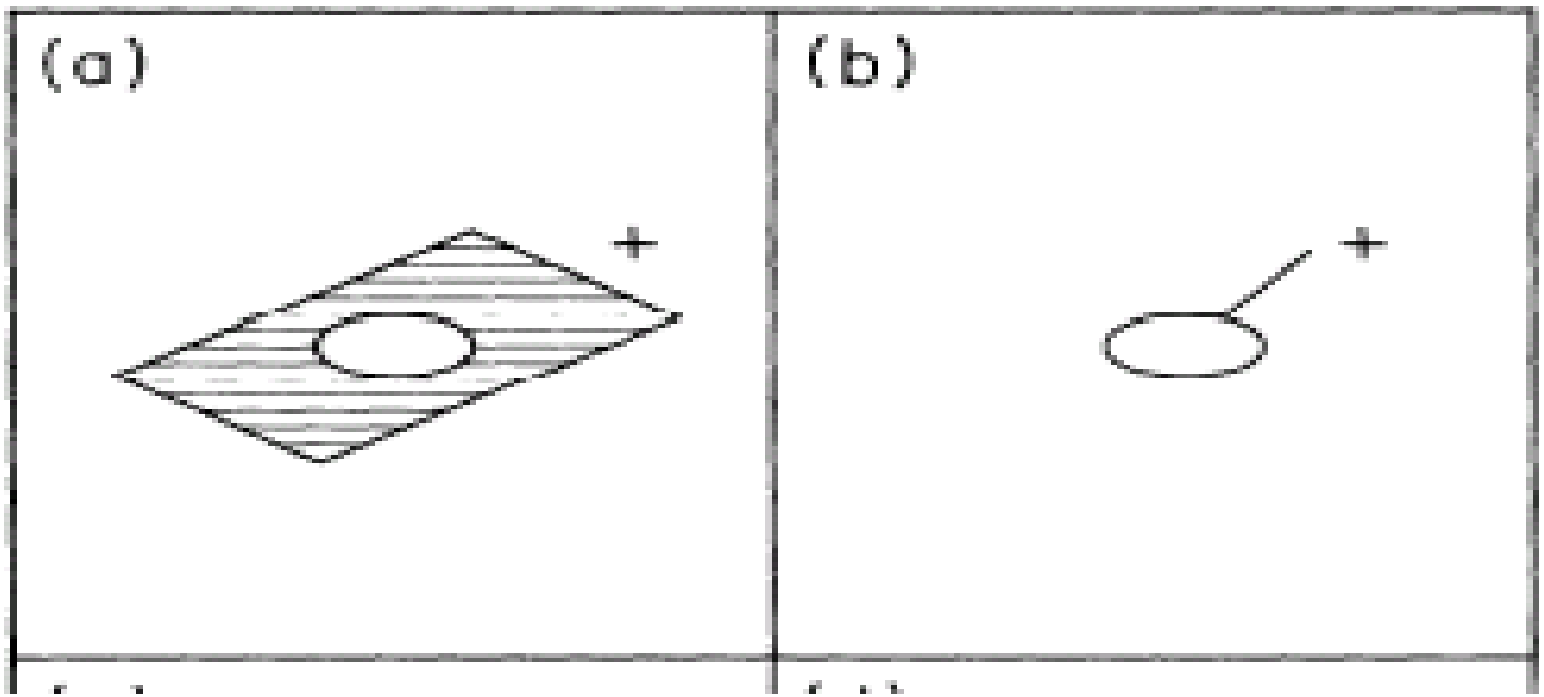
Alternative trap geometries

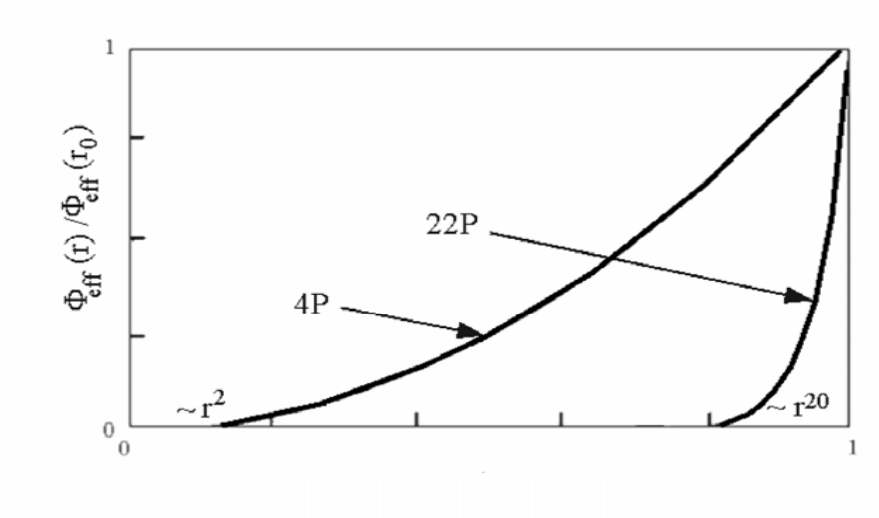
Paul-Straubel trap:



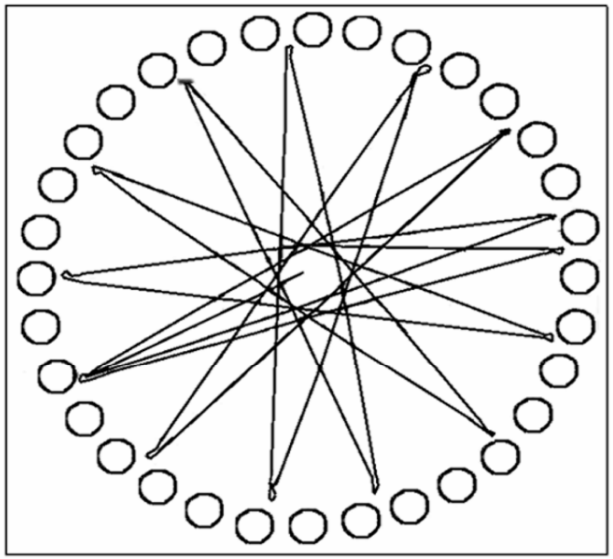
Multipole traps

Potential of an n-pole trap:

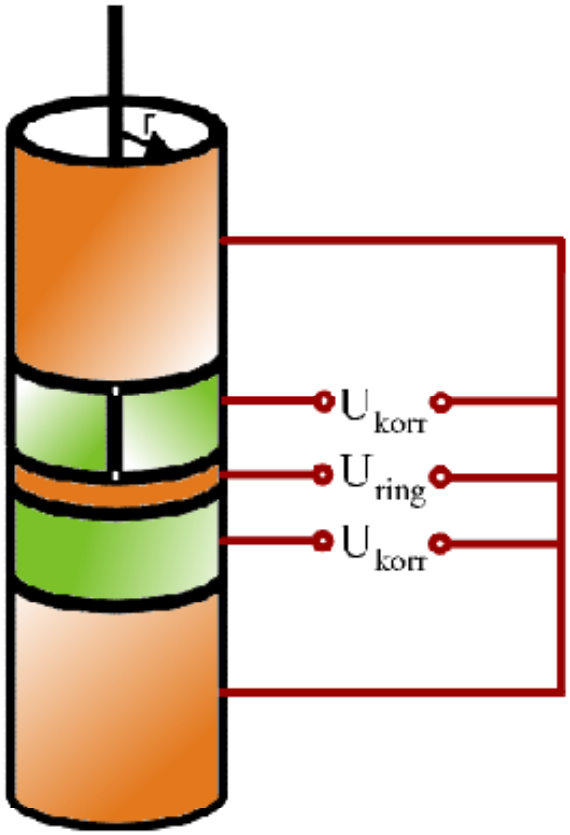
$$\Phi \propto \left(\frac{r}{r_0}\right)^{n-2}$$



Ion trajectories in a 32-pole trap

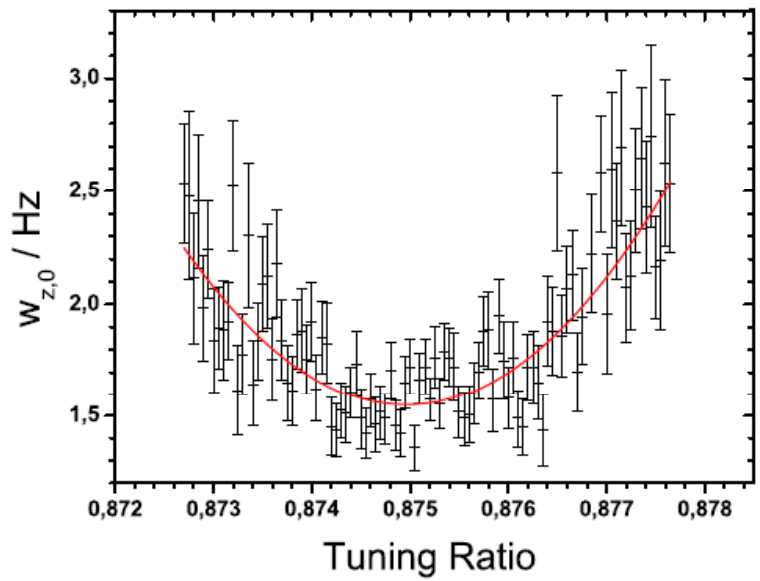


Cylindrical trap

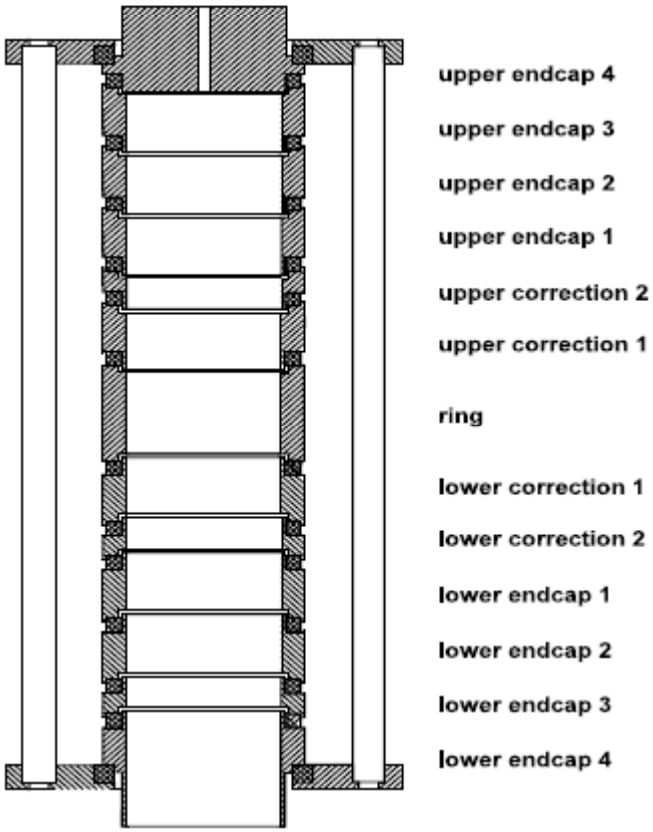


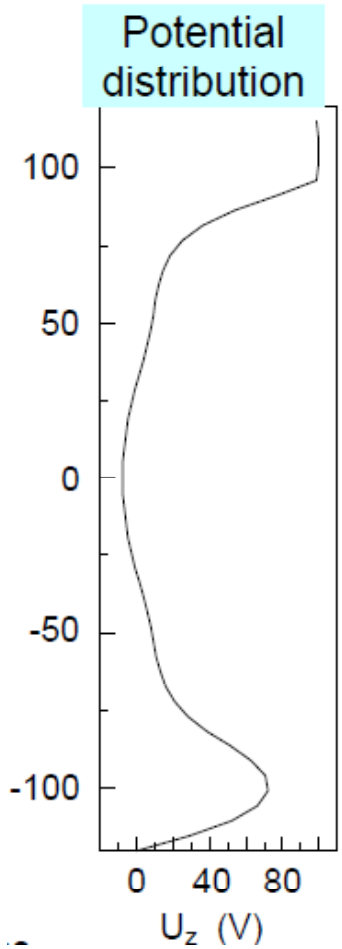
$$V = \frac{1}{2} V_0 \sum_{k=0}^{\infty} C_k \left(\frac{r}{d}\right)^k P_k(\cos\theta)$$

$$d^2 = \frac{1}{2}\left(z_0^2 + \frac{1}{2}\rho_0^2\right)$$

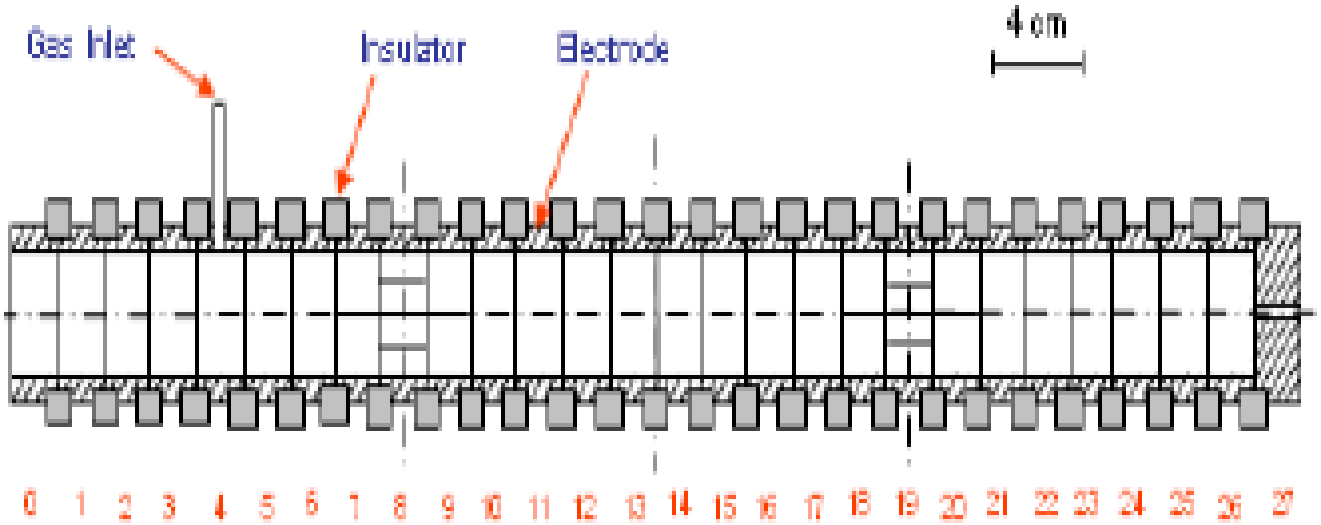


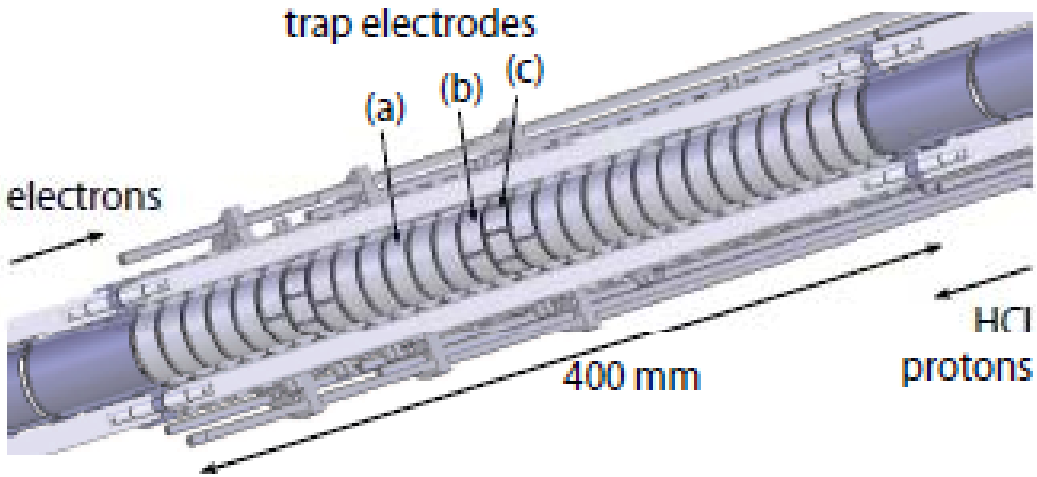
Optimizing trap potential:
Width of axial resonance vs. Tuning Ratio
Tunig Ratio: U(korr)/U(ring)


upper endcap 4
upper endcap 3
upper endcap 2
upper endcap 1
upper correction 2
upper correction 1
ring
lower correction 1
lower correction 2
lower endcap 1
lower endcap 2
lower endcap 3
lower endcap 4

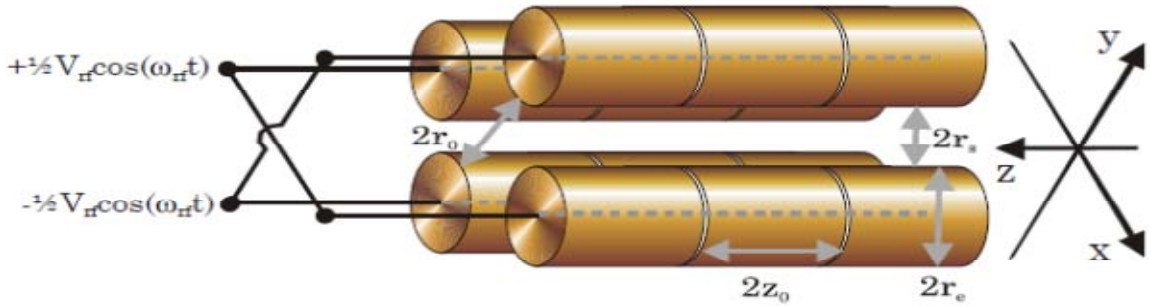

Potential distribution
100
50
0
-50
-100
0
40
80
U_z (V)

TITAN Cooler Trap



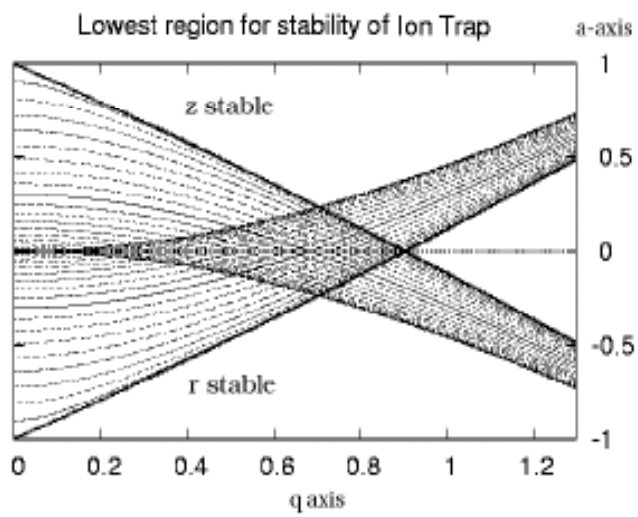


Linear Traps

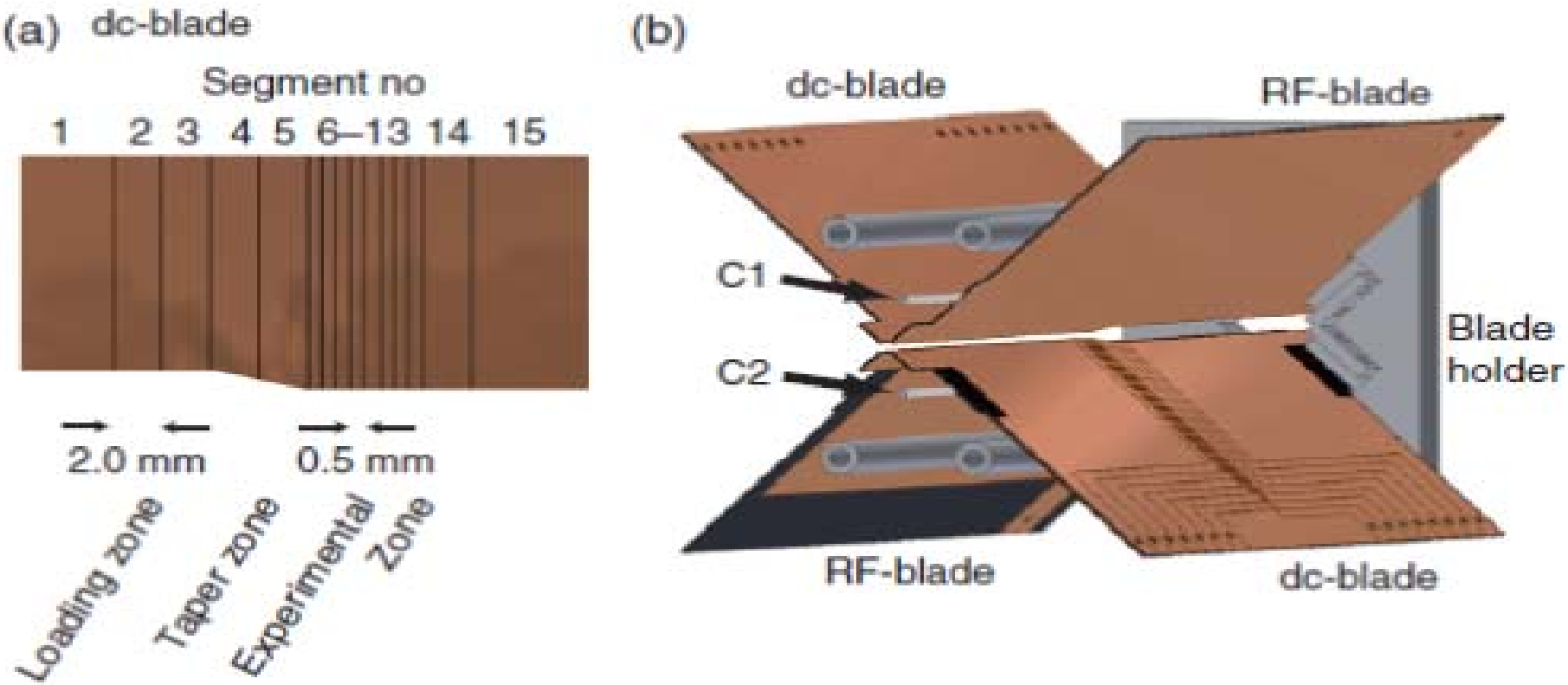


$$m\frac{d^2}{dt^2}\begin{bmatrix} X_x \\ X_y \\ X_z \end{bmatrix} = -Q\begin{bmatrix} \left(-\frac{\kappa V_{ec}}{z_0^2} + \frac{V_{rf}}{r_0^2}\cos(\omega_{rf}t)\right)x \\ \left(-\frac{\kappa V_{ec}}{z_0^2} - \frac{V_{rf}}{r_0^2}\cos(\omega_{rf}t)\right)y \\ \left(2\frac{\kappa V_{ec}}{z_0^2}\right)z \end{bmatrix}$$

Stability diagram for radial motion



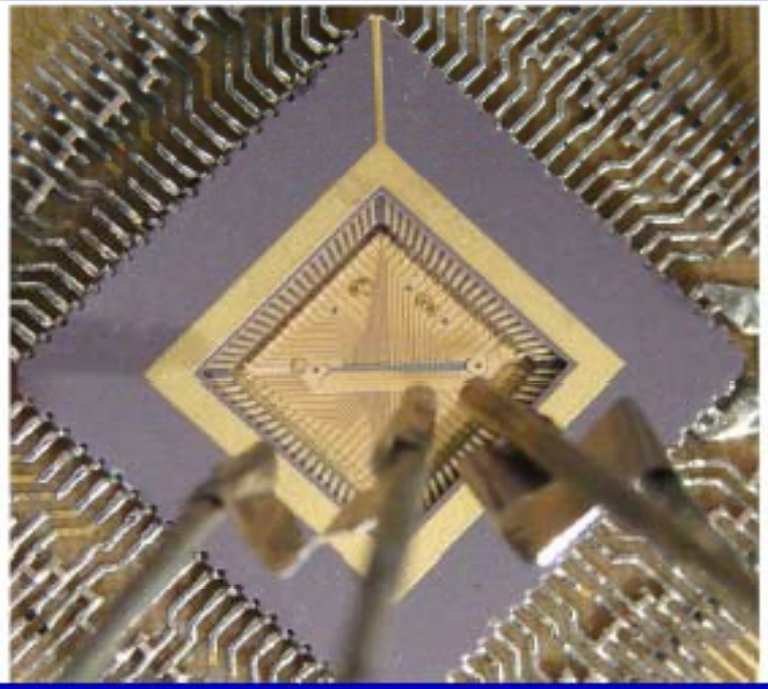
Blade trap with segmented electrodes



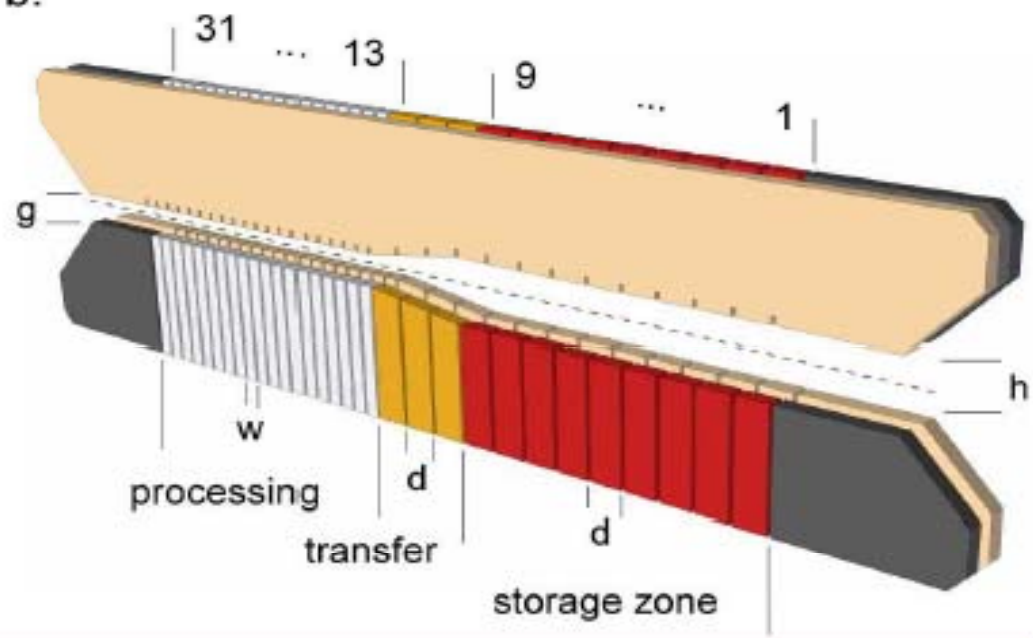
Univ. Ulm, Innsbruck

Ulm linear multizone trap

a.

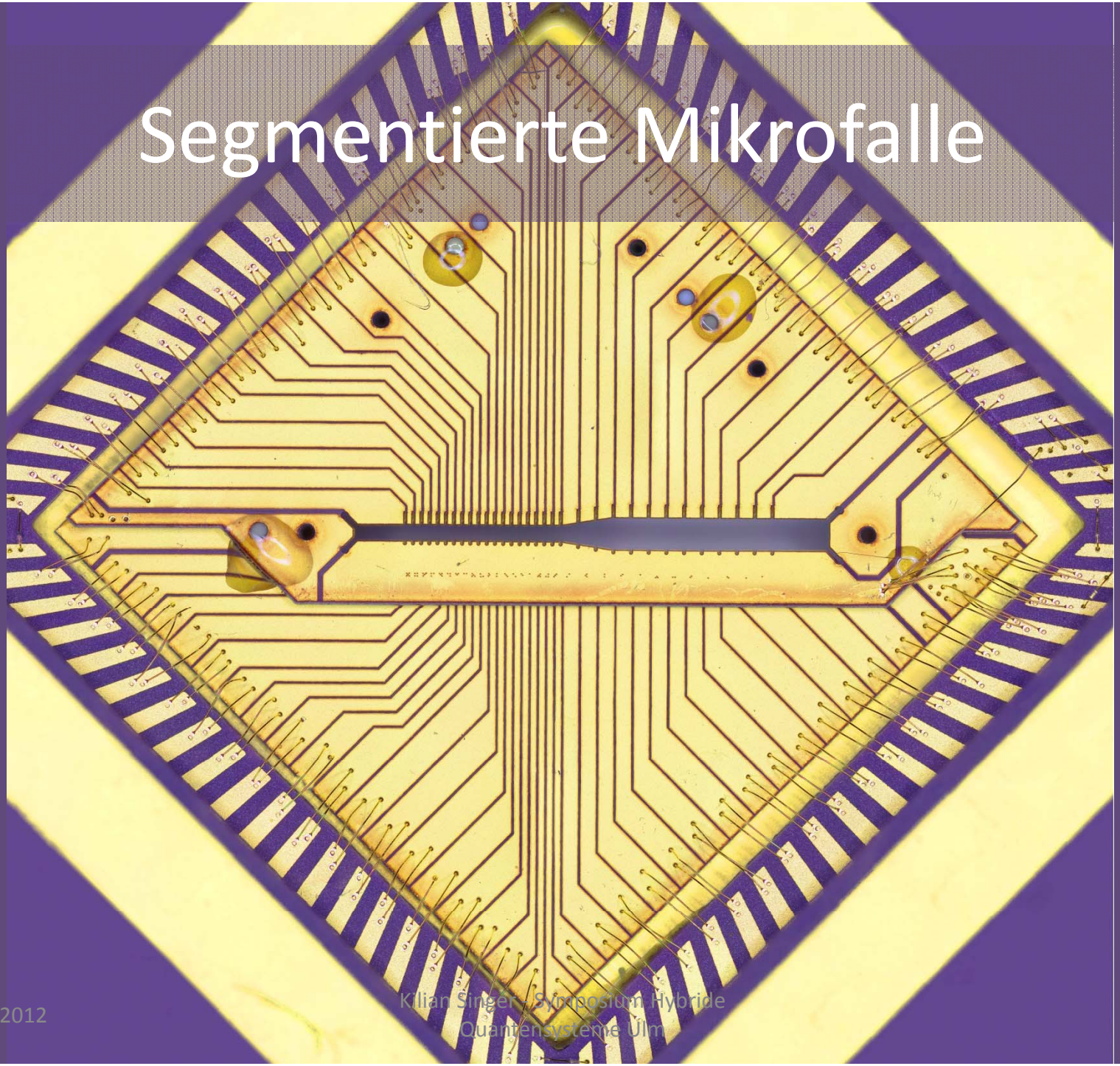


b.



Stefan Schulz, Ulrich Poschinger, Frank Ziesel and Ferdinand Schmidt-Kaler

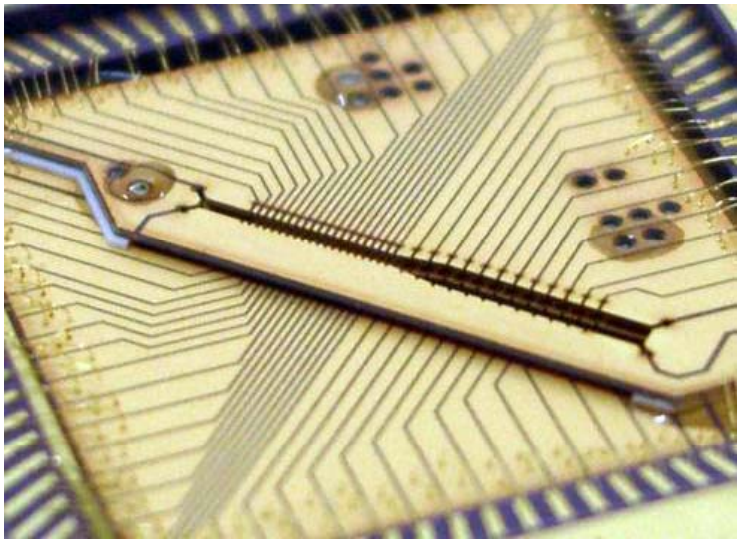
Segmentierte Mikrofalle

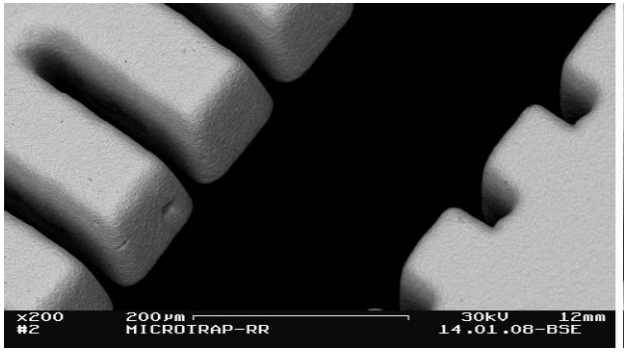


3D Microchip Traps

- Ti/Au on Al_2O_3-Wafer 10nm/400nm
- fs-Laser cut Au/Ti and Al2O3 accurate to 1µm
- mounting on Chip Carrier
- optinally cooled in He flow cryostat, 300K … 77K … 4.2K

U. Poschinger et. al, Jour. Phys. B 42, 154013 (2009)

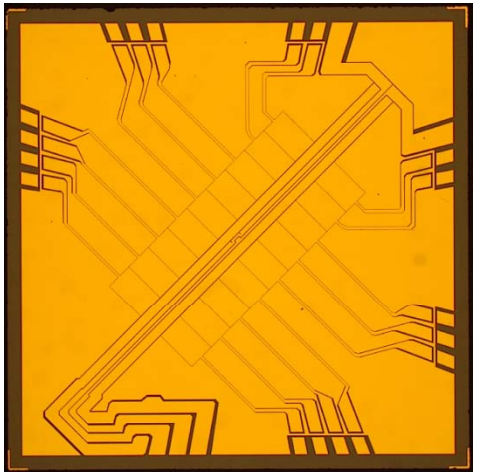


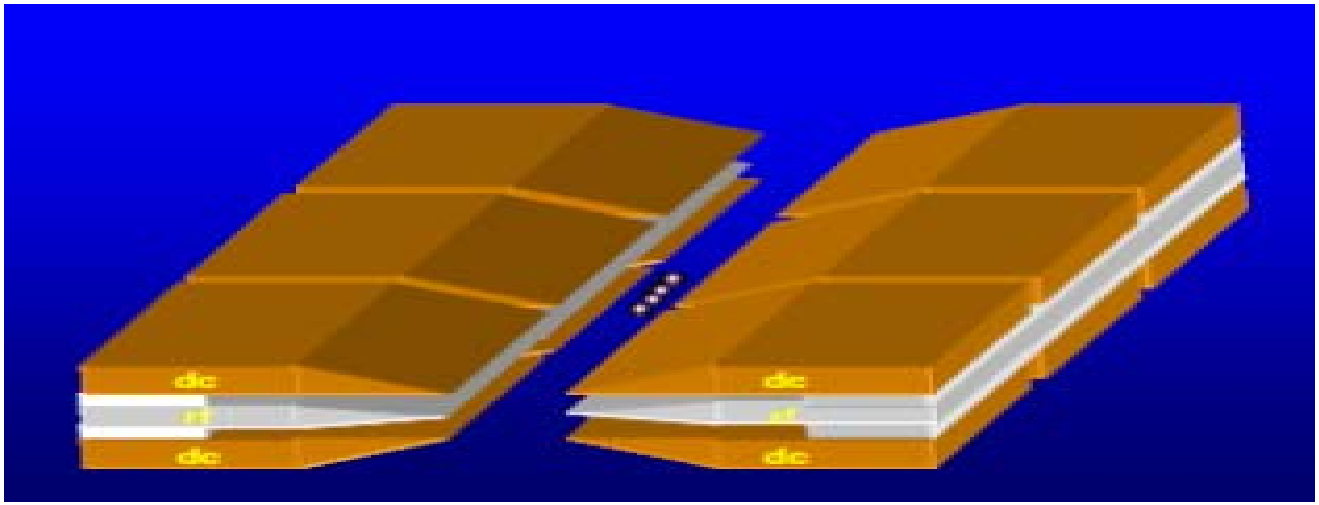


Planar Traps

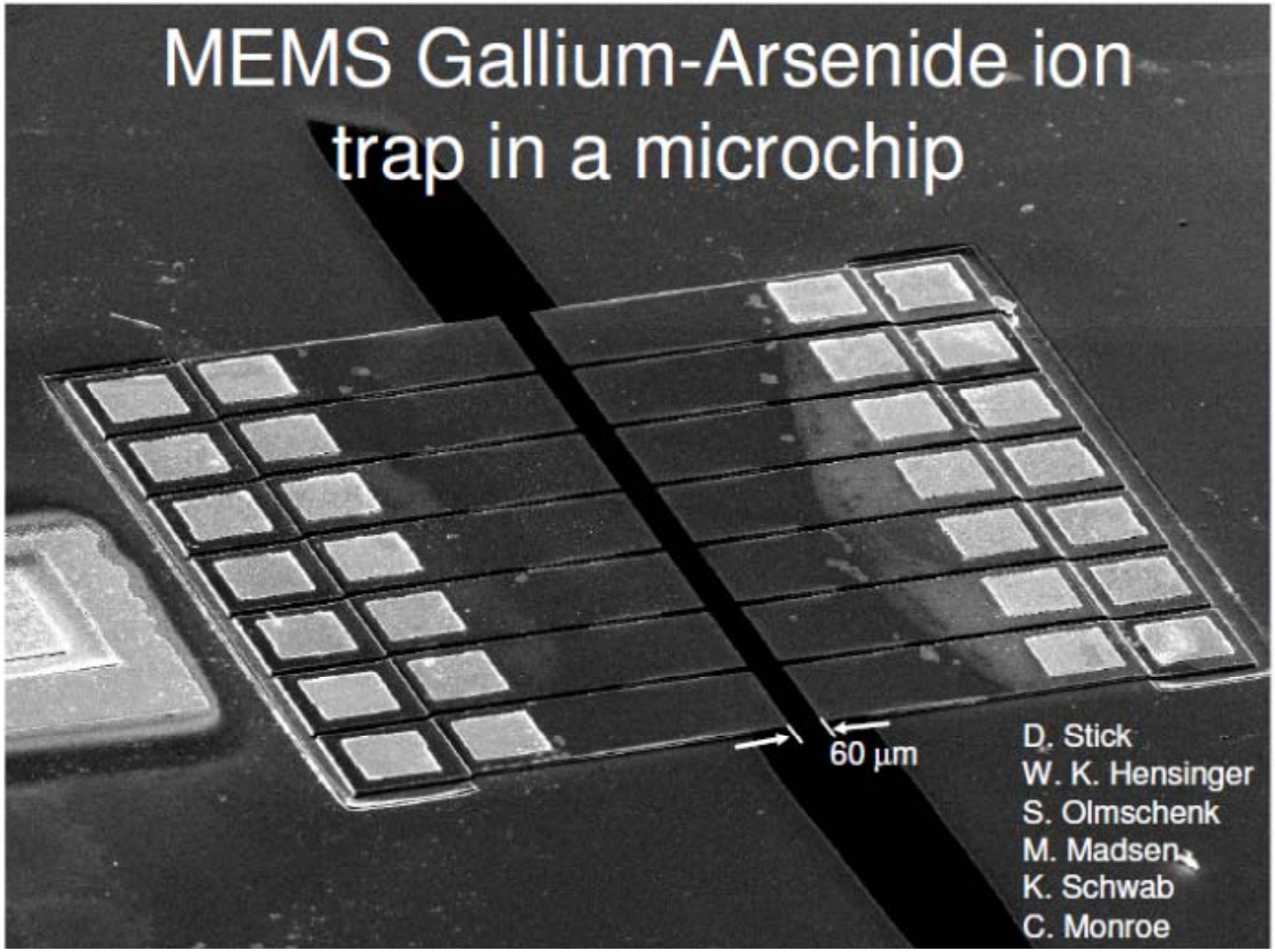
- Thick resist technique, liftoff, evaporation
- Au, few µm, on Sapphire
- Integration of high magnetic field gradient current lead

M. Hellwig, et al., NJP 12, 065019 (2010)





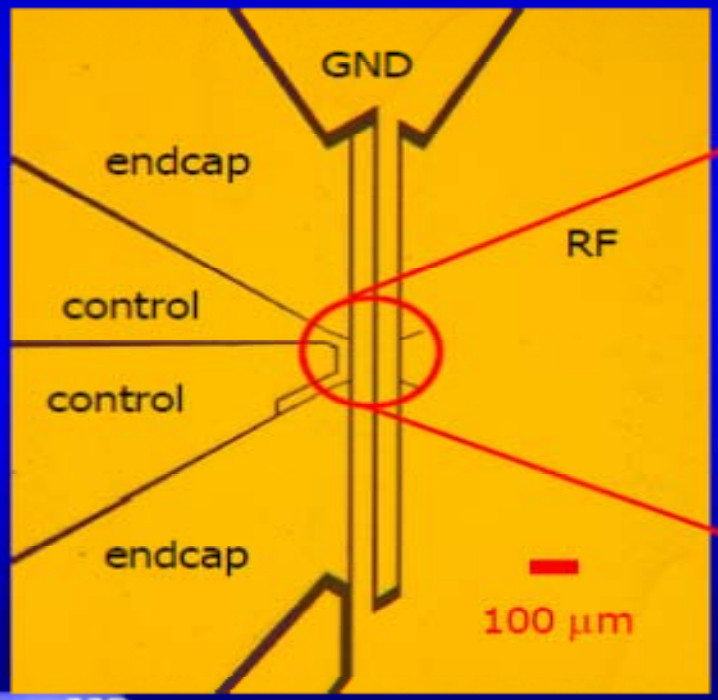
Univ. of Michigan



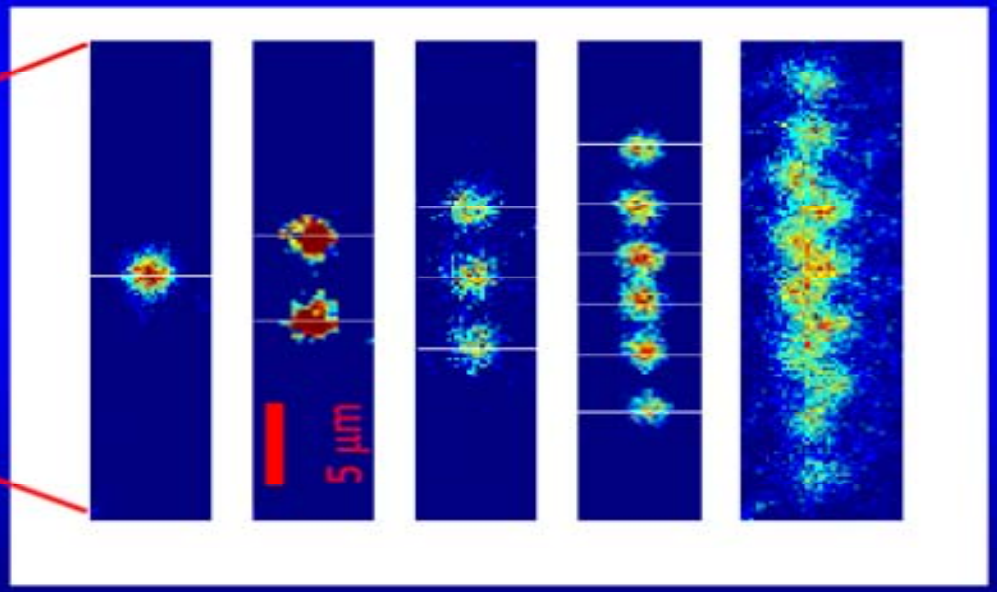
Univ. Michigan

NIST Planar Trap Chip

Magnified trap electrodes



CCD pictures of strings of Mg^+ ions
(trapped 40 mm above surface)

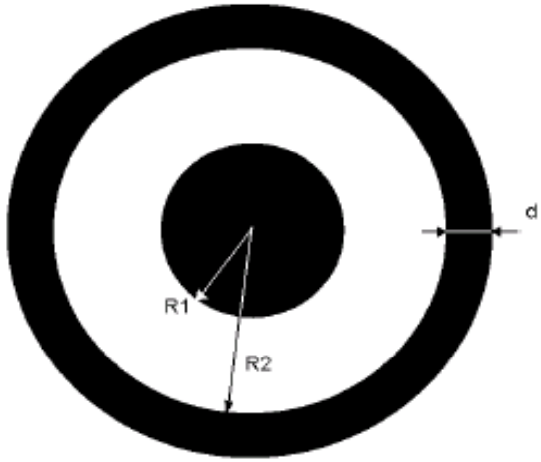


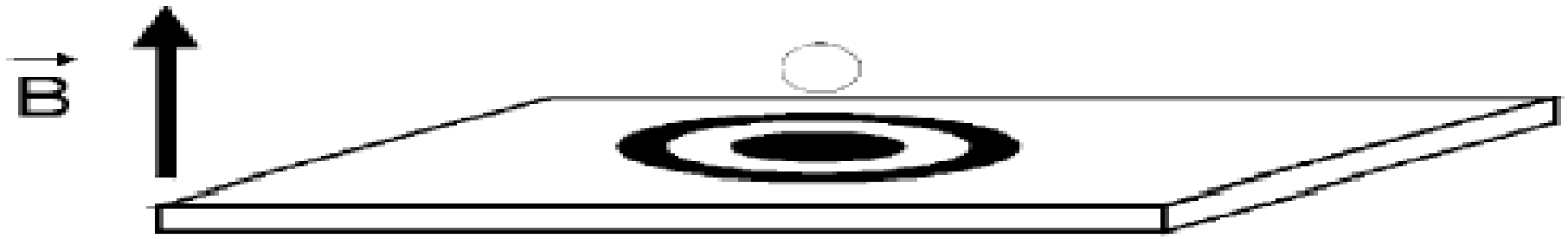
Seidelin *et al.*, PRL **96**, 253003 (2006).

John Chiaverini, Signe Seidelin, Didi Leibfried, David Wineland

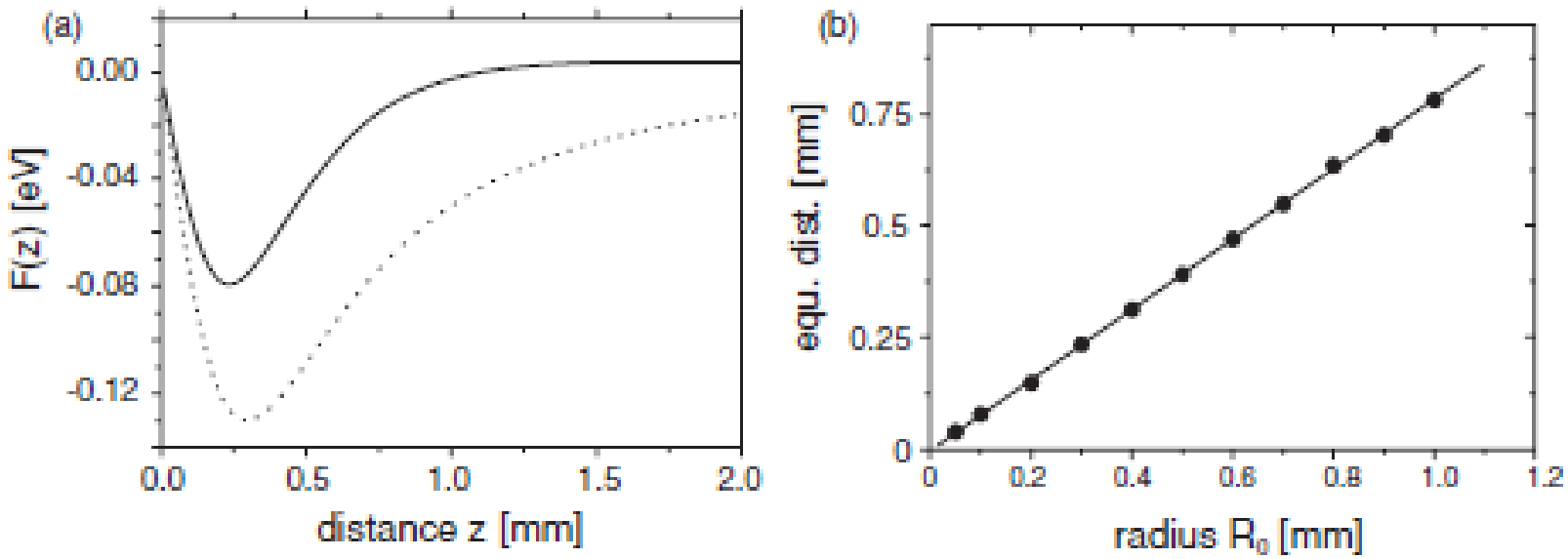
Planar traps:
Ring structures on a surface

Mainz 2006





Trap potentials
for a 3 ring configuration and different voltage settings

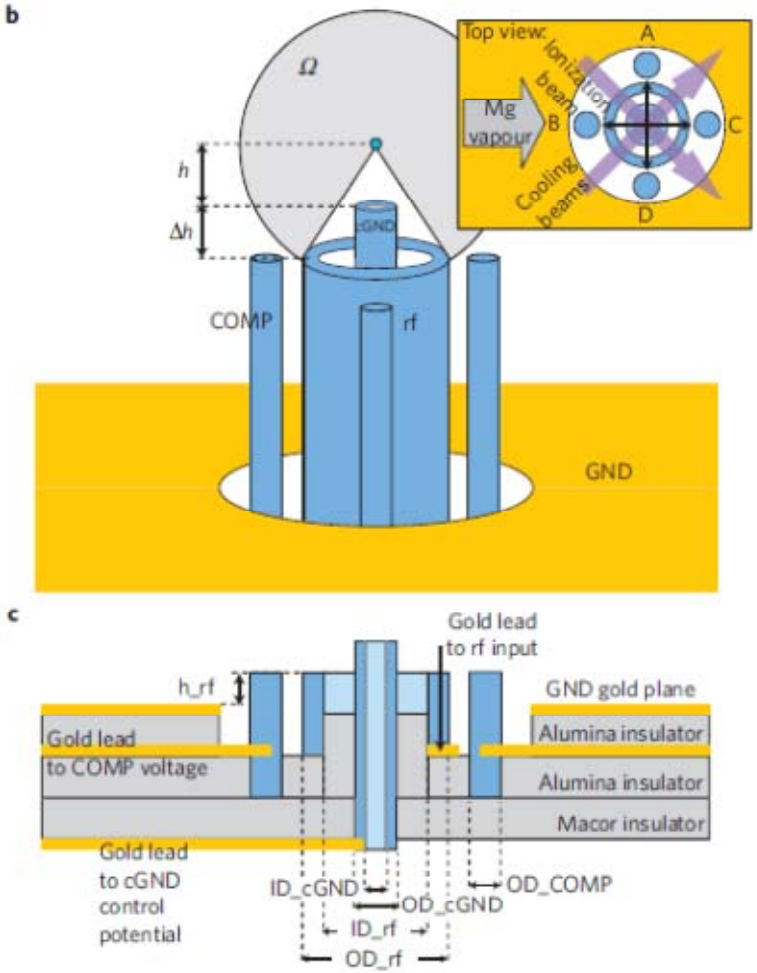


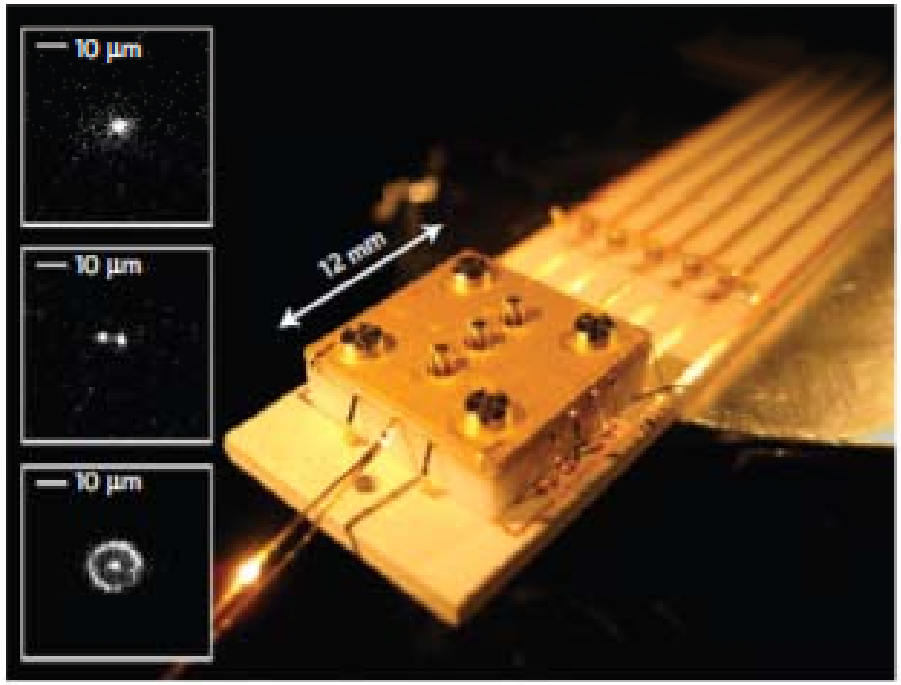
Potential depth and minimum position varies with voltage settings

Realisation of a prototype multi-ring planar trap by thick film technology (silver of ceramic substrate)
Total diameter 1 cm

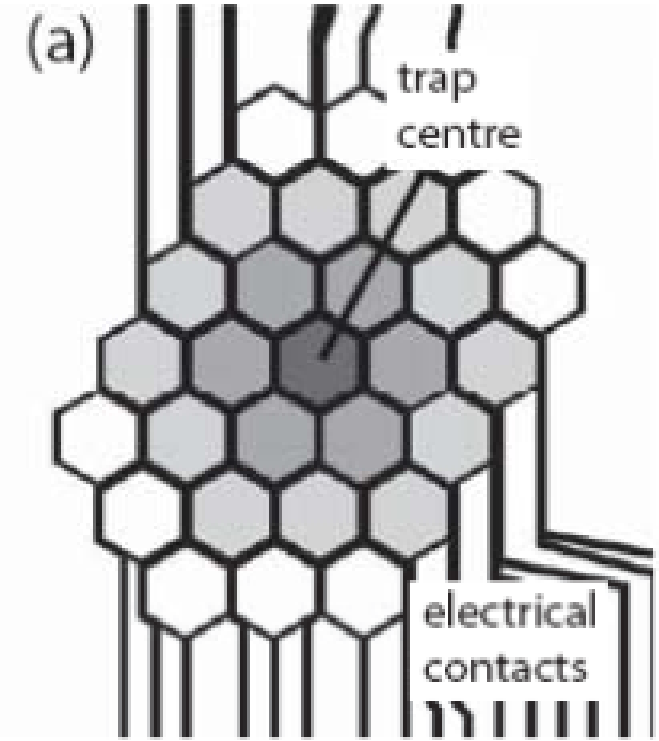
„Stylos Trap“

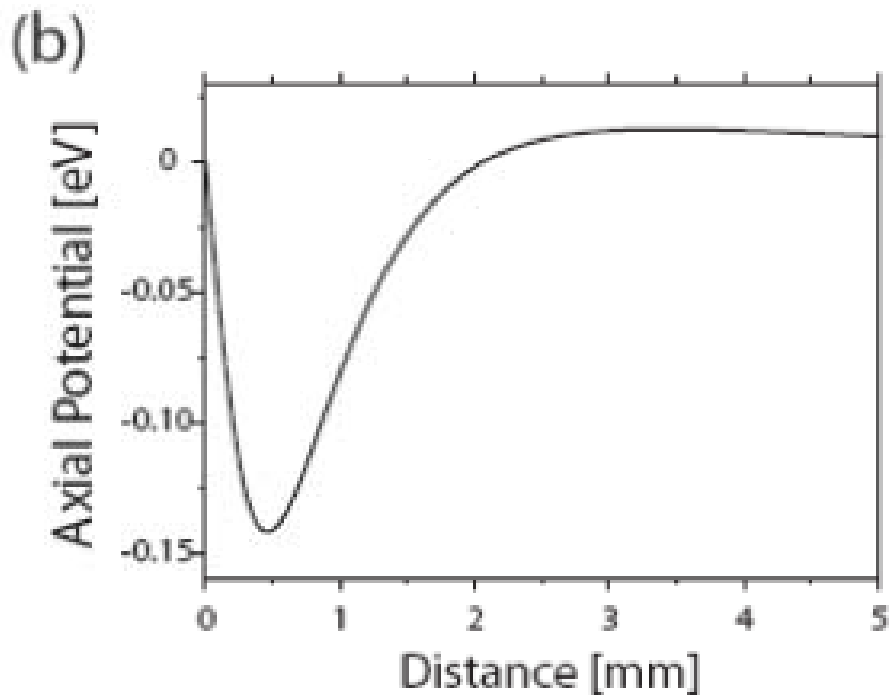
Maiwald et al., Nature Physics online (2009)



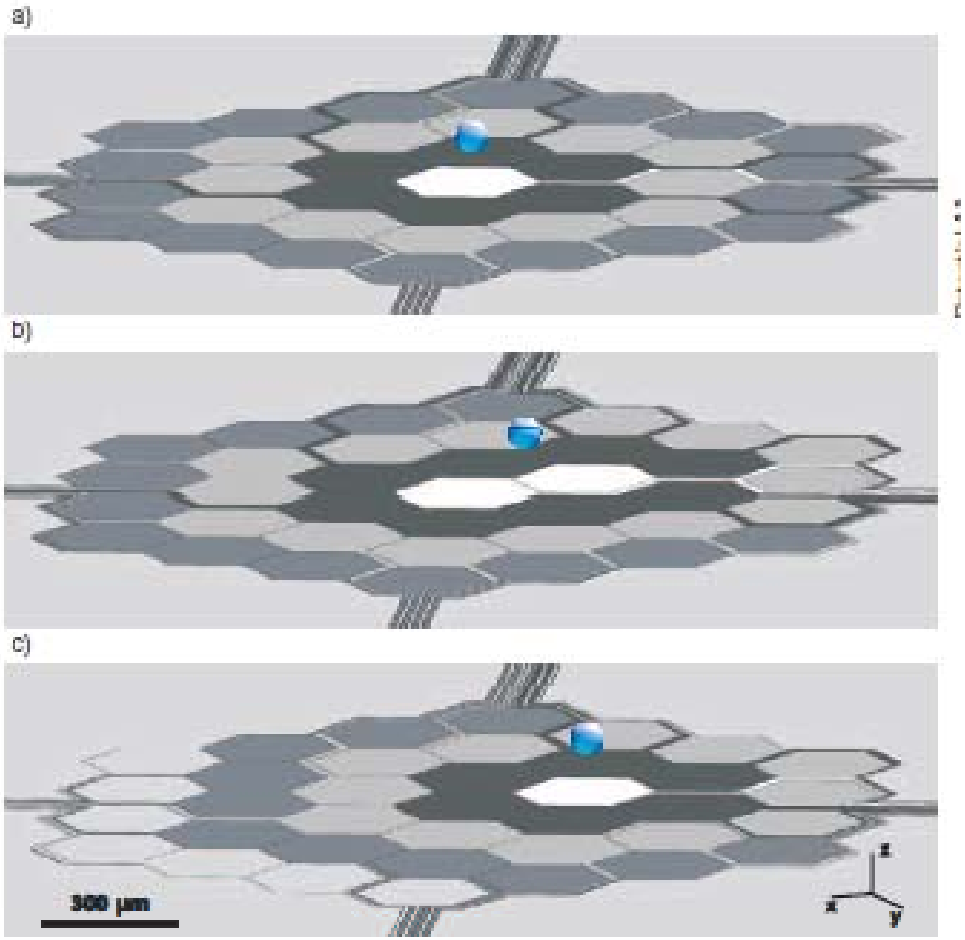


Pixel trap


(a)
trap
centre
electrical
contacts

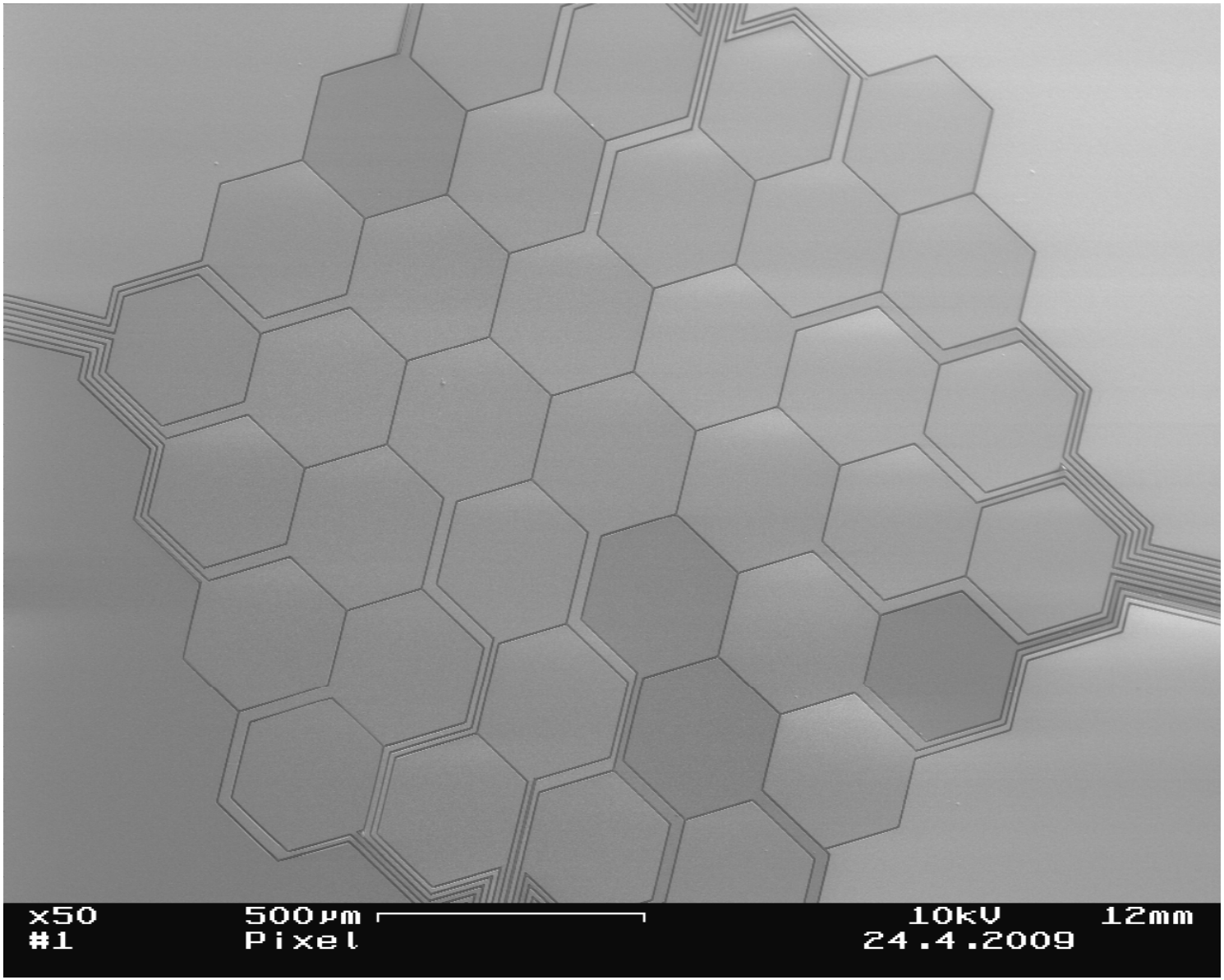

(b)
Axial Potential [eV]
0
-0.05
-0.10
-0.15
0
1
2
3
4
5
Distance [mm]

Moving center of Pixel Trap



M. Hellwig et al. *New Journal of Physics* **12** (2010) 065019

Pixel trap



Onion trap