CPOTS – 3rd ERASMUS Intensive Program

Introduction to Charged Particle Optics: Theory and Simulation

Education and Culture DG

Lifelong Learning Programme

- http://cpots2013.physics.uoc.gr
- Dept. of Physics, University of Crete
- Aug 15 – 30, 2013
- Heraklion, Crete, GREECE

Project Presentation Linear Electrostatic Traps

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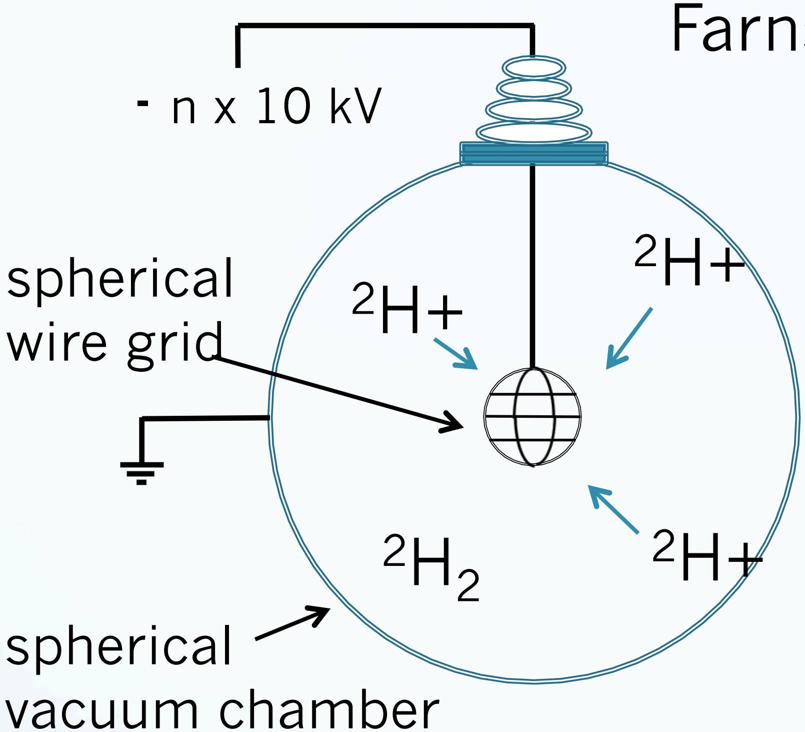
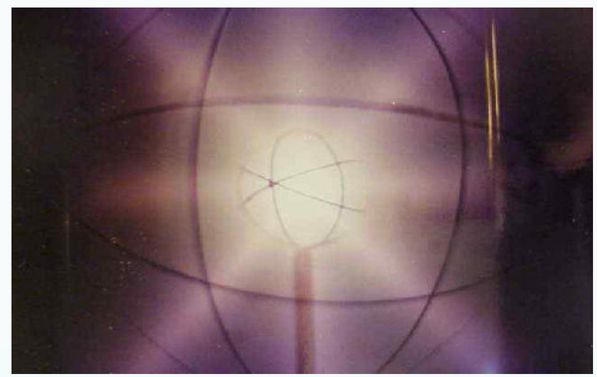
Farnsworth "Fusor"



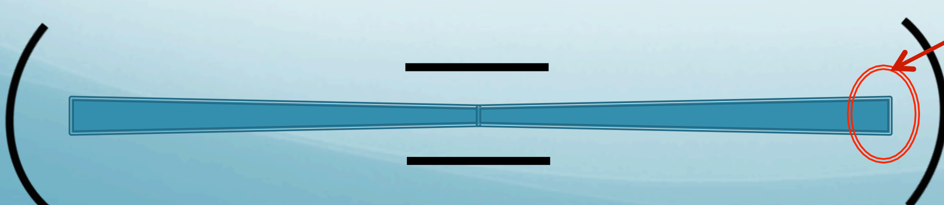
$^2H + ^2H \rightarrow ^3He$ (0.82 MeV) + n (2.45

$^2H + ^2H \rightarrow ^3H$ (1.01 MeV) + p (3.02



"star mode"

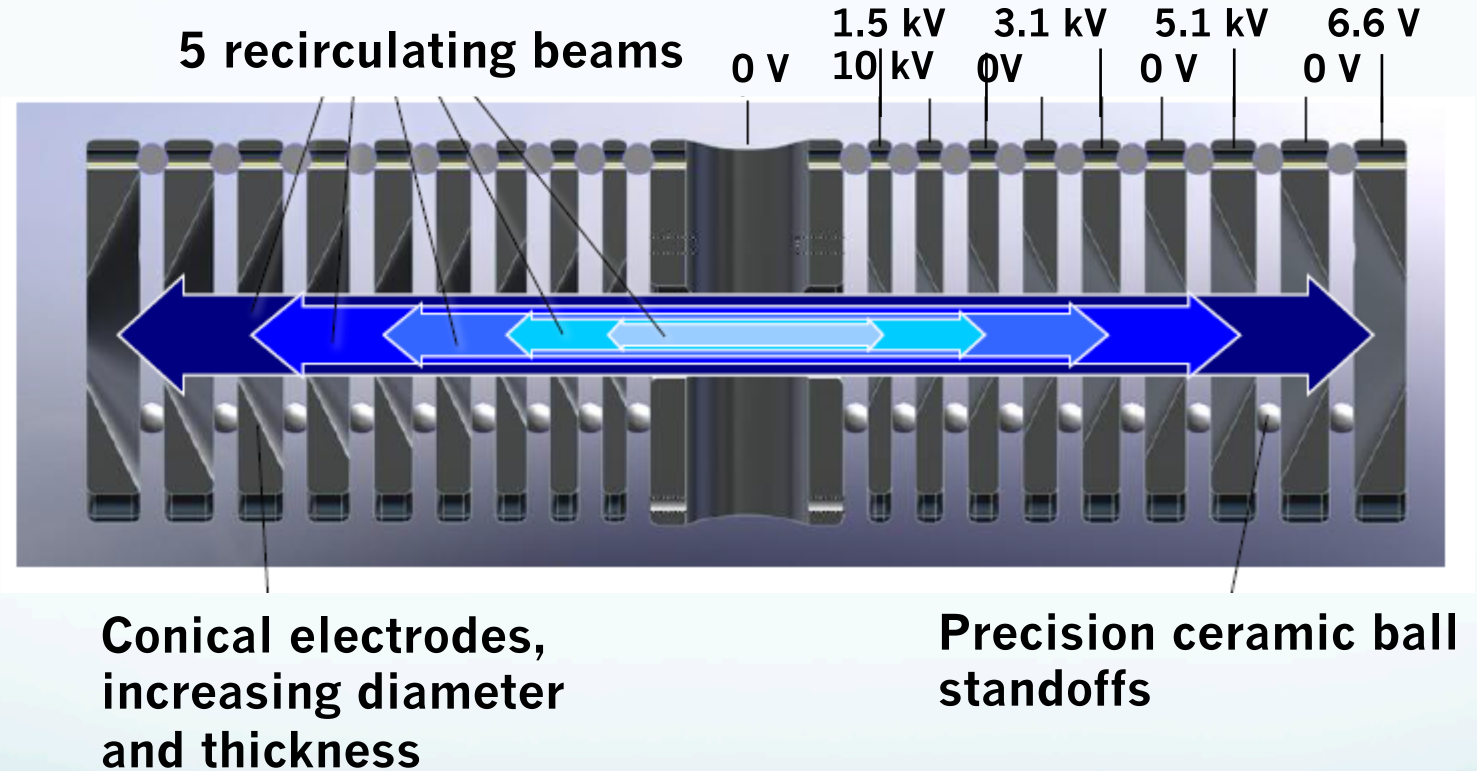
Linear Electrostatic Trap



Space charge effects in turning region limit number of ions that can be trapped

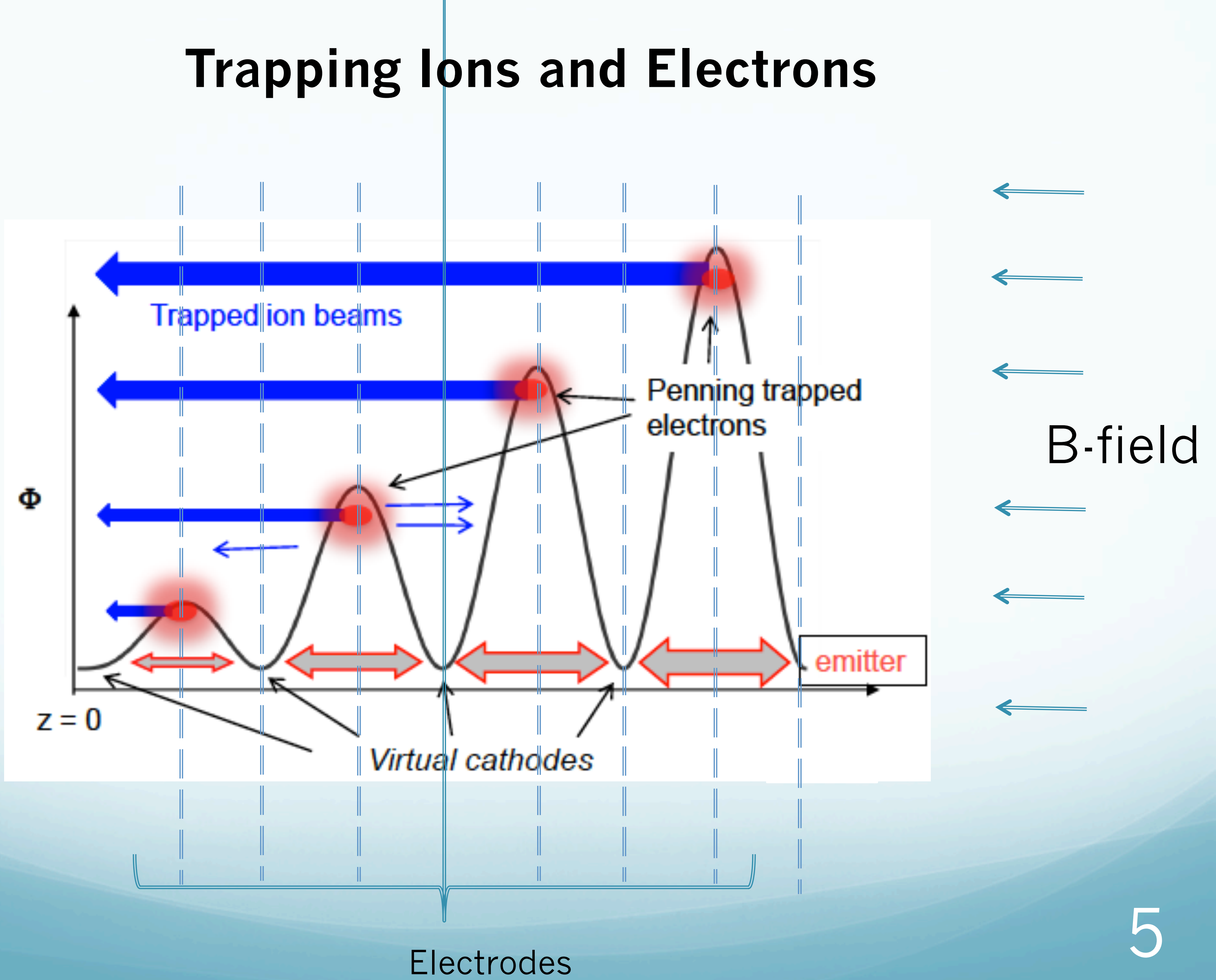
Multiple **A**mbipolar **B**eam **L**ine **E**xperiment

(A. Klein, 13th US-Japan IEC workshop, Sydney 2011)



This gridless device was proposed to increase the number of trapped ions by superimposing multiple linear ion traps. The “ambipolar” term reflects the fact that the reported device also employed a solenoid coil on the outside of the cylindrical vacuum housing to trap the electrons in the contained plasma.

Trapping Ions and Electrons



Questions which could be explored with SIMION

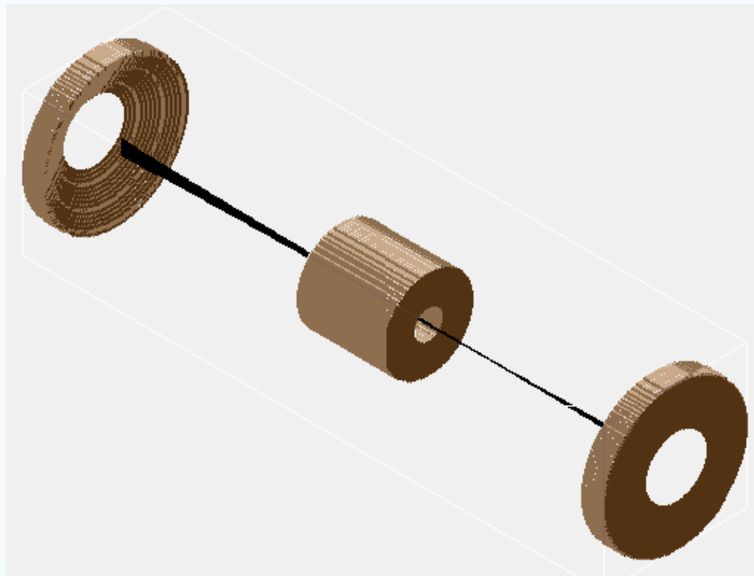
1. Trapping – Will a series of overlapping traps actually trap ions and electrons as Klein claimed in his presentation?

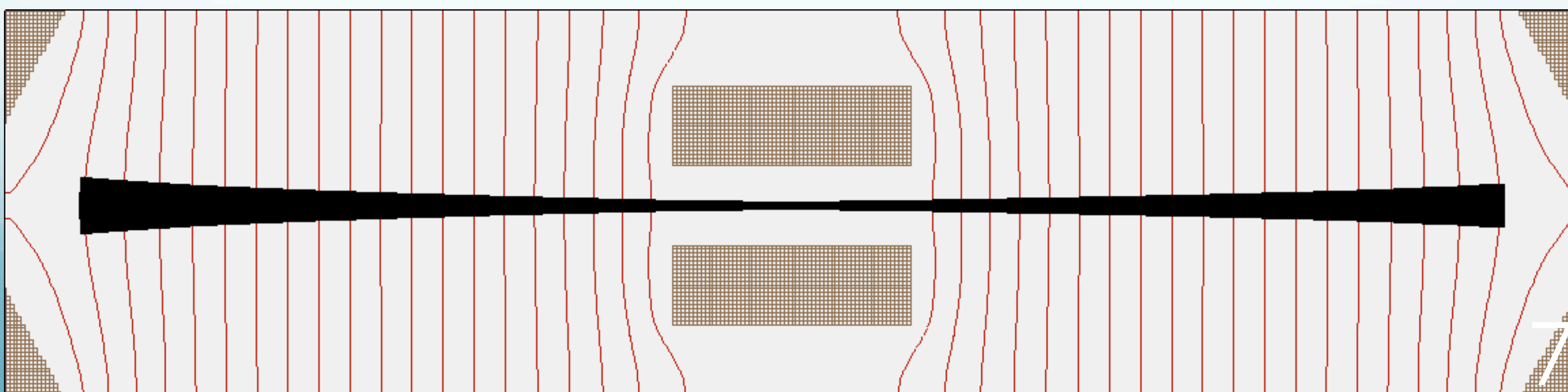
2. Collisional Scattering – How much gas pressure will the trap tolerate before scattering losses impair ion trapping?

3. Space charge effects - How many ions can be recirculated in a beam before space charge effects at the turning region begin to affect the trajectories and impair trapping?

Description of the Workbench Device

1. Single trap device





Description of the Workbench Device

2.Multiple trap device

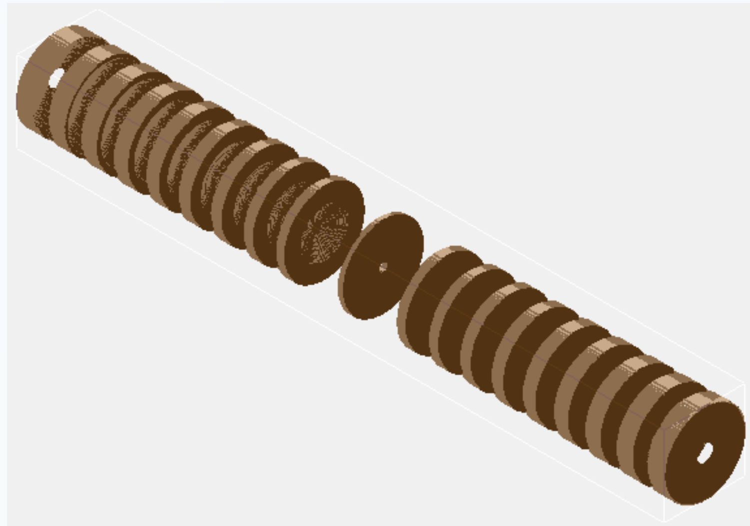
- a. GEM file / Polyline command

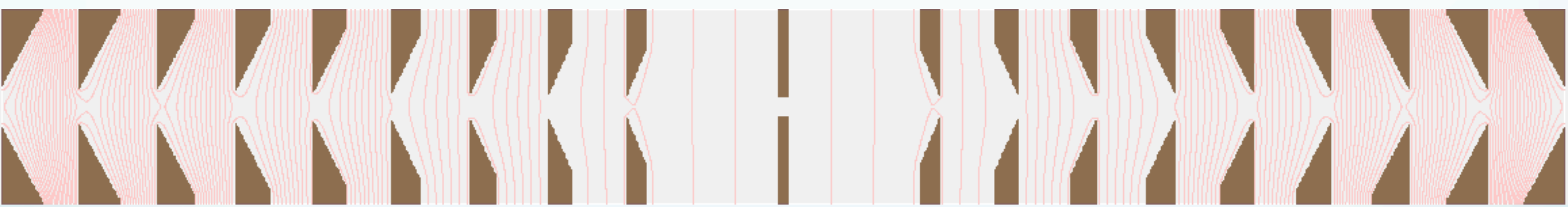
```
polyline(x_1,y_1,x_2,y_2,...)
```

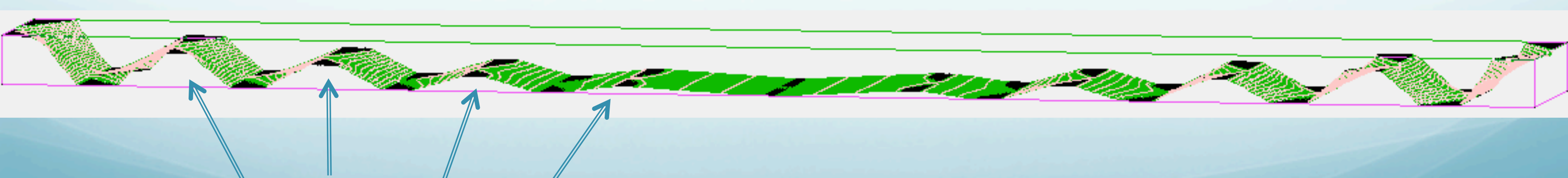
- b. Magnetic field / Lua program
  - add empty pa-file (magnetic)
  - use Lua-command:

```
function segment.mfiled_adjust()
    ion_bfieldx_gu=200
    ion_bfieldy_gu=0
    ion_bfieldz_gu=0
end
```

Illustration of our Device

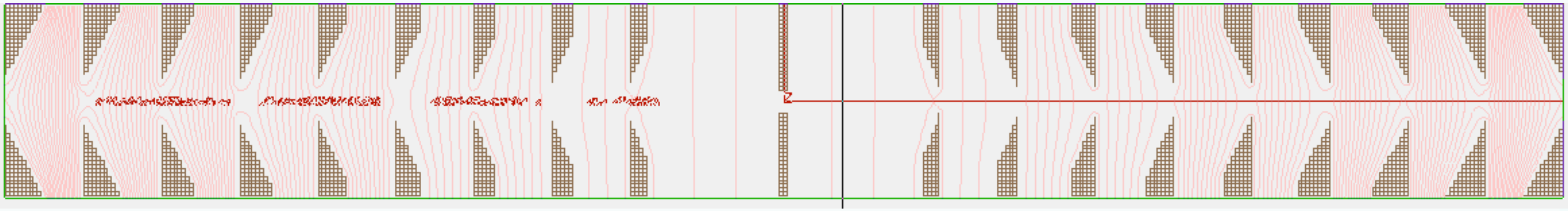






Electron Trapping

Illustration of Trapping Electrons



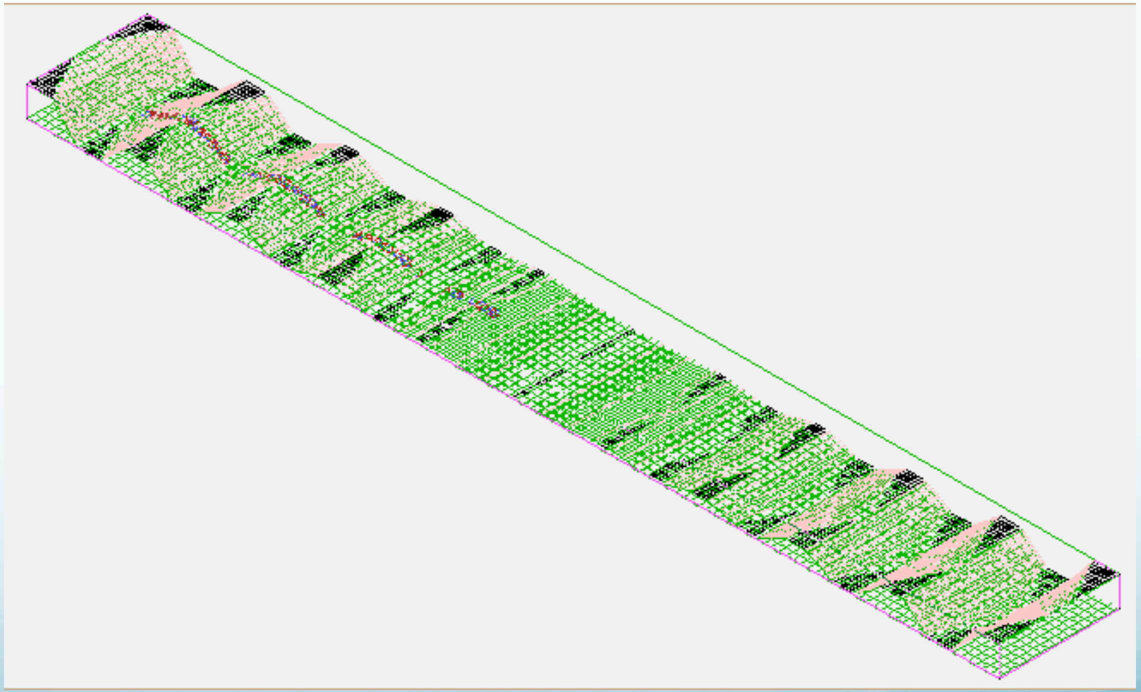
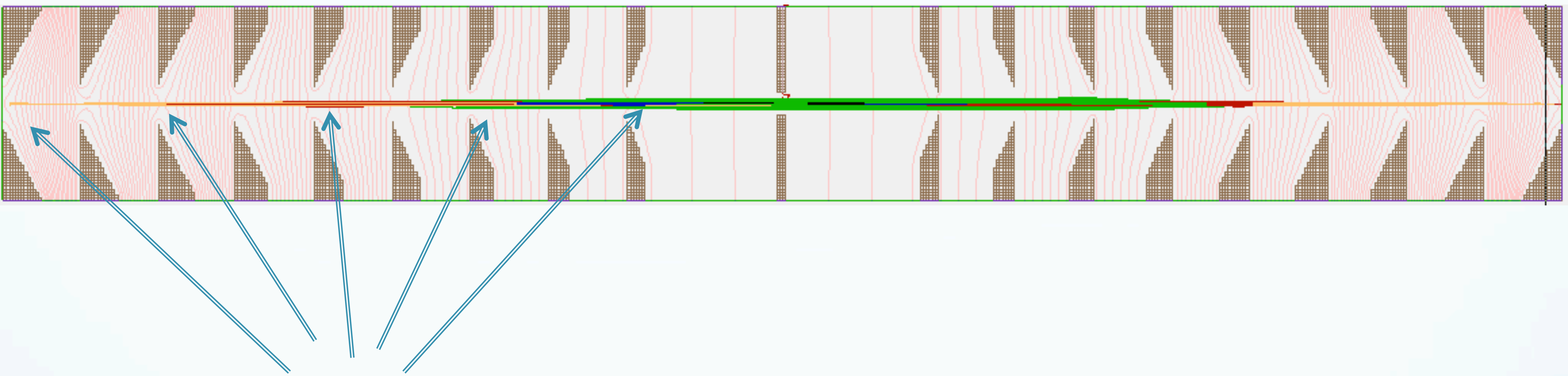


Illustration of Trapping Ions



Ions:

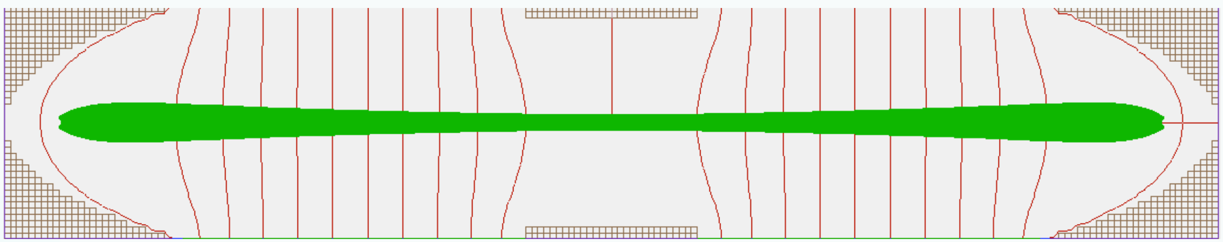
- Mass: 2u
- Charge: +1e
- Source Distribution: Circle Distribution (Radius: 1mm)

Ion Scattering from Background Gas

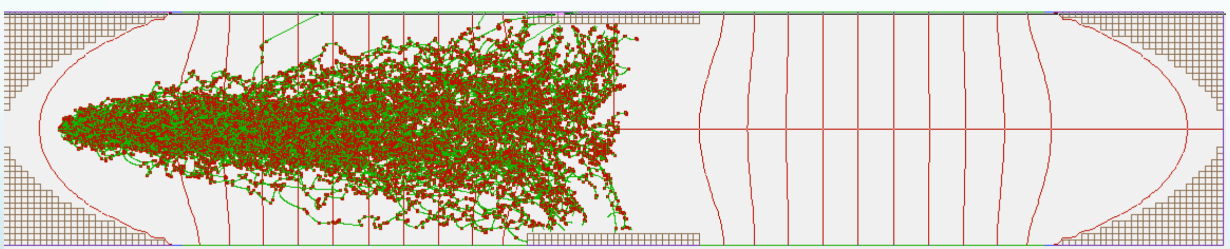
A hard-sphere, elastic, ion-neutral collision model can be found in the SIMION-examples: collision_hs1.lua

Background gas:

- Mass: 4u
- Temperature: 273K



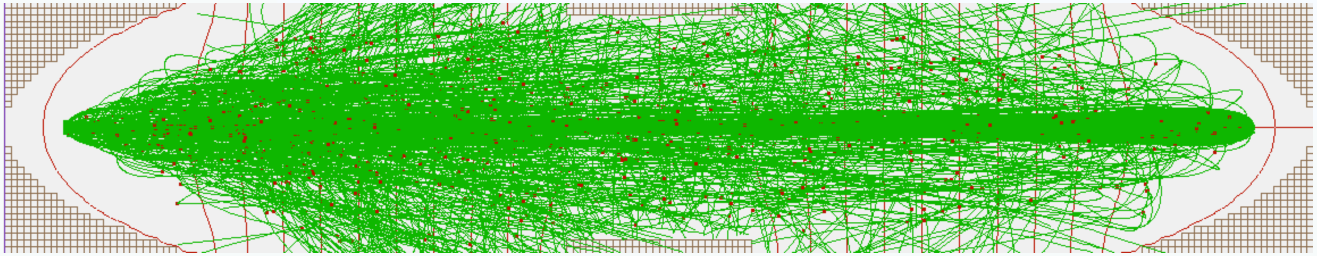
No Background Gas



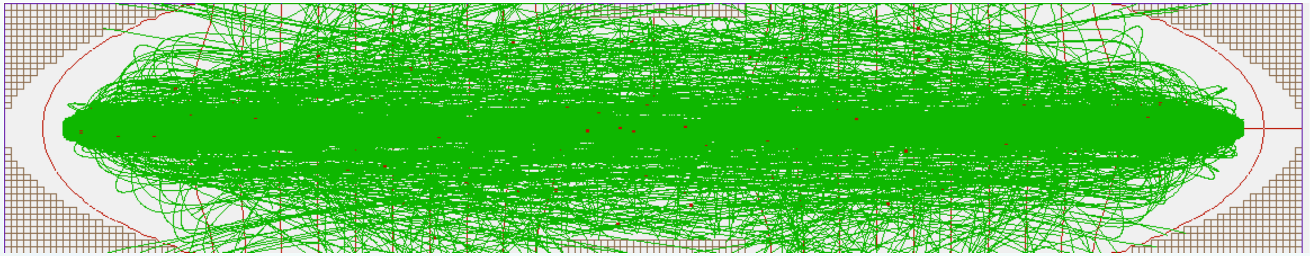
Pressure: 2 Pa

Pressure: 0.2 Pa

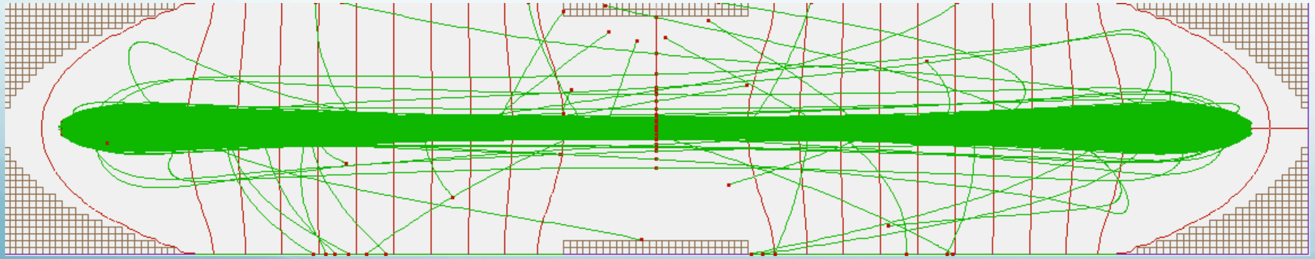
Ion Scattering from Background Gas



Pressure: 0.02 Pa



Pressure: 0.002 Pa

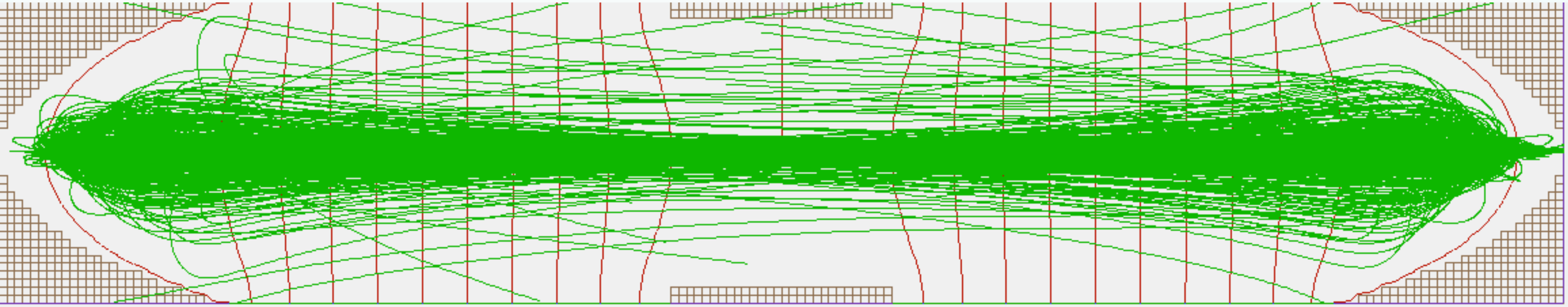


Pressure: 0.0002 Pa

Space Charge Repulsion Effects

- Simulating Coulomb-Repulsion in Single-Ion-Trap

- Space Charge Effects are the Reason for using a Multiple Linear Ion-Traps



Conclusions

1. The device traps ions and electrons as described.

2. Scattering from background gas can be demonstrated, and we found that the pressure had to be reduced from normal operating pressure (2 Pa) to maintain trapping.

3. Space charge repulsion effects can be observed, but we have not defined the maximum number of ions that can be trapped.