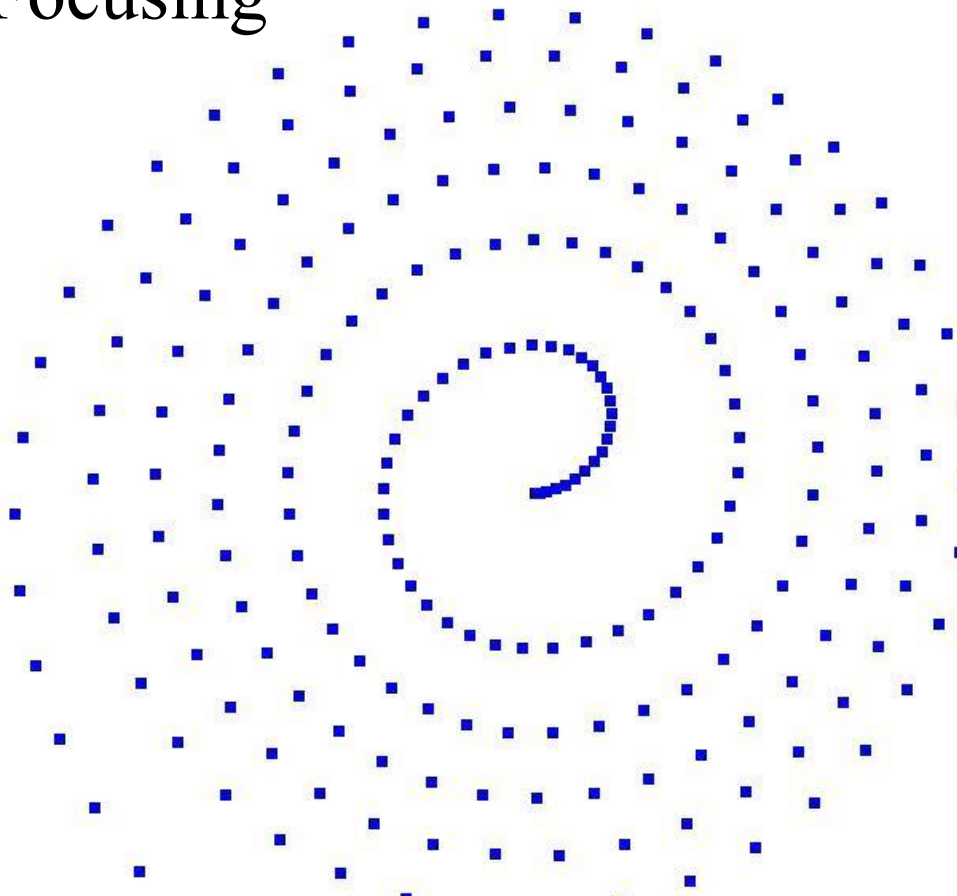
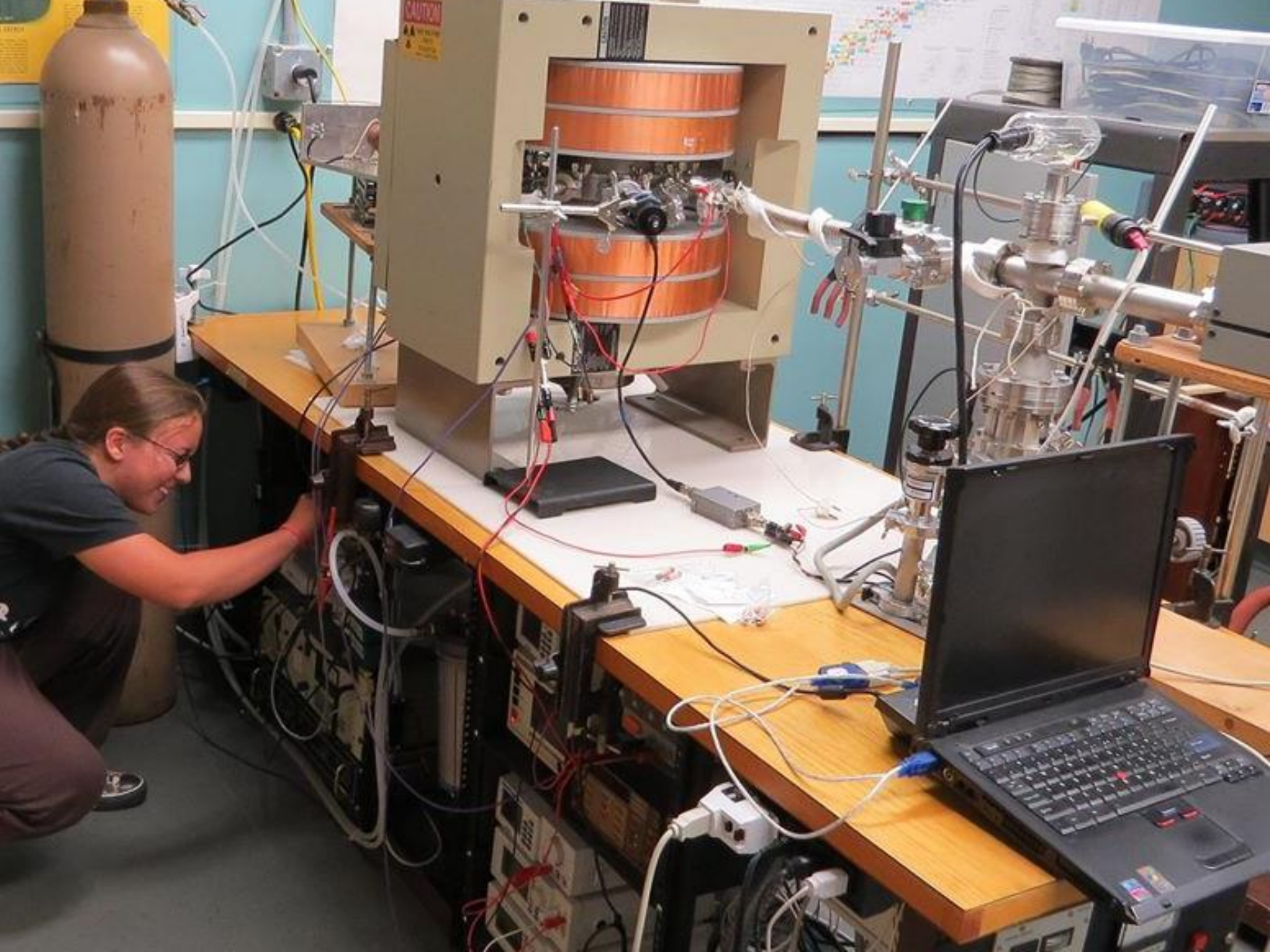
The Houghton College Cyclotron

A Study of Weak Magnetic Focusing

Sylvia Morrow, Mark Yuly

Houghton College





Force on Ion:

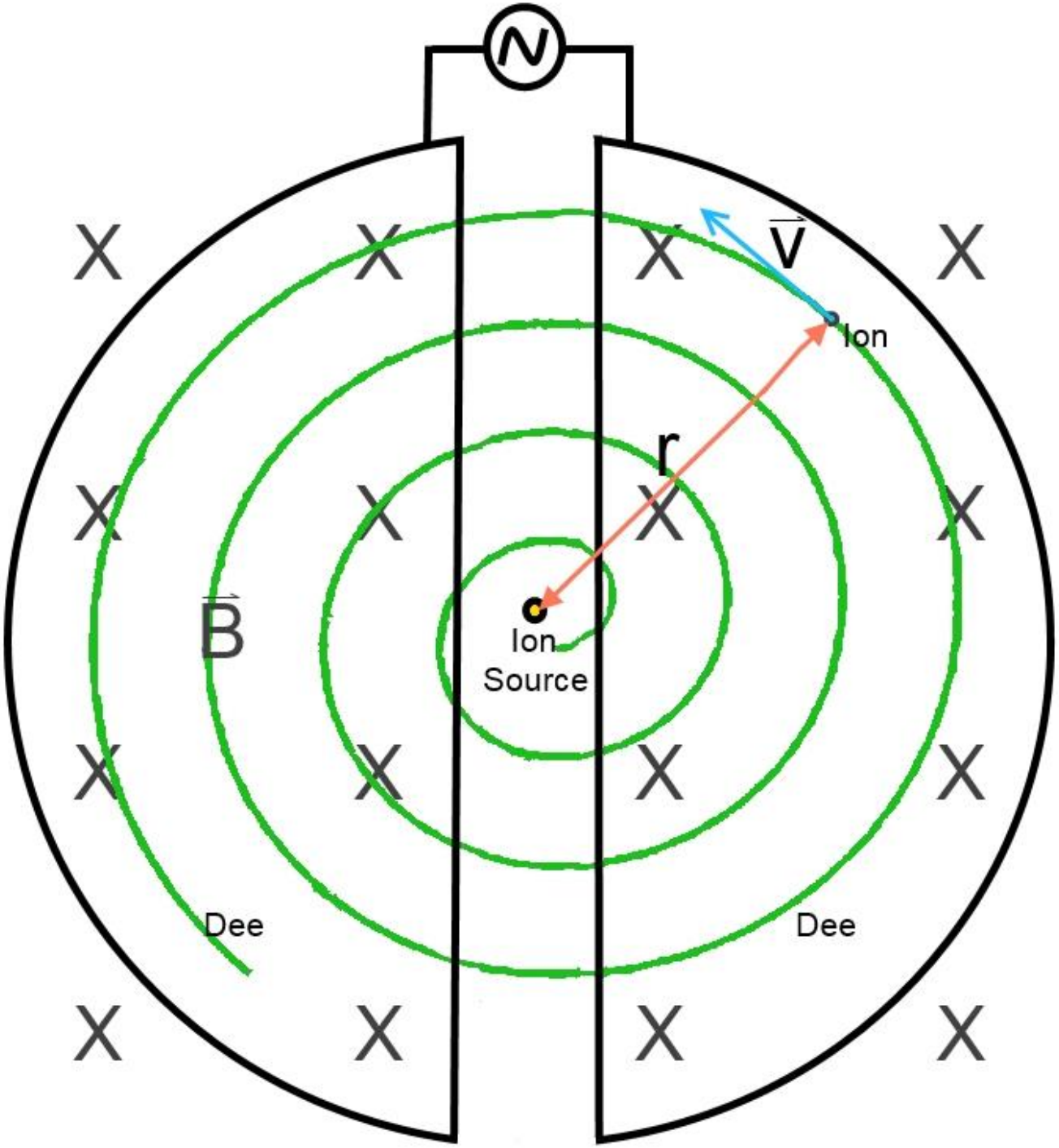
$$\frac{mv^2}{r} = qvB$$

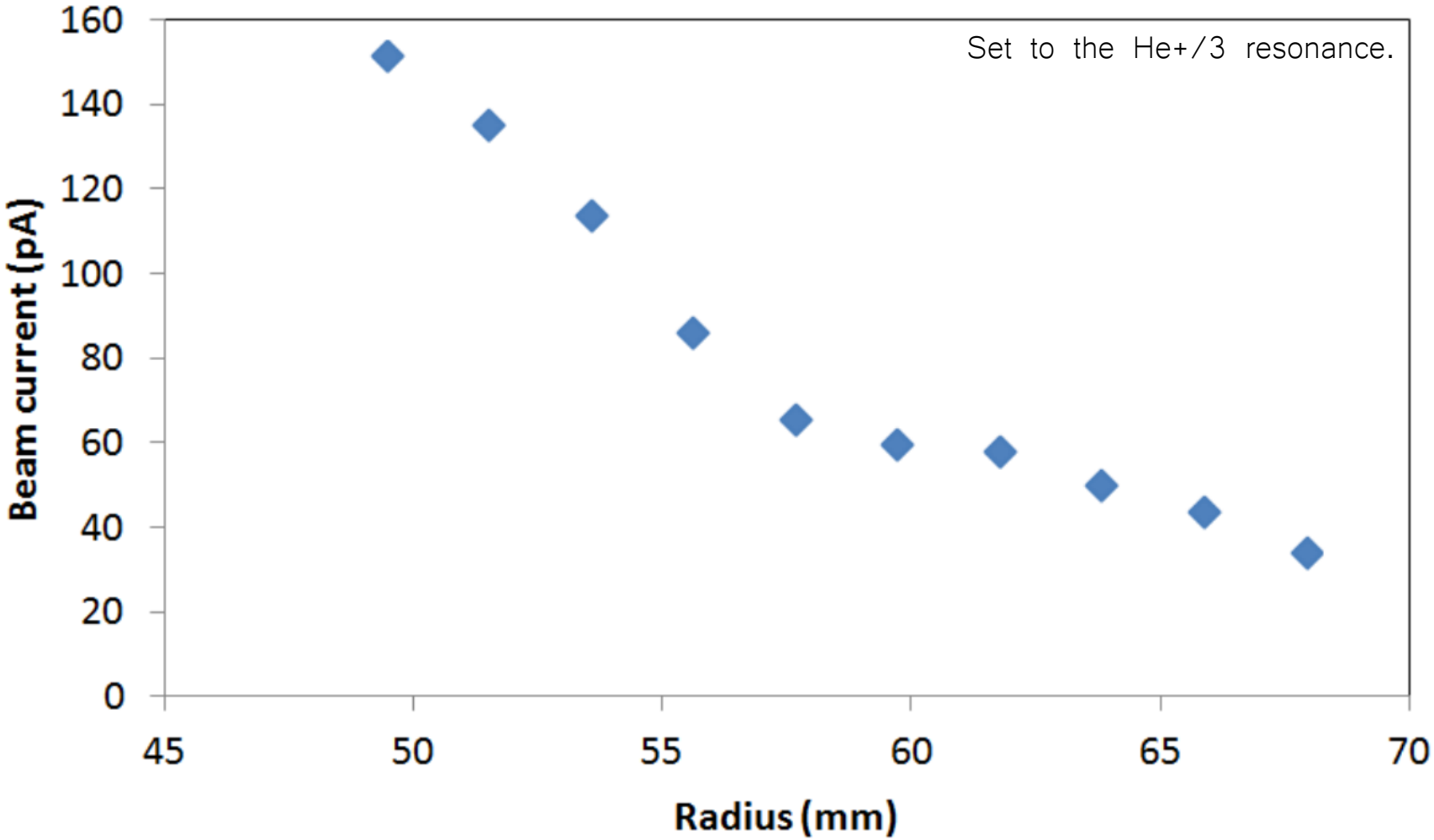
Resonance:

$$f = \frac{qB}{2\pi m}$$

Kinetic Energy:

$$T = \frac{q^2B^2r^2}{2m}$$

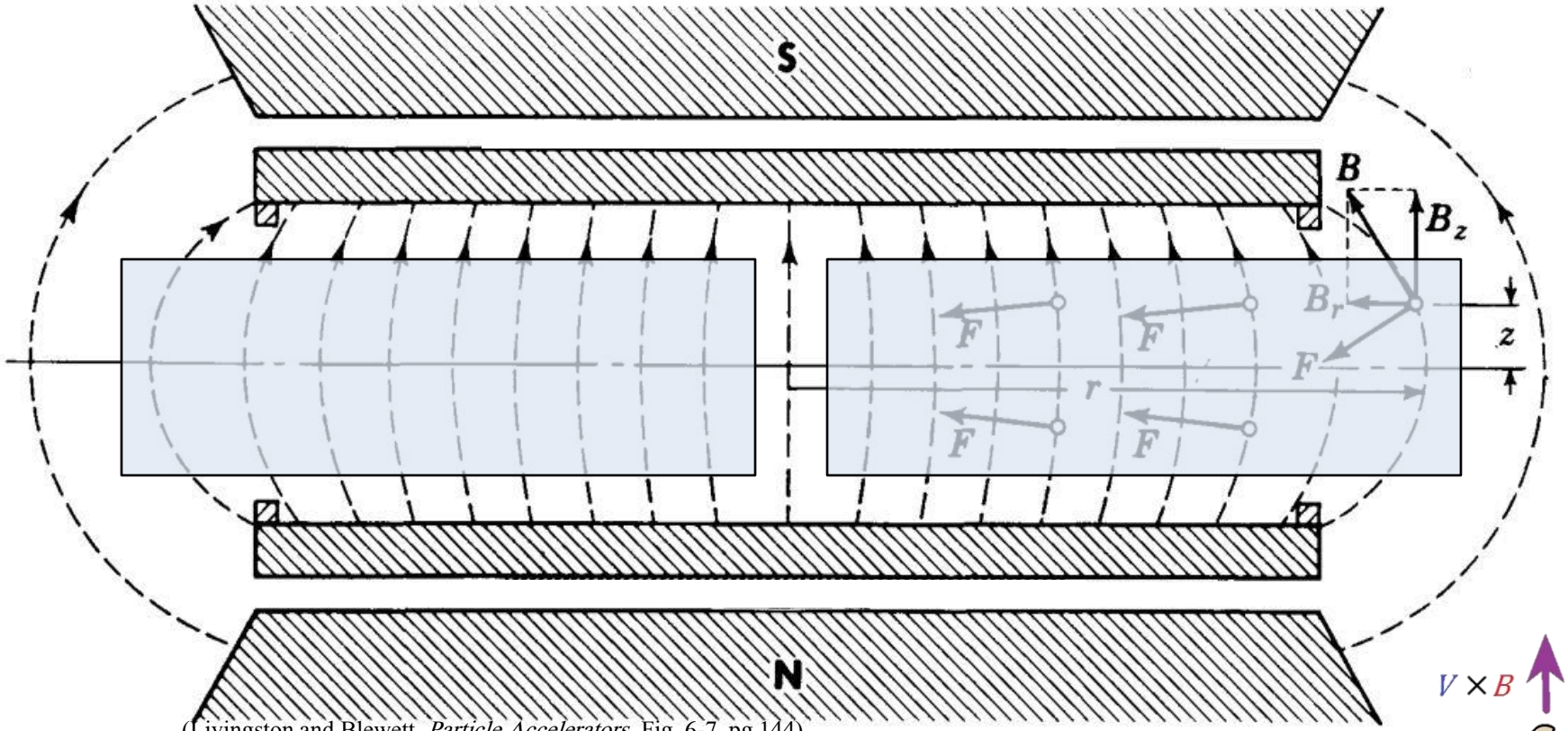




$T \alpha r^2$

$$T\alpha\left[\left(\frac{3r}{4}\right)^2 \approx 0.56r^2\right]$$

Maximum radius: 78mm

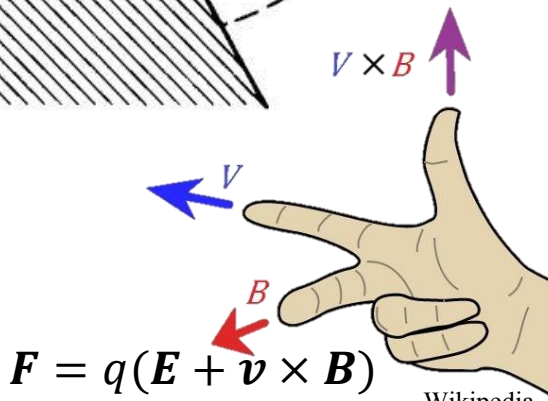


(Livingston and Blewett, *Particle Accelerators*, Fig. 6-7, pg 144).

Linearly decrease B_z by 2% from the middle to the outer edge.

Field index: $n = -\frac{r}{B_z}\frac{dB_z}{dr}$

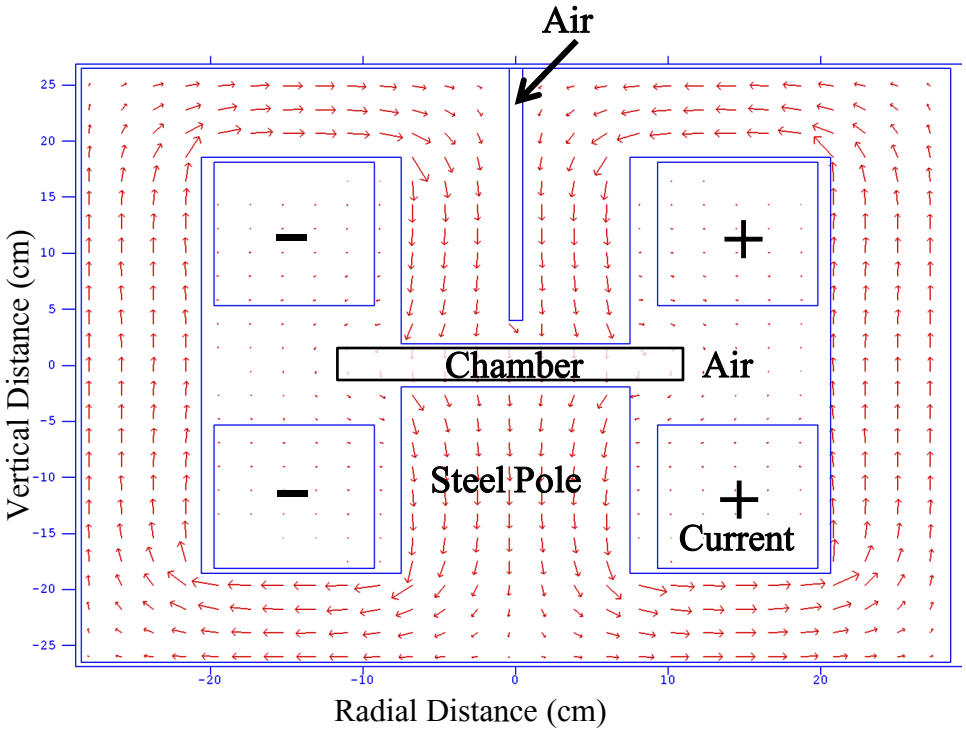
Resonant frequency: $f = \frac{qB_z}{2\pi m}$

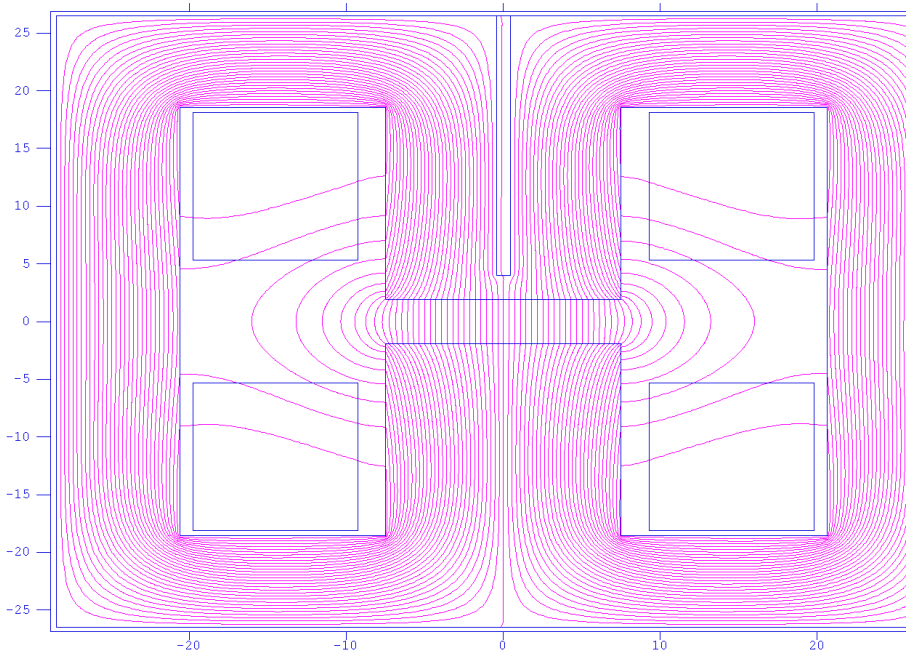


$\boldsymbol{F} = q(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})$

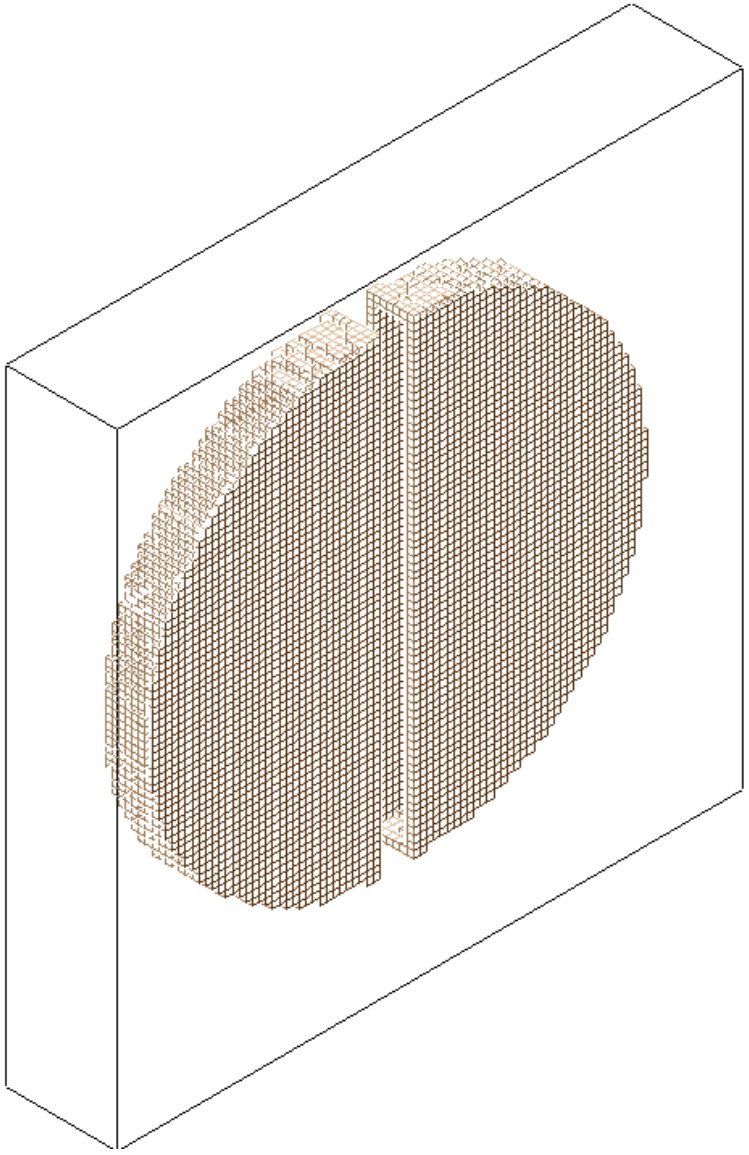
Wikipedia

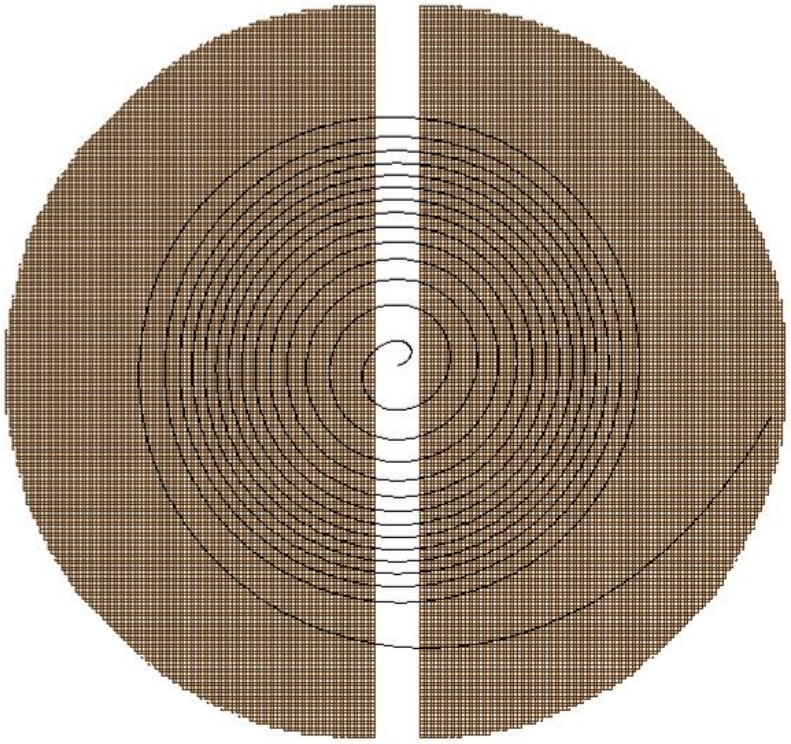
Poisson Superfish

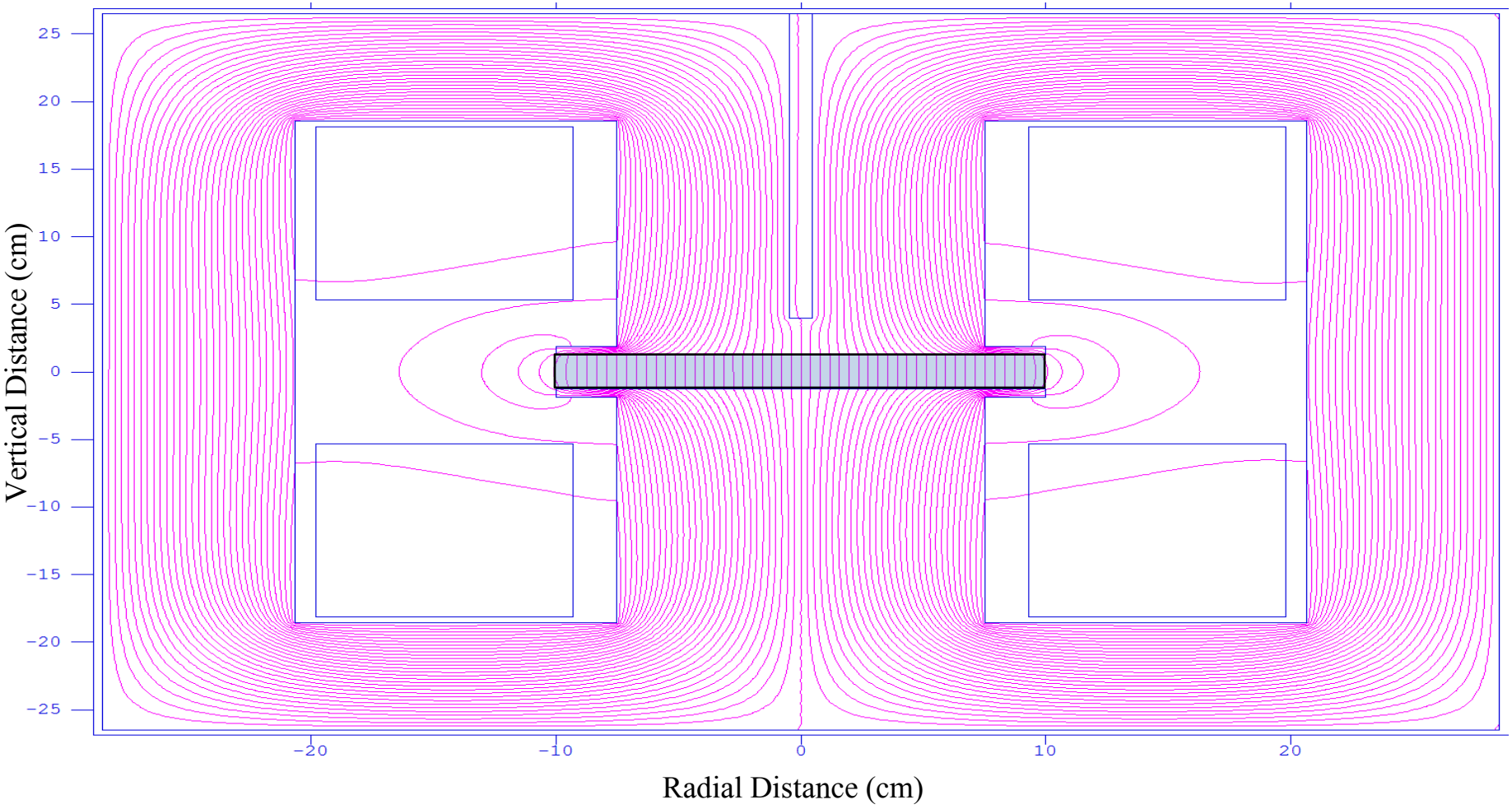


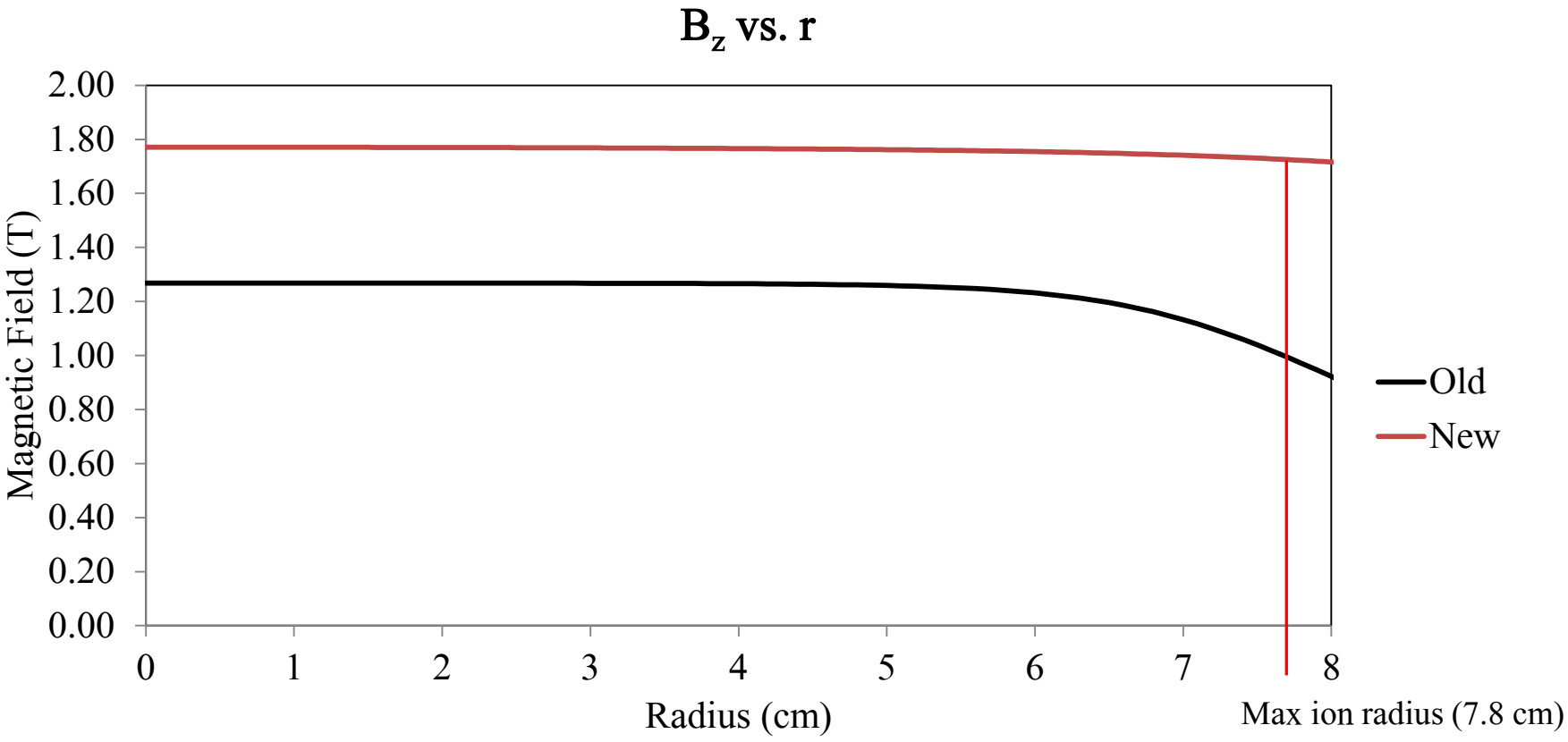


Simion

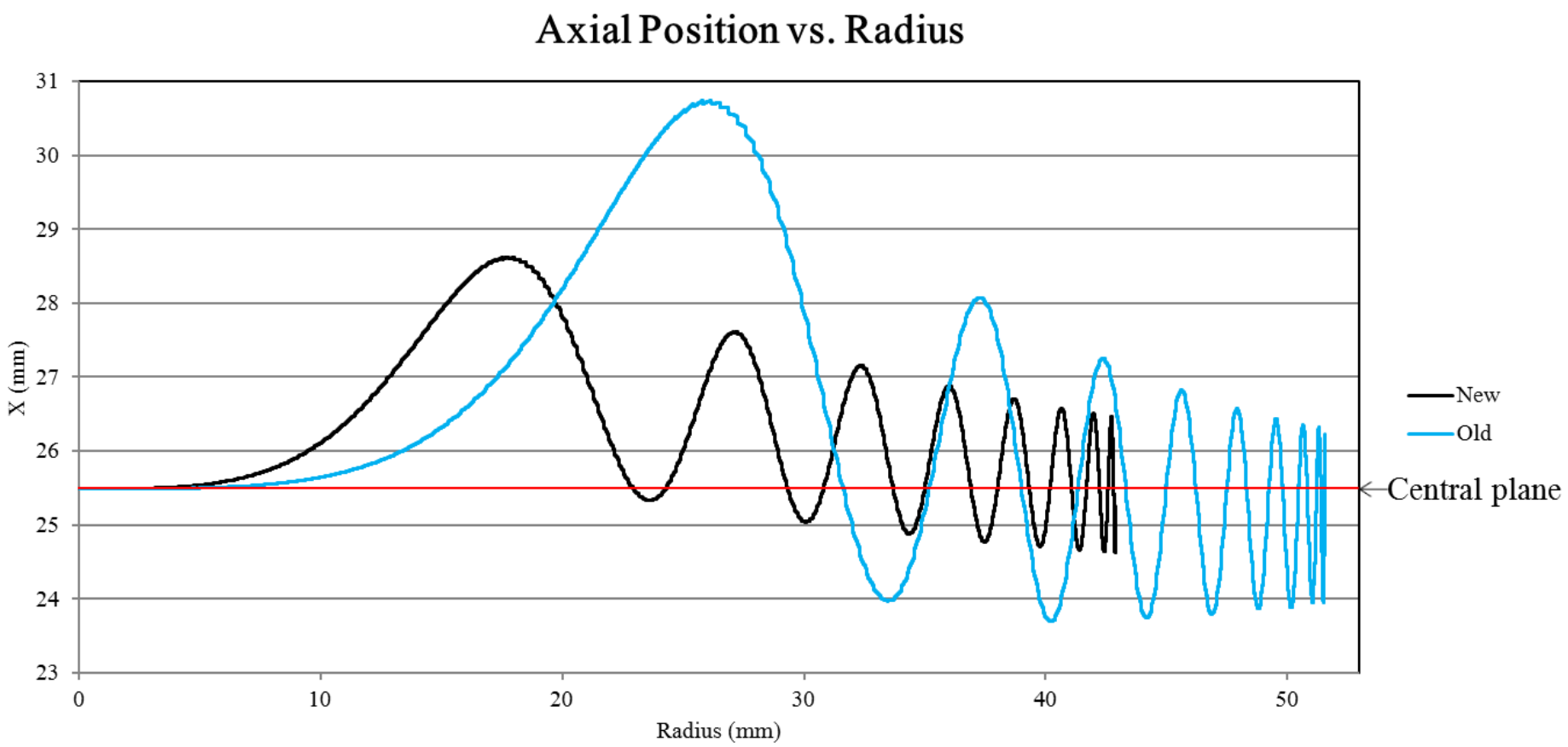


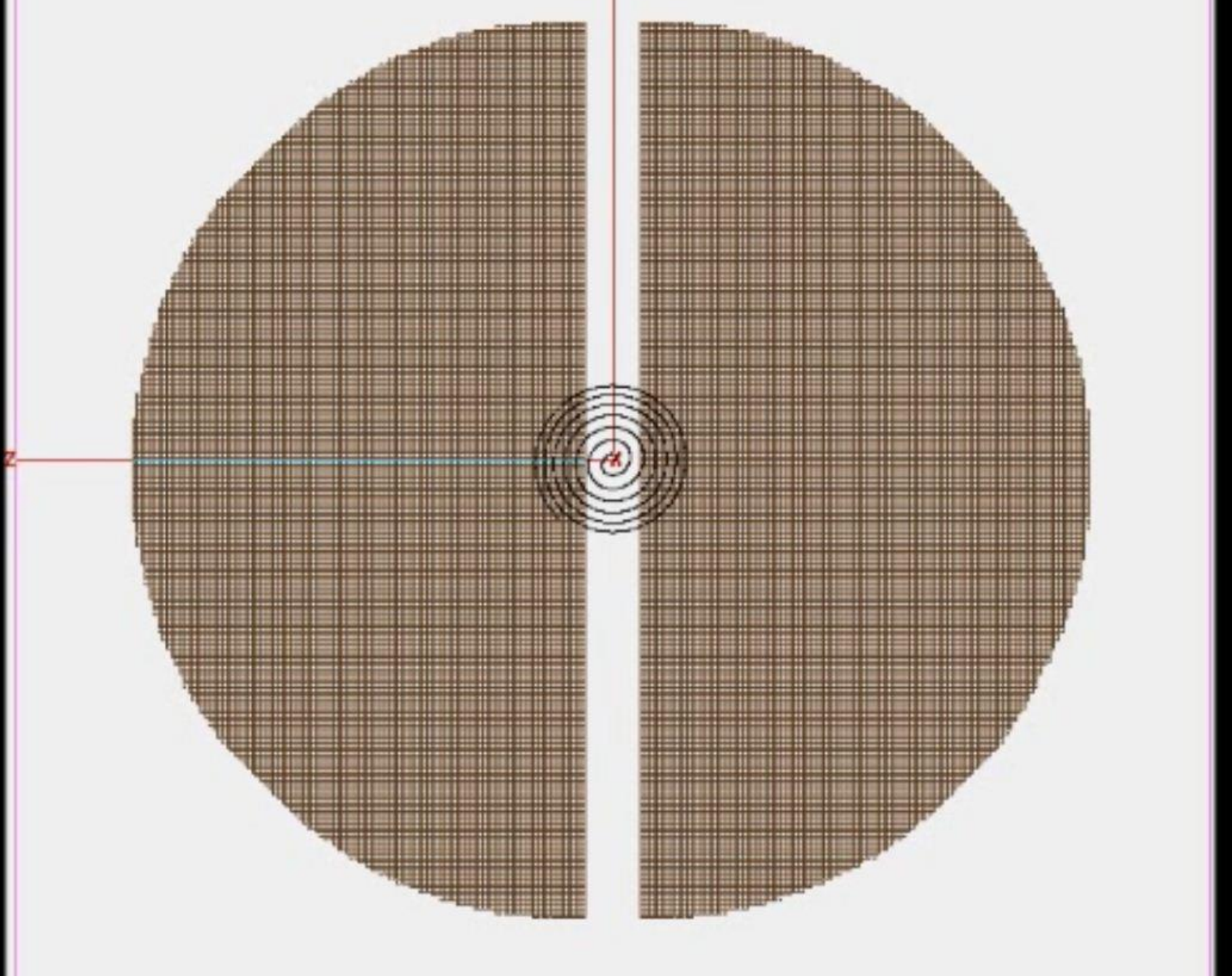


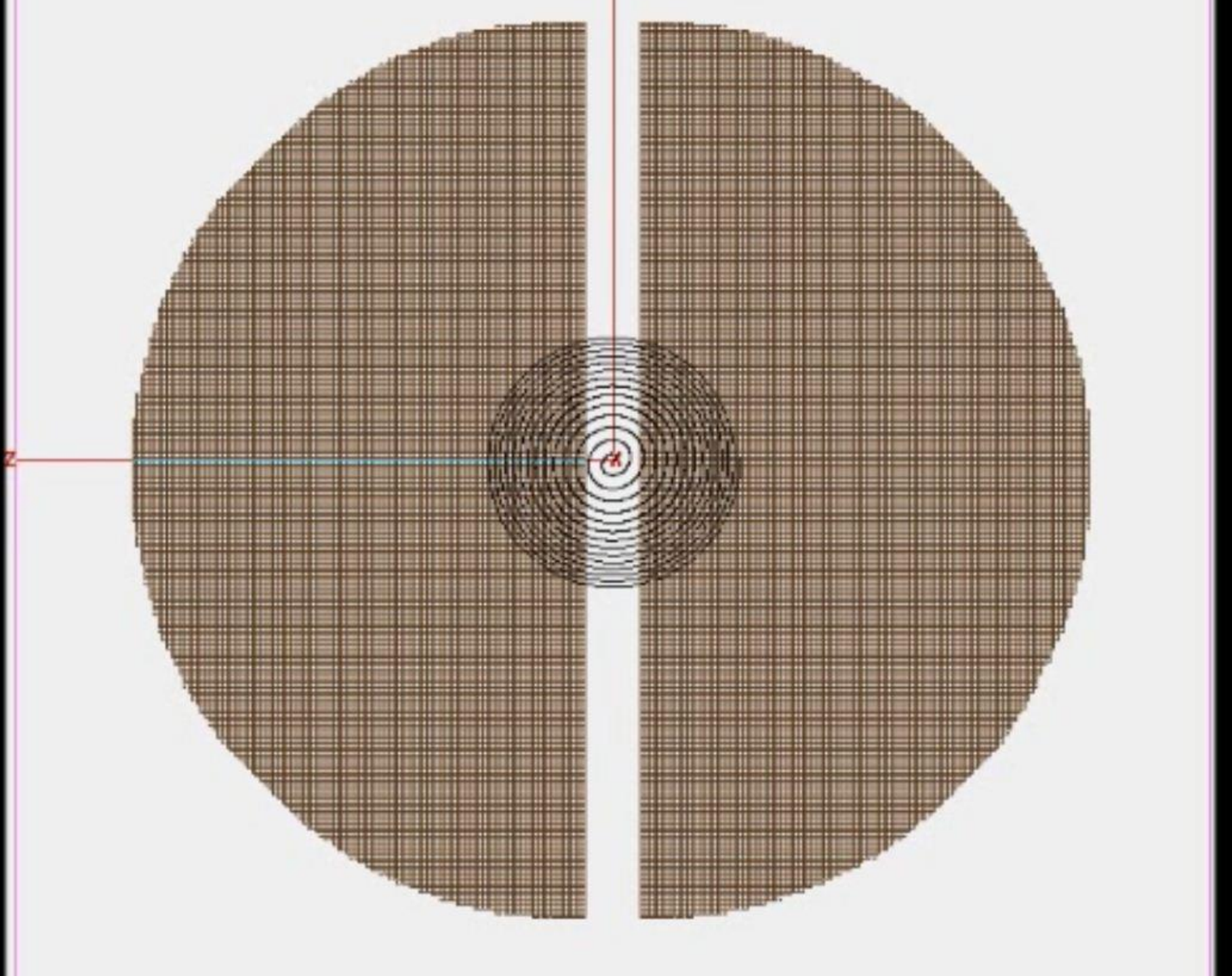

25
20
15
10
5
0
-5
-10
-15
-20
-25
-20
-10
0
10
20
Vertical Distance (cm)
Radial Distance (cm)

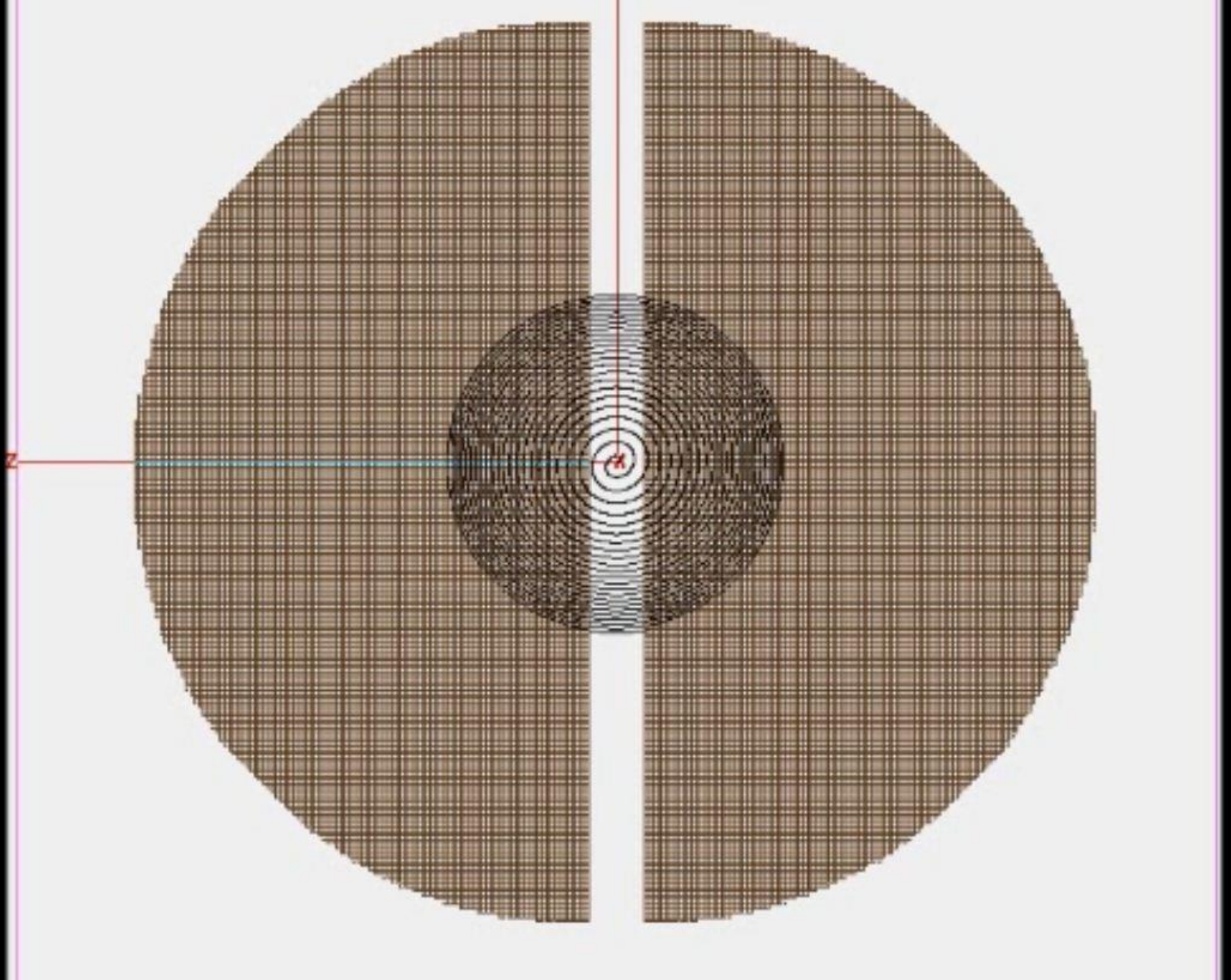


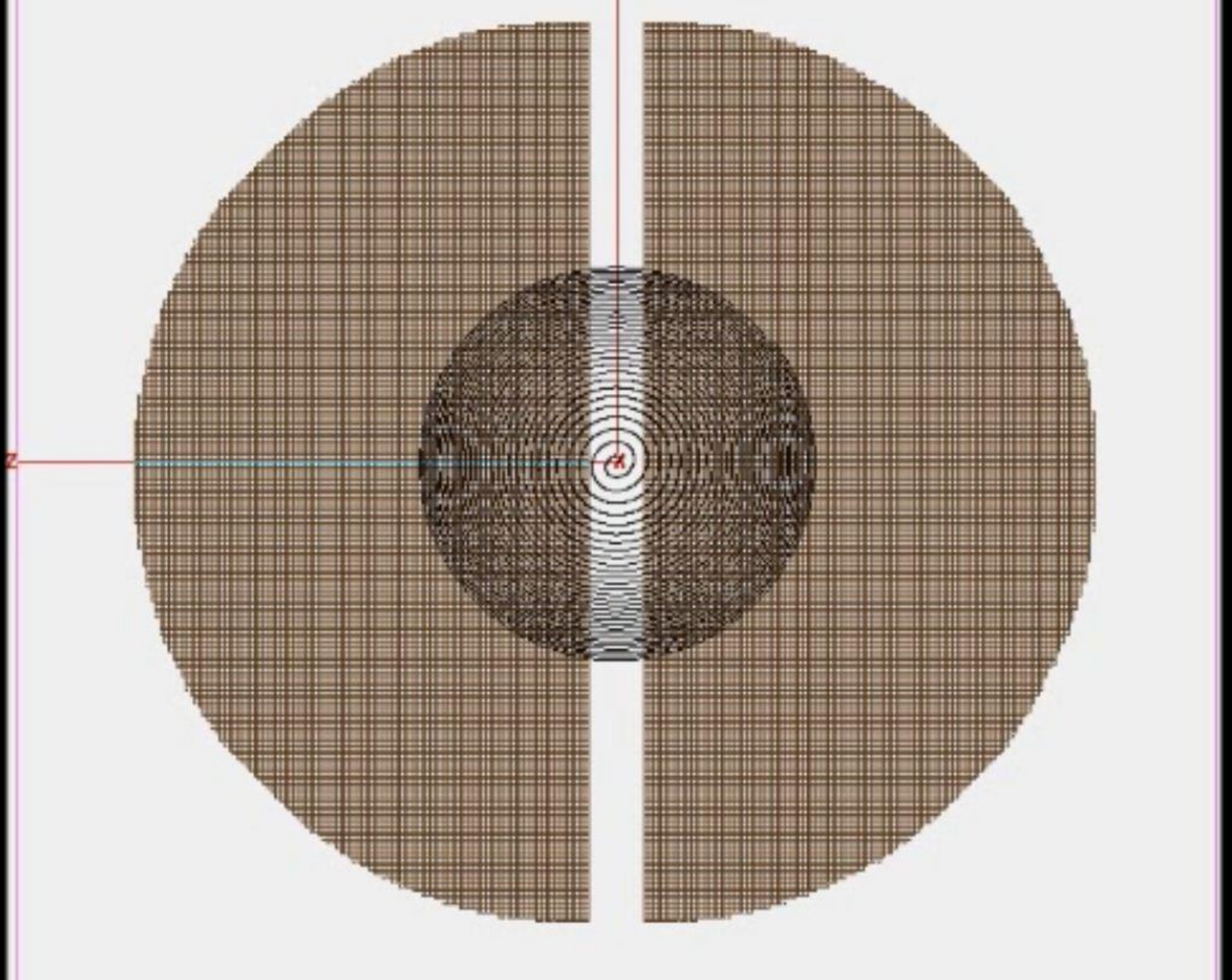
B changes by 2% at:	n=0.2 occurs at:	T at max ion radius:
Old: 5.8 cm	Old: 6.3 cm	Old: T=0.47 MeV
New: 7.3 cm	New: 8.3 cm	New: T=0.92 MeV

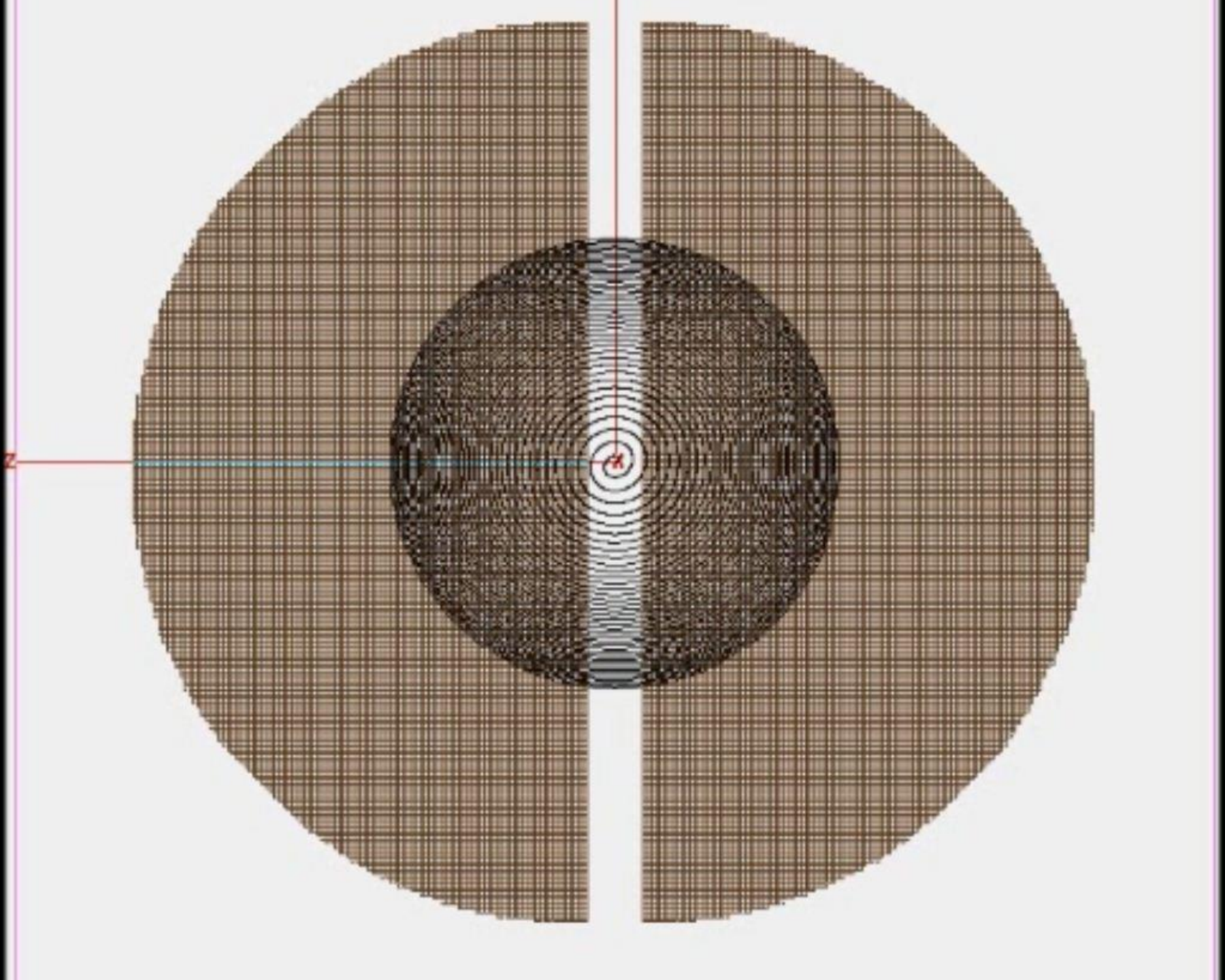

Axial Position vs. Radius
31
30
29
28
27
26
25
24
23
X (mm)
0
10
20
30
40
50
Radius (mm)
New
Old
Central plane

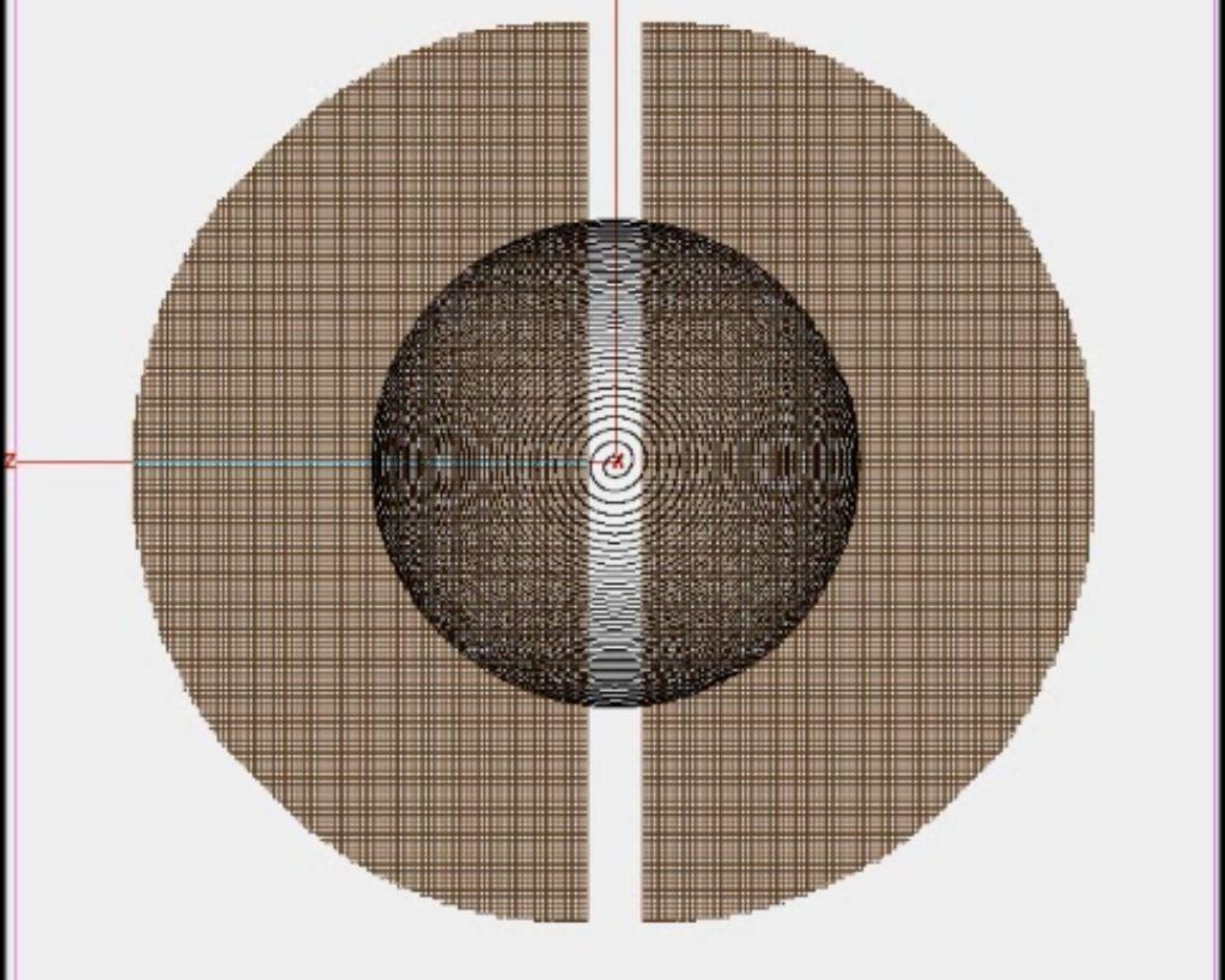

z

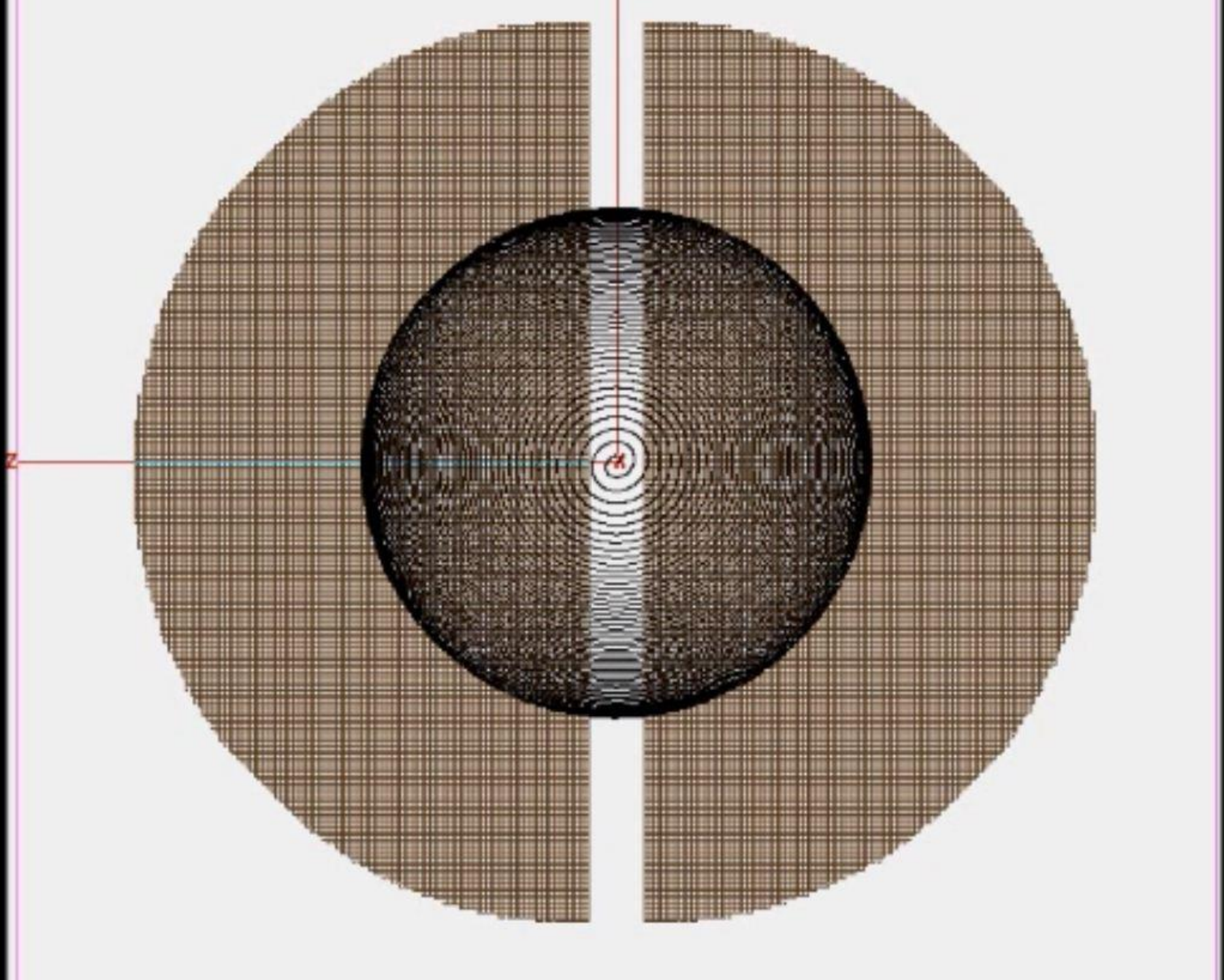

z

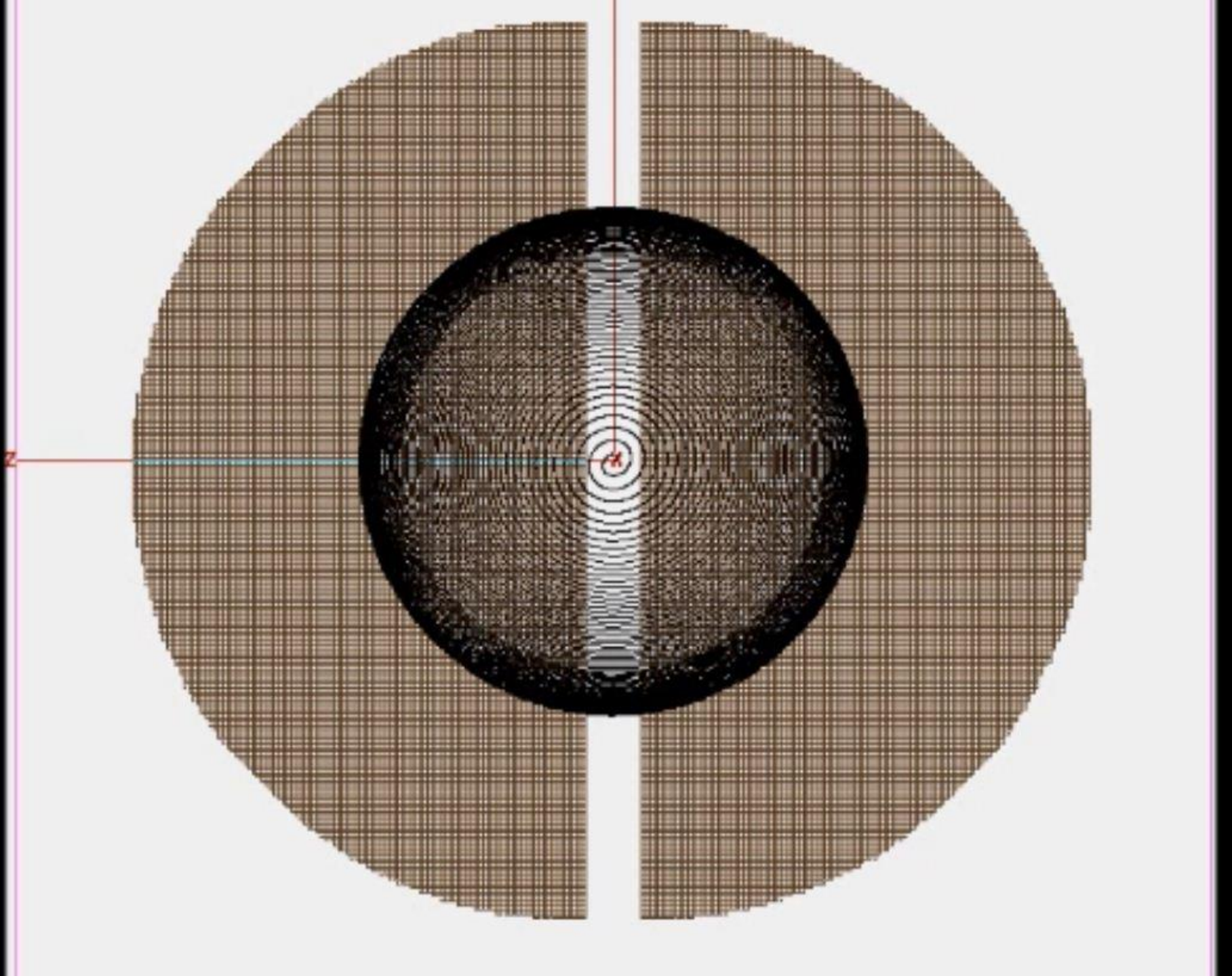

z

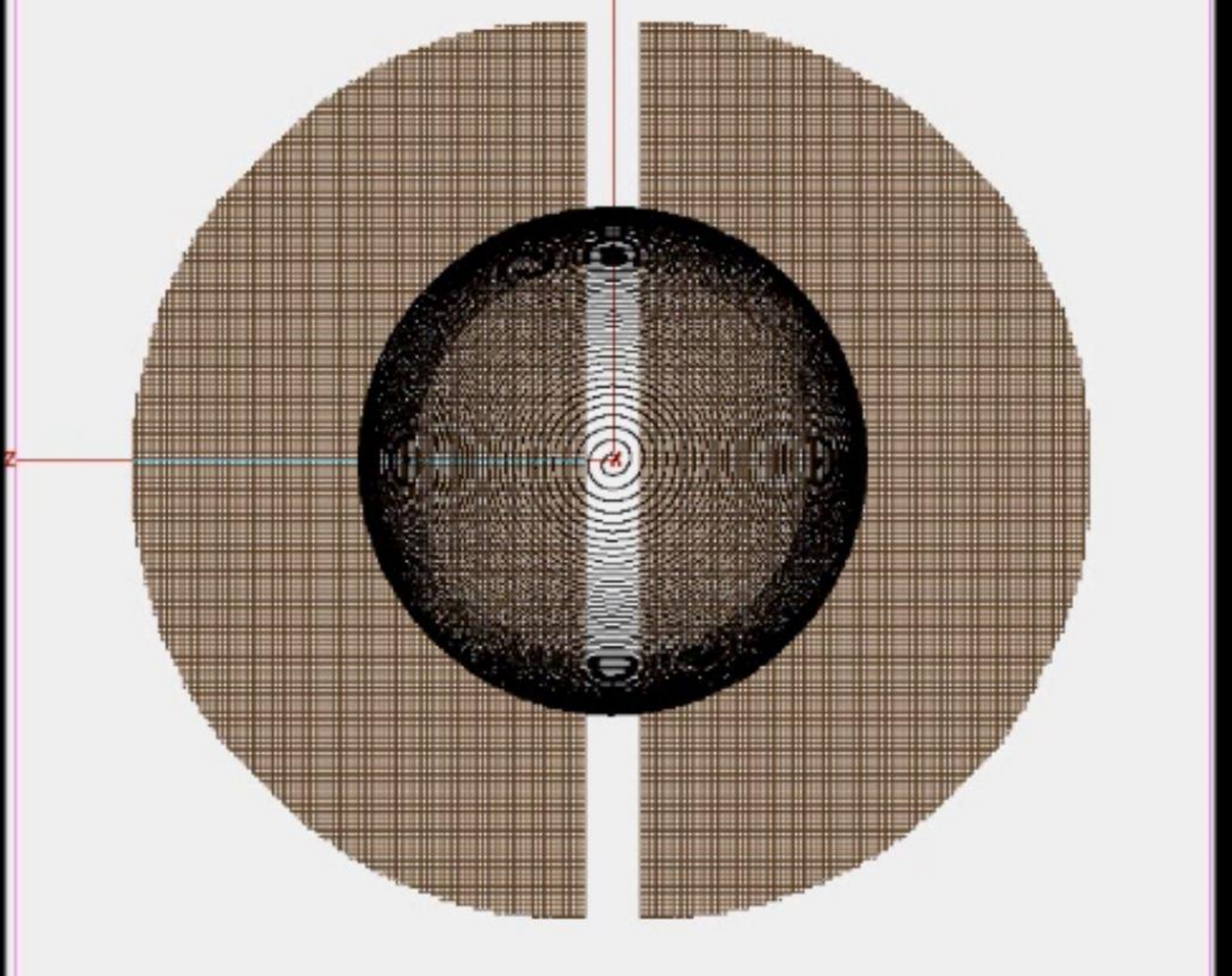

Z

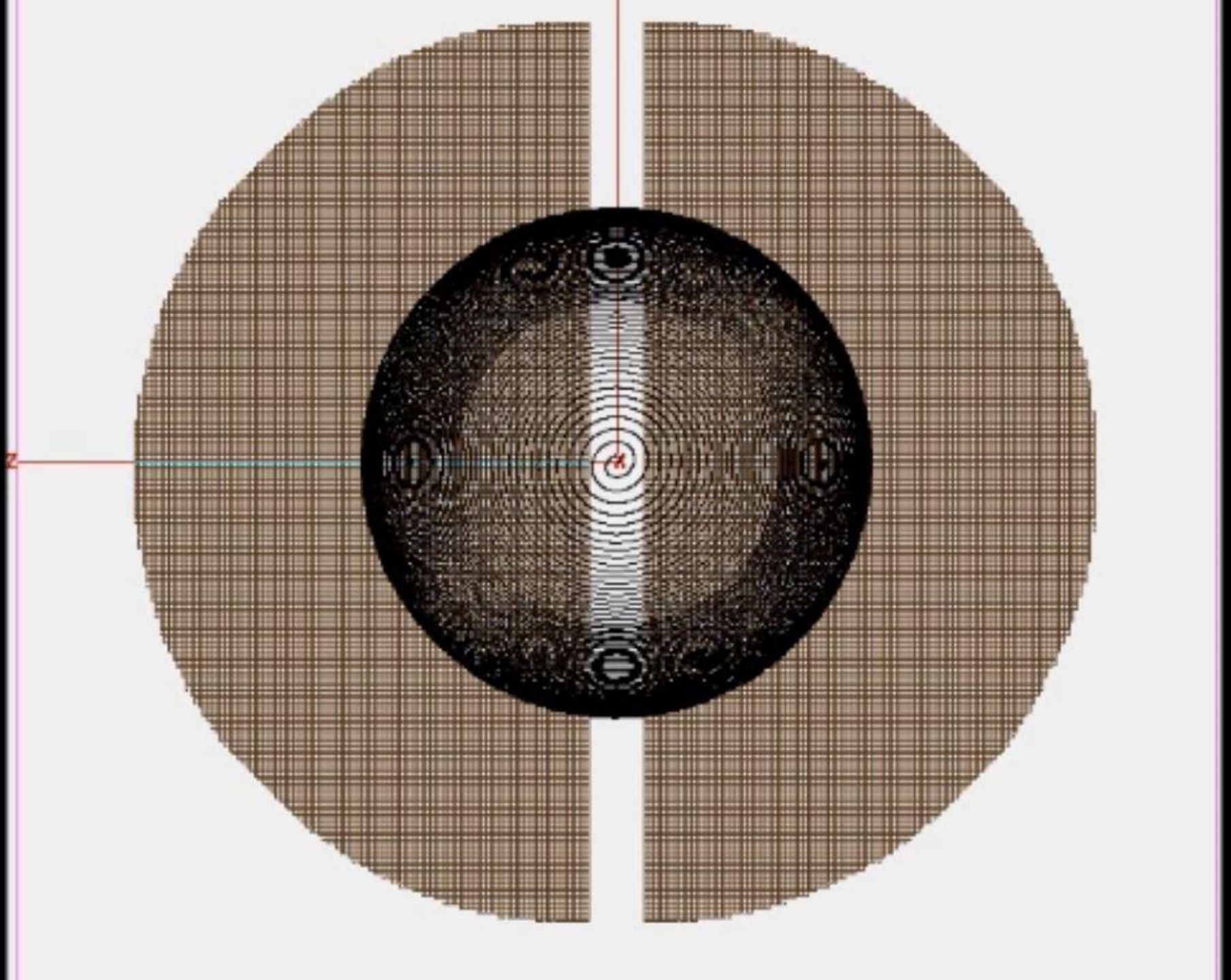

Z

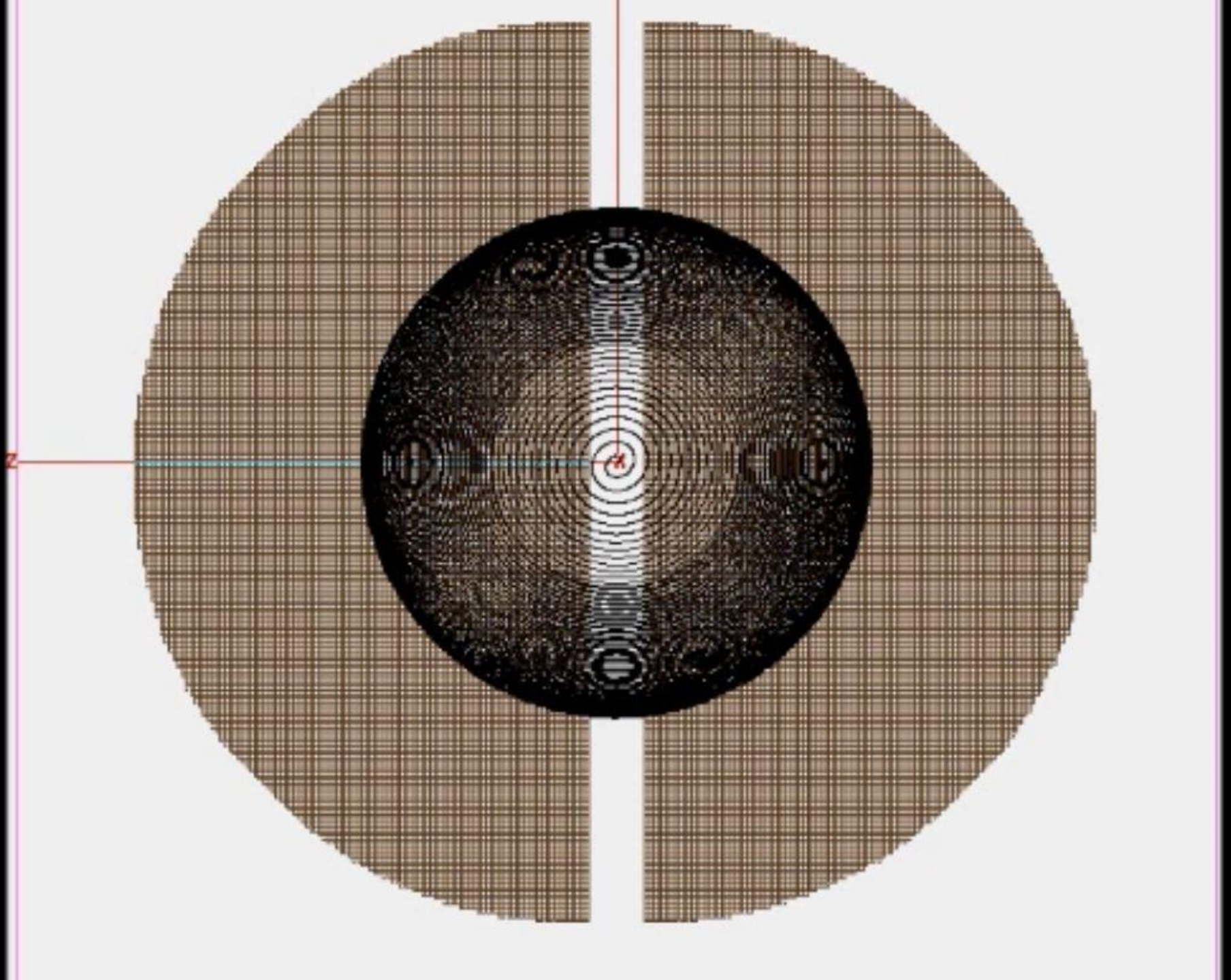

Z

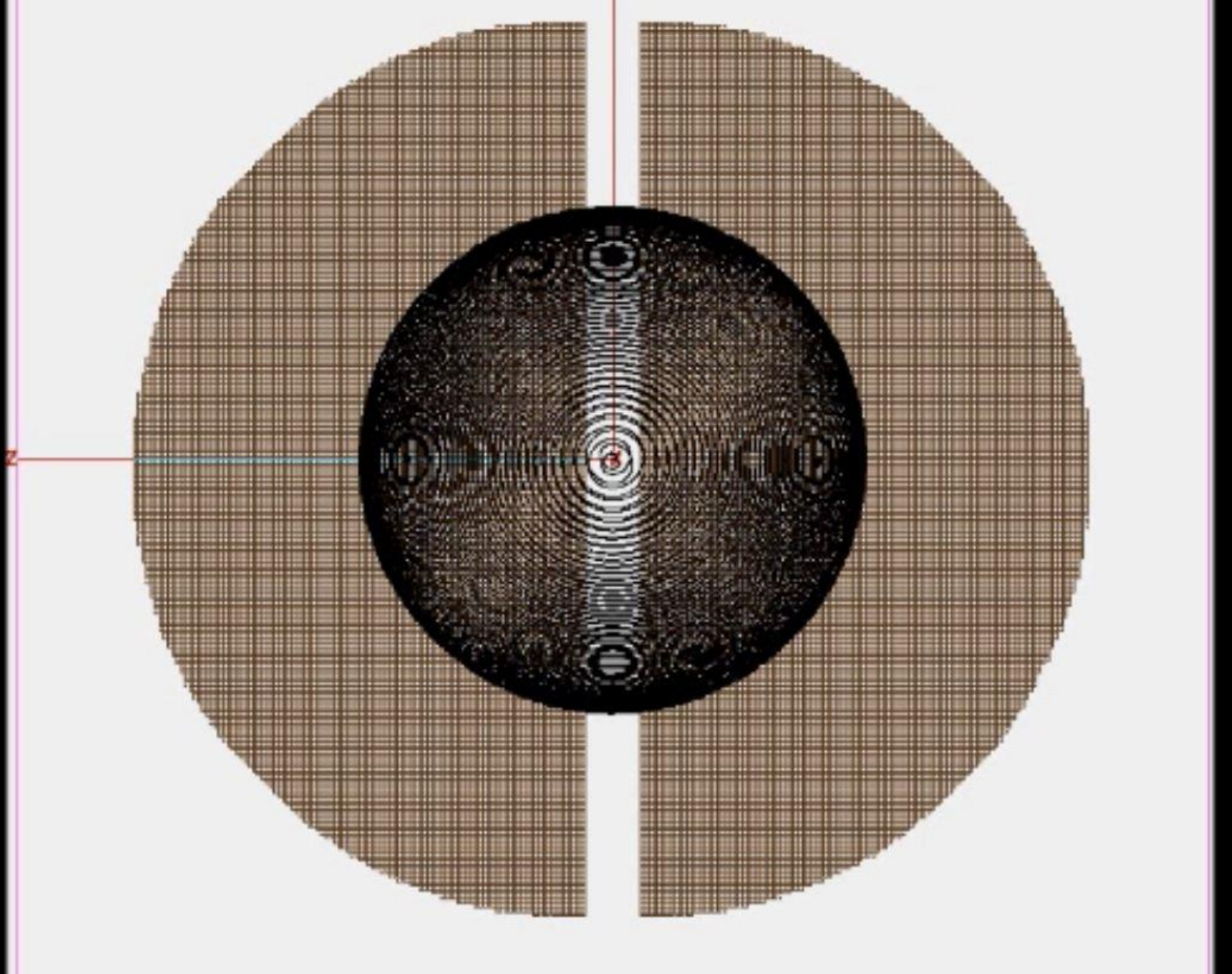


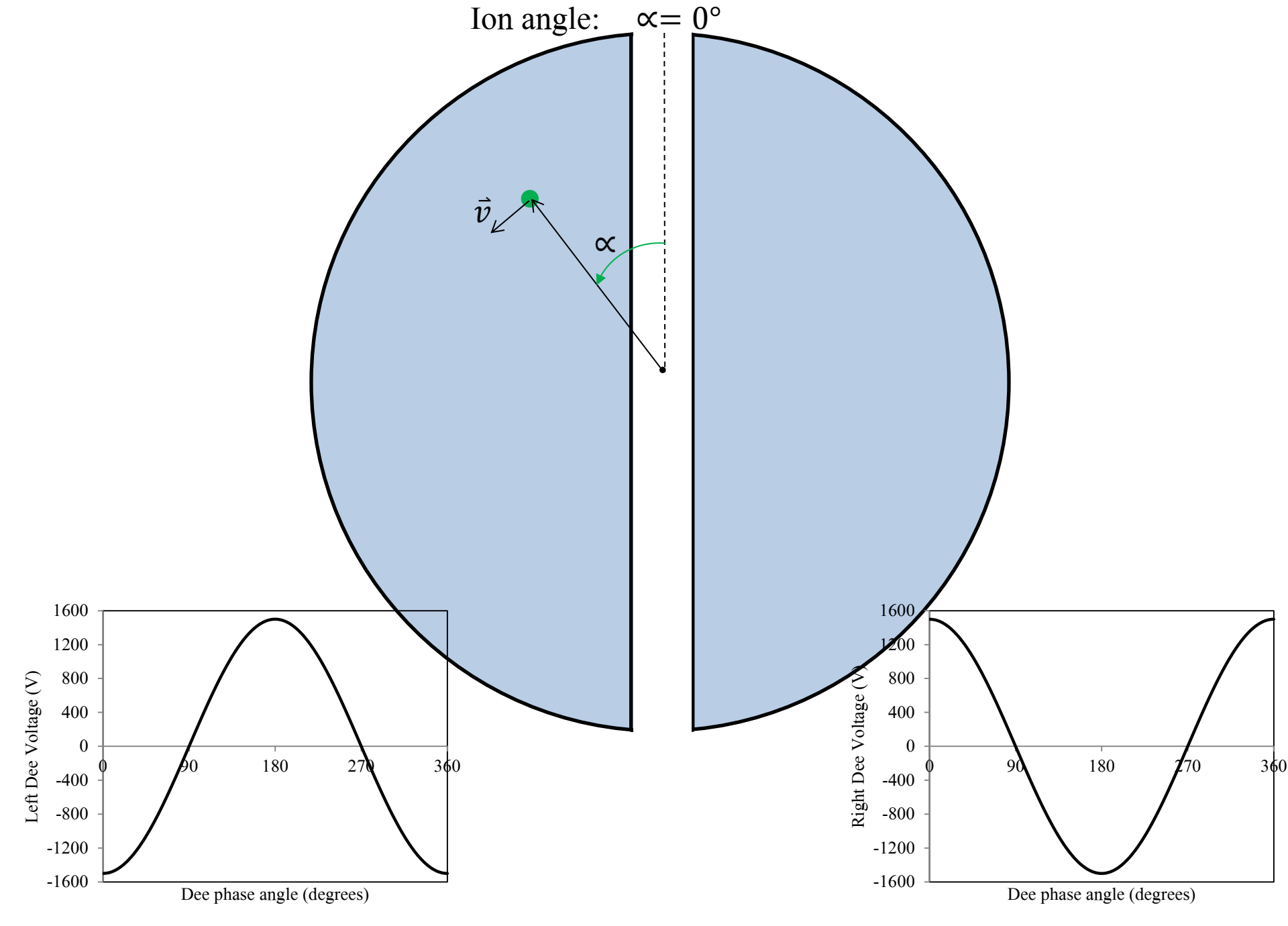

Z

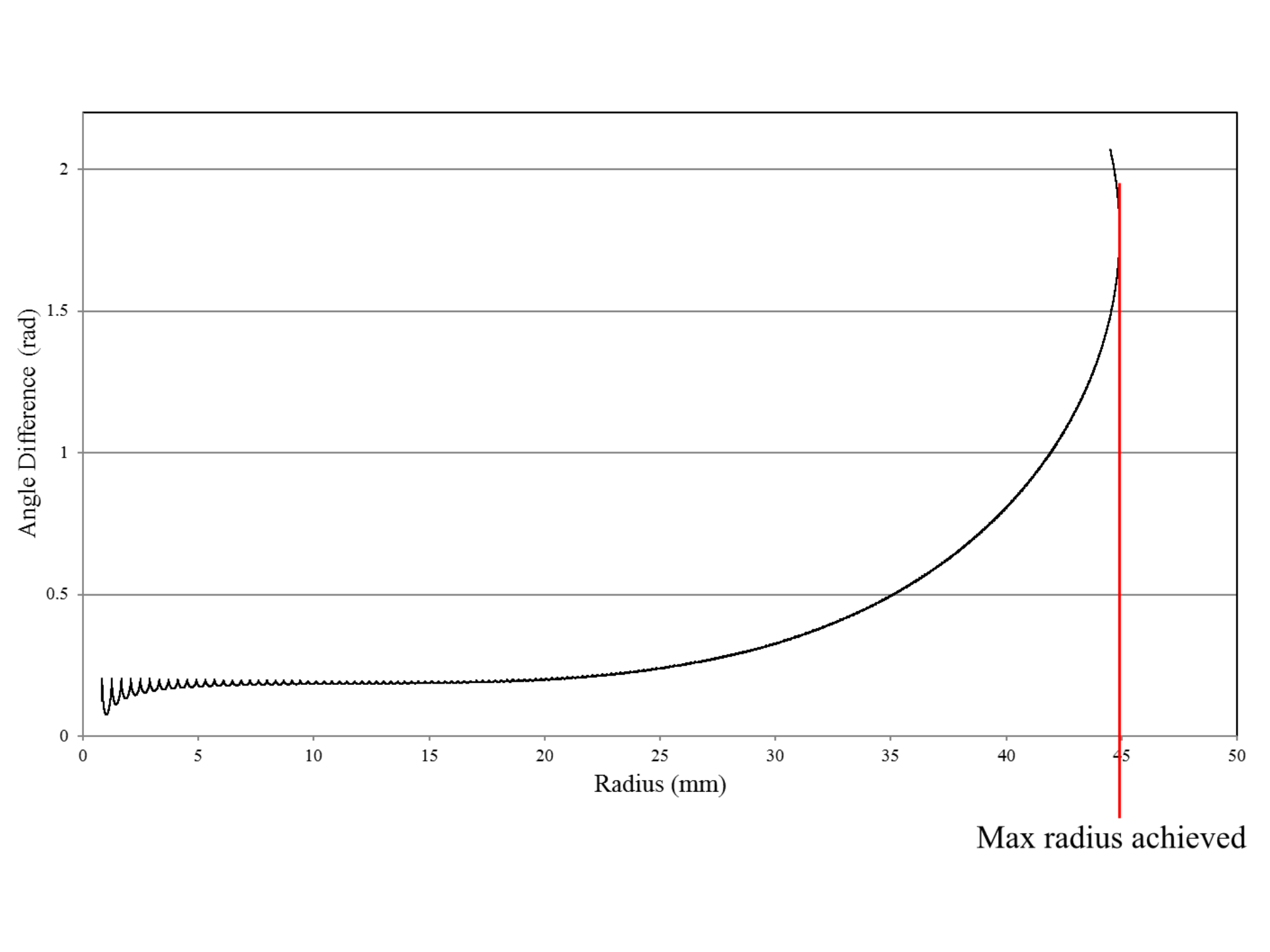



Z


Z



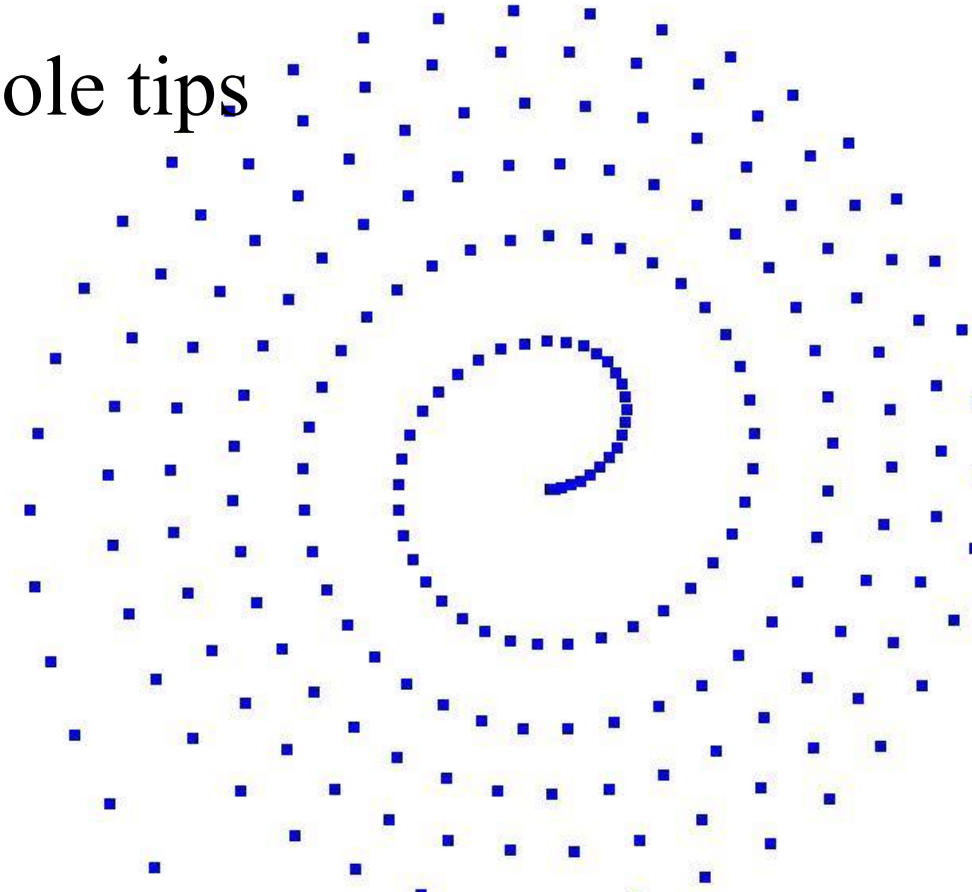

Ion angle: ∝= 0°
$\vec{v}$
∝
1600
1200
800
400
0
-400
-800
-1200
-1600
0
90
180
270
360
Left Dee Voltage (V)
Dee phase angle (degrees)
Right Dee Voltage (V)
Dee phase angle (degrees)


Angle Difference (rad)
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
45
50
Radius (mm)
Max radius achieved

Easiest solution: increased Dee voltage.

Future steps:

- Optimize parameters
- Strong focusing/sector pole tips



Questions?