Superconducting Quantum Computing Experiments: Trends and Challenges

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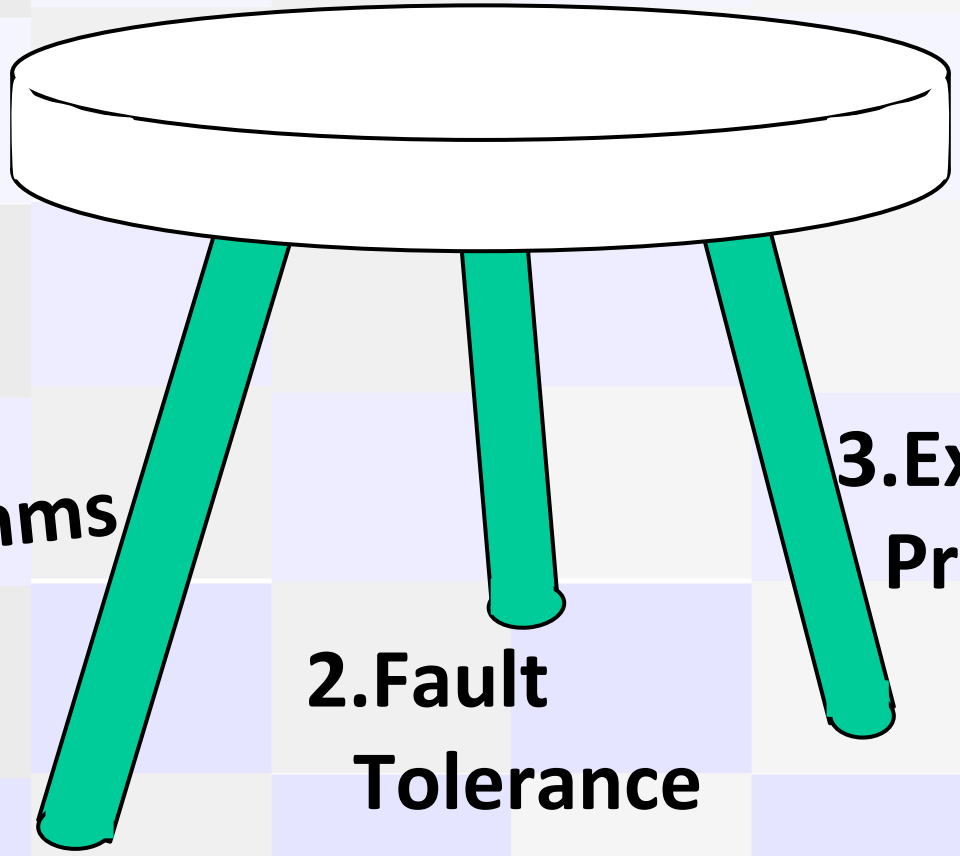
Superconducting Quantum Computing Experiments : Trends and Challenges

OUTLINE

1. Intro to speaker & experimental QC program at LPS
2. Intro to superconducting QC Experiments
   - Why is this a future direction in computation?
   - Why discuss superconducting circuits today?
   - Experimental description
3. Trends in superconducting quantum logic circuits
4. Challenges in superconducting quantum logic circuits
5. Opportunities for collaboration
6. Summary

Quantum Computing Research

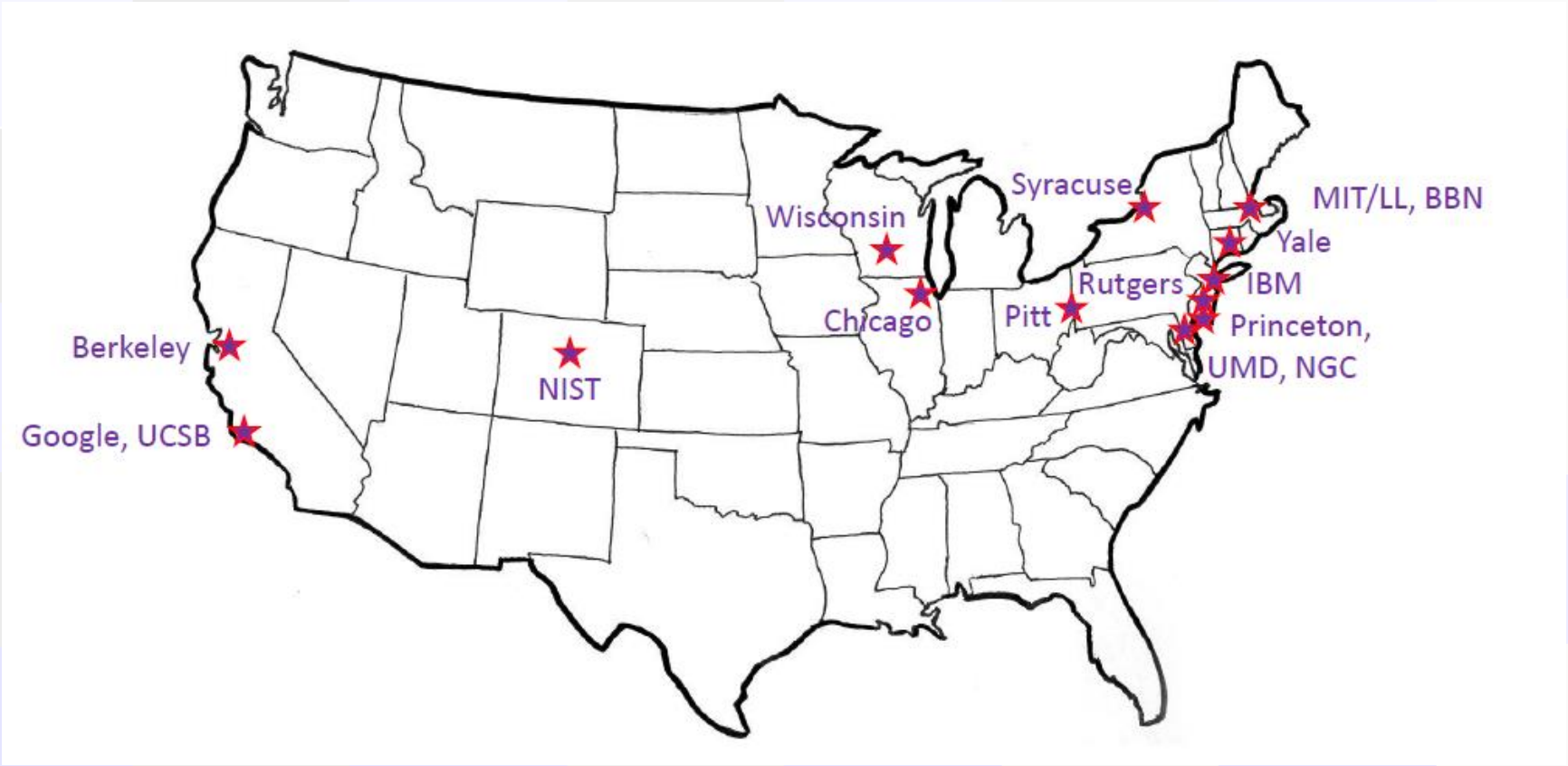
What makes this a promising future direction for computing?



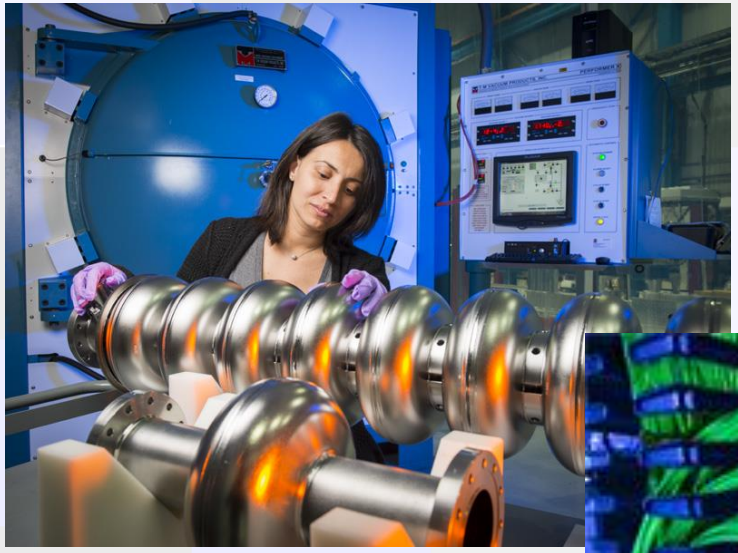
Future implementations uncertain

Economist, 2015

Superconducting QC Groups Across U.S.



Superconducting QC Experiments:
Why discuss at Fermilab?



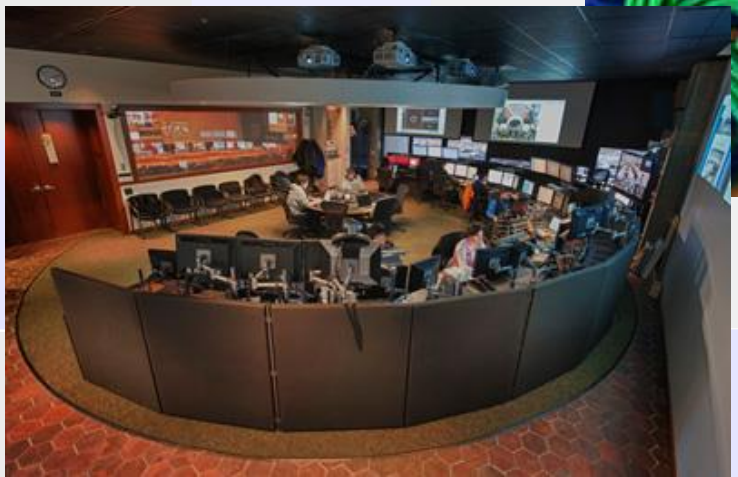


Photo credits: www.fnal.gov, August 2017

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Superconducting QC Experiments:

Experimental View

Photo from Centre for Nanosciences and Nanotechnology - CNRS / Paris Sud University

Experiment Circuit Diagram

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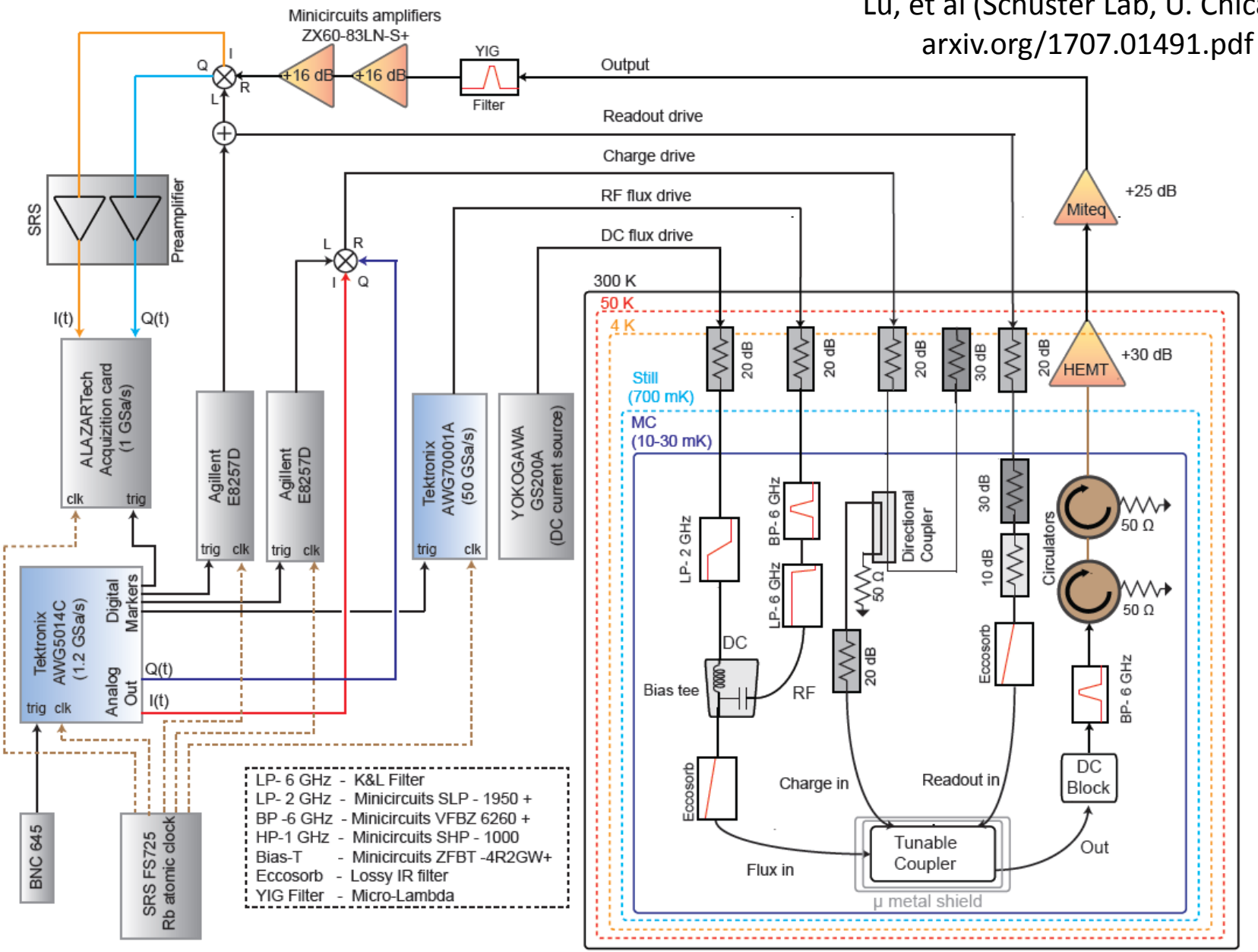
Lu, et al (Schuster Lab, U. Chicago)
arxiv.org/1707.01491.pdf



Superconducting QC Experiments:

Superconducting Circuit

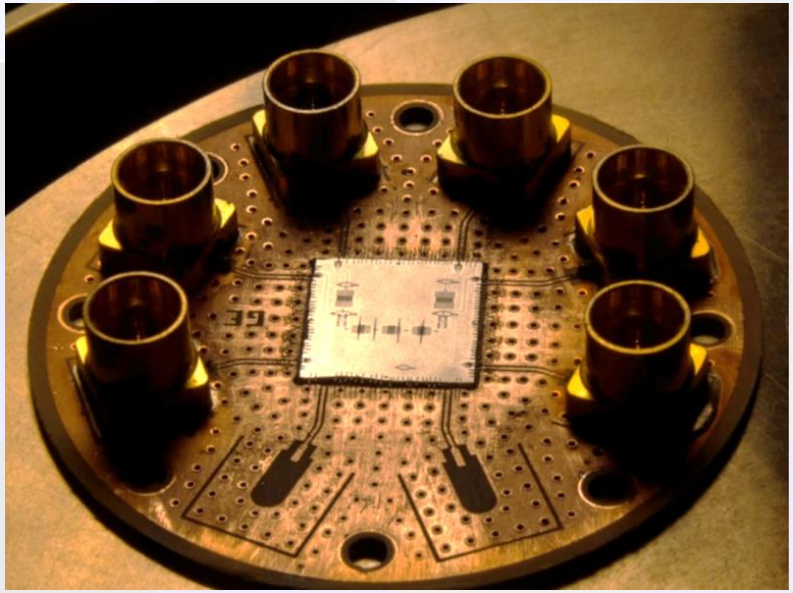
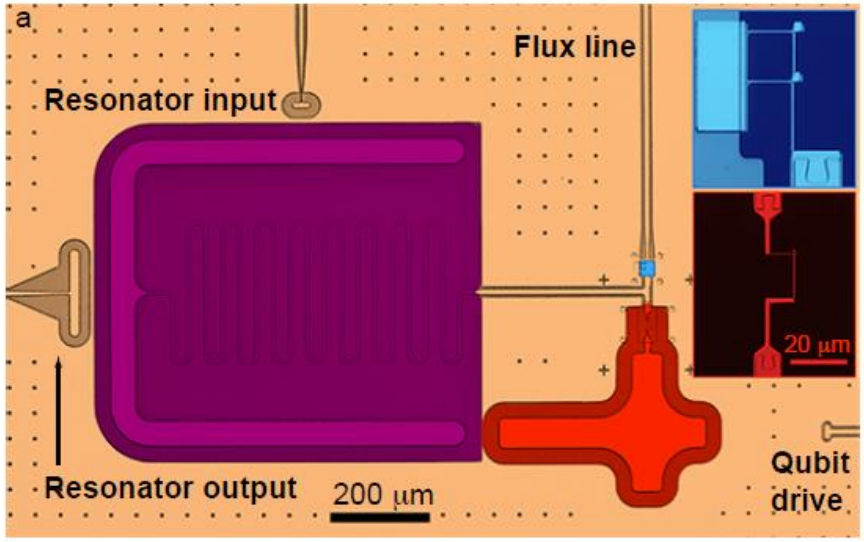
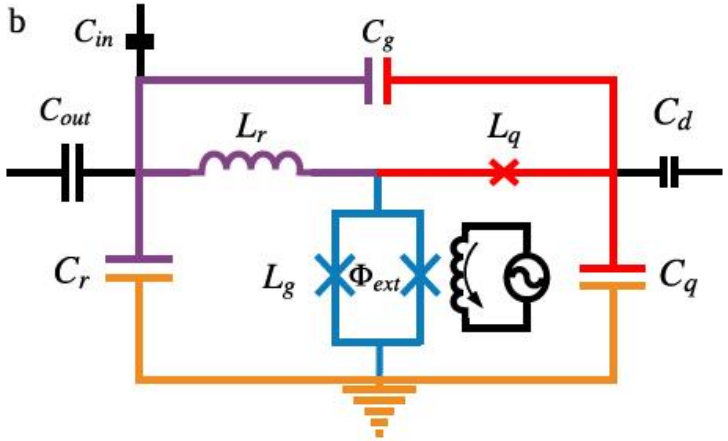


Photo Credit:
Courtesy of D. Schuster (U. Chicago)





Lu, et al (Schuster Lab, U. Chicago)

Trends & Challenges (circa August 2017)

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Superconducting QC Experiments

Trends

- Better qubits
- Lower barrier to entry
- Using more Hilbert Space
- 3D Structures

Challenges

- Taming the topology
- Reducing errors using control
- Reducing errors by design, fab, packaging

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Trend for Superconducting QC Experiment: Better Qubits

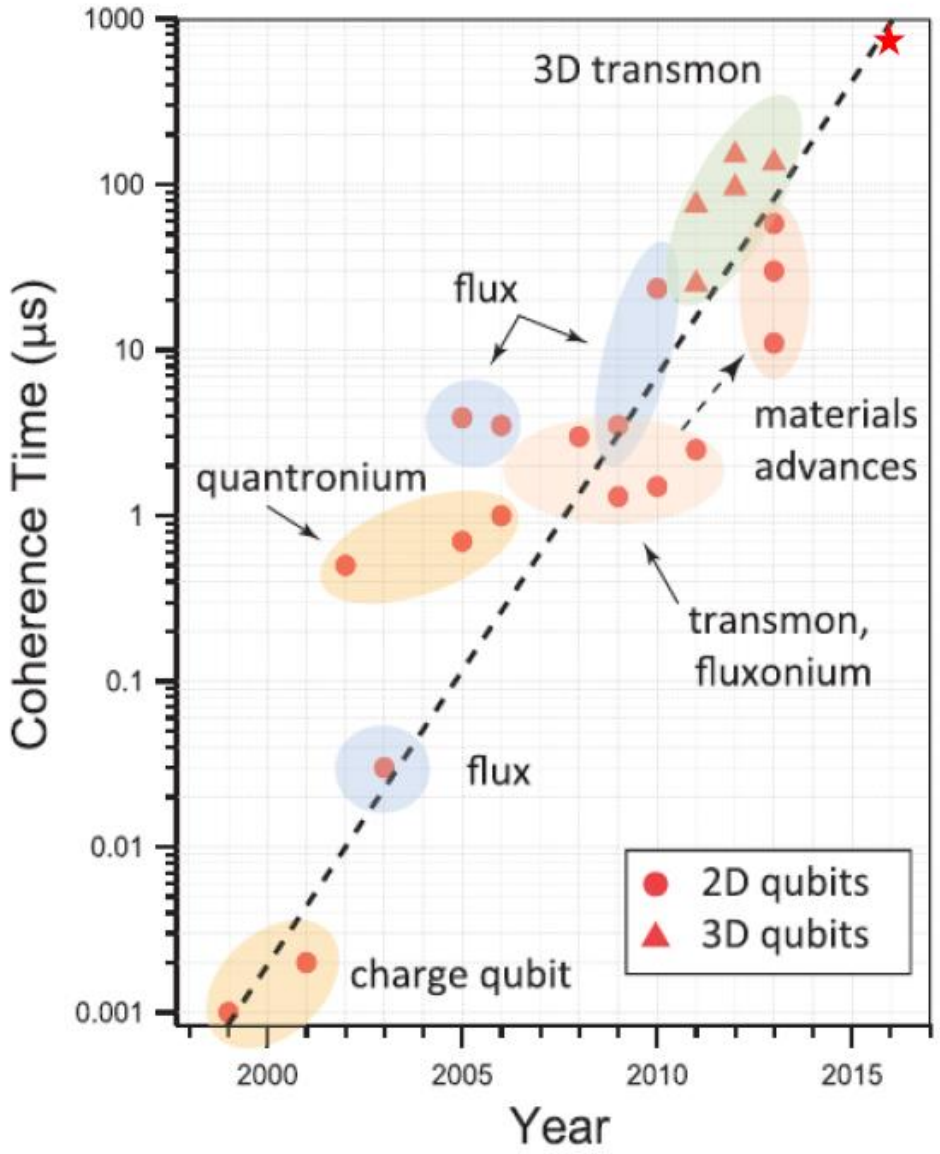

Figure Credit:
Oliver, Welander MRS Bulletin
28, 816 (2013)

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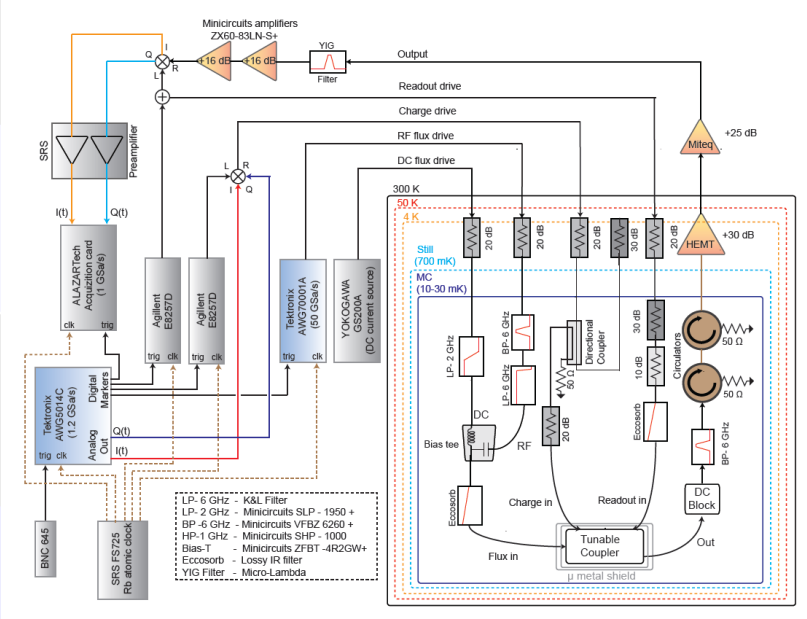
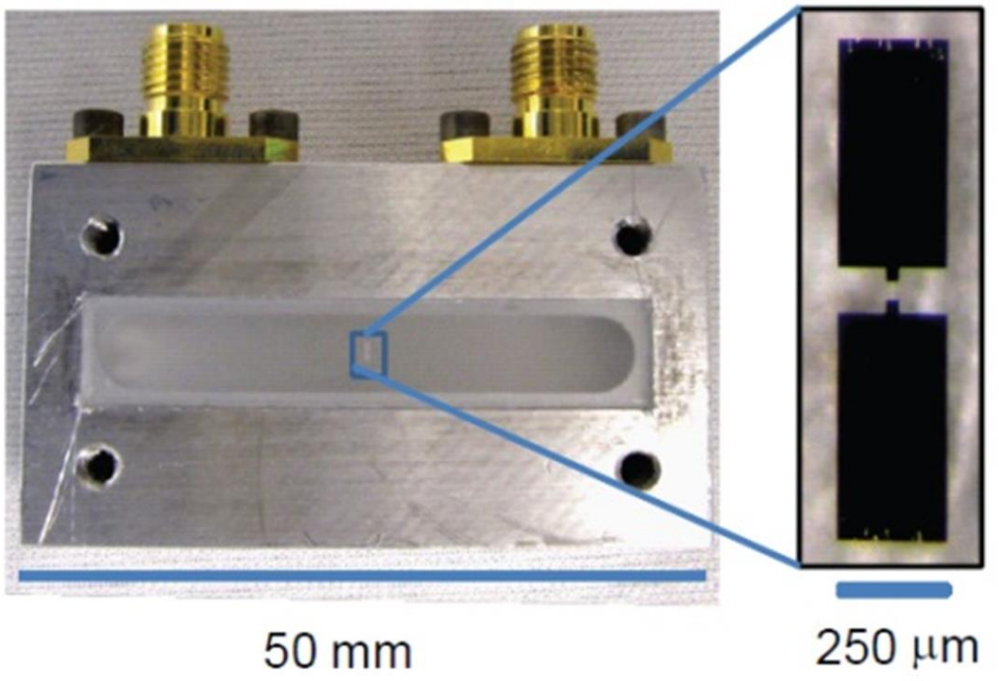
Trend for Superconducting QC Experiment:

Lower Barrier to Entry



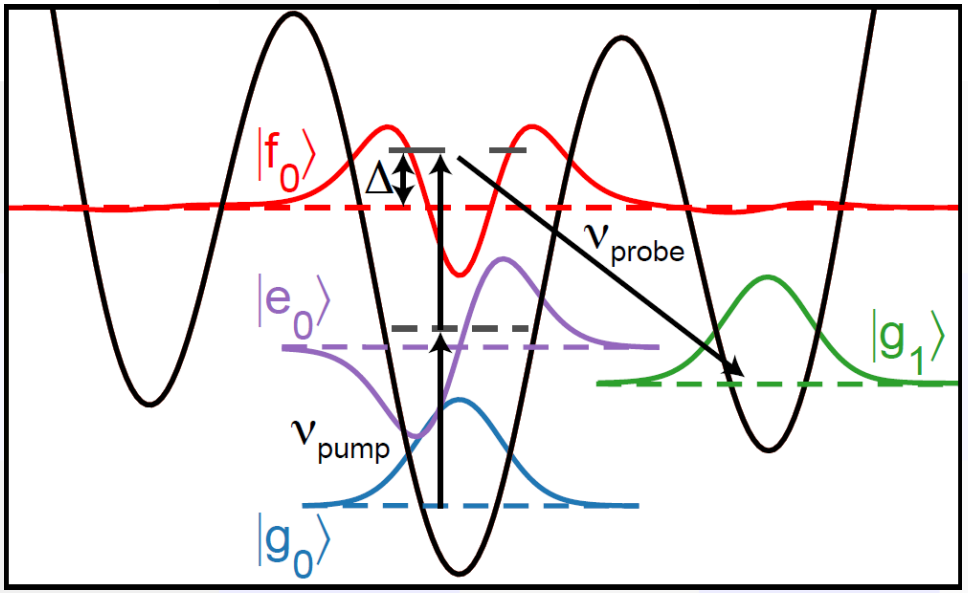


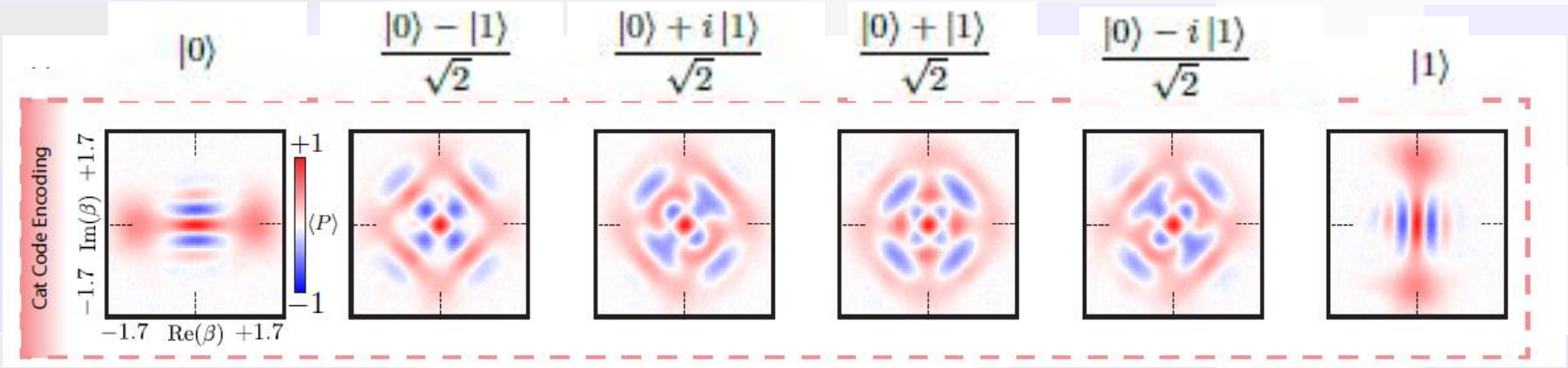
2011 Development in Yale labs

Trend for Superconducting QC Experiments:

Using more Hilbert space

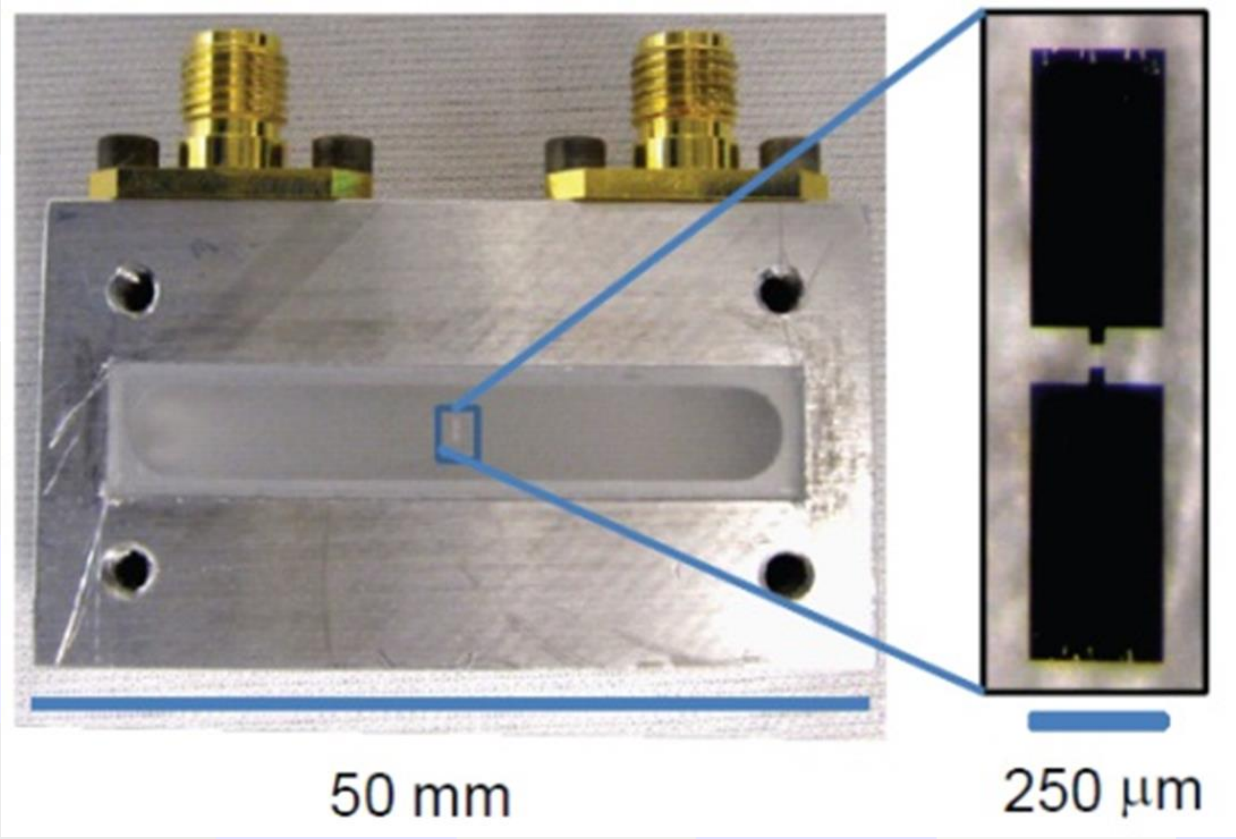
Earnest et al (Chicago, Northwestern, Dartmouth, 2017)
arxiv.org/1706.04116



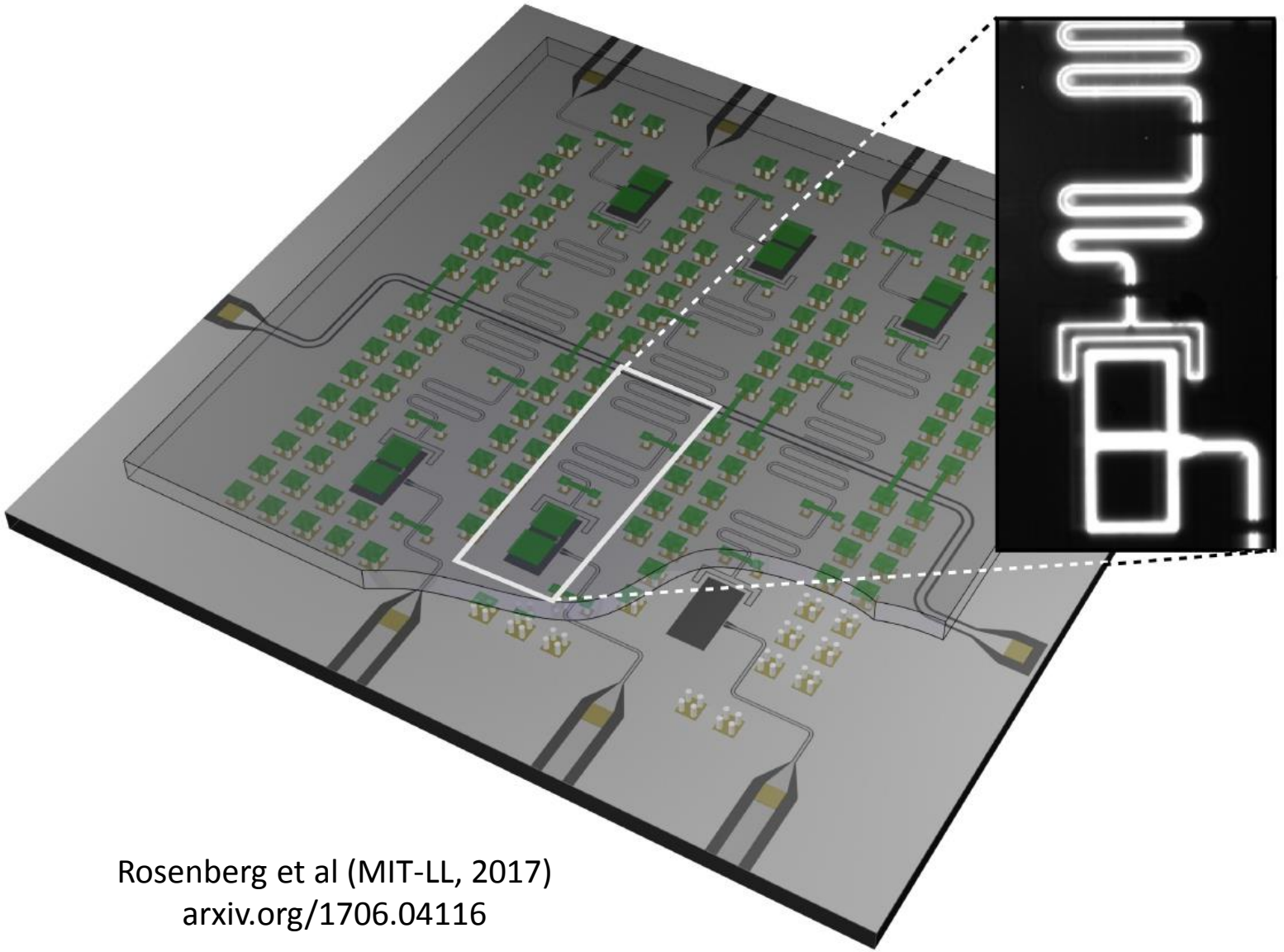


Ofek et al (Yale, 2016)
arxiv.org/1602.04768

Trend for Superconducting QC Experiments: 3D Structures



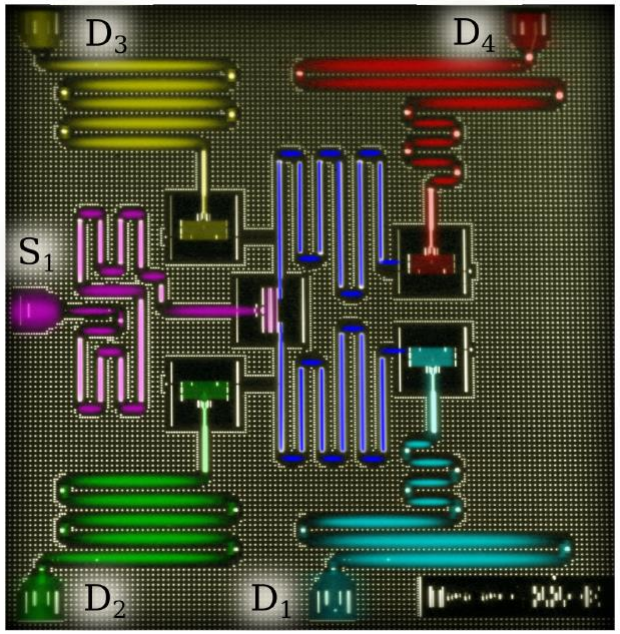
Trend for Superconducting QC Experiments: 3D Structures



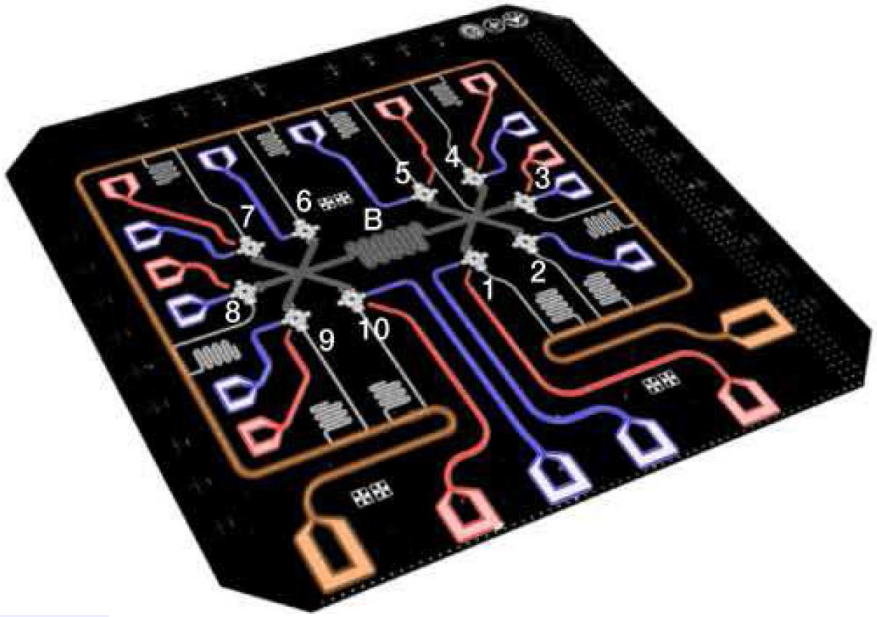
Rosenberg et al (MIT-LL, 2017)
arxiv.org/1706.04116

Challenge for Superconducting QC Experiments:

Taming the topology



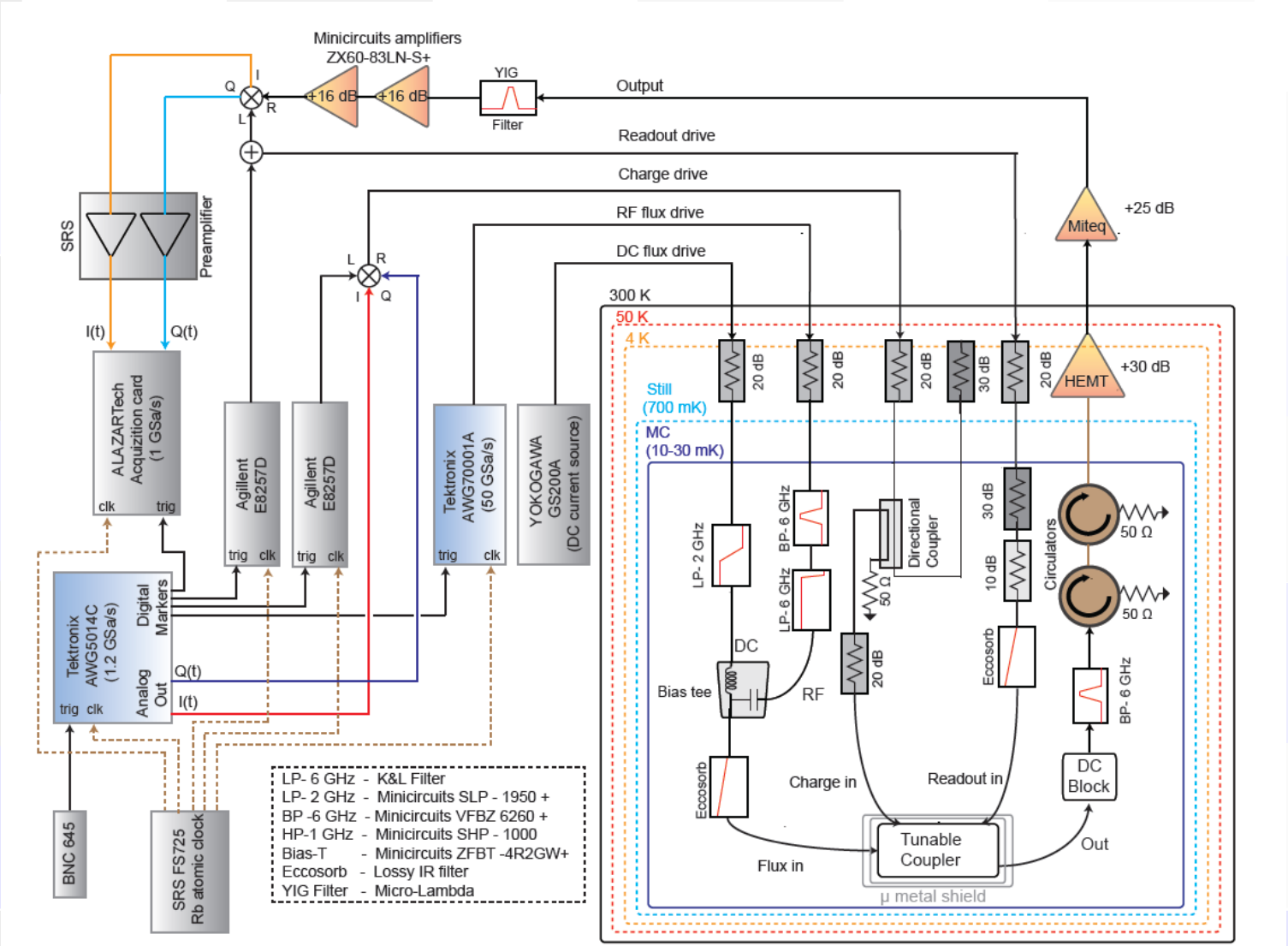
Takita et al (IBM, 2017)
arxiv.org/1705.09259



Song et al (Hefei China, 2017)
arxiv.org/1706.04116

Kelly et al (Google, UCSB 2016)
arxiv.org/1603.03082.pdf

Challenge for Superconducting QC Experiments: Reducing errors with better control



Challenge for Superconducting QC Experiments: Reducing errors via chip design, fab, packaging

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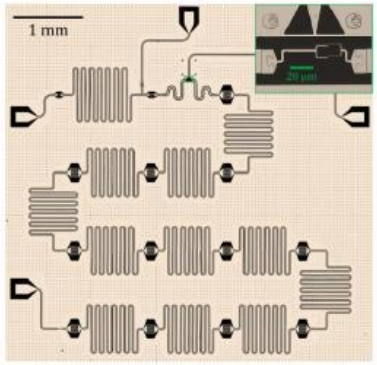
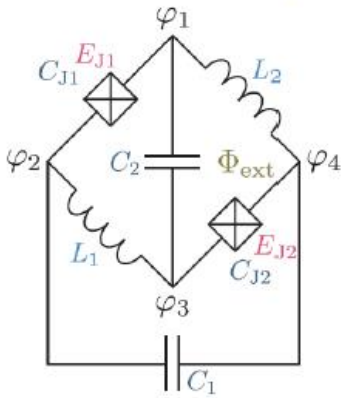
Multi-mode resonator device with Transmon mediated gates



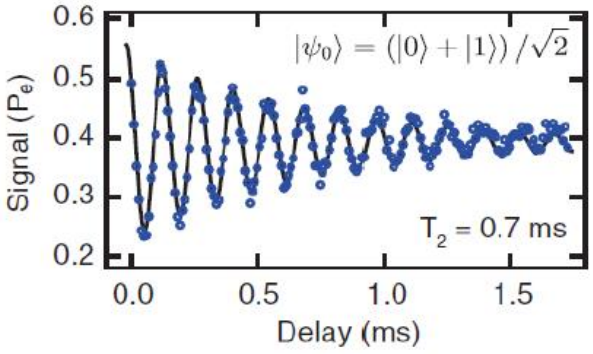
REF: Naik et. al, arXiV: 1705.00579v1

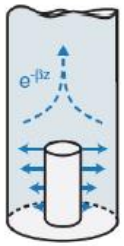
Schematic of 0-π qubit



REF: Dempster et. al. PRB, 90, (2014)

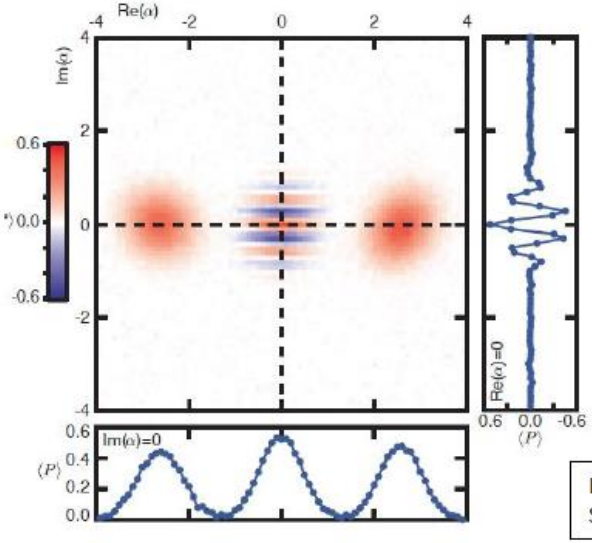
Ramsey decay for a cavity Fock state





REF: Reagor et. al. PRB, 94, (2016)

Wigner tomography of 2-component "Cat-states"



REF: Vlastakis et. al. Science, 342, (2013)

Opportunities for collaboration

- Visit LPS
- Apply for position – permanent staff, postdocs, grad students
- Calls for proposals

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