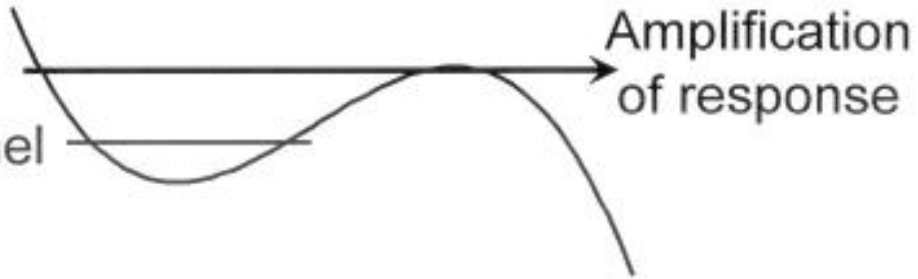
Dissipative Readout

(ionization of atom depends on state)

Current pulse:

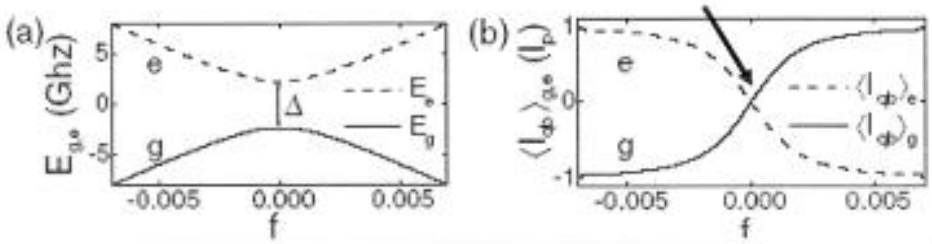
|1> : tunnel

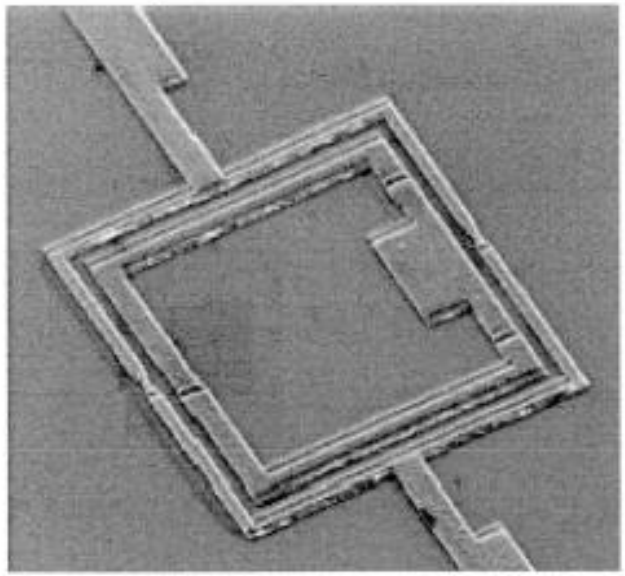
|0> : no tunnel



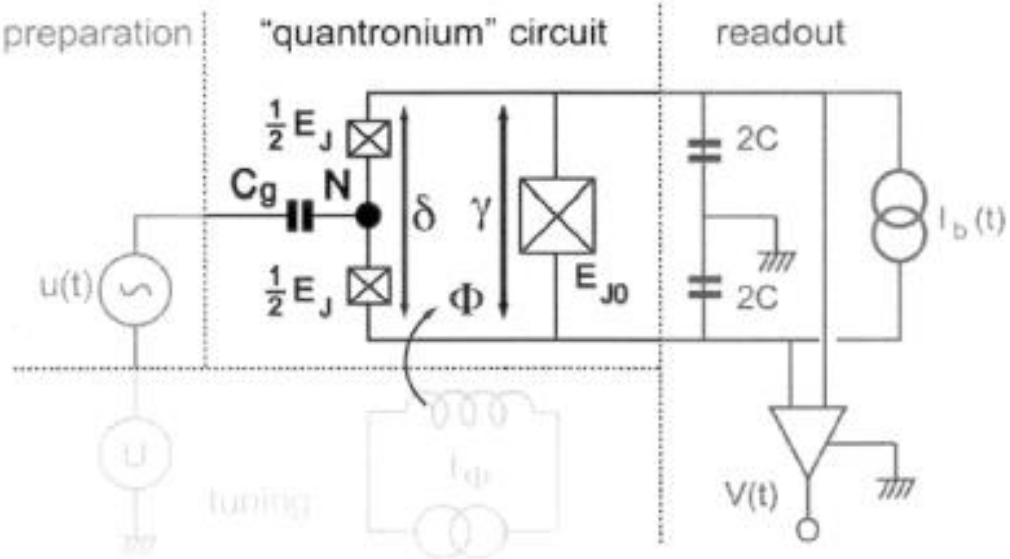
Flux Qubit:

No change in circulating current





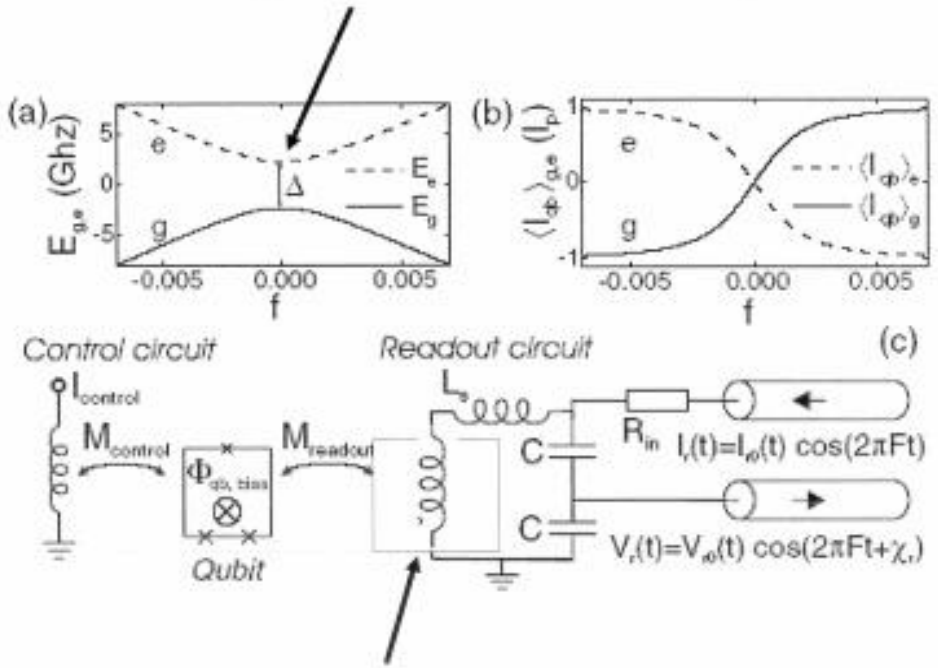
Charge Qubit:



Dispersive Readout : Delft Flux Qubit

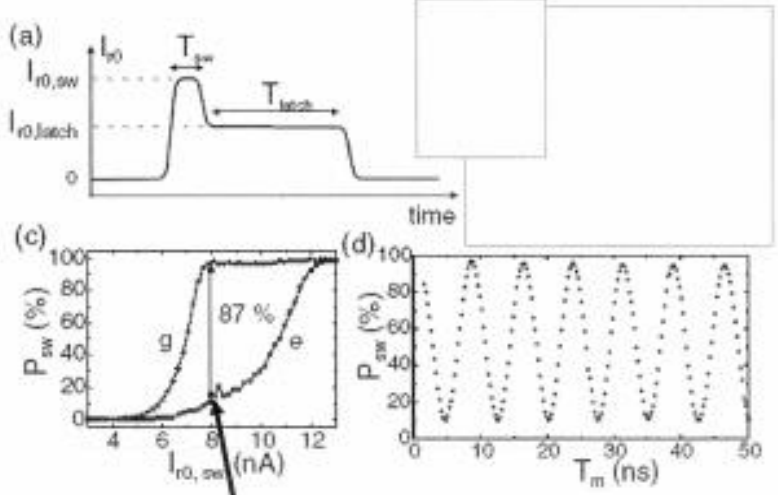
(Reflection of light depends on state)

Change in inductance of qubit



Change in LC resonance frequency

(+ non-linear amplification)



Good fidelity of readout

(+ projection of state)

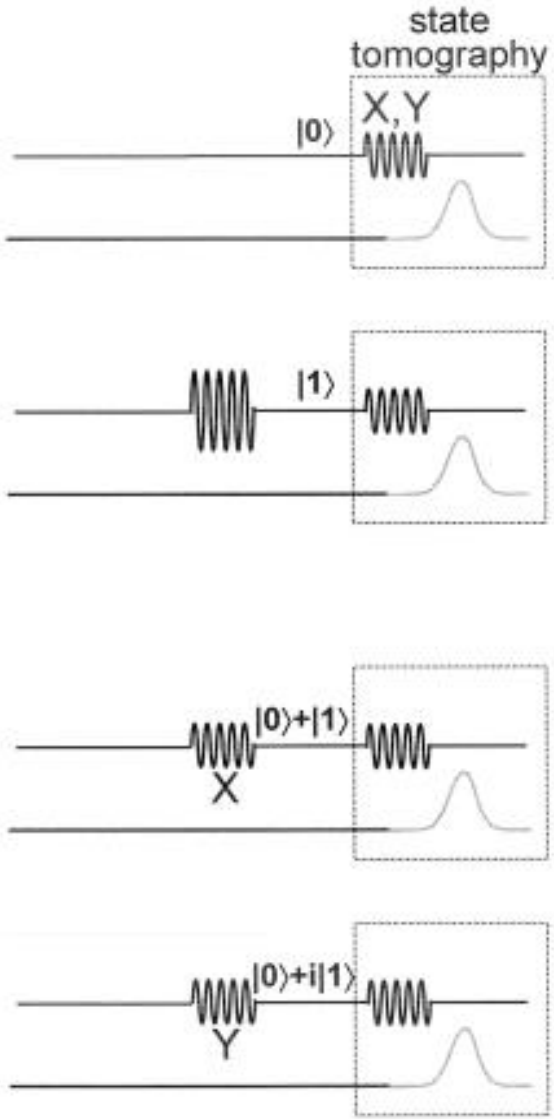
Measurement: Summary

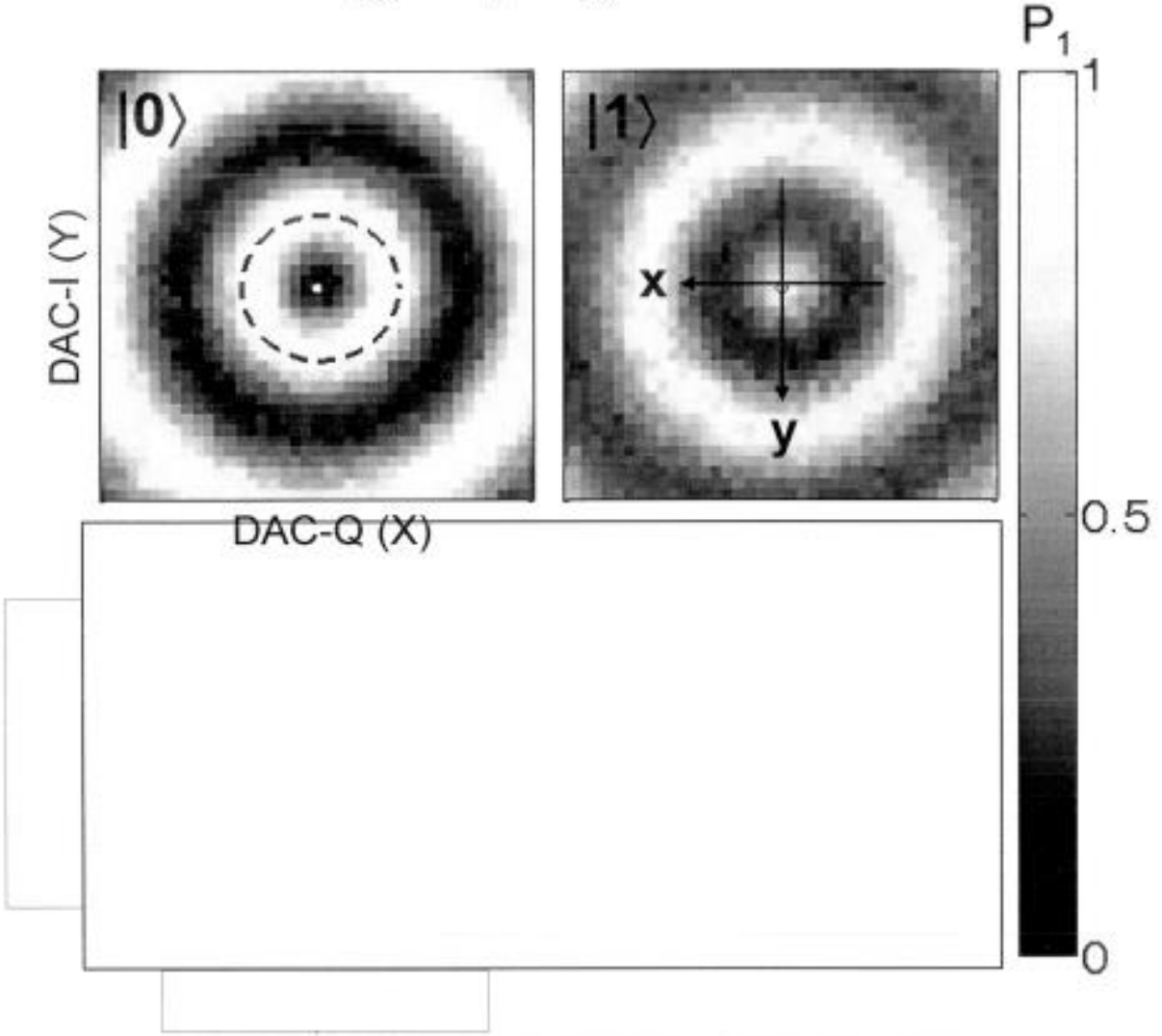
- Be aware, most exp's have lousy fidelity of meas! (10%-50% common)
- Dispersive def. better for degen. pt.
- Dispersive gives proj of state into $|0\rangle$ or $|1\rangle$ after meas.
  (Dissip only to $|0\rangle$)

  This allows "recycling of qubits"
  (+ Prevents Global warming of chips from dissip msmt)
- What is much more important is fidelity of measurement?

  Not sure what is best yet.

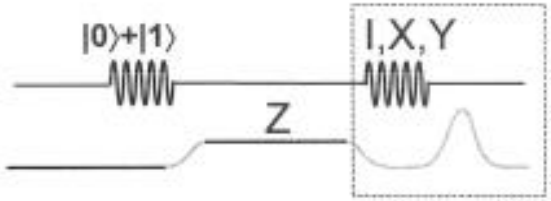
State Tomography

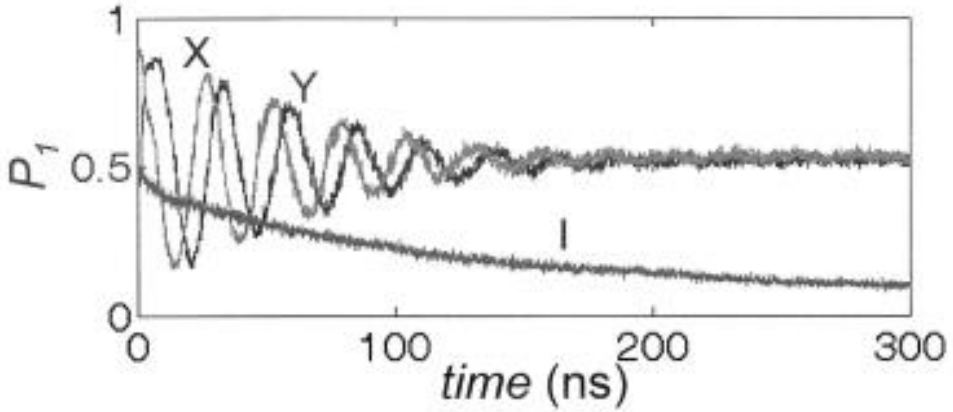


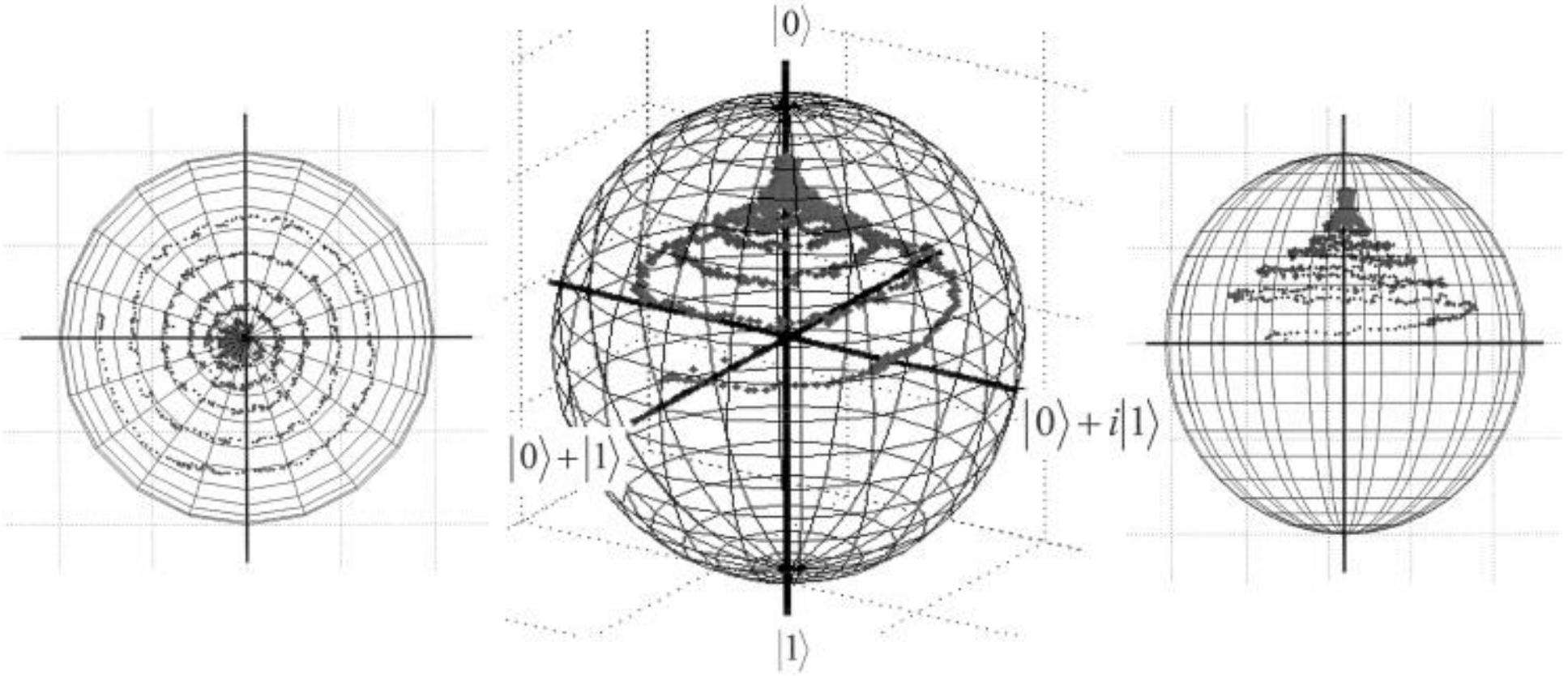


- Good agreement with QM
- Peak position gives state (θ,ϕ), amplitude gives coherence

Standard State Tomography (I,X,Y)





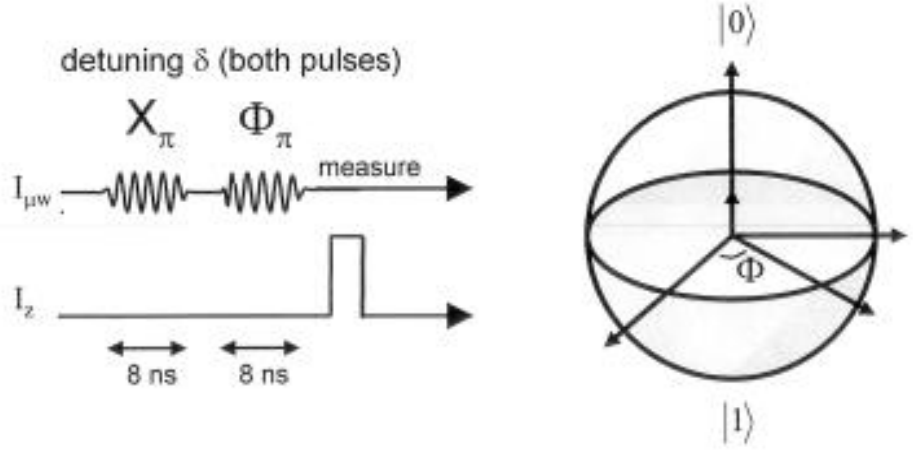


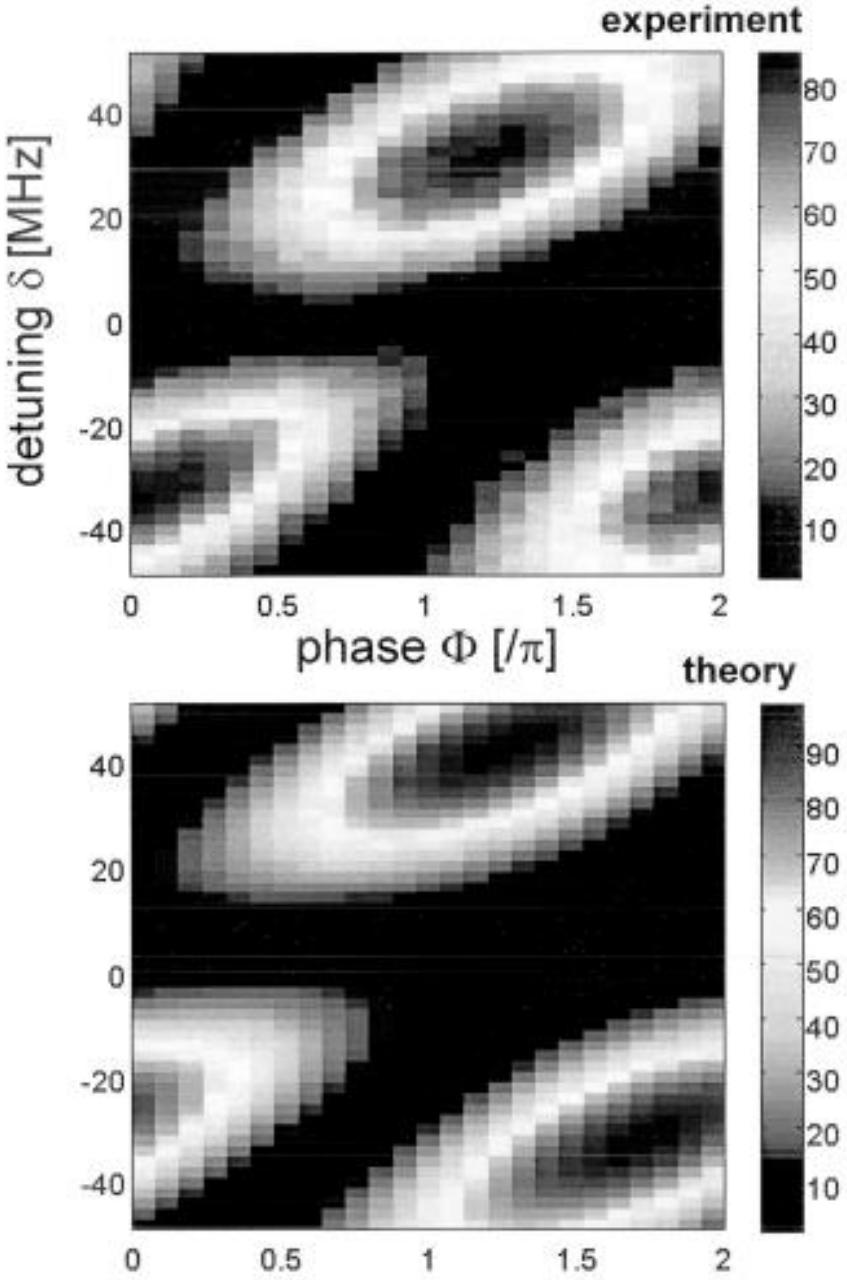
Single-Qubit Gate Errors: Tomography Check

Goal:
Measure fidelity of pi-pulse (longest single-qubit gate) *separately from measurement errors.*

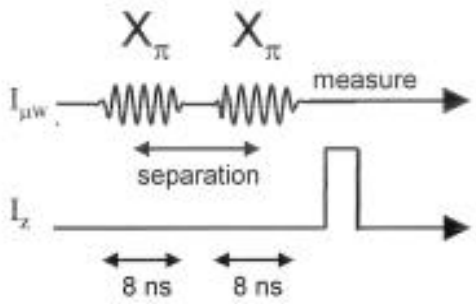
Idea:
Two pi-pulses bring state back to |0>, where the *only measurement error is stray tunneling.* Remaining error is due to pi-pulses only.

Tomography Check:
On resonance, phase of second pulse has no effect, as expected for pi-pulses.

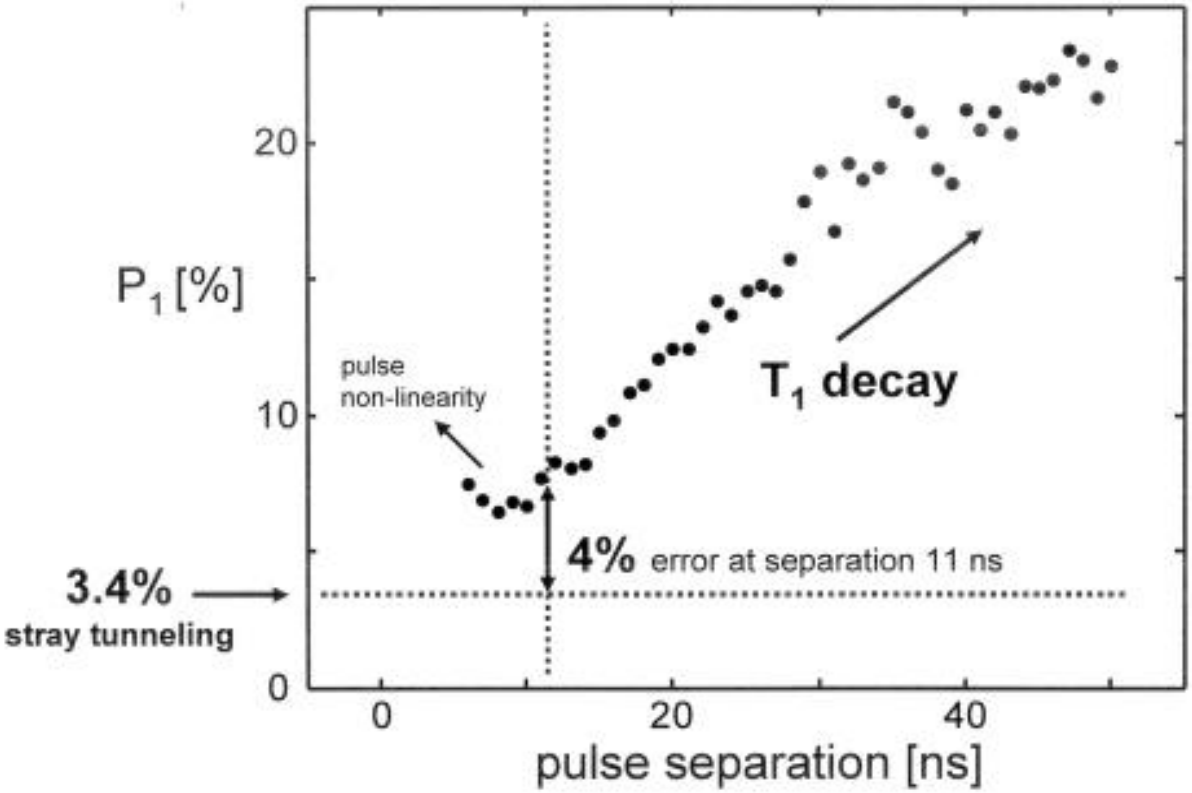




Single-Qubit Gate Errors: Limited by T_1



Vary the time between pi pulses to separate gate fidelity from decoherence due to T1 decay.



double - π error:

4%

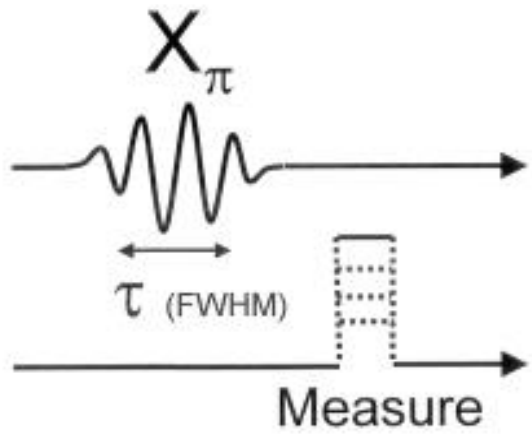
single-qubit gate fidelity:

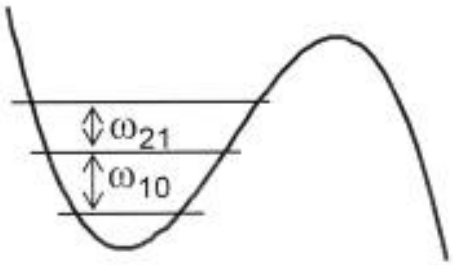
98%

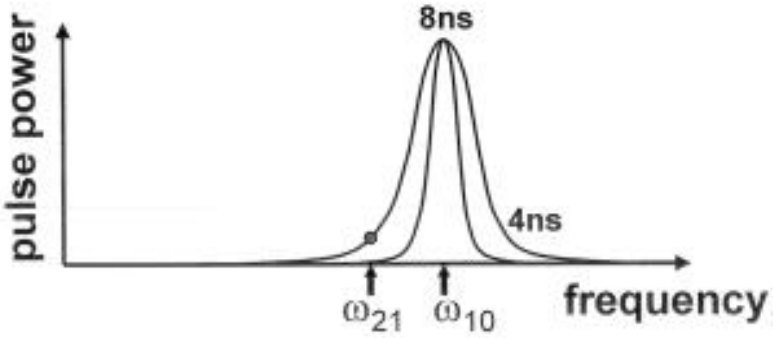
(limited by T_1)

Direct measure of probability
Checks on measurement & π-gates

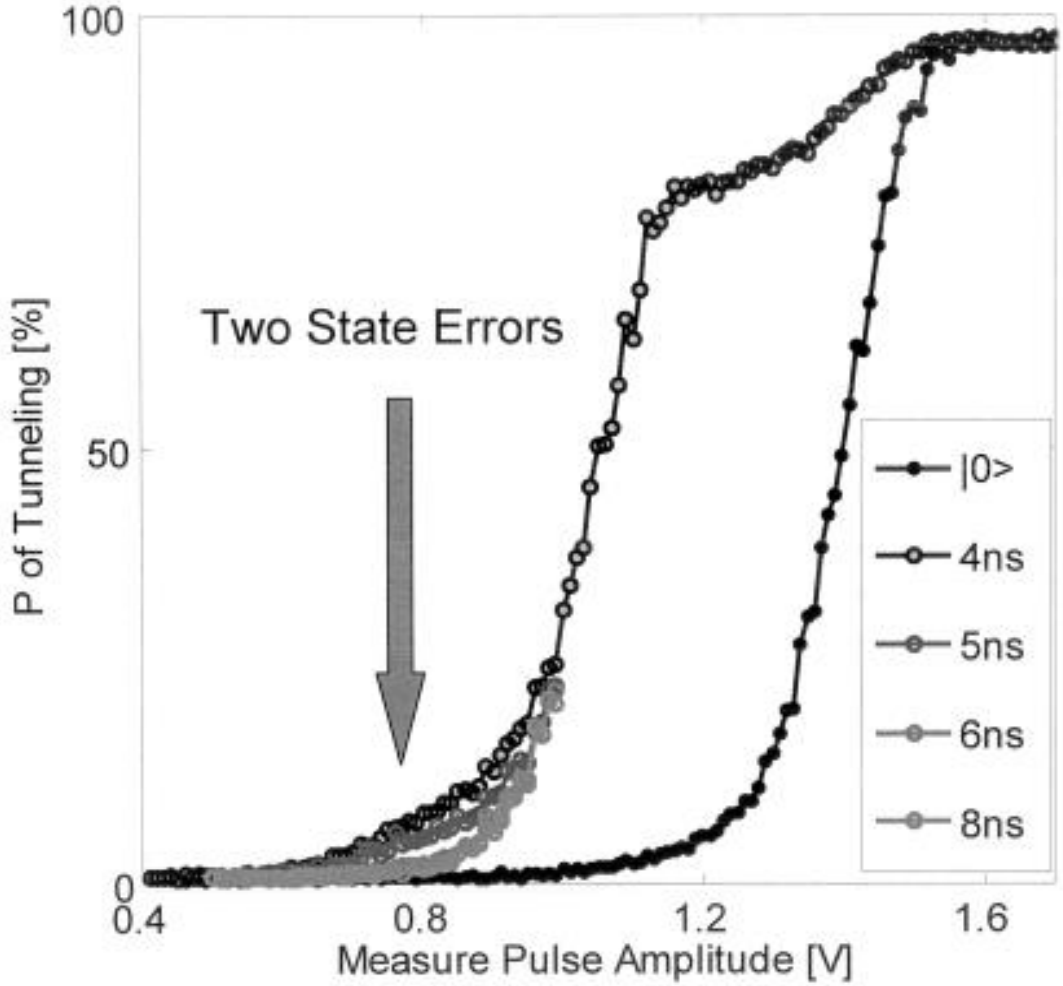
|2> Errors from Fast Pulses

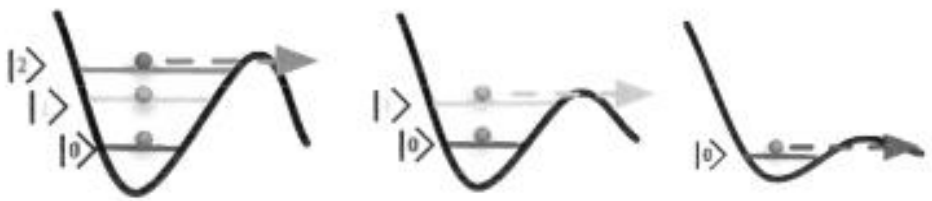




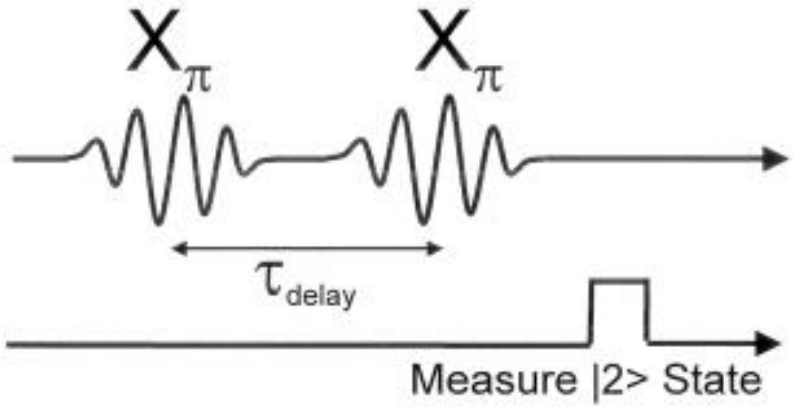


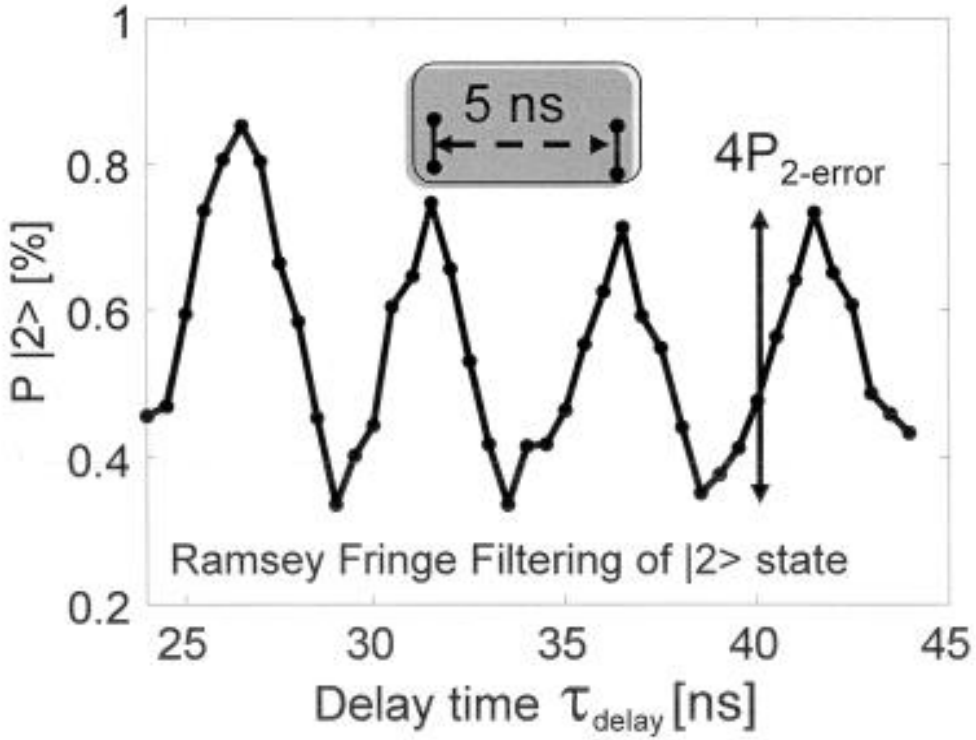
Gaussian pulses:
Minimum width in time and frequency

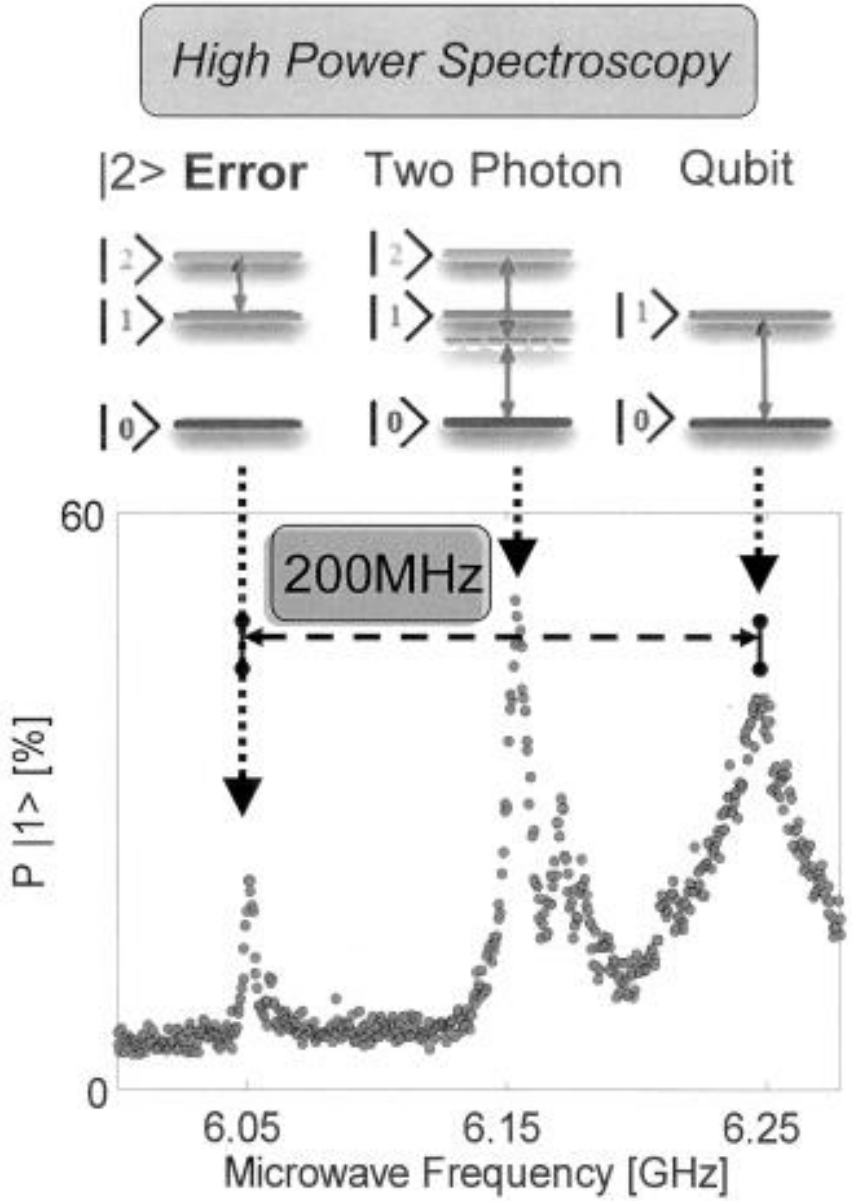




π - π Pulses Give Low Background & Error Filtering







Error vs. Gaussian Pulse Width