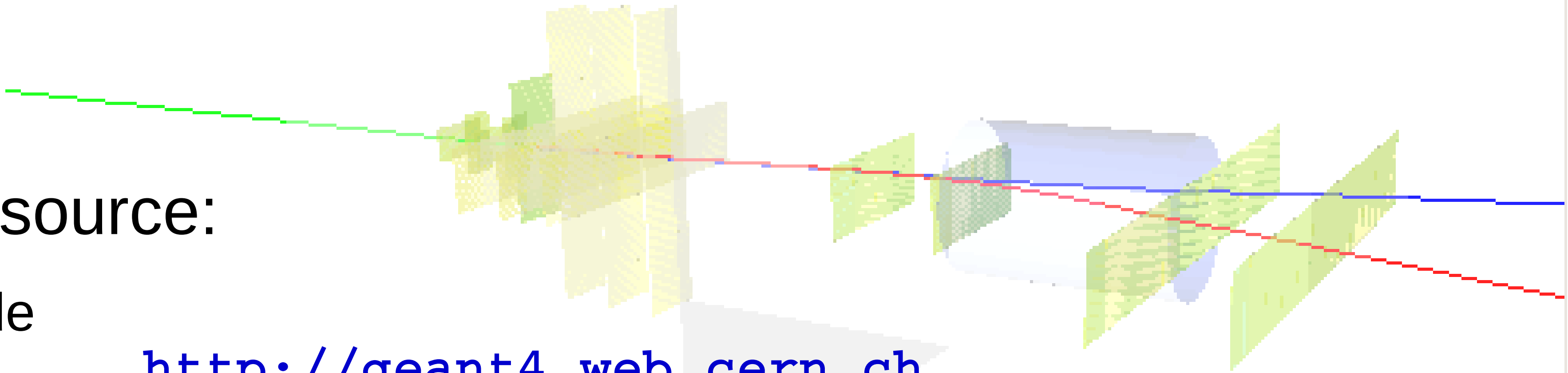
GEometryANdTracking

Simulation toolkit in C++:

- Variety of geometries → choose your own setup
- Variety of materials → choose your own materials
- Variety of particles → choose particle type energy position direction
- Variety of physics processes →available physics models, cuts



Open source:

- Code
- Manuals
- Examples

http://geant4.web.cern.ch

Nucl. Inst. and Methods Phys. Res. A, 506, 250

Transaction on Nuclear Science 53, 270

Geometry

Very complex geometries can be described at three levels:

- **Solid**: shapes and dimensions, boolean operations

- **LogicalVolume**: materials, sensitivity, mother and daughter volumes, visualization etc

- **PhysicalVolume**: position in space and rotation

  a logical volume can be placed multiple times originating different physical volumes

  → single or repeated placements (replicas,parameterizations)

Physics

- electromagnetic interactions for all particles
- inelastic interactions
- elastic scattering
- capture
- decay of unstable particles

plug&play Geant4 physics list

$G4SOURCE/ source/physics_lists/lists

```
class MyPhysicsList: public G4VUserPhysicsList {
public:
MyPhysicsList();
~MyPhysicsList();
void ConstructParticle();
void ConstructProcess();
void SetCuts();
}
```

user can implement the methods to define particles processes and cuts (range based) on generation of secondaries ex. delta rays from ionization, or gamma from bremsstrahlung

Tracking

Transportation of a particle ‘step-by-step’taking into account all possible interactions with materials and fields

The transport ends if the particle:

- is slowed down to zero kinetic energy (and it doesn't have any interaction at rest)
- disappears in some interaction
- reaches the end of the simulation volume

Geant4 allows the User to access the transportation process and retrieve the results (USER ACTIONS)

- at the beginning and end of the transport
- at the end of each step in transportation
- if a particle reaches a sensitive detector

Geant4 example: compile

```
/home/isapp/geant4/geant/share/Geant4-10.1.3/examples/
```

- **Source the geant4 script:**

```
$ source /home/isapp/geant4/geant/bin/geant4.sh
```

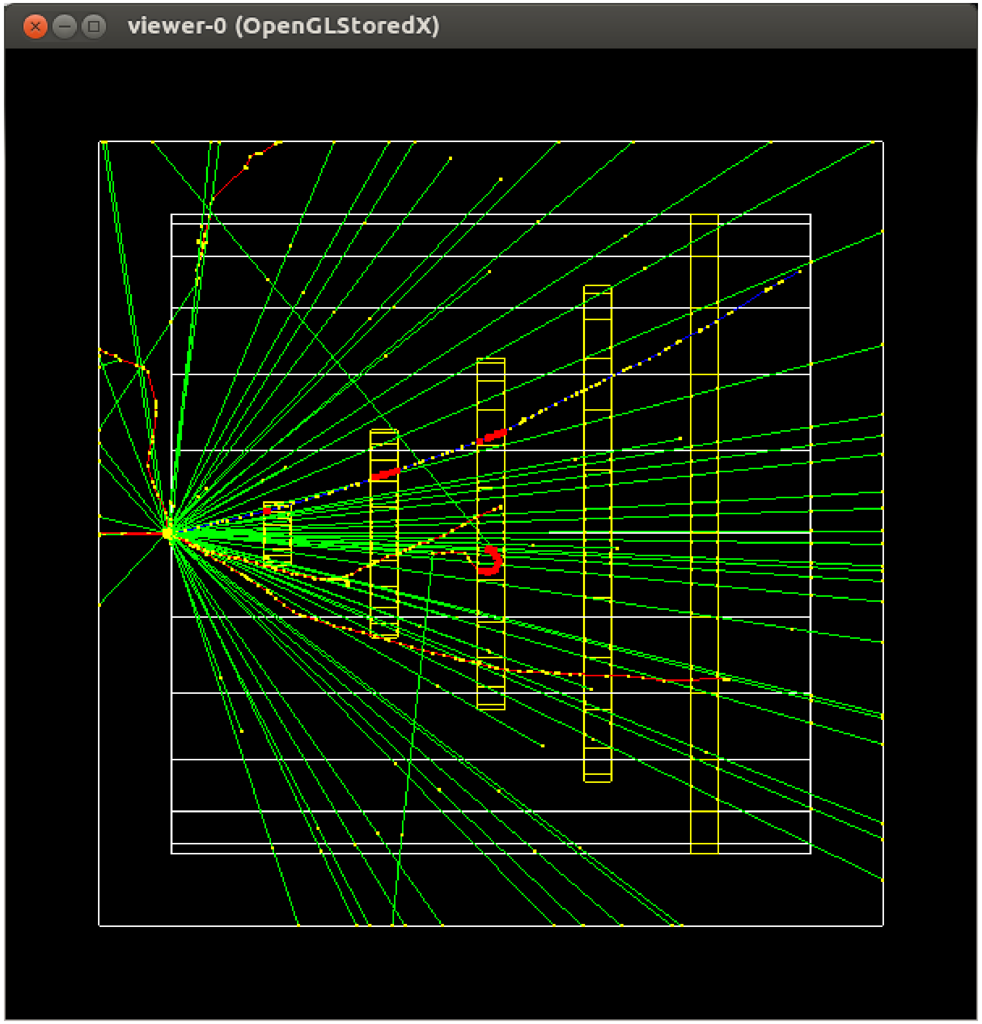
- copy the example source code somewhere $path

```
$ cp -r /home/isapp/geant4/geant/share/Geant4-10.1.3/examples/basic/B2 $path-to-your-dir

$ cd $path-to-your-dir

$ mkdir B2-build

$ cd B2-build

$ cmake -DGeant4_DIR=/home/isapp/geant4/geant/lib /home/isapp/path-to-your-dir/B2

$ make
```

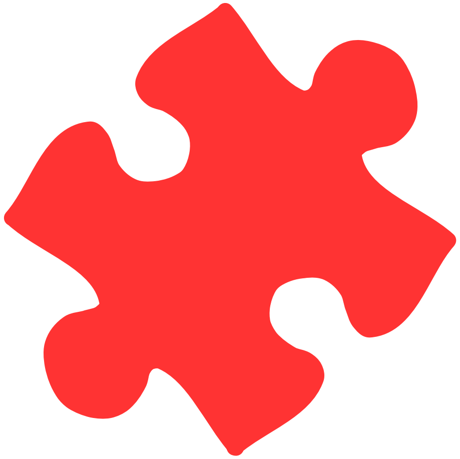
Geant4 example: run

- **$ ./exampleB2a**
- /gun/particle e-
- /gun/energy 300 MeV
- /run/beamOn 1

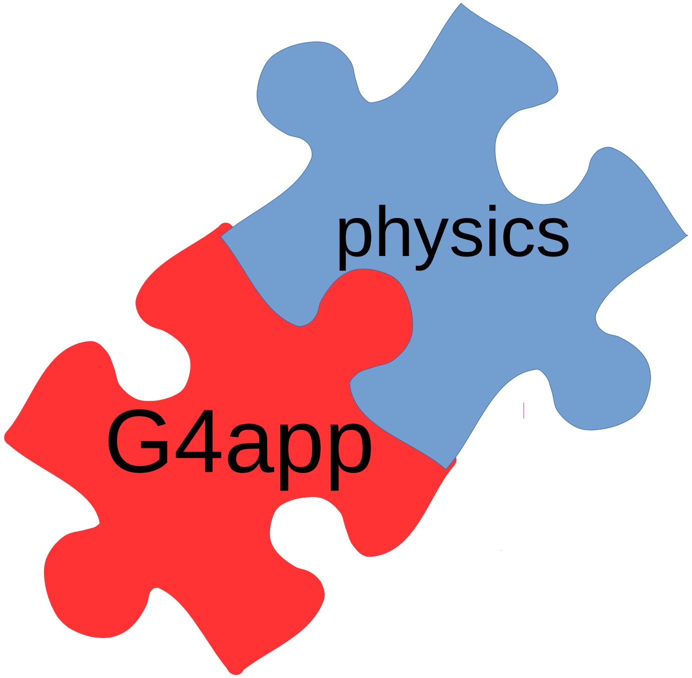
here you go!



writing your G4 application



writing your G4 application



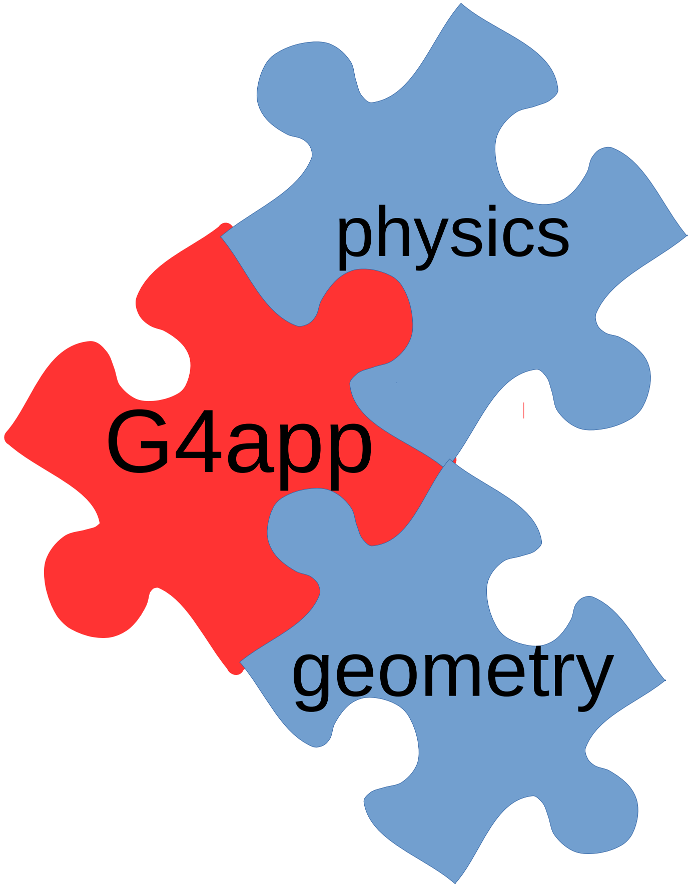
Physics:

- use the Geant4 standard provided physic lists:

`$G4SOURCE/ source/physics_lists/lists`

- build/taylor our own models

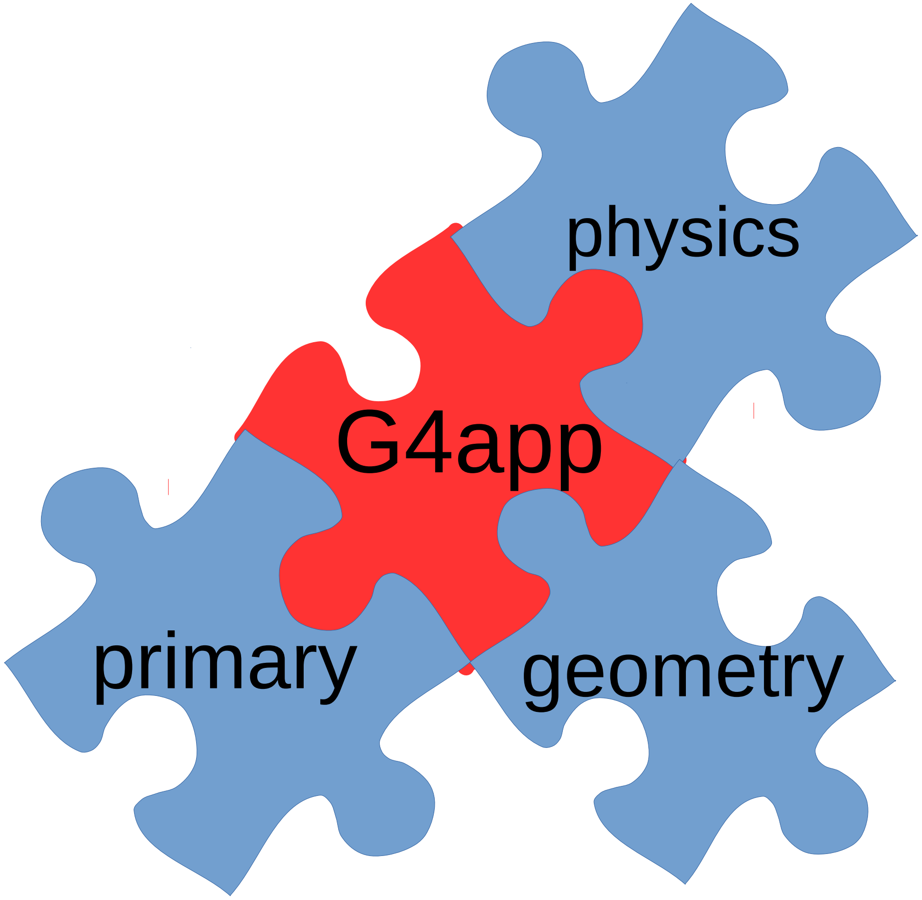
writing your G4 application



Your detector geometry:

- shapes
- materials
- volumes
- placements
- sensitivity

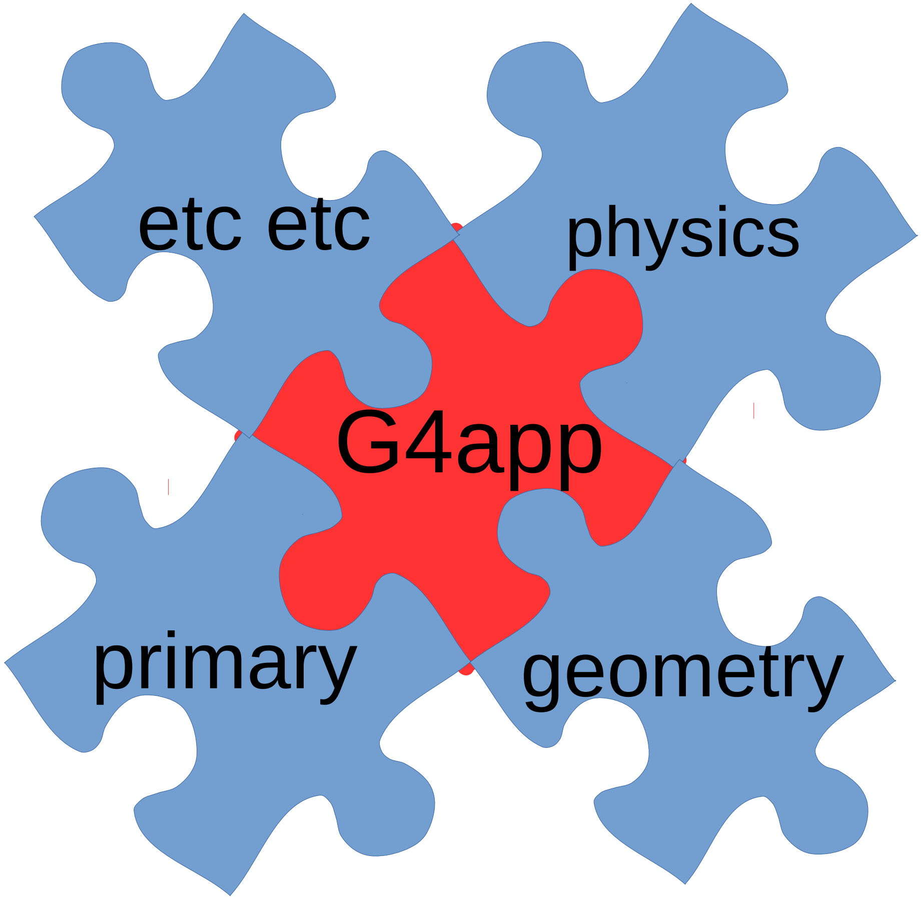
writing your G4 application



The source of radiation:

- simple gun
- generic source
- external file

writing your G4 application



et cetera..

- G4UserActions

- G4Hit/G4Digi read out and digitization

- G4Visualization

- Analysis

G4VRecipe

writing an application you must have:

- a class derived from G4VUserDetectorConstruction

  definition of your detector geometry
- a class derived from G4VUserPhysicsList

  selection of the physics processes
- a class derived from G4VUserPrimaryGeneratorAction

  producing primary events

optional classes inherit from:

- G4UserRunAction
- G4UserEventAction → to be done at the beginning/end of an event
- G4UserTrackingAction
- G4UserStackingAction
- G4UserSteppingAction

example of Main()

```
{
// Construct the default run manager
G4RunManager* runManager = new G4RunManager ;
// Set mandatory user initialization classes
MyDetectorConstruction* detector = new MyDetectorConstruction ;
runManager->SetUserInitialization(detector);
MyPhysicsList* physicsList = new MyPhysicsList;
runManager→SetUserInitialization(myPhysicsList);
// Set mandatory user action class (Primary Generator)
runManager->SetUserAction(new MyPrimaryGeneratorAction);

// Set optional user action classes (e.g. only a few of them)
MyEventAction* eventAction = new MyEventAction() ;
runManager->SetUserAction(eventAction);
MyRunAction* runAction = new MyRunAction() ;
runManager->SetUserAction(runAction);

delete runManager;
}
```

Generic Geant Simulation

thanks to Nicola Mori

- Generic implementation of G4 user classes
  - Hits, event actions, run actions,…
  - Persistence on Root files
  - Extensible with plugins
- Speeds-up the development of a G4 Monte Carlo simulation
  - Only geometry has to be created
- Code:
  - `https://baltig.infn.it/mori/GGSSoftware`
- User’s guide:
  - https://wizard.fi.infn.it/ggs/manual/

Auger SD Simulation

- CORSIKA: primary CR propagated in the Atmosphere

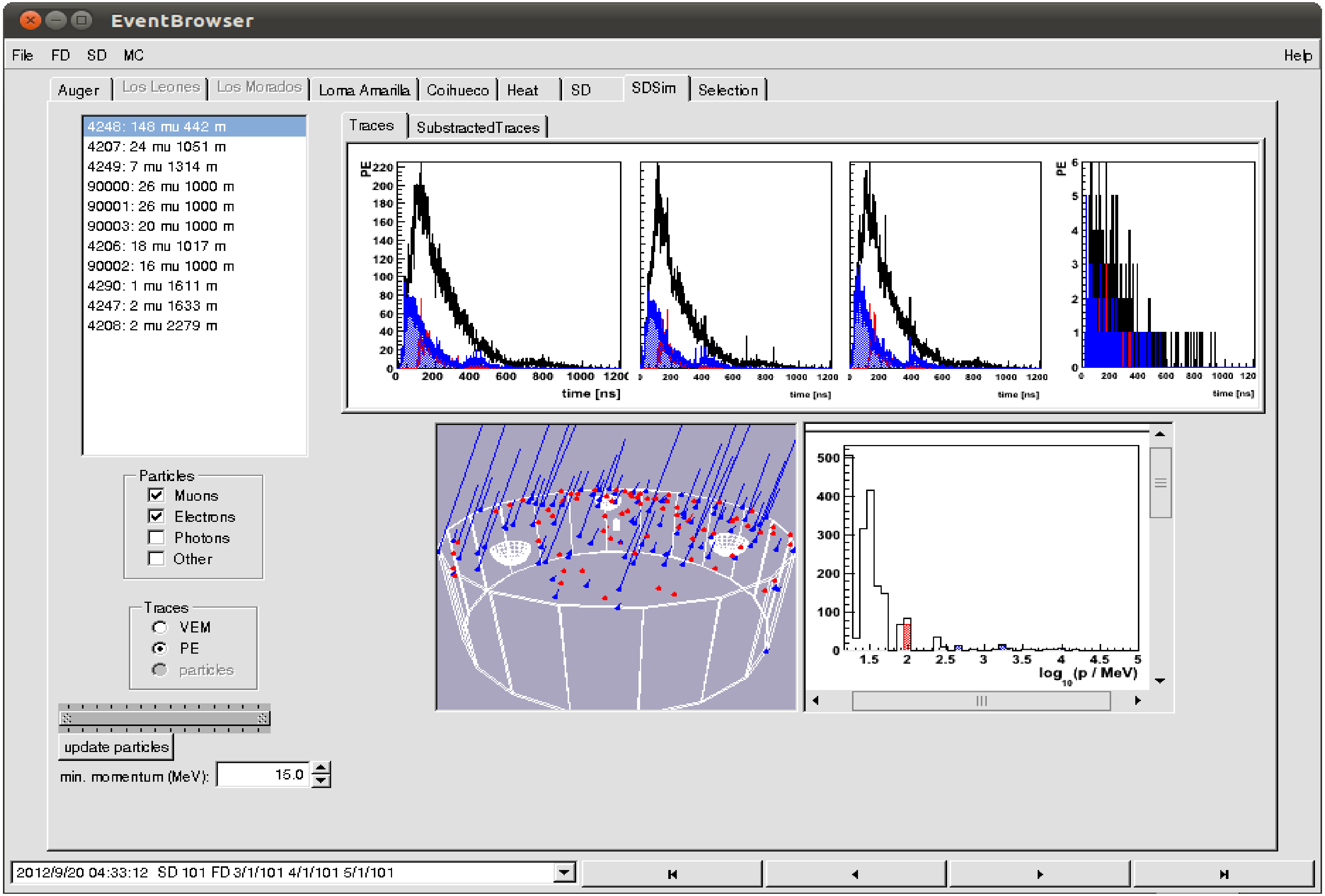
  output→ particle distribution at the ground

- Geant4: particles hit Water Cherenkov detectors → emission of light & tracking incl. reflections → detection in PMTs

  output → photoelectron time distribution

- electronics and PMT: response to single ph.el. to transform collected charge into a pulse in V → ADC

From p.el.(t) to ADCs



4248: 148 mu 442 m
4207: 24 mu 1051 m
4249: 7 mu 1314 m
90000: 26 mu 1000 m
90001: 26 mu 1000 m
90003: 20 mu 1000 m
4206: 18 mu 1017 m
90002: 16 mu 1000 m
4290: 1 mu 1611 m
4247: 2 mu 1633 m
4208: 2 mu 2279 m

Particles

☑ Muons
☑ Electrons
☐ Photons
☐ Other

Traces

○ VEM
● PE
○ particles

min. momentum (MeV): 15.0

2012/9/20 04:33:12 SD 101 FD 3/1/101 4/1/101 5/1/101