# TOP QUARK

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# WHAT WE GONNA DISCUSS

Introduction

Basic properties of the top quark

Discovery of the top quark

Production and decay of top quarks

Role of the top quark in physics

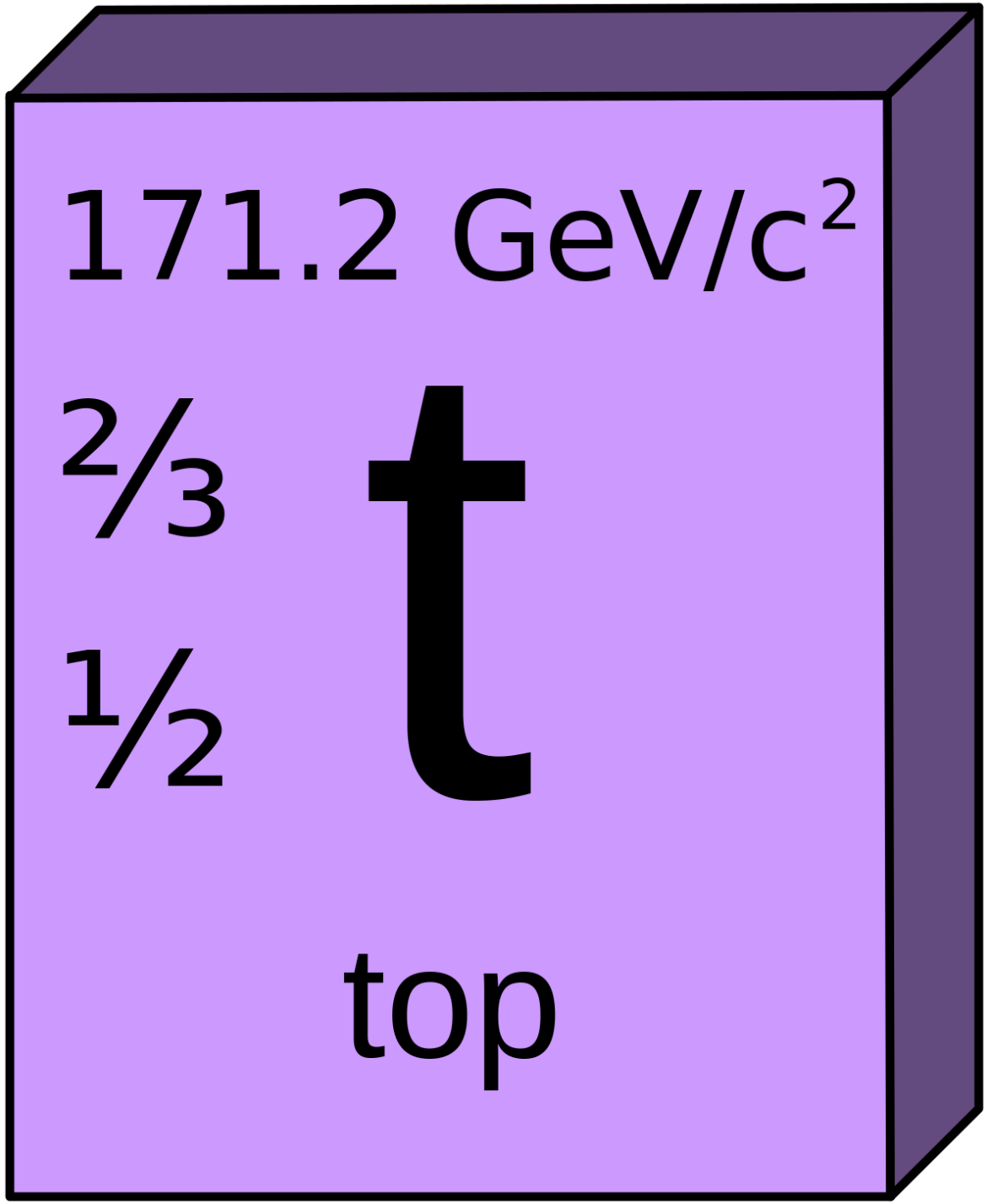
Experimental observations and ongoing research

# Introduction

- What quarks are, and their role as fundamental particles in the Standard Model of particle physics?
- Quarks come in six flavors: up, down, charm, strange, top, and bottom

# BASIC PROPERTIES OF THE TOP QUARK

- **Mass**: 173 GeV/c²
- **Electric Charge**: $+{}^{2}/_{3}$e
- **Spin:** ${}^{1}/_{2}$
- **Lifetime:** $5 * 10^{-25}$ seconds.
- **Production:** high-energy particle collisions
- **Partner Quark:** bottom quark ($-{}^{1}/_{3}$ e)



# DISCOVERY OF THE TOP QUARK

- In 1973, Makoto Kobayashi and Toshihide Maskawa predicted the existence of a third generation of quarks to explain observed CP violations in kaon decay.

- In 1995, the collaborative efforts of the CDF and DZero experiments at Fermilab's Tevatron collider unveiled the existence of the top quark, completing the quark generations predicted by the Standard Model.

- It is the development of techniques that ultimately allowed such precision calculations that led to Gerardus 't Hooft and Martinus Veltman winning the Nobel Prize in physics in 1999.

# PRODUCTION AND DECAY OF TOP QUARKS

1. **Production Mechanisms:** Top quarks are predominantly produced in high-energy particle collisions, particularly in proton-antiproton or proton-proton collisions.

2. **Cross-section:** The production of top quarks is characterized by a relatively high cross-section, meaning that top quarks are produced more frequently compared to other heavy particles.

3. **Pair Production:** The most common production mode of top quarks is the creation of top-antitop quark pairs.

4. **Decay Modes:** Top quarks decay almost instantaneously before they can form bound states with other particles. There are two primary decay modes of the top quark:
   - Hadronic Decay
   - Leptonic Decay

5. **Signatures and Detection:** Experimental detection of top quarks relies on identifying the characteristic signatures of their decay products.

6. **Cross-section Measurements:** Experimental measurements of the production cross-section of top quarks provide valuable information about their interactions with other particles and serve as tests of the Standard Model.

# ROLE OF THE TOP QUARK IN PHYSICS

1. **Testing the Standard Model**: The top quark plays a crucial role in testing and validating the Standard Model of particle physics.
2. **Mass Hierarchy**: The top quark's enormous mass—approximately 173 GeV/$c^2$—far surpasses that of any other known elementary particle.
3. **Electroweak Symmetry Breaking:** The top quark's large mass is closely linked to the mechanism of electroweak symmetry breaking, which endows other particles with mass.
4. **Strong Interaction and Quantum Chromodynamics (QCD):** As the heaviest quark, the top quark has a unique role in studying the strong force and QCD.
5. **New Physics Searches:** The top quark serves as a testing ground for new physics beyond the Standard Model.
6. **Collider Experiments:** The production and study of top quarks are a central focus of high-energy collider experiments.
7. **Particle Mass Hierarchy**: The top quark's large mass influences the stability and structure of matter.
8. **Cosmological Implications:** The study of top quarks also has implications for cosmology and the evolution of the universe.

# EXPERIMENTAL OBSERVATIONS AND ONGOING RESEARCH

1. **Precision Measurements:** Experimental observations have focused on precise measurements of the top quark's properties, such as its mass, electric charge, and spin.
2. **Production Cross-section:** Ongoing research continues to explore the production mechanisms of top quarks and their cross-sections.
3. **Decay Modes and Couplings:** The study of top quark decays remains an active area of research.
4. **Rare Processes and New Physics Searches:** Experimental investigations of top quark events strive to uncover rare processes and search for deviations from the predictions of the Standard Model.
5. **Top Quark Pair Production and Beyond:** The production of top quark pairs remains a rich area of study.
6. **Quantum Chromodynamics (QCD) Studies:** Experimental efforts continue to deepen our understanding of QCD, the theory describing the strong interactions.
7. **Future Colliders and Upcoming Experiments:** The exploration of top quarks will continue at future colliders, such as the High-Luminosity Large Hadron Collider (HL-LHC) and potential next-generation machines.

# THANK YOU

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