International University of Health and Welfare,
Department of Radiological Sciences

Examination of the real-time exposure dosimetry system using synthetic ruby on the radiation therapy.

International University of Health and Welfare, Department of Radiological Sciences
Ayaka Maruyama, Toshiya Yamaguchi, Daisuke Ono, Takuya Kikuchi, Yuto Kikuchi, Risako Sato, Yoshiyuki Hosokai
South Miyagi Medical Center, Radiology
Satoru Watanabe

Background

It is part of reason in the occurrence of medical accidents on the radiation therapy that the local exposure dose cannot be direct monitoring in real-time.
We developed a real-time exposure dosimetry system using synthetic ruby for interventional radiology (IVR)*.

(*Y.Hosokai et. al., *Development of real-time radiation dosimetry system using synthetic ruby for interventional radiology.*, RPD (2017), pp. 1-6)

Ruby sensor and developed system(Fig.1, 2)

The ruby sensor is provided at the tip of the optical fiber to make a recess.
In Fig.1, the tip of the optical fiber is displayed with removal of the silicon cap.
We have known that "Synthetic ruby emits light in response to radiation", in the same manner as the diamond or sapphire.
This ruby's luminous wavelength is 693 nm, possible to monitor the radiation dose by detecting the emitted light.
Fig.2 is optical acrylic fiber and close up view of the fiber tip and a small box.
The photon counting head and the power supply unit are enclosed in this box.

Fig.1 Ruby sensor

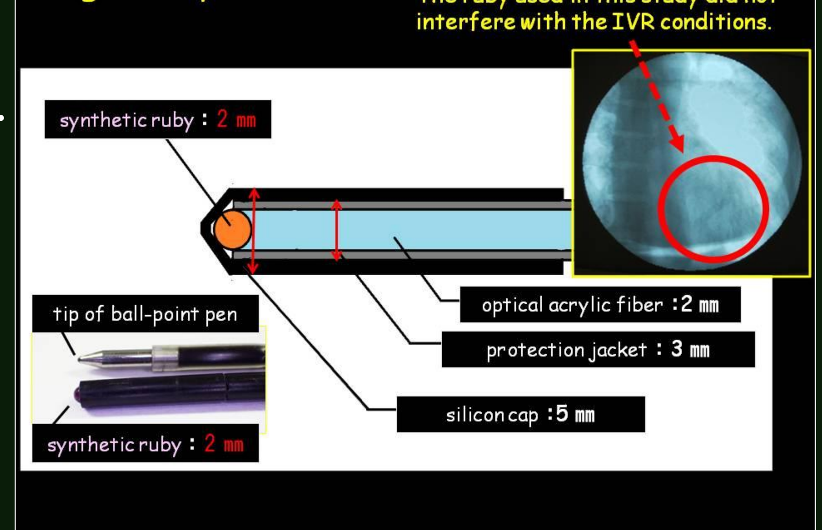
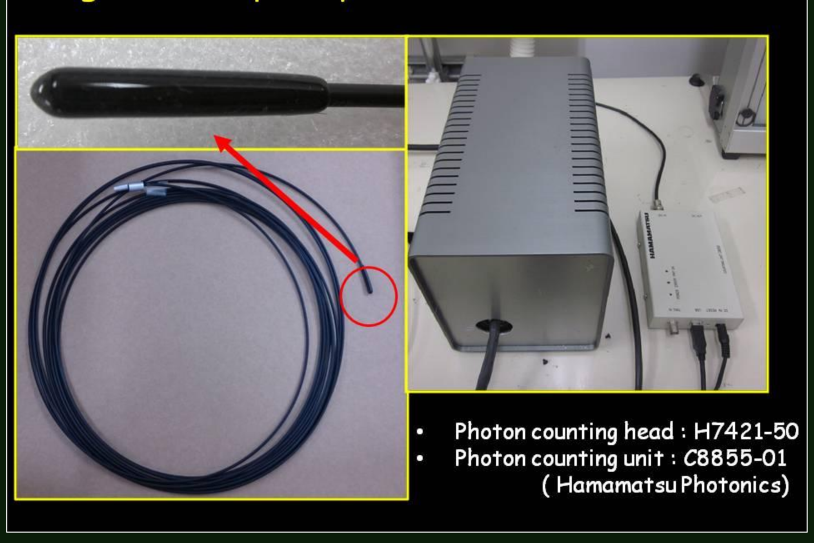


Fig.2 Developed system



Objective

To discuss some of the characteristics of the developed real-time radiation dosimetry system for use in radiation therapy, that employs a small spherical synthetic ruby and a photon counting system.

The advantages of the developed system

- not interfere with IVR
- to measure in real-time
- small size sensor (higher spatial resolution)
- higher temporal resolution
- easily obtainable and cheap etc.

Aims

1. Characteristic features of the percentage depth dose (photon)
2. Characteristic features of the percentage depth dose (electron)
3. Characteristic features of coefficient of variance of MU value
4. Linearity of the number of photons in terms of MU value

Materials

- Synthetic ruby (Φ : 2mm) : Hitachi Maxell
- Acrylic optical fiber (10m) : Saiden co.
- Photon counting head (H7421-50) : Hamamatsu Photonics
- Photon counting unit (C8855-01) : Hamamatsu Photonics
- RapidArc : Varian inc.
- Ion chamber : Type 34001 (PTW, USA)
- Cistern : 1233-1D SCANNER (Sun Nuclear Co., USA)

Results 1,2 : Characteristic features of the percentage depth dose (photon, electron)

Irradiation condition : photon
- 10 MV (10×10 cm^2, 20×20 cm^2)
- 6 MV (10×10 cm^2)
- 50 MU (500 MU/min)
- Source to surface distance (SSD) : 100 cm
- Measurement depth : 0 cm – 20 cm (68 points)
- sampling time : 10 msec

Irradiation condition : electron
- 12 MeV (0cm～8cm, 38points)
- 9 MeV (0cm～6cm, 30points)
- 6 MeV (0cm～5cm, 24points)
- 100 MU (500 MU/min)
- SSD : 100 cm
- sampling time : 10 msec

In fig.3 and fig.4 the similar trend is seen in the graph between the reference dosimeter and the ruby dosimeter.
The dose maximum depth of photon was 2.3 g/cm^2 for both.
In electron, the reference dosimeter and the ruby dosimeter's dose maximum depth were 1.3 g/cm^2 and 1.4 g/cm^2 respectively.
Dose maximum depth of the PDD was no clear difference between the reference dosimeter and the ruby dosimeter using different irradiation conditions.

Fig.3 characteristic features of PDD (photon)

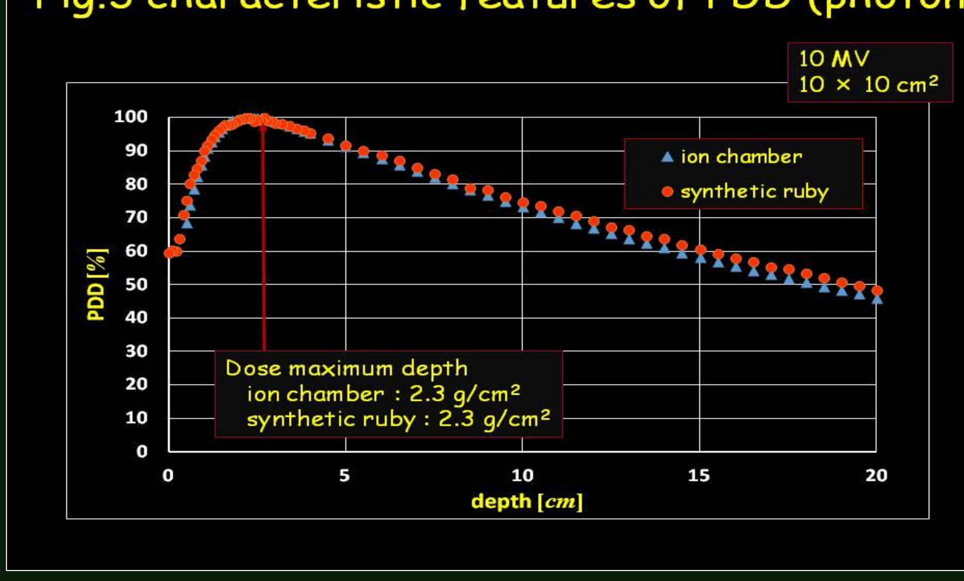
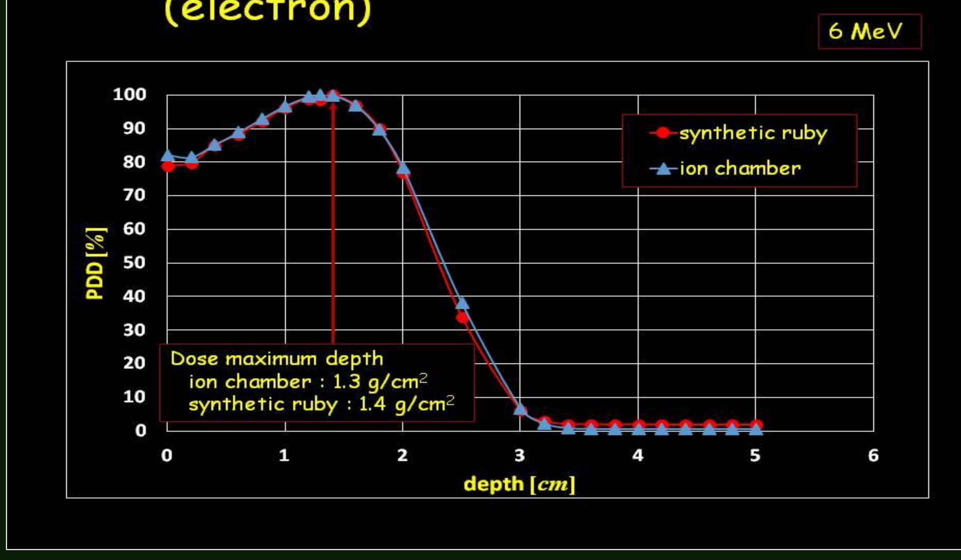


Fig.4 characteristic features of PDD (electron)

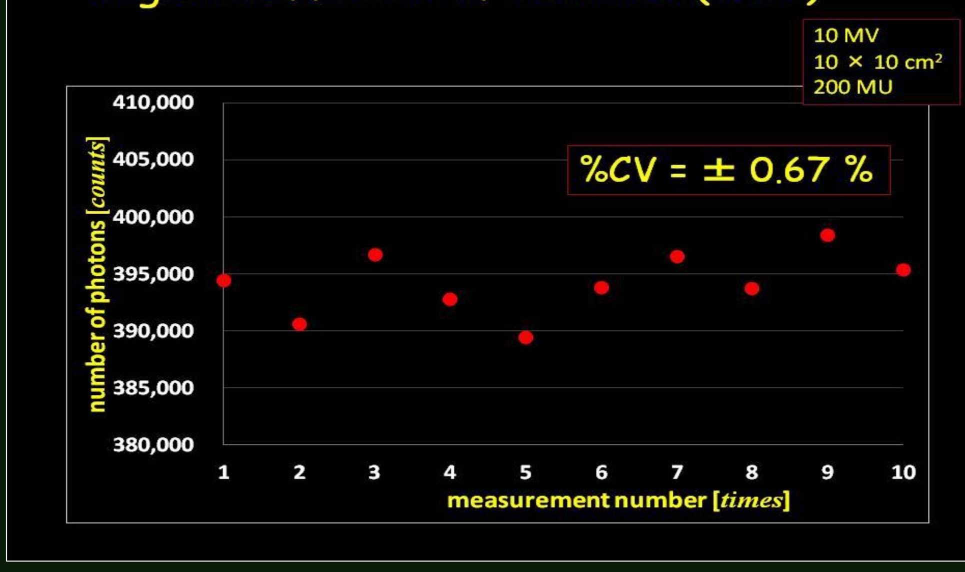


Results 3 : Characteristic features of coefficient of variance of MU value

Irradiation condition : photon
- 10 MV (10×10 cm^2)
- 200 MU (500 MU/min)
- measurement depth : 10 cm (SSD : 100 cm)
- measurement number : 10 times
- sampling time : 10 msec

The coefficient of variance is calculated from the results, the %CV was ±0.67% at 10 times measurements.

Fig.5 coefficient of variance (%CV)

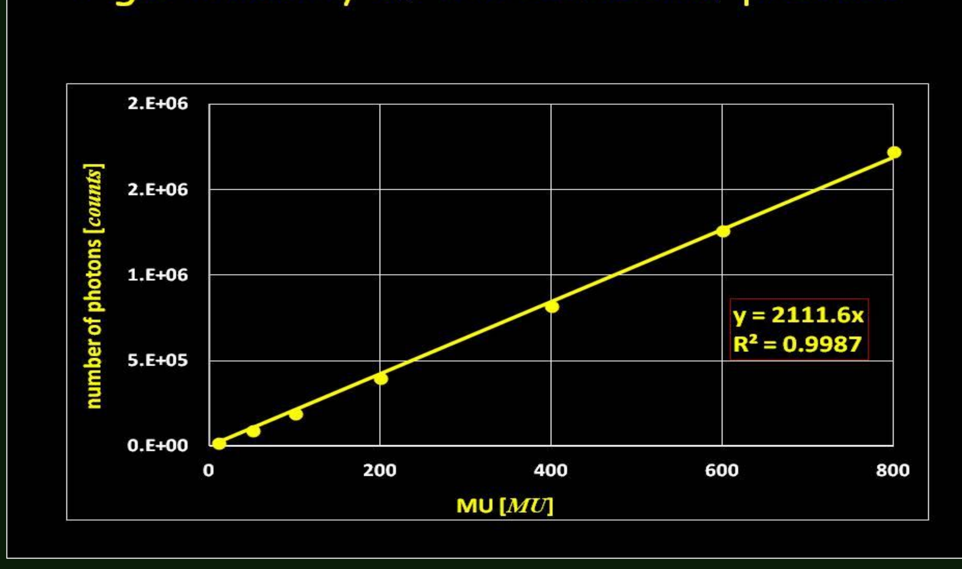


Results 4 : Linearity of the number of photons in terms of MU value

Irradiation condition : photon
- 10 MV (10×10 cm^2)
- measurement depth : 10 cm (SSD : 100 cm)
- 10, 50, 100, 200, 400, 600, 800 MU (500 MU/min)
- sampling time : 10 msec

There is a clear correlation between the MU value and the number of photons.
The value for the correlation coefficient was greater than 0.99.
By using this equation, we will enable to convert the radiation dose from the photon counts.

Fig.6 linearity of the number of photons



Conclusion

The synthetic ruby system which we developed have high temporal resolution, thus, it is possible to measure the total exposure time to read the rise time and the fall time on the graph. The MU value increased linearly with the number of photons which was same as the reference dosimeter, the synthetic ruby system have a potential for the real-time exposure dosimetry system on the radiation therapy. However, we have to discuss the influence of the developed system in the exposure filed, pursuit of the precision, the possibility of multipoint measurement, the size and the covering material of dosimeter.

1. EP-1702
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Ayaka Maruyama (mail: hosokai@iuhw.ac.jp)
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