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**Development of phosphor screen having  
“gridded energy analyzer”  
for  
two-fluid nonneutral plasma experiments**

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## **Motivation**

**The process reached this development**

## **Design of the proposed instrument**

**The fluorescent screen**

**The energy analyzer**

## **Test of the energy analyzer**

**Flowing current from the fluorescent screen**

**Photograph of emission from fluorescent screen**

## **Summary**



# Motivation

## Conventional measurement methods

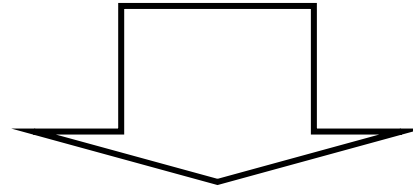
Measurement of 2D  
distribution of particle flux  $\Gamma$

Fluorescent screen  
+ CCD camera



Analyzing particle energy

Most popular one is so called  
“Faraday cup”

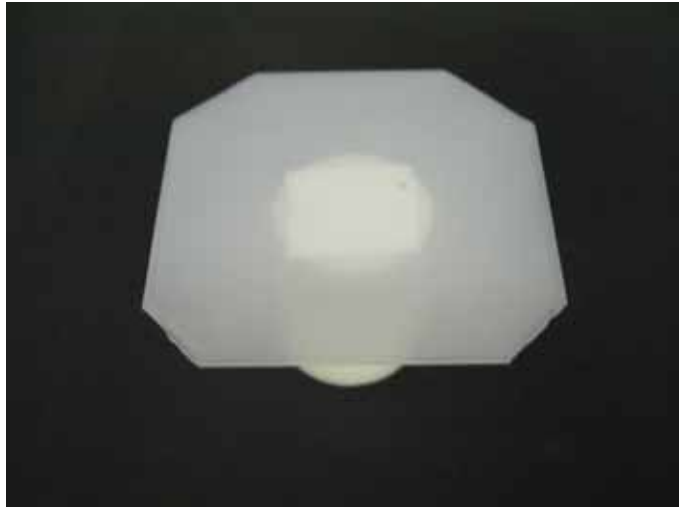


## A new proposed measuring instrument

Measurement of 2D distribution of analyzed particle flux  $\Gamma$

Fluorescent screen with a gridded energy analyzer

# Fluorescent screen



The fluorescent screen

Phosphor : ZnO:Zn (P15)

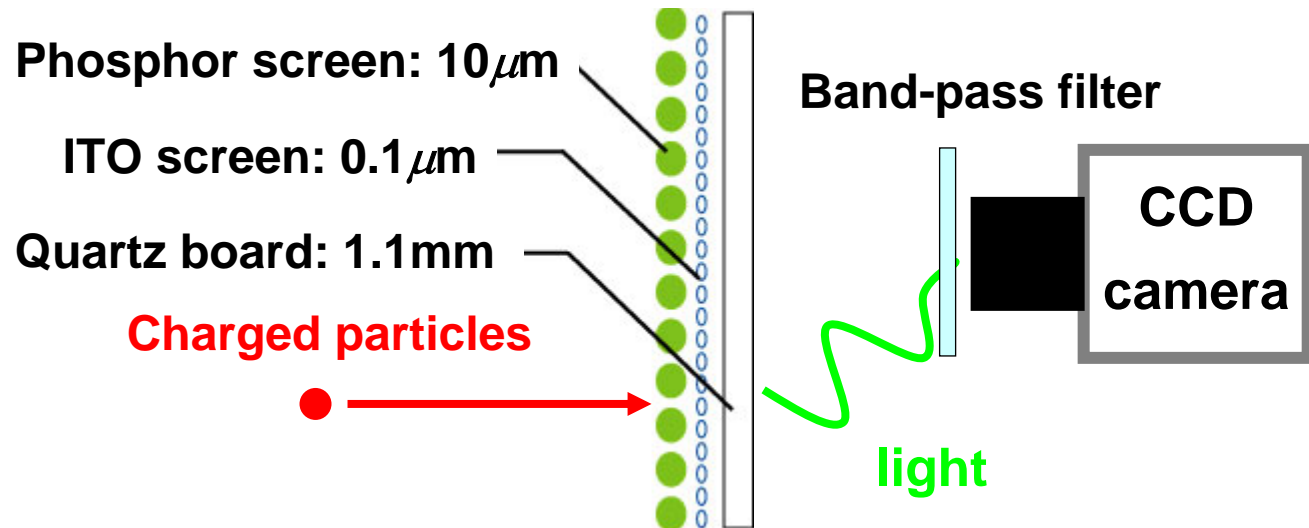
green emission (505nm)

less than 1ms (1/10decay)

This phosphor is emitted  
by low energy particles  
( ~ many hundred eV).

ITO screen is  
pre-coated on  
the surface of  
a quartz board.

## The transmitted light method





# Analysis of particle energy

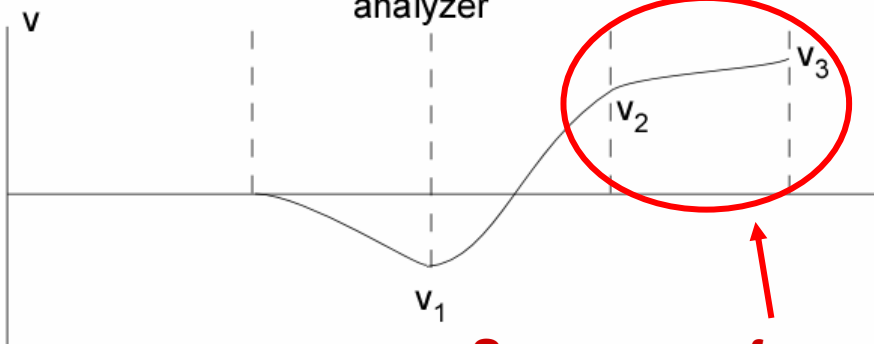
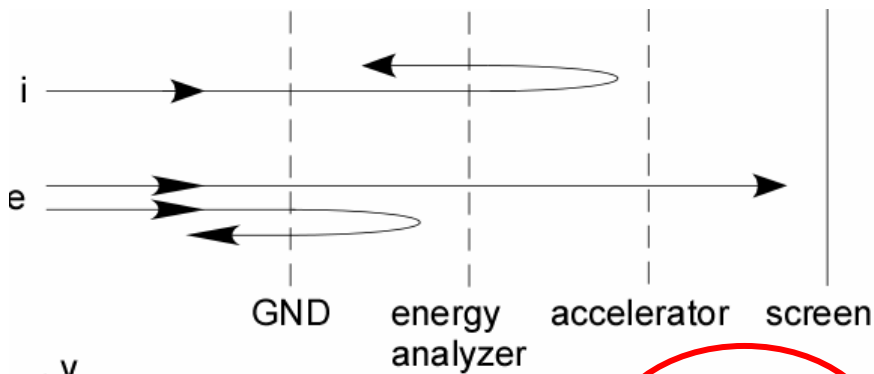
“ gridded energy analyzer ”

This scheme has four potential grids.

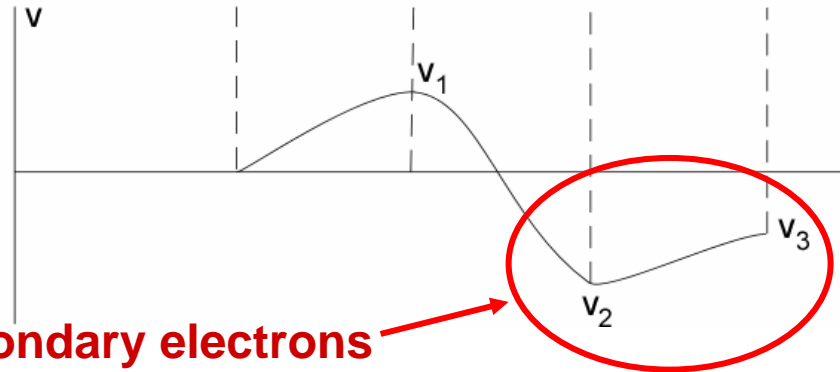
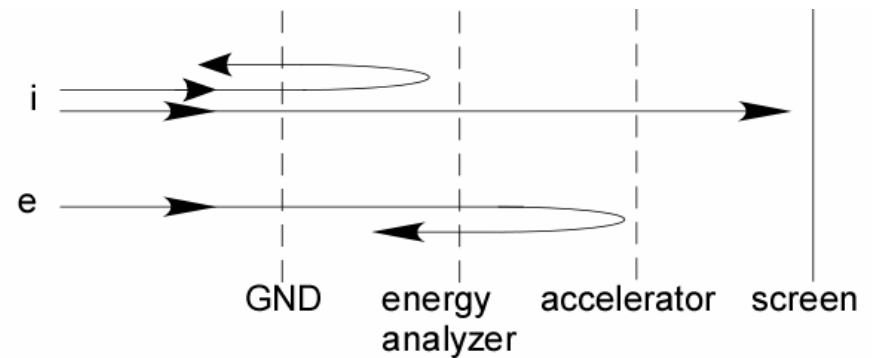
$V_1 \sim$  many ten V

$V_2 \sim$  few kV

$V_3 \sim$  few kV



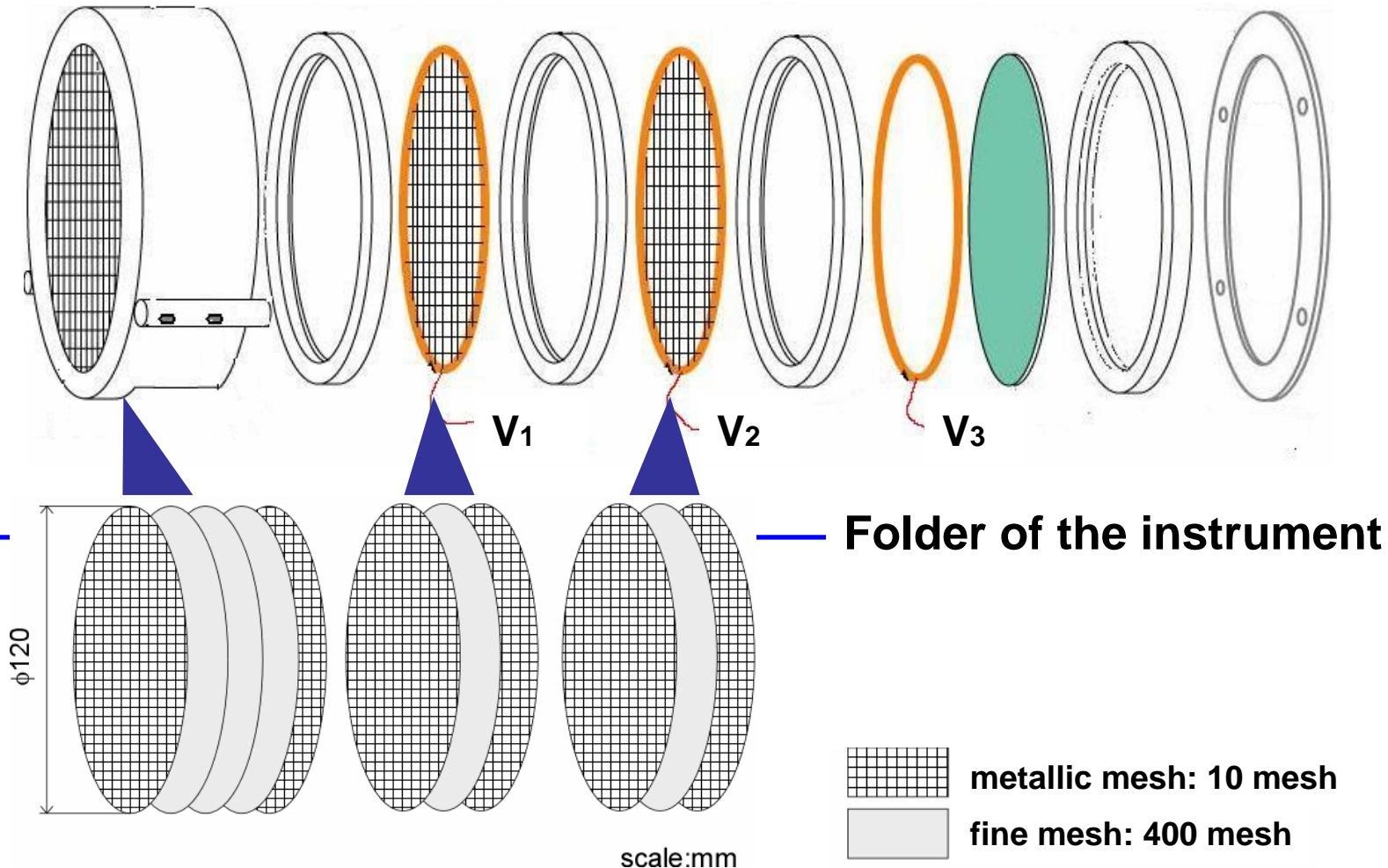
For electrons



For ions

# Design of grids 1

The distance between the first and second grids is 5mm, while 10mm between all other grids. Also, all grid are insulated each other by Teflon.





## Design of grids 2

**Metallic mesh : permeability 64 % - spacing distance 2.0 mm  
diameter of the wires 0.5 mm**

**Fine mesh : permeability 37 % - spacing distance 0.039 mm  
diameter of the wires 0.039 mm**

**When A mesh is decided, Debye shielding is considered.**

**The permeability of the first grid is 2 %.**

**Small one of diameter of the wires is 0.039 mm.**

**As mentioned above, from the formula of  $\lambda_D$ , the ration of plasma temperature  $T$  to  $n$  must satisfy the following relation:**

$$\frac{T}{n} \geq 5.53 \times 10^{-19}$$

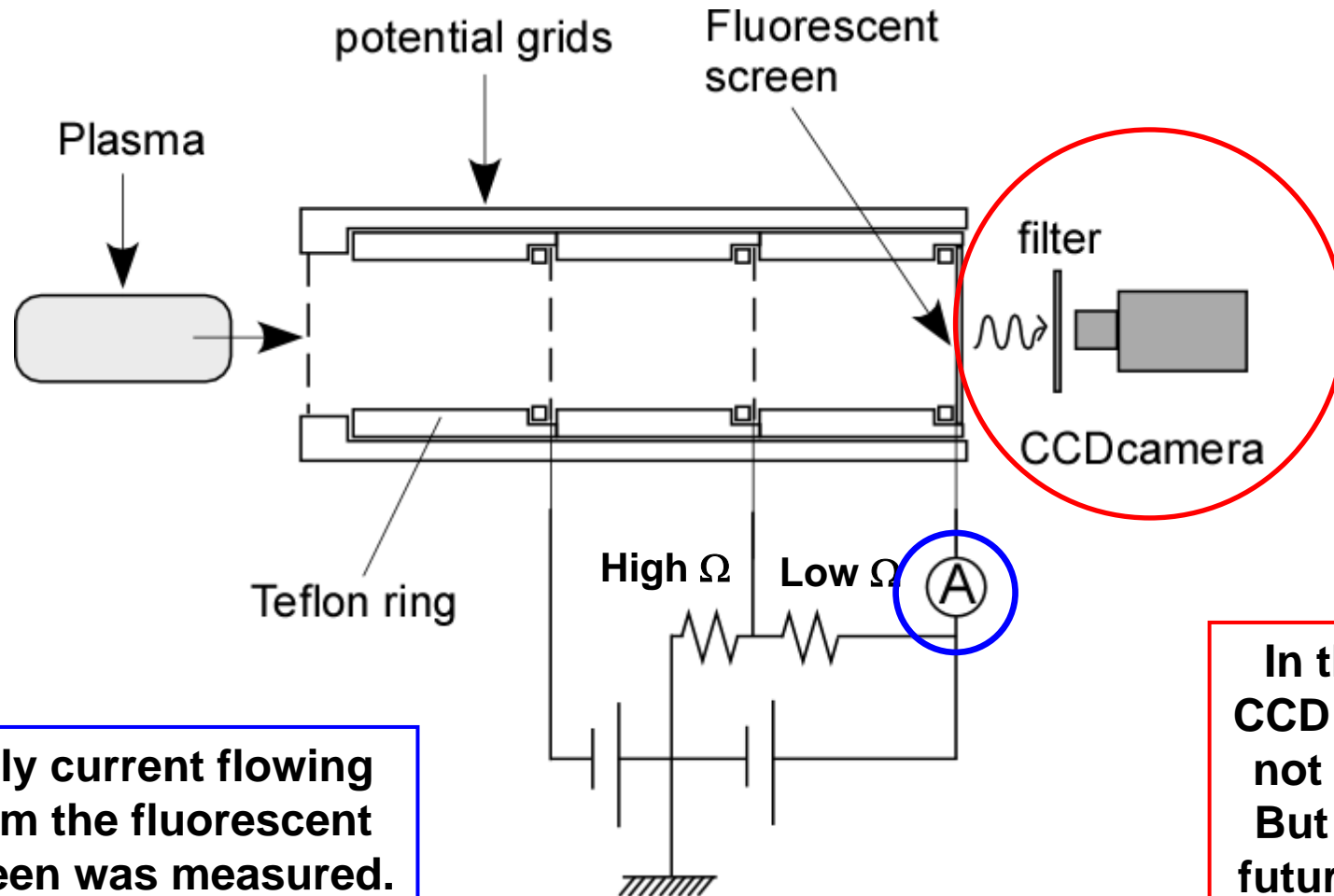
**For example,  $T = 0.3$  V and  $n = 10^{13}$  (for electron)       $T/N = 3 \times 10^{-14}$ .**

**$T = 5$  V and  $n = 10^{18}$  (for ion)       $T/N = 5 \times 10^{-18}$ .**



# Schematic drawing the instrument

The first test of analyzing the electron energy was performed on BX-U.



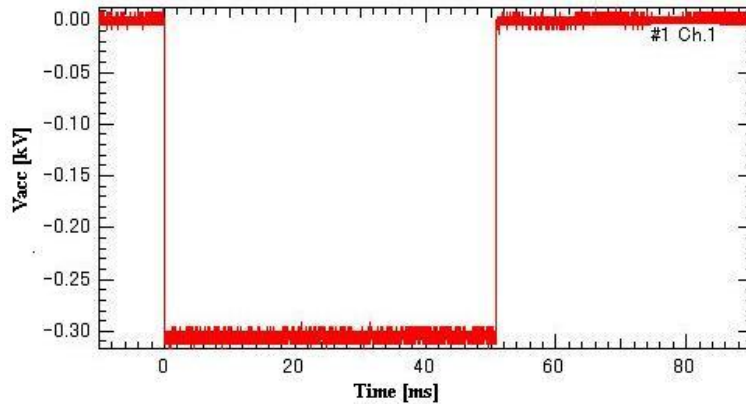
Only current flowing from the fluorescent screen was measured.

In the present CCD camera has not been used. But in the near future it is used.

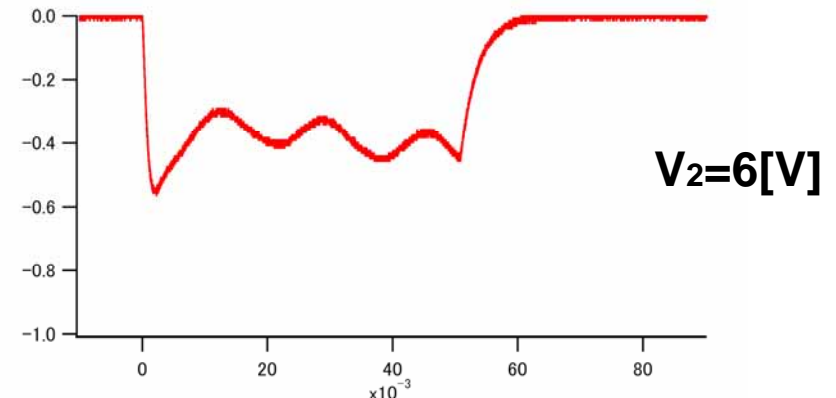
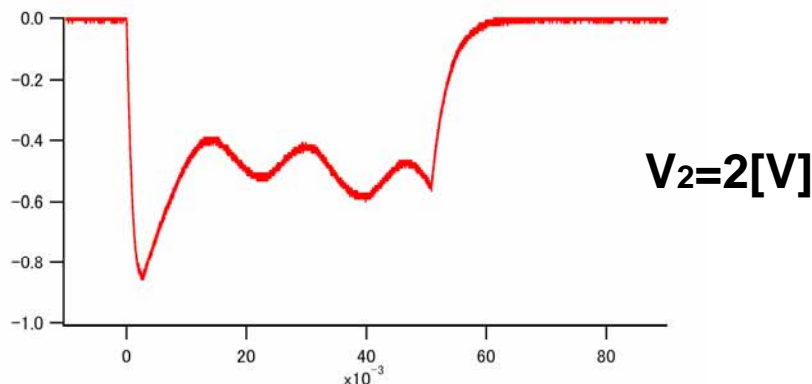
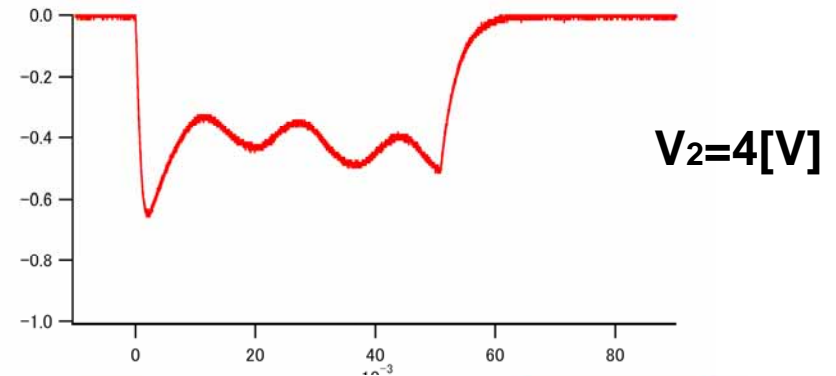
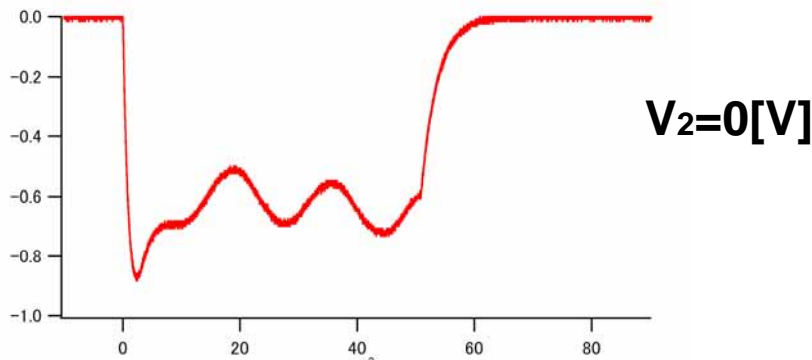




# Current flowing from the fluorescent screen

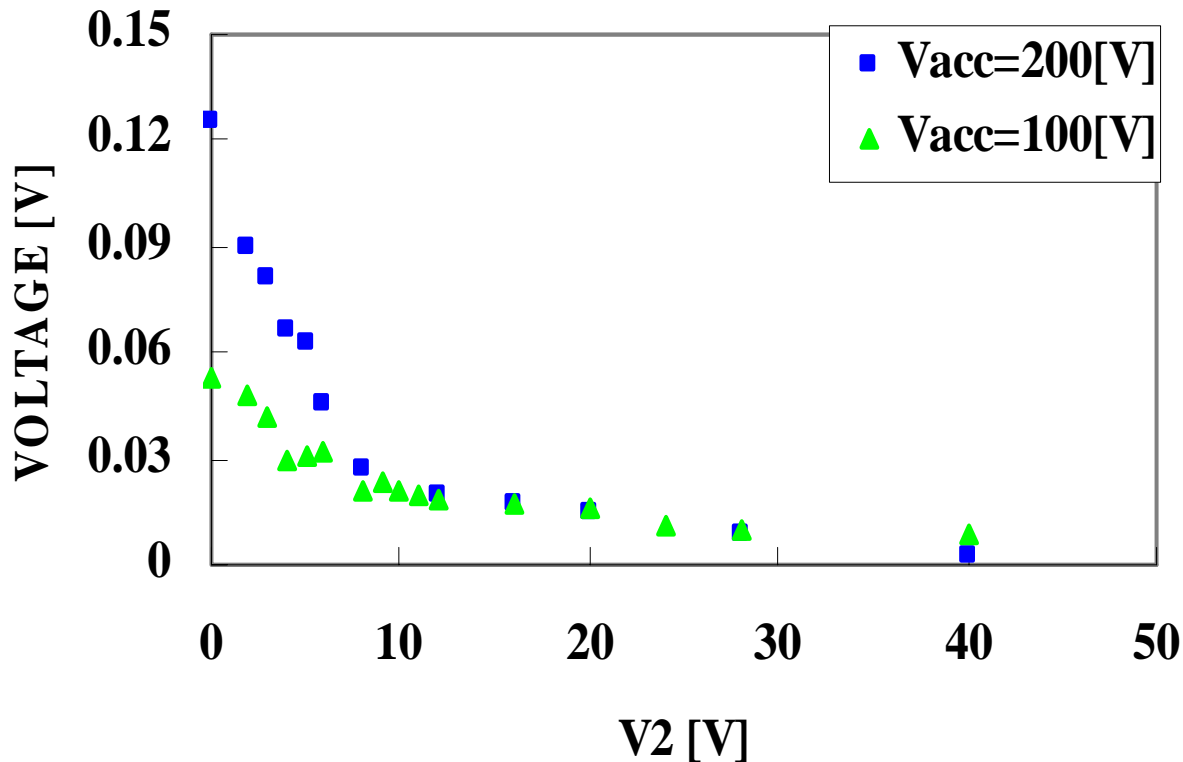


While  $V_{acc} = 300$  V (for 50 ms), the time evolution of the current flowing out from the fluorescent screen.





# Current flowing from the fluorescent screen



The axis of ordinate is voltage both ends of  $1M\Omega$  which is a ampere meter.

$$I = V / 1M\Omega$$

$$\sim 0.1 \mu A$$



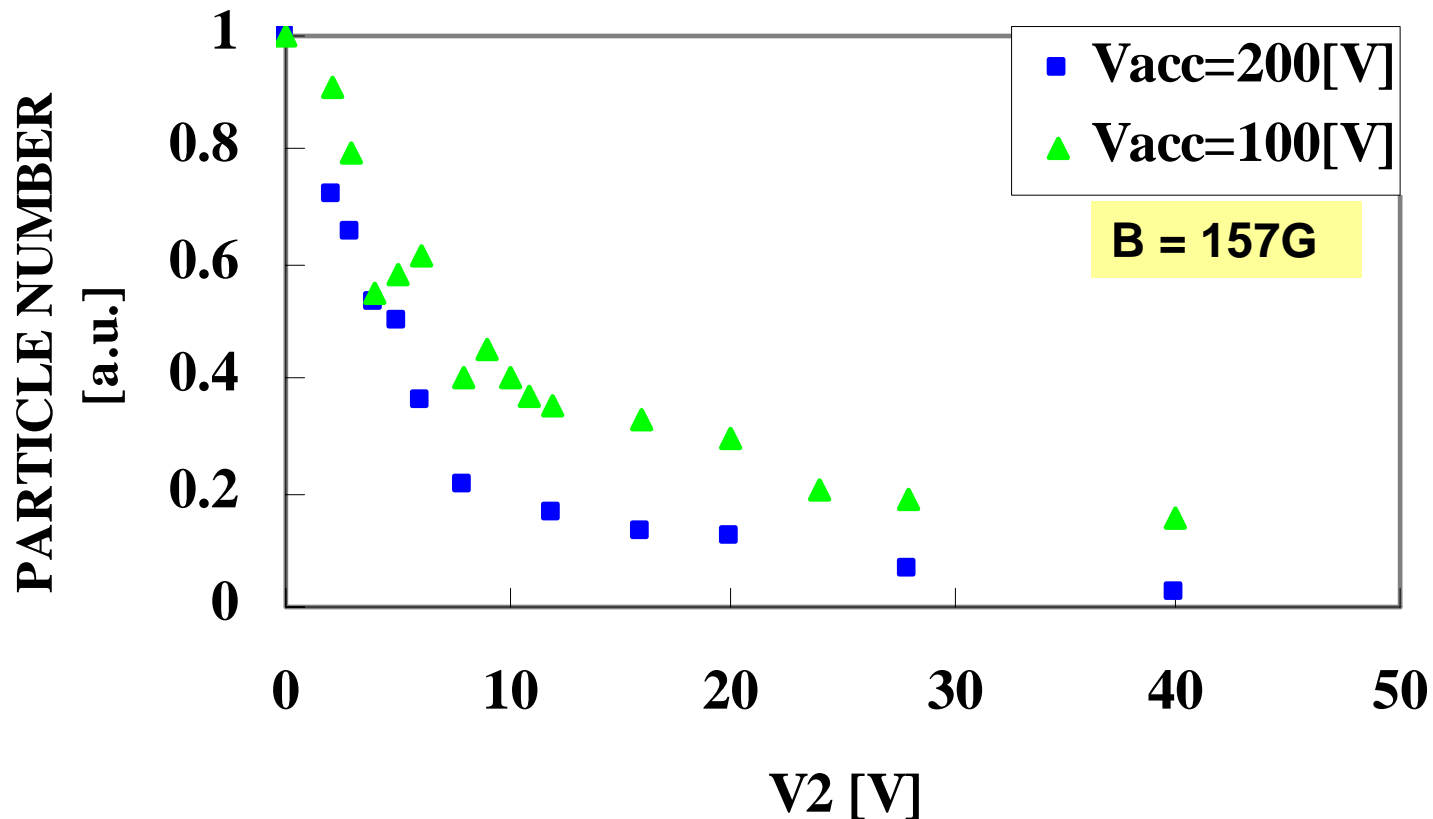
Particle number hitting the fluorescent screen is obtained.



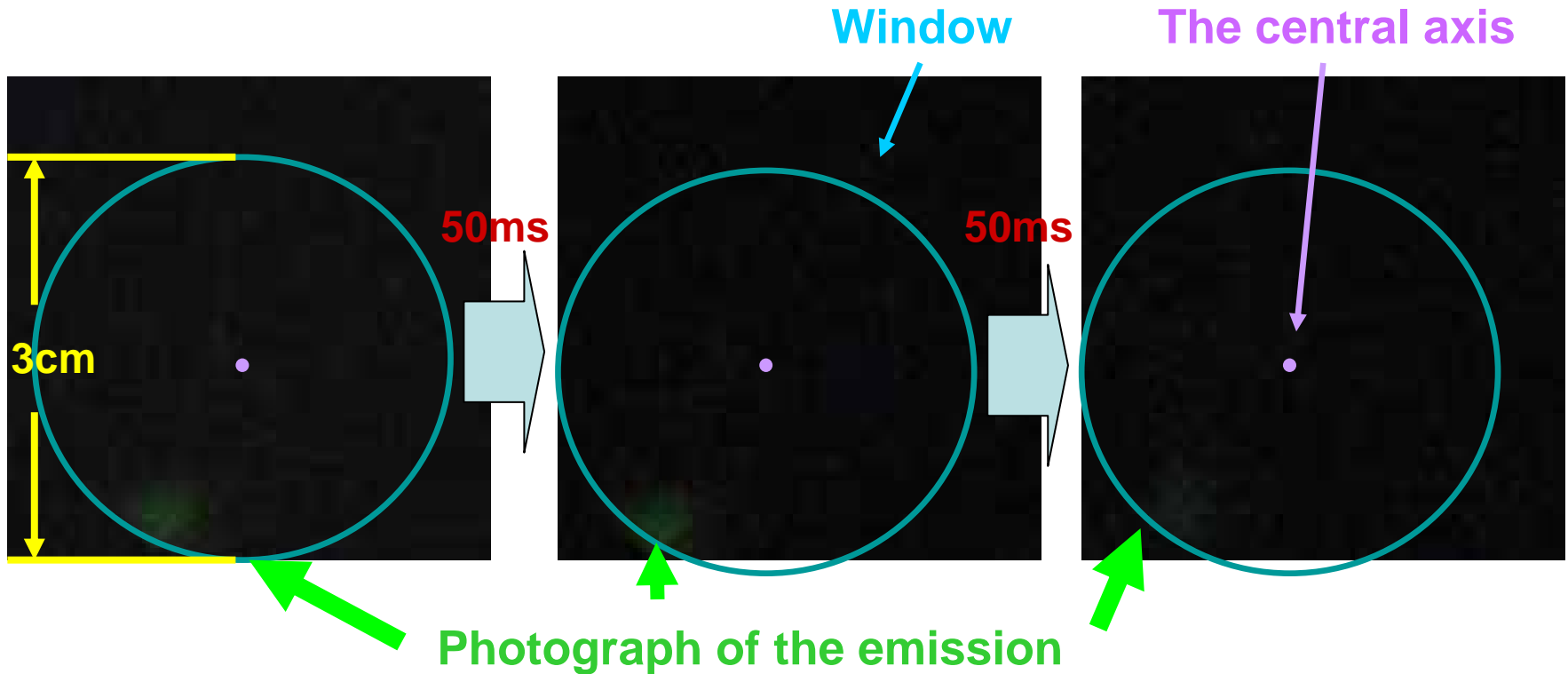
# Current flowing from the fluorescent screen

The total number of electron hitting the fluorescent screen

This date is normalized by a particle number at the case  $V_2 = 0$ , respectively.



# Emission from the fluorescent screen



Images are obtained with digital camera

- $B=157\text{G}$
- $V_{acc} = 200\text{ V}$

# Summary

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**A new type of fluorescent screen with the particle energy analyzer is proposed. This new method clearly has an advantage of clarifying both space distribution of number density and particle energy simultaneously.**

**A preliminary data show that the energy analyzer works well. The fluorescent screen emits visible green light with reducing the number of electrons.**

**After completing an ICCD camera, the proposed instrument will be totally tested.**

# Malmberg type trap device BX-U

The measuring instrument is installed here.

