NE697: Introduction to Geant4

C++ Geant4 Intro

September 28th, 2021 Dr. Micah Folsom



THE UNIVERSITY OF TENNESSEE KNOXVILLE



Today's Agenda

Administrative items

Compile Geant4 and run exampleB1

Geant4 basics



Last Time, On NE697...

- Assignment 3
 - Due tonight at midnight, Pacific time
 - Need more time?

Class inheritance – any follow-up questions?



- GEometry ANd Tracking
- Developed by CERN for their high energy physics experiments
- Initial release as GEANT in 1974, written in FORTRAN
- GEANT4, C++, released in 1998
- Also does optical photon transport
- Not frequently used for fission beyond spontaneous fission for common sources

- Also includes tools for geometry/materials definition, run management, visualization, and some analysis
- Visualization is useful for verifying what you're running
- Analysis is less useful (you'll want to do this yourself)
- Once developed and tested, run in batch mode (.mac) on a beefy computer
- Sequential vs multi-threaded
 - We'll be using the latter



Geant4 Resources

- Application Developer's Guide
 - https://geant4userdoc.web.cern.ch/UsersGuides/ForApplicationDeveloper/html/index.html
 - Read this!!!
- Doxygen documentation (source code browsing)
 - <u>https://geant4.kek.jp/Reference/</u>
- Examples
 - https://geant4-userdoc.web.cern.ch/Doxygen/examples_doc/html/index.html
- [DEMO]
 - Compiling Geant4



- [DEMO]
 - Geant4 exampleB1
 - Directory structure and build system
 - Macros/scripts (.mac files)
 - Run interactively
 - Components of visualization configuration (vis.mac)
 - Run1.mac, run2.mac
 - Run in batch mode
 - Changing the verbosity level (control, tracking)
 - Changing the number of particles to run

Example B1

- · Simple geometry with a few solids
- Geometry with simple placements (G4PVPlacement)
- Scoring total dose in a selected volume user action classes
- · Using G4Accumulable for automatic merging of scored values in multi-threading mode
- Geant4 physics list (QBBC)

- Anatomy of a basic Geant4 program
 - Set up the G4RunManager
 - Register actions with ActionInitialization
 - RunAction
 - EventAction
 - PrimaryGeneratorAction (particle source)
 - Create geometry with inherited G4VUserDetectorConstruction
 - Define physics with a physics list
- In main() we handle command-line args and deal with visualization



Geant4: RunManager

- G4RunManager (G4MTRunManager)
- Initialize() (/run/initialize)
- Remember run() from our MC1D assignment?
 - BeamOn() (/run/beamOn)
- SetUserAction() is deprecated
- SetUserInitialization() ->
 ActionInitialization

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void CutOffHasBeenModified () void ReOptimize (G4LogicalVolume *) void ReOptimize (G4LogicalVolume *) void SetVerboseLevel (G4int vl) G4int GetVerboseLevel () const void SetGeometry ToBeOptimized (G4bool vl) G4bool GetGeometry ToBeOptimized () void SetNumberOfEvents ToBeStored (G4int val) const G4Run * GetCurrentRun () const const G4Event * GetCurrentEvent () const const G4Event * GetPreviousEvent (G4int i) const setNumberOfParallelWorld () const SetNumberOfParallelWorld () const void SetNumberOfEvents ToBeProcessed (G4int val) void SetUtable (G4DCtable *DCtbl)		
void ReOptimizeMotherOf (GAVPhysicalVolume *)		
void ReOptimize (G4LogicalVolume *) void SetVerboseLevel (G4int vI) G4int void GetVerboseLevel (Const void G4bool GetGeometryToBeOptimized (G4bool vI) G4bool void SetGeometryToBeOptimized (O4bool vI) G5beCometryToBeOptimized (O4bool vI) G5beCometryToBeOptimized (O4bool vI) G5beCometryToBeOptimized (O4bool vI) G5beCometryToBeOptimized (O4bool vI) G6bCometryToBeOptimized (O4bool vI) SetNumberOfFarallelWorld (O5bool vI) SetDCtable (G4DCtable *DCtbl)		
void SetVerboseLevel (G4int vl) G4int GetVerboseLevel () const void SetGeometry ToBeOptimized (G4bool vl) G4bool GetGeometry ToBeOptimized () void SetNumberOfEvents ToBeStored (G4int val) const G4Event * GetCurrentRun () const const G4Event * GetCurrentEvent () const setNumIDC ounter (G4int i) SetNumIDC ounter (G4int i) G4int GetNumberOfParallelWorld () const void SetNumberOfEvents ToBeProcessed (G4int val) void SetOtable (G4DCtable *DCtbl)		
G4int GetVerboseLevel () const		
void SetGeometryToBeOptimized (G4bool vI) G4bool void SetGeometryToBeOptimized () SetNumberOfEventsToBeStored (G4int val) const G4Event * GetCurrentEvent () const const G4Event * GetFeviousEvent (G4int i) const const G4Event * GetPreviousEvent (G4int i) const setNumberOfEventsToBeTeventSevent (G4int i) G4int G4int G4int i) SetNumberOfEventsToBeProcessed (G4int val) void SetOctable (G4DCtable *DCtbl)		
G4bool GetGeometryToBeOptimized () setNumberOfEventsToBeStored (G4int val) const G4Run * GetCurrentRun () const const G4Event * GetCurrentEvent () const const G4Event * GetCurrentEvent (G4int i) const void SetNumberOfParallelWorld () const void SetNumberOfParallelWorld () const void SetNumberOfEventsToBeProcessed (G4int val) void SetOctable (C4DCtable *DCtbl)		
void SetNumberÖfEventsToBeStored (G4int val) const G4Run * GetCurrentRun () const const G4Event * GetCurrentCevent () const const G4Event * GetPreviousEvent (G4int i) const void SetRunIDCounter (G4int i) G4int GetNumberOfParallelWorld () const void SetNumberOfFeventsToBeProcessed (G4int val) void SetDCtable (G4DCtable *DCtbl)		
const G4Run * GetCurrentRun () const const G4Event * GetCurrentCvent () const const G4Event * GetPreviousEvent (G4int i) const void SetRunlDCounter (G4int i) G4int GetNumberOfParallelWorld () const void SetNumberOfEventsToBeProcessed (G4int val) void SetDCtable (G4DCtable *DCtbl)		
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Const G4Event GetPreviousEvent (G4int i) const		
void SetRunIDCounter (G4int i) G4int GetNumberOfParallelWorld () const void SetNumberOfEventsToBeProcessed (G4int val) void SetDCtable (G4DCtable *DCtbl)		
void SetNumberOfEventsToBeProcessed (G4int val) void SetDCtable (G4DCtable *DCtbl)		
void SetDCtable (G4DCtable *DCtbl)		
void ConstructScoringWorlds ()	void	ConstructScoringWorlds ()



Geant4: ActionInitialization

	G4VUserActionInitialization ()
virtual	~G4VUserActionInitialization ()
virtual void	Build () const =0
virtual void	BuildForMaster () const
virtual G4VSteppingVerbose *	$Initialize Stepping Verbose\ ()\ const$

- Used for "registering" user-defined action classes with Geant4
 - Register: give Geant4 a pointer to an instance of the object
 - Using inheritance; Geant4 keeps a G4VUserActionInitialization*
- Build() is called by each thread
- BuildForMaster() is called by the master thread (often just RunAction)

Geant4: RunAction

- Used for Run management
- Functions called at the start and stop of a Run
- Allows us to provide a custom Run object (inherits from G4Run)
- Note "const G4Run*": cannot change Run objects in these functions!
 - Reminder, same as G4Run const*
- We'll revisit the Run objects later

Public Member Functions

	G4UserRunAction ()
virtual	~G4UserRunAction ()
virtual G4Run *	GenerateRun ()
virtual void	BeginOfRunAction (const G4Run *aRun)
virtual void	EndOfRunAction (const G4Run *aRun)
virtual void	SetMaster (G4bool val=true)
G4bool	IsMaster () const

Protected Attributes

G4bool isMaster



Geant4: EventAction

- Used for Event management
- Functions called at the start and stop of an Event
- Often used for printing periodic updates (event number)
- EndOfEventAction() historically used for getting Event hit information (now done in Run::RecordEvent())

	G4UserEventAction ()
virtual	~G4UserEventAction ()
virtual void	SetEventManager (G4EventManager *value)
virtual void	BeginOfEventAction (const G4Event *anEvent)
virtual void	EndOfEventAction (const G4Event *anEvent)



Geant4: PrimaryGeneratorAction

- Sets the primary particle properties for the G4Event
 - Which, how many, position, direction, energy, etc
- GeneratePrimaries() is usually a pass-through to a particle gun's GeneratePrimaryVertex()
- G4GeneralParticleSource (GPS) built-in option

Public Member Functions

G4VUserPrimaryGeneratorAction ()

virtual ~G4VUserPrimaryGeneratorAction ()

virtual void GeneratePrimaries (G4Event *anEvent)=0



Geant4: DetectorConstruction

	G4VUserDetectorConstruction ()
virtual	~G4VUserDetectorConstruction ()
virtual G4VPhysicalVolume *	Construct ()=0
virtual void	ConstructSDandField ()
virtual void	CloneSD ()
virtual void	CloneF ()
void	RegisterParallelWorld (G4VUserParallelWorld *)
G4int	ConstructParallelGeometries ()
void	ConstructParallelSD ()
G4int	GetNumberOfParallelWorld () const
G4VUserParallelWorld *	GetParallelWorld (G4int i) const

- Interface for providing geometry to Geant4
- Also handles SensitiveDetectors (more on this later)
- Parallel geometries (l've never used these)
- Construct() returns your top level simulation physical volume ("world")

Geant4: Physics Lists

- We can define what physics we want, how we want
- We usually want to use the physics we all know* and love
- Most people 1) copy from a similar example and then modify or 2) use a builtin
- Completely dependent on details of the use case

	G4VUserPhysicsList ()
virtual	~G4VUserPhysicsList ()
	G4VUserPhysicsList (const G4VUserPhysicsList &)
G4VUserPhysicsList &	operator= (const G4VUserPhysicsList &)
virtual void	ConstructParticle ()=0
void	Construct ()
virtual void	ConstructProcess ()=0
void	UseCoupled Transportation (G4bool vi=true)
virtual void	SetCuts ()
void	SetDefaultCutValue (G4double newCutValue)
G4double	GetDefaultCutValue () const
void	BuildPhysicsTable ()
void	PreparePhysicsTable (G4ParticleDefinition *)
void	BuildPhysicsTable (G4ParticleDefinition *)
G4bool	StorePhysicsTable (const G4String &directory=".")
G4bool	IsPhysicsTableRetrieved () const
G4bool	IsStoredInAscii () const
const G4String &	GetPhysicsTableDirectory () const
void	SetPhysicsTableRetrieved (const G4String &directory=""")
void	SetStoredInAscii ()
void	ResetPhysicsTableRetrieved ()
void	ResetStoredInAscii ()
void	DumpList () const
void	DumpCutValuesTable (G4int flag=1)
void	DumpCutValuesTableIfRequested ()
void	SetVerboseLevel (G4int value)
G4int	GetVerboseLevel () const
void	SetCutsWithDefault ()
void	SetCutValue (G4double aCut, const G4String &pname)
G4double	GetCutValue (const G4String &pname) const
void	SetCutValue (G4double aCut, const G4String &pname, const G4String &mame)
void	SetParticleCuts (G4double cut, G4ParticleDefinition *particle, G4Region *region=0)
void	SetParticleCuts (G4double cut, const G4String &particleName, G4Region *region=0)
void	SetCutsForRegion (G4double aCut, const G4String &rname)
void	ResetCuts ()
void	SetApplyCuts (G4bool value, const G4String &name)
G4bool	GetApplyCuts (const G4String &name) const
void	RemoveProcessManager ()
void	${\bf AddProcessManager} \ ({\bf G4ParticleDefinition} \ ^*newParticle, \ {\bf G4ProcessManager} \ ^*newManager=0)$
void	CheckParticleList ()
void	DisableCheckParticleList ()
G4int	GetInstanceID () const
virtual void	InitializeWorker ()
virtual void	TerminateWorker ()



Geant4 Example B1 Revisited

• [DEMO]

- Look at the code anatomy of exampleB1
- We'll be doing things a little bit cleaner, more best practices
 - Namespace instead of B1 prefix
 - No need for virtual prefix on inheriting functions
 - override keyword usage
 - All .cpp files in src/
 - Scripts in scripts/