Resolution improvement of electrostatic ion analyzer using additional slit for laser ion source

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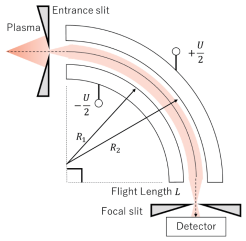
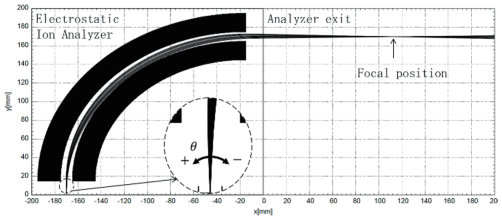
Background and Motivation

A laser ion source provides an ion beam extracted from a plasma produced by irradiating a high power laser on a solid target. The ion species contained in the plasma can be analyzed with an electrostatic ion analyzer. In order to distinguish the ions, the spectral width of ion signals in the mass spectrum has to be smaller than the difference of time-of-flight between the different ion species and charge-states. Therefore a high resolution is required for analyzing ion species which have similar charge-to-mass ratio. In this study, we investigated an analyzer structure for reducing the spectral width to improve the resolution of the analyzer.

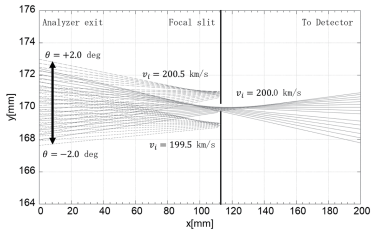
Simulation of ion trajectory



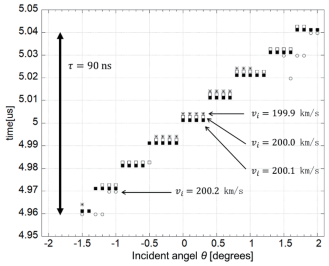
Schematic of electrostatic ion analyzer



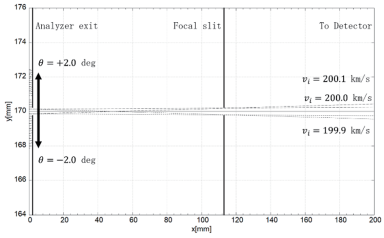
Particle orbit of $^{7}Li^{3+}$ with applied voltage U= 62.0 V （v_i=200.0 km/s, θ=-2.0~+2.0°）



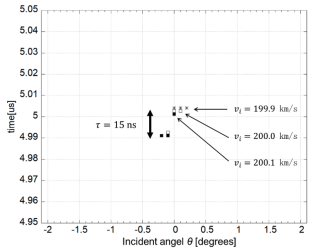
Particle orbit around analyzer exit when focal slit of 0.5 mm width is added to 115 mm from the analyzer exit.



Time of flight for the incident angle at 10 mm behind the focal slit when the length of the ion passing through the central orbit from the target to the detector is 1 m.



Particle orbit around analyzer exit when the slit of 0.5 mm width is added to 2 mm from analyzer exit.

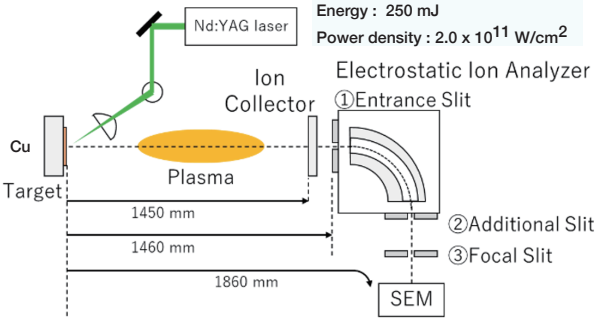


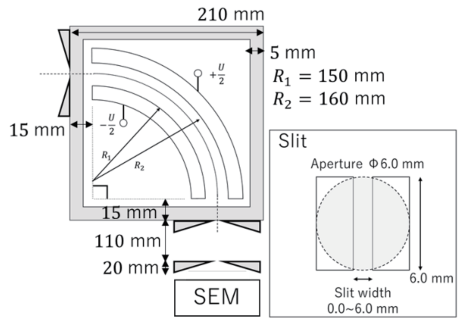
Time of flight for the incident angle at 10 mm behind the focal slit when the length of the ion passing through the central orbit from the target to the detector is 1 m.

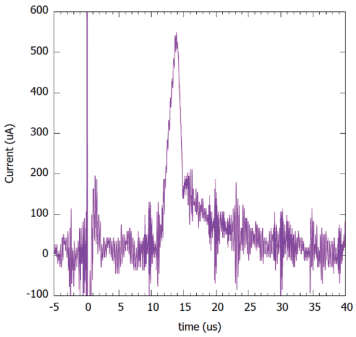
Experimental Results

Experimental setup

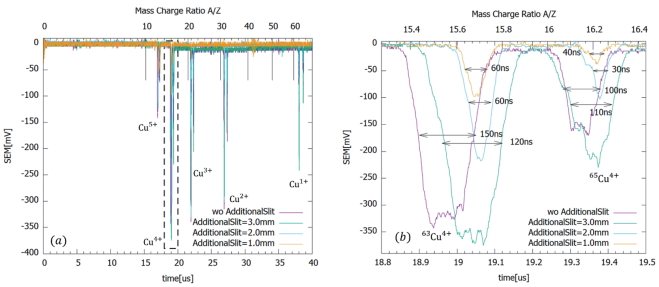
Laser : Nd:YAG laser (532nm/17ns)
Energy : 250 mJ
Power density : 2.0 x 10^{11} W/cm^2



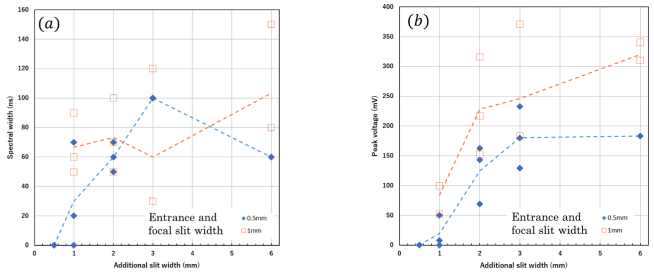




Ion current waveform at ion collector



(a) Spectral diagram obtained with the electrostatic analyzer with the additional slit. The width of entrance and focal slit were fixed 1.0 mm and the deflection electrodes was biased at U=100 V.
(b) Enlarged view of Cu^{4+}.



(a) Spectral width and (b) peak of the signal of $^{63}Cu^{4+}$ ion as a function of the additional slit width. The points are the data of each shot, and the dashed lines are the average values of the data of 3 shots.

Summary

In this study, we investigated experimentally the variation of the spectral width of ion signals with a proposed electrostatic ion analyzer. The results showed that the spectral width was shortened by reducing the width of the additional slit placed between the focal point of the electrostatic analyzer and the analyzer exit. Therefore, the resolution of the analyzer can be improved by adding a slit to the analyzer.