Questions:

- Why is the result of W boson mass measurement important to modern particle physics?
    - Direct test of the fundamental theory of nature (SM)
- What's the implication of the deviation in the W boson mass measurement?
    - Honest mistake made by excellent scientists?
    - Demanding new theory or new particles?

Outline:

- Role of the W boson in particle physics → ZF (5 minutes)
    - Standard Model introduction
- Electroweak unification introduction → ZF (9 minutes)
    - How can we unify weak and EM interactions?
    - The weak mixing angle $cos\theta_W$
    - Theoretical prediction of W boson mass in SM

      $M_W = M_Z \ cos\theta_W$ equivalently $m_W^2\left(1-\frac{m_W^2}{m_Z^2}\right)=\frac{\pi\alpha}{\sqrt{2}G_F}(1+\Delta r)$
    - The loop-induced correction Δr (higher order correction):
        - Different predicted values due to different calculations of Δr.

- Technical approach for measuring W boson mass → Ku
    - General introduction to particle physics experiments (7 minutes)
        - Pre-collision process: Generation & acceleration
        - Post-collision process: Reconstruction & event analysis
    - Technical challenge faced by the measurement of W boson mass (3 minutes)
        - undetectable Neutrino momentum
        - Solution: Neutrino transverse momentum is deduced by the conservation of transverse momentum.
- Comparing results from different experiments of W bosons → Ku (5 minutes)
    - Collider Detector at Fermilab II (CDF II)
        - Cosmic-ray muon rejection
        - Proton-antiproton collision: smaller momentum uncertainty
        - Improved understanding of the distribution function.
    - Large-Hadron Collider (LHC)
    - Outlook: remains mysterious in the near future
        - Lack of independent comparable precise measurement

- Conclusion → ZF (1 minute)
    - The result is very important if it is correct:
        - Both experimental part and theoretical part can make mistakes
    - If everything is correct within SM
        - New particles?
        - Evidence of Supersymmetry theories?

Abstract

W bosons mediate the weak interaction, one of the fundamental forces in physics. Under the Standard Model (SM) of particle physics, the mass of W boson is tightly related to the weak mixing angle and Z boson mass. Measuring the W boson mass gives a direct test of the SM. The Collider Detector at Fermilab released the latest measurement result of the W boson mass by the Tevatron particle accelerator recently. The result is remarkably precise, with a discrepancy of 7 standard deviations from the predicted value calculated by one theoretical group using SM. If the result is correct, this deviation implies the incompleteness of SM and the need for new physics theories.