



Proposal of Introduction of a Simple Variable Density Approach

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Outline

- Motivation
- Requirements
- Involved Geant4 categories
- Proposed modifications
- Possible strategy for implementation

Motivation general

- **Proposal was discussed in 2010:**
 - EM mini-workshop at CERN, May, 12
 - Bordeaux DNA meeting June, 16
 - Annecy architecture review meeting June, 30
- **Main motivation – extension of Geant4 material DB capabilities:**
 - Recent years number of new tables with evaluated data were included
 - ASTAR and PSTAR data
 - ICRU73 data
 - Density effect parameters
 - access via G4 material DB name

Motivation for medical applications

- There are many medical applications in which many voxels with materials slightly different from each other
 - DICOM interface
- Optimisation of EM packages performance for applications with many voxels
 - CPU performance for initialisation and run time
 - Size of the application

Motivation for other applications

- In general the name of a material may be defined by geometry description which may not coincide with the NIST name
- Is it possible to reduce size of EM tables for LHC simulation without modification of geometry description?
- Cosmic rays in atmosphere
- DNA project – materials are scaled from water in many cases

Requirements

- Data from NIST, ICRU and other sources associated with Geant4 material name. Users should be able to give his/her original name for his/her material but use data from Geant4 database
- There are many similar materials different only by its density and not atomic composition, in that case only one Physics Table per cross section should be created
- Data for gases are given for normal conditions, it should be possible to have a several gas materials reusing one set of gas parameters in normal conditions and one table per cross section



Proposal

Involved Geant4 categories

- source/materials
- source/processes/cuts
- source/processes/electromagnetic/utils
- Others modifications are not mandatory and necessary modifications should be identified

Proposed changing for materials

- **G4Material:**
 - Add fNominalMaterial pointer and access method
 - Const G4Material* GetNominalMaterial();
 - By default return 0;
 - Add extra constructor which will build new material from existing material
 - G4Material(const G4String& newname, const G4Material* oldmaterial, G4double newdensity);
- **G4NistManager:**
 - Add extra method to build material with given density from NIST material
 - BulidNewMaterialWithDensity(const G4String& newname, const G4String& NISTname, G4double newdensity);
- These modifications are easy
- **Potential change and benefit if the project will be approved:** analysis of user define material and identification of identical description, so concept of nominal material can be applied automatically reducing size of tables in user application

Proposed changing in kernel

- **G4MaterialsCutsCouple**
 - Currently during creation of vector of G4MaterialCutsCouple vector a couple Material/ProductionCut is added only if the material is used in corresponding G4Region
 - Add a couple NominalMaterial/ProductionCut even if this NominalMaterial is not used in the G4Region
 - The vector of G4MaterialCutsCouple will be longer
 - New method may be useful

```
const G4MaterialCutsCouple* GetNominalCouple();
```
- **PreparePhysicsTable:**
 - Flag of construction of a PhysicsVector is **FALSE** if current material –cuts-couple has non-zero pointer to the NominalCouple.

Proposed changing in EM utils

- **G4VEnergyLossProcess, G4VEmProcess, G4VMultipleScattering**
 - When value of a cross section or dE_{dx} is extracted from Physics Tables it is multiplied by a factor equal to density ratio of the current material to its nominal material
 - By default factor is 1.0



Possible time-scale and strategy

Proposed order of modifications

- **Update materials and electromagnetic/utlis with the main goals:**
 - No change in any result
 - No performance penalty
- **Update processes/cuts and check:**
 - No change in any result
 - No performance penalty
- **Demonstrate capabilities for DICOM**
 - CPU/ size of an application should be improved
- **Introduce modifications needed in other categories:**
 - Geometry (GDML), EM standard, and low-energy

Possible time-scale

1. If the proposal will be approved
2. **Materials** (V.Ivanchenko January 2011)
 - Simple addition, will not affect any application
3. **EM utils – necessary additions which should not affect performance** (V.Ivanchenko January 2011)
4. **The most important change in the table management in kernel**
 - ../processes/cuts (H.Kurashige)
5. **Proof of conception should be performed**
 - Test on CPU and memory in existing applications including LHC simulation
 - **DICOM example**
 - **We would need help from the Collaboration**
6. **Other packages**
 - Introduce necessary modifications in EM , GDML and other s