News, Updates and Best Practices for Geant4 Applications in Medical Physics

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SLAC National Accelerator Laboratory

G4NAMU Meeting at
AAPM Anaheim

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Purpose and Structure of this Talk

- Advise you of updates
  - Your applications probably started as a copy of some specific Geant4 code from a published example or another user
  - More robust solutions may now be available for much of what you're doing
  - I'll start from the particle source and work my way towards the scoring
- Point out key code examples
- Describe activities in Europe and Asia
- Point out communication channels
- Tell you what's in recent and upcoming releases
- Tell you about upcoming events (tutorials, meetings)
- Somehow get through this in 25 minutes

G4GeneralPartcleSource

More convenient than the default G4ParticleGun for most applications

- Developed by QinetiQ in the UK for European Space Agency
  - included in the Geant4 release
  - detailed documentation at: http://reat.space.qinetiq.com/gps/

> - **Spectrum**: linear, exponential, power-law, Gaussian, blackbody, or piece-wise fits to data.
> - **Angular distribution**: unidirectional, isotropic, cosine-law, beam or arbitrary (user defined).
> - **Spatial sampling**: on simple 2D or 3D surfaces such as discs, spheres, and boxes.
> - **Multiple sources:** multiple independent sources can be used in the same run.

- Create from a single line in your EventGenerator
  - particleGun = new G4GeneralParticleSource();
- Control from Macro:
  - /gps/energy 13.00 MeV
  - /gps/particle e-
  - /gps/direction 0. 0. 1.
  - /gps/pos/type Beam
  - /gps/pos/shape Circle
  - /gps/pos/sigma_r 0.042 cm
  - /gps/pos/centre 0. 0. -57.7 cm

Import of CAD Designs through GDML

Another advance that came through the aerospace community

- Still requires a fairly complex chain to convert: STEP files (from CAD) to GDML (for Geant4) via a converter such as Fastrad
  - but capable of modeling imported structures in great detail

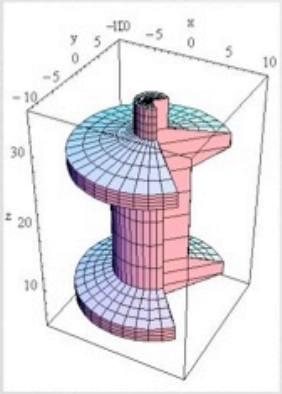
Recent updates to solids - 2

G4TessellatedSolid

- Reviewed implementation of triangular facets (PR #931)
- Reviewed `CalculateExtent()` for robustness and precision (PR #983)
- Fixes in computation of normal to facets

9.1

9.1.p01



G4Polycone

- Fix for numerical errors in `G4IntersectingCone` to correct use of tolerance for the cone limits in `R` and in `Z`

9.1.p02

- Enhanced `GetPointOnSurface()` with a new triangulation algorithm for the facets
  - Also applicable to `G4Polyhedra`

9.2

Other minor fixes …

9.1.p02

- … in `G4Cons`, `G4Torus`, `G4Trap`, `G4EllipticalCone` and BREPS

13th Geant4 Collaboration Workshop, Kobe 6 October 2008

NIST Materials Database

An easier and less error-prone way to specify your materials

```
void ElectronBenchmarkDetector::DefineMaterials(){
    // Use NIST database for elements and materials whereever possible.
    G4NistManager* man = G4NistManager::Instance();
    man->SetVerbose(1);

    // Define elements from NIST
    G4Element* C  = man->FindOrBuildElement("C");
    G4Element* Cr = man->FindOrBuildElement("Cr");
    ...

    // Define pure NIST materials
    man->FindOrBuildMaterial("G4_Al");
    man->FindOrBuildMaterial("G4_Ti");

    // Define other NIST materials
    man->FindOrBuildMaterial("G4_WATER");
    man->FindOrBuildMaterial("G4_KAPTON");

    // Define materials not in NIST
    G4double density;
    G4int ncomponents;
    G4double fractionmass;
    G4Material* StainlessSteel = new G4Material("StainlessSteel", density= 8.06*g/cm3, ncomponents=6);
    StainlessSteel->AddElement(C, fractionmass=0.001);
    StainlessSteel->AddElement(Si, fractionmass=0.007);
    StainlessSteel->AddElement(Cr, fractionmass=0.18);
    StainlessSteel->AddElement(Mn, fractionmass=0.01);
    StainlessSteel->AddElement(Fe, fractionmass=0.712);
    StainlessSteel->AddElement(Ni, fractionmass=0.09);
```

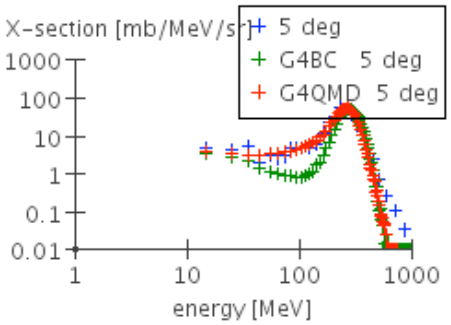
- makes your papers easier to write
  - "we used NIST materials specifications..."

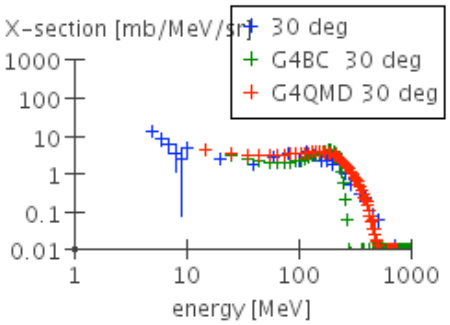
Physics

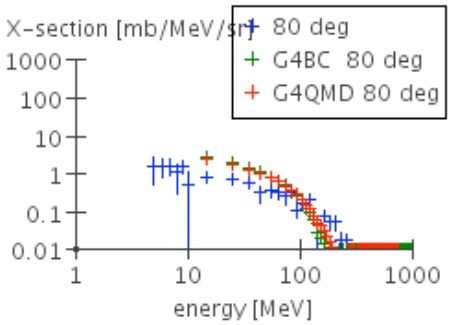
- EM
  - G4StandardPhysics may be the best option now for many electron and gamma medical linac applications
  - Multiple Scattering has improved greatly in recent releases
  - Standard and LowE groups working together closely now
    - shared interfaces, allowing single physics list to mix processes from both domains
- Hadronics
  - Heavy development in ion physics, driven by medical and aerospace
  - QMD model

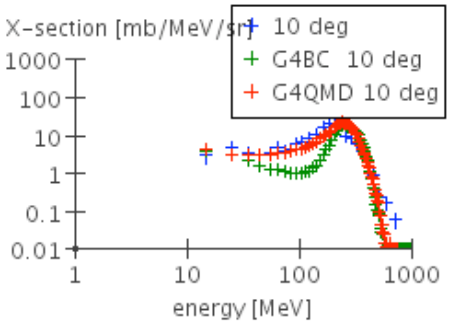
Progress in Neutrons and Ions

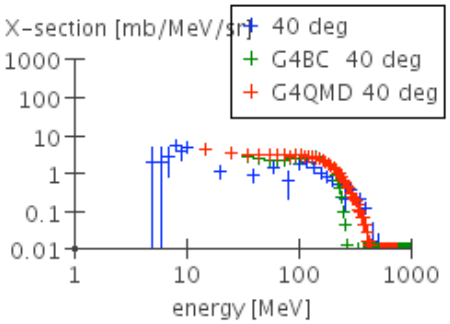
C12 290MeV/n on Carbon Secondary neutron spectra

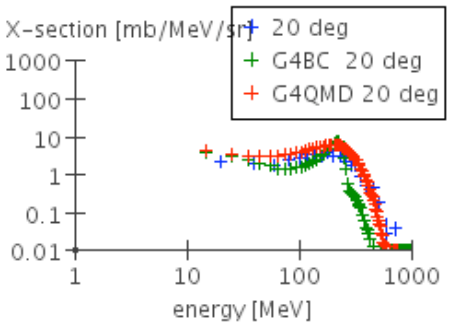


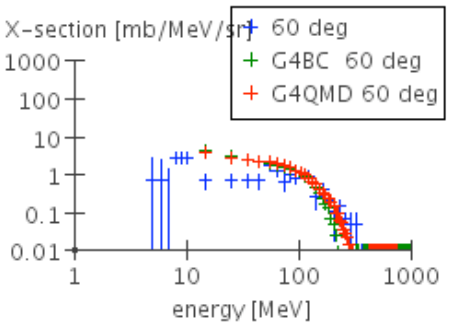












+ Data
+ G4BinaryCascade
+ G4QMD

Tatsumi Koi, SLAC

Physics is Your Job

- Geant4 is a toolkit
  - It is not a ready-made and nicely packaged application.
  - It is not meant to be used by a technician.
  - It assumes that a physicist is checking the results, adjusting options, paying attention (what all of you in this room are paid to do)
  - Particularly at Medical Physics energies, Geant4 physics is being actively developed at every release.
- You need to read the release notes
  - Because Geant4 has so many different application domains, there will be a lot in those notes that doesn't matter to you (processes above 100 GeV, exotic particles, etc.). You'll have to wade through that.
  - I'll point out a few specific physics changes later, but this can't take the place of you reading those full release notes.
- And though we test a large number of example applications at every release, there may be something in your particular application that we did not test.
  - You need to be watchful.
  - Later tonight let's come back to whether this group could take an active role in helping with those tests.

Nano-scale Effects

See separate talk later in this session about the Geant4-DNA Project

- DNA
- RBE
- Open to new collaborators worldwide

PENELOPE Interface

For modeling of electrons and photons down to 50 eV

- Direct connection from Geant4 to PENELOPE
  - not just a copying of algorithms
- Still a beta
  - available from the SLAC Geant4 group to those interested in testing and publishing on this with us

PENELOPE Example

Makoto Asai (SLAC)

Standard EM down to 500 keV
Penelope from there to 50 eV

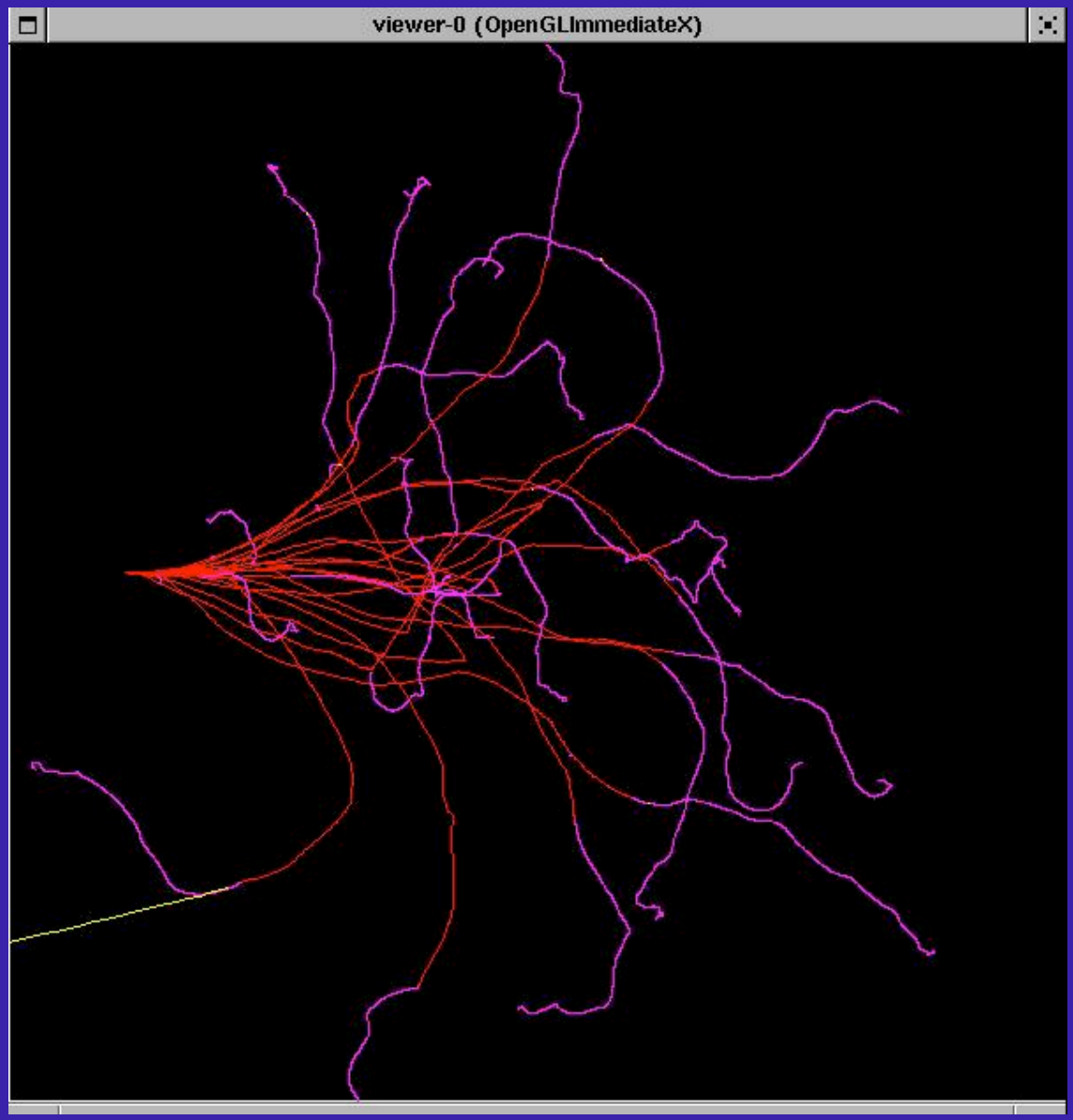
Red : electrons with Standard EM

Pink : electrons with Penelope

Blue : positrons with Standard EM

Light Blue : positrons with Penelope

Yellow : gammas with Penelope



Technical Challenge #1 for Geant4 Med Apps: Accuracy

Geant4 developers get this

- Geant4 was not originally optimized for medical physics energies
  - but no intrinsic reason for this, just funding history
- Geant4 physics options are highly configurable
  - many choices of models
  - ability to adjust models or implement new ones
  - flexible architecture can take us where ever we want to go

Validation Studies

Anything you read about Geant4 based on a 5 year old code version is irrelevant.

- Accuracy of EGSnrc, Geant4 and Penelope Monte Carlo systems for simulation of electron scatter in external beam radiotherapy
  - Bruce A Faddegon, Iwan Kawrakow, Laszlo Urban, Joseph Perl, Yuri Kubyshin and Josep Sempau
  - submitted to Physics in Medicine and Biology
- Benchmarking of Monte Carlo Simulation of Bremsstrahlung from Thick Targets at Radiotherapy Energies
  - B Faddegon, M Asai, J Perl, C Ross, J Sempau, J Tinslay, F Salvat
  - Medical Physics, 2008 Oct;35(10):4308-17
- Monte Carlo Simulation of Large Electron Fields
  - B Faddegon, J Perl, M Asai
  - Physics in Medicine and Biology, 53, 1497–1510, 21 February 2008
- Verification of Bremsstrahlung Splitting in Geant4 for Radiotherapy Quality Beams
  - J Tinslay, B Faddegon, J Perl, M Asai, poster presented at the American Association of Physicists in Medicine, Minneapolis, 2007, SU-FF-T-447, Med Phys 34(6):2504, June 2007

- Other Huge Validation Efforts, especially for Hadronics, by SLAC Geant4 Colleagues Dennis Wright and Tatsumi Koi
- Many many more validation studies from our colleagues around the world

DICOM Navigation

G4NestedParameterization and G4RegularParameterization are both reasonable options for handling large numbers of voxels with reasonable speed and memory

- Bring typical DICOM memory footprints down from 1GB to 25MB
- G4RegularNavigation
  - A navigator that takes advantage of regularity of voxel geometries
  - See DICOM example for details
  - Option to skip boundaries if next voxel is of same material type
    - First release did not correctly handle dose sharing when skipping boundaries
    - Corrected in most recent beta release

Smart Particle Stack

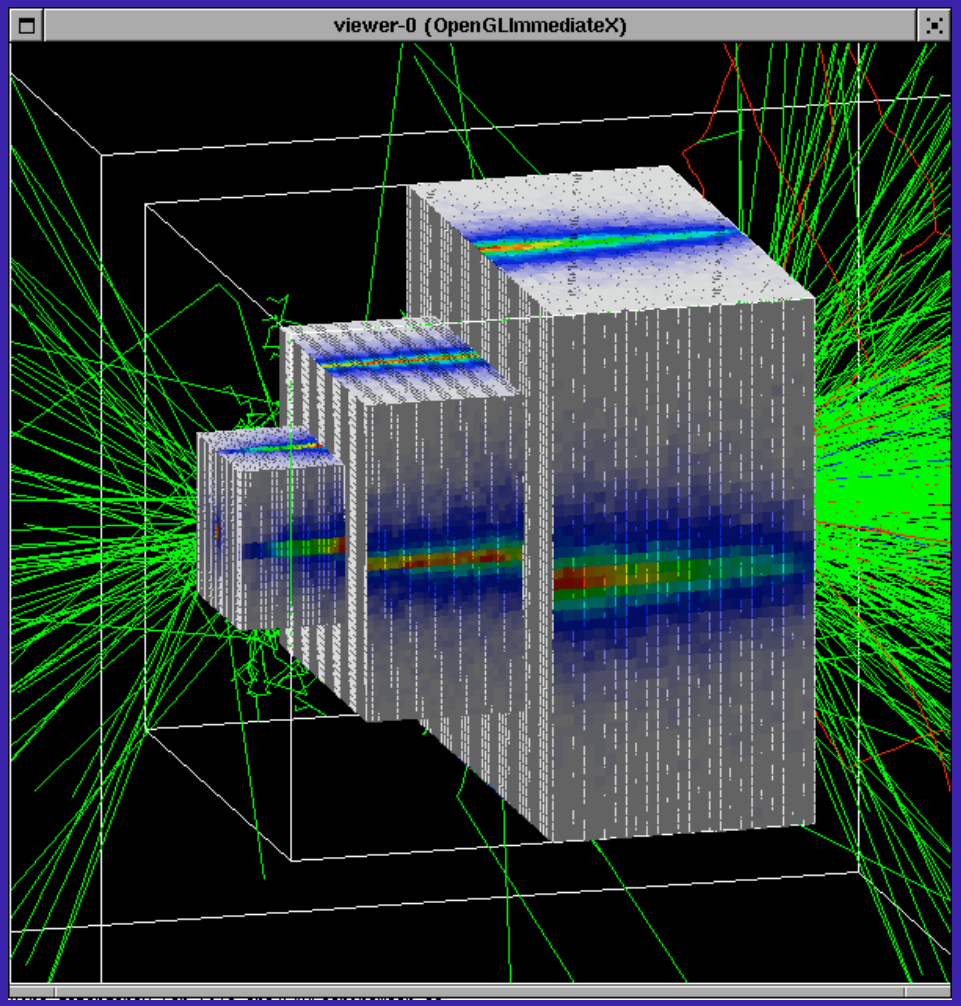
New option in particle stack allows you to iterate to next particle of a given type rather than just next particle

- Reduces time cost of swapping cross section tables in and out of cache
  - Even if have plenty of RAM, local cache is a constraint
- Not yet in release, but can be made available by request from SLAC group

Scoring

For most cases, it is no longer necessary to score dose by hand, from hand-coded “sensitive detectors” or from user stepping actions

- Standard scorers can be called from C++ or can be invoked by commands
  - Energy
  - Flux
  - Charge
  - Surface Current
  - Population, etc., etc.
  - See geant4/digits_hits/scorer for all the options
- Standard filters
  - control which kinds of particles get scored
- Geometry options
  - Rectangular
  - Cylindrical
  - Spherical



Control Scoring from Commands

For command-based scoring, add the following in your main:

- #include "G4ScoringManager.hh”
- G4ScoringManager::GetScoringManager();

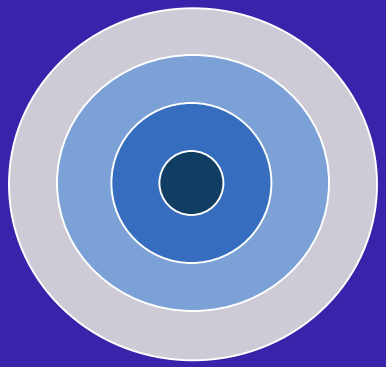
Then control from macro

```
# Define mesh
/score/create/boxMesh inputMesh
/score/mesh/boxSize 20. 20. .1 cm
/score/mesh/translate/xyz 0. 0. -180. cm
/score/mesh/nBin 100 100 40
#
# Specify quantity to score
# Can include filtering to score only specific particles
/score/quantity/flatSurfaceFlux fluxTotal 1
/score/quantity/flatSurfaceFlux fluxProton 1
/score/filter/particle protonFilter proton
/score/quantity/flatSurfaceFlux fluxNeutron 1
/score/filter/particle neutronFilter neutron
#
/score/close
```

```
# Define as many additional meshes as you wish
/score/create/boxMesh outputMesh
/score/mesh/boxSize 20. 20. .1 cm
/score/mesh/translate/xyz -180. 0. 0. cm
/score/mesh/rotate/rotateY 90.
/score/mesh/nBin 1 1 1
#
/score/quantity/flatSurfaceFlux fluxTotal 1
/score/quantity/flatSurfaceFlux fluxProton 1
...
# Perform the run
/run/beamOn 500000
#
# Dump scored results to files
/score/dumpAllQuantitiesToFile inputMesh outputAt1.txt
/score/dumpAllQuantitiesToFile outputMesh outputAt2.txt
```

Details on Scoring

- Command-based option currently only implemented for rectangular geometry
  - For cylindrical or spherical geometries, invoke these scorers from C++
- For cylindrically parameterized geometries, area is not correctly computed.
  - all rings are treated as if had area of entire cylinder face



  - still worthwhile using these ready-made scorers
  - simple matter to rescale to correct ring area yourself during or after output
  - will be corrected in next release

Visualization

If you have your own G4VisManager, you can almost certainly remove it

- G4VisExecutive
  - Generic Vis Manager
  - Provides all reasonable defaults (probably more than you currently have)
  - Respects flags you set during Geant4 ./Configure -build
  - Makes it so when we add new Visualization options, they'll automatically be available to you
- Just add the following in your main:

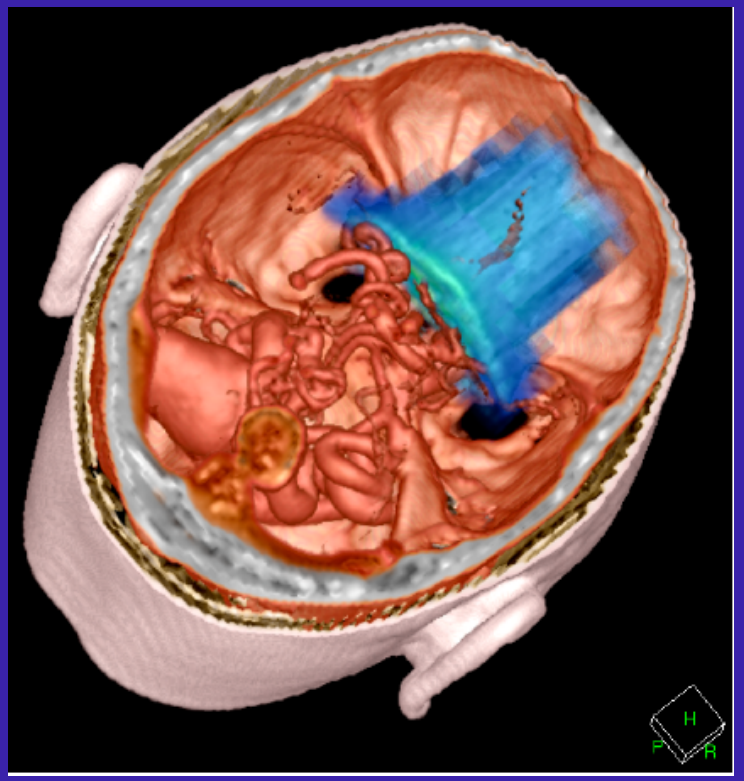
```
#include "G4VisExecutive.hh"
...
G4VisManager* visManager = new G4VisExecutive;
visManager->Initialize();
```

- G4Trajectory
  - If you implemented your own Trajectory, it was probably to assign some visualization attributes. These are done better now by the default trajectory.
  - Default trajectory understands wide set of vis options to control trajectory representation from commands

gMocren

Great tool available for volume visualization

- From JST/CREST project (Japan) to improve Geant4 for medical physics
- Able to visualize:
  - Volume data
    (including overlay of more than one set)
  - Trajectories
  - Geometry
- Runs on:
  - Windows and Linux
  - Mac will likely happen soon
  - Based on a commercial package but offered freely to all Geant4 users
  - http://geant4.kek.jp/gMocren
  - Installation is straightforward, follow the Download link on the above page
    - First run gMocren's one-click installer
    - Then, inside C:\Program Files\gMocren\gtk, you will find the one-click installer for gtk

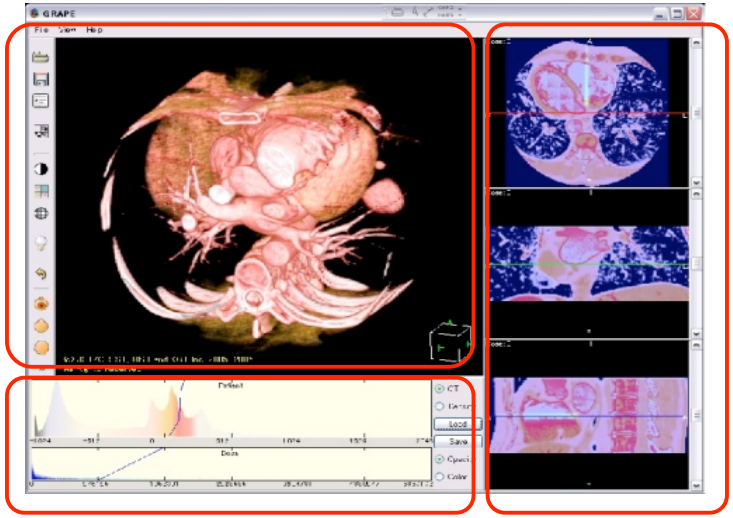


gMocren : A Visualization Tool

http://geant4.kek.jp/gMocren/

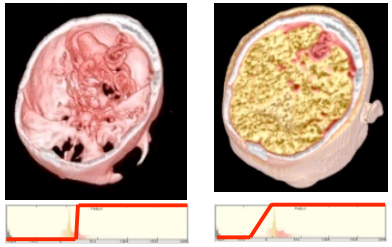
gMocren and utility software are freely available.

3D (ray casting) 2D (MPR)



Opacity curve and color map editor

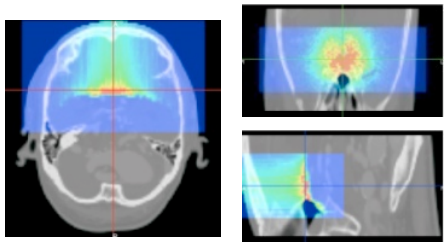
Opacity curve and color map editor



free hand or templates with WW&WL editing

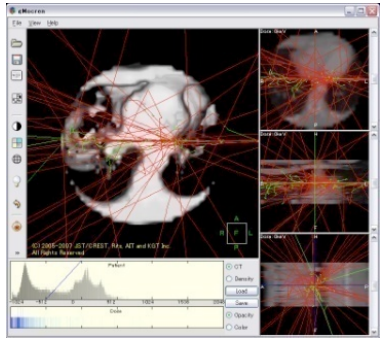
Supported system :
- Windows 2k/XP or PC Linux OS
- Pentium 4 or faster
- more than 1 GB (recommend)

Calculated dose distribution



color mapping

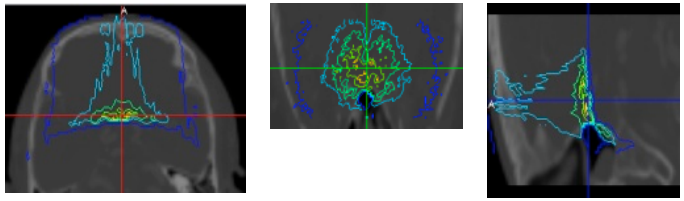
Particle trajectories



Trajectory information in the simulation is available.

Functionality Requirements :

- To visualize
  - the modality image used by the simulation,
  - the calculated dose distribution and
  - the particle trajectories
  - in an agreeable speed
- Transfer function editor
- Multi-platform



contour plot

Key Geant4 Examples (1 of 3)

The following examples are most worth studying for Medical Physics users (find these in the examples/extended and examples/advanced directories)

- Brachytherapy (in examples/advanced)
  - Energy deposited in Phantom for various sources
- Hadron Therapy (in examples/advanced)
  - Based on the Catania proton therapy facility
- Medical Linac (in examples/advanced)
  - Basic x-ray linac
  - Not updated in some time. Contact other users for more recent examples they may be willing to share (I have one). Many users have done these, but once they become useful they tend to contain vendor proprietary information
- Gamma Therapy (in examples/extended/medical)
  - Basic x-ray linac
  - Simplified geometry, mainly to demonstrate EM options

Key Geant4 Examples (2 of 3)

- DICOM (in examples/extended/medical)
  - Data import, Hounsfield conversion
  - Demonstrates several different options for parameterization and navigation
- Fano Cavity and Fano Cavity 2 (in examples/extended/medical)
  - Demonstrates the most precise physics for this case
  - Includes use of single coulomb scattering near boudaries
  - dose in one is from photon beam, in the other is from extended electron source
- RE02 (in examples/extended/runAndEvent)
  - Demonstrates use of the built in scorers, calling them from C++
- RE03 (in examples/extended/runAndEvent)
  - Demonstrates use of the built in scorers, calling from commands
- TestEM0 through 18 (in examples/extended/electromagnetic)
  - Demonstrates all of the features and details of the Stanard EM package
  - If you raise any issue with the EM experts, it is in one of these tests that they will attempt to replicate it

Key Geant4 Examples (3 of 3)

- Micro Beam (in examples/advanced)
  - Cellular irradiation beam line at CENBG, Bordeaux, France
- Micro Dosimetry (in examples/advanced)
  - Demonstrates G4DNA process
  - Note that this example is quite old, and there is significant new work in this area
  - See later talk on Geant4-DNA Project
- Nano Beam
  - Beam optics of the CENBG beam line, Bordeaux, France
- Bremsstrahlung Splitting (not in release, see SLAC Tutorial)
  - Demonstration of this variance reduction technique
    - http://geant4.slac.stanford.edu/SLACTutorial07/HandsOn5/HandsOn5.htm
  - Additional biasing techniques discussed at:
    - http://geant4.slac.stanford.edu/SLACTutorial07/EventBiasing.pdf

Activities in Europe and Asia

Geant4 Medical developers work together closely on a worldwide basis.

I'll show some slides from just a few key institutions.

- Catania group, Italy
  - Hadron Therapy
- Madrid, Spain
  - GAMOS
- Bordeaux, France
  - Microdosimetry, DNA and RBE
- JST/CREST, Japan
  - Hadron Therapy
  - gMocren

and even Goyang, Korea and Wollongong, Australia

The Geant4 group of LNS-INFN (Italian National Institute for Nuclear Physic)

Laboratori Nazionali del Sud - Catania

G. Cuttone research Director and responsible for the Italian Geant4-INFN project and GEANT4 Hadronic, Advanced and LowE WGs

G.A.P.Cirrone, PhD researcher at LNS, coordinator of the GEANT4 Advanced example Working group also Hadronic and LowE WGs

G.Russo, Medical Physicist, GEANT4 Advanced Example and LowE WGs

F.Di Rosa, Medical Physicist, GEANT4 Advanced Example and LowE WGs

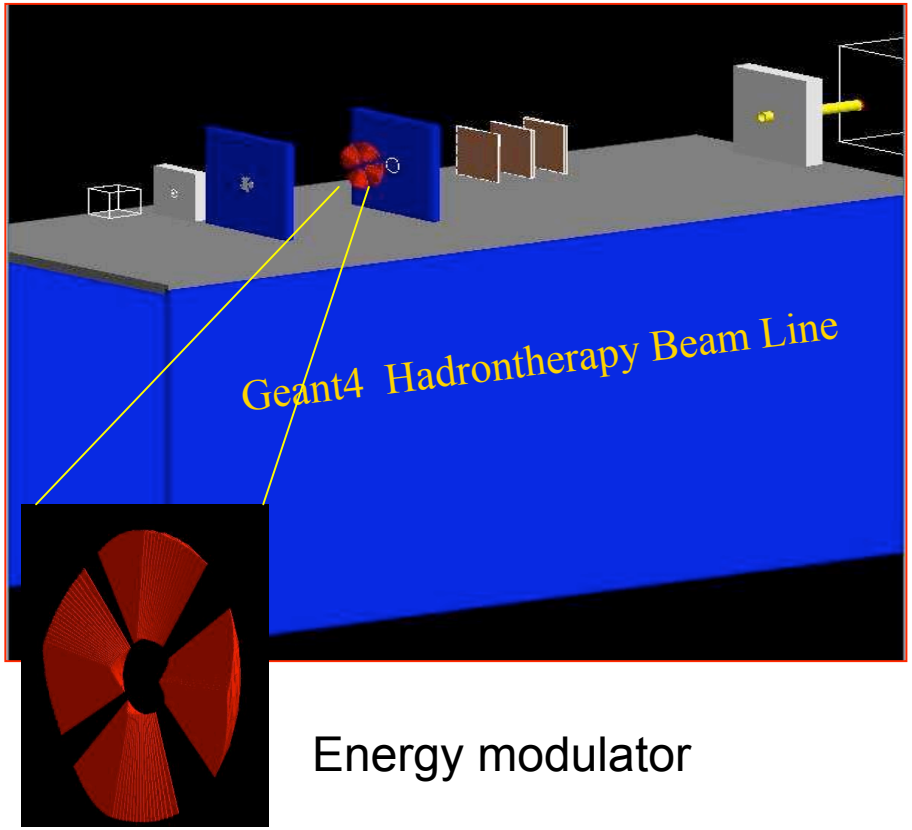
F.Romano, Nuclear Physicist, GEANT4 Hadronic WG

…. and two students and two INFN fellows

Our web site
http://geant4infn.wikispaces.com/

GEANT4 ACTIVITY ON PROTON/ION THERAPY

- Dose distributions measurements and comparison with experiments, beam line optimization, treatment planning system verification, Linear Energy Transfer effect studies, ….
- Maintain the Geant4 advanced example, *Hadrontherapy*, simulation of generic proton/ion therapy beamline in all its elements (from transport elements to detectors for dose distribution measurements)



Energy modulator

Geometry from text files

- Based on simple tags, with same order of parameters as corresponding GEANT4 classes
- Available since geant4.9.2

MATERIALS: Isotopes, Elements, Simple materials, Material mixtures by weight, volume or number of atoms, GEANT4 intrinsic materials (NIST database)

SOLIDS: All GEANT4 "CSG" and "specific" solids, Twisted solids, Tesellated solids, Boolean solids

PLACEMENTS: Simple placements, Divisions, Replicas, Parameterisations (Linear, circular, square, 3D voxels)

COLOUR

VISUALISATION ON/OFF

PARAMETERS: Can be defined to use them later

```
:P InnerR 12.
:VOLU yoke :TUBS  Iron   3  $InnerR  820.  1270.
```

ARITHMETIC EXPRESSIONS:

```
:SOLID  yoke TUBE sin($ANGX)*2+4*exp(1.5)  820.*m 1270.*cm
```

INCLUDE OTHER FILES (hierarchical approach): #include mygeom2.txt.

```
:ROTM R00 0. 0. 0.
:VOLU world BOX 100. 100. 100. G4_AIR
:VIS world OFF
:VOLU "my tube" TUBE 0. 10. 20.  G4_WATER
:P POSZ 5
:PLACE "my tube" 1 world R00 0. 0. -$POSZ
:VOLU sphere ORB 5.  G4_Si
:PLACE sphere 1 "my tube" R00 0. 1. $POSZ
```

- Users can extend it: add new tags and process it without touching base code
- Can mix a C++ geometry with a text geometry
- Automatic conversion GEANT4 in memory geometry → text files

GAMOS

✓ **GAMOS is a user-friendly and flexible framework to do medical simulations**

- ✓ **EASY**: many utilities allow to do full Geant4 simulation through **user commands**
- ✓ **FLEXIBLE**: **plug-in's** allow to **extend functionality** by converting **C++** classes into **user commands,** by adding one or a few lines

✓ **Special effort to provide analysis and optimisation tools**

- ➢ +200 histograms & 23 scorers (with errors) combined with 89 filters & 12 classifiers, all managed with simple user commands: **vast amount of possibilities to extract required information without C++**
  - ➢ User actions/scorers/filters/classifiers are plug-in's: **easy to add a new one**
- ➢ several tools to optimise CPU performance

❑ **GAMOS core is application independent**

- ✓ Several **medical applications** are being built on top of GAMOS core
  - ✓ **PET and radiotherapy fully functional**
- ✓ **About 20 groups are already using GAMOS, not only in the medical field**

❖ **The core of GAMOS will be included into Geant4**

http://fismed.ciemat.es/GAMOS

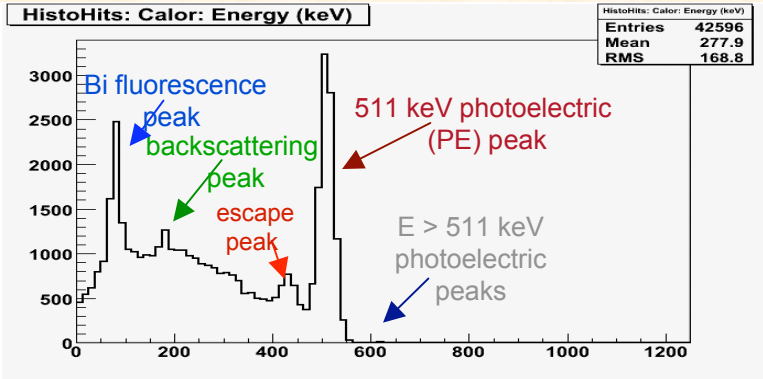
PET

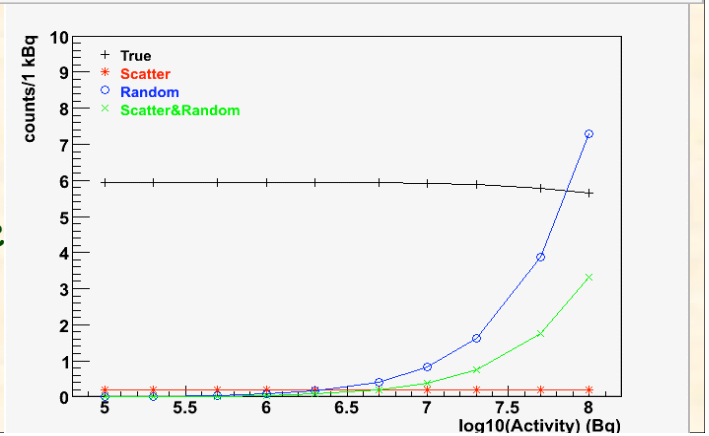
Full simulation with simple user commands

- Any PET detector can be simulated with simple text format
  - Utility to create simple geometries from a few parameters
- Automatic creation of sensitive detectors and hits with user commands

```
/gamos/assocSD2LogVol GmSDSimple SD_TYPE VOLUME_NAME
```

- Writing hits into text or binary file
- Digitizer and reconstructed hits framework and examples
- Detector effects
  - Energy resolution
  - Time resolution
  - Dead time (paralyzable / non-paralyzable)
  - Measuring time
  - PET coincidence time
- Table of PET classification
  - True / scattered / random coincidences
  - PET line far or close to vertex
  - Optionally merge hits if there is more than one because of Compton interactions
- Several control histograms

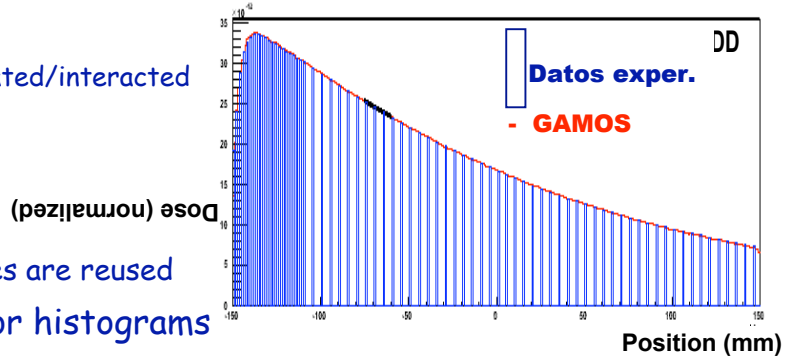


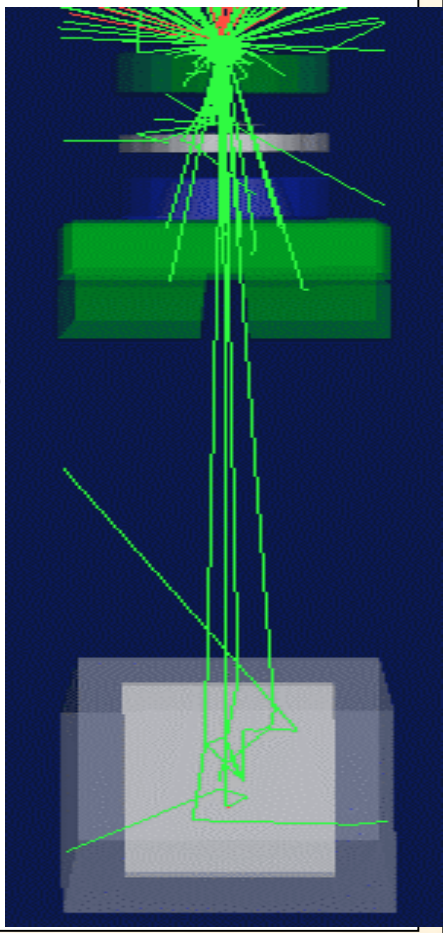


gamma/electron radiotherapy

Full simulation with simple user commands

- Any accelerator (with any kind of MLCs) can be simulated with simple text format
  - Building complicated parts (MLCs/jaws/applicators) with a few parameters under progress
- Write/read phase space files in IAEA format
  - Reuse phase space particles
  - Save extra info:
    - Regions particle traversed/created/interacted
    - Particle origin Z
- Dose in voxelised phantoms
  - Errors included
    - With correlations if particles are reused
  - Save in text file, binary file or histograms





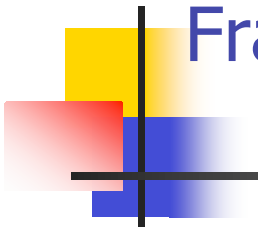
☺ We have developed a tool that allows to **insert objects in phantom geometries** and produce the interactions in them

✓ Realistic simulation of brachytherapy sources or ionisation chambers even if overlapping with voxels!

☺ We have reached CPU times similar to EGSnrc/DOSXYZnrc

☺ We have developed several variance reduction techniques

- Preliminary results: 40 times less time for same dose error

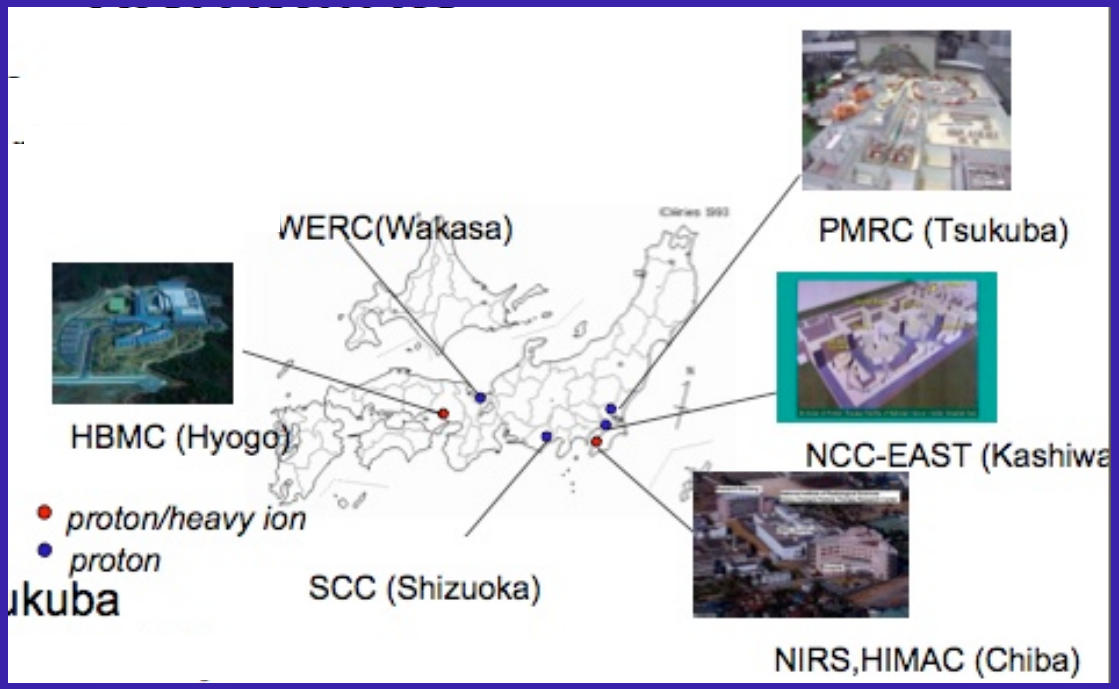


France, Geant4-DNA Project

- **See later talk on this project**

Geant4 Medical Physics in Japan

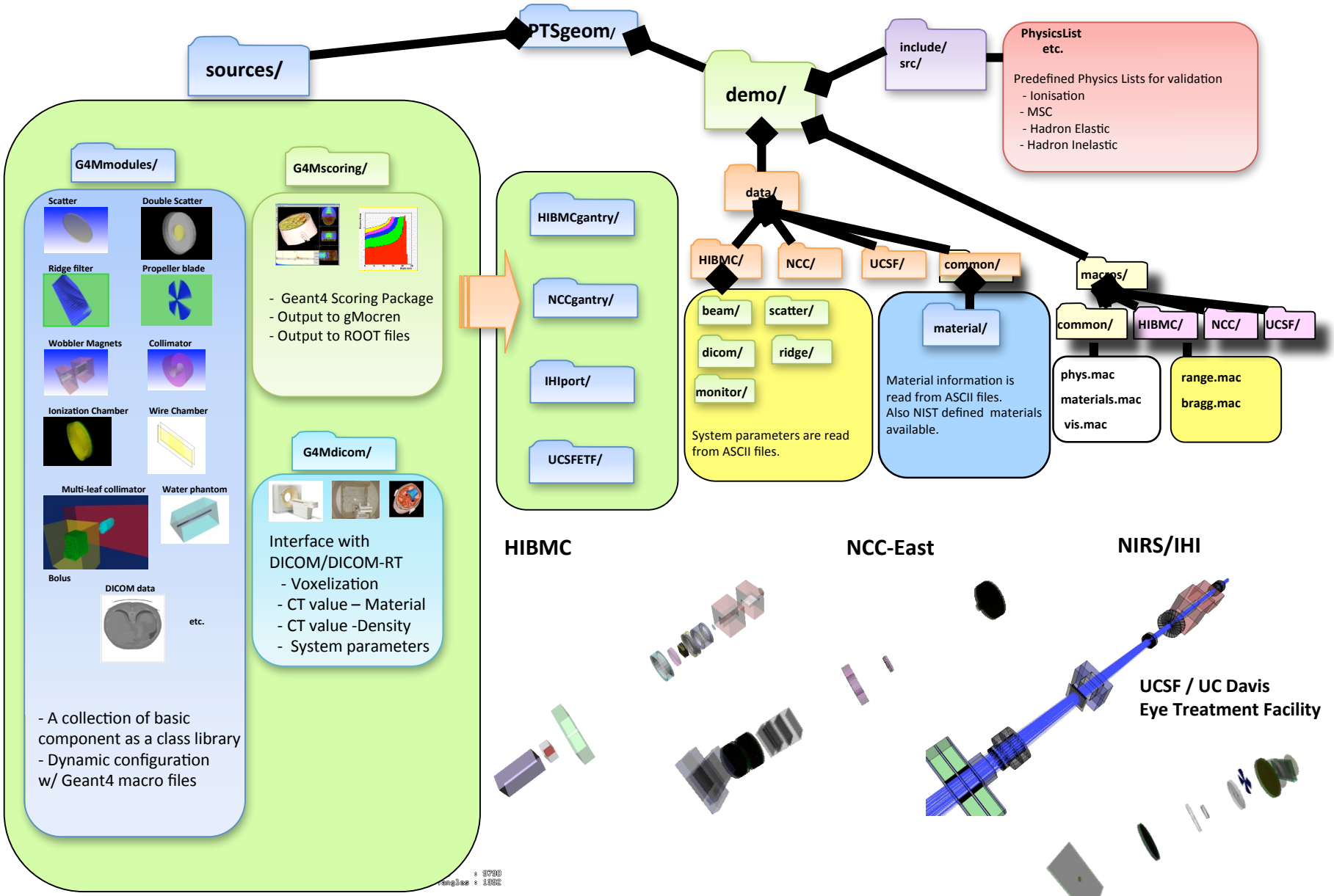
- Large concentration of Proton and Ion therapy machines



- Major 5 yr Geant4 project led by Takashi Sasaki with Koichi Murakami, Akinori Kimura, Tsukasa Aso and colleagues
  - http://g4med.kek.jp/

- Asia Simulation Conference 2009, JSST 2009
  - October 7 - 9, 2009, Ritsumeikan University, Shiga, Japan
  - http://www.jsst.jp/e/asc2009

Software Structure for Particle Therapy Simulation

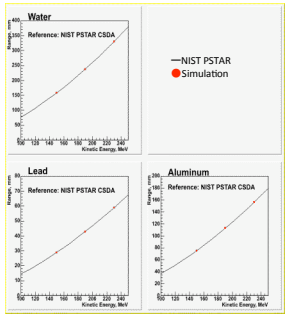


Validation Activities

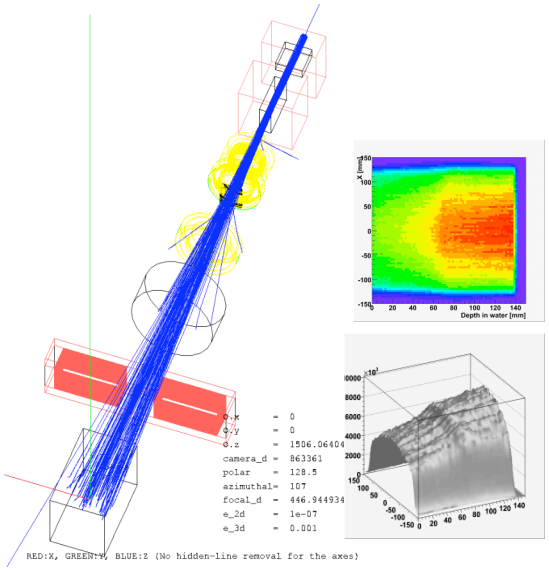
for Proton Therapy

Material Properties

Proton range

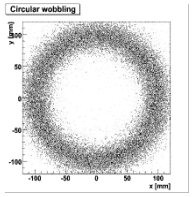


Stopping Power/Range , checked with NIST data

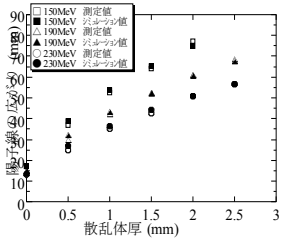


Beam Delivery system validation

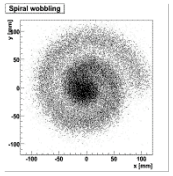
Wobbler Magnet



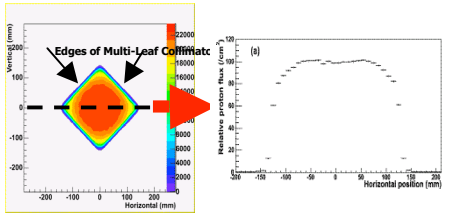
Lead Scatterer



Wobbler demonstration: Spiral Wobbling



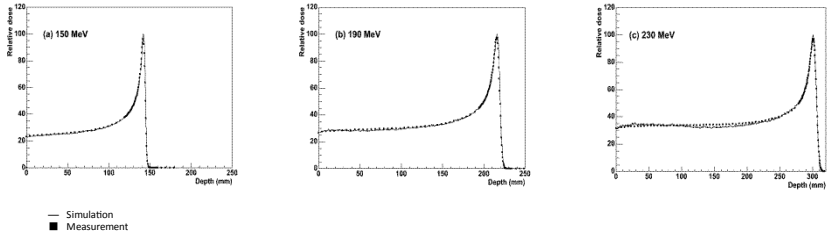
Uniform Irradiation Field



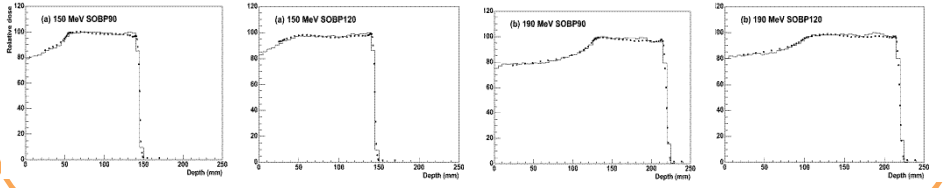
Depth-Dose distribution

IEEE TNS V52,Issue4,(2005)pp.896-901

Bragg Peak (with Wobbler and Scatter)

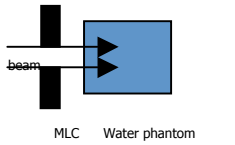


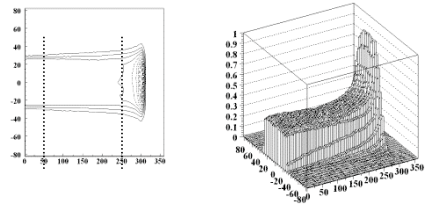
Spread Out Bragg Peak (SOBP) (with Wobbler, Scatter, and Ridge filter)



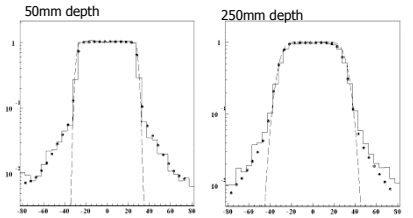
Nuclear Interaction Effect

by T.Akagi (HIBMC)





● : Measurements
— : TPS calculations
□ : G4 (histograms)

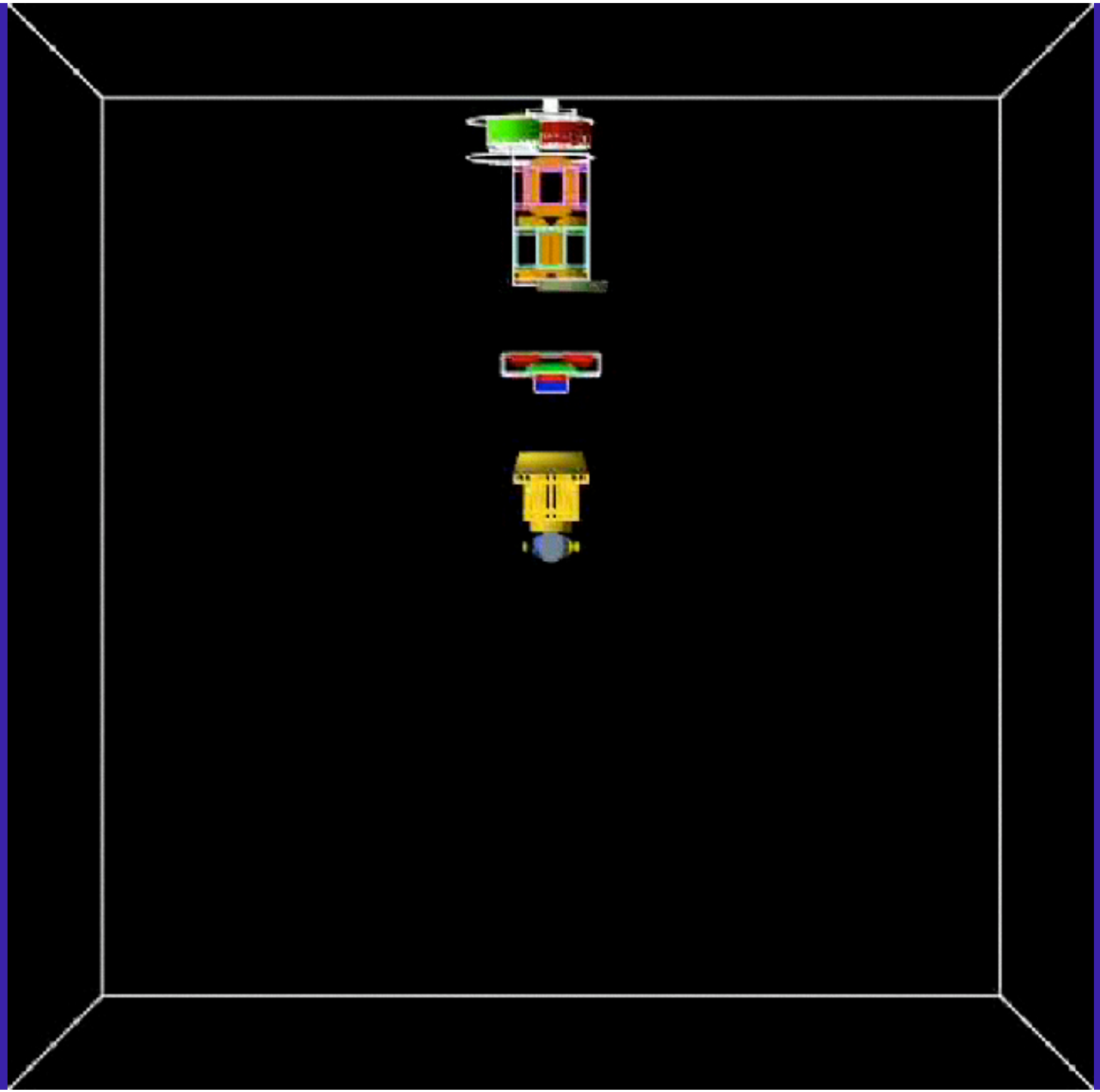


Dr. Takashi Akagi and Dr. Tomohiro Yamashita, Hyogo Ion Beam Medical Center

Source:

Jungwook Shin

Proton Therapy Center, NCC, Goyang, South Korea



Biological effect of a magnetic field

Effect of a magnetic field on dose distribution

- High magnetic fields (MF) of 3-6 T confine high energy electrons from medical LINAC
- Deposition of absorbed dose and biological effect of most kinds of radiation due to low energy electrons
- **MF affecting the distribution of low energy electrons without changing the absorbed dose**

Radiobiology

- **Target volume** in radiotherapy:
  DNA-segment of 10 base pairs,
  2.3 nm in diameter, 3.4 nm in height
- DNA strand breaks induced by energy deposition events
- Complex DSB induced by the secondary electron track, leading to mutation or cell death

WHY?

Biological effect

It was hypothesised at CMRP:
For cell lines, a decreased survival rate and a higher number of double-strand breaks (DSB) can be found when irradiated in a 0.8-1.5 T MF

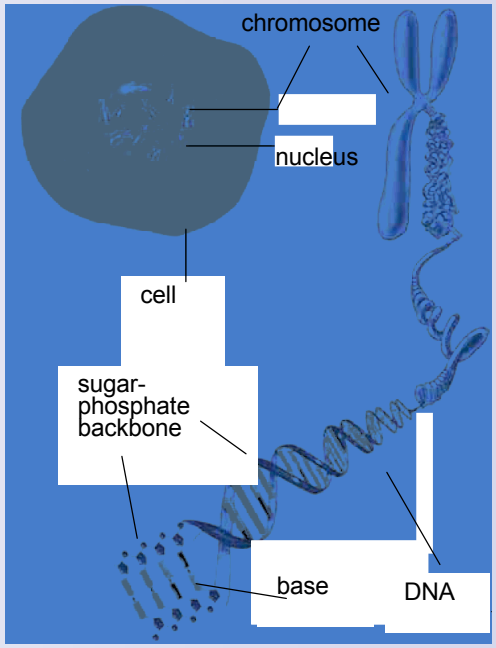


Fig.1: DNA structure
(National Institute of General Medical Science)

Communication Channels

As the medical applications community has grown, so has the pool of potential collaborators, mentors, advisors.

Stay in Touch! There's no need to reinvent everything yourself and there's plenty of innovative work to go around.

- G4EMU (European user group somewhat analogous to G4NAMU)
  - http://g4emu.wikispaces.com
  - they are more of a Wiki, whereas we've been mainly a mailing list
- Geant4 Medical Physics Wiki
  - https://twiki.cern.ch/twiki/bin/view/Geant4/Geant4MedicalPhysics
  - links to talks, publications and other resources
  - moderated, not entirely open, but new authors are welcome to join
- Geant4 Medical Applications Forum
  - http://hypernews.slac.stanford.edu/HyperNews/geant4/get/medical_app.html
  - seems to have recently reached critical mass.
    - For example, nice discussion recently about how to calculate statistical uncertainties.
  - search engine for these forums work very well, so don't forget to use the search

What was New in Release 4.9.1

December 2007

- EM Changes Summarized in
  - *Changes in Geant4 Electromagnetics from Release 4.6.1 to 4.9.1*
    J Perl, Technical Note SLAC-TN-08-002, SLAC, 4pp, 25 March 2008
  - Summarize changes that have occurred in Geant4 electromagnetics since the publication of the significant paper by E. Poon et. al that used release 4.6.1. The focus is on changes that would be of relevance to medical physics applications.
- New voxel option, G4RegularNavigation
- Alpha release of QMD (quantum molecular dynamics) model for nucleus-nucleus interactions
- Beta release of Command-based scoring
  - Leveraged a very large amount of work on “Parallel Worlds”

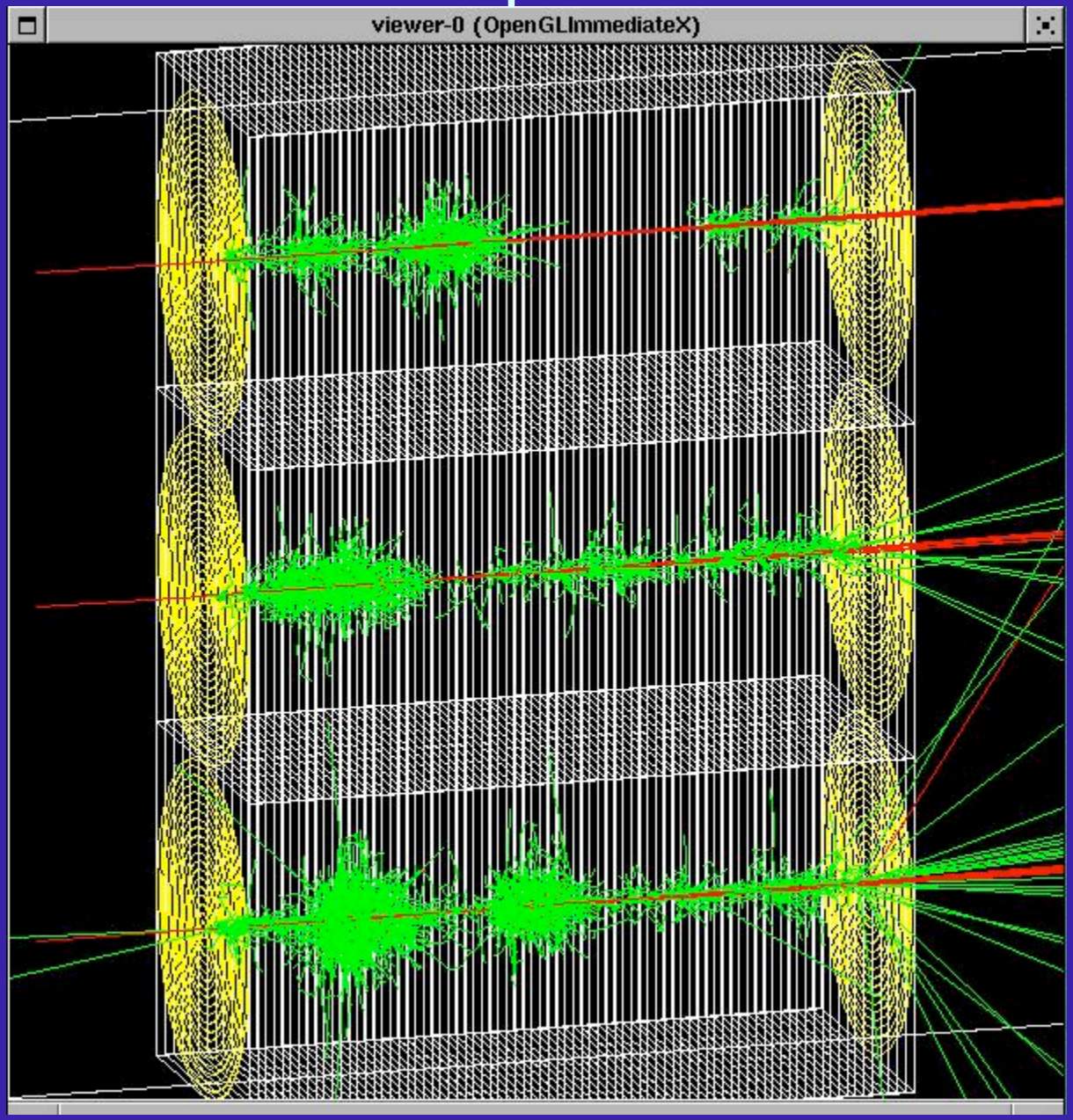
Parallel Worlds - Example N07

Mass geometry

- sandwich of rectangular absorbers and scintillators

Scored in overlaying parallel geometry

- of cylindrical layers



What was New in Release 4.9.2 (1 of 3)

December 2008
(showing only those items that may be of particular interest for medical physics)

- EM Physics
  - Low Energy processes handle more X-ray emission effects
  - New stopping power model for ions using ICRU 73
  - Improvements to Geant4-DNA processes
  - Improvements to multiple scattering (G4UrbanMscModel2)
  - G4EmStandardPhysics_option3 for precision simulations at scale much below 1mm
- Hadronic Physics
  - Binary cascade, changes in the pre-compound and de-excitation code
  - Beta release of QMD model. vaid from 50 MeV to 5 GeV
- Transportation in fields
  - New options let you control trade-offs between accuracy and speed
- Scoring
  - Beta release of cylindrical scoring meshes

What was New in Release 4.9.2 (2 of 3)

- Improvements to code for some solids
  - speed up tracking in G4Tubs and G4Cons
  - speed up and improve accuracy in G4Polycone and G4Polyhedra
- G4RegularNavigation
  - corrected handling of dose sharing for boundary skipping
- Upgrade of GDML capability
  - allow export as well as import
  - support more kinds of solids and parameterizations
- Ability to build geometry from ascii files
  - another way to build geometry without C++ (in addition to GDML)

What was New in Release 4.9.2 (3 of 3)

- New Data Sets
  - G4NDL 3.13 add isotopes in neutron files, updated cross sections
  - G4EMLOW 6.2 new DNA tables
- New CLHEP version
  - update masses and widths of particles to PDG-2008
  - fix for storing/restoring status of Random engines on 64-bit platforms
- Updated Step-by-Step Installation Guides
  - http://geant4.slac.stanford.edu/installation

Why a Beta Release?

- Gean4 is in a period of testing and subtle improvements
  - We don't see enough major new features to justify bothering the overall user base with a new release. Want to wait until December.
  - But we also have concern about going a full year without having at least some of our users (outside of the collaboration) shake down the code.
  - So we've called this a Beta release. Play with it only if you like, or if there is something there that you really need.
  - For high precision studies at medical physics energies,
    I would say yes, use the Beta

What was New in Release 4.9.3beta1

- EM Physics
  - Retuned multiple scattering model (G4UrbanScatteringModel2)
  - Many improvements for Geant4-DNA
- G4RegularNavigation
  - Corrects which voxel dose is assigned to in special case where boundary-skipping is turned on (this is the non-default case, navigator steps across boundary if adjacent voxels have same material)
- Examples
  - Hadrontherapy example significantly revised, including new README
    - pdf format, far more detailed than README for any other example
  - Microdosimetry example now demonstrates Geant4-DNA processes

Geant4 Release Schedule

December 18th, 2009, Geant4 version 4.9.3

- This will be a “minor” release, not a “major”
  - This means your existing 4.9 user code is guaranteed to work with the new release
  - Improvements, bug fixes, but no interface changes or removal of older features
  - Any code that worked since release 4.9.0 (June 2007) will still work
- What will be in the release (beyond what’s already in the beta):
  - Beta release of Reverse Monte Carlo
  - Check and alert for improper physics list (e.g., EM without e-/e+/gamma/p)
  - Introduce spherical mesh for command-based scoring
  - Prototype multi-core extension of the kernel
  - gMocren driver integrated directly into visualization system
- You can count on the release date
  - Release team has never missed a date

Improved Funding Outlook

Last year at this time I told you that funding for core Geant4 development in the US was very tight (due to very tight budgets overall in HEP). Better Now!

- DOE is now providing line-item support for Geant4
  - First time Geant4 has had its own DOE funding lines, rather than being dependent on sub-awards from the HEP experiment contracts
  - SLAC and FNAL are hiring for core Hadronics and Speed issues
- NASA continues to provide some direct support
  - Limited, but it's something. Many of their needs correspond closely with those of Medical users (dose, ion physics, etc.)
- NIH is now providing R01 funding for core developments for Proton Therapy
  - New R01 for Paganetti, Faddegon and Perl
  - Fast and Easy to Use Monte Carlo System for Proton Therapy
  - Aimed at all users, research and clinical, free of charge, for windows, linux and mac (we are interviewing post docs this week)
- There's plenty more work to be done. Let's collaboration on some proposals
  - For example, can we create tools to make Geant4 easier to use for Brachy?

Upcoming Geant4 Tutorials

- SLAC, November 2-6, 2009
  - http://www-public.slac.stanford.edu/geant4/Tutorial2009.asp
  - No charge, but pre-registration required
  - Will fill by end of this week
  - If you don't get in, do go on the waiting list, spaces will probably open up (and contact me personally if it's very important for you to get in)
- Senegal, Mid-November 2009 (still in final planning)
  - major involvement by the SLAC team
- Japan, Dec 7-12, 2009 (probably)
- Contact me to talk about arranging future tutorials

geant4.slac.stanford.edu

Geant4 @ SLAC

U.S. DEPARTMENT OF ENERGY

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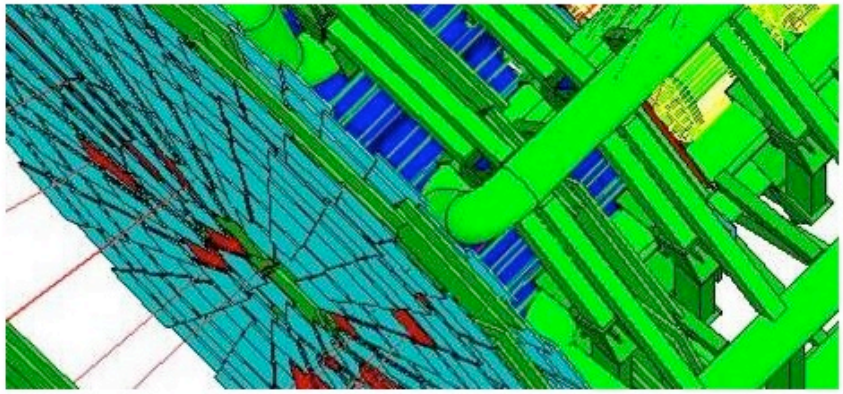


Geant4 at SLAC

Geant4 is a toolkit for the simulation of particles passing through and interacting with matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. Geant4 is developed and maintained by the international Geant4 Collaboration. Members of the SLAC Geant4 team have been actively participating in the Geant4 collaboration since its beginning, and currently take leading roles in several key areas of the collaboration. SLAC Geant4 members made significant contributions in simulation development for the BaBar experiment at SLAC, which pioneered the use of Geant4 in the simulation of high energy physics experiments. The SLAC Geant4 Team supports the use of Geant4 for on-site users including ATLAS, BaBar, Enriched Xenon Observatory (EXO), Fermi Gamma-ray Space Telescope, and International Linear Collider. The team also supports general Geant4 users of all application domains in North America and beyond.

News

- *Jun. 12, 2009* - Step by Step Installation Guide is updated for Geant4 v9.2p01.
- *Jun. 05, 2009* - Geant4 version 9.3-beta is released.
- *Mar. 16, 2009* - Geant4 version 9.2 patch01 is released.

Events

- *Jul. 26, 2009* - Annual G4NAMU meeting, Anaheim, CA
- *Oct. 15-22, 2009* - 14th Geant4 Collaboration Workshop and Users Conference, Catania, Italy

Visits

Visitors

160	18	7
34	15	6
29	14	6
27	13	5
20	11	4
18	11	4

FLAG counter

since Apr.24,2009

SLAC Geant4 Group

- Looking to increase engagement with interested groups outside of our our original high energy and nuclear physics community

- Makoto Asai:
  - Expert in Geant4 kernel, tracking, geometry
  - Coordinator of Geant4 run, event and detector working groups
  - Geant4 collaboration deputy spokesperson
  - Geant4-Penelope interface
- Tatsumi Koi:
  - Expert in Geant4 hadronic interactions, neutrons and ions
  - Significant experience in spacecraft radiation effects
- Joseph Perl:
  - Coordinator of Geant4 visualization working group
  - Coordinator of Geant4 North American Medical Users Organization
- Dennis Wright:
  - Coordinator of Geant4 hadronics working group

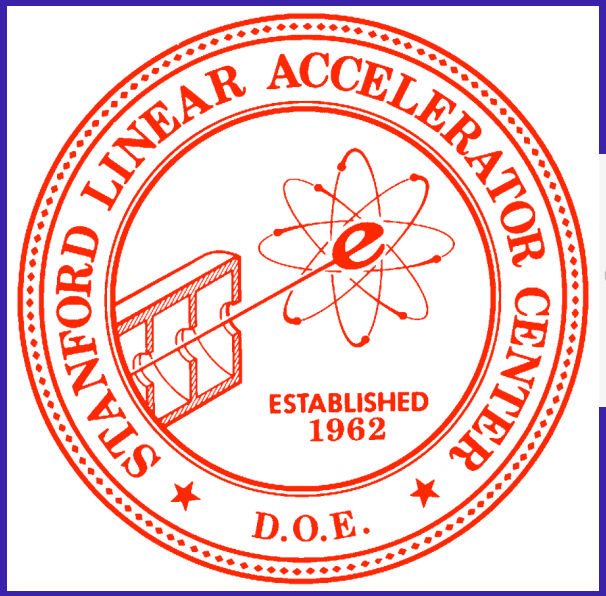
Upcoming Geant4 Users Workshop

Catania, Italy

- User Workshop, October 15-17
  - Timing was adjusted specifically to accommodate medical users
    - original plan had workshop overlapping with key medical meeting, MCTP2009, Cardiff
  - As it is now, you can make a pleasant european tour by starting at the Geant4 Workshop in Catania and then heading on to Cardiff for MCTP.
  - Great opportunity to connect names with faces in the Gean4 collaboration
  - Always a pleasant meeting
- Collaboration Meeting, October 19-22
  - Can be open to non-members by special arrangement (contact me)
  - Invited medical physicists have had great impact on the collaboration by attending these sessions

Geant4 is Flexible and Free.
http://geant4.web.cern.ch/geant4

Teach yourself from course materials at:
http://geant4.slac.stanford.edu/SLACTutorial07
or attend the next tutorial at SLAC this November



Geant 4

Thanks