

Scoring I

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Geant4 Tutorial Course

- Introduction to sensitivity
- Command-based scoring
- Add a new scorer/filter

Retrieving information from Geant4

- Given geometry, physics and primary track generation, Geant4 does proper physics simulation “silently”.
 - You have to do something to **extract information useful to you**.
- There are three ways:
 - Built-in scoring commands
 - Most commonly-used physics quantities are available.
 - Use scorers in the tracking volume
 - Create scores for each event
 - Create own Run class to accumulate scores
 - Assign **G4VSensitiveDetector** to a volume to generate “hit”.
 - Use user hooks (G4UserEventAction, G4UserRunAction) to get event / run summary
- You may also use user hooks (G4UserTrackingAction, G4UserSteppingAction, etc.)
 - You have full access to almost all information
 - Straight-forward, but do-it-yourself



This talk

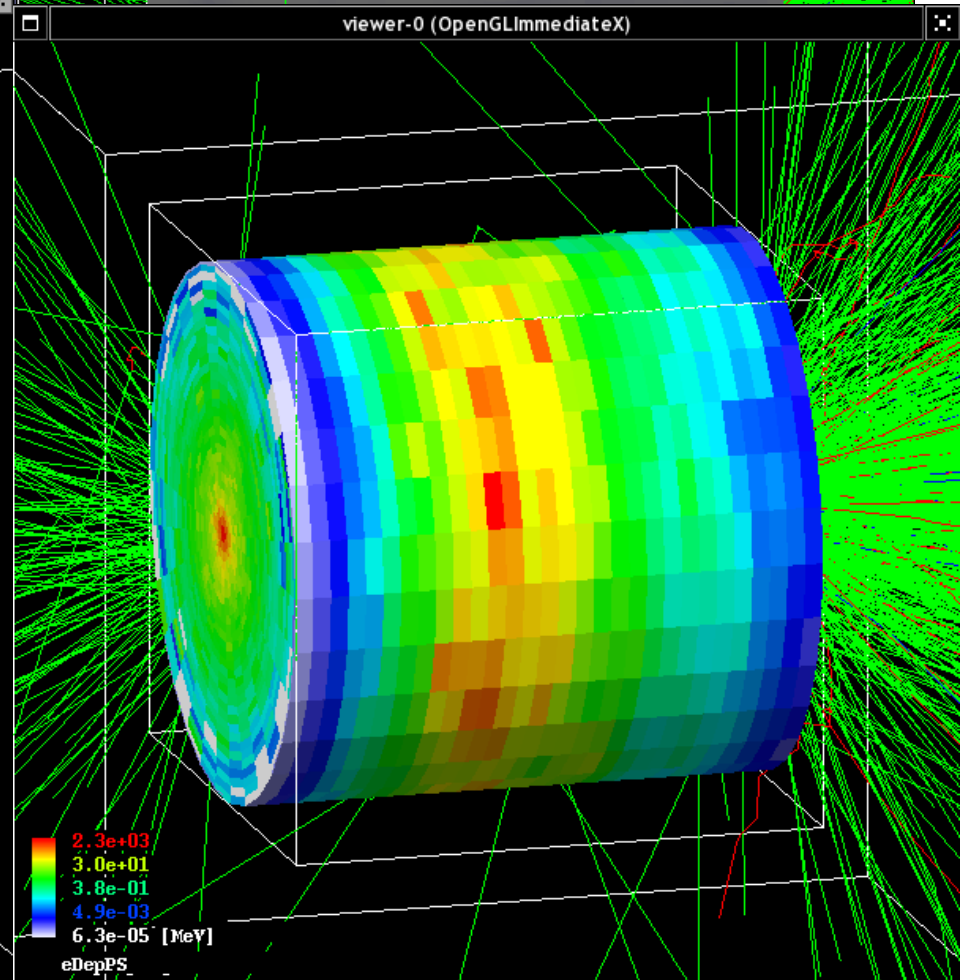
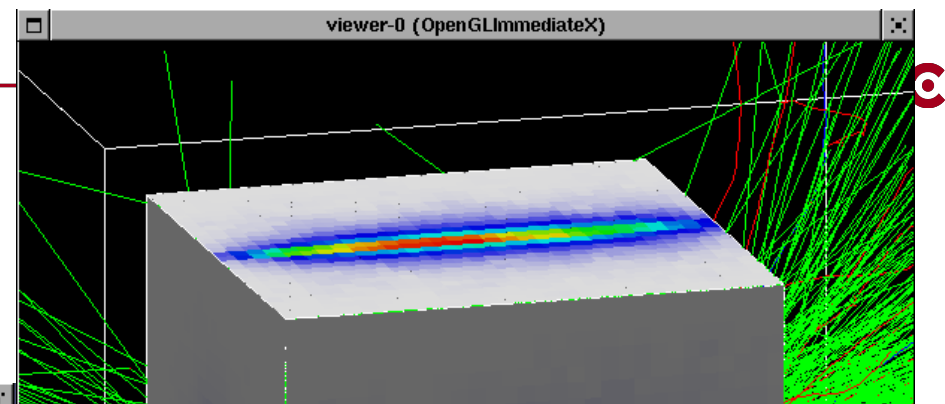
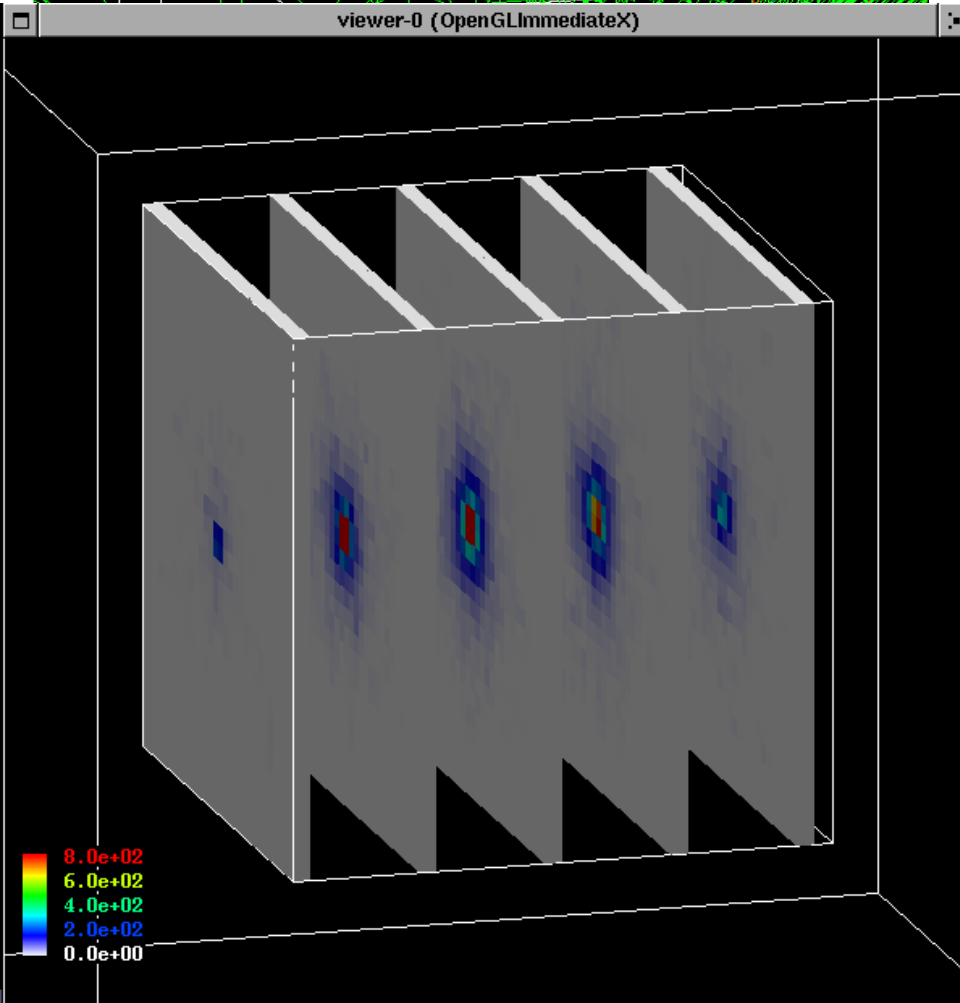
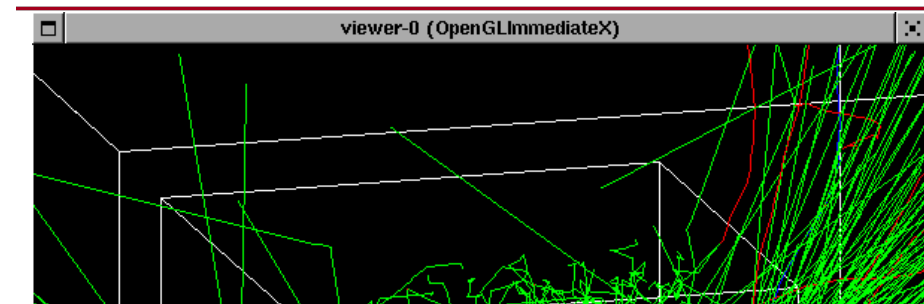
Command-based scoring

- Command-based scoring functionality offers the built-in scoring mesh and various scorers for commonly-used physics quantities such as dose, flux, etc.
 - Due to small performance overhead, it does not come by default.
- To use this functionality, access to the G4ScoringManager pointer after the instantiation of G4(MT)RunManager in your *main()*.

```
#include "G4ScoringManager.hh"
int main()
{
    G4RunManager* runManager = new G4MTRunManager;
    G4ScoringManager* scoringManager =
        G4ScoringManager::GetScoringManager();
    ...
}
```

- All of the UI commands of this functionality are in /score/ directory.
- /examples/extended/runAndEvent/RE03

Command-based scorers



Define a scoring mesh



- To define a scoring mesh, the user has to specify the followings.
 1. **Shape and name** of the 3D scoring mesh.
 - Currently, box and cylinder are available.
 2. Size of the scoring mesh.
 - Mesh size must be specified as "**half width**" similar to the arguments of G4Box / G4Tubs.
 3. **Number of bins** for each axes.
 - Note that too many bins causes immense memory consumption.
 4. Specify position and rotation of the mesh.
 - If not specified, the mesh is positioned at the center of the world volume without rotation.

```
# define scoring mesh
/score/create/boxMesh boxMesh_1
/score/mesh/boxSize 100. 100. 100. cm
/score/mesh/nBin 30 30 30
/score/mesh/translate/xyz 0. 0. 100. cm
```

- The mesh geometry can be completely independent to the real material geometry.

Scoring quantities

- A mesh may have arbitrary number of scorers. Each scorer scores one physics quantity.
 - energyDeposit * Energy deposit scorer.
 - cellCharge * Cell charge scorer.
 - cellFlux * Cell flux scorer.
 - passageCellFlux * Passage cell flux scorer
 - doseDeposit * Dose deposit scorer.
 - nOfStep * Number of step scorer.
 - nOfSecondary * Number of secondary scorer.
 - trackLength * Track length scorer.
 - passageCellCurrent * Passage cell current scorer.
 - passageTrackLength * Passage track length scorer.
 - flatSurfaceCurrent * Flat surface current Scorer.
 - flatSurfaceFlux * Flat surface flux scorer.
 - nOfCollision * Number of collision scorer.
 - population * Population scorer.
 - nOfTrack * Number of track scorer.
 - nOfTerminatedTrack * Number of terminated tracks scorer.

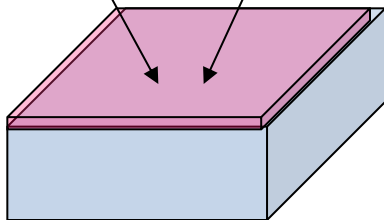
/score/quantity/xxxxx <scorer_name> <unit>

List of provided primitive scorers

- Concrete Primitive Scorers (See Application Developers Guide 4.4.6)
 - Track length
 - G4PSTrackLength, G4PSPassageTrackLength
 - Deposited energy
 - G4PSEnergyDeposit, G4PSDoseDeposit, G4PSChargeDeposit
 - Current/Flux
 - G4PSFlatSurfaceCurrent, G4PSSphereSurfaceCurrent, G4PSPassageCurrent, G4PSFlatSurfaceFlux, G4PSCellFlux, G4PSPassageCellFlux
 - Others
 - G4PSMinKinEAtGeneration, G4PSNofSecondary, G4PSNofStep

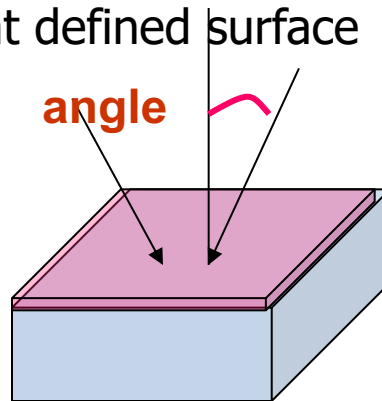
SurfaceCurrent :

Count number of injecting particles at defined surface.



SurfaceFlux :

Sum up $1/\cos(\text{angle})$ of injecting particles at defined surface

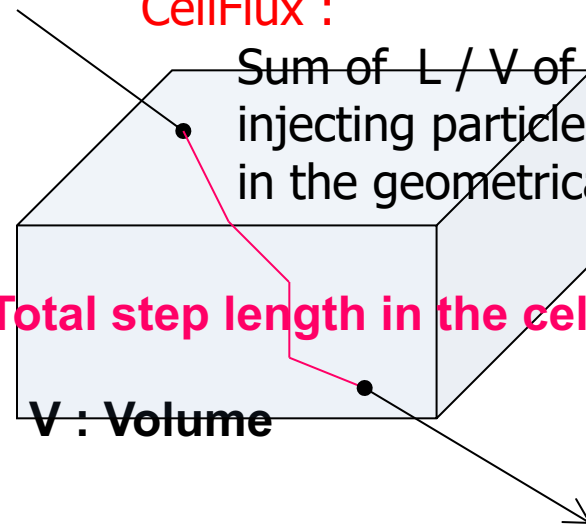


CellFlux :

Sum of L / V of injecting particles in the geometrical cell.

L : Total step length in the cell.

V : Volume



- Each scorer may take a filter.
 - charged * Charged particle filter.
`/score/filter/kineticEnergy <fname> <eLow> <eHigh> <unit>`
 - neutral * Neutral particle filter.
`/score/filter/particle <fname> <p1> ... <pn>`
 - kineticEnergy * Kinetic energy filter.
`/score/filter/ParticleWithKineticEnergy <fname> <eLow> <eHigh> <unit> <p1> ... <pn>`

```
/score/quantity/energyDeposit eDep MeV
/score/quantity/nOfStep nOfStepGamma
/score/filter/particle gammaFilter gamma
/score/quantity/nOfStep nOfStepEMinus
/score/filter/particle eMinusFilter e-
/score/quantity/nOfStep nOfStepEPlus
/score/filter/particle ePlusFilter e+
```

**Same primitive scorers
with different filters
may be defined.**

```
/score/close
```



Close the mesh when defining scorers is done.

- Projection

`/score/drawProjection <mesh_name> <scorer_name> <color_map>`

- Slice

`/score/drawColumn <mesh_name> <scorer_name> <plane> <column>
<color_map>`

- Color map

- By default, linear and log-scale color maps are available.
- Minimum and maximum values can be defined by
`/score/colorMap/setMinMax` command. Otherwise, min and max values are taken from the current score.

- Single score
 /score/dumpQuantityToFile <mesh_name> <scorer_name> <file_name>
- All scores
 /score/dumpAllQuantitiesToFile <mesh_name> <file_name>
- By default, values are written in CSV.
- By creating a concrete class derived from **G4VScoreWriter** base class, the user can define his own file format.
 - Example in /examples/extended/runAndEvent/RE03
 - User's score writer class should be registered to G4ScoringManager.

- One of most frequently asked questions is “How to get energy spectrum?”.
- Create arbitrary number of flux scorers of same kind combined with particle and kinetic energy filters.

```
/score/quantity/flatSurfaceFlux flux0
```

```
/score/filter/particleWithKineticEnergy range0 10. 20. MeV e-
```

```
/score/quantity/flatSurfaceFlux flux1
```

```
/score/filter/particleWithKineticEnergy range1 20. 30. MeV e-
```

```
/score/quantity/flatSurfaceFlux flux2
```

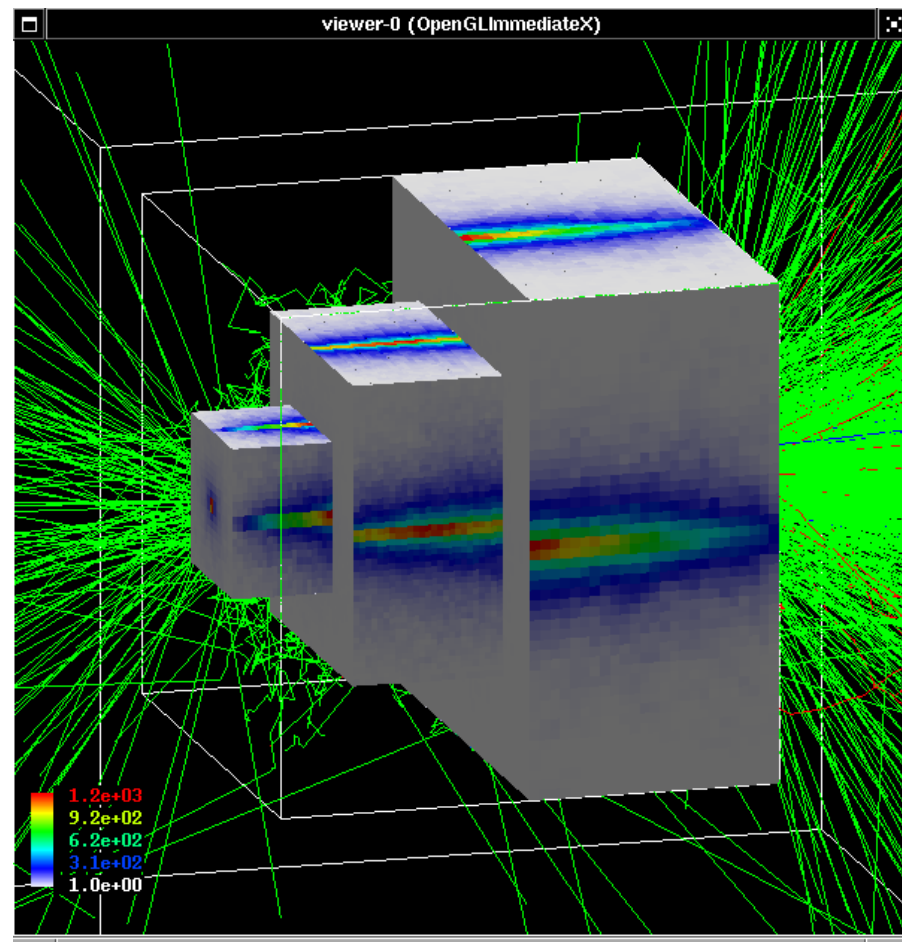
```
/score/filter/particleWithKineticEnergy range2 30. 40. MeV e-
```

```
/score/quantity/flatSurfaceFlux flux3
```

```
/score/filter/particleWithKineticEnergy range3 40. 50. MeV e-
```

More than one scoring meshes

- You may define more than one scoring mesh.
 - And, you may define arbitrary number of primitive scorers to each scoring mesh.
- Mesh volumes may overlap with other meshes and/or with mass geometry.
- A step is limited on any boundary.
- Please be cautious of too many meshes, too granular meshes and/or too many primitive scorers.
 - Memory consumption
 - Computing speed



Add a new scorer/filter to command-based scorers

- G4VPrimitiveScorer is the abstract base of all scorer classes.
- To make your own scorer you have to implement at least:
 - Constructor
 - Initialize()
 - Initialize G4THitsMap<G4double> map object
 - ProcessHits()
 - Get the physics quantity you want from G4Step, etc. and fill the map
 - Clear()
 - GetIndex()
 - Convert **three copy numbers** into an index of the map
- G4PSEnergyDeposit3D could be a good example.
- Create your own messenger class to define /score/quantity/<your_quantity> command.
 - Refer to G4ScorerQuantityMessengerQCmd class.

Creating your own scorer

- Though we provide most commonly-used scorers, you may want to create your own.
 - If you believe your requirement is quite common, just let us know, so that we will add a new scorer.

- G4VPrimitiveScorer is the abstract base class.

```
class G4VPrimitiveScorer
{
public:
    G4VPrimitiveScorer(G4String name, G4int depth=0);
    virtual ~G4VPrimitiveScorer();
protected:
    virtual G4bool ProcessHits(G4Step*,
                                G4TouchableHistory*) = 0;
    virtual G4int GetIndex(G4Step*);
public:
    virtual void Initialize(G4HCofThisEvent*);
    virtual void EndOfEvent(G4HCofThisEvent*);
    virtual void clear();
    ...
};
```

- Methods written in red will be discussed at “Scoring 2” talk.

- G4VSDFilter
 - Abstract base class which you can use to make your own filter
- ```
class G4VSDFilter
{
 public:
 G4VSDFilter(G4String name);
 virtual ~G4VSDFilter();
 public:
 virtual G4bool Accept(const G4Step*) const = 0;
 ...
}
```
- Create your own messenger class to define /score/filter/<your\_filter> command.
    - Refer to G4ScorerQuantityMessenger class.