“TACK” ION TRAP

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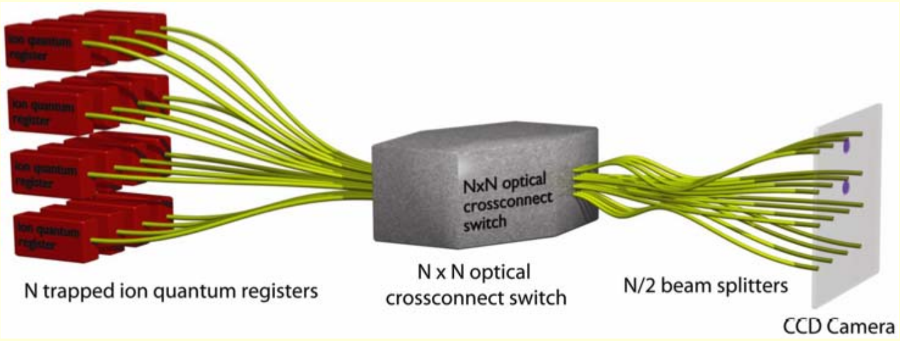
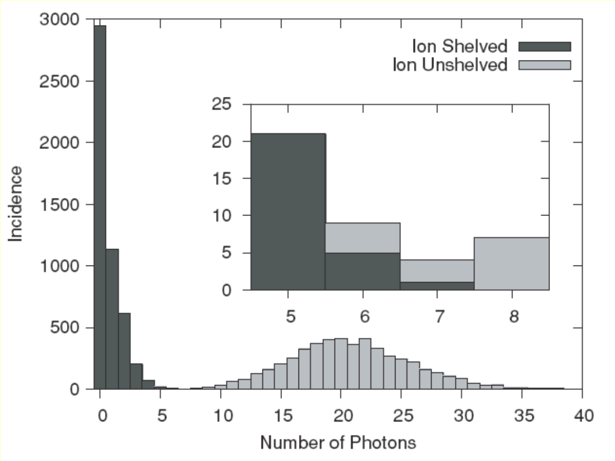
More light from trapped ions!

more light really helps!

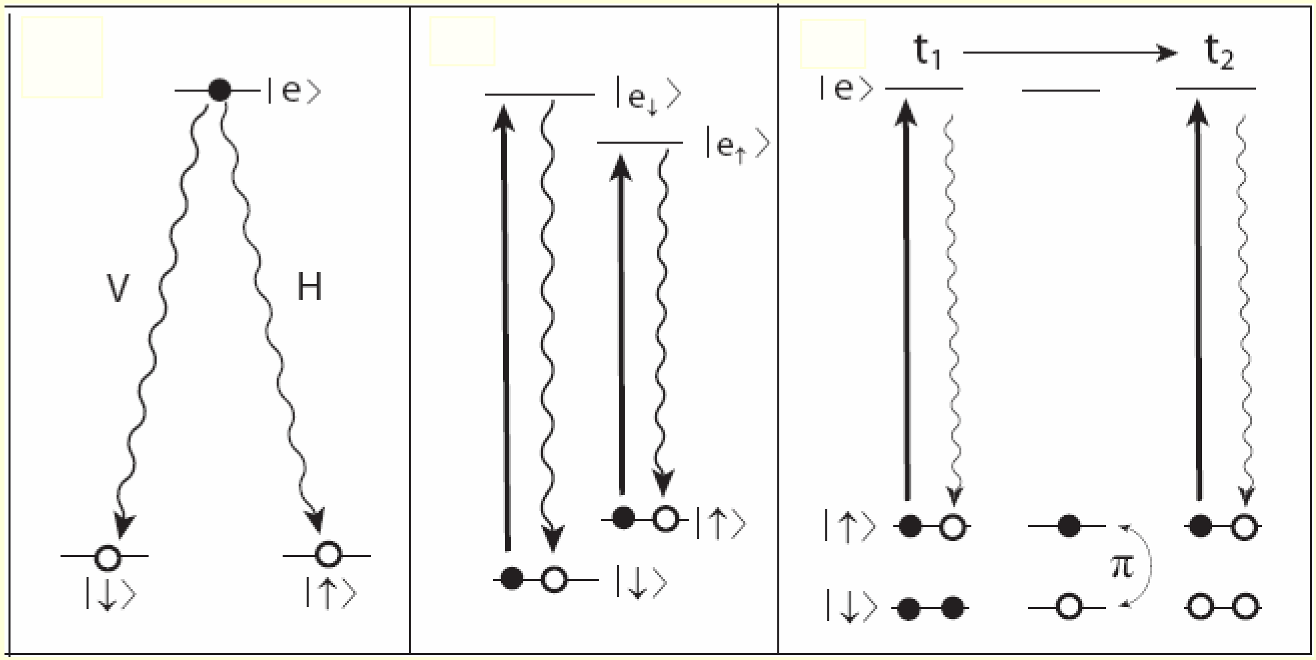
photonic link

state detection





Photonic link: qubit types



polarization	frequency	time-bin
polarization purity requires small solid angle collection	requires frequency-independent collection	requires fast microwave or laser pi-pulse

Photonic link: requirements

- Collect as much light as possible (currently: ~2%)
- Mode-match collected light into a single-mode fiber (currently ~20% fiber coupling efficiency)
- Polarization/frequency selectivity?

Solutions:

- Cavity QED system (clean mode, perfect for fiber coupling; not suitable for frequency qubit; polarization?)
- Large N.A. diffractive/refractive optics in vacuum
- Large N.A. reflective optics in-vacuum (frequency and polarization insensitive; typically poor mode quality)
- Large N.A. Fresnel mirrors on-chip

Photon collection: requirements

• Collect as much light as possible (currently: ~ 2%)
• Collect at multiple locations (or large field of view)
• Mode quality not important as long as images of neighboring ions ~10 micron apart do not overlap

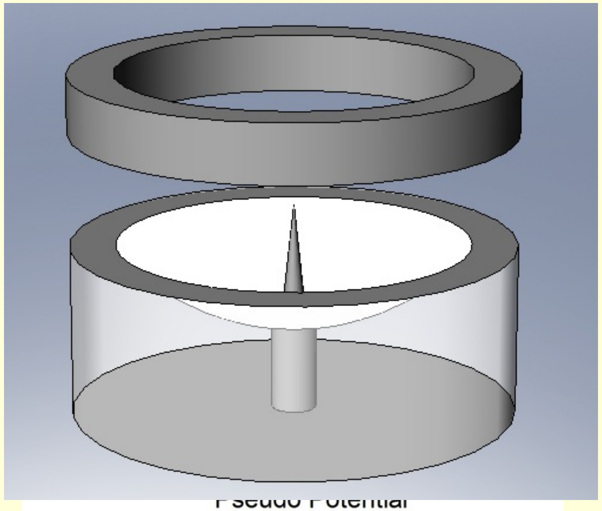
Solutions:

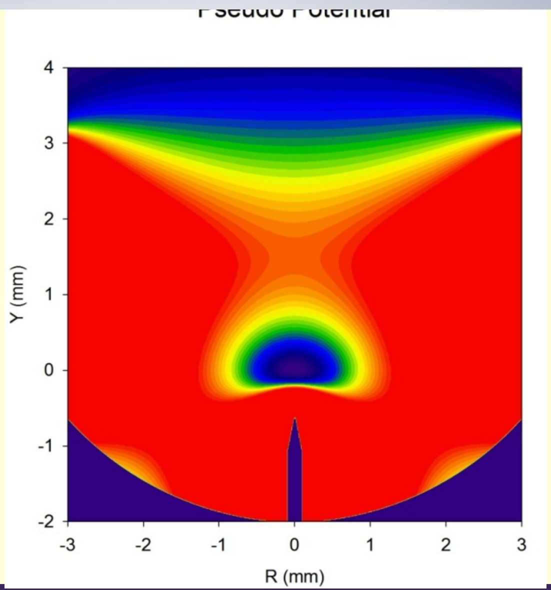
- micro mirrors integrated with the trap structure
- large FOV bulk lenses
- ...

Reflective optics in vacuum: the UW “tack” trap*

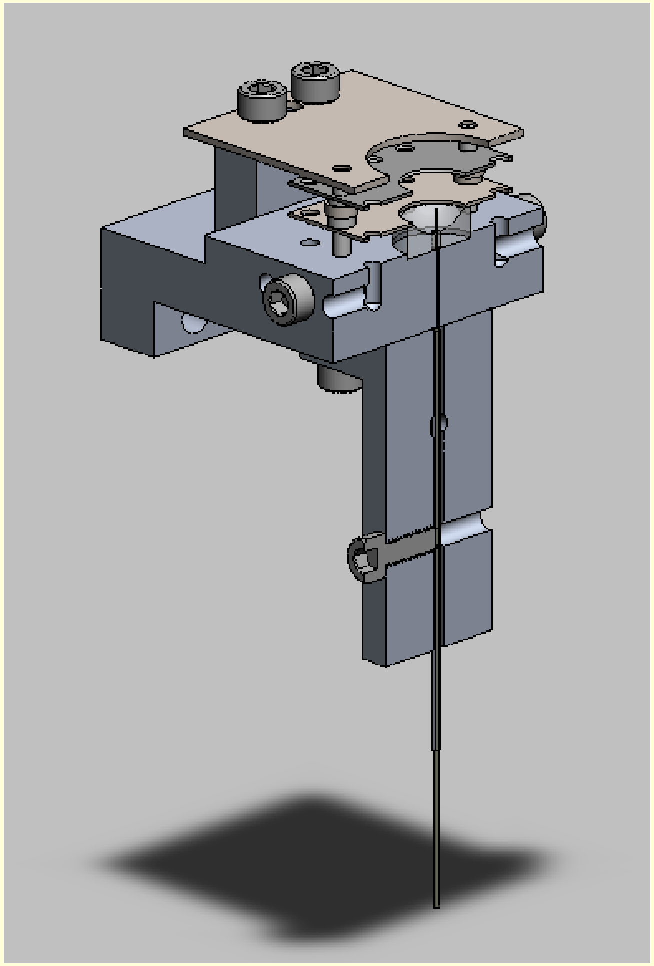
- Photons collected by a large N.A. metallic spherical mirror
- Mirror surface serves as the RF electrode of the trap
- Trapping point set by an adjustable needle electrode
- Other mirror geometries (parabolic, ellipsoidal) possible, perhaps desirable?

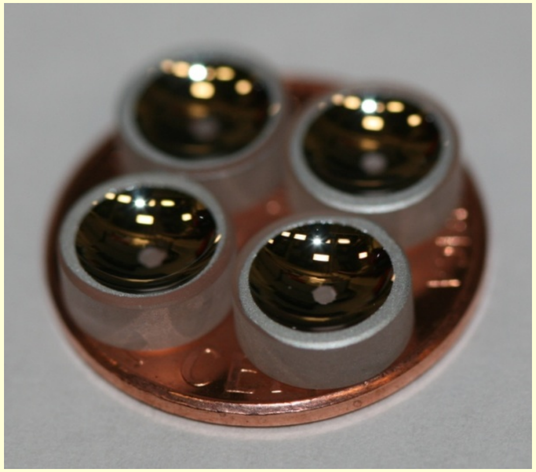
*compare to NIST “stylus” trap.

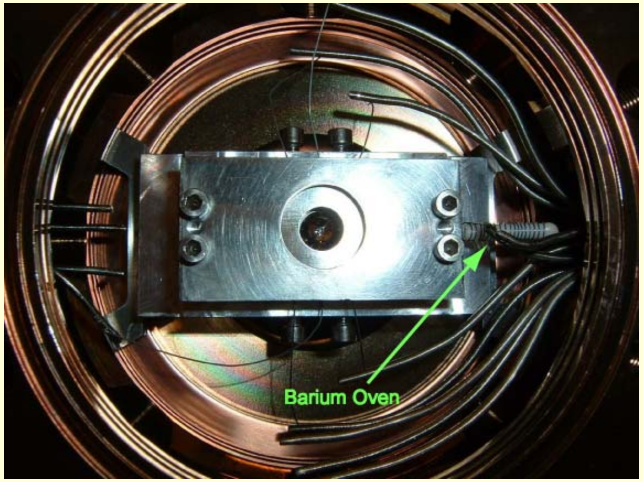




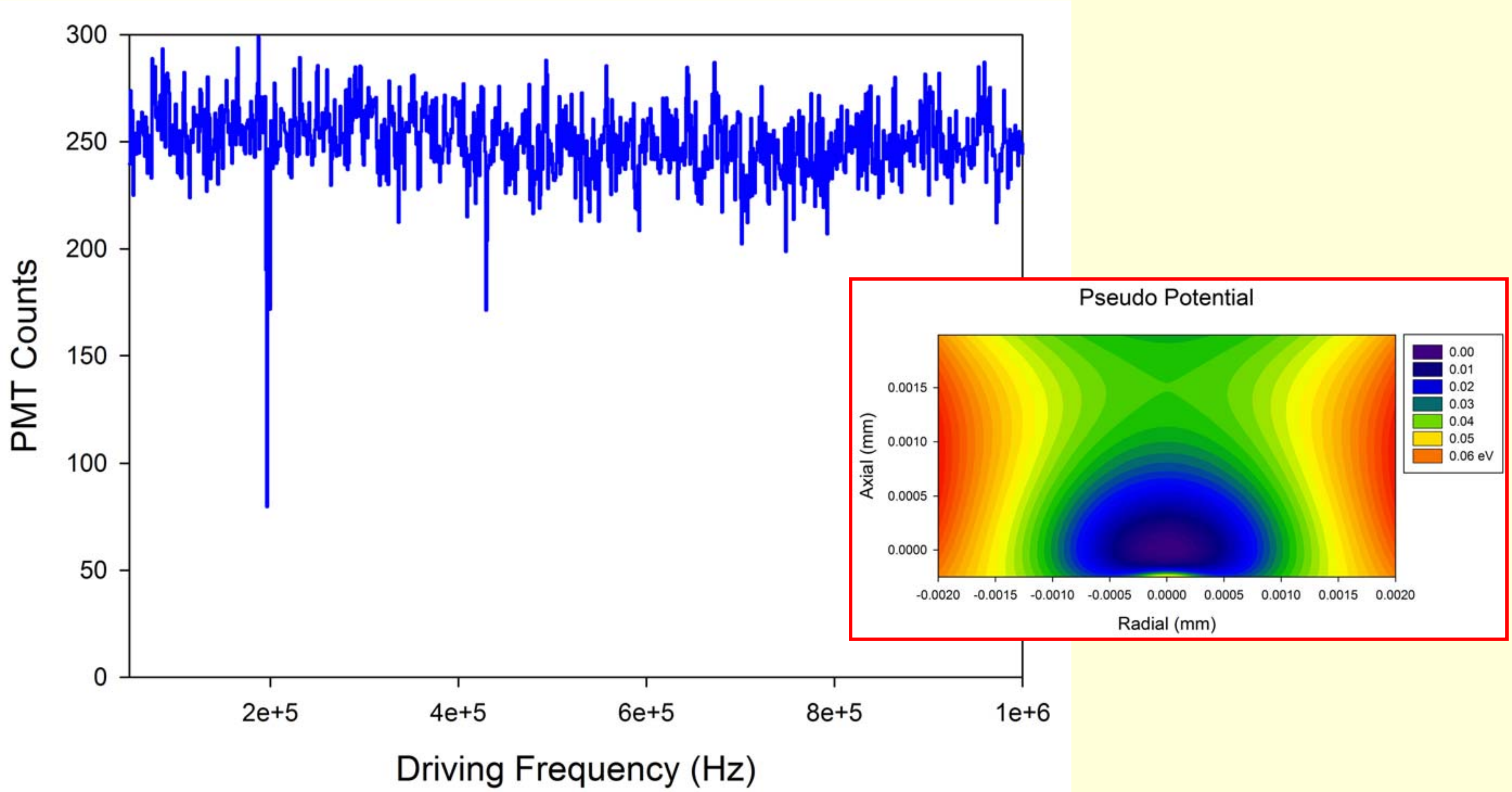
Trap design



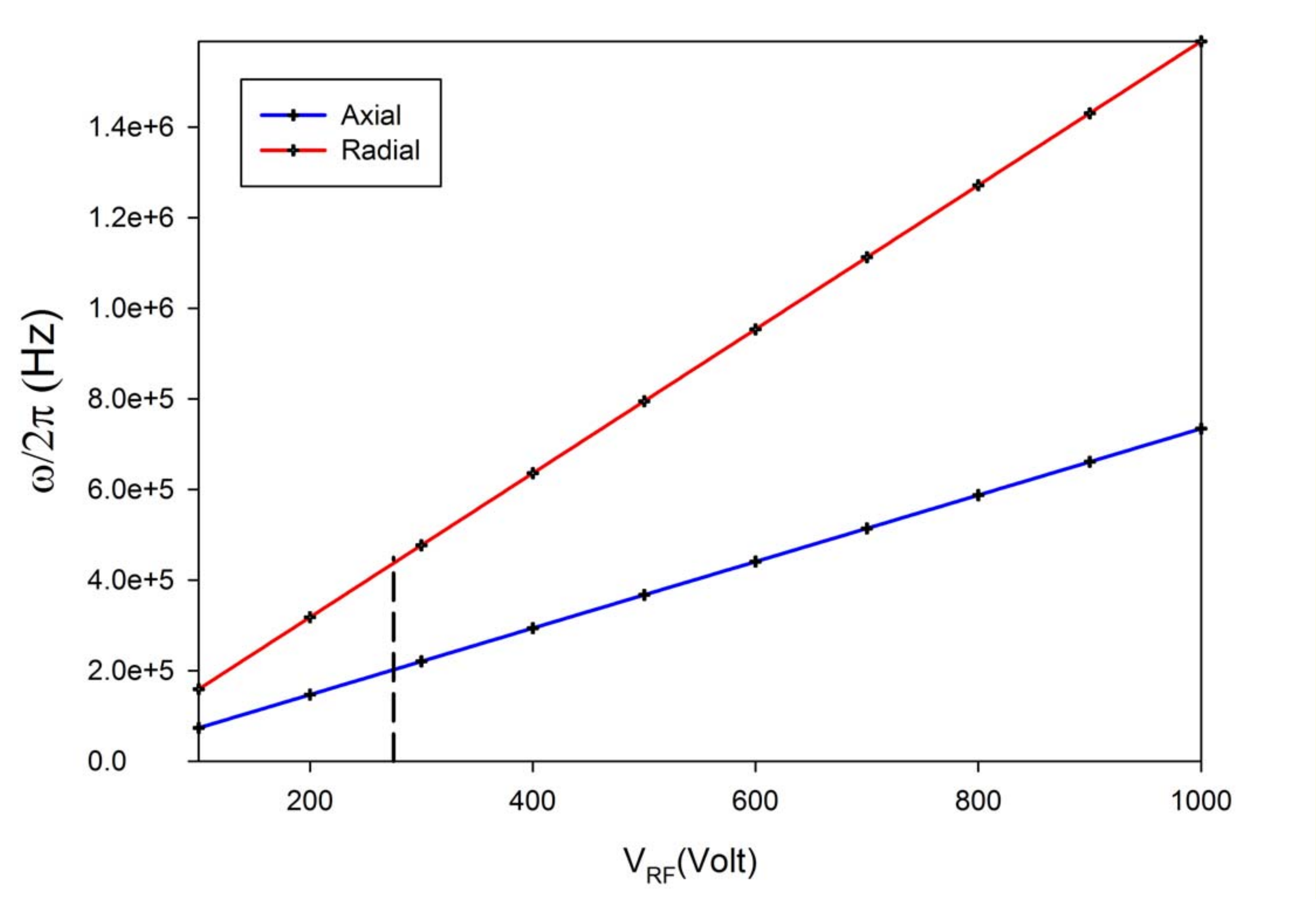




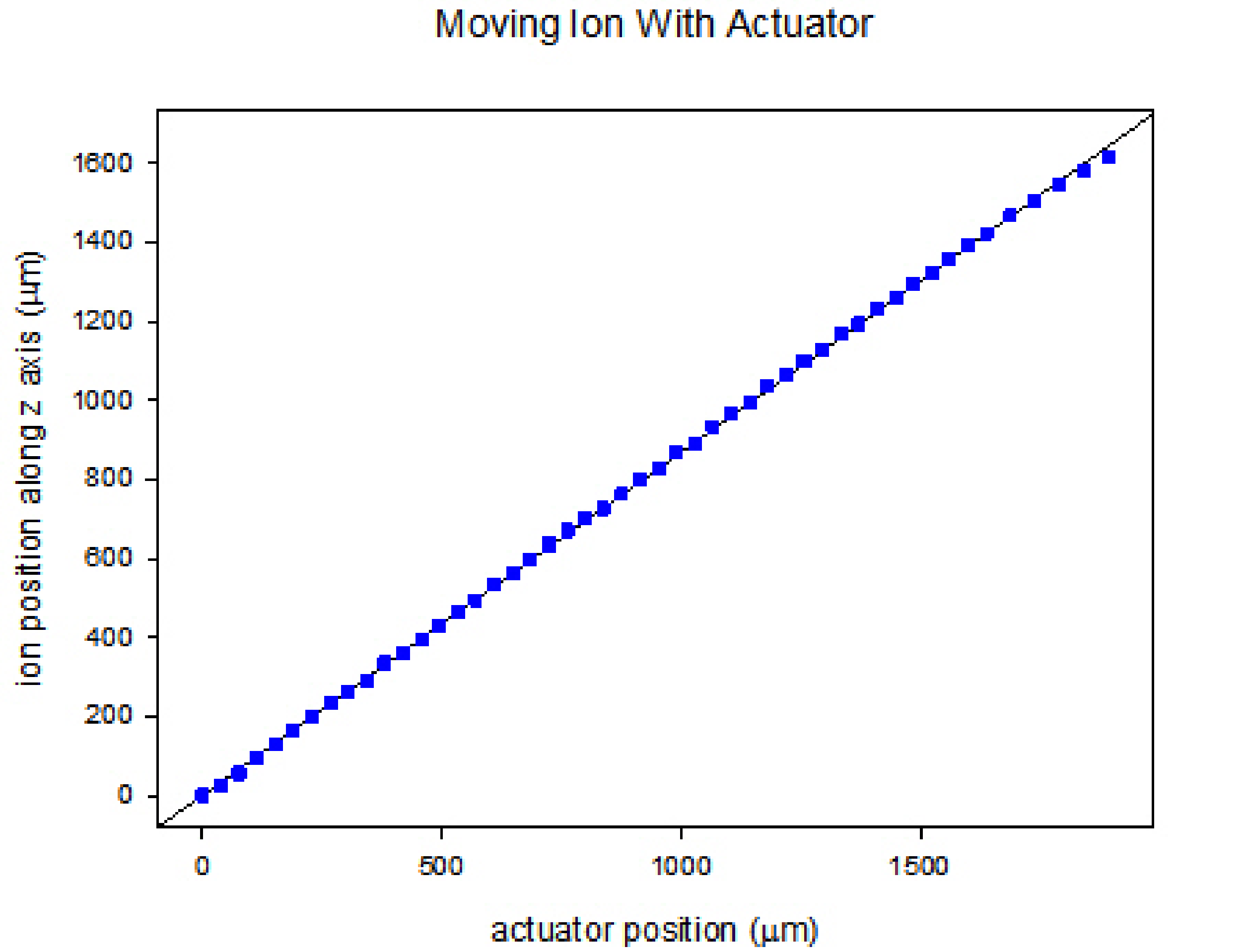
Performance: secular frequencies



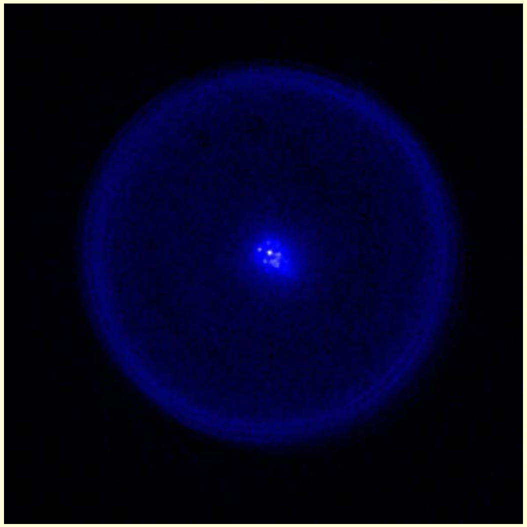
Performance: secular frequencies

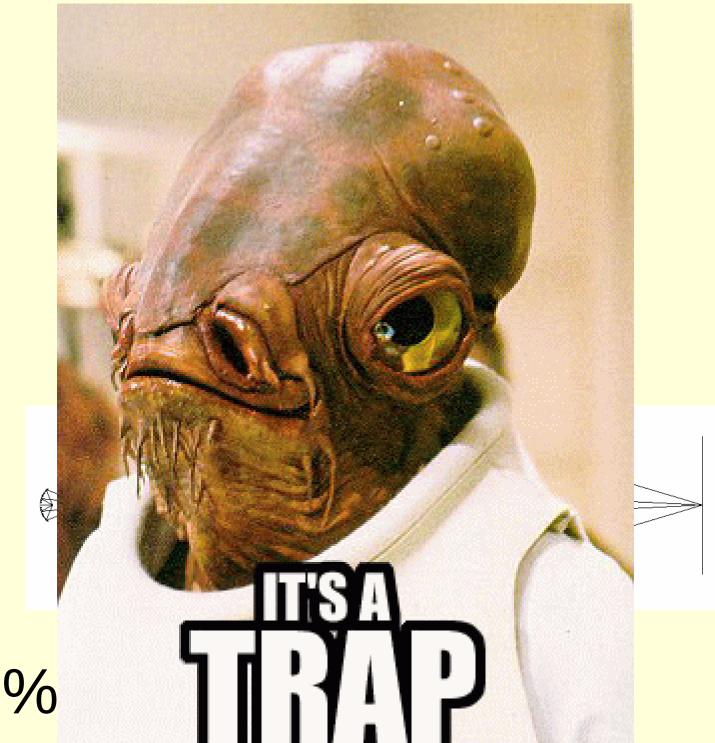


Performance: ion position vs. needle position



It’s a trap! What now?.. Imaging!

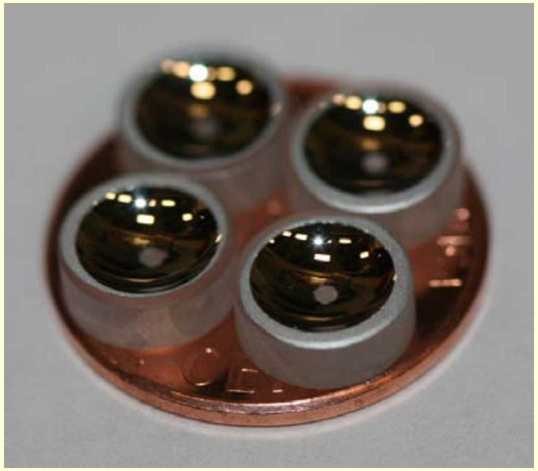


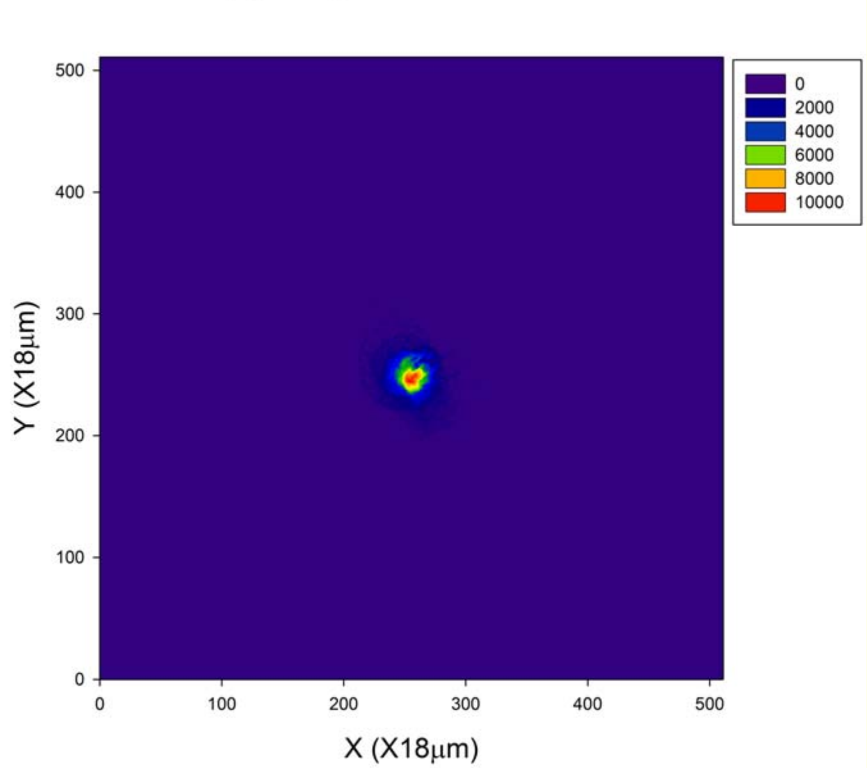


- measured ~ 23%
- 30 um spot size with “original” corrector...
- ... but that spot may not be all there is...

Correcting the corrector shape

- These mirrors are *cheap*
- The original corrector was calculated based on the “specs”
- We measured all (but one) mirrors; ROC = 4.3 mm (not 4.0 mm)
- New corrector... more light!.. but bigger spot.

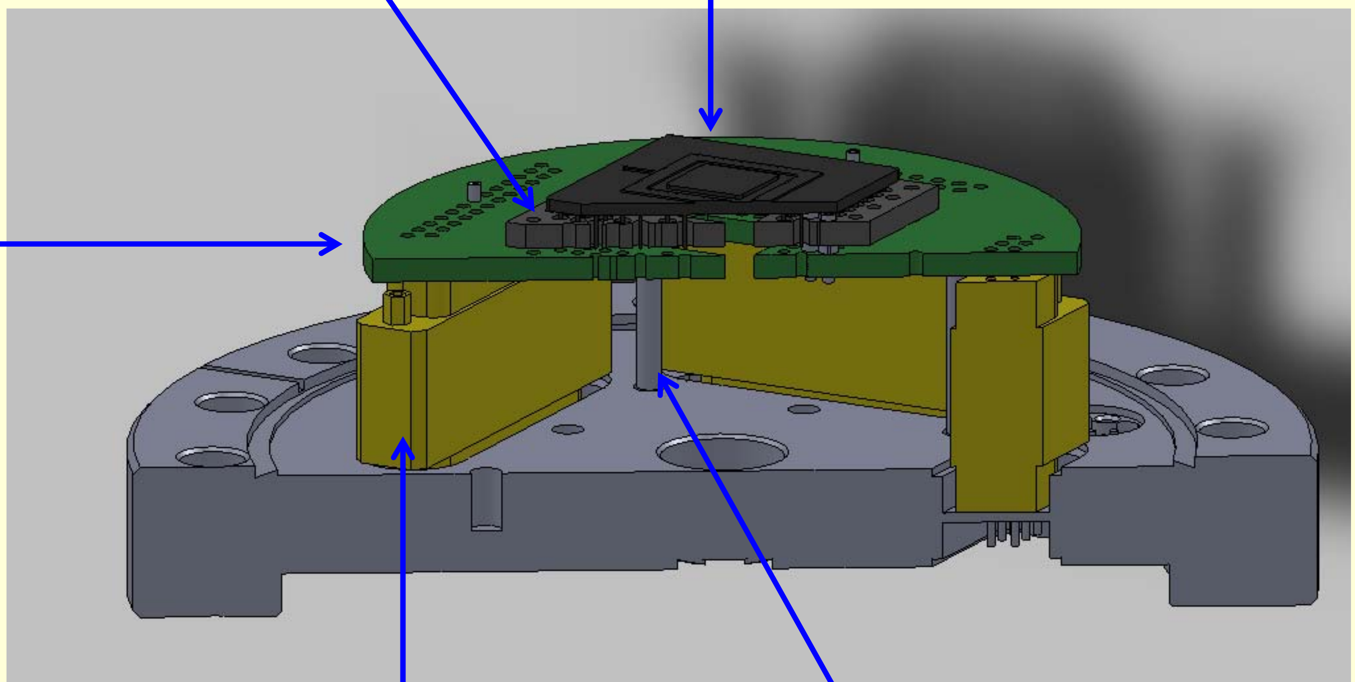




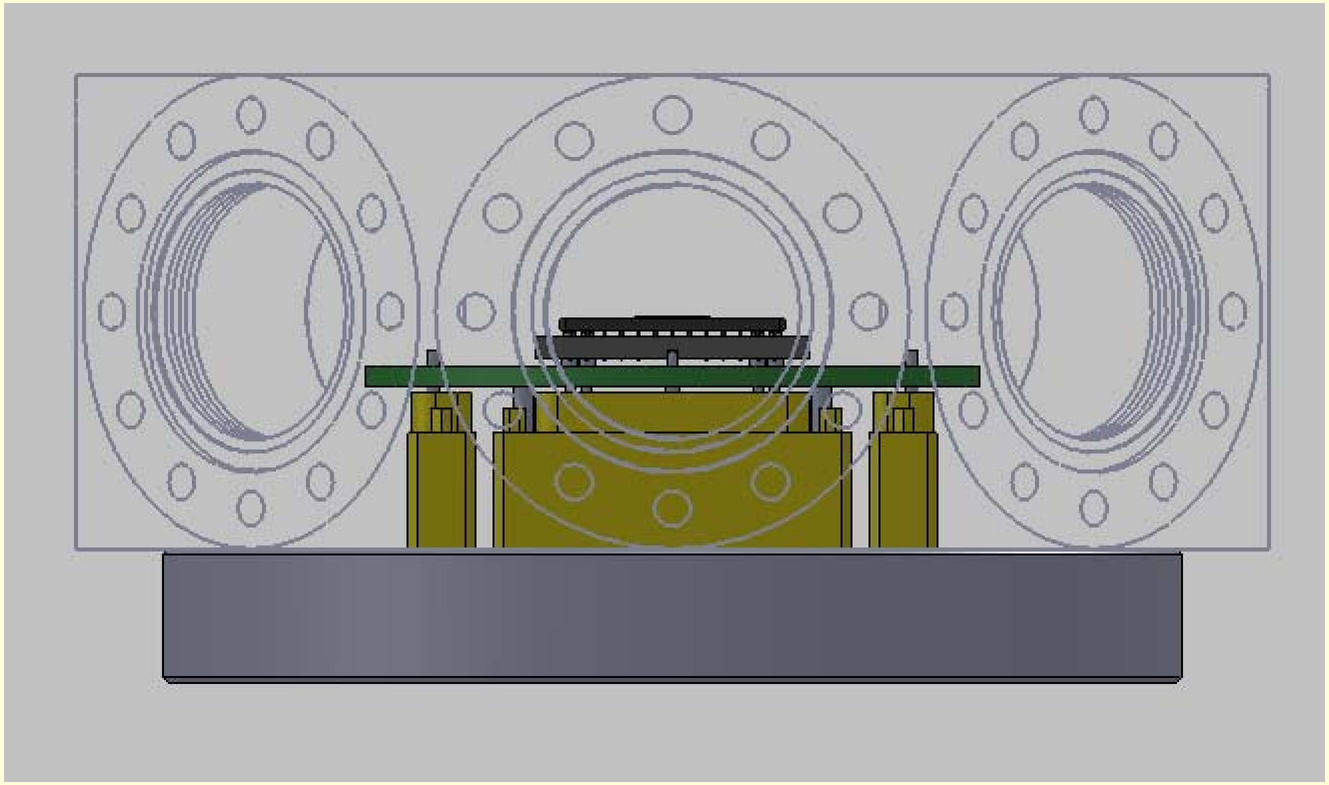
“Tack” trap conclusions (this is not the end!)

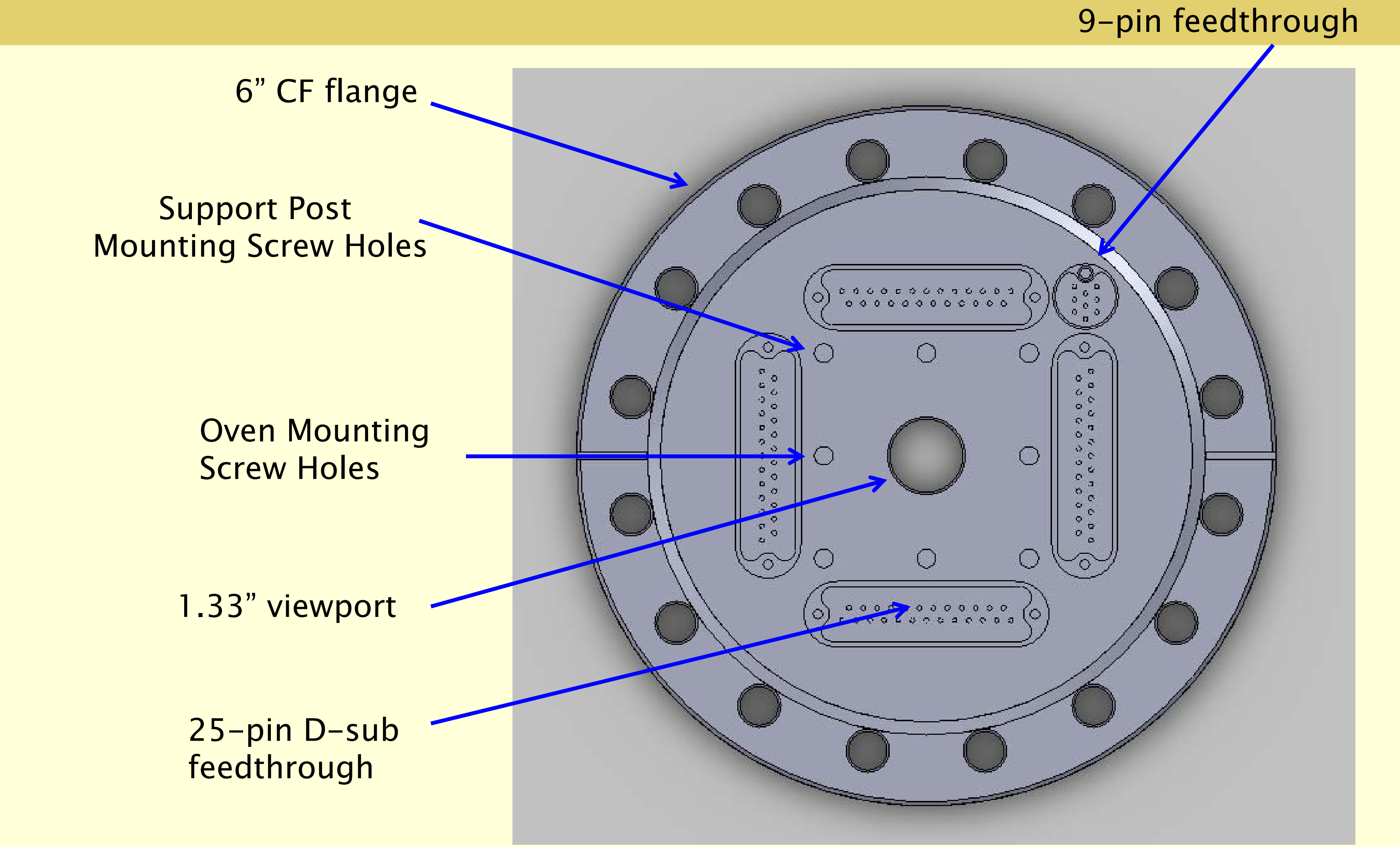
- Metallic reflectors work well in UHV (even if they are not designed to be UHV-compatible.
- Small (and shall I add “cheap”?), high-NA spherical mirrors are suitable for ion fluorescence detection.
- Diffraction-limited imaging should be achievable with appropriate aberration correction, but the exact mirror shape does have to be known – need better mirrors!
- Other possibilities: Fresnel mirrors – maybe natural fit for the chip traps? – micromirrors, ...

Chip trap setup using non-traditional UHV-compatible stuff

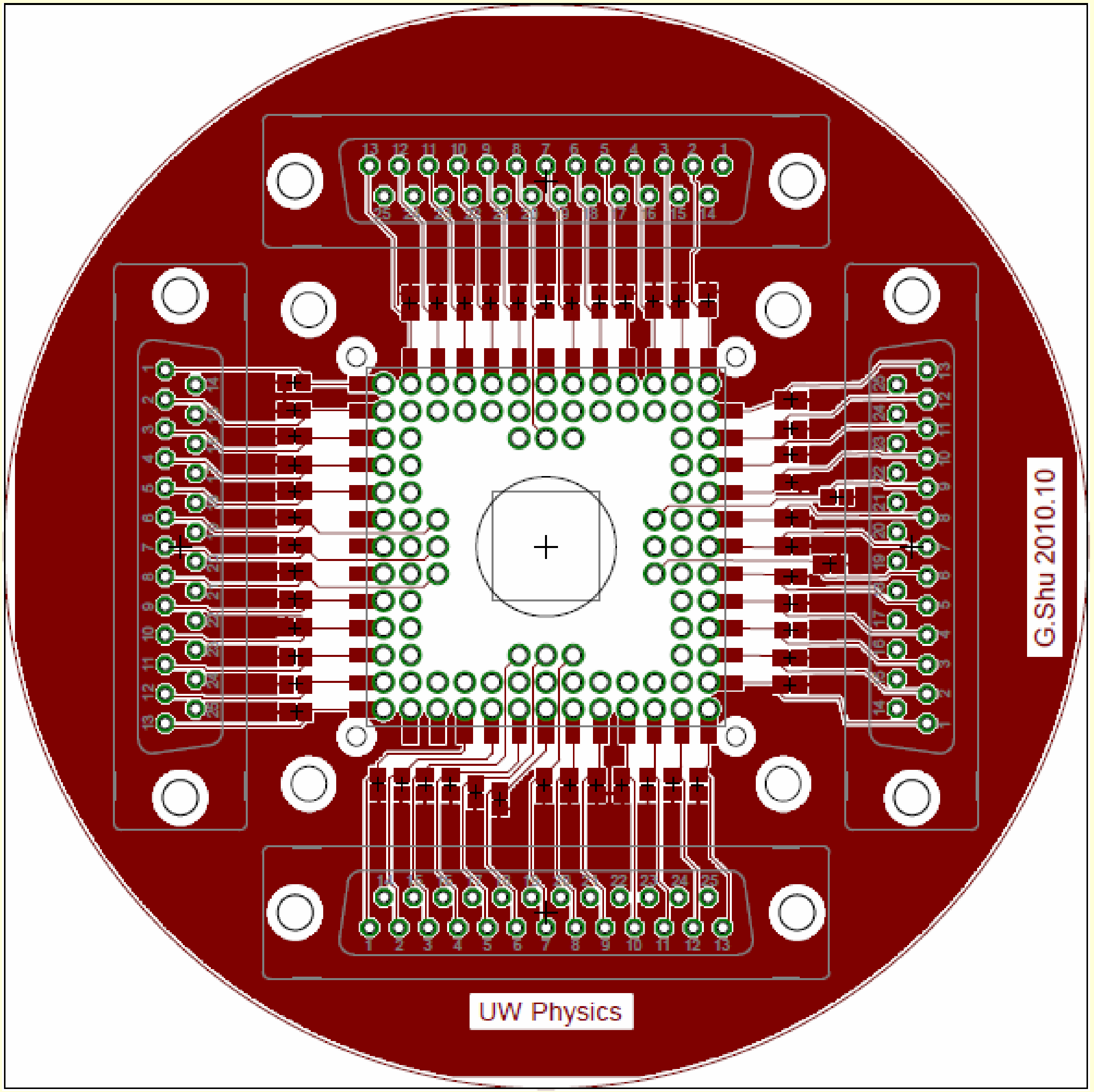


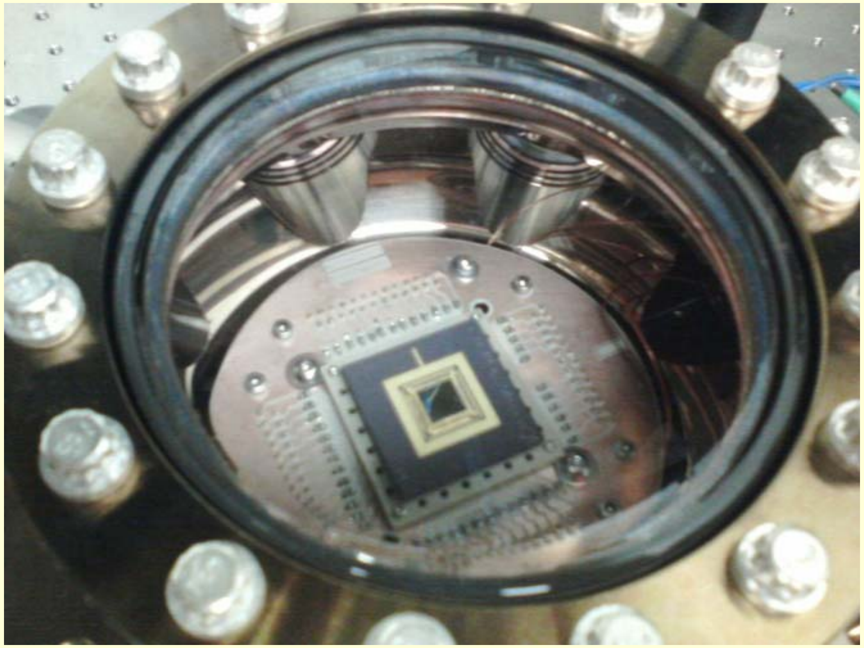
Chip trap setup using non-traditional UHV-compatible stuff



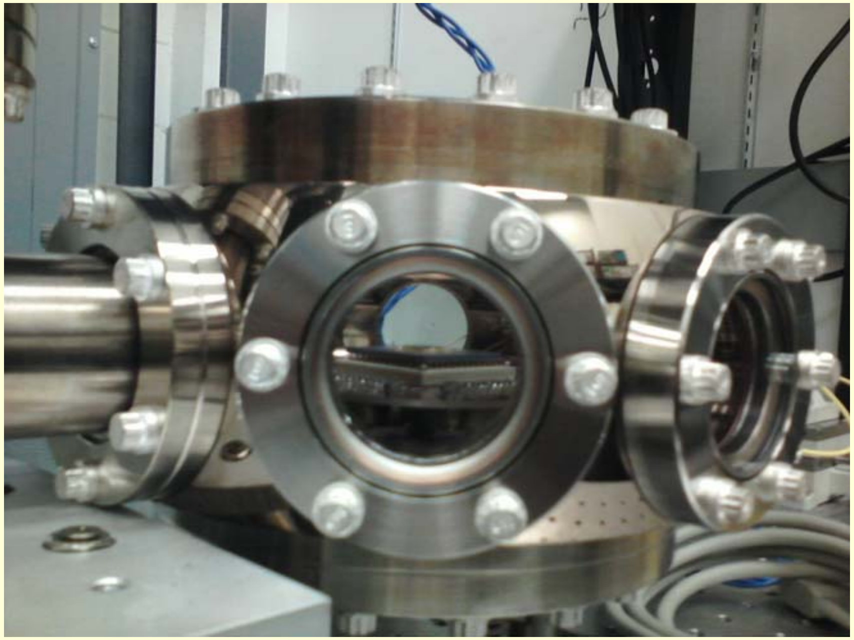

9-pin feedthrough
6” CF flange
Support Post
Mounting Screw Holes
Oven Mounting
Screw Holes
1.33” viewport
25-pin D-sub
feedthrough

- On-site filtering capacitors
- No crimping, no messy wires
- Can be mass-produced!





Here it is!..



- Sandia iTrap installed
- 1.6 x 10^{-10} torr, still coming down
- Second system on the way

We put "ion" in "quantum computation"

UW Trapped Ion Quantum Computing