



Optical Photons

1. Optical Processes in Geant4
2. Photon Production Mechanisms
 - Cerenkov
 - Scintillation
3. Transportation of photons
 - Bulk Processes
 - Boundary Processes
4. Code implementation of optical processes
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(Documentation Co-ordinator)
5. "Idiosyncrasies"

- **\$G4INSTALL/examples/extended/optical**
- **LXe**
 - Multi-purpose detector setup implementing:
 - (1) scintillation inside a bulk scintillator with PMTs
 - (2) large wall of small PMTs opposite a Cerenkov slab to show the cone
 - (3) plastic scintillator with wave-length-shifting fiber readout.

Hands-On - Tasks



(1) Source:

`$G4INSTALL/examples/extended/optical/LXe`

(2) Compile and load the example

(3) What do you see?

(4) Produce photons in the geometry →
photon.mac

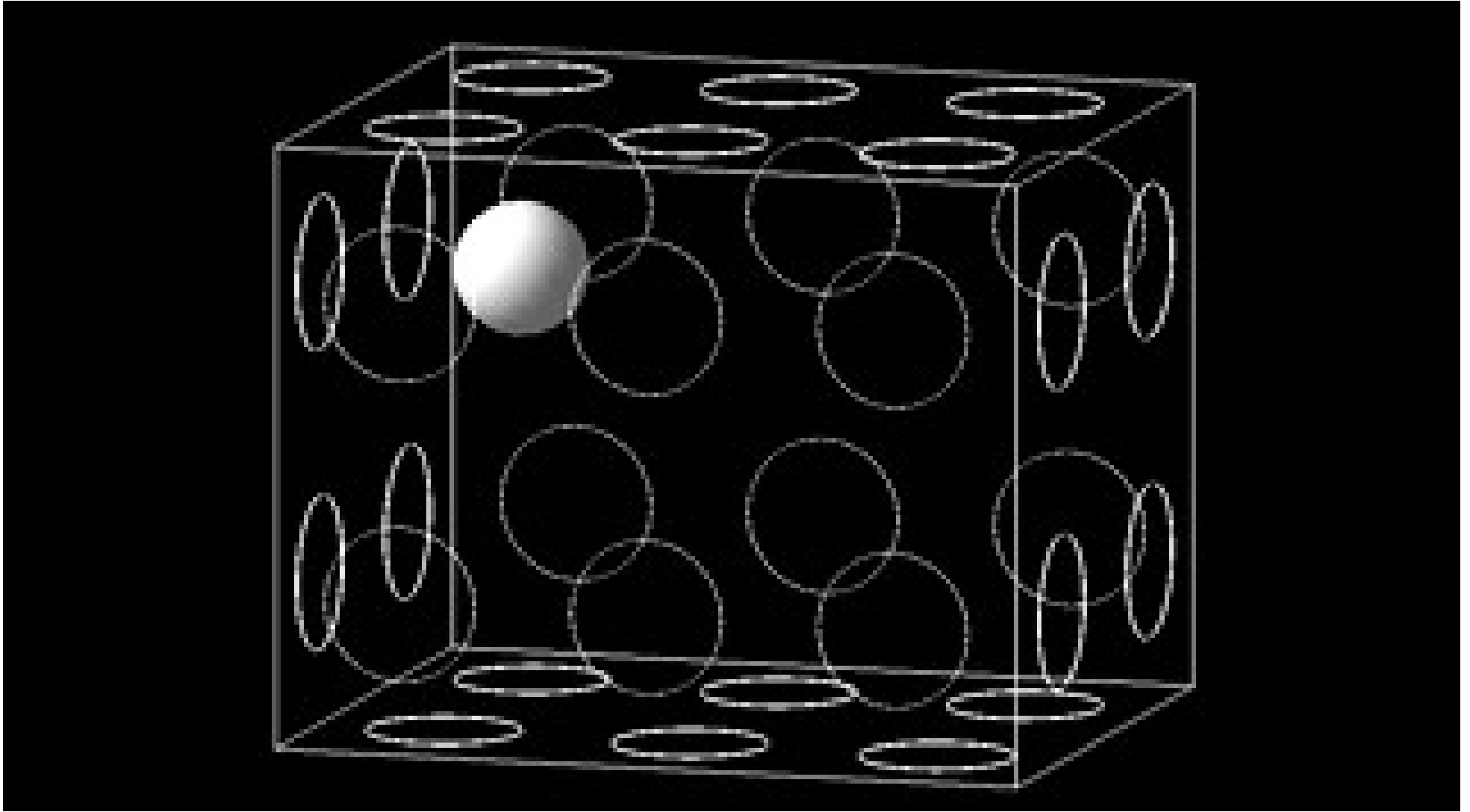
(5) Observe ionising particle interaction →
cerenkov.mac

Reduce number of events first!!!!

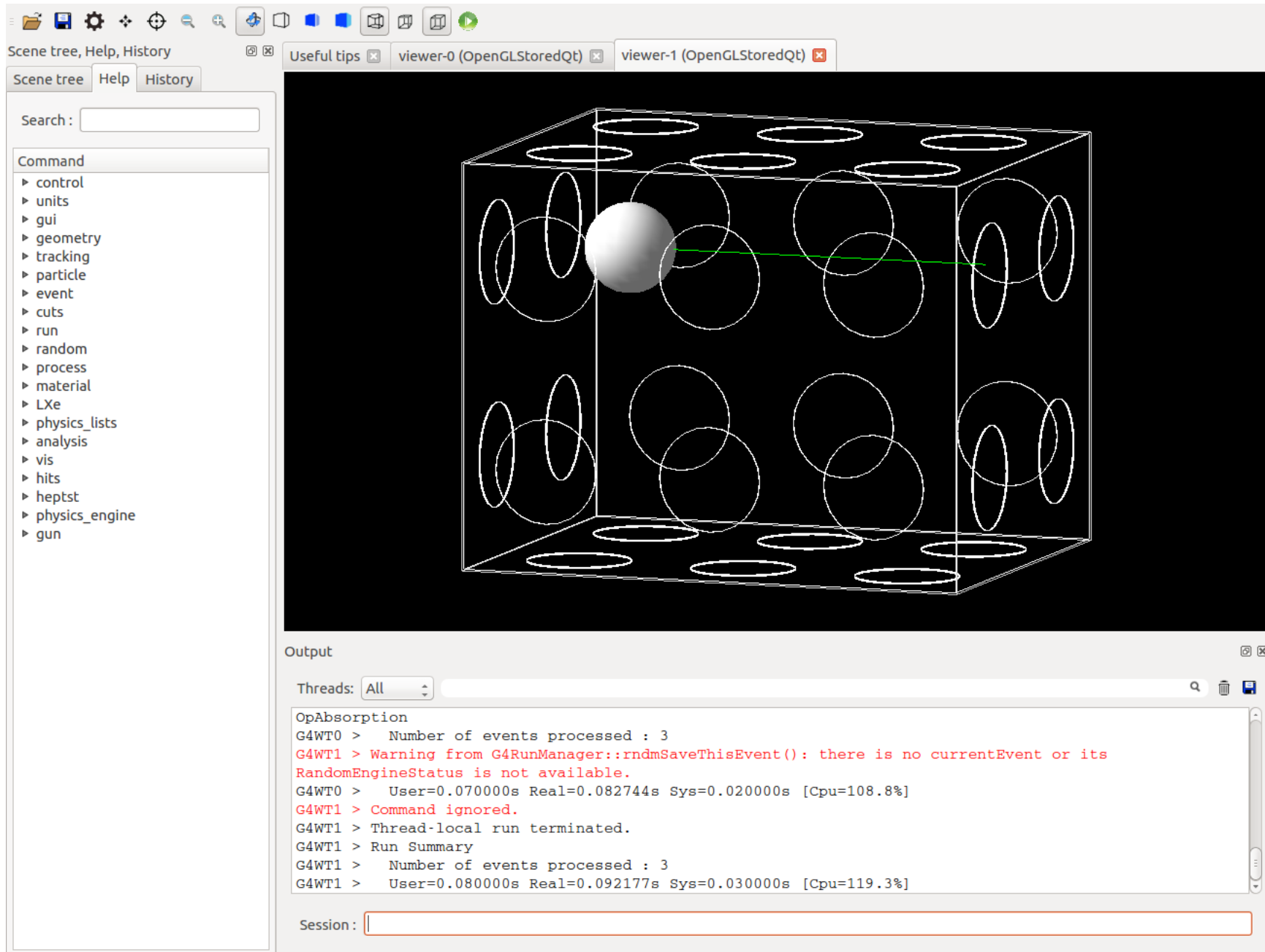
(6) Look at the macro

→ what should you do to see **ONLY** cerenkov

Solution (3)



Solution (4)

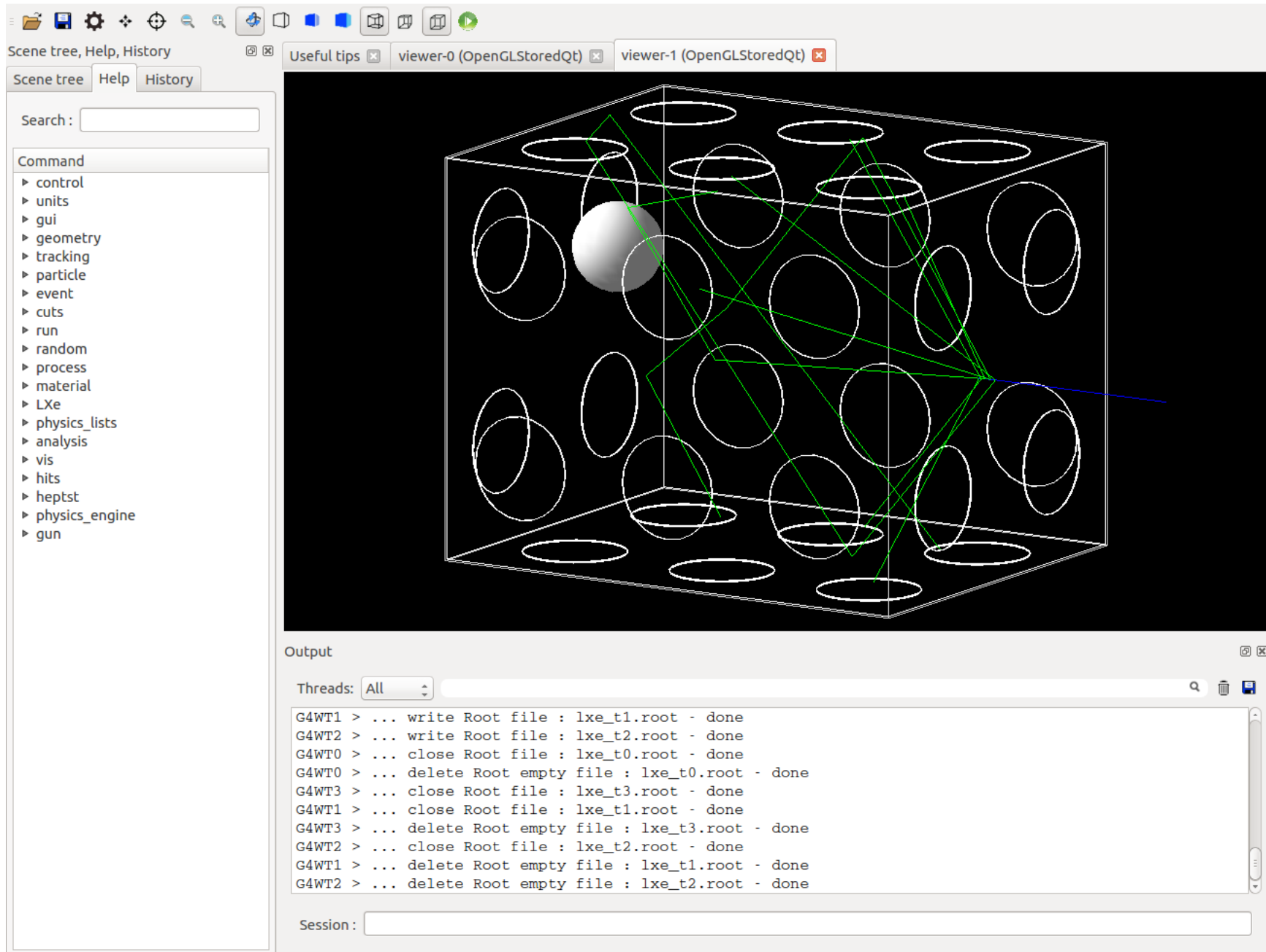


The screenshot displays the Geant4 graphical user interface. On the left, the 'Scene tree' panel is visible, containing a search bar and a list of commands such as 'control', 'units', 'gui', 'geometry', 'tracking', 'particle', 'event', 'cuts', 'run', 'random', 'process', 'material', 'LXe', 'physics_lists', 'analysis', 'vis', 'hits', 'heptst', 'physics_engine', and 'gun'. The main window shows a 3D visualization of a particle detector, featuring a central white sphere and a grid of white circles on a black background. A green line extends from the sphere towards the right. Below the visualization, the 'Output' window shows the following text:

```
OpAbsorption
G4WT0 > Number of events processed : 3
G4WT1 > Warning from G4RunManager::rndmSaveThisEvent(): there is no currentEvent or its
RandomEngineStatus is not available.
G4WT0 > User=0.070000s Real=0.082744s Sys=0.020000s [Cpu=108.8%]
G4WT1 > Command ignored.
G4WT1 > Thread-local run terminated.
G4WT1 > Run Summary
G4WT1 > Number of events processed : 3
G4WT1 > User=0.080000s Real=0.092177s Sys=0.030000s [Cpu=119.3%]
```

At the bottom of the output window, there is a 'Session:' label followed by an empty text input field.

Solution (5)



The screenshot displays the Geant4 graphical user interface. The main window shows a 3D visualization of a detector geometry, consisting of a central sphere and a surrounding structure of overlapping ellipsoids, all rendered in white wireframe on a black background. A blue line indicates a particle's path through the geometry. The interface includes a top toolbar with various icons, a scene tree on the left, and an output console at the bottom.

Scene tree, Help, History

Search:

Command

- ▶ control
- ▶ units
- ▶ gui
- ▶ geometry
- ▶ tracking
- ▶ particle
- ▶ event
- ▶ cuts
- ▶ run
- ▶ random
- ▶ process
- ▶ material
- ▶ LXe
- ▶ physics_lists
- ▶ analysis
- ▶ vis
- ▶ hits
- ▶ heptst
- ▶ physics_engine
- ▶ gun

viewer-0 (OpenGLStoredQt) **viewer-1 (OpenGLStoredQt)**

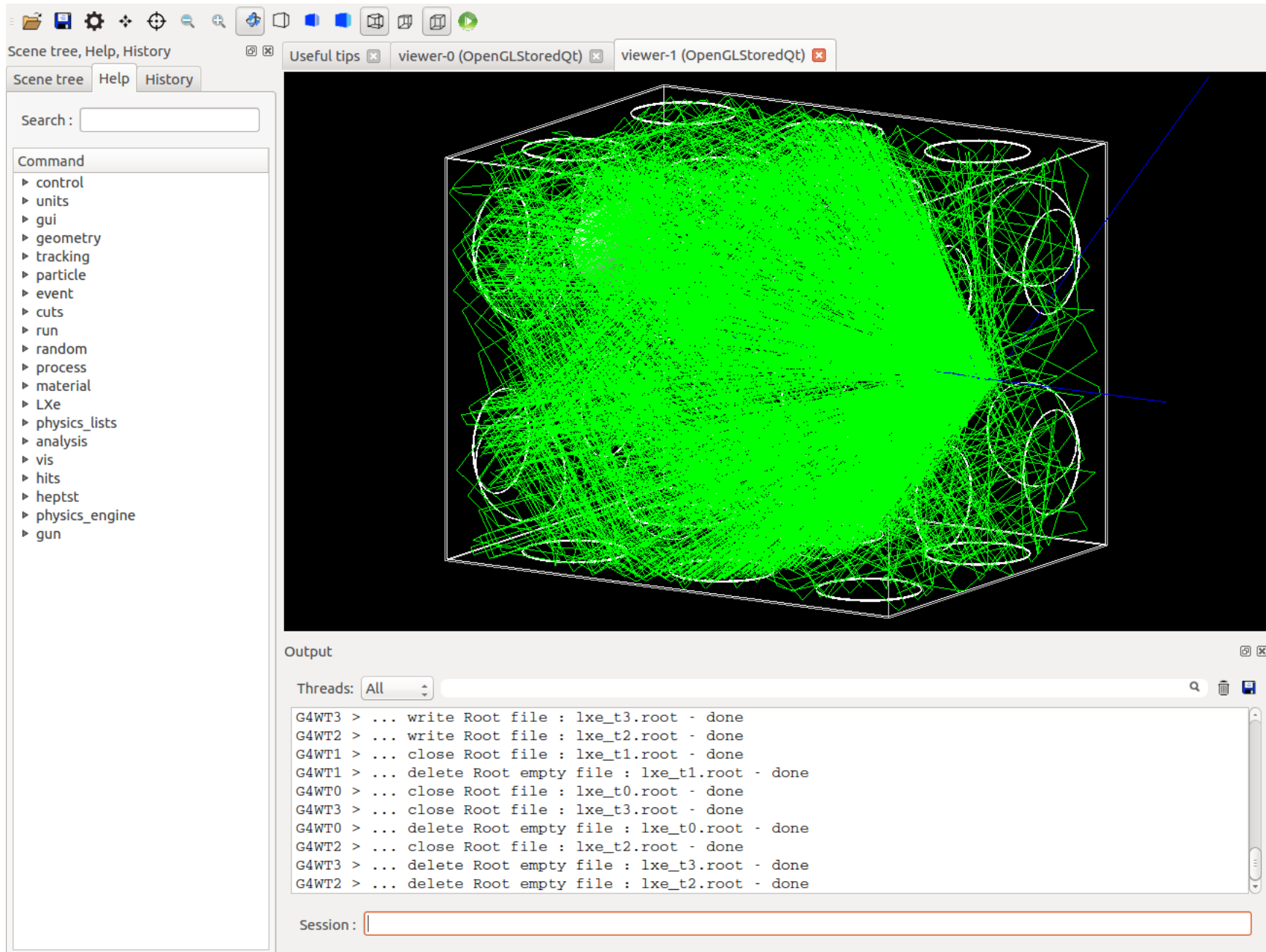
Output

Threads:

```
G4WT1 > ... write Root file : lxe_t1.root - done
G4WT2 > ... write Root file : lxe_t2.root - done
G4WT0 > ... close Root file : lxe_t0.root - done
G4WT0 > ... delete Root empty file : lxe_t0.root - done
G4WT3 > ... close Root file : lxe_t3.root - done
G4WT1 > ... close Root file : lxe_t1.root - done
G4WT3 > ... delete Root empty file : lxe_t3.root - done
G4WT2 > ... close Root file : lxe_t2.root - done
G4WT1 > ... delete Root empty file : lxe_t1.root - done
G4WT2 > ... delete Root empty file : lxe_t2.root - done
```

Session:

Solution (5)

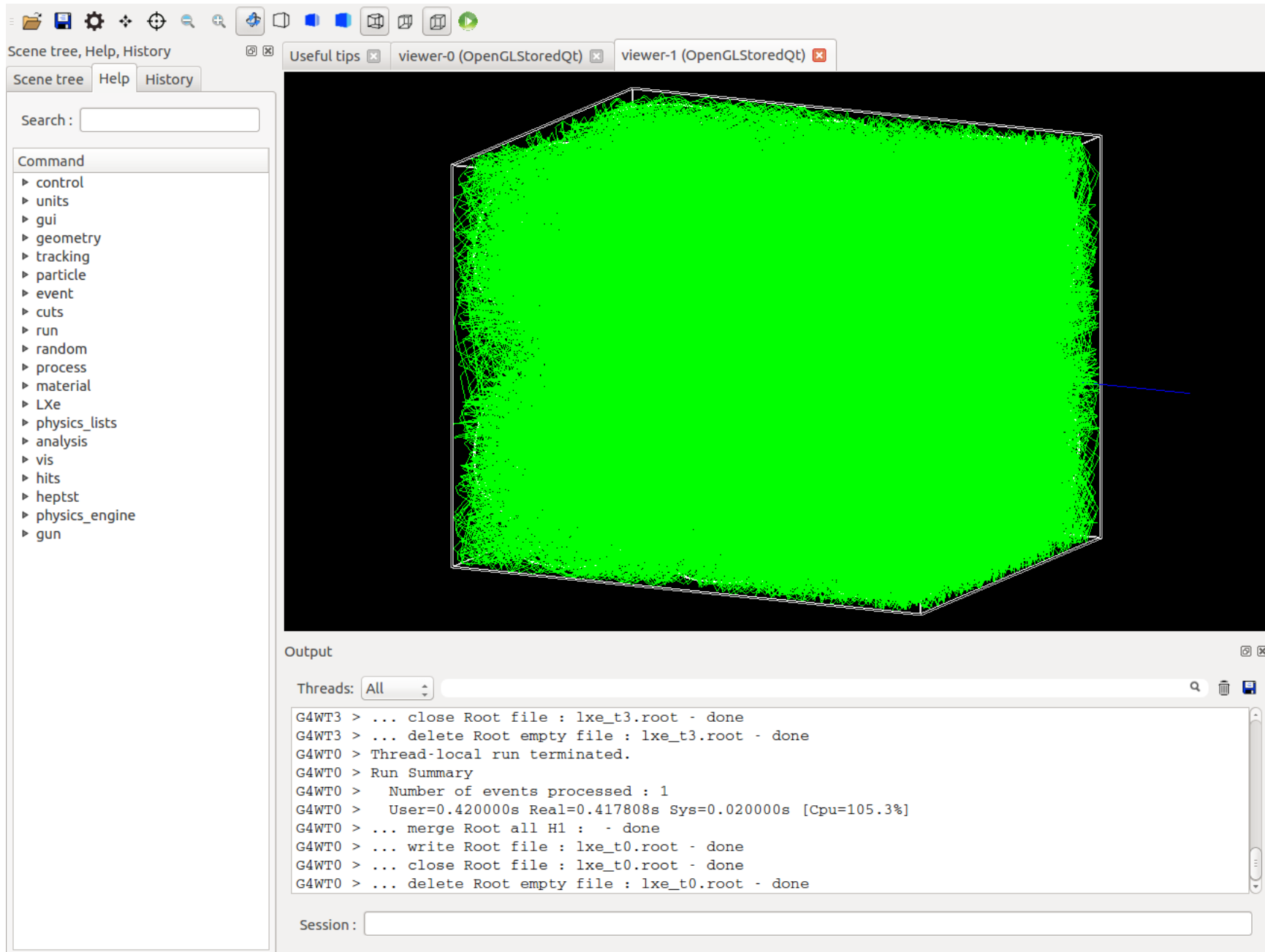


The screenshot displays the Geant4 graphical user interface. On the left, the 'Scene tree' panel is visible, containing a search bar and a 'Command' list with the following items: control, units, gui, geometry, tracking, particle, event, cuts, run, random, process, material, LXe, physics_lists, analysis, vis, hits, heptst, physics_engine, and gun. The main window shows a 3D visualization of a particle detector, rendered in green, with a blue line indicating a particle's path. The 'Output' window at the bottom shows the following log entries:

```
Threads: All
G4WT3 > ... write Root file : lxe_t3.root - done
G4WT2 > ... write Root file : lxe_t2.root - done
G4WT1 > ... close Root file : lxe_t1.root - done
G4WT1 > ... delete Root empty file : lxe_t1.root - done
G4WT0 > ... close Root file : lxe_t0.root - done
G4WT3 > ... close Root file : lxe_t3.root - done
G4WT0 > ... delete Root empty file : lxe_t0.root - done
G4WT2 > ... close Root file : lxe_t2.root - done
G4WT3 > ... delete Root empty file : lxe_t3.root - done
G4WT2 > ... delete Root empty file : lxe_t2.root - done
```

Below the output window is a 'Session:' input field.

Solution (7)



The screenshot displays the Geant4 graphical user interface. On the left, the 'Scene tree' panel shows a hierarchical list of components: control, units, gui, geometry, tracking, particle, event, cuts, run, random, process, material, LXe, physics_lists, analysis, vis, hits, heptst, physics_engine, and gun. The central viewer window shows a 3D visualization of a detector volume, which is a rectangular prism filled with a dense field of green points representing particle hits. A blue line points to the right side of the volume. The bottom panel is the 'Output' console, showing the following text:

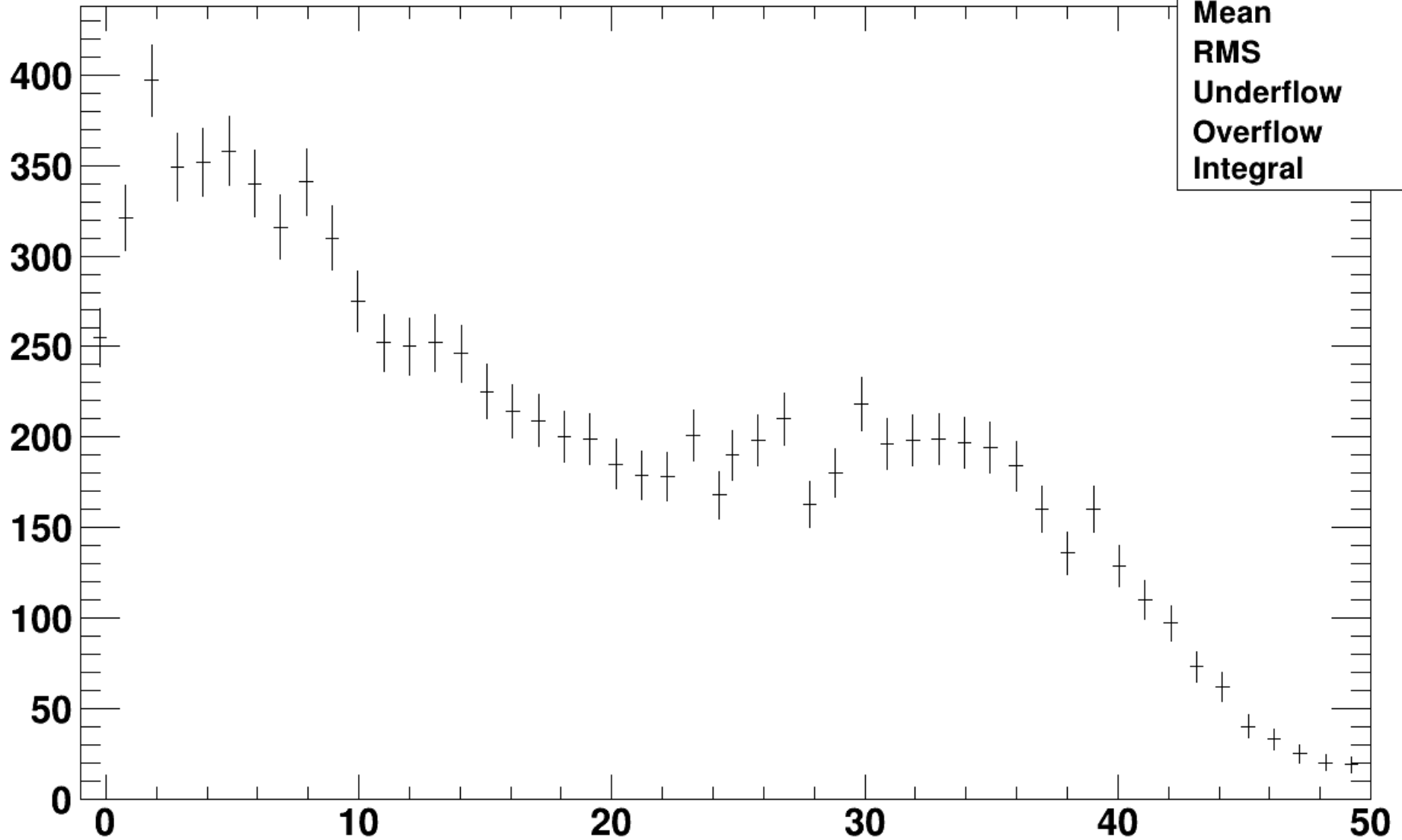
```
Threads: All
G4WT3 > ... close Root file : lxe_t3.root - done
G4WT3 > ... delete Root empty file : lxe_t3.root - done
G4WT0 > Thread-local run terminated.
G4WT0 > Run Summary
G4WT0 >   Number of events processed : 1
G4WT0 >   User=0.420000s Real=0.417808s Sys=0.020000s [Cpu=105.3%]
G4WT0 > ... merge Root all H1 : - done
G4WT0 > ... write Root file : lxe_t0.root - done
G4WT0 > ... close Root file : lxe_t0.root - done
G4WT0 > ... delete Root empty file : lxe_t0.root - done
```

Below the output console is a 'Session:' input field.

Solution (9)

hits per event

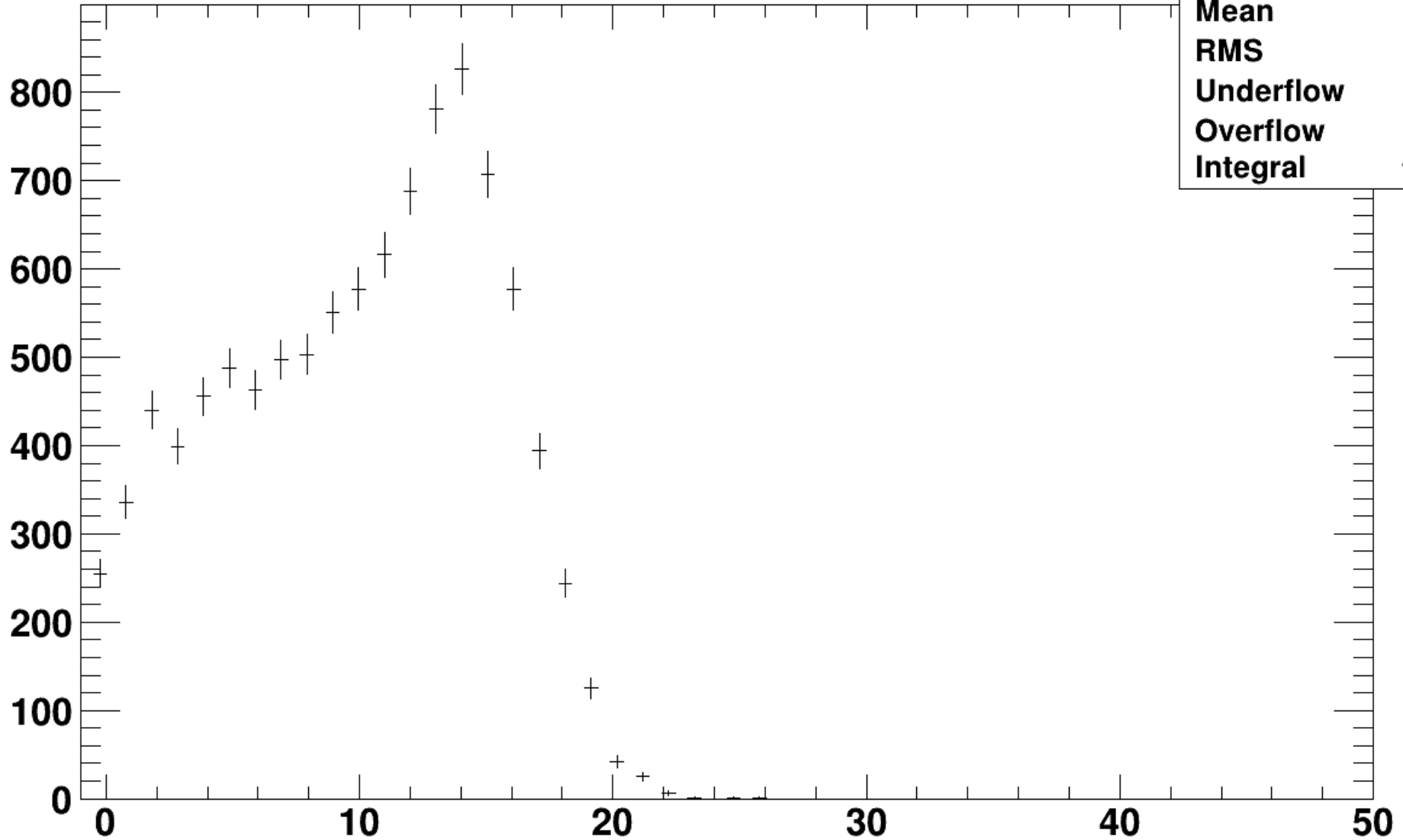
h1	
Entries	10000
Mean	18.31
RMS	12.87
Underflow	0
Overflow	37
Integral	9963



Solution (9)

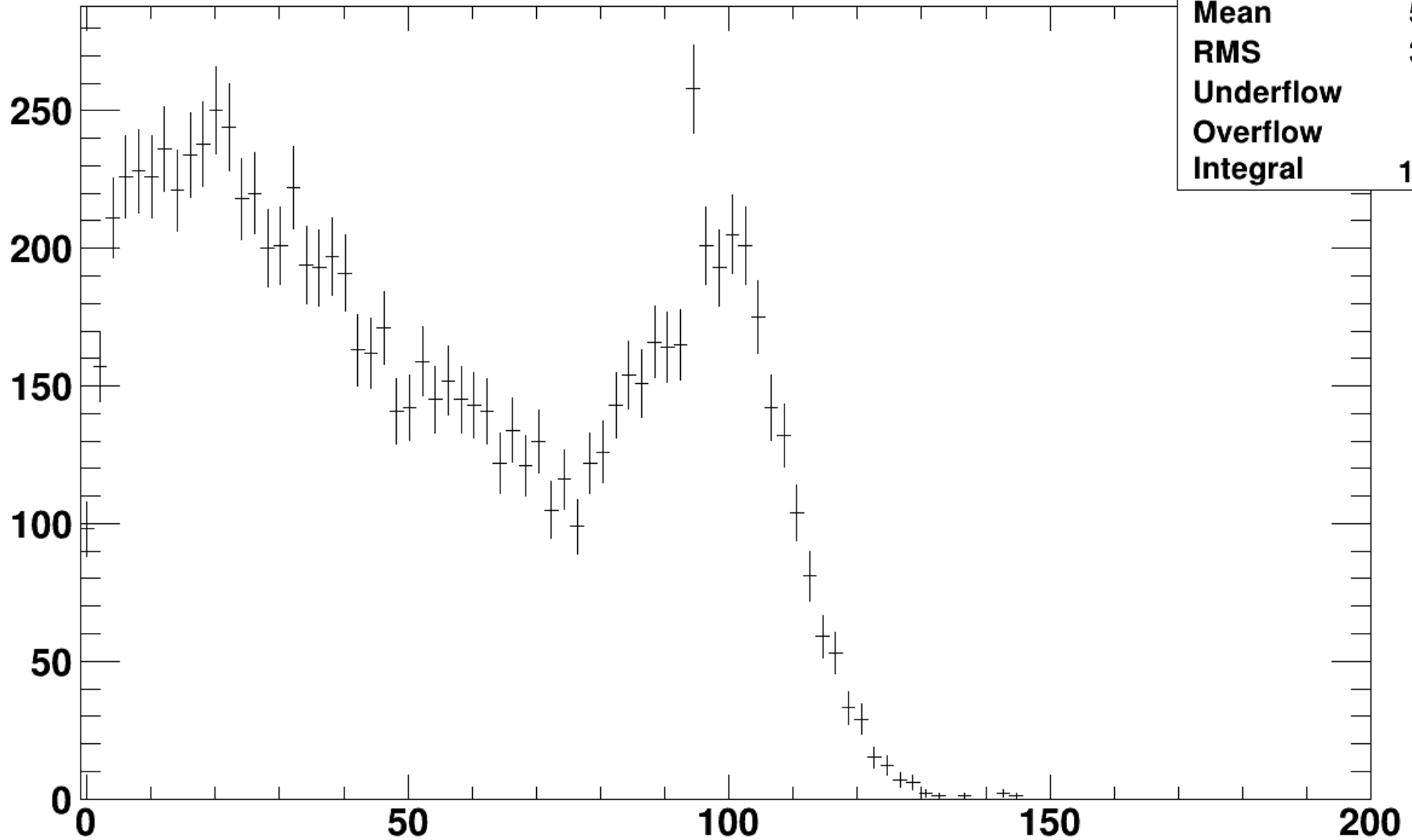
hits per event above threshold

h2	
Entries	10000
Mean	9.932
RMS	5.092
Underflow	0
Overflow	0
Integral	1e+04



Solution (9)

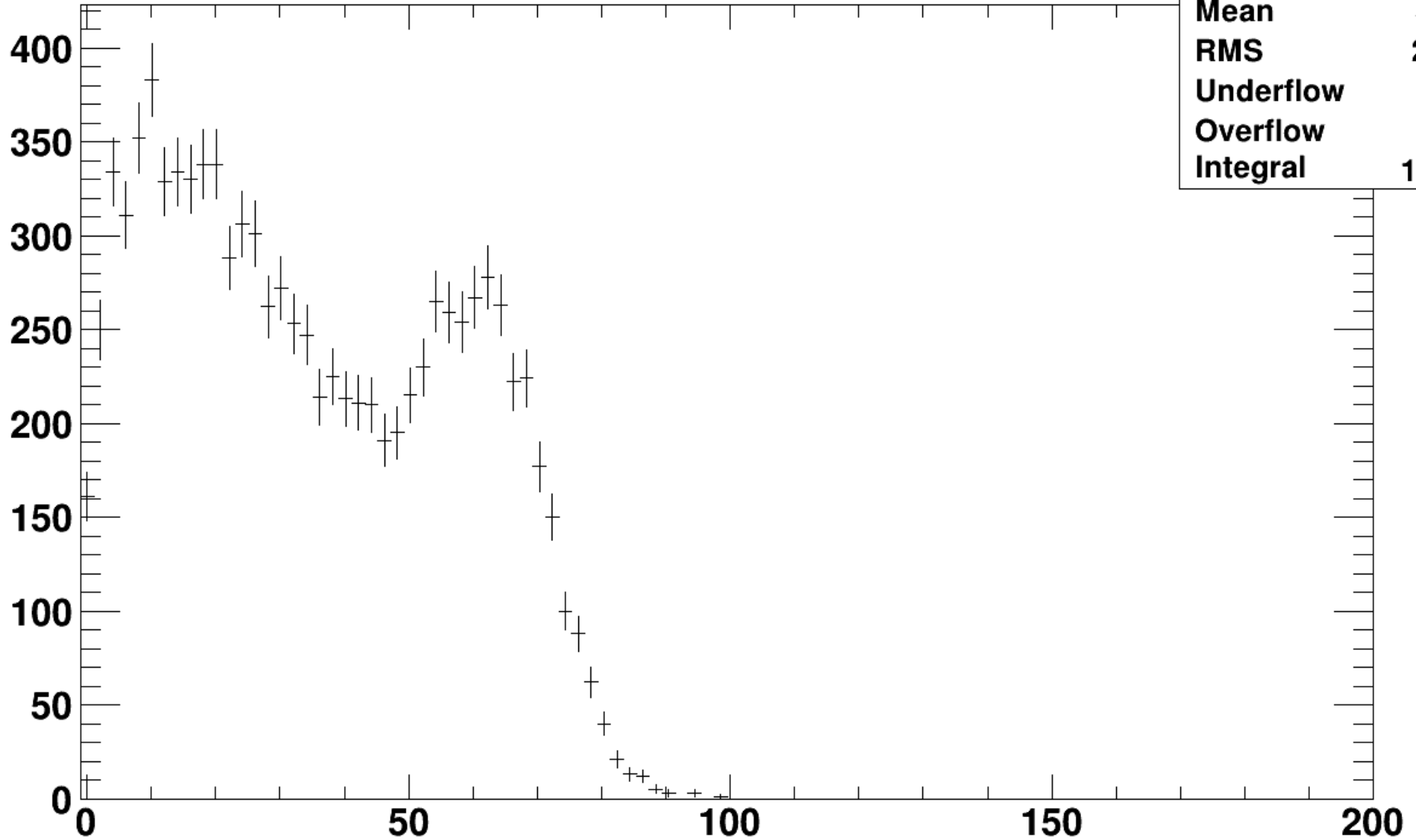
Cerenkov photons per event



Solution (9)



absorbed photons per event

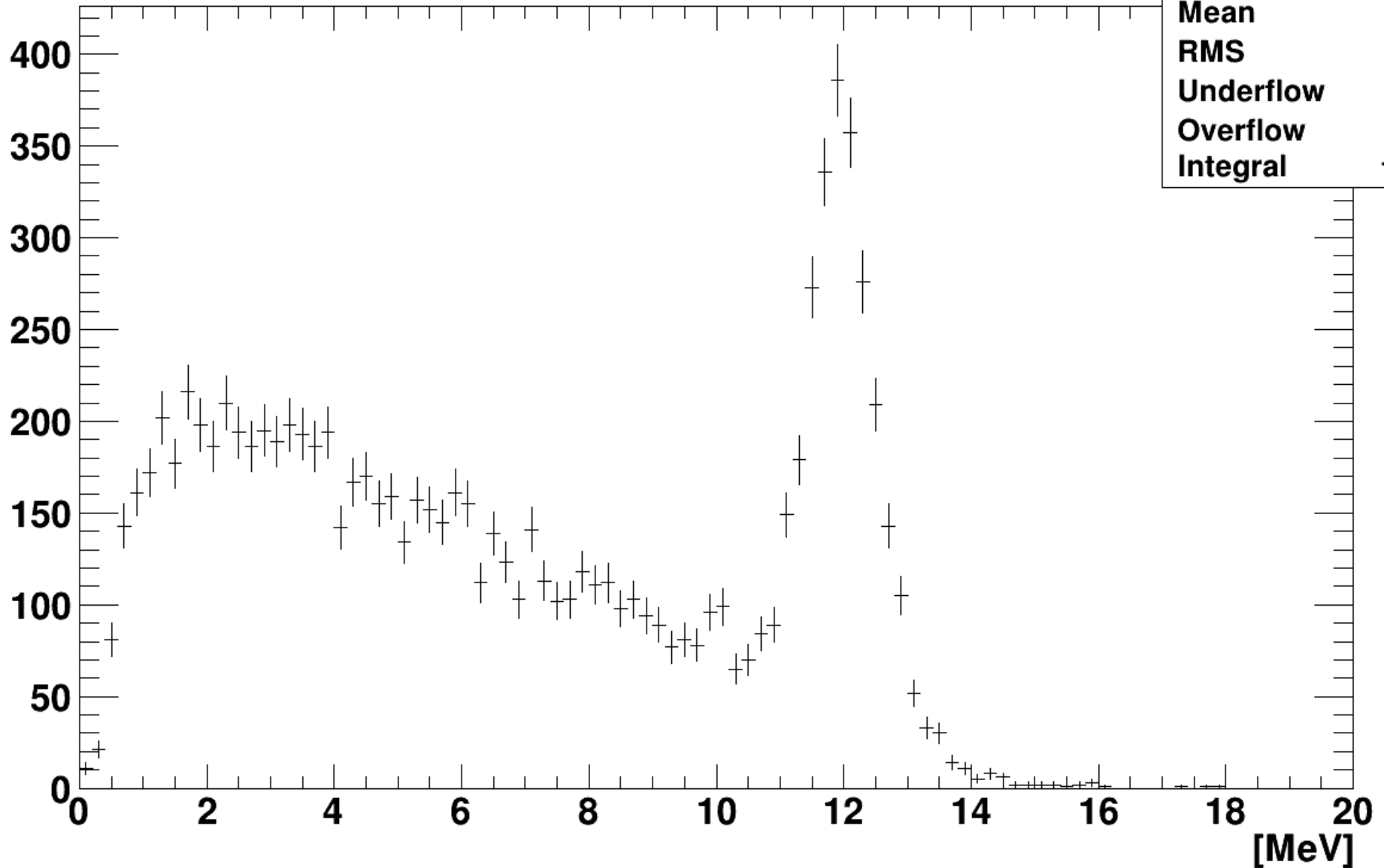


h5	
Entries	10000
Mean	35.31
RMS	22.26
Underflow	0
Overflow	0
Integral	1e+04

Solution (9)

energy deposition in scintillator per event

h7	
Entries	10000
Mean	6.757
RMS	4.005
Underflow	0
Overflow	0
Integral	1e+04

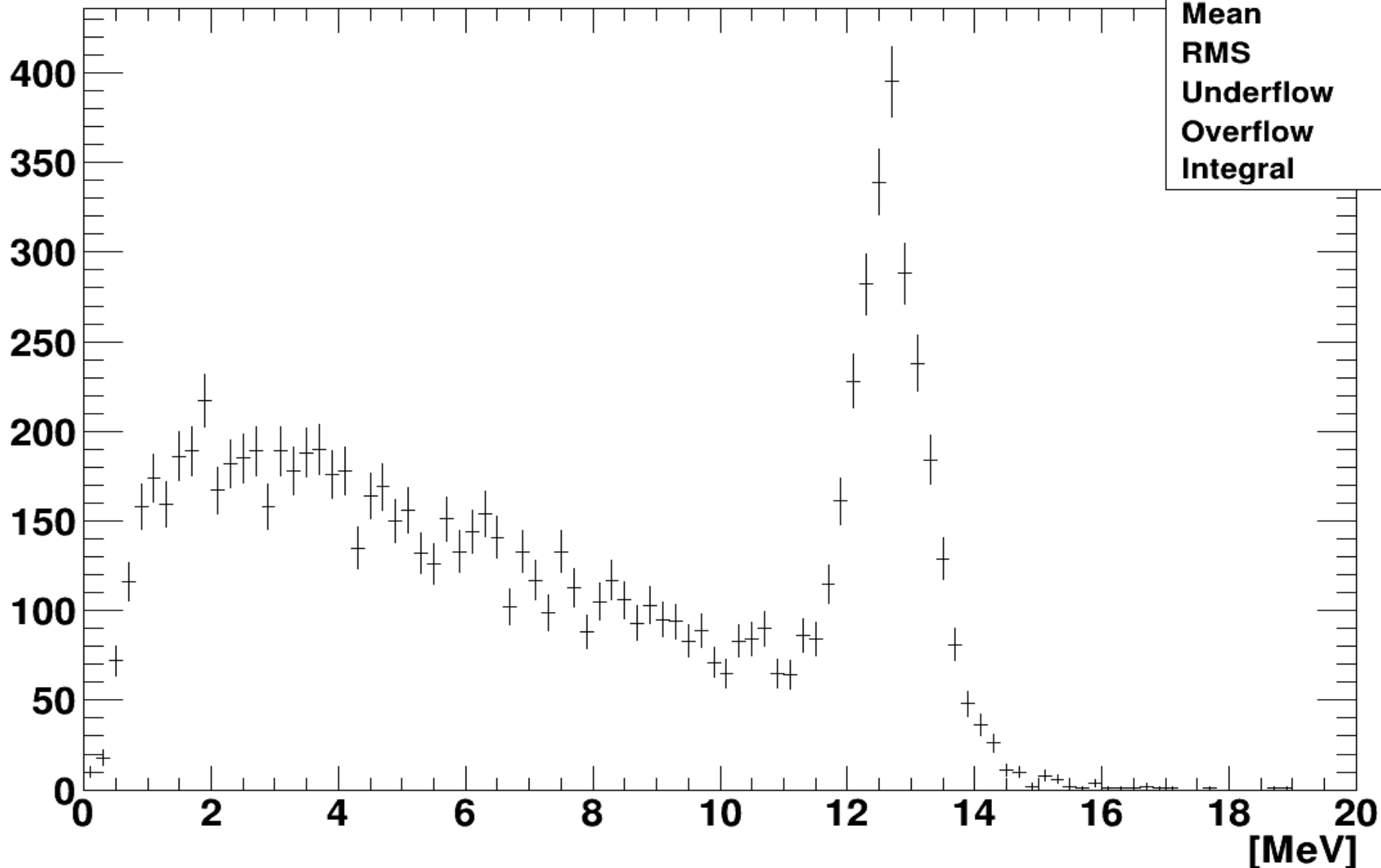


Solution (9) - scintillation



energy deposition in scintillator per event

h7	
Entries	10000
Mean	7.15
RMS	4.239
Underflow	0
Overflow	0
Integral	1e+04

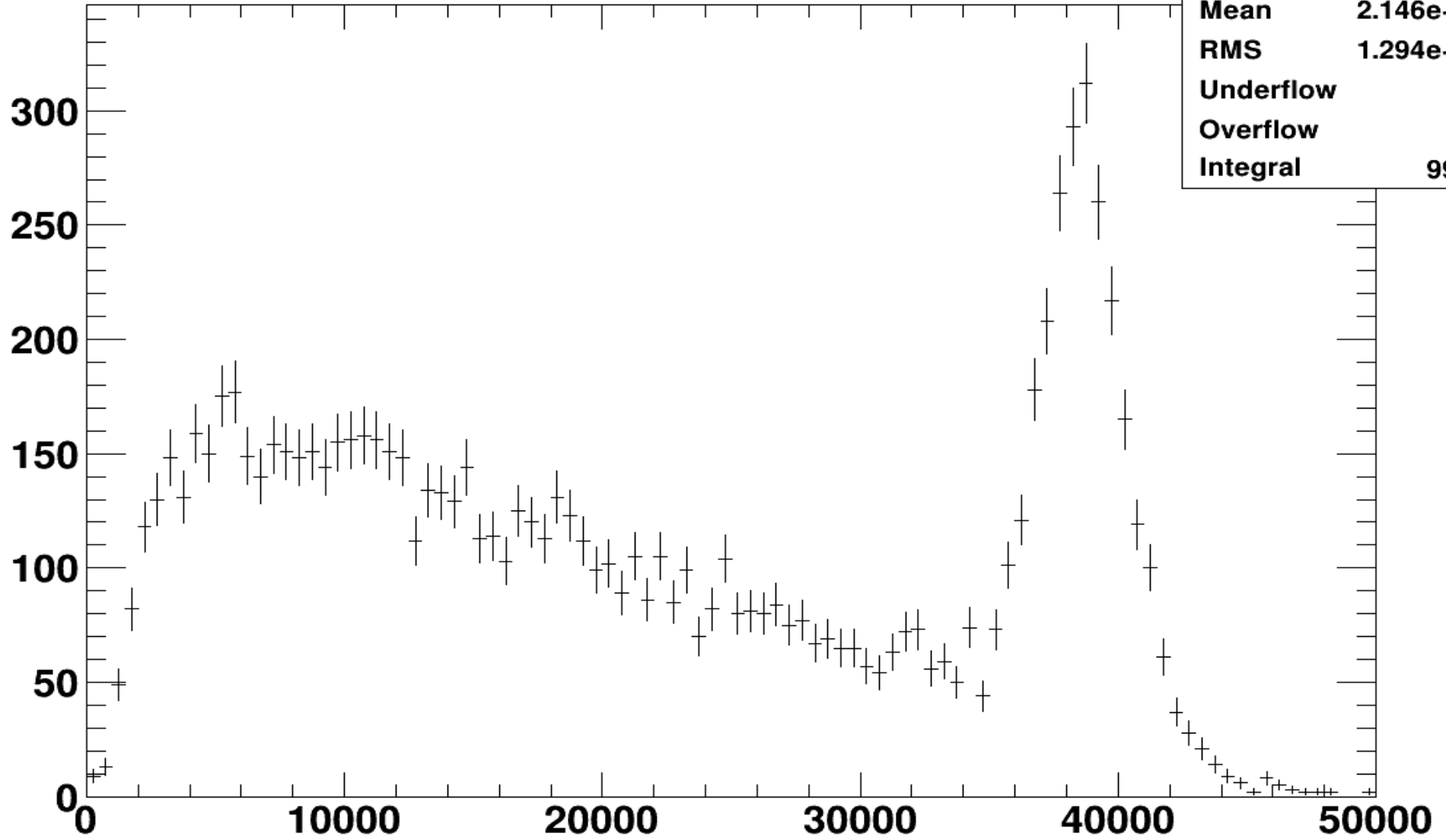


Solution (9) - scintillation

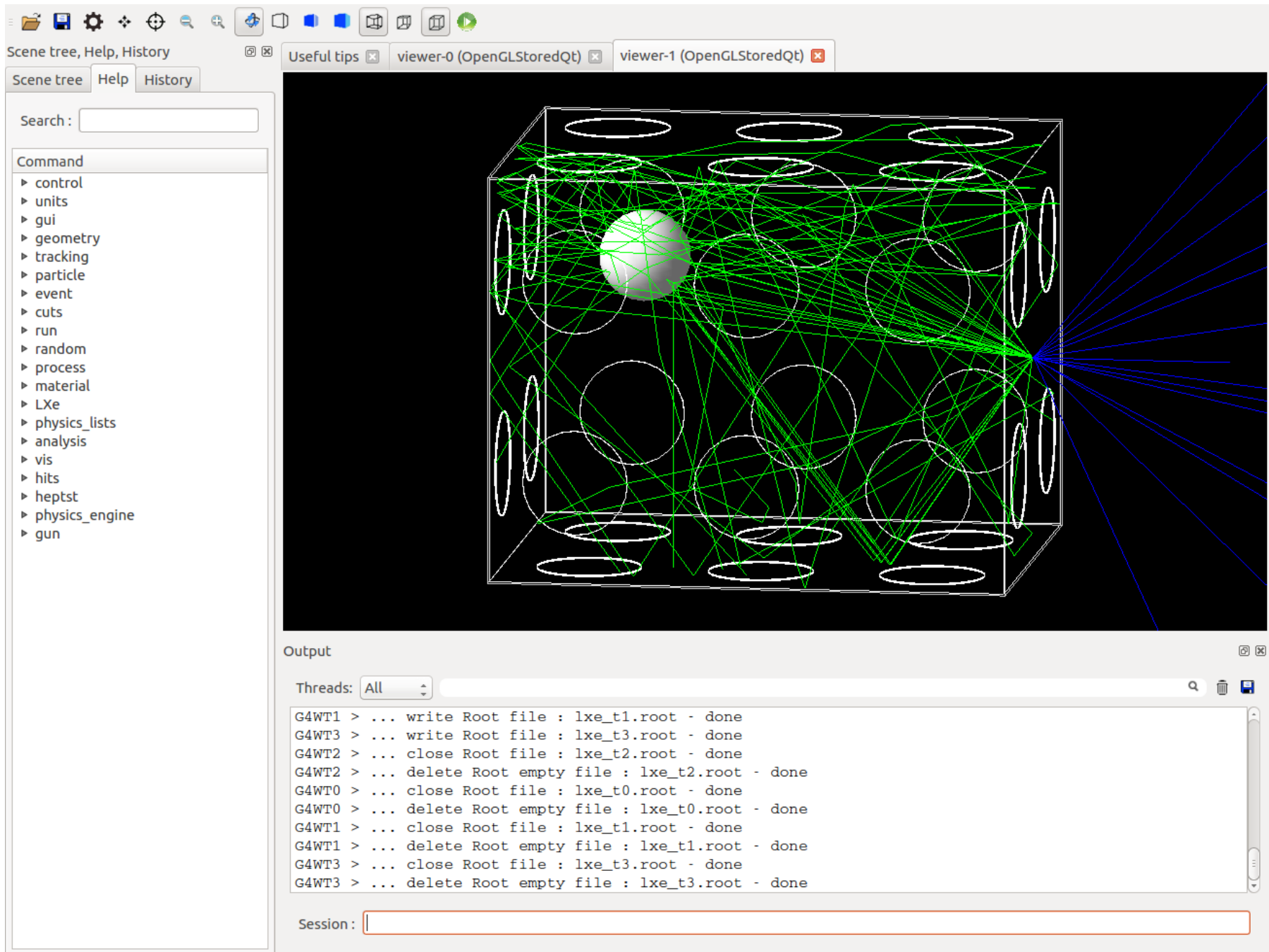


hits per event

h1	
Entries	10000
Mean	2.146e+04
RMS	1.294e+04
Underflow	0
Overflow	8
Integral	9992



Solution (10)



Scene tree, Help, History

Useful tips viewer-0 (OpenGLStoredQt) viewer-1 (OpenGLStoredQt)

Search:

Command

- ▶ control
- ▶ units
- ▶ gui
- ▶ geometry
- ▶ tracking
- ▶ particle
- ▶ event
- ▶ cuts
- ▶ run
- ▶ random
- ▶ process
- ▶ material
- ▶ LXe
- ▶ physics_lists
- ▶ analysis
- ▶ vis
- ▶ hits
- ▶ heptst
- ▶ physics_engine
- ▶ gun

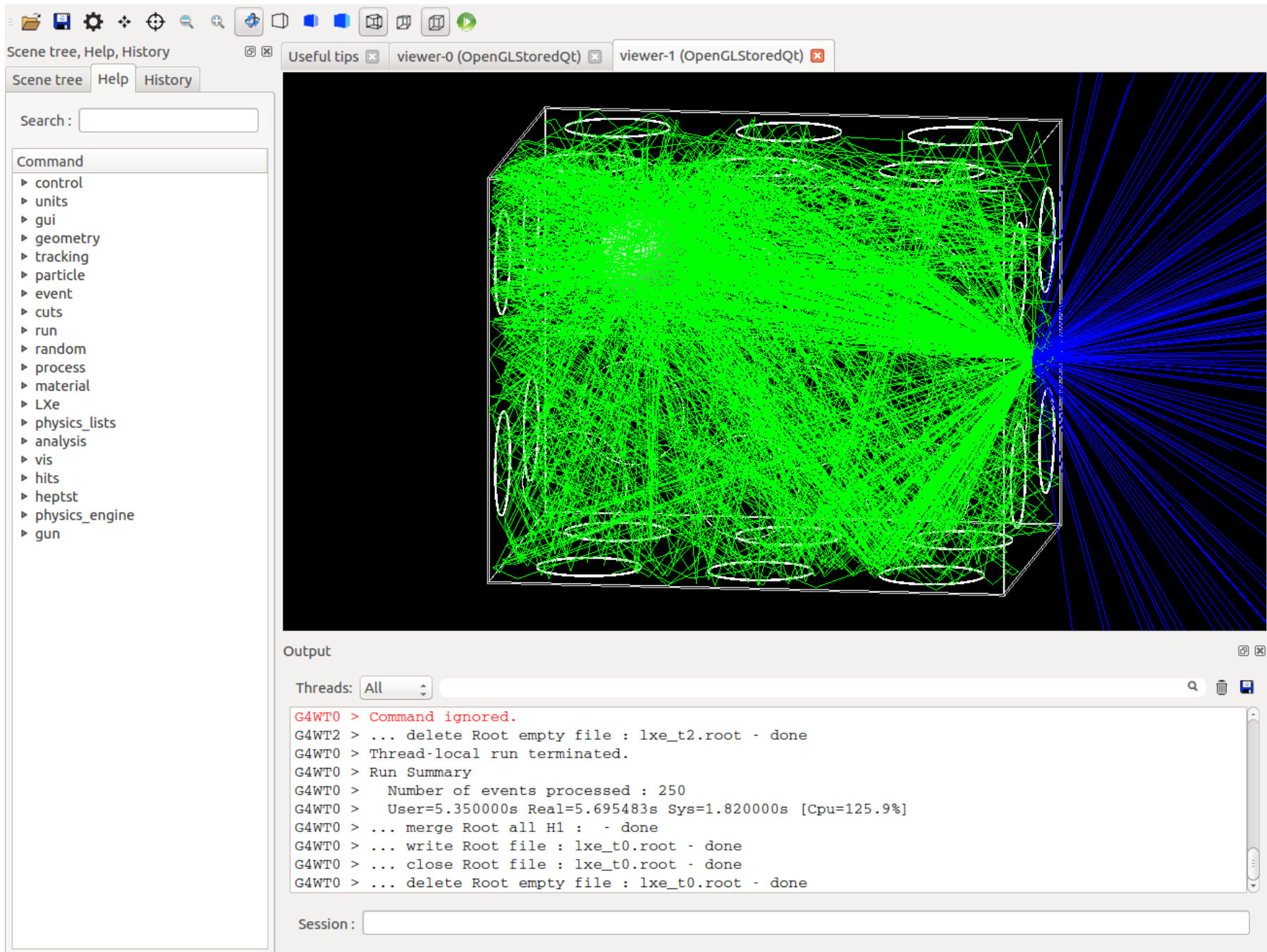
Output

Threads: All

```
G4WT1 > ... write Root file : lxe_t1.root - done
G4WT3 > ... write Root file : lxe_t3.root - done
G4WT2 > ... close Root file : lxe_t2.root - done
G4WT2 > ... delete Root empty file : lxe_t2.root - done
G4WT0 > ... close Root file : lxe_t0.root - done
G4WT0 > ... delete Root empty file : lxe_t0.root - done
G4WT1 > ... close Root file : lxe_t1.root - done
G4WT1 > ... delete Root empty file : lxe_t1.root - done
G4WT3 > ... close Root file : lxe_t3.root - done
G4WT3 > ... delete Root empty file : lxe_t3.root - done
```

Session:

Solution (10)



Scene tree, Help, History

Useful tips viewer-0 (OpenGLStoredQt) viewer-1 (OpenGLStoredQt)

Search :

Command

- ▶ control
- ▶ units
- ▶ gui
- ▶ geometry
- ▶ tracking
- ▶ particle
- ▶ event
- ▶ cuts
- ▶ run
- ▶ random
- ▶ process
- ▶ material
- ▶ LXe
- ▶ physics_lists
- ▶ analysis
- ▶ vis
- ▶ hits
- ▶ heptst
- ▶ physics_engine
- ▶ gun

Output

Threads: All

```
G4WT0 > Command ignored.  
G4WT2 > ... delete Root empty file : lxe_t2.root - done  
G4WT0 > Thread-local run terminated.  
G4WT0 > Run Summary  
G4WT0 >   Number of events processed : 250  
G4WT0 >   User=5.350000s Real=5.695483s Sys=1.820000s [Cpu=125.9%]  
G4WT0 > ... merge Root all H1 : - done  
G4WT0 > ... write Root file : lxe_t0.root - done  
G4WT0 > ... close Root file : lxe_t0.root - done  
G4WT0 > ... delete Root empty file : lxe_t0.root - done
```

Session: