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King Faisal Specialist Hospital & Research Centre
Gen. Org.

Design and Simulation of Cyclotron Magnet using COMSOL Environment®

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Outline

-Introduction

-Purpose of this work

-Multiphysics Model

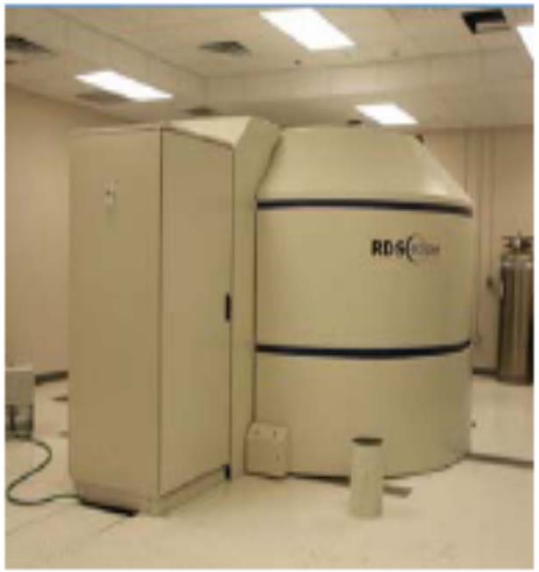
-Results and Discussion

-Conclusion

Cyclotrons at KFSHRC

Beam Energy, Fixed*	External Beam Current	Internal Beam Current
Protons - 26 MeV	60 μA	200 μA
Deuterons - 15 MeV	100 μA	300 μA
Helium-3++- 38 MeV	60 μA	135 μA
Helium-4++- 30 MeV	40 μA	90 μA

*With a tolerance of ± .5 MeV



The RDS Eclipse
111, Siemens

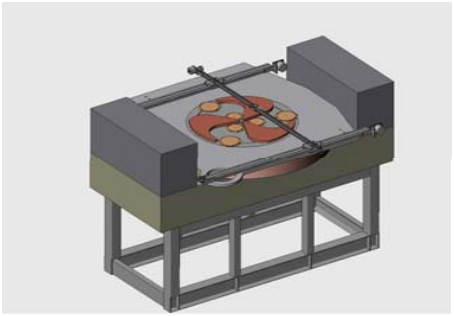
C-30
IBA

The CS-30

1- Harmonic coils
2- magnetic sectors
3- Cyclotron chamber
4- Magnet yoke

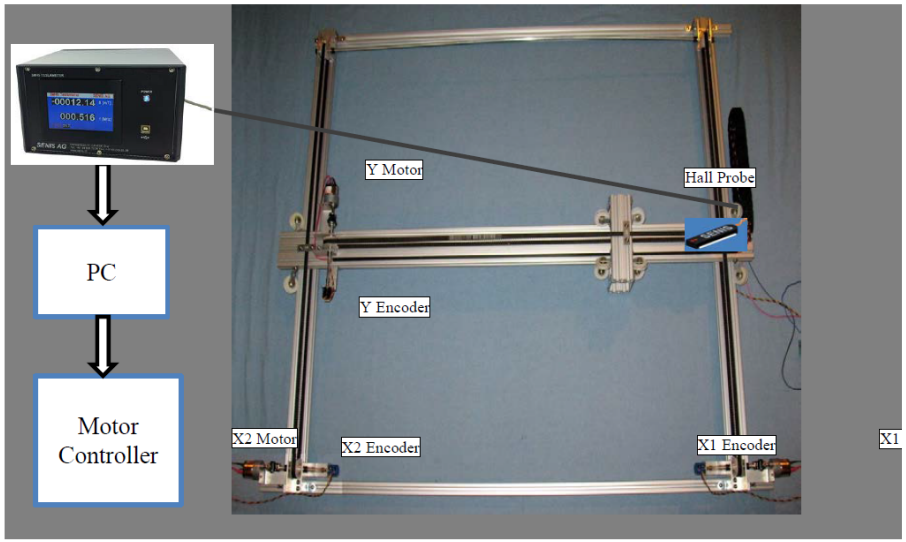
Empirical tests

- 3MH5 digital Teslameter: high performance magnetic field measuring instrumen.t.



3D model of the CS30 “Sledworks”

- Hall probe is mounted on a high precision X – Y stage, which is driven by three stepping motors, two motors for X – axis and one motor for Y – axis .



3-A

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US

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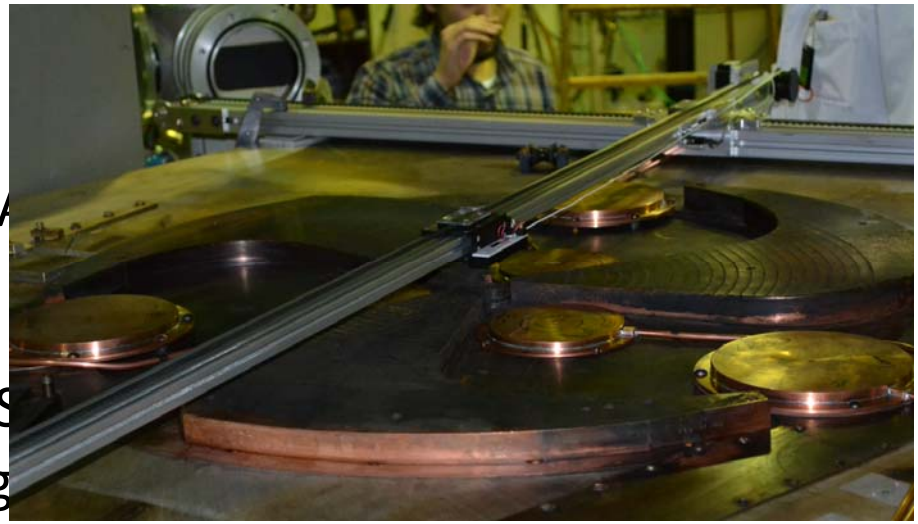
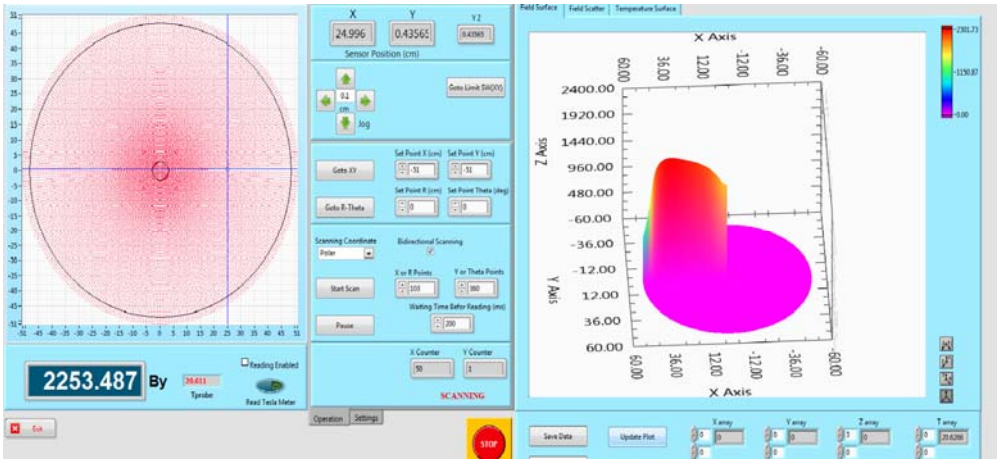
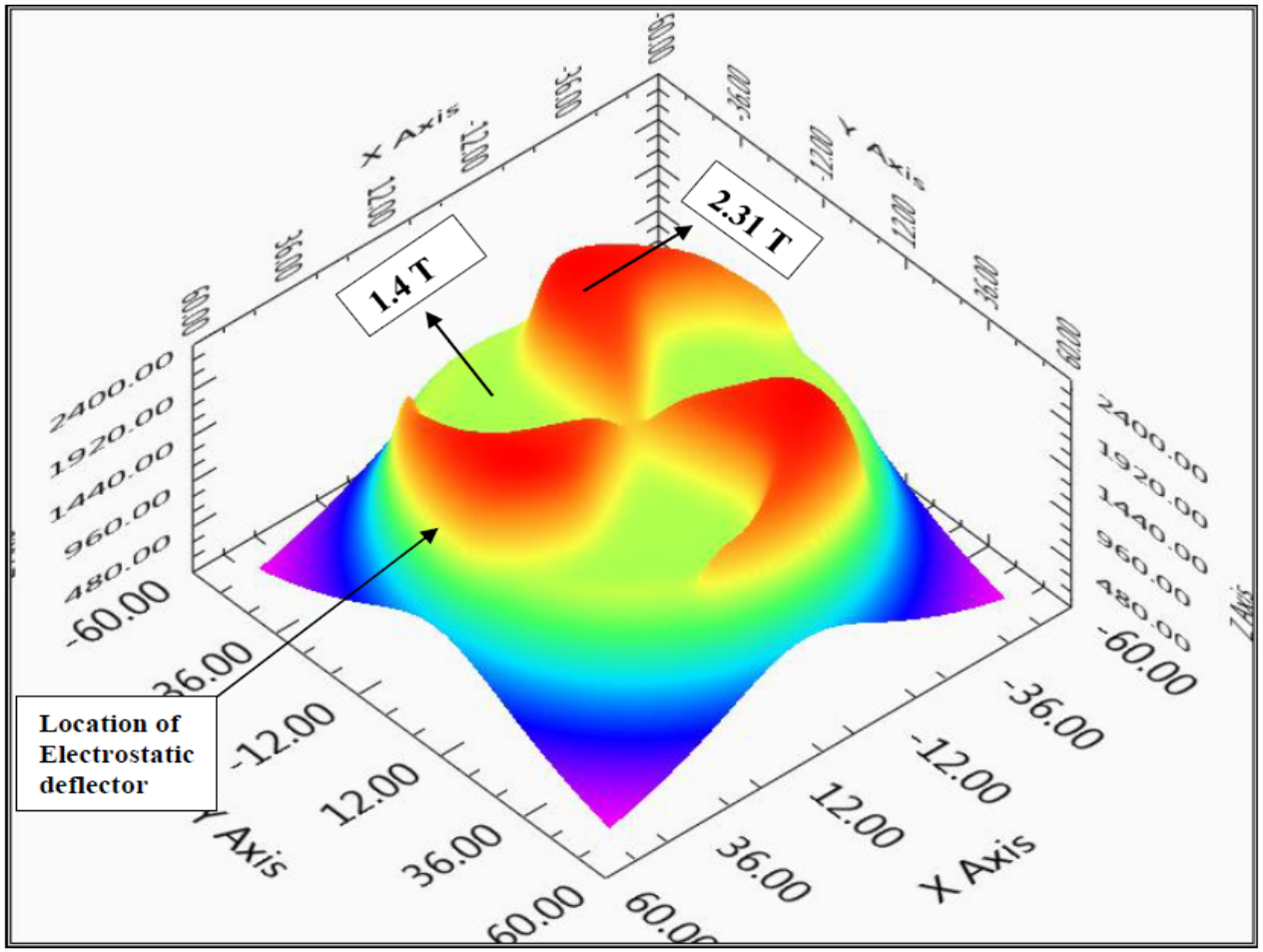


Our computer connected to TMCM – 3110 will control 3- stepper motors in X – Y direction through Lab View program. Figure (3).



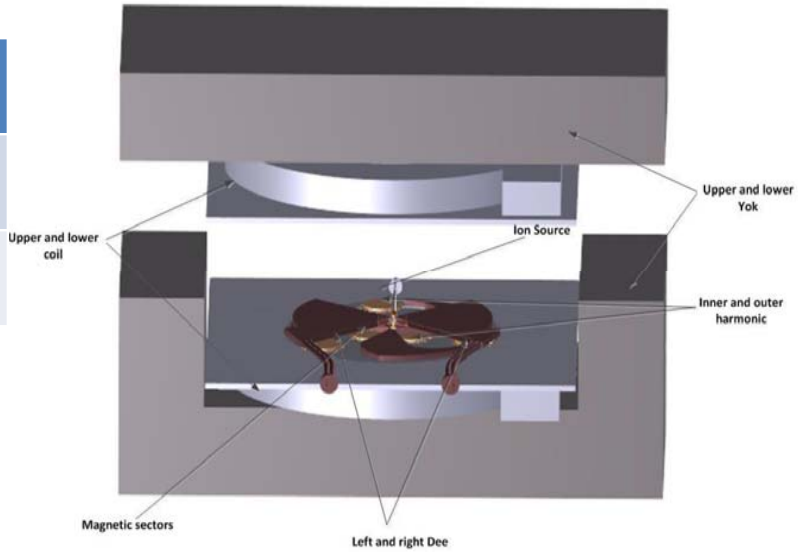
Magnetic mapping output

Maximum Field was 2.3 T
Minimum Field was 1.4 T



CS30 model

	copper	Cyclotron coil
	steel	Magnet sector



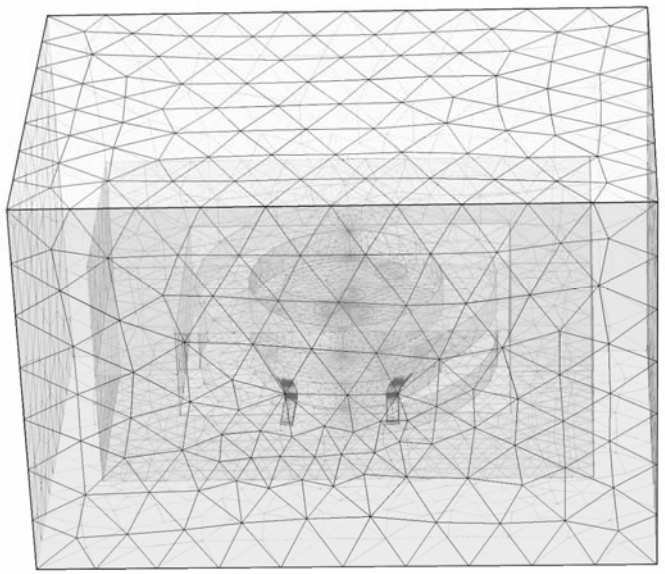
3D model drawn by Solidworks

Property	Name	Value	Unit	Property group
Relative permeability	mur	1	1	Basic
Relative permittivity	epsilonr	1	1	Basic
Dynamic viscosity	mu	eta(T[1/K])...	Pa·s	Basic
Ratio of specific heats	gamma	1.4	1	Basic
Electrical conductivity	sigma	0[S/m]	S/m	Basic
Heat capacity at constant pressure	Cp	Cp(T[1/K])...	J/(kg·K)	Basic
Density	rho	rho(pA[1/...	kg/m^3	Basic
Thermal conductivity	k	k(T[1/K])[...	W/(m·K)	Basic
Speed of sound	c	cs(T[1/K])[...	m/s	Basic
Refractive index, real part	n	1	1	Refractive index
Refractive index, imaginary part	ki	0	1	Refractive index

Physics Interface

AC/DC

- Magnetic field (mf)
- Stationary study
- Coil Windings n=265
- Electrical current= 320A
- Material is steel= (1010)
- Mesh size = Normal



C/DC

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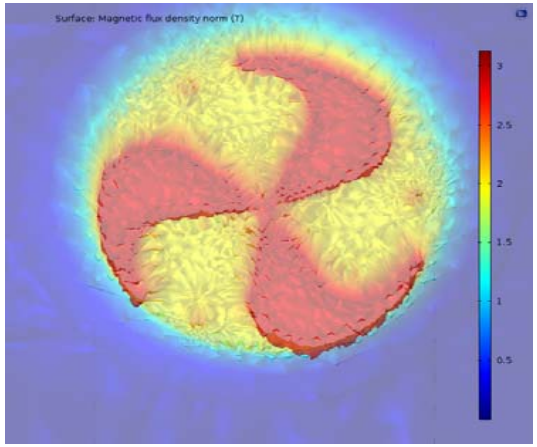
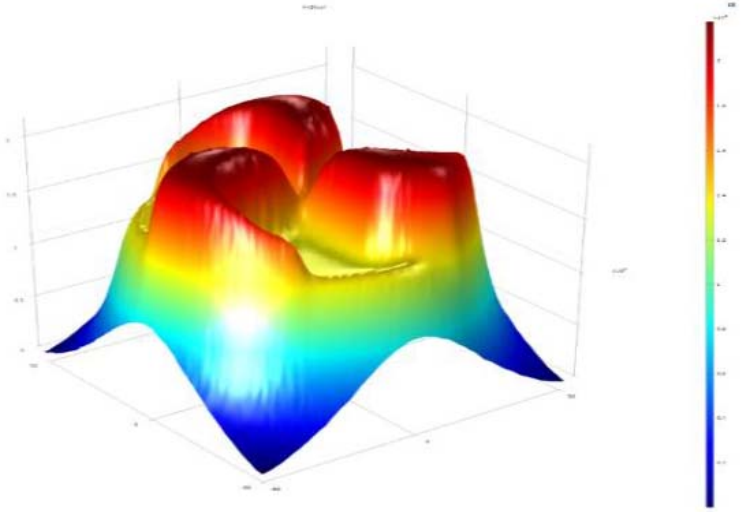
Our requirements:

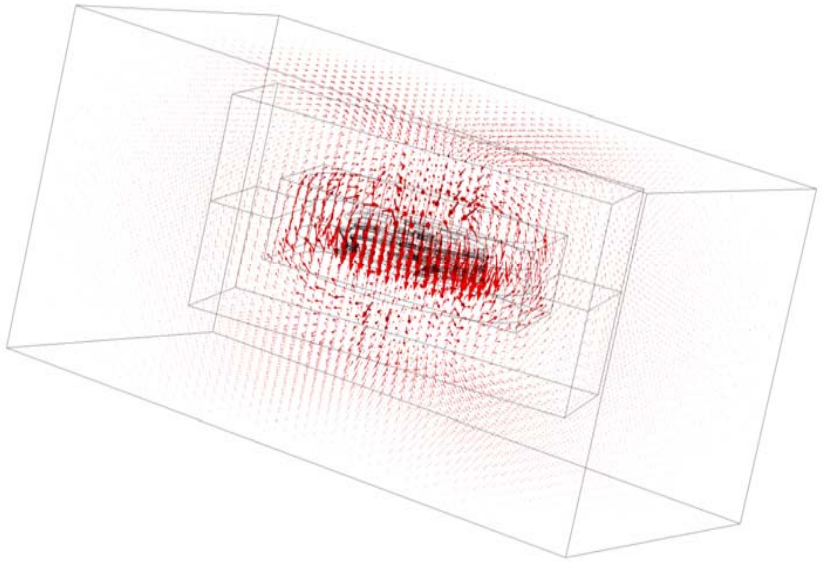
-Hill Field 2.2 T

-Valley Field 1.4 T

-Average Field 1.8 T

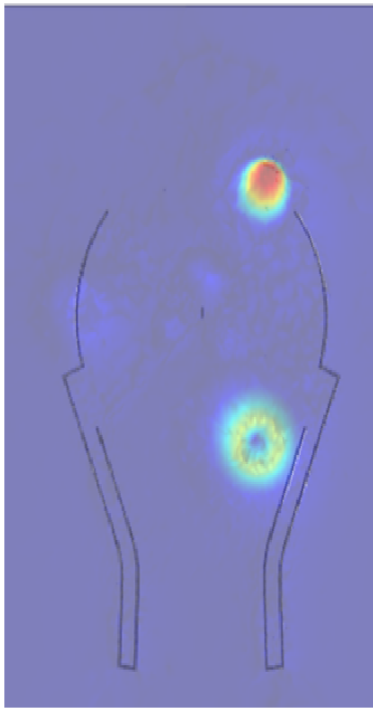


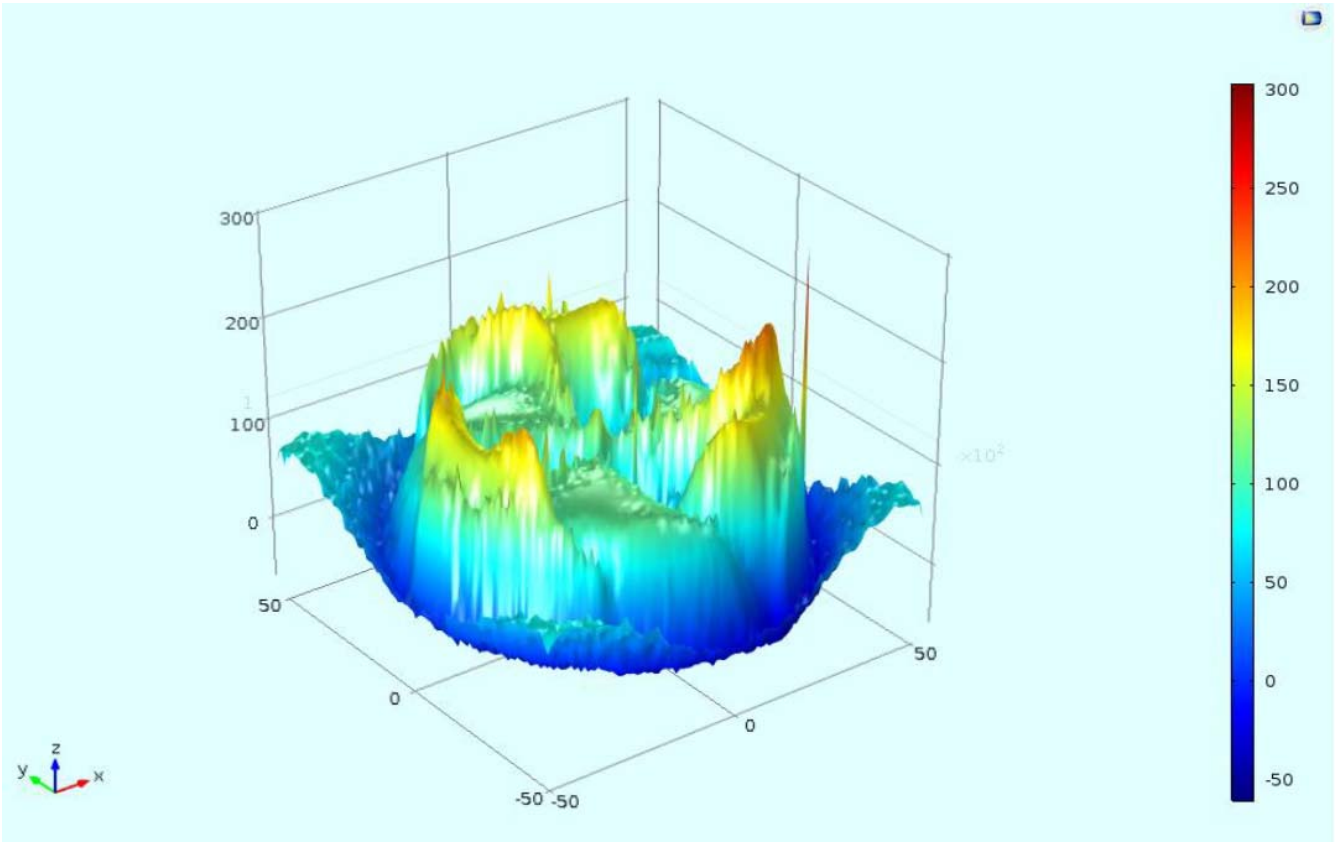




Difference

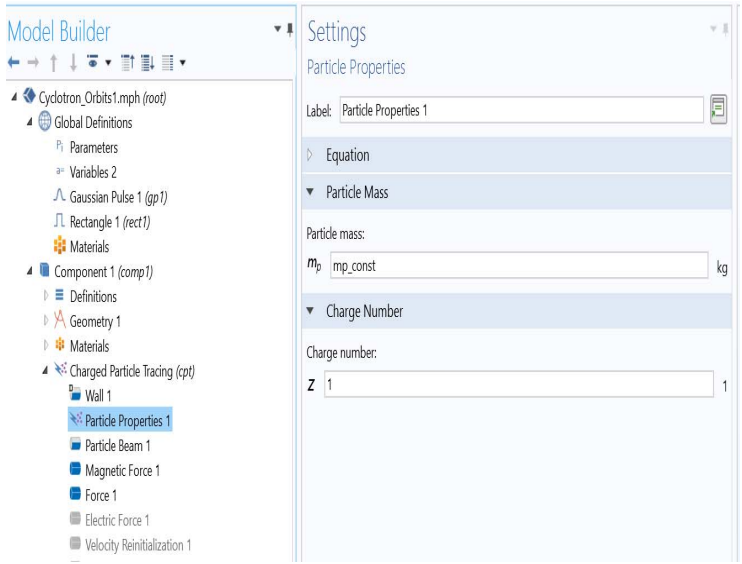
Results show that the difference between
actual and simulated values was less than 10%.

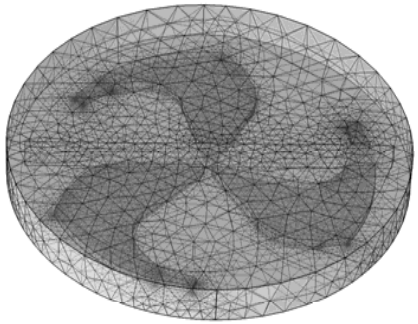




Physics Interface
Particle tracing module

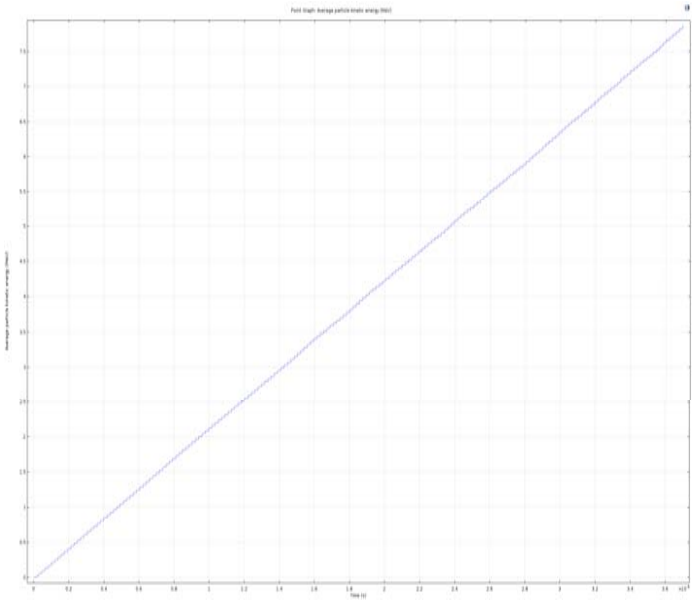
- Time dependent for particle tracing model
- One particle accelerated

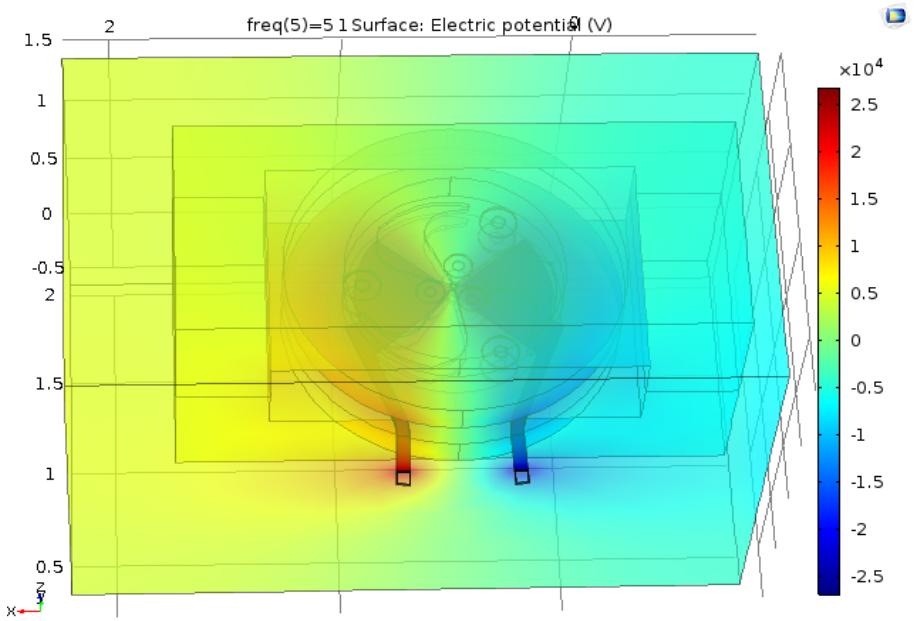




Physics Interface
Particle tracing module

- Cyclotron frequency supplies the particle with needed energy to gain energy from orbit To next.





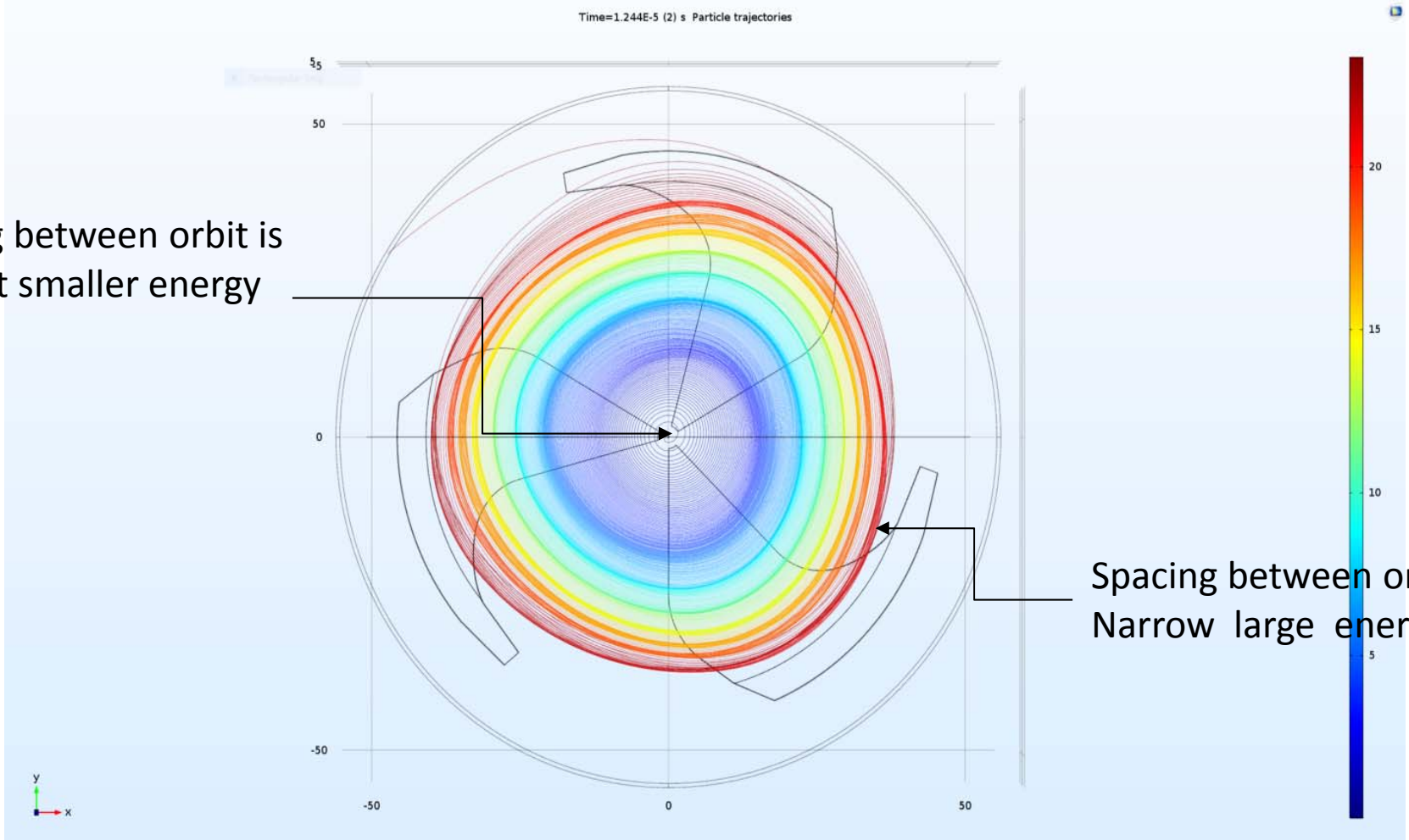
Frequency is 26.7 Mhz

Amplitude is 25 kV

Physics Interface
Particle tracing module

During accelerations, ions should be synchronized within a given phase of cyclotron frequency. This is achieved by slightly increasing the average field B (r) with radius (r).

Spacing between orbit is
Large at smaller energy



Spacing between orbits
Narrow large energy

conclusions

- Results show that the difference between actual and simulated values was less than 10%.

- Simulated particles encountered orbital overlapping before reach to the final extraction level

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Thank you