
(Hands-on)
Proton beamline modeling

T. Toshito, Nagoya Proton Therapy Center

Outline

- Exercise 1
 - Introduce a patient collimator
 - material
 - geometry description
- Exercise 2
 - Test with uniform beam exposure
 - GPS command

Exercise 1 Implementation of collimator

- Try to introduce a collimator in your simulation
 - A schematic view of the collimator is shown in the right figure.
 - Use G4ExtrudeSolid for the air volume.
 - See: [Solids](#)

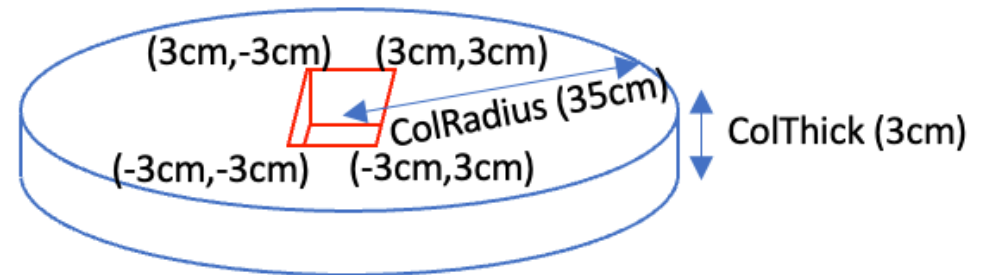
- Parameters

- Collimator Frame

- G4Tubs (Cylinder)
 - Rout = 35 cm (Rin = 0 cm)
 - Thick = 3 cm (Full length)
 - Material: G4_BRASS

- Air hole

- G4ExtrudedSolid
 - Vertex coordinates (-3 cm, -3cm), (-3 cm, 3 cm), (3 cm, 3 cm), (3 cm, -3 cm)
 - Thick = 3 cm (Full length)



Answer of Exercise 1 (Material)

- Edit DetectorConstruction.cc and add a line in DefineMaterials() method.

```
#include "G4ExtrudedSolid.hh" ← include header file "G4ExtrudedSolid.hh"

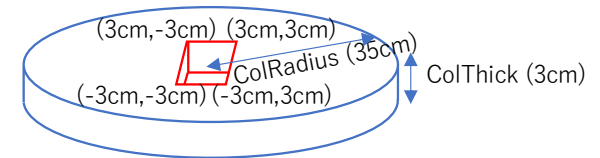
void DetectorConstruction::DefineMaterials() {
    ...
    nist->FindOrBuildMaterial("G4_BRASS"); ← build material of "G4_BRASS"
    ...
}
```

Answer of Exercise 1 (Collimator geometry)

- Edit the DetectorConstruction.cc and describe the collimator in the DefineVolumes() method.

```
G4VPhysicalVolume* DetectorConstruction::DefineVolumes() {
    ... snippet
    //
    // Collimator
    //
    std::vector<G4TwoVector> ColAirVec;
    ColAirVec.push_back(G4TwoVector(-3.*cm, -3.*cm));
    ColAirVec.push_back(G4TwoVector(-3.*cm, 3.*cm));
    ColAirVec.push_back(G4TwoVector(3.*cm, 3.*cm));
    ColAirVec.push_back(G4TwoVector(3.*cm, -3.*cm));

    G4ThreeVector Coltran(0,0,17*cm);
    G4double ColRadius = 35.*cm;
    G4double ColThick = 3.*cm;
    G4VSolid* CoIS
    = new G4Tubs("Col", 0., ColRadius, ColThick/2., 0., twopi);
    G4LogicalVolume* ColLV
    = new G4LogicalVolume(CoIS, G4Material::GetMaterial("G4_BRASS"), "ColLV");
    G4TwoVector off1 = G4TwoVector(0.,0.);
    G4TwoVector off2 = G4TwoVector(0.,0.);
    G4VSolid* ColAirS
    = new G4ExtrudedSolid("ColAir", ColAirVec, ColThick/2., off1, 1., off2, 1.);
    G4LogicalVolume* ColAirLV
    = new G4LogicalVolume(ColAirS, G4Material::GetMaterial("G4_AIR"), "ColAirLV");
    new G4PVPlacement(nullptr, G4ThreeVector(0.,0.,0.), ColAirLV, "ColAirPV",
        ColLV, false, 0);
}
```



- ← create solid (Tubs) of the collimator
- ← create logical volume of the collimator
- ← create solid (Extruded volume) of a hole of collimator
- ← create logical volume of a hole of collimator
- ← place a hole of collimator in the collimator

Cont'd

Answer of Exercise 1 (Cont' d)

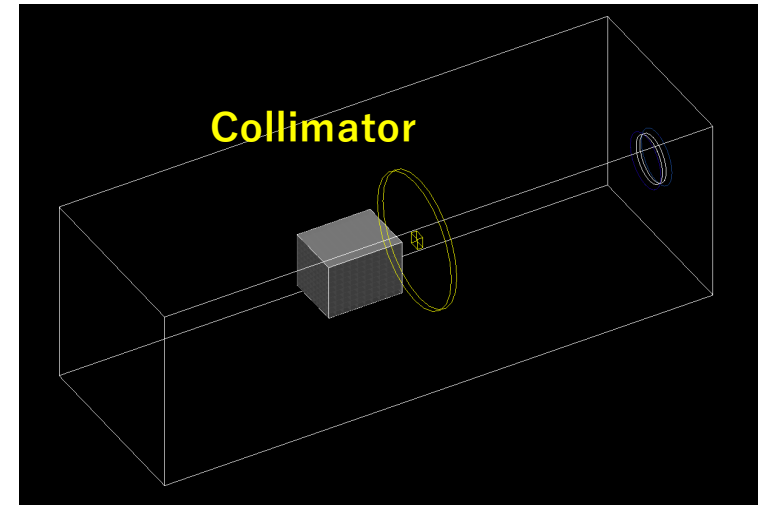
- Edit the DetectorConstruction.cc and describe the collimator in the DefineVolumes() method.

(Cont' d from previous side)

```
G4VisAttributes* ColAirVisAtt=
  new G4VisAttributes(G4Colour(1.0,1.0,0.0,0.8));
ColAirVisAtt->SetVisibility(true);
ColAirLV->SetVisAttributes(ColAirVisAtt);
// G4VPhysicalVolume* ColPhys =
new G4VPPlacement(nullptr, Coltran, ColLV, "ColPV",
                  worldLV, false, 1, fCheckOverlaps);
//          (Rotation, Position, logical, name,
//          Mother-Logical,boolean-operation, copyNo, check overlaps)
G4VisAttributes* ColVisAtt=
  new G4VisAttributes(G4Colour(1.0,1.0,0.0,0.8));
ColVisAtt->SetVisibility(true);
ColLV->SetVisAttributes(ColVisAtt);

... snippet
// Always return the physical World
return worldPV;
}
```

After completing ,
Save and rebuild the application



Exercise 2 Test with uniform beam exposure

- Run the application and apply following GPS parameters
 - GPS parameters
 - Particle proton
 - Direction (0, 0, -1)
 - Energy 150 MeV
 - Position (0., 0., 130 cm)
 - Position type Beam
 - Sigma in X 50.0 mm
 - Sigma in Y 50.0 mm
 - Number of histories
 - 100 protons

Answer of Exercise 2 (Simulation of uniform beam exposure)

1. Invoke Galet

```
./Galet
```

2. Define uniform beam using gps

```
/gps/particle proton  
/gps/energy 150. MeV  
/gps/direction 0. 0. -1.  
/gps/position 0. 0. 130. cm  
/gps/pos/type Beam  
/gps/pos/sigma_x 50.0 mm  
/gps/pos/sigma_y 50.0 mm
```

3. Generates 100 protons

```
/run/beamOn 100
```

