

# LhARA WP3 Capture weekly meeting

27<sup>th</sup> Jan 2021

C. Baker

# Single Particle (Magnetron motion)

- Penning Trap theory/model

- Cyclotron frequency

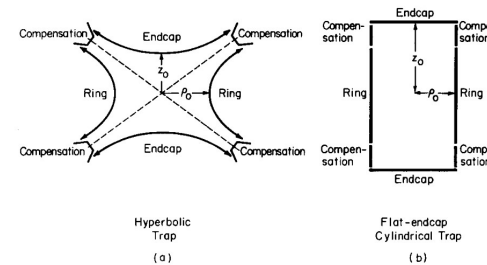
$$\Omega_c = \frac{q B}{m} ;$$

- Bounce frequency

$$\omega_z = \sqrt{\frac{q V}{m d^2}} ; \quad d^2 = \frac{1}{2} \left( z_0^2 + \frac{1}{2} \rho_0^2 \right)$$

- Magnetron frequency

$$\omega_m = \frac{1}{2} \left( \Omega_c - \sqrt{\Omega_c^2 - 2 \omega_z^2} \right) ;$$



*International Journal of Mass Spectrometry and Ion Processes*, 88 (1989) 319–332  
Elsevier Science Publishers B.V., Amsterdam – Printed in The Netherlands

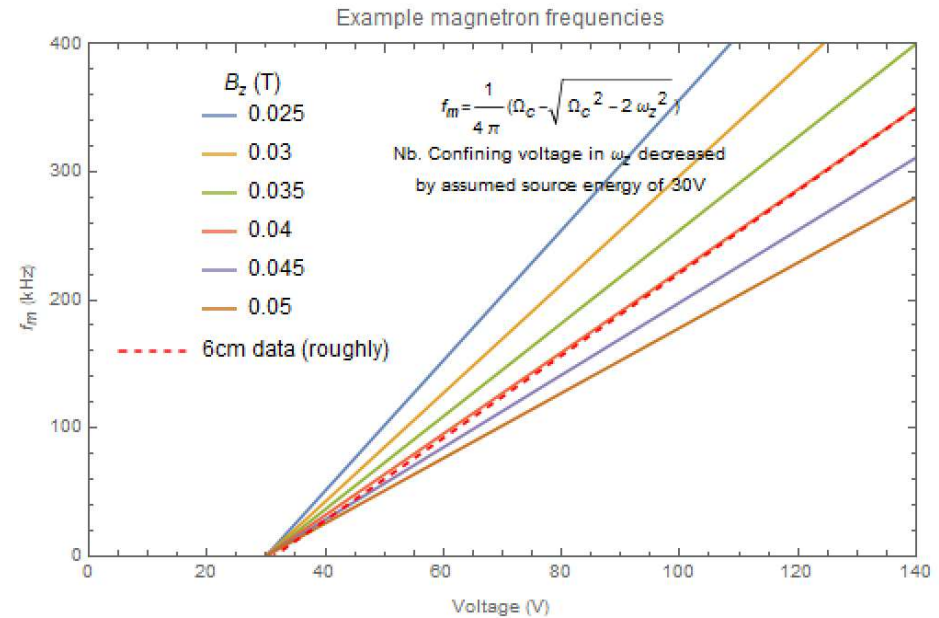
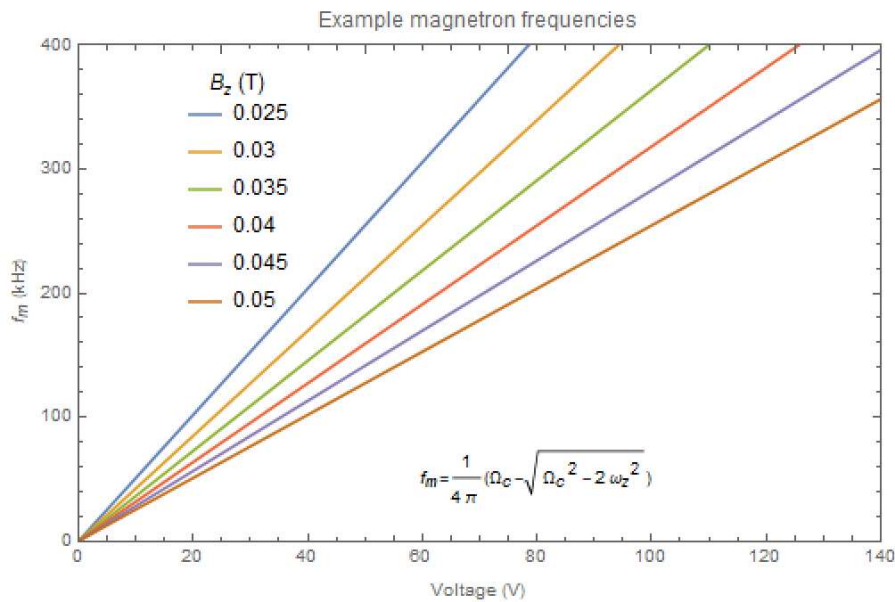
## OPEN-ENDCAP PENNING TRAPS FOR HIGH PRECISION EXPERIMENTS

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- SimION ([www.simion.com](http://www.simion.com))

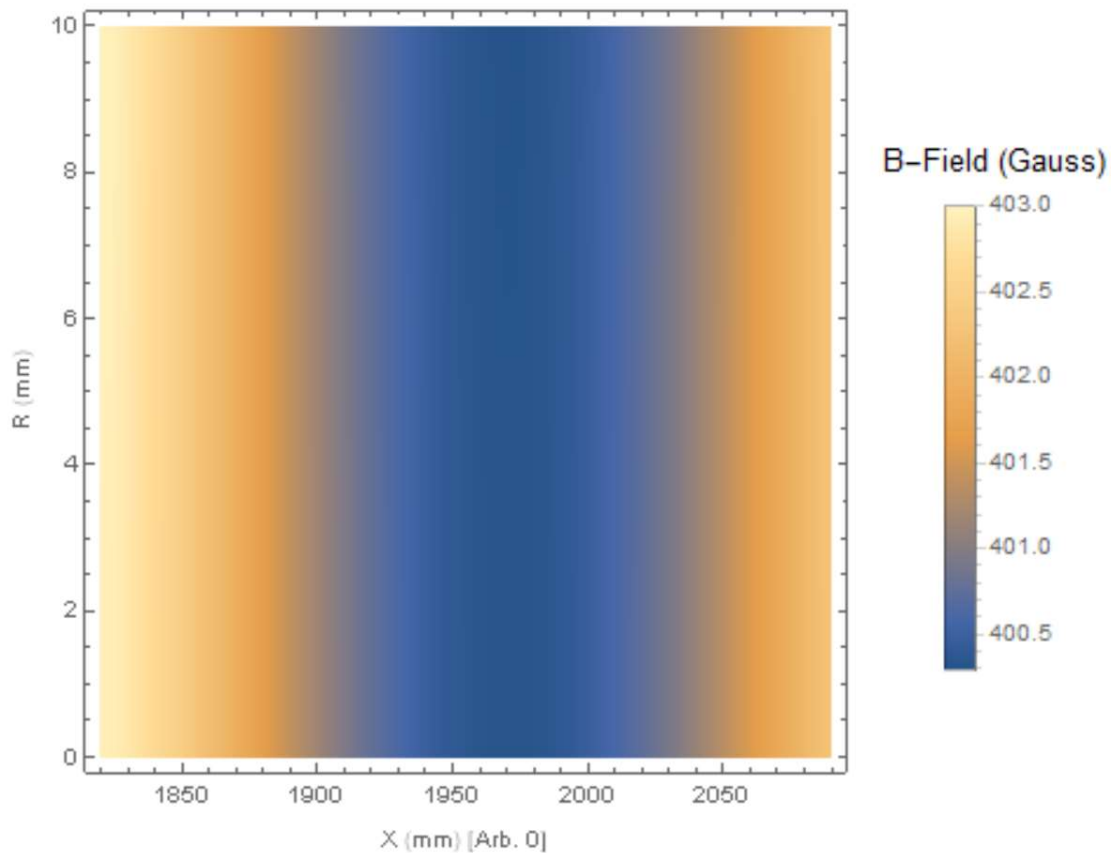
- E & B field generation
- Single particle tracking software

# Penning Trap theory/model



- Voltage is ambiguous
  - It can refer to bias applied to electrodes
  - Or maximum potential experienced by particle due to geometry
  - Or it can refer to potential energy barrier encountered by particle
- These are NOT synonymous
  - E.g. Left hand plot is the applied bias, whereas right hand plot above is the difference between the applied bias and particle total energy
- Note: '6cm data (roughly)' is a by eye interpolation between 2 extreme data points presented on 20/01/22 by Titus

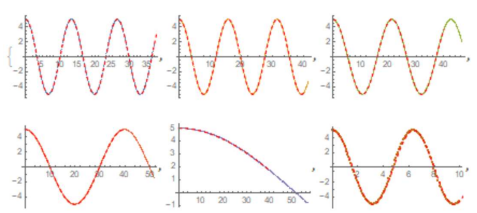
# SimION Biot-Savart B-field example



- 30A solenoid current, with guiding, quazi-Helmholtz, coils present
- 6cm  $\Delta B < 0.1\%$
- 20cm  $\Delta B < 1\%$

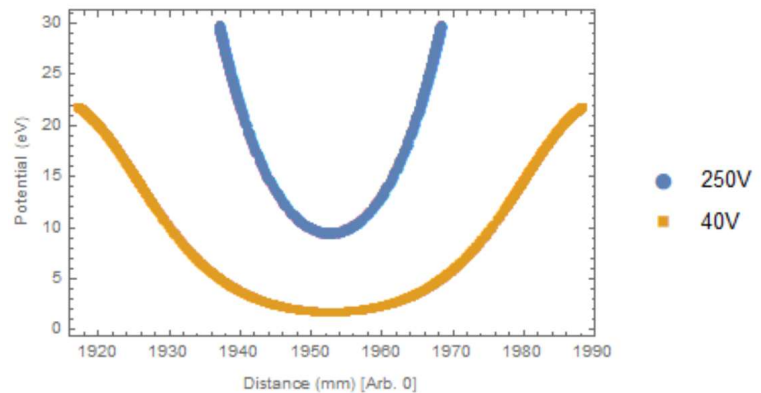
# SimION - I

1. 'Y'-plane displacement w.r.t. simulation time plots used to generate data:



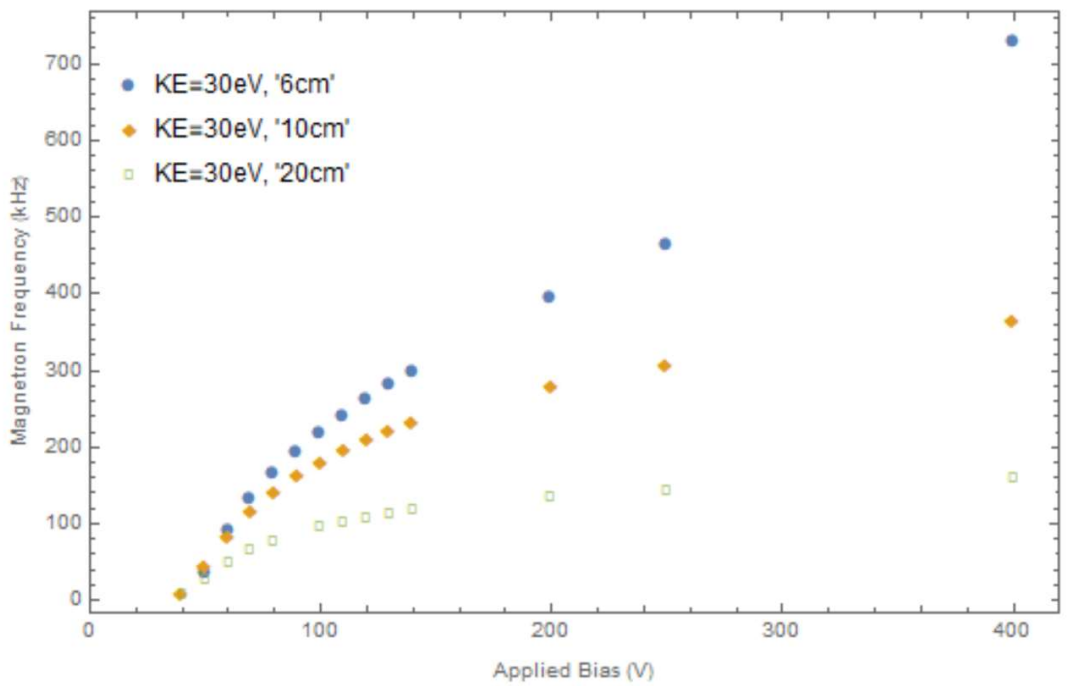
3. Non-linear behaviour at low biases possibly due to asymmetric / non-SHM motion.

Bounce/'plasma' length varies considerably with confining potential



\* Above plot with KE=(0,0,20)eV particle initialised at Distance=1955mm for illustration only

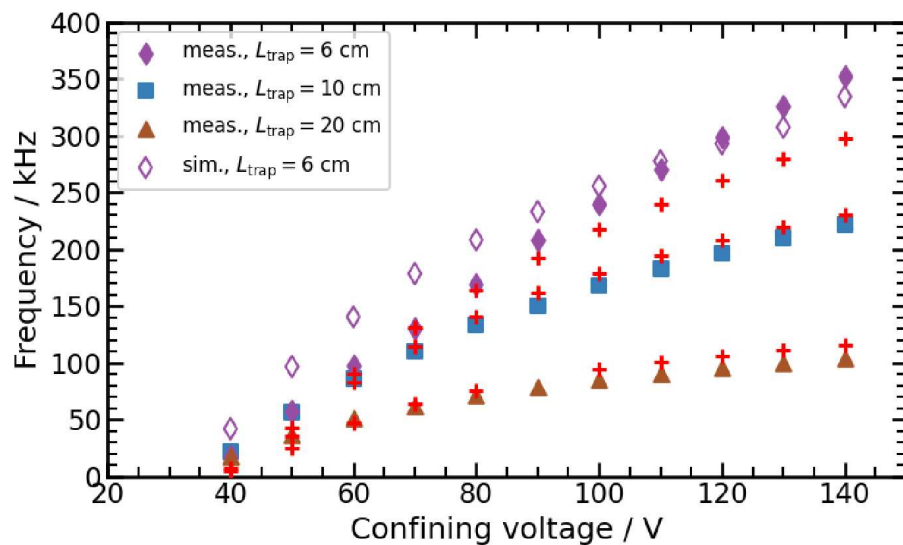
2. Data plotted for 3 anode lengths (6, 10, 20 cm) with initial KE=(0,0,30)eV



# SimION - I expt. comparison

Slide 5 Titus' presentation 27/01/2022:

Magnetron freq. vs. end-gate voltage

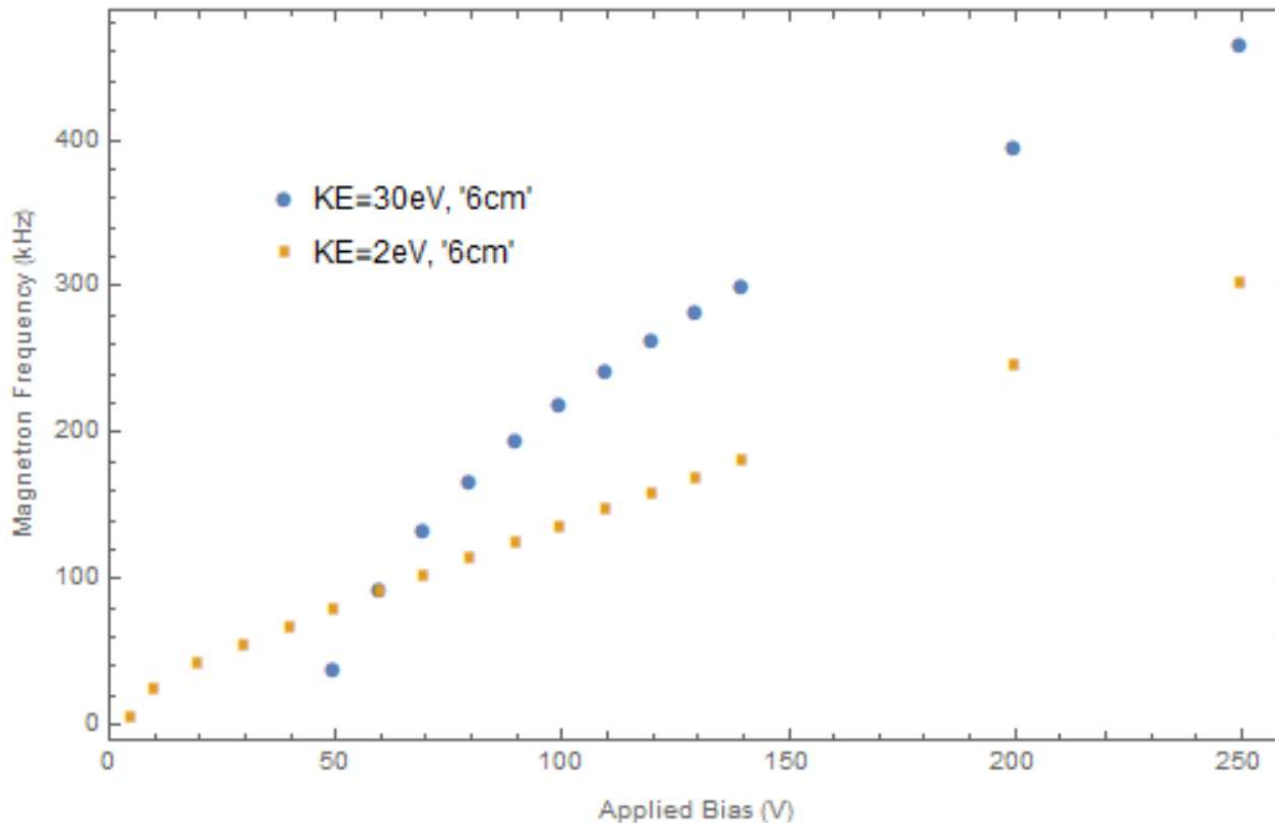


+ Numerical calc.  
(C. Baker)

- Reasonably good agreement also  
(additional support for VSIM reliability )
- Better for 10 & 20cm  
(surprising to CB as wells are less harmonic)

# SimION - II

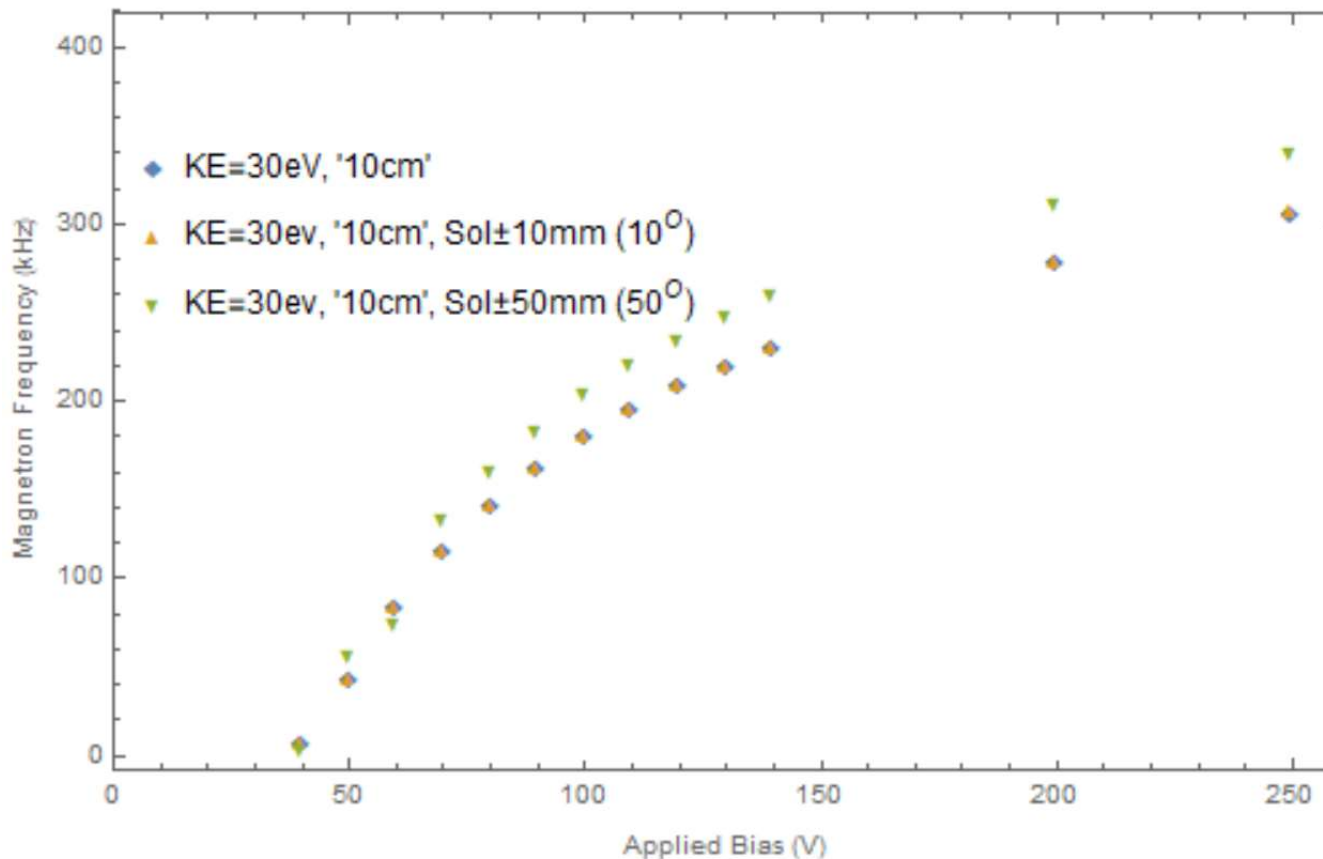
- Frequency w.r.t particle energy



- Linear behaviour (as suggested by earlier model) for well confined particle
- 'low bias' curvature & 0 Hz related to particle energy (see not on 'voltage' earlier)

# SimION - III

- Frequency w.r.t. B-field misalignment



- Directional tilt of solenoid causes shift in magnetron frequency
- Even  $10^\circ$  misalignment practically unlikely due to geometry
- Possibly a rationale for VSIM implied 10% lower B-field?