Particle Interaction with Matter

- Electromagnetic interactions
  1. Interactions of charged particles
  2. Interaction of photon
- Strong interactions

Excitation and ionization

- Interaction with the bound electrons in the atoms of the matter
  - Incident particle much heavier than electron
  - Incident particle is electron
  - The Bethe-Bloch formula of dE/dx
    - Proportional to z^2
    - MIPs and relativistic rise
    - Use GEANT4 to produce Fig. 1.2

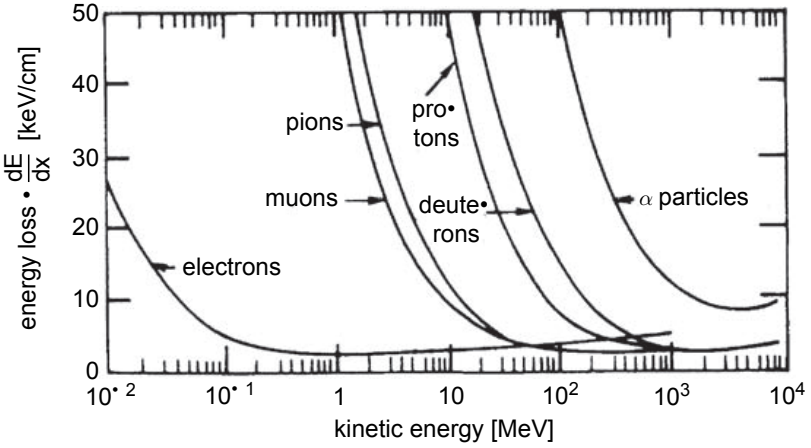

Fig. 1.2. Energy loss for electrons, muons, pions, protons, deuterons and α particles in air [14].

Channeling

- Excitation and ionization in a crystal (atoms on a regular lattice)

Ionization yield

- Generated electron-hole (ion) pairs
- What is the take away from this section?

Multiple scattering

- What is the take away from this section?

Bremsstrahlung

- Energy loss due to radiation produced in the strong electric field near a nucleus.
- The dE/dx ?
- Compare this with the Bethe-Bloch formula, what do you find?

Direct electron-pair production

- What is this?

Photonuclear interaction

- What is this?

Total energy loss

- All that go into dE/dx ?
- Can you reproduce Fig 1.7 with muon and electron? Discuss about each contribution's relative importance. Remember, electron and muon from Z decays at LEP are about 45 GeV

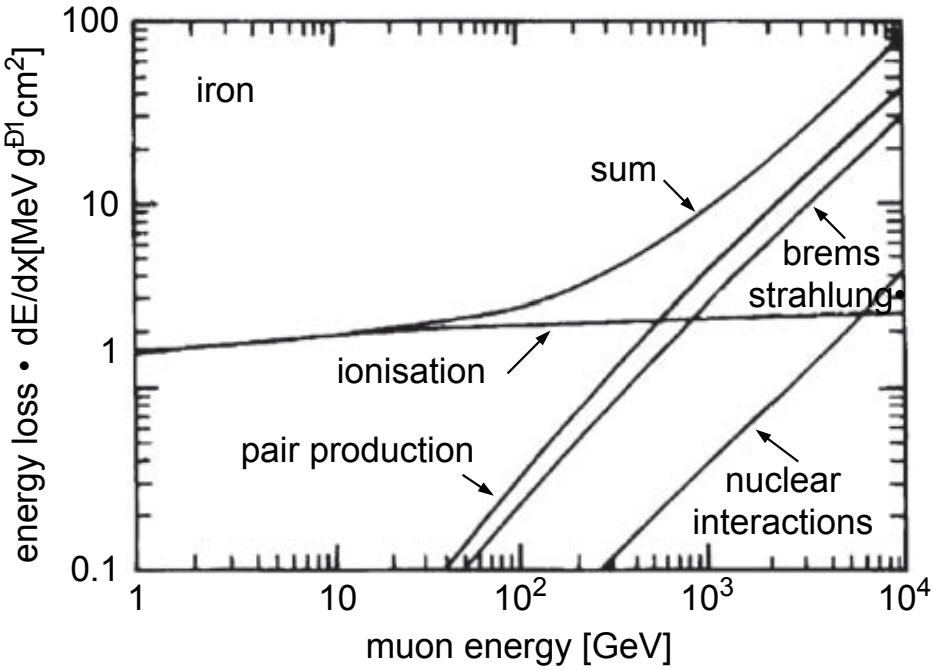

Fig. 1.7. Contributions to the energy loss of muons in iron [42].

Energy-range relationship

- What is the take-away from this section?

Synchrotron radiation

- Other radiations:
  - Cerenkov radiation
  - Transition radiation
  - Synchrotron radiation
- Synchrotron radiation

Photon specific interactions

- Photoelectric effect
- Compton scattering
- Pair production
- Now add them up and use GEANT to reproduce Fig. 1.15

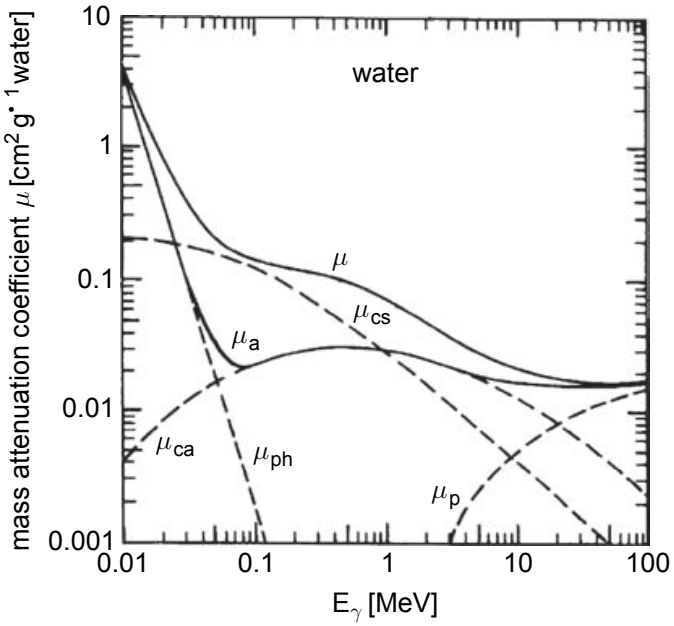

Fig. 1.15. Energy dependence of the mass attenuation coefficient μ and mass absorption coefficient μ_a for photons in water [48, 56, 61, 62]. μ_{ph} describes the photoelectric effect, μ_{cs} the Compton scattering, μ_{ca} the Compton absorption and μ_p the pair production. μ_a is the total mass absorption coefficient ($\mu_a = \mu_{ph} + \mu_p + \mu_{ca}$) and μ is the total mass attenuation coefficient ($\mu = \mu_{ph} + \mu_p + \mu_c$, where $\mu_c = \mu_{cs} + \mu_{ca}$).