$

- Single particle energy-level spectrum is indep of # of e^-. $U(N) = U(N, C_i, V_i) + \sum_n E_n(B)$

$$\mu(N) = U(N) - U(N-1)$$

E_N (P.I.B)

Dependence of $U(N), \mu(N)$ on V_G is the same $\forall N$

→ LADDER convenient

$$E_{addl}(N) = \mu_e(N+1) - \mu(N) = E_C + \Delta E$$

E_C: charging (el. static)

ΔE: price of level (sometimes free ~~#~~)

Coulomb Blockade

- Transport only possible, when level within bias window

Low bias regime: (SET)

Broadening:
- Bias?
- Thermal?

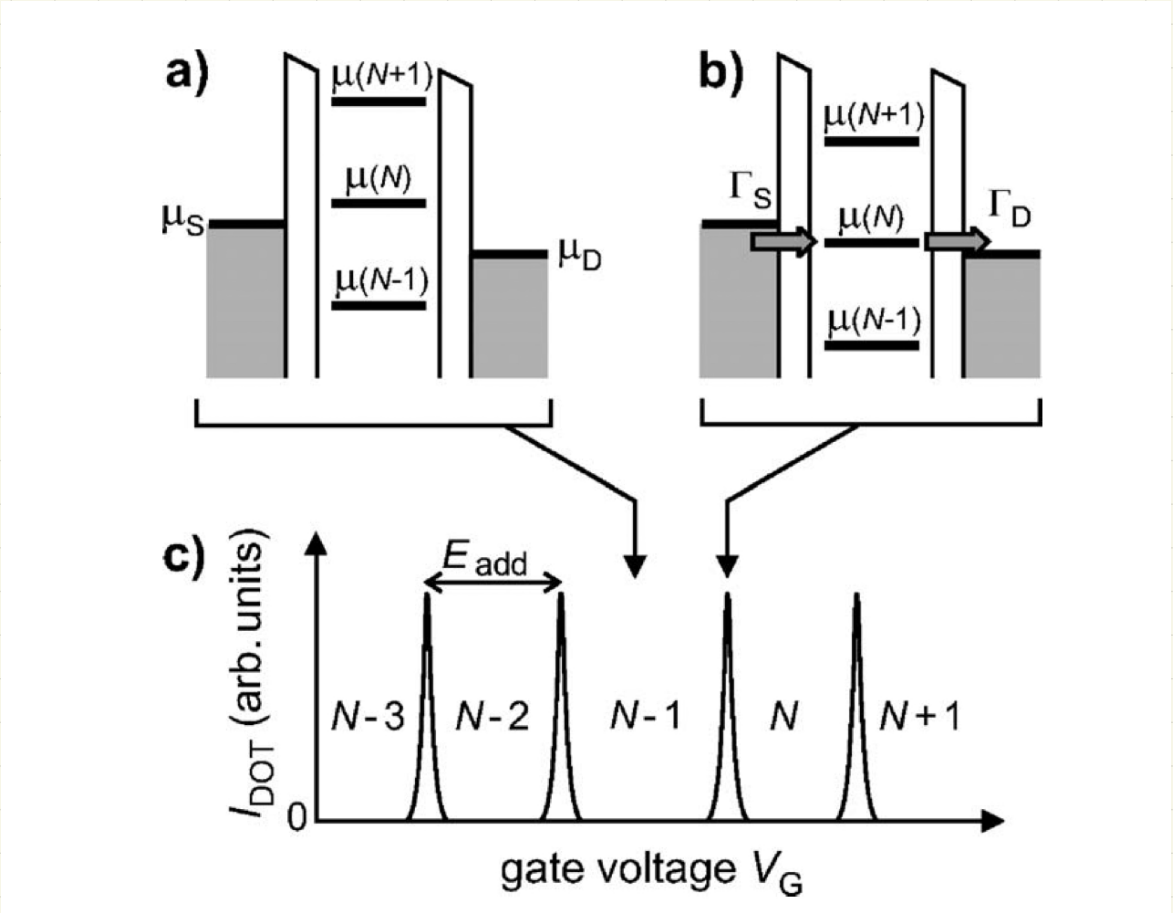


Fig 3

High Bias

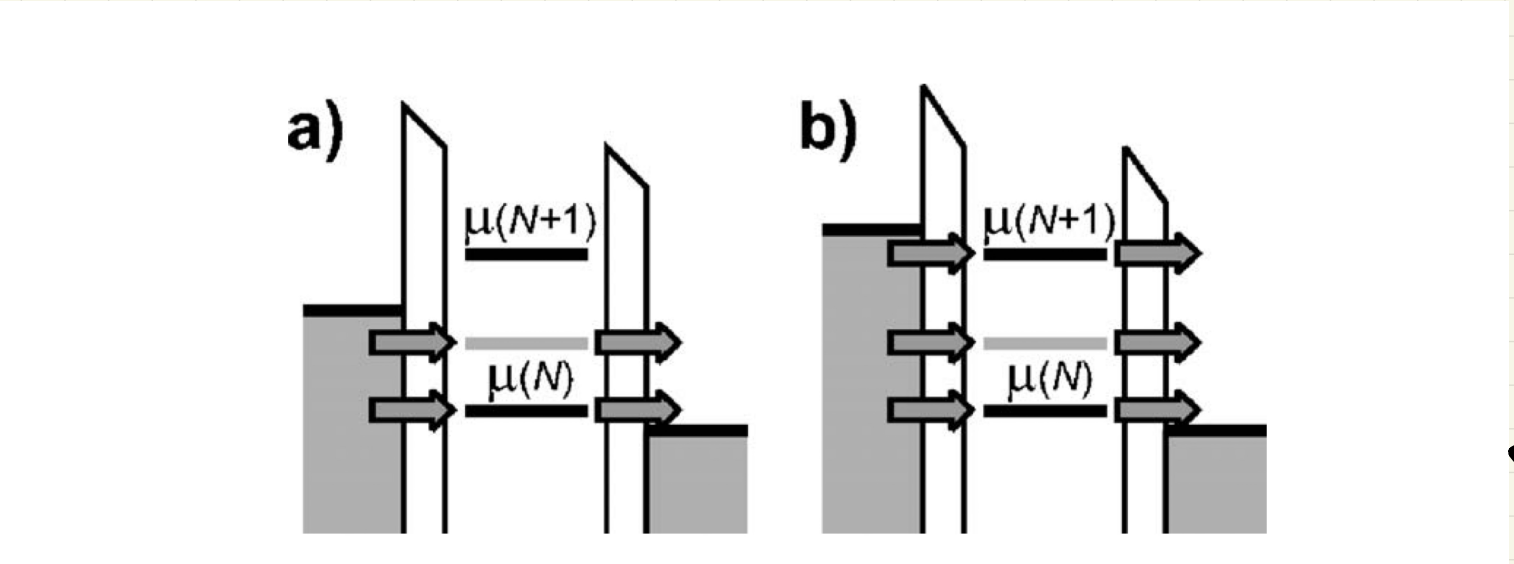


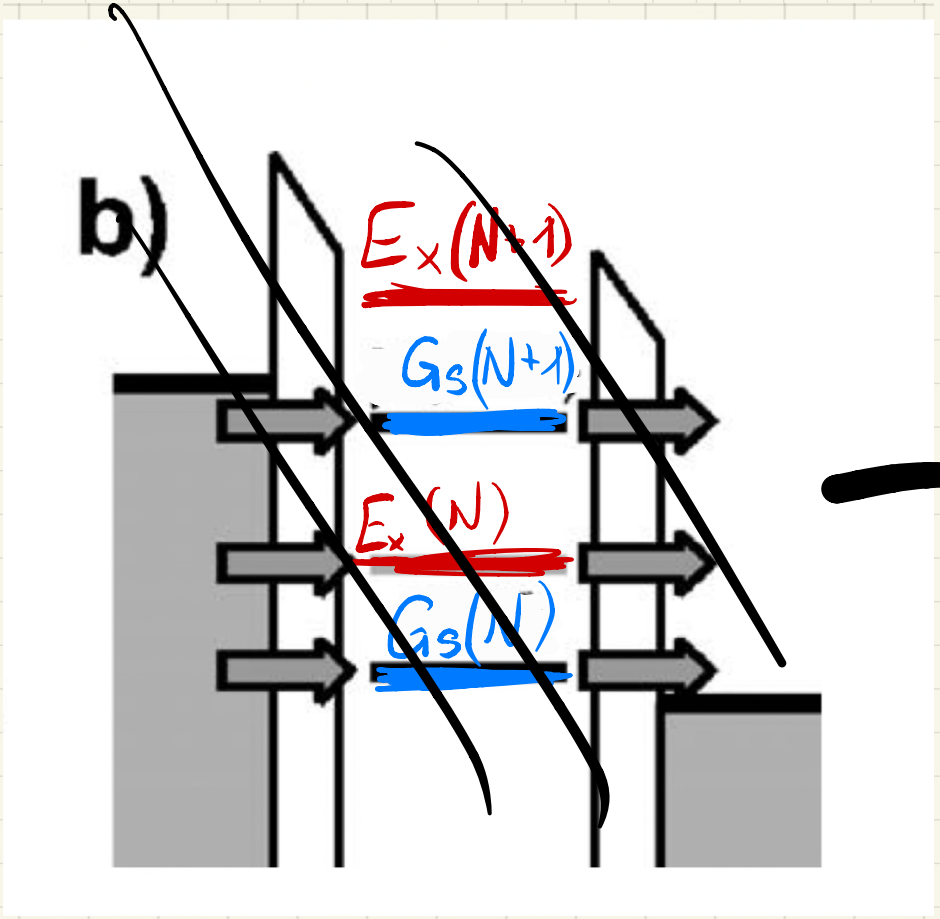
Fig 4

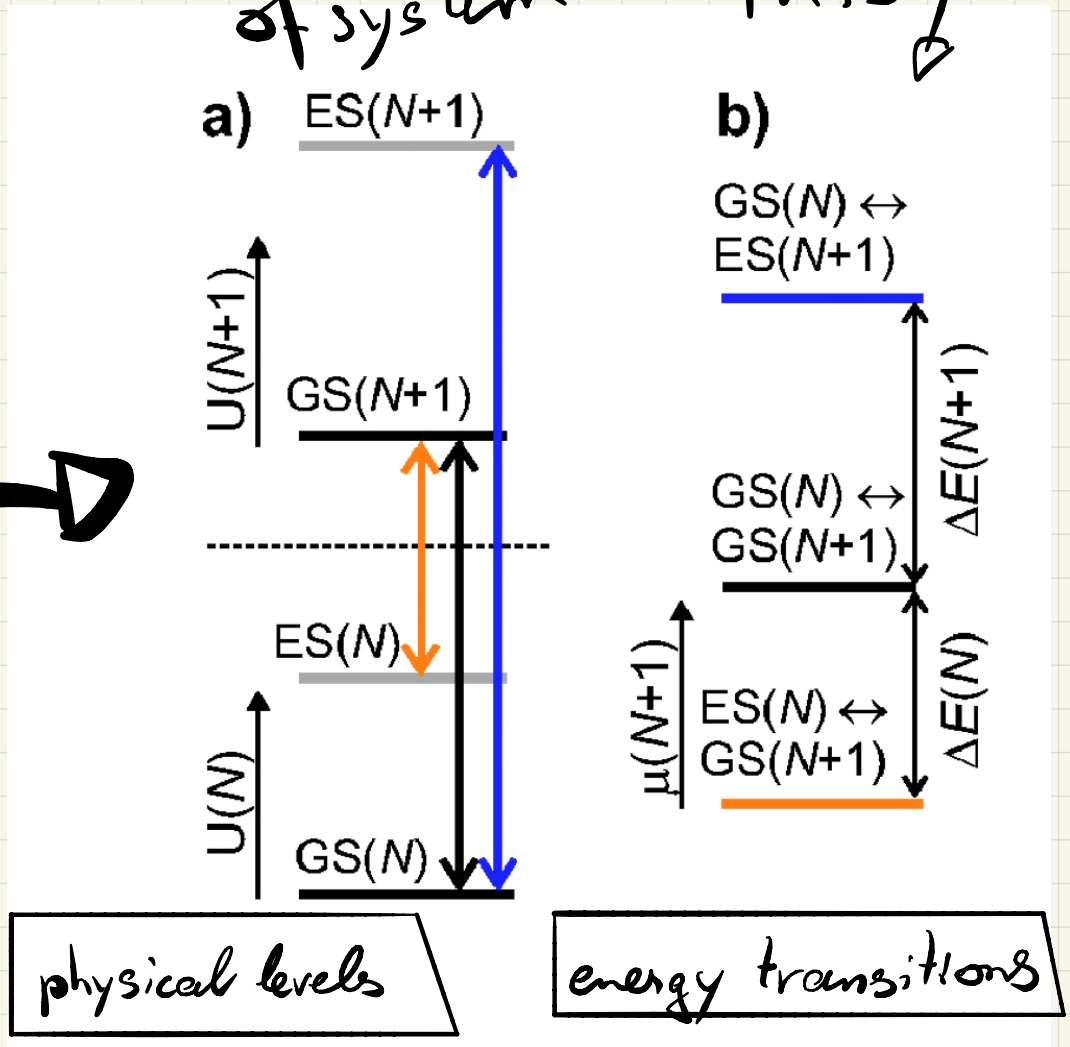
- can involve transport of excited states
- further bias, V_{SD} exceeds E_{add} → double e^- tunnelling

Level Transitions

total E of system

we probe this!



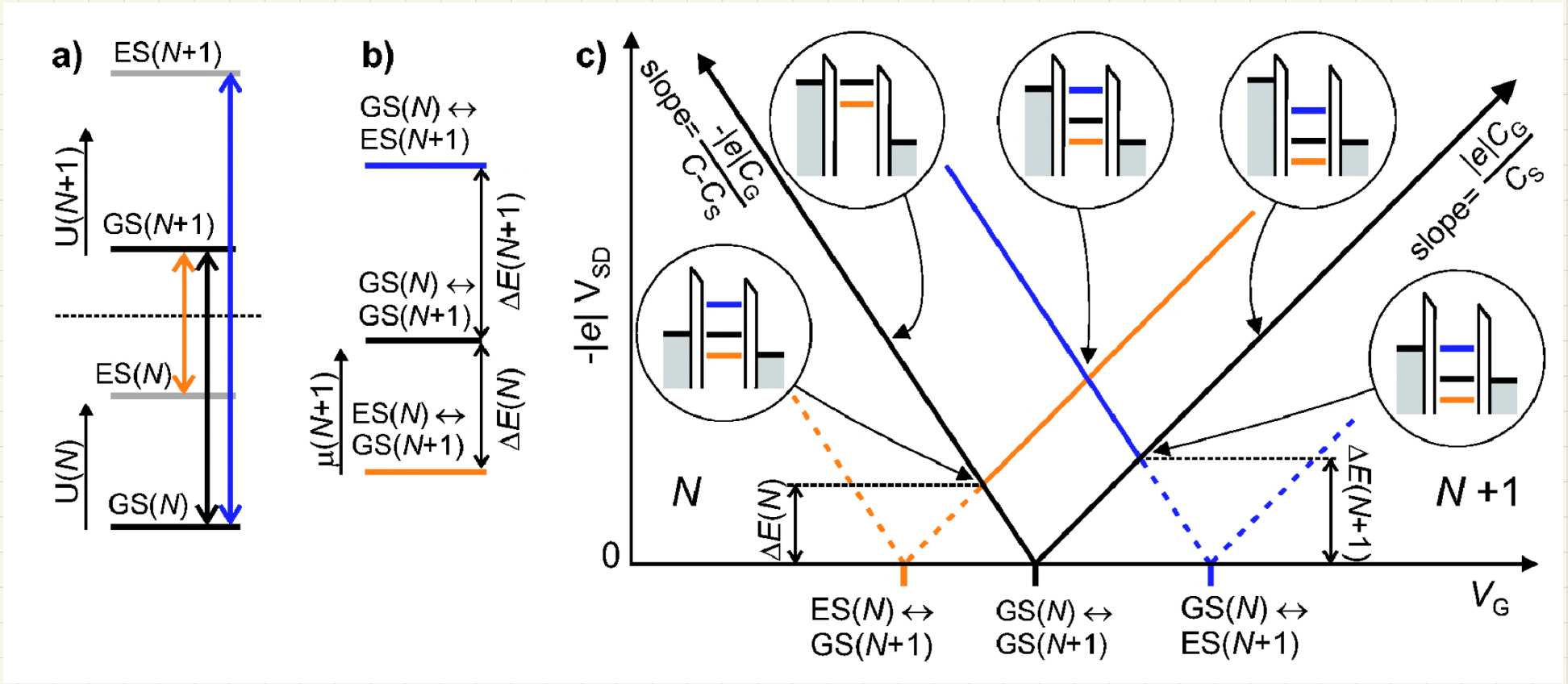


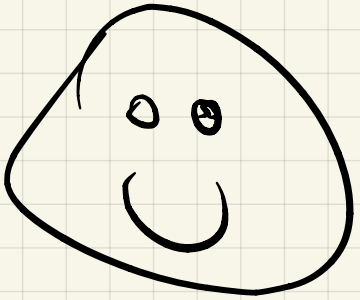
physical levels

energy transitions

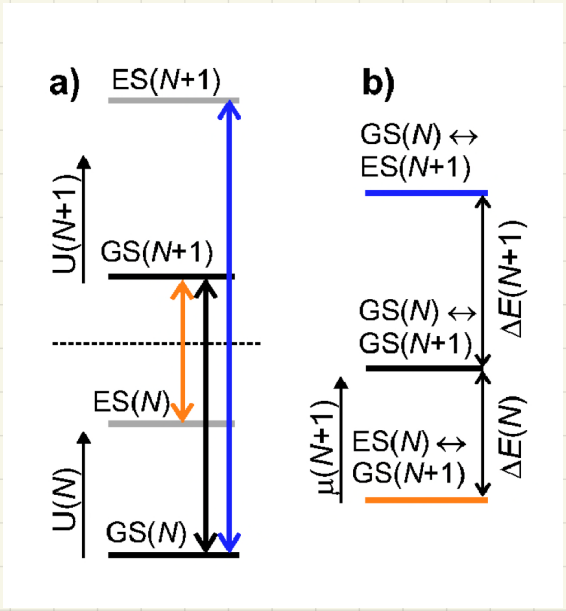
Fig. 5

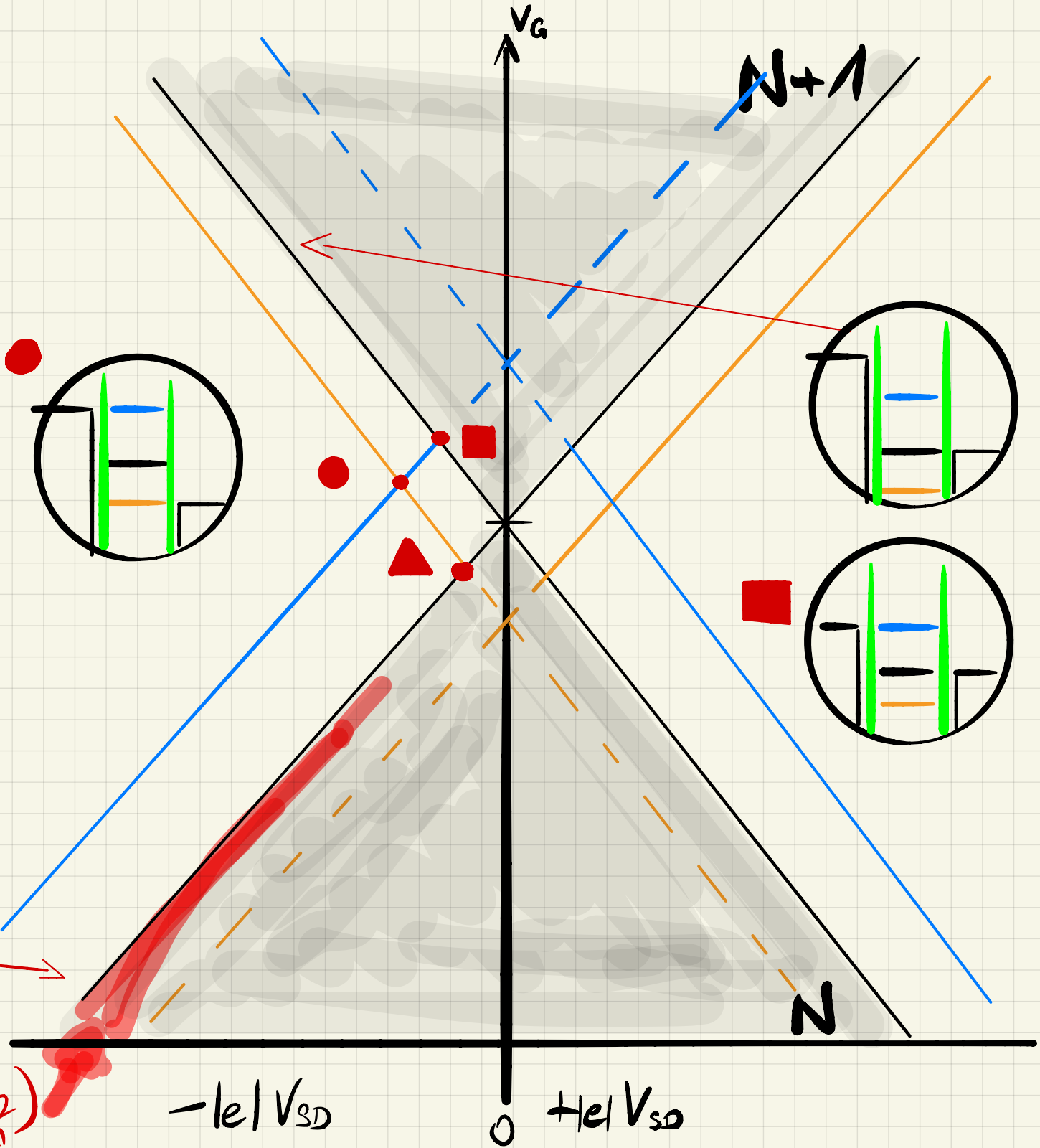
apply π/2 pulse





not how I can used to see it...





! (co tunnelling)

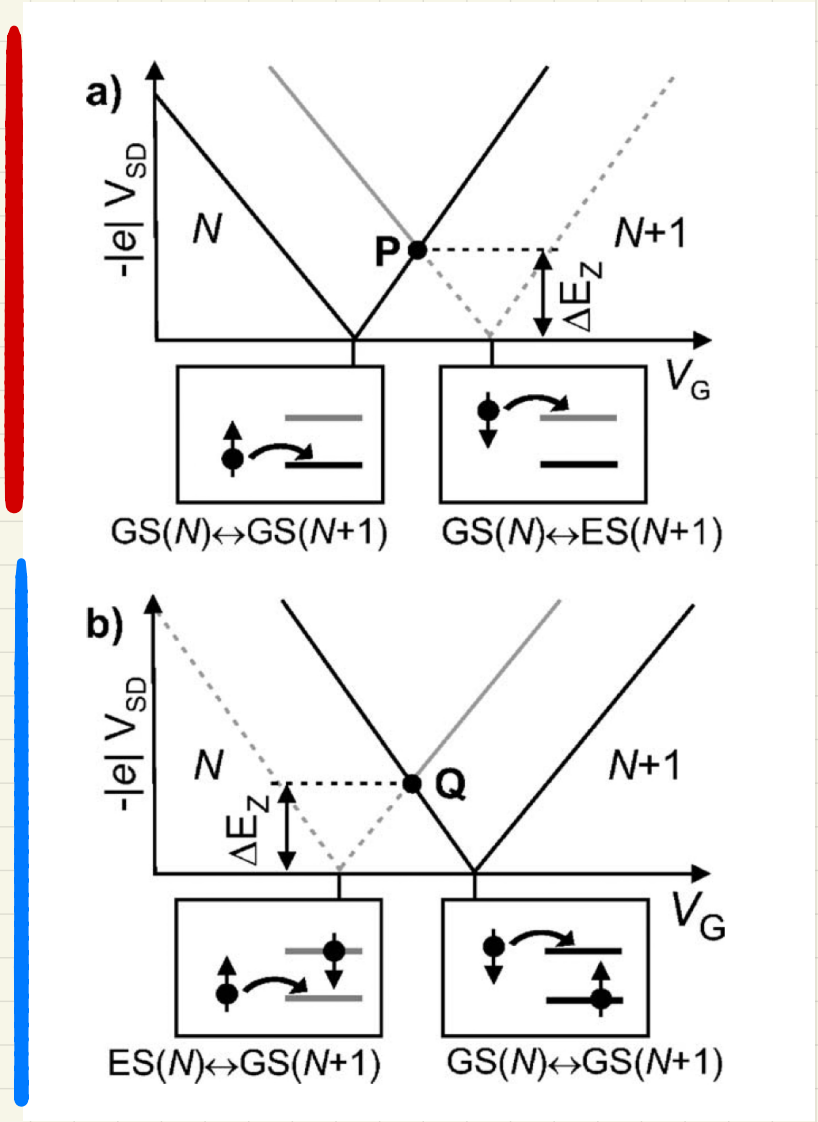
Introducing B-field

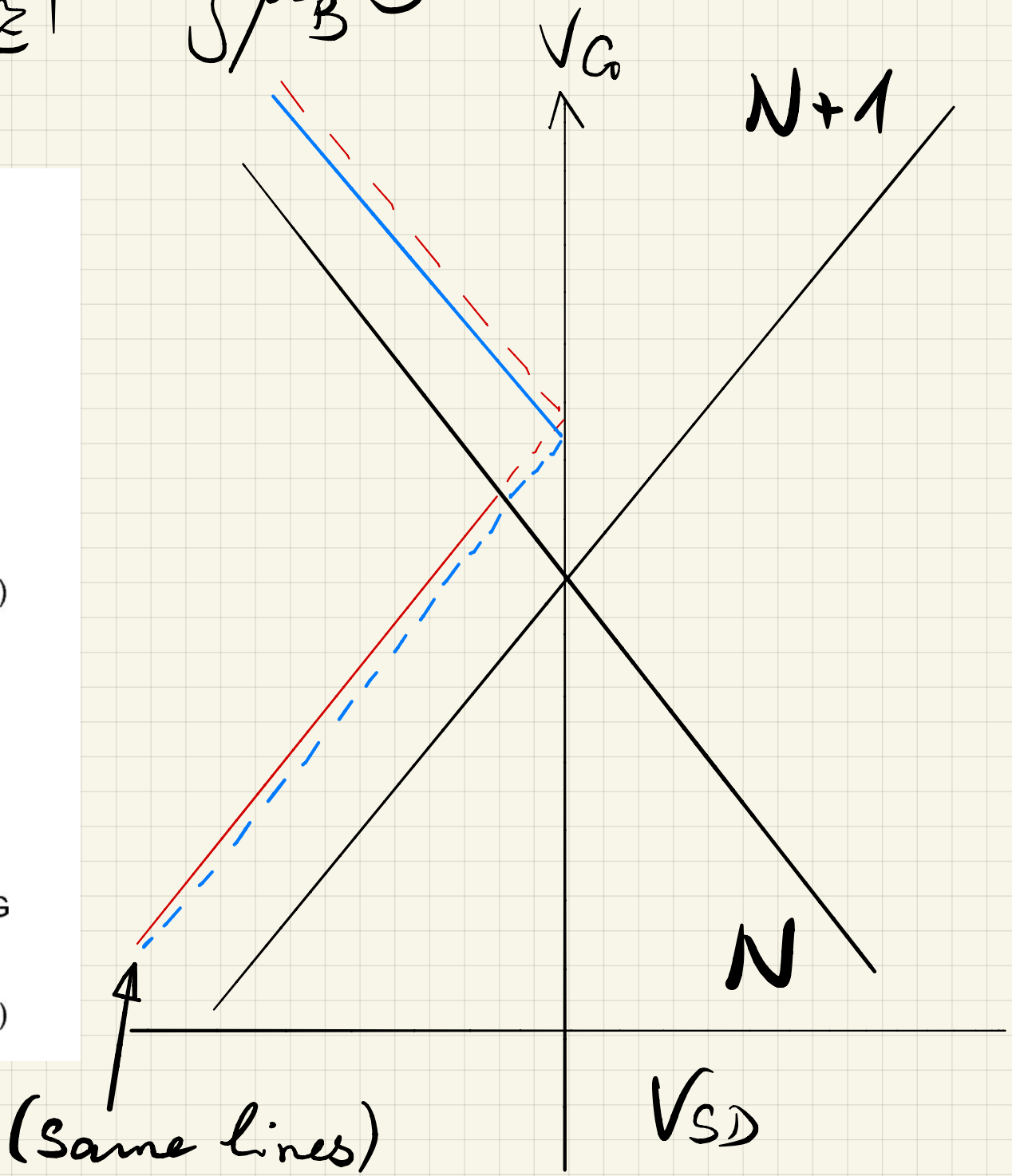
- Zeeman splitting $E_z = S_z g \mu_B B$, ($\hat{S}$, pauli's)

- Coulomb-int. leads to energy difference (exchange energy) between states w/ sym & anti-sym orbital WFs.
  Since $\psi = \phi_{orb} \cdot \chi_{spin,\, antisym.}$ ⇒ Sym of orb is linked to sym of spin!

- for: $g > 0$, ↑ lifts energy by $\frac{1}{2}$
  $N \to N+1$ ↓ lowers −//−

$$\Delta E_Z = 2|E_Z| = g\mu_B B$$





One e⁻ spin states in a dot

$$\mu_{0\leftrightarrow\uparrow,0} = E_{\uparrow,0},$$

$$\mu_{0\leftrightarrow\downarrow,0} = E_{\downarrow,0} = E_{\uparrow,0} + \Delta E_Z,$$

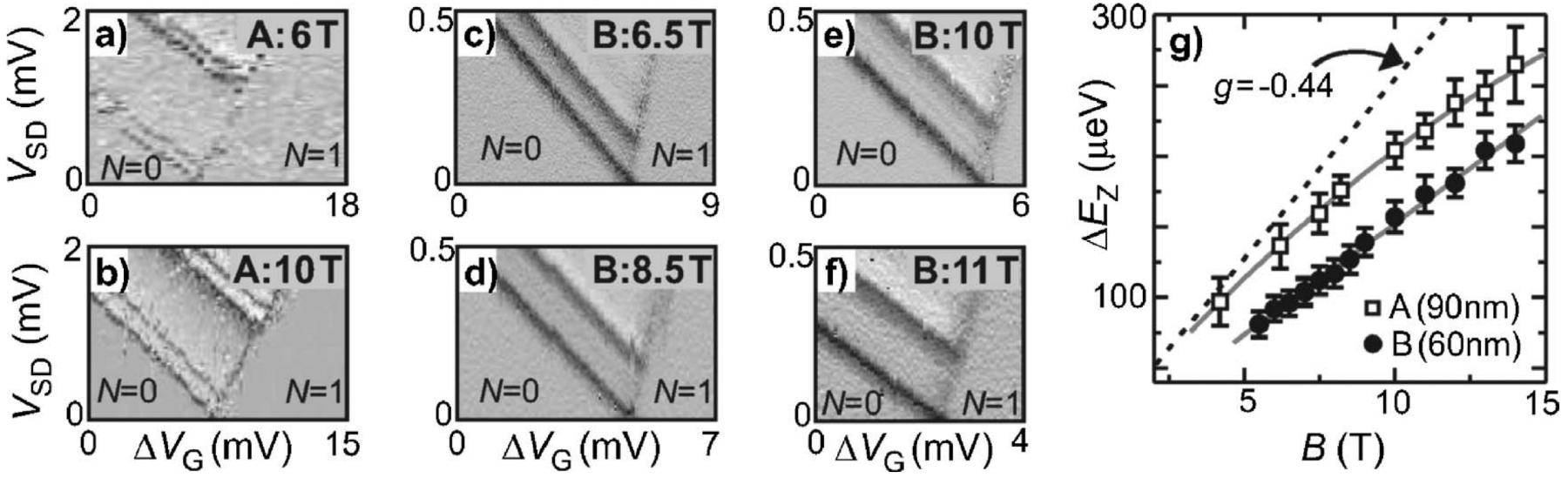
$$\mu_{0\leftrightarrow\uparrow,1} = E_{\uparrow,1} = E_{\uparrow,0} + \Delta E_{\mathrm{orb}},$$

$$\mu_{0\leftrightarrow\downarrow,1} = E_{\downarrow,1} = E_{\uparrow,0} + \Delta E_{\mathrm{orb}} + \Delta E_Z,$$

Zeeman

orbital level spacing

(MSC, Question)



Two e^- spins in a dot

GS: $|S\rangle = (|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle)/\sqrt{2}$ // $S=0$ Sym

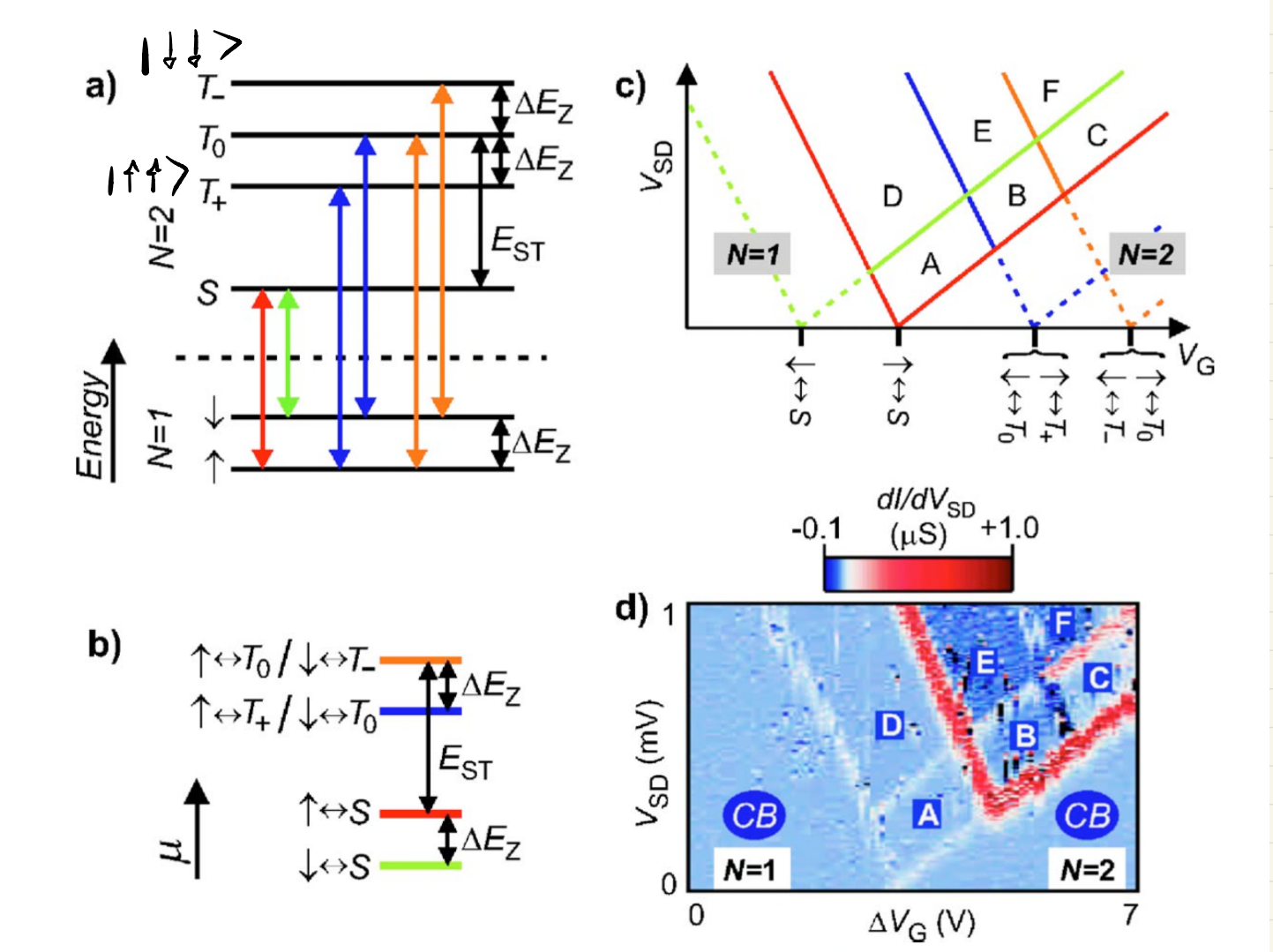
1EX: $|T\rangle = \begin{cases} T_+ |\uparrow\uparrow\rangle \\ T_0 (|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle)/\sqrt{2} \\ T_- |\downarrow\downarrow\rangle \end{cases}$ // $S=1$ anti sym

N.B.: $\hat{T}[\phi_1, \phi_2] \to [\phi_2, \phi_1]$ transposition

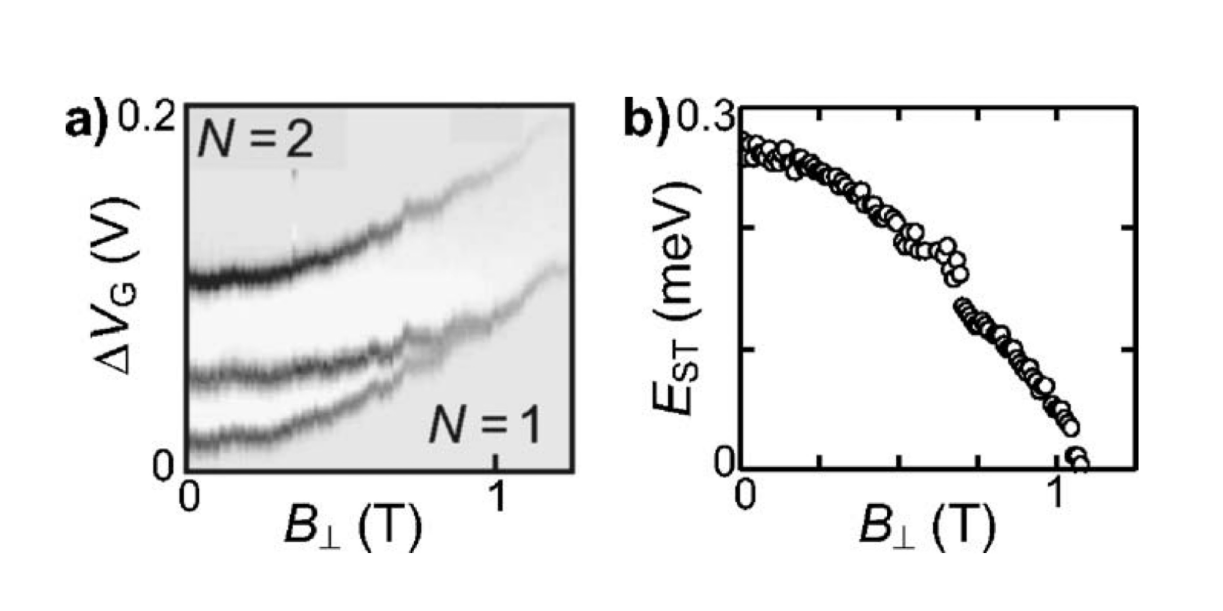
$\hat{T}|\uparrow\downarrow\rangle = -|\downarrow\uparrow\rangle$

$\hat{T}|S\rangle = |S\rangle$ $\quad \hat{T}|T\rangle = -|T\rangle$

possible transitions w/o flipping spin (extra cost)



Singlet triplet crossing



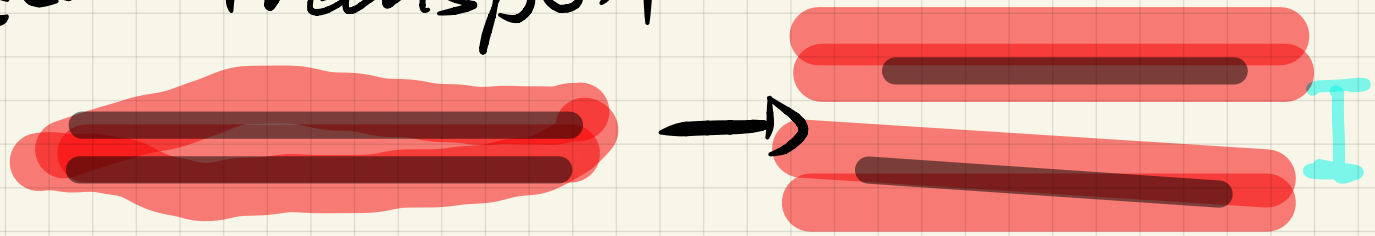
i) B reduces ΔE between GS & 1EX

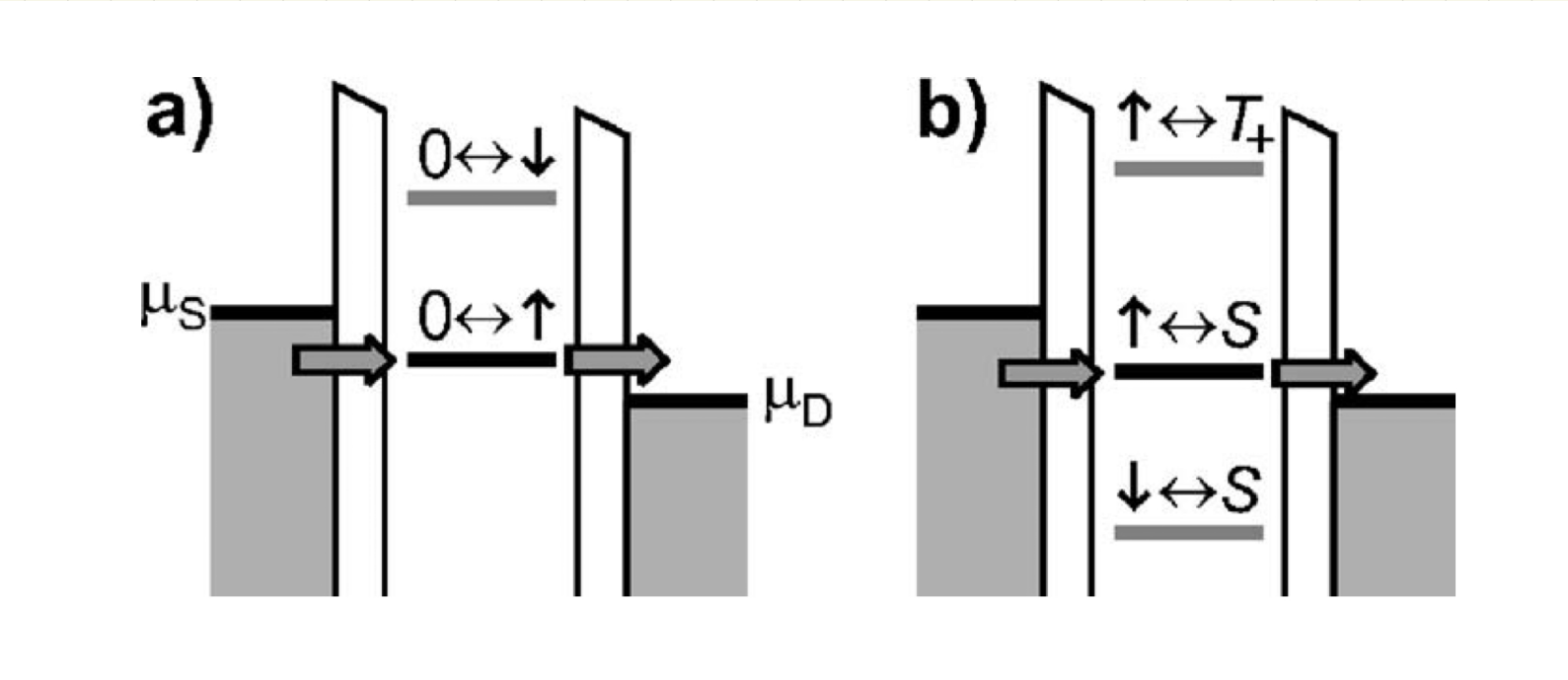
ii) B increases Coulomb interactions

(→ cheaper two orbitals)

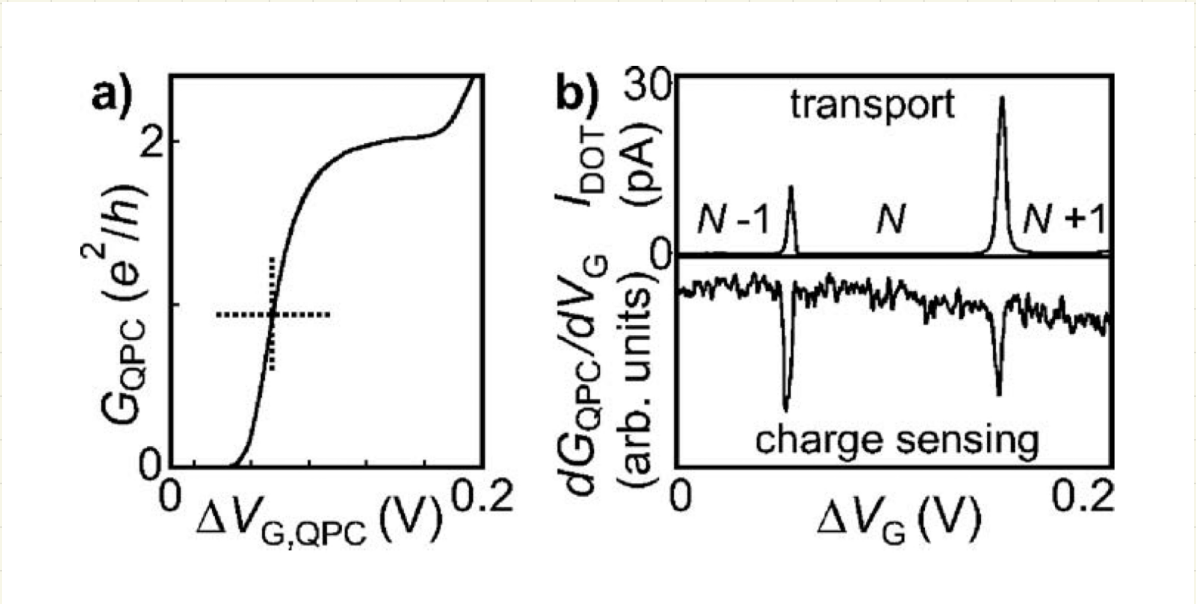
(MC?)

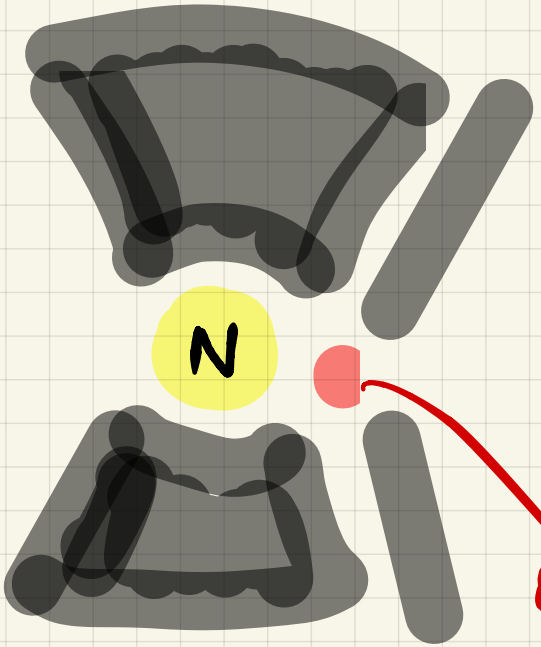
If Zeeman split exceeds width of energy levels (set by E_{therm}) we get spin polarized transport





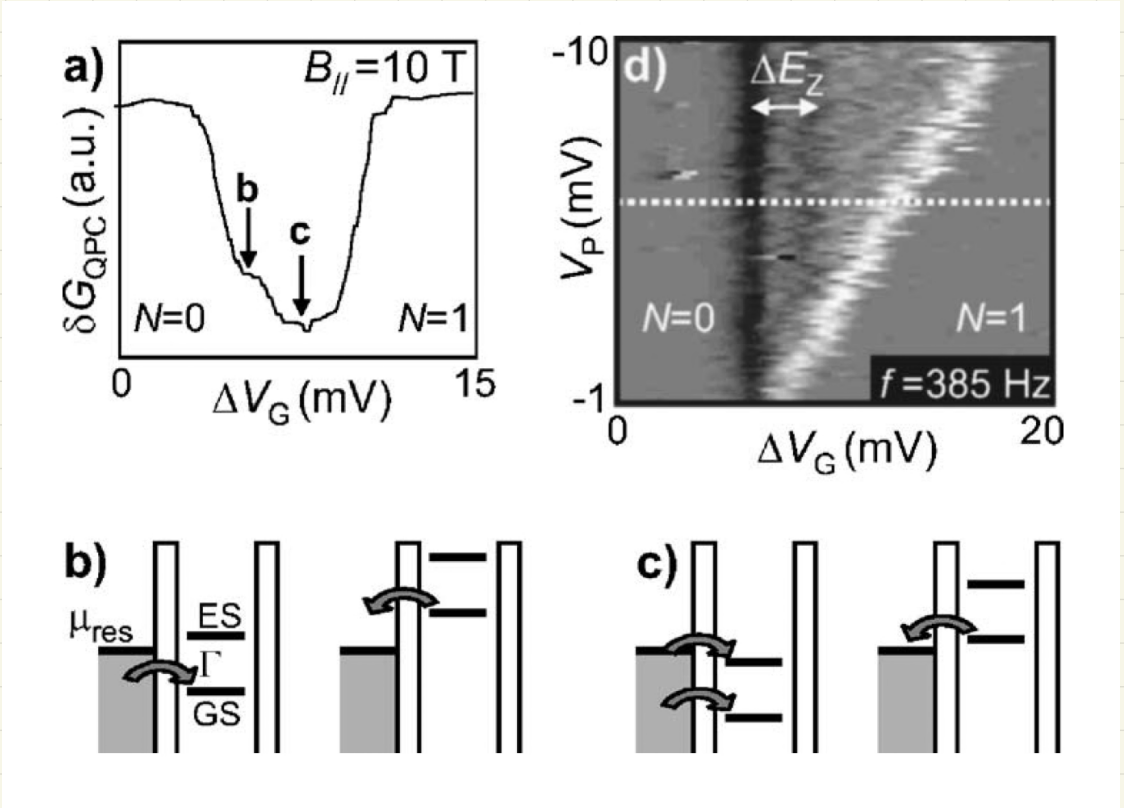
Charge sensing

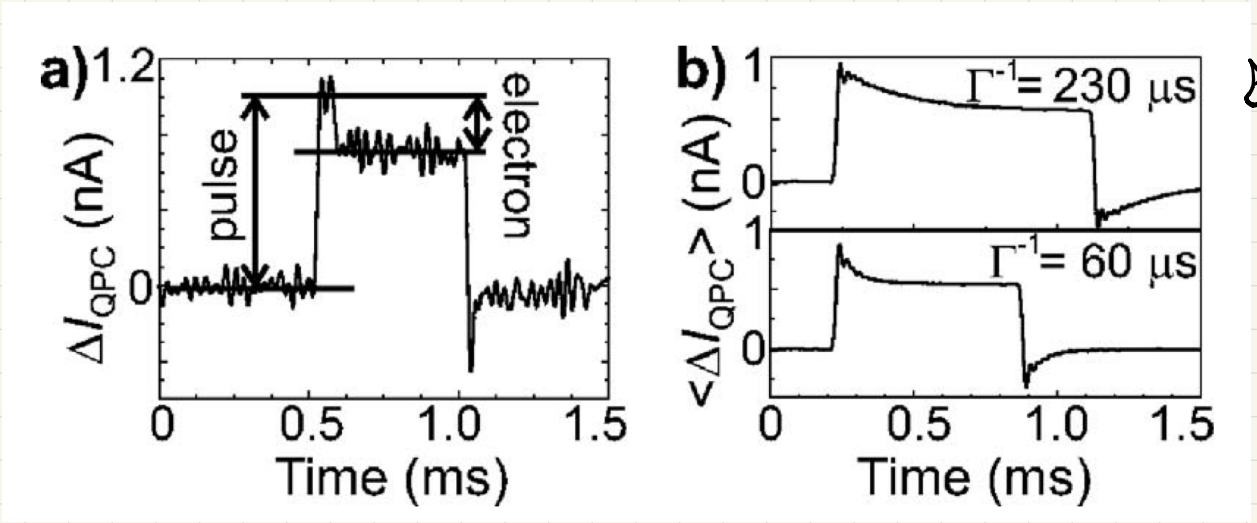




I could say that N acts as a "gate" on ●.

Fails if tunnel time > meas time



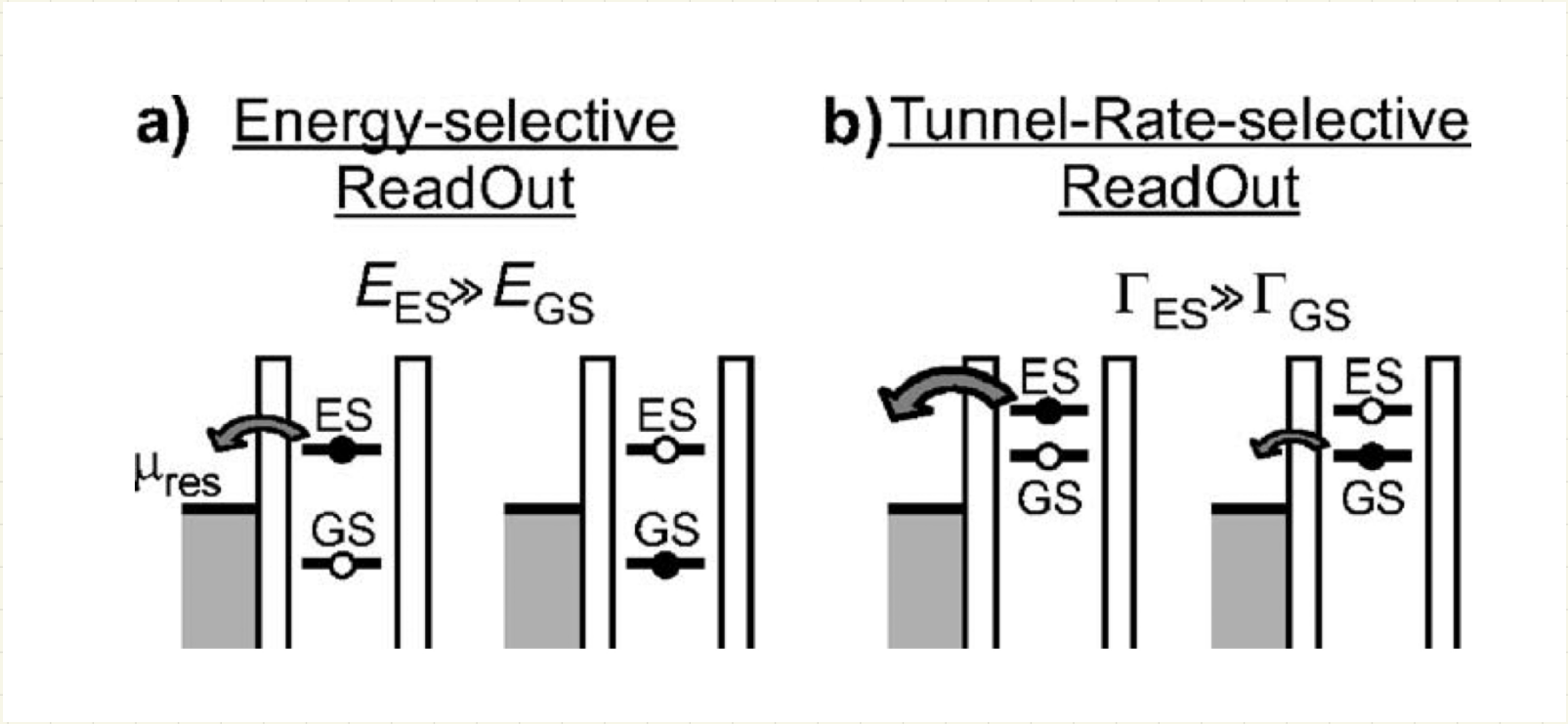


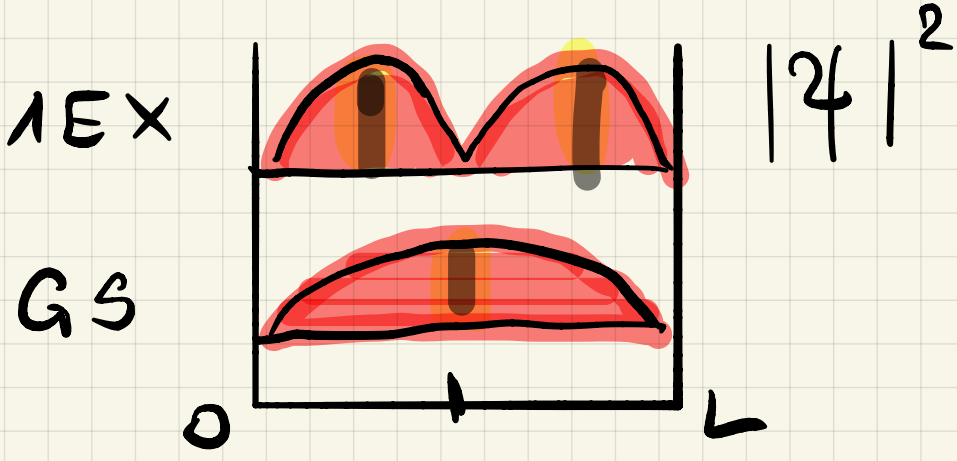
Different Gate Settings

Different

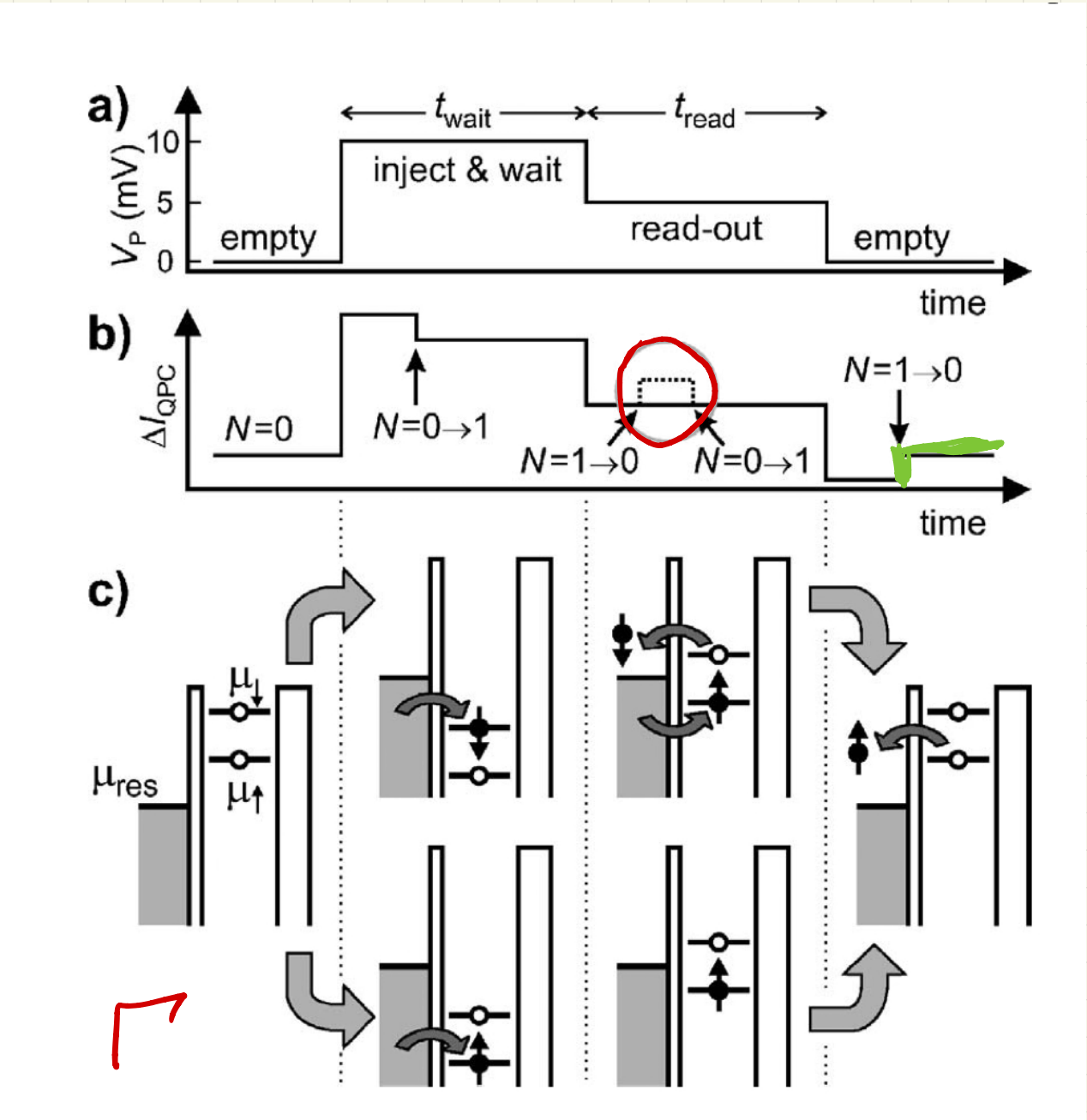
Single shot readout

Spin to charge conv. (destractive)



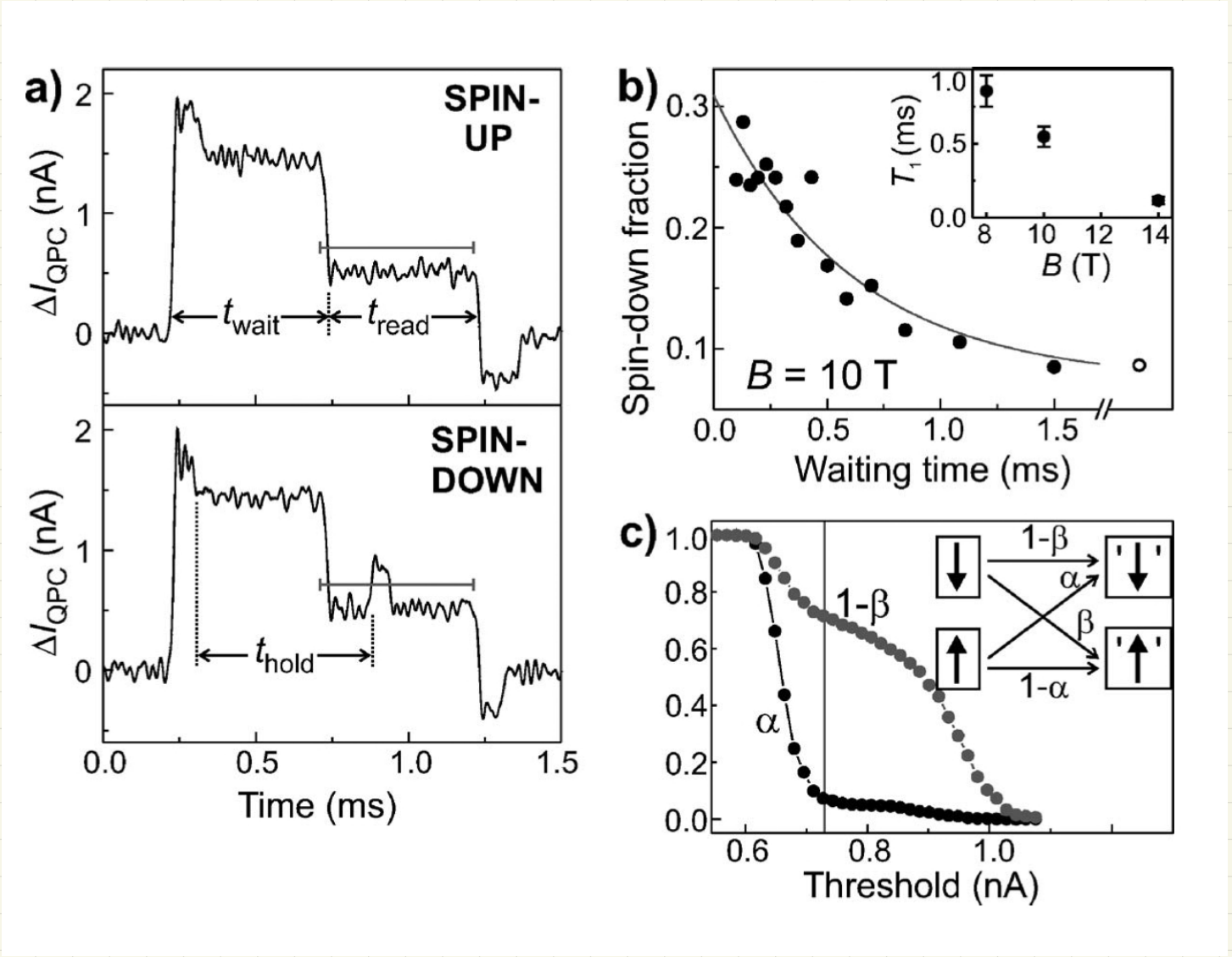


ERO

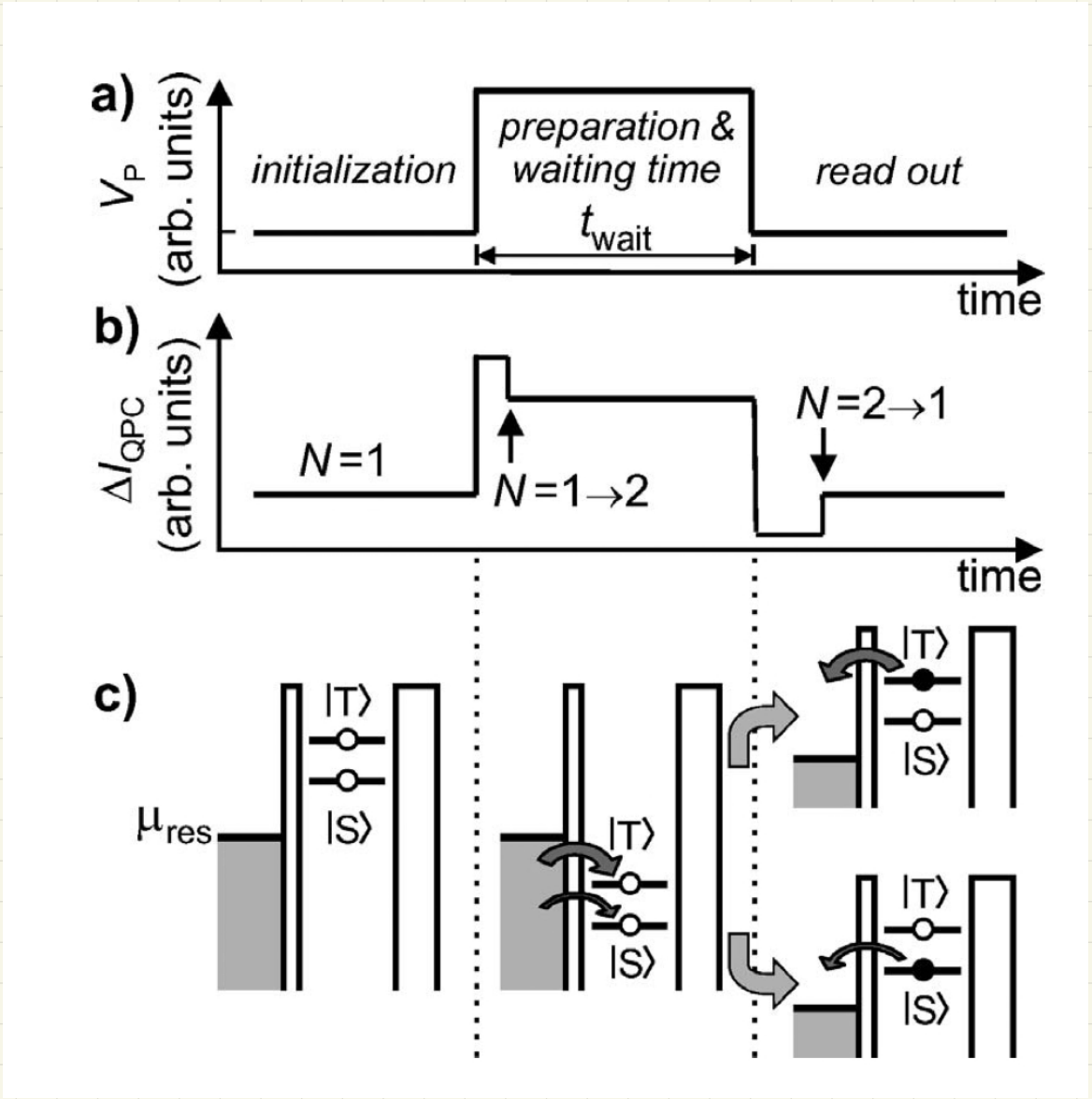


if the bump is missing → GS which is seen by the step in the end

more likely to exchange with lead if wait long



TR - RO


a)
V_P (arb. units)
initialization
preparation & waiting time
t_{wait}
read out
time
b)
ΔI_{QPC} (arb. units)
$N=1$
$N=1\rightarrow2$
$N=2\rightarrow1$
time
c)
μ_{res}
|T⟩
|S⟩