

**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

*Faire avancer la sûreté nucléaire*

# DNADamage1 example (Geant4.10.6Beta)

Hoang TRAN

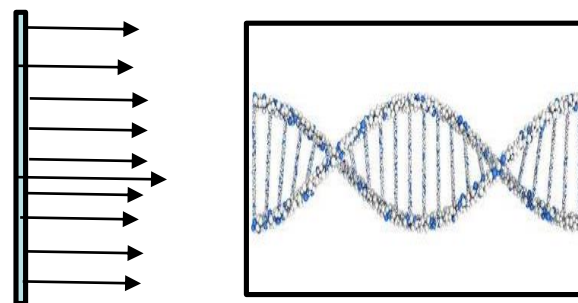
PSE-SANTE/SDOS/LDRI

EM meeting (12 July 2019)

# Context

- To improve the understanding of the mechanisms involved in the generation of early DNA damage (double strand break and single strand break)
- Simulation of the physical, physicochemical and chemical stages of early radiation damage in GEANT4-DNA

</extended/medical/dna/dnadamage1>

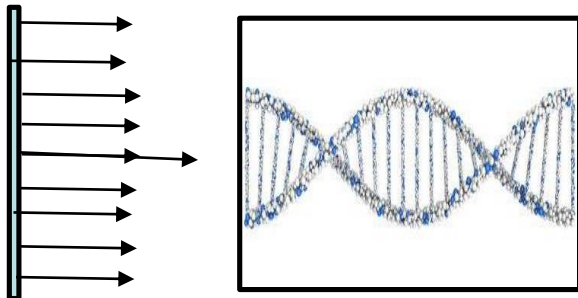


# DNA-radiation damage application

- A chain of simulations: physical stage + chemical stage + DNA damage recording

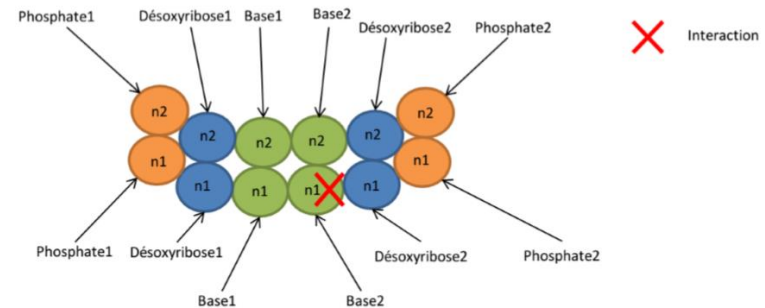
## Physical stage:

- The position and volume of each constituent “or DNA Element” within the nucleotide pair was calculated from PDB file data.
- 17.5 eV threshold for the energy deposited in the backbone of a nucleotide to determine an SSB direct.



Voxel «Straight» around 24.000 nucleotides

DNA Geometry from DNAFabric software (IRSN)



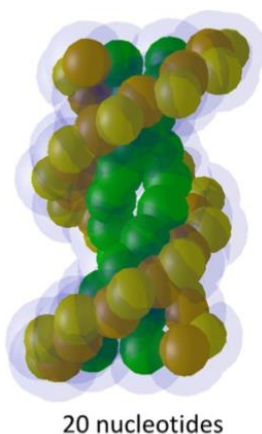
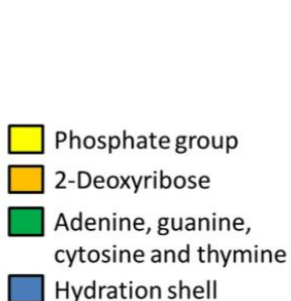
Using a big input file of DNA geometry (Thanks to Gunter this file can be downloaded by Cmake)

# A chain of simulations

## Chemistry and DNA damage

- The idea is to consider the DNA model not as a group of Geant4 physical volumes but as a set of spatially ordered molecules that should not diffuse over time
- A chemical stage duration is limited by 2.5 ns.
- 40% of the chemical reactions between  $\text{OH}\cdot$  and a sugar (2-deoxyribose and phosphate) give rise to an SSB indirect.

Physical volumes



Molecule

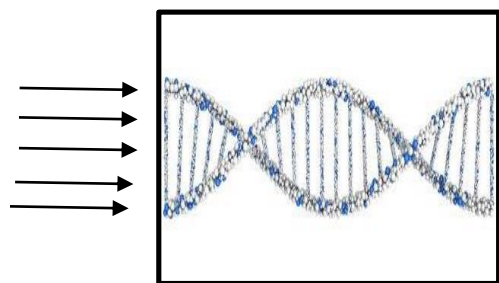


Reaction	Reaction rate ( $10^9 M^{-1} \cdot s^{-1}$ )
2-deoxyribose + $\text{OH}\cdot$	2.5
Adenine + $\text{OH}\cdot$	6.10
Guanine + $\text{OH}\cdot$	9.20
Thymine + $\text{OH}\cdot$	6.40
Cytosine + $\text{OH}\cdot$	6.10
Histone + molecule $\rightarrow$ histone <sub>modified</sub>	—

S. Meylan et al., Sc. Rep. 7 (2017)

# « parallel navigator » for chemistry

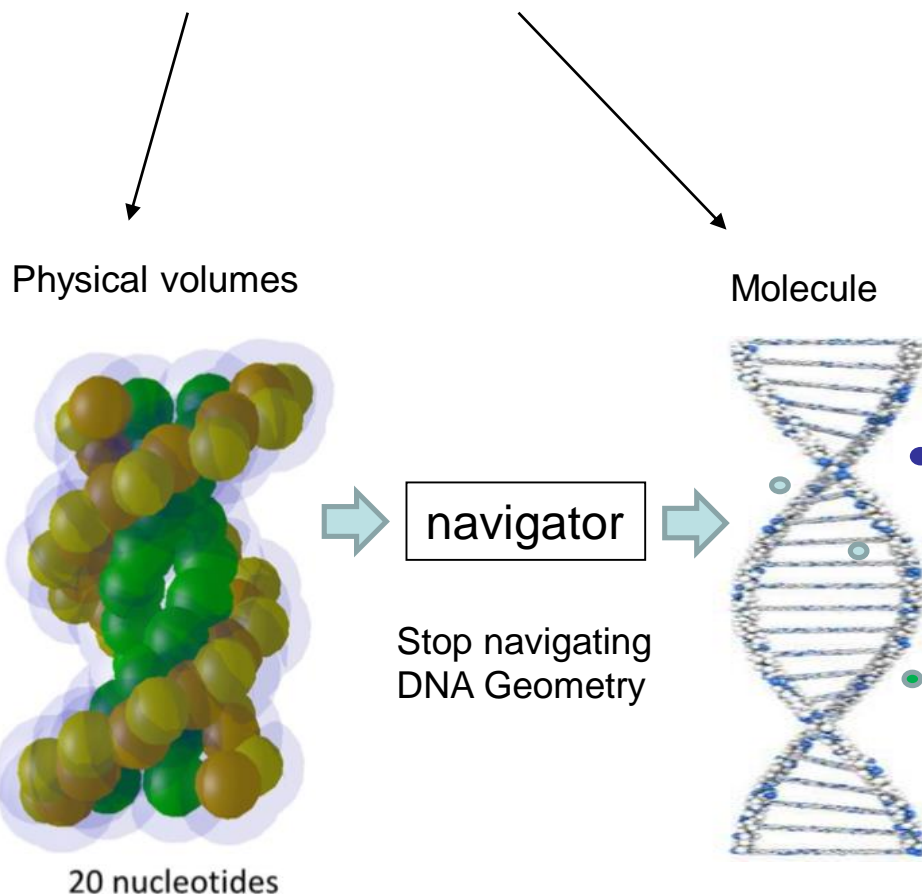
■ In the chain of simulations : physics + chemistry



Voxel «Straight»

Avantage:

- Reduce time consuming for navigator of chemical molecule in the physical DNA molecule



# Analyse SSB damage in ROOT

- Using the Standard DNA Damage data format (Shuemann et al. 2019 Rad. Res. (191) 76-92)

## To improve for the next release

- Correcte «divised by zero» of chemical transportation
- Optimize DNA molecules by separating DNA elements and chemical molecules
- Provide new chemistry models