Kern- und Teilchenphysik II
Exercise Sheet 1

HS 16
Prof. Nicola Serra,
Dr. Annapaola De Cosa

Dr. Marcin Chrzaszcz
http://www.physik.uzh.ch/de/lehre/PHY213/FS2017.html

Issued: 25.03.2017
Due: 31.03.2017

Exercise 1: Conservation laws (3.5 Pts.)

Under which interactions are the following interactions possible (please not that some of the processes) are not possible at all):

- $\pi^- p \to \pi^0 n$
- $\pi^0 \to \gamma\gamma\gamma$
- $\pi^0 \to \gamma\gamma$
- $\pi^+ \to \mu^+ \nu_\mu$
- $\pi^+ \to \mu^+ \bar{\nu}_\mu$
- $p\bar{p} \to \Lambda_0 \Lambda_0$
- $p\bar{p} \to \gamma$

Exercise 2: Forbade decays (2.0 Pts.)

Which conservation laws forbade the following decays:

- $n \to pe^-$
- $n \to \pi^+ e^-$
- $n \to p\pi^-$
- $n \to p\gamma^-$

Exercise 3: Suppress decays (2.0 Pts.)

Which conservation laws forbade or suppress the following processes:

- $pn \to p\Lambda^0$
- $K^+ \to \pi^-\pi^+\pi^-\pi^+\pi^+\pi^0$
- $\Lambda_0 \to K^0\pi^0$

- $K \to \pi\gamma$
- $K^- \to \pi^0 e^-$
- $K^+ \to \pi^+\pi^-\pi^0$

Exercise 4: Pion decay (16 Pts.)

Please calculate the matrix element of the dacay $\pi^- \to \mu\nu_\mu$. The form factor for the pion has the form of $F^\mu = p_\mu f_\pi$, where f_π is so called pion decay constant and is calculated on lattice to be $f_\pi = 130$ MeV. Using the matrix element calculate the Γ. Calculate also the Γ for the $\pi^- \to e\nu_e$. Why is the electron mode different then the muon one?

Please read about the "Casimir trick" in the D. Griffiths handbook (Sec. 7.7).

Exercise 5: Muon decay (16 Pts.)

Calculate the matrix element for the dacay of the muon: $\mu^- \to e^-\nu_\mu\bar{\nu_e}$. Using "Golden Rule" calculate the calculate the Γ and the lifetime of the muon.

Exercise 6: Muon decay simulation (12 Pts.)

Please simulate the muon decay from exercise 5 using ROOT. Please assume for the moment flat phase space (aka matrix element =1). The example can be found:

`https://root.cern.ch/root/html/tutorials/physics/PhaseSpace.C.html`

having simulate this decay please calculate the electron energy in the muon central of mass and draw it for your simulated events. Simulate at least 100.000 events.