



# Search for a heavy gauge boson decaying to a charged lepton and a neutrino in $1 \text{ fb}^{-1}$ of $pp$ collisions at $\sqrt{s} = 7 \text{ TeV}$ using the ATLAS detector $\star$

ATLAS Collaboration  $\star$

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## ABSTRACT

The ATLAS detector at the LHC is used to search for high-mass states, such as heavy charged gauge bosons ( $W'$ ), decaying to a charged lepton (electron or muon) and a neutrino. Results are presented based on the analysis of  $pp$  collisions at a center-of-mass energy of 7 TeV corresponding to an integrated luminosity of  $1.04 \text{ fb}^{-1}$ . No excess above Standard Model expectations is observed. A  $W'$  with Sequential Standard Model couplings is excluded at the 95% confidence level for masses up to 2.15 TeV.

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## 1. Introduction

The high-energy collisions at the CERN Large Hadron Collider provide new opportunities to search for physics beyond the Standard Model (SM) of strong and electroweak interactions. One extension common to many models is the existence of additional heavy gauge bosons [1], the charged ones commonly denoted  $W'$ . Such particles are most easily searched for in their decay to a charged lepton (electron or muon) and a neutrino.

This Letter describes such a search performed using 7 TeV  $pp$  collision data collected with the ATLAS detector during 2011 and corresponding to a total integrated luminosity of  $1.04 \text{ fb}^{-1}$ . No  $W'$  signal is observed, and the data are used to extend current limits [2–4] on  $\sigma B$  (cross section times branching fraction) as a function of  $W'$  mass. The significant improvement over the previous ATLAS result [4] comes mostly from the increase in available integrated luminosity, but also reflects optimization of the event selection and increased acceptance in the muon channel. A lower limit on the mass of a  $W'$  boson in the Sequential Standard Model (SSM), i.e. the extended gauge model of Ref. [5] with  $W'$  coupling to  $WZ$  set to zero, is also reported. In this model, the  $W'$  has the same couplings to fermions as the SM  $W$  boson and thus a width which increases linearly with the  $W'$  mass.

The analysis presented here identifies candidates in the electron and muon channels and sets separate limits for  $W' \rightarrow e\nu$  and  $W' \rightarrow \mu\nu$ . In addition, combined limits are evaluated, assuming the same branching fraction for both channels. The kinematic variable used to identify the  $W'$  is the transverse mass

$$m_T = \sqrt{2p_T E_T^{\text{miss}} (1 - \cos \varphi_{l\nu})}, \quad (1)$$

which displays a Jacobian peak that falls sharply above the resonance mass. Here  $p_T$  is the lepton transverse momentum,  $E_T^{\text{miss}}$  is the magnitude of the missing transverse momentum (missing  $E_T$ ), and  $\varphi_{l\nu}$  is the angle between the  $p_T$  and missing  $E_T$  vectors. Throughout this Letter, transverse refers to the plane perpendicular to the colliding beams, longitudinal means parallel to the beams,  $\theta$  and  $\phi$  are the polar and azimuthal angles with respect to the longitudinal direction, and pseudorapidity is defined as  $\eta = -\ln(\tan(\theta/2))$ .

The main background to the  $W' \rightarrow \ell\nu$  signal comes from the high- $m_T$  tail of SM  $W$  boson decay to the same final state. Other backgrounds are  $Z$  bosons decaying into two leptons where one lepton is not reconstructed,  $W$  or  $Z$  decaying to  $\tau$ -leptons where a  $\tau$  subsequently decays to an electron or muon, and diboson production. These are collectively referred to as the electroweak (EW) background. In addition, there is a background contribution from  $t\bar{t}$  production which is most important for the lowest  $W'$  masses considered here, where it constitutes about 10% of the background after event selection. Other strong-interaction background sources, where a light or heavy hadron decays semileptonically or a jet is misidentified as an electron, are estimated to be at most 10% of the total background in the electron channel and a negligible fraction in the muon channel, again after final selection. These are called QCD background in the following.

## 2. Data

The ATLAS detector [6] has three major components: the inner tracking detector, the calorimeter and the muon spectrometer. Charged particle tracks and vertices are reconstructed with silicon pixel and silicon strip detectors covering  $|\eta| < 2.5$  and transition radiation detectors covering  $|\eta| < 2.0$ , all immersed in a homogeneous 2 T magnetic field provided by a superconducting solenoid. This tracking detector is surrounded by a finely-segmented, hermetic calorimeter system that covers  $|\eta| < 4.9$  and

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$\star$  E-mail address: atlas.publications@cern.ch.

provides three-dimensional reconstruction of particle showers. It uses liquid argon for the inner, electromagnetic compartment followed by a hadronic compartment based on scintillating tiles in the central region ( $|\eta| < 1.7$ ) and additional liquid argon for higher  $|\eta|$ . Outside the calorimeter, there is a muon spectrometer with air-core toroids providing a magnetic field, whose integral averages about 3 Tm. The deflection of the muons in the magnetic field is measured with three layers of precision drift-tube chambers for  $|\eta| < 2.0$  and one layer of cathode-strip chambers followed by two layers of drift-tube chambers for  $2.0 < |\eta| < 2.7$ . Additional resistive-plate and thin-gap chambers provide muon triggering capability and measurement of the  $\varphi$  coordinate.

The data used in the electron channel are the events recorded with a trigger requiring the presence of an electron with  $p_T > 20$  GeV. The efficiency of this trigger is 98%. For the muon channel, matching tracks in the muon spectrometer and inner detector with combined  $p_T > 22$  GeV are used to identify events. Events are also recorded if a muon with  $p_T > 40$  GeV is found in the muon spectrometer. The muon trigger efficiency is 80–90% in the regions of interest.

Each energy cluster reconstructed in the electromagnetic compartment of the calorimeter with  $E_T > 25$  GeV and  $|\eta| < 1.37$  or  $1.52 < |\eta| < 2.47$  is considered as an electron candidate if it matches with an inner detector track. The electron direction is defined as that of the reconstructed track and its energy as that of the cluster, with a small (less than 2%)  $\eta$ -dependent energy scale correction. The resolution of the energy measurement is 2% for  $E_T \approx 50$  GeV and approaches 1% in the high- $E_T$  range relevant to this analysis. To discriminate against hadronic jets, requirements are imposed on the lateral shower shapes in the first two layers of the electromagnetic part of the calorimeter and the fraction of energy leaking into the hadronic compartment. A hit in the first pixel layer is required to reduce background from photon conversions in the inner detector material. These requirements give about 90% identification efficiency for electrons with  $E_T > 25$  GeV and a  $2 \times 10^{-4}$  probability to falsely identify jets as electrons before isolation requirements are imposed [7].

Muon tracks can be reconstructed independently in both the inner detector and muon spectrometer, and the muons used in this study are required to have matching tracks in both systems. The muons are required to have  $p_T > 25$  GeV, where the momentum of the muon is obtained by combining the inner detector and muon spectrometer measurements. To ensure precise measurement of the momentum, muons are required to have hits in all three muon layers and are restricted to those  $\eta$ -ranges where the muon spectrometer alignment is best understood: approximately  $|\eta| < 1.0$  and  $1.3 < |\eta| < 2.0$ . The average momentum resolution is currently about 15% at  $p_T = 1$  TeV. About 80% of the muons in these  $\eta$ -ranges are reconstructed, with most of the loss coming from regions with limited detector coverage.

The missing  $E_T$  in the electron channel is obtained from a vector sum over calorimeter cells associated with topological clusters and using local hadronic calibration [8]:

$$\mathbf{E}_T^{\text{miss}} = \mathbf{E}_{\text{Tcalo}}^{\text{miss}} = - \sum_{\text{topo}} \mathbf{E}_T^{\text{cell}}. \quad (2)$$

The topological clusters reduce contributions from electronic noise. The  $E_T$  of cells associated with the electron is corrected so their sum equals the electron  $E_T$ . Muons only deposit a small fraction of their energy in the calorimeter, and so, in the muon channel, the missing  $E_T$  is obtained from

$$\mathbf{E}_T^{\text{miss}} = \mathbf{E}_{\text{Tcalo}}^{\text{miss}} - \mathbf{p}_T^\mu + \mathbf{E}_T^{\mu, \text{loss}}. \quad (3)$$

The second term in this vector sum subtracts the muon transverse momentum and the last corrects for the transverse component of

the energy deposited in the calorimeter by the muon, which is included in both of the first two terms. The energy loss is estimated by integrating the amount of material traversed and applying a calibrated conversion from path length to energy for each material type.

This analysis makes use of all the  $\sqrt{s} = 7$  TeV data collected in March–June 2011 that satisfy data quality requirements which guarantee the relevant detector systems were operating properly. The integrated luminosity for the data used in this study is  $1.04 \text{ fb}^{-1}$  in both the electron and muon decay channels. The uncertainty on this estimate is 3.7%.

### 3. Simulation

Except for the QCD background, which is estimated from data, expected signal and background levels are evaluated with simulated samples and normalized using calculated cross sections and the integrated luminosity of the data.

The  $W'$  signal and the  $W/Z$  boson backgrounds are generated with PYTHIA 6.421 [9] using MRST LO\* [10] parton distribution functions (PDFs). The  $t\bar{t}$  background is generated with MC@NLO 3.41 [11]. For all samples, final-state photon radiation is handled by PHOTOS [12]. ATLAS full detector simulation [13] based on GEANT4 [14] is used to propagate the particles and account for the response of the detector.

The PYTHIA signal model for  $W'$  has  $V-A$  SM couplings but does not include interference between  $W$  and  $W'$ . Decays to channels other than  $e\nu$  and  $\mu\nu$ , including  $\tau\nu$ ,  $ud$ ,  $sc$  and  $tb$  are included in the calculation of the  $W'$  widths but are not explicitly included as signal or background. At high mass ( $m_{W'} > 1$  TeV), the branching fraction to any of the lepton decay channels is 8.2%.

The  $W \rightarrow \ell\nu$  events are reweighted to have the NNLO (next-to-next-to-leading-order QCD) mass dependence of ZWPROD [15] with MSTW2008 PDFs [16] and following the  $G_\mu$  scheme [17]. Higher-order electroweak corrections (in addition to the photon radiation included in the simulation) are calculated using HORACE [17,18]. In the high-mass region of interest, the electroweak corrections reduce the cross sections by 11% at  $m_{\ell\nu} = 1$  TeV and by 18% at  $m_{\ell\nu} = 2$  TeV.

The  $W \rightarrow \ell\nu$  and  $Z \rightarrow \ell\ell$  cross sections are calculated at NNLO using FEWZ [19,20] with the same PDFs, scheme and electroweak corrections used in the ZWPROD event reweighting. The  $W' \rightarrow \ell\nu$  cross sections are calculated in the same way, except the electroweak corrections beyond final-state radiation are not included because the calculation for the SM  $W$  cannot be applied directly. The  $t\bar{t}$  cross section is calculated at approximate-NNLO [21–23] assuming a top-quark mass of 172.5 GeV. The signal and most important background values for  $\sigma B$  are listed in Table 1.

Cross-section uncertainties for  $W' \rightarrow \ell\nu$  and the  $W/Z$  [7] and  $t\bar{t}$  [24] backgrounds are estimated from the MSTW2008 PDF error sets, the difference between MSTW2008 and CTEQ6.6 [25] PDF sets, and variation of renormalization and factorization scales by a factor of two. The estimates from the three sources are combined in quadrature. Most of the net uncertainty comes from the error sets and the MSTW–CTEQ difference, in roughly equal proportion. The uncertainty on the cross section for the  $W \rightarrow \ell\nu$  background varies from 5% at  $m_{\ell\nu} = 500$  GeV to 19% at  $m_{\ell\nu} = 2500$  GeV.

### 4. Event selection

Events are required to have their primary vertex reconstructed from at least three tracks with  $p_T > 0.4$  GeV and longitudinal distance less than 200 mm from the center of the collision region. Due to the high luminosity, there were typically five additional interactions per event and the primary vertex is defined to be the

**Table 1**

Calculated values of  $\sigma B$  for  $W' \rightarrow \ell\nu$  and the leading backgrounds. The value for  $t\bar{t} \rightarrow \ell X$  includes all final states with at least one lepton ( $e, \mu$  or  $\tau$ ). The others are exclusive and are used for both  $\ell = e$  and  $\ell = \mu$ . All calculations are NNLO except  $t\bar{t}$  which is approximate-NNLO.

Process	Mass [GeV]	$\sigma B$ [pb]
$W' \rightarrow \ell\nu$	500	17.25
	600	8.27
	750	3.20
	1000	0.837
	1250	0.261
	1500	0.0887
	1750	0.0325
	2000	0.0126
	2250	0.00526
	2500	0.00234
$W \rightarrow \ell\nu$		10 460
$Z/\gamma^* \rightarrow \ell\ell$ ( $m_{Z/\gamma^*} > 60$ GeV)		989
$t\bar{t} \rightarrow \ell X$		89.4

one with the highest summed track  $p_T^2$ . Spurious tails in missing  $E_T$  arising from calorimeter noise and other detector problems are suppressed by checking the quality of each reconstructed jet and discarding events where any jet has a shape indicating such problems, following Ref. [26]. Events are required to have exactly one candidate electron or one candidate muon satisfying the requirements described above. In addition, the inner detector track associated with the electron or muon is required to be compatible with originating from the primary vertex, specifically to have transverse distance of closest approach  $|d_0| < 1$  mm and longitudinal distance at this point  $|z_0| < 5$  mm.

To suppress the QCD background, the lepton is required to be isolated. In the electron channel, the isolation energy is measured with the calorimeter in a cone  $\Delta R < 0.4$  ( $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ ) around the electron track, and the requirement is  $\sum E_T < 9$  GeV, where the sum includes all calorimeter energy clusters in the cone excluding the core energy deposited by the electron. The sum is corrected to account for additional interactions and leakage of the electron energy outside this core. In the muon channel, the isolation energy is measured using inner detector tracks with  $p_T^{\text{trk}} > 1$  GeV in a cone  $\Delta R < 0.3$  around the muon track. The isolation requirement is  $\sum p_T^{\text{trk}} < 0.05 p_T$ , where the muon track is excluded from the sum. The scaling of the threshold with the muon  $p_T$  reduces efficiency losses due to radiation from the muon at high  $p_T$ .

Finally, missing  $E_T$  requirements are imposed to further suppress the QCD background. In both channels, a fixed threshold is applied:  $E_T^{\text{miss}} > 25$  GeV. In the electron channel, where hadronic jets may be misidentified as electrons, a threshold proportional to the electron  $E_T$  is also applied:  $E_T^{\text{miss}} > 0.6 E_T$ .

In the electron channel, the QCD background is estimated from data using the ABCD technique [27] with the isolation energy and missing  $E_T$  serving as discriminants. Consistent results are obtained using the “inverted isolation” technique described in Ref. [4]. In the higher mass bins ( $m_T > 700$  GeV) where no events remain in the estimate, the QCD background level is set to zero and assigned an uncertainty equal to 10% of the total background level, a conservative upper limit based on the QCD contribution to the electron  $m_T$  distribution.

The QCD background for the muon channel is evaluated using a non-isolated data sample following the same procedure used for the 2010 analysis [4]. With the higher statistics now available, it is clear this background is less than 1% of the total background, so it is neglected in the following.

**Table 2**

Expected numbers of events in  $1.04 \text{ fb}^{-1}$  from the various background sources in each decay channel for  $m_T > 891$  GeV, the region used to search for a  $W'$  with a mass of 1500 GeV. The  $W \rightarrow \ell\nu$  and  $Z \rightarrow \ell\ell$  entries include the expected contributions from the  $\tau$ -lepton. No muon events are found in the  $t\bar{t}$  sample above this  $m_T$  threshold. The uncertainties are statistical.

	$e\nu$	$\mu\nu$
$W \rightarrow \ell\nu$	$1.59 \pm 0.13$	$1.36 \pm 0.13$
$Z \rightarrow \ell\ell$	$0.00010 \pm 0.00004$	$0.095 \pm 0.005$
diboson	$0.08 \pm 0.08$	$0.11 \pm 0.08$
$t\bar{t}$	$0.08 \pm 0.08$	0
QCD	$0_{-0}^{+0.17}$	$0.01_{-0.01}^{+0.02}$
Total	$1.75_{-0.18}^{+0.24}$	$1.57 \pm 0.15$

The same reconstruction and event selection are applied to both data and simulated samples. Fig. 1 shows the  $p_T$ , missing  $E_T$ , and  $m_T$  spectra for each channel after event selection for the data, for the expected background, and for three examples of  $W'$  signals at different masses. The agreement between the data and expected background is good. Table 2 shows as an example how different sources contribute to the background for  $m_T > 891$  GeV, the region used to search for a  $W'$  with a mass of 1500 GeV. The  $W \rightarrow \ell\nu$  background dominates. The  $Z \rightarrow \ell\ell$  background is much larger in the muon channel because most of the energy of the undetected muon is not captured in the calorimeter.

## 5. Statistical analysis

A Bayesian analysis is performed to determine if there is significant evidence for existence of a  $W' \rightarrow \ell\nu$  signal above the SM background and to set limits on that process. For each candidate mass and decay channel, events are counted above an  $m_T$  threshold,  $m_T > m_{T,\text{min}}$ , with the threshold chosen to maximize sensitivity. The expected number of events in each channel is

$$N_{\text{exp}} = \varepsilon_{\text{sig}} L_{\text{int}} \sigma B + N_{\text{bg}}, \quad (4)$$

where  $L_{\text{int}}$  is the integrated luminosity of the data sample and  $\varepsilon_{\text{sig}}$  is the event selection efficiency, i.e. the fraction of events that pass event selection criteria and have  $m_T$  above threshold.  $N_{\text{bg}}$  is the expected number of background events. Using Poisson statistics, the likelihood to observe  $N_{\text{obs}}$  events is

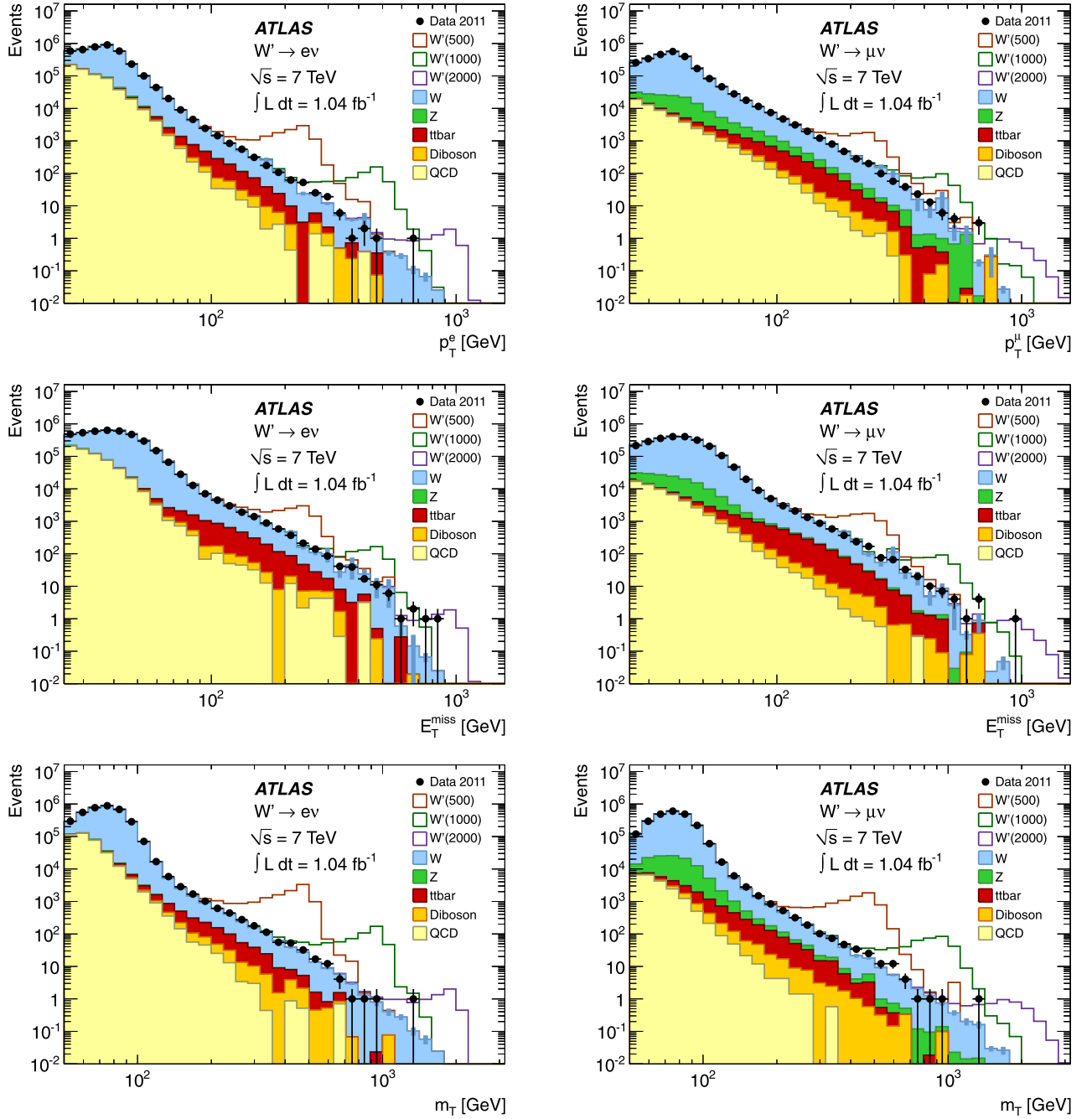
$$\mathcal{L}(N_{\text{obs}}|\sigma B) = \frac{(L_{\text{int}} \varepsilon_{\text{sig}} \sigma B + N_{\text{bg}})^{N_{\text{obs}}} e^{-(L_{\text{int}} \varepsilon_{\text{sig}} \sigma B + N_{\text{bg}})}}{N_{\text{obs}}!}. \quad (5)$$

Uncertainties are handled by introducing Gaussian nuisance parameters  $\theta_i$ , each with a probability density function (pdf)  $g_i(\theta_i)$ , and integrating the product of the Poisson likelihood with the pdfs. The integrated likelihood is

$$\mathcal{L}_B(N_{\text{obs}}|\sigma B) = \int \mathcal{L}(N_{\text{obs}}|\sigma B) \prod g_i(\theta_i) d\theta_i. \quad (6)$$

The nuisance parameters are taken to be the explicit dependencies:  $L_{\text{int}}$ ,  $\varepsilon_{\text{sig}}$  and  $N_{\text{bg}}$ , with the latter evaluated at the central value of  $L_{\text{int}}$ . Correlations between the nuisance parameters are neglected. This is justified by the small effect that the nuisance parameters themselves have on the limits, as demonstrated below.

The measurements in the two decay channels are combined assuming the same branching fraction for each. Eq. (6) remains valid with the Poisson likelihood replaced by the product of the Poisson likelihoods for the two channels. The electron and muon integrated luminosity measurements are fully correlated. The selection efficiencies are uncorrelated and the background levels are partly correlated, including only the full correlation between the cross section uncertainties in the two channels. The effect of this correlation is small: if it is not included, the observed  $\sigma B$  limits for



**Fig. 1.** Spectra of  $p_T$  (top), missing  $E_T$  (center) and  $m_T$  (bottom) for the electron (left) and muon (right) channels after event selection. The points represent data and the filled histograms show the stacked backgrounds. Open histograms are  $W' \rightarrow \ell\nu$  signals added to the background with masses in GeV indicated in parentheses in the legend. The QCD backgrounds estimated from data are also shown. The signal and other background samples are normalized using the integrated luminosity of the data and the NNLO (approximate-NNLO for  $t\bar{t}$ ) cross sections listed in Table 1.

the lowest mass points improve by 2% and those for the high-mass points are unchanged.

Bayes theorem gives the posterior probability that the  $W' \rightarrow \ell\nu$  has signal strength  $\sigma B$ :

$$P_{\text{post}}(\sigma B | N_{\text{obs}}) = N \mathcal{L}_B(N_{\text{obs}} | \sigma B) P_{\text{prior}}(\sigma B) \quad (7)$$

where  $P_{\text{prior}}(\sigma B)$  is the assumed prior probability, here chosen to be one (i.e. flat in  $\sigma B$ ) for  $\sigma B > 0$ . The constant factor  $N$  normalizes the total probability to one. The posterior probability is evaluated for each mass and each decay channel and their combination, and then used to assess discovery significance and set a limit on  $\sigma B$ .

## 6. Parameter estimation and systematics

The inputs for the evaluation of  $\mathcal{L}_B$  (and hence  $P_{\text{post}}$ ) are  $L_{\text{int}}$ ,  $\varepsilon_{\text{sig}}$ ,  $N_{\text{bg}}$ ,  $N_{\text{obs}}$  and the uncertainties on the first three. Except for  $L_{\text{int}}$  and its uncertainty, these inputs are all listed in Table 3. The uncertainties on  $\varepsilon_{\text{sig}}$  and  $N_{\text{bg}}$  account for simulation statistics and all relevant experimental and theoretical effects except for the uncertainty on the integrated luminosity. The latter is included separately to allow for the correlation between signal and background. The table also lists the predicted numbers of signal events,  $N_{\text{sig}}$ , with their uncertainties accounting for the uncertainties in both  $\varepsilon_{\text{sig}}$  and the cross-section calculation.

**Table 3**  
Inputs for the  $W' \rightarrow e\nu$  and  $W' \rightarrow \mu\nu \sigma B$  limit calculations. The first three columns are the  $W'$  mass,  $m_T$  threshold and decay channel. The next two are the signal selection efficiency,  $\varepsilon_{\text{sig}}$ , and the prediction for the number of signal events,  $N_{\text{sig}}$ , obtained with this efficiency. The last two columns are the expected number of background events,  $N_{\text{bg}}$ , and the number of events observed in data,  $N_{\text{obs}}$ . The uncertainties on  $N_{\text{sig}}$  and  $N_{\text{bg}}$  include contributions from the uncertainties on the cross sections but not from that on the integrated luminosity

$m_{W'}$ [GeV]	$m_{T\text{min}}$ [GeV]		$\varepsilon_{\text{sig}}$	$N_{\text{sig}}$	$N_{\text{bg}}$	$N_{\text{obs}}$
500	398	$e\nu$	$0.388 \pm 0.019$	$6930 \pm 620$	$101.9 \pm 10.8$	121
		$\mu\nu$	$0.252 \pm 0.015$	$4500 \pm 430$	$63.7 \pm 6.5$	91
600	447	$e\nu$	$0.456 \pm 0.022$	$3910 \pm 330$	$62.1 \pm 7.1$	69
		$\mu\nu$	$0.286 \pm 0.016$	$2450 \pm 220$	$41.8 \pm 4.7$	57
750	562	$e\nu$	$0.429 \pm 0.020$	$1420 \pm 110$	$20.7 \pm 3.7$	20
		$\mu\nu$	$0.293 \pm 0.017$	$970 \pm 79$	$14.3 \pm 1.4$	20
1000	708	$e\nu$	$0.482 \pm 0.022$	$417 \pm 35$	$6.13 \pm 0.92$	4
		$\mu\nu$	$0.326 \pm 0.019$	$282 \pm 26$	$4.98 \pm 0.54$	4
1250	794	$e\nu$	$0.527 \pm 0.024$	$143 \pm 14$	$3.09 \pm 0.49$	3
		$\mu\nu$	$0.367 \pm 0.021$	$99 \pm 10$	$2.87 \pm 0.34$	3
1500	891	$e\nu$	$0.541 \pm 0.026$	$49.6 \pm 6.0$	$1.75 \pm 0.32$	2
		$\mu\nu$	$0.374 \pm 0.024$	$34.4 \pm 4.4$	$1.57 \pm 0.23$	2
1750	1000	$e\nu$	$0.515 \pm 0.024$	$17.3 \pm 2.4$	$0.89 \pm 0.20$	1
		$\mu\nu$	$0.338 \pm 0.020$	$11.4 \pm 1.7$	$0.82 \pm 0.14$	1
2000	1122	$e\nu$	$0.472 \pm 0.023$	$6.16 \pm 0.99$	$0.48 \pm 0.10$	1
		$\mu\nu$	$0.323 \pm 0.021$	$4.21 \pm 0.70$	$0.44 \pm 0.09$	1
2250	1122	$e\nu$	$0.415 \pm 0.019$	$2.84 \pm 0.50$	$0.48 \pm 0.10$	1
		$\mu\nu$	$0.288 \pm 0.018$	$1.97 \pm 0.36$	$0.44 \pm 0.09$	1
2500	1122	$e\nu$	$0.333 \pm 0.018$	$0.81 \pm 0.16$	$0.48 \pm 0.10$	1
		$\mu\nu$	$0.221 \pm 0.017$	$0.53 \pm 0.11$	$0.44 \pm 0.09$	1

The maximum value for the signal selection efficiency is at  $m_{W'} = 1500$  GeV. For lower masses, the efficiency falls because the relative  $m_T$  threshold,  $m_{T\text{min}}/m_{W'}$ , increases to reduce the background level. For higher masses, the efficiency falls because a large fraction of the cross section goes to off-shell production with  $m_{\ell\nu} \ll m_{W'}$ .

The fraction of fully simulated signal events that pass the event selection and are above the  $m_T$  threshold provides the initial estimate of  $\varepsilon_{\text{sig}}$  for each mass. Small corrections are made to account for the difference in acceptance at NNLO (obtained from FEWZ) and that in the LO simulation. These vary from a 7% increase for  $m_{W'} = 500$  GeV to a 10% decrease for  $m_{W'} = 2500$  GeV. Contributions from  $W' \rightarrow \tau\nu$  with the  $\tau$ -lepton decaying leptonically have been neglected and would increase the  $W'$  event selection efficiencies by 3–4% for the highest masses. The background level is estimated for each mass by summing the EW and  $t\bar{t}$  event counts from simulation, and adding the small QCD contribution in the electron channel.

The experimental systematic uncertainties include efficiencies for the electron or muon trigger, reconstruction and selection. Lepton momentum and missing  $E_T$  response, characterized by scale and resolution, are also included. Most of these performance metrics are measured at relatively low  $p_T$  and their values are extrapolated to the high- $p_T$  regime relevant to this analysis. The uncertainties in these extrapolations are included but are too small to significantly affect the results. The uncertainty on the QCD background estimate also contributes to the background level uncertainties for the electron channel. In some cases, e.g. the missing  $E_T$  scale and the muon QCD background, the experimental systematic uncertainties are significantly reduced from the previous study [4] because the additional available data allow more precise determination. In other cases they are similar or even larger, but have little effect on the final results.

**Table 4**

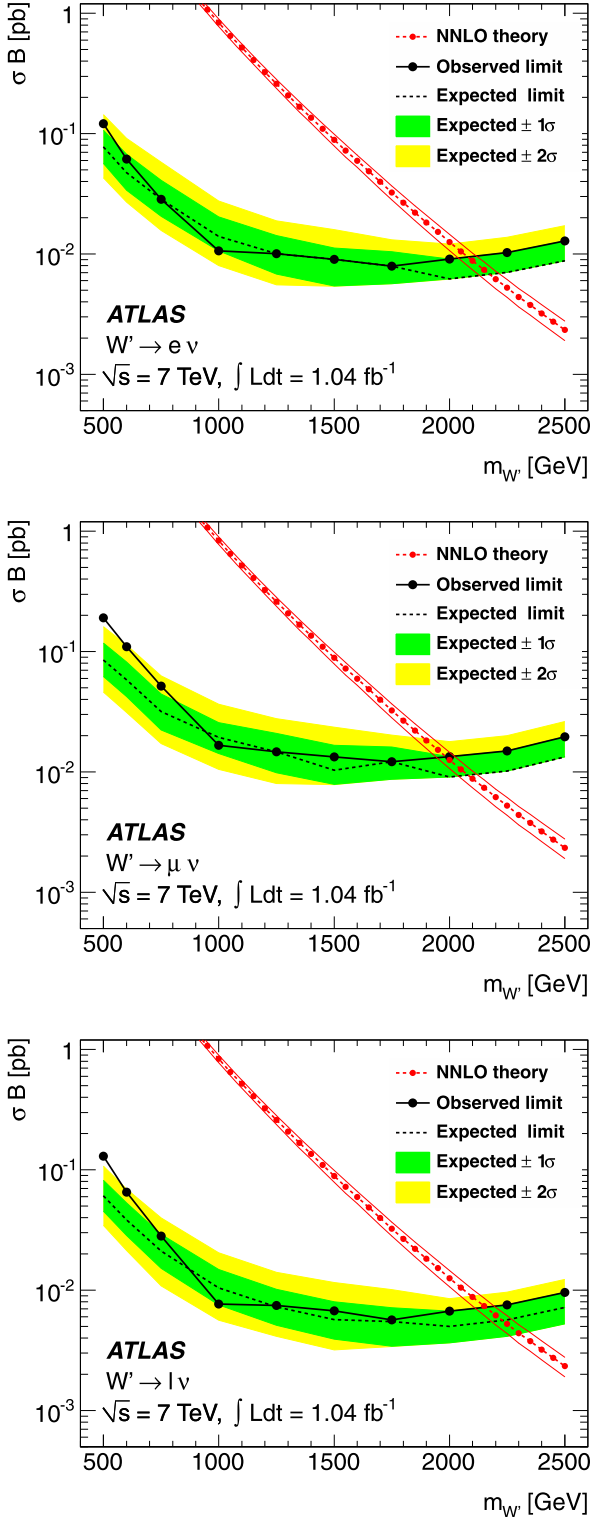
Relative uncertainties on the event selection efficiency and background level for a  $W'$  with a mass of 1500 GeV. The efficiency uncertainties include contributions from trigger, reconstruction and event selection. The cross section uncertainty for  $\varepsilon_{\text{sig}}$  is that assigned to the acceptance correction described in the text. The last row gives the total uncertainties.

Source	$\varepsilon_{\text{sig}}$		$N_{\text{bg}}$	
	$e\nu$	$\mu\nu$	$e\nu$	$\mu\nu$
Efficiency	3%	4%	3%	4%
Energy/momentum resolution	-	2%	3%	1%
Energy/momentum scale	1%	1%	5%	3%
QCD background	-	-	10%	1%
Monte Carlo statistics	3%	3%	9%	10%
Cross section (shape/level)	3%	3%	10%	10%
All	5%	6%	18%	15%

Table 4 summarizes the uncertainties on the event selection efficiencies and background levels for the  $W' \rightarrow \ell\nu$  signal with  $m_{W'} = 1500$  GeV using  $m_T > 891$  GeV.

## 7. Results

None of the observations for any mass in either channel or their combination has a significance above three-sigma, so there is no evidence for the observation of  $W' \rightarrow \ell\nu$ . Table 5 and Fig. 2 present the 95% CL (confidence level) observed limits on  $\sigma B$  for both  $W' \rightarrow \ell\nu$  decay channels and their combination. The figure also shows the expected limits and the theoretical  $\sigma B$  for an SSM  $W'$ . The intersection between the central theoretical prediction and the observed limits provides the 95% CL lower limit on the mass. Table 6 presents the expected and observed  $W'$  mass limits for the electron and muon decay channels and for the combination of the two channels. The observed combined mass limit is 2.15 TeV.



**Fig. 2.** Expected and observed limits on  $\sigma B$  for  $W' \rightarrow e\nu$  (top),  $W' \rightarrow \mu\nu$  (center), and the combination (bottom) assuming the same branching fraction for both channels. The NNLO calculated cross section and its uncertainty are also shown.

The above results are obtained using a prior probability flat in  $\sigma B$ . If this prior is replaced by one flat in coupling strength, the  $\sigma B$  limits improve by 20–28% for  $m_{W'} \geq 1000$  GeV and by smaller amounts at the lower masses. The reference prior [28,29], which minimizes the information supplied by the prior, gives intermediate results. Limits evaluated with  $CL_s$  [30] for the electron and

**Table 5**

Upper limits on  $\sigma B$  for  $W' \rightarrow \ell\nu$ . The first two columns are the mass and decay channel and the following columns are the 95% CL limits with headers indicating the nuisance parameters for which uncertainties are included: S for the event selection efficiency ( $\epsilon_{\text{sig}}$ ), B for the background level ( $N_{\text{bg}}$ ), and L for the integrated luminosity ( $L_{\text{int}}$ ). Columns labeled SBL include all uncertainties and are used to evaluate mass limits. Results are given for the electron and muon channels and both combined.

$m_{W'}$ [GeV]		95% CL limit on $\sigma B$ [fb]			
		none	S	SB	SBL
500	$e\nu$	97	98	117	121
	$\mu\nu$	171	174	186	191
	both	109	110	127	130
600	$e\nu$	49	49	59	61
	$\mu\nu$	99	100	108	110
	both	55	55	64	65
750	$e\nu$	23.0	23.1	28.1	28.5
	$\mu\nu$	49.2	49.8	50.9	51.7
	both	23.7	23.8	27.8	28.1
1000	$e\nu$	10.1	10.2	10.5	10.6
	$\mu\nu$	16.1	16.3	16.5	16.7
	both	7.3	7.3	7.6	7.7
1250	$e\nu$	9.8	9.9	10.0	10.1
	$\mu\nu$	14.4	14.5	14.6	14.7
	both	7.3	7.3	7.4	7.5
1500	$e\nu$	8.8	8.9	9.0	9.0
	$\mu\nu$	13.0	13.2	13.2	13.3
	both	6.6	6.6	6.7	6.7
1750	$e\nu$	7.8	7.9	7.9	7.9
	$\mu\nu$	12.0	12.1	12.1	12.2
	both	5.6	5.6	5.7	5.7
2000	$e\nu$	8.9	9.0	9.0	9.1
	$\mu\nu$	13.2	13.3	13.3	13.4
	both	6.6	6.7	6.7	6.7
2250	$e\nu$	10.2	10.2	10.3	10.3
	$\mu\nu$	14.8	14.9	14.9	15.0
	both	7.5	7.5	7.6	7.6
2500	$e\nu$	12.7	12.8	12.8	12.9
	$\mu\nu$	19.2	19.5	19.6	19.7
	both	9.5	9.6	9.6	9.6

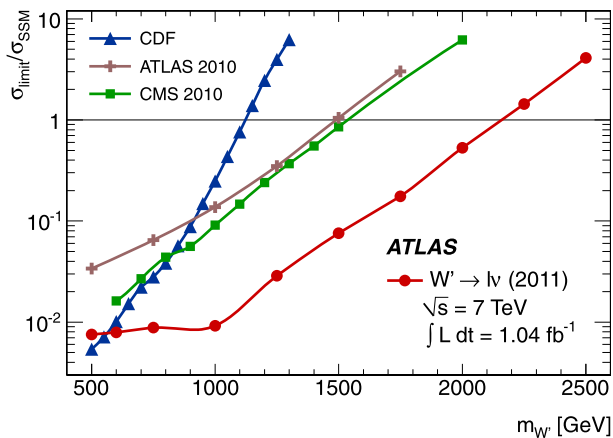
**Table 6**

Lower limits at 95% CL on the SSM  $W'$  mass. The first column is the decay channel ( $e\nu$ ,  $\mu\nu$  or both combined) and the following columns give the expected (Exp.) and observed (Obs.) mass limits.

	$m_{W'}$ [TeV]	
	Exp.	Obs.
$e\nu$	2.17	2.08
$\mu\nu$	2.08	1.98
both	2.23	2.15

muon channels and including all uncertainties are nearly identical to the corresponding values in Table 5.

Prior to this Letter, the best limits for  $500 < m_{W'} < 800$  GeV were established by CDF [2] in  $W' \rightarrow e\nu$  with  $p\bar{p}$  collisions at  $\sqrt{s} = 1.96$  TeV using an integrated luminosity of  $5.3 \text{ fb}^{-1}$ . At higher masses, the best limits were set by CMS [3] and ATLAS [4], each combining electron and muon channels and using  $pp$  collisions at  $\sqrt{s} = 7$  TeV with  $36 \text{ pb}^{-1}$  of data acquired in 2010. The CDF and CMS limits were obtained with a Bayesian approach, and the earlier ATLAS results were established with  $CL_s$ . Fig. 3 compares the limits obtained here with those earlier measurements. The comparison is made using the ratio of the limit to the calculated value of  $\sigma B$ , a quantity that is proportional to the square of the coupling strength. The NNLO cross sections in Table 1 are used



**Fig. 3.** Normalized cross section limits ( $\sigma_{\text{limit}}/\sigma_{\text{SSM}}$ ) for  $W' \rightarrow \ell\nu$  as a function of mass for this measurement and from CDF [2], CMS [3] and the previous ATLAS search [4]. The cross section calculations assume the  $W'$  has the same couplings as the standard model  $W$  boson. The region above each curve is excluded at the 95% CL.

for both the ATLAS and CMS points. The limits presented here provide significant improvement for masses above 600 GeV.

## 8. Conclusions

The ATLAS detector has been used to search for new high-mass states decaying to a lepton plus missing  $E_T$ . The search is performed in  $pp$  collisions at  $\sqrt{s} = 7$  TeV using  $1.04 \text{ fb}^{-1}$  of integrated luminosity. No excess above SM expectations is observed. Bayesian limits on  $\sigma B$  are shown in Figs. 2 and 3. These are the best published limits for  $m_{W'} > 600$  GeV. A  $W'$  with SSM couplings is excluded for masses up to 2.15 TeV at the 95% CL.

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## References

- [1] K. Nakamura, et al., *J. Phys. G* 37 (2010) 075021.
- [2] T. Aaltonen, et al., CDF Collaboration, *Phys. Rev. D* 83 (2011) 031102.
- [3] CMS Collaboration, *Phys. Lett. B* 701 (2011) 160.
- [4] ATLAS Collaboration, *Phys. Lett. B* 701 (2011) 50.
- [5] G. Altarelli, B. Mele, M. Ruiz-Altaba, *Z. Phys. C* 45 (1989) 109.
- [6] ATLAS Collaboration, *JINST* 3 (2008) S08003.
- [7] ATLAS Collaboration, *JHEP* 1012 (2010) 060.
- [8] ATLAS Collaboration, CERN-OPEN-2008-020, 2009.
- [9] T. Sjostrand, S. Mrenna, P. Skands, *JHEP* 0605 (2006) 026.
- [10] A. Sherstnev, R.S. Thorne, *Eur. Phys. J. C* 55 (2008) 553.
- [11] S. Frixione, B.R. Webber, *JHEP* 0206 (2002) 029.
- [12] P. Golonka, Z. Was, *Eur. Phys. J. C* 45 (2006) 97.
- [13] ATLAS Collaboration, *Eur. Phys. J. C* 70 (2010) 823.
- [14] S. Agostinelli, et al., *Nucl. Instrum. Methods A* 506 (2003) 250.
- [15] R. Hamberg, W.L. van Neerven, T. Matsuura, *Nucl. Phys. B* 359 (1991) 343; R. Hamberg, W.L. van Neerven, T. Matsuura, *Nucl. Phys. B* 644 (2002) 403 (Erratum).
- [16] A. Martin, W. Stirling, R. Thorne, G. Watt, *Eur. Phys. J. C* 63 (2009) 189.
- [17] C. Carloni Calame, G. Montagna, O. Nicrosini, A. Vicini, *JHEP* 0612 (2006) 016.
- [18] C.M. Carloni Calame, G. Montagna, O. Nicrosini, A. Vicini, *JHEP* 0710 (2007) 109.
- [19] K. Melnikov, F. Petriello, *Phys. Rev. D* 74 (2006) 114017.
- [20] R. Gavin, Y. Li, F. Petriello, S. Quackenbush, *Comput. Phys. Commun.* 182 (2011) 2388.
- [21] S. Moch, P. Uwer, *Phys. Rev. D* 78 (2008) 034003.
- [22] U. Langenfeld, S. Moch, P. Uwer, arXiv:0907.2527 [hep-ph], 2009.
- [23] M. Aliev, et al., *Comput. Phys. Commun.* 182 (2010) 1034.
- [24] ATLAS Collaboration, *Eur. Phys. J. C* 71 (2011) 1577.
- [25] P.M. Nadolsky, et al., *Phys. Rev. D* 78 (2008) 013004.
- [26] ATLAS Collaboration, ATLAS-CONF-2010-038, 2010, <http://cdsweb.cern.ch/record/1277678>.
- [27] ATLAS Collaboration, *Phys. Rev. D* 83 (2011) 052005.
- [28] J. Bernardo, in: *Handbook of Statistics*, vol. 25, 2005, p. 17.
- [29] L. Demortier, S. Jain, H. Prosper, *Phys. Rev. D* 82 (2010) 034002.
- [30] T. Junk, *Nucl. Instrum. Methods A* 434 (1999) 435.

## 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. Aharrouché<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. Andreatza<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>, 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>29</sup>, A. Belloni<sup>57</sup>, O. Beloborodova<sup>107</sup>, K. Belotskiy<sup>96</sup>,  
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 S. Bentvelsen<sup>105</sup>, D. Berge<sup>29</sup>, E. Bergeas 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>,  
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 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. Bondioli<sup>163</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. 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. Buira-Clark<sup>118</sup>, O. Bulekov<sup>96</sup>,  
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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>, 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,aa</sup>, O.E. Vickey Boeriu<sup>145b</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>2</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,ab</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,r</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.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,p</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. Wingerter-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,i</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,ac</sup>, E. Wulf<sup>34</sup>, R. Wunstorf<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,ad</sup>, D. Xu<sup>139</sup>, G. Xu<sup>32a</sup>, B. Yabsley<sup>150</sup>, S. Yacoob<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>, 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,ad</sup>, L. Yuan<sup>32a,ae</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>, M. Zeman<sup>125</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,ab</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,af</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<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;<sup>(d)</sup> 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<sup>6</sup> Department of Physics, University of Arizona, Tucson, AZ, United States<sup>7</sup> Department of Physics, The University of Texas at Arlington, Arlington, TX, United States<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 Departament de Física de la 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
- <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
- <sup>22</sup> Department of Physics, Brandeis University, Waltham, MA, United States
- <sup>23</sup> <sup>(a)</sup> Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; <sup>(b)</sup> Federal University of Juiz de Fora (UFJF), Juiz de Fora; <sup>(c)</sup> Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei; <sup>(d)</sup> Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil
- <sup>24</sup> Physics Department, Brookhaven National Laboratory, Upton, NY, United States
- <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
- <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
- <sup>35</sup> Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
- <sup>36</sup> <sup>(a)</sup> INFN Gruppo Collegato di Cosenza; <sup>(b)</sup> Dipartimento di Fisica, Università della Calabria, Arcavacata 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
- <sup>40</sup> Physics Department, University of Texas at Dallas, Richardson, TX, United States
- <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
- <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
- <sup>57</sup> Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, MA, United States
- <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
- <sup>62</sup> Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- <sup>63</sup> University of Iowa, Iowa City, IA, United States
- <sup>64</sup> Department of Physics and Astronomy, Iowa State University, Ames, IA, United States
- <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

- 84 Department of Physics, University of Massachusetts, Amherst, MA, United States  
 85 Department of Physics, McGill University, Montreal, QC, Canada  
 86 School of Physics, University of Melbourne, Victoria, Australia  
 87 Department of Physics, The University of Michigan, Ann Arbor, MI, United States  
 88 Department of Physics and Astronomy, Michigan State University, East Lansing, MI, United States  
 89 <sup>(a)</sup> INFN Sezione di Milano; <sup>(b)</sup> Dipartimento di Fisica, Università di Milano, Milano, Italy  
 90 B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Belarus  
 91 National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Belarus  
 92 Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, United States  
 93 Group of Particle Physics, University of Montreal, Montreal, QC, Canada  
 94 P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia  
 95 Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia  
 96 Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia  
 97 Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia  
 98 Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany  
 99 Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany  
 100 Nagasaki Institute of Applied Science, Nagasaki, Japan  
 101 Graduate School of Science, Nagoya University, Nagoya, Japan  
 102 <sup>(a)</sup> INFN Sezione di Napoli; <sup>(b)</sup> Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy  
 103 Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM, United States  
 104 Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands  
 105 Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands  
 106 Department of Physics, Northern Illinois University, DeKalb, IL, United States  
 107 Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia  
 108 Department of Physics, New York University, New York, NY, United States  
 109 Ohio State University, Columbus, OH, United States  
 110 Faculty of Science, Okayama University, Okayama, Japan  
 111 Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, OK, United States  
 112 Department of Physics, Oklahoma State University, Stillwater, OK, United States  
 113 Palacký University, RCPTM, Olomouc, Czech Republic  
 114 Center for High Energy Physics, University of Oregon, Eugene, OR, United States  
 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  
 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  
 124 <sup>(a)</sup> Laboratório de Instrumentação e Física Experimental de Partículas – LIP, Lisboa, Portugal; <sup>(b)</sup> Departamento de Física Teórica 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’Energie 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 à l’Energie Atomique), Gif-sur-Yvette, France  
 137 Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, CA, United States  
 138 Department of Physics, University of Washington, Seattle, WA, United States  
 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  
 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  
 147 Physics Department, Royal Institute of Technology, Stockholm, Sweden  
 148 Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY, United States  
 149 Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom  
 150 School of Physics, University of Sydney, Sydney, Australia  
 151 Institute of Physics, Academia Sinica, Taipei, Taiwan  
 152 Department of Physics, Technion: Israel Inst. of Technology, Haifa, Israel  
 153 Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel  
 154 Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece  
 155 International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan  
 156 Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan  
 157 Department of Physics, Tokyo Institute of Technology, Tokyo, Japan  
 158 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  
<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  
<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  
<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  
<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  
<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.

<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 Fermilab, Batavia, IL, United States.

<sup>i</sup> Also at Department of Physics, University of Coimbra, Coimbra, Portugal.

<sup>j</sup> Also at Università di Napoli Parthenope, Napoli, Italy.

<sup>k</sup> Also at Institute of Particle Physics (IPP), Canada.

<sup>l</sup> Also at Department of Physics, Middle East Technical University, Ankara, Turkey.

<sup>m</sup> Also at Louisiana Tech University, Ruston, LA, United States.

<sup>n</sup> Also at Group of Particle Physics, University of Montreal, Montreal, QC, Canada.

<sup>o</sup> Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.

<sup>p</sup> Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.

<sup>q</sup> Also at Manhattan College, New York, NY, United States.

<sup>r</sup> Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.

<sup>s</sup> Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.

<sup>t</sup> Also at High Energy Physics Group, Shandong University, Shandong, China.

<sup>u</sup> Also at Section de Physique, Université de Genève, Geneva, Switzerland.

<sup>v</sup> Also at Departamento de Física, Universidade de Minho, Braga, Portugal.

<sup>w</sup> Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, United States.

<sup>x</sup> Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary.

<sup>y</sup> Also at California Institute of Technology, Pasadena, CA, United States.

<sup>z</sup> Also at Institute of Physics, Jagiellonian University, Krakow, Poland.

<sup>aa</sup> Also at Department of Physics, Oxford University, Oxford, United Kingdom.

<sup>ab</sup> Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.

<sup>ac</sup> Also at Department of Physics, The University of Michigan, Ann Arbor, MI, United States.

<sup>ad</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>ae</sup> Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.

<sup>af</sup> Also at Department of Physics, Nanjing University, Jiangsu, China.

\* Deceased.