MONTE CARLO TRANSPORT SIMULATION

Panda Computing Week 2012, Torino

What is a Monte-Carlo simulation?

- The expression "Monte Carlo method" is actually very general. Monte Carlo (MC) methods are stochastic techniques, meaning they are based on the use of random numbers and probability statistics to investigate a problem

- A **Monte Carlo method** is a technique that involves using random numbers and probability to solve problems. The term Monte Carlo Method was coined by S. Ulam and Nicholas Metropolis in reference to games of chance, a popular attraction in Monte Carlo, Monaco

# What is a MC transport simulation?

- A Monte Carlo transport simulation is a program which simulates the passage of elementary particles through matter. [Geant3 User's Guide]

- In consists of the following parts:
  - Geometry package
  - Transport package
  - Visualization package
  - Detector response package
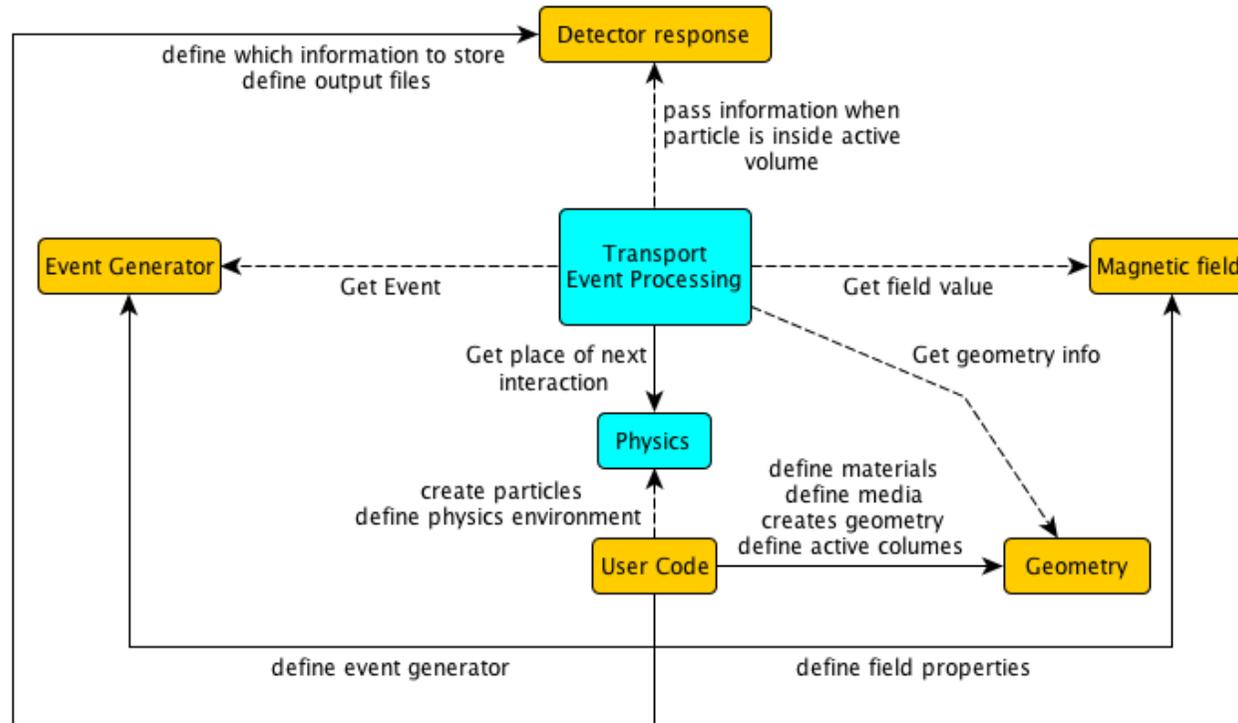 - User Code

How does a MC simulation work?

- Initialization
  - Create geometry
    - Define materials and media
    - Create the geometrical setup of the experiment
    - Define active sensitive volumes in the setup
  - Define/Create particles and their physics properties
- Event processing
  - Read one event from event generator
  - Transport one event through the setup
  - Cleanup to be ready for the next event
- Final Cleanup
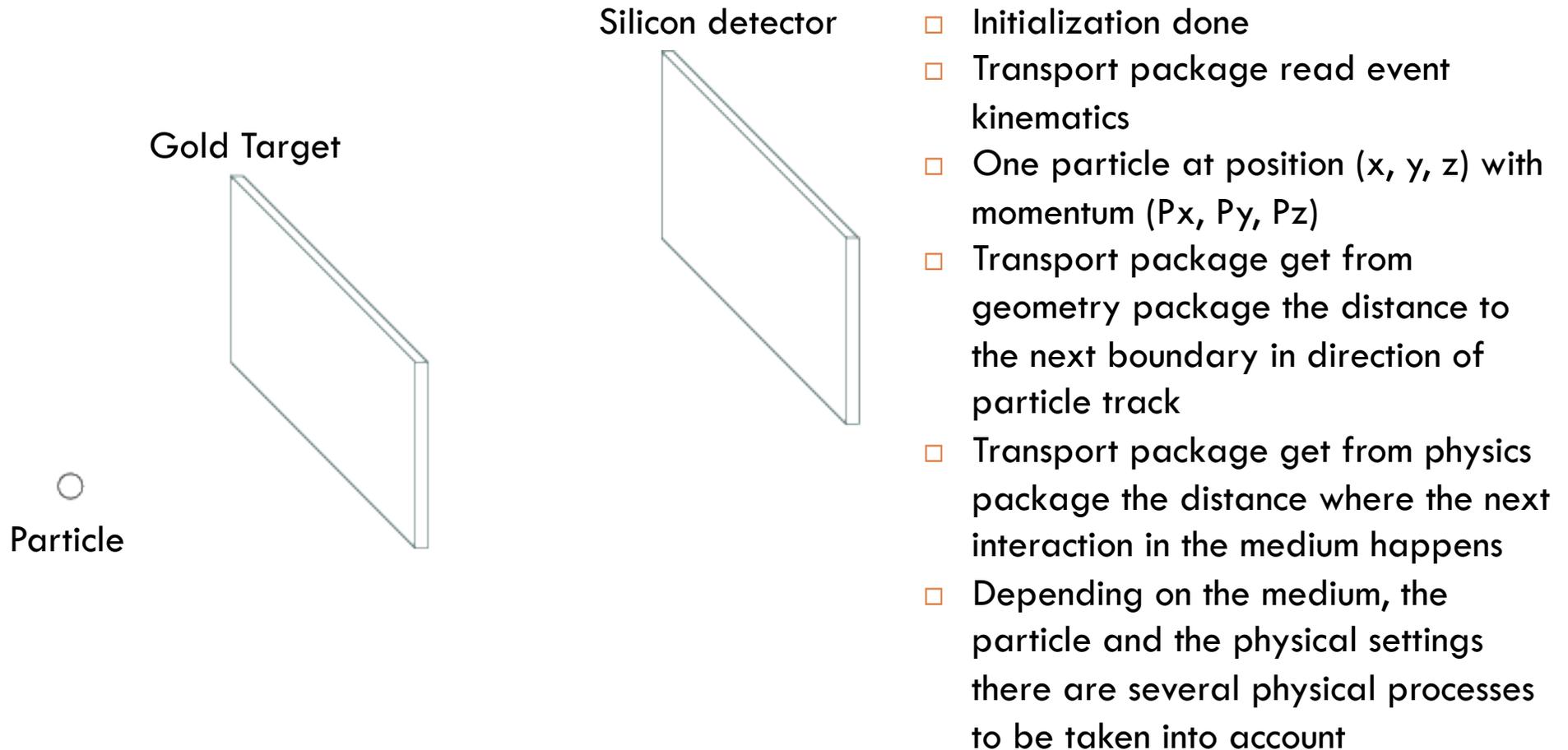 - Write data to file

How does a MC simulation work?
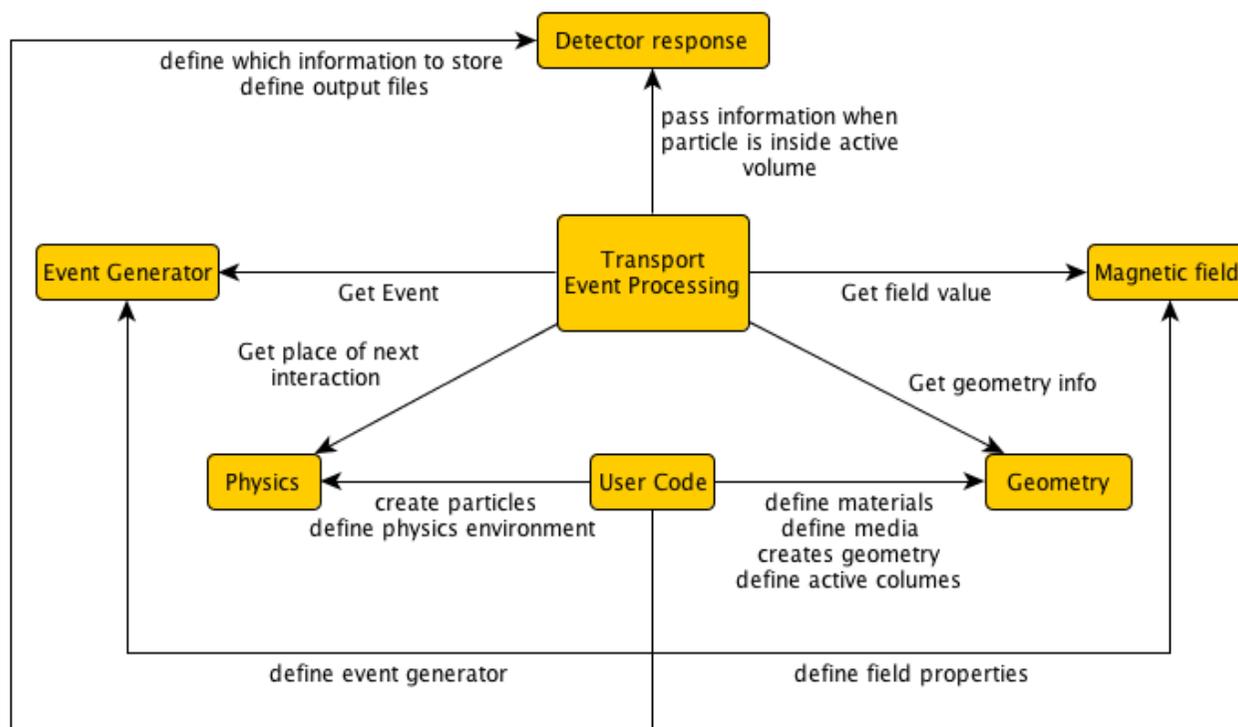
- Quite complex dependencies
- User code implemented "inside" the MC framework
- Complete rewrite needed for new MC framework
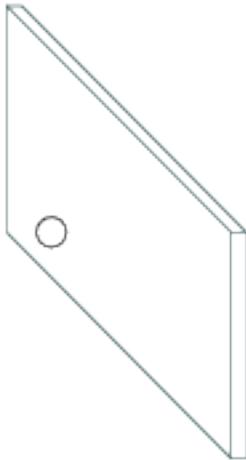
How does VMC work?

□ Use interfaces which decouple the user code and the concrete Monte Carlo

□ Use different Monte Carlo's with same user code
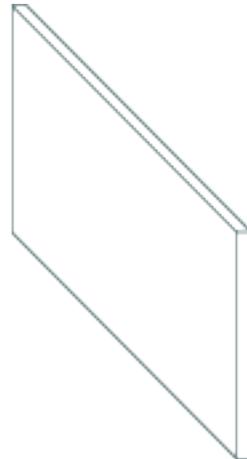
MC transport in detail (1)

Silicon detector

Gold Target

○
Particle

- Initialization done
- Transport package read event kinematics
- One particle at position (x, y, z) with momentum (Px, Py, Pz)
- Transport package get from geometry package the distance to the next boundary in direction of particle track
- Transport package get from physics package the distance where the next interaction in the medium happens
- Depending on the medium, the particle and the physical settings there are several physical processes to be taken into account
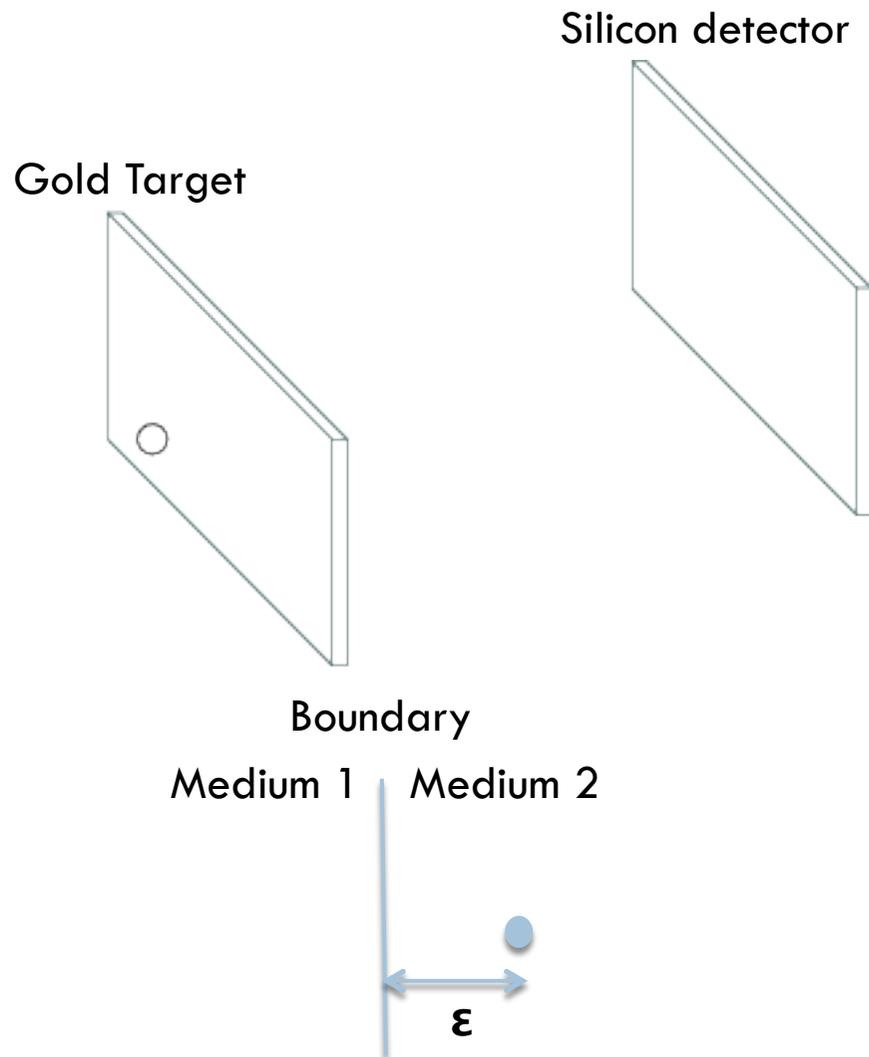
MC transport in detail (2)

Silicon detector

Gold Target

- Assume particle is in vacuum, so no interaction
- Transport moves particle on the next boundary to be crossed

MC transport in detail (3)

Silicon detector

Gold Target

Boundary

Medium 1 | Medium 2

ε

- Assume particle is in vacuum, so no interaction
- Transport moves particle on the next boundary to be crossed
- If one looks much closer, one can see that the particle is moved slightly inside the new volume
- Now the transport again checks for distance to next boundary and physical interaction
- Particle has an interaction inside the target (scattering) so the kinematic properties of the particle are updated
- Particle leave target without any further interaction.

MC transport in detail (4)

Silicon detector

Gold Target
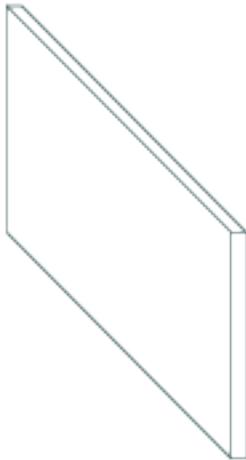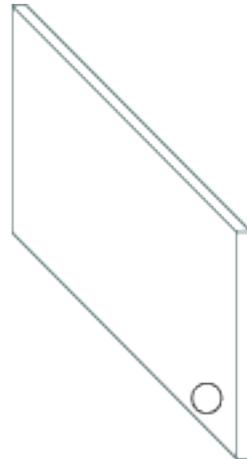
- Since particle is in vacuum again, it is moved across the next boundary
- This time we are in a detector (active medium)
- Detector response function is called for every step inside the detector which has access to the following information
    - Position
    - Momentum
    - Energy loss
    - PID
    - Track length
    - Time of flight

MC transport in detail (5)
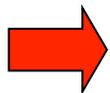
Sensitive Volume

2

1
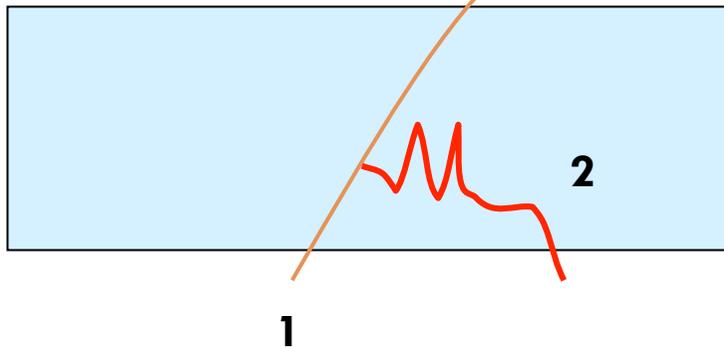
Geant 3
1: entering
1: exiting
2: entering
2: exiting

Geant4/Fluka
1: entering
1: disappeared
2: entering
2: exiting
1: entering
1:exiting

➡ **2 MC points**

3 MC points

- Tracks are transported sequentially
- Two possible ways
    - Put particle 1 on stack
    - Put particle 2 on stack
- Handled differently by different MC
- In CbmRoot
    - Save info when particle is entering a sensitive volume
    - Sum up energy loss while inside sensitive volume
    - Write complete MCPoint to output when particle leave sensitive volume

➡ **Only one MCPoint**
Second case handled wrong