Hands-On on physics

microdosimetry

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1st Geant4-DNA tutorial

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microdosimetry

- We are going to try the microdosimetry example which make use of Geant4 & Geant4-DNA Physics processes
- This is an extended example and it is located in $G4INSTALL/examples/extended/electromagnetic/dna

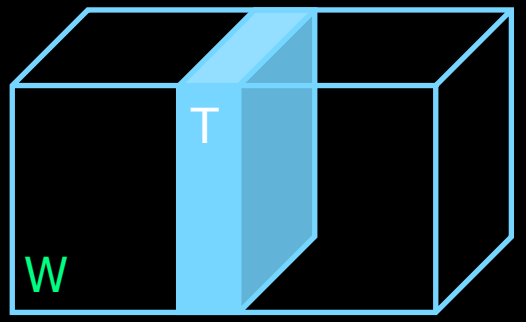
microdosimetry

- Shows the multi-scale combination of
  - Geant4 Standard EM Physics (condensed/discrete)
    - Geant4 Standard EM
  - Purely discrete processes
    - Geant4-DNA
  - For protons/hydrogen
  - In two regions (the « World » and « Target »)

- Useful when the user in interested in simulating efficiently high energy incident particles with Geant4 EM Standard Physics, providing a space phase input for Geant4-DNA simulations applied to much smaller volumes

- Also shows how to create a process to kill particles below a certain energy threshold
  - G4ElectronCapture

Geometry



- A 50 μm thick « Target » volume placed in a 1 mm thick « World » mother volume
- Both contain liquid water only
- We would like to use
  - EM Standard models in the « World »
  - Geant4-DNA models in the « Target » below 1 MeV for e-

1) Create a Region for the target volume in DetectorConstruction

```
fRegion = new G4Region("Target");

G4ProductionCuts* cuts = new G4ProductionCuts();

G4double defCut = 1*nanometer;
cuts->SetProductionCut(defCut,"gamma");
cuts->SetProductionCut(defCut,"e-");
cuts->SetProductionCut(defCut,"e+");
cuts->SetProductionCut(defCut,"proton");

fRegion->SetProductionCuts(cuts);

fRegion->AddRootLogicalVolume(logicTarget);
```

2) Define Physics for the World in PhysicsList.cc

- Let's consider the case of electrons

- In the loop over particles, activate EM standard processes
  - they will be ACTIVE IN THE WORLD

```
if (particleName == "e-") {

    // STANDARD msc is active in the world
    G4eMultipleScattering* msc = new G4eMultipleScattering();
    pmanager->AddProcess(msc, -1, 1, 1);

    // STANDARD ionisation is active in the world
    G4eIonisation* eion = new G4eIonisation();
    eion->SetEmModel(new G4MollerBhabhaModel(), 1);
    pmanager->AddProcess(eion, -1, 2, 2);
```

Define Physics for the World

- then INACTIVATE Geant4-DNA processes using a G4DummyModel and the SetModel method.

  They will be INACTIVE IN THE WORLD.

```
// DNA elastic is not active in the world
G4DNAElastic* theDNAElasticProcess = new G4DNAElastic("e-_G4DNAElastic");
theDNAElasticProcess->SetModel (new G4DummyModel(),1);
pmanager->AddDiscreteProcess(theDNAElasticProcess);
// DNA excitation is not active in the world
G4DNAExcitation* dnaex = new G4DNAExcitation("e-_G4DNAExcitation");
dnaex->SetModel (new G4DummyModel(),1);
pmanager->AddDiscreteProcess(dnaex);
// DNA ionisation is not active in the world
G4DNAIonisation* dnaioni = new G4DNAIonisation("e-_G4DNAIonisation");
dnaioni->SetModel (new G4DummyModel(),1);
pmanager->AddDiscreteProcess(dnaioni);
// DNA attachment is not active in the world
G4DNAAttachment* dnaatt = new G4DNAAttachment("e-_G4DNAAttachment");
dnaatt->SetModel (new G4DummyModel(),1);
pmanager->AddDiscreteProcess(dnaatt);
// DNA vib. excitation is not active in the world
G4DNAVibExcitation* dnavib = new G4DNAVibExcitation("e-_G4DNAVibExcitation");
dnavib->SetModel (new G4DummyModel(),1);
pmanager->AddDiscreteProcess(dnavib);
```

Eventually, kill all very low energy electrons

```
// THE FOLLOWING PROCESS WILL KILL ALL ELECTRONS BELOW A SELECTED ENERY THRESHOLD

// Capture of low-energy e-


G4ElectronCapture* ecap = new G4ElectronCapture("Target", 5.1*eV);

pmanager->AddDiscreteProcess(ecap);
```

3) Define Physics for the Target

- Inactivate EM Standard processes in the TARGET Region below 1 MeV

  by registering corresponding EM Standard models to the G4EmConfigurator

```
G4EmConfigurator* em_config = G4LossTableManager::Instance()->EmConfigurator();
  G4VEmModel* mod;

  mod = new G4UrbanMscModel();
  mod->SetActivationLowEnergyLimit(1*MeV);
  em_config->SetExtraEmModel("e-","msc",mod,"Target");

  mod = new G4MollerBhabhaModel();
  mod->SetActivationLowEnergyLimit(1*MeV);
  em_config->SetExtraEmModel("e-","eIoni",mod,"Target",0.0,100*TeV,
   new G4UniversalFluctuation());
```

Specify the low enery limit of activation you need

Specify particle name, process name, model and region name and energy interval (option if more than one models are used)

Define Physics for the Target

- ACTIVATE Geant4-DNA processes in the TARGET Region by registering the corresponding Geant4-DNA models to the G4EmConfigurator

```
mod = new G4DNAChampionElasticModel();
em_config->SetExtraEmModel("e-","e-_G4DNAElastic",mod,"Target",0.,1*MeV);

mod = new G4DNABornIonisationModel();
em_config->SetExtraEmModel("e-","e-_G4DNAIonisation",mod,"Target",11*eV,1*MeV);

mod = new G4DNABornExcitationModel();
em_config->SetExtraEmModel("e-","e-_G4DNAExcitation",mod,"Target",9*eV,1*MeV);

mod = new G4DNAMeltonAttachmentModel();
em_config->SetExtraEmModel("e-","e-_G4DNAAttachment",mod,"Target",4*eV,13*eV);

mod = new G4DNASancheExcitationModel();
em_config->SetExtraEmModel("e-","e-_G4DNAVibExcitation",mod,"Target",2*eV,100*eV);
```

Specify energy range of applicability

Don't forget to ALWAYS check at run time that EM standard and DNA processes are not active simultaneoulsy or that the processes that you want to activate are indeed really active if this is the case, tune your energy limits …

Selecting limits of models

C++ G4EmConfigurator* em_config = G4LossTableManager::Instance()->EmConfigurator(); G4VEmModel* mod = new G4DNABornIonisationModel();	Displayed at initialization time	Used at run time for transport
em_config ->SetExtraEmModel("e-","e_G4DNAIonisation", mod,"Target",X*MeV,Y*MeV);	Emin = 0 MeV Emax = Y MeV	Emin = inner low limit of model (11 eV) Emax=inner max limit of model (1 MeV)
mod ->SetActivationLowEnergyLimit(W*MeV);	Emin = W MeV	Emin = W MeV
mod ->SetActivationHighEnergyLimit(Z*MeV);	Emax = Z MeV	Emax = Z MeV

Make sure that W is > than the model's inner low energy limit
And that Z is < than the model's inner high energy limit

microdosimetry

- Copy the microdosimetry extended example to your local directory, create your build directory and compile microdosimetry

```
cd
cp –R /mnt/g4tuto/geant4-10.01-install/share/Geant4-10.1.0/examples/extended/medical/dna/microdosimetry .
mkdir build-microdosimetry
cd build-microdosimetry
cmake ../microdosimetry
make
```

- Run dnaphysics (microdosimetry.mac is read by default)

```
./microdosimetry
```

  - 2 protons of 5 MeV are shot
  - No visualization by default
  - Results are saved in dna.root files

- Results can be analyzed using ROOT

```
root plot.C
```