Detector sensitivity

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Geant4

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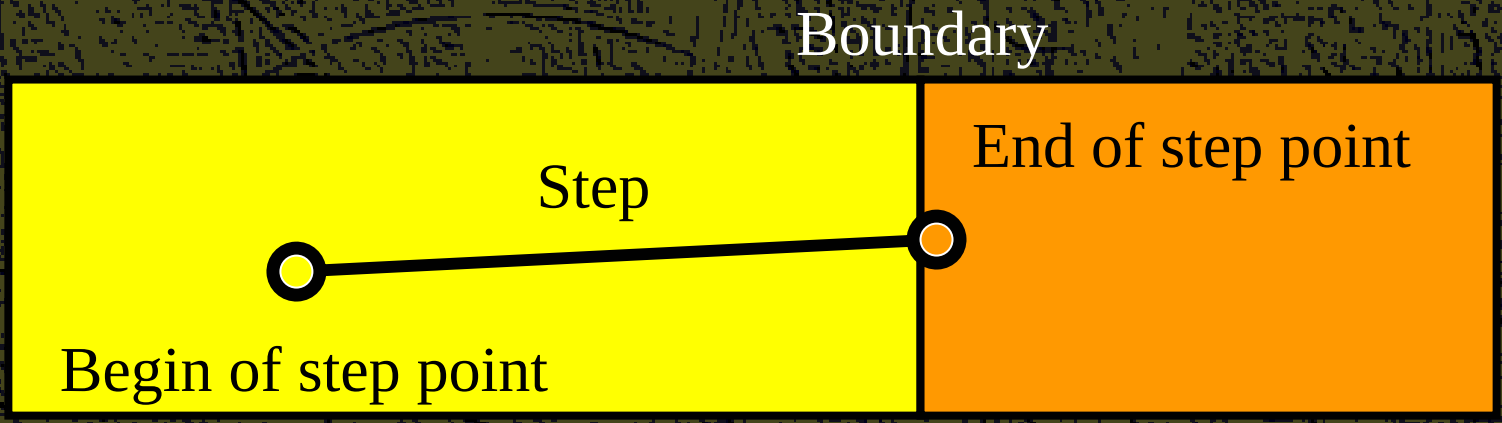
Sensitive detector and Hit

- Each Logical Volume can have a pointer to a sensitive detector.
  - Then this volume becomes sensitive.
- Hit is a snapshot of the physical interaction of a track or an accumulation of interactions of tracks in the sensitive region of your detector.
- A sensitive detector creates hit(s) using the information given in G4Step object. The user has to provide his/her own implementation of the detector response.
  - UserSteppingAction class should NOT do this.
- Hit objects, which are still the user's class objects, are collected in a G4Event object at the end of an event.

Detector sensitivity

- A sensitive detector either
  - constructs one or more hit objects or
  - accumulates values to existing hits

  using information given in a G4Step object.
- Note that you must get the volume information from the “PreStepPoint”.



Digitizer module and digit

- Digit represents a detector output (e.g. ADC/TDC count, trigger signal, etc.).
- Digit is created with one or more hits and/or other digits by a user's concrete implementation derived from G4VDigitizerModule.
- In contradiction to the sensitive detector which is accessed at tracking time automatically, the digitize() method of each G4VDigitizerModule must be explicitly invoked by the user's code (e.g. at EventAction).

Hit class

- Hit is a user-defined class derived from G4VHit.
- You can store various types information by implementing your own concrete Hit class. For example:
  - Position and time of the step
  - Momentum and energy of the track
  - Energy deposition of the step
  - Geometrical information
  - or any combination of above
- Hit objects of a concrete hit class must be stored in a dedicated collection which is instantiated from G4THitsCollection template class.
- The collection will be associated to a G4Event object via G4HCofThisEvent.
- Hits collections are accessible
  - through G4Event at the end of event.
    - to be used for analyzing an event
  - through G4SDManager during processing an event.
    - to be used for event filtering.

Implementation of Hit class

```
#include "G4VHit.hh"
class MyDriftChamberHit : public G4VHit
{
  public:
      MyDriftChamberHit();
      virtual ~MyDriftChamberHit();
      virtual void Draw();
      virtual void Print();
  private:
      // some data members
  public:
      // some set/get methods
};

#include “G4THitsCollection.hh”
typedef G4THitsCollection<MyDriftChamberHit>
  MyDriftChamberHitsCollection;
```

Sensitive Detector class

- Sensitive detector is a user-defined class derived from G4VSensitiveDetector.

```
#include "G4VSensitiveDetector.hh"
#include "MyDriftChamberHit.hh"
class G4Step;
class G4HCofThisEvent;
class MyDriftChamber : public G4VSensitiveDetector
{
  public:
      MyDriftChamber(G4String name);
      virtual ~MyDriftChamber();
      virtual void Initialize(G4HCofThisEvent*HCE);
      virtual G4bool ProcessHits(G4Step*aStep,
                                 G4TouchableHistory*ROhist);
      virtual void EndOfEvent(G4HCofThisEvent*HCE);
  private:
      MyDriftChamberHitsCollection * hitsCollection;
      G4int collectionID;
};
```

Implementation of Sensitive Detector

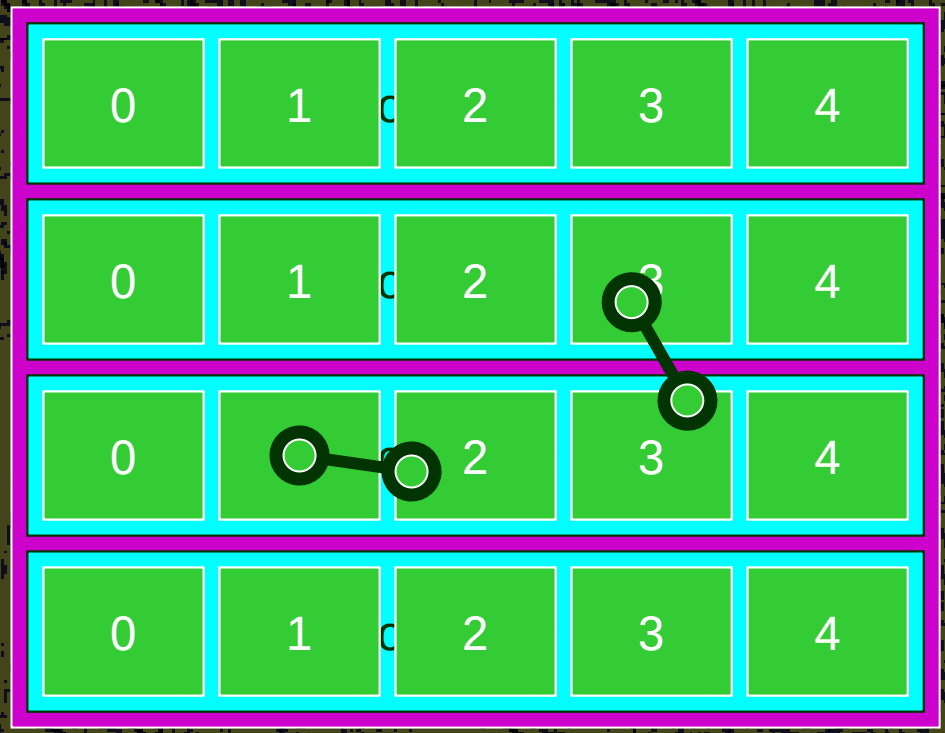
```
MyDriftChamber::MyDriftChamber(G4String name)
                :G4VSensitiveDetector(name)
{ collectionName.insert("driftChamberCollection");
  collectionID = -1;}

void MyDriftChamber::Initialize(G4HCofThisEvent*HCE)
{ hitsCollection = new MyDriftChamberHitsCollection
       (SensitiveDetectorName,collectionName[0]);
  if(collectionID<0)
  { collectionID = G4SDManager::GetSDMpointer()
                  ->GetCollectionID(hitsCollection); }
  HCE->AddHitsCollection(collectionID,hitsCollection); }

G4bool MyDriftChamber::ProcessHits
  (G4Step*aStep,G4TouchableHistory*ROhist)
{ MyDriftChamberHit* aHit = new MyDriftChamberHit();
  // some set methods
  ...
  hitsCollection->insert(aHit);
  return true; }

void MyDriftChamber::EndOfEvent(G4HCofThisEvent*HCE) {;}
```

Touchable

- As mentioned already, G4Step has two G4StepPoint objects as its starting and ending points. All the geometrical information of the particular step should be taken from "PreStepPoint".
  - Geometrical information associated with G4Track is basically same as "PostStepPoint".
- Each G4StepPoint object has
  - Position in world coordinate system
  - Global and local time
  - Material
  - G4TouchableHistory for geometrical information
- G4TouchableHistory object is a vector of information for each geometrical hierarchy.
  - copy number
  - transformation / rotation to its mother
- Since release 4.0, *handles* (or *smart-pointers*) to touchables are intrinsically used. Touchables are reference counted

Copy number

- Suppose a calorimeter is made of 4x5 cells.
  - and it is implemented by two levels of replica.
- In reality, there is only one physical volume object for each level. Its position is parameterized by its copy number.
- To get the copy number of each level, suppose what happens if a step belongs to two cells.
  - Remember geometrical information in G4Track is identical to "PostStepPoint".
  - You cannot get the collect copy number for "PreStepPoint" if you directly access to the physical volume.
- Use touchable to get the proper copy number, transform matrix, etc.



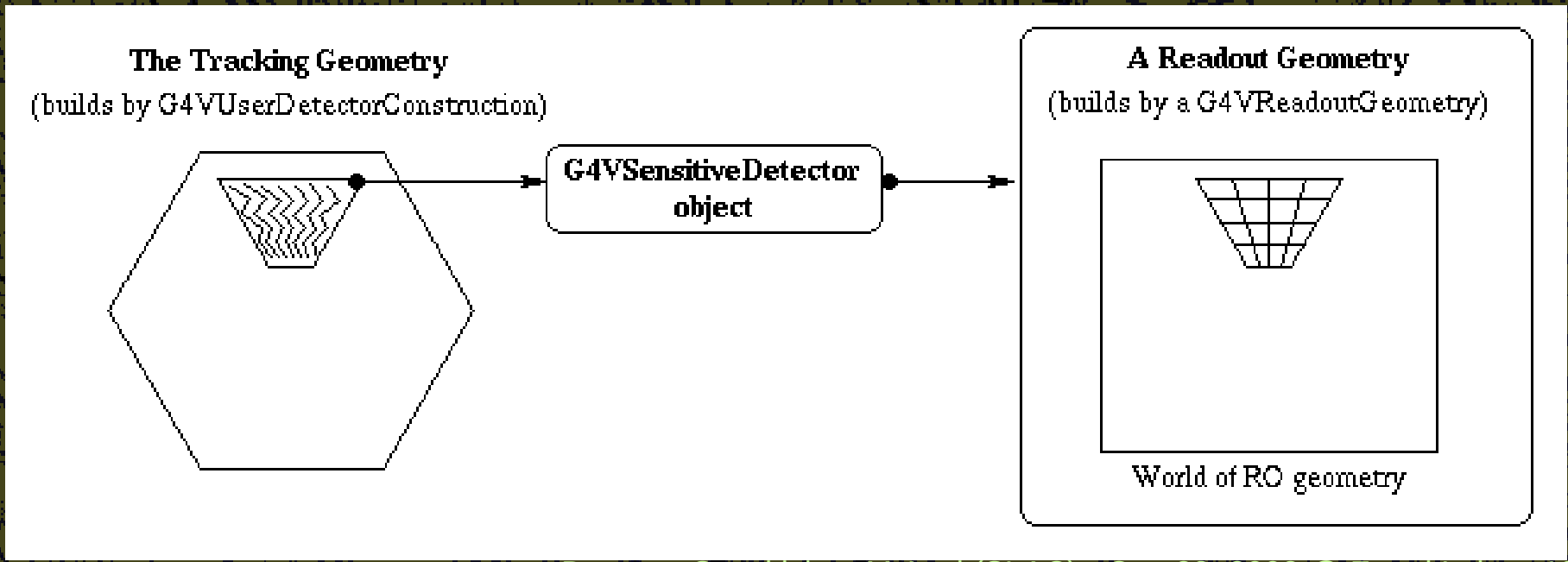
Touchable

- G4TouchableHistory has information of geometrical hierarchy of the point.

```
G4Step* aStep;
G4StepPoint* preStepPoint = aStep->GetPreStepPoint();
G4TouchableHistory* theTouchable =
    (G4TouchableHistory*)(preStepPoint->GetTouchable());
G4int copyNo = theTouchable->GetVolume()->GetCopyNo();
G4int motherCopyNo
          = theTouchable->GetVolume(1)->GetCopyNo();
G4ThreeVector worldPos = preStepPoint->GetPosition();
G4ThreeVector localPos = theTouchable->GetHistory()
    ->GetTopTransform().TransformPoint(worldPos);
```

Readout geometry

- In some cases of most complicated geometries, it is not easy to define volume boundaries corresponding to the readout segmentation.
- Readout geometry is a virtual and artificial geometry which can be defined in parallel to the real detector geometry.
- Readout geometry is optional. May have more than one.
  - Each one should be associated to a sensitive detector.
- Note that a step is not limited by the boundary of readout geometry.



Defining a sensitive detector

- Basic strategy

```
G4LogicalVolume* myLogCalor = ……;
G4VSensetiveDetector* pSensetivePart =
   new MyCalorimeter(“/mydet/calorimeter1”);
G4SDManager* SDMan = G4SDManager::GetSDMpointer();
SDMan->AddNewDetector(pSensitivePart);
myLogCalor->SetSensitiveDetector(pSensetivePart);
```

- Each detector object must have a unique name.
  - Some logical volumes can share one detector object
  - More than one detector objects can be made from one detector class with different detector name.
  - One logical volume cannot have more than one detector objects. But, one detector object can generate more than one kinds of hits.
    - e.g. a drift chamber class may generate anode and cathode hits separately.

G4HCofThisEvent

- A G4Event object has a G4HCofThisEvent object at the end of (successful) event processing. G4HCofThisEvent object stores all hits collections made within the event.
  - Pointer(s) may be NULL if collection(s) are not created in the particular event.
  - Hits collections are stored by pointers of G4VHitsCollection base class. Thus, you have to cast them to types of individual concrete classes.

Usage of G4HCofThisEvent

```
int CHCID = G4SDManager::GetSDMpointer()
   ->GetCollectionID("myDet/calorimeter1/collection1");
G4HCofThisEvent* HCE = evt->GetHCofThisEvent();
MyCalorimeterHitsCollection* CHC = 0;
if(HCE)
{CHC = (MyCalorimeterHitsCollection*)(HCE->GetHC(CHCID));}
if(CHC)
{ int n_hit = CHC->entries();
  G4cout<<"Calorimeter has "<<n_hit<<" hits."<<G4endl;
  for(int i1=0;i1<n_hit;i1++)
  { MyCalorimeterHit* aHit = (*CHC)[i1];
    aHit->Print(); }
}
```

- This scheme can be utilized also for Digitization.