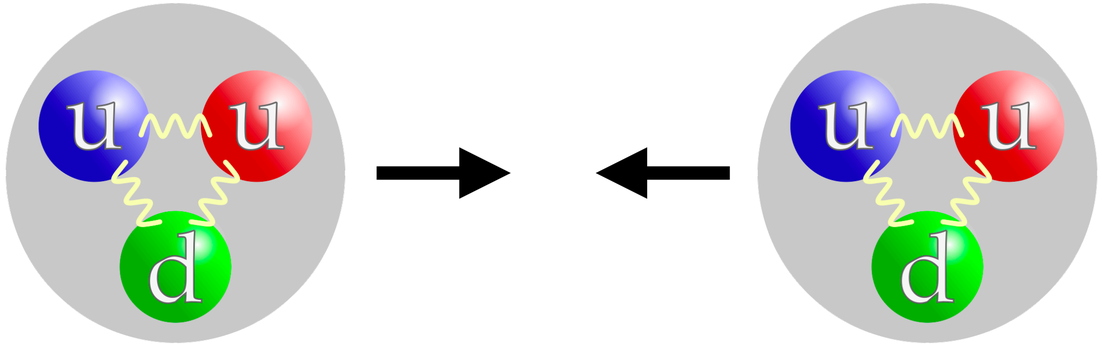
# PHYS 142/242

## Lecture 18: Particle Physics & VEGAS

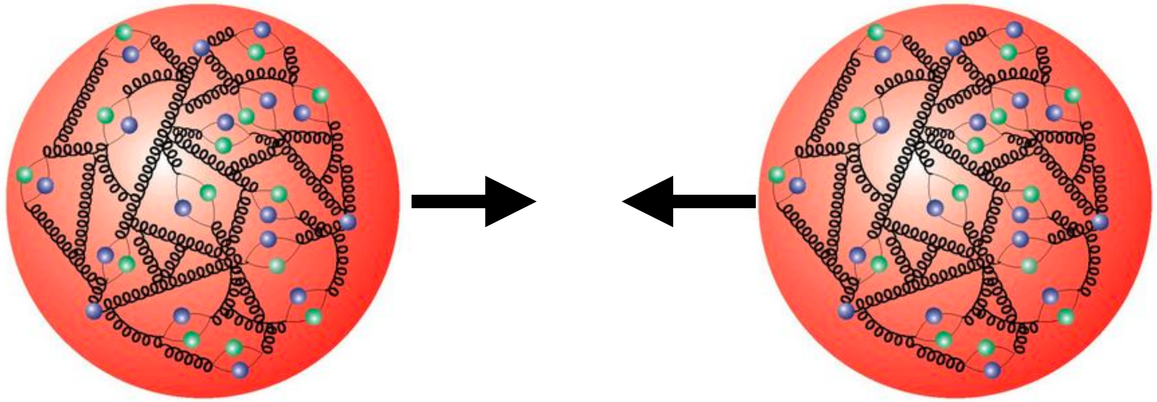
Javier Duarte — February 24, 2025

# Motivation

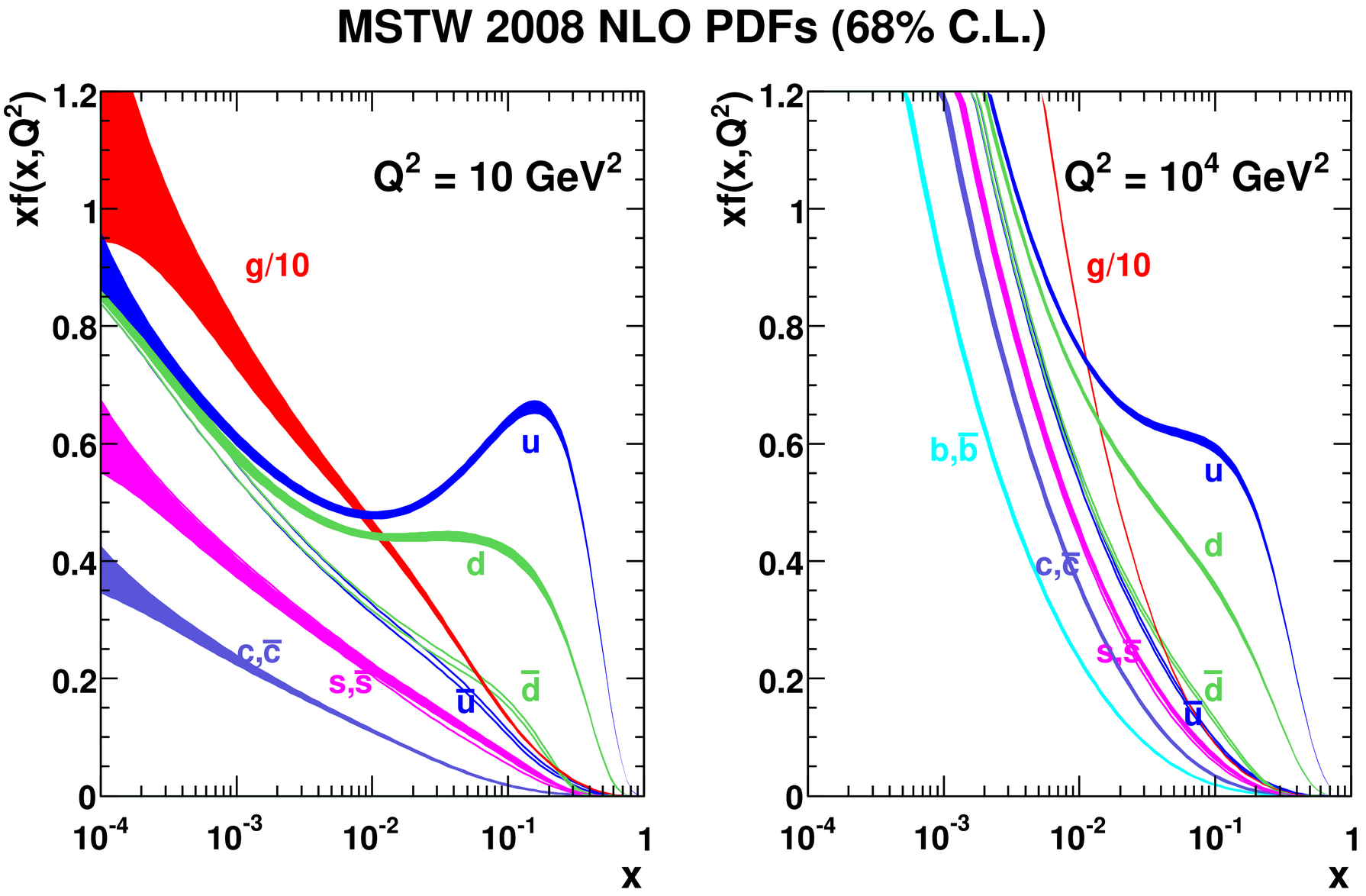
In high energy particle physics, we often want to calculate what happens when we collide two protons




But protons are actually filled with a lot of “stuff” (quarks and gluons, collectively called partons)



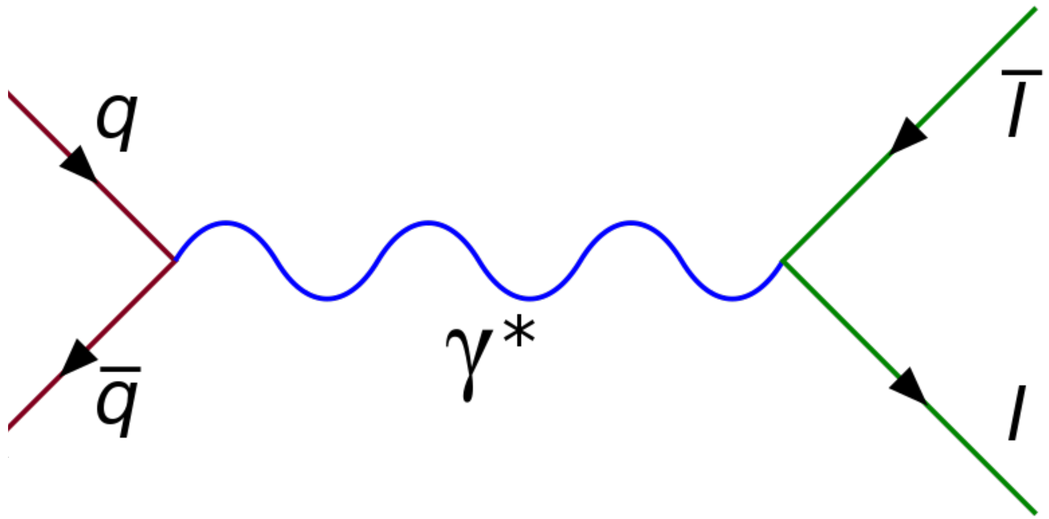
# Parton distribution functions



# Drell-Yan production

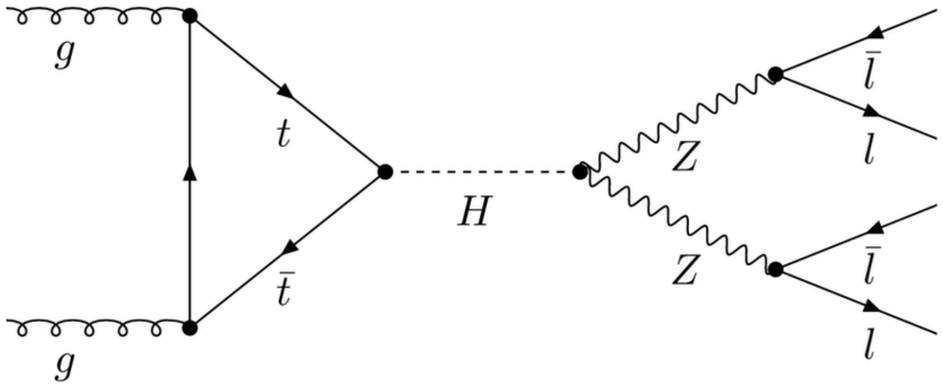
We can calculate using a “path integral” approach: sum/integrate over all the possible ways go from the initial state (two quarks) to the final state (two leptons)

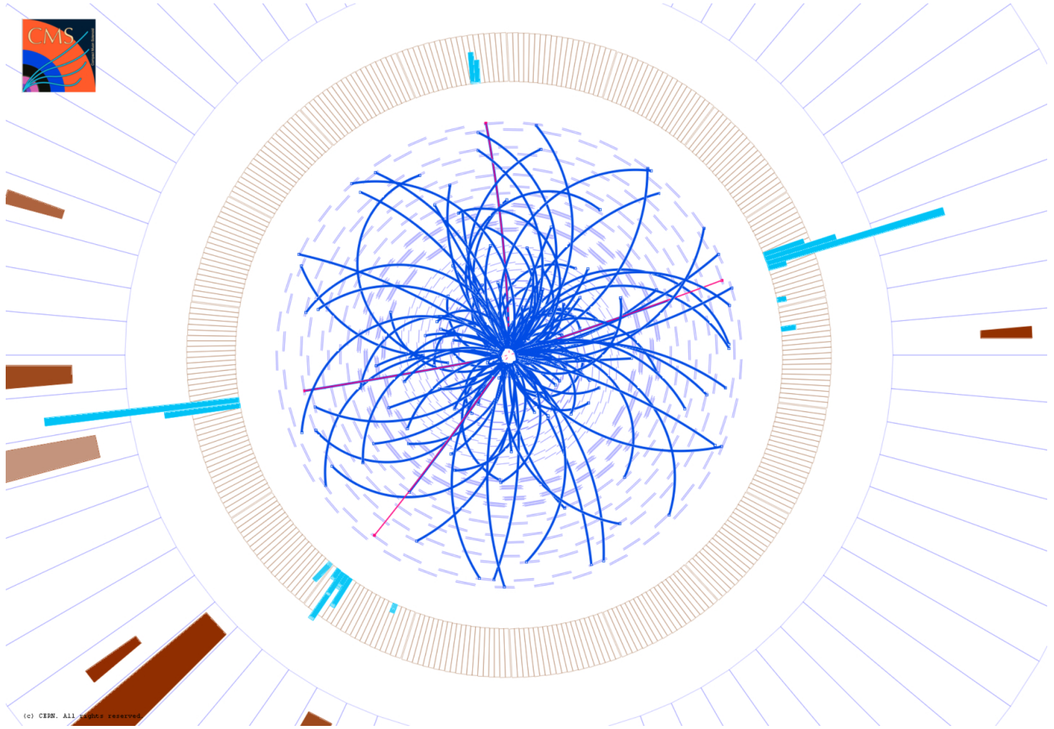
Feynman rules tell us the amplitude $\mathscr{M}$ for each “path” which can be represented by a diagram



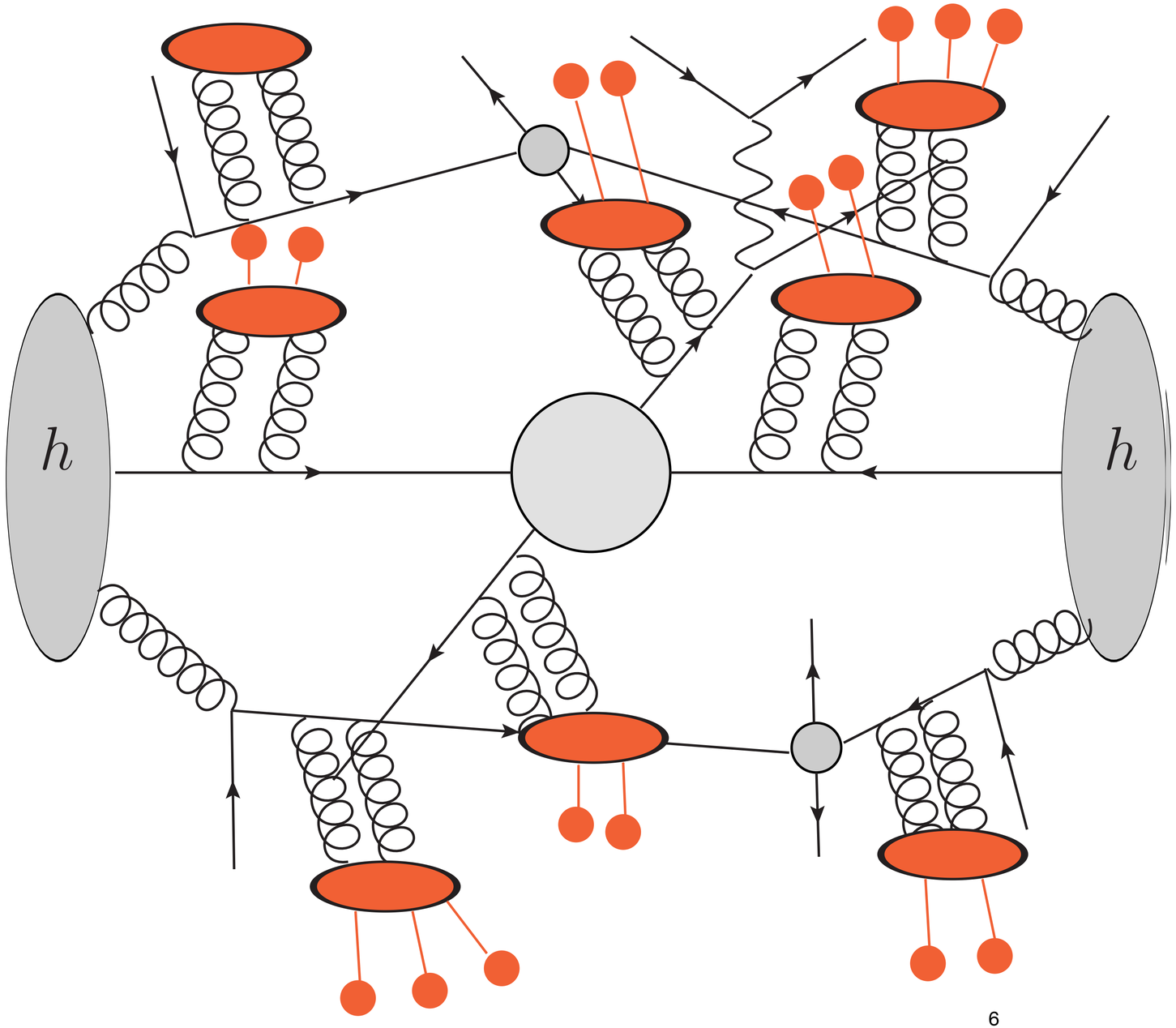
# Higgs boson production in CMS

In reality, even more complicated



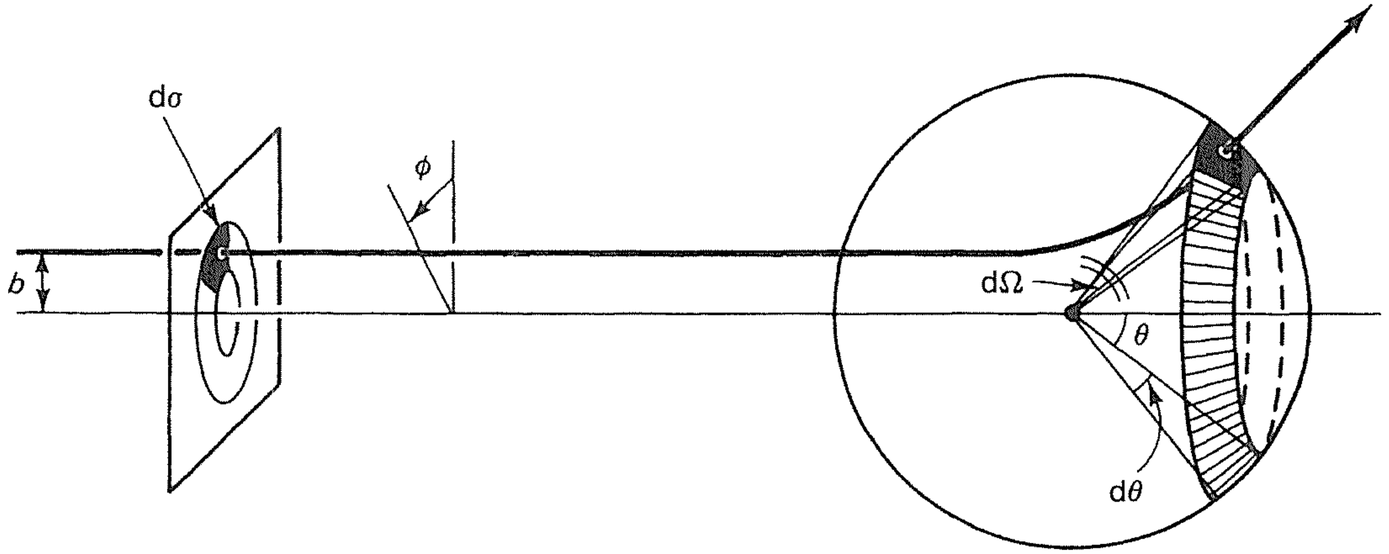
# Particle physics event generation steps




1. Hard process
2. Heavy resonance decays
3. Parton showers
4. Multiple parton interactions
5. Hadronization and hadron decays

# Cross section

Differential scattering cross section $\frac{d\sigma}{d\Omega}$ usually depends on the scattering angle $\theta$




Total cross section is given by integral over solid angle

$$\sigma = \int d\Omega \frac{d\sigma}{d\Omega} = \int d\theta d\phi \sin\theta \frac{d\sigma}{d\Omega}$$

Cross section can be thought of as the probability for a given process to occur