Catania, .....

**TITLE: Monte Carlo Techniques (2 CFU)**

Lecturer: Dr. L. Pandola (INFN, Laboratori Nazionali del Sud)

**Abstract:**
The course is meant to provide an overview of the Monte Carlo techniques for physics. No specific Monte Carlo codes are considered, but rather the theoretical basic information is provided for the understanding of the basic principles of Monte Carlo simulations for particle tracking. The final aim of the course is that students are able to treat Monte Carlo codes not as "black boxes", but to assert autonomously the validity and the coherence of the results that are provided in output. In particular, the course will cover: sampling of random variables, numerical integration, error estimation in Monte Carlo calculations, particle tracking in homogeneous media, condensed, detailed and mixed Monte Carlo simulations, biasing techniques.

Blackboard lectures will be complemented by a few practical exercises. Lecture notes will be provided.

**Syllabus:**

1. Introduction to Monte Carlo techniques: applications and use cases
2. Random variables
   2.1 Continuous and discrete probability distributions
   2.2 Random number generators
   2.3 Sampling of random numbers from arbitrary distributions
3. Random numbers and numerical precision issues
4. Error estimation in Monte Carlo techniques
5. Monte Carlo numerical integration
6. Particle transport in homogeneous media
   6.1 Translation, rotation and changes of reference frame
   6.2 Basic concept of particle transport (gamma-rays)
   6.3 Markov chains
   6.4 Connection to the deterministic view
7. Mixed Monte Carlo simulation
   7.1 Delta interactions and soft energy losses
   7.2 Tracking algorithms for electrons and positrons (Penelope and Geant4)
   7.3 Effect of multiple Coulomb scattering
   7.4 Geometries and fields
8. Variance reduction techniques
9. Monte Carlo simulation codes
   9.1 Zoology of commonly-used Monte Carlo codes
   9.2 Tracking/production cuts and regions



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## Bibliography

1. F. Salvat, J.M. Fernandez-Varea and J. Sempau, “PENELOPE, a code system for Monte Carlo simulation of electron and photon transport”, PENELOPE User Manual, NEA (2008)
2. A.F. Bjelajew, “Fundamentals of the Monte Carlo method for neutral and charged particle transport” (2001)