

# Validating Geant4-DNA for DNA Double Strand Breaks (DSB): A preliminary study

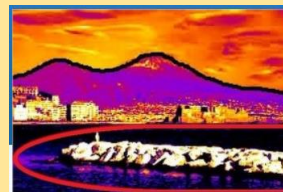
**Konstantinos Chatzipapas<sup>1</sup>**, Panagiotis Papadimitroulas<sup>2</sup>, Mohammad Ali Obeidat<sup>3</sup>,  
Neil Kirby<sup>3</sup>, George Loudos<sup>4</sup>, Niko Papanikolaou<sup>3</sup> and George C. Kagadis<sup>1</sup>

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# Outline

- Introduction
- DNA-DSB Dosimeter
- DNA-DSB Algorithm
- Results
- Discussion



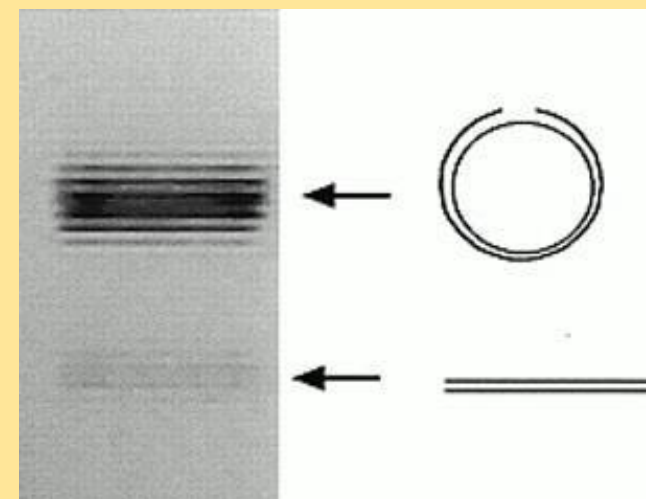
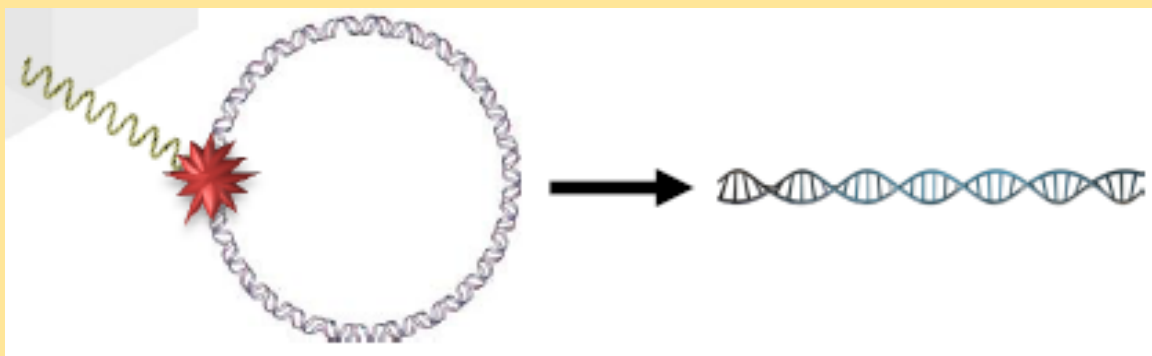
# Introduction (1/2)

- Geant4-DNA:
  - is a common platform available to all (Villagrasa et al, 2011)
  - can simulate free radical (Karamitros et al, 2014)
  - can simulate DNA irradiation and count SSB and DSB (Delage et al, 2015)
  - can accumulate complex DNA models created by DnaFabric (Meylan et al, 2017)
  - needs validation studies for evaluation of its accuracy (Incerti et al, 2016)
  
- Prediction of biological consequences



# Introduction (2/2)

- Measuring DNA DSB for dosimetry
- Gel Electrophoresis
  - W. Chen, E. Blazek, and I. Rosenberg. "The relaxation of supercoiled DNA molecules as a biophysical dosimeter for ionizing radiations: a feasibility study." *Medical Physics* 22.9 (1995): 1369-1375.
- Precision was just 5%
- Not simple or fast

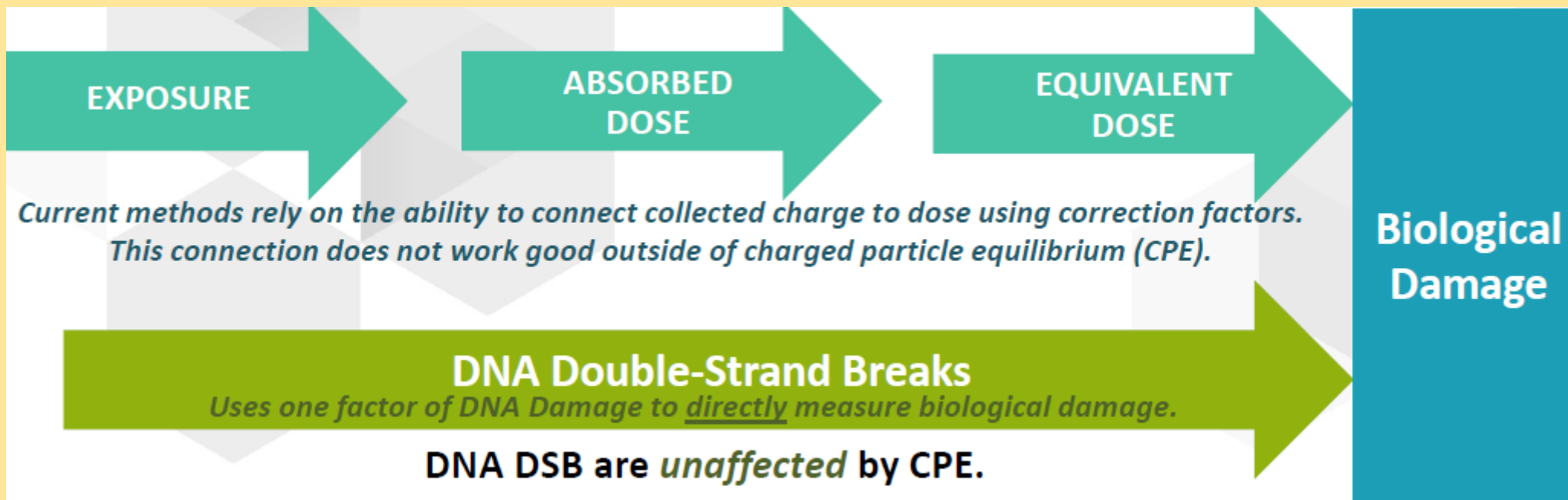




# DNA-DSB Dosimeter (1/2)

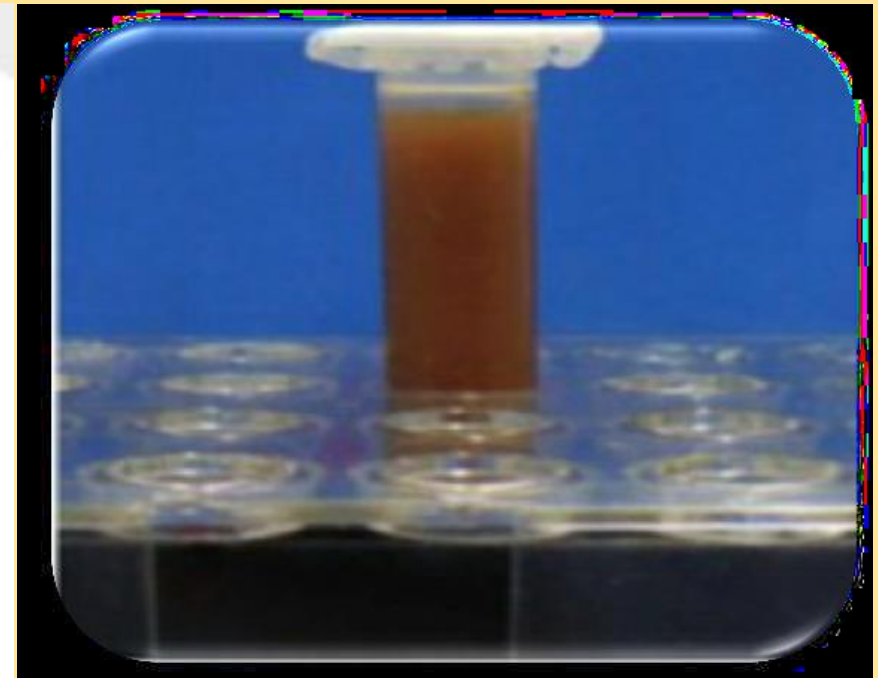
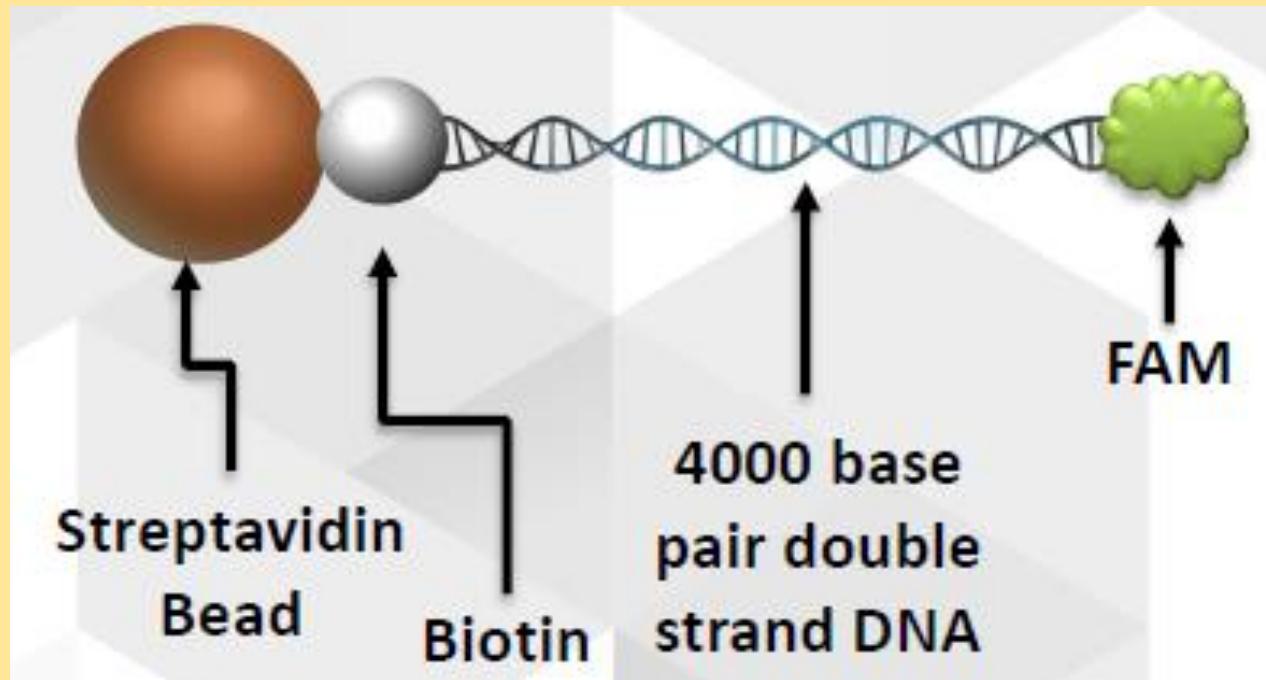
- Measures directly the biological effect.

- M.Obeidat, K.Cline, S.Stathakis, N.Papanikolaou, K.Rasmussen, A.Gutierrez, CS.Ha, SE.Lee, EY.Shim, N.Kirby, “MO-AB-BRA-04: Radiation Measurements with a DNA Double-Strand-Break Dosimeter”, in Medical Physics 43(6), June 2016
- M.Obeidat, K.Cline, S.Stathakis, N.Papanikolaou, K.Rasmussen, A.Gutierrez, CS.Ha, SE.Lee, EY.Shim, N.Kirby, “TH-CD-201-11: Optimizing the Response and Cost of a DNA Double-Strand-Brake Dosimeter”, in Medical Physics 43(6), June 2016



# DNA-DSB Dosimeter (2/2)

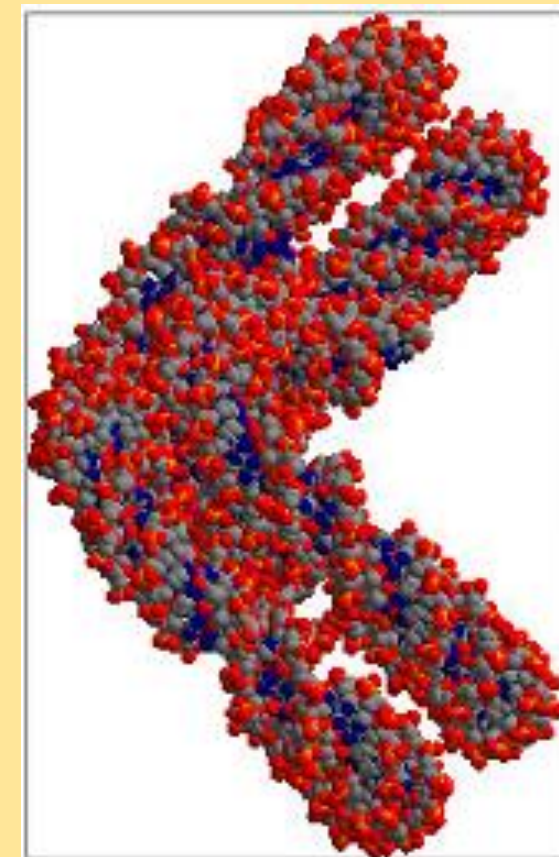
- Taking advantage of the magnetic properties of Streptavidin.
- User-friendly
- Accurate





# DNA-DSB Calculation Algorithm

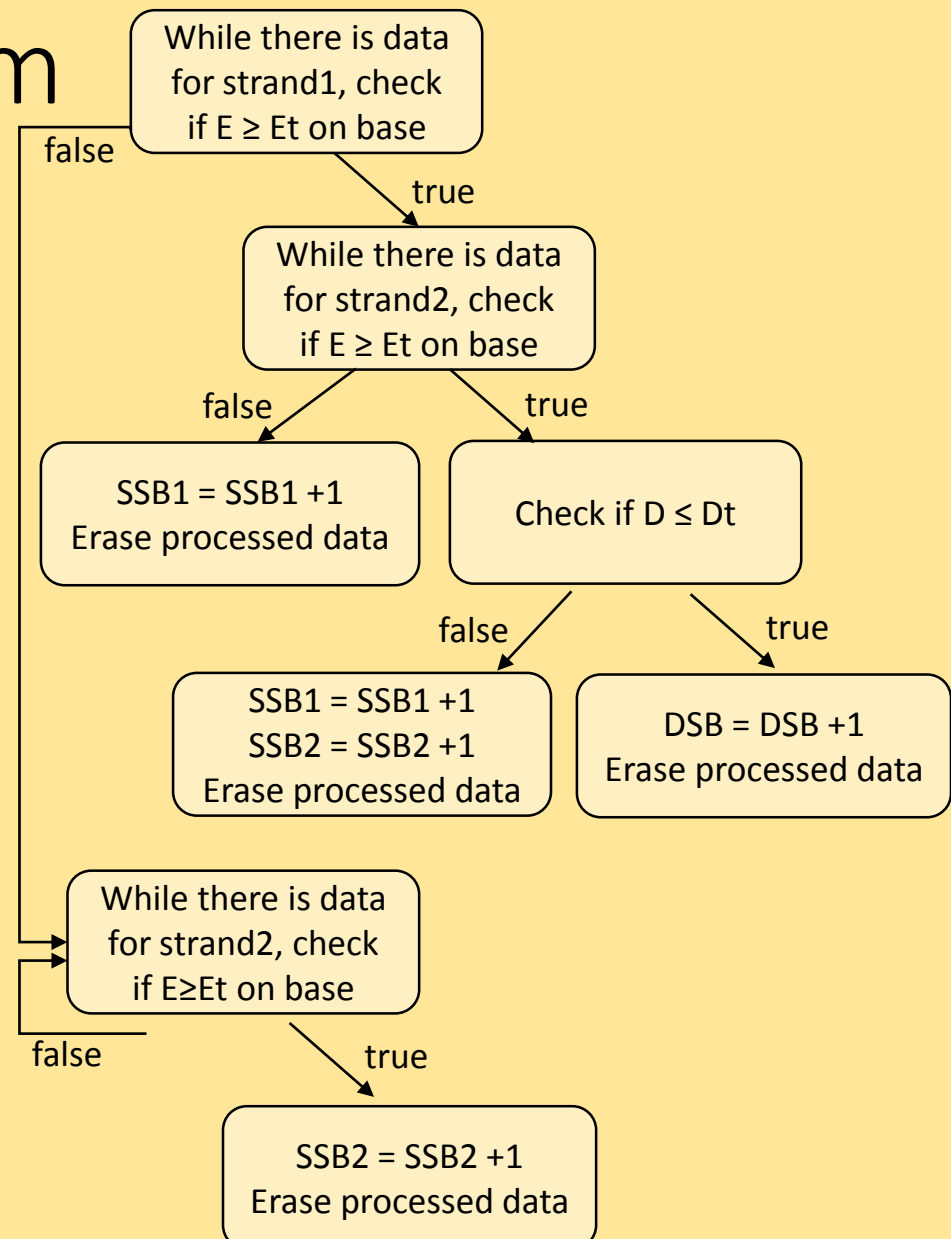
- Simulation of direct damage on the DNA molecule
- PDB4DNA example
- Dinucleosome as the DNA molecule
- Radiation by an 6MV Varian Linac (Ankit, 2016)
- The class that calculates SSB and DSB needed modification, because:
  - Overestimation of SSB number
  - Does not find every DSB





# DNA-DSB Calculation Algorithm

- The new class:
  - checks every SSB if it is DSB
- Two main parameters can be defined (as in the default example)
- With trial and error we defined:
  - Energy threshold ( 9 eV )
  - Distance threshold ( 2 bases )

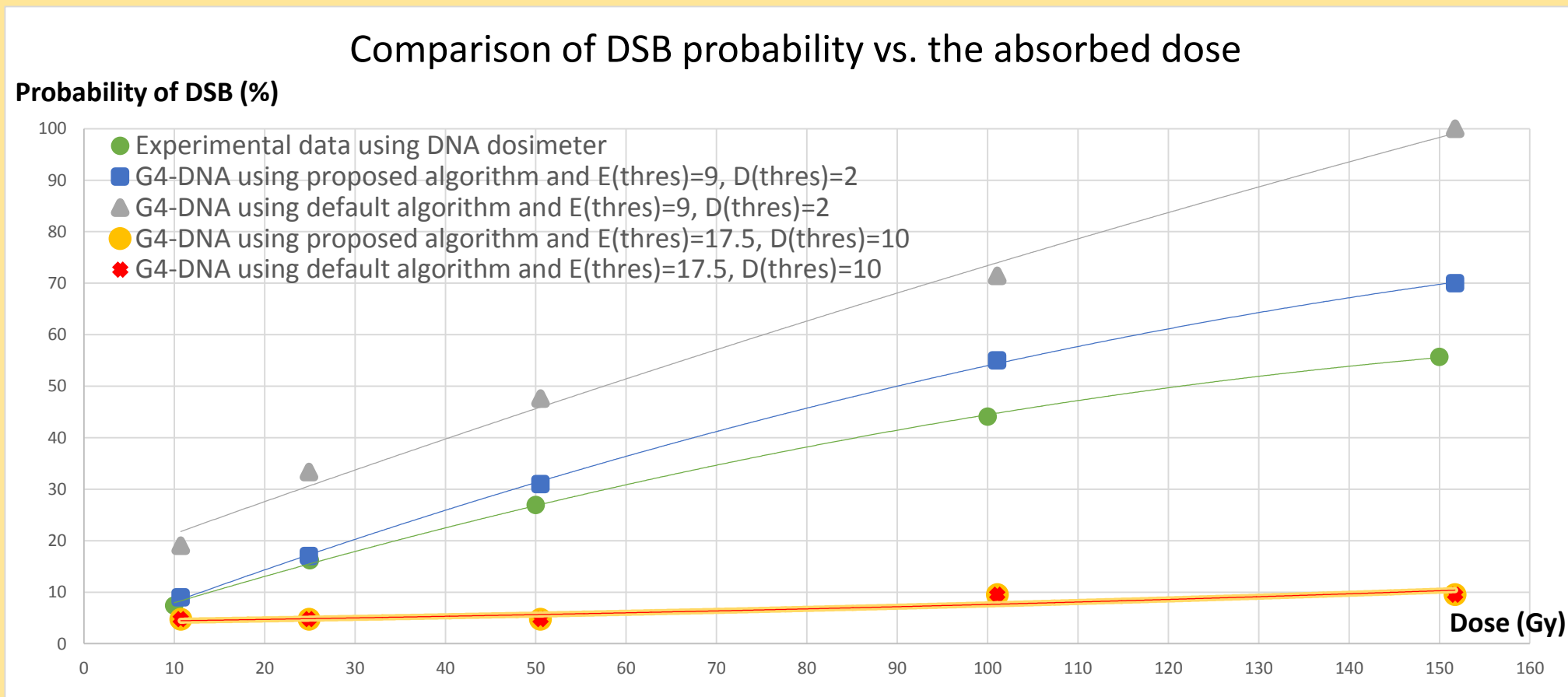






# Results (1/2)

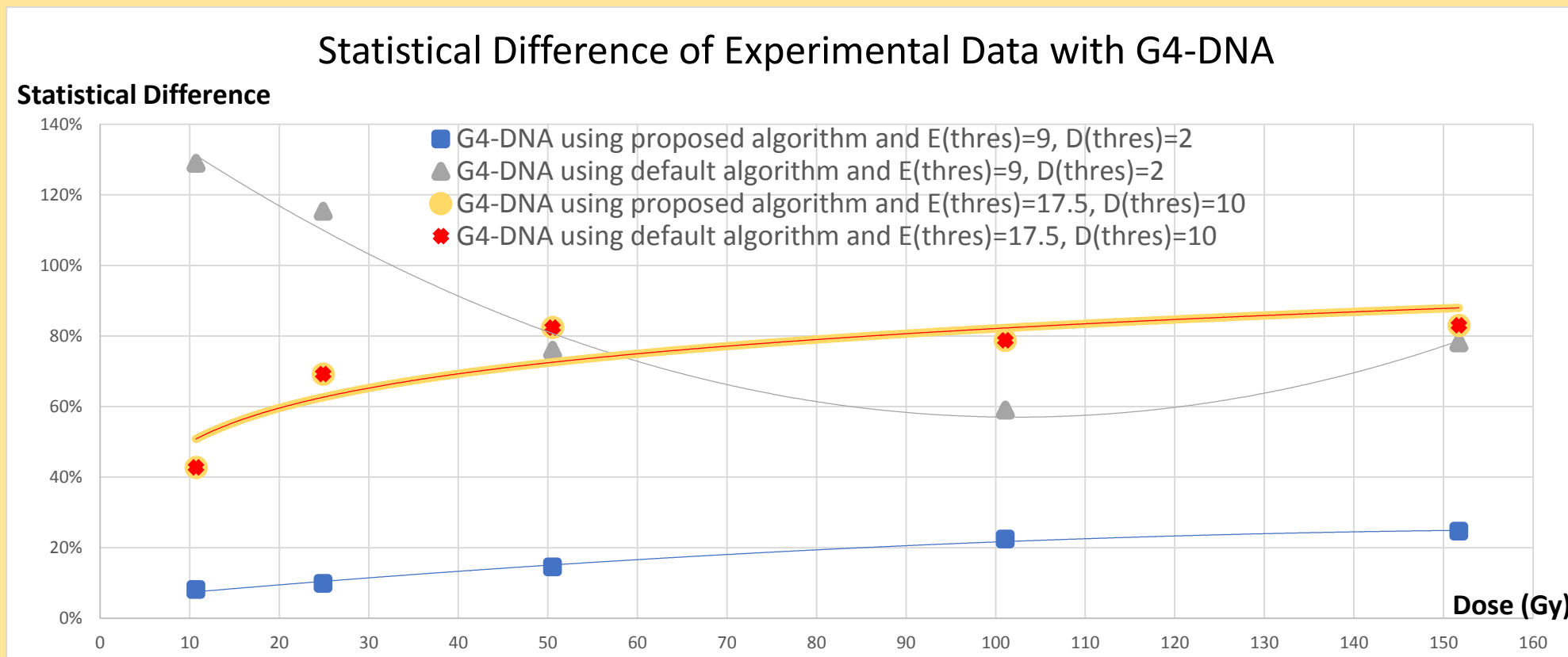
- Diagram presenting the probability of DSB depending on Dose.





# Results (2/2)

- We compare the output of both algorithms (default- proposed) with experimental data using the DNA dosimeter.





# Discussion

- Experimental data for quantifying DNA-DSB were used for validation study of Geant4-DNA code
- The proposed algorithm for the calculation of DNA-DSB provides results with enough accuracy and the difference ranging from 8%-25%
- The proposed study need to be extended to more DNA molecules and to a variety of irradiations (keV-MeV)
- More experimental data are needed for better evaluation
- Chemical interactions need to be considered for more accurate simulations



# Acknowledgments

**This study is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 691203.**



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**Thank you for your attention**



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