First evidence of an incredibly rare particle decay

Prelims: *Current events of national and international importance| Science and Technology*

Why in News?

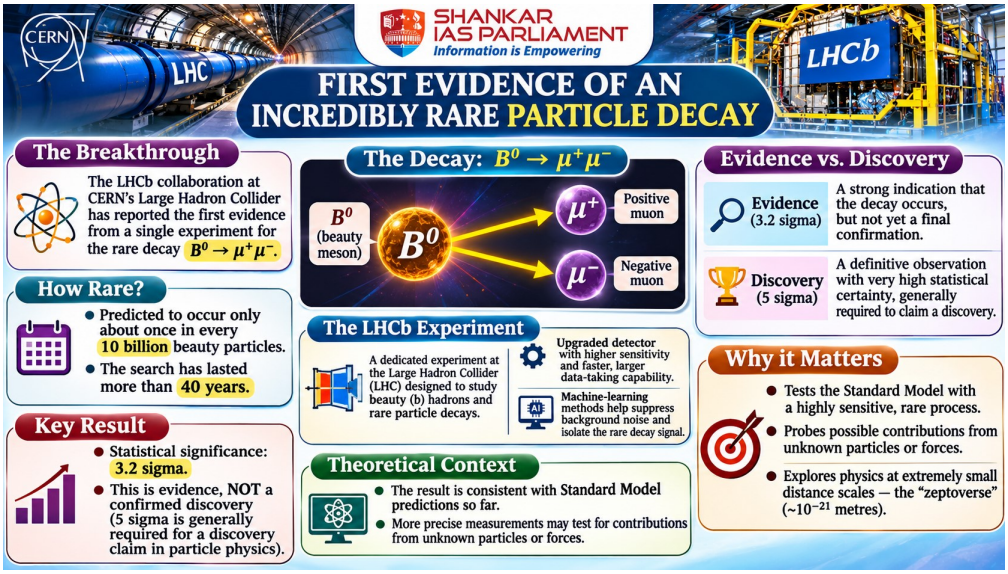
*Physicists on the **LHCb** collaboration at CERN's Large Hadron Collider have found the first single-experiment evidence of the **$B_d \to \mu^+\mu^-$** decay, a process where a beauty (B_{d}) meson decays into two muons.*

Announced on November 3, 2026, the decay is theorized to happen only about once in every 10 billion beauty particle decays.

- **The Decay Process-** A B_{d} particle (made of a beauty quark and a down antiquark) transforms into a muon and an antimuon ($\mu ^{+}\mu ^{-}$).
- **Decades-Long Search-** Theorized since 1984, it took over 40 years of searching to reach evidence from a single experiment.
- **Statistical Significance-** The result reaches **3.2 sigma** using combined data from 2011–2018 and 2024–2025. This meets the threshold for "evidence," though particle physicists require **5 sigma** to claim a confirmed discovery.
- **Measured Rate-** The combined analysis indicates a B^{0} (B_{d}) decay rate of roughly **1.14 in 10 billion**, matching Standard Model predictions.

Why It Matters?

- **Testing the Standard Model-** Rare decays act as sensitive probes into the "zeptoverse" (scales around a billionth of a trillionth of a meter).
- **Probing New Physics-** Any deviation from predicted rates could hint at undiscovered particles, new forces, or clues about dark matter, while alignment tightens limits on where unseen heavy particles might hide.
- **Upgraded Detector-** Higher collision recording rates, upgraded LHCb hardware, and machine learning helped isolate the rare signal alongside more precise measurements of the related $B_s \to \mu^+\mu^-$ decay.



Reference

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