Summary of Medical Physics Parallel Sessions and Discussions

Joseph Perl

Stanford Linear Accelerator Center

Geant4 Workshop

Hebden Bridge, UK

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GATE/G4 simulations of ^{125}I brachytherapy sources

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Credits: C.O. Thiam

http://clrpcsv.in2p3.fr

➢ Several Brachy sources
➢Comparisons with other MC Codes
➢and various Geant4 versions

➢**Little discrepancies between Geant4 Standard and Low-energy packages (7%)**
➢ **Good agreement between G4 versions**
➢ **Good agreement with other MC and measurements**

Plateforme de Calcul pour les Sciences du Vivant
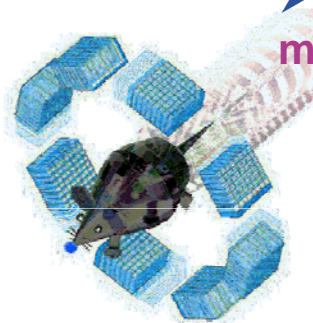
PCSV

Geant4/GATE simulations using grid computing

Experience running Geant4 on GRID
RPMs
Random Number management
Portals
etc

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Crédits: V. Breton, Y. Legré, C.O. Thiam, A. Fessy, M. Diarena
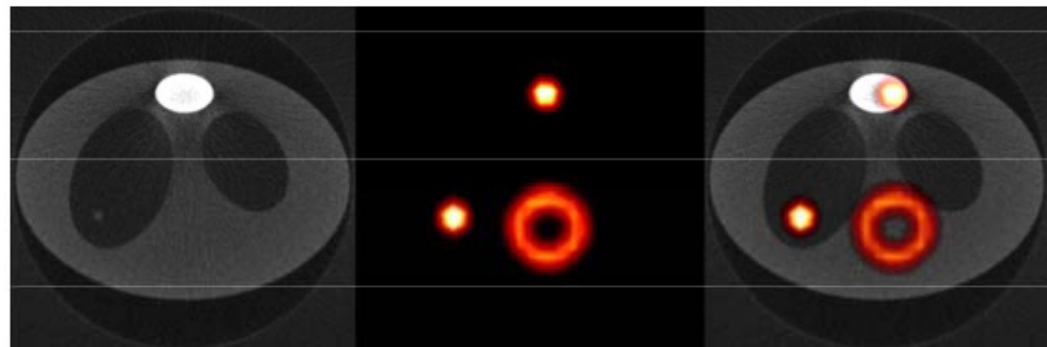
Simulating CT imaging with GATE

F.Cassol Brunner

imXgam group, http://imxgam.in2p3.fr

Centre de Physiqu

GATE will help us in the following analysis:

- Optimization of the next PIXSCAN geometry :
  new chip with pixels of 130 x 130 µm²
- Dose estimations
- Contrast studies based on simulated animal phantoms
- Design of a simultaneous CT-PET scanner

Profiling study of Geant4-GATE

VRTs discussion

Nicolas Karakatsanis

Alexander Howard

- Simulation efficiency with voxelized phantoms
- Compressed Voxel Parameterization
- Profiling study - Conclusions
- Geometry VRTs so far
- Discussion of possible new geometry VRTs

The Italian activity of the LNS – INFN group

Francesco Romano
on behalf of Geant4 group at LNS-INFN, Catania

Involvement in the hadronic and advanced examples WGs

- thirty researchers
- seven institutions
- two external collaborations

We are working for the constitution of a user group composed by people with common interest to Geant4 in medical physics

GAMOS
(GEANT4-based Architecture for Medical-Oriented Simulations)
## *Status and plans*

Pedro Arce Dubois
Pedro Rato Mendes
CIEMAT, Madrid

➢ **GAMOS is a <u>user-friendly</u> and <u>flexible</u> GEANT4-based framework for medical simulations**
  ✓ allows the user to do GEANT4 simulation through **user commands**
  ✓ **plug-in's** allow to **easily extend its functionality** by writing **C++** classes that can then be used through **user commands**

❑ Software engineering techniques have been applied with the aim of building a framework
  ✓ **Easy to use, complete and flexible**

➢ **GAMOS core is application independent**
  ✓ Several **medical applications** are being built on top of GAMOS core (PET, Dosimetry, Radiotherapy, Hadrotherapy)

Recent developments in Geant4 related activities at CENBG

Sébastien INCERTI (IN2P3/CENBG)
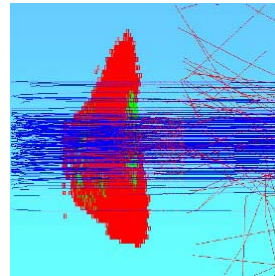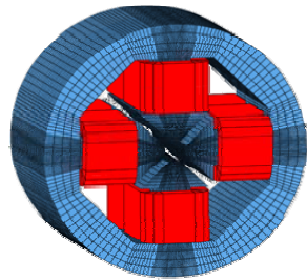
Four simulation projects

Ray tracing for nanobeam line design

The Geant4 DNA project

A mission to Mars

(3D phantoms for microdosimetry)

General Observations

- Large, diverse, international community of Geant4 medical users.
- Involved in everything that Monte Carlo can do in Med Phys:
  - Characterizing machines and sources
    - Beam Therapy
      - electron, gamma, proton, ion
    - Brachytherapy
  - Treatment planning
  - Retrospective studies
  - Imaging
- Strong communication between them and Geant4 is needed
  - And is improving
  - GATE/Geant4 relationship beautifully enhanced this week

Word of the Week: Clarity

- We need to clarify guidance on which Physics options to use
    - processes
    - step Sizes
    - range Cuts
    - other parameters
- We heard this same thing from the Geant4 reviewers

From the External Review

Recommendation 1: We recommend setting up an easily accessible central repository with detailed references to data comparisons and validation papers for the models, e.g. a web page linked from the EM home page.

Recommendation 2: We recommend rapid integration of the ICRU 73 heavy ion stopping power model.

Recommendation 3: We recommend providing guidance on the tradeoff between physics accuracy and computing speed. For example, collect and publish via the web results from users in various domains regarding computing speed vs range cut, and provide a Wiki-like forum where users can document their experience; etc.

Users have been confused by the existence of two independent EM packages. They have overlapping ranges, where they give different results for identical geometry. Which package gives the more correct result in this kinematic range?

Recommendation 4: We recommend providing guidance on the choice between the two EM models for specific particle species, energies, etc.

The two models do not have identical ranges of applicability. It is therefore natural to want to use one model in one region and the other model in another region, each in a range where it has better performance. This is impossible as the models have been implemented as independent packages.

Recommendation 5: We recommend integrating the two EM models into a single package, similar to what exists in hadronic models. This will allow a user to choose one model in one energy range and the other model in a different energy range in order to optimize physics and computing performance for his application.

Priorities

- At beginning of this meeting, I said top priorities were:

  1. Accuracy
  2. Clarity
  3. Speed

- Based on what I've seen this week, I would reverse the first two:

  1. Clarity
  2. Accuracy
  3. Speed

How to Provide that Clarity

- From Gunter's talk on Saturday

> ### User input
> - Identify requirements
> - Provide feedback on quality of simulation
> - Evaluate possible alternative options
>
> ### Geant4 developers provide experience/knowledge
> - Physics performance of specific processes/models
> - Evolution of physics modeling and cross sections
> - Available new options
>
> Hebden Bridge   5

- Side meeting of Giuseppe, David, Pedro, Giovanni, Joseph
  - Agreed to start forming international working groups to this end
  - Not Geant4 Working Groups, but Users + Developers
    - Geant4 Medical Physics List Working Group
    - Geant4 Medical Application Working Group
  - Will call for participation from G4EMU/G4NAMU/Japan, etc.

Speed

- Slower than EGSnrc by factor of 2 to 10 depending who you talk to
  - Do we know that this is true?
  - If we are slower, do we know why?

- Fermilab recently joined Geant4 collaboration and is contributing software engineering/profiling expertise
  - they've shown profiling for HEP applications
  - would be good to apply same profiling tools to some medical applications

- Specialized navigators for Voxel geometries
  - work goes back to Paganetti years ago
  - talk last week by Pedro Arce (includes full history of such efforts)

- Compressed voxel parameterization
  - early work, OCTREE, by Vincent Hubert-Tremblay and Louis Archambault from Canada
  - talk last week from Nicolas Karakatsanis, George Loudos, Arion Chatziioannou
  - fastGATE talk last week by Arion, George, Nicolas, Richard
  - summary and new implementation by Pedro Arce shown last week

Other Issues for Med Phys

- DICOM Compatibility
  - Much to be done to get to where the EGS community already is
    - But promising work already in several Geant4 applications
- Memory
  - Not such a serious issue in all cases (depends on specific application)
    - Would help if we allowed materials to be parameterized by density
- Volume Rendering
  - Much to be done to get to where the EGS community already is
    - Promising work coming out of Japan
- Scoring
  - Good news here
    - Rapidly approaching best functionality offered by other codes
- Ease of Use
  - Various applications have been produced
  - Bring some of them together through user/developer working group
    - GATE (+ThIS = fGATE)
    - GAMOS/MIRAS
    - Japanese effort
    - Interactive scoring coming from Makoto
  - Perhaps can wrap best parts of the above to share a plug-in architecture

Ranking of Issues for Med Phys

Top Priorities (In This Order):

1. Clarity - guidance on which physics options to use
2. Accuracy - with stability against step size and range cut variation
3. Speed

Less Critical:

- DICOM Compatibility
  - Our users are willing to bolt this stuff together themselves if need be (they're used to doing things the hard way, even willing to use MORTRAN)

- Memory
  - Our users are willing to use the various available workarounds

- Volume Rendering
  - Our users are willing to do this part themselves by various complicated hacks

- Scoring
  - Recent improvements, and others almost ready, have essentially solved this

- Ease of Use
  - Our users are willing to do whatever it takes provided we are CLEAR about how to get sufficient ACCURACY with acceptable SPEED