GEANT4
A SIMULATION TOOLKIT

Visualization

Mihaly Novak (CERN, EP-SFT)

Getting Started with **`Geant4`** at CERN, Geneva (Switzerland)

- What can be visualized?
- Type of visualization drivers
- Qt GUI with OpenGL driver

Visualization

WHAT CAN BE VISUALIZED?

- **Simulation data**:
  - geometrical components, detector, simulation set-up
  - particle trajectories and their tracking steps
  - hits of particles in the geometry or
  - quantities like energy deposit, dose, etc.
- **User defined objects** (not directly related to the simulation itself):
  - polylines (connected lines as an object): e.g. coordinate axes
  - 3D markers: e.g. eye guides
  - text:
    - descriptive character strings (e.g. some dynamic properties during tracking)
    - comments or titles
- **`Geant4` visualization documentation:** Visualization Documentation

Visualization

TYPE OF VISUALIZATION DRIVERS

A variety of choices depending on the requirements:

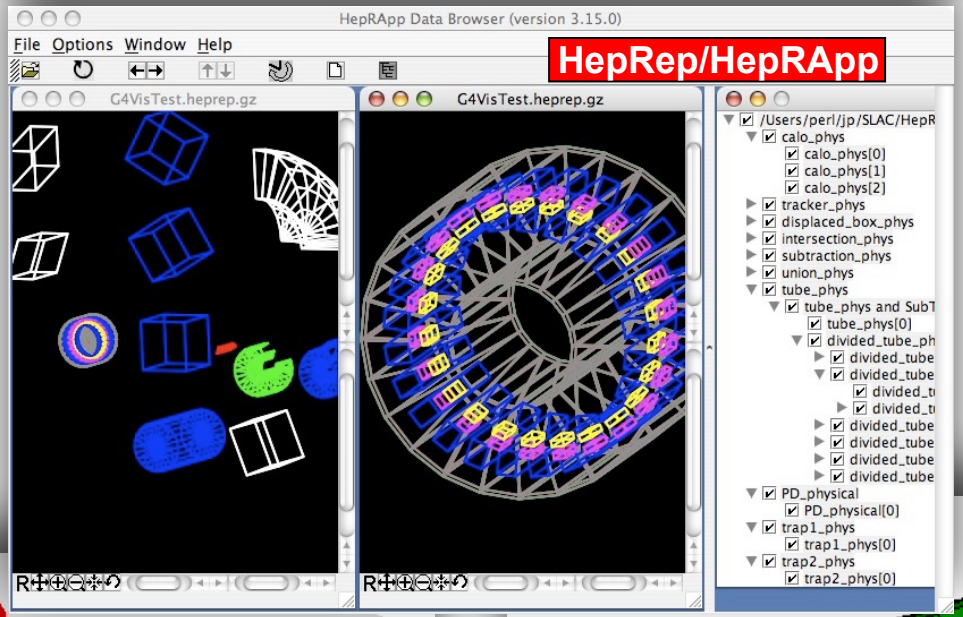
Driver	Variant	Hight quality print	Interactive	browse geometry hierarchies	Direct access to G4 kernel	Make movies	Web
OpenGL	X						
	Xm						
	Qt						
	Win32						
OpenInventor	Xt						
	Win32						
DAWN							
VRML							
HepRep							
gMocren							
RayTracer							
ACSII File							

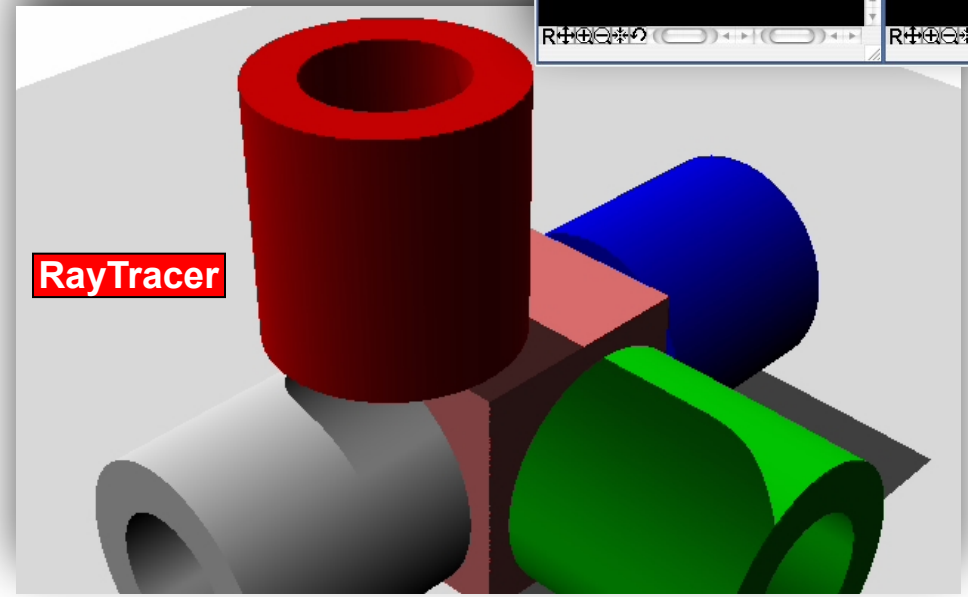
Comput. Phys. Comm. 178 (2008) 331-365

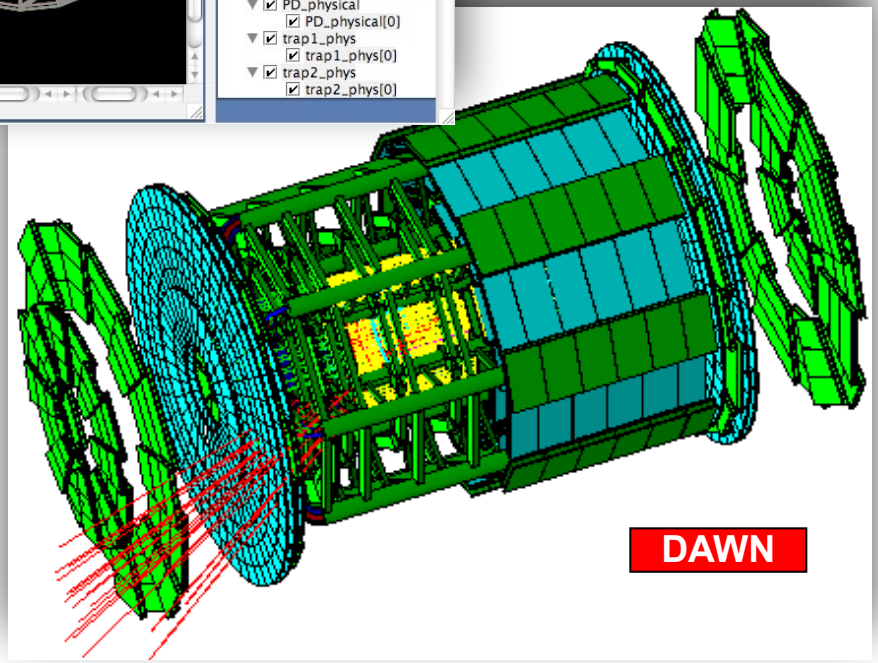
- From **controlling** point of view:
  - some visualization drivers work **directly from Geant4:**
    - OpenGL, OpenInventor, RayTracer, ASCIITree
  - for other visualization drivers, **a** (special) **file** must be **first produced by `Geant4`** then this file will be **rendered by another application**:
    - HepRep, DAWN, VRML, gMocren
- The **`Geant4`** code stays basically the same independently from the choice of the driver
- Visualization is performed either with commands or from C++ code
    - for the present tutorial, we confine ourselves to **command-driven** visualization (both in interactive and batch modes)

- Availability of drives:
  - six of the visualization drivers are always included by default (since they require no external libraries):
    - RayTracer, ASCIITree, HepRep, DAWN, VRML, gMocren
  - other visualization drives (e.g. OpenGL, OpenInventor) will be included only if they were explicitly required during the Geant4 build (through ***cmake*** using the appropriate ***cmake option***):
    - `-DGEANT4_USE_OPENGL_X11=ON` OpenGL visualization driver with X11 window
    - `-DGEANT4_USE_QT=ON` Qt GUI with OpenGL visualization driver
    - in all cases some headers and libraries (X11, Qt, OpenGL or MesaGL) need to be available on the system
    - on your virtual machine, `Geant4` is available with Qt GUI and OpenGL support

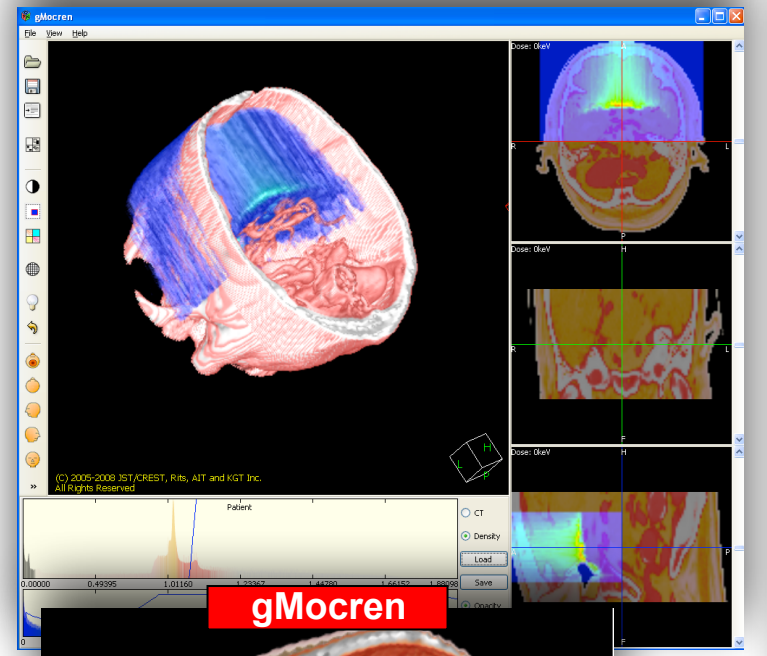
Type of visualization drivers

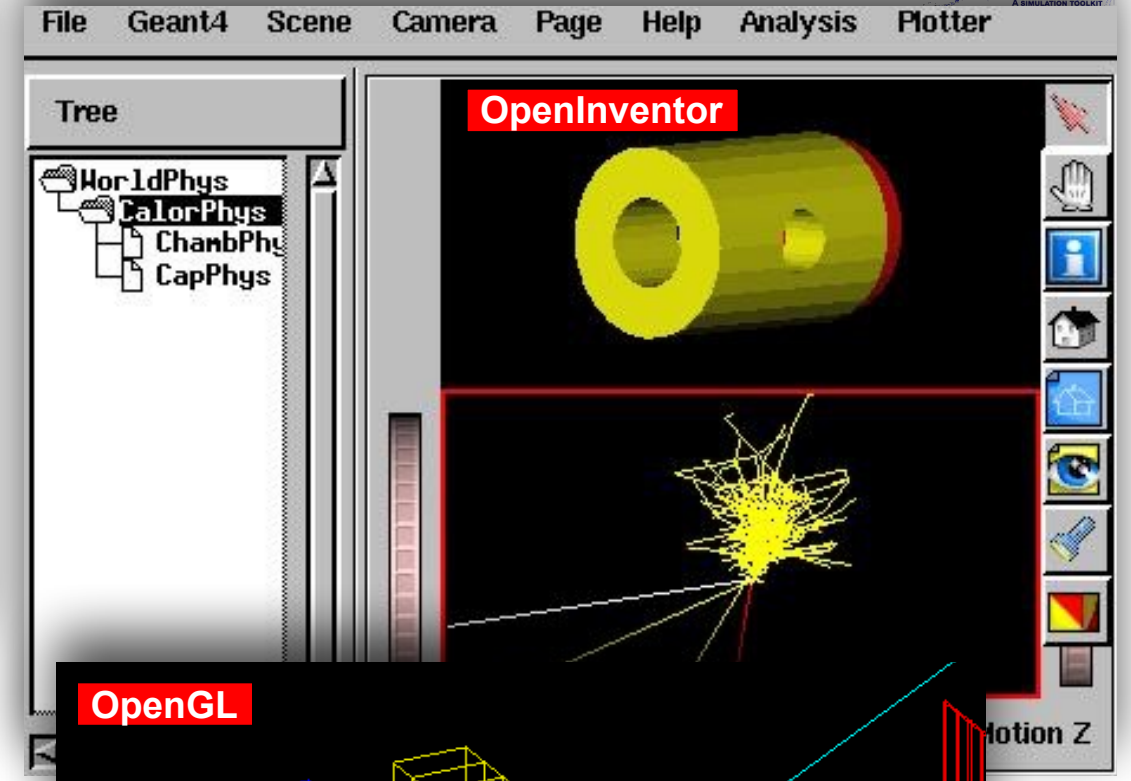


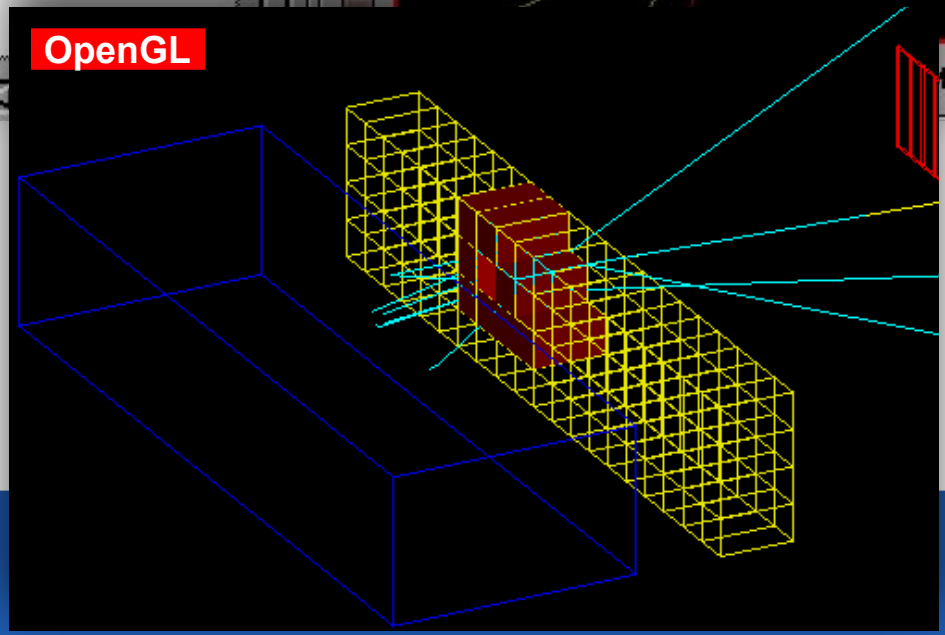




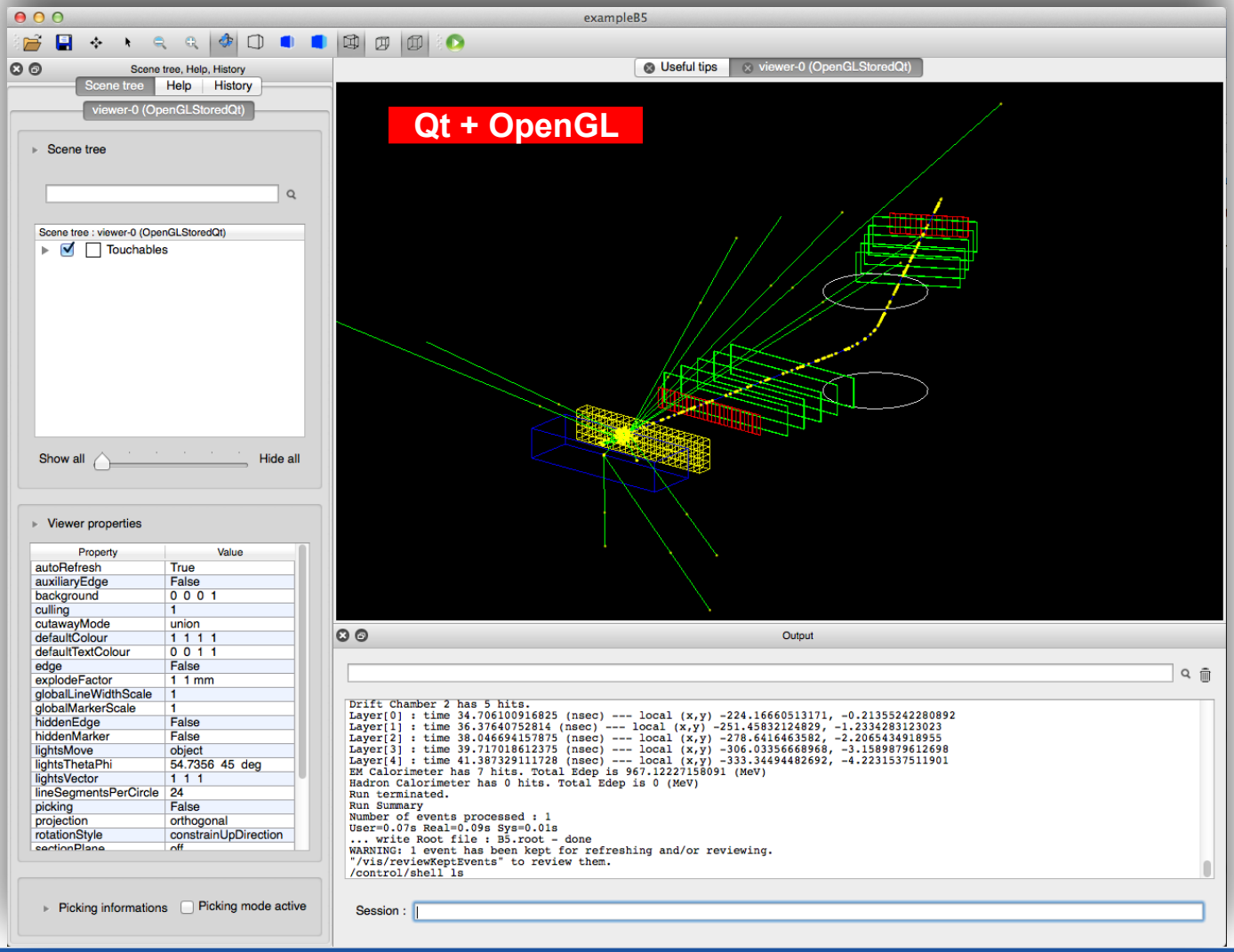
Type of visualization drivers







Qt GUI with **OpenGL visualization driver:**

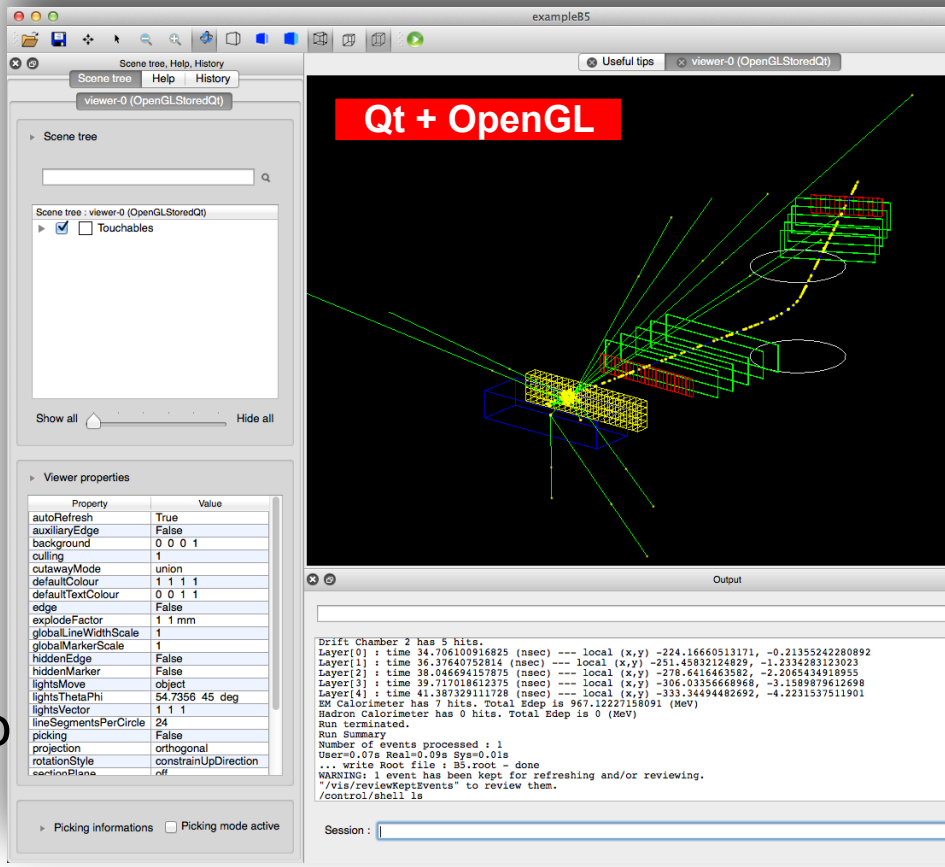


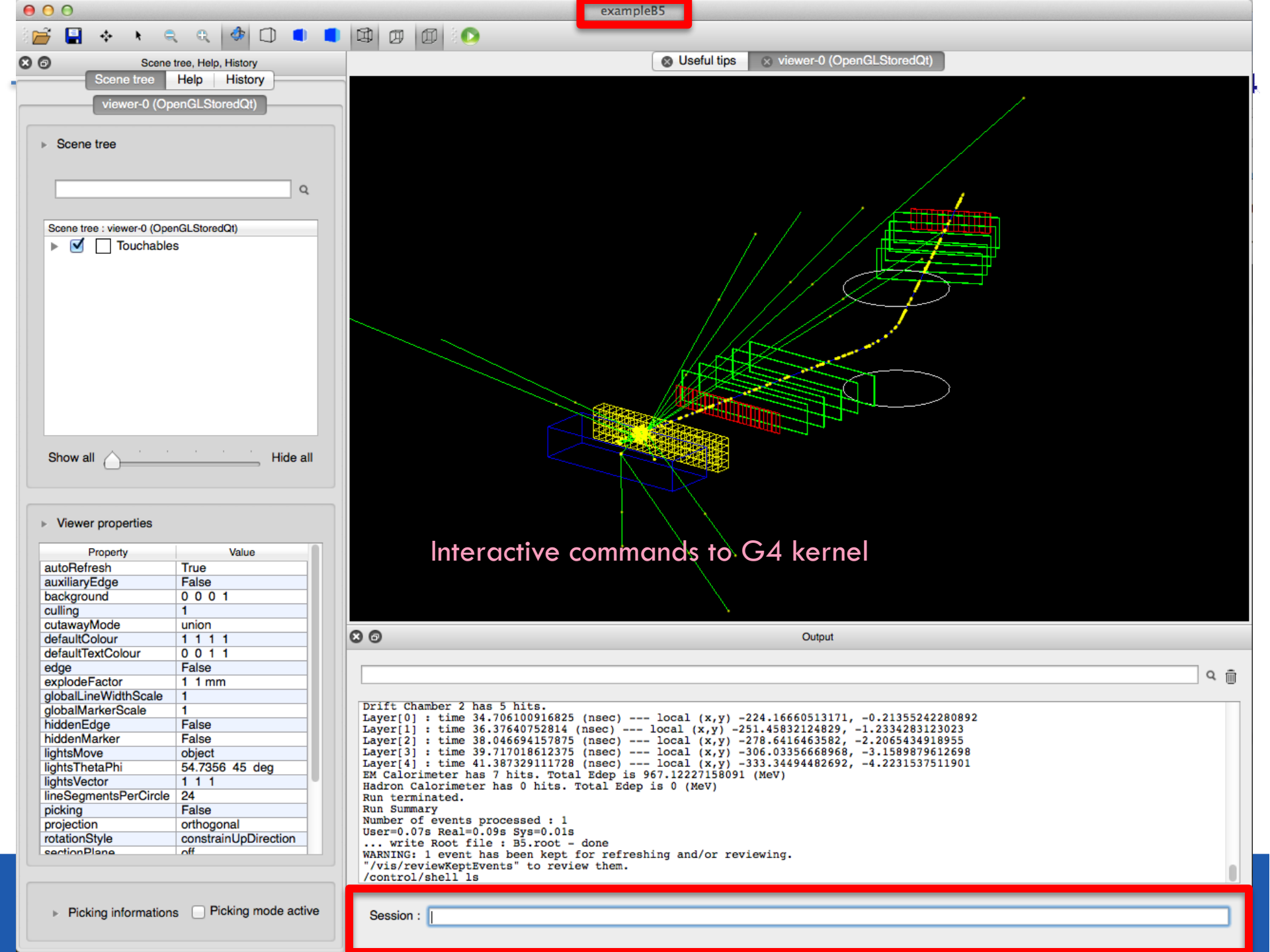
Visualization

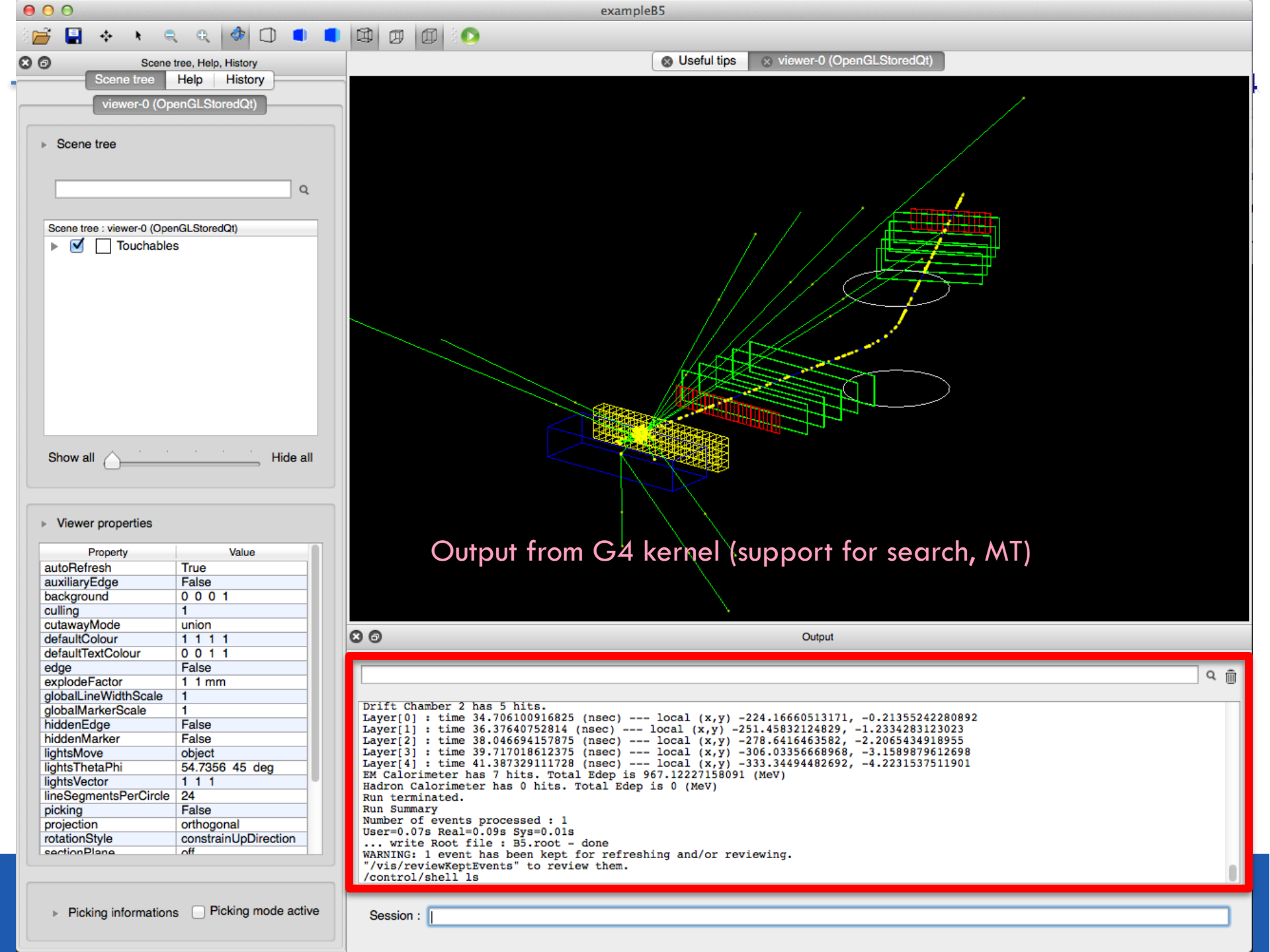
QT GUI WITH OPENGL DRIVER

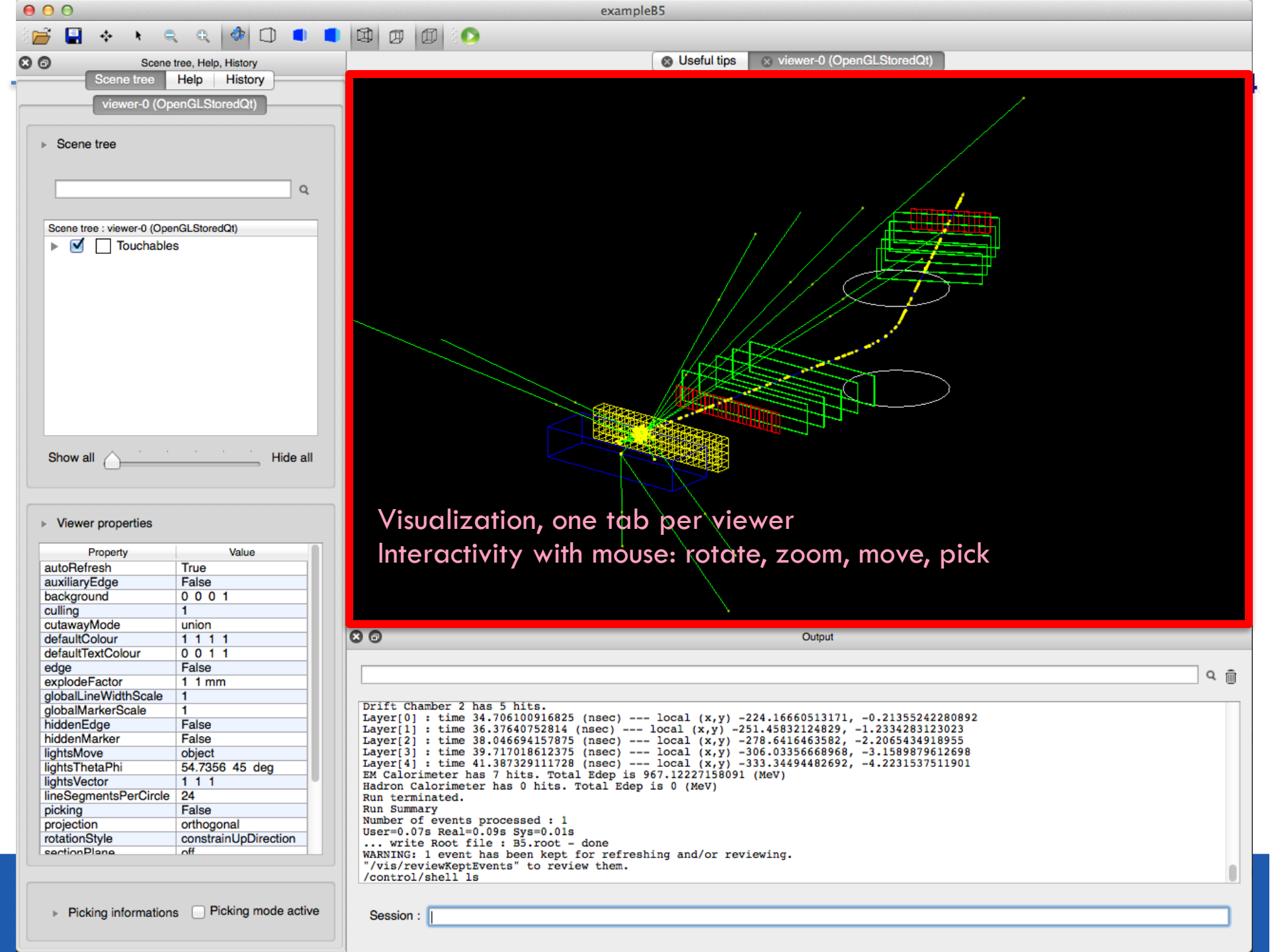
Qt GUI with **OpenGL visualization driver:**

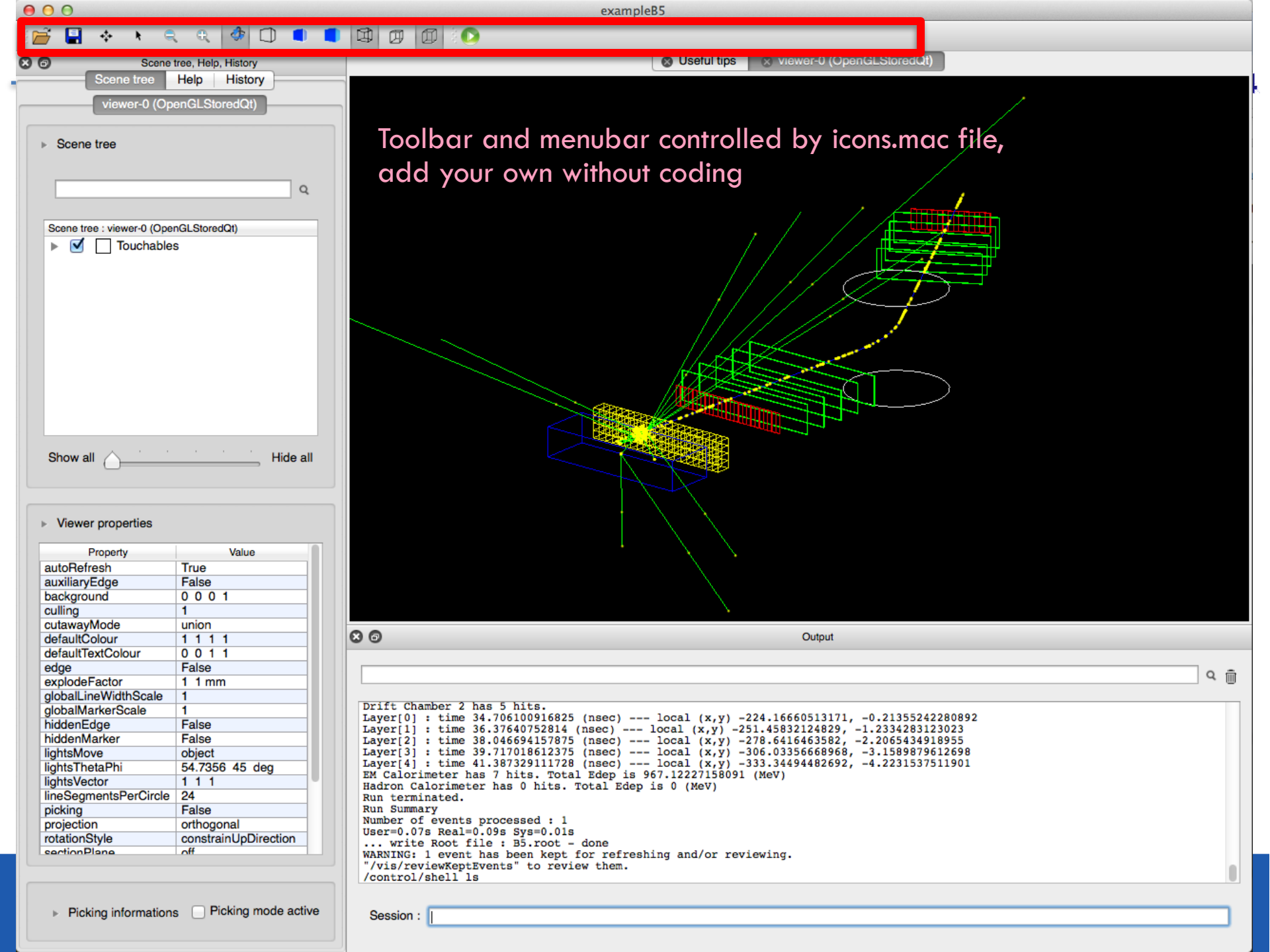
- recent developments focused on this combination
- documentation is available at **Qt+OpenGL**
- `Geant4` OpenGL tutorial with commands **here**
- to visualize the geometry:
  - ***/vis/open OGL***
  - ***/vis/drawVolume***
- most of the Geant4 examples comes with a visualization macro (***`vis.mac`***)
- we will write ours

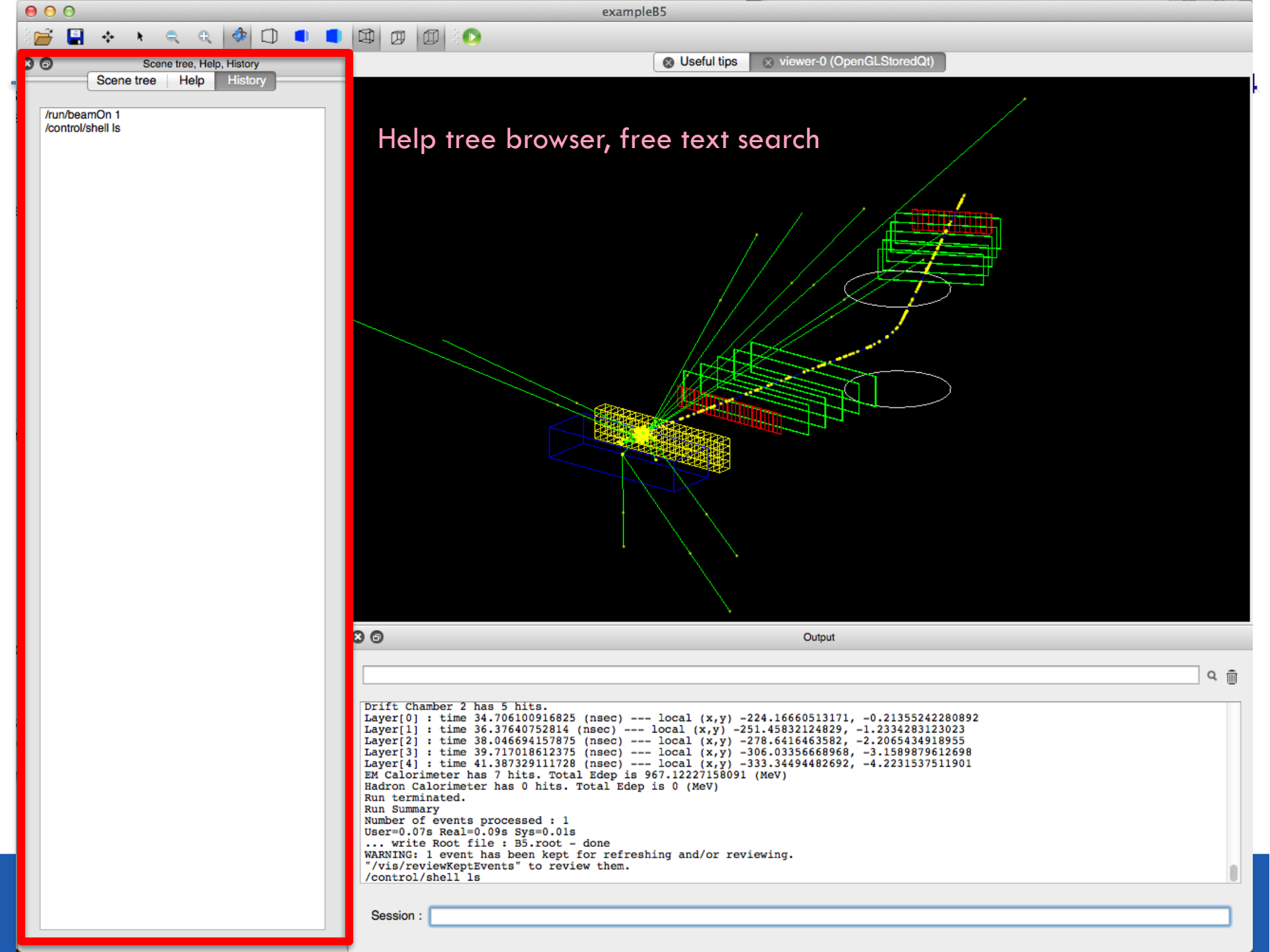


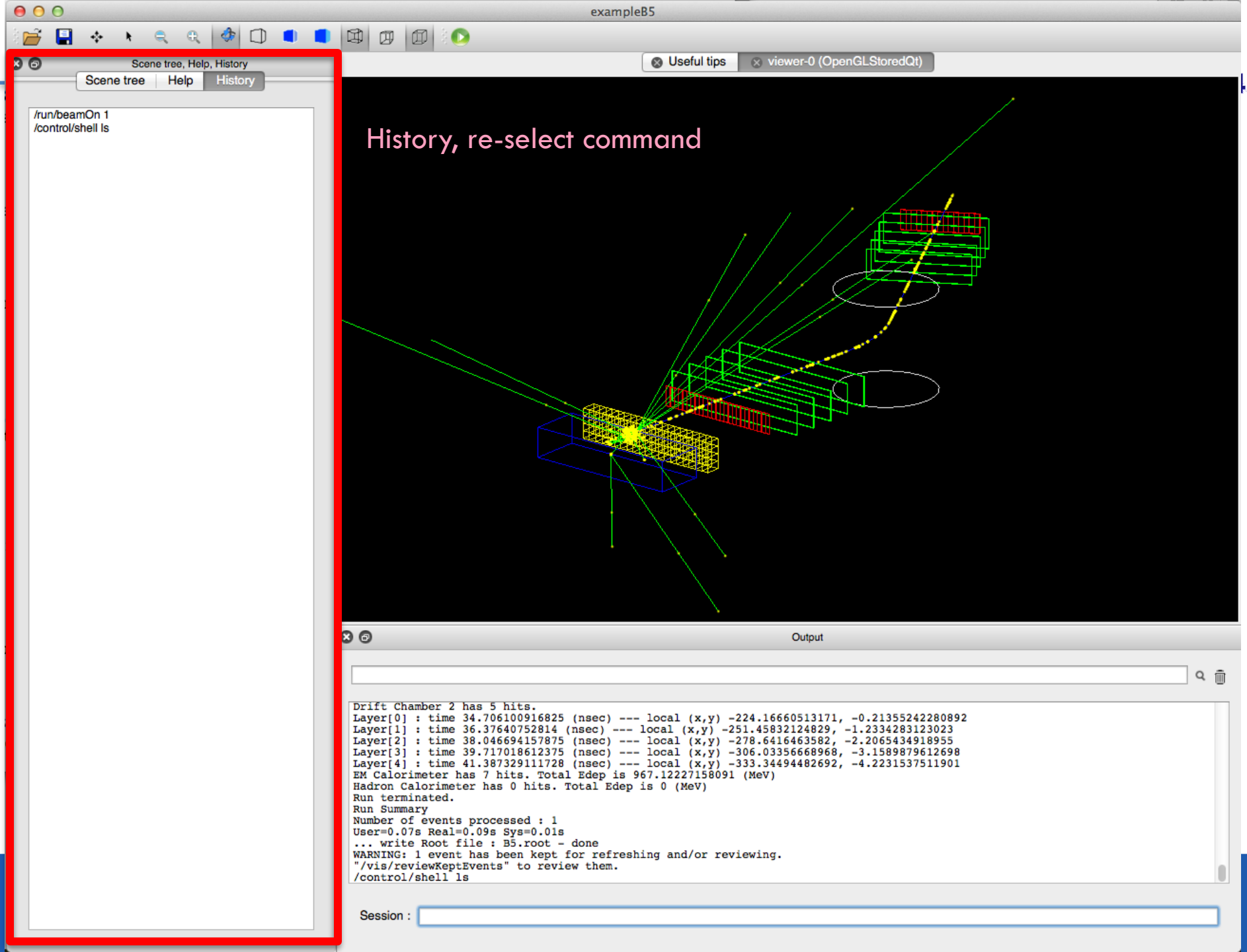

exampleB5
Scene tree, Help, History
Scene tree
Help
History
viewer-0 (OpenGLStoredQt)
Scene tree
Scene tree : viewer-0 (OpenGLStoredQt)
Touchables
Show all
Hide all
Viewer properties
Property
Value
autoRefresh
True
auxiliaryEdge
False
background
0 0 0 1
culling
1
cutawayMode
union
defaultColour
1 1 1 1
defaultTextColour
0 0 1 1
edge
False
explodeFactor
1 1 mm
globalLineWidthScale
1
globalMarkerScale
1
hiddenEdge
False
hiddenMarker
False
lightsMove
object
lightsThetaPhi
54.7356 45 deg
lightsVector
1 1 1
lineSegmentsPerCircle
24
picking
False
projection
orthogonal
rotationStyle
constrainUpDirection
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Interactive commands to G4 kernel
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :

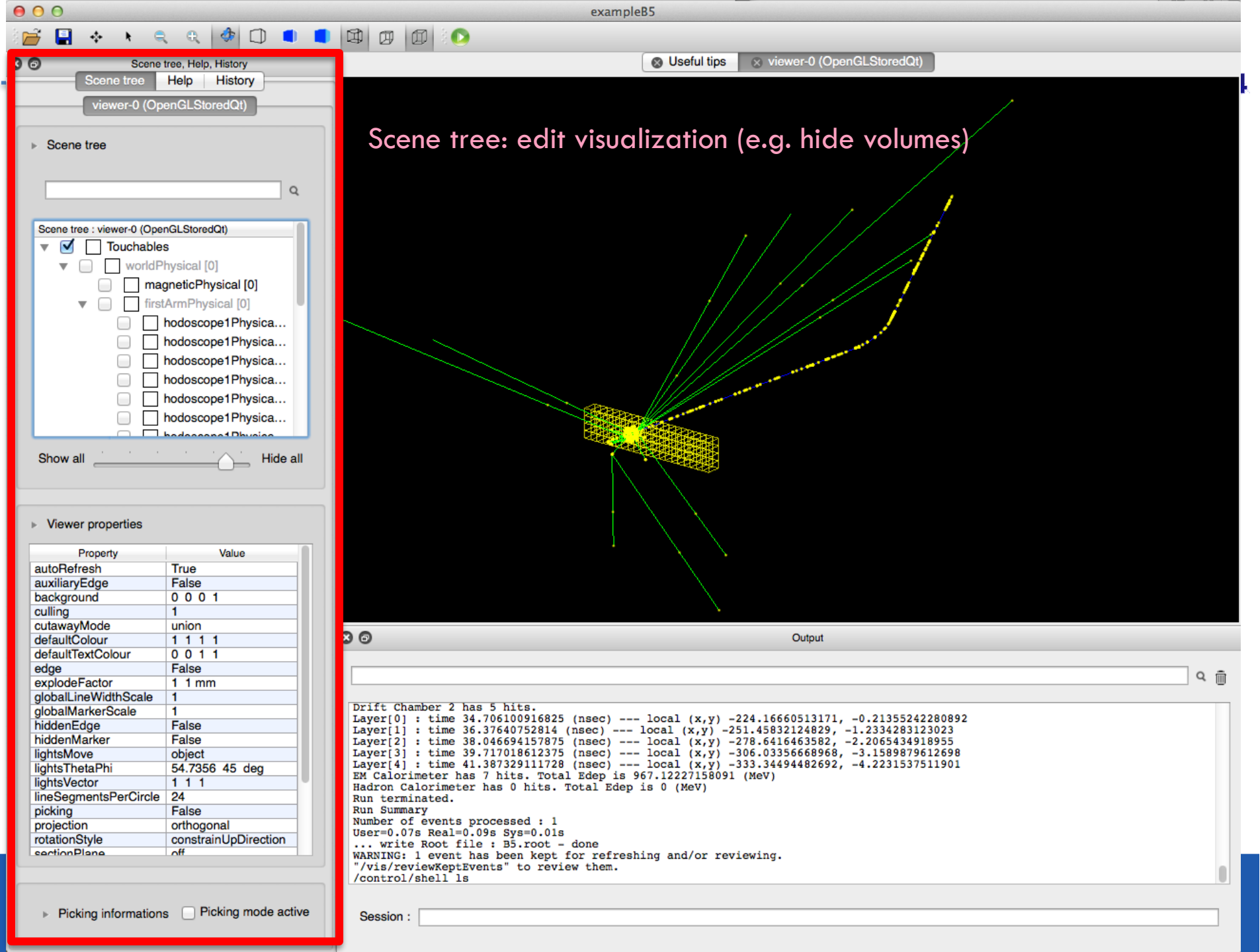

exampleB5
Scene tree, Help, History
Scene tree
Help
History
viewer-0 (OpenGLStoredQt)
Scene tree
Scene tree : viewer-0 (OpenGLStoredQt)
Touchables
Show all
Hide all
Viewer properties
Property
Value
autoRefresh
True
auxiliaryEdge
False
background
0 0 0 1
culling
1
cutawayMode
union
defaultColour
1 1 1 1
defaultTextColour
0 0 1 1
edge
False
explodeFactor
1 1 mm
globalLineWidthScale
1
globalMarkerScale
1
hiddenEdge
False
hiddenMarker
False
lightsMove
object
lightsThetaPhi
54.7356 45 deg
lightsVector
1 1 1
lineSegmentsPerCircle
24
picking
False
projection
orthogonal
rotationStyle
constrainUpDirection
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Output from G4 kernel (support for search, MT)
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
viewer-0 (OpenGLStoredQt)
Scene tree
Scene tree : viewer-0 (OpenGLStoredQt)
Touchables
Show all
Hide all
Viewer properties
Property
Value
autoRefresh
True
auxiliaryEdge
False
background
0 0 0 1
culling
1
cutawayMode
union
defaultColour
1 1 1 1
defaultTextColour
0 0 1 1
edge
False
explodeFactor
1 1 mm
globalLineWidthScale
1
globalMarkerScale
1
hiddenEdge
False
hiddenMarker
False
lightsMove
object
lightsThetaPhi
54.7356 45 deg
lightsVector
1 1 1
lineSegmentsPerCircle
24
picking
False
projection
orthogonal
rotationStyle
constrainUpDirection
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Visualization, one tab per viewer
Interactivity with mouse: rotate, zoom, move, pick
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
viewer-0 (OpenGLStoredQt)
Scene tree
Scene tree : viewer-0 (OpenGLStoredQt)
Touchables
Show all
Hide all
Viewer properties
Property
Value
autoRefresh
True
auxiliaryEdge
False
background
0 0 0 1
culling
1
cutawayMode
union
defaultColour
1 1 1 1
defaultTextColour
0 0 1 1
edge
False
explodeFactor
1 1 mm
globalLineWidthScale
1
globalMarkerScale
1
hiddenEdge
False
hiddenMarker
False
lightsMove
object
lightsThetaPhi
54.7356 45 deg
lightsVector
1 1 1
lineSegmentsPerCircle
24
picking
False
projection
orthogonal
rotationStyle
constrainUpDirection
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Toolbar and menubar controlled by icons.mac file,
add your own without coding
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
/run/beamOn 1
/control/shell ls
Help tree browser, free text search
Useful tips
viewer-0 (OpenGLStoredQt)
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
/run/beamOn 1
/control/shell ls
Useful tips
viewer-0 (OpenGLStoredQt)
History, re-select command
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
viewer-0 (OpenGLStoredQt)
Scene tree
Scene tree : viewer-0 (OpenGLStoredQt)
Touchables
worldPhysical [0]
magneticPhysical [0]
firstArmPhysical [0]
hodoscope1Physica...
Show all
Hide all
Viewer properties
Property
Value
autoRefresh
True
auxiliaryEdge
False
background
0 0 0 1
culling
1
cutawayMode
union
defaultColour
1 1 1 1
defaultTextColour
0 0 1 1
edge
False
explodeFactor
1 1 mm
globalLineWidthScale
1
globalMarkerScale
1
hiddenEdge
False
hiddenMarker
False
lightsMove
object
lightsThetaPhi
54.7356 45 deg
lightsVector
1 1 1
lineSegmentsPerCircle
24
picking
False
projection
orthogonal
rotationStyle
constrainUpDirection
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Scene tree: edit visualization (e.g. hide volumes)
Output
Drift Chamber 2 has 5 hits.
Layer[0] : time 34.706100916825 (nsec) --- local (x,y) -224.16660513171, -0.21355242280892
Layer[1] : time 36.37640752814 (nsec) --- local (x,y) -251.45832124829, -1.2334283123023
Layer[2] : time 38.046694157875 (nsec) --- local (x,y) -278.6416463582, -2.2065434918955
Layer[3] : time 39.717018612375 (nsec) --- local (x,y) -306.03356668968, -3.1589879612698
Layer[4] : time 41.387329111728 (nsec) --- local (x,y) -333.34494482692, -4.2231537511901
EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
Hadron Calorimeter has 0 hits. Total Edep is 0 (MeV)
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :

Visualization

TIME TO ADD VISUALISATION OPTION TO OUR APPLICATION

Activate visualisation in the `main` method:

- visualization is controlled by the Visualization Manager
- the **`G4VisManager`** base class (with the `RegisterGraphicsSystems()` pure virtual method) is available in the **`Geant4`** toolkit to implement **any graphics system**
- **`Geant4`** provides the **`G4VisExecutive`** as one implementation of this interface, that can be used directly in the `main` method of the application:
  - **include** the default Visualization Manager i.e. **`G4VisExecutive`**
  - **create** the Visualization Manager object and **initialise** it **before the run**
  - **delete** the Visualization Manager object **at the end** of the application

Activate visualisation in the `main` method:

- visualization is controlled by the Visualization Manager

```
// inlcude the default Visualization Manager i.e. G4VisExecutive
#include "G4VisManager.hh"
...
...
...
//
// Add visualization:
// - create a G4VisExecutive object as the Visualization Manager
G4VisManager* visManager = new G4VisExecutive;
// - note, that G4VisExecutive can take a verbosity argument
// G4VisManager* visManager = new G4VisExecutive("Quiet");
// - initialize the Visualization Manager (will handle all vis components)
visManager->Initialize();
...
...
...
// delete the Visualization Manager at the end
delete visManager;
```

Simple visualisation setup (the run must be initialised before **`/run/initialize`**) :

```
# Use this open statement to create an OpenGL view:
/vis/open OGLI
#
# Draw the geometry
/vis/drawVolume
#
# Set the World volume (“logic-World”) invisible
/vis/geometry/set/visibility logic-World 0  false
#
/vis/geometry/set/colour logic-Target 0 0 0 255 0.3
/vis/viewer/set/style surface
#
# Add axes (orientation) and a scale (size)
/vis/scene/add/axes
/vis/scene/add/scale
#
# Add (smooth) trajectories
/vis/scene/add/trajectories smooth
#
# Set to accumulate trajectories up to 100 events
/vis/scene/endOfEventAction accumulate 100
```