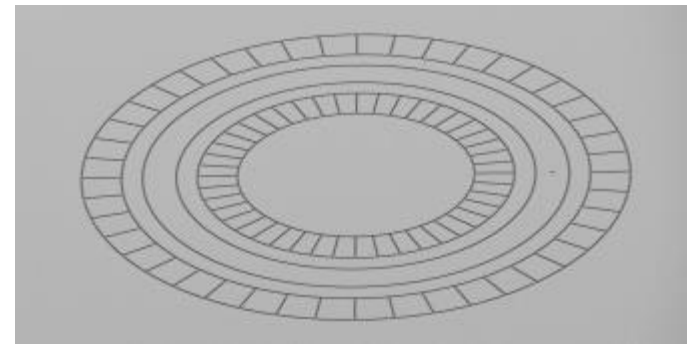
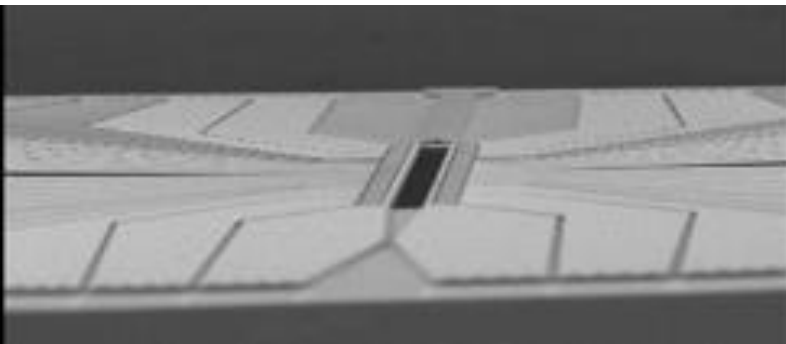


Exceptional service in the national interest



Qubit experiments and characterization of Sandia micro-fabricated ion traps

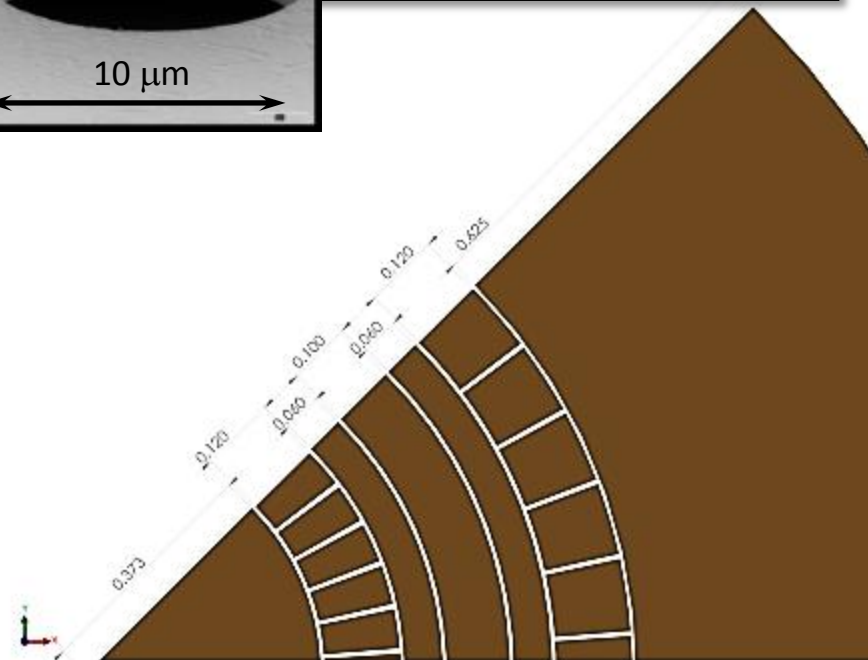
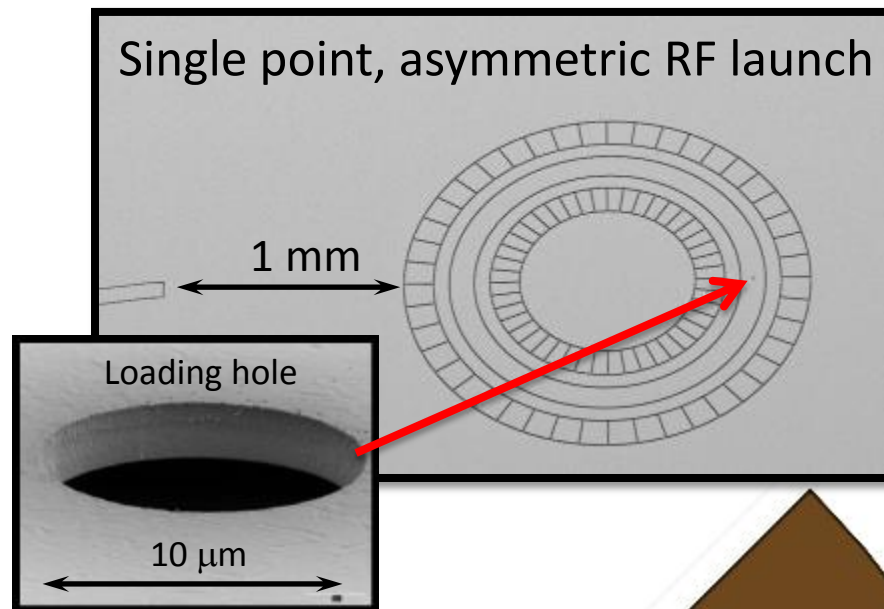
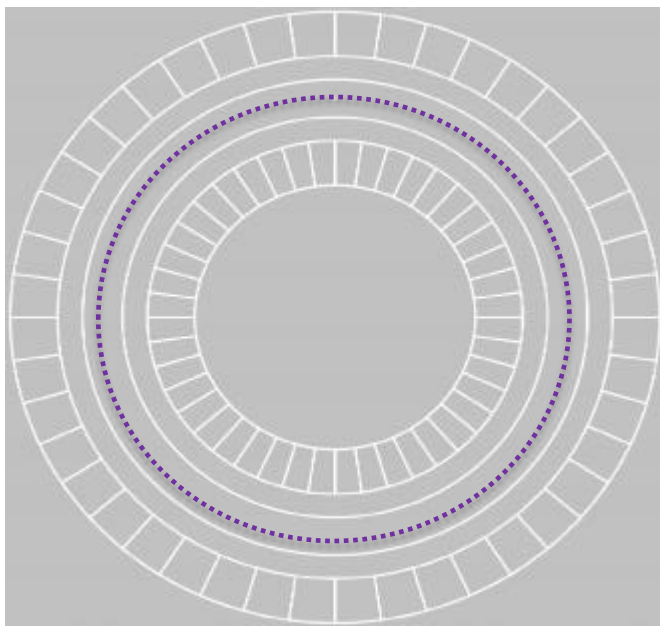
Craig R. Clark, Susan Clark, Boyan Tabakov, and Peter Maunz

Sandia National Laboratories

Ring ion Trap

Trap specifics

- 4 metal level fabrication
- 89 control electrodes
- 624 μm ion radius
- Trap designed to minimize perturbations to the rf angular symmetry



Physics with a ring ion trap

PRL 104, 043004 (2010)

PHYSICAL REVIEW LETTERS

week ending
29 JANUARY 2010

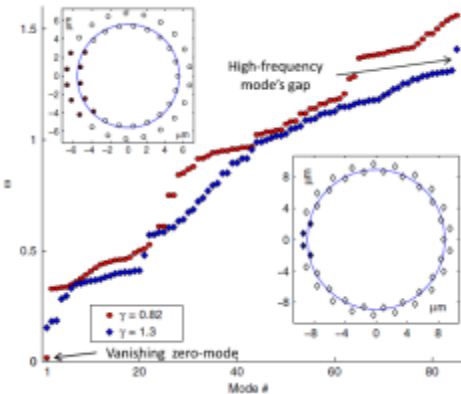
Quantum Coherence of Discrete Kink Solitons in Ion Traps

H. Landa,¹ S. Marcovitch,¹ A. Retzker,² M. B. Plenio,² and B. Reznik¹

¹Ray Sackler Faculty of Exact Sciences, School of Chemistry, Tel Aviv University, Ramat Aviv 69978, Israel
²Imperial College London, London SW7 2BQ, United Kingdom
³Universität Ulm, D-89069 Ulm, Germany
Published 29 January 2010

is with cold trapped ions. We demonstrate the formation of the zigzag structure in a ring ion trap with an odd number of ions. We show that the separated internal mode of a stationary ion is Doppler limited. The spectral properties of the ion ring are studied using current technology. This study opens up new ideas for quantum information processing.

PACS numbers



New Journal of Physics

The open-access journal for physics

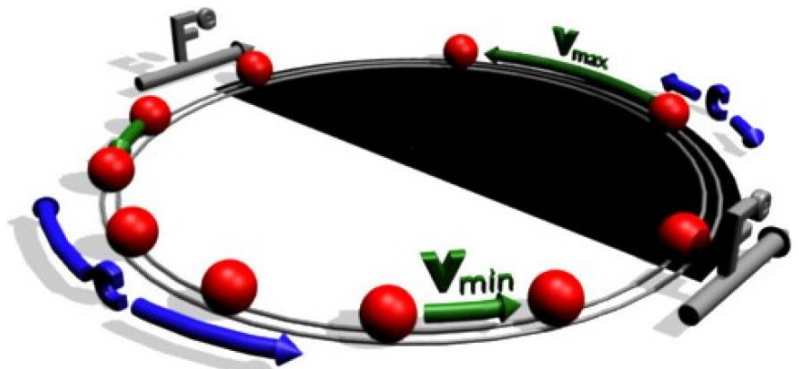
Erratum

Hawking radiation on an ion ring in the quantum regime

Birger Horstmann, Ralf Schützhold, Benni Reznik, Serena Fagnocchi and Ignacio Cirac 2011 *New J. Phys.* **13** 045008

New Journal of Physics **13** (2011) 045008

IOP Institute of Physics Φ DEUTSCHE PHYSIKALISCHE GESELLSCHAFT



PRL 109, 163001 (2012)

Selected for a Viewpoint in *Physics*
PHYSICAL REVIEW LETTERS

Space-Time Crystals of Trapped Ions

Tongcang Li,¹ Zhe-Xuan Gong,^{2,3} Zhang-Qi Yin,^{3,4} H. T. Quan,⁵ Xiaobo Yin,⁴ Peng Zhu,^{1,6} L.-M. Duan,^{2,3} and Xiang Zhang^{1,6,*}

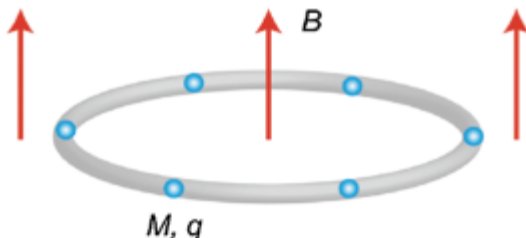
¹NSF Nanoscale Science and Engineering Center, 3112 Echeverry Hall, University of California, Berkeley, California 94720, USA
²Department of Physics, University of Michigan, Ann Arbor, Michigan 48109, USA
³Center for Quantum Information, Institute for Interdisciplinary Information Sciences, Tsinghua University, Beijing 100084, China

⁴China, Chinese Academy of Sciences, Beijing 100049, China
⁵University of Maryland, College Park, Maryland 20742, USA
⁶Department of Physics, University of California, Berkeley, California 94720, USA

is, as well as spatial crystals, can be realized experimentally. The ions spontaneously form a space-time crystal at the lowest rotation of trapped ions. We show that these space-time crystals provide a new platform for studying the effects of finite size of trapped ions on quantum information processing.

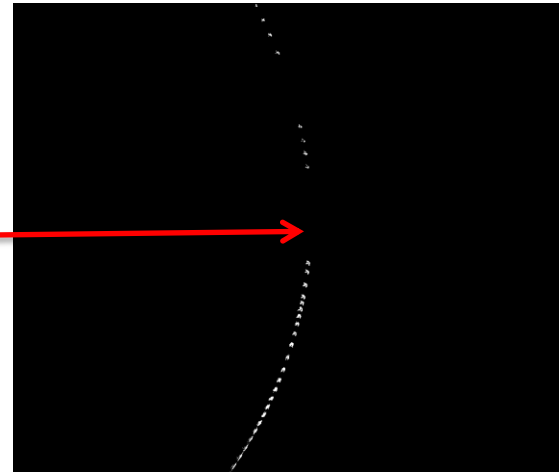
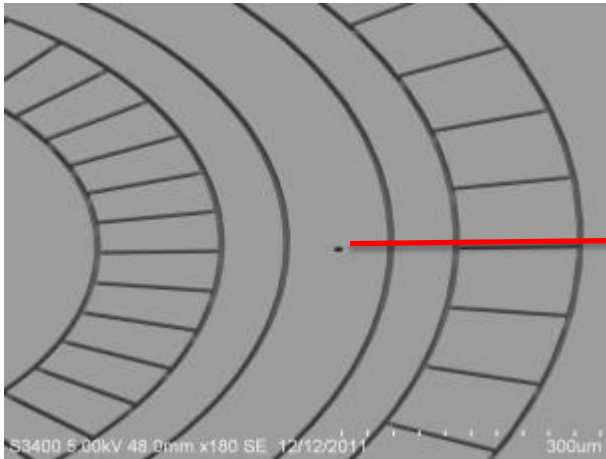
DOI: 10.1103/PhysRevLett.109.163001

(b)

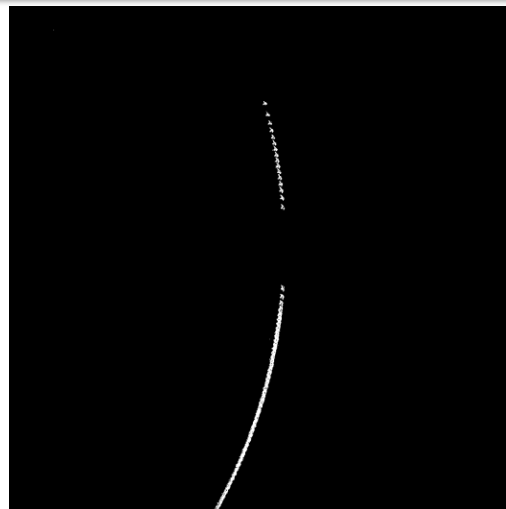


Potential Defects

Loading Hole



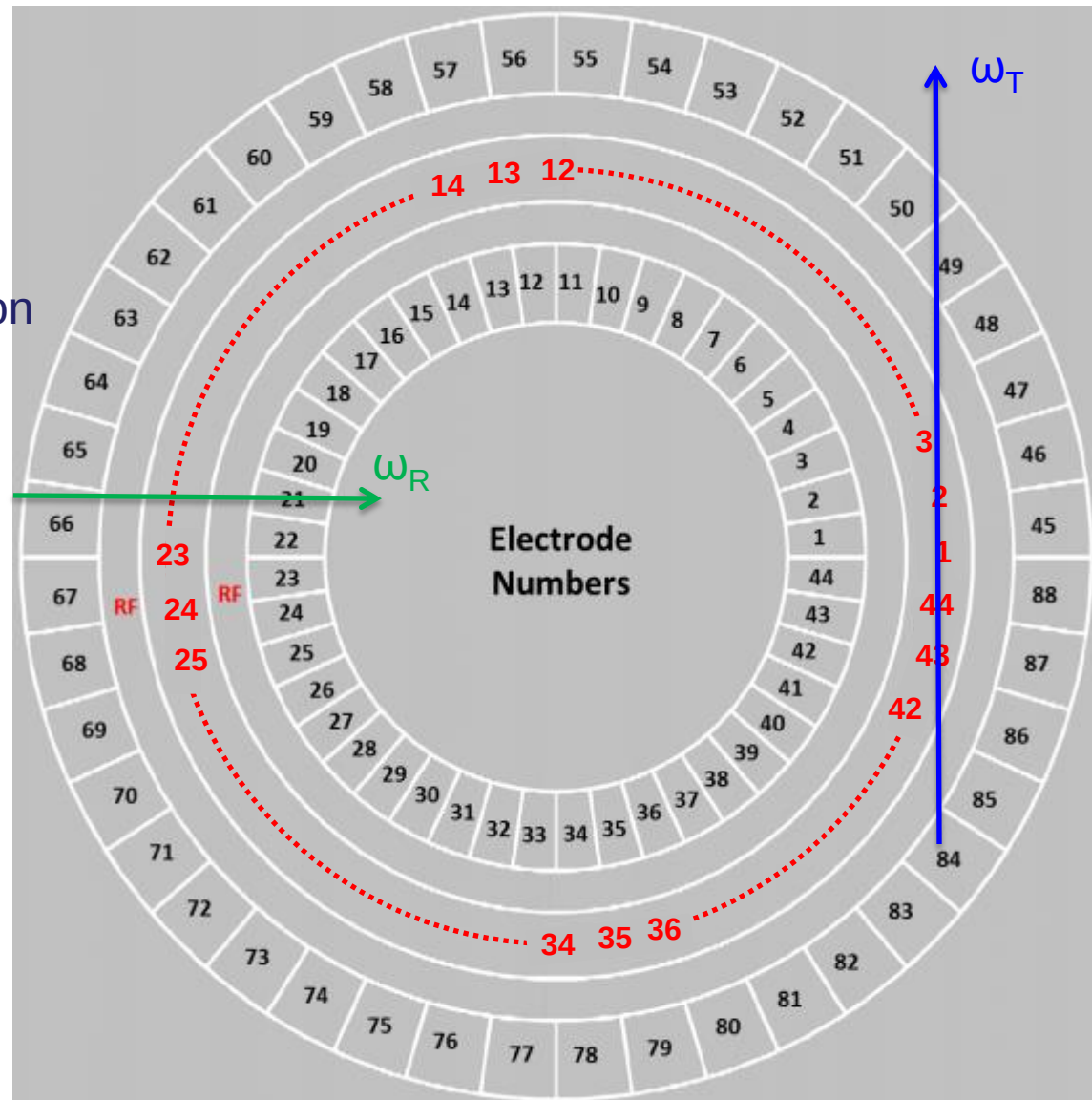
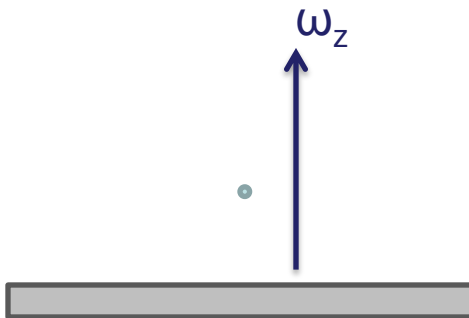
Stray Electric Fields



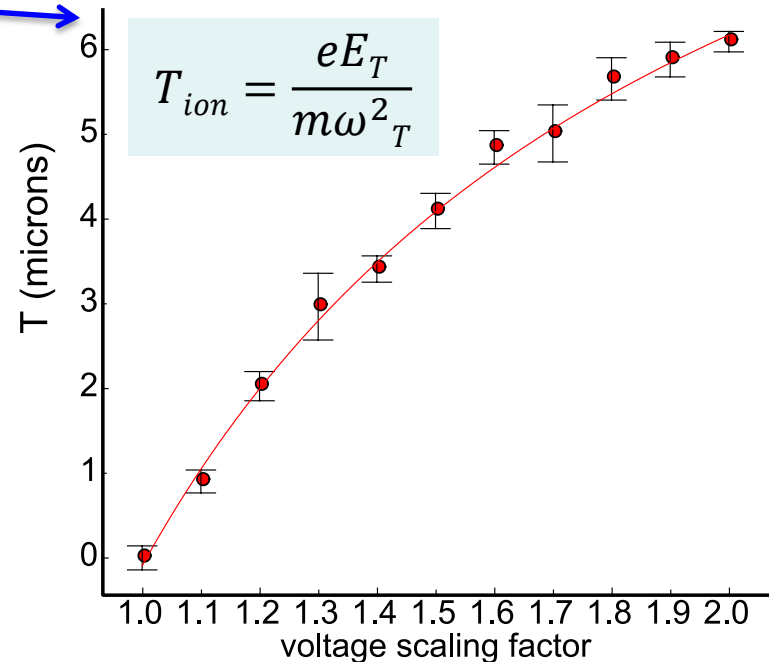
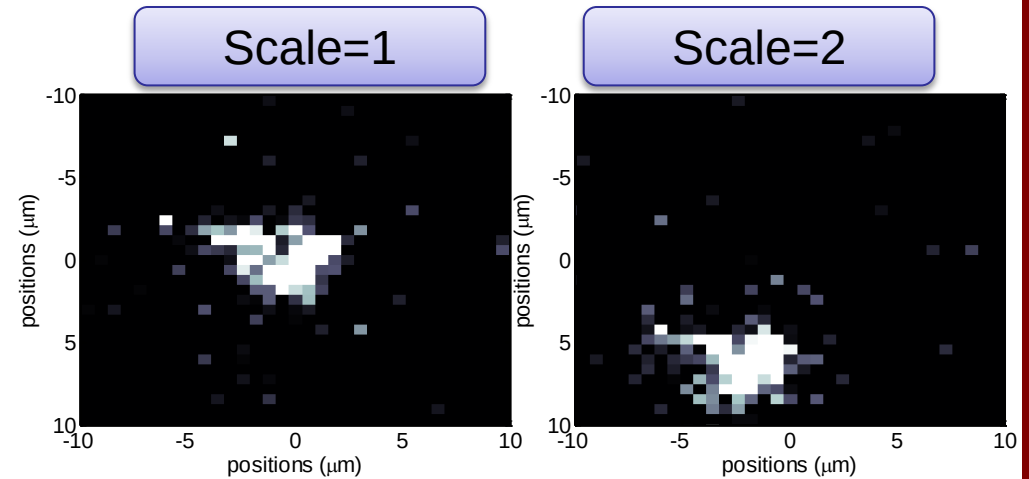
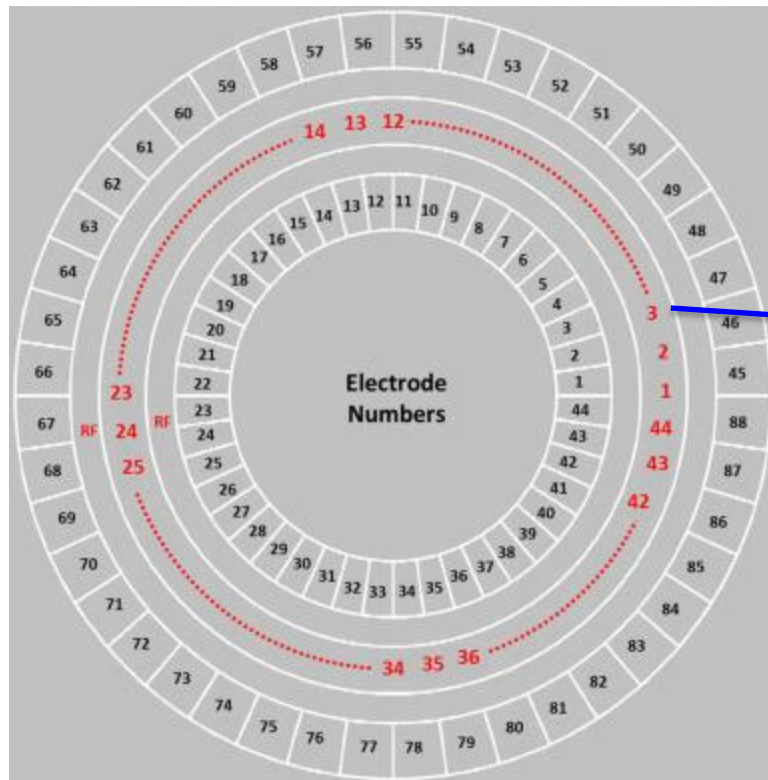
It is no surprise that we can not load a chain of 300 ion without compensating for stray electric fields.

Ring Trap

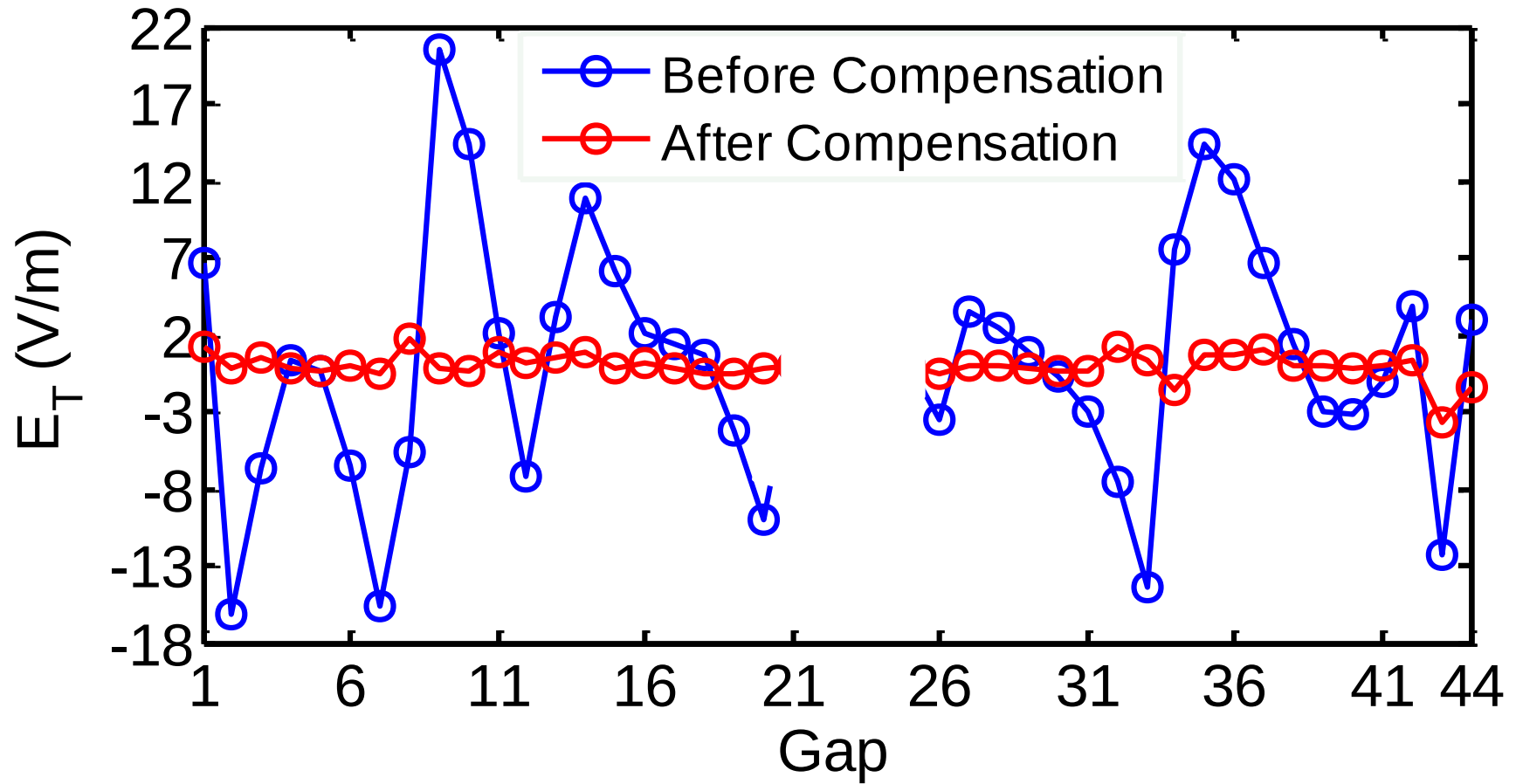
- Electrodes
- Gaps
- ω_T = Tangential motion
- ω_R = Radial motion
- ω_z = Out of plane motion



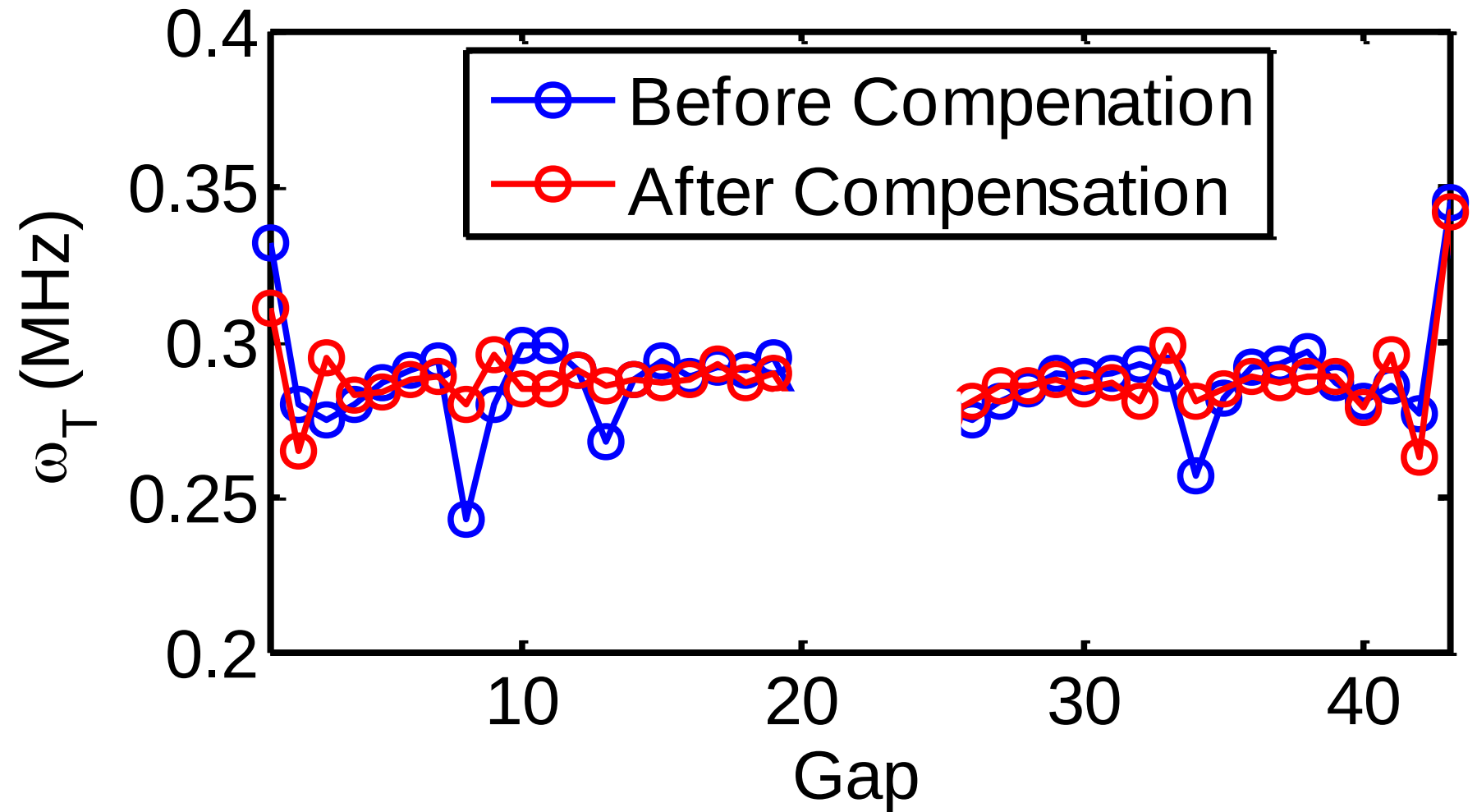
Tangential Compensation



Tangential Compensation

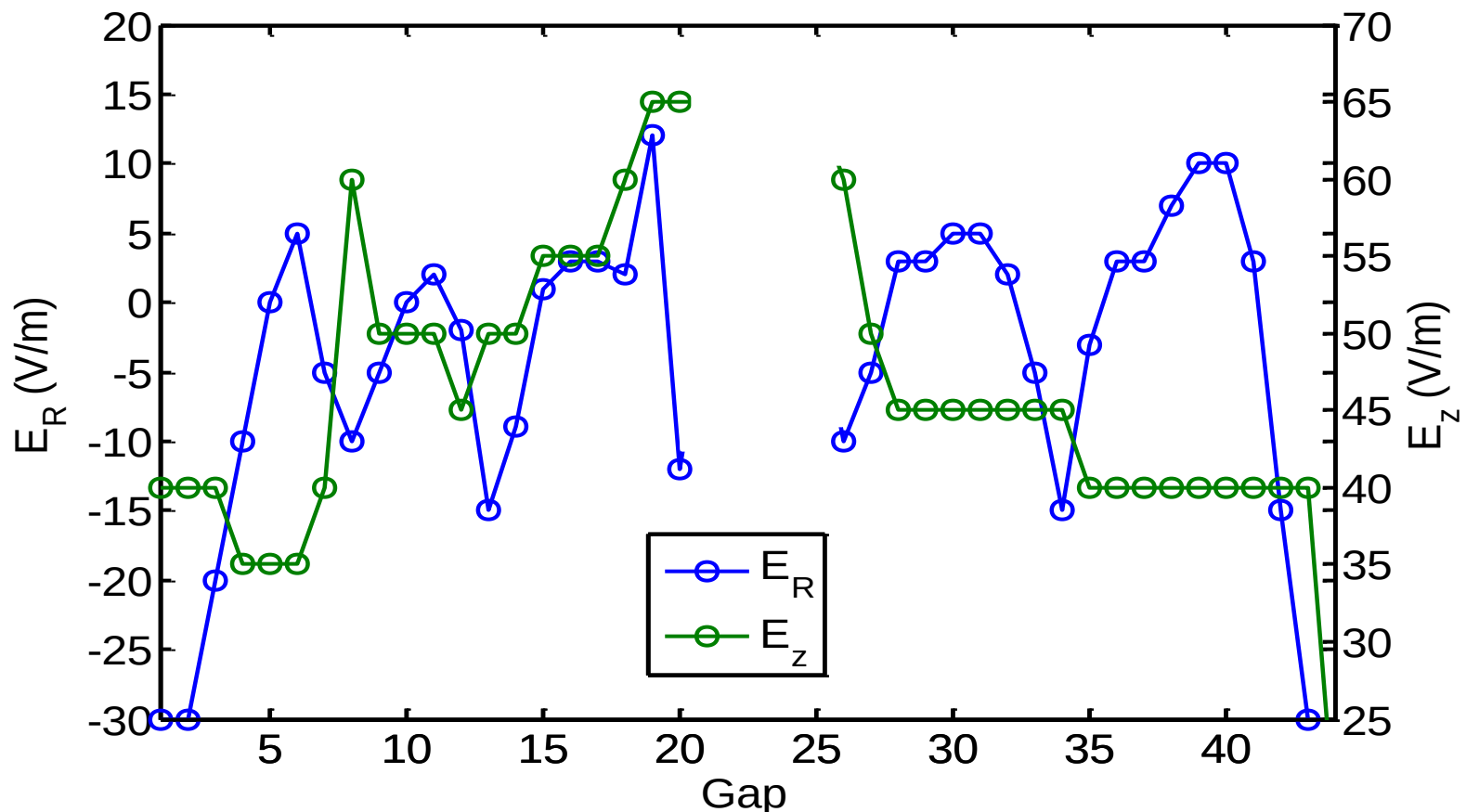


Tangential Secular Freq.



Radial Fields Uncompensated

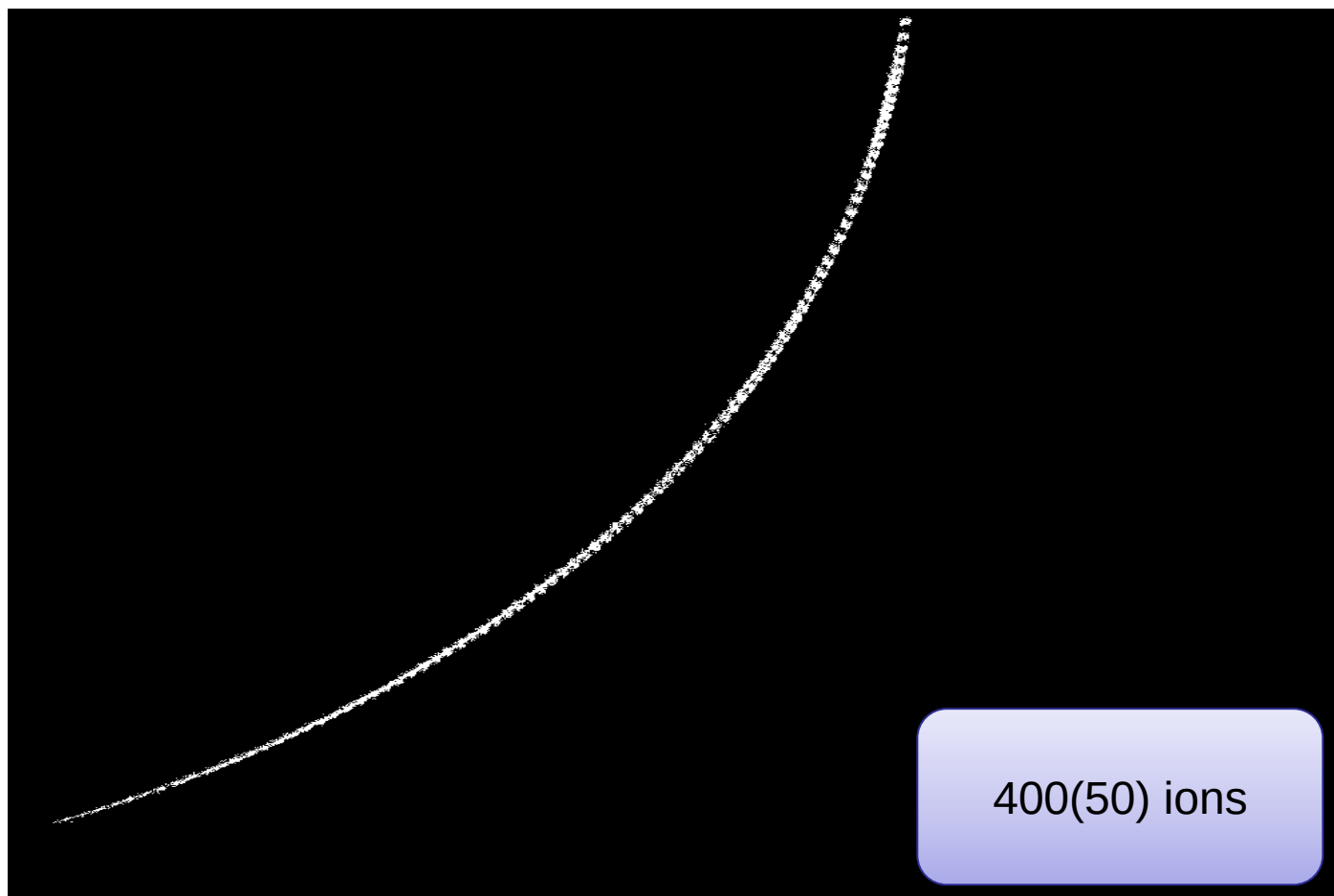
1. Time-of-Arrival compensation methods to determine E_R
2. Parametric RF tickle compensation methods to determine E_z



- 1) D. J. Berkeland, J. D. Miller, J. C. Bergquist, W. M. Itano, and D. J. Wineland, J. Appl. Phys. 83, 5025 (1998).
- 2) Y. Ibaraki, U. Tanaka, and S. Urabe, Appl. Phys. B 105, 219 (2011).

Compensated Ring Trap

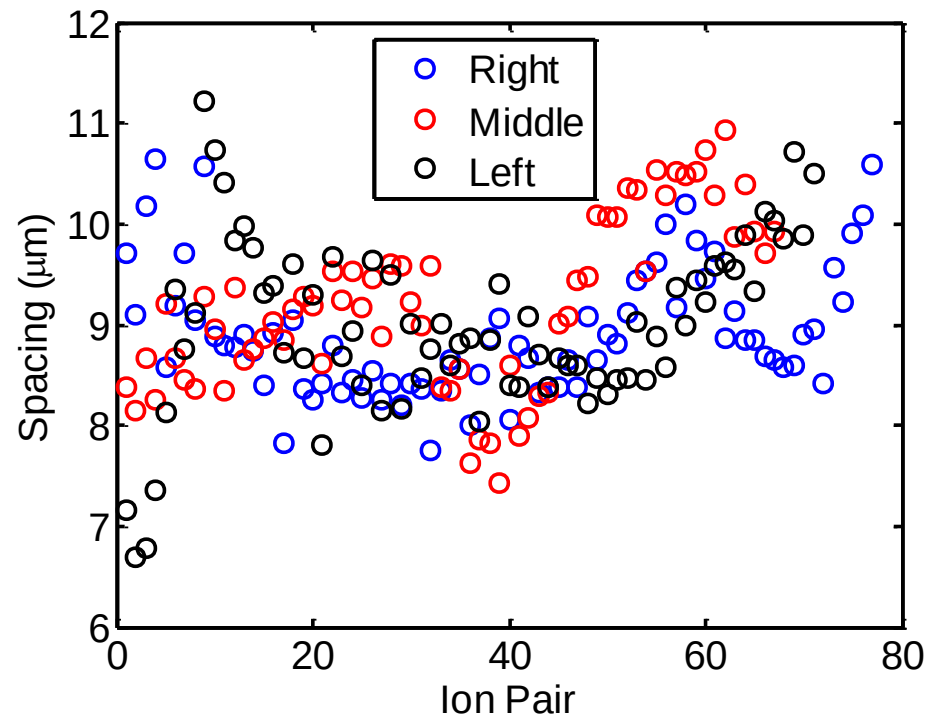
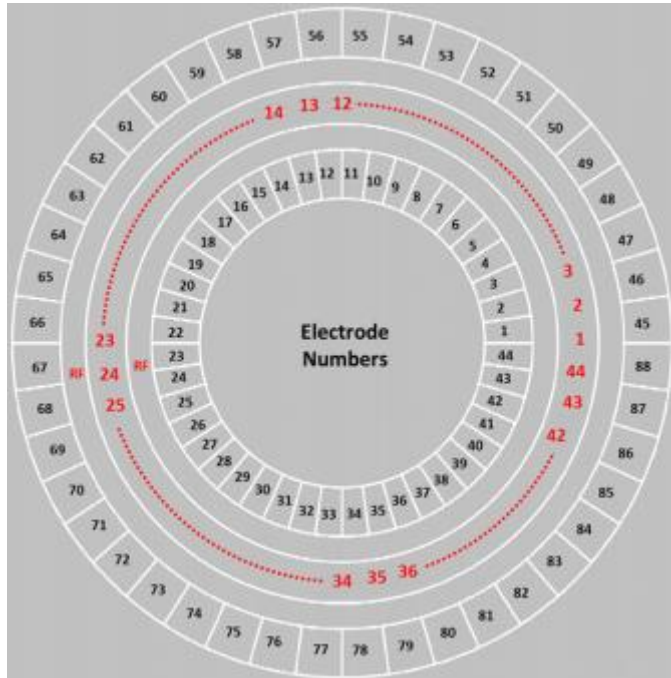
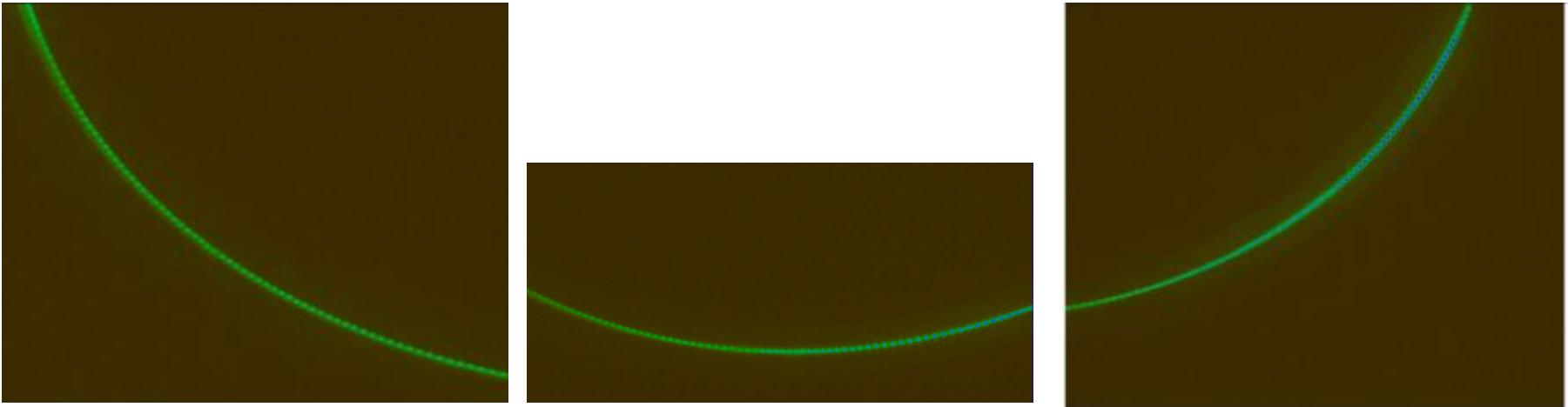
Plug the tangential stray field data for each gap into the CPO simulation to determine a solution to fill the ring trap with single chain of ions.



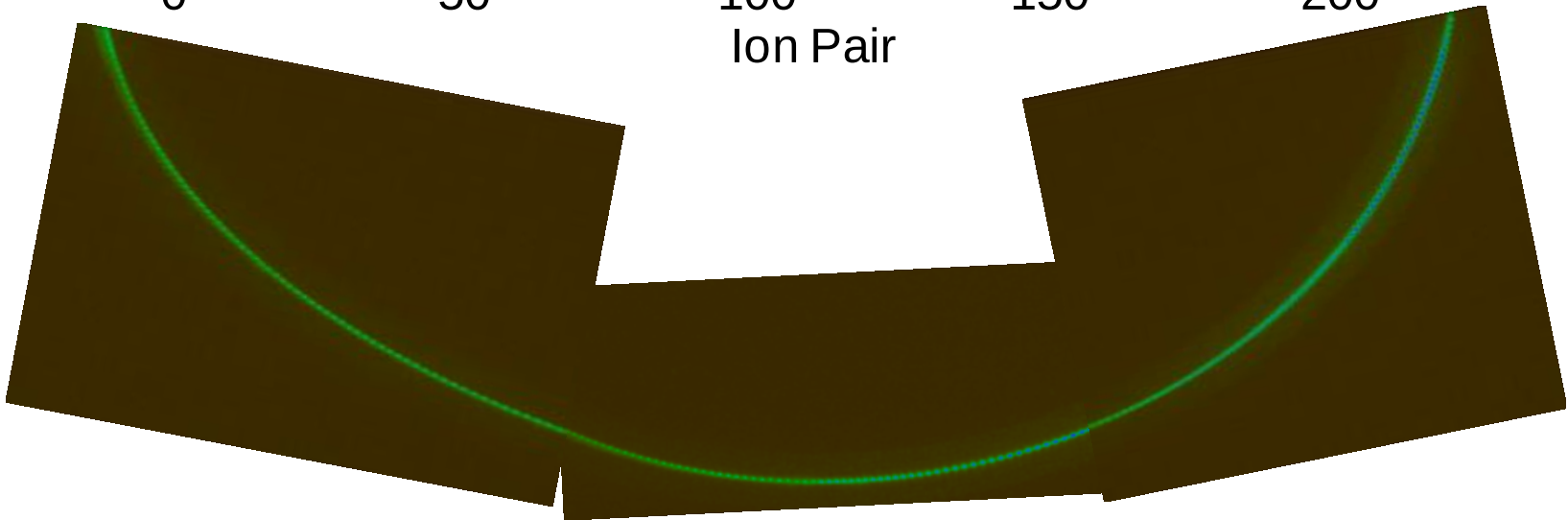
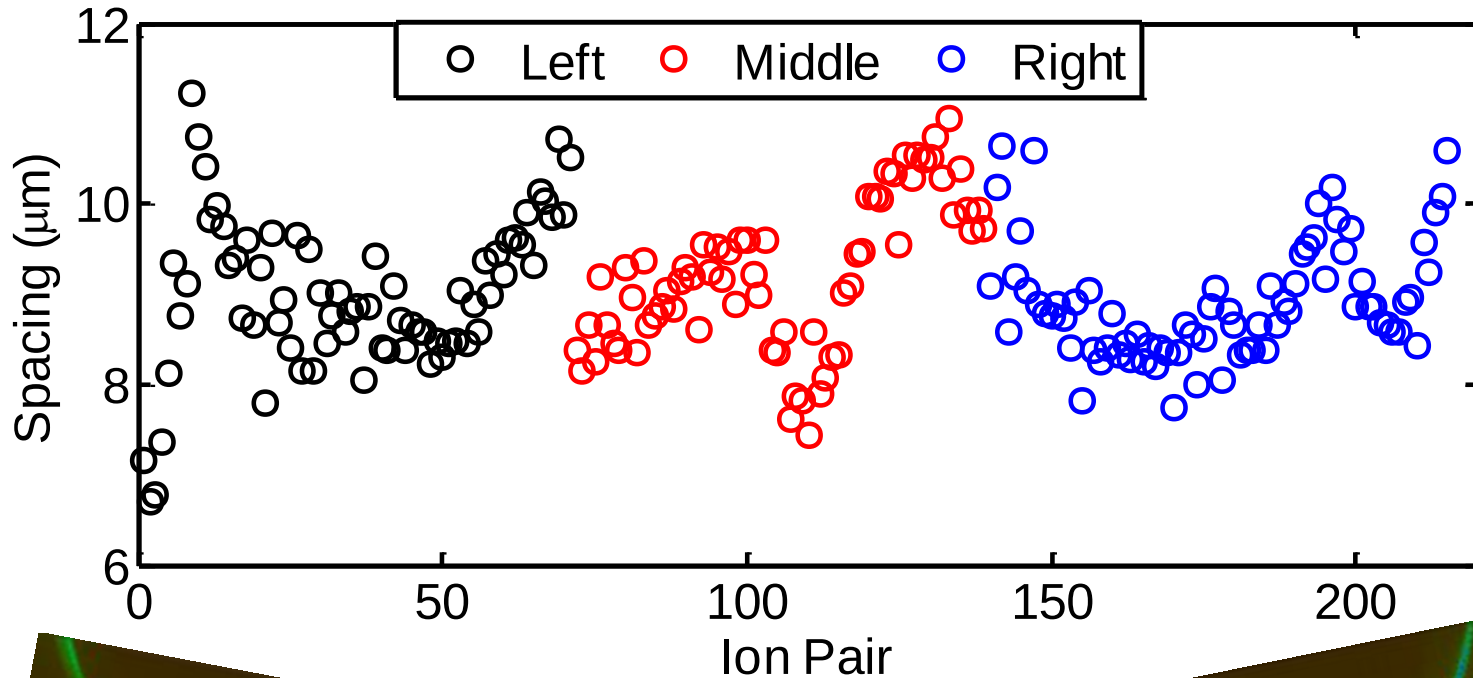
Compensating the trap



Average ion distance

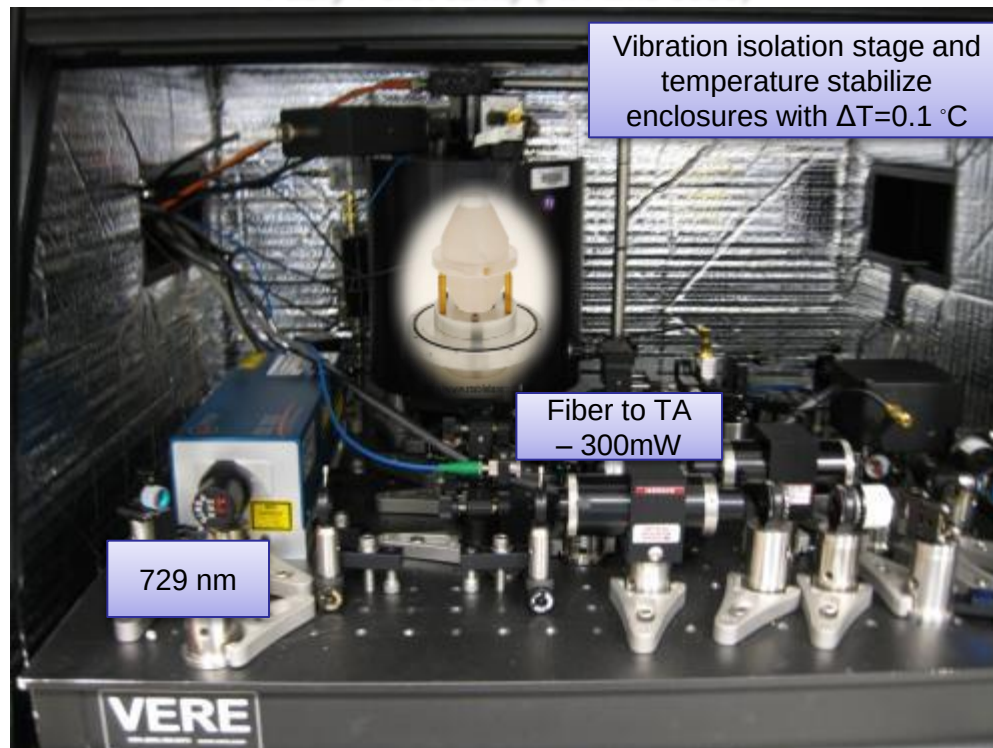


Average ion distance

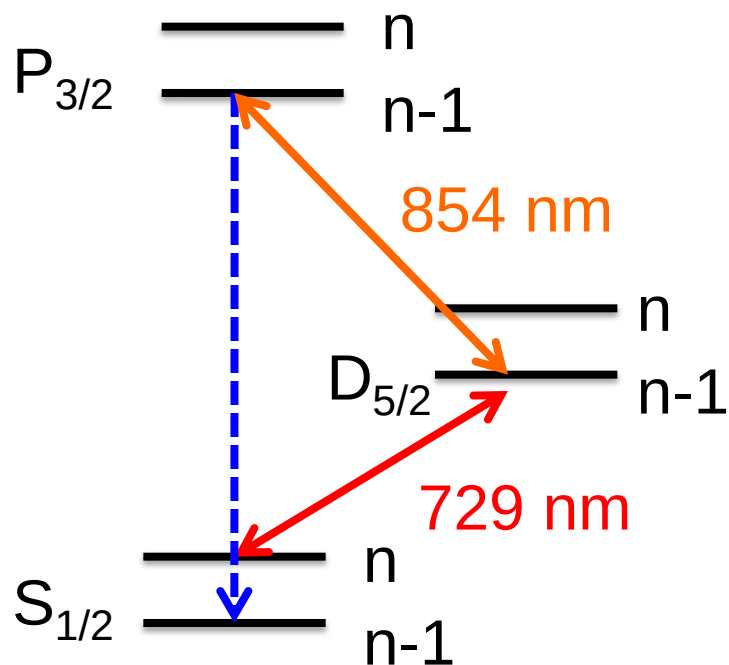


729 nm laser system

ULE Optical Cavity Fabry-Perot cavity (ATFilms 6030)



Calcium Optical Quibit



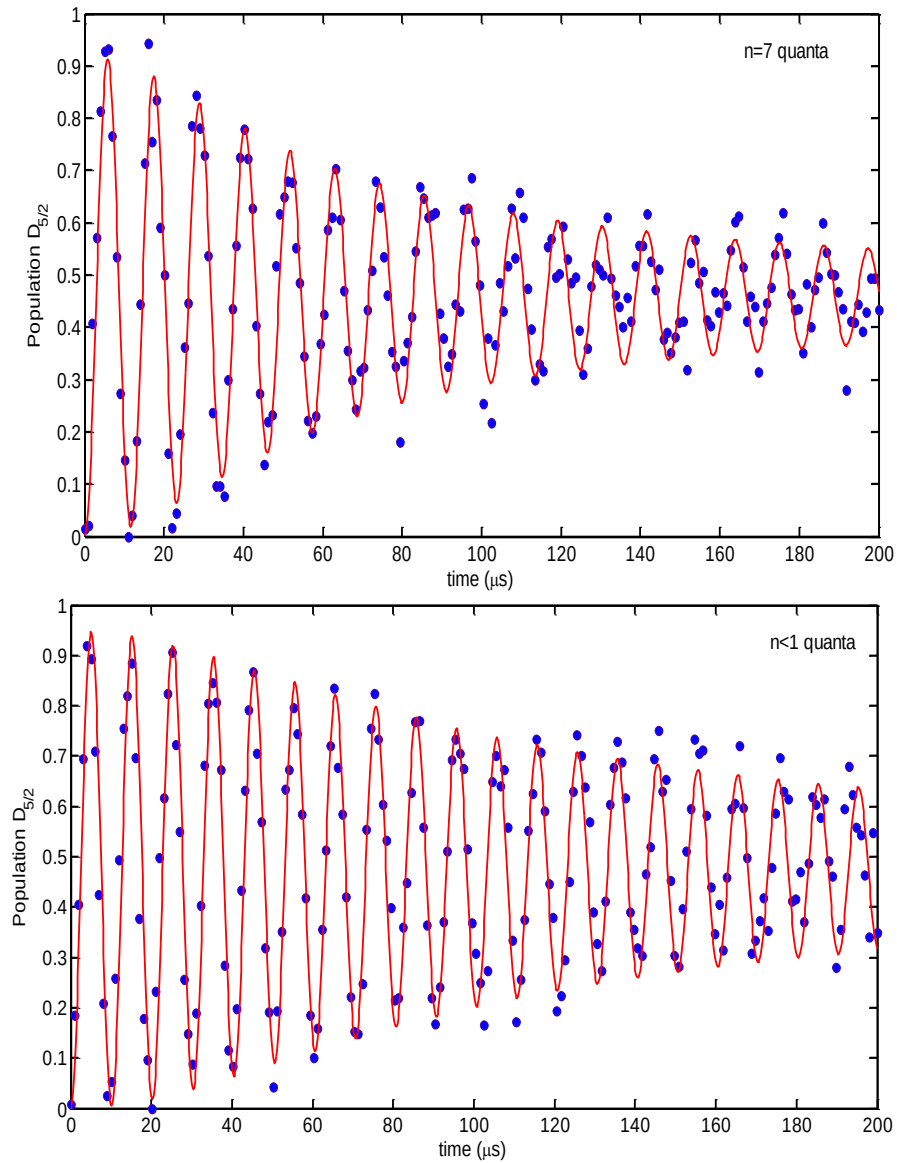
$$F = 200000$$

$$\nu_F = 1.93 \text{ GHz}$$

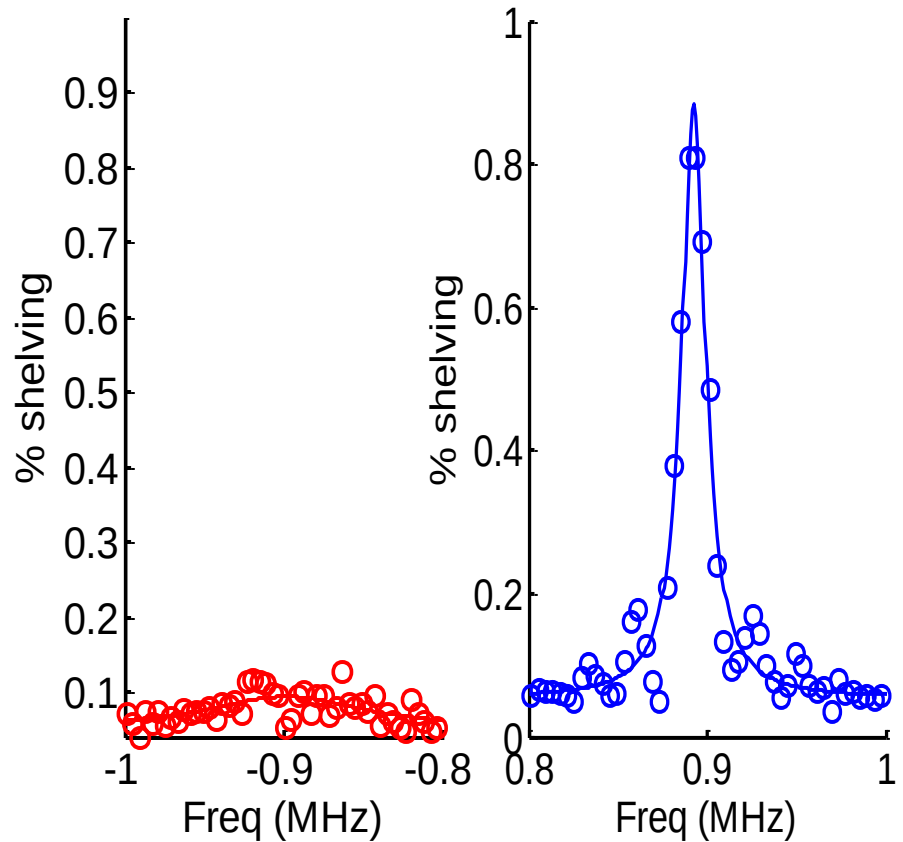
$$\delta_v = \frac{\nu_F}{F} = 9.65 \text{ kHz}$$

$$T_c = 24.2 \text{ }^\circ\text{C}$$

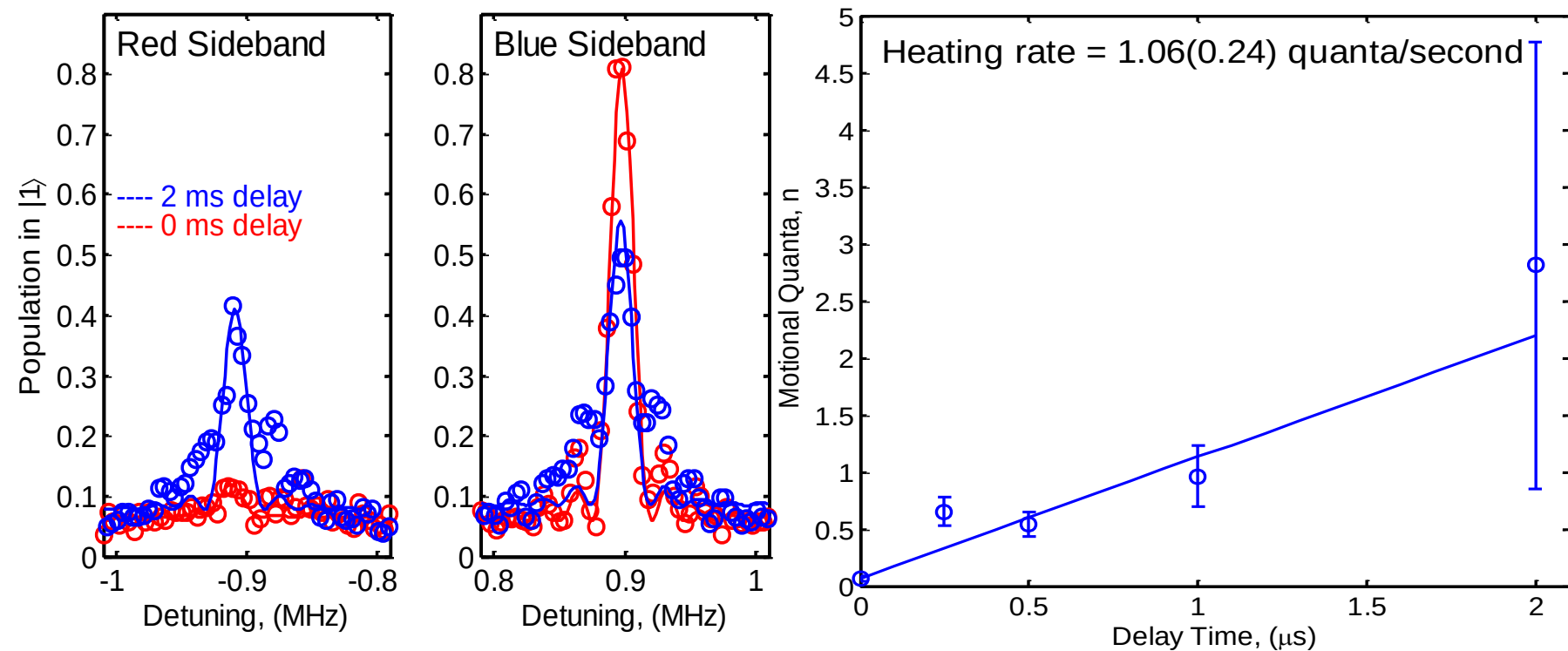
Sideband cooling



$\bar{n}=0.12$ quanta



Heating rate Measurements



Future of the Ring Trap

Au Coated

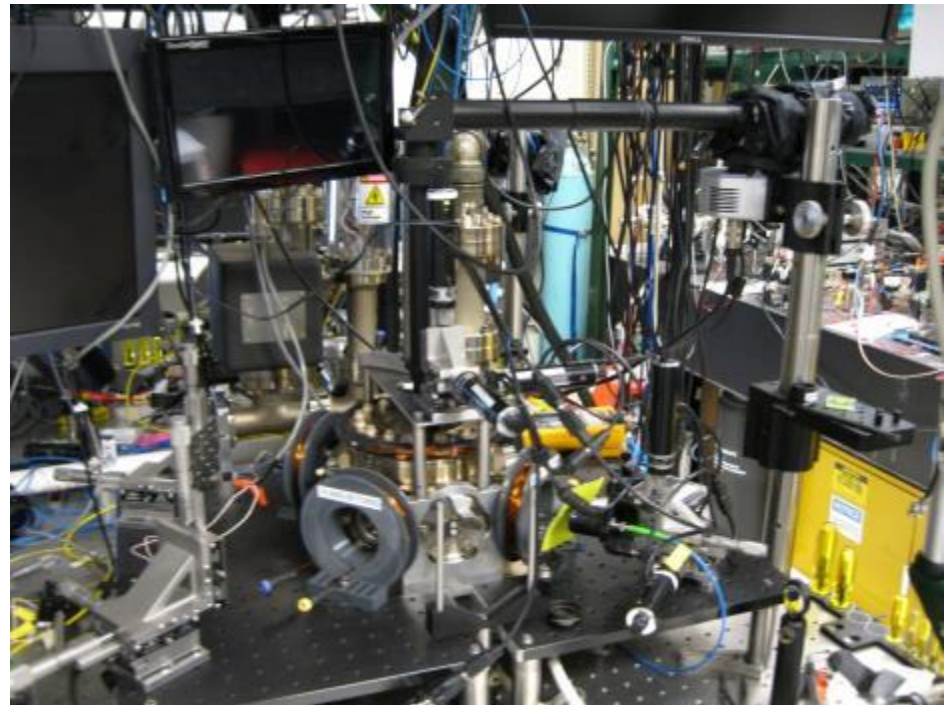
Al surface

Surface coating

/2013

1.00mm

Improved Setup



Interposer Chip

1.00mm