H^- Ion Source in KURRI FFAG

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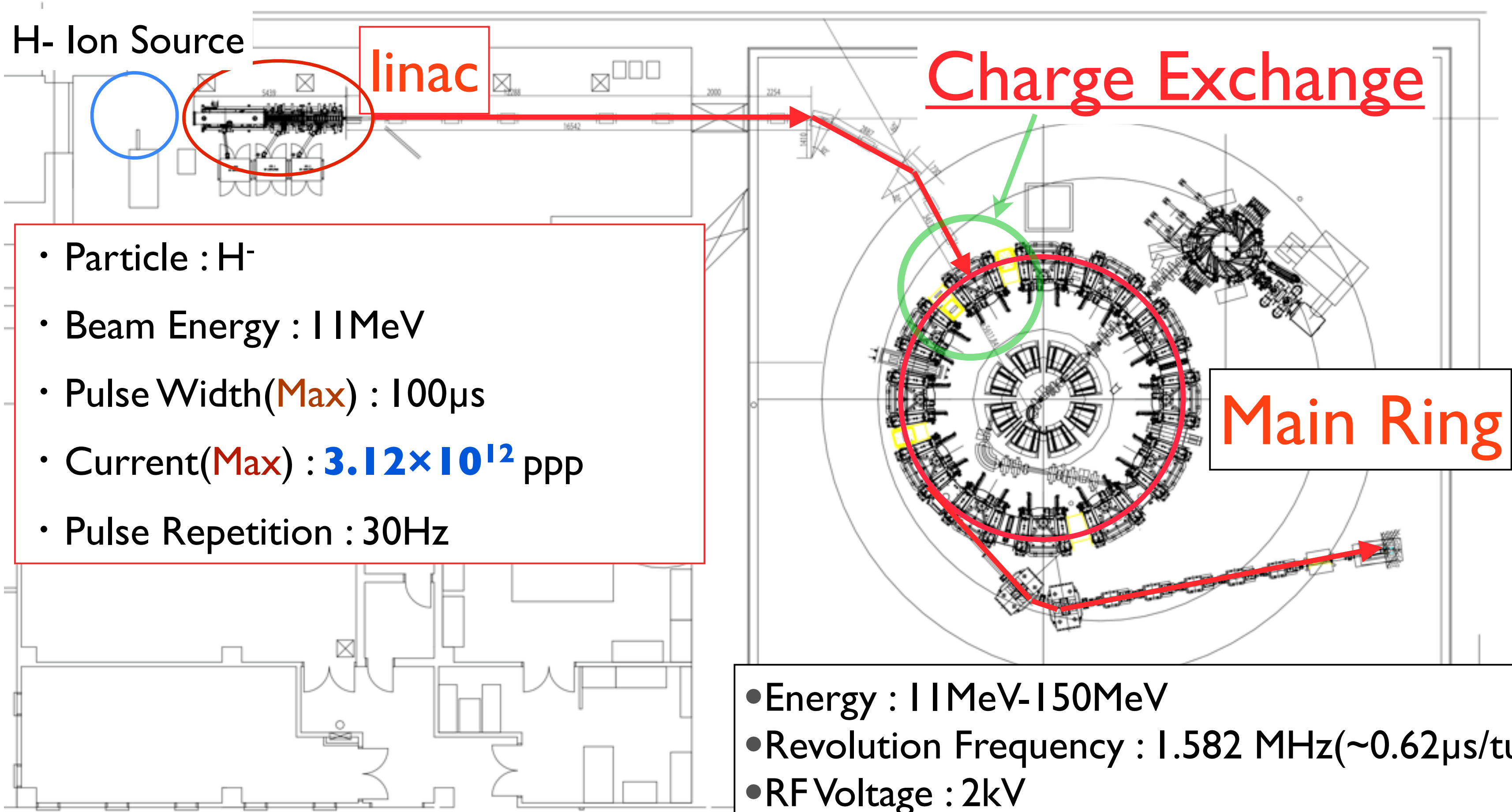
Contents

New H- Injection Line



- Particle : H^-
- Beam Energy : 11MeV
- Pulse Width(Max) : 100μs
- Current(Max) : **3.12×10^{12}** ppp
- Pulse Repetition : 30Hz

- Energy : 11MeV-150MeV
- Revolution Frequency : 1.582 MHz(~0.62μs/turn)
- RF Voltage : 2kV

Charge of the Beam from linac is exchanged at that point.

Try to optimize the H- ion source

H- Ion Source

There are two kinds of ion source.

	Surface Production	Volume Production
power efficiency	high	low
Gas efficiency	high	low
Cesium injection	necessary	unnecessary
Beam Brightness	low	high

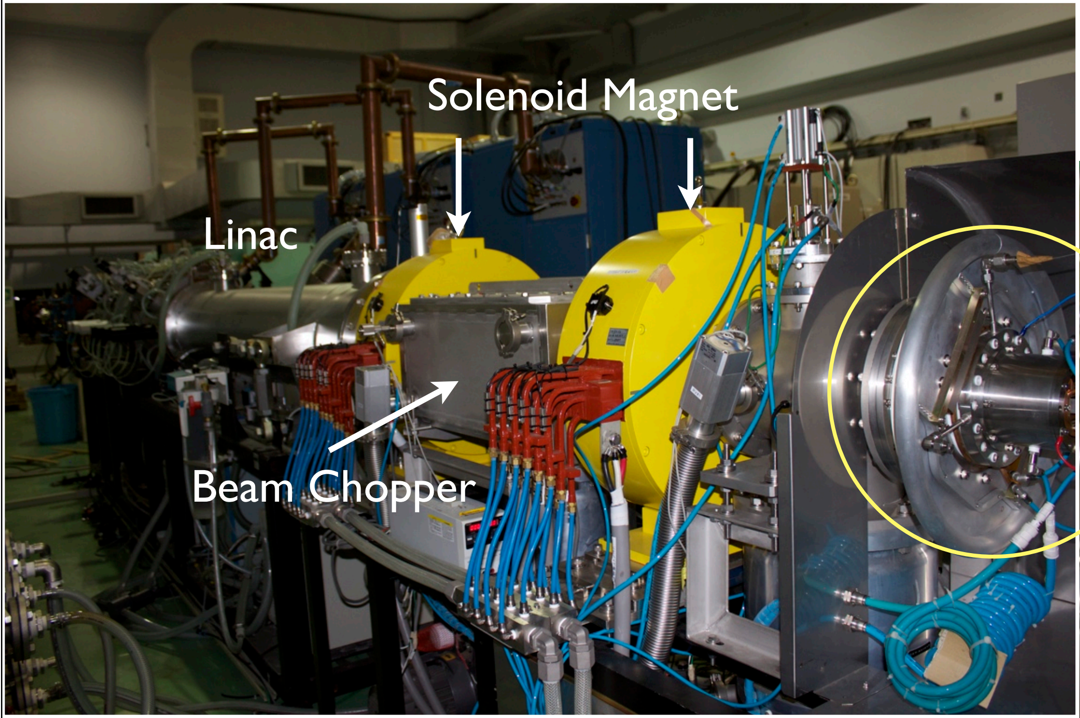
The first invented ion source is surface production type but recently volume production type is invented.

In a surface production type , an efficiency of creating H- ion is high but cesium injection is necessary , so the emittance of the extracted ion beam becomes larger.

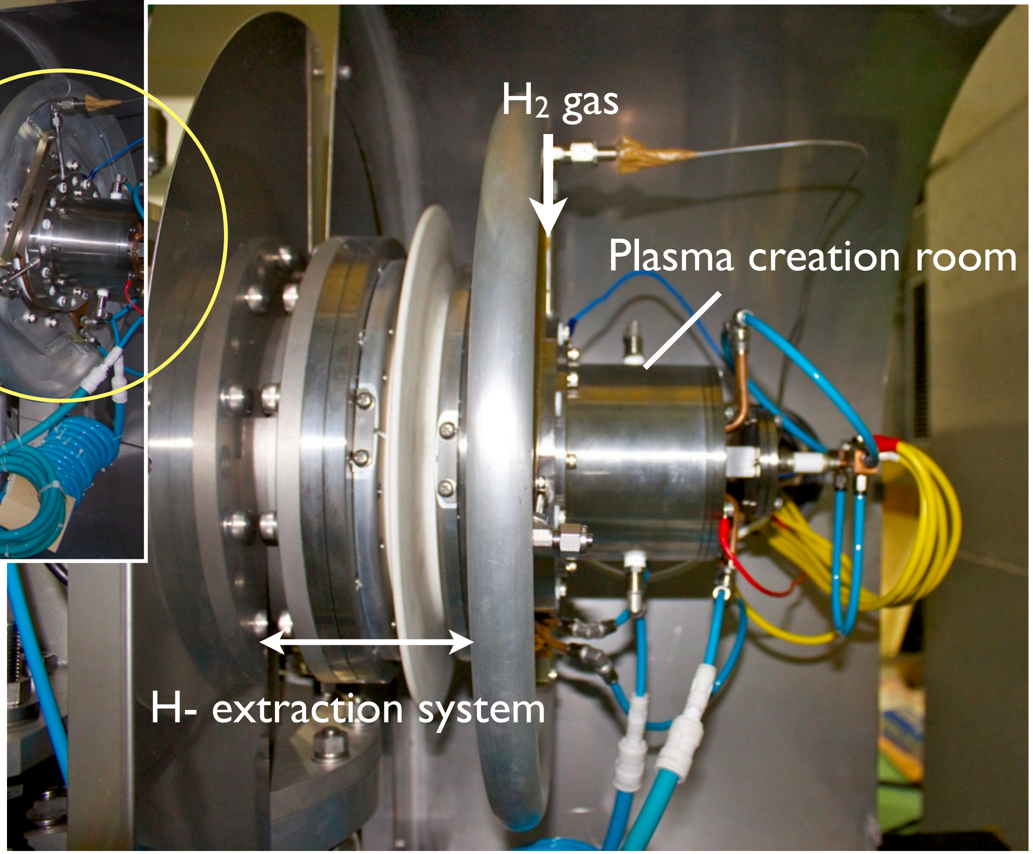
While , in a volume production type , cesium injection is not necessary but if a little cesium is injected , high current is obtained. The Beam emittance relatively becomes smaller.

So , we use an ion source of volume production type.

H- Ion Source in KURRI FFAG



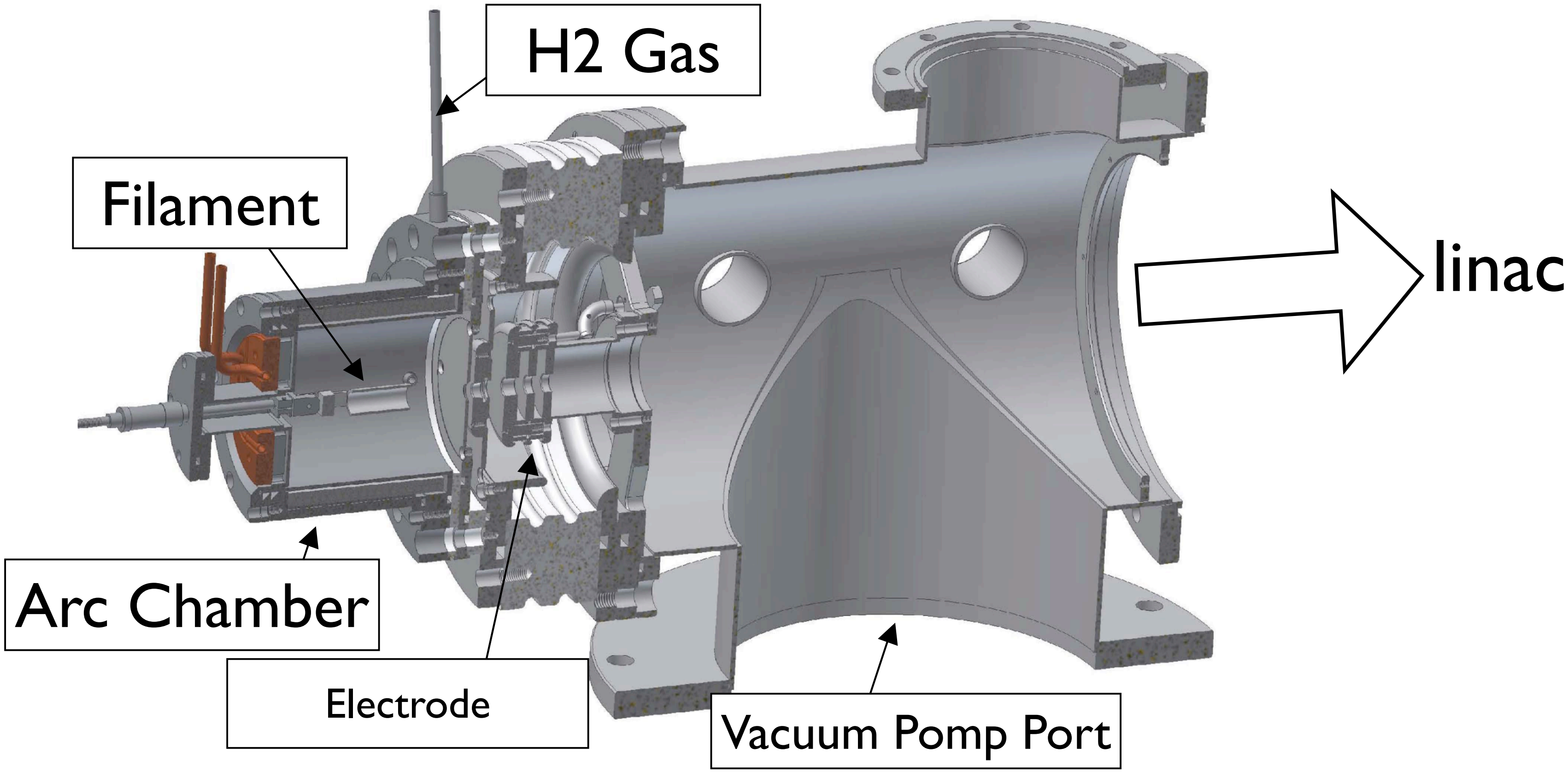
Enlargement



- Particle : H-
- type :Volume Production
- Extraction Energy : 30keV
- Repetition Rate (max): 200Hz
- Pulse width (max) : 100μs
- Beam Current : 5mA(peak) ⟶

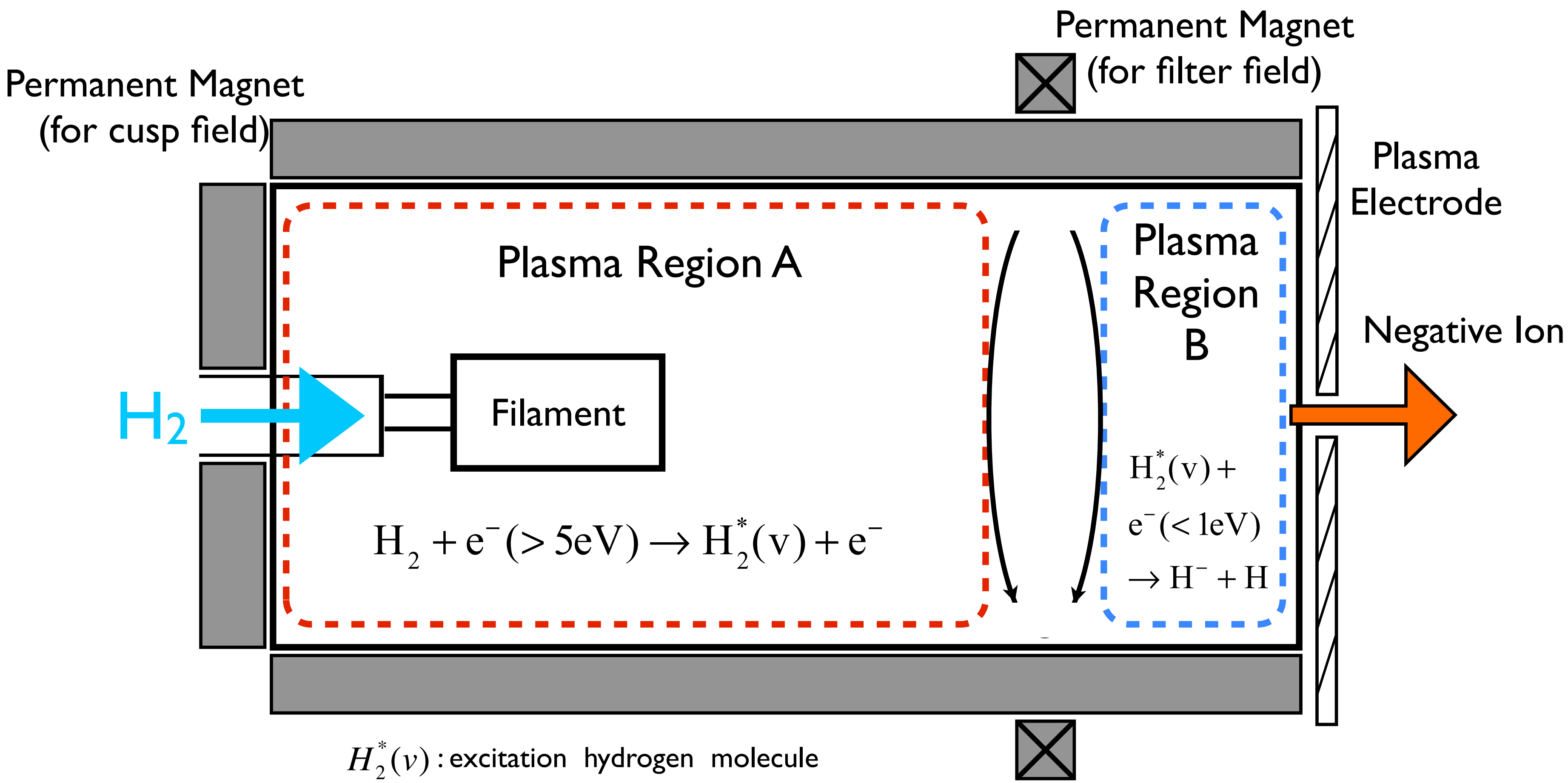
Target: Up to 10mA

Cross Section of H^- Ion Source



The filament is in the arc chamber. injecting H2 gas into arc chamber , plasma is created by arc discharge. Negative hydrogen ion is extracted by electric field which electrode create.

Volume Production



$H_2^*(v)$: excitation hydrogen molecule

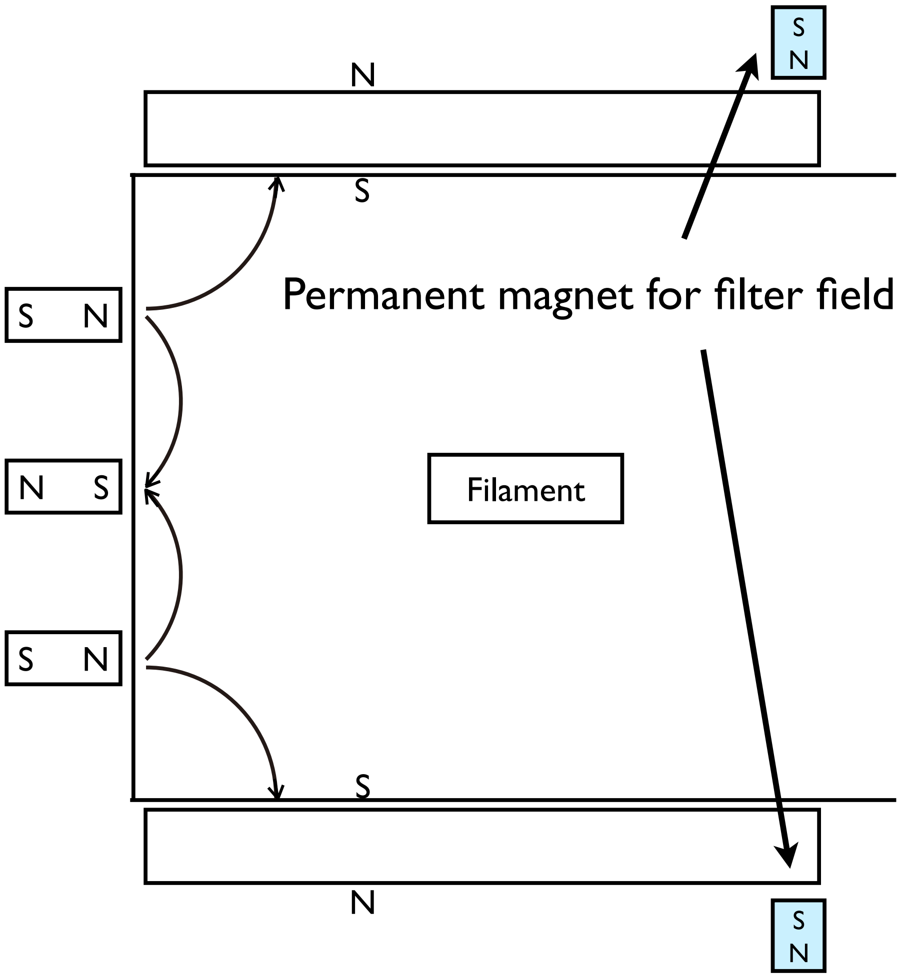
To separate a plasma region A and B , set the permanent magnets as filter field

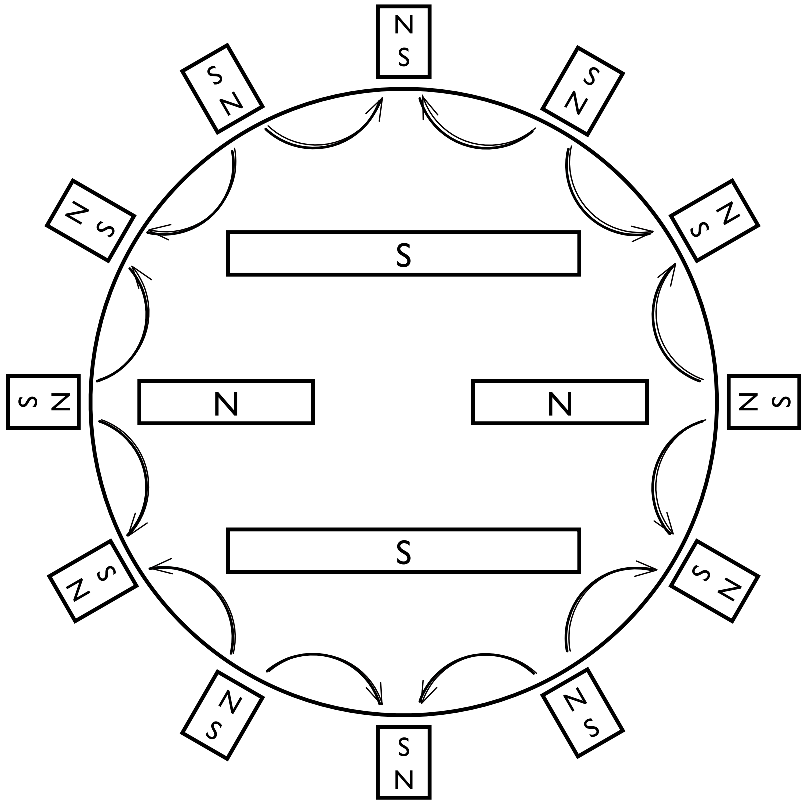
In the plasma region A , high electron temperature is needed to excite the hydrogen molecule.

In the plasma region B , low electron temperature is needed to capture an electron in the excitation hydrogen molecule.

Through these processes , a negative hydrogen is created

Cusp and Filter Field

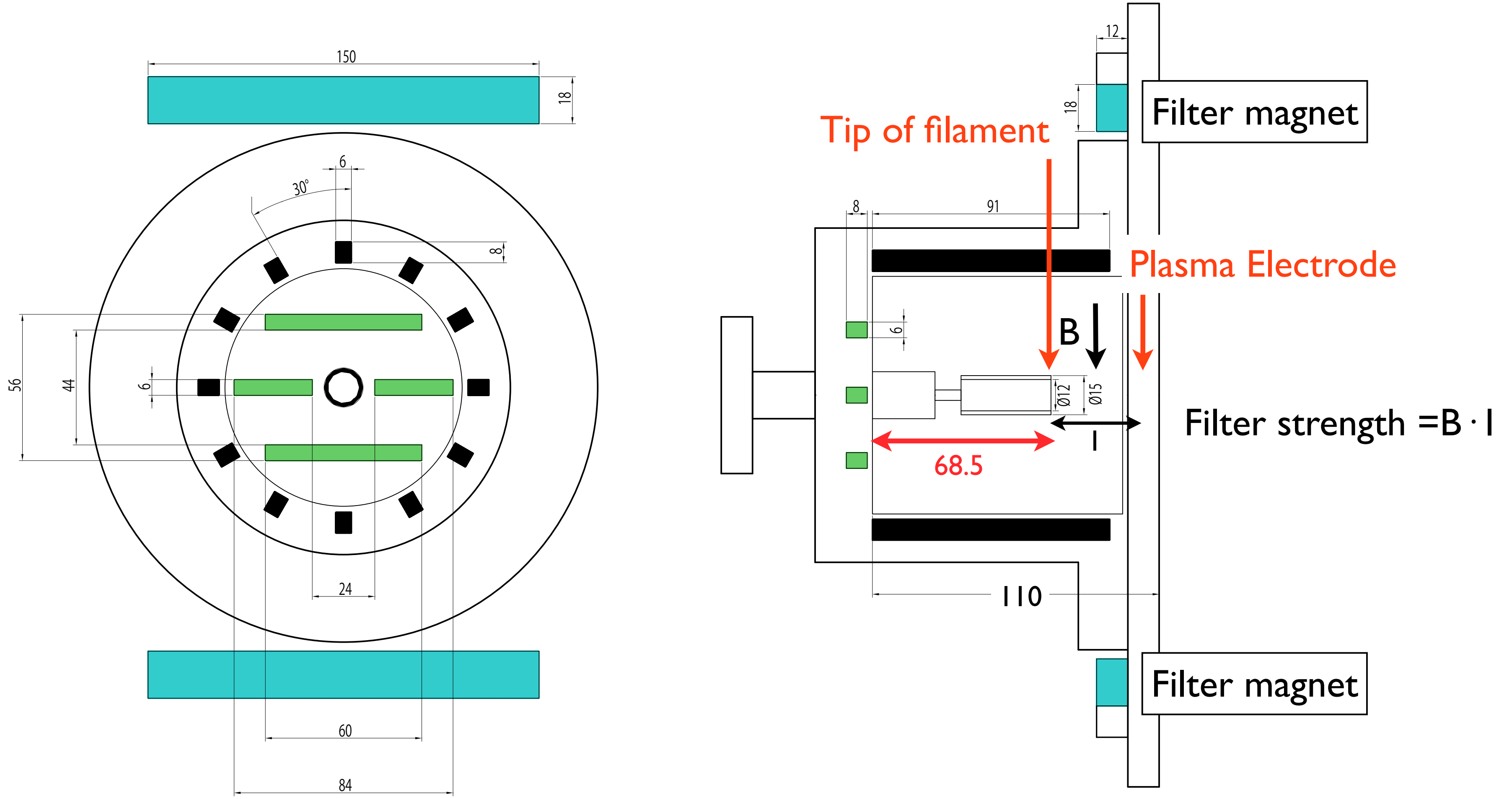




If the magnetic field strength is not suitable , high temperature electron may go into the low temperature region. In this case produced H- ion may be detached by the high temperature electron.

→The optimization of the magnetic field strength is needed.

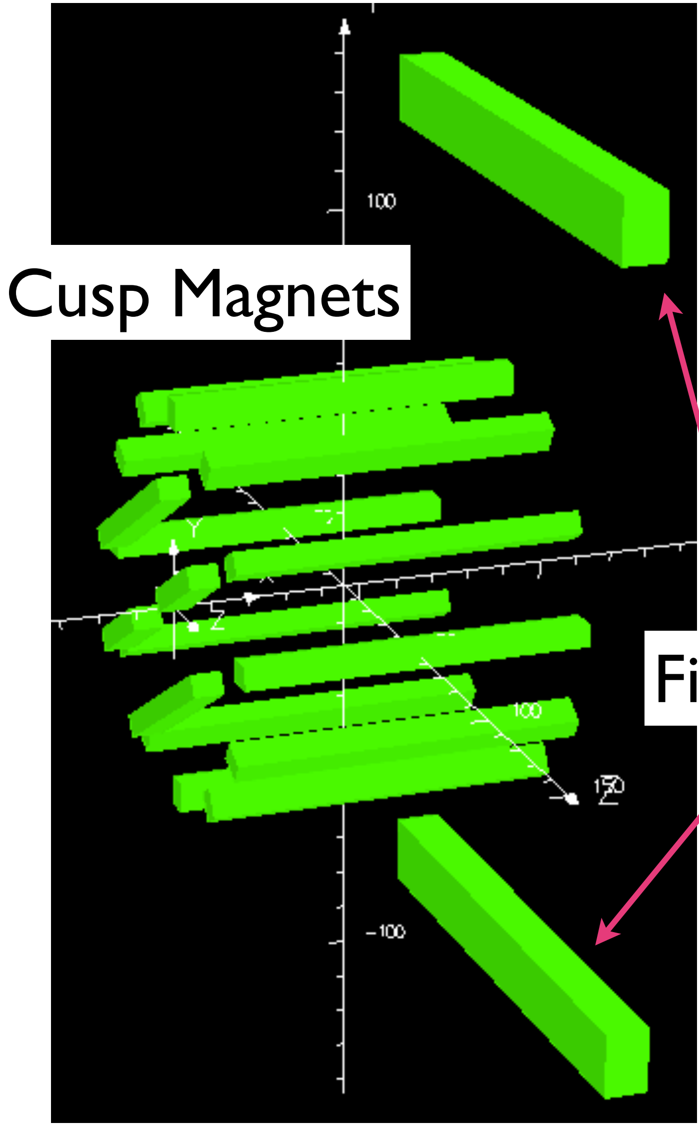
Present Condition



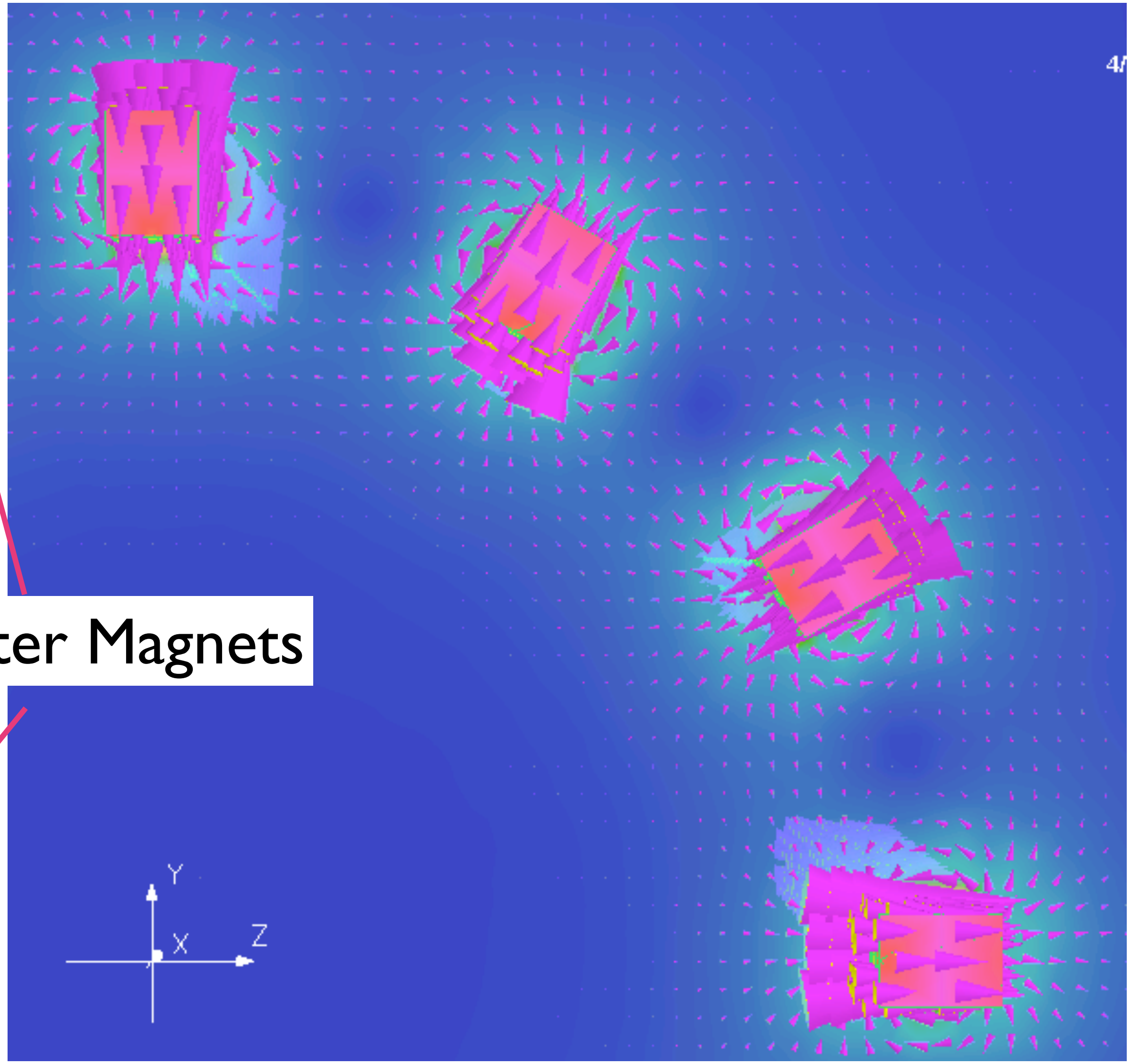
Filter strength of the magnets is given by integral from the tip of a filament to plasma electrode.

Using TOSCA , 3D magnetic model is created.

TOSCA Model

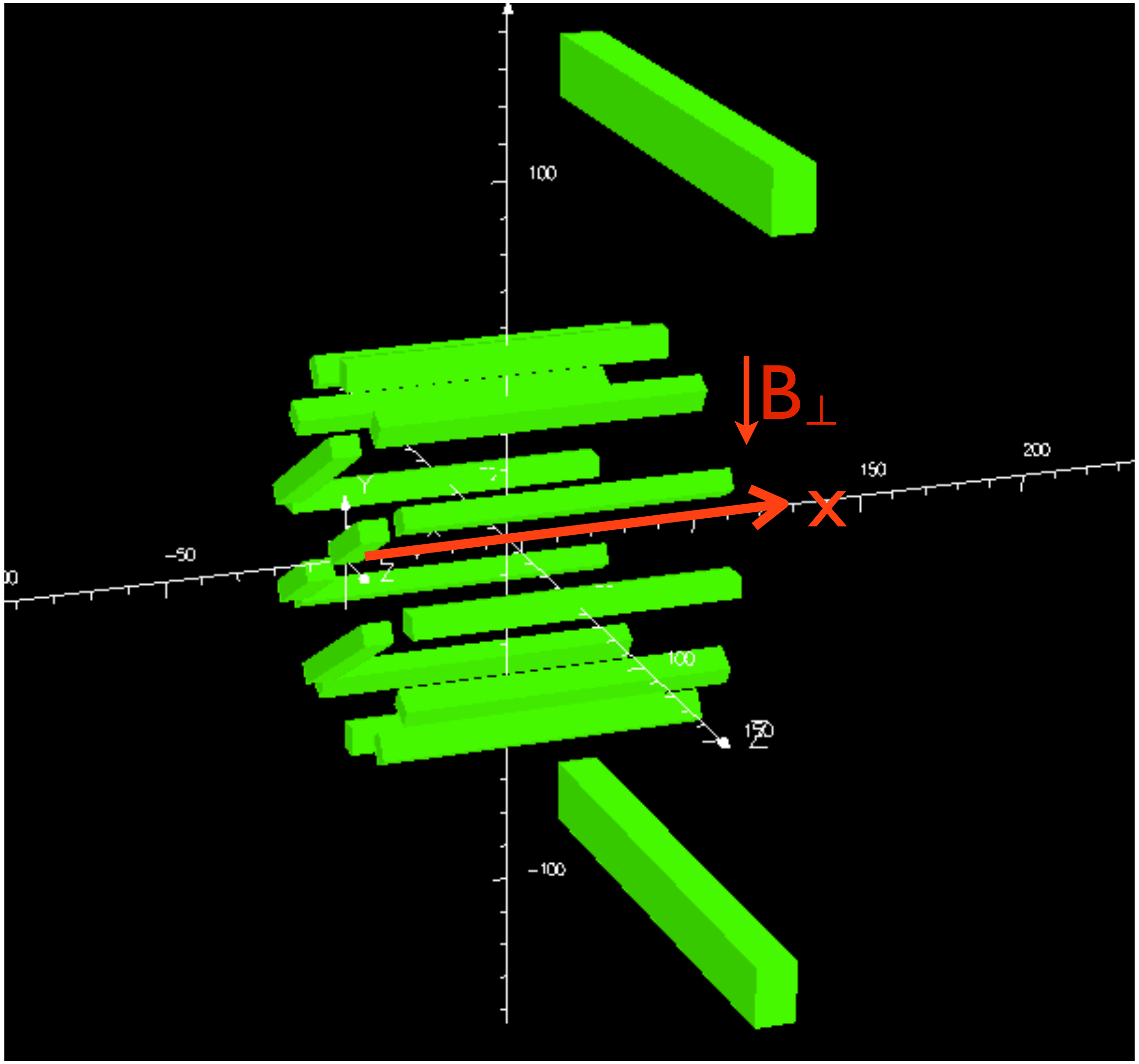


TOSCA model



Magnetic field made by cusp magnet

TOSCA Model

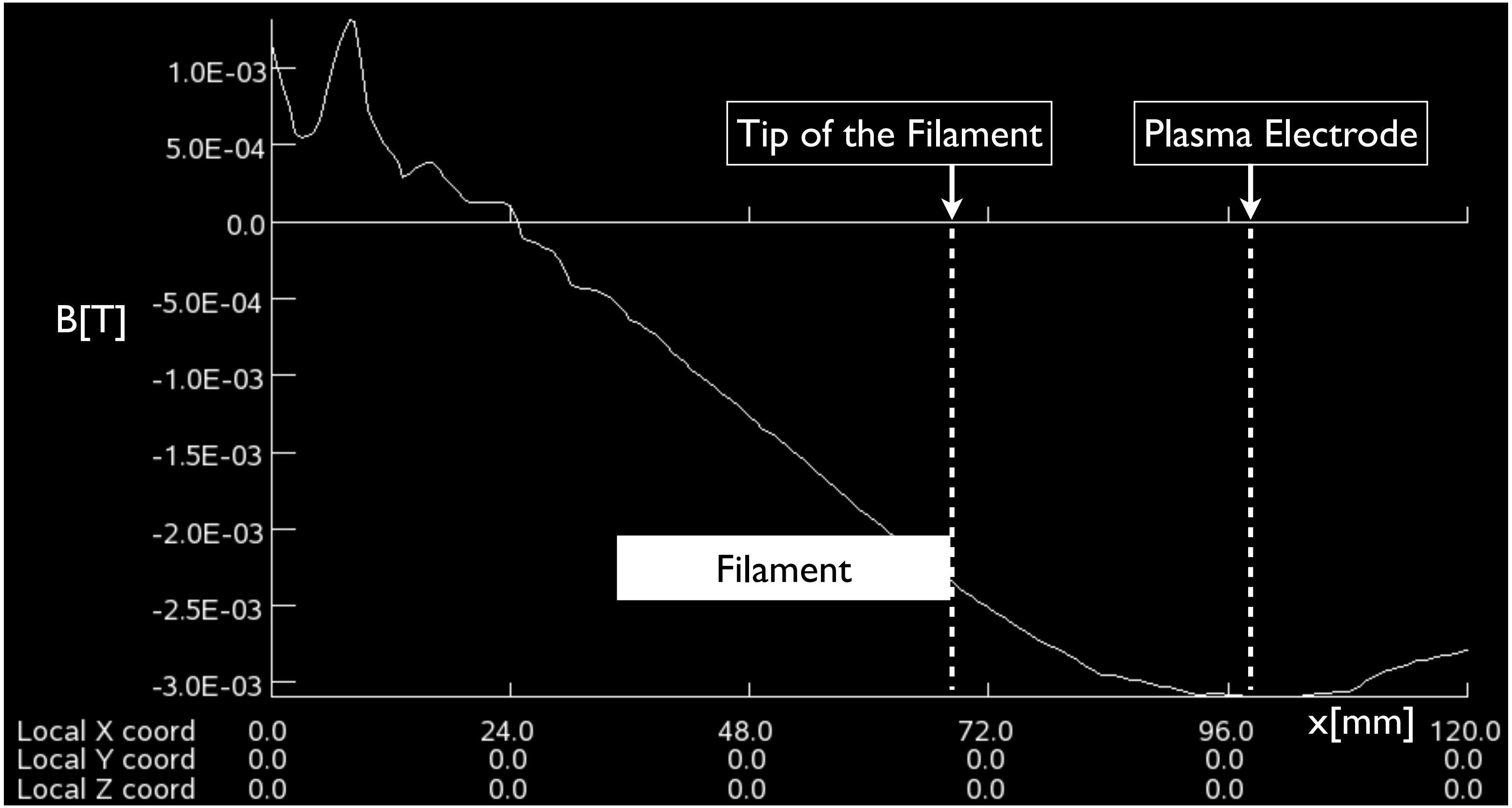


Calculate the filter strength Using TOSCA along the red line

The red line is center of arc chamber.

B is Magnetic strength on the x direction and in a vertical to a x axis.

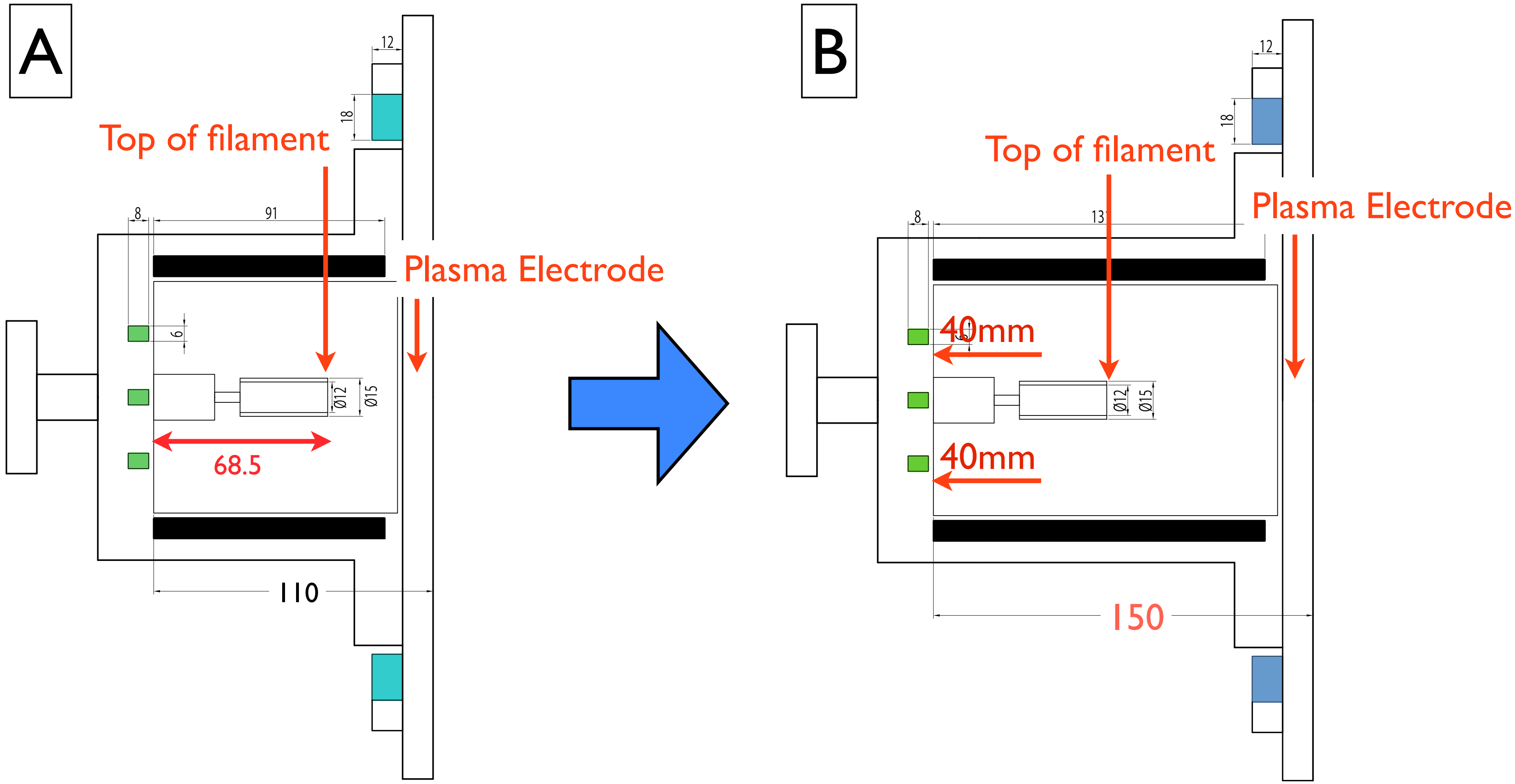
Current Condition



B · l=128 Gauss · cm

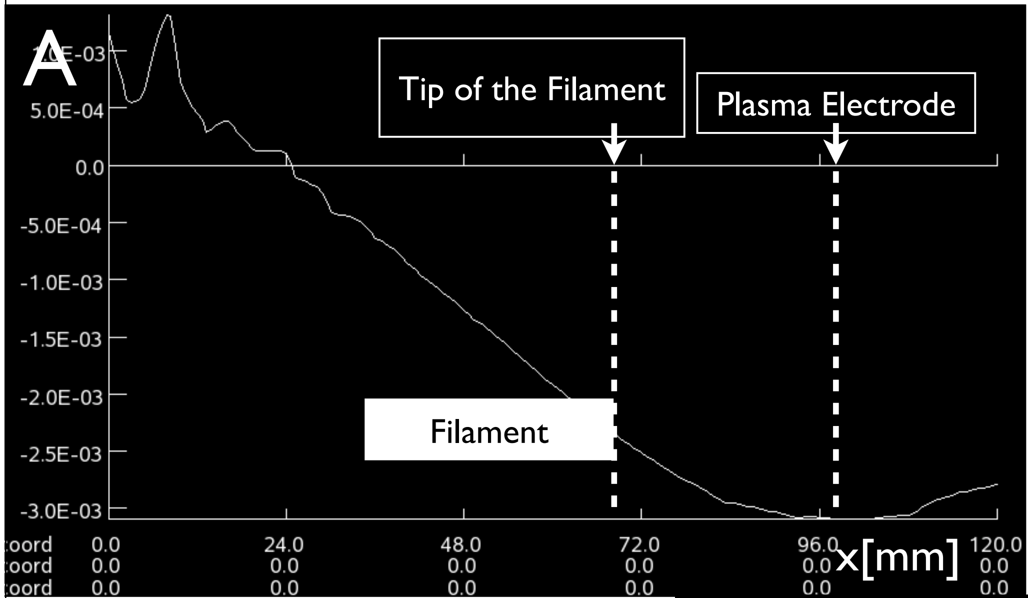
In this case , emitted electrons feel a magnetic potential. This causes efficiency of the creating plasma may become worse. So, try to expand the plasma chamber to reduce the magnetic strength at the filament.

Optimization



expand the arc chamber by 40 mm.

After optimization



Filament is near zero cross line.

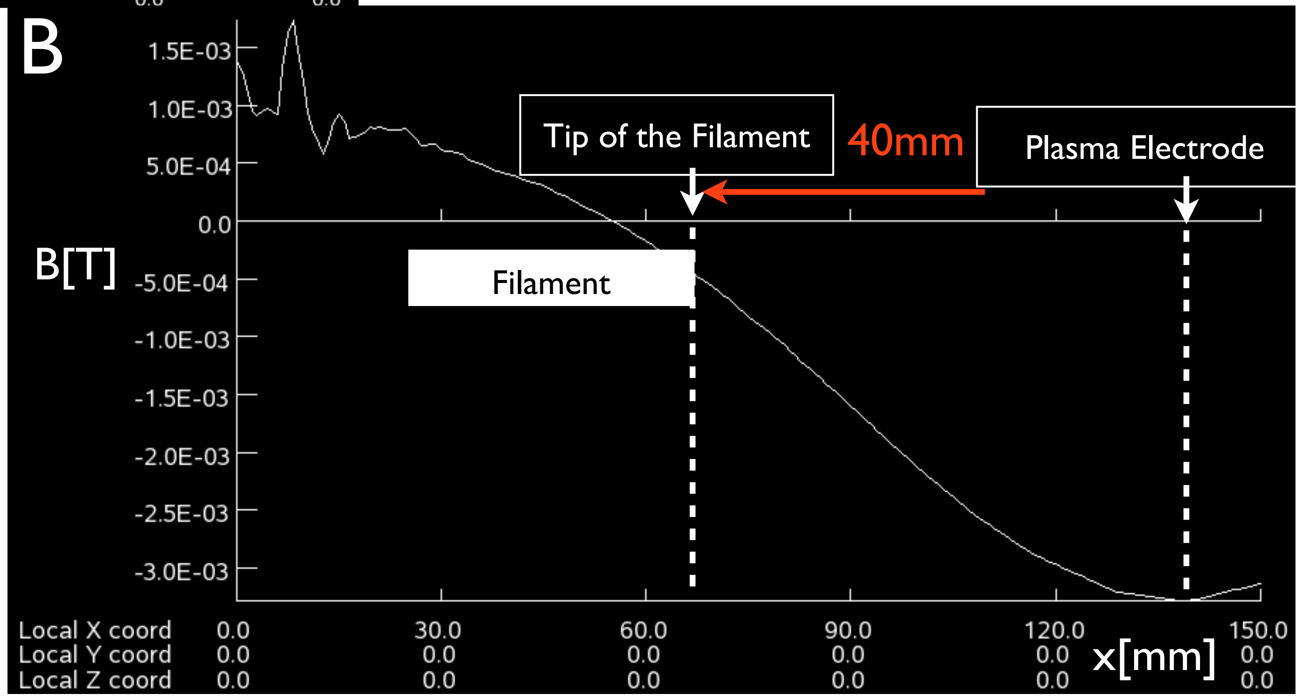
Compared with previous condition , this filament place is better.

A : B · l=128 Gauss · cm

↓

B : B · l=188 Gauss · cm

This difference is not understood bad or good.



Summary

- Introduction of the two kinds of ion source

  >Our using source is volume production type.

- Magnetic field calculation in plasma chamber by "TOSCA" code
- Optimization of filament position

Future Plan

- Electron tracking simulation in the plasma chamber using TOSCA field map
- To be more optimization (filament position , magnet position , magnetic field distribution , etc.)
- Design and create a new ion source
- Experiment

Thank you for your attention.