New extended example /medical/dna/chem4

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Radiochemical yields

- Radiochemical yields or G-values
  Number of species over time for 100 eV of deposited energy

$$G(t) = \frac{N_{mol}(t) \cdot 100\ eV}{E_{dep}}$$

- For a given species, irradiation condition, can be compared to experimental values

- Goal of chem4: record the G-values over time for each species

Run application
Relevant classes

- G4MoleculeCounter

  Where Component of Geant4

  Role Records only the changes of chemical species over time

  Usage

```
void ActionInitialization::Build() const
{
  G4MoleculeCounter::Use();
  // G4MoleculeCounter::Instance()->SetVerbose(2);
  G4MoleculeCounter::Instance()->DontRegister(G4H2O::Definition());

  // sequential mode
  if(G4Threading::IsMultithreadedApplication() == false)
  {
    G4DNAChemistryManager::Instance()->ResetCounterWhenRunEnds(false);
  }

  SetUserAction(new PrimaryGeneratorAction());
  SetUserAction(new RunAction());
  SetUserAction(new StackingAction());
}
```

Run application
Relevant classes

- G4MoleculeCounter

  Where Component of Geant4

  Role Records only the changes of chemical species over time

- ScoreSpecies

  Where Component of the application

  Role 1. Scores the total energy deposited
  2. Retrieves from G4MoleculeCounter the number of chemical species at given time (use SpeciesScorer::AddTimeToRecord)

Run application
Relevant classes

- ScoreSpecies

  Where Component of the application

  Role 1. Scores the total energy deposited
  2. Retrieves from G4MoleculeCounter the number of chemical species at given time (use SpeciesScorer::AddTimeToRecord)

  Usage

```
ScoreSpecies::ScoreSpecies(G4String name, G4int depth)
: G4VPrimitiveScorer(name,depth),
  fEdep(0),
  fOutputToRoot(true),
  fOutputToXml(false),
  fOutputToCsv(false),
  fHCID(-1),
  fEvtMap(0)
{
  fNEvent = 0;
  AddTimeToRecord(1 * CLHEP::picosecond);
  AddTimeToRecord(10 * CLHEP::picosecond);
  AddTimeToRecord(100 * CLHEP::picosecond);
  AddTimeToRecord(1000 * CLHEP::picosecond);
  AddTimeToRecord(10000 * CLHEP::picosecond);
  AddTimeToRecord(100000 * CLHEP::picosecond);
  AddTimeToRecord(999999 * CLHEP::picosecond);
  fEdep = 0;
}
```

Time to record is hard coded
can be removed using
ScoreSpecies::ClearTimeToRecord()

Run application
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- PrimaryKiller

  Where Component of the application

  Role Kills the primary track after it has lost more than a certain threshold

  UI /primaryKiller/eLoss 600 eV

Run application
Relevant classes

- Usage of PrimaryKiller and ScoreSpecies

```
void DetectorConstruction::ConstructSDandField()
{
  G4SDManager::GetSDMpointer()->SetVerboseLevel(1);

  // declare World as a MultiFunctionalDetector scorer
  //
  G4MultiFunctionalDetector* mfDetector =
  new G4MultiFunctionalDetector("mfDetector");

  //--
  // Kill primary track after a chosen energy loss OR under a chosen
  // kinetic energy
  PrimaryKiller* primaryKiller = new PrimaryKiller("PrimaryKiller");
  primaryKiller->SetLossEnergyLimit(500.*eV);
  mfDetector->RegisterPrimitive(primaryKiller);

  //--
  // Record Species scorer:
  //  - scores number of species over time
  //  - score the total energy deposition
  //  - compute the radiochemical yields (G values)
  G4VPrimitiveScorer* primitivSpecies = new ScoreSpecies("Species");
  mfDetector->RegisterPrimitive(primitivSpecies);

  SetSensitiveDetector("World", mfDetector);
}
```

Default value
Can be modified through UI
/primaryKiller/eLoss 600 eV

Run application Usage

- Basic geometry: a cube
- Constructors: G4EmDNAPhysics & G4EmDNAChemistry
- Launch the application

  $ chem4 -mac beam.in -mt 6

- An output file called Species.root is created

Plot application

- Launch the application

  $ plot Species.root

  Alternatively, launch plot without argument, a window will open to select the ROOT file

- Display G-values in respect to time
  Default unit is nanosecond

- Each tab = a different species

- Example
  Primary: 1 MeV electron,
  Energy loss limit: 600 eV,
  Only few events considered