

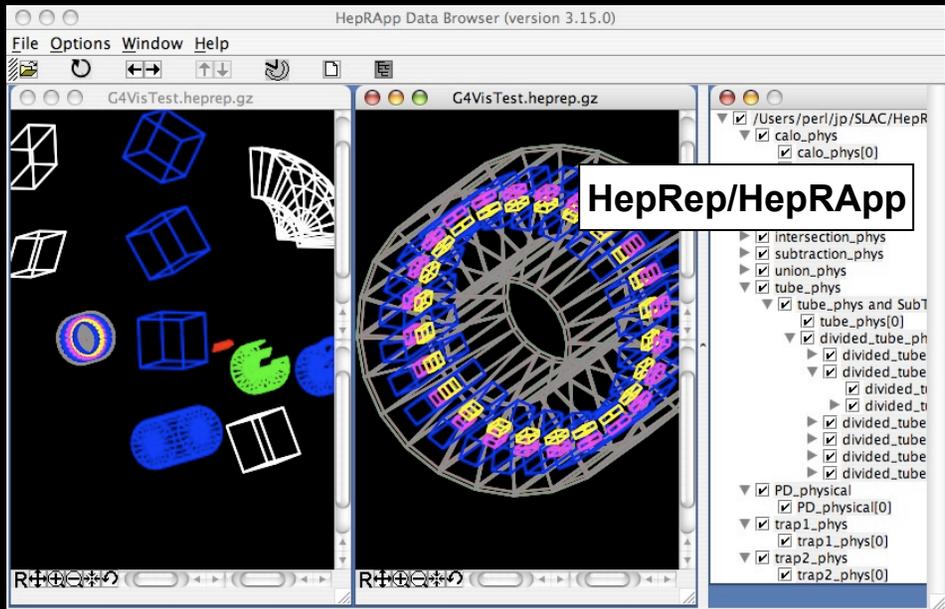
# Geant4 Visualization

Andrea Dotti

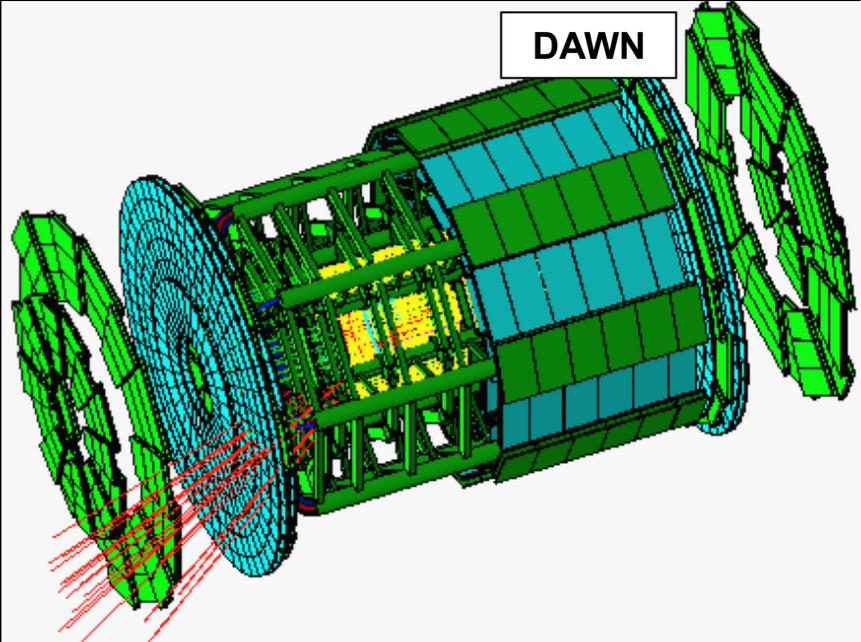
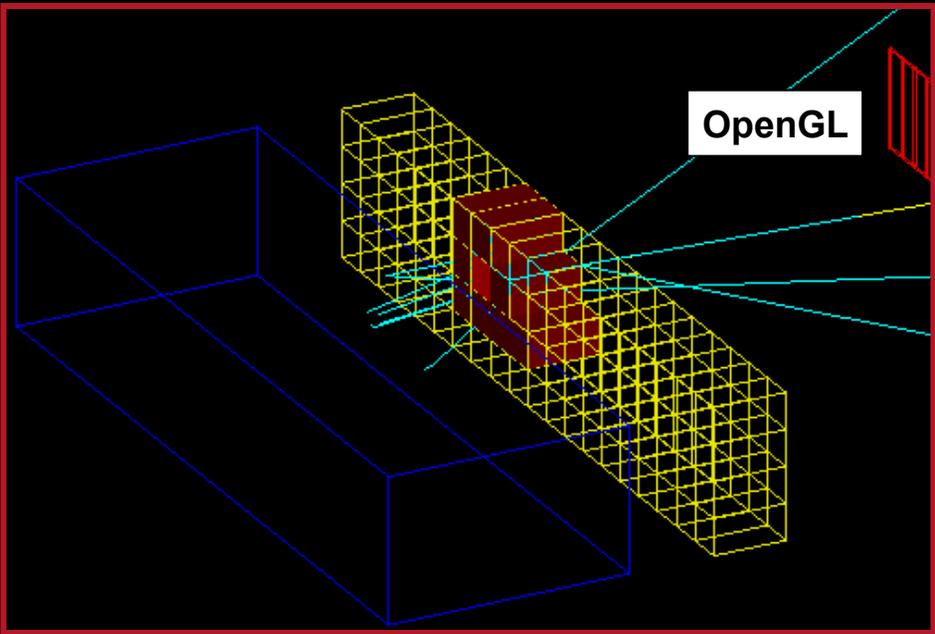
April 19th, 2015

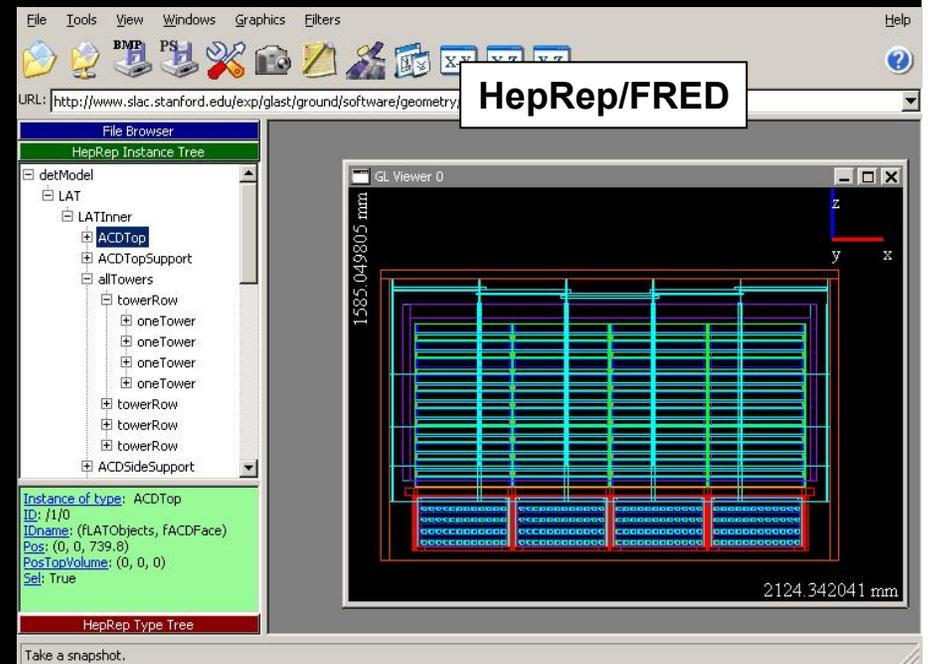
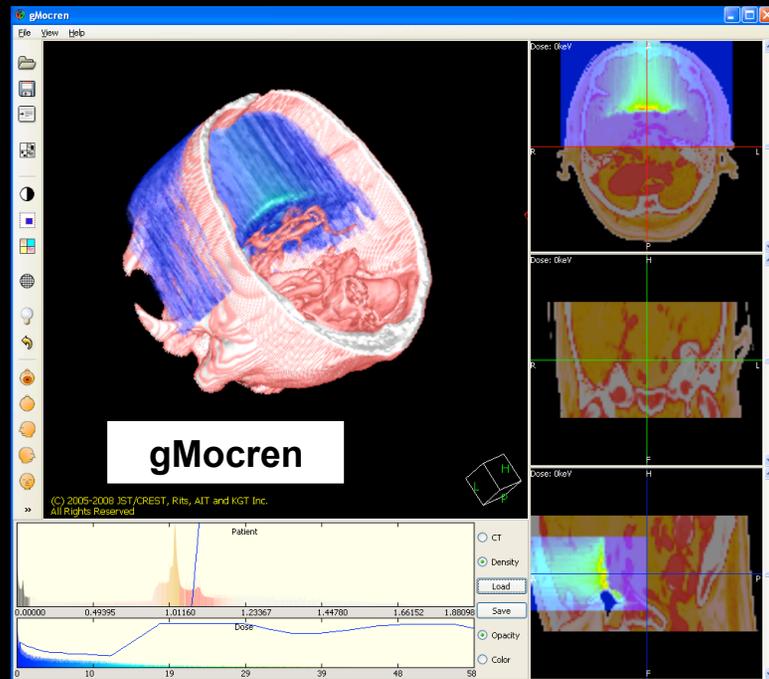
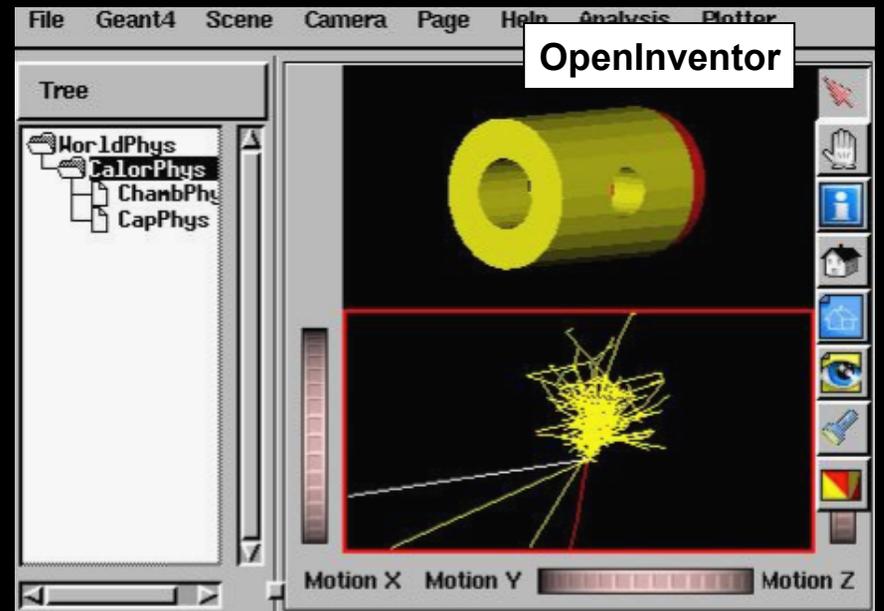
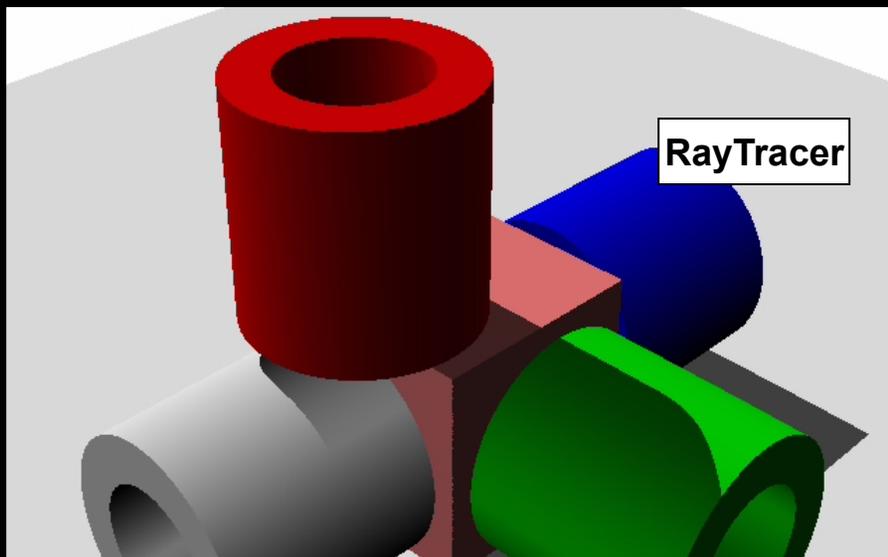
Geant4 tutorial @ M&C+SNA+MC 2015





Slides from Joseph Perl (SLAC) and  
Laurent Garnier (LAL/IN2P3)





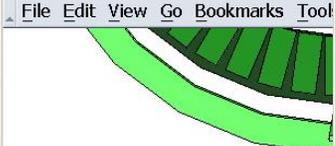


# Tutorials

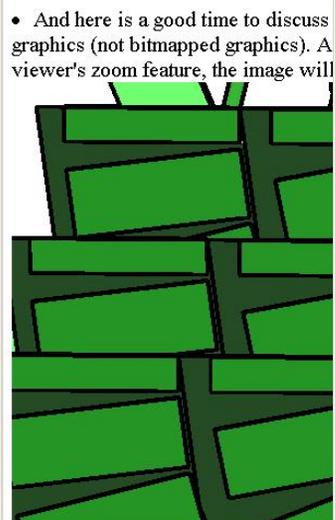
CLAC

**Geant4 Vis Tutorial using th**

File Edit View Go Bookmarks Tool



- And here is a good time to discuss graphics (not bitmapped graphics). A viewer's zoom feature, the image will



- Now that you have some basic fam created during the previous tutorial w file called: geant4\examples\extended\analysis\A

**Orientation Actions**

To select from among s right mouse button (Ma

**Orientation A**

**Orientation T**

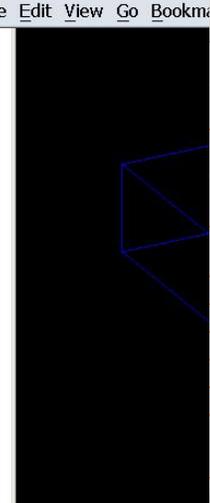
**Projection**

**Mouse Functi**

**Drawing Opti**

**Geant4 Vis Tutorial**

File Edit View Go Bookm



- The output appears as s included automatically
- One last command for t the detector was drawn command:

```

/vis/viewer/se
/run/beamOn 1
        
```

The detector will then ; to still see the tracks p

**viewer-0 (Open**

Geant4 @ IN2P3 – Geant4 Qt User Interface tutorial (based on 4.9.6 version)

http://geant4.in2p3.fr/spip.php?article84&lang=en

Bethesda AnatomyAtlas SearchHypernews TopasBeta BetaExtra BetaGroup TOPAS Alpha AlphaGroup topas CMakeSyntax

Geant4@IN2P3

CNRS IN2P3 Geant4



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The BioRad project

BioRad Collaboration

The BioRad II project

BioRad II Collaboration

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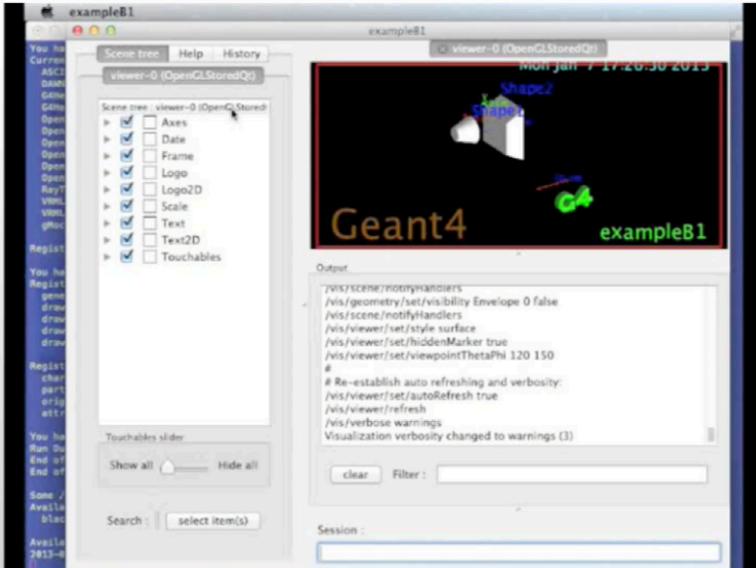
Home > Visualization & Qt

Geant4 Qt User interface tutorial (based on 4.9.6 version)

**Geant4 Qt User Interface tutorial (based on 4.9.6 version)**

**First tutorial : Download/Compilation/Installation/Launch B1**

- Step 1: Download Geant4
- Step 2: Compilation and Installation (at 25")
- Step 3: Example (B1) compilation (at 2'06)
- Step 4: Run example (at 2'32)



**Second tutorial : User interface demo**

- Step 5: Qt interface
- Step 6: Making movies (at 6'12)
- Step 7: Export high quality pictures (at 8'00)

# 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 be visualized:

- Polylines
  - such as coordinate axes
- 3D Markers
  - such as eye guides
- Text
  - descriptive character strings
  - comments or titles

# 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

- You may ask why Geant4 has so many different visualization systems.
- This is a natural result of Geant4 being a toolkit and not a single application.
- To support user communities who incorporate Geant4 into their own pre-existing software frameworks, Geant4 visualization is built around a set of well defined interfaces.
  - These interfaces make it straightforward to connect Geant4's core visualization tools to any visualization system
    - able to drive advanced systems that can natively display complex solids such as Geant4's cut cylinders
    - able to drive more basic systems that do not understand such solids (system can ask Geant4 visualization to deconstruct complex solids into simpler polygons)
  - For those users who want a ready-made visualization solution from Geant4, these same interfaces have made it straightforward for us to provide a variety of solutions, each with particular areas of strength.
- Interfaces discussed in detail in: [The Geant4 Visualisation System](#)  
J Allison, M Asai, G Barrand, M Donszelmann, K Minamimoto, J Perl, S Tanaka, E Tcherniaev, J Tinslay, Computer Physics Communications, Volume 178, Issue 5, 331-365, 1 March 2008

# 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 more complete:  
good starting point

## Screenshots on the Visualization drivers

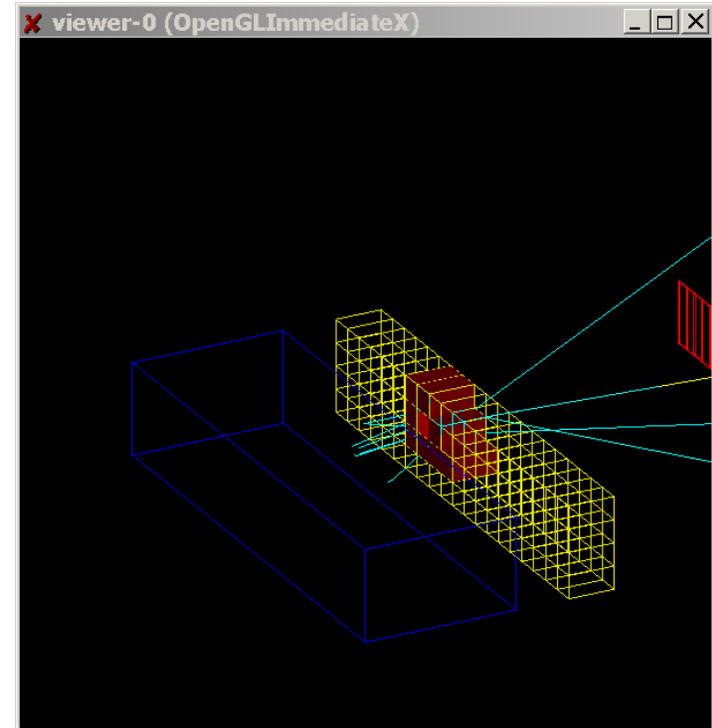
---

SLAC

- OpenGL
- OpenInventor
- HepRep
- DAWN
- VRML
- RayTracer
- gMocren

# 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



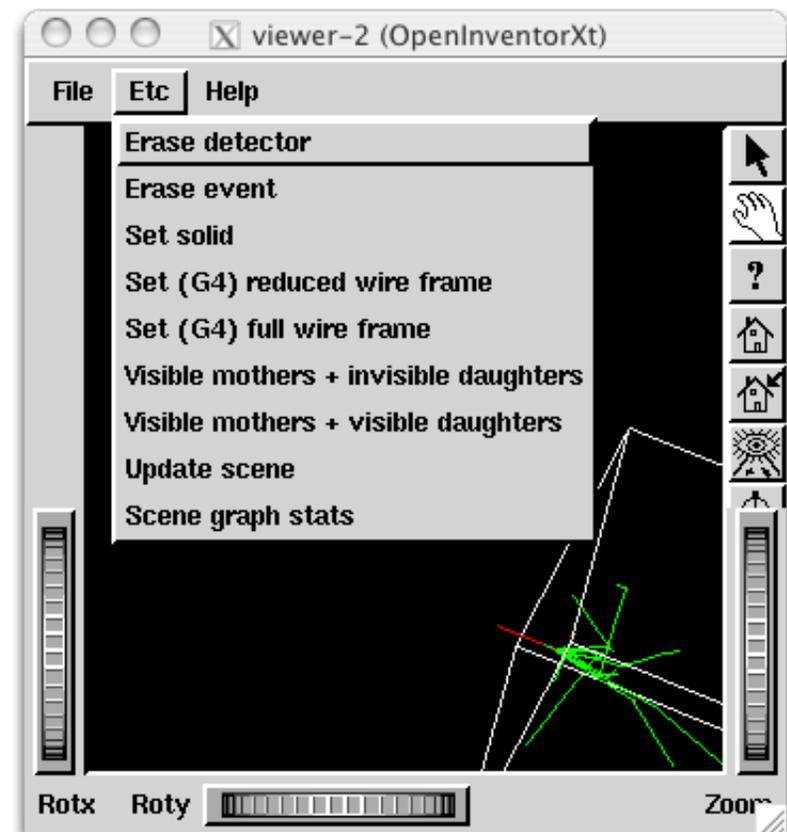
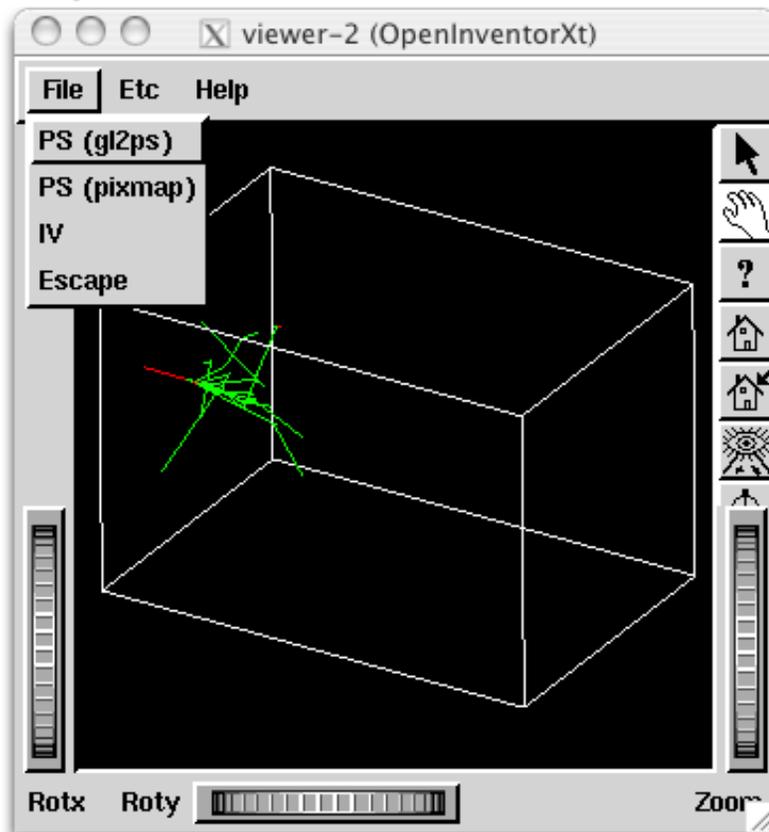
# OpenInventor

- `/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

# OpenInventor: Start from Geant4

- With OpenInventor, start from Geant4, but then some control from OpenInventor GUI

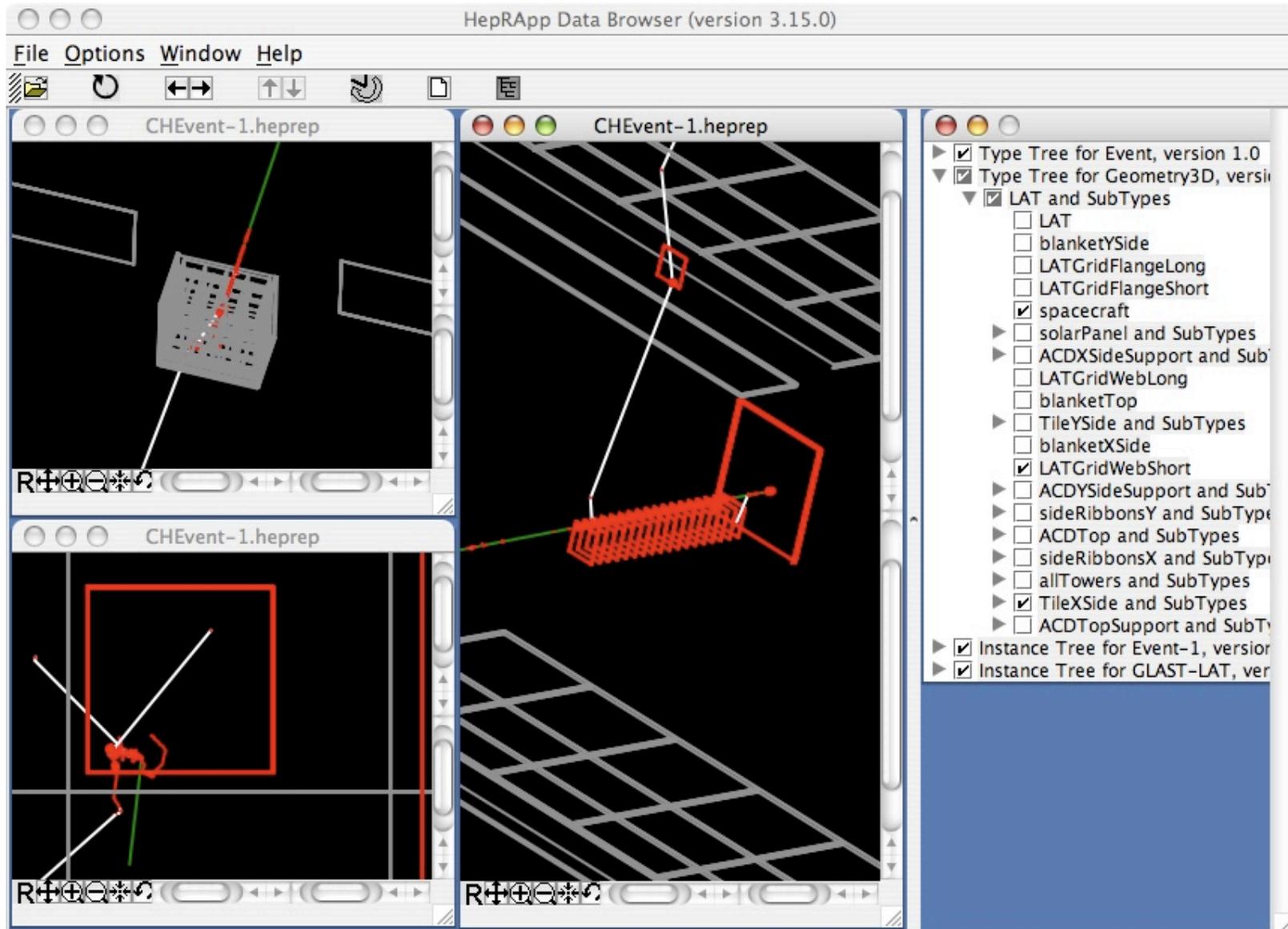


# HepRep

- /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

# HepRApp: Shows Geometry Hierarchy



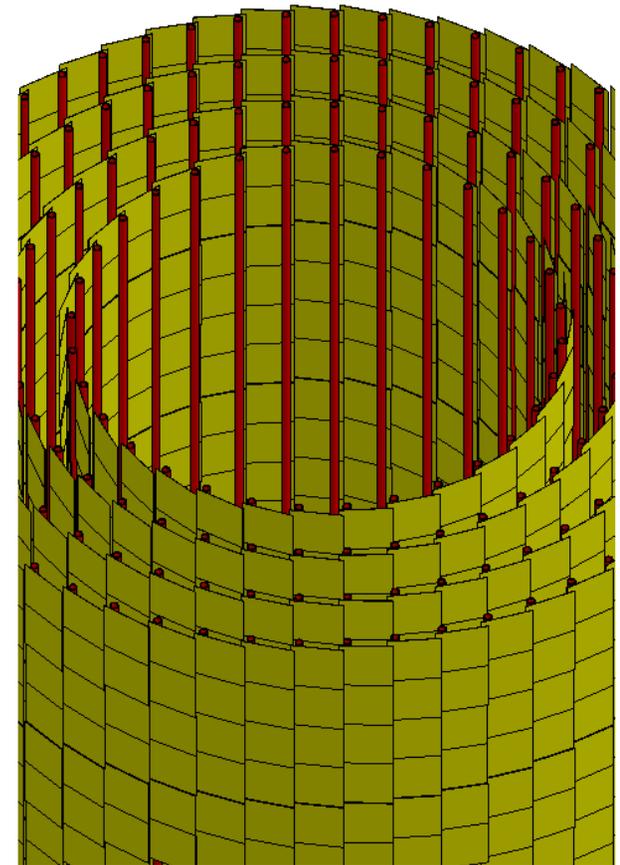
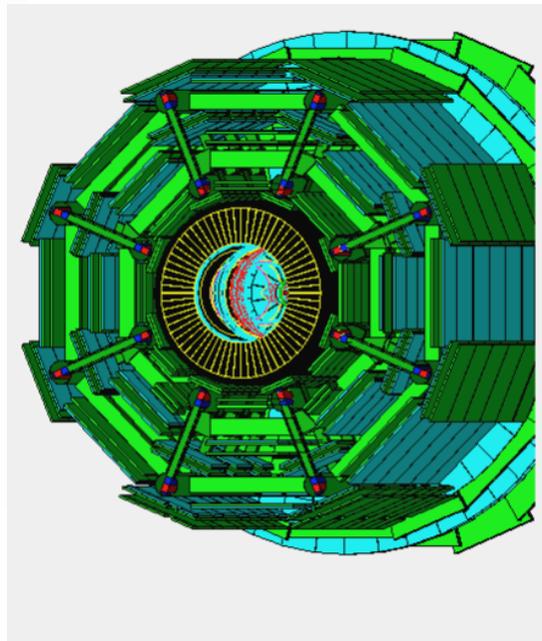
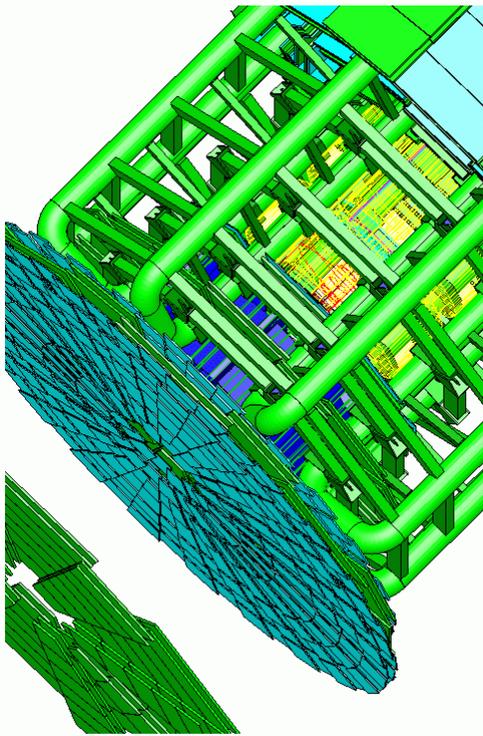
# DAWN

- /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**

# DAWN Examples

From a repository of images at

- [http://geant4.kek.jp/~tanaka/GEANT4/ATLAS\\_G4\\_GIFFIG/](http://geant4.kek.jp/~tanaka/GEANT4/ATLAS_G4_GIFFIG/)



# DAWNCUT and DAVID

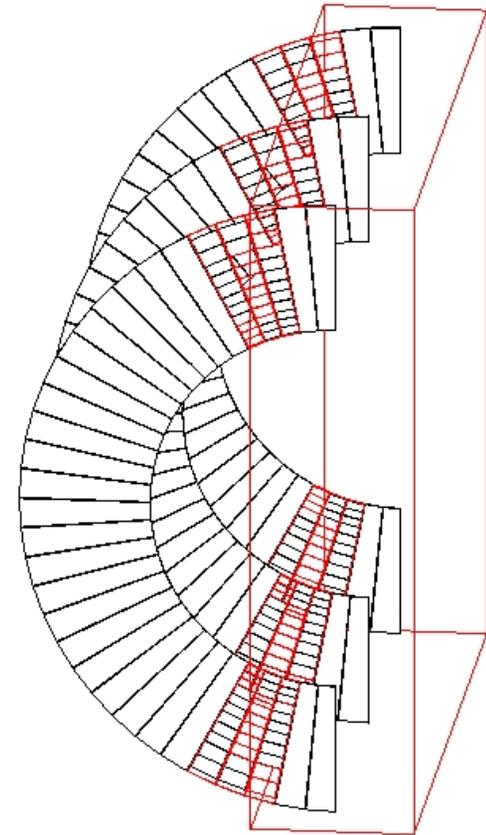
A standalone program, DAWNCUT, can perform a planar cut on a DAWN image.

- 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.

Details at <http://geant4.kek.jp/~tanaka/>

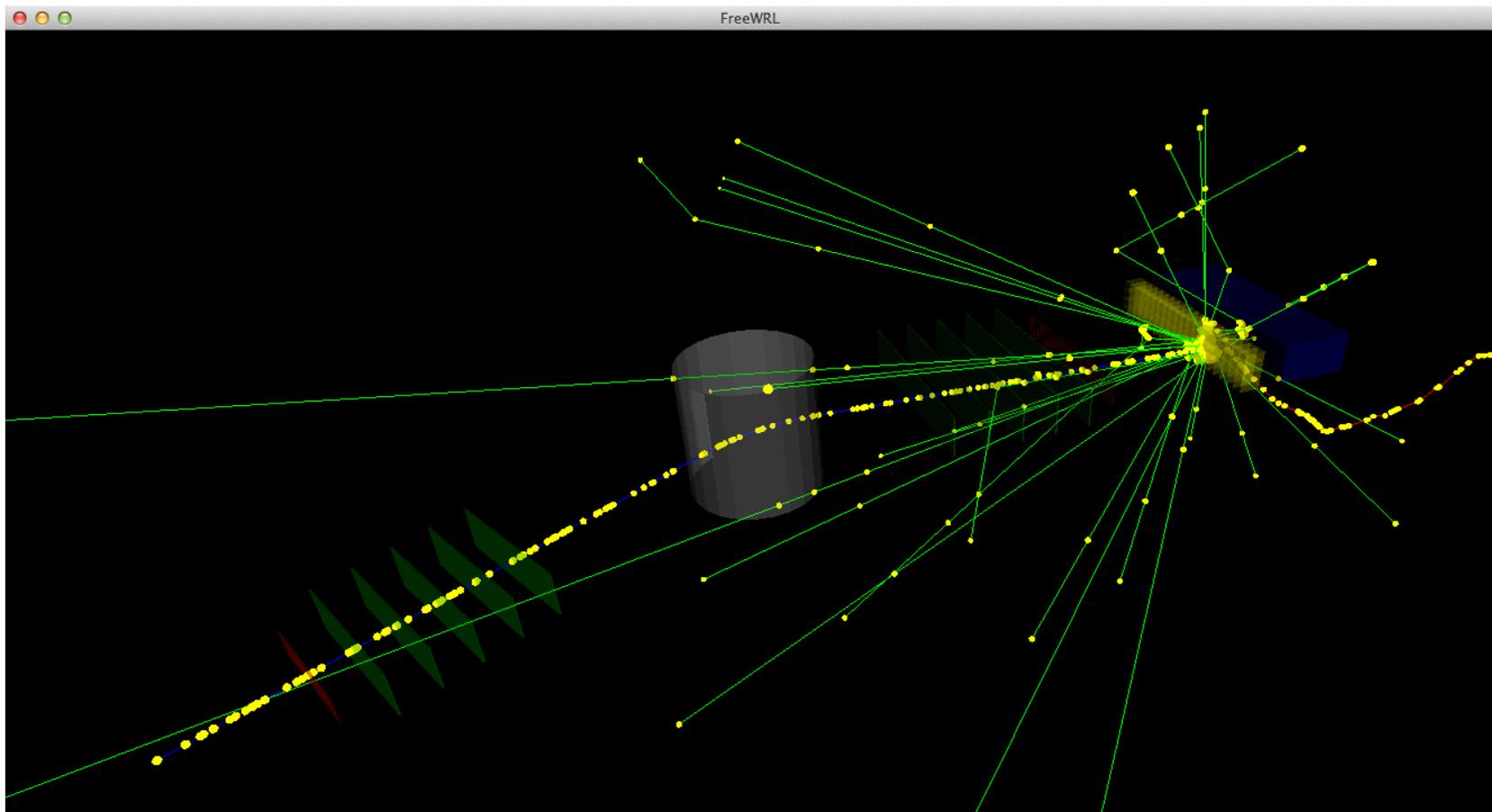


# VRML

- `/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).
  - Rendered, photorealistic image with some interactive features
    - zoom, rotate, translate
  - Limited printing ability (pixel graphics, not vector graphics)

# VRML

- Geant4 creates VRML File
  - /vis/open VRML1FILE or /vis/open VRML2FILE
- View file in a VRML Browser
  - Many free options, for example, here is one from freeWRL



# 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

RayTracer works by using Geant4's own tracking to shoot photons through the detector onto a sensitive plane. The resulting image is presented as a jpeg file.

- /vis/open RayTracer

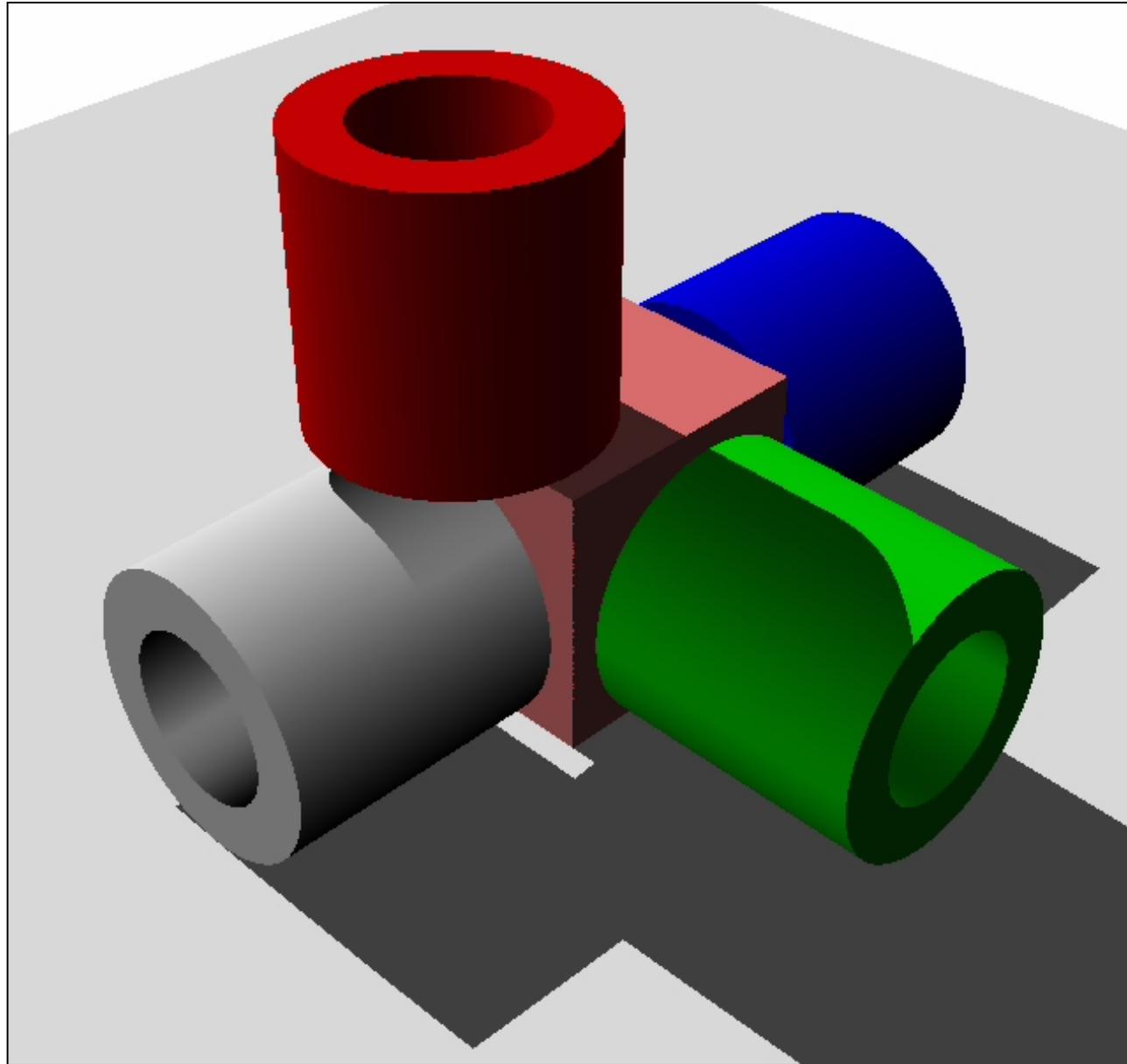
Some pieces of geometries may fail to show up in other visualization drivers (due to algorithms those drivers use to compute visualizable shapes and polygons), but RayTracer can handle any geometry that the Geant4 navigator can handle.

RayTracer can not be used to visualize Trajectories.

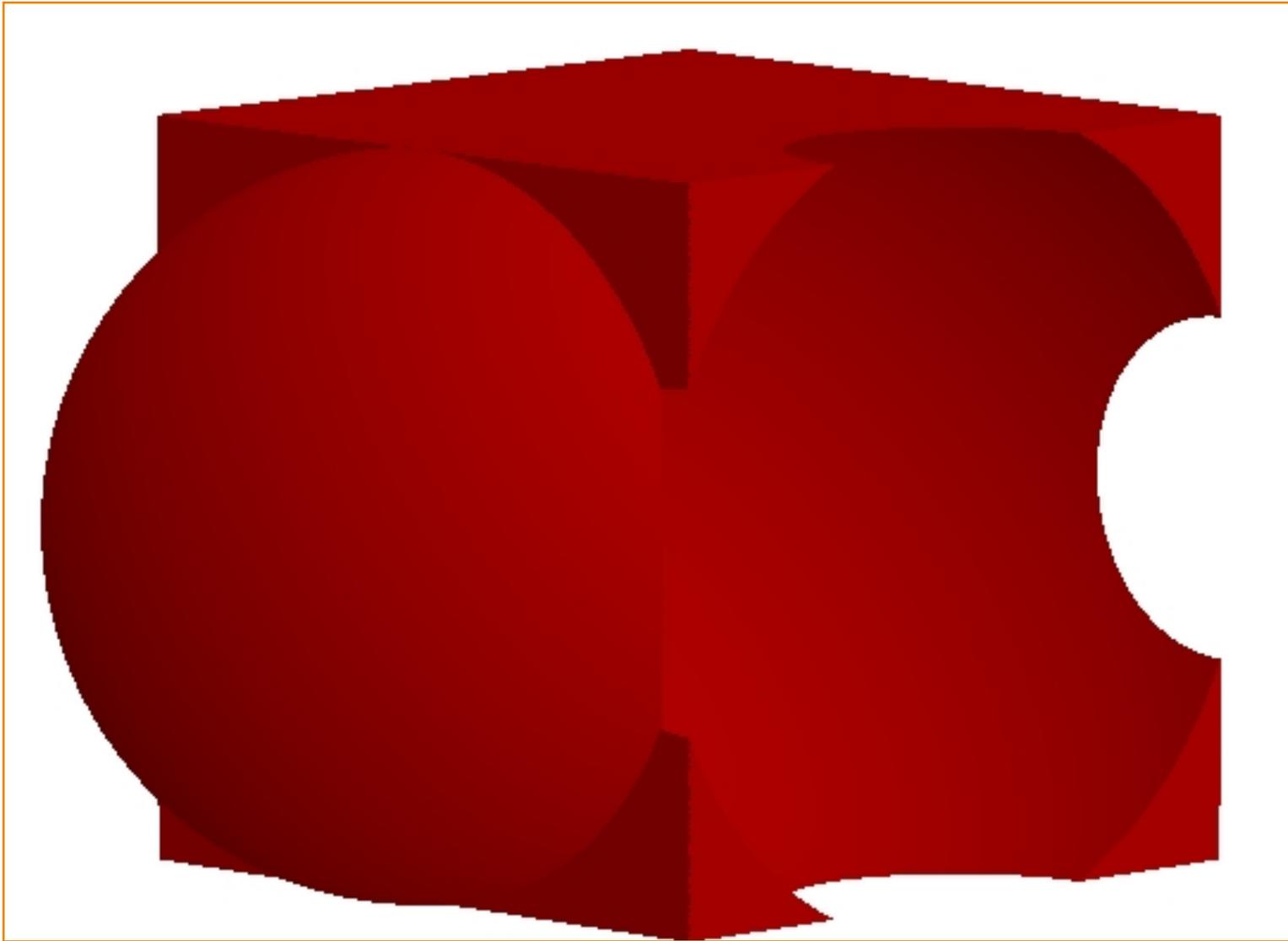
Commands:

- 1) trace \* Start the ray tracing.
- 2) column \* Define the number of horizontal pixels.
- 3) row \* Define the number of vertical pixels.
- 4) target \* Define the center position of the target.
- 5) eyePosition \* Define the eye position.
- 6) lightDirection \* Define the direction of illumination light.
- 7) span \* Define the angle per 100 pixels.
- 8) headAngle \* Define the head direction.
- 9) attenuation \* Define the attenuation length for transparent material.
- 10) distortion \* Distortion effect of the fish eye lens.
- 11) ignoreTransparency \* Ignore transparency even if the alpha of G4Colour < 1
- 12) backgroundColour \* Set background colour: red green blue: range 0.->1.

# RayTracer Shows Shadows



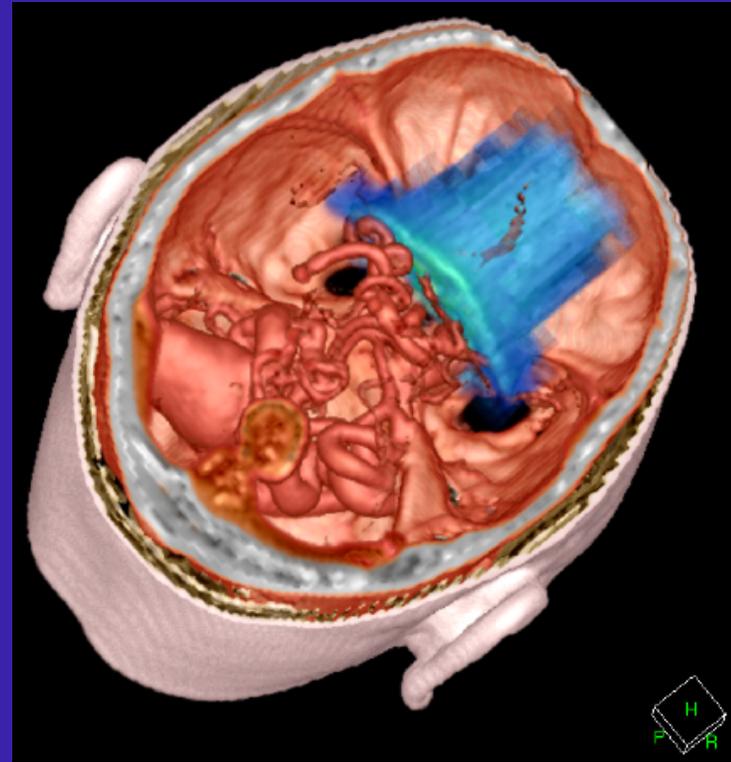
## RayTracer Handles Boolean Solids



# 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
  - Geometry
- Runs on:
  - Windows and Linux
  - Mac will likely happen soon
  - 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 C:\Program Files\gMocren\gtk, you will find the one-click installer for gtk



## Qt Driver (with OpenGL visualization)

---

SLAC

- 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

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 :  41

Scene tree, Help, History

Scene tree Help History

viewer-0 (OpenGLStoredQt)

Scene tree

Scene tree : viewer-0 (OpenGLStoredQt)

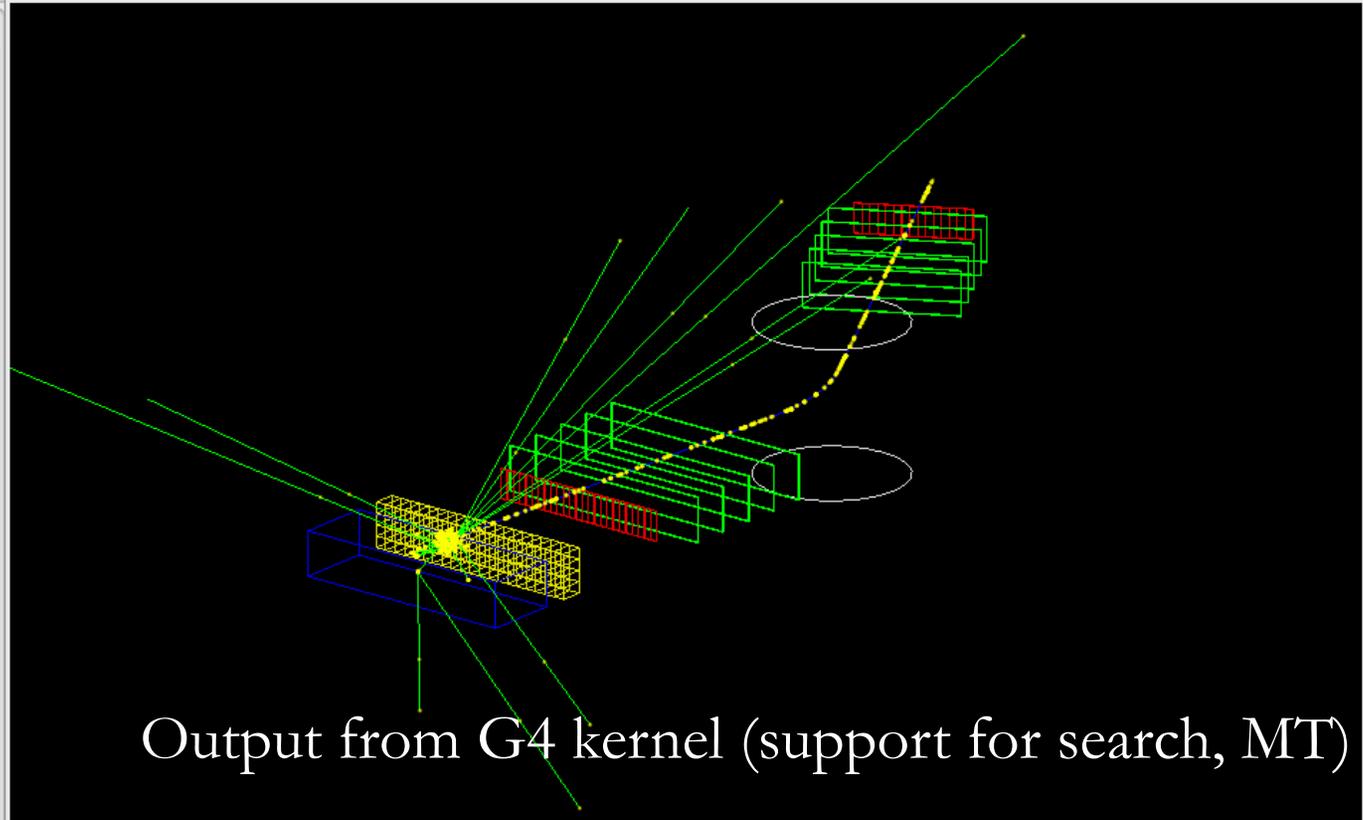
  Touchables
Show all  Hide all

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
sectionPlane	off

 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 :

42

exampleB5

Scene tree, Help, History

Useful tips viewer-0 (OpenGLStoredQt)

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

Picking mode active

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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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 :

43

exampleB5

Scene tree, Help, History

viewer-0 (OpenGLStoredQt)

Scene tree

viewer-0 (OpenGLStoredQt)

Scene tree : viewer-0 (OpenGLStoredQt)

- Touchables

Show all  Hide all

Viewer properties

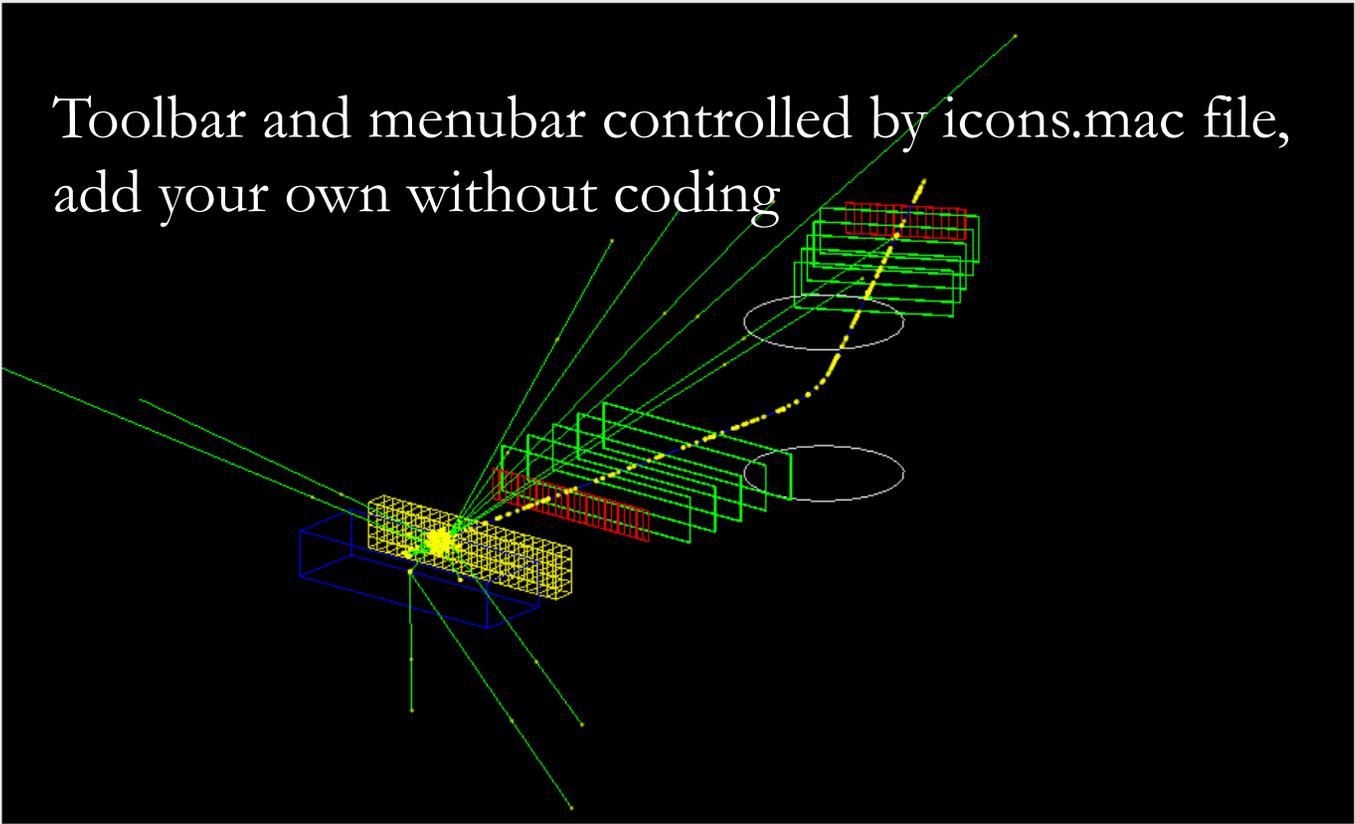
Property	Value
autoRefresh	True
auxiliaryEdge	False
background	0 0 0 1
culling	1
cutawayMode	union
defaultColour	1 1 1 1
defaultTextColour	0 0 1 1
edge	False
explodeFactor	1 1 mm
globalLineWidthScale	1
globalMarkerScale	1
hiddenEdge	False
hiddenMarker	False
lightsMove	object
lightsThetaPhi	54.7356 45 deg
lightsVector	1 1 1
lineSegmentsPerCircle	24
picking	False
projection	orthogonal
rotationStyle	constrainUpDirection
sectionPlane	off

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
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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 :

44

Scene tree, Help, History

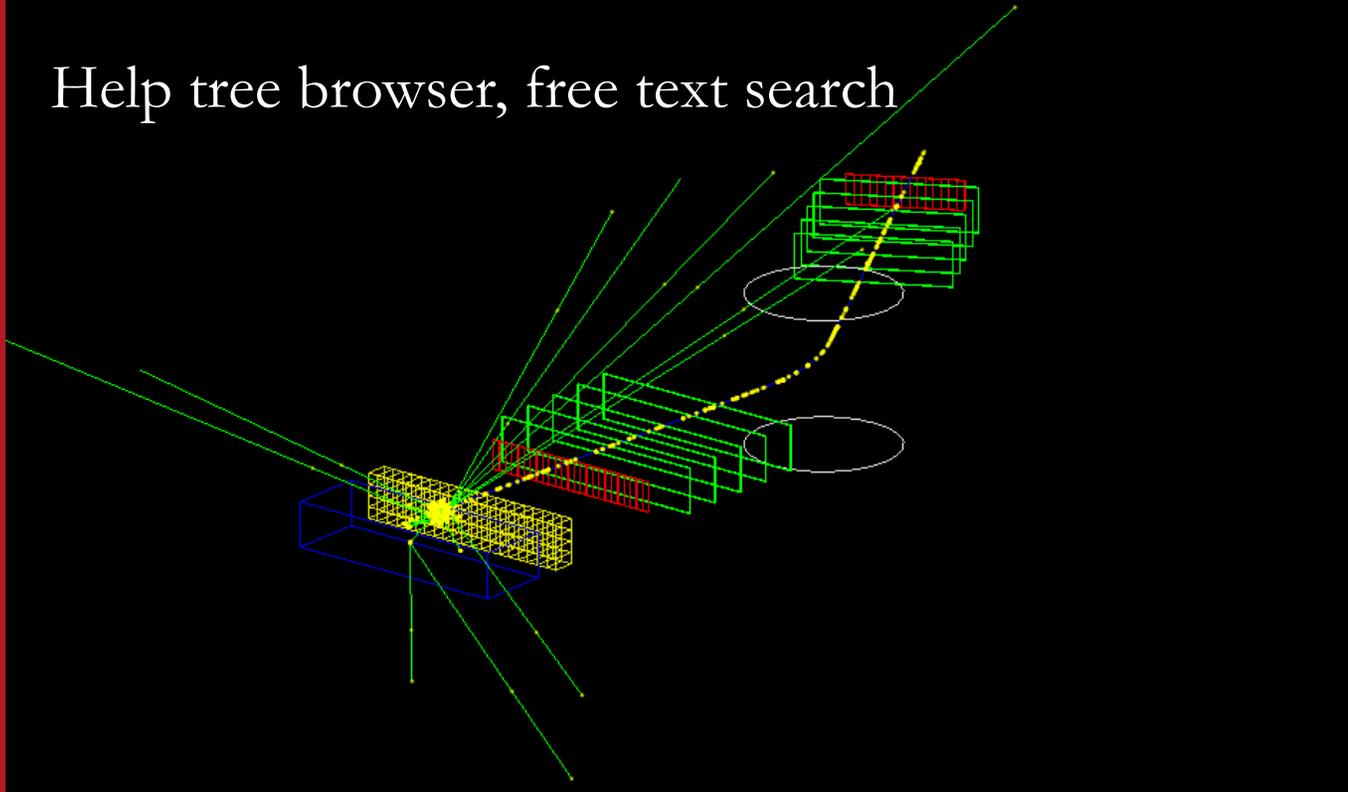
Scene tree Help History

```
/run/beamOn 1  
/control/shell ls
```

Useful tips

viewer-0 (OpenGLStoredQt)

# Help tree browser, free text search



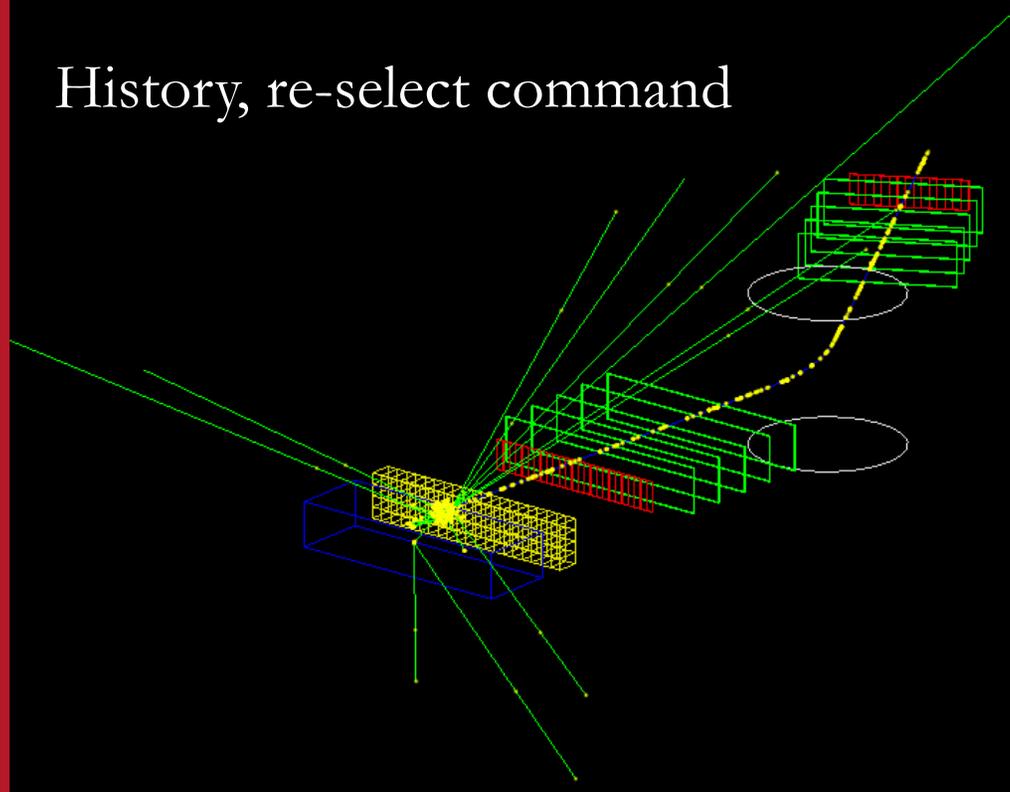
Output

```
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 :

```
/run/beamOn 1  
/control/shell ls
```

## History, re-select command



```
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Useful tips viewer-0 (OpenGLStoredQt)

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

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...

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

Picking informations  Picking mode active

Output

```

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Session :

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# 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 newer 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/>

How-To Presentation:

<http://geant4.slac.stanford.edu/Presentations/vis/HowToMakeAMovie.ppt>

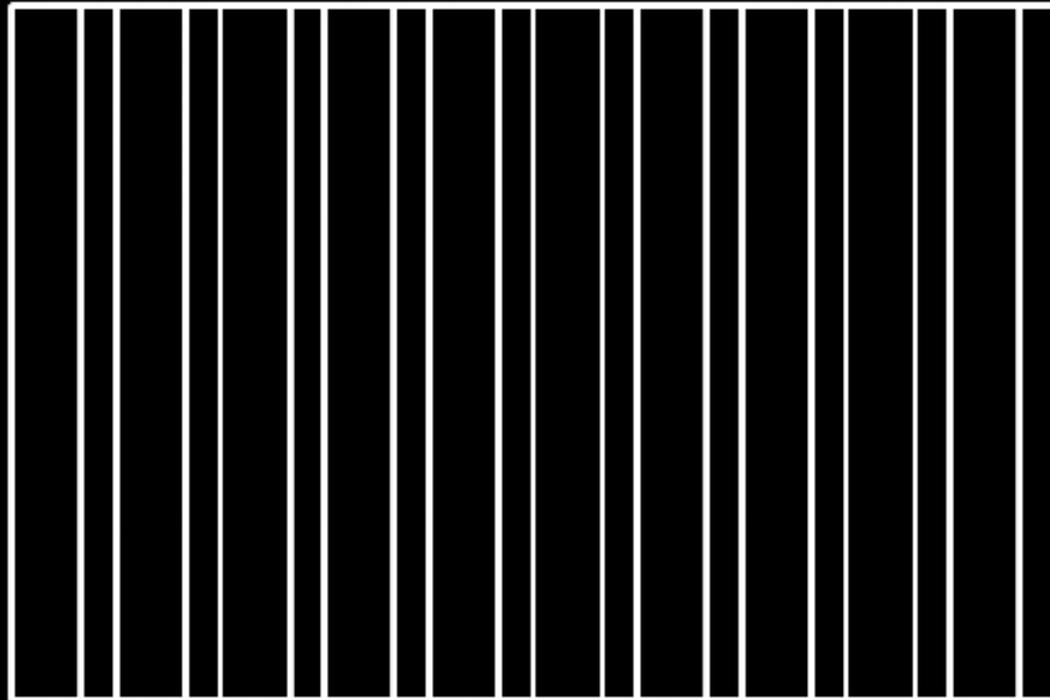
<http://geant4.slac.stanford.edu/Presentations/vis/HowToMakeAMovie.pdf>

<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



# References

- Geant4 Qt Home Page  
<http://geant4.in2p3.fr/spip.php?rubrique25&lang=en>
- gMocren Home Page <http://geant4.kek.jp/gMocren>
- DAWN Home Page  
[http://geant4.kek.jp/~tanaka/DAWN/About\\_DAWN.html](http://geant4.kek.jp/~tanaka/DAWN/About_DAWN.html)
  - DAWNCUT Home Page  
[http://geant4.kek.jp/~tanaka/DAWN/About\\_DAWNCUT.html](http://geant4.kek.jp/~tanaka/DAWN/About_DAWNCUT.html)
  - DAVID Home Page  
[http://geant4.kek.jp/~tanaka/DAWN/About\\_DAVID.html](http://geant4.kek.jp/~tanaka/DAWN/About_DAVID.html)
  - Satoshi Tanaka's GEANT4 Ritsumeikan University Group Home Page (more information on DAWN, sample PRIM files, images, etc.) <http://geant4.kek.jp/~tanaka/>
- HepRApp HepRep Browser  
<http://www.slac.stanford.edu/~perl/HepRApp>
- OpenScientist Home Page <http://openscientist.lal.in2p3.fr>
- Under Development: Wt driver, support for browser based visualization (e.g. visualization in a dynamic webpage)

