# Fast Simulation

A shortcut to the tracking

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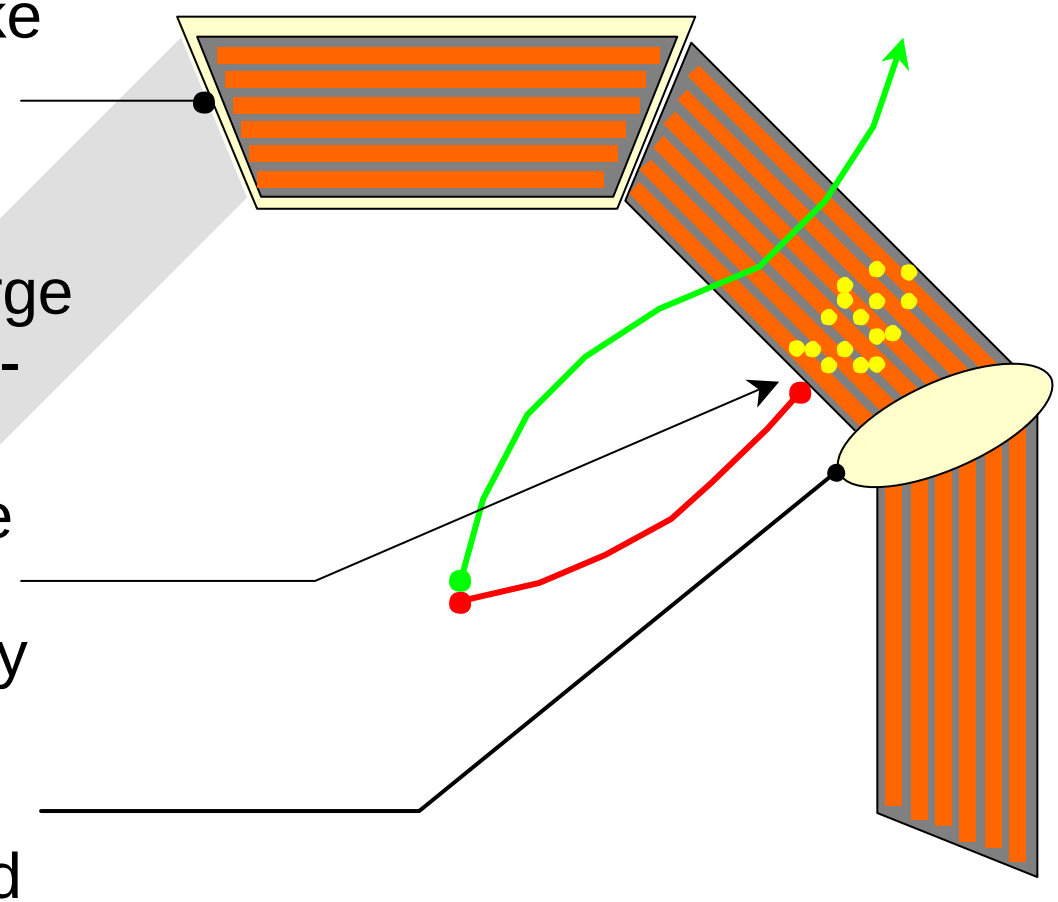
# I. Introduction

# Generalities

- Fast Simulation, also called parameterisation, is a shortcut to the tracking.
- Fast Simulation allows you to take over the tracking to implement your own fast physics and detector response.
- The classical use case of fast simulation is the shower parameterisation where the typically several thousand steps per GeV computed by the tracking are replaced by a few ten of deposits per GeV.
- Parameterisations are generally experiment dependent.

# Parameterisation features

- Parameterisations take place in an *envelope*. This is typically the mother volume of a sub-system or of a large module of such a sub-system.
- Parameterisations are often *particle type* dependent and/or may apply only to some.
- They are often not applied in complicated regions.



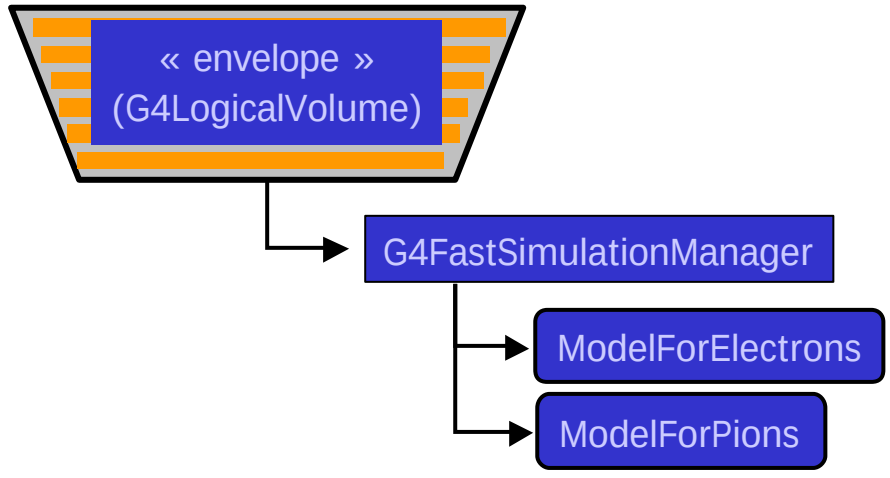
# II. Fast Simulation Components of Geant4

# G4VFastSimulationModel

- This is the base class allowing to implement concrete parameterisation models.
- It has three pure virtual methods to be overriden :
  - G4bool IsApplicable(const G4ParticleDefinition *)
    - Which specify for which particles the model is valid
  - G4bool ModelTrigger(const G4FastTrack &)
    - Which allow to decide or not to trigger the model at the current point, in order to avoid to trigger in a « complicated region ».
  - void DoIt(const G4FastTrack &, G4FastStep &)
    - Which is the parameterisation properly said, invoked when the model has triggered.
- The G4FastTrack provides input information to the model (G4Track, envelope information, …).
- The G4FastStep allows to return the state of the G4Track after parameterisation (alive/killed, position, …) and potential secondaries back to the tracking.

# Binding concrete models to an envelope

- Concrete models are bound to the envelope through a G4Fast-SimulationManager object.
- This allows several models to be bound to a same envelope.
- The « envelope » is simply a G4LogicalVolume which has received a G4FastSimulation-Manager.
- All its [grand[…]]daughters will be sensitive to the parameterisations.



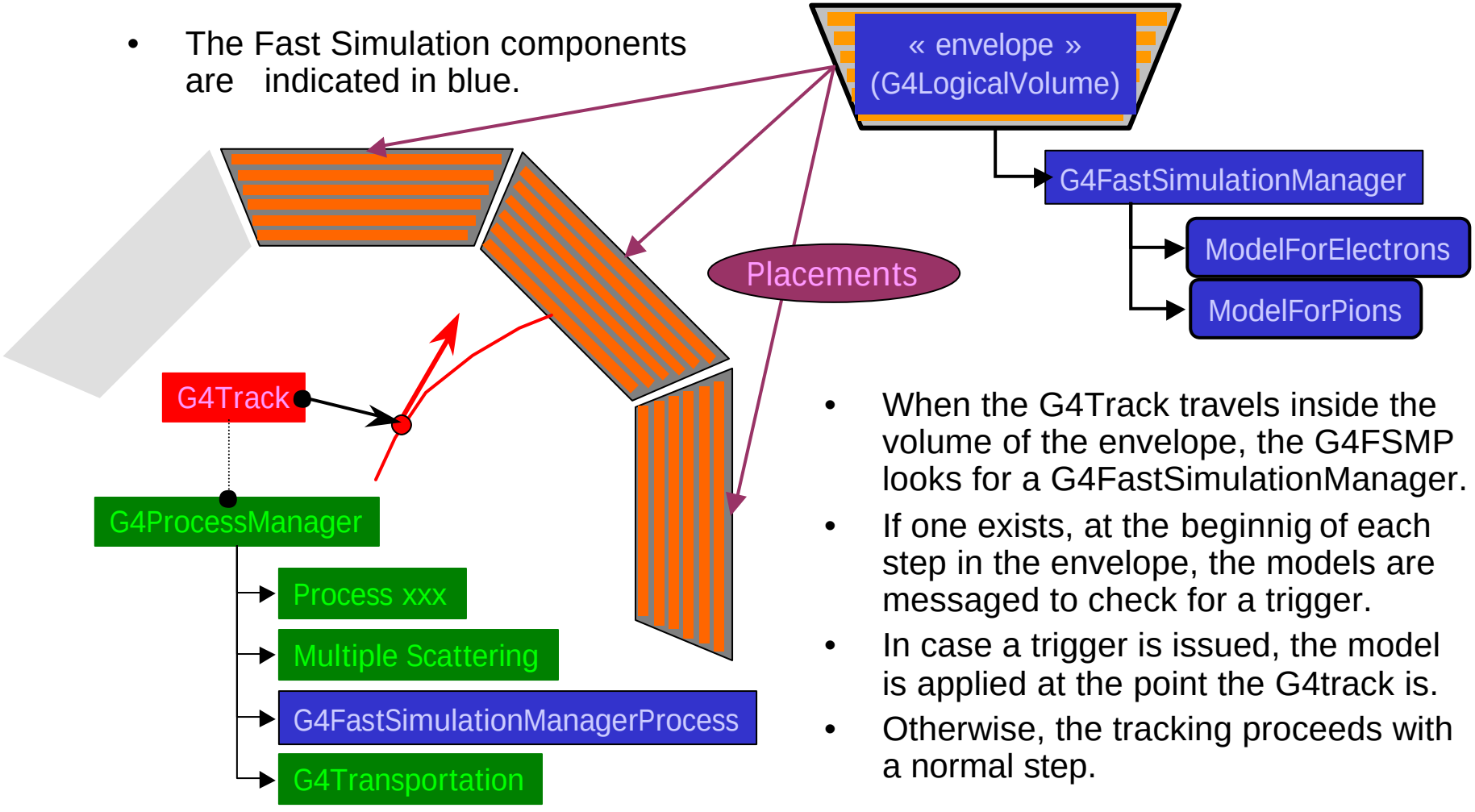
# G4FastSimulationManagerProcess

- The G4FastSimulationManagerProcess is a process providing the ***interface*** between the tracking and the fast simulation.
- It has to be set to the particles to be parameterised:
  - The process ordering is the following:

    [n-3] ...
    [n-2] Multiple Scattering
    [n-1] G4FastSimulationManagerProcess
    [ n ] G4Transportation
  - It can be set as a discrete process or it must be set as a continuous & discrete process if using ghost volumes (treated later on in this unit).

# Summary Picture of Fast Simulation Mechanism

- The Fast Simulation components are indicated in blue.




- When the G4Track travels inside the volume of the envelope, the G4FSMP looks for a G4FastSimulationManager.
- If one exists, at the beginnig of each step in the envelope, the models are messaged to check for a trigger.
- In case a trigger is issued, the model is applied at the point the G4track is.
- Otherwise, the tracking proceeds with a normal step.

# III. Fast Simulation using Ghost Volumes

# Ghost Volumes (1)

- Ghost volumes allow to define envelopes independently of the volumes of the tracking geometry.
- This allows to group together the electromagnetic and hadronic calorimeters for pion parameterisation for example or to define envelopes for geometries coming out of a CAD system which don’t have a hierarchical structure.
- In addition Ghost volumes are sensitive the to particle flavor, allowing to define in a completely independant way envelopes for electrons, envelopes for pion etc…

# Ghost Volumes (2)

- Ghost Volumes of a given particle flavor are placed in a clone of the world volume for tracking.
- This is done automatically by a singleton class: the G4GlobalFastSimulationManager.
- The G4FastSimulationManagerProcess provides the additional navigation inside this « parallel » geometry.
- This navigation is done transparently to the user.
- As before, when a parameterisation model attached to a ghost volume issues a trigger, the parameterisation is applied, taking over the tracking.

# IV. Example (1)

- Show sample code extracted from example/novice/N05;
- Simulate a (very crude ☹) EM shower:
  - Valid for electrons and gammas;
  - Triggering above 100 MeV;
  - Show in particular a way to collect « hits » created by the parameterisation;

# IV. Example (2)

```
G4bool ExN05EMShowerModel::IsApplicable(const G4ParticleDefinition&
    particleType)
    {
      return
        &particleType == G4Electron::ElectronDefinition() ||
        &particleType == G4Positron::PositronDefinition() ||
        &particleType == G4Gamma::GammaDefinition();
    }

    G4bool ExN05EMShowerModel::ModelTrigger(const G4FastTrack&
    fastTrack)
    {
      // Applies the parameterisation above 100 MeV:
      return fastTrack.GetPrimaryTrack()->GetKineticEnergy() > 100*MeV;
    }
```

# IV. Example (3)

```
void ExN05EMShowerModel::DoIt(const G4FastTrack& fastTrack,
                              G4FastStep& fastStep)
    {
      G4cout << "ExN05EMShowerModel::DoIt" << G4endl;

      // Kill the parameterised particle:
      fastStep.KillPrimaryTrack();
      fastStep.SetPrimaryTrackPathLength(0.0);
      fastStep.SetTotalEnergyDeposited(fastTrack.GetPrimaryTrack()->
                                                    GetKineticEnergy());

      // split into "energy spots" energy according to the shower shape:
      Explode(fastTrack); // Energy spot = (x, y, z, E)

      // and put those energy spots into the crystals:
      BuildDetectorResponse();
    }
```

# IV. Example (4)

- To set « energy spot » in sensitive volume, mimic the stepping part regarding hits creation:

```
void ExN05EMShowerModel::AssignSpotAndCallHit(const ExN05EnergySpot &eSpot)
 {
     // "converts" the energy spot into the fake G4Step to pass to sensitive detector:
     FillFakeStep(eSpot);
     // call sensitive part: taken/adapted from the stepping:
     // Send G4Step information to Hit/Dig if the volume is sensitive
     G4VPhysicalVolume* pCurrentVolume =
          fFakeStep->GetPreStepPoint()->GetPhysicalVolume();
     G4VSensitiveDetector* pSensitive;

     if( pCurrentVolume != 0 ) {
        pSensitive = pCurrentVolume->GetLogicalVolume()->
          GetSensitiveDetector();
        if( pSensitive != 0 )  pSensitive->Hit(fFakeStep);
     }
 }
```