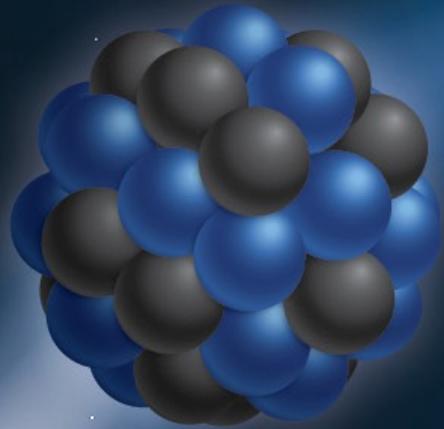


GEANT4
A SIMULATION TOOLKIT



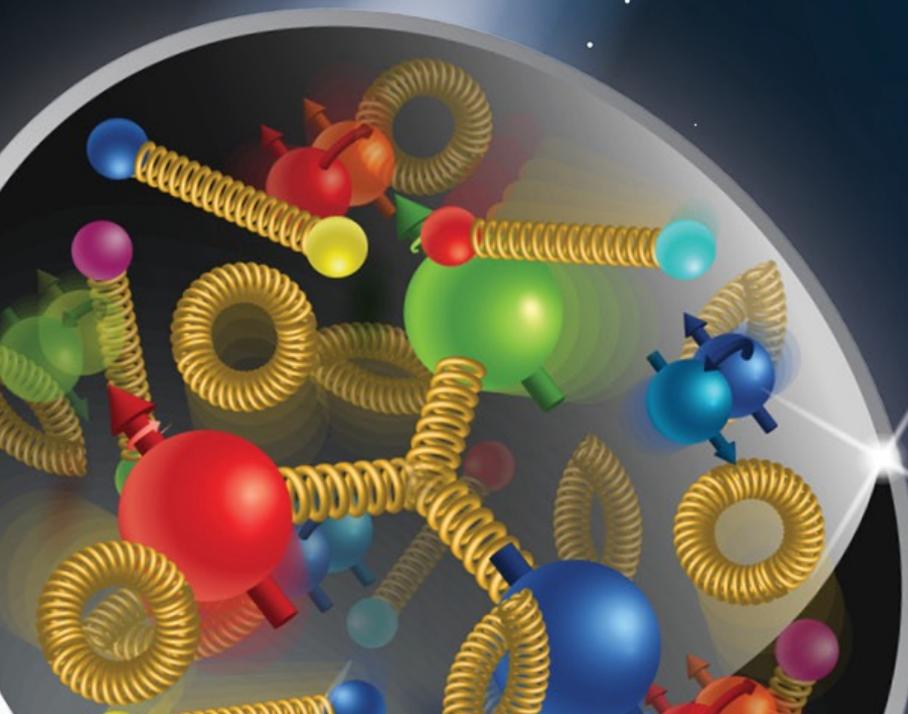
Version 11.1-p02



Visualization

Makoto Asai (Jefferson Lab)
Geant4 Tutorial Course

Original slides created by
Joseph Perl (SLAC)



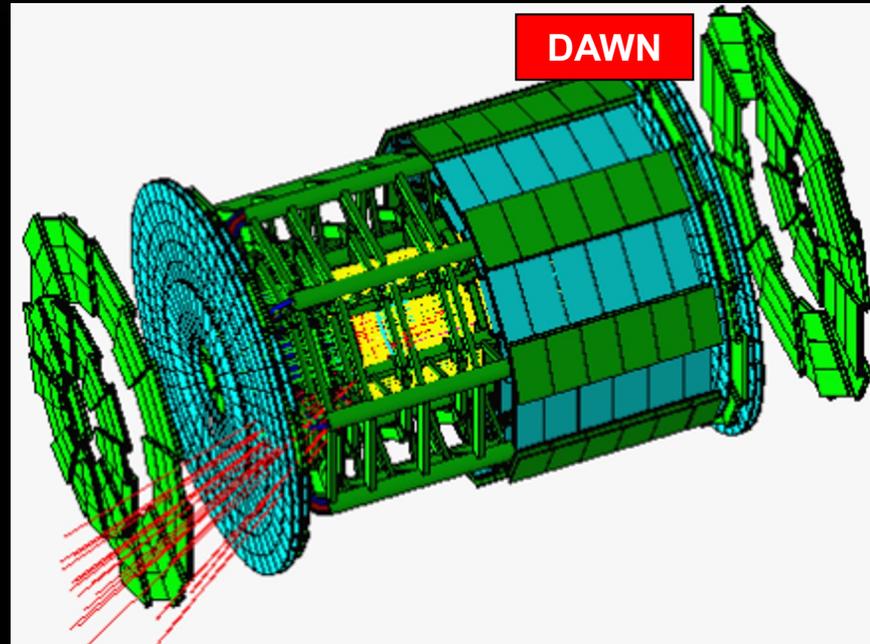
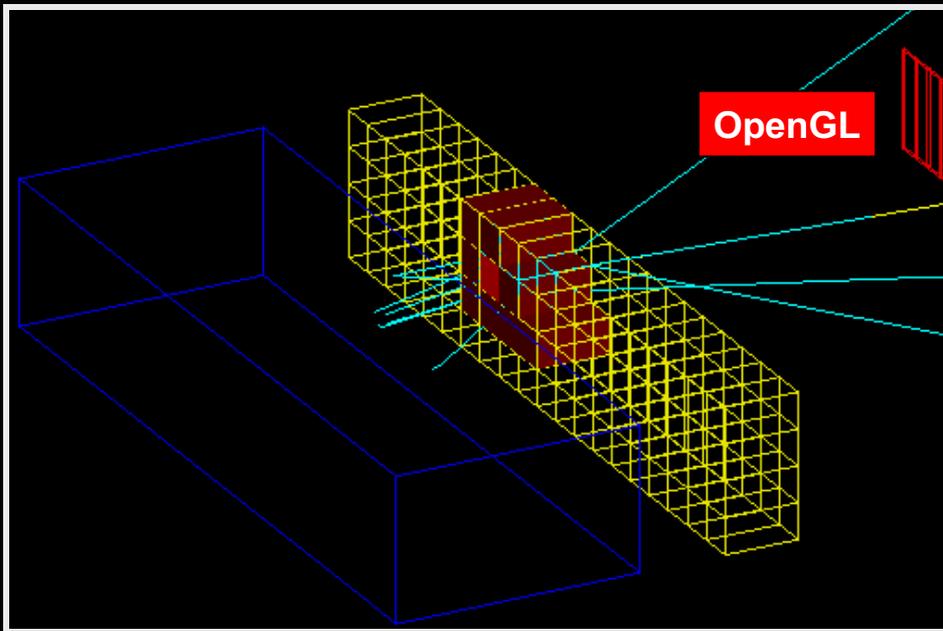
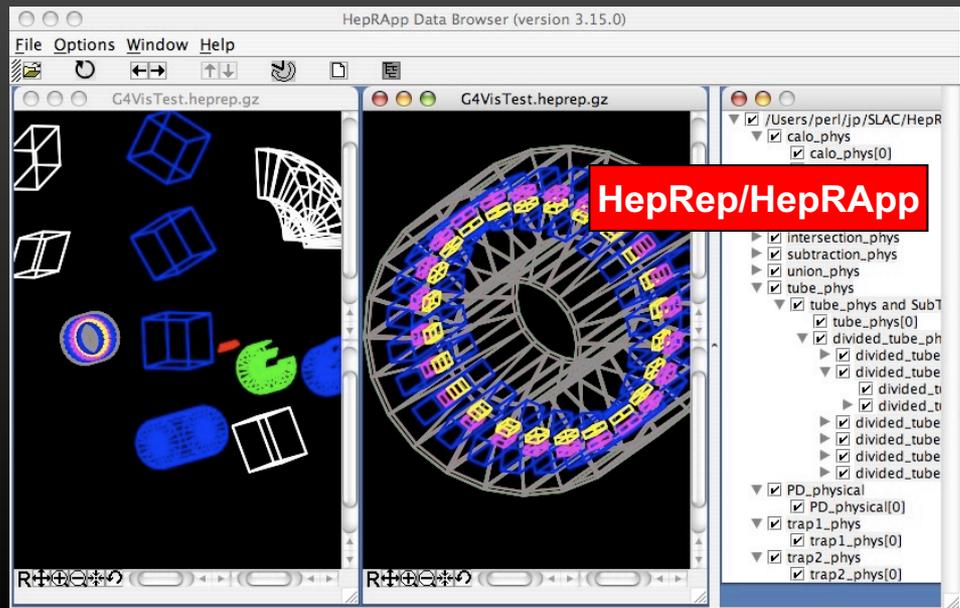
 **Jefferson Lab**



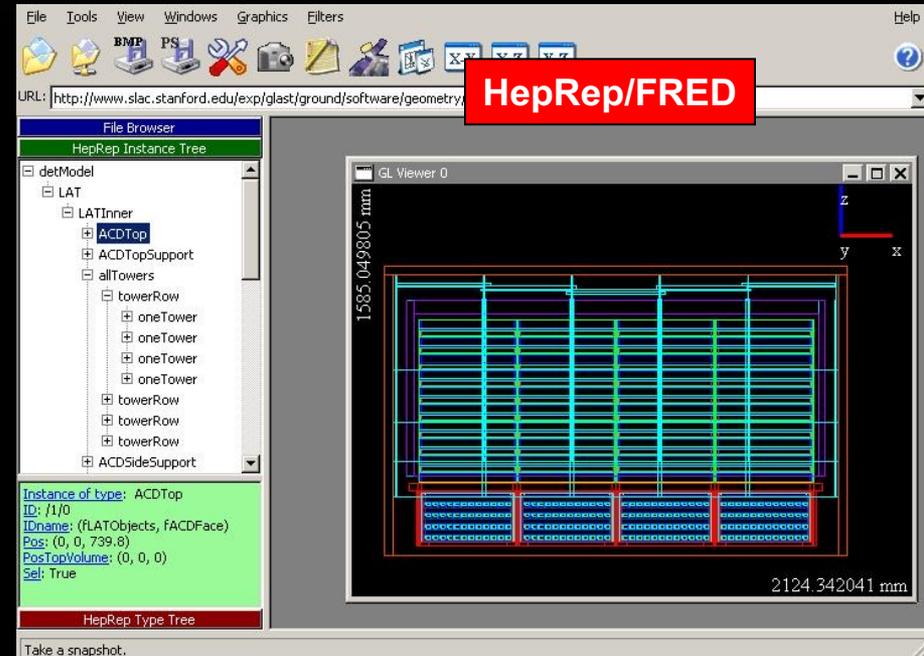
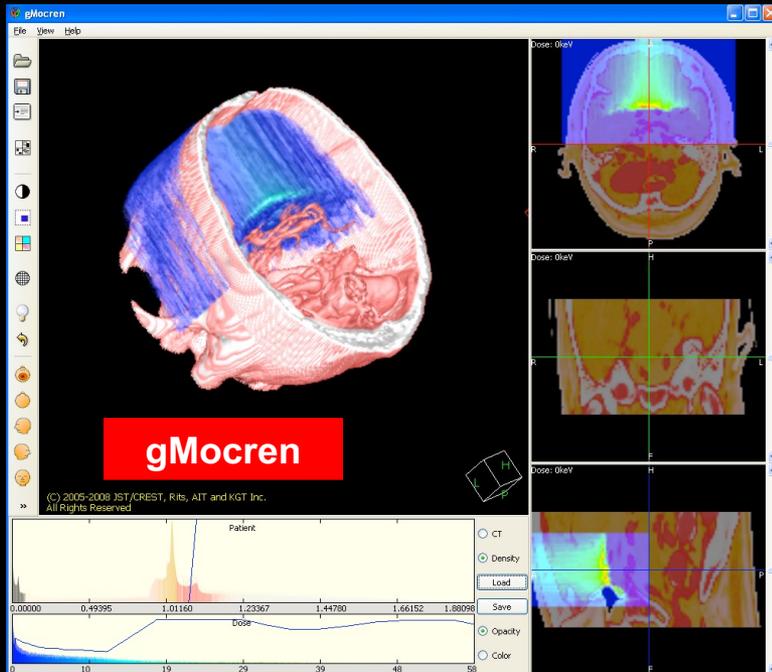
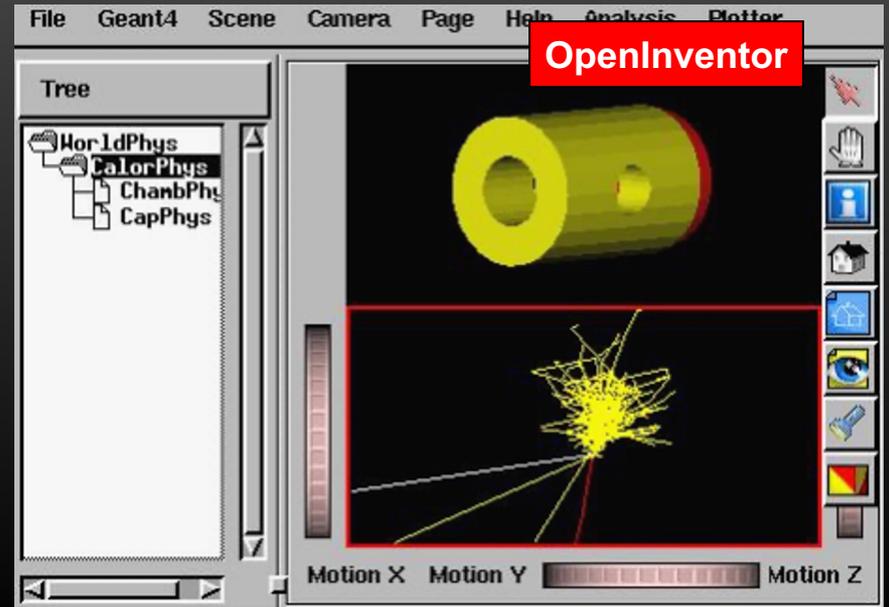
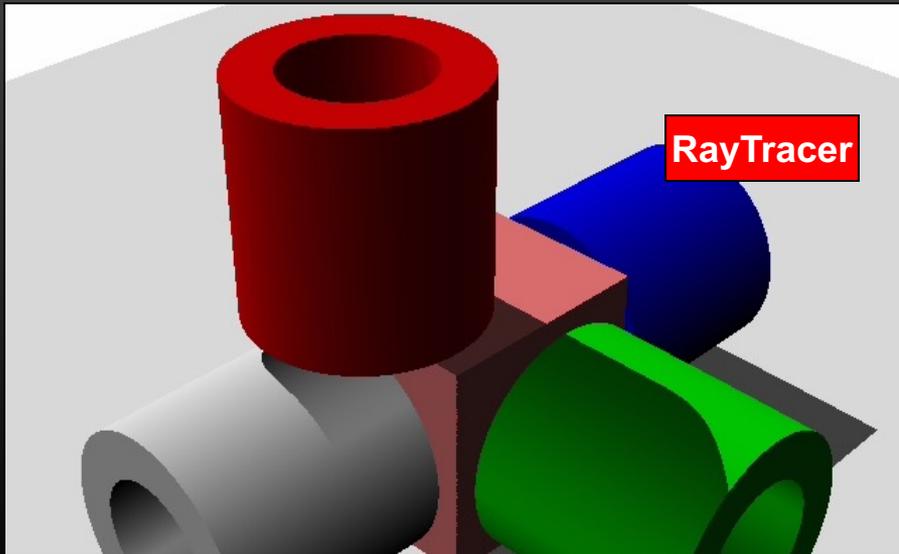
U.S. DEPARTMENT OF
ENERGY

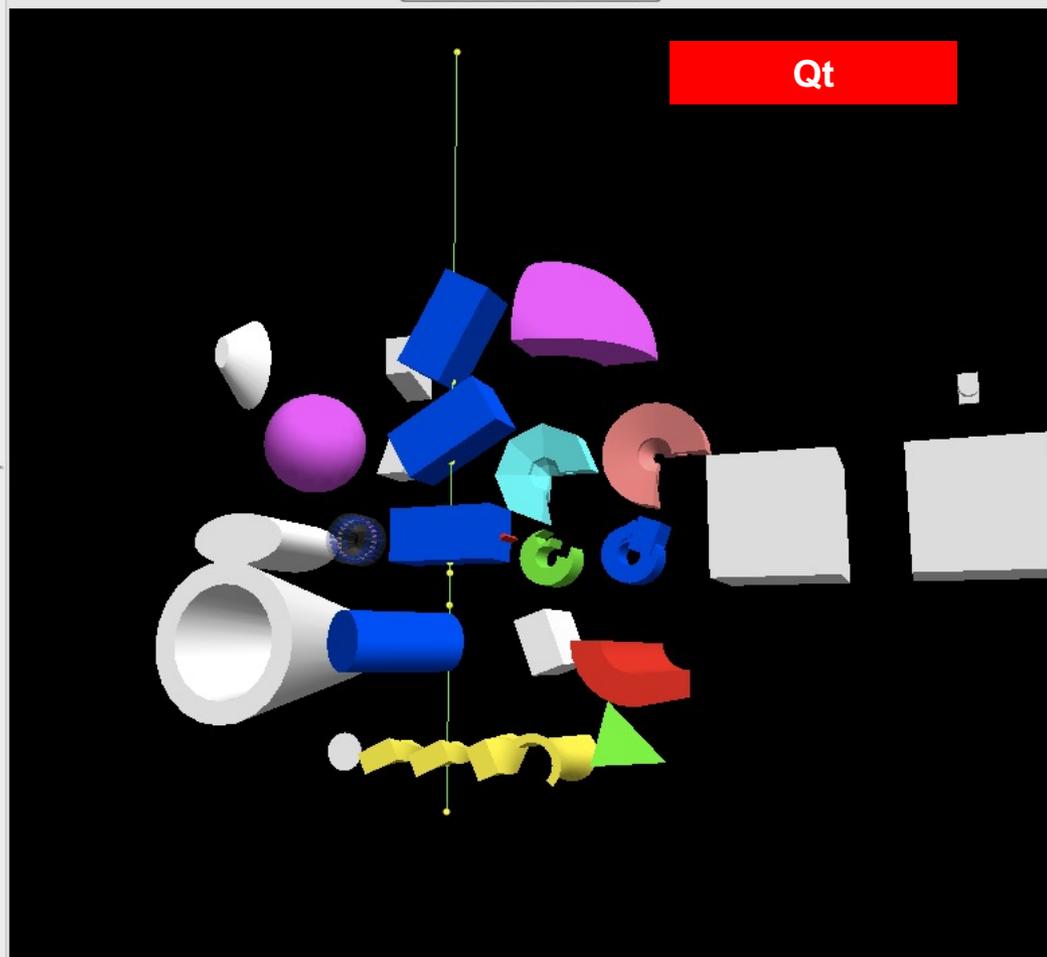
Office of
Science





Visualization - M. Asai (JLab)





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/unThetaPhi

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 :

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	Green	Green	Red	Green	Green	Red
	Xm	Green	Green	Red	Green	Green	Red
	Qt	Green	Green	Green	Green	Green	Red
	Win32	Green	Green	Red	Green	Green	Red
OpenInventor	Xt	Green	Green	Red	Green	Red	Red
	Win32	Green	Green	Red	Green	Red	Red
DAWN		Green	Red	Red	Red	Red	Red
VRML		Red	Green	Red	Red	Red	Green
HepRep		Red	Green	Green	Red	Red	Red
gMocren		Red	Green	Red	Red	Red	Red
RayTracer		Green	Red	Red	Red	Red	Red
ACSII File		Red	Red	Green	Green	Red	Red

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
 - ASCII Tree
- 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
 - ASCIIITree
- 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...

Scene tree, Help, History

viewer-0 (OpenGLStoredQt)

Scene tree

viewer-0 (OpenGLStoredQt)

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
sectionPlane	off

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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 :



viewer-0 (OpenGLStoredQt)

Scene tree

Scene tree : viewer-0 (OpenGLStoredQt)

Touchables

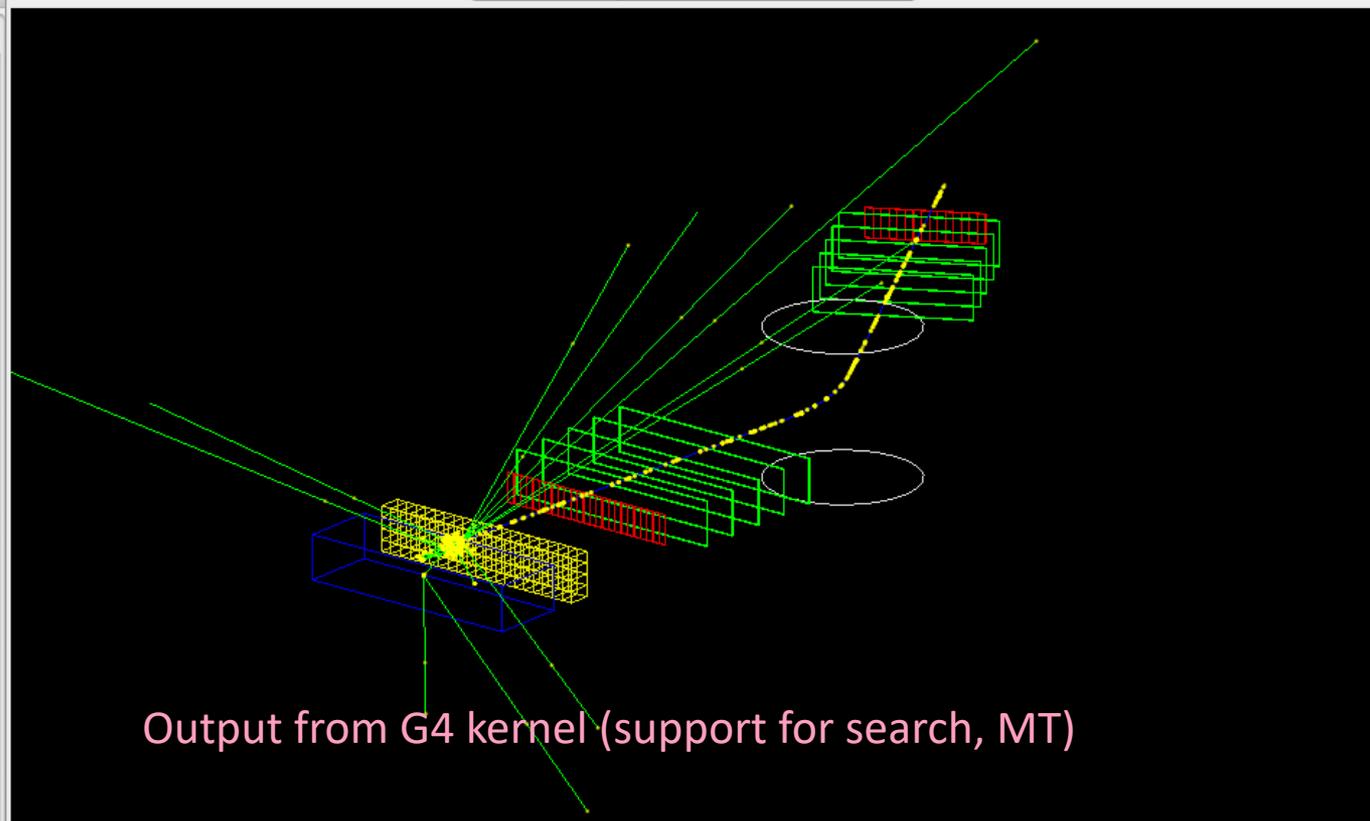
Show all Hide all

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
sectionPlane	off

13

Picking informations Picking mode active



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
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... 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 :

Scene tree, Help, History

viewer-0 (OpenGLStoredQt)

Scene tree

viewer-0 (OpenGLStoredQt)

Scene tree : viewer-0 (OpenGLStoredQt)

Touchables

Show all Hide all

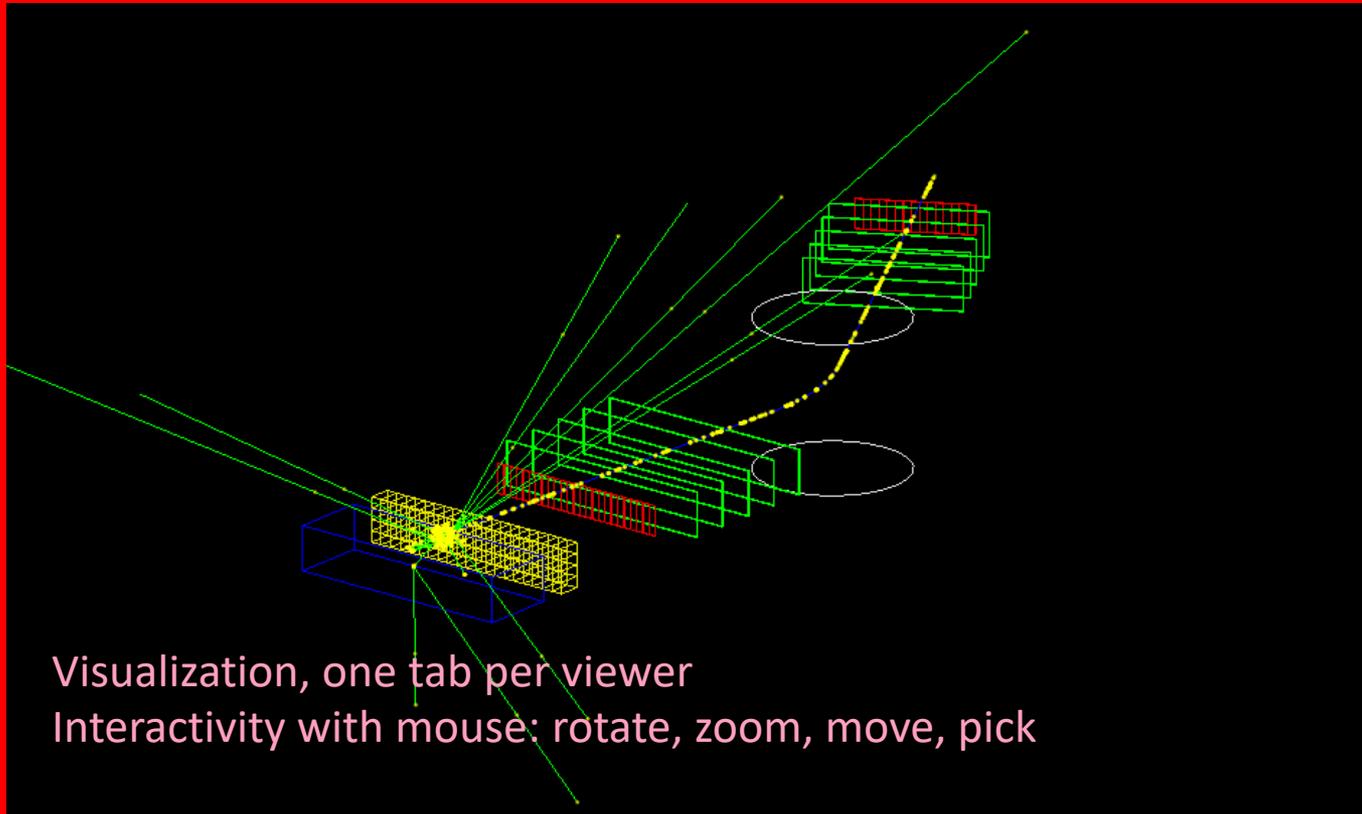
Viewer properties

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
sectionPlane	off

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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
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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 :

Toolbar and menubar controlled by icons.mac file, add your own without coding

The interface consists of several panels:

- Scene tree:** Contains a search bar and a list of objects. The "Touchable" checkbox is checked.
- Viewer properties:** A table of properties and their values.
- Output:** A text window displaying simulation results and a terminal prompt.

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
sectionPlane	off

```

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)
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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
  
```

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Picking informations Picking mode active

Session :



Scene tree, Help, History
Scene tree Help History

Search :

Command

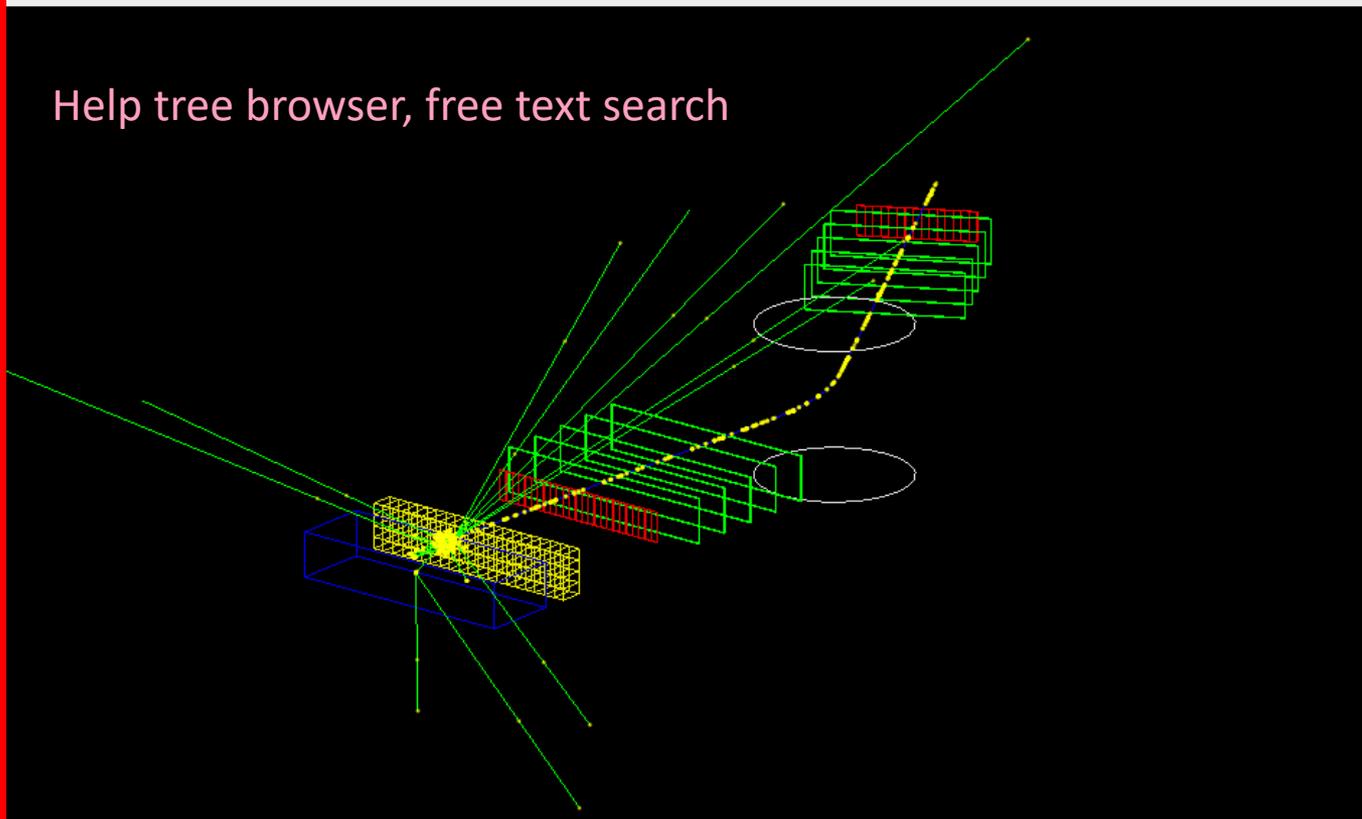
- ▶ control
- ▶ units
- ▶ process
- ▶ gui
- ▶ geometry
- ▶ tracking
- ▶ event
- ▶ cuts
- ▼ run
 - ▼ particle
 - verbose
 - dumpList
 - addProcManager**
 - buildPhysicsTable
 - storePhysicsTable
 - retrievePhysicsTable
 - setStoredInAscii
 - applyCuts
 - dumpCutValues
 - dumpOrderingParam
 - initialize
 - beamOn
 - verbose
 - printProgress
 - numberOfThreads
 - useMaximumLogicalCores
 - pinAffinity
 - eventModulo
 - dumpRegion
 - dumoCouples

Command /run/particle/addProcManager
Guidance : add process manager to specified particle type

	Parameter	Guidance	Type	Ommitable	Default	Range
1	particleType		s	True		

16

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
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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 :

Scene tree, Help, History

Scene tree Help History

```

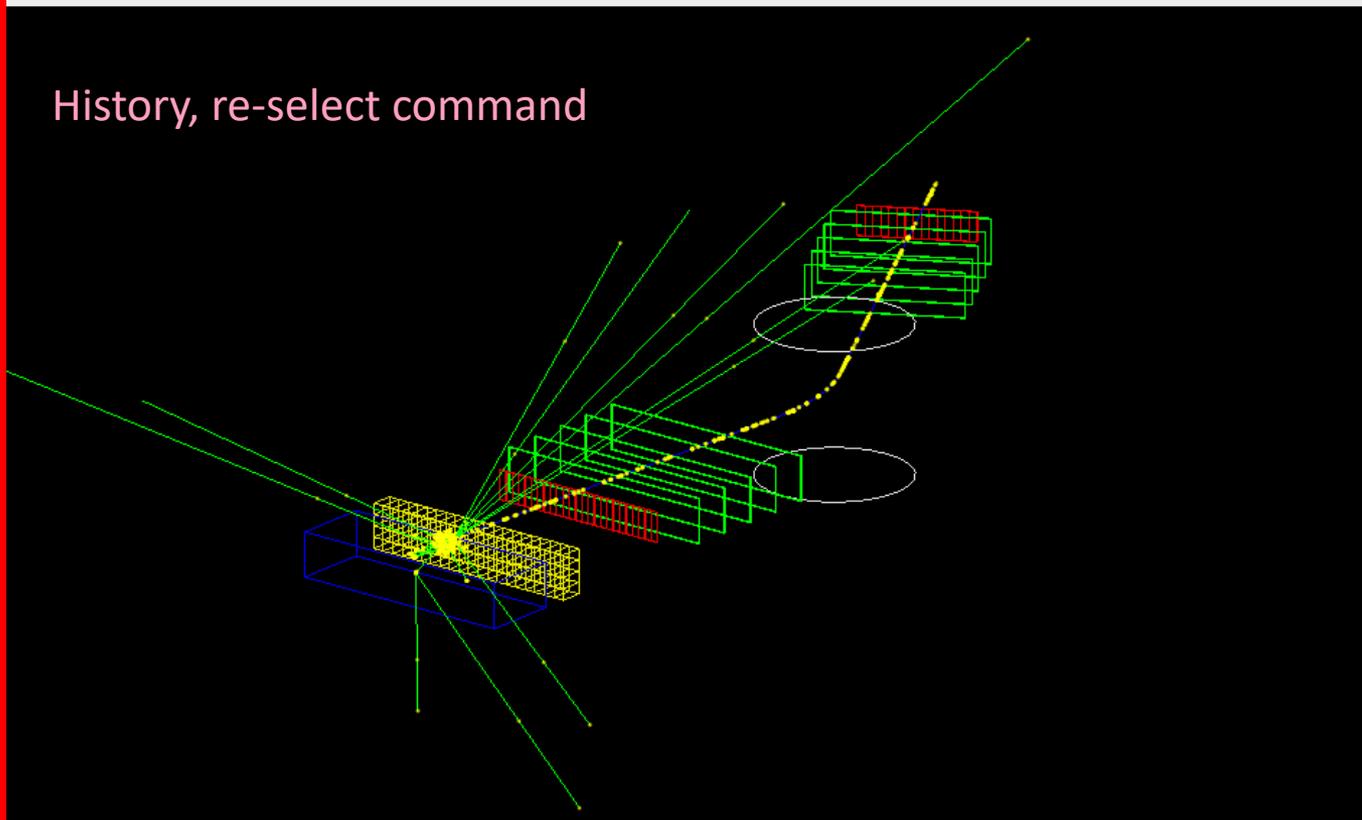
/run/beamOn 1
/control/shell ls

```

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:

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...
 - hodoscope1Physica...
 - hodoscope1Physica...
 - hodoscope1Physica...
 - hodoscope1Physica...
 - hodoscope1Physica...
 - 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
sectionPlane	off

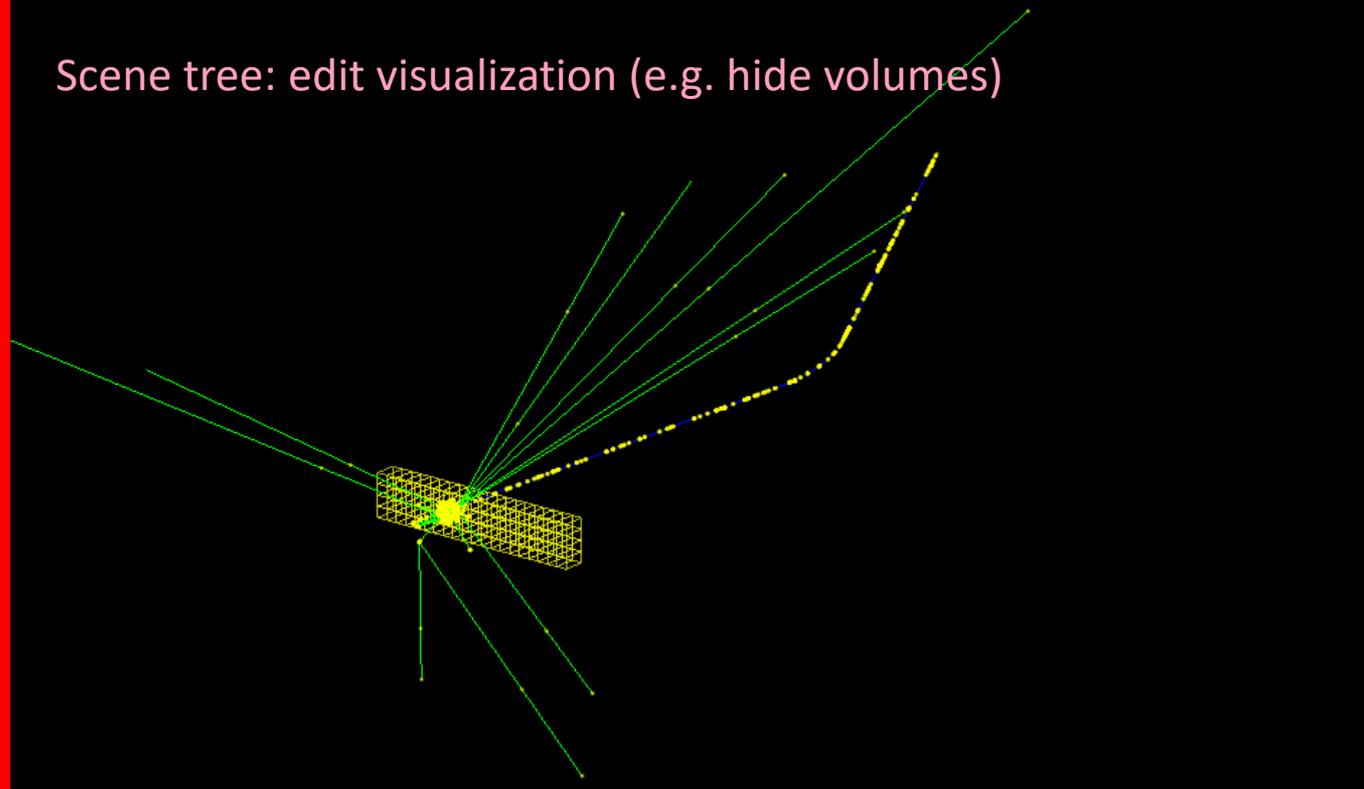
18

 Picking informations Picking mode active

Useful tips

viewer-0 (OpenGLStoredQt)

Scene tree: edit visualization (e.g. hide volumes)



Output

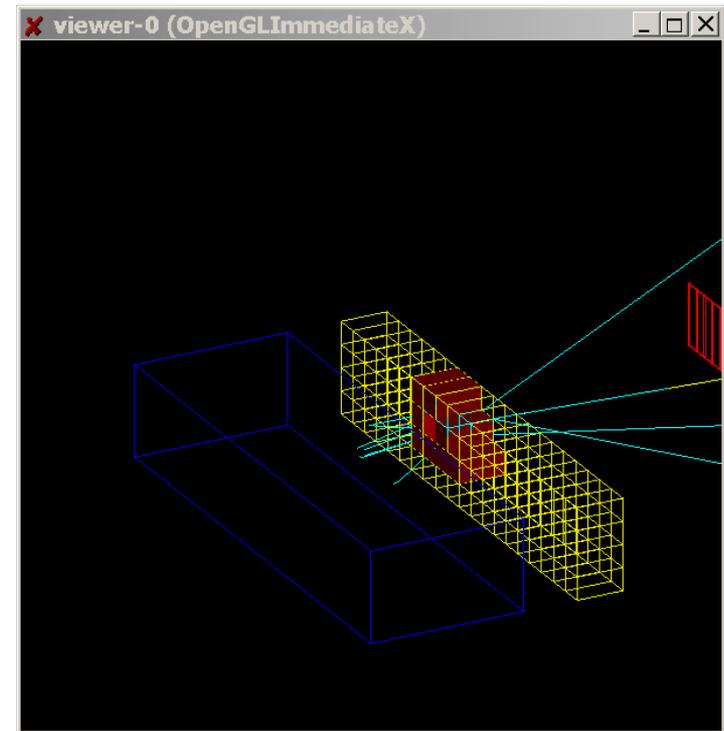
```

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
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EM Calorimeter has 7 hits. Total Edep is 967.12227158091 (MeV)
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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 :

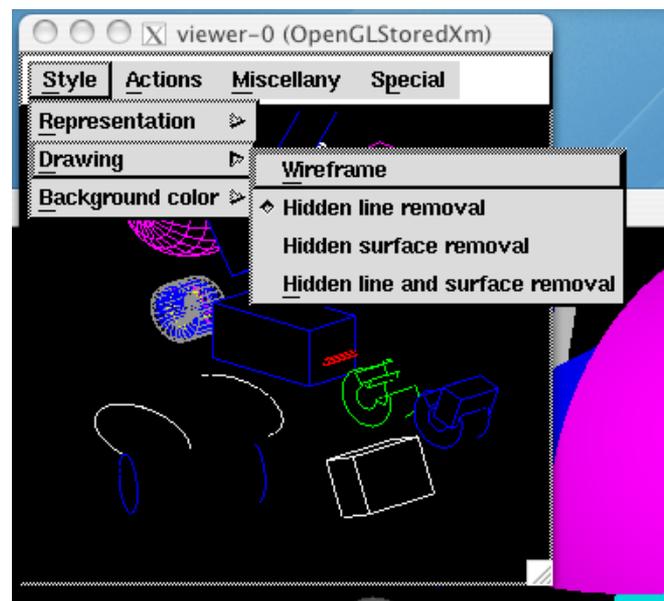
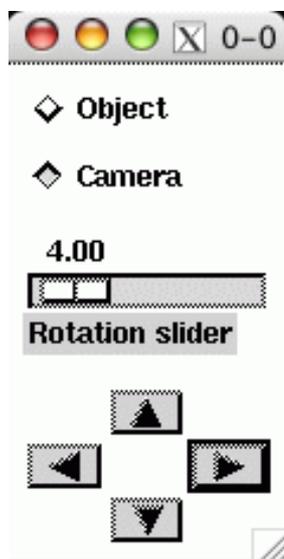
2) OpenGL

- /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



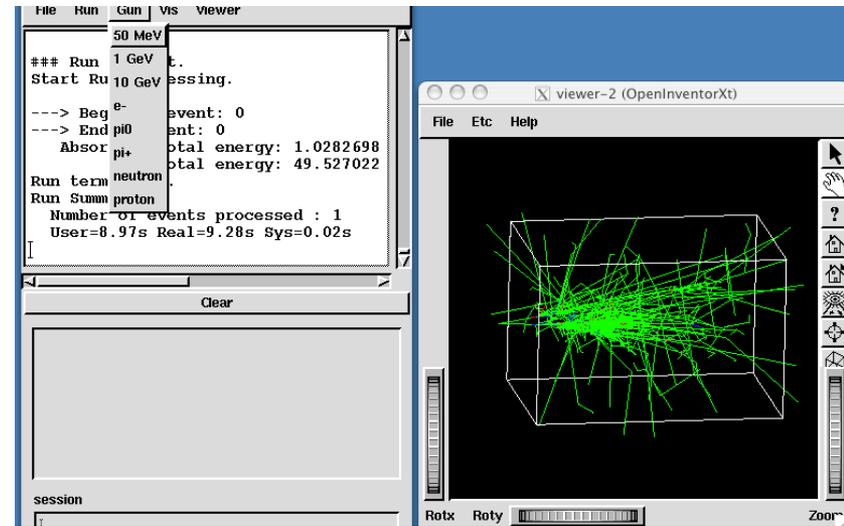
3) OpenInventor

- `/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

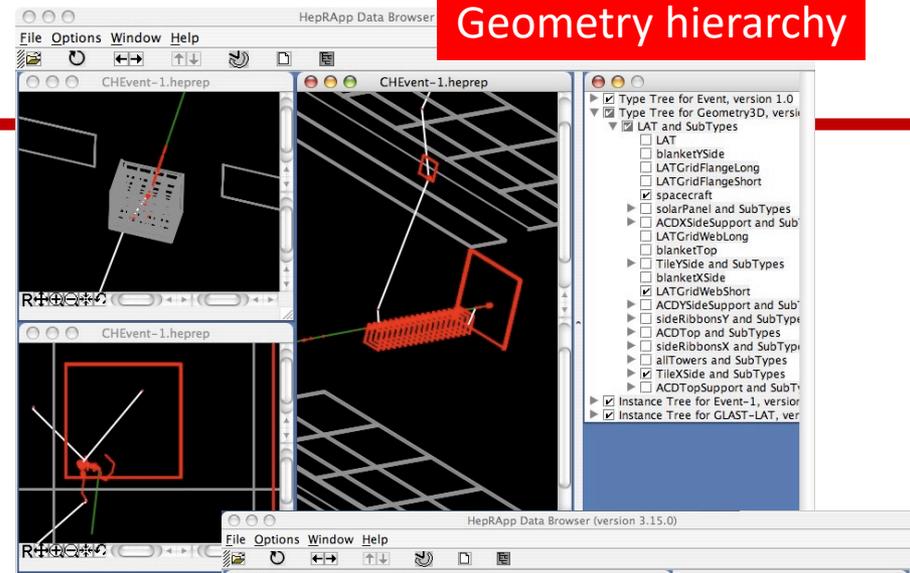
• /vis/open HepRepFile

• Features

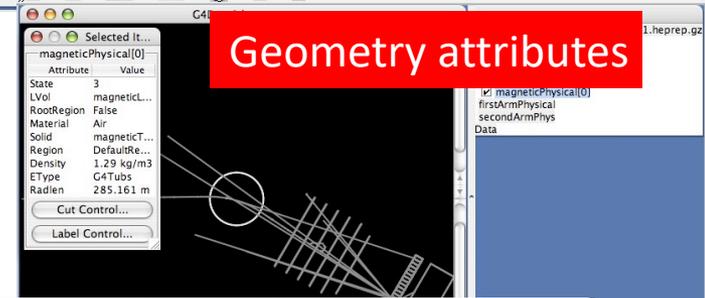
- Create a file to view in the
 - HepRApp HepRep Browser
 - WIRED4 JAS Plugin
 - or FRED Event Display
- Requires one of the above browsers (freely available for all systems)
- Wireframe or simple area fills (not photorealistic)
- Many interactive features
 - zoom, rotate, translate
 - click to show 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

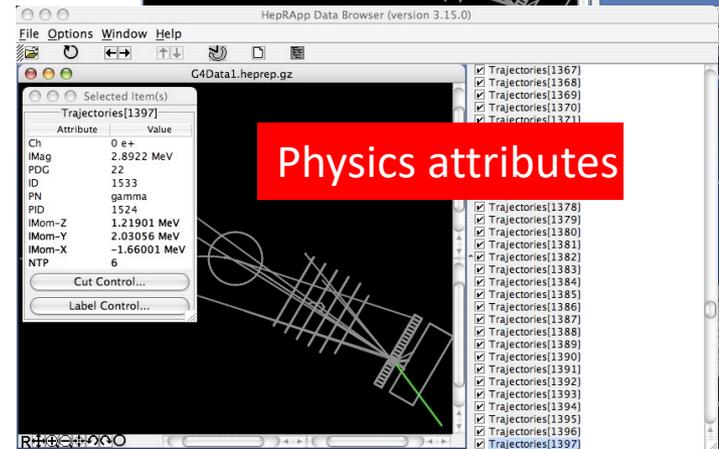
Geometry hierarchy



Geometry attributes



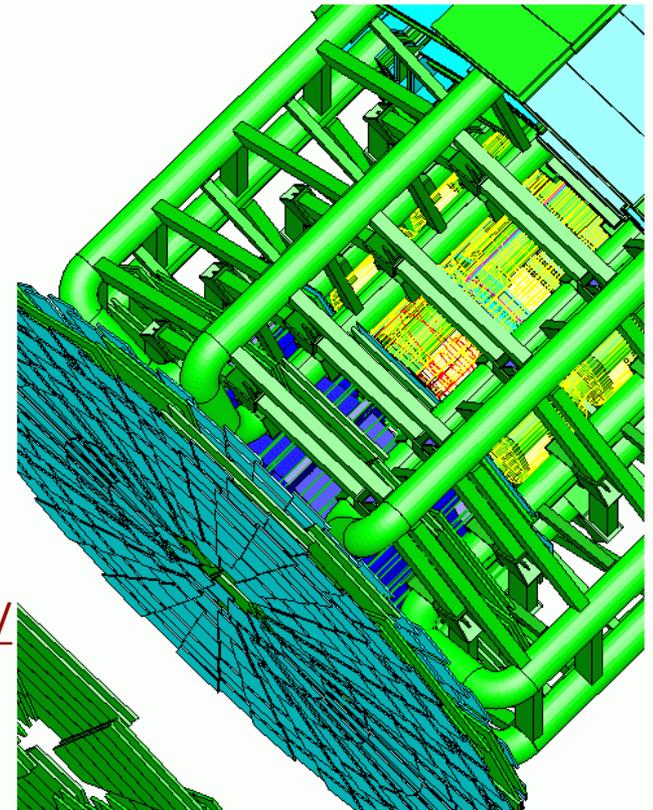
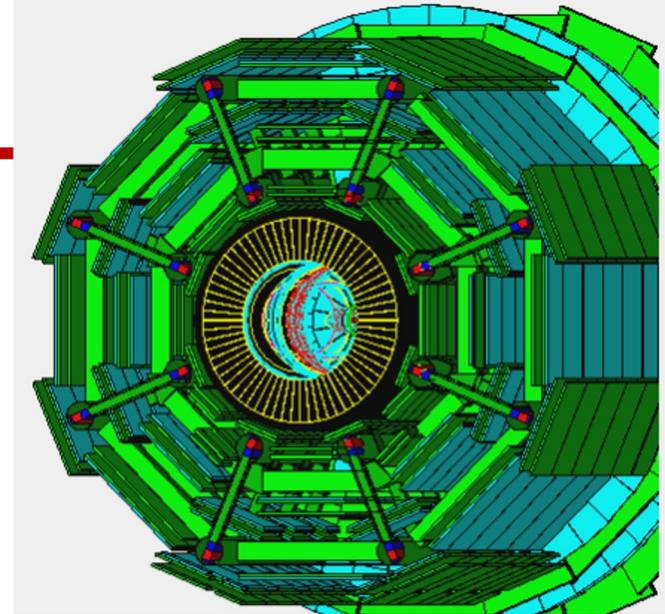
Physics attributes



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

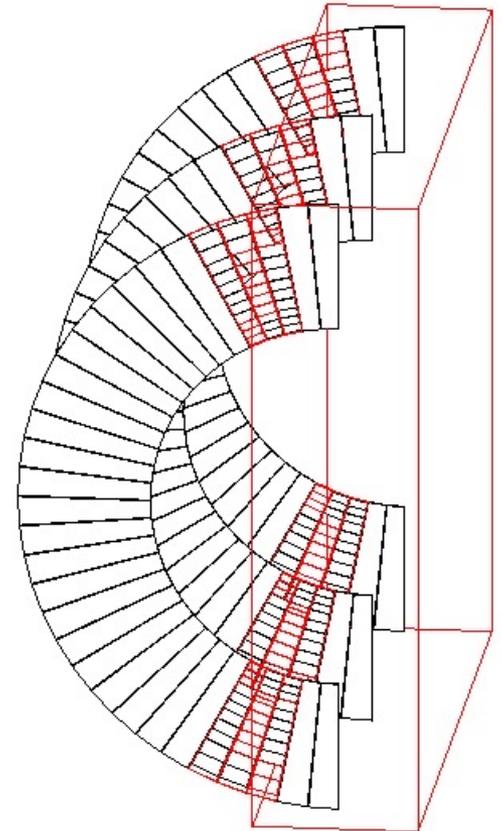
http://geant4.kek.jp/~tanaka/GEANT4/ATLAS_G4_GIFFIG/



DAWNCUT and DAVID

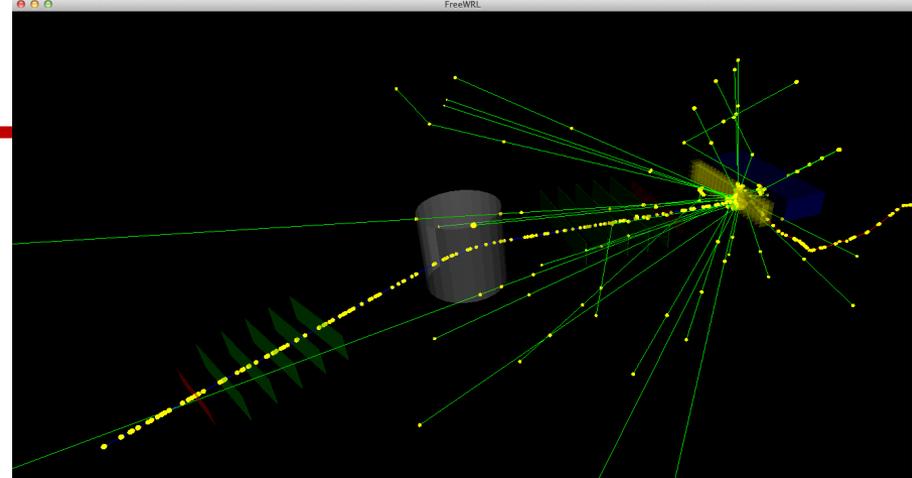
- A standalone program, **DAWNCUT**, can perform a planar cut on a DAWN image
 - DAWNCUT takes as input a .prim file and some cut parameters. Its output is a new .prim file to which the cut has been applied.
- Another standalone program, **DAVID**, **can show you any volume overlap errors** in your geometry
 - 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/>



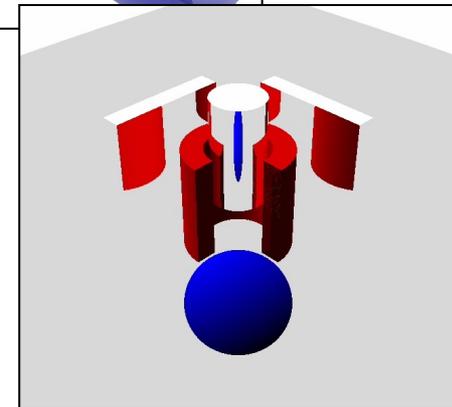
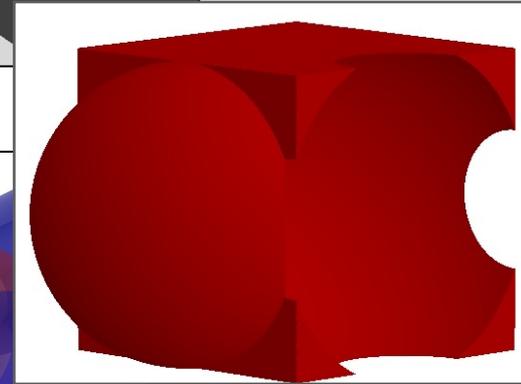
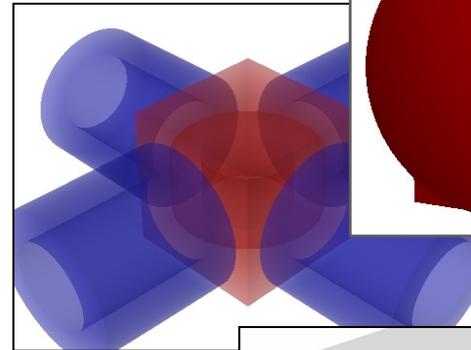
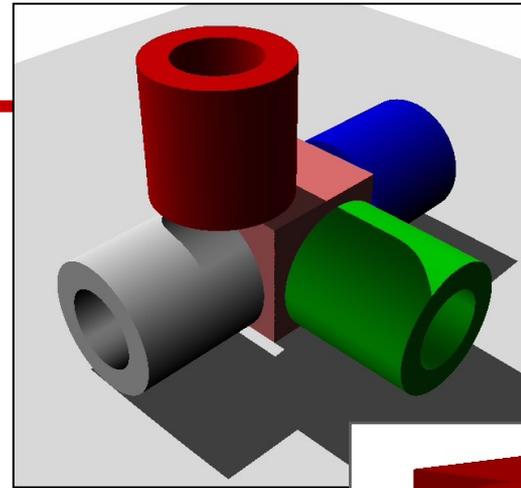
6) VRML

- `/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)



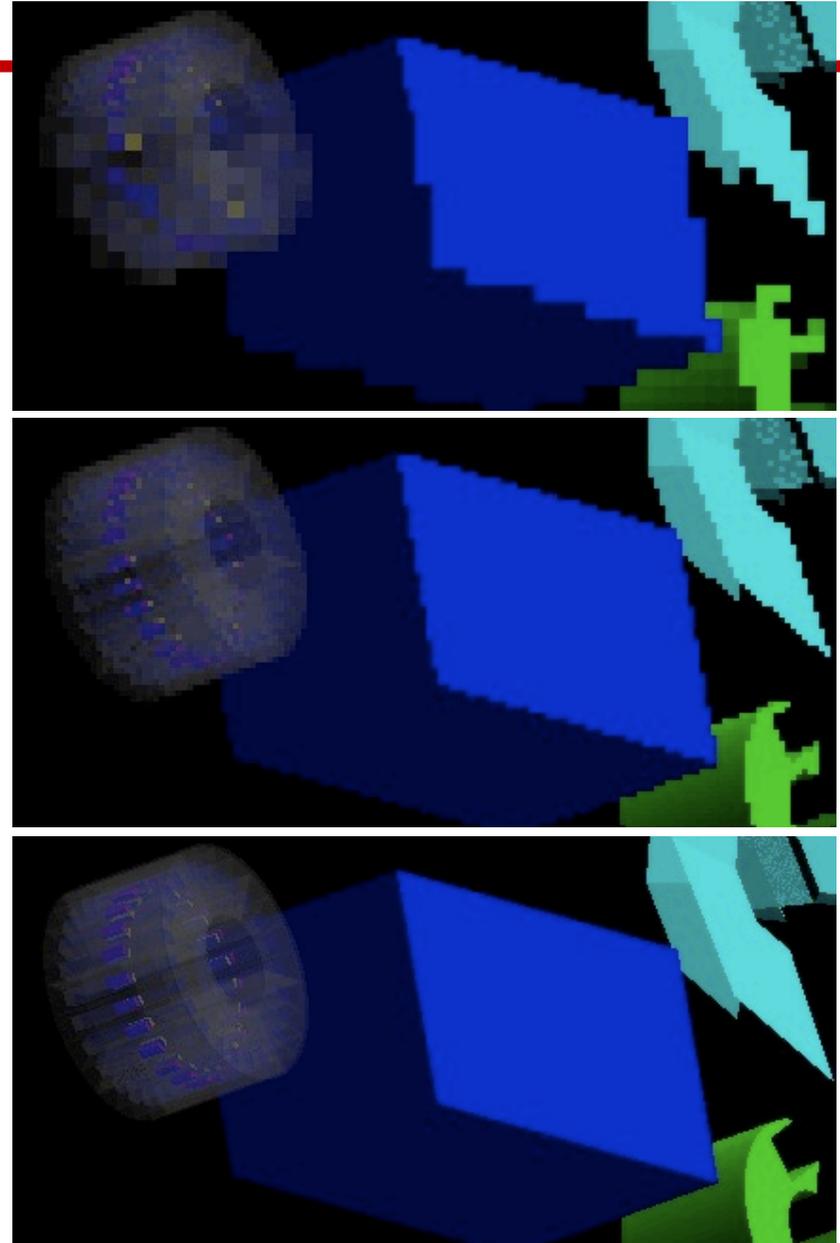
7) RayTracer

- `/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



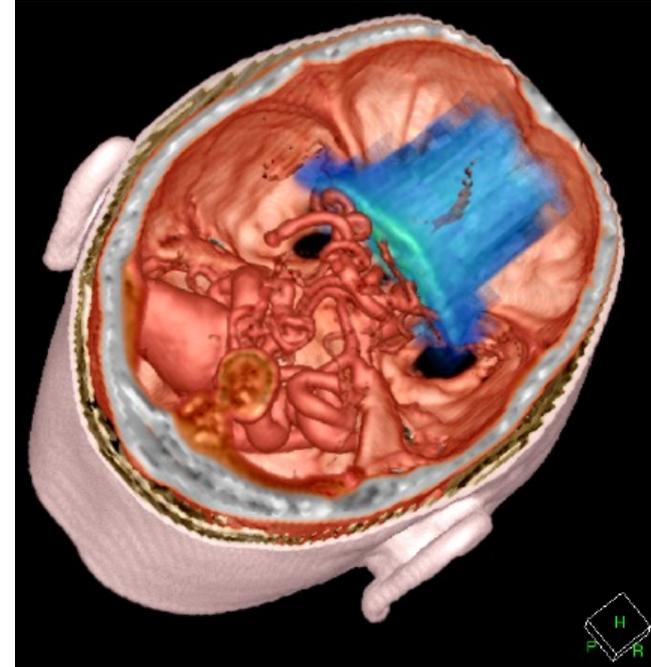
RayTracerX

- 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.

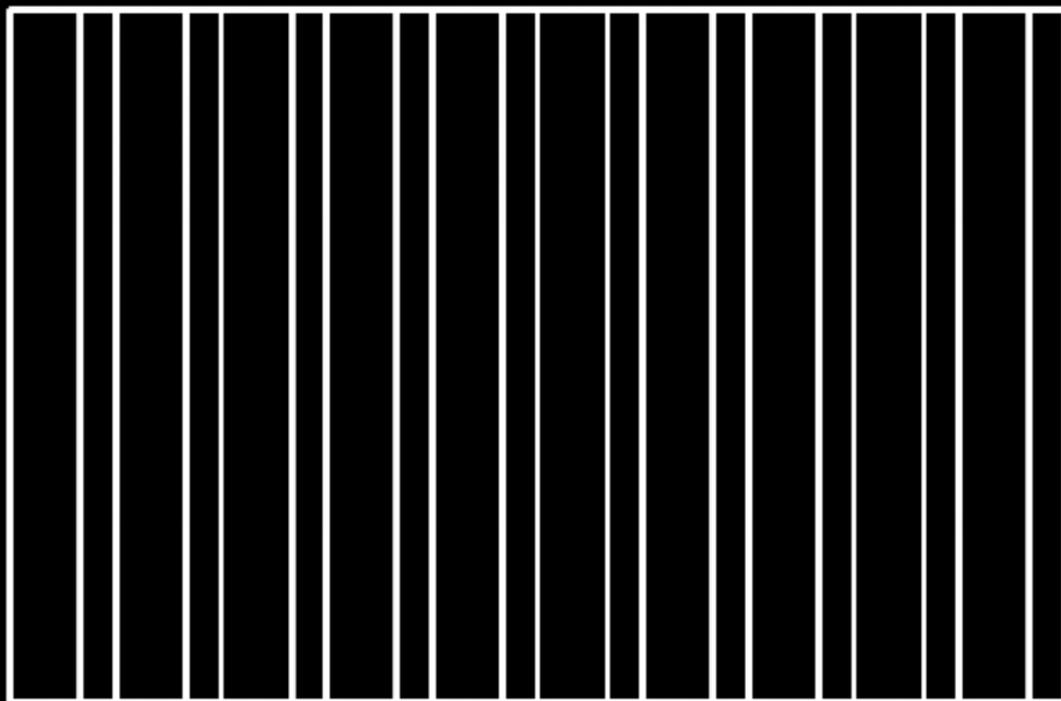
Movies: time development of the event

- 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/>

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.jp/~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>