Search for Higgs boson pair production in the gamma bb- final state using pp collision data at s = 8 TeV from the ATLAS detector

Aad, G.; et al., [Unknown]; Aben, R.; Angelozzi, I.; Beemster, L.J.; Bentvelsen, S.C.M.; Berge, D.; Bobbink, G.J.; Bos, K.; Boterenbrood, H.; Butti, P.; Castelli, A.; Colijn, A.P.; de Jong, P.J.; de Nooij, L.; Deigaard, I.; Deluca, C.; Deviveiros, P.O.; Dhaliwal, S.; Ferrari, P.; Gadatsch, S.; Geerts, D.A.A.; Hartjes, F.G.; Hessey, N.P.; Hod, N.; Igonkina, O.; Kluit, P.M.; Koffeman, E.N.; Lee, H.C.; Lenz, T.; Linde, F.L.; Mahlstedt, J.; Mechnich, J.; Oussoren, K.P.; Pani, P.; Salek, D.; Valencic, N.; van den Wollenberg, W.; van der Deijl, P.C.; van der Geer, R.; van der Graaf, H.; van der Leeuw, R.H.L.; van Vulpen, I.B.; Verkerke, W.; Vermeulen, J.C.; Vranjes Milosavljevic, M.; Vreeswijk, M.; Weits, H.

Published in:
Physical Review Letters

DOI:
10.1103/PhysRevLett.114.081802

Search for Higgs Boson Pair Production in the $\gamma\gamma b\bar{b}$ Final State Using pp Collision Data at $\sqrt{s} = 8$ TeV from the ATLAS Detector

G. Aad *et al.*[*]
(ATLAS Collaboration)

(Received 19 June 2014; published 26 February 2015)

Searches are performed for resonant and nonresonant Higgs boson pair production in the $\gamma\gamma b\bar{b}$ final state using 20 fb^{-1} of proton-proton collisions at a center-of-mass energy of 8 TeV recorded with the ATLAS detector at the CERN Large Hadron Collider. A 95% confidence level upper limit on the cross section times branching ratio of nonresonant production is set at 2.2 pb, while the expected limit is 1.0 pb. The difference derives from a modest excess of events, corresponding to 2.4 standard deviations from the background-only hypothesis. The limit observed in the search for a narrow $X \to hh$ resonance ranges between 0.7 and 3.5 pb as a function of the resonance mass.

DOI: 10.1103/PhysRevLett.114.081802 PACS numbers: 12.60.Fr, 13.85.Rm, 14.80.Da, 14.80.Ec

Within two years of discovering a new boson with a mass near 125 GeV [1,2], the ATLAS and CMS Collaborations have completed a slate of measurements demonstrating that its spin and couplings conform to the predictions of the standard model (SM) Higgs boson within current experimental and theoretical uncertainties [3,4]. Despite the lack of deviations from SM predictions, the Higgs boson h offers a rich potential for new physics searches. This Letter reports on searches for non-SM physics with events consistent with either resonant ($X \to hh$) or nonresonant pair production of Higgs bosons in the $hh \to \gamma\gamma b\bar{b}$ channel.

The predicted rate for Higgs boson pair production in the SM is several orders of magnitude smaller than the rate for the single h process [5–8]; hh production is thus not expected to be observable with current LHC data sets. However, a variety of extensions to the SM predict an enhancement of Higgs boson pair production. In two Higgs doublet models (2HDMs) [9–11] the heavier of the neutral scalar Higgs bosons H may decay to a pair of its lighter scalar partners, h. Depending on the parameters of the 2HDM, the $H \to hh$ production cross section may exceed a picobarn [11]. A deviation of the Higgs boson self-coupling λ_{hhh} from the SM predicted value could also increase the nonresonant production rate. Such deviations could be observed with future data sets [8]. Larger enhancements in the $pp \to hh$ rate could arise from the top-Higgs quartic $t\bar{t}hh$ coupling predicted in composite models [12,13], or from the addition of light colored scalars to the SM [14]. Resonant production of two Higgs bosons could appear from the production and decay of gravitons, radions, or stoponium [15–17], as well as from a hidden sector mixing with the observed Higgs boson [18].

The $\gamma\gamma b\bar{b}$ channel is an excellent final state for a search for Higgs boson pair production [19] thanks to the large $h \to b\bar{b}$ branching ratio, clean diphoton trigger, excellent diphoton invariant mass resolution, and low backgrounds. This channel is particularly important in the search for resonances with mass m_X in the range $260 < m_X < 500$ GeV considered in this Letter, where backgrounds and combinatorics make other channels such as $b\bar{b}b\bar{b}$ or $b\bar{b}\tau^+\tau^-$ challenging.

Processes that do not contain Higgs bosons are estimated from data; all other processes are simulated using Monte Carlo techniques. The standard ATLAS detector simulation [20] based on GEANT4 [21] is used. The simulation parameters are tuned to describe soft components of hadronic final states [22,23]. Simulated minimum bias collisions are overlaid on the hard scatter process, and events are reweighted so that the average number of interactions per bunch crossing (~20) matches the observed distribution.

Background events with a single Higgs boson produced in association with a W or Z boson or $t\bar{t}$ (Wh, Zh, $t\bar{t}h$) are simulated with PYTHIA8 [24] using CTEQ6L1 parton distribution functions of the proton (PDFs) [25]. Higgs boson production via gluon or vector-boson fusion (ggF, VBF) is simulated using CT10 PDFs [26] with POWHEG-BOX [27,28] interfaced to PYTHIA8 for showering and hadronization. Cross sections and associated uncertainties are taken from Ref. [29].

Two benchmark signal models are defined: SM Higgs boson pair production for the nonresonance search, and a gluon-initiated, spin-zero resonant state in the narrow-width approximation for the resonance search. The SM hh process is too small to observe with current data sets, but the SM kinematics are used to model generic nonresonant beyond-SM physics. Both models are generated using

* Full author list given at the end of the article.

MadGraph5 [30,31] and CTEQ6L1 PDFs. A generator filter requires a pair of b quarks and a pair of photons in each event. Pythia8 is used to decay the two Higgs bosons, and to shower and hadronize the events. The implementation of SM Higgs boson pair production includes the interference between diagrams with trilinear Higgs boson couplings and box diagrams. For the SM hh process, which is a background to the resonance search, the next-to-leading-order inclusive production cross section of 9.2 fb is taken from Ref. [8]. Resonant samples are generated with a width of 10 MeV (corresponding to a narrow width approximation) at masses $m_X = 260$, 300, 350, and 500 GeV. Production cross sections for benchmark 2HDMs are calculated with SusHi [32], and branching ratios with 2hdmc [33].

The analysis described in this Letter uses the full $\sqrt{s} = 8$ TeV data set of proton-proton collisions recorded by the ATLAS experiment in 2012, corresponding to an integrated luminosity of $20.3 \pm 0.6\ \mathrm{fb}^{-1}$ [34]. Data quality criteria are applied to reject events with diminished detector performance [35,36]. A description of the ATLAS detector can be found elsewhere [37].

The photon and event selection for the present search largely follows those of published ATLAS $h \to \gamma\gamma$ analyses [3,38]. Events are selected using a loose diphoton trigger that is nearly 100% efficient for events passing the offline photon selection. Photons are reconstructed starting from clusters of energy deposited in the electromagnetic calorimeter. Events are required to contain two photon candidates whose calorimeter energy clusters match the expectations for photon-induced electromagnetic showers [39,40]. The pseudorapidity [41] η of the two photons must fall within the geometric acceptance of the detector for photons, $|\eta| < 2.37$, excluding the region between the barrel and end-cap calorimeters ($1.37 < |\eta| < 1.56$). The ratio of the transverse momentum of the leading (subleading) photon to the invariant mass of the pair, $p_T/m_{\gamma\gamma}$, must exceed 0.35(0.25). The invariant mass of the pair is calculated as in Ref. [3]. Photons are required to be isolated: the energy in the calorimeter [3,42] within a cone of size $\Delta R \equiv \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.4$ around the photon direction must be less than 6 GeV, and the scalar sum of the p_T of the tracks in a cone of $\Delta R = 0.2$ must be less than 2.6 GeV. In addition, the photon pair must satisfy a broad requirement $105 < m_{\gamma\gamma} < 160$ GeV for an event to be considered [3,38].

Jets are reconstructed from clusters of energy in the electromagnetic and hadronic calorimeters using the anti-k_t algorithm [43] with a radius parameter of 0.4, starting from energy deposits grouped into topological clusters [44]. Simulation is used to correct jets for instrumental effects [45] and to account for the average energy in the detector in the event due to additional pp interactions and the underlying event [46]. The calibration is refined using *in situ* measurements. Jets are required to fall within the tracker acceptance of $|\eta| < 2.5$ and satisfy $p_T > 35$ GeV, with the leading jet in the event required to have $p_T > 55$ GeV. Events with jets arising from noisy regions in the calorimeters, beam backgrounds, or cosmic rays are rejected [45]. Low-p_T jets from additional proton-proton interactions in the same bunch crossing are rejected with a requirement on the scalar sum of the p_T of tracks associated with the jet: for jets with $|\eta| < 2.4$ and $p_T < 50$ GeV, tracks associated with the hard scatter vertex must contribute over 50% of the sum.

Jets from the decay of long-lived heavy-flavor hadrons are selected using a multivariate tagging algorithm (b tagging) [47] with an efficiency of 70% for jets from b-quark fragmentation in $t\bar{t}$ simulation. The four-momenta of muons [48] closer than $\Delta R = 0.4$ to a b-tagged jet and with $p_T > 4$ GeV are included in the jet four-momentum.

Events with at least two photons and two or more jets are selected for further analysis if the invariant mass of the two leading jets is consistent with the decay of a Higgs boson. While the invariant mass resolution for the pairs of b-tagged jets is approximately 13 GeV, the mass window is chosen as $95 < m_{jj} < 135$ GeV to account for the downward shift of the mean from the true value due to effects such as unmeasured neutrinos from semileptonic b decays.

In the nonresonance search, the background and potential signal are fit to the unbinned $m_{\gamma\gamma}$ distribution of all events passing the dijet and diphoton selections described above. This fit has three components: the signal with a pair of Higgs bosons, the background processes with a single Higgs boson resonant at $m_{\gamma\gamma} = m_h$, and the continuum background. The single Higgs boson backgrounds are dominated by the processes with pairs of b quarks, namely $t\bar{t}h$ and $(Z \to b\bar{b})h$, with smaller contributions from ggF, VBF, and Wh. The combined acceptance and selection efficiency for the SM Higgs boson pair production signal is 7.4%. Simulation studies show that the continuum contribution in the signal region is split between events with two photons and events with a single photon in association with a jet faking the second photon. The b-tagged jets include real heavy-flavor jets and mistagged light-flavor jets. The contribution from dileptonic decays of $t\bar{t}$ events where two electrons fake the two photons is roughly 10% of the total background. The contribution from other processes is negligible.

The fit is performed simultaneously in two categories. The first category is the signal region, in which at least two jets are b-tagged. The second is a control region, containing events with fewer than two b tags. The two classes of events are kinematically identical: in the signal region, the mass and p_T requirements defined above must be satisfied by the two leading tagged jets, whereas in the control region, they are met by the two leading jets.

Following earlier ATLAS analyses, the shape of the $m_{\gamma\gamma}$ resonance is described by the sum of a Crystal Ball function and a wide Gaussian component that models the tails of the distribution [3]. An exponential function describes the continuum backgrounds that fall with $m_{\gamma\gamma}$. The slope of the exponential is shared in the fit between the two categories so that the control region constrains the background shape in the signal region. Figure 1 shows the separate diphoton mass distributions for events with $\geq 2b$ tags and events with $\leq 1b$ tag.

The search for resonant production of pairs of Higgs bosons starts with the same signal selection as above but imposes an additional requirement on $m_{\gamma\gamma b\bar{b}}$. Because of the small number of expected events after this additional requirement, the resonance analysis uses a counting experiment with cuts on $m_{\gamma\gamma}$ and $m_{\gamma\gamma b\bar{b}}$, in place of the unbinned fit in $m_{\gamma\gamma}$. The cut on the diphoton mass is set as a window of twice the mass resolution, $\pm 2\sigma_{m_{\gamma\gamma}}$, around the Higgs boson mass $m_h = 125.5$ GeV [3]. For this cut, the $m_{\gamma\gamma}$ resolution is set to the expected value of 1.6 GeV. The acceptance of this requirement on background events without Higgs bosons, $\epsilon_{m_{\gamma\gamma}}$, is measured by fitting an exponential function to the $m_{\gamma\gamma}$ sidebands for events with fewer than two b-tagged jets. For this fit, the $m_{\gamma\gamma}$ region of $m_h \pm 5$ GeV is excluded to eliminate any potential contamination from resonant Higgs boson production. For N observed events with two b tags in the sideband ($|m_{\gamma\gamma} - m_h| > 2\sigma_{m_{\gamma\gamma}}$), the number of expected non-Higgs boson background events $N_{m_{\gamma\gamma}}$ within $2\sigma_{m_{\gamma\gamma}}$ around m_h is given by

$$N_{m_{\gamma\gamma}} = N\frac{\epsilon_{m_{\gamma\gamma}}}{1-\epsilon_{m_{\gamma\gamma}}}, \tag{1}$$

where the denominator compensates for the fact that $\epsilon_{m_{\gamma\gamma}} = 0.13$ is derived relative to the full $m_{\gamma\gamma}$ spectrum while N contains only those events in the sidebands.

Before reconstructing the four-object mass, $m_{\gamma\gamma b\bar{b}}$, a scaling factor of $m_h/m_{b\bar{b}}$ is applied to the four-momentum of the $b\bar{b}$ system, where m_h is set to the value of 125 GeV used in simulation. This improves the $m_{\gamma\gamma b\bar{b}}$ resolution by 30%–60% depending on the mass hypothesis, without biasing or significantly altering the shape of the background. Requirements are then made on $m_{\gamma\gamma b\bar{b}}$ to select the smallest window containing 95% of the previously selected events, simulated for the narrow resonant signal hypotheses. These requirements vary linearly with the mass m_X of the resonance considered. The width of the signal window varies from 17 GeV at $m_X = 260$ GeV to 60 GeV at $m_X = 500$ GeV. The acceptance for the continuum background to pass this requirement, $\epsilon_{m_{\gamma\gamma b\bar{b}}}$, also varies with m_X. It is measured using events in data with $|m_{\gamma\gamma} - m_h| < 2\sigma_{m_{\gamma\gamma}}$ and fewer than two b tags. Studies in both data sidebands and simulation show that the shapes of $m_{\gamma\gamma b\bar{b}}$ and $m_{\gamma\gamma jj}$ agree within statistical uncertainties. The distribution of $m_{\gamma\gamma jj}$ in data is fitted with a Landau function, which is integrated in the signal window to obtain $\epsilon_{m_{\gamma\gamma b\bar{b}}}$ for each mass hypothesis. The bottom panel of Fig. 2 shows this fit. The value of $\epsilon_{m_{\gamma\gamma b\bar{b}}}$ is small ($< 8\%$) at low and high m_X, and peaks at 18% for $m_X = 300$ GeV. The combined acceptance and selection efficiency for a resonance signal to pass

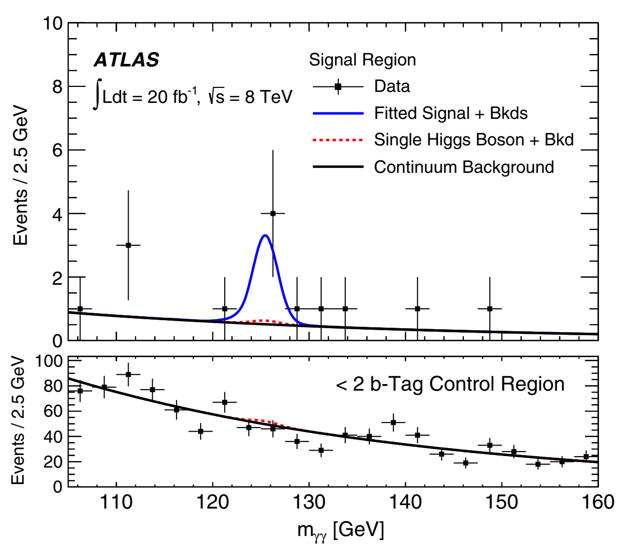

FIG. 1 (color online). Upper plot: diphoton invariant mass spectrum for data and the corresponding fitted signal and background in the signal region for the nonresonance search. Lower plot: the diphoton invariant mass spectrum in the continuum background from events with fewer than two b tags and the corresponding fitted curve, the shape of which is also used in the upper plot.

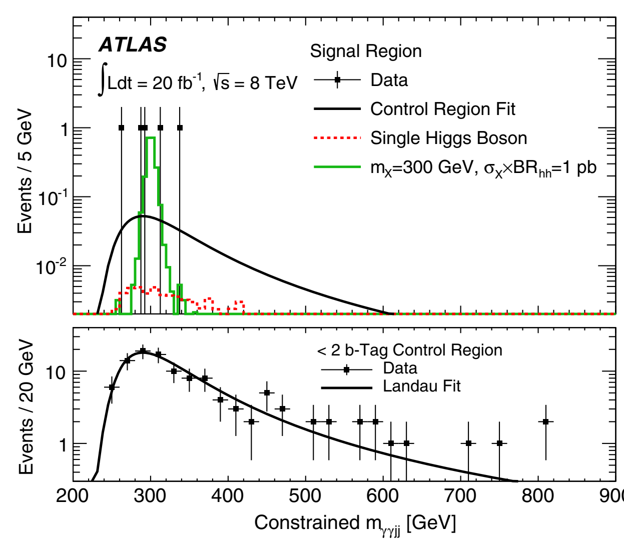

FIG. 2 (color online). Upper plot: the constrained four-object invariant mass $m_{\gamma\gamma jj}$ for data events in the resonance signal region. The expected backgrounds are also shown. A narrow width resonance at 300 GeV is displayed for comparison only. Lower plot: the diphoton invariant mass spectrum in the continuum background from events with fewer than two b tags and the corresponding fitted curve, the shape of which is also used in the upper plot.

all requirements varies from 3.8% at $m_X = 260$ GeV to 8.2% at $m_X = 500$ GeV.

The total background from sources without Higgs boson decays in the resonance analysis N_B is given by

$$N_B = N \frac{\epsilon_{m_{\gamma\gamma}}}{1 - \epsilon_{m_{\gamma\gamma}}} \epsilon_{m_{\gamma\gamma b\bar{b}}}, \tag{2}$$

where N is the number of events in the $m_{\gamma\gamma}$ sidebands, and N_B and $\epsilon_{m_{\gamma\gamma b\bar{b}}}$ are functions of m_X. Uncertainties on this extrapolation are described below.

Because they are not accounted for by the above $m_{\gamma\gamma}$ sideband techniques, contributions from single Higgs bosons produced in association with jets (particularly with $c\bar{c}$ or $b\bar{b}$ pairs) are estimated using simulation. In the resonance analysis, the yield from the nonresonant SM hh processes is similarly included. SM cross sections and branching fractions are assumed in all cases [29].

Most systematic uncertainties are small when compared to statistical uncertainties, in particular for the resonance search.

The evaluation of experimental uncertainties on photon identification (2.4%) and isolation efficiencies (2%) follows the methods used in the inclusive ATLAS $h \to \gamma\gamma$ analyses [3,38]. The theoretical uncertainties [29] on the single Higgs boson backgrounds are similarly adopted. Because there are no heavy flavor quarks at lowest order associated with ggF or VBF production, additional uncertainties are evaluated for these higher-order processes. These uncertainties are derived from a comparison of simulated predictions to data for similar initial states: gluon-initiated production of $t\bar{t}$ with heavy flavor [49] for ggF, and quark-initiated W boson production with heavy flavor [50] for VBF. Since the ggF and VBF contributions are less than 15% of the expected single Higgs boson yield in the signal region, the net impact of these uncertainties remains small. PDF and scale uncertainties on SM hh production are taken from Ref. [8].

Because of the cuts on the ratio $p_T/m_{\gamma\gamma}$, photon energy scale uncertainties are negligible. The uncertainty of 13% on the diphoton mass resolution $\sigma_{m_{\gamma\gamma}}$ is propagated into the resonance search as a 1.6% uncertainty on the number of events migrating into and out of the signal region. This represents the fraction of events where an upward variation of the photon resolution causes the diphoton mass to leave the $m_h \pm 2\sigma_{m_{\gamma\gamma}}$ window required for the signal region. The uncertainty on m_h impacts the peak position in $m_{\gamma\gamma}$ in the signal plus background fit of the nonresonance analysis, and in the resonance search it is transformed into a 1.7% uncertainty on the number of signal events in the mass window. The uncertainty for the acceptance of the $m_{\gamma\gamma}$ cuts on non-Higgs boson backgrounds is estimated by comparing fits of $m_{\gamma\gamma}$ to data in control regions with reversed photon identification or b-tagging requirements, and using different functional forms. The largest deviation observed from these fits (11%) is used for all searches.

Three components contribute to the uncertainty on $\epsilon_{m_{\gamma\gamma b\bar{b}}}$, and are combined in quadrature. (1) The limited number of events in the control region with fewer than two b tags used for the Landau fit leads to a relative statistical uncertainty of 3%–18% that varies as a function of m_X. (2) The $m_{\gamma\gamma jj}$ shape for untagged jets might not exactly mirror the one for tagged jets. The tagged and untagged samples are compared in simulation and the relative difference in $\epsilon_{m_{\gamma\gamma b\bar{b}}}$ is taken as the uncertainty. This value varies with m_X and is always less than 30%. (3) Finally, an uncertainty of 16%–30%, depending on m_X, is included to cover the choice of the analytic function. This was evaluated via comparisons of Landau shapes to alternate functions in simulation, including Landau shapes where the width varies with $m_{\gamma\gamma b\bar{b}}$, as well as Crystal Ball functions. Potential contamination from SM single Higgs boson processes in the control region is estimated to be less than 4% and is subtracted with negligible impact on the shape.

Uncertainties due to the b-tagging calibration are typically 2%–4% for both the single Higgs boson and signal processes. Uncertainties due to the jet energy scale are 7% (22%) for single Higgs boson backgrounds in the nonresonance (resonance) analysis, and 1.4% (4.4%) for signal processes. Uncertainties due to the jet energy resolution are 4.8% (21%) for single Higgs boson backgrounds, and 6.3% (9.3%) for signal processes. The uncertainty on the integrated luminosity is 2.8%. It is derived, following the same methodology as that detailed in Ref. [34], from a preliminary calibration of the luminosity scale derived from beam-separation scans performed in November 2012.

The combined, unbinned signal plus background fit for the nonresonance analysis is shown in Fig. 1. Within a $\pm 2\sigma_{m_{\gamma\gamma}}$ window around the Higgs boson mass, 1.5 events are expected, with 1.3 ± 0.5 from the continuum background and 0.17 ± 0.04 from single Higgs boson production, which is dominated by $t\bar{t}h$ events. About 0.04 events are expected from SM Higgs boson pair production. Five events are observed, corresponding to 2.4σ from the background-only hypothesis, using the test statistic based on the profile likelihood ratio [51] with the hypothesized signal rate set to zero. The 95% confidence level (CL) upper limit on the Higgs boson pair production cross section is calculated using the frequentist CL_S method [52]. Exclusions and significances are evaluated using pseudoexperiments. Assuming SM branching ratios for the light Higgs boson decays, the expected upper limit is $1.0^{+0.5}_{-0.2}$ pb; the observed limit is 2.2 pb.

For the resonance analysis, as before, SM branching fractions for the light Higgs boson are assumed. The expected exclusion improves from 1.7 to 0.7 pb as a function of m_X from 260 to 500 GeV, as shown in Fig. 3. This behavior derives from increased event-level acceptance at larger masses. The observed exclusion ranges from 3.5 to 0.7 pb. The five events selected in the $m_{\gamma\gamma}$ signal

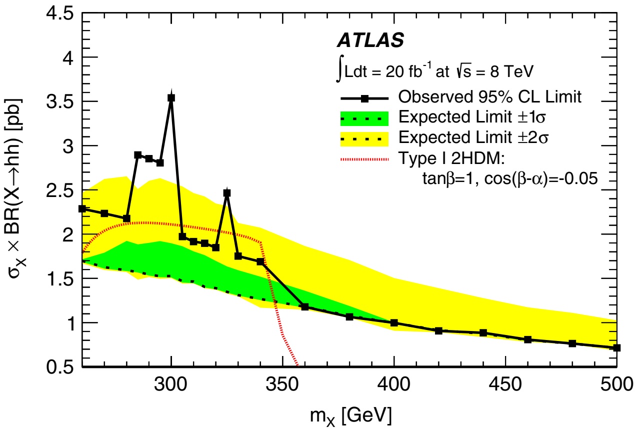

FIG. 3 (color online). A 95% CL upper limit on the cross section times branching ratio of a narrow resonance decaying to pairs of Higgs bosons as a function of m_X (see text for more details).

region are shown in $m_{\gamma\gamma b\bar{b}}$, in Fig. 2. The local probability of compatibility to the background-only hypothesis, p_0, reaches a minimum of 0.002 at $m_X = 300$ GeV, corresponding to 3.0σ. The number of events lying within the $m_{\gamma\gamma b\bar{b}}$ window of each mass hypothesis is readily apparent in "steps" in the exclusion plot. The step size used for the limit is reduced in the range near the observed events, to show this structure. A look-elsewhere effect [53,54] is evaluated by generating pseudodatasets of the background-only hypothesis, and identifying the mass hypothesis with the lowest p value in each. The global probability of an excess as significant as the observation to occur at any mass in the range studied is found to be 0.019, corresponding to 2.1σ.

The limits derived are juxtaposed in Fig. 3 with the prediction for an illustrative type I 2HDM [32,33,55] not excluded by current data with $\cos(\beta - \alpha) = -0.05$ and $\tan(\beta) = 1$. The heavy Higgs bosons are taken to be degenerate in mass, and the mass of the lightest CP-even Higgs boson is set to 125 GeV. All major production mechanisms of $H \to hh$ are considered. Cross sections and branching ratios were calculated as described in Ref. [56].

In conclusion, this Letter presents searches for resonant and nonresonant Higgs boson pair production using 20.3 fb^{-1} of proton-proton collision data at $\sqrt{s} = 8$ TeV generated by the Large Hadron Collider and recorded by the ATLAS detector in 2012. A 95% confidence level upper limit is placed on the nonresonant production cross section at 2.2 pb, while the expected limit is $1.0^{+0.5}_{-0.2}$ pb. The difference derives from a small excess of events, corresponding to 2.4σ.

In the search for a narrow resonance decaying to a pair of Higgs bosons, the expected exclusion on the production cross section falls from 1.7 pb for a resonance at 260 GeV to 0.7 pb at 500 GeV. The observed exclusion ranges from 0.7–3.5 pb. It is weaker than expected for resonances below 350 GeV.

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently. We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC, and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST, and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR, and VSC CR, Czech Republic; DNRF, DNSRC, and Lundbeck Foundation, Denmark; EPLANET, ERC, and NSRF, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG, and AvH Foundation, Germany; GSRT and NSRF, Greece; ISF, MINERVA, GIF, I-CORE, and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW and NCN, Poland; GRICES and FCT, Portugal; MNE/IFA, Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MINECO, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF, and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; U.S. DOE and NSF, U.S. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (United Kingdom), and BNL (U.S.), and in the Tier-2 facilities worldwide.

[1] ATLAS Collaboration, Phys. Lett. B **716**, 1 (2012).
[2] CMS Collaboration, Phys. Lett. B **716**, 30 (2012).
[3] ATLAS Collaboration, Phys. Lett. B **726**, 88 (2013).
[4] CMS Collaboration, Phys. Rev. D **89**, 092007 (2014).
[5] S. Dawson, S. Dittmaier, and M. Spira, Phys. Rev. D **58**, 115012 (1998).
[6] J. Grigo, J. Hoff, K. Melnikov, and M. Steinhauser, Nucl. Phys. **B875**, 1 (2013).
[7] D. de Florian and J. Mazzitelli, Phys. Rev. Lett. **111**, 201801 (2013).
[8] J. Baglio, A. Djouadi, R. Gröber, M. M. Mühlleitner, J. Quevillon, and M. Spira, J. High Energy Phys. 04 (2013) 151.
[9] A. Djouadi, Phys. Rep. **459**, 1 (2008).
[10] J. Baglio, O. Eberhardt, U. Nierste, and M. Wiebusch, Phys. Rev. D **90**, 015008 (2014).
[11] N. Craig, J. Galloway, and S. Thomas, arXiv:1305.2424.

[12] R. Grober and M. Muhlleitner, J. High Energy Phys. 06 (2011) 020.
[13] R. Contino, M. Ghezzi, M. Moretti, G. Panico, F. Piccinini, and A. Wulzer, J. High Energy Phys. 08 (2012) 154.
[14] G. D. Kribs and A. Martin, Phys. Rev. D **86**, 095023 (2012).
[15] Y. Tang, J. High Energy Phys. 08 (2012) 078.
[16] K. Cheung, Phys. Rev. D **63**, 056007 (2001).
[17] N. Kumar and S. P. Martin, Phys. Rev. D **90**, 055007 (2014).
[18] M. J. Dolan, C. Englert, and M. Spannowsky, Phys. Rev. D **87**, 055002 (2013).
[19] U. Baur, T. Plehn, and D. L. Rainwater, Phys. Rev. D **69**, 053004 (2004).
[20] ATLAS Collaboration, Eur. Phys. J. C **70**, 823 (2010).
[21] S. Agostinelli *et al.* (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[22] ATLAS Collaboration, Report No. ATL-PHYS-PUB-2012-003 (2012), http://cdsweb.cern.ch/record/1474107.
[23] ATLAS Collaboration, Report No. ATL-PHYS-PUB-2011-014 (2011), http://cdsweb.cern.ch/record/1400677.
[24] T. Sjostrand, S. Mrenna, and P. Z. Skands, Comput. Phys. Commun. **178**, 852 (2008).
[25] P. Nadolsky, H.-L. Lai, Q.-H. Cao, J. Huston, J. Pumplin, D. Stump, W.-K. Tung, and C.-P. Yuan, Phys. Rev. D **78**, 013004 (2008).
[26] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P. M. Nadolsky, J. Pumplin, and C.-P. Yuan, Phys. Rev. D **82**, 074024 (2010).
[27] S. Alioli, P. Nason, C. Oleari, and E. Re, J. High Energy Phys. 04 (2009) 002.
[28] P. Nason and C. Oleari, J. High Energy Phys. 02 (2010) 037.
[29] LHC Higgs Cross Section Working Group, Report No. 10.5170/CERN-2013-004 (2013).
[30] J. Alwall, M. Herquet, F. Maltoni, O. Mattelaer, and T. Stelzer, J. High Energy Phys. 06 (2011) 128.
[31] B. Hespel and E. Vryonidou, Higgs Pair Production, https://cp3.irmp.ucl.ac.be/projects/madgraph/wiki/HiggsPairProduction.
[32] R. V. Harlander, S. Liebler, and H. Mantler, Comput. Phys. Commun. **184**, 1605 (2013).
[33] D. Eriksson, J. Rathsman, and O. Stal, Comput. Phys. Commun. **181**, 189 (2010).
[34] ATLAS Collaboration, Eur. Phys. J. C **73**, 2518 (2013).
[35] ATLAS Collaboration, JINST **9**, P07024 (2014).
[36] J. Adelman *et al.*, J. Phys. Conf. Ser. **219**, 042018 (2010).
[37] ATLAS Collaboration, JINST **3**, S08003 (2008).
[38] ATLAS Collaboration, Phys. Lett. B **726**, 120 (2013).
[39] ATLAS Collaboration, Report No. ATL-PHYS-PUB-2011-007 (2011), http://cdsweb.cern.ch/record/1345329.
[40] ATLAS Collaboration, Report No. ATLAS-CONF-2012-123 (2012), http://cdsweb.cern.ch/record/1473426.
[41] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the center of the detector and the z axis along the beam pipe. The x axis points from the interaction point to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.
[42] ATLAS Collaboration, Phys. Rev. D **83**, 052005 (2011).
[43] M. Cacciari, G. P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 063.
[44] T. Barillari *et al.*, Report No. ATL-LARG-PUB-2009-001-2 (2008), http://cdsweb.cern.ch/record/1112035.
[45] ATLAS Collaboration, arXiv:1406.0076.
[46] M. Cacciari and G. P. Salam, Phys. Lett. B **659**, 119 (2008).
[47] ATLAS Collaboration, Report No. ATLAS-CONF-2014-004 (2014), http://cdsweb.cern.ch/record/1664335.
[48] ATLAS Collaboration, Report No. ATLAS-CONF-2013-088 (2013), http://cdsweb.cern.ch/record/1580207.
[49] ATLAS Collaboration, Phys. Rev. D **89**, 072012 (2014).
[50] ATLAS Collaboration, J. High Energy Phys. 06 (2013) 084.
[51] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Eur. Phys. J. C **71**, 1554 (2011).
[52] A. L. Read, J. Phys. G **28**, 2693 (2002).
[53] L. Lyons, Ann. Appl. Stat. **2**, 887 (2008).
[54] E. Gross and O. Vitells, Eur. Phys. J. C **70**, 525 (2010).
[55] G. Branco, P. Ferreira, L. Lavoura, M. Rebelo, M. Sher, and J. Silva, Phys. Rep. **516**, 1 (2012).
[56] R. Harlander, M. Mühlleitner, J. Rathsman, M. Spira, and O. Stål, arXiv:1312.5571.

G. Aad,[84] B. Abbott,[112] J. Abdallah,[152] S. Abdel Khalek,[116] O. Abdinov,[11] R. Aben,[106] B. Abi,[113] M. Abolins,[89] O. S. AbouZeid,[159] H. Abramowicz,[154] H. Abreu,[153] R. Abreu,[30] Y. Abulaiti,[147a,147b] B. S. Acharya,[165a,165b,b] L. Adamczyk,[38a] D. L. Adams,[25] J. Adelman,[177] S. Adomeit,[99] T. Adye,[130] T. Agatonovic-Jovin,[13a] J. A. Aguilar-Saavedra,[125a,125f] M. Agustoni,[17] S. P. Ahlen,[22] F. Ahmadov,[64,c] G. Aielli,[134a,134b] H. Akerstedt,[147a,147b] T. P. A. Åkesson,[80] G. Akimoto,[156] A. V. Akimov,[95] G. L. Alberghi,[20a,20b] J. Albert,[170] S. Albrand,[55] M. J. Alconada Verzini,[70] M. Aleksa,[30] I. N. Aleksandrov,[64] C. Alexa,[26a] G. Alexander,[154] G. Alexandre,[49] T. Alexopoulos,[10] M. Alhroob,[165a,165c] G. Alimonti,[90a] L. Alio,[84] J. Alison,[31] B. M. M. Allbrooke,[18] L. J. Allison,[71] P. P. Allport,[73] J. Almond,[83] A. Aloisio,[103a,103b] A. Alonso,[36] F. Alonso,[70] C. Alpigiani,[75] A. Altheimer,[35] B. Alvarez Gonzalez,[89] M. G. Alviggi,[103a,103b] K. Amako,[65] Y. Amaral Coutinho,[24a] C. Amelung,[23] D. Amidei,[88] S. P. Amor Dos Santos,[125a,125c] A. Amorim,[125a,125b] S. Amoroso,[48] N. Amram,[154] G. Amundsen,[23] C. Anastopoulos,[140] L. S. Ancu,[49] N. Andari,[30] T. Andeen,[35] C. F. Anders,[58b] G. Anders,[30] K. J. Anderson,[31] A. Andreazza,[90a,90b] V. Andrei,[58a] X. S. Anduaga,[70] S. Angelidakis,[9] I. Angelozzi,[106] P. Anger,[44] A. Angerami,[35] F. Anghinolfi,[30] A. V. Anisenkov,[108] N. Anjos,[125a] A. Annovi,[47] A. Antonaki,[9] M. Antonelli,[47] A. Antonov,[97] J. Antos,[145b] F. Anulli,[133a] M. Aoki,[65] L. Aperio Bella,[18] R. Apolle,[119,d] G. Arabidze,[89] I. Aracena,[144]

Y. Arai,[65] J. P. Araque,[125a] A. T. H. Arce,[45] J-F. Arguin,[94] S. Argyropoulos,[42] M. Arik,[19a] A. J. Armbruster,[30] O. Arnaez,[30] V. Arnal,[81] H. Arnold,[48] M. Arratia,[28] O. Arslan,[21] A. Artamonov,[96] G. Artoni,[23] S. Asai,[156] N. Asbah,[42] A. Ashkenazi,[154] B. Åsman,[147a,147b] L. Asquith,[6] K. Assamagan,[25] R. Astalos,[145a] M. Atkinson,[166] N. B. Atlay,[142] B. Auerbach,[6] K. Augsten,[127] M. Aurousseau,[146b] G. Avolio,[30] G. Azuelos,[94,e] Y. Azuma,[156] M. A. Baak,[30] A. Baas,[58a] C. Bacci,[135a,135b] H. Bachacou,[137] K. Bachas,[155] M. Backes,[30] M. Backhaus,[30] J. Backus Mayes,[144] E. Badescu,[26a] P. Bagiacchi,[133a,133b] P. Bagnaia,[133a,133b] Y. Bai,[33a] T. Bain,[35] J. T. Baines,[130] O. K. Baker,[177] P. Balek,[128] F. Balli,[137] E. Banas,[39] Sw. Banerjee,[174] A. A. E. Bannoura,[176] V. Bansal,[170] H. S. Bansil,[18] L. Barak,[173] S. P. Baranov,[95] E. L. Barberio,[87] D. Barberis,[50a,50b] M. Barbero,[84] T. Barillari,[100] M. Barisonzi,[176] T. Barklow,[144] N. Barlow,[28] B. M. Barnett,[130] R. M. Barnett,[15] Z. Barnovska,[5] A. Baroncelli,[135a] G. Barone,[49] A. J. Barr,[119] F. Barreiro,[81] J. Barreiro Guimarães da Costa,[57] R. Bartoldus,[144] A. E. Barton,[71] P. Bartos,[145a] V. Bartsch,[150] A. Bassalat,[116] A. Basye,[166] R. L. Bates,[53] L. Batkova,[145a] J. R. Batley,[28] M. Battaglia,[138] M. Battistin,[30] F. Bauer,[137] H. S. Bawa,[144,f] T. Beau,[79] P. H. Beauchemin,[162] R. Beccherle,[123a,123b] P. Bechtle,[21] H. P. Beck,[17] K. Becker,[176] S. Becker,[99] M. Beckingham,[171] C. Becot,[116] A. J. Beddall,[19c] A. Beddall,[19c] S. Bedikian,[177] V. A. Bednyakov,[64] C. P. Bee,[149] L. J. Beemster,[106] T. A. Beermann,[176] M. Begel,[25] K. Behr,[119] C. Belanger-Champagne,[86] P. J. Bell,[49] W. H. Bell,[49] G. Bella,[154] L. Bellagamba,[20a] A. Bellerive,[29] M. Bellomo,[85] K. Belotskiy,[97] O. Beltramello,[30] O. Benary,[154] D. Benchekroun,[136a] K. Bendtz,[147a,147b] N. Benekos,[166] Y. Benhammou,[154] E. Benhar Noccioli,[49] J. A. Benitez Garcia,[160b] D. P. Benjamin,[45] J. R. Bensinger,[23] K. Benslama,[131] S. Bentvelsen,[106] D. Berge,[106] E. Bergeaas Kuutmann,[16] N. Berger,[5] F. Berghaus,[170] J. Beringer,[15] C. Bernard,[22] P. Bernat,[77] C. Bernius,[78] F. U. Bernlochner,[170] T. Berry,[76] P. Berta,[128] C. Bertella,[84] G. Bertoli,[147a,147b] F. Bertolucci,[123a,123b] D. Bertsche,[112] M. I. Besana,[90a] G. J. Besjes,[105] O. Bessidskaia Bylund,[147a,147b] M. F. Bessner,[42] N. Besson,[137] C. Betancourt,[48] S. Bethke,[100] W. Bhimji,[46] R. M. Bianchi,[124] L. Bianchini,[23] M. Bianco,[30] O. Biebel,[99] S. P. Bieniek,[77] K. Bierwagen,[54] J. Biesiada,[15] M. Biglietti,[135a] J. Bilbao De Mendizabal,[49] H. Bilokon,[47] M. Bindi,[54] S. Binet,[116] A. Bingul,[19c] C. Bini,[133a,133b] C. W. Black,[151] J. E. Black,[144] K. M. Black,[22] D. Blackburn,[139] R. E. Blair,[6] J.-B. Blanchard,[137] T. Blazek,[145a] I. Bloch,[42] C. Blocker,[23] W. Blum,[82,a] U. Blumenschein,[54] G. J. Bobbink,[106] V. S. Bobrovnikov,[108] S. S. Bocchetta,[80] A. Bocci,[45] C. Bock,[99] C. R. Boddy,[119] M. Boehler,[48] T. T. Boek,[176] J. A. Bogaerts,[30] A. G. Bogdanchikov,[108] A. Bogouch,[91,a] C. Bohm,[147a] J. Bohm,[126] V. Boisvert,[76] T. Bold,[38a] V. Boldea,[26a] A. S. Boldyrev,[98] M. Bomben,[79] M. Bona,[75] M. Boonekamp,[137] A. Borisov,[129] G. Borissov,[71] M. Borri,[83] S. Borroni,[42] J. Bortfeldt,[99] V. Bortolotto,[135a,135b] K. Bos,[106] D. Boscherini,[20a] M. Bosman,[12] H. Boterenbrood,[106] J. Boudreau,[124] J. Bouffard,[2] E. V. Bouhova-Thacker,[71] D. Boumediene,[34] C. Bourdarios,[116] N. Bousson,[113] S. Boutouil,[136d] A. Boveia,[31] J. Boyd,[30] I. R. Boyko,[64] J. Bracinik,[18] A. Brandt,[8] G. Brandt,[15] O. Brandt,[58a] U. Bratzler,[157] B. Brau,[85] J. E. Brau,[115] H. M. Braun,[176,a] S. F. Brazzale,[165a,165c] B. Brelier,[159] K. Brendlinger,[121] A. J. Brennan,[87] R. Brenner,[167] S. Bressler,[173] K. Bristow,[146c] T. M. Bristow,[46] D. Britton,[53] F. M. Brochu,[28] I. Brock,[21] R. Brock,[89] C. Bromberg,[89] J. Bronner,[100] G. Brooijmans,[35] T. Brooks,[76] W. K. Brooks,[32b] J. Brosamer,[15] E. Brost,[115] J. Brown,[55] P. A. Bruckman de Renstrom,[39] D. Bruncko,[145b] R. Bruneliere,[48] S. Brunet,[60] A. Bruni,[20a] G. Bruni,[20a] M. Bruschi,[20a] L. Bryngemark,[80] T. Buanes,[14] Q. Buat,[143] F. Bucci,[49] P. Buchholz,[142] R. M. Buckingham,[119] A. G. Buckley,[53] S. I. Buda,[26a] I. A. Budagov,[64] F. Buehrer,[48] L. Bugge,[118] M. K. Bugge,[118] O. Bulekov,[97] A. C. Bundock,[73] H. Burckhart,[30] S. Burdin,[73] B. Burghgrave,[107] S. Burke,[130] I. Burmeister,[43] E. Busato,[34] D. Büscher,[48] V. Büscher,[82] P. Bussey,[53] C. P. Buszello,[167] B. Butler,[57] J. M. Butler,[22] A. I. Butt,[3] C. M. Buttar,[53] J. M. Butterworth,[77] P. Butti,[106] W. Buttinger,[28] A. Buzatu,[53] M. Byszewski,[10] S. Cabrera Urbán,[168] D. Caforio,[20a,20b] O. Cakir,[4a] P. Calafiura,[15] A. Calandri,[137] G. Calderini,[79] P. Calfayan,[99] R. Calkins,[107] L. P. Caloba,[24a] D. Calvet,[34] S. Calvet,[34] R. Camacho Toro,[49] S. Camarda,[42] D. Cameron,[118] L. M. Caminada,[15] R. Caminal Armadans,[12] S. Campana,[30] M. Campanelli,[77] A. Campoverde,[149] V. Canale,[103a,103b] A. Canepa,[160a] M. Cano Bret,[75] J. Cantero,[81] R. Cantrill,[76] T. Cao,[40] M. D. M. Capeans Garrido,[30] I. Caprini,[26a] M. Caprini,[26a] M. Capua,[37a,37b] R. Caputo,[82] R. Cardarelli,[134a] T. Carli,[30] G. Carlino,[103a] L. Carminati,[90a,90b] S. Caron,[105] E. Carquin,[32a] G. D. Carrillo-Montoya,[146c] J. R. Carter,[28] J. Carvalho,[125a,125c] D. Casadei,[77] M. P. Casado,[12] M. Casolino,[12] E. Castaneda-Miranda,[146b] A. Castelli,[106] V. Castillo Gimenez,[168] N. F. Castro,[125a] P. Catastini,[57] A. Catinaccio,[30] J. R. Catmore,[118] A. Cattai,[30] G. Cattani,[134a,134b] S. Caughron,[89] V. Cavaliere,[166] D. Cavalli,[90a] M. Cavalli-Sforza,[12] V. Cavasinni,[123a,123b] F. Ceradini,[135a,135b] B. Cerio,[45] K. Cerny,[128] A. S. Cerqueira,[24b] A. Cerri,[150] L. Cerrito,[75] F. Cerutti,[15] M. Cerv,[30] A. Cervelli,[17] S. A. Cetin,[19b] A. Chafaq,[136a] D. Chakraborty,[107] I. Chalupkova,[128] P. Chang,[166] B. Chapleau,[86] J. D. Chapman,[28] D. Charfeddine,[116] D. G. Charlton,[18] C. C. Chau,[159] C. A. Chavez Barajas,[150] S. Cheatham,[86] A. Chegwidden,[89] S. Chekanov,[6] S. V. Chekulaev,[160a] G. A. Chelkov,[64,g] M. A. Chelstowska,[88] C. Chen,[63] H. Chen,[25] K. Chen,[149] L. Chen,[33d,h] S. Chen,[33c] X. Chen,[146c] Y. Chen,[35]

H. C. Cheng,[88] Y. Cheng,[31] A. Cheplakov,[64] R. Cherkaoui El Moursli,[136e] V. Chernyatin,[25,a] E. Cheu,[7] L. Chevalier,[137] V. Chiarella,[47] G. Chiefari,[103a,103b] J. T. Childers,[6] A. Chilingarov,[71] G. Chiodini,[72a] A. S. Chisholm,[18] R. T. Chislett,[77] A. Chitan,[26a] M. V. Chizhov,[64] S. Chouridou,[9] B. K. B. Chow,[99] D. Chromek-Burckhart,[30] M. L. Chu,[152] J. Chudoba,[126] J. J. Chwastowski,[39] L. Chytka,[114] G. Ciapetti,[133a,133b] A. K. Ciftci,[4a] R. Ciftci,[4a] D. Cinca,[53] V. Cindro,[74] A. Ciocio,[15] P. Cirkovic,[13b] Z. H. Citron,[173] M. Citterio,[90a] M. Ciubancan,[26a] A. Clark,[49] P. J. Clark,[46] R. N. Clarke,[15] W. Cleland,[124] J. C. Clemens,[84] C. Clement,[147a,147b] Y. Coadou,[84] M. Cobal,[165a,165c] A. Coccaro,[139] J. Cochran,[63] L. Coffey,[23] J. G. Cogan,[144] J. Coggeshall,[166] B. Cole,[35] S. Cole,[107] A. P. Colijn,[106] J. Collot,[55] T. Colombo,[58c] G. Colon,[85] G. Compostella,[100] P. Conde Muiño,[125a,125b] E. Coniavitis,[48] M. C. Conidi,[12] S. H. Connell,[146b] I. A. Connelly,[76] S. M. Consonni,[90a,90b] V. Consorti,[48] S. Constantinescu,[26a] C. Conta,[120a,120b] G. Conti,[57] F. Conventi,[103a,i] M. Cooke,[15] B. D. Cooper,[77] A. M. Cooper-Sarkar,[119] N. J. Cooper-Smith,[76] K. Copic,[15] T. Cornelissen,[176] M. Corradi,[20a] F. Corriveau,[86,j] A. Corso-Radu,[164] A. Cortes-Gonzalez,[12] G. Cortiana,[100] G. Costa,[90a] M. J. Costa,[168] D. Costanzo,[140] D. Côté,[8] G. Cottin,[28] G. Cowan,[76] B. E. Cox,[83] K. Cranmer,[109] G. Cree,[29] S. Crépé-Renaudin,[55] F. Crescioli,[79] W. A. Cribbs,[147a,147b] M. Crispin Ortuzar,[119] M. Cristinziani,[21] V. Croft,[105] G. Crosetti,[37a,37b] C.-M. Cuciuc,[26a] T. Cuhadar Donszelmann,[140] J. Cummings,[177] M. Curatolo,[47] C. Cuthbert,[151] H. Czirr,[142] P. Czodrowski,[3] Z. Czyczula,[177] S. D'Auria,[53] M. D'Onofrio,[73] M. J. Da Cunha Sargedas De Sousa,[125a,125b] C. Da Via,[83] W. Dabrowski,[38a] A. Dafinca,[119] T. Dai,[88] O. Dale,[14] F. Dallaire,[94] C. Dallapiccola,[85] M. Dam,[36] A. C. Daniells,[18] M. Dano Hoffmann,[137] V. Dao,[105] G. Darbo,[50a] S. Darmora,[8] J. A. Dassoulas,[42] A. Dattagupta,[60] W. Davey,[21] C. David,[170] T. Davidek,[128] E. Davies,[119,d] M. Davies,[154] O. Davignon,[79] A. R. Davison,[77] P. Davison,[77] Y. Davygora,[58a] E. Dawe,[143] I. Dawson,[140] R. K. Daya-Ishmukhametova,[85] K. De,[8] R. de Asmundis,[103a] S. De Castro,[20a,20b] S. De Cecco,[79] N. De Groot,[105] P. de Jong,[106] H. De la Torre,[81] F. De Lorenzi,[63] L. De Nooij,[106] D. De Pedis,[133a] A. De Salvo,[133a] U. De Sanctis,[165a,165b] A. De Santo,[150] J. B. De Vivie De Regie,[116] W. J. Dearnaley,[71] R. Debbe,[25] C. Debenedetti,[138] B. Dechenaux,[55] D. V. Dedovich,[64] I. Deigaard,[106] J. Del Peso,[81] T. Del Prete,[123a,123b] F. Deliot,[137] C. M. Delitzsch,[49] M. Deliyergiyev,[74] A. Dell'Acqua,[30] L. Dell'Asta,[22] M. Dell'Orso,[123a,123b] M. Della Pietra,[103a,i] D. della Volpe,[49] M. Delmastro,[5] P. A. Delsart,[55] C. Deluca,[106] S. Demers,[177] M. Demichev,[64] A. Demilly,[79] S. P. Denisov,[129] D. Derendarz,[39] J. E. Derkaoui,[136d] F. Derue,[79] P. Dervan,[73] K. Desch,[21] C. Deterre,[42] P. O. Deviveiros,[106] A. Dewhurst,[130] S. Dhaliwal,[106] A. Di Ciaccio,[134a,134b] L. Di Ciaccio,[5] A. Di Domenico,[133a,133b] C. Di Donato,[103a,103b] A. Di Girolamo,[30] B. Di Girolamo,[30] A. Di Mattia,[153] B. Di Micco,[135a,135b] R. Di Nardo,[47] A. Di Simone,[48] R. Di Sipio,[20a,20b] D. Di Valentino,[29] F. A. Dias,[46] M. A. Diaz,[32a] E. B. Diehl,[88] J. Dietrich,[42] T. A. Dietzsch,[58a] S. Diglio,[84] A. Dimitrievska,[13a] J. Dingfelder,[21] C. Dionisi,[133a,133b] P. Dita,[26a] S. Dita,[26a] F. Dittus,[30] F. Djama,[84] T. Djobava,[51b] M. A. B. do Vale,[24c] A. Do Valle Wemans,[125a,125g] T. K. O. Doan,[5] D. Dobos,[30] C. Doglioni,[49] T. Doherty,[53] T. Dohmae,[156] J. Dolejsi,[128] Z. Dolezal,[128] B. A. Dolgoshein,[97,a] M. Donadelli,[24d] S. Donati,[123a,123b] P. Dondero,[120a,120b] J. Donini,[34] J. Dopke,[130] A. Doria,[103a] M. T. Dova,[70] A. T. Doyle,[53] M. Dris,[10] J. Dubbert,[88] S. Dube,[15] E. Dubreuil,[34] E. Duchovni,[173] G. Duckeck,[99] O. A. Ducu,[26a] D. Duda,[176] A. Dudarev,[30] F. Dudziak,[63] L. Duflot,[116] L. Duguid,[76] M. Dührssen,[30] M. Dunford,[58a] H. Duran Yildiz,[4a] M. Düren,[52] A. Durglishvili,[51b] M. Dwuznik,[38a] M. Dyndal,[38a] J. Ebke,[99] W. Edson,[2] N. C. Edwards,[46] W. Ehrenfeld,[21] T. Eifert,[144] G. Eigen,[14] K. Einsweiler,[15] T. Ekelof,[167] M. El Kacimi,[136c] M. Ellert,[167] S. Elles,[5] F. Ellinghaus,[82] N. Ellis,[30] J. Elmsheuser,[99] M. Elsing,[30] D. Emeliyanov,[130] Y. Enari,[156] O. C. Endner,[82] M. Endo,[117] R. Engelmann,[149] J. Erdmann,[177] A. Ereditato,[17] D. Eriksson,[147a] G. Ernis,[176] J. Ernst,[2] M. Ernst,[25] J. Ernwein,[137] D. Errede,[166] S. Errede,[166] E. Ertel,[82] M. Escalier,[116] H. Esch,[43] C. Escobar,[124] B. Esposito,[47] A. I. Etienvre,[137] E. Etzion,[154] H. Evans,[60] A. Ezhilov,[122] L. Fabbri,[20a,20b] G. Facini,[31] R. M. Fakhrutdinov,[129] S. Falciano,[133a] R. J. Falla,[77] J. Faltova,[128] Y. Fang,[33a] M. Fanti,[90a,90b] A. Farbin,[8] A. Farilla,[135a] T. Farooque,[12] S. Farrell,[164] S. M. Farrington,[171] P. Farthouat,[30] F. Fassi,[168] P. Fassnacht,[30] D. Fassouliotis,[9] A. Favareto,[50a,50b] L. Fayard,[116] P. Federic,[145a] O. L. Fedin,[122,k] W. Fedorko,[169] M. Fehling-Kaschek,[48] S. Feigl,[30] L. Feligioni,[84] C. Feng,[33d] E. J. Feng,[6] H. Feng,[88] A. B. Fenyuk,[129] S. Fernandez Perez,[30] S. Ferrag,[53] J. Ferrando,[53] A. Ferrari,[167] P. Ferrari,[106] R. Ferrari,[120a] D. E. Ferreira de Lima,[53] A. Ferrer,[168] D. Ferrere,[49] C. Ferretti,[88] A. Ferretto Parodi,[50a,50b] M. Fiascaris,[31] F. Fiedler,[82] A. Filipčič,[74] M. Filipuzzi,[42] F. Filthaut,[105] M. Fincke-Keeler,[170] K. D. Finelli,[151] M. C. N. Fiolhais,[125a,125c] L. Fiorini,[168] A. Firan,[40] A. Fischer,[2] J. Fischer,[176] W. C. Fisher,[89] E. A. Fitzgerald,[23] M. Flechl,[48] I. Fleck,[142] P. Fleischmann,[88] S. Fleischmann,[176] G. T. Fletcher,[140] G. Fletcher,[75] T. Flick,[176] A. Floderus,[80] L. R. Flores Castillo,[174,l] A. C. Florez Bustos,[160b] M. J. Flowerdew,[100] A. Formica,[137] A. Forti,[83] D. Fortin,[160a] D. Fournier,[116] H. Fox,[71] S. Fracchia,[12] P. Francavilla,[79] M. Franchini,[20a,20b] S. Franchino,[30] D. Francis,[30] M. Franklin,[57] S. Franz,[61] M. Fraternali,[120a,120b] S. T. French,[28] C. Friedrich,[42] F. Friedrich,[44] D. Froidevaux,[30] J. A. Frost,[28] C. Fukunaga,[157]

E. Fullana Torregrosa,[82] B. G. Fulsom,[144] J. Fuster,[168] C. Gabaldon,[55] O. Gabizon,[173] A. Gabrielli,[20a,20b] A. Gabrielli,[133a,133b] S. Gadatsch,[106] S. Gadomski,[49] G. Gagliardi,[50a,50b] P. Gagnon,[60] C. Galea,[105] B. Galhardo,[125a,125c] E. J. Gallas,[119] V. Gallo,[17] B. J. Gallop,[130] P. Gallus,[127] G. Galster,[36] K. K. Gan,[110] R. P. Gandrajula,[62] J. Gao,[33b,h] Y. S. Gao,[144,f] F. M. Garay Walls,[46] F. Garberson,[177] C. García,[168] J. E. García Navarro,[168] M. Garcia-Sciveres,[15] R. W. Gardner,[31] N. Garelli,[144] V. Garonne,[30] C. Gatti,[47] G. Gaudio,[120a] B. Gaur,[142] L. Gauthier,[94] P. Gauzzi,[133a,133b] I. L. Gavrilenko,[95] C. Gay,[169] G. Gaycken,[21] E. N. Gazis,[10] P. Ge,[33d] Z. Gecse,[169] C. N. P. Gee,[130] D. A. A. Geerts,[106] Ch. Geich-Gimbel,[21] K. Gellerstedt,[147a,147b] C. Gemme,[50a] A. Gemmell,[53] M. H. Genest,[55] S. Gentile,[133a,133b] M. George,[54] S. George,[76] D. Gerbaudo,[164] A. Gershon,[154] H. Ghazlane,[136b] N. Ghodbane,[34] B. Giacobbe,[20a] S. Giagu,[133a,133b] V. Giangiobbe,[12] P. Giannetti,[123a,123b] F. Gianotti,[30] B. Gibbard,[25] S. M. Gibson,[76] M. Gilchriese,[15] T. P. S. Gillam,[28] D. Gillberg,[30] G. Gilles,[34] D. M. Gingrich,[3,e] N. Giokaris,[9] M. P. Giordani,[165a,165c] R. Giordano,[103a,103b] F. M. Giorgi,[20a] F. M. Giorgi,[16] P. F. Giraud,[137] D. Giugni,[90a] C. Giuliani,[48] M. Giulini,[58b] B. K. Gjelsten,[118] S. Gkaitatzis,[155] I. Gkialas,[155,m] L. K. Gladilin,[98] C. Glasman,[81] J. Glatzer,[30] P. C. F. Glaysher,[46] A. Glazov,[42] G. L. Glonti,[64] M. Goblirsch-Kolb,[100] J. R. Goddard,[75] J. Godfrey,[143] J. Godlewski,[30] C. Goeringer,[82] S. Goldfarb,[88] T. Golling,[177] D. Golubkov,[129] A. Gomes,[125a,125b,125d] L. S. Gomez Fajardo,[42] R. Gonçalo,[125a] J. Goncalves Pinto Firmino Da Costa,[137] L. Gonella,[21] S. González de la Hoz,[168] G. Gonzalez Parra,[12] S. Gonzalez-Sevilla,[49] L. Goossens,[30] P. A. Gorbounov,[96] H. A. Gordon,[25] I. Gorelov,[104] B. Gorini,[30] E. Gorini,[72a,72b] A. Gorišek,[74] E. Gornicki,[39] A. T. Goshaw,[6] C. Gössling,[43] M. I. Gostkin,[64] M. Gouighri,[136a] D. Goujdami,[136c] M. P. Goulette,[49] A. G. Goussiou,[139] C. Goy,[5] S. Gozpinar,[23] H. M. X. Grabas,[137] L. Graber,[54] I. Grabowska-Bold,[38a] P. Grafström,[20a,20b] K-J. Grahn,[42] J. Gramling,[49] E. Gramstad,[118] S. Grancagnolo,[16] V. Grassi,[149] V. Gratchev,[122] H. M. Gray,[30] E. Graziani,[135a] O. G. Grebenyuk,[122] Z. D. Greenwood,[78,n] K. Gregersen,[77] I. M. Gregor,[42] P. Grenier,[144] J. Griffiths,[8] A. A. Grillo,[138] K. Grimm,[71] S. Grinstein,[12,o] Ph. Gris,[34] Y. V. Grishkevich,[98] J.-F. Grivaz,[116] J. P. Grohs,[44] A. Grohsjean,[42] E. Gross,[173] J. Grosse-Knetter,[54] G. C. Grossi,[134a,134b] J. Groth-Jensen,[173] Z. J. Grout,[150] L. Guan,[33b] F. Guescini,[49] D. Guest,[177] O. Gueta,[154] C. Guicheney,[34] E. Guido,[50a,50b] T. Guillemin,[116] S. Guindon,[2] U. Gul,[53] C. Gumpert,[44] J. Gunther,[127] J. Guo,[35] S. Gupta,[119] P. Gutierrez,[112] N. G. Gutierrez Ortiz,[53] C. Gutschow,[77] N. Guttman,[154] C. Guyot,[137] C. Gwenlan,[119] C. B. Gwilliam,[73] A. Haas,[109] C. Haber,[15] H. K. Hadavand,[8] N. Haddad,[136e] P. Haefner,[21] S. Hageböck,[21] Z. Hajduk,[39] H. Hakobyan,[178] M. Haleem,[42] D. Hall,[119] G. Halladjian,[89] K. Hamacher,[176] P. Hamal,[114] K. Hamano,[170] M. Hamer,[54] A. Hamilton,[146a] S. Hamilton,[162] P. G. Hamnett,[42] L. Han,[33b] K. Hanagaki,[117] K. Hanawa,[156] M. Hance,[15] P. Hanke,[58a] R. Hanna,[137] J. B. Hansen,[36] J. D. Hansen,[36] P. H. Hansen,[36] K. Hara,[161] A. S. Hard,[174] T. Harenberg,[176] F. Hariri,[116] S. Harkusha,[91] D. Harper,[88] R. D. Harrington,[46] O. M. Harris,[139] P. F. Harrison,[171] F. Hartjes,[106] S. Hasegawa,[102] Y. Hasegawa,[141] A. Hasib,[112] S. Hassani,[137] S. Haug,[17] M. Hauschild,[30] R. Hauser,[89] M. Havranek,[126] C. M. Hawkes,[18] R. J. Hawkings,[30] A. D. Hawkins,[80] T. Hayashi,[161] D. Hayden,[89] C. P. Hays,[119] H. S. Hayward,[73] S. J. Haywood,[130] S. J. Head,[18] T. Heck,[82] V. Hedberg,[80] L. Heelan,[8] S. Heim,[121] T. Heim,[176] B. Heinemann,[15] L. Heinrich,[109] J. Hejbal,[126] L. Helary,[22] C. Heller,[99] M. Heller,[30] S. Hellman,[147a,147b] D. Hellmich,[21] C. Helsens,[30] J. Henderson,[119] R. C. W. Henderson,[71] Y. Heng,[174] C. Hengler,[42] A. Henrichs,[177] A. M. Henriques Correia,[30] S. Henrot-Versille,[116] C. Hensel,[54] G. H. Herbert,[16] Y. Hernández Jiménez,[168] R. Herrberg-Schubert,[16] G. Herten,[48] R. Hertenberger,[99] L. Hervas,[30] G. G. Hesketh,[77] N. P. Hessey,[106] R. Hickling,[75] E. Higón-Rodriguez,[168] E. Hill,[170] J. C. Hill,[28] K. H. Hiller,[42] S. Hillert,[21] S. J. Hillier,[18] I. Hinchliffe,[15] E. Hines,[121] M. Hirose,[158] D. Hirschbuehl,[176] J. Hobbs,[149] N. Hod,[106] M. C. Hodgkinson,[140] P. Hodgson,[140] A. Hoecker,[30] M. R. Hoeferkamp,[104] J. Hoffman,[40] D. Hoffmann,[84] J. I. Hofmann,[58a] M. Hohlfeld,[82] T. R. Holmes,[15] T. M. Hong,[121] L. Hooft van Huysduynen,[109] J-Y. Hostachy,[55] S. Hou,[152] A. Hoummada,[136a] J. Howard,[119] J. Howarth,[42] M. Hrabovsky,[114] I. Hristova,[16] J. Hrivnac,[116] T. Hryn'ova,[5] C. Hsu,[146c] P. J. Hsu,[82] S.-C. Hsu,[139] D. Hu,[35] X. Hu,[25] Y. Huang,[42] Z. Hubacek,[30] F. Hubaut,[84] F. Huegging,[21] T. B. Huffman,[119] E. W. Hughes,[35] G. Hughes,[71] M. Huhtinen,[30] T. A. Hülsing,[82] M. Hurwitz,[15] N. Huseynov,[64,c] J. Huston,[89] J. Huth,[57] G. Iacobucci,[49] G. Iakovidis,[10] I. Ibragimov,[142] L. Iconomidou-Fayard,[116] E. Ideal,[177] P. Iengo,[103a] O. Igonkina,[106] T. Iizawa,[172] Y. Ikegami,[65] K. Ikematsu,[142] M. Ikeno,[65] Y. Ilchenko,[31,p] D. Iliadis,[155] N. Ilic,[159] Y. Inamaru,[66] T. Ince,[100] P. Ioannou,[9] M. Iodice,[135a] K. Iordanidou,[9] V. Ippolito,[57] A. Irles Quiles,[168] C. Isaksson,[167] M. Ishino,[67] M. Ishitsuka,[158] R. Ishmukhametov,[110] C. Issever,[119] S. Istin,[19a] J. M. Iturbe Ponce,[83] R. Iuppa,[134a,134b] J. Ivarsson,[80] W. Iwanski,[39] H. Iwasaki,[65] J. M. Izen,[41] V. Izzo,[103a] B. Jackson,[121] M. Jackson,[73] P. Jackson,[1] M. R. Jaekel,[30] V. Jain,[2] K. Jakobs,[48] S. Jakobsen,[30] T. Jakoubek,[126] J. Jakubek,[127] D. O. Jamin,[152] D. K. Jana,[78] E. Jansen,[77] H. Jansen,[30] J. Janssen,[21] M. Janus,[171] G. Jarlskog,[80] N. Javadov,[64,c] T. Javůrek,[48] L. Jeanty,[15] J. Jejelava,[51a,q] G.-Y. Jeng,[151] D. Jennens,[87] P. Jenni,[48,r] J. Jentzsch,[43] C. Jeske,[171] S. Jézéquel,[5] H. Ji,[174] W. Ji,[82] J. Jia,[149] Y. Jiang,[33b] M. Jimenez Belenguer,[42] S. Jin,[33a] A. Jinaru,[26a] O. Jinnouchi,[158] M. D. Joergensen,[36]

K. E. Johansson,[147a,147b] P. Johansson,[140] K. A. Johns,[7] K. Jon-And,[147a,147b] G. Jones,[171] R. W. L. Jones,[71] T. J. Jones,[73] J. Jongmanns,[58a] P. M. Jorge,[125a,125b] K. D. Joshi,[83] J. Jovicevic,[148] X. Ju,[174] C. A. Jung,[43] R. M. Jungst,[30] P. Jussel,[61] A. Juste Rozas,[12,o] M. Kaci,[168] A. Kaczmarska,[39] M. Kado,[116] H. Kagan,[110] M. Kagan,[144] E. Kajomovitz,[45] C. W. Kalderon,[119] S. Kama,[40] A. Kamenshchikov,[129] N. Kanaya,[156] M. Kaneda,[30] S. Kaneti,[28] V. A. Kantserov,[97] J. Kanzaki,[65] B. Kaplan,[109] A. Kapliy,[31] D. Kar,[53] K. Karakostas,[10] N. Karastathis,[10] M. Karnevskiy,[82] S. N. Karpov,[64] Z. M. Karpova,[64] K. Karthik,[109] V. Kartvelishvili,[71] A. N. Karyukhin,[129] L. Kashif,[174] G. Kasieczka,[58b] R. D. Kass,[110] A. Kastanas,[14] Y. Kataoka,[156] A. Katre,[49] J. Katzy,[42] V. Kaushik,[7] K. Kawagoe,[69] T. Kawamoto,[156] G. Kawamura,[54] S. Kazama,[156] V. F. Kazanin,[108] M. Y. Kazarinov,[64] R. Keeler,[170] R. Kehoe,[40] M. Keil,[54] J. S. Keller,[42] J. J. Kempster,[76] H. Keoshkerian,[5] O. Kepka,[126] B. P. Kerševan,[74] S. Kersten,[176] K. Kessoku,[156] J. Keung,[159] F. Khalil-zada,[11] H. Khandanyan,[147a,147b] A. Khanov,[113] A. Khodinov,[97] A. Khomich,[58a] T. J. Khoo,[28] G. Khoriauli,[21] A. Khoroshilov,[176] V. Khovanskiy,[96] E. Khramov,[64] J. Khubua,[51b] H. Y. Kim,[8] H. Kim,[147a,147b] S. H. Kim,[161] N. Kimura,[172] O. Kind,[16] B. T. King,[73] M. King,[168] R. S. B. King,[119] S. B. King,[169] J. Kirk,[130] A. E. Kiryunin,[100] T. Kishimoto,[66] D. Kisielewska,[38a] F. Kiss,[48] T. Kittelmann,[124] K. Kiuchi,[161] E. Kladiva,[145b] M. Klein,[73] U. Klein,[73] K. Kleinknecht,[82] P. Klimek,[147a,147b] A. Klimentov,[25] R. Klingenberg,[43] J. A. Klinger,[83] T. Klioutchnikova,[30] P. F. Klok,[105] E.-E. Kluge,[58a] P. Kluit,[106] S. Kluth,[100] E. Kneringer,[61] E. B. F. G. Knoops,[84] A. Knue,[53] D. Kobayashi,[158] T. Kobayashi,[156] M. Kobel,[44] M. Kocian,[144] P. Kodys,[128] P. Koevesarki,[21] T. Koffas,[29] E. Koffeman,[106] L. A. Kogan,[119] S. Kohlmann,[176] Z. Kohout,[127] T. Kohriki,[65] T. Koi,[144] H. Kolanoski,[16] I. Koletsou,[5] J. Koll,[89] A. A. Komar,[95,a] Y. Komori,[156] T. Kondo,[65] N. Kondrashova,[42] K. Köneke,[48] A. C. König,[105] S. König,[82] T. Kono,[65,s] R. Konoplich,[109,t] N. Konstantinidis,[77] R. Kopeliansky,[153] S. Koperny,[38a] L. Köpke,[82] A. K. Kopp,[48] K. Korcyl,[39] K. Kordas,[155] A. Korn,[77] A. A. Korol,[108,u] I. Korolkov,[12] E. V. Korolkova,[140] V. A. Korotkov,[129] O. Kortner,[100] S. Kortner,[100] V. V. Kostyukhin,[21] V. M. Kotov,[64] A. Kotwal,[45] C. Kourkoumelis,[9] V. Kouskoura,[155] A. Koutsman,[160a] R. Kowalewski,[170] T. Z. Kowalski,[38a] W. Kozanecki,[137] A. S. Kozhin,[129] V. Kral,[127] V. A. Kramarenko,[98] G. Kramberger,[74] D. Krasnopevtsev,[97] M. W. Krasny,[79] A. Krasznahorkay,[30] J. K. Kraus,[21] A. Kravchenko,[25] S. Kreiss,[109] M. Kretz,[58c] J. Kretzschmar,[73] K. Kreutzfeldt,[52] P. Krieger,[159] K. Kroeninger,[54] H. Kroha,[100] J. Kroll,[121] J. Kroseberg,[21] J. Krstic,[13a] U. Kruchonak,[64] H. Krüger,[21] T. Kruker,[17] N. Krumnack,[63] Z. V. Krumshteyn,[64] A. Kruse,[174] M. C. Kruse,[45] M. Kruskal,[22] T. Kubota,[87] S. Kuday,[4a] S. Kuehn,[48] A. Kugel,[58c] A. Kuhl,[138] T. Kuhl,[42] V. Kukhtin,[64] Y. Kulchitsky,[91] S. Kuleshov,[32b] M. Kuna,[133a,133b] J. Kunkle,[121] A. Kupco,[126] H. Kurashige,[66] Y. A. Kurochkin,[91] R. Kurumida,[66] V. Kus,[126] E. S. Kuwertz,[148] M. Kuze,[158] J. Kvita,[114] A. La Rosa,[49] L. La Rotonda,[37a,37b] C. Lacasta,[168] F. Lacava,[133a,133b] J. Lacey,[29] H. Lacker,[16] D. Lacour,[79] V. R. Lacuesta,[168] E. Ladygin,[64] R. Lafaye,[5] B. Laforge,[79] T. Lagouri,[177] S. Lai,[48] H. Laier,[58a] L. Lambourne,[77] S. Lammers,[60] C. L. Lampen,[7] W. Lampl,[7] E. Lançon,[137] U. Landgraf,[48] M. P. J. Landon,[75] V. S. Lang,[58a] A. J. Lankford,[164] F. Lanni,[25] K. Lantzsch,[30] S. Laplace,[79] C. Lapoire,[21] J. F. Laporte,[137] T. Lari,[90a] M. Lassnig,[30] P. Laurelli,[47] W. Lavrijsen,[15] A. T. Law,[138] P. Laycock,[73] B. T. Le,[55] O. Le Dortz,[79] E. Le Guirriec,[84] E. Le Menedeu,[12] T. LeCompte,[6] F. Ledroit-Guillon,[55] C. A. Lee,[152] H. Lee,[106] J. S. H. Lee,[117] S. C. Lee,[152] L. Lee,[177] G. Lefebvre,[79] M. Lefebvre,[170] F. Legger,[99] C. Leggett,[15] A. Lehan,[73] M. Lehmacher,[21] G. Lehmann Miotto,[30] X. Lei,[7] W. A. Leight,[29] A. Leisos,[155] A. G. Leister,[177] M. A. L. Leite,[24d] R. Leitner,[128] D. Lellouch,[173] B. Lemmer,[54] K. J. C. Leney,[77] T. Lenz,[106] G. Lenzen,[176] B. Lenzi,[30] R. Leone,[7] S. Leone,[123a,123b] K. Leonhardt,[44] C. Leonidopoulos,[46] S. Leontsinis,[10] C. Leroy,[94] C. G. Lester,[28] C. M. Lester,[121] M. Levchenko,[122] J. Levêque,[5] D. Levin,[88] L. J. Levinson,[173] M. Levy,[18] A. Lewis,[119] G. H. Lewis,[109] A. M. Leyko,[21] M. Leyton,[41] B. Li,[33b,v] B. Li,[84] H. Li,[149] H. L. Li,[31] L. Li,[45] L. Li,[33e] S. Li,[45] Y. Li,[33c,w] Z. Liang,[138] H. Liao,[34] B. Liberti,[134a] P. Lichard,[30] K. Lie,[166] J. Liebal,[21] W. Liebig,[14] C. Limbach,[21] A. Limosani,[87] S. C. Lin,[152,x] T. H. Lin,[82] F. Linde,[106] B. E. Lindquist,[149] J. T. Linnemann,[89] E. Lipeles,[121] A. Lipniacka,[14] M. Lisovyi,[42] T. M. Liss,[166] D. Lissauer,[25] A. Lister,[169] A. M. Litke,[138] B. Liu,[152] D. Liu,[152] J. B. Liu,[33b] K. Liu,[33b,y] L. Liu,[88] M. Liu,[45] M. Liu,[33b] Y. Liu,[33b] M. Livan,[120a,120b] S. S. A. Livermore,[119] A. Lleres,[55] J. Llorente Merino,[81] S. L. Lloyd,[75] F. Lo Sterzo,[152] E. Lobodzinska,[42] P. Loch,[7] W. S. Lockman,[138] T. Loddenkoetter,[21] F. K. Loebinger,[83] A. E. Loevschall-Jensen,[36] A. Loginov,[177] C. W. Loh,[169] T. Lohse,[16] K. Lohwasser,[42] M. Lokajicek,[126] V. P. Lombardo,[5] B. A. Long,[22] J. D. Long,[88] R. E. Long,[71] L. Lopes,[125a] D. Lopez Mateos,[57] B. Lopez Paredes,[140] I. Lopez Paz,[12] J. Lorenz,[99] N. Lorenzo Martinez,[60] M. Losada,[163] P. Loscutoff,[15] X. Lou,[41] A. Lounis,[116] J. Love,[6] P. A. Love,[71] A. J. Lowe,[144,f] F. Lu,[33a] H. J. Lubatti,[139] C. Luci,[133a,133b] A. Lucotte,[55] F. Luehring,[60] W. Lukas,[61] L. Luminari,[133a] O. Lundberg,[147a,147b] B. Lund-Jensen,[148] M. Lungwitz,[82] D. Lynn,[25] R. Lysak,[126] E. Lytken,[80] H. Ma,[25] L. L. Ma,[33d] G. Maccarrone,[47] A. Macchiolo,[100] J. Machado Miguens,[125a,125b] D. Macina,[30] D. Madaffari,[84] R. Madar,[48] H. J. Maddocks,[71] W. F. Mader,[44] A. Madsen,[167] M. Maeno,[8] T. Maeno,[25] E. Magradze,[54] K. Mahboubi,[48] J. Mahlstedt,[106] S. Mahmoud,[73] C. Maiani,[137]

C. Maidantchik,[24a] A. A. Maier,[100] A. Maio,[125a,125b,125d] S. Majewski,[115] Y. Makida,[65] N. Makovec,[116] P. Mal,[137,z] B. Malaescu,[79] Pa. Malecki,[39] V. P. Maleev,[122] F. Malek,[55] U. Mallik,[62] D. Malon,[6] C. Malone,[144] S. Maltezos,[10] V. M. Malyshev,[108] S. Malyukov,[30] J. Mamuzic,[13b] B. Mandelli,[30] L. Mandelli,[90a] I. Mandić,[74] R. Mandrysch,[62] J. Maneira,[125a,125b] A. Manfredini,[100] L. Manhaes de Andrade Filho,[24b] J. A. Manjarres Ramos,[160b] A. Mann,[99] P. M. Manning,[138] A. Manousakis-Katsikakis,[9] B. Mansoulie,[137] R. Mantifel,[86] L. Mapelli,[30] L. March,[168] J. F. Marchand,[29] G. Marchiori,[79] M. Marcisovsky,[126] C. P. Marino,[170] M. Marjanovic,[13a] C. N. Marques,[125a] F. Marroquim,[24a] S. P. Marsden,[83] Z. Marshall,[15] L. F. Marti,[17] S. Marti-Garcia,[168] B. Martin,[30] B. Martin,[89] T. A. Martin,[171] V. J. Martin,[46] B. Martin dit Latour,[14] H. Martinez,[137] M. Martinez,[12,o] S. Martin-Haugh,[130] A. C. Martyniuk,[77] M. Marx,[139] F. Marzano,[133a] A. Marzin,[30] L. Masetti,[82] T. Mashimo,[156] R. Mashinistov,[95] J. Masik,[83] A. L. Maslennikov,[108] I. Massa,[20a,20b] N. Massol,[5] P. Mastrandrea,[149] A. Mastroberardino,[37a,37b] T. Masubuchi,[156] P. Mättig,[176] J. Mattmann,[82] J. Maurer,[26a] S. J. Maxfield,[73] D. A. Maximov,[108,u] R. Mazini,[152] L. Mazzaferro,[134a,134b] G. Mc Goldrick,[159] S. P. Mc Kee,[88] A. McCarn,[88] R. L. McCarthy,[149] T. G. McCarthy,[29] N. A. McCubbin,[130] K. W. McFarlane,[56,a] J. A. Mcfayden,[77] G. Mchedlidze,[54] S. J. McMahon,[130] R. A. McPherson,[170,j] A. Meade,[85] J. Mechnich,[106] M. Medinnis,[42] S. Meehan,[31] S. Mehlhase,[99] A. Mehta,[73] K. Meier,[58a] C. Meineck,[99] B. Meirose,[80] C. Melachrinos,[31] B. R. Mellado Garcia,[146c] F. Meloni,[17] A. Mengarelli,[20a,20b] S. Menke,[100] E. Meoni,[162] K. M. Mercurio,[57] S. Mergelmeyer,[21] N. Meric,[137] P. Mermod,[49] L. Merola,[103a,103b] C. Meroni,[90a] F. S. Merritt,[31] H. Merritt,[110] A. Messina,[30,aa] J. Metcalfe,[25] A. S. Mete,[164] C. Meyer,[82] C. Meyer,[31] J-P. Meyer,[137] J. Meyer,[30] R. P. Middleton,[130] S. Migas,[73] L. Mijović,[21] G. Mikenberg,[173] M. Mikestikova,[126] M. Mikuž,[74] A. Milic,[30] D. W. Miller,[31] C. Mills,[46] A. Milov,[173] D. A. Milstead,[147a,147b] D. Milstein,[173] A. A. Minaenko,[129] I. A. Minashvili,[64] A. I. Mincer,[109] B. Mindur,[38a] M. Mineev,[64] Y. Ming,[174] L. M. Mir,[12] G. Mirabelli,[133a] T. Mitani,[172] J. Mitrevski,[99] V. A. Mitsou,[168] S. Mitsui,[65] A. Miucci,[49] P. S. Miyagawa,[140] J. U. Mjörnmark,[80] T. Moa,[147a,147b] K. Mochizuki,[84] S. Mohapatra,[35] W. Mohr,[48] S. Molander,[147a,147b] R. Moles-Valls,[168] K. Mönig,[42] C. Monini,[55] J. Monk,[36] E. Monnier,[84] J. Montejo Berlingen,[12] F. Monticelli,[70] S. Monzani,[133a,133b] R. W. Moore,[3] A. Moraes,[53] N. Morange,[62] D. Moreno,[82] M. Moreno Llácer,[54] P. Morettini,[50a] M. Morgenstern,[44] M. Morii,[57] S. Moritz,[82] A. K. Morley,[148] G. Mornacchi,[30] J. D. Morris,[75] L. Morvaj,[102] H. G. Moser,[100] M. Mosidze,[51b] J. Moss,[110] K. Motohashi,[158] R. Mount,[144] E. Mountricha,[25] S. V. Mouraviev,[95,a] E. J. W. Moyse,[85] S. Muanza,[84] R. D. Mudd,[18] F. Mueller,[58a] J. Mueller,[124] K. Mueller,[21] T. Mueller,[28] T. Mueller,[82] D. Muenstermann,[49] Y. Munwes,[154] J. A. Murillo Quijada,[18] W. J. Murray,[171,130] H. Musheghyan,[54] E. Musto,[153] A. G. Myagkov,[129,bb] M. Myska,[127] O. Nackenhorst,[54] J. Nadal,[54] K. Nagai,[61] R. Nagai,[158] Y. Nagai,[84] K. Nagano,[65] A. Nagarkar,[110] Y. Nagasaka,[59] M. Nagel,[100] A. M. Nairz,[30] Y. Nakahama,[30] K. Nakamura,[65] T. Nakamura,[156] I. Nakano,[111] H. Namasivayam,[41] G. Nanava,[21] R. Narayan,[58b] T. Nattermann,[21] T. Naumann,[42] G. Navarro,[163] R. Nayyar,[7] H. A. Neal,[88] P. Yu. Nechaeva,[95] T. J. Neep,[83] P. D. Nef,[144] A. Negri,[120a,120b] G. Negri,[30] M. Negrini,[20a] S. Nektarijevic,[49] A. Nelson,[164] T. K. Nelson,[144] S. Nemecek,[126] P. Nemethy,[109] A. A. Nepomuceno,[24a] M. Nessi,[30,cc] M. S. Neubauer,[166] M. Neumann,[176] R. M. Neves,[109] P. Nevski,[25] P. R. Newman,[18] D. H. Nguyen,[6] R. B. Nickerson,[119] R. Nicolaidou,[137] B. Nicquevert,[30] J. Nielsen,[138] N. Nikiforou,[35] A. Nikiforov,[16] V. Nikolaenko,[129,bb] I. Nikolic-Audit,[79] K. Nikolics,[49] K. Nikolopoulos,[18] P. Nilsson,[8] Y. Ninomiya,[156] A. Nisati,[133a] R. Nisius,[100] T. Nobe,[158] L. Nodulman,[6] M. Nomachi,[117] I. Nomidis,[155] S. Norberg,[112] M. Nordberg,[30] S. Nowak,[100] M. Nozaki,[65] L. Nozka,[114] K. Ntekas,[10] G. Nunes Hanninger,[87] T. Nunnemann,[99] E. Nurse,[77] F. Nuti,[87] B. J. O'Brien,[46] F. O'grady,[7] D. C. O'Neil,[143] V. O'Shea,[53] F. G. Oakham,[29,e] H. Oberlack,[100] T. Obermann,[21] J. Ocariz,[79] A. Ochi,[66] M. I. Ochoa,[77] S. Oda,[69] S. Odaka,[65] H. Ogren,[60] A. Oh,[83] S. H. Oh,[45] C. C. Ohm,[30] H. Ohman,[167] T. Ohshima,[102] W. Okamura,[117] H. Okawa,[25] Y. Okumura,[31] T. Okuyama,[156] A. Olariu,[26a] A. G. Olchevski,[64] S. A. Olivares Pino,[46] D. Oliveira Damazio,[25] E. Oliver Garcia,[168] A. Olszewski,[39] J. Olszowska,[39] A. Onofre,[125a,125e] P. U. E. Onyisi,[31,p] C. J. Oram,[160a] M. J. Oreglia,[31] Y. Oren,[154] D. Orestano,[135a,135b] N. Orlando,[72a,72b] C. Oropeza Barrera,[53] R. S. Orr,[159] B. Osculati,[50a,50b] R. Ospanov,[121] G. Otero y Garzon,[27] H. Otono,[69] M. Ouchrif,[136d] E. A. Ouellette,[170] F. Ould-Saada,[118] A. Ouraou,[137] K. P. Oussoren,[106] Q. Ouyang,[33a] A. Ovcharova,[15] M. Owen,[83] V. E. Ozcan,[19a] N. Ozturk,[8] K. Pachal,[119] A. Pacheco Pages,[12] C. Padilla Aranda,[12] M. Pagáčová,[48] S. Pagan Griso,[15] E. Paganis,[140] C. Pahl,[100] F. Paige,[25] P. Pais,[85] K. Pajchel,[118] G. Palacino,[160b] S. Palestini,[30] M. Palka,[38b] D. Pallin,[34] A. Palma,[125a,125b] J. D. Palmer,[18] Y. B. Pan,[174] E. Panagiotopoulou,[10] J. G. Panduro Vazquez,[76] P. Pani,[106] N. Panikashvili,[88] S. Panitkin,[25] D. Pantea,[26a] L. Paolozzi,[134a,134b] Th. D. Papadopoulou,[10] K. Papageorgiou,[155,m] A. Paramonov,[6] D. Paredes Hernandez,[34] M. A. Parker,[28] F. Parodi,[50a,50b] J. A. Parsons,[35] U. Parzefall,[48] E. Pasqualucci,[133a] S. Passaggio,[50a] A. Passeri,[135a] F. Pastore,[135a,135b,a] Fr. Pastore,[76] G. Pásztor,[29] S. Pataraia,[176] N. D. Patel,[151] J. R. Pater,[83] S. Patricelli,[103a,103b] T. Pauly,[30] J. Pearce,[170] M. Pedersen,[118]

S. Pedraza Lopez,[168] R. Pedro,[125a,125b] S. V. Peleganchuk,[108] D. Pelikan,[167] H. Peng,[33b] B. Penning,[31] J. Penwell,[60] D. V. Perepelitsa,[25] E. Perez Codina,[160a] M. T. Pérez García-Estañ,[168] V. Perez Reale,[35] L. Perini,[90a,90b] H. Pernegger,[30] R. Perrino,[72a] R. Peschke,[42] V. D. Peshekhonov,[64] K. Peters,[30] R. F. Y. Peters,[83] B. A. Petersen,[30] T. C. Petersen,[36] E. Petit,[42] A. Petridis,[147a,147b] C. Petridou,[155] E. Petrolo,[133a] F. Petrucci,[135a,135b] N. E. Pettersson,[158] R. Pezoa,[32b] P. W. Phillips,[130] G. Piacquadio,[144] E. Pianori,[171] A. Picazio,[49] E. Piccaro,[75] M. Piccinini,[20a,20b] R. Piegaia,[27] D. T. Pignotti,[110] J. E. Pilcher,[31] A. D. Pilkington,[77] J. Pina,[125a,125b,125d] M. Pinamonti,[165a,165c,dd] A. Pinder,[119] J. L. Pinfold,[3] A. Pingel,[36] B. Pinto,[125a] S. Pires,[79] M. Pitt,[173] C. Pizio,[90a,90b] L. Plazak,[145a] M.-A. Pleier,[25] V. Pleskot,[128] E. Plotnikova,[64] P. Plucinski,[147a,147b] S. Poddar,[58a] F. Podlyski,[34] R. Poettgen,[82] L. Poggioli,[116] D. Pohl,[21] M. Pohl,[49] G. Polesello,[120a] A. Policicchio,[37a,37b] R. Polifka,[159] A. Polini,[20a] C. S. Pollard,[45] V. Polychronakos,[25] K. Pommès,[30] L. Pontecorvo,[133a] B. G. Pope,[89] G. A. Popeneciu,[26b] D. S. Popovic,[13a] A. Poppleton,[30] X. Portell Bueso,[12] S. Pospisil,[127] K. Potamianos,[15] I. N. Potrap,[64] C. J. Potter,[150] C. T. Potter,[115] G. Poulard,[30] J. Poveda,[60] V. Pozdnyakov,[64] P. Pralavorio,[84] A. Pranko,[15] S. Prasad,[30] R. Pravahan,[8] S. Prell,[63] D. Price,[83] J. Price,[73] L. E. Price,[6] D. Prieur,[124] M. Primavera,[72a] M. Proissl,[46] K. Prokofiev,[47] F. Prokoshin,[32b] E. Protopapadaki,[137] S. Protopopescu,[25] J. Proudfoot,[6] M. Przybycien,[38a] H. Przysiezniak,[5] E. Ptacek,[115] D. Puddu,[135a,135b] E. Pueschel,[85] D. Puldon,[149] M. Purohit,[25,ee] P. Puzo,[116] J. Qian,[88] G. Qin,[53] Y. Qin,[83] A. Quadt,[54] D. R. Quarrie,[15] W. B. Quayle,[165a,165b] M. Queitsch-Maitland,[83] D. Quilty,[53] A. Qureshi,[160b] V. Radeka,[25] V. Radescu,[42] S. K. Radhakrishnan,[149] P. Radloff,[115] P. Rados,[87] F. Ragusa,[90a,90b] G. Rahal,[179] S. Rajagopalan,[25] M. Rammensee,[30] A. S. Randle-Conde,[40] C. Rangel-Smith,[167] K. Rao,[164] F. Rauscher,[99] T. C. Rave,[48] T. Ravenscroft,[53] M. Raymond,[30] A. L. Read,[118] N. P. Readioff,[73] D. M. Rebuzzi,[120a,120b] A. Redelbach,[175] G. Redlinger,[25] R. Reece,[138] K. Reeves,[41] L. Rehnisch,[16] H. Reisin,[27] M. Relich,[164] C. Rembser,[30] H. Ren,[33a] Z. L. Ren,[152] A. Renaud,[116] M. Rescigno,[133a] S. Resconi,[90a] O. L. Rezanova,[108,u] P. Reznicek,[128] R. Rezvani,[94] R. Richter,[100] M. Ridel,[79] P. Rieck,[16] J. Rieger,[54] M. Rijssenbeek,[149] A. Rimoldi,[120a,120b] L. Rinaldi,[20a] E. Ritsch,[61] I. Riu,[12] F. Rizatdinova,[113] E. Rizvi,[75] S. H. Robertson,[86,j] A. Robichaud-Veronneau,[86] D. Robinson,[28] J. E. M. Robinson,[83] A. Robson,[53] C. Roda,[123a,123b] L. Rodrigues,[30] S. Roe,[30] O. Røhne,[118] S. Rolli,[162] A. Romaniouk,[97] M. Romano,[20a,20b] E. Romero Adam,[168] N. Rompotis,[139] L. Roos,[79] E. Ros,[168] S. Rosati,[133a] K. Rosbach,[49] M. Rose,[76] P. L. Rosendahl,[14] O. Rosenthal,[142] V. Rossetti,[147a,147b] E. Rossi,[103a,103b] L. P. Rossi,[50a] R. Rosten,[139] M. Rotaru,[26a] I. Roth,[173] J. Rothberg,[139] D. Rousseau,[116] C. R. Royon,[137] A. Rozanov,[84] Y. Rozen,[153] X. Ruan,[146c] F. Rubbo,[12] I. Rubinskiy,[42] V. I. Rud,[98] C. Rudolph,[44] M. S. Rudolph,[159] F. Rühr,[48] A. Ruiz-Martinez,[30] Z. Rurikova,[48] N. A. Rusakovich,[64] A. Ruschke,[99] J. P. Rutherfoord,[7] N. Ruthmann,[48] Y. F. Ryabov,[122] M. Rybar,[128] G. Rybkin,[116] N. C. Ryder,[119] A. F. Saavedra,[151] S. Sacerdoti,[27] A. Saddique,[3] I. Sadeh,[154] H. F-W. Sadrozinski,[138] R. Sadykov,[64] F. Safai Tehrani,[133a] H. Sakamoto,[156] Y. Sakurai,[172] G. Salamanna,[135a,135b] A. Salamon,[134a] M. Saleem,[112] D. Salek,[106] P. H. Sales De Bruin,[139] D. Salihagic,[100] A. Salnikov,[144] J. Salt,[168] B. M. Salvachua Ferrando,[6] D. Salvatore,[37a,37b] F. Salvatore,[150] A. Salvucci,[105] A. Salzburger,[30] D. Sampsonidis,[155] A. Sanchez,[103a,103b] J. Sánchez,[168] V. Sanchez Martinez,[168] H. Sandaker,[14] R. L. Sandbach,[75] H. G. Sander,[82] M. P. Sanders,[99] M. Sandhoff,[176] T. Sandoval,[28] C. Sandoval,[163] R. Sandstroem,[100] D. P. C. Sankey,[130] A. Sansoni,[47] C. Santoni,[34] R. Santonico,[134a,134b] H. Santos,[125a] I. Santoyo Castillo,[150] K. Sapp,[124] A. Sapronov,[64] J. G. Saraiva,[125a,125d] B. Sarrazin,[21] G. Sartisohn,[176] O. Sasaki,[65] Y. Sasaki,[156] G. Sauvage,[5,a] E. Sauvan,[5] P. Savard,[159,e] D. O. Savu,[30] C. Sawyer,[119] L. Sawyer,[78,n] D. H. Saxon,[53] J. Saxon,[121] C. Sbarra,[20a] A. Sbrizzi,[3] T. Scanlon,[77] D. A. Scannicchio,[164] M. Scarcella,[151] V. Scarfone,[37a,37b] J. Schaarschmidt,[173] P. Schacht,[100] D. Schaefer,[121] R. Schaefer,[42] S. Schaepe,[21] S. Schaetzel,[58b] U. Schäfer,[82] A. C. Schaffer,[116] D. Schaile,[99] R. D. Schamberger,[149] V. Scharf,[58a] V. A. Schegelsky,[122] D. Scheirich,[128] M. Schernau,[164] M. I. Scherzer,[35] C. Schiavi,[50a,50b] J. Schieck,[99] C. Schillo,[48] M. Schioppa,[37a,37b] S. Schlenker,[30] E. Schmidt,[48] K. Schmieden,[30] C. Schmitt,[82] C. Schmitt,[99] S. Schmitt,[58b] B. Schneider,[17] Y. J. Schnellbach,[73] U. Schnoor,[44] L. Schoeffel,[137] A. Schoening,[58b] B. D. Schoenrock,[89] A. L. S. Schorlemmer,[54] M. Schott,[82] D. Schouten,[160a] J. Schovancova,[25] S. Schramm,[159] M. Schreyer,[175] C. Schroeder,[82] N. Schuh,[82] M. J. Schultens,[21] H.-C. Schultz-Coulon,[58a] H. Schulz,[16] M. Schumacher,[48] B. A. Schumm,[138] Ph. Schune,[137] C. Schwanenberger,[83] A. Schwartzman,[144] Ph. Schwegler,[100] Ph. Schwemling,[137] R. Schwienhorst,[89] J. Schwindling,[137] T. Schwindt,[21] M. Schwoerer,[5] F. G. Sciacca,[17] E. Scifo,[116] G. Sciolla,[23] W. G. Scott,[130] F. Scuri,[123a,123b] F. Scutti,[21] J. Searcy,[88] G. Sedov,[42] E. Sedykh,[122] S. C. Seidel,[104] A. Seiden,[138] F. Seifert,[127] J. M. Seixas,[24a] G. Sekhniaidze,[103a] S. J. Sekula,[40] K. E. Selbach,[46] D. M. Seliverstov,[122,a] G. Sellers,[73] N. Semprini-Cesari,[20a,20b] C. Serfon,[30] L. Serin,[116] L. Serkin,[54] T. Serre,[84] R. Seuster,[160a] H. Severini,[112] T. Sfiligoj,[74] F. Sforza,[100] A. Sfyrla,[30] E. Shabalina,[54] M. Shamim,[115] L. Y. Shan,[33a] R. Shang,[166] J. T. Shank,[22] M. Shapiro,[15] P. B. Shatalov,[96] K. Shaw,[165a,165b] C. Y. Shehu,[150] P. Sherwood,[77] L. Shi,[152,ff] S. Shimizu,[66] C. O. Shimmin,[164]

M. Shimojima,[101] M. Shiyakova,[64] A. Shmeleva,[95] M. J. Shochet,[31] D. Short,[119] S. Shrestha,[63] E. Shulga,[97] M. A. Shupe,[7] S. Shushkevich,[42] P. Sicho,[126] O. Sidiropoulou,[155] D. Sidorov,[113] A. Sidoti,[133a] F. Siegert,[44] Dj. Sijacki,[13a] J. Silva,[125a,125d] Y. Silver,[154] D. Silverstein,[144] S. B. Silverstein,[147a] V. Simak,[127] O. Simard,[5] Lj. Simic,[13a] S. Simion,[116] E. Simioni,[82] B. Simmons,[77] R. Simoniello,[90a,90b] M. Simonyan,[36] P. Sinervo,[159] N. B. Sinev,[115] V. Sipica,[142] G. Siragusa,[175] A. Sircar,[78] A. N. Sisakyan,[64,a] S. Yu. Sivoklokov,[98] J. Sjölin,[147a,147b] T. B. Sjursen,[14] H. P. Skottowe,[57] K. Yu. Skovpen,[108] P. Skubic,[112] M. Slater,[18] T. Slavicek,[127] K. Sliwa,[162] V. Smakhtin,[173] B. H. Smart,[46] L. Smestad,[14] S. Yu. Smirnov,[97] Y. Smirnov,[97] L. N. Smirnova,[98,gg] O. Smirnova,[80] K. M. Smith,[53] M. Smizanska,[71] K. Smolek,[127] A. A. Snesarev,[95] G. Snidero,[75] S. Snyder,[25] R. Sobie,[170,j] F. Socher,[44] A. Soffer,[154] D. A. Soh,[152,ff] C. A. Solans,[30] M. Solar,[127] J. Solc,[127] E. Yu. Soldatov,[97] U. Soldevila,[168] E. Solfaroli Camillocci,[133a,133b] A. A. Solodkov,[129] A. Soloshenko,[64] O. V. Solovyanov,[129] V. Solovyev,[122] P. Sommer,[48] H. Y. Song,[33b] N. Soni,[1] A. Sood,[15] A. Sopczak,[127] B. Sopko,[127] V. Sopko,[127] V. Sorin,[12] M. Sosebee,[8] R. Soualah,[165a,165c] P. Soueid,[94] A. M. Soukharev,[108] D. South,[42] S. Spagnolo,[72a,72b] F. Spanò,[76] W. R. Spearman,[57] F. Spettel,[100] R. Spighi,[20a] G. Spigo,[30] M. Spousta,[128] T. Spreitzer,[159] B. Spurlock,[8] R. D. St. Denis,[53,a] S. Staerz,[44] J. Stahlman,[121] R. Stamen,[58a] E. Stanecka,[39] R. W. Stanek,[6] C. Stanescu,[135a] M. Stanescu-Bellu,[42] M. M. Stanitzki,[42] S. Stapnes,[118] E. A. Starchenko,[129] J. Stark,[55] P. Staroba,[126] P. Starovoitov,[42] R. Staszewski,[39] P. Stavina,[145a,a] P. Steinberg,[25] B. Stelzer,[143] H. J. Stelzer,[30] O. Stelzer-Chilton,[160a] H. Stenzel,[52] S. Stern,[100] G. A. Stewart,[53] J. A. Stillings,[21] M. C. Stockton,[86] M. Stoebe,[86] G. Stoicea,[26a] P. Stolte,[54] S. Stonjek,[100] A. R. Stradling,[8] A. Straessner,[44] M. E. Stramaglia,[17] J. Strandberg,[148] S. Strandberg,[147a,147b] A. Strandlie,[118] E. Strauss,[144] M. Strauss,[112] P. Strizenec,[145b] R. Ströhmer,[175] D. M. Strom,[115] R. Stroynowski,[40] S. A. Stucci,[17] B. Stugu,[14] N. A. Styles,[42] D. Su,[144] J. Su,[124] HS. Subramania,[3] R. Subramaniam,[78] A. Succurro,[12] Y. Sugaya,[117] C. Suhr,[107] M. Suk,[127] V. V. Sulin,[95] S. Sultansoy,[4c] T. Sumida,[67] X. Sun,[33a] J. E. Sundermann,[48] K. Suruliz,[140] G. Susinno,[37a,37b] M. R. Sutton,[150] Y. Suzuki,[65] M. Svatos,[126] S. Swedish,[169] M. Swiatlowski,[144] I. Sykora,[145a] T. Sykora,[128] D. Ta,[89] C. Taccini,[135a,135b] K. Tackmann,[42] J. Taenzer,[159] A. Taffard,[164] R. Tafirout,[160a] N. Taiblum,[154] Y. Takahashi,[102] H. Takai,[25] R. Takashima,[68] H. Takeda,[66] T. Takeshita,[141] Y. Takubo,[65] M. Talby,[84] A. A. Talyshev,[108,u] J. Y. C. Tam,[175] K. G. Tan,[87] J. Tanaka,[156] R. Tanaka,[116] S. Tanaka,[132] S. Tanaka,[65] A. J. Tanasijczuk,[143] B. B. Tannenwald,[110] N. Tannoury,[21] S. Tapprogge,[82] S. Tarem,[153] F. Tarrade,[29] G. F. Tartarelli,[90a] P. Tas,[128] M. Tasevsky,[126] T. Tashiro,[67] E. Tassi,[37a,37b] A. Tavares Delgado,[125a,125b] Y. Tayalati,[136d] F. E. Taylor,[93] G. N. Taylor,[87] W. Taylor,[160b] F. A. Teischinger,[30] M. Teixeira Dias Castanheira,[75] P. Teixeira-Dias,[76] K. K. Temming,[48] H. Ten Kate,[30] P. K. Teng,[152] J. J. Teoh,[117] S. Terada,[65] K. Terashi,[156] J. Terron,[81] S. Terzo,[100] M. Testa,[47] R. J. Teuscher,[159,j] J. Therhaag,[21] T. Theveneaux-Pelzer,[34] J. P. Thomas,[18] J. Thomas-Wilsker,[76] E. N. Thompson,[35] P. D. Thompson,[18] P. D. Thompson,[159] A. S. Thompson,[53] L. A. Thomsen,[36] E. Thomson,[121] M. Thomson,[28] W. M. Thong,[87] R. P. Thun,[88,a] F. Tian,[35] M. J. Tibbetts,[15] V. O. Tikhomirov,[95,hh] Yu. A. Tikhonov,[108,u] S. Timoshenko,[97] E. Tiouchichine,[84] P. Tipton,[177] S. Tisserant,[84] T. Todorov,[5] S. Todorova-Nova,[128] B. Toggerson,[7] J. Tojo,[69] S. Tokár,[145a] K. Tokushuku,[65] K. Tollefson,[89] L. Tomlinson,[83] M. Tomoto,[102] L. Tompkins,[31] K. Toms,[104] N. D. Topilin,[64] E. Torrence,[115] H. Torres,[143] E. Torró Pastor,[168] J. Toth,[84,ii] F. Touchard,[84] D. R. Tovey,[140] H. L. Tran,[116] T. Trefzger,[175] L. Tremblet,[30] A. Tricoli,[30] I. M. Trigger,[160a] S. Trincaz-Duvoid,[79] M. F. Tripiana,[12] N. Triplett,[25] W. Trischuk,[159] B. Trocmé,[55] C. Troncon,[90a] M. Trottier-McDonald,[143] M. Trovatelli,[135a,135b] P. True,[89] M. Trzebinski,[39] A. Trzupek,[39] C. Tsarouchas,[30] J. C-L. Tseng,[119] P. V. Tsiareshka,[91] D. Tsionou,[137] G. Tsipolitis,[10] N. Tsirintanis,[9] S. Tsiskaridze,[12] V. Tsiskaridze,[48] E. G. Tskhadadze,[51a] I. I. Tsukerman,[96] V. Tsulaia,[15] S. Tsuno,[65] D. Tsybychev,[149] A. Tudorache,[26a] V. Tudorache,[26a] A. N. Tuna,[121] S. A. Tupputi,[20a,20b] S. Turchikhin,[98,gg] D. Turecek,[127] I. Turk Cakir,[4d] R. Turra,[90a,90b] P. M. Tuts,[35] A. Tykhonov,[49] M. Tylmad,[147a,147b] M. Tyndel,[130] K. Uchida,[21] I. Ueda,[156] R. Ueno,[29] M. Ughetto,[84] M. Ugland,[14] M. Uhlenbrock,[21] F. Ukegawa,[161] G. Unal,[30] A. Undrus,[25] G. Unel,[164] F. C. Ungaro,[48] Y. Unno,[65] D. Urbaniec,[35] P. Urquijo,[87] G. Usai,[8] A. Usanova,[61] L. Vacavant,[84] V. Vacek,[127] B. Vachon,[86] N. Valencic,[106] S. Valentinetti,[20a,20b] A. Valero,[168] L. Valery,[34] S. Valkar,[128] E. Valladolid Gallego,[168] S. Vallecorsa,[49] J. A. Valls Ferrer,[168] W. Van Den Wollenberg,[106] P. C. Van Der Deijl,[106] R. van der Geer,[106] H. van der Graaf,[106] R. Van Der Leeuw,[106] D. van der Ster,[30] N. van Eldik,[30] P. van Gemmeren,[6] J. Van Nieuwkoop,[143] I. van Vulpen,[106] M. C. van Woerden,[30] M. Vanadia,[133a,133b] W. Vandelli,[30] R. Vanguri,[121] A. Vaniachine,[6] P. Vankov,[42] F. Vannucci,[79] G. Vardanyan,[178] R. Vari,[133a] E. W. Varnes,[7] T. Varol,[85] D. Varouchas,[79] A. Vartapetian,[8] K. E. Varvell,[151] F. Vazeille,[34] T. Vazquez Schroeder,[54] J. Veatch,[7] F. Veloso,[125a,125c] S. Veneziano,[133a] A. Ventura,[72a,72b] D. Ventura,[85] M. Venturi,[170] N. Venturi,[159] A. Venturini,[23] V. Vercesi,[120a] M. Verducci,[133a,133b] W. Verkerke,[106] J. C. Vermeulen,[106] A. Vest,[44] M. C. Vetterli,[143,e] O. Viazlo,[80] I. Vichou,[166] T. Vickey,[146c,jj] O. E. Vickey Boeriu,[146c] G. H. A. Viehhauser,[119] S. Viel,[169] R. Vigne,[30] M. Villa,[20a,20b] M. Villaplana Perez,[90a,90b]

E. Vilucchi,[47] M. G. Vincter,[29] V. B. Vinogradov,[64] J. Virzi,[15] I. Vivarelli,[150] F. Vives Vaque,[3] S. Vlachos,[10] D. Vladoiu,[99] M. Vlasak,[127] A. Vogel,[21] M. Vogel,[32a] P. Vokac,[127] G. Volpi,[123a,123b] M. Volpi,[87] H. von der Schmitt,[100] H. von Radziewski,[48] E. von Toerne,[21] V. Vorobel,[128] K. Vorobev,[97] M. Vos,[168] R. Voss,[30] J. H. Vossebeld,[73] N. Vranjes,[137] M. Vranjes Milosavljevic,[106] V. Vrba,[126] M. Vreeswijk,[106] T. Vu Anh,[48] R. Vuillermet,[30] I. Vukotic,[31] Z. Vykydal,[127] P. Wagner,[21] W. Wagner,[176] H. Wahlberg,[70] S. Wahrmund,[44] J. Wakabayashi,[102] J. Walder,[71] R. Walker,[99] W. Walkowiak,[142] R. Wall,[177] P. Waller,[73] B. Walsh,[177] C. Wang,[152,kk] C. Wang,[45] F. Wang,[174] H. Wang,[15] H. Wang,[40] J. Wang,[42] J. Wang,[33a] K. Wang,[86] R. Wang,[104] S. M. Wang,[152] T. Wang,[21] X. Wang,[177] C. Wanotayaroj,[115] A. Warburton,[86] C. P. Ward,[28] D. R. Wardrope,[77] M. Warsinsky,[48] A. Washbrook,[46] C. Wasicki,[42] P. M. Watkins,[18] A. T. Watson,[18] I. J. Watson,[151] M. F. Watson,[18] G. Watts,[139] S. Watts,[83] B. M. Waugh,[77] S. Webb,[83] M. S. Weber,[17] S. W. Weber,[175] J. S. Webster,[31] A. R. Weidberg,[119] P. Weigell,[100] B. Weinert,[60] J. Weingarten,[54] C. Weiser,[48] H. Weits,[106] P. S. Wells,[30] T. Wenaus,[25] D. Wendland,[16] Z. Weng,[152,ff] T. Wengler,[30] S. Wenig,[30] N. Wermes,[21] M. Werner,[48] P. Werner,[30] M. Wessels,[58a] J. Wetter,[162] K. Whalen,[29] A. White,[8] M. J. White,[1] R. White,[32b] S. White,[123a,123b] D. Whiteson,[164] D. Wicke,[176] F. J. Wickens,[130] W. Wiedenmann,[174] M. Wielers,[130] P. Wienemann,[21] C. Wiglesworth,[36] L. A. M. Wiik-Fuchs,[21] P. A. Wijeratne,[77] A. Wildauer,[100] M. A. Wildt,[42,ll] H. G. Wilkens,[30] J. Z. Will,[99] H. H. Williams,[121] S. Williams,[28] C. Willis,[89] S. Willocq,[85] A. Wilson,[88] J. A. Wilson,[18] I. Wingerter-Seez,[5] F. Winklmeier,[115] B. T. Winter,[21] M. Wittgen,[144] T. Wittig,[43] J. Wittkowski,[99] S. J. Wollstadt,[82] M. W. Wolter,[39] H. Wolters,[125a,125c] B. K. Wosiek,[39] J. Wotschack,[30] M. J. Woudstra,[83] K. W. Wozniak,[39] M. Wright,[53] M. Wu,[55] S. L. Wu,[174] X. Wu,[49] Y. Wu,[88] E. Wulf,[35] T. R. Wyatt,[83] B. M. Wynne,[46] S. Xella,[36] M. Xiao,[137] D. Xu,[33a] L. Xu,[33b,mm] B. Yabsley,[151] S. Yacoob,[146b,nn] M. Yamada,[65] H. Yamaguchi,[156] Y. Yamaguchi,[117] A. Yamamoto,[65] K. Yamamoto,[63] S. Yamamoto,[156] T. Yamamura,[156] T. Yamanaka,[156] K. Yamauchi,[102] Y. Yamazaki,[66] Z. Yan,[22] H. Yang,[33e] H. Yang,[174] U. K. Yang,[83] Y. Yang,[110] S. Yanush,[92] L. Yao,[33a] W-M. Yao,[15] Y. Yasu,[65] E. Yatsenko,[42] K. H. Yau Wong,[21] J. Ye,[40] S. Ye,[25] A. L. Yen,[57] E. Yildirim,[42] M. Yilmaz,[4b] R. Yoosoofmiya,[124] K. Yorita,[172] R. Yoshida,[6] K. Yoshihara,[156] C. Young,[144] C. J. S. Young,[30] S. Youssef,[22] D. R. Yu,[15] J. Yu,[8] J. M. Yu,[88] J. Yu,[113] L. Yuan,[66] A. Yurkewicz,[107] I. Yusuff,[28,oo] B. Zabinski,[39] R. Zaidan,[62] A. M. Zaitsev,[129,bb] A. Zaman,[149] S. Zambito,[23] L. Zanello,[133a,133b] D. Zanzi,[100] C. Zeitnitz,[176] M. Zeman,[127] A. Zemla,[38a] K. Zengel,[23] O. Zenin,[129] T. Ženiš,[145a] D. Zerwas,[116] G. Zevi della Porta,[57] D. Zhang,[88] F. Zhang,[174] H. Zhang,[89] J. Zhang,[6] L. Zhang,[152] X. Zhang,[33d] Z. Zhang,[116] Z. Zhao,[33b] A. Zhemchugov,[64] J. Zhong,[119] B. Zhou,[88] L. Zhou,[35] N. Zhou,[164] C. G. Zhu,[33d] H. Zhu,[33a] J. Zhu,[88] Y. Zhu,[33b] X. Zhuang,[33a] K. Zhukov,[95] A. Zibell,[175] D. Zieminska,[60] N. I. Zimine,[64] C. Zimmermann,[82] R. Zimmermann,[21] S. Zimmermann,[21] S. Zimmermann,[48] Z. Zinonos,[54] M. Ziolkowski,[142] G. Zobernig,[174] A. Zoccoli,[20a,20b] M. zur Nedden,[16] G. Zurzolo,[103a,103b] V. Zutshi,[107] and L. Zwalinski[30]

(ATLAS Collaboration)

[1]*Department of Physics, University of Adelaide, Adelaide, Australia*
[2]*Physics Department, SUNY Albany, Albany, New York, USA*
[3]*Department of Physics, University of Alberta, Edmonton, Alberta, Canada*
[4a]*Department of Physics, Ankara University, Ankara, Turkey*
[4b]*Department of Physics, Gazi University, Ankara, Turkey*
[4c]*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[4d]*Turkish Atomic Energy Authority, Ankara, Turkey*
[5]*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
[6]*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
[7]*Department of Physics, University of Arizona, Tucson, Arizona, USA*
[8]*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
[9]*Physics Department, University of Athens, Athens, Greece*
[10]*Physics Department, National Technical University of Athens, Zografou, Greece*
[11]*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[12]*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona, Barcelona, Spain*
[13a]*Institute of Physics, University of Belgrade, Belgrade, Serbia*
[13b]*Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*
[14]*Department for Physics and Technology, University of Bergen, Bergen, Norway*
[15]*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
[16]*Department of Physics, Humboldt University, Berlin, Germany*
[17]*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*

[18]School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom
[19a]Department of Physics, Bogazici University, Istanbul, Turkey
[19b]Department of Physics, Dogus University, Istanbul, Turkey
[19c]Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey
[20a]INFN Sezione di Bologna, Italy
[20b]Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy
[21]Physikalisches Institut, University of Bonn, Bonn, Germany
[22]Department of Physics, Boston University, Boston, Massachusetts, USA
[23]Department of Physics, Brandeis University, Waltham, Massachusetts, USA
[24a]Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil
[24b]Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil
[24c]Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil
[24d]Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil
[25]Physics Department, Brookhaven National Laboratory, Upton, New York, USA
[26a]National Institute of Physics and Nuclear Engineering, Bucharest, Romania
[26b]National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj Napoca, Romania
[26c]University Politehnica Bucharest, Bucharest, Romania
[26d]West University in Timisoara, Timisoara, Romania
[27]Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
[28]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
[29]Department of Physics, Carleton University, Ottawa, Ontario, Canada
[30]CERN, Geneva, Switzerland
[31]Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA
[32a]Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile
[32b]Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
[33a]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
[33b]Department of Modern Physics, University of Science and Technology of China, Anhui, China
[33c]Department of Physics, Nanjing University, Jiangsu, China
[33d]School of Physics, Shandong University, Shandong, China
[33e]Physics Department, Shanghai Jiao Tong University, Shanghai, China
[34]Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France
[35]Nevis Laboratory, Columbia University, Irvington, New York, USA
[36]Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
[37a]INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati, Italy
[37b]Dipartimento di Fisica, Università della Calabria, Rende, Italy
[38a]AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland
[38b]Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland
[39]The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
[40]Physics Department, Southern Methodist University, Dallas, Texas, USA
[41]Physics Department, University of Texas at Dallas, Richardson, Texas, USA
[42]DESY, Hamburg and Zeuthen, Germany
[43]Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
[44]Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany
[45]Department of Physics, Duke University, Durham, North Carolina, USA
[46]SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
[47]INFN Laboratori Nazionali di Frascati, Frascati, Italy
[48]Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany
[49]Section de Physique, Université de Genève, Geneva, Switzerland
[50a]INFN Sezione di Genova, Italy
[50b]Dipartimento di Fisica, Università di Genova, Genova, Italy
[51a]E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia
[51b]High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
[52]II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
[53]SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
[54]II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
[55]Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble, France
[56]Department of Physics, Hampton University, Hampton, Virginia, USA
[57]Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA

[58a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[58b]*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[58c]*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
[59]*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
[60]*Department of Physics, Indiana University, Bloomington, Indiana, USA*
[61]*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
[62]*University of Iowa, Iowa City, Iowa, USA*
[63]*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
[64]*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
[65]*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
[66]*Graduate School of Science, Kobe University, Kobe, Japan*
[67]*Faculty of Science, Kyoto University, Kyoto, Japan*
[68]*Kyoto University of Education, Kyoto, Japan*
[69]*Department of Physics, Kyushu University, Fukuoka, Japan*
[70]*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
[71]*Physics Department, Lancaster University, Lancaster, United Kingdom*
[72a]*INFN Sezione di Lecce, Italy*
[72b]*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[73]*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
[74]*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
[75]*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
[76]*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
[77]*Department of Physics and Astronomy, University College London, London, United Kingdom*
[78]*Louisiana Tech University, Ruston, Los Angeles, USA*
[79]*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
[80]*Fysiska institutionen, Lunds universitet, Lund, Sweden*
[81]*Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain*
[82]*Institut für Physik, Universität Mainz, Mainz, Germany*
[83]*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
[84]*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
[85]*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
[86]*Department of Physics, McGill University, Montreal QC, Canada*
[87]*School of Physics, University of Melbourne, Victoria, Australia*
[88]*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
[89]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
[90a]*INFN Sezione di Milano, Italy*
[90b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[91]*B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
[92]*National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus*
[93]*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
[94]*Group of Particle Physics, University of Montreal, Montreal QC, Canada*
[95]*P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*
[96]*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
[97]*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
[98]*D.V. Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia*
[99]*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
[100]*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
[101]*Nagasaki Institute of Applied Science, Nagasaki, Japan*
[102]*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
[103a]*INFN Sezione di Napoli, Italy*
[103b]*Dipartimento di Fisica, Università di Napoli, Napoli, Italy*
[104]*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
[105]*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
[106]*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
[107]*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
[108]*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
[109]*Department of Physics, New York University, New York, New York, USA*
[110]*Ohio State University, Columbus, Ohio, USA*
[111]*Faculty of Science, Okayama University, Okayama, Japan*
[112]*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*

[113]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
[114]*Palacký University, RCPTM, Olomouc, Czech Republic*
[115]*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
[116]*LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France*
[117]*Graduate School of Science, Osaka University, Osaka, Japan*
[118]*Department of Physics, University of Oslo, Oslo, Norway*
[119]*Department of Physics, Oxford University, Oxford, United Kingdom*
[120a]*INFN Sezione di Pavia, Italy*
[120b]*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
[121]*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
[122]*Petersburg Nuclear Physics Institute, Gatchina, Russia*
[123a]*INFN Sezione di Pisa, Italy*
[123b]*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
[124]*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
[125a]*Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal*
[125b]*Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal*
[125c]*Department of Physics, University of Coimbra, Coimbra, Portugal*
[125d]*Centro de Física Nuclear da Universidade de Lisboa, Lisboa, Portugal*
[125e]*Departamento de Fisica, Universidade do Minho, Braga, Portugal*
[125f]*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
[125g]*Dep Fisica and CEFITEC of Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal*
[126]*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
[127]*Czech Technical University in Prague, Praha, Czech Republic*
[128]*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
[129]*State Research Center Institute for High Energy Physics, Protvino, Russia*
[130]*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[131]*Physics Department, University of Regina, Regina, Saskatchewan, Canada*
[132]*Ritsumeikan University, Kusatsu, Shiga, Japan*
[133a]*INFN Sezione di Roma, Italy*
[133b]*Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
[134a]*INFN Sezione di Roma Tor Vergata, Italy*
[134b]*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[135a]*INFN Sezione di Roma Tre, Italy*
[135b]*Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
[136a]*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca, Morocco*
[136b]*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
[136c]*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
[136d]*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
[136e]*Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco*
[137]*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique et aux Energies Alternatives), Gif-sur-Yvette, France*
[138]*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
[139]*Department of Physics, University of Washington, Seattle, Washington, USA*
[140]*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
[141]*Department of Physics, Shinshu University, Nagano, Japan*
[142]*Fachbereich Physik, Universität Siegen, Siegen, Germany*
[143]*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*
[144]*SLAC National Accelerator Laboratory, Stanford, California, USA*
[145a]*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
[145b]*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
[146a]*Department of Physics, University of Cape Town, Cape Town, South Africa*
[146b]*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
[146c]*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
[147a]*Department of Physics, Stockholm University, Sweden*
[147b]*The Oskar Klein Centre, Stockholm, Sweden*
[148]*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
[149]*Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA*
[150]*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
[151]*School of Physics, University of Sydney, Sydney, Australia*

[152]*Institute of Physics, Academia Sinica, Taipei, Taiwan*
[153]*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
[154]*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[155]*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[156]*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
[157]*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
[158]*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
[159]*Department of Physics, University of Toronto, Toronto, Ontario, Canada*
[160a]*TRIUMF, Vancouver BC, Canada*
[160b]*Department of Physics and Astronomy, York University, Toronto, Ontario, Canada*
[161]*Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan*
[162]*Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA*
[163]*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
[164]*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
[165a]*INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine, Italy*
[165b]*ICTP, Trieste, Italy*
[165c]*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*
[166]*Department of Physics, University of Illinois, Urbana, Illinois, USA*
[167]*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
[168]*Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
[169]*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada*
[170]*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada*
[171]*Department of Physics, University of Warwick, Coventry, United Kingdom*
[172]*Waseda University, Tokyo, Japan*
[173]*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*
[174]*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*
[175]*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
[176]*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[177]*Department of Physics, Yale University, New Haven, Connecticut, USA*
[178]*Yerevan Physics Institute, Yerevan, Armenia*
[179]*Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France*

[a]Deceased.
[b]Also at Department of Physics, King's College London, London, United Kingdom.
[c]Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
[d]Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.
[e]Also at TRIUMF, Vancouver, British Columbia, Canada.
[f]Also at Department of Physics, California State University, Fresno, California, USA.
[g]Also at Tomsk State University, Tomsk, Russia.
[h]Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
[i]Also at Università di Napoli Parthenope, Napoli, Italy.
[j]Also at Institute of Particle Physics (IPP), Canada.
[k]Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.
[l]Also at Chinese University of Hong Kong, China.
[m]Also at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece.
[n]Also at Louisiana Tech University, Ruston, Los Angeles, USA.
[o]Also at Institucio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.
[p]Also at Department of Physics, The University of Texas at Austin, Austin, Texas, USA.
[q]Also at Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia.
[r]Also at CERN, Geneva, Switzerland.
[s]Also at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan.
[t]Also at Manhattan College, New York, New York, USA.
[u]Also at Novosibirsk State University, Novosibirsk, Russia.
[v]Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
[w]Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.
[x]Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
[y]Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.
[z]Also at School of Physical Sciences, National Institute of Science Education and Research, Bhubaneswar, India.

[aa]Also at Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy.
[bb]Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.
[cc]Also at Section de Physique, Université de Genève, Geneva, Switzerland.
[dd]Also at International School for Advanced Studies (SISSA), Trieste, Italy.
[ee]Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, United States of America.
[ff]Also at School of Physics and Engineering, Sun Yat-sen University, Guangzhou, China.
[gg]Also at Faculty of Physics, M.V.Lomonosov Moscow State University, Moscow, Russia.
[hh]Also at Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia.
[ii]Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
[jj]Also at Department of Physics, Oxford University, Oxford, United Kingdom.
[kk]Also at Department of Physics, Nanjing University, Jiangsu, China.
[ll]Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
[mm]Also at Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA.
[nn]Also at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa.
[oo]Also at University of Malaya, Department of Physics, Kuala Lumpur, Malaysia.