USRP PLATFORM FOR SUPERCONDUCTING QUANTUM SENSING
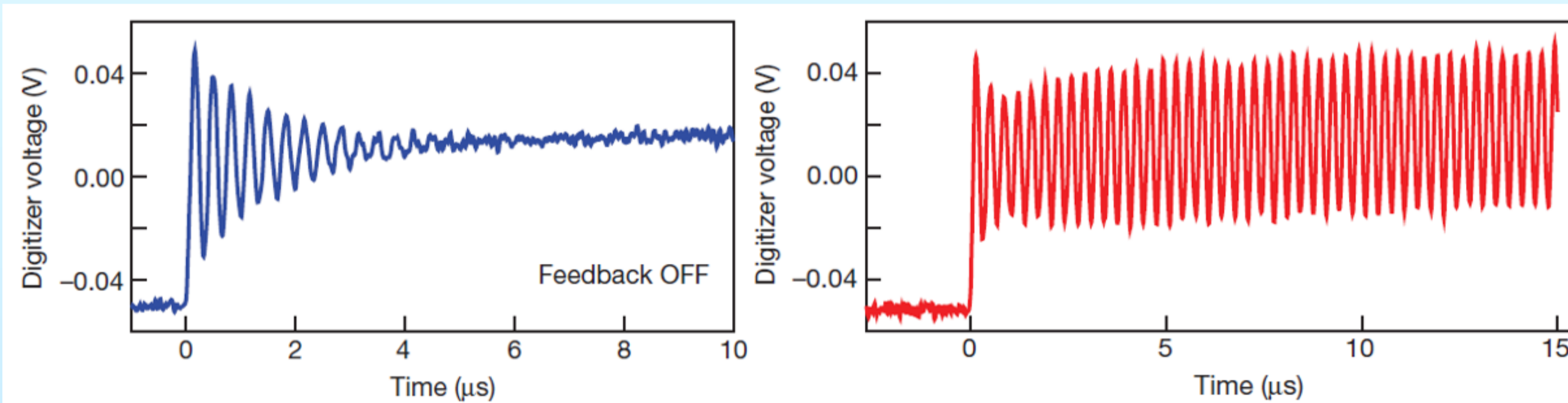
## Aaron Wubshet, John Breneman, Lisa Poyneer

BACKGROUND & APPLICATIONS

- DOE National Strategic Computing Initiative and LLNL's HPC, Simulation, and Data Science core competency
- We want to rapidly control a superconducting qubit
  - Desirable output

Figures from Vijay, R. et al Stabilizing Rabi Oscillations in a Superconducting Qubit Using Quantum Feedback, Nature 2012

- Axion detection research
- Quantum information processing

Progress
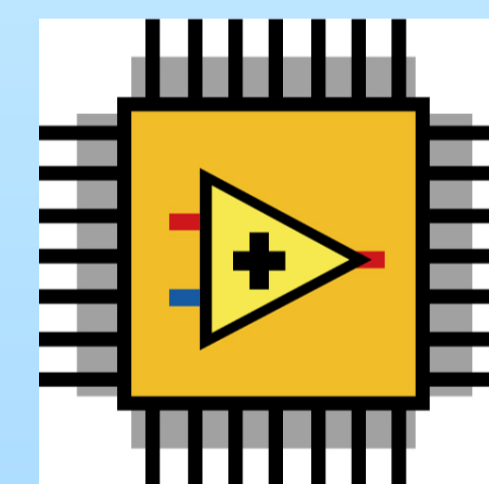
- Design:
  - Leverage and adapt existing IP
  - Simulate and validate functional behavior via testbench
- Synthesis:
  - Resource utilization determined
 - Netlist generated
- Place & Route:
  - Timing constraints
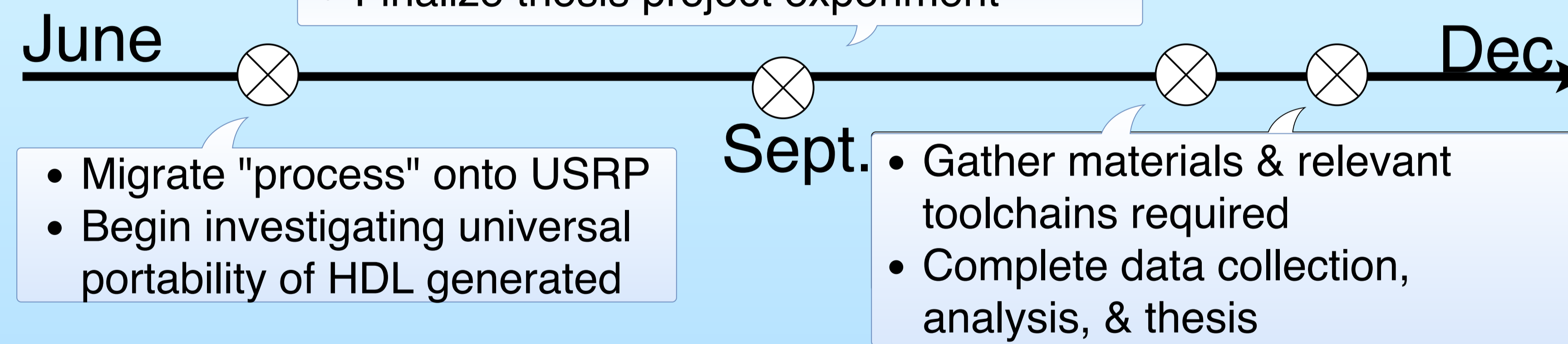 - Programming file generated

MATLAB

XILINX®

- Combining multiple toolchains into cohesive workflow
- Created VHDL "wrapper" to enable portability of HDL being generated
- Validation of USRP implementation
  - Unique testbench for USRP platform
  - Additional handshaking required
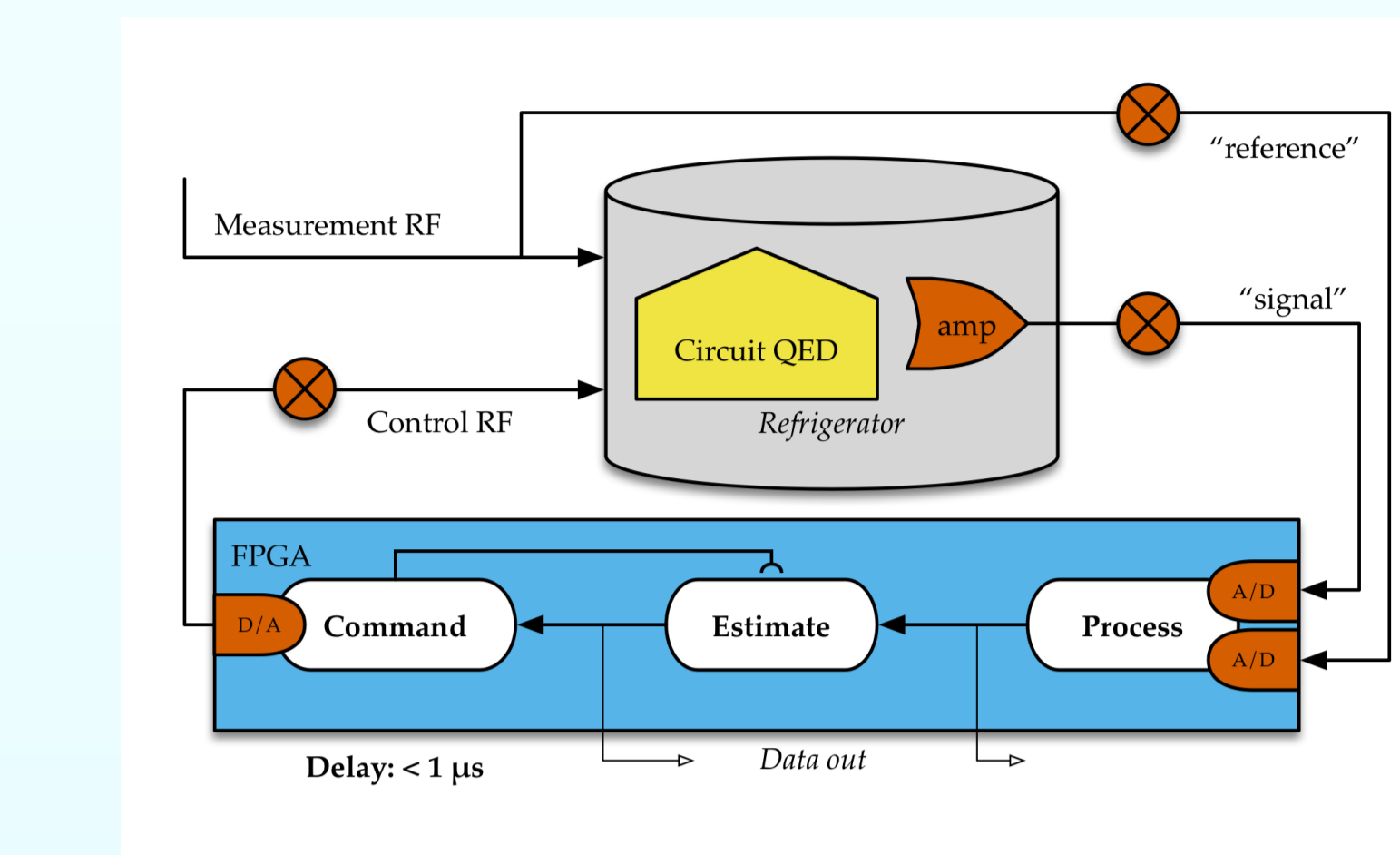
EXPERIMENTAL SETUP

Kintex-7

Virtex-6
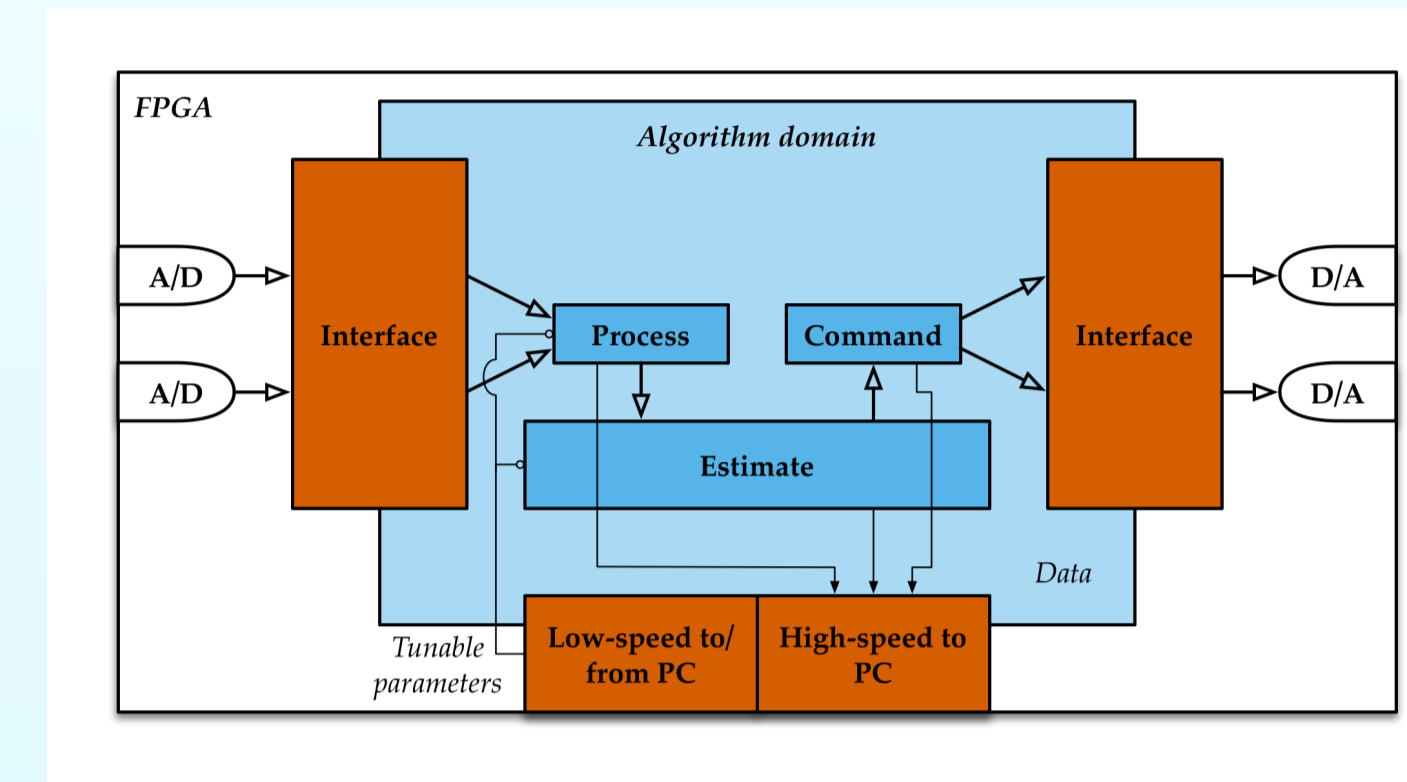
- Implement complete algorithm on USRP with timing constraints met
- Finalize thesis project experiment

June —⊗——————⊗——————⊗—⊗— Dec

Sept.

- Migrate "process" onto USRP
- Begin investigating universal portability of HDL generated

- Gather materials & relevant toolchains required
- Complete data collection, analysis, & thesis

NEXT STEPS

CURRENT PROJECT

- The goal is to develop and experimentally validate algorithmic, FPGA-based control of a transmon
- Current progress is concentrated on II FPGA, but migration to USRP (and other platforms) is underway
- Modify implementation in order to meet timing requirements

POSSIBLE THESIS EXPERIMENTS

- Implement less computationally intensive control scheme on FPGA (PID, state space, etc)
- Implement processing, control, and estimation in native VHDL to ensure portability
- Validate and characterize SDR capabilities relative to existing testing RF equipment

Acknowledgements & References

- Vijay, R., et al. "Stabilizing Rabi Oscillations in a Superconducting Qubit Using Quantum Feedback." *Nature News*, Nature Publishing Group, 3 Oct. 2012, www.nature.com/articles/nature11505.
- *Quantum Science Program*, qis.fnal.gov/axion-dark-matter-detection/.