

*Monte Carlo modeling of a conventional x-ray
computed tomography scanner for
gel dosimetry purposes*

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Gel dosimetry Using MR images

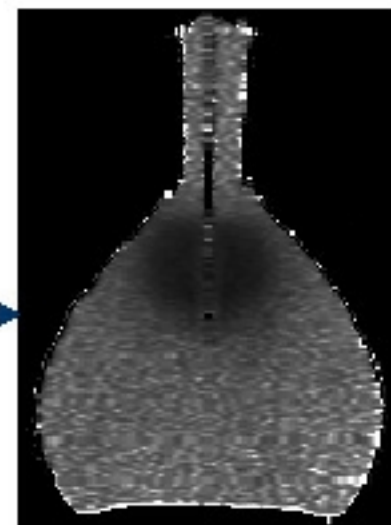
- The standard approach for polymer gel dosimetry is MR T2-weighted images, but....



Irradiation (^{192}Ir)

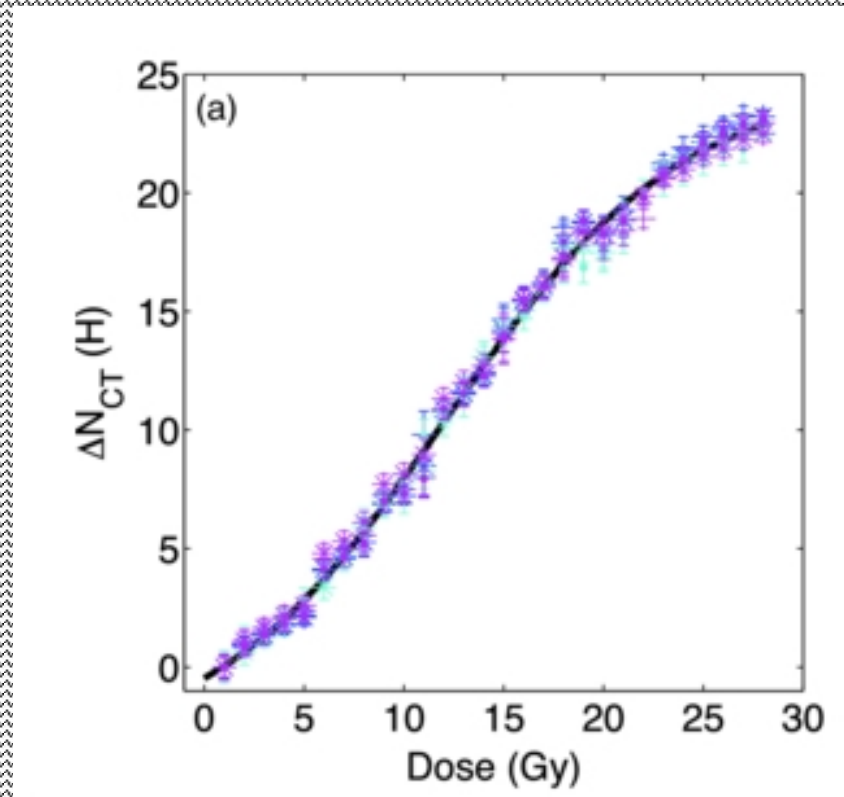
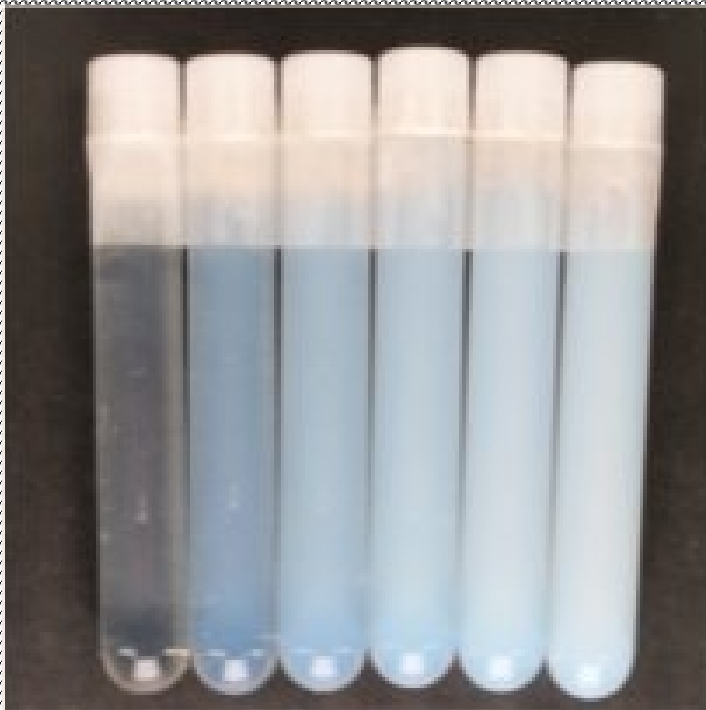


Magnetic Resonance Imaging
MRI



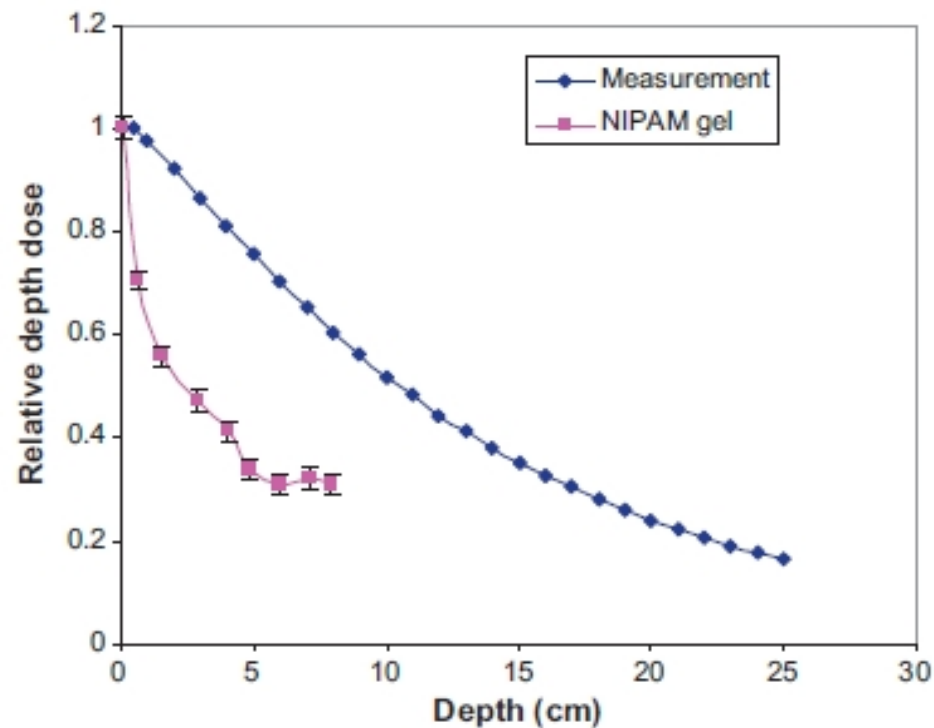
Result of MR imaging
– single plane of T2
relaxation time distribution

The CT number is changed after irradiation and it can be quantized by x-ray CT scanner.



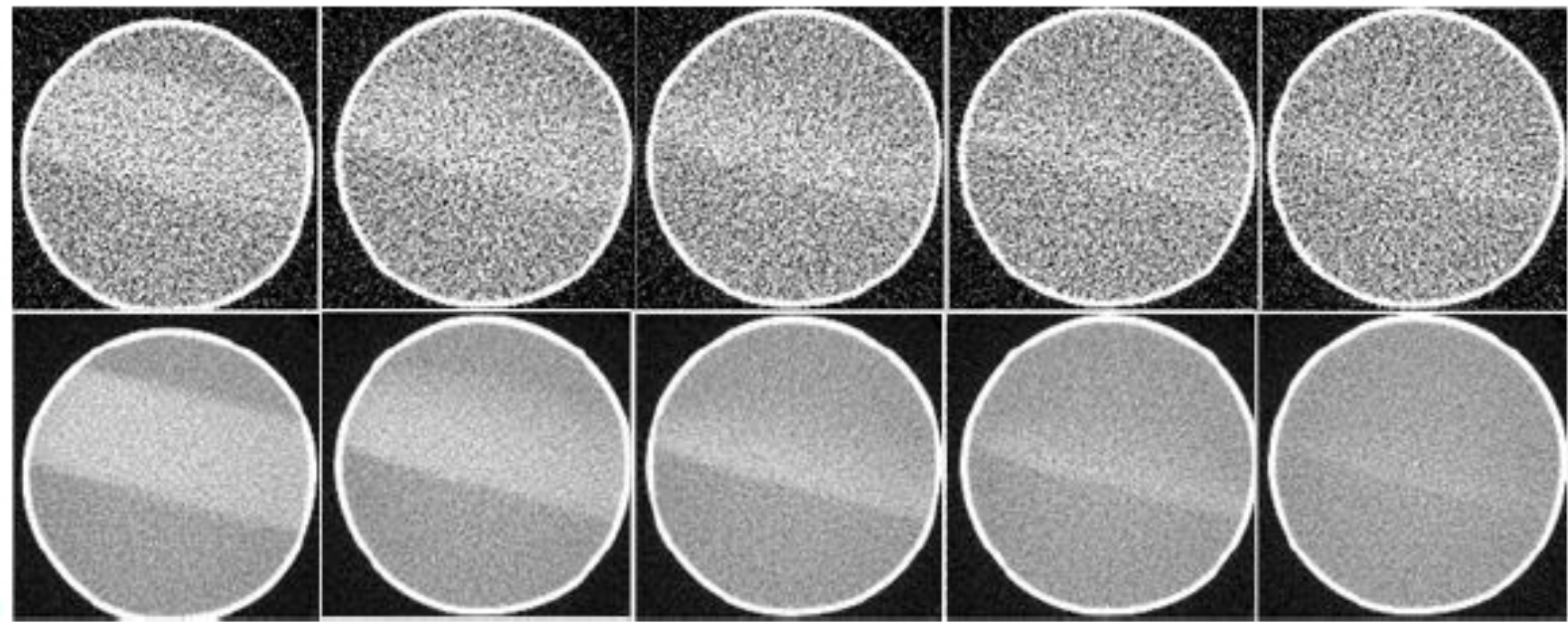
What is the **problem?**

- The CT images are So noisy and dose resolution is not sufficient for accurate dose mapping.



Relative depth dose comparison between NIPAM/bis gel and water phantom measurements.

Noisy and lower contrast



A feasibility study of multislice X-ray CT imaging of gel dosimeters using the “zero scan” method

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Purpose of the Current research

- Because the CT number is dependent on photon energy and spectrum we can build a Monte Carlo model and investigate the photon energy and spectrum on Gel images/
- **First step was to Do Monte Carlo simulation of X-Ray CT imaging of irradiated Gel**

Methods and materials

- A typical third-generation CT system with the fan beam and a detector row was simulated with use of the MCNPX MC code
- A cylindrical water phantom with a diameter of 12 cm and a thickness of 20 cm was simulated in the center of the gantry,
- and a polymer gel vial with a diameter of 6 cm and the same thickness was located in the center of the water phantom

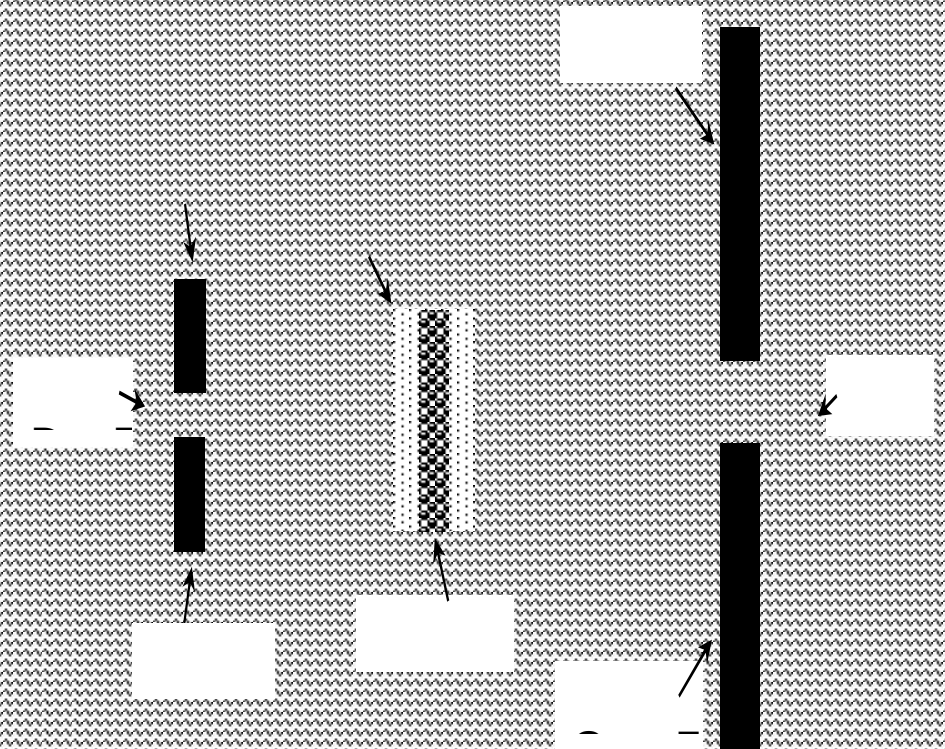
Monte

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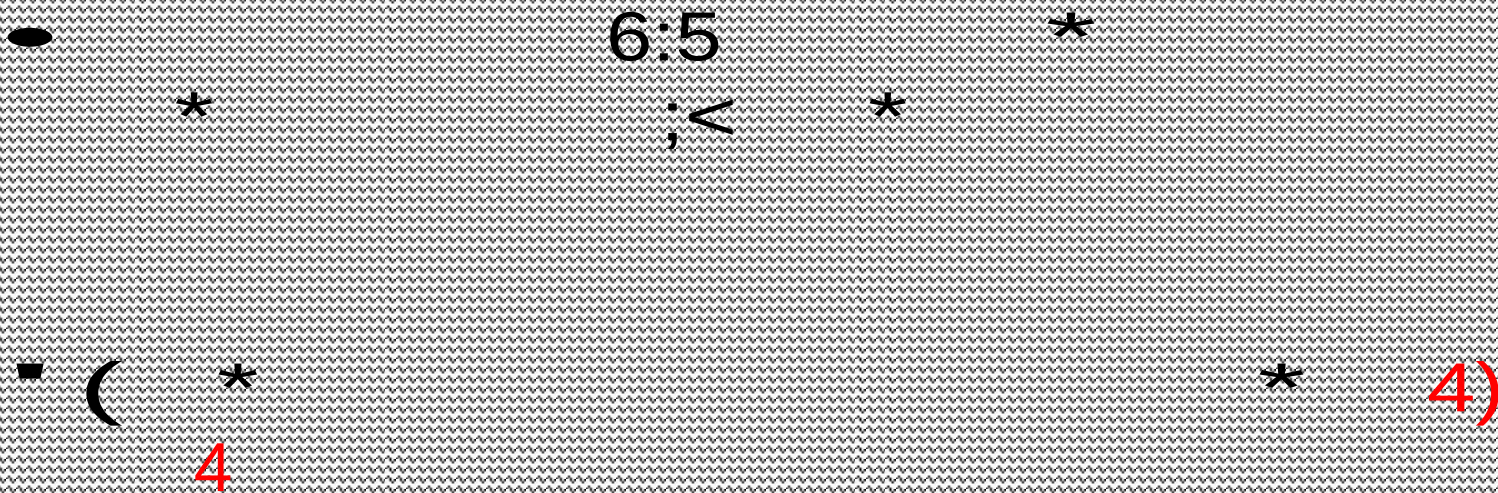
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Monte Carlo Simulation



Monte Carlo simulation

$$\bullet \left(\frac{1}{8} * \frac{1}{3} \right)$$

$$\blacksquare \left(\frac{3}{8} * \frac{4}{5} * \frac{1}{4} \right) * \frac{1}{8}$$

Used spectra for 140
kVp

Water phantom simulation

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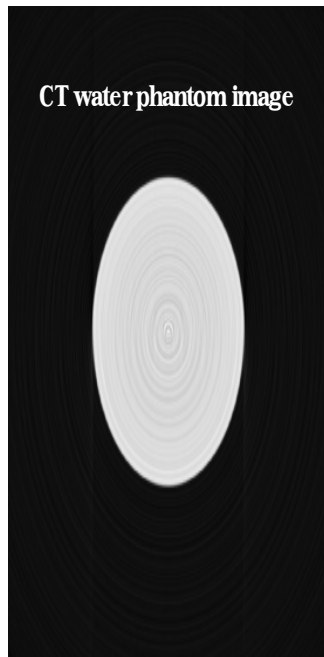
Monte Carlo calculation

- we used the F4 tally for calculation of the photon fluence in each detector cell.
- Each run lasted 60 minutes on a personal desktop 4 GHz CPU to provide results with a statistical uncertainty of less than 0.5% in each cell.
- The variance reduction method of FCL:P (forced collisions) was used for simulation of the imaging process.
- Image reconstruction was performed with use of the image processing toolbox of MATLAB software (The Mathworks, Inc)

Irradiated Gel simulation

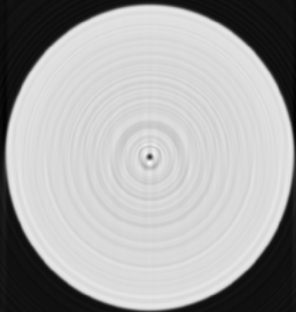
- The PAGAT gel dosimeter used in this study contained gelatin (5 wt%), the monomer of acrylamide (3 wt%), N,N-methylene-bis-acrylamide (3 wt%), and tetrakis (hydroxyl methyl) phosphonium chloride.
- The value of density changes following radiation exposure was taken from a previous study of Trapp et al

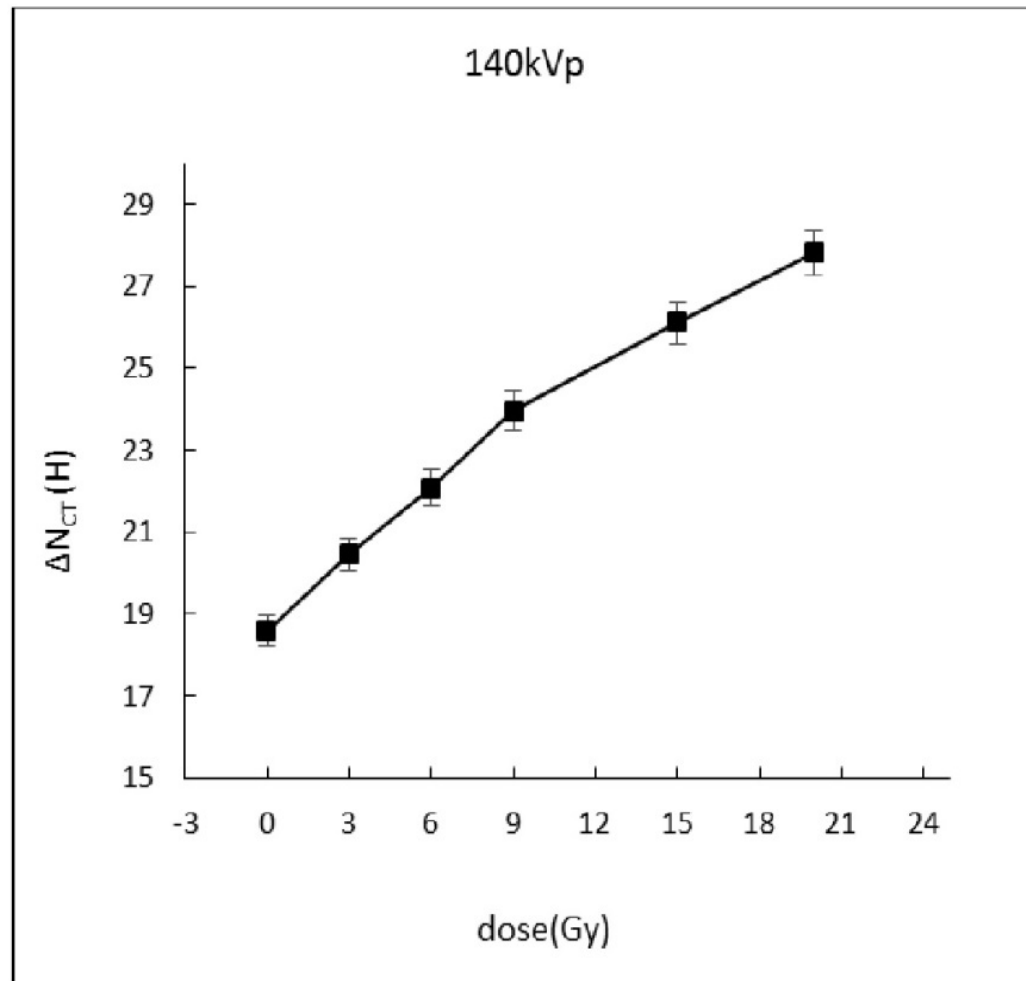
Results: plain water phantom



Results: water phantom with 2 mm air tube

2 m m a i r t u b e i n s i d e w a t e r p h a n t o m





CT number variations in PAGAT gel with dose at 140 kVp beam calculated from MC results. Error bars shows uncertainty of MC results

conclusion

- It is possible to simulate the x-ray CT gel dosimetry process with Monte Carlo method
- Our Monte Carlo model can provide images for gel dosimetry purpose
- Our model can quantify the density changes after irradiation in PAGAT polymer gel
- The effect of photon beam spectra on polymer gel sensitivity can be studied by this model.