Open and new requirements: medical and bio science

26th Geant4 Collaboration Meeting

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« Radiobiology » requirements : Geant4-DNA

Source: S. Incerti

1. **Physics** : more discrete & accurate (low energy) models for a variety of materials
   Liquid water, DNA, amino-acids, gas (micro/nanodosimetry), solid state (e.g. high Z materials for NP-aided radiotherapy)

2. **Chemistry**
   Mesoscopic approach under development (longer times, larger volumes) compared to existing Geant4 (step by step and IRT) approaches

3. **Geometry**
   Provide (external) files to describe geometries of biomolecules (e.g. plasmids, bacterium & cell genome)

4. **Verification & validation**
   Continue efforts in chemistry under irradiation & radiobiology
   - G-values, under variety of exp. conditions : T, pH, scavengers…
   - Radiobiological damage : beyond strand-breaks towards macroscopic observables (e.g. requiring analytical repair models)

   Addition of related extended and advanced examples for users

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5.Multiscale combination

Mixing condensed-history and discrete approaches, e.g. for radioprotection in space : cosmic spectra – space habitat – human phantom – « microscopic » & « macroscopic » biological end-effects

6.Optimization (speed & memory usage)

Faster navigation in detailed geometries

GPU porting (physics & chemistry & geometries) – see Takashi's / KEK team developments

Some of these activities are **currently on-going** through

the ESA BioRad III project (2021-2023) : CEA (FR), CHUV (CH), G4AI Ltd. (UK), IN2P3 (FR – coord.), INFN (IT), Ioannina U. (GR), IRSN (FR), Sevilla U. (ES), Swhard (IT)

the MAGIC project (2020-2023) : CHUV (CH – coord.), CENBG (FR)

collaboration with the TOPAS-nBio team

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Physics

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Physics: the pB nuclear fusion reaction

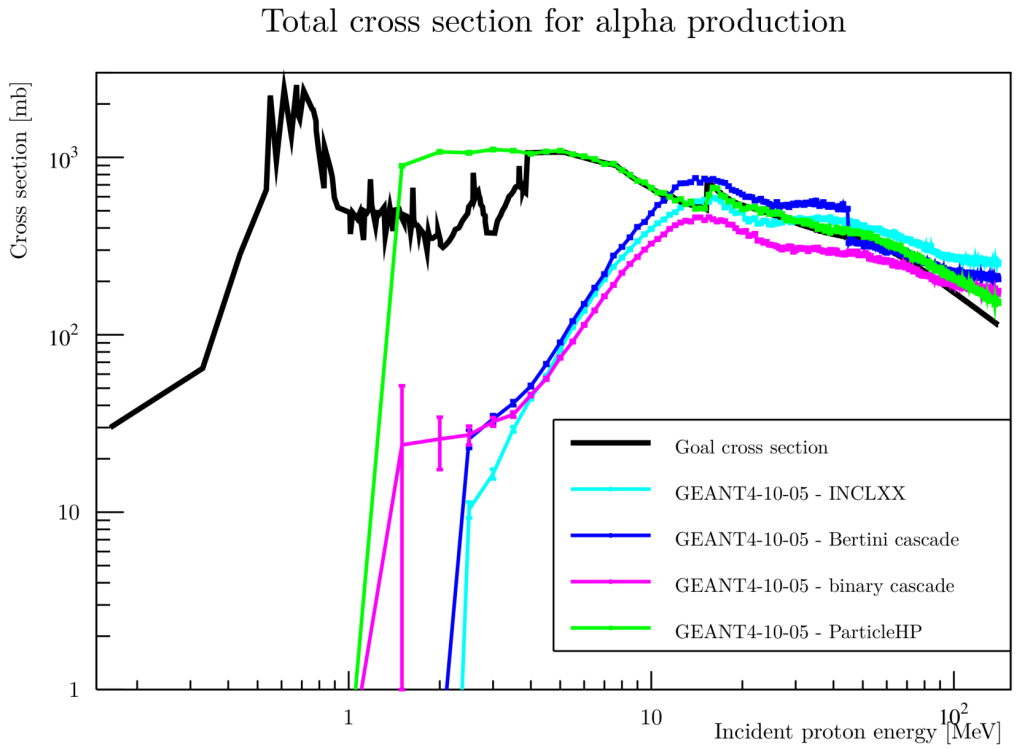
Source: P. Cirrone

WHAT WE ARE DOING:

- We are realising a comparative study between all the hadronic physics models for the **p+B11 —> 3 alpha** reaction.

WHAT DO WE NEED:

- Extend the hadronic physics models below **1 MeV**
- Improve the issue of non conservation of the **baryonic number** in PHP



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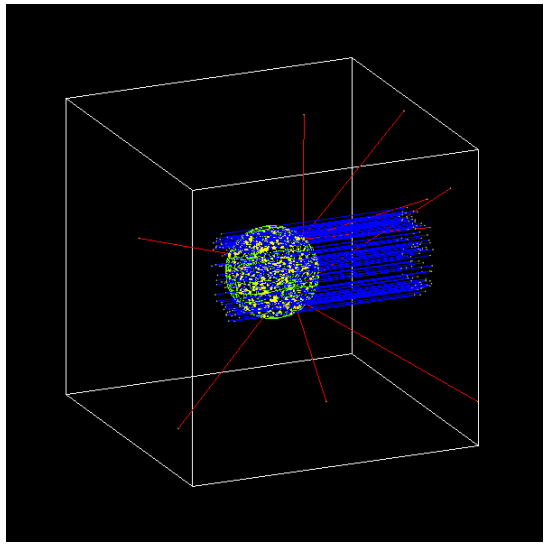
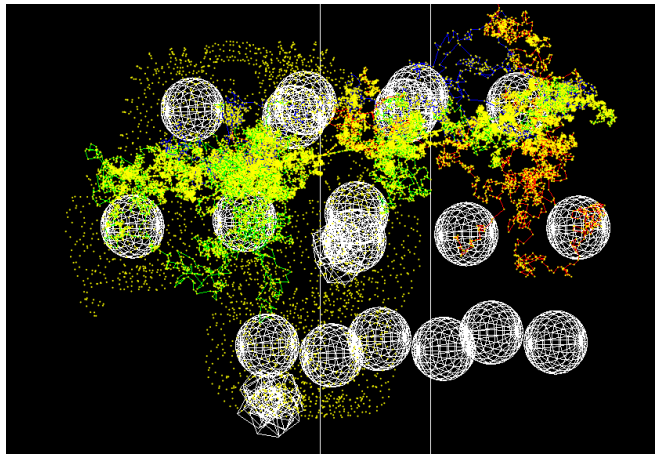


WHAT WE ARE DOING:

- We are trying to evaluate, at nanometric scale, DNA damage enhancement due to the **p+B11 —> 3 alpha** reaction.

WHAT DO WE NEED:

- Extend **material** coverage of Geant4-DNA beyond DNA and liquid water (i.e. include **Boron**)
- Include **hadronic interactions** in Geant4-DNA Physics Lists



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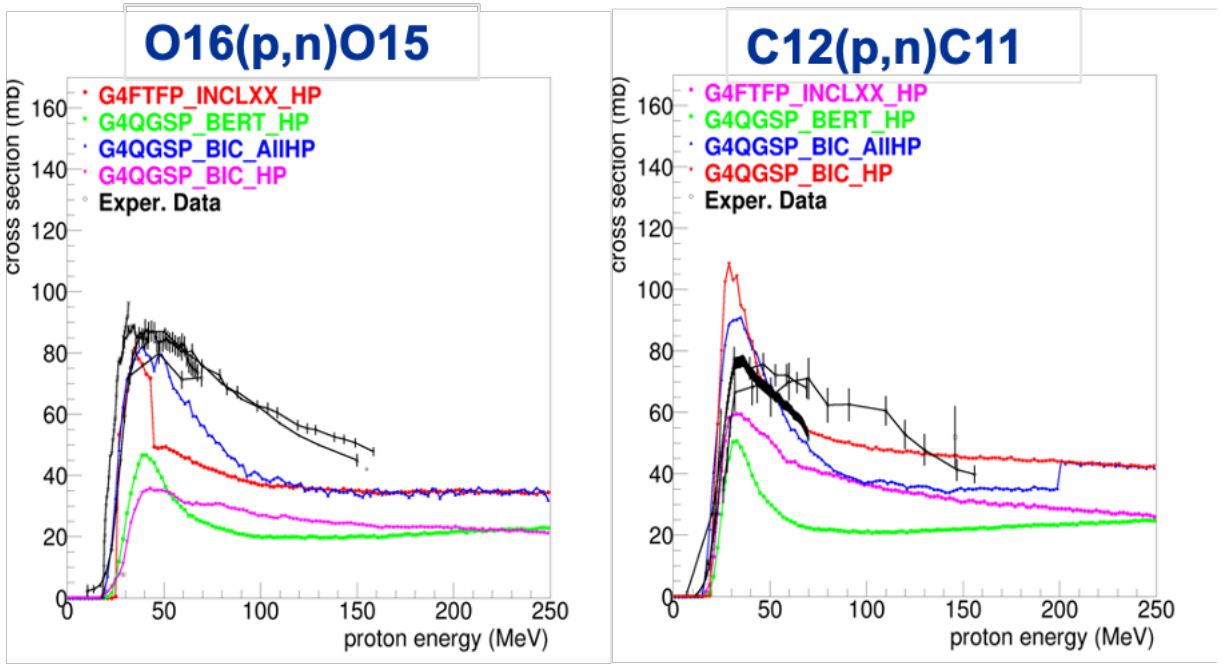
Physics: Isotope production from protons

Source: P. Arce

❖No good Geant4 model to reproduce isotope production cross section

- ✓ PET range studies for protontherapy
- ✓ Design of isotope production
- ✓ Cyclotron
- ….



❑ IAEA has made an extensive work to cover isotope production for medical applications (https://www-nds.iaea.org/medical/)

- ➢ **Put IAEA medical cross section into Geant4 ParticleHP database**

☹ Not all energies covered**: fit to experimental data**

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AtRest in Geant4 Biasing framework

Source: P. Arce

☹ Bremsstrahlung splitting is not optimized for gamma radiotherapy linac simulations
- ❖ Produce many gammas not directed towards patient

☺ Play Russian Roulette with those gammas not directed towards patient
☺ Will end having scoring particles with very different weigts ➔ bigger statistical uncertainty

☺ Treat all particles (from any interaction) so that all scoring particles have same weight (method developed in GAMOS)
☹ Geant4 Biasing framework does not support AtRest (for annihilition gammas)

Request: **add AtRest in Geant4 Biasing framework**

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Validation

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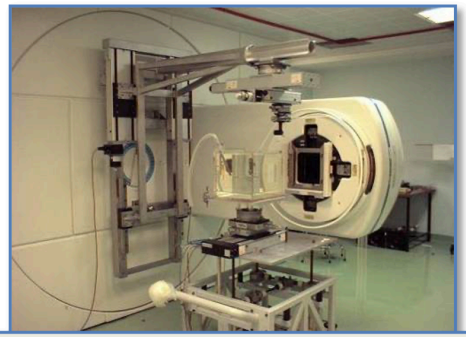
Finding reliable data for MedLinac Advanced Example

Source: B. Caccia

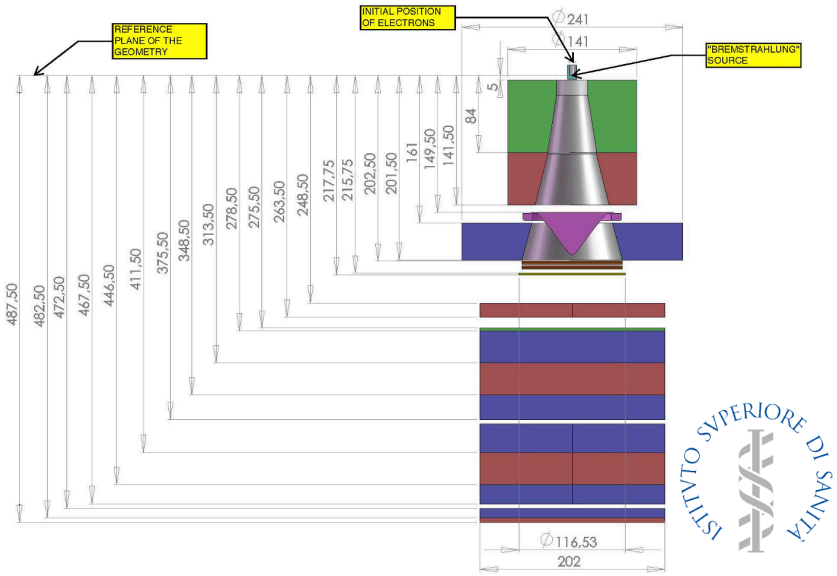
An example of reliable data to validate MedLinac advanced example



Saturne 43 LNHB linac
Exercise : photons mode, 12 MV

This simple Linac and the complete dataset of the dosimetric data used for the inter comparison can help users to develop the skills needed to build and calibrate a Monte Carlo simulation and perform a dosimetric analysis.
It is not simple to have a model of a LINAC and a dosimetric data set to use for test own MC model.

EURADOS Report 2020-05: B. Caccia, V. Blideanu, M. Le Roy, H. Rabus, R. Tanner: "A model validation scheme for Monte Carlo simulations of a medical linear accelerator: geometrical description and dosimetric data used in the "Linac Action"", Neuherberg, October 2020. The Report is placed at the EURADOS SharePoint.
DOI: 10.12768/9rvp-fq82



EURADOS European Radiation Dosimetry Group

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New examples

Extended Examples

To have an extended example to retrieve directly from the simulation Auger electron energy and associated atomic transition

A. Mantero: update of the unit test and implementation in an extended example of Geant4 (in discussion phase)

Source: S. Guatelli

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User Forum: DICOM

DICOM RT ION PLAN to GPS

Ideas and Requirements

mrxak Jun 25

Can you provide an example of DICOM RT ION PLAN conversion to GeneralParticleSource or some reader of DICOM RT ION PLAN?

Note: I know you have a reader interface of DICOM RT PLAN implemented in /examples/extended/medical/DICOM/dicomReader/src/DicomFilePlan.cc though it's not used in the actual code of this example itself, but I'm talking of another DICOM document (https://dicom.innolitics.com/ciods/rt-ion-plan 5).

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User Forum: Radiation Damage

Modelling Radiation damage in Semiconductor devices

Applications

sanchitsharma Jul 19

Hello,

I need to model radiation damage in semiconductor devices. Does anyone here has any example that I could follow?

Thanks!

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Geant4 is hard!!

- There is the idea in the medical physics community that to use Geant4 is hard.
- Personally I think that there have been many improvements to make Geant4 “easier” for novel users, but it seems not enough.
- Possible ideas:
  - A new general purpose interface as part of Geant4?
  - Develop Geant4 examples for medical physics which are easier to use, more flexible, with an extended/advanced user interface? E.g. the user needs to change parameters in input macro files only, at least for some emblematic applications.
  - Improve documentation
  - Online tutorials/videos on how to use the Extended/Advanced Examples in medical physics
  - Establish a Geant4 bio-medical user forum
- Maybe extend the activities of the G4-Med to a subset of ideas listed above

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Thank you
for your attention!

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