Decoherence Suppression of a Solid State Qubit Using Uncollapsing

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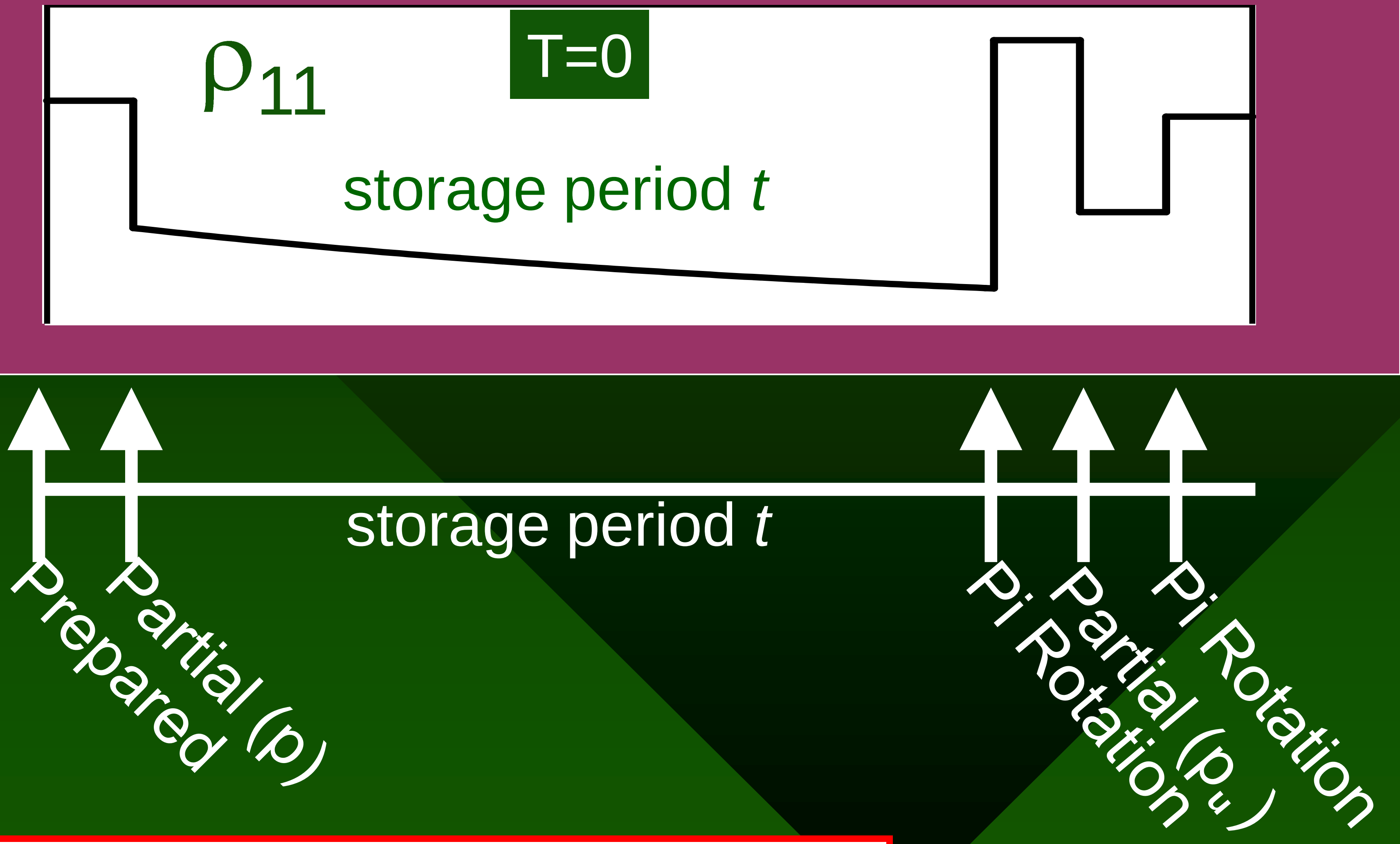
I A R P A

Other Proposed Methods

- Quantum Error Correcting Codes
  – Complicated and Resource Hungry
- Decoherence-Free Subspace
  – Complicated and Resource Hungry
- Dynamical Decoupling
  – Does Not Protect Against Markovian Processes

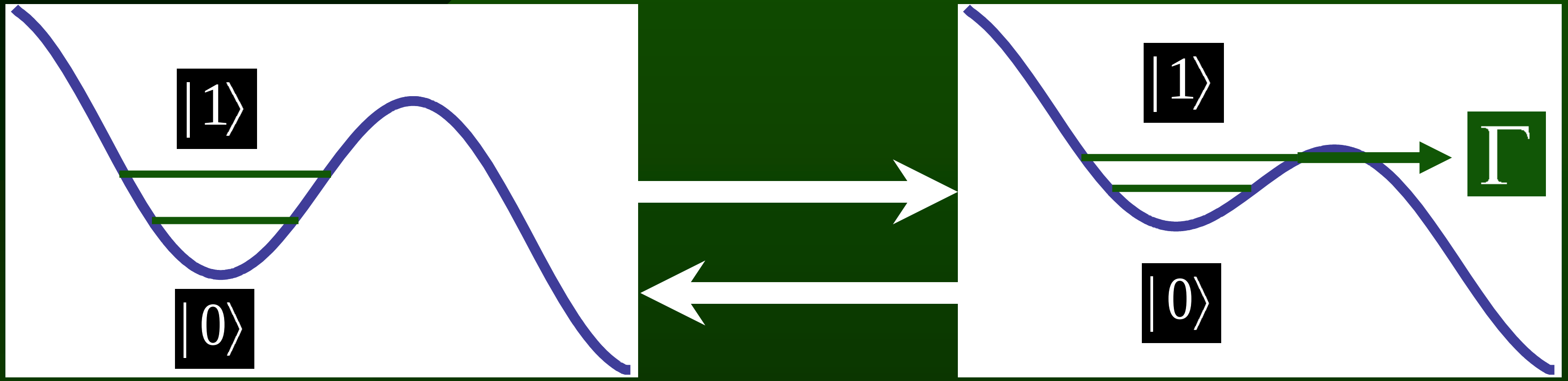
Our Method: Phase Qubit

Protocol:



almost the same as existing experiment!

Phase Qubit:
Partial ***M***easurement (PM)



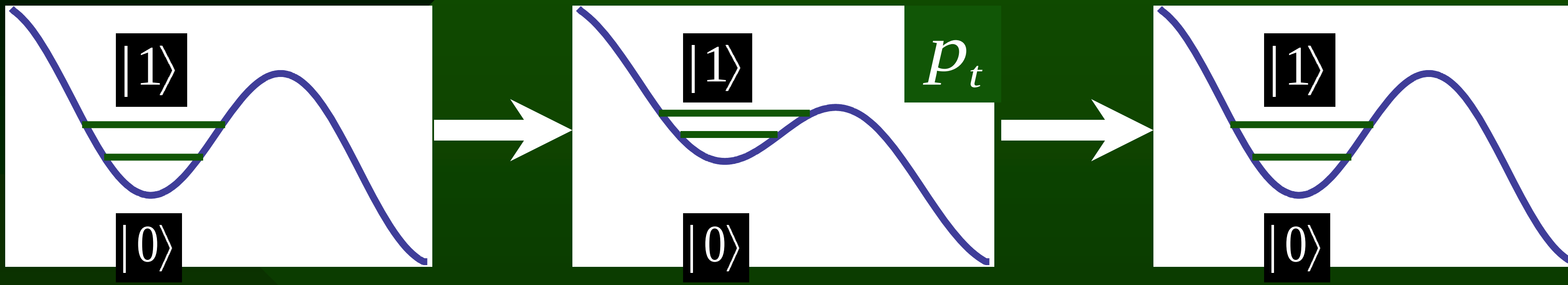
Bloch Equations

$$\frac{\partial}{\partial t}\rho_{1,1}(t) = -\Gamma\rho_{1,1}(t)$$

$$P_{T^C|1}(t) = e^{-\Gamma t} \equiv 1 - p_t(t)$$

$$P_{T^C}(t) = \rho_{0,0}(0) + [1 - p_t(t)]\rho_{1,1}(0)$$

Phase Qubit: Effect of ***N***ull ***R***esult ***P***artial ***M***easurement (NRPM)



$$\psi_0 = \alpha|0\rangle + \beta|1\rangle \rightarrow \psi_{pm1} = \frac{\alpha}{\mathrm{P}}|0\rangle + \frac{\beta\sqrt{1-p_t}}{\mathrm{P}}|1\rangle$$

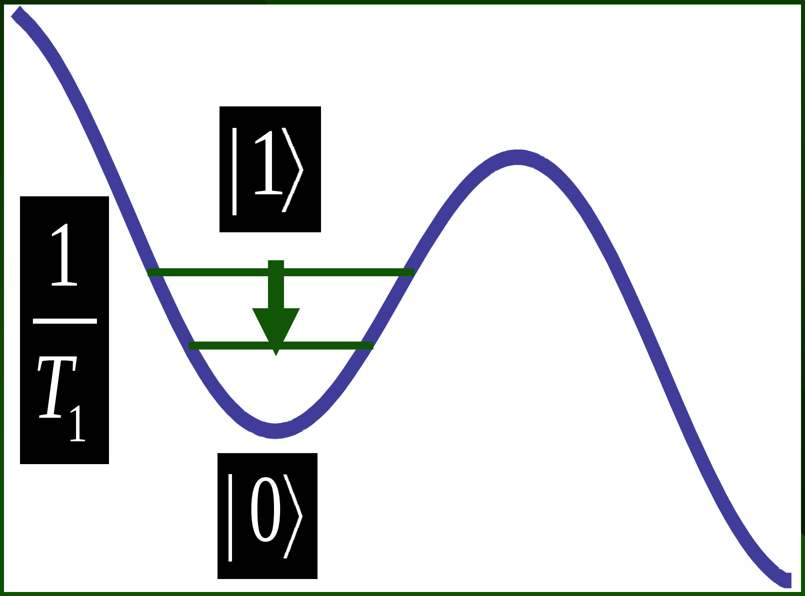
The NRPM reduces the probability that the qubit is in state $|1\rangle$ after the NRPM is complete

$$\frac{\alpha}{\mathrm{P}} > \alpha \qquad \frac{\beta\sqrt{1-p_t}}{\mathrm{P}} < \beta$$

$$\mathrm{P} \equiv \sqrt{|\alpha|^2 + |\beta|^2(1-p)}$$

ZTER:
*Z*ero *T*emp *E*nergy *R*elaxation

$$\frac{\partial}{\partial t}\rho_{1,1}(t) = -\frac{\rho_{1,1}(t)}{T_1} \rightarrow P_{R^C|1}(t) = e^{-t/T_1} \equiv 1 - p_r(t)$$



Relaxation Probability

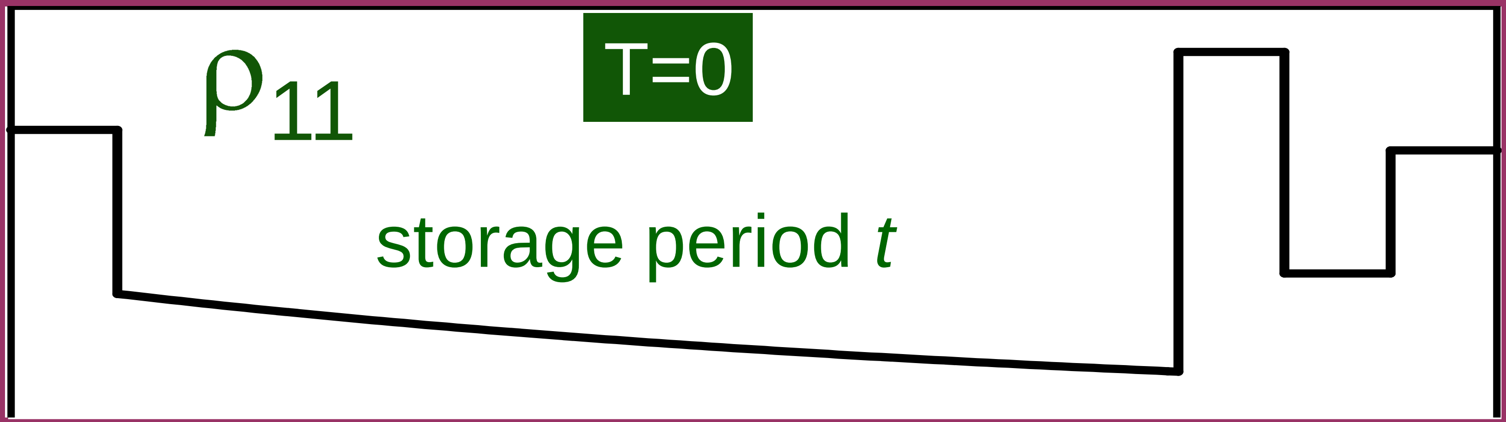
$$P_R(t) = P_{R|1}(t)\rho_{1,1}(0)$$

$$P_R(t) = p_r(t)\rho_{1,1}(0)$$

The probability that a qubit relaxes during a ZTER period is proportional to the probability that it was in state $|1\rangle$ at the beginning of the ZTER period

Phase Qubit: Intuitive Understanding

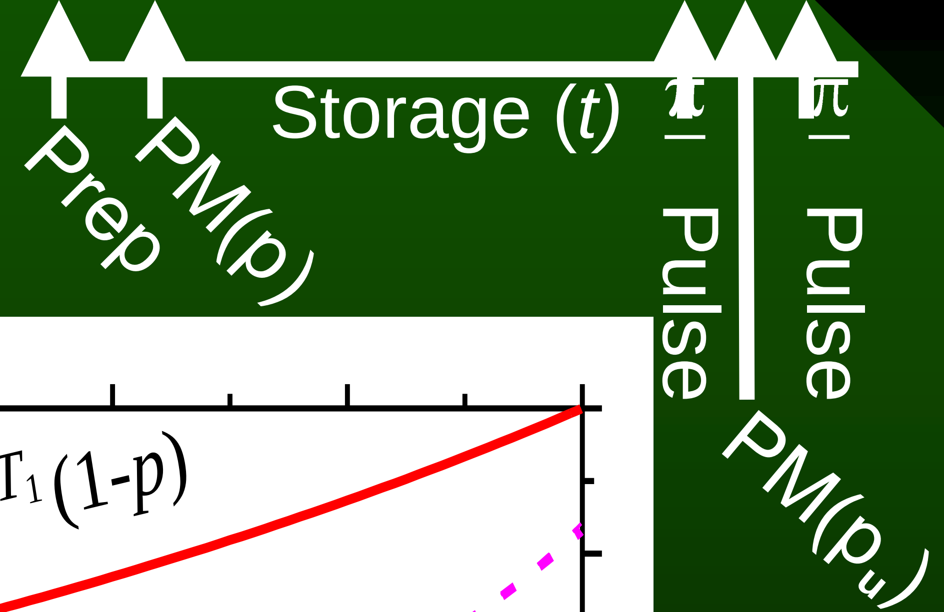
Protocol:

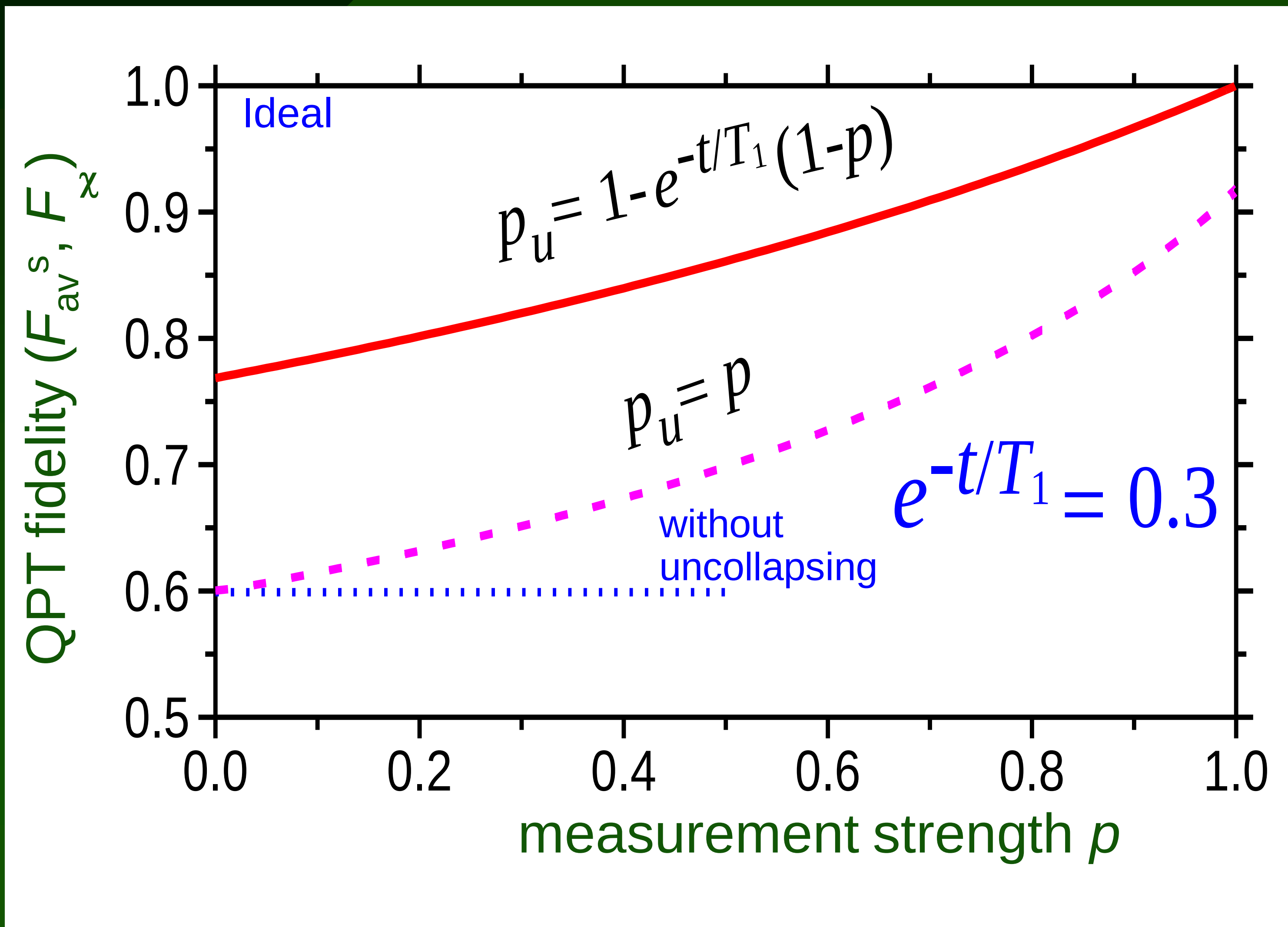


The first PM reduces the probability that the qubit is in state $|1\rangle$ after the PM is complete

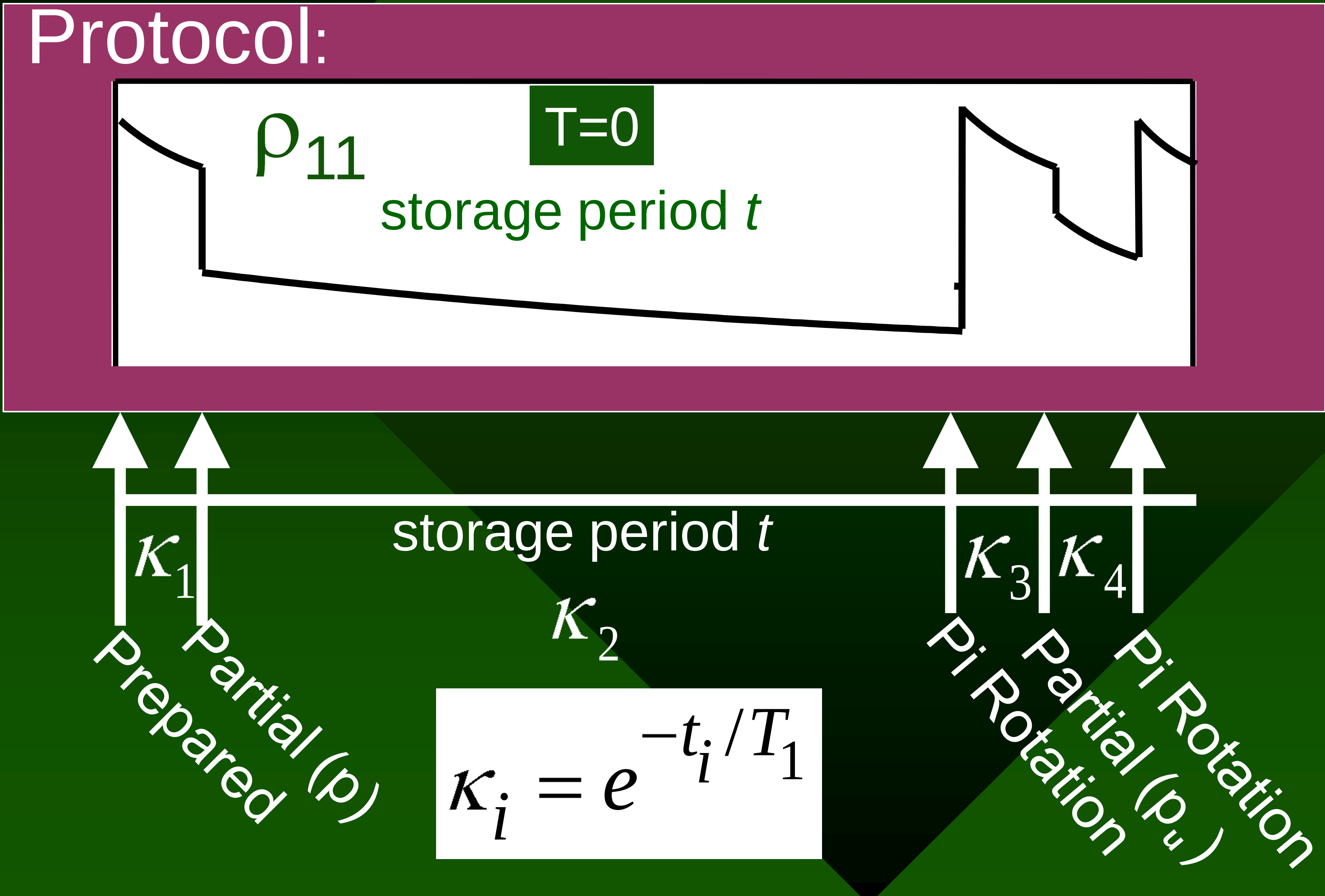
The probability that the qubit relaxes during the storage period is proportional to the probability that it was in state $|1\rangle$ at the beginning of the storage

Results
Ideal Operations



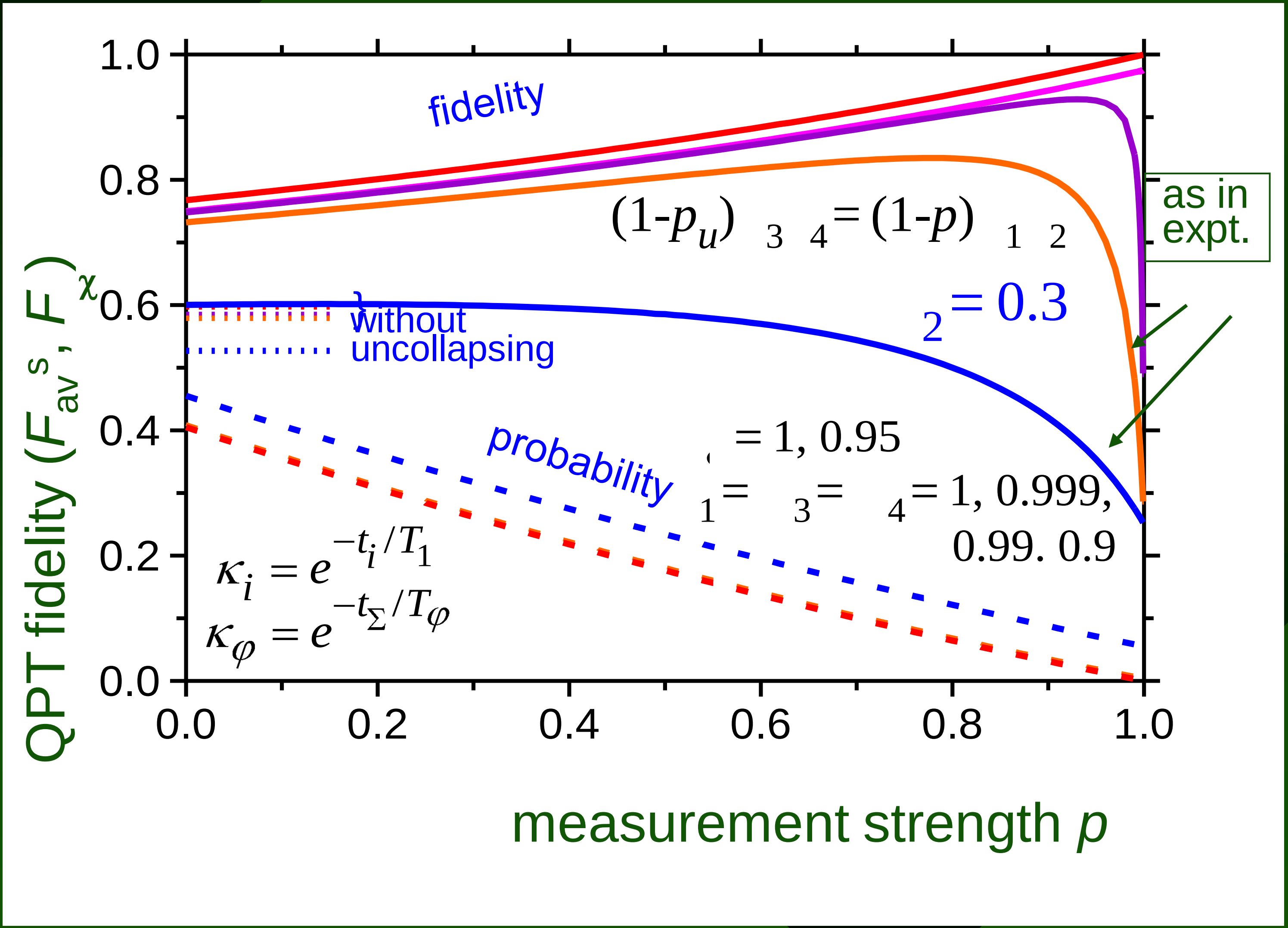


Non-Ideal Operations



$$\kappa_i = e^{-t_i/T_1}$$

Results
Non-Ideal Operations



Conclusions

Decoherence Suppression by Uncollapsing:

- Requires ***NO*** Extra Resources
- Protects Against Markovian Processes
- Works Even With Non-Ideal Operations
- Can Be Experimentally Realized With a Very Simple Extension of a Previous Experiment