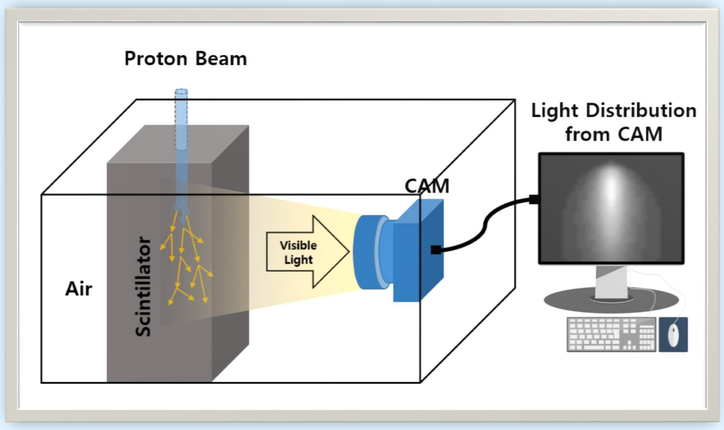
A methodology to predict the proton beam range from the scintillated light distribution using deep-learning

Eunho Lee[1], Youngmoon Goh[1], Byungchul Cho[1], Jungwon Kwak[1], Chiyoung Jeong[1], KyoungJun Yoon[1], Min-Jae Park[1], Sung-woo Kim[1], Changhwan Kim[1], Minsik Lee[1], Jun-Bong Shin[1], Seung Mo Hong[1] and Si Yeol Song[1]
[1)]Department of Radiation Oncology, Asan Medical Center, Seoul, Korea

Introduction



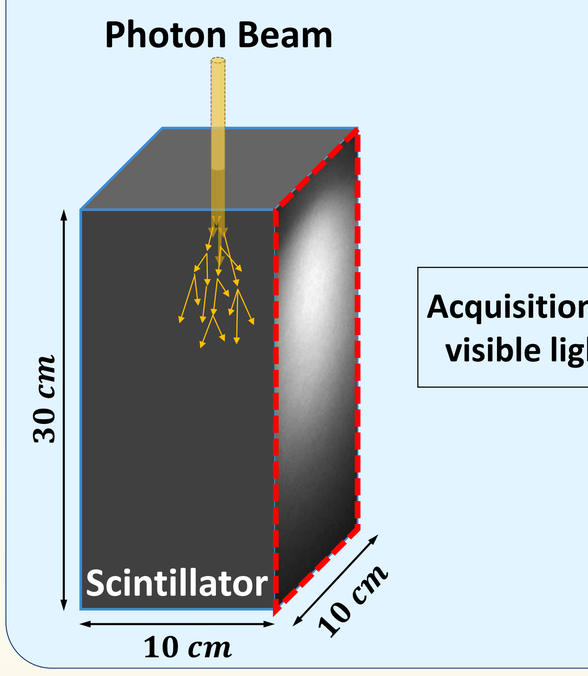
- For “small device” & “quick procedure” of proton beam range measurement, the scintillator light and CCD cam are used.
- To utilize all information of 2D scintillated light distribution, convolution neural network (CNN) method (light-to-dose conversion) is chosen.
- To verify the method for “light-to-dose conversion”, this study has been initiated.

Purpose

- This study aims to predict the proton beam range with the conversion of the scintillated light distribution into the proton depth-dose distribution.
- The feasibility of the methodology using Deep-Learning and Monte Carlo (MC) simulation was tested in this stage.

Materials & Methods

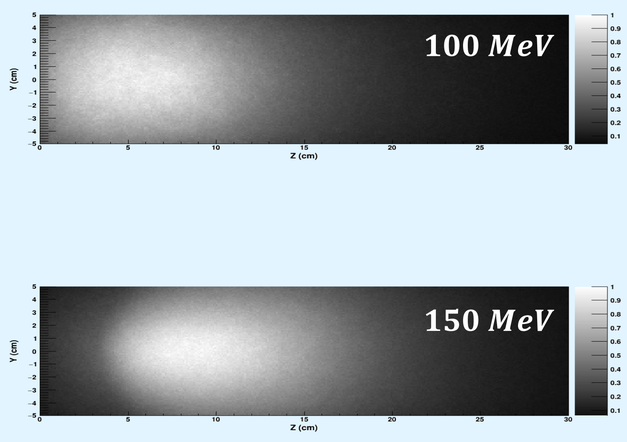
Scintillated lights & Dose from proton beam in MC → **Training with Res-U-net modeling** → **Analysis of predicted dose-map with test dataset** → **Compare “predicted” vs “input” Bragg-peak position**



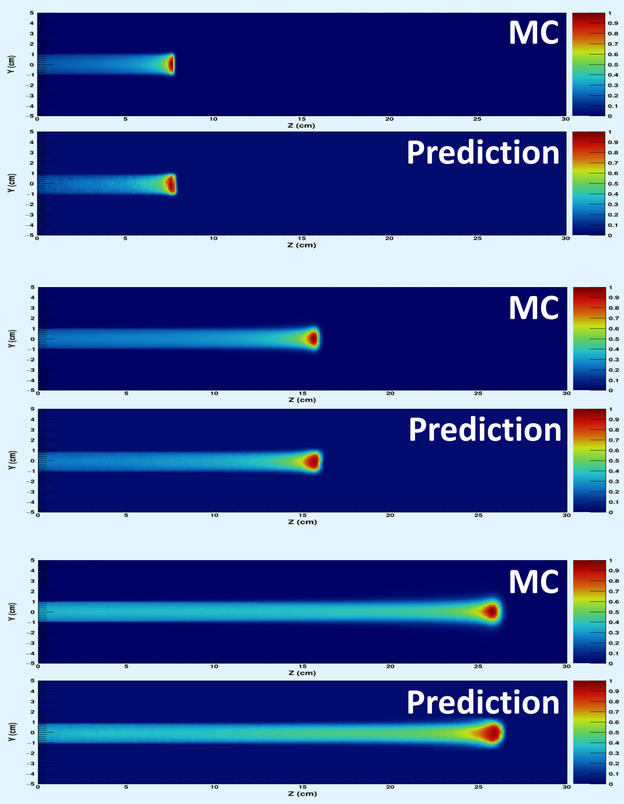
Conversion Method: Deep-Learning	
Modeling	2D Residual U-net with Tensorflow & Keras
Test Environment	MC simulation (TOPAS MC)
Input Image	Light map in the plastic scintillator (1.05 g/cm^3)
Output Image	Depth-dose map in water
Datasets (100~200 MeV)	• Training set: 201 (0.5 MeV step size) • Test & Validation sets: 11 (10 MeV step size)

Results and Summary

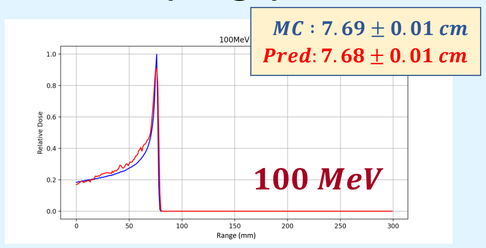
Scintillated Light in MC

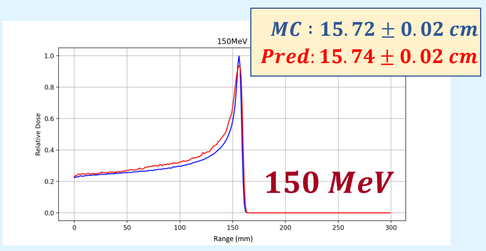


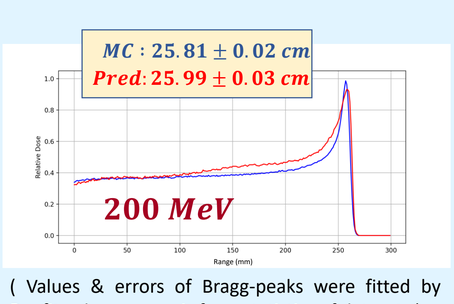
Depth-dose in MC & Prediction



Bragg-peak position (range)



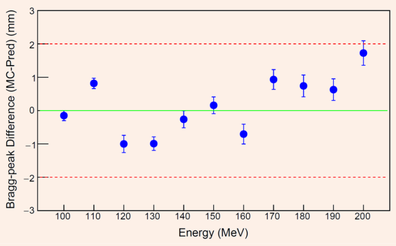




(Values & errors of Bragg-peaks were fitted by Roofit, where errors is from statistics of datasets)

Deep-Learning (DL) Performance

- **DL Bragg-peak accuracies** analyzed from scintillated lights are **less than 2 mm**.



- **DL Bragg-peak positions** are **NOT depending on** the proton **beam spot size** less than 3 cm.
- **Limitations :**
  - Broad peak,
  - Higher yield on middle region,
  - Fluctuation

  in dose profile due to dataset size & small computational resources

Conclusion

- The DL methodology to analyze the scintillated light distribution for the proton beam range estimation is feasible in terms of the acceptable range accuracy.
- The fine-tuning of parameters and structure for DL model as well as the larger dataset would be need for the consistence with simulated results in future studies.

Contact Youngmoon Goh (umipolaris@gmail.com)

This research was supported by the NRF grant funded by the Korea government (NRF-2019R1H1A1102039)