# News from the Low Energy Electromagnetic package

**Sébastien Incerti**
on behalf of the Low Energy EM working group

**September 3rd, 2008**
**LAPP, Annecy**

# Overview

# The Geant4 collaboration

SPOKESPERSON : JOHN APOSTOLAKIS (CERN)

STEERING BOARD (SB)

14 WG

- Standard EM physics
- Low Energy EM physics (S. Incerti)
- Hadronic physics
- Materials and generic processes
- Geometry and transport
- Particles and track
- Persistency
- Run, Event, Detector response
- User and category interface
- Advanced examples (P. Cirrone, S. Incerti)
- Testing and quality assurance
- Software management
- Visualization
- Documentation

OVERSIGHT BOARD (OB)

(IN2P3 : DSA Etienne Augé)

CERN, ESA, FNAL, INFN, IN2P3, KEK, LIP, TRIUMF, LPI, STFC, HIP, SLAC
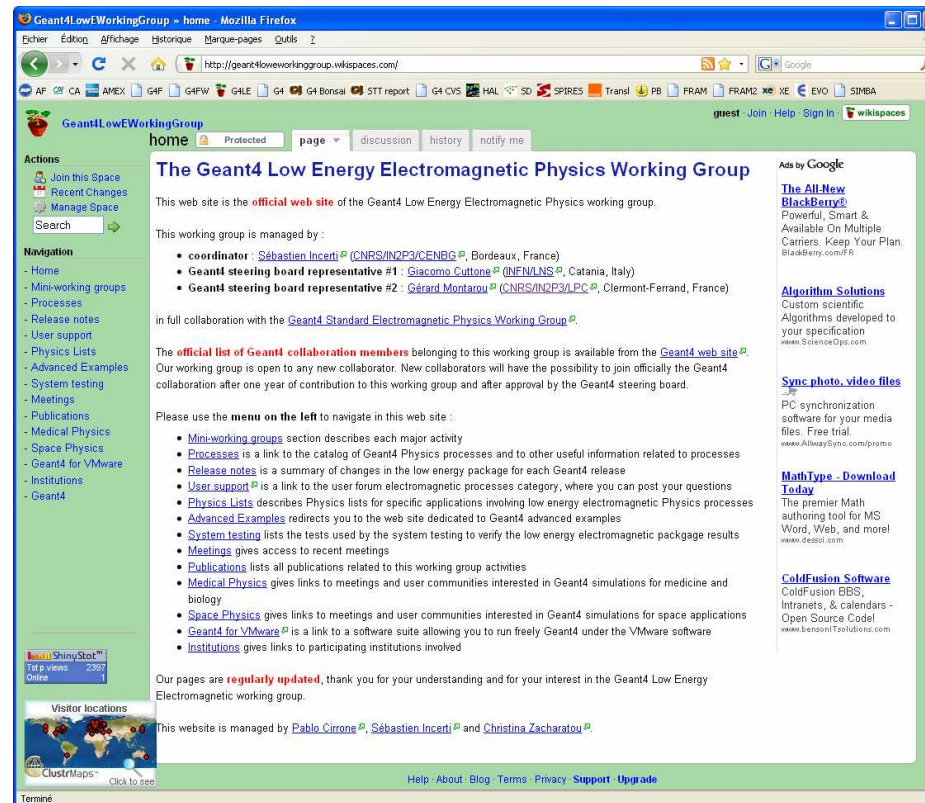
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# New organization of the Low Energy EM WG

- **Coordinator** : S. Incerti (IN2P3/CENBG)

- **SB representatives** : G. Cuttone (INFN/LNS), G. Montarou (IN2P3/LPCC),

- **19 Members today (they are already members of the Geant4 collaboration)**

  - **Haifa Ben Albelwahed** (CNSTN, Tunisia)
  - **Stephane Chauvie** (INFN, Torino U., Italy)
  - **Pablo Cirrone** (INFN/LNS, Italy)
  - **Giacomo Cuttone** (INFN/LNS, Italy)
  - **Gerardo De Paola** (FAMAF, Argentina)
  - **Francesco Di Rosa** (INFN/LNS, Italy)
  - **Ziad Francis** (CNRS/IN2P3/IPHC, France)
  - **Susanna Guatelli** (ANSTO, Australia)
  - **Alexander Howard** (CERN, Switzerland)
  - **Sebastien Incerti** (CNRS/IN2P3/CENBG, France)
  - **Anton Lechner** (CERN, Switzerland)
  - **Francesco Longo** (INFN/Trieste, Italy)
  - **Alfonso Mantero** (INFN/Genova, Italy)
  - **Barbara Mascialino** (Karolinska Institute, Sweden)
  - **Gerard Montarou** (CNRS/IN2P3/LPC Clermont, France)
  - **Jakub Moscicki** (CERN, Switzerland)
  - **Luciano Pandola** (INFN/LNGS, GNO, Italy)
  - **Giorgio Russo** (INFN/LNS, Italy)
  - **Giovanni Santin** (ESA/ESTEC, The Netherlands)
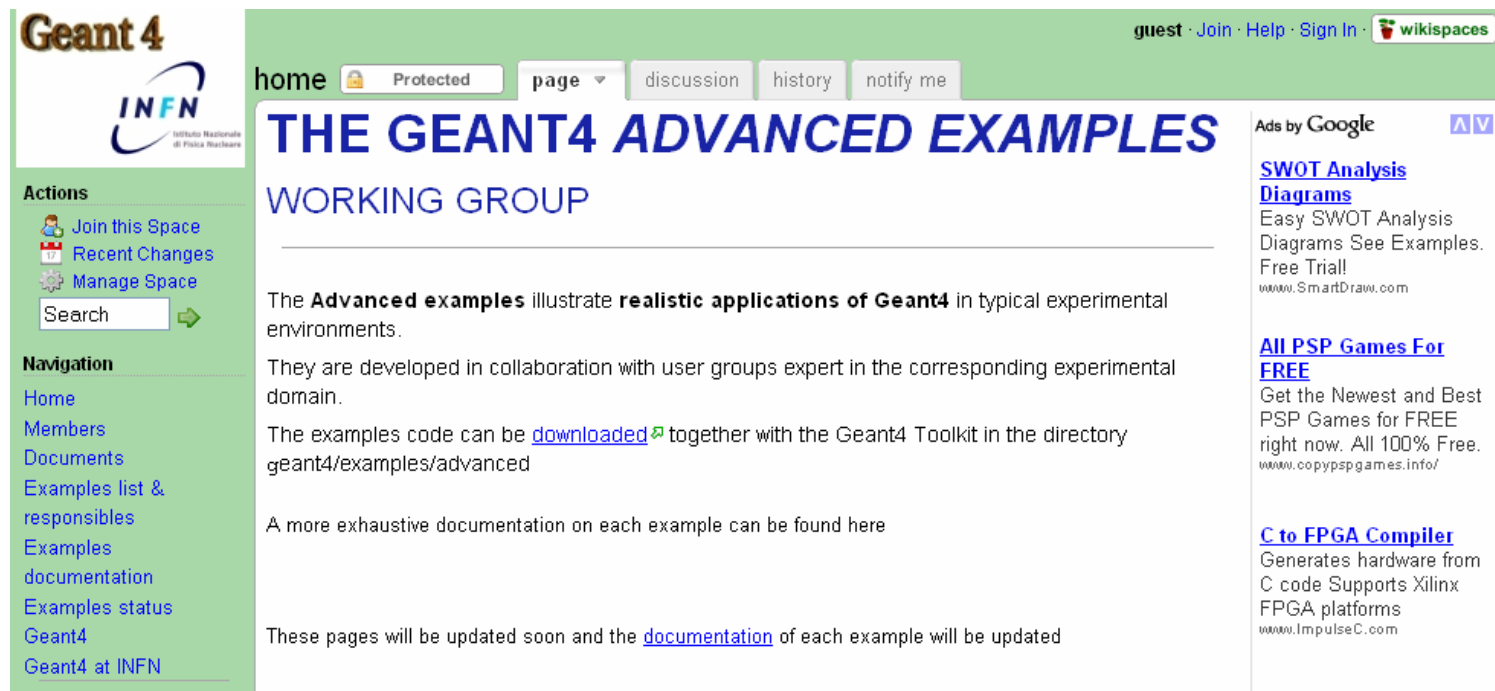
**We are open to any Geant4 collaboration member !**

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# Web site

- access from Geant4 web site : http://cern.ch/geant4
- http://geant4loweworkinggroup.wikispaces.com/

Official web page of
the working group !

# Advanced Examples

- [http://geant4advancedexampleswg.wikispaces.com/](http://geant4advancedexampleswg.wikispaces.com/)
- Most of them use the Low Energy EM package

# 5 mini Working Groups

- **mWG #1** : software design & migration, managed by Alfonso Mantero (INFN)

- **mWG #2** : debugging & testing of existing code, managed by Pablo Cirrone (INFN)

- **mWG #3** : validation, managed by Giacomo Cuttone (INFN)

- **mWG #4** : new interaction models, managed by Sebastien Incerti (IN2P3)

- **mWG #5** : Penelope interface, managed by Luciano Pandola (INFN)

- These mini Working Groups include **consultants** with expertise in specific areas, **who are not members of the Geant4 collaboration**

# mWG#1:
# software design & migration

- **1.1**
  Implementation of new PIXE process cross sections for protons and alphas
  Alfonso, Haifa

- **1.2**
  Implementation of new PIXE process final states for protons and alphas
  Alfonso, Haifa

- **1.3**
  Management of code migration
  (from LE EM to standard EM)
  Alfonso, Pablo (testing), Sébastien, Standard EM

- This mini-Working Group is managed by **Alfonso Mantero**

# mWG#2:
# debugging and testing of existing code

- **2.1**
  Collect and address issues from user forum
  All

- **2.2**
  Investigate differences between Low Energy and Standard package and try to investigate where Low Energy can have advantage
  Susanna ?

- **2.3**
  Make sure that processes behave consistently between Low Energy EM and Standard EM
  (technical forum issue #309)
  Giacomo, Pablo

- **2.4**
  Check all LE tests are working
  (test 14, 17, 20, 50, 52)
  Sebastien

- **2.5**
  Add missing processes in tests (proton range, Bragg peak…)
  Sebastien

- **2.6**
  Write tests common with Standard EM package (like TestEM1), in collaboration with 1.3
  Pablo

- **PRIORITY : 2.7**
  Investigate existing bugs
  (proton range for ex.)
  Alfonso, Pablo (testing), Sebastien, Standard EM

- This mini-Working Group is managed by **Pablo Cirrone**

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# mWG#3: validation

- **3.1**
Implement testing suite & procedure for validation
Barbara

- **3.2**
Implement key Physics Lists for users in specific applications
(technical forum issue #1503)
Christina, Giacomo, Giovanni, Harald, Lydia, Pablo, Sebastien, Vladimir

- **3.3**
Validation of multiple scattering models : comparison of Geant4 dose distributions in water against EGSnrc
and measured distributions for photon beams, comparison of CPU performance and accuracy
Christina, Harald, Lydia, Standard EM, Tony, Yan

- **3.4**
Validation for therapeutic irradiation with Catania group : Proton and ion therapy, Proton Computed
Tomography, Light nuclei fragmentation on different targets
Christina, Giacomo, Pablo

- **3.5**
Collaboration with GDR MI2B
Gérard

- **3.6**
Auger and X-ray emission probabilities validation
Alfonso

- This mini-Working Group is managed by **Giacomo Cuttone**.

# mWG#4: new processes

- **4.1**
  New Physics processes
  Anton, Christina, Christophe, Elizabeth, Lydia, Sébastien

- **4.2**
  New Chemistry processes
  Alfonso, Christina, Christophe, Djamel, Gérard, Sébastien

- **4.3**
  New geometries
  Christina, Christophe, Djamel, Elizabeth, Gérard, Sébastien

- **4.4**
  New damage processes
  Christophe, David, Djamel, Elizabeth, Gérard, Sébastien

- **4.5**
  Documentation (web, UML, …)
  Sébastien

- **4.6**
  Publications
  All

- **4.7**
  Collaboration with GDR MI2B
  Gérard

- This mini-Working Group is managed by **Sébastien Incerti**.

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# mWG#5: Penelope

- **5.1**
  Organize meeting with F. Salvat
  Giacomo, Luciano

- **5.2**
  Interface implementation and complete rewriting of Penelope
  Luciano

- This mini-Working Group is managed by **Luciano Pandola**.

# Some recent activities

# Low Energy processes migration

- Migrate all low energy processes to Standard EM design (from G4VEmProcess, G4VEmModel classes)

- In full collaboration with Standard EM WG

- Will allow direct comparison between Standard EM processes and Low Energy EM processes
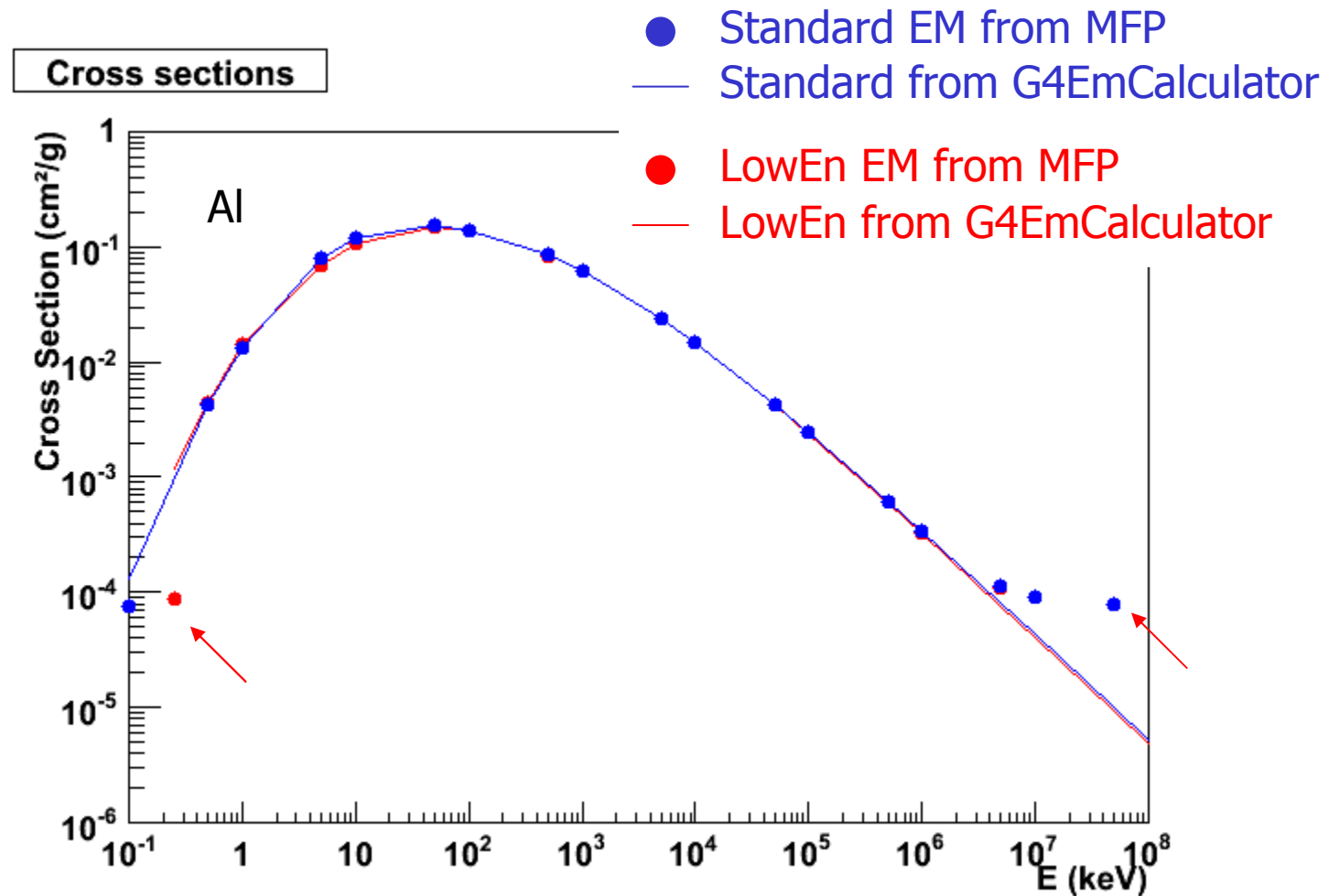
- Hopefully, easier debbugging of Low Energy processes…

# Ex : Compton scattering

Test suite built from
TestEm14

thanks to Michel
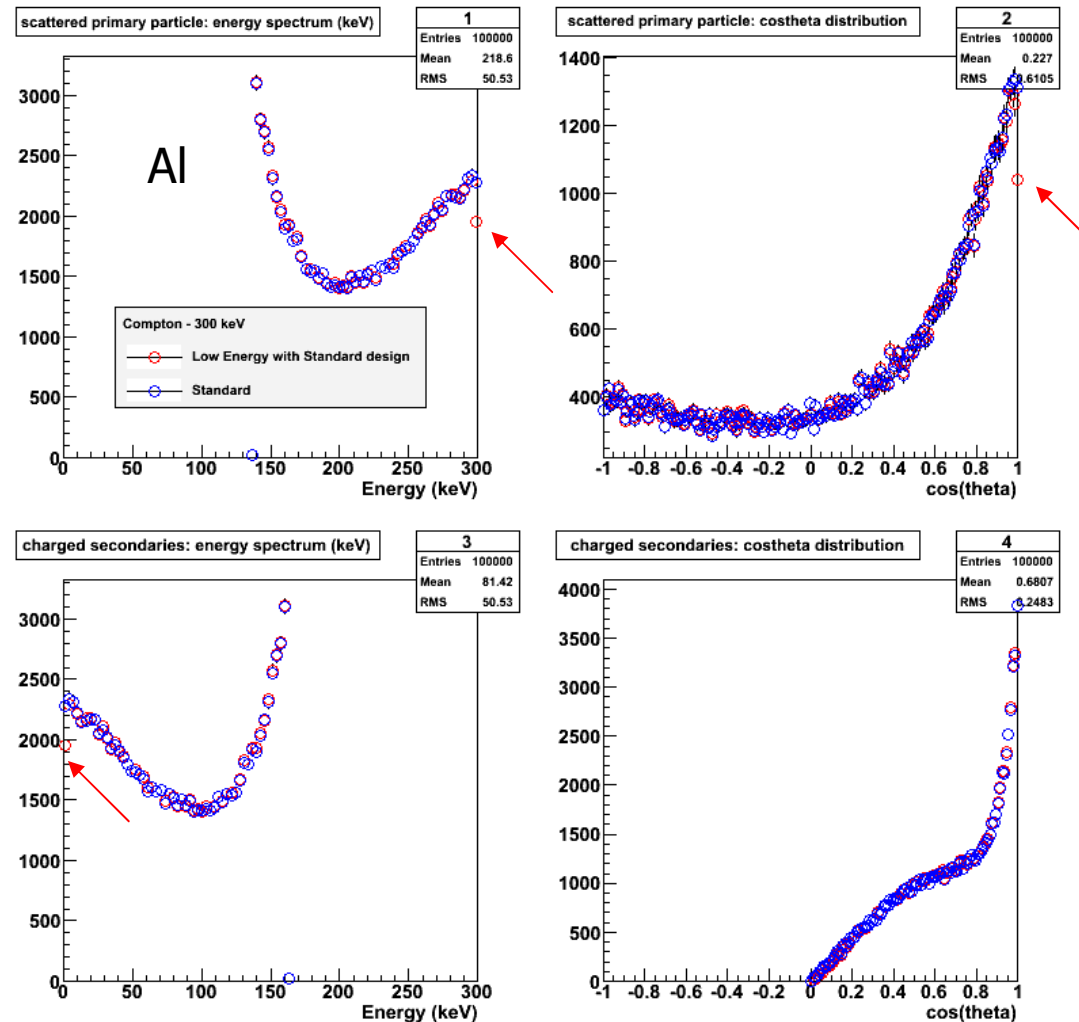
# Compton scattering : cross section computation

# Short term plans

- Each process will be converted and compared with Standard EM equivalent

- Much work

- <span style="color:red">If you are interested</span>, we will be happy to collaborate with you
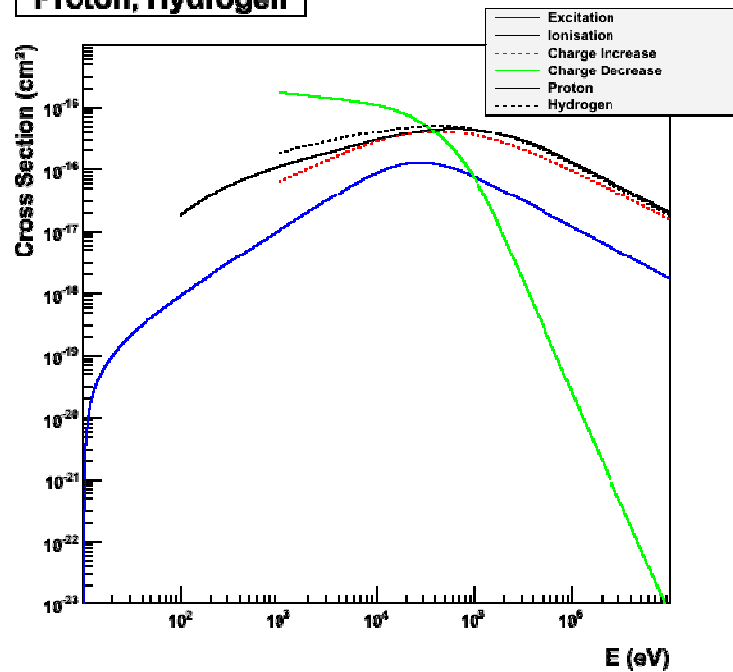
# Current Physics models in Geant4 DNA

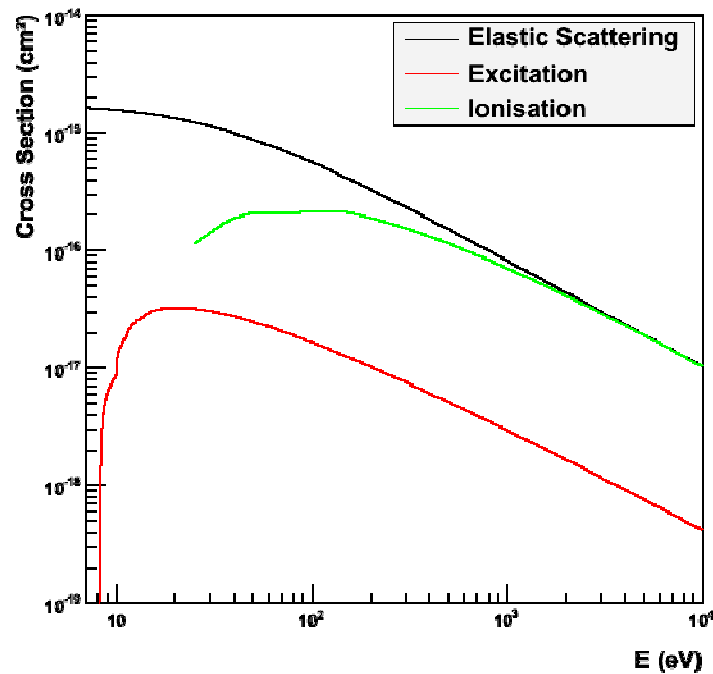**Analytical or interpolated from tables**

**Liquid water only**

**Down to the eV scale**

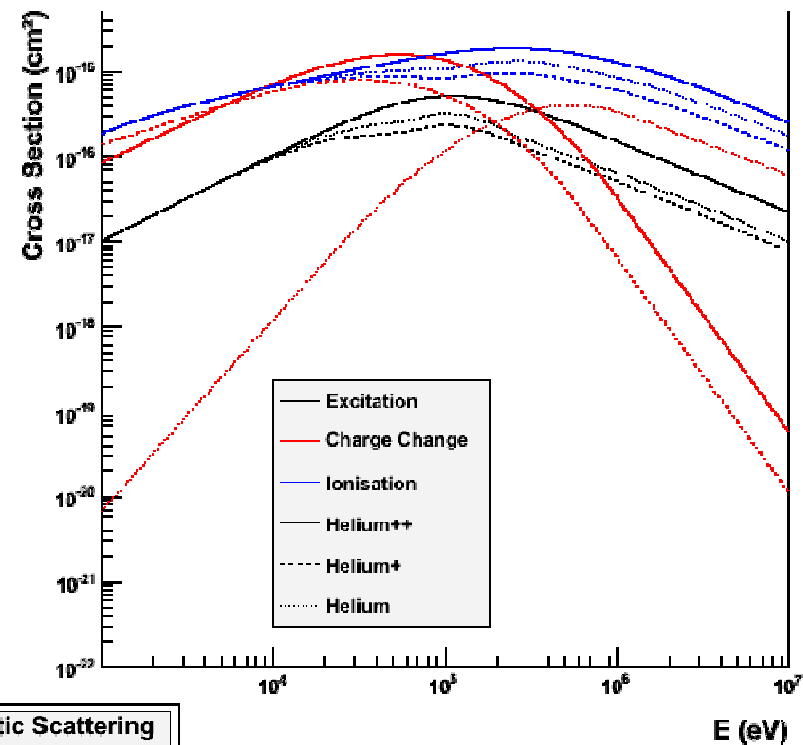| | e | p | H | $\alpha$, He+, He |
|---|---|---|---|---|
| **Elastic scattering** | > 7.5 eV<br>Screened Rutherford<br>**> 7.5 eV Champion** (T) | - | - | - |
| **Excitation**<br><br>$A_1B_1$, $B_1A_1$, Ryd A+B, Ryd C+D, diffuse bands | 7 eV – 10 keV<br>Emfietzoglou | 10 eV – 500 keV<br>Miller Green<br>500 keV – 10 MeV (T)<br>Born | - | Effective charge scaling from same models as for proton |
| **Charge Change** | - | 1 keV – 10 MeV (T)<br>Dingfelder | 1 keV – 10 MeV<br>Dingfelder | |
| **Ionisation**<br><br>$1b_1$, $3a_1$, $1b_2$, $2a_1 + 1a_1$ | 7 eV – 10 keV (T)<br>Born | 100 eV – 500 keV<br>Rudd<br>500 keV – 10 MeV (T)<br>Born | 100 eV – 100 MeV (T)<br>Rudd | (T) |

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**Proton, Hydrogen**

Cross Section (cm²) vs E (eV)

Legend: Excitation, Ionisation, Charge Increase, Charge Decrease, Proton, Hydrogen

**Helium++, Helium+ and Helium**

Cross Section (cm²) vs E (eV)

Legend: Excitation, Charge Change, Ionisation, Helium++, Helium+, Helium

**Electrons**

Cross Section (cm²) vs E (eV)

Legend: Elastic Scattering, Excitation, Ionisation

# Details of mWG#4

- **4.1- New Physics processes**
  - Complementary very low energy interaction models : ionisation, excitation, charge change, positronium (impact on imaging resolution in GATE)
  - Comparison of interpolation methods
  - Models for other targets than liquid water

- **4.2- New chemistry processes**
  - Definition of chemical species (molecules, oxydative species)
  - Implementation of water molecules follow up
  - Implementation of diffusion
  - Implementation of chemical reactions
  - Transition Physics / Chemistry

- **4.3- New geometries**
  - Implementation of DNA geometries in several conformations (voxellized and atomistic)
  - Interface PDB format - Geant4
  - Implementation of 3D cellular phantoms from confocal microscopy and ion beam analysis

- **4.4- New damage processes**
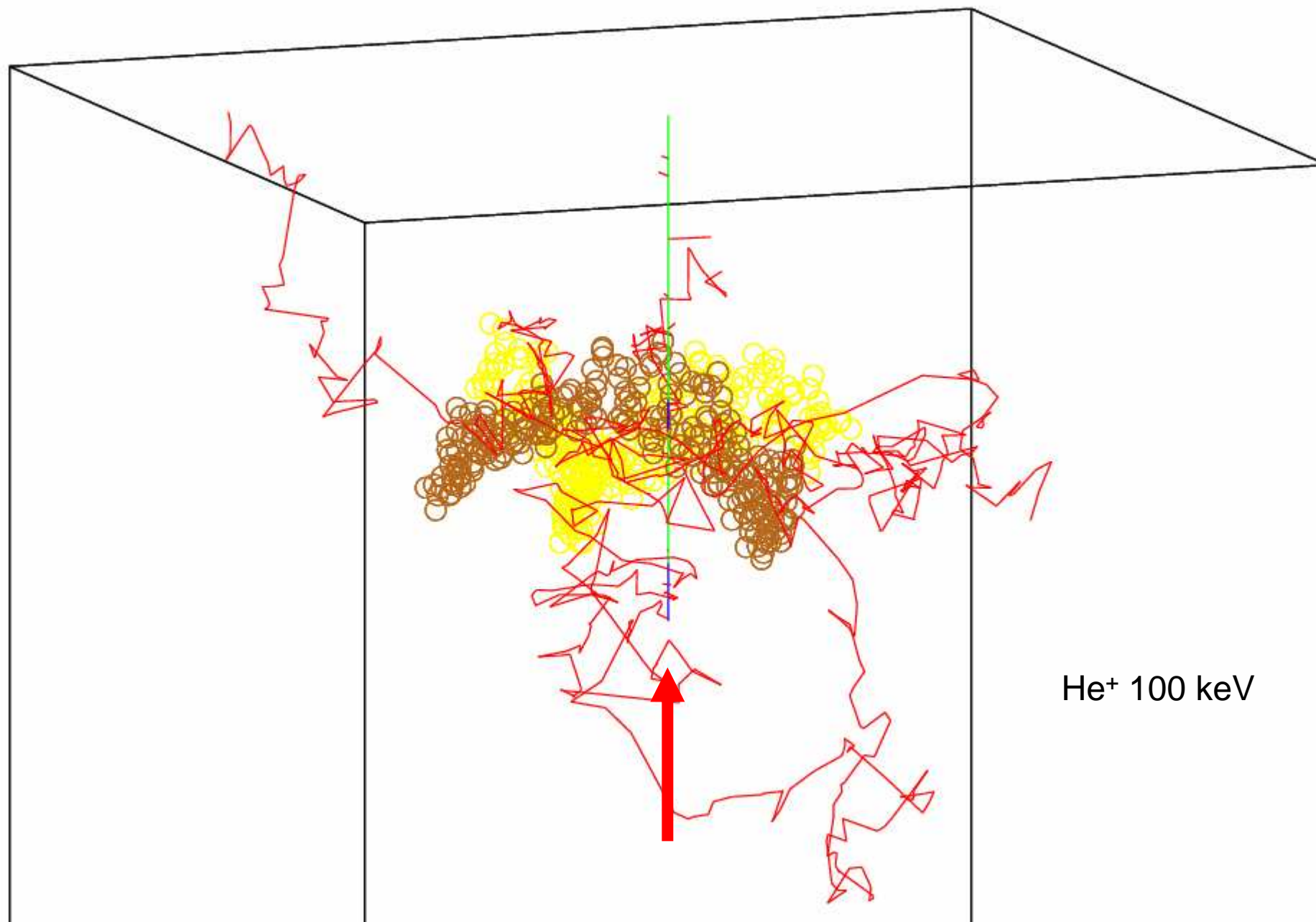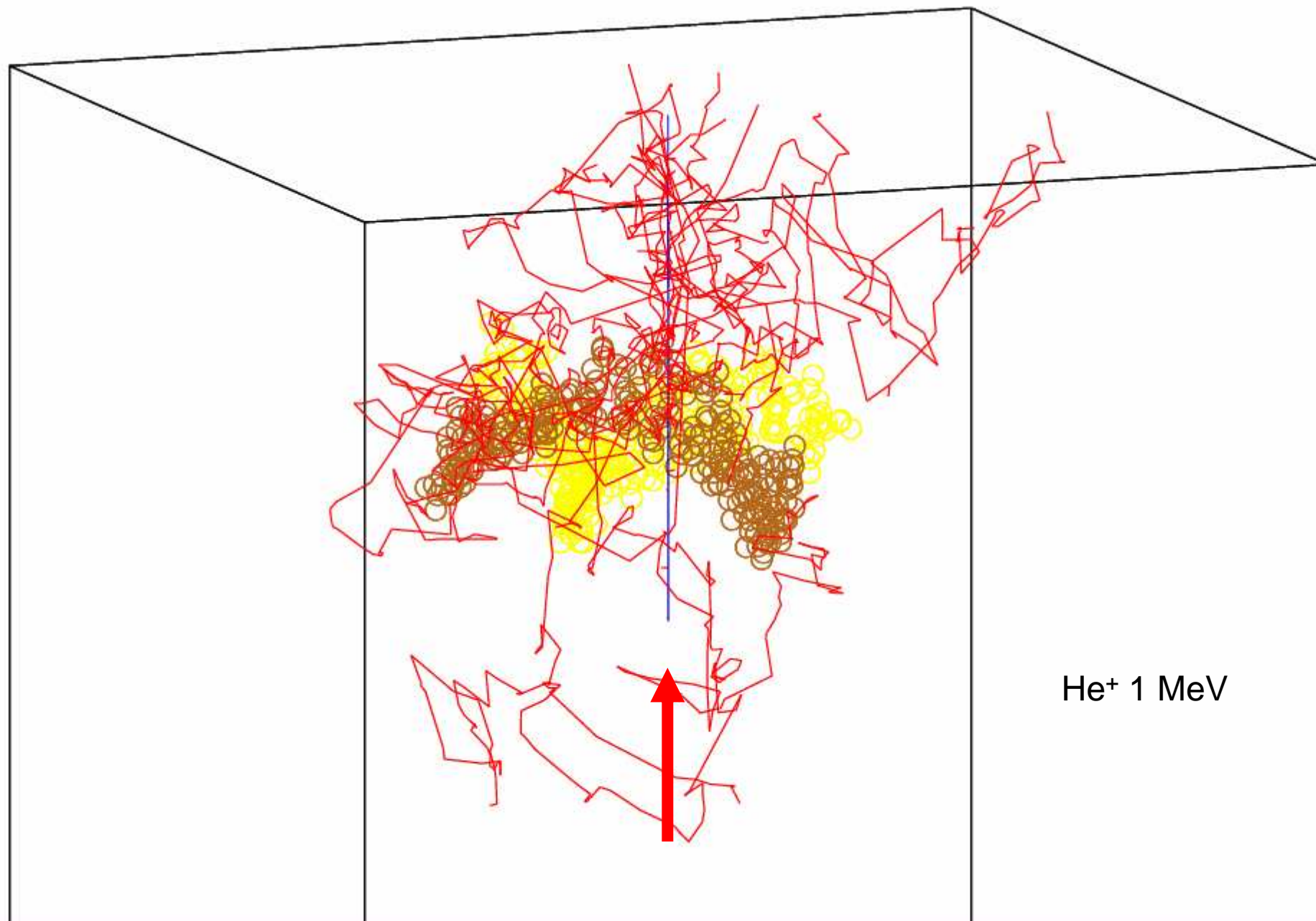  - track structure with 3D DNA model and chemical species tracks

# DNA in Geant4 DNA ?



most common DNA conformation in cells

**Protein Data Base**

PDB file ▶ Geant4

DNA helix
486 atoms

He+ 10 keV

He$^+$ 100 keV
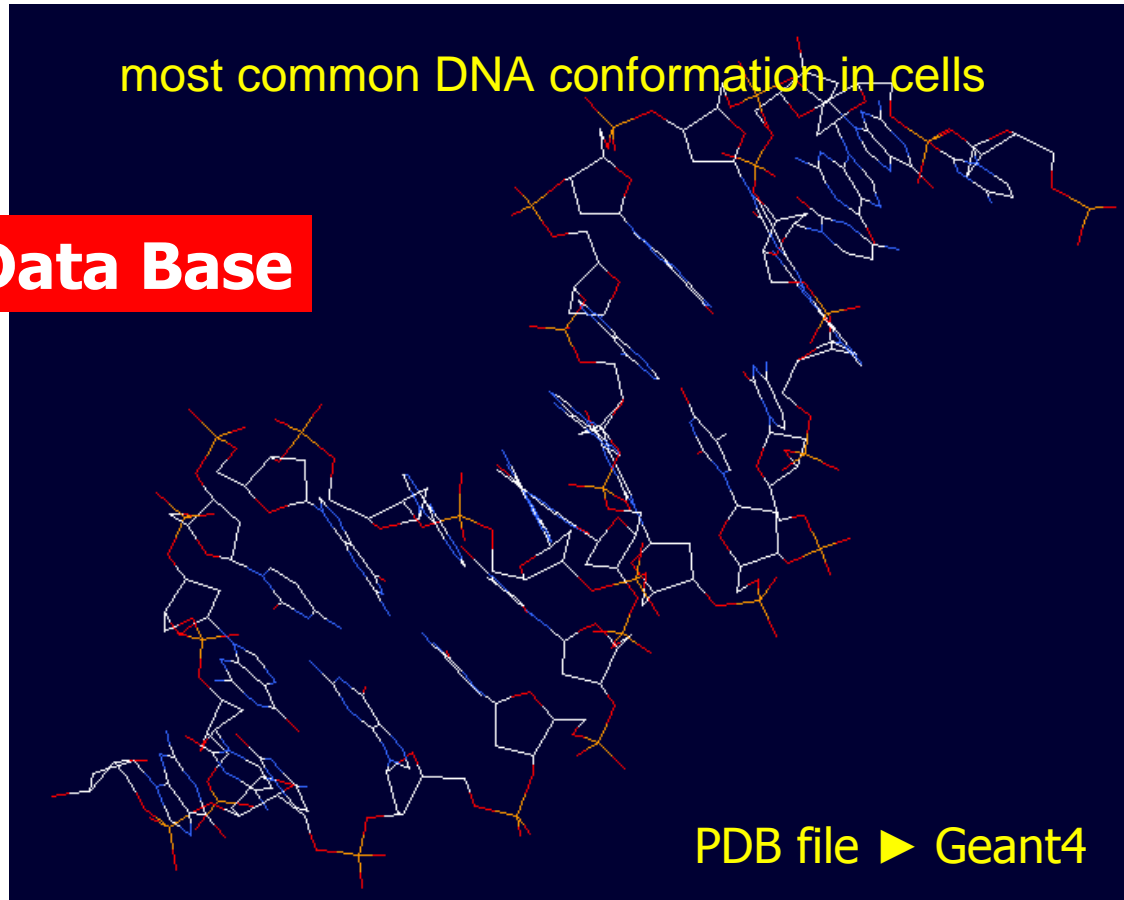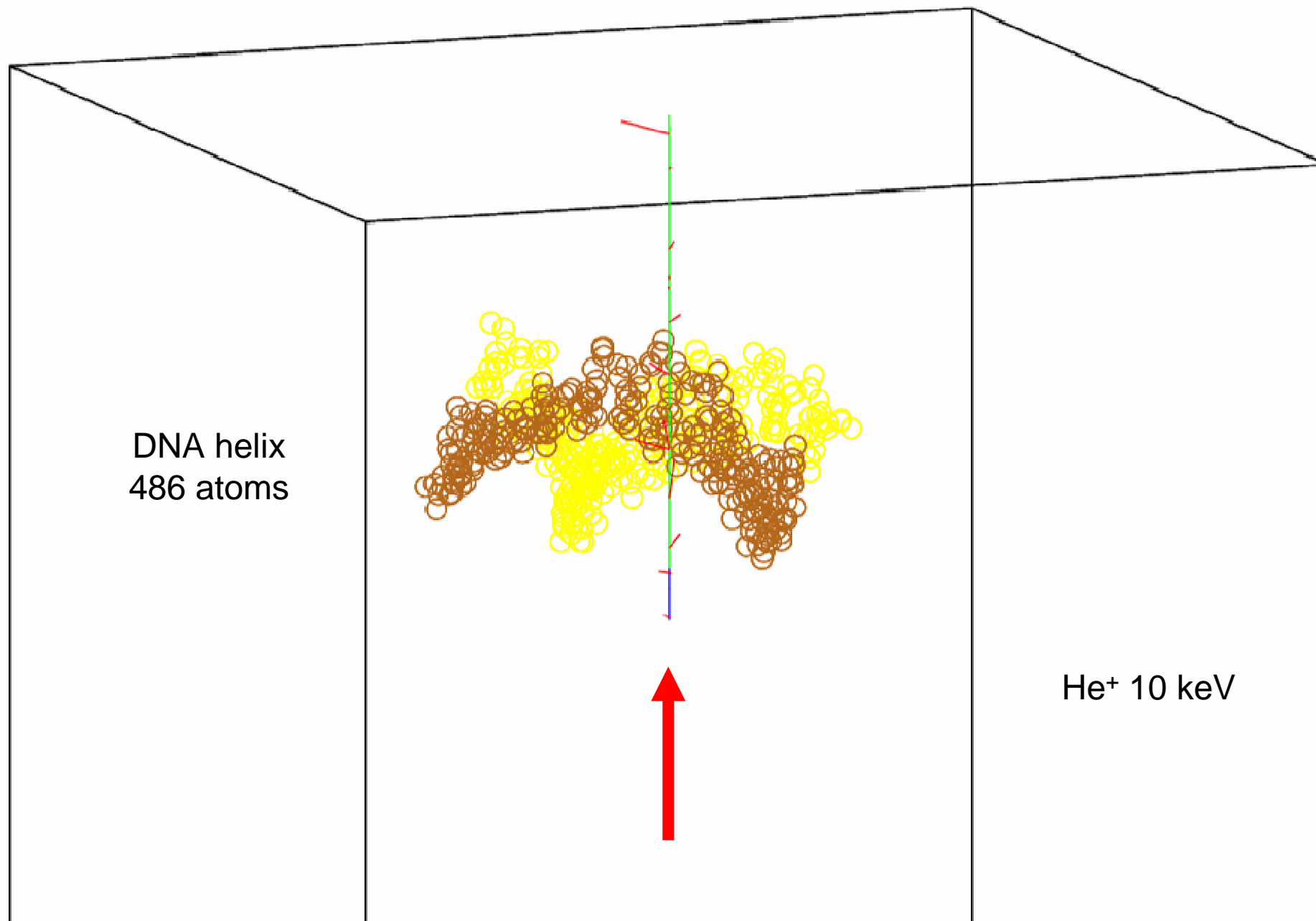
He$^+$ 1 MeV

# Perspectives 1

- Dedicated technical session on these new chemistry processes planned at the next Geant4 workshop

- More sophisticated geometrical models are in preparation (I will present results at Kobe workshop)

- DNA direct damage estimation in preparation (idem)

- Is anyone from FJPPL interested ?

# Perspectives 2

- New project 2009-2011

  **RESEARCH : Radiation Effects for Studies in Exobiology And exploRation of spaCe by Humans**

- Fully funded by Bordeaux Université and Aquitaine Région (100 kilo-euros)

- Has just started

- This project will be my priority for the next 3 years

- All Geant4 DNA developments will take place in the framework of this project

- Coordinator : S. Incerti

# Perspectives 3

- I wish to publish urgently a paper with Akinori and you in the framework of FJPPL on cellular phantoms modelling, dosimetry and visualization with Geant4/gMocren
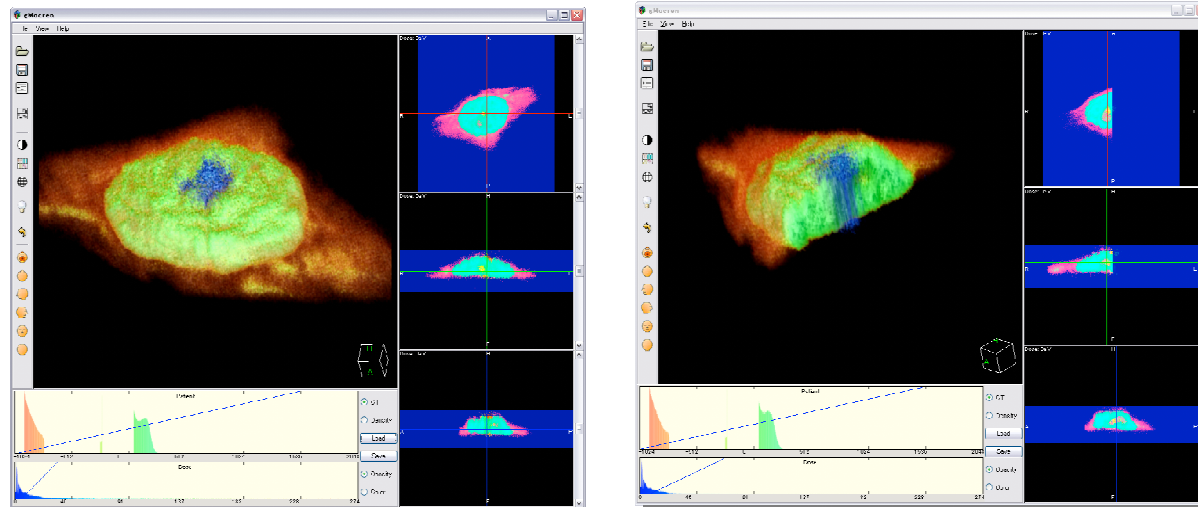


- single HaCat cell
- 3 MeV alpha$^+$ particles
- 512x512x60 phantom resolution 90x90x160 nm$^3$ per voxel

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# FJPPL : Next year

- end of fiscal year is Mars 31st, 2009

- money for French side (less than 3000 euros) must be 'engaged' before Dec. 1st 2008

- need to decide when/where to meet in Japan in 2009

- if you publish, please give me publication details so that we can dispatch this information on our web site

# Thank you !