

**원자력의학원 데이터 미팅
(GATEv7.1 GPU 시뮬레이션)**

2015.07.17.

강한규

내용

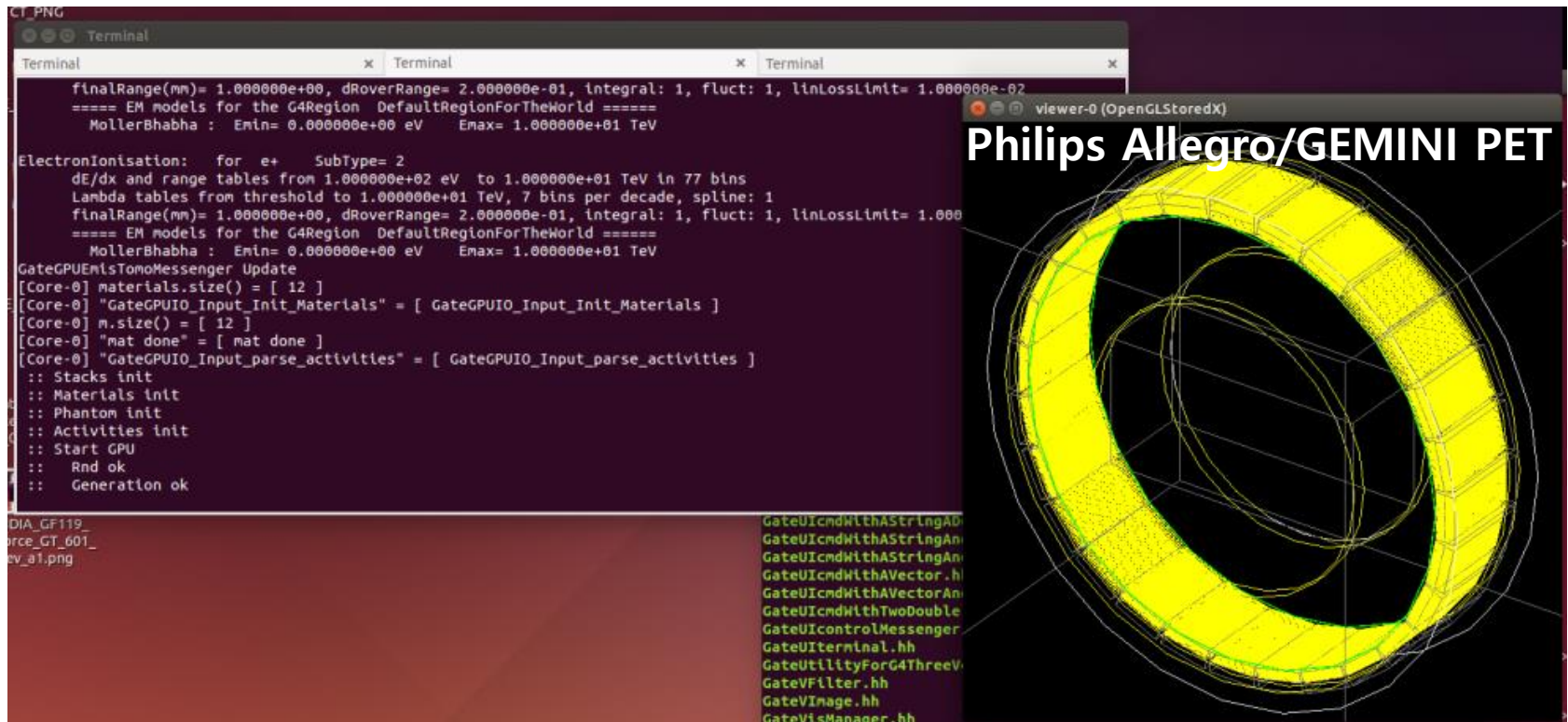
- GATEv7.1 및 CUDA 설치 조건
- GPU example 시뮬레이션 결과
- CPU vs. GPU 시뮬레이션 시간 비교

GATE 설치 조건

- ✓ **Ubuntu 14.04.1 LTS**
- ✓ CLHEP 2.2.0.4
- ✓ cmake-2.8.10.2
- ✓ **CUDA-v7.0**
- ✓ root_v5.34.30
- ✓ **Geant4.10.01.p02**
- ✓ **GATEv7.1**

GPU PET 시뮬레이션

- ✓ Voxelized-source(PET)
- ✓ Voxelized-phantom(CT)



Validation of a Monte Carlo simulation of the **Philips Allegro/GEMINI PET** systems using GATE (2006_PMB)

GPU Optical 시뮬레이션

- ✓ Voxelized-source(optical)
- ✓ Voxelized-phantom(CT)

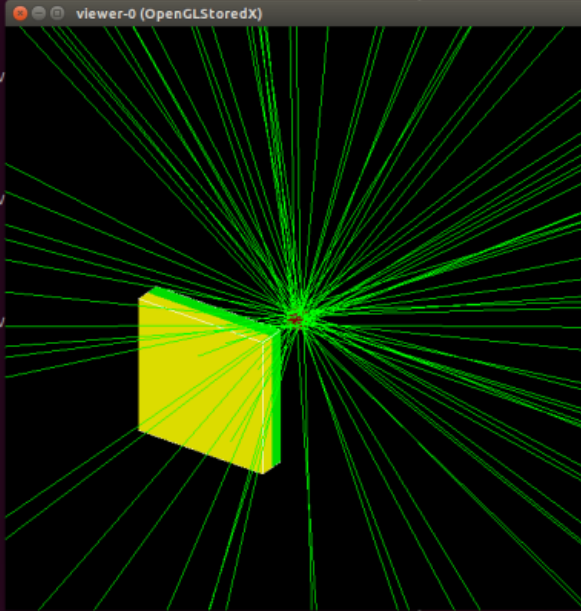
```
Terminal x example_GPU_optical x Terminal x
Material : Air
Range cuts : gamma 1.000e+00 mm e- 1.000e+00 mm e+ 1.000e+00 mm proton 1.000e+00 mm
Energy thresholds : gamma 2.500e+02 eV e- 3.362e+02 eV e+ 3.333e+02 eV proton 1.000e+02 keV
Region(s) which use this couple :
  Electronics

Index : 4 used in the geometry : Yes
Material : Vacuum
Range cuts : gamma 1.000e+00 mm e- 1.000e+00 mm e+ 1.000e+00 mm proton 1.000e+00 mm
Energy thresholds : gamma 2.500e+02 eV e- 2.500e+02 eV e+ 2.500e+02 eV proton 1.000e+02 keV
Region(s) which use this couple :
  biolumi

Index : 5 used in the geometry : Yes
Material : GPU_01_Water
Range cuts : gamma 1.000e+00 mm e- 1.000e+00 mm e+ 1.000e+00 mm proton 1.000e+00 mm
Energy thresholds : gamma 2.941e+00 keV e- 3.519e+02 keV e+ 3.418e+02 keV proton 1.000e+02 keV
Region(s) which use this couple :
  biolumi

Index : 6 used in the geometry : Yes
Material : GPU_03_Lung
Range cuts : gamma 1.000e+00 mm e- 1.000e+00 mm e+ 1.000e+00 mm proton 1.000e+00 mm
Energy thresholds : gamma 1.641e+00 keV e- 1.488e+02 keV e+ 1.467e+02 keV proton 1.000e+02 keV
Region(s) which use this couple :
  biolumi

=====
### Run 0 starts.
GateOpticalBiolumG4Messenger Update
[Core-0] "GateGPUIO_Input_parse_activities" = [ GateGPUIO_Input_parse_activities ]
[Core-0] E = [ 0e-06 ]
[Core-0] m_gpu_output->particles.size() = [ 500000 ]
[Core-0] m_current_particle_index_in_buffer = [ 0 ]
WARNING: G4VisManager::EndOfEvent: Automatic event keeping suspended.
The number of events exceeds the maximum, 100, that may be kept by
the vis manager.
Run terminated.
Run Summary
Run Aborted after 500001 events processed.
User=1.124e+01s Real=1.209e+01s Sys=4.400e-01s
WARNING: 100 events have been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them.
WARNING: G4VisManager::EndOfRun: Automatic event keeping was suspended.
The number of events in the run exceeded the maximum, 100, that may be
kept by the vis manager.
The number of events kept by the vis manager can be changed with
"/vis/scene/endOfEventAction [accumulate|refresh] <N>", where N
is the maximum number you wish to allow. N < 0 means "unlimited".
G4VisManager: Using G4TrajectoryDrawByCharge as default trajectory model.
See commands in /vis/modeling/trajectories/ for other options.
```



GPU CT 시뮬레이션

- ✓ source(80 keV photon)
- ✓ Voxelized-phantom(CT)

The image shows a screenshot of a GPU CT simulation interface. On the left is a terminal window displaying configuration details for a patient phantom. On the right is a 3D viewer window showing a CT scan of a patient's head. Annotations with arrows point to specific components: 'ParticleInVolumeActor(Out)' points to the top-right corner of the 3D volume, 'ParticleInVolumeActor(In)' points to the top-left corner, and 'X-ray source (80 keV)' points to the origin of the X-ray beam.

```
patient
Index : 41 used in the geometry : Yes
Material : MetallImplants_38
Range cuts : gamma 10 m e- 10 m e+ 10 m proton 1 mm
Energy thresholds : gamma 10 GeV e- 10 GeV e+ 10 GeV proton 100 keV
Region(s) which use this couple :
patient
Index : 42 used in the geometry : Yes
Material : MetallImplants_39
Range cuts : gamma 10 m e- 10 m e+ 10 m proton 1 mm
Energy thresholds : gamma 10 GeV e- 10 GeV e+ 10 GeV proton 100 keV
Region(s) which use this couple :
patient
Index : 43 used in the geometry : Yes
Material : MetallImplants_40
Range cuts : gamma 10 m e- 10 m e+ 10 m proton 1 mm
Energy thresholds : gamma 10 GeV e- 10 GeV e+ 10 GeV proton 100 keV
Region(s) which use this couple :
patient
Index : 44 used in the geometry : Yes
Material : Vacuum
Range cuts : gamma 10 m e- 10 m e+ 10 m proton 1 mm
Energy thresholds : gamma 250 eV e- 250 eV e+ 250 eV proton 100 keV
Region(s) which use this couple :
detectorOut
Index : 45 used in the geometry : Yes
Material : Vacuum
Range cuts : gamma 10 m e- 10 m e+ 10 m proton 1 mm
Energy thresholds : gamma 250 eV e- 250 eV e+ 250 eV proton 100 keV
Region(s) which use this couple :
detectorIn

=====
[Core-0] "GateGPUTransTomoActor::BeginOfRunAction" = [ GateGPUTransTomoActor::BeginOfRunAction ]
[Core-0] "GateGPUInput_Init_Materials" = [ GateGPUInput_Init_Materials ]
[Core-0] m.size() = [ 42 ]
[Core-0] a->IsTotalAmountOfPrimariesModeEnabled() = [ 1 ]
[Core-0] a->GetRequestedAmountOfPrimariesPerRun() = [ 0 ]
[Core-0] seed = [ 4091778891 ]
:: Stack init
:: Materials init
:: Phantoms init
[Core-0] max_buffer_size = [ 100000 ]
WARNING: G4VisManager::EndOfEvent: Automatic event keeping suspended.
The number of events exceeds the maximum, 100, that may be kept by
the vis manager.
```

ParticleInVolumeActor(Out)

ParticleInVolumeActor(In)

X-ray source (80 keV)

GPU vs. CPU simulation time 비교

	PET	Optical	CT
CPU/GPU	3.7	4.1	7.3

GPU가 CPU에 비해 약 **4배** 정도 시뮬레이션 시간이 빠름.

PET	CPU	GPU	CPU/GPU
User [sec]	101.4	27.2	3.7
Real [sec]	101.4	32.5	3.1
System [sec]	0.03	5.4	0.01