Observation of a New Excited Beauty Strange Baryon Decaying to $\Xi_b^- \pi^+ \pi^-$

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The $\Xi_b^- \pi^+ \pi^-$ invariant mass spectrum is investigated with an event sample of proton-proton collisions at $\sqrt{s} = 13$ TeV, collected by the CMS experiment at the LHC in 2016–2018 and corresponding to an integrated luminosity of 140 fb^{-1}. The ground state Ξ_b^- is reconstructed via its decays to $J/\psi\Xi^-$ and $J/\psi\Lambda K^-$. A narrow resonance, labeled $\Xi_b(6100)^-$, is observed at a $\Xi_b^- \pi^+ \pi^-$ invariant mass of $6100.3 \pm 0.2(\text{stat}) \pm 0.1(\text{syst}) \pm 0.6(\Xi_b^-)$ MeV, where the last uncertainty reflects the precision of the Ξ_b^- baryon mass. The upper limit on the $\Xi_b(6100)^-$ natural width is determined to be 1.9 MeV at 95% confidence level. The low $\Xi_b(6100)^-$ signal yield observed in data does not allow a measurement of the quantum numbers of the new state. However, following analogies with the established excited Ξ_c baryon states, the new $\Xi_b(6100)^-$ resonance and its decay sequence are consistent with the orbitally excited Ξ_b^- baryon, with spin and parity quantum numbers $J^P = 3/2^-$.

The Ξ_b baryon family consists of isodoublet states composed of bsq quarks, where q represents an up or a down quark for the Ξ_b^0 and Ξ_b^- states, respectively. According to the quark model for baryons containing one heavy quark [1], three such isodoublets that are neither orbitally nor radially excited should exist, including one with the light diquark angular momentum $j_{qs} = 0$ and spin parity $J^P = 1/2^+$ (the Ξ_b ground states), one with $j_{qs} = 1$ and $J^P = 1/2^+$ (the Ξ_b'), and one with $j_{qs} = 1$ and $J^P = 3/2^+$ (the Ξ_b^*). Various theoretical models and calculations predict a spectrum of excited Ξ_b baryons [2–16]. Three of the four excited states with $j_{qs} = 1$ have been observed at the CERN LHC [17–19] via their $\Xi_b^- \pi^+$ and $\Xi_b^0 \pi^-$ decays, in agreement with predictions [2–4]. The fourth state, $\Xi_b'^0$, is expected to be lighter than the $\Xi_b^- \pi^+$ mass threshold, making a strong transition to Ξ_b^- kinematically impossible. The next prominent isodoublets, in analogy with the quark model assumptions for the well-established excited Ξ_c baryons [20], are orbitally excited P-wave Ξ_b^{**} states with $J^P = 1/2^-$ $(3/2^-)$, expected to decay to $\Xi_b'(\Xi_b^*)\pi$ [12,13,21]. Recently, the LHCb Collaboration reported the observation of the $\Xi_b(6227)^-$ [22] and $\Xi_b(6227)^0$ [23] states, the former decaying to both $\Lambda_b^0 K^-$ and $\Xi_b^0 \pi^-$, and the latter to $\Xi_b^- \pi^+$.

This Letter presents a search for Ξ_b^- excited states in the $\Xi_b^- \pi^+ \pi^-$ invariant mass spectrum, performed using proton-proton (pp) collision data samples collected by the CMS experiment at the LHC at $\sqrt{s} = 13$ TeV in 2016–2018, corresponding to an integrated luminosity of 140 fb^{-1}. The ground state Ξ_b^- is reconstructed via its decays to $J/\psi\Xi^-$ and $J/\psi\Lambda K^-$, followed by the decays $J/\psi \to \mu^+\mu^-$, $\Xi^- \to \Lambda\pi^-$, and $\Lambda \to p\pi^-$. The decay topologies are illustrated in Fig. 1. For the $\Xi_b^- \to J/\psi\Lambda K^-$ decay mode, following the studies reported by the LHCb Collaboration [24], the partially reconstructed $\Xi_b^- \to J/\psi\Sigma^0 K^-$ channel is also used, where the photon from the $\Sigma^0 \to \Lambda\gamma$ decay is too soft to be detected. The inclusion of charge-conjugated states is implied throughout this Letter. A signal peak, hereafter referred to as $\Xi_b(6100)^-$, is clearly observed near the $\Xi_b^- \pi^+ \pi^-$ kinematic threshold, with a decay sequence consistent with being the $\Xi_b(6100)^- \to \Xi_b^{*0}\pi^- \to \Xi_b^- \pi^+ \pi^-$ decay. The $\Xi_b(6100)^-$ mass and an upper limit on its width are also measured.

The central feature of the CMS apparatus is a superconducting solenoid of 6 m internal diameter, providing a magnetic field of 3.8 T. Within the solenoid volume are a silicon pixel and strip tracker, a lead tungstate crystal electromagnetic calorimeter, and a brass and scintillator hadron calorimeter, each composed of a barrel and two end cap sections. Muons are detected in gas-ionization chambers embedded in the steel flux-return yoke outside the solenoid. A more detailed description of the CMS detector, together with a definition of the coordinate system used and the relevant kinematic variables, can be found in Ref. [25].

Events of interest are selected using a two-tiered trigger system. The first level (L1), composed of custom hardware processors, uses information from the calorimeters and muon detectors [26]. The second level, known as the high-level trigger (HLT), consists of a farm of processors
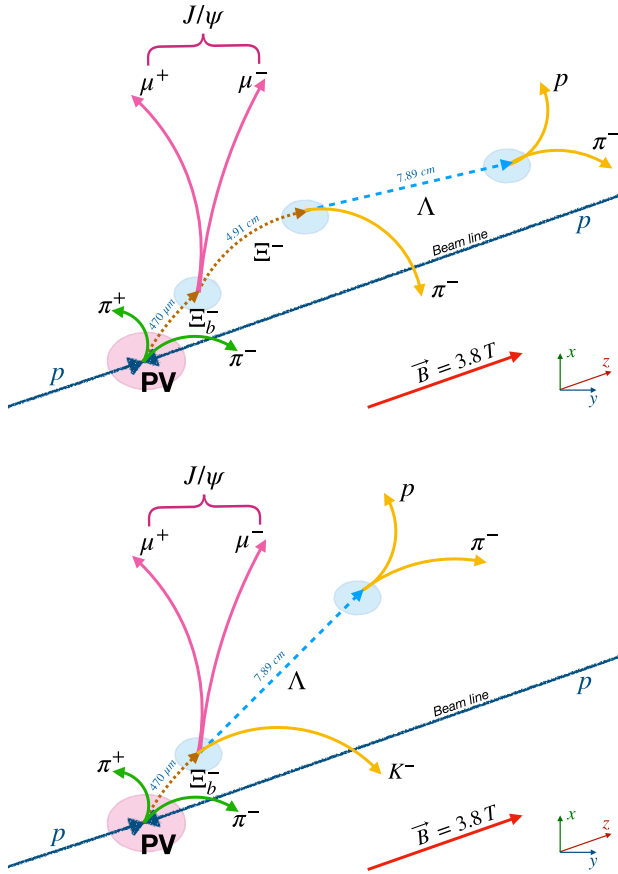
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FIG. 1. The $\Xi_b(6100)^- \to \Xi_b^- \pi^+ \pi^-$ decay topology, where the Ξ_b^- decays to $J/\psi\Xi^-$ (upper) or to $J/\psi\Lambda K^-$ (lower). The numbers in blue are average decay lengths.

running a version of the full event reconstruction software optimized for fast processing [27]. The events used in the analysis were selected at L1 by requiring the presence of at least two muons and at HLT by requiring that the two muons have opposite sign (OS), with various thresholds on the pseudorapidity η and momentum transverse to the beam axis p_T, compatible with being produced in the dimuon decay of J/ψ mesons.

Several simulated event samples are used in the analysis. The PYTHIA 8.230 package [28] is used to simulate the production of the $\Xi_b(6100)^-$ state, where the Σ_b^- baryon, with a modified mass value, is used as a proxy for an excited $\Xi_b(6100)^-$ state. The $\Xi_b(6100)^- \to \Xi_b^- \pi^+ \pi^-$ (including both resonant $\Xi_b^{*0}\pi^+ \to \Xi_b^- \pi^+ \pi^-$ and nonresonant $\Xi_b^- \pi^+ \pi^-$ modes), $\Xi_b^- \to J/\psi\Xi^-$, $\Xi_b^- \to J/\psi\Lambda K^-$ (including $\Xi_b^- \to J/\psi\Sigma^0 K^-$, $\Sigma^0 \to \Lambda\gamma$), and $J/\psi \to \mu^+\mu^-$ decays are modeled with EVTGEN 1.6.0 [29], where final-state photon radiation is included using PHOTOS 3.61 [30,31]. The generated events are then passed to a detailed GEANT4-based simulation [32] of the CMS detector, including the same trigger and reconstruction algorithms as used for the collision data. The simulation includes effects from multiple pp interactions in the same or nearby bunch

crossings (pileup) with a multiplicity distribution matching the measured one.

The selection criteria are optimized using the Punzi figure of merit [33], which does not rely on the signal normalization. The expected background is estimated from data using the same-sign (SS) control region described below, while the signal efficiency is obtained from the simulated $\Xi_b(6100)^- \to \Xi_b^- \pi^+ \pi^-$ events. The $\Xi_b^- \to J/\psi\Xi^-$ and $\Xi_b^- \to J/\psi\Lambda K^-$ requirements are optimized separately.

Events are required to have two OS muons passing the CMS soft-muon selection criteria [34] and satisfying $p_T(\mu^\pm) > 3$ GeV and $|\eta(\mu^\pm)| < 2.4$. The muons must form a common vertex with χ^2 probability P_{vtx} above 1%. The dimuon invariant mass must be within 100 MeV of $m_{J/\psi}^{\text{PDG}}$ (hereafter, m_X^{PDG} denotes the world-average mass of hadron X [20]), corresponding to about three times the mass resolution. The Λ candidates are formed from displaced two-prong vertices, assuming the decay $\Lambda \to p\pi^-$, as described in Ref. [35]. The $p\pi^-$ reconstructed mass is required to be within 10 MeV of m_Λ^{PDG}, corresponding to about three times the mass resolution. The two tracks are then refitted with their invariant mass constrained to m_Λ^{PDG}. The obtained Λ candidates are required to have $p_T > 1$ GeV and $P_{\text{vtx}} > 1\%$.

For the $\Xi_b^- \to J/\psi\Xi^-$ channel, the $\Xi^- \to \Lambda\pi^-$ candidates are obtained by combining charged particles of $p_T > 0.25$ GeV with the selected Λ candidates. The reconstructed Ξ^- must have $P_{\text{vtx}} > 1\%$, $p_T > 3$ GeV, and invariant mass within 9.5 MeV of $m_{\Xi^-}^{\text{PDG}}$, corresponding to about three times the mass resolution. The Ξ_b^- candidates are obtained by performing a $\mu^+\mu^-\Xi^-$ kinematic vertex fit, constraining the dimuon invariant mass to $m_{J/\psi}^{\text{PDG}}$.

For the $\Xi_b^- \to J/\psi\Lambda K^-$ decay channel, the Λ candidates must pass stricter requirements: $p_T > 2$ GeV and $|M(p\pi^-) - m_\Lambda^{\text{PDG}}| < 9$ MeV. The charged kaon candidates are particle tracks with kaon mass assignment satisfying high-purity tracking requirements [36] and $p_T > 1.2$ GeV. The Ξ_b^- candidates are reconstructed by fitting the $\mu^+\mu^-\Lambda K^-$ vertex with the J/ψ mass constraint. Because the photon from the $\Sigma^0 \to \Lambda\gamma$ decay is not detected, both $\Xi_b^- \to J/\psi\Lambda K^-$ and $\Xi_b^- \to J/\psi\Sigma^0 K^-$ decays contribute to the $\mu^+\mu^-\Lambda K^-$ reconstructed combination.

The Ξ_b^- candidates are required to have $P_{\text{vtx}} > 1\%$ and $p_T > 10(15)$ GeV for the $\Xi_b^- \to J/\psi\Xi^-$ ($\Xi_b^- \to J/\psi\Lambda K^-$) channel. From all reconstructed pp collision vertices, the primary vertex (PV) is chosen as the one with the smallest pointing angle, as done in Refs. [37–40]. The pointing angle is the three-dimensional angle between the Ξ_b^- candidate momentum and the vector joining the PV with the reconstructed Ξ_b^- candidate decay vertex. The decay length L_{xy} of the Ξ_b^- candidate in the transverse plane, computed as the two-dimensional distance between the PV and the Ξ_b^- decay vertex, is required to be at least three times larger than its uncertainty $\sigma_{L_{xy}}$. The $\overrightarrow{p_T}(\Xi_b^-)$ is

required to be aligned with the transverse displacement vector: $\cos[\alpha(\Xi_b^-, \mathrm{PV})] > 0.99(0.993)$ for the $\Xi_b^- \to J/\psi\Xi^-$ ($\Xi_b^- \to J/\psi\Lambda K^-$) channel, where $\alpha(\Xi_b^-, \mathrm{PV})$ is the pointing angle in the plane transverse to the beams. Two additional topological requirements are applied: the cosine of the pointing angle $\cos[\alpha(\Xi^-, \Xi_b^-)]$ must be larger than 0.999 for the $\Xi_b^- \to J/\psi\Xi^-$ channel; and $L_{xy}/\sigma_{L_{xy}}(\Lambda, \Xi_b^-) > 20$ for the $\Xi_b^- \to J/\psi\Lambda K^-$ channel. In addition, the pion emitted in the $\Xi^- \to \Lambda\pi^-$ decay and the kaon emitted in the $\Xi_b^- \to J/\psi\Lambda K^-$ decay must have $d_{xy}/\sigma_{d_{xy}} > 0.9$ and 0.6, respectively, where d_{xy} is the impact parameter in the transverse plane with respect to the PV, and $\sigma_{d_{xy}}$ is its uncertainty.

The invariant mass distributions of the selected Ξ_b^- candidates are shown in Fig. 2 for the $J/\psi\Xi^-$ (upper) and $J/\psi\Lambda K^-$ (lower) channels. The two plots also show the results of independent unbinned extended maximum-likelihood fits. In both cases, the fully reconstructed Ξ_b^- signal is described by a double-Gaussian function with two free
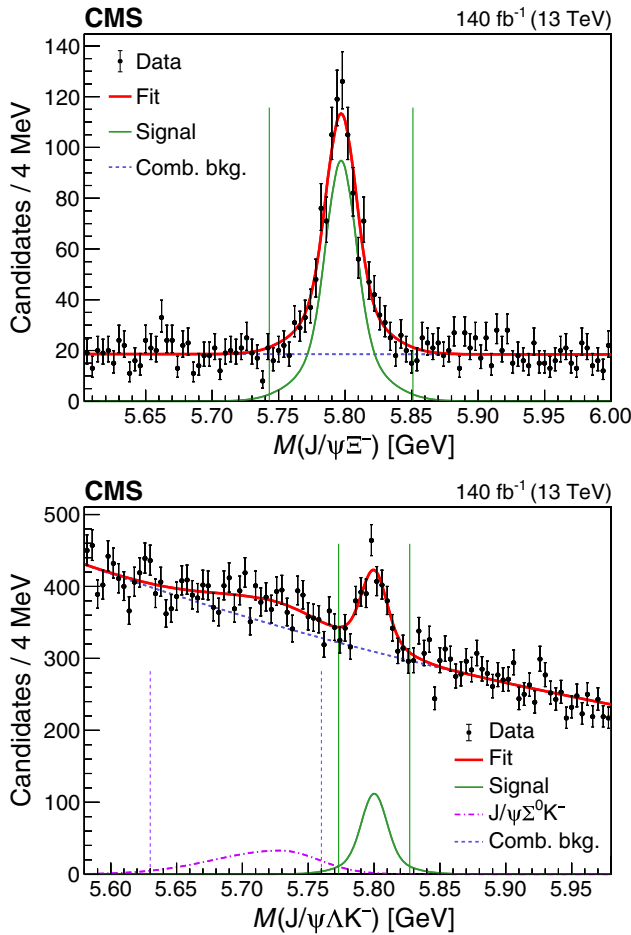

FIG. 2. Invariant mass distributions of the selected Ξ_b^- candidates in the $J/\psi\Xi^-$ (upper) and $J/\psi\Lambda K^-$ (lower) decay channels with the fit results superimposed. The vertical solid (dashed) lines show the mass windows discussed in the text and used in the reconstruction of the $\Xi_b^-\pi^+\pi^-$ candidates in $J/\psi\Xi^-$ and $J/\psi\Lambda K^-$ ($J/\psi\Sigma^0 K^-$) channels.

parameters: the common mean and the total yield; the two width parameters and the proportion of each Gaussian are fixed from simulation studies. The background is described by a first-order polynomial in the $J/\psi\Xi^-$ fit and an exponential function in the $J/\psi\Lambda K^-$ fit. In the latter fit, the signal contribution from the partially reconstructed $\Xi_b^- \to J/\psi\Sigma^0 K^-$ decays is taken into account by including an asymmetric Gaussian in the fit model, with the shape parameters fixed from simulation studies. All normalization values (signals and backgrounds) are free parameters of the fit.

The signal yields from the fits described above are 859 ± 36 and 815 ± 74 for the $\Xi_b^- \to J/\psi\Xi^-$ and fully reconstructed $\Xi_b^- \to J/\psi\Lambda K^-$ decay modes, respectively, with the uncertainties being statistical only. The fitted Ξ_b^- masses of 5797.0 ± 0.7 and 5800.1 ± 1.2 MeV, respectively for the $J/\psi\Xi^-$ and $J/\psi\Lambda K^-$ channels, the uncertainties being statistical only, are consistent with each other and with the world-average value, 5797.0 ± 0.6 MeV [20]. The signal components corresponding to fully reconstructed Ξ_b^- candidates are shown by the solid green curves. The fitted yield of the partially reconstructed $\Xi_b^- \to J/\psi\Sigma^0 K^-$ contribution, reconstructed as $J/\psi\Lambda K^-$, is 820 ± 158, represented by the dotted-dashed curve in Fig. 2 (lower). The Ξ_b^- fit results illustrate this part of the reconstruction procedure and provide the first confirmation of the $\Xi_b^- \to J/\psi\Lambda K^-$ decay observed by LHCb [24].

When reconstructing $\Xi_b^-\pi^+\pi^-$ candidates, we select events with Ξ_b^- invariant mass within 54 (27) MeV of the fitted Ξ_b^- mass for the $J/\psi\Xi^-$ ($J/\psi\Lambda K^-$) channel, corresponding to approximately 2.8 (1.8) times the mass resolution, as shown by the vertical solid lines in Fig. 2. The $5.63 < M(J/\psi\Lambda K^-) < 5.76$ GeV mass region is used for the partially reconstructed $\Xi_b^- \to J/\psi\Sigma^0 K^-$ decay mode, shown by the dashed vertical lines in Fig. 2 (lower). These mass ranges are selected through the same optimization procedure as used for the other selection criteria.

Because the lifetime of the excited Ξ_b states is expected to be negligible, the $\Xi_b^-\pi^+\pi^-$ candidates are formed by combining the selected Ξ_b^- candidates with two OS tracks originating from the PV, as in Refs. [37–40]. Combinations of a Ξ_b^- candidate with two SS pions from the PV are used as a control channel and form the SS control region. The analysis is performed using the mass difference variable $\Delta M = M(\Xi_b^-\pi^+\pi^-) - M(\Xi_b^-) - 2m_{\pi^\pm}^{\mathrm{PDG}}$, which has a better mass resolution than $M(\Xi_b^-\pi^+\pi^-)$, where $M(\Xi_b^-)$ represents the reconstructed Ξ_b^- mass. According to the simulation studies, this variable also has the advantage of being insensitive to a potential mass shift caused by the fact that the photon emitted in the $\Xi_b^- \to J/\psi\Sigma^0 K^-$, $\Sigma^0 \to \Lambda\gamma$ decay sequence is not reconstructed. Following the technique developed in Ref. [40], the selected Ξ_b^- candidate and all tracks forming the PV are refit to a common vertex, further improving the $\Xi_b^-\pi^+\pi^-$ invariant mass resolution of the fully reconstructed channels from 1.39 ± 0.11 to

0.94 ± 0.06 MeV (statistical uncertainties only), as obtained from simulation studies.

Theoretical studies [12,13,21] and analogous decays of excited charm baryons [20,41] suggest that the decay $\Xi_b^{**-} \to \Xi_b^- \pi^+ \pi^-$ should proceed predominantly through $\Xi_b^{**-} \to \Xi_b^{*0} \pi^-$, followed by $\Xi_b^{*0} \to \Xi_b^- \pi^+$. Therefore, an additional requirement is applied to enhance this contribution. As the Ξ_b^{*0} state has a mass of 5952.3 ± 0.6 MeV, the mass difference $M(\Xi_b^{*0}) - M(\Xi_b^-) - m_{\pi^+}^{\mathrm{PDG}}$ will peak at 15.73 MeV [20]. To avoid complications in understanding the $\Xi_b^- \pi^+ \pi^-$ threshold, we do not apply a minimum cut on this mass difference but simply require it to be less than 20.73 MeV, with the 5 MeV addition found to be optimal when considering the Ξ_b^{*0} natural width and our detector resolution.

The invariant mass distribution of the selected $\Xi_b^- \pi^+ \pi^-$ candidates is shown in Fig. 3, using the mass difference variable ΔM. The left plot combines the data from the $\Xi_b^- \to J/\psi \Xi^-$ and $\Xi_b^- \to J/\psi \Lambda K^-$ channels, which have

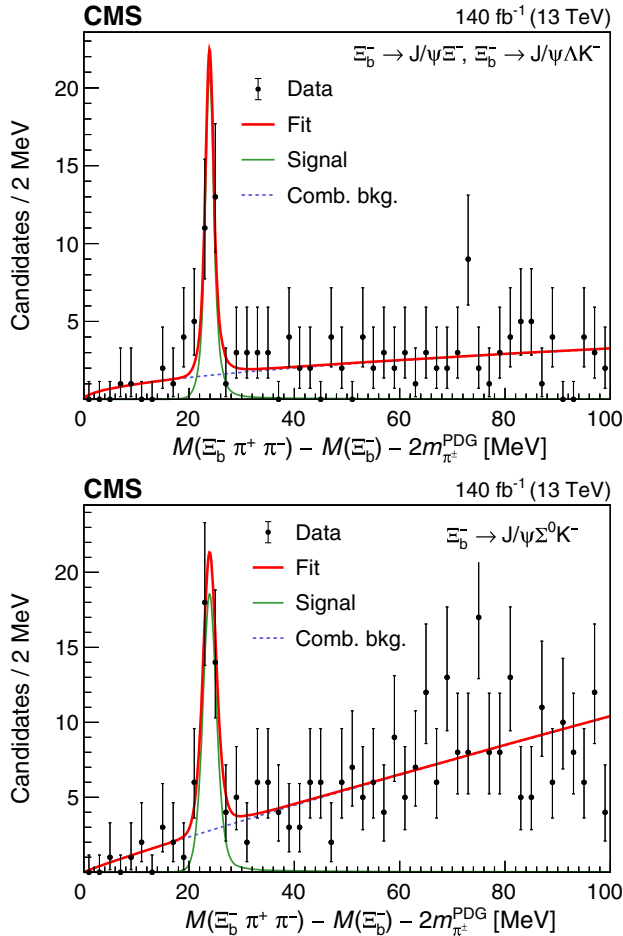FIG. 3. Distributions of the invariant mass difference ΔM for the selected $\Xi_b^- \pi^+ \pi^-$ candidates, with the Ξ_b^- reconstructed in the $J/\psi \Xi^-$ and $J/\psi \Lambda K^-$ channels (upper) or partially reconstructed in the $J/\psi \Sigma^0 K^-$ channel (lower). The result of the simultaneous fit is also shown.

identical mass resolutions, according to simulation studies (the Ξ_b^- is fully reconstructed in both channels). The right plot shows the events that use the partially reconstructed $\Xi_b^- \to J/\psi \Sigma^0 K^-$ channel, with a 30% larger mass resolution. Given the definition of the ΔM variable, the mean mass of the signal peaks should not depend on the Ξ_b^- reconstruction channel.

A narrow peak is seen near the threshold of the $\Xi_b^- \pi^+ \pi^-$ system in both plots of Fig. 3. The excess is also visible in each of the two independent decay channels, $J/\psi \Xi^-$ and $J/\psi \Lambda K^-$. We have also studied the OS and SS distributions in a wider range of ΔM (up to 280 MeV) and found no other significant peaks. A simultaneous unbinned extended maximum-likelihood fit is performed on the two data samples shown in Fig. 3, the result being represented by the red curves. The signal component is described with a relativistic Breit-Wigner (RBW) function [42,43] for the $\Xi_b(6100)^- \to \Xi_b^{*0} \pi^-$ decay, convolved with a double-Gaussian resolution function. The mass and natural width of the signal function are the two parameters of interest in the fit. The normalization and background parameters are different for the fully and partially reconstructed channels, as are the resolution parameters, which are fixed from the simulation studies. The background component is modeled with the threshold function $(\Delta M)^\alpha$, where α is a free parameter.

The fitted mass difference of the new $\Xi_b(6100)^-$ state is $\Delta M_{\Xi_b(6100)^-} = 24.14 \pm 0.22$ MeV, where the uncertainty is statistical only. The fitted signal yields are 26 ± 7 and 34 ± 9 for the fully reconstructed and the $\Xi_b^- \to J/\psi \Sigma^0 K^-$ channels, respectively. The relative yield of the $\Xi_b(6100)^-$, with respect to the Ξ_b^- yield, is found to be noticeably larger in the partially reconstructed Ξ_b^- channel, compared to the fully reconstructed channels. Given the large uncertainties in the observed small $\Xi_b(6100)^-$ signal yields, this discrepancy is consistent with being a statistical fluctuation. The order-of-magnitude larger signals of the $\Xi_b^{*0} \to \Xi_b^- \pi^+$ decays, with respect to the Ξ_b^- ground state signals, are found to be consistent between all three Ξ_b^- reconstruction channels.

The natural width of the $\Xi_b(6100)^-$ is too small to be measured with the present data sample and experimental resolution. An upper limit on $\Gamma[\Xi_b(6100)^-]$ has been obtained through a scan of the profiled likelihood, assuming an asymptotic distribution. The measured upper limit, at 95% confidence level, is $\Gamma[\Xi_b(6100)^-] < 1.9$ MeV, where the systematic uncertainties, discussed below, are taken into account.

The local statistical significance of the $\Xi_b(6100)^-$ signal is evaluated with the likelihood ratio technique, comparing the background-only and signal-plus-background hypotheses (with four additional free parameters), using asymptotic formulas [44,45]. The resulting significance of the $\Xi_b(6100)^-$ signal varies between 6.2 and 6.7 standard deviations, depending on the fit model variations used to evaluate the systematic uncertainties.

Several sources of systematic uncertainties in the measured mass difference $\Delta M_{\Xi_b(6100)^-}$ are considered. To evaluate the systematic uncertainties related to the choice of the fit model, several alternative functions are tested. Uncertainties related to the choice of the signal model are estimated by changing the resolution function from a double-Gaussian function to a single-Gaussian function or a sum of three Gaussian functions. Two alternative background models are considered: the threshold function multiplied by an exponential and the threshold function multiplied by a first-order polynomial. The largest deviations in the measured mass are 0.01 and 0.04 MeV, respectively, for the variations of the signal and background models; these values are taken as the two corresponding systematic uncertainties.

The RBW function used in the signal modeling includes Blatt-Weisskopf barrier factors [43], which depend on the radial parameter r and on the angular momentum l (spin). In the baseline fit, $r = 3.5$ GeV^{-1} and $l = 1$. The corresponding systematic uncertainties are obtained by varying r between 1 and 5 GeV^{-1} or by assigning $l = 0$. The r variations have a negligible effect on the results, while fixing $l = 0$ changes the signal shape and induces a mass difference variation of 0.01 MeV, taken as the corresponding systematic uncertainty.

To account for a possible difference between the measured and simulated mass resolutions, the fits are repeated with resolutions scaled up or down by 1.074, a factor determined from the comparison of the Ξ_b^- resolutions in data and simulation. The resulting systematic uncertainty of the $\Xi_b(6100)^-$ mass difference is 0.02 MeV.

Simulation studies show a shift of 0.07 MeV between the generated and reconstructed mass differences; this shift is treated as an additional systematic uncertainty in the $\Delta M_{\Xi_b(6100)^-}$ measurement.

The systematic uncertainty reflecting the ΔM fit range is evaluated by changing the upper end of the ΔM fit range from its default 100 MeV to 80, 120, and 150 MeV. The largest mass difference change of 0.02 MeV is taken as the corresponding systematic uncertainty.

A potential bias due to a possible misalignment of the tracker detectors is evaluated by comparing the results obtained with the data collected in 2016, 2017, and 2018. This is a reasonable evaluation, given that the inner part of the CMS tracker was replaced between the 2016 and 2017 data-taking periods. The measured mass is found to be insensitive to alignment uncertainties.

The total systematic uncertainty in the measured mass difference $\Delta M_{\Xi_b(6100)^-}$, calculated as the sum in quadrature of the partial terms, is 0.09 MeV.

In summary, we report the observation of a new excited beauty strange baryon, decaying to $\Xi_b^- \pi^+ \pi^-$. The analysis uses proton-proton collision data collected by the CMS experiment at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of 140 fb^{-1}. The measured mass difference of this state is $M[\Xi_b(6100)^-] - M(\Xi_b^-) - 2m_{\pi^\pm}^{\mathrm{PDG}} = 24.14 \pm 0.22(\mathrm{stat}) \pm 0.09(\mathrm{syst})$ MeV. The known Ξ_b^- mass of 5797.0 ± 0.6 MeV [20] is used to obtain $M[\Xi_b(6100)^-] = 6100.3 \pm 0.2(\mathrm{stat}) \pm 0.1(\mathrm{syst}) \pm 0.6(\Xi_b^-)$ MeV. It is particularly remarkable that if the $\Xi_b(6100)^-$ baryon were only 13 MeV heavier, it would be above the $\Lambda_b^0 K^-$ mass threshold and could decay to this final state. The natural width of this resonance is compatible with zero and a 95% confidence level upper limit of 1.9 MeV has been determined.

Following analogies with the established excited Ξ_c baryon states [20], and considering several theoretical predictions [12,13,21], the new $\Xi_b(6100)^-$ resonance and its decay sequence are consistent with the lightest orbitally excited Ξ_b^- baryon, with the light diquark angular momentum $j_{ds} = 1$ and $J^P = 3/2^-$ (excitation with orbital momentum $L = 1$ between the b quark and the ds diquark). This suggests that it is the beauty analog of the $\Xi_c(2815)$ baryon [41]. Measuring a natural width of the $\Xi_b(6100)^-$ smaller than 1.9 MeV comes as a surprise, given the larger values predicted by the theory calculations [12,13,21], based on the assumption that the $\Xi_b^{**-} \to \Xi_b^{*0} \pi^-$ decay proceeds predominantly via S wave $(3/2^- \to 3/2^+ 0^-)$. The observation of this baryon and the measurement of its properties provide information that should help to distinguish between different theoretical models used to calculate the properties of the excited Ξ_b states.

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Pant,[62] P. Shukla,[62] T. Aziz,[63] S. Dugad,[63] M. Kumar,[63] G. B. Mohanty,[63] U. Sarkar,[63] S. Banerjee,[64] S. Bhattacharya,[64] R. Chudasama,[64] M. Guchait,[64] S. Karmakar,[64] S. Kumar,[64] G. Majumder,[64] K. Mazumdar,[64] S. Mukherjee,[64] D. Roy,[64] S. Dube,[65] B. Kansal,[65] S. Pandey,[65] A. Rane,[65] A. Rastogi,[65] S. Sharma,[65] H. Bakhshiansohi,[66,oo] M. Zeinali,[66,pp] S. Chenarani,[67,qq] S. M. Etesami,[67] M. Khakzad,[67] M. Mohammadi Najafabadi,[67] M. Felcini,[68] M. Grunewald,[68] M. Abbrescia,[69a,69b] R. Aly,[69a,69b,rr] C. Aruta,[69a,69b] A. Colaleo,[69a] D. Creanza,[69a,69c] N. De Filippis,[69a,69c] M. De Palma,[69a,69b] A. Di Florio,[69a,69b] A. Di Pilato,[69a,69b] W. Elmetenawee,[69a,69b] L. Fiore,[69a] A. Gelmi,[69a,69b] M. Gul,[69a] G. Iaselli,[69a,69c] M. Ince,[69a,69b] S. Lezki,[69a,69b] G. Maggi,[69a,69c] M. Maggi,[69a] I. Margjeka,[69a,69b] V. Mastrapasqua,[69a,69b] J. A. Merlin,[69a] S. My,[69a,69b] S. Nuzzo,[69a,69b] A. Pellecchia,[69a,69b] A. Pompili,[69a,69b] G. Pugliese,[69a,69c] A. Ranieri,[69a] G. Selvaggi,[69a,69b] L. Silvestris,[69a] F. M. Simone,[69a,69b] R. Venditti,[69a] P. Verwilligen,[69a] G. Abbiendi,[70a] C. Battilana,[70a,70b] D. Bonacorsi,[70a,70b] L. Borgonovi,[70a] S. Braibant-Giacomelli,[70a,70b] L. Brigliadori,[70a] R. Campanini,[70a,70b] P. Capiluppi,[70a,70b] A. Castro,[70a,70b] F. R. Cavallo,[70a] C. Ciocca,[70a] M. Cuffiani,[70a,70b] G. M. Dallavalle,[70a] T. Diotalevi,[70a,70b] F. Fabbri,[70a] A. Fanfani,[70a,70b] P. Giacomelli,[70a] L. Giommi,[70a,70b] C. Grandi,[70a] L. Guiducci,[70a,70b] S. Lo Meo,[70a,ss] L. Lunerti,[70a,70b] S. Marcellini,[70a] G. Masetti,[70a] F. L. Navarria,[70a,70b] A. Perrotta,[70a] F. Primavera,[70a,70b] A. M. Rossi,[70a,70b] T. Rovelli,[70a,70b] G. P. Siroli,[70a,70b] N. Tosi,[70a] S. Albergo,[71a,71b,tt] S. Costa,[71a,71b,tt] A. Di Mattia,[71a] R. Potenza,[71a,71b] A. Tricomi,[71a,71b,tt] C. Tuve,[71a,71b] G. Barbagli,[72a] A. Cassese,[72a] R. Ceccarelli,[72a,72b] V. Ciulli,[72a,72b] C. Civinini,[72a] R. D'Alessandro,[72a,72b] F. Fiori,[72a,72b] E. Focardi,[72a,72b] G. Latino,[72a,72b] P. Lenzi,[72a,72b] M. Lizzo,[72a,72b] M. Meschini,[72a] S. Paoletti,[72a] R. Seidita,[72a,72b] G. Sguazzoni,[72a] L. Viliani,[72a] L. Benussi,[73] S. Bianco,[73] D. Piccolo,[73] M. Bozzo,[74a,74b] F. Ferro,[74a] R. Mulargia,[74a,74b] E. Robutti,[74a] S. Tosi,[74a,74b] A. Benaglia,[75a] F. Brivio,[75a,75b] F. Cetorelli,[75a,75b] V. Ciriolo,[75a,75b,v] F. De Guio,[75a,75b] M. E. Dinardo,[75a,75b] P. Dini,[75a] S. Gennai,[75a] A. Ghezzi,[75a,75b] P. Govoni,[75a,75b] L. Guzzi,[75a,75b] M. Malberti,[75a] S. Malvezzi,[75a] A. Massironi,[75a] D. Menasce,[75a] F. Monti,[75a,75b] L. Moroni,[75a] M. Paganoni,[75a,75b] D. Pedrini,[75a] S. Ragazzi,[75a,75b] T. Tabarelli de Fatis,[75a,75b] D. Valsecchi,[75a,75b,v] D. Zuolo,[75a,75b] S. Buontempo,[76a] F. Carnevali,[76a,76b] N. Cavallo,[76a,76c] A. De Iorio,[76a,76b] F. Fabozzi,[76a,76c] A. O. M. Iorio,[76a,76b] L. Lista,[76a,76b] S. Meola,[76a,76d,v] P. Paolucci,[76a,v] B. Rossi,[76a] C. Sciacca,[76a,76b] P. Azzi,[77a] N. Bacchetta,[77a] D. Bisello,[77a,77b] P. Bortignon,[77a] A. Bragagnolo,[77a,77b] R. Carlin,[77a,77b] P. Checchia,[77a] P. De Castro Manzano,[77a] T. Dorigo,[77a] F. Gasparini,[77a,77b] U. Gasparini,[77a,77b] S. Y. Hoh,[77a,77b] L. Layer,[77a,uu] M. Margoni,[77a,77b] A. T. Meneguzzo,[77a,77b] M. Presilla,[77a,77b] P. Ronchese,[77a,77b] R. Rossin,[77a,77b] F. Simonetto,[77a,77b] G. Strong,[77a] M. Tosi,[77a,77b] H. Yarar,[77a,77b] M. Zanetti,[77a,77b] P. Zotto,[77a,77b] A. Zucchetta,[77a,77b] G. Zumerle,[77a,77b] C. Aime`,[78a,78b] A. Braghieri,[78a] S. Calzaferri,[78a,78b] D. Fiorina,[78a,78b] P. Montagna,[78a,78b] S. P. Ratti,[78a,78b] V. Re,[78a]

M. Ressegotti,[78a,78b] C. Riccardi,[78a,78b] P. Salvini,[78a] I. Vai,[78a] P. Vitulo,[78a,78b] G. M. Bilei,[79a] D. Ciangottini,[79a,79b] L. Fanò,[79a,79b] P. Lariccia,[79a,79b] M. Magherini,[79a,79b] G. Mantovani,[79a,79b] V. Mariani,[79a,79b] M. Menichelli,[79a] F. Moscatelli,[79a] A. Piccinelli,[79a,79b] A. Rossi,[79a,79b] A. Santocchia,[79a,79b] D. Spiga,[79a] T. Tedeschi,[79a,79b] P. Azzurri,[80a] G. Bagliesi,[80a] V. Bertacchi,[80a,80c] L. Bianchini,[80a] T. Boccali,[80a] E. Bossini,[80a,80b] R. Castaldi,[80a] M. A. Ciocci,[80a,80b] R. Dell'Orso,[80a] M. R. Di Domenico,[80a,80d] S. Donato,[80a] A. Giassi,[80a] M. T. Grippo,[80a] F. Ligabue,[80a,80c] E. Manca,[80a,80c] G. Mandorli,[80a,80c] A. Messineo,[80a,80b] F. Palla,[80a] S. Parolia,[80a,80b] G. Ramirez-Sanchez,[80a,80c] A. Rizzi,[80a,80b] G. Rolandi,[80a,80c] S. Roy Chowdhury,[80a,80c] A. Scribano,[80a] N. Shafiei,[80a,80b] P. Spagnolo,[80a] R. Tenchini,[80a] G. Tonelli,[80a,80b] N. Turini,[80a,80d] A. Venturi,[80a] P. G. Verdini,[80a] M. Campana,[81a,81b] F. Cavallari,[81a] M. Cipriani,[81a,81b] D. Del Re,[81a,81b] E. Di Marco,[81a] M. Diemoz,[81a] E. Longo,[81a,81b] P. Meridiani,[81a] G. Organtini,[81a,81b] F. Pandolfi,[81a] R. Paramatti,[81a,81b] C. Quaranta,[81a,81b] S. Rahatlou,[81a,81b] C. Rovelli,[81a] F. Santanastasio,[81a,81b] L. Soffi,[81a] R. Tramontano,[81a,81b] N. Amapane,[82a,82b] R. Arcidiacono,[82a,82c] S. Argiro,[82a,82b] M. Arneodo,[82a,82c] N. Bartosik,[82a] R. Bellan,[82a,82b] A. Bellora,[82a,82b] J. Berenguer Antequera,[82a,82b] C. Biino,[82a] N. Cartiglia,[82a] S. Cometti,[82a] M. Costa,[82a,82b] R. Covarelli,[82a,82b] N. Demaria,[82a] B. Kiani,[82a,82b] F. Legger,[82a] C. Mariotti,[82a] S. Maselli,[82a] E. Migliore,[82a,82b] E. Monteil,[82a,82b] M. Monteno,[82a] M. M. Obertino,[82a,82b] G. Ortona,[82a] L. Pacher,[82a,82b] N. Pastrone,[82a] M. Pelliccioni,[82a] G. L. Pinna Angioni,[82a,82b] M. Ruspa,[82a,82c] R. Salvatico,[82a,82b] K. Shchelina,[82a,82b] F. Siviero,[82a,82b] V. Sola,[82a] A. Solano,[82a,82b] D. Soldi,[82a,82b] A. Staiano,[82a] M. Tornago,[82a,82b] D. Trocino,[82a,82b] S. Belforte,[83a] V. Candelise,[83a,83b] M. Casarsa,[83a] F. Cossutti,[83a] A. Da Rold,[83a,83b] G. Della Ricca,[83a,83b] G. Sorrentino,[83a,83b] F. Vazzoler,[83a,83b] S. Dogra,[84] C. Huh,[84] B. Kim,[84] D. H. Kim,[84] G. N. Kim,[84] J. Kim,[84] J. Lee,[84] S. W. Lee,[84] C. S. Moon,[84] Y. D. Oh,[84] S. I. Pak,[84] B. C. Radburn-Smith,[84] S. Sekmen,[84] Y. C. Yang,[84] H. Kim,[85] D. H. Moon,[85] T. J. Kim,[86] J. Park,[86] S. Cho,[87] S. Choi,[87] Y. Go,[87] B. Hong,[87] K. Lee,[87] K. S. Lee,[87] J. Lim,[87] J. Park,[87] S. K. Park,[87] J. Yoo,[87] J. Goh,[88] A. Gurtu,[88] H. S. Kim,[89] Y. Kim,[89] J. Almond,[90] J. H. Bhyun,[90] J. Choi,[90] S. Jeon,[90] J. Kim,[90] J. S. Kim,[90] S. Ko,[90] H. Kwon,[90] H. Lee,[90] S. Lee,[90] B. H. Oh,[90] M. Oh,[90] S. B. Oh,[90] H. Seo,[90] U. K. Yang,[90] I. Yoon,[90] D. Jeon,[91] J. H. Kim,[91] B. Ko,[91] J. S. H. Lee,[91] I. C. Park,[91] Y. Roh,[91] D. Song,[91] I. J. Watson,[91] S. Ha,[92] H. D. Yoo,[92] Y. Choi,[93] Y. Jeong,[93] H. Lee,[93] Y. Lee,[93] I. Yu,[93] T. Beyrouthy,[94] Y. Maghrbi,[94] V. Veckalns,[95,vv] M. Ambrozas,[96] A. Juodagalvis,[96] A. Rinkevicius,[96] G. Tamulaitis,[96] A. Vaitkevicius,[96] N. Bin Norjoharuddeen,[97] W. A. T. Wan Abdullah,[97] M. N. Yusli,[97] Z. Zolkapli,[97] J. F. Benitez,[98] A. Castaneda Hernandez,[98] J. A. Murillo Quijada,[98] L. Valencia Palomo,[98] G. Ayala,[99] H. Castilla-Valdez,[99] E. De La Cruz-Burelo,[99] I. Heredia-De La Cruz,[99,ww] R. Lopez-Fernandez,[99] C. A. Mondragon Herrera,[99] D. A. Perez Navarro,[99] A. Sanchez-Hernandez,[99] S. Carrillo Moreno,[100] C. Oropeza Barrera,[100] M. Ramirez-Garcia,[100] F. Vazquez Valencia,[100] I. Pedraza,[101] H. A. Salazar Ibarguen,[101] C. Uribe Estrada,[101] J. Mijuskovic,[102,xx] N. Raicevic,[102] D. Krofcheck,[103] S. Bheesette,[104] P. H. Butler,[104] A. Ahmad,[105] M. I. Asghar,[105] A. Awais,[105] M. I. M. Awan,[105] H. R. Hoorani,[105] W. A. Khan,[105] M. A. Shah,[105] M. Shoaib,[105] M. Waqas,[105] V. Avati,[106] L. Grzanka,[106] M. Malawski,[106] H. Bialkowska,[107] M. Bluj,[107] B. Boimska,[107] T. Frueboes,[107] M. Górski,[107] M. Kazana,[107] M. Szleper,[107] P. Traczyk,[107] P. Zalewski,[107] K. Bunkowski,[108] K. Doroba,[108] A. Kalinowski,[108] M. Konecki,[108] J. Krolikowski,[108] M. Walczak,[108] M. Araujo,[109] P. Bargassa,[109] D. Bastos,[109] A. Boletti,[109] P. Faccioli,[109] M. Gallinaro,[109] J. Hollar,[109] N. Leonardo,[109] T. Niknejad,[109] M. Pisano,[109] J. Seixas,[109] O. Toldaiev,[109] J. Varela,[109] S. Afanasiev,[110] D. Budkouski,[110] P. Bunin,[110] M. Gavrilenko,[110] I. Golutvin,[110] I. Gorbunov,[110] A. Kamenev,[110] V. Karjavine,[110] A. Lanev,[110] A. Malakhov,[110] V. Matveev,[110,yy,zz] V. Palichik,[110] V. Perelygin,[110] M. Savina,[110] D. Seitova,[110] V. Shalaev,[110] S. Shmatov,[110] S. Shulha,[110] V. Smirnov,[110] O. Teryaev,[110] N. Voytishin,[110] A. Zarubin,[110] I. Zhizhin,[110] G. Gavrilov,[111] V. Golovtcov,[111] Y. Ivanov,[111] V. Kim,[111,aaa] E. Kuznetsova,[111,bbb] V. Murzin,[111] V. Oreshkin,[111] I. Smirnov,[111] D. Sosnov,[111] V. Sulimov,[111] L. Uvarov,[111] S. Volkov,[111] A. Vorobyev,[111] Yu. Andreev,[112] A. Dermenev,[112] S. Gninenko,[112] N. Golubev,[112] A. Karneyeu,[112] M. Kirsanov,[112] N. Krasnikov,[112] A. Pashenkov,[112] G. Pivovarov,[112] D. Tlisov,[112,a] A. Toropin,[112] V. Epshteyn,[113] V. Gavrilov,[113] N. Lychkovskaya,[113] A. Nikitenko,[113,ccc] V. Popov,[113] G. Safronov,[113] A. Spiridonov,[113] A. Stepennov,[113] M. Toms,[113] E. Vlasov,[113] A. Zhokin,[113] T. Aushev,[114] K. Ivanov,[114] R. Chistov,[115,ddd] M. Danilov,[115,eee] A. Oskin,[115] P. Parygin,[115] S. Polikarpov,[115,eee] V. Andreev,[116] M. Azarkin,[116] I. Dremin,[116] M. Kirakosyan,[116] A. Terkulov,[116] A. Belyaev,[117] E. Boos,[117] M. Dubinin,[117,fff] L. Dudko,[117] A. Ershov,[117] A. Gribushin,[117] V. Klyukhin,[117] O. Kodolova,[117] I. Lokhtin,[117] S. Obraztsov,[117] S. Petrushanko,[117] V. Savrin,[117] A. Snigirev,[117] V. Blinov,[118,ggg] T. Dimova,[118,ggg] L. Kardapoltsev,[118,ggg] I. Ovtin,[118,ggg] Y. Skovpen,[118,ggg] I. Azhgirey,[119] I. Bayshev,[119] V. Kachanov,[119] A. Kalinin,[119] D. Konstantinov,[119] V. Petrov,[119] R. Ryutin,[119] A. Sobol,[119] S. Troshin,[119] N. Tyurin,[119] A. Uzunian,[119] A. Volkov,[119] A. Babaev,[120] V. Okhotnikov,[120] L. Sukhikh,[120] V. Borchsh,[121] V. Ivanchenko,[121] E. Tcherniaev,[121] P. Adzic,[122,hhh] M. Dordevic,[122] P. Milenovic,[122] J. Milosevic,[122] V. Milosevic,[122] M. Aguilar-Benitez,[123]

J. Alcaraz Maestre,[123] A. Álvarez Fernández,[123] I. Bachiller,[123] M. Barrio Luna,[123] Cristina F. Bedoya,[123] C. A. Carrillo Montoya,[123] M. Cepeda,[123] M. Cerrada,[123] N. Colino,[123] B. De La Cruz,[123] A. Delgado Peris,[123] J. P. Fernández Ramos,[123] J. Flix,[123] M. C. Fouz,[123] O. Gonzalez Lopez,[123] S. Goy Lopez,[123] J. M. Hernandez,[123] M. I. Josa,[123] J. León Holgado,[123] D. Moran,[123] Á. Navarro Tobar,[123] A. Pérez-Calero Yzquierdo,[123] J. Puerta Pelayo,[123] I. Redondo,[123] L. Romero,[123] S. Sánchez Navas,[123] M. S. Soares,[123] L. Urda Gómez,[123] C. Willmott,[123] J. F. de Trocóniz,[124] R. Reyes-Almanza,[124] B. Alvarez Gonzalez,[125] J. Cuevas,[125] C. Erice,[125] J. Fernandez Menendez,[125] S. Folgueras,[125] I. Gonzalez Caballero,[125] E. Palencia Cortezon,[125] C. Ramón Álvarez,[125] J. Ripoll Sau,[125] V. Rodríguez Bouza,[125] A. Trapote,[125] J. A. Brochero Cifuentes,[126] I. J. Cabrillo,[126] A. Calderon,[126] B. Chazin Quero,[126] J. Duarte Campderros,[126] M. Fernandez,[126] C. Fernandez Madrazo,[126] P. J. Fernández Manteca,[126] A. García Alonso,[126] G. Gomez,[126] C. Martinez Rivero,[126] P. Martinez Ruiz del Arbol,[126] F. Matorras,[126] P. Matorras Cuevas,[126] J. Piedra Gomez,[126] C. Prieels,[126] F. Ricci-Tam,[126] T. Rodrigo,[126] A. Ruiz-Jimeno,[126] L. Scodellaro,[126] N. Trevisani,[126] I. Vila,[126] J. M. Vizan Garcia,[126] MK Jayananda,[127] B. Kailasapathy,[127,iii] D. U. J. Sonnadara,[127] D. D. C. Wickramarathna,[127] W. G. D. Dharmaratna,[128] K. Liyanage,[128] N. Perera,[128] N. Wickramage,[128] T. K. Aarrestad,[129] D. Abbaneo,[129] J. Alimena,[129] E. Auffray,[129] G. Auzinger,[129] J. Baechler,[129] P. Baillon,[129,a] A. H. Ball,[129] D. Barney,[129] J. Bendavid,[129] N. Beni,[129] M. Bianco,[129] A. Bocci,[129] E. Brondolin,[129] T. Camporesi,[129] M. Capeans Garrido,[129] G. Cerminara,[129] S. S. Chhibra,[129] L. Cristella,[129] D. d'Enterria,[129] A. Dabrowski,[129] N. Daci,[129] A. David,[129] A. De Roeck,[129] M. Deile,[129] R. Di Maria,[129] M. Dobson,[129] M. Dünser,[129] N. Dupont,[129] A. Elliott-Peisert,[129] N. Emriskova,[129] F. Fallavollita,[129,jjj] D. Fasanella,[129] S. Fiorendi,[129] A. Florent,[129] G. Franzoni,[129] J. Fulcher,[129] W. Funk,[129] S. Giani,[129] D. Gigi,[129] K. Gill,[129] F. Glege,[129] L. Gouskos,[129] M. Haranko,[129] J. Hegeman,[129] Y. Iiyama,[129] V. Innocente,[129] T. James,[129] P. Janot,[129] J. Kaspar,[129] J. Kieseler,[129] M. Komm,[129] N. Kratochwil,[129] C. Lange,[129] S. Laurila,[129] P. Lecoq,[129] K. Long,[129] C. Lourenço,[129] L. Malgeri,[129] S. Mallios,[129] M. Mannelli,[129] F. Meijers,[129] S. Mersi,[129] E. Meschi,[129] F. Moortgat,[129] M. Mulders,[129] S. Orfanelli,[129] L. Orsini,[129] F. Pantaleo,[129] L. Pape,[129] E. Perez,[129] M. Peruzzi,[129] A. Petrilli,[129] G. Petrucciani,[129] A. Pfeiffer,[129] M. Pierini,[129] M. Pitt,[129] H. Qu,[129] T. Quast,[129] D. Rabady,[129] A. Racz,[129] M. Rieger,[129] M. Rovere,[129] H. Sakulin,[129] J. Salfeld-Nebgen,[129] S. Scarfi,[129] C. Schäfer,[129] C. Schwick,[129] M. Selvaggi,[129] A. Sharma,[129] P. Silva,[129] W. Snoeys,[129] P. Sphicas,[129,kkk] S. Summers,[129] V. R. Tavolaro,[129] D. Treille,[129] A. Tsirou,[129] G. P. Van Onsem,[129] M. Verzetti,[129] J. Wanczyk,[129,lll] K. A. Wozniak,[129] W. D. Zeuner,[129] L. Caminada,[130,mmm] A. Ebrahimi,[130] W. Erdmann,[130] R. Horisberger,[130] Q. Ingram,[130] H. C. Kaestli,[130] D. Kotlinski,[130] U. Langenegger,[130] M. Missiroli,[130] T. Rohe,[130] K. Androsov,[131,lll] M. Backhaus,[131] P. Berger,[131] A. Calandri,[131] N. Chernyavskaya,[131] A. De Cosa,[131] G. Dissertori,[131] M. Dittmar,[131] M. Donegà,[131] C. Dorfer,[131] F. Eble,[131] T. Gadek,[131] T. A. Gómez Espinosa,[131] C. Grab,[131] D. Hits,[131] W. Lustermann,[131] A.-M. Lyon,[131] R. A. Manzoni,[131] C. Martin Perez,[131] M. T. Meinhard,[131] F. Micheli,[131] F. Nessi-Tedaldi,[131] J. Niedziela,[131] F. Pauss,[131] V. Perovic,[131] G. Perrin,[131] S. Pigazzini,[131] M. G. Ratti,[131] M. Reichmann,[131] C. Reissel,[131] T. Reitenspiess,[131] B. Ristic,[131] D. Ruini,[131] D. A. Sanz Becerra,[131] M. Schönenberger,[131] V. Stampf,[131] J. Steggemann,[131,lll] R. Wallny,[131] D. H. Zhu,[131] C. Amsler,[132,nnn] P. Bärtschi,[132] C. Botta,[132] D. Brzhechko,[132] M. F. Canelli,[132] A. De Wit,[132] R. Del Burgo,[132] J. K. Heikkilä,[132] M. Huwiler,[132] A. Jofrehei,[132] B. Kilminster,[132] S. Leontsinis,[132] A. Macchiolo,[132] P. Meiring,[132] V. M. Mikuni,[132] U. Molinatti,[132] I. Neutelings,[132] G. Rauco,[132] A. Reimers,[132] P. Robmann,[132] S. Sanchez Cruz,[132] K. Schweiger,[132] Y. Takahashi,[132] C. Adloff,[133,ooo] C. M. Kuo,[133] W. Lin,[133] A. Roy,[133] T. Sarkar,[133,mm] S. S. Yu,[133] L. Ceard,[134] P. Chang,[134] Y. Chao,[134] K. F. Chen,[134] P. H. Chen,[134] W.-S. Hou,[134] Y. y. Li,[134] R.-S. Lu,[134] E. Paganis,[134] A. Psallidas,[134] A. Steen,[134] E. Yazgan,[134] P. r. Yu,[134] B. Asavapibhop,[135] C. Asawatangtrakuldee,[135] N. Srimanobhas,[135] F. Boran,[136] S. Damarseckin,[136,ppp] Z. S. Demiroglu,[136] F. Dolek,[136] I. Dumanoglu,[136,qqq] E. Eskut,[136] G. Gokbulut,[136] Y. Guler,[136] E. Gurpinar Guler,[136,rrr] I. Hos,[136,sss] C. Isik,[136] E. E. Kangal,[136,ttt] O. Kara,[136] A. Kayis Topaksu,[136] U. Kiminsu,[136] G. Onengut,[136] K. Ozdemir,[136,uuu] A. Polatoz,[136] A. E. Simsek,[136] B. Tali,[136,vvv] U. G. Tok,[136] S. Turkcapar,[136] I. S. Zorbakir,[136] C. Zorbilmez,[136] B. Isildak,[137,www] G. Karapinar,[137,xxx] K. Ocalan,[137,yyy] M. Yalvac,[137,zzz] B. Akgun,[138] I. O. Atakisi,[138] E. Gülmez,[138] M. Kaya,[138,aaaa] O. Kaya,[138,bbbb] Ö. Özçelik,[138] S. Tekten,[138,cccc] E. A. Yetkin,[138,dddd] A. Cakir,[139] K. Cankocak,[139,qqq] Y. Komurcu,[139] S. Sen,[139,eeee] F. Aydogmus Sen,[140] S. Cerci,[140,vvv] B. Kaynak,[140] S. Ozkorucuklu,[140] D. Sunar Cerci,[140,vvv] B. Grynyov,[141] L. Levchuk,[142] D. Anthony,[143] E. Bhal,[143] S. Bologna,[143] J. J. Brooke,[143] A. Bundock,[143] E. Clement,[143] D. Cussans,[143] H. Flacher,[143] J. Goldstein,[143] G. P. Heath,[143] H. F. Heath,[143] L. Kreczko,[143] B. Krikler,[143] S. Paramesvaran,[143] T. Sakuma,[143] S. Seif El Nasr-Storey,[143] V. J. Smith,[143] N. Stylianou,[143,ffff] J. Taylor,[143] A. Titterton,[143] R. White,[143] K. W. Bell,[144] A. Belyaev,[144,gggg] C. Brew,[144] R. M. Brown,[144] D. J. A. Cockerill,[144] K. V. Ellis,[144] K. Harder,[144] S. Harper,[144] J. Linacre,[144]

K. Manolopoulos,[144] D. M. Newbold,[144] E. Olaiya,[144] D. Petyt,[144] T. Reis,[144] T. Schuh,[144]
C. H. Shepherd-Themistocleous,[144] A. Thea,[144] I. R. Tomalin,[144] T. Williams,[144] R. Bainbridge,[145] P. Bloch,[145]
S. Bonomally,[145] J. Borg,[145] S. Breeze,[145] O. Buchmuller,[145] V. Cepaitis,[145] G. S. Chahal,[145,hhhh] D. Colling,[145]
P. Dauncey,[145] G. Davies,[145] M. Della Negra,[145] S. Fayer,[145] G. Fedi,[145] G. Hall,[145] M. H. Hassanshahi,[145] G. Iles,[145]
J. Langford,[145] L. Lyons,[145] A.-M. Magnan,[145] S. Malik,[145] A. Martelli,[145] J. Nash,[145,iiii] V. Palladino,[145] M. Pesaresi,[145]
D. M. Raymond,[145] A. Richards,[145] A. Rose,[145] E. Scott,[145] C. Seez,[145] A. Shtipliyski,[145] A. Tapper,[145] K. Uchida,[145]
T. Virdee,[145,v] N. Wardle,[145] S. N. Webb,[145] D. Winterbottom,[145] A. G. Zecchinelli,[145] K. Coldham,[146] J. E. Cole,[146]
A. Khan,[146] P. Kyberd,[146] C. K. Mackay,[146] I. D. Reid,[146] L. Teodorescu,[146] S. Zahid,[146] S. Abdullin,[147] A. Brinkerhoff,[147]
B. Caraway,[147] J. Dittmann,[147] K. Hatakeyama,[147] A. R. Kanuganti,[147] B. McMaster,[147] N. Pastika,[147] S. Sawant,[147]
C. Smith,[147] C. Sutantawibul,[147] J. Wilson,[147] R. Bartek,[148] A. Dominguez,[148] R. Uniyal,[148] A. M. Vargas Hernandez,[148]
A. Buccilli,[149] O. Charaf,[149] S. I. Cooper,[149] D. Di Croce,[149] S. V. Gleyzer,[149] C. Henderson,[149] C. U. Perez,[149]
P. Rumerio,[149,jjjj] C. West,[149] A. Akpinar,[150] A. Albert,[150] D. Arcaro,[150] C. Cosby,[150] Z. Demiragli,[150] E. Fontanesi,[150]
D. Gastler,[150] J. Rohlf,[150] K. Salyer,[150] D. Sperka,[150] D. Spitzbart,[150] I. Suarez,[150] A. Tsatsos,[150] S. Yuan,[150] D. Zou,[150]
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X. Yan,[151] D. Yu,[151] W. Zhang,[151] C. Brainerd,[152] R. Breedon,[152] M. Calderon De La Barca Sanchez,[152] M. Chertok,[152]
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W. A. Nash,[153] S. Regnard,[153] D. Saltzberg,[153] C. Schnaible,[153] B. Stone,[153] V. Valuev,[153] K. Burt,[154] Y. Chen,[154] R. Clare,[154]
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T. Mudholkar,[158] M. Paulini,[158] I. Vorobiev,[158] J. P. Cumalat,[159] W. T. Ford,[159] E. MacDonald,[159] R. Patel,[159] A. Perloff,[159]
K. Stenson,[159] K. A. Ulmer,[159] S. R. Wagner,[159] J. Alexander,[160] Y. Cheng,[160] J. Chu,[160] D. J. Cranshaw,[160] K. Mcdermott,[160]
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P. Wittich,[160] M. Zientek,[160] M. Albrow,[161] M. Alyari,[161] G. Apollinari,[161] A. Apresyan,[161] A. Apyan,[161] S. Banerjee,[161]
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J. Hirschauer,[161] B. Jayatilaka,[161] S. Jindariani,[161] M. Johnson,[161] U. Joshi,[161] P. Klabbers,[161] T. Klijnsma,[161] B. Klima,[161]
M. J. Kortelainen,[161] K. H. M. Kwok,[161] S. Lammel,[161] D. Lincoln,[161] R. Lipton,[161] T. Liu,[161] J. Lykken,[161] C. Madrid,[161]
K. Maeshima,[161] C. Mantilla,[161] D. Mason,[161] P. McBride,[161] P. Merkel,[161] S. Mrenna,[161] S. Nahn,[161] V. O'Dell,[161]
V. Papadimitriou,[161] K. Pedro,[161] C. Pena,[161,fff] O. Prokofyev,[161] F. Ravera,[161] A. Reinsvold Hall,[161] L. Ristori,[161]
B. Schneider,[161] E. Sexton-Kennedy,[161] N. Smith,[161] A. Soha,[161] L. Spiegel,[161] S. Stoynev,[161] J. Strait,[161] L. Taylor,[161]
S. Tkaczyk,[161] N. V. Tran,[161] L. Uplegger,[161] E. W. Vaandering,[161] H. A. Weber,[161] A. Woodard,[161] D. Acosta,[162] P. Avery,[162]
D. Bourilkov,[162] L. Cadamuro,[162] V. Cherepanov,[162] F. Errico,[162] R. D. Field,[162] D. Guerrero,[162] B. M. Joshi,[162] M. Kim,[162]
J. Konigsberg,[162] A. Korytov,[162] K. H. Lo,[162] K. Matchev,[162] N. Menendez,[162] G. Mitselmakher,[162] D. Rosenzweig,[162]
S. Rosenzweig,[162] K. Shi,[162] J. Sturdy,[162] J. Wang,[162] E. Yigitbasi,[162] X. Zuo,[162] T. Adams,[163] A. Askew,[163] D. Diaz,[163]
R. Habibullah,[163] S. Hagopian,[163] V. Hagopian,[163] K. F. Johnson,[163] R. Khurana,[163] T. Kolberg,[163] G. Martinez,[163]
H. Prosper,[163] C. Schiber,[163] R. Yohay,[163] J. Zhang,[163] M. M. Baarmand,[164] S. Butalla,[164] T. Elkafrawy,[164,o]
M. Hohlmann,[164] R. Kumar Verma,[164] D. Noonan,[164] M. Rahmani,[164] M. Saunders,[164] F. Yumiceva,[164] M. R. Adams,[165]
L. Apanasevich,[165] H. Becerril Gonzalez,[165] R. Cavanaugh,[165] X. Chen,[165] S. Dittmer,[165] O. Evdokimov,[165] C. E. Gerber,[165]

D. A. Hangal,[165] D. J. Hofman,[165] C. Mills,[165] G. Oh,[165] T. Roy,[165] M. B. Tonjes,[165] N. Varelas,[165] J. Viinikainen,[165] X. Wang,[165] Z. Wu,[165] Z. Ye,[165] M. Alhusseini,[166] K. Dilsiz,[166,mmmm] S. Durgut,[166] R. P. Gandrajula,[166] M. Haytmyradov,[166] V. Khristenko,[166] O. K. Köseyan,[166] J.-P. Merlo,[166] A. Mestvirishvili,[166,nnnn] A. Moeller,[166] J. Nachtman,[166] H. Ogul,[166,oooo] Y. Onel,[166] F. Ozok,[166,pppp] A. Penzo,[166] C. Snyder,[166] E. Tiras,[166,qqqq] J. Wetzel,[166] O. Amram,[167] B. Blumenfeld,[167] L. Corcodilos,[167] J. Davis,[167] M. Eminizer,[167] A. V. Gritsan,[167] S. Kyriacou,[167] P. Maksimovic,[167] J. Roskes,[167] M. Swartz,[167] T. Á. Vámi,[167] C. Baldenegro Barrera,[168] P. Baringer,[168] A. Bean,[168] A. Bylinkin,[168] T. Isidori,[168] S. Khalil,[168] J. King,[168] G. Krintiras,[168] A. Kropivnitskaya,[168] C. Lindsey,[168] N. Minafra,[168] M. Murray,[168] C. Rogan,[168] C. Royon,[168] S. Sanders,[168] E. Schmitz,[168] J. D. Tapia Takaki,[168] Q. Wang,[168] J. Williams,[168] G. Wilson,[168] S. Duric,[169] A. Ivanov,[169] K. Kaadze,[169] D. Kim,[169] Y. Maravin,[169] T. Mitchell,[169] A. Modak,[169] K. Nam,[169] F. Rebassoo,[170] D. Wright,[170] E. Adams,[171] A. Baden,[171] O. Baron,[171] A. Belloni,[171] S. C. Eno,[171] Y. Feng,[171] N. J. Hadley,[171] S. Jabeen,[171] R. G. Kellogg,[171] T. Koeth,[171] A. C. Mignerey,[171] S. Nabili,[171] M. Seidel,[171] A. Skuja,[171] S. C. Tonwar,[171] L. Wang,[171] K. Wong,[171] D. Abercrombie,[172] G. Andreassi,[172] R. Bi,[172] S. Brandt,[172] W. Busza,[172] I. A. Cali,[172] Y. Chen,[172] M. D'Alfonso,[172] G. Gomez Ceballos,[172] M. Goncharov,[172] P. Harris,[172] M. Hu,[172] M. Klute,[172] D. Kovalskyi,[172] J. Krupa,[172] Y.-J. Lee,[172] B. Maier,[172] A. C. Marini,[172] C. Mironov,[172] C. Paus,[172] D. Rankin,[172] C. Roland,[172] G. Roland,[172] Z. Shi,[172] G. S. F. Stephans,[172] K. Tatar,[172] J. Wang,[172] Z. Wang,[172] B. Wysrouch,[172] R. M. Chatterjee,[173] A. Evans,[173] P. Hansen,[173] J. Hiltbrand,[173] Sh. Jain,[173] M. Krohn,[173] Y. Kubota,[173] Z. Lesko,[173] J. Mans,[173] M. Revering,[173] R. Rusack,[173] R. Saradhy,[173] N. Schroeder,[173] N. Strobbe,[173] M. A. Wadud,[173] J. G. Acosta,[174] S. Oliveros,[174] K. Bloom,[175] M. Bryson,[175] S. Chauhan,[175] D. R. Claes,[175] C. Fangmeier,[175] L. Finco,[175] F. Golf,[175] J. R. González Fernández,[175] C. Joo,[175] I. Kravchenko,[175] M. Musich,[175] J. E. Siado,[175] G. R. Snow,[175,a] W. Tabb,[175] F. Yan,[175] G. Agarwal,[176] H. Bandyopadhyay,[176] L. Hay,[176] I. Iashvili,[176] A. Kharchilava,[176] C. McLean,[176] D. Nguyen,[176] J. Pekkanen,[176] S. Rappoccio,[176] A. Williams,[176] G. Alverson,[177] E. Barberis,[177] C. Freer,[177] Y. Haddad,[177] A. Hortiangtham,[177] J. Li,[177] G. Madigan,[177] B. Marzocchi,[177] D. M. Morse,[177] V. Nguyen,[177] T. Orimoto,[177] A. Parker,[177] L. Skinnari,[177] A. Tishelman-Charny,[177] T. Wamorkar,[177] B. Wang,[177] A. Wisecarver,[177] D. Wood,[177] S. Bhattacharya,[178] J. Bueghly,[178] Z. Chen,[178] A. Gilbert,[178] T. Gunter,[178] K. A. Hahn,[178] N. Odell,[178] M. H. Schmitt,[178] K. Sung,[178] M. Velasco,[178] R. Band,[179] R. Bucci,[179] N. Dev,[179] R. Goldouzian,[179] M. Hildreth,[179] K. Hurtado Anampa,[179] C. Jessop,[179] K. Lannon,[179] N. Loukas,[179] N. Marinelli,[179] I. Mcalister,[179] F. Meng,[179] K. Mohrman,[179] Y. Musienko,[179,yy] R. Ruchti,[179] P. Siddireddy,[179] M. Wayne,[179] A. Wightman,[179] M. Wolf,[179] M. Zarucki,[179] L. Zygala,[179] B. Bylsma,[180] B. Cardwell,[180] L. S. Durkin,[180] B. Francis,[180] C. Hill,[180] A. Lefeld,[180] M. Nunez Ornelas,[180] K. Wei,[180] B. L. Winer,[180] B. R. Yates,[180] F. M. Addesa,[181] B. Bonham,[181] P. Das,[181] G. Dezoort,[181] P. Elmer,[181] A. Frankenthal,[181] B. Greenberg,[181] N. Haubrich,[181] S. Higginbotham,[181] A. Kalogeropoulos,[181] G. Kopp,[181] S. Kwan,[181] D. Lange,[181] M. T. Lucchini,[181] D. 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