

Geant4 Report Domain: Medical Physics

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Geant4 Collaboration Meeting

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Please Stop Calling Medicine a New Domain for Geant4

- Geant4 in medical applications is a well established art
 - Many users have been using Geant4 for as many as ten years (such as our guest Dr Enger, 6 years)
- Heavy use going way back in
 - Japan
 - Catania
 - Madrid
 - In the US, at MGH,
 - or UPENN, the newest proton center completed in the US
- Exact user metrics
 - we don't know, but my G4NAMU meeting at AAPM this year had 50 people (may have attended 6 years in a row)

My Epiphany at PENN

- Seeing their Geant4-designed MLC:
- As developers we are approached by users mainly when they have problems, they don't need us when things are going well.
- We develop a skewed sense towards the negative.
- So you may not even notice a success like this MLC unless you are lucky enough to be touring the center, and then there it is.

Now on to Issues

- Don't Panic: the Medical Physics community does not expect the Geant4 Collaboration to solve everything for them
- They will apply their own manpower, or at least understand if we don't have it
- Just important for us to make clear to them which areas we're working on so they know how to invest their resources.

Geometry - 1

- Patient Handling always involves issues from the large numbers of voxels in a typical DICOM.
 - Nested Parameterization and RegularParameterization are often helpful but can not always be used.
- Talk in Parallel 6B "Layered Mass Geometries" by Shirin Enger
 - A requirement coming from Brachytherapy but also relevant for external beam and imaging.
 - Allow one to have multiple mass geometries, such as Brachy Seeds plus DICOM
 - Or to handle the common problem in External Beam or Imaging that the cubic shape of the DICOM partially overlaps the treatment head or imager bore. As in Photoshop or Illustrator, the user can decide which layer to bring to the foreground in which case.
- One solution is already in GAMOS.
- Pedro Arce working on a solution for trimming air space around DICOM

Geometry - 2

- CAD import is being accepted by this community.
 - RADSAFE is an almost good enough tool to convert from STEP to GDML, but not quite.
 - Space and Medical vendors have interest in helping make it better even if that requires money.
- For volume visualization, gMocren is very helpful but not yet widely adopted, needs better promotion.
 - Expect OSX versions by December, meaning gMocren is supported on all Geant4 platforms.

Physics - 1

- Confusion about multiple scattering options.
 - Talk in Parallel 2A "Multiple scattering model validation at low energy in water for Dose point kernels and pencil beam kernels (comparisons with EGSnrc and MCNP4C)" by Yann Perrot
- Low energy and small scale
 - Plenary talk this afternoon and on microdosimetry in Silicon during parallel session 2A
- Confusion about physics list options in general.
 - From Pablo: We are doing all the works with the QGSP_BIC using the G4emStandard_opt3.
 - Important to have a more appropriate name. Helps increase comprehension and reuse.
 - FLUKA has a physics lists called DEFAULT HADRON THERAPY.
- Do likewise for electron therapy, x-ray therapy and other medical domains.
- Published papers such as Christina's are ideal, but hard to keep current with latest Geant4 version

Physics - 2

- Ion Physics:
 - From Francesco:
 - lack of low energy ion-ion models
- Accuracy:
 - Talk in Parallel 2A: "Validation of electron, proton and alpha ranges" C. Zacharatou
 - From Pedro:
 - Issues of MSC for Nanodosimetry structures.
 - Issues in Bremsstrahlung for standard, better in low energy but at speed cost.
 - Deexcitation does not conserve energy.
 - Protons in low-Z
- State of medical examples:
 - With the exception of Hadrontherapy, support is extremely spotty, like so many G4 examples.

Speed - 1

- Talk in Parallel 2A: "Validations of the standard EM physics for Radiotherapy applications (comparisons with measurements and EGSnrc)" by Lydia Maigne
- Catania group is starting to compare (using exact same geometry) a Geant4 simulation with a FLUKA to compare physics and compute time.
 - Starting with depth dose and profile for therapeutic protons and carbon ions in water.
- Speed remains an issue, but most med phys users do not apply variance reduction, just don't have time to get to it, but ball is in their court.
 - Difficult to provide published validation of these methods for Geant4, because the range of ways we can be used is so broad. Easier to validate such techniques in a specific applications.
 - Tools like PTSim, GAMOS, GATE, TOPAS can help with this by tightening this scope.
- Most users do not exploit production cuts or user limits.

Speed - 2

- Profiling tools can be very helpful.
 - Most non-software people don't understand enough about profiling.
- Frequent use of multiple parallel jobs
 - Many of these users have significant computing clusters
 - Would take full advantage of any tools we provided such as to collate AIDA results
- Strong interest in multiple core

Installation and Configuration

- We need to make our code fit well into medical application frameworks.
- We also need to maintain support for Windows.
- CMake should help.
- Our guest Greg Sharp of MGH has significant expertise in these areas.

Overall

- Heavy use, strong acceptance, in proton and ion therapy community and in PET/SPECT.
- Motion and onboard imaging for guidance and range verification are big topics
- Biology frontier is active and exciting
- Next two tutorials in US will be medical associated
 - Texas A&M, Jan 10-14, now open for registration
 - UPENN, Philadelphia, in discussion for co-location with PTCOG, May 8-10
- More conventional applications, CT imaging, x-ray or electron therapy, we are still at least perceived as being significantly slower than other codes.
 - Need for well done speed comparisons and profiling.

Closing Thoughts

- Proof that the medical physics community values Monte Carlo:
 - AAPM's Highest Award, the Coolidge Award, was given this year to Dave Rogers, who brought EGS to the Medical Physics community as BEAMnrc/DOSxyz
- Please discuss all these topics with our medical physics invited guests:
 - Shirin Enger of ULaval
 - Greg Sharp of MGH