Experimental Results from an IEC Device Employing a 5-stage High Voltage Feedthrough

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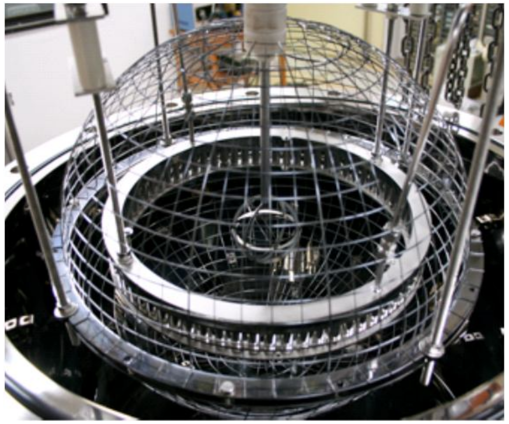
Contents

- Motivation
- Design of 5-stage feedthrough
- Experimental setup
- Experimental results
- Summary and conclusion

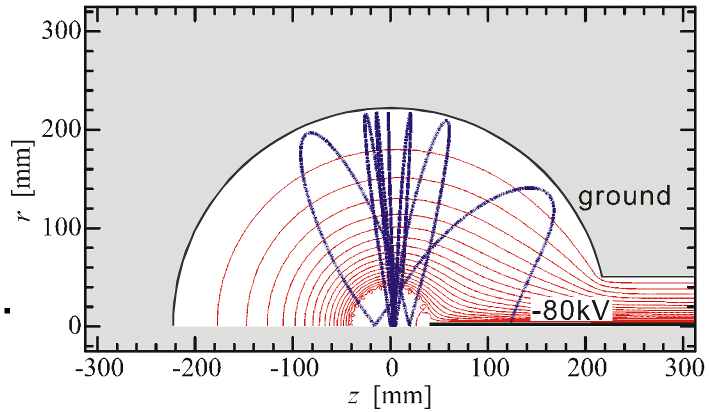
RS-MIS IEC Device



Feature of our RS-MIS device

・Running either under glow mode or RS-MIS mode.

RS-MIS mode : Ions are driven by Ring-Shaped Magnetron Ion Source (RS-MIS)



Feature of RS-MIS mode

・running under extremely low pressure (5 mPa).

・We have plan of enhancement of ion current.

・Ion trajectory is shorter than mean free path.

Objective1 : To increase ion recirculation number.

HEU Detection Project

- For HEU(highly enriched uranium) detection project, we are planning -200 kV – 5 A pulse power supply.

Problem with Applying High Voltage

In order to apply higher voltage, we need larger bore of feedthrough.

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Electric field gets asymmetry.

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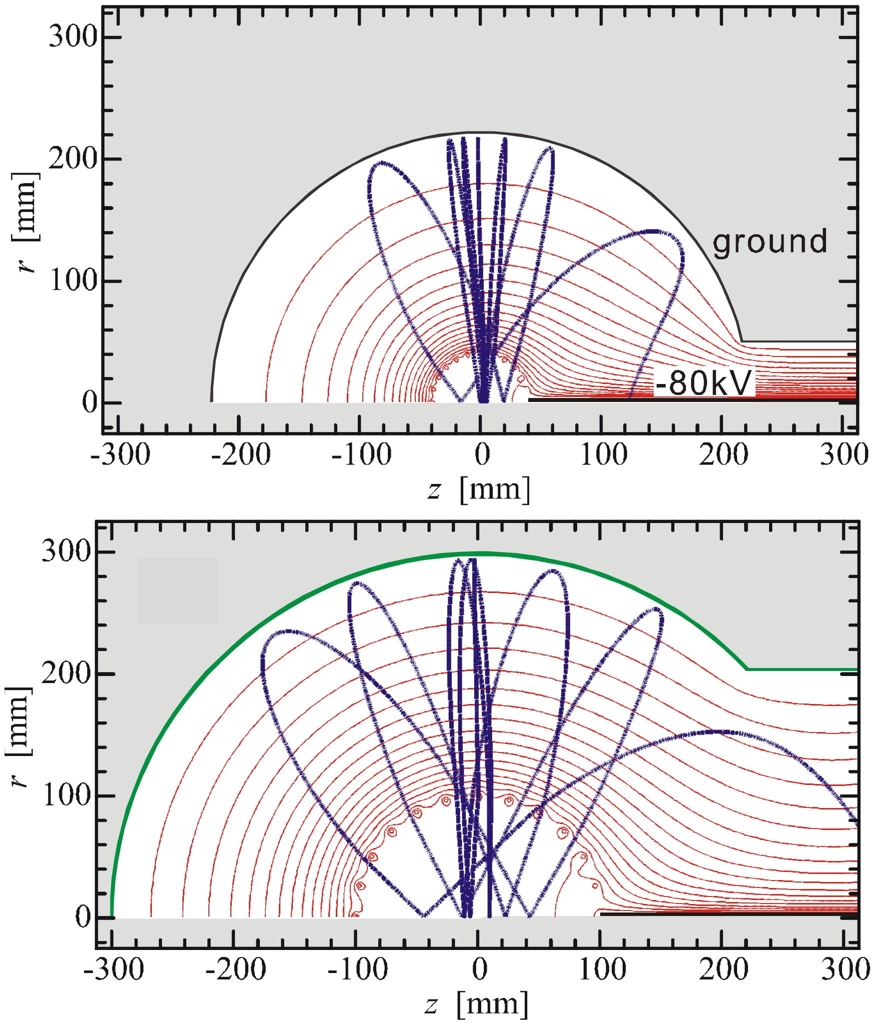
Recirculation number of ion trajectory decrease.



Objective2 : to apply higher voltage (-200 kV) with small bore of feedthrough

Objective

- To enhance ion recirculation.
- To apply higher voltage (-200 kV) with a small bore (ϕ = 200 mm).

↓

We designed a 5-stage high voltage feedthrough

Comparing of 2 mode

	HEU project	Study for beam-beam
Requirement	To apply higher voltage	Improvement of ion recirculation
Pressure	1 Pa	5 mPa
Mean free path	Few tens cm	More than 10 m
Dominant process of ion lost	Charge exchange	Collision to cathode of feedthrough
Ion energy	1/3 of applied voltage	About applied voltage
Cross section of D-D fusion	square of applied voltage	Linear of applied voltage

Contents

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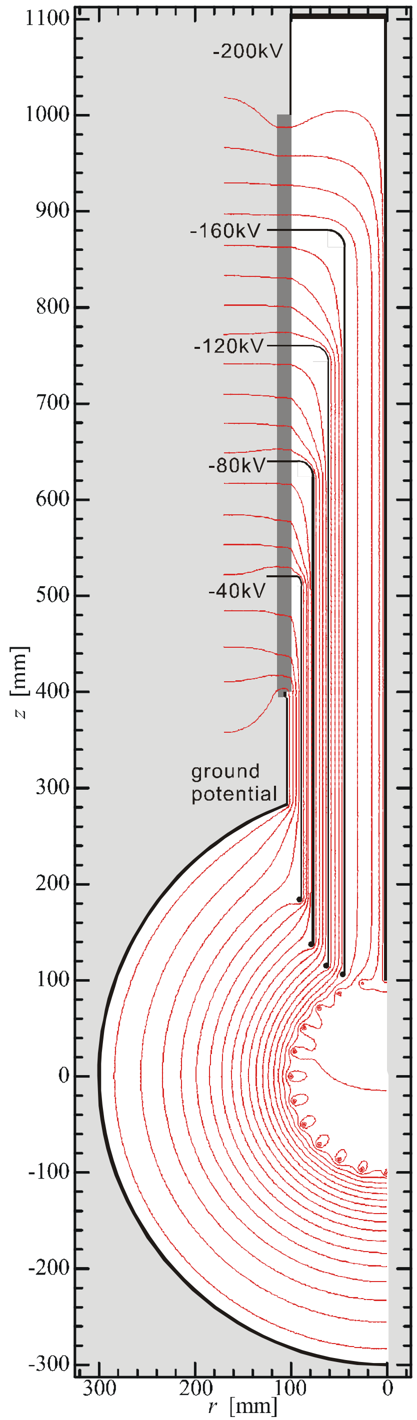
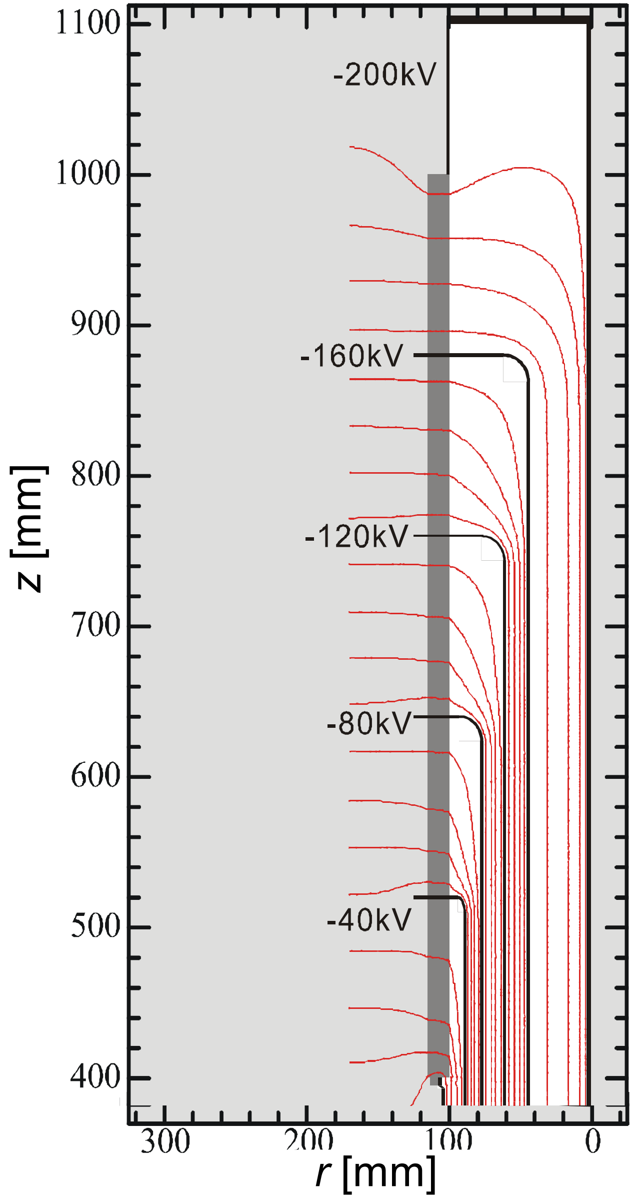
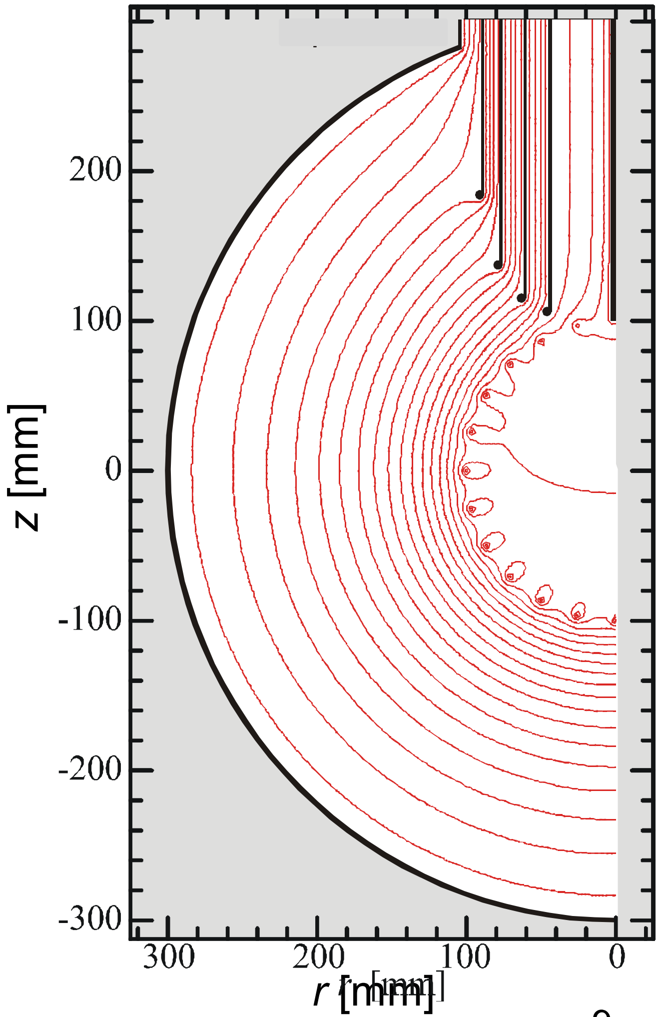
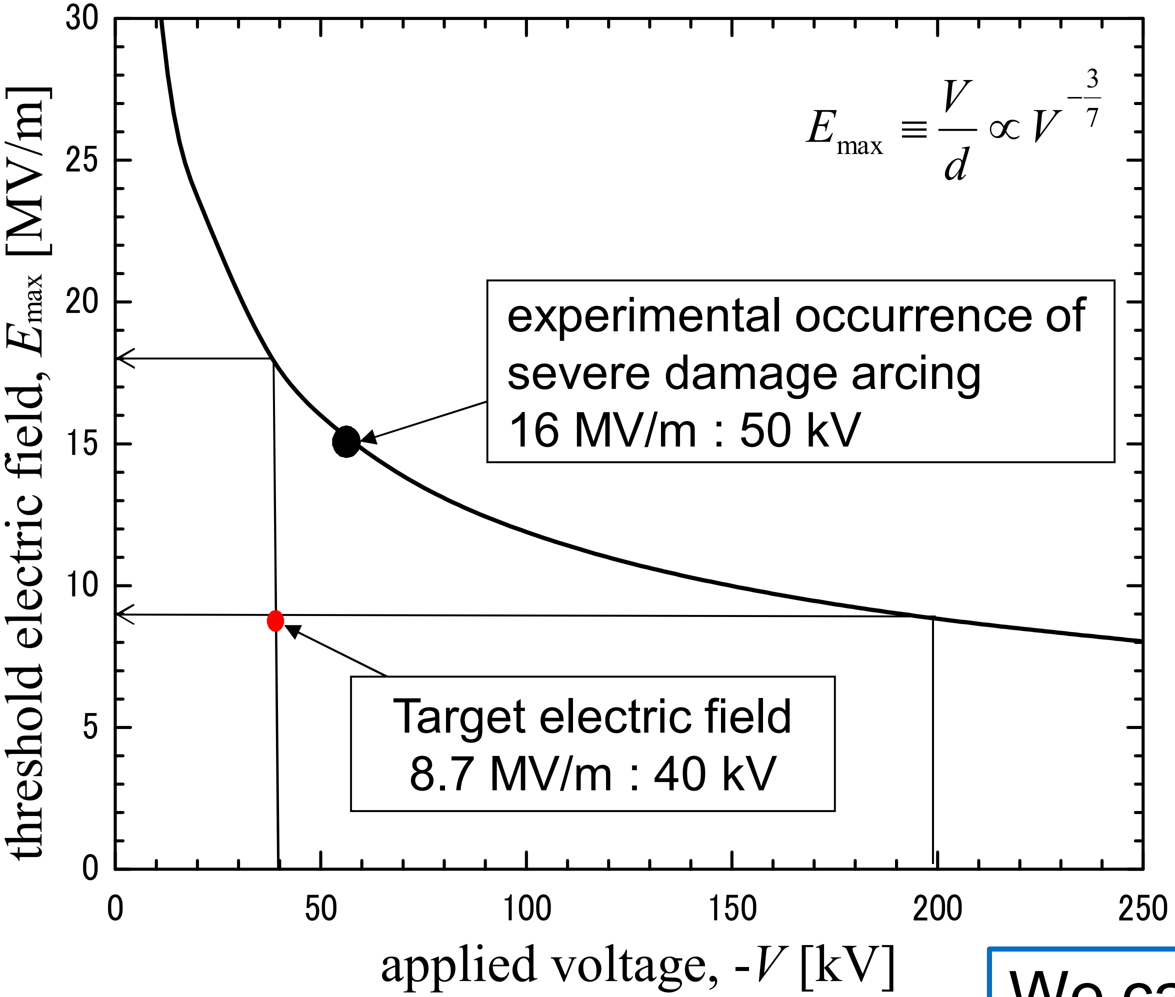
Design of a 5-stage High Voltage Feedthrough



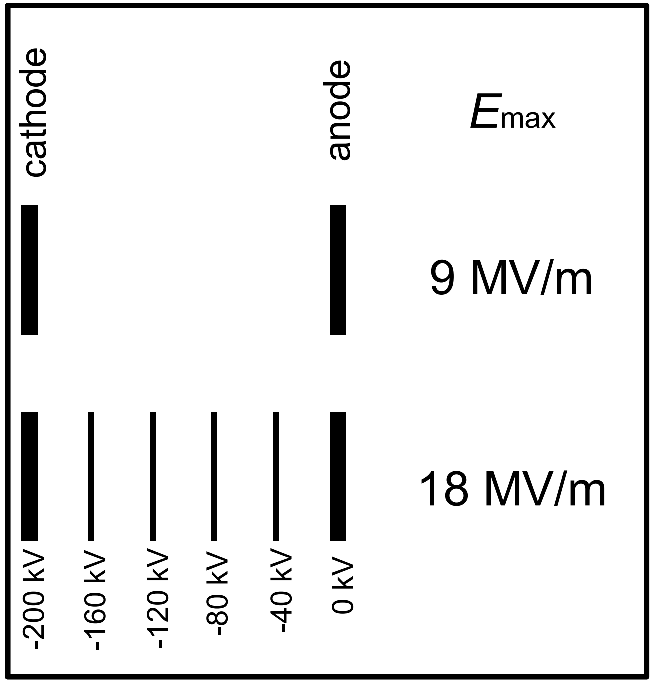




Threshold Electric Field, E_{max} Depend on Applied Voltage



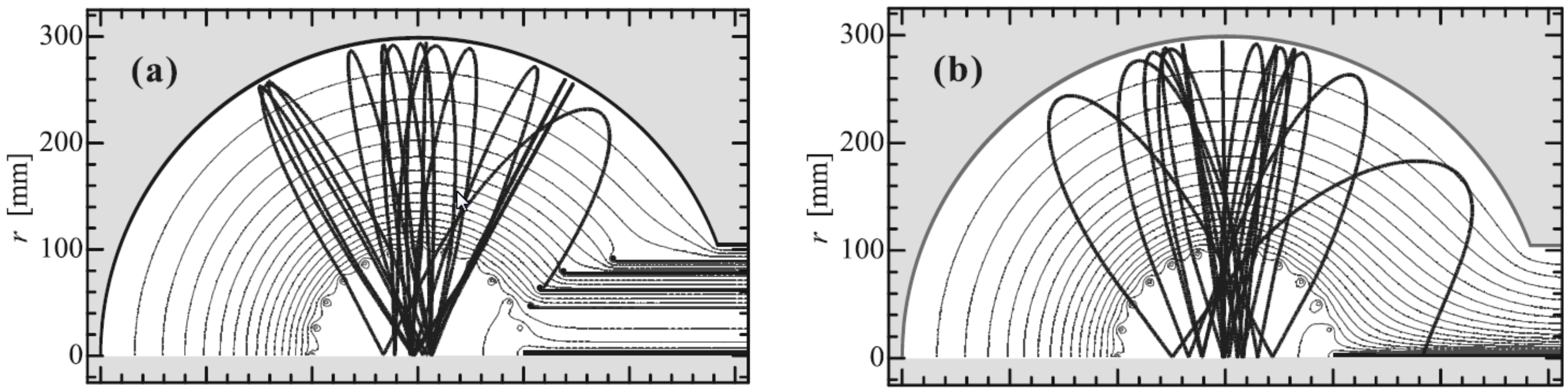
Threshold electric field, $E_{max} \propto V^{-\frac{3}{7}}$.



We can apply higher voltage by using 5-stage feedthrough.

Results from Calculation

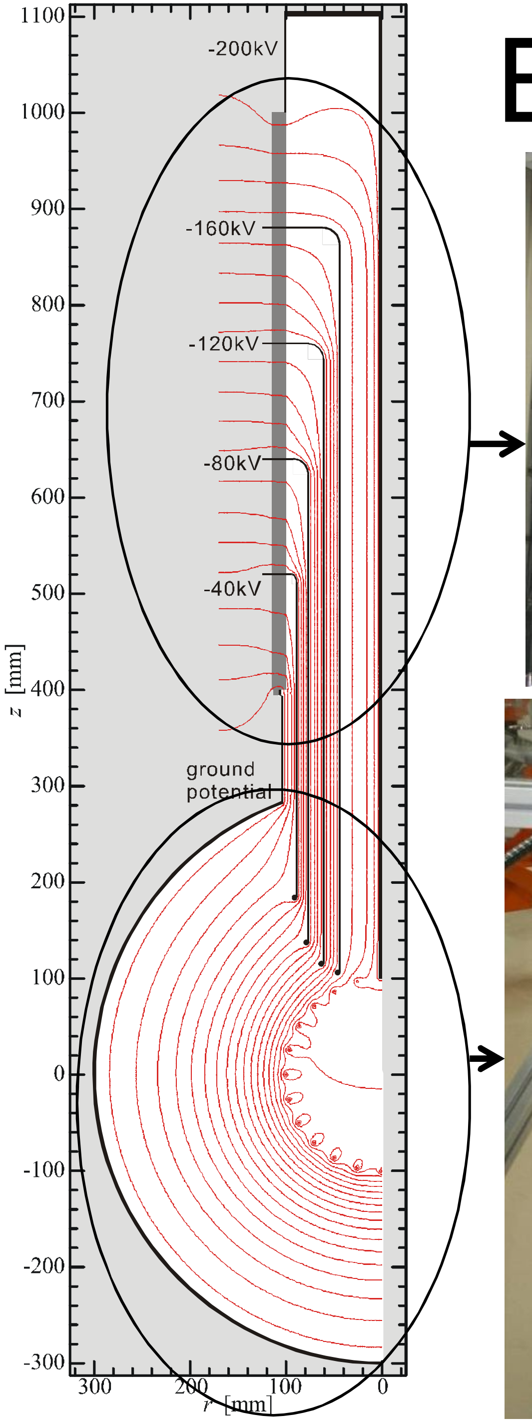
- The maximum electric field is 8.7 MV/m when applied voltage is -200 kV.
- The averaged recirculation number of injected ions is 3 times as large as that in the present experimental device.



Kai Masuda, et al., Fusion Science and Technology, vol.60, 2011, p625.

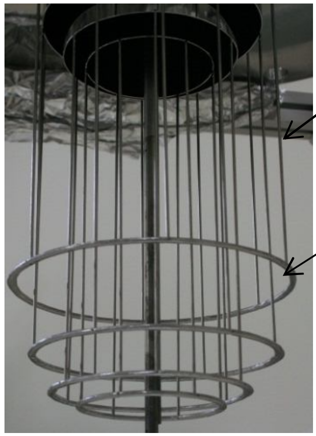
Contents

Experimental Device



	diameter	material
anode	560 mm	Stainless
cathode	200 mm	Molybdenum

Intermediately Biased Electrodes



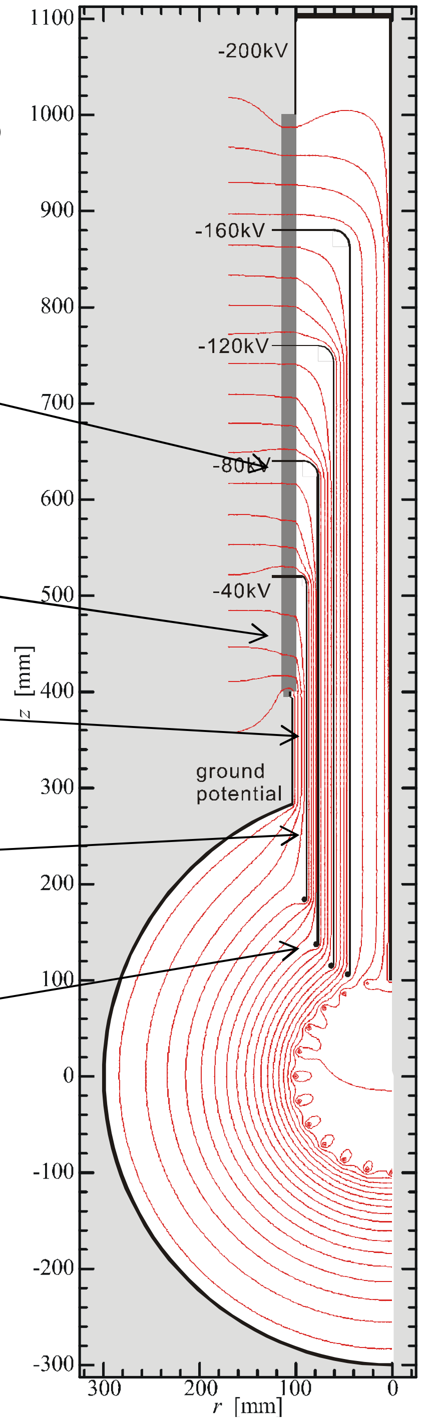
alloys of ferrous, nickel and cobalt

ceramic cylinder

stainless flared tube

stainless rod

duralumin ring



Contents

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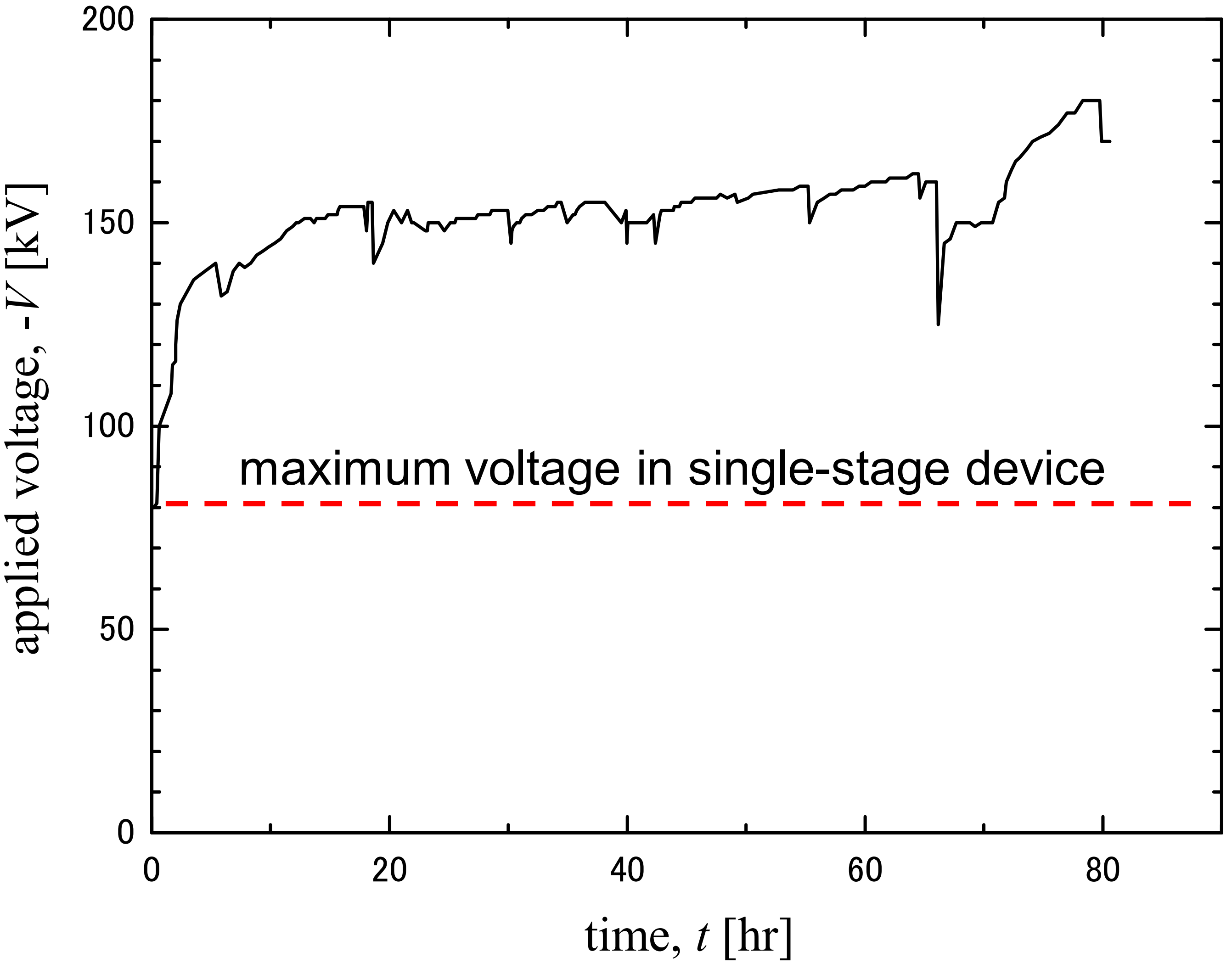
Experiment

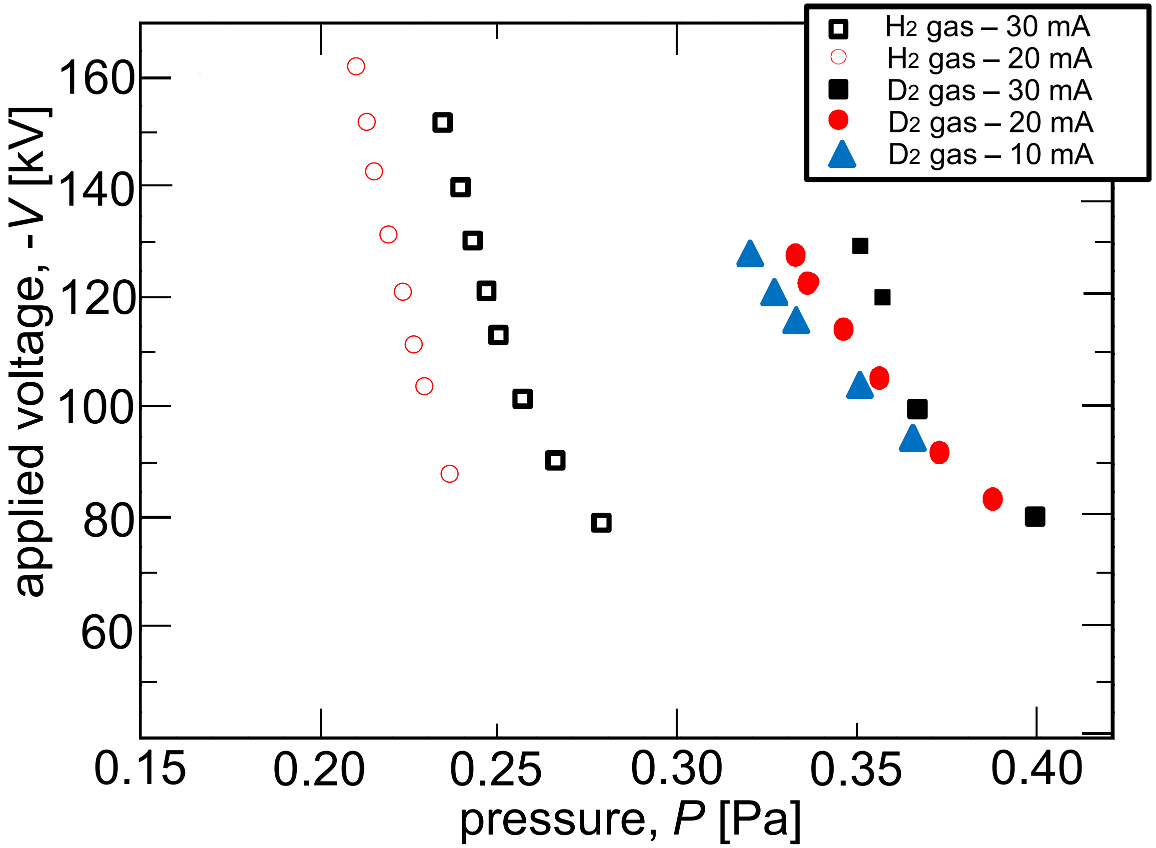
- Conditioning under vacuum
- P-V characteristics of glow discharge with H_2 and D_2 gas
- Measure NPR under glow mode

Conditioning under Vacuum



・After 80 hours conditioning, -180 kV (E_{max} is 7.8 MV/m).

P-V characteristics of H_2 and D_2



@H_2 gas
We have applied -160 kV.
Problem of X ray radiation hazard.

@D_2 gas
After applying -130 kV, current was not stable.
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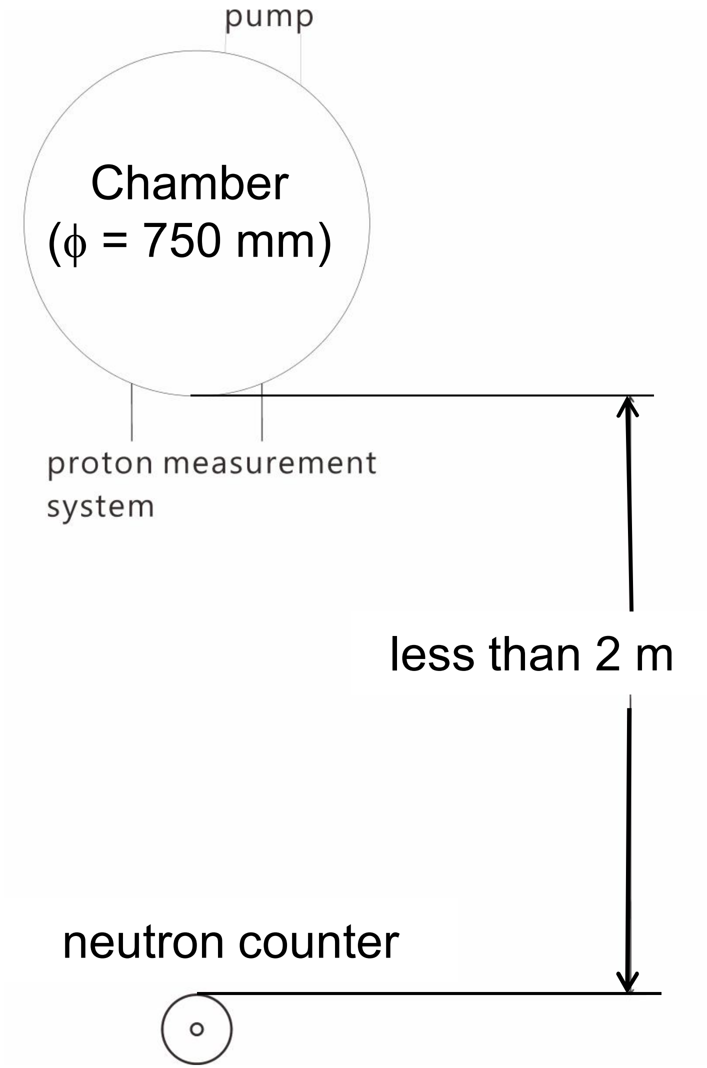
We are solving for this problem.

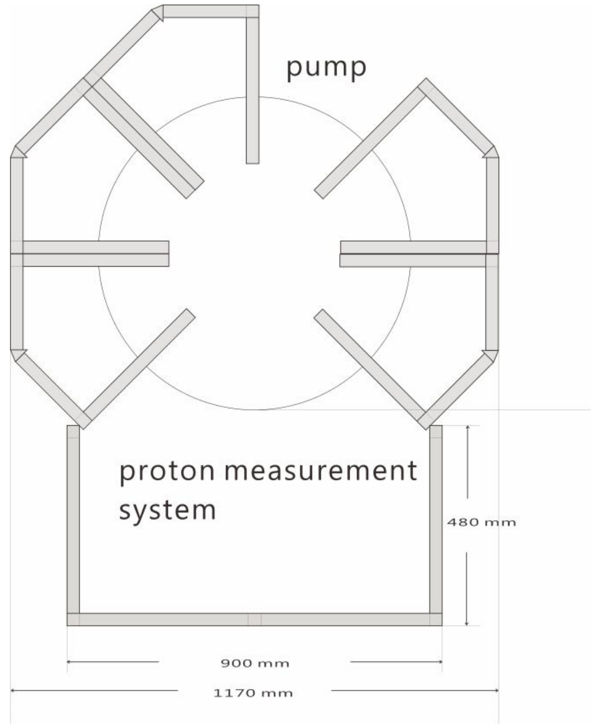
At same applied voltage, *P* of H_2 gas is less than that of D_2 gas.

Calibration of Neutron Detector

Neutron detector

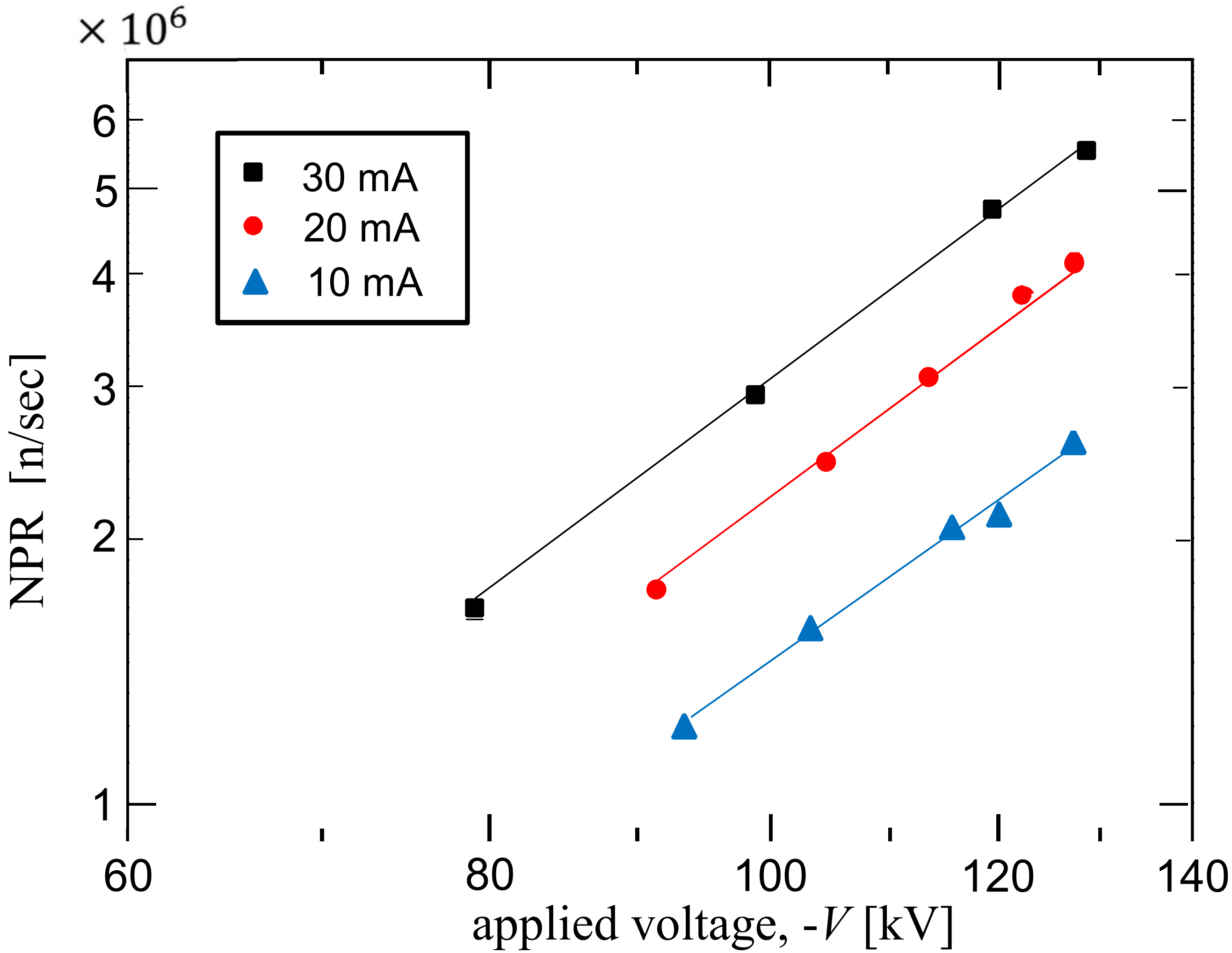


Shield of lead for X ray hazard



We need calibration of neutron counter again.

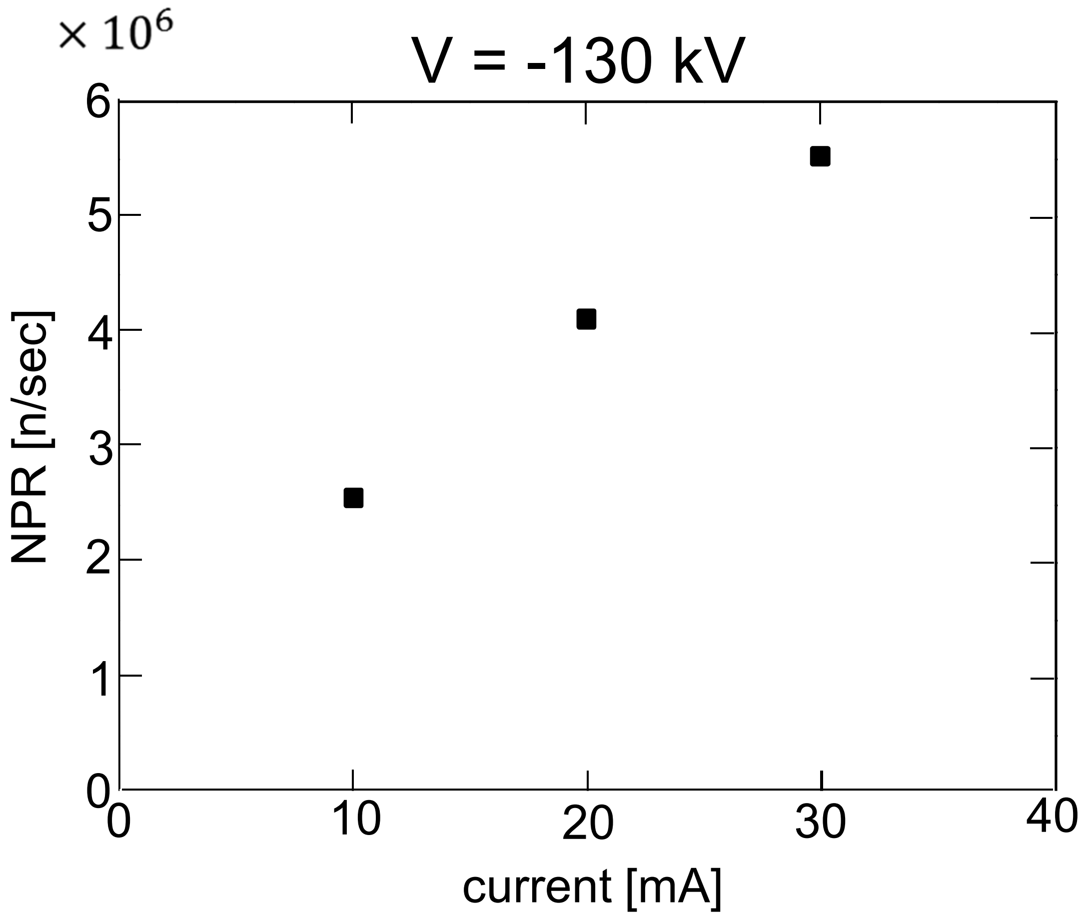
Result of NPR



NPR$\propto V^{2.4\pm0.3}$

Ion energy seems to be 45 keV – 60 keV

NPR Dependence on Current



NPR is nonlinear dependence on *I*.

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Effect of heating anode?

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Summary and Conclusion

- In order to increase ion recirculation and to apply higher voltage, we proposed an IEC device employing a 5-stage feedthrough.
- We expect trajectory with 5-stage feedthrough is 3 times as long as that of single-stage (PIC simulation).
- Applied voltage has reached -180 kV.
- NPR is in proportion to the $V^{2.4\pm0.3}$ when applied voltage is -80 kV to -130 kV.

Future Work

- X-ray shielding.
- Calibration of neutron counter.
- Further conditioning to -200 kV.
- Measure and consider the relation between applied voltage and NPR more.
- Make magnetron ion source for 5-stage device.
- Compare the NPR between single-stage and 5-stage at RS-MIS mode.