

# MEASUREMENT OF DOSE DISTRIBUTION FROM A CROOKES TUBE USING TL DOSIMETER



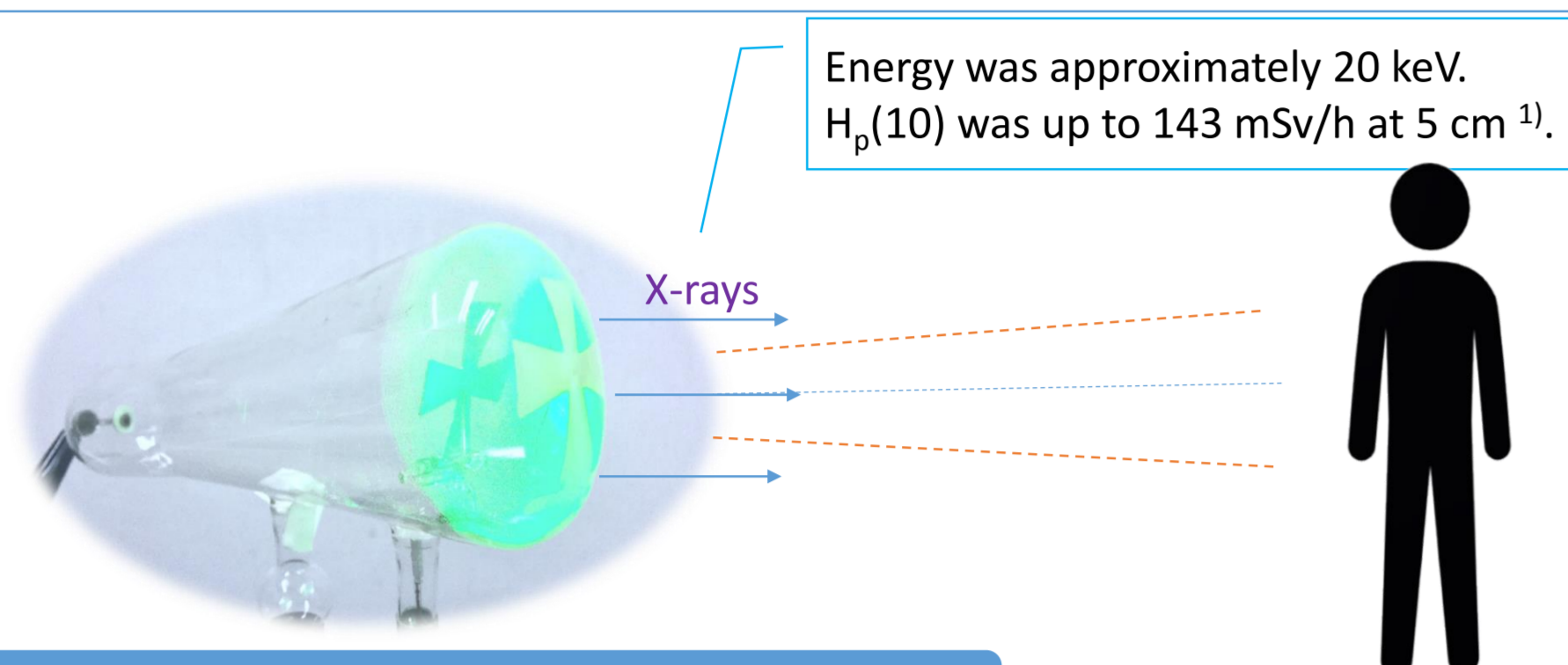
Do Duy KHIEM, Masaya YASHIKI, Hiroto MATSUURA, Masafumi AKIYOSH  
 Graduate School of Engineering, Osaka Prefecture University  
 1-1 Gakuen-cho, Naka-ku, Sakai-shi, Osaka 599-8531, Japan  
 E-mail: akiyoshi@riast.osakafu-u.ac.jp, doduy\_khiem@yahoo.com

The 19th International Conference on Solid State Dosimetry (SSD19)  
 Hiroshima, September 15<sup>th</sup> – 20<sup>th</sup>, 2019

## INTRODUCTION

### BACKGROUND

- In Japan, a Crookes tube, as a discharge tube, has been used in junior-high science classes, and the primary purpose is to teach the characteristics of electrons and current.
- X-rays emitted by the Crookes tube might cause exposure to teachers and participating students.
- A radiation safety guideline has not been evaluated sufficiently yet in Japan.

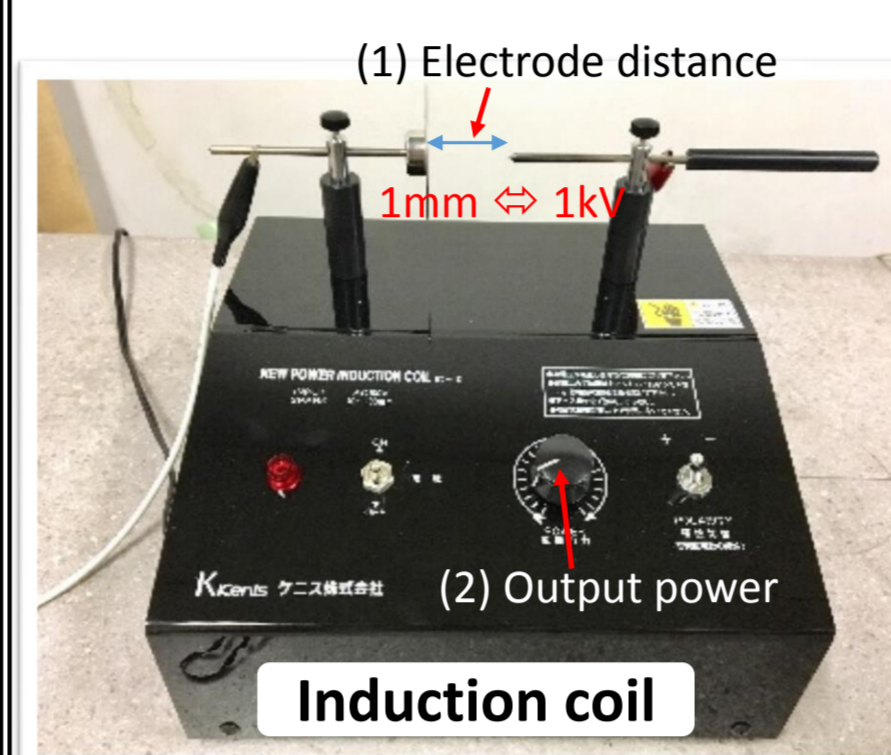


### SCOPES OF THE RESEARCH

- Estimating the characteristics and properties of X-rays emitted by a Crookes tube used in educational sites.
- Investigating the relevance between electric settings and X-rays properties (energy, dose).
- Evaluating the dose distribution surrounding the Crookes tube using Thermoluminescence (TL) dosimeters and glass badge.
- Submitting the results as the recommendation and guideline for radiation protection at junior-high school science class.

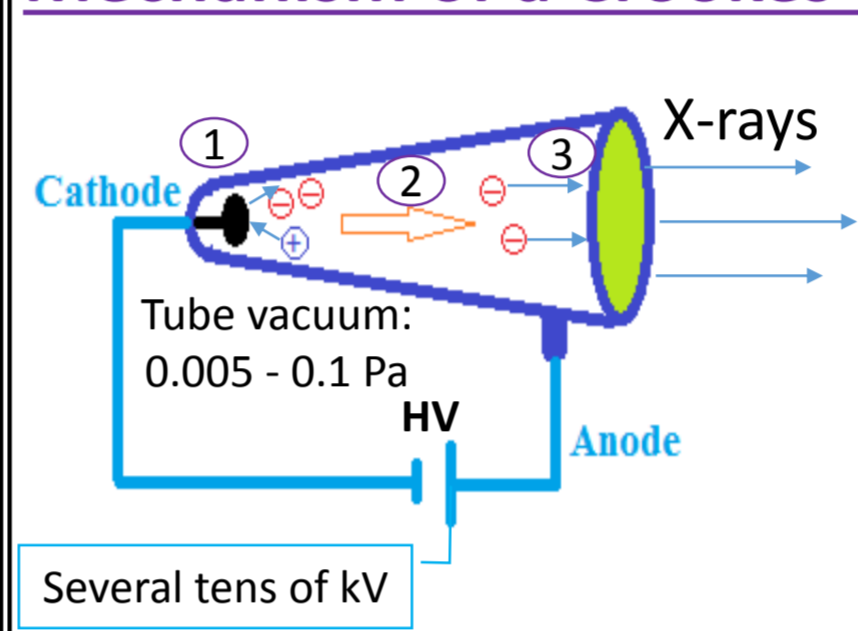
## MATERIALS AND METHODS

### X-RAY SPECTROMETER



- On the induction coil, the desired output voltage can be obtained by regulating:
  - The electrode distance ranges from 10 to 100 mm. Each of the distances limits a maximum voltage to the Crookes tube.
  - The output power controller (PW) ranges from 0 to 20. By increasing the output power, the applied voltage will continually increase until a spark occurs to reach the maximum voltage.
- Applied voltage is approximately 1 kV at 1 mm.

### Mechanism of a Crookes tube

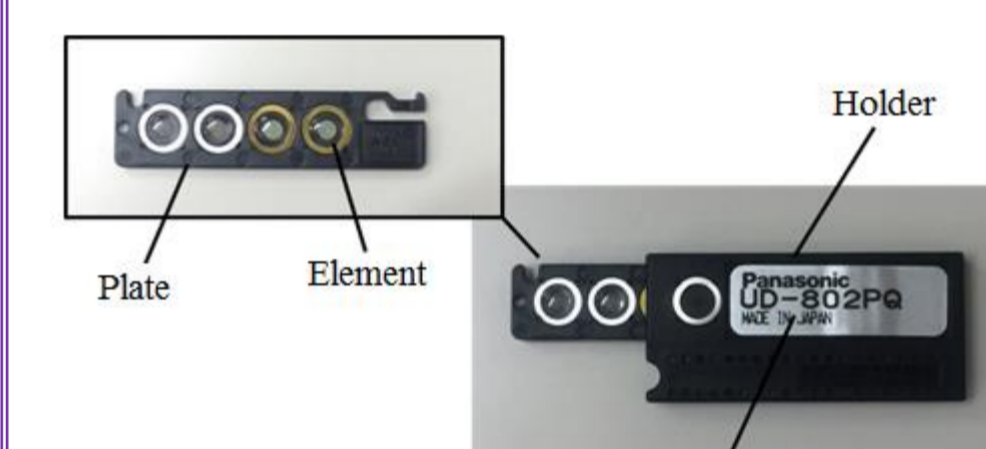


- Cations in the evacuated tube are accelerated and impact the cathode, and knock out secondary electrons.
- These electrons are accelerated under the applied HV.
- Accelerated electrons collide the glass wall to radiate bremsstrahlung X-rays.

### TL DOSIMETER SYSTEM



Panasonic TLD Reader UD-706

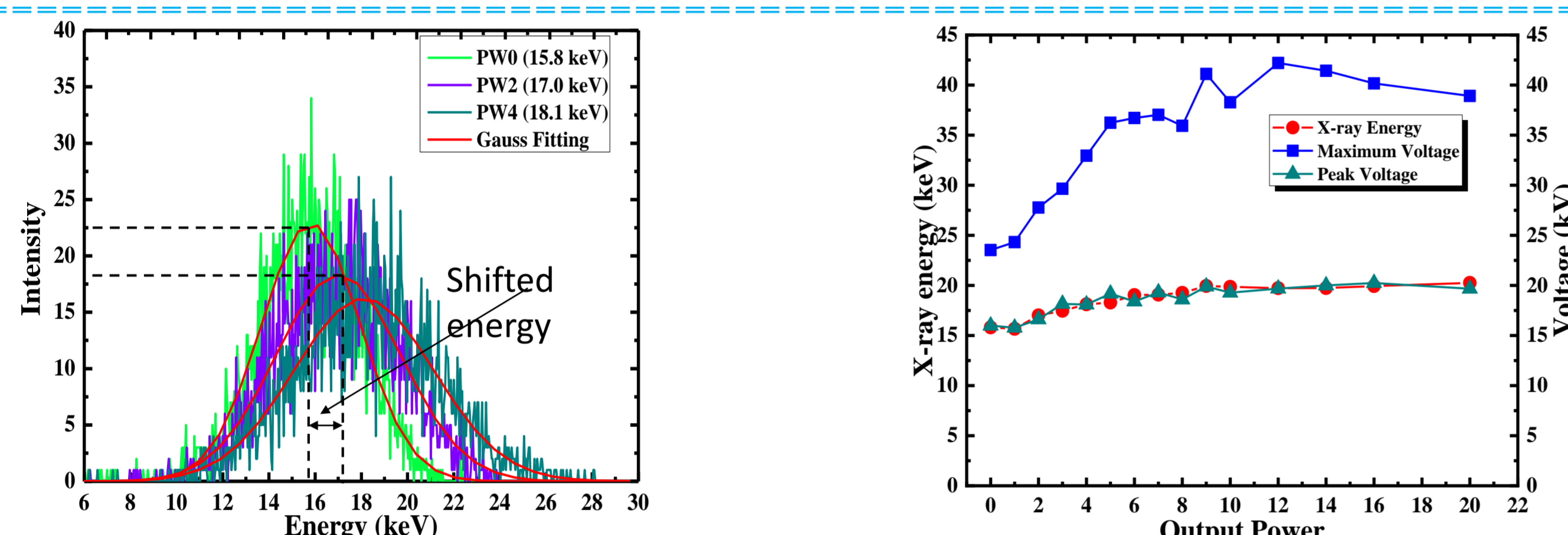


Panasonic TL dosimeters, types of UD-802PQ.

## DOSE DISTRIBUTION ASSESSMENT

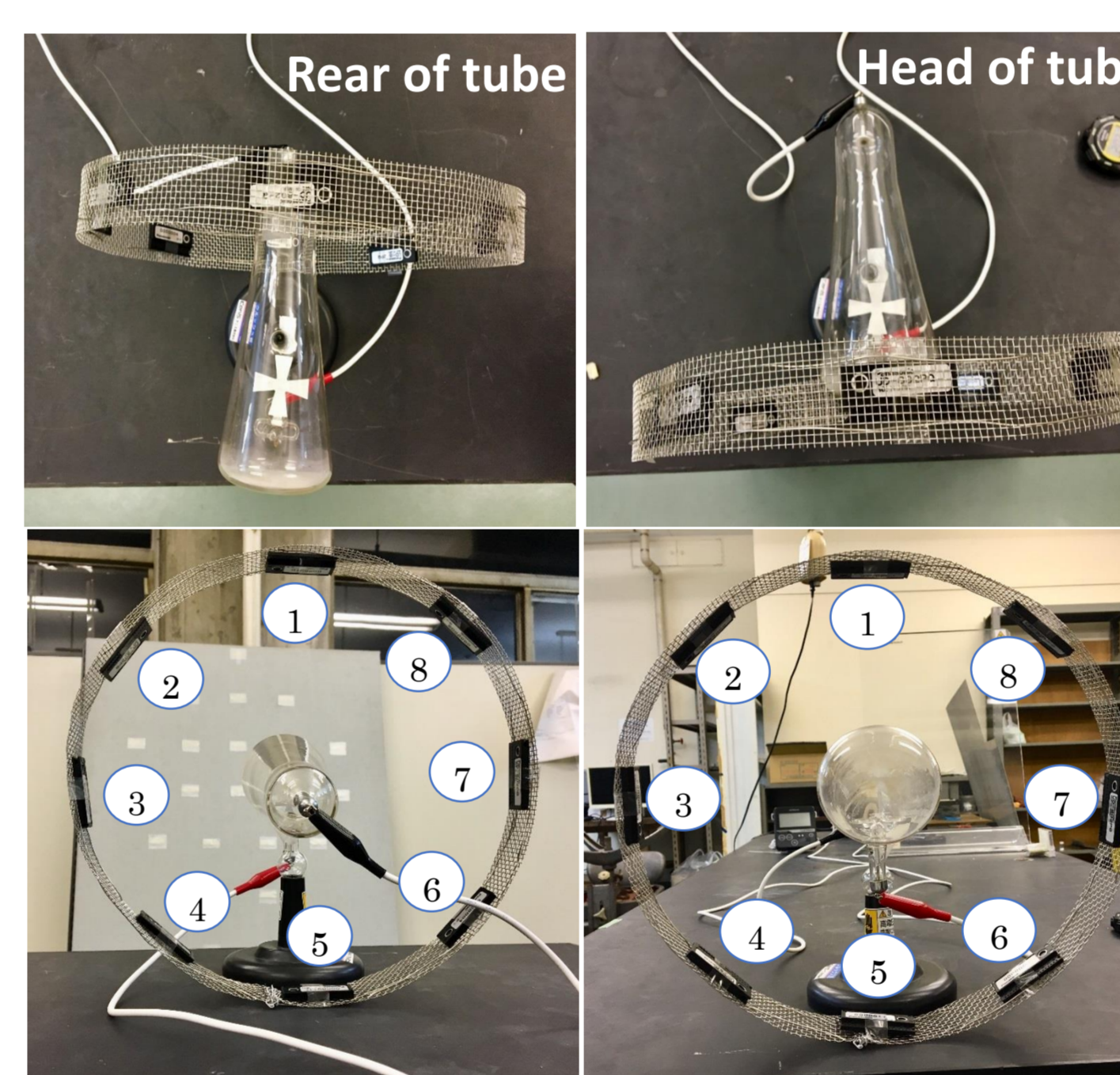
### CORRELATION BETWEEN APPLIED VOLTAGE AND X-RAY ENERGY

- The Crookes tube emitted X-rays with soft energy of approximately 20 keV.
- The exposure and X-ray energy changed with electrical settings such as output power, and electrode distance<sup>2,3</sup>.



### Experiment 02

#### CIRCLE DISTRIBUTION OF DOSE



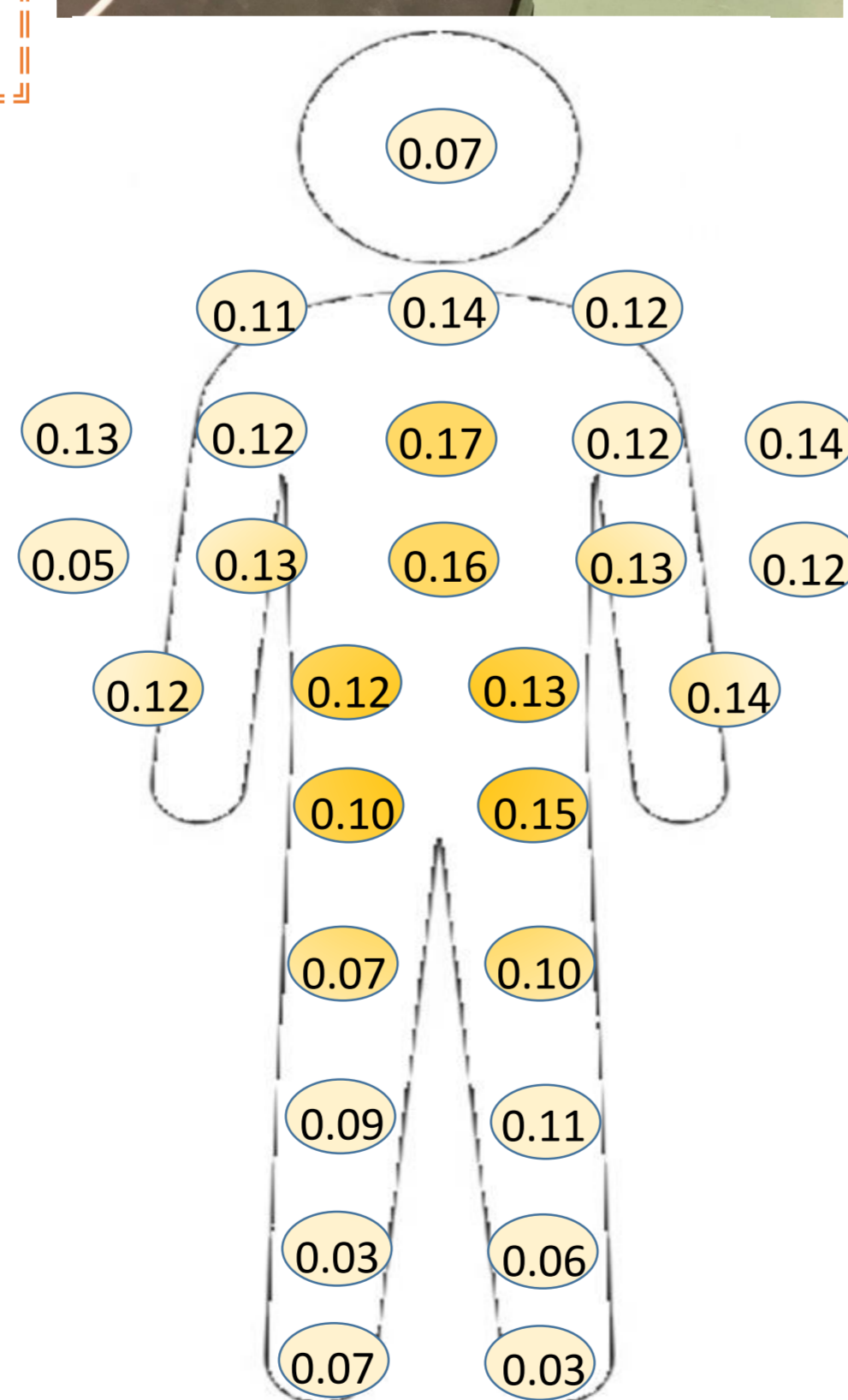
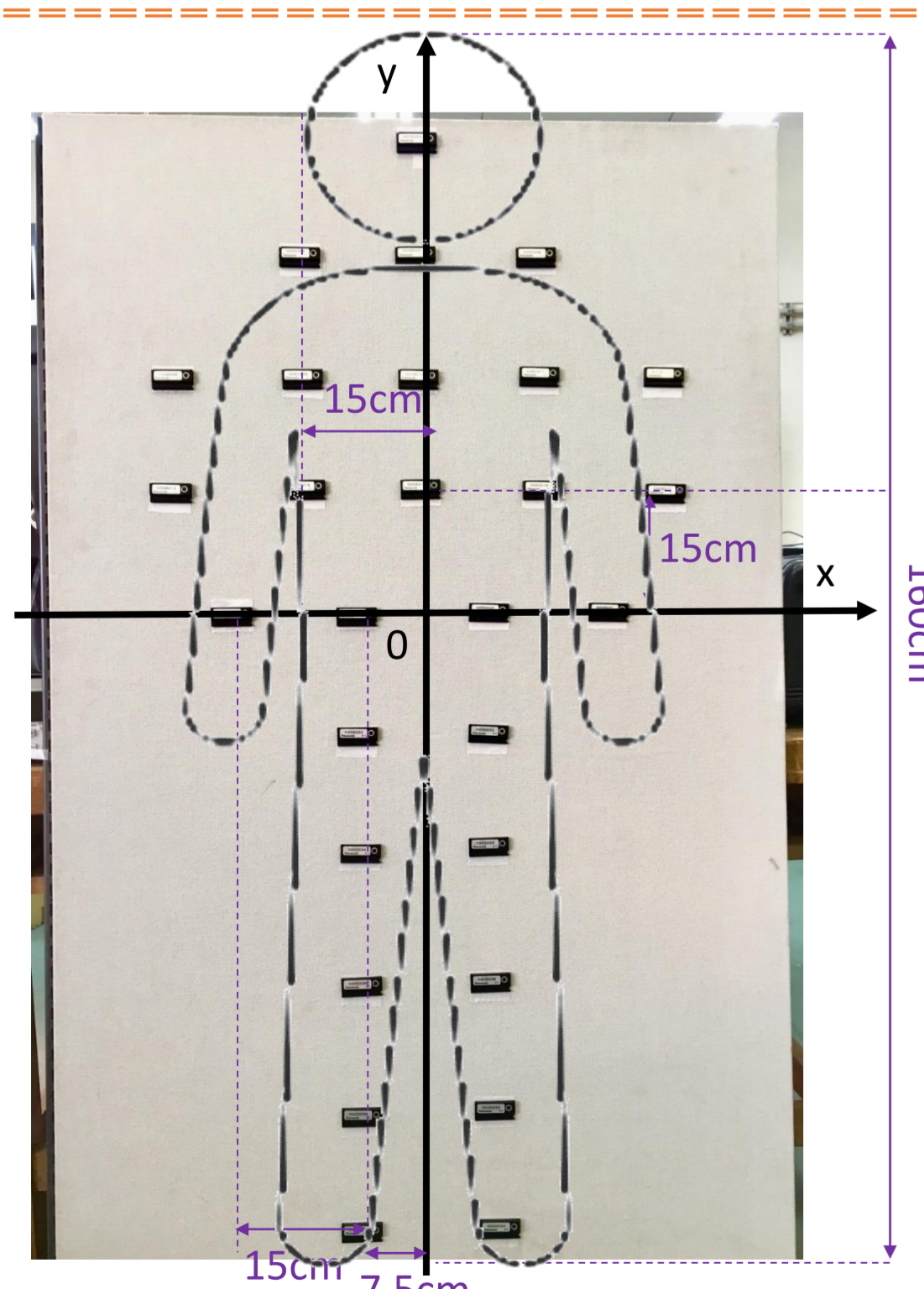
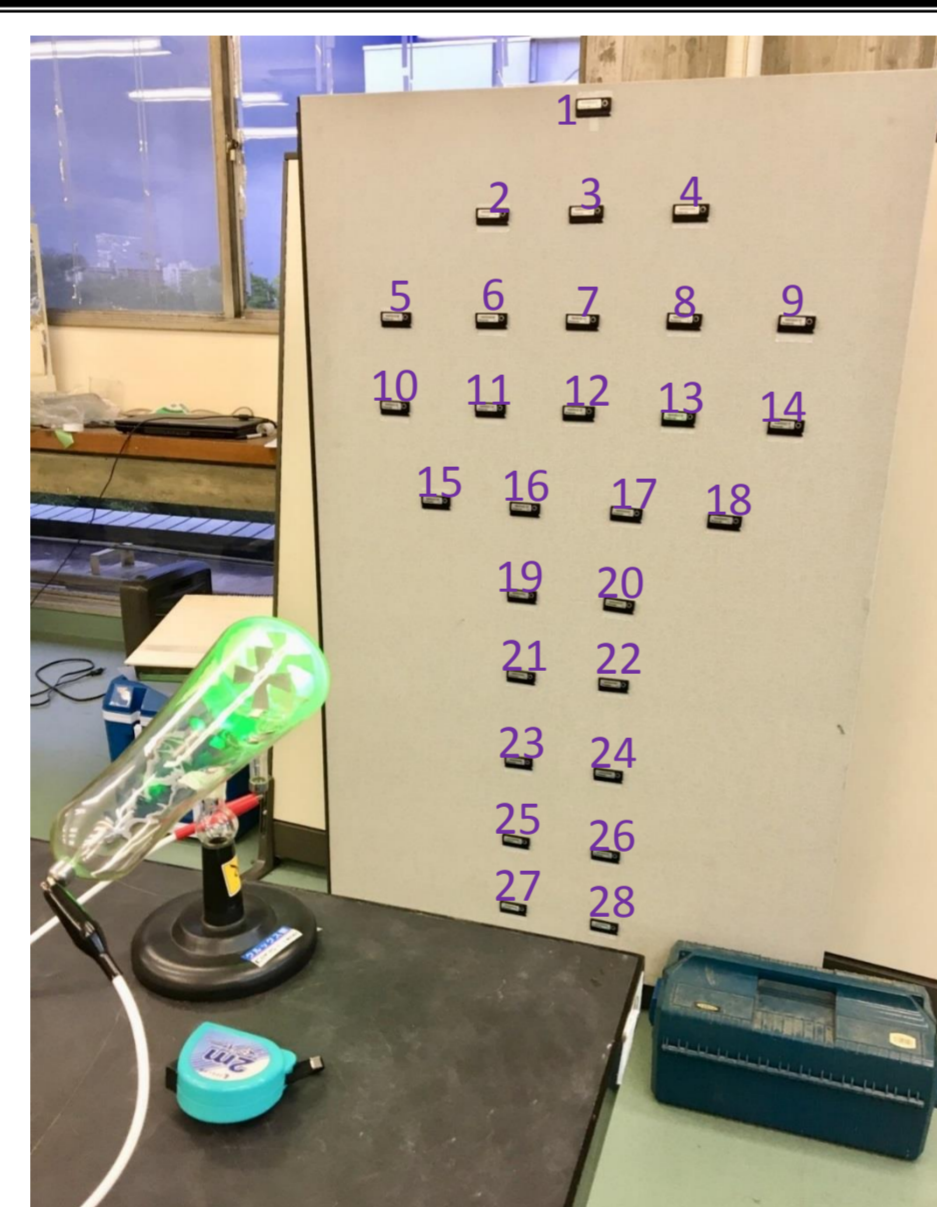
- TL dosimeters attached on the circle of 31 cm in diameter.
- The tube put in the central circle.
- Distance of 15 cm from the central tube to dosimeters.
- Irradiation time of 30 min.

Position	H <sub>p</sub> (0.07) (mSv/h)	
	Head of tube	Rear of tube
1	1.52	1.82
2	1.56	1.72
3	1.51	1.38
4	1.59	0.96
5	2.02	0.57
6	1.91	1.03
7	0.81	1.46
8	1.28	1.83

### Experiment 01

#### DOSE DISTRIBUTION ON BODY

- Dosimeters attached on the human body shape fitting to a junior-high school student.
- A H<sub>p</sub>(0.07) dose (mSv/h) at E1 position on dosimeter represents a skin dose affecting to students.
- Measurement distance of 1 m, irradiation time of 1 hour.
- Distribution of H<sub>p</sub>(0.07) dose enclosing the Crookes tube at 0.03 – 0.17 mSv/h.
- The dose concentrates in the central human body and relatively descend to expanded area.

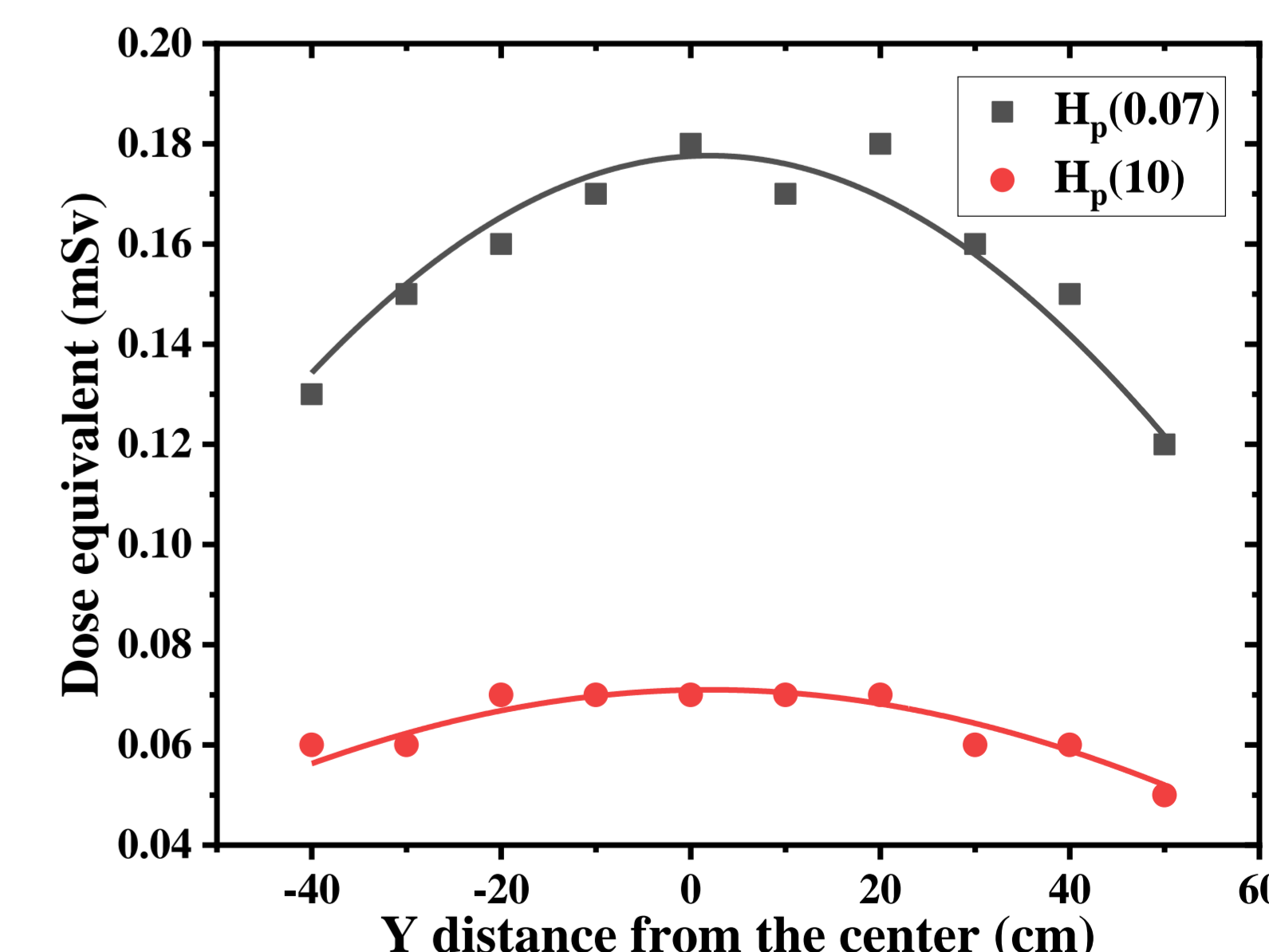
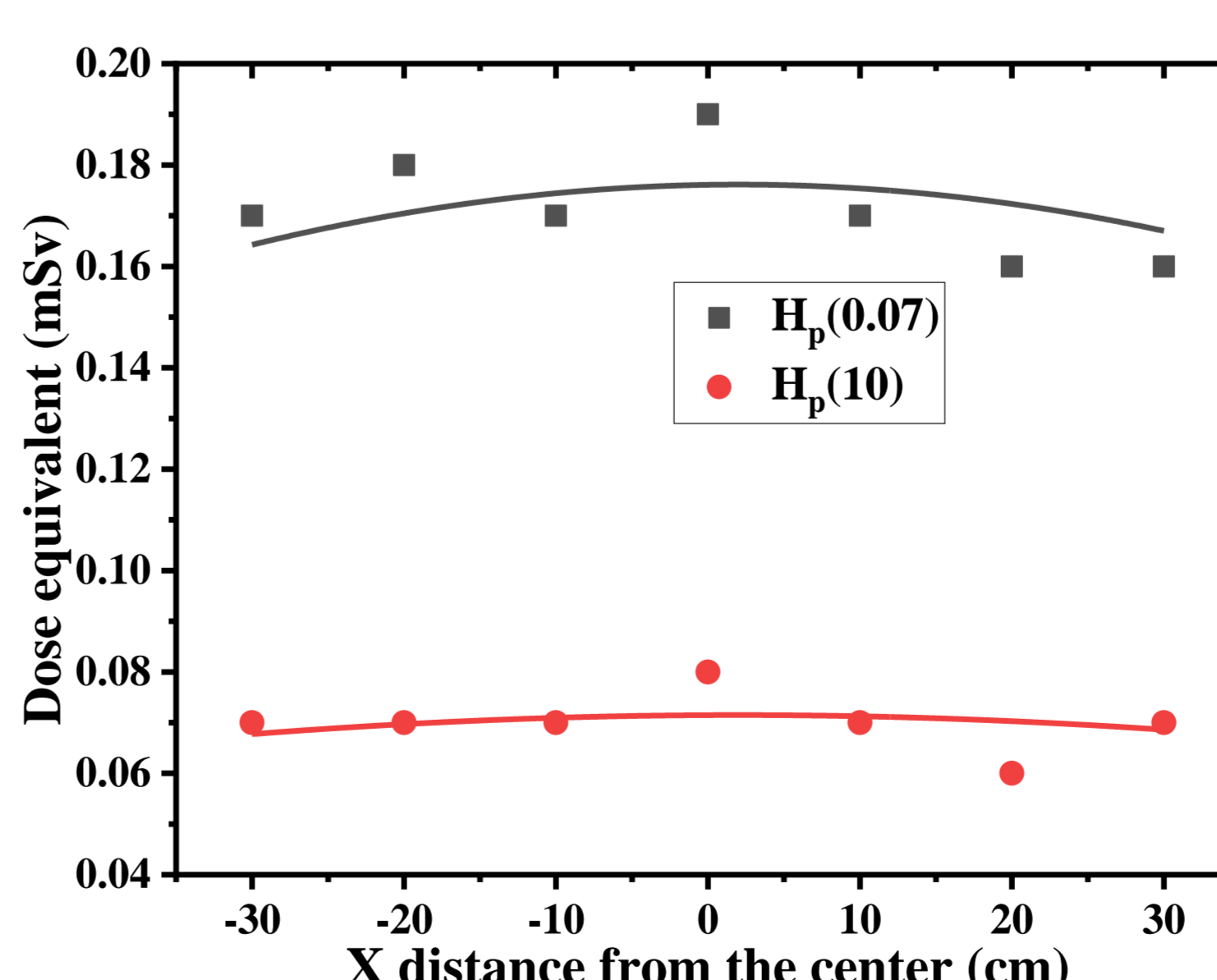
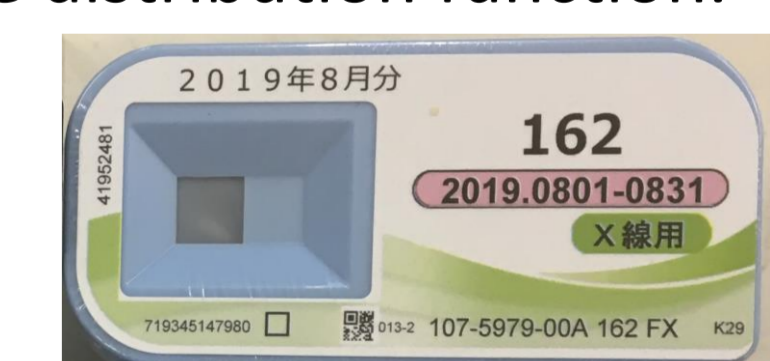


### Experiment 03

#### DOSE DISTRIBUTION ON (X, Y) COORDINATE



- Glass badge dosimeters (FX-type, Chiyoda Technol, Japan) attached on the X and Y axes.
- Measurement distance of 1 m, irradiation time of 30 min.
- The dose at any point on (X, Y) coordinate can be determined by the dose distribution function.



## SUMMARY

- The Crookes tube emitted X-rays with soft energy of approximately 20 keV. The exposure and X-ray energy changed with electrical settings such as output power, and discharge distance.
- Distribution of H<sub>p</sub>(0.07) dose on the body was 0.03 – 0.17 mSv/h at 1 m. The dose concentrates in the central human body and relatively descend to expanded area.
- The dose distributed circling the Crookes tube with higher dose at the head of the tube.
- Participants should stand at 1m from the tube during a demonstration to ensure radiation safety.

### References:

1) Ohmori Gihro, X-ray exposure in the teaching of science at junior and senior high schools. *NIRS-M-105*, Japan, 107-112 (1995) (in Japanese).  
 2) M. Akiyoshi, et al., Development of evaluation techniques for low energy X-rays from a Crookes tube, *Radiation chemistry*, 106 (2018) 31-38 (in Japanese).  
 3) Do Duy KHIEM, et al., Investigation of Characteristics of Low-energy X-ray Radiated from the Crookes Tube Used in Radiological Education, *Radiation Safety Management*, Vol. 18, 9-15 (2019).