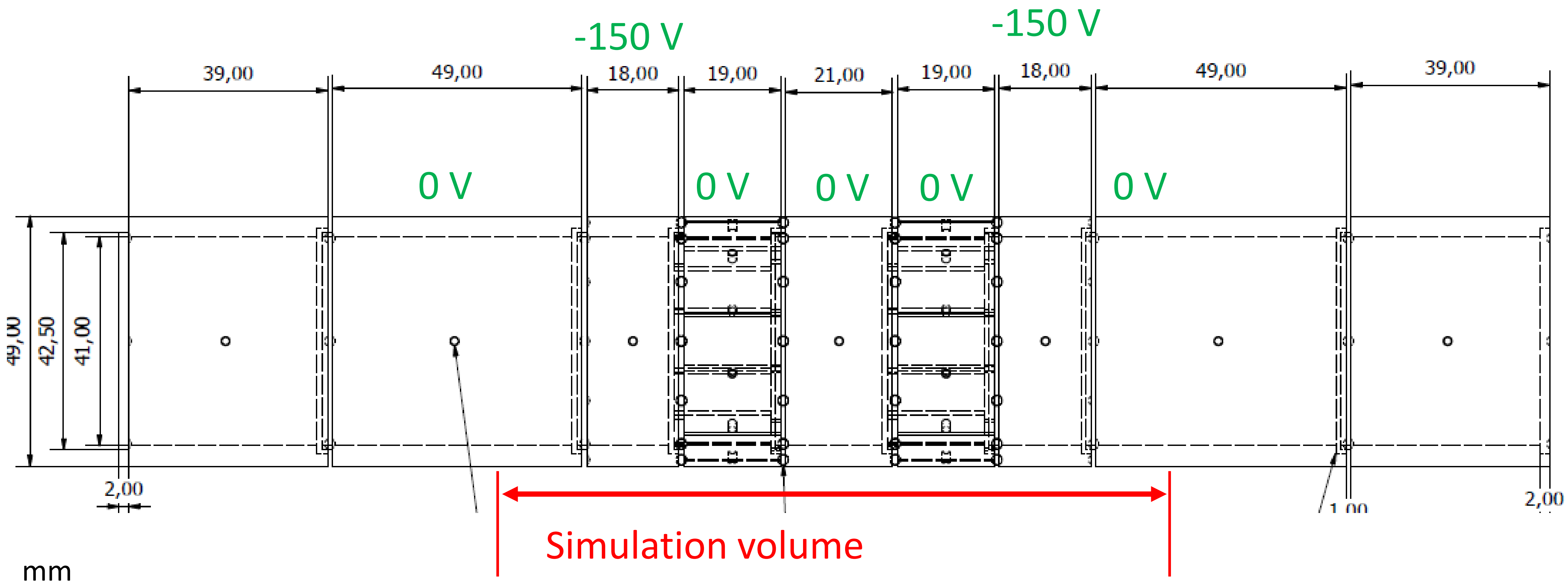
LhARA Capture Meeting

9th September 2021

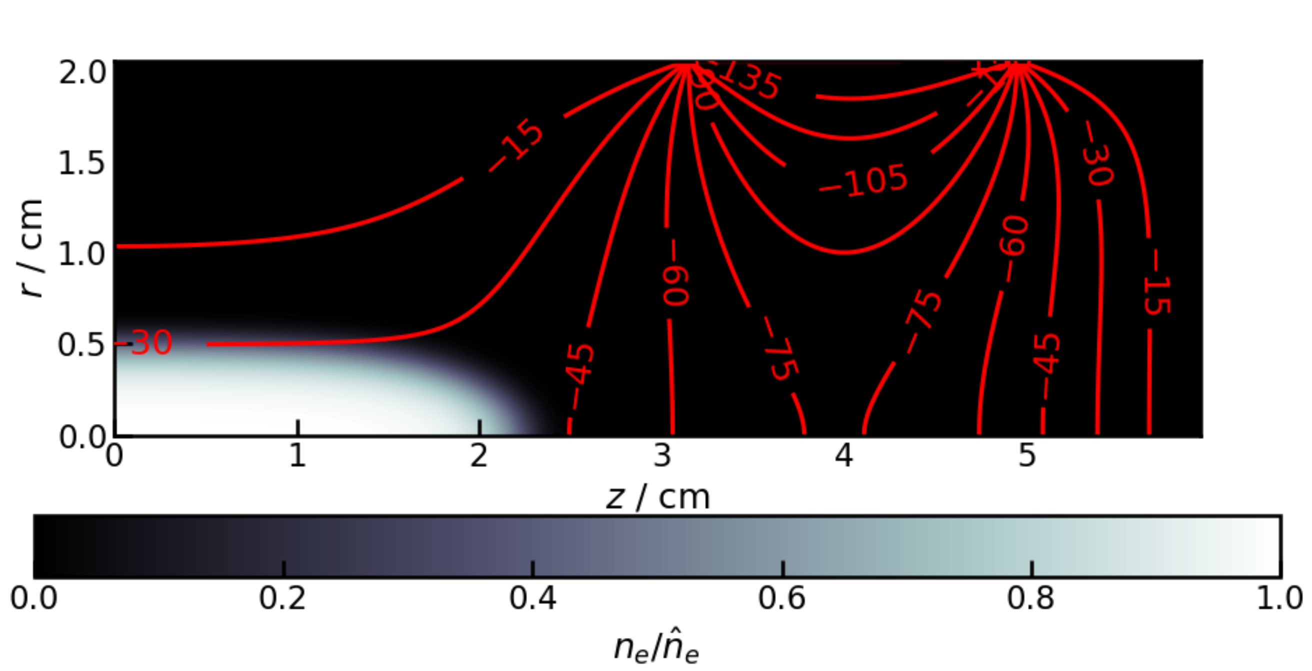
Titus Dascalu

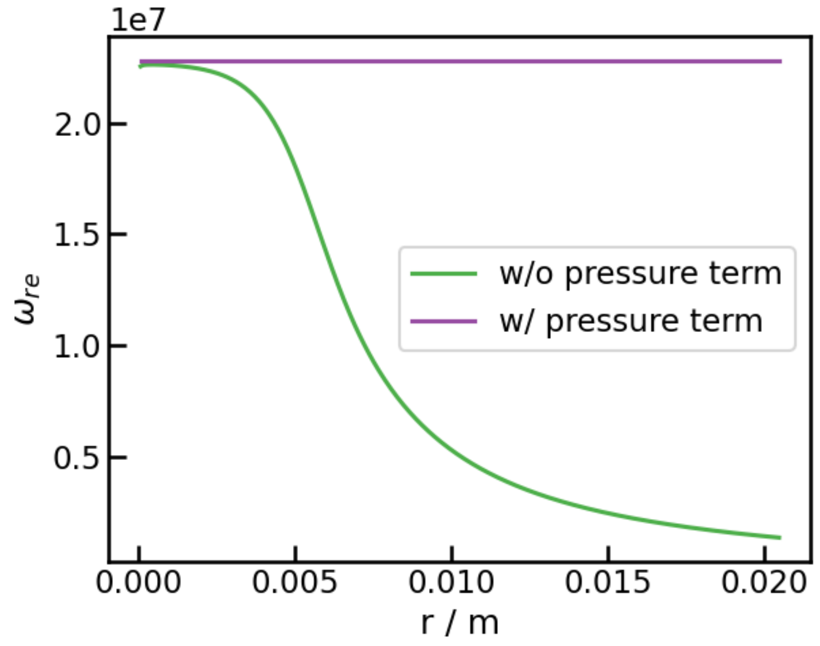
Swansea storage trap



$$n_e = 1 \times 10^{14}\ \mathrm{m}^{-3}$$
$$B = 0.04\ \mathrm{T}$$

Initial electron cloud

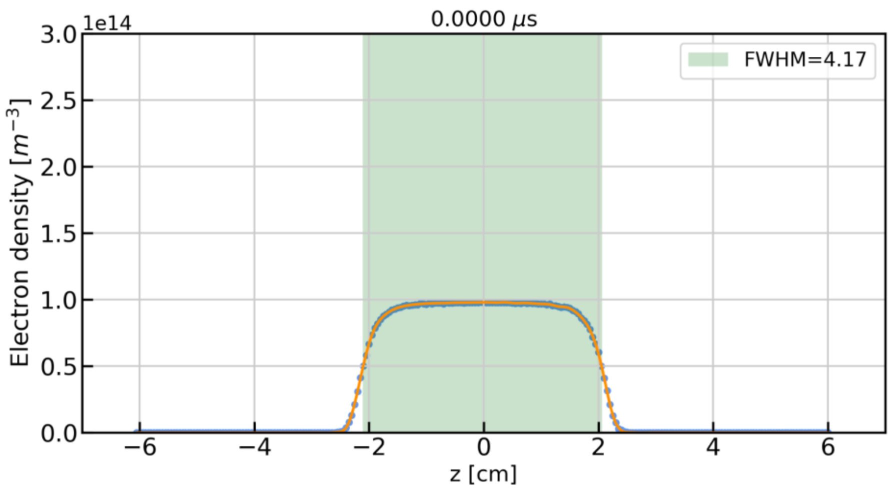


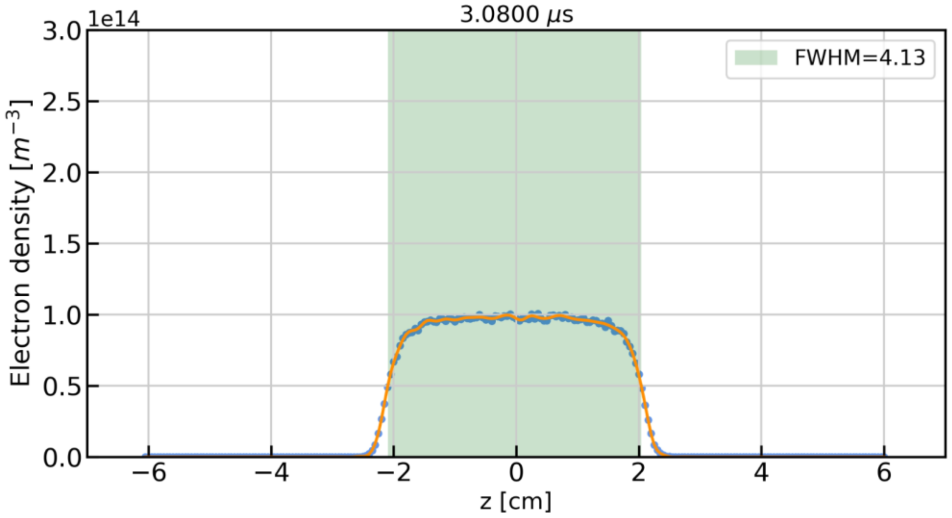


- Plasma density obtained from solving axisymmetric Poisson equation in 2D
  - Uniform angular velocity
  - Uniform $T = 1\ eV$
- Radial velocity profile obtained from density distribution assuming a cold plasma
  - Lack of collisions in the simulation
  - Slow rotation solution
- Axial velocity profile – Maxwellian with $T = 1\ eV$

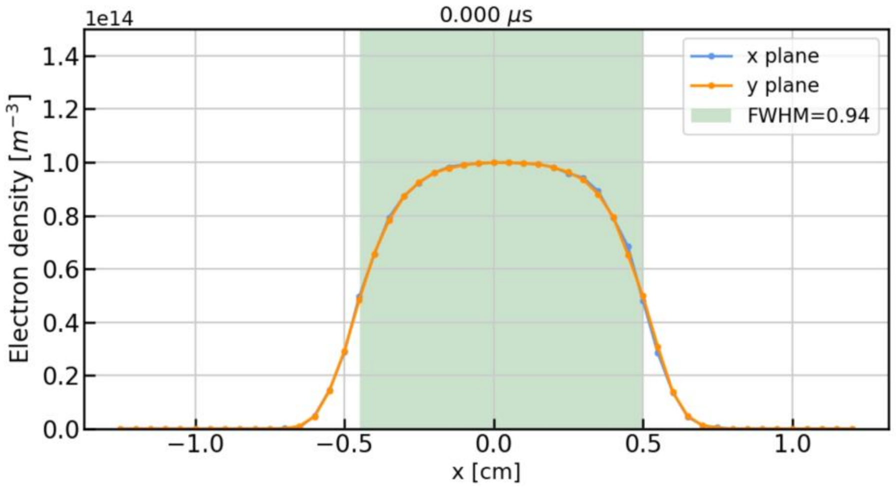
Changes in density distribution

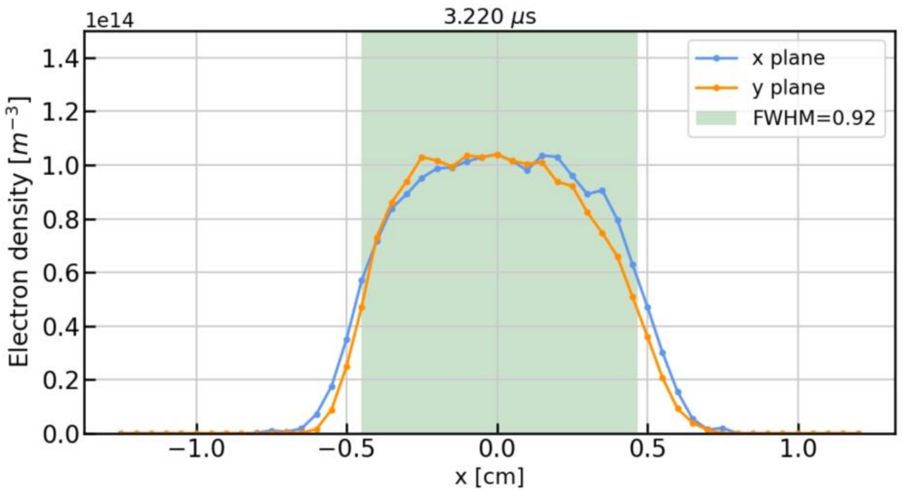
- Due to the initial density + velocity distributions of the plasma, little expansion is seen during the diocotron rotation





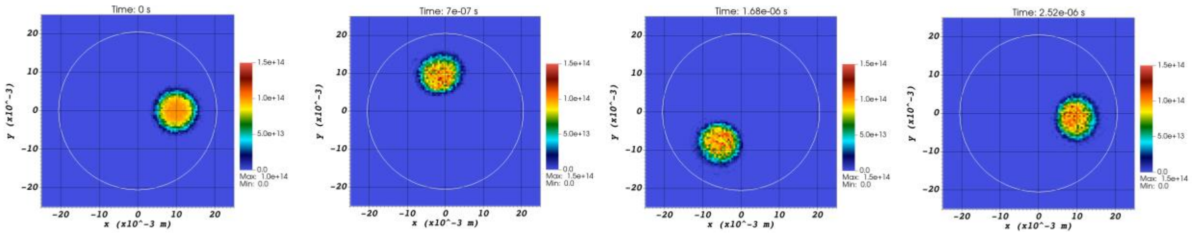
$$\frac{\Delta L_p}{L_p} \approx 3\%$$

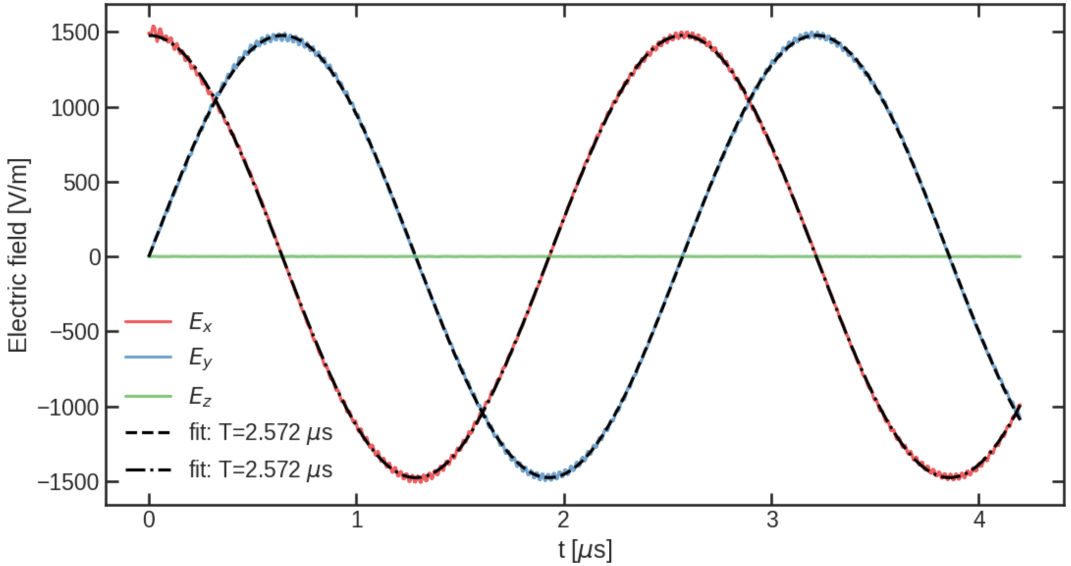




$$\frac{\Delta R_p}{R_p} \approx 2\%$$

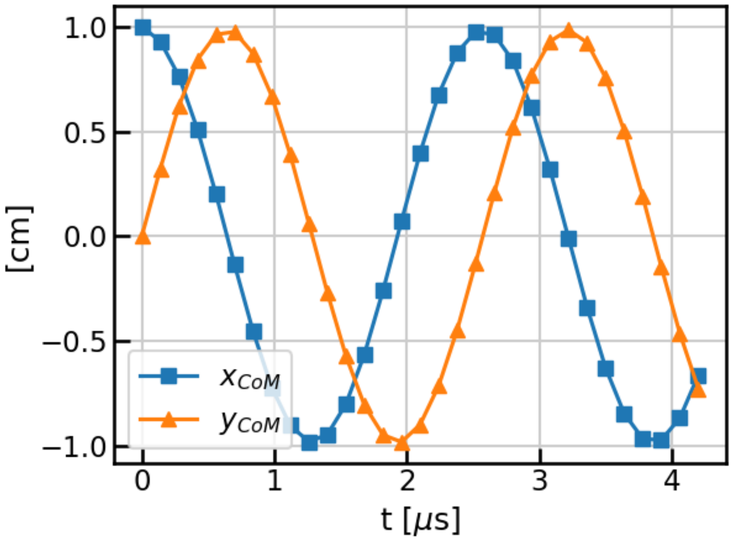
Diocotron drift (1)

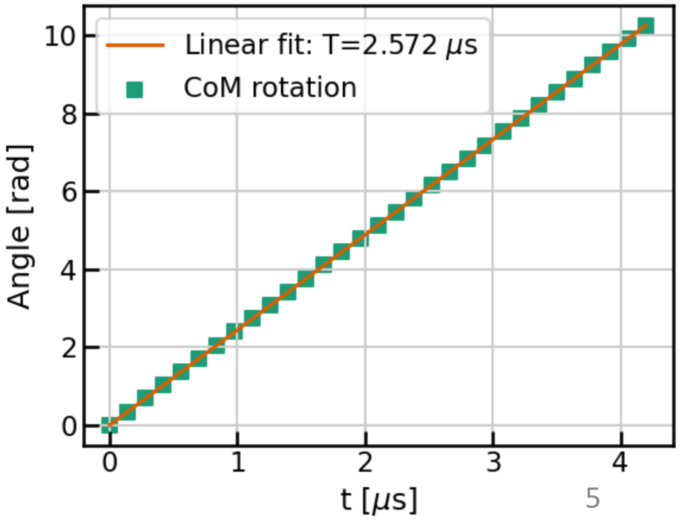




- Extract period from:
  a) Variation of the electric field at the centre of the trap
  b) Motion of the centre of mass of the plasma

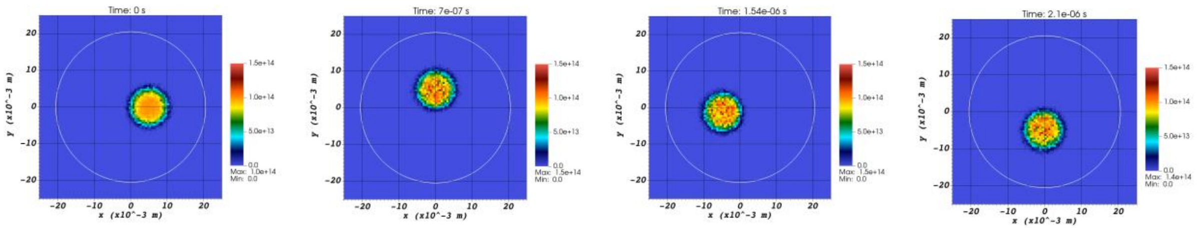
Amplitude $D = 1$ cm

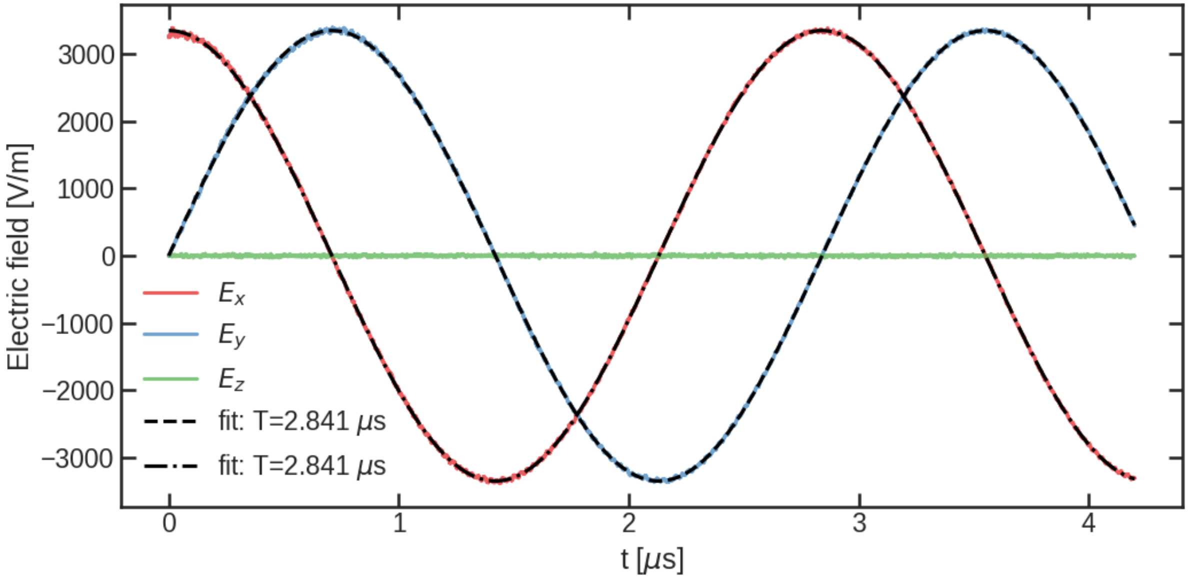




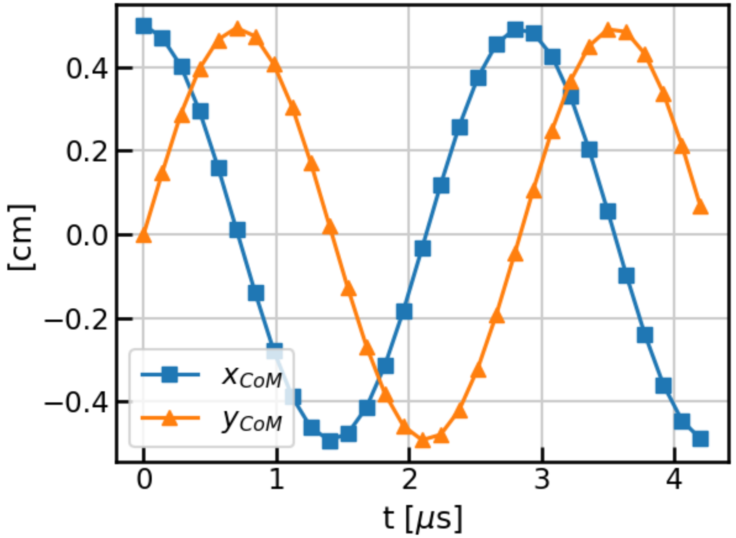
Diocotron drift (2)

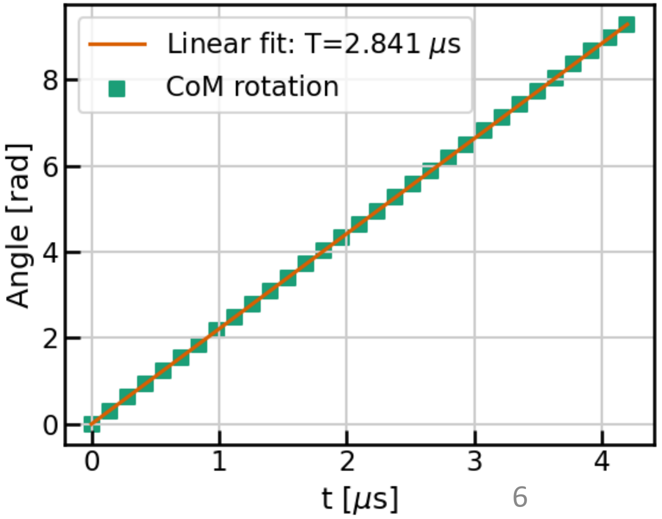
- Extract period from:
  a) Variation of the electric field at the centre of the trap





  b) Motion of the centre of mass of the plasma





Amplitude $D = 0.5$ cm

Theoretical expectation

- Finite radius, non-linear formula for diocotron frequency:

$$f_{\mathrm{NL}} = f_\infty + f_\infty \left(\frac{1 - 2(R_p/R_w)^2}{[1 - (R_p/R_w)^2]^2} \right) \left(\frac{D}{R_w} \right)^2$$

$$f_\infty \sim \frac{1}{L_p}$$

$$\frac{f_{NL}(D = 1\ \mathrm{cm})}{f_{NL}(D = 0.5\ \mathrm{cm})} = 1.154 \pm 0.046$$

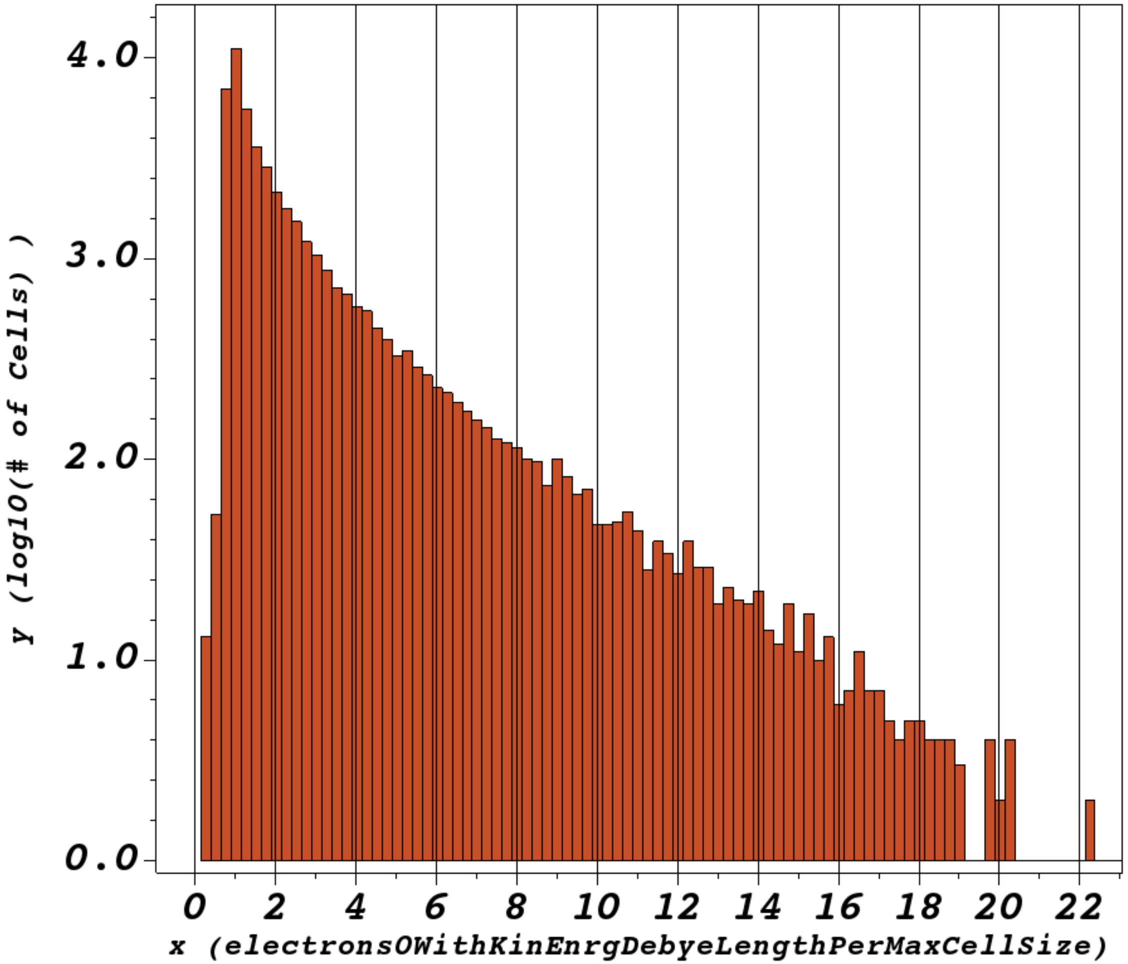
(from uncertainty in L_p in the two simulations)

$$\frac{f_{\mathrm{sim}}(D = 1\ \mathrm{cm})}{f_{\mathrm{sim}}(D = 0.5\ \mathrm{cm})} = \frac{2.841\ \mu\mathrm{s}}{2.572\ \mu\mathrm{s}} = 1.105$$

Resolution and CPU time

- Grid size $\Delta x = \Delta y = \Delta z = 0.5$ mm
- Debye length $\lambda_D = 0.74$ mm

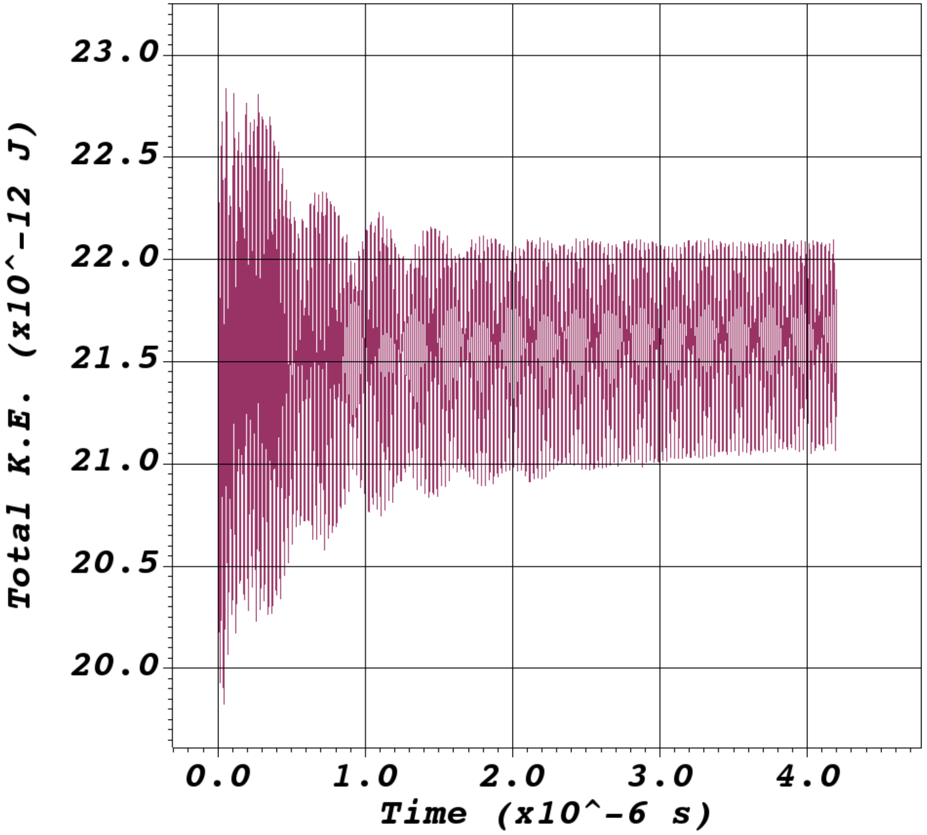
- To simulate one period it takes
  ≈ 4 h on 16 CPUs



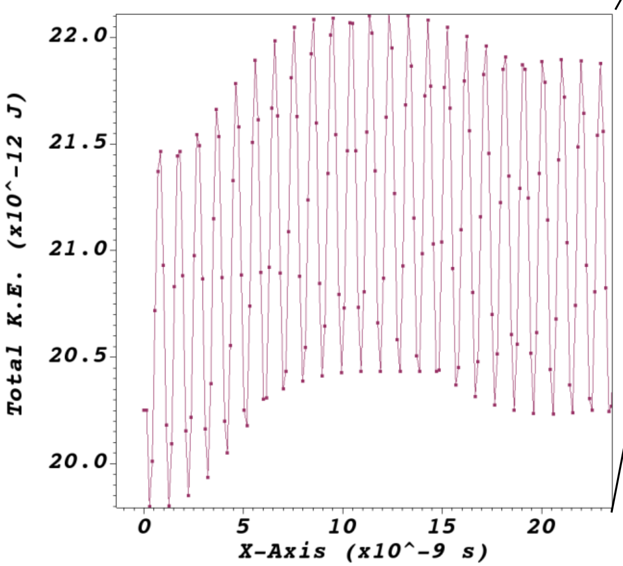
$\lambda_D / \Delta x$

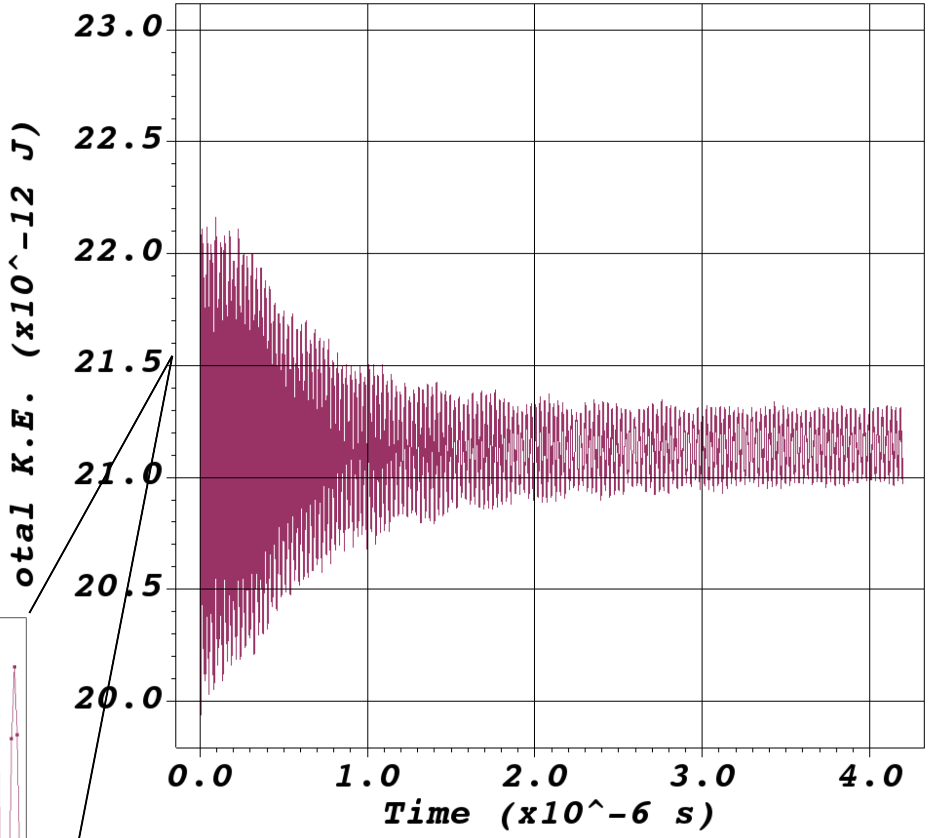
For each cell calculate
$\lambda_D(\mathrm{T(total\ KE\ in\ cell), electron\ density\ in\ cell})$

Results of low resolution



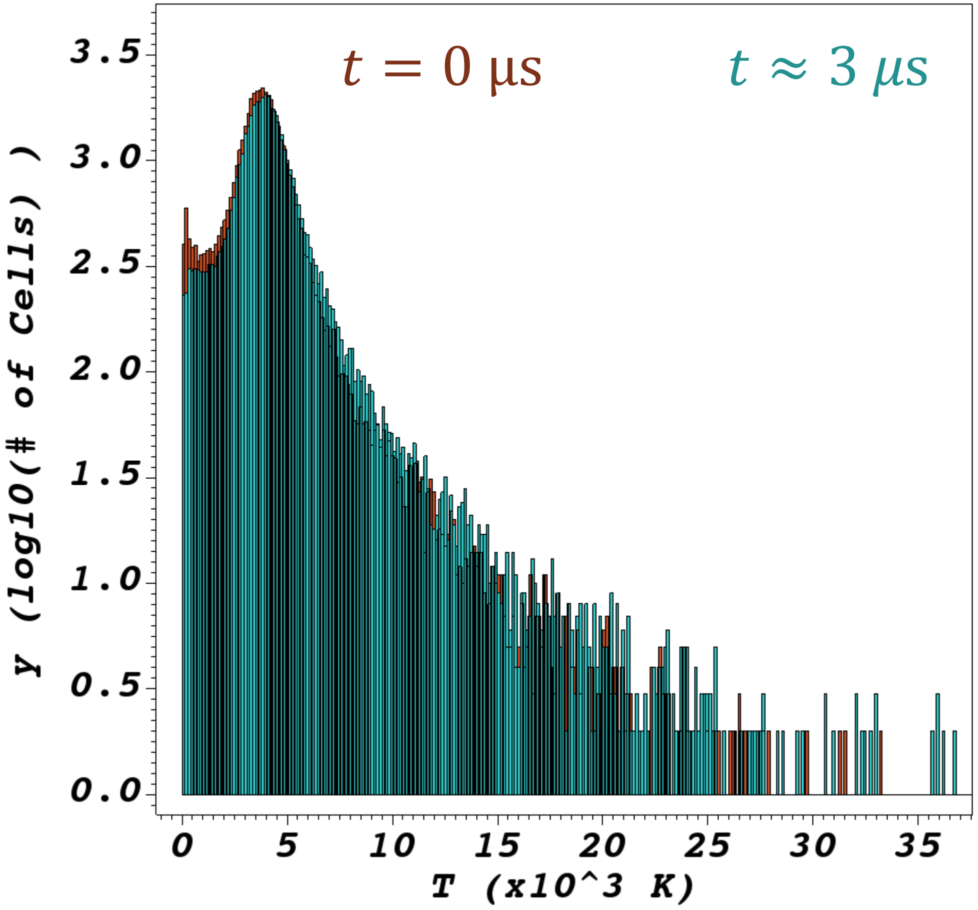
Amplitude $D = 1$ cm





Amplitude $D = 0.5$ cm

Results of low resolution

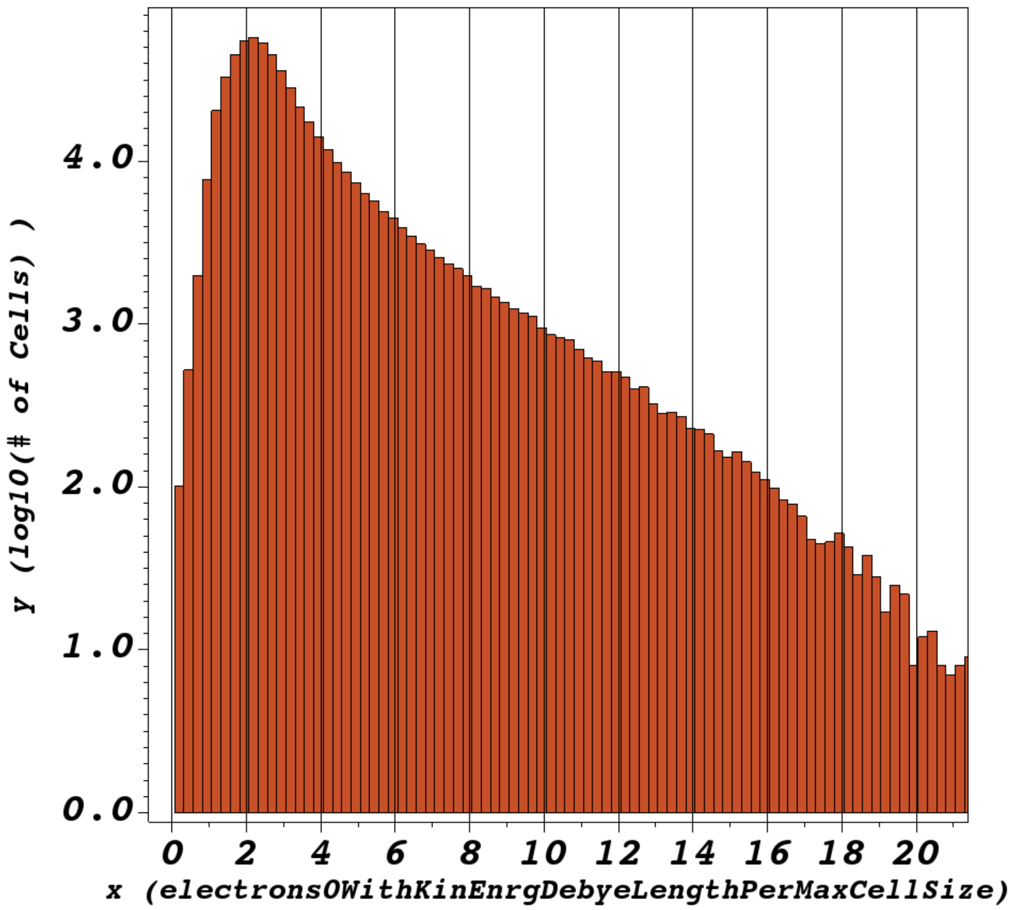


$$T = \frac{2}{3k_B} KE$$

Increasing the resolution

- Grid size $\Delta x = \Delta y = \Delta z = 0.2\ \mathrm{mm}$
- Debye length $\lambda_D = 0.74\ \mathrm{mm}$

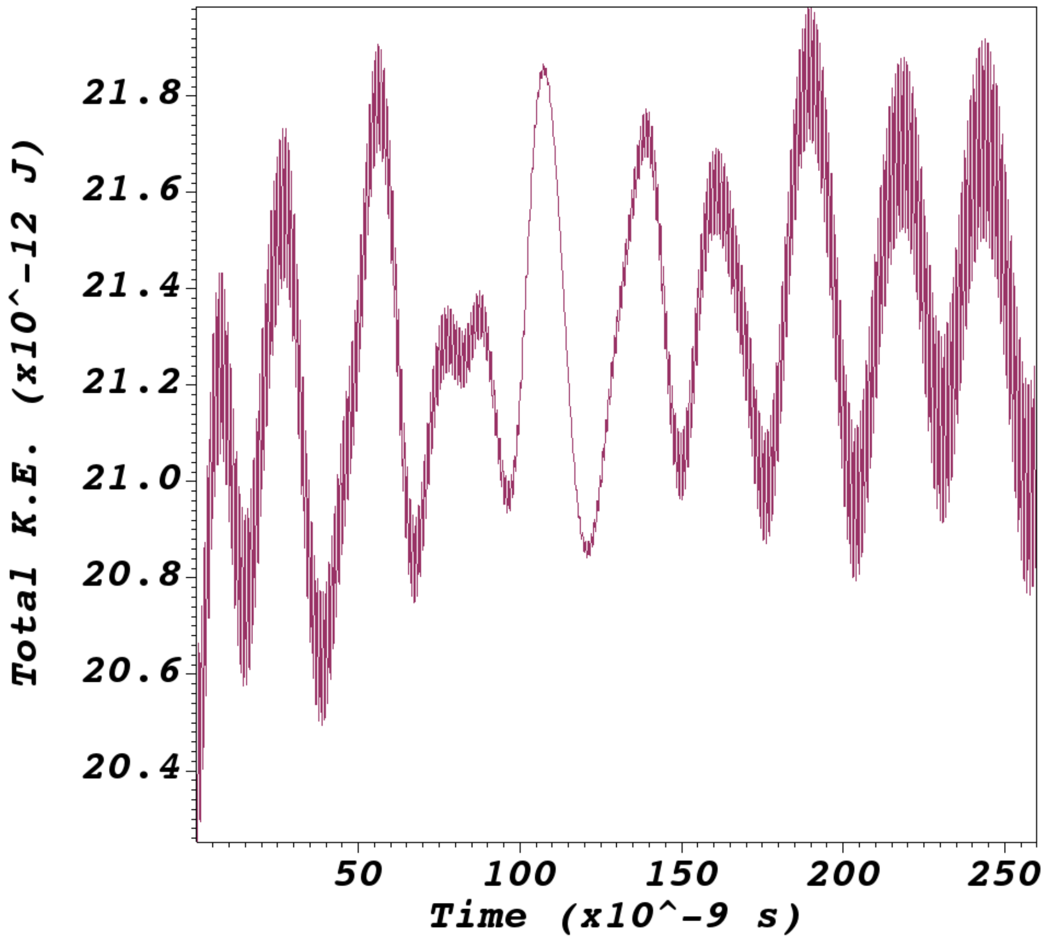
- To simulate one period it takes
  $\approx 120\ \mathrm{h}$ on 16 CPUs



$\lambda_D / \Delta x$

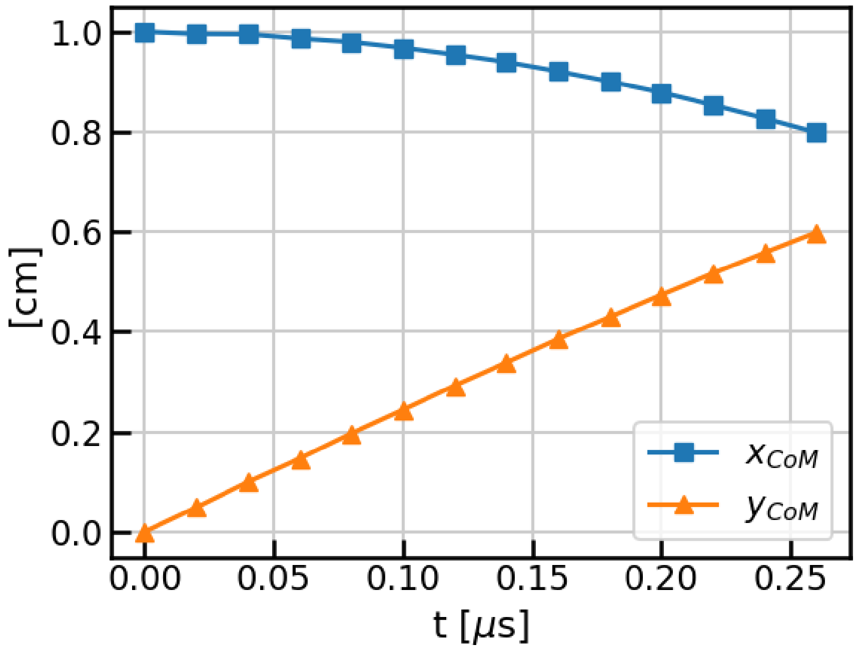
Amplitude $D = 1\ \mathrm{cm}$

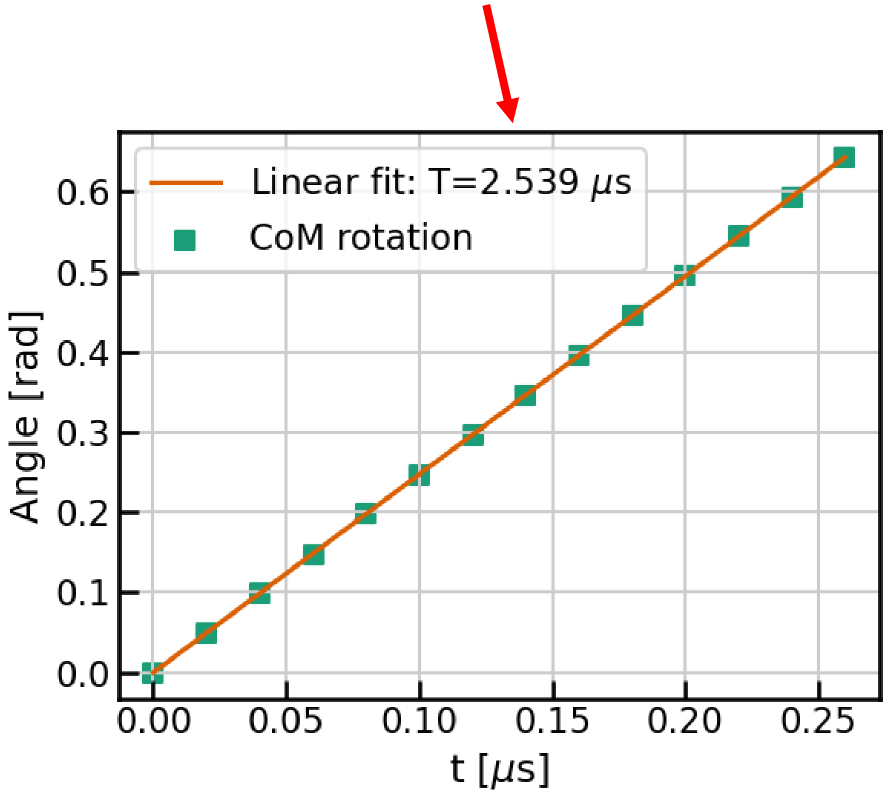
Increasing the resolution



Increasing the resolution

Compared to 2.572 μs with lower resolution





Amplitude $D = 1$ cm