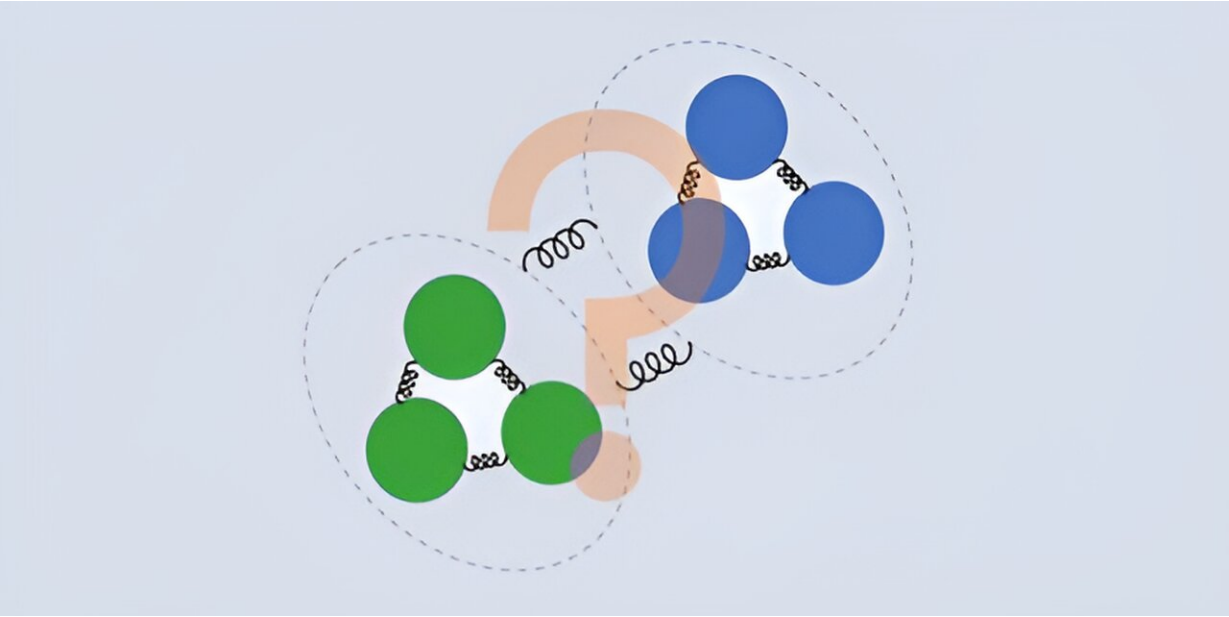
Evidence of a new subatomic particle observed

April 12 2024



A portrait of nucleon-antinucleon bound state. Credit: *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.151901

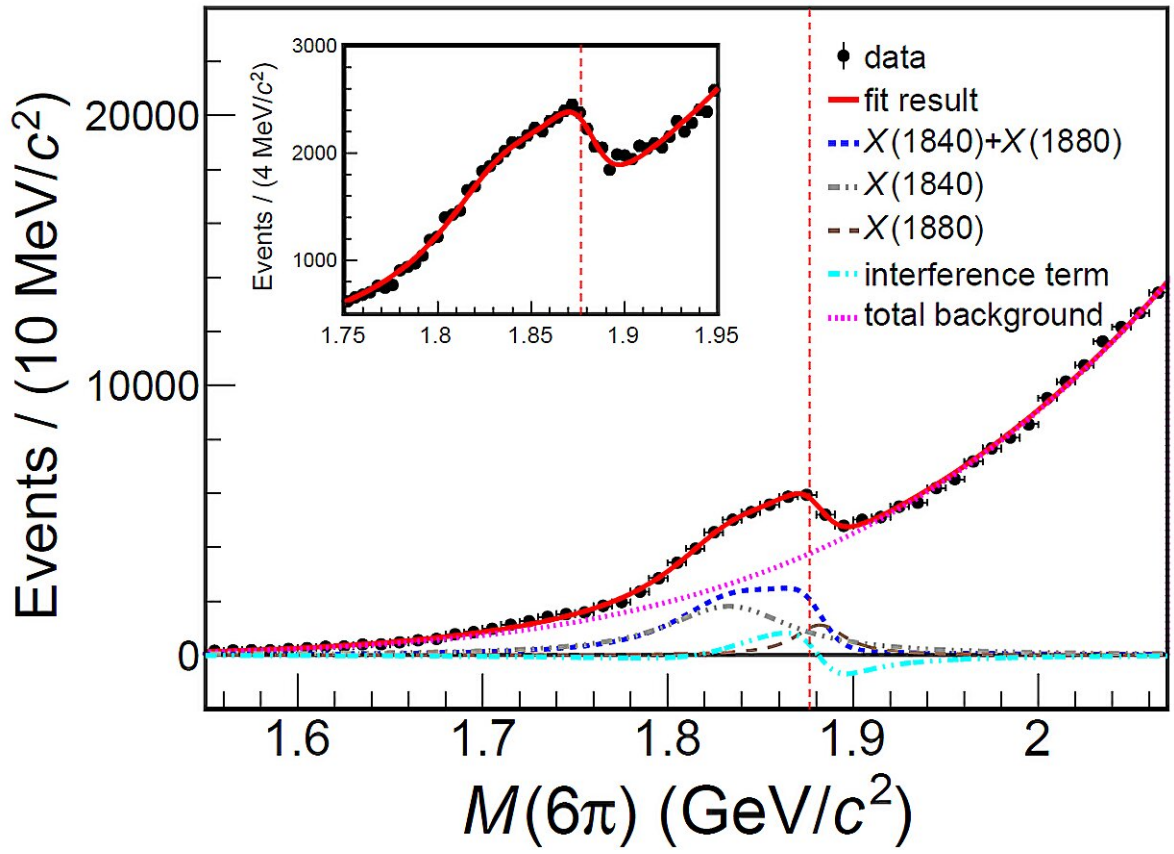
The BESIII collaboration have reported the observation of an anomalous line shape around ppbar mass threshold in the $J/\psi \to \gamma 3(\pi^+\pi^-)$ decay, which indicates the existence of a ppbar bound state. The paper was

published online in *Physical Review Letters*.

The proximity in mass to $2m_p$ is suggestive of nucleon-antinucleon bound states, an idea that has a long history. Before the birth of Quark Model, a nucleon-antinucleon bound state was already proposed by Prof. E. Fermi and Prof. C. N. Yang.

There is an accumulation of evidence for anomalous behavior in the proton-antiproton system near the ppbar mass threshold, e.g., $J/\psi\rightarrow\gamma$ppabr , $J/\psi\rightarrow\gamma\pi^+\pi^-\eta'$ and the proton's effective form factor determined from $e^+e^-\rightarrow$ppbar, exhibiting a narrow peak or a very steep falloff around the ppbar mass threshold, which inspired many speculations and renewed the interests on the nucleon-antinucleon bound state.

X(1840) is a new structure discovered in the $J/\psi\rightarrow\gamma 3(\pi^+\pi^-)$ process in 2013 with subdata sample of BESIII experiment, which is also located near the ppbar mass threshold. A further exploration of line shape of X(1840) is essential to have a better understanding of its nature. Therefore, the BESIII experiment performed an investigation on the $3(\pi^+\pi^-)$ mass spectrum with 10 billion J/ψ events, which is about 45 times larger than the subdata sample used in the previous measurement.



The anomalous line shape of the resonant structure around ppbar mass threshold in 3(π+π-) mass spectrum. Credit: *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.151901

An anomalous line shape of X(1840) near the ppbar mass threshold was observed for the first time. After many attempts, it was found that the model with a coherent sum of two Breit-Wigner parameterizations could provide a good description of data, which revealed a new resonance X(1880) with a statistical significance greater than 10σ, and the mass and width were determined to be 1882.1±1.7±0.7 MeV/c^2 and 30.7±5.5±2.4 MeV/c, respectively.

The proximity of its mass to the ppbar mass threshold supported the existence of a ppbar bound state. After publication, this result was selected as "Featured in Physics" by *Physical Review Letters*.

More information: M. Ablikim et al, Observation of the Anomalous Shape of X(1840) in J/ψ→γ3($\pi^+\pi^-$) Indicating a Second Resonance Near $p\bar{p}^-$ Threshold, *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.151901

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