PROCEEDINGS OF SCIENCE

Exotic hadrons at LHC (experiment)

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We present an overview of the latest experimental results on exotic hadrons at the LHCb experiment at CERN.

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A short selection of experimental results on exotic states is presented here. The LHC provides unprecedented production cross-sections and high efficiencies for hadronic states. More than 60 new hadrons were discovered at the LHC since 2011 and their number is increasing ever since, both in the c and b sector [1]. More spectroscopy searches are expected in the near future when more data will become available after the upgrade of both the accelerator and the detectors.

1. Observation of a new T_{cc}^+ state [2, 3]

A new state was reported for the first time at the EPS-HEP 2021 conference [4]. A very narrow peak just above the $D^0D^0\pi^+$ invariant mass was observed with striking significance over the background (Fig.1). A charged state with double charm content is manifestly exotic, with an expected quark content of $cc\bar{u}\bar{d}$. Its mass lies just below the $D^{*+}D^0$ mass threshold and is consistent with the expected isoscalar $J^P = 1^+$. In [3] a detailed study of the new T_{cc}^+ state was performed: the study of the DD mass spectrum disfavours the interpretation of the resonance as the isovector state and the $D^0\pi^+$ mass distribution seems to indicate a decay structure via intermediate off-shell D^{*+} mesons. Furthermore, an unexpected dependence of the production rate on track multiplicity is observed. This search nicely complements previous studies on states with double heavy quark content, e.g. a new structure in the $J/\Psi J/\Psi$ [5] final state and the discovery of the first double-heavy Ξ_{cc}^{++} baryon [6].

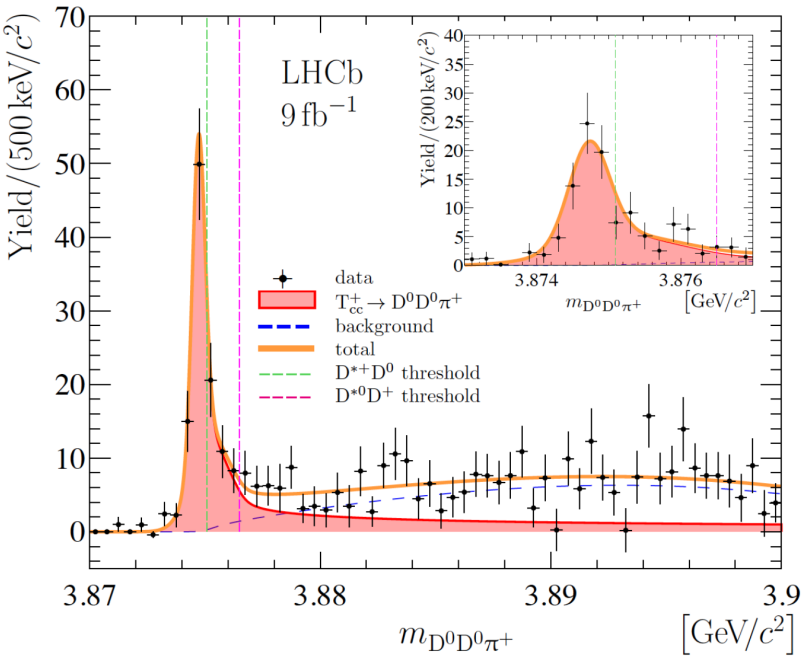

Figure 1: Observation of a new peak in the $D^0D^0\pi^+$ invariant mass.

2. Evidence for a new structure in the $J/\Psi p(\bar{p})$ systems in $B_s^0 \to J/\Psi p(\bar{p})$ decays [7]

This analysis presents a new search involving pentaquark states in meson decays. LHCb has investigated many modes in the past involving the J/Ψ system, but in baryon decays. This analysis

reports the first amplitude analysis of the flavour-untagged $B_s^0 \to J/\Psi p\bar{p}$. This decay, reported in 2019, has now been studied in detail with a full amplitude analysis. This final state appears paricularly interesting because of its symmetry in the Dalitz plot. A sample of 797 ± 31 signal events is selected with very good purity. A 4D amplitude analysis in $\Phi = (m_{p\bar{p}}, \cos\theta_l, \cos\theta_\nu, \phi)$ shows evidence for a new structure in the $J/\Psi p$ and $J/\Psi\bar{p}$ systems (Fig.2). A significance in the range of 3.1σ to 3.7σ, depending on the assigned J^P hypothesis, is reported for the new state. No significant structures are found in the $p\bar{p}$ mass instead, where a glueball candidate could be present.

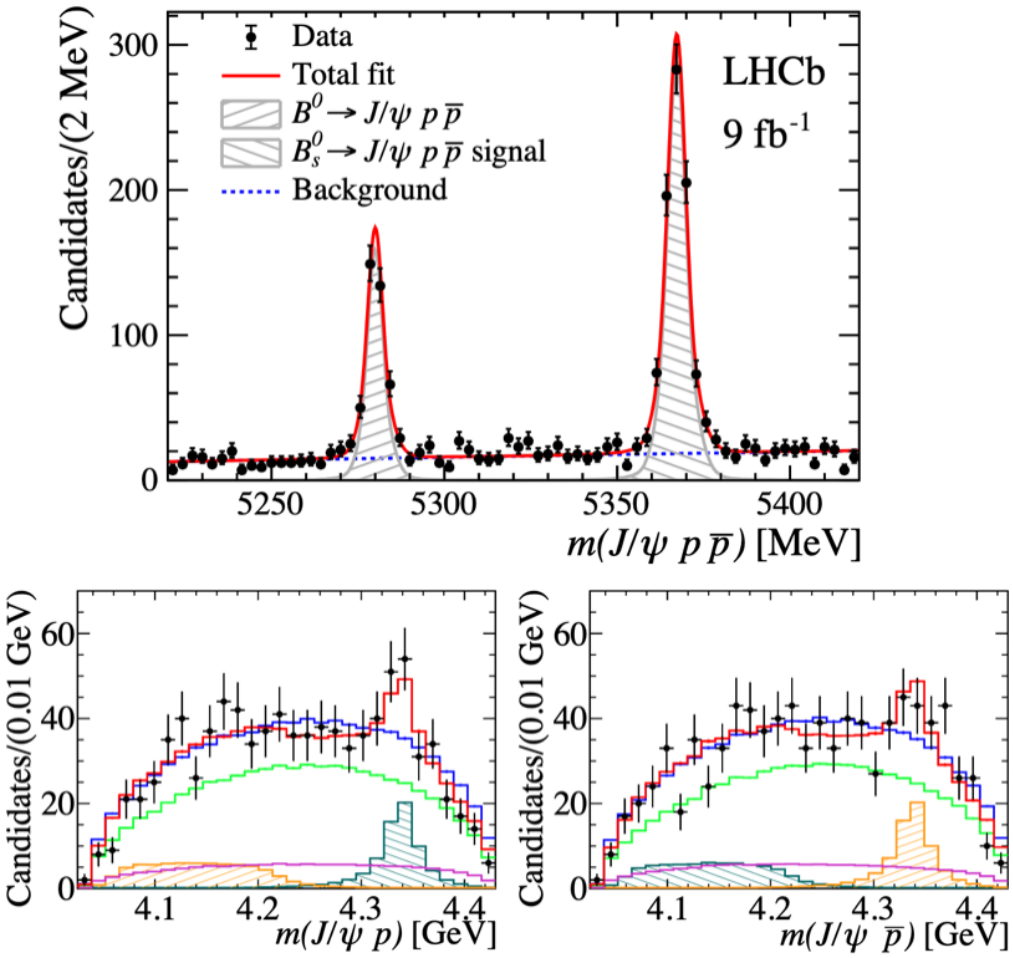

Figure 2: Top: mass plot of the signal candidate. Bottom $J/\Psi p$ and $J/\Psi\bar{p}$ projections.

3. Short overview of recent results on $X(3872)$, now $\chi_{c1}(3872)$ [8–10]

Several progresses are ongoing on the production measurement of the $X(3872)$, now renamed $\chi_{c1}(3872)$. This resonance has been known since 2003 (discovered in B decays) and appears as a narrow state at threshold. Debate is still ongoing on the molecular/particle nature of its structure. Cross-section measurements in different experimental scenarios could help shedding light on its properties. An overview of recent results is shown in Fig.3, using proton-proton, proton-ion and

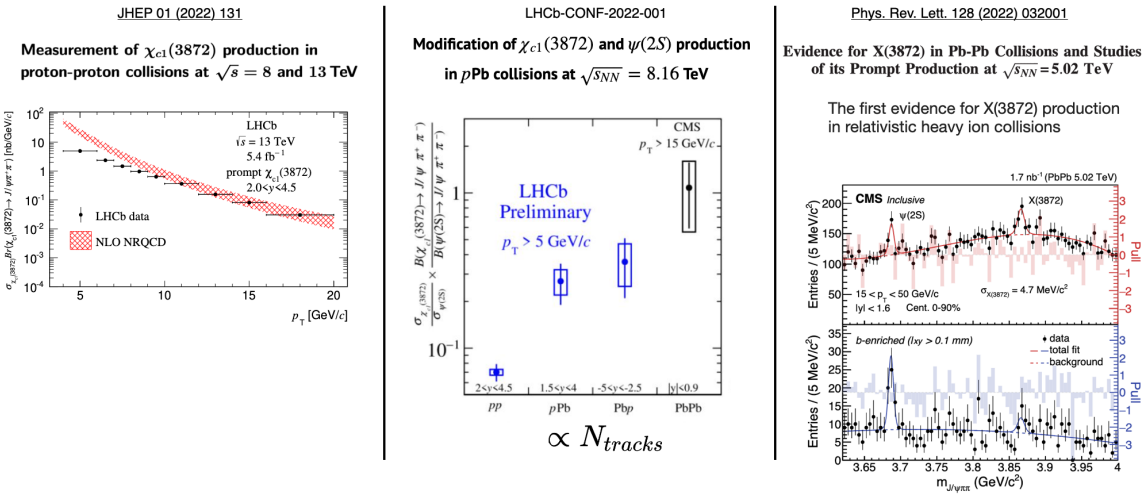

Figure 3: Measurements of $\chi_{c1}(3872)$ production in ion collisions.

ion-ion collisions. Furthermore, we presented a recent paper on the subject, where the observation of resonant structures in the $\pi\pi$ mass spectrum is described [11]. A sizeable contribution from the isospin conserving $\chi_{c1}(3872) \to \omega J/\Psi$ is established at the level of more than 20%, using $B^+ \to K^+\chi_{c1}(3872)$ decays. The amplitude of isospin violating decay $\chi_{c1}(3872) \to \rho^0 J/\Psi$ (relative to isospin conserving decay $\omega J/\Psi$) is a factor of six larger than expected for a pure charmonium state.

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