

# Radiolysis of DNA

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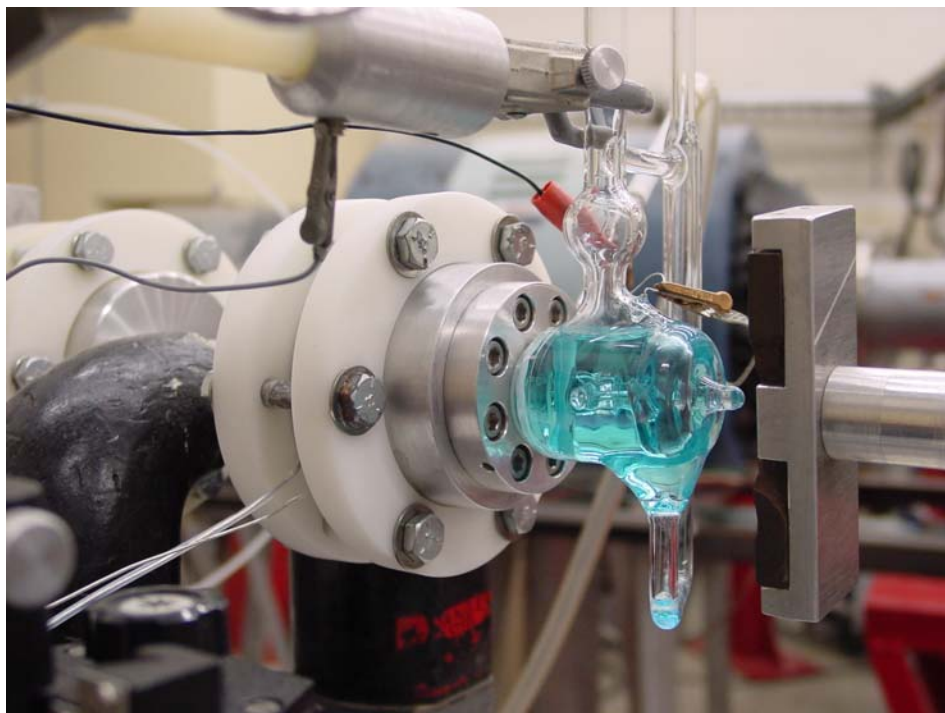
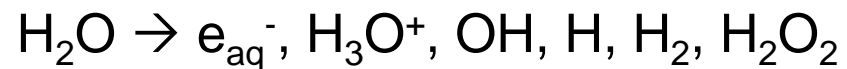
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Jaime Milligan, UC-San Diego



# Water and Aqueous Solutions

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$e_{\text{aq}}^-$  : e transfer,  $\text{H}_2$  formation

$\text{H}_2$  : explosive, flammable

$\text{H}_2\text{O}_2$  : corrosive

$\text{OH}^{\cdot-}$  : biological

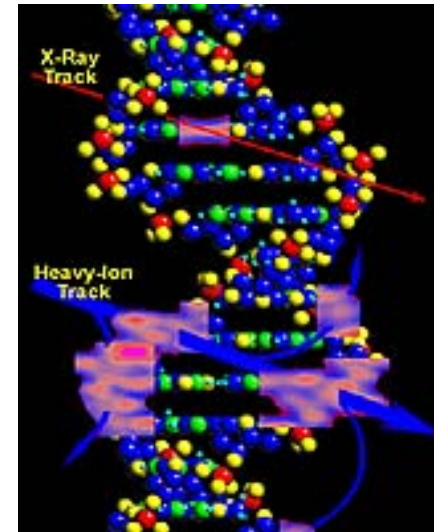
# Radiation Effects of Heavy Ions on DNA

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Probe relative strand breaks of DNA  
as a function of LET ( $-dE/dx$ )

Studies to complement the extensive  
work using x-rays and  $\gamma$ -rays

Data used to set standards for therapy  
and in space travel



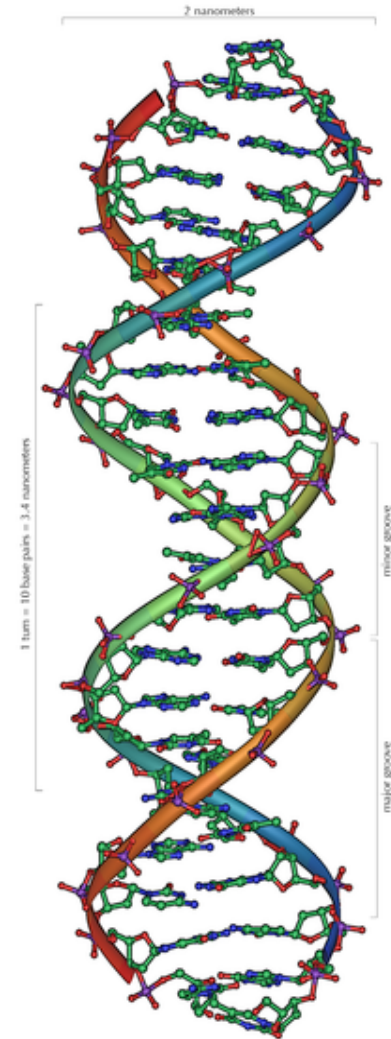
# DNA Radiation Damage

## Direct Effects

DNA → single strand breaks, SSB  
double strand breaks, DSB  
multiply damaged sites, MDS

## Indirect Effects

$\text{H}_2\text{O} \rightarrow \text{OH}$   
 $\text{OH} + \text{DNA} \rightarrow \text{SSB}$   
 $\text{OH} + \text{SSB} \rightarrow \text{DSB, MDS}$

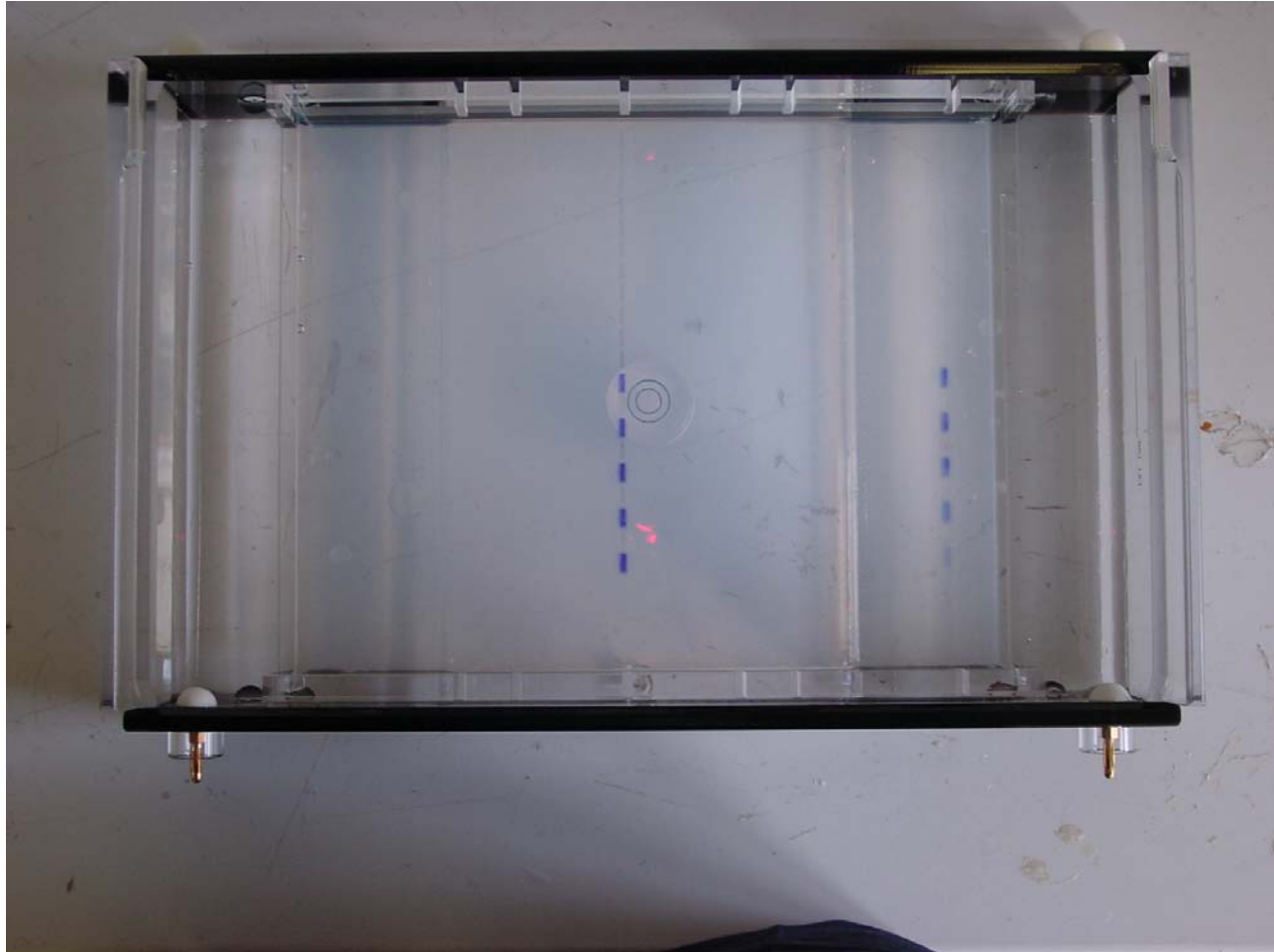


# Radiolysis with $\gamma$ -rays

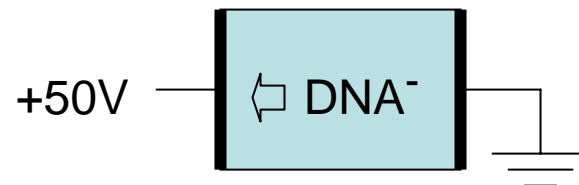
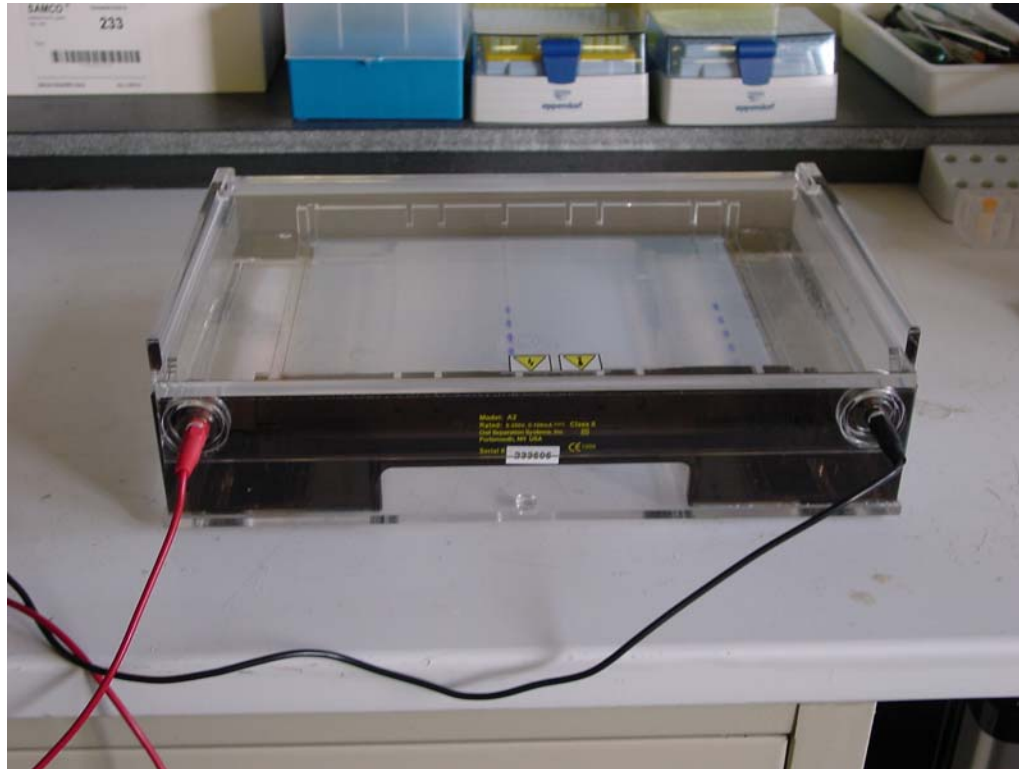


# Gel Electrophoresis

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# Gel Electrophoresis



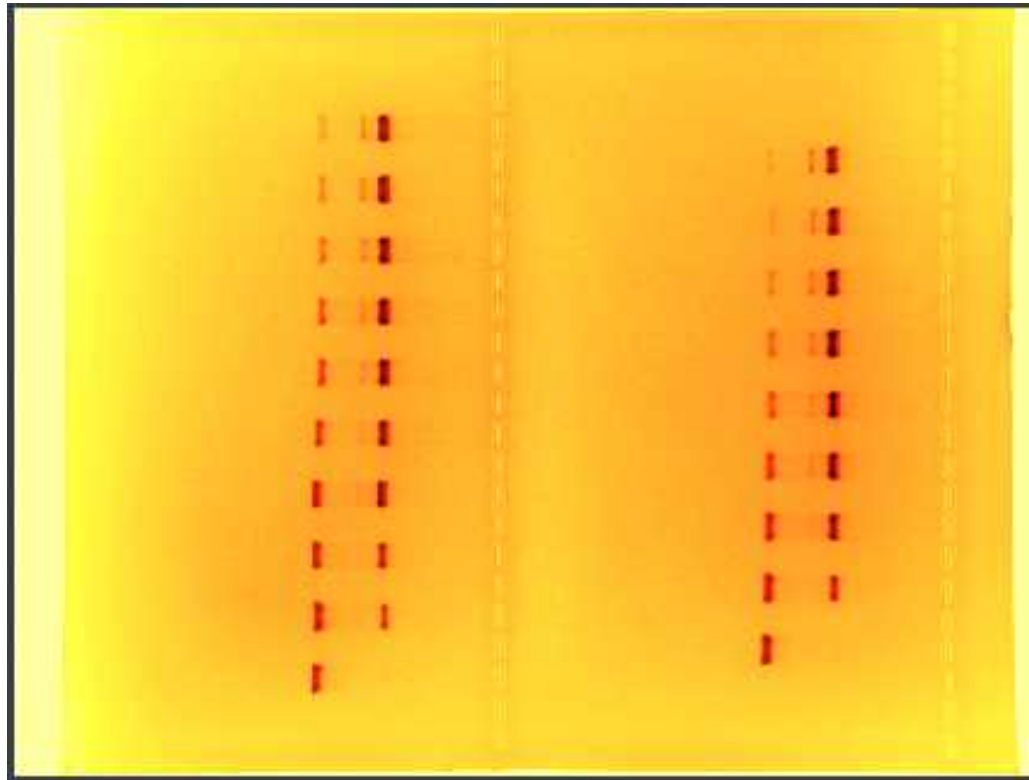
# Gel Imager

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# Fluorescence of Stained DNA



↑  
DOSE  
|

← SIZE —

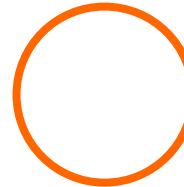
**pUC18**



**DSB**

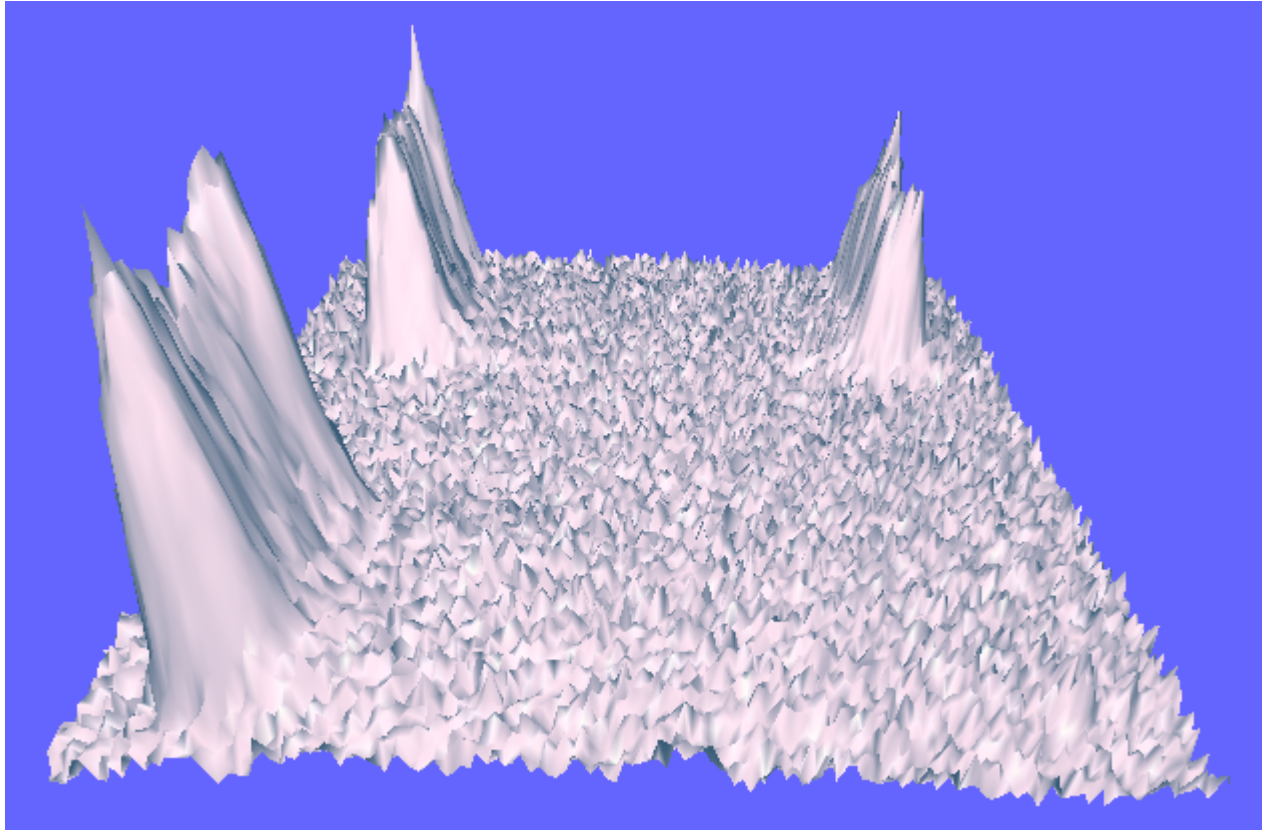


**SSB**



# Fluorescence of Stained DNA

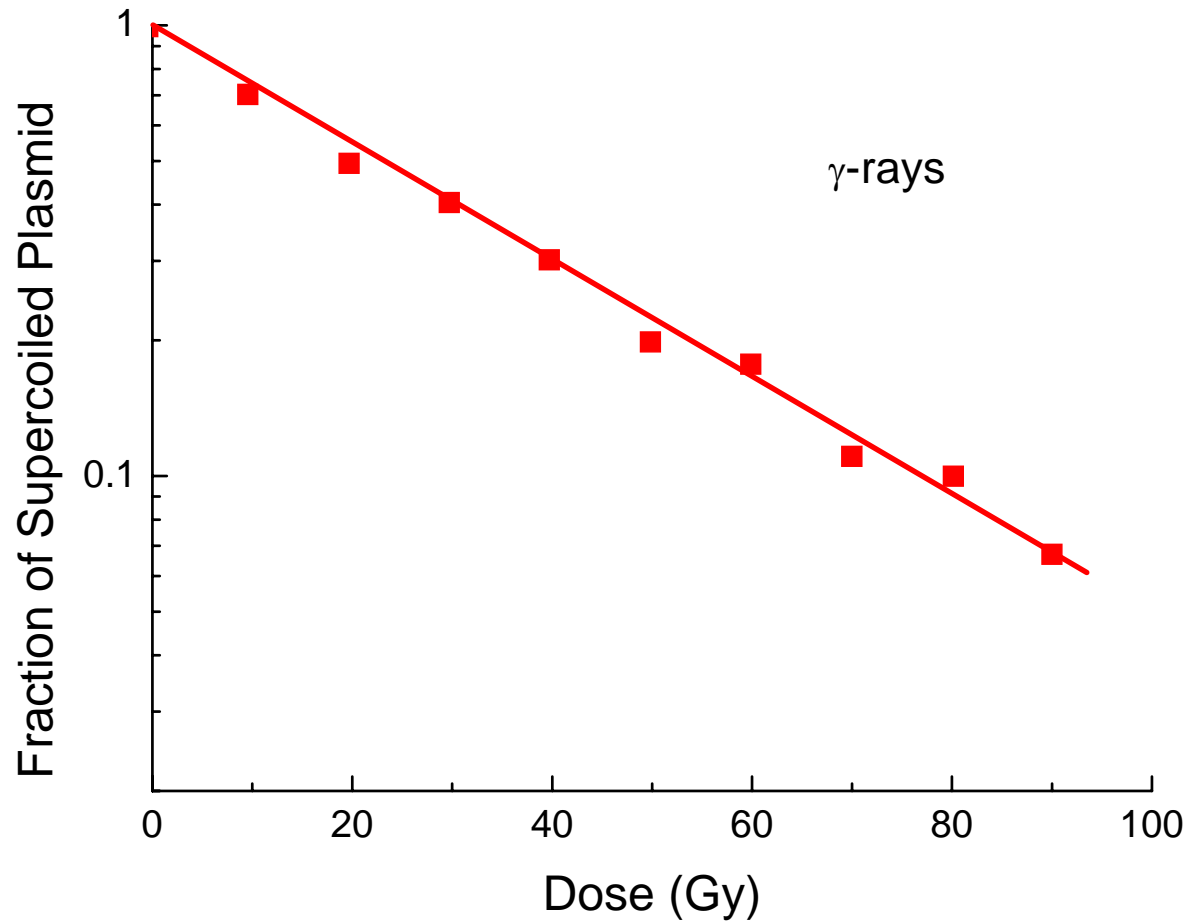
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DNA amount is proportional to volume.

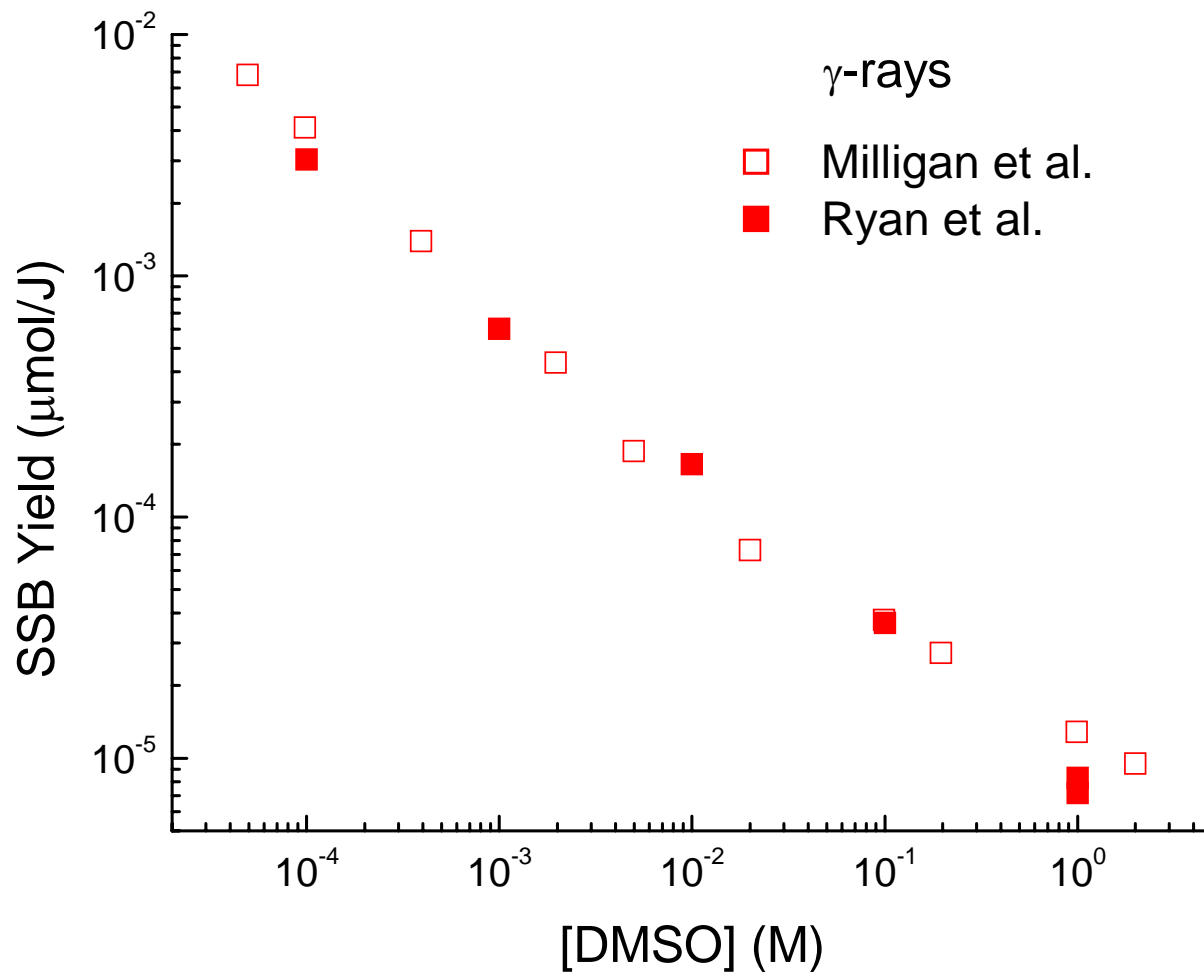
# Survival Plot

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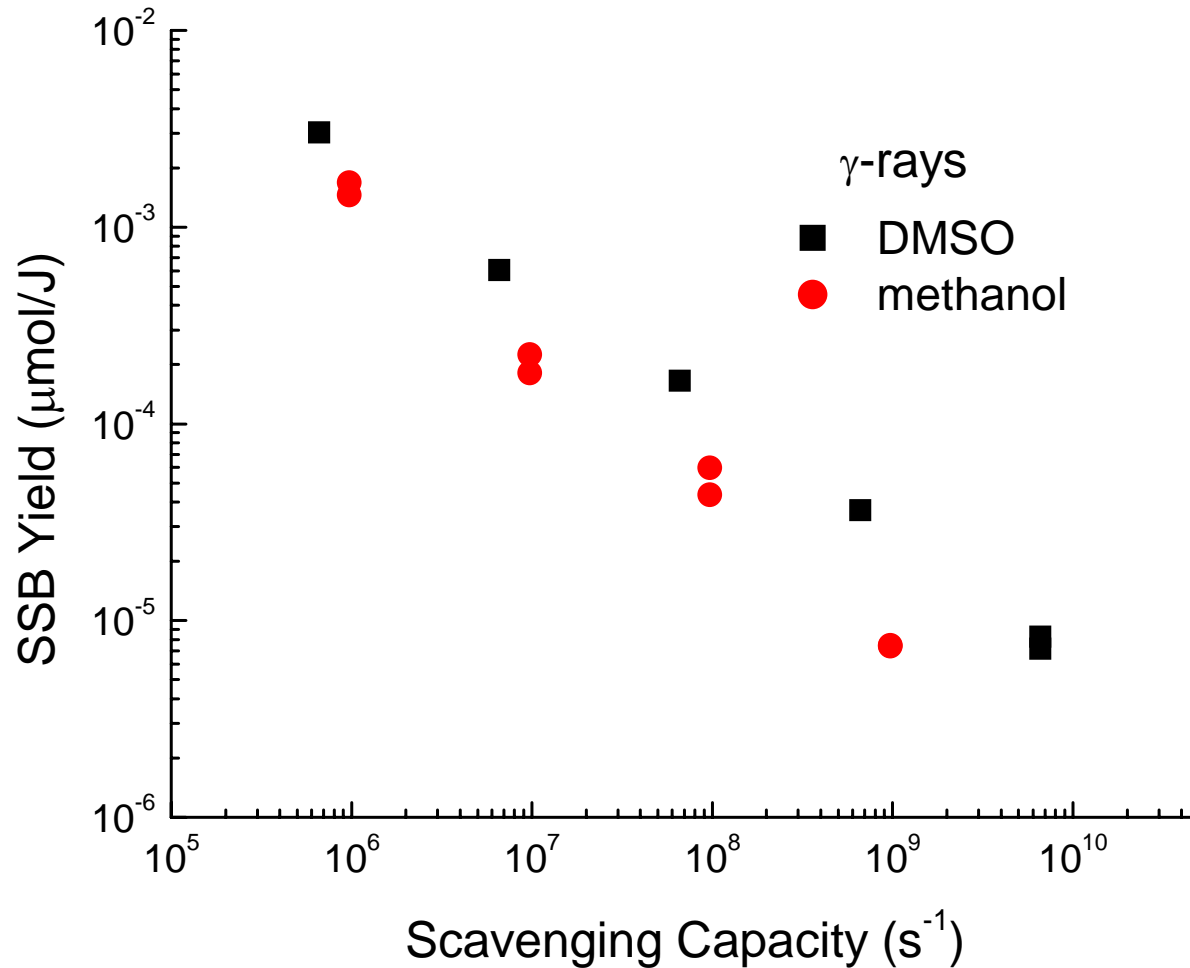


Radiation sensitivity / yield is proportional to slope.

# Scavenger Concentration Dependence



# Scavenger Concentration Dependence

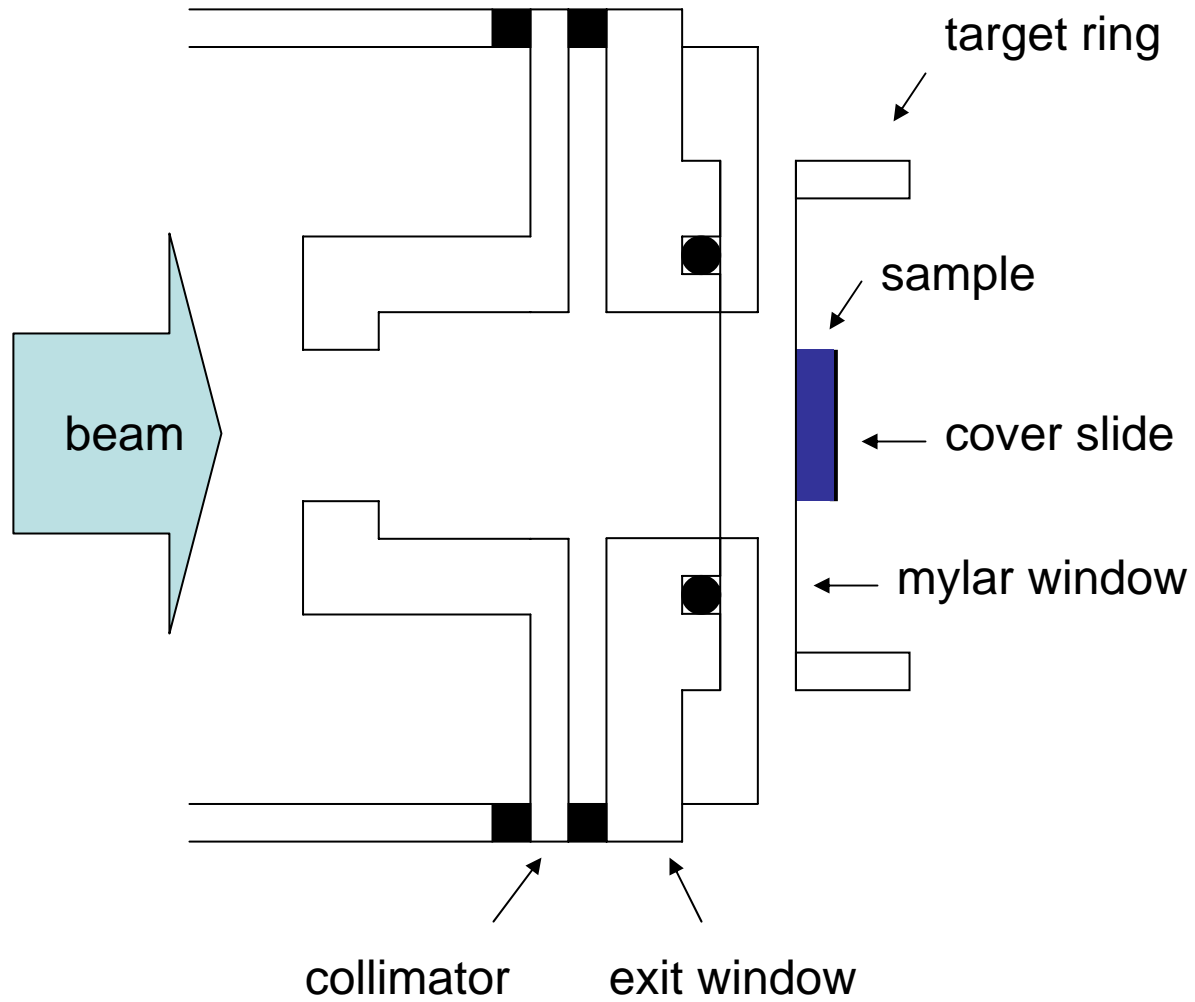


# Target Ring

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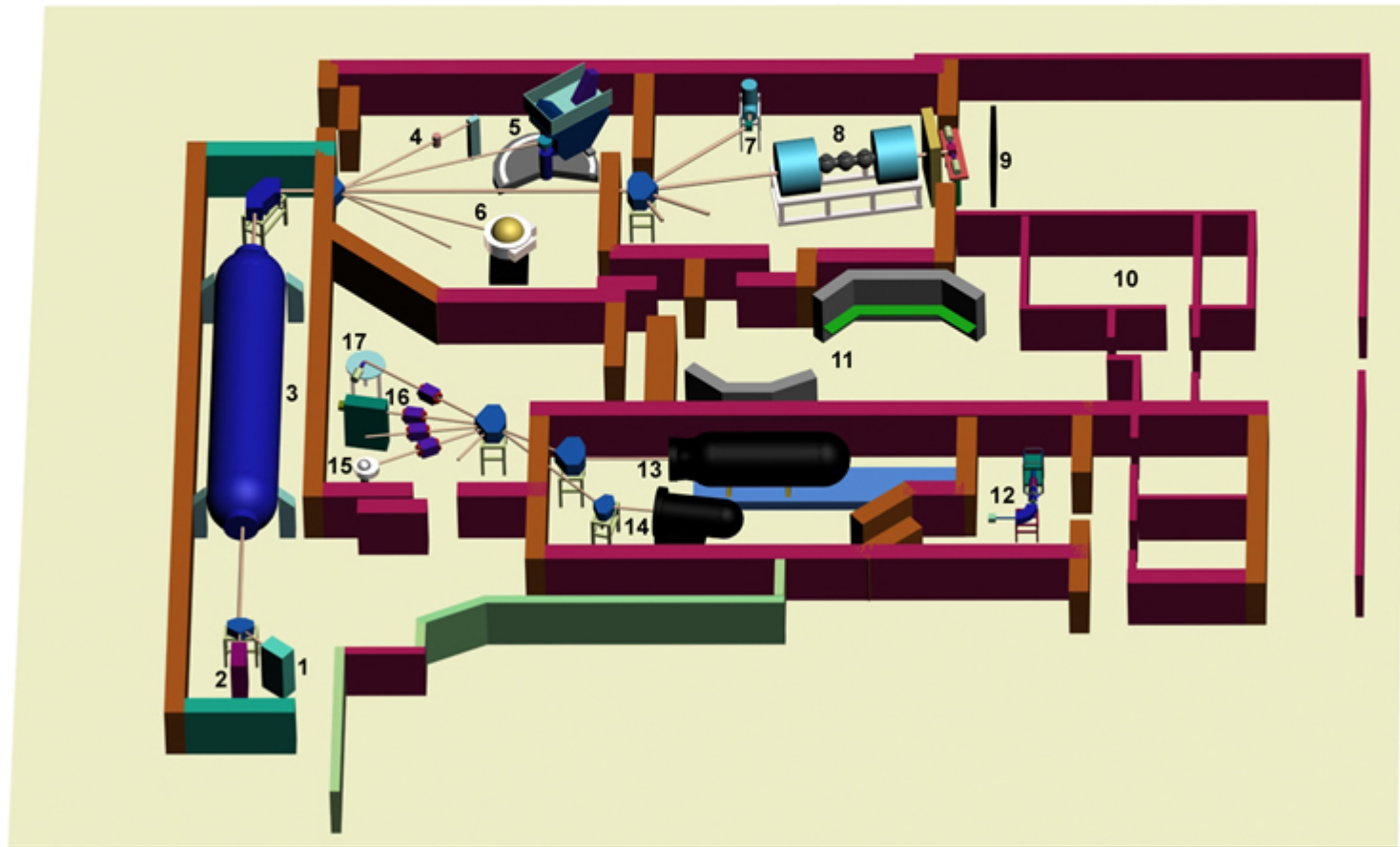


# Window Assembly



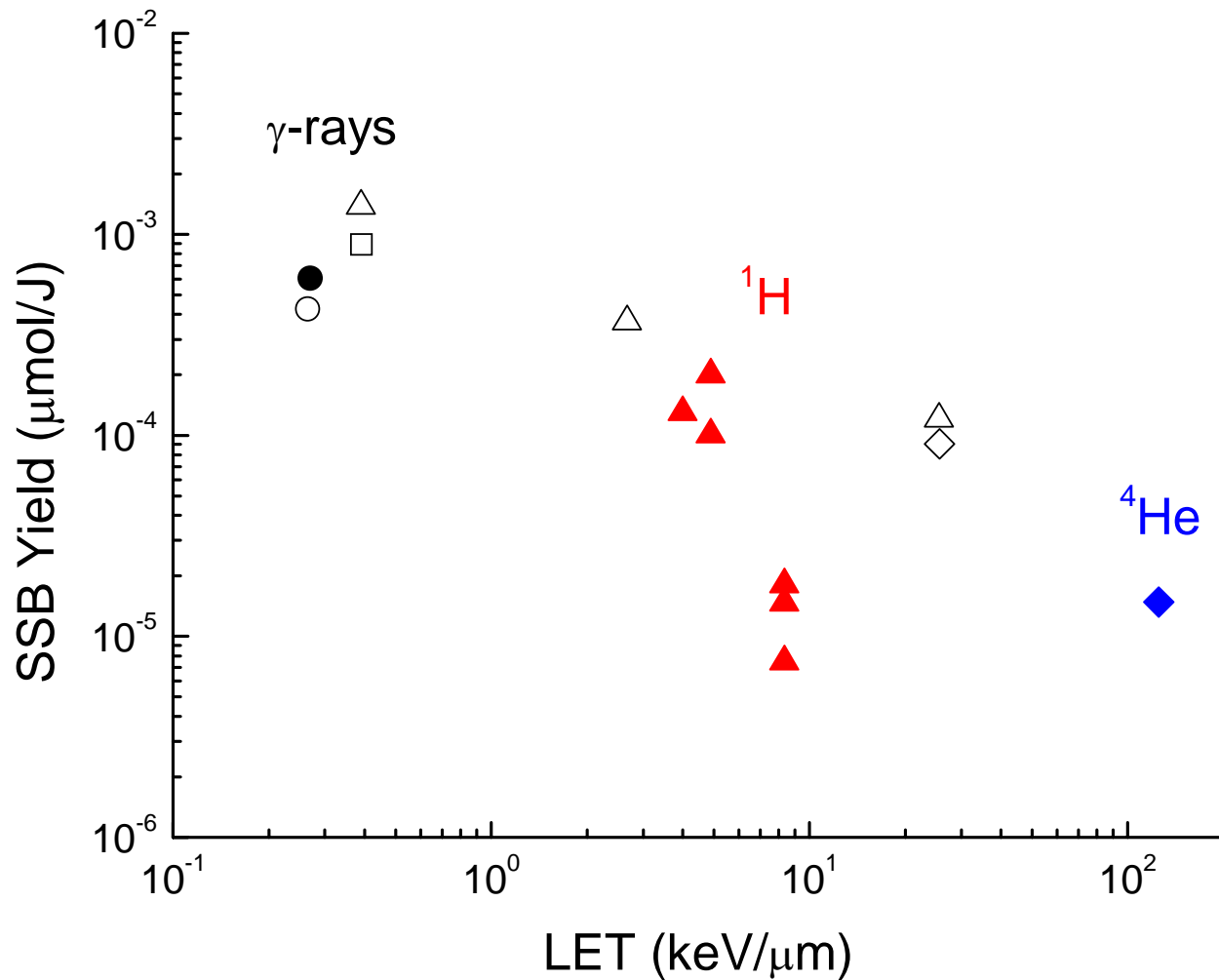
# Notre Dame Nuclear Structure Laboratory

1. SNICS Ion Source
2. HIS Ion Source
3. FN Van de Graaff Accelerator
4. Gamma Spectroscopy Beamline
5. Spectrograph Beam Line
6. R2D2 Beam Line (1 m scattering chamber)
7. Weak Interaction Beam Line
8. RNB Beam Line
9. Neutron Detection Wall
10. Conference Room
11. Accelerator Control Consoles
12. ECR Ion Source Test Setup
13. KN Van de Graaff Accelerator
14. JN Van de Graaff Accelerator
15. ORTEC Scattering Chamber
16. Windowless Gas Target Beam Line
17. Gamma Table





# SSB Yield Dependence on LET



Radiation effects depend on particle type and energy.

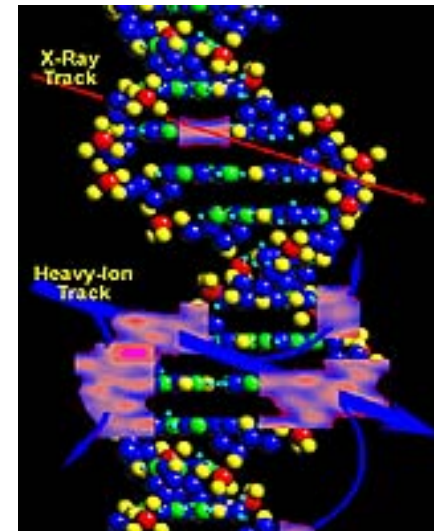
# Future Studies of Heavy Ions on DNA

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Probe relative strand breaks of DNA  
as a function of LET ( $-dE/dx$ )

Determine partition of damage due to  
direct and indirect effects

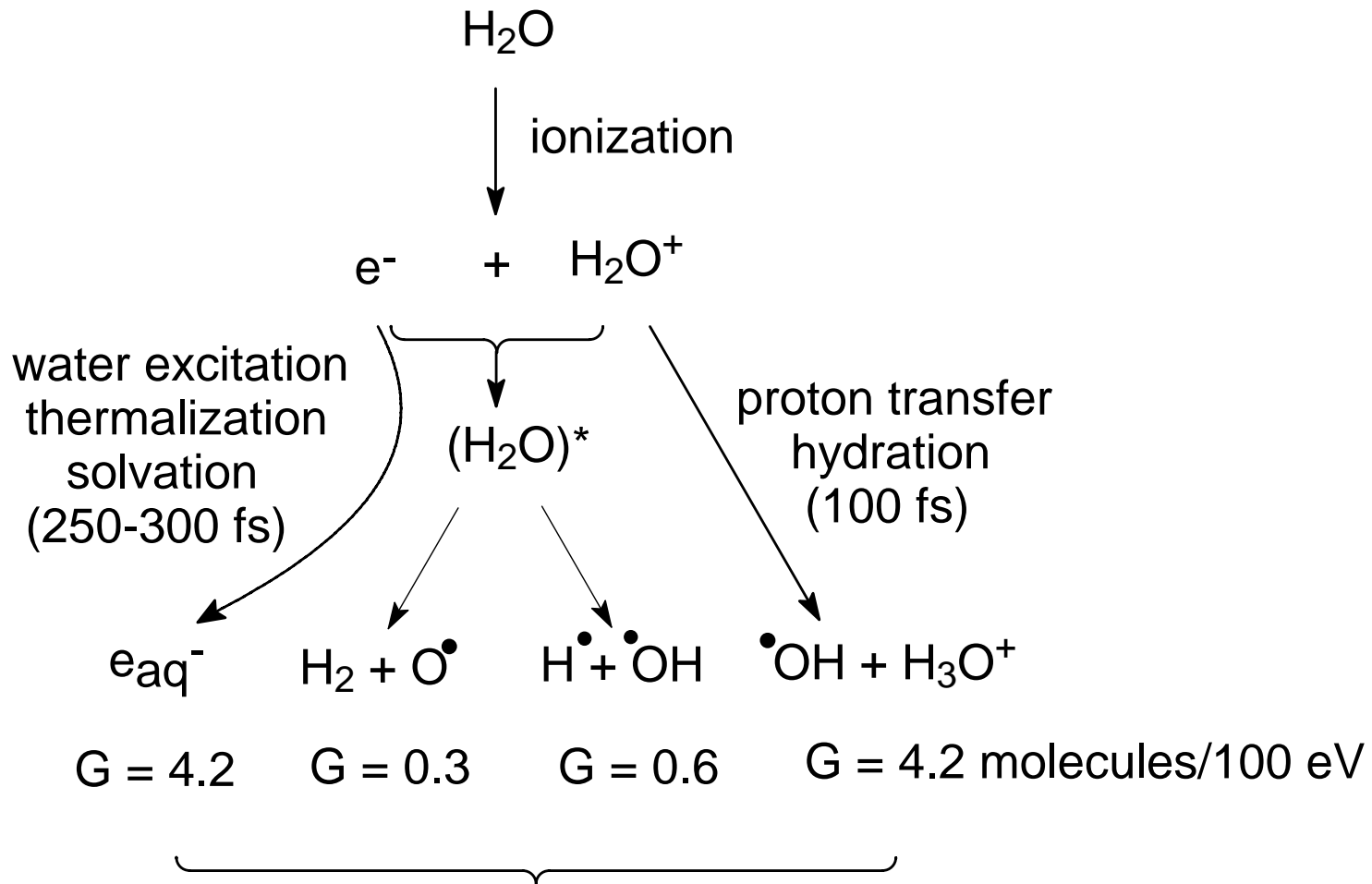
Examine specific damage to DNA and  
how it affects the cell



The End

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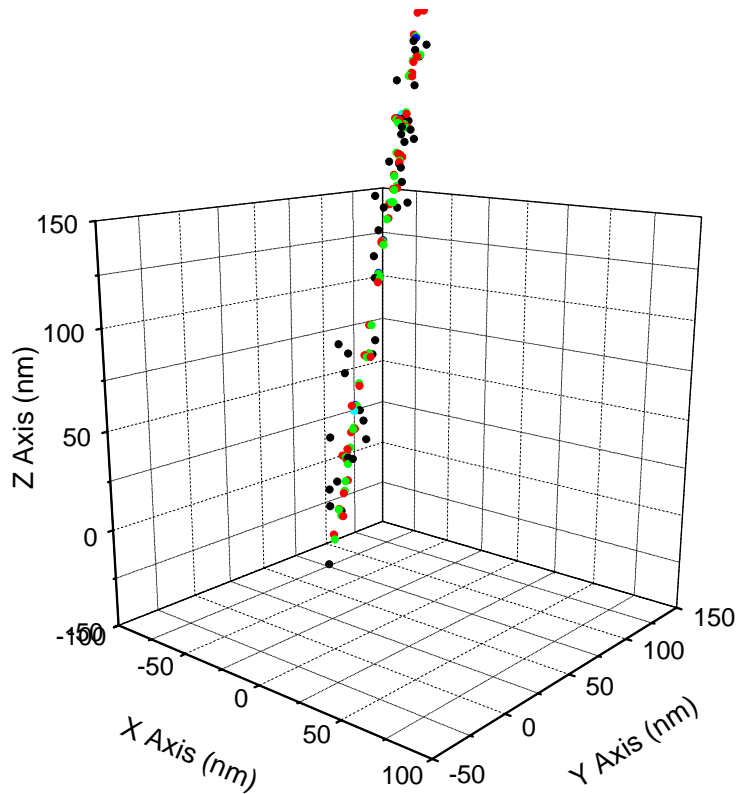
# Water Decomposition



radical reactions  
(0.1 ns - 1 μs)

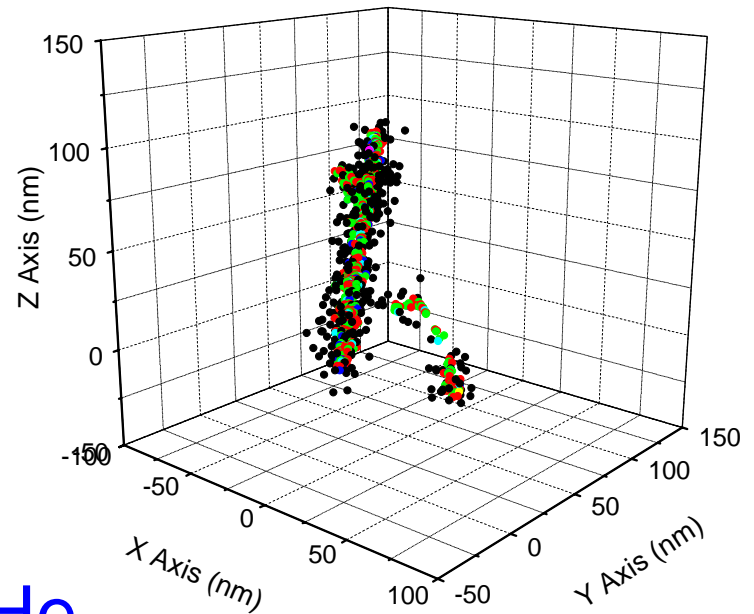
Radiation effects are  
generally over within  
a microsecond.

# Differences in 10 keV Track Segments at 1 ps



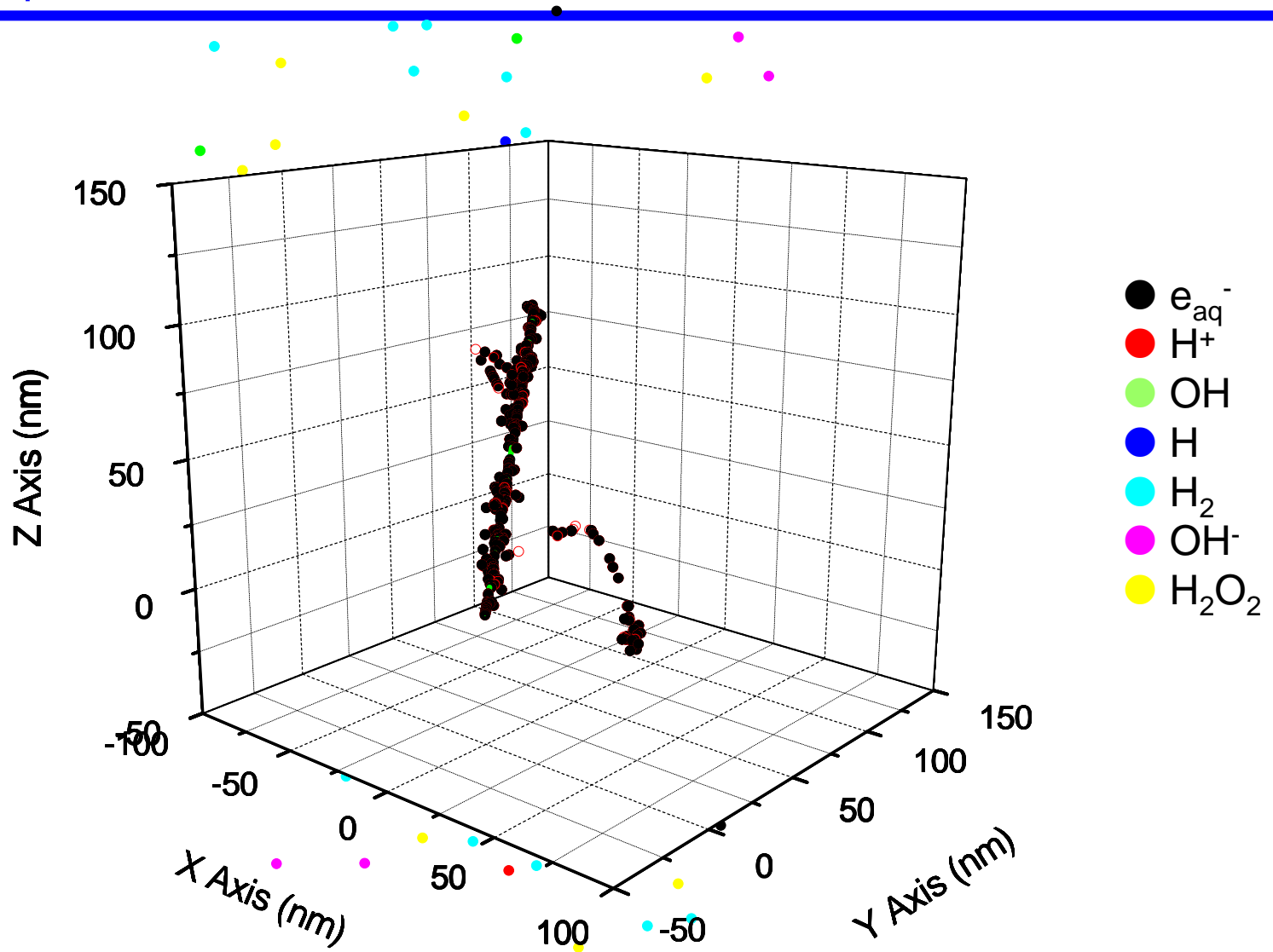
- Black :  $e_{\text{aq}}^-$
- Red :  $\text{H}_3\text{O}^+$
- Green :  $\text{OH}$
- Blue :  $\text{H}$
- Cyan :  $\text{H}_2$
- Magenta :  $\text{OH}^-$
- Yellow :  $\text{H}_2\text{O}_2$
- Dark yellow :  $\text{O}(^3\text{P})$

10 MeV  $^1\text{H}$



5 MeV  $^4\text{He}$

# Development of a 10 keV Section of a 5 MeV $^4\text{He}^{2+}$ Ion Track in Water



Development of a 10 keV section of a 5 MeV  $^4\text{He}^{2+}$  ion track in water