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Delineating the Differences in Microbiological Effects Arising from Exposure to Varying Ionizing Radiation Dose Rates and Energies

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Study Motivation

- The Relative Biological Effectiveness (RBE) of different ionizing radiation sources is still under debate
 - Dodd and Vetter, 2009, Miyahara and Miyahara, 2002, Lopez-Gonzalez et. al., 1999., Thayer and Boyd, 1993, Zeitz et. al., 1977,
- In the past, different dosimetry systems were used
- Access to different ionizing radiation sources
- One dosimetry system: alanine pellets

Radiation Sources

- 1.59 MeV Lanthanum-140 (ca. 4 Gy/min)
- 100 kV x-ray (0.6 Gy/min)
- 5 MeV x-ray (135 Gy/s)
- 10 MeV e-beam (3750 Gy/s)

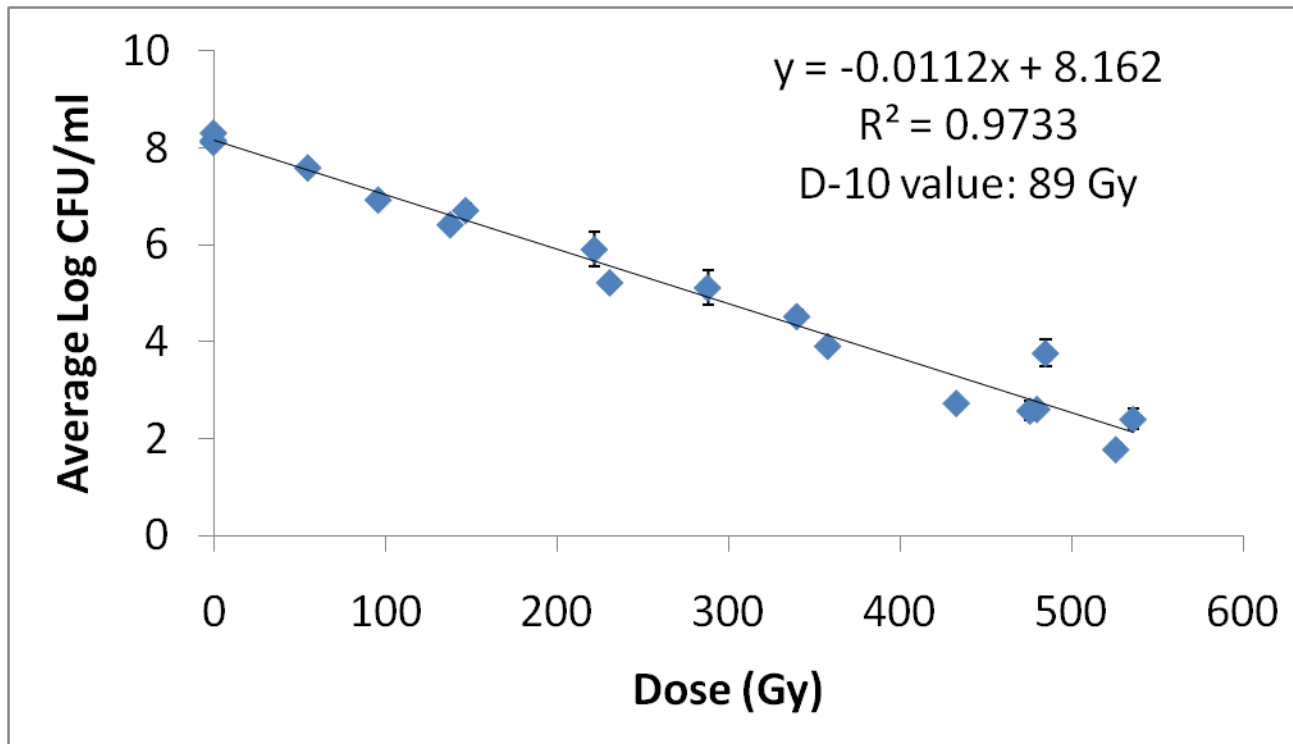
Hypothesis and Objective

- Either dose rate or energy or both will influence microbial inactivation
- Study the inactivation kinetics of the three different microbial targets (*E.coli*, *E.coli* O157:H7, and *Salmonella*) when exposed to the four different ionizing radiation sources that differ in source energy and dose-rate

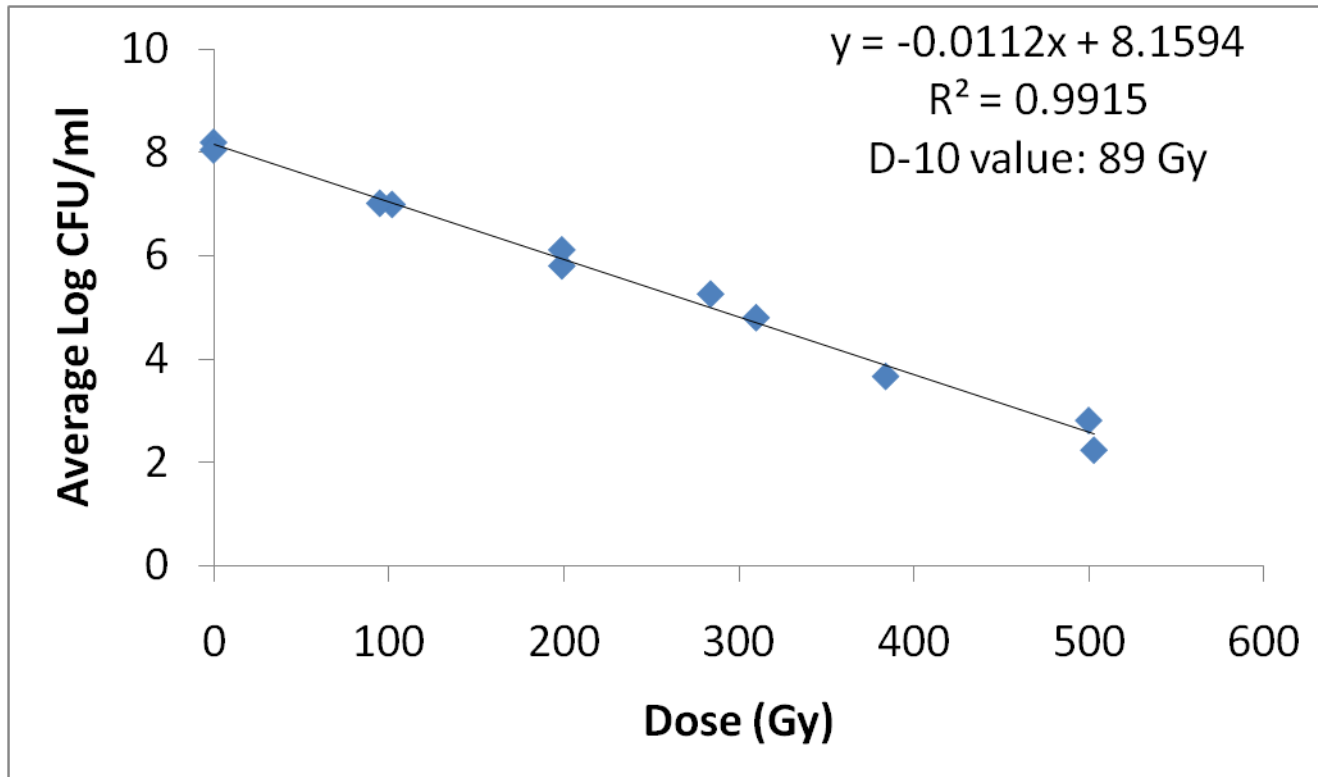
Methods

- Overnight bacterial cultures
 - O.D. ₆₀₀: ca 1.0 (approx. 10^8 cfu/ml)
- Cell suspensions in PBS were triple bagged
- Samples were analyzed the same day they were irradiated
- Samples were analyzed for growth, membrane integrity, and metabolic activity

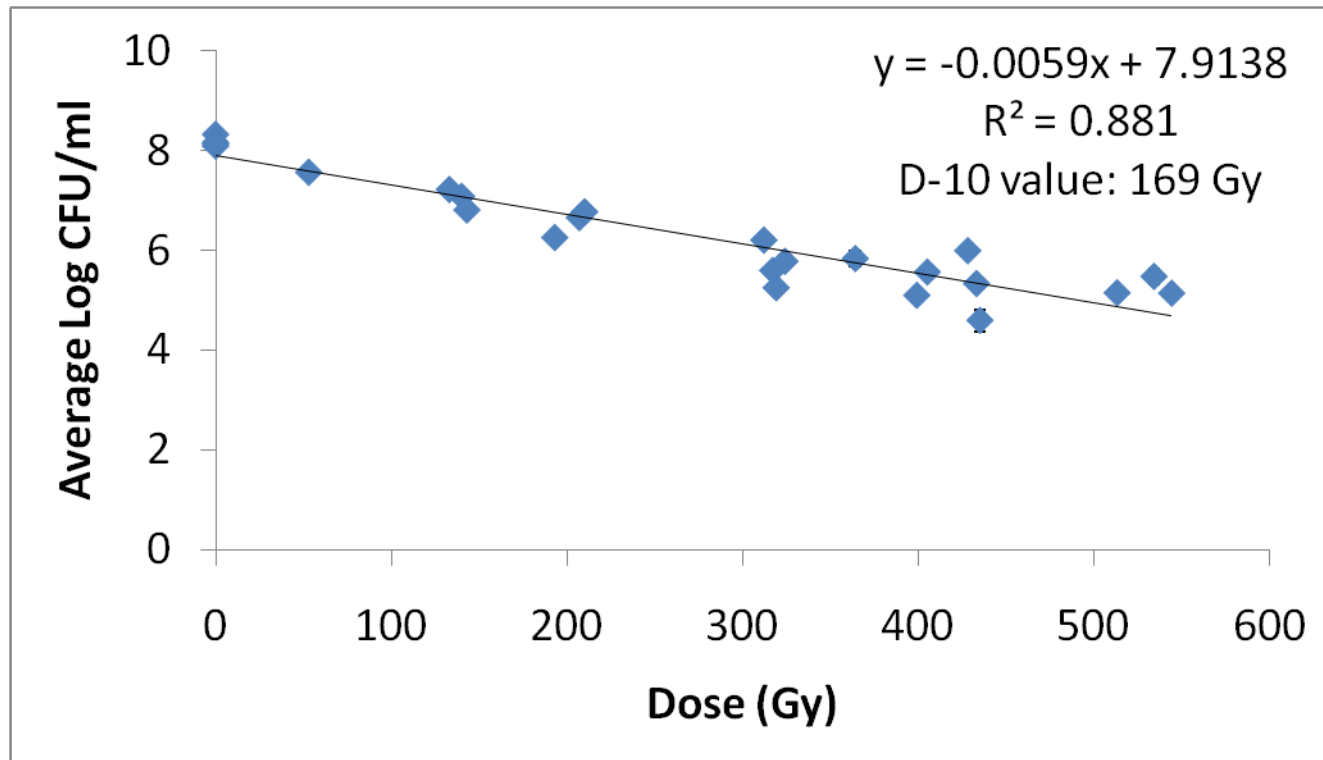
Results – La-140



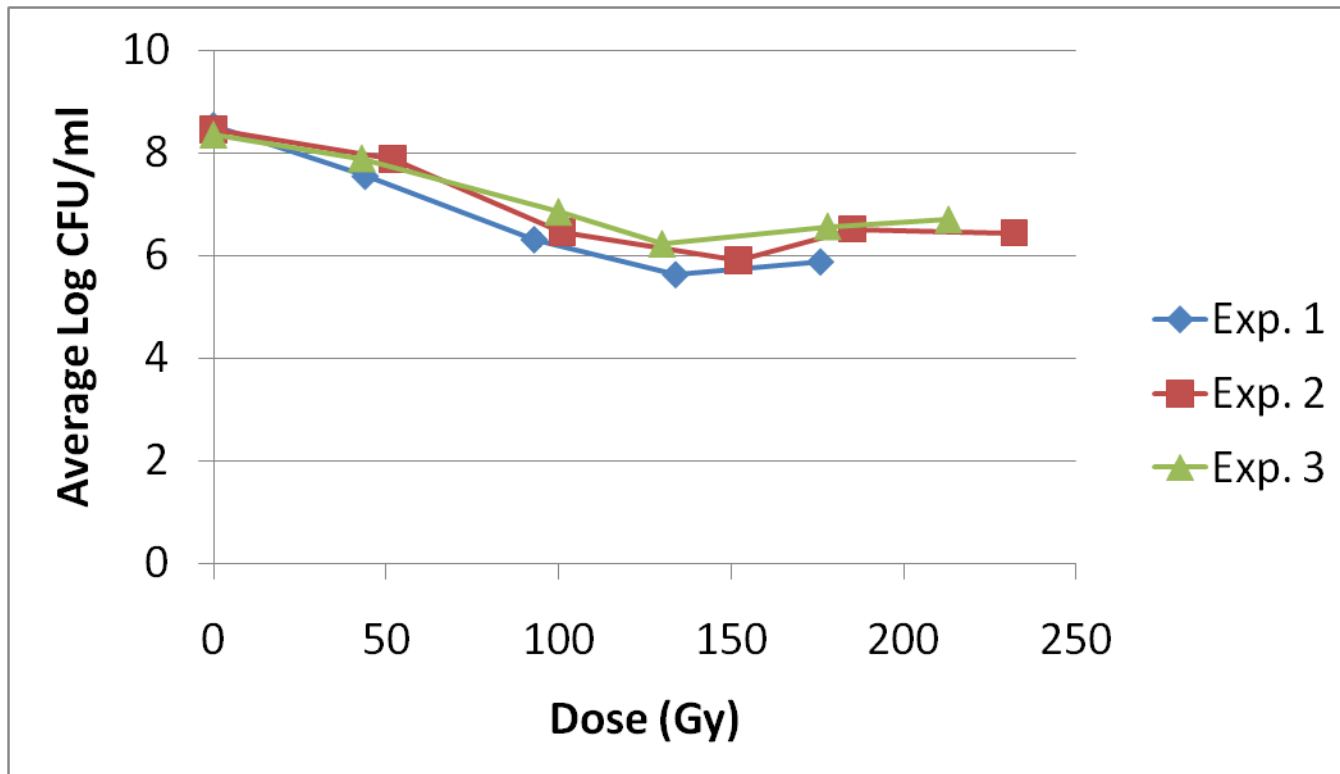
Results – 5 MeV X-Ray



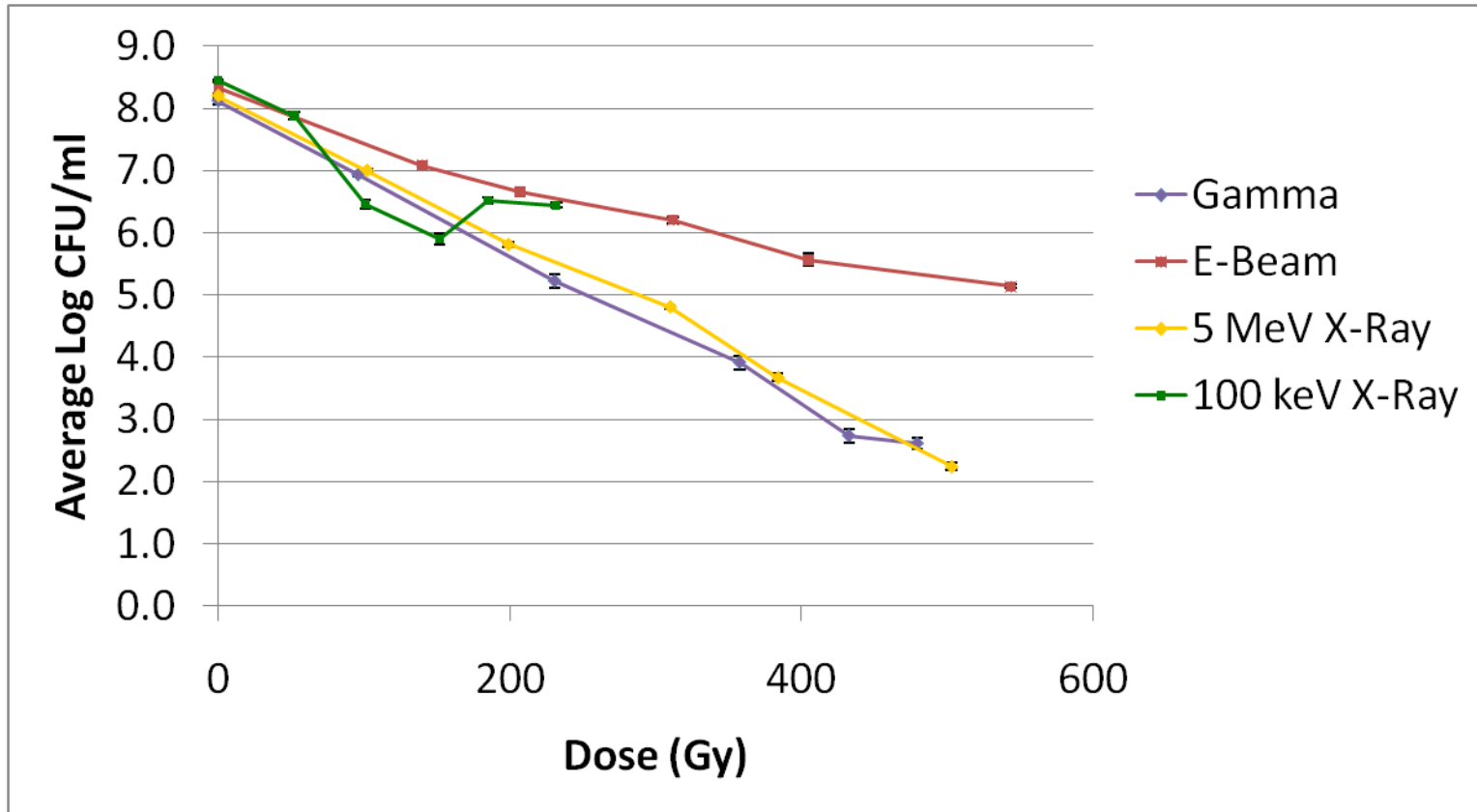
Results – 10 MeV E-beam



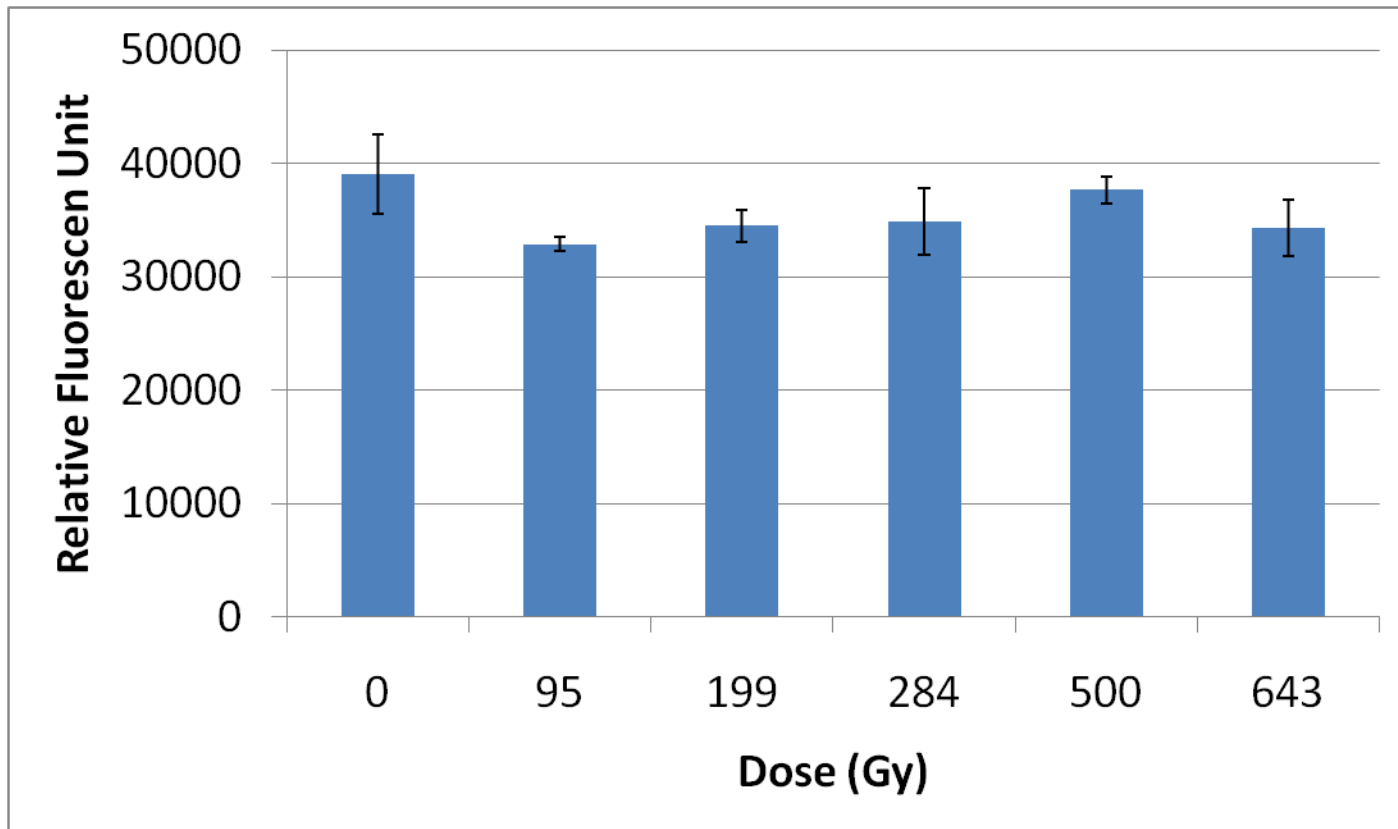
Results – 100 kV X-Ray



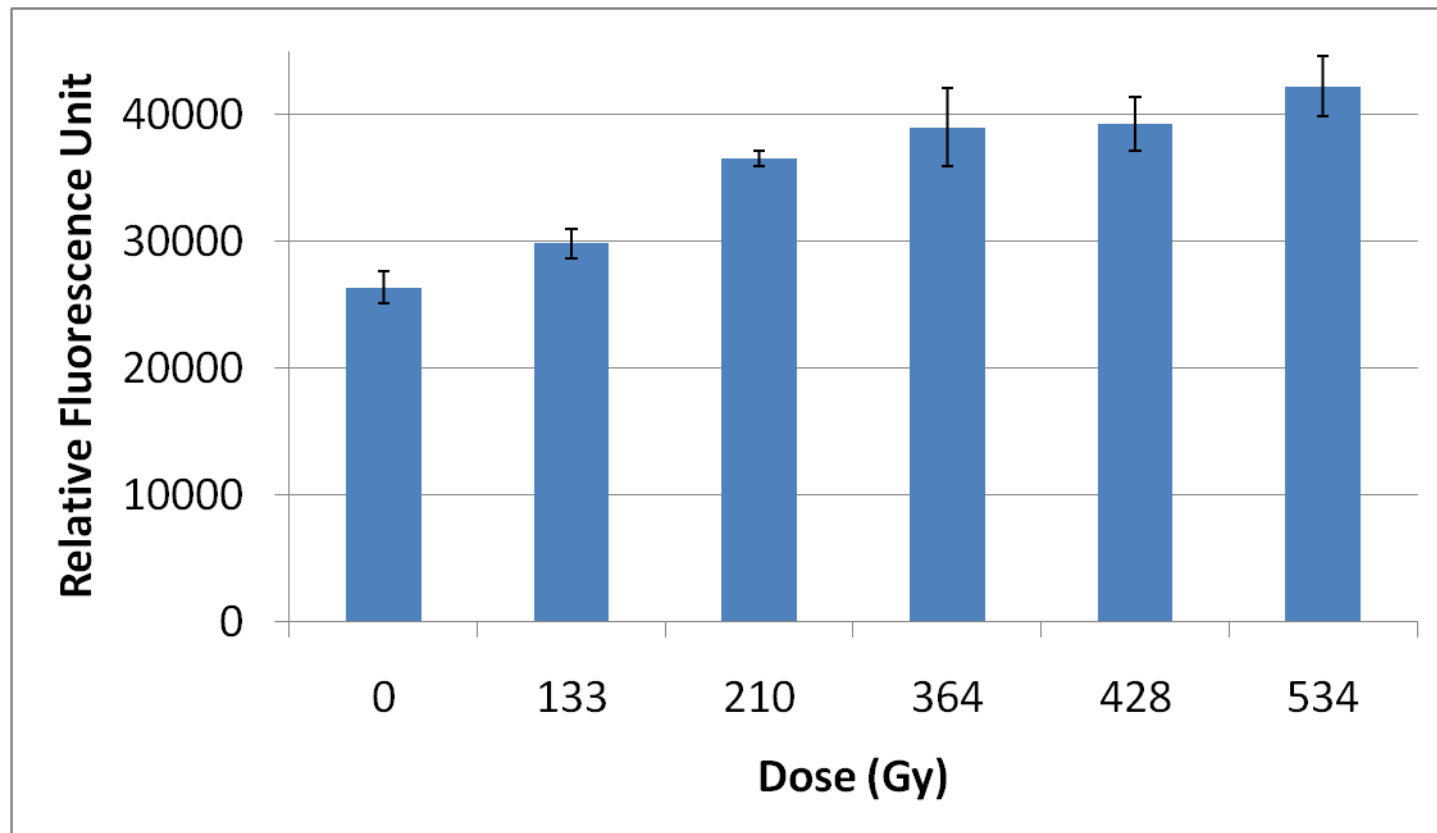
Comparison



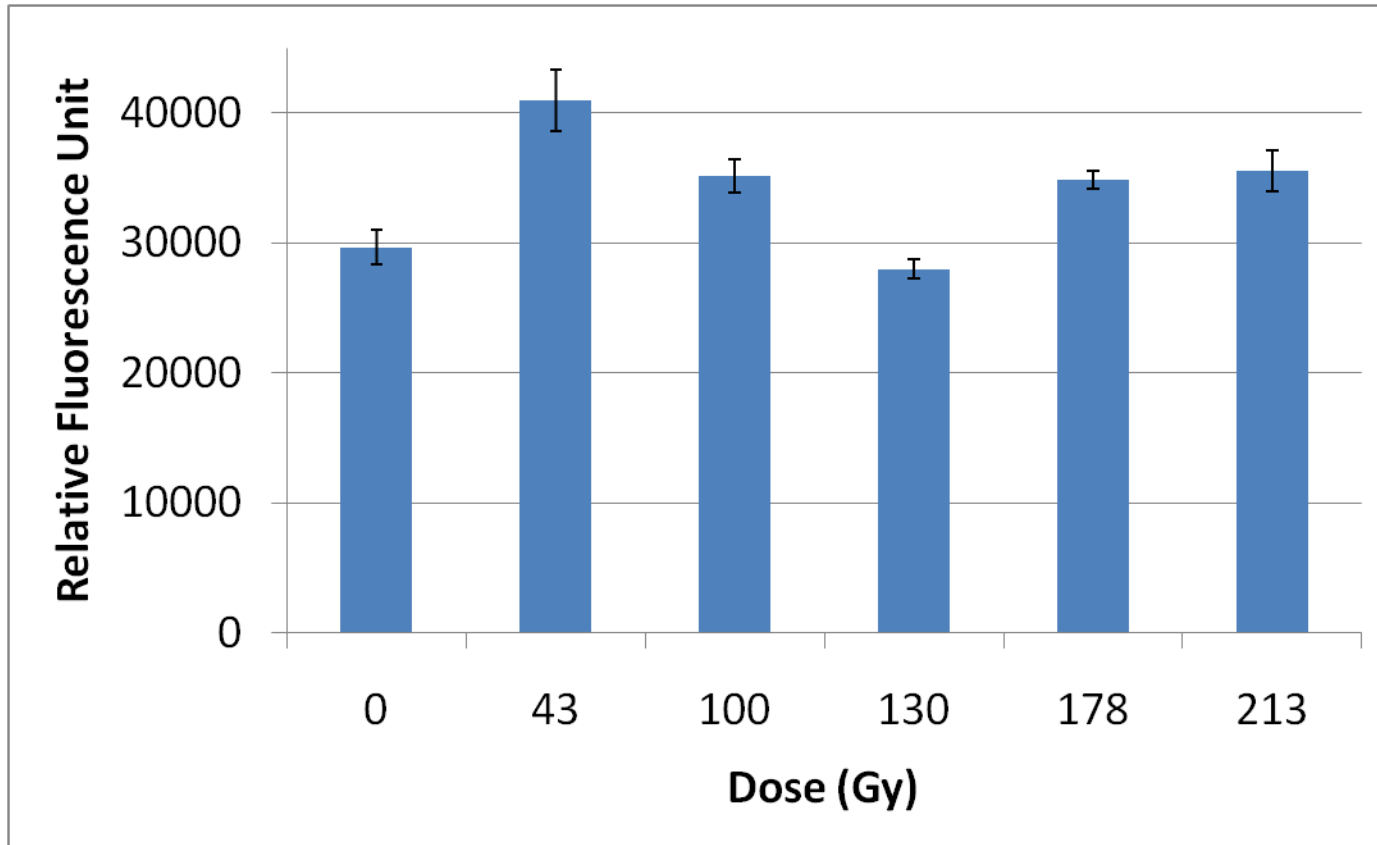
5 MeV X-Ray – Membrane Integrity



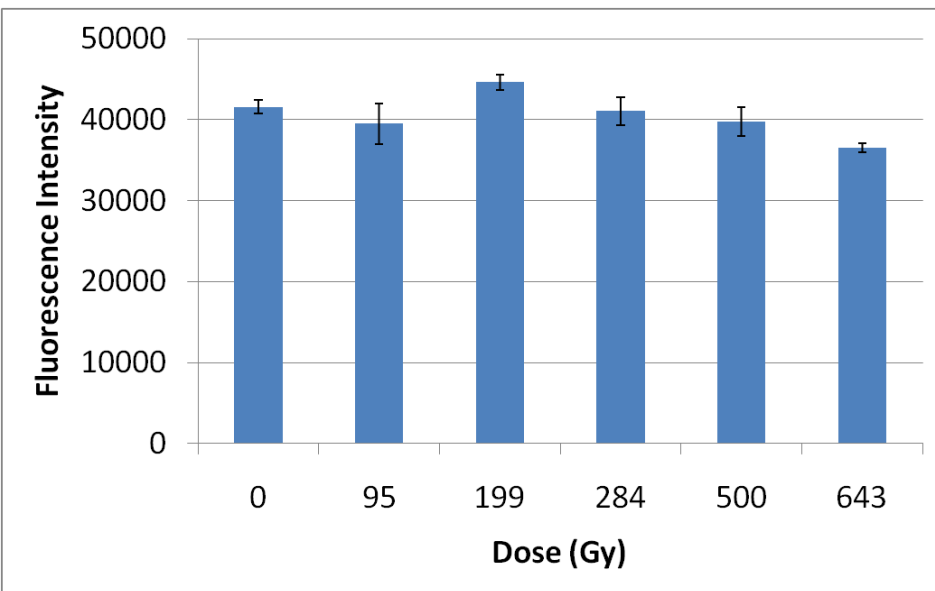
10 MeV E-Beam – Membrane Integrity



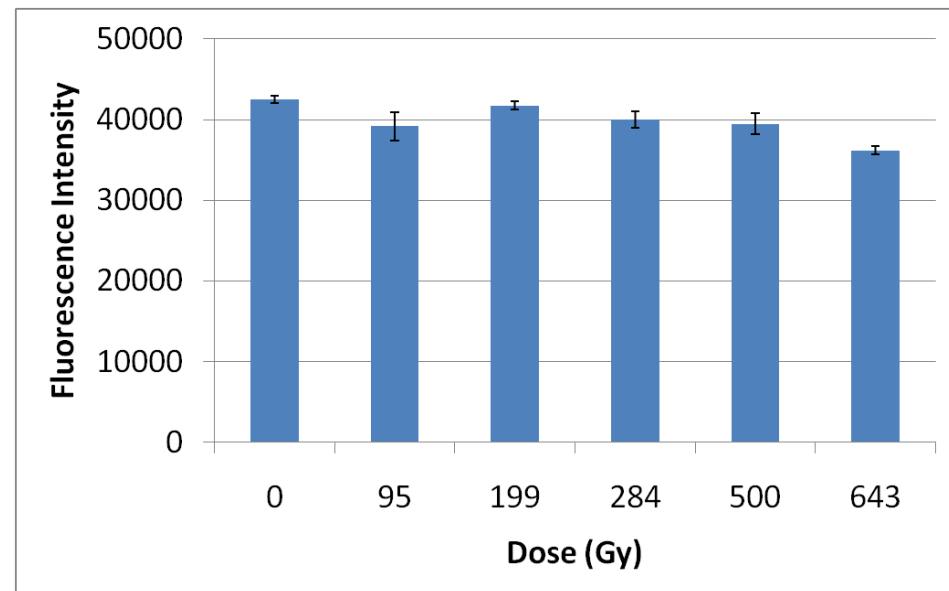
100 kV X-Ray – Membrane Integrity



5 MeV X-Ray – Metabolic Activity

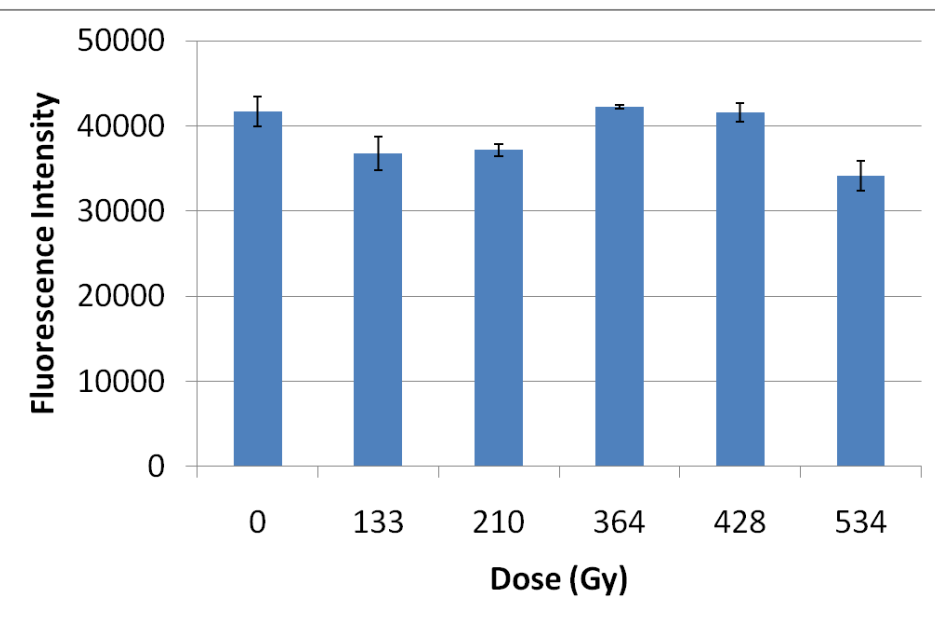


After 1 hour of incubation

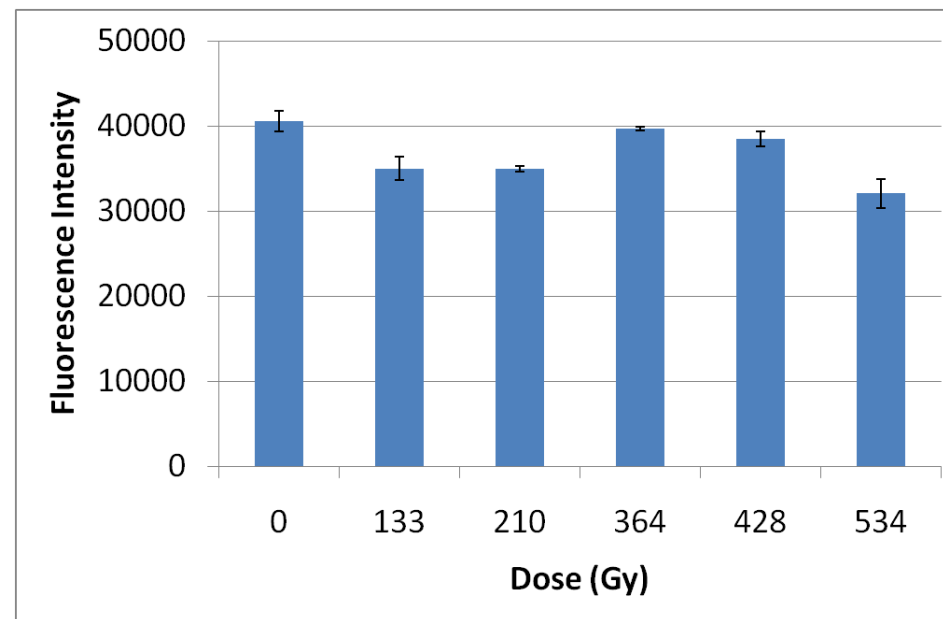


After 24 hours of incubation

10 MeV E-Beam – Metabolic Activity

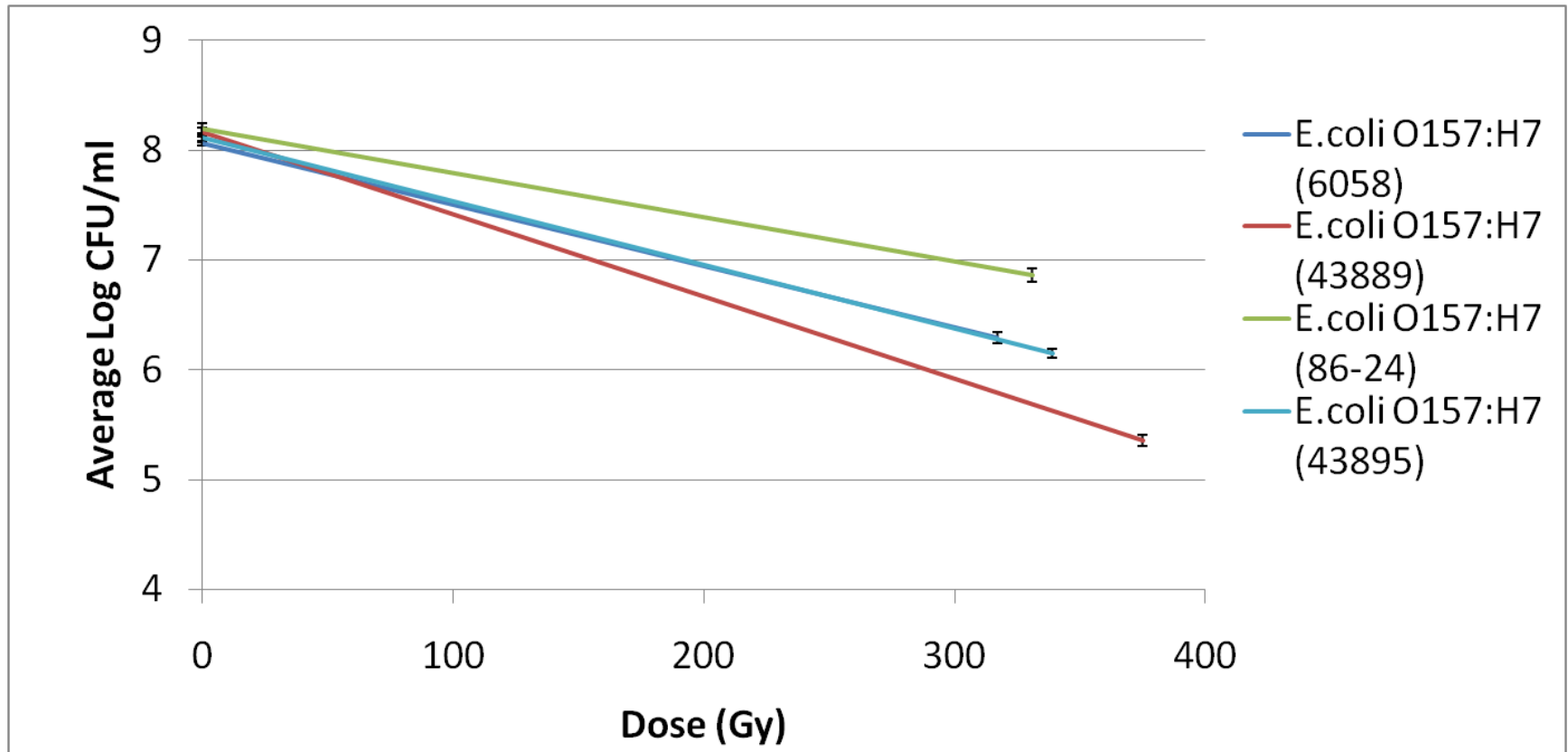


After 1 hour of incubation

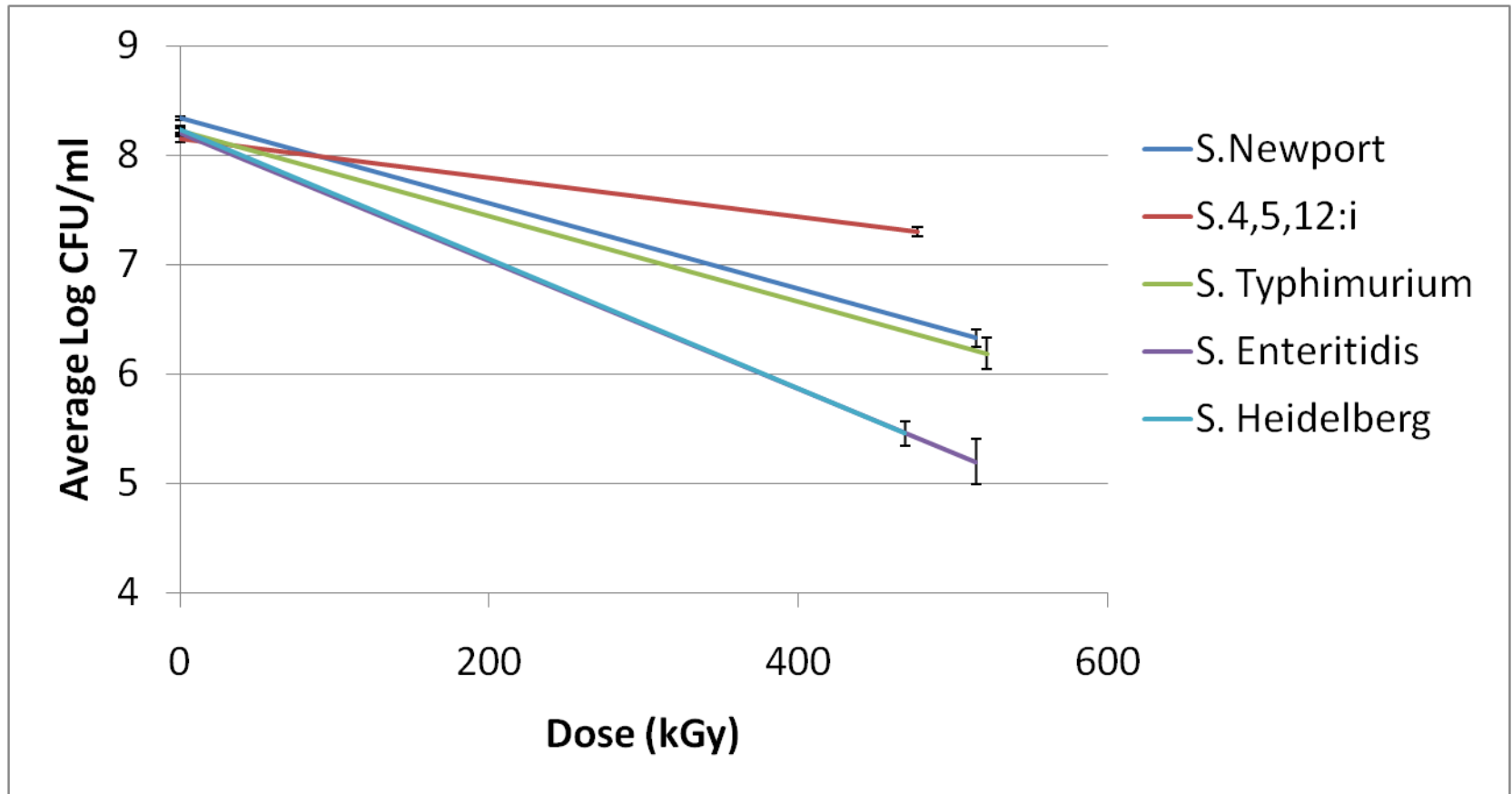


After 24 hours of incubation

E.coli O157:H7



Salmonella



Conclusions

- Significant difference between gamma + x-ray and E-beam
- Membrane remains intact after irradiation
- Cells are metabolically active after irradiation
- 100kV x-ray: cells seem to repair DNA faster than it is damaged by x-rays
- Different bacterial strains show different inactivation curves

More Questions

- How long after irradiation do bacterial cells remain metabolically active?
- Why do irradiated bacterial cells remain metabolically active even after the DNA has supposedly been irreparably damaged?
- How do we determine whether or not a cell is dead?

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