Optional User Actions

Geant4 PHENIICS & IN2P3 Tutorial,

22 – 26 May 2023,

Orsay

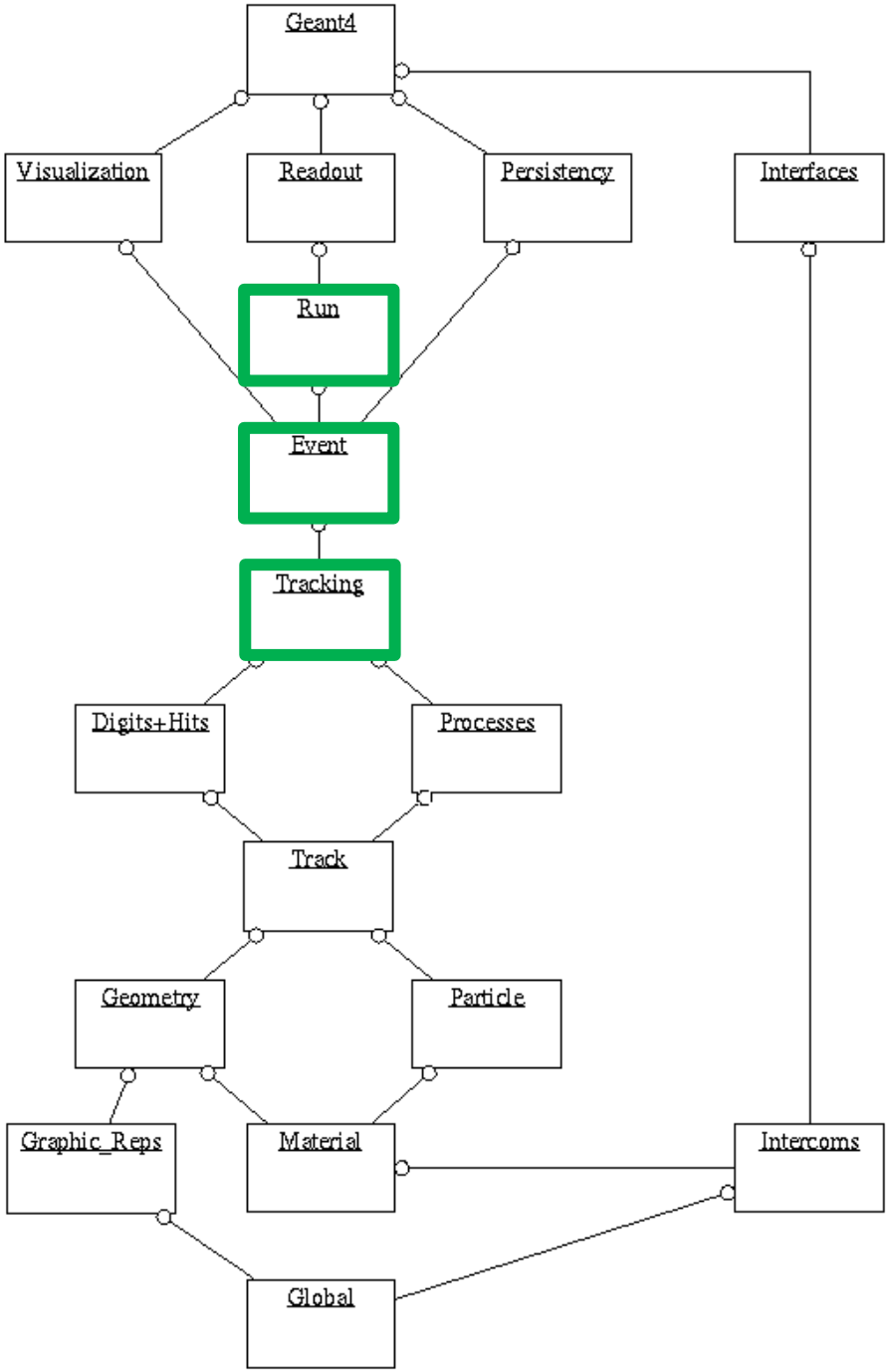
Marc Verderi

LLR, Ecole polytechnique

Where will we look in the toolkit ?

Main categories and directories involved:

- Run
  - geant4/source/run
- Event
  - geant4/source/event
- Tracking
  - geant4/source/tracking



Introduction

- Geant4 works as a set of nested loops:
  - **A job =**
    - Run manager construction and initialization;
    - Then one or several runs or launched;
    - **A run =**
      - Physics and detector construction;
      - Then loop on events;
      - **An event =**
        - » Generation of primary particles;
        - » Then loop for tracking of these particles and all subsequent secondary particles;
        - » **A particle tracking:**
          - Loop on steps, propagating a G4Track object, up to the point this object “dies”;
          - **A step =**
            - Loop on physics processes that apply to the current track to apply physics interactions, generate secondary particles, compute energy deposit in the step, etc.;

Introduction

- Geant4 works as a set of nested loops:
  - **A job =**
    - Run manager construction and initialization;
    - Then one or several runs or launched;
    - **A run =**
      - Physics and detector construction;
      - Then loop on events;
      - **An event =**
        - » Generation of primary particles;
        - » Then loop for tracking of these particles and all subsequent secondary particles;
        - » **A particle tracking:**
          - Loop on steps, propagating a G4Track object, up to the point this object "dies";
          - **A step =**
            - Loop on physics processes that apply to the current track to apply physics interactions, generate secondary particles, compute energy deposit in the step, etc.;

- You can follow the progression of the simulation and take actions through a set of optional user's actions:
  - ➢ **G4UserRunAction**
    - ➢ **G4UserEventAction**
      - ➢ **G4UserTrackingAction**
        - ➢ **G4UserSteppingAction**
  - **Explained in this presentation**

Introduction

- Geant4 works as a set of nested loops:
  - **A job =**
    - Run manager construction and initialization;
    - Then one or several runs or launched;
    - **A run =**
      - Physics and detector construction;
      - Then loop on events;
      - **An event =**
        - » Generation of primary particles;
        - » Then loop for tracking of these particles and all subsequent secondary particles;
        - » **A particle tracking:**
          - Loop on steps, propagating a G4Track object, up to the point this object "dies";
          - **A step =**
            - Loop on physics processes that apply to the current track to apply physics interactions, generate secondary particles, compute energy deposit in the step, etc.;

- You can follow the progression of the simulation and take actions through a set of optional user's actions:
  - ➢ **G4UserRunAction**
    - ➢ **G4UserEventAction**
      - ➢ **G4UserTrackingAction**
        - ➢ **G4UserSteppingAction**
  - **Explained in this presentation**

- You are also given some handles to control the simulation flow:
  - **G4UserStackingAction** : allows to control in what ordering tracks are processed
  - **This will be shown in an other presentation**

- All these actions are optional… but are almost always used in sizeable applications.

User actions classes: virtual methods and invocation sequence

G4UserRunAction:

Object default lifecycles

Run	Event	Track	Step
✓	✗	✗	✗

- **G4Run* GenerateRun()**

  Allows user to generate a G4Run object of his/her type if void G4Run::RecordEvent(const G4Event*) method is overridden.

  void BeginOfRunAction(const G4Run* currentRun)

- **void EndOfRunAction(const G4Run* currentRun)** ✓ ✗ ✗ ✗

User actions classes: virtual methods and invocation sequence

G4UserRunAction:

- **G4Run* GenerateRun()**
  Allows user to generate a G4Run object of his/her type if void G4Run::RecordEvent(const G4Event*) method is overridden.

void BeginOfRunAction(const G4Run* currentRun)

↑

Loop on events

↓

- **void EndOfRunAction(const G4Run* currentRun)**

Object default lifecycles

Run	Event	Track	Step
✓	✗	✗	✗
✓	✗	✗	✗

User actions classes: virtual methods and invocation sequence

G4UserRunAction:

Object default lifecycles

	Run	Event	Track	Step
• **G4Run* GenerateRun()** Allows user to generate a G4Run object of his/her type if void G4Run::RecordEvent(const G4Event*) method is overridden.				
void BeginOfRunAction(const G4Run* currentRun)	✓	✗	✗	✗

Loop on events ↑

G4UserEventAction:

• **void BeginOfEventAction(const G4Event* currentEvent)**	✓	✓	✗	✗
• **void EndOfEventAction(const G4Event* currentEvent)**	✓	✓	✗	✗

Loop on events ↓

• **void EndOfRunAction(const G4Run* currentRun)**	✓	✗	✗	✗

User actions classes: virtual methods and invocation sequence

G4UserRunAction:

- **G4Run* GenerateRun()**
  Allows user to generate a G4Run object of his/her type if void G4Run::RecordEvent(const G4Event*) method is overridden.

Object default lifecycles

	Run	Event	Track	Step
void BeginOfRunAction(const G4Run* currentRun)	✓	✗	✗	✗

Loop on events →

G4UserEventAction:

	Run	Event	Track	Step
• **void BeginOfEventAction(const G4Event* currentEvent)**	✓	✓	✗	✗

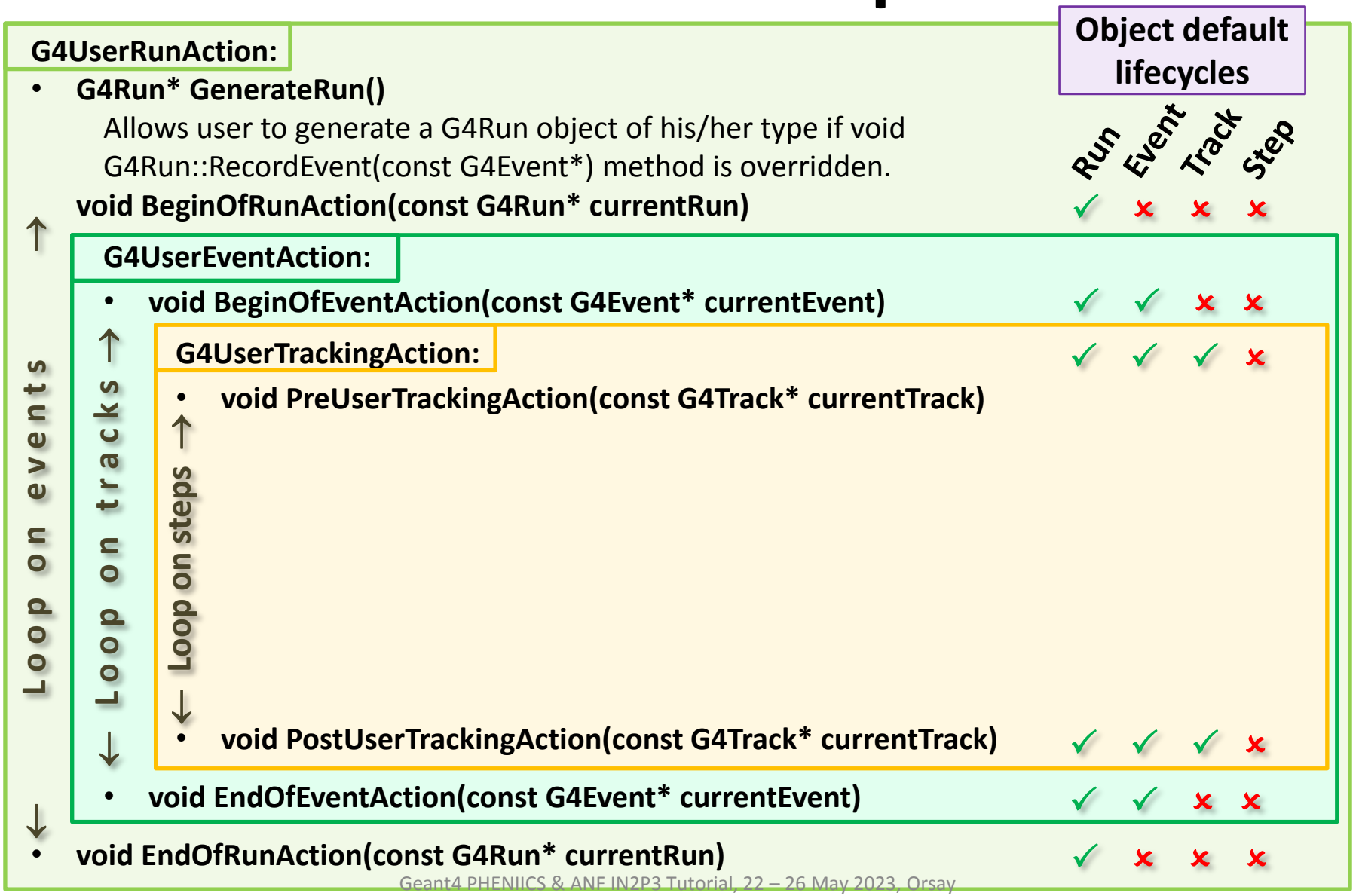
Loop on tracks →

	Run	Event	Track	Step
• **void EndOfEventAction(const G4Event* currentEvent)**	✓	✓	✗	✗

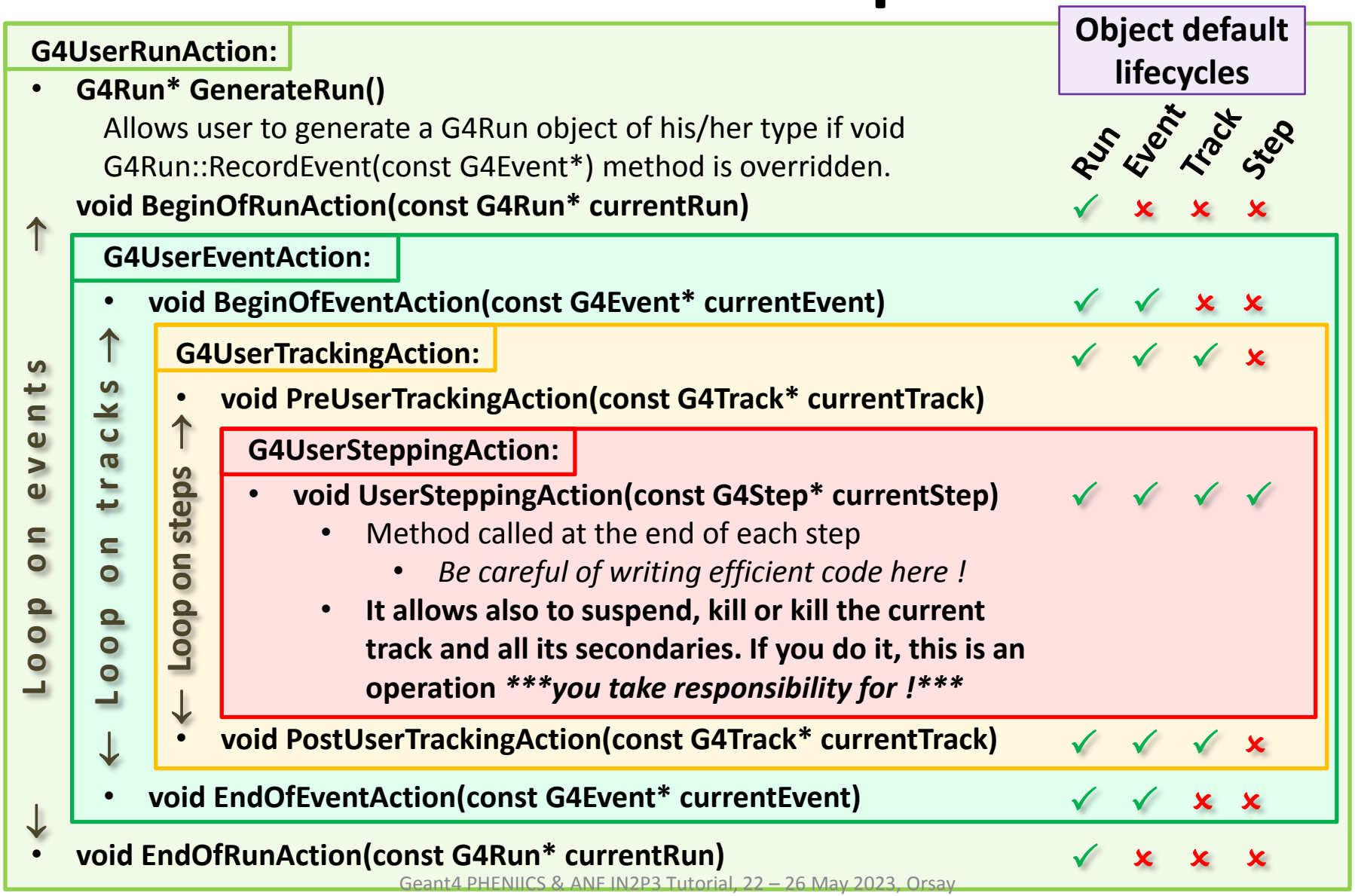
Loop on events ↓

	Run	Event	Track	Step
• **void EndOfRunAction(const G4Run* currentRun)**	✓	✗	✗	✗

User actions classes: virtual methods and invocation sequence



User actions classes: virtual methods and invocation sequence



User Action Classes : virtual methods and usage examples

- **G4UserRunAction**

  Usage examples

  G4Run* GenerateRun() ..... Instantiate user-customized run object

  void BeginOfRunAction(const G4Run*) ..... Define histograms

  void EndOfRunAction(const G4Run*) ..... Analyze the run, store histograms

- **G4UserEventAction**

  void BeginOfEventAction(const G4Event*) ..... Event selection

  void EndOfEventAction(const G4Event*) ..... Output event information

- **G4TrackingAction**

  void PreUserTrackingAction(const G4Track*) ..... Decide to store or not a trajectory; Create user-defined trajectory

  void PostUserTrackingAction(const G4Track*) ..... Delete unecessary trajectory

- **G4UserSteppingAction**

  void UserSteppingAction(const G4Step*) ..... Kill / suspend / postpone the track; Draw the step (for a track not to be stored as a trajectory)

Declaring Users Actions

- You define you user actions inheriting from the proper base classes:
  - class MyRunAction : public G4UserRunAction {…};
  - class MyEventAction : public G4UserEventAction {…};
  - class MyTrackingAction : public G4UserTrackingAction {…};
  - class MySteppingAction : public G4UserSteppingAction {…};
  - Overwriting the proper virtual methods.

- To take effect, these actions objects must be passed to the runManager:

  - **In your action initialization class:**

```
void MyActionInitialization::Build() const
{
  SetUserAction(new MyRunAction);
  SetUserAction(new MyEventAction);
  SetUserAction(new MyTrackingAction);
  SetUserAction(new MySteppingAction);
}
void MyActionInitialization::BuildForMaster() const
{
  SetUserAction(new MyRunAction);
}
```

  - **And in your main program:**

```
runManager->SetUserInitialization(new MyActionInitialization);
```

Mandatory method, must be provided.

Make your "new MyXXXAction" here !
(And *not* in constructor for example)

Only used in Multithreading mode (presented in session 7)

```
G4RunManager* runManager = new G4RunManager;
or
G4MTRunManager* runManager = new G4MTRunManager;
```

  - **if Geant4 version < Geant4 v10.0 (obsoleting):**
    - **In your main program:**

```
G4RunManager* runManager = new G4RunManager;
runManager->SetUserAction(new MyRunAction);
runManager->SetUserAction(new MyEventAction);
runManager->SetUserAction(new MyTrackingAction);
runManager->SetUserAction(new MySteppingAction);
```

Kept in v10.0 for backward compatibility

Summary

- Geant4 provides user action classes that allow you to take actions at the various stages of the simulation:
  - Start and end of run : **G4UserRunAction**
  - Start and end of event : **G4UserEventAction**
  - Start and end of tracking of one track : **G4UserTrackingAction**
  - End of each step : **G4UserSteppingAction**
    - This is the only of these classes with which **you can modify the simulation behavior**
      - eg: killing a track
    - But you take responsibility for this !
- You inherit from these base classes to implement you own actions

- You declare them to the run manager
  - Which is either a G4RunManager object, or your own run manager object, or a G4MTRunManager one, that will be presented later (session 7).
  - Using your concrete G4VUserActionInitialization class
  - Or invoking the runManager->SetUserAction(new MyXXXAction), if < v10.0 (obsoleting)

- An other user action class, **G4UserStackingAction**, that allows to control the simulation flow will be presented later.