16th US-Japan Workshop

Characterization of the discharge plasma in Cylindrical Inertial Electrostatic Confinement Fusion device

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Hotta Lab
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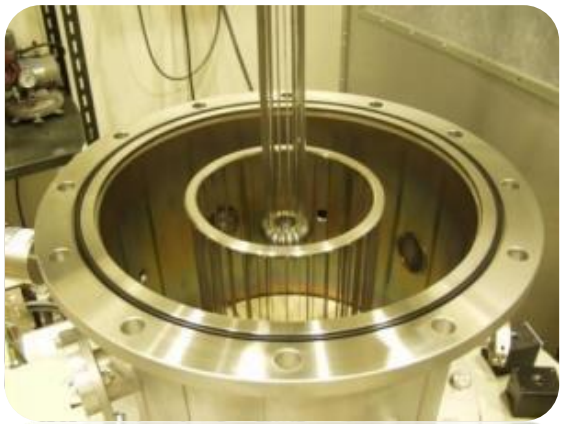
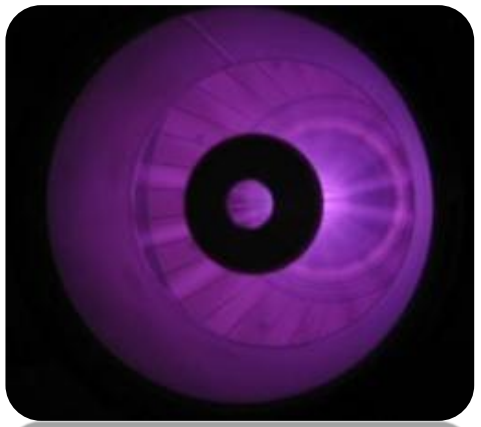
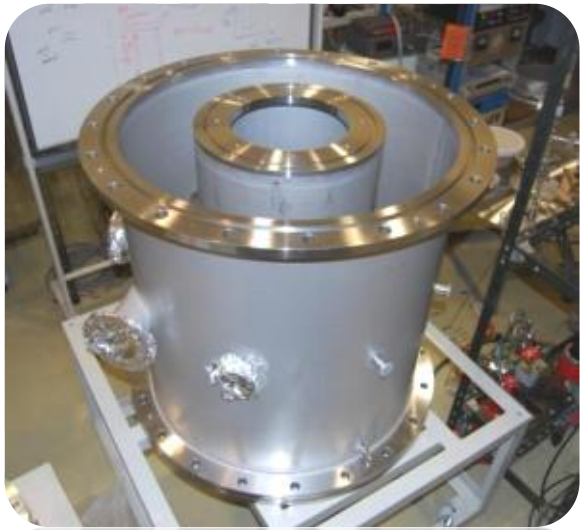
0. IEC DEVICE @ TOKYO TECH

Spherical IEC

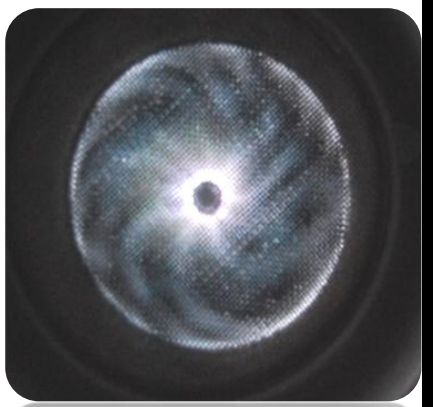




Cylindrical IEC



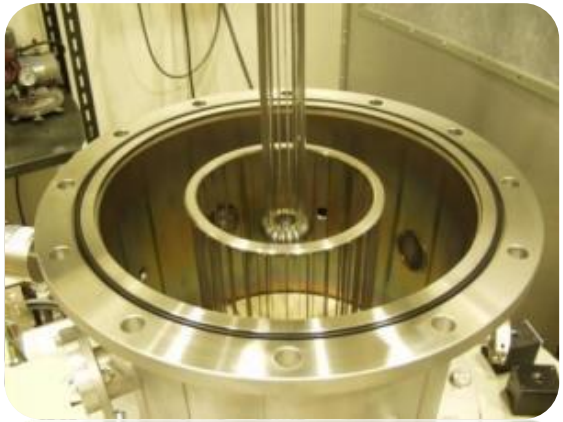
Coaxial Double Cylindrical IEC

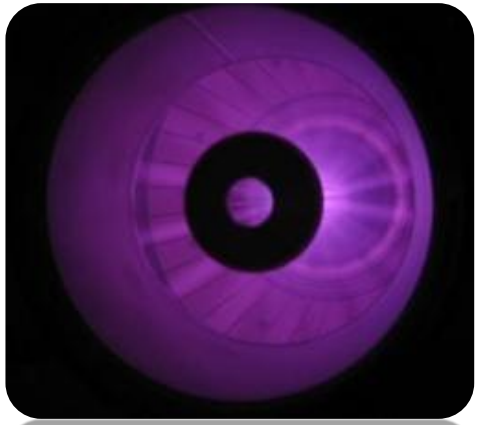


Cylindrical: Magnetic - assisted IEC

0. IEC DEVICE @ TOKYO TECH

Spherical IEC



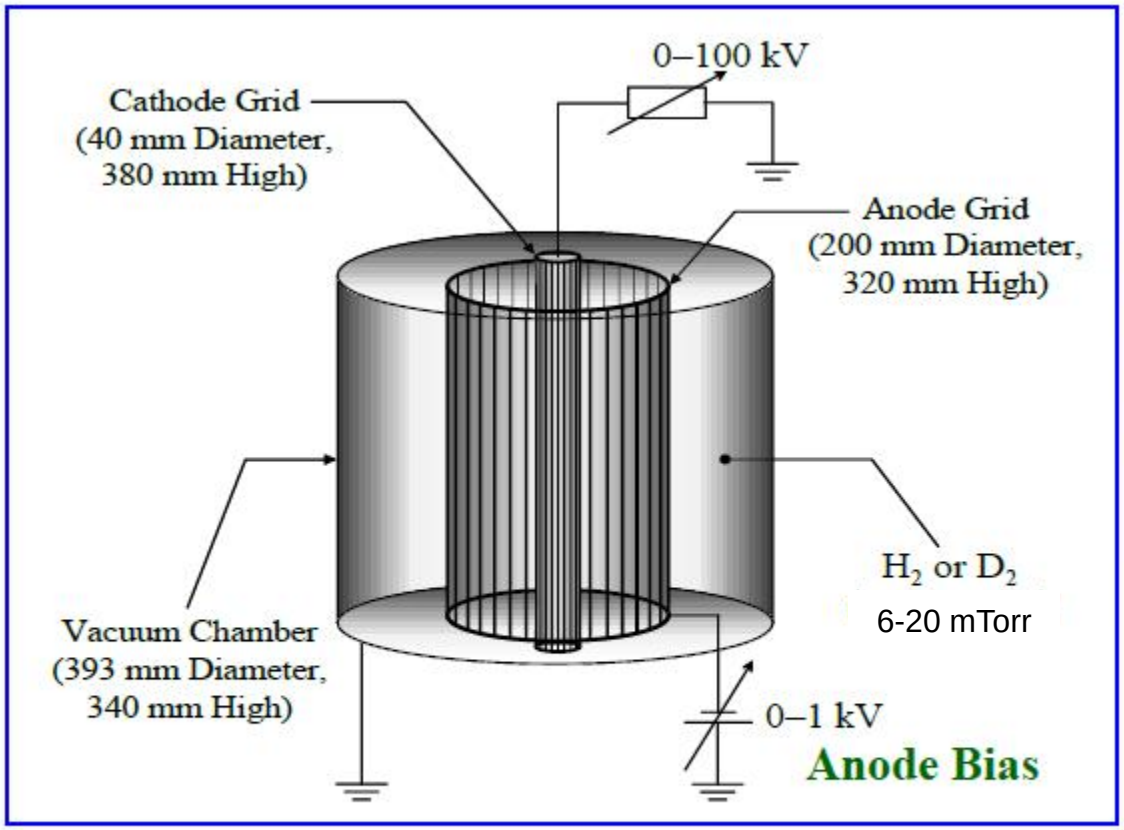


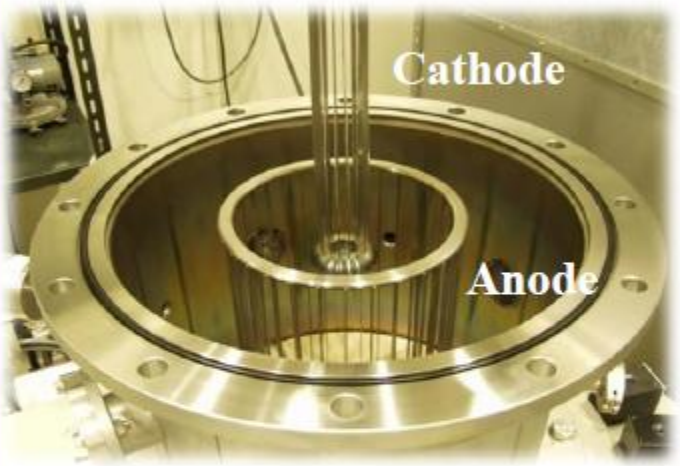
Cylindrical IEC

Coaxial Double Cylindrical IEC

Cylindrical: Magnetic - assisted IEC

1. CYLINDRICAL IEC DEVICE



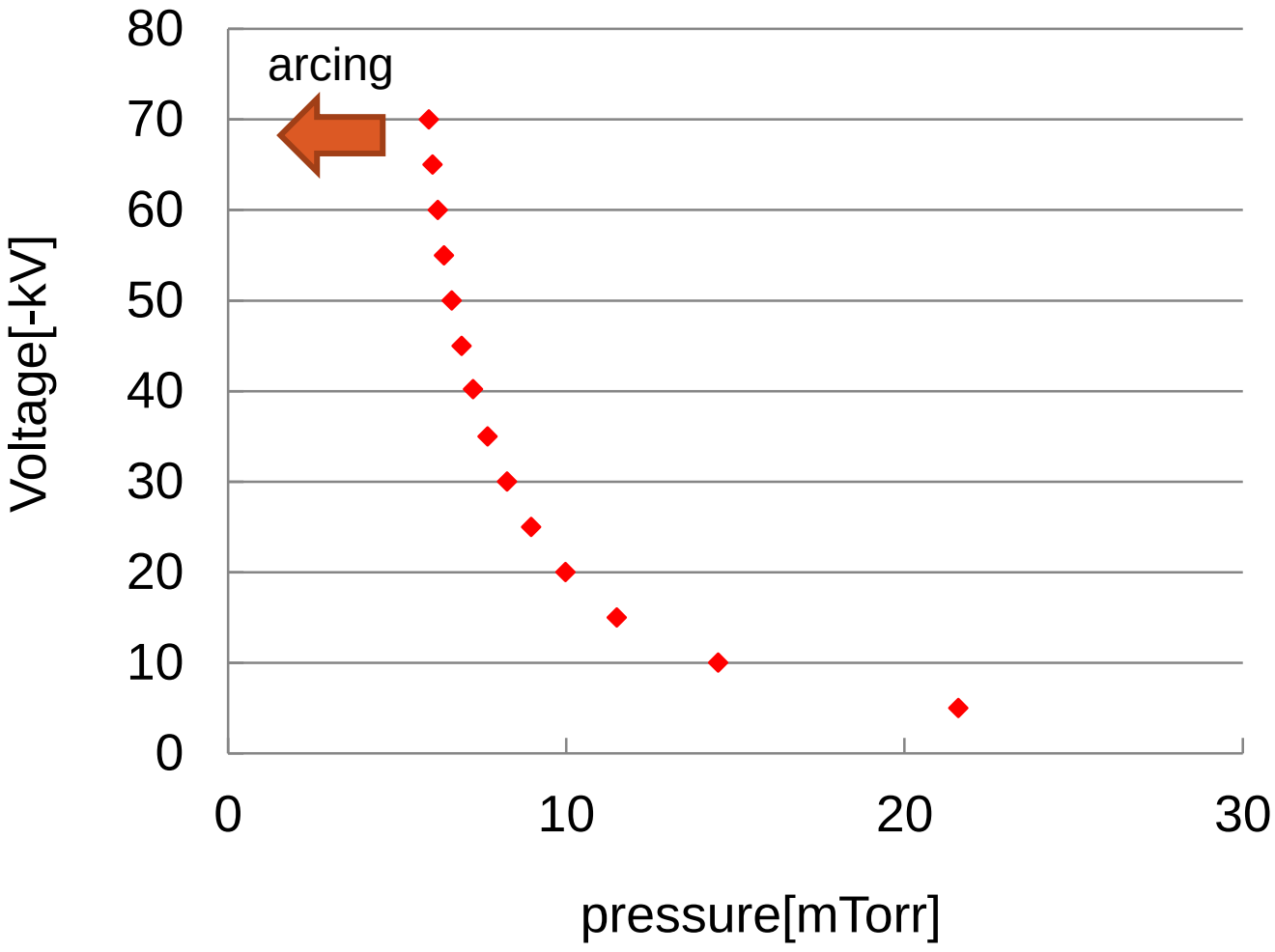


Grid electrodes

Cathode: ϕ1.6-mm Stainless Steel Rod x16
Anode: ϕ1.2-mm Stainless Steel Rod x32

The advantages of cylindrical device

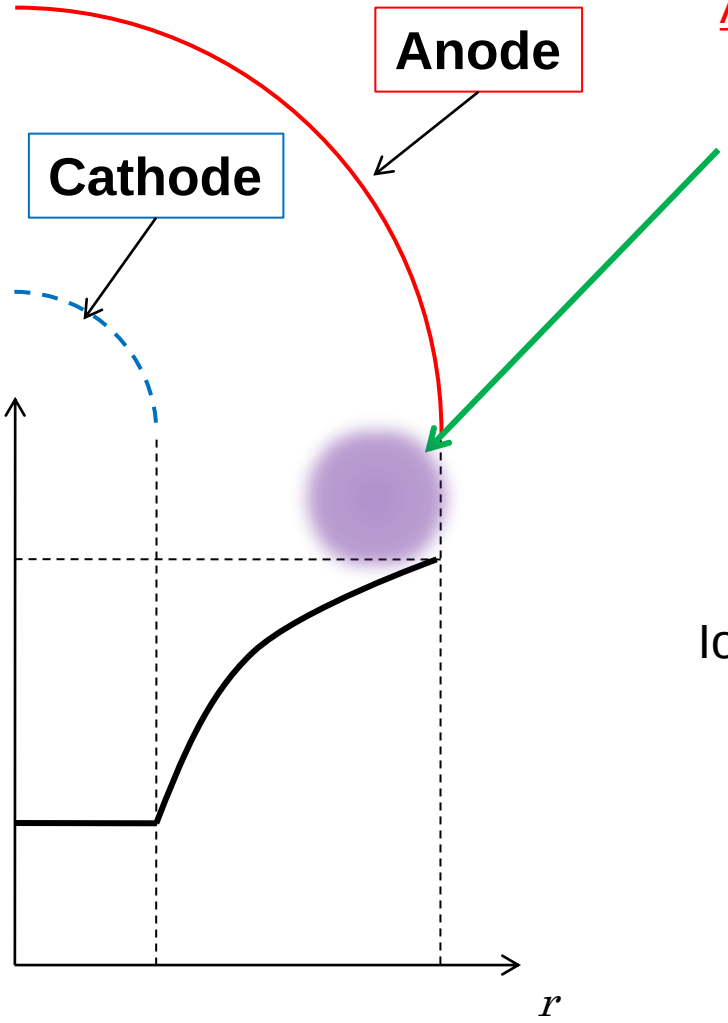
- disturbance of electric field by the feedthrough is small
- the flux of neutron varies in inverse proportion to the distance



Paschen curve (2014/09/19)

Maximum voltage: -70 kV

2. HOW TO INCREASE NPR?



Potential distribution in IEC device

Applying magnetic field

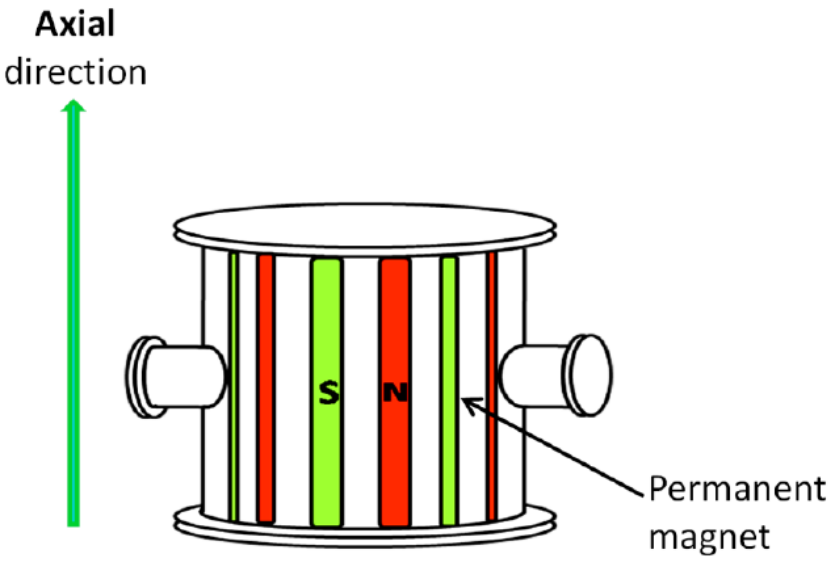
Magnetic field Traps electron around the edge of the potential well

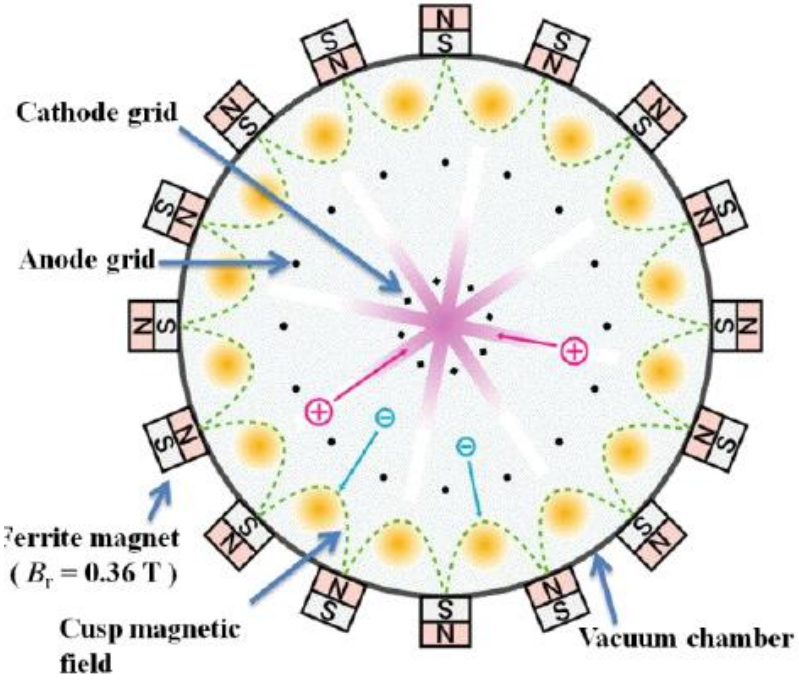
Ionization occurs around there

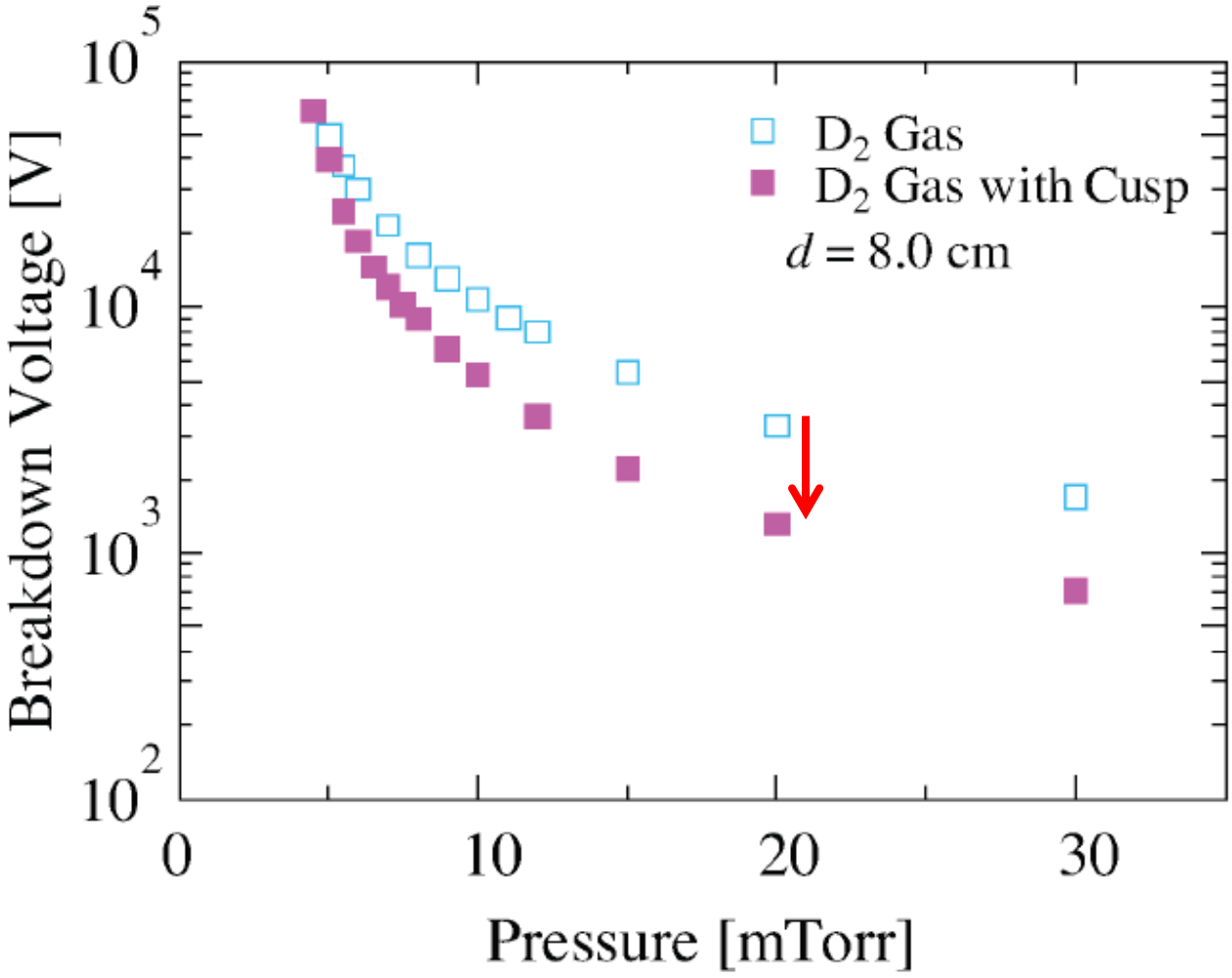
Ions are fully accelerated by the potential

Nuclear fusion reaction UP

3. AXIAL CUSP MAGNETIC FIELD

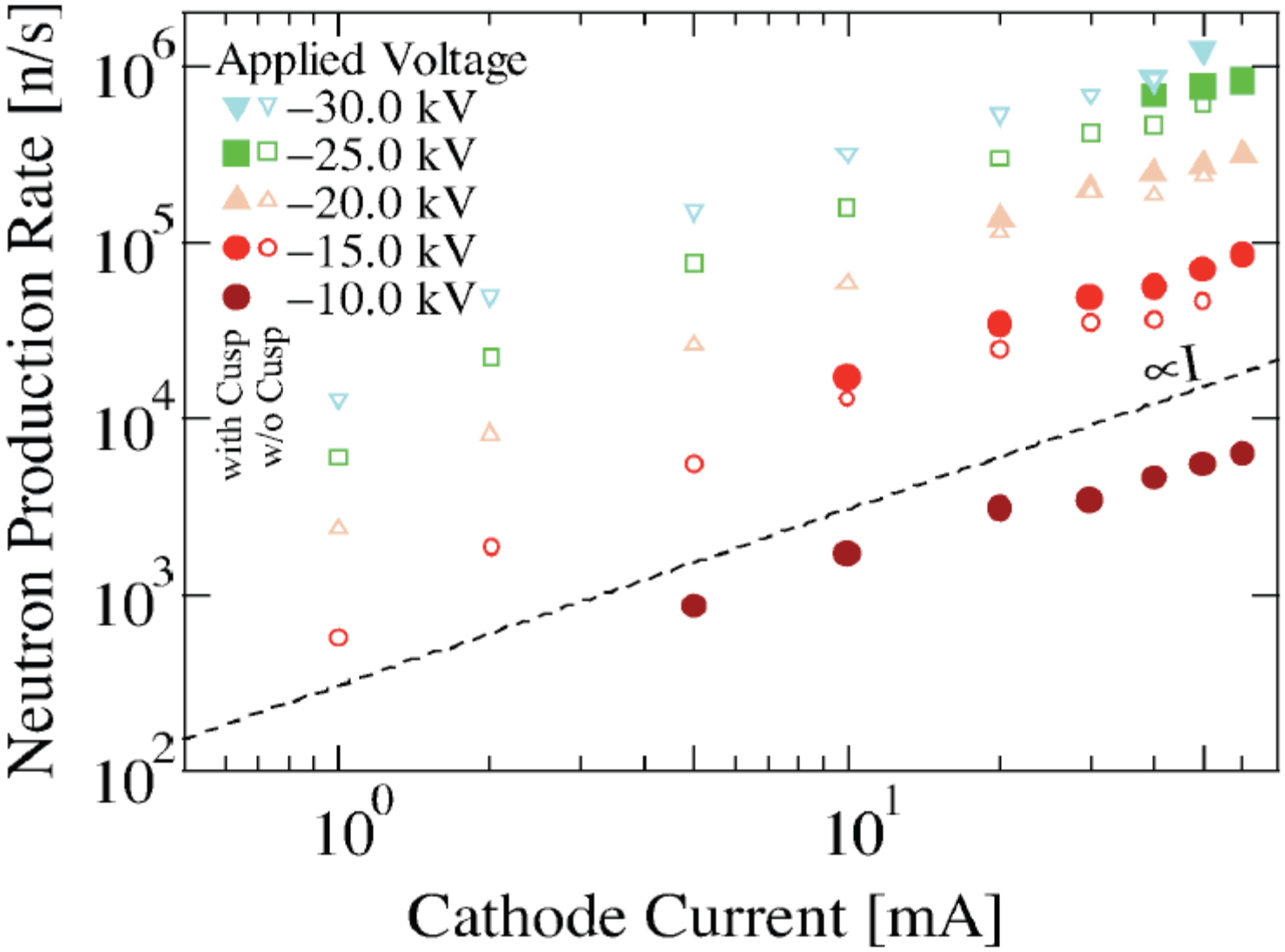




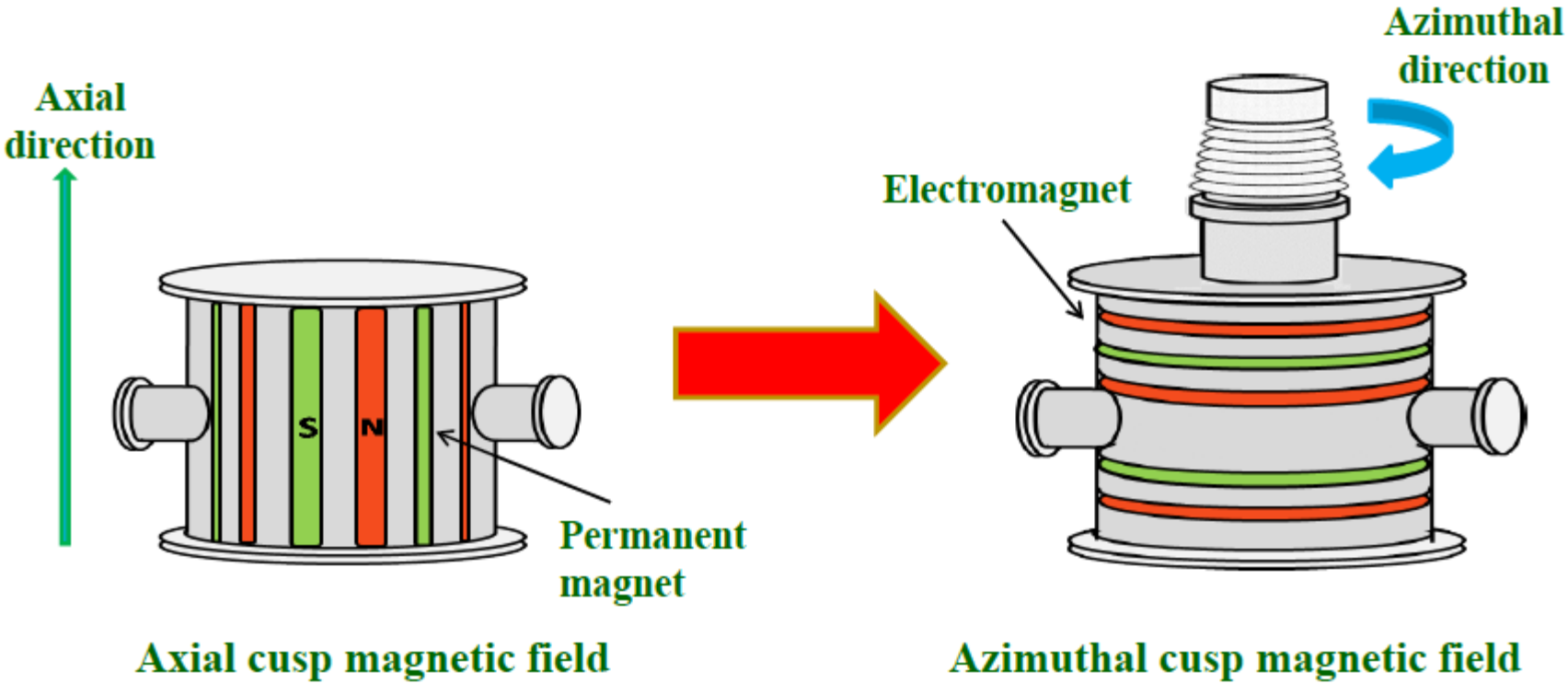


Paschen curve with cusp magnetic field

magnetic field → ions produced → Breakdown voltage decreased

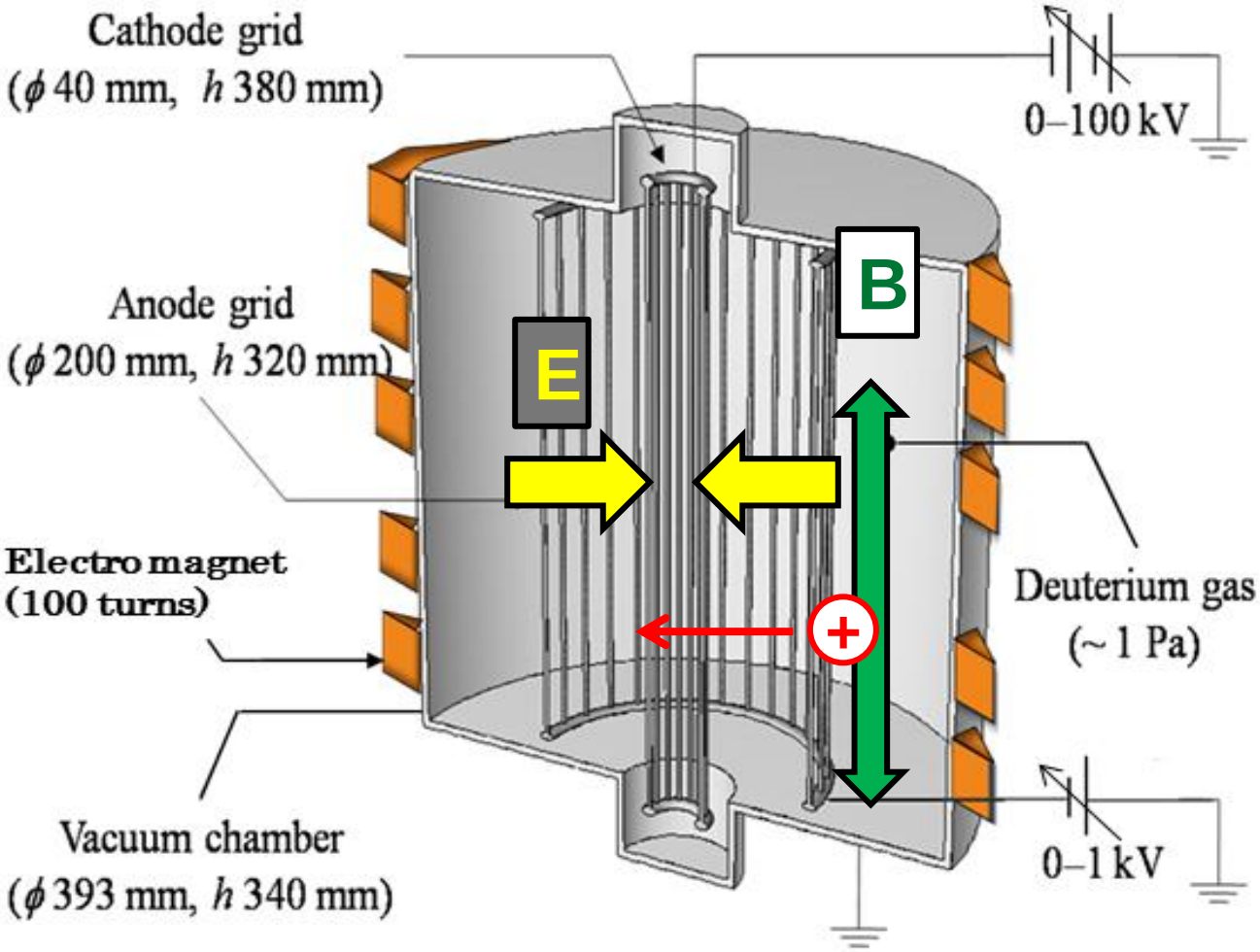


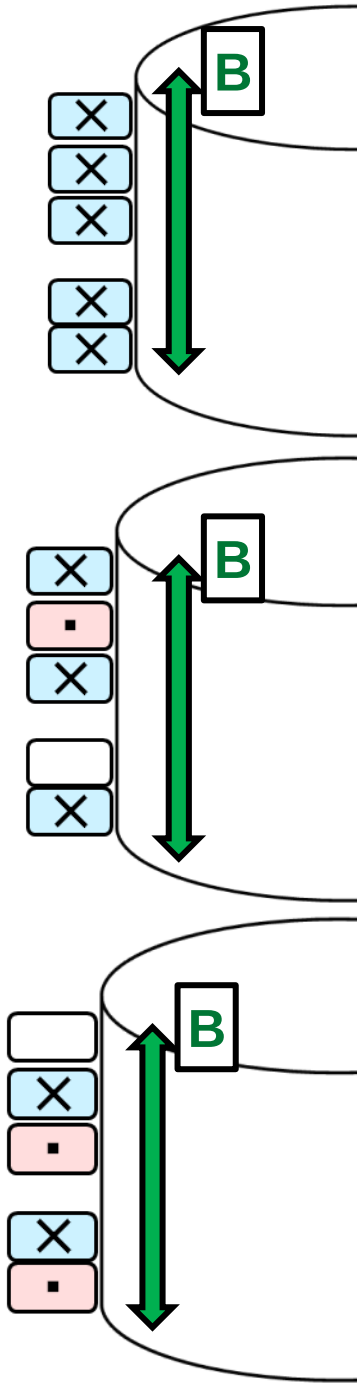
NPR vs. Cathode Current with axial cusp magnetic field

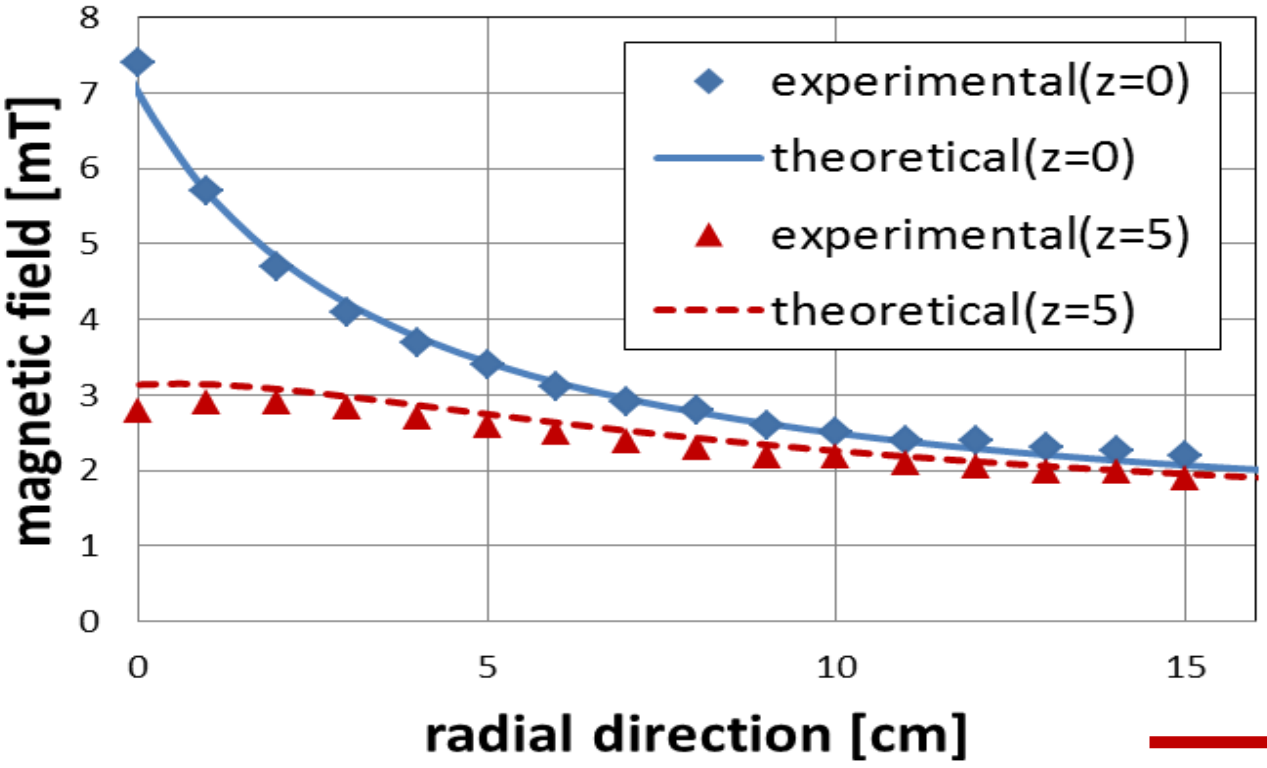


Electron moves to axial direction by $\boldsymbol{E} \times \boldsymbol{B}$ drift

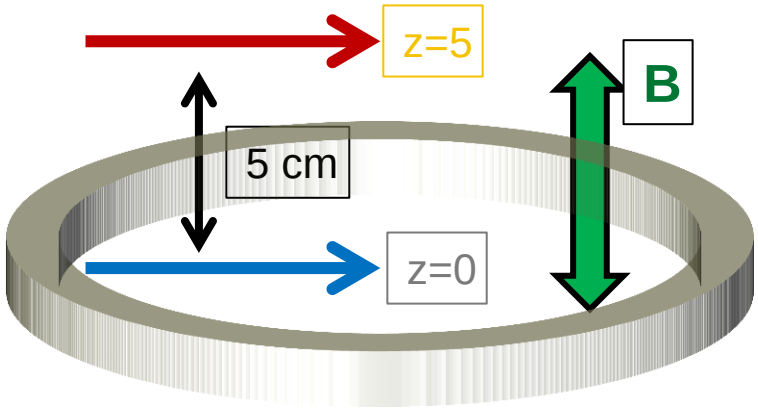
4. AZIMUTHAL CUSP MAGNETIC FIELD



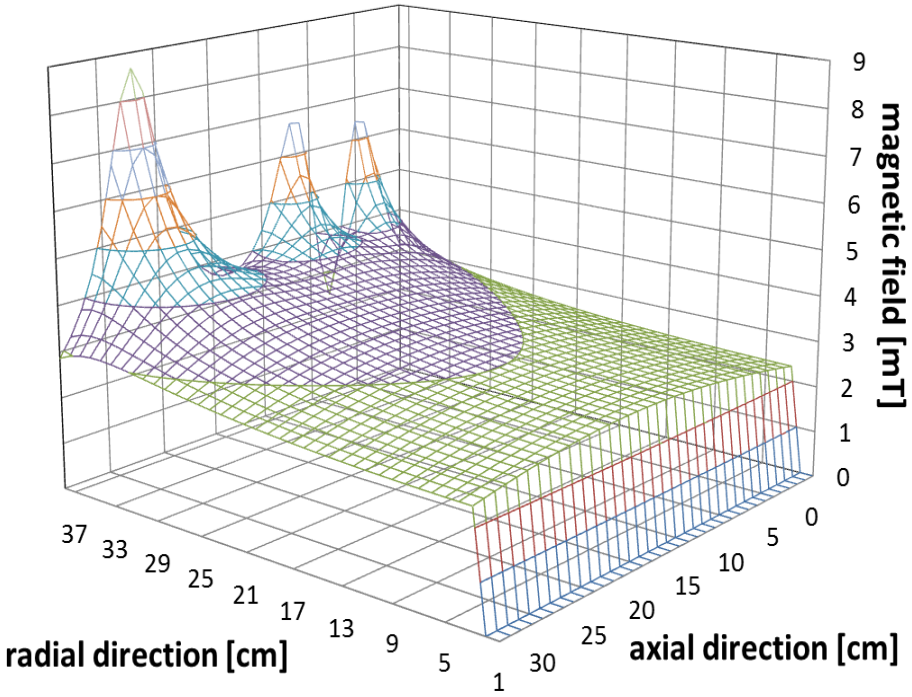


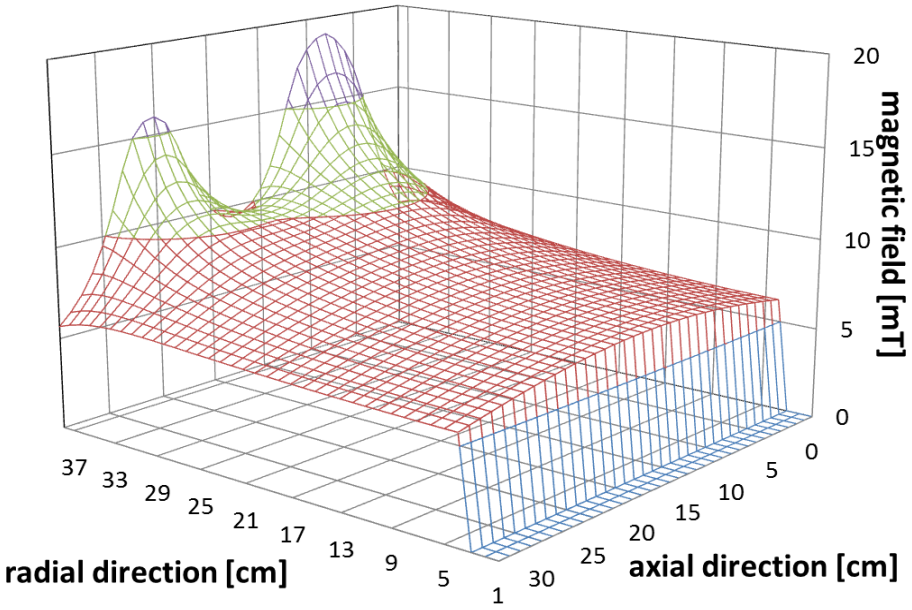


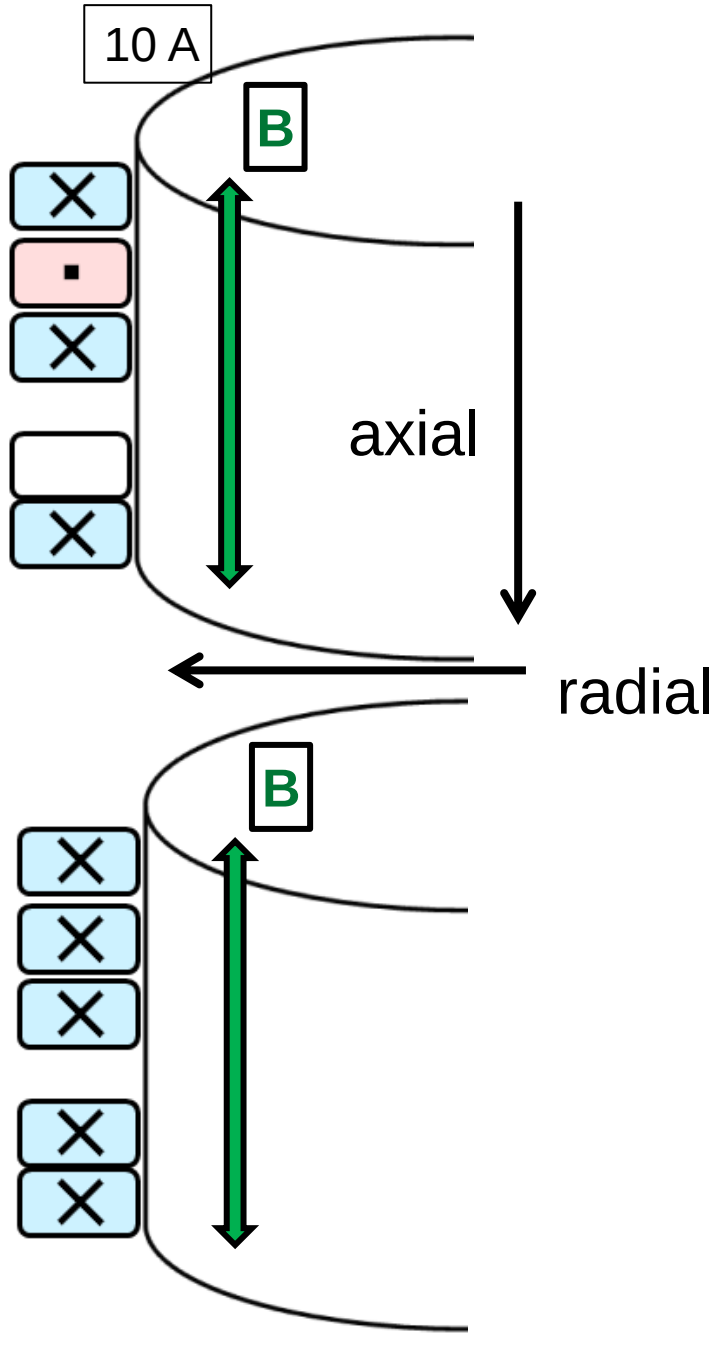
coil (10 A)

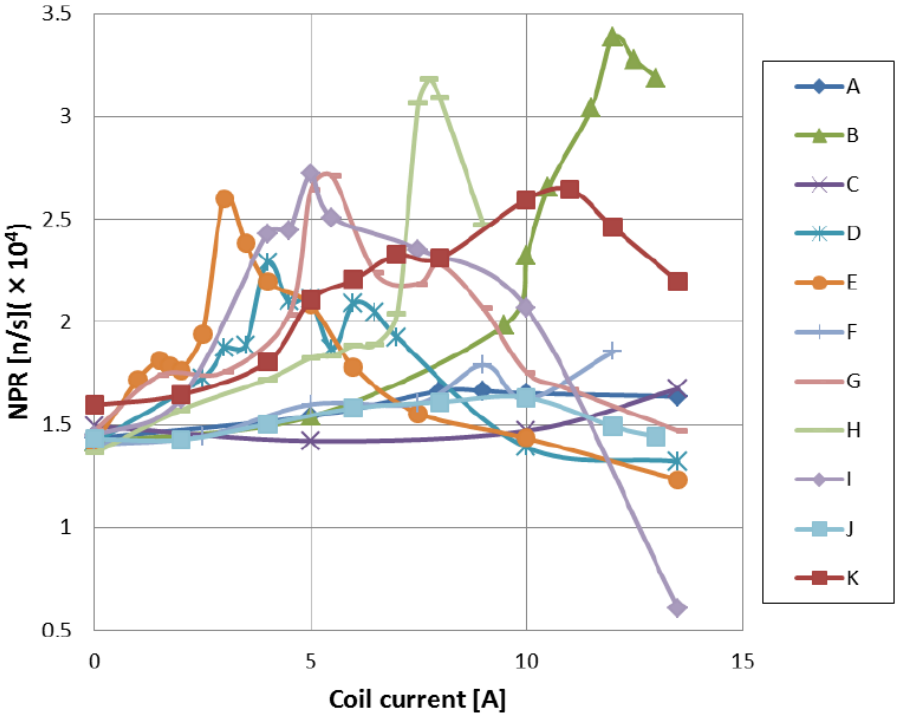


experimental value is
consistent with theoretical value

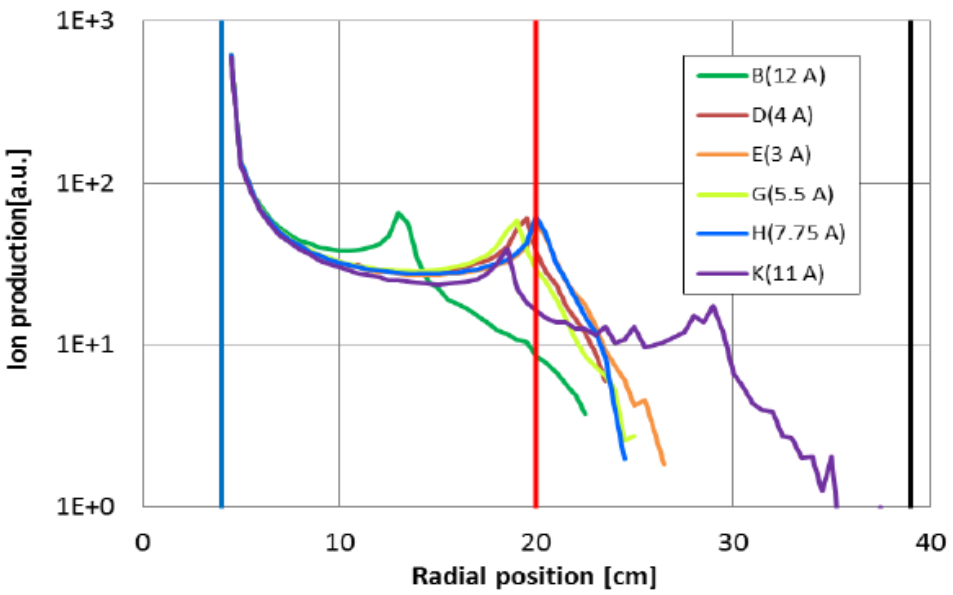

magnetic field [mT]
0
1
2
3
4
5
6
7
8
9
radial direction [cm]
37
33
29
25
21
17
13
9
5
1
axial direction [cm]
0
5
10
15
20
25
30


magnetic field [mT]
0
5
10
15
20
radial direction [cm]
37
33
29
25
21
17
13
9
5
1
axial direction [cm]
0
5
10
15
20
25
30

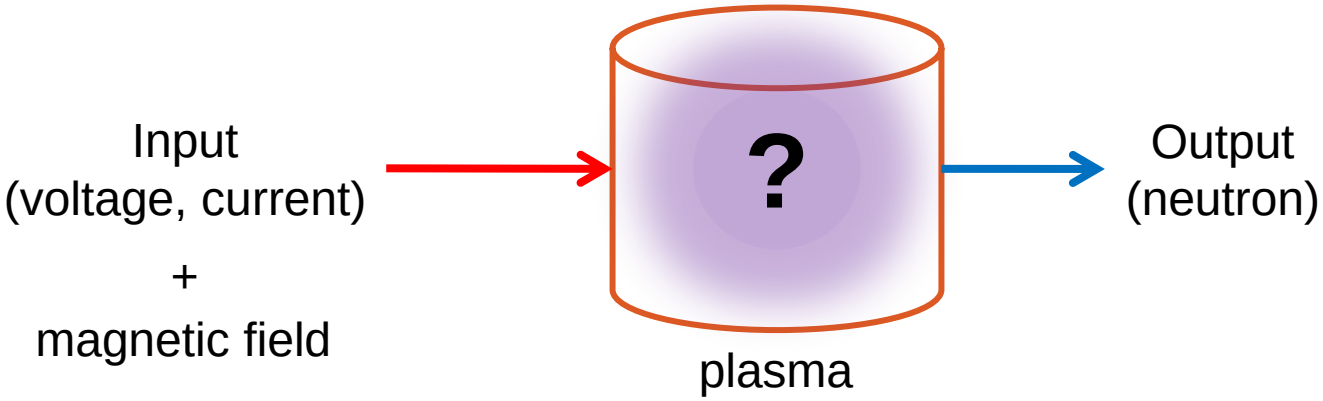

10 A
B
axial
radial
B

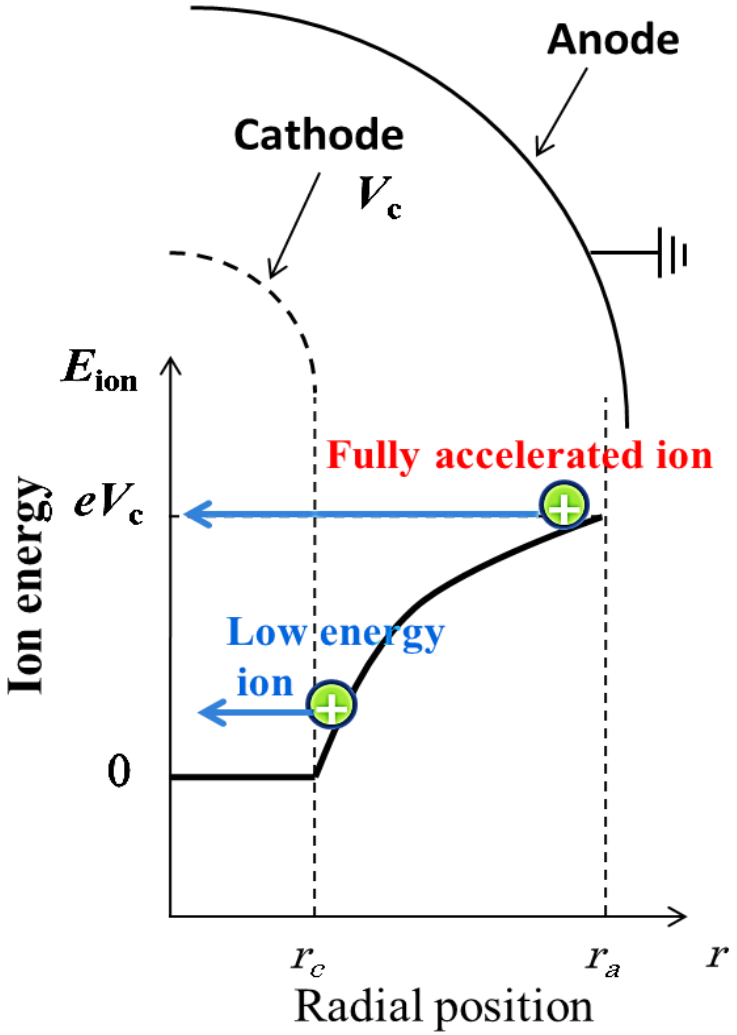


NPR vs. magnetic field strength (coil current)



Ion production at NPR max (simulation)





Ions are produced near the anode (Simulation)

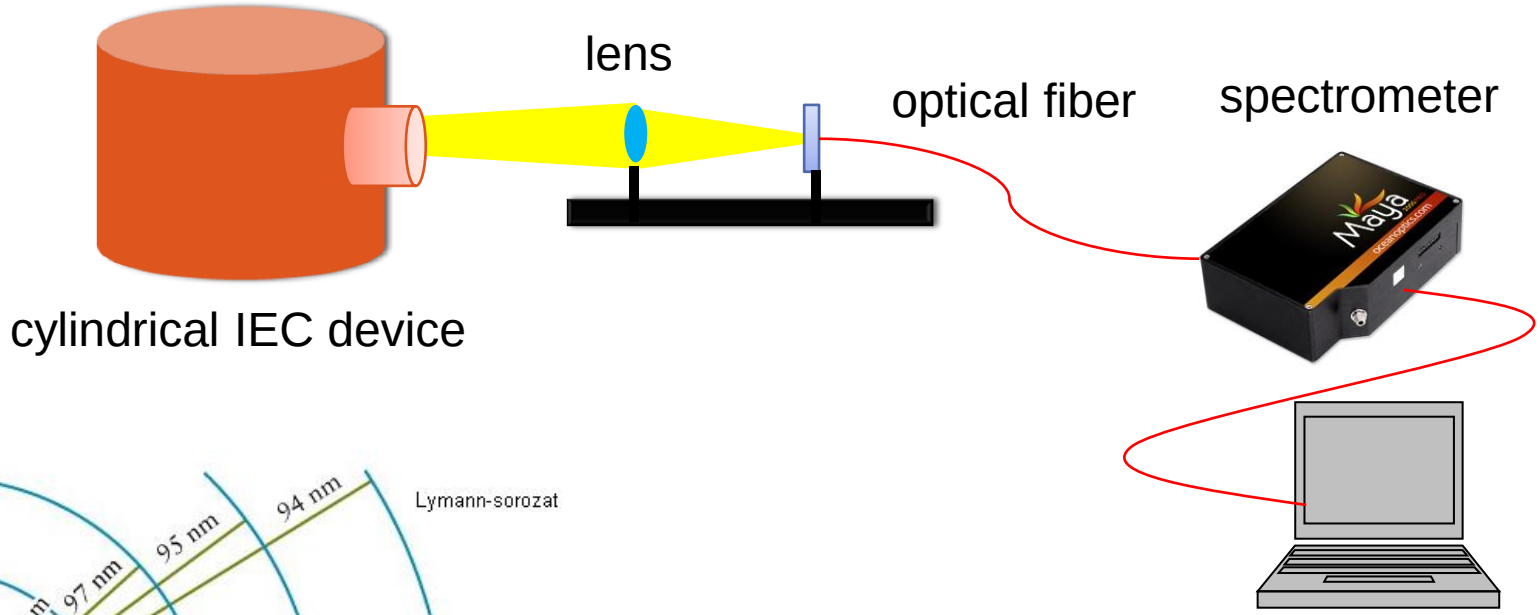
Ions are fully accelerated by the potential...?

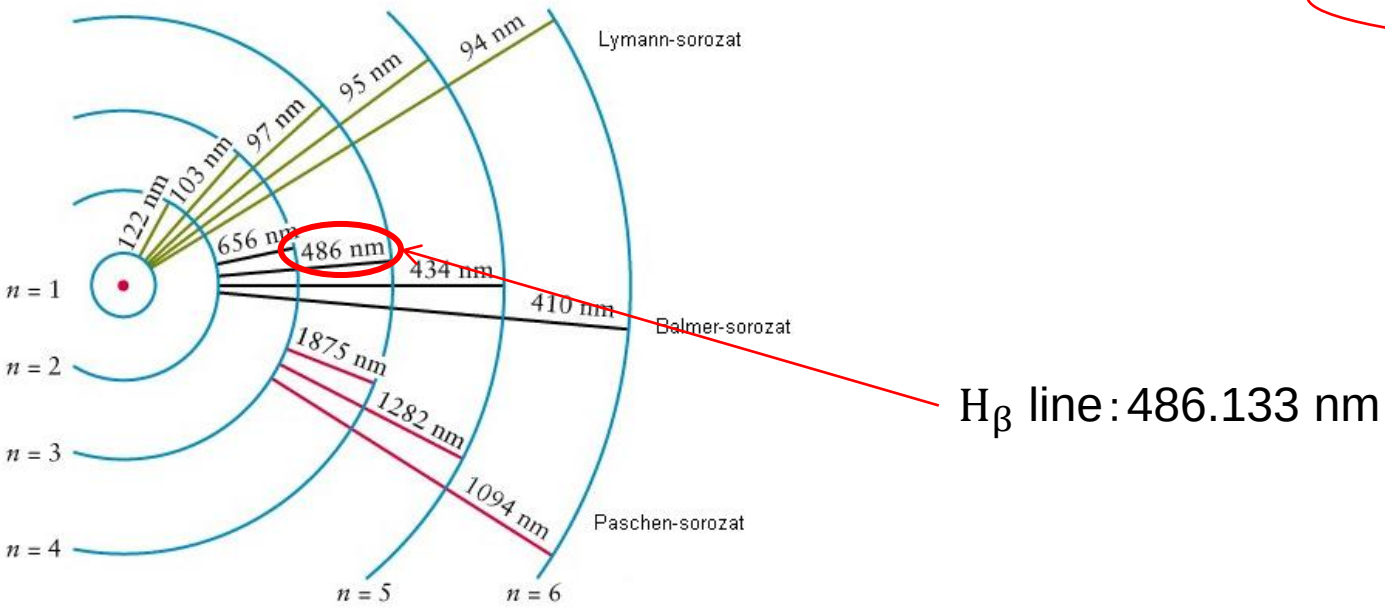
Measure the ion energy distribution

→ Spectroscopy

■Advantage of spectroscopy
- non-contact
- not use probe

5. SPECTROSCOPY





H_β line : 486.133 nm

6. SPECTRAL PROFILE

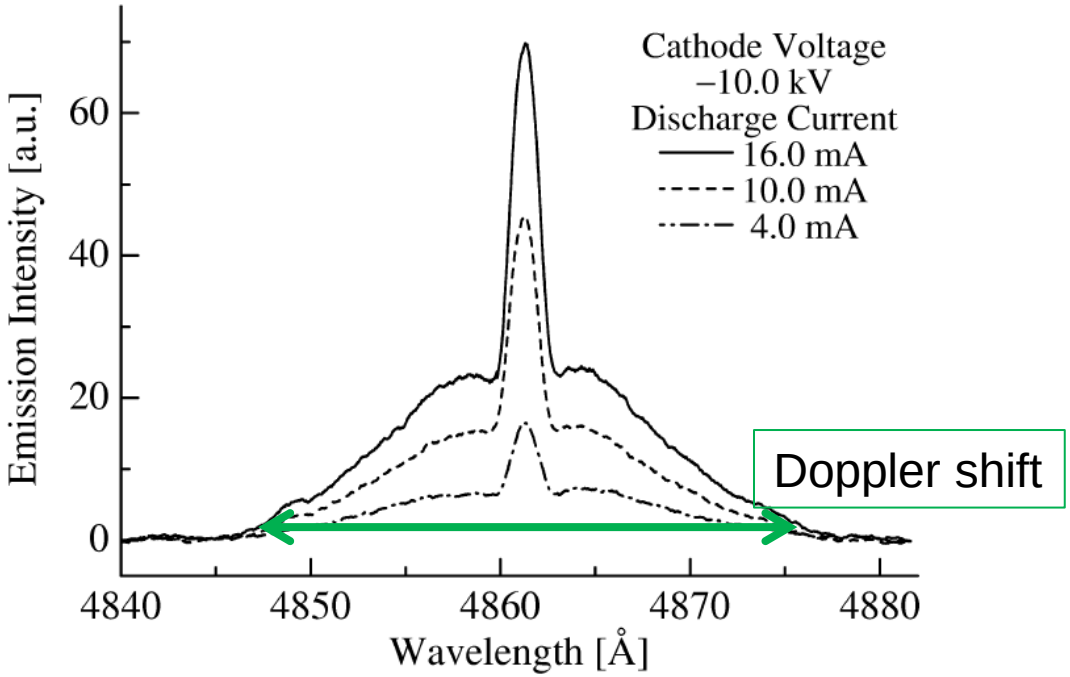
Ions(H^+, H_2^+, H_3^+) are produced by discharge

acceleration →

Charge-Exchange reaction: $H^+(\text{fast}) + H \rightarrow H^*(\text{fast}) + H^+$

same direction

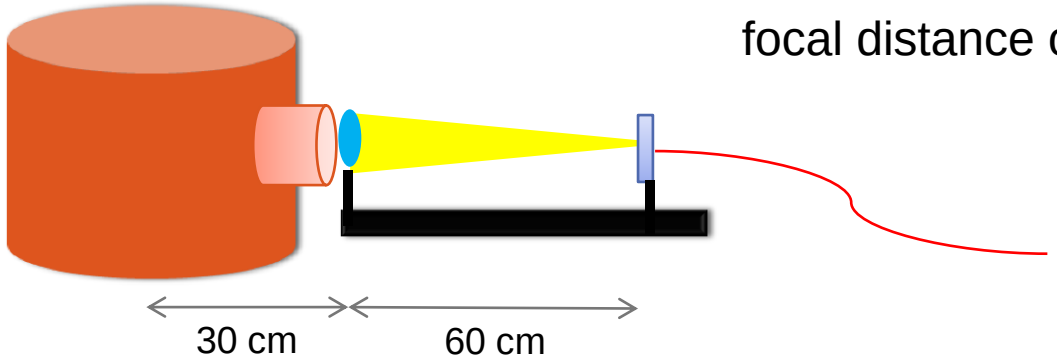
λ



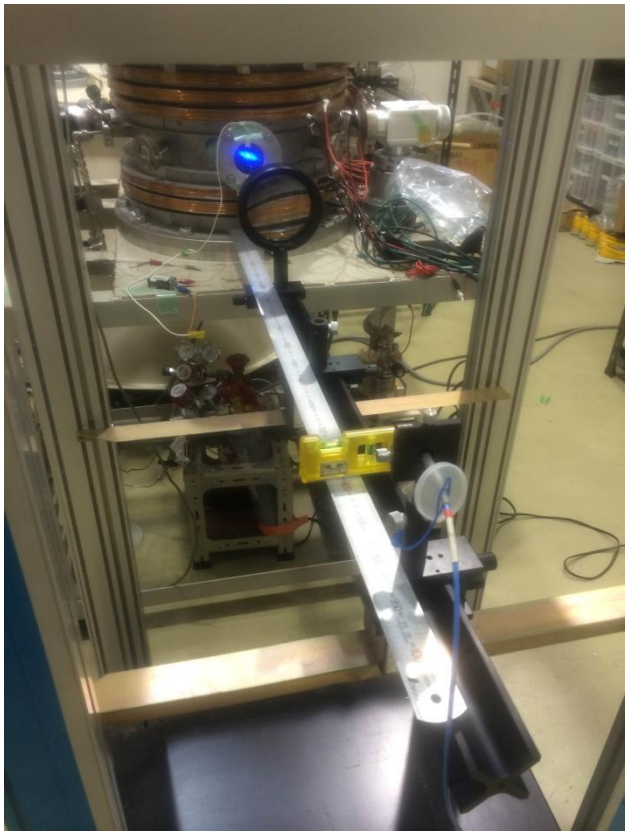
$$\lambda = \lambda_0 \pm \frac{v}{c}\lambda_0$$

spectral profile of H_β line(measured in spherical device)

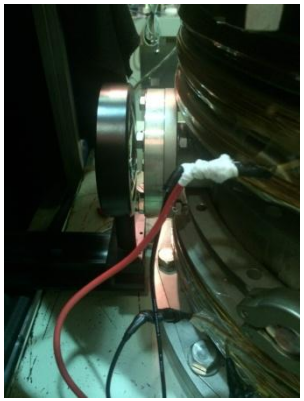
Σ(Energy of neutral particle)≒Energy of ion beam



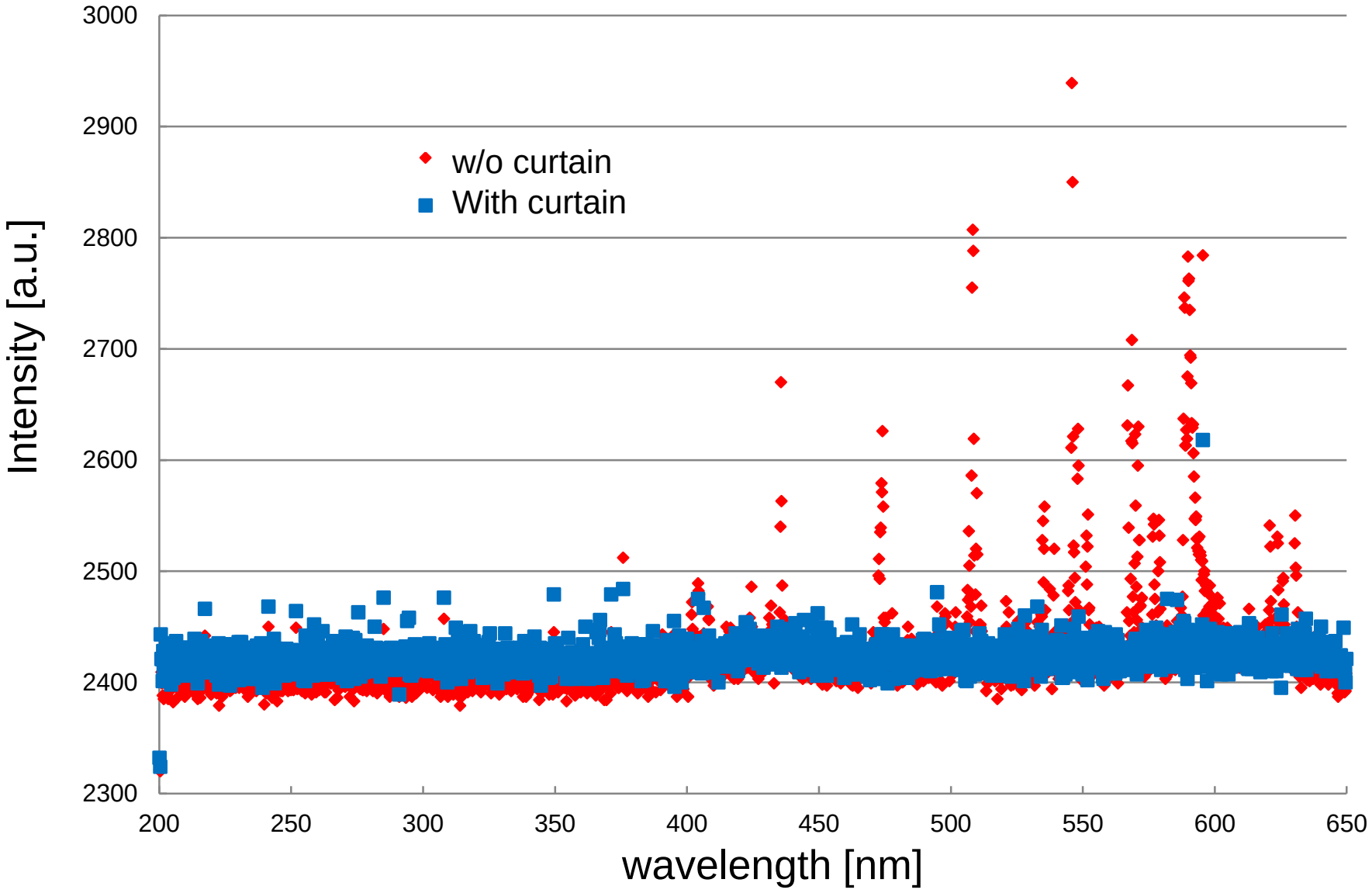
focal distance of lens: 20 cm



Alignment of the spectroscopic system



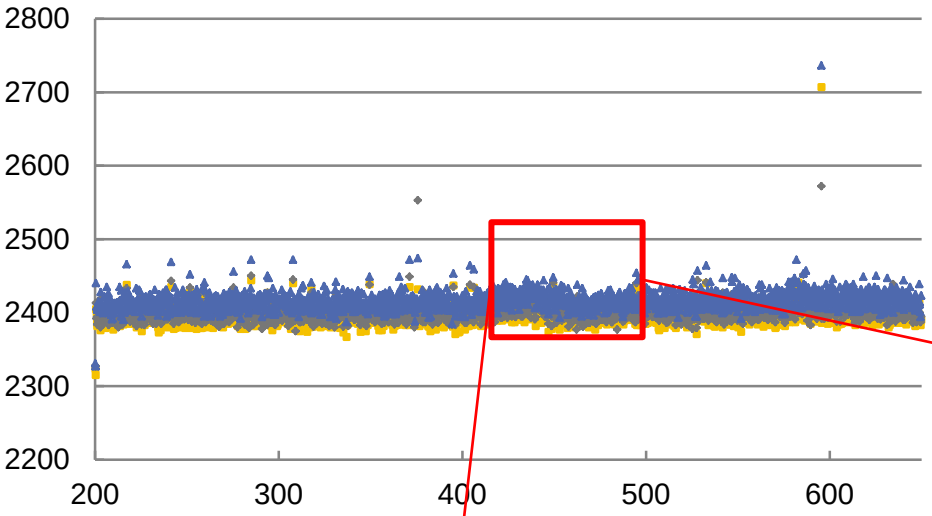
The lens and optical fiber is covered with blackout curtain

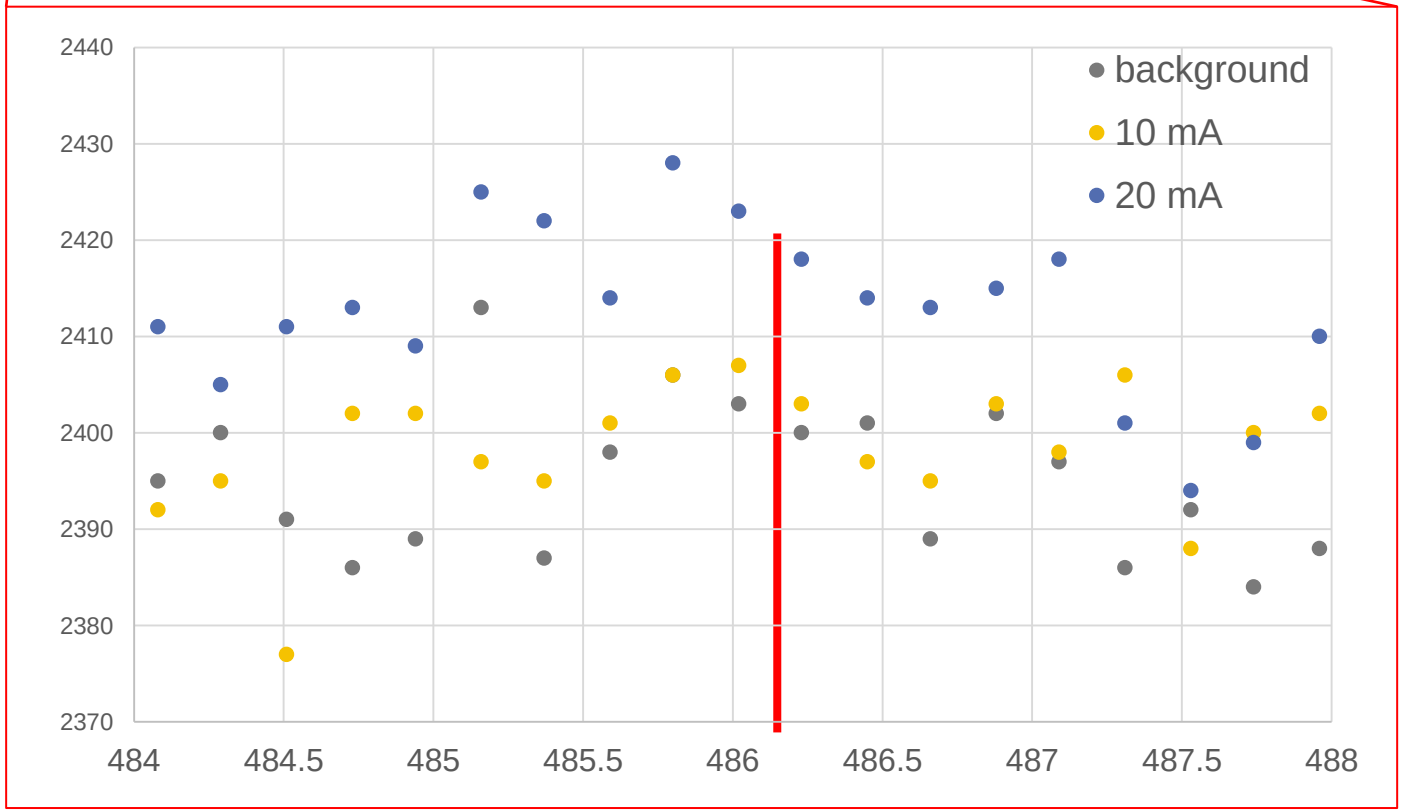


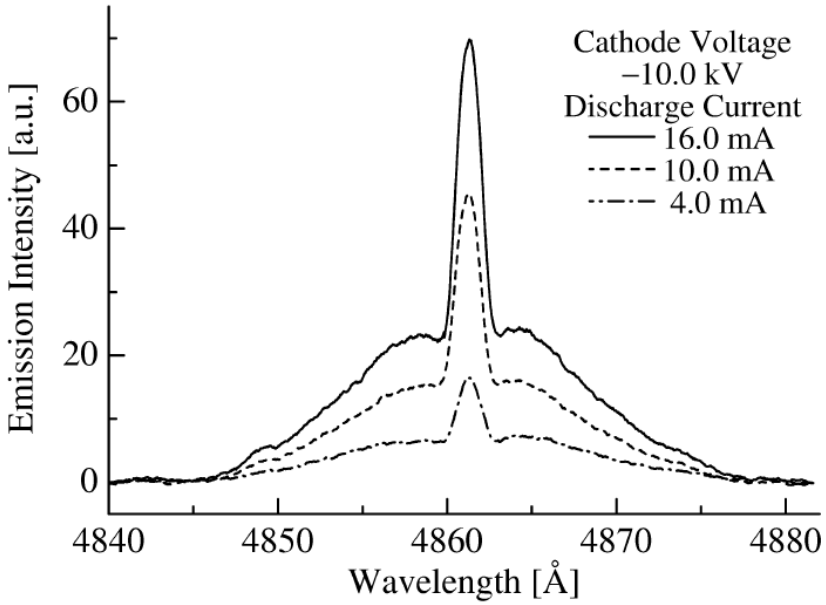
Effect of the blackout curtain(2014/09/20)

6. RESULT

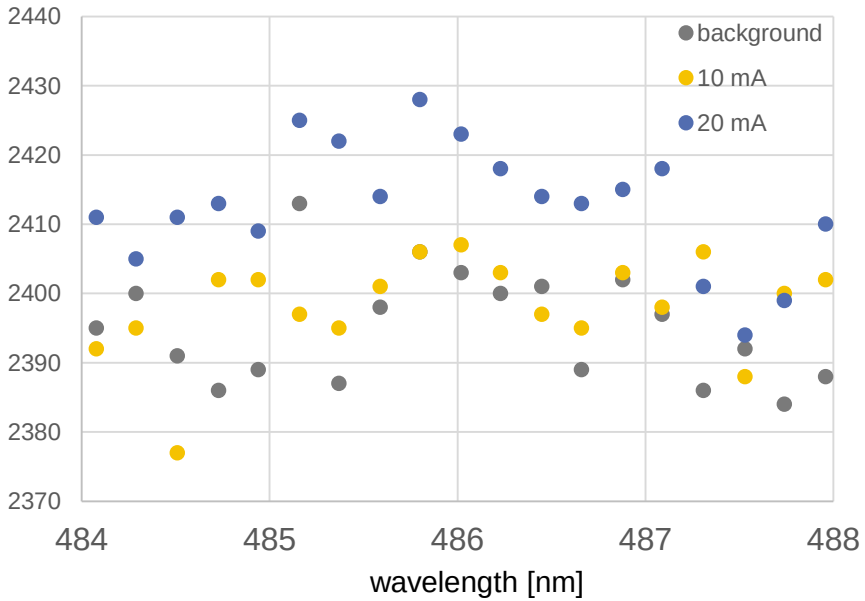
pressure: 10 mTorr
voltage: -12 kV
(2014/09/21)







expectation



result

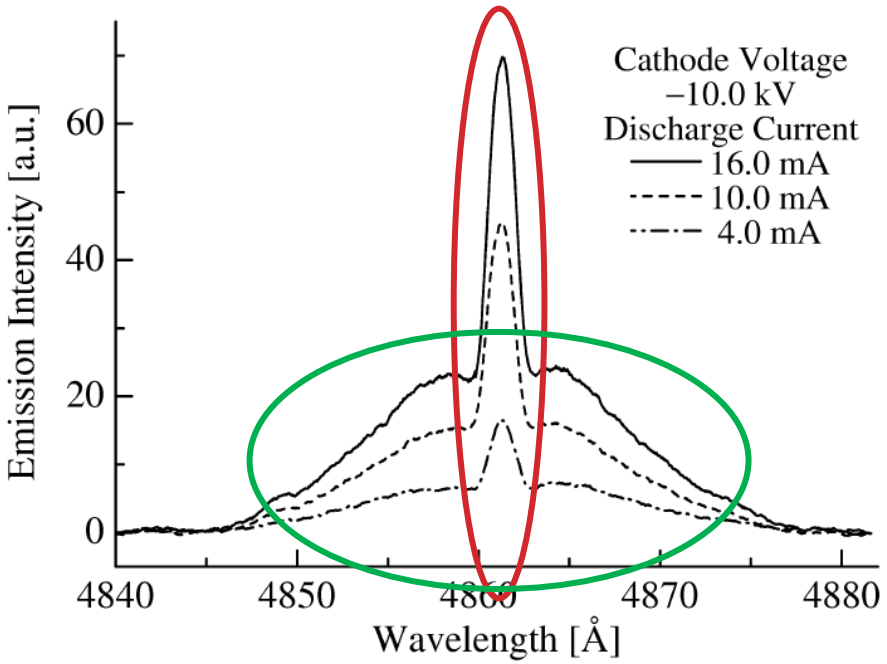
Why?

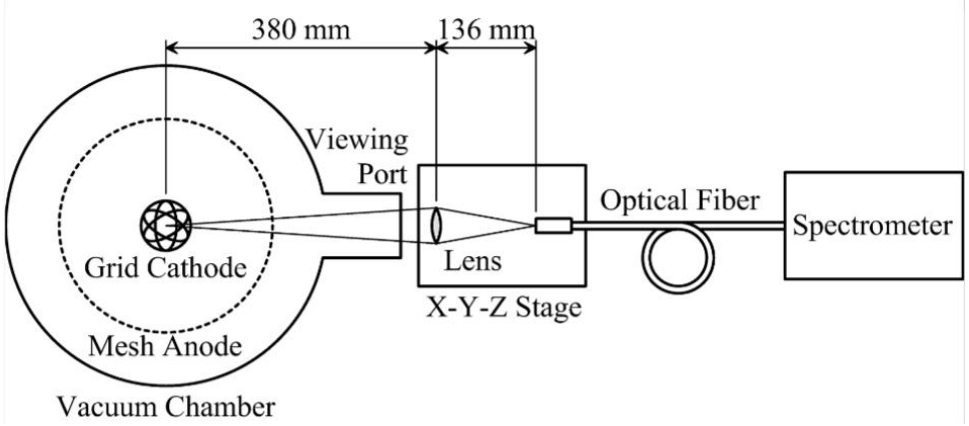
7. DISCUSSION

Why the spectra can not be measured?

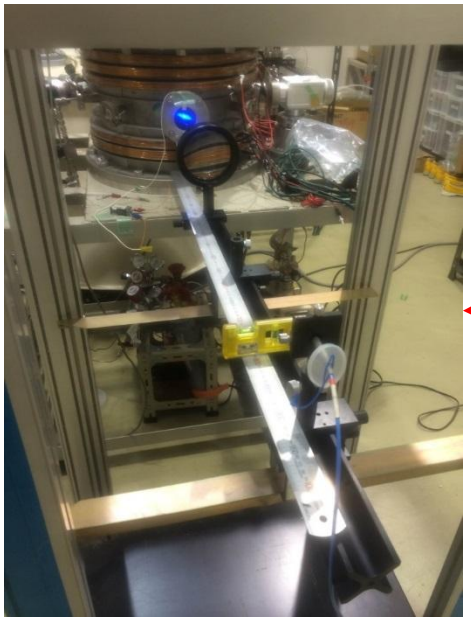
Wavelength resolution of the spectrometer: 2.2 Åm

→ Peak around can not be measured...
but why spread around the center can not be measured?





Spectroscopy system in previous research



My spectroscopic system

There may be something that not on paper…?

8. SUMMARY AND PLAN

Main topic of my research

Cylindrical IEC device + Magnetic field → spectroscopy

Magnetic field : Suppose to increase neutron production rate
Spectroscopy: To measure the spectra and energy distribution

Future plans

- Study on measuring the spectra w/o magnetic field
  ex. Intensity of spectra vs. distance from center of the device
- Study on measuring the spectra with magnetic field
  ex. Comparison with w/o magnetic field for energy distribution