Computing for HEP experiments

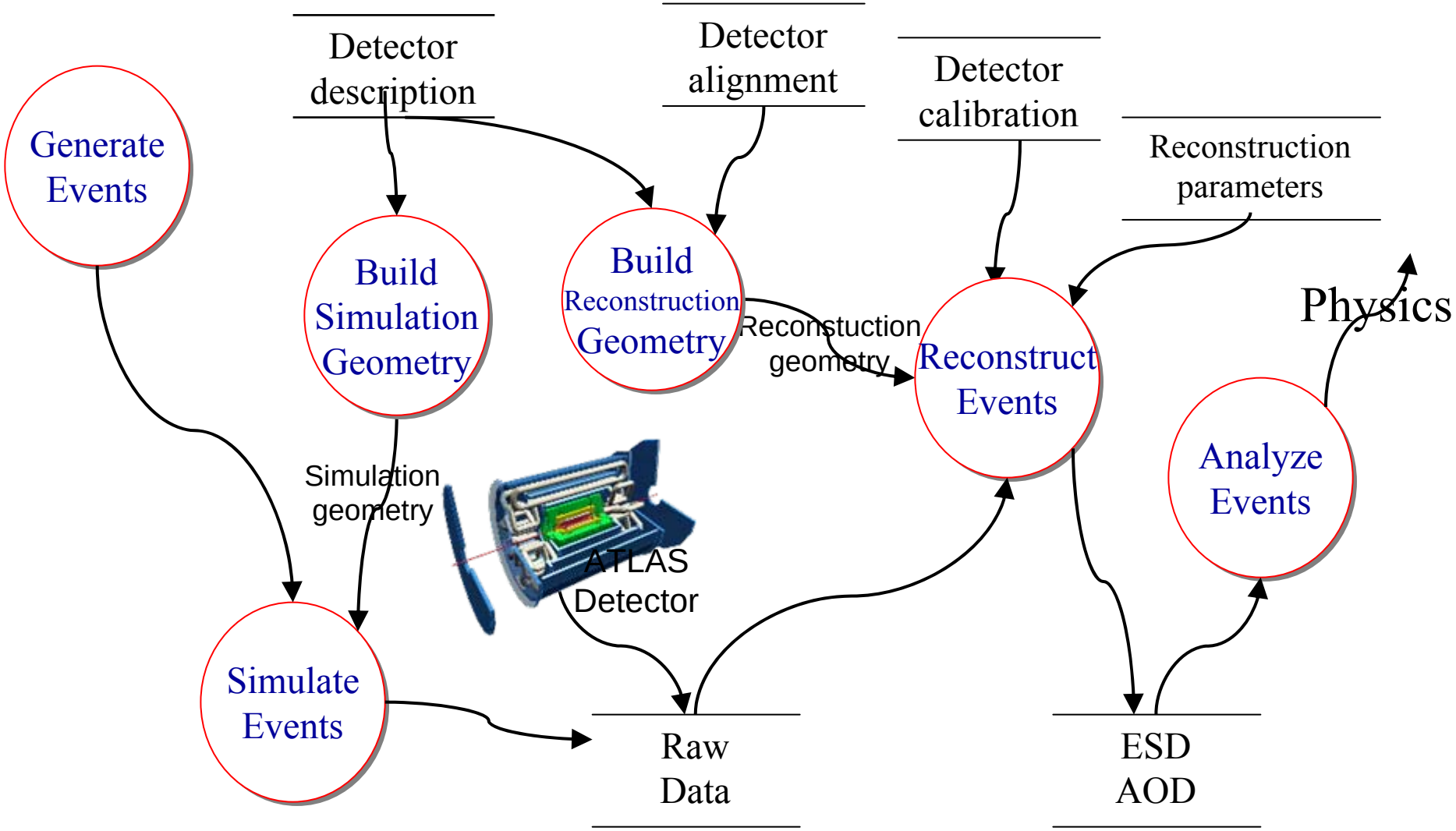
Outline of this course

Geant4:

toolkit for simulating the particles passage through matter material based on course given by Geant4 Collaboration, Dresden, October 2008.

http://www.ge.infn.it/geant4/events/nss2008/geant4course.html

'Where we are in the road path for data analysis"?



Geant 4

- Geant 4 is a toolkit for the simulation of the passage of particles through matter. Its area of application include high energy, nuclear and accelerator physics, as well as studies in medical physics and imaging and space science, radio-protection and radiation background studies. It exploits advanced software engineering techniques and Object Oriented technology to achieve transparency of the physics implementation, as well as openess to extension and evolution.

- Two main reference papers for Geant4 are published in Nuclear Intruments and Methods in Physics Research A 506 (2003) 250-303, and IEEE Transactions on Nuclear Science 53 No.1 (2006) 270-278.
- Geant4 will celebrate irs 10th birthday on 15 December 2008. mature system: 1000 citations of reference NIM paper.

The role of simulation

- Simulation plays a fundamental role in various domains and phases of an experimental physics project
  - design of the experimental set-up
  - evaluation and definition of the potential physics output of the project
  - evaluation of potential risks to the project
  - assessment of the performance of the experiment
  - development, test and optimisation of reconstruction and physics analysis software
  - contribution to the calculation and validation of physics results

- The scope of these lectures (and of Geant4) encompasses the simulation of the passage of particles through matter
  - there are other kinds of simulation components, such as *physics event generators*, *electronics response* generation, etc.
  - often the simulation of a complex experiment consists of several of these components interfaced to one another

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Detector Simulation - General

- General characteristics of a detector simulation system
  - You specify the set-up of an experimental system
  - Then the software system automatically transports the particle you shoot into the defined system by simulating their interactions in matter based on the Monte Carlo method
- The heart of the simulation: the Monte Carlo method
  - A method to search for solutions to a mathematical problem using statistical sampling with random numbers

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Basic requirements for a simulation system

- Modeling the experimental set-up
- Tracking particles through matter
- Interaction of particles with matter
- Modeling the detector response
- Run and event control
- Accessory utilities *(random number generators, PDG particle information etc.)*
- Interface to event generators
- Visualisation of the set-up, tracks and hits
- User interface
- Persistency

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What can Geant4 do for you?

- Transports a particle step-by-step by taking into account the interactions with materials and external electromagnetic fields, until the particle
  - loses its kinetic energy to zero,
  - disappears by an interaction,
  - comes to the end of the simulation volume
- Provides a way for the user to interact with the transportation process and access the simulation results
  - at the beginning and end of transportation
  - at the end of each step in transportation
  - at the time when the particle is in the sensitive volume of the apparatus
  - etc.

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What should you do for Geant4?

- Three essential pieces information you must provide:
  - Geometrical and material description of the detector
  - Choice of physics processes
  - Kinematical information of the primary particles to be tracked

- Auxiliary matter you could provide, if you wish:
  - Magnetic and electric field
  - Actions you want to take when you access particle transportation
  - Actions you want to take when a particle goes into a sensitive volume of the detector
  - etc.

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