



# Plasma measurement of mercury free lamp by laser absorption spectroscopy

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## Introduction

× mercury fluorescent lamp → ○ xenon fluorescent lamp

Problematic of xenon fluorescent lamp

luminance and efficiency are low

Solution

use of an external electrode

luminance and efficiency become equivalent to those of mercury fluorescent lamp

To clarify the mechanism of high luminance and efficacy by setting an external electrode the change of plasma characteristics is investigated by using the laser absorption spectroscopy in this study.

## Experimental setup

- Diode laser is used for a laser light source.
- Laser wavelength : 823.16 nm
- He-Ne laser is used for alignment of optical path.
- The waveform of the transmitted laser intensity detected by PMT was recorded by an oscilloscope.

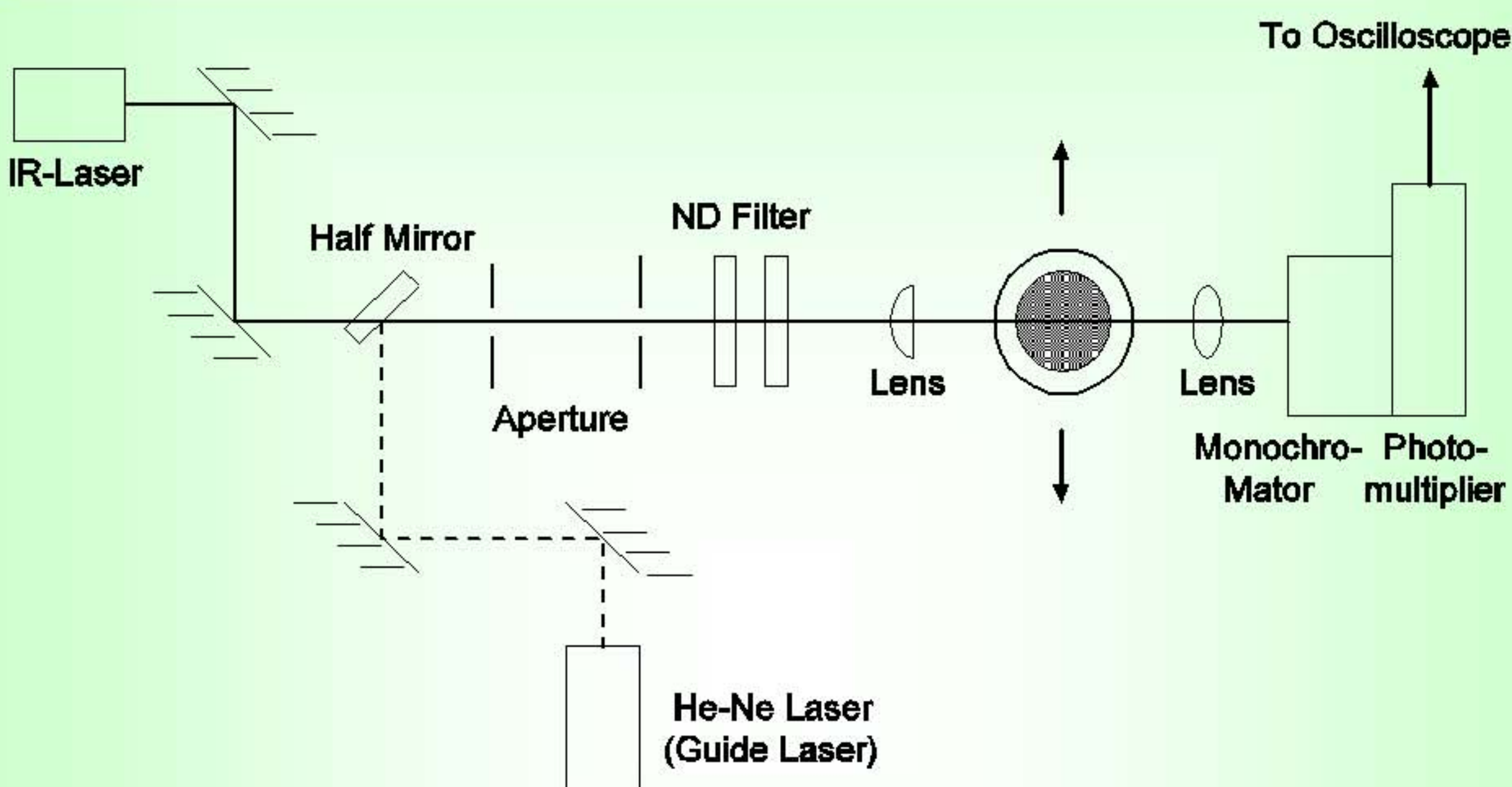


Fig.1 : Schematic diagram of optical system

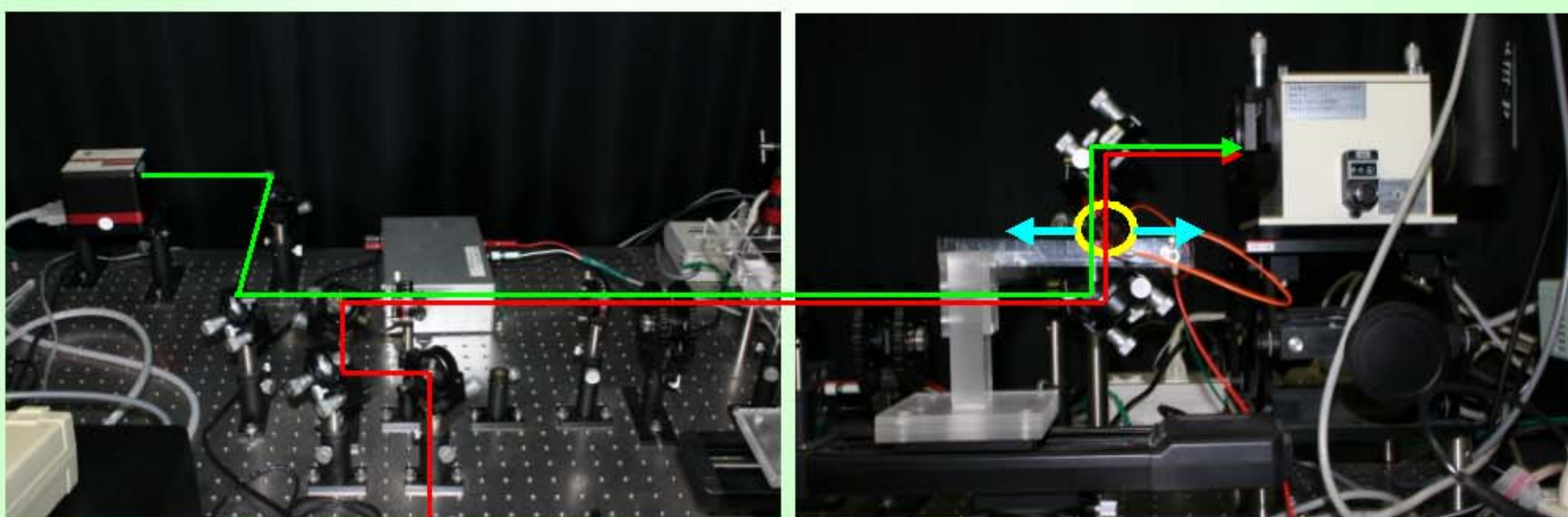


Fig.2 : Photograph of optical system

## Lamp structure and experimental method

### Lamp structure

- Distance between electrodes : 60mm
- Inside diameter of lamp : 26mm
- Filled gas : Xe
- Filling without phosphor pressure : 50 Torr

### Experimental method

- Laser is irradiated at middle between electrodes.
- The lamp is moved across the lamp axis every 1mm up to ±8mm of radius.
- Metastable atom density is measured in each position.

External electrode width : 2.5mm

### Measurement conditions

Frequency 25kHz · Pulse width 5μs

- With an external electrode : voltage 2500V, current 12mA, power consumption 1.61W
- Without external electrode : voltage 2600V, current 12mA, power consumption 1.64W

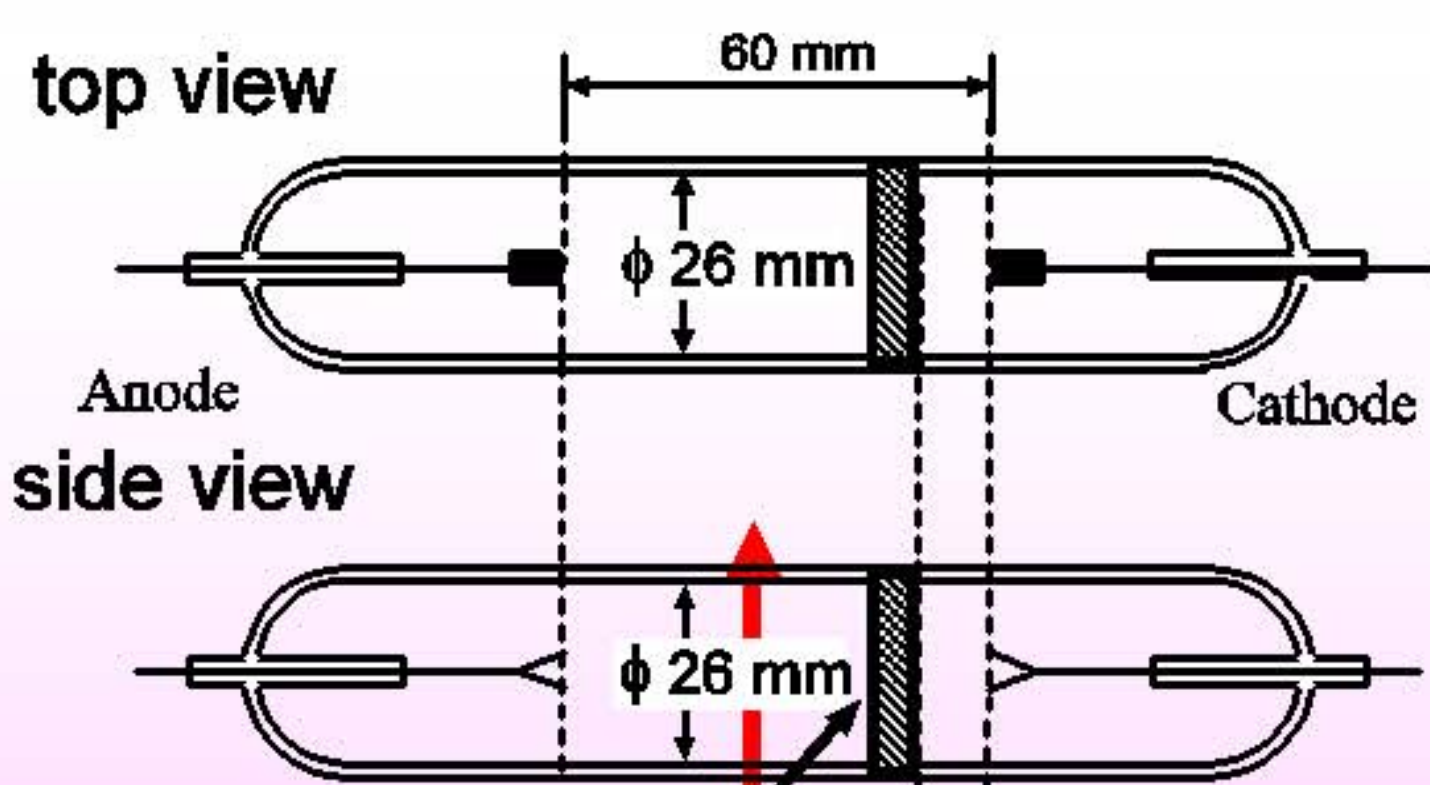


Fig.3 : Lamp structure

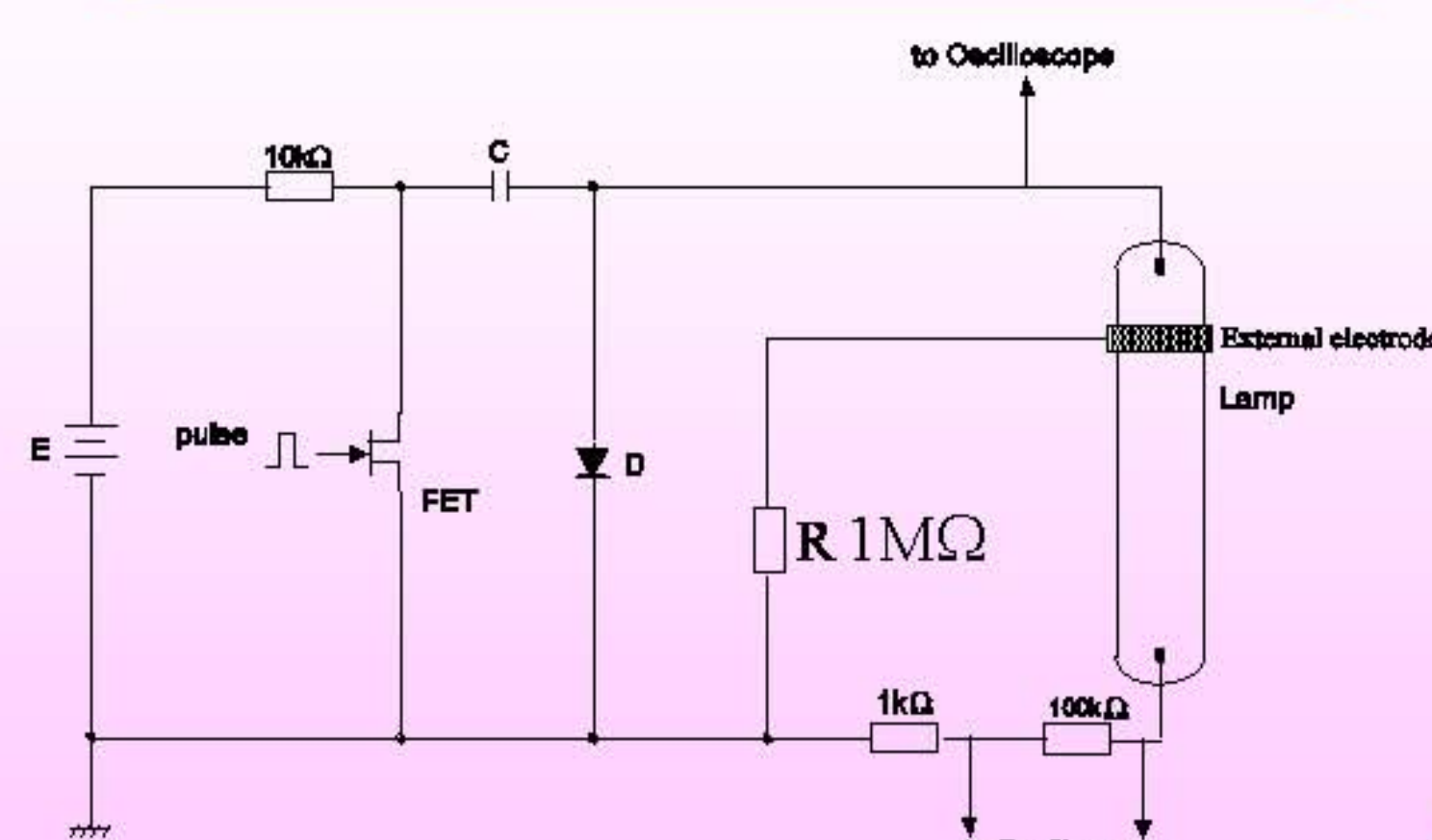


Fig.4 : Lighting circuit

## Results

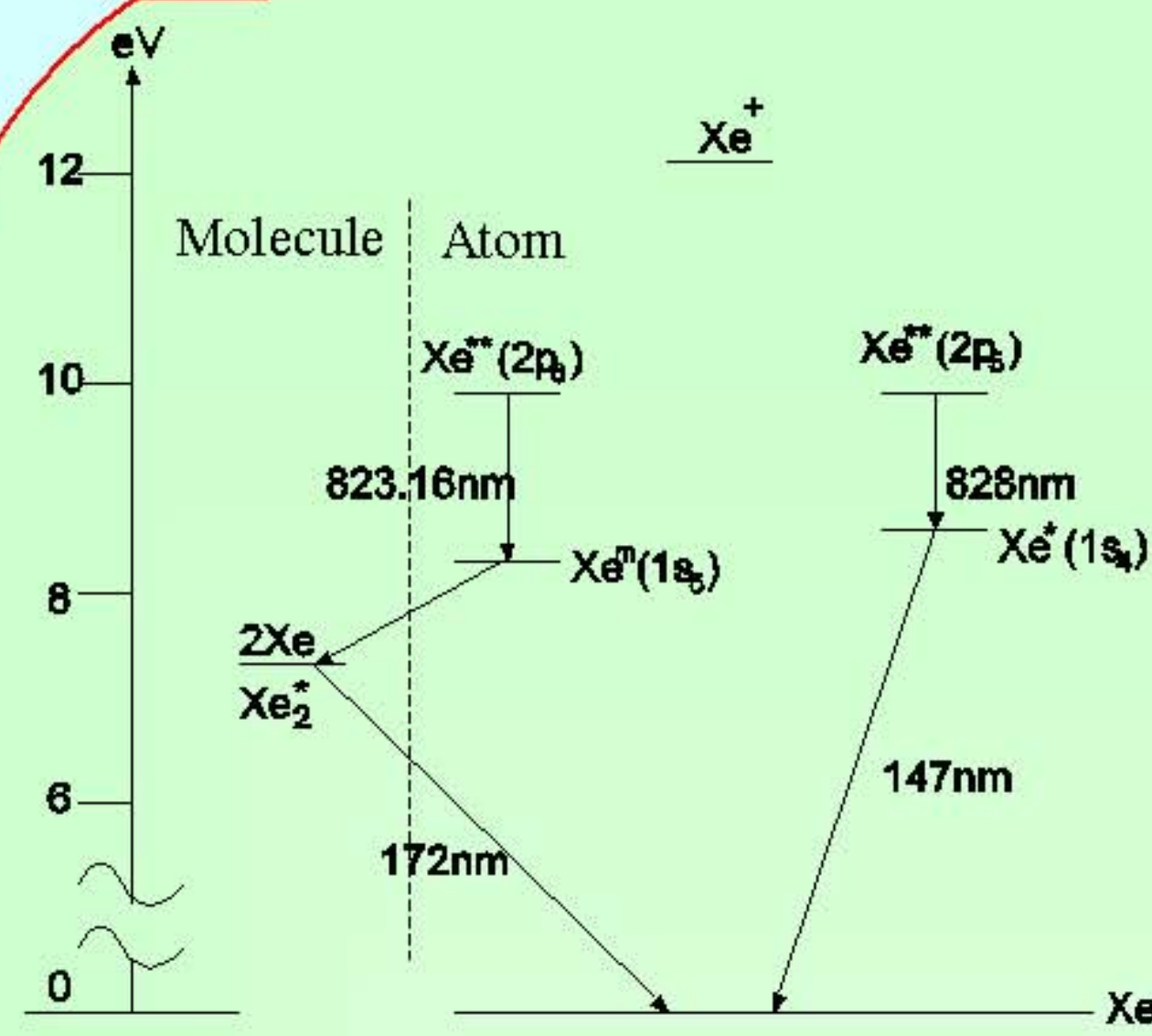


Fig.7 : Energy level diagram

The calculation method of density

$$N_1 = \frac{8\pi g_1}{\lambda^2 g_2 A_{21}} \int_{-\infty}^{+\infty} k(\nu) d\nu$$

### Without external electrode



Fig.5 : An actual lamp

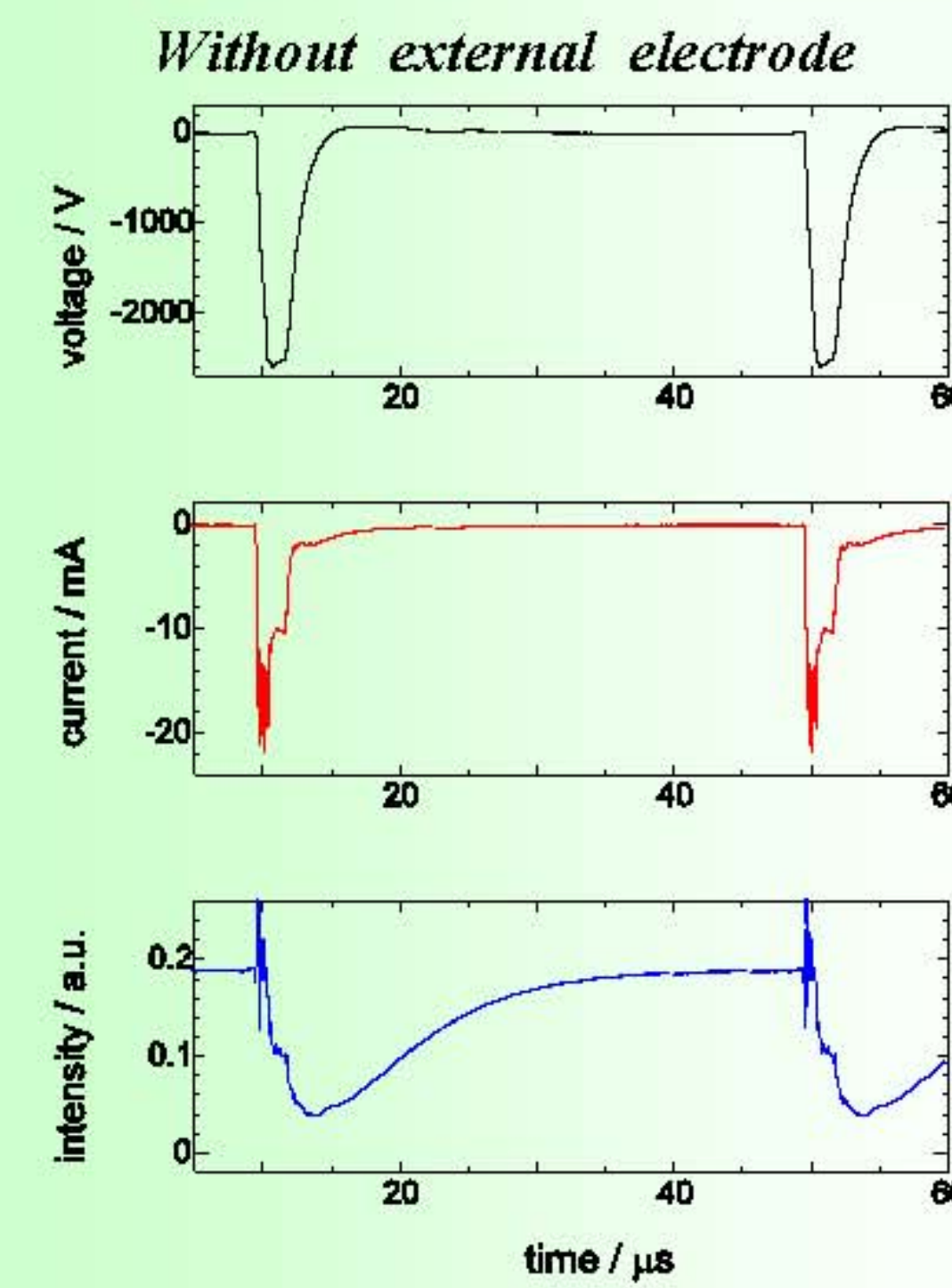


Fig.8 : Voltage, Current and Intensity waveform (Without external electrode)

### With an external electrode



Fig.6 : An actual lamp

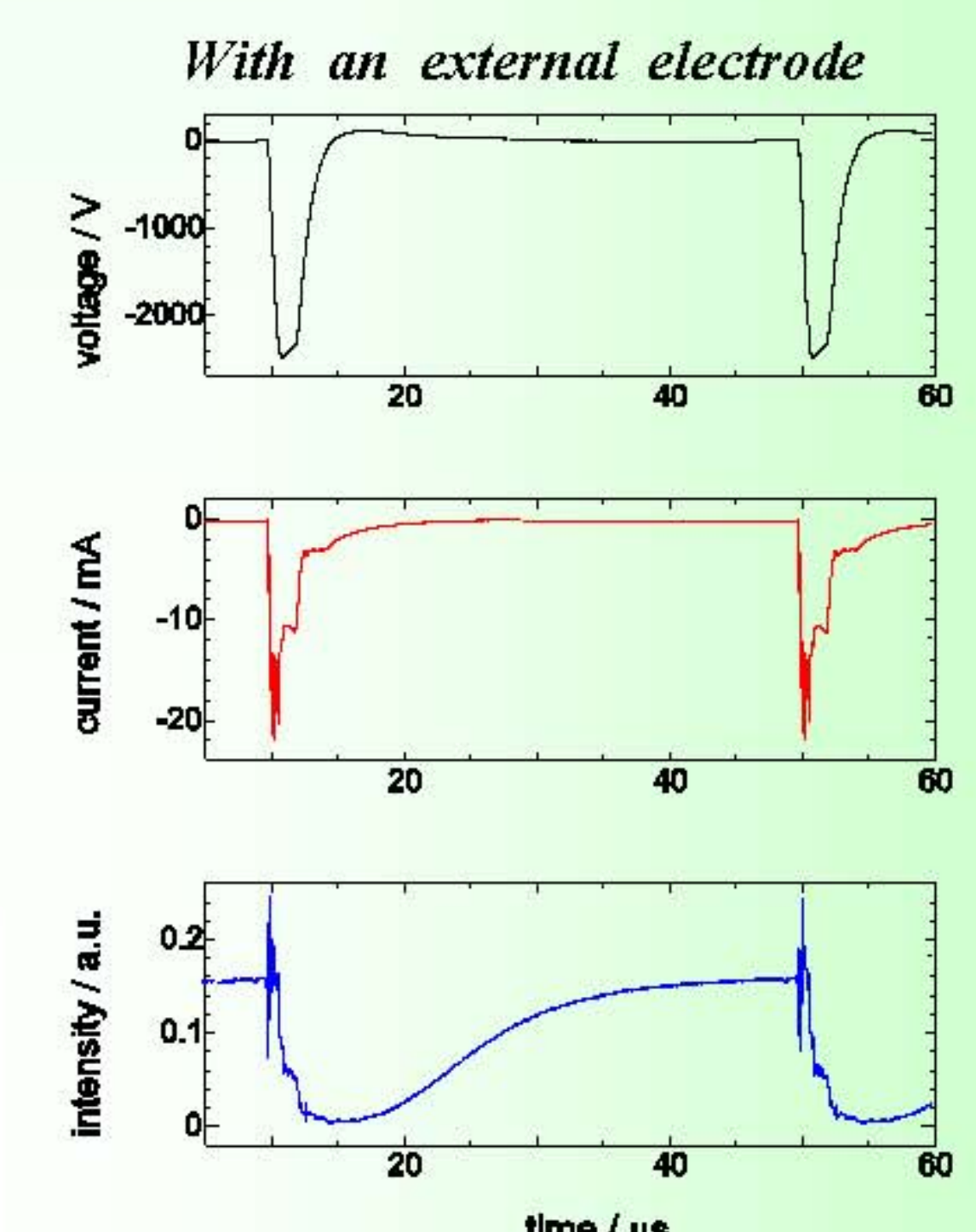


Fig.9 : Voltage, Current and Intensity waveform (With an external electrode)

Fig.8, 9 : Measurement data → calculate → Fig.10, 11 : Radial distribution of metastable density

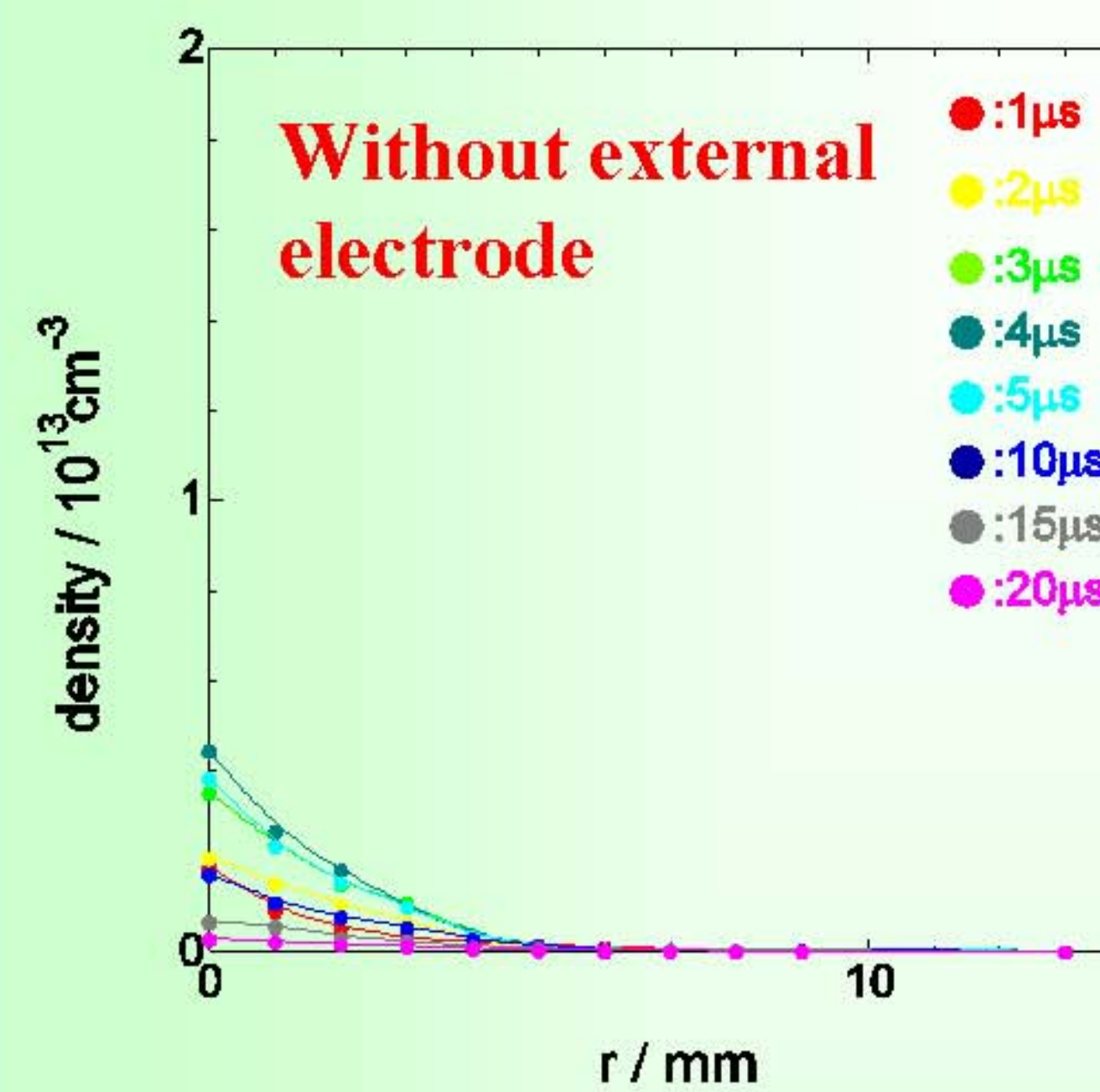


Fig.10 : Metastable atom density VS radius at each time (Without external electrode)

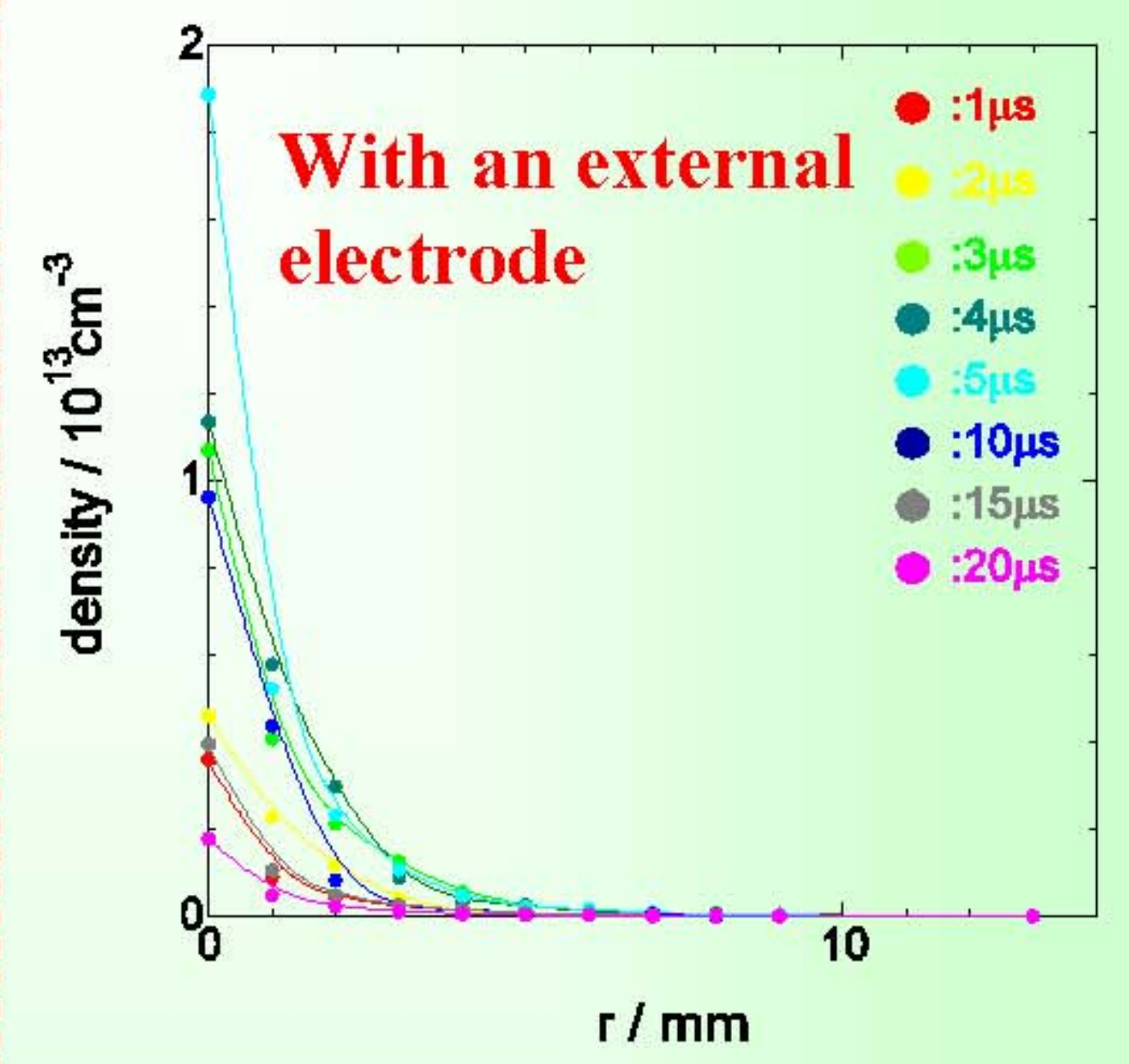


Fig.11 : Metastable atom density VS radius at each time (With an external electrode)

The difference in the metastable density by with and without an external electrode

Metastable atom density

Without external electrode << With an external electrode

Ultraviolet radiation of 172nm increases by the external electrode

**Luminance improvement**