

# Observation of a family of all-charm tetraquarks with spin-2 and positive parity at CMS

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We present a comprehensive study of near-threshold structures in the  $J/\psi J/\psi$  mass spectrum using the fully reconstructed  $J/\psi J/\psi \rightarrow 4\mu$  final state, based on proton-proton collision data at  $\sqrt{s} = 13$  and 13.6 TeV collected by the CMS experiment. With approximately four times more  $J/\psi$  pair candidates compared to the previous Run 2 dataset, the combined data sample enables a significantly enhanced sensitivity to rare structures. In the mass range between 6 and 8 GeV, three peaks are observed with significances well above  $5\sigma$ , consistent with the previously reported tetraquark candidates  $X(6600)$ ,  $X(6900)$ , and  $X(7100)$ . Two pronounced dips, also exceeding  $5\sigma$  in significance, are identified between the peaks, highlighting the presence of strong interference effects. A complementary search in the  $J/\psi \psi(2S) \rightarrow 4\mu$  final state reveals a consistent two-peak structure corresponding to the  $X(6900)$  and  $X(7100)$ , with measured masses and widths compatible within uncertainties. To further investigate the nature of the observed states, a spin-parity analysis is performed using a matrix-element-based approach, testing multiple  $J^P$  hypotheses. The results favor a  $J^P = 2^+$  assignment, offering new insights into the internal dynamics of these exotic resonances. This analysis, based on the Run 2 data, provides the most detailed picture to date of the fully-charm tetraquark landscape.

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