Evaluation of a High Dose X-ray Irradiator for High Risk Microbial Inactivation

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Introduction: What do we irradiate and why

- Higher risk group microbial agents
- Render inactive, but unaltered
- Work at lower containment levels
- Shipping to other labs

Introduction: How do we irradiate?

What Do We Currently Use?

Ionizing gamma radiation used by many high containment labs to inactivate agents by disrupting genetic structure

- Contain nuclear material such as Cobalt-60 as the radiation source
- Half life is 5.26 years
- Radiation dose declines with each half-life
- Results in ever increasing sample processing times
- 5 Mrads delivered to CL4 samples
- Higher burden of regulatory compliance
- Safety and security concerns
- Source replacement-expensive and time consuming
- Burdensome decommissioning process

Introduction: Irradiation options

Non-nuclear x-ray irradiators promising as an alternative

- Sustainable high dose of ionizing radiation dependant on energy supplied rather than presence of nuclear material
- Fewer safety considerations for staff
- Reportedly being installed in other higher containment laboratories
- However, little data available in literature detailing inactivation potential of x-rays

Objective

- The objective of this study was to determine and compare the inactivation efficacies of x-ray and gamma radiation on representative microbial agents

Study Methods

- A Gammacell 220 Excel irradiator (MDS Nordion) and an RS2500 x-ray irradiator (Rad Source Technologies, Inc.) were used

- A selection of RG 2, 3 and 4 microbial agents were used as test agents.
  - *Bacillus pumilus* spores (biological indicator for ionizing radiation),*Vesicular Stomatitis Virus, Staphylococcus aureus*
  - *West Nile Virus*
  - *Ebola virus*, *Nipah virus*, and *Rift Valley fever virus*

- Vials containing 1 ml virus or bacterial cultures with titres $\geq 10^6$ ($TCID_{50}$ or CFU) were exposed to varying doses of gamma and x-ray radiation and their D-values calculated

Study Methods

- The number and location of vials in the irradiation chamber remained constant for each process; although they must vary necessarily between a cylindrical chamber (gamma cell):

Study Methods

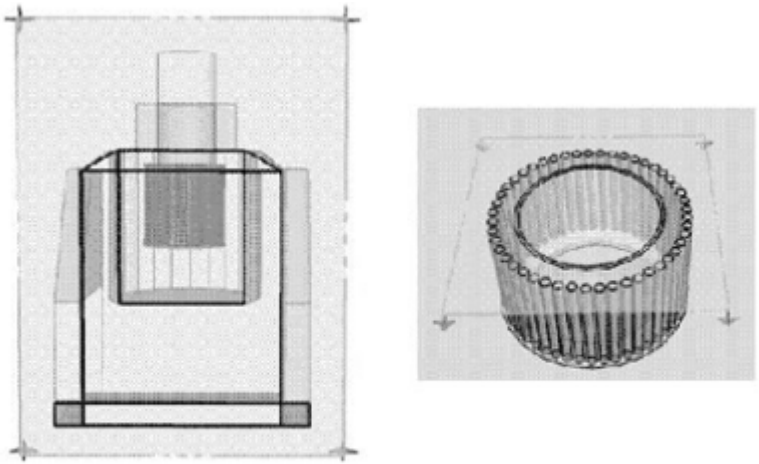
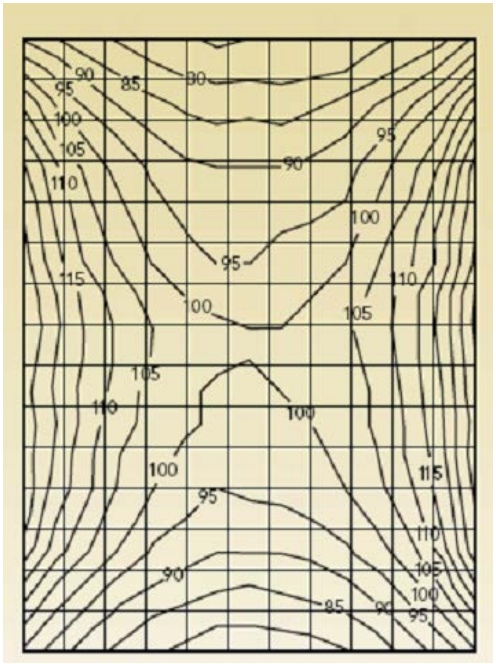


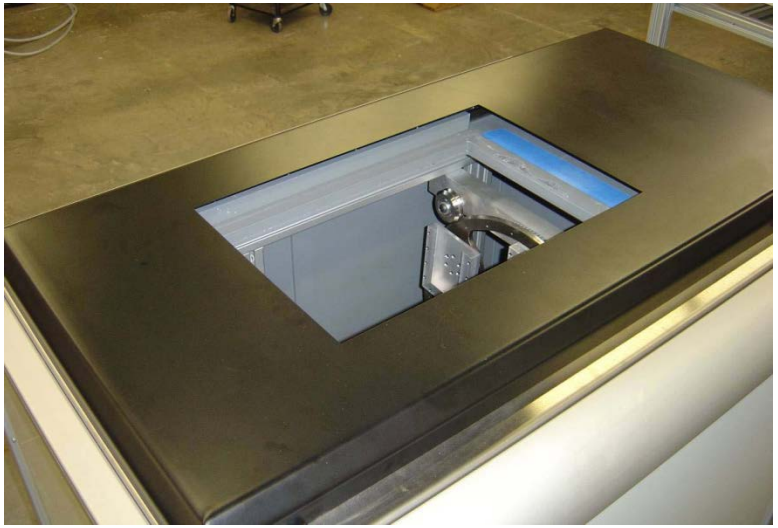
FIG. 2: Frontal cut-away view of GammaCell 220 and top view of sources.




DO NOT INSERT ANY PART OF THE BODY

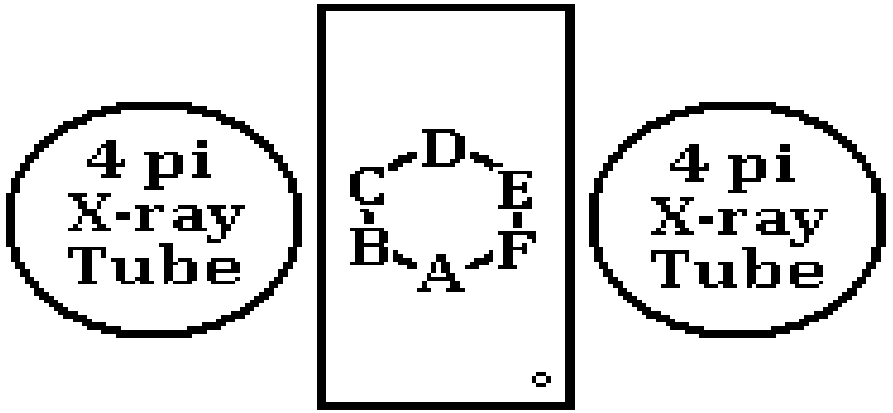
Study Methods

..and rectangular (x-ray).



Study Methods

A 8.29 kGy/h (to air)
B 9.74 kGy/h (to air)
C 9.75 kGy/h (to air)
D 8.19 kGy/h (to air)
E 10.23 kGy/h (to air)
F 10.85 kGy/h (to air



Irradiation Chamber Top View



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Results

D values: Radiation (Mrads) required for one log reduction		
	Gamma	X-ray
Ebola	0.35	0.33
Nipah	0.45	0.45
RVFV	0.30	0.33
VSV	0.38	0.40
B.Pumilus*	0.40	0.23
WNV	0.45	N/A
Staph	0.16	N/A

Results

- High dose x-ray irradiators are as effective as gamma irradiators.
- Both gamma and x-ray radiation proved to inactivate all the agents tested; 20-30 kGy (2-3 Mrads) was required for their complete inactivation ($\geq 10^6$ $TCID_{50}$).
- Our data shows no significant differences in viral inactivation efficacies between gamma and x-ray irradiation
- However, inactivation of *B. pumilus* spores required 42.5% more gamma dose vs. x-ray

Summary

- No significant difference in accumulated dose required to completely inactivate RG4 viruses tested
- *B. pumilus* spores required 40% more accumulated gamma radiation in comparison to x-ray
- Long term studies are warranted to further assess the viability and dependability of non-nuclear irradiators

  - » **However…**

Problems

- Although the technology works in theory, in practice it is untested and appears to be unreliable
  - » Constantly breaking down, requiring repeat visits for expert technical repair
  - » Excessive time spent with company trying to diagnose problem
  - » Parts are custom and cannot be purchased off the shelf e.g. generator is made in the UK, x-ray tubes are custom
  - » Seamless functioning would require a team of in house technical experts (i.e. electrician experienced in high voltage and a health physicist or someone well versed in x-ray technology)

- We acknowledge that to the best of our knowledge, this is the only unit of its kind in the world that is actually running

Questions?

All thanks must go to:

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