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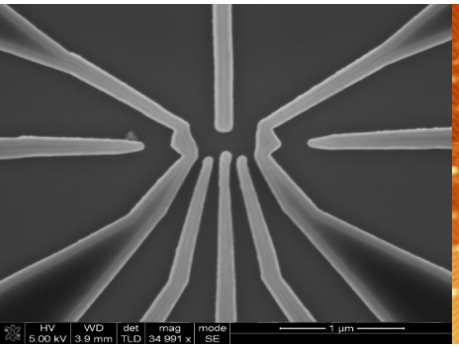
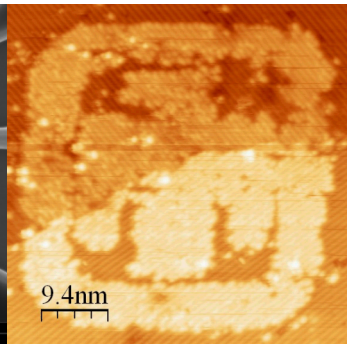
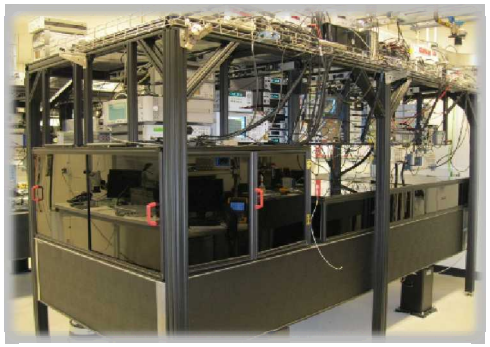
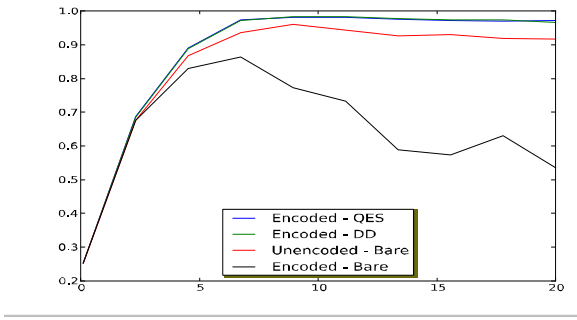








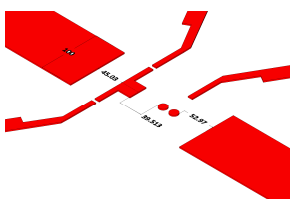
AQUARIUS
Programmatic Overview

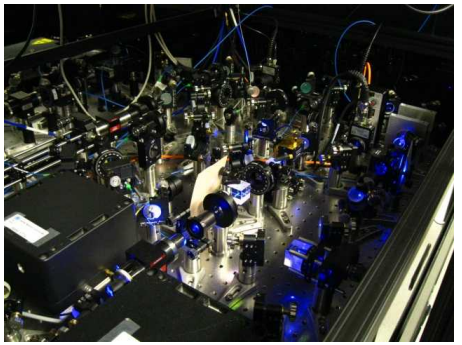
Steven M. Rinaldi
Program Manager

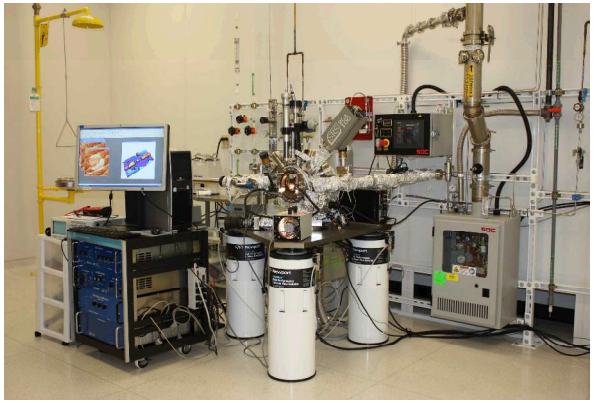
June 28, 2012

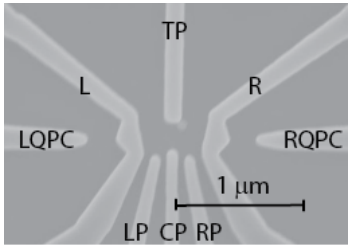
Overview

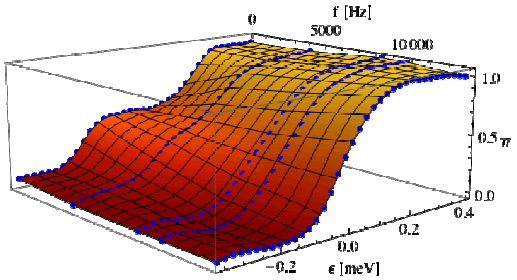
- Charge
- Vision and Objectives
- Programmatic Review
  - Milestones
  - Financial Report
  - Staffing
  - AQC Workshop
  - Outreach
  - Intellectual Property Strategy
  - Risks
- Future Vision and Plans
- Questions

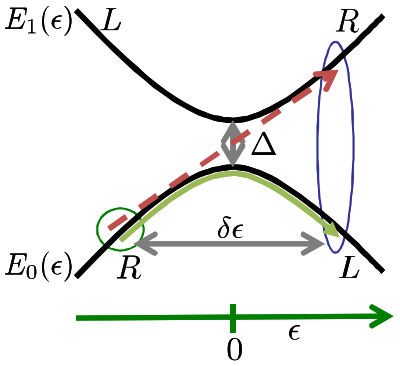












EAB Charge (1)

Purpose and Vision

- Do the AQUARIUS technical and program goals remain clear, important, and timely?
- Have we identified the biggest challenges to achieving success and appropriate paths to overcome them?

Proposed R&D

- Do our project plan, R&D approach, milestones, and success metrics remain appropriate in support of AQUARIUS goals?
- Have we identified the key experiments and theoretical analyses needed to demonstrate our goals?
- Have we appropriately identified integration opportunities across our three technical tasks? Are there additional areas for cross-fertilization among these tasks that we should explore?
- Are there other collaborations or external opportunities that would accelerate our technical progress?
- We have developed and are implementing a new benchmarking ("smoking gun") test that determines if our qubits are operating adiabatically. The test also enables direct measurement of relaxation times.
  - Is this a new measurement technique to examine general science questions about adiabaticity and relaxation?
  - Should we promote this test as a cross-platform benchmark?
  - With regards to adiabaticity benchmarking, what else should we be examining?

EAB Charge (2)

Quality, Relevance, and Impact

- Please comment on the extent to which you believe AQUARIUS is on track to attain the following Sandia LDRD objectives:
  - Relevance: Are we addressing technical challenges relevant to the Quantum Information Science community?
  - Quality: Is the research of high quality; have the approaches demonstrated creative / innovative thinking?
  - Impact: If we accomplish our stated goals, what are likely short- and/or long-term impacts?
- Based on our technical progress during the first twenty-one months, are there specific, high-impact areas that we should emphasize in this coming year?

Programmatic:

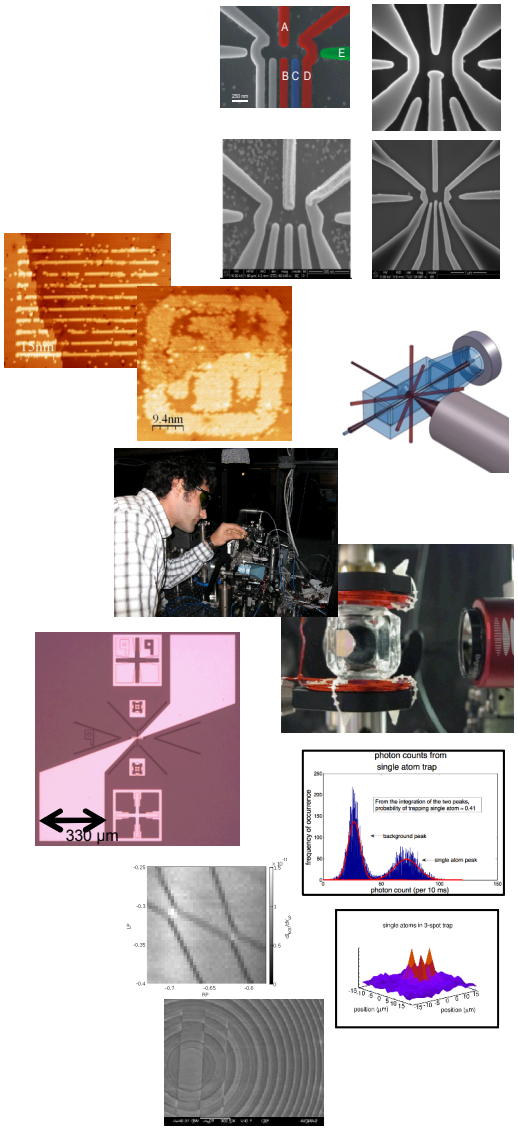
- We are developing our post-LDRD vision and exploring opportunities to continue this research in FY14 and beyond. What are we doing that you believe will have the most interest for follow-on funding?

Vision and objectives

VISION: Develop a quantum-computing architecture whose resource requirements are more achievable than conventional approaches due to the intrinsic noise immunity offered by adiabatic physics

OBJECTIVES:

- Demonstrate two-qubit *special-purpose* adiabatic quantum optimization algorithms in:
  1. Neutral atoms trapped by a nanofabricated optical-trap array
  2. Electrons trapped by semiconductor nanostructures
- And for these technologies to:
  3. Evaluate the potential for fault-tolerant general-purpose adiabatic quantum computation architectures through design & simulation



Milestones

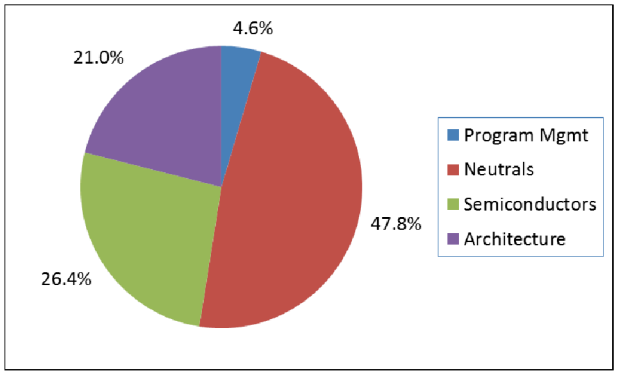
- **Year 1:**
  - Establish AQUARIUS EAB (Oct 2010)
  - Market and external environment report (Dec 2010)
  - EAB Meeting #1 (Feb 2011)
  - Management assurance review for Chief Technology Officer (CTO) (Mar 2011)
  - Hire staff, postdocs (ongoing throughout FY)
  - Establish contracts (ongoing throughout FY)
  - CTO Management Assurance Review (Sep 2011)
  - Year 1 final report (LDRD requirement) (Sep 2011)
- **Year 2:**
  - EAB Meeting #2 (Oct 2011)
  - Workshop #1 (Mar 2012)
  - CTO Management Assurance Review (Mar 2012)
  - Report on EAB #2 Recommendations (Jun 2012)
  - EAB Meeting #3 (Jun 2012)
  - Quarterly tracking and benchmarking reports (Jun 2013, Sep 2013)
  - FY13 renewal process (Jul 2012)
  - CTO Management Assurance Review (Sep 2012)
  - Develop/implement intellectual property strategy (Sep 2012)
  - Report on EAB #3 Recommendations (Sep 2012)
  - Year 2 final report (LDRD requirement) (Sep 2012)
- **Year 3:**
  - Quarterly tracking and benchmarking reports (Dec 2012, Mar 2013, Jun 2013)
  - Second International AQC Workshop (Mar 2013)
  - CTO Management Assurance Review (Mar, Sep 2013)
  - EAB Meeting #4 (Apr 2013)
  - Report on EAB #4 Recommendations (Jun 2013)
  - Year 3 final report (LDRD requirement) (Sep 2013)

Green – satisfactory
Yellow – in progress
Red – pending

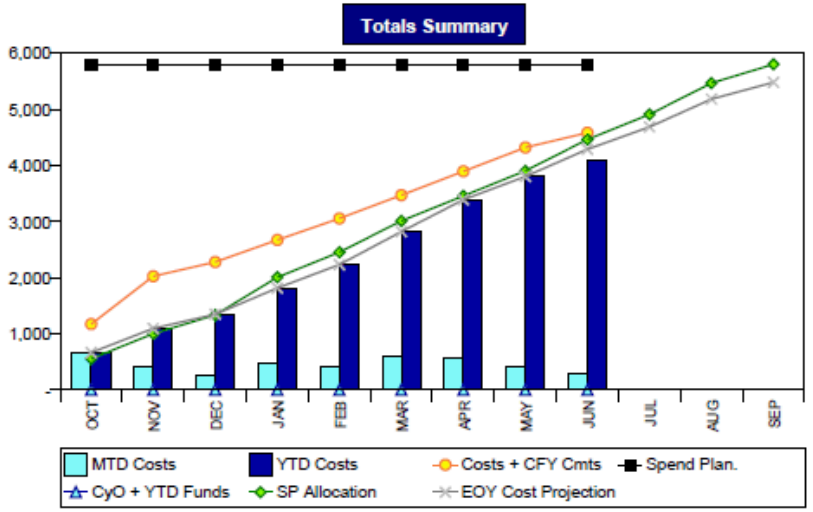
Financial report

- FY13 budget request ($6.034M) submitted with FY13 renewal proposal
- FY13 cost breakout reflective of previous years

Task	FY11	FY12	FY13	Total
1.0	433	337	**538**	1,308
2.0	2,657	2,674	**2,744**	8,075
3.0	2,217	1,385	**1,401**	5,003
4.0	1,110	1,404	**1,351**	3,865
Totals:	6,417	5,800	**6,034**	18,251



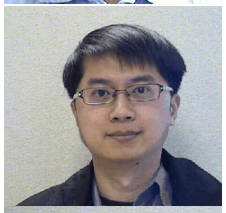
As of June 18, 2012



Staffing

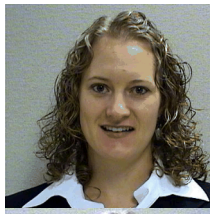
- New AQUARIUS team members:
  - Robin Blume-Kohout

  - Chin-wen (James) Chow



  - Victor Chavez

  - Amber Young



  - Andy Ferdinand (UNM)

- Losses:
  - Rusty Gillen (working internal hire to backfill)
  - Jonas Anderson (UNM, now **Dr.** Anderson!)
  - Gavin Brennen

AQC workshop

- Highly successful first workshop – March 7-8, 2012
  - 12 presentations (6 AQUARIUS including 2 collaborators, 6 external research)
  - Over 60 participants
  - Included international attendees from University College London and D-Wave
- AQC 2013 set for March 6-8, 2013
  - Hosted by Paul Warburton, University College London
  - Venue is the Headquarters of the Institute of Physics, London

Outreach

- Publications
  - Concur with EAB
  - Publications since beginning:
    - 6 papers (+6 in preparation)
    - 26 presentations
    - 16 posters
  - Will continue to publish results in major conferences and journals
  - AQC 2013 – major international venue to disseminate research results

EAB: We encourage Sandia to maintain an ambitious publication strategy, and to present its results at major conferences such as the American Physical Society (APS) March meeting.

- New academic connections
  - Purdue University
    - Application of QUBO to solving partial differential equations
    - Hosting summer visiting research – Rishabh Chandra
    - Mentor – Toby Jacobson
  - USC / Information Sciences Institute
    - Visited ISI on Jan 24, 2012; discussed potential areas of collaboration
    - AQC expertise from AQUARIUS underpinned discussions

Intellectual property strategy

- Grand Challenge LDRDs directed to develop IP strategies
  - Will report out to CTO Steve Rottler when strategy is complete and implemented
- Developing strategy in close consultation with Sandia Legal
  - Held initial discussions with Legal
  - Target completion date: Sep 2012
  - Numerous questions remain to be worked with Legal:
    - Publish or patent? What levels of "protection" do each provide? Publish first or patent first?
    - Implications of new patent laws?
    - Obtain "defensive" patents as service to the Nation and scientific community?
  - IP protection issues are particularly critical given potential for patents based on research results to date

Risks

- Dilution refrigerator
  - Problems uncovered during installation
    - First temperature stage did not reach target of 70K – only achieved 84K
    - Required installation of new first stage heat exchanger
  - Returned to Cryomagnetics for rework; return date TBD
  - Workaround – rely on two existing 1K pot(s) for simple characterization measurements
  - Impacts
    - Ultimately a throughput issue (workaround easing impact)
    - 6 months measurement time at T < 1K lost to date
    - Will lose additional time during re-installation and wire-up
  - Examining potential budget contingencies for final payment
- Budget
  - Running high on labor (~$400K)
  - Initial scrub last month; shifted $180K from PM to technical tasks
  - Will re-scrub budget in next two weeks; develop fallback plan

Future vision and plans

- Objectives
  1. Continue technology development through sponsored and internally funded research
  2. Insert technologies into sponsored and internally funded projects
  3. Build upon the partnerships developed under AQUARIUS
- Gameplan:
  - Get the word out – publications, AQC workshops, sponsor interactions are critical
  - Follow the leads – Perspectives' reports, BAAs, SNL-sponsor interactions
    - Sponsor interest in near-term, novel applications – ties to AQC
    - Potential linkage between quantum simulation and AQC – AFOSR
    - Growing interest in STM (e.g., Atomically Precise Manufacturing Consortium workshop, June 7-8)
  - Transfer technologies internally
    - Support other sponsored research, LDRD projects
  - Tie to near term and novel applications – upcoming SNL workshop, AQC 2013
  - Examine potential for expanded partnerships in AQC
  - IP protection strategy will be important

QUESTIONS?