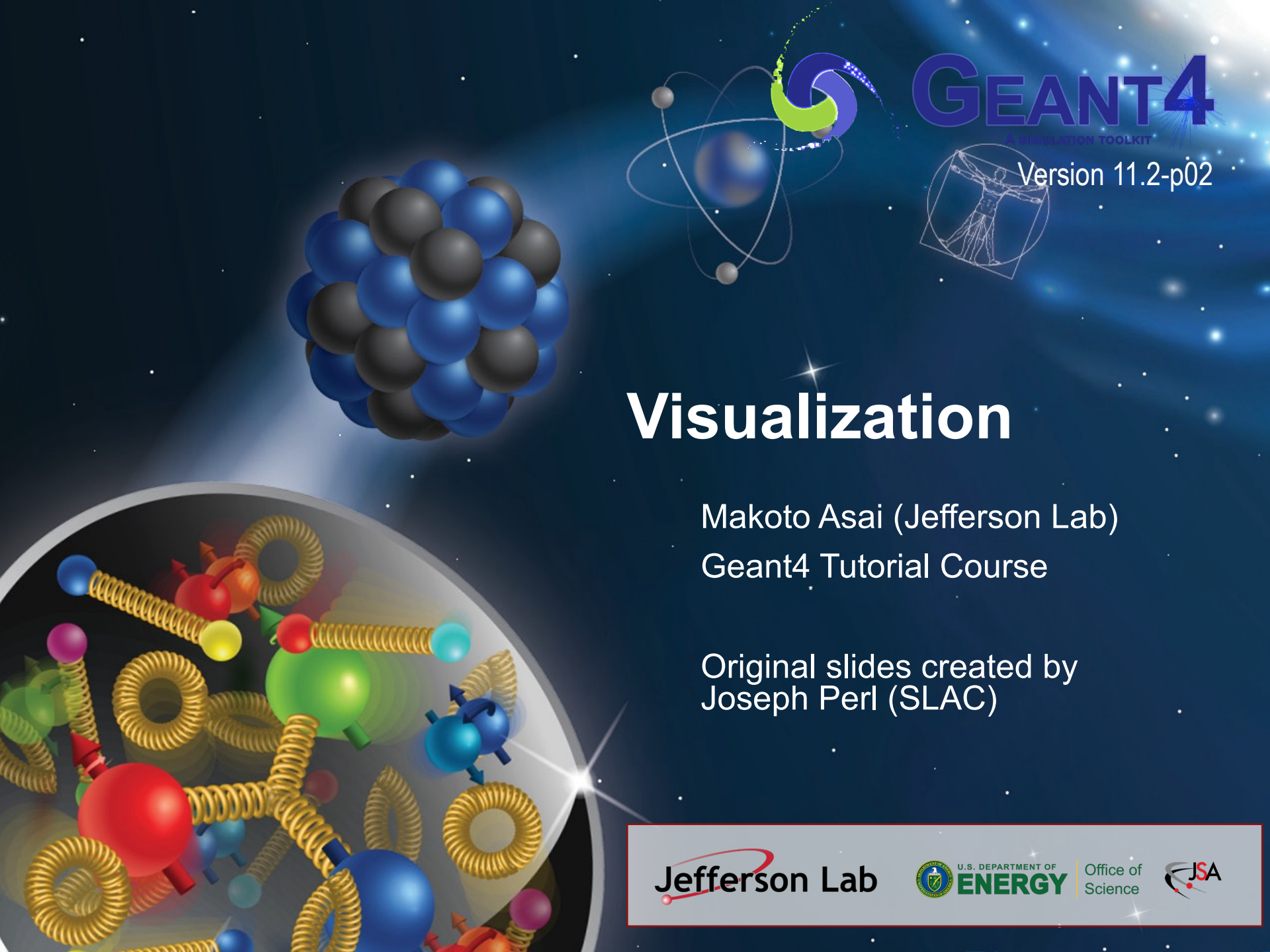


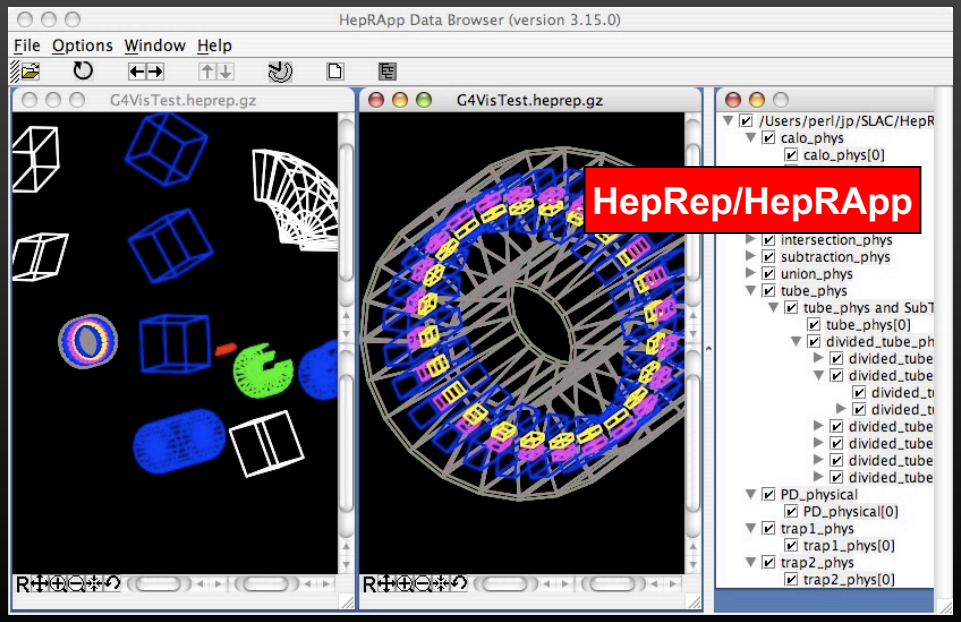
Visualization

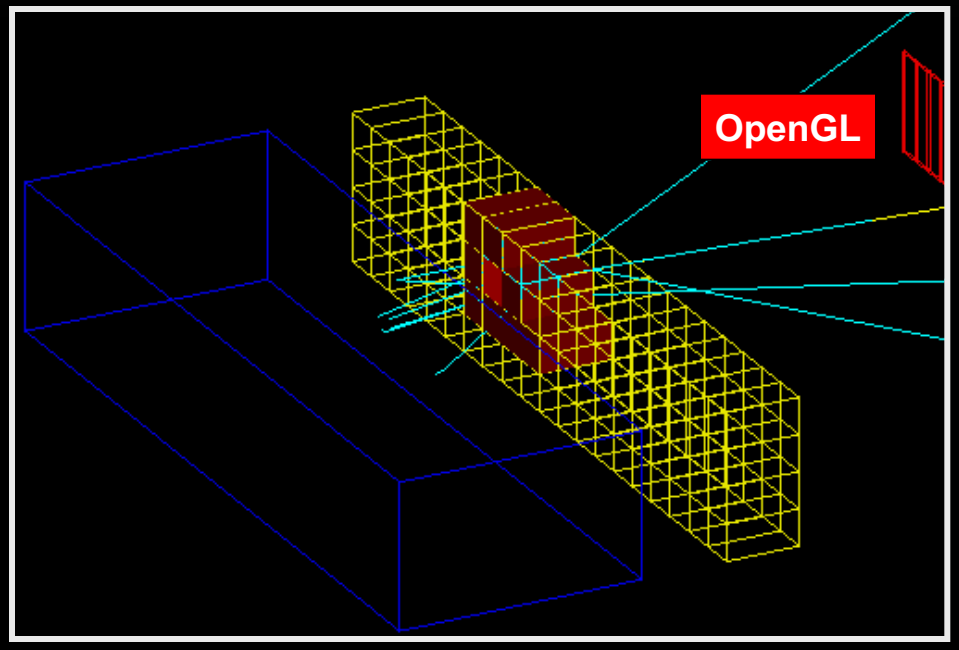
Makoto Asai (Jefferson Lab)

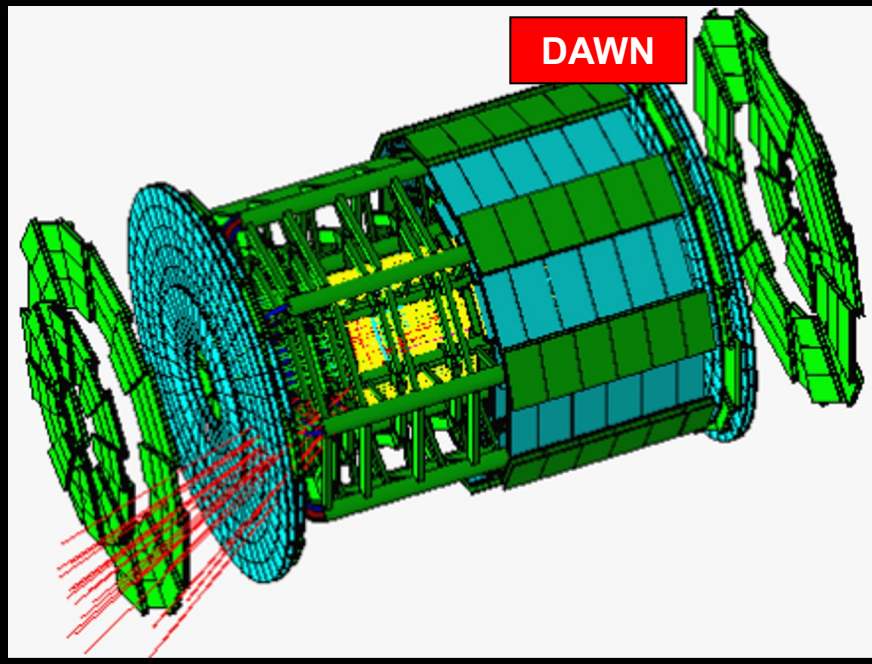
Geant4 Tutorial Course

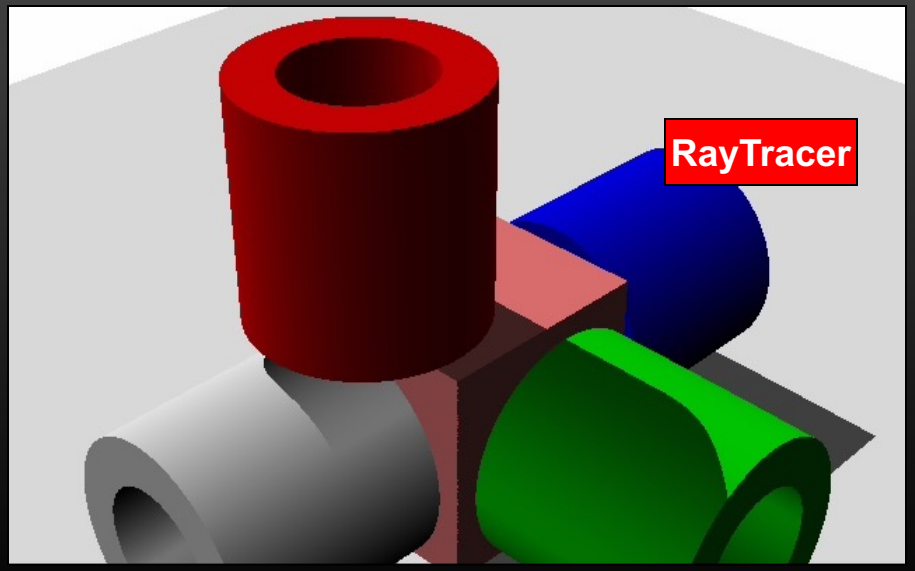
Original slides created by
Joseph Perl (SLAC)

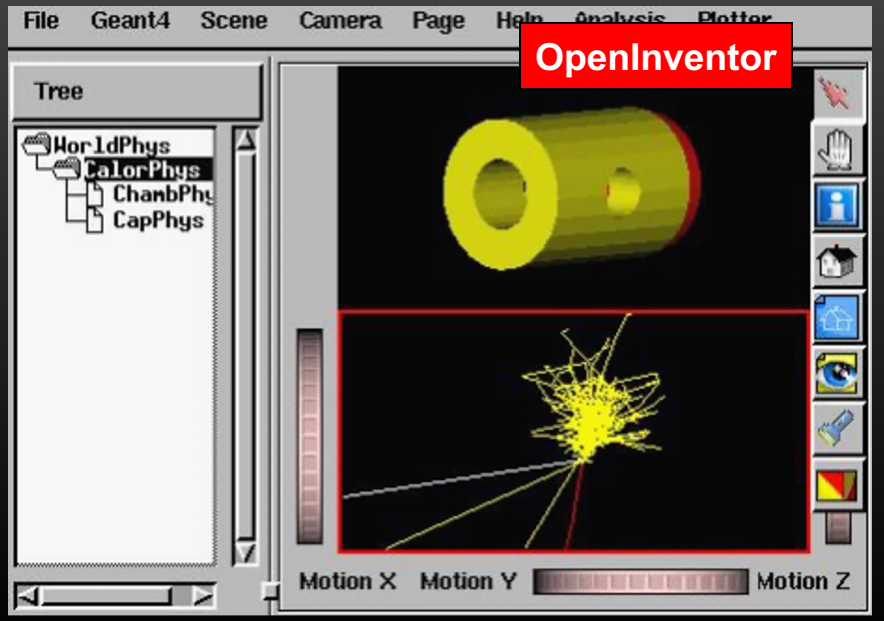
Jefferson Lab
U.S. DEPARTMENT OF ENERGY | Office of Science
JSA

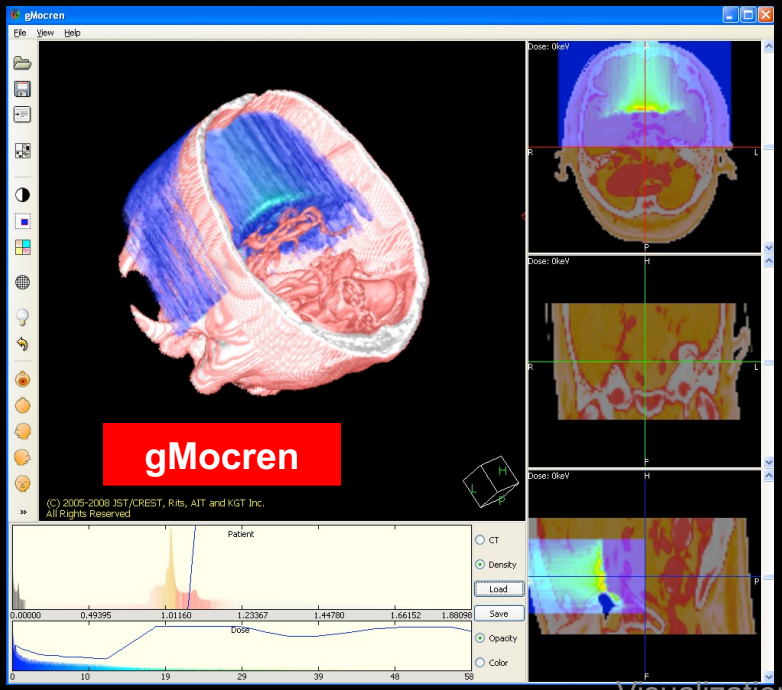

HepRApp Data Browser (version 3.15.0)
File Options Window Help
G4VisTest.heprep.gz
G4VisTest.heprep.gz
HepRep/HepRApp
/Users/perl/jp/SLAC/HepR
calo_phys
calo_phys[0]
intersection_phys
subtraction_phys
union_phys
tube_phys
tube_phys and SubT
tube_phys[0]
divided_tube_ph
divided_tube
divided_tube
divided_tube
divided_tube
divided_tube
divided_tube
divided_tube
PD_physical
PD_physical[0]
trap1_phys
trap1_phys[0]
trap2_phys
trap2_phys[0]

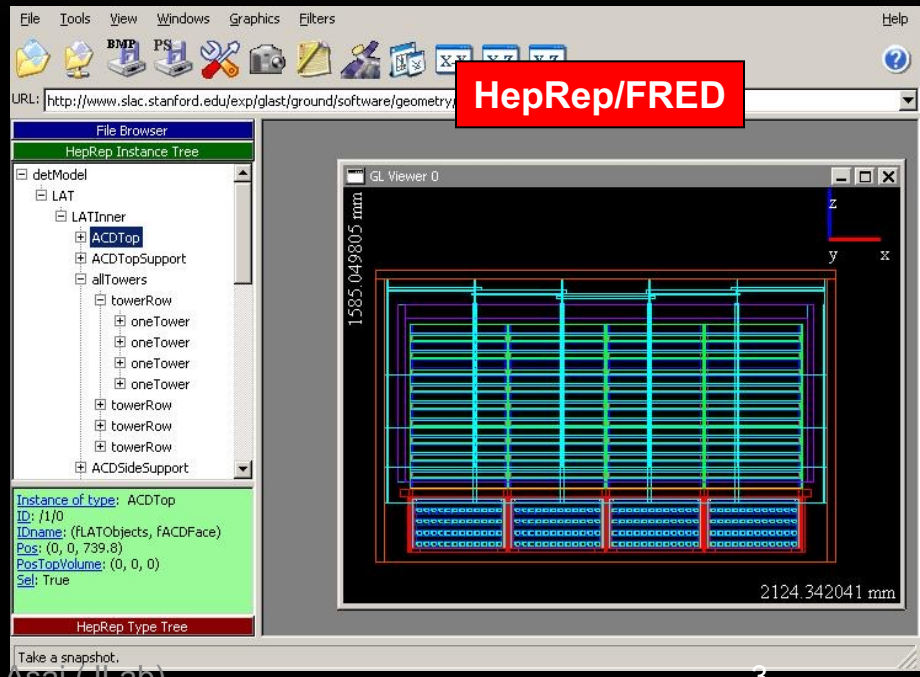

OpenGL

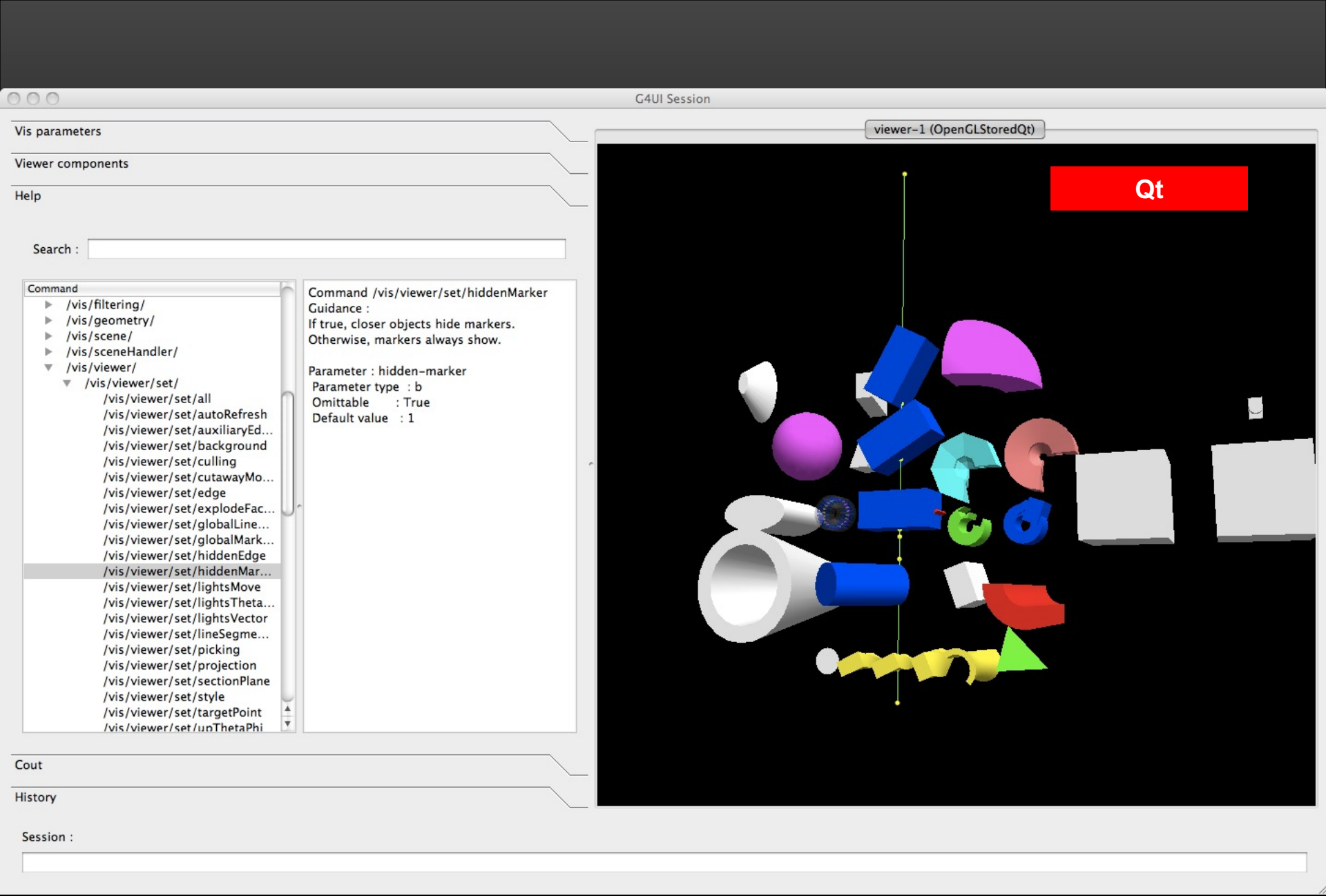

DAWN


RayTracer


File
Geant4
Scene
Camera
Page
Tree
WorldPhys
CalorPhys
ChambPhy
CapPhys
OpenInventor
Motion X
Motion Y
Motion Z


gMocren
(C) 2005-2008 JST/CREST, Rits, AIT and KGT Inc.
All Rights Reserved


File
Tools
View
Windows
Graphics
Filters
Help
HepRep/FRED
File Browser
HepRep Instance Tree
detModel
LAT
LATInner
ACDTop
ACDTopSupport
allTowers
towerRow
oneTower
ACDSideSupport
HepRep Type Tree
GL Viewer 0
1585.049805 mm
2124.342041 mm
Take a snapshot.


G4UI Session
Vis parameters
Viewer components
Help
Search :
Command
/vis/filtering/
/vis/geometry/
/vis/scene/
/vis/sceneHandler/
/vis/viewer/
/vis/viewer/set/
/vis/viewer/set/all
/vis/viewer/set/autoRefresh
/vis/viewer/set/auxiliaryEd...
/vis/viewer/set/background
/vis/viewer/set/culling
/vis/viewer/set/cutawayMo...
/vis/viewer/set/edge
/vis/viewer/set/explodeFac...
/vis/viewer/set/globalLine...
/vis/viewer/set/globalMark...
/vis/viewer/set/hiddenEdge
/vis/viewer/set/hiddenMar...
/vis/viewer/set/lightsMove
/vis/viewer/set/lightsTheta...
/vis/viewer/set/lightsVector
/vis/viewer/set/lineSegme...
/vis/viewer/set/picking
/vis/viewer/set/projection
/vis/viewer/set/sectionPlane
/vis/viewer/set/style
/vis/viewer/set/targetPoint
/vis/viewer/set/upThetaPhi
Command /vis/viewer/set/hiddenMarker
Guidance :
If true, closer objects hide markers.
Otherwise, markers always show.
Parameter : hidden-marker
Parameter type : b
Omittable : True
Default value : 1
Cout
History
Session :
viewer-1 (OpenGLStoredQt)
Qt

What can be visualized ?

- Simulation data can be visualized
  - Geometrical components
  - Particle trajectories and tracking steps
  - Hits of particles in the geometry
  - Scored energy, dose, etc.

- Other user defined objects can also be visualized
  - Polylines
    - such as coordinate axes
  - 3D Markers
    - such as eye guides
  - Text
    - descriptive character strings
    - comments or titles

A variety of choices

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

Controlling visualization

- Your Geant4 code stays basically the same no matter which driver you use
- Visualization is performed either with commands or from C++ code
  - For the present tutorial, we confine ourselves to command-driven visualization.
- Some visualization drivers work directly from Geant4
  - OpenGL
  - OpenInventor
  - RayTracer
  - ASCIITree
- For other visualization drivers, you first have Geant4 produce a file, and then you have that file rendered by another application (which may have GUI control)
  - HepRepFile
  - DAWNFILE
  - VRML2FILE
  - gMocrenFile
- You can open more than one drivers at a time
  - For example, do a quick check in OpenGL, then save the same event for a beautiful DAWN plot

Controlling which drivers are available

- Six of the visualization drivers are always included by default (since they require no external libraries):
  - HepRepFile
  - DAWNFILE
  - VRMLFILE
  - RayTracer
  - gMocrenFile
  - ASCIITree

- Other visualization drivers are included only if you request them in your cmake options.

- You can also add your own visualization driver
  - Geant4's visualization system is modular.
    By creating just three new classes, you can direct Geant4 information to your own visualization system.

Simplest command example

- Visualize your geometry in OpenGL
  - /vis/open OGL
  - /vis/drawVolume
- Most examples come with a visualization macro
  - good starting point

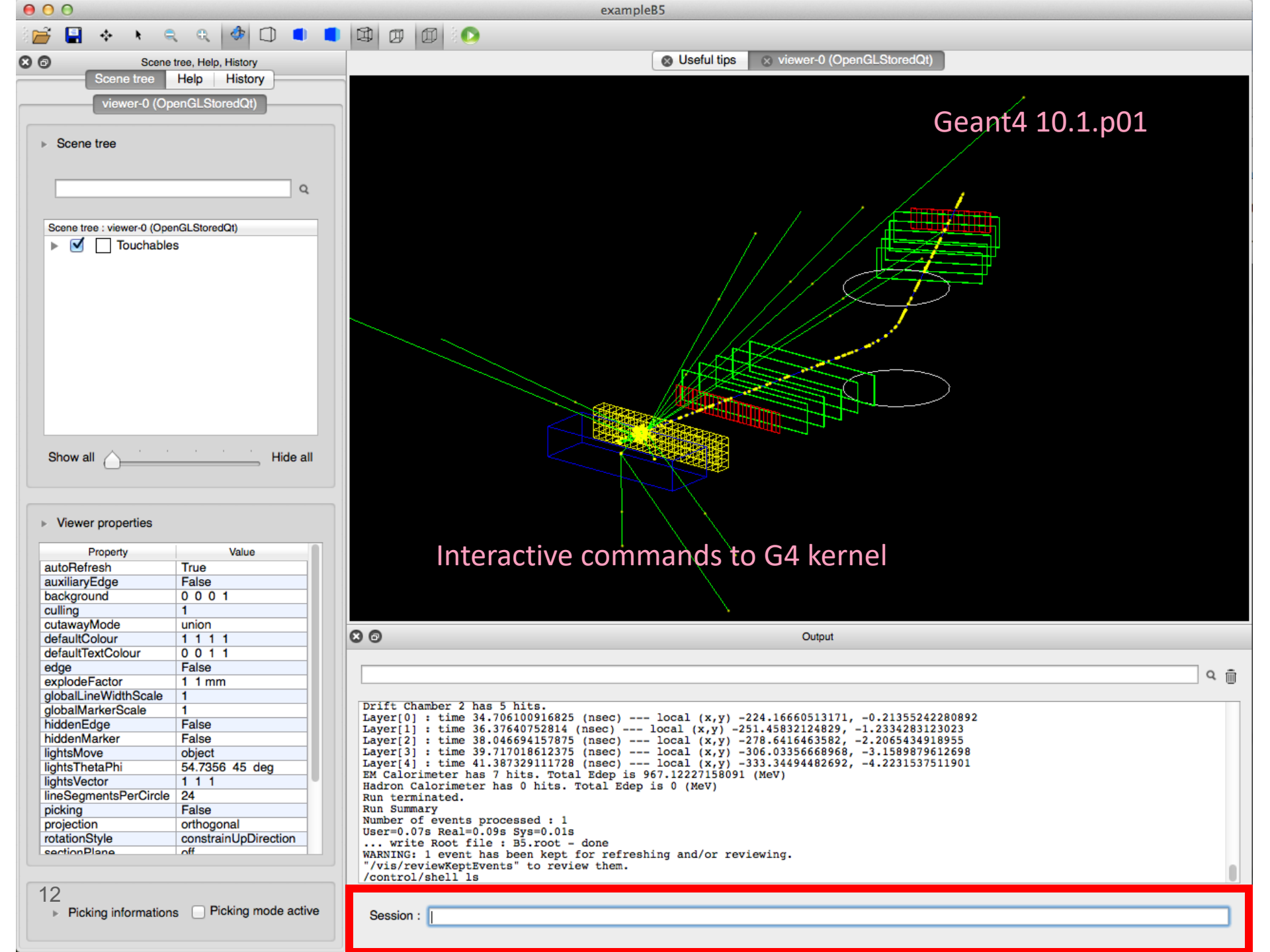
Screenshots on the visualization drivers

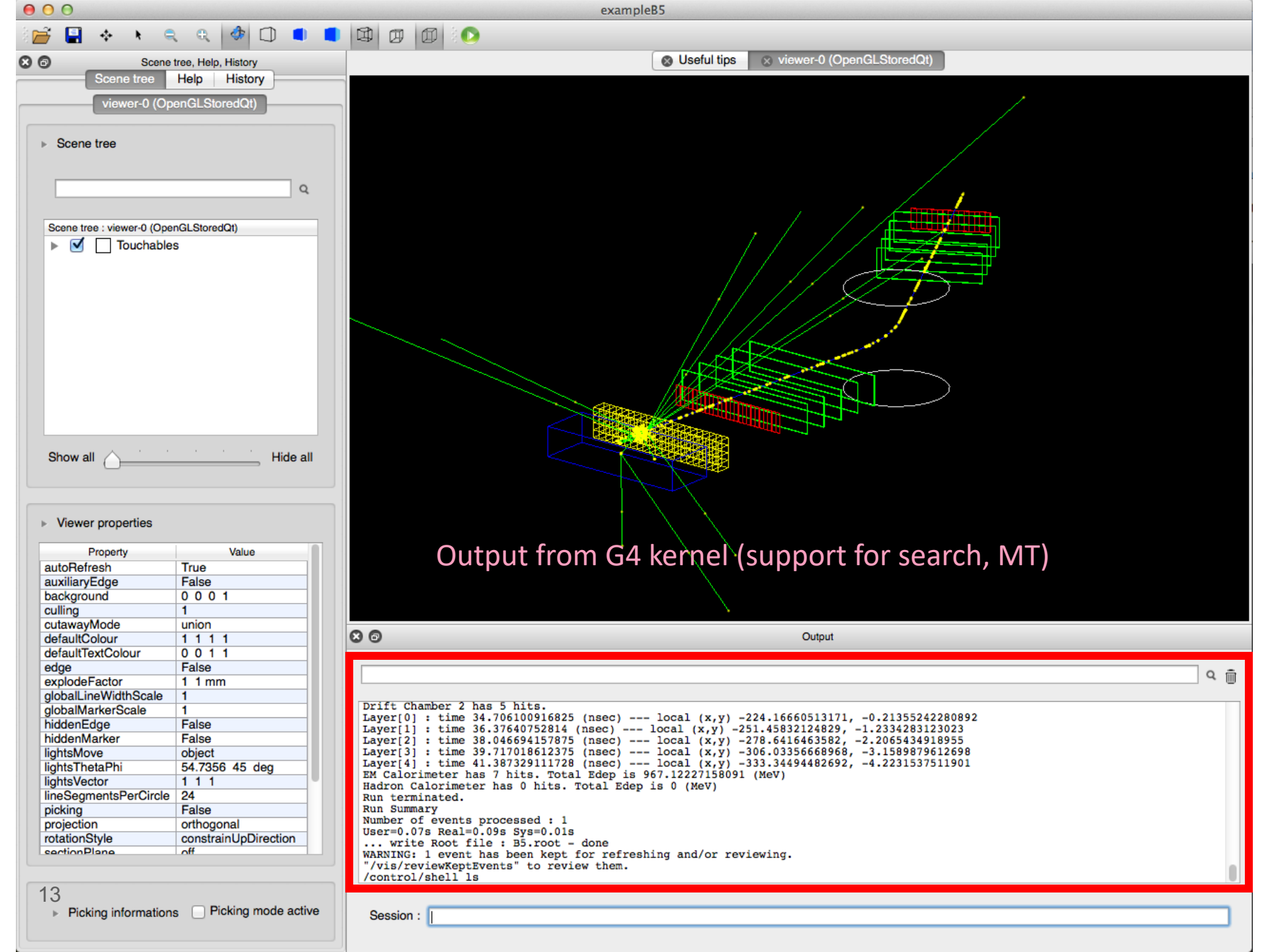
- Qt with OpenGL
  - Requires that you install Qt
  - Visualization driver + user interface
  - You can customize the interface to control any Geant4 command
- OpenGL
- OpenInventor
- HepRep
- DAWN
- VRML
- RayTracer
- gMocren
- ASCIITree

1) Qt Driver with OpenGL visualization

- Recent developments focused on Qt User Interface and Visualization

- Demo…


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
12
Picking informations
Picking mode active
Useful tips
viewer-0 (OpenGLStoredQt)
Geant4 10.1.p01
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
13
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
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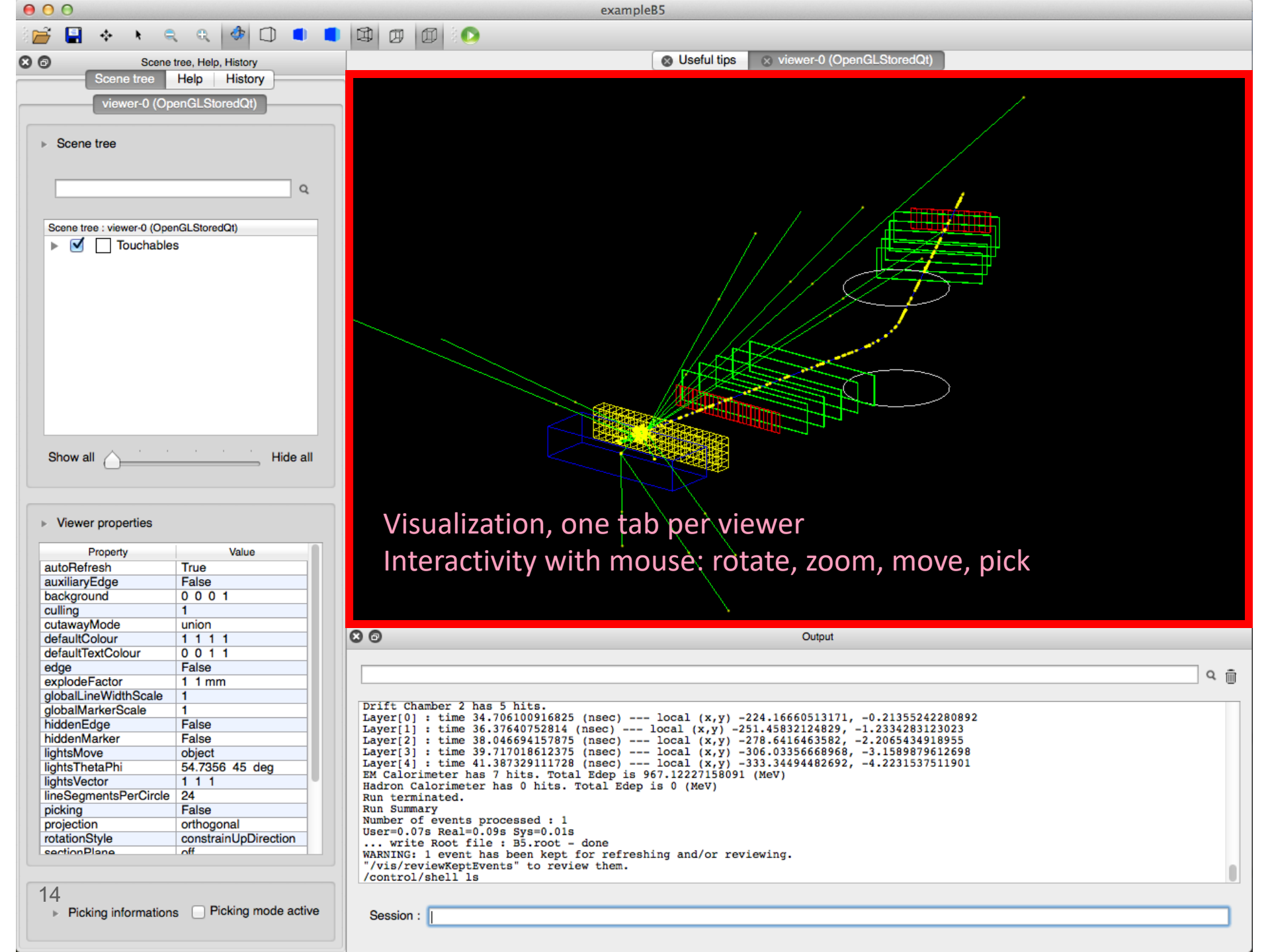
Session :


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
14
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
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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.
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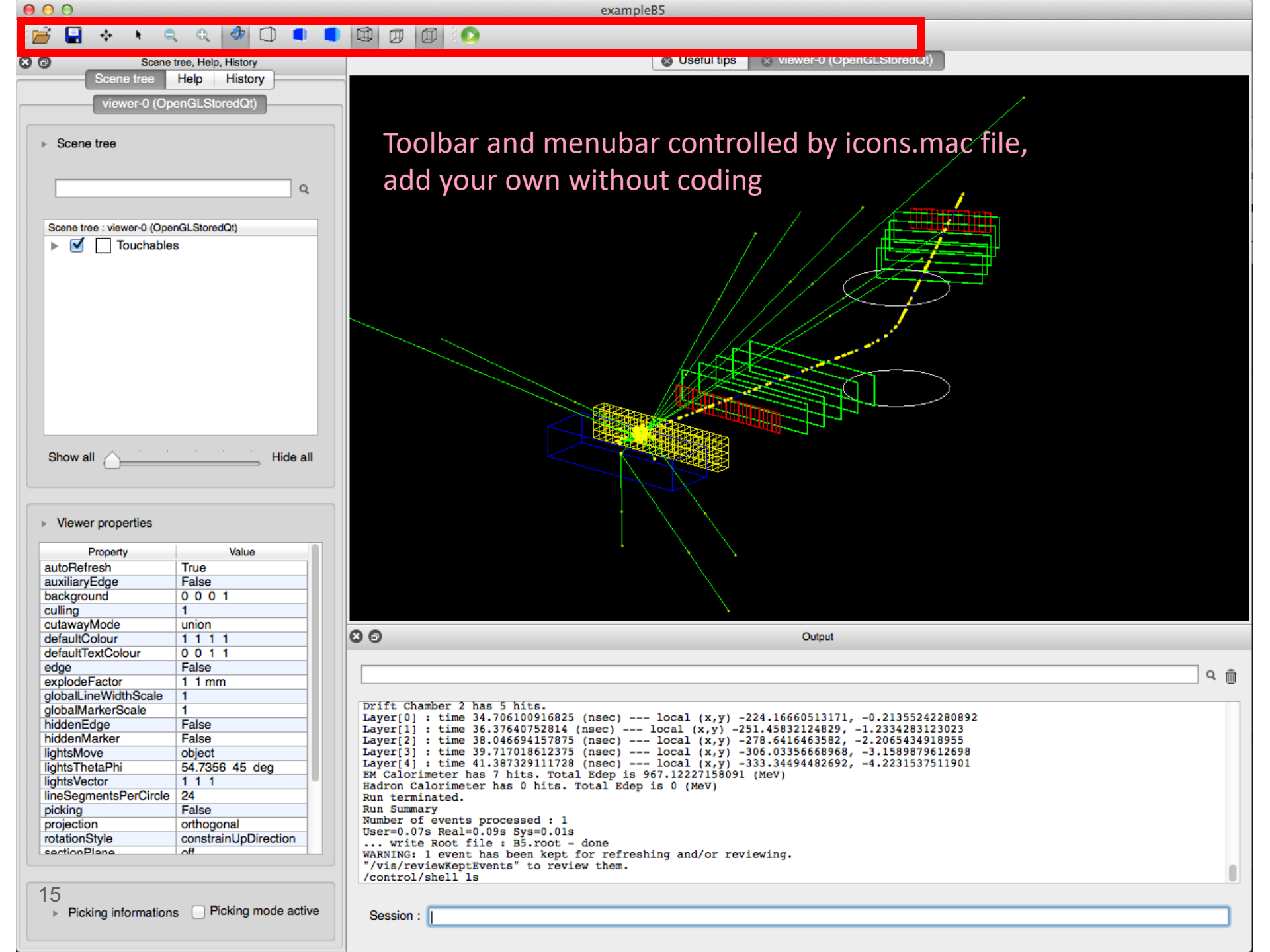
Session :


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
15
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
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Run Summary
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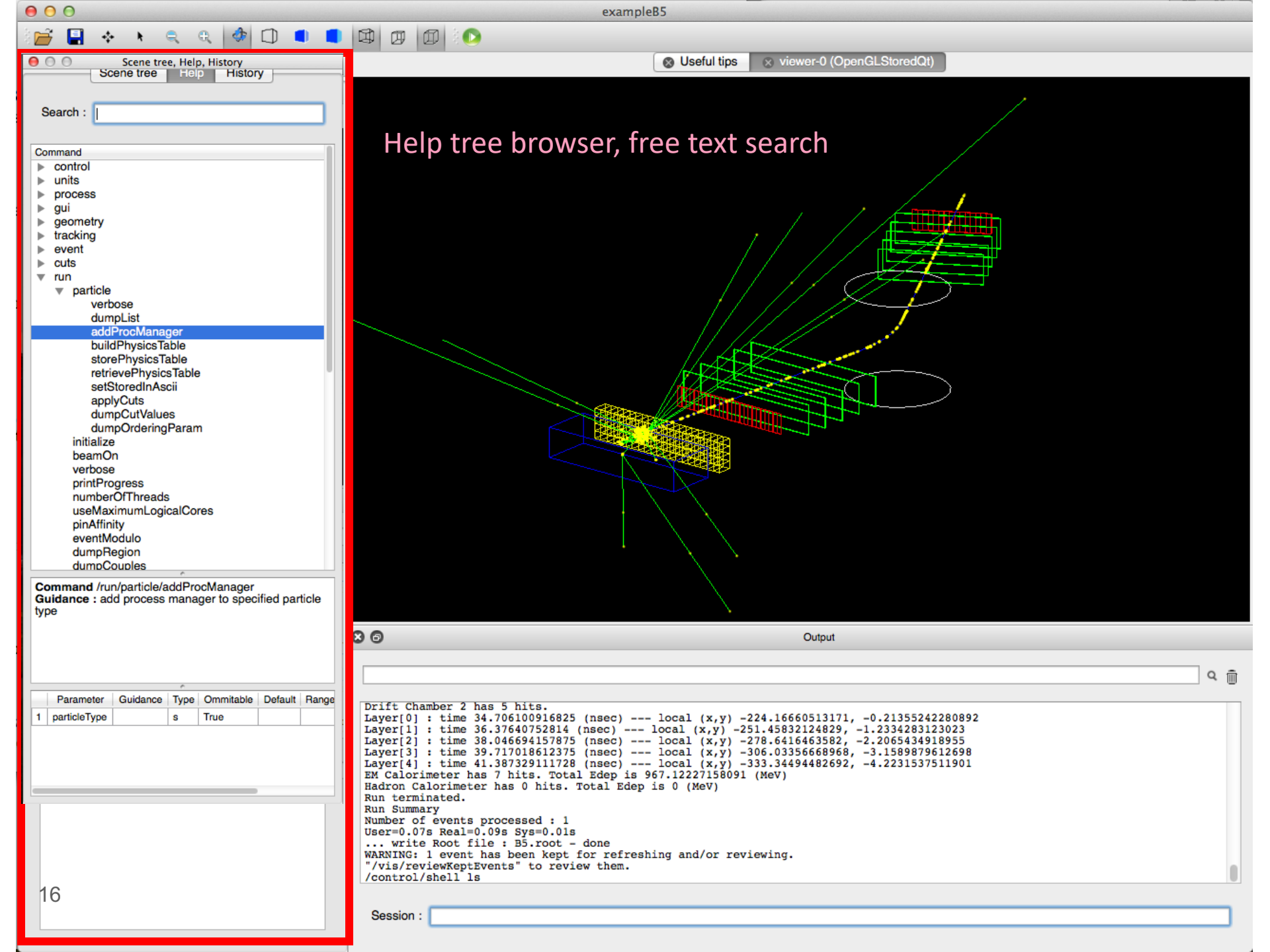
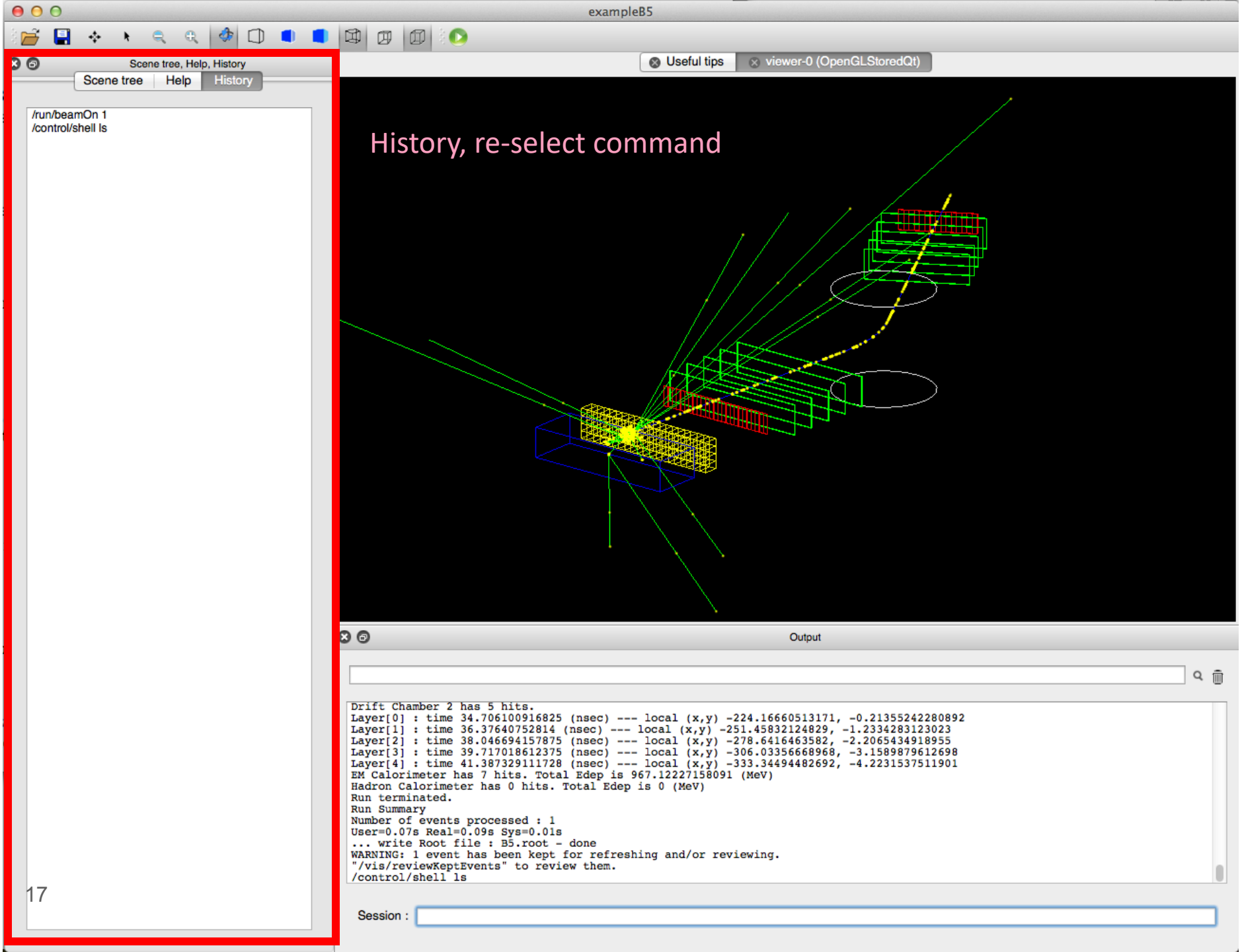
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


exampleB5
Scene tree, Help, History
Scene tree
Help
History
Search :
Command
control
units
process
gui
geometry
tracking
event
cuts
run
particle
verbose
dumpList
addProcManager
buildPhysicsTable
storePhysicsTable
retrievePhysicsTable
setStoredInAscii
applyCuts
dumpCutValues
dumpOrderingParam
initialize
beamOn
verbose
printProgress
numberOfThreads
useMaximumLogicalCores
pinAffinity
eventModulo
dumpRegion
dumpCouples
Command /run/particle/addProcManager
Guidance : add process manager to specified particle type
Parameter
Guidance
Type
Ommitable
Default
Range
1
particleType
s
True
Useful tips
viewer-0 (OpenGLStoredQt)
Help tree browser, free text search
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
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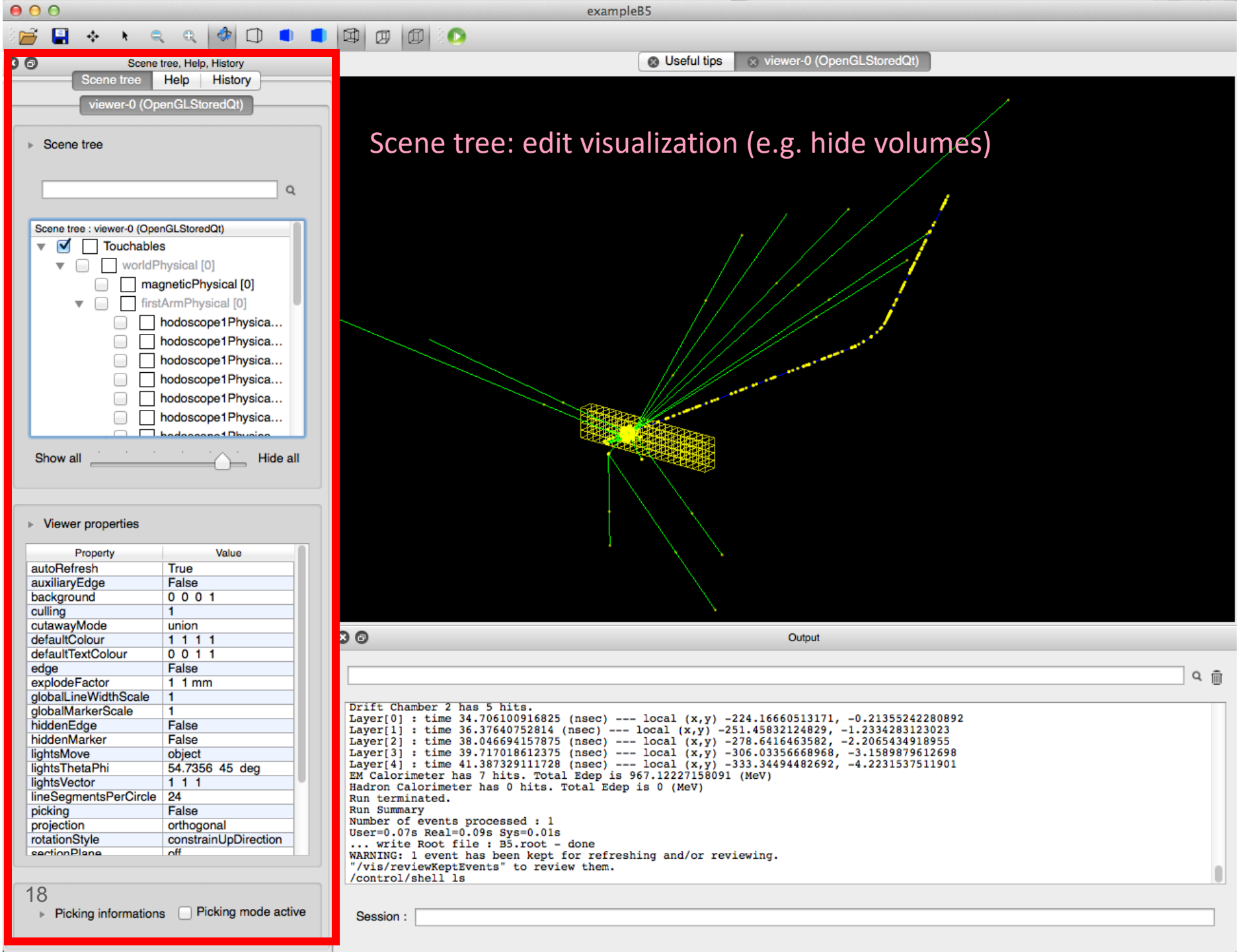
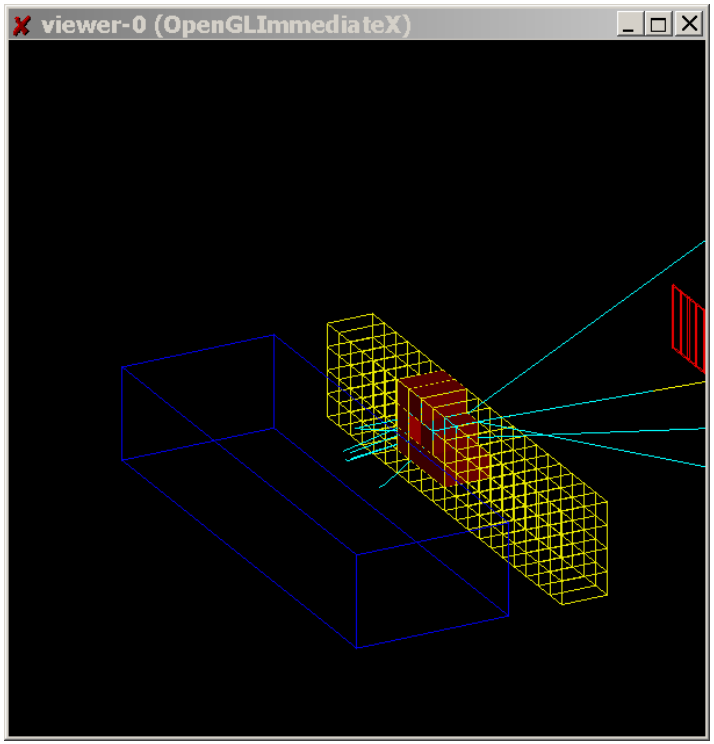
Run terminated.
Run Summary
Number of events processed : 1
User=0.07s Real=0.09s Sys=0.01s
... write Root file : B5.root - done
WARNING: 1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
/control/shell ls
Session :


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
18
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 :

2) OpenGL

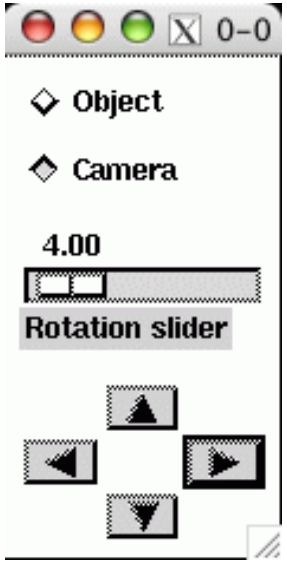
- /vis/open OGL

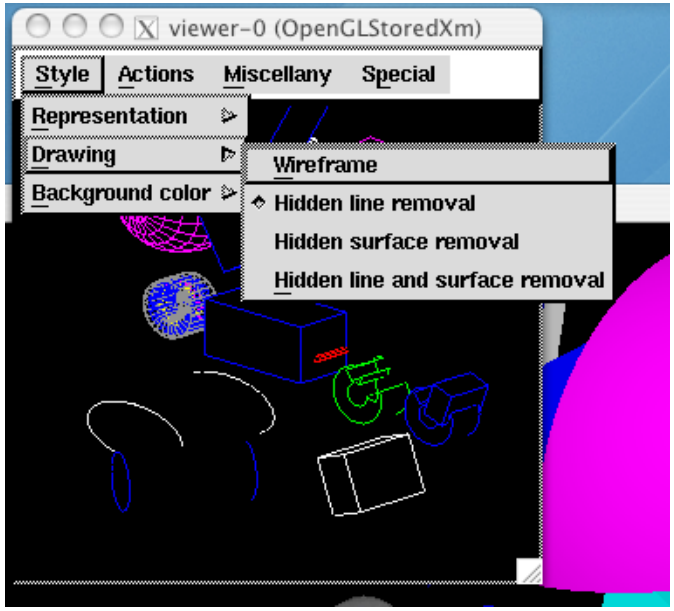
- Features
  - Control directly from Geant4
  - Uses GL libraries that are already included on most Linux and Windows systems
  - Rendered, photorealistic image with some interactive features
    - zoom, rotate, translate
  - Fast response (can usually exploit full potential of graphics hardware)
  - Save as pixel graphics or vector EPS
  - Live movies



OpenGL with Motif Control

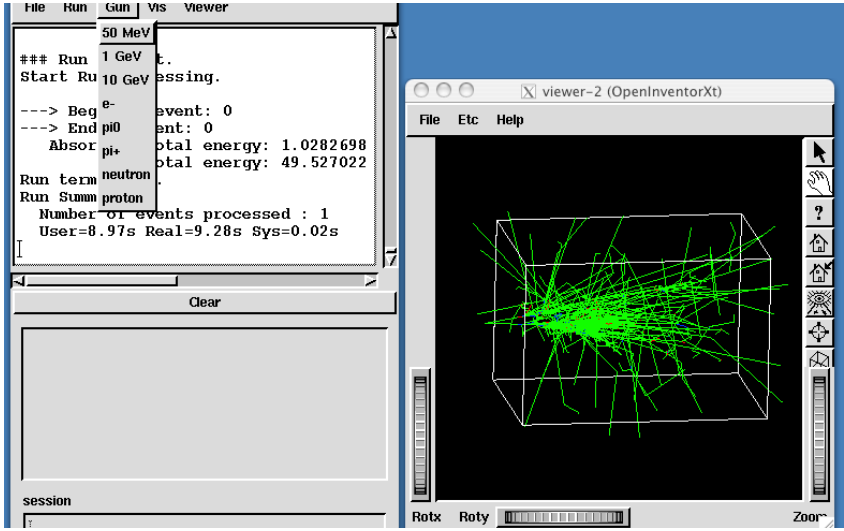
- Somewhat obsolete now that Qt can take over this functionality
  - but still supported
  - requires that you have Motif and link against this in your Geant4





3) OpenInventor

- /vis/open OIX or /vis/open IOWin32



- Features
  - Control from the OpenInventor GUI
  - Requires addition of OpenInventor libraries (freely available for most Linux systems and Windows)
  - Rendered, photorealistic image
  - Many interactive features
    - zoom, rotate, translate
    - click to “see inside” opaque volumes
    - click to show attributes (momentum, etc., dumps to standard output)
  - Fast response (can usually exploit full potential of graphics hardware)
  - Expanded printing ability (vector and pixel graphics)

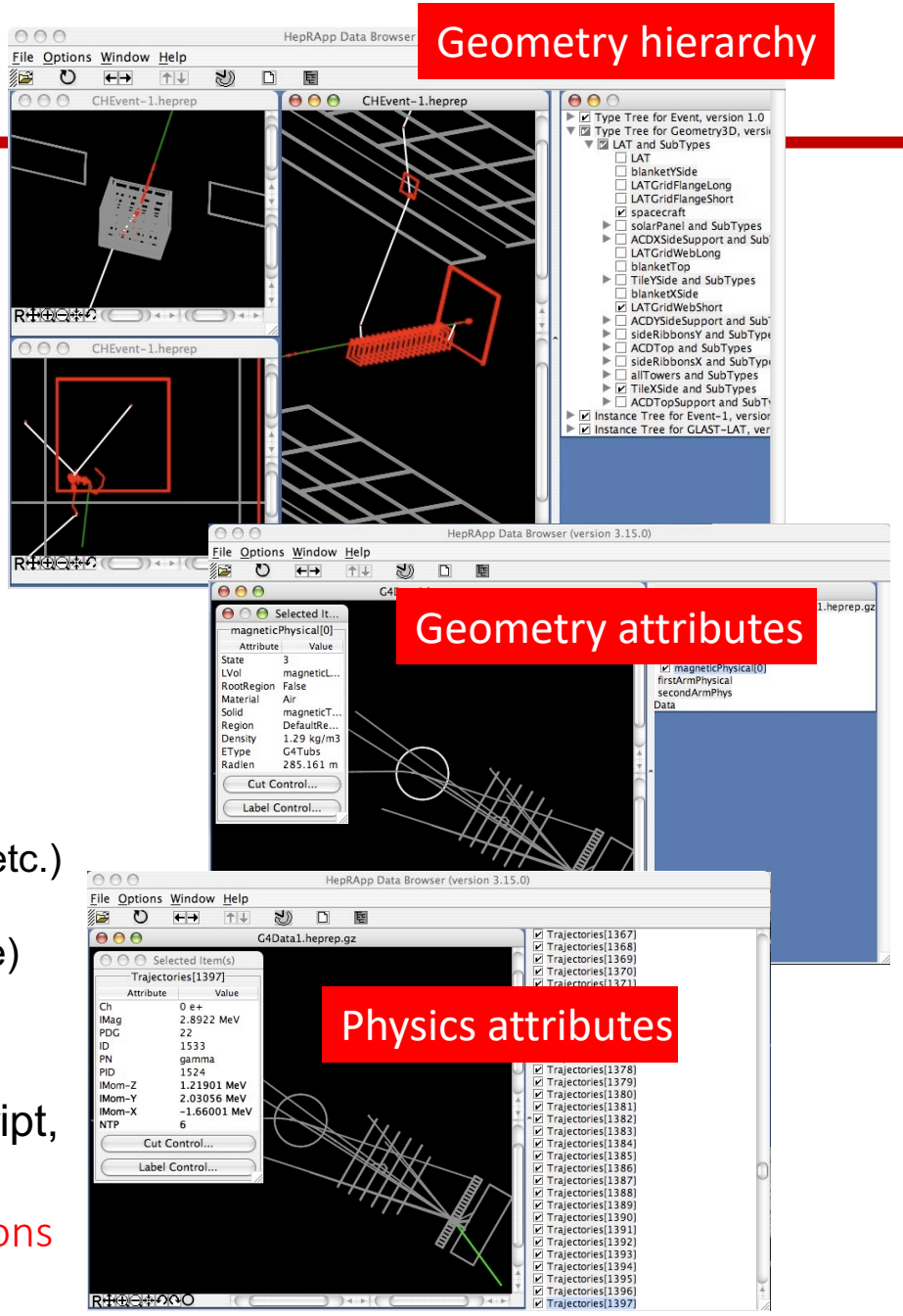
Warning:
OpenScientist (implementing our OI driver) is discontinued, but you could still try to use it

4) HepRep

- /vis/open HepRepFile

- Features
  - Create a file to view in the
    - HepRApp HepRep Browser
    - WIRED4 JAS Plugin
    - or FRED Event Display
  - Requires one of the above browsers (freely available for all systems)
  - Wireframe or simple area fills (not photorealistic)
  - Many interactive features
    - zoom, rotate, translate
    - click to show attributes (momentum, etc.)
    - special projections (FishEye, etc.)
    - control visibility from hierarchical (tree) view of data
  - Hierarchical view of the geometry
  - HepRApp and WIRED4 can export to many vector graphic formats (PostScript, PDF, etc.)

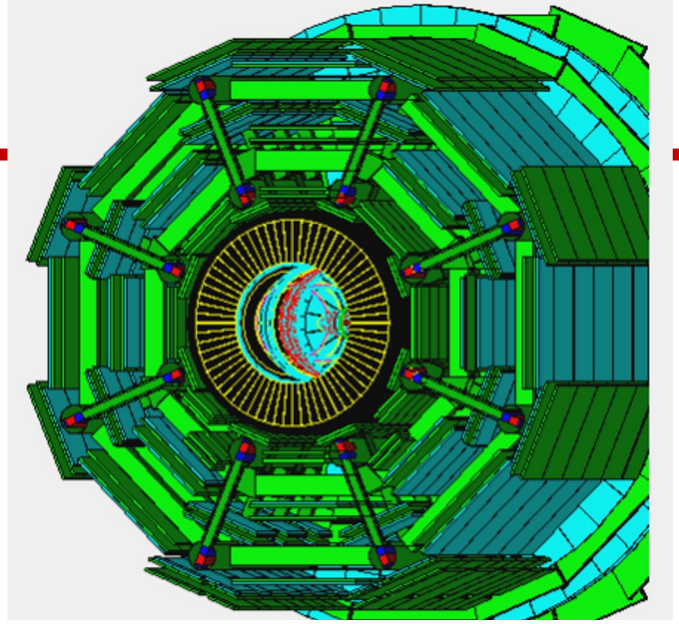
Warning: Issues with recent java versions being worked out

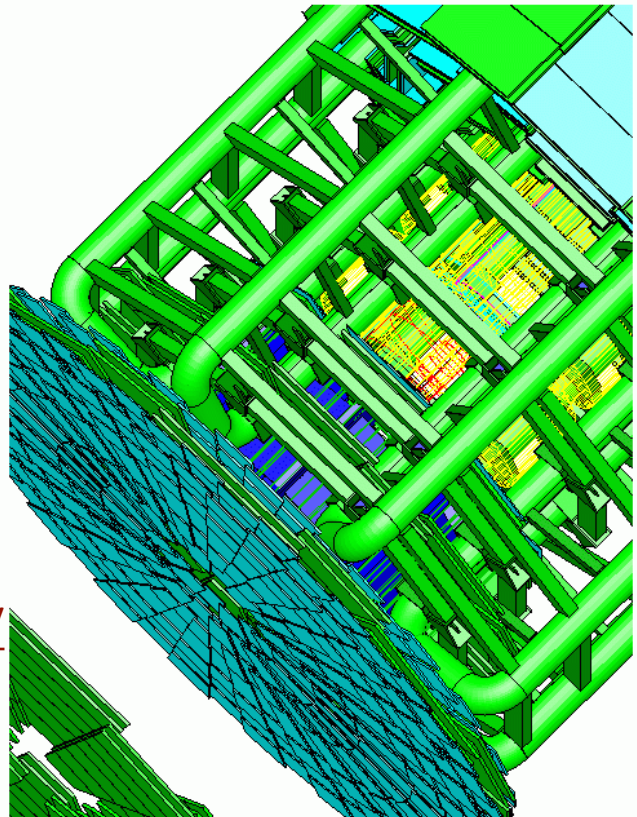


5) DAWN

- /vis/open DAWNFILE

- Features
  - Create a .prim file
  - Requires DAWN, available for all Linux and Windows systems
  - DAWN creates a rendered, photorealistic PostScript image
  - No interactive features once at PostScript stage
  - Highest quality technical rendering - vector PostScript
  - View or print from your favorite PostScript application





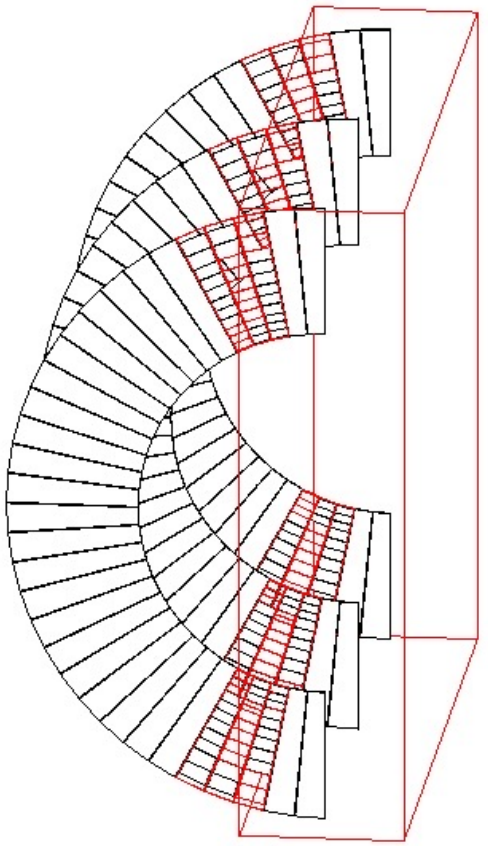
http://geant4.kek.jp/~tanaka/GEANT4/ATLAS_G4_GIFFIG/

DAWNCUT and DAVID

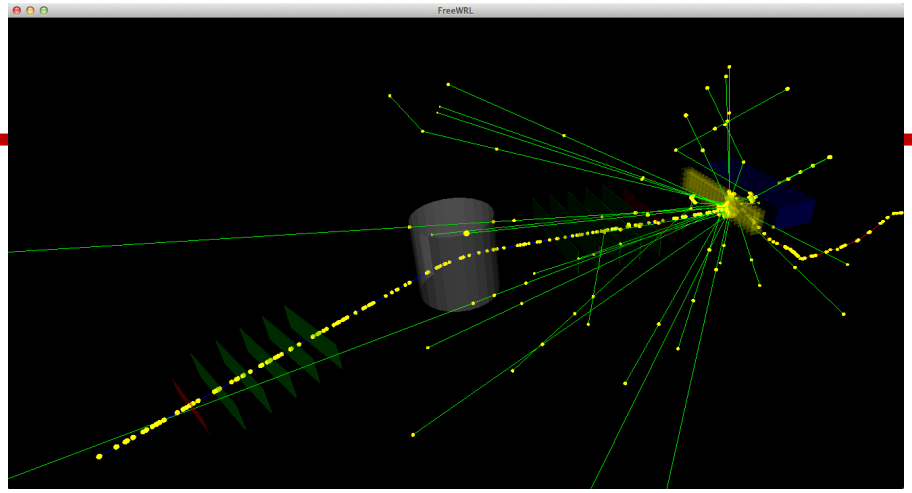
- A standalone program, DAWNCUT, can perform a planar cut on a DAWN image
  - DAWNCUT takes as input a .prim file and some cut parameters. Its output is a new .prim file to which the cut has been applied.

- Another standalone program, DAVID, can show you any volume overlap errors in your geometry
  - DAVID takes as input a .prim file and outputs a new .prim file in which overlapping volumes have been highlighted.

http://geant4.kek.jp/~tanaka/



6) VRML



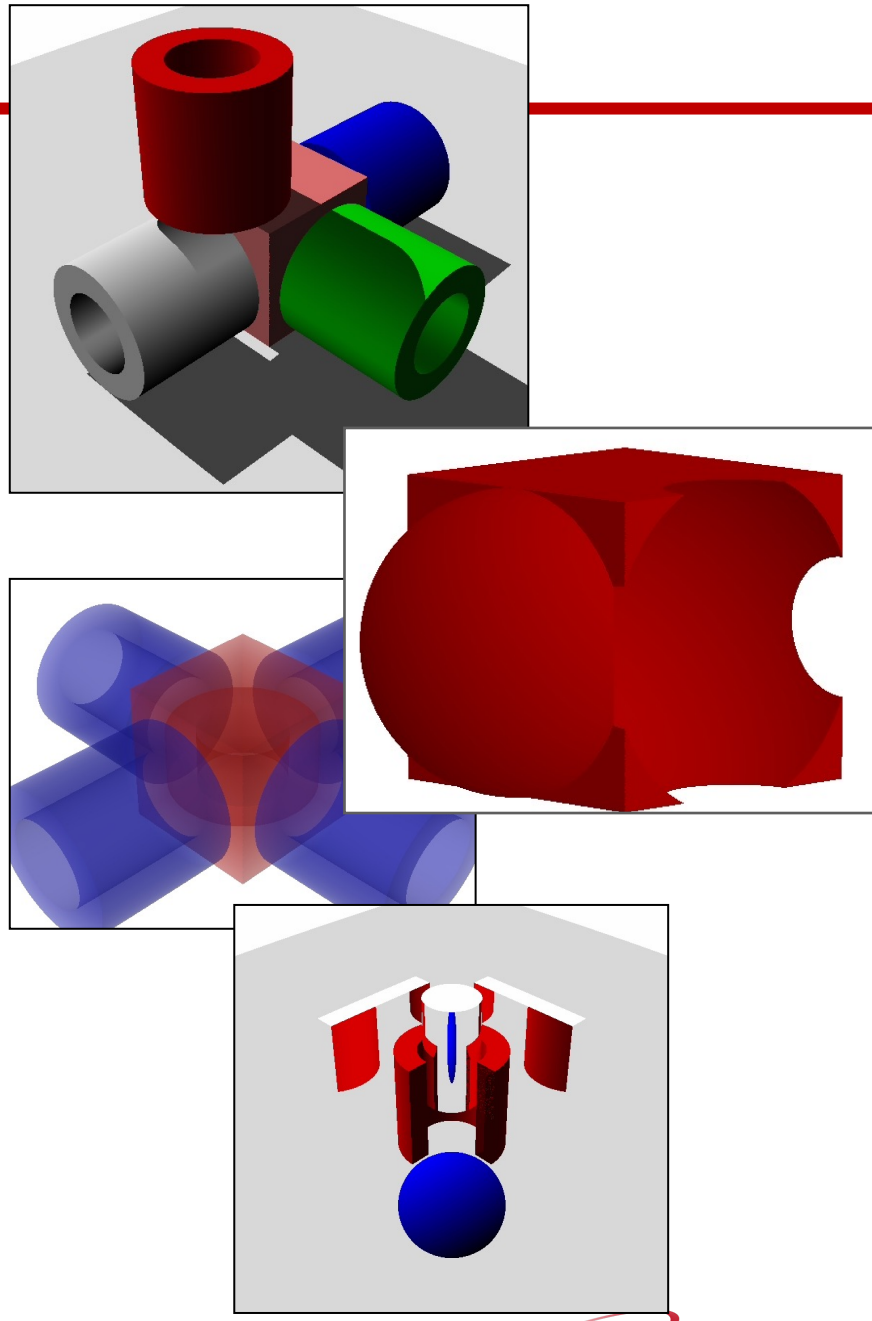
- /vis/open VRML1FILE or /vis/open VRML2FILE

- Features
  - Create a file to view in any VRML browser (some as web browser plug-ins)
  - Requires VRML browser (many different choices for different operating systems)
    - FreeWRL
  - Rendered, photorealistic image with some interactive features
    - zoom, rotate, translate
  - Limited printing ability (pixel graphics, not vector graphics)

7) RayTracer

- /vis/open RayTracer

- Features
  - Create a jpeg file (and with RayTracerX option, also draws to x window)
  - Forms image by using Geant4's own tracking to follow photons through the detector
  - Can show geometry but not trajectories
  - Can render any geometry that Geant4 can handle (such as Boolean solids) - no other Vis driver can handle every case
  - Supports shadows, transparency and mirrored surfaces

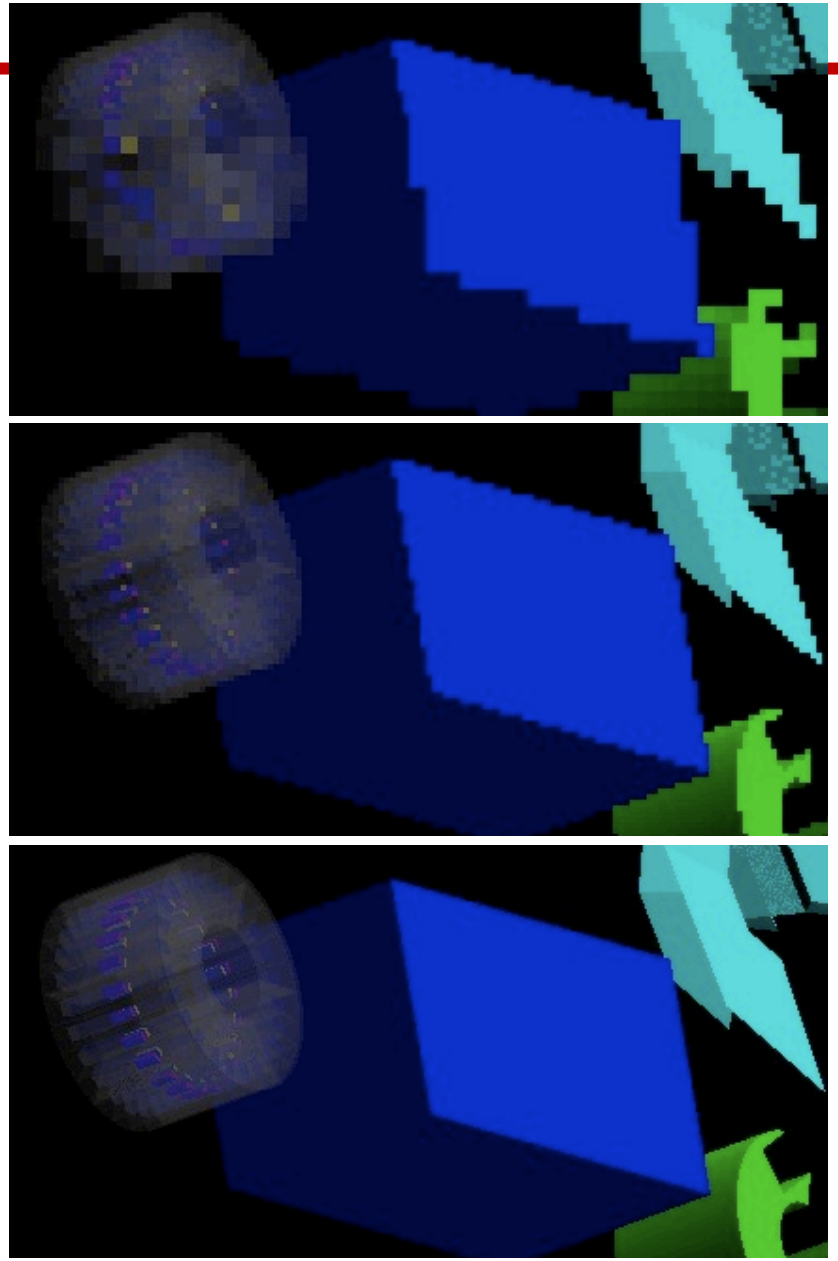


RayTracerX

- You have the option of
  - /vis/open RayTracerX

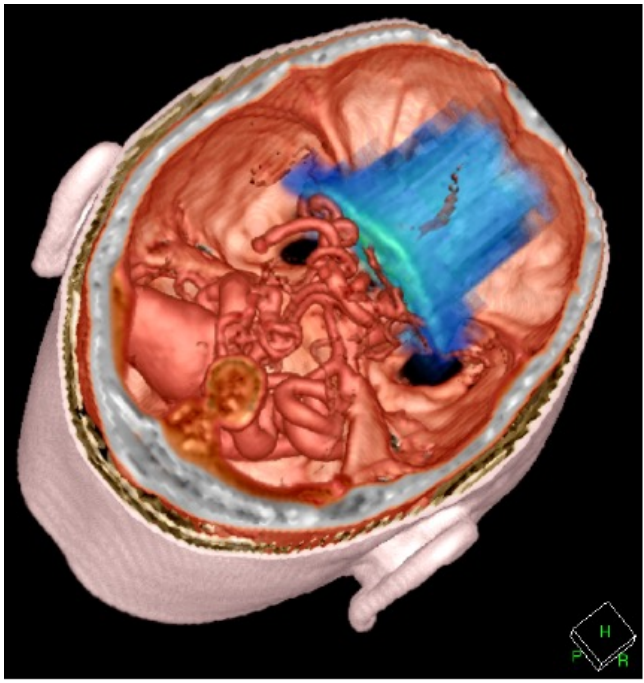
- Builds same jpeg file as RayTracer, but simultaneously renders to screen so you can watch as rendering grows progressively smoother

- Means you can abort and retry the rendering with different view parameters without having to wait for the complete refinement of the image



8) gMocren

- Great tool available for volume visualization
- From JST/CREST project (Japan) to improve Geant4 for medical physics
- Able to visualize
  - Volume data
    (including overlay of more than one set)
  - Trajectories
- Runs on
  - Based on a commercial package but offered freely to all Geant4 users
  - http://geant4.kek.jp/gMocren
  - Installation is straightforward, follow the Download link on the above page
    - First run gMocren's one-click installer
    - Then, inside <gMocren-dir>/gtk, you will find the one-click installer for gtk
- To export Geant4 visualization to gMocren files
  - /vis/open gMocrenFile
  - /vis/scene/add/psHits
  - /vis/viewer/flush
  - many other options available with /score/draw ... commands



9) ASCIITree

- /vis/open ATree

- Features
  - Text dump of the geometry hierarchy
  - Not graphical
  - Control over level of detail to be dumped
  - Can calculate mass and volume of any hierarchy of volumes

```
/vis/viewer/flush
        "worldPhysical":0
         "magneticPhysical":0
         "firstArmPhysical":0
          "hodoscope1Physical":0
          "hodoscope1Physical":1 (repeated placement)
          "hodoscope1Physical":2 (repeated placement)
          "hodoscope1Physical":3 (repeated placement)
          "hodoscope1Physical":4 (repeated placement)

Can be set to various levels of detail
        /vis/ASCIITree/verbose <verbosity>
        0: prints physical volume name.
        1: prints logical volume name.
        2: prints solid name and type.
        3: prints volume and density of solid.
        4: calculates and prints mass(es) of volume(s) in
        scene.

        By default, shows only daughters of first placement
        and not repeat replicas.

        Add 10 to the above to also show repeated
        placements and replicas.
```

Movies: time development of the event

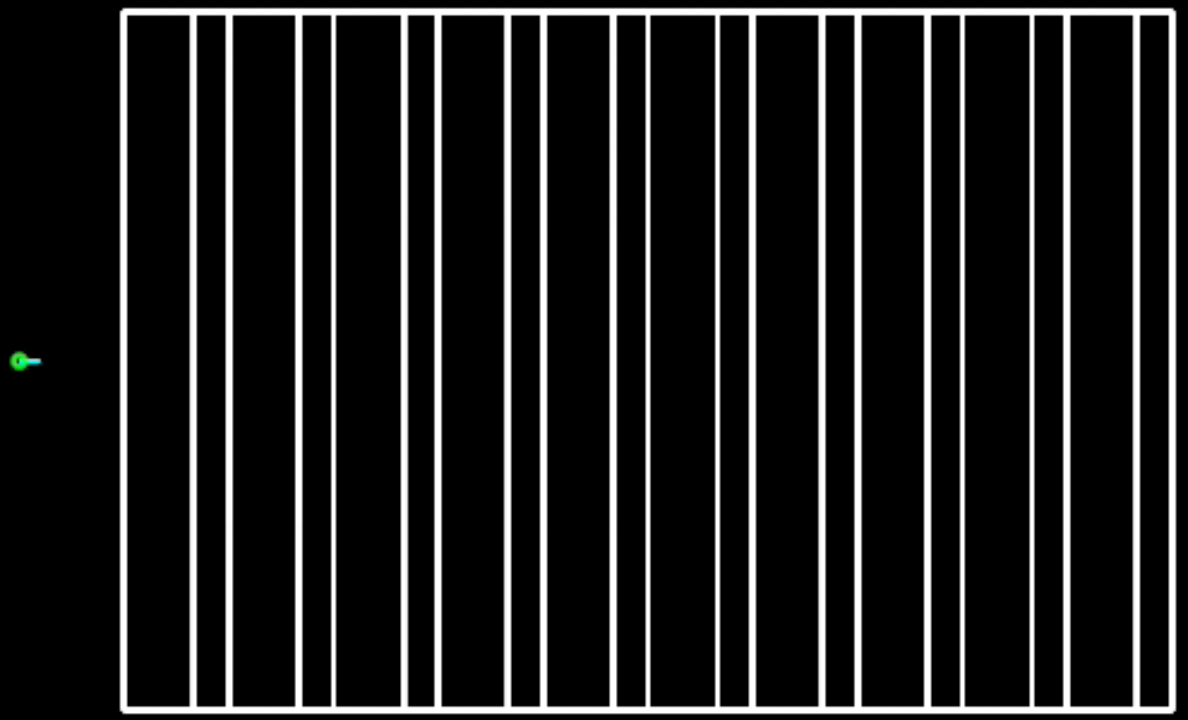
- You can make movies that show time development of an event
  - i.e., a shower in slow motion
- Based on technique of "time-slicing", breaking trajectories into individual slices, each with a time attribute.
  - requires some visualization features, rich trajectory and some extensions to the OpenGL driver
  - you can run these animations Directly from Geant4, does NOT involve stitching together a movie by hand
- A collection of example movies has been prepared by John Allison: http://www.hep.man.ac.uk/u/johna/pub/Geant4/Movies/

http://www.hep.man.ac.uk/u/johna/pub/Geant4/Movies/pi-10Gevpi+neutronSideView.mp4

10 GeV pion

3 ns

Mpeg4 encoding
with QuickTime Pro



Tutorials and references on the Web !

- DAWN
  - http://geant4.slac.stanford.edu/Presentations/vis/G4DAWNTutorial/G4DAWNTutorial.html
  - http://geant4.kek.jp/~tanaka/DAWN/About_DAWN.html
  - DAWNCUT
    - http://geant4.kek.jpJ/~tanaka/DAWN/About_DAWNCUT.html
  - DAVID
    - http://geant4.kek.jp/~tanaka/DAWN/About_DAVID.html
  - And more…
    - http://geant4.kek.jp/~tanaka/
- gMocren
  - http://geant4.kek.jp/gMocren
- HepRApp
  - http://www.slac.stanford.edu/~perl/HepRApp
  - http://geant4.slac.stanford.edu/Presentations/vis/G4HepRAppTutorial/G4HepRAppTutorial.html
- OpenGL
  - http://geant4.slac.stanford.edu/Presentations/vis/G4OpenGLTutorial/G4OpenGLTutorial.html
- OpenScientist
  - http://openscientist.lal.in2p3.fr
- Qt
  - http://geant4.in2p3.fr/spip.php?rubrique25&lang=en