Geant4 Visualization
user commands

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Simplest Example

- Visualize your geometry in OpenGL:
  - /vis/open OGL
  - /vis/drawVolume

Slides from J. Perl (SLAC)

```
/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
#/vis/viewer/set/viewpointThetaPhi 90. 0.
#/vis/viewer/zoom 2.
#/vis/viewer/set/style wireframe
#/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
#/vis/scene/add/hits
#/vis/filtering/trajectories/create/particleFilter
#/vis/filtering/trajectories/particleFilter-0/add gamma
#/vis/filtering/trajectories/particleFilter-0/invert true
#/vis/modeling/trajectories/create/drawByParticleID
#/vis/modeling/trajectories/drawByParticleID-0/set e- blue
#/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush
```

Many examples contain a vis.mac that demonstrates many commands. Here's that macro with the comments removed.

I'll cover all of this commands in this presentation.

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Simplest Command Sequence

To Open Visualization

- To Open a Driver

```
/vis/open <driver name>
```

- for example

```
/vis/open OGL
/vis/open DAWNFILE
/vis/open HepRepFile
/vis/open VRML2FILE
```

- The set of available drivers is listed when you first start Geant4,
  but you can also get this list with the command:

```
help /vis/open
```

More about Open, and about DrawVolume

- Some drivers have additional options at open

  e.g., for OpenGL, can specify size and location of window

  ```
  /vis/open OGL 600x600-0+0
  ```

- You can open more than one viewer at a time:

  ```
  /vis/open OGL
  /vis/open HepRepFile
  ```

  - To see what viewers you then have:

    ```
    /vis/viewer/list
    ```

  - To select which viewer is the current one:

    ```
    /vis/viewer/select viewer-0
    /vis/viewer/select viewer-1
    ```

  - All other vis commands affect only the currently selected viewer

- To draw the entire detector geometry:

  ```
  /vis/drawVolume
  ```

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What we've covered so far

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Controlling the viewpoint and zoom

The /vis/viewer/… Commands

- Set view angles

  ```
  /vis/viewer/set/viewpointThetaPhi <theta_angle>
  <phi_angle>
  ```

- Zoom

  ```
  /vis/viewer/zoom <scale factor>
  ```

- Reset viewpoint

  ```
  /vis/viewer/reset
  ```

- Set drawing style

  ```
  /vis/viewer/set/style <style>
  ```

  - Options for style: wireframe , surface
  - but note that this will not affect volumes that have style explicitly forced by “setForceWireframe” or “setForceSolid” commands in the c++ code

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```



Add axes, trajectories and hits

Axes, Trajectories and Hits

- Axes

  `/vis/scene/add/axes <x_origin> <y_origin> <z_origin> <size> <units>`

- Trajectories

  `/vis/scene/add/trajectories`

  - By default, trajectories are redrawn at every event, try: `/run/beamOn 1`

- Hits (if application has hits defined)

  `/vis/scene/add/hits`

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/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush
```

Visualizing step points

Visualizing Step Points

- By default, the trajectory is drawn just as a line
- To also show the step points:

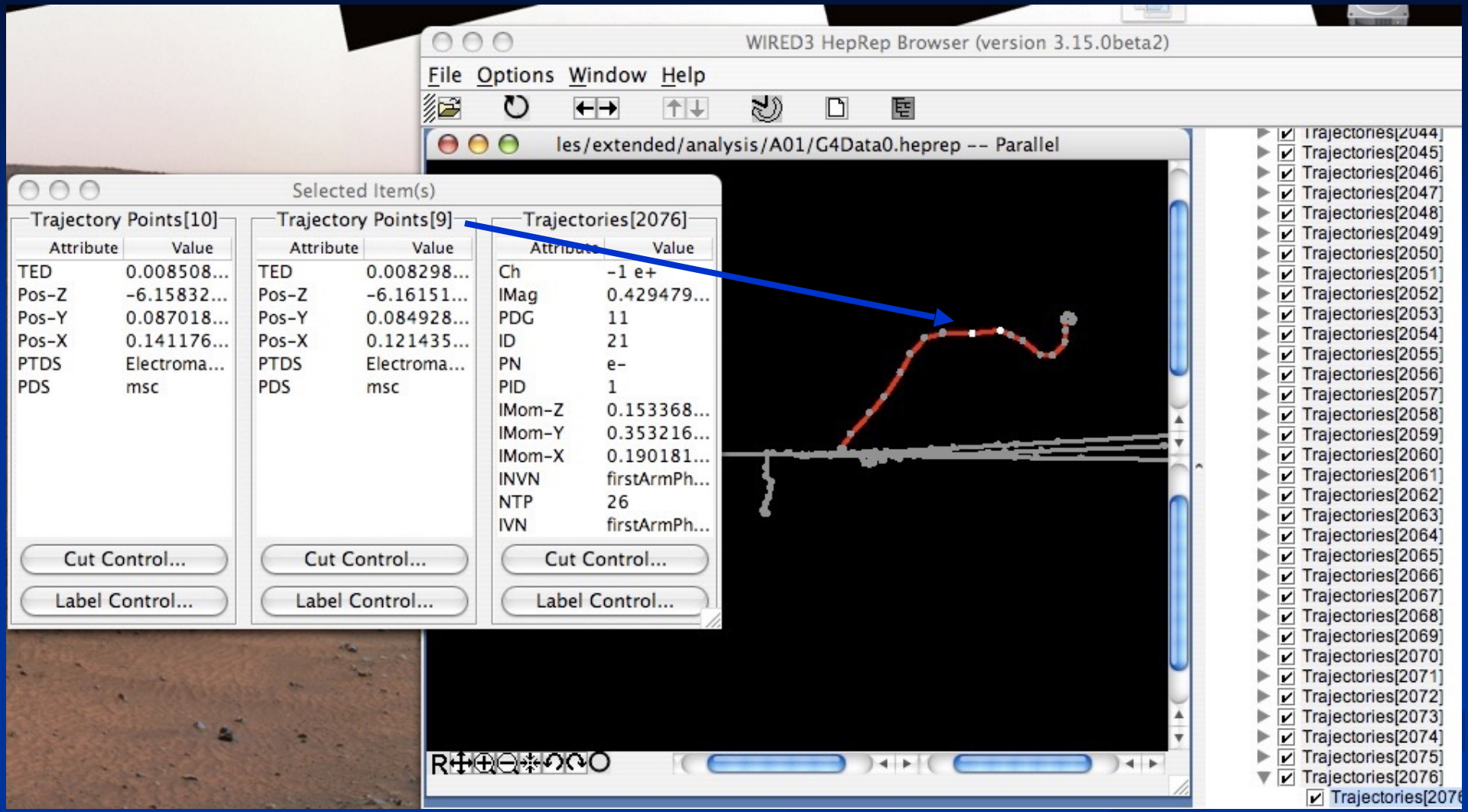
```
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/
setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/
setStepPtsSize 2
```

  This syntax is complicated because it actually supports many more options on how trajectories and step points should be modeled.

- Trajectories and step points can contain additional, non-displayed information
  - such as particle id, momentum, etc.
  - shown when you pick on the trajectory in some visualization drivers.
- Turn on extra info with parameter rich:

```
/vis/scene/add/trajectories rich
```

Rich Trajectory Has Details on Every Step Point



Rich Trajectory and Points

G4RichTrajectory:

- Extra:
  - Creator Process Name
  - Creator Process Type Name
  - Charge (Ch): unit: e+
  - Ending Process Name
  - Ending Process Type Name
  - Final kinetic energy
  - Final Next Volume Path
  - Final Volume Path
- Already in regular Trajectory:
  - Track ID
  - Initial kinetic energy
  - Initial momentum magnitude
  - Initial momentum
  - Initial Next Volume Path
  - Initial Volume Path
  - No. of points
  - PDG Encoding
  - Parent ID
  - Particle Name

G4RichTrajectoryPoint:

- Extra:
  - Auxiliary Point Position
  - Process Defined Step
  - Process Type Defined
  - Position
  - Post-step-point global time
  - Post-step Volume Path
  - Pre-step-point global time
  - Pre-step Volume Path
  - Remaining Energy
  - Total Energy Deposit
- Already in regular TrajectoryPoint
  - nothing is included by default

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/vis/verbose warnings
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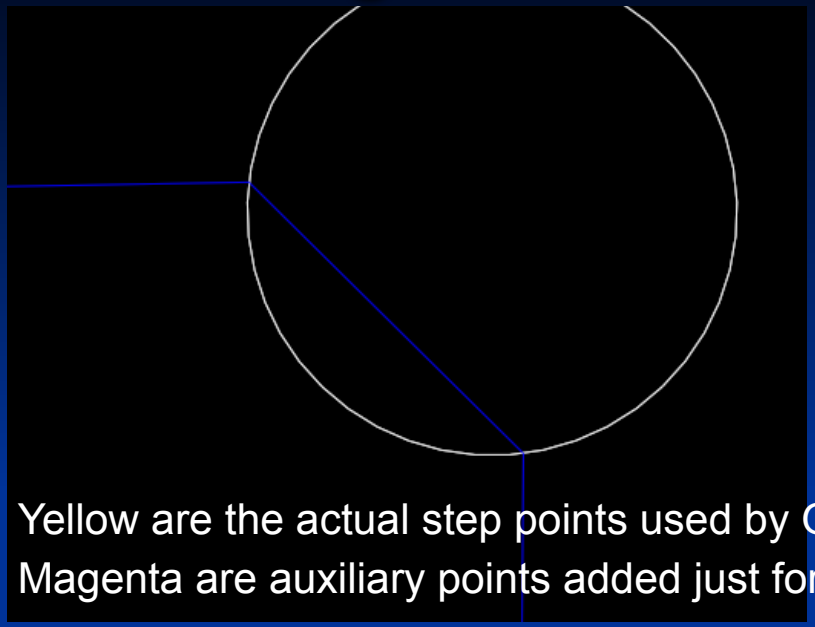
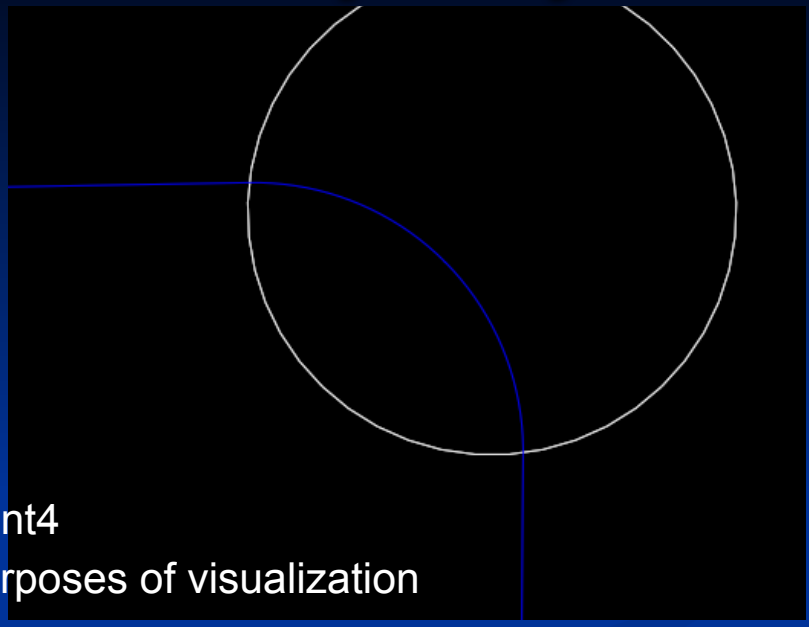
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush
```

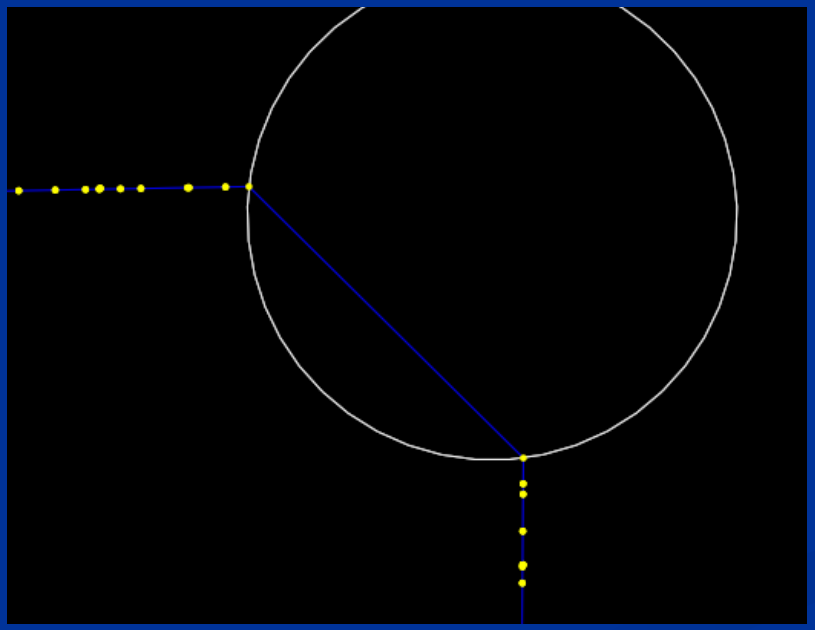
Smooth Trajectories

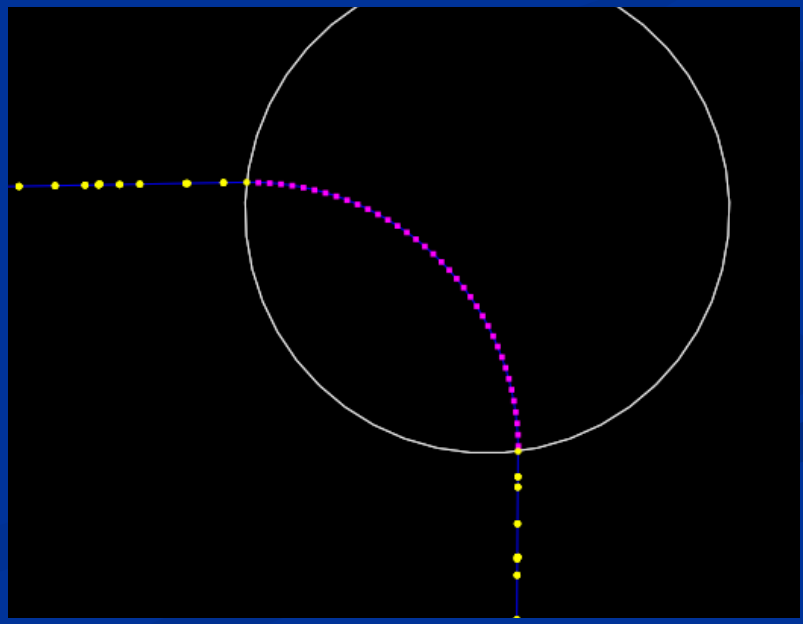
Regular versus Smooth Trajectory





Yellow are the actual step points used by Geant4
Magenta are auxiliary points added just for purposes of visualization





Smooth Trajectories

- By default, the trajectory is represented as a series of line segments from one step point to the next.
  - For the case of strong fields, this may result in jagged looking tracks.

- Can ask visualization to smooth the lines with:

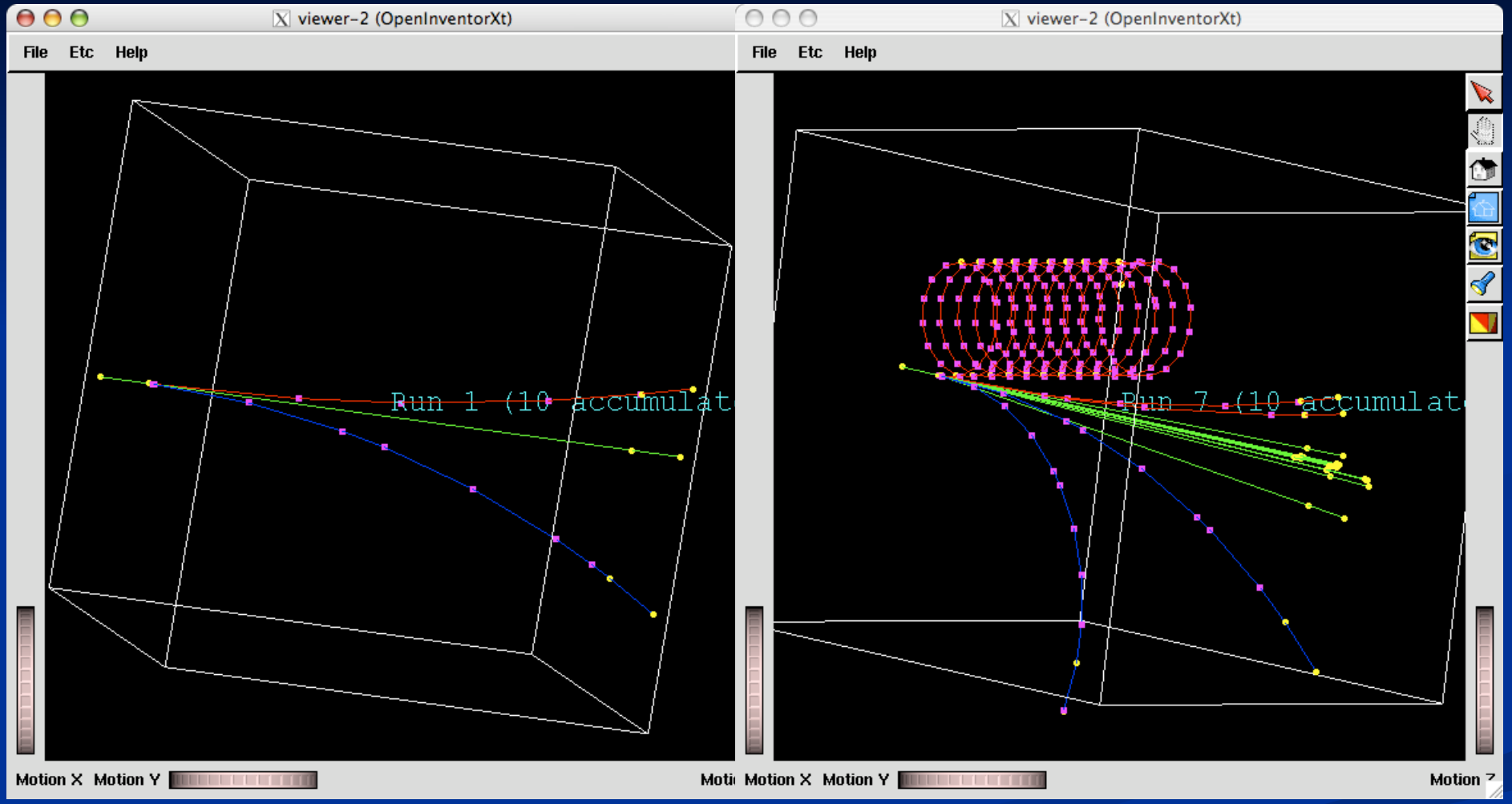
```
/vis/scene/add/trajectories smooth
```

  The extra points are not actual Geant4 step points.
  Smooth does not change how Geant4 actually does its stepping.
  These extra “auxiliary points” are only added to make a smoother line.

- Trajectories can be smooth, rich or both:

```
/vis/scene/add/trajectories smooth rich
```

Smooth Trajectory Makes Big Difference for Trajectories that Loop in a Magnetic Field



- Yellow dots are the actual step points used by Geant4
- Magenta dots are auxiliary points added just for purposes of visualization

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```

Basic trajectory modeling

Basic Trajectory Modeling

- By default, trajectories are color-coded by charge
  - /vis/modeling/trajectories/drawByParticleID-0/set e- red
  - /vis/modeling/trajectories/drawByParticleID-0/set e+ blue
  - /vis/modeling/trajectories/drawByParticleID-0/set proton cyan
  - /vis/modeling/trajectories/drawByParticleID-0/set gamma green
  - /vis/modeling/trajectories/drawByParticleID-0/set neutron yellow
  - /vis/modeling/trajectories/drawByParticleID-0/set pi+ magenta
  - /vis/modeling/trajectories/drawByParticleID-0/set pi- magenta
  - /vis/modeling/trajectories/drawByParticleID-0/set pi0 magenta
  - # and everything else still grey
- But you can choose other modeling options, such as color by particle ID
  - /vis/modeling/trajectories/create/drawByParticleID
  - /vis/modeling/trajectories/drawByParticleID-0/set e- blue

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```

Accumulating trajectories and hits

Accumulating Trajectories and Hits

- By default, you will get a drawing after each event. To instead get just one drawing with all of the accumulated events from that run

```
/vis/scene/endOfEventAction accumulate
```

- To even suppress that one drawing from the end of the /run/beamOn, use

```
/vis/scene/endOfRunAction accumulate
```

- When you actually want to draw, you then have to explicitly issue the command

```
/vis/viewer/flush
```

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/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
#/vis/filtering/trajectories/create/particleFilter
#/vis/filtering/trajectories/particleFilter-0/add gamma
#/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush

What we've covered so far

Filtering Trajectories

```
/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
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/vis/filtering/trajectories/create/particleFilter
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/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush
```

Filtering Trajectories

- By default, all trajectories are drawn
- You apply a filter so that only certain trajectories are drawn:

```
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
```

- The above adds a filter that only allows gammas to draw
- To instead do the opposite, drawing everything except gammas,
  include the above, but also add the following:

```
/vis/filtering/trajectories/particleFilter-0/invert
true
```

/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
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/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
#/vis/viewer/flush

What we've covered so far

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/vis/viewer/zoom 2.
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/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
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/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush
```

To force output of a new file

To Force Output of a New File

- There are two classes of Geant4 visualization drivers:
  - Immediate drivers: draw directly to the screen (such as OpenGL)
  - File-based drivers: create a file on disk (HepRepFile, VRML2FILE)
- For immediate drivers you see the results or your /vis commands immediately
- For the file-based drivers:
  - the default is to only create a new file (showing your changes) when you do `/run/beamOn`
- If you want to see visualization at some other time, such as after you set up geometry, but before you do /run/beamOn, use: `/vis/viewer/flush`

/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush

What we've covered so far

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/vis/open OGL 600x600-0+0
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#/vis/open VRML2FILE
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/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush
```

To avoid excessive redrawing on immediate viewers

To Avoid Excessive Redrawing

- By default, immediate viewers will redraw after every vis command that might change the view, such as:

```
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
```

- If the geometry is very complex (such as in some imported patient geometries for medical applications), this can result in slow performance
- To temporarily turn off this redrawing:

```
/vis/viewer/set/autoRefresh false
```

- And then once everything is set up:

```
/vis/viewer/set/autoRefresh true
```

/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush

What we've covered so far

```
/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
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/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush
```

To turn off unwanted visualization messages on the console

To Turn off Unwanted Visualization Messages

- You can control how many messages visualization puts on the console by:

`/vis/verbose <level>`

0) quiet, // Nothing is printed.
1) startup, // Startup and endup messages are printed...
2) errors, // ...and errors...
3) warnings, // ...and warnings...
4) confirmations, // ...and confirming messages...
5) parameters, // ...and parameters of scenes and views...
6) all // ...and everything available.

```
/vis/open OGL 600x600-0+0
#/vis/open DAWNFILE
#/vis/open HepRepFile
#/vis/open VRML2FILE
/vis/viewer/set/autoRefresh false
/vis/verbose errors
/vis/drawVolume
/vis/viewer/set/viewpointThetaPhi 90. 0.
/vis/viewer/zoom 2.
/vis/viewer/set/style wireframe
/vis/scene/add/axes 0 0 0 1 m
/vis/scene/add/trajectories smooth
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 2
/vis/scene/add/hits
/vis/filtering/trajectories/create/particleFilter
/vis/filtering/trajectories/particleFilter-0/add gamma
/vis/filtering/trajectories/particleFilter-0/invert true
/vis/modeling/trajectories/create/drawByParticleID
/vis/modeling/trajectories/drawByParticleID-0/set e- blue
/vis/scene/endOfEventAction accumulate
/vis/viewer/set/autoRefresh true
/vis/verbose warnings
/vis/viewer/flush
```

We've covered all of it

Now on to some extra topics

Printing from OpenGL

- Open your OGL viewer and set up the view as usual

```
/vis/open OGL
/vis/drawVolume
/vis/viewer/zoom 2.
/vis/viewer/set/viewpointThetaPhi 30. 30.
```

- Then print

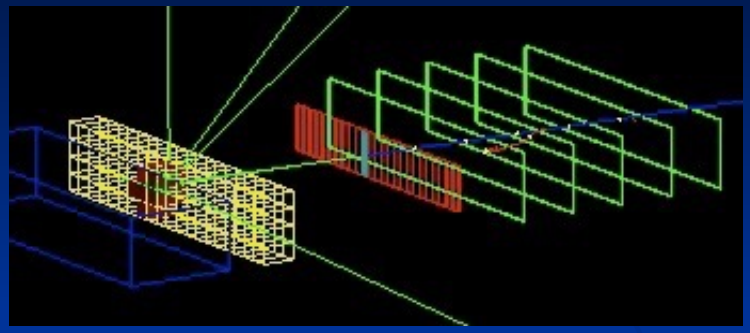
```
/vis/ogl/printEPS
```

- Extra options allows you to control output style and transparency

```
/vis/ogl/set/printMode vectored or pixmap
/vis/ogl/set/transparency True or False
```

Hidden Line Removal

- OpenGL supports hidden line removal.
- You can control whether this removal is done and whether trajectories and hits are affected by this feature.

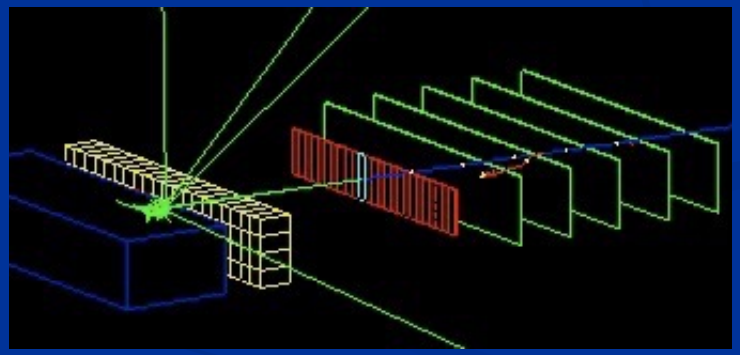


- By default, hidden line removal is disabled

- To turn on hidden line removal

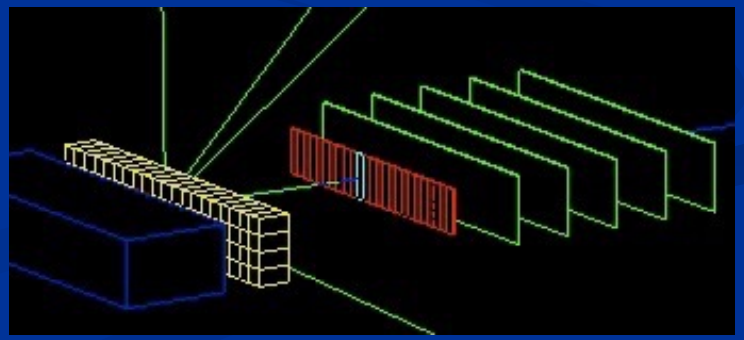
```
/vis/viewer/set/hiddenEdge 1
```

- This hides edges of geometry, but lets trajectories through.



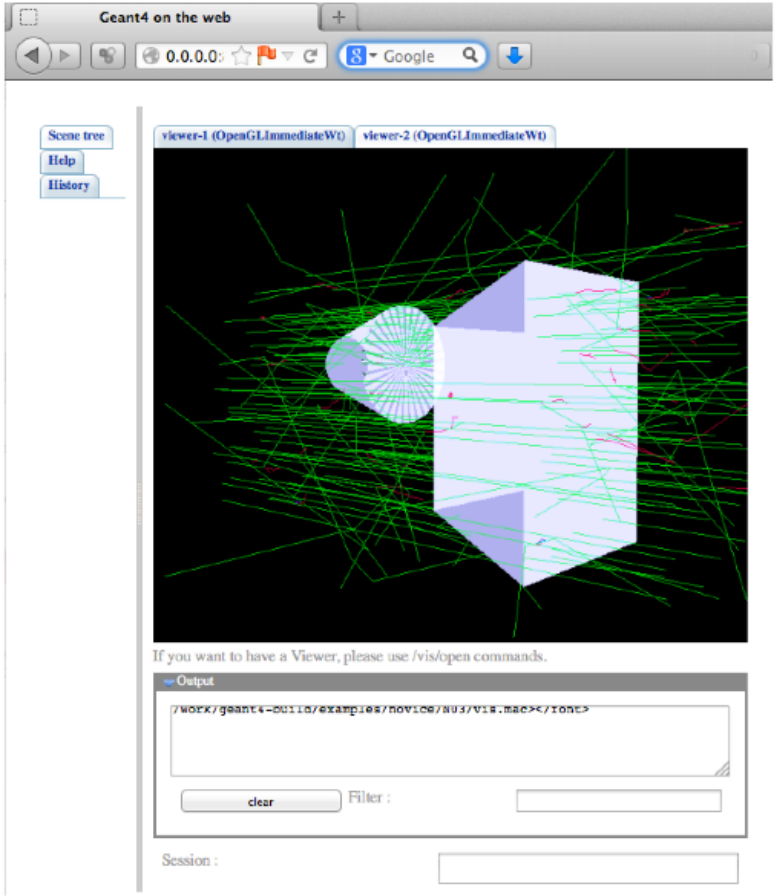
- To hide trajectories and hits as well

```
/vis/viewer/set/hiddenMarker 1
```



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
  - DAWNCUT Home Page http://geant4.kek.jpJ/~tanaka/DAWN/About_DAWNCUT.html
  - DAVID Home Page 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



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