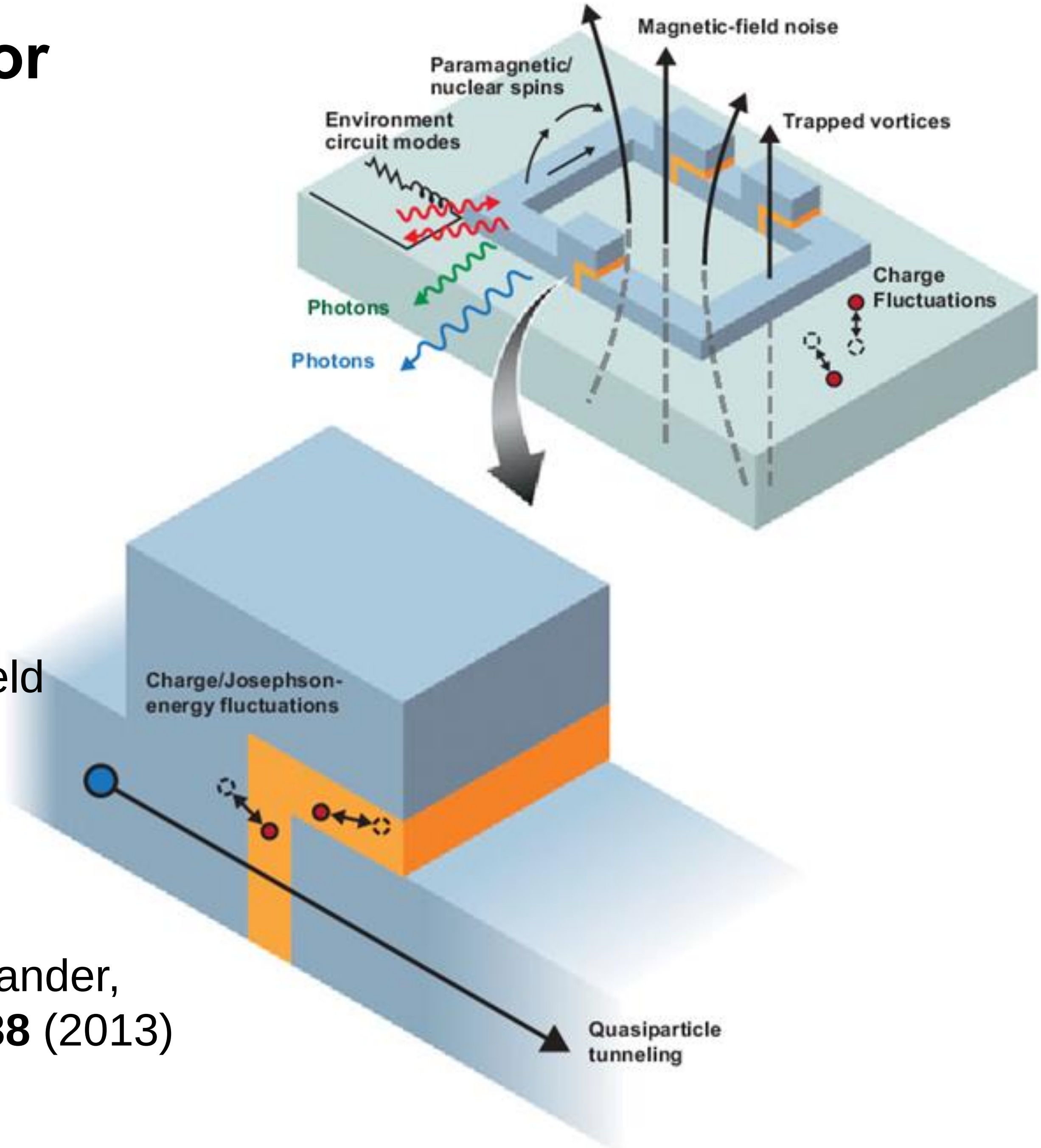
Achille’s heel for SC hardware: Decoherence

- Surface spins
- Dangling bonds
- Surface charges
- Parasitic uW modes
- Stray photons
- Stray phonons
- Trapped magnetic field
- Broken Cooper pairs
- etc.



Oliver and Welander, MRS bulletin, **38** (2013)

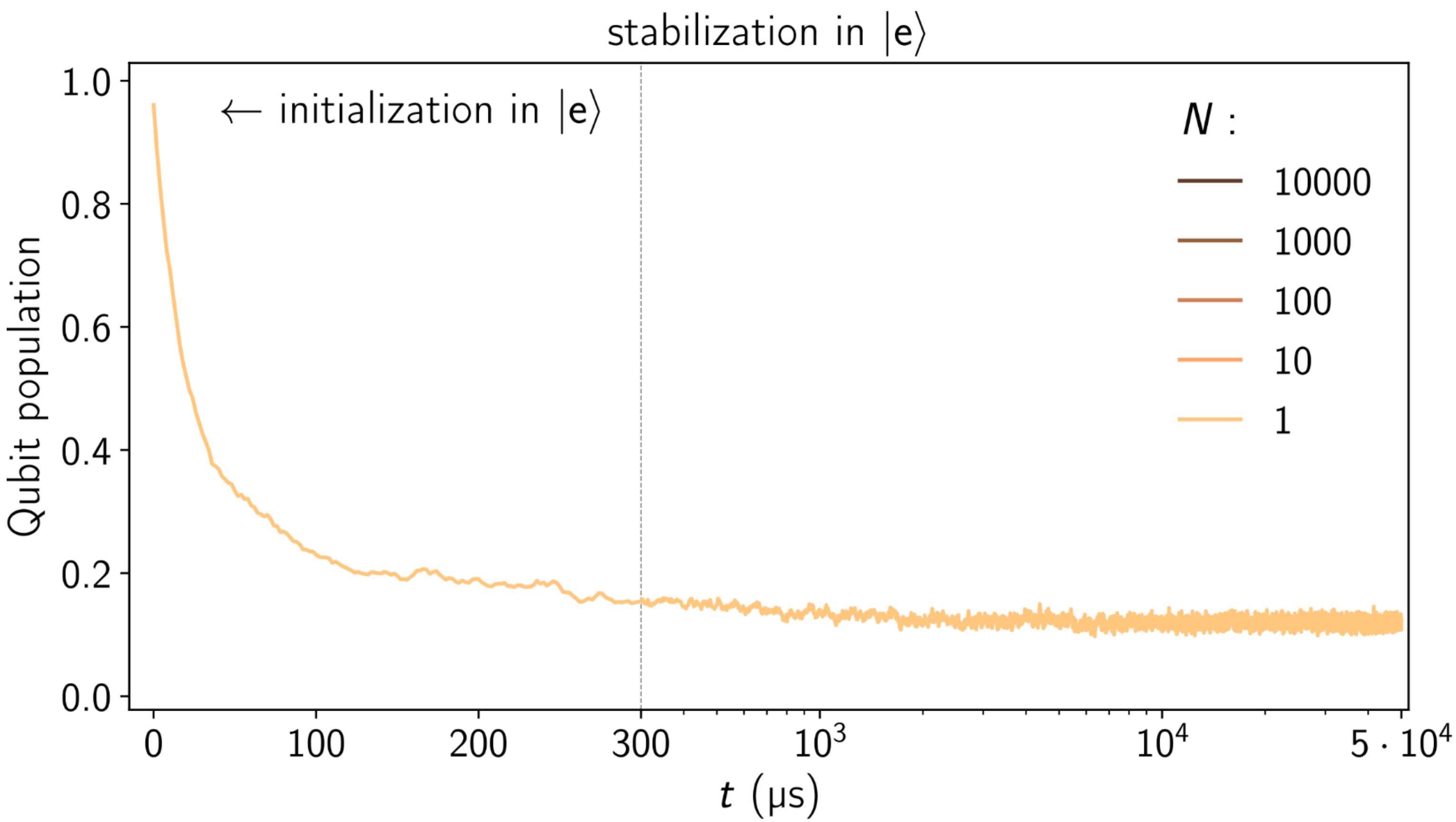
Calculating losses

$$\frac{1}{T_{1X}} = \frac{1}{\hbar^2}\left|\langle 0|\hat{C}|1\rangle\right|^2 \mathrm{Re}[Y_X(\omega_{01})]\hbar\omega_{01}\left[1+\coth\left(\frac{\hbar\omega_{01}}{2k_B T}\right)\right]$$

loss mechanism	$\langle 0\| \hat{C} \|1\rangle$	$\mathrm{Re}\left[Y_X(\omega_{01})\right]$
capacitive	$\Phi_0 \langle 0\| \hat{\varphi} \|1\rangle$	$\frac{\omega_{01} C}{Q_{cap}}$
inductive	$\Phi_0 \langle 0\| \hat{\varphi} \|1\rangle$	$\frac{1}{\omega_{01} L Q_{ind}}$
quasiparticle	$\langle 0\| \sin(\hat{\varphi}/2) \|1\rangle$	$\frac{G_t}{2Q_{qp}}\left(\frac{2\Delta}{\hbar\omega_{01}}\right)^{3/2}$
radiative (Purcell)	$\Phi_0 \langle 0\| \hat{\varphi} \|1\rangle$	HFSS numerical simulations

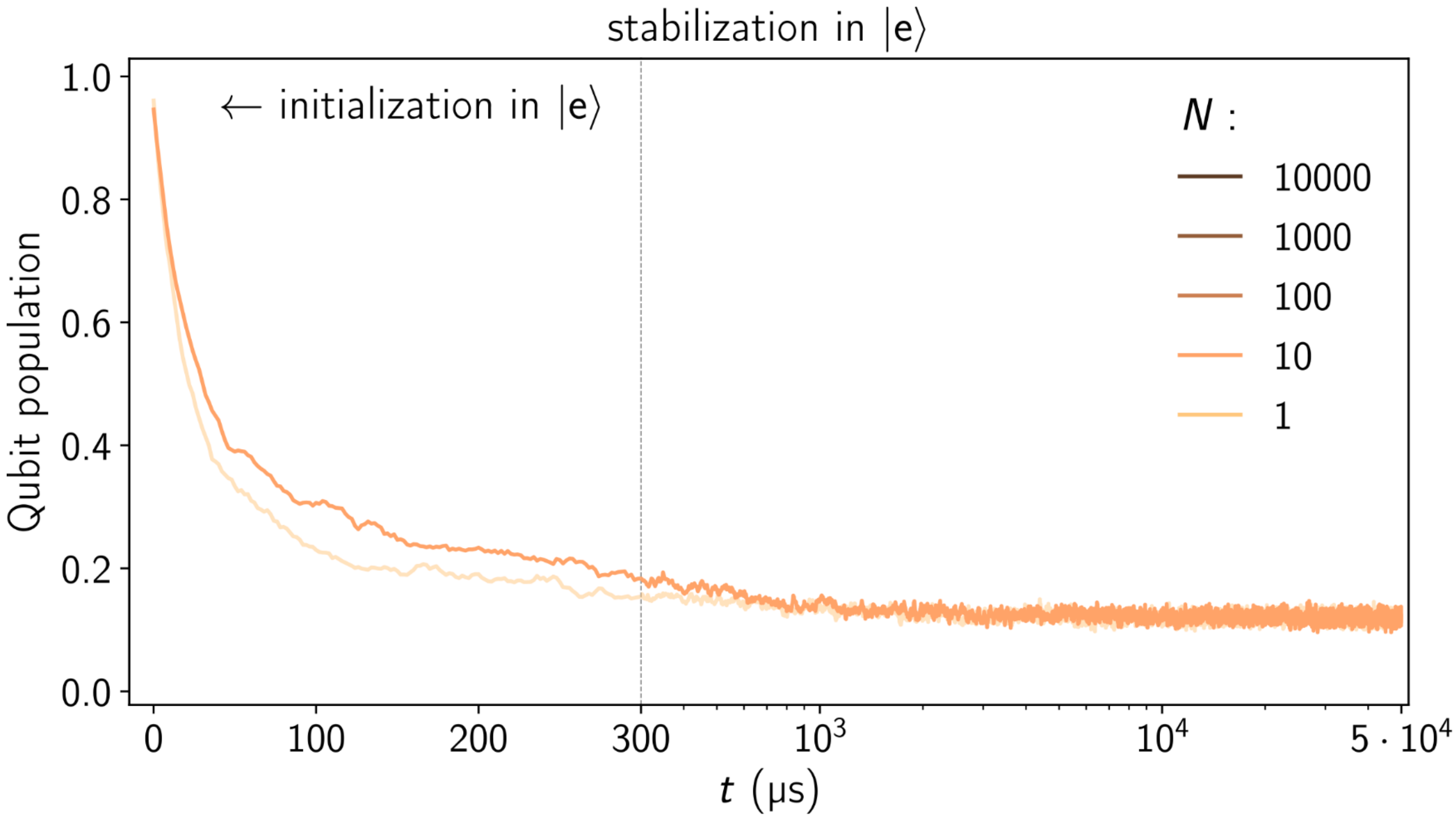
Schoelkopf et al. Quantum Noise in Mesoscopic Physics (2002)
Catelani et al. Decoherence of superconducting qubits caused by quasiparticle tunneling (2012)

Qubit relaxation after TLS environment polarization



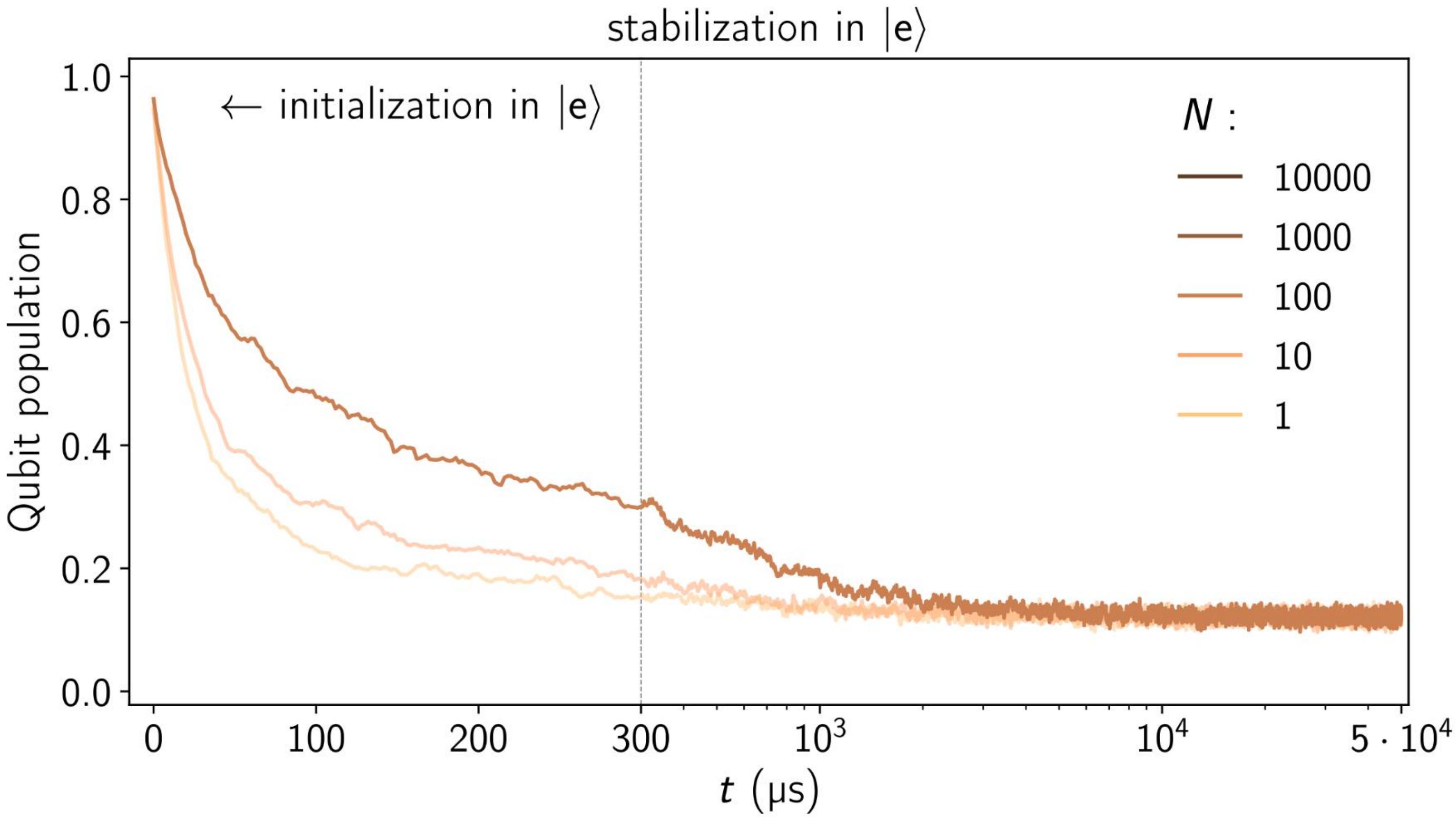
Spiecker et al. Nature Phys. 2023

Qubit relaxation after TLS environment polarization



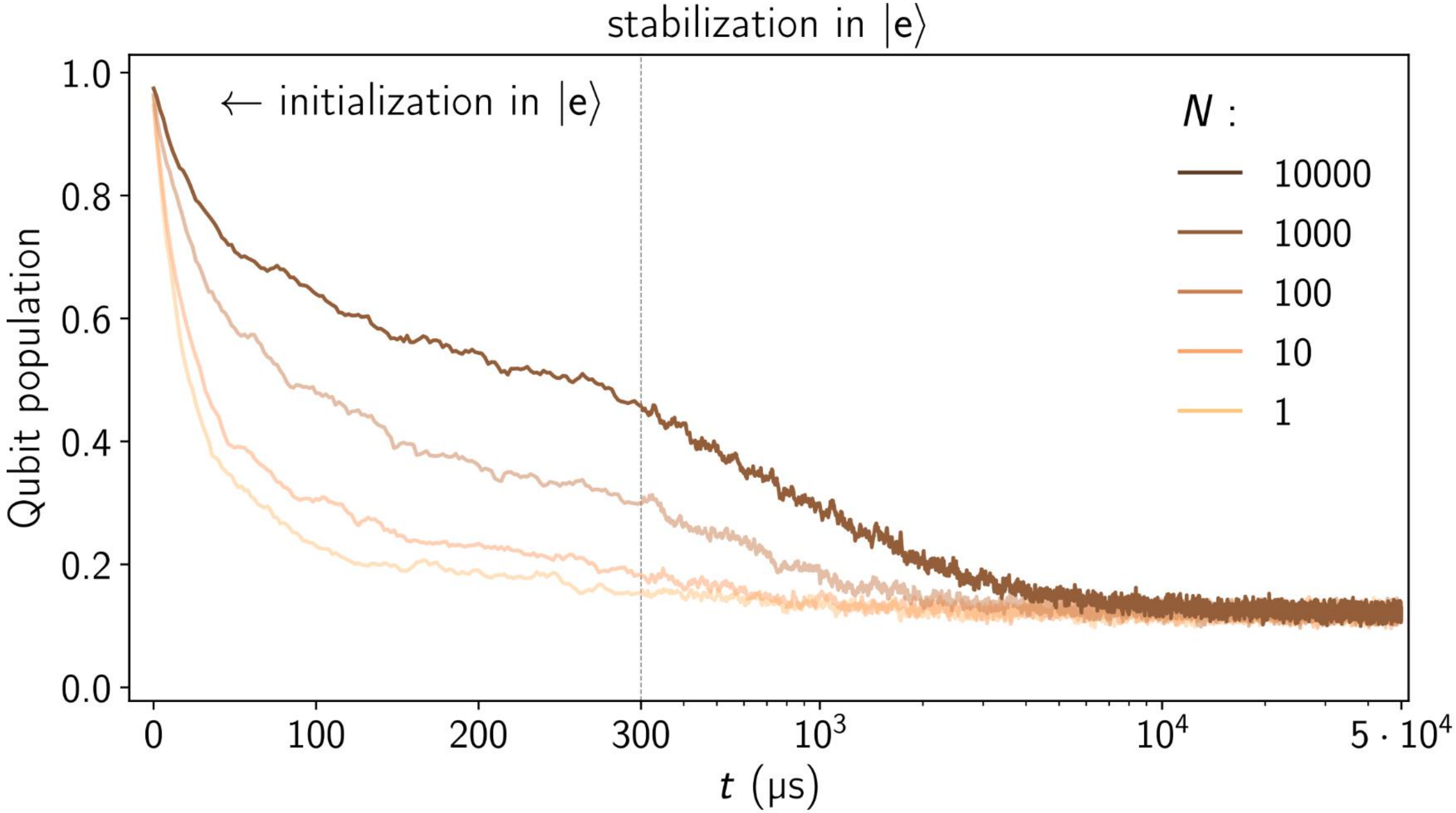
Spiecker et al. Nature Phys. 2023

Qubit relaxation after TLS environment polarization



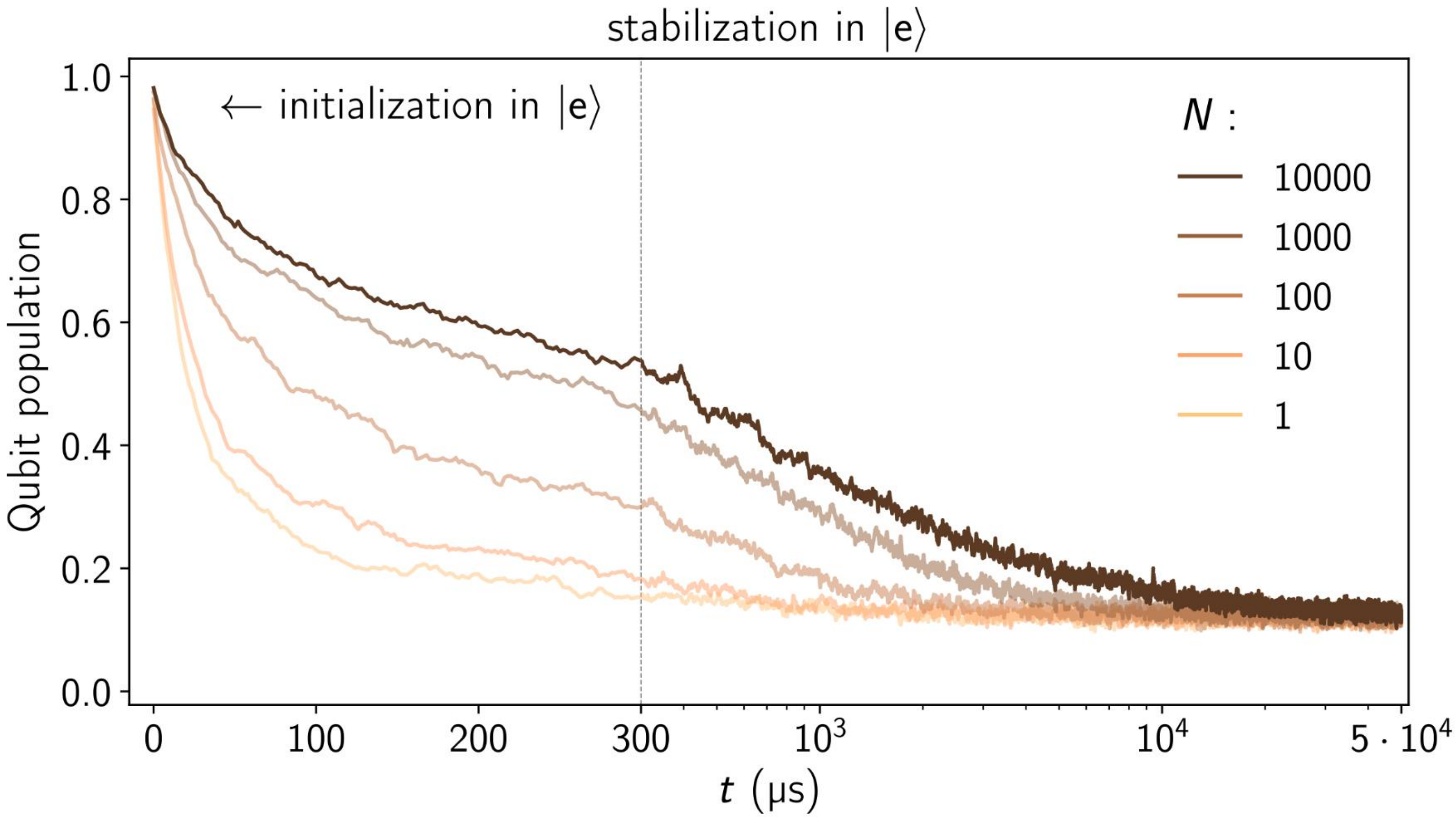
Spiecker et al. Nature Phys. 2023

Qubit relaxation after TLS environment polarization



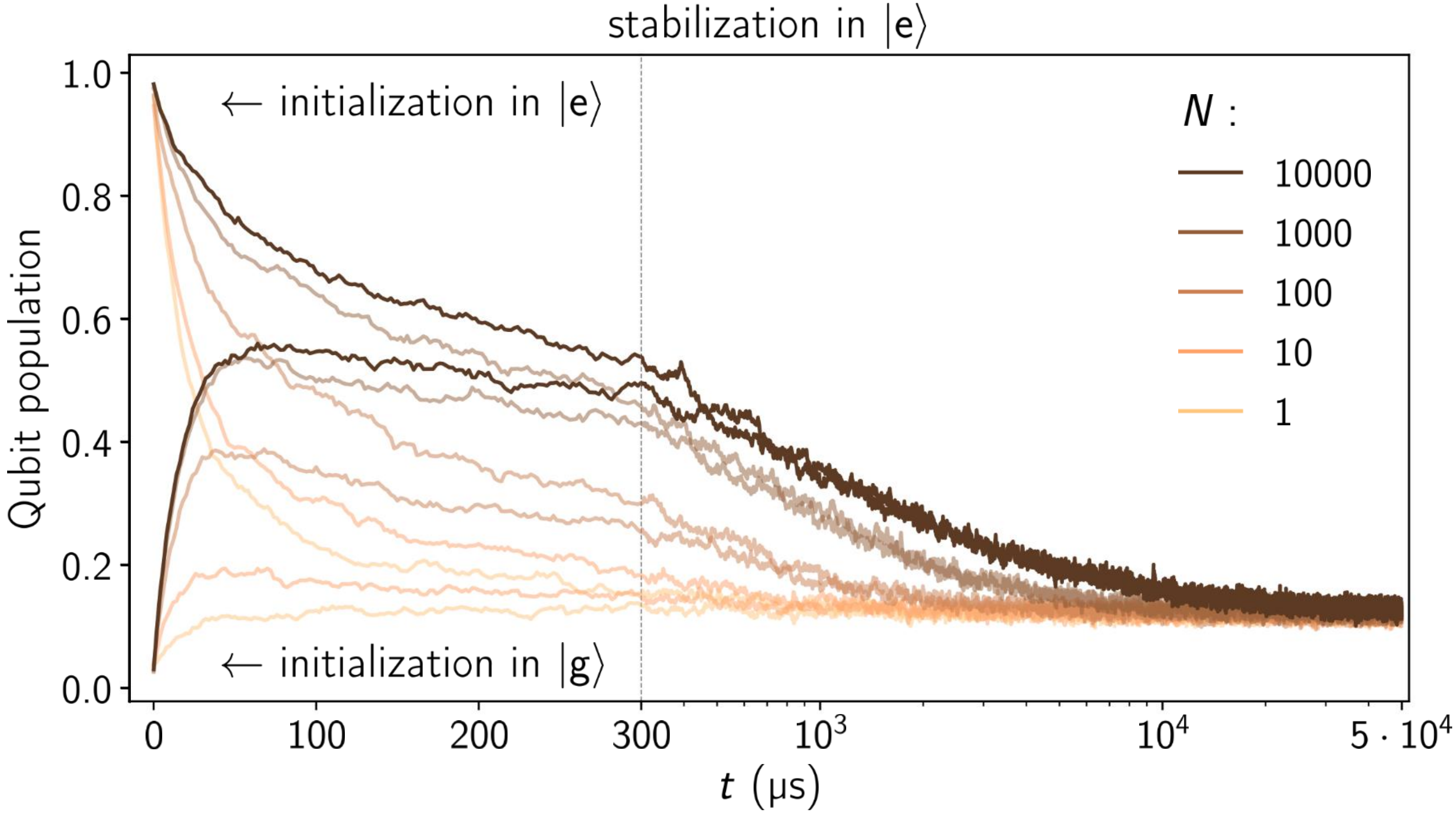
Spiecker et al. Nature Phys. 2023

Qubit relaxation after TLS environment polarization



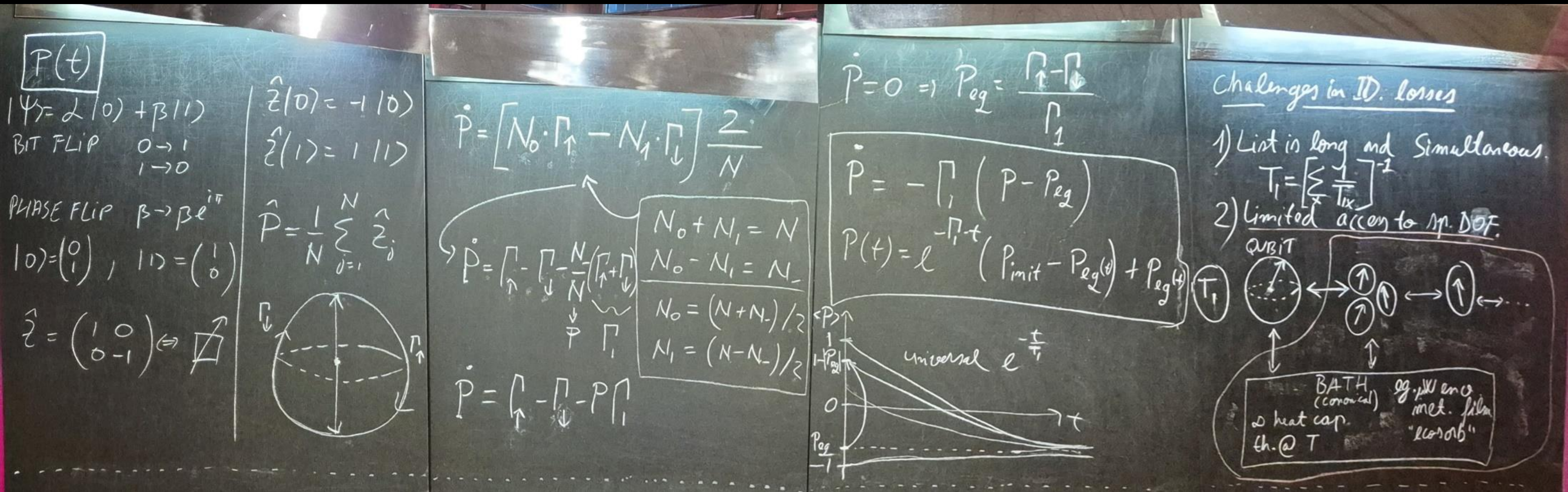
Spiecker et al. Nature Phys. 2023

Qubit relaxation after TLS environment polarization



Spiecker et al. Nature Phys. 2023
Spiecker et al. Phys Rev A 2024

The Board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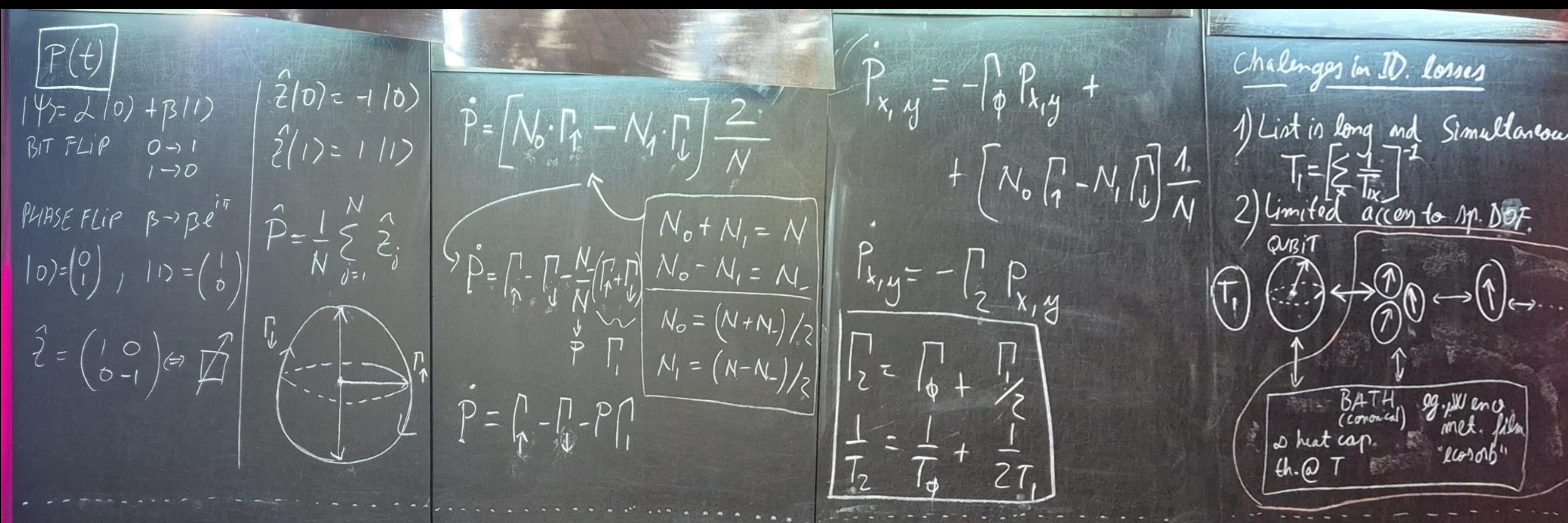
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