Measurement of the Azimuthal Angle Dependence of Inclusive Jet Yields in Pb plus Pb Collisions at root s(NN)=2.76 TeV with the ATLAS Detector

Aad, G.; Abajyan, T.; Abbott, B.; Abdallah, J.; Khalek, S. Abdel; Abdinov, O.; Aben, R.; Abi, B.; Abolins, M.; AbouZeid, O. S.; Abramowicz, H.; Abreu, H.; Abulaiti, Y.; Acharya, B. S.; Adamczyk, L.; Adams, D. L.; Addy, T. N.; Adelman, J.; Adomeit, S.; Adye, T.; Aefsky, S.; Agatonovic-Jovin, T.; Aguilar-Saavedra, J. A.; Agustoni, M.; Ahlen, S. P.; Ahmad, A.; Ahsan, M.; Aielli, G.; Åkesson, Torsten; Akimoto, G.; Akimov, A. V.; Alam, M. A.; Albert, J.; Albrand, S.; Verzini, M. J. Alconada; Aleksa, M.; Aleksandrov, I. N.; Alessandria, F.; Alexa, C.; Alexander, G.; Alexandre, G.; Alexopoulos, T.; Alhroob, M.; Aliev, M.; Alimonti, G.; Alio, L.; Alison, J.; Allbrooke, B. M. M.; Allison, L. J.; Allport, P. P.

Published in:
Physical Review Letters

DOI:
10.1103/PhysRevLett.111.152301

2013

Citation for published version (APA):
Aad, G., Abajyan, T., Abbott, B., Abdallah, J., Khalek, S. A., Abdinov, O., Aben, R., Abi, B., Abolins, M., AbouZeid, O. S., Abramowicz, H., Abreu, H., Abulaiti, Y., Acharya, B. S., Adamczyk, L., Adams, D. L., Addy, T. N., Adelman, J., Adomeit, S., ... Zwalinski, L. (2013). Measurement of the Azimuthal Angle Dependence of Inclusive Jet Yields in Pb plus Pb Collisions at root s(NN)=2.76 TeV with the ATLAS Detector. *Physical Review Letters*, *111*(15), Article 152301. https://doi.org/10.1103/PhysRevLett.111.152301

Total number of authors:
2916

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Measurement of the Azimuthal Angle Dependence of Inclusive Jet Yields in Pb + Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS Detector

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

(Received 26 June 2013; published 9 October 2013)

Measurements of the variation of inclusive jet suppression as a function of relative azimuthal angle, $\Delta\phi$, with respect to the elliptic event plane provide insight into the path-length dependence of jet quenching. ATLAS has measured the $\Delta\phi$ dependence of jet yields in 0.14 nb^{-1} of $\sqrt{s_{NN}} = 2.76$ TeV Pb + Pb collisions at the LHC for jet transverse momenta $p_T > 45$ GeV in different collision centrality bins using an underlying event subtraction procedure that accounts for elliptic flow. The variation of the jet yield with $\Delta\phi$ was characterized by the parameter, v_2^{jet}, and the ratio of out-of-plane ($\Delta\phi \sim \pi/2$) to in-plane ($\Delta\phi \sim 0$) yields. Nonzero v_2^{jet} values were measured in all centrality bins for $p_T < 160$ GeV. The jet yields are observed to vary by as much as 20% between in-plane and out-of-plane directions.

DOI: 10.1103/PhysRevLett.111.152301 PACS numbers: 25.75.−q

Studies of jet production in Pb + Pb collisions at the LHC [1,2] show behavior consistent with "jet quenching," a general term for the modification of parton showers in the hot dense medium created in ultrarelativistic nuclear collisions. For example, the inclusive yield of jets was observed to be suppressed by a factor of approximately 2 in central Pb + Pb collisions relative to peripheral collisions [3], consistent with a medium-induced reduction in the jet energies. Perturbative or weak-coupling calculations model jet energy loss, dE/dx, through a combination of collisional and radiative energy loss of the partons traversing the medium. The radiative contributions are subject to coherence effects [4] that explicitly depend on the in-medium path length of the parton. Strong-coupling calculations also have an explicit path-length dependence that differs from that predicted by weak-coupling calculations [5,6]. Measurements of the jet yield as a function of quantities providing indirect control over the jet path lengths may provide insight into the physical mechanisms responsible for jet quenching [7,8]. Such quantities include the Pb + Pb collision centrality and the azimuthal angle of the jet with respect to the elliptic event plane.

Elliptic flow refers to a $\cos 2\phi$ modulation of the azimuthal angle (ϕ) distribution of particles produced in ultrarelativistic nuclear collisions [9]. This modulation is understood to arise from an approximately elliptic anisotropy of the initial-state transverse energy density profile that is imprinted on the azimuthal angle distribution of final-state particles [10] by the strong collective evolution of the medium. The resulting azimuthal angle distribution is often parametrized by the form

$$\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \Psi_2), \qquad (1)$$

where the elliptic event plane angle, Ψ_2, specifies the orientation of the initial density profile in the transverse plane, and the parameter v_2 quantifies the magnitude of the modulation. Jets measured at different azimuthal angles relative to the event plane, $\Delta\phi \equiv \phi_{\mathrm{jet}} - \Psi_2$, result from partons that traverse, on average, different path lengths and density profiles in the medium. Thus, a measurement of the variation of the jet yield as a function of $\Delta\phi$ should provide a direct constraint on theoretical models of the path-length dependence of the energy loss. This measurement is not directly sensitive to potential variations in the jet yield with respect to higher-order event plane angles. Such variations may result from fluctuations in the initial geometry that also give rise to higher-order flow harmonics [11–13].

Variations in jet yield as a function of $\Delta\phi$ have been observed indirectly through measurements of single hadrons with large transverse momentum (p_T) at the RHIC [14–16] and the LHC [17–19]. The utility of such measurements is limited by the weak relationship between hadron p_T and the transverse momentum of the parent parton shower. This Letter presents the results of measurements using fully reconstructed jets, which have kinematic properties that are more closely related to those of the parent partons. The $\Delta\phi$ dependence of the inclusive jet yield was measured in $\sqrt{s_{NN}} = 2.76$ TeV Pb + Pb collisions as a function of jet p_{T} and Pb + Pb collision centrality. The measurement was performed with the anti-k_t algorithm [20] with distance parameter $R = 0.2$, chosen to limit the contribution of the underlying event (UE) to the measurement. The $\Delta\phi$ dependence was characterized by the jet v_2, v_2^{jet}, and the ratio of out-of-plane ($3\pi/8 \leq \Delta\phi \leq \pi/2$) to in-plane ($0 \leq \Delta\phi < \pi/8$) jet yields at

---

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

fixed p_T and centrality. Such dependence is expected to be small in either the most central or most peripheral collisions, due to the lack of initial-state anisotropy and the lack of quenching, respectively. For intermediate centralities, measurement of the $\Delta\phi$ dependence of the jet yields probes the interplay between dependence of quenching on the overall system size and energy density, as well as on the initial-state anisotropy.

The measurements presented here were performed with the ATLAS detector [21] using its calorimeter, inner detector, trigger, and data acquisition systems. The calorimeter system consists of a liquid-argon electromagnetic (EM) calorimeter covering $|\eta| < 3.2$, a steel-scintillator sampling hadronic calorimeter covering $|\eta| < 1.7$, a liquid-argon hadronic calorimeter covering $1.5 < |\eta| < 3.2$, and a forward calorimeter (FCal) covering $3.2 < |\eta| < 4.9$. Charged-particle tracks were measured over the range $|\eta| < 2.5$ using the inner detector [22], which is composed of silicon pixel detectors in the innermost layers, followed by silicon microstrip detectors and a straw-tube transition-radiation tracker ($|\eta| < 2.0$), all immersed in a 2 T axial magnetic field. The zero-degree calorimeters (ZDCs) are located symmetrically at $z = \pm 140$ m and cover $|\eta| > 8.3$. In Pb + Pb collisions the ZDCs primarily measure noninteracting "spectator" neutrons from the incident nuclei. A ZDC coincidence trigger was defined by requiring a signal consistent with one or more neutrons in each of the calorimeters.

Pb + Pb collisions corresponding to a total integrated luminosity of 0.14 nb^{-1} were analyzed. The events were recorded using either a minimum-bias trigger, formed from the logical OR of triggers based on a ZDC coincidence or total transverse energy in the event, or a jet trigger implemented using the Pb + Pb jet reconstruction algorithm. The jet trigger selected events having at least one jet with transverse energy $E_T > 20$ GeV. Event selection and background rejection criteria were applied [17] yielding 52×10^6 and 14×10^6 events in the minimum-bias and jet-triggered samples, respectively. For each event, Ψ_2 was computed from the azimuthal distribution of the transverse energy measured in the FCal [17,23], and angles with respect to Ψ_2 were defined over $0 \leq \Delta\phi \leq \pi/2$. The centrality of Pb + Pb collisions was characterized by $\Sigma E_{\mathrm{T}}^{\mathrm{FCal}}$, the total transverse energy measured in the FCal [17]. The results reported here were obtained using the following centrality intervals defined according to successive percentiles of the $\Sigma E_T^{\mathrm{FCal}}$ distribution ordered from the most central (highest $\Sigma E_T^{\mathrm{FCal}}$) to the most peripheral collisions: 5%–10%, 10%–20%, 20%–30%, 30%–40%, 40%–50%, and 50%–60%. The centrality interval 5%–60% coincides to the range over which the Ψ_2 resolution is adequate for the measurement. A Glauber model analysis [24,25] of the $\Sigma E_T^{\mathrm{FCal}}$ distribution [17] was used to evaluate the average number of nucleons participating in the collision, $\langle N_{\mathrm{part}} \rangle$, in each centrality interval.

The jet reconstruction and underlying event subtraction procedures are the same as those used in Ref. [3], which is summarized in the following. The anti-k_t algorithm was applied to calorimeter towers with segmentation $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$. A two-step iterative procedure was used to obtain an event-by-event estimate of the average η-dependent UE energy density while excluding actual jets from that estimate. The jet kinematics were obtained by subtracting the UE energy from the towers within the jet. This subtraction accounts for elliptic flow by modulating the average background density by the magnitude of the elliptic flow measured by the calorimeter, v_2^{calo}, over the interval $|\eta| < 3.2$ and excluding η regions containing jets. Following reconstruction, the jet energies were corrected to account for the calorimeter energy response using an η- and E_T-dependent multiplicative factor that was derived from Monte Carlo (MC) simulations [26].

Separate from the calorimeter jets, "track jets" were reconstructed by applying the anti-k_t algorithm with $R = 0.4$ to charged particles having $p_T > 4$ GeV. The p_T of the track jets, p_T^{trkjet}, is largely unaffected by the UE due to the $p_T > 4$ GeV requirement. To exclude the contribution to the jet yield from UE fluctuations of soft particles falsely identified as calorimeter jets, the jets used in this analysis were required to be within $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.2$ of a track jet with $p_T^{\mathrm{trkjet}} > 10$ GeV or an EM cluster [27] with $p_T > 9$ GeV.

The performance of the jet reconstruction was evaluated using the GEANT4-simulated detector response [28,29] in a MC sample of pp hard scattering events at $\sqrt{s_{NN}} = 2.76$ TeV. The events were produced with the PYTHIA event generator [30] version 6.423 using the AUET2B tune [31] and overlaid on minimum-bias Pb + Pb collisions recorded by ATLAS. Through this embedding procedure, the MC sample contains a UE contribution that is identical in all respects to the data, including azimuthal modulation of the UE due to harmonic flow. Jets reconstructed in the MC events using the same algorithms as applied to data were compared to generator-level jets reconstructed from final-state PYTHIA hadrons. Potential variations in the jet energy resolution (JER) and jet energy scale (JES) with $\Delta\phi$ due to elliptic and higher-order modulation [11–13] of the UE were investigated in the MC sample; no significant variation was found.

The dependence of the JES on $\Delta\phi$ was further constrained by comparing the calorimeter jets to matched track jets in the data. For different values of $\Delta\phi$, the mean p_T of calorimeter jets was evaluated as a function of the p_T of the matched track jet, and no significant variation with $\Delta\phi$ was observed. This study provides an upper limit on the variation in the JES between jets at $\Delta\phi = 0$ and $\Delta\phi = \pi/2$ of 0.1% for $p_T > 45$ GeV.

Double differential jet yields, $d^2N_{\mathrm{jet}}/dp_T d\Delta\phi$, were measured over $|\eta| < 2.1$ for each of the centrality ranges described above and in five p_T intervals: 45–60 GeV, 60–80 GeV, 80–110 GeV, 110–160 GeV, and 160–210 GeV. The measurement in each p_T range was performed using events selected by the jet trigger except for the 45–60 GeV p_T range, in which minimum-bias events were used. The $\Delta\phi$ dependence of the jet yields in the 60–80 GeV p_T interval is shown for each centrality range in Fig. 1. A significant $\Delta\phi$ variation that is consistent with a $\cos 2\Delta\phi$ modulation is seen for all centrality intervals.

The measured yields and the resulting $v_2^{\rm jet}|_{\rm meas}$ values are distorted by the finite resolutions in Ψ_2 and the jet p_T. The Ψ_2 resolution was evaluated using a subevent technique [17,23] in which Ψ_2 was measured separately in the positive and negative η halves of the FCal yielding values Ψ_2^+ and Ψ_2^-, respectively. The width of the $\Psi_2^+ - \Psi_2^-$ distribution was used [23] to estimate a factor, κ, that was used to correct each measured v_2 value for the finite Ψ_2 resolution according to

$$v_2 = v_2|_{\rm meas}/\kappa. \tag{2}$$

This factor was evaluated for events containing jets to account for the relevant distribution of events within each centrality interval.

The p_T dependence, and possibly also the $\Delta\phi$ dependence, of the measured yields are affected by the JER, which arises from both fluctuations in the UE and the detector response. The MC study shows that for the $R = 0.2$ jets used in this analysis, the JER-induced migration between jet p_T intervals is sufficiently small that a "bin-by-bin" unfolding method, utilizing multiplicative corrections to the jet yields, is appropriate. The bin-by-bin correction factors are defined to be the number of generator-level jets divided by the number of reconstructed jets in each p_T, $\Delta\phi$, and centrality interval. The MC studies show no significant $\Delta\phi$ variation of the JER, JES, and the correction factors, and so these correction factors were taken to be $\Delta\phi$ independent. Since the measurements presented here depend only on the ratios of jet yields between different $\Delta\phi$ intervals for the same p_T range, the correction factors do not affect any of the final results; the potential for a $\Delta\phi$ dependence of the correction factors is included in the estimates of the systematic uncertainty.

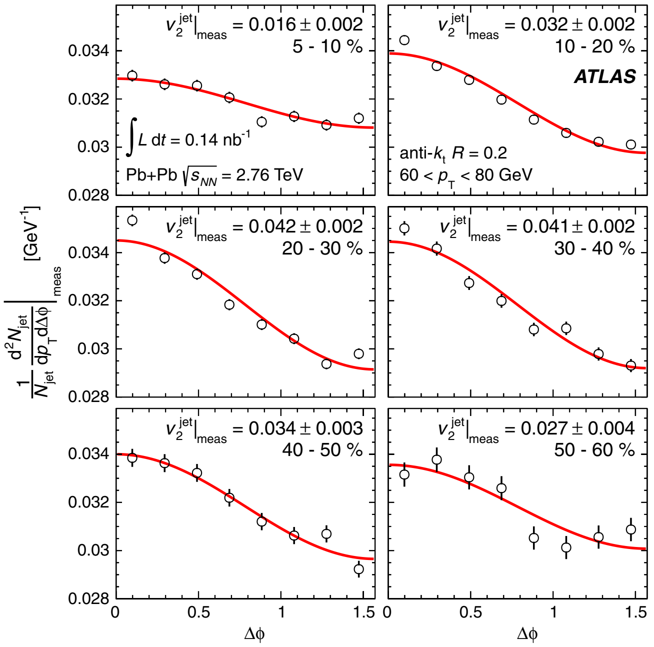

FIG. 1 (color online). $\Delta\phi$ dependence of measured $d^2N_{\rm jet}/dp_T d\Delta\phi$ in the $60 < p_T < 80$ GeV interval for six ranges of collision centrality. The yields are normalized by the total number of jets in the p_T interval. The solid curves indicate the results of fitting the data to the functional form of Eq. (1), with the resulting v_2 values, $v_2^{\rm jet}|_{\rm meas}$, listed in each panel. The error bars and errors on $v_2^{\rm jet}|_{\rm meas}$ indicate statistical uncertainties.

Systematic uncertainties on the corrected v_2 values arise due to uncertainties on the two correction procedures described above. Uncertainties on κ were estimated by using the values obtained in previous studies [17]. The uncertainties were found to vary between 1% and 4% from central to peripheral collisions. Potential distortions in the measurement of Ψ_2 due to the production of jets in the FCal pseudorapidity range were studied in the MC sample and found to be negligible for the centrality intervals included in this analysis.

Uncertainties on the measurements arising from $\Delta\phi$-dependent systematic uncertainties on the bin-by-bin correction factors were estimated by determining the sensitivity of these correction factors to each systematic variation and then parametrizing that sensitivity with a $\cos 2\Delta\phi$ dependence. The sensitivity to the $\Delta\phi$ dependence of the spectrum was evaluated by varying the p_T spectrum of the generator-level jets in each $\Delta\phi$ interval within a range consistent with the measured $v_2^{\rm jet}$ values. The JES and JER contributions to the uncertainty were obtained by varying the relationship between generator-level and reconstructed jet p_T in the determination of the correction factors. These procedures utilized the JES constraints obtained from track jets and direct measurements of the UE contribution to the JER [3]. Parametrizations of the measured $v_2^{\rm calo}$ and the average background E_T underlying a typical jet measured in the data were used to provide the dependence of variations on centrality.

The azimuthal dependence of jet suppression can be characterized by $v_2^{\rm jet}$, which was obtained by correcting the $v_2^{\rm jet}|_{\rm meas}$ values using Eq. (2). Figure 2 shows the resulting $v_2^{\rm jet}$ values as a function of jet p_T for all centrality intervals. Significant, nonzero values are observed over the range $45 < p_T < 160$ GeV for all centrality intervals. A direct comparison between the v_2 of single high-p_T charged particles and $v_2^{\rm jet}$ is generally not possible; however, the fact that both quantities exhibit only a weak p_T dependence leads to the expectation that they should be of similar magnitude. In the charged-particle measurements,

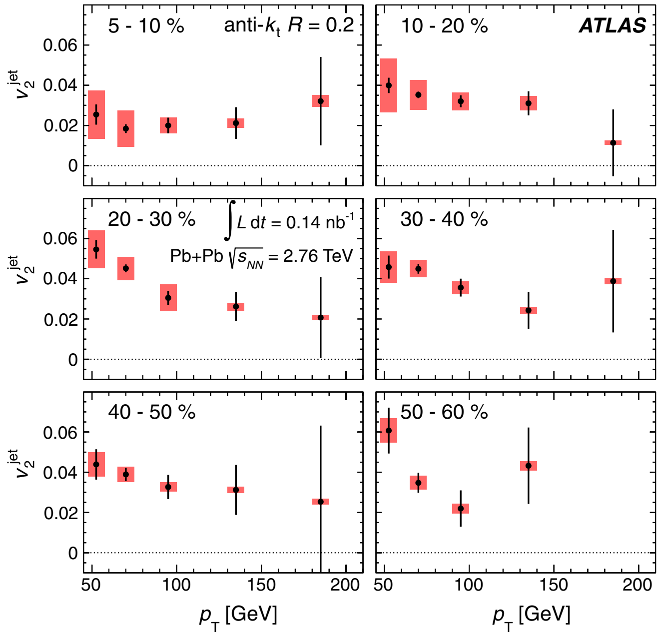

FIG. 2 (color online). $v_2^{\rm jet}$ as a function of jet p_T in each centrality interval. The error bars on the points indicate statistical uncertainties while the shaded boxes represent the systematic uncertainties (see text). The horizontal width of the systematic error band is chosen for presentation purposes only.

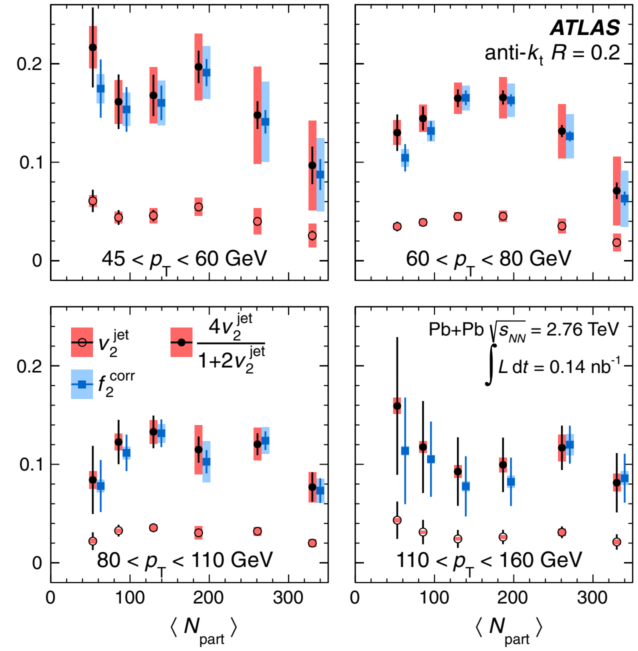

FIG. 3 (color online). The $\langle N_{\rm part}\rangle$ dependence of $v_2^{\rm jet}$ (○), $f_2^{\rm corr}$ (■), and $4v_2^{\rm jet}/(1+2v_2^{\rm jet})$ (●). All quantities have statistical and systematic uncertainties that are indicated by error bars and shaded bands, respectively. The uncertainties for all quantities are strongly correlated. The horizontal positions of the points have been offset slightly for presentation purposes and the width of the error bands indicates the uncertainty on $\langle N_{\rm part}\rangle$.

the v_2 values of charged particles with $28 < p_T < 48$ GeV were found to vary between 0.02 and 0.05 for the 10%–50% centrality range [18], which are generally in agreement with $v_2^{\rm jet}$ values reported here indicating no obvious inconsistencies between the two results.

The centrality dependence of $v_2^{\rm jet}$ is shown in Fig. 3 as a function of $\langle N_{\rm part}\rangle$ for different ranges in p_T. The variation of jet yields with $\Delta\phi$ can also be characterized by the ratio of jet yields between the most out-of-plane and most in-plane bins,

$$R_{\Delta\phi}^{\max} \equiv d^2N_{\rm jet}/dp_Td\Delta\phi|_{\rm out}/d^2N_{\rm jet}/dp_Td\Delta\phi|_{\rm in}. \quad (3)$$

This quantity is more general than $v_2^{\rm jet}$ as it does not assume a functional form for the $\Delta\phi$ dependence of the jet yields. The nuclear modification factor, R_{AA}, is a measure of the effect of quenching on hard scattering rates, and $R_{\Delta\phi}^{\max}$ can be interpreted as the ratio of $\Delta\phi$-dependent R_{AA} factors, $R_{\Delta\phi}^{\max} = R_{AA}|_{\rm out}/R_{AA}|_{\rm in}$ [16]. The yields were corrected for Ψ_2 resolution assuming that the $\Delta\phi$ variation is dominated by the $\cos 2\Delta\phi$ modulation,

$$\frac{d^2N_{\rm jet}^{\rm corr}}{dp_Td\Delta\phi} = \frac{d^2N_{\rm jet}^{\rm meas}}{dp_Td\Delta\phi}\left(\frac{1+2v_2^{\rm jet}\cos 2\Delta\phi}{1+2v_2^{\rm jet}|_{\rm meas}\cos 2\Delta\phi}\right). \quad (4)$$

The results, expressed in terms of the quantity $f_2 \equiv 1 - R_{\Delta\phi}^{\max}$, show as much as a 20% variation between the out-of-plane and in-plane jet yields, but they are reduced slightly from the maximal difference, evaluated at $\Delta\phi = \pi/2$ and $\Delta\phi = 0$, by the finite bin size used in the measurement. That reduction was corrected by assuming a $1 + 2v_2^{\rm jet}\cos 2\Delta\phi$ variation of the jet yields *within* the $\Delta\phi$ bins containing $\Delta\phi = 0$ and $\pi/2$, and calculating the corresponding yields at those $\Delta\phi$ values. From these yields, $f_2^{\rm corr}$ was calculated analogously to f_2. The magnitude of the correction is typically a few percent. The $f_2^{\rm corr}$ values are shown in Fig. 3. For a pure $\cos 2\Delta\phi$ modulation of the jet yields, $f_2^{\rm corr}$ would be given by $4v_2^{\rm jet}/(1+2v_2^{\rm jet})$. To test for deviations of the $\Delta\phi$ dependence of the jet yields from a pure $\cos 2\Delta\phi$ variation, $4v_2^{\rm jet}/(1+2v_2^{\rm jet})$ was calculated using the measured $v_2^{\rm jet}$ values and is shown for each $p_{\rm T}$ and centrality interval in Fig. 3.

Similar variations of $v_2^{\rm jet}$, $f_2^{\rm corr}$, and $4v_2^{\rm jet}/(1+2v_2^{\rm jet})$ with $\langle N_{\rm part}\rangle$ are seen in the 60–80 GeV range, which has the best statistical precision. A reduction in $f_2^{\rm corr}$ and $v_2^{\rm jet}$ in both the most central and peripheral collisions is not surprising; for very central collisions, the anisotropy of the initial state is small and the possible $\Delta\phi$ variation of path lengths in the medium is limited. Although the anisotropy is greater in peripheral collisions, there is little suppression in the jet yields [3]. Therefore large variations in jet yield as a function of $\Delta\phi$ would be unexpected. The $f_2^{\rm corr}$ and $4v_2^{\rm jet}/(1+2v_2^{\rm jet})$ values are generally in agreement within uncertainties, indicating an azimuthal dependence of relative suppression when measured with respect to the elliptic event plane that is dominated by second-harmonic modulation.

This Letter has presented results of ATLAS measurements of the variation of $R = 0.2$ anti-k_t jet yields in $\sqrt{s_{NN}} = 2.76$ TeV Pb + Pb collisions as a function of $\Delta\phi$, the relative azimuthal angle of the jet with respect to the elliptic event plane. A significant $\Delta\phi$ variation in the jet yield is observed for all centrality intervals and in all $p_{\rm T}$ ranges except for the 160–210 GeV p_T interval where the statistical uncertainties are large. The observed azimuthal variation of jet yields amounts to a reduction of 10%–20% in the jet yields between in-plane and out-of-plane directions. These results establish a relationship between jet suppression and the initial nuclear geometry that should constrain models of the path-length dependence of the quenching mechanism.

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

[1] ATLAS Collaboration, Phys. Rev. Lett. **105**, 252303 (2010).
[2] CMS Collaboration, Phys. Rev. C **84**, 024906 (2011).
[3] ATLAS Collaboration, Phys. Lett. B **719**, 220 (2013).
[4] R. Baier, Y.L. Dokshitzer, A.J. Mueller, and D. Schiff, Phys. Rev. C **58**, 1706 (1998).
[5] S.S. Gubser, D.R. Gulotta, S.S. Pufu, and F.D. Rocha, J. High Energy Phys. 10 (2008) 052.
[6] C. Marquet and T. Renk, Phys. Lett. B **685**, 270 (2010).
[7] M. Gyulassy, I. Vitev, and X.N. Wang, Phys. Rev. Lett. **86**, 2537 (2001).
[8] X. Zhang and J. Liao, Phys. Rev. C **87**, 044910 (2013).
[9] 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 from the IP to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.
[10] J.-Y. Ollitrault, Phys. Rev. D **46**, 229 (1992).
[11] ALICE Collaboration, Phys. Rev. Lett. **107**, 032301 (2011).
[12] ATLAS Collaboration, Phys. Rev. C **86**, 014907 (2012).
[13] CMS Collaboration, Eur. Phys. J. C **72**, 2012 (2012).
[14] STAR Collaboration, Phys. Rev. Lett. **93**, 252301 (2004).
[15] PHENIX Collaboration, Phys. Rev. C **76**, 034904 (2007).
[16] PHENIX Collaboration, Phys. Rev. Lett. **105**, 142301 (2010).
[17] ATLAS Collaboration, Phys. Lett. B **707**, 330 (2012).
[18] CMS Collaboration, Phys. Rev. Lett. **109**, 022301 (2012).
[19] ALICE Collaboration, Phys. Lett. B **719**, 18 (2013).
[20] M. Cacciari, G.P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 063.
[21] ATLAS Collaboration, JINST **3**, S08003 (2008).
[22] ATLAS Collaboration, Eur. Phys. J. C **70**, 787 (2010).
[23] A.M. Poskanzer and S.A. Voloshin, Phys. Rev. C **58**, 1671 (1998).
[24] M.L. Miller, K. Reygers, S.J. Sanders, and P. Steinberg, Annu. Rev. Nucl. Part. Sci. **57**, 205 (2007).
[25] B. Alver, M. Baker, C. Loizides, and P. Steinberg, arXiv:0805.4411.
[26] ATLAS Collaboration, Eur. Phys. J. C **73**, 2304 (2013).
[27] ATLAS Collaboration, arXiv:0901.0512.
[28] S. Agostinelli *et al.* (GEANT4), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[29] ATLAS Collaboration, Eur. Phys. J. C **70**, 823 (2010).
[30] T. Sjostrand, S. Mrenna, and P. Skands, J. High Energy Phys. 05 (2006) 026.
[31] ATLAS Collaboration, Report No. ATL-PHYS-PUB-2011-009, 2011, http://cds.cern.ch/record/1363300/files/ATL-PHYS-PUB-2011-009.pdf.

G. Aad,[48] T. Abajyan,[21] B. Abbott,[112] J. Abdallah,[12] S. Abdel Khalek,[116] O. Abdinov,[11] R. Aben,[106] B. Abi,[113] M. Abolins,[89] O. S. AbouZeid,[159] H. Abramowicz,[154] H. Abreu,[137] Y. Abulaiti,[147a,147b] B. S. Acharya,[165a,165b,b]

L. Adamczyk,[38a] D. L. Adams,[25] T. N. Addy,[56] J. Adelman,[177] S. Adomeit,[99] T. Adye,[130] S. Aefsky,[23]
T. Agatonovic-Jovin,[13b] J. A. Aguilar-Saavedra,[125b,c] M. Agustoni,[17] S. P. Ahlen,[22] A. Ahmad,[149] M. Ahsan,[41]
G. Aielli,[134a,134b] T. P. A. Åkesson,[80] G. Akimoto,[156] A. V. Akimov,[95] M. A. Alam,[76] J. Albert,[170] S. Albrand,[55]
M. J. Alconada Verzini,[70] M. Aleksa,[30] I. N. Aleksandrov,[64] F. Alessandria,[90a] C. Alexa,[26a] G. Alexander,[154]
G. Alexandre,[49] T. Alexopoulos,[10] M. Alhroob,[165a,165c] M. Aliev,[16] G. Alimonti,[90a] L. Alio,[84] J. Alison,[31]
B. M. M. Allbrooke,[18] L. J. Allison,[71] P. P. Allport,[73] S. E. Allwood-Spiers,[53] J. Almond,[83] A. Aloisio,[103a,103b]
R. Alon,[173] A. Alonso,[36] F. Alonso,[70] A. Altheimer,[35] B. Alvarez Gonzalez,[89] M. G. Alviggi,[103a,103b] K. Amako,[65]
Y. Amaral Coutinho,[24a] C. Amelung,[23] V. V. Ammosov,[129,a] S. P. Amor Dos Santos,[125a] A. Amorim,[125a,d]
S. Amoroso,[48] N. Amram,[154] C. Anastopoulos,[30] L. S. Ancu,[17] N. Andari,[30] T. Andeen,[35] C. F. Anders,[58b]
G. Anders,[58a] K. J. Anderson,[31] A. Andreazza,[90a,90b] V. Andrei,[58a] X. S. Anduaga,[70] S. Angelidakis,[9] P. Anger,[44]
A. Angerami,[35] F. Anghinolfi,[30] A. V. Anisenkov,[108] N. Anjos,[125a] A. Annovi,[47] A. Antonaki,[9] M. Antonelli,[47]
A. Antonov,[97] J. Antos,[145b] F. Anulli,[133a] M. Aoki,[102] L. Aperio Bella,[18] R. Apolle,[119,e] G. Arabidze,[89] I. Aracena,[144]
Y. Arai,[65] A. T. H. Arce,[45] S. Arfaoui,[149] J-F. Arguin,[94] S. Argyropoulos,[42] E. Arik,[19a,a] M. Arik,[19a]
A. J. Armbruster,[88] O. Arnaez,[82] V. Arnal,[81] A. Artamonov,[96] G. Artoni,[133a,133b] D. Arutinov,[21] S. Asai,[156]
N. Asbah,[94] S. Ask,[28] B. Åsman,[147a,147b] L. Asquith,[6] K. Assamagan,[25] R. Astalos,[145a] A. Astbury,[170]
M. Atkinson,[166] N. B. Atlay,[142] B. Auerbach,[6] E. Auge,[116] K. Augsten,[127] M. Aurousseau,[146b] G. Avolio,[30]
D. Axen,[169] G. Azuelos,[94,f] Y. Azuma,[156] M. A. Baak,[30] C. Bacci,[135a,135b] A. M. Bach,[15] H. Bachacou,[137]
K. Bachas,[155] M. Backes,[49] M. Backhaus,[21] J. Backus Mayes,[144] E. Badescu,[26a] P. Bagiacchi,[133a,133b]
P. Bagnaia,[133a,133b] Y. Bai,[33a] D. C. Bailey,[159] T. Bain,[35] J. T. Baines,[130] O. K. Baker,[177] S. Baker,[77] P. Balek,[128]
F. Balli,[137] E. Banas,[39] Sw. Banerjee,[174] D. Banfi,[30] A. Bangert,[151] V. Bansal,[170] H. S. Bansil,[18] L. Barak,[173]
S. P. Baranov,[95] T. Barber,[48] E. L. Barberio,[87] D. Barberis,[50a,50b] M. Barbero,[84] D. Y. Bardin,[64] T. Barillari,[100]
M. Barisonzi,[176] T. Barklow,[144] N. Barlow,[28] B. M. Barnett,[130] R. M. Barnett,[15] A. Baroncelli,[135a] G. Barone,[49]
A. J. Barr,[119] F. Barreiro,[81] J. Barreiro Guimarães da Costa,[57] R. Bartoldus,[144] A. E. Barton,[71] V. Bartsch,[150]
A. Basye,[166] R. L. Bates,[53] L. Batkova,[145a] J. R. Batley,[28] M. Battistin,[30] F. Bauer,[137] H. S. Bawa,[144,g] S. Beale,[99]
T. Beau,[79] P. H. Beauchemin,[162] R. Beccherle,[50a] P. Bechtle,[21] H. P. Beck,[17] K. Becker,[176] S. Becker,[99]
M. Beckingham,[139] K. H. Becks,[176] A. J. Beddall,[19c] A. Beddall,[19c] S. Bedikian,[177] V. A. Bednyakov,[64] C. P. Bee,[84]
L. J. Beemster,[106] T. A. Beermann,[176] M. Begel,[25] C. Belanger-Champagne,[86] P. J. Bell,[49] W. H. Bell,[49] G. Bella,[154]
L. Bellagamba,[20a] A. Bellerive,[29] M. Bellomo,[30] A. Belloni,[57] O. L. Beloborodova,[108,h] K. Belotskiy,[97]
O. Beltramello,[30] O. Benary,[154] D. Benchekroun,[136a] K. Bendtz,[147a,147b] N. Benekos,[166] Y. Benhammou,[154]
E. Benhar Noccioli,[49] J. A. Benitez Garcia,[160b] D. P. Benjamin,[45] J. R. Bensinger,[23] K. Benslama,[131]
S. Bentvelsen,[106] D. Berge,[30] E. Bergeaas Kuutmann,[16] N. Berger,[5] F. Berghaus,[170] E. Berglund,[106] J. Beringer,[15]
C. Bernard,[22] P. Bernat,[77] R. Bernhard,[48] C. Bernius,[78] F. U. Bernlochner,[170] T. Berry,[76] C. Bertella,[84]
F. Bertolucci,[123a,123b] M. I. Besana,[90a,90b] G. J. Besjes,[105] O. Bessidskaia,[147a,147b] N. Besson,[137] S. Bethke,[100]
W. Bhimji,[46] R. M. Bianchi,[124] L. Bianchini,[23] M. Bianco,[72a,72b] O. Biebel,[99] S. P. Bieniek,[77] K. Bierwagen,[54]
J. Biesiada,[15] M. Biglietti,[135a] J. Bilbao De Mendizabal,[49] H. Bilokon,[47] M. Bindi,[20a,20b] S. Binet,[116] A. Bingul,[19c]
C. Bini,[133a,133b] B. Bittner,[100] C. W. Black,[151] J. E. Black,[144] K. M. Black,[22] D. Blackburn,[139] R. E. Blair,[6]
J.-B. Blanchard,[137] T. Blazek,[145a] I. Bloch,[42] C. Blocker,[23] J. Blocki,[39] W. Blum,[82,a] U. Blumenschein,[54]
G. J. Bobbink,[106] V. S. Bobrovnikov,[108] S. S. Bocchetta,[80] A. Bocci,[45] C. R. Boddy,[119] M. Boehler,[48] J. Boek,[176]
T. T. Boek,[176] N. Boelaert,[36] J. A. Bogaerts,[30] A. G. Bogdanchikov,[108] A. Bogouch,[91,a] C. Bohm,[147a] J. Bohm,[126]
V. Boisvert,[76] T. Bold,[38a] V. Boldea,[26a] N. M. Bolnet,[137] M. Bomben,[79] M. Bona,[75] M. Boonekamp,[137] S. Bordoni,[79]
C. Borer,[17] A. Borisov,[129] G. Borissov,[71] M. Borri,[83] S. Borroni,[42] J. Bortfeldt,[99] V. Bortolotto,[135a,135b] K. Bos,[106]
D. Boscherini,[20a] M. Bosman,[12] H. Boterenbrood,[106] J. Bouchami,[94] J. Boudreau,[124] E. V. Bouhova-Thacker,[71]
D. Boumediene,[34] C. Bourdarios,[116] N. Bousson,[84] S. Boutouil,[136d] A. Boveia,[31] J. Boyd,[30] I. R. Boyko,[64]
I. Bozovic-Jelisavcic,[13b] J. Bracinik,[18] P. Branchini,[135a] A. Brandt,[8] G. Brandt,[15] O. Brandt,[54] U. Bratzler,[157]
B. Brau,[85] J. E. Brau,[115] H. M. Braun,[176,a] S. F. Brazzale,[165a,165c] B. Brelier,[159] J. Bremer,[30] K. Brendlinger,[121]
R. Brenner,[167] S. Bressler,[173] T. M. Bristow,[46] D. Britton,[53] F. M. Brochu,[28] I. Brock,[21] R. Brock,[89] F. Broggi,[90a]
C. Bromberg,[89] J. Bronner,[100] G. Brooijmans,[35] T. Brooks,[76] W. K. Brooks,[32b] E. Brost,[115] G. Brown,[83] J. Brown,[55]
P. A. Bruckman de Renstrom,[39] D. Bruncko,[145b] R. Bruneliere,[48] S. Brunet,[60] A. Bruni,[20a] G. Bruni,[20a]
M. Bruschi,[20a] L. Bryngemark,[80] T. Buanes,[14] Q. Buat,[55] F. Bucci,[49] J. Buchanan,[119] P. Buchholz,[142]
R. M. Buckingham,[119] A. G. Buckley,[46] S. I. Buda,[26a] I. A. Budagov,[64] B. Budick,[109] L. Bugge,[118] O. Bulekov,[97]
A. C. Bundock,[73] M. Bunse,[43] T. Buran,[118,a] H. Burckhart,[30] S. Burdin,[73] T. Burgess,[14] S. Burke,[130] E. Busato,[34]

V. Büscher,[82] P. Bussey,[53] C. P. Buszello,[167] B. Butler,[57] J. M. Butler,[22] C. M. Buttar,[53] J. M. Butterworth,[77]
W. Buttinger,[28] M. Byszewski,[10] S. Cabrera Urbán,[168] D. Caforio,[20a,20b] O. Cakir,[4a] P. Calafiura,[15] G. Calderini,[79]
P. Calfayan,[99] R. Calkins,[107] L. P. Caloba,[24a] R. Caloi,[133a,133b] D. Calvet,[34] S. Calvet,[34] R. Camacho Toro,[49]
P. Camarri,[134a,134b] D. Cameron,[118] L. M. Caminada,[15] R. Caminal Armadans,[12] S. Campana,[30] M. Campanelli,[77]
V. Canale,[103a,103b] F. Canelli,[31] A. Canepa,[160a] J. Cantero,[81] R. Cantrill,[76] T. Cao,[40] M. D. M. Capeans Garrido,[30]
I. Caprini,[26a] M. Caprini,[26a] D. Capriotti,[100] M. Capua,[37a,37b] R. Caputo,[82] R. Cardarelli,[134a] T. Carli,[30]
G. Carlino,[103a] L. Carminati,[90a,90b] S. Caron,[105] E. Carquin,[32b] G. D. Carrillo-Montoya,[146c] A. A. Carter,[75]
J. R. Carter,[28] J. Carvalho,[125a,i] D. Casadei,[77] M. P. Casado,[12] M. Cascella,[123a,123b] C. Caso,[50a,50b,a]
E. Castaneda-Miranda,[174] A. Castelli,[106] V. Castillo Gimenez,[168] N. F. Castro,[125a] G. Cataldi,[72a] P. Catastini,[57]
A. Catinaccio,[30] J. R. Catmore,[30] A. Cattai,[30] G. Cattani,[134a,134b] S. Caughron,[89] V. Cavaliere,[166] D. Cavalli,[90a]
M. Cavalli-Sforza,[12] V. Cavasinni,[123a,123b] F. Ceradini,[135a,135b] B. Cerio,[45] A. S. Cerqueira,[24b] A. Cerri,[15]
L. Cerrito,[75] F. Cerutti,[15] A. Cervelli,[17] S. A. Cetin,[19b] A. Chafaq,[136a] D. Chakraborty,[107] I. Chalupkova,[128] K. Chan,[3]
P. Chang,[166] B. Chapleau,[86] J. D. Chapman,[28] J. W. Chapman,[88] D. G. Charlton,[18] V. Chavda,[83]
C. A. Chavez Barajas,[30] S. Cheatham,[86] S. Chekanov,[6] S. V. Chekulaev,[160a] G. A. Chelkov,[64] M. A. Chelstowska,[88]
C. Chen,[63] H. Chen,[25] S. Chen,[33c] X. Chen,[174] Y. Chen,[35] Y. Cheng,[31] A. Cheplakov,[64] R. Cherkaoui El Moursli,[136e]
V. Chernyatin,[25,a] E. Cheu,[7] L. Chevalier,[137] V. Chiarella,[47] G. Chiefari,[103a,103b] J. T. Childers,[30] A. Chilingarov,[71]
G. Chiodini,[72a] A. S. Chisholm,[18] R. T. Chislett,[77] A. Chitan,[26a] M. V. Chizhov,[64] G. Choudalakis,[31] S. Chouridou,[9]
B. K. B. Chow,[99] I. A. Christidi,[77] A. Christov,[48] D. Chromek-Burckhart,[30] M. L. Chu,[152] J. Chudoba,[126]
G. Ciapetti,[133a,133b] A. K. Ciftci,[4a] R. Ciftci,[4a] D. Cinca,[62] V. Cindro,[74] A. Ciocio,[15] M. Cirilli,[88] P. Cirkovic,[13b]
Z. H. Citron,[173] M. Citterio,[90a] M. Ciubancan,[26a] A. Clark,[49] P. J. Clark,[46] R. N. Clarke,[15] J. C. Clemens,[84]
B. Clement,[55] C. Clement,[147a,147b] Y. Coadou,[84] M. Cobal,[165a,165c] A. Coccaro,[139] J. Cochran,[63] S. Coelli,[90a]
L. Coffey,[23] J. G. Cogan,[144] J. Coggeshall,[166] J. Colas,[5] B. Cole,[35] S. Cole,[107] A. P. Colijn,[106] C. Collins-Tooth,[53]
J. Collot,[55] T. Colombo,[120a,120b] G. Colon,[85] G. Compostella,[100] P. Conde Muiño,[125a] E. Coniavitis,[167]
M. C. Conidi,[12] S. M. Consonni,[90a,90b] V. Consorti,[48] S. Constantinescu,[26a] C. Conta,[120a,120b] G. Conti,[57]
F. Conventi,[103a,j] M. Cooke,[15] B. D. Cooper,[77] A. M. Cooper-Sarkar,[119] N. J. Cooper-Smith,[76] K. Copic,[15]
T. Cornelissen,[176] M. Corradi,[20a] F. Corriveau,[86,k] A. Corso-Radu,[164] A. Cortes-Gonzalez,[166] G. Cortiana,[100]
G. Costa,[90a] M. J. Costa,[168] D. Costanzo,[140] D. Côté,[8] G. Cottin,[32a] L. Courneyea,[170] G. Cowan,[76] B. E. Cox,[83]
K. Cranmer,[109] S. Crépé-Renaudin,[55] F. Crescioli,[79] M. Cristinziani,[21] G. Crosetti,[37a,37b] C.-M. Cuciuc,[26a]
C. Cuenca Almenar,[177] T. Cuhadar Donszelmann,[140] J. Cummings,[177] M. Curatolo,[47] C. Cuthbert,[151] H. Czirr,[142]
P. Czodrowski,[44] Z. Czyczula,[177] S. D'Auria,[53] M. D'Onofrio,[73] A. D'Orazio,[133a,133b]
M. J. Da Cunha Sargedas De Sousa,[125a] C. Da Via,[83] W. Dabrowski,[38a] A. Dafinca,[119] T. Dai,[88] F. Dallaire,[94]
C. Dallapiccola,[85] M. Dam,[36] D. S. Damiani,[138] A. C. Daniells,[18] H. O. Danielsson,[30] V. Dao,[105] G. Darbo,[50a]
G. L. Darlea,[26c] S. Darmora,[8] J. A. Dassoulas,[42] W. Davey,[21] C. David,[170] T. Davidek,[128] E. Davies,[119,e] M. Davies,[94]
O. Davignon,[79] A. R. Davison,[77] Y. Davygora,[58a] E. Dawe,[143] I. Dawson,[140] R. K. Daya-Ishmukhametova,[23] K. De,[8]
R. de Asmundis,[103a] S. De Castro,[20a,20b] S. De Cecco,[79] J. de Graat,[99] N. De Groot,[105] P. de Jong,[106]
C. De La Taille,[116] H. De la Torre,[81] F. De Lorenzi,[63] L. De Nooij,[106] D. De Pedis,[133a] A. De Salvo,[133a]
U. De Sanctis,[165a,165c] A. De Santo,[150] J. B. De Vivie De Regie,[116] G. De Zorzi,[133a,133b] W. J. Dearnaley,[71]
R. Debbe,[25] C. Debenedetti,[46] B. Dechenaux,[55] D. V. Dedovich,[64] J. Degenhardt,[121] J. Del Peso,[81]
T. Del Prete,[123a,123b] T. Delemontex,[55] M. Deliyergiyev,[74] A. Dell'Acqua,[30] L. Dell'Asta,[22] M. Della Pietra,[103a,j]
D. della Volpe,[103a,103b] M. Delmastro,[5] P. A. Delsart,[55] C. Deluca,[106] S. Demers,[177] M. Demichev,[64] A. Demilly,[79]
B. Demirkoz,[12,l] S. P. Denisov,[129] D. Derendarz,[39] J. E. Derkaoui,[136d] F. Derue,[79] P. Dervan,[73] K. Desch,[21]
P. O. Deviveiros,[106] A. Dewhurst,[130] B. DeWilde,[149] S. Dhaliwal,[106] R. Dhullipudi,[78,m] A. Di Ciaccio,[134a,134b]
L. Di Ciaccio,[5] C. Di Donato,[103a,103b] A. Di Girolamo,[30] B. Di Girolamo,[30] S. Di Luise,[135a,135b] A. Di Mattia,[153]
B. Di Micco,[135a,135b] R. Di Nardo,[47] A. Di Simone,[48] R. Di Sipio,[20a,20b] M. A. Diaz,[32a] E. B. Diehl,[88] J. Dietrich,[42]
T. A. Dietzsch,[58a] S. Diglio,[87] K. Dindar Yagci,[40] J. Dingfelder,[21] F. Dinut,[26a] C. Dionisi,[133a,133b] P. Dita,[26a]
S. Dita,[26a] F. Dittus,[30] F. Djama,[84] T. Djobava,[51b] M. A. B. do Vale,[24c] A. Do Valle Wemans,[125a,n] T. K. O. Doan,[5]
D. Dobos,[30] E. Dobson,[77] J. Dodd,[35] C. Doglioni,[49] T. Doherty,[53] T. Dohmae,[156] Y. Doi,[65,a] J. Dolejsi,[128]
Z. Dolezal,[128] B. A. Dolgoshein,[97,a] M. Donadelli,[24d] J. Donini,[34] J. Dopke,[30] A. Doria,[103a] A. Dos Anjos,[174]
A. Dotti,[123a,123b] M. T. Dova,[70] A. T. Doyle,[53] M. Dris,[10] J. Dubbert,[88] S. Dube,[15] E. Dubreuil,[34] E. Duchovni,[173]
G. Duckeck,[99] D. Duda,[176] A. Dudarev,[30] F. Dudziak,[63] L. Duflot,[116] M-A. Dufour,[86] L. Duguid,[76] M. Dührssen,[30]
M. Dunford,[58a] H. Duran Yildiz,[4a] M. Düren,[52] M. Dwuznik,[38a] J. Ebke,[99] W. Edson,[2] C. A. Edwards,[76]

N. C. Edwards,[53] W. Ehrenfeld,[21] T. Eifert,[144] G. Eigen,[14] K. Einsweiler,[15] E. Eisenhandler,[75] T. Ekelof,[167]
M. El Kacimi,[136c] M. Ellert,[167] S. Elles,[5] F. Ellinghaus,[82] K. Ellis,[75] N. Ellis,[30] J. Elmsheuser,[99] M. Elsing,[30]
D. Emeliyanov,[130] Y. Enari,[156] O. C. Endner,[82] R. Engelmann,[149] A. Engl,[99] J. Erdmann,[177] A. Ereditato,[17]
D. Eriksson,[147a] J. Ernst,[2] M. Ernst,[25] J. Ernwein,[137] D. Errede,[166] S. Errede,[166] E. Ertel,[82] M. Escalier,[116] H. Esch,[43]
C. Escobar,[124] X. Espinal Curull,[12] B. Esposito,[47] F. Etienne,[84] A. I. Etienvre,[137] E. Etzion,[154] D. Evangelakou,[54]
H. Evans,[60] L. Fabbri,[20a,20b] C. Fabre,[30] G. Facini,[30] R. M. Fakhrutdinov,[129] S. Falciano,[133a] Y. Fang,[33a]
M. Fanti,[90a,90b] A. Farbin,[8] A. Farilla,[135a] T. Farooque,[159] S. Farrell,[164] S. M. Farrington,[171] P. Farthouat,[30]
F. Fassi,[168] P. Fassnacht,[30] D. Fassouliotis,[9] B. Fatholahzadeh,[159] A. Favareto,[90a,90b] L. Fayard,[116] P. Federic,[145a]
O. L. Fedin,[122] W. Fedorko,[169] M. Fehling-Kaschek,[48] L. Feligioni,[84] C. Feng,[33d] E. J. Feng,[6] H. Feng,[88]
A. B. Fenyuk,[129] J. Ferencei,[145b] W. Fernando,[6] S. Ferrag,[53] J. Ferrando,[53] V. Ferrara,[42] A. Ferrari,[167] P. Ferrari,[106]
R. Ferrari,[120a] D. E. Ferreira de Lima,[53] A. Ferrer,[168] D. Ferrere,[49] C. Ferretti,[88] A. Ferretto Parodi,[50a,50b]
M. Fiascaris,[31] F. Fiedler,[82] A. Filipčič,[74] M. Filipuzzi,[42] F. Filthaut,[105] M. Fincke-Keeler,[170] K. D. Finelli,[45]
M. C. N. Fiolhais,[125a,i] L. Fiorini,[168] A. Firan,[40] J. Fischer,[176] M. J. Fisher,[110] E. A. Fitzgerald,[23] M. Flechl,[48]
I. Fleck,[142] P. Fleischmann,[175] S. Fleischmann,[176] G. T. Fletcher,[140] G. Fletcher,[75] T. Flick,[176] A. Floderus,[80]
L. R. Flores Castillo,[174] A. C. Florez Bustos,[160b] M. J. Flowerdew,[100] T. Fonseca Martin,[17] A. Formica,[137] A. Forti,[83]
D. Fortin,[160a] D. Fournier,[116] H. Fox,[71] P. Francavilla,[12] M. Franchini,[20a,20b] S. Franchino,[30] D. Francis,[30]
M. Franklin,[57] S. Franz,[61] M. Fraternali,[120a,120b] S. Fratina,[121] S. T. French,[28] C. Friedrich,[42] F. Friedrich,[44]
D. Froidevaux,[30] J. A. Frost,[28] C. Fukunaga,[157] E. Fullana Torregrosa,[128] B. G. Fulsom,[144] J. Fuster,[168]
C. Gabaldon,[30] O. Gabizon,[173] A. Gabrielli,[20a,20b] A. Gabrielli,[133a,133b] S. Gadatsch,[106] T. Gadfort,[25] S. Gadomski,[49]
G. Gagliardi,[50a,50b] P. Gagnon,[60] C. Galea,[99] B. Galhardo,[125a] E. J. Gallas,[119] V. Gallo,[17] B. J. Gallop,[130] P. Gallus,[127]
G. Galster,[36] K. K. Gan,[110] R. P. Gandrajula,[62] Y. S. Gao,[144,g] A. Gaponenko,[15] F. M. Garay Walls,[46] F. Garberson,[177]
C. García,[168] J. E. García Navarro,[168] M. Garcia-Sciveres,[15] R. W. Gardner,[31] N. Garelli,[144] V. Garonne,[30] C. Gatti,[47]
G. Gaudio,[120a] B. Gaur,[142] L. Gauthier,[94] P. Gauzzi,[133a,133b] I. L. Gavrilenko,[95] C. Gay,[169] G. Gaycken,[21]
E. N. Gazis,[10] P. Ge,[33d,o] Z. Gecse,[169] C. N. P. Gee,[130] D. A. A. Geerts,[106] Ch. Geich-Gimbel,[21]
K. Gellerstedt,[147a,147b] C. Gemme,[50a] A. Gemmell,[53] M. H. Genest,[55] S. Gentile,[133a,133b] M. George,[54] S. George,[76]
D. Gerbaudo,[164] A. Gershon,[154] H. Ghazlane,[136b] N. Ghodbane,[34] B. Giacobbe,[20a] S. Giagu,[133a,133b]
V. Giangiobbe,[12] P. Giannetti,[123a,123b] F. Gianotti,[30] B. Gibbard,[25] S. M. Gibson,[76] M. Gilchriese,[15] T. P. S. Gillam,[28]
D. Gillberg,[30] A. R. Gillman,[130] D. M. Gingrich,[3,f] N. Giokaris,[9] M. P. Giordani,[165c] R. Giordano,[103a,103b]
F. M. Giorgi,[16] P. Giovannini,[100] P. F. Giraud,[137] D. Giugni,[90a] C. Giuliani,[48] M. Giunta,[94] B. K. Gjelsten,[118]
I. Gkialas,[155,p] L. K. Gladilin,[98] C. Glasman,[81] J. Glatzer,[21] A. Glazov,[42] G. L. Glonti,[64] M. Goblirsch-Kolb,[100]
J. R. Goddard,[75] J. Godfrey,[143] J. Godlewski,[30] M. Goebel,[42] C. Goeringer,[82] S. Goldfarb,[88] T. Golling,[177]
D. Golubkov,[129] A. Gomes,[125a,d] L. S. Gomez Fajardo,[42] R. Gonçalo,[76] J. Goncalves Pinto Firmino Da Costa,[42]
L. Gonella,[21] S. González de la Hoz,[168] G. Gonzalez Parra,[12] M. L. Gonzalez Silva,[27] S. Gonzalez-Sevilla,[49]
J. J. Goodson,[149] L. Goossens,[30] P. A. Gorbounov,[96] H. A. Gordon,[25] I. Gorelov,[104] G. Gorfine,[176] B. Gorini,[30]
E. Gorini,[72a,72b] A. Gorišek,[74] E. Gornicki,[39] A. T. Goshaw,[6] C. Gössling,[43] M. I. Gostkin,[64] I. Gough Eschrich,[164]
M. Gouighri,[136a] D. Goujdami,[136c] M. P. Goulette,[49] A. G. Goussiou,[139] C. Goy,[5] S. Gozpinar,[23] H. M. X. Grabas,[137]
L. Graber,[54] I. Grabowska-Bold,[38a] P. Grafström,[20a,20b] K-J. Grahn,[42] E. Gramstad,[118] F. Grancagnolo,[72a]
S. Grancagnolo,[16] V. Grassi,[149] V. Gratchev,[122] H. M. Gray,[30] J. A. Gray,[149] E. Graziani,[135a] O. G. Grebenyuk,[122]
T. Greenshaw,[73] Z. D. Greenwood,[78,m] K. Gregersen,[36] I. M. Gregor,[42] P. Grenier,[144] J. Griffiths,[8] N. Grigalashvili,[64]
A. A. Grillo,[138] K. Grimm,[71] S. Grinstein,[12,q] Ph. Gris,[34] Y. V. Grishkevich,[98] J.-F. Grivaz,[116] J. P. Grohs,[44]
A. Grohsjean,[42] E. Gross,[173] J. Grosse-Knetter,[54] J. Groth-Jensen,[173] K. Grybel,[142] F. Guescini,[49] D. Guest,[177]
O. Gueta,[154] C. Guicheney,[34] E. Guido,[50a,50b] T. Guillemin,[116] S. Guindon,[2] U. Gul,[53] J. Gunther,[127] J. Guo,[35]
S. Gupta,[119] P. Gutierrez,[112] N. G. Gutierrez Ortiz,[53] N. Guttman,[154] O. Gutzwiller,[174] C. Guyot,[137] C. Gwenlan,[119]
C. B. Gwilliam,[73] A. Haas,[109] S. Haas,[30] C. Haber,[15] H. K. Hadavand,[8] P. Haefner,[21] Z. Hajduk,[39] H. Hakobyan,[178]
D. Hall,[119] G. Halladjian,[62] K. Hamacher,[176] P. Hamal,[114] K. Hamano,[87] M. Hamer,[54] A. Hamilton,[146a,r]
S. Hamilton,[162] L. Han,[33b] K. Hanagaki,[117] K. Hanawa,[156] M. Hance,[15] C. Handel,[82] P. Hanke,[58a] J. R. Hansen,[36]
J. B. Hansen,[36] J. D. Hansen,[36] P. H. Hansen,[36] P. Hansson,[144] K. Hara,[161] A. S. Hard,[174] T. Harenberg,[176]
S. Harkusha,[91] D. Harper,[88] R. D. Harrington,[46] O. M. Harris,[139] J. Hartert,[48] F. Hartjes,[106] A. Harvey,[56]
S. Hasegawa,[102] Y. Hasegawa,[141] S. Hassani,[137] S. Haug,[17] M. Hauschild,[30] R. Hauser,[89] M. Havranek,[21]
C. M. Hawkes,[18] R. J. Hawkings,[30] A. D. Hawkins,[80] T. Hayashi,[161] D. Hayden,[89] C. P. Hays,[119] H. S. Hayward,[73]
S. J. Haywood,[130] S. J. Head,[18] T. Heck,[82] V. Hedberg,[80] L. Heelan,[8] S. Heim,[121] B. Heinemann,[15] S. Heisterkamp,[36]

J. Hejbal,[126] L. Helary,[22] C. Heller,[99] M. Heller,[30] S. Hellman,[147a,147b] D. Hellmich,[21] C. Helsens,[30] J. Henderson,[119] R. C. W. Henderson,[71] A. Henrichs,[177] A. M. Henriques Correia,[30] S. Henrot-Versille,[116] C. Hensel,[54] G. H. Herbert,[16] C. M. Hernandez,[8] Y. Hernández Jiménez,[168] R. Herrberg-Schubert,[16] G. Herten,[48] R. Hertenberger,[99] L. Hervas,[30] G. G. Hesketh,[77] N. P. Hessey,[106] R. Hickling,[75] E. Higón-Rodriguez,[168] J. C. Hill,[28] K. H. Hiller,[42] S. Hillert,[21] S. J. Hillier,[18] I. Hinchliffe,[15] E. Hines,[121] M. Hirose,[117] D. Hirschbuehl,[176] J. Hobbs,[149] N. Hod,[106] M. C. Hodgkinson,[140] P. Hodgson,[140] A. Hoecker,[30] M. R. Hoeferkamp,[104] J. Hoffman,[40] D. Hoffmann,[84] J. I. Hofmann,[58a] M. Hohlfeld,[82] S. O. Holmgren,[147a] J. L. Holzbauer,[89] T. M. Hong,[121] L. Hooft van Huysduynen,[109] J-Y. Hostachy,[55] S. Hou,[152] A. Hoummada,[136a] J. Howard,[119] J. Howarth,[83] M. Hrabovsky,[114] I. Hristova,[16] J. Hrivnac,[116] T. Hryn'ova,[5] P. J. Hsu,[82] S.-C. Hsu,[139] D. Hu,[35] X. Hu,[25] Z. Hubacek,[30] F. Hubaut,[84] F. Huegging,[21] A. Huettmann,[42] T. B. Huffman,[119] E. W. Hughes,[35] G. Hughes,[71] M. Huhtinen,[30] T. A. Hülsing,[82] M. Hurwitz,[15] N. Huseynov,[64,s] J. Huston,[89] J. Huth,[57] G. Iacobucci,[49] G. Iakovidis,[10] I. Ibragimov,[142] L. Iconomidou-Fayard,[116] J. Idarraga,[116] P. Iengo,[103a] O. Igonkina,[106] Y. Ikegami,[65] K. Ikematsu,[142] M. Ikeno,[65] D. Iliadis,[155] N. Ilic,[159] T. Ince,[100] P. Ioannou,[9] M. Iodice,[135a] K. Iordanidou,[9] V. Ippolito,[133a,133b] A. Irles Quiles,[168] C. Isaksson,[167] M. Ishino,[67] M. Ishitsuka,[158] R. Ishmukhametov,[110] C. Issever,[119] S. Istin,[19a] A. V. Ivashin,[129] W. Iwanski,[39] H. Iwasaki,[65] J. M. Izen,[41] V. Izzo,[103a] B. Jackson,[121] J. N. Jackson,[73] P. Jackson,[1] M. R. Jaekel,[30] V. Jain,[2] K. Jakobs,[48] S. Jakobsen,[36] T. Jakoubek,[126] J. Jakubek,[127] D. O. Jamin,[152] D. K. Jana,[112] E. Jansen,[77] H. Jansen,[30] J. Janssen,[21] M. Janus,[171] R. C. Jared,[174] G. Jarlskog,[80] L. Jeanty,[57] G.-Y. Jeng,[151] I. Jen-La Plante,[31] D. Jennens,[87] P. Jenni,[30] J. Jentzsch,[43] C. Jeske,[171] S. Jézéquel,[5] M. K. Jha,[20a] H. Ji,[174] W. Ji,[82] J. Jia,[149] Y. Jiang,[33b] M. Jimenez Belenguer,[42] S. Jin,[33a] O. Jinnouchi,[158] M. D. Joergensen,[36] D. Joffe,[40] K. E. Johansson,[147a] P. Johansson,[140] S. Johnert,[42] K. A. Johns,[7] K. Jon-And,[147a,147b] G. Jones,[171] R. W. L. Jones,[71] T. J. Jones,[73] P. M. Jorge,[125a] K. D. Joshi,[83] J. Jovicevic,[148] X. Ju,[174] C. A. Jung,[43] R. M. Jungst,[30] P. Jussel,[61] A. Juste Rozas,[12,q] M. Kaci,[168] A. Kaczmarska,[39] P. Kadlecik,[36] M. Kado,[116] H. Kagan,[110] M. Kagan,[57] E. Kajomovitz,[153] S. Kalinin,[176] S. Kama,[40] N. Kanaya,[156] M. Kaneda,[30] S. Kaneti,[28] T. Kanno,[158] V. A. Kantserov,[97] J. Kanzaki,[65] B. Kaplan,[109] A. Kapliy,[31] D. Kar,[53] K. Karakostas,[10] N. Karastathis,[10] M. Karnevskiy,[82] S. N. Karpov,[64] V. Kartvelishvili,[71] A. N. Karyukhin,[129] L. Kashif,[174] G. Kasieczka,[58b] R. D. Kass,[110] A. Kastanas,[14] Y. Kataoka,[156] A. Katre,[49] J. Katzy,[42] V. Kaushik,[7] K. Kawagoe,[69] T. Kawamoto,[156] G. Kawamura,[54] S. Kazama,[156] V. F. Kazanin,[108] M. Y. Kazarinov,[64] R. Keeler,[170] P. T. Keener,[121] R. Kehoe,[40] M. Keil,[54] J. S. Keller,[139] H. Keoshkerian,[5] O. Kepka,[126] B. P. Kerševan,[74] S. Kersten,[176] K. Kessoku,[156] J. Keung,[159] F. Khalil-zada,[11] H. Khandanyan,[147a,147b] A. Khanov,[113] D. Kharchenko,[64] A. Khodinov,[97] A. Khomich,[58a] T. J. Khoo,[28] G. Khoriauli,[21] A. Khoroshilov,[176] V. Khovanskiy,[96] E. Khramov,[64] J. Khubua,[51b] H. Kim,[147a,147b] S. H. Kim,[161] N. Kimura,[172] O. Kind,[16] B. T. King,[73] M. King,[66] R. S. B. King,[119] S. B. King,[169] J. Kirk,[130] A. E. Kiryunin,[100] T. Kishimoto,[66] D. Kisielewska,[38a] T. Kitamura,[66] T. Kittelmann,[124] K. Kiuchi,[161] E. Kladiva,[145b] M. Klein,[73] U. Klein,[73] K. Kleinknecht,[82] M. Klemetti,[86] P. Klimek,[147a,147b] A. Klimentov,[25] R. Klingenberg,[43] J. A. Klinger,[83] E. B. Klinkby,[36] T. Klioutchnikova,[30] P. F. Klok,[105] E.-E. Kluge,[58a] P. Kluit,[106] S. Kluth,[100] E. Kneringer,[61] E. B. F. G. Knoops,[84] A. Knue,[54] B. R. Ko,[45] T. Kobayashi,[156] M. Kobel,[44] M. Kocian,[144] P. Kodys,[128] S. Koenig,[82] P. Koevesarki,[21] T. Koffas,[29] E. Koffeman,[106] L. A. Kogan,[119] S. Kohlmann,[176] F. Kohn,[54] Z. Kohout,[127] T. Kohriki,[65] T. Koi,[144] H. Kolanoski,[16] I. Koletsou,[90a] J. Koll,[89] A. A. Komar,[95] Y. Komori,[156] T. Kondo,[65] K. Köneke,[48] A. C. König,[105] T. Kono,[42,t] A. I. Kononov,[48] R. Konoplich,[109,u] N. Konstantinidis,[77] R. Kopeliansky,[153] S. Koperny,[38a] L. Köpke,[82] A. K. Kopp,[48] K. Korcyl,[39] K. Kordas,[155] A. Korn,[46] A. A. Korol,[108] I. Korolkov,[12] E. V. Korolkova,[140] V. A. Korotkov,[129] O. Kortner,[100] S. Kortner,[100] V. V. Kostyukhin,[21] S. Kotov,[100] V. M. Kotov,[64] A. Kotwal,[45] C. Kourkoumelis,[9] V. Kouskoura,[155] A. Koutsman,[160a] R. Kowalewski,[170] T. Z. Kowalski,[38a] W. Kozanecki,[137] A. S. Kozhin,[129] V. Kral,[127] V. A. Kramarenko,[98] G. Kramberger,[74] M. W. Krasny,[79] A. Krasznahorkay,[109] J. K. Kraus,[21] A. Kravchenko,[25] S. Kreiss,[109] J. Kretzschmar,[73] K. Kreutzfeldt,[52] N. Krieger,[54] P. Krieger,[159] K. Kroeninger,[54] H. Kroha,[100] J. Kroll,[121] J. Kroseberg,[21] J. Krstic,[13a] U. Kruchonak,[64] H. Krüger,[21] T. Kruker,[17] N. Krumnack,[63] Z. V. Krumshteyn,[64] A. Kruse,[174] M. K. Kruse,[45] M. Kruskal,[22] T. Kubota,[87] S. Kuday,[4a] S. Kuehn,[48] A. Kugel,[58c] T. Kuhl,[42] V. Kukhtin,[64] Y. Kulchitsky,[91] S. Kuleshov,[32b] M. Kuna,[79] J. Kunkle,[121] A. Kupco,[126] H. Kurashige,[66] M. Kurata,[161] Y. A. Kurochkin,[91] V. Kus,[126] E. S. Kuwertz,[148] M. Kuze,[158] J. Kvita,[143] R. Kwee,[16] A. La Rosa,[49] L. La Rotonda,[37a,37b] L. Labarga,[81] S. Lablak,[136a] C. Lacasta,[168] F. Lacava,[133a,133b] J. Lacey,[29] H. Lacker,[16] D. Lacour,[79] V. R. Lacuesta,[168] E. Ladygin,[64] R. Lafaye,[5] B. Laforge,[79] T. Lagouri,[177] S. Lai,[48] H. Laier,[58a] E. Laisne,[55] L. Lambourne,[77] C. L. Lampen,[7] W. Lampl,[7] E. Lançon,[137] U. Landgraf,[48] M. P. J. Landon,[75] V. S. Lang,[58a] C. Lange,[42] A. J. Lankford,[164] F. Lanni,[25] K. Lantzsch,[30] A. Lanza,[120a] S. Laplace,[79]

C. Lapoire,[21] J. F. Laporte,[137] T. Lari,[90a] A. Larner,[119] M. Lassnig,[30] P. Laurelli,[47] V. Lavorini,[37a,37b] W. Lavrijsen,[15]
P. Laycock,[73] B. T. Le,[55] O. Le Dortz,[79] E. Le Guirriec,[84] E. Le Menedeu,[12] T. LeCompte,[6] F. Ledroit-Guillon,[55]
C. A. Lee,[152] H. Lee,[106] J. S. H. Lee,[117] S. C. Lee,[152] L. Lee,[177] G. Lefebvre,[79] M. Lefebvre,[170] M. Legendre,[137]
F. Legger,[99] C. Leggett,[15] A. Lehan,[73] M. Lehmacher,[21] G. Lehmann Miotto,[30] A. G. Leister,[177] M. A. L. Leite,[24d]
R. Leitner,[128] D. Lellouch,[173] B. Lemmer,[54] V. Lendermann,[58a] K. J. C. Leney,[146c] T. Lenz,[106] G. Lenzen,[176]
B. Lenzi,[30] R. Leone,[7] K. Leonhardt,[44] S. Leontsinis,[10] C. Leroy,[94] J-R. Lessard,[170] C. G. Lester,[28] C. M. Lester,[121]
J. Levêque,[5] D. Levin,[88] L. J. Levinson,[173] A. Lewis,[119] G. H. Lewis,[109] A. M. Leyko,[21] M. Leyton,[16] B. Li,[33b,v]
B. Li,[84] H. Li,[149] H. L. Li,[31] S. Li,[33b,w] X. Li,[88] Z. Liang,[119,x] H. Liao,[34] B. Liberti,[134a] P. Lichard,[30] K. Lie,[166]
J. Liebal,[21] W. Liebig,[14] C. Limbach,[21] A. Limosani,[87] M. Limper,[62] S. C. Lin,[152,y] F. Linde,[106] B. E. Lindquist,[149]
J. T. Linnemann,[89] E. Lipeles,[121] A. Lipniacka,[14] M. Lisovyi,[42] T. M. Liss,[166] D. Lissauer,[25] A. Lister,[169]
A. M. Litke,[138] B. Liu,[152] D. Liu,[152] J. B. Liu,[33b] K. Liu,[33b,z] L. Liu,[88] M Liu,[45] M. Liu,[33b] Y. Liu,[33b]
M. Livan,[120a,120b] S. S. A. Livermore,[119] A. Lleres,[55] J. Llorente Merino,[81] S. L. Lloyd,[75] F. Lo Sterzo,[133a,133b]
E. Lobodzinska,[42] P. Loch,[7] W. S. Lockman,[138] T. Loddenkoetter,[21] F. K. Loebinger,[83] A. E. Loevschall-Jensen,[36]
A. Loginov,[177] C. W. Loh,[169] T. Lohse,[16] K. Lohwasser,[48] M. Lokajicek,[126] V. P. Lombardo,[5] R. E. Long,[71]
L. Lopes,[125a] D. Lopez Mateos,[57] B. Lopez Paredes,[140] J. Lorenz,[99] N. Lorenzo Martinez,[116] M. Losada,[163]
P. Loscutoff,[15] M. J. Losty,[160a,a] X. Lou,[41] A. Lounis,[116] K. F. Loureiro,[163] J. Love,[6] P. A. Love,[71] A. J. Lowe,[144,g]
F. Lu,[33a] H. J. Lubatti,[139] C. Luci,[133a,133b] A. Lucotte,[55] D. Ludwig,[42] I. Ludwig,[48] J. Ludwig,[48] F. Luehring,[60]
W. Lukas,[61] L. Luminari,[133a] E. Lund,[118] J. Lundberg,[147a,147b] O. Lundberg,[147a,147b] B. Lund-Jensen,[148]
M. Lungwitz,[82] D. Lynn,[25] R. Lysak,[126] E. Lytken,[80] H. Ma,[25] L. L. Ma,[33d] G. Maccarrone,[47] A. Macchiolo,[100]
B. Maček,[74] J. Machado Miguens,[125a] D. Macina,[30] R. Mackeprang,[36] R. Madar,[48] R. J. Madaras,[15]
H. J. Maddocks,[71] W. F. Mader,[44] A. Madsen,[167] M. Maeno,[5] T. Maeno,[25] L. Magnoni,[164] E. Magradze,[54]
K. Mahboubi,[48] J. Mahlstedt,[106] S. Mahmoud,[73] G. Mahout,[18] C. Maiani,[137] C. Maidantchik,[24a] A. Maio,[125a,d]
S. Majewski,[115] Y. Makida,[65] N. Makovec,[116] P. Mal,[137,aa] B. Malaescu,[79] Pa. Malecki,[39] P. Malecki,[39]
V. P. Maleev,[122] F. Malek,[55] U. Mallik,[62] D. Malon,[6] C. Malone,[144] S. Maltezos,[10] V. M. Malyshev,[108] S. Malyukov,[30]
J. Mamuzic,[13b] L. Mandelli,[90a] I. Mandić,[74] R. Mandrysch,[62] J. Maneira,[125a] A. Manfredini,[100]
L. Manhaes de Andrade Filho,[24b] J. A. Manjarres Ramos,[137] A. Mann,[99] P. M. Manning,[138]
A. Manousakis-Katsikakis,[9] B. Mansoulie,[137] R. Mantifel,[86] L. Mapelli,[30] L. March,[168] J. F. Marchand,[29]
F. Marchese,[134a,134b] G. Marchiori,[79] M. Marcisovsky,[126] C. P. Marino,[170] C. N. Marques,[125a] F. Marroquim,[24a]
Z. Marshall,[121] L. F. Marti,[17] S. Marti-Garcia,[168] B. Martin,[30] B. Martin,[89] J. P. Martin,[94] T. A. Martin,[171]
V. J. Martin,[46] B. Martin dit Latour,[49] H. Martinez,[137] M. Martinez,[12,q] S. Martin-Haugh,[150] A. C. Martyniuk,[170]
M. Marx,[83] F. Marzano,[133a] A. Marzin,[112] L. Masetti,[82] T. Mashimo,[156] R. Mashinistov,[95] J. Masik,[83]
A. L. Maslennikov,[108] I. Massa,[20a,20b] N. Massol,[5] P. Mastrandrea,[149] A. Mastroberardino,[37a,37b] T. Masubuchi,[156]
H. Matsunaga,[156] T. Matsushita,[66] P. Mättig,[176] S. Mättig,[42] J. Mattmann,[82] C. Mattravers,[119,e] J. Maurer,[84]
S. J. Maxfield,[73] D. A. Maximov,[108,h] R. Mazini,[152] L. Mazzaferro,[134a,134b] M. Mazzanti,[90a] S. P. Mc Kee,[88]
A. McCarn,[166] R. L. McCarthy,[149] T. G. McCarthy,[29] N. A. McCubbin,[130] K. W. McFarlane,[56,a] J. A. Mcfayden,[140]
G. Mchedlidze,[51b] T. Mclaughlan,[18] S. J. McMahon,[130] R. A. McPherson,[170,k] A. Meade,[85] J. Mechnich,[106]
M. Mechtel,[176] M. Medinnis,[42] S. Meehan,[31] R. Meera-Lebbai,[112] S. Mehlhase,[36] A. Mehta,[73] K. Meier,[58a]
C. Meineck,[99] B. Meirose,[80] C. Melachrinos,[31] B. R. Mellado Garcia,[146c] F. Meloni,[90a,90b] L. Mendoza Navas,[163]
A. Mengarelli,[20a,20b] S. Menke,[100] E. Meoni,[162] K. M. Mercurio,[57] N. Meric,[137] P. Mermod,[49] L. Merola,[103a,103b]
C. Meroni,[90a] F. S. Merritt,[31] H. Merritt,[110] A. Messina,[30,bb] J. Metcalfe,[25] A. S. Mete,[164] C. Meyer,[82] C. Meyer,[31]
J-P. Meyer,[137] J. Meyer,[30] J. Meyer,[54] S. Michal,[30] R. P. Middleton,[130] S. Migas,[73] L. Mijović,[137] G. Mikenberg,[173]
M. Mikestikova,[126] M. Mikuž,[74] D. W. Miller,[31] W. J. Mills,[169] C. Mills,[57] A. Milov,[173] D. A. Milstead,[147a,147b]
D. Milstein,[173] A. A. Minaenko,[129] M. Miñano Moya,[168] I. A. Minashvili,[64] A. I. Mincer,[109] B. Mindur,[38a]
M. Mineev,[64] Y. Ming,[174] L. M. Mir,[12] G. Mirabelli,[133a] T. Mitani,[172] J. Mitrevski,[138] V. A. Mitsou,[168] S. Mitsui,[65]
P. S. Miyagawa,[140] J. U. Mjörnmark,[80] T. Moa,[147a,147b] V. Moeller,[28] S. Mohapatra,[149] W. Mohr,[48] R. Moles-Valls,[168]
A. Molfetas,[30] K. Mönig,[42] C. Monini,[55] J. Monk,[36] E. Monnier,[84] J. Montejo Berlingen,[12] F. Monticelli,[70]
S. Monzani,[20a,20b] R. W. Moore,[3] C. Mora Herrera,[49] A. Moraes,[53] N. Morange,[62] J. Morel,[54] D. Moreno,[82]
M. Moreno Llácer,[168] P. Morettini,[50a] M. Morgenstern,[44] M. Morii,[57] S. Moritz,[82] A. K. Morley,[148] G. Mornacchi,[30]
J. D. Morris,[75] L. Morvaj,[102] H. G. Moser,[100] M. Mosidze,[51b] J. Moss,[110] R. Mount,[144] E. Mountricha,[10,cc]
S. V. Mouraviev,[95,a] E. J. W. Moyse,[85] R. D. Mudd,[18] F. Mueller,[58a] J. Mueller,[124] K. Mueller,[21] T. Mueller,[28]
T. Mueller,[82] D. Muenstermann,[49] Y. Munwes,[154] J. A. Murillo Quijada,[18] W. J. Murray,[130] I. Mussche,[106]

E. Musto,[153] A. G. Myagkov,[129,dd] M. Myska,[126] O. Nackenhorst,[54] J. Nadal,[12] K. Nagai,[161] R. Nagai,[158] Y. Nagai,[84]
K. Nagano,[65] A. Nagarkar,[110] Y. Nagasaka,[59] M. Nagel,[100] A. M. Nairz,[30] Y. Nakahama,[30] K. Nakamura,[65]
T. Nakamura,[156] I. Nakano,[111] H. Namasivayam,[41] G. Nanava,[21] A. Napier,[162] R. Narayan,[58b] M. Nash,[77,e]
T. Nattermann,[21] T. Naumann,[42] G. Navarro,[163] H. A. Neal,[88] P. Yu. Nechaeva,[95] T. J. Neep,[83] A. Negri,[120a,120b]
G. Negri,[30] M. Negrini,[20a] S. Nektarijevic,[49] A. Nelson,[164] T. K. Nelson,[144] S. Nemecek,[126] P. Nemethy,[109]
A. A. Nepomuceno,[24a] M. Nessi,[30,ee] M. S. Neubauer,[166] M. Neumann,[176] A. Neusiedl,[82] R. M. Neves,[109]
P. Nevski,[25] F. M. Newcomer,[121] P. R. Newman,[18] D. H. Nguyen,[6] V. Nguyen Thi Hong,[137] R. B. Nickerson,[119]
R. Nicolaidou,[137] B. Nicquevert,[30] J. Nielsen,[138] N. Nikiforou,[35] A. Nikiforov,[16] V. Nikolaenko,[129,dd]
I. Nikolic-Audit,[79] K. Nikolics,[49] K. Nikolopoulos,[18] P. Nilsson,[8] Y. Ninomiya,[156] A. Nisati,[133a] R. Nisius,[100]
T. Nobe,[158] L. Nodulman,[6] M. Nomachi,[117] I. Nomidis,[155] S. Norberg,[112] M. Nordberg,[30] J. Novakova,[128]
M. Nozaki,[65] L. Nozka,[114] K. Ntekas,[10] A.-E. Nuncio-Quiroz,[21] G. Nunes Hanninger,[87] T. Nunnemann,[99] E. Nurse,[77]
B. J. O'Brien,[46] F. O'grady,[7] D. C. O'Neil,[143] V. O'Shea,[53] L. B. Oakes,[99] F. G. Oakham,[29,f] H. Oberlack,[100]
J. Ocariz,[79] A. Ochi,[66] M. I. Ochoa,[77] S. Oda,[69] S. Odaka,[65] J. Odier,[84] H. Ogren,[60] A. Oh,[83] S. H. Oh,[45] C. C. Ohm,[30]
T. Ohshima,[102] W. Okamura,[117] H. Okawa,[25] Y. Okumura,[31] T. Okuyama,[156] A. Olariu,[26a] A. G. Olchevski,[64]
S. A. Olivares Pino,[46] M. Oliveira,[125a,i] D. Oliveira Damazio,[25] E. Oliver Garcia,[168] D. Olivito,[121] A. Olszewski,[39]
J. Olszowska,[39] A. Onofre,[125a,ff] P. U. E. Onyisi,[31,gg] C. J. Oram,[160a] M. J. Oreglia,[31] Y. Oren,[154] D. Orestano,[135a,135b]
N. Orlando,[72a,72b] C. Oropeza Barrera,[53] R. S. Orr,[159] B. Osculati,[50a,50b] R. Ospanov,[121] G. Otero y Garzon,[27]
H. Otono,[69] J. P. Ottersbach,[106] M. Ouchrif,[136d] E. A. Ouellette,[170] F. Ould-Saada,[118] A. Ouraou,[137]
K. P. Oussoren,[106] Q. Ouyang,[33a] A. Ovcharova,[15] M. Owen,[83] S. Owen,[140] V. E. Ozcan,[19a] N. Ozturk,[8] K. Pachal,[119]
A. Pacheco Pages,[12] C. Padilla Aranda,[12] S. Pagan Griso,[15] E. Paganis,[140] C. Pahl,[100] F. Paige,[25] P. Pais,[85]
K. Pajchel,[118] G. Palacino,[160b] C. P. Paleari,[7] S. Palestini,[30] D. Pallin,[34] A. Palma,[125a] J. D. Palmer,[18] Y. B. Pan,[174]
E. Panagiotopoulou,[10] J. G. Panduro Vazquez,[76] P. Pani,[106] N. Panikashvili,[88] S. Panitkin,[25] D. Pantea,[26a]
A. Papadelis,[147a] Th. D. Papadopoulou,[10] K. Papageorgiou,[155,p] A. Paramonov,[6] D. Paredes Hernandez,[34]
M. A. Parker,[28] F. Parodi,[50a,50b] J. A. Parsons,[35] U. Parzefall,[48] S. Pashapour,[54] E. Pasqualucci,[133a] S. Passaggio,[50a]
A. Passeri,[135a] F. Pastore,[135a,135b,a] Fr. Pastore,[76] G. Pásztor,[49,hh] S. Pataraia,[176] N. D. Patel,[151] J. R. Pater,[83]
S. Patricelli,[103a,103b] T. Pauly,[30] J. Pearce,[170] M. Pedersen,[118] S. Pedraza Lopez,[168] M. I. Pedraza Morales,[174]
S. V. Peleganchuk,[108] D. Pelikan,[167] H. Peng,[33b] B. Penning,[31] A. Penson,[35] J. Penwell,[60] D. V. Perepelitsa,[35]
T. Perez Cavalcanti,[42] E. Perez Codina,[160a] M. T. Pérez García-Estañ,[168] V. Perez Reale,[35] L. Perini,[90a,90b]
H. Pernegger,[30] R. Perrino,[72a] V. D. Peshekhonov,[64] K. Peters,[30] R. F. Y. Peters,[54,ii] B. A. Petersen,[30] J. Petersen,[30]
T. C. Petersen,[36] E. Petit,[5] A. Petridis,[147a,147b] C. Petridou,[155] E. Petrolo,[133a] F. Petrucci,[135a,135b] M. Petteni,[143]
R. Pezoa,[32b] A. Phan,[87] P. W. Phillips,[130] G. Piacquadio,[144] E. Pianori,[171] A. Picazio,[49] E. Piccaro,[75]
M. Piccinini,[20a,20b] S. M. Piec,[42] R. Piegaia,[27] D. T. Pignotti,[110] J. E. Pilcher,[31] A. D. Pilkington,[77] J. Pina,[125a,d]
M. Pinamonti,[165a,165c,jj] A. Pinder,[119] J. L. Pinfold,[3] A. Pingel,[36] B. Pinto,[125a] C. Pizio,[90a,90b] M.-A. Pleier,[25]
V. Pleskot,[128] E. Plotnikova,[64] P. Plucinski,[147a,147b] S. Poddar,[58a] F. Podlyski,[34] R. Poettgen,[82] L. Poggioli,[116]
D. Pohl,[21] M. Pohl,[49] G. Polesello,[120a] A. Policicchio,[37a,37b] R. Polifka,[159] A. Polini,[20a] C. S. Pollard,[45]
V. Polychronakos,[25] D. Pomeroy,[23] K. Pommès,[30] L. Pontecorvo,[133a] B. G. Pope,[89] G. A. Popeneciu,[26b]
D. S. Popovic,[13a] A. Poppleton,[30] X. Portell Bueso,[12] G. E. Pospelov,[100] S. Pospisil,[127] I. N. Potrap,[64] C. J. Potter,[150]
C. T. Potter,[115] G. Poulard,[30] J. Poveda,[60] V. Pozdnyakov,[64] R. Prabhu,[77] P. Pralavorio,[84] A. Pranko,[15] S. Prasad,[30]
R. Pravahan,[25] S. Prell,[63] D. Price,[60] J. Price,[73] L. E. Price,[6] D. Prieur,[124] M. Primavera,[72a] M. Proissl,[46]
K. Prokofiev,[109] F. Prokoshin,[32b] E. Protopapadaki,[137] S. Protopopescu,[25] J. Proudfoot,[6] X. Prudent,[44]
M. Przybycien,[38a] H. Przysiezniak,[5] S. Psoroulas,[21] E. Ptacek,[115] E. Pueschel,[85] D. Puldon,[149] M. Purohit,[25,kk]
P. Puzo,[116] Y. Pylypchenko,[62] J. Qian,[88] A. Quadt,[54] D. R. Quarrie,[15] W. B. Quayle,[146c] D. Quilty,[53] M. Raas,[105]
V. Radeka,[25] V. Radescu,[42] P. Radloff,[115] F. Ragusa,[90a,90b] G. Rahal,[179] S. Rajagopalan,[25] M. Rammensee,[48]
M. Rammes,[142] A. S. Randle-Conde,[40] C. Rangel-Smith,[79] K. Rao,[164] F. Rauscher,[99] T. C. Rave,[48] T. Ravenscroft,[53]
M. Raymond,[30] A. L. Read,[118] D. M. Rebuzzi,[120a,120b] A. Redelbach,[175] G. Redlinger,[25] R. Reece,[121] K. Reeves,[41]
A. Reinsch,[115] I. Reisinger,[43] M. Relich,[164] C. Rembser,[30] Z. L. Ren,[152] A. Renaud,[116] M. Rescigno,[133a]
S. Resconi,[90a] B. Resende,[137] P. Reznicek,[99] R. Rezvani,[94] R. Richter,[100] E. Richter-Was,[38b] M. Ridel,[79] P. Rieck,[16]
M. Rijssenbeek,[149] A. Rimoldi,[120a,120b] L. Rinaldi,[20a] R. R. Rios,[40] E. Ritsch,[61] I. Riu,[12] G. Rivoltella,[90a,90b]
F. Rizatdinova,[113] E. Rizvi,[75] S. H. Robertson,[86,k] A. Robichaud-Veronneau,[119] D. Robinson,[28] J. E. M. Robinson,[83]
A. Robson,[53] J. G. Rocha de Lima,[107] C. Roda,[123a,123b] D. Roda Dos Santos,[30] A. Roe,[54] S. Roe,[30] O. Røhne,[118]
S. Rolli,[162] A. Romaniouk,[97] M. Romano,[20a,20b] G. Romeo,[27] E. Romero Adam,[168] N. Rompotis,[139] L. Roos,[79]

E. Ros,[168] S. Rosati,[133a] K. Rosbach,[49] A. Rose,[150] M. Rose,[76] P. L. Rosendahl,[14] O. Rosenthal,[142] V. Rossetti,[12]
E. Rossi,[133a,133b] L. P. Rossi,[50a] M. Rotaru,[26a] I. Roth,[173] J. Rothberg,[139] D. Rousseau,[116] C. R. Royon,[137]
A. Rozanov,[84] Y. Rozen,[153] X. Ruan,[146c] F. Rubbo,[12] I. Rubinskiy,[42] N. Ruckstuhl,[106] V. I. Rud,[98] C. Rudolph,[44]
M. S. Rudolph,[159] F. Rühr,[7] A. Ruiz-Martinez,[63] L. Rumyantsev,[64] Z. Rurikova,[48] N. A. Rusakovich,[64] A. Ruschke,[99]
J. P. Rutherfoord,[7] N. Ruthmann,[48] P. Ruzicka,[126] Y. F. Ryabov,[122] M. Rybar,[128] G. Rybkin,[116] N. C. Ryder,[119]
A. F. Saavedra,[151] A. Saddique,[3] I. Sadeh,[154] H. F-W. Sadrozinski,[138] R. Sadykov,[64] F. Safai Tehrani,[133a]
H. Sakamoto,[156] G. Salamanna,[75] A. Salamon,[134a] M. Saleem,[112] D. Salek,[30] D. Salihagic,[100] A. Salnikov,[144]
J. Salt,[168] B. M. Salvachua Ferrando,[6] D. Salvatore,[37a,37b] F. Salvatore,[150] A. Salvucci,[105] A. Salzburger,[30]
D. Sampsonidis,[155] A. Sanchez,[103a,103b] J. Sánchez,[168] V. Sanchez Martinez,[168] H. Sandaker,[14] H. G. Sander,[82]
M. P. Sanders,[99] M. Sandhoff,[176] T. Sandoval,[28] C. Sandoval,[163] R. Sandstroem,[100] D. P. C. Sankey,[130] A. Sansoni,[47]
C. Santoni,[34] R. Santonico,[134a,134b] H. Santos,[125a] I. Santoyo Castillo,[150] K. Sapp,[124] J. G. Saraiva,[125a] T. Sarangi,[174]
E. Sarkisyan-Grinbaum,[8] B. Sarrazin,[21] F. Sarri,[123a,123b] G. Sartisohn,[176] O. Sasaki,[65] Y. Sasaki,[156] N. Sasao,[67]
I. Satsounkevitch,[91] G. Sauvage,[5,a] E. Sauvan,[5] J. B. Sauvan,[116] P. Savard,[159,f] V. Savinov,[124] D. O. Savu,[30]
C. Sawyer,[119] L. Sawyer,[78,m] D. H. Saxon,[53] J. Saxon,[121] C. Sbarra,[20a] A. Sbrizzi,[3] D. A. Scannicchio,[164]
M. Scarcella,[151] J. Schaarschmidt,[116] P. Schacht,[100] D. Schaefer,[121] A. Schaelicke,[46] S. Schaepe,[21] S. Schaetzel,[58b]
U. Schäfer,[82] A. C. Schaffer,[116] D. Schaile,[99] R. D. Schamberger,[149] V. Scharf,[58a] V. A. Schegelsky,[122] D. Scheirich,[88]
M. Schernau,[164] M. I. Scherzer,[35] C. Schiavi,[50a,50b] J. Schieck,[99] C. Schillo,[48] M. Schioppa,[37a,37b] S. Schlenker,[30]
E. Schmidt,[48] K. Schmieden,[21] C. Schmitt,[82] C. Schmitt,[99] S. Schmitt,[58b] B. Schneider,[17] Y. J. Schnellbach,[73]
U. Schnoor,[44] L. Schoeffel,[137] A. Schoening,[58b] A. L. S. Schorlemmer,[54] M. Schott,[82] D. Schouten,[160a]
J. Schovancova,[126] M. Schram,[86] C. Schroeder,[82] N. Schroer,[58c] M. J. Schultens,[21] H.-C. Schultz-Coulon,[58a]
H. Schulz,[16] M. Schumacher,[48] B. A. Schumm,[138] Ph. Schune,[137] A. Schwartzman,[144] Ph. Schwegler,[100]
Ph. Schwemling,[137] R. Schwienhorst,[89] J. Schwindling,[137] T. Schwindt,[21] M. Schwoerer,[5] F. G. Sciacca,[17]
E. Scifo,[116] G. Sciolla,[23] W. G. Scott,[130] F. Scutti,[21] J. Searcy,[88] G. Sedov,[42] E. Sedykh,[122] S. C. Seidel,[104]
A. Seiden,[138] F. Seifert,[44] J. M. Seixas,[24a] G. Sekhniaidze,[103a] S. J. Sekula,[40] K. E. Selbach,[46] D. M. Seliverstov,[122]
G. Sellers,[73] M. Seman,[145b] N. Semprini-Cesari,[20a,20b] C. Serfon,[30] L. Serin,[116] L. Serkin,[54] T. Serre,[84] R. Seuster,[160a]
H. Severini,[112] A. Sfyrla,[30] E. Shabalina,[54] M. Shamim,[115] L. Y. Shan,[33a] J. T. Shank,[22] Q. T. Shao,[87] M. Shapiro,[15]
P. B. Shatalov,[96] K. Shaw,[165a,165c] P. Sherwood,[77] S. Shimizu,[66] M. Shimojima,[101] T. Shin,[56] M. Shiyakova,[64]
A. Shmeleva,[95] M. J. Shochet,[31] D. Short,[119] S. Shrestha,[63] E. Shulga,[97] M. A. Shupe,[7] S. Shushkevich,[42] P. Sicho,[126]
A. Sidoti,[133a] F. Siegert,[48] Dj. Sijacki,[13a] O. Silbert,[173] J. Silva,[125a] Y. Silver,[154] D. Silverstein,[144]
S. B. Silverstein,[147a] V. Simak,[127] O. Simard,[5] Lj. Simic,[13a] S. Simion,[116] E. Simioni,[82] B. Simmons,[77]
R. Simoniello,[90a,90b] M. Simonyan,[36] P. Sinervo,[159] N. B. Sinev,[115] V. Sipica,[142] G. Siragusa,[175] A. Sircar,[78]
A. N. Sisakyan,[64,a] S. Yu. Sivoklokov,[98] J. Sjölin,[147a,147b] T. B. Sjursen,[14] L. A. Skinnari,[15] H. P. Skottowe,[57]
K. Yu. Skovpen,[108] P. Skubic,[112] M. Slater,[18] T. Slavicek,[127] K. Sliwa,[162] V. Smakhtin,[173] B. H. Smart,[46]
L. Smestad,[118] S. Yu. Smirnov,[97] Y. Smirnov,[97] L. N. Smirnova,[98,ll] O. Smirnova,[80] K. M. Smith,[53] M. Smizanska,[71]
K. Smolek,[127] A. A. Snesarev,[95] G. Snidero,[75] J. Snow,[112] S. Snyder,[25] R. Sobie,[170,k] J. Sodomka,[127] A. Soffer,[154]
D. A. Soh,[152,x] C. A. Solans,[30] M. Solar,[127] J. Solc,[127] E. Yu. Soldatov,[97] U. Soldevila,[168]
E. Solfaroli Camillocci,[133a,133b] A. A. Solodkov,[129] O. V. Solovyanov,[129] V. Solovyev,[122] N. Soni,[1] A. Sood,[15]
V. Sopko,[127] B. Sopko,[127] M. Sosebee,[8] R. Soualah,[165a,165c] P. Soueid,[94] A. M. Soukharev,[108] D. South,[42]
S. Spagnolo,[72a,72b] F. Spanò,[76] W. R. Spearman,[57] R. Spighi,[20a] G. Spigo,[30] R. Spiwoks,[30] M. Spousta,[128,mm]
T. Spreitzer,[159] B. Spurlock,[8] R. D. St. Denis,[53] J. Stahlman,[121] R. Stamen,[58a] E. Stanecka,[39] R. W. Stanek,[6]
C. Stanescu,[135a] M. Stanescu-Bellu,[42] M. M. Stanitzki,[42] S. Stapnes,[118] E. A. Starchenko,[129] J. Stark,[55] P. Staroba,[126]
P. Starovoitov,[42] R. Staszewski,[39] A. Staude,[99] P. Stavina,[145a,a] G. Steele,[53] P. Steinbach,[44] P. Steinberg,[25] I. Stekl,[127]
B. Stelzer,[143] H. J. Stelzer,[89] O. Stelzer-Chilton,[160a] H. Stenzel,[52] S. Stern,[100] G. A. Stewart,[30] J. A. Stillings,[21]
M. C. Stockton,[86] M. Stoebe,[86] K. Stoerig,[48] G. Stoicea,[26a] S. Stonjek,[100] A. R. Stradling,[8] A. Straessner,[44]
J. Strandberg,[148] S. Strandberg,[147a,147b] A. Strandlie,[118] M. Strang,[110] E. Strauss,[144] M. Strauss,[112] P. Strizenec,[145b]
R. Ströhmer,[175] D. M. Strom,[115] J. A. Strong,[76,a] R. Stroynowski,[40] B. Stugu,[14] I. Stumer,[25,a] J. Stupak,[149]
P. Sturm,[176] N. A. Styles,[42] D. Su,[144] HS. Subramania,[3] R. Subramaniam,[78] A. Succurro,[12] Y. Sugaya,[117] C. Suhr,[107]
M. Suk,[127] V. V. Sulin,[95] S. Sultansoy,[4c] T. Sumida,[67] X. Sun,[55] J. E. Sundermann,[48] K. Suruliz,[140] G. Susinno,[37a,37b]
M. R. Sutton,[150] Y. Suzuki,[65] M. Svatos,[126] S. Swedish,[169] M. Swiatlowski,[144] I. Sykora,[145a] T. Sykora,[128] D. Ta,[106]
K. Tackmann,[42] A. Taffard,[164] R. Tafirout,[160a] N. Taiblum,[154] Y. Takahashi,[102] H. Takai,[25] R. Takashima,[68]
H. Takeda,[66] T. Takeshita,[141] Y. Takubo,[65] M. Talby,[84] A. A. Talyshev,[108,h] J. Y. C. Tam,[175] M. C. Tamsett,[78,nn]

K. G. Tan,[87] J. Tanaka,[156] R. Tanaka,[116] S. Tanaka,[132] S. Tanaka,[65] A. J. Tanasijczuk,[143] K. Tani,[66] N. Tannoury,[84]
S. Tapprogge,[82] S. Tarem,[153] F. Tarrade,[29] G. F. Tartarelli,[90a] P. Tas,[128] M. Tasevsky,[126] T. Tashiro,[67] E. Tassi,[37a,37b]
A. Tavares Delgado,[125a] Y. Tayalati,[136d] C. Taylor,[77] F. E. Taylor,[93] G. N. Taylor,[87] W. Taylor,[160b] M. Teinturier,[116]
F. A. Teischinger,[30] M. Teixeira Dias Castanheira,[75] P. Teixeira-Dias,[76] K. K. Temming,[48] H. Ten Kate,[30]
P. K. Teng,[152] S. Terada,[65] K. Terashi,[156] J. Terron,[81] M. Testa,[47] R. J. Teuscher,[159,k] J. Therhaag,[21]
T. Theveneaux-Pelzer,[34] S. Thoma,[48] J. P. Thomas,[18] E. N. Thompson,[35] P. D. Thompson,[18] P. D. Thompson,[159]
A. S. Thompson,[53] L. A. Thomsen,[36] E. Thomson,[121] M. Thomson,[28] W. M. Thong,[87] R. P. Thun,[88,a] F. Tian,[35]
M. J. Tibbetts,[15] T. Tic,[126] V. O. Tikhomirov,[95] Yu. A. Tikhonov,[108,h] S. Timoshenko,[97] E. Tiouchichine,[84]
P. Tipton,[177] S. Tisserant,[84] T. Todorov,[5] S. Todorova-Nova,[128] B. Toggerson,[164] J. Tojo,[69] S. Tokár,[145a]
K. Tokushuku,[65] K. Tollefson,[89] L. Tomlinson,[83] M. Tomoto,[102] L. Tompkins,[31] K. Toms,[104] A. Tonoyan,[14]
C. Topfel,[17] N. D. Topilin,[64] E. Torrence,[115] H. Torres,[79] E. Torró Pastor,[168] J. Toth,[84,hh] F. Touchard,[84]
D. R. Tovey,[140] H. L. Tran,[116] T. Trefzger,[175] L. Tremblet,[30] A. Tricoli,[30] I. M. Trigger,[160a] S. Trincaz-Duvoid,[79]
M. F. Tripiana,[70] N. Triplett,[25] W. Trischuk,[159] B. Trocmé,[55] C. Troncon,[90a] M. Trottier-McDonald,[143]
M. Trovatelli,[135a,135b] P. True,[89] M. Trzebinski,[39] A. Trzupek,[39] C. Tsarouchas,[30] J. C-L. Tseng,[119] M. Tsiakiris,[106]
P. V. Tsiareshka,[91] D. Tsionou,[137] G. Tsipolitis,[10] S. Tsiskaridze,[12] V. Tsiskaridze,[48] E. G. Tskhadadze,[51a]
I. I. Tsukerman,[96] V. Tsulaia,[15] J.-W. Tsung,[21] S. Tsuno,[65] D. Tsybychev,[149] A. Tua,[140] A. Tudorache,[26a]
V. Tudorache,[26a] J. M. Tuggle,[31] A. N. Tuna,[121] M. Turala,[39] S. Turchikhin,[98,ll] D. Turecek,[127] I. Turk Cakir,[4d]
R. Turra,[90a,90b] P. M. Tuts,[35] A. Tykhonov,[74] M. Tylmad,[147a,147b] M. Tyndel,[130] K. Uchida,[21] I. Ueda,[156] R. Ueno,[29]
M. Ughetto,[84] M. Ugland,[14] M. Uhlenbrock,[21] F. Ukegawa,[161] G. Unal,[30] A. Undrus,[25] G. Unel,[164] F. C. Ungaro,[48]
Y. Unno,[65] D. Urbaniec,[35] P. Urquijo,[21] G. Usai,[8] A. Usanova,[61] L. Vacavant,[84] V. Vacek,[127] B. Vachon,[86]
S. Vahsen,[15] N. Valencic,[106] S. Valentinetti,[20a,20b] A. Valero,[168] L. Valery,[34] S. Valkar,[128] E. Valladolid Gallego,[168]
S. Vallecorsa,[153] J. A. Valls Ferrer,[168] R. Van Berg,[121] P. C. Van Der Deijl,[106] R. van der Geer,[106] H. van der Graaf,[106]
R. Van Der Leeuw,[106] D. van der Ster,[30] N. van Eldik,[30] P. van Gemmeren,[6] J. Van Nieuwkoop,[143] I. van Vulpen,[106]
M. Vanadia,[100] W. Vandelli,[30] A. Vaniachine,[6] P. Vankov,[42] F. Vannucci,[79] R. Vari,[133a] E. W. Varnes,[7] T. Varol,[85]
D. Varouchas,[15] A. Vartapetian,[8] K. E. Varvell,[151] V. I. Vassilakopoulos,[56] F. Vazeille,[34] T. Vazquez Schroeder,[54]
J. Veatch,[7] F. Veloso,[125a] S. Veneziano,[133a] A. Ventura,[72a,72b] D. Ventura,[85] M. Venturi,[48] N. Venturi,[159]
V. Vercesi,[120a] M. Verducci,[139] W. Verkerke,[106] J. C. Vermeulen,[106] A. Vest,[44] M. C. Vetterli,[143,f] I. Vichou,[166]
T. Vickey,[146c,oo] O. E. Vickey Boeriu,[146c] G. H. A. Viehhauser,[119] S. Viel,[169] R. Vigne,[30] M. Villa,[20a,20b]
M. Villaplana Perez,[168] E. Vilucchi,[47] M. G. Vincter,[29] V. B. Vinogradov,[64] J. Virzi,[15] O. Vitells,[173] M. Viti,[42]
I. Vivarelli,[48] F. Vives Vaque,[3] S. Vlachos,[10] D. Vladoiu,[99] M. Vlasak,[127] A. Vogel,[21] P. Vokac,[127] G. Volpi,[47]
M. Volpi,[87] G. Volpini,[90a] H. von der Schmitt,[100] H. von Radziewski,[48] E. von Toerne,[21] V. Vorobel,[128] M. Vos,[168]
R. Voss,[30] J. H. Vossebeld,[73] N. Vranjes,[137] M. Vranjes Milosavljevic,[106] V. Vrba,[126] M. Vreeswijk,[106] T. Vu Anh,[48]
R. Vuillermet,[30] I. Vukotic,[31] Z. Vykydal,[127] W. Wagner,[176] P. Wagner,[21] S. Wahrmund,[44] J. Wakabayashi,[102]
S. Walch,[88] J. Walder,[71] R. Walker,[99] W. Walkowiak,[142] R. Wall,[177] P. Waller,[73] B. Walsh,[177] C. Wang,[45] H. Wang,[174]
H. Wang,[40] J. Wang,[152] J. Wang,[33a] K. Wang,[86] R. Wang,[104] S. M. Wang,[152] T. Wang,[21] X. Wang,[177] A. Warburton,[86]
C. P. Ward,[28] D. R. Wardrope,[77] M. Warsinsky,[48] A. Washbrook,[46] C. Wasicki,[42] I. Watanabe,[66] P. M. Watkins,[18]
A. T. Watson,[18] I. J. Watson,[151] M. F. Watson,[18] G. Watts,[139] S. Watts,[83] A. T. Waugh,[151] B. M. Waugh,[77]
M. S. Weber,[17] J. S. Webster,[31] A. R. Weidberg,[119] P. Weigell,[100] J. Weingarten,[54] C. Weiser,[48] H. Weits,[106]
P. S. Wells,[30] T. Wenaus,[25] D. Wendland,[16] Z. Weng,[152,x] T. Wengler,[30] S. Wenig,[30] N. Wermes,[21] M. Werner,[48]
P. Werner,[30] M. Werth,[164] M. Wessels,[58a] J. Wetter,[162] K. Whalen,[29] A. White,[8] M. J. White,[87] R. White,[32b]
S. White,[123a,123b] D. Whiteson,[164] D. Whittington,[60] D. Wicke,[176] F. J. Wickens,[130] W. Wiedenmann,[174]
M. Wielers,[80,e] P. Wienemann,[21] C. Wiglesworth,[36] L. A. M. Wiik-Fuchs,[21] P. A. Wijeratne,[77] A. Wildauer,[100]
M. A. Wildt,[42,t] I. Wilhelm,[128] H. G. Wilkens,[30] J. Z. Will,[99] E. Williams,[35] H. H. Williams,[121] S. Williams,[28]
W. Willis,[35,a] S. Willocq,[85] J. A. Wilson,[18] A. Wilson,[88] I. Wingerter-Seez,[5] S. Winkelmann,[48] F. Winklmeier,[30]
M. Wittgen,[144] T. Wittig,[43] J. Wittkowski,[99] S. J. Wollstadt,[82] M. W. Wolter,[39] H. Wolters,[125a,i] W. C. Wong,[41]
G. Wooden,[88] B. K. Wosiek,[39] J. Wotschack,[30] M. J. Woudstra,[83] K. W. Wozniak,[39] K. Wraight,[53] M. Wright,[53]
B. Wrona,[73] S. L. Wu,[174] X. Wu,[49] Y. Wu,[88] E. Wulf,[35] B. M. Wynne,[46] S. Xella,[36] M. Xiao,[137] C. Xu,[33b,cc] D. Xu,[33a]
L. Xu,[33b,pp] B. Yabsley,[151] S. Yacoob,[146b,qq] M. Yamada,[65] H. Yamaguchi,[156] Y. Yamaguchi,[156] A. Yamamoto,[65]
K. Yamamoto,[63] S. Yamamoto,[156] T. Yamamura,[156] T. Yamanaka,[156] K. Yamauchi,[102] Y. Yamazaki,[66] Z. Yan,[22]
H. Yang,[33e] H. Yang,[174] U. K. Yang,[83] Y. Yang,[110] Z. Yang,[147a,147b] S. Yanush,[92] L. Yao,[33a] Y. Yasu,[65] E. Yatsenko,[42]
K. H. Yau Wong,[21] J. Ye,[40] S. Ye,[25] A. L. Yen,[57] E. Yildirim,[42] M. Yilmaz,[4b] R. Yoosoofmiya,[124] K. Yorita,[172]

R. Yoshida,[6] K. Yoshihara,[156] C. Young,[144] C. J. S. Young,[119] S. Youssef,[22] D. R. Yu,[15] J. Yu,[8] J. Yu,[113] L. Yuan,[66] A. Yurkewicz,[107] B. Zabinski,[39] R. Zaidan,[62] A. M. Zaitsev,[129,dd] S. Zambito,[23] L. Zanello,[133a,133b] D. Zanzi,[100] A. Zaytsev,[25] C. Zeitnitz,[176] M. Zeman,[127] A. Zemla,[39] O. Zenin,[129] T. Ženiš,[145a] D. Zerwas,[116] G. Zevi della Porta,[57] D. Zhang,[88] H. Zhang,[89] J. Zhang,[6] L. Zhang,[152] X. Zhang,[33d] Z. Zhang,[116] Z. Zhao,[33b] A. Zhemchugov,[64] J. Zhong,[119] B. Zhou,[88] N. Zhou,[164] C. G. Zhu,[33d] H. Zhu,[42] J. Zhu,[88] Y. Zhu,[33b] X. Zhuang,[33a] A. Zibell,[99] D. Zieminska,[60] N. I. Zimin,[64] C. Zimmermann,[82] R. Zimmermann,[21] S. Zimmermann,[21] S. Zimmermann,[48] Z. Zinonos,[123a,123b] M. Ziolkowski,[142] R. Zitoun,[5] L. Živković,[35] G. Zobernig,[174] A. Zoccoli,[20a,20b] M. zur Nedden,[16] V. Zutshi,[107] and L. Zwalinski[30]

(ATLAS Collaboration)

[1]*School of Chemistry and Physics, University of Adelaide, Adelaide, Australia*
[2]*Physics Department, SUNY Albany, Albany, New York, USA*
[3]*Department of Physics, University of Alberta, Edmonton, Alberta, Canada*
[4a]*Department of Physics, Ankara University, Ankara, Turkey*
[4b]*Department of Physics, Gazi University, Ankara, Turkey*
[4c]*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[4d]*Turkish Atomic Energy Authority, Ankara, Turkey*
[5]*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
[6]*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
[7]*Department of Physics, University of Arizona, Tucson, Arizona, USA*
[8]*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
[9]*Physics Department, University of Athens, Athens, Greece*
[10]*Physics Department, National Technical University of Athens, Zografou, Greece*
[11]*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[12]*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona, Barcelona, Spain*
[13a]*Institute of Physics, University of Belgrade, Belgrade, Serbia*
[13b]*Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*
[14]*Department for Physics and Technology, University of Bergen, Bergen, Norway*
[15]*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
[16]*Department of Physics, Humboldt University, Berlin, Germany*
[17]*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
[18]*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
[19a]*Department of Physics, Bogazici University, Istanbul, Turkey*
[19b]*Department of Physics, Dogus University, Istanbul, Turkey*
[19c]*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
[20a]*INFN Sezione di Bologna, Bologna, Italy*
[20b]*Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy*
[21]*Physikalisches Institut, University of Bonn, Bonn, Germany*
[22]*Department of Physics, Boston University, Boston, Massachusetts, USA*
[23]*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
[24a]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
[24b]*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
[24c]*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
[24d]*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*
[25]*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
[26a]*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
[26b]*National Institute for Research and Development of Isotopic and Molecular Technologies,*
Physics Department, Cluj Napoca, Romania
[26c]*University Politehnica Bucharest, Bucharest, Romania*
[26d]*West University in Timisoara, Timisoara, Romania*
[27]*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
[28]*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
[29]*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
[30]*CERN, Geneva, Switzerland*
[31]*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
[32a]*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
[32b]*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
[33a]*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*

[33b]*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
[33c]*Department of Physics, Nanjing University, Jiangsu, China*
[33d]*School of Physics, Shandong University, Shandong, China*
[33e]*Physics Department, Shanghai Jiao Tong University, Shanghai, China*
[34]*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France*
[35]*Nevis Laboratory, Columbia University, Irvington, New York, USA*
[36]*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
[37a]*INFN Gruppo Collegato di Cosenza, Cosenza, Italy*
[37b]*Dipartimento di Fisica, Università della Calabria, Rende, Italy*
[38a]*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
[38b]*Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland*
[39]*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
[40]*Physics Department, Southern Methodist University, Dallas, Texas, USA*
[41]*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
[42]*DESY, Hamburg and Zeuthen, Germany*
[43]*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
[44]*Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany*
[45]*Department of Physics, Duke University, Durham, North Carolina, USA*
[46]*SUPA-School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
[47]*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
[48]*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany*
[49]*Section de Physique, Université de Genève, Geneva, Switzerland*
[50a]*INFN Sezione di Genova, Genova, Italy*
[50b]*Dipartimento di Fisica, Università di Genova, Genova, Italy*
[51a]*E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[51b]*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
[52]*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
[53]*SUPA-School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
[54]*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
[55]*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
[56]*Department of Physics, Hampton University, Hampton, Virginia, USA*
[57]*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
[58a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[58b]*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[58c]*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
[59]*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
[60]*Department of Physics, Indiana University, Bloomington, Indiana, USA*
[61]*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
[62]*University of Iowa, Iowa City, Iowa, USA*
[63]*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
[64]*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
[65]*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
[66]*Graduate School of Science, Kobe University, Kobe, Japan*
[67]*Faculty of Science, Kyoto University, Kyoto, Japan*
[68]*Kyoto University of Education, Kyoto, Japan*
[69]*Department of Physics, Kyushu University, Fukuoka, Japan*
[70]*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
[71]*Physics Department, Lancaster University, Lancaster, United Kingdom*
[72a]*INFN Sezione di Lecce, Lecce, Italy*
[72b]*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[73]*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
[74]*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
[75]*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
[76]*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
[77]*Department of Physics and Astronomy, University College London, London, United Kingdom*
[78]*Louisiana Tech University, Ruston, Louisiana, USA*
[79]*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
[80]*Fysiska institutionen, Lunds universitet, Lund, Sweden*
[81]*Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain*

[82]*Institut für Physik, Universität Mainz, Mainz, Germany*
[83]*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
[84]*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
[85]*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
[86]*Department of Physics, McGill University, Montreal, Quebec City, Canada*
[87]*School of Physics, University of Melbourne, Victoria, Australia*
[88]*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
[89]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
[90a]*INFN Sezione di Milano, Milano, Italy*
[90b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[91]*B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
[92]*National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus*
[93]*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
[94]*Group of Particle Physics, University of Montreal, Montreal, Quebec City, Canada*
[95]*P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*
[96]*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
[97]*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
[98]*D.V.Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia*
[99]*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
[100]*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
[101]*Nagasaki Institute of Applied Science, Nagasaki, Japan*
[102]*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
[103a]*INFN Sezione di Napoli, Napoli, Italy*
[103b]*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
[104]*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
[105]*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
[106]*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
[107]*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
[108]*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
[109]*Department of Physics, New York University, New York, New York, USA*
[110]*Ohio State University, Columbus, Ohio, USA*
[111]*Faculty of Science, Okayama University, Okayama, Japan*
[112]*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
[113]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
[114]*Palacký University, RCPTM, Olomouc, Czech Republic*
[115]*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
[116]*LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France*
[117]*Graduate School of Science, Osaka University, Osaka, Japan*
[118]*Department of Physics, University of Oslo, Oslo, Norway*
[119]*Department of Physics, Oxford University, Oxford, United Kingdom*
[120a]*INFN Sezione di Pavia, Pavia, Italy*
[120b]*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
[121]*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
[122]*Petersburg Nuclear Physics Institute, Gatchina, Russia*
[123a]*INFN Sezione di Pisa, Pisa, Italy*
[123b]*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
[124]*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
[125a]*Laboratorio de Instrumentacao e Fisica Experimental de Particulas-LIP, Lisboa, Portugal*
[125b]*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
[126]*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
[127]*Czech Technical University in Prague, Praha, Czech Republic*
[128]*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
[129]*State Research Center Institute for High Energy Physics, Protvino, Russia*
[130]*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[131]*Physics Department, University of Regina, Regina, Saskatchewan, Canada*
[132]*Ritsumeikan University, Kusatsu, Shiga, Japan*
[133a]*INFN Sezione di Roma I, Roma, Italy*
[133b]*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
[134a]*INFN Sezione di Roma Tor Vergata, Italy*
[134b]*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[135a]*INFN Sezione di Roma Tre, Roma, Italy*

[135b]*Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
[136a]*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies-Université Hassan II, Casablanca, Morocco*
[136b]*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
[136c]*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
[136d]*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
[136e]*Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco*
[137]*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique et aux Energies Alternatives), Gif-sur-Yvette, France*
[138]*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
[139]*Department of Physics, University of Washington, Seattle, Washington, USA*
[140]*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
[141]*Department of Physics, Shinshu University, Nagano, Japan*
[142]*Fachbereich Physik, Universität Siegen, Siegen, Germany*
[143]*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*
[144]*SLAC National Accelerator Laboratory, Stanford, California, USA*
[145a]*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
[145b]*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
[146a]*Department of Physics, University of Cape Town, Cape Town, South Africa*
[146b]*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
[146c]*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
[147a]*Department of Physics, Stockholm University, Stockholm, Sweden*
[147b]*The Oskar Klein Centre, Stockholm, Sweden*
[148]*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
[149]*Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA*
[150]*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
[151]*School of Physics, University of Sydney, Sydney, Australia*
[152]*Institute of Physics, Academia Sinica, Taipei, Taiwan*
[153]*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
[154]*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[155]*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[156]*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
[157]*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
[158]*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
[159]*Department of Physics, University of Toronto, Toronto, Ontario, Canada*
[160a]*TRIUMF, Vancouver, British Columbia, Canada*
[160b]*Department of Physics and Astronomy, York University, Toronto, Ontario, Canada*
[161]*Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan*
[162]*Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA*
[163]*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
[164]*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
[165a]*INFN Gruppo Collegato di Udine, Udine, Italy*
[165b]*ICTP, Trieste, Italy*
[165c]*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*
[166]*Department of Physics, University of Illinois, Urbana, Illinois, USA*
[167]*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
[168]*Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
[169]*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada*
[170]*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada*
[171]*Department of Physics, University of Warwick, Coventry, United Kingdom*
[172]*Waseda University, Tokyo, Japan*
[173]*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*
[174]*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*
[175]*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
[176]*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[177]*Department of Physics, Yale University, New Haven, Connecticut, USA*
[178]*Yerevan Physics Institute, Yerevan, Armenia*
[179]*Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France*

[a] Deceased.
[b] Also at Department of Physics, King's College London, London, United Kingdom.
[c] Also at Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal.
[d] Also at Faculdade de Ciencias and CFNUL, Universidade de Lisboa, Lisboa, Portugal.
[e] Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.
[f] Also at TRIUMF, Vancouver, BC, Canada.
[g] Also at Department of Physics, California State University, Fresno, CA, USA.
[h] Also at Novosibirsk State University, Novosibirsk, Russia.
[i] Also at Department of Physics, University of Coimbra, Coimbra, Portugal.
[j] Also at Università di Napoli Parthenope, Napoli, Italy.
[k] Also at Institute of Particle Physics (IPP), Canada.
[l] Also at Department of Physics, Middle East Technical University, Ankara, Turkey.
[m] Also at Louisiana Tech University, Ruston, LA, USA.
[n] Also at Dep Fisica and CEFITEC of Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal.
[o] Also at Department of Physics and Astronomy, Michigan State University, East Lansing, MI, USA.
[p] Also at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece.
[q] Also at Institucio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.
[r] Also at Department of Physics, University of Cape Town, Cape Town, South Africa.
[s] Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
[t] Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
[u] Also at Manhattan College, New York, NY, USA.
[v] Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
[w] Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
[x] Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.
[y] Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
[z] Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.
[aa] Also at School of Physical Sciences, National Institute of Science Education and Research, Bhubaneswar, India.
[bb] Also at Dipartimento di Fisica, Università La Sapienza, Roma, Italy.
[cc] Also at 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.
[dd] Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.
[ee] Also at Section de Physique, Université de Genève, Geneva, Switzerland.
[ff] Also at Departamento de Fisica, Universidade de Minho, Braga, Portugal.
[gg] Also at Department of Physics, The University of Texas at Austin, Austin, TX, USA.
[hh] Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
[ii] Also at DESY, Hamburg and Zeuthen, Germany.
[jj] Also at International School for Advanced Studies (SISSA), Trieste, Italy.
[kk] Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.
[ll] Also at Faculty of Physics, M.V.Lomonosov Moscow State University, Moscow, Russia.
[mm] Also at Nevis Laboratory, Columbia University, Irvington, NY, USA.
[nn] Also at Physics Department, Brookhaven National Laboratory, Upton, NY, USA.
[oo] Also at Department of Physics, Oxford University, Oxford, United Kingdom.
[pp] Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.
[qq] Also at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa.