

Analysis of the Plasma Characteristics for Beam Current Optimization for TR-13 Cyclotron Ion Source

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Abstract

The extracted beam current from the cyclotron is critically depends on the initial beam from the ion source. The voltage or current which is applied to this system can affect the final beam. It is possible to use varying inputs in various conditions, and the beam current is able to be stabilized much better than applying the constant input values. And this paper represents the plasma characteristics that critically influence the beam current

Experiments



Figure 1 Vacuum level in ion source chamber with 8 SCCM gas injection

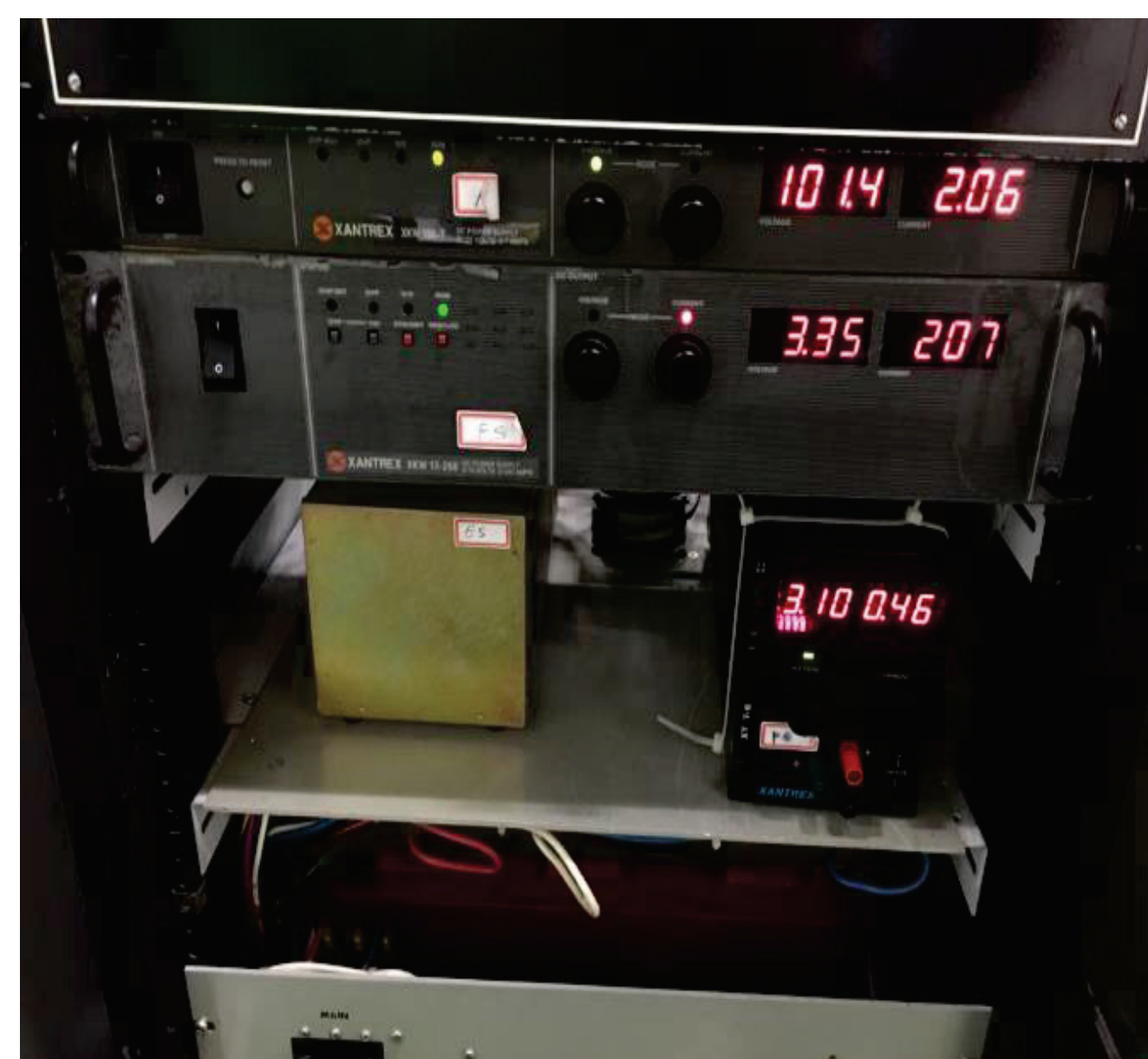


Figure 2 Ion source power supplying units: arc P/S, filament P/S, plasma P/S manufactured by Xantrex

Hydrogen gas injection level	Arc output	Plasma potential	Filament current
8 SCCM	100 V / 2 A	3.1 V	208 A

Table 1 The operating inputs for figure 2

The amount of the plasma generation in the ion source chamber is a powerful factor for extracting good beam profile after the ion source. The features of the bunch of plasma is placed by the voltages or currents applied to lens electrodes(plasma, extractor) or the hydrogen gas injection level. The inputs are controlled by PLC and the experiments are performed under various conditions

Results

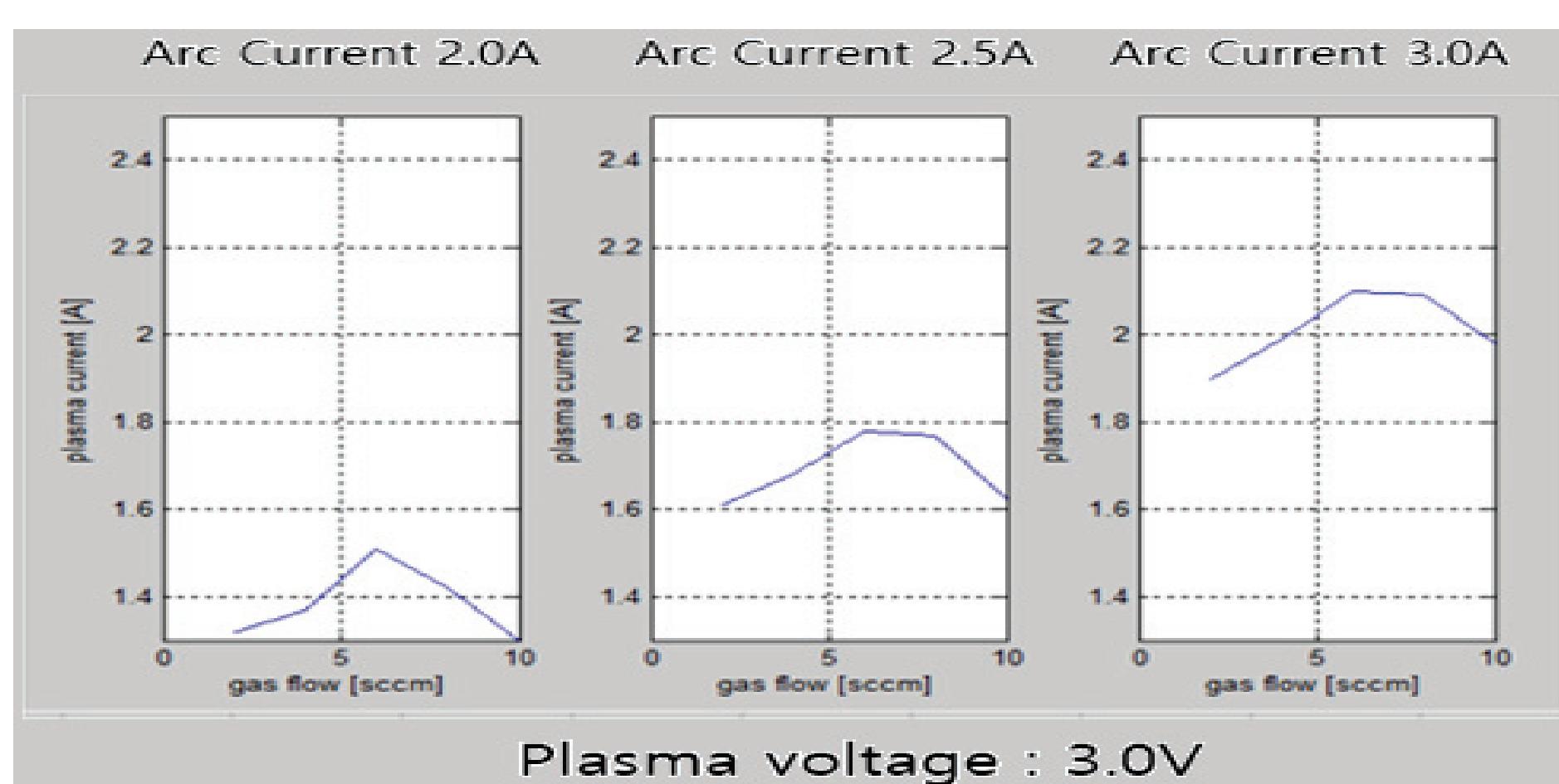


Figure 3 Plasma current with MFC control and various arc current in plasma potential 3.0V

The gas injection level is optimized around 6~8 SCCM that makes the quantity of the plasma maximized in figure 3. However, the it does not have great meaning that plasma had been generated as much as possible. There must be another method to make plasma to be the beam well. That is the plasma potential which decide the displacement of the plasma bunch in the ion source chamber.

Conclusion

According to the results, there are three main suggested approach for improving the beam current

- Adjust the plasma voltage to modulate the displacement of the plasma region where the beam initially start
- Increase the arc current considering with the injection of gas flow
- Take account for the load resistance of the extractor lens power supply to make the extraction current weakly

For these reasons the plasma generation and extractor power supply capacity can be the significant factor to be considered in order to make better the whole performance of the cyclotron

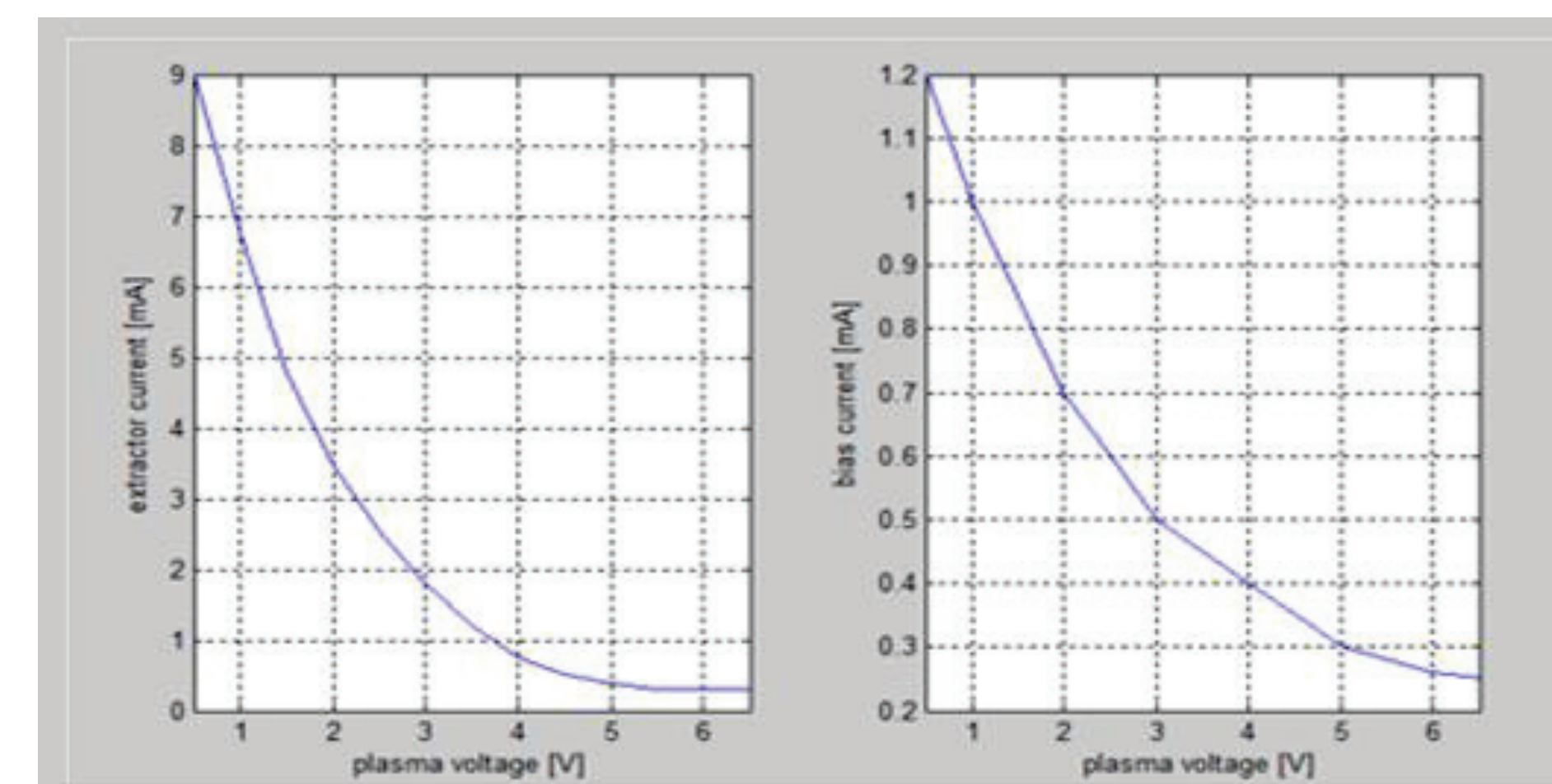


Figure 4 Extractor lens current and bias power supply current with plasma voltage control

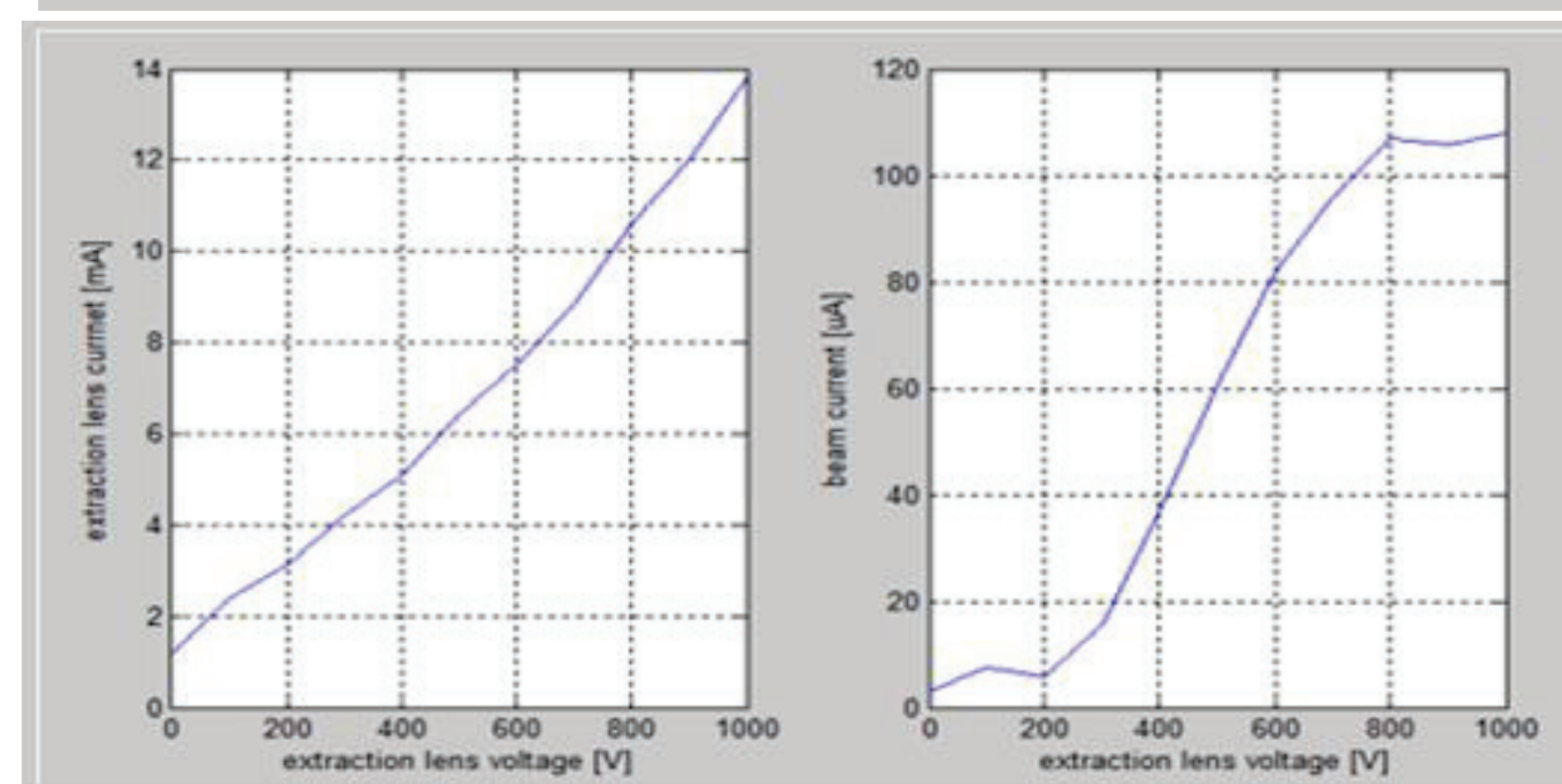


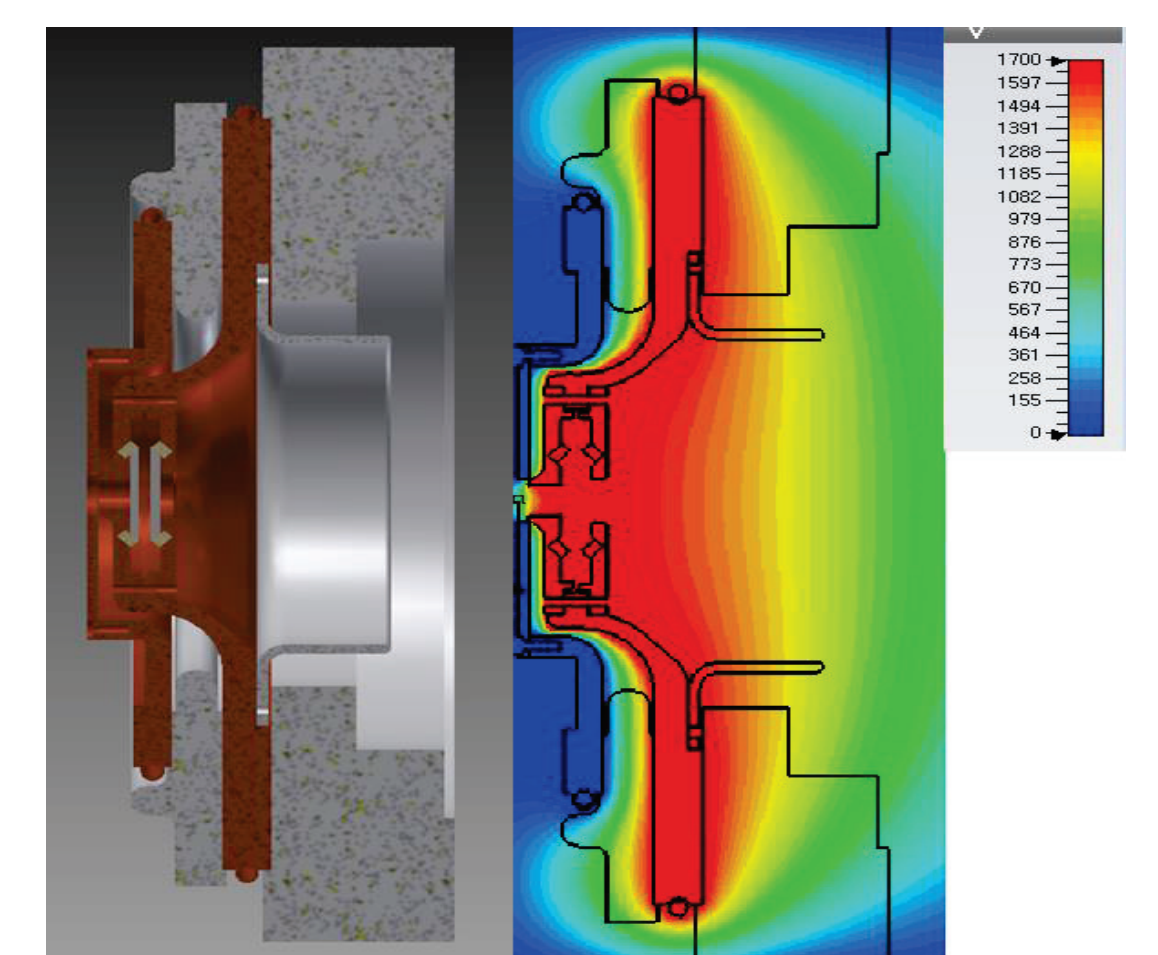
Figure 5 Extractor lens current and beam current with extractor lens voltage control

From figure 4, the extraction current and bias current show keep going down since the bunch of the beam in the plasma gets closer to the lens electrodes that makes the P/S output flows into the plasma region. And that produces the extraction P/S shows CC mode. Also the plasma makes the common ground of the whole P/S to be connected with short circuit. Whenever the flowing current exceeds the limitation of the power supply output current, then the beam cannot be extracted anymore as like shown in the figure 5.(saturated beam current)

Plasma voltage [V]	Plasma current [A]	Extraction voltage when CC mode starts in extraction P/S [V]	Extraction current when extraction voltage is 0V [mA]
0.0	0.43	0	15, CC mode
0.4	0.43	0	15, CC mode
0.8	0.43	0	15, CC mode
1.2	0.43	0	15, CC mode
1.6	0.43	0	15, CC mode
2.0	0.43	0	15, CC mode
2.4	0.43	0	15, CC mode
2.8	0.53	35	13.35
3.2	0.77	40	9.75
3.6	1.03	45	7.5
4.0	1.27	60	5.7
4.4	1.43	75	4.35
4.8	1.58	105	2.85
5.2	1.78	185	1.35
5.6	1.92	255	0.585
6.0	2.05	295	0.405
6.4	2.12	300	0.315
6.8	2.14	300	0.255
7.2	2.18	295	0.225
7.6	2.19	305	0.180
8.0	2.23	305	0.150

Table 2 Extractor lens constant current mode experiment result

Figure 7 Electrical potential analysis of the plasma & extractor lens CST studio suite E-solver



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