Display by time

4D Viewing

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Mpeg files

- If this presentation doesn't run on your computer
  - The movies can be downloaded from http://www.hep.man.ac.uk/u/johna/pub/Geant4/Movies/
  - Individual files are indicated on relevant slides
  - Get a Mac

Getting time information

- Get from track or step (see `G4RichTrajectory`)
  - `aTrack->GetGlobalTime()`
    `aStep->GetPreStepPoint()->GetGlobalTime()`
    `aStep->GetPostStepPoint()->GetGlobalTime()`
  - Accessed through `CreateAttValues` at display time in your trajectory model
- Instantiate trajectory in tracking action (see `N03`)
  - `MyTrackingAction::PreUserTrackingAction...`
    `fpTrackingManager->SetTrajectory(new G4RichTrajectory(track))`
- Instantiate tracking action in `main`
  - `runManager->SetUserAction(new MyTrackingAction)`

Time slicing

- Add trajectories
  - **`/vis/scene/add/trajectories`**
- Create a trajectory model
  - **`/vis/modeling/trajectories/create/drawByCharge`**
- Specify time slice
  - **`/vis/modeling/trajectories/drawByCharge-0/default/setTimeSliceInterval 0.1 ns`**
  - Chops trajectory into pieces, each assigned a time range

Display by time

- Only in OpenGL stored mode (OGLS*) at present
  - **`/vis/ogl/set/fade 1`**
    `/vis/ogl/set/displayHeadTime true`
    `/vis/ogl/set/displayLightFront true -90 0 0 mm`
    `/vis/ogl/set/startTime 2 ns 1 ns`
  - Specifies a time window
  - Items are displayed if their time range* and viewer's time window overlap

*Default time range is -∞ to ∞, so normal items are always drawn

- Make a loop (see `exN03Vis12/13.mac`)
  - **`/control/alias timeRange 0.1`**
    `/control/alias dx 0.3`
    `/control/loop loop.mac endTime 0 0.7 0.001`
- where `loop.mac` is
  - **`/vis/viewer/pan {dx} 0 mm`**
    `/vis/ogl/set/endTime {endTime} ns {timeRange} ns`

exampleN03

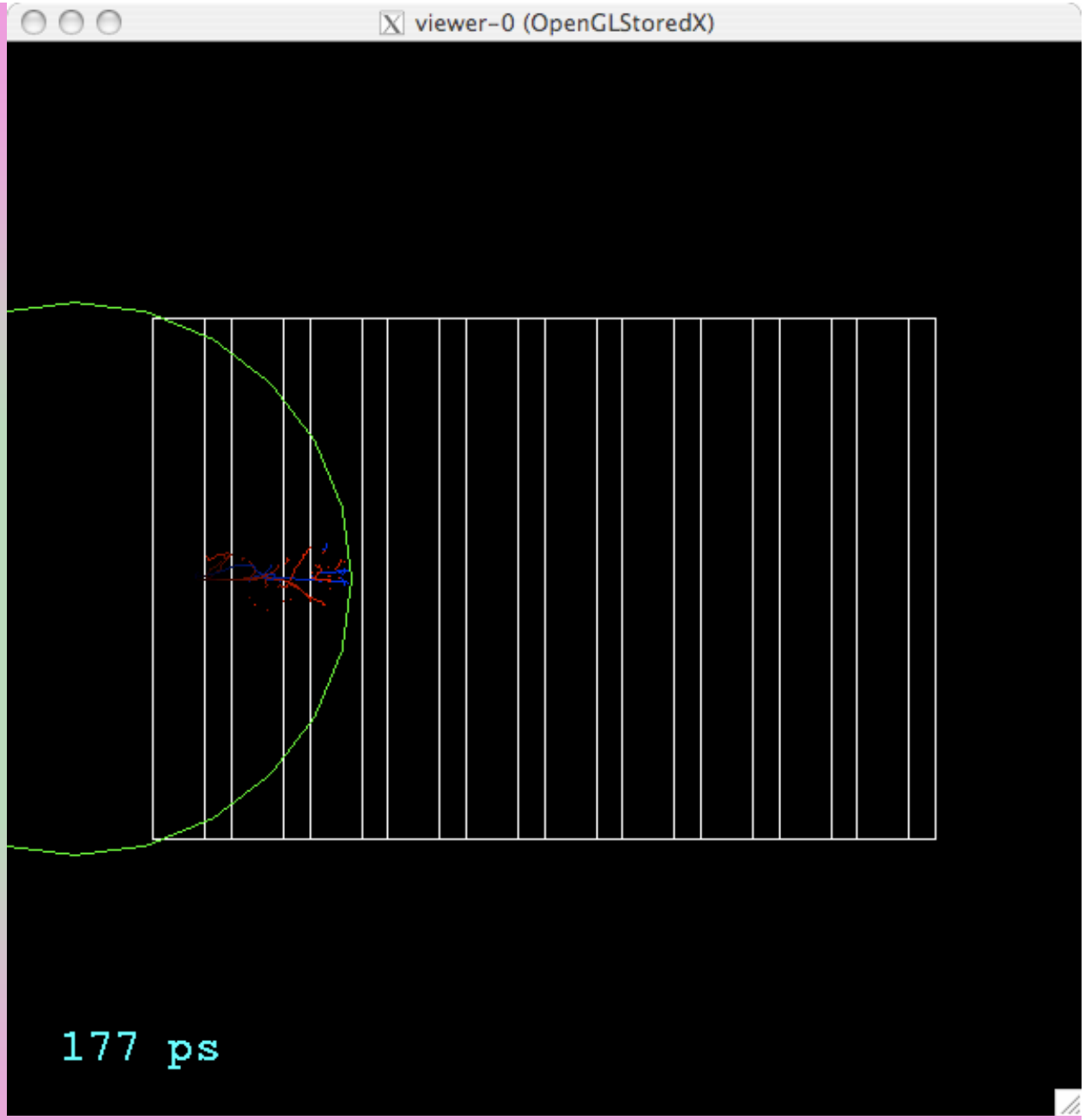
- Activate instantiation of `G4RichTrajectory`
  - `ExN03TrackingAction::PreUserTrackingAction`
- `exampleN03 visTutor/exN03Vis12.mac`
  a) Draw by charge with trajectory points
  b) Draw by particle ID (remove γ's)
  c) π-μ-e decay
- `exampleN03 visTutor/exN03Vis13.mac`
  - 10 GeV EM shower showing light front
  - Camera follows (pans) at speed of light

Still from
`exampleN03 visTutor/exN03Vis12.mac`

1 GeV electron into lead-liqAr calorimeter

Demo

Unfortunately text is lost making a movie (a current OpenGL→eps "feature")



Commands for previous demo

```
/vis/modeling/trajectories/create/drawByCharge
/vis/modeling/trajectories/drawByCharge-0/default/setDrawStepPts true
/vis/modeling/trajectories/drawByCharge-0/default/setStepPtsSize 5
/vis/modeling/trajectories/drawByCharge-0/default/setDrawAuxPts true
/vis/modeling/trajectories/drawByCharge-0/default/setAuxPtsSize 5
/vis/modeling/trajectories/drawByCharge-0/default/setTimeSliceInterval 0.001 ns
/run/beamOn
/vis/ogl/set/fade 1
/vis/ogl/set/displayHeadTime true
/control/alias timeRange 0.1
/control/loop visTutor/exN03Vis12.loop startTime -{timeRange} 0.7 0.005
```

where `visTutor/exN03Vis12.loop` is

```
/vis/ogl/set/startTime {startTime} ns {timeRange} ns
/vis/viewer/update
```

Making a movie

- Add `/vis/ogl/set/printEPS`
  - Writes encapsulated PostScript file on `/vis/viewer/update`
- Makes 1000's of eps files
  - Convert and encode as described in "Making a movie" (see parallel session)

50 MeV electron into lead-liqAr calorimeter

e^- red
e^+ blue
γ green

Yellow circles are step points -- geometrical boundaries or physical processes

Single50MeV.mpg

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

10 GeV electron into lead-liqAr calorimeter over 800 ps

Single10GeVSlow.mpg

Gammas filtered out

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

Electrons red
Positrons blue

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

Same 10 GeV electron, camera follows by panning at light speed
Single10GeVFollowed.mpg

Shows light front (wave front of light starting at same time and place)

```
/vis/ogl/set/
displayLightFront true -
90 0 0 m m
```

Time range 800 ps

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

100 MeV π^+

pi+100MeVmu+e+.mpg

Stops, decays to μ^+

Stops, dallies (meanlife 2 μs), decays to e^+

Annihilates to gamma-gamma

Compton scattering

Duration 4 μs

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

10 Gev π^-
pi-10GeVEMShower.mpg

N04 hadronic physics

Interacts early
(potential confusion
with EM shower)

Produces EM shower,
presumably via charge
exchange to $\pi^0 \rightarrow \gamma\gamma$

Neutrons also
produced

π^+ magenta
π^- cyan
n yellow
ν green
Others grey
Duration 2 ns

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

10 Gev π^-
pi-10GeVNeutrons.mpg

N04 hadronic physics

Produces neutron chain reaction

γ filtered
e- red
e^+ blue
π^+ magenta
π^- cyan
n yellow
ν green
Others grey

Duration 2 ns

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

Another 10 GeV π^-

pi-10Gevpi+neutron SideView.mp4

3 fast π^-

π^+ interaction

3 ns

Mpeg4 encoding with QuickTime Pro

QuickTime™ and a decompressor are needed to see this picture.

Same

pi-10Gevpi+neutron Zoom.mp4

Perspective view

Slow zoom

Detector drawing suppressed

3 ns

QuickTime™ and a
decompressor
are needed to see this picture.

Demo

Future directions?

- Add interaction (4D flying!)
  - Movie player controls for OGLSXm and Open Inventor
- Add sound?

Conclusions

- Time slicing and display by time are great new features of the Geant4 Visualisation System
- Understand troublesome backgrounds
- Design detectors and electronics for better discrimination of particle types
- Educational tool