Measurements of beam current and energy-dispersion for ion Beam with multi-components

State Key Laboratory of Nuclear Physics and Technology

ZHANG AiLin[1, 2], PENG ShiXiang[1]*, REN HaiTao[1], XU Yuan[1], ZHAO Jie[1], ZHANG Tao[1], GUO ZhiYu[1] & CHEN JiaEr[1, 2]

[1] *State Key Laboratory of Nuclear Physics and Technology & Institute of Heavy Ion Physics, School of Physics, Peking University Beijing 100871, China;*

[2]*University of Chinese Academy of Sciences, Beijing 100049, China*

Abstract The multi-component ion beam is very common in nuclear physics, materials physics and most kind of ion source. But the diagnosis of multi-component ion beam [1] can be difficult because of its complex composition and irregular energy-dispersion. We need an effective way to analyze the multi-component ion beam. There is a multi-component ion beam whose total beam current varies from 1 mA to 50mA and the beam energy can be 20keV to 150keV. In this paper, four methods to analyzing this multi-component ion beam are described, which are Faraday cup array, fluorescent screen with Faraday cup, movable aperture with conductive fluorescent screen, and current calibration method, respectively.

Introduction

There is a multi-component beam come from ion source whose total current vary from 1mA to 50mA and the beam energy can be 20keV to 150keV. The beam contains more or less 6 kinds of particles and the energy can be 20keV to 150kev. In order to research the composition of the multi-component ion beam, an orthogonal magnetic and electric fields is used to separating the ions with different charge-mass ratio. With numerical simulation, we expect that after the beam crossed the orthogonal magnetic and electric fields the separated ions may have 5 groups of distribution which was showed in figure1.

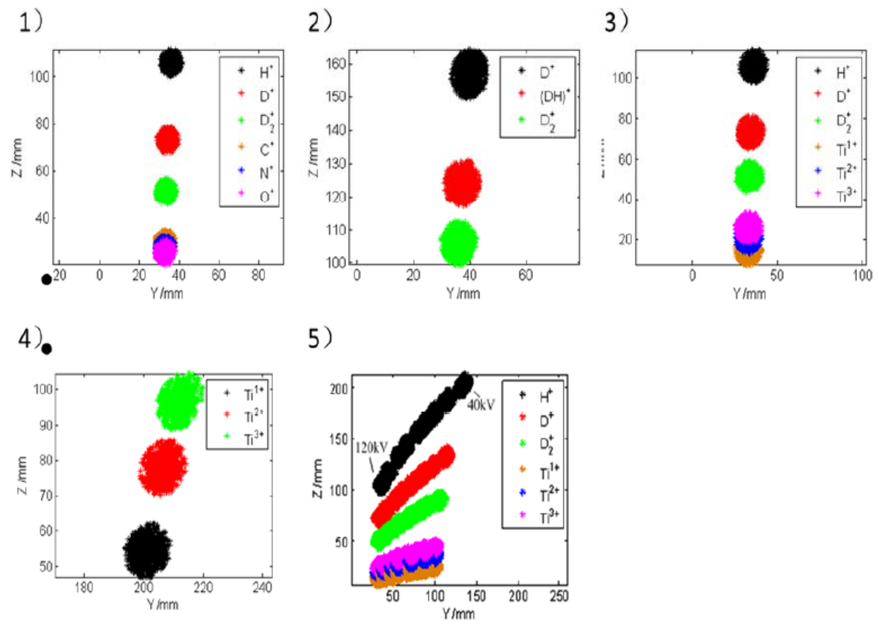

Figure 1: 5 possible distributions of the separated ions

FOURE METHODS TO ANALYZING THE MUTI-ION BEAM

1.Faraday cup array

We use independent faraday cups to install in array and use appropriate acquisition circuit connect each faraday cup to the computer [2]. sketch of this device is showed in figure2..

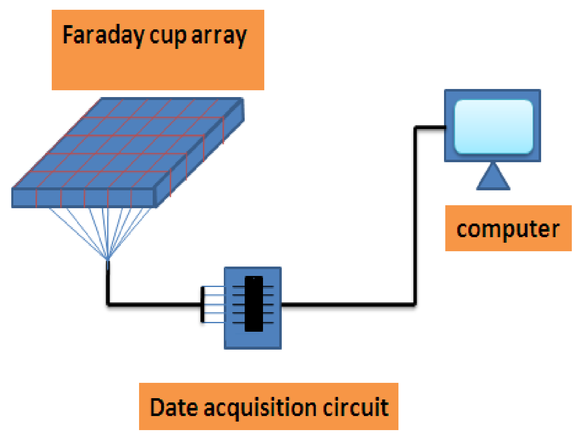

Figure 2: Faraday cup array

2 Fluorescent screen and faraday cup

We need two steps to complete the measurement.

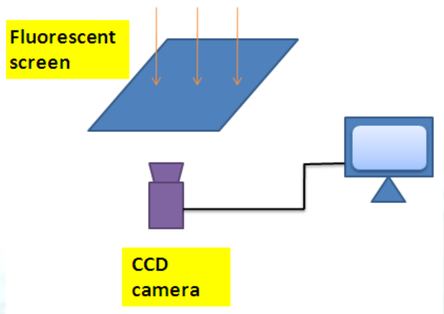

Figure 3: First step: use the fluorescent screen to get the distribution

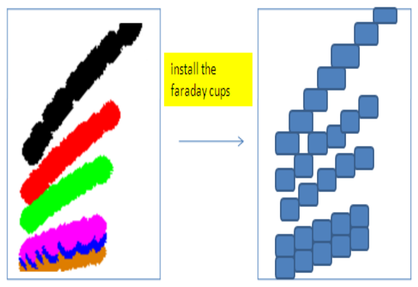

Figure 4: Second step: install the faraday cups

3 A movable aperture and conductive fluorescent screen

The third way is using a movable and variable size aperture which made of four insulating barriers each connecting to stepper motor to select the target area but block out others(figure5）.

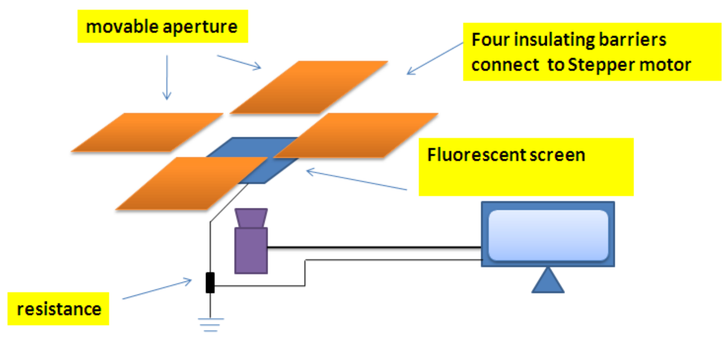

Figure 4: A movable aperture and conductive fluorescent screen

.

4 Current Calibration method

The fluorescent screen gets the beam distribution of the ions from its luminance distribution. The current must have some connection to the luminance, too. We can use some faraday cups to define the connection between the luminance and the current for each kind ion.

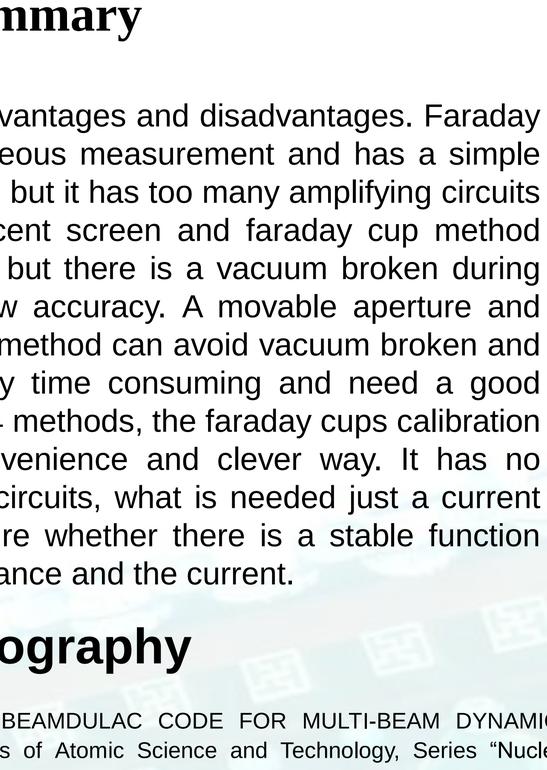

Figure 5: Faraday cups calibration method

Summary

Four methods have their advantages and disadvantages. Faraday cup array method is instantaneous measurement and has a simple structure and simple operating, but it has too many amplifying circuits and in low accuracy. Fluorescent screen and faraday cup method need fewer amplifying circuits but there is a vacuum broken during the measuring and also in low accuracy. A movable aperture and conductive fluorescent screen method can avoid vacuum broken and complex circuits, but it is very time consuming and need a good repeatability condition. All the 4 methods, the faraday cups calibration method maybe the most convenience and clever way. It has no vacuum broken and complex circuits, what is needed just a current calibration. But we are not sure whether there is a stable function relationship between the luminance and the current.

Bibliography

[1] Masunov E S, Polozov S M. USING BEAMDULAC CODE FOR MULTI-BEAM DYNAMICS INVESTIGATION IN ION LINAC[J]. Problems of Atomic Science and Technology, Series “Nuclear Physics Investigations”(50), 2008 (5): 136-139.

[2]Dastoori, K., Al-Shabaan, G., Kolhe, M., Thompson, D., & Makin, B. (2014). Charge measurement using an array of faraday's cups on a printed circuit board. Measurement, 47,116119.doi:10.1016/j.measurement.2013.08.038.

[3] Yoshinobu T, Iwasaki H, Ui Y, et al. The light-addressable potentiometric sensor for multi-ion sensing and imaging[J]. Methods, 2005, 37(1): 94-102.

[4] Jung R, Ferioli G, Hutchins S. Single pass optical profile monitoring[R]. 2003.

*This work is supported by the National Science Foundation of China（Grant Nos. 91126004).