Charge Noise in FDSOI nMOS quantum dots

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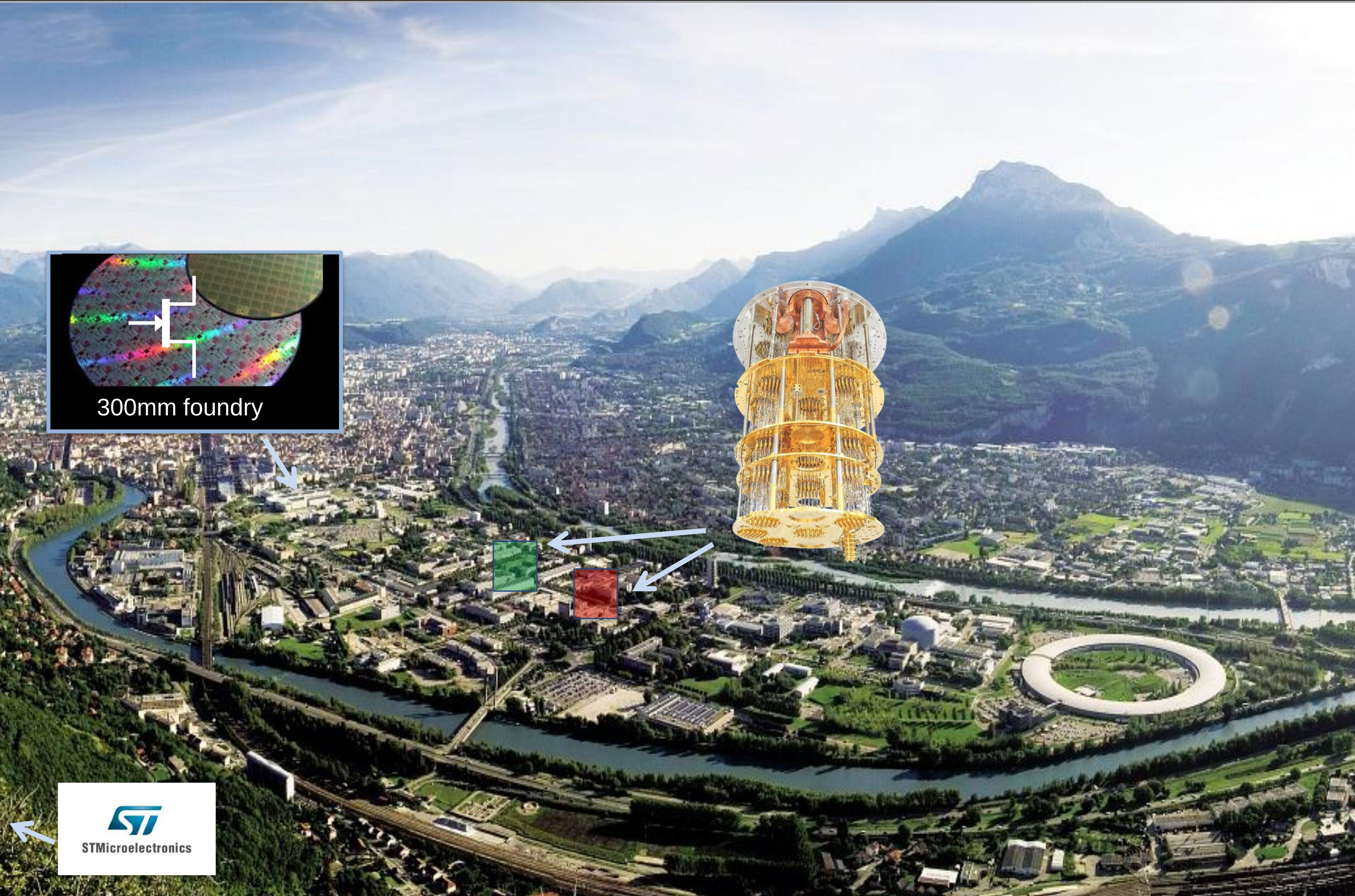
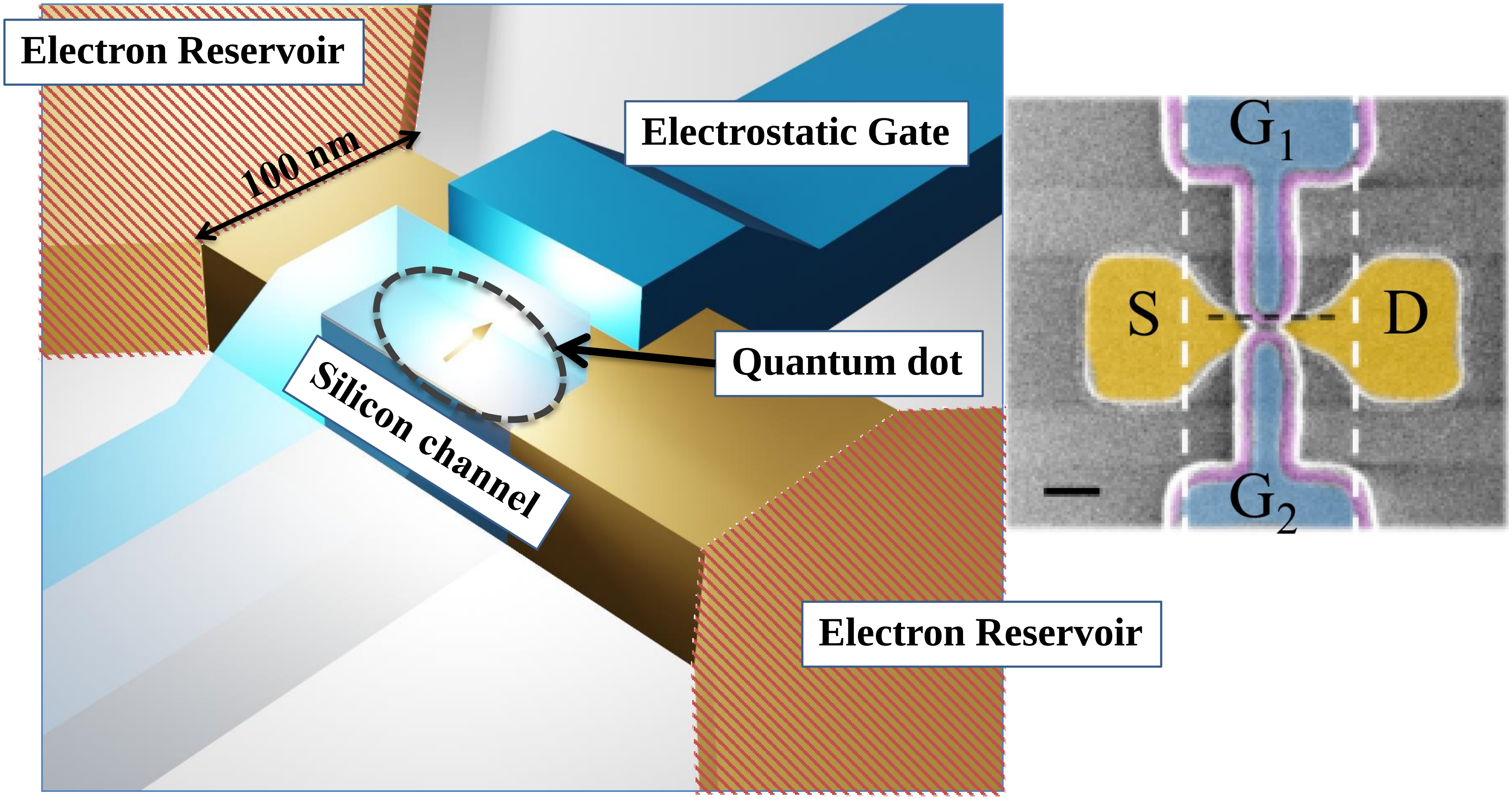
Institut Néel, CNRS

Charge Noise in Semiconductor Spin Qubits
9 & 10 June 2022
Rüschlikon, Switzerland

Quantum Silicon Grenoble



FDSOI nMOS device



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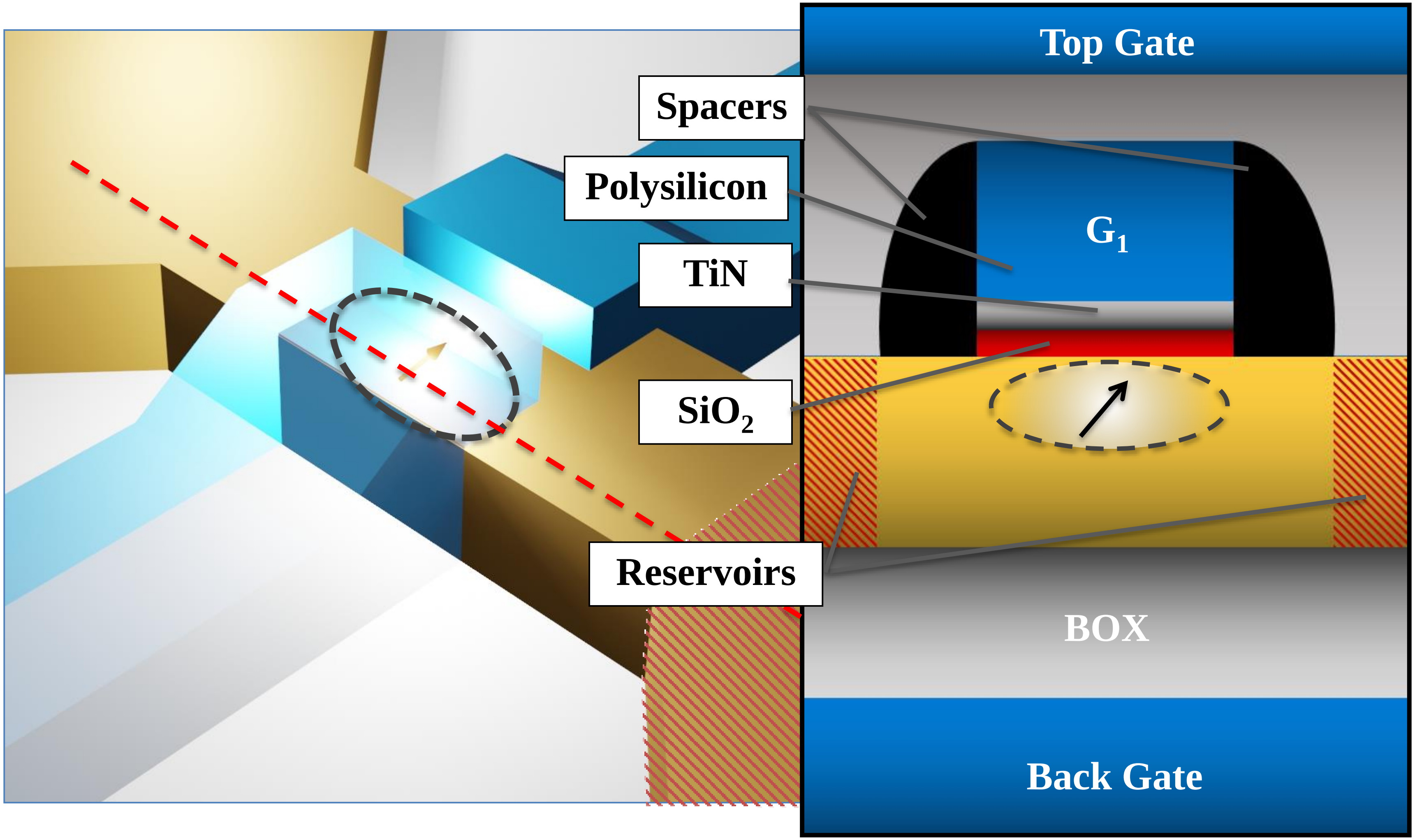

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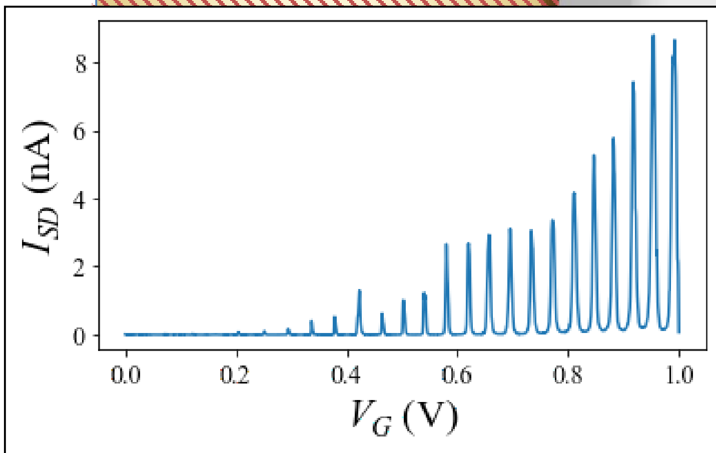
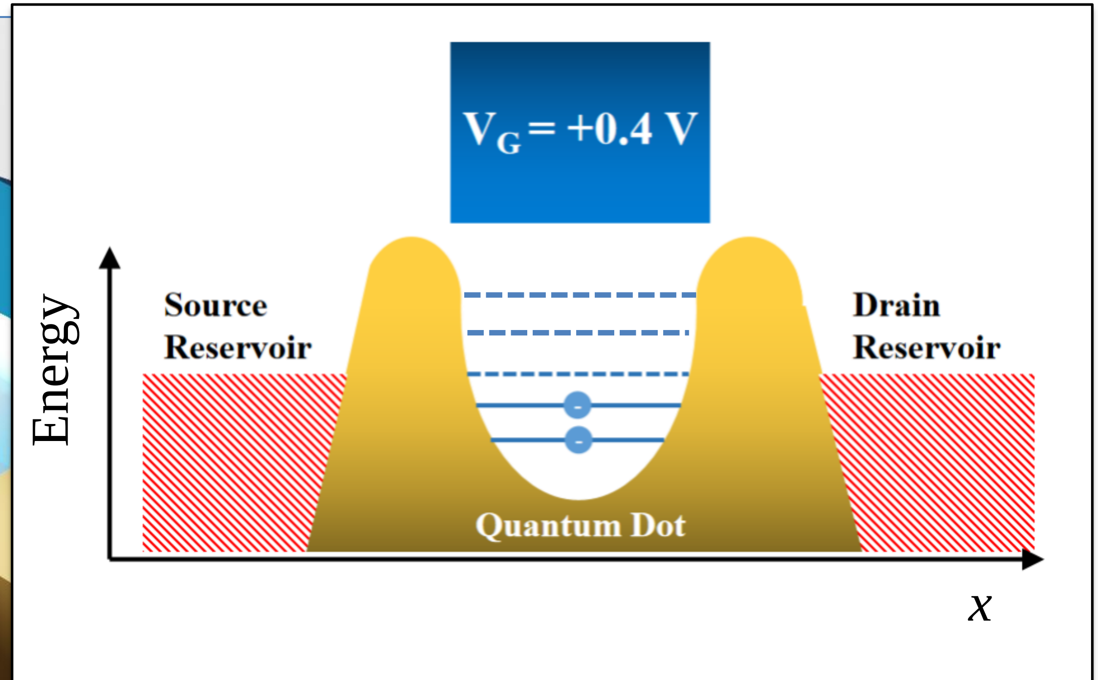
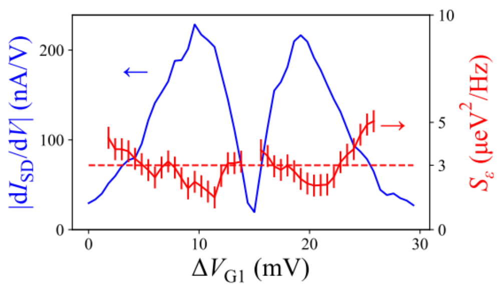


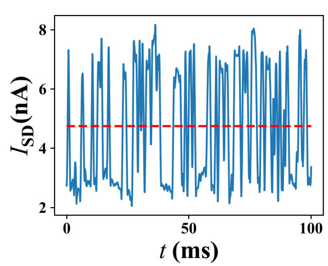


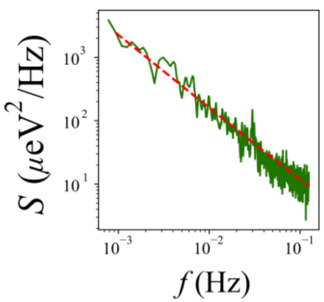
Outlines

Charge noise in nMOS QDs



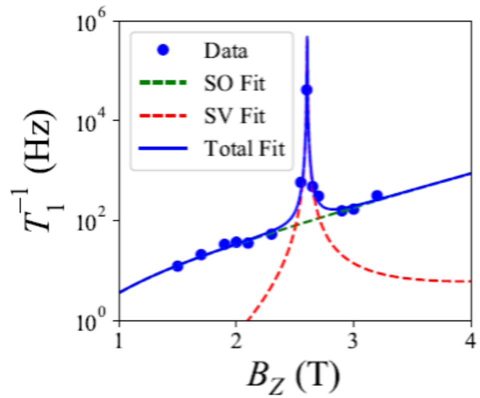
Many-electron regime

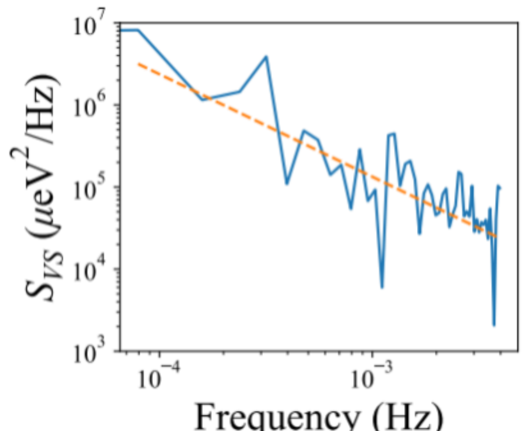




Single-electron regime

Charge noise on qubit





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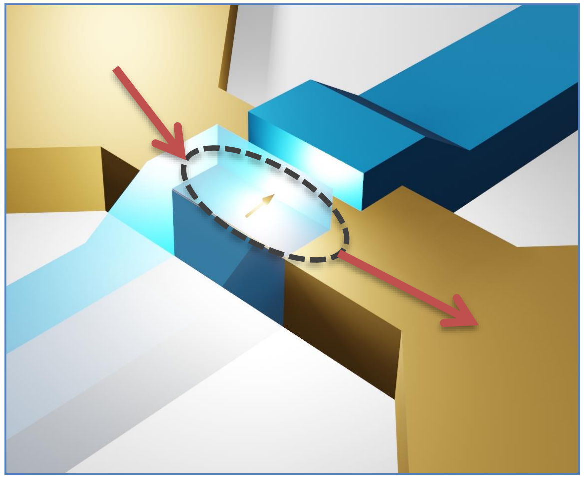
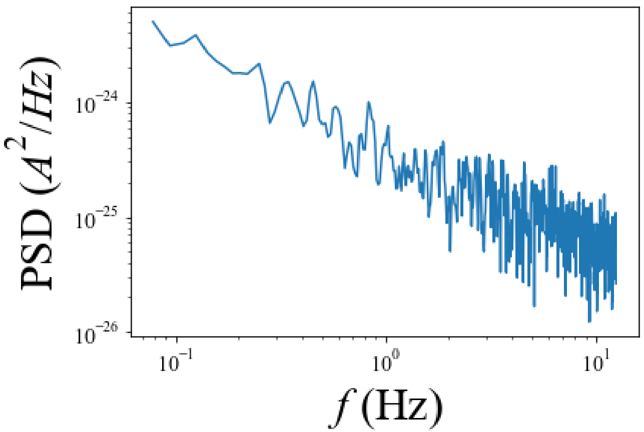
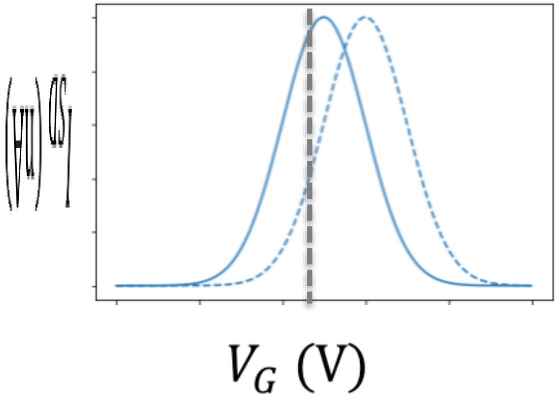
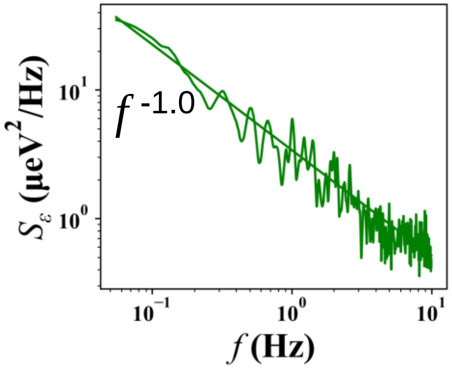
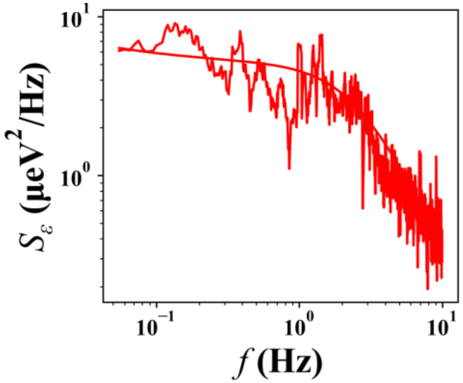




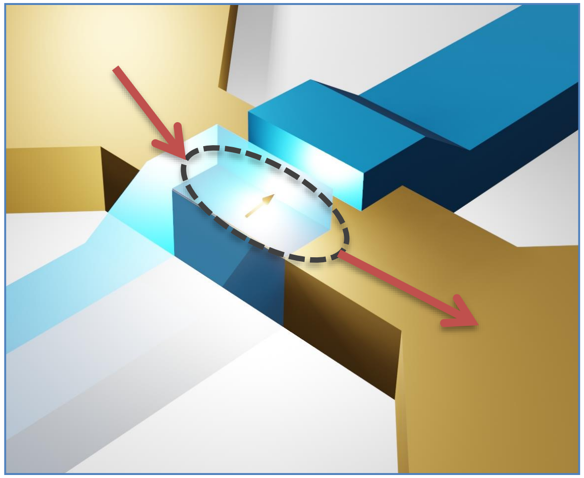


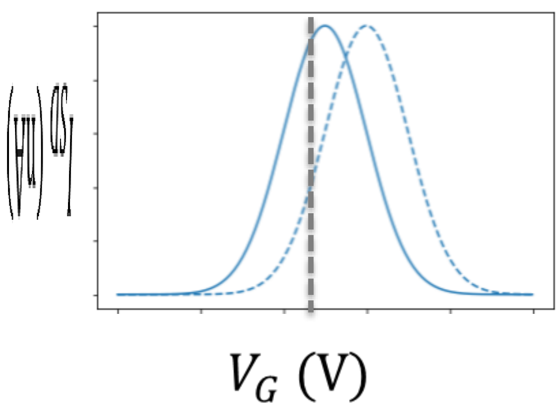


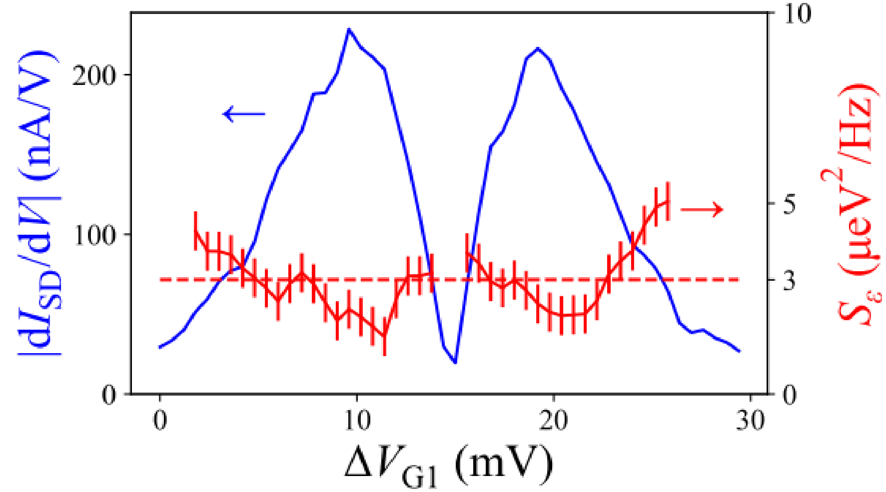


W.H. Matteus et al, PRL 1986
D.L. Gilden et al, Science 1995
B.J. West and M.F. Shlesinger, IJMPB 1989

FDSOI nMOS device

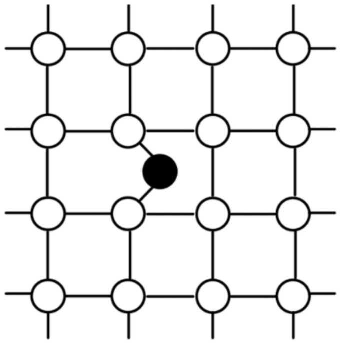




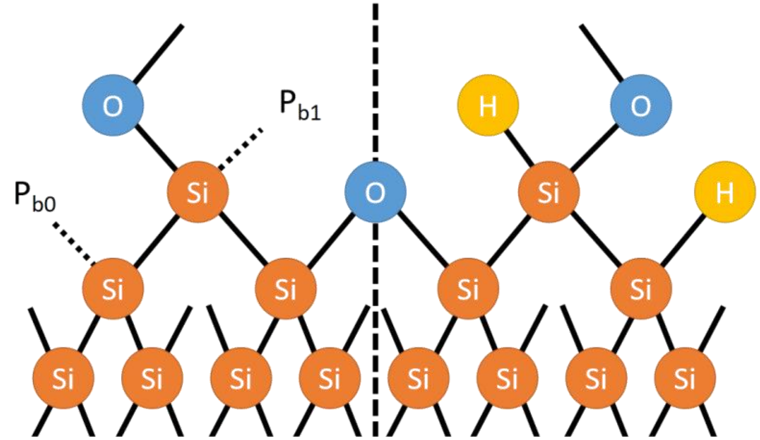


FDSOI nMOS device

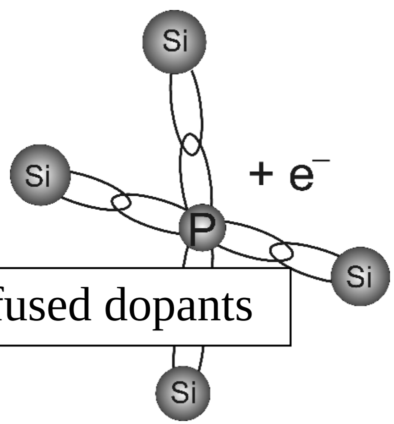
What are the sources of **charge noise**?



Interstitial defects (in gate oxide or bulk)

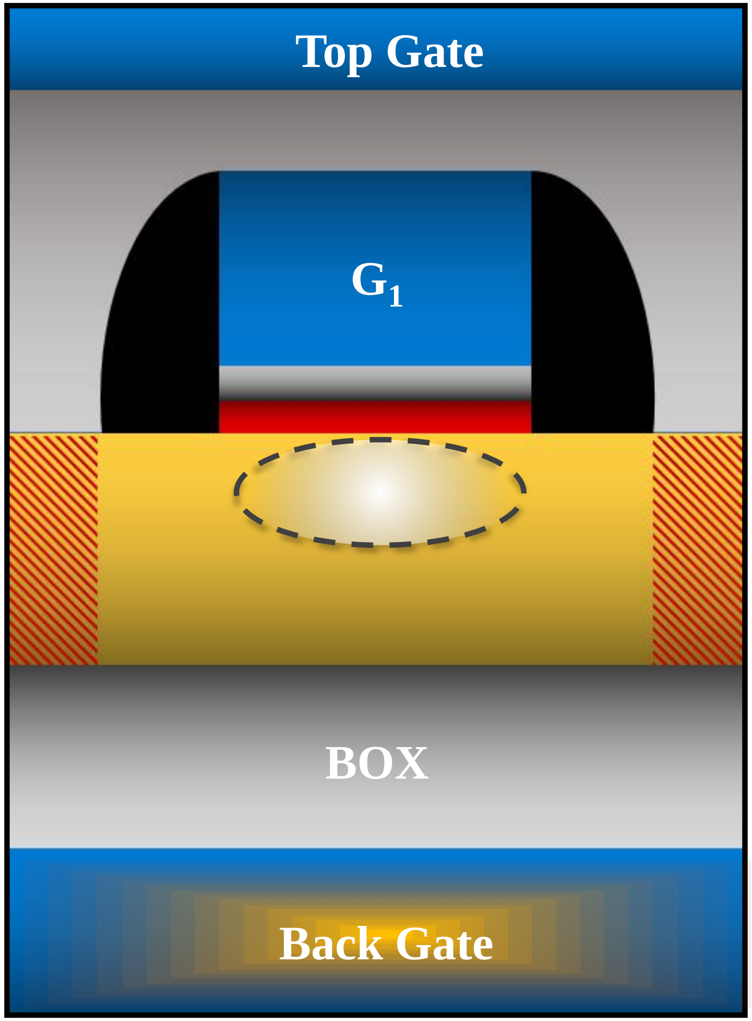


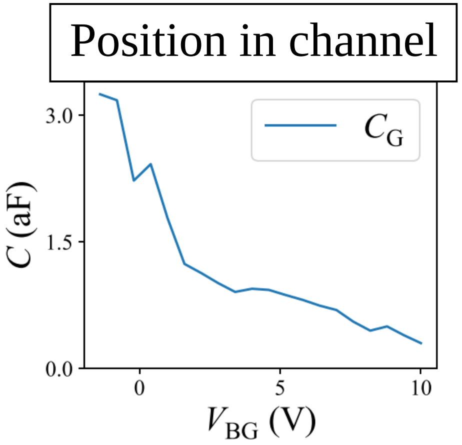
Dangling bonds at interfaces

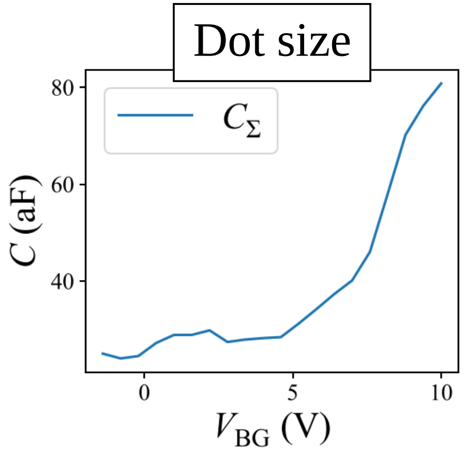


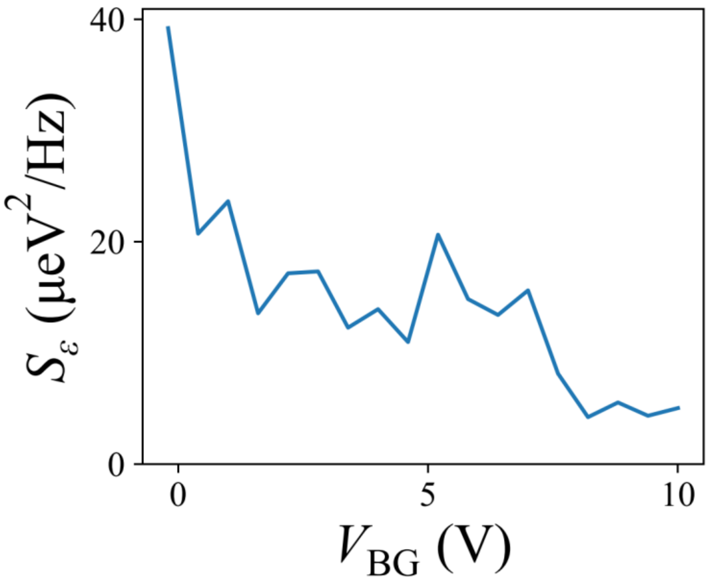
Diffused dopants

FDSOI nMOS device









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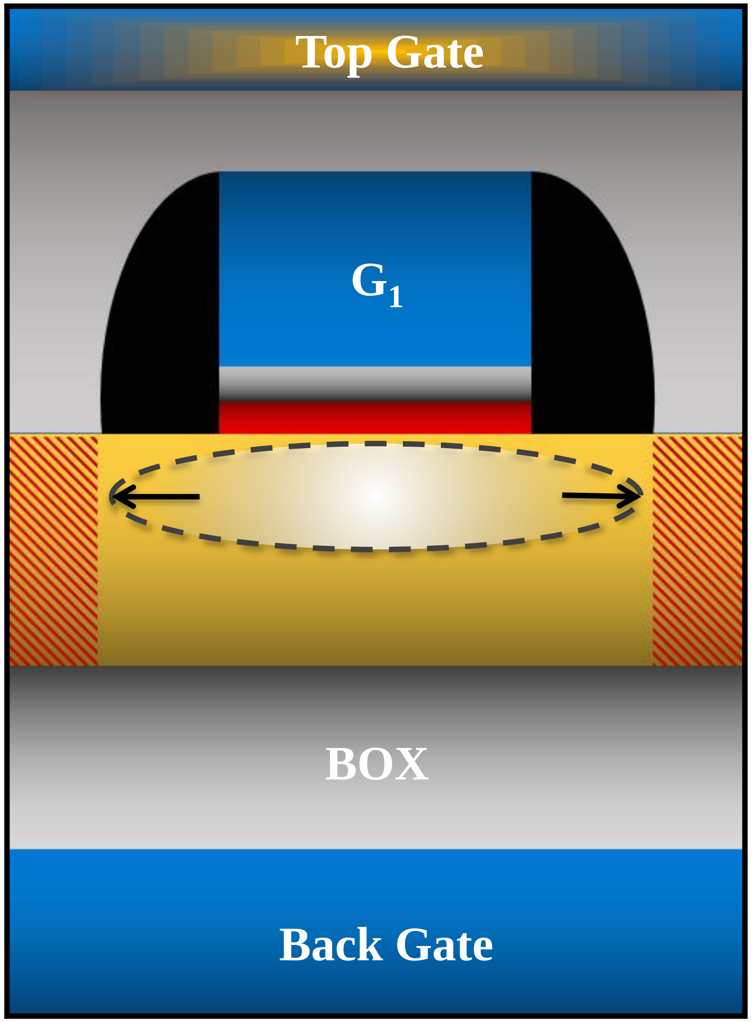
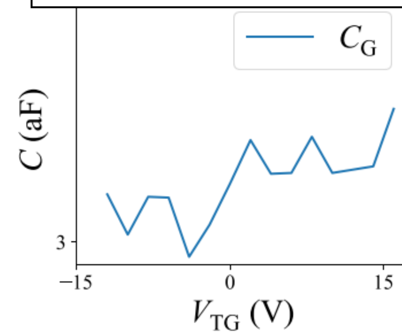
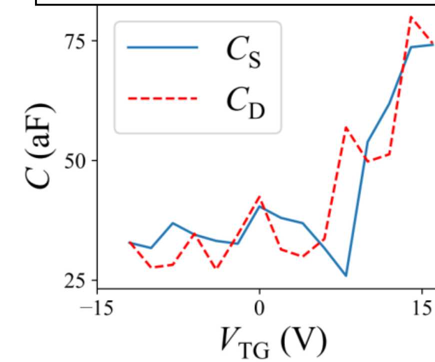
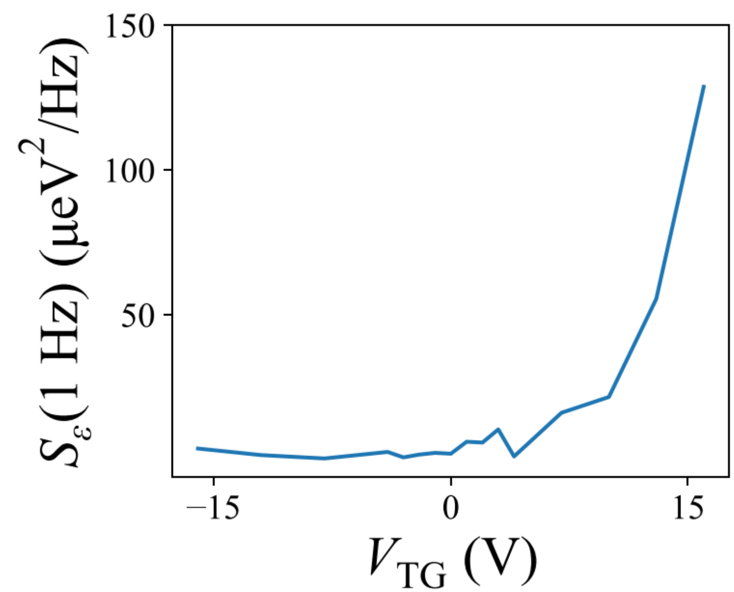


Position in channel



Coupling to reservoirs





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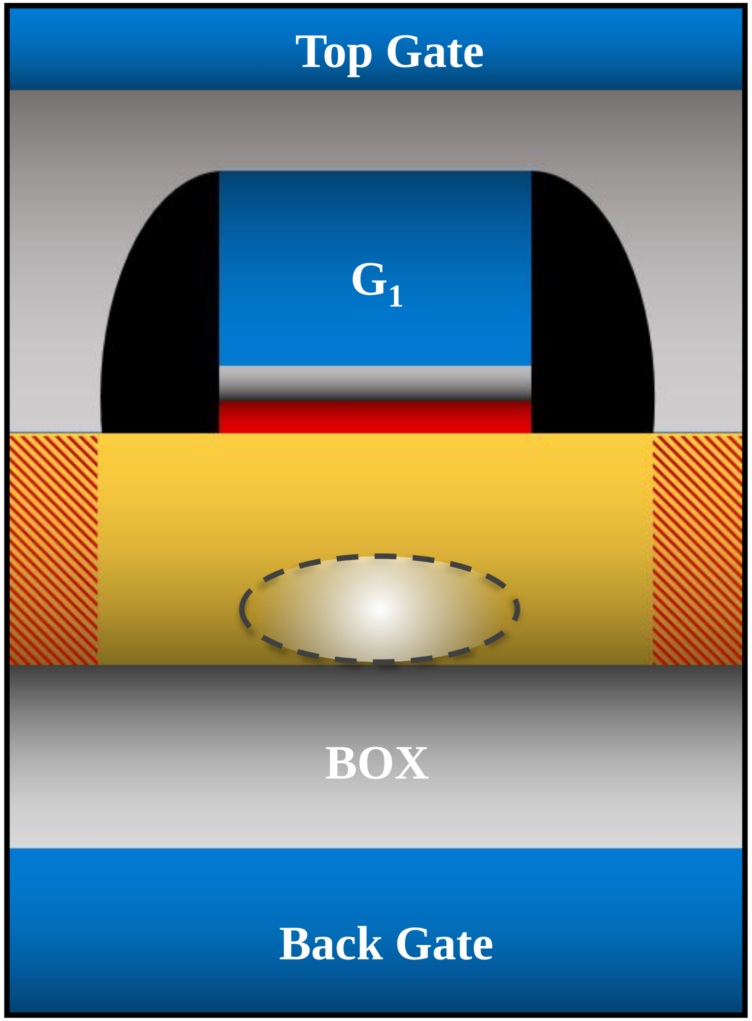


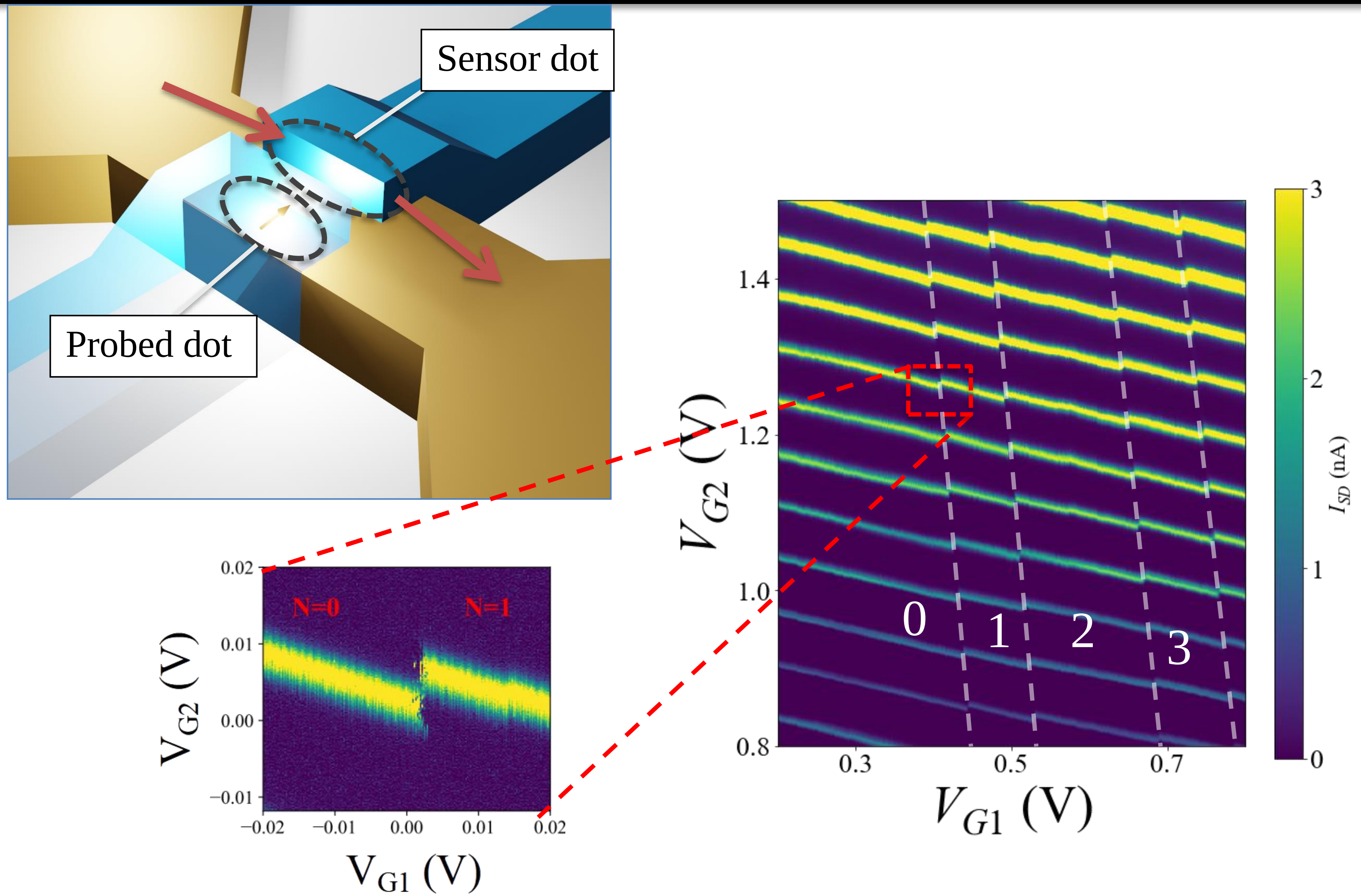
Effects of Interfaces

Si/SiO_2 - decreased charge noise at back interface (BOX)

Spacers and doped reservoirs detrimental source of CN

Detected charge noise between 0.1 and 100 $\mu eV^2/Hz$ @1Hz

FDSOI nMOS device



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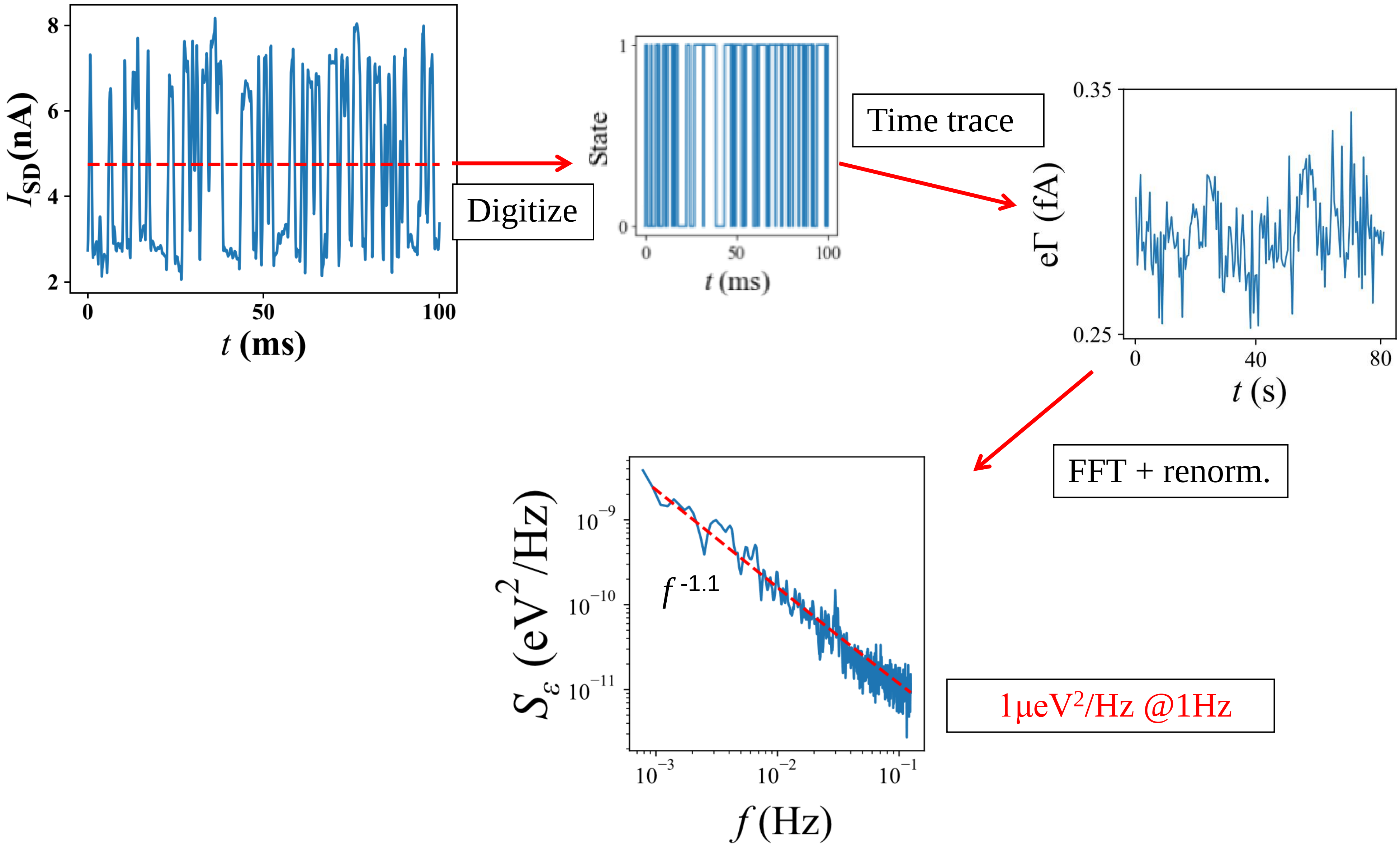

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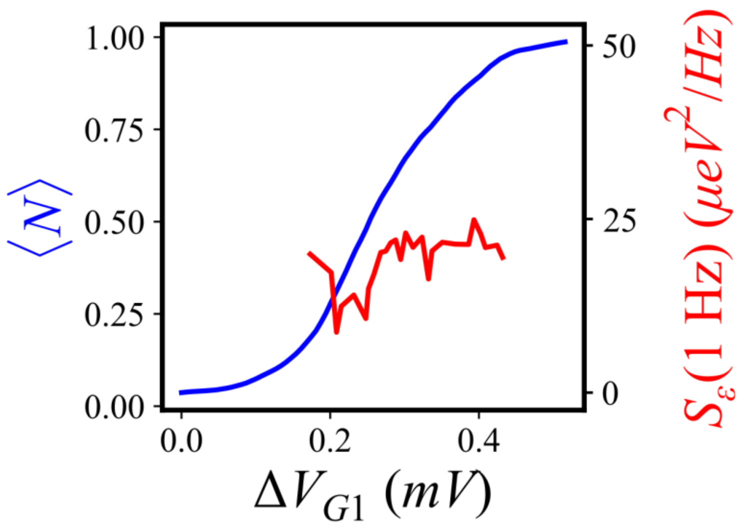

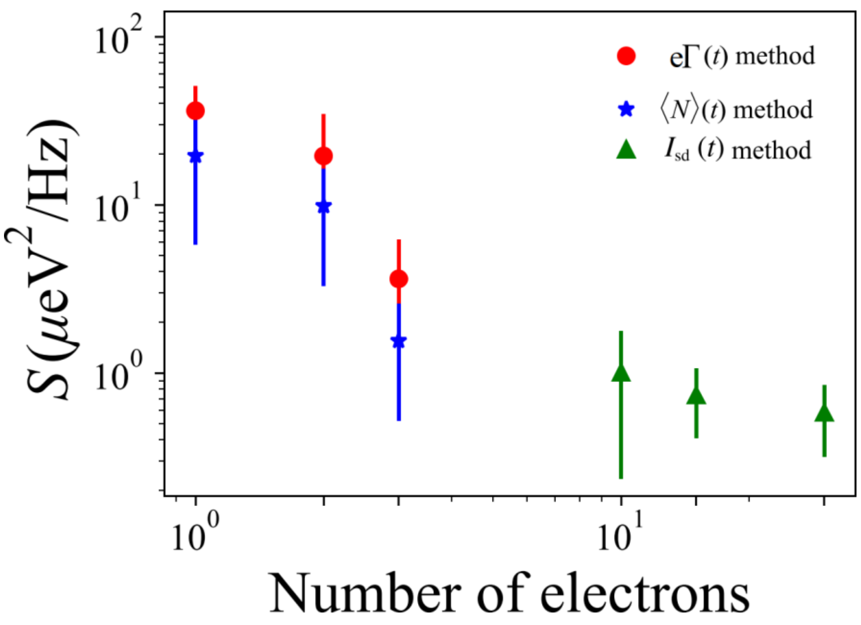

Outlines

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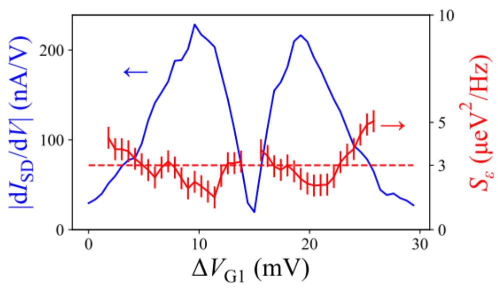
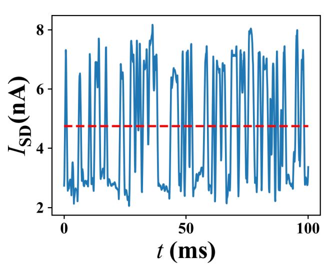
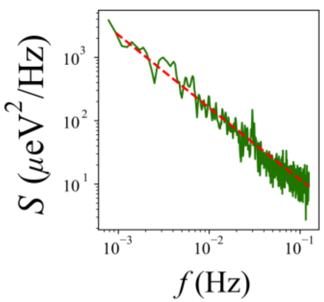


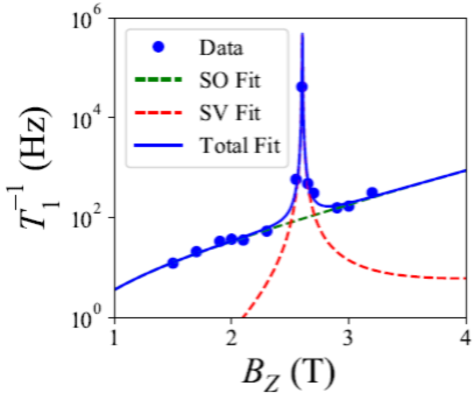
Many-electron regime

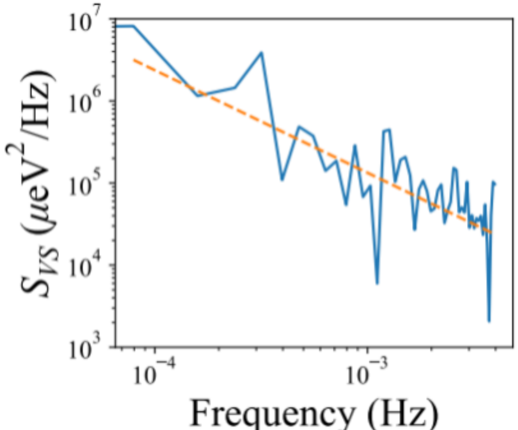




Single-electron regime

Charge noise on qubit





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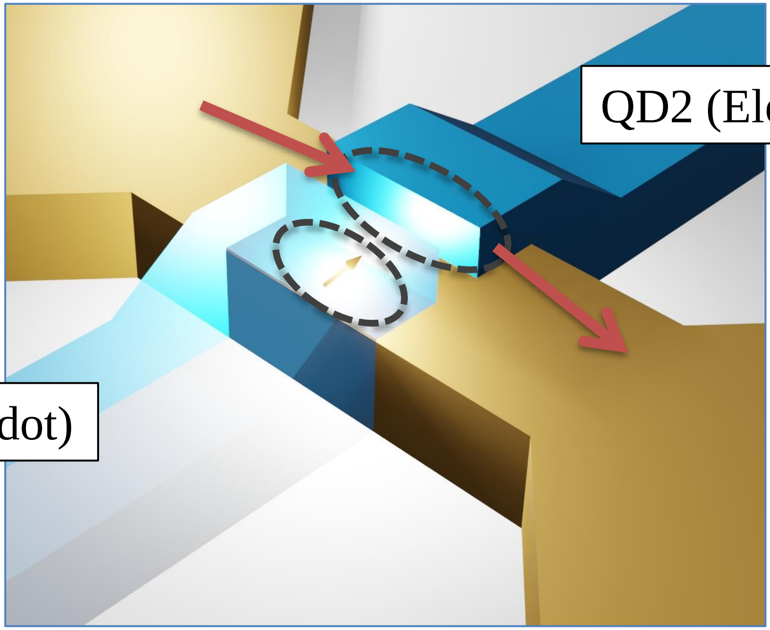

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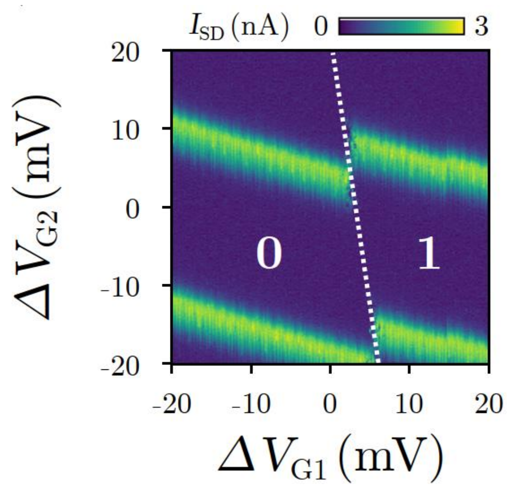

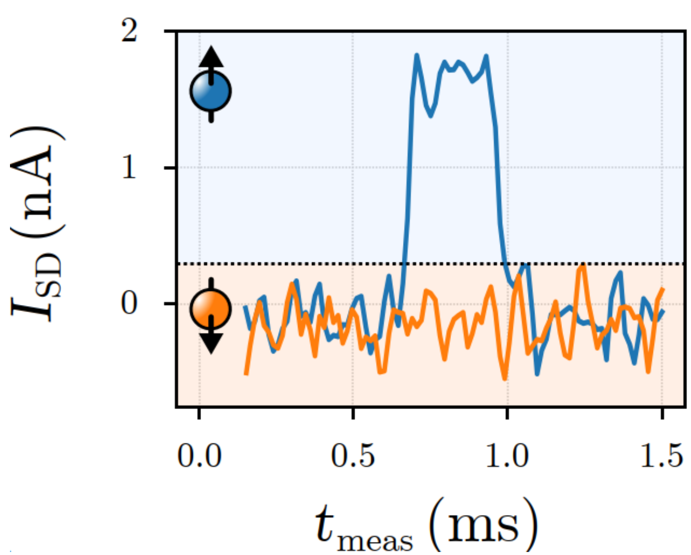

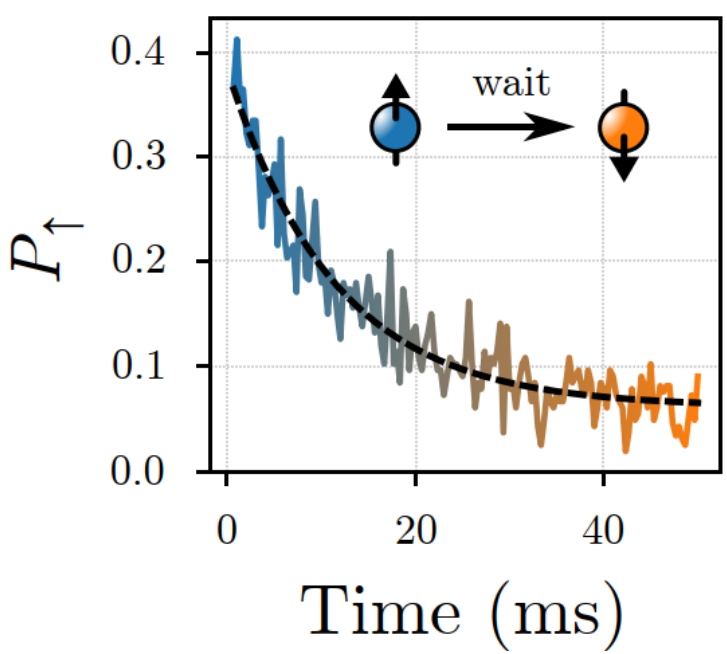

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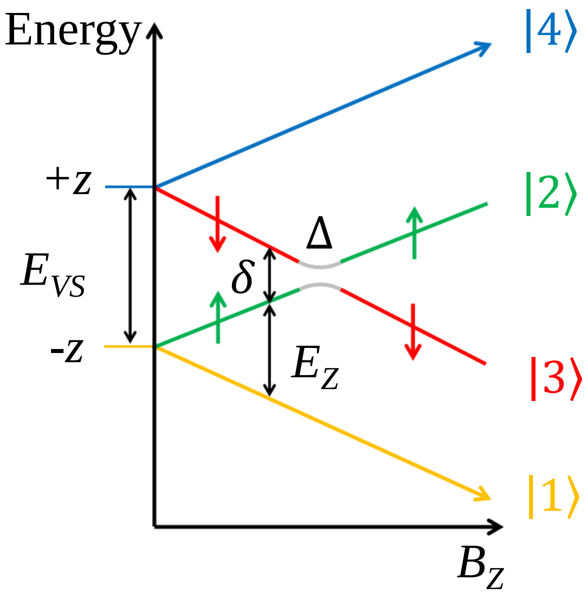
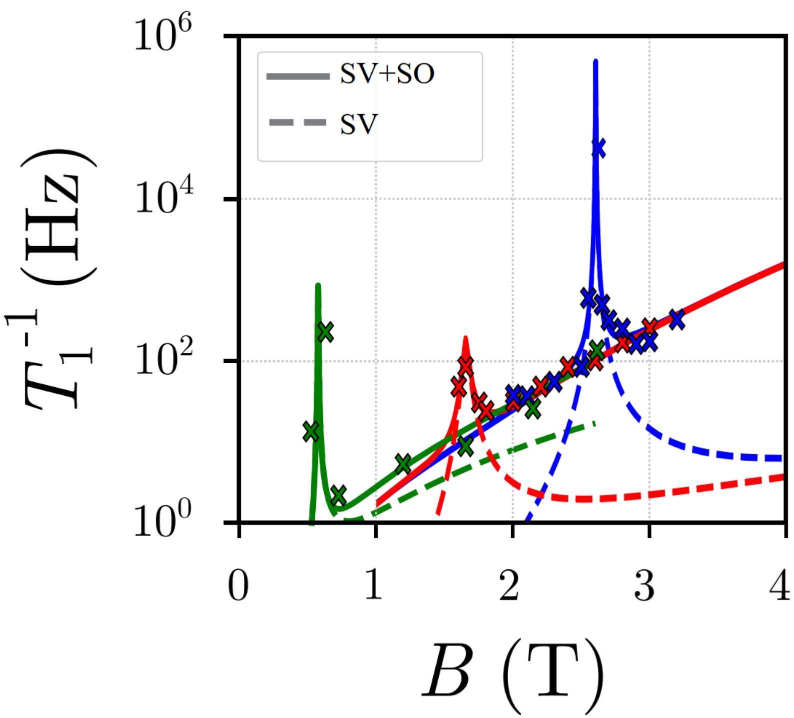


$|2\rangle = |v_-,\uparrow\rangle$

$|3\rangle = |v_+,\downarrow\rangle$

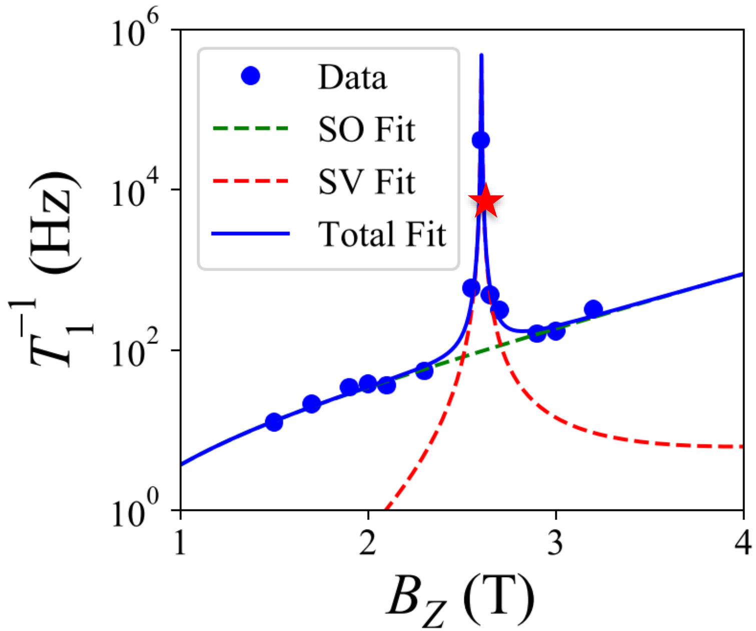
$$|\bar{2}\rangle = \frac{1}{\sqrt{2}}|v_-,\uparrow\rangle + \frac{1}{\sqrt{2}}|v_+,\downarrow\rangle$$

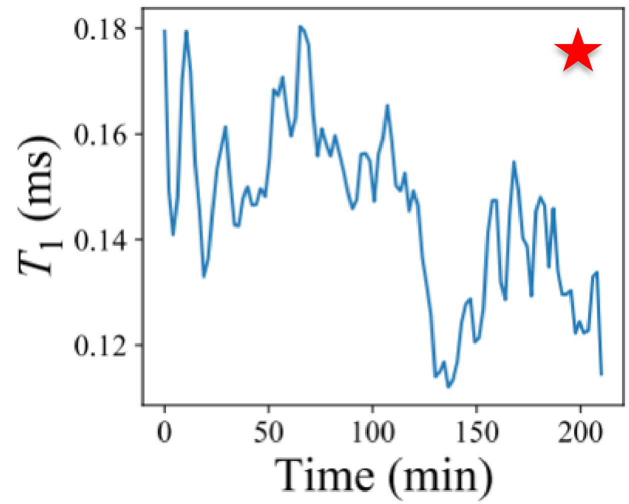
$$|\bar{3}\rangle = \frac{1}{\sqrt{2}}|v_-,\uparrow\rangle - \frac{1}{\sqrt{2}}|v_+,\downarrow\rangle$$

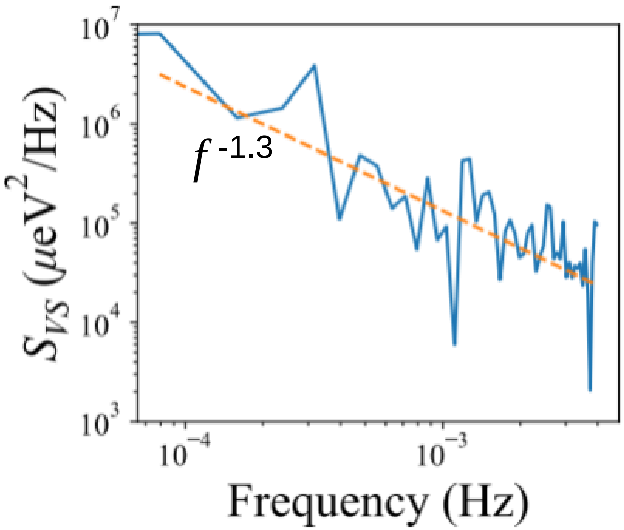


E_{VS} ranging from 80 to 300 μeV

FDSOI nMOS device

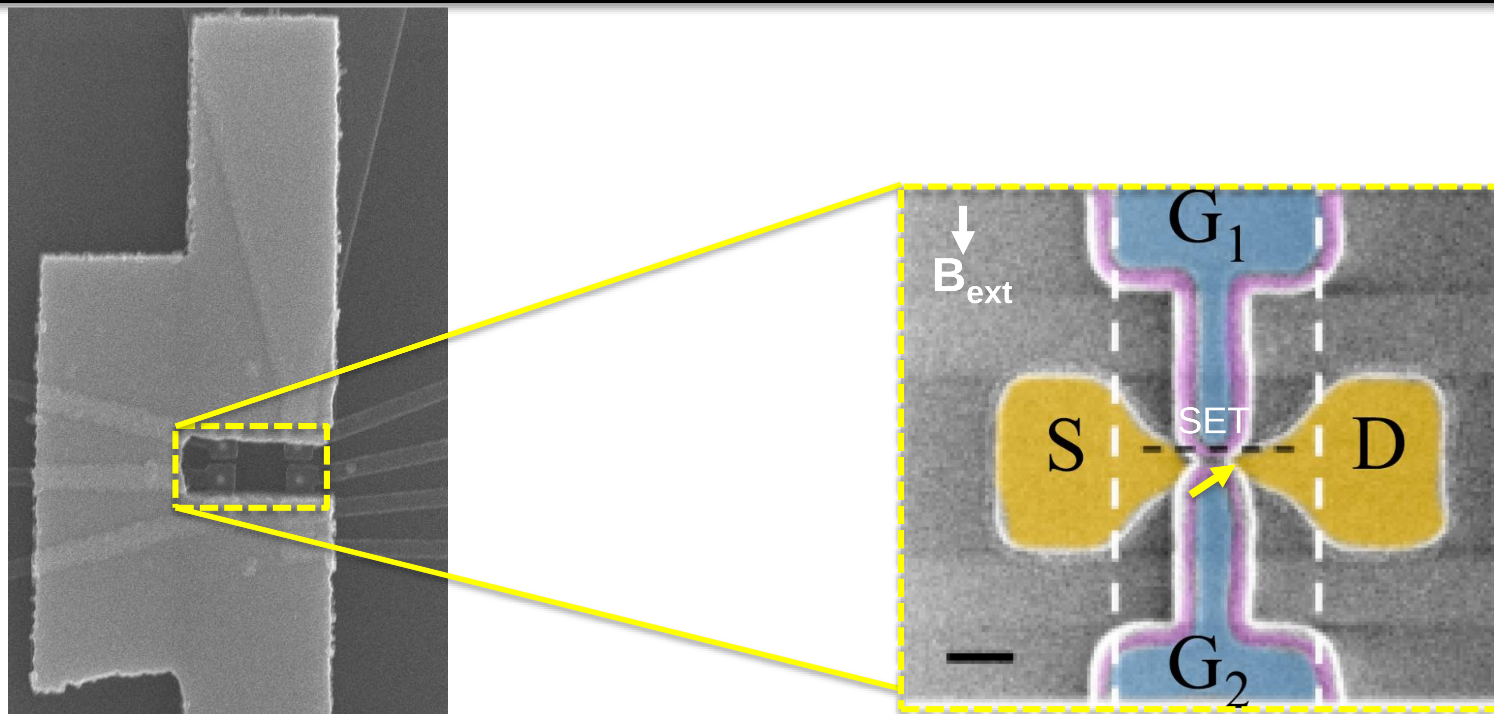


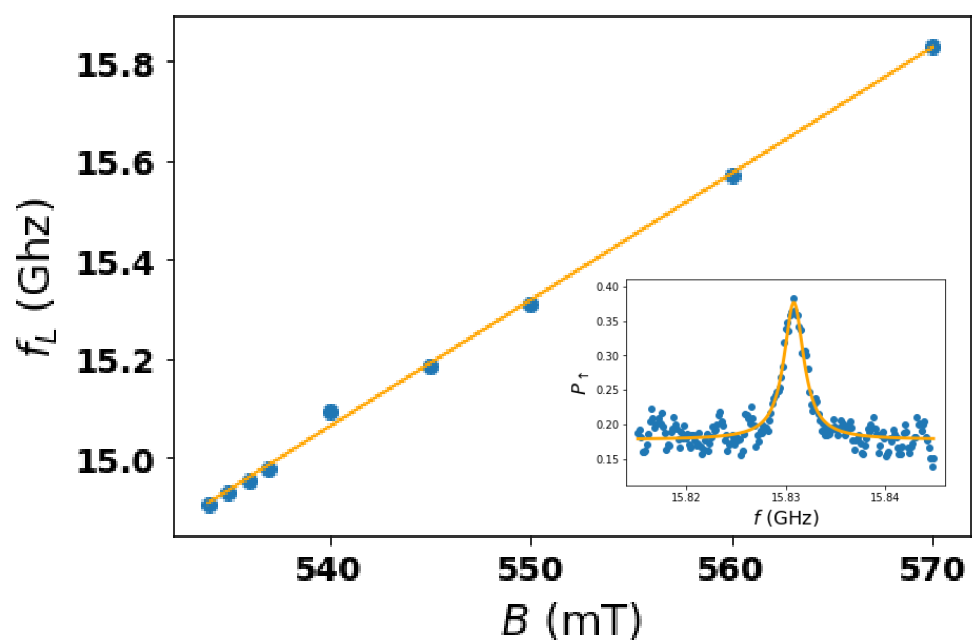




E_{VS} fluctuations of 4 μeV/$\sqrt{}$Hz @1Hz

FDSOI nMOS device





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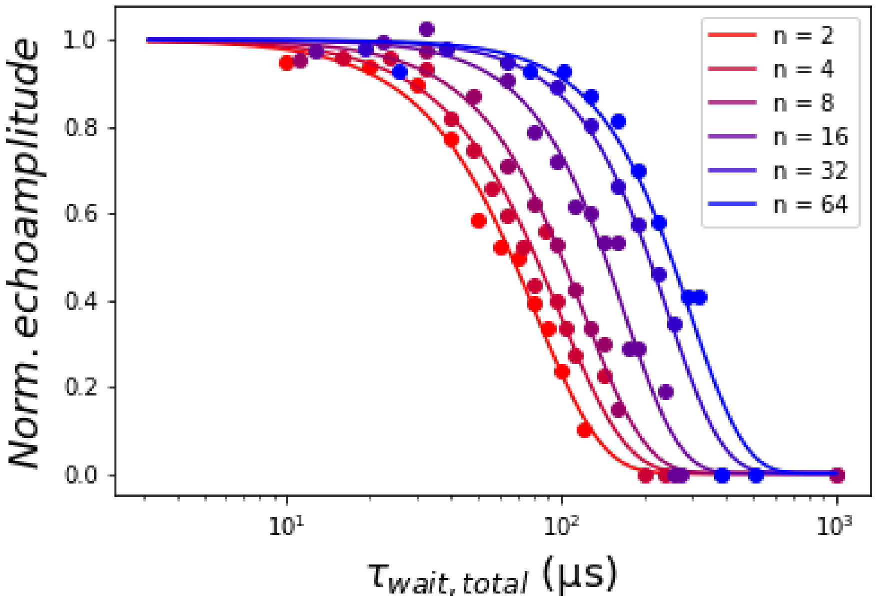
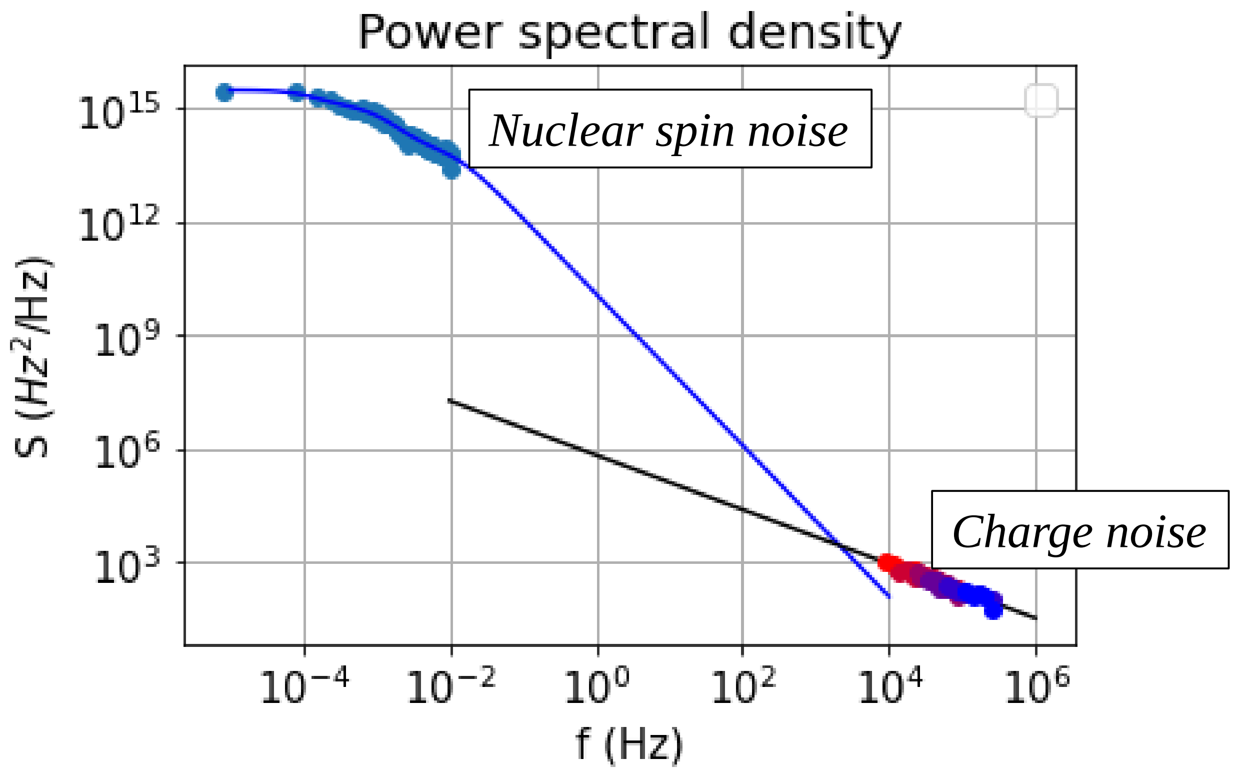
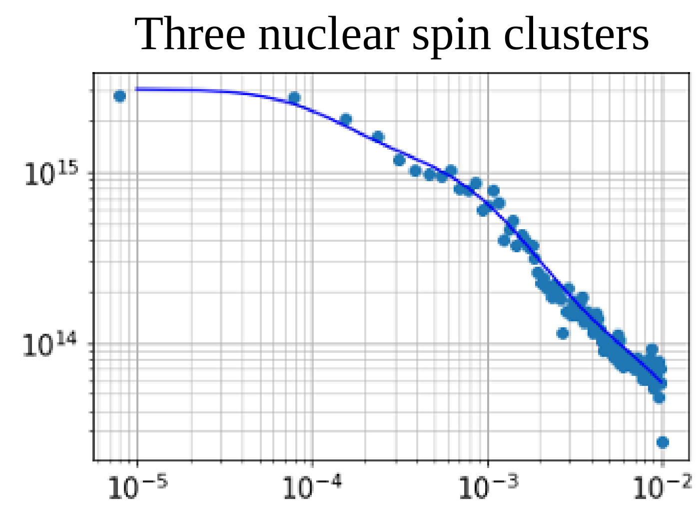
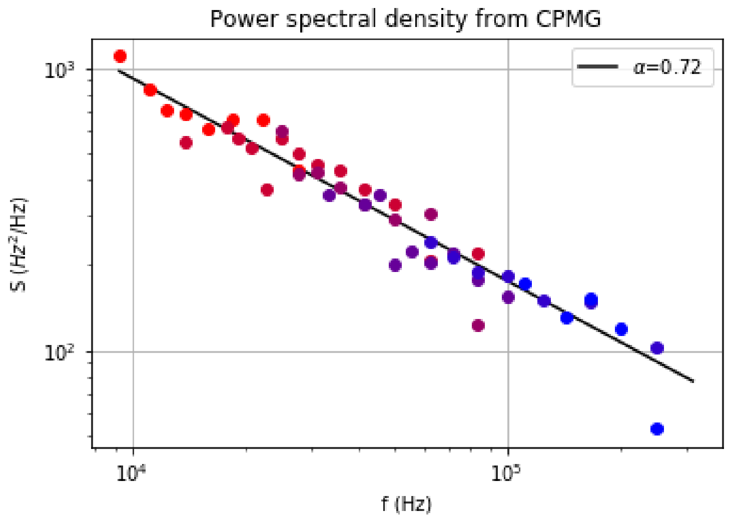


Coherence time extended from $T_2^* \approx 330$ ns to $T_2^{CPMG64} \approx 300$ μs

FDSOI nMOS device







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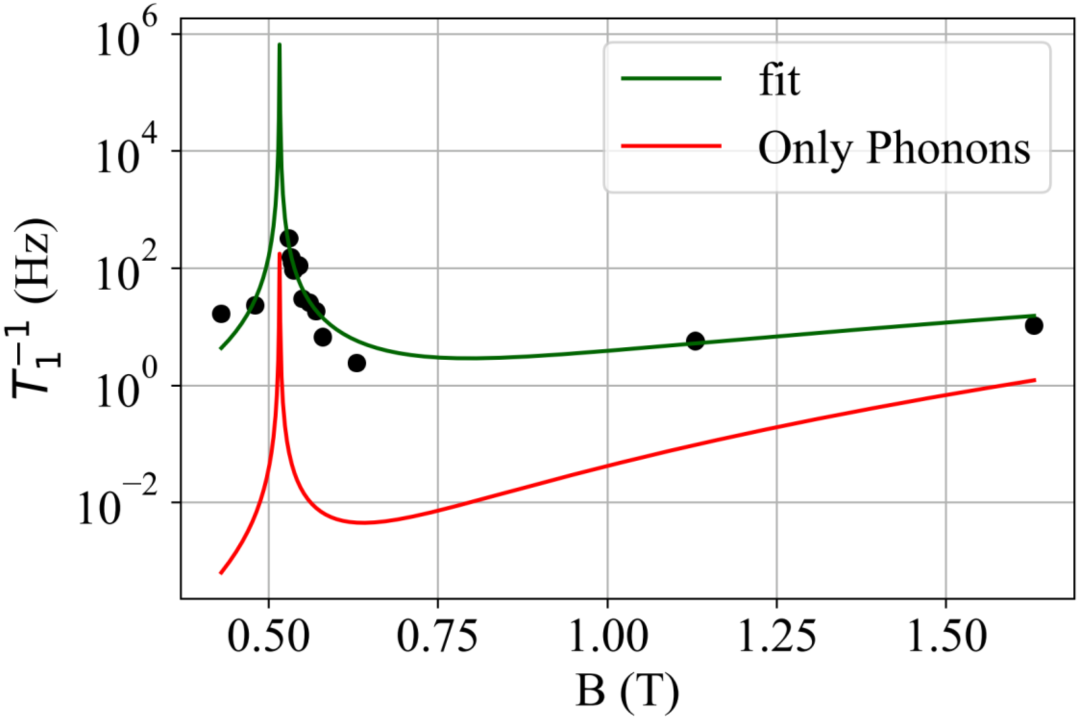
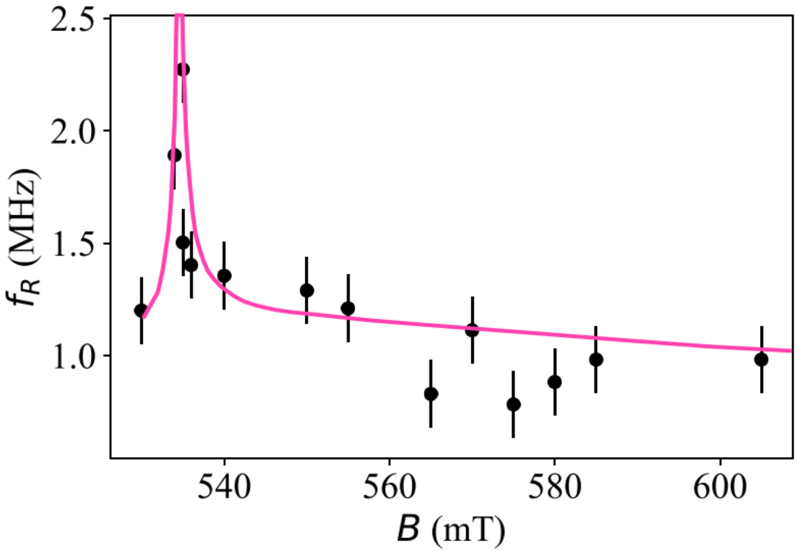
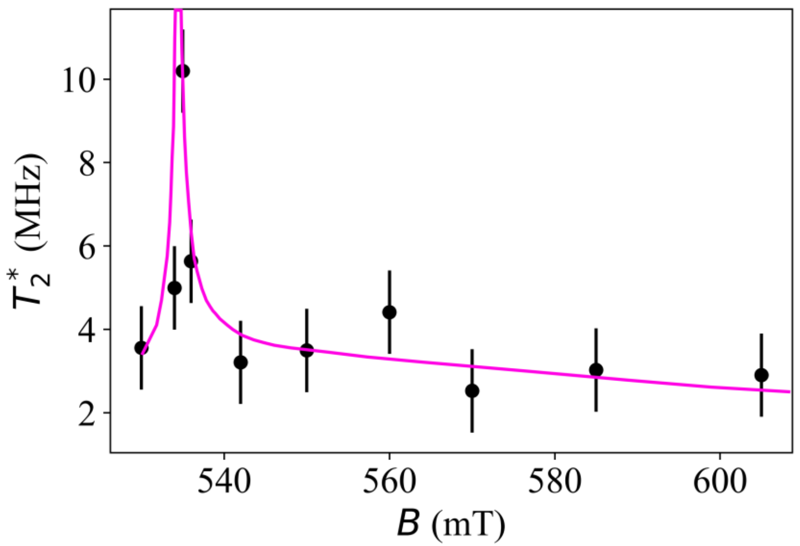
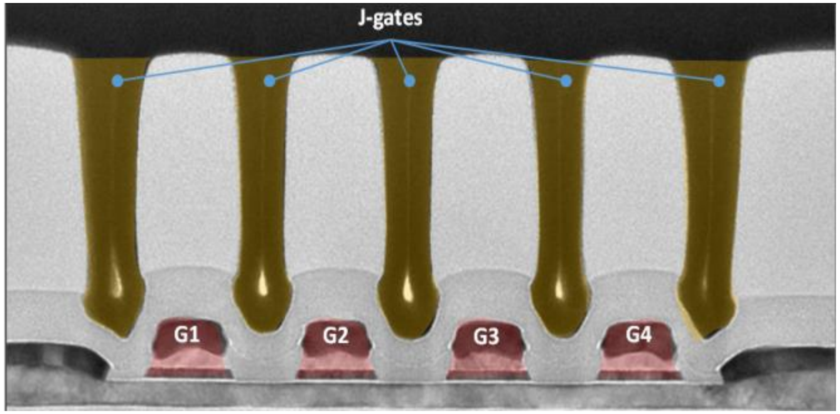






Outlook



Outlook

Deeper characterisation of fluctuator species

$$f_i = f_0 e^{-\frac{E_\alpha}{k_B T}}$$

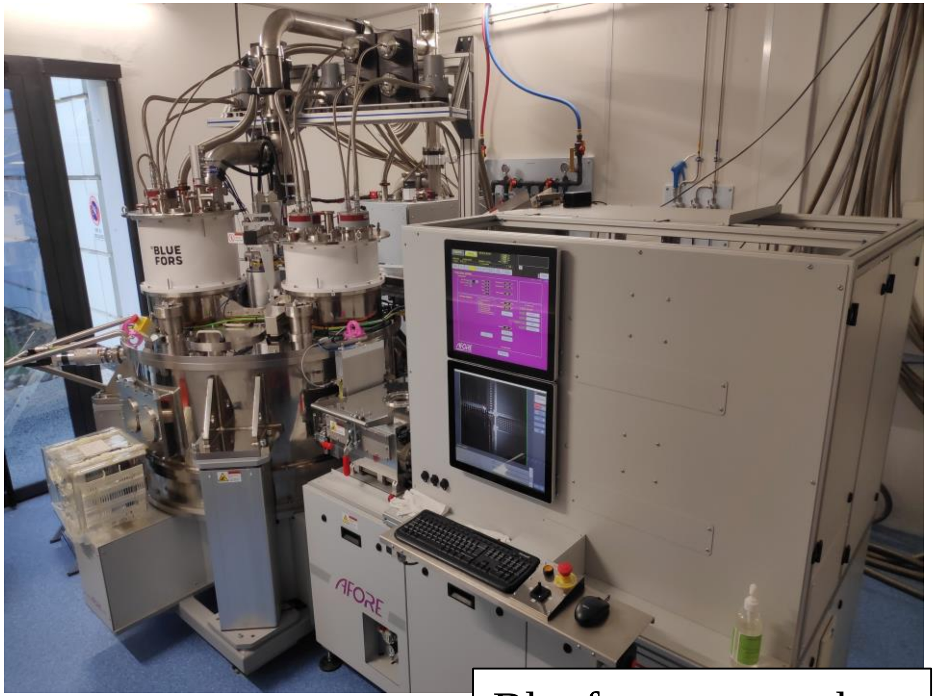
$$E_\alpha = k_B T \ln\left(\frac{f_i}{f_0}\right)$$

In-situ doped reservoir devices
- no implantation

Accumulation gate reservoirs
- no annealing

Mass characterization at < 2 K using cryo-prober (many-electron and few-electron regimes) on 300 mm wafers

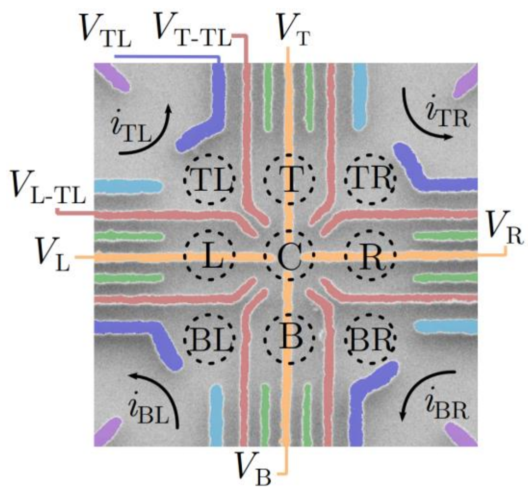
Move towards purified Si-28 wafers has promising implications for electron coherence

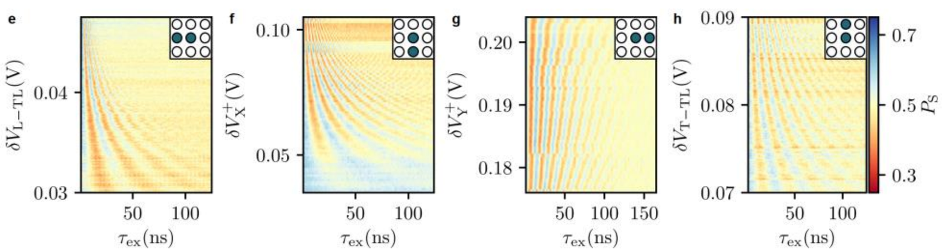


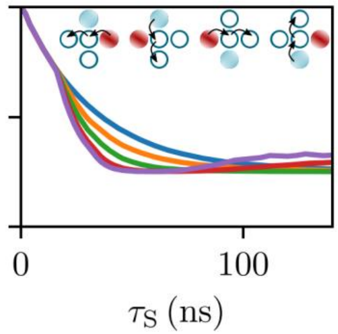
Bluefors cryo-prober

Spin qubits in semiconductors

Probing charge noise using motional narrowing

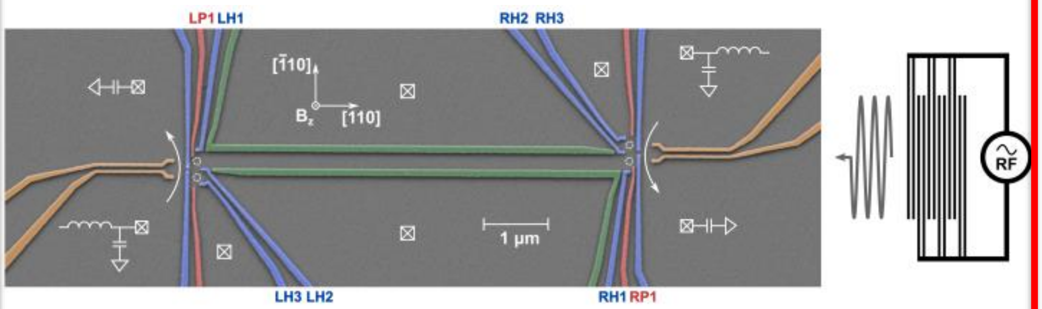


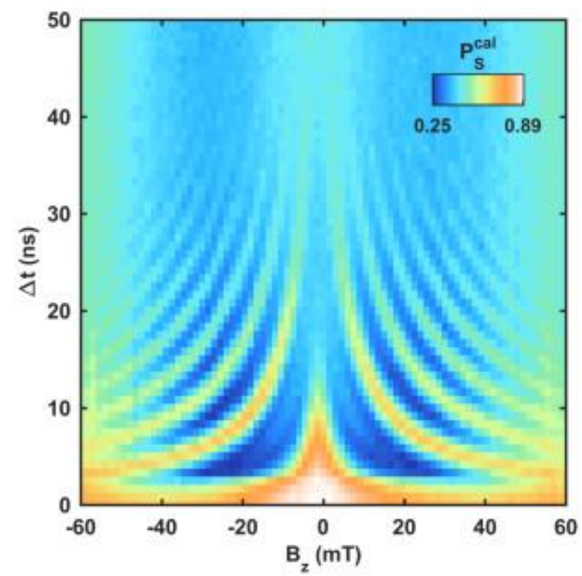




Mortemousque PRX Quantum 2, 030331 (2021)

Probing charge noise using
displacement-induced spin orbit coupling





Jadot Nat. Nanotechnol. 16, 570 (2021)

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