The Nuclear Physics Weekly IV

Anish

September 2, 2021

Contents

1 Overview

We start with revisiting our motivation for the current research which is to understand how different particles decay and why do they do so. The challenging part of this process is finding all the stages of decay process which may involve intermediate particles with ultra-low lifetime. QCD spectroscopy deals with just this and Lattice QCD is the tool that is used to accomplish this.

We then moved on to Particle Data Group's website where different particles and their decay products with (a lot) more details is maintained. A particle can decay in multiple pathways - which obey all the conservation rules - with different probabilities, some higher than others. For example $\pi^{\pm}$ decays into $\mu^{\pm}$ and ν_{mu} 99% of the time. Other decay pathways are there but they have low probability. The lifetime also depends on the force through which the particle is decaying. Stronger the force, faster will be the decay. Hence, particles decaying through QCD will have much lower lifetime compared to other decay mechanisms.

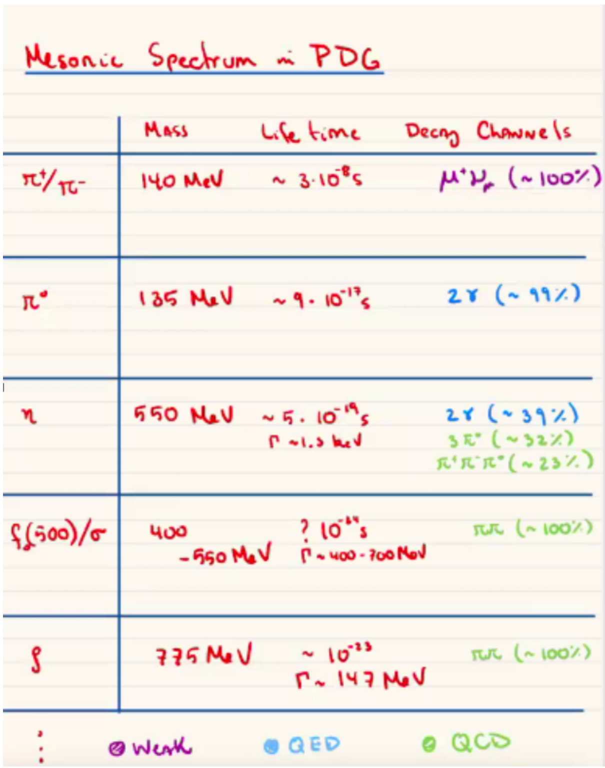

Figure 1: Some common particles and their decay products. Green → QCD, Blue → QED, Violet → Weak

QCD is very strongly interacting. This make it mathematically much more complex than other forces. So for simplifying things, we consider a simpler standard model where forces other than QCD are not present. As a consequence of this, particles that majorly decay through forces other than QCD are essentially stable (lifetime $\to \infty$). For example, $\pi^{\pm}$ which decays generally through weak force is now stable. This is not a catastrophic simplification because most mesonic and baryonic particles decay through QCD.

We then looked at how higher the mass a particle has, more will be the possible decay states. This is simply due to the fact that a particle with high mass will have higher energy which can then in turn be used to produce more particles. Higher the energy, more will be the particles of which the energy clears production threshold of and hence more possible decay states. This is illustrated in the figure below.

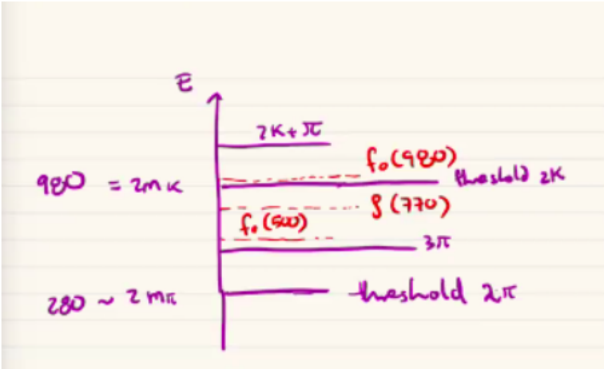

Figure 2: Energy thresholds for different particles.

We then discussed how these hardonic resonances are produced in different facilities. Three different ways to prodcuing a ρ resonance are show below in figure below. Note that although these resonances are created through different mechanisms, the ρ thus produced have same properties i.e., resonances are universal.

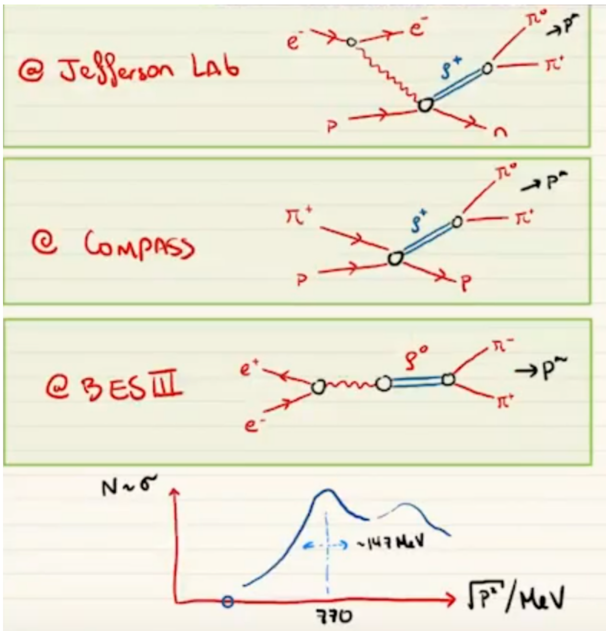

Figure 3: ρ resonance production at Jlab, COMPASS and BES III.