Sensitivity Analysis of Influence Parameter on Radiological Risk for LINAC Facility

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Introduction

Background

- IAEA and ICRP have recommended to concern about potential risk of facilities using radiation.
- Various types of linear accelerator manufactured have been installed nationwide in Korea.
  - 104 medical linear accelerators(LINAC) have been installed (2009). (IAEA DIRAC database)
- The probability of occurring an accident of radiation exposure to radiological workers and the public is considerably low.
- However, when the unexpected accidents occur workers and patients may receive high doses because of high energy photon beam from LINAC.
- In the cases of that radiological workers did not wear dosimeters or that exposure accidents were occurred for public members, it is difficult to estimate their radiological risk.

Objectives

- To estimate probability of occurring an accident or an incident with various scenarios during patient treatment in LINAC facility.
- To calculate spatial dose rate distribution in a LINAC treatment room and dose to workers and public.
- To assess radiological risk of LINAC treatment and perform sensitivity analysis of influence parameters for radiological risk.

Methods

Risk assessment

- **Risk** : products of the frequency and consequence associated with possible states of a system

$$\text{Risk} = \sum_i (\text{Frequency}_i \times \text{Consequences}_i)$$

Where, i is the number of possible state

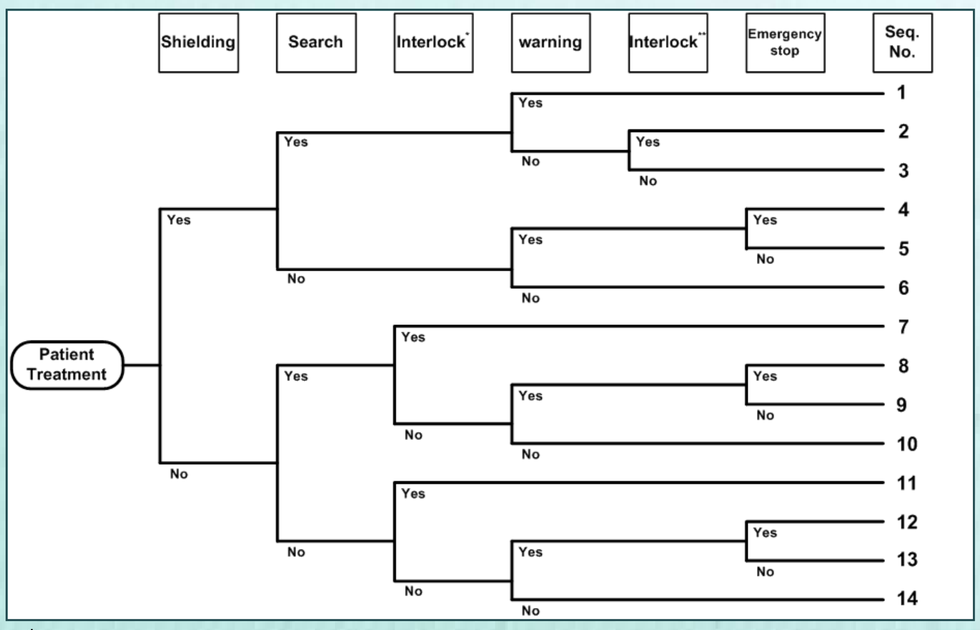
- **Frequency** : frequency of the initial event times the probability of the state

$$\text{Frequency} = \text{frequency(initial event)} \times \text{probability(state)}$$

- **Consequence** : calculated by using MCNP and dose conversion factor

Frequency

- **Event tree analysis** : composed with success or failure probability of 6 safety factors



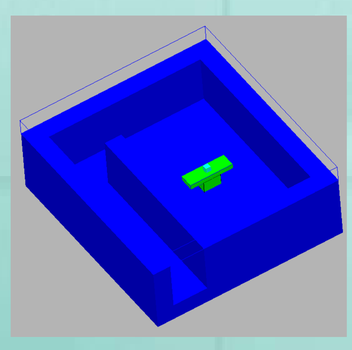
*Interlock before irradiating, **Interlock during irradiating

< Event tree for operating task >

- **Delphi survey :** Method that estimate values based on the empirical judgments of experts then through feedback of the results and derive an agreed result finally

Task	Scenario	Expert group	Survey method	Repetition	Contents
Treatment patient	Event Tree Analysis	•Medical Physicist	1:1 E-mail survey between researcher-panel	3 times	• Determining safety factors • Failure probability of safety function

Consequence



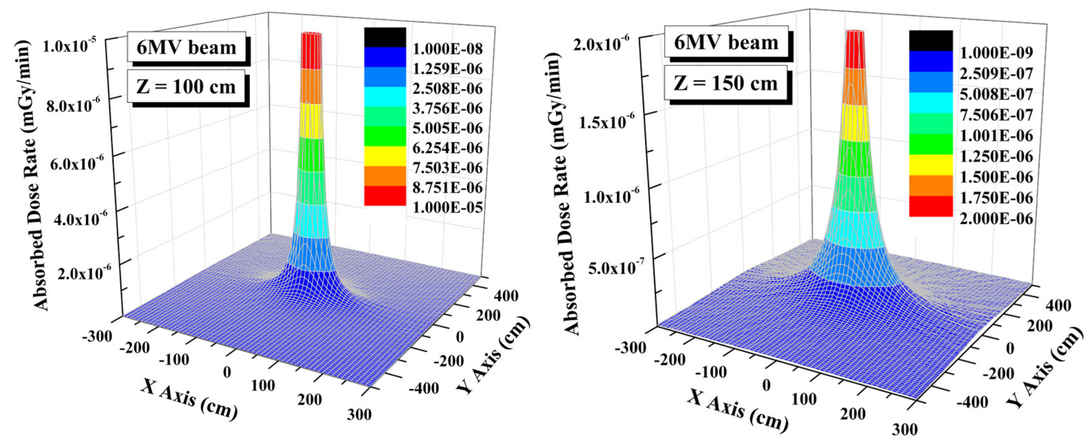
- **MCNP Simulation**
  - **Geometry modeling** : simplified LINAC treatment room
  - **Source term**
    - 15 MV LINAC beam spectrum
    - 10×10 cm^2 field size and scattered after incidence into a $30 \times 30 \times 30$ cm^3 water phantom
  - **Tally**
    - 3-dimensional internal space of the treatment room was equally divided into $10 \times 10 \times 10$ cm^3 small cubic forms by using energy deposition mesh tally.
    - Spatial dose rate distribution arisen from scattered x-ray beam was calculated.

Sensitivity analysis

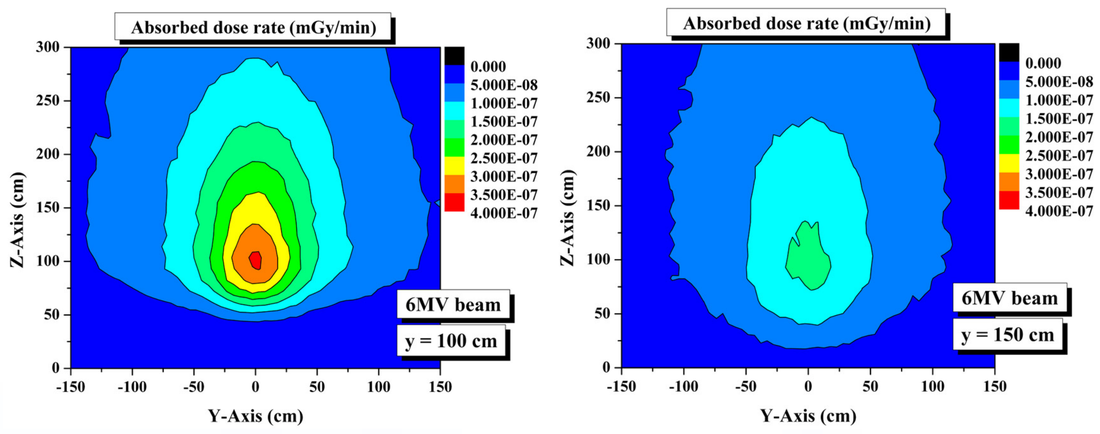
- **Influence parameter** : shielding, access control, distance from radiation source to receptor, exposed time, etc.
- Changing the values of influence parameters and comparing the radiological risk with each other.

Results

Spatial dose rate distribution

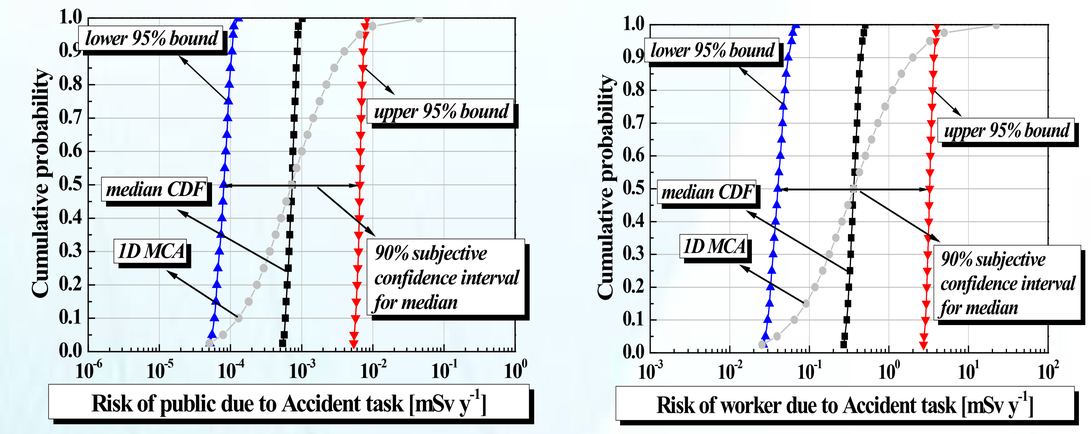


< Spatial dose rate distribution for 6 MV LINAC beam in air at 100 and 150 cm height from the bottom >



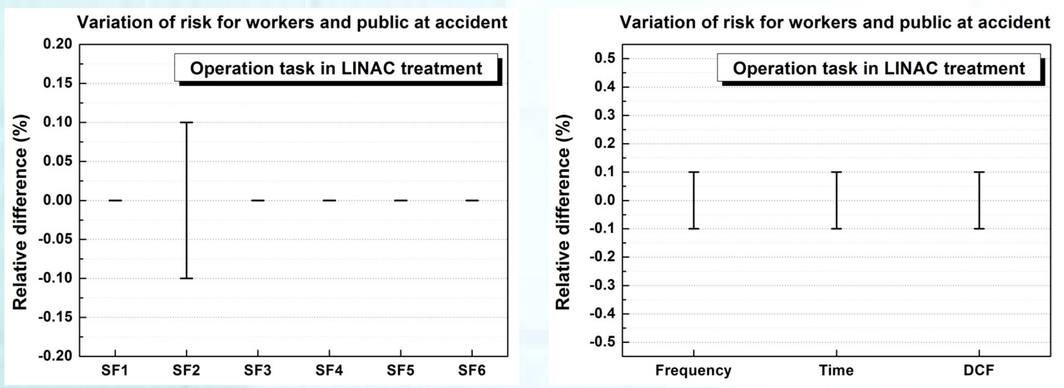
< Transverse sectional diagram of spatial dose distributions at 100 and 150 cm from isocenter of the beam >

Radiological risk



< 90% confidence interval of risk for operating; (a)public (b)worker due to an accident scenario >

Sensitivity analysis



SF1: shielding, SF2: search, SF3: interlock*, SF4: warning, SF5: interlock**, SF6: emergency stop, DCF: Dose Conversion Factor

*Interlock before irradiating, **Interlock during irradiating

< Results of sensitivity analysis of influence parameters for operating task at LINAC treatment >

Conclusion

- Assessment of radiological risk for operating task at LINAC treatment was performed with experts' judgment and MCNP simulation in order to obtain the frequency of accident and dose to workers and public due to an accident
- According to the result of sensitivity analysis, SF2 (searching remainders in the treatment room) have influenced the highest effect on the radiological risk.
- The best way to reduce the radiological risk is to check the risks and to comply with the safety procedures.

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