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RADIATION IMAGING LABORATORY

Analytical dose estimation In dental cone-beam computed tomography

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Outline

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2. Materials and Methods
3. Results
   I. Validation
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   III. Beam width
   IV. The type of energy
4. Discussion and Conclusion

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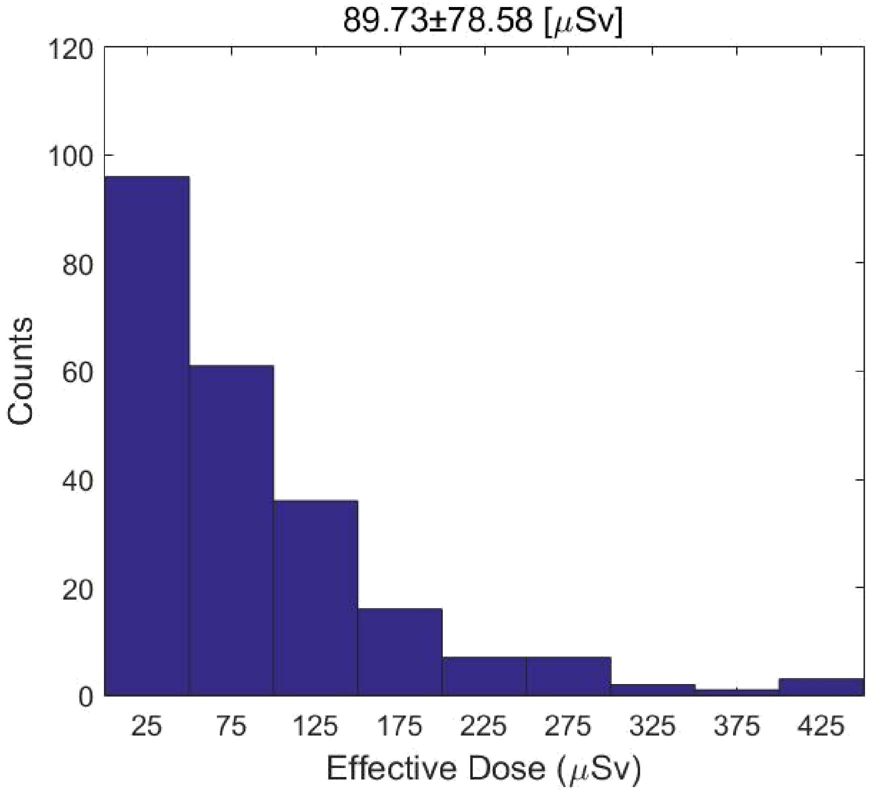
Introduction

Dental CBCT

Patient dose



Effective dose of dental CBCT, J B Ludlow, Dentomaxillofacial Radiology (2015)

Objectives

- To develop the absorbed dose estimation algorithm for dental CBCT examinations with an analytic calculation method
  - Validate with
    a. Experimental measurements
    b. Monte Carlo simulations

- To investigate the dose distributions in cylindrical head phantom as
  - The number of views changes
  - The beam width changes
  - The number of energy changes

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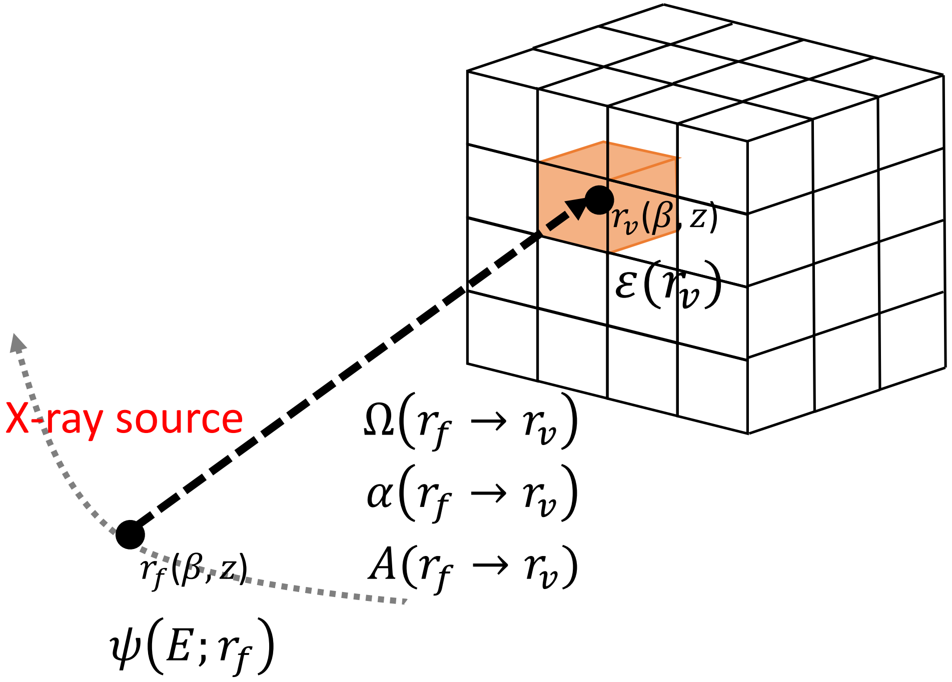
Algorithm

1. Calculating the primary dose



$$D_p(r_v) = \sum_E \sum_\beta \sum_z \psi(E; r_f)\Omega(r_f \to r_v)\alpha(r_f \to r_v)A(r_f \to r_v)\varepsilon(r_v)$$

- $\psi(E; r_f)$ = the fluence at the source position $r_f(\beta, z)$
- $\Omega(r_f \to r_v)$ = the solid angles subtended by r_f by a voxel at r_v
- $\alpha(r_f \to r_v)$ = the effective voxel area at r_v by a voxel at r_f
- $A(r_f \to r_v)$ = the attenuation along the vector $r_f - r_v$
- $\varepsilon(r_v) = \left\{\frac{\mu_{pe}(r_v)}{\mu_{tot}(r_f)}\right\}$ E; the energy deposition at a voxel at r_v

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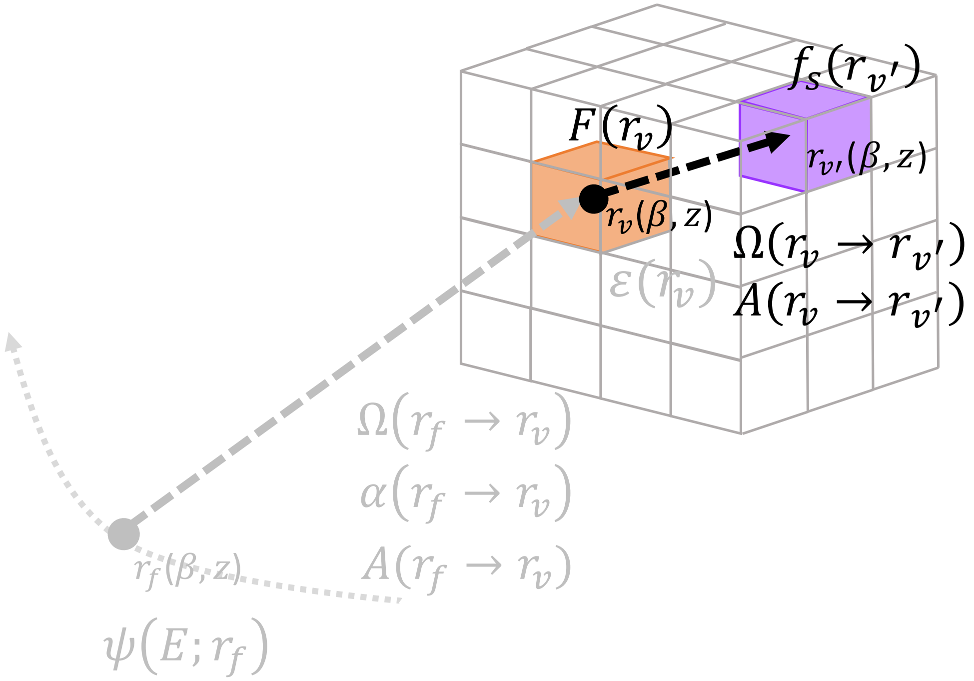
Algorithm

2. Calculating the scattered dose



$$D_s(r_v) = \sum_{r_{v'} \in R} D_p(r_{v'}) f_s(r_{v'}) \Omega(r_v \rightarrow r_{v'}) A(r_v \rightarrow r_{v'}) F(r_v)$$

$$D_s(r_{v'}) = D_p(r_{v'}) + f_s(r_{v'})(1 \rightarrow F(r_v))\varepsilon(r_{v'})$$

- $f_s(r_{v'})$ = the scatter fraction
- $F(r_v) = E'/E$

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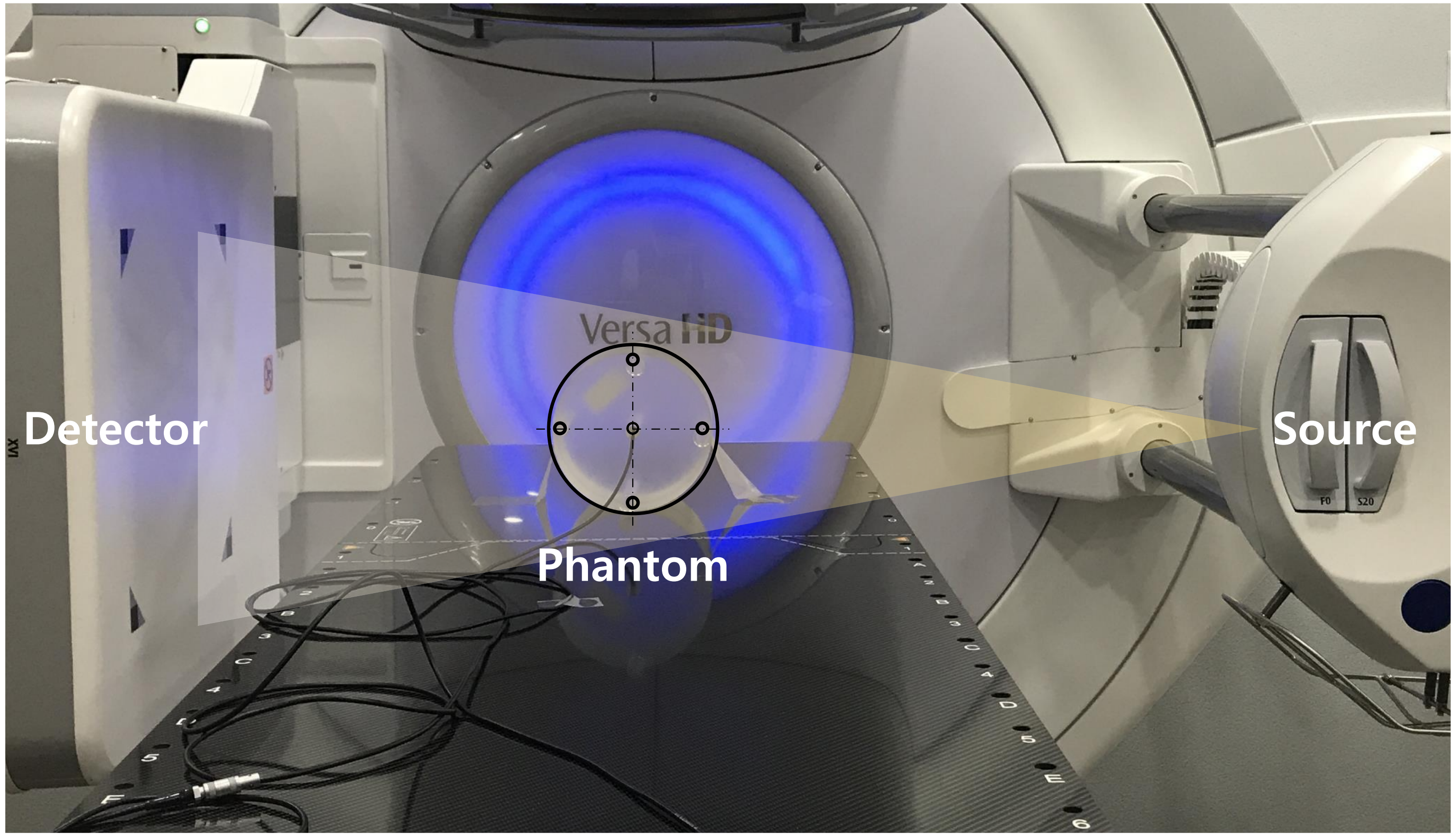
Validations

- Experimental measurements



- PNUYH CBCT scanner
- CTDI head phantom
- CT Probe
- Scan angle 200°
- 70, 100, 120 kVp
- 18.3 mAs

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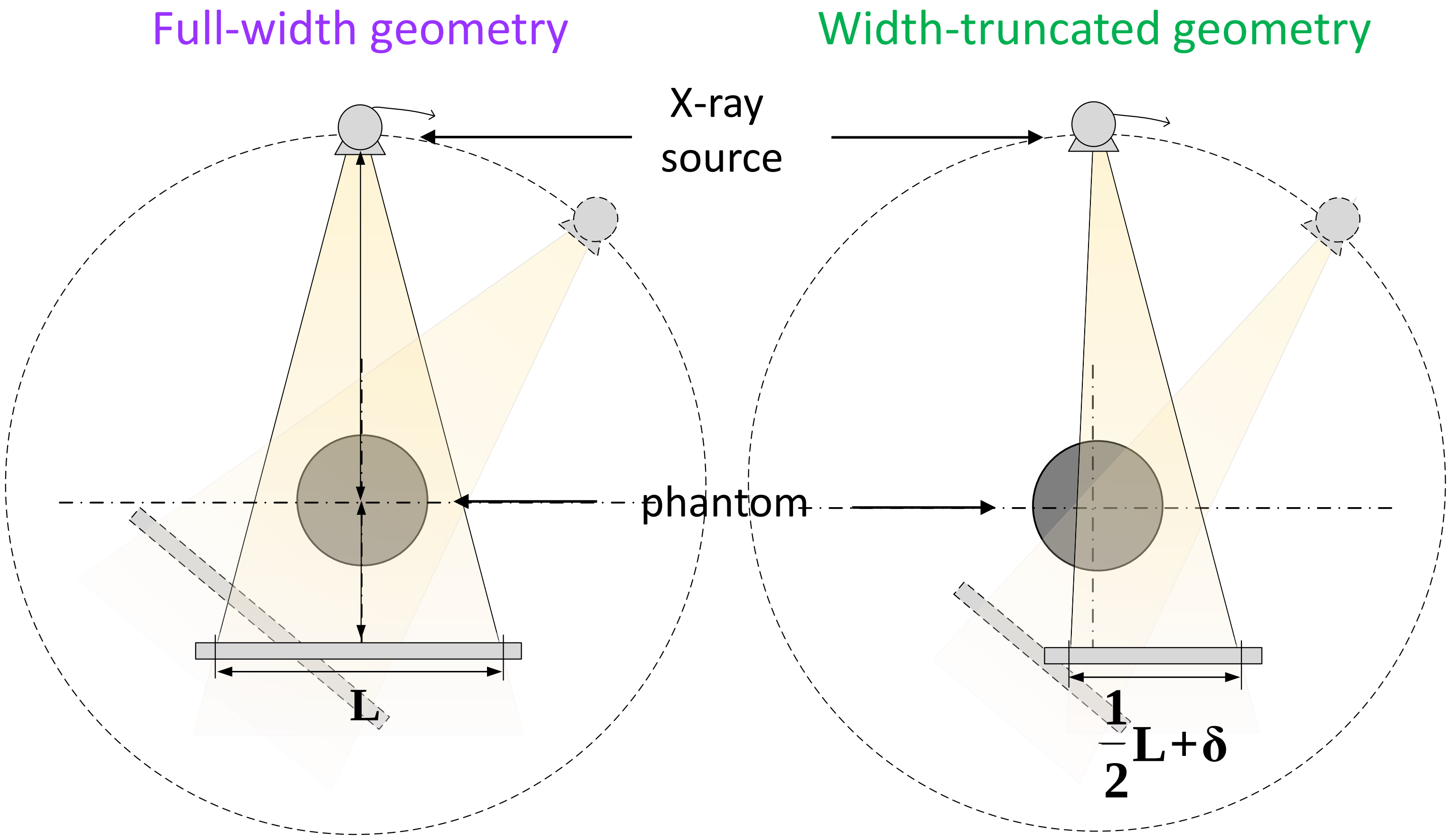
Dose calculations

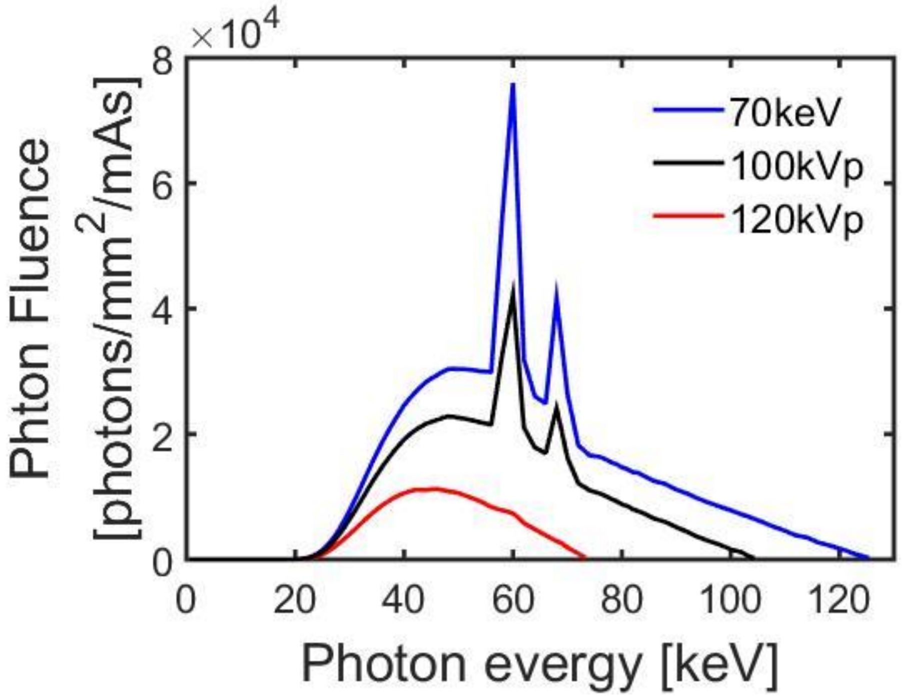
Energy	70, 100, 120 kVp - Average energy - 10 keV binning
Phantom	- Homogeneous - Heterogeneous
Scan angle	360°
# views	360, 180, 90
Beam width	- Full-width - Width-truncated

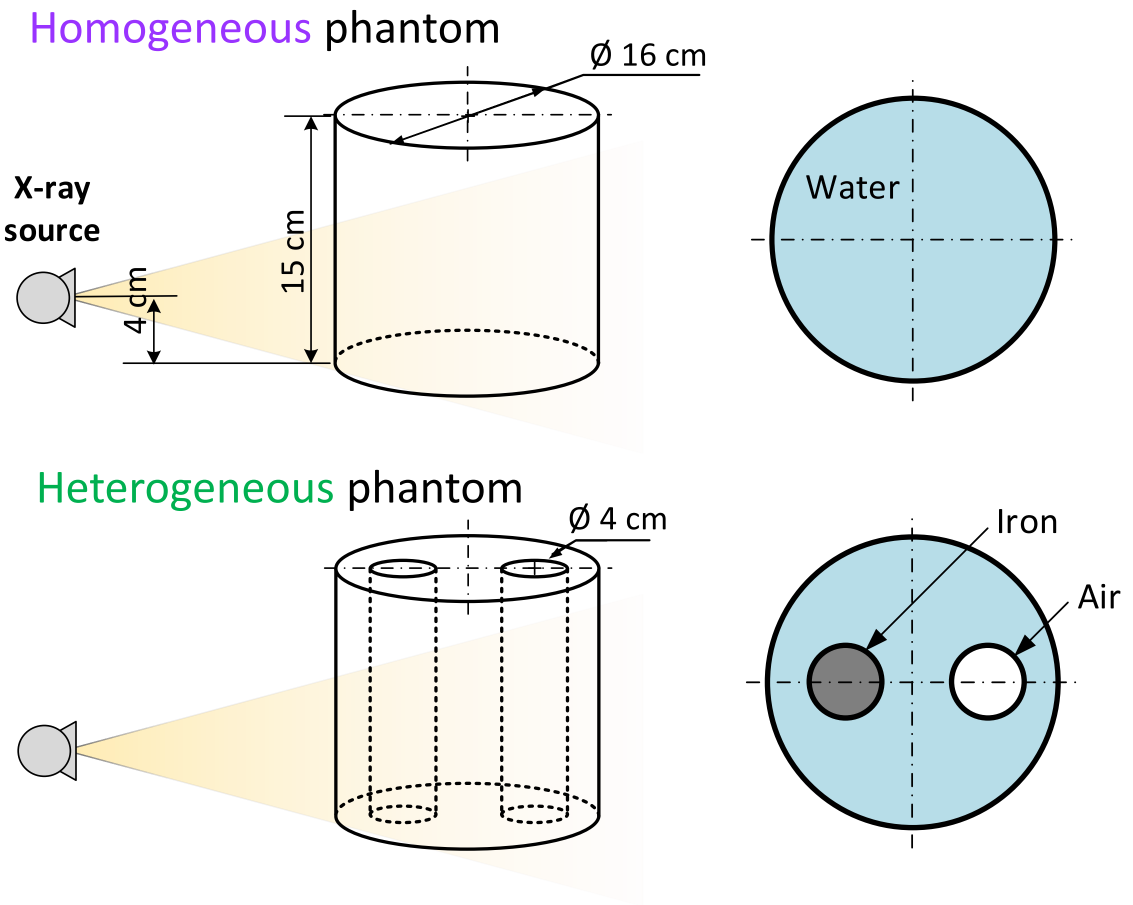


$$\delta = 0.08L$$

Validations

- Monte Carlo simulations





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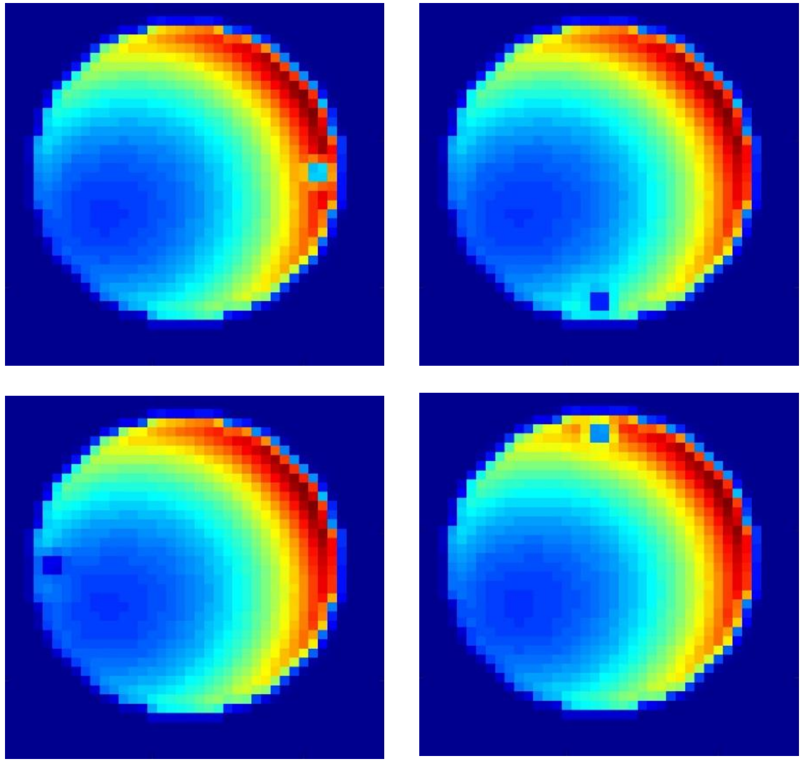
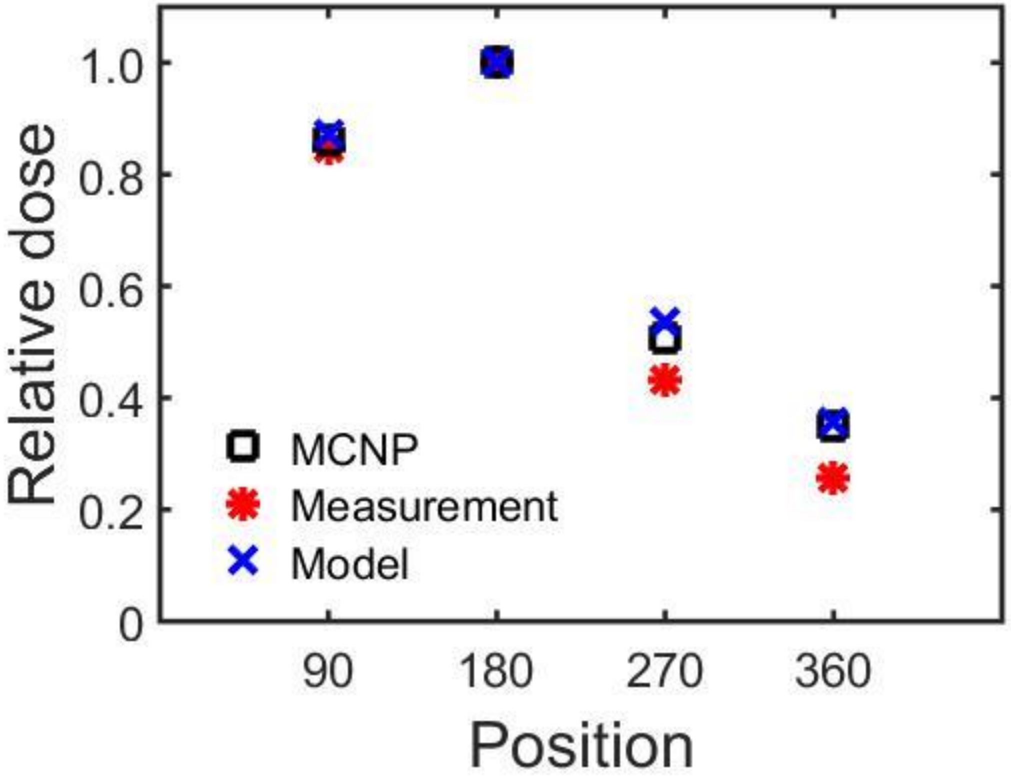
Validations

- with the experimental measurements





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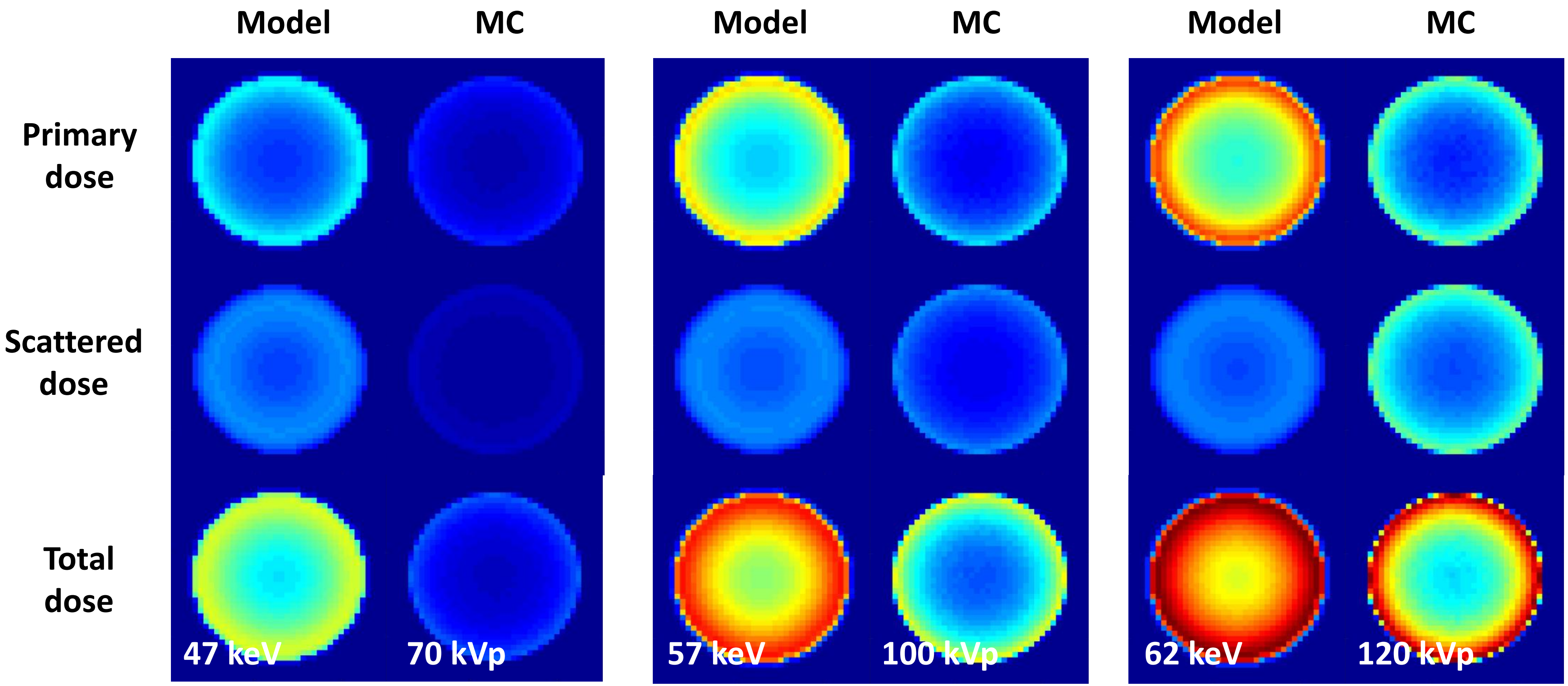
Validations

- with the Monte Carlo simulations (homogeneous phantom)



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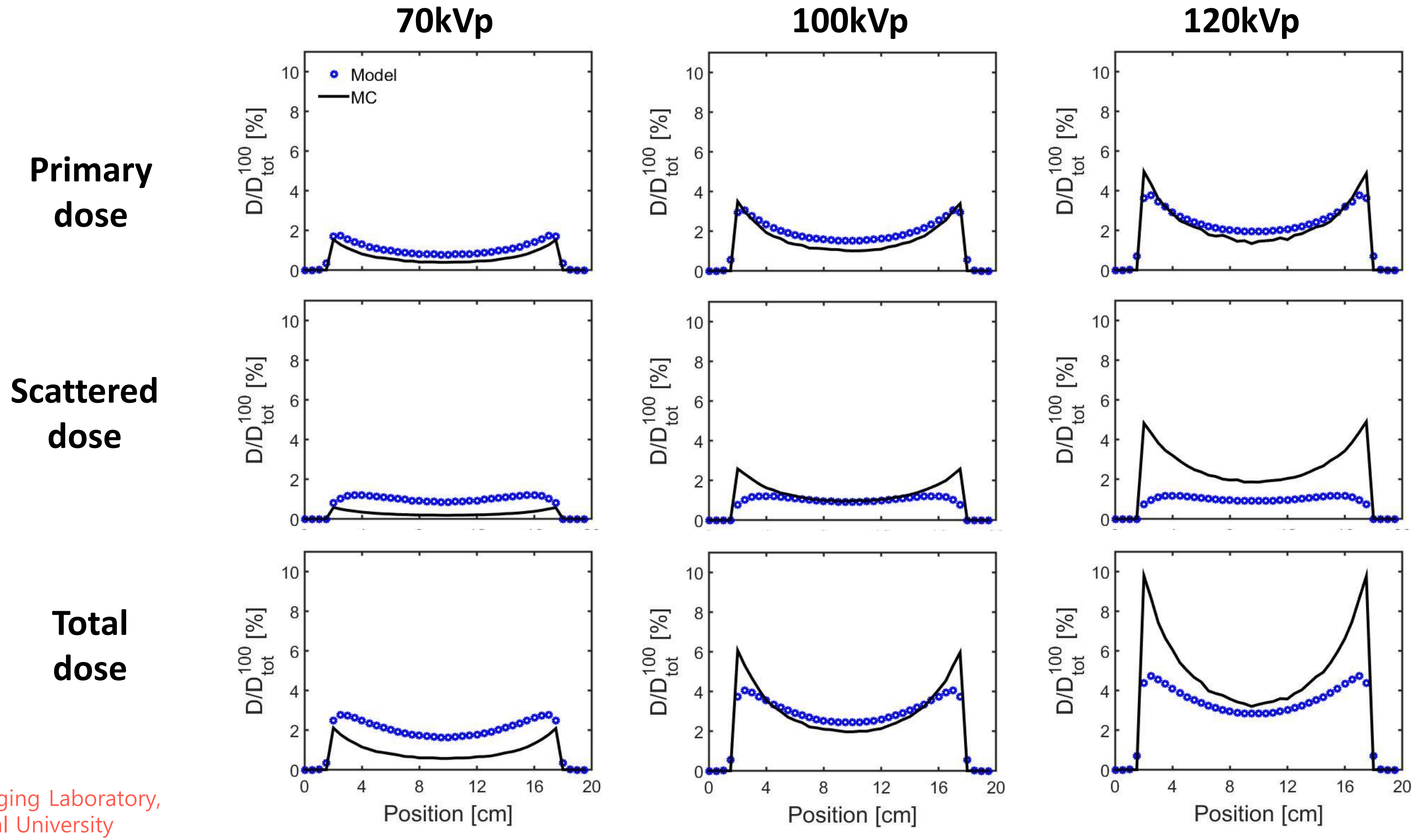
Validations

- with the Monte Carlo simulations (homogeneous phantom)



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Validations

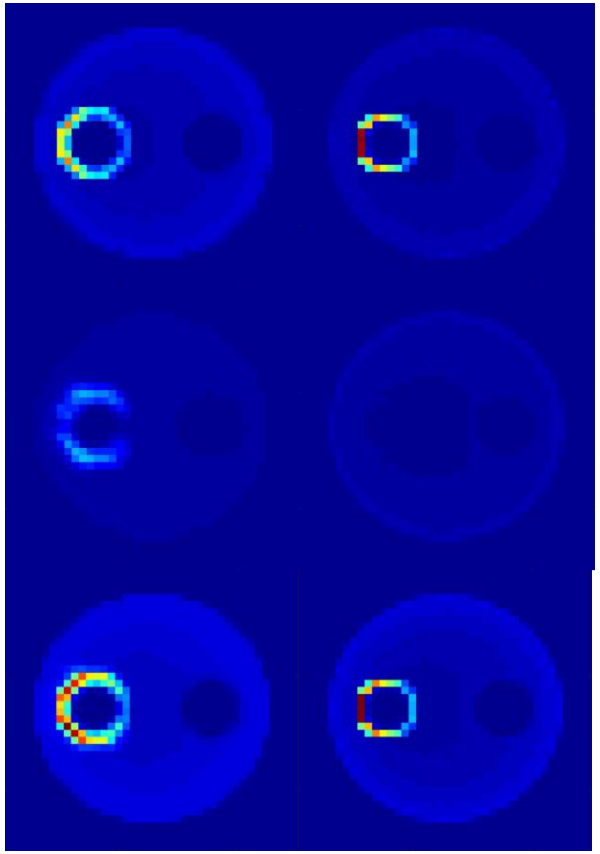
- with the Monte Carlo simulations (heterogeneous phantom)

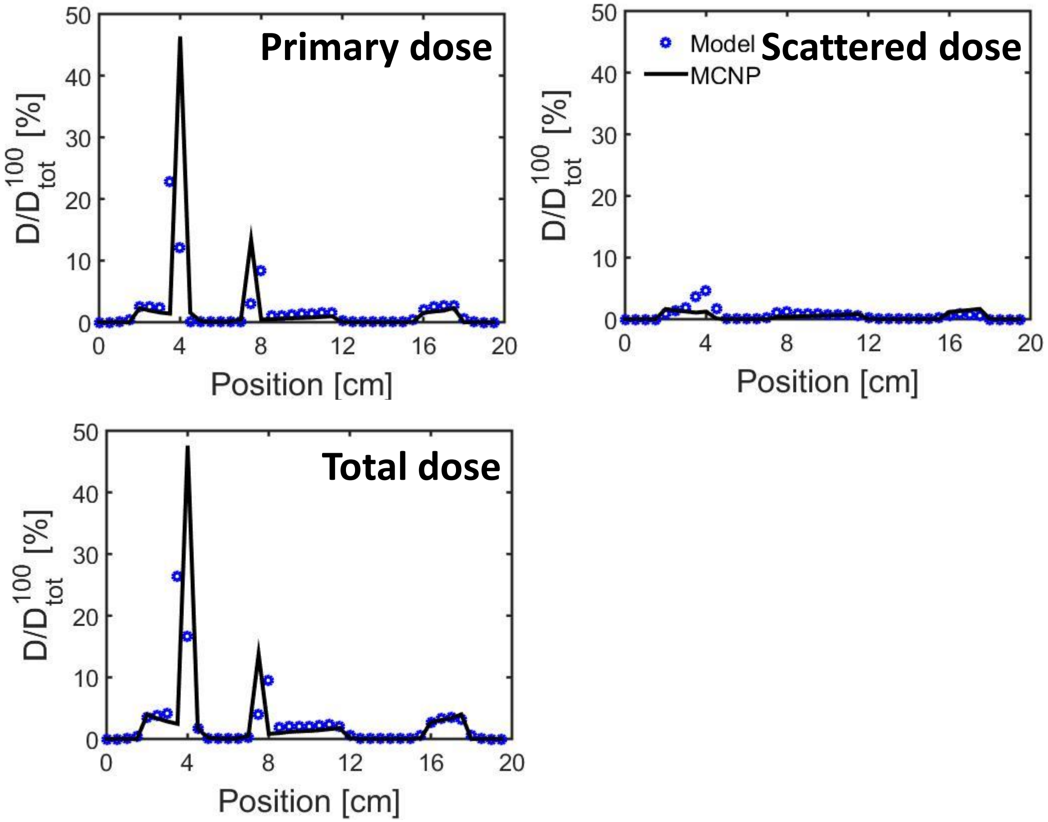
Model **MC**

Primary dose

Scattered dose

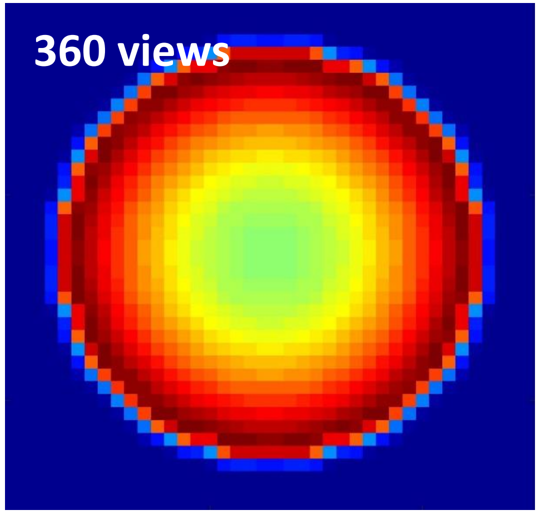
Total dose

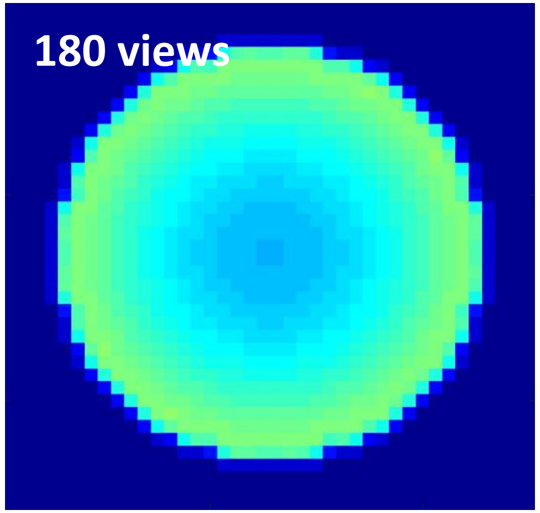


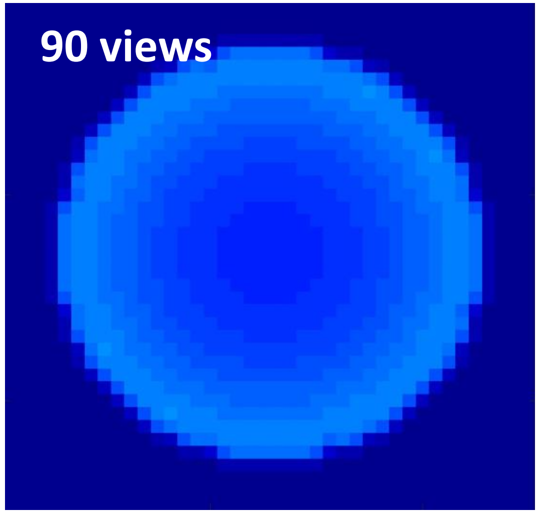


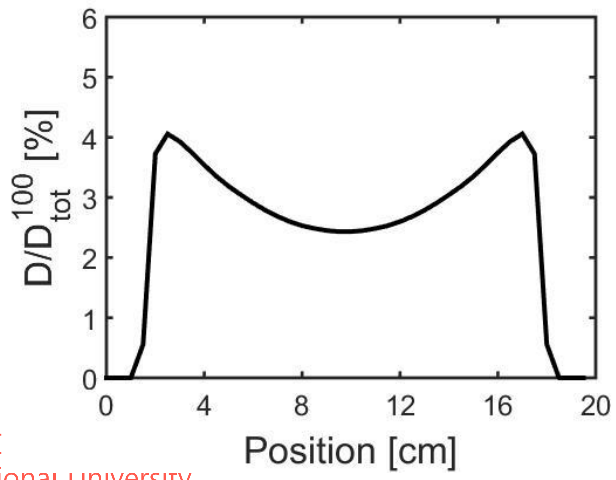
Results

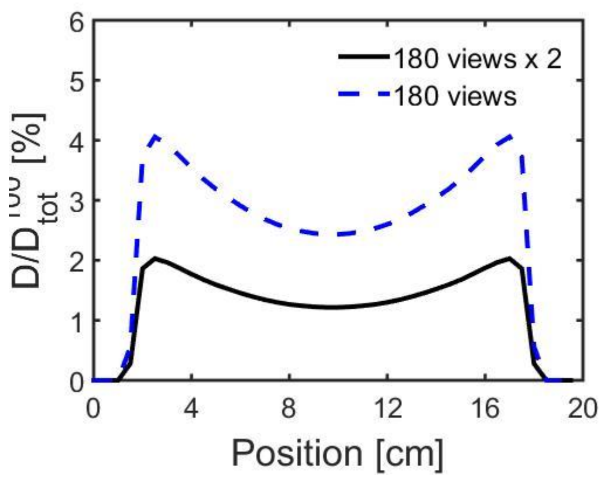
- Number of views

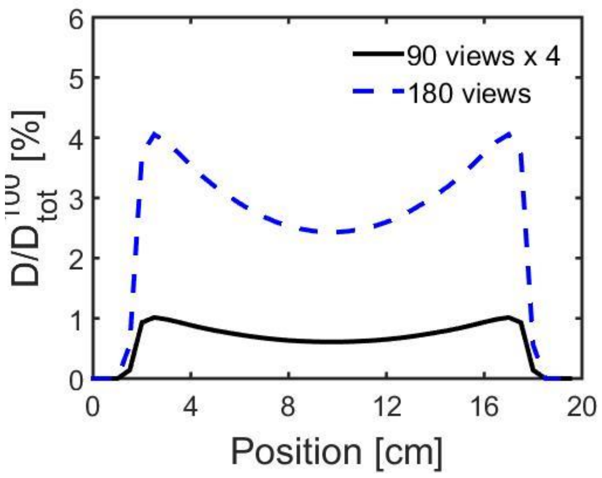












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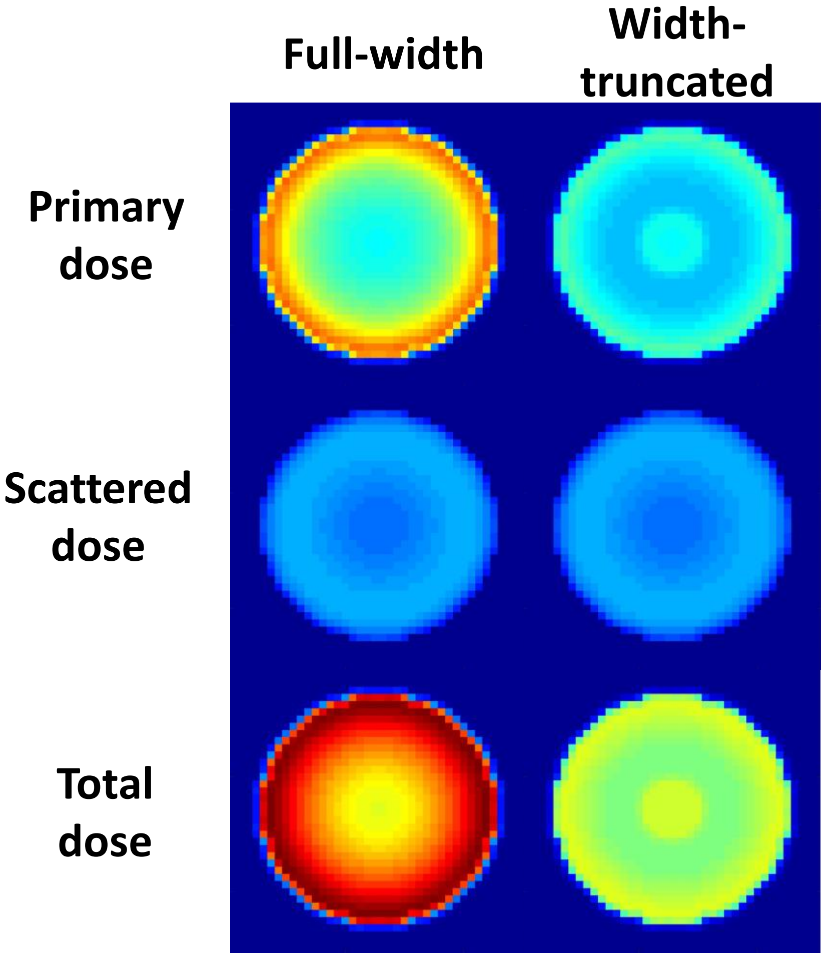
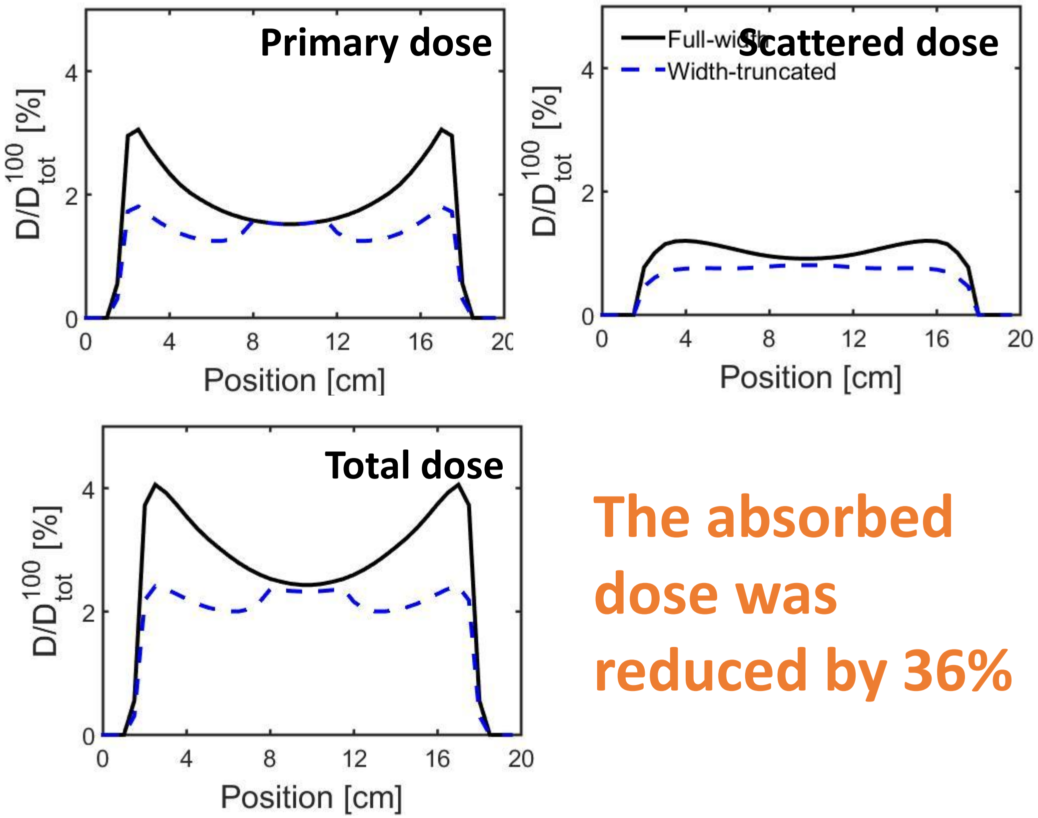
Results

- Width-truncated geometry (delta: 8% L)





The absorbed dose was reduced by 36%

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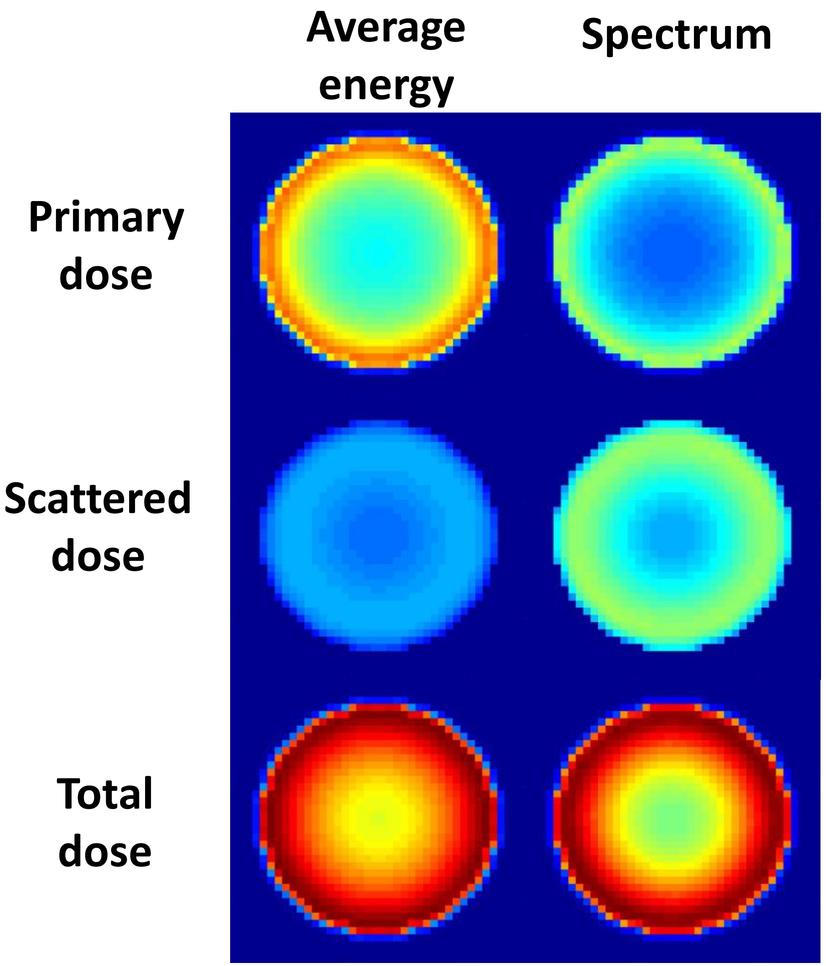
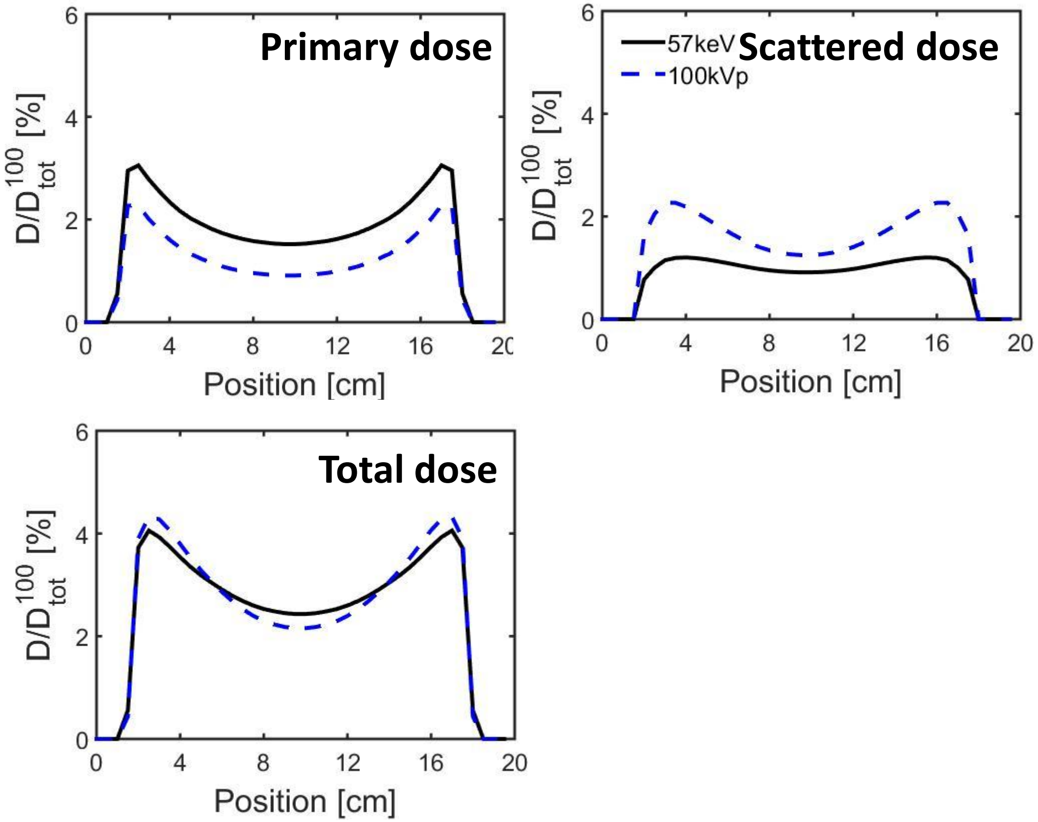
Results

- Type of energy





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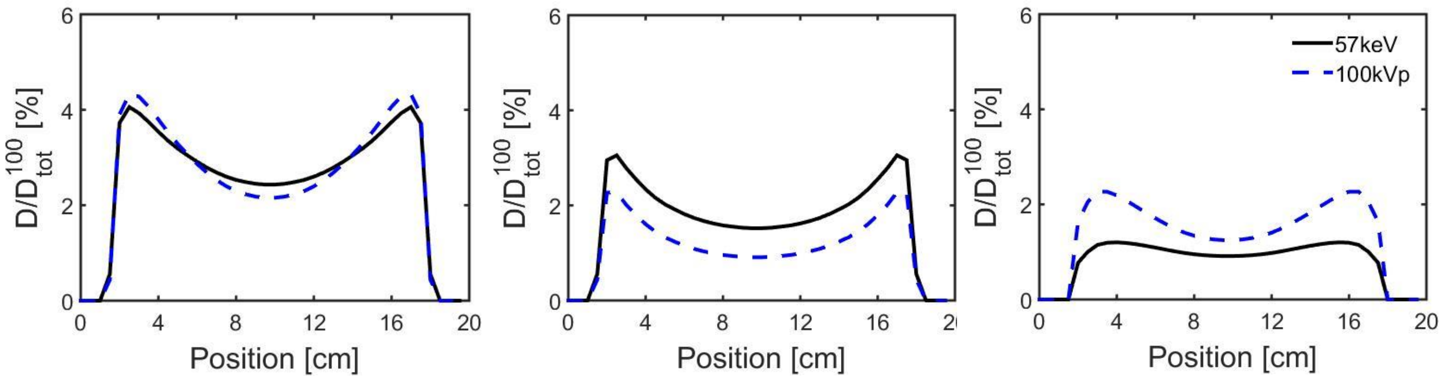
Discussions & Conclusion

- 모델과 MC primary에서 잘 맞음
- 하지만 scatter에서 차이 - > 낮은 에너지에서 scatter가 높게 측정-> 평균 에너지 계산으로는 고려가 힘듦 - > 스펙트럼 에너지로 계산 필요
- -> 그 결과가 아래 그래프와 같음
- View수가 변하더라도 전체 선량 분포는 유사하며 배수 고려 시 거의 동일 - > view 수를 줄여서 계산 가능
  - Validate with
    a. Monte Carlo simulations
    b. E



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Discussions & Conclusion

- High resolution 팬텀고려
- 계산 가속화 ex mfp gpu 등 적용
  - Patient-specific dose estimation
  - Validate with
    a. Monte Carlo simulations
    b. E

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