Monte Carlo Method of Decay

T.C. Liu
LeCosPA,
National Taiwan University

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Outline

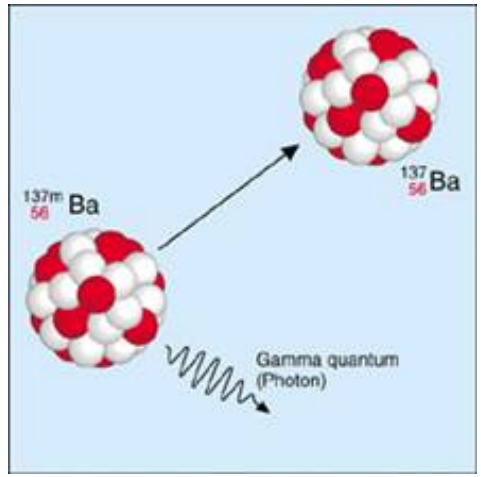
- What is decay?
- How to simulate the decay process by Monte-Carlo Method.
- UFFO
- Summary & Launch Schedule

Radioactive Decay

The basic random process

- Consider a system of N_0 unstable nuclei. How many parent nuclei, N, change with time?

$$N = N_0 e^{-\lambda t} \tag{1}$$

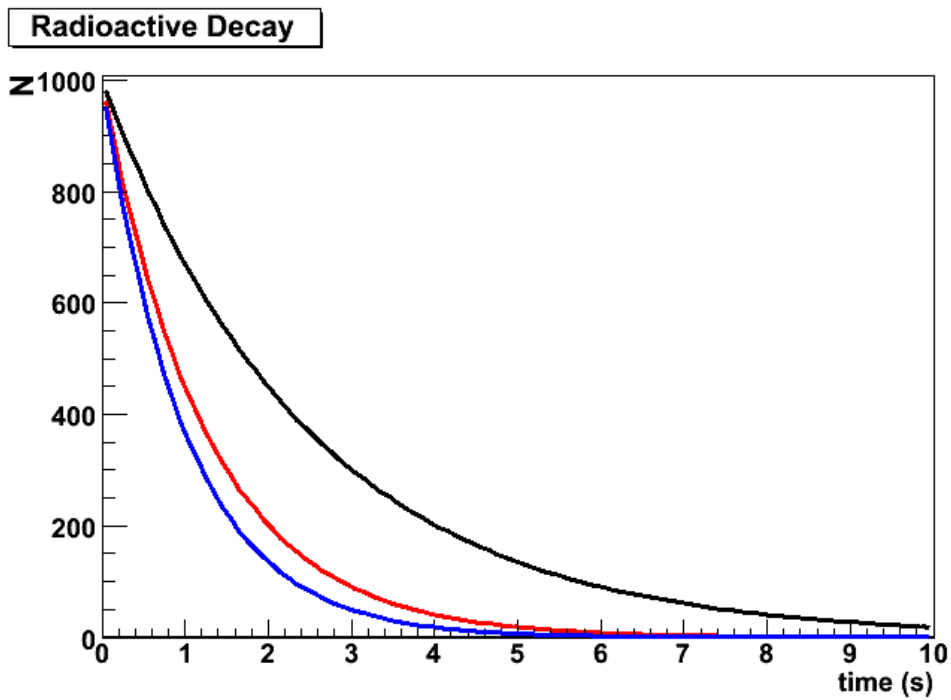


Radioactive Decay

Theory

$$N = N_0 e^{-\lambda t},\ N_0 \equiv 1000$$

Black Curve:$\lambda = 0.4$, Red Curve:$\lambda = 0.8$, Blue Curve:$\lambda = 1$

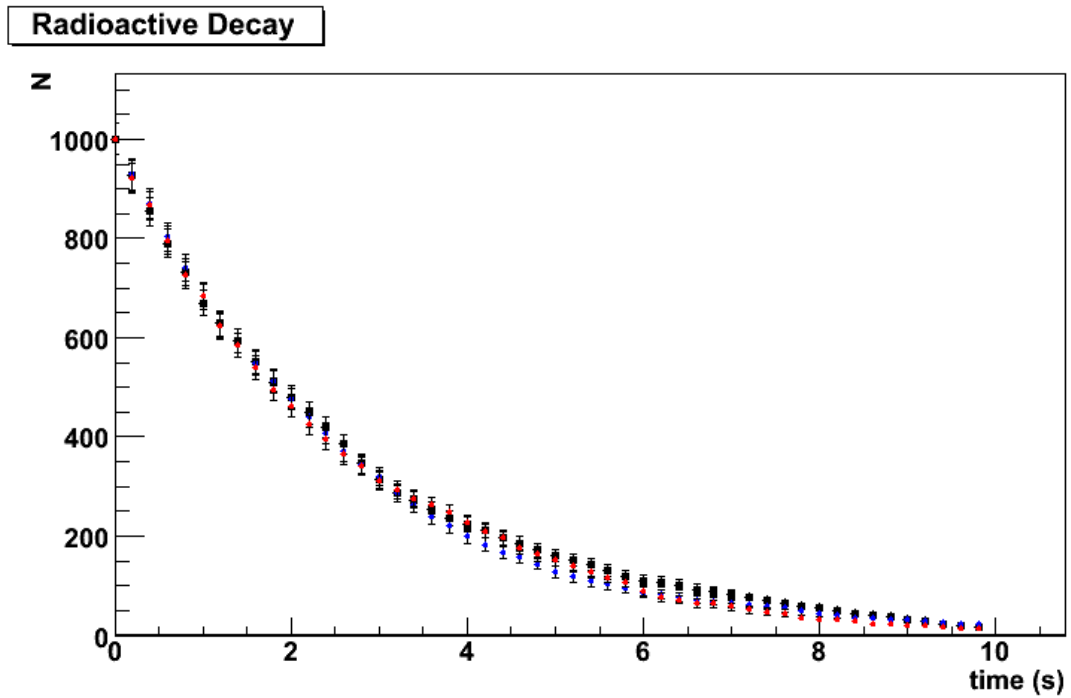


Radioactive Decay

The Basic Random Process

$$N = N_0 e^{-\lambda t},\ N_0 \equiv 1000$$

All of outputs are simulated result with $\lambda \equiv 0.4$.

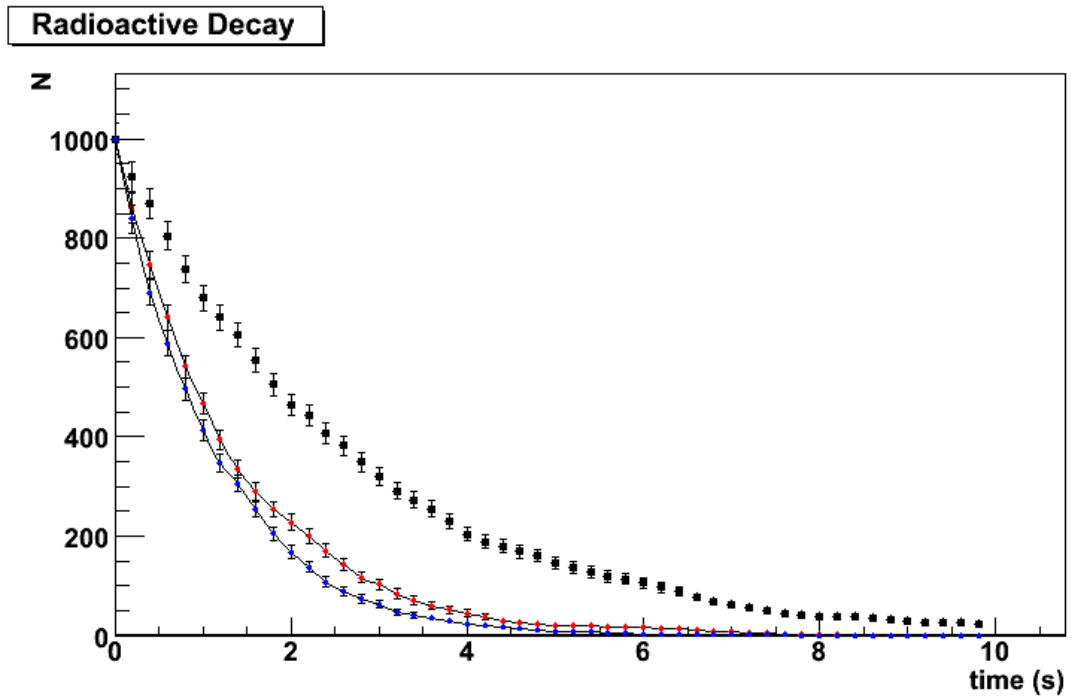


Radioactive Decay

The Basic Random Process

$$N = N_0 e^{-\lambda t},\ N_0 \equiv 1000$$

Black points:$\lambda = 0.4$, Red points:$\lambda = 0.8$, Blue points:$\lambda = 1$.

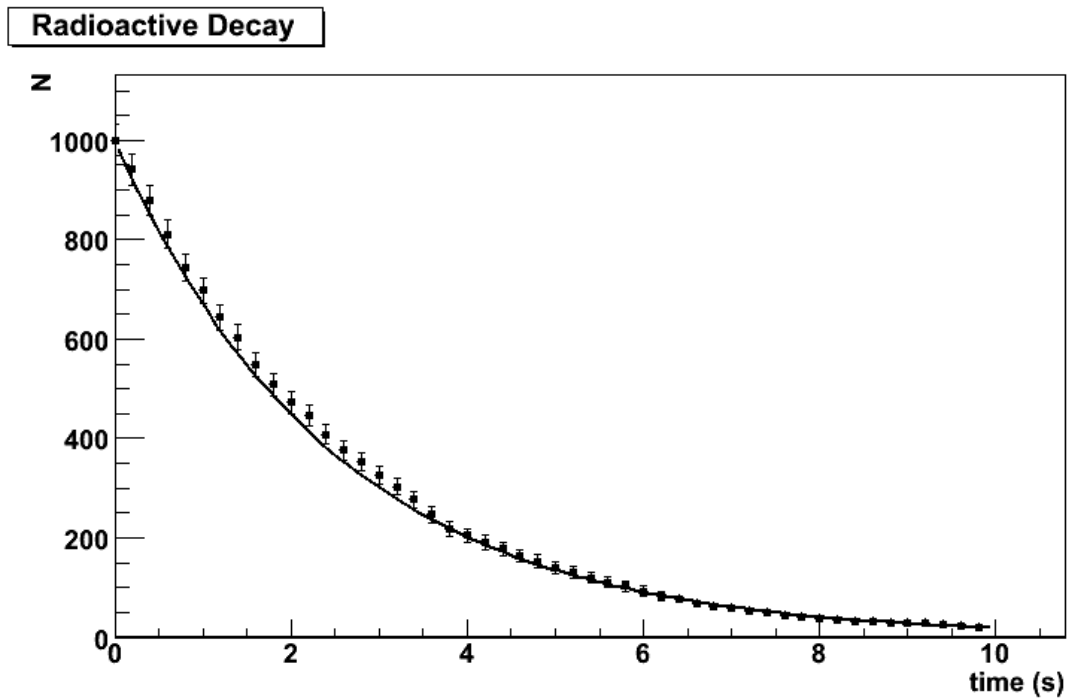


Radioactive Decay

Comparing the Simulation Outputs with Theory

$$N = N_0 e^{-\lambda t},\ N_0 \equiv 1000$$

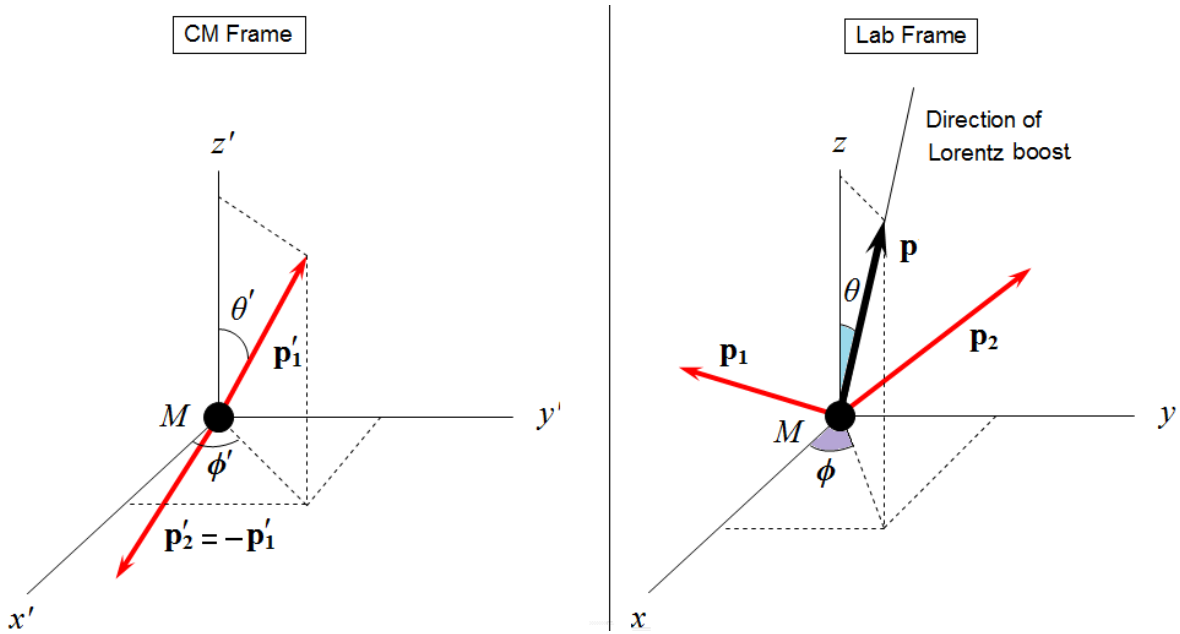
Black curve and dots correspond to the theory result and monte-carlo outputs.



Momentum Conservation

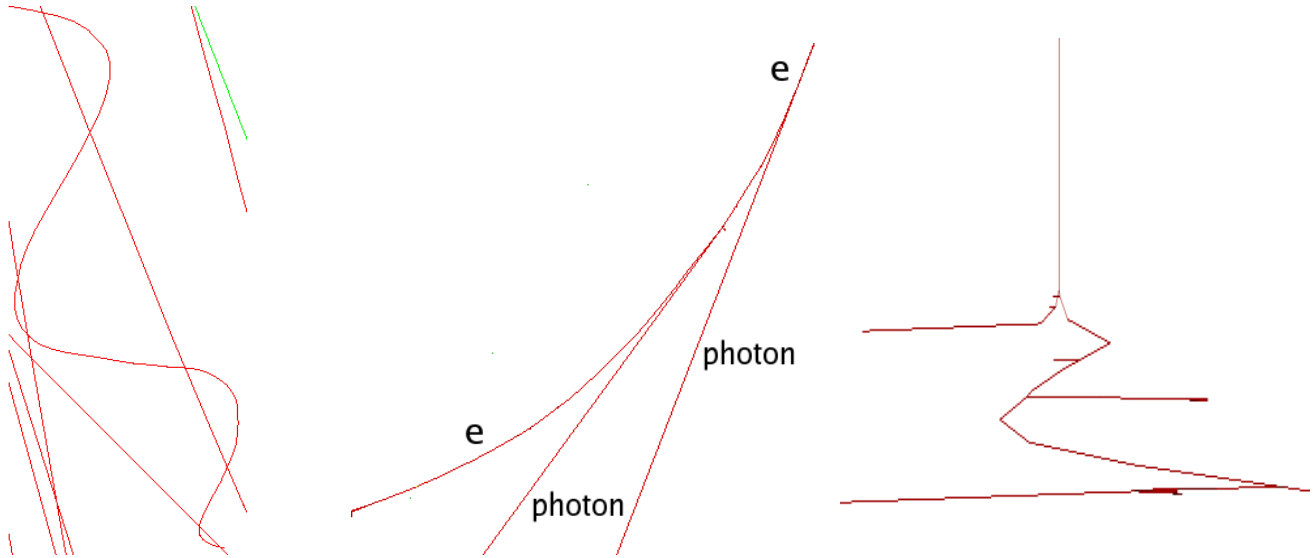
Four momentum : $p = (E, \vec{p})$

Momentum conservation: $p = p_1 + p_2$



Transpot of Particle

Ionization.
PhotoNuclear; Pair Production; Bremsstrahlung.

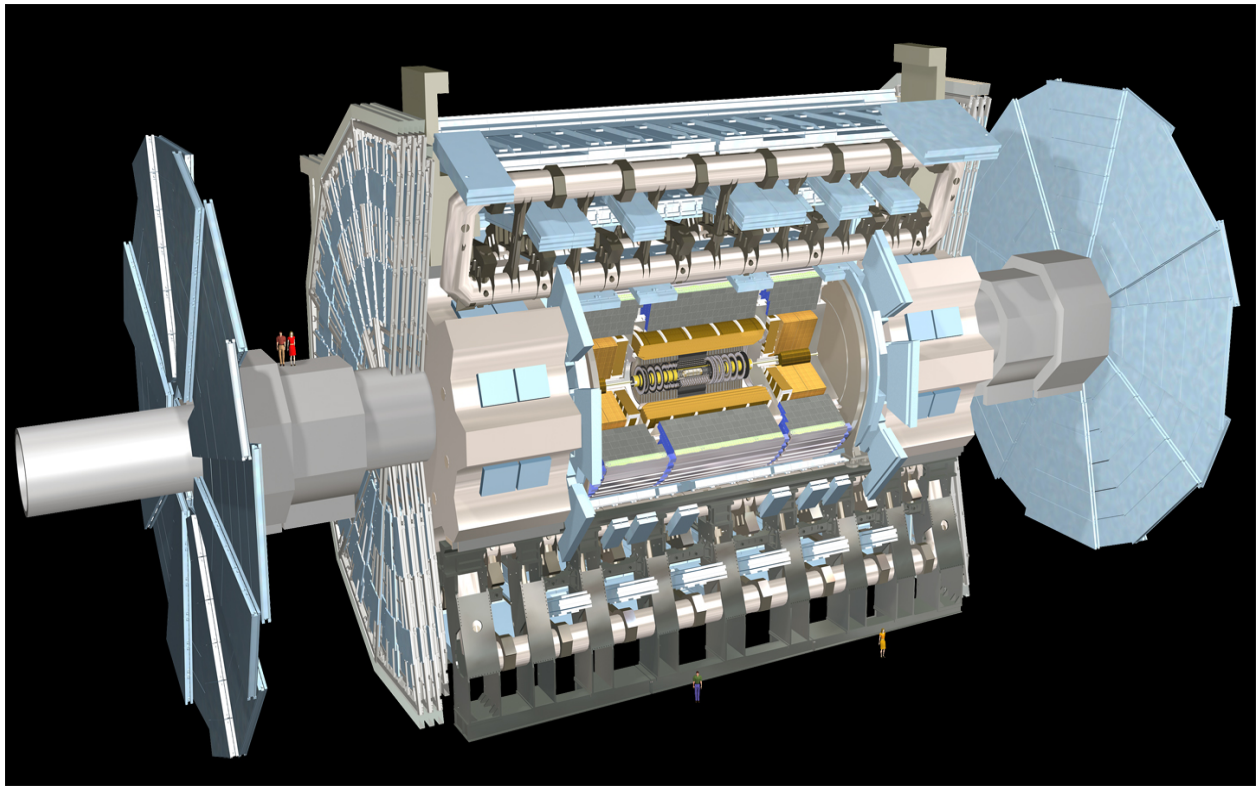


(a) Deflection (b) Bremsstrahlung (c) Pair Production

Figure: Red = electrons, positrons, gammas; Green = muons; Blue = hadrons.

Particle Interaction Simulation

GEANT4: http://geant4.cern.ch/
FLUKA: http://www.fluka.org/fluka.php
MCNP5: http://mcnp-green.lanl.gov/index.html



Figure

Particle Interaction Simulation

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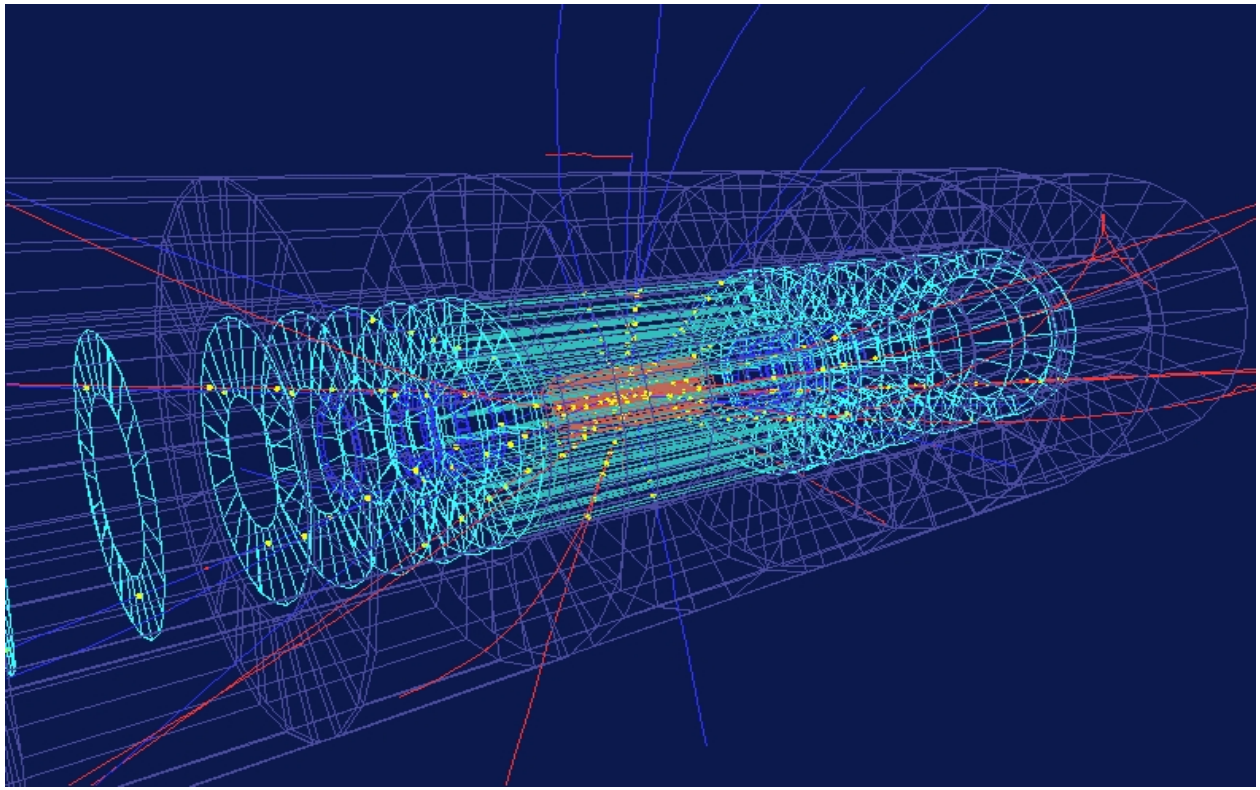


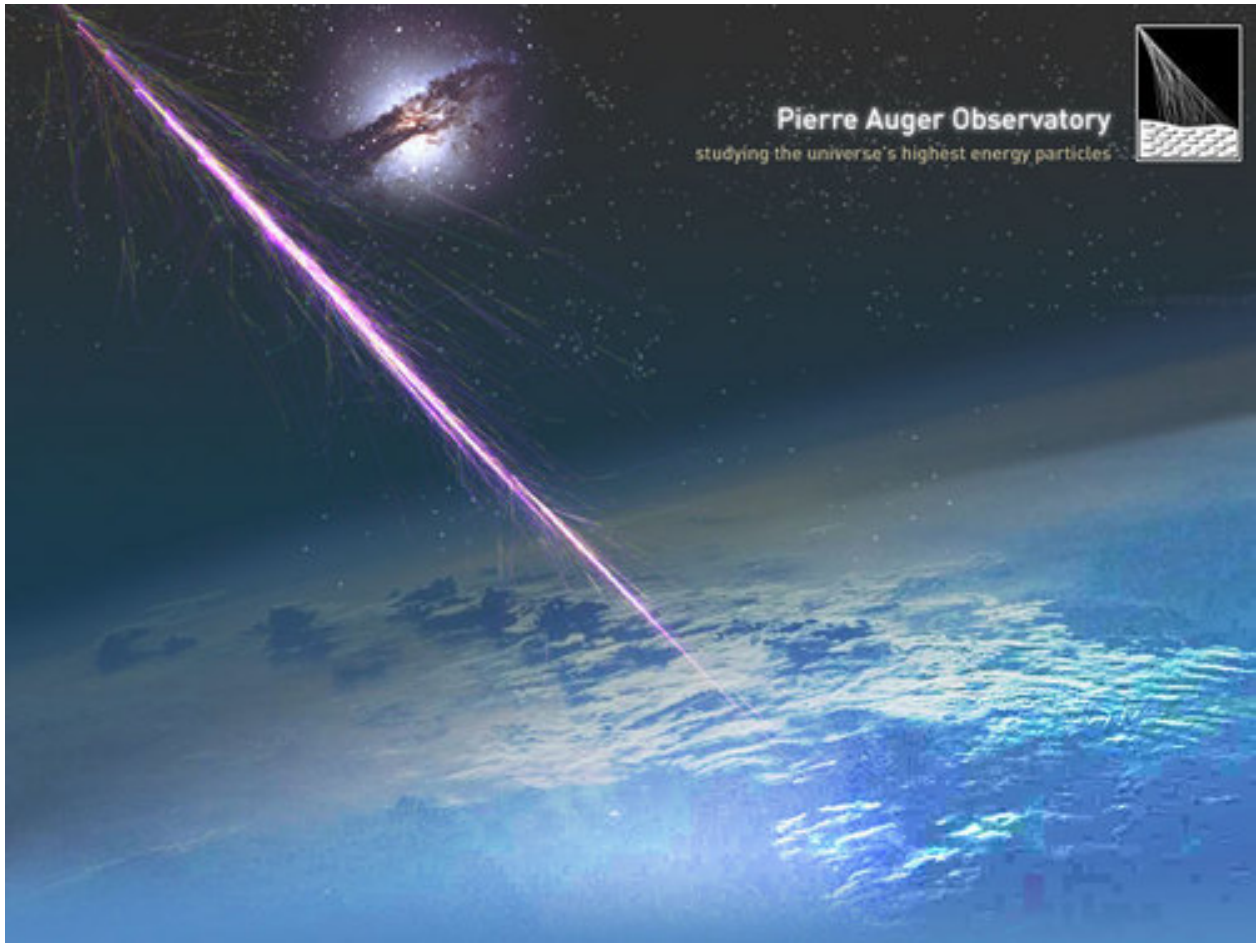
Figure

Air Shower Simulation

Aires: http://astro.uchicago.edu/cosmus/projects/aires/
Corsika: http://www-ik.fzk.de/corsika/

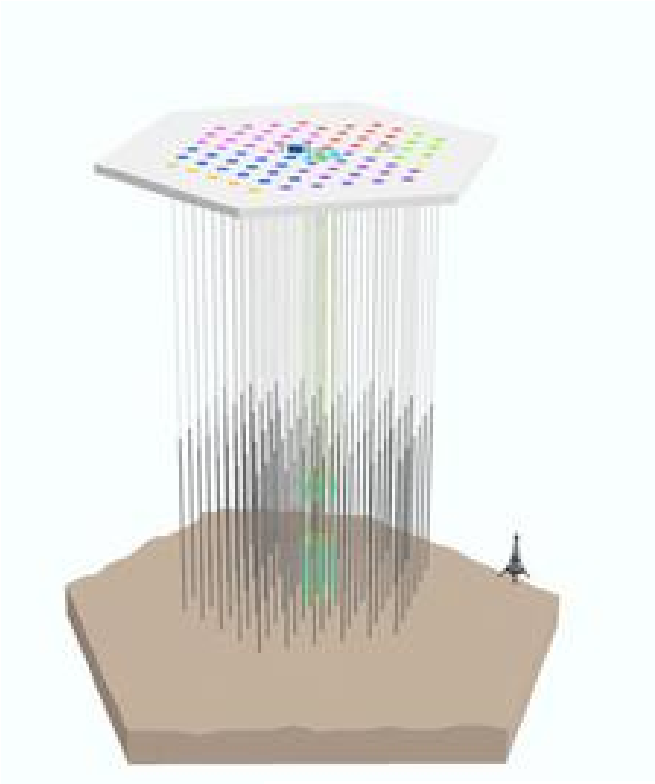
Pierre Auger

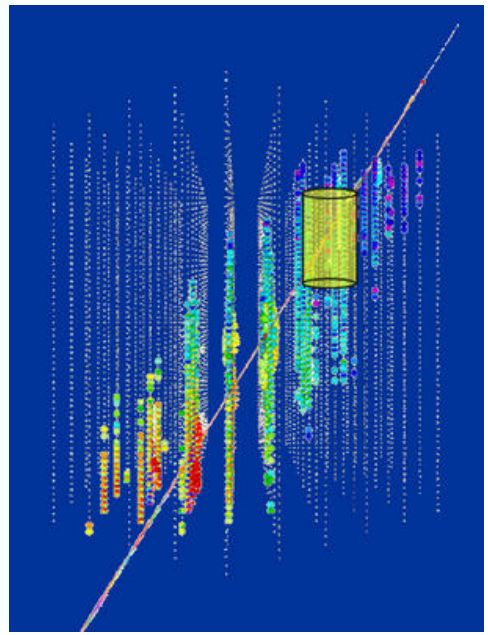
http://www.auger.org/

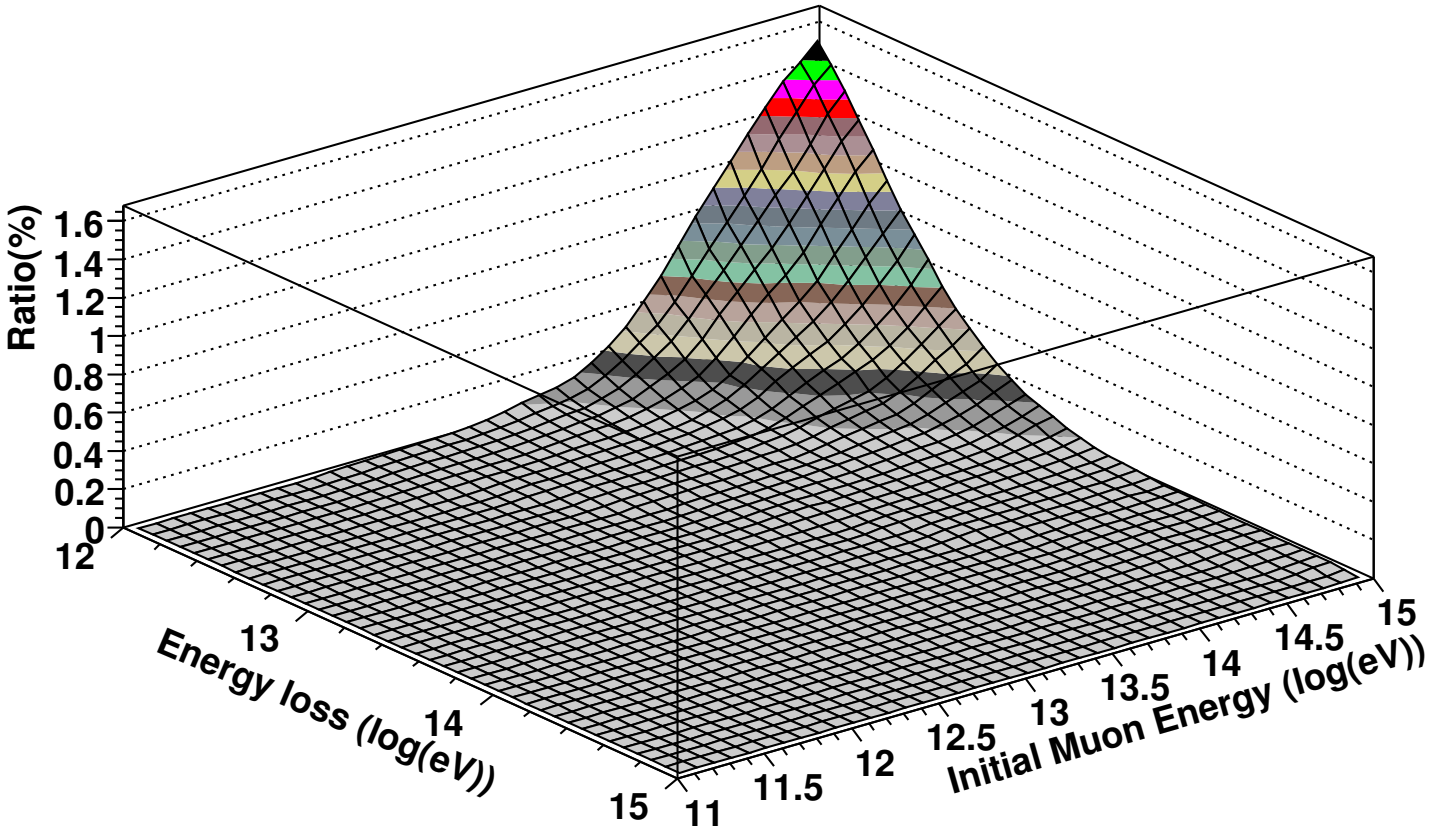


IceCube

http://icecube.wisc.edu/






Ratio(%)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
12
13
14
15
Energy loss (log(eV))
11
11.5
12
12.5
13
13.5
14
14.5
15
Initial Muon Energy (log(eV))

Figure