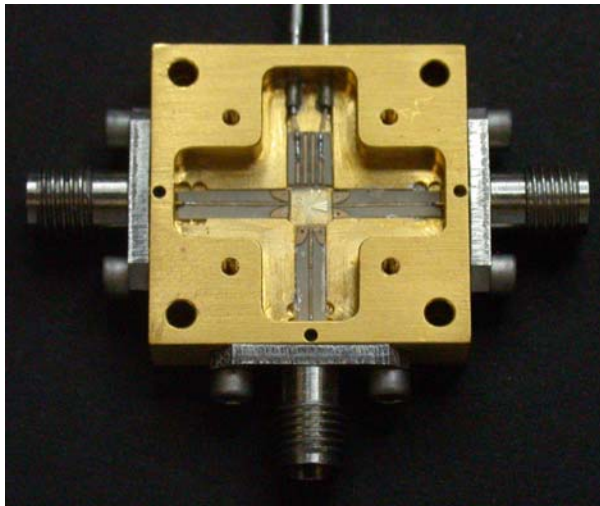


# Coherent Oscillations on a Single Cooper-Pair Box with RF-SET Readout

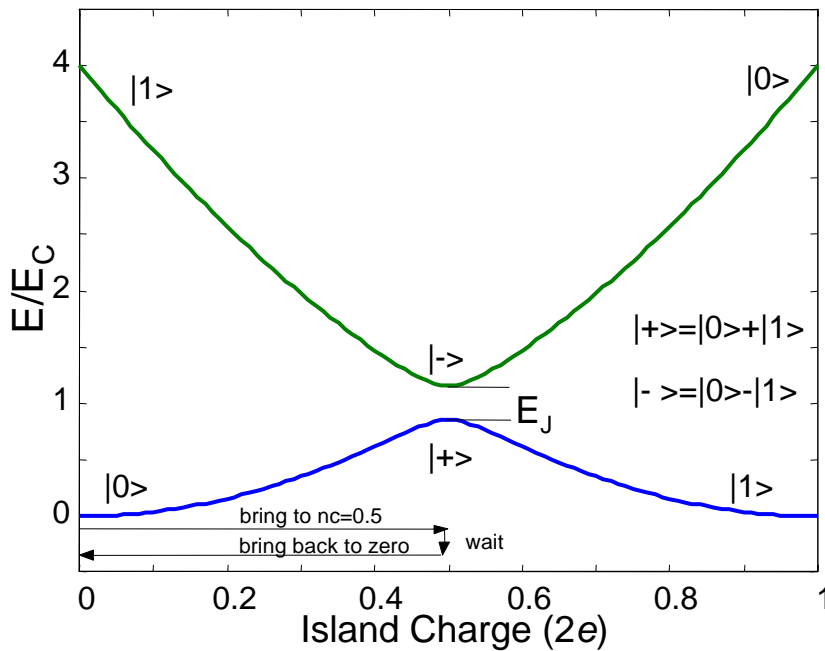
<sup>1</sup>J.F. Schneiderman, <sup>2</sup>A. Guillaume, <sup>3</sup>P. Delsing,  
<sup>1</sup>H.M. Bozler, & <sup>2</sup>P.M. Echternach

With <sup>1</sup>Matt Kenyon, <sup>4</sup>Alexander Korotkov, & <sup>4</sup>Rusko Ruskov

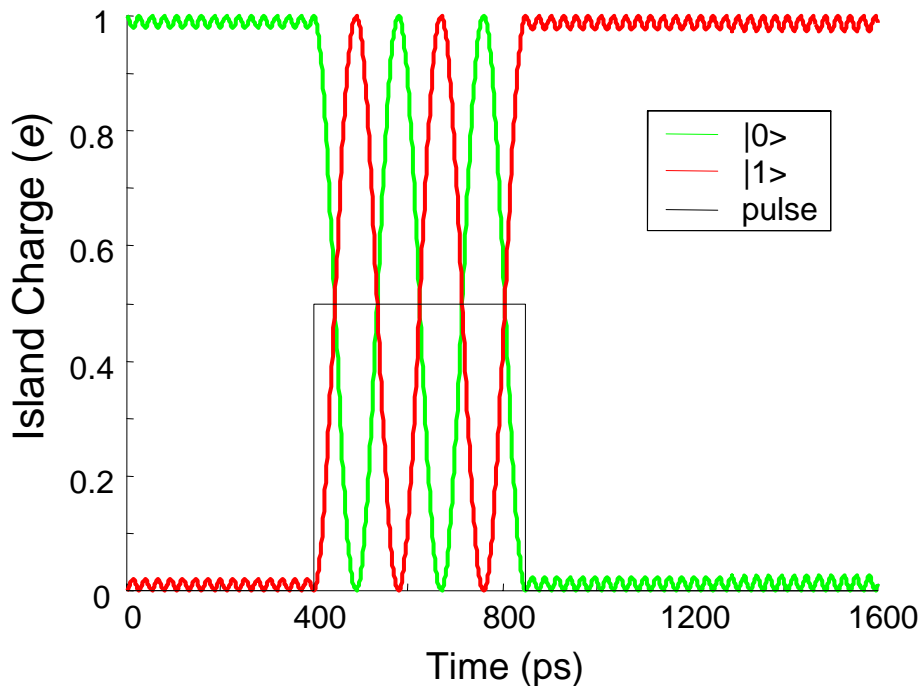
(<sup>1</sup>USC, <sup>2</sup>JPL, <sup>3</sup>Chalmers, <sup>4</sup>UCR)



- Demonstrated tuning of energy spacing ( $E_J$ ) of 2-level quantum system (Single Cooper-Pair Box)
- Observed temporal evolution of superposition states (coherent oscillations)
- Made a measurement of energy relaxation ( $T_1$ ) and dephasing ( $T_2$ ) times

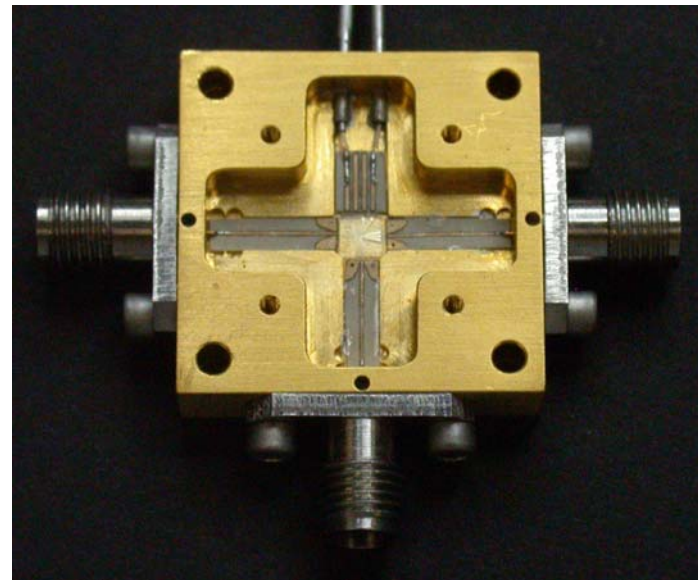
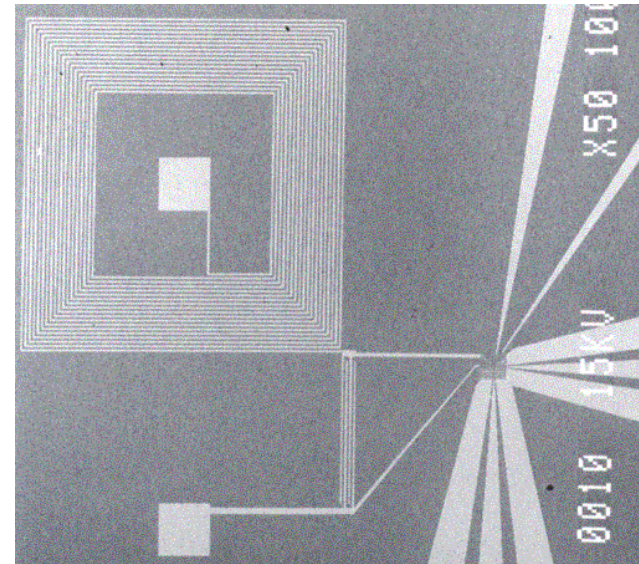
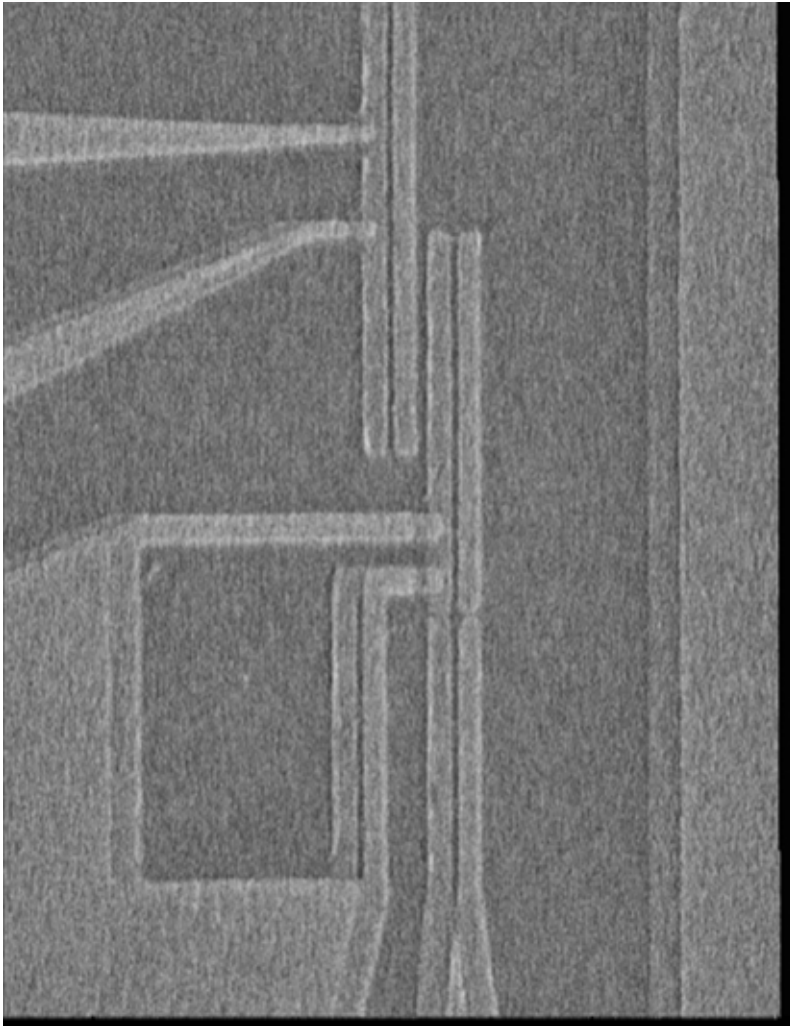


- 2-level system with level splitting  $E_J$  at degeneracy point

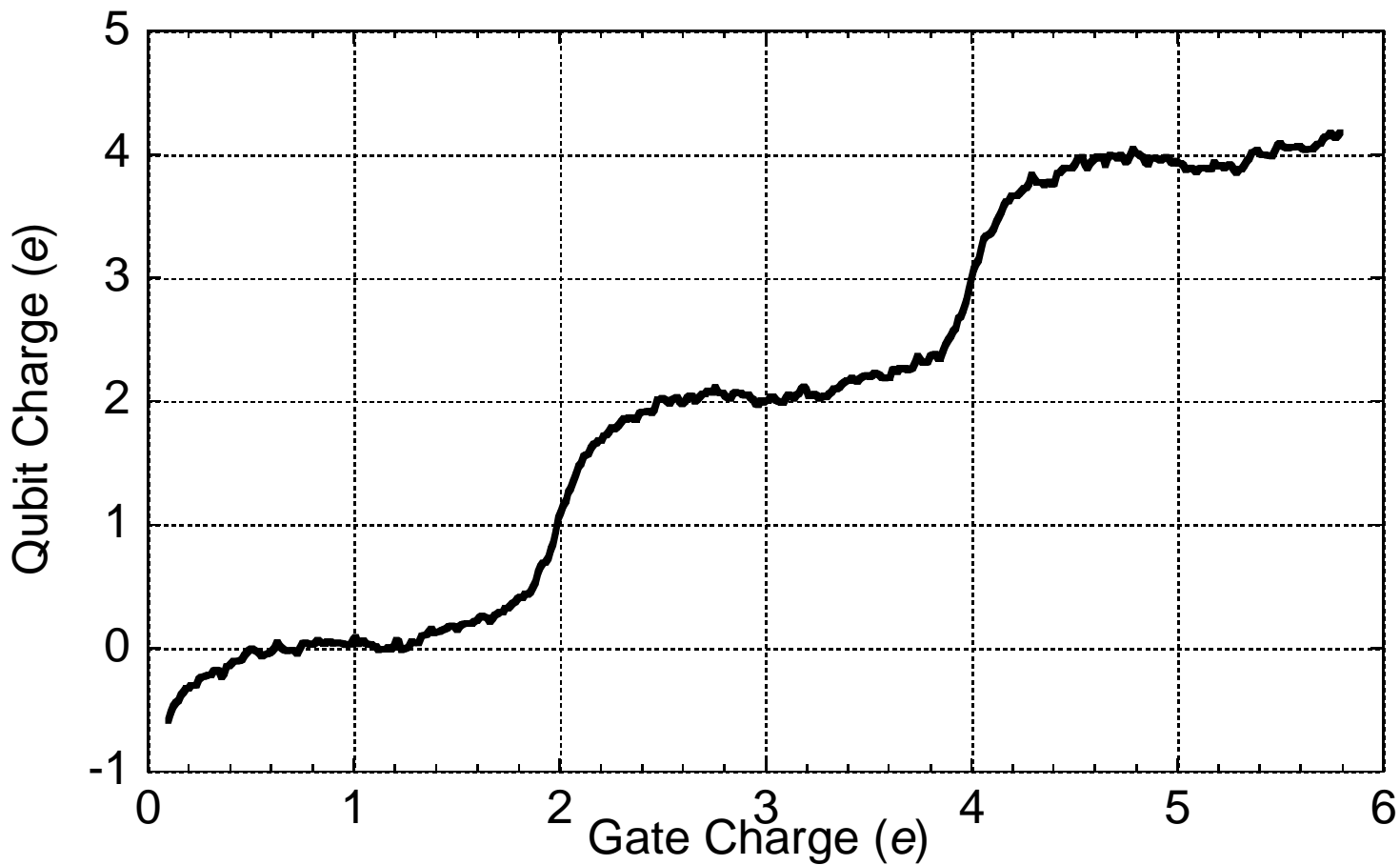


- Qubit manipulation with DC pulses:
  - start with  $|0\rangle$
  - DC pulse brings system to degeneracy point and back

# SCB & RF-SET

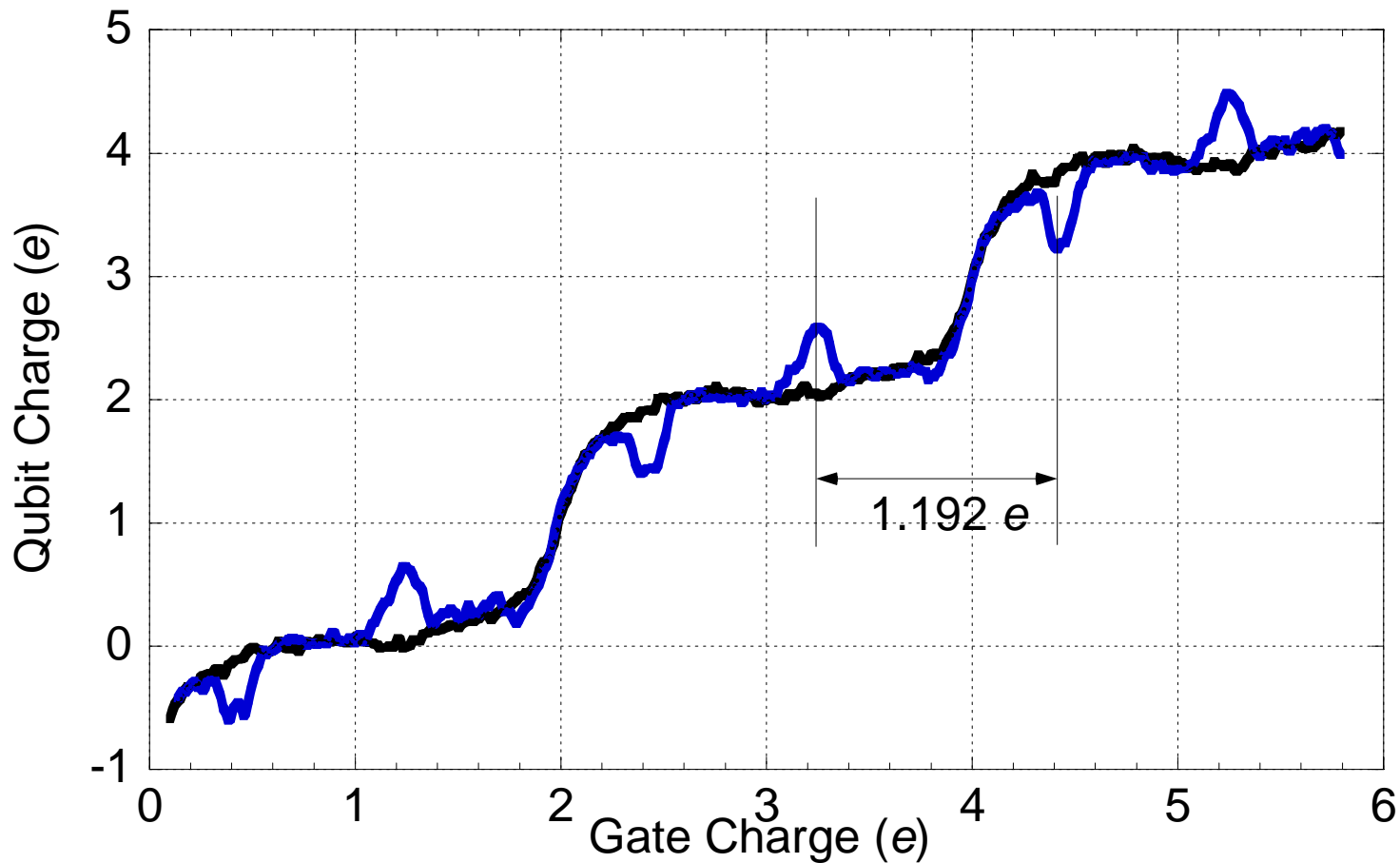


# Measured $2e$ periodic staircase



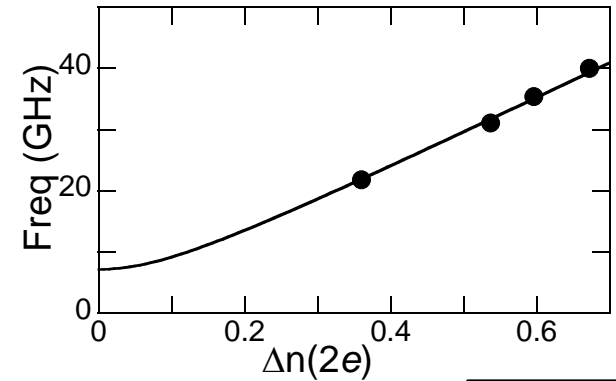
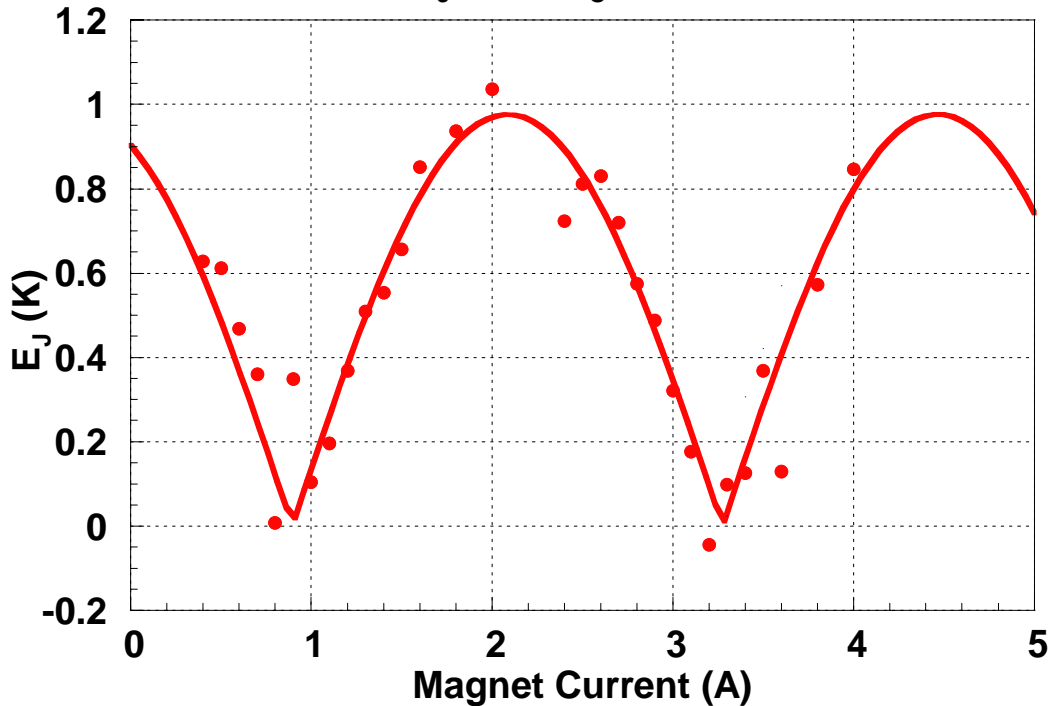
# Effect of Continuous Wave Radiation (Spectroscopy)

35.4 GHz Continuous MW



# Magnetic Field Tuning of $E_J$

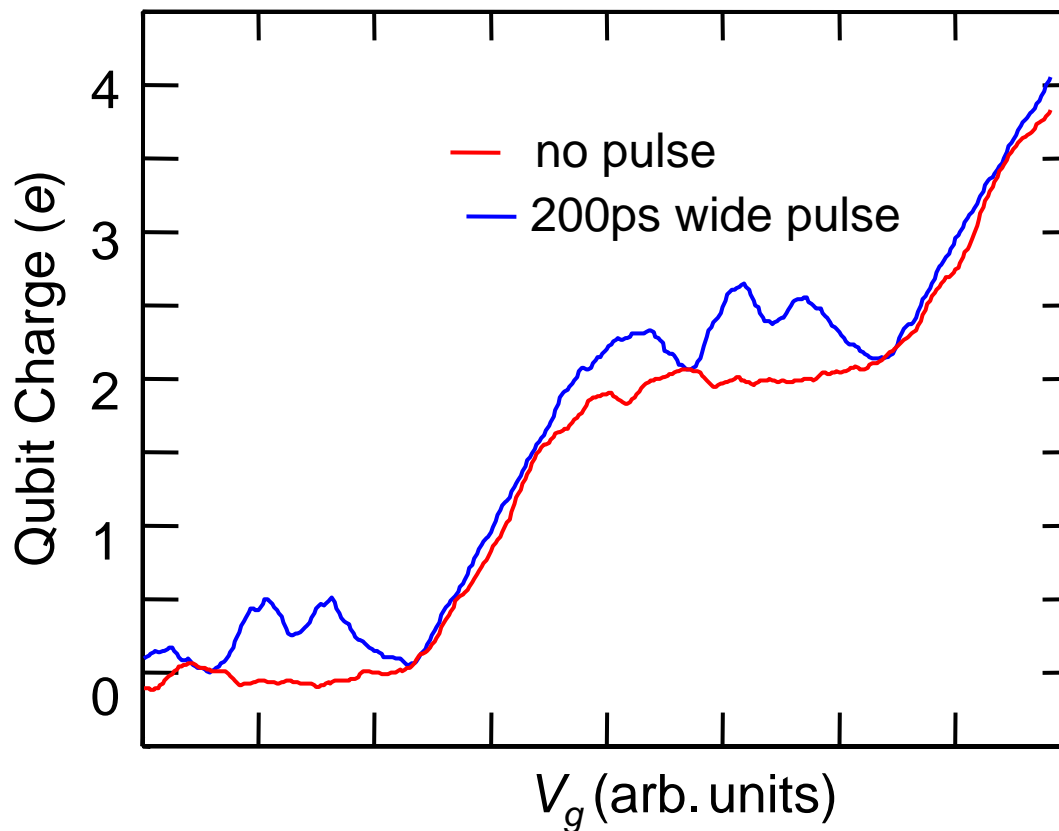
$E_J$  vs B ( $E_C = 0.692K$ )



$$f(\text{GHz}) = 20.8 * 4 * E_C * \sqrt{n^2 + \left(\frac{E_J}{E_C}\right)^2}$$

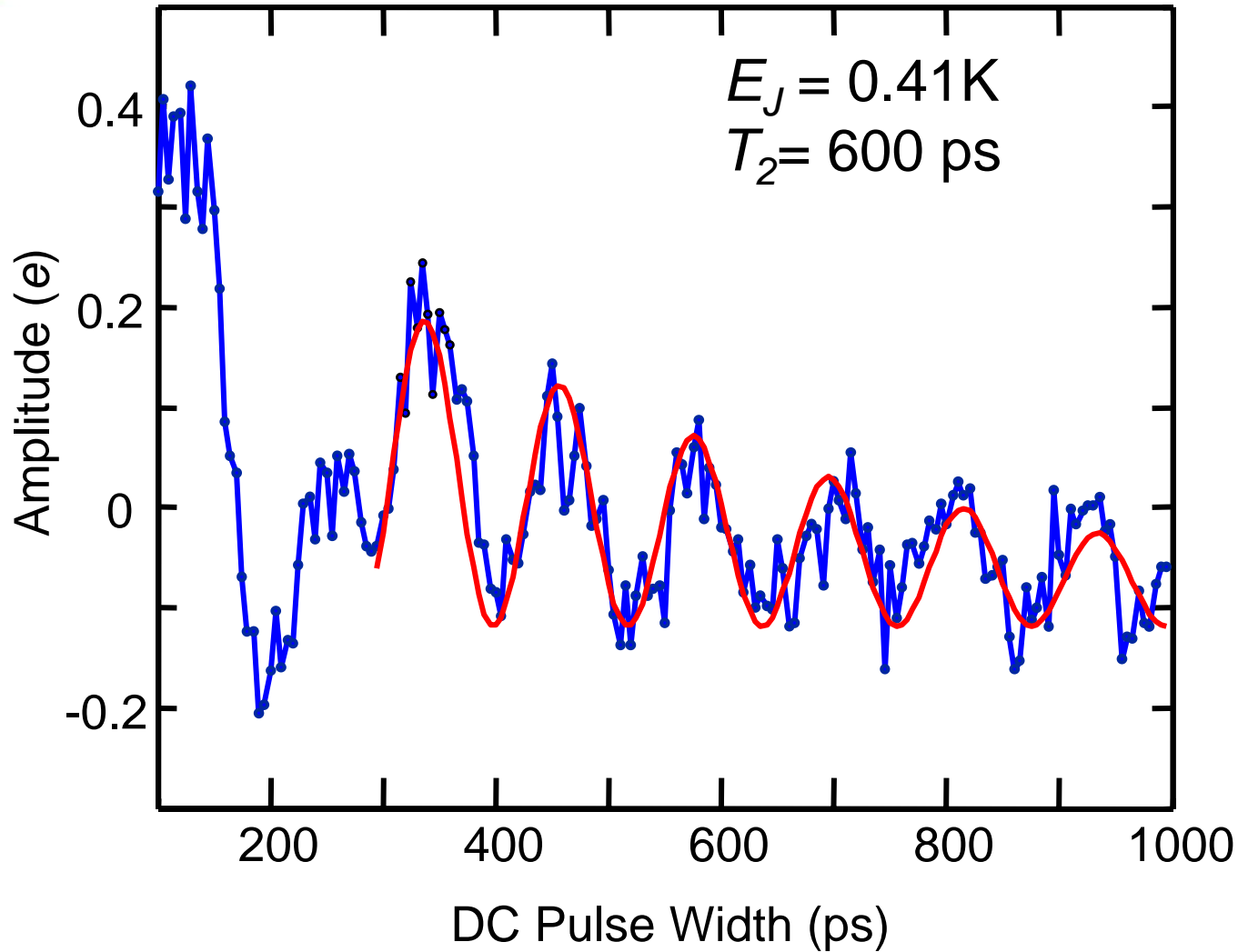
- Follows  $E_J = E_J^{\max} \left| \cos\left(\frac{\pi\Phi}{\Phi_0}\right) \right|$  closely

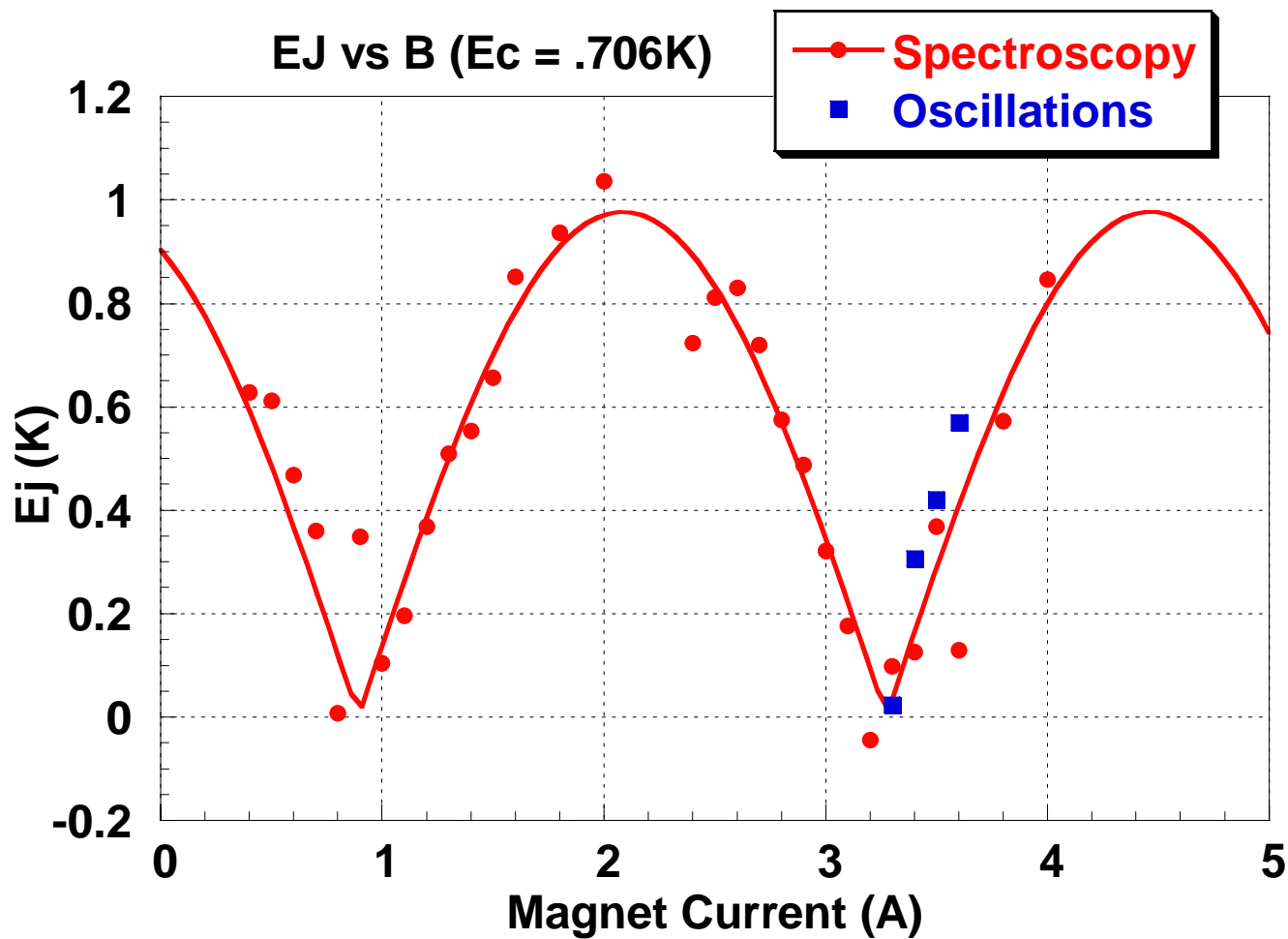
# Qubit Manipulation



- Effect of continuous DC pulse train
- Vary pulse width to follow coherent oscillations

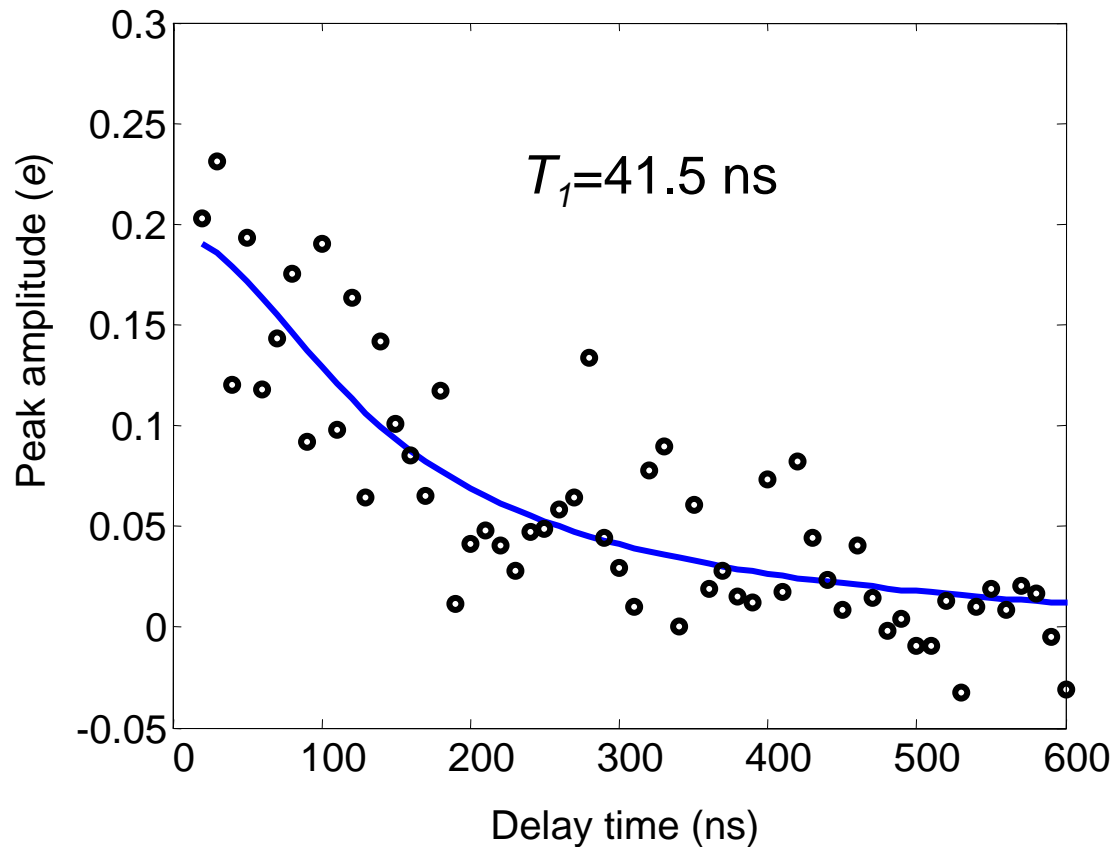
# Coherent Oscillations





- Use period of oscillations to find  $E_J$  at different magnetic fields
- Oscillations correspond well with  $E_J$  extracted from spectroscopy

# $T_1$ Measurements



- $T_1$  measurement from decay of spectroscopy peak
- From decay of DC pulse induced oscillation amplitude  $T_1$  is one order of magnitude shorter

# Future Directions

- Further investigation of coherence times – different methods yield vastly different values
- Increase attenuation on pulse lines – reduce thermal noise
- New sample design – less coupling
- New HEMT Amplifier – higher S/N

...multi-pulse gates