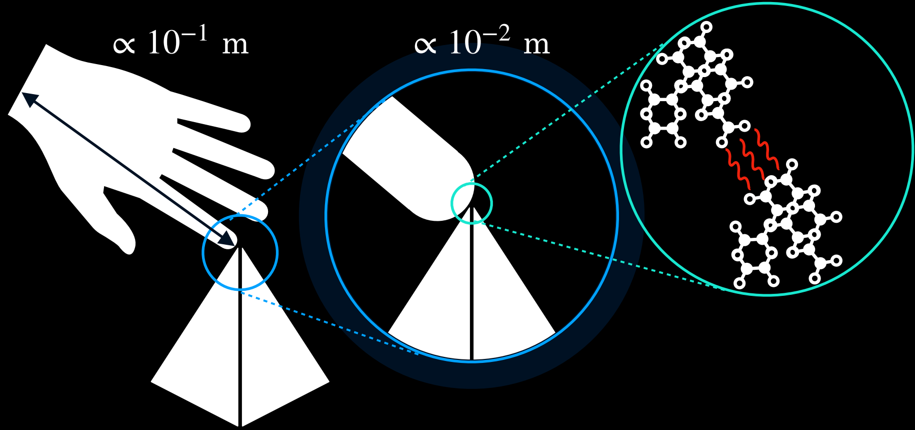
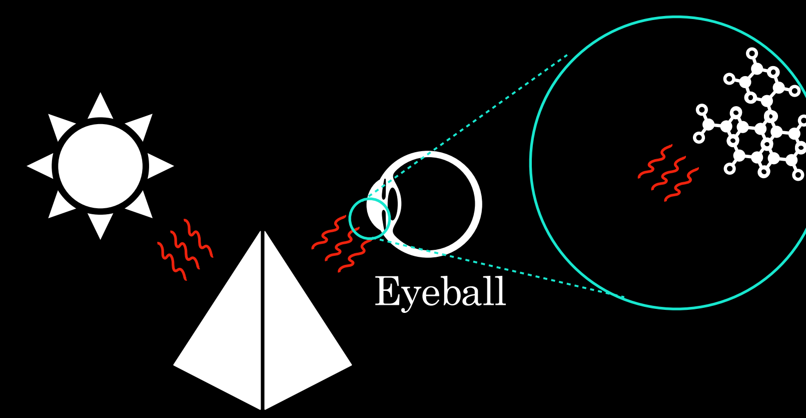
The nature of reality



carrier of the
electromagnetic force

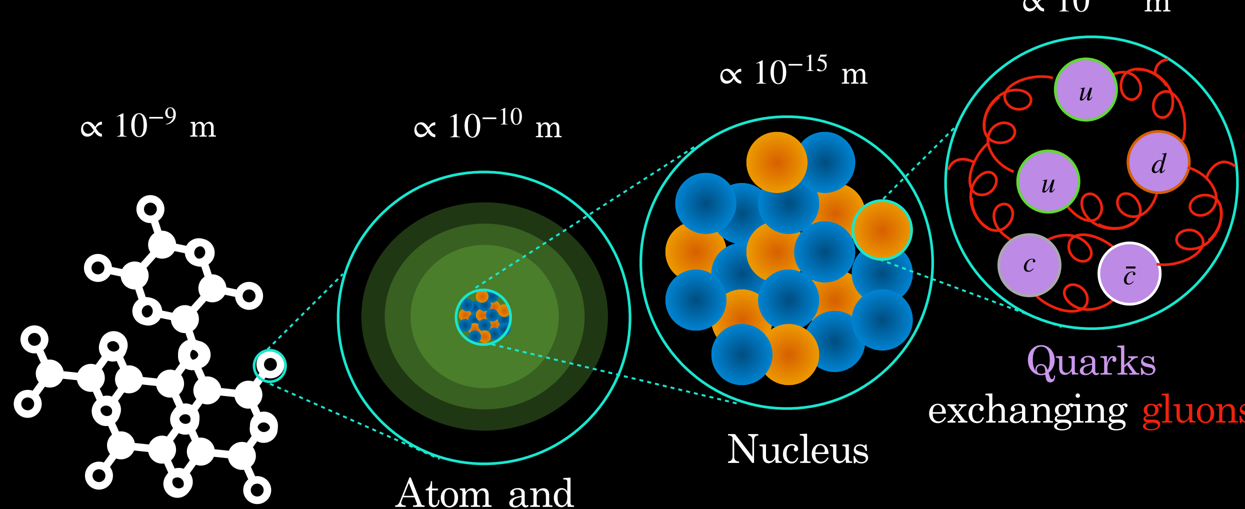


Molecules are groupings of atoms, composed of a nucleus and electrons.

An atom's nucleus is made out of nucleons

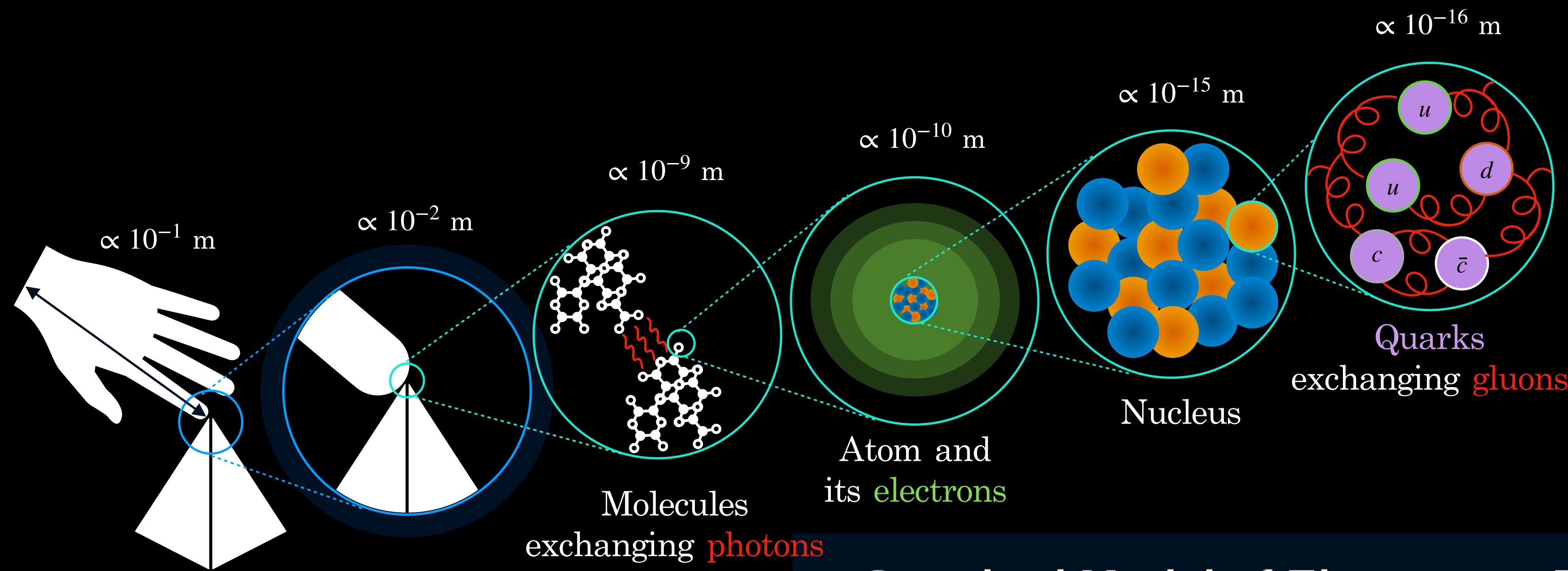
- positively charged particles called protons
- neutrally charged particles called neutrons

} composed of quarks, held together by means of gluons.



carrier of the
strong force

Substructure of matter

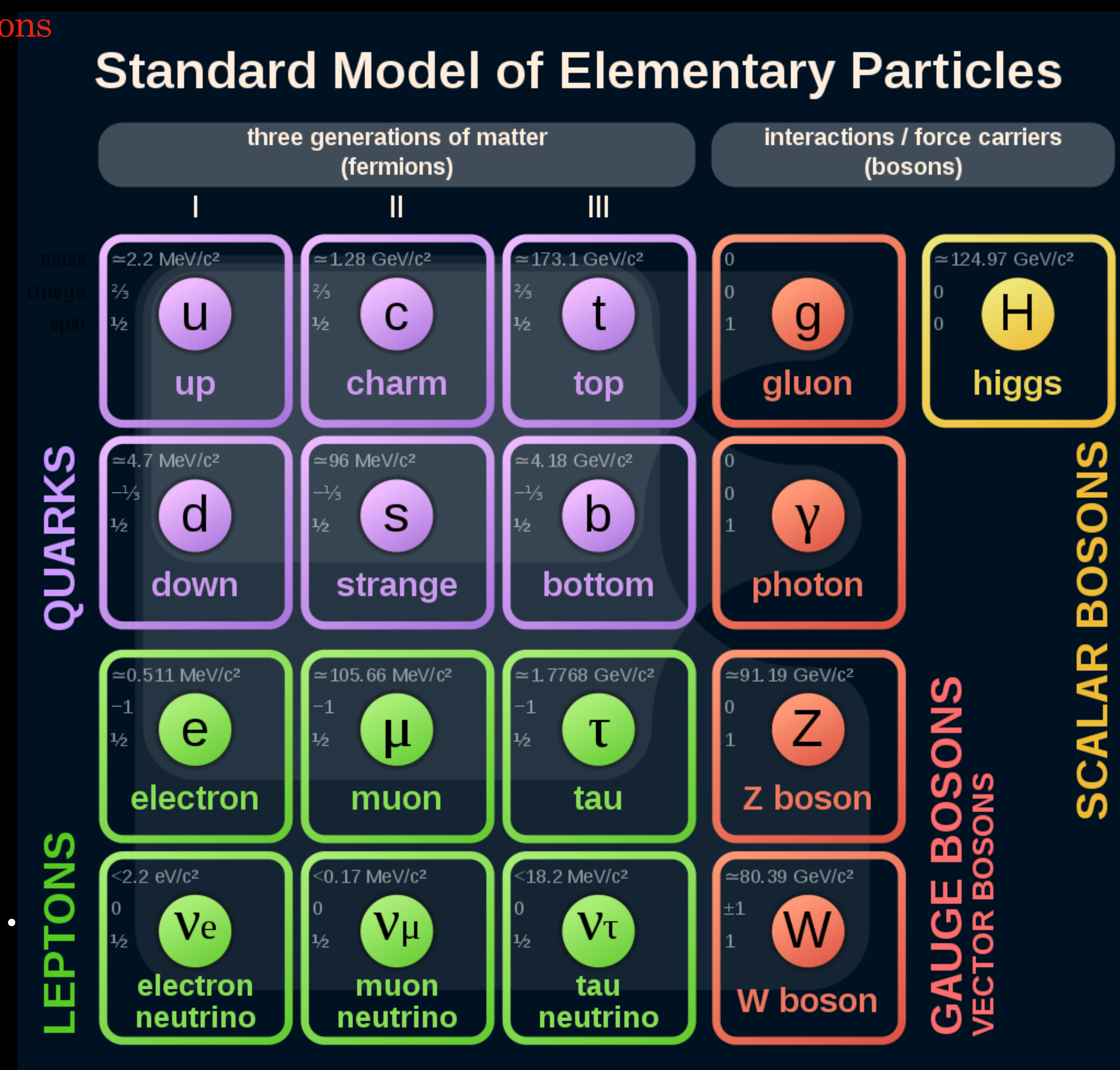


Quarks and electrons are the elementary building blocks of matter.

Their interactions are mediated by different force carriers (strong, electroweak, Higgs).

The Standard Model is the theory that unifies successfully (so far) the description of all these interactions.

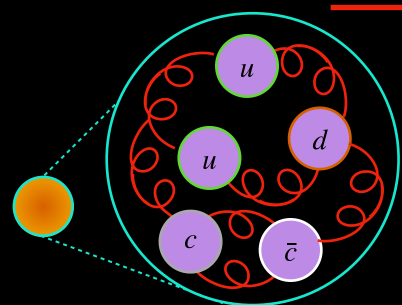
The main focus of my research is on the implications of the strong force, described by the theory of Quantum Chromodynamics.



Substructure of nucleons and nuclei

To a certain approximation, the probability of finding quarks and gluons in a hadron carrying a momentum-fraction x of the hadron's momentum is encoded in non-perturbative parton distribution functions (PDFs).

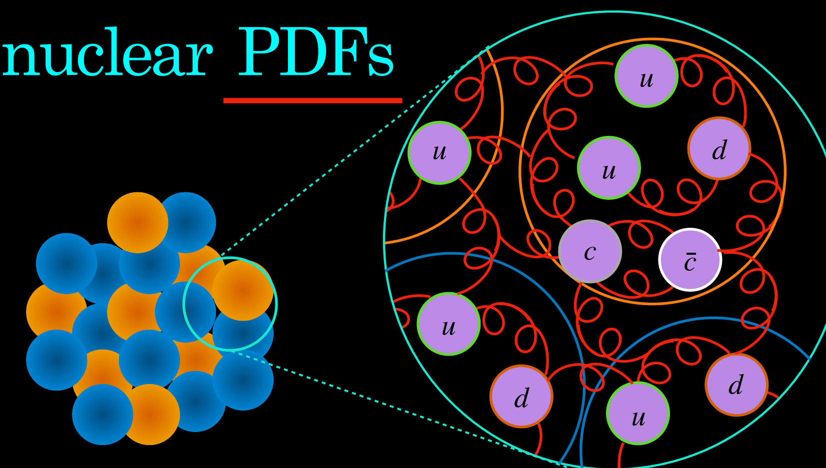
PDFs



Free proton

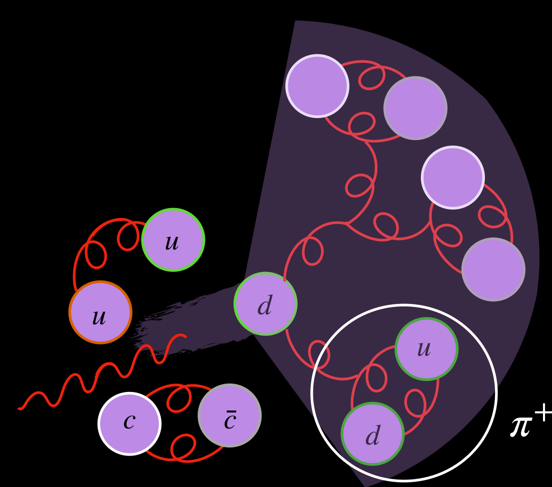
Turns out they are quite different!!

nuclear PDFs



Proton bound within a nucleus

Fragmentation functions (FFs) encode the probability of producing a hadron from a quark fragmentation.

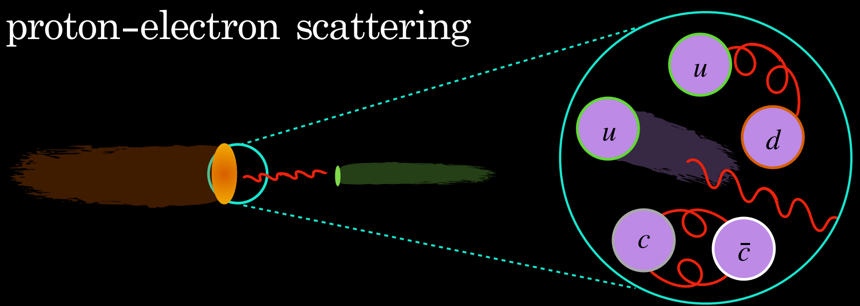


FFs

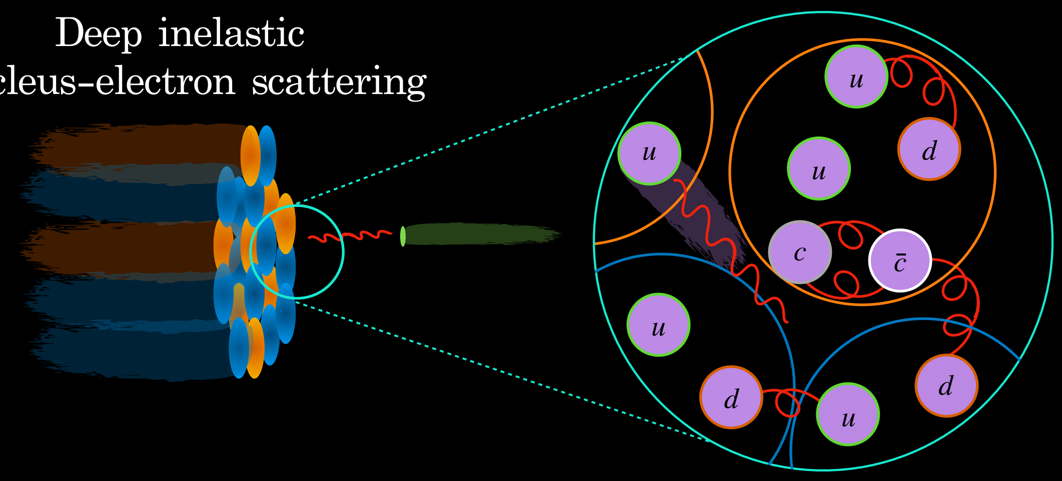
Substructure of nucleons and nuclei

We extract these objects from the scattering-probabilities off protons and nuclei that we measure in collider-experiments.

Deep inelastic
proton-electron scattering



Deep inelastic
Nucleus-electron scattering

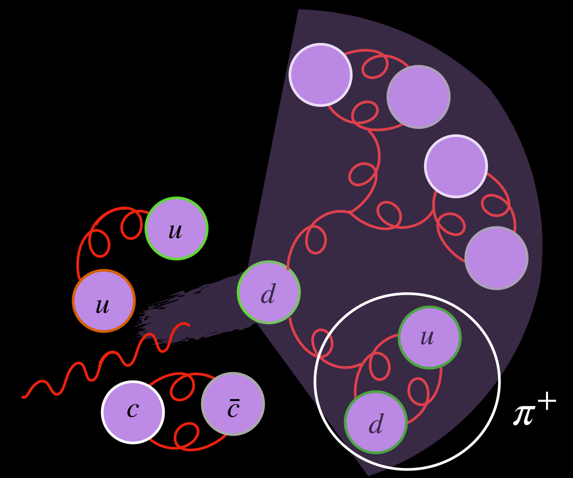


Scattering probability $= \hat{\sigma} \otimes f^{(p)}$

Perturbative — Non-perturbative PDFs

Scattering probability $= \hat{\sigma} \otimes f^{(A)}$

Perturbative — Non-perturbative nuclear PDFs



Scattering probability $= \hat{\sigma} \otimes f^{(p)} \otimes D^{(\pi^{\pm})}$

Perturbative — Non-perturbative PDFs — FFs

The help of machine learning

How do we extract these objects from data?

Scattering probability $= \hat{\sigma} \otimes f^{(p)}$

Scattering probability $= \hat{\sigma} \otimes f^{(A)}$

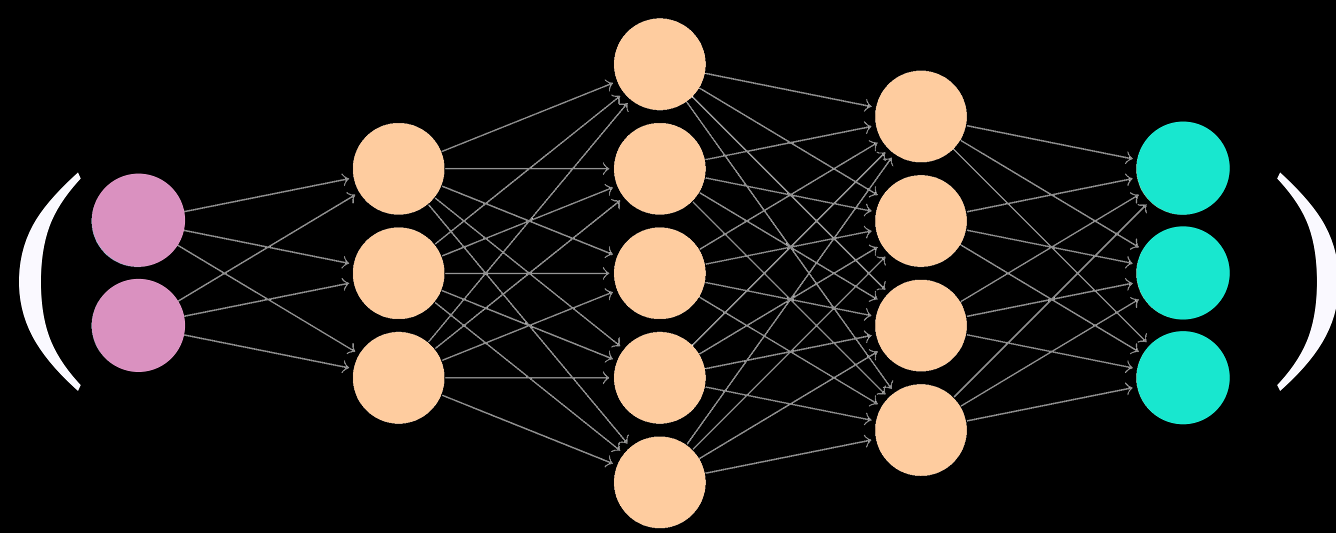
Scattering probability $= \hat{\sigma} \otimes f^{(p)} \otimes D^{(\pi^{\pm})}$

Knowing that none of them is predicted by QCD, we parameterise them by

Artificial neural networks (NNs)

since NNs can "learn" any continuous function within the data range

Scattering probability $= \hat{\sigma} \otimes$



NNs (PDFs, FFs) keep on being tuned until the data matches the prediction.