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Search for Hexaquarks in CMS at the LHC – feasibility study

The quark model, developed in 1964 by Gell-Mann [1] and Zweig [2], explains structure of mesons (quark-antiquark pairs) and baryons (3-quark states), such as protons and neutrons. The initial idea has been extended to 4-quark states (tetraquarks) in 1976 by Jeffe [3] and then in 1987 also to 5-quark states (pentaquarks) by Lipkin [4].

All of the above particles have been extensively studied, with baryons and mesons being standard objects in any modern particle physics experiment, pentaquarks being discovered in 2015 by LHCb [5] and tetraquark candidates showing up in various experiments, with statistically significant discoveries consistent with the tetraquark hypothesis recently reported by LHCb [6] and ATLAS in 2020-2022.

A natural question following the development of the quark model and associated experimental discoveries is: do states composed of more than 5 quarks exist? Hexaquarks, sexaquarks or di-baryons are all names for 6-quark states, which can differ in internal structure.

In this project we would like to focus on hexaquarks containing 3 quarks and 3 antiquarks, and decaying to 3 particles. Hints of existence of such states have been showing up in experiments from the ‘80s [7][8]. In 2020 measurements of the characteristics of the strong interaction from ALICE [9] confirmed that baryons and antibaryons form bound states. However, to this day, no direct, statistically significant measurement of hexaquarks has been performed.

The goal of the project would be to implement Monte Carlo generation of various hexaquark states with multiple decay channels. Simple feasibility study would be carried out, testing which states would result in events passing CMS triggers, as well as verifying that background (combinatorial and coming from associated known particles’ decays) can be sufficiently reduced. Finally, expected signal significance for different hexaquark states would be estimated, providing a foundation for a discovery of hexaquarks.

Special Qualifications expected from the student (Computing,...) :
- general particle physics knowledge,
- python or C++ programming skills,
- familiarity with Monte Carlo generators would be a plus.

Field

B1: Particle physics analysis (software-oriented)

DESY Place

Hamburg

DESY Division

FH

DESY Group

CMS

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