



University of California
San Francisco

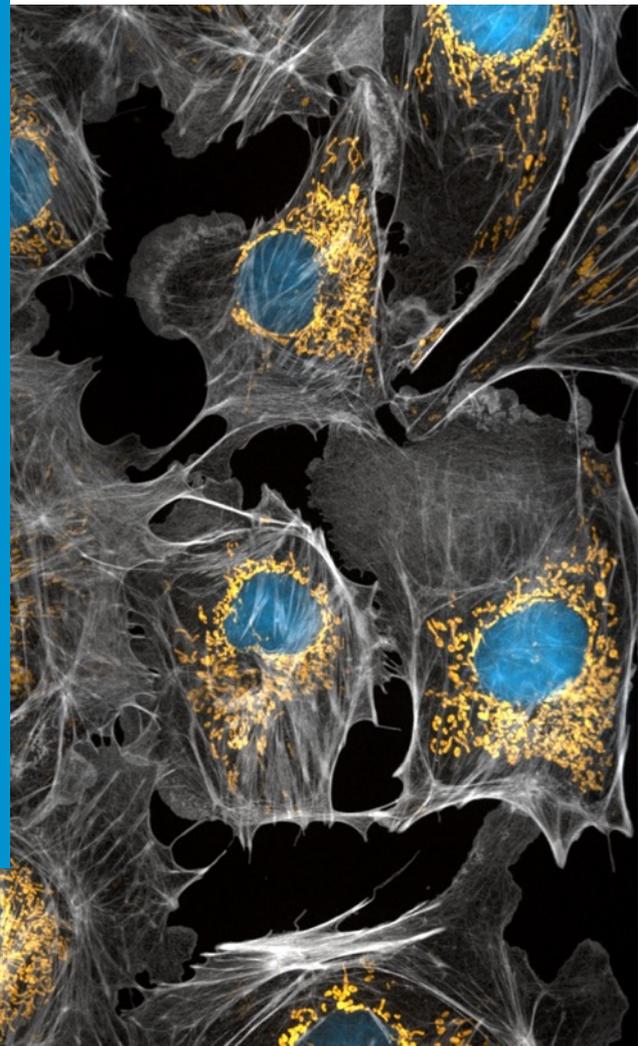
Open and new requirements: Medical and bio science.

24th Geant4 Collaboration Meeting,

Thomas Jefferson National Accelerator Facility, September 2019.

José Ramos-Méndez

Department of Radiation Oncology.



Review of User's requirements 2018

2018 User requirements

- **Double strand breaks calculation for protons.**

- S. Meylan and C. Villagrasa (IRSN, France).
- **Status:** A new example was developed by Hoang Tran, more details in parallel7B.
- Sakata D, et al., 2019 Evaluation of early radiation DNA damage in a fractal cell nucleus model using Geant4-DNA *Phys. Medica* **62** 152–7
- Lampe N, et al., 2018 Mechanistic DNA damage simulations in Geant4-DNA part 1: A parameter study in a simplified geometry *Phys. Medica*.
- Meylan S, et al., 2017 Simulation of early DNA damage after the irradiation of a fibroblast cell nucleus using Geant4-DNA *Sci. Rep.* **7** 1–15
- de la Fuente Rosales L, et al., *Phys. Medica* **51** 108–16.

2018 User requirements.

- **Validation of chemistry water radiolysis.**

- Eva Bezak, University of South Australia.
- Geant4-DNA working group.
- **Status:** Published work, see Parallel 3B and Parallel 8A.

Peukert et al., Validation and investigation of reactive species yields of Geant4 chemistry models. *Med. Phys.*, 46(2), 2019.

Shin WG. Evaluation of the influence of physical and chemical parameters on water radiolysis simulations under MeV electron irradiation using Geant4-DNA. *J. Applied Phys.* 2019. *In Press.*

2018 User requirements.

- **Models to calculate RBE**

- Giada Petringa, Pablo Cirrone and Giacomo Cuttone (LNS)
- **Status:** a dedicated example extracted from Hadrontherapy example is in progress.

- **Proton transport models for Geant4-DNA above 100 MeV**

- Including proton transport cross sections and final state models in Geant4-DNA above 100 MeV. The need is the coverage of the entire range of interest in proton therapy (250-300 MeV).
- **Status:** Carried out by Damián Domínguez-Muñoz, PhD student, currently doing an internship with Marie-Claude Bordage.

New User's requirements

Examples.

- **An extended example** which shows how to calculate a Bragg Peak and retrieve the dose in 3D
- **IAEA-phsp:** a code properly updated has been asked many times. Susanna's group have developed a code doing that. We will talk to organize this along the conference.
 - **Status:** Sussana, Ivana and Miguel Cortes are working on this.
- **ICRU90 tables in Geant4.** Lucas Burigo at DKFZ already provided Vladimir with the data tables and he is working on it.
 - **Status:** available.

Examples.

- **Scoring of LET and dose-averaged LET (LET_d):**

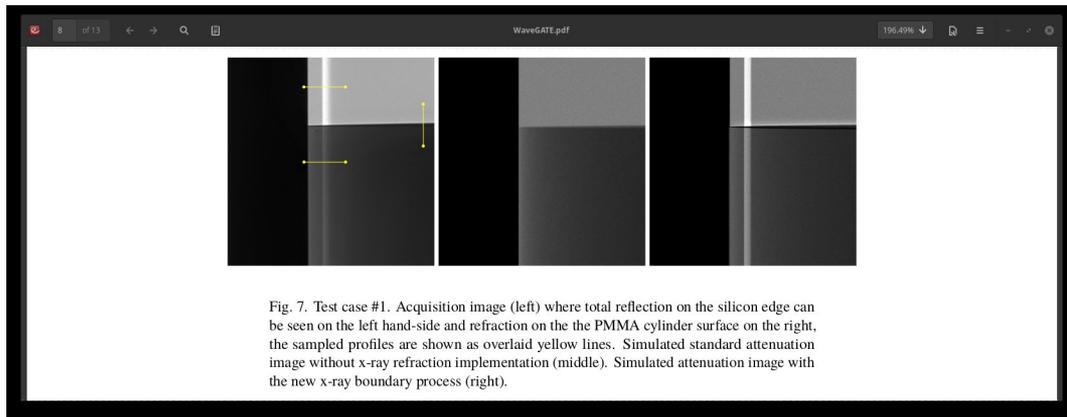
- It was found(*) that scoring LET_d via intuitive methods may give biased results when steps are often cut artificially (MaxStep restriction, voxel boundaries). There is still some confusion on this, thus proper scoring of LET_d could be shown in various relevant examples (extended EM, hadrontherapy, etc.). (*) Cortés-Giraldo & Carabe PMB 2015.

- **Microdosimetry:**

- For proton and ion beams, to link microdosimetric quantities (such as lineal energy) with macroscopic ones, such as LET and LET_d , it is needed to score, among others, the energy imparted per individual ionization produced by the initial particle (i.e. including *all* generations of electrons (2nd, 3rd, etc.)). The proper scoring is not trivial for many users; thus it could be shown in an example similar to *microyz*, or complementing it. We can provide as example a code done in our group (see presentation during this meeting)

Models.

- To implement the x-ray refraction we need the real part of the refractive index. To do this, we had to link Gate with the xraylib library (<https://github.com/tschoonj/xraylib>) as Geant4 does not provide the form factors. It would be nice to have it implemented in Geant4.
- **Contact person (email):** jean-michel.letang@creatis.insa-lyon.fr
- Zhenjie Cen, Max Langer and Simon Rit



Courtesy of Jean Michel Letang.

Implement X-ray refraction effect in Geant4 for phase contrast imaging

Zhentian Wang, Zhifeng Huang, Li Zhang, Zhiqiang Chen and Kejun Kang

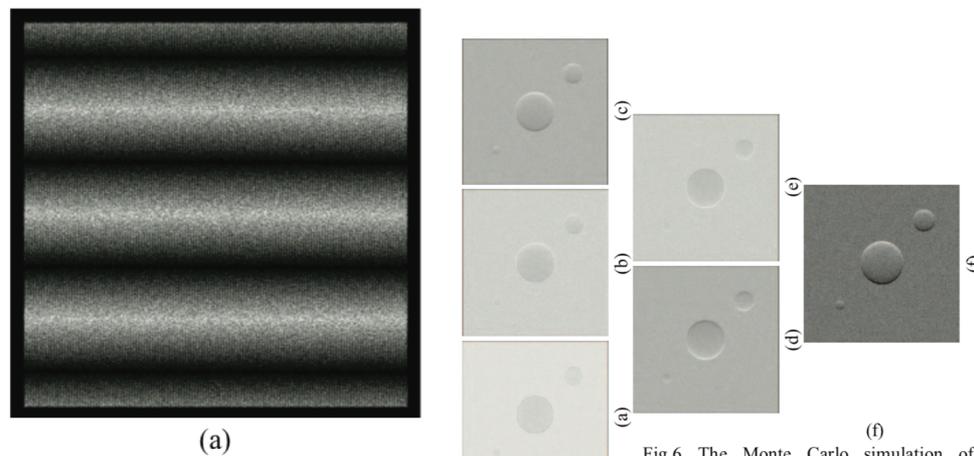


Fig.6 The Monte Carlo simulation of the five steps phase-stepping process of grating-based phase contrast imaging. χ denotes the displacement of the two gratings. (a) $\chi = 0$; (b) $\chi = 0.8\mu m$; (c) $\chi = 1.6\mu m$; (d) $\chi = 2.4\mu m$; (e) $\chi = 3.2\mu m$; (f) The refraction angle information retrieved from above 5 intensity images.

Models.

- **Low Energy electromagnetic Physics**

- Make EPICS2017 models available in Geant4 (electrons, photons) as an alternative to Livermore
- Increase energy coverage of PIXE models (up to a few tens of MeV)

- **Geant4-DNA**

- Develop track structure models for specific materials (beyond liquid water and DNA)
- Extend energy coverage of existing models (ex. option4 is limited to 10 keV for electrons)
- Improve accuracy of Physics models when possible

Models.

- Boron-neutron capture
 - physics models for ions below 1 MeV/u.
 - Naoki Domínguez (Ph.D. student at BUAP, México), José Ramos (UCSF)
 - **Status:** warming.

- Include "Independent Reaction Times" as an alternative to step-by-step approach
- **Status:** see Parallel 7B.

Track management.

- Flash: Lurent Desorgher's group have received funding for a 4 year projects with among other activities
- G4DNA development and simulations .
 - **Status:** to start concretely the simulation activity before end of the year.

Geometry and tools.

- Geometries
 - Library of multi-scale geometries of biological targets (from DNA to variety of cells)
- Geant4-DNA
 - Provide a variety of examples of application illustrating the physical, chemical and geometrical functionalities and useful for verification & validation (link to [geant-val](#))
- Performance
 - GPU deployment, see Parallel 4A.



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