ZA1

FEBIAD Ion Source Optimization at The ALTO Facility

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Diapositiva 1

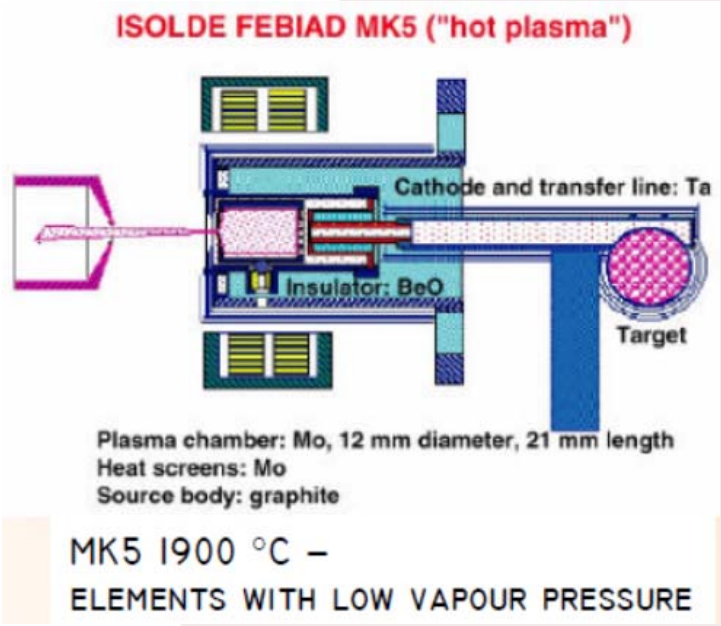
ZA1 Zhang Ailin; 21/06/2018

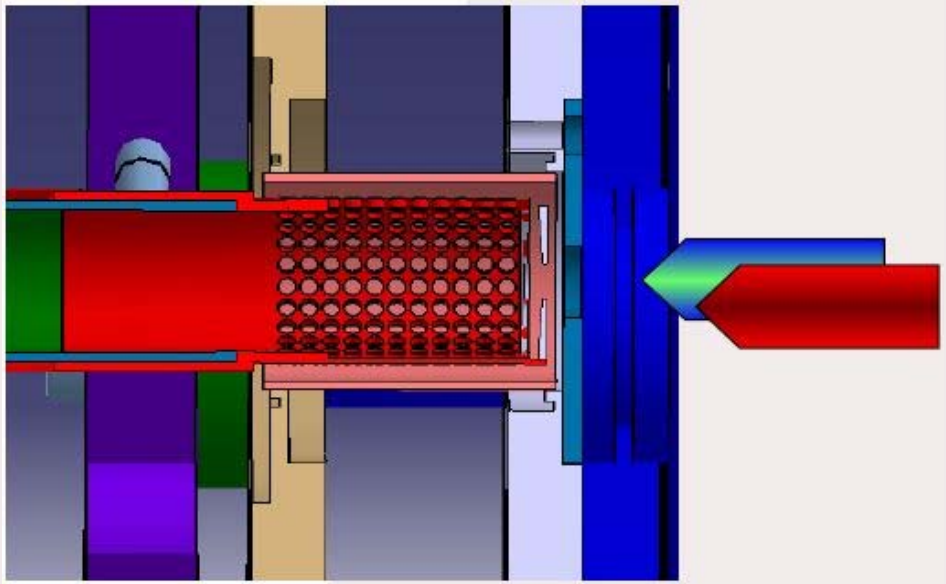
Content

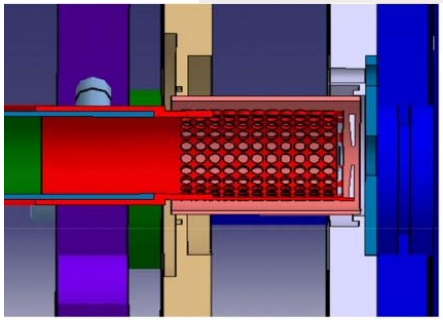
1. FEBIAD type ion sources at ALTO
2. Simulation for IRENA3
3. Simulation for extraction

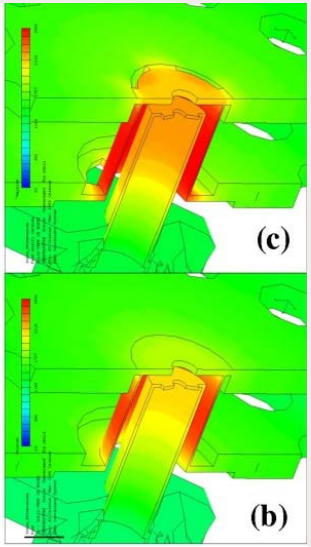
FEBIAD type ion sources at ALTO

(Forced-Electron Beam for Ionisation by Arc Discharge)









IRENA (**I**onization by **R**adial **E**lectron **N**eat **A**daptation)
:a new radial-type FEBIAD ion source

IRENA2

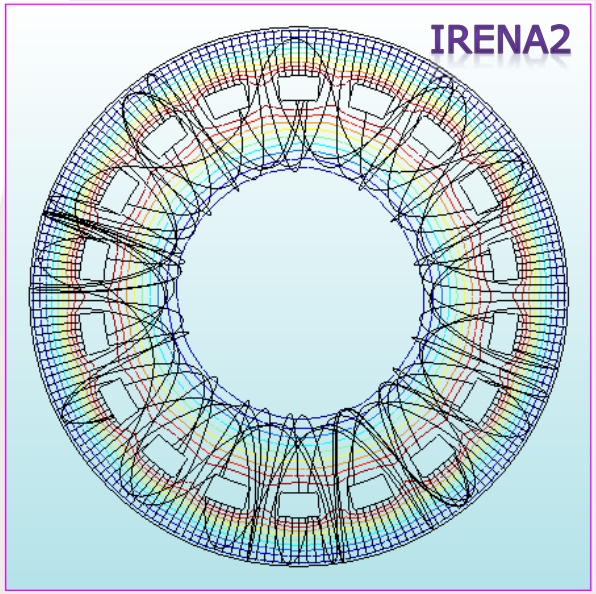
(**I**onization by **R**adial **E**lectron **N**eat **A**daptation)

	IRENA2	FEBIAD MK5 at ALTO
Ar	≥ 26 %	20 %
Kr	≥ 15 %	9 %
Xe	≥ 30 %	22 %

- Small ion source without magnet
- Fast and efficient ionization

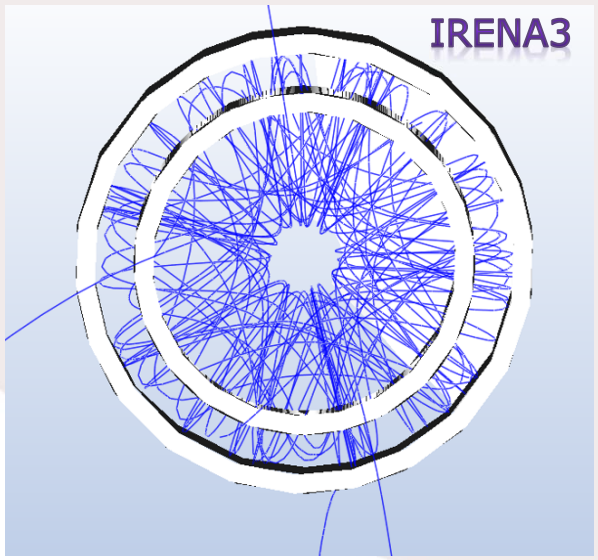
SIMULATION RESEARCH FOR IRENA3

Single electron



Moving trajectory

Multiple electrons



Moving trajectory

\+

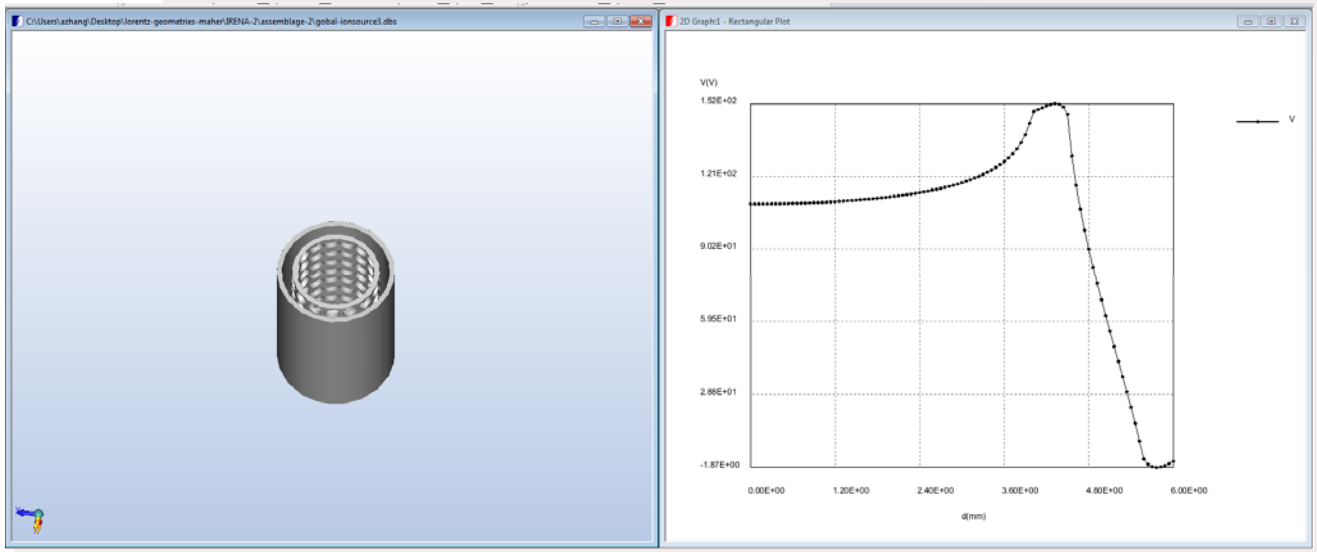
Mean lifetime !

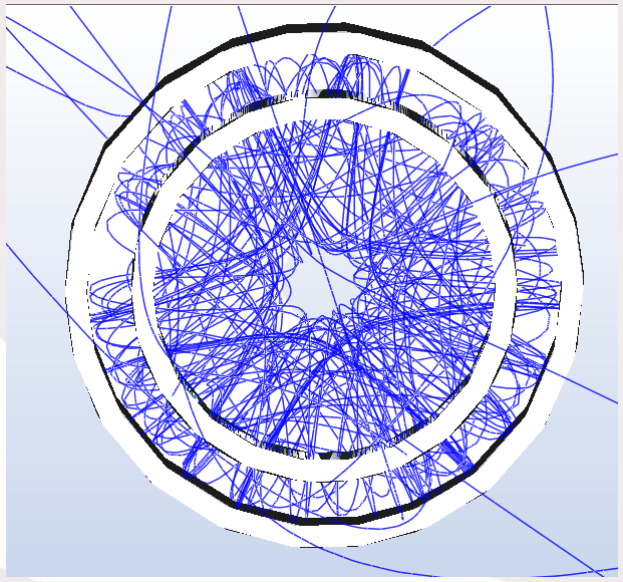
Simulation process

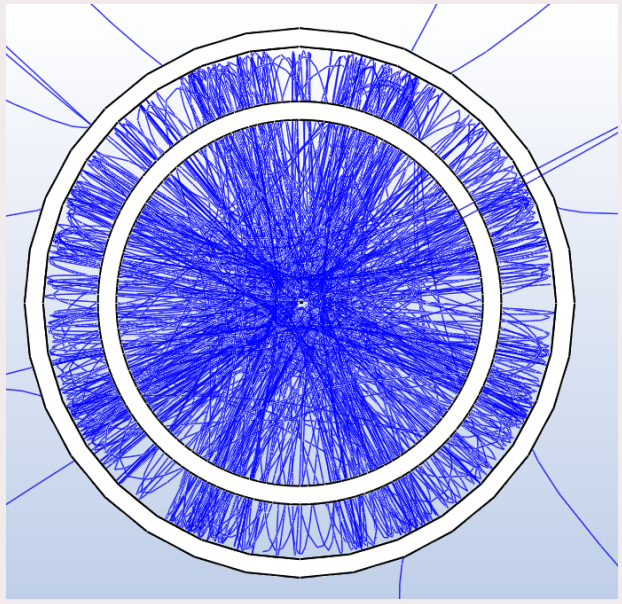
① Electron production
② Electron acceleration
③ Reflector and secondary emitter
④ Electron decelerated by space charge
⑤ Space charge and space charge compensation
⑥ Reflector and secondary emitter
⑦ Electron extinction

Without magnet ! Space charge → repelling the electrons.

SIMULATION PROCESS

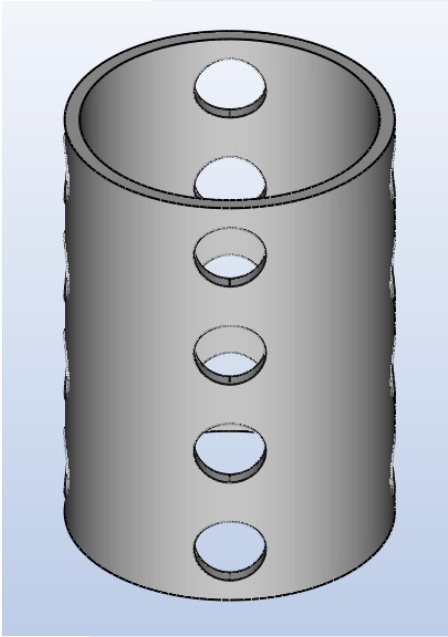


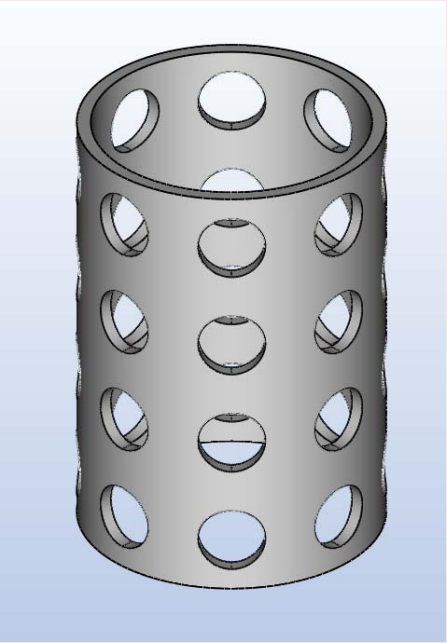


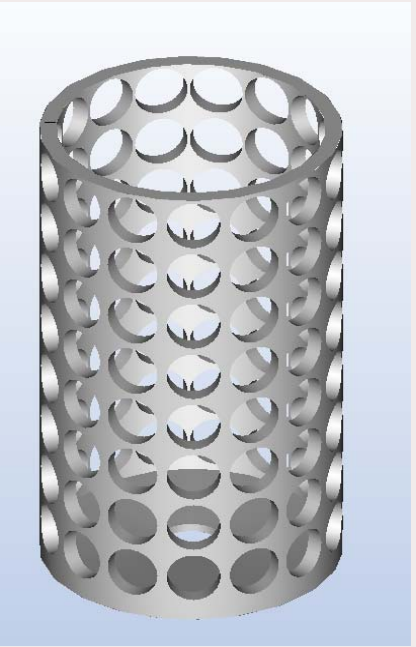


How space charge repel the electron? ➡ Space charge

DIFFERENT ANODE

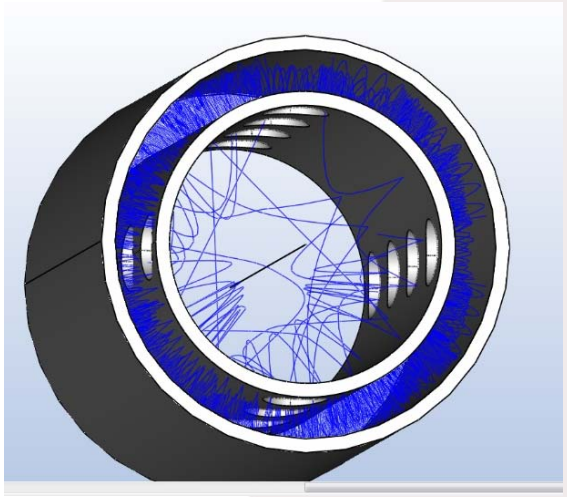


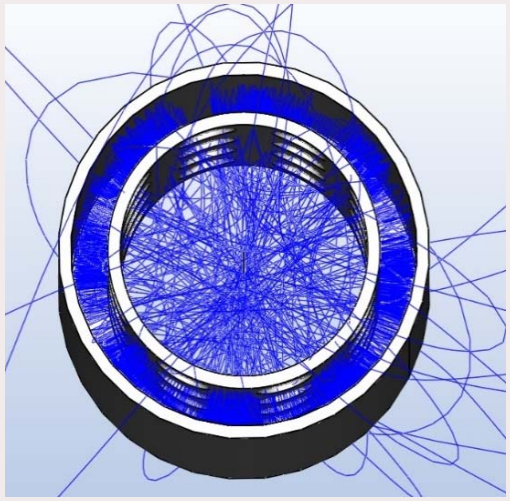


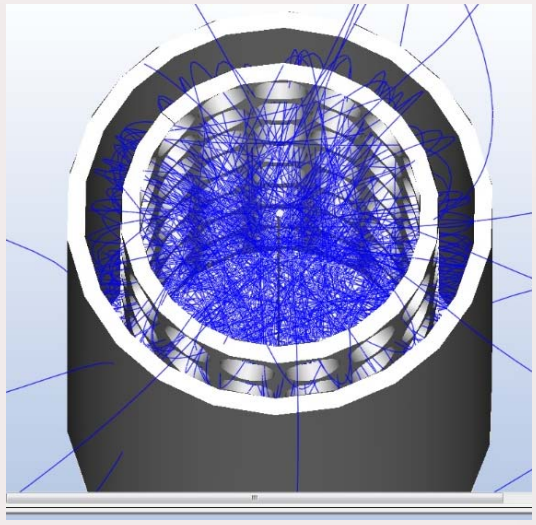


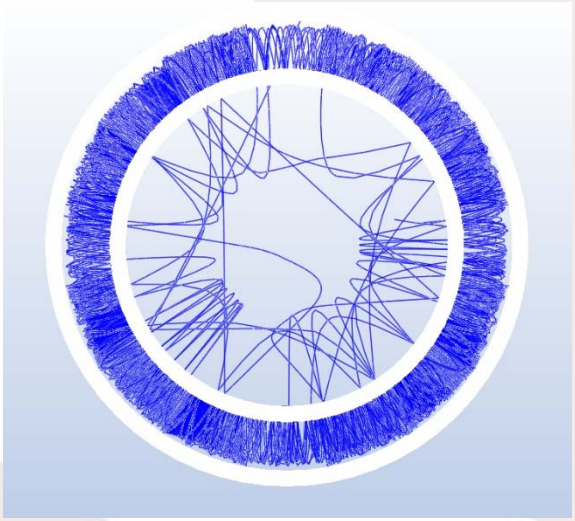
Holes :	4x4	4x8	16x8
Holes/anode	22.4%	44.8%	76.8%

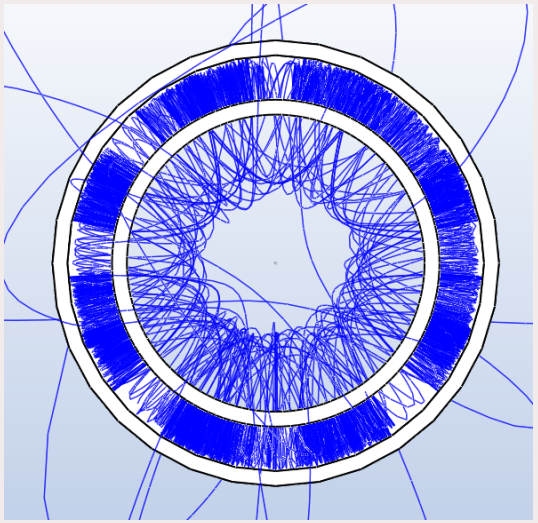
DIFFERENT ANODE

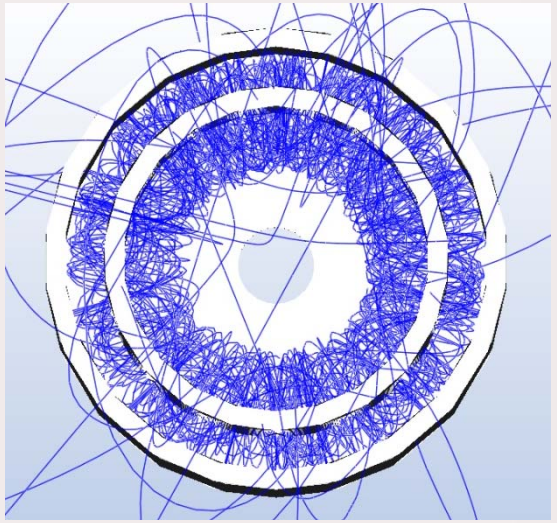










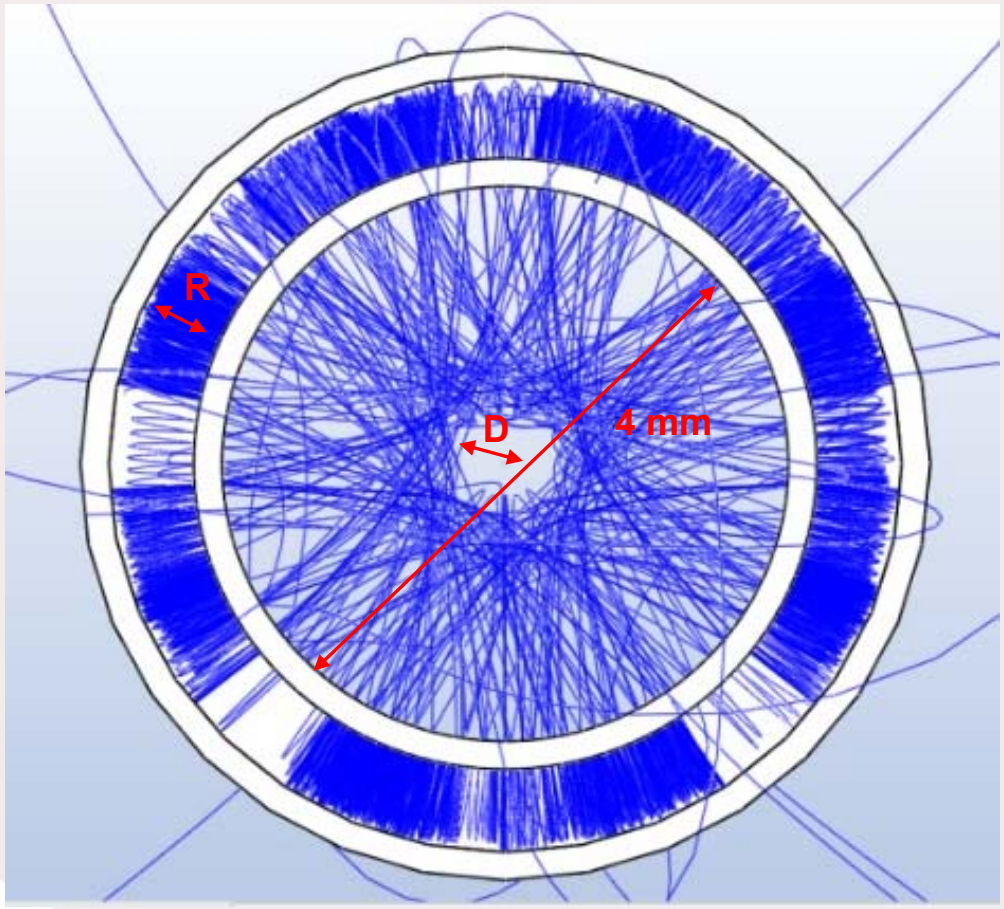


4x4
22.4%

4x8
44.8%

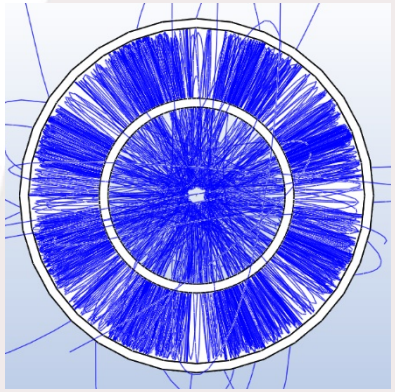
16x8
76.8%

PARAMETERS FOR ANODE

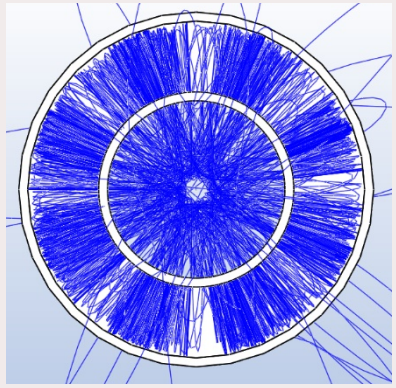


PARAMETERS FOR ANODE

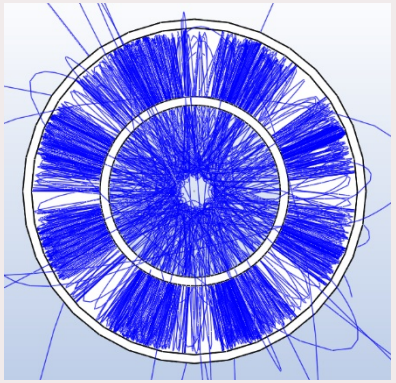
R= 4.5 mm



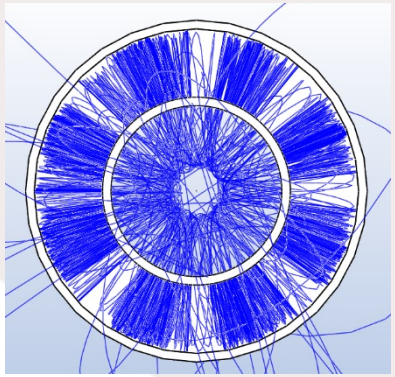
210v



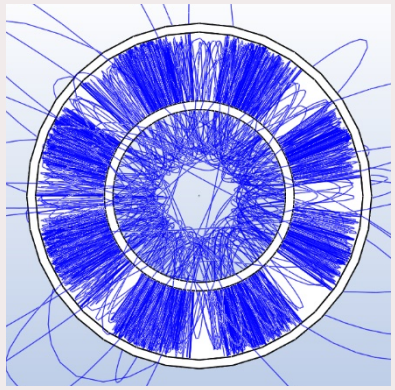
170v



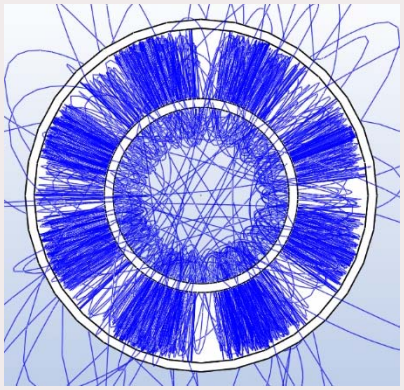
140v



110v



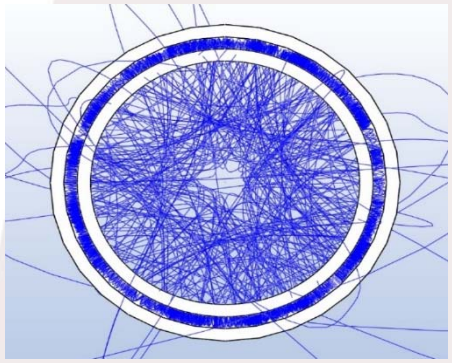
80v



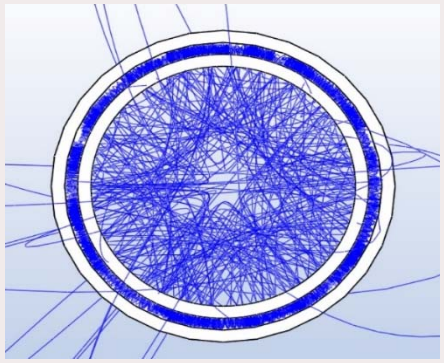
50v

PARAMETERS FOR ANODE

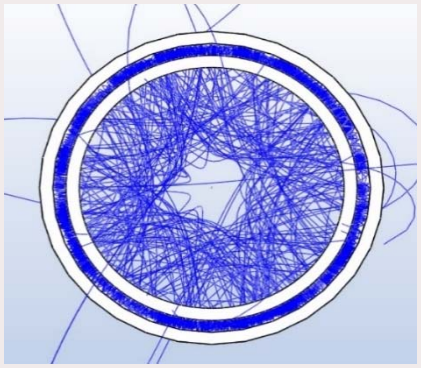
R= 1.0 mm



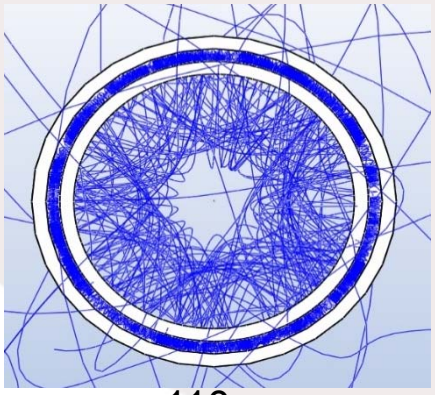
210v



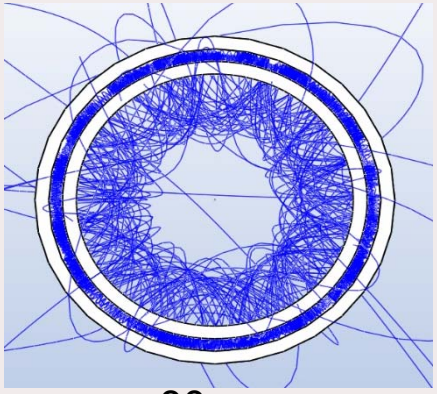
170v



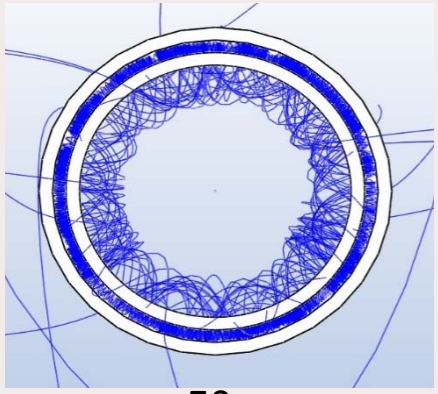
140v



110v



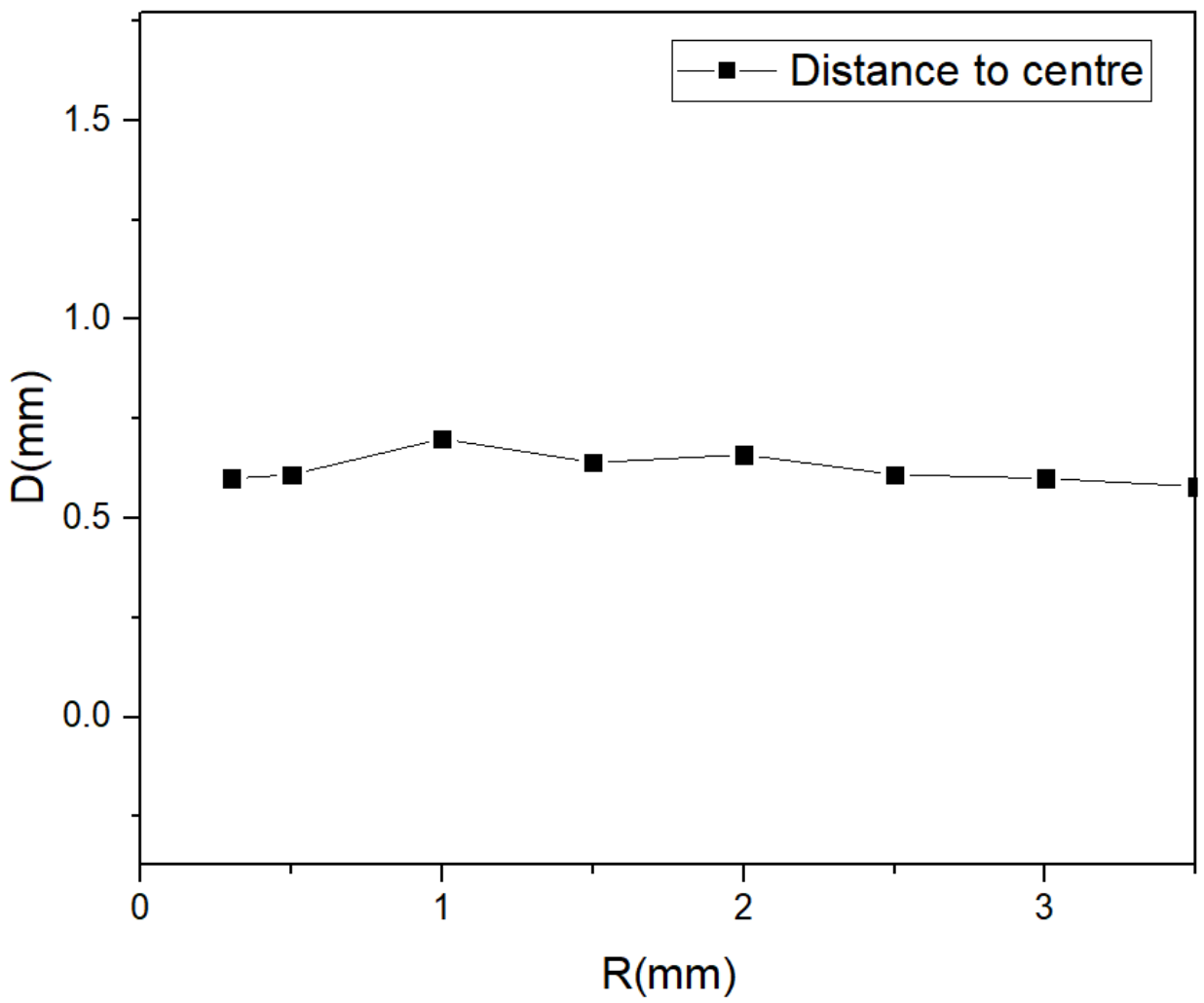
80v



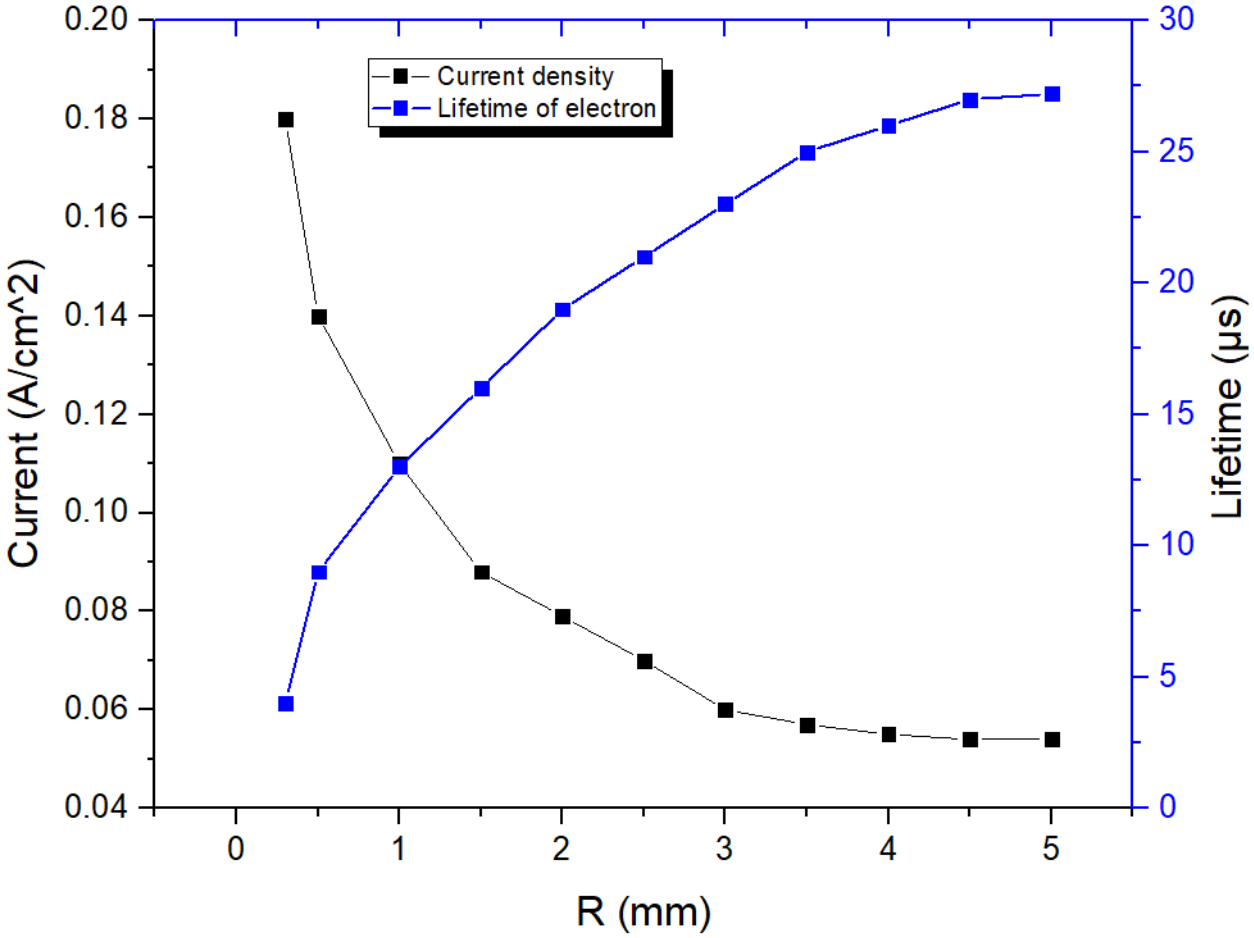
50v

R＜0.3mm, the electrons production maybe unstable.

PARAMETERS FOR ANODE



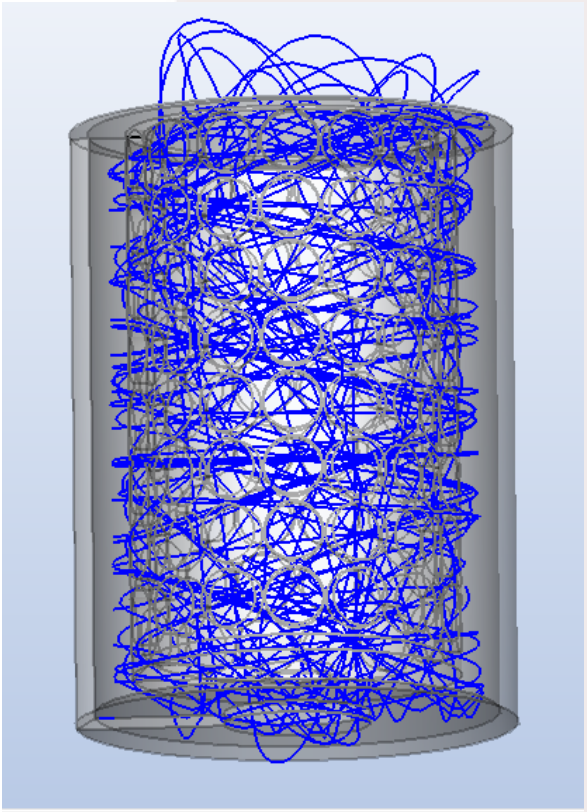
BEST R

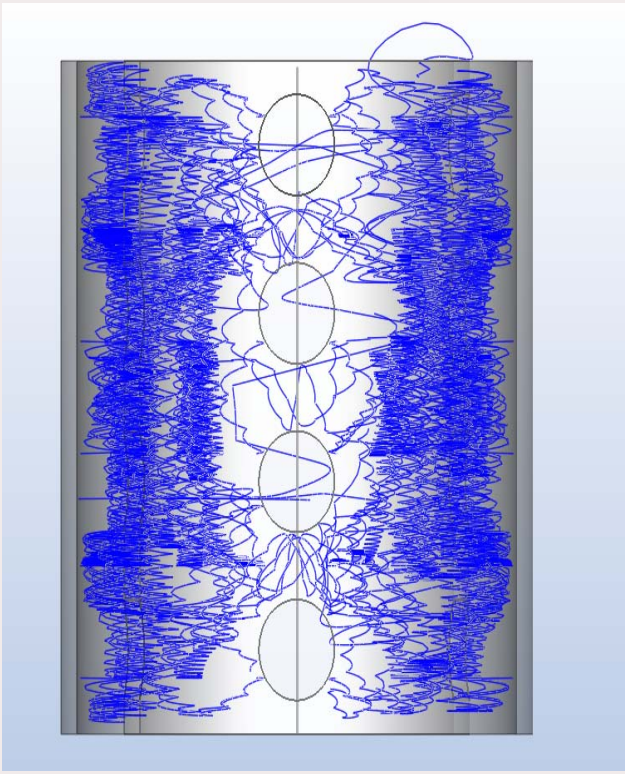


2000℃

1.5mm

DIFFERENT MATERIAL

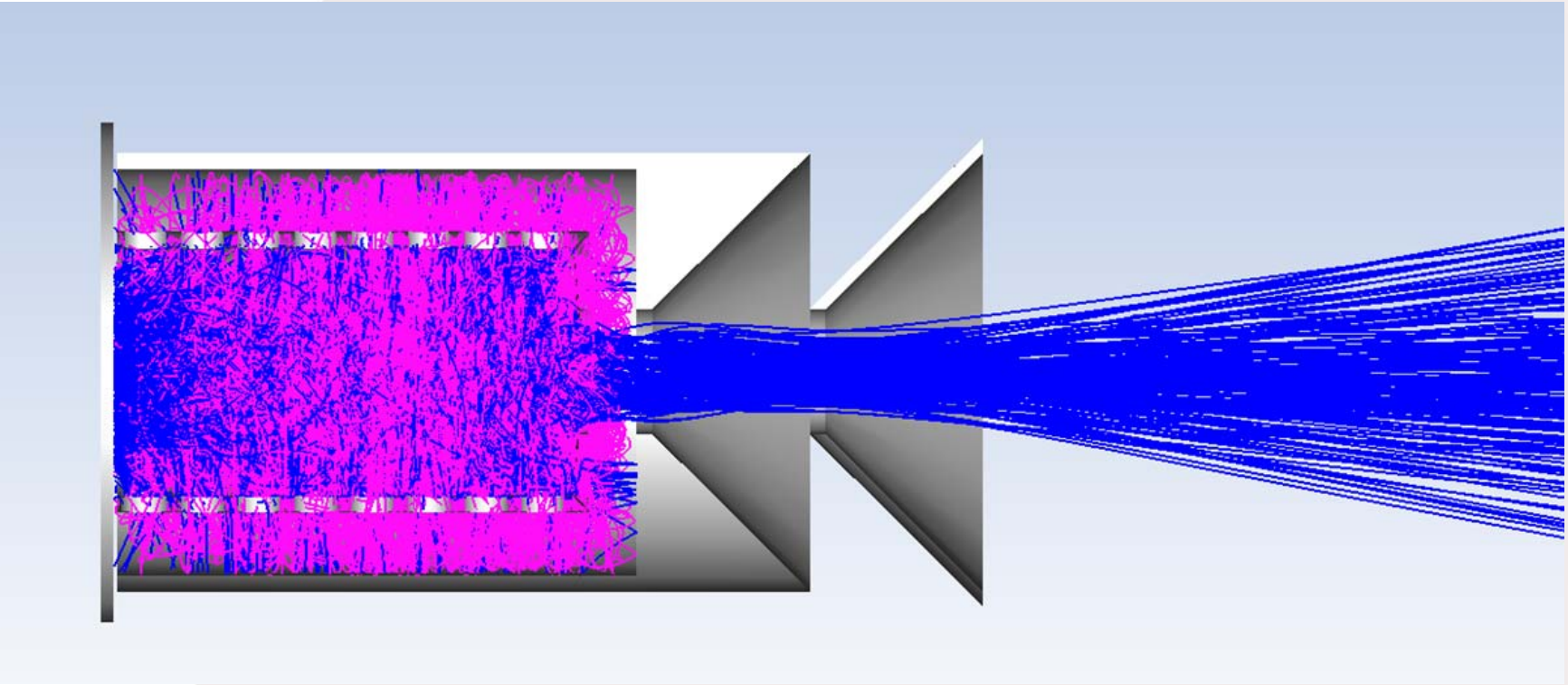




For current :
Tantalum＞Tungsten＞molybdenum

For electron lifetime :
molybdenum ＞ Tantalum ＞ Tungsten

EXTRACTION SIMULATION

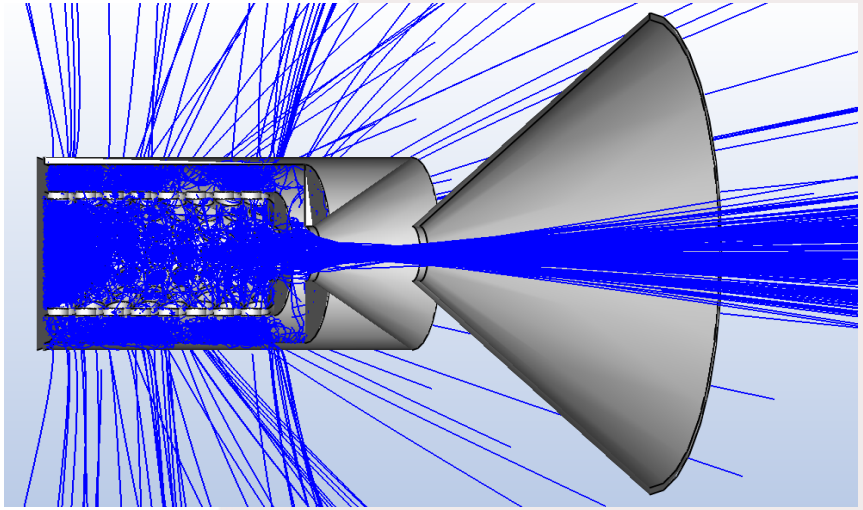


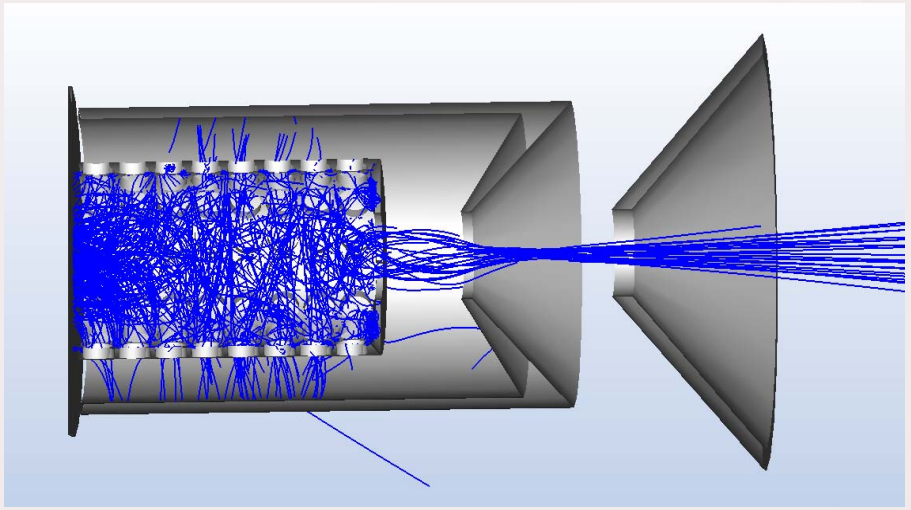
Ar^+ ions

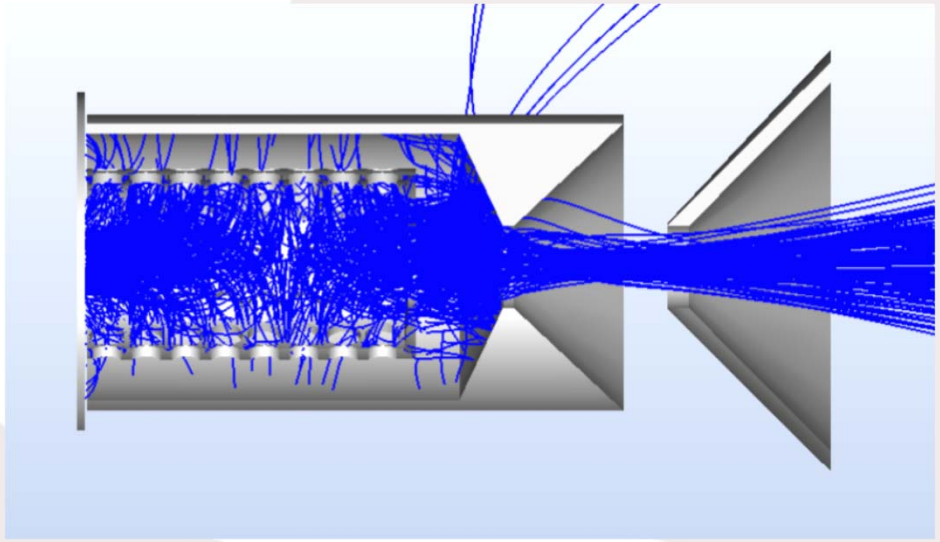
Input

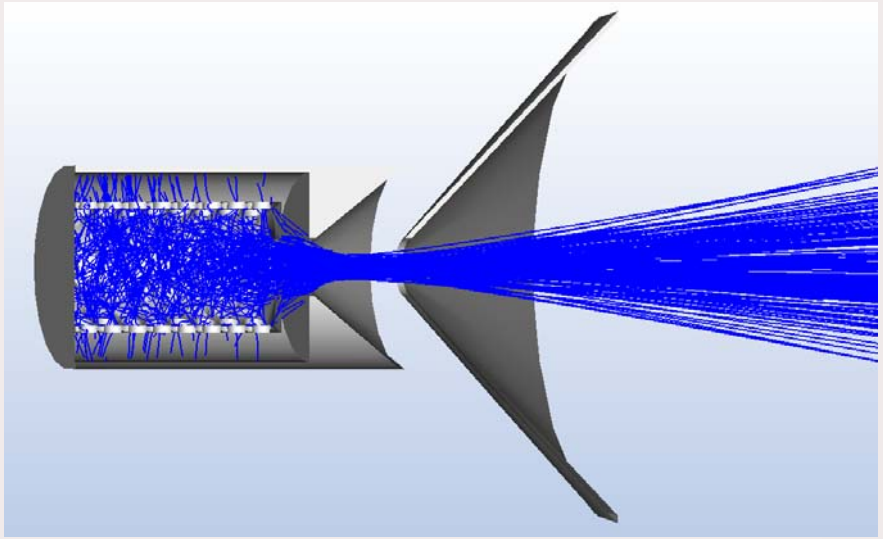
Electron

EXTRACTION SIMULATION

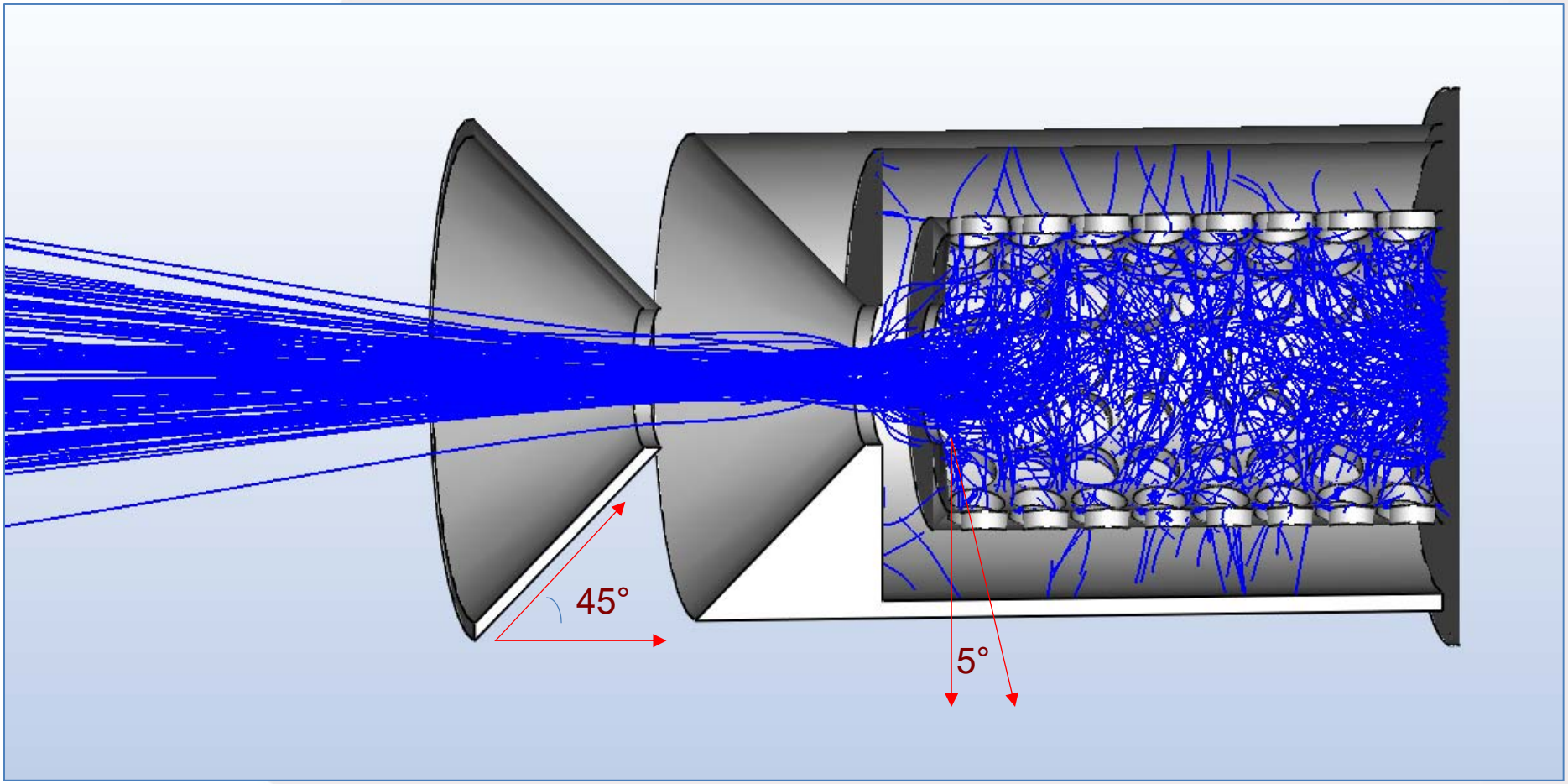






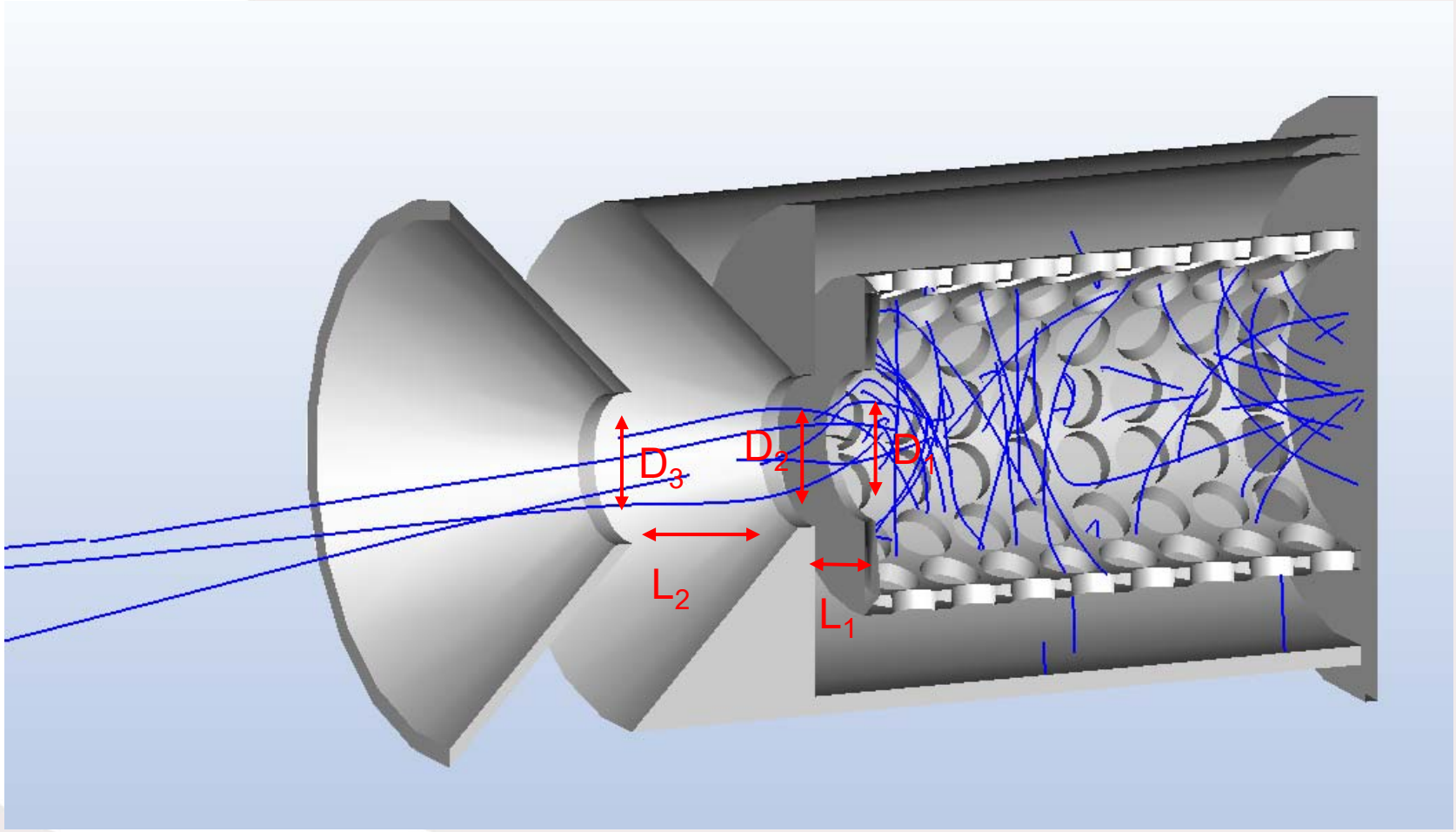


EXTRACTION SIMULATION



The best !

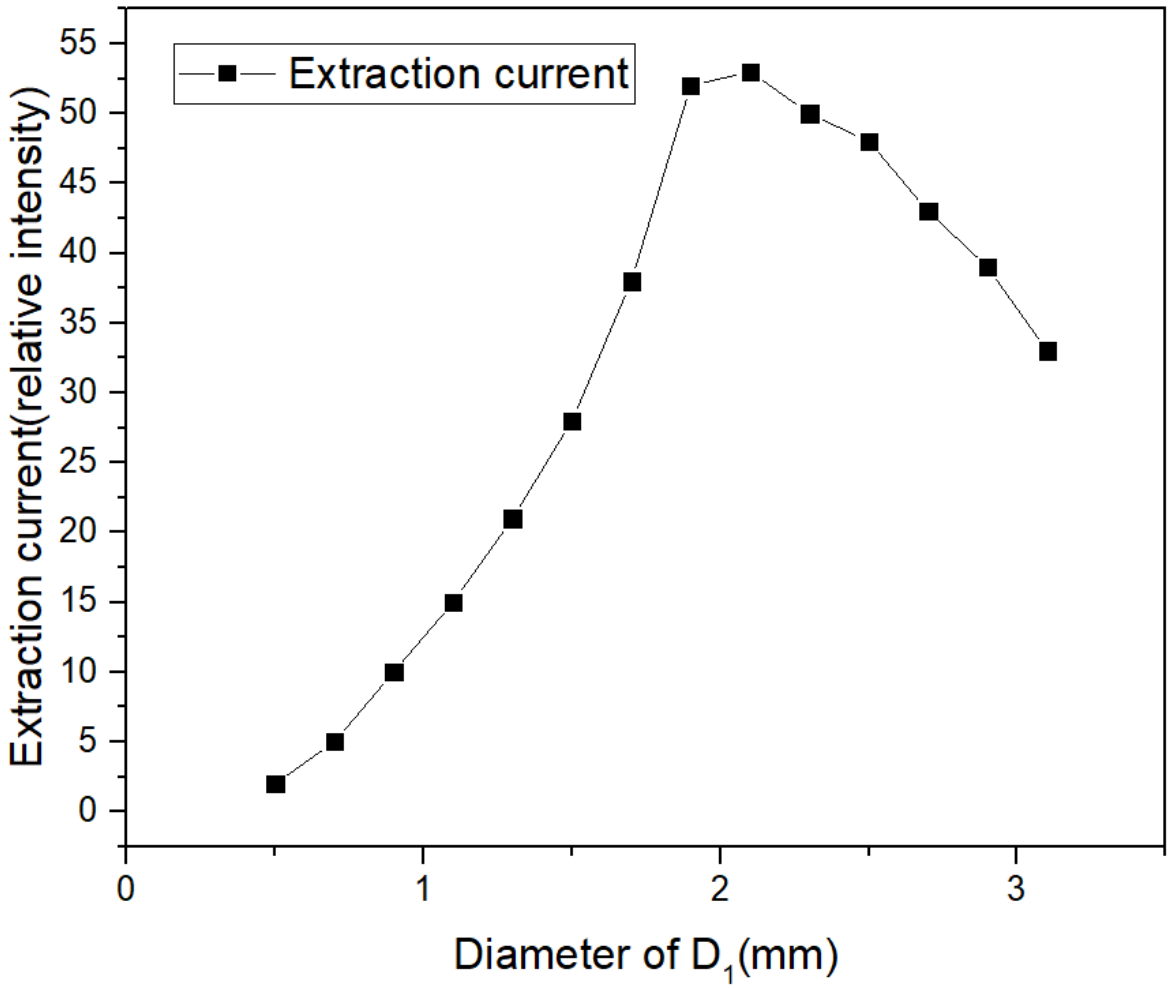
EXTRACTION SIMULATION

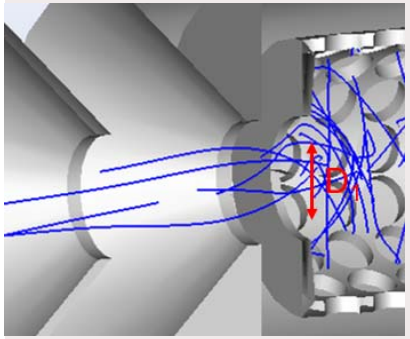


SIMULATION RESULT OF D_1

D_2=2 mm
D_3=2 mm
L_1=2 mm
L_2=10 mm

Determin d by L_1

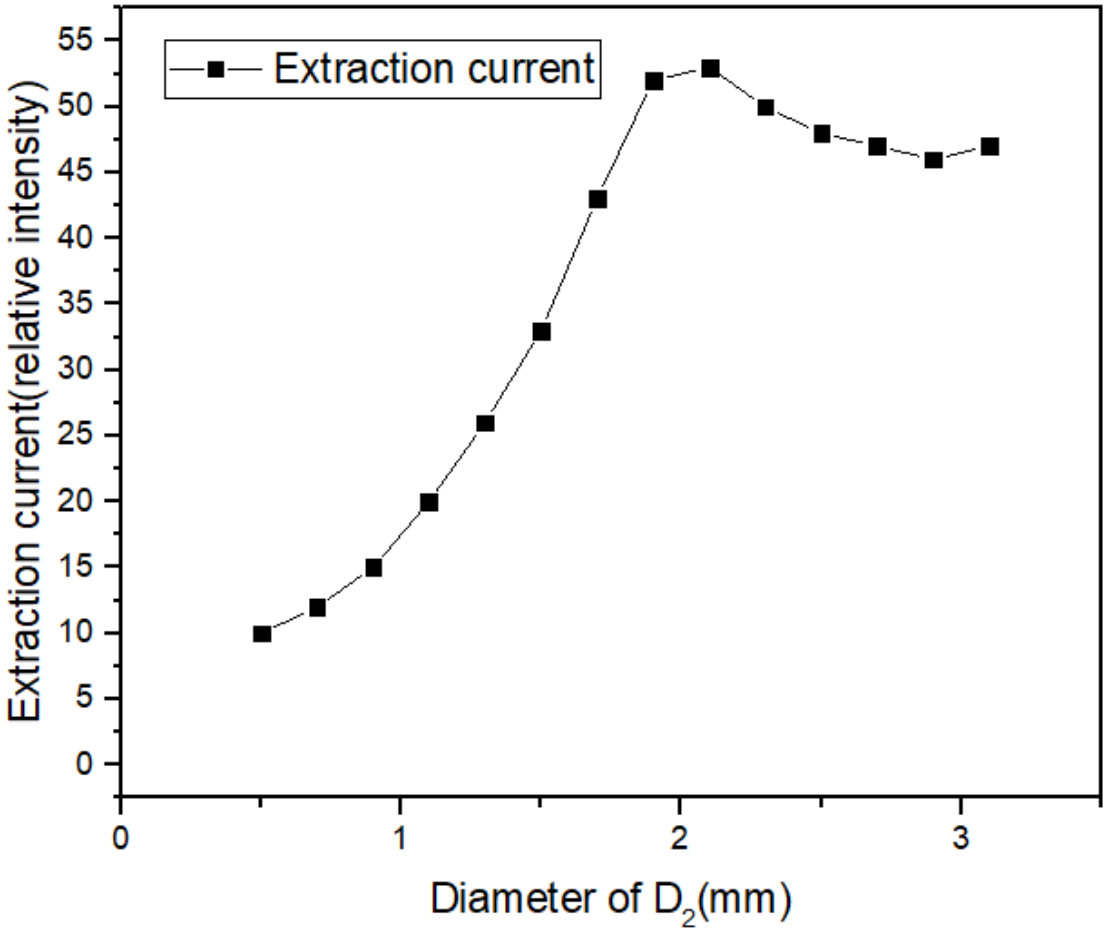


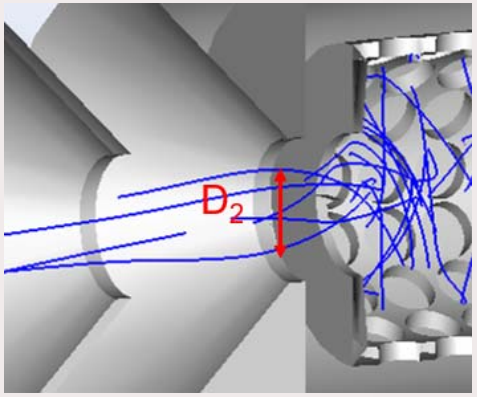


D_1: 2 mm

SIMULATION RESULT OF D_2

D_1=2 mm
D_3=2 mm
L_1=2 mm
L_2=10 mm

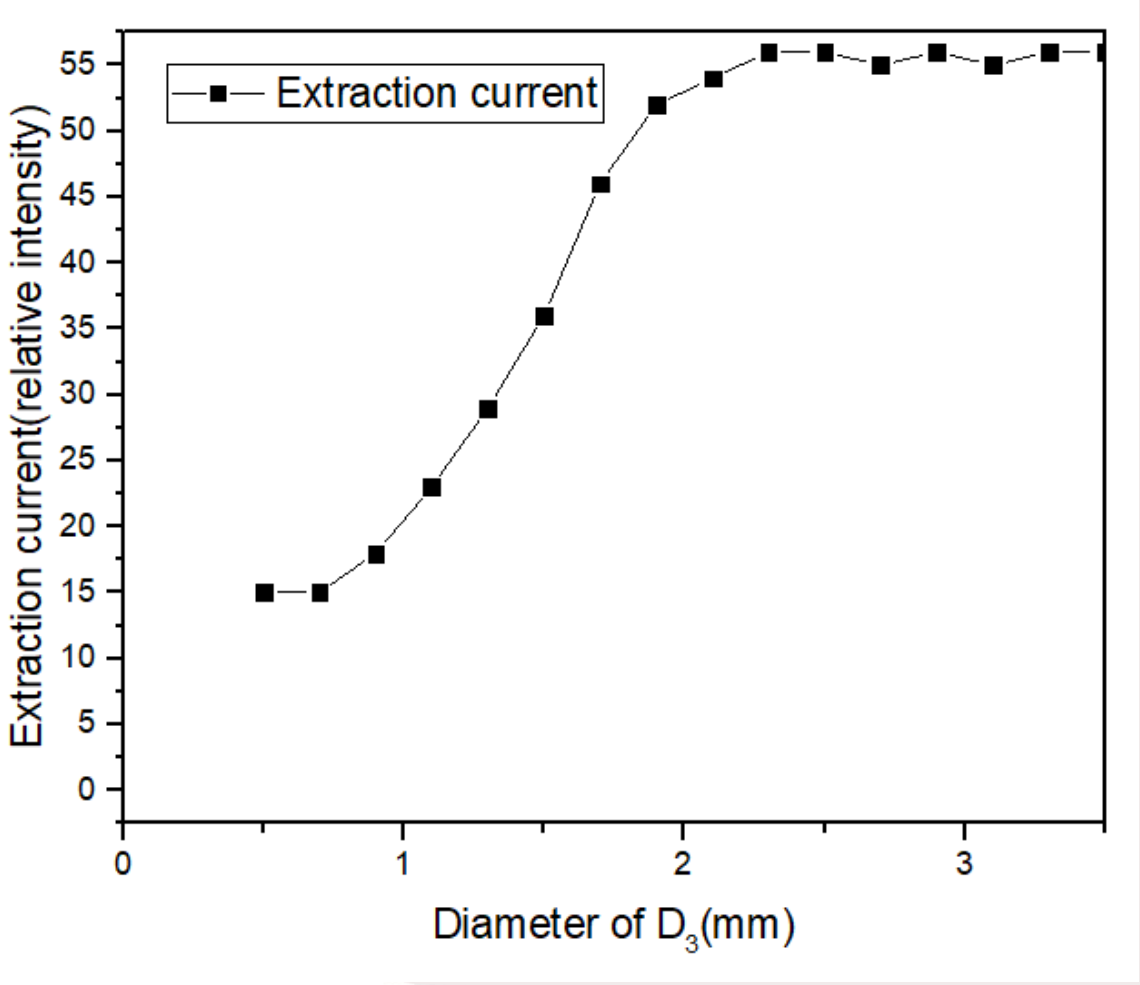


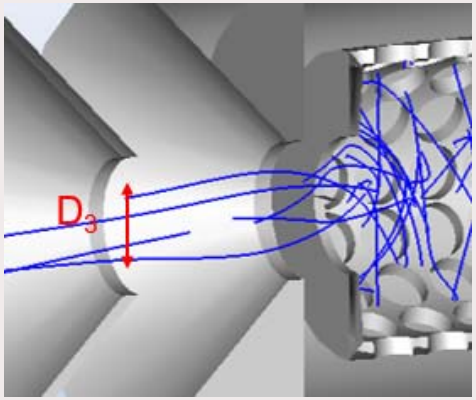


D_2: 2 mm

SIMULATION RESULT OF D_3

D_1=2 mm
D_2=2 mm
L_1=2 mm
L_2=10 mm

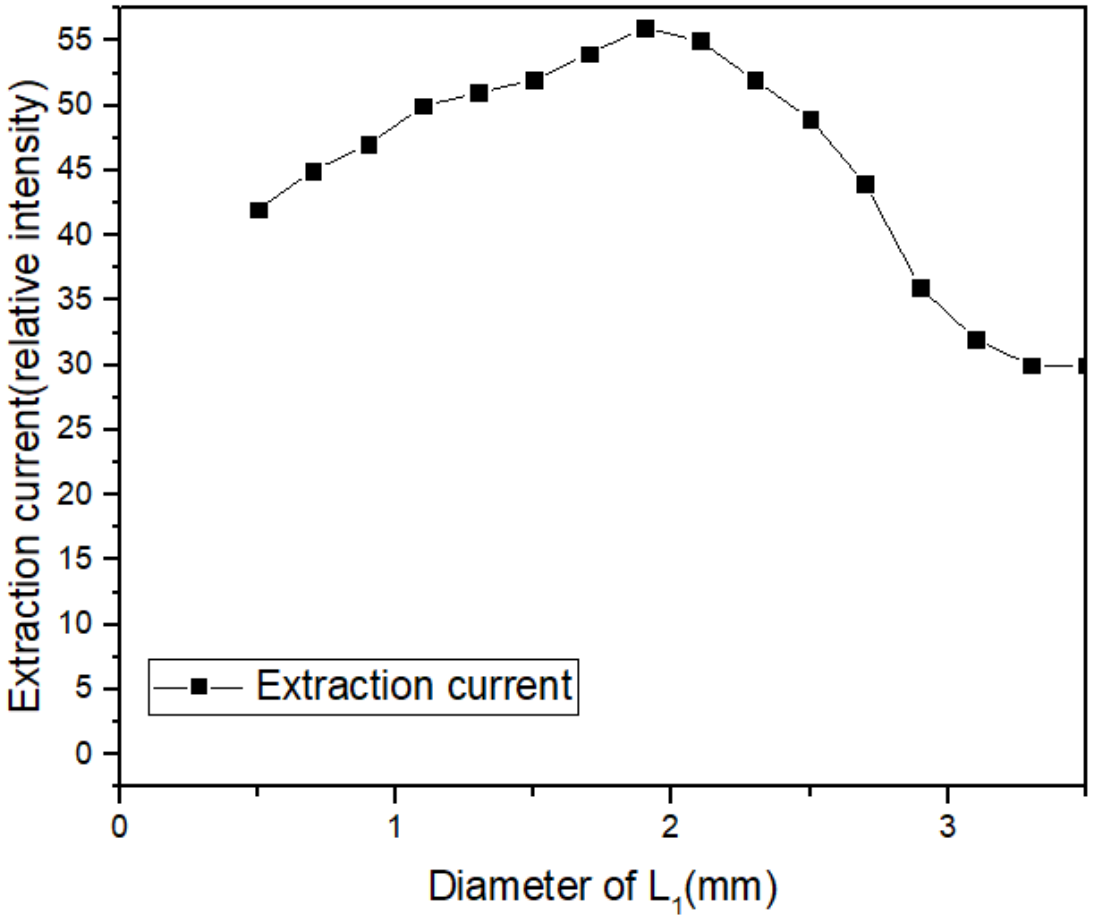


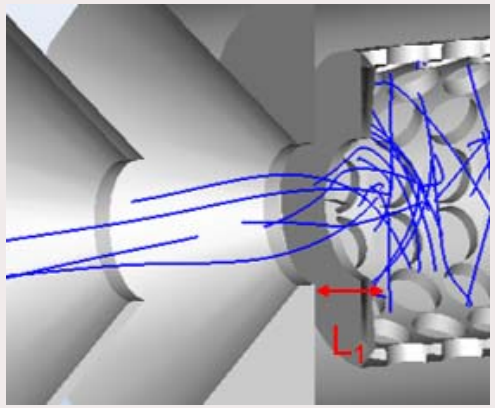


D_3: 2 mm

SIMULATION RESULT OF L_1

D_1=2 mm
D_2=2 mm
D_3=2 mm
L_2=10 mm



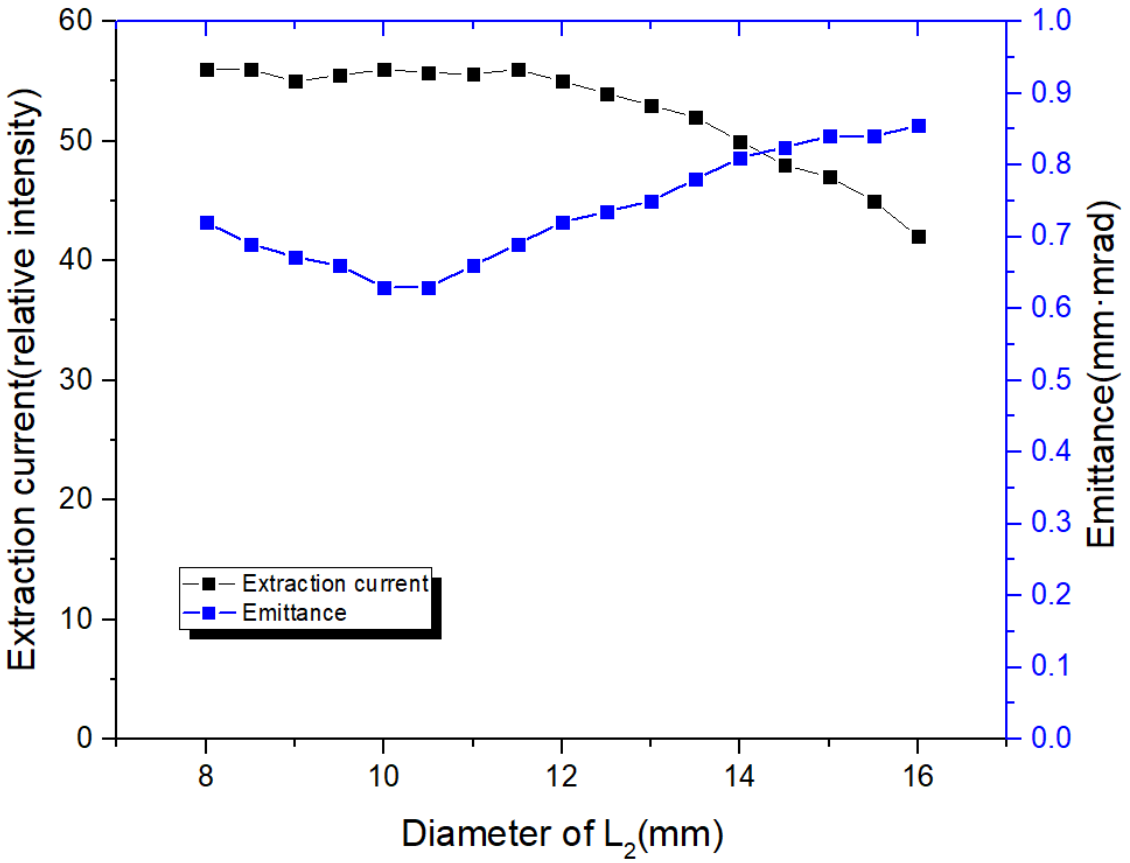


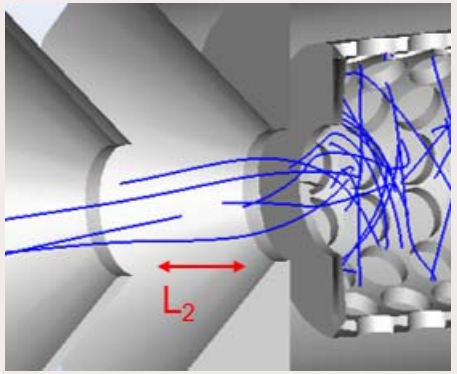
L_1: 2 mm

L_1 barely depend on the other parameters

SIMULATION RESULT OF L_2

D_1=2 mm
D_2=2 mm
D_3=2 mm
L_1=2 mm



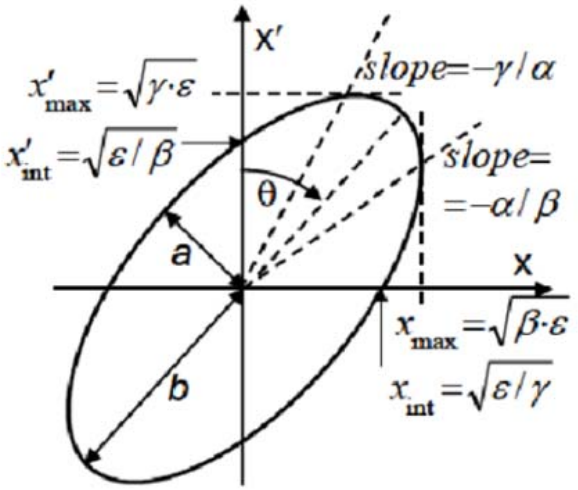


1 π.mm.mrad

L_2 <8 mm: sparks at 30 kV

L_2: 10 mm

EMITTANCE AND RMS EMITTANCE



$$\gamma X^2 + 2\alpha XX' + \beta X'^2 = A/\pi = \varepsilon$$

By Beam optical

Emittance

$$\varepsilon_{rms} = \sqrt{\langle X^2\rangle\langle X'^2\rangle - \langle X\cdot X'\rangle^2}$$

(Normalized Root-Mean-Square Emittance)

$$\varepsilon_{rms\ (i.j)} = \frac{1}{n}\overline{\rho^2}\varepsilon_{\ (i.j)}$$

Depend on beam distribution

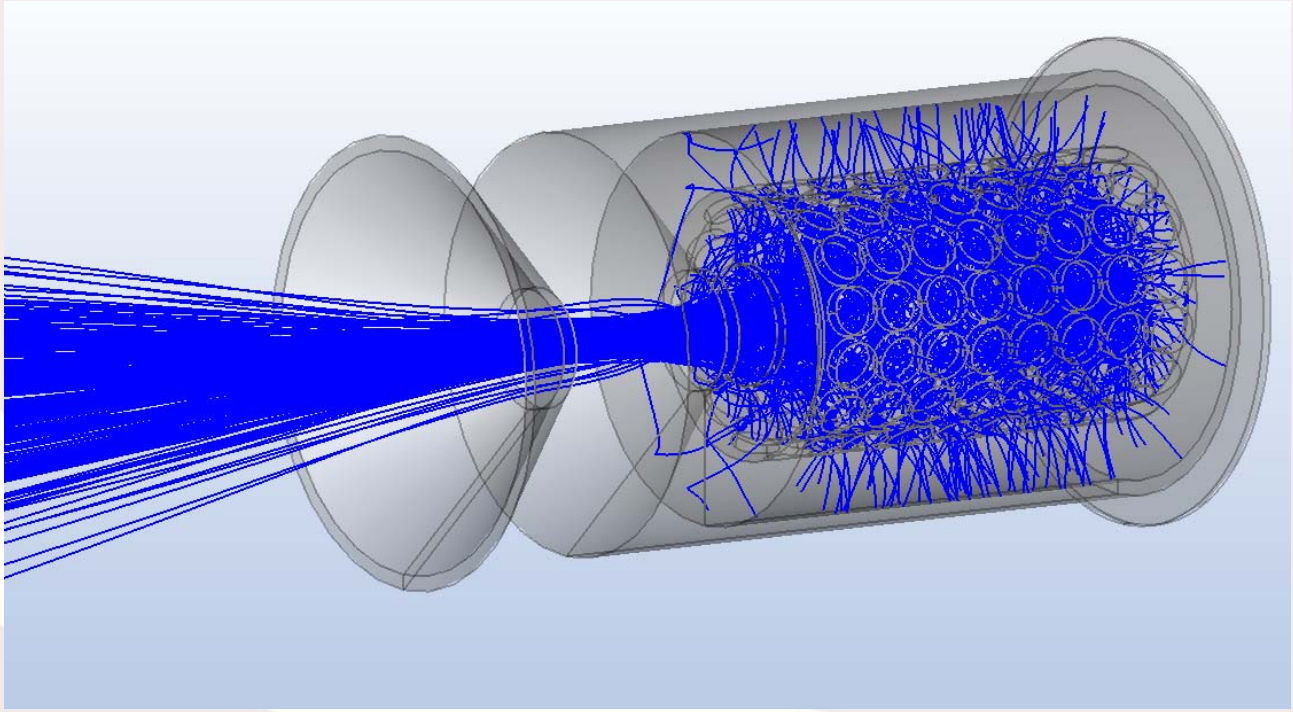
For example：K-V distribution

$\varepsilon_{rms}=1/4\varepsilon$

Measurement in reality

CONCLUSION

1. Space charge and space charge compensation are treated carefully in the simulation.
2. Multiple electrons were used in the simulation to get the mean lifetime of electrons.
3. Mechanical optimizations were completed through the simulation work.
4. The extraction simulation work had proposed a new type of electrode which can increase the current as well as reduce the emittance of the ion beam.



NEXT STEP

1. Thermal simulation
2. Mechanical design and manufacture
3. Off-line test

Thank you for your attention