



## UvA-DARE (Digital Academic Repository)

### Measurement of dijet production with a veto on additional central jet activity in pp collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector

Aad, G.; et al., [Unknown]; Bentvelsen, S.; Colijn, A.P.; de Jong, P.; de Nooij, L.; Doxiadis, A.D.; Ferrari, P.; Garitaonandia, H.; Geerts, D.A.A.; Gosselink, M.; Kayl, M.S.; Koffeman, E.; Lee, H.; Linde, F.; Mechnich, J.; Mussche, I.; Ottersbach, J.P.; Tsiakiris, M.; van der Kraaij, E.; van der Leeuw, R.; van Kesteren, Z.; van Vulpen, I.B.; Vermeulen, J.C.; Vreeswijk, M.

**DOI**

[10.1007/JHEP09\(2011\)053](https://doi.org/10.1007/JHEP09(2011)053)

**Publication date**

2011

**Document Version**

Final published version

**Published in**

The Journal of High Energy Physics

[Link to publication](#)

**Citation for published version (APA):**

Aad, G., et al., U., Bentvelsen, S., Colijn, A. P., de Jong, P., de Nooij, L., Doxiadis, A. D., Ferrari, P., Garitaonandia, H., Geerts, D. A. A., Gosselink, M., Kayl, M. S., Koffeman, E., Lee, H., Linde, F., Mechnich, J., Mussche, I., Ottersbach, J. P., Tsiakiris, M., ... Vreeswijk, M. (2011). Measurement of dijet production with a veto on additional central jet activity in pp collisions at  $\sqrt{s} = 7$  TeV using the ATLAS detector. *The Journal of High Energy Physics*, 2011(9), 53. [https://doi.org/10.1007/JHEP09\(2011\)053](https://doi.org/10.1007/JHEP09(2011)053)

**General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

**Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library, <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.



# Measurement of dijet production with a veto on additional central jet activity in $pp$ collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector

---

## The ATLAS collaboration

**ABSTRACT:** A measurement of jet activity in the rapidity interval bounded by a dijet system is presented. Events are vetoed if a jet with transverse momentum greater than 20 GeV is found between the two boundary jets. The fraction of dijet events that survive the jet veto is presented for boundary jets that are separated by up to six units of rapidity and with mean transverse momentum  $50 < \bar{p}_T < 500$  GeV. The mean multiplicity of jets above the veto scale in the rapidity interval bounded by the dijet system is also presented as an alternative method for quantifying perturbative QCD emission. The data are compared to a next-to-leading order plus parton shower prediction from the POWHEG-BOX, an all-order resummation using the HEJ calculation and the PYTHIA, HERWIG++ and ALPGEN event generators. The measurement was performed using  $pp$  collisions at  $\sqrt{s} = 7$  TeV using data recorded by the ATLAS detector in 2010.

**KEYWORDS:** Hadron-Hadron Scattering

---

**Contents**

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>The ATLAS detector</b>	<b>2</b>
<b>3</b>	<b>Measurement definition</b>	<b>3</b>
<b>4</b>	<b>Monte Carlo event simulation</b>	<b>3</b>
<b>5</b>	<b>Theory predictions</b>	<b>4</b>
<b>6</b>	<b>Jet reconstruction and energy scale determination</b>	<b>5</b>
<b>7</b>	<b>Event selection</b>	<b>5</b>
<b>8</b>	<b>Correction for detector effects</b>	<b>6</b>
<b>9</b>	<b>Results and discussion</b>	<b>8</b>
<b>10</b>	<b>Summary</b>	<b>13</b>
	<b>The ATLAS collaboration</b>	<b>19</b>

---

**1 Introduction**

Dijet production with a veto on additional hadronic activity in the rapidity interval between the jets has previously been studied at HERA [1–3] and the Tevatron [4–8]. The Large Hadron Collider (LHC) offers the opportunity to study this process at an increased centre-of-mass energy and with a wider coverage in rapidity between jets. Historically, the main purpose of these measurements has been to search for evidence of colour singlet exchange. With this aim, a very low cut on the total hadronic activity between the jets (less than a few GeV) was traditionally chosen, to suppress contributions from colour octet exchange.

In this measurement, a jet veto is used to identify the absence of additional activity. This approach is useful because it allows a diverse range of perturbative QCD phenomena to be studied, as the veto scale is chosen to be much larger than  $\Lambda_{\text{QCD}}$ . First, BFKL-like dynamics<sup>1</sup> [10–13] are expected to become increasingly important for large rapidity intervals [14–17]. Alternatively, the effects of wide-angle soft-gluon radiation can be studied in the limit that the average dijet transverse momentum is much larger than the scale used to veto on additional jet activity [18, 19]. Finally, colour singlet exchange is expected to

---

<sup>1</sup>BFKL dynamics propose an evolution in  $\ln(1/x)$ , where  $x$  is the Bjorken variable, as opposed to the DGLAP [9] evolution in  $\ln(Q^2)$ , where  $Q^2$  is the parton virtuality

be important if both limits are satisfied at the same time, i.e the jets are widely separated and the jet veto scale is small in comparison to the dijet transverse momentum. The measurement is therefore targeted at studying the effects of QCD radiation in those regions of phase space that may not be adequately described by standard event generators.

A central jet veto is also used in the search for Higgs production via vector boson fusion in the Higgs-plus-two-jet channel in order to reject backgrounds. Furthermore, should the Higgs boson be discovered, the contribution from gluon fusion to this channel needs to be determined in order to extract the Higgs boson couplings [20–23]. This measurement, therefore, could be used to constrain the theoretical modelling in current Higgs searches and future precision Higgs measurements.

## 2 The ATLAS detector

ATLAS is a general-purpose detector surrounding interaction point one of the LHC [24, 25]. The main detector components relevant to this analysis are the inner tracking detector, the calorimeters and the minimum bias trigger scintillators (MBTS). The inner tracking detector covers the pseudorapidity range  $|\eta| < 2.5$ , and has full coverage in azimuth.<sup>2</sup> There are three main components to the inner tracker; the silicon pixel detector, the silicon microstrip detector and the transition-radiation detector. These components are arranged in concentric layers and immersed in a 2 T magnetic field provided by the inner solenoid magnet.

The ATLAS calorimeter is also divided into sub-detectors. The electromagnetic calorimeter ( $|\eta| < 3.2$ ) is a high-granularity sampling detector in which the active medium is liquid argon (LAr) inter-spaced with layers of lead absorber. The hadronic calorimeters are divided into three sections: a tile scintillator/steel calorimeter is used in both the barrel ( $|\eta| < 1.0$ ) and extended barrel cylinders ( $0.8 < |\eta| < 1.7$ ); the hadronic endcap covers the region  $1.5 < |\eta| < 3.2$  and consists of LAr/copper calorimeter modules; the forward calorimeter measures both electromagnetic and hadronic energy in the range  $3.2 < |\eta| < 4.9$  using LAr/copper and LAr/tungsten modules. The total coverage of the ATLAS calorimeters is  $|\eta| < 4.9$ .

The primary triggers used to readout the ATLAS detector were the calorimeter jet triggers [26]. The calorimeter jet triggers were validated for this measurement using a fully efficient minimum bias trigger derived from the MBTS. The MBTS consists of 32 scintillator counters arranged on two disks located in front of the end-cap calorimeter cryostats. The MBTS cover the region  $2.1 < |\eta| < 3.8$ .

---

<sup>2</sup>ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the centre of the detector and the  $z$ -axis along the beam pipe. The  $x$ -axis points from the IP to the centre of the LHC ring, and the  $y$  axis points upward. Cylindrical coordinates  $(r, \phi)$  are used in the transverse plane,  $\phi$  being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle  $\theta$  as  $\eta = -\ln \tan(\theta/2)$ . The rapidity of a particle with respect to the beam axis is defined as  $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$ .

### 3 Measurement definition

Jets are reconstructed using the anti- $k_t$  algorithm [27] with distance parameter  $R = 0.6$  and full four momentum recombination. Jets are required to have transverse momentum  $p_T > 20$  GeV and rapidity  $|y| < 4.4$ , ensuring that they are in a region in which the jet energy scale has been validated (section 6). The dijet system is identified using two different selection criteria. In the first, the two highest transverse momentum jets in the event are used, which probes wide-angle soft gluon radiation in  $p_T$ -ordered jet configurations. In the second, the most forward and the most backward jets in the event are used (i.e. those with the largest rapidity separation,  $\Delta y$ ), which favours BFKL-like dynamics because the dijet invariant mass is much larger than the transverse momentum of the jets. For both definitions, the mean transverse momentum of the jets that define the dijet system,  $\bar{p}_T$ , is required to be greater than 50 GeV. This ensures that the measurement is in the high efficiency region of the calorimeter jet trigger (section 7).

Two variables are used to quantify the amount of additional radiation in the rapidity interval bounded by the dijet system. The first is the gap fraction, which is the fraction of events that do not have an additional jet with a transverse momentum greater than a given veto scale,  $Q_0$ , in the rapidity interval bounded by the dijet system. The default value of the veto scale is chosen to be  $Q_0 = 20$  GeV. The second variable is the mean number of jets with  $p_T > Q_0$  in the rapidity interval bounded by the dijet system. The measurements of these two variables are fully corrected for experimental effects. The final distributions therefore correspond to the ‘hadron-level’, in which the jets are reconstructed using all final state particles that have a proper lifetime longer than 10 ps. This includes muons and neutrinos.

### 4 Monte Carlo event simulation

Simulated proton-proton collisions at  $\sqrt{s} = 7$  TeV were produced using Monte Carlo (MC) event generators. These samples were used to derive systematic uncertainties and correct for detector effects. The reference generator was PYTHIA 6.4.2.3 [28], which implements leading-order (LO) QCD matrix elements for  $2 \rightarrow 2$  processes followed by a  $p_T$ -ordered parton shower and the Lund string model of hadronisation. The underlying event in PYTHIA is modelled by multiple parton interactions interleaved with the initial state parton shower. The events were generated using the MRST LO\* parton distribution functions (PDF) [29, 30] and the AMBT1 tune [31]. The final state particles were passed through a detailed GEANT4 [32] simulation of the ATLAS detector [33] and reconstructed using the same analysis chain as for the data.

Fully simulated event samples were also generated using HERWIG++ 2.5.0 [34] and ALPGEN [35]. HERWIG++ implements leading order  $2 \rightarrow 2$  matrix elements, but uses an angular-ordered parton shower and a cluster hadronisation model. The underlying event is modelled by multiple parton interactions. The HERWIG++ event samples are generated using the MRST LO\* PDF set with the LHC-UE7-1 tune for the underlying event [36]. ALPGEN provides LO matrix elements with up to six partons in the final state. The

ALPGEN samples are generated using the CTEQ6L1 PDF set [37] and passed through HERWIG 6.5 [38] and JIMMY [39] to provide parton showering, hadronisation and multiple partonic interactions with tune AUET1 [40].

## 5 Theory predictions

The measurements presented in this paper probe perturbative QCD in the region where the energy scale of the dijet system is larger than the scale of the additional radiation. At large values of  $\bar{p}_T/Q_0$  or  $\Delta y$ , it is expected that fixed order calculations are unlikely to describe the data and that a resummation to all orders in perturbation theory is necessary. The measurement is not particularly sensitive to non-perturbative physics because  $Q_0$  is chosen to be much greater than  $\Lambda_{\text{QCD}}$ . The net effect of the non-perturbative physics corrections was estimated by turning the hadronisation and underlying event on and off in PYTHIA — the resulting shift in the gap fraction was less than 2% and the change in the mean number of jets in the rapidity interval bounded by the dijet system was less than 4%.

The theoretical predictions were produced using HEJ [15, 41] and the POWHEG-BOX [42–44]. HEJ is a parton-level event generator that provides an all-order description of wide-angle emissions of similar transverse momentum. In this BFKL-inspired limit, HEJ reproduces the full QCD results and is especially suited for events with at least two jets separated by a large rapidity interval.<sup>3</sup> The events were generated with the MSTW 2008 NLO PDF set [29] and the partons were clustered into jets using the anti- $k_t$  algorithm with distance parameter  $R = 0.6$ . The renormalisation/factorisation scale (one parameter in HEJ) was chosen to be the  $p_T$  of the leading parton and the uncertainty due to this choice was estimated by increasing and decreasing the scale by a factor of two. The uncertainty from the choice of PDF was estimated using the full set of eigenvector errors provided by MSTW and also by changing the PDF to CTEQ61 [37]. The overall uncertainty in the HEJ calculation is dominated by the scale choice and is typically 5% for the gap fraction and 8% for the mean number of jets in the rapidity interval bounded by the dijet system. These uncertainties are larger than the non-perturbative physics corrections and the HEJ parton-level predictions are therefore used for data-theory comparisons.

The POWHEG-BOX provides a full next-to-leading order (NLO) dijet calculation and is interfaced to PYTHIA or HERWIG to provide all-order resummation of soft and collinear emissions using the parton shower approximation. The POWHEG events were generated using the MSTW 2008 NLO PDF set with the renormalisation and factorisation scales set to the  $p_T$  of the leading parton. These events were passed through both PYTHIA (tune AMBT1) and HERWIG (tune AUET1) to provide different hadron-level predictions. The difference between these two predictions was found to be larger than the intrinsic uncertainty in the NLO calculation, estimated by varying the PDFs and the renormalisation and factorisation scales. Therefore, the POWHEG+PYTHIA and POWHEG+HERWIG predictions are both used for data-theory comparisons.

---

<sup>3</sup>In the default setup (used in this analysis), HEJ matches the resummation to leading order  $2 \rightarrow 3$  and  $2 \rightarrow 4$  matrix elements. However, the option to include the additional running coupling terms from next-to-leading-log BFKL was not used.

## 6 Jet reconstruction and energy scale determination

Jets are reconstructed at detector level using electromagnetic (EM) scale topological clusters,<sup>4</sup> which are three-dimensional objects built from calorimeter cells [45]. The jet energies are corrected using  $p_T$  and  $\eta$  dependent jet energy scale (JES) calibration factors derived from simulated MC events [46]. The JES calibration is obtained by dividing the true jet energy, defined using stable interacting particles in the MC event record (i.e. excluding muons and neutrinos), by the EM scale energy of the matching detector-level jet. The corrections are derived for jets with  $p_T > 10$  GeV at the EM scale and parameterised as a function of jet  $p_T$  and  $|\eta|$ . An additional correction factor is applied to the  $\eta$  of jets that fall in the crack-regions of the detector, to remove the bias caused by the constituents of jets falling in regions of very different calorimeter response. The final stage recalculates the jet kinematics using the primary vertex position, rather than the ATLAS geometric centre (0,0,0).

The absolute JES uncertainty has been determined using data for the well-understood barrel region ( $|\eta| < 0.8$ ), by propagating the uncertainty in the single-particle response, measured by the tracking and calorimeter systems, to the jet constituents [47]. An additional uncertainty has been obtained for other calorimeter regions using dijet  $\eta$ -intercalibration [48]; the jet calorimeter response relative to the barrel region was studied by balancing the transverse momenta of dijets and the uncertainty estimated by comparing the results obtained with data to a variety of MC based predictions. The total JES uncertainty in each calorimeter region was taken to be the sum in quadrature of the absolute uncertainty (from the barrel) and relative uncertainty from the dijet intercalibration [46]. The final JES uncertainty is approximately 2–5% in the barrel region, but rises to 13% in the forward calorimeter for jets with  $p_T \sim 20$  GeV.

The impact of the JES uncertainty on the measurement of dijet production with a jet veto was studied by varying the energy scale of jets within the JES uncertainty, allowing for different calorimeter regions to have correlated/uncorrelated calorimeter responses. The associated uncertainty on the gap fraction is typically 3% (7%) for  $\Delta y \sim 3$  (6). The uncertainty on the mean number of jets in the rapidity interval bounded by the dijet system is approximately 5% and only weakly dependent on  $\Delta y$ . The effect of the JES uncertainty is the largest systematic uncertainty in the measurement for most of the phase space regions that are presented.

## 7 Event selection

The measurement was performed using data taken during 2010. The primary trigger selections used to readout the ATLAS detector were the calorimeter jet triggers. In particular, distinct regions of  $\bar{p}_T$  were defined and, in each region, only events that passed a specific jet trigger (at least one jet above a defined threshold) were used. The  $\bar{p}_T$  regions were de-

---

<sup>4</sup>The electromagnetic scale is the basic calorimeter signal scale for the ATLAS calorimeters. It gives the correct response for the energy deposited in electromagnetic showers, while it does not correct for the lower hadron response.



fined using PYTHIA events and validated using data collected with a minimum bias trigger derived from the MBTS. The chosen trigger for each region was required to be the highest threshold (and therefore least prescaled) trigger that was at least 99% efficient for both gap events and inclusive events. The bias in the measurement from the use of jet triggers was estimated to be less than 0.25%. This was determined using MC simulations and also data collected with the minimum bias trigger.

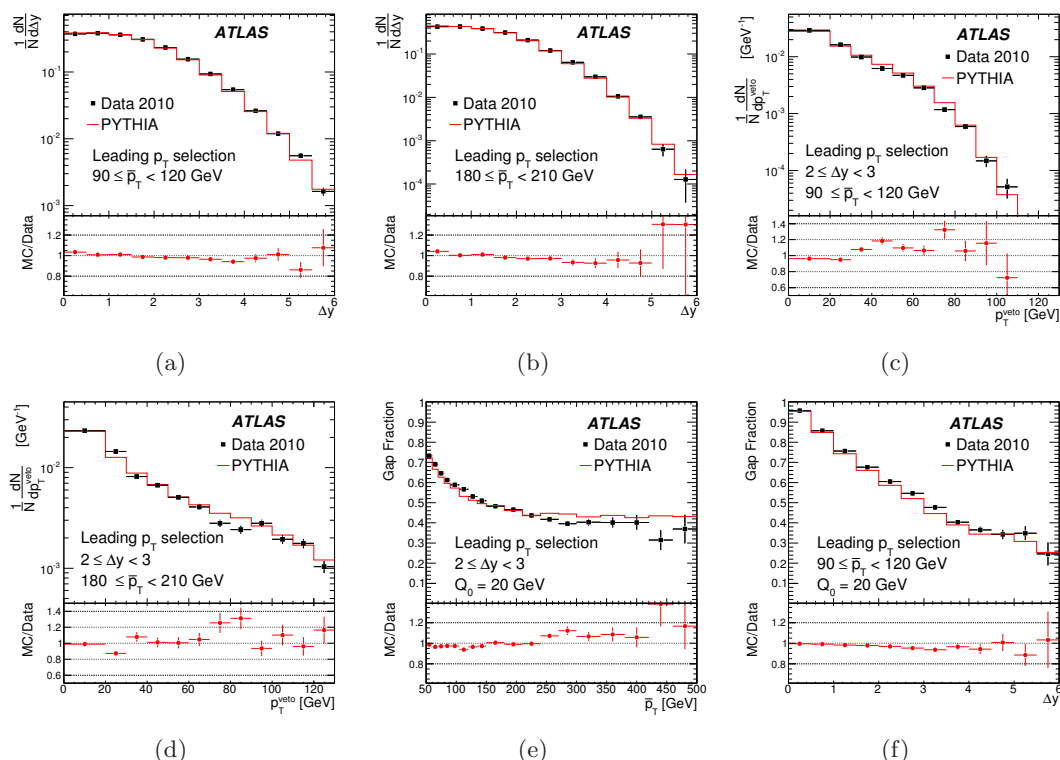
To minimise the impact of pile-up, each event was required to have exactly one reconstructed primary vertex, defined as a vertex with at least five tracks that was consistent with the beamspot. The fraction of events in each run with only one reconstructed vertex was 90% in the early low luminosity runs, falling to 20% in the high luminosity runs at the end of 2010. With the single vertex selection applied, the gap fraction was observed to be independent of the data taking period and the systematic bias due to residual pile-up events was determined to be less than 0.5%. Events were also rejected if they contained any ‘fake’ jets with  $p_T > 20$  GeV that originated from calorimeter noise bursts, cosmic rays or beam-backgrounds. The criteria for rejection were determined from events with spuriously large missing transverse energy. The efficiency for jets was determined to be greater than 99% using a tag-and-probe method in dijet events. The overall impact of these cleaning cuts was to reduce the number of events by less than 0.4%. Finally, the impact of beam related backgrounds and cosmic rays were studied using data collected with special-purpose trigger selections, and estimated to be less than 0.1%.

In total, 533063 events pass the selection criteria and kinematic cuts if the dijet system is defined as the two leading- $p_T$  jets in the event. Of these, 85546 events have  $\bar{p}_T > 210$  GeV, for which the unprescaled jet triggers are used. If the dijet system is defined as the most forward and most backward jets in the event, then 306364 events pass the selection criteria and kinematic cuts, with 33997 events satisfying  $\bar{p}_T > 210$  GeV.

The distribution of dijet events as a function of the rapidity interval between the two jets is presented for uncorrected data in figures 1 (a) and (b) for the regions  $90 \leq \bar{p}_T < 120$  GeV and  $180 \leq \bar{p}_T < 210$  GeV, respectively. The dijet system is defined as the two leading transverse momentum jets in the event. The transverse momentum of the leading jet in the rapidity interval bounded by the dijet system,  $p_T^{\text{veto}}$ , is presented in figures 1 (c) and (d). Finally the gap fraction is presented as a function of  $\bar{p}_T$  and as a function of  $\Delta y$  in figures 1 (e) and (f), respectively. In all such distributions, the baseline PYTHIA event generator with GEANT4 detector simulation gives a reasonable description of the uncorrected data.

## 8 Correction for detector effects

The corrections for detector effects were calculated with a bin-by-bin unfolding procedure. In this approach, the correction is defined in each bin as the ratio of the hadron-level distribution (including muons and neutrinos) to the detector level distributions, using the PYTHIA event generator. The bin sizes were chosen to be commensurate with the jet energy resolution to ensure that the bin-to-bin migration was not too large. In particular,

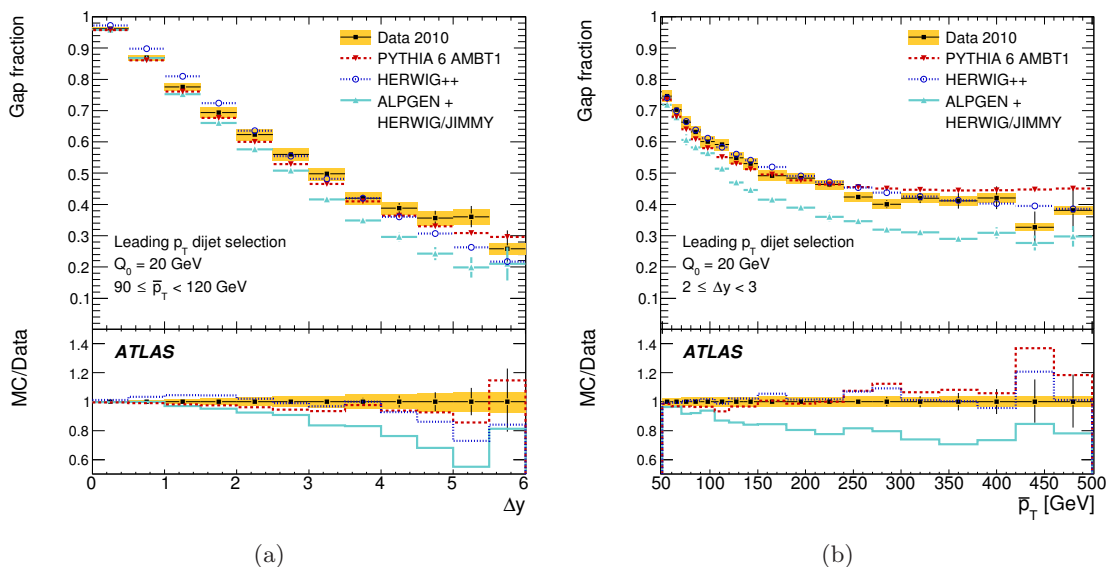


**Figure 1.** Control distributions comparing uncorrected data and the PYTHIA MC (tune AMBT1) with GEANT4 detector simulation. The dijet system is defined as the two leading- $p_T$  jets in the event. The rapidity interval between those jets is shown for the phase space regions  $90 \leq \bar{p}_T < 120$  GeV and  $180 \leq \bar{p}_T < 210$  GeV in (a) and (b), respectively. The transverse momentum of the leading jet in this rapidity interval,  $p_T^{\text{veto}}$  is shown for  $90 \leq \bar{p}_T < 120$  GeV and  $2 \leq \Delta y < 3$  in (c) and for  $180 \leq \bar{p}_T < 210$  GeV and  $2 \leq \Delta y < 3$  in (d). The gap fraction is shown as a function of  $\bar{p}_T$  and  $\Delta y$  in (e) and (f), respectively.

the purity<sup>5</sup> of each bin was required to be at least 50% (the typical bin purity was between 60% and 70%). The typical correction factor was observed to be a few percent for the gap fraction distribution and between 5% and 10% for the distribution of mean number of jets in the rapidity interval between the boundary jets.

The systematic uncertainty on the detector correction was determined in two steps. The physics modelling uncertainty was estimated by reweighting the  $\bar{p}_T$ ,  $\Delta y$  and  $p_T^{\text{veto}}$  distributions to account for any deviation between data and MC and also to cover the maximal variation in shape allowed by the JES uncertainty. The detector modelling uncertainty was determined by reweighting the  $z$ -vertex distribution and varying the jet reconstruction efficiency and the jet energy resolution within the allowed uncertainties as determined from data [49]. The modelling uncertainties were cross-checked using the HERWIG++ and ALPGEN samples, which agreed with the baseline PYTHIA values within the statistical un-

<sup>5</sup>The bin purity is calculated using PYTHIA events and defined as the number of events that are both reconstructed and generated in a particular bin divided by the number of events that are reconstructed in that bin.

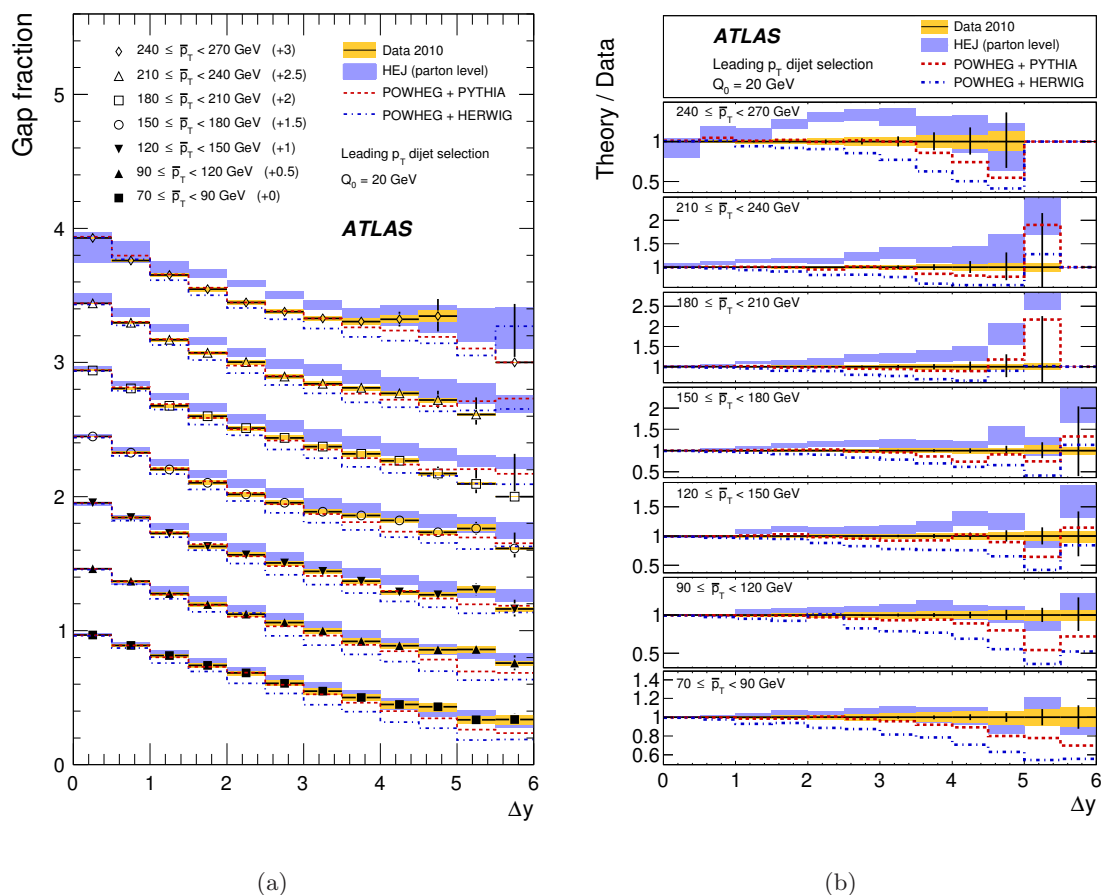


**Figure 2.** Gap fraction as a function of  $\Delta y$ , given that the dijet system is defined as the leading- $p_T$  jets in the event and satisfies  $90 \leq \bar{p}_T < 120$  GeV (a). Gap fraction as a function of  $\bar{p}_T$  given that the rapidity interval is  $2 \leq \Delta y < 3$  (b). The (corrected) data are the black points, with error bars representing the statistical uncertainty. The total systematic uncertainty on the measurement is represented by the solid (yellow) band. The dashed (red) points represents the PYTHIA prediction (tune AMBT1), the dot-dashed (blue) points represents the HERWIG++ prediction (tune LHC-UE7-1) and the solid (cyan) points represents the ALPGEN prediction (tune AUET1).

certainty of each sample. The total systematic uncertainty in the detector correction was defined as the quadrature sum of the physics/detector modelling uncertainties and the statistical uncertainty of the PYTHIA samples. The systematic uncertainty on the correction procedure is typically 2-3%. This uncertainty increases when  $\Delta y$  and  $\bar{p}_T$  are both large, due to an increased statistical uncertainty in the MC samples, and the maximum uncertainty is about 10% at  $\Delta y \sim 5$  and  $\bar{p}_T \sim 240$  GeV. This does not have a detrimental impact on the measurement, however, as the statistical uncertainty on the data in these regions of phase space is much larger.

## 9 Results and discussion

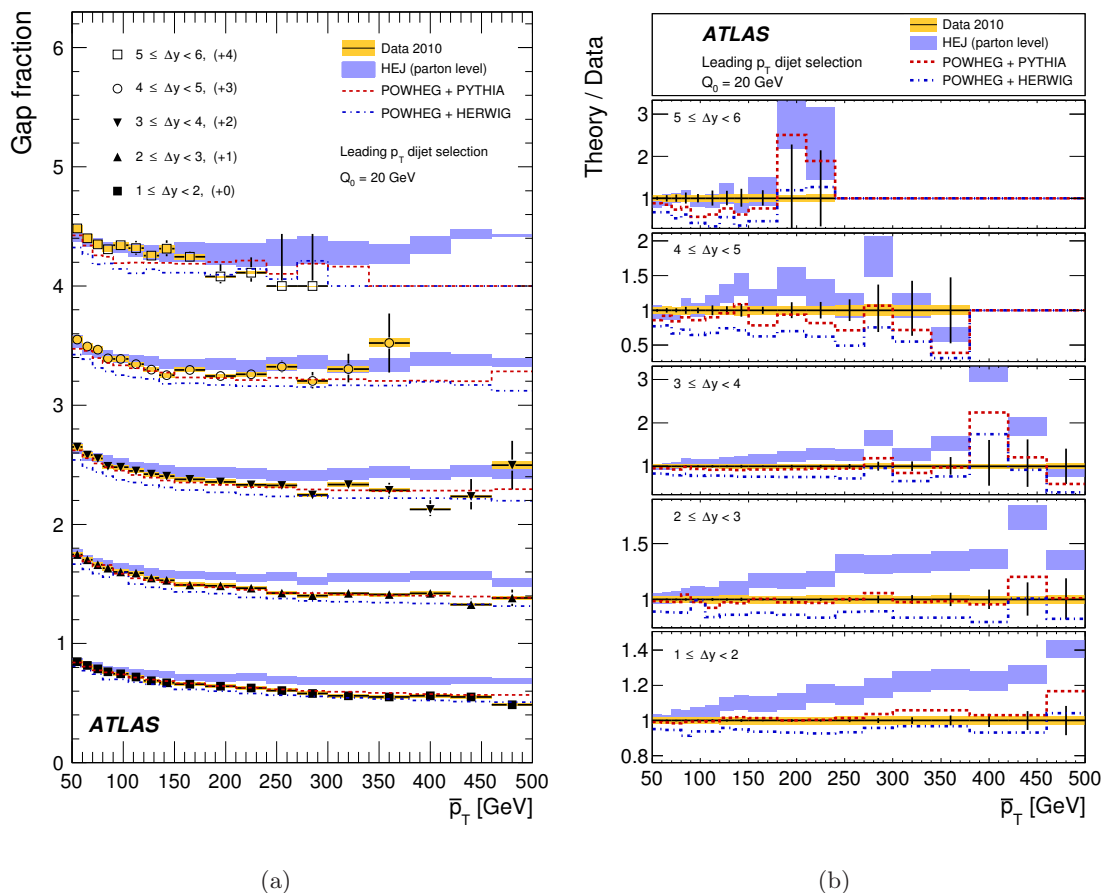
Figure 2 shows the gap fraction as a function of  $\Delta y$  and  $\bar{p}_T$ , with the data compared to the PYTHIA, HERWIG++ and ALPGEN event generators. The dijet system is defined as the two leading- $p_T$  jets in the event. The data are corrected for detector effects, as discussed in section 8. The total uncertainty due to systematic effects is the sum in quadrature of the uncertainty due to JES (section 6) and the uncertainty due to the correction for detector effects (section 8). All other systematic effects were determined to have negligible impact and were therefore not included in the final systematic uncertainty. Both PYTHIA and HERWIG++ give a good description of the data as a function of  $\bar{p}_T$ . PYTHIA also gives the best description of the data as a function of  $\Delta y$ , although the gap fraction is slightly



**Figure 3.** Gap fraction as a function of  $\Delta y$  for various  $\bar{p}_T$  slices. The dijet system is defined as the two leading- $p_T$  jets in the event. The data are compared to the HEJ and POWHEG predictions in (a). The ratio of these theory predictions to the data are shown in (b). The (unfolded) data are the black points, with error bars representing the statistical uncertainty and a solid (yellow) band representing the total systematic uncertainty. The darker (blue) band represents the theoretical uncertainty in the HEJ calculation from variation of the PDF and renormalisation/factorisation scales. The dashed (red) and dot-dashed (blue) curves represent the POWHEG predictions after showering, hadronisation and underlying event simulation with PYTHIA (tune AMBT1) and HERWIG/JIMMY (tune AUET1), respectively.

underestimated for  $\Delta y \sim 3$ . HERWIG++ overestimates the gap fraction at low values of  $\Delta y$  and underestimates the gap fraction at large values of  $\Delta y$ . ALPGEN shows the largest deviation from the data, predicting a gap fraction that is too small at large values of  $\Delta y$  or  $\bar{p}_T$ .

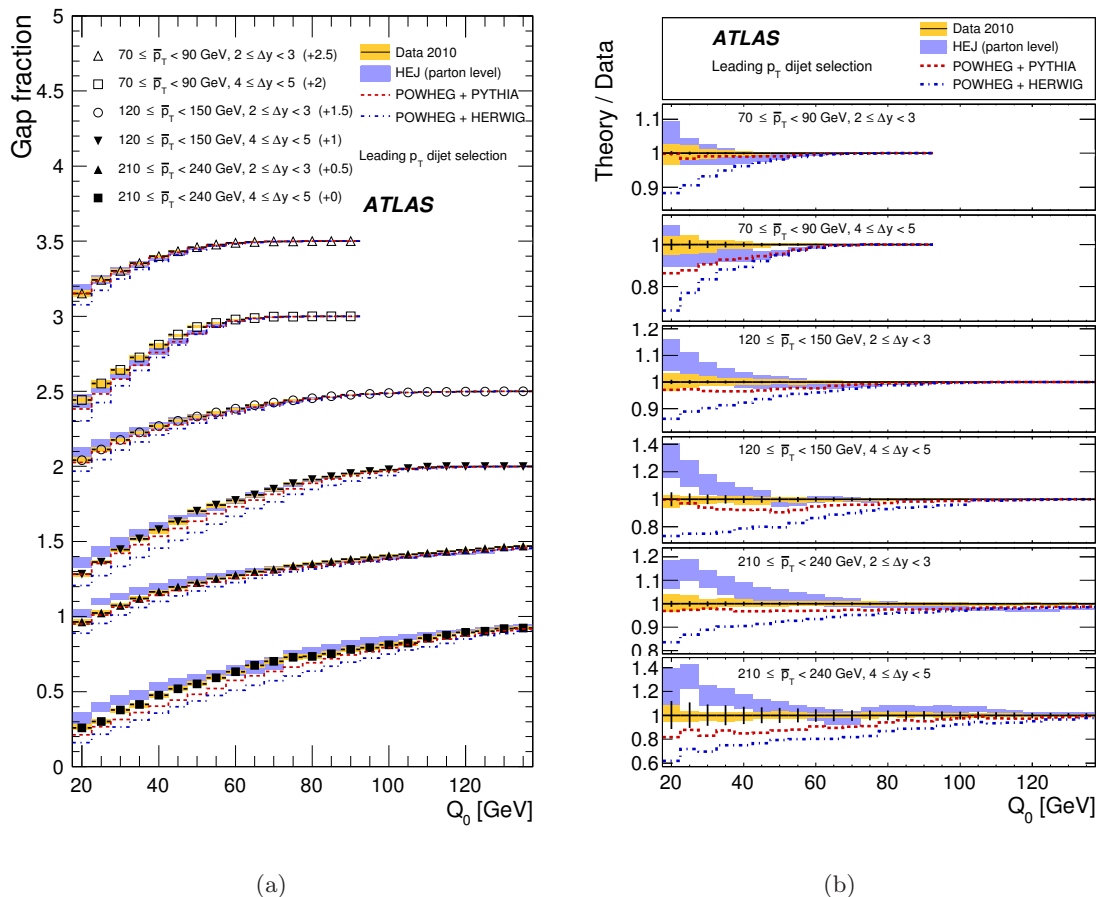
The data are compared to the HEJ and POWHEG predictions in figure 3 and figure 4 as a function of  $\Delta y$  and  $\bar{p}_T$ , respectively. The dijet system is again defined as the two leading- $p_T$  jets in the event. The dependence of the gap fraction on one variable is studied after fixing the phase space of the other variable to well defined and narrow regions. The HEJ prediction describes the data well as a function of  $\Delta y$  at low values of  $\bar{p}_T$ . However, at large values of  $\bar{p}_T$ , HEJ predicts too many gap events. It should be noted that HEJ is designed



**Figure 4.** Gap fraction as a function of  $\bar{p}_T$  for various  $\Delta y$  slices. The dijet system is defined as the two leading- $p_T$  jets in the event. The data are compared to the HEJ and POWHEG predictions in (a). The ratio of these theory predictions to the data are shown in (b). The data and theory are presented in the same way as figure 3.

to give a good description of QCD in the limit that all the jets have similar transverse momentum. Therefore, the failure of the HEJ calculation as  $\bar{p}_T$  becomes much larger than  $Q_0$  is not unexpected. The description of the data may be improved by matching the HEJ calculation to a standard parton shower, to account for soft and collinear emissions [50].

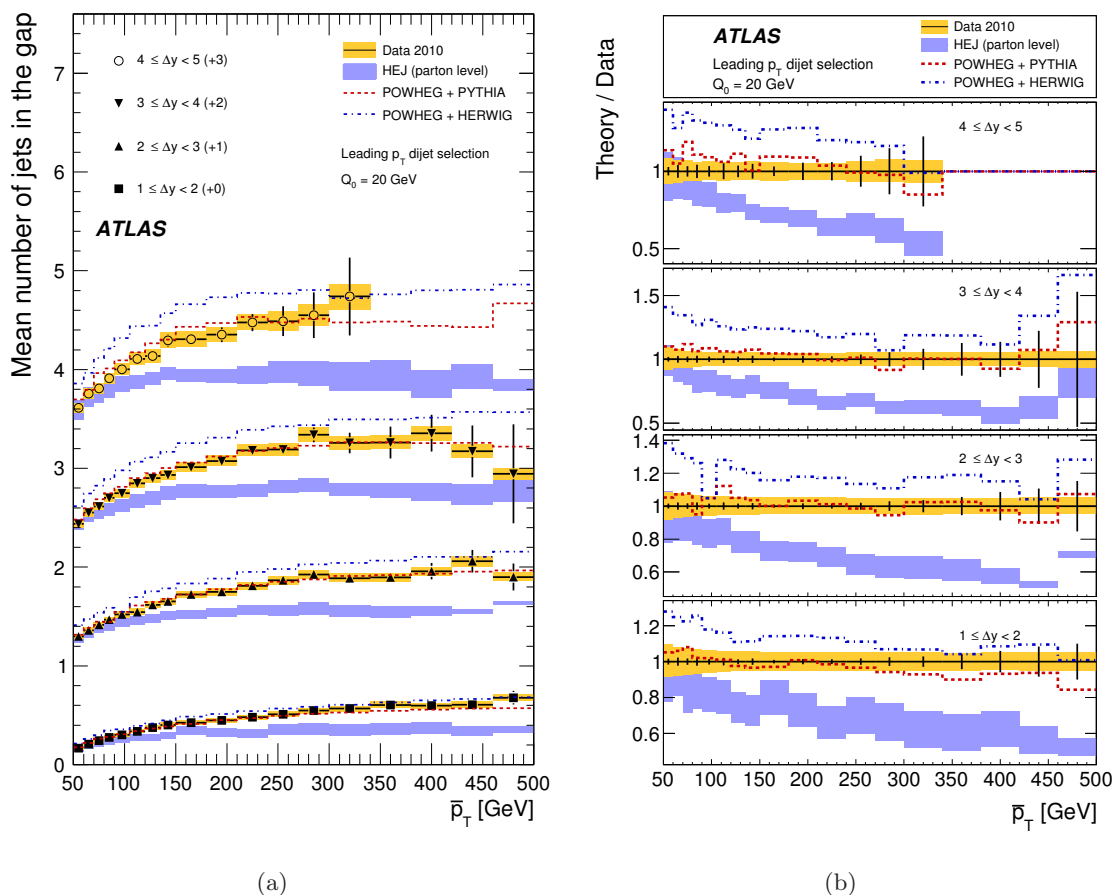
In general, POWHEG+PYTHIA provides the best description of the data, when considered over all the phase space regions presented. However, at large values of  $\Delta y$ , the gap fraction predicted by POWHEG+PYTHIA deviates from the data. This is expected because the NLO-plus-parton-shower approximation does not contain the contributions to a full QCD calculation that become important as  $\Delta y$  increases. The gap fraction as a function of  $\bar{p}_T$  is, however, well described by POWHEG+PYTHIA at low  $\Delta y$ . Furthermore, although the absolute value of the gap fraction is not correct at larger  $\Delta y$ , the shape of the distributions in  $\bar{p}_T$  remain well described. POWHEG+HERWIG tends to produce too much activity across the full phase-space. However, the difference between POWHEG+HERWIG and the data increases with  $\Delta y$ , reproducing the effect observed with POWHEG+PYTHIA.



**Figure 5.** Gap fraction as a function of  $Q_0$  for various  $\bar{p}_T$  and  $\Delta y$  slices. The dijet system is defined as the two leading- $p_T$  jets in the event. The data are compared to the HEJ and POWHEG predictions in (a). The data points for  $Q_0 > \bar{p}_T$  have been removed because the gap fraction is always equal to one for this dijet selection, by definition. The ratio of the theory predictions to the data are shown in (b). The data and theory are presented in the same way as figure 3.

The dependence of the gap fraction on the veto scale is presented in figure 5 for specific regions of  $\bar{p}_T$  and  $\Delta y$ . The  $Q_0$  dependence of the cross-section is useful in studying the colour structure of the event [51]. The difference between POWHEG+PYTHIA and POWHEG+HERWIG remains large for all values of  $Q_0$ . The HEJ description of the data improves as  $Q_0$  approaches  $\bar{p}_T$ , a kinematic configuration more suited to the HEJ approximations. At large values of  $\bar{p}_T$ , none of the theoretical predictions describe the data well as a function of  $Q_0$ . In particular, the description of the data is particularly poor when both  $\bar{p}_T$  and  $\Delta y$  become large, corresponding to the region in which colour singlet exchange is expected to play an increasingly important role.

Figure 6 shows the mean number of jets in the rapidity interval bounded by the dijet system as a function of  $\bar{p}_T$ . This is an alternative way of studying the activity between the boundary jets. The prediction of POWHEG+PYTHIA again gives the best description of the data, replicating the result obtained using the gap fraction. The POWHEG+HERWIG

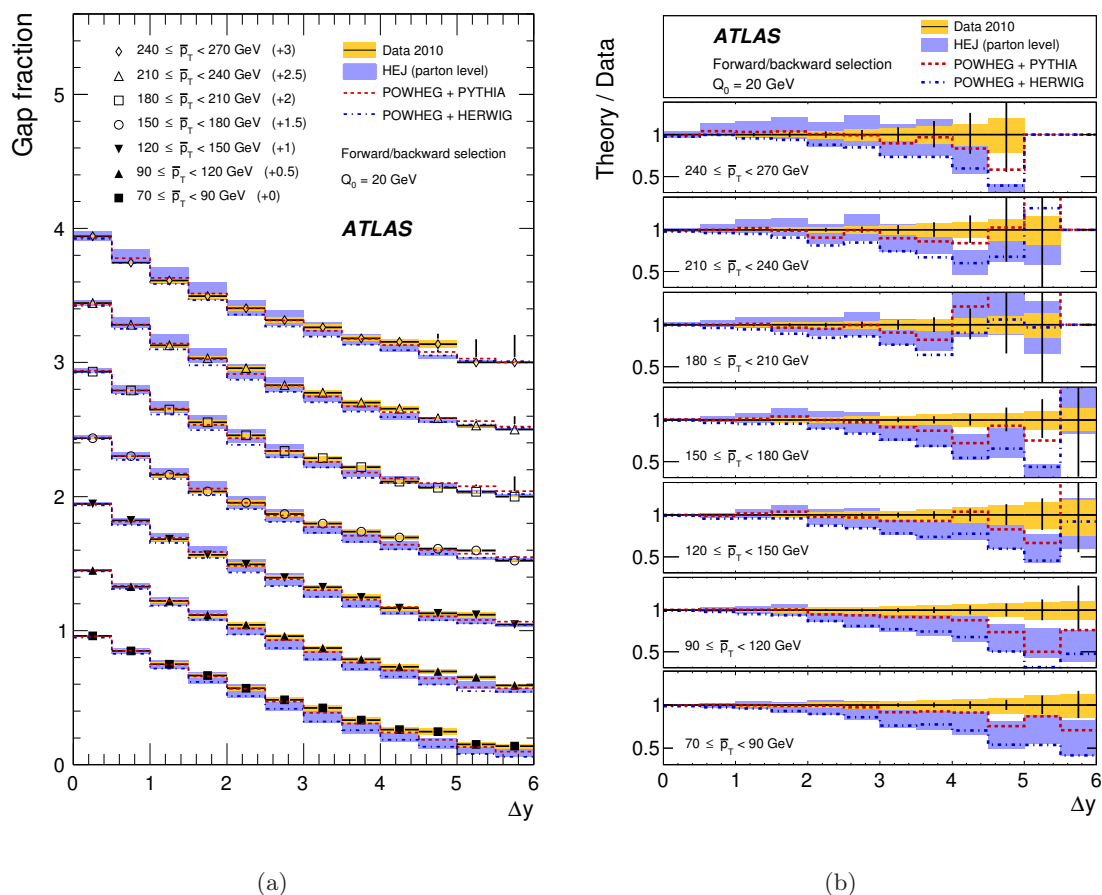


**Figure 6.** Mean number of jets in the gap as a function of  $\bar{p}_T$  for various  $\Delta y$  slices. The dijet system is defined as the two leading- $p_T$  jets in the event. The data are compared to the HEJ and POWHEG predictions in (a). The ratio of these theory predictions to the data are shown in (b). The data and theory are presented in the same way as figure 3.

description of the data as a function of  $\bar{p}_T$  becomes worse as  $\bar{p}_T$  decreases, which was not observed in the gap fraction distribution. In particular, POWHEG+HERWIG predicts a mean jet multiplicity that is too large. The HEJ prediction deviates from the data at large values of  $\bar{p}_T$ , producing too little jet activity. This is the same effect as was observed using the gap fraction, although the deviations from the data are larger.

Figure 7 shows the gap fraction as a function of  $\Delta y$ , with the dijet system defined as the most forward and the most backward jets in the event. For this selection, the  $p_T$ -imbalance between the two jets is typically much larger than when the dijet system is defined as the two leading- $p_T$  jets in the event. The data are not well described by HEJ at low values of  $\bar{p}_T$ , implying that the resummation of soft emissions are important for this configuration. The POWHEG prediction is similar to the HEJ prediction in all regions of phase space, that is, both calculations result in a gap fraction that is too small at large  $\Delta y$ .

In figure 8, the dijet system is again defined as the most forward and the most backward jets in the event, but the veto scale is now set to  $Q_0 = \bar{p}_T$ . In this case, both



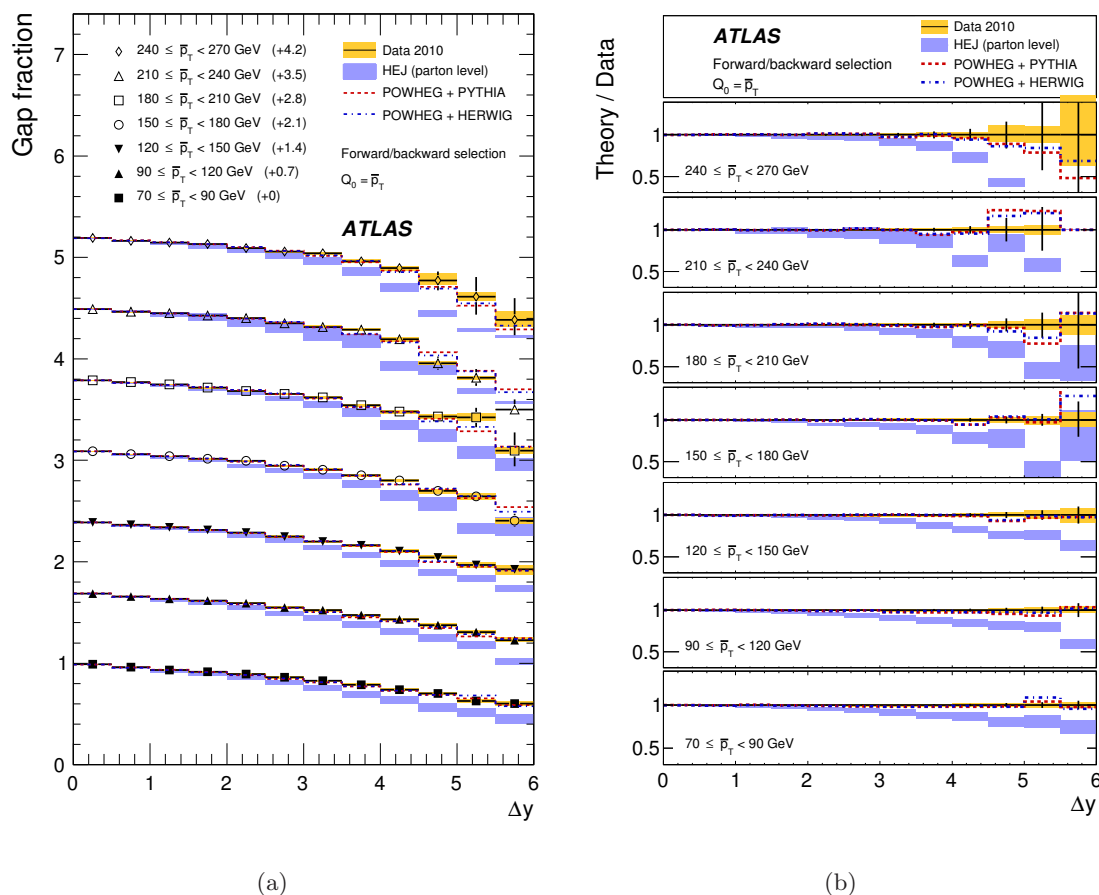
**Figure 7.** Gap fraction as a function of  $\Delta y$  for various  $\bar{p}_T$  slices. The dijet system is defined as the most forward and the most backward jets in the event. The data are compared to the HEJ and POWHEG predictions in (a). The ratio of these theory predictions to the data are shown in (b). The data and theory are presented in the same way as figure 3.

POWHEG+PYTHIA and POWHEG+HERWIG give a good description of the gap fraction as a function of  $\Delta y$ , implying a smaller dependence on the generator modelling of the parton shower, hadronisation and underlying event. The HEJ description of the data, however, does not improve with the increase in veto scale.

## 10 Summary

A central jet veto was used to study the fraction of events that do not contain hadronic activity in the rapidity interval bounded by a dijet system (gap fraction). The dijet system was identified in two ways: using the two leading transverse momentum jets in the event and, alternatively, using the most forward and most backward jets in the event. The first approach examines the effect of wide-angle soft gluon radiation for  $p_T$ -ordered jet configurations, whereas the second favours very forward-backward configurations and, therefore, BFKL-like dynamics. In addition, the mean number of jets in the rapidity in-





**Figure 8.** Gap fraction as a function of  $\Delta y$  for various  $\bar{p}_T$  slices. The dijet system is defined as the most forward and the most backward jets in the event and the veto scale is set to  $Q_0 = \bar{p}_T$ . The data are compared to the HEJ and POWHEG predictions in (a). The ratio of these theory predictions to the data are shown in (b). The data and theory are presented in the same way as figure 3.

terval bounded by the dijet system was presented, as an alternative variable for studying perturbative QCD emission.

The gap fraction was studied as a function of the rapidity separation between the boundary jets,  $\Delta y$ , the mean transverse momentum of the boundary jets,  $\bar{p}_T$  and the jet veto scale,  $Q_0$ . The mean number of jets in the rapidity interval was studied as a function of  $\bar{p}_T$  and  $\Delta y$ . In all cases, the data were corrected for detector effects. The data show the expected behaviour of a reduction of gap events, or an increase in jet activity, for large values of  $\bar{p}_T$  or  $\Delta y$  [18]. The PYTHIA, HERWIG++ and ALPGEN leading-order MC event generators were compared to the data. It was observed that PYTHIA and HERWIG++ gave the best description of the data as a function of  $\bar{p}_T$  and that PYTHIA gave the best description of the data as a function of  $\Delta y$ . ALPGEN did not describe the data well at large values of  $\bar{p}_T$  or  $\Delta y$ .

The data were compared to the NLO-plus-parton-shower predictions provided by POWHEG when interfaced to PYTHIA (tune AMBT1) or HERWIG (tune AUET1). In general,

POWHEG+PYTHIA gave the best description of the data, with POWHEG+HERWIG predicting too much jet activity in the rapidity interval between the boundary jets. Both POWHEG predictions result in too low a gap fraction at large values of  $\Delta y$ , implying that the fixed order plus parton shower approach does not contain higher order QCD effects that become important as  $\Delta y$  increases.

The data were also compared to the HEJ resummation of wide-angle emissions of similar transverse momentum. A particularly striking feature is that the parton-level HEJ prediction has too little jet activity and too large a gap fraction at large values of  $\bar{p}_T/Q_0$ . This means that the HEJ calculation is missing higher order QCD effects that become important as  $\bar{p}_T/Q_0$  increases, i.e. those effects that are provided by a traditional parton shower approach. However, HEJ does describe the data well as a function of  $\Delta y$  when the dijet system is defined as the two leading  $p_T$  jets in the event and those jets do not have a value of  $\bar{p}_T$  that is much larger than the veto scale.

In most of the phase-space regions presented, the experimental uncertainty is smaller than the theoretical uncertainty. Furthermore, the experimental uncertainty is much smaller than the spread of LO Monte Carlo event generator predictions. This data can therefore be used to constrain the event generator modelling of QCD radiation between widely separated jets. Such a constraint would be useful for the current Higgs-plus-two-jet searches and also for any future measurements that are sensitive to higher order QCD emissions.

## Acknowledgments

We thank Jeppe Andersen, Jeff Forshaw, Hendrik Hoeth, Frank Krauss, Simone Marzani, Paolo Nason, Emanuele Re, Mike Seymour and Jennifer Smillie for very useful discussions regarding the theory predictions used in this analysis.

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, 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; ARTEMIS, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNAS, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; 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.

**Open Access.** This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

## References

- [1] ZEUS collaboration, M. Derrick et al., *Rapidity gaps between jets in photoproduction at HERA*, *Phys. Lett. B* **369** (1996) 55 [[hep-ex/9510012](#)] [[SPIRES](#)].
- [2] H1 collaboration, C. Adloff et al., *Energy flow and rapidity gaps between jets in photoproduction at HERA*, *Eur. Phys. J. C* **24** (2002) 517 [[hep-ex/0203011](#)] [[SPIRES](#)].
- [3] ZEUS collaboration, S. Chekanov et al., *Photoproduction of events with rapidity gaps between jets at HERA*, *Eur. Phys. J. C* **50** (2007) 283 [[hep-ex/0612008](#)] [[SPIRES](#)].
- [4] D0 collaboration, S. Abachi et al., *Rapidity gaps between jets in  $p\bar{p}$  collisions at  $\sqrt{s} = 1.8$  TeV*, *Phys. Rev. Lett.* **72** (1994) 2332 [[SPIRES](#)].
- [5] CDF collaboration, F. Abe et al., *Observation of rapidity gaps in  $p\bar{p}$  collisions at 1.8 TeV*, *Phys. Rev. Lett.* **74** (1995) 855 [[SPIRES](#)].
- [6] CDF collaboration, F. Abe et al., *Events with a rapidity gap between jets in  $p\bar{p}$  collisions at  $\sqrt{s} = 630$  GeV*, *Phys. Rev. Lett.* **81** (1998) 5278 [[SPIRES](#)].
- [7] D0 collaboration, B. Abbott et al., *Probing hard color singlet exchange in  $p\bar{p}$  collisions at  $\sqrt{s} = 630$  GeV and 1800 GeV*, *Phys. Lett. B* **440** (1998) 189 [[hep-ex/9809016](#)] [[SPIRES](#)].
- [8] CDF collaboration, F. Abe et al., *Dijet production by color-singlet exchange at the Fermilab Tevatron*, *Phys. Rev. Lett.* **80** (1998) 1156 [[SPIRES](#)].
- [9] G. Altarelli and G. Parisi, *Asymptotic freedom in parton language*, *Nucl. Phys. B* **126** (1977) 298 [[SPIRES](#)].
- [10] V.S. Fadin, E.A. Kuraev and L.N. Lipatov, *On the Pomeron singularity in asymptotically free theories*, *Phys. Lett. B* **60** (1975) 50 [[SPIRES](#)].
- [11] E.A. Kuraev, L.N. Lipatov and V.S. Fadin, *Multi-reggeon processes in the Yang-Mills theory*, *Sov. Phys. JETP* **44** (1976) 443 [*Zh. Eksp. Teor. Fiz.* **71** (1976) 840] [[SPIRES](#)].
- [12] E.A. Kuraev, L.N. Lipatov and V.S. Fadin, *The Pomeron singularity in nonabelian gauge theories*, *Sov. Phys. JETP* **45** (1977) 199 [*Zh. Eksp. Teor. Fiz.* **72** (1977) 377] [[SPIRES](#)].
- [13] I.I. Balitsky and L.N. Lipatov, *The Pomeron singularity in quantum chromodynamics*, *Sov. J. Nucl. Phys.* **28** (1978) 822 [*Yad. Fiz.* **28** (1978) 1597] [[SPIRES](#)].
- [14] J.R. Andersen and J.M. Smillie, *Constructing all-order corrections to multi-jet rates*, *JHEP* **01** (2010) 039 [[arXiv:0908.2786](#)] [[SPIRES](#)].
- [15] J.R. Andersen and J.M. Smillie, *High energy description of processes with multiple hard jets*, *Nucl. Phys. Proc. Suppl.* **205–206** (2010) 205 [[arXiv:1007.4449](#)] [[SPIRES](#)].

- [16] J.R. Forshaw, A. Kyrielleis and M.H. Seymour, *Gaps between jets in the high energy limit*, *JHEP* **06** (2005) 034 [[hep-ph/0502086](#)] [[SPIRES](#)].
- [17] A.H. Mueller and H. Navelet, *An inclusive minijet cross-section and the bare Pomeron in QCD*, *Nucl. Phys. B* **282** (1987) 727 [[SPIRES](#)].
- [18] J. Forshaw, J. Keates and S. Marzani, *Jet vetoing at the LHC*, *JHEP* **07** (2009) 023 [[arXiv:0905.1350](#)] [[SPIRES](#)].
- [19] J.R. Forshaw, A. Kyrielleis and M.H. Seymour, *Super-leading logarithms in non-global observables in QCD*, *JHEP* **08** (2006) 059 [[hep-ph/0604094](#)] [[SPIRES](#)].
- [20] M. Dürrssen et al., *Extracting Higgs boson couplings from LHC data*, *Phys. Rev. D* **70** (2004) 113009 [[hep-ph/0406323](#)] [[SPIRES](#)].
- [21] R. Lafaye, T. Plehn, M. Rauch, D. Zerwas and M. Dürrssen, *Measuring the Higgs sector*, *JHEP* **08** (2009) 009 [[arXiv:0904.3866](#)] [[SPIRES](#)].
- [22] J.M. Campbell, R.K. Ellis and G. Zanderighi, *Next-to-leading order Higgs + 2 jet production via gluon fusion*, *JHEP* **10** (2006) 028 [[hep-ph/0608194](#)] [[SPIRES](#)].
- [23] B.E. Cox, J.R. Forshaw and A.D. Pilkington, *Extracting Higgs boson couplings using a jet veto*, *Phys. Lett. B* **696** (2011) 87 [[arXiv:1006.0986](#)] [[SPIRES](#)].
- [24] ATLAS collaboration, G. Aad et al., *The ATLAS experiment at the CERN Large Hadron Collider*, *2008 JINST* **3** S08003 [[SPIRES](#)].
- [25] ATLAS collaboration, *Expected performance of the ATLAS experiment detector, trigger, physics*, [arXiv:0901.0512](#) [[CERN-OPEN-2008-020](#)].
- [26] ATLAS collaboration, *Performance of the ATLAS jet trigger with pp collisions at  $\sqrt{s} = 900$  GeV*, *ATLAS-CONF-2010-028* (2010).
- [27] M. Cacciari, G.P. Salam and G. Soyez, *The anti- $k_t$  jet clustering algorithm*, *JHEP* **04** (2008) 063 [[arXiv:0802.1189](#)] [[SPIRES](#)].
- [28] T. Sjöstrand, S. Mrenna and P.Z. Skands, *PYTHIA 6.4 physics and manual*, *JHEP* **05** (2006) 026 [[hep-ph/0603175](#)] [[SPIRES](#)].
- [29] A.D. Martin, W.J. Stirling, R.S. Thorne and G. Watt, *Parton distributions for the LHC*, *Eur. Phys. J. C* **63** (2009) 189 [[arXiv:0901.0002](#)] [[SPIRES](#)].
- [30] A. Sherstnev and R.S. Thorne, *Different PDF approximations useful for LO Monte Carlo generators*, [arXiv:0807.2132](#) [[SPIRES](#)].
- [31] ATLAS collaboration, *Charged particle multiplicities in pp interactions at  $\sqrt{s} = 0.9$  and 7 TeV in a diffractive limited phase-space measured with the ATLAS detector at the LHC and new PYTHIA6 tune*, *ATLAS-CONF-2010-031* (2010).
- [32] S. Agostinelli et al., *GEANT4: a simulation toolkit*, *Nucl. Instrum. Meth. A* **506** (2003) 250.
- [33] ATLAS collaboration, G. Aad et al., *The ATLAS simulation infrastructure*, *Eur. Phys. J. C* **70** (2010) 823 [[arXiv:1005.4568](#)] [[SPIRES](#)].
- [34] M. Bahr et al., *HERWIG++ physics and manual*, *Eur. Phys. J. C* **58** (2008) 639 [[arXiv:0803.0883](#)] [[SPIRES](#)].
- [35] M.L. Mangano, M. Moretti, F. Piccinini, R. Pittau and A.D. Polosa, *ALPGEN, a generator for hard multiparton processes in hadronic collisions*, *JHEP* **07** (2003) 001 [[hep-ph/0206293](#)] [[SPIRES](#)].

- [36] S. Gieseke et al., *HERWIG++ 2.5 release note*, [arXiv:1102.1672](#) [SPIRES].
- [37] J. Pumplin et al., *New generation of parton distributions with uncertainties from global QCD analysis*, *JHEP* **07** (2002) 012 [[hep-ph/0201195](#)] [SPIRES].
- [38] G. Corcella et al., *HERWIG 6.5: an event generator for Hadron Emission Reactions With Interfering Gluons (including supersymmetric processes)*, *JHEP* **01** (2001) 010 [[hep-ph/0011363](#)] [SPIRES].
- [39] J.M. Butterworth, J.R. Forshaw and M.H. Seymour, *Multiparton interactions in photoproduction at HERA*, *Z. Phys. C* **72** (1996) 637 [[hep-ph/9601371](#)] [SPIRES].
- [40] ATLAS collaboration, *First tuning of HERWIG/JIMMY to ATLAS data*, [ATL-PHYS-PUB-2010-014](#) (2010).
- [41] J.R. Andersen and J.M. Smillie, *Multiple jets at the LHC with high energy jets*, *JHEP* **06** (2011) 010 [[arXiv:1101.5394](#)] [SPIRES].
- [42] P. Nason, *A new method for combining NLO QCD with shower Monte Carlo algorithms*, *JHEP* **11** (2004) 040 [[hep-ph/0409146](#)] [SPIRES].
- [43] S. Alioli, P. Nason, C. Oleari and E. Re, *A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX*, *JHEP* **06** (2010) 043 [[arXiv:1002.2581](#)] [SPIRES].
- [44] S. Alioli, K. Hamilton, P. Nason, C. Oleari and E. Re, *Jet pair production in POWHEG*, *JHEP* **04** (2011) 081 [[arXiv:1012.3380](#)] [SPIRES].
- [45] M. Aharrouché et al., *Measurement of the response of the ATLAS liquid argon barrel calorimeter to electrons at the 2004 combined test-beam*, *Nucl. Instrum. Meth. A* **614** (2010) 400 [SPIRES].
- [46] ATLAS collaboration, *Update on the jet energy scale systematic uncertainty for jets produced in proton-proton collisions at  $\sqrt{s} = 7$  TeV measured with the ATLAS detector*, [ATLAS-CONF-2011-032](#) (2011).
- [47] ATLAS collaboration, *ATLAS calorimeter response to single isolated hadrons and estimation of the calorimeter jet scale uncertainty*, [ATLAS-CONF-2011-028](#) (2011).
- [48] ATLAS collaboration, *In-situ pseudo-rapidity inter-calibration to evaluate jet energy scale uncertainty using dijet events in proton-proton collisions at  $\sqrt{s} = 7$  TeV*, [ATLAS-CONF-2011-014](#) (2011).
- [49] ATLAS collaboration, *Jet energy resolution and reconstruction efficiencies from in-situ techniques with the ATLAS Detector Using Proton-Proton Collisions at a Center of Mass Energy  $\sqrt{s} = 7$  TeV*, [ATLAS-CONF-2010-054](#) (2010).
- [50] J.R. Andersen, L. Lönnblad and J.M. Smillie, *A parton shower for high energy jets*, *JHEP* **07** (2011) 110 [[arXiv:1104.1316](#)] [SPIRES].
- [51] A. Schofield and M.H. Seymour, *Jet vetoing and HERWIG++*, [arXiv:1103.4811](#) [SPIRES].

## The ATLAS collaboration

G. Aad<sup>48</sup>, B. Abbott<sup>111</sup>, J. Abdallah<sup>11</sup>, A.A. Abdelalim<sup>49</sup>, A. Abdesselam<sup>118</sup>, O. Abdinov<sup>10</sup>, B. Abi<sup>112</sup>, M. Abolins<sup>88</sup>, H. Abramowicz<sup>153</sup>, H. Abreu<sup>115</sup>, E. Acerbi<sup>89a,89b</sup>, B.S. Acharya<sup>164a,164b</sup>, D.L. Adams<sup>24</sup>, T.N. Addy<sup>56</sup>, J. Adelman<sup>175</sup>, M. Aderholz<sup>99</sup>, S. Adomeit<sup>98</sup>, P. Adragna<sup>75</sup>, T. Adye<sup>129</sup>, S. Aefsky<sup>22</sup>, J.A. Aguilar-Saavedra<sup>124b,a</sup>, M. Aharrouche<sup>81</sup>, S.P. Ahlen<sup>21</sup>, F. Ahles<sup>48</sup>, A. Ahmad<sup>148</sup>, M. Ahsan<sup>40</sup>, G. Aielli<sup>133a,133b</sup>, T. Akdogan<sup>18a</sup>, T.P.A. Åkesson<sup>79</sup>, G. Akimoto<sup>155</sup>, A.V. Akimov<sup>94</sup>, A. Akiyama<sup>67</sup>, M.S. Alam<sup>1</sup>, M.A. Alam<sup>76</sup>, J. Albert<sup>169</sup>, S. Albrand<sup>55</sup>, M. Aleksa<sup>29</sup>, I.N. Aleksandrov<sup>65</sup>, F. Alessandria<sup>89a</sup>, C. Alexa<sup>25a</sup>, G. Alexander<sup>153</sup>, G. Alexandre<sup>49</sup>, T. Alexopoulos<sup>9</sup>, M. Alhroob<sup>20</sup>, M. Aliev<sup>15</sup>, G. Alimonti<sup>89a</sup>, J. Alison<sup>120</sup>, M. Aliyev<sup>10</sup>, P.P. Allport<sup>73</sup>, S.E. Allwood-Spiers<sup>53</sup>, J. Almond<sup>82</sup>, A. Aloisio<sup>102a,102b</sup>, R. Alon<sup>171</sup>, A. Alonso<sup>79</sup>, M.G. Alviggi<sup>102a,102b</sup>, K. Amako<sup>66</sup>, P. Amaral<sup>29</sup>, C. Amelung<sup>22</sup>, V.V. Ammosov<sup>128</sup>, A. Amorim<sup>124a,b</sup>, G. Amorós<sup>167</sup>, N. Amram<sup>153</sup>, C. Anastopoulos<sup>29</sup>, L.S. Ancu<sup>16</sup>, N. Andari<sup>115</sup>, T. Andeen<sup>34</sup>, C.F. Anders<sup>20</sup>, G. Anders<sup>58a</sup>, K.J. Anderson<sup>30</sup>, A. Andreazza<sup>89a,89b</sup>, V. Andrei<sup>58a</sup>, M-L. Andrieux<sup>55</sup>, X.S. Anduaga<sup>70</sup>, A. Angerami<sup>34</sup>, F. Anghinolfi<sup>29</sup>, N. Anjos<sup>124a</sup>, A. Annovi<sup>47</sup>, A. Antonaki<sup>8</sup>, M. Antonelli<sup>47</sup>, A. Antonov<sup>96</sup>, J. Antos<sup>144b</sup>, F. Anulli<sup>132a</sup>, S. Aoun<sup>83</sup>, L. Aperio Bella<sup>4</sup>, R. Apolle<sup>118,c</sup>, G. Arabidze<sup>88</sup>, I. Aracena<sup>143</sup>, Y. Arai<sup>66</sup>, A.T.H. Arce<sup>44</sup>, J.P. Archambault<sup>28</sup>, S. Arfaoui<sup>29,d</sup>, J-F. Arguin<sup>14</sup>, E. Arik<sup>18a,\*</sup>, M. Arik<sup>18a</sup>, A.J. Armbruster<sup>87</sup>, O. Arnaez<sup>81</sup>, C. Arnault<sup>115</sup>, A. Artamonov<sup>95</sup>, G. Artoni<sup>132a,132b</sup>, D. Arutinov<sup>20</sup>, S. Asai<sup>155</sup>, R. Asfandiyarov<sup>172</sup>, S. Ask<sup>27</sup>, B. Åsman<sup>146a,146b</sup>, L. Asquith<sup>5</sup>, K. Assamagan<sup>24</sup>, A. Astbury<sup>169</sup>, A. Astvatsatourov<sup>52</sup>, G. Atoian<sup>175</sup>, B. Aubert<sup>4</sup>, B. Auerbach<sup>175</sup>, E. Auge<sup>115</sup>, K. Augsten<sup>127</sup>, M. Aurousseau<sup>145a</sup>, N. Austin<sup>73</sup>, G. Avolio<sup>163</sup>, R. Avramidou<sup>9</sup>, D. Axen<sup>168</sup>, C. Ay<sup>54</sup>, G. Azuelos<sup>93,e</sup>, Y. Azuma<sup>155</sup>, M.A. Baak<sup>29</sup>, G. Baccaglioni<sup>89a</sup>, C. Bacci<sup>134a,134b</sup>, A.M. Bach<sup>14</sup>, H. Bachacou<sup>136</sup>, K. Bachas<sup>29</sup>, G. Bachy<sup>29</sup>, M. Backes<sup>49</sup>, M. Backhaus<sup>20</sup>, E. Badescu<sup>25a</sup>, P. Bagnaia<sup>132a,132b</sup>, S. Bahinipati<sup>2</sup>, Y. Bai<sup>32a</sup>, D.C. Bailey<sup>158</sup>, T. Bain<sup>158</sup>, J.T. Baines<sup>129</sup>, O.K. Baker<sup>175</sup>, M.D. Baker<sup>24</sup>, S. Baker<sup>77</sup>, E. Banas<sup>38</sup>, P. Banerjee<sup>93</sup>, Sw. Banerjee<sup>172</sup>, D. Banfi<sup>29</sup>, A. Bangert<sup>137</sup>, V. Bansal<sup>169</sup>, H.S. Bansil<sup>17</sup>, L. Barak<sup>171</sup>, S.P. Baranov<sup>94</sup>, A. Barashkou<sup>65</sup>, A. Barbaro Galtieri<sup>14</sup>, T. Barber<sup>27</sup>, E.L. Barberio<sup>86</sup>, D. Barberis<sup>50a,50b</sup>, M. Barbero<sup>20</sup>, D.Y. Bardin<sup>65</sup>, T. Barillari<sup>99</sup>, M. Barisonzi<sup>174</sup>, T. Barklow<sup>143</sup>, N. Barlow<sup>27</sup>, B.M. Barnett<sup>129</sup>, R.M. Barnett<sup>14</sup>, A. Baroncelli<sup>134a</sup>, G. Barone<sup>49</sup>, A.J. Barr<sup>118</sup>, F. Barreiro<sup>80</sup>, J. Barreiro Guimarães da Costa<sup>57</sup>, P. Barrillon<sup>115</sup>, R. Bartoldus<sup>143</sup>, A.E. Barton<sup>71</sup>, D. Bartsch<sup>20</sup>, V. Bartsch<sup>149</sup>, R.L. Bates<sup>53</sup>, L. Batkova<sup>144a</sup>, J.R. Batley<sup>27</sup>, A. Battaglia<sup>16</sup>, M. Battistin<sup>29</sup>, G. Battistoni<sup>89a</sup>, F. Bauer<sup>136</sup>, H.S. Bawa<sup>143,f</sup>, B. Beare<sup>158</sup>, T. Beau<sup>78</sup>, P.H. Beauchemin<sup>118</sup>, R. Beccherle<sup>50a</sup>, P. Bechtel<sup>41</sup>, H.P. Beck<sup>16</sup>, M. Beckingham<sup>48</sup>, K.H. Becks<sup>174</sup>, A.J. Beddall<sup>18c</sup>, A. Beddall<sup>18c</sup>, S. Bedikian<sup>175</sup>, V.A. Bednyakov<sup>65</sup>, C.P. Bee<sup>83</sup>, M. Begel<sup>24</sup>, S. Behar Harpaz<sup>152</sup>, P.K. Behera<sup>63</sup>, M. Beimforde<sup>99</sup>, C. Belanger-Champagne<sup>85</sup>, P.J. Bell<sup>49</sup>, W.H. Bell<sup>49</sup>, G. Bella<sup>153</sup>, L. Bellagamba<sup>19a</sup>, F. Bellina<sup>29</sup>, M. Bellomo<sup>119a</sup>, A. Belloni<sup>57</sup>, O. Beloborodova<sup>107</sup>, K. Belotskiy<sup>96</sup>, O. Beltramello<sup>29</sup>, S. Ben Ami<sup>152</sup>, O. Benary<sup>153</sup>, D. Benchekroun<sup>135a</sup>, C. Benchouk<sup>83</sup>, M. Bendel<sup>81</sup>, B.H. Benedict<sup>163</sup>, N. Benekos<sup>165</sup>, Y. Benhammou<sup>153</sup>, D.P. Benjamin<sup>44</sup>, M. Benoit<sup>115</sup>, J.R. Bensinger<sup>22</sup>, K. Benslama<sup>130</sup>, S. Bentvelsen<sup>105</sup>, D. Berge<sup>29</sup>, E. Bergeaas Kuutmann<sup>41</sup>, N. Berger<sup>4</sup>, F. Berghaus<sup>169</sup>, E. Berglund<sup>49</sup>, J. Beringer<sup>14</sup>, K. Bernardet<sup>83</sup>, P. Bernat<sup>77</sup>, R. Bernhard<sup>48</sup>, C. Bernius<sup>24</sup>, T. Berry<sup>76</sup>, A. Bertin<sup>19a,19b</sup>, F. Bertinelli<sup>29</sup>, F. Bertolucci<sup>122a,122b</sup>, M.I. Besana<sup>89a,89b</sup>, N. Besson<sup>136</sup>, S. Bethke<sup>99</sup>, W. Bhimji<sup>45</sup>, R.M. Bianchi<sup>29</sup>, M. Bianco<sup>72a,72b</sup>, O. Biebel<sup>98</sup>, S.P. Bieniek<sup>77</sup>, K. Bierwagen<sup>54</sup>, J. Biesiada<sup>14</sup>, M. Biglietti<sup>134a,134b</sup>, H. Bilokon<sup>47</sup>, M. Bindi<sup>19a,19b</sup>, S. Binet<sup>115</sup>, A. Bingul<sup>18c</sup>, C. Bini<sup>132a,132b</sup>, C. Biscarat<sup>177</sup>, U. Bitenc<sup>48</sup>, K.M. Black<sup>21</sup>, R.E. Blair<sup>5</sup>, J.-B. Blanchard<sup>115</sup>, G. Blanchot<sup>29</sup>, T. Blazek<sup>144a</sup>, C. Blocker<sup>22</sup>, J. Blocki<sup>38</sup>, A. Blondel<sup>49</sup>, W. Blum<sup>81</sup>, U. Blumenschein<sup>54</sup>, G.J. Bobbink<sup>105</sup>, V.B. Bobrovnikov<sup>107</sup>, S.S. Bocchetta<sup>79</sup>, A. Bocci<sup>44</sup>, C.R. Boddy<sup>118</sup>, M. Boehler<sup>41</sup>, J. Boek<sup>174</sup>, N. Boelaert<sup>35</sup>, S. Böser<sup>77</sup>,

J.A. Bogaerts<sup>29</sup>, A. Bogdanchikov<sup>107</sup>, A. Bogouch<sup>90,\*</sup>, C. Boehm<sup>146a</sup>, V. Boisvert<sup>76</sup>, T. Bold<sup>163.g</sup>,  
 V. Boldea<sup>25a</sup>, N.M. Bolnet<sup>136</sup>, M. Bona<sup>75</sup>, V.G. Bondarenko<sup>96</sup>, M. Boonekamp<sup>136</sup>, G. Boorman<sup>76</sup>,  
 C.N. Booth<sup>139</sup>, S. Bordini<sup>78</sup>, C. Borer<sup>16</sup>, A. Borisov<sup>128</sup>, G. Borissov<sup>71</sup>, I. Borjanovic<sup>12a</sup>,  
 S. Borroni<sup>132a,132b</sup>, K. Bos<sup>105</sup>, D. Boscherini<sup>19a</sup>, M. Bosman<sup>11</sup>, H. Boterenbrood<sup>105</sup>,  
 D. Botterill<sup>129</sup>, J. Bouchami<sup>93</sup>, J. Boudreau<sup>123</sup>, E.V. Bouhova-Thacker<sup>71</sup>, C. Boulahouache<sup>123</sup>,  
 C. Bourdarios<sup>115</sup>, N. Bousson<sup>83</sup>, A. Boveia<sup>30</sup>, J. Boyd<sup>29</sup>, I.R. Boyko<sup>65</sup>, N.I. Bozhko<sup>128</sup>,  
 I. Bozovic-Jelisavcic<sup>12b</sup>, J. Bracinik<sup>17</sup>, A. Braem<sup>29</sup>, P. Branchini<sup>134a</sup>, G.W. Brandenburg<sup>57</sup>,  
 A. Brandt<sup>7</sup>, G. Brandt<sup>15</sup>, O. Brandt<sup>54</sup>, U. Bratzler<sup>156</sup>, B. Brau<sup>84</sup>, J.E. Brau<sup>114</sup>, H.M. Braun<sup>174</sup>,  
 B. Brelier<sup>158</sup>, J. Bremer<sup>29</sup>, R. Brenner<sup>166</sup>, S. Bressler<sup>152</sup>, D. Breton<sup>115</sup>, D. Britton<sup>53</sup>,  
 F.M. Brochu<sup>27</sup>, I. Brock<sup>20</sup>, R. Brock<sup>88</sup>, T.J. Brodbeck<sup>71</sup>, E. Brodet<sup>153</sup>, F. Broggi<sup>89a</sup>,  
 C. Bromberg<sup>88</sup>, G. Brooijmans<sup>34</sup>, W.K. Brooks<sup>31b</sup>, G. Brown<sup>82</sup>, H. Brown<sup>7</sup>,  
 P.A. Bruckman de Renstrom<sup>38</sup>, D. Bruncko<sup>144b</sup>, R. Bruneliere<sup>48</sup>, S. Brunet<sup>61</sup>, A. Bruni<sup>19a</sup>,  
 G. Bruni<sup>19a</sup>, M. Bruschi<sup>19a</sup>, T. Buanes<sup>13</sup>, F. Bucci<sup>49</sup>, J. Buchanan<sup>118</sup>, N.J. Buchanan<sup>2</sup>,  
 P. Buchholz<sup>141</sup>, R.M. Buckingham<sup>118</sup>, A.G. Buckley<sup>45</sup>, S.I. Buda<sup>25a</sup>, I.A. Budagov<sup>65</sup>,  
 B. Budick<sup>108</sup>, V. Büscher<sup>81</sup>, L. Bugge<sup>117</sup>, D. Buiria-Clark<sup>118</sup>, O. Bulekov<sup>96</sup>, M. Bunse<sup>42</sup>,  
 T. Buran<sup>117</sup>, H. Burckhart<sup>29</sup>, S. Burdin<sup>73</sup>, T. Burgess<sup>13</sup>, S. Burke<sup>129</sup>, E. Busato<sup>33</sup>, P. Bussey<sup>53</sup>,  
 C.P. Buszello<sup>166</sup>, F. Butin<sup>29</sup>, B. Butler<sup>143</sup>, J.M. Butler<sup>21</sup>, C.M. Buttar<sup>53</sup>, J.M. Butterworth<sup>77</sup>,  
 W. Buttinger<sup>27</sup>, T. Byatt<sup>77</sup>, S. Cabrera Urbán<sup>167</sup>, D. Caforio<sup>19a,19b</sup>, O. Cakir<sup>3a</sup>, P. Calafiura<sup>14</sup>,  
 G. Calderini<sup>78</sup>, P. Calfayan<sup>98</sup>, R. Calkins<sup>106</sup>, L.P. Caloba<sup>23a</sup>, R. Caloi<sup>132a,132b</sup>, D. Calvet<sup>33</sup>,  
 S. Calvet<sup>33</sup>, R. Camacho Toro<sup>33</sup>, P. Camarri<sup>133a,133b</sup>, M. Cambiaghi<sup>119a,119b</sup>, D. Cameron<sup>117</sup>,  
 S. Campana<sup>29</sup>, M. Campanelli<sup>77</sup>, V. Canale<sup>102a,102b</sup>, F. Canelli<sup>30</sup>, A. Canepa<sup>159a</sup>, J. Cantero<sup>80</sup>,  
 L. Capasso<sup>102a,102b</sup>, M.D.M. Capeans Garrido<sup>29</sup>, I. Caprini<sup>25a</sup>, M. Caprini<sup>25a</sup>, D. Capriotti<sup>99</sup>,  
 M. Capua<sup>36a,36b</sup>, R. Caputo<sup>148</sup>, C. Caramarcu<sup>25a</sup>, R. Cardarelli<sup>133a</sup>, T. Carli<sup>29</sup>, G. Carlino<sup>102a</sup>,  
 L. Carminati<sup>89a,89b</sup>, B. Caron<sup>159a</sup>, S. Caron<sup>48</sup>, G.D. Carrillo Montoya<sup>172</sup>, A.A. Carter<sup>75</sup>,  
 J.R. Carter<sup>27</sup>, J. Carvalho<sup>124a,h</sup>, D. Casadei<sup>108</sup>, M.P. Casado<sup>11</sup>, M. Cascella<sup>122a,122b</sup>,  
 C. Caso<sup>50a,50b,\*</sup>, A.M. Castaneda Hernandez<sup>172</sup>, E. Castaneda-Miranda<sup>172</sup>,  
 V. Castillo Gimenez<sup>167</sup>, N.F. Castro<sup>124a</sup>, G. Cataldi<sup>72a</sup>, F. Cataneo<sup>29</sup>, A. Catinaccio<sup>29</sup>,  
 J.R. Catmore<sup>71</sup>, A. Cattai<sup>29</sup>, G. Cattani<sup>133a,133b</sup>, S. Caughron<sup>88</sup>, D. Cauz<sup>164a,164c</sup>, P. Cavalleri<sup>78</sup>,  
 D. Cavalli<sup>89a</sup>, M. Cavalli-Sforza<sup>11</sup>, V. Cavasinni<sup>122a,122b</sup>, F. Ceradini<sup>134a,134b</sup>, A.S. Cerqueira<sup>23a</sup>,  
 A. Cerri<sup>29</sup>, L. Cerrito<sup>75</sup>, F. Cerutti<sup>47</sup>, S.A. Cetin<sup>18b</sup>, F. Cevenini<sup>102a,102b</sup>, A. Chafaq<sup>135a</sup>,  
 D. Chakraborty<sup>106</sup>, K. Chan<sup>2</sup>, B. Chapleau<sup>85</sup>, J.D. Chapman<sup>27</sup>, J.W. Chapman<sup>87</sup>, E. Chareyre<sup>78</sup>,  
 D.G. Charlton<sup>17</sup>, V. Chavda<sup>82</sup>, C.A. Chavez Barajas<sup>29</sup>, S. Cheatham<sup>85</sup>, S. Chekanov<sup>5</sup>,  
 S.V. Chekulaev<sup>159a</sup>, G.A. Chelkov<sup>65</sup>, M.A. Chelstowska<sup>104</sup>, C. Chen<sup>64</sup>, H. Chen<sup>24</sup>, S. Chen<sup>32c</sup>,  
 T. Chen<sup>32c</sup>, X. Chen<sup>172</sup>, S. Cheng<sup>32a</sup>, A. Cheplakov<sup>65</sup>, V.F. Chepurinov<sup>65</sup>,  
 R. Cherkaoui El Moursli<sup>135e</sup>, V. Chernyatin<sup>24</sup>, E. Cheu<sup>6</sup>, S.L. Cheung<sup>158</sup>, L. Chevalier<sup>136</sup>,  
 G. Chiefari<sup>102a,102b</sup>, L. Chikovani<sup>51</sup>, J.T. Childers<sup>58a</sup>, A. Chilingarov<sup>71</sup>, G. Chiodini<sup>72a</sup>,  
 M.V. Chizhov<sup>65</sup>, G. Choudalakis<sup>30</sup>, S. Chouridou<sup>137</sup>, I.A. Christidi<sup>77</sup>, A. Christov<sup>48</sup>,  
 D. Chromek-Burckhart<sup>29</sup>, M.L. Chu<sup>151</sup>, J. Chudoba<sup>125</sup>, G. Ciapetti<sup>132a,132b</sup>, K. Ciba<sup>37</sup>,  
 A.K. Ciftci<sup>3a</sup>, R. Ciftci<sup>3a</sup>, D. Cinca<sup>33</sup>, V. Cindro<sup>74</sup>, M.D. Ciobotaru<sup>163</sup>, C. Ciocca<sup>19a,19b</sup>,  
 A. Ciochio<sup>14</sup>, M. Cirilli<sup>87</sup>, M. Ciubancan<sup>25a</sup>, A. Clark<sup>49</sup>, P.J. Clark<sup>45</sup>, W. Cleland<sup>123</sup>,  
 J.C. Clemens<sup>83</sup>, B. Clement<sup>55</sup>, C. Clement<sup>146a,146b</sup>, R.W. Clift<sup>129</sup>, Y. Coadou<sup>83</sup>,  
 M. Cobal<sup>164a,164c</sup>, A. Coccaro<sup>50a,50b</sup>, J. Cochran<sup>64</sup>, P. Coe<sup>118</sup>, J.G. Cogan<sup>143</sup>, J. Coggeshall<sup>165</sup>,  
 E. Cogneras<sup>177</sup>, C.D. Cojocaru<sup>28</sup>, J. Colas<sup>4</sup>, A.P. Colijn<sup>105</sup>, C. Collard<sup>115</sup>, N.J. Collins<sup>17</sup>,  
 C. Collins-Tooth<sup>53</sup>, J. Collot<sup>55</sup>, G. Colon<sup>84</sup>, P. Conde Muiño<sup>124a</sup>, E. Coniavitis<sup>118</sup>, M.C. Conidi<sup>11</sup>,  
 M. Consonni<sup>104</sup>, V. Consorti<sup>48</sup>, S. Constantinescu<sup>25a</sup>, C. Conta<sup>119a,119b</sup>, F. Conventi<sup>102a,i</sup>,  
 J. Cook<sup>29</sup>, M. Cooke<sup>14</sup>, B.D. Cooper<sup>77</sup>, A.M. Cooper-Sarkar<sup>118</sup>, N.J. Cooper-Smith<sup>76</sup>, K. Copic<sup>34</sup>,  
 T. Cornelissen<sup>50a,50b</sup>, M. Corradi<sup>19a</sup>, F. Corriveau<sup>85,j</sup>, A. Cortes-Gonzalez<sup>165</sup>, G. Cortiana<sup>99</sup>,  
 G. Costa<sup>89a</sup>, M.J. Costa<sup>167</sup>, D. Costanzo<sup>139</sup>, T. Costin<sup>30</sup>, D. Côté<sup>29</sup>, R. Coura Torres<sup>23a</sup>,

L. Courneyea<sup>169</sup>, G. Cowan<sup>76</sup>, C. Cowden<sup>27</sup>, B.E. Cox<sup>82</sup>, K. Cranmer<sup>108</sup>, F. Crescioli<sup>122a,122b</sup>,  
 M. Cristinziani<sup>20</sup>, G. Crosetti<sup>36a,36b</sup>, R. Crupi<sup>72a,72b</sup>, S. Crépé-Renaudin<sup>55</sup>, C.-M. Cuciuc<sup>25a</sup>,  
 C. Cuenca Almenar<sup>175</sup>, T. Cuhadar Donszelmann<sup>139</sup>, M. Curatolo<sup>47</sup>, C.J. Curtis<sup>17</sup>,  
 P. Cwetanski<sup>61</sup>, H. Czirr<sup>141</sup>, Z. Czyczula<sup>117</sup>, S. D'Auria<sup>53</sup>, M. D'Onofrio<sup>73</sup>, A. D'Orazio<sup>132a,132b</sup>,  
 P.V.M. Da Silva<sup>23a</sup>, C. Da Via<sup>82</sup>, W. Dabrowski<sup>37</sup>, T. Dai<sup>87</sup>, C. Dallapiccola<sup>84</sup>, M. Dam<sup>35</sup>,  
 M. Dameri<sup>50a,50b</sup>, D.S. Damiani<sup>137</sup>, H.O. Danielsson<sup>29</sup>, D. Dannheim<sup>99</sup>, V. Dao<sup>49</sup>, G. Darbo<sup>50a</sup>,  
 G.L. Darlea<sup>25b</sup>, C. Daum<sup>105</sup>, J.P. Dauvergne<sup>29</sup>, W. Davey<sup>86</sup>, T. Davidek<sup>126</sup>, N. Davidson<sup>86</sup>,  
 R. Davidson<sup>71</sup>, E. Davies<sup>118,c</sup>, M. Davies<sup>93</sup>, A.R. Davison<sup>77</sup>, Y. Davygora<sup>58a</sup>, E. Dawe<sup>142</sup>,  
 I. Dawson<sup>139</sup>, J.W. Dawson<sup>5,\*</sup>, R.K. Daya<sup>39</sup>, K. De<sup>7</sup>, R. de Asmundis<sup>102a</sup>, S. De Castro<sup>19a,19b</sup>,  
 P.E. De Castro Faria Salgado<sup>24</sup>, S. De Cecco<sup>78</sup>, J. de Graat<sup>98</sup>, N. De Groot<sup>104</sup>, P. de Jong<sup>105</sup>,  
 C. De La Taille<sup>115</sup>, H. De la Torre<sup>80</sup>, B. De Lotto<sup>164a,164c</sup>, L. De Mora<sup>71</sup>, L. De Nooij<sup>105</sup>,  
 M. De Oliveira Branco<sup>29</sup>, D. De Pedis<sup>132a</sup>, A. De Salvo<sup>132a</sup>, U. De Sanctis<sup>164a,164c</sup>, A. De Santo<sup>149</sup>,  
 J.B. De Vivie De Regie<sup>115</sup>, S. Dean<sup>77</sup>, D.V. Dedovich<sup>65</sup>, J. Degenhardt<sup>120</sup>, M. Dehchar<sup>118</sup>,  
 C. Del Papa<sup>164a,164c</sup>, J. Del Peso<sup>80</sup>, T. Del Prete<sup>122a,122b</sup>, M. Deliyergiyev<sup>74</sup>, A. Dell'Acqua<sup>29</sup>,  
 L. Dell'Asta<sup>89a,89b</sup>, M. Della Pietra<sup>102a,i</sup>, D. della Volpe<sup>102a,102b</sup>, M. Delmastro<sup>29</sup>, P. Delpierre<sup>83</sup>,  
 N. Delruelle<sup>29</sup>, P.A. Delsart<sup>55</sup>, C. Deluca<sup>148</sup>, S. Demers<sup>175</sup>, M. Demichev<sup>65</sup>, B. Demirkoz<sup>11,k</sup>,  
 J. Deng<sup>163</sup>, S.P. Denisov<sup>128</sup>, D. Derendarz<sup>38</sup>, J.E. Derkaoui<sup>135d</sup>, F. Derue<sup>78</sup>, P. Dervan<sup>73</sup>,  
 K. Desch<sup>20</sup>, E. Devetak<sup>148</sup>, P.O. Deviveiros<sup>158</sup>, A. Dewhurst<sup>129</sup>, B. DeWilde<sup>148</sup>, S. Dhaliwal<sup>158</sup>,  
 R. Dhullipudi<sup>24,l</sup>, A. Di Ciaccio<sup>133a,133b</sup>, L. Di Ciaccio<sup>4</sup>, A. Di Girolamo<sup>29</sup>, B. Di Girolamo<sup>29</sup>,  
 S. Di Luise<sup>134a,134b</sup>, A. Di Mattia<sup>88</sup>, B. Di Micco<sup>29</sup>, R. Di Nardo<sup>133a,133b</sup>, A. Di Simone<sup>133a,133b</sup>,  
 R. Di Sipio<sup>19a,19b</sup>, M.A. Diaz<sup>31a</sup>, F. Diblen<sup>18c</sup>, E.B. Diehl<sup>87</sup>, J. Dietrich<sup>41</sup>, T.A. Dietzsch<sup>58a</sup>,  
 S. Diglio<sup>115</sup>, K. Dindar Yagci<sup>39</sup>, J. Dingfelder<sup>20</sup>, C. Dionisi<sup>132a,132b</sup>, P. Dita<sup>25a</sup>, S. Dita<sup>25a</sup>,  
 F. Dittus<sup>29</sup>, F. Djama<sup>83</sup>, T. Djobava<sup>51</sup>, M.A.B. do Vale<sup>23a</sup>, A. Do Valle Wemans<sup>124a</sup>,  
 T.K.O. Doan<sup>4</sup>, M. Dobbs<sup>85</sup>, R. Dobinson<sup>29,\*</sup>, D. Dobos<sup>42</sup>, E. Dobson<sup>29</sup>, M. Dobson<sup>163</sup>,  
 J. Dodd<sup>34</sup>, C. Doglioni<sup>118</sup>, T. Doherty<sup>53</sup>, Y. Doi<sup>66,\*</sup>, J. Dolejsi<sup>126</sup>, I. Dolenc<sup>74</sup>, Z. Dolezal<sup>126</sup>,  
 B.A. Dolgoshein<sup>96,\*</sup>, T. Dohmae<sup>155</sup>, M. Donadelli<sup>23b</sup>, M. Donega<sup>120</sup>, J. Donini<sup>55</sup>, J. Dopke<sup>29</sup>,  
 A. Doria<sup>102a</sup>, A. Dos Anjos<sup>172</sup>, M. Dosil<sup>11</sup>, A. Dotti<sup>122a,122b</sup>, M.T. Dova<sup>70</sup>, J.D. Dowell<sup>17</sup>,  
 A.D. Doxiadis<sup>105</sup>, A.T. Doyle<sup>53</sup>, Z. Drasal<sup>126</sup>, J. Drees<sup>174</sup>, N. Dressnandt<sup>120</sup>, H. Drevermann<sup>29</sup>,  
 C. Driouichi<sup>35</sup>, M. Dris<sup>9</sup>, J. Dubbert<sup>99</sup>, T. Dubbs<sup>137</sup>, S. Dube<sup>14</sup>, E. Duchovni<sup>171</sup>, G. Duckeck<sup>98</sup>,  
 A. Dudarev<sup>29</sup>, F. Dudziak<sup>64</sup>, M. Dührssen<sup>29</sup>, I.P. Duerdoth<sup>82</sup>, L. Duflot<sup>115</sup>, M-A. Dufour<sup>85</sup>,  
 M. Dunford<sup>29</sup>, H. Duran Yildiz<sup>3b</sup>, R. Duxfield<sup>139</sup>, M. Dwuznik<sup>37</sup>, F. Dydak<sup>29</sup>, D. Dzahini<sup>55</sup>,  
 M. Düren<sup>52</sup>, W.L. Ebenstein<sup>44</sup>, J. Ebke<sup>98</sup>, S. Eckert<sup>48</sup>, S. Eckweiler<sup>81</sup>, K. Edmonds<sup>81</sup>,  
 C.A. Edwards<sup>76</sup>, N.C. Edwards<sup>53</sup>, W. Ehrenfeld<sup>41</sup>, T. Ehrich<sup>99</sup>, T. Eifert<sup>29</sup>, G. Eigen<sup>13</sup>,  
 K. Einsweiler<sup>14</sup>, E. Eisenhandler<sup>75</sup>, T. Ekelof<sup>166</sup>, M. El Kacimi<sup>135c</sup>, M. Ellert<sup>166</sup>, S. Elles<sup>4</sup>,  
 F. Ellinghaus<sup>81</sup>, K. Ellis<sup>75</sup>, N. Ellis<sup>29</sup>, J. Elmsheuser<sup>98</sup>, M. Elsing<sup>29</sup>, R. Ely<sup>14</sup>, D. Emelianov<sup>129</sup>,  
 R. Engelmann<sup>148</sup>, A. Engl<sup>98</sup>, B. Epp<sup>62</sup>, A. Eppig<sup>87</sup>, J. Erdmann<sup>54</sup>, A. Ereditato<sup>16</sup>,  
 D. Eriksson<sup>146a</sup>, J. Ernst<sup>1</sup>, M. Ernst<sup>24</sup>, J. Ernwein<sup>136</sup>, D. Errede<sup>165</sup>, S. Errede<sup>165</sup>, E. Ertel<sup>81</sup>,  
 M. Escalier<sup>115</sup>, C. Escobar<sup>167</sup>, X. Espinal Curull<sup>11</sup>, B. Esposito<sup>47</sup>, F. Etienne<sup>83</sup>, A.I. Etienvre<sup>136</sup>,  
 E. Etzion<sup>153</sup>, D. Evangelakou<sup>54</sup>, H. Evans<sup>61</sup>, L. Fabbri<sup>19a,19b</sup>, C. Fabre<sup>29</sup>, R.M. Fakhruddinov<sup>128</sup>,  
 S. Falciano<sup>132a</sup>, Y. Fang<sup>172</sup>, M. Fanti<sup>89a,89b</sup>, A. Farbin<sup>7</sup>, A. Farilla<sup>134a</sup>, J. Farley<sup>148</sup>,  
 T. Farooque<sup>158</sup>, S.M. Farrington<sup>118</sup>, P. Farthouat<sup>29</sup>, P. Fassnacht<sup>29</sup>, D. Fassouliotis<sup>8</sup>,  
 B. Fathollahzadeh<sup>158</sup>, A. Favareto<sup>89a,89b</sup>, L. Fayard<sup>115</sup>, S. Fazio<sup>36a,36b</sup>, R. Febbraro<sup>33</sup>,  
 P. Federic<sup>144a</sup>, O.L. Fedin<sup>121</sup>, W. Fedorko<sup>88</sup>, M. Fehling-Kaschek<sup>48</sup>, L. Feligioni<sup>83</sup>, D. Fellmann<sup>5</sup>,  
 C.U. Felzmann<sup>86</sup>, C. Feng<sup>32d</sup>, E.J. Feng<sup>30</sup>, A.B. Fenyuk<sup>128</sup>, J. Ferencei<sup>144b</sup>, J. Ferland<sup>93</sup>,  
 W. Fernando<sup>109</sup>, S. Ferrag<sup>53</sup>, J. Ferrando<sup>53</sup>, V. Ferrara<sup>41</sup>, A. Ferrari<sup>166</sup>, P. Ferrari<sup>105</sup>,  
 R. Ferrari<sup>119a</sup>, A. Ferrer<sup>167</sup>, M.L. Ferrer<sup>47</sup>, D. Ferrere<sup>49</sup>, C. Ferretti<sup>87</sup>, A. Ferretto Parodi<sup>50a,50b</sup>,  
 M. Fiascaris<sup>30</sup>, F. Fiedler<sup>81</sup>, A. Filipčić<sup>74</sup>, A. Filippas<sup>9</sup>, F. Filthaut<sup>104</sup>, M. Fincke-Keeler<sup>169</sup>,  
 M.C.N. Fiolhais<sup>124a,h</sup>, L. Fiorini<sup>167</sup>, A. Firan<sup>39</sup>, G. Fischer<sup>41</sup>, P. Fischer<sup>20</sup>, M.J. Fisher<sup>109</sup>,



S.M. Fisher<sup>129</sup>, M. Flechl<sup>48</sup>, I. Fleck<sup>141</sup>, J. Fleckner<sup>81</sup>, P. Fleischmann<sup>173</sup>, S. Fleischmann<sup>174</sup>,  
 T. Flick<sup>174</sup>, L.R. Flores Castillo<sup>172</sup>, M.J. Flowerdew<sup>99</sup>, F. Föhlisch<sup>58a</sup>, M. Fokitis<sup>9</sup>,  
 T. Fonseca Martin<sup>16</sup>, D.A. Forbush<sup>138</sup>, A. Formica<sup>136</sup>, A. Forti<sup>82</sup>, D. Fortin<sup>159a</sup>, J.M. Foster<sup>82</sup>,  
 D. Fournier<sup>115</sup>, A. Foussat<sup>29</sup>, A.J. Fowler<sup>44</sup>, K. Fowler<sup>137</sup>, H. Fox<sup>71</sup>, P. Francavilla<sup>122a,122b</sup>,  
 S. Franchino<sup>119a,119b</sup>, D. Francis<sup>29</sup>, T. Frank<sup>171</sup>, M. Franklin<sup>57</sup>, S. Franz<sup>29</sup>, M. Fraternali<sup>119a,119b</sup>,  
 S. Fratina<sup>120</sup>, S.T. French<sup>27</sup>, F. Friedrich<sup>43</sup>, R. Froeschl<sup>29</sup>, D. Froidevaux<sup>29</sup>, J.A. Frost<sup>27</sup>,  
 C. Fukunaga<sup>156</sup>, E. Fullana Torregrosa<sup>29</sup>, J. Fuster<sup>167</sup>, C. Gabaldon<sup>29</sup>, O. Gabizon<sup>171</sup>,  
 T. Gadfort<sup>24</sup>, S. Gadomski<sup>49</sup>, G. Gagliardi<sup>50a,50b</sup>, P. Gagnon<sup>61</sup>, C. Galea<sup>98</sup>, E.J. Gallas<sup>118</sup>,  
 M.V. Gallas<sup>29</sup>, V. Gallo<sup>16</sup>, B.J. Gallop<sup>129</sup>, P. Gallus<sup>125</sup>, E. Galyaev<sup>40</sup>, K.K. Gan<sup>109</sup>,  
 Y.S. Gao<sup>143,f</sup>, V.A. Gapienko<sup>128</sup>, A. Gaponenko<sup>14</sup>, F. Garberson<sup>175</sup>, M. Garcia-Sciveres<sup>14</sup>,  
 C. García<sup>167</sup>, J.E. García Navarro<sup>49</sup>, R.W. Gardner<sup>30</sup>, N. Garelli<sup>29</sup>, H. Garitaonandia<sup>105</sup>,  
 V. Garonne<sup>29</sup>, J. Garvey<sup>17</sup>, C. Gatti<sup>47</sup>, G. Gaudio<sup>119a</sup>, O. Gaumer<sup>49</sup>, B. Gaur<sup>141</sup>, L. Gauthier<sup>136</sup>,  
 I.L. Gavrilenko<sup>94</sup>, C. Gay<sup>168</sup>, G. Gaycken<sup>20</sup>, J-C. Gayde<sup>29</sup>, E.N. Gaziz<sup>9</sup>, P. Ge<sup>32d</sup>, C.N.P. Gee<sup>129</sup>,  
 D.A.A. Geerts<sup>105</sup>, Ch. Geich-Gimbel<sup>20</sup>, K. Gellerstedt<sup>146a,146b</sup>, C. Gemme<sup>50a</sup>, A. Gemmell<sup>53</sup>,  
 M.H. Genest<sup>98</sup>, S. Gentile<sup>132a,132b</sup>, M. George<sup>54</sup>, S. George<sup>76</sup>, P. Gerlach<sup>174</sup>, A. Gershon<sup>153</sup>,  
 C. Geweniger<sup>58a</sup>, H. Ghazlane<sup>135b</sup>, P. Ghez<sup>4</sup>, N. Ghodbane<sup>33</sup>, B. Giacobbe<sup>19a</sup>, S. Giagu<sup>132a,132b</sup>,  
 V. Giakoumopoulou<sup>8</sup>, V. Giangiobbe<sup>122a,122b</sup>, F. Gianotti<sup>29</sup>, B. Gibbard<sup>24</sup>, A. Gibson<sup>158</sup>,  
 S.M. Gibson<sup>29</sup>, L.M. Gilbert<sup>118</sup>, M. Gilchriese<sup>14</sup>, V. Gilevsky<sup>91</sup>, D. Gillberg<sup>28</sup>, A.R. Gillman<sup>129</sup>,  
 D.M. Gingrich<sup>2,e</sup>, J. Ginzburg<sup>153</sup>, N. Giokaris<sup>8</sup>, R. Giordano<sup>102a,102b</sup>, F.M. Giorgi<sup>15</sup>,  
 P. Giovannini<sup>99</sup>, P.F. Giraud<sup>136</sup>, D. Giugni<sup>89a</sup>, M. Giunta<sup>132a,132b</sup>, P. Giusti<sup>19a</sup>, B.K. Gjelsten<sup>117</sup>,  
 L.K. Gladilin<sup>97</sup>, C. Glasman<sup>80</sup>, J. Glatzer<sup>48</sup>, A. Glazov<sup>41</sup>, K.W. Glitza<sup>174</sup>, G.L. Glonti<sup>65</sup>,  
 J. Godfrey<sup>142</sup>, J. Godlewski<sup>29</sup>, M. Goebel<sup>41</sup>, T. Göpfert<sup>43</sup>, C. Goeringer<sup>81</sup>, C. Gössling<sup>42</sup>,  
 T. Göttfert<sup>99</sup>, S. Goldfarb<sup>87</sup>, D. Goldin<sup>39</sup>, T. Golling<sup>175</sup>, S.N. Golovnia<sup>128</sup>, A. Gomes<sup>124a,b</sup>,  
 L.S. Gomez Fajardo<sup>41</sup>, R. Gonçalo<sup>76</sup>, J. Goncalves Pinto Firmino Da Costa<sup>41</sup>, L. Gonella<sup>20</sup>,  
 A. Gonidec<sup>29</sup>, S. Gonzalez<sup>172</sup>, S. González de la Hoz<sup>167</sup>, M.L. Gonzalez Silva<sup>26</sup>,  
 S. Gonzalez-Sevilla<sup>49</sup>, J.J. Goodson<sup>148</sup>, L. Goossens<sup>29</sup>, P.A. Gorbounov<sup>95</sup>, H.A. Gordon<sup>24</sup>,  
 I. Gorelov<sup>103</sup>, G. Gorfine<sup>174</sup>, B. Gorini<sup>29</sup>, E. Gorini<sup>72a,72b</sup>, A. Gorišek<sup>74</sup>, E. Gornicki<sup>38</sup>,  
 S.A. Gorokhov<sup>128</sup>, V.N. Goryachev<sup>128</sup>, B. Gosdzik<sup>41</sup>, M. Gosselink<sup>105</sup>, M.I. Gostkin<sup>65</sup>,  
 M. Gouanère<sup>4</sup>, I. Gough Eschrich<sup>163</sup>, M. Goughri<sup>135a</sup>, D. Goujdami<sup>135c</sup>, M.P. Goulette<sup>49</sup>,  
 A.G. Goussiou<sup>138</sup>, C. Goy<sup>4</sup>, I. Grabowska-Bold<sup>163,g</sup>, V. Grabski<sup>176</sup>, P. Grafström<sup>29</sup>, C. Grah<sup>174</sup>,  
 K-J. Grah<sup>41</sup>, F. Grancagnolo<sup>72a</sup>, S. Grancagnolo<sup>15</sup>, V. Grassi<sup>148</sup>, V. Gratchev<sup>121</sup>, N. Grau<sup>34</sup>,  
 H.M. Gray<sup>29</sup>, J.A. Gray<sup>148</sup>, E. Graziani<sup>134a</sup>, O.G. Grebenyuk<sup>121</sup>, D. Greenfield<sup>129</sup>,  
 T. Greenshaw<sup>73</sup>, Z.D. Greenwood<sup>24,l</sup>, I.M. Gregor<sup>41</sup>, P. Grenier<sup>143</sup>, J. Griffiths<sup>138</sup>,  
 N. Grigalashvili<sup>65</sup>, A.A. Grillo<sup>137</sup>, S. Grinstein<sup>11</sup>, Y.V. Grishkevich<sup>97</sup>, J.-F. Grivaz<sup>115</sup>,  
 J. Grognuz<sup>29</sup>, M. Groh<sup>99</sup>, E. Gross<sup>171</sup>, J. Grosse-Knetter<sup>54</sup>, J. Groth-Jensen<sup>171</sup>, K. Grybel<sup>141</sup>,  
 V.J. Guarino<sup>5</sup>, D. Guest<sup>175</sup>, C. Guicheney<sup>33</sup>, A. Guida<sup>72a,72b</sup>, T. Guillemin<sup>4</sup>, S. Guindon<sup>54</sup>,  
 H. Guler<sup>85,m</sup>, J. Gunther<sup>125</sup>, B. Guo<sup>158</sup>, J. Guo<sup>34</sup>, A. Gupta<sup>30</sup>, Y. Gusakov<sup>65</sup>, V.N. Gushchin<sup>128</sup>,  
 A. Gutierrez<sup>93</sup>, P. Gutierrez<sup>111</sup>, N. Guttman<sup>153</sup>, O. Gutzwiller<sup>172</sup>, C. Guyot<sup>136</sup>, C. Gwenlan<sup>118</sup>,  
 C.B. Gwilliam<sup>73</sup>, A. Haas<sup>143</sup>, S. Haas<sup>29</sup>, C. Haber<sup>14</sup>, R. Hackenburg<sup>24</sup>, H.K. Hadavand<sup>39</sup>,  
 D.R. Hadley<sup>17</sup>, P. Haefner<sup>99</sup>, F. Hahn<sup>29</sup>, S. Haider<sup>29</sup>, Z. Hajduk<sup>38</sup>, H. Hakobyan<sup>176</sup>, J. Haller<sup>54</sup>,  
 K. Hamacher<sup>174</sup>, P. Hamal<sup>113</sup>, A. Hamilton<sup>49</sup>, S. Hamilton<sup>161</sup>, H. Han<sup>32a</sup>, L. Han<sup>32b</sup>,  
 K. Hanagaki<sup>116</sup>, M. Hance<sup>120</sup>, C. Handel<sup>81</sup>, P. Hanke<sup>58a</sup>, J.R. Hansen<sup>35</sup>, J.B. Hansen<sup>35</sup>,  
 J.D. Hansen<sup>35</sup>, P.H. Hansen<sup>35</sup>, P. Hansson<sup>143</sup>, K. Hara<sup>160</sup>, G.A. Hare<sup>137</sup>, T. Harenberg<sup>174</sup>,  
 S. Harkusha<sup>90</sup>, D. Harper<sup>87</sup>, R.D. Harrington<sup>21</sup>, O.M. Harris<sup>138</sup>, K. Harrison<sup>17</sup>, J. Hartert<sup>48</sup>,  
 F. Hartjes<sup>105</sup>, T. Haruyama<sup>66</sup>, A. Harvey<sup>56</sup>, S. Hasegawa<sup>101</sup>, Y. Hasegawa<sup>140</sup>, S. Hassani<sup>136</sup>,  
 M. Hatch<sup>29</sup>, D. Hauff<sup>99</sup>, S. Haug<sup>16</sup>, M. Hauschild<sup>29</sup>, R. Hauser<sup>88</sup>, M. Havranek<sup>20</sup>, B.M. Hawes<sup>118</sup>,  
 C.M. Hawkes<sup>17</sup>, R.J. Hawkins<sup>29</sup>, D. Hawkins<sup>163</sup>, T. Hayakawa<sup>67</sup>, D. Hayden<sup>76</sup>, H.S. Hayward<sup>73</sup>,  
 S.J. Haywood<sup>129</sup>, E. Hazen<sup>21</sup>, M. He<sup>32d</sup>, S.J. Head<sup>17</sup>, V. Hedberg<sup>79</sup>, L. Heelan<sup>7</sup>, S. Heim<sup>88</sup>,

B. Heinemann<sup>14</sup>, S. Heisterkamp<sup>35</sup>, L. Helary<sup>4</sup>, M. Heller<sup>115</sup>, S. Hellman<sup>146a,146b</sup>, D. Hellmich<sup>20</sup>,  
 C. Helsen<sup>11</sup>, R.C.W. Henderson<sup>71</sup>, M. Henke<sup>58a</sup>, A. Henrichs<sup>54</sup>, A.M. Henriques Correia<sup>29</sup>,  
 S. Henrot-Versille<sup>115</sup>, F. Henry-Couannier<sup>83</sup>, C. Hensel<sup>54</sup>, T. Henß<sup>174</sup>, C.M. Hernandez<sup>7</sup>,  
 Y. Hernández Jiménez<sup>167</sup>, R. Herrberg<sup>15</sup>, A.D. Hershenhorn<sup>152</sup>, G. Herten<sup>48</sup>, R. Hertenberger<sup>98</sup>,  
 L. Hervas<sup>29</sup>, N.P. Hessey<sup>105</sup>, A. Hidvegi<sup>146a</sup>, E. Higón-Rodríguez<sup>167</sup>, D. Hill<sup>5,\*</sup>, J.C. Hill<sup>27</sup>,  
 N. Hill<sup>5</sup>, K.H. Hiller<sup>41</sup>, S. Hillert<sup>20</sup>, S.J. Hillier<sup>17</sup>, I. Hinchliffe<sup>14</sup>, E. Hines<sup>120</sup>, M. Hirose<sup>116</sup>,  
 F. Hirsch<sup>42</sup>, D. Hirschbuehl<sup>174</sup>, J. Hobbs<sup>148</sup>, N. Hod<sup>153</sup>, M.C. Hodgkinson<sup>139</sup>, P. Hodgson<sup>139</sup>,  
 A. Hoecker<sup>29</sup>, M.R. Hoferkamp<sup>103</sup>, J. Hoffman<sup>39</sup>, D. Hoffmann<sup>83</sup>, M. Hohlfeld<sup>81</sup>, M. Holder<sup>141</sup>,  
 A. Holmes<sup>118</sup>, S.O. Holmgren<sup>146a</sup>, T. Holy<sup>127</sup>, J.L. Holzbauer<sup>88</sup>, Y. Homma<sup>67</sup>, T.M. Hong<sup>120</sup>,  
 L. Hooft van Huysduynen<sup>108</sup>, T. Horazdovsky<sup>127</sup>, C. Horn<sup>143</sup>, S. Horner<sup>48</sup>, K. Horton<sup>118</sup>,  
 J.-Y. Hostachy<sup>55</sup>, S. Hou<sup>151</sup>, M.A. Houlden<sup>73</sup>, A. Hoummada<sup>135a</sup>, J. Howarth<sup>82</sup>, D.F. Howell<sup>118</sup>,  
 I. Hristova<sup>15</sup>, J. Hrivnac<sup>115</sup>, I. Hruska<sup>125</sup>, T. Hryn'ova<sup>4</sup>, P.J. Hsu<sup>175</sup>, S.-C. Hsu<sup>14</sup>, G.S. Huang<sup>111</sup>,  
 Z. Hubacek<sup>127</sup>, F. Hubaut<sup>83</sup>, F. Huegging<sup>20</sup>, T.B. Huffman<sup>118</sup>, E.W. Hughes<sup>34</sup>, G. Hughes<sup>71</sup>,  
 R.E. Hughes-Jones<sup>82</sup>, M. Huhtinen<sup>29</sup>, P. Hurst<sup>57</sup>, M. Hurwitz<sup>14</sup>, U. Husemann<sup>41</sup>,  
 N. Huseynov<sup>65,n</sup>, J. Huston<sup>88</sup>, J. Huth<sup>57</sup>, G. Iacobucci<sup>49</sup>, G. Iakovidis<sup>9</sup>, M. Ibbotson<sup>82</sup>,  
 I. Ibragimov<sup>141</sup>, R. Ichimiya<sup>67</sup>, L. Iconomidou-Fayard<sup>115</sup>, J. Idarraga<sup>115</sup>, M. Idzik<sup>37</sup>,  
 P. Iengo<sup>102a,102b</sup>, O. Igonkina<sup>105</sup>, Y. Ikegami<sup>66</sup>, M. Ikeno<sup>66</sup>, Y. Ilchenko<sup>39</sup>, D. Iliadis<sup>154</sup>,  
 D. Imbault<sup>78</sup>, M. Imhaeuser<sup>174</sup>, M. Imori<sup>155</sup>, T. Ince<sup>20</sup>, J. Inigo-Golfin<sup>29</sup>, P. Ioannou<sup>8</sup>,  
 M. Iodice<sup>134a</sup>, G. Ionescu<sup>4</sup>, A. Irls Quiles<sup>167</sup>, K. Ishii<sup>66</sup>, A. Ishikawa<sup>67</sup>, M. Ishino<sup>66</sup>,  
 R. Ishmukhametov<sup>39</sup>, C. Issever<sup>118</sup>, S. Istin<sup>18a</sup>, A.V. Ivashin<sup>128</sup>, W. Iwanski<sup>38</sup>, H. Iwasaki<sup>66</sup>,  
 J.M. Izen<sup>40</sup>, V. Izzo<sup>102a</sup>, B. Jackson<sup>120</sup>, J.N. Jackson<sup>73</sup>, P. Jackson<sup>143</sup>, M.R. Jaekel<sup>29</sup>, V. Jain<sup>61</sup>,  
 K. Jakobs<sup>48</sup>, S. Jakobsen<sup>35</sup>, J. Jakubek<sup>127</sup>, D.K. Jana<sup>111</sup>, E. Jankowski<sup>158</sup>, E. Jansen<sup>77</sup>,  
 A. Jantsch<sup>99</sup>, M. Janus<sup>20</sup>, G. Jarlskog<sup>79</sup>, L. Jeanty<sup>57</sup>, K. Jelen<sup>37</sup>, I. Jen-La Plante<sup>30</sup>, P. Jenni<sup>29</sup>,  
 A. Jeremie<sup>4</sup>, P. Jež<sup>35</sup>, S. Jézéquel<sup>4</sup>, M.K. Jha<sup>19a</sup>, H. Ji<sup>172</sup>, W. Ji<sup>81</sup>, J. Jia<sup>148</sup>, Y. Jiang<sup>32b</sup>,  
 M. Jimenez Belenguer<sup>41</sup>, G. Jin<sup>32b</sup>, S. Jin<sup>32a</sup>, O. Jinnouchi<sup>157</sup>, M.D. Joergensen<sup>35</sup>, D. Joffe<sup>39</sup>,  
 L.G. Johansen<sup>13</sup>, M. Johansen<sup>146a,146b</sup>, K.E. Johansson<sup>146a</sup>, P. Johansson<sup>139</sup>, S. Johnert<sup>41</sup>,  
 K.A. Johns<sup>6</sup>, K. Jon-And<sup>146a,146b</sup>, G. Jones<sup>82</sup>, R.W.L. Jones<sup>71</sup>, T.W. Jones<sup>77</sup>, T.J. Jones<sup>73</sup>,  
 O. Jonsson<sup>29</sup>, C. Joram<sup>29</sup>, P.M. Jorge<sup>124a,b</sup>, J. Joseph<sup>14</sup>, T. Jovin<sup>12b</sup>, X. Ju<sup>130</sup>, V. Juranek<sup>125</sup>,  
 P. Jussel<sup>62</sup>, A. Juste Rozas<sup>11</sup>, V.V. Kabachenko<sup>128</sup>, S. Kabana<sup>16</sup>, M. Kaci<sup>167</sup>, A. Kaczmarska<sup>38</sup>,  
 P. Kadlecik<sup>35</sup>, M. Kado<sup>115</sup>, H. Kagan<sup>109</sup>, M. Kagan<sup>57</sup>, S. Kaiser<sup>99</sup>, E. Kajomovitz<sup>152</sup>,  
 S. Kalinin<sup>174</sup>, L.V. Kalinovskaya<sup>65</sup>, S. Kama<sup>39</sup>, N. Kanaya<sup>155</sup>, M. Kaneda<sup>29</sup>, T. Kanno<sup>157</sup>,  
 V.A. Kantserov<sup>96</sup>, J. Kanzaki<sup>66</sup>, B. Kaplan<sup>175</sup>, A. Kapliy<sup>30</sup>, J. Kaplon<sup>29</sup>, D. Kar<sup>43</sup>,  
 M. Karagoz<sup>118</sup>, M. Karnevskiy<sup>41</sup>, K. Karr<sup>5</sup>, V. Kartvelishvili<sup>71</sup>, A.N. Karyukhin<sup>128</sup>, L. Kashif<sup>172</sup>,  
 A. Kasmi<sup>39</sup>, R.D. Kass<sup>109</sup>, A. Kastanas<sup>13</sup>, M. Kataoka<sup>4</sup>, Y. Kataoka<sup>155</sup>, E. Katsoufis<sup>9</sup>, J. Katzy<sup>41</sup>,  
 V. Kaushik<sup>6</sup>, K. Kawagoe<sup>67</sup>, T. Kawamoto<sup>155</sup>, G. Kawamura<sup>81</sup>, M.S. Kayl<sup>105</sup>, V.A. Kazanin<sup>107</sup>,  
 M.Y. Kazarinov<sup>65</sup>, J.R. Keates<sup>82</sup>, R. Keeler<sup>169</sup>, R. Kehoe<sup>39</sup>, M. Keil<sup>54</sup>, G.D. Kekelidze<sup>65</sup>,  
 M. Kelly<sup>82</sup>, J. Kennedy<sup>98</sup>, C.J. Kenney<sup>143</sup>, M. Kenyon<sup>53</sup>, O. Kepka<sup>125</sup>, N. Kerschen<sup>29</sup>,  
 B.P. Kerševan<sup>74</sup>, S. Kersten<sup>174</sup>, K. Kessoku<sup>155</sup>, C. Ketterer<sup>48</sup>, J. Keung<sup>158</sup>, M. Khakzad<sup>28</sup>,  
 F. Khalil-zada<sup>10</sup>, H. Khandanyan<sup>165</sup>, A. Khanov<sup>112</sup>, D. Kharchenko<sup>65</sup>, A. Khodinov<sup>96</sup>,  
 A.G. Kholodenko<sup>128</sup>, A. Khomich<sup>58a</sup>, T.J. Khoo<sup>27</sup>, G. Khoriauli<sup>20</sup>, A. Khoroshilov<sup>174</sup>,  
 N. Khovanskiy<sup>65</sup>, V. Khovanskiy<sup>95</sup>, E. Khramov<sup>65</sup>, J. Khubua<sup>51</sup>, H. Kim<sup>7</sup>, M.S. Kim<sup>2</sup>,  
 P.C. Kim<sup>143</sup>, S.H. Kim<sup>160</sup>, N. Kimura<sup>170</sup>, O. Kind<sup>15</sup>, B.T. King<sup>73</sup>, M. King<sup>67</sup>, R.S.B. King<sup>118</sup>,  
 J. Kirk<sup>129</sup>, G.P. Kirsch<sup>118</sup>, L.E. Kirsch<sup>22</sup>, A.E. Kiryunin<sup>99</sup>, T. Kishimoto<sup>67</sup>, D. Kisielewska<sup>37</sup>,  
 T. Kittelmann<sup>123</sup>, A.M. Kiver<sup>128</sup>, H. Kiyamura<sup>67</sup>, E. Kladiva<sup>144b</sup>, J. Klaiber-Lodewigs<sup>42</sup>,  
 M. Klein<sup>73</sup>, U. Klein<sup>73</sup>, K. Kleinknecht<sup>81</sup>, M. Klemetti<sup>85</sup>, A. Klier<sup>171</sup>, A. Klimentov<sup>24</sup>,  
 R. Klingenberg<sup>42</sup>, E.B. Klinkby<sup>35</sup>, T. Klioutchnikova<sup>29</sup>, P.F. Klok<sup>104</sup>, S. Klous<sup>105</sup>, E.-E. Kluge<sup>58a</sup>,  
 T. Kluge<sup>73</sup>, P. Kluit<sup>105</sup>, S. Kluth<sup>99</sup>, N.S. Knecht<sup>158</sup>, E. Kneringer<sup>62</sup>, J. Knobloch<sup>29</sup>,  
 E.B.F.G. Knoops<sup>83</sup>, A. Knue<sup>54</sup>, B.R. Ko<sup>44</sup>, T. Kobayashi<sup>155</sup>, M. Kobel<sup>43</sup>, M. Kocian<sup>143</sup>,

A. Kocnar<sup>113</sup>, P. Kodys<sup>126</sup>, K. Köneke<sup>29</sup>, A.C. König<sup>104</sup>, S. Koenig<sup>81</sup>, L. Köpke<sup>81</sup>,  
 F. Koetsveld<sup>104</sup>, P. Kovesarki<sup>20</sup>, T. Koffas<sup>29</sup>, E. Koffeman<sup>105</sup>, F. Kohn<sup>54</sup>, Z. Kohout<sup>127</sup>,  
 T. Kohriki<sup>66</sup>, T. Koi<sup>143</sup>, T. Kokott<sup>20</sup>, G.M. Kolachev<sup>107</sup>, H. Kolanoski<sup>15</sup>, V. Kolesnikov<sup>65</sup>,  
 I. Koletsou<sup>89a</sup>, J. Koll<sup>88</sup>, D. Kollar<sup>29</sup>, M. Kollefrath<sup>48</sup>, S.D. Kolya<sup>82</sup>, A.A. Komar<sup>94</sup>,  
 J.R. Komaragiri<sup>142</sup>, Y. Komori<sup>155</sup>, T. Kondo<sup>66</sup>, T. Kono<sup>41,o</sup>, A.I. Kononov<sup>48</sup>, R. Konoplich<sup>108,p</sup>,  
 N. Konstantinidis<sup>77</sup>, A. Kootz<sup>174</sup>, S. Koperny<sup>37</sup>, S.V. Kopikov<sup>128</sup>, K. Korcyl<sup>38</sup>, K. Kordas<sup>154</sup>,  
 V. Koreshev<sup>128</sup>, A. Korn<sup>14</sup>, A. Korol<sup>107</sup>, I. Korolkov<sup>11</sup>, E.V. Korolkova<sup>139</sup>, V.A. Korotkov<sup>128</sup>,  
 O. Kortner<sup>99</sup>, S. Kortner<sup>99</sup>, V.V. Kostyukhin<sup>20</sup>, M.J. Kotamäki<sup>29</sup>, S. Kotov<sup>99</sup>, V.M. Kotov<sup>65</sup>,  
 A. Kotwal<sup>44</sup>, C. Kourkoumelis<sup>8</sup>, V. Kouskoura<sup>154</sup>, A. Koutsman<sup>105</sup>, R. Kowalewski<sup>169</sup>,  
 T.Z. Kowalski<sup>37</sup>, W. Kozanecki<sup>136</sup>, A.S. Kozhin<sup>128</sup>, V. Kral<sup>127</sup>, V.A. Kramarenko<sup>97</sup>,  
 G. Kramberger<sup>74</sup>, M.W. Krasny<sup>78</sup>, A. Krasznahorkay<sup>108</sup>, J. Kraus<sup>88</sup>, A. Kreisel<sup>153</sup>, F. Krejci<sup>127</sup>,  
 J. Kretzschmar<sup>73</sup>, N. Krieger<sup>54</sup>, P. Krieger<sup>158</sup>, K. Kroeninger<sup>54</sup>, H. Kroha<sup>99</sup>, J. Kroll<sup>120</sup>,  
 J. Kroseberg<sup>20</sup>, J. Krstic<sup>12a</sup>, U. Kruchonak<sup>65</sup>, H. Krüger<sup>20</sup>, T. Kruker<sup>16</sup>, Z.V. Krumshteyn<sup>65</sup>,  
 A. Kruth<sup>20</sup>, T. Kubota<sup>86</sup>, S. Kuehn<sup>48</sup>, A. Kugel<sup>58c</sup>, T. Kuhl<sup>41</sup>, D. Kuhn<sup>62</sup>, V. Kukhtin<sup>65</sup>,  
 Y. Kulchitsky<sup>90</sup>, S. Kuleshov<sup>31b</sup>, C. Kummer<sup>98</sup>, M. Kuna<sup>78</sup>, N. Kundu<sup>118</sup>, J. Kunkle<sup>120</sup>,  
 A. Kupco<sup>125</sup>, H. Kurashige<sup>67</sup>, M. Kurata<sup>160</sup>, Y.A. Kurochkin<sup>90</sup>, V. Kus<sup>125</sup>, W. Kuykendall<sup>138</sup>,  
 M. Kuze<sup>157</sup>, P. Kuzhir<sup>91</sup>, O. Kvasnicka<sup>125</sup>, J. Kvita<sup>29</sup>, R. Kwee<sup>15</sup>, A. La Rosa<sup>172</sup>,  
 L. La Rotonda<sup>36a,36b</sup>, L. Labarga<sup>80</sup>, J. Labbe<sup>4</sup>, S. Lablak<sup>135a</sup>, C. Lacasta<sup>167</sup>, F. Lacava<sup>132a,132b</sup>,  
 H. Lacker<sup>15</sup>, D. Lacour<sup>78</sup>, V.R. Lacuesta<sup>167</sup>, E. Ladygin<sup>65</sup>, R. Lafaye<sup>4</sup>, B. Laforge<sup>78</sup>, T. Lagouri<sup>80</sup>,  
 S. Lai<sup>48</sup>, E. Laisne<sup>55</sup>, M. Lamanna<sup>29</sup>, C.L. Lampen<sup>6</sup>, W. Lampl<sup>6</sup>, E. Lancon<sup>136</sup>, U. Landgraf<sup>48</sup>,  
 M.P.J. Landon<sup>75</sup>, H. Landsman<sup>152</sup>, J.L. Lane<sup>82</sup>, C. Lange<sup>41</sup>, A.J. Lankford<sup>163</sup>, F. Lanni<sup>24</sup>,  
 K. Lantzsch<sup>29</sup>, S. Laplace<sup>78</sup>, C. Lapoire<sup>20</sup>, J.F. Laporte<sup>136</sup>, T. Lari<sup>89a</sup>, A.V. Larionov<sup>128</sup>,  
 A. Larner<sup>118</sup>, C. Lasseur<sup>29</sup>, M. Lassnig<sup>29</sup>, P. Laurelli<sup>47</sup>, A. Lavorato<sup>118</sup>, W. Lavrijsen<sup>14</sup>,  
 P. Laycock<sup>73</sup>, A.B. Lazarev<sup>65</sup>, O. Le Dortz<sup>78</sup>, E. Le Guirriec<sup>83</sup>, C. Le Maner<sup>158</sup>,  
 E. Le Menedeu<sup>136</sup>, C. Lebel<sup>93</sup>, T. LeCompte<sup>5</sup>, F. Ledroit-Guillon<sup>55</sup>, H. Lee<sup>105</sup>, J.S.H. Lee<sup>150</sup>,  
 S.C. Lee<sup>151</sup>, L. Lee<sup>175</sup>, M. Lefebvre<sup>169</sup>, M. Legendre<sup>136</sup>, A. Leger<sup>49</sup>, B.C. LeGeyt<sup>120</sup>, F. Legger<sup>98</sup>,  
 C. Leggett<sup>14</sup>, M. Lehmacher<sup>20</sup>, G. Lehmann Miotto<sup>29</sup>, X. Lei<sup>6</sup>, M.A.L. Leite<sup>23b</sup>, R. Leitner<sup>126</sup>,  
 D. Lellouch<sup>171</sup>, J. Lellouch<sup>78</sup>, M. Leltchouk<sup>34</sup>, B. Lemmer<sup>54</sup>, V. Lendermann<sup>58a</sup>, K.J.C. Leney<sup>145b</sup>,  
 T. Lenz<sup>174</sup>, G. Lenzen<sup>174</sup>, B. Lenzi<sup>29</sup>, K. Leonhardt<sup>43</sup>, S. Leontsinis<sup>9</sup>, C. Leroy<sup>93</sup>, J-R. Lessard<sup>169</sup>,  
 J. Lesser<sup>146a</sup>, C.G. Lester<sup>27</sup>, A. Leung Fook Cheong<sup>172</sup>, J. Levêque<sup>4</sup>, D. Levin<sup>87</sup>, L.J. Levinson<sup>171</sup>,  
 M.S. Levitski<sup>128</sup>, M. Lewandowska<sup>21</sup>, A. Lewis<sup>118</sup>, G.H. Lewis<sup>108</sup>, A.M. Leyko<sup>20</sup>, M. Leyton<sup>15</sup>,  
 B. Li<sup>83</sup>, H. Li<sup>172</sup>, S. Li<sup>32b,d</sup>, X. Li<sup>87</sup>, Z. Liang<sup>39</sup>, Z. Liang<sup>118,q</sup>, B. Liberti<sup>133a</sup>, P. Lichard<sup>29</sup>,  
 M. Lichtnecker<sup>98</sup>, K. Lie<sup>165</sup>, W. Liebig<sup>13</sup>, R. Lifshitz<sup>152</sup>, J.N. Lilley<sup>17</sup>, C. Limbach<sup>20</sup>,  
 A. Limosani<sup>86</sup>, M. Limper<sup>63</sup>, S.C. Lin<sup>151,r</sup>, F. Linde<sup>105</sup>, J.T. Linnemann<sup>88</sup>, E. Lipeles<sup>120</sup>,  
 L. Lipinsky<sup>125</sup>, A. Lipniacka<sup>13</sup>, T.M. Liss<sup>165</sup>, D. Lissauer<sup>24</sup>, A. Lister<sup>49</sup>, A.M. Litke<sup>137</sup>, C. Liu<sup>28</sup>,  
 D. Liu<sup>151,s</sup>, H. Liu<sup>87</sup>, J.B. Liu<sup>87</sup>, M. Liu<sup>32b</sup>, S. Liu<sup>2</sup>, Y. Liu<sup>32b</sup>, M. Livan<sup>119a,119b</sup>,  
 S.S.A. Livermore<sup>118</sup>, A. Lleres<sup>55</sup>, J. Llorente Merino<sup>80</sup>, S.L. Lloyd<sup>75</sup>, E. Lobodzinska<sup>41</sup>, P. Loch<sup>6</sup>,  
 W.S. Lockman<sup>137</sup>, S. Lockwitz<sup>175</sup>, T. Loddenkoetter<sup>20</sup>, F.K. Loebinger<sup>82</sup>, A. Loginov<sup>175</sup>,  
 C.W. Loh<sup>168</sup>, T. Lohse<sup>15</sup>, K. Lohwasser<sup>48</sup>, M. Lokajicek<sup>125</sup>, J. Loken<sup>118</sup>, V.P. Lombardo<sup>4</sup>,  
 R.E. Long<sup>71</sup>, L. Lopes<sup>124a,b</sup>, D. Lopez Mateos<sup>57</sup>, M. Losada<sup>162</sup>, P. Loscutoff<sup>14</sup>,  
 F. Lo Sterzo<sup>132a,132b</sup>, M.J. Losty<sup>159a</sup>, X. Lou<sup>40</sup>, A. Lounis<sup>115</sup>, K.F. Loureiro<sup>162</sup>, J. Love<sup>21</sup>,  
 P.A. Love<sup>71</sup>, A.J. Lowe<sup>143,f</sup>, F. Lu<sup>32a</sup>, H.J. Lubatti<sup>138</sup>, C. Luci<sup>132a,132b</sup>, A. Lucotte<sup>55</sup>,  
 A. Ludwig<sup>43</sup>, D. Ludwig<sup>41</sup>, I. Ludwig<sup>48</sup>, J. Ludwig<sup>48</sup>, F. Luehring<sup>61</sup>, G. Luijkx<sup>105</sup>, D. Lumb<sup>48</sup>,  
 L. Luminari<sup>132a</sup>, E. Lund<sup>117</sup>, B. Lund-Jensen<sup>147</sup>, B. Lundberg<sup>79</sup>, J. Lundberg<sup>146a,146b</sup>,  
 J. Lundquist<sup>35</sup>, M. Lungwitz<sup>81</sup>, A. Lupi<sup>122a,122b</sup>, G. Lutz<sup>99</sup>, D. Lynn<sup>24</sup>, J. Lys<sup>14</sup>, E. Lytken<sup>79</sup>,  
 H. Ma<sup>24</sup>, L.L. Ma<sup>172</sup>, J.A. Macana Goia<sup>93</sup>, G. Maccarrone<sup>47</sup>, A. Macchiolo<sup>99</sup>, B. Maček<sup>74</sup>,  
 J. Machado Miguens<sup>124a</sup>, D. Macina<sup>49</sup>, R. Mackeprang<sup>35</sup>, R.J. Madaras<sup>14</sup>, W.F. Mader<sup>43</sup>,  
 R. Maenner<sup>58c</sup>, T. Maeno<sup>24</sup>, P. Mättig<sup>174</sup>, S. Mättig<sup>41</sup>, P.J. Magalhaes Martins<sup>124a,h</sup>,

L. Magnoni<sup>29</sup>, E. Magradze<sup>54</sup>, Y. Mahalalel<sup>153</sup>, K. Mahboubi<sup>48</sup>, G. Mahout<sup>17</sup>, C. Maiani<sup>132a,132b</sup>, C. Maidantchik<sup>23a</sup>, A. Maio<sup>124a,b</sup>, S. Majewski<sup>24</sup>, Y. Makida<sup>66</sup>, N. Makovec<sup>115</sup>, P. Mal<sup>6</sup>, Pa. Malecki<sup>38</sup>, P. Malecki<sup>38</sup>, V.P. Maleev<sup>121</sup>, F. Malek<sup>55</sup>, U. Mallik<sup>63</sup>, D. Malon<sup>5</sup>, S. Maltezos<sup>9</sup>, V. Malyshev<sup>107</sup>, S. Malyukov<sup>29</sup>, R. Mameghani<sup>98</sup>, J. Mamuzic<sup>12b</sup>, A. Manabe<sup>66</sup>, L. Mandelli<sup>89a</sup>, I. Mandić<sup>74</sup>, R. Mandrysch<sup>15</sup>, J. Maneira<sup>124a</sup>, P.S. Mangedard<sup>88</sup>, I.D. Manjavidze<sup>65</sup>, A. Mann<sup>54</sup>, P.M. Manning<sup>137</sup>, A. Manousakis-Katsikakis<sup>8</sup>, B. Mansoulie<sup>136</sup>, A. Manz<sup>99</sup>, A. Mapelli<sup>29</sup>, L. Mapelli<sup>29</sup>, L. March<sup>80</sup>, J.F. Marchand<sup>29</sup>, F. Marchese<sup>133a,133b</sup>, G. Marchiori<sup>78</sup>, M. Marcisovsky<sup>125</sup>, A. Marin<sup>21,\*</sup>, C.P. Marino<sup>61</sup>, F. Marroquim<sup>23a</sup>, R. Marshall<sup>82</sup>, Z. Marshall<sup>29</sup>, F.K. Martens<sup>158</sup>, S. Marti-Garcia<sup>167</sup>, A.J. Martin<sup>175</sup>, B. Martin<sup>29</sup>, B. Martin<sup>88</sup>, F.F. Martin<sup>120</sup>, J.P. Martin<sup>93</sup>, Ph. Martin<sup>55</sup>, T.A. Martin<sup>17</sup>, B. Martin dit Latour<sup>49</sup>, S. Martin-Haugh<sup>149</sup>, M. Martinez<sup>11</sup>, V. Martinez Outschoorn<sup>57</sup>, A.C. Martyniuk<sup>82</sup>, M. Marx<sup>82</sup>, F. Marzano<sup>132a</sup>, A. Marzin<sup>111</sup>, L. Masetti<sup>81</sup>, T. Mashimo<sup>155</sup>, R. Mashinistov<sup>94</sup>, J. Masik<sup>82</sup>, A.L. Maslennikov<sup>107</sup>, I. Massa<sup>19a,19b</sup>, G. Massaro<sup>105</sup>, N. Massol<sup>4</sup>, P. Mastrandrea<sup>132a,132b</sup>, A. Mastroberardino<sup>36a,36b</sup>, T. Masubuchi<sup>155</sup>, M. Mathes<sup>20</sup>, P. Matricon<sup>115</sup>, H. Matsumoto<sup>155</sup>, H. Matsunaga<sup>155</sup>, T. Matsushita<sup>67</sup>, C. Mattravers<sup>118,c</sup>, J.M. Maugain<sup>29</sup>, S.J. Maxfield<sup>73</sup>, D.A. Maximov<sup>107</sup>, E.N. May<sup>5</sup>, A. Mayne<sup>139</sup>, R. Mazini<sup>151</sup>, M. Mazur<sup>20</sup>, M. Mazzanti<sup>89a</sup>, E. Mazzoni<sup>122a,122b</sup>, S.P. Mc Kee<sup>87</sup>, A. McCarn<sup>165</sup>, R.L. McCarthy<sup>148</sup>, T.G. McCarthy<sup>28</sup>, N.A. McCubbin<sup>129</sup>, K.W. McFarlane<sup>56</sup>, J.A. Mcfayden<sup>139</sup>, H. McGlone<sup>53</sup>, G. Mchedlidze<sup>51</sup>, R.A. McLaren<sup>29</sup>, T. McLaughlan<sup>17</sup>, S.J. McMahan<sup>129</sup>, R.A. McPherson<sup>169,j</sup>, A. Meade<sup>84</sup>, J. Mechnich<sup>105</sup>, M. Mechtel<sup>174</sup>, M. Medinnis<sup>41</sup>, R. Meera-Lebbai<sup>111</sup>, T. Meguro<sup>116</sup>, R. Mehdiyev<sup>93</sup>, S. Mehlhase<sup>35</sup>, A. Mehta<sup>73</sup>, K. Meier<sup>58a</sup>, J. Meinhardt<sup>48</sup>, B. Meirose<sup>79</sup>, C. Melachrinou<sup>30</sup>, B.R. Mellado Garcia<sup>172</sup>, L. Mendoza Navas<sup>162</sup>, Z. Meng<sup>151,s</sup>, A. Mengarelli<sup>19a,19b</sup>, S. Menke<sup>99</sup>, C. Menot<sup>29</sup>, E. Meoni<sup>11</sup>, K.M. Mercurio<sup>57</sup>, P. Mermod<sup>118</sup>, L. Merola<sup>102a,102b</sup>, C. Meroni<sup>89a</sup>, F.S. Merritt<sup>30</sup>, A. Messina<sup>29</sup>, J. Metcalfe<sup>103</sup>, A.S. Mete<sup>64</sup>, S. Meuser<sup>20</sup>, C. Meyer<sup>81</sup>, J-P. Meyer<sup>136</sup>, J. Meyer<sup>173</sup>, J. Meyer<sup>54</sup>, T.C. Meyer<sup>29</sup>, W.T. Meyer<sup>64</sup>, J. Miao<sup>32d</sup>, S. Michal<sup>29</sup>, L. Micu<sup>25a</sup>, R.P. Middleton<sup>129</sup>, P. Miele<sup>29</sup>, S. Migas<sup>73</sup>, L. Mijović<sup>41</sup>, G. Mikenberg<sup>171</sup>, M. Mikestikova<sup>125</sup>, M. Mikuz<sup>74</sup>, D.W. Miller<sup>143</sup>, R.J. Miller<sup>88</sup>, W.J. Mills<sup>168</sup>, C. Mills<sup>57</sup>, A. Milov<sup>171</sup>, D.A. Milstead<sup>146a,146b</sup>, D. Milstein<sup>171</sup>, A.A. Minaenko<sup>128</sup>, M. Miñano<sup>167</sup>, I.A. Minashvili<sup>65</sup>, A.I. Mincer<sup>108</sup>, B. Mindur<sup>37</sup>, M. Mineev<sup>65</sup>, Y. Ming<sup>130</sup>, L.M. Mir<sup>11</sup>, G. Mirabelli<sup>132a</sup>, L. Miralles Verge<sup>11</sup>, A. Misiejuk<sup>76</sup>, J. Mitrevski<sup>137</sup>, G.Y. Mitrofanov<sup>128</sup>, V.A. Mitsou<sup>167</sup>, S. Mitsui<sup>66</sup>, P.S. Miyagawa<sup>82</sup>, K. Miyazaki<sup>67</sup>, J.U. Mjörnmark<sup>79</sup>, T. Moe<sup>146a,146b</sup>, P. Mockett<sup>138</sup>, S. Moed<sup>57</sup>, V. Moeller<sup>27</sup>, K. Mönig<sup>41</sup>, N. Möser<sup>20</sup>, S. Mohapatra<sup>148</sup>, W. Mohr<sup>48</sup>, S. Mohrdieck-Möck<sup>99</sup>, A.M. Moisseev<sup>128,\*</sup>, R. Moles-Valls<sup>167</sup>, J. Molina-Perez<sup>29</sup>, J. Monk<sup>77</sup>, E. Monnier<sup>83</sup>, S. Montesano<sup>89a,89b</sup>, F. Monticelli<sup>70</sup>, S. Monzani<sup>19a,19b</sup>, R.W. Moore<sup>2</sup>, G.F. Moorhead<sup>86</sup>, C. Mora Herrera<sup>49</sup>, A. Moraes<sup>53</sup>, A. Morais<sup>124a,b</sup>, N. Morange<sup>136</sup>, J. Morel<sup>54</sup>, G. Morello<sup>36a,36b</sup>, D. Moreno<sup>81</sup>, M. Moreno Llácer<sup>167</sup>, P. Morettini<sup>50a</sup>, M. Morii<sup>57</sup>, J. Morin<sup>75</sup>, Y. Morita<sup>66</sup>, A.K. Morley<sup>29</sup>, G. Mornacchi<sup>29</sup>, M-C. Morone<sup>49</sup>, S.V. Morozov<sup>96</sup>, J.D. Morris<sup>75</sup>, L. Morvaj<sup>101</sup>, H.G. Moser<sup>99</sup>, M. Mosidze<sup>51</sup>, J. Moss<sup>109</sup>, R. Mount<sup>143</sup>, E. Mountricha<sup>136</sup>, S.V. Mouraviev<sup>94</sup>, E.J.W. Moyse<sup>84</sup>, M. Mudrinic<sup>12b</sup>, F. Mueller<sup>58a</sup>, J. Mueller<sup>123</sup>, K. Mueller<sup>20</sup>, T.A. Müller<sup>98</sup>, D. Muenstermann<sup>29</sup>, A. Muir<sup>168</sup>, Y. Munwes<sup>153</sup>, K. Murakami<sup>66</sup>, W.J. Murray<sup>129</sup>, I. Mussche<sup>105</sup>, E. Musto<sup>102a,102b</sup>, A.G. Myagkov<sup>128</sup>, M. Myska<sup>125</sup>, J. Nadal<sup>11</sup>, K. Nagai<sup>160</sup>, K. Nagano<sup>66</sup>, Y. Nagasaka<sup>60</sup>, A.M. Nairz<sup>29</sup>, Y. Nakahama<sup>29</sup>, K. Nakamura<sup>155</sup>, I. Nakano<sup>110</sup>, G. Nanava<sup>20</sup>, A. Napier<sup>161</sup>, M. Nash<sup>77,c</sup>, N.R. Nasion<sup>21</sup>, T. Nattermann<sup>20</sup>, T. Naumann<sup>41</sup>, G. Navarro<sup>162</sup>, H.A. Neal<sup>87</sup>, E. Nebot<sup>80</sup>, P.Yu. Nechaeva<sup>94</sup>, A. Negri<sup>119a,119b</sup>, G. Negri<sup>29</sup>, S. Nektarijevic<sup>49</sup>, S. Nelson<sup>143</sup>, T.K. Nelson<sup>143</sup>, S. Nemecek<sup>125</sup>, P. Nemethy<sup>108</sup>, A.A. Nepomuceno<sup>23a</sup>, M. Nessi<sup>29,t</sup>, S.Y. Nesterov<sup>121</sup>, M.S. Neubauer<sup>165</sup>, A. Neusiedl<sup>81</sup>, R.M. Neves<sup>108</sup>, P. Nevski<sup>24</sup>, P.R. Newman<sup>17</sup>, V. Nguyen Thi Hong<sup>136</sup>, R.B. Nickerson<sup>118</sup>, R. Nicolaidou<sup>136</sup>, L. Nicolas<sup>139</sup>, B. Nicquevert<sup>29</sup>, F. Niedercorn<sup>115</sup>, J. Nielsen<sup>137</sup>, T. Niinikoski<sup>29</sup>, N. Nikiforou<sup>34</sup>, A. Nikiforov<sup>15</sup>, V. Nikolaenko<sup>128</sup>,

K. Nikolaev<sup>65</sup>, I. Nikolic-Audit<sup>78</sup>, K. Nikolics<sup>49</sup>, K. Nikolopoulos<sup>24</sup>, H. Nilsen<sup>48</sup>, P. Nilsson<sup>7</sup>,  
 Y. Ninomiya<sup>155</sup>, A. Nisati<sup>132a</sup>, T. Nishiyama<sup>67</sup>, R. Nisius<sup>99</sup>, L. Nodulman<sup>5</sup>, M. Nomachi<sup>116</sup>,  
 I. Nomidis<sup>154</sup>, M. Nordberg<sup>29</sup>, B. Nordkvist<sup>146a,146b</sup>, P.R. Norton<sup>129</sup>, J. Novakova<sup>126</sup>,  
 M. Nozaki<sup>66</sup>, M. Nožička<sup>41</sup>, L. Nozka<sup>113</sup>, I.M. Nugent<sup>159a</sup>, A.-E. Nuncio-Quiroz<sup>20</sup>,  
 G. Nunes Hanninger<sup>86</sup>, T. Nunnemann<sup>98</sup>, E. Nurse<sup>77</sup>, T. Nyman<sup>29</sup>, B.J. O'Brien<sup>45</sup>,  
 S.W. O'Neale<sup>17,\*</sup>, D.C. O'Neil<sup>142</sup>, V. O'Shea<sup>53</sup>, F.G. Oakham<sup>28,e</sup>, H. Oberlack<sup>99</sup>, J. Ocariz<sup>78</sup>,  
 A. Ochi<sup>67</sup>, S. Oda<sup>155</sup>, S. Odaka<sup>66</sup>, J. Odier<sup>83</sup>, H. Ogren<sup>61</sup>, A. Oh<sup>82</sup>, S.H. Oh<sup>44</sup>, C.C. Ohm<sup>146a,146b</sup>,  
 T. Ohshima<sup>101</sup>, H. Ohshita<sup>140</sup>, T.K. Ohska<sup>66</sup>, T. Ohsugi<sup>59</sup>, S. Okada<sup>67</sup>, H. Okawa<sup>163</sup>,  
 Y. Okumura<sup>101</sup>, T. Okuyama<sup>155</sup>, M. Olcese<sup>50a</sup>, A.G. Olchevski<sup>65</sup>, M. Oliveira<sup>124a,h</sup>,  
 D. Oliveira Damazio<sup>24</sup>, E. Oliver Garcia<sup>167</sup>, D. Olivito<sup>120</sup>, A. Olszewski<sup>38</sup>, J. Olszowska<sup>38</sup>,  
 C. Omachi<sup>67</sup>, A. Onofre<sup>124a,u</sup>, P.U.E. Onyisi<sup>30</sup>, C.J. Oram<sup>159a</sup>, M.J. Oreglia<sup>30</sup>, Y. Oren<sup>153</sup>,  
 D. Orestano<sup>134a,134b</sup>, I. Orlov<sup>107</sup>, C. Oropeza Barrera<sup>53</sup>, R.S. Orr<sup>158</sup>, B. Osculati<sup>50a,50b</sup>,  
 R. Ospanov<sup>120</sup>, C. Osuna<sup>11</sup>, G. Otero y Garzon<sup>26</sup>, J.P. Ottersbach<sup>105</sup>, M. Ouchrif<sup>135d</sup>,  
 F. Ould-Saada<sup>117</sup>, A. Ouraou<sup>136</sup>, Q. Ouyang<sup>32a</sup>, M. Owen<sup>82</sup>, S. Owen<sup>139</sup>, V.E. Ozcan<sup>18a</sup>,  
 N. Ozturk<sup>7</sup>, A. Pacheco Pages<sup>11</sup>, C. Padilla Aranda<sup>11</sup>, S. Pagan Griso<sup>14</sup>, E. Paganis<sup>139</sup>,  
 F. Paige<sup>24</sup>, K. Pajchel<sup>117</sup>, C.P. Paleari<sup>6</sup>, S. Palestini<sup>29</sup>, D. Pallin<sup>33</sup>, A. Palma<sup>124a,b</sup>, J.D. Palmer<sup>17</sup>,  
 Y.B. Pan<sup>172</sup>, E. Panagiotopoulou<sup>9</sup>, B. Panes<sup>31a</sup>, N. Panikashvili<sup>87</sup>, S. Panitkin<sup>24</sup>, D. Pantea<sup>25a</sup>,  
 M. Panuskova<sup>125</sup>, V. Paolone<sup>123</sup>, A. Papadelis<sup>146a</sup>, Th.D. Papadopoulou<sup>9</sup>, A. Paramonov<sup>5</sup>,  
 W. Park<sup>24,v</sup>, M.A. Parker<sup>27</sup>, F. Parodi<sup>50a,50b</sup>, J.A. Parsons<sup>34</sup>, U. Parzefall<sup>48</sup>, E. Pasqualucci<sup>132a</sup>,  
 A. Passeri<sup>134a</sup>, F. Pastore<sup>134a,134b</sup>, Fr. Pastore<sup>29</sup>, G. Pásztor<sup>49,w</sup>, S. Pataraiia<sup>172</sup>, N. Patel<sup>150</sup>,  
 J.R. Pater<sup>82</sup>, S. Patricelli<sup>102a,102b</sup>, T. Pauly<sup>29</sup>, M. Pecsny<sup>144a</sup>, M.I. Pedraza Morales<sup>172</sup>,  
 S.V. Peleganchuk<sup>107</sup>, H. Peng<sup>172</sup>, R. Pengo<sup>29</sup>, A. Penson<sup>34</sup>, J. Penwell<sup>61</sup>, M. Perantoni<sup>23a</sup>,  
 K. Perez<sup>34,x</sup>, T. Perez Cavalcanti<sup>41</sup>, E. Perez Codina<sup>11</sup>, M.T. Pérez García-Estañ<sup>167</sup>,  
 V. Perez Reale<sup>34</sup>, L. Perini<sup>89a,89b</sup>, H. Pernegger<sup>29</sup>, R. Perrino<sup>72a</sup>, P. Perrodo<sup>4</sup>, S. Perseme<sup>3a</sup>,  
 V.D. Peshekhonov<sup>65</sup>, O. Peters<sup>105</sup>, B.A. Petersen<sup>29</sup>, J. Petersen<sup>29</sup>, T.C. Petersen<sup>35</sup>, E. Petit<sup>83</sup>,  
 A. Petridis<sup>154</sup>, C. Petridou<sup>154</sup>, E. Petrolo<sup>132a</sup>, F. Petrucci<sup>134a,134b</sup>, D. Petschull<sup>41</sup>, M. Petteni<sup>142</sup>,  
 R. Pezoa<sup>31b</sup>, A. Phan<sup>86</sup>, A.W. Phillips<sup>27</sup>, P.W. Phillips<sup>129</sup>, G. Piacquadio<sup>29</sup>, E. Piccaro<sup>75</sup>,  
 M. Piccinini<sup>19a,19b</sup>, A. Pickford<sup>53</sup>, S.M. Piec<sup>41</sup>, R. Piegaiia<sup>26</sup>, J.E. Pilcher<sup>30</sup>, A.D. Pilkington<sup>82</sup>,  
 J. Pina<sup>124a,b</sup>, M. Pinamonti<sup>164a,164c</sup>, A. Pinder<sup>118</sup>, J.L. Pinfold<sup>2</sup>, J. Ping<sup>32c</sup>, B. Pinto<sup>124a,b</sup>,  
 O. Pirotte<sup>29</sup>, C. Pizio<sup>89a,89b</sup>, R. Placakyte<sup>41</sup>, M. Plamondon<sup>169</sup>, W.G. Plano<sup>82</sup>, M.-A. Pleier<sup>24</sup>,  
 A.V. Pleskach<sup>128</sup>, A. Poblaguev<sup>24</sup>, S. Poddar<sup>58a</sup>, F. Podlyski<sup>33</sup>, L. Poggioli<sup>115</sup>, T. Poghosyan<sup>20</sup>,  
 M. Pohl<sup>49</sup>, F. Polci<sup>55</sup>, G. Polesello<sup>119a</sup>, A. Policicchio<sup>138</sup>, A. Polini<sup>19a</sup>, J. Poll<sup>75</sup>,  
 V. Polychronakos<sup>24</sup>, D.M. Pomarede<sup>136</sup>, D. Pomeroy<sup>22</sup>, K. Pommès<sup>29</sup>, L. Pontecorvo<sup>132a</sup>,  
 B.G. Pope<sup>88</sup>, G.A. Popeneciu<sup>25a</sup>, D.S. Popovic<sup>12a</sup>, A. Poppleton<sup>29</sup>, X. Portell Bueso<sup>29</sup>,  
 R. Porter<sup>163</sup>, C. Posch<sup>21</sup>, G.E. Pospelov<sup>99</sup>, S. Pospisil<sup>127</sup>, I.N. Potrap<sup>99</sup>, C.J. Potter<sup>149</sup>,  
 C.T. Potter<sup>114</sup>, G. Poulard<sup>29</sup>, J. Poveda<sup>172</sup>, R. Prabhu<sup>77</sup>, P. Pralavorio<sup>83</sup>, S. Prasad<sup>57</sup>,  
 R. Pravahan<sup>7</sup>, S. Prell<sup>64</sup>, K. Pretzl<sup>16</sup>, L. Pribyl<sup>29</sup>, D. Price<sup>61</sup>, L.E. Price<sup>5</sup>, M.J. Price<sup>29</sup>,  
 P.M. Prichard<sup>73</sup>, D. Prieur<sup>123</sup>, M. Primavera<sup>72a</sup>, K. Prokofiev<sup>108</sup>, F. Prokoshin<sup>31b</sup>,  
 S. Protopopescu<sup>24</sup>, J. Proudfoot<sup>5</sup>, X. Prudent<sup>43</sup>, H. Przysiezniak<sup>4</sup>, S. Psoroulas<sup>20</sup>, E. Ptacek<sup>114</sup>,  
 J. Purdham<sup>87</sup>, M. Purohit<sup>24,v</sup>, P. Puzo<sup>115</sup>, Y. Pylypchenko<sup>117</sup>, J. Qian<sup>87</sup>, Z. Qian<sup>83</sup>, Z. Qin<sup>41</sup>,  
 A. Quadt<sup>54</sup>, D.R. Quarrie<sup>14</sup>, W.B. Quayle<sup>172</sup>, F. Quinonez<sup>31a</sup>, M. Raas<sup>104</sup>, V. Radescu<sup>58b</sup>,  
 B. Radics<sup>20</sup>, T. Rador<sup>18a</sup>, F. Ragusa<sup>89a,89b</sup>, G. Rahal<sup>177</sup>, A.M. Rahimi<sup>109</sup>, D. Rahm<sup>24</sup>,  
 S. Rajagopalan<sup>24</sup>, M. Rammensee<sup>48</sup>, M. Rammes<sup>141</sup>, M. Ramstedt<sup>146a,146b</sup>, A.S. Randle-Conde<sup>39</sup>,  
 K. Randrianarivony<sup>28</sup>, P.N. Ratoff<sup>71</sup>, F. Rauscher<sup>98</sup>, E. Rauter<sup>99</sup>, M. Raymond<sup>29</sup>, A.L. Read<sup>117</sup>,  
 D.M. Rebuzzi<sup>119a,119b</sup>, A. Redelbach<sup>173</sup>, G. Redlinger<sup>24</sup>, R. Reece<sup>120</sup>, K. Reeves<sup>40</sup>, A. Reichold<sup>105</sup>,  
 E. Reinherz-Aronis<sup>153</sup>, A. Reinsch<sup>114</sup>, I. Reisinger<sup>42</sup>, D. Reljic<sup>12a</sup>, C. Rembser<sup>29</sup>, Z.L. Ren<sup>151</sup>,  
 A. Renaud<sup>115</sup>, P. Renkel<sup>39</sup>, M. Rescigno<sup>132a</sup>, S. Resconi<sup>89a</sup>, B. Resende<sup>136</sup>, P. Reznicek<sup>98</sup>,  
 R. Rezvani<sup>158</sup>, A. Richards<sup>77</sup>, R. Richter<sup>99</sup>, E. Richter-Was<sup>38,y</sup>, M. Ridel<sup>78</sup>, S. Rieke<sup>81</sup>,

M. Rijpstra<sup>105</sup>, M. Rijssenbeek<sup>148</sup>, A. Rimoldi<sup>119a,119b</sup>, L. Rinaldi<sup>19a</sup>, R.R. Rios<sup>39</sup>, I. Riu<sup>11</sup>,  
 G. Rivoltella<sup>89a,89b</sup>, F. Rizatdinova<sup>112</sup>, E. Rizvi<sup>75</sup>, S.H. Robertson<sup>85,j</sup>, A. Robichaud-Veronneau<sup>49</sup>,  
 D. Robinson<sup>27</sup>, J.E.M. Robinson<sup>77</sup>, M. Robinson<sup>114</sup>, A. Robson<sup>53</sup>, J.G. Rocha de Lima<sup>106</sup>,  
 C. Roda<sup>122a,122b</sup>, D. Roda Dos Santos<sup>29</sup>, S. Rodier<sup>80</sup>, D. Rodriguez<sup>162</sup>, A. Roe<sup>54</sup>, S. Roe<sup>29</sup>,  
 O. Røhne<sup>117</sup>, V. Rojo<sup>1</sup>, S. Rolli<sup>161</sup>, A. Romaniouk<sup>96</sup>, V.M. Romanov<sup>65</sup>, G. Romeo<sup>26</sup>,  
 D. Romero Maltrana<sup>31a</sup>, L. Roos<sup>78</sup>, E. Ros<sup>167</sup>, S. Rosati<sup>132a,132b</sup>, K. Rosbach<sup>49</sup>, A. Rose<sup>149</sup>,  
 M. Rose<sup>76</sup>, G.A. Rosenbaum<sup>158</sup>, E.I. Rosenberg<sup>64</sup>, P.L. Rosendahl<sup>13</sup>, L. Rosselet<sup>49</sup>, V. Rossetti<sup>11</sup>,  
 E. Rossi<sup>102a,102b</sup>, L.P. Rossi<sup>50a</sup>, L. Rossi<sup>89a,89b</sup>, M. Rotaru<sup>25a</sup>, I. Roth<sup>171</sup>, J. Rothberg<sup>138</sup>,  
 D. Rousseau<sup>115</sup>, C.R. Royon<sup>136</sup>, A. Rozanov<sup>83</sup>, Y. Rozen<sup>152</sup>, X. Ruan<sup>115</sup>, I. Rubinskiy<sup>41</sup>,  
 B. Ruckert<sup>98</sup>, N. Ruckstuhl<sup>105</sup>, V.I. Rud<sup>97</sup>, C. Rudolph<sup>43</sup>, G. Rudolph<sup>62</sup>, F. Rühr<sup>6</sup>,  
 F. Ruggieri<sup>134a,134b</sup>, A. Ruiz-Martinez<sup>64</sup>, E. Rulikowska-Zarebska<sup>37</sup>, V. Rumiantsev<sup>91,\*</sup>,  
 L. Rumyantsev<sup>65</sup>, K. Runge<sup>48</sup>, O. Runolfsson<sup>20</sup>, Z. Rurikova<sup>48</sup>, N.A. Rusakovich<sup>65</sup>, D.R. Rust<sup>61</sup>,  
 J.P. Rutherford<sup>6</sup>, C. Ruwiedel<sup>14</sup>, P. Ruzicka<sup>125</sup>, Y.F. Ryabov<sup>121</sup>, V. Ryadovikov<sup>128</sup>, P. Ryan<sup>88</sup>,  
 M. Rybar<sup>126</sup>, G. Rybkin<sup>115</sup>, N.C. Ryder<sup>118</sup>, S. Rzaeva<sup>10</sup>, A.F. Saavedra<sup>150</sup>, I. Sadeh<sup>153</sup>,  
 H.F.W. Sadrozinski<sup>137</sup>, R. Sadykov<sup>65</sup>, F. Safai Tehrani<sup>132a,132b</sup>, H. Sakamoto<sup>155</sup>, G. Salamanna<sup>75</sup>,  
 A. Salamon<sup>133a</sup>, M. Saleem<sup>111</sup>, D. Salihagic<sup>99</sup>, A. Salknikov<sup>143</sup>, J. Salt<sup>167</sup>,  
 B.M. Salvachua Ferrando<sup>5</sup>, D. Salvatore<sup>36a,36b</sup>, F. Salvatore<sup>149</sup>, A. Salvucci<sup>104</sup>, A. Salzburger<sup>29</sup>,  
 D. Sampsonidis<sup>154</sup>, B.H. Samset<sup>117</sup>, A. Sanchez<sup>102a,102b</sup>, H. Sandaker<sup>13</sup>, H.G. Sander<sup>81</sup>,  
 M.P. Sanders<sup>98</sup>, M. Sandhoff<sup>174</sup>, T. Sandoval<sup>27</sup>, C. Sandoval<sup>162</sup>, R. Sandstroem<sup>99</sup>, S. Sandvoss<sup>174</sup>,  
 D.P.C. Sankey<sup>129</sup>, A. Sansoni<sup>47</sup>, C. Santamarina Rios<sup>85</sup>, C. Santoni<sup>33</sup>, R. Santonico<sup>133a,133b</sup>,  
 H. Santos<sup>124a</sup>, J.G. Saraiva<sup>124a,b</sup>, T. Sarangi<sup>172</sup>, E. Sarkisyan-Grinbaum<sup>7</sup>, F. Sarri<sup>122a,122b</sup>,  
 G. Sartisohn<sup>174</sup>, O. Sasaki<sup>66</sup>, T. Sasaki<sup>66</sup>, N. Sasao<sup>68</sup>, I. Satsounkevitch<sup>90</sup>, G. Sauvage<sup>4</sup>,  
 E. Sauvan<sup>4</sup>, J.B. Sauvan<sup>115</sup>, P. Savard<sup>158,e</sup>, V. Savinov<sup>123</sup>, D.O. Savu<sup>29</sup>, P. Savva<sup>9</sup>, L. Sawyer<sup>24,l</sup>,  
 D.H. Saxon<sup>53</sup>, L.P. SAYS<sup>33</sup>, C. Sbarra<sup>19a,19b</sup>, A. Sbrizzi<sup>19a,19b</sup>, O. Scallion<sup>93</sup>, D.A. Scannicchio<sup>163</sup>,  
 J. Schaarschmidt<sup>115</sup>, P. Schacht<sup>99</sup>, U. Schäfer<sup>81</sup>, S. Schaepe<sup>20</sup>, S. Schaezel<sup>58b</sup>, A.C. Schaffer<sup>115</sup>,  
 D. Schaile<sup>98</sup>, R.D. Schamberger<sup>148</sup>, A.G. Schamov<sup>107</sup>, V. Scharf<sup>58a</sup>, V.A. Schegelsky<sup>121</sup>,  
 D. Scheirich<sup>87</sup>, M. Schernau<sup>163</sup>, M.I. Scherzer<sup>14</sup>, C. Schiavi<sup>50a,50b</sup>, J. Schieck<sup>98</sup>, M. Schioppa<sup>36a,36b</sup>,  
 S. Schlenker<sup>29</sup>, J.L. Schlereth<sup>5</sup>, E. Schmidt<sup>48</sup>, K. Schmieden<sup>20</sup>, C. Schmitt<sup>81</sup>, S. Schmitt<sup>58b</sup>,  
 M. Schmitz<sup>20</sup>, A. Schöning<sup>58b</sup>, M. Schott<sup>29</sup>, D. Schouten<sup>142</sup>, J. Schovancova<sup>125</sup>, M. Schram<sup>85</sup>,  
 C. Schroeder<sup>81</sup>, N. Schroer<sup>58c</sup>, S. Schuh<sup>29</sup>, G. Schuler<sup>29</sup>, J. Schultes<sup>174</sup>, H.-C. Schultz-Coulon<sup>58a</sup>,  
 H. Schulz<sup>15</sup>, J.W. Schumacher<sup>20</sup>, M. Schumacher<sup>48</sup>, B.A. Schumm<sup>137</sup>, Ph. Schune<sup>136</sup>,  
 C. Schwanenberger<sup>82</sup>, A. Schwartzman<sup>143</sup>, Ph. Schwemling<sup>78</sup>, R. Schwienhorst<sup>88</sup>, R. Schwierz<sup>43</sup>,  
 J. Schwindling<sup>136</sup>, T. Schwindt<sup>20</sup>, W.G. Scott<sup>129</sup>, J. Searcy<sup>114</sup>, E. Sedykh<sup>121</sup>, E. Segura<sup>11</sup>,  
 S.C. Seidel<sup>103</sup>, A. Seiden<sup>137</sup>, F. Seifert<sup>43</sup>, J.M. Seixas<sup>23a</sup>, G. Sekhniadze<sup>102a</sup>, D.M. Seliverstov<sup>121</sup>,  
 B. Sellden<sup>146a</sup>, G. Sellers<sup>73</sup>, M. Seman<sup>144b</sup>, N. Semprini-Cesari<sup>19a,19b</sup>, C. Serfon<sup>98</sup>, L. Serin<sup>115</sup>,  
 R. Seuster<sup>99</sup>, H. Severini<sup>111</sup>, M.E. Seviar<sup>86</sup>, A. Sfyrla<sup>29</sup>, E. Shabalina<sup>54</sup>, M. Shamim<sup>114</sup>,  
 L.Y. Shan<sup>32a</sup>, J.T. Shank<sup>21</sup>, Q.T. Shao<sup>86</sup>, M. Shapiro<sup>14</sup>, P.B. Shatalov<sup>95</sup>, L. Shaver<sup>6</sup>, C. Shaw<sup>53</sup>,  
 K. Shaw<sup>164a,164c</sup>, D. Sherman<sup>175</sup>, P. Sherwood<sup>77</sup>, A. Shibata<sup>108</sup>, H. Shichi<sup>101</sup>, S. Shimizu<sup>29</sup>,  
 M. Shimojima<sup>100</sup>, T. Shin<sup>56</sup>, A. Shmeleva<sup>94</sup>, M.J. Shochet<sup>30</sup>, D. Short<sup>118</sup>, M.A. Shupe<sup>6</sup>,  
 P. Sicho<sup>125</sup>, A. Sidoti<sup>132a,132b</sup>, A. Siebel<sup>174</sup>, F. Siegert<sup>48</sup>, J. Siegrist<sup>14</sup>, Dj. Sijacki<sup>12a</sup>, O. Silbert<sup>171</sup>,  
 J. Silva<sup>124a,b</sup>, Y. Silver<sup>153</sup>, D. Silverstein<sup>143</sup>, S.B. Silverstein<sup>146a</sup>, V. Simak<sup>127</sup>, O. Simard<sup>136</sup>,  
 Lj. Simic<sup>12a</sup>, S. Simion<sup>115</sup>, B. Simmons<sup>77</sup>, M. Simonyan<sup>35</sup>, P. Sinervo<sup>158</sup>, N.B. Sinev<sup>114</sup>,  
 V. Sipica<sup>141</sup>, G. Siragusa<sup>173</sup>, A. Sircar<sup>24</sup>, A.N. Sisakyan<sup>65</sup>, S.Yu. Sivoklov<sup>97</sup>, J. Sjölin<sup>146a,146b</sup>,  
 T.B. Sjurson<sup>13</sup>, L.A. Skinnari<sup>14</sup>, K. Skovpen<sup>107</sup>, P. Skubic<sup>111</sup>, N. Skvorodnev<sup>22</sup>, M. Slater<sup>17</sup>,  
 T. Slavicek<sup>127</sup>, K. Sliwa<sup>161</sup>, T.J. Sloan<sup>71</sup>, J. Sloper<sup>29</sup>, V. Smakhtin<sup>171</sup>, S.Yu. Smirnov<sup>96</sup>,  
 L.N. Smirnova<sup>97</sup>, O. Smirnova<sup>79</sup>, B.C. Smith<sup>57</sup>, D. Smith<sup>143</sup>, K.M. Smith<sup>53</sup>, M. Smizanska<sup>71</sup>,  
 K. Smolek<sup>127</sup>, A.A. Snesarev<sup>94</sup>, S.W. Snow<sup>82</sup>, J. Snow<sup>111</sup>, J. Snuverink<sup>105</sup>, S. Snyder<sup>24</sup>,  
 M. Soares<sup>124a</sup>, R. Sobie<sup>169,j</sup>, J. Sodomka<sup>127</sup>, A. Soffer<sup>153</sup>, C.A. Solans<sup>167</sup>, M. Solar<sup>127</sup>, J. Solc<sup>127</sup>,

E. Soldatov<sup>96</sup>, U. Soldevila<sup>167</sup>, E. Solfaroli Camillocci<sup>132a,132b</sup>, A.A. Solodkov<sup>128</sup>,  
 O.V. Solovyanov<sup>128</sup>, J. Sondericker<sup>24</sup>, N. Soni<sup>2</sup>, V. Sopko<sup>127</sup>, B. Sopko<sup>127</sup>, M. Sorbi<sup>89a,89b</sup>,  
 M. Sosebee<sup>7</sup>, A. Soukharev<sup>107</sup>, S. Spagnolo<sup>72a,72b</sup>, F. Spanò<sup>76</sup>, R. Spighi<sup>19a</sup>, G. Spigo<sup>29</sup>,  
 F. Spila<sup>132a,132b</sup>, E. Spiriti<sup>134a</sup>, R. Spiwoks<sup>29</sup>, M. Spousta<sup>126</sup>, T. Spreitzer<sup>158</sup>, B. Spurlock<sup>7</sup>,  
 R.D. St. Denis<sup>53</sup>, T. Stahl<sup>141</sup>, J. Stahlman<sup>120</sup>, R. Stamen<sup>58a</sup>, E. Stanecka<sup>29</sup>, R.W. Stanek<sup>5</sup>,  
 C. Stanescu<sup>134a</sup>, S. Stapnes<sup>117</sup>, E.A. Starchenko<sup>128</sup>, J. Stark<sup>55</sup>, P. Staroba<sup>125</sup>, P. Starovoitov<sup>91</sup>,  
 A. Staude<sup>98</sup>, P. Stavina<sup>144a</sup>, G. Stavropoulos<sup>14</sup>, G. Steele<sup>53</sup>, P. Steinbach<sup>43</sup>, P. Steinberg<sup>24</sup>,  
 I. Stekl<sup>127</sup>, B. Stelzer<sup>142</sup>, H.J. Stelzer<sup>41</sup>, O. Stelzer-Chilton<sup>159a</sup>, H. Stenzel<sup>52</sup>, K. Stevenson<sup>75</sup>,  
 G.A. Stewart<sup>29</sup>, J.A. Stillings<sup>20</sup>, T. Stockmanns<sup>20</sup>, M.C. Stockton<sup>29</sup>, K. Stoerig<sup>48</sup>, G. Stoicea<sup>25a</sup>,  
 S. Stonjek<sup>99</sup>, P. Strachota<sup>126</sup>, A.R. Stradling<sup>7</sup>, A. Straessner<sup>43</sup>, J. Strandberg<sup>147</sup>,  
 S. Strandberg<sup>146a,146b</sup>, A. Strandlie<sup>117</sup>, M. Strang<sup>109</sup>, E. Strauss<sup>143</sup>, M. Strauss<sup>111</sup>,  
 P. Strizenec<sup>144b</sup>, R. Ströhmer<sup>173</sup>, D.M. Strom<sup>114</sup>, J.A. Strong<sup>76,\*</sup>, R. Stroynowski<sup>39</sup>, J. Strube<sup>129</sup>,  
 B. Stugu<sup>13</sup>, I. Stumer<sup>24,\*</sup>, J. Stupak<sup>148</sup>, P. Sturm<sup>174</sup>, D.A. Soh<sup>151,q</sup>, D. Su<sup>143</sup>, HS. Subramania<sup>2</sup>,  
 A. Succurro<sup>11</sup>, Y. Sugaya<sup>116</sup>, T. Sugimoto<sup>101</sup>, C. Suhr<sup>106</sup>, K. Suita<sup>67</sup>, M. Suk<sup>126</sup>, V.V. Sulin<sup>94</sup>,  
 S. Sultansoy<sup>3d</sup>, T. Sumida<sup>29</sup>, X. Sun<sup>55</sup>, J.E. Sundermann<sup>48</sup>, K. Suruliz<sup>139</sup>, S. Sushkov<sup>11</sup>,  
 G. Susinno<sup>36a,36b</sup>, M.R. Sutton<sup>149</sup>, Y. Suzuki<sup>66</sup>, M. Svatos<sup>125</sup>, Yu.M. Sviridov<sup>128</sup>, S. Swedish<sup>168</sup>,  
 I. Sykora<sup>144a</sup>, T. Sykora<sup>126</sup>, B. Szeless<sup>29</sup>, J. Sánchez<sup>167</sup>, D. Ta<sup>105</sup>, K. Tackmann<sup>41</sup>, A. Taffard<sup>163</sup>,  
 R. Tafirout<sup>159a</sup>, A. Taga<sup>117</sup>, N. Taiblum<sup>153</sup>, Y. Takahashi<sup>101</sup>, H. Takai<sup>24</sup>, R. Takashima<sup>69</sup>,  
 H. Takeda<sup>67</sup>, T. Takeshita<sup>140</sup>, M. Talby<sup>83</sup>, A. Talyshev<sup>107</sup>, M.C. Tamssett<sup>24</sup>, J. Tanaka<sup>155</sup>,  
 R. Tanaka<sup>115</sup>, S. Tanaka<sup>131</sup>, S. Tanaka<sup>66</sup>, Y. Tanaka<sup>100</sup>, K. Tani<sup>67</sup>, N. Tannoury<sup>83</sup>,  
 G.P. Tappern<sup>29</sup>, S. Tapprogge<sup>81</sup>, D. Tardif<sup>158</sup>, S. Tarem<sup>152</sup>, F. Tarrade<sup>24</sup>, G.F. Tartarelli<sup>89a</sup>,  
 P. Tas<sup>126</sup>, M. Tasevsky<sup>125</sup>, E. Tassi<sup>36a,36b</sup>, M. Tatarkhanov<sup>14</sup>, C. Taylor<sup>77</sup>, F.E. Taylor<sup>92</sup>,  
 G.N. Taylor<sup>86</sup>, W. Taylor<sup>159b</sup>, M. Teixeira Dias Castanheira<sup>75</sup>, P. Teixeira-Dias<sup>76</sup>,  
 K.K. Temming<sup>48</sup>, H. Ten Kate<sup>29</sup>, P.K. Teng<sup>151</sup>, S. Terada<sup>66</sup>, K. Terashi<sup>155</sup>, J. Terron<sup>80</sup>,  
 M. Terwort<sup>41,o</sup>, M. Testa<sup>47</sup>, R.J. Teuscher<sup>158,j</sup>, J. Thadome<sup>174</sup>, J. Therhaag<sup>20</sup>,  
 T. Theveneaux-Pelzer<sup>78</sup>, M. Thioye<sup>175</sup>, S. Thoma<sup>48</sup>, J.P. Thomas<sup>17</sup>, E.N. Thompson<sup>84</sup>,  
 P.D. Thompson<sup>17</sup>, P.D. Thompson<sup>158</sup>, A.S. Thompson<sup>53</sup>, E. Thomson<sup>120</sup>, M. Thomson<sup>27</sup>,  
 R.P. Thun<sup>87</sup>, F. Tian<sup>34</sup>, T. Tic<sup>125</sup>, V.O. Tikhomirov<sup>94</sup>, Y.A. Tikhonov<sup>107</sup>,  
 C.J.W.P. Timmermans<sup>104</sup>, P. Tipton<sup>175</sup>, F.J. Tique Aires Viegas<sup>29</sup>, S. Tisserant<sup>83</sup>, J. Tobias<sup>48</sup>,  
 B. Toczek<sup>37</sup>, T. Todorov<sup>4</sup>, S. Todorova-Nova<sup>161</sup>, B. Toggerson<sup>163</sup>, J. Tojo<sup>66</sup>, S. Tokár<sup>144a</sup>,  
 K. Tokunaga<sup>67</sup>, K. Tokushuku<sup>66</sup>, K. Tollefson<sup>88</sup>, M. Tomoto<sup>101</sup>, L. Tompkins<sup>14</sup>, K. Toms<sup>103</sup>,  
 G. Tong<sup>32a</sup>, A. Tonoyan<sup>13</sup>, C. Topfel<sup>16</sup>, N.D. Topilin<sup>65</sup>, I. Torchiani<sup>29</sup>, E. Torrence<sup>114</sup>, H. Torres<sup>78</sup>,  
 E. Torró Pastor<sup>167</sup>, J. Toth<sup>83,w</sup>, F. Touchard<sup>83</sup>, D.R. Tovey<sup>139</sup>, D. Traynor<sup>75</sup>, T. Trefzger<sup>173</sup>,  
 L. Tremblet<sup>29</sup>, A. Tricoli<sup>29</sup>, I.M. Trigger<sup>159a</sup>, S. Trincaz-Duvoid<sup>78</sup>, T.N. Trinh<sup>78</sup>, M.F. Tripiana<sup>70</sup>,  
 W. Trischuk<sup>158</sup>, A. Trivedi<sup>24,v</sup>, B. Trocmé<sup>55</sup>, C. Troncon<sup>89a</sup>, M. Trotter-McDonald<sup>142</sup>,  
 A. Trzupek<sup>38</sup>, C. Tsarouchas<sup>29</sup>, J.C-L. Tseng<sup>118</sup>, M. Tsiakiris<sup>105</sup>, P.V. Tsiarehka<sup>90</sup>, D. Tsionou<sup>4</sup>,  
 G. Tsipolitis<sup>9</sup>, V. Tsiskaridze<sup>48</sup>, E.G. Tskhadadze<sup>51</sup>, I.I. Tsukerman<sup>95</sup>, V. Tsulaia<sup>14</sup>,  
 J.-W. Tsung<sup>20</sup>, S. Tsuno<sup>66</sup>, D. Tsybychev<sup>148</sup>, A. Tua<sup>139</sup>, J.M. Tuggle<sup>30</sup>, M. Turala<sup>38</sup>,  
 D. Turecek<sup>127</sup>, I. Turk Cakir<sup>3e</sup>, E. Turlay<sup>105</sup>, R. Turra<sup>89a,89b</sup>, P.M. Tuts<sup>34</sup>, A. Tykhonov<sup>74</sup>,  
 M. Tylmad<sup>146a,146b</sup>, M. Tyndel<sup>129</sup>, H. Tyrvaainen<sup>29</sup>, G. Tzanakos<sup>8</sup>, K. Uchida<sup>20</sup>, I. Ueda<sup>155</sup>,  
 R. Ueno<sup>28</sup>, M. Uglan<sup>13</sup>, M. Uhlenbrock<sup>20</sup>, M. Uhrmacher<sup>54</sup>, F. Ukegawa<sup>160</sup>, G. Unal<sup>29</sup>,  
 D.G. Underwood<sup>5</sup>, A. Undrus<sup>24</sup>, G. Unel<sup>163</sup>, Y. Unno<sup>66</sup>, D. Urbaniec<sup>34</sup>, E. Urkovsky<sup>153</sup>,  
 P. Urrejola<sup>31a</sup>, G. Usai<sup>7</sup>, M. Uslenghi<sup>119a,119b</sup>, L. Vacavant<sup>83</sup>, V. Vacek<sup>127</sup>, B. Vachon<sup>85</sup>,  
 S. Vahsen<sup>14</sup>, J. Valenta<sup>125</sup>, P. Valente<sup>132a</sup>, S. Valentinetti<sup>19a,19b</sup>, S. Valkar<sup>126</sup>,  
 E. Valladolid Gallego<sup>167</sup>, S. Vallecorsa<sup>152</sup>, J.A. Valls Ferrer<sup>167</sup>, H. van der Graaf<sup>105</sup>,  
 E. van der Kraaij<sup>105</sup>, R. Van Der Leeuw<sup>105</sup>, E. van der Poel<sup>105</sup>, D. van der Ster<sup>29</sup>, B. Van Eijk<sup>105</sup>,  
 N. van Eldik<sup>84</sup>, P. van Gemmeren<sup>5</sup>, Z. van Kesteren<sup>105</sup>, I. van Vulpen<sup>105</sup>, W. Vandelli<sup>29</sup>,  
 G. Vandoni<sup>29</sup>, A. Vaniachine<sup>5</sup>, P. Vankov<sup>41</sup>, F. Vannucci<sup>78</sup>, F. Varela Rodriguez<sup>29</sup>, R. Vari<sup>132a</sup>,

E.W. Varnes<sup>6</sup>, D. Varouchas<sup>14</sup>, A. Vartapetian<sup>7</sup>, K.E. Varvell<sup>150</sup>, V.I. Vassilakopoulos<sup>56</sup>,  
 F. Vazeille<sup>33</sup>, G. Vegni<sup>89a,89b</sup>, J.J. Veillet<sup>115</sup>, C. Vellidis<sup>8</sup>, F. Veloso<sup>124a</sup>, R. Veness<sup>29</sup>,  
 S. Veneziano<sup>132a</sup>, A. Ventura<sup>72a,72b</sup>, D. Ventura<sup>138</sup>, M. Venturi<sup>48</sup>, N. Venturi<sup>16</sup>, V. Vercesi<sup>119a</sup>,  
 M. Verducci<sup>138</sup>, W. Verkerke<sup>105</sup>, J.C. Vermeulen<sup>105</sup>, A. Vest<sup>43</sup>, M.C. Vetterli<sup>142,e</sup>, I. Vichou<sup>165</sup>,  
 T. Vickey<sup>145b,z</sup>, G.H.A. Viehhauser<sup>118</sup>, S. Viel<sup>168</sup>, M. Villa<sup>19a,19b</sup>, M. Villaplana Perez<sup>167</sup>,  
 E. Vilucchi<sup>47</sup>, M.G. Vincter<sup>28</sup>, E. Vinek<sup>29</sup>, V.B. Vinogradov<sup>65</sup>, M. Virchaux<sup>136,\*</sup>, J. Virzi<sup>14</sup>,  
 O. Vitells<sup>171</sup>, M. Viti<sup>41</sup>, I. Vivarelli<sup>48</sup>, F. Vives Vaque<sup>11</sup>, S. Vlachos<sup>9</sup>, M. Vlasak<sup>127</sup>, N. Vlasov<sup>20</sup>,  
 A. Vogel<sup>20</sup>, P. Vokac<sup>127</sup>, G. Volpi<sup>47</sup>, M. Volpi<sup>86</sup>, G. Volpini<sup>89a</sup>, H. von der Schmitt<sup>99</sup>,  
 J. von Loeben<sup>99</sup>, H. von Radziewski<sup>48</sup>, E. von Toerne<sup>20</sup>, V. Vorobel<sup>126</sup>, A.P. Vorobiev<sup>128</sup>,  
 V. Vorwerk<sup>11</sup>, M. Vos<sup>167</sup>, R. Voss<sup>29</sup>, T.T. Voss<sup>174</sup>, J.H. Vosseveld<sup>73</sup>, N. Vranjes<sup>12a</sup>,  
 M. Vranjes Milosavljevic<sup>105</sup>, V. Vrba<sup>125</sup>, M. Vreeswijk<sup>105</sup>, T. Vu Anh<sup>81</sup>, R. Vuillermet<sup>29</sup>,  
 I. Vukotic<sup>115</sup>, W. Wagner<sup>174</sup>, P. Wagner<sup>120</sup>, H. Wahlen<sup>174</sup>, J. Wakabayashi<sup>101</sup>, J. Walbersloh<sup>42</sup>,  
 S. Walch<sup>87</sup>, J. Walder<sup>71</sup>, R. Walker<sup>98</sup>, W. Walkowiak<sup>141</sup>, R. Wall<sup>175</sup>, P. Waller<sup>73</sup>, C. Wang<sup>44</sup>,  
 H. Wang<sup>172</sup>, H. Wang<sup>32b,aa</sup>, J. Wang<sup>151</sup>, J. Wang<sup>32d</sup>, J.C. Wang<sup>138</sup>, R. Wang<sup>103</sup>, S.M. Wang<sup>151</sup>,  
 A. Warburton<sup>85</sup>, C.P. Ward<sup>27</sup>, M. Warsinsky<sup>48</sup>, P.M. Watkins<sup>17</sup>, A.T. Watson<sup>17</sup>, M.F. Watson<sup>17</sup>,  
 G. Watts<sup>138</sup>, S. Watts<sup>82</sup>, A.T. Waugh<sup>150</sup>, B.M. Waugh<sup>77</sup>, J. Weber<sup>42</sup>, M. Weber<sup>129</sup>,  
 M.S. Weber<sup>16</sup>, P. Weber<sup>54</sup>, A.R. Weidberg<sup>118</sup>, P. Weigell<sup>99</sup>, J. Weingarten<sup>54</sup>, C. Weiser<sup>48</sup>,  
 H. Wellenstein<sup>22</sup>, P.S. Wells<sup>29</sup>, M. Wen<sup>47</sup>, T. Wenaus<sup>24</sup>, S. Wendler<sup>123</sup>, Z. Weng<sup>151,q</sup>,  
 T. Wengler<sup>29</sup>, S. Wenig<sup>29</sup>, N. Wermes<sup>20</sup>, M. Werner<sup>48</sup>, P. Werner<sup>29</sup>, M. Werth<sup>163</sup>, M. Wessels<sup>58a</sup>,  
 C. Weydert<sup>55</sup>, K. Whalen<sup>28</sup>, S.J. Wheeler-Ellis<sup>163</sup>, S.P. Whitaker<sup>21</sup>, A. White<sup>7</sup>, M.J. White<sup>86</sup>,  
 S. White<sup>24</sup>, S.R. Whitehead<sup>118</sup>, D. Whiteson<sup>163</sup>, D. Whittington<sup>61</sup>, F. Wicek<sup>115</sup>, D. Wicke<sup>174</sup>,  
 F.J. Wickens<sup>129</sup>, W. Wiedenmann<sup>172</sup>, M. Wielers<sup>129</sup>, P. Wienemann<sup>20</sup>, C. Wiglesworth<sup>75</sup>,  
 L.A.M. Wiik<sup>48</sup>, P.A. Wijeratne<sup>77</sup>, A. Wildauer<sup>167</sup>, M.A. Wildt<sup>41,o</sup>, I. Wilhelm<sup>126</sup>, H.G. Wilkens<sup>29</sup>,  
 J.Z. Will<sup>98</sup>, E. Williams<sup>34</sup>, H.H. Williams<sup>120</sup>, W. Willis<sup>34</sup>, S. Willocq<sup>84</sup>, J.A. Wilson<sup>17</sup>,  
 M.G. Wilson<sup>143</sup>, A. Wilson<sup>87</sup>, I. Wingarter-Seez<sup>4</sup>, S. Winkelmann<sup>48</sup>, F. Winklmeier<sup>29</sup>,  
 M. Wittgen<sup>143</sup>, M.W. Wolter<sup>38</sup>, H. Wolters<sup>124a,h</sup>, W.C. Wong<sup>40</sup>, G. Wooden<sup>118</sup>, B.K. Wosiek<sup>38</sup>,  
 J. Wotschack<sup>29</sup>, M.J. Woudstra<sup>84</sup>, K. Wraight<sup>53</sup>, C. Wright<sup>53</sup>, B. Wrona<sup>73</sup>, S.L. Wu<sup>172</sup>, X. Wu<sup>49</sup>,  
 Y. Wu<sup>32b,ab</sup>, E. Wulf<sup>34</sup>, R. Wunstorff<sup>42</sup>, B.M. Wynne<sup>45</sup>, L. Xaplanteris<sup>9</sup>, S. Xella<sup>35</sup>, S. Xie<sup>48</sup>,  
 Y. Xie<sup>32a</sup>, C. Xu<sup>32b,ac</sup>, D. Xu<sup>139</sup>, G. Xu<sup>32a</sup>, B. Yabsley<sup>150</sup>, S. Yacoo<sup>145b</sup>, M. Yamada<sup>66</sup>,  
 H. Yamaguchi<sup>155</sup>, A. Yamamoto<sup>66</sup>, K. Yamamoto<sup>64</sup>, S. Yamamoto<sup>155</sup>, T. Yamamura<sup>155</sup>,  
 T. Yamanaka<sup>155</sup>, J. Yamaoka<sup>44</sup>, T. Yamazaki<sup>155</sup>, Y. Yamazaki<sup>67</sup>, Z. Yan<sup>21</sup>, H. Yang<sup>87</sup>,  
 U.K. Yang<sup>82</sup>, Y. Yang<sup>61</sup>, Y. Yang<sup>32a</sup>, Z. Yang<sup>146a,146b</sup>, S. Yanush<sup>91</sup>, W-M. Yao<sup>14</sup>, Y. Yao<sup>14</sup>,  
 Y. Yasu<sup>66</sup>, G.V. Ybeles Smit<sup>130</sup>, J. Ye<sup>39</sup>, S. Ye<sup>24</sup>, M. Yilmaz<sup>3c</sup>, R. Yoosoofmiya<sup>123</sup>, K. Yorita<sup>170</sup>,  
 R. Yoshida<sup>5</sup>, C. Young<sup>143</sup>, S. Youssef<sup>21</sup>, D. Yu<sup>24</sup>, J. Yu<sup>7</sup>, J. Yu<sup>32c,ac</sup>, L. Yuan<sup>32a,ad</sup>,  
 A. Yurkewicz<sup>148</sup>, V.G. Zaets<sup>128</sup>, R. Zaidan<sup>63</sup>, A.M. Zaitsev<sup>128</sup>, Z. Zajacova<sup>29</sup>, Yo.K. Zalite<sup>121</sup>,  
 L. Zanello<sup>132a,132b</sup>, P. Zarzhitsky<sup>39</sup>, A. Zaytsev<sup>107</sup>, C. Zeitnitz<sup>174</sup>, M. Zeller<sup>175</sup>, A. Zemla<sup>38</sup>,  
 C. Zender<sup>20</sup>, O. Zenin<sup>128</sup>, T. Ženiš<sup>144a</sup>, Z. Zenonos<sup>122a,122b</sup>, S. Zenz<sup>14</sup>, D. Zerwas<sup>115</sup>,  
 G. Zevi della Porta<sup>57</sup>, Z. Zhan<sup>32d</sup>, D. Zhang<sup>32b,aa</sup>, H. Zhang<sup>88</sup>, J. Zhang<sup>5</sup>, X. Zhang<sup>32d</sup>,  
 Z. Zhang<sup>115</sup>, L. Zhao<sup>108</sup>, T. Zhao<sup>138</sup>, Z. Zhao<sup>32b</sup>, A. Zhemchugov<sup>65</sup>, S. Zheng<sup>32a</sup>, J. Zhong<sup>151,ae</sup>,  
 B. Zhou<sup>87</sup>, N. Zhou<sup>163</sup>, Y. Zhou<sup>151</sup>, C.G. Zhu<sup>32d</sup>, H. Zhu<sup>41</sup>, J. Zhu<sup>87</sup>, Y. Zhu<sup>172</sup>, X. Zhuang<sup>98</sup>,  
 V. Zhuravlov<sup>99</sup>, D. Zieminska<sup>61</sup>, R. Zimmermann<sup>20</sup>, S. Zimmermann<sup>20</sup>, S. Zimmermann<sup>48</sup>,  
 M. Ziolkowski<sup>141</sup>, R. Zitoun<sup>4</sup>, L. Živković<sup>34</sup>, V.V. Zmouchko<sup>128,\*</sup>, G. Zobernig<sup>172</sup>,  
 A. Zoccoli<sup>19a,19b</sup>, Y. Zolnierowski<sup>4</sup>, A. Zsenei<sup>29</sup>, M. zur Nedden<sup>15</sup>, V. Zutshi<sup>106</sup>, L. Zwalinski<sup>29</sup>.

<sup>1</sup> University at Albany, Albany NY, United States of America

<sup>2</sup> Department of Physics, University of Alberta, Edmonton AB, Canada

<sup>3</sup> (a)Department of Physics, Ankara University, Ankara; (b)Department of Physics, Dumlupinar University, Kutahya; (c)Department of Physics, Gazi University, Ankara; (d)Division of Physics,



- TOBB University of Economics and Technology, Ankara; <sup>(e)</sup>Turkish Atomic Energy Authority, Ankara, Turkey
- <sup>4</sup> LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France
- <sup>5</sup> High Energy Physics Division, Argonne National Laboratory, Argonne IL, United States of America
- <sup>6</sup> Department of Physics, University of Arizona, Tucson AZ, United States of America
- <sup>7</sup> Department of Physics, The University of Texas at Arlington, Arlington TX, United States of America
- <sup>8</sup> Physics Department, University of Athens, Athens, Greece
- <sup>9</sup> Physics Department, National Technical University of Athens, Zografou, Greece
- <sup>10</sup> Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan
- <sup>11</sup> Institut de Física d'Altes Energies and Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain
- <sup>12</sup> <sup>(a)</sup>Institute of Physics, University of Belgrade, Belgrade; <sup>(b)</sup>Vinca Institute of Nuclear Sciences, Belgrade, Serbia
- <sup>13</sup> Department for Physics and Technology, University of Bergen, Bergen, Norway
- <sup>14</sup> Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley CA, United States of America
- <sup>15</sup> Department of Physics, Humboldt University, Berlin, Germany
- <sup>16</sup> Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland
- <sup>17</sup> School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom
- <sup>18</sup> <sup>(a)</sup>Department of Physics, Bogazici University, Istanbul; <sup>(b)</sup>Division of Physics, Dogus University, Istanbul; <sup>(c)</sup>Department of Physics Engineering, Gaziantep University, Gaziantep; <sup>(d)</sup>Department of Physics, Istanbul Technical University, Istanbul, Turkey
- <sup>19</sup> <sup>(a)</sup>INFN Sezione di Bologna; <sup>(b)</sup>Dipartimento di Fisica, Università di Bologna, Bologna, Italy
- <sup>20</sup> Physikalisches Institut, University of Bonn, Bonn, Germany
- <sup>21</sup> Department of Physics, Boston University, Boston MA, United States of America
- <sup>22</sup> Department of Physics, Brandeis University, Waltham MA, United States of America
- <sup>23</sup> <sup>(a)</sup>Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; <sup>(b)</sup>Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil
- <sup>24</sup> Physics Department, Brookhaven National Laboratory, Upton NY, United States of America
- <sup>25</sup> <sup>(a)</sup>National Institute of Physics and Nuclear Engineering, Bucharest; <sup>(b)</sup>University Politehnica Bucharest, Bucharest; <sup>(c)</sup>West University in Timisoara, Timisoara, Romania
- <sup>26</sup> Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
- <sup>27</sup> Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
- <sup>28</sup> Department of Physics, Carleton University, Ottawa ON, Canada
- <sup>29</sup> CERN, Geneva, Switzerland
- <sup>30</sup> Enrico Fermi Institute, University of Chicago, Chicago IL, United States of America
- <sup>31</sup> <sup>(a)</sup>Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; <sup>(b)</sup>Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
- <sup>32</sup> <sup>(a)</sup>Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; <sup>(b)</sup>Department of Modern Physics, University of Science and Technology of China, Anhui; <sup>(c)</sup>Department of Physics, Nanjing University, Jiangsu; <sup>(d)</sup>High Energy Physics Group, Shandong University, Shandong, China
- <sup>33</sup> Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France
- <sup>34</sup> Nevis Laboratory, Columbia University, Irvington NY, United States of America

- <sup>35</sup> Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
- <sup>36</sup> <sup>(a)</sup>INFN Gruppo Collegato di Cosenza; <sup>(b)</sup>Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy
- <sup>37</sup> Faculty of Physics and Applied Computer Science, AGH-University of Science and Technology, Krakow, Poland
- <sup>38</sup> The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
- <sup>39</sup> Physics Department, Southern Methodist University, Dallas TX, United States of America
- <sup>40</sup> Physics Department, University of Texas at Dallas, Richardson TX, United States of America
- <sup>41</sup> DESY, Hamburg and Zeuthen, Germany
- <sup>42</sup> Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
- <sup>43</sup> Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany
- <sup>44</sup> Department of Physics, Duke University, Durham NC, United States of America
- <sup>45</sup> SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
- <sup>46</sup> Fachhochschule Wiener Neustadt, Johannes Gutenbergstrasse 3 2700 Wiener Neustadt, Austria
- <sup>47</sup> INFN Laboratori Nazionali di Frascati, Frascati, Italy
- <sup>48</sup> Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg i.Br., Germany
- <sup>49</sup> Section de Physique, Université de Genève, Geneva, Switzerland
- <sup>50</sup> <sup>(a)</sup>INFN Sezione di Genova; <sup>(b)</sup>Dipartimento di Fisica, Università di Genova, Genova, Italy
- <sup>51</sup> Institute of Physics and HEP Institute, Georgian Academy of Sciences and Tbilisi State University, Tbilisi, Georgia
- <sup>52</sup> II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
- <sup>53</sup> SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
- <sup>54</sup> II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
- <sup>55</sup> Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France
- <sup>56</sup> Department of Physics, Hampton University, Hampton VA, United States of America
- <sup>57</sup> Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge MA, United States of America
- <sup>58</sup> <sup>(a)</sup>Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; <sup>(b)</sup>Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; <sup>(c)</sup>ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
- <sup>59</sup> Faculty of Science, Hiroshima University, Hiroshima, Japan
- <sup>60</sup> Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
- <sup>61</sup> Department of Physics, Indiana University, Bloomington IN, United States of America
- <sup>62</sup> Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- <sup>63</sup> University of Iowa, Iowa City IA, United States of America
- <sup>64</sup> Department of Physics and Astronomy, Iowa State University, Ames IA, United States of America
- <sup>65</sup> Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
- <sup>66</sup> KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
- <sup>67</sup> Graduate School of Science, Kobe University, Kobe, Japan
- <sup>68</sup> Faculty of Science, Kyoto University, Kyoto, Japan
- <sup>69</sup> Kyoto University of Education, Kyoto, Japan
- <sup>70</sup> Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
- <sup>71</sup> Physics Department, Lancaster University, Lancaster, United Kingdom
- <sup>72</sup> <sup>(a)</sup>INFN Sezione di Lecce; <sup>(b)</sup>Dipartimento di Fisica, Università del Salento, Lecce, Italy
- <sup>73</sup> Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom

- <sup>74</sup> Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
- <sup>75</sup> Department of Physics, Queen Mary University of London, London, United Kingdom
- <sup>76</sup> Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- <sup>77</sup> Department of Physics and Astronomy, University College London, London, United Kingdom
- <sup>78</sup> Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- <sup>79</sup> Fysiska institutionen, Lunds universitet, Lund, Sweden
- <sup>80</sup> Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
- <sup>81</sup> Institut für Physik, Universität Mainz, Mainz, Germany
- <sup>82</sup> School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- <sup>83</sup> CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- <sup>84</sup> Department of Physics, University of Massachusetts, Amherst MA, United States of America
- <sup>85</sup> Department of Physics, McGill University, Montreal QC, Canada
- <sup>86</sup> School of Physics, University of Melbourne, Victoria, Australia
- <sup>87</sup> Department of Physics, The University of Michigan, Ann Arbor MI, United States of America
- <sup>88</sup> Department of Physics and Astronomy, Michigan State University, East Lansing MI, United States of America
- <sup>89</sup> <sup>(a)</sup>INFN Sezione di Milano; <sup>(b)</sup>Dipartimento di Fisica, Università di Milano, Milano, Italy
- <sup>90</sup> B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
- <sup>91</sup> National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus
- <sup>92</sup> Department of Physics, Massachusetts Institute of Technology, Cambridge MA, United States of America
- <sup>93</sup> Group of Particle Physics, University of Montreal, Montreal QC, Canada
- <sup>94</sup> P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
- <sup>95</sup> Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- <sup>96</sup> Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
- <sup>97</sup> Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
- <sup>98</sup> Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- <sup>99</sup> Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
- <sup>100</sup> Nagasaki Institute of Applied Science, Nagasaki, Japan
- <sup>101</sup> Graduate School of Science, Nagoya University, Nagoya, Japan
- <sup>102</sup> <sup>(a)</sup>INFN Sezione di Napoli; <sup>(b)</sup>Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy
- <sup>103</sup> Department of Physics and Astronomy, University of New Mexico, Albuquerque NM, United States of America
- <sup>104</sup> Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
- <sup>105</sup> Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
- <sup>106</sup> Department of Physics, Northern Illinois University, DeKalb IL, United States of America
- <sup>107</sup> Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia
- <sup>108</sup> Department of Physics, New York University, New York NY, United States of America
- <sup>109</sup> Ohio State University, Columbus OH, United States of America
- <sup>110</sup> Faculty of Science, Okayama University, Okayama, Japan
- <sup>111</sup> Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman OK, United States of America
- <sup>112</sup> Department of Physics, Oklahoma State University, Stillwater OK, United States of America

- 113 Palacký University, RCPTM, Olomouc, Czech Republic
- 114 Center for High Energy Physics, University of Oregon, Eugene OR, United States of America
- 115 LAL, Univ. Paris-Sud and CNRS/IN2P3, Orsay, France
- 116 Graduate School of Science, Osaka University, Osaka, Japan
- 117 Department of Physics, University of Oslo, Oslo, Norway
- 118 Department of Physics, Oxford University, Oxford, United Kingdom
- 119 <sup>(a)</sup>INFN Sezione di Pavia; <sup>(b)</sup>Dipartimento di Fisica Nucleare e Teorica, Università di Pavia, Pavia, Italy
- 120 Department of Physics, University of Pennsylvania, Philadelphia PA, United States of America
- 121 Petersburg Nuclear Physics Institute, Gatchina, Russia
- 122 <sup>(a)</sup>INFN Sezione di Pisa; <sup>(b)</sup>Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
- 123 Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh PA, United States of America
- 124 <sup>(a)</sup>Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal; <sup>(b)</sup>Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain
- 125 Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
- 126 Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic
- 127 Czech Technical University in Prague, Praha, Czech Republic
- 128 State Research Center Institute for High Energy Physics, Protvino, Russia
- 129 Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
- 130 Physics Department, University of Regina, Regina SK, Canada
- 131 Ritsumeikan University, Kusatsu, Shiga, Japan
- 132 <sup>(a)</sup>INFN Sezione di Roma I; <sup>(b)</sup>Dipartimento di Fisica, Università La Sapienza, Roma, Italy
- 133 <sup>(a)</sup>INFN Sezione di Roma Tor Vergata; <sup>(b)</sup>Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy
- 134 <sup>(a)</sup>INFN Sezione di Roma Tre; <sup>(b)</sup>Dipartimento di Fisica, Università Roma Tre, Roma, Italy
- 135 <sup>(a)</sup>Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca; <sup>(b)</sup>Centre National de l'Énergie des Sciences Techniques Nucleaires, Rabat; <sup>(c)</sup>Université Cadi Ayyad, Faculté des sciences Semlalia Département de Physique, B.P. 2390 Marrakech 40000; <sup>(d)</sup>Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda; <sup>(e)</sup>Faculté des Sciences, Université Mohammed V, Rabat, Morocco
- 136 DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Énergie Atomique), Gif-sur-Yvette, France
- 137 Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz CA, United States of America
- 138 Department of Physics, University of Washington, Seattle WA, United States of America
- 139 Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
- 140 Department of Physics, Shinshu University, Nagano, Japan
- 141 Fachbereich Physik, Universität Siegen, Siegen, Germany
- 142 Department of Physics, Simon Fraser University, Burnaby BC, Canada
- 143 SLAC National Accelerator Laboratory, Stanford CA, United States of America
- 144 <sup>(a)</sup>Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava; <sup>(b)</sup>Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
- 145 <sup>(a)</sup>Department of Physics, University of Johannesburg, Johannesburg; <sup>(b)</sup>School of Physics, University of the Witwatersrand, Johannesburg, South Africa
- 146 <sup>(a)</sup>Department of Physics, Stockholm University; <sup>(b)</sup>The Oskar Klein Centre, Stockholm, Sweden

- <sup>147</sup> Physics Department, Royal Institute of Technology, Stockholm, Sweden
- <sup>148</sup> Department of Physics and Astronomy, Stony Brook University, Stony Brook NY, United States of America
- <sup>149</sup> Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
- <sup>150</sup> School of Physics, University of Sydney, Sydney, Australia
- <sup>151</sup> Institute of Physics, Academia Sinica, Taipei, Taiwan
- <sup>152</sup> Department of Physics, Technion: Israel Inst. of Technology, Haifa, Israel
- <sup>153</sup> Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
- <sup>154</sup> Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
- <sup>155</sup> International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
- <sup>156</sup> Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
- <sup>157</sup> Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
- <sup>158</sup> Department of Physics, University of Toronto, Toronto ON, Canada
- <sup>159</sup> <sup>(a)</sup>TRIUMF, Vancouver BC; <sup>(b)</sup>Department of Physics and Astronomy, York University, Toronto ON, Canada
- <sup>160</sup> Institute of Pure and Applied Sciences, University of Tsukuba, Ibaraki, Japan
- <sup>161</sup> Science and Technology Center, Tufts University, Medford MA, United States of America
- <sup>162</sup> Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
- <sup>163</sup> Department of Physics and Astronomy, University of California Irvine, Irvine CA, United States of America
- <sup>164</sup> <sup>(a)</sup>INFN Gruppo Collegato di Udine; <sup>(b)</sup>ICTP, Trieste; <sup>(c)</sup>Dipartimento di Fisica, Università di Udine, Udine, Italy
- <sup>165</sup> Department of Physics, University of Illinois, Urbana IL, United States of America
- <sup>166</sup> Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
- <sup>167</sup> 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
- <sup>168</sup> Department of Physics, University of British Columbia, Vancouver BC, Canada
- <sup>169</sup> Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada
- <sup>170</sup> Waseda University, Tokyo, Japan
- <sup>171</sup> Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel
- <sup>172</sup> Department of Physics, University of Wisconsin, Madison WI, United States of America
- <sup>173</sup> Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany
- <sup>174</sup> Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany
- <sup>175</sup> Department of Physics, Yale University, New Haven CT, United States of America
- <sup>176</sup> Yerevan Physics Institute, Yerevan, Armenia
- <sup>177</sup> Domaine scientifique de la Doua, Centre de Calcul CNRS/IN2P3, Villeurbanne Cedex, France
- <sup>a</sup> Also at Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa, Portugal
- <sup>b</sup> Also at Faculdade de Ciências and CFNUL, Universidade de Lisboa, Lisboa, Portugal
- <sup>c</sup> Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
- <sup>d</sup> Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- <sup>e</sup> Also at TRIUMF, Vancouver BC, Canada
- <sup>f</sup> Also at Department of Physics, California State University, Fresno CA, United States of America
- <sup>g</sup> Also at Faculty of Physics and Applied Computer Science, AGH-University of Science and Technology, Krakow, Poland
- <sup>h</sup> Also at Department of Physics, University of Coimbra, Coimbra, Portugal

- <sup>i</sup> Also at Università di Napoli Parthenope, Napoli, Italy
- <sup>j</sup> Also at Institute of Particle Physics (IPP), Canada
- <sup>k</sup> Also at Department of Physics, Middle East Technical University, Ankara, Turkey
- <sup>l</sup> Also at Louisiana Tech University, Ruston LA, United States of America
- <sup>m</sup> Also at Group of Particle Physics, University of Montreal, Montreal QC, Canada
- <sup>n</sup> Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan
- <sup>o</sup> Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany
- <sup>p</sup> Also at Manhattan College, New York NY, United States of America
- <sup>q</sup> Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China
- <sup>r</sup> Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan
- <sup>s</sup> Also at High Energy Physics Group, Shandong University, Shandong, China
- <sup>t</sup> Also at section de Physique, Université de Genève, Geneva, Switzerland
- <sup>u</sup> Also at Departamento de Física, Universidade de Minho, Braga, Portugal
- <sup>v</sup> Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, United States of America
- <sup>w</sup> Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
- <sup>x</sup> Also at California Institute of Technology, Pasadena CA, United States of America
- <sup>y</sup> Also at Institute of Physics, Jagiellonian University, Krakow, Poland
- <sup>z</sup> Also at Department of Physics, Oxford University, Oxford, United Kingdom
- <sup>aa</sup> Also at Institute of Physics, Academia Sinica, Taipei, Taiwan
- <sup>ab</sup> Also at Department of Physics, The University of Michigan, Ann Arbor MI, United States of America
- <sup>ac</sup> Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France
- <sup>ad</sup> Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- <sup>ae</sup> Also at Department of Physics, Nanjing University, Jiangsu, China
- \* Deceased