Lecture : Introduction to Elementary Particle Physics
DESY Summer Student Program 2005
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# TEST : Did I learn the essentials ?

1. Leptons of 2 GeV total energy scatter on protons at rest. How big is the invariant mass of the lepton-proton system in case the lepton is a a) neutrino, b) electron, c) $\tau$ - lepton
2. What was the crucial experiment to demonstrate that one has to differentiate between $\nu_e$ and $\nu_\mu$ ?
3. What conservation laws are violated in weak interactions compared to electromagnetic interactions ?
4. How does the $\pi^+$ decay ? Why does it decay so rarely into $\pi^+ \to e^+\nu_e$ ?
5. How do the charged lepton spectra differ in the decays of $\pi^+$ and $\mu^+$ ?
6. Which data show that quarks come in 3 degrees of freedom (color) ?
7. How does the $W$ decay ? Quantitative relation between the leptonic and hadronic decay channels.
8. What does *lepton universality* mean ? Examples.
9. How do we know that there are just 3 generations of fundamental fermions ?
10. What limits the maximal reachable energy of proton accelerators and that of electron accelerators ?
11. What distance (in vacuum) does a $\pi^+$ , $\pi^-$, $\pi^0$ of 140 GeV reach on average before decaying ?
12. How can one experimentally distinguish between $\gamma, e^+, \pi^+, \mu^+, \tau^+$ ?
13. What was the experimental evidence for 'strange quarks' ?
14. What was the experimental evidence for 'charmed quarks' ?
15. What was the experimental evidence for 'top quarks' ?

16. What was the experimental evidence for $\tau$ ?

17. How does the $\tau^-$ decay ?

18. What is the quark composition of the $\Delta^{++}$? How does it decay ? Via which interaction ? What life time ?

19. What is the quark composition of the lightest strange Baryon ? How does it decay ? Via which interaction ? What life time ?

20. What type of neutrino is dominantly produced in a) the sun, b) at a reactor, c) at accelerators ?

21. How can one produce a pure $\nu_\mu$ beam with only minimal Anti-$\nu_\mu$ admixture ?

22. How did one discover the existence of weak neutral currents ?

23. Give some examples for parity violation in weak interactions.

24. Under which conditions are neutral particles their own antiparticles ? Give examples and counter examples.

25. The $J/\Psi$ particle ('HEP-November revolution 1974') was found at a mass of 3.1 GeV at the SPEAR $e^+e^-$ storage ring. At slightly higher masses one discovered the $\Psi'$ and $\Psi''$ particles. Why is the width of the $\Psi''$ so much larger (factor 100) than that of the $\Psi'$ ?

26. How is it possible to separate in lepton-proton scattering experiments the scattering on quarks from the scattering on antiquarks ?

27. How is it possible to separate in lepton-proton scattering experiments the scattering on u-quarks from the scattering on d-quarks ?

28. Which data prove that the quarks have charges 1/3 and 2/3 ?

29. Draw all (relevant) Feynman diagrams for the following leptonic reactions
    $e^+e^- \rightarrow e^+e^-$
    $e^+e^- \rightarrow \tau^+\tau^-$
    $\nu_\mu e^- \rightarrow \nu_\mu e^-$
    $\nu_e e^- \rightarrow \nu_e e^-$

30. Why does the electron have a mass of 0.5109989 MeV ?