Search for Dark Matter Produced in Association with a Higgs Boson Decaying to $b\bar{b}$ Using 36 fb^{-1} of pp Collisions at $\sqrt{s} = 13$ TeV with the ATLAS Detector

M. Aaboud *et al.*[*]

(ATLAS Collaboration)

(Received 6 July 2017; published 1 November 2017)

Several extensions of the standard model predict associated production of dark-matter particles with a Higgs boson. Such processes are searched for in final states with missing transverse momentum and a Higgs boson decaying to a $b\bar{b}$ pair with the ATLAS detector using 36.1 fb^{-1} of pp collisions at a center-of-mass energy of 13 TeV at the LHC. The observed data are in agreement with the standard model predictions and limits are placed on the associated production of dark-matter particles and a Higgs boson.

One of the central open questions in physics today is the nature of dark matter (DM) that comprises most of the matter in the Universe [1]. A compelling candidate for DM is a stable electrically neutral particle χ whose nongravitational interactions with standard model (SM) particles are weak. This extension of the SM could be detectable at the scale of electroweak symmetry breaking [2] and accommodate the observed DM relic density [3,4]. Many models predict detectable production rates of such DM particles at the Large Hadron Collider (LHC) [5].

Most collider-based searches for DM rely on the signature of missing transverse momentum [6] E_T^{miss} from DM particles recoiling against one SM particle X radiated off the initial state, denoted by the "$X + E_T^{\mathrm{miss}}$" signature. LHC experiments have searched for this $X + E_T^{\mathrm{miss}}$ signature, where X is a light quark or gluon [7–9], a b or t quark [10–12], a photon [13–17], or a W or Z boson [18–21]. The discovery of the Higgs boson h [22,23] opens a new opportunity through the $h + E_T^{\mathrm{miss}}$ signature [24–26]. Because h radiation off the initial state is Yukawa suppressed, the $h + E_T^{\mathrm{miss}}$ process represents a direct probe of the hard interaction involving DM particles.

This Letter presents a search for DM in association with a Higgs boson decaying to a pair of b quarks, $h \to b\bar{b}$, with a branching ratio $\mathcal{B} = 57\%$ [27], using 36.1 fb^{-1} of pp collisions at $\sqrt{s} = 13$ TeV recorded with the ATLAS detector [28,29] in run 2 of the LHC in 2015 and 2016. This search substantially extends the sensitivity relative to previous results at 8 [30,31] and 13 TeV [32–34] in the $h \to b\bar{b}$ and $h \to \gamma\gamma$ channels.

A type-II two-Higgs-doublet model (2HDM) with an additional U(1)$_{Z'}$ gauge symmetry yielding an additional massive Z' boson provides an $h + E_T^{\mathrm{miss}}$ signature [26] used for the optimization of the search and its interpretation. This model results in five physical Higgs bosons: a light scalar h identified with the SM Higgs boson in the alignment limit [35], a heavy scalar H, a pseudoscalar A, and two charged scalars $H^{\pm}$. The $h + \mathrm{DM}$ signal in this Z'-2HDM model is produced through $pp \to Z' \to Ah$, where A decays to $\chi\bar{\chi}$ with a large $\mathcal{B}$. Relevant model parameters are the ratio of the vacuum expectation values of the two Higgs fields coupling to the up-type and down-type quarks $\tan\beta$, the Z' gauge coupling $g_{Z'}$, and the masses $m_{Z'}$, m_A, and m_χ. The results are also generically interpreted in terms of the production cross section of non-SM events with large E_T^{miss} and a Higgs boson without extra model assumptions.

Monte Carlo (MC) event generators were used to simulate the $h + \mathrm{DM}$ signal and all SM background processes, except the multijet background, which was evaluated using data. All MC event samples were processed through a detailed simulation of the ATLAS detector [36] based on GEANT4 [37], and contributions from additional pp interactions (pileup) were simulated using PYTHIA 8.186 [38] and the MSTW2008LO parton distribution function (PDF) set [39].

Signal samples for the $pp \to Z' \to Ah \to \chi\bar{\chi}b\bar{b}$ process were generated at leading order using MADGRAPH_AMC@NLO 2.2.3 [5,40] interfaced to PYTHIA 8.186, using the NNPDF3.0 PDF set [41]. Samples were generated in the $(m_{Z'}, m_A)$ plane for 0.2 TeV $< m_{Z'} <$ 3 TeV and 0.2 TeV $< m_A <$ 0.8 TeV with $m_\chi = 100$ GeV, $\tan\beta = 1$, $g_{Z'} = 0.8$, $m_H = m_{H^\pm} = 300$ GeV [5].

Backgrounds from top quark pair production and single top quark production were generated at next-to-leading order (NLO) in quantum chromodynamics (QCD) with POWHEG-BOX [42–46] using CT10 PDFs [47], where the parton shower was simulated with PYTHIA 6.428 [48]. The $t\bar{t}$ samples are normalized using calculations at next-to-next-to-leading order (NNLO) in QCD including

next-to-next-to-leading logarithmic corrections for soft-gluon radiation [49]. The single-top-quark processes are normalized with cross sections at NLO in QCD [50–54]. Background processes involving a vector boson $V = W, Z$ decaying leptonically in association with jets, $V +$ jets, were simulated with SHERPA 2.2.1 [55] including mass effects for b and c quarks and using NNPDF3.0 PDFs. The perturbative calculations for $V +$ jets were performed at NLO for up to two partons and at leading order for up to four partons [56,57], and matched to the parton shower [58] using the ME+PS@NLO prescription from Ref. [59]. The normalizations are determined at NNLO in QCD [60]. Diboson processes (VV) were simulated at NLO in QCD with SHERPA 2.1.1 and CT10 PDFs. Backgrounds from associated Vh production were generated with PYTHIA 8.186 using NNPDF3.0 PDFs for $qq \to Vh$, and POWHEG interfaced to PYTHIA 8.186 using CT10 PDFs for $gg \to Vh$.

Events are selected by an E_T^{miss} trigger based on calorimeter information [61]. Its threshold was 110 GeV for most of the data taking period, and lower in the first third. Events are required to have at least one pp collision vertex reconstructed from at least two inner detector (ID) tracks with $p_T^{\text{track}} > 0.4$ GeV. The primary vertex (PV) for each event is the vertex with the highest $\sum (p_T^{\text{track}})^2$.

Reconstruction of muons (μ) incorporates tracks or track segments found in the muon spectrometer and matched ID tracks. Identified muons must satisfy the "loose" quality criteria [62] and have $|\eta| < 2.7$. Electrons (e) are reconstructed by matching an ID track to a cluster of energy in the calorimeter. Electron candidates are identified through a likelihood-based method [63] and must satisfy the loose operating point and be within $|\eta| < 2.47$. Muon and electron candidates must have $p_T > 7$ GeV and are required to be isolated by limiting the sum of p_T for tracks within a cone in ΔR around the lepton direction, as in Ref. [32].

Jets reconstructed from three-dimensional clusters of calorimeter cells [64] with the anti-k_t algorithm [65] are used to identify the $h \to b\bar{b}$ decay. For small to moderate h momenta, the decay products can be resolved using jets with a radius parameter $R = 0.4$ (small-R jets or j). The decay products of high-momenta h become collimated and are reconstructed using a single jet with $R = 1.0$ (large-R jet or J). Small-R jets with $|\eta| < 2.5$ must satisfy $p_T > 20$ GeV and are called "central," while those with $2.5 < |\eta| < 4.5$ must have $p_T > 30$ GeV and are called "forward." Small-R jets are corrected for pileup [66], and central small-R jets with $20\ \text{GeV} < p_T < 60$ GeV and $|\eta| < 2.4$ are additionally required to be identified as originating from the PV using associated tracks [67]. Small-R jets closer than $\Delta R = 0.2$ to an electron candidate are rejected. Large-R jets are reconstructed independently of small-R jets and trimmed [68,69] to reduce the effects of pileup and the underlying event. Furthermore, large-R jets must fulfill $p_T > 200$ GeV and $|\eta| < 2.0$. To improve the

resolution and minimize uncertainties, the mass of large-R jets is determined by the resolution-weighted mean of the mass measured using calorimeter information alone and the track-assisted jet mass [70]. The latter is obtained by scaling the mass determined using ID tracks alone by the ratio of jet p_T measured in the calorimeter and in the ID.

Multivariate algorithms are used to identify jets containing b hadrons (b tagging), which are expected in $h \to b\bar{b}$ decays [69,71]. These algorithms are applied directly to small-R jets, while for large-R jets they are applied to track jets matched to large-R jets. Track jets are reconstructed from ID tracks matched to the PV using the anti-k_t algorithm with $R = 0.2$, and must fulfill $p_T > 10$ GeV and $|\eta| < 2.5$.

The $\vec{E}_T^{\text{miss}}$ observable is calculated as the negative of the vector sum of the transverse momenta of e, μ, and jet candidates in the event. The transverse momenta not associated with any e, μ, or jet candidates are accounted for using ID tracks [72,73]. Similarly, $\vec{p}_T^{\text{miss,trk}}$ is defined as the negative of the vector sum of the transverse momenta of tracks with $p_T > 0.5$ GeV associated with the PV and within $|\eta| < 2.5$.

The signal is characterized by high E_T^{miss}, no isolated leptons, and an invariant mass of the h candidate m_h compatible with the observed Higgs boson mass of 125 GeV [74]. In the signal region (SR) described below, the dominant backgrounds from $Z(\nu\nu) +$ jets, $W +$ jets, and $t\bar{t}$ production contribute, respectively, 30%–60%, 10%–25%, and 15%–50% of the total background, depending on E_T^{miss} and the b-tag multiplicity. The models for $V +$ jets and $t\bar{t}$ are constrained using two control regions (CR): the single-muon control region (1μ-CR) is designed to constrain the $t\bar{t}$ and $W +$ jets backgrounds, while the two-lepton control region (2ℓ-CR) constrains the $Z +$ jets background contribution.

The SR requires $E_T^{\text{miss}} > 150$ GeV, and no isolated e or μ. The multijet background contributes due to mismeasured jet momenta. To suppress it, additional selections are required: $\min [\Delta\phi(\vec{E}_T^{\text{miss}}, \vec{p}_T^j)] > \pi/9$ for the three highest-p_T (leading) small-R jets, $\Delta\phi(\vec{E}_T^{\text{miss}}, \vec{p}_T^{\text{miss,trk}}) < \pi/2$, and $p_T^{\text{miss,trk}} > 30$ GeV for events with fewer than two central b-tagged small-R jets. The requirements using $p_T^{\text{miss,trk}}$ also reduce noncollision backgrounds.

In the "resolved" regime, defined by $E_T^{\text{miss}} < 500$ GeV, the h candidate is reconstructed from two leading b-tagged central small-R jets, or, if only one b tag is present in the event, from the b-tagged central small-R jet and the leading non-b-tagged central small-R jet. At least one of the jets comprising the h candidate must satisfy $p_T > 45$ GeV. A separation in $\Delta\phi$ between the h candidate and $\vec{E}_T^{\text{miss}}$ of more than $2\pi/3$ is required following the back-to-back configuration of the Higgs boson recoiling against DM. To improve the trigger efficiency modeling, events are retained only if the scalar sum H_T of the p_T of the two (three) leading jets fulfills $H_{T,2j} > 120$ GeV ($H_{T,3j} > 150$ GeV) if two (more

than two) central jets are present. Further optimization of the event selection described below provides an additional background reduction of up to 60% relative to Ref. [32], for a small signal loss. Events with a hadronic τ-lepton candidate, identified either by an algorithm based on a boosted decision tree [75] or as small-R jets containing one to four tracks within the jet core and $\Delta\phi(\vec{E}_T^{\text{miss}}, \vec{p}_T^j) < \pi/8$, are rejected to reduce the $t\bar{t}$ background, which can enter the SR if at least one top quark decays as $t \to Wb \to \tau\nu b$. This background is further reduced by removing events with more than two b-tagged central jets, which typically happens for $t\bar{t}$ events with $t \to Wb \to csb$ decays. Since most of the hadronic activity in a signal event is expected from the $h \to b\bar{b}$ decay, the scalar sum of the p_T of the two jets forming the h candidate and, if present, the highest-p_T additional jet must be larger than $0.63 \times H_{T,\text{all jets}}$. Finally, $\Delta R(\vec{p}_h^{j_1}, \vec{p}_h^{j_2}) < 1.8$ is required for the two jets forming the h candidate.

In the "merged" regime, defined by $E_T^{\text{miss}} > 500$ GeV, the leading large-R jet represents the h candidate. Further selection optimization reduces backgrounds, primarily $t\bar{t}$ production, by up to 30% relative to Ref. [32], for a small signal loss: events containing τ-lepton candidates with $\Delta R(\vec{p}^\tau, \vec{p}^J) > 1.0$ are vetoed; no b-tagged central small-R jets with $\Delta R(\vec{p}^{j,b\text{-tag}}, \vec{p}^J) > 1.0$ are allowed in the event; and the scalar sum of p_T of the small-R jets with $\Delta R(\vec{p}^j, \vec{p}^J) > 1.0$ is required to be smaller than 0.57 times that sum added to p_T^J.

The resolution in m_h is improved using muons associated with small-R jets in the resolved regime or with track jets matched to large-R jets in the merged regime [69,76].

The event selection in the 1μ-CR is identical to the SR, except that exactly one isolated μ candidate with $p_T^\mu > 27$ GeV is required, and that $\vec{p}_T^\mu$ is added to $\vec{E}_T^{\text{miss}}$ to mimic the behavior of events contaminating the SR when the charged lepton is not detected.

Events in the 2ℓ-CR are collected using a single-e or single-μ trigger, and selected by requiring one pair of isolated e or μ, one of which must have $p_T^\ell > 27$ GeV. Events with a Z boson candidate are retained, identified as having 83 GeV $< m_{ee} <$ 99 GeV or 71 GeV $< m_{\mu\mu} <$ 106 GeV with an opposite-charge requirement in the $\mu\mu$ case. In addition, a measure of the E_T^{miss} significance given by the ratio of the E_T^{miss} to the square root of the scalar sum of p_T of all leptons and small-R jets in the event must be less than 3.5 GeV$^{1/2}$. This requirement separates $Z(\ell\ell) +$ jets processes from $t\bar{t}$ production, as E_T^{miss} originates from finite detector resolution for the former and mainly from neutrinos for the latter. To mimic $Z \to \nu\nu$ decays in the SR, the $\vec{E}_T^{\text{miss}}$ is set to the $\vec{p}_T$ of the dilepton system, which is then ignored in the subsequent analysis. All other selection requirements are identical between the 2ℓ-CR and the SR.

Subdominant backgrounds, including diboson, Vh, single top quark, and multijet production, contribute less than 10% of the total background in the SR. Multijet production is negligible for $E_T^{\text{miss}} > 350$ GeV. Its m_h distribution is determined from data in a dedicated multijet-enriched sideband, defined by inverting the min $[\Delta\phi(\vec{E}_T^{\text{miss}}, \vec{p}_T^j)]$ requirement.

Dominant sources of experimental systematic uncertainty arise from the number of background MC events, the calibration of the b-tagging efficiency and integrated luminosity, as well as the scale and resolution of the energy and the mass of jets. Uncertainties associated with the τ vetoes are found to be negligible. Dominant sources of theoretical systematic uncertainty originate from the modeling of the signal and background processes such as $t\bar{t}$, $V +$ jets, Vh, diboson, and multijet production. The few relevant changes in the estimation of systematic uncertainties relative to Ref. [32] encompass the improved calibrations of the b-tagging efficiency using $t\bar{t}$ events [69,71] as well as of the jet energy and mass scales using various *in situ* methods [70,77]; the reduced uncertainty from the new jet-mass observable [69,70]; and the uncertainty of 3.4% on the integrated luminosity of data collected in 2016. Table I quantifies dominant sources of uncertainty after the fit to data assuming three representative Z'-2HDM scenarios. This search is statistically limited for $E_T^{\text{miss}} \gtrsim 300$ GeV.

A fit to the m_h observable based on a binned likelihood approach [78,79] is used to search for a signal. Systematic uncertainties are included in the likelihood function as nuisance parameters with Gaussian or log-normal constraints and profiled [76]. To account for changes in the background composition and to benefit from a higher signal sensitivity with increasing E_T^{miss} and b-tag multiplicity, the data are split into categories that are fit

TABLE I. Dominant sources of uncertainty for three representative Z'-2HDM scenarios after the fit to data (a) with $(m_{Z'}, m_A) = (0.6, 0.3\,\text{TeV})$, (b) with $(m_{Z'}, m_A) = (1.4, 0.6\,\text{TeV})$, and (c) with $(m_{Z'}, m_A) = (2.6, 0.3\,\text{TeV})$. The effect is expressed as the fractional uncertainty on the signal yield. The total is the quadrature sum of statistical and total systematic uncertainties. The impact of the luminosity uncertainty, which does not affect backgrounds with free normalizations, varies due to the changing background composition with increasing E_T^{miss}.

| Source of uncertainty	Impact [%]		
	(a)	(b)	(c)
$V +$ jets modeling	5.0	5.7	8.2
$t\bar{t}$, single-t modeling	3.2	3.0	3.9
SM $Vh(b\bar{b})$ normalization	2.2	6.9	6.9
Signal modeling	3.9	2.9	2.1
MC statistics	4.9	11	22
Luminosity	3.2	4.5	5.4
b tagging, track jets	1.4	11	17
b tagging, calo jets	5.0	3.4	4.7
Jets with $R = 0.4$	1.7	3.8	2.1
Jets with $R = 1.0$	<0.1	1.2	4.7
Total systematic uncertainty	10	21	36
Statistical uncertainty	6	38	62
Total uncertainty	12	43	71
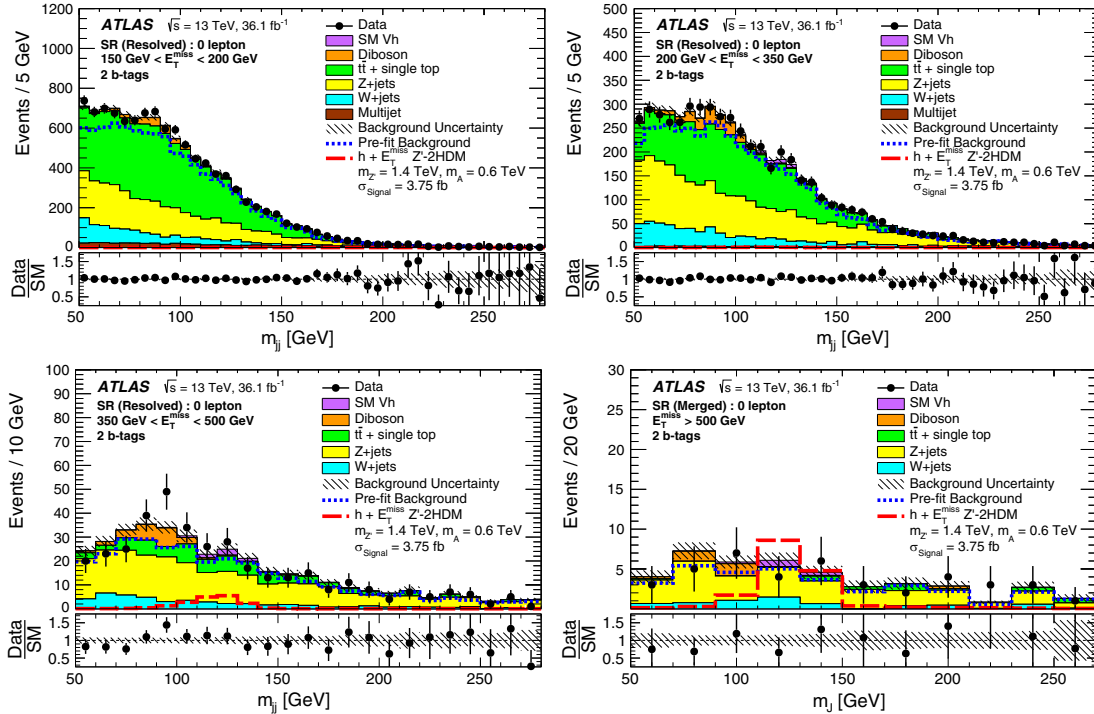
FIG. 1.   Distributions of the invariant mass of the Higgs boson candidates $m_h = m_{jj}, m_J$ with two b tags in the SR for the four E_T^{miss} categories that are used as inputs to the fit. The upper panels show a comparison of data to the SM expectation before (dashed lines) and after the fit (solid histograms) with no signal included. The lower panels display the ratio of data to SM expectations after the fit, with its systematic uncertainty considering correlations between individual contributions indicated by the hatched band. The expected signal from a representative Z'-2HDM model is also shown (long-dashed line).

simultaneously. Eight categories are defined for the SR and each of the two CRs: four ranges in E_T^{miss}/GeV as [150, 200), [200, 350), [350, 500), and [500, ∞), which are each split into two subregions with one and two b tags. In the 1μ-CR, the electric charge of the μ is used to separate $t\bar{t}$ from $V + \text{jets}$ since the former provides an equal number of μ^+ and μ^-, while a prevalence of μ^+ is expected from the latter process due to PDFs [80]. Only the total event yield is considered in the 2ℓ-CR due to limited data statistics. The normalizations of $t\bar{t}$, $W + \text{HF}$, and $Z + \text{HF}$ processes are free parameters in the fit, where HF represents jets containing b or c quarks. In the SR, the contribution from $Z + \text{jets}$ is increased by about 50% by the fit relative to theory predictions, staying within uncertainties, while $t\bar{t}$ is reduced by up to 30% at high E_T^{miss}. The normalizations of other backgrounds modeled using MC simulations are constrained to theory predictions within uncertainties, as detailed in Ref. [32].

The distributions of m_h for SR events with two b tags provide the highest signal sensitivity and are shown in the four E_T^{miss} regions in Fig. 1. No significant deviation from SM predictions is observed.

The results are interpreted as exclusion limits at 95% confidence level (C.L.) on the production cross section of $h + \text{DM}$ events $\sigma_{h+\text{DM}}$ times $\mathcal{B}(h \to b\bar{b})$ with the CL_s formalism [81] using a profile likelihood ratio [82] as test

statistic. Exclusion contours in the $(m_{Z'}, m_A)$ space in the Z'-2HDM scenario are presented in Fig. 2, excluding $m_{Z'}$ up to 2.6 TeV and m_A up to 0.6 TeV, substantially extending previous limits [30–34]. Furthermore, upper limits on $\sigma_{h+\text{DM}} \times \mathcal{B}(h \to b\bar{b})$ are provided under the minimal $h + \text{DM}$ model assumption that a Higgs boson is produced in a generic back-to-back configuration relative to $\vec{E}_T^{miss}$
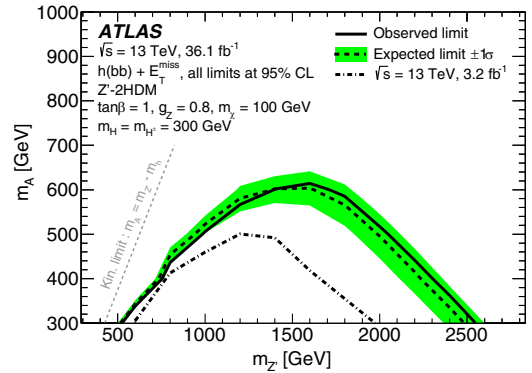
FIG. 2.   Exclusion contours for the Z'-2HDM scenario in the $(m_{Z'}, m_A)$ plane for $\tan\beta = 1$, $g_{Z'} = 0.8$, and $m_\chi = 100$ GeV. The observed limits (solid line) are consistent with the expectation under the SM-only hypothesis (dashed line) within uncertainties (solid band). Observed limits from previous ATLAS results at $\sqrt{s} = 13$ TeV (dash-dotted line) [32] are also shown.

TABLE II.   Observed (obs) and expected (exp) upper limits at 95% C.L. on $\sigma_{\text{vis},h(b\bar{b})+\text{DM}} \equiv \sigma_{h+\text{DM}} \times \mathcal{B}(h \to b\bar{b}) \times \mathcal{A} \times \varepsilon$ of $h(b\bar{b}) + \text{DM}$ events. Also shown are the acceptance × efficiency ($\mathcal{A} \times \varepsilon$) probabilities to reconstruct and select an event in the same E_T^{miss} bin as generated.

Range in E_T^{miss} [GeV]	$\sigma_{\text{vis},h(b\bar{b})+\text{DM}}^{\text{obs}}$ [fb]	$\sigma_{\text{vis},h(b\bar{b})+\text{DM}}^{\text{exp}}$ [fb]	$\mathcal{A} \times \varepsilon$ [%]
[150, 200)	19.1	$18.3^{+7.2}_{-5.1}$	15
[200, 350)	13.1	$10.5^{+4.1}_{-2.9}$	35
[350, 500)	2.4	$1.7^{+0.7}_{-0.5}$	40
[500, ∞)	1.7	$1.8^{+0.7}_{-0.5}$	55

from DM particles. For this, limits are set on $\sigma_{\text{vis},h(b\bar{b})+\text{DM}} \equiv \sigma_{h+\text{DM}} \times \mathcal{B}(h \to b\bar{b}) \times \mathcal{A} \times \varepsilon$ of $h(b\bar{b}) + \text{DM}$ events per E_T^{miss} bin at detector level, after all SR selections except the requirements on b-tag multiplicity and m_h range as used in the fit. The $\mathcal{A} \times \varepsilon$ term quantifies the probability for an event to be reconstructed in the same E_T^{miss} bin as generated and to pass all $\sigma_{\text{vis},h(b\bar{b})+\text{DM}}$ selections, where $\mathcal{A}$ represents the kinematic acceptance and ε accounts for the experimental efficiency. The results are shown in Table II. To minimize the dependence on the E_T^{miss} distribution of a potential $h + \text{DM}$ signal, the standard fit approach is modified to analyze one E_T^{miss} range at a time in the SR. The Z'-2HDM model is used to evaluate the dependence of the $\sigma_{\text{vis},h(b\bar{b})+\text{DM}}$ limits and of $\mathcal{A} \times \varepsilon$ on the event kinematics within a given E_T^{miss} bin. A range of $(m_{Z'}, m_A)$ parameters that yield a sizable contribution of $\gtrsim 10\% \times \sigma_{h+\text{DM}} \times \mathcal{B}(h \to b\bar{b})$ in a given E_T^{miss} bin is considered. Corresponding variations of 25% (70%) in the expected limits and of 50% (25%) in $\mathcal{A} \times \varepsilon$ are found in the resolved (merged) regime. Table II quotes the least stringent limit and the lowest $\mathcal{A} \times \varepsilon$ value in a given E_T^{miss} bin after rounding. The limits are valid for $p_{T,h} \lesssim 1.5$ TeV.

In summary, a search for DM produced in association with a Higgs boson in final states with E_T^{miss} and a $b\bar{b}$ pair from the $h \to b\bar{b}$ decay was conducted using 36.1 fb^{-1} of pp collisions at $\sqrt{s} = 13$ TeV recorded by the ATLAS detector at the LHC. The results are in agreement with SM predictions, and a substantial region of the parameter space of a representative Z'-2HDM model is excluded, significantly improving upon previous results. Stringent limits are also placed on the production cross section of non-SM events with large E_T^{miss} and a Higgs boson without extra model assumptions.

---

[1] G. Bertone, D. Hooper, and J. Silk, Particle dark matter: Evidence, candidates and constraints, Phys. Rep. **405**, 279 (2005).

[2] G. Jungman, M. Kamionkowski, and K. Griest, Supersymmetric dark matter, Phys. Rep. **267**, 195 (1996).

[3] G. Steigman and M. S. Turner, Cosmological constraints on the properties of weakly interacting massive particles, Nucl. Phys. **B253**, 375 (1985).

[4] R. J. Scherrer and M. S. Turner, On the relic, cosmic abundance of stable, weakly interacting massive particles, Phys. Rev. D **33**, 1585 (1986); **34**, 3263E (1986).

[5] D. Abercrombie et al., Dark matter benchmark models for early LHC run-2 searches: Report of the ATLAS/CMS Dark Matter Forum, arXiv:1507.00966.

[6] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the center of the detector and the z axis along the beam pipe. The x axis

points 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 z axis. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$. The distance between two objects in η–ϕ space is $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$. Transverse momentum is defined by $p_T = p\sin\theta$.

[7] ATLAS Collaboration, Search for new phenomena in final states with an energetic jet and large missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, Eur. Phys. J. C **75**, 299 (2015).

[8] CMS Collaboration, Search for dark matter, extra dimensions, and unparticles in monojet events in proton-proton collisions at $\sqrt{s} = 8$ TeV, Eur. Phys. J. C **75**, 235 (2015).

[9] ATLAS Collaboration, Search for new phenomena in final states with an energetic jet and large missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector, Phys. Rev. D **94**, 032005 (2016).

[10] ATLAS Collaboration, Search for dark matter in events with heavy quarks and missing transverse momentum in pp collisions with the ATLAS detector, Eur. Phys. J. C **75**, 92 (2015).

[11] CMS Collaboration, Search for Monotop Signatures in Proton-Proton Collisions at $\sqrt{s} = 8$ TeV, Phys. Rev. Lett. **114**, 101801 (2015).

[12] CMS Collaboration, Search for the production of dark matter in association with top-quark pairs in the single-lepton final state in proton-proton collisions at $\sqrt{s} = 8$ TeV, J. High Energy Phys. 06 (2015) 121.

[13] ATLAS Collaboration, Search for new phenomena in events with a photon and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, Phys. Rev. D **91**, 012008 (2015).

[14] CMS Collaboration, Search for Dark Matter and Large Extra Dimensions in pp Collisions Yielding a Photon and Missing Transverse Energy, Phys. Rev. Lett. **108**, 261803 (2012).

[15] CMS Collaboration, Search for new phenomena in mono-photon final states in proton-proton collisions at $\sqrt{s} = 8$ TeV, Phys. Lett. B **755**, 102 (2016).

[16] CMS Collaboration, Search for physics beyond the standard model in final states with a lepton and missing transverse energy in proton-proton collisions at $\sqrt{s} = 8$ TeV, Phys. Rev. D **91**, 092005 (2015).

[17] ATLAS Collaboration, Search for new phenomena in events with a photon and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 06 (2016) 059.

[18] ATLAS Collaboration, Search for new particles in events with one lepton and missing transverse momentum in pp collisions at $\sqrt{(s)} = 8$ TeV with the ATLAS detector, J. High Energy Phys. 09 (2014) 037.

[19] ATLAS Collaboration, Search for dark matter in events with a Z boson and missing transverse momentum in pp collisions at $\sqrt{s}$ TeV with the ATLAS detector, Phys. Rev. D **90**, 012004 (2014).

[20] ATLAS Collaboration, Search for Dark Matter in Events with a Hadronically Decaying W or Z Boson and Missing Transverse Momentum in pp Collisions at $\sqrt{s} = 8$ TeV

[21] CMS Collaboration, Search for dark matter and unparticles produced in association with a Z boson in proton-proton collisions at $\sqrt{s} = 8$ TeV, Phys. Rev. D **93**, 052011 (2016).

[22] ATLAS Collaboration, Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC, Phys. Lett. B **716**, 1 (2012).

[23] CMS Collaboration, Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, Phys. Lett. B **716**, 30 (2012).

[24] A. A. Petrov and W. Shepherd, Searching for dark matter at LHC with Mono-Higgs production, Phys. Lett. B **730**, 178 (2014).

[25] L. Carpenter, A. DiFranzo, M. Mulhearn, C. Shimmin, S. Tulin, and D. Whiteson, Mono-Higgs-boson: A new collider probe of dark matter, Phys. Rev. D **89**, 075017 (2014).

[26] A. Berlin, T. Lin, and L.-T. Wang, Mono-Higgs detection of dark matter at the LHC, J. High Energy Phys. 06 (2014) 078.

[27] D. de Florian et al., Handbook of LHC Higgs Cross Sections: 4. Deciphering the Nature of the Higgs Sector, arXiv:1610.07922.

[28] ATLAS Collaboration, The ATLAS Experiment at the CERN Large Hadron Collider, J. Instrum. **3**, S08003 (2008).

[29] ATLAS Collaboration, ATLAS Insertable B-Layer Technical Design Report, Report No. ATLAS-TDR-19, 2010, http://cds.cern.ch/record/1291633; ATLAS Insertable B-Layer Technical Design Report Addendum, Report No. ATLAS-TDR-19-ADD-1, 2012, http://cds.cern.ch/record/1451888.

[30] ATLAS Collaboration, Search for dark matter produced in association with a Higgs boson decaying to two bottom quarks in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, Phys. Rev. D **93**, 072007 (2016).

[31] ATLAS Collaboration, Search for Dark Matter in Events with Missing Transverse Momentum and a Higgs Boson Decaying to Two Photons in pp Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector, Phys. Rev. Lett. **115**, 131801 (2015).

[32] ATLAS Collaboration, Search for dark matter in association with a Higgs boson decaying to b-quarks in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **765**, 11 (2017).

[33] ATLAS Collaboration, Search for dark matter in association with a Higgs boson decaying to two photons at $\sqrt{s} = 13$ TeV with the ATLAS detector, arXiv:1706.03948.

[34] CMS Collaboration, Search for associated production of dark matter with a Higgs boson decaying to $\gamma\gamma$ or $\sqrt{s} = 13$ TeV, arXiv:1703.05236.

[35] G. C. Branco, P. M. Ferreira, L. Lavoura, M. N. Rebelo, M. Sher, and J. P. Silva, Theory and phenomenology of two-Higgs-doublet models, Phys. Rep. **516**, 1 (2012).

[36] ATLAS Collaboration, The ATLAS Simulation Infrastructure, Eur. Phys. J. C **70**, 823 (2010).

[37] S. Agostinelli et al., GEANT4—a simulation toolkit, Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).

[38] T. Sjöstrand, S. Mrenna, and P. Z. Skands, A brief introduction to PYTHIA 8.1, Comput. Phys. Commun. **178**, 852 (2008).

[39] G. Watt and R. Thorne, Study of Monte Carlo approach to experimental uncertainty propagation with MSTW 2008 PDFs, J. High Energy Phys. 08 (2012) 052.

[40] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H.-S. Shao, T. Stelzer, P. Torrielli, and M. Zaro, The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, J. High Energy Phys. 07 (2014) 079.

[41] R. D. Ball et al., Parton distributions for the LHC Run II, J. High Energy Phys. 04 (2015) 040.

[42] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, J. High Energy Phys. 11 (2004) 040.

[43] S. Frixione, P. Nason, and C. Oleari, Matching NLO QCD computations with Parton Shower simulations: The POW-HEG method, J. High Energy Phys. 11 (2007) 070.

[44] S. Alioli, P. Nason, C. Oleari, and E. Re, A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX, J. High Energy Phys. 06 (2010) 043.

[45] S. Alioli, P. Nason, C. Oleari, and E. Re, NLO single-top production matched with shower in POWHEG: s and t channel contributions, J. High Energy Phys. 09 (2009) 111; 02 (2010) 011E.

[46] E. Re, Single-top Wt-channel production matched with parton showers using the POWHEG method, Eur. Phys. J. C **71**, 1547 (2011).

[47] J. Gao, M. Guzzi, J. Huston, H.-L. Lai, Z. Li, P. Nadolsky, J. Pumplin, D. Stump, and C.-P. Yuan, CT10 next-to-next-to-leading order global analysis of QCD, Phys. Rev. D **89**, 033009 (2014).

[48] T. Sjöstrand, S. Mrenna, and P. Z. Skands, PYTHIA 6.4 physics and manual, J. High Energy Phys. 05 (2006) 026.

[49] M. Czakon, P. Fiedler, and A. Mitov, The Total Top Quark Pair Production Cross-Section at Hadron Colliders through $O(\alpha_S^4)$, Phys. Rev. Lett. **110**, 252004 (2013).

[50] G. Bordes and B. van Eijk, Calculating QCD corrections to single top production in hadronic interactions, Nucl. Phys. **B435**, 23 (1995).

[51] T. Stelzer, Z. Sullivan, and S. Willenbrock, Single-top-quark production via W-gluon fusion at next-to-leading order, Phys. Rev. D **56**, 5919 (1997).

[52] T. Stelzer, Z. Sullivan, and S. Willenbrock, Single top quark production at hadron colliders, Phys. Rev. D **58**, 094021 (1998).

[53] M. C. Smith and S. Willenbrock, QCD and Yukawa corrections to single top quark production via $q\bar{q} \to t\bar{b}$, Phys. Rev. D **54**, 6696 (1996).

[54] N. Kidonakis, Top Quark Production, arXiv:1311.0283.

[55] T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, S. Schumann, F. Siegert, and J. Winter, Event generation with SHERPA 1.1, J. High Energy Phys. 02 (2009) 007.

[56] T. Gleisberg and S. Höche, Comix, a new matrix element generator, J. High Energy Phys. 12 (2008) 039.

[57] F. Cascioli, P. Maierhofer, and S. Pozzorini, Scattering Amplitudes with Open Loops, Phys. Rev. Lett. **108**, 111601 (2012).

[58] S. Schumann and F. Krauss, A Parton shower algorithm based on Catani-Seymour dipole factorisation, J. High Energy Phys. 03 (2008) 038.

[59] S. Höche, F. Krauss, M. Schönherr, and F. Siegert, QCD matrix elements + parton showers: The NLO case, J. High Energy Phys. 04 (2013) 027.

[60] K. Melnikov and F. Petriello, Electroweak gauge boson production at hadron colliders through $O(\mathcal{O}(\alpha_s^2))$, Phys. Rev. D **74**, 114017 (2006).

[61] ATLAS Collaboration, Performance of the ATLAS Trigger System in 2015, Eur. Phys. J. C **77**, 317 (2017).

[62] ATLAS Collaboration, Muon reconstruction performance of the ATLAS detector in proton-proton collision data at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **76**, 292 (2016).

[63] ATLAS Collaboration, Electron effciency measurements with the ATLAS detector using 2012 LHC proton-proton collision data, Eur. Phys. J. C **77**, 195 (2017).

[64] ATLAS Collaboration, Topological cell clustering in the ATLAS calorimeters and its performance in LHC Run 1, Eur. Phys. J. C **77**, 490 (2017).

[65] M. Cacciari, G. P. Salam, and G. Soyez, The anti-k_t jet clustering algorithm, J. High Energy Phys. 04 (2008) 063.

[66] M. Cacciari, G. P. Salam, and G. Soyez, The catchment area of jets, J. High Energy Phys. 04 (2008) 005.

[67] ATLAS Collaboration, Tagging and suppression of pileup jets with the ATLAS detector, Report No. ATLAS-CONF-2014-018 (2014), https://cds.cern.ch/record/1700870.

[68] D. Krohn, J. Thaler, and L.-T. Wang, Jet trimming, J. High Energy Phys. 02 (2010) 084.

[69] ATLAS Collaboration, Boosted Higgs ($\to b\bar{b}$) Boson Identification with the ATLAS Detector at $\sqrt{s} = 13$ TeV, Reort No. ATLAS-CONF-2016-039 (2016), https://cds.cern.ch/record/2206038.

[70] ATLAS Collaboration, Jet mass reconstruction with the ATLAS Detector in early Run 2 data, Report No. ATLAS-CONF-2016-035 (2016), https://cds.cern.ch/record/2200211.

[71] ATLAS Collaboration, Optimisation of the ATLAS b-tagging performance for the 2016 LHC Run, Report No. ATL-PHYS-PUB-2016-012 (2016), https://cds.cern.ch/record/2160731.

[72] ATLAS Collaboration, Expected performance of missing transverse momentum reconstruction for the ATLAS detector at $\sqrt{s} = 13$ TeV, Report No. ATL-PHYS-PUB-2015-023, 2015, https://cds.cern.ch/record/2037700.

[73] ATLAS Collaboration, Performance of missing transverse momentum reconstruction in proton-proton collisions at 7 TeV with ATLAS, Eur. Phys. J. C **72**, 1844 (2012).

[74] ATLAS and CMS Collaborations, Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments, Phys. Rev. Lett. **114**, 191803 (2015).

[75] ATLAS Collaboration, Reconstruction of hadronic decay products of tau leptons with the ATLAS experiment, Eur. Phys. J. C **76**, 295 (2016).

[76] ATLAS Collaboration, Search for the $b\bar{b}$ decay of the Standard Model Higgs boson in associated (W/Z)H production with the ATLAS detector, J. High Energy Phys. 01 (2015) 069.

[77] ATLAS Collaboration, Jet energy scale measurements and their systematic uncertainties in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, arXiv:1703.09665.

[78] L. Moneta *et al.*, The RooStats Project, *Proc. Sci.*, ACAT2010 (2010) 057.

[79] W. Verkerke and D. P. Kirkby, The RooFit toolkit for data modeling, arXiv:physics/0306116.

[80] C.-H. Kom and W. J. Stirling, Charge asymmetry in W + jets production at the LHC, Eur. Phys. J. C **69**, 67 (2010).

[81] A. L. Read, Presentation of search results: the CL_s technique, J. Phys. G **28**, 2693 (2002).

[82] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, Eur. Phys. J. C **71**, 1554 (2011); **73**, 2501 (2013).

[83] ATLAS Collaboration, ATLAS Computing Acknowledgements 2016-2017, Report No. ATL-GEN-PUB-2016-002, 2016, https://cds.cern.ch/record/2202407.

M. Aaboud,[137d] G. Aad,[88] B. Abbott,[115] O. Abdinov,[12,a] B. Abeloos,[119] S. H. Abidi,[161] O. S. AbouZeid,[139] N. L. Abraham,[151] H. Abramowicz,[155] H. Abreu,[154] R. Abreu,[118] Y. Abulaiti,[148a,148b] B. S. Acharya,[167a,167b,b] S. Adachi,[157] L. Adamczyk,[41a] J. Adelman,[110] M. Adersberger,[102] T. Adye,[133] A. A. Affolder,[139] T. Agatonovic-Jovin,[14] C. Agheorghiesei,[28c] J. A. Aguilar-Saavedra,[128a,128f] S. P. Ahlen,[24] F. Ahmadov,[68,c] G. Aielli,[135a,135b] S. Akatsuka,[71] H. Akerstedt,[148a,148b] T. P. A. Åkesson,[84] E. Akilli,[52] A. V. Akimov,[98] G. L. Alberghi,[22a,22b] J. Albert,[172] P. Albicocco,[50] M. J. Alconada Verzini,[74] S. C. Alderweireldt,[108] M. Aleksa,[32] I. N. Aleksandrov,[68] C. Alexa,[28b] G. Alexander,[155] T. Alexopoulos,[10] M. Alhroob,[115] B. Ali,[130] M. Aliev,[76a,76b] G. Alimonti,[94a] J. Alison,[33] S. P. Alkire,[38] B. M. M. Allbrooke,[151] B. W. Allen,[118] P. P. Allport,[19] A. Aloisio,[106a,106b] A. Alonso,[39] F. Alonso,[74] C. Alpigiani,[140] A. A. Alshehri,[56] M. I. Alstaty,[88] B. Alvarez Gonzalez,[32] D. Álvarez Piqueras,[170] M. G. Alviggi,[106a,106b] B. T. Amadio,[16] Y. Amaral Coutinho,[26a] C. Amelung,[25] D. Amidei,[92] S. P. Amor Dos Santos,[128a,128c] A. Amorim,[128a,128b] S. Amoroso,[32] G. Amundsen,[25] C. Anastopoulos,[141] L. S. Ancu,[52] N. Andari,[19] T. Andeen,[11] C. F. Anders,[60b] J. K. Anders,[77] K. J. Anderson,[33] A. Andreazza,[94a,94b] V. Andrei,[60a] S. Angelidakis,[9] I. Angelozzi,[109] A. Angerami,[38] A. V. Anisenkov,[111,d] N. Anjos,[13] A. Annovi,[126a,126b] C. Antel,[60a] M. Antonelli,[50] A. Antonov,[100,a] D. J. Antrim,[166] F. Anulli,[134a] M. Aoki,[69] L. Aperio Bella,[32] G. Arabidze,[93] Y. Arai,[69] J. P. Araque,[128a] V. Araujo Ferraz,[26a] A. T. H. Arce,[48] R. E. Ardell,[80] F. A. Arduh,[74] J-F. Arguin,[97] S. Argyropoulos,[66] M. Arik,[20a] A. J. Armbruster,[32] L. J. Armitage,[79] O. Arnaez,[161] H. Arnold,[51] M. Arratia,[30] O. Arslan,[23] A. Artamonov,[99] G. Artoni,[122] S. Artz,[86] S. Asai,[157] N. Asbah,[45] A. Ashkenazi,[155] L. Asquith,[151] K. Assamagan,[27] R. Astalos,[146a] M. Atkinson,[169] N. B. Atlay,[143] K. Augsten,[130] G. Avolio,[32] B. Axen,[16] M. K. Ayoub,[119] G. Azuelos,[97,e] A. E. Baas,[60a] M. J. Baca,[19] H. Bachacou,[138] K. Bachas,[76a,76b] M. Backes,[122] M. Backhaus,[32] P. Bagnaia,[134a,134b] M. Bahmani,[42] H. Bahrasemani,[144] J. T. Baines,[133] M. Bajic,[39] O. K. Baker,[179] E. M. Baldin,[111,d] P. Balek,[175] F. Balli,[138] W. K. Balunas,[124] E. Banas,[42] A. Bandyopadhyay,[23] Sw. Banerjee,[176,f] A. A. E. Bannoura,[178] L. Barak,[32] E. L. Barberio,[91] D. Barberis,[53a,53b] M. Barbero,[88] T. Barillari,[103] M-S Barisits,[32] J. T. Barkeloo,[118] T. Barklow,[145] N. Barlow,[30] S. L. Barnes,[36c] B. M. Barnett,[133] R. M. Barnett,[16] Z. Barnovska-Blenessy,[36a] A. Baroncelli,[136a] G. Barone,[25] A. J. Barr,[122] L. Barranco Navarro,[170] F. Barreiro,[85] J. Barreiro Guimarães da Costa,[35a] R. Bartoldus,[145] A. E. Barton,[75] P. Bartos,[146a] A. Basalaev,[125] A. Bassalat,[119,g] R. L. Bates,[56] S. J. Batista,[161] J. R. Batley,[30] M. Battaglia,[139] M. Bauce,[134a,134b] F. Bauer,[138] H. S. Bawa,[145,h] J. B. Beacham,[113] M. D. Beattie,[75] T. Beau,[83] P. H. Beauchemin,[165] P. Bechtle,[23] H. P. Beck,[18,i] H. C. Beck,[57] K. Becker,[122] M. Becker,[86] M. Beckingham,[173] C. Becot,[112] A. J. Beddall,[20e] A. Beddall,[20b] V. A. Bednyakov,[68] M. Bedognetti,[109] C. P. Bee,[150] T. A. Beermann,[32] M. Begalli,[26a] M. Begel,[27] J. K. Behr,[45] A. S. Bell,[81] G. Bella,[155] L. Bellagamba,[22a] A. Bellerive,[31] M. Bellomo,[154] K. Belotskiy,[100] O. Beltramello,[32] N. L. Belyaev,[100] O. Benary,[155,a] D. Benchekroun,[137a] M. Bender,[102] K. Bendtz,[148a,148b] N. Benekos,[10] Y. Benhammou,[155] E. Benhar Noccioli,[179] J. Benitez,[66] D. P. Benjamin,[48] M. Benoit,[52] J. R. Bensinger,[25] S. Bentvelsen,[109] L. Beresford,[122] M. Beretta,[50] D. Berge,[109] E. Bergeaas Kuutmann,[168] N. Berger,[5] J. Beringer,[16] S. Berlendis,[58] N. R. Bernard,[89] G. Bernardi,[83] C. Bernius,[145] F. U. Bernlochner,[23] T. Berry,[80] P. Berta,[131] C. Bertella,[35a] G. Bertoli,[148a,148b] F. Bertolucci,[126a,126b] I. A. Bertram,[75] C. Bertsche,[45] D. Bertsche,[115] G. J. Besjes,[39] O. Bessidskaia Bylund,[148a,148b] M. Bessner,[45] N. Besson,[138] C. Betancourt,[51] A. Bethani,[87] S. Bethke,[103] A. J. Bevan,[79] J. Beyer,[103] R. M. Bianchi,[127] O. Biebel,[102] D. Biedermann,[17] R. Bielski,[87] K. Bierwagen,[86] N. V. Biesuz,[126a,126b] M. Biglietti,[136a] T. R. V. Billoud,[97] H. Bilokon,[50] M. Bindi,[57] A. Bingul,[20b] C. Bini,[134a,134b] S. Biondi,[22a,22b] T. Bisanz,[57] C. Bittrich,[47] D. M. Bjergaard,[48] C. W. Black,[152] J. E. Black,[145] K. M. Black,[24] R. E. Blair,[6] T. Blazek,[146a] I. Bloch,[45] C. Blocker,[25] A. Blue,[56] W. Blum,[86,a] U. Blumenschein,[79] S. Blunier,[34a] G. J. Bobbink,[109] V. S. Bobrovnikov,[111,d] S. S. Bocchetta,[84] A. Bocci,[48] C. Bock,[102] M. Boehler,[51] D. Boerner,[178] D. Bogavac,[102] A. G. Bogdanchikov,[111] C. Bohm,[148a] V. Boisvert,[80] P. Bokan,[168,j] T. Bold,[41a] A. S. Boldyrev,[101] A. E. Bolz,[60b]

M. Bomben,[83] M. Bona,[79] M. Boonekamp,[138] A. Borisov,[132] G. Borissov,[75] J. Bortfeldt,[32] D. Bortoletto,[122] V. Bortolotto,[62a,62b,62c] D. Boscherini,[22a] M. Bosman,[13] J. D. Bossio Sola,[29] J. Boudreau,[127] J. Bouffard,[2] E. V. Bouhova-Thacker,[75] D. Boumediene,[37] C. Bourdarios,[119] S. K. Boutle,[56] A. Boveia,[113] J. Boyd,[32] I. R. Boyko,[68] J. Bracinik,[19] A. Brandt,[8] G. Brandt,[57] O. Brandt,[60a] U. Bratzler,[158] B. Brau,[89] J. E. Brau,[118] W. D. Breaden Madden,[56] K. Brendlinger,[45] A. J. Brennan,[91] L. Brenner,[109] R. Brenner,[168] S. Bressler,[175] D. L. Briglin,[19] T. M. Bristow,[49] D. Britton,[56] D. Britzger,[45] F. M. Brochu,[30] I. Brock,[23] R. Brock,[93] G. Brooijmans,[38] T. Brooks,[80] W. K. Brooks,[34b] J. Brosamer,[16] E. Brost,[110] J. H Broughton,[19] P. A. Bruckman de Renstrom,[42] D. Bruncko,[146b] A. Bruni,[22a] G. Bruni,[22a] L. S. Bruni,[109] BH Brunt,[30] M. Bruschi,[22a] N. Bruscino,[23] P. Bryant,[33] L. Bryngemark,[45] T. Buanes,[15] Q. Buat,[144] P. Buchholz,[143] A. G. Buckley,[56] I. A. Budagov,[68] F. Buehrer,[51] M. K. Bugge,[121] O. Bulekov,[100] D. Bullock,[8] T. J. Burch,[110] S. Burdin,[77] C. D. Burgard,[51] A. M. Burger,[5] B. Burghgrave,[110] K. Burka,[42] S. Burke,[133] I. Burmeister,[46] J. T. P. Burr,[122] E. Busato,[37] D. Büscher,[51] V. Büscher,[86] P. Bussey,[56] J. M. Butler,[24] C. M. Buttar,[56] J. M. Butterworth,[81] P. Butti,[32] W. Buttinger,[27] A. Buzatu,[35c] A. R. Buzykaev,[111,d] S. Cabrera Urbán,[170] D. Caforio,[130] V. M. Cairo,[40a,40b] O. Cakir,[4a] N. Calace,[52] P. Calafiura,[16] A. Calandri,[88] G. Calderini,[83] P. Calfayan,[64] G. Callea,[40a,40b] L. P. Caloba,[26a] S. Calvente Lopez,[85] D. Calvet,[37] S. Calvet,[37] T. P. Calvet,[88] R. Camacho Toro,[33] S. Camarda,[32] P. Camarri,[135a,135b] D. Cameron,[121] R. Caminal Armadans,[169] C. Camincher,[58] S. Campana,[32] M. Campanelli,[81] A. Camplani,[94a,94b] A. Campoverde,[143] V. Canale,[106a,106b] M. Cano Bret,[36c] J. Cantero,[116] T. Cao,[155] M. D. M. Capeans Garrido,[32] I. Caprini,[28b] M. Caprini,[28b] M. Capua,[40a,40b] R. M. Carbone,[38] R. Cardarelli,[135a] F. Cardillo,[51] I. Carli,[131] T. Carli,[32] G. Carlino,[106a] B. T. Carlson,[127] L. Carminati,[94a,94b] R. M. D. Carney,[148a,148b] S. Caron,[108] E. Carquin,[34b] S. Carrá,[94a,94b] G. D. Carrillo-Montoya,[32] J. Carvalho,[128a,128c] D. Casadei,[19] M. P. Casado,[13,k] M. Casolino,[13] D. W. Casper,[166] R. Castelijn,[109] V. Castillo Gimenez,[170] N. F. Castro,[128a,l] A. Catinaccio,[32] J. R. Catmore,[121] A. Cattai,[32] J. Caudron,[23] V. Cavaliere,[169] E. Cavallaro,[13] D. Cavalli,[94a] M. Cavalli-Sforza,[13] V. Cavasinni,[126a,126b] E. Celebi,[20d] F. Ceradini,[136a,136b] L. Cerda Alberich,[170] A. S. Cerqueira,[26b] A. Cerri,[151] L. Cerrito,[135a,135b] F. Cerutti,[16] A. Cervelli,[18] S. A. Cetin,[20d] A. Chafaq,[137a] D. Chakraborty,[110] S. K. Chan,[59] W. S. Chan,[109] Y. L. Chan,[62a] P. Chang,[169] J. D. Chapman,[30] D. G. Charlton,[19] C. C. Chau,[31] C. A. Chavez Barajas,[151] S. Che,[113] S. Cheatham,[167a,167c] A. Chegwidden,[93] S. Chekanov,[6] S. V. Chekulaev,[163a] G. A. Chelkov,[68,m] M. A. Chelstowska,[32] C. Chen,[67] H. Chen,[27] J. Chen,[36a] S. Chen,[35b] S. Chen,[157] X. Chen,[35c,n] Y. Chen,[70] H. C. Cheng,[92] H. J. Cheng,[35a] A. Cheplakov,[68] E. Cheremushkina,[132] R. Cherkaoui El Moursli,[137e] E. Cheu,[7] K. Cheung,[63] L. Chevalier,[138] V. Chiarella,[50] G. Chiarelli,[126a,126b] G. Chiodini,[76a] A. S. Chisholm,[32] A. Chitan,[28b] Y. H. Chiu,[172] M. V. Chizhov,[68] K. Choi,[64] A. R. Chomont,[37] Y. Chou,[63] S. Chouridou,[156] Y. S. Chow,[62a] V. Christodoulou,[81] M. C. Chu,[62a] J. Chudoba,[129] A. J. Chuinard,[90] J. J. Chwastowski,[42] L. Chytka,[117] A. K. Ciftci,[4a] D. Cinca,[46] V. Cindro,[78] I. A. Cioara,[23] C. Ciocca,[22a,22b] A. Ciocio,[16] F. Cirotto,[106a,106b] Z. H. Citron,[175] M. Citterio,[94a] M. Ciubancan,[28b] A. Clark,[52] B. L. Clark,[59] M. R. Clark,[38] P. J. Clark,[49] R. N. Clarke,[16] C. Clement,[148a,148b] Y. Coadou,[88] M. Cobal,[167a,167c] A. Coccaro,[52] J. Cochran,[67] L. Colasurdo,[108] B. Cole,[38] A. P. Colijn,[109] J. Collot,[58] T. Colombo,[166] P. Conde Muiño,[128a,128b] E. Coniavitis,[51] S. H. Connell,[147b] I. A. Connelly,[87] S. Constantinescu,[28b] G. Conti,[32] F. Conventi,[106a,o] M. Cooke,[16] A. M. Cooper-Sarkar,[122] F. Cormier,[171] K. J. R. Cormier,[161] M. Corradi,[134a,134b] F. Corriveau,[90,p] A. Cortes-Gonzalez,[32] G. Cortiana,[103] G. Costa,[94a] M. J. Costa,[170] D. Costanzo,[141] G. Cottin,[30] G. Cowan,[80] B. E. Cox,[87] K. Cranmer,[112] S. J. Crawley,[56] R. A. Creager,[124] G. Cree,[31] S. Crépé-Renaudin,[58] F. Crescioli,[83] W. A. Cribbs,[148a,148b] M. Cristinziani,[23] V. Croft,[108] G. Crosetti,[40a,40b] A. Cueto,[85] T. Cuhadar Donszelmann,[141] A. R. Cukierman,[145] J. Cummings,[179] M. Curatolo,[50] J. Cúth,[86] S. Czekierda,[42] P. Czodrowski,[32] G. D'amen,[22a,22b] S. D'Auria,[56] L. D'eramo,[83] M. D'Onofrio,[77] M. J. Da Cunha Sargedas De Sousa,[128a,128b] C. Da Via,[87] W. Dabrowski,[41a] T. Dado,[146a] T. Dai,[92] O. Dale,[15] F. Dallaire,[97] C. Dallapiccola,[89] M. Dam,[39] J. R. Dandoy,[124] M. F. Daneri,[29] N. P. Dang,[176] A. C. Daniells,[19] N. S. Dann,[87] M. Danninger,[171] M. Dano Hoffmann,[138] V. Dao,[150] G. Darbo,[53a] S. Darmora,[8] J. Dassoulas,[3] A. Dattagupta,[118] T. Daubney,[45] W. Davey,[23] C. David,[45] T. Davidek,[131] D. R. Davis,[48] P. Davison,[81] E. Dawe,[91] I. Dawson,[141] K. De,[8] R. de Asmundis,[106a] A. De Benedetti,[115] S. De Castro,[22a,22b] S. De Cecco,[83] N. De Groot,[108] P. de Jong,[109] H. De la Torre,[93] F. De Lorenzi,[67] A. De Maria,[57] D. De Pedis,[134a] A. De Salvo,[134a] U. De Sanctis,[135a,135b] A. De Santo,[151] K. De Vasconcelos Corga,[88] J. B. De Vivie De Regie,[119] W. J. Dearnaley,[75] R. Debbe,[27] C. Debenedetti,[139] D. V. Dedovich,[68] N. Dehghanian,[3] I. Deigaard,[109] M. Del Gaudio,[40a,40b] J. Del Peso,[85] D. Delgove,[119] F. Deliot,[138] C. M. Delitzsch,[7] A. Dell'Acqua,[32] L. Dell'Asta,[24] M. Dell'Orso,[126a,126b] M. Della Pietra,[106a,106b] D. della Volpe,[52] M. Delmastro,[5] C. Delporte,[119] P. A. Delsart,[58] D. A. DeMarco,[161] S. Demers,[179] M. Demichev,[68] A. Demilly,[83] S. P. Denisov,[132] D. Denysiuk,[138] D. Derendarz,[42] J. E. Derkaoui,[137d] F. Derue,[83] P. Dervan,[77] K. Desch,[23] C. Deterre,[45] K. Dette,[46] M. R. Devesa,[29] P. O. Deviveiros,[32] A. Dewhurst,[133] S. Dhaliwal,[25] F. A. Di Bello,[52]

A. Di Ciaccio,[135a,135b] L. Di Ciaccio,[5] W. K. Di Clemente,[124] C. Di Donato,[106a,106b] A. Di Girolamo,[32] B. Di Girolamo,[32] B. Di Micco,[136a,136b] R. Di Nardo,[32] K. F. Di Petrillo,[59] A. Di Simone,[51] R. Di Sipio,[161] D. Di Valentino,[31] C. Diaconu,[88] M. Diamond,[161] F. A. Dias,[39] M. A. Diaz,[34a] E. B. Diehl,[92] J. Dietrich,[17] S. Díez Cornell,[45] A. Dimitrievska,[14] J. Dingfelder,[23] P. Dita,[28b] S. Dita,[28b] F. Dittus,[32] F. Djama,[88] T. Djobava,[54b] J. I. Djuvsland,[60a] M. A. B. do Vale,[26c] D. Dobos,[32] M. Dobre,[28b] C. Doglioni,[84] J. Dolejsi,[131] Z. Dolezal,[131] M. Donadelli,[26d] S. Donati,[126a,126b] P. Dondero,[123a,123b] J. Donini,[37] J. Dopke,[133] A. Doria,[106a] M. T. Dova,[74] A. T. Doyle,[56] E. Drechsler,[57] M. Dris,[10] Y. Du,[36b] J. Duarte-Campderros,[155] A. Dubreuil,[52] E. Duchovni,[175] G. Duckeck,[102] A. Ducourthial,[83] O. A. Ducu,[97,q] D. Duda,[109] A. Dudarev,[32] A. Chr. Dudder,[86] E. M. Duffield,[16] L. Duflot,[119] M. Dührssen,[32] M. Dumancic,[175] A. E. Dumitriu,[28b] A. K. Duncan,[56] M. Dunford,[60a] H. Duran Yildiz,[4a] M. Düren,[55] A. Durglishvili,[54b] D. Duschinger,[47] B. Dutta,[45] D. Duvnjak,[1] M. Dyndal,[45] B. S. Dziedzic,[42] C. Eckardt,[45] K. M. Ecker,[103] R. C. Edgar,[92] T. Eifert,[32] G. Eigen,[15] K. Einsweiler,[16] T. Ekelof,[168] M. El Kacimi,[137c] R. El Kosseifi,[88] V. Ellajosyula,[88] M. Ellert,[168] S. Elles,[5] F. Ellinghaus,[178] A. A. Elliot,[172] N. Ellis,[32] J. Elmsheuser,[27] M. Elsing,[32] D. Emeliyanov,[133] Y. Enari,[157] O. C. Endner,[86] J. S. Ennis,[173] J. Erdmann,[46] A. Ereditato,[18] M. Ernst,[27] S. Errede,[169] M. Escalier,[119] C. Escobar,[170] B. Esposito,[50] O. Estrada Pastor,[170] A. I. Etienvre,[138] E. Etzion,[155] H. Evans,[64] A. Ezhilov,[125] M. Ezzi,[137e] F. Fabbri,[22a,22b] L. Fabbri,[22a,22b] V. Fabiani,[108] G. Facini,[81] R. M. Fakhrutdinov,[132] S. Falciano,[134a] R. J. Falla,[81] J. Faltova,[32] Y. Fang,[35a] M. Fanti,[94a,94b] A. Farbin,[8] A. Farilla,[136a] C. Farina,[127] E. M. Farina,[123a,123b] T. Farooque,[93] S. Farrell,[16] S. M. Farrington,[173] P. Farthouat,[32] F. Fassi,[137e] P. Fassnacht,[32] D. Fassouliotis,[9] M. Faucci Giannelli,[80] A. Favareto,[53a,53b] W. J. Fawcett,[122] L. Fayard,[119] O. L. Fedin,[125,r] W. Fedorko,[171] S. Feigl,[121] L. Feligioni,[88] C. Feng,[36b] E. J. Feng,[32] H. Feng,[92] M. J. Fenton,[56] A. B. Fenyuk,[132] L. Feremenga,[8] P. Fernandez Martinez,[170] S. Fernandez Perez,[13] J. Ferrando,[45] A. Ferrari,[168] P. Ferrari,[109] R. Ferrari,[123a] D. E. Ferreira de Lima,[60b] A. Ferrer,[170] D. Ferrere,[52] C. Ferretti,[92] F. Fiedler,[86] A. Filipčič,[78] M. Filipuzzi,[45] F. Filthaut,[108] M. Fincke-Keeler,[172] K. D. Finelli,[152] M. C. N. Fiolhais,[128a,128c,s] L. Fiorini,[170] A. Fischer,[2] C. Fischer,[13] J. Fischer,[178] W. C. Fisher,[93] N. Flaschel,[45] I. Fleck,[143] P. Fleischmann,[92] R. R. M. Fletcher,[124] T. Flick,[178] B. M. Flierl,[102] L. R. Flores Castillo,[62a] M. J. Flowerdew,[103] G. T. Forcolin,[87] A. Formica,[138] F. A. Förster,[13] A. Forti,[87] A. G. Foster,[19] D. Fournier,[119] H. Fox,[75] S. Fracchia,[141] P. Francavilla,[83] M. Franchini,[22a,22b] S. Franchino,[60a] D. Francis,[32] L. Franconi,[121] M. Franklin,[59] M. Frate,[166] M. Fraternali,[123a,123b] D. Freeborn,[81] S. M. Fressard-Batraneanu,[32] B. Freund,[97] D. Froidevaux,[32] J. A. Frost,[122] C. Fukunaga,[158] T. Fusayasu,[104] J. Fuster,[170] C. Gabaldon,[58] O. Gabizon,[154] A. Gabrielli,[22a,22b] A. Gabrielli,[16] G. P. Gach,[41a] S. Gadatsch,[32] S. Gadomski,[80] G. Gagliardi,[53a,53b] L. G. Gagnon,[97] C. Galea,[108] B. Galhardo,[128a,128c] E. J. Gallas,[122] B. J. Gallop,[133] P. Gallus,[130] G. Galster,[39] K. K. Gan,[113] S. Ganguly,[37] Y. Gao,[77] Y. S. Gao,[145,h] F. M. Garay Walls,[49] C. García,[170] J. E. García Navarro,[170] J. A. García Pascual,[35a] M. Garcia-Sciveres,[16] R. W. Gardner,[33] N. Garelli,[145] V. Garonne,[121] A. Gascon Bravo,[45] K. Gasnikova,[45] C. Gatti,[50] A. Gaudiello,[53a,53b] G. Gaudio,[123a] I. L. Gavrilenko,[98] C. Gay,[171] G. Gaycken,[23] E. N. Gazis,[10] C. N. P. Gee,[133] J. Geisen,[57] M. Geisen,[86] M. P. Geisler,[60a] K. Gellerstedt,[148a,148b] C. Gemme,[53a] M. H. Genest,[58] C. Geng,[92] S. Gentile,[134a,134b] C. Gentsos,[156] S. George,[80] D. Gerbaudo,[13] A. Gershon,[155] G. Geßner,[46] S. Ghasemi,[143] M. Ghneimat,[23] B. Giacobbe,[22a] S. Giagu,[134a,134b] N. Giangiacomi,[22a,22b] P. Giannetti,[126a,126b] S. M. Gibson,[80] M. Gignac,[171] M. Gilchriese,[16] D. Gillberg,[31] G. Gilles,[178] D. M. Gingrich,[3,e] N. Giokaris,[9,a] M. P. Giordani,[167a,167c] F. M. Giorgi,[22a] P. F. Giraud,[138] P. Giromini,[59] G. Giugliarelli,[167a,167c] D. Giugni,[94a] F. Giuli,[122] C. Giuliani,[103] M. Giulini,[60b] B. K. Gjelsten,[121] S. Gkaitatzis,[156] I. Gkialas,[9,t] E. L. Gkougkousis,[139] P. Gkountoumis,[10] L. K. Gladilin,[101] C. Glasman,[85] J. Glatzer,[13] P. C. F. Glaysher,[45] A. Glazov,[45] M. Goblirsch-Kolb,[25] J. Godlewski,[42] S. Goldfarb,[91] T. Golling,[52] D. Golubkov,[132] A. Gomes,[128a,128b,128d] R. Gonçalo,[128a] R. Goncalves Gama,[26a] J. Goncalves Pinto Firmino Da Costa,[138] G. Gonella,[51] L. Gonella,[19] A. Gongadze,[68] S. González de la Hoz,[170] S. Gonzalez-Sevilla,[52] L. Goossens,[32] P. A. Gorbounov,[99] H. A. Gordon,[27] I. Gorelov,[107] B. Gorini,[32] E. Gorini,[76a,76b] A. Gorišek,[78] A. T. Goshaw,[48] C. Gössling,[46] M. I. Gostkin,[68] C. A. Gottardo,[23] C. R. Goudet,[119] D. Goujdami,[137c] A. G. Goussiou,[140] N. Govender,[147b,u] E. Gozani,[154] L. Graber,[57] I. Grabowska-Bold,[41a] P. O. J. Gradin,[168] J. Gramling,[166] E. Gramstad,[121] S. Grancagnolo,[17] V. Gratchev,[125] P. M. Gravila,[28f] C. Gray,[56] H. M. Gray,[16] Z. D. Greenwood,[82,v] C. Grefe,[23] K. Gregersen,[81] I. M. Gregor,[45] P. Grenier,[145] K. Grevtsov,[5] J. Griffiths,[8] A. A. Grillo,[139] K. Grimm,[75] S. Grinstein,[13,w] Ph. Gris,[37] J.-F. Grivaz,[119] S. Groh,[86] E. Gross,[175] J. Grosse-Knetter,[57] G. C. Grossi,[82] Z. J. Grout,[81] A. Grummer,[107] L. Guan,[92] W. Guan,[176] J. Guenther,[65] F. Guescini,[163a] D. Guest,[166] O. Gueta,[155] B. Gui,[113] E. Guido,[53a,53b] T. Guillemin,[5] S. Guindon,[2] U. Gul,[56] C. Gumpert,[32] J. Guo,[36c] W. Guo,[92] Y. Guo,[36a] R. Gupta,[43] S. Gupta,[122] G. Gustavino,[115] P. Gutierrez,[115] N. G. Gutierrez Ortiz,[81] C. Gutschow,[81] C. Guyot,[138] M. P. Guzik,[41a] C. Gwenlan,[122] C. B. Gwilliam,[77] A. Haas,[112] C. Haber,[16] H. K. Hadavand,[8] N. Haddad,[137e] A. Hadef,[88] S. Hageböck,[23] M. Hagihara,[164]

H. Hakobyan,[180,a] M. Haleem,[45] J. Haley,[116] G. Halladjian,[93] G. D. Hallewell,[88] K. Hamacher,[178] P. Hamal,[117] K. Hamano,[172] A. Hamilton,[147a] G. N. Hamity,[141] P. G. Hamnett,[45] L. Han,[36a] S. Han,[35a] K. Hanagaki,[69,x] K. Hanawa,[157] M. Hance,[139] B. Haney,[124] P. Hanke,[60a] J. B. Hansen,[39] J. D. Hansen,[39] M. C. Hansen,[23] P. H. Hansen,[39] K. Hara,[164] A. S. Hard,[176] T. Harenberg,[178] F. Hariri,[119] S. Harkusha,[95] R. D. Harrington,[49] P. F. Harrison,[173] N. M. Hartmann,[102] M. Hasegawa,[70] Y. Hasegawa,[142] A. Hasib,[49] S. Hassani,[138] S. Haug,[18] R. Hauser,[93] L. Hauswald,[47] L. B. Havener,[38] M. Havranek,[130] C. M. Hawkes,[19] R. J. Hawkings,[32] D. Hayakawa,[159] D. Hayden,[93] C. P. Hays,[122] J. M. Hays,[79] H. S. Hayward,[77] S. J. Haywood,[133] S. J. Head,[19] T. Heck,[86] V. Hedberg,[84] L. Heelan,[8] S. Heer,[23] K. K. Heidegger,[51] S. Heim,[45] T. Heim,[16] B. Heinemann,[45,y] J. J. Heinrich,[102] L. Heinrich,[112] C. Heinz,[55] J. Hejbal,[129] L. Helary,[32] A. Held,[171] S. Hellman,[148a,148b] C. Helsens,[32] R. C. W. Henderson,[75] Y. Heng,[176] S. Henkelmann,[171] A. M. Henriques Correia,[32] S. Henrot-Versille,[119] G. H. Herbert,[17] H. Herde,[25] V. Herget,[177] Y. Hernández Jiménez,[147c] H. Herr,[86] G. Herten,[51] R. Hertenberger,[102] L. Hervas,[32] T. C. Herwig,[124] G. G. Hesketh,[81] N. P. Hessey,[163a] J. W. Hetherly,[43] S. Higashino,[69] E. Higón-Rodriguez,[170] K. Hildebrand,[33] E. Hill,[172] J. C. Hill,[30] K. H. Hiller,[45] S. J. Hillier,[19] M. Hils,[47] I. Hinchliffe,[16] M. Hirose,[51] D. Hirschbuehl,[178] B. Hiti,[78] O. Hladik,[129] X. Hoad,[49] J. Hobbs,[150] N. Hod,[163a] M. C. Hodgkinson,[141] P. Hodgson,[141] A. Hoecker,[32] M. R. Hoeferkamp,[107] F. Hoenig,[102] D. Hohn,[23] T. R. Holmes,[33] M. Homann,[46] S. Honda,[164] T. Honda,[69] T. M. Hong,[127] B. H. Hooberman,[169] W. H. Hopkins,[118] Y. Horii,[105] A. J. Horton,[144] J-Y. Hostachy,[58] S. Hou,[153] A. Hoummada,[137a] J. Howarth,[87] J. Hoya,[74] M. Hrabovsky,[117] J. Hrdinka,[32] I. Hristova,[17] J. Hrivnac,[119] T. Hryn'ova,[5] A. Hrynevich,[96] P. J. Hsu,[63] S.-C. Hsu,[140] Q. Hu,[36a] S. Hu,[36c] Y. Huang,[35a] Z. Hubacek,[130] F. Hubaut,[88] F. Huegging,[23] T. B. Huffman,[122] E. W. Hughes,[38] G. Hughes,[75] M. Huhtinen,[32] P. Huo,[150] N. Huseynov,[68,c] J. Huston,[93] J. Huth,[59] G. Iacobucci,[52] G. Iakovidis,[27] I. Ibragimov,[143] L. Iconomidou-Fayard,[119] Z. Idrissi,[137e] P. Iengo,[32] O. Igonkina,[109,z] T. Iizawa,[174] Y. Ikegami,[69] M. Ikeno,[69] Y. Ilchenko,[11,aa] D. Iliadis,[156] N. Ilic,[145] G. Introzzi,[123a,123b] P. Ioannou,[9,a] M. Iodice,[136a] K. Iordanidou,[38] V. Ippolito,[59] M. F. Isacson,[168] N. Ishijima,[120] M. Ishino,[157] M. Ishitsuka,[159] C. Issever,[122] S. Istin,[20a] F. Ito,[164] J. M. Iturbe Ponce,[62a] R. Iuppa,[162a,162b] H. Iwasaki,[69] J. M. Izen,[44] V. Izzo,[106a] S. Jabbar,[3] P. Jackson,[1] R. M. Jacobs,[23] V. Jain,[2] K. B. Jakobi,[86] K. Jakobs,[51] S. Jakobsen,[65] T. Jakoubek,[129] D. O. Jamin,[116] D. K. Jana,[82] R. Jansky,[52] J. Janssen,[23] M. Janus,[57] P. A. Janus,[41a] G. Jarlskog,[84] N. Javadov,[68,c] T. Javůrek,[51] M. Javurkova,[51] F. Jeanneau,[138] L. Jeanty,[16] J. Jejelava,[54a,bb] A. Jelinskas,[173] P. Jenni,[51,cc] C. Jeske,[173] S. Jézéquel,[5] H. Ji,[176] J. Jia,[150] H. Jiang,[67] Y. Jiang,[36a] Z. Jiang,[145] S. Jiggins,[81] J. Jimenez Pena,[170] S. Jin,[35a] A. Jinaru,[28b] O. Jinnouchi,[159] H. Jivan,[147c] P. Johansson,[141] K. A. Johns,[7] C. A. Johnson,[64] W. J. Johnson,[140] K. Jon-And,[148a,148b] R. W. L. Jones,[75] S. D. Jones,[151] S. Jones,[7] T. J. Jones,[77] J. Jongmanns,[60a] P. M. Jorge,[128a,128b] J. Jovicevic,[163a] X. Ju,[176] A. Juste Rozas,[13,w] M. K. Köhler,[175] A. Kaczmarska,[42] M. Kado,[119] H. Kagan,[113] M. Kagan,[145] S. J. Kahn,[88] T. Kaji,[174] E. Kajomovitz,[48] C. W. Kalderon,[84] A. Kaluza,[86] S. Kama,[43] A. Kamenshchikov,[132] N. Kanaya,[157] L. Kanjir,[78] V. A. Kantserov,[100] J. Kanzaki,[69] B. Kaplan,[112] L. S. Kaplan,[176] D. Kar,[147c] K. Karakostas,[10] N. Karastathis,[10] M. J. Kareem,[57] E. Karentzos,[10] S. N. Karpov,[68] Z. M. Karpova,[68] K. Karthik,[112] V. Kartvelishvili,[75] A. N. Karyukhin,[132] K. Kasahara,[164] L. Kashif,[176] R. D. Kass,[113] A. Kastanas,[149] Y. Kataoka,[157] C. Kato,[157] A. Katre,[52] J. Katzy,[45] K. Kawade,[70] K. Kawagoe,[73] T. Kawamoto,[157] G. Kawamura,[57] E. F. Kay,[77] V. F. Kazanin,[111,d] R. Keeler,[172] R. Kehoe,[43] J. S. Keller,[31] E. Kellermann,[84] J. J. Kempster,[80] J Kendrick,[19] H. Keoshkerian,[161] O. Kepka,[129] B. P. Kerševan,[78] S. Kersten,[178] R. A. Keyes,[90] M. Khader,[169] F. Khalil-zada,[12] A. Khanov,[116] A. G. Kharlamov,[111,d] T. Kharlamova,[111,d] A. Khodinov,[160] T. J. Khoo,[52] V. Khovanskiy,[99,a] E. Khramov,[68] J. Khubua,[54b,dd] S. Kido,[70] C. R. Kilby,[80] H. Y. Kim,[8] S. H. Kim,[164] Y. K. Kim,[33] N. Kimura,[156] O. M. Kind,[17] B. T. King,[77] D. Kirchmeier,[47] J. Kirk,[133] A. E. Kiryunin,[103] T. Kishimoto,[157] D. Kisielewska,[41a] V. Kitali,[45] K. Kiuchi,[164] O. Kivernyk,[5] E. Kladiva,[146b] T. Klapdor-Kleingrothaus,[51] M. H. Klein,[38] M. Klein,[77] U. Klein,[77] K. Kleinknecht,[86] P. Klimek,[110] A. Klimentov,[27] R. Klingenberg,[46] T. Klingl,[23] T. Klioutchnikova,[32] E.-E. Kluge,[60a] P. Kluit,[109] S. Kluth,[103] E. Kneringer,[65] E. B. F. G. Knoops,[88] A. Knue,[103] A. Kobayashi,[157] D. Kobayashi,[159] T. Kobayashi,[157] M. Kobel,[47] M. Kocian,[145] P. Kodys,[131] T. Koffas,[31] E. Koffeman,[109] N. M. Köhler,[103] T. Koi,[145] M. Kolb,[60b] I. Koletsou,[5] A. A. Komar,[98,a] Y. Komori,[157] T. Kondo,[69] N. Kondrashova,[36c] K. Köneke,[51] A. C. König,[108] T. Kono,[69,ee] R. Konoplich,[112,ff] N. Konstantinidis,[81] R. Kopeliansky,[64] S. Koperny,[41a] A. K. Kopp,[51] K. Korcyl,[42] K. Kordas,[156] A. Korn,[81] A. A. Korol,[111,d] I. Korolkov,[13] E. V. Korolkova,[141] O. Kortner,[103] S. Kortner,[103] T. Kosek,[131] V. V. Kostyukhin,[23] A. Kotwal,[48] A. Koulouris,[10] A. Kourkoumeli-Charalampidi,[123a,123b] C. Kourkoumelis,[9] E. Kourlitis,[141] V. Kouskoura,[27] A. B. Kowalewska,[42] R. Kowalewski,[172] T. Z. Kowalski,[41a] C. Kozakai,[157] W. Kozanecki,[138] A. S. Kozhin,[132] V. A. Kramarenko,[101] G. Kramberger,[78] D. Krasnopevtsev,[100] M. W. Krasny,[83] A. Krasznahorkay,[32] D. Krauss,[103] J. A. Kremer,[41a] J. Kretzschmar,[77] K. Kreutzfeldt,[55] P. Krieger,[161] K. Krizka,[33] K. Kroeninger,[46] H. Kroha,[103] J. Kroll,[129]

J. Kroll,[124] J. Kroseberg,[23] J. Krstic,[14] U. Kruchonak,[68] H. Krüger,[23] N. Krumnack,[67] M. C. Kruse,[48] T. Kubota,[91] H. Kucuk,[81] S. Kuday,[4b] J. T. Kuechler,[178] S. Kuehn,[32] A. Kugel,[60a] F. Kuger,[177] T. Kuhl,[45] V. Kukhtin,[68] R. Kukla,[88] Y. Kulchitsky,[95] S. Kuleshov,[34b] Y. P. Kulinich,[169] M. Kuna,[134a,134b] T. Kunigo,[71] A. Kupco,[129] T. Kupfer,[46] O. Kuprash,[155] H. Kurashige,[70] L. L. Kurchaninov,[163a] Y. A. Kurochkin,[95] M. G. Kurth,[35a] V. Kus,[129] E. S. Kuwertz,[172] M. Kuze,[159] J. Kvita,[117] T. Kwan,[172] D. Kyriazopoulos,[141] A. La Rosa,[103] J. L. La Rosa Navarro,[26d] L. La Rotonda,[40a,40b] F. La Ruffa,[40a,40b] C. Lacasta,[170] F. Lacava,[134a,134b] J. Lacey,[45] H. Lacker,[17] D. Lacour,[83] E. Ladygin,[68] R. Lafaye,[5] B. Laforge,[83] T. Lagouri,[179] S. Lai,[57] S. Lammers,[64] W. Lampl,[7] E. Lançon,[27] U. Landgraf,[51] M. P. J. Landon,[79] M. C. Lanfermann,[52] V. S. Lang,[60a] J. C. Lange,[13] R. J. Langenberg,[32] A. J. Lankford,[166] F. Lanni,[27] K. Lantzsch,[23] A. Lanza,[123a] A. Lapertosa,[53a,53b] S. Laplace,[83] J. F. Laporte,[138] T. Lari,[94a] F. Lasagni Manghi,[22a,22b] M. Lassnig,[32] P. Laurelli,[50] W. Lavrijsen,[16] A. T. Law,[139] P. Laycock,[77] T. Lazovich,[59] M. Lazzaroni,[94a,94b] B. Le,[91] O. Le Dortz,[83] E. Le Guirriec,[88] E. P. Le Quilleuc,[138] M. LeBlanc,[172] T. LeCompte,[6] F. Ledroit-Guillon,[58] C. A. Lee,[27] G. R. Lee,[133,gg] S. C. Lee,[153] L. Lee,[59] B. Lefebvre,[90] G. Lefebvre,[83] M. Lefebvre,[172] F. Legger,[102] C. Leggett,[16] G. Lehmann Miotto,[32] X. Lei,[7] W. A. Leight,[45] M. A. L. Leite,[26d] R. Leitner,[131] D. Lellouch,[175] B. Lemmer,[57] K. J. C. Leney,[81] T. Lenz,[23] B. Lenzi,[32] R. Leone,[7] S. Leone,[126a,126b] C. Leonidopoulos,[49] G. Lerner,[151] C. Leroy,[97] A. A. J. Lesage,[138] C. G. Lester,[30] M. Levchenko,[125] J. Levêque,[5] D. Levin,[92] L. J. Levinson,[175] M. Levy,[19] D. Lewis,[79] B. Li,[36a,hh] Changqiao Li,[36a] H. Li,[150] L. Li,[36c] Q. Li,[35a] S. Li,[48] X. Li,[36c] Y. Li,[143] Z. Liang,[35a] B. Liberti,[135a] A. Liblong,[161] K. Lie,[62c] J. Liebal,[23] W. Liebig,[15] A. Limosani,[152] S. C. Lin,[182] T. H. Lin,[86] R. A. Linck,[64] B. E. Lindquist,[150] A. E. Lionti,[52] E. Lipeles,[124] A. Lipniacka,[15] M. Lisovyi,[60b] T. M. Liss,[169,ii] A. Lister,[171] A. M. Litke,[139] B. Liu,[153,jj] H. Liu,[92] H. Liu,[27] J. K. K. Liu,[122] J. Liu,[36b] J. B. Liu,[36a] K. Liu,[88] L. Liu,[169] M. Liu,[36a] Y. L. Liu,[36a] Y. Liu,[36a] M. Livan,[123a,123b] A. Lleres,[58] J. Llorente Merino,[35a] S. L. Lloyd,[79] C. Y. Lo,[62b] F. Lo Sterzo,[153] E. M. Lobodzinska,[45] P. Loch,[7] F. K. Loebinger,[87] A. Loesle,[51] K. M. Loew,[25] A. Loginov,[179,a] T. Lohse,[17] K. Lohwasser,[141] M. Lokajicek,[129] B. A. Long,[24] J. D. Long,[169] R. E. Long,[75] L. Longo,[76a,76b] K. A. Looper,[113] J. A. Lopez,[34b] D. Lopez Mateos,[59] I. Lopez Paz,[13] A. Lopez Solis,[83] J. Lorenz,[102] N. Lorenzo Martinez,[5] M. Losada,[21] P. J. Lösel,[102] X. Lou,[35a] A. Lounis,[119] J. Love,[6] P. A. Love,[75] H. Lu,[62a] N. Lu,[92] Y. J. Lu,[63] H. J. Lubatti,[140] C. Luci,[134a,134b] A. Lucotte,[58] C. Luedtke,[51] F. Luehring,[64] W. Lukas,[65] L. Luminari,[134a] O. Lundberg,[148a,148b] B. Lund-Jensen,[149] M. S. Lutz,[89] P. M. Luzi,[83] D. Lynn,[27] R. Lysak,[129] E. Lytken,[84] F. Lyu,[35a] V. Lyubushkin,[68] H. Ma,[27] L. L. Ma,[36b] Y. Ma,[36b] G. Maccarrone,[50] A. Macchiolo,[103] C. M. Macdonald,[141] B. Maček,[78] J. Machado Miguens,[124,128b] D. Madaffari,[170] R. Madar,[37] W. F. Mader,[47] A. Madsen,[45] J. Maeda,[70] S. Maeland,[15] T. Maeno,[27] A. S. Maevskiy,[101] V. Magerl,[51] J. Mahlstedt,[109] C. Maiani,[119] C. Maidantchik,[26a] A. A. Maier,[103] T. Maier,[102] A. Maio,[128a,128b,128d] O. Majersky,[146a] S. Majewski,[118] Y. Makida,[69] N. Makovec,[119] B. Malaescu,[83] Pa. Malecki,[42] V. P. Maleev,[125] F. Malek,[58] U. Mallik,[66] D. Malon,[6] C. Malone,[30] S. Maltezos,[10] S. Malyukov,[32] J. Mamuzic,[170] G. Mancini,[50] I. Mandić,[78] J. Maneira,[128a,128b] L. Manhaes de Andrade Filho,[26b] J. Manjarres Ramos,[47] K. H. Mankinen,[84] A. Mann,[102] A. Manousos,[32] B. Mansoulie,[138] J. D. Mansour,[35a] R. Mantifel,[90] M. Mantoani,[57] S. Manzoni,[94a,94b] L. Mapelli,[32] G. Marceca,[29] L. March,[52] L. Marchese,[122] G. Marchiori,[83] M. Marcisovsky,[129] M. Marjanovic,[37] D. E. Marley,[92] F. Marroquim,[26a] S. P. Marsden,[87] Z. Marshall,[16] M. U. F Martensson,[168] S. Marti-Garcia,[170] C. B. Martin,[113] T. A. Martin,[173] V. J. Martin,[49] B. Martin dit Latour,[15] M. Martinez,[13,w] V. I. Martinez Outschoorn,[169] S. Martin-Haugh,[133] V. S. Martoiu,[28b] A. C. Martyniuk,[81] A. Marzin,[32] L. Masetti,[86] T. Mashimo,[157] R. Mashinistov,[98] J. Masik,[87] A. L. Maslennikov,[111,d] L. Massa,[135a,135b] P. Mastrandrea,[5] A. Mastroberardino,[40a,40b] T. Masubuchi,[157] P. Mättig,[178] J. Maurer,[28b] S. J. Maxfield,[77] D. A. Maximov,[111,d] R. Mazini,[153] I. Maznas,[156] S. M. Mazza,[94a,94b] N. C. Mc Fadden,[107] G. Mc Goldrick,[161] S. P. Mc Kee,[92] A. McCarn,[92] R. L. McCarthy,[150] T. G. McCarthy,[103] L. I. McClymont,[81] E. F. McDonald,[91] J. A. Mcfayden,[81] G. Mchedlidze,[57] S. J. McMahon,[133] P. C. McNamara,[91] R. A. McPherson,[172,p] S. Meehan,[140] T. J. Megy,[51] S. Mehlhase,[102] A. Mehta,[77] T. Meideck,[58] K. Meier,[60a] B. Meirose,[44] D. Melini,[170,kk] B. R. Mellado Garcia,[147c] J. D. Mellenthin,[57] M. Melo,[146a] F. Meloni,[18] A. Melzer,[23] S. B. Menary,[87] L. Meng,[77] X. T. Meng,[92] A. Mengarelli,[22a,22b] S. Menke,[103] E. Meoni,[40a,40b] S. Mergelmeyer,[17] P. Mermod,[52] L. Merola,[106a,106b] C. Meroni,[94a] F. S. Merritt,[33] A. Messina,[134a,134b] J. Metcalfe,[6] A. S. Mete,[166] C. Meyer,[124] J-P. Meyer,[138] J. Meyer,[109] H. Meyer Zu Theenhausen,[60a] F. Miano,[151] R. P. Middleton,[133] S. Miglioranzi,[53a,53b] L. Mijović,[49] G. Mikenberg,[175] M. Mikestikova,[129] M. Mikuž,[78] M. Milesi,[91] A. Milic,[161] D. W. Miller,[33] C. Mills,[49] A. Milov,[175] D. A. Milstead,[148a,148b] A. A. Minaenko,[132] Y. Minami,[157] I. A. Minashvili,[68] A. I. Mincer,[112] B. Mindur,[41a] M. Mineev,[68] Y. Minegishi,[157] Y. Ming,[176] L. M. Mir,[13] K. P. Mistry,[124] T. Mitani,[174] J. Mitrevski,[102] V. A. Mitsou,[170] A. Miucci,[18] P. S. Miyagawa,[141] A. Mizukami,[69] J. U. Mjörnmark,[84] T. Mkrtchyan,[180] M. Mlynarikova,[131] T. Moa,[148a,148b] K. Mochizuki,[97] P. Mogg,[51] S. Mohapatra,[38] S. Molander,[148a,148b]

R. Moles-Valls,[23] R. Monden,[71] M. C. Mondragon,[93] K. Mönig,[45] J. Monk,[39] E. Monnier,[88] A. Montalbano,[150]
J. Montejo Berlingen,[32] F. Monticelli,[74] S. Monzani,[94a,94b] R. W. Moore,[3] N. Morange,[119] D. Moreno,[21] M. Moreno Llácer,[32]
P. Morettini,[53a] S. Morgenstern,[32] D. Mori,[144] T. Mori,[157] M. Morii,[59] M. Morinaga,[157] V. Morisbak,[121] A. K. Morley,[32]
G. Mornacchi,[32] J. D. Morris,[79] L. Morvaj,[150] P. Moschovakos,[10] M. Mosidze,[54b] H. J. Moss,[141] J. Moss,[145,ll]
K. Motohashi,[159] R. Mount,[145] E. Mountricha,[27] E. J. W. Moyse,[89] S. Muanza,[88] F. Mueller,[103] J. Mueller,[127]
R. S. P. Mueller,[102] D. Muenstermann,[75] P. Mullen,[56] G. A. Mullier,[18] F. J. Munoz Sanchez,[87] W. J. Murray,[173,133]
H. Musheghyan,[32] M. Muškinja,[78] A. G. Myagkov,[132,mm] M. Myska,[130] B. P. Nachman,[16] O. Nackenhorst,[52] K. Nagai,[122]
R. Nagai,[69,ee] K. Nagano,[69] Y. Nagasaka,[61] K. Nagata,[164] M. Nagel,[51] E. Nagy,[88] A. M. Nairz,[32] Y. Nakahama,[105]
K. Nakamura,[69] T. Nakamura,[157] I. Nakano,[114] R. F. Naranjo Garcia,[45] R. Narayan,[11] D. I. Narrias Villar,[60a] I. Naryshkin,[125]
T. Naumann,[45] G. Navarro,[21] R. Nayyar,[7] H. A. Neal,[92] P. Yu. Nechaeva,[98] T. J. Neep,[138] A. Negri,[123a,123b] M. Negrini,[22a]
S. Nektarijevic,[108] C. Nellist,[119] A. Nelson,[166] M. E. Nelson,[122] S. Nemecek,[129] P. Nemethy,[112] M. Nessi,[32,nn]
M. S. Neubauer,[169] M. Neumann,[178] P. R. Newman,[19] T. Y. Ng,[62c] T. Nguyen Manh,[97] R. B. Nickerson,[122] R. Nicolaidou,[138]
J. Nielsen,[139] V. Nikolaenko,[132,mm] I. Nikolic-Audit,[83] K. Nikolopoulos,[19] J. K. Nilsen,[121] P. Nilsson,[27] Y. Ninomiya,[157]
A. Nisati,[134a] N. Nishu,[35c] R. Nisius,[103] I. Nitsche,[46] T. Nitta,[174] T. Nobe,[157] Y. Noguchi,[71] M. Nomachi,[120] I. Nomidis,[31]
M. A. Nomura,[27] T. Nooney,[79] M. Nordberg,[32] N. Norjoharuddeen,[122] O. Novgorodova,[47] S. Nowak,[103] M. Nozaki,[69]
L. Nozka,[117] K. Ntekas,[166] E. Nurse,[81] F. Nuti,[91] K. O'connor,[25] D. C. O'Neil,[144] A. A. O'Rourke,[45] V. O'Shea,[56]
F. G. Oakham,[31,e] H. Oberlack,[103] T. Obermann,[23] J. Ocariz,[83] A. Ochi,[70] I. Ochoa,[38] J. P. Ochoa-Ricoux,[34a] S. Oda,[73]
S. Odaka,[69] A. Oh,[87] S. H. Oh,[48] C. C. Ohm,[16] H. Ohman,[168] H. Oide,[53a,53b] H. Okawa,[164] Y. Okumura,[157] T. Okuyama,[69]
A. Olariu,[28b] L. F. Oleiro Seabra,[128a] S. A. Olivares Pino,[34a] D. Oliveira Damazio,[27] A. Olszewski,[42] J. Olszowska,[42]
A. Onofre,[128a,128e] K. Onogi,[105] P. U. E. Onyisi,[11,aa] H. Oppen,[121] M. J. Oreglia,[33] Y. Oren,[155] D. Orestano,[136a,136b]
N. Orlando,[62b] R. S. Orr,[161] B. Osculati,[53a,53b,a] R. Ospanov,[36a] G. Otero y Garzon,[29] H. Otono,[73] M. Ouchrif,[137d]
F. Ould-Saada,[121] A. Ouraou,[138] K. P. Oussoren,[109] Q. Ouyang,[35a] M. Owen,[56] R. E. Owen,[19] V. E. Ozcan,[20a] N. Ozturk,[8]
K. Pachal,[144] A. Pacheco Pages,[13] L. Pacheco Rodriguez,[138] C. Padilla Aranda,[13] S. Pagan Griso,[16] M. Paganini,[179]
F. Paige,[27] G. Palacino,[64] S. Palazzo,[40a,40b] S. Palestini,[32] M. Palka,[41b] D. Pallin,[37] E. St. Panagiotopoulou,[10] I. Panagoulias,[10]
C. E. Pandini,[126a,126b] J. G. Panduro Vazquez,[80] P. Pani,[32] S. Panitkin,[27] D. Pantea,[28b] L. Paolozzi,[52] Th. D. Papadopoulou,[10]
K. Papageorgiou,[9,t] A. Paramonov,[6] D. Paredes Hernandez,[179] A. J. Parker,[75] M. A. Parker,[30] K. A. Parker,[45] F. Parodi,[53a,53b]
J. A. Parsons,[38] U. Parzefall,[51] V. R. Pascuzzi,[161] J. M. Pasner,[139] E. Pasqualucci,[134a] S. Passaggio,[53a] Fr. Pastore,[80]
S. Pataraia,[86] J. R. Pater,[87] T. Pauly,[32] B. Pearson,[103] S. Pedraza Lopez,[170] R. Pedro,[128a,128b] S. V. Peleganchuk,[111,d]
O. Penc,[129] C. Peng,[35a] H. Peng,[36a] J. Penwell,[64] B. S. Peralva,[26b] M. M. Perego,[138] D. V. Perepelitsa,[27] F. Peri,[17]
L. Perini,[94a,94b] H. Pernegger,[32] S. Perrella,[106a,106b] R. Peschke,[45] V. D. Peshekhonov,[68,a] K. Peters,[45] R. F. Y. Peters,[87]
B. A. Petersen,[32] T. C. Petersen,[39] E. Petit,[58] A. Petridis,[1] C. Petridou,[156] P. Petroff,[119] E. Petrolo,[134a] M. Petrov,[122]
F. Petrucci,[136a,136b] N. E. Pettersson,[89] A. Peyaud,[138] R. Pezoa,[34b] F. H. Phillips,[93] P. W. Phillips,[133] G. Piacquadio,[150]
E. Pianori,[173] A. Picazio,[89] E. Piccaro,[79] M. A. Pickering,[122] R. Piegaia,[29] J. E. Pilcher,[33] A. D. Pilkington,[87] A. W. J. Pin,[87]
M. Pinamonti,[135a,135b] J. L. Pinfold,[3] H. Pirumov,[45] M. Pitt,[175] L. Plazak,[146a] M.-A. Pleier,[27] V. Pleskot,[86] E. Plotnikova,[68]
D. Pluth,[67] P. Podberezko,[111] R. Poettgen,[84] R. Poggi,[123a,123b] L. Poggioli,[119] D. Pohl,[23] G. Polesello,[123a] A. Poley,[45]
A. Policicchio,[40a,40b] R. Polifka,[32] A. Polini,[22a] C. S. Pollard,[56] V. Polychronakos,[27] K. Pommès,[32] D. Ponomarenko,[100]
L. Pontecorvo,[134a] G. A. Popeneciu,[28d] D. M. Portillo Quintero,[83] S. Pospisil,[130] K. Potamianos,[16] I. N. Potrap,[68]
C. J. Potter,[30] T. Poulsen,[84] J. Poveda,[32] M. E. Pozo Astigarraga,[32] P. Pralavorio,[88] A. Pranko,[16] S. Prell,[67] D. Price,[87]
M. Primavera,[76a] S. Prince,[90] N. Proklova,[100] K. Prokofiev,[62c] F. Prokoshin,[34b] S. Protopopescu,[27] J. Proudfoot,[6]
M. Przybycien,[41a] A. Puri,[169] P. Puzo,[119] J. Qian,[92] G. Qin,[56] Y. Qin,[87] A. Quadt,[57] M. Queitsch-Maitland,[45] D. Quilty,[56]
S. Raddum,[121] V. Radeka,[27] V. Radescu,[122] S. K. Radhakrishnan,[150] P. Radloff,[118] P. Rados,[91] F. Ragusa,[94a,94b] G. Rahal,[181]
J. A. Raine,[87] S. Rajagopalan,[27] C. Rangel-Smith,[168] T. Rashid,[119] S. Raspopov,[5] M. G. Ratti,[94a,94b] D. M. Rauch,[45]
F. Rauscher,[102] S. Rave,[86] I. Ravinovich,[175] J. H. Rawling,[87] M. Raymond,[32] A. L. Read,[121] N. P. Readioff,[58] M. Reale,[76a,76b]
D. M. Rebuzzi,[123a,123b] A. Redelbach,[177] G. Redlinger,[27] R. Reece,[139] R. G. Reed,[147c] K. Reeves,[44] L. Rehnisch,[17]
J. Reichert,[124] A. Reiss,[86] C. Rembser,[32] H. Ren,[35a] M. Rescigno,[134a] S. Resconi,[94a] E. D. Resseguie,[124] S. Rettie,[171]
E. Reynolds,[19] O. L. Rezanova,[111,d] P. Reznicek,[131] R. Rezvani,[97] R. Richter,[103] S. Richter,[81] E. Richter-Was,[41b] O. Ricken,[23]
M. Ridel,[83] P. Rieck,[103] C. J. Riegel,[178] J. Rieger,[57] O. Rifki,[115] M. Rijssenbeek,[150] A. Rimoldi,[123a,123b] M. Rimoldi,[18]
L. Rinaldi,[22a] G. Ripellino,[149] B. Ristić,[32] E. Ritsch,[32] I. Riu,[13] F. Rizatdinova,[116] E. Rizvi,[79] C. Rizzi,[13] R. T. Roberts,[87]
S. H. Robertson,[90,p] A. Robichaud-Veronneau,[90] D. Robinson,[30] J. E. M. Robinson,[45] A. Robson,[56] E. Rocco,[86]

C. Roda,[126a,126b] Y. Rodina,[88,oo] S. Rodriguez Bosca,[170] A. Rodriguez Perez,[13] D. Rodriguez Rodriguez,[170] S. Roe,[32]
C. S. Rogan,[59] O. Røhne,[121] J. Roloff,[59] A. Romaniouk,[100] M. Romano,[22a,22b] S. M. Romano Saez,[37] E. Romero Adam,[170]
N. Rompotis,[77] M. Ronzani,[51] L. Roos,[83] S. Rosati,[134a] K. Rosbach,[51] P. Rose,[139] N.-A. Rosien,[57] E. Rossi,[106a,106b]
L. P. Rossi,[53a] J. H. N. Rosten,[30] R. Rosten,[140] M. Rotaru,[28b] J. Rothberg,[140] D. Rousseau,[119] A. Rozanov,[88] Y. Rozen,[154]
X. Ruan,[147c] F. Rubbo,[145] F. Rühr,[51] A. Ruiz-Martinez,[31] Z. Rurikova,[51] N. A. Rusakovich,[68] H. L. Russell,[90]
J. P. Rutherfoord,[7] N. Ruthmann,[32] Y. F. Ryabov,[125] M. Rybar,[169] G. Rybkin,[119] S. Ryu,[6] A. Ryzhov,[132] G. F. Rzehorz,[57]
A. F. Saavedra,[152] G. Sabato,[109] S. Sacerdoti,[29] H. F-W. Sadrozinski,[139] R. Sadykov,[68] F. Safai Tehrani,[134a] P. Saha,[110]
M. Sahinsoy,[60a] M. Saimpert,[45] M. Saito,[157] T. Saito,[157] H. Sakamoto,[157] Y. Sakurai,[174] G. Salamanna,[136a,136b]
J. E. Salazar Loyola,[34b] D. Salek,[109] P. H. Sales De Bruin,[168] D. Salihagic,[103] A. Salnikov,[145] J. Salt,[170] D. Salvatore,[40a,40b]
F. Salvatore,[151] A. Salvucci,[62a,62b,62c] A. Salzburger,[32] D. Sammel,[51] D. Sampsonidis,[156] D. Sampsonidou,[156] J. Sánchez,[170]
V. Sanchez Martinez,[170] A. Sanchez Pineda,[167a,167c] H. Sandaker,[121] R. L. Sandbach,[79] C. O. Sander,[45] M. Sandhoff,[178]
C. Sandoval,[21] D. P. C. Sankey,[133] M. Sannino,[53a,53b] Y. Sano,[105] A. Sansoni,[50] C. Santoni,[37] H. Santos,[128a]
I. Santoyo Castillo,[151] A. Sapronov,[68] J. G. Saraiva,[128a,128d] B. Sarrazin,[23] O. Sasaki,[69] K. Sato,[164] E. Sauvan,[5] G. Savage,[80]
P. Savard,[161,e] N. Savic,[103] C. Sawyer,[133] L. Sawyer,[82,v] J. Saxon,[33] C. Sbarra,[22a] A. Sbrizzi,[22a,22b] T. Scanlon,[81]
D. A. Scannicchio,[166] M. Scarcella,[152] J. Schaarschmidt,[140] P. Schacht,[103] B. M. Schachtner,[102] D. Schaefer,[32] L. Schaefer,[124]
R. Schaefer,[45] J. Schaeffer,[86] S. Schaepe,[23] S. Schaetzel,[60b] U. Schäfer,[86] A. C. Schaffer,[119] D. Schaile,[102]
R. D. Schamberger,[150] V. A. Schegelsky,[125] D. Scheirich,[131] M. Schernau,[166] C. Schiavi,[53a,53b] S. Schier,[139]
L. K. Schildgen,[23] C. Schillo,[51] M. Schioppa,[40a,40b] S. Schlenker,[32] K. R. Schmidt-Sommerfeld,[103] K. Schmieden,[32]
C. Schmitt,[86] S. Schmitt,[45] S. Schmitz,[86] U. Schnoor,[51] L. Schoeffel,[138] A. Schoening,[60b] B. D. Schoenrock,[93] E. Schopf,[23]
M. Schott,[86] J. F. P. Schouwenberg,[108] J. Schovancova,[32] S. Schramm,[52] N. Schuh,[86] A. Schulte,[86] M. J. Schultens,[23]
H.-C. Schultz-Coulon,[60a] H. Schulz,[17] M. Schumacher,[51] B. A. Schumm,[139] Ph. Schune,[138] A. Schwartzman,[145]
T. A. Schwarz,[92] H. Schweiger,[87] Ph. Schwemling,[138] R. Schwienhorst,[93] J. Schwindling,[138] A. Sciandra,[23] G. Sciolla,[25]
M. Scornajenghi,[40a,40b] F. Scuri,[126a,126b] F. Scutti,[91] J. Searcy,[92] P. Seema,[23] S. C. Seidel,[107] A. Seiden,[139] J. M. Seixas,[26a]
G. Sekhniaidze,[106a] K. Sekhon,[92] S. J. Sekula,[43] N. Semprini-Cesari,[22a,22b] S. Senkin,[37] C. Serfon,[121] L. Serin,[119]
L. Serkin,[167a,167b] M. Sessa,[136a,136b] R. Seuster,[172] H. Severini,[115] T. Sfiligoj,[78] F. Sforza,[32] A. Sfyrla,[52] E. Shabalina,[57]
N. W. Shaikh,[148a,148b] L. Y. Shan,[35a] R. Shang,[169] J. T. Shank,[24] M. Shapiro,[16] P. B. Shatalov,[99] K. Shaw,[167a,167b]
S. M. Shaw,[87] A. Shcherbakova,[148a,148b] C. Y. Shehu,[151] Y. Shen,[115] N. Sherafati,[31] P. Sherwood,[81] L. Shi,[153,pp] S. Shimizu,[70]
C. O. Shimmin,[179] M. Shimojima,[104] I. P. J. Shipsey,[122] S. Shirabe,[73] M. Shiyakova,[68,qq] J. Shlomi,[175] A. Shmeleva,[98]
D. Shoaleh Saadi,[97] M. J. Shochet,[33] S. Shojaii,[94a] D. R. Shope,[115] S. Shrestha,[113] E. Shulga,[100] M. A. Shupe,[7] P. Sicho,[129]
A. M. Sickles,[169] P. E. Sidebo,[149] E. Sideras Haddad,[147c] O. Sidiropoulou,[177] A. Sidoti,[22a,22b] F. Siegert,[47] Dj. Sijacki,[14]
J. Silva,[128a,128d] S. B. Silverstein,[148a] V. Simak,[130] Lj. Simic,[14] S. Simion,[119] E. Simioni,[86] B. Simmons,[81] M. Simon,[86]
P. Sinervo,[161] N. B. Sinev,[118] M. Sioli,[22a,22b] G. Siragusa,[177] I. Siral,[92] S. Yu. Sivoklokov,[101] J. Sjölin,[148a,148b] M. B. Skinner,[75]
P. Skubic,[115] M. Slater,[19] T. Slavicek,[130] M. Slawinska,[42] K. Sliwa,[165] R. Slovak,[131] V. Smakhtin,[175] B. H. Smart,[5]
J. Smiesko,[146a] N. Smirnov,[100] S. Yu. Smirnov,[100] Y. Smirnov,[100] L. N. Smirnova,[101,rr] O. Smirnova,[84] J. W. Smith,[57]
M. N. K. Smith,[38] R. W. Smith,[38] M. Smizanska,[75] K. Smolek,[130] A. A. Snesarev,[98] I. M. Snyder,[118] S. Snyder,[27]
R. Sobie,[172,p] F. Socher,[47] A. Soffer,[155] A. Søgaard,[49] D. A. Soh,[153] G. Sokhrannyi,[78] C. A. Solans Sanchez,[32] M. Solar,[130]
E. Yu. Soldatov,[100] U. Soldevila,[170] A. A. Solodkov,[132] A. Soloshenko,[68] O. V. Solovyanov,[132] V. Solovyev,[125] P. Sommer,[51]
H. Son,[165] A. Sopczak,[130] D. Sosa,[60b] C. L. Sotiropoulou,[126a,126b] R. Soualah,[167a,167c] A. M. Soukharev,[111,d] D. South,[45]
B. C. Sowden,[80] S. Spagnolo,[76a,76b] M. Spalla,[126a,126b] M. Spangenberg,[173] F. Spanò,[80] D. Sperlich,[17] F. Spettel,[103]
T. M. Spieker,[60a] R. Spighi,[22a] G. Spigo,[32] L. A. Spiller,[91] M. Spousta,[131] R. D. St. Denis,[56,a] A. Stabile,[94a] R. Stamen,[60a]
S. Stamm,[17] E. Stanecka,[42] R. W. Stanek,[6] C. Stanescu,[136a] M. M. Stanitzki,[45] B. S. Stapf,[109] S. Stapnes,[121]
E. A. Starchenko,[132] G. H. Stark,[33] J. Stark,[58] S. H Stark,[39] P. Staroba,[129] P. Starovoitov,[60a] S. Stärz,[32] R. Staszewski,[42]
P. Steinberg,[27] B. Stelzer,[144] H. J. Stelzer,[32] O. Stelzer-Chilton,[163a] H. Stenzel,[55] G. A. Stewart,[56] M. C. Stockton,[118]
M. Stoebe,[90] G. Stoicea,[28b] P. Stolte,[57] S. Stonjek,[103] A. R. Stradling,[8] A. Straessner,[47] M. E. Stramaglia,[18] J. Strandberg,[149]
S. Strandberg,[148a,148b] M. Strauss,[115] P. Strizenec,[146b] R. Ströhmer,[177] D. M. Strom,[118] R. Stroynowski,[43] A. Strubig,[49]
S. A. Stucci,[27] B. Stugu,[15] N. A. Styles,[45] D. Su,[145] J. Su,[127] S. Suchek,[60a] Y. Sugaya,[120] M. Suk,[130] V. V. Sulin,[98]
DMS Sultan,[162a,162b] S. Sultansoy,[4c] T. Sumida,[71] S. Sun,[59] X. Sun,[3] K. Suruliz,[151] C. J. E. Suster,[152] M. R. Sutton,[151]
S. Suzuki,[69] M. Svatos,[129] M. Swiatlowski,[33] S. P. Swift,[2] I. Sykora,[146a] T. Sykora,[131] D. Ta,[51] K. Tackmann,[45] J. Taenzer,[155]
A. Taffard,[166] R. Tafirout,[163a] E. Tahirovic,[79] N. Taiblum,[155] H. Takai,[27] R. Takashima,[72] E. H. Takasugi,[103] T. Takeshita,[142]

Y. Takubo,[69] M. Talby,[88] A. A. Talyshev,[111,d] J. Tanaka,[157] M. Tanaka,[159] R. Tanaka,[119] S. Tanaka,[69] R. Tanioka,[70] B. B. Tannenwald,[113] S. Tapia Araya,[34b] S. Tapprogge,[86] S. Tarem,[154] G. F. Tartarelli,[94a] P. Tas,[131] M. Tasevsky,[129] T. Tashiro,[71] E. Tassi,[40a,40b] A. Tavares Delgado,[128a,128b] Y. Tayalati,[137e] A. C. Taylor,[107] G. N. Taylor,[91] P. T. E. Taylor,[91] W. Taylor,[163b] P. Teixeira-Dias,[80] D. Temple,[144] H. Ten Kate,[32] P. K. Teng,[153] J. J. Teoh,[120] F. Tepel,[178] S. Terada,[69] K. Terashi,[157] J. Terron,[85] S. Terzo,[13] M. Testa,[50] R. J. Teuscher,[161,p] T. Theveneaux-Pelzer,[88] F. Thiele,[39] J. P. Thomas,[19] J. Thomas-Wilsker,[80] P. D. Thompson,[19] A. S. Thompson,[56] L. A. Thomsen,[179] E. Thomson,[124] M. J. Tibbetts,[16] R. E. Ticse Torres,[88] V. O. Tikhomirov,[98,ss] Yu. A. Tikhonov,[111,d] S. Timoshenko,[100] P. Tipton,[179] S. Tisserant,[88] K. Todome,[159] S. Todorova-Nova,[5] S. Todt,[47] J. Tojo,[73] S. Tokár,[146a] K. Tokushuku,[69] E. Tolley,[59] L. Tomlinson,[87] M. Tomoto,[105] L. Tompkins,[145,tt] K. Toms,[107] B. Tong,[59] P. Tornambe,[51] E. Torrence,[118] H. Torres,[144] E. Torró Pastor,[140] J. Toth,[88,uu] F. Touchard,[88] D. R. Tovey,[141] C. J. Treado,[112] T. Trefzger,[177] F. Tresoldi,[151] A. Tricoli,[27] I. M. Trigger,[163a] S. Trincaz-Duvoid,[83] M. F. Tripiana,[13] W. Trischuk,[161] B. Trocmé,[58] A. Trofymov,[45] C. Troncon,[94a] M. Trottier-McDonald,[16] M. Trovatelli,[172] L. Truong,[147b] M. Trzebinski,[42] A. Trzupek,[42] K. W. Tsang,[62a] J. C-L. Tseng,[122] P. V. Tsiareshka,[95] G. Tsipolitis,[10] N. Tsirintanis,[9] S. Tsiskaridze,[13] V. Tsiskaridze,[51] E. G. Tskhadadze,[54a] K. M. Tsui,[62a] I. I. Tsukerman,[99] V. Tsulaia,[16] S. Tsuno,[69] D. Tsybychev,[150] Y. Tu,[62b] A. Tudorache,[28b] V. Tudorache,[28b] T. T. Tulbure,[28a] A. N. Tuna,[59] S. A. Tupputi,[22a,22b] S. Turchikhin,[68] D. Turgeman,[175] I. Turk Cakir,[4b,vv] R. Turra,[94a] P. M. Tuts,[38] G. Ucchielli,[22a,22b] I. Ueda,[69] M. Ughetto,[148a,148b] F. Ukegawa,[164] G. Unal,[32] A. Undrus,[27] G. Unel,[166] F. C. Ungaro,[91] Y. Unno,[69] C. Unverdorben,[102] J. Urban,[146b] P. Urquijo,[91] P. Urrejola,[86] G. Usai,[8] J. Usui,[69] L. Vacavant,[88] V. Vacek,[130] B. Vachon,[90] K. O. H. Vadla,[121] A. Vaidya,[81] C. Valderanis,[102] E. Valdes Santurio,[148a,148b] M. Valente,[52] S. Valentinetti,[22a,22b] A. Valero,[170] L. Valéry,[13] S. Valkar,[131] A. Vallier,[5] J. A. Valls Ferrer,[170] W. Van Den Wollenberg,[109] H. van der Graaf,[109] P. van Gemmeren,[6] J. Van Nieuwkoop,[144] I. van Vulpen,[109] M. C. van Woerden,[109] M. Vanadia,[135a,135b] W. Vandelli,[32] A. Vaniachine,[160] P. Vankov,[109] G. Vardanyan,[180] R. Vari,[134a] E. W. Varnes,[7] C. Varni,[53a,53b] T. Varol,[43] D. Varouchas,[119] A. Vartapetian,[8] K. E. Varvell,[152] J. G. Vasquez,[179] G. A. Vasquez,[34b] F. Vazeille,[37] T. Vazquez Schroeder,[90] J. Veatch,[57] V. Veeraraghavan,[7] L. M. Veloce,[161] F. Veloso,[128a,128c] S. Veneziano,[134a] A. Ventura,[76a,76b] M. Venturi,[172] N. Venturi,[32] A. Venturini,[25] V. Vercesi,[123a] M. Verducci,[136a,136b] W. Verkerke,[109] A. T. Vermeulen,[109] J. C. Vermeulen,[109] M. C. Vetterli,[144,e] N. Viaux Maira,[34b] O. Viazlo,[84] I. Vichou,[169,a] T. Vickey,[141] O. E. Vickey Boeriu,[141] G. H. A. Viehhauser,[122] S. Viel,[16] L. Vigani,[122] M. Villa,[22a,22b] M. Villaplana Perez,[94a,94b] E. Vilucchi,[50] M. G. Vincter,[31] V. B. Vinogradov,[68] A. Vishwakarma,[45] C. Vittori,[22a,22b] I. Vivarelli,[151] S. Vlachos,[10] M. Vogel,[178] P. Vokac,[130] G. Volpi,[126a,126b] H. von der Schmitt,[103] E. von Toerne,[23] V. Vorobel,[131] K. Vorobev,[100] M. Vos,[170] R. Voss,[32] J. H. Vossebeld,[77] N. Vranjes,[14] M. Vranjes Milosavljevic,[14] V. Vrba,[130] M. Vreeswijk,[109] R. Vuillermet,[32] I. Vukotic,[33] P. Wagner,[23] W. Wagner,[178] J. Wagner-Kuhr,[102] H. Wahlberg,[74] S. Wahrmund,[47] J. Wakabayashi,[105] J. Walder,[75] R. Walker,[102] W. Walkowiak,[143] V. Wallangen,[148a,148b] C. Wang,[35b] C. Wang,[36b,ww] F. Wang,[176] H. Wang,[16] H. Wang,[3] J. Wang,[45] J. Wang,[152] Q. Wang,[115] R. Wang,[6] S. M. Wang,[153] T. Wang,[38] W. Wang,[153,xx] W. Wang,[36a] Z. Wang,[36c] C. Wanotayaroj,[118] A. Warburton,[90] C. P. Ward,[30] D. R. Wardrope,[81] A. Washbrook,[49] P. M. Watkins,[19] A. T. Watson,[19] M. F. Watson,[19] G. Watts,[140] S. Watts,[87] B. M. Waugh,[81] A. F. Webb,[11] S. Webb,[86] M. S. Weber,[18] S. W. Weber,[177] S. A. Weber,[31] J. S. Webster,[6] A. R. Weidberg,[122] B. Weinert,[64] J. Weingarten,[57] M. Weirich,[86] C. Weiser,[51] H. Weits,[109] P. S. Wells,[32] T. Wenaus,[27] T. Wengler,[32] S. Wenig,[32] N. Wermes,[23] M. D. Werner,[67] P. Werner,[32] M. Wessels,[60a] T. D. Weston,[18] K. Whalen,[118] N. L. Whallon,[140] A. M. Wharton,[75] A. S. White,[92] A. White,[8] M. J. White,[1] R. White,[34b] D. Whiteson,[166] B. W. Whitmore,[75] F. J. Wickens,[133] W. Wiedenmann,[176] M. Wielers,[133] C. Wiglesworth,[39] L. A. M. Wiik-Fuchs,[51] A. Wildauer,[103] F. Wilk,[87] H. G. Wilkens,[32] H. H. Williams,[124] S. Williams,[109] C. Willis,[93] S. Willocq,[89] J. A. Wilson,[19] I. Wingerter-Seez,[5] E. Winkels,[151] F. Winklmeier,[118] O. J. Winston,[151] B. T. Winter,[23] M. Wittgen,[145] M. Wobisch,[82,v] T. M. H. Wolf,[109] R. Wolff,[88] M. W. Wolter,[42] H. Wolters,[128a,128c] V. W. S. Wong,[171] S. D. Worm,[19] B. K. Wosiek,[42] J. Wotschack,[32] K. W. Wozniak,[42] M. Wu,[33] S. L. Wu,[176] X. Wu,[52] Y. Wu,[92] T. R. Wyatt,[87] B. M. Wynne,[49] S. Xella,[39] Z. Xi,[92] L. Xia,[35c] D. Xu,[35a] L. Xu,[27] T. Xu,[138] B. Yabsley,[152] S. Yacoob,[147a] D. Yamaguchi,[159] Y. Yamaguchi,[120] A. Yamamoto,[69] S. Yamamoto,[157] T. Yamanaka,[157] M. Yamatani,[157] K. Yamauchi,[105] Y. Yamazaki,[70] Z. Yan,[24] H. Yang,[36c] H. Yang,[16] Y. Yang,[153] Z. Yang,[15] W-M. Yao,[16] Y. C. Yap,[83] Y. Yasu,[69] E. Yatsenko,[5] K. H. Yau Wong,[23] J. Ye,[43] S. Ye,[27] I. Yeletskikh,[68] E. Yigitbasi,[24] E. Yildirim,[86] K. Yorita,[174] K. Yoshihara,[124] C. Young,[145] C. J. S. Young,[32] J. Yu,[8] J. Yu,[67] S. P. Y. Yuen,[23] I. Yusuff,[30,yy] B. Zabinski,[42] G. Zacharis,[10] R. Zaidan,[13] A. M. Zaitsev,[132,mm] N. Zakharchuk,[45] J. Zalieckas,[15] A. Zaman,[150] S. Zambito,[59] D. Zanzi,[91] C. Zeitnitz,[178] G. Zemaityte,[122] A. Zemla,[41a] J. C. Zeng,[169] Q. Zeng,[145] O. Zenin,[132] T. Ženiš,[146a] D. Zerwas,[119] D. Zhang,[92] F. Zhang,[176] G. Zhang,[36a,zz] H. Zhang,[35b]

J. Zhang,[6] L. Zhang,[51] L. Zhang,[36a] M. Zhang,[169] P. Zhang,[35b] R. Zhang,[23] R. Zhang,[36a,ww] X. Zhang,[36b] Y. Zhang,[35a] Z. Zhang,[119] X. Zhao,[43] Y. Zhao,[36b,aaa] Z. Zhao,[36a] A. Zhemchugov,[68] B. Zhou,[92] C. Zhou,[176] L. Zhou,[43] M. Zhou,[35a] M. Zhou,[150] N. Zhou,[35c] C. G. Zhu,[36b] H. Zhu,[35a] J. Zhu,[92] Y. Zhu,[36a] X. Zhuang,[35a] K. Zhukov,[98] A. Zibell,[177] D. Zieminska,[64] N. I. Zimine,[68] C. Zimmermann,[86] S. Zimmermann,[51] Z. Zinonos,[103] M. Zinser,[86] M. Ziolkowski,[143] L. Živković,[14] G. Zobernig,[176] A. Zoccoli,[22a,22b] R. Zou,[33] M. zur Nedden,[17] and L. Zwalinski[32]

(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]*Istanbul Aydin University, Istanbul, Turkey*
[4c]*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[5]*LAPP, CNRS/IN2P3 and Université Savoie Mont Blanc, 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, National and Kapodistrian University of Athens, Athens, Greece*
[10]*Physics Department, National Technical University of Athens, Zografou, Greece*
[11]*Department of Physics, The University of Texas at Austin, Austin, Texas, USA*
[12]*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[13]*Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Barcelona, Spain*
[14]*Institute of Physics, University of Belgrade, Belgrade, Serbia*
[15]*Department for Physics and Technology, University of Bergen, Bergen, Norway*
[16]*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
[17]*Department of Physics, Humboldt University, Berlin, Germany*
[18]*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
[19]*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
[20a]*Department of Physics, Bogazici University, Istanbul, Turkey*
[20b]*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
[20d]*Istanbul Bilgi University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey*
[20e]*Bahcesehir University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey*
[21]*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
[22a]*INFN Sezione di Bologna, Italy*
[22b]*Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy*
[23]*Physikalisches Institut, University of Bonn, Bonn, Germany*
[24]*Department of Physics, Boston University, Boston, Massachusetts, USA*
[25]*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
[26a]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
[26b]*Electrical Circuits Department, Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
[26c]*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
[26d]*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*
[27]*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
[28a]*Transilvania University of Brasov, Brasov, Romania*
[28b]*Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
[28c]*Department of Physics, Alexandru Ioan Cuza University of Iasi, Iasi, Romania*
[28d]*National Institute for Research and Development of Isotopic and Molecular Technologies,*
Physics Department, Cluj Napoca, Romania
[28e]*University Politehnica Bucharest, Bucharest, Romania*
[28f]*West University in Timisoara, Timisoara, Romania*
[29]*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
[30]*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
[31]*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
[32]*CERN, Geneva, Switzerland*
[33]*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
[34a]*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*

[34b]*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
[35a]*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
[35b]*Department of Physics, Nanjing University, Jiangsu, China*
[35c]*Physics Department, Tsinghua University, Beijing, China*
[36a]*Department of Modern Physics and State Key Laboratory of Particle Detection and Electronics,*
University of Science and Technology of China, Anhui, China
[36b]*School of Physics, Shandong University, Shandong, China*
[36c]*Department of Physics and Astronomy, Key Laboratory for Particle Physics, Astrophysics and Cosmology, Ministry of Education;*
Shanghai Key Laboratory for Particle Physics and Cosmology, Shanghai Jiao Tong University, Shanghai(also at PKU-CHEP), China
[37]*Université Clermont Auvergne, CNRS/IN2P3, LPC, Clermont-Ferrand, France*
[38]*Nevis Laboratory, Columbia University, Irvington, New York, USA*
[39]*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
[40a]*INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati, Italy*
[40b]*Dipartimento di Fisica, Università della Calabria, Rende, Italy*
[41a]*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
[41b]*Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland*
[42]*Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland*
[43]*Physics Department, Southern Methodist University, Dallas, Texas, USA*
[44]*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
[45]*DESY, Hamburg and Zeuthen, Germany*
[46]*Lehrstuhl für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
[47]*Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany*
[48]*Department of Physics, Duke University, Durham, North Carolina, USA*
[49]*SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
[50]*INFN e Laboratori Nazionali di Frascati, Frascati, Italy*
[51]*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany*
[52]*Departement de Physique Nucleaire et Corpusculaire, Université de Genève, Geneva, Switzerland*
[53a]*INFN Sezione di Genova, Italy*
[53b]*Dipartimento di Fisica, Università di Genova, Genova, Italy*
[54a]*E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[54b]*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
[55]*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
[56]*SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
[57]*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
[58]*Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble, France*
[59]*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
[60a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[60b]*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[61]*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
[62a]*Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China*
[62b]*Department of Physics, The University of Hong Kong, Hong Kong, China*
[62c]*Department of Physics and Institute for Advanced Study, The Hong Kong University of Science and Technology,*
Clear Water Bay, Kowloon, Hong Kong, China
[63]*Department of Physics, National Tsing Hua University, Taiwan, Taiwan*
[64]*Department of Physics, Indiana University, Bloomington, Indiana, USA*
[65]*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
[66]*University of Iowa, Iowa City, Iowa, USA*
[67]*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
[68]*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
[69]*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
[70]*Graduate School of Science, Kobe University, Kobe, Japan*
[71]*Faculty of Science, Kyoto University, Kyoto, Japan*
[72]*Kyoto University of Education, Kyoto, Japan*
[73]*Research Center for Advanced Particle Physics and Department of Physics, Kyushu University, Fukuoka, Japan*
[74]*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
[75]*Physics Department, Lancaster University, Lancaster, United Kingdom*
[76a]*INFN Sezione di Lecce, Italy*
[76b]*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[77]*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*

[78]Department of Experimental Particle Physics, Jožef Stefan Institute and Department of Physics,
University of Ljubljana, Ljubljana, Slovenia

[79]School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom

[80]Department of Physics, Royal Holloway University of London, Surrey, United Kingdom

[81]Department of Physics and Astronomy, University College London, London, United Kingdom

[82]Louisiana Tech University, Ruston, Los Angeles, USA

[83]Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France

[84]Fysiska institutionen, Lunds universitet, Lund, Sweden

[85]Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain

[86]Institut für Physik, Universität Mainz, Mainz, Germany

[87]School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom

[88]CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France

[89]Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA

[90]Department of Physics, McGill University, Montreal, Québec, Canada

[91]School of Physics, University of Melbourne, Victoria, Australia

[92]Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA

[93]Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA

[94a]INFN Sezione di Milano, Italy

[94b]Dipartimento di Fisica, Università di Milano, Milano, Italy

[95]B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus

[96]Research Institute for Nuclear Problems of Byelorussian State University, Minsk, Republic of Belarus

[97]Group of Particle Physics, University of Montreal, Montreal, Québec, Canada

[98]P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia

[99]Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia

[100]National Research Nuclear University MEPhI, Moscow, Russia

[101]D.V. Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia

[102]Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany

[103]Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany

[104]Nagasaki Institute of Applied Science, Nagasaki, Japan

[105]Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan

[106a]INFN Sezione di Napoli, Italy

[106b]Dipartimento di Fisica, Università di Napoli, Napoli, Italy

[107]Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA

[108]Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands

[109]Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands

[110]Department of Physics, Northern Illinois University, DeKalb, Illinois, USA

[111]Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia

[112]Department of Physics, New York University, New York, New York, USA

[113]Ohio State University, Columbus, Ohio, USA

[114]Faculty of Science, Okayama University, Okayama, Japan

[115]Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA

[116]Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA

[117]Palacký University, RCPTM, Olomouc, Czech Republic

[118]Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA

[119]LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France

[120]Graduate School of Science, Osaka University, Osaka, Japan

[121]Department of Physics, University of Oslo, Oslo, Norway

[122]Department of Physics, Oxford University, Oxford, United Kingdom

[123a]INFN Sezione di Pavia, Italy

[123b]Dipartimento di Fisica, Università di Pavia, Pavia, Italy

[124]Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA

[125]National Research Centre "Kurchatov Institute" B.P.Konstantinov Petersburg Nuclear Physics Institute, St. Petersburg, Russia

[126a]INFN Sezione di Pisa, Italy

[126b]Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy

[127]Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

[128a]Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa, Portugal

[128b]Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal

[128c]Department of Physics, University of Coimbra, Coimbra, Portugal

[128d]Centro de Física Nuclear da Universidade de Lisboa, Lisboa, Portugal

[128e]Departamento de Fisica, Universidade do Minho, Braga, Portugal

[128f]Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Portugal

[128g]Dep Fisica and CEFITEC of Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal

[129]Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic

[130]Czech Technical University in Prague, Praha, Czech Republic

[131]Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic

[132]State Research Center Institute for High Energy Physics (Protvino), NRC KI, Russia

[133]Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom

[134a]INFN Sezione di Roma, Italy

[134b]Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy

[135a]INFN Sezione di Roma Tor Vergata, Italy

[135b]Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy

[136a]INFN Sezione di Roma Tre, Italy

[136b]Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy

[137a]Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II,
Casablanca, Morocco

[137b]Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco

[137c]Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco

[137d]Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco

[137e]Faculté des sciences, Université Mohammed V, Rabat, Morocco

[138]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

[139]Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA

[140]Department of Physics, University of Washington, Seattle, Washington, USA

[141]Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom

[142]Department of Physics, Shinshu University, Nagano, Japan

[143]Department Physik, Universität Siegen, Siegen, Germany

[144]Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada

[145]SLAC National Accelerator Laboratory, Stanford, California, USA

[146a]Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic

[146b]Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic

[147a]Department of Physics, University of Cape Town, Cape Town, South Africa

[147b]Department of Physics, University of Johannesburg, Johannesburg, South Africa

[147c]School of Physics, University of the Witwatersrand, Johannesburg, South Africa

[148a]Department of Physics, Stockholm University, Sweden

[148b]The Oskar Klein Centre, Stockholm, Sweden

[149]Physics Department, Royal Institute of Technology, Stockholm, Sweden

[150]Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA

[151]Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom

[152]School of Physics, University of Sydney, Sydney, Australia

[153]Institute of Physics, Academia Sinica, Taipei, Taiwan

[154]Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel

[155]Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel

[156]Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece

[157]International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan

[158]Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan

[159]Department of Physics, Tokyo Institute of Technology, Tokyo, Japan

[160]Tomsk State University, Tomsk, Russia

[161]Department of Physics, University of Toronto, Toronto, Ontario, Canada

[162a]INFN-TIFPA, Italy

[162b]University of Trento, Trento, Italy

[163a]TRIUMF, Vancouver, British Columbia, Canada

[163b]Department of Physics and Astronomy, York University, Toronto, Ontario, Canada

[164]Faculty of Pure and Applied Sciences, and Center for Integrated Research in Fundamental Science and Engineering,
University of Tsukuba, Tsukuba, Japan

[165]Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA

[166]Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA

[167a]INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine, Italy

[167b]ICTP, Trieste, Italy

[167c]Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy

[168]Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden

[169]Department of Physics, University of Illinois, Urbana, Illinois, USA

[170]Instituto de Fisica Corpuscular (IFIC), Centro Mixto Universidad de Valencia - CSIC, Spain

[171]Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada

[172]Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada

[173]Department of Physics, University of Warwick, Coventry, United Kingdom

[174]Waseda University, Tokyo, Japan

[175]Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel

[176]Department of Physics, University of Wisconsin, Madison, Wisconsin, USA

[177]Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany

[178]Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal, Germany

[179]Department of Physics, Yale University, New Haven, Connecticut, USA

[180]Yerevan Physics Institute, Yerevan, Armenia

[181]Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France

[182]Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan

[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 Novosibirsk State University, Novosibirsk, Russia.

[e]Also at TRIUMF, Vancouver, BC, Canada.

[f]Also at Department of Physics & Astronomy, University of Louisville, Louisville, KY, USA.

[g]Also at Physics Department, An-Najah National University, Nablus, Palestine.

[h]Also at Department of Physics, California State University, Fresno, CA, USA.

[i]Also at Department of Physics, University of Fribourg, Fribourg, Switzerland.

[j]Also at II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany.

[k]Also at Departament de Fisica de la Universitat Autonoma de Barcelona, Barcelona, Spain.

[l]Also at Departamento de Fisica e Astronomia, Faculdade de Ciencias, Universidade do Porto, Portugal.

[m]Also at Tomsk State University, Tomsk, Russia.

[n]Also at The Collaborative Innovation Center of Quantum Matter (CICQM), Beijing, China.

[o]Also at Universita di Napoli Parthenope, Napoli, Italy.

[p]Also at Institute of Particle Physics (IPP), Canada.

[q]Also at Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania.

[r]Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.

[s]Also at Borough of Manhattan Community College, City University of New York, New York City, USA.

[t]Also at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece.

[u]Also at Centre for High Performance Computing, CSIR Campus, Rosebank, Cape Town, South Africa.

[v]Also at Louisiana Tech University, Ruston, LA, USA.

[w]Also at Institucio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.

[x]Also at Graduate School of Science, Osaka University, Osaka, Japan.

[y]Also at Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany.

[z]Also at Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands.

[aa]Also at Department of Physics, The University of Texas at Austin, Austin, TX, USA.

[bb]Also at Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia.

[cc]Also at CERN, Geneva, Switzerland.

[dd]Also at Georgian Technical University (GTU),Tbilisi, Georgia.

[ee]Also at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan.

[ff]Also at Manhattan College, New York, NY, USA.

[gg]Also at Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile.

[hh]Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.

[ii]Also at The City College of New York, New York, NY, USA.

[jj]Also at School of Physics, Shandong University, Shandong, China.

[kk]Also at Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Portugal.

[ll]Also at Department of Physics, California State University, Sacramento, CA, USA.

[mm]Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.

[nn]Also at Departement de Physique Nucleaire et Corpusculaire, Université de Genève, Geneva, Switzerland.

[oo]Also at Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Barcelona, Spain.

[pp]Also at School of Physics, Sun Yat-sen University, Guangzhou, China.

[qq]Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.

[rr]Also at Faculty of Physics, M.V.Lomonosov Moscow State University, Moscow, Russia.

[ss]Also at National Research Nuclear University MEPhI, Moscow, Russia.

[tt]Also at Department of Physics, Stanford University, Stanford, CA, USA.

[uu]Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.

[vv]Also at Giresun University, Faculty of Engineering, Turkey.

[ww]Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.

[xx]Also at Department of Physics, Nanjing University, Jiangsu, China.

[yy]Also at University of Malaya, Department of Physics, Kuala Lumpur, Malaysia.

[zz]Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.

[aaa]Also at LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France.