

MIT Open Access Articles

Combination of inclusive top-quark pair production cross-section measurements using ATLAS and CMS data at $\sqrt{s} = 7$ and 8 TeV

The MIT Faculty has made this article openly available. **Please share** how this access benefits you. Your story matters.

Citation: Journal of High Energy Physics. 2023 Jul 27;2023(7):213

As Published: [https://doi.org/10.1007/JHEP07\(2023\)213](https://doi.org/10.1007/JHEP07(2023)213)

Publisher: Springer Berlin Heidelberg

Persistent URL: <https://hdl.handle.net/1721.1/152105>

Version: Final published version: final published article, as it appeared in a journal, conference proceedings, or other formally published context

Terms of use: Creative Commons Attribution



Combination of inclusive top-quark pair production cross-section measurements using ATLAS and CMS data at $\sqrt{s} = 7$ and 8 TeV



The ATLAS collaboration and the CMS collaboration

E-mail: atlas.publications@cern.ch

ABSTRACT: A combination of measurements of the inclusive top-quark pair production cross-section performed by ATLAS and CMS in proton–proton collisions at centre-of-mass energies of 7 and 8 TeV at the LHC is presented. The cross-sections are obtained using top-quark pair decays with an opposite-charge electron–muon pair in the final state and with data corresponding to an integrated luminosity of about 5 fb^{-1} at $\sqrt{s} = 7$ TeV and about 20 fb^{-1} at $\sqrt{s} = 8$ TeV for each experiment. The combined cross-sections are determined to be $178.5 \pm 4.7 \text{ pb}$ at $\sqrt{s} = 7$ TeV and $243.3_{-5.9}^{+6.0} \text{ pb}$ at $\sqrt{s} = 8$ TeV with a correlation of 0.41, using a reference top-quark mass value of 172.5 GeV. The ratio of the combined cross-sections is determined to be $R_{8/7} = 1.363 \pm 0.032$. The combined measured cross-sections and their ratio agree well with theory calculations using several parton distribution function (PDF) sets. The values of the top-quark pole mass (with the strong coupling fixed at 0.118) and the strong coupling (with the top-quark pole mass fixed at 172.5 GeV) are extracted from the combined results by fitting a next-to-next-to-leading-order plus next-to-next-to-leading-log QCD prediction to the measurements. Using a version of the NNPDF3.1 PDF set containing no top-quark measurements, the results obtained are $m_t^{\text{pole}} = 173.4_{-2.0}^{+1.8} \text{ GeV}$ and $\alpha_s(m_Z) = 0.1170_{-0.0018}^{+0.0021}$.

KEYWORDS: Hadron-Hadron Scattering, Top Physics

ARXIV EPRINT: [2205.13830](https://arxiv.org/abs/2205.13830)

Contents

1	Introduction	1
2	ATLAS measurements	2
3	CMS measurements	4
4	Combination method and assumptions	5
4.1	ATLAS and CMS systematic uncertainties	7
4.2	Correlation assumptions	8
5	Results	12
5.1	Cross-section combination	12
5.2	Top-quark pole mass and strong coupling	14
6	Summary and conclusions	17
	The ATLAS collaboration	24
	The CMS collaboration	43

1 Introduction

The top quark is the most massive known fundamental particle, with a mass close to the scale of the electroweak symmetry breaking [1]. Studying the production and decay of the top quark in proton–proton (pp) collisions is a crucial element of the CERN LHC physics programme and provides precise tests of the Standard Model (SM). At the LHC, top quarks are produced mostly in quark–antiquark pairs ($t\bar{t}$). For this production mode, precise predictions at next-to-next-to-leading order (NNLO) in perturbative quantum chromodynamics (QCD) including resummation of next-to-next-to-leading-log (NNLL) soft-gluon terms are available [2–7]. Consequently, precise measurements of the $t\bar{t}$ production cross-section ($\sigma_{t\bar{t}}$) may reveal contributions from non-SM processes that modify $\sigma_{t\bar{t}}$, such as those in supersymmetric models with R-parity conservation [8]. Moreover, measurements of $\sigma_{t\bar{t}}$ can provide constraints on essential parameters of the SM, such as the top-quark pole mass (m_t^{pole}) and the strong coupling (α_s), and on parton distribution functions (PDFs).

The predicted $t\bar{t}$ production cross-section in pp collisions depends on the PDF set. Table 1 shows the predictions for the NNLO PDF sets CT14 [9], MMHT14 [10], and NNPDF3.1NNLO_ascorr_notop (referred to as NNPDF3.1_a) [11].¹ The precision of the

¹The PDF sets NNPDF3.1_a and CT14 do not include any top-quark-related measurements, such that any potential bias can be avoided when using them together with the combined cross-sections to extract a top-quark mass and the strong coupling. The MMHT14 PDF set does include information from the $t\bar{t}$ cross-section at the LHC (but no alternative PDF sets were provided by the authors).

PDF set	$\sigma_{t\bar{t}}(\sqrt{s} = 7 \text{ TeV})$ [pb]	$\sigma_{t\bar{t}}(\sqrt{s} = 8 \text{ TeV})$ [pb]	$R_{8/7}$
CT14	$181.7^{+10.6}_{-10.3}$	$258.9^{+13.8}_{-14.3}$	$1.425^{+0.007}_{-0.008}$
MMHT14	$181.2^{+9.6}_{-10.3}$	$258.1^{+12.8}_{-14.1}$	$1.424^{+0.005}_{-0.004}$
NNPDF3.1_a	$178.8^{+7.8}_{-8.8}$	$255.3^{+10.6}_{-12.2}$	$1.428^{+0.005}_{-0.004}$

Table 1. Predicted $t\bar{t}$ production cross-sections at different centre-of-mass energies and for different PDF sets. The uncertainties comprise PDF and α_s uncertainties as well as uncertainties in the renormalisation and factorisation scales. The ratio of the predicted $t\bar{t}$ production cross-sections at $\sqrt{s} = 8$ TeV and 7 TeV, $R_{8/7}$, is also shown. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements.

prediction depends on the uncertainties in the PDF set, the dependence of the PDF set and the calculation on α_s , and the choice of factorisation and renormalisation scales. These predictions are calculated at NNLO+NNLL accuracy in QCD for a top-quark pole mass of 172.5 GeV with TOP++ [12]. The quoted scale uncertainty is derived from the envelope obtained by independently varying the renormalisation and factorisation scales from m_t^{pole} by factors of 0.5 and 2.0. Variations where these scales differ from each other by a factor of more than two are not included.

Measurements of $\sigma_{t\bar{t}}$ were performed previously by the ATLAS [13] and CMS [14] Collaborations at $\sqrt{s} = 7$ TeV and 8 TeV in various decay channels [15–28]. Each top quark decays almost exclusively into a W boson and a b -quark. The subsequent decays of the W bosons define the $t\bar{t}$ final-state topology to be either fully hadronic, with one, or with two leptonic decays. In this paper, ATLAS and CMS present a combination of their most precise measurements of $\sigma_{t\bar{t}}$ in pp collisions at $\sqrt{s} = 7$ and 8 TeV, obtained using $t\bar{t}$ decays into electron–muon ($e\mu$) pairs [15, 19]. The final-state topology of this decay mode is defined by the two leptons of opposite charge and different flavour, two jets which are identified as originating from final-state b -quarks (b -tagged jets), and missing transverse momentum from the undetected neutrinos. This final state also includes small contributions from $W \rightarrow \tau\nu_\tau$ with subsequent leptonic τ decays. The combined $\sigma_{t\bar{t}}$ values are then used to extract m_t^{pole} and α_s through comparison with NNLO+NNLL predictions for various PDF sets.

The individual input measurements are briefly summarised in sections 2 and 3. The combination method and the correlation assumptions used for the systematic uncertainties from ATLAS and CMS are described in section 4. The combined results are presented in section 5, along with the extraction of m_t^{pole} and α_s . The summary and conclusions can be found in section 6.

2 ATLAS measurements

The most precise measurements of the inclusive $t\bar{t}$ cross-section in pp collisions at $\sqrt{s} = 7$ and 8 TeV from the ATLAS Collaboration used events with an opposite-charge $e\mu$ pair and one or two b -tagged jets [15]. The $t\bar{t}$ production cross-section was determined by counting the numbers of opposite-charge $e\mu$ events formed from an isolated electron and isolated muon with exactly one (N_1) or with exactly two (N_2) b -tagged jets. A working point of

70% efficiency for tagging b -jets from top-quark decays, corresponding to a rejection factor of about 140 against light-quark and gluon jets, was used. The two event counts can be expressed as

$$\begin{aligned} N_1 &= L\sigma_{t\bar{t}} \epsilon_{e\mu} 2\epsilon_b(1 - C_b\epsilon_b) + N_1^{\text{bkg}}, \\ N_2 &= L\sigma_{t\bar{t}} \epsilon_{e\mu} C_b\epsilon_b^2 + N_2^{\text{bkg}}, \end{aligned} \tag{2.1}$$

where L is the integrated luminosity of the sample and $\epsilon_{e\mu}$ is the efficiency for a $t\bar{t}$ event to pass the opposite-charge $e\mu$ preselection. The combined probability for a jet from the quark q in the $t \rightarrow Wq$ decay to fall within the acceptance of the detector, be reconstructed as a jet with transverse momentum $p_T > 25$ GeV and pseudorapidity $|\eta| < 2.5$, and be tagged as a b -jet, is denoted by ϵ_b . If the decays of the two top quarks and the subsequent reconstruction of the two b -tagged jets are completely independent, the probability to tag both b -jets is given by ϵ_b^2 . In practice, small correlations are present for both physical and instrumental reasons, and these are taken into account with the b -tagging correlation factor C_b . This correlation factor is close to unity such that a value greater than one corresponds to a positive correlation (i.e., where a second jet is more likely to be selected if the first one is already selected). The background sources also contribute to the event counts N_1 and N_2 . These contributions are represented by the terms N_1^{bkg} and N_2^{bkg} . The preselection efficiency $\epsilon_{e\mu}$ and tagging correlation C_b were taken from $t\bar{t}$ event simulation, assuming a top-quark mass of 172.5 GeV, and the background contributions N_1^{bkg} and N_2^{bkg} were estimated using a combination of simulation and data-driven methods, allowing the two equations in eq. (2.1) to be solved for $\sigma_{t\bar{t}}$ and ϵ_b , independently for 7 and 8 TeV. The effect of the small contributions from $t\bar{t}$ production in association with other heavy-flavour quarks ($c\bar{c}$ or $b\bar{b}$) was absorbed into C_b .

The largest systematic uncertainties in these measurements came from $t\bar{t}$ modelling, PDFs, and imperfect knowledge of the integrated luminosities. A summary of the uncertainties in $\sigma_{t\bar{t}}$ is shown in table 2. The uncertainty from each source was evaluated by repeatedly solving eqs. (2.1) with all their parameters simultaneously changed according to the parameter's dependence on a variation of ± 1 standard deviation (σ) of that particular source. Correlated effects of the parameters variations on the measurements were thus taken into account. The total uncertainties in $\sigma_{t\bar{t}}$ and ϵ_b were calculated by adding the statistical uncertainties and effects of all the individual systematic components in quadrature, assuming them to be independent. In order to facilitate the combination with the CMS measurements, several ATLAS uncertainties are merged in quadrature compared to the list of uncertainties presented in ref. [15].

The cross-sections were measured to be

$$\begin{aligned} \sigma_{t\bar{t}}(\sqrt{s} = 7 \text{ TeV}) &= 182.9 \pm 3.1 \text{ (stat.)} \pm 4.2 \text{ (exp.+theo.)} \pm 3.6 \text{ (lumi.) pb} \text{ and} \\ \sigma_{t\bar{t}}(\sqrt{s} = 8 \text{ TeV}) &= 242.9 \pm 1.7 \text{ (stat.)} \pm 5.5 \text{ (exp.+theo.)} \pm 5.1 \text{ (lumi.) pb,} \end{aligned}$$

where the three uncertainties arose from the statistical power of the data, experimental and theoretical systematic effects, and imperfect knowledge of the integrated luminosity, respectively. Although included in the original references, the LHC beam energy uncertainty is not used in the combination presented in this paper due to its reduced value as

ATLAS Source	Merged uncertainty [%]	
	7 TeV	8 TeV
Trigger	0.2	0.2
Lepton (mis-)ID/isolation	0.9	0.8
Lepton energy scale	0.3	0.5
JES flavour composition/specific response	0.2	0.4
JES modelling	0.04	0.2
JES central/forward balance	0.03	0.1
JES pile-up	0.03	0.2
Other JES	0.03	0.2
Jet energy resolution	0.3	0.5
<i>b</i> -jet ID	0.4	0.4
<i>b</i> -jet mis-ID	0.02	0.02
<i>tW</i> background	0.8	0.8
Drell–Yan background	0.05	0.02
Diboson background	0.1	0.1
<i>t</i> \bar{t} scale choice	0.3	0.3
<i>t</i> \bar{t} generator modelling	1.4	1.2
PDF	1.0	1.1
Integrated luminosity	2.0	2.1
Statistical	1.7	0.7
Total uncertainty	3.5	3.2

Table 2. Summary of the relative statistical, systematic and total uncertainties in the ATLAS measurements of the $t\bar{t}$ production cross-section, $\sigma_{t\bar{t}}$, at $\sqrt{s} = 7$ and 8 TeV from ref. [15], where ID stands for identification and JES for jet-energy scale. The grouping of the systematic uncertainties is modified with respect to ref. [15] to allow for the combination with the CMS measurements.

shown in refs. [29, 30].² The results are consistent with theoretical QCD calculations at NNLO+NNLL accuracy.

3 CMS measurements

The CMS measurements of $\sigma_{t\bar{t}}$ at $\sqrt{s} = 7$ and 8 TeV were based on a binned likelihood fit to final-state observables and were also performed in the $e\mu$ channel [19]. All events with an oppositely charged pair formed from an isolated electron and isolated muon were divided into three categories in *b*-tagged jet multiplicity (N_b). The event counts in the categories with exactly one or two *b*-tagged jets were expressed using eq. (2.1). The remaining events were assigned to a category with either zero or more than two *b*-tagged jets ($N_{0,\geq 3}$), for which the event count was given by

$$N_{0,\geq 3} = L\sigma_{t\bar{t}} \epsilon_{e\mu} - (N_1 - N_1^{\text{bkg}}) - (N_2 - N_2^{\text{bkg}}) + N_{0,\geq 3}^{\text{bkg}}, \quad (3.1)$$

where $N_{0,\geq 3}^{\text{bkg}}$ is the number of background events in the category with either zero or more than two *b*-tagged jets. For *b*-tagging, a high-purity working point with a 0.1% average

²This was a 1.8% uncertainty in the $t\bar{t}$ cross-section value for a 0.66% uncertainty in beam energy, while the beam energy is now known to an accuracy of 0.1%.

misidentification rate for light-flavour quark and gluon jets was used, such that the contribution from events with three or more b -tagged jets in this category is negligible. The variables $\epsilon_{e\mu}$, C_b , and ϵ_b in eqs. (2.1) and (3.1) were centred at the values predicted by the simulation and varied according to the uncertainties assigned to the simulation as opposed to determining ϵ_b and $\sigma_{t\bar{t}}$ by solving the equations as is done for the ATLAS measurement.

In each N_b category, the events were further categorised according to the number of additional non- b -tagged jets. The cross-section extraction was performed treating all systematic uncertainties as nuisance parameters in a binned profile likelihood fit. As input to this fit, the p_T distribution of the lowest- p_T additional jet was used, if present, to tighten the constraints on jet-energy scale (JES) uncertainties. In subcategories with zero additional jets, only the total event yield was fitted. The cross-sections were determined simultaneously at $\sqrt{s} = 7$ and 8 TeV. For this purpose, systematic uncertainties partially correlated between $\sqrt{s} = 7$ and 8 TeV were split into a correlated component and two uncorrelated contributions, one for each centre-of-mass energy. Uncertainties were only constrained in the fiducial phase space defined by the kinematic acceptance for the $e\mu$ pair. Additional uncertainties were assigned to the extrapolation to the full phase space and were added in quadrature. The largest contributions to the total uncertainty stem from trigger and lepton efficiencies, the Drell–Yan background modelling, and imperfect knowledge of the luminosity.

The final results, assuming a top-quark mass of 172.5 GeV, were

$$\begin{aligned} \sigma_{t\bar{t}}(\sqrt{s} = 7 \text{ TeV}) &= 173.6 \pm 2.1 \text{ (stat.)}_{-4.0}^{+4.5} \text{ (exp.+theo.)} \pm 3.8 \text{ (lumi.) pb and} \\ \sigma_{t\bar{t}}(\sqrt{s} = 8 \text{ TeV}) &= 244.9 \pm 1.4 \text{ (stat.)}_{-5.5}^{+6.3} \text{ (exp.+theo.)} \pm 6.4 \text{ (lumi.) pb,} \end{aligned}$$

where the uncertainties arose from the statistical power of the data, experimental and theoretical systematic effects, and imperfect knowledge of the integrated luminosity, respectively. As a result of the combined fit of the nuisance parameters and cross-sections, correlations were introduced among all fitted parameters, described by a covariance matrix which included the uncertainties in the nuisance parameters as well as the uncertainties in the cross-sections. For illustration, the impact of groups of related uncertainties is summarised in table 3. The impact of each group of systematic uncertainties was estimated by fixing the corresponding parameters to their best-fit values, repeating the combination to assess the remaining uncertainty, and hence the size of an uncorrelated additional uncertainty that would reproduce the original total uncertainty. The latter estimate was taken as the impact of that uncertainty group, and only served as an illustrative estimate, since the full information is only contained in the full covariance matrix. For the statistical component, all nuisance parameters were fixed to their best-fit value and the remaining uncertainty contribution from statistics alone was evaluated. The results are in good agreement with theoretical QCD calculations at NNLO+NNLL accuracy.

4 Combination method and assumptions

The CMS measurement was performed with simultaneously profiled uncertainties, leading to non-negligible post-fit correlations between them. Commonly used BLUE combination

CMS Source	Uncertainty [%]	
	7 TeV	8 TeV
Trigger	1.3	1.2
Lepton (mis-)ID/isolation	1.5	1.5
Lepton energy scale	0.2	0.1
JES total	0.8	0.9
Jet energy resolution	0.1	0.1
<i>b</i> -jet ID	0.5	0.5
<i>b</i> -jet mis-ID	0.2	0.1
Pile-up	0.3	0.3
<i>tW</i> background	1.0	0.6
Drell–Yan background	1.4	1.3
Non- <i>eμ</i> <i>t</i> \bar{t}	0.1	0.1
<i>t</i> \bar{t} <i>V</i> background	0.1	0.1
Diboson background	0.2	0.6
<i>W</i> +jets/QCD background	0.1	0.2
<i>t</i> \bar{t} scale choice	0.3	0.6
ME/PS matching	0.1	0.1
ME generator	0.4	0.5
Hadronisation (JES)	0.7	0.7
Top-quark <i>p</i> _T modelling	0.3	0.4
Colour reconnection	0.1	0.2
Underlying event	0.1	0.1
PDF	0.2	0.3
Integrated luminosity	2.2	2.6
Statistical	1.2	0.6
<i>t</i> \bar{t} scale choice (extrapolation)	+0.1 −0.4	+0.2 −0.1
ME/PS matching (extrapolation)	+0.1 −0.1	+0.3 −0.3
Top-quark <i>p</i> _T (extrapolation)	+0.5 −0.3	+0.6 −0.3
PDF (extrapolation)	+0.1 −0.1	+0.1 −0.1
Total uncertainty	+3.6 −3.5	+3.7 −3.5

Table 3. Illustrative summary of the individual contributions to the total uncertainty in the CMS *t* \bar{t} cross-section measurements from ref. [19], where ID stands for identification, JES for jet-energy scale, ME for matrix element and PS for parton shower.

techniques [31, 32] provide no method to account for these correlations, and it is known that neglecting these correlations can lead to severe biases and incorrect uncertainty estimates [33]. Therefore, the combination is performed using an algorithm which allows the consistent modelling of these correlations, implemented in the software tool Convino [33] using the covariance matrices of the individual measurements. It is performed using a Pearson χ^2 [34] minimisation, where the systematic uncertainties are represented by nuisance parameters. The χ^2 is defined using three terms: one representing the results of each

measurement and their statistical uncertainties, another one describing the correlations between the nuisance parameters and constraints on them from the data for each measurement, and finally a term incorporating prior knowledge of the systematic uncertainties and the assumed correlations between uncertainties, modelled by a multivariate Gaussian with non-zero correlations. The method takes as input the full covariance matrix provided by CMS, in addition to the publicly available data. For the ATLAS measurements, where the systematic uncertainties are unconstrained in the fit procedure, the uncertainties are either fully correlated or uncorrelated between $\sqrt{s} = 7$ and 8 TeV, and the correlated uncertainty sources are modelled by a single parameter per source.

The covariance matrix C for a measurement can be expressed using four components

$$C = \begin{pmatrix} U & \kappa^T \\ \kappa & M \end{pmatrix},$$

where the first diagonal block matrix U describes the (co)variance of the nuisance parameters representing the systematic uncertainties. In the ATLAS case it is an identity matrix since the parameters describing the uncertainties are uncorrelated and are normalised to unity. A second block M describes the measured cross-sections, and also has diagonal form, with entries representing the variance of the individual measurements. The last part of the matrix, denoted by κ , describes the impact of a 1σ variation of a nuisance parameter on each of the cross-section measurements. The asymmetric extrapolation uncertainties in the CMS measurements have not been part of the fit to the data. These uncertainties are symmetrised by taking the maximum absolute impact as the symmetric uncertainty and are incorporated into the CMS covariance matrix using the same procedure. The components of the covariance matrix C as well as the covariance matrix of the CMS input measurement are available in HEPdata [35].

In this representation, the combination can be performed accounting for the correlation between the measurements as well as for the correlations and constraints within each individual measurement. For this purpose, the constraints from the data are separated from the prior assumptions on the nuisance parameters within Convino. These prior assumptions are assumed to follow a Gaussian distribution and express the range of a 1σ variation of the respective parameters within the profile likelihood fit. After separating these terms, the individual χ^2 terms of the ATLAS and CMS measurements are combined. The Gaussian terms are reintroduced through a covariance matrix in which the assumed correlations between the systematic uncertainties from the ATLAS and CMS measurements are also included. A more detailed description of the method, including a validation based on pseudo-experiments, can be found in ref. [33].

4.1 ATLAS and CMS systematic uncertainties

The differences in the sizes of the systematic uncertainties between the input ATLAS and CMS measurements (tables 2 and 3) arise from differences in the analysis methods and in the trigger and event selections. Full descriptions of each of the systematic uncertainties used in the individual measurements are available in refs. [15, 19]. As mentioned above, in order to facilitate the combination with the CMS measurements, several of the original

ATLAS uncertainties are merged through summation in quadrature, while taking into account the correlations between the ATLAS $\sqrt{s} = 7$ and 8 TeV uncertainties. Given that all CMS uncertainties are all to some degree correlated, it is not possible to sum them into groups by adding them in quadrature. Instead, each component, or set of components has to be correlated with the corresponding merged uncertainty in the ATLAS measurement as described in the following section.

4.2 Correlation assumptions

Several systematic uncertainties are assumed to be correlated between the ATLAS and CMS measurements. The correlation assumptions used in this combination are summarised in table 4. For each correlated systematic uncertainty, except that in the integrated luminosity, the level of correlation is set to be one of the following values: LOW (0.25), HALF (0.5), HIGH (0.75) and FULL (1.0). Moreover, the correlations have also been scanned, one at a time, in a range around the given assumption value, bounded by the adjacent levels of correlation, e.g., two parameters correlated with a correlation coefficient of 0.5 are scanned from 0.25 to 0.75. No such variation changes the results significantly. The largest change originates from the luminosity correlation coefficient, which changes the total uncertainty by only 0.15% when increased from 0.1 to 0.25. In cases where the sign of the correlation could not be determined unambiguously, the sign that maximises the total uncertainty of the combined result is chosen. This is the case for the correlation of, e.g., the matrix-element generator uncertainty of the CMS measurement with the generator uncertainty of the ATLAS result. Therefore, a conservative estimate is used in these cases.

Trigger: ATLAS uses single-lepton triggers, while CMS only considers dilepton triggers ($e\mu$). In addition, the techniques used to derive the trigger efficiencies are very different: in the case of ATLAS, the single-lepton trigger efficiencies are measured using tag-and-probe techniques, while for CMS, the efficiencies are derived from an orthogonal set of trigger paths based on missing transverse momentum. Therefore, the trigger uncertainties are considered to be uncorrelated.

Lepton-related uncertainties: for both the ATLAS and CMS measurements, the lepton energy scale, resolution, identification and isolation efficiencies are studied using $Z \rightarrow ee/\mu\mu$, $J/\Psi \rightarrow ee/\mu\mu$, and $W \rightarrow e\nu$ events. Parts of the corresponding uncertainties are detector- and algorithm-specific; however, other parts are systematic uncertainties related to the measurement methods, which are similar for the two experiments. Therefore, the correlation is considered to be HALF for the lepton-related uncertainties.

Jet-energy scale: the correlations between the JES uncertainties from ATLAS and CMS follow the guidelines explained in refs. [36, 37]. Many components of the uncertainties, such as statistical and detector-related uncertainties from in situ techniques, pile-up uncertainties, high- p_T uncertainties, and jet fragmentation energy scale uncertainties, are considered uncorrelated, including the ATLAS b -jet energy scale uncertainty. Three remaining components are taken as partially correlated. The first component refers to the JES flavour composition uncertainties. These account for the flavour composition of the

ATLAS merged uncertainties	Value	CMS uncertainties
Lepton ID and energy resolution	HALF	Lepton ID and energy resolution
JES flavour composition/specific response	HIGH	JES flavour composition
	–LOW	b -jet fragmentation tune
JES modelling	LOW	b -jet neutrino decay fraction
	HALF	JES: AbsoluteMPFBias 7 TeV
JES central/forward balance	HALF	JES: AbsoluteMPFBias 8 TeV
	HIGH	JES: RelativeFSR 7 TeV
tW background	HIGH	JES: RelativeFSR 8 TeV
	LOW	tW single top quark correlated
	LOW	tW single top quark 7 TeV
Diboson	LOW	tW single top quark 8 TeV
	LOW	Diboson correlated
	LOW	Diboson 7 TeV
$t\bar{t}$ scale choice	LOW	Diboson 8 TeV
	HALF	$t\bar{t}$ scale choice
$t\bar{t}$ generator	HALF	$t\bar{t}$ scale choice (extrapolation)
	LOW	Top-quark p_T
	LOW	Top-quark p_T (extrapolation)
	–LOW	ME generator
	LOW	ME/PS matching
	LOW	ME/PS matching (extrapolation)
	–LOW	Colour reconnection
–LOW	Underlying-event tune	
Each PDF CT10 eigenvector	FULL	Each PDF CT10 eigenvector
Integrated luminosity	0.1	Integrated luminosity

Table 4. Assumed correlations between ATLAS and CMS systematic uncertainties. The assigned sign is based on the nature of the systematic uncertainty (e.g., minus for an ‘up’ variation in the ATLAS measurement that corresponds to a ‘down’ variation in the CMS measurement due to conventions within the collaborations). If the sign is ambiguous, the sign maximising the total uncertainty in the combined cross-section is chosen. Any uncertainties not included in the table are considered uncorrelated.

jets and the calorimeter response to jets of different flavours. In addition, for the CMS measurement, a variation of the b -hadron neutrino decay fraction as well as a variation of the b -quark fragmentation tune is also performed, which is assigned a LOW correlation with the flavour-dependent jet response in the ATLAS analysis. In this case, the sign of the chosen correlation coefficient cannot be determined unambiguously. Therefore, a negative correlation, which maximises the total uncertainty in the combined values, is chosen. The second component includes the CMS *AbsoluteMPFBias*, which refers to the part of the absolute JES uncertainty related with the p_T -dependent calibration coming from a potential bias in the Missing Projection Fraction (MPF) method [37]. The corresponding merged uncertainty in ATLAS is estimated with a mix of the same MPF method and a method using p_T -balance between a jet and either a Z or γ reference object in the central η region; this uncertainty is referred to as *JES modelling*. The recommended correlation between

ATLAS and CMS from refs. [36, 37] for this uncertainty is between 0 and 0.5, therefore the correlation assigned is HALF.

The third component includes the CMS *RelativeFSR*, which refers to the part of the relative JES uncertainty related to the η -dependent calibration and comes from the modelling of the final-state radiation effects. ATLAS refers to this transferring of the calibration to the forward region as *JES central/forward balance* (also referred to as the *η -intercalibration modelling* in some references). The recommended correlation between ATLAS and CMS from refs. [36, 37] for this uncertainty is between 0.5 and 1.0. This component is considered uncorrelated between $\sqrt{s} = 7$ and 8 TeV in the case of the CMS measurements, and it is considered correlated between $\sqrt{s} = 7$ and 8 TeV for the ATLAS measurements. Because of this inconsistency between the two experiments, the highest correlation which does not lead to a non-positive-definite covariance matrix is 0.7 (HIGH), which is used in this combination. The effect of this choice is negligible since the contribution from RelativeFSR uncertainties is below 5% of the total uncertainty for each input measurement.

b -jet identification: the b -jet identification uncertainties also include uncertainties due to c -jet, light-flavour jet and gluon jet identification. In the ATLAS measurement, the b -jet identification efficiencies for signal events are determined in situ by solving eq. (2.1), consequently uncertainties affect the background contributions and the b -tagging correlation C_b , both derived from simulation. In the CMS measurement, the b -jet identification efficiencies are corrected by comparing efficiencies in data and simulation using a combination of several independent methods and calibration samples [38]. Therefore, these uncertainties are considered to be uncorrelated.

Backgrounds: the ATLAS tW background uncertainty is the combination of four separate uncertainties assessed in the original ATLAS measurement: an uncertainty in the tW cross-section, an uncertainty associated with the scheme handling the tW and $t\bar{t}$ interference, an uncertainty from the impact of initial- and final-state radiation on the tW background, and an uncertainty from the generator used to simulate the tW background. For both the tW background and the diboson background, CMS includes an uncertainty component which is correlated between the measurements at $\sqrt{s} = 7$ and 8 TeV since Monte Carlo (MC) simulations are used to estimate the uncertainties from these backgrounds. This component is assigned a HIGH correlation with the corresponding ATLAS uncertainty because both experiments use a method relying on simulation. In addition, an uncertainty component specific to each centre-of-mass energy is used in the CMS measurement, for example related to using different MC parameters and parton shower tunings in the event generation for those backgrounds. This latter component is assigned a LOW correlation with the corresponding ATLAS uncertainty. Finally, due to the different event selections employed by ATLAS and CMS, the contributions from the Drell–Yan background are also different and in both analyses partly constrained by data control regions. The uncertainties associated with this background are considered as uncorrelated between ATLAS and CMS.

$t\bar{t}$ modelling: the scale uncertainty refers to the uncertainties estimated by varying the factorisation and renormalisation scales in the $t\bar{t}$ signal simulation by a factor of two. ATLAS uses the POWHEG BOX [39–41] generator where the default scale is defined using the top-quark mass and transverse momentum as $Q^2 = m_t^2 + p_{T,t}^2$, while CMS uses the MADGRAPH [42] generator where the default scale is $Q^2 = m_t^2 + \Sigma p_T^2$, where the sum runs over all additional final-state partons in the matrix-element calculations. Due to this slightly different Q^2 definition and also due to the fact that ATLAS varies the scales independently while CMS varies them simultaneously, the correlation is assumed to be HALF. The $t\bar{t}$ generator uncertainty corresponds in the ATLAS case to comparing a sample of $t\bar{t}$ events generated with POWHEG BOX interfaced to PYTHIA 6 [43] with a sample generated with MC@NLO [44, 45] interfaced to HERWIG [46], thereby incorporating different matrix-element treatments as well as different parton shower and hadronisation modelling. In the CMS case, the equivalent uncertainty was calculated by varying relevant parameters within the MADGRAPH generator. In addition to affecting the fit of the cross-section in the fiducial phase space, these variations are applied a second time when extrapolating to the full phase space. Since both methods address similar physical effects it is expected that the $t\bar{t}$ modelling uncertainties will be somewhat correlated; however, since the methods and generators used to obtain them are different, the correlation is assumed to be LOW. Another contribution to the modelling uncertainties is the variation of the underlying-event and colour-reconnection tunes, as well as a comparison between different matrix-element generators and the reweighting of the simulated top-quark p_T spectrum to match the one observed in data in the case of the CMS measurement. These individual sources are assigned a LOW correlation with the combined ATLAS generator uncertainty. Also, here the sign of some components is chosen such that the total uncertainty is maximised.

PDF: for the purpose of the combination, the ATLAS $t\bar{t}$ PDF uncertainty is split into two components: an uncertainty from the CT10 eigenvectors only, which is considered fully correlated with the CMS PDF CT10 uncertainties, and a remainder PDF uncertainty (from MSTW2008 and NNPDF2.3) which is uncorrelated with the CMS PDF uncertainty. The sum in quadrature of these two ATLAS components equals the original ATLAS PDF uncertainty.

Integrated luminosity: the integrated-luminosity uncertainty affects the determination of the signal yield and most background yields. This uncertainty is assumed to be uncorrelated between the $\sqrt{s} = 7$ and 8 TeV data by both the ATLAS and CMS measurements as well as in the combination. For the $\sqrt{s} = 7$ TeV (8 TeV) running period, the luminosity uncertainty for ATLAS is 1.8% (1.9%) [47, 48], with 1.5% (1.2%) estimated from the van der Meer scan analysis and 0.9% (1.5%) from the long-term luminosity monitoring and the transfer of the luminosity scale from the van der Meer regime to the physics regime. For CMS the uncertainties are 2.2% (2.6%) for 7 TeV (8 TeV) [49, 50], of which 1.8% (2.3%) is estimated from the van der Meer scan analysis, and 1.2% (1.2%) from the luminosity-monitoring uncertainty. The uncertainty estimated from the long-term luminosity monitoring is detector-specific and thus uncorrelated between ATLAS and CMS. The uncertainty estimated from the van der Meer scan analysis is partially correlated. For the

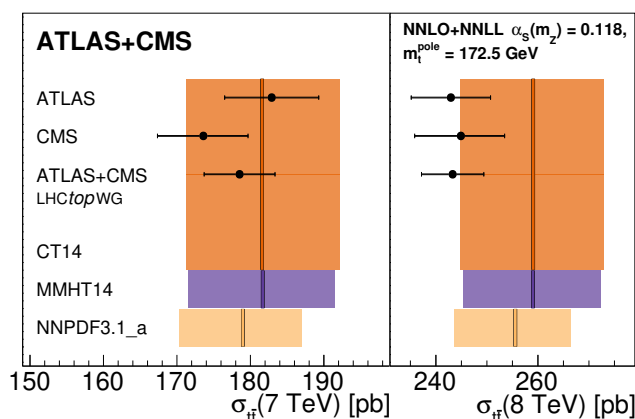


Figure 1. Measured $t\bar{t}$ production cross-sections at $\sqrt{s} = 7$ and 8 TeV compared with predictions using different PDF sets. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements. The shaded bands represent the total uncertainties in the predictions.

$\sqrt{s} = 7$ TeV (8 TeV) running period, the correlated components amount to 0.5% (0.6%) and 0.5% (0.7%) for ATLAS and CMS, respectively; they arise from the measurement of the bunch intensities based on a common device, the correction for beam-to-beam-induced biases extracted from a common simulation, and the models used to fit the visible interaction rate as a function of the separation between the beams, referred to as beam modelling. Taking into account the covariance matrix built from those correlations, the resulting correlation coefficients are computed to be 0.065 for the 7 TeV running period and 0.085 for the 8 TeV running period. Both values are rounded to 0.1 for this combination.

5 Results

5.1 Cross-section combination

The combination of the cross-sections is performed simultaneously at $\sqrt{s} = 7$ and 8 TeV, such that the corresponding correlations are taken into account. The resulting cross-sections are

$$\begin{aligned}\sigma_{t\bar{t}}(\sqrt{s} = 7 \text{ TeV}) &= 178.5 \pm 4.7 \text{ pb} \\ \sigma_{t\bar{t}}(\sqrt{s} = 8 \text{ TeV}) &= 243.3^{+6.0}_{-5.9} \text{ pb},\end{aligned}$$

with a correlation between the $\sqrt{s} = 7$ and 8 TeV values of $\rho = 0.41$ and minimum Pearson χ^2 of 1.6 for two degrees of freedom. A comparison of the combined result with the input measurements and the prediction using different PDF sets is shown in figure 1.

The impact of individual groups of uncertainties on the combined results is estimated as is done for the CMS input measurement, described in section 3. The resulting impacts are listed in table 5. The integrated luminosity is still the dominant uncertainty although its impact is reduced by up to 35% compared to the individual results. The statistical uncertainty is reduced by up to 40% by the combination. The next largest uncertainty

Uncertainty	$\Delta\sigma_{t\bar{t}}(7 \text{ TeV})$ [%]	$\Delta\sigma_{t\bar{t}}(8 \text{ TeV})$ [%]
Trigger	0.6	0.5
Lepton (mis-)ID, isolation and energy	1.0	0.9
JES flavour composition	0.4	0.4
JES modelling	< 0.1	0.1
JES central/forward balance	0.2	0.2
b -jet (mis-)ID	0.4	0.4
Pile-up	0.2	0.2
tW background	0.8	0.6
Drell–Yan background	0.7	0.4
Diboson background	0.2	0.4
$t\bar{t}$ generator	0.8	0.8
$t\bar{t}$ scale choice	0.4	0.4
PDF	0.4	0.3
Integrated luminosity	1.7	1.7
Statistical	1.0	0.4
Total uncertainty	+2.7 −2.6	+2.5 −2.4

Table 5. Illustration of the impact $\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ of the dominant groups of systematic uncertainties on the combined cross-sections at $\sqrt{s} = 7$ and 8 TeV.

in the ATLAS measurement was the $t\bar{t}$ generator uncertainty, which is reduced by 40% by the combination, while for CMS the next largest uncertainty was associated with the lepton ID and energy, and is also reduced by up to 40% by the combination. Overall, the nuisance parameter constraints are similar to the ones coming from the CMS input measurement. The observed reduction of the luminosity uncertainty on the combined cross-section is consistent with the expected reduction factor for this weighted average, given the magnitude of the correlated and uncorrelated components of the ATLAS and CMS luminosity measurements. Relative to the most precise input measurements, the combination improves the precision by 25% (28%) at $\sqrt{s} = 7$ TeV (8 TeV), and therefore the combined results are the most precise measurements of the inclusive $t\bar{t}$ cross-section to date at those centre-of-mass energies. The experimental uncertainty is smaller than the theoretical uncertainty of the NNLO+NNLL predictions for the corresponding cross-sections.

The ratio of the cross-section at $\sqrt{s} = 8$ TeV to that at 7 TeV is determined to be

$$R_{8/7} = 1.363 \pm 0.015 \text{ (stat.)} \pm 0.028 \text{ (syst.)},$$

based on the fitted values of the individual cross-sections, and accounting for the correlated uncertainties.

The measured ratio is compared with predictions using different PDF sets in figure 2. Since correlated uncertainties cancel out in the ratio, uncorrelated sources, such as the statistical uncertainty, play a larger role. The cross-section ratio therefore benefits most from the combination, with the precision improving by 45% relative to the most precise input measurements. Both the individual cross-sections and their ratio are in agreement

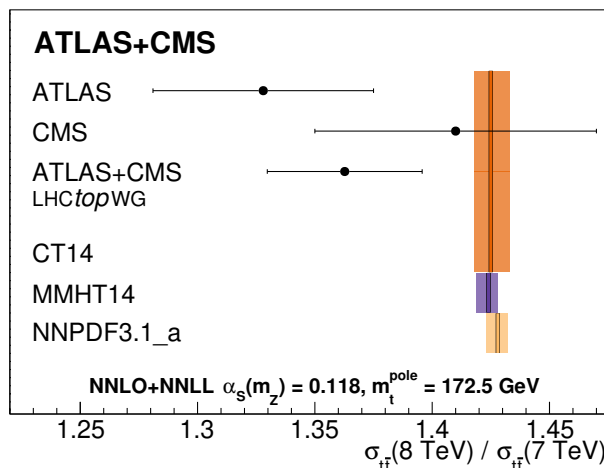


Figure 2. Measured ratios of the $t\bar{t}$ production cross-sections at $\sqrt{s} = 7$ and 8 TeV compared with predictions using different PDF sets. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements. The shaded bands represent the total uncertainties in the predictions.

with the SM prediction. The level of agreement observed when comparing the measured 7 TeV cross-section, the 8 TeV cross-section and the ratio with the corresponding predictions is found to be 0.3σ , 1.0σ and 1.9σ respectively, using $m_t^{\text{pole}} = 172.5$ GeV, the CT14 PDF, and taking into account the uncertainties in the combined cross-sections and the predictions. The uncertainties in the predicted ratios include the effects on the cross-section calculations from the renormalisation and factorisation scale uncertainties (treated as correlated between $\sqrt{s} = 7$ and 8 TeV), the PDF uncertainty (the ratio is evaluated for each individual PDF eigenvector and the relevant prescription for the given PDF set is applied), $\alpha_s(m_Z) = 0.118 \pm 0.001$, and a top-quark pole mass uncertainty of 1.0 GeV with 172.5 GeV as the central value (both treated as fully correlated between $\sqrt{s} = 7$ and 8 TeV). The predicted ratio's uncertainty is smaller than the uncertainty in the measured ratio since those effects mostly cancel out in the ratio, and it is dominated by the PDF uncertainty, while variations of the pole mass and $\alpha_s(m_Z)$ do not contribute significantly to the predicted ratio's uncertainty (also described in ref. [51]).

5.2 Top-quark pole mass and strong coupling

The predicted value of the inclusive cross-section for $t\bar{t}$ production is very sensitive to m_t^{pole} and $\alpha_s(m_Z)$. The estimates of m_t^{pole} and $\alpha_s(m_Z)$ from the inclusive cross-section measurement are fully correlated. Therefore, the measured cross-sections can only be used to extract a measurement of $\alpha_s(m_Z)$ by using an assumed value for m_t^{pole} and vice versa. Either parameter can be determined by comparing the combined cross-sections with their predictions as a function of that parameter while fixing the other. While a few percent change in $\alpha_s(m_Z)$ in the matrix-element calculation leads to a negligible change in the measured cross-section, the extrapolation to the full phase space has a mild residual dependence

of the order of 0.2% per GeV on the top-quark mass for both the ATLAS and CMS measurements. The parameterisation of this dependence is different for each experiment, although the dependence is almost identical for m_t^{pole} between 170 and 180 GeV. To account for the different functional forms, the combination is performed assuming top-quark masses of 166.5 GeV and 178.5 GeV, in addition to the nominal value of 172.5 GeV. For each of the three mass points, weights for the ATLAS and CMS measurements are determined based on their contribution to the combination at that mass point. The weights at other mass points are interpolated or extrapolated linearly from the values at the reference points. The final parameterisation used for the parameter extraction is calculated as a weighted mean of the ATLAS and CMS parameterisations, using the weights from this linear interpolation or extrapolation. The relative uncertainty in the combined results is also interpolated or extrapolated linearly over the mass range, and is almost constant. Finally, the ambiguities in the interpretation of the top-quark mass involved in MC and fixed-order calculations imply an additional uncertainty obtained by shifting the mass in the acceptance dependence by ± 1.0 GeV [53]. Due to the mild dependence of the measurements on this mass assumption, this contribution is negligible in the final result.

The predicted dependence of the $t\bar{t}$ cross-section on the top-quark pole mass is evaluated using TOP++, assuming $\alpha_s(m_Z) = 0.118$ as a baseline. The dependence is derived using ten mass points. In addition, the prediction is evaluated for five different values of $\alpha_s(m_Z)$, assuming $m_t^{\text{pole}} = 172.5$ GeV, by varying $\alpha_s(m_Z)$ consistently in the PDF and the calculation. In each case the cross-section is fitted with a fourth-order polynomial. The relative effects of these variations are assumed to be independent. The comparisons with the combined cross-sections are shown in figure 3. The relative variations with m_t^{pole} and $\alpha_s(m_Z)$ are very similar for different PDF sets and the mild dependence of the measured cross-sections on m_t^{pole} is visible.

The values of $\alpha_s(m_Z)$ and m_t^{pole} are extracted from the combined cross-sections using a χ^2 minimisation technique. The χ^2 is defined as

$$\chi^2 = \frac{1}{1 - \rho^2} \left(\Delta(7 \text{ TeV})^2 + \Delta(8 \text{ TeV})^2 - 2\rho\Delta(7 \text{ TeV})\Delta(8 \text{ TeV}) \right), \text{ with} \quad (5.1)$$

$$\Delta = \frac{\sigma_{t\bar{t}}(m_t^{\text{pole}}) - \sigma_{t\bar{t}}^{\text{p}}(m_t^{\text{pole}}, \alpha_s(m_Z))}{\delta}, \quad (5.2)$$

and where $\sigma_{t\bar{t}}^{\text{p}}$ is the predicted $t\bar{t}$ cross-section as a function of m_t^{pole} and $\alpha_s(m_Z)$, $\sigma_{t\bar{t}}(m_t^{\text{pole}})$ is the measured cross-section with a residual pole mass dependence, δ represents the experimental uncertainty of the combined cross-section, and ρ is the correlation coefficient (0.41) between the combined cross-section values. The uncertainties in the $t\bar{t}$ cross-section prediction from each renormalisation and factorisation scale and PDF eigenvector variation are propagated to the final result by re-extracting the top-quark pole mass with different assumptions about the scales and PDF. The total scale uncertainty is determined from the envelope of its individual contributions, and the total PDF uncertainty is calculated using the prescription of the corresponding PDF set. For the case of the CT14 PDF set, the uncertainties are rescaled to 68% CL, as appropriate for this PDF set. Figure 4 shows the constraints in the $\alpha_s(m_Z)$ - m_t^{pole} plane from the combined cross-sections. The

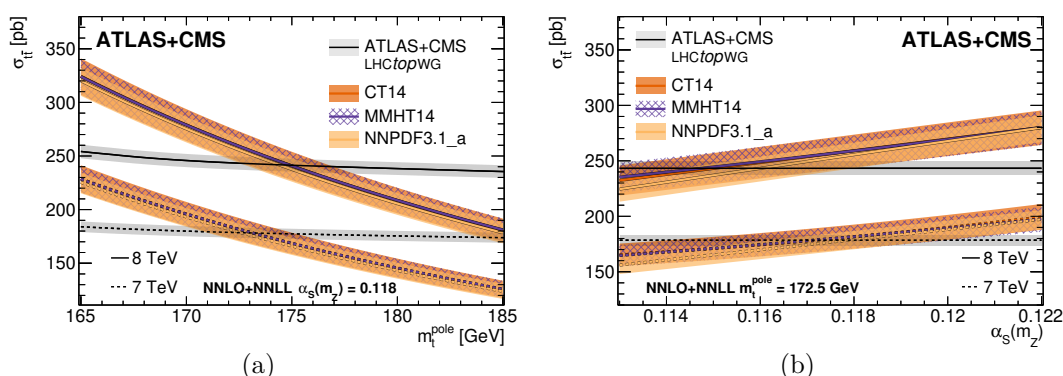


Figure 3. Dependence of the predicted cross-section and the combined measured cross-section on (a) the top-quark pole mass m_t^{pole} and (b) the strong coupling $\alpha_s(m_Z)$. The prediction is evaluated for three different PDF sets and assumes (a) $\alpha_s(m_Z) = 0.118 \pm 0.001$ or (b) $m_t^{\text{pole}} = 172.5 \pm 1.0$ GeV. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements. The uncertainty bands include the effects of the uncertainties in the combined cross-sections (interpolated or extrapolated linearly from the values at the reference points) and of the factorisation and renormalisation scale and PDF uncertainties in the predicted cross-sections.

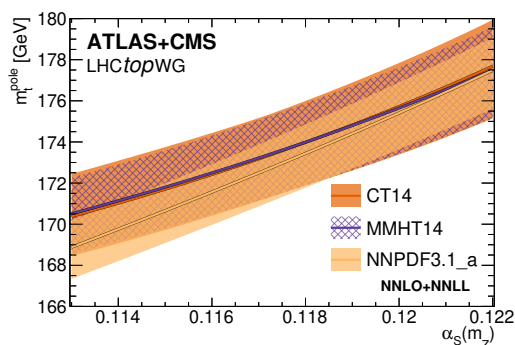


Figure 4. Dependence of the top-quark pole mass, m_t^{pole} , on the assumed value for the strong coupling, $\alpha_s(m_Z)$, including constraints from the combined measured cross-sections for three different PDF sets. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements. The shaded band represents the 68% CL uncertainty on the extracted $\alpha_s(m_Z)$ when fixing m_t^{pole} and on m_t^{pole} when fixing $\alpha_s(m_Z)$. The uncertainty bands include the effects of the uncertainties in the combined cross-sections and of the renormalisation and factorisation scale and PDF uncertainties in the predicted cross-sections.

uncertainty bands include the effects of the uncertainties in the combined cross-sections and of the renormalisation and factorisation scale and PDF uncertainties in the predicted cross-sections.

The dependence shown in figure 4 is used subsequently to extract either m_t^{pole} or $\alpha_s(m_Z)$. The confidence intervals cover the negligible difference that results from minimising eq. (5.1) with respect to m_t^{pole} while stepping over values of α_s instead of minimising with respect to α_s while stepping over values of m_t^{pole} . Therefore, figure 4 can

PDF set	m_t^{pole} ($\alpha_s = 0.118 \pm 0.001$)	$\alpha_s(m_Z)$ ($m_t = 172.5 \pm 1.0$ GeV)
CT14	$174.0^{+2.3}_{-2.3}$ GeV	$0.1161^{+0.0030}_{-0.0033}$
MMHT2014	$174.0^{+2.1}_{-2.3}$ GeV	$0.1160^{+0.0031}_{-0.0030}$
NNPDF3.1_a	$173.4^{+1.8}_{-2.0}$ GeV	$0.1170^{+0.0021}_{-0.0018}$

Table 6. Measured m_t^{pole} and $\alpha_s(m_Z)$ values for each PDF set using the measured 7 and 8 TeV combined cross-sections. NNPDF3.1_a is a version of this PDF set containing no top-quark measurements.

be used to extract $\alpha_s(m_Z)$ for a fixed value of m_t^{pole} and vice versa. When extracting m_t^{pole} , $\alpha_s(m_Z) = 0.118 \pm 0.001$ is used, whereas when determining $\alpha_s(m_Z)$, m_t^{pole} is assumed to be $m_t^{\text{pole}} = 172.5 \pm 1.0$ GeV. The corresponding results for each PDF set are reported in table 6. These results represent the most precise determinations of $\alpha_s(m_Z)$ at the scale of inclusive $t\bar{t}$ production ($\mathcal{O}(2m_t^{\text{pole}})$), being more precise than the previous measurements reported by CMS in refs. [52, 54], and are among the most precise top-quark pole mass measurements. The results for m_t^{pole} are compatible with the values reported in refs. [15, 19].

6 Summary and conclusions

A combination of measurements of the inclusive $t\bar{t}$ production cross-section performed by the ATLAS and CMS experiments at $\sqrt{s} = 7$ and 8 TeV is presented, accounting for correlations between the measurements from different experiments as well as correlations within the ATLAS and CMS measurements. The resulting cross-sections are

$$\begin{aligned} \sigma_{t\bar{t}}(\sqrt{s} = 7 \text{ TeV}) &= 178.5 \pm 4.7 \text{ pb} \\ \sigma_{t\bar{t}}(\sqrt{s} = 8 \text{ TeV}) &= 243.3^{+6.0}_{-5.9} \text{ pb}. \end{aligned}$$

The combined results improve on the precision of the most precise individual results by 25% at $\sqrt{s} = 7$ TeV, and by 28% at $\sqrt{s} = 8$ TeV, making these combined results the most precise measurements of the inclusive $t\bar{t}$ cross-section to date at those respective centre-of-mass energies. The correlation between the combined cross-sections values is 0.41, and their ratio is determined to be

$$R_{8/7} = 1.363 \pm 0.032.$$

Furthermore, the combined values for $\sigma_{t\bar{t}}$ are used to determine the top-quark pole mass and the strong coupling by comparing them with the predicted evolution of $\sigma_{t\bar{t}}$ as a function of m_t^{pole} and $\alpha_s(m_Z)$, for different PDF sets. The measurement yields the most precise values, $m_t^{\text{pole}} = 173.4^{+1.8}_{-2.0}$ GeV (1.2% relative uncertainty) and $\alpha_s(m_Z) = 0.1170^{+0.0021}_{-0.0018}$ (1.8% relative uncertainty), when using the NNPDF3.1_a PDF set. The extracted $\alpha_s(m_Z)$ value is more precise than previous measurements performed using top-quark events.

Acknowledgments

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently.

We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; ANID, Chile; CAS, MOST and NSFC, China; Minciencias, Colombia; MEYS CR, Czech Republic; DNRF and DNSRC, Denmark; IN2P3-CNRS and CEA-DRF/IRFU, France; SRNSFG, Georgia; BMBF, HGF and MPG, Germany; GSRI, Greece; RGC and Hong Kong SAR, China; ISF and Benozziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; NWO, Netherlands; RCN, Norway; MEiN, Poland; FCT, Portugal; MNE/IFA, Romania; MESTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DSI/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SERI, SNSF and Cantons of Bern and Geneva, Switzerland; MOST, Taiwan; TENMAK, Türkiye; STFC, United Kingdom; DOE and NSF, United States of America. In addition, individual groups and members have received support from BCKDF, CANARIE, Compute Canada and CRC, Canada; PRIMUS 21/SCI/017 and UNCE SCI/013, Czech Republic; COST, ERC, ERDF, Horizon 2020 and Marie Skłodowska-Curie Actions, European Union; Investissements d’Avenir Labex, Investissements d’Avenir Idex and ANR, France; DFG and AvH Foundation, Germany; Herakleitos, Thales and Aristeia programmes co-financed by EU-ESF and the Greek NSRF, Greece; BSF-NSF and MINERVA, Israel; Norwegian Financial Mechanism 2014-2021, Norway; NCN and NAWA, Poland; La Caixa Banking Foundation, CERCA Programme Generalitat de Catalunya and PROMETEO and GenT Programmes Generalitat Valenciana, Spain; Göran Gustafssons Stiftelse, Sweden; The Royal Society and Leverhulme Trust, United Kingdom.

The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN, 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), the Tier-2 facilities worldwide and large non-WLCG resource providers. Major contributors of computing resources are listed in ref. [55].

We congratulate our colleagues in the CERN accelerator departments for the excellent performance of the LHC and thank the technical and administrative staffs at CERN and at other CMS institutes for their contributions to the success of the CMS effort. In addition, we gratefully acknowledge the computing centres and personnel of the Worldwide LHC Computing Grid and other centres for delivering so effectively the computing infrastructure essential to our analyses. Finally, we acknowledge the enduring support for the construction and operation of the LHC, the CMS detector, and the supporting computing infrastructure provided by the following funding agencies: BMBWF and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, FAPERGS, and FAPESP (Brazil); MES and BNSF (Bulgaria); CERN; CAS, MoST, and NSFC (China); MINCIENCIAS (Colombia); MSES and CSF (Croatia); RIF (Cyprus); SENESCYT (Ecuador); MoER,

ERC PUT and ERDF (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRI (Greece); NKFIH (Hungary); DAE and DST (India); IPM (Iran); SFI (Ireland); INFN (Italy); MSIP and NRF (Republic of Korea); MES (Latvia); LAS (Lithuania); MOE and UM (Malaysia); BUAP, CINVESTAV, CONACYT, LNS, SEP, and UASLP-FAI (Mexico); MOS (Montenegro); MBIE (New Zealand); PAEC (Pakistan); MES and NSC (Poland); FCT (Portugal); MESTD (Serbia); MCIN/AEI and PCTI (Spain); MOSTR (Sri Lanka); Swiss Funding Agencies (Switzerland); MST (Taipei); MHESI and NSTDA (Thailand); TUBITAK and TENMAK (Turkey); NASU (Ukraine); STFC (United Kingdom); DOE and NSF (USA).

Individuals have received support from the Marie-Curie programme and the European Research Council and Horizon 2020 Grant, contract Nos. 675440, 724704, 752730, 758316, 765710, 824093, 884104, and COST Action CA16108 (European Union); the Leventis Foundation; the Alfred P. Sloan Foundation; the Alexander von Humboldt Foundation; the Belgian Federal Science Policy Office; the Fonds pour la Formation à la Recherche dans l’Industrie et dans l’Agriculture (FRIA-Belgium); the Agentschap voor Innovatie door Wetenschap en Technologie (IWT-Belgium); the F.R.S.-FNRS and FWO (Belgium) under the “Excellence of Science — EOS” — be.h project n. 30820817; the Beijing Municipal Science & Technology Commission, No. Z191100007219010; the Ministry of Education, Youth and Sports (MEYS) of the Czech Republic; the Hellenic Foundation for Research and Innovation (HFRI), Project Number 2288 (Greece); the Deutsche Forschungsgemeinschaft (DFG), under Germany’s Excellence Strategy — EXC 2121 “Quantum Universe” — 390833306, and under project number 400140256 - GRK2497; the Hungarian Academy of Sciences, the New National Excellence Program — ÚNKP, the NKFIH research grants K 124845, K 124850, K 128713, K 128786, K 129058, K 131991, K 133046, K 138136, K 143460, K 143477, 2020-2.2.1-ED-2021-00181, and TKP2021-NKTA-64 (Hungary); the Council of Science and Industrial Research, India; the Latvian Council of Science; the Ministry of Education and Science, project no. 2022/WK/14, and the National Science Center, contracts Opus 2021/41/B/ST2/01369 and 2021/43/B/ST2/01552 (Poland); the Fundação para a Ciência e a Tecnologia, grant CEECIND/01334/2018 (Portugal); the National Priorities Research Program by Qatar National Research Fund; MCIN/AEI/10.13039/501100011033, ERDF “a way of making Europe”, and the Programa Estatal de Fomento de la Investigación Científica y Técnica de Excelencia María de Maeztu, grant MDM-2017-0765 and Programa Severo Ochoa del Principado de Asturias (Spain); the Chulalongkorn Academic into Its 2nd Century Project Advancement Project, and the National Science, Research and Innovation Fund via the Program Management Unit for Human Resources & Institutional Development, Research and Innovation, grant B05F650021 (Thailand); the Kavli Foundation; the Nvidia Corporation; the SuperMicro Corporation; the Welch Foundation, contract C-1845; and the Weston Havens Foundation (USA).

Open Access. This article is distributed under the terms of the Creative Commons Attribution License ([CC-BY 4.0](https://creativecommons.org/licenses/by/4.0/)), which permits any use, distribution and reproduction in any medium, provided the original author(s) and source are credited.

References

- [1] PARTICLE DATA GROUP collaboration, *Review of particle physics*, *Phys. Rev. D* **98** (2018) 030001 [INSPIRE].
- [2] M. Cacciari et al., *Top-pair production at hadron colliders with next-to-next-to-leading logarithmic soft-gluon resummation*, *Phys. Lett. B* **710** (2012) 612 [arXiv:1111.5869] [INSPIRE].
- [3] P. Bärnreuther, M. Czakon and A. Mitov, *Percent level precision physics at the Tevatron: first genuine NNLO QCD Corrections to $q\bar{q} \rightarrow t\bar{t} + X$* , *Phys. Rev. Lett.* **109** (2012) 132001 [arXiv:1204.5201] [INSPIRE].
- [4] M. Czakon and A. Mitov, *NNLO corrections to top-pair production at hadron colliders: the all-fermionic scattering channels*, *JHEP* **12** (2012) 054 [arXiv:1207.0236] [INSPIRE].
- [5] M. Czakon and A. Mitov, *NNLO corrections to top pair production at hadron colliders: the quark-gluon reaction*, *JHEP* **01** (2013) 080 [arXiv:1210.6832] [INSPIRE].
- [6] M. Czakon, P. Fiedler and A. Mitov, *Total top-quark pair-production cross section at hadron colliders through $O(\alpha_S^4)$* , *Phys. Rev. Lett.* **110** (2013) 252004 [arXiv:1303.6254] [INSPIRE].
- [7] S. Catani et al., *Top-quark pair hadroproduction at next-to-next-to-leading order in QCD*, *Phys. Rev. D* **99** (2019) 051501 [arXiv:1901.04005] [INSPIRE].
- [8] G.R. Farrar and P. Fayet, *Phenomenology of the production, decay, and detection of new hadronic states associated with supersymmetry*, *Phys. Lett. B* **76** (1978) 575 [INSPIRE].
- [9] S. Dulat et al., *New parton distribution functions from a global analysis of quantum chromodynamics*, *Phys. Rev. D* **93** (2016) 033006 [arXiv:1506.07443] [INSPIRE].
- [10] L.A. Harland-Lang, A.D. Martin, P. Motylinski and R.S. Thorne, *Parton distributions in the LHC era: MMHT 2014 PDFs*, *Eur. Phys. J. C* **75** (2015) 204 [arXiv:1412.3989] [INSPIRE].
- [11] NNPDF collaboration, *Precision determination of the strong coupling constant within a global PDF analysis*, *Eur. Phys. J. C* **78** (2018) 408 [arXiv:1802.03398] [INSPIRE].
- [12] M. Czakon and A. Mitov, *Top++: a program for the calculation of the top-pair cross-section at hadron colliders*, *Comput. Phys. Commun.* **185** (2014) 2930 [arXiv:1112.5675] [INSPIRE].
- [13] ATLAS collaboration, *The ATLAS Experiment at the CERN Large Hadron Collider*, 2008 *JINST* **3** S08003 [INSPIRE].
- [14] CMS collaboration, *The CMS Experiment at the CERN LHC*, 2008 *JINST* **3** S08004 [INSPIRE].
- [15] ATLAS collaboration, *Measurement of the $t\bar{t}$ production cross-section using $e\mu$ events with b -tagged jets in pp collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS detector*, *Eur. Phys. J. C* **74** (2014) 3109 [Addendum *ibid.* **76** (2016) 642] [arXiv:1406.5375] [INSPIRE].
- [16] ATLAS collaboration, *Measurements of the top quark branching ratios into channels with leptons and quarks with the ATLAS detector*, *Phys. Rev. D* **92** (2015) 072005 [arXiv:1506.05074] [INSPIRE].
- [17] ATLAS collaboration, *Simultaneous measurements of the $t\bar{t}$, W^+W^- , and $Z/\gamma^* \rightarrow \tau\tau$ production cross-sections in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector*, *Phys. Rev. D* **91** (2015) 052005 [arXiv:1407.0573] [INSPIRE].

- [18] ATLAS collaboration, *Measurement of the $t\bar{t}$ production cross section in the tau+jets channel using the ATLAS detector*, *Eur. Phys. J. C* **73** (2013) 2328 [[arXiv:1211.7205](#)] [[INSPIRE](#)].
- [19] CMS collaboration, *Measurement of the t - $t\bar{b}$ production cross section in the $e\mu$ channel in proton-proton collisions at $\sqrt{s} = 7$ and 8 TeV*, *JHEP* **08** (2016) 029 [[arXiv:1603.02303](#)] [[INSPIRE](#)].
- [20] CMS collaboration, *Measurement of the $t\bar{t}$ production cross section in the all-jet final state in pp collisions at $\sqrt{s} = 7$ TeV*, *JHEP* **05** (2013) 065 [[arXiv:1302.0508](#)] [[INSPIRE](#)].
- [21] CMS collaboration, *Measurement of the $t\bar{t}$ Production Cross Section in the τ +Jets Channel in pp Collisions at $\sqrt{s} = 7$ TeV*, *Eur. Phys. J. C* **73** (2013) 2386 [[arXiv:1301.5755](#)] [[INSPIRE](#)].
- [22] CMS collaboration, *Measurement of the top quark pair production cross section in pp collisions at $\sqrt{s} = 7$ TeV in dilepton final states containing a τ* , *Phys. Rev. D* **85** (2012) 112007 [[arXiv:1203.6810](#)] [[INSPIRE](#)].
- [23] ATLAS collaboration, *Measurement of the inclusive and fiducial $t\bar{t}$ production cross-sections in the lepton+jets channel in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector*, *Eur. Phys. J. C* **78** (2018) 487 [[arXiv:1712.06857](#)] [[INSPIRE](#)].
- [24] ATLAS collaboration, *Measurement of the $t\bar{t}$ production cross section in the τ +jets final state in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector*, *Phys. Rev. D* **95** (2017) 072003 [[arXiv:1702.08839](#)] [[INSPIRE](#)].
- [25] CMS collaboration, *Measurements of the $t\bar{t}$ production cross section in lepton+jets final states in pp collisions at 8 TeV and ratio of 8 to 7 TeV cross sections*, *Eur. Phys. J. C* **77** (2017) 15 [[arXiv:1602.09024](#)] [[INSPIRE](#)].
- [26] CMS collaboration, *Measurement of the $t\bar{t}$ production cross section in pp collisions at $\sqrt{s} = 8$ TeV in dilepton final states containing one τ lepton*, *Phys. Lett. B* **739** (2014) 23 [[arXiv:1407.6643](#)] [[INSPIRE](#)].
- [27] CMS collaboration, *Measurement of the $t\bar{t}$ production cross section in the dilepton channel in pp collisions at $\sqrt{s} = 8$ TeV*, *JHEP* **02** (2014) 024 [Erratum *ibid.* **02** (2014) 102] [[arXiv:1312.7582](#)] [[INSPIRE](#)].
- [28] CMS collaboration, *Measurement of the $t\bar{t}$ production cross section in the all-jets final state in pp collisions at $\sqrt{s} = 8$ TeV*, *Eur. Phys. J. C* **76** (2016) 128 [[arXiv:1509.06076](#)] [[INSPIRE](#)].
- [29] ATLAS collaboration, *Measurement of lepton differential distributions and the top quark mass in $t\bar{t}$ production in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector*, *Eur. Phys. J. C* **77** (2017) 804 [[arXiv:1709.09407](#)] [[INSPIRE](#)].
- [30] E. Todesco and J. Wenninger, *Large Hadron Collider momentum calibration and accuracy*, *Phys. Rev. Accel. Beams* **20** (2017) 081003 [[INSPIRE](#)].
- [31] R. Nisius, *On the combination of correlated estimates of a physics observable*, *Eur. Phys. J. C* **74** (2014) 3004 [[arXiv:1402.4016](#)] [[INSPIRE](#)].
- [32] R. Nisius, *BLUE: combining correlated estimates of physics observables within ROOT using the Best Linear Unbiased Estimate method*, [arXiv:2001.10310](#) [[DOI:10.1016/j.softx.2020.100468](#)] [[INSPIRE](#)].

- [33] J. Kieseler, *A method and tool for combining differential or inclusive measurements obtained with simultaneously constrained uncertainties*, *Eur. Phys. J. C* **77** (2017) 792 [[arXiv:1706.01681](#)] [[INSPIRE](#)].
- [34] K. Pearson, *On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling*, *Philos. Mag.* **50** (1900) 157.
- [35] E. Maguire, L. Heinrich and G. Watt, *HEPData: a repository for high energy physics data*, *J. Phys. Conf. Ser.* **898** (2017) 102006 [[arXiv:1704.05473](#)] [[INSPIRE](#)].
- [36] ATLAS and CMS collaborations, *Jet energy scale uncertainty correlations between ATLAS and CMS*, [ATL-PHYS-PUB-2014-020](#), CERN, Geneva (2014).
- [37] ATLAS and CMS collaborations, *Jet energy scale uncertainty correlations between ATLAS and CMS at 8 TeV*, [CMS-PAS-JME-15-001](#), CERN, Geneva (2015).
- [38] CMS collaboration, *Performance of b tagging at sqrt(s)=8 TeV in multijet, ttbar and boosted topology events*, [CMS-PAS-BTV-13-001](#), CERN, Geneva (2013).
- [39] P. Nason, *A new method for combining NLO QCD with shower Monte Carlo algorithms*, *JHEP* **11** (2004) 040 [[hep-ph/0409146](#)] [[INSPIRE](#)].
- [40] S. Frixione, P. Nason and G. Ridolfi, *A positive-weight next-to-leading-order Monte Carlo for heavy flavour hadroproduction*, *JHEP* **09** (2007) 126 [[arXiv:0707.3088](#)] [[INSPIRE](#)].
- [41] S. Frixione, P. Nason and C. Oleari, *Matching NLO QCD computations with Parton Shower simulations: the POWHEG method*, *JHEP* **11** (2007) 070 [[arXiv:0709.2092](#)] [[INSPIRE](#)].
- [42] J. Alwall et al., *The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations*, *JHEP* **07** (2014) 079 [[arXiv:1405.0301](#)] [[INSPIRE](#)].
- [43] T. Sjostrand, S. Mrenna and P.Z. Skands, *PYTHIA 6.4 physics and manual*, *JHEP* **05** (2006) 026 [[hep-ph/0603175](#)] [[INSPIRE](#)].
- [44] S. Frixione and B.R. Webber, *Matching NLO QCD computations and parton shower simulations*, *JHEP* **06** (2002) 029 [[hep-ph/0204244](#)] [[INSPIRE](#)].
- [45] S. Frixione, P. Nason and B.R. Webber, *Matching NLO QCD and parton showers in heavy flavor production*, *JHEP* **08** (2003) 007 [[hep-ph/0305252](#)] [[INSPIRE](#)].
- [46] G. Corcella et al., *HERWIG 6: an event generator for hadron emission reactions with interfering gluons (including supersymmetric processes)*, *JHEP* **01** (2001) 010 [[hep-ph/0011363](#)] [[INSPIRE](#)].
- [47] ATLAS collaboration, *Improved luminosity determination in pp collisions at sqrt(s) = 7 TeV using the ATLAS detector at the LHC*, *Eur. Phys. J. C* **73** (2013) 2518 [[arXiv:1302.4393](#)] [[INSPIRE](#)].
- [48] ATLAS collaboration, *Luminosity determination in pp collisions at sqrt(s) = 8 TeV using the ATLAS detector at the LHC*, *Eur. Phys. J. C* **76** (2016) 653 [[arXiv:1608.03953](#)] [[INSPIRE](#)].
- [49] CMS collaboration, *Absolute calibration of the luminosity measurement at CMS: winter 2012 update*, [CMS-PAS-SMP-12-008](#), CERN, Geneva (2012).
- [50] CMS collaboration, *CMS luminosity based on pixel cluster counting — summer 2013 update*, [CMS-PAS-LUM-13-001](#), CERN, Geneva (2013).

- [51] M.L. Mangano and J. Rojo, *Cross section ratios between different cm energies at the LHC: opportunities for precision measurements and BSM sensitivity*, *JHEP* **08** (2012) 010 [[arXiv:1206.3557](#)] [[INSPIRE](#)].
- [52] CMS collaboration, *Determination of the top-quark pole mass and strong coupling constant from the $t\bar{t}$ production cross section in pp collisions at $\sqrt{s} = 7$ TeV*, *Phys. Lett. B* **728** (2014) 496 [[arXiv:1307.1907](#)] [[INSPIRE](#)].
- [53] A.H. Hoang, *What is the top quark mass?*, *Ann. Rev. Nucl. Part. Sci.* **70** (2020) 225 [[arXiv:2004.12915](#)] [[INSPIRE](#)].
- [54] CMS collaboration, *Measurement of the $t\bar{t}$ production cross section, the top quark mass, and the strong coupling constant using dilepton events in pp collisions at $\sqrt{s} = 13$ TeV*, *Eur. Phys. J. C* **79** (2019) 368 [[arXiv:1812.10505](#)] [[INSPIRE](#)].
- [55] ATLAS collaboration, *ATLAS Computing Acknowledgements*, [ATL-SOFT-PUB-2021-003](#) (2021).

The ATLAS collaboration

G. Aad ⁹⁹, B. Abbott ¹¹⁶, D.C. Abbott ¹⁰⁰, A. Abed Abud ³⁴, K. Abeling ⁵³,
D.K. Abhayasinghe ⁹², S.H. Abidi ²⁷, A. Aboulhorma ^{33e}, H. Abramowicz ¹⁴⁸,
H. Abreu ¹⁴⁷, Y. Abulaiti ⁵, A.C. Abusleme Hoffman ^{133a}, B.S. Acharya ^{66a,66b,p},
B. Achkar ⁵³, L. Adam ⁹⁷, C. Adam Bourdarios ⁴, L. Adamczyk ^{82a}, L. Adamek ¹⁵²,
S.V. Addepalli ²⁴, J. Adelman ¹¹², A. Adiguzel ^{11c,aa}, S. Adorni ⁵⁴, T. Adye ¹³⁰,
A.A. Affolder ¹³², Y. Afik ³⁴, C. Agapopoulou ⁶⁴, M.N. Agaras ¹², J. Agarwala ^{70a,70b},
A. Aggarwal ¹¹⁰, C. Agheorghiesei ^{25c}, J.A. Aguilar-Saavedra ^{126f,126a,z}, A. Ahmad ³⁴,
F. Ahmadov ^{36,x}, W.S. Ahmed ¹⁰¹, X. Ai ⁴⁶, G. Aielli ^{73a,73b}, I. Aizenberg ¹⁶⁵,
S. Akatsuka ⁸⁴, M. Akbiyik ⁹⁷, T.P.A. Åkesson ⁹⁵, A.V. Akimov ³⁵, K. Al Khoury ³⁹,
G.L. Alberghi ^{21b}, J. Albert ¹⁶¹, P. Albicocco ⁵¹, M.J. Alconada Verzini ⁸⁷,
S. Alderweireldt ⁵⁰, M. Aleksa ³⁴, I.N. Aleksandrov ³⁶, C. Alexa ^{25b}, T. Alexopoulos ⁹,
A. Alfonsi ¹¹¹, F. Alfonsi ^{21b}, M. Alhroob ¹¹⁶, B. Ali ¹²⁸, S. Ali ¹⁴⁵, M. Aliev ³⁵,
G. Alimonti ^{68a}, C. Allaire ³⁴, B.M.M. Allbrooke ¹⁴³, P.P. Allport ¹⁹, A. Aloisio ^{69a,69b},
F. Alonso ⁸⁷, C. Alpigiani ¹³⁵, E. Alunno Camelia ^{73a,73b}, M. Alvarez Estevez ⁹⁶,
M.G. Alviggi ^{69a,69b}, Y. Amaral Coutinho ^{79b}, A. Ambler ¹⁰¹, L. Ambroz ¹²², C. Amelung ³⁴,
D. Amidei ¹⁰³, S.P. Amor Dos Santos ^{126a}, S. Amoroso ⁴⁶, C.S. Amrouche ⁵⁴,
C. Anastopoulos ¹³⁶, N. Andari ¹³¹, T. Andeen ¹⁰, J.K. Anders ¹⁸, S.Y. Andrean ^{45a,45b},
A. Andreazza ^{68a,68b}, S. Angelidakis ⁸, A. Angerami ³⁹, A.V. Anisenkov ³⁵, A. Annovi ^{71a},
C. Antel ⁵⁴, M.T. Anthony ¹³⁶, E. Antipov ¹¹⁷, M. Antonelli ⁵¹, D.J.A. Antrim ^{16a},
F. Anulli ^{72a}, M. Aoki ⁸⁰, J.A. Aparisi Pozo ¹⁵⁹, M.A. Aparo ¹⁴³, L. Aperio Bella ⁴⁶,
N. Aranzabal ³⁴, V. Araujo Ferraz ^{79a}, C. Arcangeletti ⁵¹, A.T.H. Arce ⁴⁹, E. Arena ⁸⁹,
J-F. Arguin ¹⁰⁵, S. Argyropoulos ⁵², J.-H. Arling ⁴⁶, A.J. Armbruster ³⁴,
A. Armstrong ¹⁵⁶, O. Arnaez ¹⁵², H. Arnold ³⁴, Z.P. Arrubarrena Tame ¹⁰⁶, G. Artoni ¹²²,
H. Asada ¹⁰⁸, K. Asai ¹¹⁴, S. Asai ¹⁵⁰, N.A. Asbah ⁵⁹, E.M. Asimakopoulou ¹⁵⁷,
L. Asquith ¹⁴³, J. Assahsah ^{33d}, K. Assamagan ²⁷, R. Astalos ^{26a}, R.J. Atkin ^{31a},
M. Atkinson ¹⁵⁸, N.B. Atlay ¹⁷, H. Atmani ^{60b}, P.A. Atmasiddha ¹⁰³, K. Augsten ¹²⁸,
S. Auricchio ^{69a,69b}, V.A. Austrup ¹⁶⁷, G. Avner ¹⁴⁷, G. Avolio ³⁴, M.K. Ayoub ^{13c},
G. Azuelos ^{105,af}, D. Babal ^{26a}, H. Bachacou ¹³¹, K. Bachas ¹⁴⁹, A. Bachi ³²,
F. Backman ^{45a,45b}, A. Badea ⁵⁹, P. Bagnaia ^{72a,72b}, H. Bahrasemani ¹³⁹, A.J. Bailey ¹⁵⁹,
V.R. Bailey ¹⁵⁸, J.T. Baines ¹³⁰, C. Bakalis ⁹, O.K. Baker ¹⁶⁸, P.J. Bakker ¹¹¹,
E. Bakos ¹⁴, D. Bakshi Gupta ⁷, S. Balaji ¹⁴⁴, R. Balasubramanian ¹¹¹, E.M. Baldin ³⁵,
P. Balek ¹²⁹, E. Ballabene ^{68a,68b}, F. Balli ¹³¹, W.K. Balunas ¹²², J. Balz ⁹⁷, E. Banas ⁸³,
M. Bandieramonte ¹²⁵, A. Bandyopadhyay ¹⁷, S. Bansal ²², L. Barak ¹⁴⁸, E.L. Barberio ¹⁰²,
D. Barberis ^{55b,55a}, M. Barbero ⁹⁹, G. Barbour ⁹³, K.N. Barends ^{31a}, T. Barillari ¹⁰⁷,
M-S. Barisits ³⁴, J. Barkeloo ¹¹⁹, T. Barklow ¹⁴⁰, B.M. Barnett ¹³⁰, R.M. Barnett ^{16a},
A. Baroncelli ^{60a}, G. Barone ²⁷, A.J. Barr ¹²², L. Barranco Navarro ^{45a,45b}, F. Barreiro ⁹⁶,
J. Barreiro Guimarães da Costa ^{13a}, U. Barron ¹⁴⁸, S. Barsov ³⁵, F. Bartels ^{61a},
R. Bartoldus ¹⁴⁰, G. Bartolini ⁹⁹, A.E. Barton ⁸⁸, P.artos ^{26a}, A. Basalae ⁴⁶,
A. Basan ⁹⁷, M. Baselga ⁴⁶, I. Bashta ^{74a,74b}, A. Bassalat ^{64,ab}, M.J. Basso ¹⁵²,
C.R. Basson ⁹⁸, R.L. Bates ⁵⁷, S. Batlamous ^{33e}, J.R. Batley ³⁰, B. Batool ¹³⁸,
M. Battaglia ¹³², M. Bauce ^{72a,72b}, F. Bauer ^{131,*}, P. Bauer ²², H.S. Bawa ²⁹, A. Bayirli ^{11c},

J.B. Beacham [ID](#)⁴⁹, T. Beau [ID](#)¹²³, P.H. Beauchemin [ID](#)¹⁵⁵, F. Becherer [ID](#)⁵², P. Bechtle [ID](#)²²,
 H.P. Beck [ID](#)^{18,q}, K. Becker [ID](#)¹⁶³, C. Becot [ID](#)⁴⁶, A.J. Beddall [ID](#)^{11a}, V.A. Bednyakov [ID](#)³⁶,
 C.P. Bee [ID](#)¹⁴², T.A. Beermann [ID](#)³⁴, M. Begalli [ID](#)^{79b}, M. Begel [ID](#)²⁷, A. Behera [ID](#)¹⁴², J.K. Behr [ID](#)⁴⁶,
 C. Beirao Da Cruz E Silva [ID](#)³⁴, J.F. Beirer [ID](#)^{53,34}, F. Beisiegel [ID](#)²², M. Belfkir [ID](#)⁴, G. Bella [ID](#)¹⁴⁸,
 L. Bellagamba [ID](#)^{21b}, A. Bellerive [ID](#)³², P. Bellos [ID](#)¹⁹, K. Beloborodov [ID](#)³⁵, K. Belotskiy [ID](#)³⁵,
 N.L. Belyaev [ID](#)³⁵, D. Benchekroun [ID](#)^{33a}, Y. Benhammou [ID](#)¹⁴⁸, D.P. Benjamin [ID](#)²⁷, M. Benoit [ID](#)²⁷,
 J.R. Bensinger [ID](#)²⁴, S. Bentvelsen [ID](#)¹¹¹, L. Beresford [ID](#)³⁴, M. Beretta [ID](#)⁵¹, D. Berge [ID](#)¹⁷,
 E. Bergeaas Kuutmann [ID](#)¹⁵⁷, N. Berger [ID](#)⁴, B. Bergmann [ID](#)¹²⁸, L.J. Bergsten [ID](#)²⁴,
 J. Beringer [ID](#)^{16a}, S. Berlendis [ID](#)⁶, G. Bernardi [ID](#)¹²³, C. Bernius [ID](#)¹⁴⁰, F.U. Bernlochner [ID](#)²²,
 T. Berry [ID](#)⁹², P. Berta [ID](#)¹²⁹, A. Berthold [ID](#)⁴⁸, I.A. Bertram [ID](#)⁸⁸, O. Bessidskaia Bylund [ID](#)¹⁶⁷,
 S. Bethke [ID](#)¹⁰⁷, A. Betti [ID](#)⁴², A.J. Bevan [ID](#)⁹¹, S. Bhatta [ID](#)¹⁴², D.S. Bhattacharya [ID](#)¹⁶²,
 P. Bhattacharjya [ID](#)²⁴, V.S. Bhopatkar [ID](#)⁵, R. Bi¹²⁵, R.M. Bianchi [ID](#)¹²⁵, O. Biebel [ID](#)¹⁰⁶, R. Bielski [ID](#)¹¹⁹,
 N.V. Biesuz [ID](#)^{71a,71b}, M. Biglietti [ID](#)^{74a}, T.R.V. Billoud [ID](#)¹²⁸, M. Bindi [ID](#)⁵³, A. Bingul [ID](#)^{11d},
 C. Bini [ID](#)^{72a,72b}, S. Biondi [ID](#)^{21b,21a}, A. Biondini [ID](#)⁸⁹, C.J. Birch-sykes [ID](#)⁹⁸, G.A. Bird [ID](#)^{19,130},
 M. Birman [ID](#)¹⁶⁵, T. Bisanz [ID](#)³⁴, D. Biswas [ID](#)^{166,k}, A. Bitadze [ID](#)⁹⁸, C. Bittrich [ID](#)⁴⁸, K. Björke [ID](#)¹²¹,
 I. Bloch [ID](#)⁴⁶, C. Blocker [ID](#)²⁴, A. Blue [ID](#)⁵⁷, U. Blumenschein [ID](#)⁹¹, J. Blumenthal [ID](#)⁹⁷,
 G.J. Bobbink [ID](#)¹¹¹, V.S. Bobrovnikov [ID](#)³⁵, M. Boehler [ID](#)⁵², D. Bogavac [ID](#)¹²,
 A.G. Bogdanchikov [ID](#)³⁵, C. Bohm [ID](#)^{45a}, V. Boisvert [ID](#)⁹², P. Bokan [ID](#)⁴⁶, T. Bold [ID](#)^{82a},
 M. Bomben [ID](#)¹²³, M. Bona [ID](#)⁹¹, M. Boonekamp [ID](#)¹³¹, C.D. Booth [ID](#)⁹², A.G. Borbély [ID](#)⁵⁷,
 H.M. Borecka-Bielska [ID](#)¹⁰⁵, L.S. Borgna [ID](#)⁹³, G. Borissov [ID](#)⁸⁸, D. Bortoletto [ID](#)¹²²,
 D. Boscherini [ID](#)^{21b}, M. Bosman [ID](#)¹², J.D. Bossio Sola [ID](#)³⁴, K. Bouaouda [ID](#)^{33a}, J. Boudreau [ID](#)¹²⁵,
 E.V. Bouhova-Thacker [ID](#)⁸⁸, D. Boumediene [ID](#)³⁸, R. Bouquet [ID](#)¹²³, A. Boveia [ID](#)¹¹⁵, J. Boyd [ID](#)³⁴,
 D. Boye [ID](#)²⁷, I.R. Boyko [ID](#)³⁶, A.J. Bozson [ID](#)⁹², J. Bracinik [ID](#)¹⁹, N. Brahimi [ID](#)^{60d,60c},
 G. Brandt [ID](#)¹⁶⁷, O. Brandt [ID](#)³⁰, F. Braren [ID](#)⁴⁶, B. Brau [ID](#)¹⁰⁰, J.E. Brau [ID](#)¹¹⁹,
 W.D. Breaden Madden⁵⁷, K. Brendlinger [ID](#)⁴⁶, R. Brenner [ID](#)¹⁶⁵, L. Brenner [ID](#)³⁴, R. Brenner [ID](#)¹⁵⁷,
 S. Bressler [ID](#)¹⁶⁵, B. Brickwedde [ID](#)⁹⁷, D.L. Briglin [ID](#)¹⁹, D. Britton [ID](#)⁵⁷, D. Britzger [ID](#)¹⁰⁷,
 I. Brock [ID](#)²², R. Brock [ID](#)¹⁰⁴, G. Brooijmans [ID](#)³⁹, W.K. Brooks [ID](#)^{133e}, E. Brost [ID](#)²⁷,
 P.A. Bruckman de Renstrom [ID](#)⁸³, B. Brüers [ID](#)⁴⁶, D. Bruncko [ID](#)^{26b,*}, A. Bruni [ID](#)^{21b}, G. Bruni [ID](#)^{21b},
 M. Bruschi [ID](#)^{21b}, N. Bruscinò [ID](#)^{72a,72b}, L. Bryngemark [ID](#)¹⁴⁰, T. Buanes [ID](#)¹⁵, Q. Buat [ID](#)¹⁴²,
 P. Buchholz [ID](#)¹³⁸, A.G. Buckley [ID](#)⁵⁷, I.A. Budagov [ID](#)^{36,*}, M.K. Bugge [ID](#)¹²¹, O. Bulekov [ID](#)³⁵,
 B.A. Bullard [ID](#)⁵⁹, S. Burdin [ID](#)⁸⁹, C.D. Burgard [ID](#)⁴⁶, A.M. Burger [ID](#)¹¹⁷, B. Burghgrave [ID](#)⁷,
 J.T.P. Burr [ID](#)⁴⁶, C.D. Burton [ID](#)¹⁰, J.C. Burzynski [ID](#)¹⁰⁰, E.L. Busch [ID](#)³⁹, V. Büscher [ID](#)⁹⁷,
 P.J. Bussey [ID](#)⁵⁷, J.M. Butler [ID](#)²³, C.M. Buttar [ID](#)⁵⁷, J.M. Butterworth [ID](#)⁹³, W. Buttinger [ID](#)¹³⁰,
 C.J. Buxo Vazquez¹⁰⁴, A.R. Buzykaev [ID](#)³⁵, G. Cabras [ID](#)^{21b}, S. Cabrera Urbán [ID](#)¹⁵⁹,
 D. Caforio [ID](#)⁵⁶, H. Cai [ID](#)¹²⁵, V.M.M. Cairo [ID](#)¹⁴⁰, O. Cakir [ID](#)^{3a}, N. Calace [ID](#)³⁴, P. Calafiura [ID](#)^{16a},
 G. Calderini [ID](#)¹²³, P. Calfayan [ID](#)⁶⁵, G. Callea [ID](#)⁵⁷, L.P. Caloba [ID](#)^{79b}, S. Calvente Lopez [ID](#)⁹⁶,
 D. Calvet [ID](#)³⁸, S. Calvet [ID](#)³⁸, T.P. Calvet [ID](#)⁹⁹, M. Calvetti [ID](#)^{71a,71b}, R. Camacho Toro [ID](#)¹²³,
 S. Camarda [ID](#)³⁴, D. Camarero Munoz [ID](#)⁹⁶, P. Camarri [ID](#)^{73a,73b}, M.T. Camerlingo [ID](#)^{74a,74b},
 D. Cameron [ID](#)¹²¹, C. Camincher [ID](#)¹⁶¹, M. Campanelli [ID](#)⁹³, A. Camplani [ID](#)⁴⁰, V. Canale [ID](#)^{69a,69b},
 A. Canesse [ID](#)¹⁰¹, M. Cano Bret [ID](#)⁷⁷, J. Cantero [ID](#)¹¹⁷, Y. Cao [ID](#)¹⁵⁸, F. Capocasa [ID](#)²⁴,
 M. Capua [ID](#)^{41b,41a}, A. Carbone [ID](#)^{68a,68b}, R. Cardarelli [ID](#)^{73a}, J.C.J. Cardenas [ID](#)⁷, F. Cardillo [ID](#)¹⁵⁹,
 T. Carli [ID](#)³⁴, G. Carlino [ID](#)^{69a}, B.T. Carlson [ID](#)¹²⁵, E.M. Carlson [ID](#)^{161,153a}, L. Carminati [ID](#)^{68a,68b},
 M. Carnesale [ID](#)^{72a,72b}, R.M.D. Carney [ID](#)¹⁴⁰, S. Caron [ID](#)¹¹⁰, E. Carquin [ID](#)^{133e}, S. Carrá [ID](#)⁴⁶,

G. Carratta [ID](#)^{21b,21a}, J.W.S. Carter [ID](#)¹⁵², T.M. Carter [ID](#)⁵⁰, D. Casadei [ID](#)^{31c}, M.P. Casado [ID](#)^{12,h}, A.F. Casha [ID](#)¹⁵², E.G. Castiglia [ID](#)¹⁶⁸, F.L. Castillo [ID](#)^{61a}, L. Castillo Garcia [ID](#)¹², V. Castillo Gimenez [ID](#)¹⁵⁹, N.F. Castro [ID](#)^{126a,126e}, A. Catinaccio [ID](#)³⁴, J.R. Catmore [ID](#)¹²¹, A. Cattai [ID](#)³⁴, V. Cavaliere [ID](#)²⁷, N. Cavalli [ID](#)^{21b,21a}, V. Cavasinni [ID](#)^{71a,71b}, E. Celebi [ID](#)^{11b}, F. Celli [ID](#)¹²², M.S. Centonze [ID](#)^{67a,67b}, K. Cerny [ID](#)¹¹⁸, A.S. Cerqueira [ID](#)^{79a}, A. Cerri [ID](#)¹⁴³, L. Cerrito [ID](#)^{73a,73b}, F. Cerutti [ID](#)^{16a}, A. Cervelli [ID](#)^{21b}, S.A. Cetin [ID](#)^{11b}, Z. Chadi [ID](#)^{33a}, D. Chakraborty [ID](#)¹¹², M. Chala [ID](#)^{126f}, J. Chan [ID](#)¹⁶⁶, W.S. Chan [ID](#)¹¹¹, W.Y. Chan [ID](#)⁸⁹, J.D. Chapman [ID](#)³⁰, B. Chargeishvili [ID](#)^{146b}, D.G. Charlton [ID](#)¹⁹, T.P. Charman [ID](#)⁹¹, M. Chatterjee [ID](#)¹⁸, S. Chekanov [ID](#)⁵, S.V. Chekulaev [ID](#)^{153a}, G.A. Chelkov [ID](#)^{36,a}, A. Chen [ID](#)¹⁰³, B. Chen [ID](#)¹⁴⁸, B. Chen [ID](#)¹⁶¹, C. Chen [ID](#)^{60a}, C.H. Chen [ID](#)⁷⁸, H. Chen [ID](#)^{13c}, H. Chen [ID](#)²⁷, J. Chen [ID](#)^{60c}, J. Chen [ID](#)²⁴, S. Chen [ID](#)¹²⁴, S.J. Chen [ID](#)^{13c}, X. Chen [ID](#)^{60c}, X. Chen [ID](#)^{13b,ae}, Y. Chen [ID](#)^{60a}, Y-H. Chen [ID](#)⁴⁶, C.L. Cheng [ID](#)¹⁶⁶, H.C. Cheng [ID](#)^{62a}, A. Cheplakov [ID](#)³⁶, E. Cheremushkina [ID](#)⁴⁶, E. Cherepanova [ID](#)³⁶, R. Cherkaoui El Moursli [ID](#)^{33e}, E. Cheu [ID](#)⁶, K. Cheung [ID](#)⁶³, L. Chevalier [ID](#)¹³¹, V. Chiarella [ID](#)⁵¹, G. Chiarelli [ID](#)^{71a}, G. Chiodini [ID](#)^{67a}, A.S. Chisholm [ID](#)¹⁹, A. Chitan [ID](#)^{25b}, Y.H. Chiu [ID](#)¹⁶¹, M.V. Chizhov [ID](#)^{36,r}, K. Choi [ID](#)¹⁰, A.R. Chomont [ID](#)^{72a,72b}, Y. Chou [ID](#)¹⁰⁰, E.Y.S. Chow [ID](#)¹¹¹, T. Chowdhury [ID](#)^{31f}, L.D. Christopher [ID](#)^{31f}, M.C. Chu [ID](#)^{62a}, X. Chu [ID](#)^{13a,13d}, J. Chudoba [ID](#)¹²⁷, J.J. Chwastowski [ID](#)⁸³, D. Cieri [ID](#)¹⁰⁷, K.M. Ciesla [ID](#)⁸³, V. Cindro [ID](#)⁹⁰, I.A. Cioară [ID](#)^{25b}, A. Ciocio [ID](#)^{16a}, F. Ciotto [ID](#)^{69a,69b}, Z.H. Citron [ID](#)^{165,l}, M. Citterio [ID](#)^{68a}, D.A. Ciubotaru [ID](#)^{25b}, B.M. Ciungu [ID](#)¹⁵², A. Clark [ID](#)⁵⁴, P.J. Clark [ID](#)⁵⁰, J.M. Clavijo Columbie [ID](#)⁴⁶, S.E. Clawson [ID](#)⁹⁸, C. Clement [ID](#)^{45a,45b}, L. Clissa [ID](#)^{21b,21a}, Y. Coadou [ID](#)⁹⁹, M. Cobal [ID](#)^{66a,66c}, A. Coccaro [ID](#)^{55b}, J. Cochran [ID](#)⁷⁸, R.F. Coelho Barrue [ID](#)^{126a}, R. Coelho Lopes De Sa [ID](#)¹⁰⁰, S. Coelli [ID](#)^{68a}, H. Cohen [ID](#)¹⁴⁸, A.E.C. Coimbra [ID](#)³⁴, B. Cole [ID](#)³⁹, J. Collot [ID](#)⁵⁸, P. Conde Muiño [ID](#)^{126a,126h}, S.H. Connell [ID](#)^{31c}, I.A. Connelly [ID](#)⁵⁷, E.I. Conroy [ID](#)¹²², F. Conventi [ID](#)^{69a,ag}, H.G. Cooke [ID](#)¹⁹, A.M. Cooper-Sarkar [ID](#)¹²², F. Cormier [ID](#)¹⁶⁰, L.D. Corpe [ID](#)³⁴, M. Corradi [ID](#)^{72a,72b}, E.E. Corrigan [ID](#)⁹⁵, F. Corriveau [ID](#)^{101,w}, M.J. Costa [ID](#)¹⁵⁹, F. Costanza [ID](#)⁴, D. Costanzo [ID](#)¹³⁶, B.M. Cote [ID](#)¹¹⁵, G. Cowan [ID](#)⁹², J.W. Cowley [ID](#)³⁰, K. Cranmer [ID](#)¹¹³, S. Crépe-Renaudin [ID](#)⁵⁸, F. Crescioli [ID](#)¹²³, M. Cristinziani [ID](#)¹³⁸, M. Cristoforetti [ID](#)^{75a,75b,c}, V. Croft [ID](#)¹⁵⁵, G. Crosetti [ID](#)^{41b,41a}, A. Cueto [ID](#)³⁴, T. Cuhadar Donszelmann [ID](#)¹⁵⁶, H. Cui [ID](#)^{13a,13d}, A.R. Cukierman [ID](#)¹⁴⁰, W.R. Cunningham [ID](#)⁵⁷, F. Curcio [ID](#)^{41b,41a}, P. Czodrowski [ID](#)³⁴, M.M. Czurylo [ID](#)^{61b}, M.J. Da Cunha Sargedas De Sousa [ID](#)^{60a}, J.V. Da Fonseca Pinto [ID](#)^{79b}, C. Da Via [ID](#)⁹⁸, W. Dabrowski [ID](#)^{82a}, T. Dado [ID](#)⁴⁷, S. Dahbi [ID](#)^{31f}, T. Dai [ID](#)¹⁰³, C. Dallapiccola [ID](#)¹⁰⁰, M. Dam [ID](#)⁴⁰, G. D’amen [ID](#)²⁷, V. D’Amico [ID](#)^{74a,74b}, J. Damp [ID](#)⁹⁷, J.R. Dandoy [ID](#)¹²⁴, M.F. Daneri [ID](#)²⁸, M. Danninger [ID](#)¹³⁹, V. Dao [ID](#)³⁴, G. Darbo [ID](#)^{55b}, S. Darmora [ID](#)⁵, A. Dattagupta [ID](#)¹¹⁹, S. D’Auria [ID](#)^{68a,68b}, C. David [ID](#)^{153b}, T. Davidek [ID](#)¹²⁹, D.R. Davis [ID](#)⁴⁹, B. Davis-Purcell [ID](#)³², I. Dawson [ID](#)⁹¹, K. De [ID](#)⁷, R. De Asmundis [ID](#)^{69a}, M. De Beurs [ID](#)¹¹¹, S. De Castro [ID](#)^{21b,21a}, N. De Groot [ID](#)¹¹⁰, P. de Jong [ID](#)¹¹¹, H. De la Torre [ID](#)¹⁰⁴, A. De Maria [ID](#)^{13c}, D. De Pedis [ID](#)^{72a}, A. De Salvo [ID](#)^{72a}, U. De Sanctis [ID](#)^{73a,73b}, M. De Santis [ID](#)^{73a,73b}, A. De Santo [ID](#)¹⁴³, J.B. De Vivie De Regie [ID](#)⁵⁸, D.V. Dedovich [ID](#)³⁶, J. Degens [ID](#)¹¹¹, A.M. Deiana [ID](#)⁴², J. Del Peso [ID](#)⁹⁶, Y. Delabat Diaz [ID](#)⁴⁶, F. Deliot [ID](#)¹³¹, C.M. Delitzsch [ID](#)⁶, M. Della Pietra [ID](#)^{69a,69b}, D. Della Volpe [ID](#)⁵⁴, A. Dell’Acqua [ID](#)³⁴, L. Dell’Asta [ID](#)^{68a,68b}, M. Delmastro [ID](#)⁴, P.A. Delsart [ID](#)⁵⁸, S. Demers [ID](#)¹⁶⁸, M. Demichev [ID](#)³⁶, S.P. Denisov [ID](#)³⁵, L. D’Eramo [ID](#)¹¹², D. Derendarz [ID](#)⁸³, J.E. Derkaoui [ID](#)^{33d}, F. Derue [ID](#)¹²³,

P. Dervan [ID](#)⁸⁹, K. Desch [ID](#)²², K. Dette [ID](#)¹⁵², C. Deutsch [ID](#)²², P.O. Deviveiros [ID](#)³⁴,
 F.A. Di Bello [ID](#)^{72a,72b}, A. Di Ciaccio [ID](#)^{73a,73b}, L. Di Ciaccio [ID](#)⁴, A. Di Domenico [ID](#)^{72a,72b},
 C. Di Donato [ID](#)^{69a,69b}, A. Di Girolamo [ID](#)³⁴, G. Di Gregorio [ID](#)^{71a,71b}, A. Di Luca [ID](#)^{75a,75b},
 B. Di Micco [ID](#)^{74a,74b}, R. Di Nardo [ID](#)^{74a,74b}, C. Diaconu [ID](#)⁹⁹, F.A. Dias [ID](#)¹¹¹, T. Dias Do Vale [ID](#)^{126a},
 M.A. Diaz [ID](#)^{133a,133b}, F.G. Diaz Capriles [ID](#)²², J. Dickinson [ID](#)^{16a}, M. Didenko [ID](#)¹⁵⁹,
 E.B. Diehl [ID](#)¹⁰³, J. Dietrich [ID](#)¹⁷, S. Díez Cornell [ID](#)⁴⁶, C. Diez Pardos [ID](#)¹³⁸, A. Dimitrievska [ID](#)^{16a},
 W. Ding [ID](#)^{13b}, J. Dingfelder [ID](#)²², I.M. Dinu [ID](#)^{25b}, S.J. Dittmeier [ID](#)^{61b}, F. Dittus [ID](#)³⁴,
 F. Djama [ID](#)⁹⁹, T. Djobava [ID](#)^{146b}, J.I. Djuvslund [ID](#)¹⁵, M.A.B. Do Vale [ID](#)¹³⁴, D. Dodsworth [ID](#)²⁴,
 C. Doglioni [ID](#)⁹⁵, J. Dolejsi [ID](#)¹²⁹, Z. Dolezal [ID](#)¹²⁹, M. Donadelli [ID](#)^{79c}, B. Dong [ID](#)^{60c}, J. Donini [ID](#)³⁸,
 A. D’Onofrio [ID](#)^{13c}, M. D’Onofrio [ID](#)⁸⁹, J. Dopke [ID](#)¹³⁰, A. Doria [ID](#)^{69a}, M.T. Dova [ID](#)⁸⁷,
 A.T. Doyle [ID](#)⁵⁷, E. Drechsler [ID](#)¹³⁹, E. Dreyer [ID](#)¹³⁹, T. Dreyer [ID](#)⁵³, A.S. Drobac [ID](#)¹⁵⁵, D. Du [ID](#)^{60a},
 T.A. du Pree [ID](#)¹¹¹, F. Dubinin [ID](#)³⁵, M. Dubovsky [ID](#)^{26a}, A. Dubreuil [ID](#)⁵⁴, E. Duchovni [ID](#)¹⁶⁵,
 G. Duckeck [ID](#)¹⁰⁶, O.A. Ducu [ID](#)^{34,25b}, D. Duda [ID](#)¹⁰⁷, A. Dudarev [ID](#)³⁴, M. D’uffizi [ID](#)⁹⁸,
 L. Dufflot [ID](#)⁶⁴, M. Dührssen [ID](#)³⁴, C. Dülßen [ID](#)¹⁶⁷, A.E. Dumitriu [ID](#)^{25b}, M. Dunford [ID](#)^{61a},
 S. Dungs [ID](#)⁴⁷, K. Dunne [ID](#)^{45a,45b}, A. Duperrin [ID](#)⁹⁹, H. Duran Yildiz [ID](#)^{3a}, M. Düren [ID](#)⁵⁶,
 A. Durglishvili [ID](#)^{146b}, B. Dutta [ID](#)⁴⁶, B.L. Dwyer [ID](#)¹¹², G.I. Dyckes [ID](#)^{16a}, M. Dyndal [ID](#)^{82a},
 S. Dysch [ID](#)⁹⁸, B.S. Dziedzic [ID](#)⁸³, B. Eckerova [ID](#)^{26a}, M.G. Eggleston [ID](#)⁴⁹,
 E. Egidio Purcino De Souza [ID](#)^{79b}, L.F. Ehrke [ID](#)⁵⁴, T. Eifert [ID](#)⁷, G. Eigen [ID](#)¹⁵, K. Einsweiler [ID](#)^{16a},
 T. Ekelof [ID](#)¹⁵⁷, Y. El Ghazali [ID](#)^{33b}, H. El Jarrari [ID](#)^{33e}, A. El Moussaouy [ID](#)^{33a}, V. Ellajosyula [ID](#)¹⁵⁷,
 M. Ellert [ID](#)¹⁵⁷, F. Ellinghaus [ID](#)¹⁶⁷, A.A. Elliot [ID](#)⁹¹, N. Ellis [ID](#)³⁴, J. Elmsheuser [ID](#)²⁷, M. Elsing [ID](#)³⁴,
 D. Emelianov [ID](#)¹³⁰, A. Emerman [ID](#)³⁹, Y. Enari [ID](#)¹⁵⁰, J. Erdmann [ID](#)⁴⁷, A. Ereditato [ID](#)¹⁸,
 P.A. Erland [ID](#)⁸³, M. Errenst [ID](#)¹⁶⁷, M. Escalier [ID](#)⁶⁴, C. Escobar [ID](#)¹⁵⁹, O. Estrada Pastor [ID](#)¹⁵⁹,
 E. Etzion [ID](#)¹⁴⁸, G. Evans [ID](#)^{126a}, H. Evans [ID](#)⁶⁵, M.O. Evans [ID](#)¹⁴³, A. Ezhilov [ID](#)³⁵, F. Fabbri [ID](#)⁵⁷,
 L. Fabbri [ID](#)^{21b,21a}, G. Facini [ID](#)¹⁶³, V. Fadeyev [ID](#)¹³², R.M. Fakhruddinov [ID](#)³⁵, S. Falciano [ID](#)^{72a},
 P.J. Falke [ID](#)²², S. Falke [ID](#)³⁴, J. Faltova [ID](#)¹²⁹, Y. Fan [ID](#)^{13a}, Y. Fang [ID](#)^{13a}, Y. Fang [ID](#)^{13a,13d},
 G. Fanourakis [ID](#)⁴⁴, M. Fanti [ID](#)^{68a,68b}, M. Faraj [ID](#)^{60c}, A. Farbin [ID](#)⁷, A. Farilla [ID](#)^{74a},
 E.M. Farina [ID](#)^{70a,70b}, T. Farooque [ID](#)¹⁰⁴, S.M. Farrington [ID](#)⁵⁰, P. Farthouat [ID](#)³⁴, F. Fassi [ID](#)^{33e},
 D. Fassoulitis [ID](#)⁸, M. Fauci Giannelli [ID](#)^{73a,73b}, W.J. Fawcett [ID](#)³⁰, L. Fayard [ID](#)⁶⁴,
 O.L. Fedin [ID](#)^{35,a}, M. Feickert [ID](#)¹⁵⁸, L. Feligioni [ID](#)⁹⁹, A. Fell [ID](#)¹³⁶, C. Feng [ID](#)^{60b}, M. Feng [ID](#)^{13b},
 M.J. Fenton [ID](#)¹⁵⁶, A.B. Fenyuk [ID](#)³⁵, S.W. Ferguson [ID](#)⁴³, J. Ferrando [ID](#)⁴⁶, A. Ferrari [ID](#)¹⁵⁷,
 P. Ferrari [ID](#)¹¹¹, R. Ferrari [ID](#)^{70a}, D. Ferrere [ID](#)⁵⁴, C. Ferretti [ID](#)¹⁰³, F. Fiedler [ID](#)⁹⁷, A. Filipčič [ID](#)⁹⁰,
 F. Filthaut [ID](#)¹¹⁰, M.C.N. Fiolhais [ID](#)^{126a,126c,b}, L. Fiorini [ID](#)¹⁵⁹, F. Fischer [ID](#)¹³⁸, W.C. Fisher [ID](#)¹⁰⁴,
 T. Fitschen [ID](#)¹⁹, I. Fleck [ID](#)¹³⁸, P. Fleischmann [ID](#)¹⁰³, T. Flick [ID](#)¹⁶⁷, B.M. Flierl [ID](#)¹⁰⁶, L. Flores [ID](#)¹²⁴,
 M. Flores [ID](#)^{31f}, L.R. Flores Castillo [ID](#)^{62a}, F.M. Follega [ID](#)^{75a,75b}, N. Fomin [ID](#)¹⁵, J.H. Foo [ID](#)¹⁵²,
 B.C. Forland [ID](#)⁶⁵, A. Formica [ID](#)¹³¹, F.A. Förster [ID](#)¹², A.C. Forti [ID](#)⁹⁸, E. Fortin [ID](#)⁹⁹, M.G. Foti [ID](#)¹²²,
 L. Fountas [ID](#)^{8,i}, D. Fournier [ID](#)⁶⁴, H. Fox [ID](#)⁸⁸, P. Francavilla [ID](#)^{71a,71b}, S. Francescato [ID](#)⁵⁹,
 M. Franchini [ID](#)^{21b,21a}, S. Franchino [ID](#)^{61a}, D. Francis [ID](#)³⁴, L. Franco [ID](#)⁴, L. Franconi [ID](#)¹⁸,
 M. Franklin [ID](#)⁵⁹, G. Frattari [ID](#)^{72a,72b}, A.C. Freegard [ID](#)⁹¹, P.M. Freeman [ID](#)¹⁹, W.S. Freund [ID](#)^{79b},
 E.M. Freundlich [ID](#)⁴⁷, D. Froidevaux [ID](#)³⁴, J.A. Frost [ID](#)¹²², Y. Fu [ID](#)^{60a}, M. Fujimoto [ID](#)¹¹⁴,
 E. Fullana Torregrosa [ID](#)^{159,*}, J. Fuster [ID](#)¹⁵⁹, A. Gabrielli [ID](#)^{21b,21a}, A. Gabrielli [ID](#)³⁴, P. Gadow [ID](#)⁴⁶,
 G. Gagliardi [ID](#)^{55b,55a}, L.G. Gagnon [ID](#)^{16a}, G.E. Gallardo [ID](#)¹²², E.J. Gallas [ID](#)¹²², B.J. Gallop [ID](#)¹³⁰,
 R. Gamboa Goni [ID](#)⁹¹, K.K. Gan [ID](#)¹¹⁵, S. Ganguly [ID](#)¹⁶⁵, J. Gao [ID](#)^{60a}, Y. Gao [ID](#)⁵⁰, Y.S. Gao [ID](#)^{29,n},
 F.M. Garay Walls [ID](#)^{133a}, C. García [ID](#)¹⁵⁹, J.E. García Navarro [ID](#)¹⁵⁹, J.A. García Pascual [ID](#)^{13a},

M. Garcia-Sciveres [ID](#)^{16a}, R.W. Gardner [ID](#)³⁷, D. Garg [ID](#)⁷⁷, R.B. Garg [ID](#)^{140,al}, S. Gargiulo [ID](#)⁵², C.A. Garner [ID](#)¹⁵², V. Garonne [ID](#)¹²¹, S.J. Gasiorowski [ID](#)¹³⁵, P. Gaspar [ID](#)^{79b}, G. Gaudio [ID](#)^{70a}, P. Gauzzi [ID](#)^{72a,72b}, I.L. Gavrilenko [ID](#)³⁵, A. Gavrilyuk [ID](#)³⁵, C. Gay [ID](#)¹⁶⁰, G. Gaycken [ID](#)⁴⁶, E.N. Gazis [ID](#)⁹, A.A. Geanta [ID](#)^{25b}, C.M. Gee [ID](#)¹³², C.N.P. Gee [ID](#)¹³⁰, J. Geisen [ID](#)⁹⁵, M. Geisen [ID](#)⁹⁷, C. Gemme [ID](#)^{55b}, M.H. Genest [ID](#)⁵⁸, S. Gentile [ID](#)^{72a,72b}, S. George [ID](#)⁹², W.F. George [ID](#)¹⁹, T. Geralis [ID](#)⁴⁴, L.O. Gerlach [ID](#)⁵³, P. Gessinger-Befurt [ID](#)³⁴, M. Ghasemi Bostanabad [ID](#)¹⁶¹, M. Ghneimat [ID](#)¹³⁸, A. Ghosh [ID](#)¹⁵⁶, A. Ghosh [ID](#)⁷⁷, B. Giacobbe [ID](#)^{21b}, S. Giagu [ID](#)^{72a,72b}, N. Giangiacomi [ID](#)¹⁵², P. Giannetti [ID](#)^{71a}, A. Giannini [ID](#)^{69a,69b}, S.M. Gibson [ID](#)⁹², M. Gignac [ID](#)¹³², D.T. Gil [ID](#)^{82b}, B.J. Gilbert [ID](#)³⁹, D. Gillberg [ID](#)³², G. Gilles [ID](#)¹¹¹, N.E.K. Gillwald [ID](#)⁴⁶, D.M. Gingrich [ID](#)^{2,af}, M.P. Giordani [ID](#)^{66a,66c}, P.F. Giraud [ID](#)¹³¹, G. Giugliarelli [ID](#)^{66a,66c}, D. Giugni [ID](#)^{68a}, F. Giuli [ID](#)^{73a,73b}, I. Gkialas [ID](#)^{8,i}, P. Gkoutoumis [ID](#)⁹, L.K. Gladilin [ID](#)³⁵, C. Glasman [ID](#)⁹⁶, G.R. Gledhill [ID](#)¹¹⁹, M. Glisic [ID](#)¹¹⁹, I. Gnesi [ID](#)^{41b,e}, M. Goblirsch-Kolb [ID](#)²⁴, D. Godin [ID](#)¹⁰⁵, S. Goldfarb [ID](#)¹⁰², T. Golling [ID](#)⁵⁴, D. Golubkov [ID](#)³⁵, J.P. Gombas [ID](#)¹⁰⁴, A. Gomes [ID](#)^{126a,126b}, R. Goncalves Gama [ID](#)⁵³, R. Gonalo [ID](#)^{126a,126c}, G. Gonella [ID](#)¹¹⁹, L. Gonella [ID](#)¹⁹, A. Gongadze [ID](#)³⁶, F. Gonnella [ID](#)¹⁹, J.L. Gonski [ID](#)³⁹, S. Gonzalez de la Hoz [ID](#)¹⁵⁹, S. Gonzalez Fernandez [ID](#)¹², R. Gonzalez Lopez [ID](#)⁸⁹, C. Gonzalez Renteria [ID](#)^{16a}, R. Gonzalez Suarez [ID](#)¹⁵⁷, S. Gonzalez-Sevilla [ID](#)⁵⁴, G.R. Gonzalvo Rodriguez [ID](#)¹⁵⁹, R.Y. Gonzalez Andana [ID](#)^{133a}, L. Goossens [ID](#)³⁴, N.A. Gorasia [ID](#)¹⁹, P.A. Gorbounov [ID](#)³⁵, B. Gorini [ID](#)³⁴, E. Gorini [ID](#)^{67a,67b}, A. Gorišek [ID](#)⁹⁰, A.T. Goshaw [ID](#)⁴⁹, M.I. Gostkin [ID](#)³⁶, C.A. Gottardo [ID](#)¹¹⁰, M. Goughri [ID](#)^{33b}, V. Goumarre [ID](#)⁴⁶, A.G. Goussiou [ID](#)¹³⁵, N. Govender [ID](#)^{31c}, C. Goy [ID](#)⁴, I. Grabowska-Bold [ID](#)^{82a}, K. Graham [ID](#)³², E. Gramstad [ID](#)¹²¹, S. Grancagnolo [ID](#)¹⁷, M. Grandi [ID](#)¹⁴³, V. Gratchev [ID](#)^{35,*}, P.M. Gravila [ID](#)^{25f}, F.G. Gravili [ID](#)^{67a,67b}, H.M. Gray [ID](#)^{16a}, C. Grefe [ID](#)²², I.M. Gregor [ID](#)⁴⁶, P. Grenier [ID](#)¹⁴⁰, K. Grevtsov [ID](#)⁴⁶, C. Grieco [ID](#)¹², N.A. Grieser [ID](#)¹¹⁶, A.A. Grillo [ID](#)¹³², K. Grimm [ID](#)^{29,m}, S. Grinstein [ID](#)^{12,t}, J.-F. Grivaz [ID](#)⁶⁴, S. Groh [ID](#)⁹⁷, E. Gross [ID](#)¹⁶⁵, J. Grosse-Knetter [ID](#)⁵³, C. Grud [ID](#)¹⁰³, A. Grummer [ID](#)¹⁰⁹, J.C. Grundy [ID](#)¹²², L. Guan [ID](#)¹⁰³, W. Guan [ID](#)¹⁶⁶, C. Gubbels [ID](#)¹⁶⁰, J. Guenther [ID](#)³⁴, J.G.R. Guerrero Rojas [ID](#)¹⁵⁹, F. Guescini [ID](#)¹⁰⁷, R. Gugel [ID](#)⁹⁷, A. Guida [ID](#)⁴⁶, T. Guillemain [ID](#)⁴, S. Guindon [ID](#)³⁴, J. Guo [ID](#)^{60c}, L. Guo [ID](#)⁶⁴, Y. Guo [ID](#)¹⁰³, R. Gupta [ID](#)⁴⁶, S. Gurbuz [ID](#)²², G. Gustavino [ID](#)¹¹⁶, M. Guth [ID](#)⁵⁴, P. Gutierrez [ID](#)¹¹⁶, L.F. Gutierrez Zagazeta [ID](#)¹²⁴, C. Gutsche [ID](#)⁹³, C. Guyot [ID](#)¹³¹, C. Gwenlan [ID](#)¹²², C.B. Gwilliam [ID](#)⁸⁹, E.S. Haaland [ID](#)¹²¹, A. Haas [ID](#)¹¹³, M. Habedank [ID](#)¹⁷, C. Haber [ID](#)^{16a}, H.K. Hadavand [ID](#)⁷, A. Hadeef [ID](#)⁹⁷, S. Hadzic [ID](#)¹⁰⁷, M. Haleem [ID](#)¹⁶², J. Haley [ID](#)¹¹⁷, J.J. Hall [ID](#)¹³⁶, G. Halladjian [ID](#)¹⁰⁴, G.D. Hallewell [ID](#)⁹⁹, L. Halser [ID](#)¹⁸, K. Hamano [ID](#)¹⁶¹, H. Hamdaoui [ID](#)^{33e}, M. Hamer [ID](#)²², G.N. Hamity [ID](#)⁵⁰, K. Han [ID](#)^{60a}, L. Han [ID](#)^{13c}, L. Han [ID](#)^{60a}, S. Han [ID](#)^{16a}, Y.F. Han [ID](#)¹⁵², K. Hanagaki [ID](#)⁸⁰, M. Hance [ID](#)¹³², M.D. Hank [ID](#)³⁷, R. Hankache [ID](#)⁹⁸, E. Hansen [ID](#)⁹⁵, J.B. Hansen [ID](#)⁴⁰, J.D. Hansen [ID](#)⁴⁰, M.C. Hansen [ID](#)²², P.H. Hansen [ID](#)⁴⁰, K. Hara [ID](#)¹⁵⁴, T. Harenberg [ID](#)¹⁶⁷, S. Harkusha [ID](#)³⁵, Y.T. Harris [ID](#)¹²², P.F. Harrison [ID](#)¹⁶³, N.M. Hartman [ID](#)¹⁴⁰, N.M. Hartmann [ID](#)¹⁰⁶, Y. Hasegawa [ID](#)¹³⁷, A. Hasib [ID](#)⁵⁰, S. Hassani [ID](#)¹³¹, S. Haug [ID](#)¹⁸, R. Hauser [ID](#)¹⁰⁴, M. Havranek [ID](#)¹²⁸, C.M. Hawkes [ID](#)¹⁹, R.J. Hawkins [ID](#)³⁴, S. Hayashida [ID](#)¹⁰⁸, D. Hayden [ID](#)¹⁰⁴, C. Hayes [ID](#)¹⁰³, R.L. Hayes [ID](#)¹⁶⁰, C.P. Hays [ID](#)¹²², J.M. Hays [ID](#)⁹¹, H.S. Hayward [ID](#)⁸⁹, S.J. Haywood [ID](#)¹³⁰, F. He [ID](#)^{60a}, Y. He [ID](#)¹⁵¹, Y. He [ID](#)¹²³, M.P. Heath [ID](#)⁵⁰, V. Hedberg [ID](#)⁹⁵, A.L. Heggelund [ID](#)¹²¹, N.D. Hehir [ID](#)⁹¹, C. Heidegger [ID](#)⁵², K.K. Heidegger [ID](#)⁵², W.D. Heidorn [ID](#)⁷⁸, J. Heilman [ID](#)³², S. Heim [ID](#)⁴⁶, T. Heim [ID](#)^{16a}, B. Heinemann [ID](#)^{46,ac}, J.G. Heinlein [ID](#)¹²⁴, J.J. Heinrich [ID](#)¹¹⁹, L. Heinrich [ID](#)³⁴, J. Hejbal [ID](#)¹²⁷,

L. Helary [ID](#)⁴⁶, A. Held [ID](#)¹¹³, S. Hellesund [ID](#)¹²¹, C.M. Helling [ID](#)¹³², S. Hellman [ID](#)^{45a,45b},
 C. Helsens [ID](#)³⁴, R.C.W. Henderson⁸⁸, L. Henkelmann [ID](#)³⁰, A.M. Henriques Correia³⁴,
 H. Herde [ID](#)¹⁴⁰, Y. Hernández Jiménez [ID](#)¹⁴², H. Herr⁹⁷, M.G. Herrmann [ID](#)¹⁰⁶, T. Herrmann [ID](#)⁴⁸,
 G. Herten [ID](#)⁵², R. Hertenberger [ID](#)¹⁰⁶, L. Hervas [ID](#)³⁴, N.P. Hessey [ID](#)^{153a}, H. Hibi [ID](#)⁸¹,
 S. Higashino [ID](#)⁸⁰, E. Higón-Rodríguez [ID](#)¹⁵⁹, K.H. Hiller⁴⁶, S.J. Hillier [ID](#)¹⁹, M. Hils [ID](#)⁴⁸,
 I. Hinchliffe [ID](#)^{16a}, F. Hinterkeuser [ID](#)²², M. Hirose [ID](#)¹²⁰, S. Hirose [ID](#)¹⁵⁴, D. Hirschbuehl [ID](#)¹⁶⁷,
 B. Hiti [ID](#)⁹⁰, O. Hladik¹²⁷, J. Hobbs [ID](#)¹⁴², R. Hobincu [ID](#)^{25e}, N. Hod [ID](#)¹⁶⁵, M.C. Hodgkinson [ID](#)¹³⁶,
 B.H. Hodgkinson [ID](#)³⁰, A. Hoecker [ID](#)³⁴, J. Hofer [ID](#)⁴⁶, D. Hohn [ID](#)⁵², T. Holm [ID](#)²², T.R. Holmes [ID](#)³⁷,
 M. Holzbock [ID](#)¹⁰⁷, L.B.A.H. Hommels [ID](#)³⁰, B.P. Honan [ID](#)⁹⁸, J. Hong [ID](#)^{60c}, T.M. Hong [ID](#)¹²⁵,
 Y. Hong [ID](#)⁵³, J.C. Honig [ID](#)⁵², A. Hönle [ID](#)¹⁰⁷, B.H. Hooberman [ID](#)¹⁵⁸, W.H. Hopkins [ID](#)⁵,
 Y. Horii [ID](#)¹⁰⁸, L.A. Horyn [ID](#)³⁷, S. Hou [ID](#)¹⁴⁵, J. Howarth [ID](#)⁵⁷, J. Hoya [ID](#)⁸⁷, M. Hrabovsky [ID](#)¹¹⁸,
 A. Hrynevich [ID](#)³⁵, T. Hryn'ova [ID](#)⁴, P.J. Hsu [ID](#)⁶³, S.-C. Hsu [ID](#)¹³⁵, Q. Hu [ID](#)³⁹, S. Hu [ID](#)^{60c},
 Y.F. Hu [ID](#)^{13a,13d,ah}, D.P. Huang [ID](#)⁹³, X. Huang [ID](#)^{13c}, Y. Huang [ID](#)^{60a}, Y. Huang [ID](#)^{13a},
 Z. Hubacek [ID](#)¹²⁸, F. Hubaut [ID](#)⁹⁹, M. Huebner [ID](#)²², F. Huegging [ID](#)²², T.B. Huffman [ID](#)¹²²,
 M. Huhtinen [ID](#)³⁴, S.K. Huiberts [ID](#)¹⁵, R. Hulsken [ID](#)⁵⁸, N. Huseynov [ID](#)^{36,x}, J. Huston [ID](#)¹⁰⁴,
 J. Huth [ID](#)⁵⁹, R. Hyneman [ID](#)¹⁴⁰, S. Hyrych [ID](#)^{26a}, G. Iacobucci [ID](#)⁵⁴, G. Iakovidis [ID](#)²⁷,
 I. Ibragimov [ID](#)¹³⁸, L. Iconomidou-Fayard [ID](#)⁶⁴, P. Iengo [ID](#)³⁴, R. Iguchi [ID](#)¹⁵⁰, T. Iizawa [ID](#)⁵⁴,
 Y. Ikegami [ID](#)⁸⁰, A. Ilg [ID](#)¹⁸, N. Ilic [ID](#)¹⁵², H. Imam [ID](#)^{33a}, T. Ingebretsen Carlson [ID](#)^{45a,45b},
 G. Introzzi [ID](#)^{70a,70b}, M. Iodice [ID](#)^{74a}, V. Ippolito [ID](#)^{72a,72b}, M. Ishino [ID](#)¹⁵⁰, W. Islam [ID](#)¹⁶⁶,
 C. Issever [ID](#)^{17,46}, S. Istin [ID](#)^{11c,ai}, J.M. Iturbe Ponce [ID](#)^{62a}, R. Iuppa [ID](#)^{75a,75b}, A. Ivina [ID](#)¹⁶⁵,
 J.M. Izen [ID](#)⁴³, V. Izzo [ID](#)^{69a}, P. Jacka [ID](#)¹²⁷, P. Jackson [ID](#)¹, R.M. Jacobs [ID](#)⁴⁶, B.P. Jaeger [ID](#)¹³⁹,
 C.S. Jagfeld [ID](#)¹⁰⁶, G. Jäkel [ID](#)¹⁶⁷, K. Jakobs [ID](#)⁵², T. Jakoubek [ID](#)¹⁶⁵, J. Jamieson [ID](#)⁵⁷,
 K.W. Janas [ID](#)^{82a}, G. Jarlskog [ID](#)⁹⁵, A.E. Jaspan [ID](#)⁸⁹, N. Javadov^{36,x}, T. Javůrek [ID](#)³⁴,
 M. Javurkova [ID](#)¹⁰⁰, F. Jeanneau [ID](#)¹³¹, L. Jeanty [ID](#)¹¹⁹, J. Jejelava [ID](#)^{146a,y}, P. Jenni [ID](#)^{52,f},
 S. Jézéquel [ID](#)⁴, J. Jia [ID](#)¹⁴², Z. Jia [ID](#)^{13c}, Y. Jiang^{60a}, S. Jiggins [ID](#)⁵⁰, J. Jimenez Pena [ID](#)¹⁰⁷,
 S. Jin [ID](#)^{13c}, A. Jinaru [ID](#)^{25b}, O. Jinnouchi [ID](#)¹⁵¹, H. Jivan [ID](#)^{31f}, P. Johansson [ID](#)¹³⁶, K.A. Johns [ID](#)⁶,
 C.A. Johnson [ID](#)⁶⁵, D.M. Jones [ID](#)³⁰, E. Jones [ID](#)¹⁶³, R.W.L. Jones [ID](#)⁸⁸, T.J. Jones [ID](#)⁸⁹,
 J. Jovicevic [ID](#)⁵³, X. Ju [ID](#)^{16a}, J.J. Junggeburth [ID](#)³⁴, A. Juste Rozas [ID](#)^{12,t}, S. Kabana [ID](#)^{133d},
 A. Kaczmarek [ID](#)⁸³, M. Kado [ID](#)^{72a,72b}, H. Kagan [ID](#)¹¹⁵, M. Kagan [ID](#)¹⁴⁰, A. Kahn³⁹, A. Kahn [ID](#)¹²⁴,
 C. Kahra [ID](#)⁹⁷, T. Kajji [ID](#)¹⁶⁴, E. Kajomovitz [ID](#)¹⁴⁷, C.W. Kalderon [ID](#)²⁷, A. Kamenshchikov [ID](#)³⁵,
 M. Kaneda [ID](#)¹⁵⁰, N.J. Kang [ID](#)¹³², S. Kang [ID](#)⁷⁸, Y. Kano [ID](#)¹⁰⁸, J. Kanzaki⁸⁰, D. Kar [ID](#)^{31f},
 K. Karava [ID](#)¹²², M.J. Kareem [ID](#)^{153b}, I. Karkanas [ID](#)¹⁴⁹, S.N. Karpov [ID](#)³⁶, Z.M. Karpova [ID](#)³⁶,
 V. Kartvelishvili [ID](#)⁸⁸, A.N. Karyukhin [ID](#)³⁵, E. Kasimi [ID](#)¹⁴⁹, C. Kato [ID](#)^{60d}, J. Katzy [ID](#)⁴⁶,
 K. Kawade [ID](#)¹³⁷, K. Kawagoe [ID](#)⁸⁶, T. Kawaguchi [ID](#)¹⁰⁸, T. Kawamoto [ID](#)¹³¹, G. Kawamura⁵³,
 E.F. Kay [ID](#)¹⁶¹, F.I. Kaya [ID](#)¹⁵⁵, S. Kazakos [ID](#)¹², V.F. Kazanin [ID](#)³⁵, Y. Ke [ID](#)¹⁴²,
 J.M. Keaveney [ID](#)^{31a}, R. Keeler [ID](#)¹⁶¹, J.S. Keller [ID](#)³², D. Kelsey [ID](#)¹⁴³, J.J. Kempster [ID](#)¹⁹,
 J. Kendrick [ID](#)¹⁹, K.E. Kennedy [ID](#)³⁹, O. Kepka [ID](#)¹²⁷, S. Kersten [ID](#)¹⁶⁷, B.P. Kerševan [ID](#)⁹⁰,
 S. Ketabchi Haghighat [ID](#)¹⁵², M. Khandoga [ID](#)¹²³, A. Khanov [ID](#)¹¹⁷, A.G. Kharlamov [ID](#)³⁵,
 T. Kharlamova [ID](#)³⁵, E.E. Khoda [ID](#)¹³⁵, T.J. Khoo [ID](#)¹⁷, G. Khoriauli [ID](#)¹⁶², J. Khubua [ID](#)^{146b},
 S. Kido [ID](#)⁸¹, M. Kiehn [ID](#)³⁴, A. Kilgallon [ID](#)¹¹⁹, E. Kim [ID](#)¹⁵¹, Y.K. Kim [ID](#)³⁷, N. Kimura [ID](#)⁹³,
 A. Kirchhoff [ID](#)⁵³, D. Kirchmeier [ID](#)⁴⁸, C. Kirfel [ID](#)²², J. Kirk [ID](#)¹³⁰, A.E. Kiryunin [ID](#)¹⁰⁷,
 T. Kishimoto [ID](#)¹⁵⁰, D.P. Kisliuk¹⁵², C. Kitsaki [ID](#)⁹, O. Kivernyk [ID](#)²²,
 T. Klapdor-Kleingrothaus [ID](#)⁵², M. Klassen [ID](#)^{61a}, C. Klein [ID](#)³², L. Klein [ID](#)¹⁶², M.H. Klein [ID](#)¹⁰³,

M. Klein ⁸⁹, U. Klein ⁸⁹, P. Klimek ³⁴, A. Klimentov ²⁷, F. Klimpel ³⁴, T. Klingl ²²,
 T. Klioutchnikova ³⁴, F.F. Klitzner ¹⁰⁶, P. Kluit ¹¹¹, S. Kluth ¹⁰⁷, E. Kneringer ⁷⁶,
 T.M. Knight ¹⁵², A. Knue ⁵², D. Kobayashi ⁸⁶, M. Kobel ⁴⁸, M. Kocian ¹⁴⁰, T. Kodama ¹⁵⁰,
 P. Kodyš ¹²⁹, D.M. Koeck ¹⁴³, P.T. Koenig ²², T. Koffas ³², N.M. Köhler ³⁴, M. Kolb ¹³¹,
 I. Koletsou ⁴, T. Komarek ¹¹⁸, K. Köneke ⁵², A.X.Y. Kong ¹, T. Kono ¹¹⁴,
 V. Konstantinides ⁹³, N. Konstantinidis ⁹³, B. Konya ⁹⁵, R. Kopeliansky ⁶⁵, S. Koperny ^{82a},
 K. Korcyl ⁸³, K. Kordas ¹⁴⁹, G. Koren ¹⁴⁸, A. Korn ⁹³, S. Korn ⁵³, I. Korolkov ¹²,
 E.V. Korolkova ¹³⁶, N. Korotkova ³⁵, B. Kortman ¹¹¹, O. Kortner ¹⁰⁷, S. Kortner ¹⁰⁷,
 W.H. Kostecka ¹¹², V.V. Kostyukhin ^{136,35}, A. Kotsokechagia ⁶⁴, A. Kotwal ⁴⁹,
 A. Koulouris ³⁴, A. Kourkouveli-Charalampidi ^{70a,70b}, C. Kourkouvelis ⁸, E. Kourlitis ⁵,
 O. Kovanda ¹⁴³, R. Kowalewski ¹⁶¹, W. Kozanecki ¹³¹, A.S. Kozhin ³⁵,
 V.A. Kramarenko ³⁵, G. Kramberger ⁹⁰, D. Krasnopevtsev ^{60a}, M.W. Krasny ¹²³,
 A. Krasznahorkay ³⁴, J.A. Kremer ⁹⁷, J. Kretzschmar ⁸⁹, K. Kreul ¹⁷, P. Krieger ¹⁵²,
 F. Krieter ¹⁰⁶, S. Krishnamurthy ¹⁰⁰, A. Krishnan ^{61b}, M. Krivos ¹²⁹, K. Krizka ^{16a},
 K. Kroeninger ⁴⁷, H. Kroha ¹⁰⁷, J. Kroll ¹²⁷, J. Kroll ¹²⁴, K.S. Krowpman ¹⁰⁴,
 U. Kruchonak ³⁶, H. Krüger ²², N. Krumnack ⁷⁸, M.C. Kruse ⁴⁹, J.A. Krzysiak ⁸³,
 A. Kubota ¹⁵¹, O. Kuchinskaia ³⁵, S. Kuday ^{3a}, D. Kuechler ⁴⁶, J.T. Kuechler ⁴⁶,
 S. Kuehn ³⁴, T. Kuhl ⁴⁶, V. Kukhtin ³⁶, Y. Kulchitsky ^{35,a}, S. Kuleshov ^{133c},
 M. Kumar ^{31f}, N. Kumari ⁹⁹, M. Kuna ⁵⁸, A. Kupco ¹²⁷, T. Kupfer ⁴⁷, O. Kuprash ⁵²,
 H. Kurashige ⁸¹, L.L. Kurchaninov ^{153a}, Y.A. Kurochkin ³⁵, A. Kurova ³⁵,
 M.G. Kurth ^{13a,13d}, E.S. Kuwertz ³⁴, M. Kuze ¹⁵¹, A.K. Kvam ¹³⁵, J. Kvita ¹¹⁸,
 T. Kwan ¹⁰¹, K.W. Kwok ^{62a}, C. Lacasta ¹⁵⁹, F. Lacava ^{72a,72b}, H. Lacker ¹⁷,
 D. Lacour ¹²³, N.N. Lad ⁹³, E. Ladygin ³⁶, R. Lafaye ⁴, B. Laforge ¹²³, T. Lagouri ^{133d},
 S. Lai ⁵³, I.K. Lakomic ^{82a}, N. Lalloue ⁵⁸, J.E. Lambert ¹¹⁶, S. Lammers ⁶⁵,
 W. Lampl ⁶, C. Lampoudis ¹⁴⁹, E. Lançon ²⁷, U. Landgraf ⁵², M.P.J. Landon ⁹¹,
 V.S. Lang ⁵², J.C. Lange ⁵³, R.J. Langenberg ¹⁰⁰, A.J. Lankford ¹⁵⁶, F. Lanni ²⁷,
 K. Lantzs ²², A. Lanza ^{70a}, A. Lapertosa ^{55b,55a}, J.F. Laporte ¹³¹, T. Lari ^{68a},
 F. Lasagni Manghi ^{21b}, M. Lassnig ³⁴, V. Latonova ¹²⁷, T.S. Lau ^{62a}, A. Laudrain ⁹⁷,
 A. Laurier ³², M. Lavorgna ^{69a,69b}, S.D. Lawlor ⁹², Z. Lawrence ⁹⁸, M. Lazzaroni ^{68a,68b},
 B. Le ⁹⁸, B. Leban ⁹⁰, A. Lebedev ⁷⁸, M. LeBlanc ³⁴, T. LeCompte ⁵, F. Ledroit-Guillon ⁵⁸,
 A.C.A. Lee ⁹³, G.R. Lee ¹⁵, L. Lee ⁵⁹, S.C. Lee ¹⁴⁵, S. Lee ⁷⁸, L.L. Leeuw ^{31c},
 B. Lefebvre ^{153a}, H.P. Lefebvre ⁹², M. Lefebvre ¹⁶¹, C. Leggett ^{16a}, K. Lehmann ¹³⁹,
 N. Lehmann ¹⁸, G. Lehmann Miotto ³⁴, W.A. Leight ⁴⁶, A. Leisos ^{149,s}, M.A.L. Leite ^{79c},
 C.E. Leitgeb ⁴⁶, R. Leitner ¹²⁹, K.J.C. Leney ⁴², T. Lenz ²², S. Leone ^{71a},
 C. Leonidopoulos ⁵⁰, A. Leopold ¹²³, C. Leroy ¹⁰⁵, R. Les ¹⁰⁴, C.G. Lester ³⁰,
 M. Levchenko ³⁵, J. Levêque ⁴, D. Levin ¹⁰³, L.J. Levinson ¹⁶⁵, D.J. Lewis ¹⁹, B. Li ^{13b},
 B. Li ^{60b}, C. Li ^{60a}, C-Q. Li ^{60c,60d}, H. Li ^{60a}, H. Li ^{60b}, H. Li ^{60b}, J. Li ^{60c}, K. Li ¹³⁵,
 L. Li ^{60c}, M. Li ^{13a,13d}, Q.Y. Li ^{60a}, S. Li ^{60d,60c,d}, T. Li ^{60b}, X. Li ⁴⁶, Y. Li ⁴⁶,
 Z. Li ^{60b}, Z. Li ¹²², Z. Li ¹⁰¹, Z. Li ⁸⁹, Z. Liang ^{13a}, M. Liberatore ⁴⁶, B. Liberti ^{73a},
 K. Lie ^{62c}, J. Lieber Marin ^{79b}, K. Lin ¹⁰⁴, R.A. Linck ⁶⁵, R.E. Lindley ⁶, J.H. Lindon ²,
 A. Linss ⁴⁶, E. Lipeles ¹²⁴, A. Lipniacka ¹⁵, T.M. Liss ^{158,ad}, A. Lister ¹⁶⁰, J.D. Little ⁷,
 B. Liu ^{13a}, B.X. Liu ¹³⁹, J.B. Liu ^{60a}, J.K.K. Liu ³⁷, K. Liu ^{60d,60c}, M. Liu ^{60a},
 M.Y. Liu ^{60a}, P. Liu ^{13a}, X. Liu ^{60a}, Y. Liu ⁴⁶, Y. Liu ^{13c,13d}, Y.L. Liu ¹⁰³,

Y.W. Liu [ID](#)^{60a}, M. Livan [ID](#)^{70a,70b}, A. Lleres [ID](#)⁵⁸, J. Llorente Merino [ID](#)¹³⁹, S.L. Lloyd [ID](#)⁹¹,
 E.M. Lobodzinska [ID](#)⁴⁶, P. Loch [ID](#)⁶, S. Loffredo [ID](#)^{73a,73b}, T. Lohse [ID](#)¹⁷, K. Lohwasser [ID](#)¹³⁶,
 M. Lokajicek [ID](#)¹²⁷, J.D. Long [ID](#)¹⁵⁸, I. Longarini [ID](#)^{72a,72b}, L. Longo [ID](#)³⁴, R. Longo [ID](#)¹⁵⁸,
 I. Lopez Paz [ID](#)¹², A. Lopez Solis [ID](#)⁴⁶, J. Lorenz [ID](#)¹⁰⁶, N. Lorenzo Martinez [ID](#)⁴, A.M. Lory [ID](#)¹⁰⁶,
 A. Lösle [ID](#)⁵², X. Lou [ID](#)^{45a,45b}, X. Lou [ID](#)^{13a,13d}, A. Lounis [ID](#)⁶⁴, J. Love [ID](#)⁵, P.A. Love [ID](#)⁸⁸,
 J.J. Lozano Bahilo [ID](#)¹⁵⁹, G. Lu [ID](#)^{13a,13d}, M. Lu [ID](#)^{60a}, S. Lu [ID](#)¹²⁴, Y.J. Lu [ID](#)⁶³, H.J. Lubatti [ID](#)¹³⁵,
 C. Luci [ID](#)^{72a,72b}, F.L. Lucio Alves [ID](#)^{13c}, A. Lucotte [ID](#)⁵⁸, F. Luehring [ID](#)⁶⁵, I. Luise [ID](#)¹⁴²,
 L. Luminari^{72a}, O. Lundberg [ID](#)¹⁴¹, B. Lund-Jensen [ID](#)¹⁴¹, N.A. Luongo [ID](#)¹¹⁹, M.S. Lutz [ID](#)¹⁴⁸,
 D. Lynn [ID](#)²⁷, H. Lyons⁸⁹, R. Lysak [ID](#)¹²⁷, E. Lytken [ID](#)⁹⁵, F. Lyu [ID](#)^{13a}, V. Lyubushkin [ID](#)³⁶,
 T. Lyubushkina [ID](#)³⁶, H. Ma [ID](#)²⁷, L.L. Ma [ID](#)^{60b}, Y. Ma [ID](#)⁹³, D.M. Mac Donell [ID](#)¹⁶¹,
 G. Maccarrone [ID](#)⁵¹, C.M. Macdonald [ID](#)¹³⁶, J.C. MacDonald [ID](#)¹³⁶, R. Madar [ID](#)³⁸, W.F. Mader [ID](#)⁴⁸,
 M. Madugoda Ralalage Don [ID](#)¹¹⁷, N. Madysa [ID](#)⁴⁸, J. Maeda [ID](#)⁸¹, T. Maeno [ID](#)²⁷, M. Maerker [ID](#)⁴⁸,
 V. Magerl [ID](#)⁵², J. Magro [ID](#)^{66a,66c}, D.J. Mahon [ID](#)³⁹, C. Maidantchik [ID](#)^{79b}, A. Maio [ID](#)^{126a,126b,126d},
 K. Maj [ID](#)^{82a}, O. Majersky [ID](#)^{26a}, S. Majewski [ID](#)¹¹⁹, N. Makovec [ID](#)⁶⁴, V. Maksimovic [ID](#)¹⁴,
 B. Malaescu [ID](#)¹²³, Pa. Malecki [ID](#)⁸³, V.P. Maleev [ID](#)³⁵, F. Malek [ID](#)⁵⁸, D. Malito [ID](#)^{41b,41a},
 U. Mallik [ID](#)⁷⁷, C. Malone [ID](#)³⁰, S. Maltezos⁹, S. Malyukov³⁶, J. Mamuzic [ID](#)¹⁵⁹, G. Mancini [ID](#)⁵¹,
 J.P. Mandalia [ID](#)⁹¹, I. Mandić [ID](#)⁹⁰, L. Manhaes de Andrade Filho [ID](#)^{79a}, I.M. Maniatis [ID](#)¹⁴⁹,
 M. Manisha [ID](#)¹³¹, J. Manjarres Ramos [ID](#)⁴⁸, K.H. Mankinen [ID](#)⁹⁵, A. Mann [ID](#)¹⁰⁶, A. Manousos [ID](#)⁷⁶,
 B. Mansoulie [ID](#)¹³¹, I. Manthos [ID](#)¹⁴⁹, S. Manzoni [ID](#)¹¹¹, A. Marantis [ID](#)^{149,s}, G. Marchiori [ID](#)¹²³,
 M. Marcisovsky [ID](#)¹²⁷, L. Marcoccia [ID](#)^{73a,73b}, C. Marcon [ID](#)⁹⁵, M. Marjanovic [ID](#)¹¹⁶,
 Z. Marshall [ID](#)^{16a}, S. Marti-Garcia [ID](#)¹⁵⁹, T.A. Martin [ID](#)¹⁶³, V.J. Martin [ID](#)⁵⁰,
 B. Martin dit Latour [ID](#)¹⁵, L. Martinelli [ID](#)^{72a,72b}, M. Martinez [ID](#)^{12,t}, P. Martinez Agullo [ID](#)¹⁵⁹,
 V.I. Martinez Outschoorn [ID](#)¹⁰⁰, S. Martin-Haugh [ID](#)¹³⁰, V.S. Martoiu [ID](#)^{25b}, A.C. Martyniuk [ID](#)⁹³,
 A. Marzin [ID](#)³⁴, S.R. Maschek [ID](#)¹⁰⁷, L. Masetti [ID](#)⁹⁷, T. Mashimo [ID](#)¹⁵⁰, J. Masik [ID](#)⁹⁸,
 A.L. Maslennikov [ID](#)³⁵, L. Massa [ID](#)^{21b}, P. Massarotti [ID](#)^{69a,69b}, P. Mastrandrea [ID](#)^{71a,71b},
 A. Mastroberardino [ID](#)^{41b,41a}, T. Masubuchi [ID](#)¹⁵⁰, D. Matakias²⁷, T. Mathisen [ID](#)¹⁵⁷, A. Matic [ID](#)¹⁰⁶,
 N. Matsuzawa¹⁵⁰, J. Maurer [ID](#)^{25b}, B. Maček [ID](#)⁹⁰, D.A. Maximov [ID](#)³⁵, R. Mazini [ID](#)¹⁴⁵,
 I. Maznas [ID](#)¹⁴⁹, S.M. Mazza [ID](#)¹³², C. Mc Ginn [ID](#)²⁷, J.P. Mc Gowan [ID](#)¹⁰¹, S.P. Mc Kee [ID](#)¹⁰³,
 T.G. McCarthy [ID](#)¹⁰⁷, W.P. McCormack [ID](#)^{16a}, E.F. McDonald [ID](#)¹⁰², A.E. McDougall [ID](#)¹¹¹,
 J.A. Mcfayden [ID](#)¹⁴³, G. Mchedlize [ID](#)^{146b}, M.A. McKay⁴², K.D. McLean [ID](#)¹⁶¹,
 S.J. McMahon [ID](#)¹³⁰, P.C. McNamara [ID](#)¹⁰², R.A. McPherson [ID](#)^{161,w}, J.E. Mdhuli [ID](#)^{31f},
 Z.A. Meadows [ID](#)¹⁰⁰, S. Meehan [ID](#)³⁴, T. Megy [ID](#)³⁸, S. Mehlhase [ID](#)¹⁰⁶, A. Mehta [ID](#)⁸⁹,
 B. Meirose [ID](#)⁴³, D. Melini [ID](#)¹⁴⁷, B.R. Mellado Garcia [ID](#)^{31f}, A.H. Melo [ID](#)⁵³, F. Meloni [ID](#)⁴⁶,
 A. Melzer [ID](#)²², E.D. Mendes Gouveia [ID](#)^{126a}, A.M. Mendes Jacques Da Costa [ID](#)¹⁹, H.Y. Meng [ID](#)¹⁵²,
 L. Meng [ID](#)³⁴, S. Menke [ID](#)¹⁰⁷, M. Mentink [ID](#)³⁴, E. Meoni [ID](#)^{41b,41a}, C. Merlassino [ID](#)¹²²,
 P. Mermod [ID](#)^{54,*}, L. Merola [ID](#)^{69a,69b}, C. Meroni [ID](#)^{68a}, G. Merz¹⁰³, O. Meshkov [ID](#)³⁵,
 J.K.R. Meshreki [ID](#)¹³⁸, J. Metcalfe [ID](#)⁵, A.S. Mete [ID](#)⁵, C. Meyer [ID](#)⁶⁵, J-P. Meyer [ID](#)¹³¹,
 M. Michetti [ID](#)¹⁷, R.P. Middleton [ID](#)¹³⁰, L. Mijović [ID](#)⁵⁰, G. Mikenberg [ID](#)¹⁶⁵, M. Mikestikova [ID](#)¹²⁷,
 M. Mikuž [ID](#)⁹⁰, H. Mildner [ID](#)¹³⁶, A. Milic [ID](#)¹⁵², C.D. Milke [ID](#)⁴², D.W. Miller [ID](#)³⁷, L.S. Miller [ID](#)³²,
 A. Milov [ID](#)¹⁶⁵, D.A. Milstead^{45a,45b}, T. Min^{13c}, A.A. Minaenko [ID](#)³⁵, I.A. Minashvili [ID](#)^{146b},
 L. Mince [ID](#)⁵⁷, A.I. Mincer [ID](#)¹¹³, B. Mindur [ID](#)^{82a}, M. Mineev [ID](#)³⁶, Y. Minegishi¹⁵⁰, Y. Mino [ID](#)⁸⁴,
 L.M. Mir [ID](#)¹², M. Miralles Lopez [ID](#)¹⁵⁹, M. Mironova [ID](#)¹²², T. Mitani [ID](#)¹⁶⁴, V.A. Mitsou [ID](#)¹⁵⁹,
 M. Mittal^{60c}, O. Miu [ID](#)¹⁵², P.S. Miyagawa [ID](#)⁹¹, Y. Miyazaki⁸⁶, A. Mizukami [ID](#)⁸⁰,

J.U. Mjörnmark [ID](#)⁹⁵, T. Mkrtchyan [ID](#)^{61a}, M. Mlynarikova [ID](#)¹¹², T. Moa [ID](#)^{45a,45b}, S. Mobius [ID](#)⁵³, K. Mochizuki [ID](#)¹⁰⁵, P. Moder [ID](#)⁴⁶, P. Mogg [ID](#)¹⁰⁶, A.F. Mohammed [ID](#)^{13a,13d}, S. Mohapatra [ID](#)³⁹, G. Mokgatitswane [ID](#)^{31f}, B. Mondal [ID](#)¹³⁸, S. Mondal [ID](#)¹²⁸, K. Mönig [ID](#)⁴⁶, E. Monnier [ID](#)⁹⁹, L. Monsonis Romero ¹⁵⁹, A. Montalbano [ID](#)¹³⁹, J. Montejo Berlingen [ID](#)³⁴, M. Montella [ID](#)¹¹⁵, F. Monticelli [ID](#)⁸⁷, N. Morange [ID](#)⁶⁴, A.L. Moreira De Carvalho [ID](#)^{126a}, M. Moreno Llácer [ID](#)¹⁵⁹, C. Moreno Martinez [ID](#)¹², P. Morettini [ID](#)^{55b}, S. Morgenstern [ID](#)¹⁶³, D. Mori [ID](#)¹³⁹, M. Morii [ID](#)⁵⁹, M. Morinaga [ID](#)¹⁵⁰, V. Morisbak [ID](#)¹²¹, A.K. Morley [ID](#)³⁴, A.P. Morris [ID](#)⁹³, L. Morvaj [ID](#)³⁴, P. Moschovakos [ID](#)³⁴, B. Moser [ID](#)¹¹¹, M. Mosidze ^{146b}, T. Moskalets [ID](#)⁵², P. Moskvitina [ID](#)¹¹⁰, J. Moss [ID](#)^{29,o}, E.J.W. Moyses [ID](#)¹⁰⁰, S. Muanza [ID](#)⁹⁹, J. Mueller [ID](#)¹²⁵, D. Muenstermann [ID](#)⁸⁸, R. Müller [ID](#)¹⁸, G.A. Mullier [ID](#)⁹⁵, J.J. Mullin ¹²⁴, D.P. Mungo [ID](#)^{68a,68b}, J.L. Munoz Martinez [ID](#)¹², F.J. Munoz Sanchez [ID](#)⁹⁸, M. Murin [ID](#)⁹⁸, P. Murin [ID](#)^{26b}, W.J. Murray [ID](#)^{163,130}, A. Murrone [ID](#)^{68a,68b}, J.M. Muse [ID](#)¹¹⁶, M. Muškinja [ID](#)^{16a}, C. Mwewa [ID](#)²⁷, A.G. Myagkov [ID](#)^{35,a}, A.J. Myers [ID](#)⁷, A.A. Myers ¹²⁵, G. Myers [ID](#)⁶⁵, M. Myska [ID](#)¹²⁸, B.P. Nachman [ID](#)^{16a}, O. Nackenhorst [ID](#)⁴⁷, A. Nag [ID](#)⁴⁸, K. Nagai [ID](#)¹²², K. Nagano [ID](#)⁸⁰, J.L. Nagle [ID](#)²⁷, E. Nagy [ID](#)⁹⁹, A.M. Nairz [ID](#)³⁴, Y. Nakahama [ID](#)¹⁰⁸, K. Nakamura [ID](#)⁸⁰, H. Nanjo [ID](#)¹²⁰, F. Napolitano [ID](#)^{61a}, R. Narayan [ID](#)⁴², E.A. Narayanan [ID](#)¹⁰⁹, I. Naryshkin [ID](#)³⁵, M. Naseri [ID](#)³², C. Nass [ID](#)²², T. Naumann [ID](#)⁴⁶, G. Navarro [ID](#)^{20a}, J. Navarro-Gonzalez [ID](#)¹⁵⁹, R. Nayak [ID](#)¹⁴⁸, P.Y. Nechaeva [ID](#)³⁵, F. Nechansky [ID](#)⁴⁶, T.J. Neep [ID](#)¹⁹, A. Negri [ID](#)^{70a,70b}, M. Negrini [ID](#)^{21b}, C. Nellist [ID](#)¹¹⁰, C. Nelson [ID](#)¹⁰¹, K. Nelson [ID](#)¹⁰³, S. Nemecek [ID](#)¹²⁷, M. Nessi [ID](#)^{34,g}, M.S. Neubauer [ID](#)¹⁵⁸, F. Neuhaus [ID](#)⁹⁷, J. Neundorff [ID](#)⁴⁶, R. Newhouse [ID](#)¹⁶⁰, P.R. Newman [ID](#)¹⁹, C.W. Ng [ID](#)¹²⁵, Y.S. Ng ¹⁷, Y.W.Y. Ng [ID](#)¹⁵⁶, B. Ngair [ID](#)^{33e}, H.D.N. Nguyen [ID](#)¹⁰⁵, R.B. Nickerson [ID](#)¹²², R. Nicolaidou [ID](#)¹³¹, D.S. Nielsen [ID](#)⁴⁰, J. Nielsen [ID](#)¹³², M. Niemeyer [ID](#)⁵³, N. Nikiforou [ID](#)¹⁰, V. Nikolaenko [ID](#)^{35,a}, I. Nikolic-Audit [ID](#)¹²³, K. Nikolopoulos [ID](#)¹⁹, P. Nilsson [ID](#)²⁷, H.R. Nindhito [ID](#)⁵⁴, A. Nisati [ID](#)^{72a}, N. Nishu [ID](#)², R. Nisius [ID](#)¹⁰⁷, T. Nitta [ID](#)¹⁶⁴, T. Nobe [ID](#)¹⁵⁰, D.L. Noel [ID](#)³⁰, Y. Noguchi [ID](#)⁸⁴, I. Nomidis [ID](#)¹²³, M.A. Nomura ²⁷, M.B. Norfolk [ID](#)¹³⁶, R.R.B. Norisam [ID](#)⁹³, J. Novak [ID](#)⁹⁰, T. Novak [ID](#)⁴⁶, O. Novgorodova [ID](#)⁴⁸, L. Novotny [ID](#)¹²⁸, R. Novotny [ID](#)¹⁰⁹, L. Nozka [ID](#)¹¹⁸, K. Ntekas [ID](#)¹⁵⁶, E. Nurse ⁹³, F.G. Oakham [ID](#)^{32,af}, J. Ocariz [ID](#)¹²³, A. Ochi [ID](#)⁸¹, I. Ochoa [ID](#)^{126a}, J.P. Ochoa-Ricoux [ID](#)^{133a}, S. Oda [ID](#)⁸⁶, S. Odaka [ID](#)⁸⁰, S. Oerdek [ID](#)¹⁵⁷, A. Ogrodnik [ID](#)^{82a}, A. Oh [ID](#)⁹⁸, C.C. Ohm [ID](#)¹⁴¹, H. Oide [ID](#)¹⁵¹, R. Oishi [ID](#)¹⁵⁰, M.L. Ojeda [ID](#)⁴⁶, Y. Okazaki [ID](#)⁸⁴, M.W. O’Keefe ⁸⁹, Y. Okumura [ID](#)¹⁵⁰, A. Olariu ^{25b}, L.F. Oleiro Seabra [ID](#)^{126a}, S.A. Olivares Pino [ID](#)^{133d}, D. Oliveira Damazio [ID](#)²⁷, D. Oliveira Goncalves [ID](#)^{79a}, J.L. Oliver [ID](#)¹⁵⁶, M.J.R. Olsson [ID](#)¹⁵⁶, A. Olszewski [ID](#)⁸³, J. Olszowska [ID](#)^{83,*}, Ö.O. Öncel [ID](#)²², D.C. O’Neil [ID](#)¹³⁹, A.P. O’Neill [ID](#)¹²², A. Onofre [ID](#)^{126a,126e}, P.U.E. Onyisi [ID](#)¹⁰, R.G. Oreamuno Madriz ¹¹², M.J. Oreglia [ID](#)³⁷, G.E. Orellana [ID](#)⁸⁷, D. Orestano [ID](#)^{74a,74b}, N. Orlando [ID](#)¹², R.S. Orr [ID](#)¹⁵², V. O’Shea [ID](#)⁵⁷, R. Ospanov [ID](#)^{60a}, G. Otero y Garzon [ID](#)²⁸, H. Otono [ID](#)⁸⁶, P.S. Ott [ID](#)^{61a}, G.J. Ottino [ID](#)^{16a}, M. Ouchrif [ID](#)^{33d}, J. Ouellette [ID](#)²⁷, F. Ould-Saada [ID](#)¹²¹, A. Ouraou [ID](#)^{131,*}, Q. Ouyang [ID](#)^{13a}, M. Owen [ID](#)⁵⁷, R.E. Owen [ID](#)¹³⁰, K.Y. Oyulmaz [ID](#)^{11c}, V.E. Ozcan [ID](#)^{11c}, N. Ozturk [ID](#)⁷, S. Ozturk [ID](#)^{11c}, J. Pacalt [ID](#)¹¹⁸, H.A. Pacey [ID](#)³⁰, K. Pachal [ID](#)⁴⁹, A. Pacheco Pages [ID](#)¹², C. Padilla Aranda [ID](#)¹², S. Pagan Griso [ID](#)^{16a}, G. Palacino [ID](#)⁶⁵, S. Palazzo [ID](#)⁵⁰, S. Palestini [ID](#)³⁴, M. Palka [ID](#)^{82b}, P. Palmi [ID](#)^{82a}, D.K. Panchal [ID](#)¹⁰, C.E. Pandini [ID](#)⁵⁴, J.G. Panduro Vazquez [ID](#)⁹², P. Pani [ID](#)⁴⁶, G. Panizzo [ID](#)^{66a,66c}, L. Paolozzi [ID](#)⁵⁴, C. Papadatos [ID](#)¹⁰⁵, S. Parajuli [ID](#)⁴², A. Paramonov [ID](#)⁵, C. Paraskevopoulos [ID](#)⁹, D. Paredes Hernandez [ID](#)^{62b}, S.R. Paredes Saenz [ID](#)¹²², B. Parida [ID](#)¹⁶⁵, T.H. Park [ID](#)¹⁵², A.J. Parker [ID](#)²⁹, M.A. Parker [ID](#)³⁰, F. Parodi [ID](#)^{55b,55a},

E.W. Parrish [ID](#)¹¹², J.A. Parsons [ID](#)³⁹, U. Parzefall [ID](#)⁵², L. Pascual Dominguez [ID](#)¹⁴⁸,
 V.R. Pascuzzi [ID](#)^{16a}, F. Pasquali [ID](#)¹¹¹, E. Pasqualucci [ID](#)^{72a}, S. Passaggio [ID](#)^{55b}, F. Pastore [ID](#)⁹²,
 P. Pasuwan [ID](#)^{45a,45b}, J.R. Pater [ID](#)⁹⁸, A. Pathak [ID](#)¹⁶⁶, J. Patton⁸⁹, T. Pauly [ID](#)³⁴, J. Pearkes [ID](#)¹⁴⁰,
 M. Pedersen [ID](#)¹²¹, L. Pedraza Diaz [ID](#)¹¹⁰, R. Pedro [ID](#)^{126a}, T. Peiffer [ID](#)⁵³, S.V. Peleganchuk [ID](#)³⁵,
 O. Penc [ID](#)¹²⁷, C. Peng [ID](#)^{62b}, H. Peng [ID](#)^{60a}, M. Penzin [ID](#)³⁵, B.S. Peralva [ID](#)^{79a},
 A.P. Pereira Peixoto [ID](#)^{126a}, L. Pereira Sanchez [ID](#)^{45a,45b}, D.V. Perepelitsa [ID](#)²⁷,
 E. Perez Codina [ID](#)^{153a}, M. Perganti [ID](#)⁹, L. Perini [ID](#)^{68a,68b,*}, H. Pernegger [ID](#)³⁴, S. Perrella [ID](#)³⁴,
 A. Perrevoort [ID](#)¹¹¹, K. Peters [ID](#)⁴⁶, R.F.Y. Peters [ID](#)⁹⁸, B.A. Petersen [ID](#)³⁴, T.C. Petersen [ID](#)⁴⁰,
 E. Petit [ID](#)⁹⁹, V. Petousis [ID](#)¹²⁸, C. Petridou [ID](#)¹⁴⁹, P. Petroff⁶⁴, F. Petrucci [ID](#)^{74a,74b},
 A. Petrukhin [ID](#)¹³⁸, M. Pettee [ID](#)¹⁶⁸, N.E. Pettersson [ID](#)³⁴, K. Petukhova [ID](#)¹²⁹, A. Peyaud [ID](#)¹³¹,
 R. Pezoa [ID](#)^{133e}, L. Pezzotti [ID](#)³⁴, G. Pezzullo [ID](#)¹⁶⁸, T. Pham [ID](#)¹⁰², P.W. Phillips [ID](#)¹³⁰,
 M.W. Phipps [ID](#)¹⁵⁸, G. Piacquadio [ID](#)¹⁴², E. Pianori [ID](#)^{16a}, F. Piazza [ID](#)^{68a,68b}, A. Picazio [ID](#)¹⁰⁰,
 R. Piegai [ID](#)²⁸, D. Pietreanu [ID](#)^{25b}, J.E. Pilcher [ID](#)³⁷, A.D. Pilkington [ID](#)⁹⁸, M. Pinamonti [ID](#)^{66a,66c},
 J.L. Pinfold [ID](#)², C. Pitman Donaldson⁹³, D.A. Pizzi [ID](#)³², L. Pizzimento [ID](#)^{73a,73b}, A. Pizzini [ID](#)¹¹¹,
 M.-A. Pleier [ID](#)²⁷, V. Plesanovs⁵², V. Pleskot [ID](#)¹²⁹, E. Plotnikova³⁶, P. Podberezko [ID](#)³⁵,
 R. Poettgen [ID](#)⁹⁵, R. Poggi [ID](#)⁵⁴, L. Poggioli [ID](#)¹²³, I. Pogrebnyak [ID](#)¹⁰⁴, D. Pohl [ID](#)²², I. Pokharel [ID](#)⁵³,
 G. Polesello [ID](#)^{70a}, A. Poley [ID](#)^{139,153a}, A. Policicchio [ID](#)^{72a,72b}, R. Polifka [ID](#)¹²⁹, A. Polini [ID](#)^{21b},
 C.S. Pollard [ID](#)¹²², Z.B. Pollock [ID](#)¹¹⁵, V. Polychronakos [ID](#)²⁷, D. Ponomarenko [ID](#)³⁵,
 L. Pontecorvo [ID](#)³⁴, S. Popa [ID](#)^{25a}, G.A. Popeneciu [ID](#)^{25d}, L. Portales [ID](#)⁴,
 D.M. Portillo Quintero [ID](#)^{153a}, S. Pospisil [ID](#)¹²⁸, P. Postolache [ID](#)^{25c}, K. Potamianos [ID](#)¹²²,
 I.N. Potrap [ID](#)³⁶, C.J. Potter [ID](#)³⁰, H. Potti [ID](#)¹, T. Poulsen [ID](#)⁴⁶, J. Poveda [ID](#)¹⁵⁹, T.D. Powell [ID](#)¹³⁶,
 G. Pownall [ID](#)⁴⁶, M.E. Pozo Astigarraga [ID](#)³⁴, A. Prades Ibanez [ID](#)¹⁵⁹, P. Pralavorio [ID](#)⁹⁹,
 M.M. Prapa [ID](#)⁴⁴, S. Prell [ID](#)⁷⁸, D. Price [ID](#)⁹⁸, M. Primavera [ID](#)^{67a}, M.A. Principe Martin [ID](#)⁹⁶,
 M.L. Proffitt [ID](#)¹³⁵, N. Proklova [ID](#)³⁵, K. Prokofiev [ID](#)^{62c}, S. Protopopescu [ID](#)²⁷, J. Proudfoot [ID](#)⁵,
 M. Przybycien [ID](#)^{82a}, D. Pudzha [ID](#)³⁵, P. Puzo⁶⁴, D. Pyatiizbyantseva [ID](#)³⁵, J. Qian [ID](#)¹⁰³,
 Y. Qin [ID](#)⁹⁸, T. Qiu [ID](#)⁹¹, A. Quadt [ID](#)⁵³, M. Queitsch-Maitland [ID](#)³⁴, G. Rabanal Bolanos [ID](#)⁵⁹,
 F. Ragusa [ID](#)^{68a,68b}, J.A. Raine [ID](#)⁵⁴, S. Rajagopalan [ID](#)²⁷, K. Ran [ID](#)^{13a,13d}, D.F. Rassloff [ID](#)^{61a},
 D.M. Rauch [ID](#)⁴⁶, S. Rave [ID](#)⁹⁷, B. Ravina [ID](#)⁵⁷, I. Ravinovich [ID](#)¹⁶⁵, M. Raymond [ID](#)³⁴,
 A.L. Read [ID](#)¹²¹, N.P. Readioff [ID](#)¹³⁶, D.M. Rebuffi [ID](#)^{70a,70b}, G. Redlinger [ID](#)²⁷, K. Reeves [ID](#)⁴³,
 D. Reikher [ID](#)¹⁴⁸, A. Reiss⁹⁷, A. Rej [ID](#)¹³⁸, C. Rembser [ID](#)³⁴, A. Renardi [ID](#)⁴⁶, M. Renda [ID](#)^{25b},
 M.B. Rendel¹⁰⁷, A.G. Rennie [ID](#)⁵⁷, S. Resconi [ID](#)^{68a}, M. Ressegotti [ID](#)^{55b,55a}, E.D. Resseguie [ID](#)^{16a},
 S. Rettie [ID](#)⁹³, B. Reynolds¹¹⁵, E. Reynolds [ID](#)¹⁹, M. Rezaei Estabragh [ID](#)¹⁶⁷, O.L. Rezanova [ID](#)³⁵,
 P. Reznicek [ID](#)¹²⁹, E. Ricci [ID](#)^{75a,75b}, R. Richter [ID](#)¹⁰⁷, S. Richter [ID](#)⁴⁶, E. Richter-Was [ID](#)^{82b},
 M. Ridel [ID](#)¹²³, P. Rieck [ID](#)¹⁰⁷, P. Riedler [ID](#)³⁴, O. Rifki [ID](#)⁴⁶, M. Rijssenbeek [ID](#)¹⁴²,
 A. Rimoldi [ID](#)^{70a,70b}, M. Rimoldi [ID](#)⁴⁶, L. Rinaldi [ID](#)^{21b,21a}, T.T. Rinn [ID](#)¹⁵⁸, M.P. Rinnagel [ID](#)¹⁰⁶,
 G. Ripellino [ID](#)¹⁴¹, I. Riu [ID](#)¹², P. Rivadeneira [ID](#)⁴⁶, J.C. Rivera Vergara [ID](#)¹⁶¹, F. Rizatdinova [ID](#)¹¹⁷,
 E. Rizvi [ID](#)⁹¹, C. Rizzi [ID](#)⁵⁴, B.A. Roberts [ID](#)¹⁶³, S.H. Robertson [ID](#)^{101,w}, M. Robin [ID](#)⁴⁶,
 D. Robinson [ID](#)³⁰, C.M. Robles Gajardo^{133e}, M. Robles Manzano [ID](#)⁹⁷, A. Robson [ID](#)⁵⁷,
 A. Rocchi [ID](#)^{73a,73b}, C. Roda [ID](#)^{71a,71b}, S. Rodriguez Bosca [ID](#)^{61a}, A. Rodriguez Rodriguez [ID](#)⁵²,
 A.M. Rodríguez Vera [ID](#)^{153b}, S. Roe³⁴, A.R. Roepe-Gier [ID](#)¹¹⁶, J. Roggel [ID](#)¹⁶⁷, O. Røhne [ID](#)¹²¹,
 R.A. Rojas [ID](#)^{133e}, B. Roland [ID](#)⁵², C.P.A. Roland [ID](#)⁶⁵, J. Roloff [ID](#)²⁷, A. Romaniouk [ID](#)³⁵,
 M. Romano [ID](#)^{21b}, A.C. Romero Hernandez [ID](#)¹⁵⁸, N. Rompotis [ID](#)⁸⁹, M. Ronzani [ID](#)¹¹³, L. Roos [ID](#)¹²³,
 S. Rosati [ID](#)^{72a}, B.J. Rosser [ID](#)¹²⁴, E. Rossi [ID](#)¹⁵², E. Rossi [ID](#)⁴, E. Rossi [ID](#)^{69a,69b}, L.P. Rossi [ID](#)^{55b},

L. Rossini [ID](#)⁴⁶, R. Rosten [ID](#)¹¹⁵, M. Rotaru [ID](#)^{25b}, B. Rottler [ID](#)⁵², D. Rousseau [ID](#)⁶⁴, D. Rouso [ID](#)³⁰,
 G. Rovelli [ID](#)^{70a,70b}, A. Roy [ID](#)¹⁰, A. Rozanov [ID](#)⁹⁹, Y. Rozen [ID](#)¹⁴⁷, X. Ruan [ID](#)^{31f}, A.J. Ruby [ID](#)⁸⁹,
 T.A. Ruggeri [ID](#)¹, F. Rühr [ID](#)⁵², A. Ruiz-Martinez [ID](#)¹⁵⁹, A. Rummeler [ID](#)³⁴, Z. Rurikova [ID](#)⁵²,
 N.A. Rusakovich [ID](#)³⁶, H.L. Russell [ID](#)³⁴, L. Rustige [ID](#)³⁸, J.P. Rutherford [ID](#)⁶, E.M. Rüttinger [ID](#)¹³⁶,
 M. Rybar [ID](#)¹²⁹, E.B. Rye [ID](#)¹²¹, A. Ryzhov [ID](#)³⁵, J.A. Sabater Iglesias [ID](#)⁴⁶, P. Sabatini [ID](#)¹⁵⁹,
 L. Sabetta [ID](#)^{72a,72b}, H.F-W. Sadrozinski [ID](#)¹³², F. Safai Tehrani [ID](#)^{72a}, B. Safarzadeh Samani [ID](#)¹⁴³,
 M. Safdari [ID](#)¹⁴⁰, P. Saha [ID](#)¹¹², S. Saha [ID](#)¹⁰¹, M. Sahinsoy [ID](#)¹⁰⁷, A. Sahu [ID](#)¹⁶⁷, M. Saimpert [ID](#)¹³¹,
 M. Saito [ID](#)¹⁵⁰, T. Saito [ID](#)¹⁵⁰, D. Salamani [ID](#)³⁴, G. Salamanna [ID](#)^{74a,74b}, A. Salnikov [ID](#)¹⁴⁰,
 J. Salt [ID](#)¹⁵⁹, A. Salvador Salas [ID](#)¹², D. Salvatore [ID](#)^{41b,41a}, F. Salvatore [ID](#)¹⁴³, A. Salzburger [ID](#)³⁴,
 D. Sammel [ID](#)⁵², D. Sampsonidis [ID](#)¹⁴⁹, D. Sampsonidou [ID](#)^{60d,60c}, J. Sánchez [ID](#)¹⁵⁹,
 A. Sanchez Pineda [ID](#)⁴, V. Sanchez Sebastian [ID](#)¹⁵⁹, H. Sandaker [ID](#)¹²¹, C.O. Sander [ID](#)⁴⁶,
 I.G. Sanderswood [ID](#)⁸⁸, J.A. Sandesara [ID](#)¹⁰⁰, M. Sandhoff [ID](#)¹⁶⁷, C. Sandoval [ID](#)^{20b},
 D.P.C. Sankey [ID](#)¹³⁰, M. Sannino [ID](#)^{55b,55a}, A. Sansoni [ID](#)⁵¹, C. Santoni [ID](#)³⁸, H. Santos [ID](#)^{126a,126b},
 S.N. Santpur [ID](#)^{16a}, A. Santra [ID](#)¹⁶⁵, K.A. Saoucha [ID](#)¹³⁶, J.G. Saraiva [ID](#)^{126a,126d}, J. Sardain [ID](#)⁹⁹,
 O. Sasaki [ID](#)⁸⁰, K. Sato [ID](#)¹⁵⁴, C. Sauer [ID](#)^{61b}, F. Sauerburger [ID](#)⁵², E. Sauvan [ID](#)⁴, P. Savard [ID](#)^{152,af},
 R. Sawada [ID](#)¹⁵⁰, C. Sawyer [ID](#)¹³⁰, L. Sawyer [ID](#)⁹⁴, I. Sayago Galvan [ID](#)¹⁵⁹, C. Sbarra [ID](#)^{21b},
 A. Sbrizzi [ID](#)^{66a,66c}, T. Scanlon [ID](#)⁹³, J. Schaarschmidt [ID](#)¹³⁵, P. Schacht [ID](#)¹⁰⁷, D. Schaefer [ID](#)³⁷,
 U. Schäfer [ID](#)⁹⁷, A.C. Schaffer [ID](#)⁶⁴, D. Schaile [ID](#)¹⁰⁶, R.D. Schamberger [ID](#)¹⁴², E. Schanet [ID](#)¹⁰⁶,
 C. Scharf [ID](#)¹⁷, N. Scharmberg [ID](#)⁹⁸, V.A. Schegelsky [ID](#)³⁵, D. Scheirich [ID](#)¹²⁹, F. Schenck [ID](#)¹⁷,
 M. Schernau [ID](#)¹⁵⁶, C. Schiavi [ID](#)^{55b,55a}, L.K. Schildgen [ID](#)²², Z.M. Schillaci [ID](#)²⁴,
 E.J. Schioppa [ID](#)^{67a,67b}, M. Schioppa [ID](#)^{41b,41a}, B. Schlag [ID](#)⁹⁷, K.E. Schleicher [ID](#)⁵², S. Schlenker [ID](#)³⁴,
 K. Schmieden [ID](#)⁹⁷, C. Schmitt [ID](#)⁹⁷, S. Schmitt [ID](#)⁴⁶, L. Schoeffel [ID](#)¹³¹, A. Schoening [ID](#)^{61b},
 P.G. Scholer [ID](#)⁵², E. Schopf [ID](#)¹²², M. Schott [ID](#)⁹⁷, J. Schovancova [ID](#)³⁴, S. Schramm [ID](#)⁵⁴,
 F. Schroeder [ID](#)¹⁶⁷, H-C. Schultz-Coulon [ID](#)^{61a}, M. Schumacher [ID](#)⁵², B.A. Schumm [ID](#)¹³²,
 Ph. Schune [ID](#)¹³¹, A. Schwartzman [ID](#)¹⁴⁰, T.A. Schwarz [ID](#)¹⁰³, Ph. Schwemling [ID](#)¹³¹,
 R. Schwienhorst [ID](#)¹⁰⁴, A. Sciandra [ID](#)¹³², G. Sciolla [ID](#)²⁴, F. Scuri [ID](#)^{71a}, F. Scutti [ID](#)¹⁰²,
 C.D. Sebastiani [ID](#)⁸⁹, K. Sedlaczek [ID](#)⁴⁷, P. Seema [ID](#)¹⁷, S.C. Seidel [ID](#)¹⁰⁹, A. Seiden [ID](#)¹³²,
 B.D. Seidlitz [ID](#)²⁷, T. Seiss [ID](#)³⁷, C. Seitz [ID](#)⁴⁶, J.M. Seixas [ID](#)^{79b}, G. Sekhniaidze [ID](#)^{69a},
 S.J. Sekula [ID](#)⁴², L. Selem [ID](#)⁴, N. Semprini-Cesari [ID](#)^{21b,21a}, S. Sen [ID](#)⁴⁹, C. Serfon [ID](#)²⁷, L. Serin [ID](#)⁶⁴,
 L. Serkin [ID](#)^{66a,66b}, M. Sessa [ID](#)^{74a,74b}, H. Severini [ID](#)¹¹⁶, S. Sevova [ID](#)¹⁴⁰, F. Sforza [ID](#)^{55b,55a},
 A. Sfyrta [ID](#)⁵⁴, E. Shabalina [ID](#)⁵³, R. Shaheen [ID](#)¹⁴¹, J.D. Shahinian [ID](#)¹²⁴, N.W. Shaikh [ID](#)^{45a,45b},
 D. Shaked Renous [ID](#)¹⁶⁵, L.Y. Shan [ID](#)^{13a}, M. Shapiro [ID](#)^{16a}, A. Sharma [ID](#)³⁴, A.S. Sharma [ID](#)¹,
 S. Sharma [ID](#)⁴⁶, P.B. Shatalov [ID](#)³⁵, K. Shaw [ID](#)¹⁴³, S.M. Shaw [ID](#)⁹⁸, P. Sherwood [ID](#)⁹³, L. Shi [ID](#)⁹³,
 C.O. Shimmin [ID](#)¹⁶⁸, Y. Shimogama [ID](#)¹⁶⁴, J.D. Shinner [ID](#)⁹², I.P.J. Shipsey [ID](#)¹²², S. Shirabe [ID](#)⁵⁴,
 M. Shiyakova [ID](#)^{36,aj}, J. Shlomi [ID](#)¹⁶⁵, M.J. Shochet [ID](#)³⁷, J. Shojaii [ID](#)¹⁰², D.R. Shope [ID](#)¹⁴¹,
 S. Shrestha [ID](#)¹¹⁵, E.M. Shrif [ID](#)^{31f}, M.J. Shroff [ID](#)¹⁶¹, E. Shulga [ID](#)¹⁶⁵, P. Sicho [ID](#)¹²⁷,
 A.M. Sickles [ID](#)¹⁵⁸, E. Sideras Haddad [ID](#)^{31f}, O. Sidiropoulou [ID](#)³⁴, A. Sidoti [ID](#)^{21b}, F. Siegert [ID](#)⁴⁸,
 Dj. Sijacki [ID](#)¹⁴, J.M. Silva [ID](#)¹⁹, M.V. Silva Oliveira [ID](#)³⁴, S.B. Silverstein [ID](#)^{45a}, S. Simion [ID](#)⁶⁴,
 R. Simoniello [ID](#)³⁴, N.D. Simpson [ID](#)⁹⁵, S. Simsek [ID](#)^{11b}, P. Sinervo [ID](#)¹⁵², V. Sinetckii [ID](#)³⁵,
 S. Singh [ID](#)¹³⁹, S. Singh [ID](#)¹⁵², S. Sinha [ID](#)⁴⁶, S. Sinha [ID](#)^{31f}, M. Sioli [ID](#)^{21b,21a}, I. Siral [ID](#)¹¹⁹,
 S.Yu. Sivoklov [ID](#)^{35,*}, J. Sjölin [ID](#)^{45a,45b}, A. Skaf [ID](#)⁵³, E. Skorda [ID](#)⁹⁵, P. Skubic [ID](#)¹¹⁶,
 M. Slawinska [ID](#)⁸³, K. Sliwa [ID](#)¹⁵⁵, V. Smakhtin [ID](#)¹⁶⁵, B.H. Smart [ID](#)¹³⁰, J. Smiesko [ID](#)¹²⁹,
 S.Yu. Smirnov [ID](#)³⁵, Y. Smirnov [ID](#)³⁵, L.N. Smirnova [ID](#)^{35,a}, O. Smirnova [ID](#)⁹⁵, E.A. Smith [ID](#)³⁷,

H.A. Smith [ID](#)¹²², M. Smizanska [ID](#)⁸⁸, K. Smolek [ID](#)¹²⁸, A. Smykiewicz [ID](#)⁸³, A.A. Snesev [ID](#)³⁵,
H.L. Snoek [ID](#)¹¹¹, S. Snyder [ID](#)²⁷, R. Sobie [ID](#)^{161,w}, A. Soffer [ID](#)¹⁴⁸, F. Sohns [ID](#)⁵³,
C.A. Solans Sanchez [ID](#)³⁴, E.Yu. Soldatov [ID](#)³⁵, U. Soldevila [ID](#)¹⁵⁹, A.A. Solodkov [ID](#)³⁵,
S. Solomon [ID](#)⁵², A. Soloshenko [ID](#)³⁶, O.V. Solovyanov [ID](#)³⁵, V. Solovyev [ID](#)³⁵, P. Sommer [ID](#)¹³⁶,
H. Son [ID](#)¹⁵⁵, A. Sonay [ID](#)¹², W.Y. Song [ID](#)^{153b}, A. Sopczak [ID](#)¹²⁸, A.L. Sopio [ID](#)⁹³, F. Sopkova [ID](#)^{26b},
S. Sottocornola [ID](#)^{70a,70b}, R. Soualah [ID](#)^{66a,66c}, Z. Soumami [ID](#)^{33e}, D. South [ID](#)⁴⁶,
S. Spagnolo [ID](#)^{67a,67b}, M. Spalla [ID](#)¹⁰⁷, M. Spangenberg [ID](#)¹⁶³, F. Spanò [ID](#)⁹², D. Sperlich [ID](#)⁵²,
T.M. Spieker [ID](#)^{61a}, G. Spigo [ID](#)³⁴, M. Spina [ID](#)¹⁴³, D.P. Spiteri [ID](#)⁵⁷, M. Spousta [ID](#)¹²⁹,
A. Stabile [ID](#)^{68a,68b}, R. Stamen [ID](#)^{61a}, M. Stamenkovic [ID](#)¹¹¹, A. Stampekis [ID](#)¹⁹, M. Standke [ID](#)²²,
E. Stanecka [ID](#)⁸³, B. Stanislaus [ID](#)³⁴, M.M. Stanitzki [ID](#)⁴⁶, M. Stankaityte [ID](#)¹²², B. Stapf [ID](#)⁴⁶,
E.A. Starchenko [ID](#)³⁵, G.H. Stark [ID](#)¹³², J. Stark [ID](#)^{99,ak}, D.M. Starko [ID](#)^{153b}, P. Staroba [ID](#)¹²⁷,
P. Starovoitov [ID](#)^{61a}, S. Stärz [ID](#)¹⁰¹, R. Staszewski [ID](#)⁸³, G. Stavropoulos [ID](#)⁴⁴, P. Steinberg [ID](#)²⁷,
A.L. Steinhebel [ID](#)¹¹⁹, B. Stelzer [ID](#)^{139,153a}, H.J. Stelzer [ID](#)¹²⁵, O. Stelzer-Chilton [ID](#)^{153a},
H. Stenzel [ID](#)⁵⁶, T.J. Stevenson [ID](#)¹⁴³, G.A. Stewart [ID](#)³⁴, M.C. Stockton [ID](#)³⁴, G. Stoica [ID](#)^{25b},
M. Stolarski [ID](#)^{126a}, S. Stonjek [ID](#)¹⁰⁷, A. Straessner [ID](#)⁴⁸, J. Strandberg [ID](#)¹⁴¹, S. Strandberg [ID](#)^{45a,45b},
M. Strauss [ID](#)¹¹⁶, T. Strebler [ID](#)⁹⁹, P. Strizenc [ID](#)^{26b}, R. Ströhmer [ID](#)¹⁶², D.M. Strom [ID](#)¹¹⁹,
L.R. Strom [ID](#)⁴⁶, R. Stroynowski [ID](#)⁴², A. Strubig [ID](#)^{45a,45b}, S.A. Stucci [ID](#)²⁷, B. Stugu [ID](#)¹⁵,
J. Stupak [ID](#)¹¹⁶, N.A. Styles [ID](#)⁴⁶, D. Su [ID](#)¹⁴⁰, S. Su [ID](#)^{60a}, W. Su [ID](#)^{60d,135,60c}, X. Su [ID](#)^{60a},
K. Sugizaki [ID](#)¹⁵⁰, V.V. Sulim [ID](#)³⁵, M.J. Sullivan [ID](#)⁸⁹, D.M.S. Sultan [ID](#)⁵⁴, L. Sultaniyeva [ID](#)³⁵,
S. Sultansoy [ID](#)^{3c}, T. Sumida [ID](#)⁸⁴, S. Sun [ID](#)¹⁰³, S. Sun [ID](#)¹⁶⁶, X. Sun [ID](#)⁹⁸,
O. Sunneborn Gudnadottir [ID](#)¹⁵⁷, C.J.E. Suster [ID](#)¹⁴⁴, M.R. Sutton [ID](#)¹⁴³, M. Svatos [ID](#)¹²⁷,
M. Swiatlowski [ID](#)^{153a}, T. Swirski [ID](#)¹⁶², I. Sykora [ID](#)^{26a}, M. Sykora [ID](#)¹²⁹, T. Sykora [ID](#)¹²⁹, D. Ta [ID](#)⁹⁷,
K. Tackmann [ID](#)^{46,u}, A. Taffard [ID](#)¹⁵⁶, R. Tafirout [ID](#)^{153a}, R.H.M. Taibah [ID](#)¹²³, R. Takashima [ID](#)⁸⁵,
K. Takeda [ID](#)⁸¹, T. Takeshita [ID](#)¹³⁷, E.P. Takeva [ID](#)⁵⁰, Y. Takubo [ID](#)⁸⁰, M. Talby [ID](#)⁹⁹,
A.A. Talyshv [ID](#)³⁵, K.C. Tam [ID](#)^{62b}, N.M. Tamir [ID](#)¹⁴⁸, A. Tanaka [ID](#)¹⁵⁰, J. Tanaka [ID](#)¹⁵⁰,
R. Tanaka [ID](#)⁶⁴, J. Tang [ID](#)^{60c}, Z. Tao [ID](#)¹⁶⁰, S. Tapia Araya [ID](#)⁷⁸, S. Tapprogge [ID](#)⁹⁷,
A. Tarek Abouelfadl Mohamed [ID](#)¹⁰⁴, S. Tarem [ID](#)¹⁴⁷, K. Tariq [ID](#)^{60b}, G. Tarna [ID](#)^{25b},
G.F. Tartarelli [ID](#)^{68a}, P. Tas [ID](#)¹²⁹, M. Tasevsky [ID](#)¹²⁷, E. Tassi [ID](#)^{41b,41a}, G. Tateno [ID](#)¹⁵⁰,
Y. Tayalati [ID](#)^{33e}, G.N. Taylor [ID](#)¹⁰², W. Taylor [ID](#)^{153b}, H. Teagle [ID](#)⁸⁹, A.S. Tee [ID](#)¹⁶⁶,
R. Teixeira De Lima [ID](#)¹⁴⁰, P. Teixeira-Dias [ID](#)⁹², H. Ten Kate [ID](#)³⁴, J.J. Teoh [ID](#)¹¹¹, K. Terashi [ID](#)¹⁵⁰,
J. Terron [ID](#)⁹⁶, S. Terzo [ID](#)¹², M. Testa [ID](#)⁵¹, R.J. Teuscher [ID](#)^{152,w}, N. Themistokleous [ID](#)⁵⁰,
T. Theveneaux-Pelzer [ID](#)¹⁷, O. Thielmann [ID](#)¹⁶⁷, D.W. Thomas [ID](#)⁹², J.P. Thomas [ID](#)¹⁹,
E.A. Thompson [ID](#)⁴⁶, P.D. Thompson [ID](#)¹⁹, E. Thomson [ID](#)¹²⁴, E.J. Thorpe [ID](#)⁹¹, Y. Tian [ID](#)⁵³,
V. Tikhomirov [ID](#)^{35,a}, Yu.A. Tikhonov [ID](#)³⁵, S. Timoshenko [ID](#)³⁵, P. Tipton [ID](#)¹⁶⁸, S. Tisserant [ID](#)⁹⁹,
S.H. Tlou [ID](#)^{31f}, A. Tmourji [ID](#)³⁸, K. Todome [ID](#)^{21b,21a}, S. Todorova-Nova [ID](#)¹²⁹, S. Todt [ID](#)⁴⁸,
M. Togawa [ID](#)⁸⁰, J. Tojo [ID](#)⁸⁶, S. Tokár [ID](#)^{26a}, K. Tokushuku [ID](#)⁸⁰, E. Tolley [ID](#)¹¹⁵, R. Tombs [ID](#)³⁰,
M. Tomoto [ID](#)^{80,108}, L. Tompkins [ID](#)^{140,al}, P. Tornambe [ID](#)¹⁰⁰, E. Torrence [ID](#)¹¹⁹, H. Torres [ID](#)⁴⁸,
E. Torró Pastor [ID](#)¹⁵⁹, M. Toscani [ID](#)²⁸, C. Tosciri [ID](#)³⁷, J. Toth [ID](#)^{99,v}, D.R. Tovey [ID](#)¹³⁶, A. Traeet [ID](#)¹⁵,
C.J. Treado [ID](#)¹¹³, T. Trefzger [ID](#)¹⁶², A. Tricoli [ID](#)²⁷, I.M. Trigger [ID](#)^{153a}, S. Trincaz-Duvoid [ID](#)¹²³,
D.A. Trischuk [ID](#)¹⁶⁰, B. Trocmé [ID](#)⁵⁸, A. Trofymov [ID](#)⁶⁴, C. Troncon [ID](#)^{68a}, F. Trovato [ID](#)¹⁴³,
L. Truong [ID](#)^{31c}, M. Trzebinski [ID](#)⁸³, A. Trzupek [ID](#)⁸³, F. Tsai [ID](#)¹⁴², A. Tsiamis [ID](#)¹⁴⁹,
P.V. Tsiarehka [ID](#)^{35,a}, A. Tsirigotis [ID](#)^{149,s}, V. Tsiskaridze [ID](#)¹⁴², E.G. Tskhadadze [ID](#)^{146a},
M. Tsopoulou [ID](#)¹⁴⁹, I.I. Tsukerman [ID](#)³⁵, V. Tsulaia [ID](#)^{16a}, S. Tsuno [ID](#)⁸⁰, O. Tsur [ID](#)¹⁴⁷,

D. Tsybychev [ID](#)¹⁴², Y. Tu [ID](#)^{62b}, A. Tudorache [ID](#)^{25b}, V. Tudorache [ID](#)^{25b}, A.N. Tuna [ID](#)³⁴,
 S. Turchikhin [ID](#)³⁶, I. Turk Cakir [ID](#)^{3a}, R.J. Turner¹⁹, R. Turra [ID](#)^{68a}, P.M. Tuts [ID](#)³⁹,
 S. Tzamarias [ID](#)¹⁴⁹, P. Tzani [ID](#)⁹, E. Tzovara [ID](#)⁹⁷, K. Uchida¹⁵⁰, F. Ukegawa [ID](#)¹⁵⁴, G. Unal [ID](#)³⁴,
 M. Unal [ID](#)¹⁰, A. Undrus [ID](#)²⁷, G. Unel [ID](#)¹⁵⁶, F.C. Ungaro [ID](#)¹⁰², K. Uno [ID](#)¹⁵⁰, J. Urban [ID](#)^{26b},
 P. Urquijo [ID](#)¹⁰², G. Usai [ID](#)⁷, R. Ushioda [ID](#)¹⁵¹, M. Usman [ID](#)¹⁰⁵, Z. Uysal [ID](#)^{11d}, V. Vacek [ID](#)¹²⁸,
 B. Vachon [ID](#)¹⁰¹, K.O.H. Vadla [ID](#)¹²¹, T. Vafeiadis [ID](#)³⁴, C. Valderanis [ID](#)¹⁰⁶,
 E. Valdes Santurio [ID](#)^{45a,45b}, M. Valente [ID](#)^{153a}, S. Valentineti [ID](#)^{21b,21a}, A. Valero [ID](#)¹⁵⁹,
 L. Valéry [ID](#)⁴⁶, R.A. Vallance [ID](#)¹⁹, A. Vallier [ID](#)^{99,ak}, J.A. Valls Ferrer [ID](#)¹⁵⁹, T.R. Van Daalen [ID](#)¹³⁵,
 P. Van Gemmeren [ID](#)⁵, S. Van Stroud [ID](#)⁹³, I. Van Vulpen [ID](#)¹¹¹, M. Vanadia [ID](#)^{73a,73b},
 W. Vandelli [ID](#)³⁴, M. Vandenbroucke [ID](#)¹³¹, E.R. Vandewall [ID](#)¹¹⁷, D. Vannicola [ID](#)¹⁴⁸,
 L. Vannoli [ID](#)^{55b,55a}, R. Vari [ID](#)^{72a}, E.W. Varnes [ID](#)⁶, C. Varni [ID](#)^{16a}, T. Varol [ID](#)¹⁴⁵,
 D. Varouchas [ID](#)⁶⁴, K.E. Varvell [ID](#)¹⁴⁴, M.E. Vasile [ID](#)^{25b}, L. Vaslin³⁸, G.A. Vasquez [ID](#)¹⁶¹,
 F. Vazeille [ID](#)³⁸, D. Vazquez Furelos [ID](#)¹², T. Vazquez Schroeder [ID](#)³⁴, J. Veatch [ID](#)⁵³, V. Vecchio [ID](#)⁹⁸,
 M.J. Veen [ID](#)¹¹¹, I. Velisek [ID](#)¹²², L.M. Veloce [ID](#)¹⁵², F. Veloso [ID](#)^{126a,126c}, S. Veneziano [ID](#)^{72a},
 A. Ventura [ID](#)^{67a,67b}, A. Verbitskyi [ID](#)¹⁰⁷, M. Verducci [ID](#)^{71a,71b}, C. Vergis [ID](#)²²,
 M. Verissimo De Araujo [ID](#)^{79b}, W. Verkerke [ID](#)¹¹¹, A.T. Vermeulen [ID](#)¹¹¹, J.C. Vermeulen [ID](#)¹¹¹,
 C. Vernieri [ID](#)¹⁴⁰, P.J. Verschuuren [ID](#)⁹², M. Vessella [ID](#)¹⁰⁰, M.L. Vesterbacka [ID](#)¹¹³,
 M.C. Vetterli [ID](#)^{139,af}, A. Vgenopoulos [ID](#)¹⁴⁹, N. Viaux Maira [ID](#)^{133e}, T. Vickey [ID](#)¹³⁶,
 O.E. Vickey Boeriu [ID](#)¹³⁶, G.H.A. Viehhauser [ID](#)¹²², L. Vigani [ID](#)^{61b}, M. Villa [ID](#)^{21b,21a},
 M. Villaplana Perez [ID](#)¹⁵⁹, E.M. Villhauer⁵⁰, E. Vilucchi [ID](#)⁵¹, M.G. Vincter [ID](#)³², G.S. Virdee [ID](#)¹⁹,
 A. Vishwakarma [ID](#)⁵⁰, C. Vittori [ID](#)^{21b,21a}, I. Vivarelli [ID](#)¹⁴³, V. Vladimirov¹⁶³, E. Voevodina [ID](#)¹⁰⁷,
 M. Vogel [ID](#)¹⁶⁷, P. Vokac [ID](#)¹²⁸, J. Von Ahnen [ID](#)⁴⁶, E. Von Toerne [ID](#)²², V. Vorobel [ID](#)¹²⁹,
 K. Vorobev [ID](#)³⁵, M. Vos [ID](#)¹⁵⁹, J.H. Vosseveld [ID](#)⁸⁹, M. Vozak [ID](#)⁹⁸, L. Vozdecky [ID](#)⁹¹, N. Vranjes [ID](#)¹⁴,
 M. Vranjes Milosavljevic [ID](#)¹⁴, V. Vrba^{128,*}, M. Vreeswijk [ID](#)¹¹¹, R. Vuillermet [ID](#)³⁴,
 O. Vujanovic [ID](#)⁹⁷, I. Vukotic [ID](#)³⁷, S. Wada [ID](#)¹⁵⁴, C. Wagner¹⁰⁰, W. Wagner [ID](#)¹⁶⁷, S. Wahdan [ID](#)¹⁶⁷,
 H. Wahlberg [ID](#)⁸⁷, R. Wakasa [ID](#)¹⁵⁴, M. Wakida [ID](#)¹⁰⁸, V.M. Walbrecht [ID](#)¹⁰⁷, J. Walder [ID](#)¹³⁰,
 R. Walker [ID](#)¹⁰⁶, S.D. Walker⁹², W. Walkowiak [ID](#)¹³⁸, A.M. Wang [ID](#)⁵⁹, A.Z. Wang [ID](#)¹⁶⁶,
 C. Wang [ID](#)^{60a}, C. Wang [ID](#)^{60c}, H. Wang [ID](#)^{16a}, J. Wang [ID](#)^{62a}, P. Wang [ID](#)⁴², R.-J. Wang [ID](#)⁹⁷,
 R. Wang [ID](#)⁵⁹, R. Wang [ID](#)¹¹², S.M. Wang [ID](#)¹⁴⁵, S. Wang [ID](#)^{60b}, T. Wang [ID](#)^{60a}, W.T. Wang [ID](#)⁷⁷,
 W.X. Wang [ID](#)^{60a}, X. Wang [ID](#)^{13c}, X. Wang [ID](#)¹⁵⁸, Y. Wang [ID](#)^{60a}, Z. Wang [ID](#)¹⁰³,
 C. Wanotayaroj [ID](#)³⁴, A. Warburton [ID](#)¹⁰¹, C.P. Ward [ID](#)³⁰, R.J. Ward [ID](#)¹⁹, N. Warrack [ID](#)⁵⁷,
 A.T. Watson [ID](#)¹⁹, M.F. Watson [ID](#)¹⁹, G. Watts [ID](#)¹³⁵, B.M. Waugh [ID](#)⁹³, A.F. Webb [ID](#)¹⁰,
 C. Weber [ID](#)²⁷, M.S. Weber [ID](#)¹⁸, S.A. Weber [ID](#)³², S.M. Weber [ID](#)^{61a}, C. Wei^{60a}, Y. Wei [ID](#)¹²²,
 A.R. Weidberg [ID](#)¹²², J. Weingarten [ID](#)⁴⁷, M. Weirich [ID](#)⁹⁷, C. Weiser [ID](#)⁵², T. Wenaus [ID](#)²⁷,
 B. Wendland [ID](#)⁴⁷, T. Wengler [ID](#)³⁴, S. Wenig [ID](#)³⁴, N. Vermes [ID](#)²², M. Wessels [ID](#)^{61a},
 K. Whalen [ID](#)¹¹⁹, A.M. Wharton [ID](#)⁸⁸, A.S. White [ID](#)⁵⁹, A. White [ID](#)⁷, M.J. White [ID](#)¹,
 D. Whiteson [ID](#)¹⁵⁶, L. Wickremasinghe [ID](#)¹²⁰, W. Wiedenmann [ID](#)¹⁶⁶, C. Wiel [ID](#)⁴⁸, M. Wielers [ID](#)¹³⁰,
 N. Wieseotte⁹⁷, C. Wiglesworth [ID](#)⁴⁰, L.A.M. Wiik-Fuchs [ID](#)⁵², D.J. Wilbern¹¹⁶, H.G. Wilkens [ID](#)³⁴,
 L.J. Wilkins [ID](#)⁹², D.M. Williams [ID](#)³⁹, H.H. Williams¹²⁴, S. Williams [ID](#)³⁰, S. Willocq [ID](#)¹⁰⁰,
 P.J. Windischhofer [ID](#)¹²², I. Wingerter-Seez [ID](#)⁴, F. Winklmeier [ID](#)¹¹⁹, B.T. Winter [ID](#)⁵²,
 M. Wittgen¹⁴⁰, M. Wobisch [ID](#)⁹⁴, A. Wolf [ID](#)⁹⁷, R. Wölker [ID](#)¹²², J. Wollrath¹⁵⁶, M.W. Wolter [ID](#)⁸³,
 H. Wolters [ID](#)^{126a,126c}, V.W.S. Wong [ID](#)¹⁶⁰, A.F. Wongel [ID](#)⁴⁶, S.D. Worm [ID](#)⁴⁶, B.K. Wosiek [ID](#)⁸³,
 K.W. Woźniak [ID](#)⁸³, K. Wraight [ID](#)⁵⁷, J. Wu [ID](#)^{13a,13d}, S.L. Wu [ID](#)¹⁶⁶, X. Wu [ID](#)⁵⁴, Y. Wu [ID](#)^{60a},

Z. Wu [ID](#)^{131,60a}, J. Wuerzinger [ID](#)¹²², T.R. Wyatt [ID](#)⁹⁸, B.M. Wynne [ID](#)⁵⁰, S. Xella [ID](#)⁴⁰, L. Xia [ID](#)^{13c}, M. Xia [ID](#)^{13b}, J. Xiang [ID](#)^{62c}, X. Xiao [ID](#)¹⁰³, M. Xie [ID](#)^{60a}, X. Xie [ID](#)^{60a}, I. Xiotidis¹⁴³, D. Xu [ID](#)^{13a}, H. Xu^{60a}, H. Xu [ID](#)^{60a}, L. Xu [ID](#)^{60a}, R. Xu [ID](#)¹²⁴, T. Xu [ID](#)^{60a}, W. Xu [ID](#)¹⁰³, Y. Xu [ID](#)^{13b}, Z. Xu [ID](#)^{60b}, Z. Xu [ID](#)¹⁴⁰, B. Yabsley [ID](#)¹⁴⁴, S. Yacoob [ID](#)^{31a}, N. Yamaguchi [ID](#)⁸⁶, Y. Yamaguchi [ID](#)¹⁵¹, M. Yamatani¹⁵⁰, H. Yamauchi [ID](#)¹⁵⁴, T. Yamazaki [ID](#)^{16a}, Y. Yamazaki [ID](#)⁸¹, J. Yan^{60c}, S. Yan [ID](#)¹²², Z. Yan [ID](#)²³, H.J. Yang [ID](#)^{60c,60d}, H.T. Yang [ID](#)^{16a}, S. Yang [ID](#)^{60a}, T. Yang [ID](#)^{62c}, X. Yang [ID](#)^{60a}, X. Yang [ID](#)^{13a}, Y. Yang [ID](#)¹⁵⁰, Z. Yang [ID](#)^{60a,103}, W-M. Yao [ID](#)^{16a}, Y.C. Yap [ID](#)⁴⁶, H. Ye [ID](#)^{13c}, J. Ye [ID](#)⁴², S. Ye [ID](#)²⁷, I. Yeletsikh [ID](#)³⁶, M.R. Yexley [ID](#)⁸⁸, P. Yin [ID](#)³⁹, K. Yorita [ID](#)¹⁶⁴, K. Yoshihara [ID](#)⁷⁸, C.J.S. Young [ID](#)⁵², C. Young [ID](#)¹⁴⁰, R. Yuan [ID](#)^{60b,j}, X. Yue [ID](#)^{61a}, M. Zaazoua [ID](#)^{33e}, B. Zabinski [ID](#)⁸³, G. Zacharis [ID](#)⁹, E. Zaid⁵⁰, T. Zakareishvili [ID](#)^{146b}, N. Zakharchuk [ID](#)³², S. Zambito [ID](#)³⁴, D. Zanzi [ID](#)⁵², S.V. Zeißner [ID](#)⁴⁷, C. Zeitnitz [ID](#)¹⁶⁷, J.C. Zeng [ID](#)¹⁵⁸, D.T. Zenger Jr [ID](#)²⁴, O. Zenin [ID](#)³⁵, T. Ženiš [ID](#)^{26a}, S. Zenz [ID](#)⁹¹, S. Zerradi [ID](#)^{33a}, D. Zerwas [ID](#)⁶⁴, B. Zhang [ID](#)^{13c}, D.F. Zhang [ID](#)^{13b}, G. Zhang [ID](#)^{13b}, J. Zhang [ID](#)⁵, K. Zhang [ID](#)^{13a,13d}, L. Zhang [ID](#)^{13c}, M. Zhang [ID](#)¹⁵⁸, R. Zhang [ID](#)¹⁶⁶, S. Zhang [ID](#)¹⁰³, X. Zhang [ID](#)^{60c}, X. Zhang [ID](#)^{60b}, Z. Zhang [ID](#)⁶⁴, P. Zhao [ID](#)⁴⁹, Y. Zhao [ID](#)¹³², Z. Zhao [ID](#)^{60a}, A. Zhemchugov [ID](#)³⁶, Z. Zheng [ID](#)¹⁴⁰, D. Zhong [ID](#)¹⁵⁸, B. Zhou¹⁰³, C. Zhou [ID](#)¹⁶⁶, H. Zhou [ID](#)⁶, N. Zhou [ID](#)^{60c}, Y. Zhou⁶, C.G. Zhu [ID](#)^{60b}, C. Zhu [ID](#)^{13a,13d}, H.L. Zhu [ID](#)^{60a}, H. Zhu [ID](#)^{13a}, J. Zhu [ID](#)¹⁰³, Y. Zhu [ID](#)^{60a}, X. Zhuang [ID](#)^{13a}, K. Zhukov [ID](#)³⁵, V. Zhulanov [ID](#)³⁵, D. Zieminska [ID](#)⁶⁵, N.I. Zimine [ID](#)³⁶, S. Zimmermann [ID](#)^{52,*}, J. Zinsser [ID](#)^{61b}, M. Ziolkowski [ID](#)¹³⁸, L. Živković [ID](#)¹⁴, A. Zoccoli [ID](#)^{21b,21a}, K. Zoch [ID](#)⁵⁴, T.G. Zorbas [ID](#)¹³⁶, O. Zormpa [ID](#)⁴⁴, W. Zou [ID](#)³⁹, L. Zwalinski [ID](#)³⁴

¹ Department of Physics, University of Adelaide, Adelaide; Australia

² Department of Physics, University of Alberta, Edmonton AB; Canada

³ ^(a) Department of Physics, Ankara University, Ankara; ^(b) Istanbul Aydın University, Application and Research Center for Advanced Studies, Istanbul; ^(c) Division of Physics, TOBB University of Economics and Technology, Ankara; Türkiye

⁴ LAPP, Univ. Savoie Mont Blanc, CNRS/IN2P3, Annecy; France

⁵ High Energy Physics Division, Argonne National Laboratory, Argonne IL; United States of America

⁶ Department of Physics, University of Arizona, Tucson AZ; United States of America

⁷ Department of Physics, University of Texas at Arlington, Arlington TX; United States of America

⁸ Physics Department, National and Kapodistrian University of Athens, Athens; Greece

⁹ Physics Department, National Technical University of Athens, Zografou; Greece

¹⁰ Department of Physics, University of Texas at Austin, Austin TX; United States of America

¹¹ ^(a) Bahcesehir University, Faculty of Engineering and Natural Sciences, Istanbul; ^(b) Istanbul Bilgi University, Faculty of Engineering and Natural Sciences, Istanbul; ^(c) Department of Physics, Bogazici University, Istanbul; ^(d) Department of Physics Engineering, Gaziantep University, Gaziantep; Türkiye

¹² Institut de Física d'Altes Energies (IFAE), Barcelona Institute of Science and Technology, Barcelona; Spain

¹³ ^(a) Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; ^(b) Physics Department, Tsinghua University, Beijing; ^(c) Department of Physics, Nanjing University, Nanjing; ^(d) University of Chinese Academy of Science (UCAS), Beijing; China

¹⁴ Institute of Physics, University of Belgrade, Belgrade; Serbia

¹⁵ Department for Physics and Technology, University of Bergen, Bergen; Norway

¹⁶ ^(a) Physics Division, Lawrence Berkeley National Laboratory, Berkeley CA; ^(b) University of California, Berkeley CA; United States of America

¹⁷ Institut für Physik, Humboldt Universität zu Berlin, Berlin; Germany

¹⁸ Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern; Switzerland

- ¹⁹ *School of Physics and Astronomy, University of Birmingham, Birmingham; United Kingdom*
- ²⁰ ^(a) *Facultad de Ciencias y Centro de Investigaciones, Universidad Antonio Nariño, Bogotá;*
^(b) *Departamento de Física, Universidad Nacional de Colombia, Bogotá; Colombia*
- ²¹ ^(a) *Dipartimento di Fisica e Astronomia A. Righi, Università di Bologna, Bologna;* ^(b) *INFN Sezione di Bologna; Italy*
- ²² *Physikalisches Institut, Universität Bonn, Bonn; Germany*
- ²³ *Department of Physics, Boston University, Boston MA; United States of America*
- ²⁴ *Department of Physics, Brandeis University, Waltham MA; United States of America*
- ²⁵ ^(a) *Transilvania University of Brasov, Brasov;* ^(b) *Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest;* ^(c) *Department of Physics, Alexandru Ioan Cuza University of Iasi, Iasi;* ^(d) *National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj-Napoca;* ^(e) *University Politehnica Bucharest, Bucharest;* ^(f) *West University in Timisoara, Timisoara; Romania*
- ²⁶ ^(a) *Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava;* ^(b) *Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice; Slovak Republic*
- ²⁷ *Physics Department, Brookhaven National Laboratory, Upton NY; United States of America*
- ²⁸ *Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Física, y CONICET, Instituto de Física de Buenos Aires (IFIBA), Buenos Aires; Argentina*
- ²⁹ *California State University, CA; United States of America*
- ³⁰ *Cavendish Laboratory, University of Cambridge, Cambridge; United Kingdom*
- ³¹ ^(a) *Department of Physics, University of Cape Town, Cape Town;* ^(b) *iThemba Labs, Western Cape;*
^(c) *Department of Mechanical Engineering Science, University of Johannesburg, Johannesburg;*
^(d) *National Institute of Physics, University of the Philippines Diliman (Philippines);* ^(e) *University of South Africa, Department of Physics, Pretoria;* ^(f) *School of Physics, University of the Witwatersrand, Johannesburg; South Africa*
- ³² *Department of Physics, Carleton University, Ottawa ON; Canada*
- ³³ ^(a) *Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies — Université Hassan II, Casablanca;* ^(b) *Faculté des Sciences, Université Ibn-Tofail, Kénitra;* ^(c) *Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech;* ^(d) *LPMR, Faculté des Sciences, Université Mohamed Premier, Oujda;* ^(e) *Faculté des sciences, Université Mohammed V, Rabat; Morocco*
- ³⁴ *CERN, Geneva; Switzerland*
- ³⁵ *Affiliated with an institute covered by a cooperation agreement with CERN*
- ³⁶ *Affiliated with an international laboratory covered by a cooperation agreement with CERN*
- ³⁷ *Enrico Fermi Institute, University of Chicago, Chicago IL; United States of America*
- ³⁸ *LPC, Université Clermont Auvergne, CNRS/IN2P3, Clermont-Ferrand; France*
- ³⁹ *Nevis Laboratory, Columbia University, Irvington NY; United States of America*
- ⁴⁰ *Niels Bohr Institute, University of Copenhagen, Copenhagen; Denmark*
- ⁴¹ ^(a) *Dipartimento di Fisica, Università della Calabria, Rende;* ^(b) *INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati; Italy*
- ⁴² *Physics Department, Southern Methodist University, Dallas TX; United States of America*
- ⁴³ *Physics Department, University of Texas at Dallas, Richardson TX; United States of America*
- ⁴⁴ *National Centre for Scientific Research "Demokritos", Agia Paraskevi; Greece*
- ⁴⁵ ^(a) *Department of Physics, Stockholm University;* ^(b) *Oskar Klein Centre, Stockholm; Sweden*
- ⁴⁶ *Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen; Germany*
- ⁴⁷ *Fakultät Physik, Technische Universität Dortmund, Dortmund; Germany*
- ⁴⁸ *Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden; Germany*
- ⁴⁹ *Department of Physics, Duke University, Durham NC; United States of America*
- ⁵⁰ *SUPA — School of Physics and Astronomy, University of Edinburgh, Edinburgh; United Kingdom*
- ⁵¹ *INFN e Laboratori Nazionali di Frascati, Frascati; Italy*
- ⁵² *Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg; Germany*

- ⁵³ II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen; Germany
- ⁵⁴ Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève; Switzerland
- ⁵⁵ ^(a) Dipartimento di Fisica, Università di Genova, Genova; ^(b) INFN Sezione di Genova; Italy
- ⁵⁶ II. Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen; Germany
- ⁵⁷ SUPA — School of Physics and Astronomy, University of Glasgow, Glasgow; United Kingdom
- ⁵⁸ LPSC, Université Grenoble Alpes, CNRS/IN2P3, Grenoble INP, Grenoble; France
- ⁵⁹ Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge MA; United States of America
- ⁶⁰ ^(a) Department of Modern Physics and State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei; ^(b) Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao; ^(c) School of Physics and Astronomy, Shanghai Jiao Tong University, Key Laboratory for Particle Astrophysics and Cosmology (MOE), SKLPPC, Shanghai; ^(d) Tsung-Dao Lee Institute, Shanghai; China
- ⁶¹ ^(a) Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; ^(b) Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; Germany
- ⁶² ^(a) Department of Physics, Chinese University of Hong Kong, Shatin, N.T., Hong Kong; ^(b) Department of Physics, University of Hong Kong, Hong Kong; ^(c) Department of Physics and Institute for Advanced Study, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong; China
- ⁶³ Department of Physics, National Tsing Hua University, Hsinchu; Taiwan
- ⁶⁴ IJCLab, Université Paris-Saclay, CNRS/IN2P3, 91405, Orsay; France
- ⁶⁵ Department of Physics, Indiana University, Bloomington IN; United States of America
- ⁶⁶ ^(a) INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine; ^(b) ICTP, Trieste; ^(c) Dipartimento Politecnico di Ingegneria e Architettura, Università di Udine, Udine; Italy
- ⁶⁷ ^(a) INFN Sezione di Lecce; ^(b) Dipartimento di Matematica e Fisica, Università del Salento, Lecce; Italy
- ⁶⁸ ^(a) INFN Sezione di Milano; ^(b) Dipartimento di Fisica, Università di Milano, Milano; Italy
- ⁶⁹ ^(a) INFN Sezione di Napoli; ^(b) Dipartimento di Fisica, Università di Napoli, Napoli; Italy
- ⁷⁰ ^(a) INFN Sezione di Pavia; ^(b) Dipartimento di Fisica, Università di Pavia, Pavia; Italy
- ⁷¹ ^(a) INFN Sezione di Pisa; ^(b) Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa; Italy
- ⁷² ^(a) INFN Sezione di Roma; ^(b) Dipartimento di Fisica, Sapienza Università di Roma, Roma; Italy
- ⁷³ ^(a) INFN Sezione di Roma Tor Vergata; ^(b) Dipartimento di Fisica, Università di Roma Tor Vergata, Roma; Italy
- ⁷⁴ ^(a) INFN Sezione di Roma Tre; ^(b) Dipartimento di Matematica e Fisica, Università Roma Tre, Roma; Italy
- ⁷⁵ ^(a) INFN-TIFPA; ^(b) Università degli Studi di Trento, Trento; Italy
- ⁷⁶ Universität Innsbruck, Department of Astro and Particle Physics, Innsbruck; Austria
- ⁷⁷ University of Iowa, Iowa City IA; United States of America
- ⁷⁸ Department of Physics and Astronomy, Iowa State University, Ames IA; United States of America
- ⁷⁹ ^(a) Departamento de Engenharia Elétrica, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora; ^(b) Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; ^(c) Instituto de Física, Universidade de São Paulo, São Paulo; Brazil
- ⁸⁰ KEK, High Energy Accelerator Research Organization, Tsukuba; Japan
- ⁸¹ Graduate School of Science, Kobe University, Kobe; Japan
- ⁸² ^(a) AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow; ^(b) Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow; Poland
- ⁸³ Institute of Nuclear Physics Polish Academy of Sciences, Krakow; Poland
- ⁸⁴ Faculty of Science, Kyoto University, Kyoto; Japan
- ⁸⁵ Kyoto University of Education, Kyoto; Japan
- ⁸⁶ Research Center for Advanced Particle Physics and Department of Physics, Kyushu University, Fukuoka; Japan
- ⁸⁷ Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata; Argentina
- ⁸⁸ Physics Department, Lancaster University, Lancaster; United Kingdom


- ⁸⁹ *Oliver Lodge Laboratory, University of Liverpool, Liverpool; United Kingdom*
- ⁹⁰ *Department of Experimental Particle Physics, Jožef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana; Slovenia*
- ⁹¹ *School of Physics and Astronomy, Queen Mary University of London, London; United Kingdom*
- ⁹² *Department of Physics, Royal Holloway University of London, Egham; United Kingdom*
- ⁹³ *Department of Physics and Astronomy, University College London, London; United Kingdom*
- ⁹⁴ *Louisiana Tech University, Ruston LA; United States of America*
- ⁹⁵ *Fysiska institutionen, Lunds universitet, Lund; Sweden*
- ⁹⁶ *Departamento de Física Teórica C-15 and CIAFF, Universidad Autónoma de Madrid, Madrid; Spain*
- ⁹⁷ *Institut für Physik, Universität Mainz, Mainz; Germany*
- ⁹⁸ *School of Physics and Astronomy, University of Manchester, Manchester; United Kingdom*
- ⁹⁹ *CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille; France*
- ¹⁰⁰ *Department of Physics, University of Massachusetts, Amherst MA; United States of America*
- ¹⁰¹ *Department of Physics, McGill University, Montreal QC; Canada*
- ¹⁰² *School of Physics, University of Melbourne, Victoria; Australia*
- ¹⁰³ *Department of Physics, University of Michigan, Ann Arbor MI; United States of America*
- ¹⁰⁴ *Department of Physics and Astronomy, Michigan State University, East Lansing MI; United States of America*
- ¹⁰⁵ *Group of Particle Physics, University of Montreal, Montreal QC; Canada*
- ¹⁰⁶ *Fakultät für Physik, Ludwig-Maximilians-Universität München, München; Germany*
- ¹⁰⁷ *Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München; Germany*
- ¹⁰⁸ *Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya; Japan*
- ¹⁰⁹ *Department of Physics and Astronomy, University of New Mexico, Albuquerque NM; United States of America*
- ¹¹⁰ *Institute for Mathematics, Astrophysics and Particle Physics, Radboud University/Nikhef, Nijmegen; Netherlands*
- ¹¹¹ *Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam; Netherlands*
- ¹¹² *Department of Physics, Northern Illinois University, DeKalb IL; United States of America*
- ¹¹³ *Department of Physics, New York University, New York NY; United States of America*
- ¹¹⁴ *Ochanomizu University, Otsuka, Bunkyo-ku, Tokyo; Japan*
- ¹¹⁵ *Ohio State University, Columbus OH; United States of America*
- ¹¹⁶ *Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman OK; United States of America*
- ¹¹⁷ *Department of Physics, Oklahoma State University, Stillwater OK; United States of America*
- ¹¹⁸ *Palacký University, Joint Laboratory of Optics, Olomouc; Czech Republic*
- ¹¹⁹ *Institute for Fundamental Science, University of Oregon, Eugene, OR; United States of America*
- ¹²⁰ *Graduate School of Science, Osaka University, Osaka; Japan*
- ¹²¹ *Department of Physics, University of Oslo, Oslo; Norway*
- ¹²² *Department of Physics, Oxford University, Oxford; United Kingdom*
- ¹²³ *LPNHE, Sorbonne Université, Université Paris Cité, CNRS/IN2P3, Paris; France*
- ¹²⁴ *Department of Physics, University of Pennsylvania, Philadelphia PA; United States of America*
- ¹²⁵ *Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh PA; United States of America*
- ¹²⁶ ^(a) *Laboratório de Instrumentação e Física Experimental de Partículas — LIP, Lisboa;*
^(b) *Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Lisboa;* ^(c) *Departamento de Física, Universidade de Coimbra, Coimbra;* ^(d) *Centro de Física Nuclear da Universidade de Lisboa, Lisboa;* ^(e) *Departamento de Física, Universidade do Minho, Braga;* ^(f) *Departamento de Física Teórica y del Cosmos, Universidad de Granada, Granada (Spain);* ^(g) *Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica;* ^(h) *Departamento de Física, Instituto Superior Técnico, Universidade de Lisboa, Lisboa; Portugal*
- ¹²⁷ *Institute of Physics of the Czech Academy of Sciences, Prague; Czech Republic*
- ¹²⁸ *Czech Technical University in Prague, Prague; Czech Republic*

- 129 *Charles University, Faculty of Mathematics and Physics, Prague; Czech Republic*
- 130 *Particle Physics Department, Rutherford Appleton Laboratory, Didcot; United Kingdom*
- 131 *IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette; France*
- 132 *Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz CA; United States of America*
- 133 ^(a) *Departamento de Física, Pontificia Universidad Católica de Chile, Santiago;* ^(b) *Millennium Institute for Subatomic physics at high energy frontier (SAPHIR), Santiago;* ^(c) *Universidad Andres Bello, Department of Physics, Santiago;* ^(d) *Instituto de Alta Investigación, Universidad de Tarapacá, Arica;* ^(e) *Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso; Chile*
- 134 *Universidade Federal de São João del Rei (UFSJ), São João del Rei; Brazil*
- 135 *Department of Physics, University of Washington, Seattle WA; United States of America*
- 136 *Department of Physics and Astronomy, University of Sheffield, Sheffield; United Kingdom*
- 137 *Department of Physics, Shinshu University, Nagano; Japan*
- 138 *Department Physik, Universität Siegen, Siegen; Germany*
- 139 *Department of Physics, Simon Fraser University, Burnaby BC; Canada*
- 140 *SLAC National Accelerator Laboratory, Stanford CA; United States of America*
- 141 *Department of Physics, Royal Institute of Technology, Stockholm; Sweden*
- 142 *Departments of Physics and Astronomy, Stony Brook University, Stony Brook NY; United States of America*
- 143 *Department of Physics and Astronomy, University of Sussex, Brighton; United Kingdom*
- 144 *School of Physics, University of Sydney, Sydney; Australia*
- 145 *Institute of Physics, Academia Sinica, Taipei; Taiwan*
- 146 ^(a) *E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi;* ^(b) *High Energy Physics Institute, Tbilisi State University, Tbilisi; Georgia*
- 147 *Department of Physics, Technion, Israel Institute of Technology, Haifa; Israel*
- 148 *Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv; Israel*
- 149 *Department of Physics, Aristotle University of Thessaloniki, Thessaloniki; Greece*
- 150 *International Center for Elementary Particle Physics and Department of Physics, University of Tokyo, Tokyo; Japan*
- 151 *Department of Physics, Tokyo Institute of Technology, Tokyo; Japan*
- 152 *Department of Physics, University of Toronto, Toronto ON; Canada*
- 153 ^(a) *TRIUMF, Vancouver BC;* ^(b) *Department of Physics and Astronomy, York University, Toronto ON; Canada*
- 154 *Division of Physics and Tomonaga Center for the History of the Universe, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba; Japan*
- 155 *Department of Physics and Astronomy, Tufts University, Medford MA; United States of America*
- 156 *Department of Physics and Astronomy, University of California Irvine, Irvine CA; United States of America*
- 157 *Department of Physics and Astronomy, University of Uppsala, Uppsala; Sweden*
- 158 *Department of Physics, University of Illinois, Urbana IL; United States of America*
- 159 *Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia — CSIC, Valencia; Spain*
- 160 *Department of Physics, University of British Columbia, Vancouver BC; Canada*
- 161 *Department of Physics and Astronomy, University of Victoria, Victoria BC; Canada*
- 162 *Fakultät für Physik und Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg; Germany*
- 163 *Department of Physics, University of Warwick, Coventry; United Kingdom*
- 164 *Waseda University, Tokyo; Japan*
- 165 *Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot; Israel*
- 166 *Department of Physics, University of Wisconsin, Madison WI; United States of America*
- 167 *Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal; Germany*
- 168 *Department of Physics, Yale University, New Haven CT; United States of America*


















- ^a Also Affiliated with an institute covered by a cooperation agreement with CERN
- ^b Also at Borough of Manhattan Community College, City University of New York, New York NY; United States of America
- ^c Also at Bruno Kessler Foundation, Trento; Italy
- ^d Also at Center for High Energy Physics, Peking University; China
- ^e Also at Centro Studi e Ricerche Enrico Fermi; Italy
- ^f Also at CERN, Geneva; Switzerland
- ^g Also at Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève; Switzerland
- ^h Also at Departament de Física de la Universitat Autònoma de Barcelona, Barcelona; Spain
- ⁱ Also at Department of Financial and Management Engineering, University of the Aegean, Chios; Greece
- ^j Also at Department of Physics and Astronomy, Michigan State University, East Lansing MI; United States of America
- ^k Also at Department of Physics and Astronomy, University of Louisville, Louisville, KY; United States of America
- ^l Also at Department of Physics, Ben Gurion University of the Negev, Beer Sheva; Israel
- ^m Also at Department of Physics, California State University, East Bay; United States of America
- ⁿ Also at Department of Physics, California State University, Fresno; United States of America
- ^o Also at Department of Physics, California State University, Sacramento; United States of America
- ^p Also at Department of Physics, King's College London, London; United Kingdom
- ^q Also at Department of Physics, University of Fribourg, Fribourg; Switzerland
- ^r Also at Faculty of Physics, Sofia University, 'St. Kliment Ohridski', Sofia; Bulgaria
- ^s Also at Hellenic Open University, Patras; Greece
- ^t Also at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona; Spain
- ^u Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg; Germany
- ^v Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest; Hungary
- ^w Also at Institute of Particle Physics (IPP); Canada
- ^x Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku; Azerbaijan
- ^y Also at Institute of Theoretical Physics, Ilia State University, Tbilisi; Georgia
- ^z Also at Instituto de Física Teórica, IFT-UAM/CSIC, Madrid; Spain
- ^{aa} Also at Istanbul University, Dept. of Physics, Istanbul; Türkiye
- ^{ab} Also at Physics Department, An-Najah National University, Nablus; Palestine
- ^{ac} Also at Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg; Germany
- ^{ad} Also at The City College of New York, New York NY; United States of America
- ^{ae} Also at The Collaborative Innovation Center of Quantum Matter (CICQM), Beijing; China
- ^{af} Also at TRIUMF, Vancouver BC; Canada
- ^{ag} Also at Università di Napoli Parthenope, Napoli; Italy
- ^{ah} Also at University of Chinese Academy of Sciences (UCAS), Beijing; China
- ^{ai} Also at Yeditepe University, Physics Department, Istanbul; Türkiye
- ^{aj} Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia; Bulgaria
- ^{ak} Also at L2IT, Université de Toulouse, CNRS/IN2P3, UPS, Toulouse; France
- ^{al} Also at Department of Physics, Stanford University, Stanford CA; United States of America
- * Deceased

The CMS collaboration

Yerevan Physics Institute, Yerevan, Armenia

A. Tumasyan ¹













Institut für Hochenergiephysik, Vienna, Austria

W. Adam , J.W. Andrejkovic, T. Bergauer , S. Chatterjee , M. Dragicevic ,
A. Escalante Del Valle , R. Frühwirth ², M. Jeitler ², N. Krammer , L. Lechner ,
D. Liko , I. Mikulec , P. Paulitsch, F.M. Pitters, J. Schieck ², R. Schöfbeck , D. Schwarz ,
S. Templ , W. Waltenberger , C.-E. Wulz ²

















Universiteit Antwerpen, Antwerpen, Belgium

M.R. Darwish ³, E.A. De Wolf, T. Janssen , T. Kello⁴, A. Lelek , H. Rejeb Sfar,
P. Van Mechelen , S. Van Putte , N. Van Remortel 









Vrije Universiteit Brussel, Brussel, Belgium

F. Blekman , E.S. Bols , J. D'Hondt , M. Delcourt , H. El Faham , S. Lowette ,
S. Moortgat , A. Morton , D. Müller , A.R. Sahasransu , S. Tavernier , W. Van Doninck,
P. Van Mulders 


















Université Libre de Bruxelles, Bruxelles, Belgium

D. Beghin, B. Bilin , B. Clerbaux , G. De Lentdecker , L. Favart , A. Grebenyuk,
A.K. Kalsi , K. Lee , M. Mahdavihorrani , I. Makarenko , L. Moureaux , L. Pétré ,
A. Popov , N. Postiau, E. Starling , L. Thomas , M. Vanden Bemden, C. Vander Velde ,
P. Vanlaer , L. Wezenbeek 

Ghent University, Ghent, Belgium

T. Cornelis , D. Dobur , J. Knolle , L. Lambrecht , G. Mestdach, M. Niedziela ,
C. Roskas , A. Samalan, K. Skovpen , M. Tytgat , B. Vermassen, M. Vit






















Université Catholique de Louvain, Louvain-la-Neuve, Belgium

A. Benecke , A. Bethani , G. Bruno , F. Bury , C. Caputo , P. David , C. Delaere ,
I.S. Donertas , A. Giammanco , K. Jaffel , Sa. Jain , V. Lemaitre, K. Mondal ,
J. Prisciandaro, A. Taliercio , M. Teklishyn , T.T. Tran , P. Vischia , S. Wertz 









Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil

G.A. Alves , C. Hensel , A. Moraes 

Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

W.L. Aldá Júnior , M. Alves Gallo Pereira , M. Barroso Ferreira Filho ,
H. Brandao Malbouisson , W. Carvalho , J. Chinellato⁵, E.M. Da Costa ,
G.G. Da Silveira ⁶, D. De Jesus Damiao , S. Fonseca De Souza , D. Matos Figueiredo ,
C. Mora Herrera , K. Mota Amarilo , L. Mundim , H. Nogima , P. Rebello Teles ,
A. Santoro , S.M. Silva Do Amaral , A. Sznajder , M. Thiel ,
F. Torres Da Silva De Araujo ⁷, A. Vilela Pereira 

Universidade Estadual Paulista, Universidade Federal do ABC, São Paulo, Brazil

C.A. Bernardes , L. Calligaris , T.R. Fernandez Perez Tomei , E.M. Gregores ,
D. S. Lemos , P.G. Mercadante , S.F. Novaes , Sandra S. Padula 




Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, Sofia, Bulgaria

A. Aleksandrov , G. Antchev , R. Hadjiiska , P. Iaydjiev , M. Misheva , M. Rodozov,
M. Shopova , G. Sultanov 





University of Sofia, Sofia, Bulgaria

A. Dimitrov , T. Ivanov , L. Litov , B. Pavlov , P. Petkov , A. Petrov

















Beihang University, Beijing, China

T. Cheng , T. Javaid⁸, M. Mittal , L. Yuan 










Department of Physics, Tsinghua University, Beijing, China

M. Ahmad , G. Bauer, C. Dozen , Z. Hu , J. Martins , Y. Wang, K. Yi^{10,11}

Institute of High Energy Physics, Beijing, China

E. Chapon , G.M. Chen ⁸, H.S. Chen ⁸, M. Chen , F. Iemmi , A. Kapoor , D. Leggat,
H. Liao , Z.-A. Liu ¹², V. Milosevic , F. Monti , R. Sharma , J. Tao ,
J. Thomas-Wilsker , J. Wang , H. Zhang , J. Zhao 



State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China

A. Agapitos , Y. An , Y. Ban , C. Chen, A. Levin , Q. Li , X. Lyu, Y. Mao, S.J. Qian ,
D. Wang , Q. Wang , J. Xiao 

Sun Yat-Sen University, Guangzhou, China

M. Lu , Z. You 

Institute of Modern Physics and Key Laboratory of Nuclear Physics and Ion-beam Application (MOE) — Fudan University, Shanghai, China

X. Gao ⁴, H. Okawa 

Zhejiang University, Hangzhou, Zhejiang, China

Z. Lin , M. Xiao 

Universidad de Los Andes, Bogota, Colombia

C. Avila , A. Cabrera , C. Florez , J. Fraga 

Universidad de Antioquia, Medellin, Colombia

J. Mejia Guisao , F. Ramirez , J.D. Ruiz Alvarez , C.A. Salazar González 

University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split, Croatia

D. Giljanovic , N. Godinovic , D. Lelas , I. Puljak 










University of Split, Faculty of Science, Split, Croatia

Z. Antunovic, M. Kovac , T. Sculac 

Institute Rudjer Boskovic, Zagreb, Croatia

V. Brigljevic , D. Ferencek , D. Majumder , M. Roguljic , A. Starodumov ¹³, T. Susa 

University of Cyprus, Nicosia, Cyprus

A. Attikis , K. Christoforou , E. Erodoutou, A. Ioannou, G. Kole , M. Kolosova ,
S. Konstantinou , J. Mousa , C. Nicolaou, F. Ptochos , P.A. Razis , H. Rykaczewski,
H. Saka 

Charles University, Prague, Czech Republic

M. Finger ¹³, M. Finger Jr. ¹³, A. Kveton 



Escuela Politecnica Nacional, Quito, Ecuador

E. Ayala 

Universidad San Francisco de Quito, Quito, Ecuador

E. Carrera Jarrin 

Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt

A.A. Abdelalim ^{14,15}, E. Salama ^{16,17}

Center for High Energy Physics (CHEP-FU), Fayoum University, El-Fayoum, Egypt

M.A. Mahmoud , Y. Mohammed 
















National Institute of Chemical Physics and Biophysics, Tallinn, Estonia

S. Bhowmik , R.K. Dewanjee , K. Ehataht , M. Kadastik, S. Nandan , C. Nielsen ,
J. Pata , M. Raidal , L. Tani , C. Veelken 

Department of Physics, University of Helsinki, Helsinki, Finland

P. Eerola , L. Forthomme , H. Kirschenmann , K. Osterberg , M. Voutilainen 


















Helsinki Institute of Physics, Helsinki, Finland

S. Bharthuar , E. Brücken , F. Garcia , J. Havukainen , M.S. Kim , R. Kinnunen,
T. Lampén , K. Lassila-Perini , S. Lehti , T. Lindén , M. Lotti, L. Martikainen ,
M. Myllymäki , J. Ott , H. Siikonen , E. Tuominen , J. Tuominiemi 



























Lappeenranta-Lahti University of Technology, Lappeenranta, Finland

P. Luukka , H. Petrow , T. Tuuva











IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France

C. Amendola , M. Besancon , F. Couderc , M. Dejardin , D. Denegri, J.L. Faure, F. Ferri ,
S. Ganjour , A. Givernaud, P. Gras , G. Hamel de Monchenault , P. Jarry , B. Lenzi ,
E. Locci , J. Malcles , J. Rander, A. Rosowsky , M.Ö. Sahin , A. Savoy-Navarro ¹⁸,
M. Titov , G.B. Yu 


















Laboratoire Leprince-Ringuet, CNRS/IN2P3, Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau, France

S. Ahuja , F. Beaudette , M. Bonanomi , A. Buchot Perraguin , P. Busson , A. Cappati ,
C. Charlot , O. Davignon , B. Diab , G. Falmagne , S. Ghosh , R. Granier de Cassagnac ,
A. Hakimi , I. Kucher , J. Motta , M. Nguyen , C. Ochando , P. Paganini , J. Rembser ,
R. Salerno , U. Sarkar , J.B. Sauvan , Y. Sirois , A. Tarabini , A. Zabi , A. Zghiche 

Université de Strasbourg, CNRS, IPHC UMR 7178, Strasbourg, France

J.-L. Agram ¹⁹, J. Andrea, D. Apparu , D. Bloch , G. Bourgatte, J.-M. Brom ,
E.C. Chabert , C. Collard , D. Darej, J.-C. Fontaine¹⁹, U. Goerlach , C. Grimault,
A.-C. Le Bihan , E. Nibigira , P. Van Hove 


Institut de Physique des 2 Infinis de Lyon (IP2I), Villeurbanne, France

E. Asilar , S. Beauceron , C. Bernet , G. Boudoul , C. Camen, A. Carle, N. Chanon ,
D. Contardo , P. Depasse , H. El Mamouni, J. Fay , S. Gascon , M. Gouzevitch , B. Ille ,
I.B. Laktineh, H. Lattaud , A. Lesauvage , M. Lethuillier , L. Mirabito, S. Perries,
K. Shchablo, V. Sordini , L. Torterotot , G. Touquet, M. Vander Donckt , S. Viret























Georgian Technical University, Tbilisi, Georgia

I. Lomidze , T. Toriashvili ²⁰, Z. Tsamalaidze ¹³












RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany

V. Botta , L. Feld , K. Klein , M. Lipinski , D. Meuser , A. Pauls , N. Röwert ,
J. Schulz, M. Teroerde 









RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany

















A. Dodonova , D. Eliseev , M. Erdmann , P. Fackeldey , B. Fischer , S. Ghosh ,
T. Hebbeker , K. Hoepfner , F. Ivone , L. Mastrolorenzo, M. Merschmeyer , A. Meyer ,
G. Mocellin , S. Mondal , S. Mukherjee , D. Noll , A. Novak , T. Pook ,
A. Pozdnyakov , Y. Rath, H. Reithler , J. Roemer, A. Schmidt , S.C. Schuler, A. Sharma ,
L. Vigilante, S. Wiedenbeck , S. Zaleski

RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany




























C. Dziwok , G. Flügge , W. Haj Ahmad ²¹, O. Hlushchenko, T. Kress , A. Nowack ,
C. Pistone, O. Pooth , D. Roy , H. Sert , A. Stahl ²², T. Ziemons , A. Zotz 

Deutsches Elektronen-Synchrotron, Hamburg, Germany






























H. Aarup Petersen, M. Aldaya Martin , P. Asmuss, S. Baxter , M. Bayatmakou , O. Behnke,
A. Bermúdez Martínez , S. Bhattacharya , A.A. Bin Anuar , K. Borrás ²³, D. Brunner 

A. Campbell , A. Cardini , C. Cheng, F. Colombina, S. Consuegra Rodríguez ,
 G. Correia Silva , V. Danilov, M. De Silva , L. Didukh , G. Eckerlin, D. Eckstein,
 L.I. Estevez Banos , O. Filatov , E. Gallo ²⁴, A. Geiser , A. Giraldi , A. Grohsjean ,
 M. Guthoff , A. Jafari ²⁵, N.Z. Jomhari , A. Kasem ²³, M. Kasemann , H. Kaveh ,
 C. Kleinwort , D. Krücker , W. Lange, J. Lidrych , K. Lipka , W. Lohmann ²⁶,
 R. Mankel , I.-A. Melzer-Pellmann , M. Mendizabal Morentin , J. Metwally, A.B. Meyer ,
 M. Meyer , J. Mnich , A. Mussgiller , Y. Otariid, D. Pérez Adán , D. Pitzl, A. Raspereza,
 B. Ribeiro Lopes , J. Rübenach, A. Saggio , A. Saibel , M. Savitskyi , M. Scham ²⁷,
 V. Scheurer, P. Schütze , C. Schwanenberger ²⁴, M. Shchedrolosiev , R.E. Sosa Ricardo ,
 D. Stafford, N. Tonon , M. Van De Klundert , R. Walsh , D. Walter , Y. Wen ,
 K. Wichmann, L. Wiens , C. Wissing , S. Wuchterl 




University of Hamburg, Hamburg, Germany

R. Aggleton, S. Albrecht , S. Bein , L. Benato , P. Connor , K. De Leo , M. Eich,
 F. Feindt, A. Fröhlich, C. Garbers , E. Garutti , P. Gunnellini, M. Hajheidari, J. Haller ,
 A. Hinzmann , G. Kasieczka , R. Klanner , R. Kogler , T. Kramer , V. Kutzner ,
 J. Lange , T. Lange , A. Lobanov , A. Malara , A. Nigamova , K.J. Pena Rodriguez ,
 O. Rieger, P. Schleper , M. Schröder , J. Schwandt , J. Sonneveld , H. Stadie ,
 G. Steinbrück , A. Tews, I. Zoi 











Karlsruher Institut fuer Technologie, Karlsruhe, Germany

J. Bechtel , S. Brommer , M. Burkart, E. Butz , R. Caspart , T. Chwalek , W. De Boer[†],
 A. Dierlamm , A. Droll, K. El Morabit , N. Faltermann , M. Giffels , J.o. Gosewisch,
 A. Gottmann , F. Hartmann ²², C. Heidecker, U. Husemann , P. Keicher, R. Koppenhöfer ,
 S. Maier , M. Metzler, S. Mitra , Th. Müller , M. Neukum, A. Nürnberg , G. Quast ,
 K. Rabbertz , J. Rauser, D. Savoie , M. Schnepf, D. Seith, I. Shvetsov, H.J. Simonis ,
 R. Ulrich , J. Van Der Linden , R.F. Von Cube , M. Wassmer , M. Weber , S. Wieland ,
 R. Wolf , S. Wozniewski , S. Wunsch

Institute of Nuclear and Particle Physics (INPP), NCSR Demokritos, Aghia Paraskevi, Greece

G. Anagnostou, G. Daskalakis , T. Geralis , A. Kyriakis, A. Stakia 







National and Kapodistrian University of Athens, Athens, Greece

M. Diamantopoulou, D. Karasavvas, G. Karathanasis , P. Kontaxakis , C.K. Koraka ,
 A. Manousakis-Katsikakis , A. Panagiotou, I. Papavergou , N. Saoulidou , K. Theofilatos ,
 E. Tziaferi , K. Vellidis , E. Vourliotis 












National Technical University of Athens, Athens, Greece

G. Bakas , K. Kousouris , I. Papakrivopoulos , G. Tsipolitis, A. Zacharopoulou






University of Ioánnina, Ioánnina, Greece

K. Adamidis, I. Bestintzanos, I. Evangelou , C. Foudas, P. Gianneios , P. Katsoulis,
 P. Kokkas , N. Manthos , I. Papadopoulos , J. Strologas 

MTA-ELTE Lendület CMS Particle and Nuclear Physics Group, Eötvös Loránd University, Budapest, Hungary

M. Csanád , K. Farkas , M.M.A. Gadallah ²⁸, S. Lökös ²⁹, P. Major , K. Mandal , A. Mehta , G. Pásztor , A.J. Rádl , O. Surányi , G.I. Veres 

Wigner Research Centre for Physics, Budapest, Hungary

M. Bartók ³⁰, G. Bencze, C. Hajdu , D. Horvath ³¹, F. Sikler , V. Veszpremi 

Institute of Nuclear Research ATOMKI, Debrecen, Hungary

S. Czellar, J. Karancsi ³⁰, J. Molnar, Z. Szillasi, D. Teyssier 





Institute of Physics, University of Debrecen, Debrecen, Hungary

P. Raics, Z.L. Trocsanyi ³², B. Ujvari 














Karoly Robert Campus, MATE Institute of Technology, Gyongyos, Hungary

T. Csorgo ³³, F. Nemes ³³, T. Novak 










Indian Institute of Science (IISc), Bangalore, India

S. Choudhury, J.R. Komaragiri , D. Kumar , L. Panwar , P.C. Tiwari 










Panjab University, Chandigarh, India

S. Bansal , S.B. Beri, V. Bhatnagar , G. Chaudhary , S. Chauhan , N. Dhingra ³⁴, R. Gupta, A. Kaur , M. Kaur , S. Kaur , P. Kumari , M. Meena , K. Sandeep , J.B. Singh , A. K. Viridi 









University of Delhi, Delhi, India

A. Ahmed , A. Bhardwaj , B.C. Choudhary , M. Gola, S. Keshri , A. Kumar , M. Naimuddin , P. Priyanka , K. Ranjan , A. Shah 





Saha Institute of Nuclear Physics, HBNI, Kolkata, India

M. Bharti³⁵, R. Bhattacharya , S. Bhattacharya , D. Bhowmik, S. Dutta , S. Dutta, B. Gomer ³⁶, M. Maity³⁷, P. Palit , P.K. Rout , G. Saha , B. Sahu , S. Sarkar, M. Sharan, B. Singh³⁵, S.Thakur ³⁵

Indian Institute of Technology Madras, Madras, India

P.K. Behera , S.C. Behera , P. Kalbhor , A. Muhammad , R. Pradhan , P.R. Pujahari , A. Sharma , A.K. Sikdar 

Bhabha Atomic Research Centre, Mumbai, India

D. Dutta , V. Jha, V. Kumar , D.K. Mishra, K. Naskar ³⁸, P.K. Netrakanti, L.M. Pant, P. Shukla 










Tata Institute of Fundamental Research-A, Mumbai, India

T. Aziz, S. Dugad, M. Kumar , G.B. Mohanty 

Tata Institute of Fundamental Research-B, Mumbai, India

S. Banerjee , R. Chudasama , M. Guchait , S. Karmakar , S. Kumar , G. Majumder ,
K. Mazumdar , S. Mukherjee 

National Institute of Science Education and Research, An OCC of Homi Bhabha National Institute, Bhubaneswar, Odisha, India

S. Bahinipati ³⁹, C. Kar , P. Mal , T. Mishra , V.K. Muraleedharan Nair Bindhu ⁴⁰,
A. Nayak ⁴⁰, P. Saha , N. Sur , S.K. Swain, D. Vats ⁴⁰

Indian Institute of Science Education and Research (IISER), Pune, India

K. Alpana , S. Dube , B. Kansal , A. Laha , S. Pandey , A. Rane , A. Rastogi ,
S. Sharma 

Isfahan University of Technology, Isfahan, Iran

H. Bakhshiansohi ⁴¹, E. Khazaie , M. Zeinali ⁴²


































Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

S. Chenarani ⁴³, S.M. Etesami , M. Khakzad , M. Mohammadi Najafabadi 





























University College Dublin, Dublin, Ireland

M. Grunewald 

INFN Sezione di Bari^a, Università di Bari^b, Politecnico di Bari^c, Bari, Italy

M. Abbrescia ^{a,b}, R. Aly ^{a,c,14}, C. Aruta ^{a,b}, A. Colaleo ^a, D. Creanza ^{a,c},
N. De Filippis ^{a,c}, M. De Palma ^{a,b}, A. Di Florio ^{a,b}, A. Di Pilato ^{a,b}, W. Elmetenawee ^{a,b},
L. Fiore ^a, A. Gelmi ^{a,b}, M. Gul ^a, G. Iaselli ^{a,c}, M. Ince ^{a,b}, S. Lezki ^{a,b}, G. Maggi ^{a,c},
M. Maggi ^a, I. Margjeka ^{a,b}, V. Mastrapasqua ^{a,b}, J.A. Merlin ^a, S. My ^{a,b}, S. Nuzzo ^{a,b},
A. Pellecchia ^{a,b}, A. Pompili ^{a,b}, G. Pugliese ^{a,c}, D. Ramos ^a, A. Ranieri ^a,
G. Selvaggi ^{a,b}, L. Silvestris ^a, F.M. Simone ^{a,b}, R. Venditti ^a, P. Verwilligen ^a
















INFN Sezione di Bologna^a, Università di Bologna^b, Bologna, Italy



















































































































G. Abbiendi ^a, C. Battilana ^{a,b}, D. Bonacorsi ^{a,b}, L. Borgonovi ^a, L. Brigliadori ^a,
R. Campanini ^{a,b}, P. Capiluppi ^{a,b}, A. Castro ^{a,b}, F.R. Cavallo ^a, M. Cuffiani ^{a,b},
G.M. Dallavalle ^a, T. Diotallevi ^{a,b}, F. Fabbri ^a, A. Fanfani ^{a,b}, P. Giacomelli ^a,
L. Giommi ^{a,b}, C. Grandi ^a, L. Guiducci ^{a,b}, S. Lo Meo ^{a,44}, L. Lunerti ^{a,b},
S. Marcellini ^a, G. Masetti ^a, F.L. Navarria ^{a,b}, A. Perrotta ^a, F. Primavera ^{a,b},
A.M. Rossi ^{a,b}, T. Rovelli ^{a,b}, G.P. Siroli ^{a,b}

INFN Sezione di Catania^a, Università di Catania^b, Catania, Italy


















S. Albergo ^{a,b,45}, S. Costa ^{a,b,45}, A. Di Mattia ^a, R. Potenza ^{a,b}, A. Tricoli ^{a,b,45},
C. Tuve ^{a,b}

INFN Sezione di Firenze^a, Università di Firenze^b, Firenze, Italy





































G. Barbagli ^a, A. Cassese ^a, R. Ceccarelli ^{a,b}, V. Ciulli ^{a,b}, C. Civinini ^a,
R. D'Alessandro ^{a,b}, E. Focardi ^{a,b}, G. Latino ^{a,b}, P. Lenzi ^{a,b}, M. Lizzo ^{a,b},
M. Meschini ^a, S. Paoletti ^a, R. Seidita ^{a,b}, G. Sguazzoni ^a, L. Viliani ^a

INFN Laboratori Nazionali di Frascati, Frascati, ItalyL. Benussi , S. Bianco , D. Piccolo **INFN Sezione di Genova^a, Università di Genova^b, Genova, Italy**M. Bozzo ^{a,b}, F. Ferro ^a, R. Mulargia ^{a,b}, E. Robutti ^a, S. Tosi ^{a,b}**INFN Sezione di Milano-Bicocca^a, Università di Milano-Bicocca^b, Milano, Italy**A. Benaglia ^a, G. Boldrini ^a, F. Brivio ^{a,b}, F. Cetorelli ^{a,b}, F. De Guio ^{a,b},
M.E. Dinardo ^{a,b}, P. Dini ^a, S. Gennai ^a, A. Ghezzi ^{a,b}, P. Govoni ^{a,b}, L. Guzzi ^{a,b},
M.T. Lucchini ^{a,b}, M. Malberti ^a, S. Malvezzi ^a, A. Massironi ^a, D. Menasce ^a,
L. Moroni ^a, M. Paganoni ^{a,b}, D. Pedrini ^a, B.S. Pinolini^a, S. Ragazzi ^{a,b}, N. Redaelli ^a,
T. Tabarelli de Fatis ^{a,b}, D. Valsecchi ^{a,b,22}, D. Zuolo ^{a,b}**INFN Sezione di Napoli^a, Università di Napoli 'Federico II'^b, Napoli, Italy;
Università della Basilicata^c, Potenza, Italy; Università G. Marconi^d, Roma, Italy**S. Buontempo ^a, F. Carnevali^{a,b}, N. Cavallo ^{a,c}, A. De Iorio ^{a,b}, F. Fabozzi ^{a,c},
A.O.M. Iorio ^{a,b}, L. Lista ^{a,b}, S. Meola ^{a,d,22}, P. Paolucci ^{a,22}, B. Rossi ^a, C. Sciacca ^{a,b}**INFN Sezione di Padova^a, Università di Padova^b, Padova, Italy; Università di Trento^c, Trento, Italy**P. Azzi ^a, N. Bacchetta ^a, D. Bisello ^{a,b}, P. Bortignon ^a, A. Bragagnolo ^{a,b}, R. Carlin ^{a,b},
P. Checchia ^a, T. Dorigo ^a, U. Dosselli ^a, F. Gasparini ^{a,b}, U. Gasparini ^{a,b}, G. Grosso^a,
S.Y. Hoh ^{a,b}, L. Layer^{a,46}, E. Lusiani ^a, M. Margoni ^{a,b}, A.T. Meneguzzo ^{a,b}, J. Pazzini ^{a,b},
P. Ronchese ^{a,b}, R. Rossin ^{a,b}, F. Simonetto ^{a,b}, G. Strong ^a, M. Tosi ^{a,b}, H. Yarar^{a,b},
M. Zanetti ^{a,b}, P. Zotto ^{a,b}, A. Zucchetta ^{a,b}, G. Zumerle ^{a,b}**INFN Sezione di Pavia^a, Università di Pavia^b, Pavia, Italy**C. Aime^c ^{a,b}, A. Braghieri ^a, S. Calzaferri ^{a,b}, D. Fiorina ^{a,b}, P. Montagna ^{a,b}, S.P. Ratti^{a,b},
V. Re ^a, C. Riccardi ^{a,b}, P. Salvini ^a, I. Vai ^a, P. Vitulo ^{a,b}**INFN Sezione di Perugia^a, Università di Perugia^b, Perugia, Italy**P. Asenov ^{a,47}, G.M. Bilei ^a, D. Ciangottini ^{a,b}, L. Fanò ^{a,b}, P. Lariccia^{a,b},
M. Magherini ^{a,b}, G. Mantovani^{a,b}, V. Mariani ^{a,b}, M. Menichelli ^a, F. Moscatelli ^{a,47},
A. Piccinelli ^{a,b}, M. Presilla ^{a,b}, A. Rossi ^{a,b}, A. Santocchia ^{a,b}, D. Spiga ^a, T. Tedeschi ^{a,b}**INFN Sezione di Pisa^a, Università di Pisa^b, Scuola Normale Superiore di Pisa^c, Pisa, Italy; Università di Siena^d, Siena, Italy**P. Azzurri ^a, G. Bagliesi ^a, V. Bertacchi ^{a,c}, L. Bianchini ^a, T. Boccali ^a, E. Bossini ^{a,b},
R. Castaldi ^a, M.A. Ciocci ^{a,b}, V. D'Amante ^{a,d}, R. Dell'Orso ^a, M.R. Di Domenico ^{a,d},
S. Donato ^a, A. Giassi ^a, F. Ligabue ^{a,c}, E. Manca ^{a,c}, G. Mandorli ^{a,c}, A. Messineo ^{a,b},
F. Palla ^a, S. Parolia ^{a,b}, G. Ramirez-Sanchez ^{a,c}, A. Rizzi ^{a,b}, G. Rolandi ^{a,c},
S. Roy Chowdhury ^{a,c}, A. Scribano ^a, N. Shafiei ^{a,b}, P. Spagnolo ^a, R. Tenchini ^a,
G. Tonelli ^{a,b}, N. Turini ^{a,d}, A. Venturi ^a, P.G. Verdini ^a









INFN Sezione di Roma^a, Sapienza Università di Roma^b, Roma, Italy

P. Barria ^a, M. Campana ^{a,b}, F. Cavallari ^a, D. Del Re ^{a,b}, E. Di Marco ^a, M. Diemoz ^a,
 E. Longo ^{a,b}, P. Meridiani ^a, G. Organtini ^{a,b}, F. Pandolfi ^a, R. Paramatti ^{a,b},
 C. Quaranta ^{a,b}, S. Rahatlou ^{a,b}, C. Rovelli ^a, F. Santanastasio ^{a,b}, L. Soffi ^a,
 R. Tramontano ^{a,b}














INFN Sezione di Torino^a, Università di Torino^b, Torino, Italy; Università del Piemonte Orientale^c, Novara, Italy

N. Amapane ^{a,b}, R. Arcidiacono ^{a,c}, S. Argiro ^{a,b}, M. Arneodo ^{a,c}, N. Bartosik ^a,
 R. Bellan ^{a,b}, A. Bellora ^{a,b}, J. Berenguer Antequera ^{a,b}, C. Biino ^a, N. Cartiglia ^a,
 S. Cometti ^a, M. Costa ^{a,b}, R. Covarelli ^{a,b}, N. Demaria ^a, B. Kiani ^{a,b}, F. Legger ^a,
 C. Mariotti ^a, S. Maselli ^a, E. Migliore ^{a,b}, E. Monteil ^{a,b}, M. Monteno ^a,
 M.M. Obertino ^{a,b}, G. Ortona ^a, L. Pacher ^{a,b}, N. Pastrone ^a, M. Pelliccioni ^a,
 G.L. Pinna Angioni^{a,b}, M. Ruspa ^{a,c}, K. Shchelina ^a, F. Siviero ^{a,b}, V. Sola ^a,
 A. Solano ^{a,b}, D. Soldi ^{a,b}, A. Staiano ^a, M. Tornago ^{a,b}, D. Trocino ^a, A. Vagnerini ^{a,b}

INFN Sezione di Trieste^a, Università di Trieste^b, Trieste, Italy

S. Belforte ^a, V. Candelise ^{a,b}, M. Casarsa ^a, F. Cossutti ^a, A. Da Rold ^{a,b},
 G. Della Ricca ^{a,b}, G. Sorrentino ^{a,b}, F. Vazzoler ^{a,b}




Kyungpook National University, Daegu, Korea

S. Dogra ^b, C. Huh ^b, B. Kim ^b, D.H. Kim ^b, G.N. Kim ^b, J. Kim, J. Lee ^b, S.W. Lee ^b,
 C.S. Moon ^b, Y.D. Oh ^b, S.I. Pak ^b, B.C. Radburn-Smith ^b, S. Sekmen ^b, Y.C. Yang ^b





Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea

H. Kim ^b, D.H. Moon ^b

Hanyang University, Seoul, Korea

B. Francois ^b, T.J. Kim ^b, J. Park ^b

Korea University, Seoul, Korea

S. Cho, S. Choi ^b, Y. Go, B. Hong ^b, K. Lee, K.S. Lee ^b, J. Lim, J. Park, S.K. Park, J. Yoo ^b


Kyung Hee University, Department of Physics, Seoul, Korea

J. Goh ^b, A. Gurtu ^b










Sejong University, Seoul, Korea

H. S. Kim ^b, Y. Kim

Seoul National University, Seoul, Korea

J. Almond, J.H. Bhyun, J. Choi ^b, S. Jeon ^b, J. Kim ^b, J.S. Kim, S. Ko ^b, H. Kwon ^b, H. Lee ^b,
 S. Lee, B.H. Oh ^b, M. Oh ^b, S.B. Oh ^b, H. Seo ^b, U.K. Yang, I. Yoon ^b




University of Seoul, Seoul, Korea

W. Jang ^b, D.Y. Kang, Y. Kang ^b, S. Kim ^b, B. Ko, J.S.H. Lee ^b, Y. Lee ^b, I.C. Park ^b,
 Y. Roh, M.S. Ryu ^b, D. Song, Watson, I.J. ^b, S. Yang ^b


Yonsei University, Department of Physics, Seoul, Korea

S. Ha , H.D. Yoo 

Sungkyunkwan University, Suwon, Korea

M. Choi , H. Lee, Y. Lee , I. Yu 

College of Engineering and Technology, American University of the Middle East (AUM), Dasman, Kuwait

T. Beyrouthy, Y. Maghrbi 

Riga Technical University, Riga, Latvia

K. Dreimanis , V. Veckalns 







Vilnius University, Vilnius, Lithuania

M. Ambrozias , A. Carvalho Antunes De Oliveira , A. Juodagalvis , A. Rinkevicius ,
G. Tamulaitis 








National Centre for Particle Physics, Universiti Malaya, Kuala Lumpur, Malaysia

N. Bin Norjoharuddeen , W.A.T. Wan Abdullah, M.N. Yusli, Z. Zolkapli

Universidad de Sonora (UNISON), Hermosillo, Mexico

J.F. Benitez , A. Castaneda Hernandez , M. León Coello , J.A. Murillo Quijada ,
A. Sehrawat , L. Valencia Palomo 

Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico

G. Ayala , H. Castilla-Valdez , E. De La Cruz-Burelo , I. Heredia-De La Cruz ⁴⁸,
R. Lopez-Fernandez , C.A. Mondragon Herrera, D.A. Perez Navarro , A. Sánchez Hernández 


Universidad Iberoamericana, Mexico City, Mexico

S. Carrillo Moreno, C. Oropeza Barrera , F. Vazquez Valencia 

Benemerita Universidad Autonoma de Puebla, Puebla, Mexico

I. Pedraza , H.A. Salazar Ibarquen , C. Uribe Estrada 

University of Montenegro, Podgorica, Montenegro

J. Mijuskovic⁴⁹, N. Raicevic 







University of Auckland, Auckland, New Zealand

D. Krofcheck 

University of Canterbury, Christchurch, New Zealand

P.H. Butler 

National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan

A. Ahmad , M.I. Asghar , A. Awais , M.I.M. Awan , H.R. Hoorani , W.A. Khan , M.A. Shah ,
M. Shoaib , M. Waqas 






AGH University of Science and Technology Faculty of Computer Science, Electronics and Telecommunications, Krakow, Poland

V. Avati , L. Grzanka , M. Malawski 






National Centre for Nuclear Research, Swierk, Poland

H. Bialkowska , M. Bluj , B. Boimska , M. Górski , M. Kazana , M. Szeleper ,
P. Zalewski 

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland

K. Bunkowski , K. Doroba , A. Kalinowski , M. Konecki , J. Krolikowski 































Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal

M. Araujo , P. Bargassa , D. Bastos , A. Boletti , P. Faccioli , M. Gallinaro , J. Hollar ,
N. Leonardo , T. Niknejad , M. Pisano , J. Seixas , O. Toldaiev , J. Varela 

VINCA Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia

P. Adzic ⁵⁰, M. Dordevic , P. Milenovic , J. Milosevic 















Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain

M. Aguilar-Benitez , J. Alcaraz Maestre , A. Álvarez Fernández , I. Bachiller , M. Barrio Luna ,
Cristina F. Bedoya , C.A. Carrillo Montoya , M. Cepeda , M. Cerrada , N. Colino ,
B. De La Cruz , A. Delgado Peris , J.P. Fernández Ramos , J. Flix , M.C. Fouz ,
O. Gonzalez Lopez , S. Goy Lopez , J.M. Hernandez , M.I. Josa , J. León Holgado ,
D. Moran , Á. Navarro Tobar , C. Perez Dengra , A. Pérez-Calero Yzquierdo ,
J. Puerta Pelayo , I. Redondo , L. Romero , S. Sánchez Navas , L. Urda Gómez , C. Willmott 



















Universidad Autónoma de Madrid, Madrid, Spain

J.F. de Trocóniz , R. Reyes-Almanza 

Universidad de Oviedo, Instituto Universitario de Ciencias y Tecnologías Espaciales de Asturias (ICTEA), Oviedo, Spain

B. Alvarez Gonzalez , J. Cuevas , C. Erice , J. Fernandez Menendez , S. Folgueras ,
I. Gonzalez Caballero , J.R. González Fernández , E. Palencia Cortezon ,
C. Ramón Álvarez , V. Rodríguez Bouza , A. Soto Rodríguez , A. Trapote , N. Trevisani ,
C. Vico Villalba 

**Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria,
Santander, Spain**

J.A. Brochero Cifuentes , I.J. Cabrillo , A. Calderon , J. Duarte Campderros ,
M. Fernandez , C. Fernandez Madrazo , P.J. Fernández Manteca , A. García Alonso,
G. Gomez , C. Martinez Rivero , P. Martinez Ruiz del Arbol , F. Matorras ,
P. Matorras Cuevas , J. Piedra Gomez , C. Prieels, T. Rodrigo , A. Ruiz-Jimeno ,
L. Scodellaro , I. Vila , J.M. Vizan Garcia 

University of Colombo, Colombo, Sri Lanka

M.K. Jayananda , B. Kailasapathy ⁵¹, D.U.J. Sonnadara , D.D.C. Wickramarathna 











University of Ruhuna, Department of Physics, Matara, Sri Lanka

W.G.D. Dharmaratna , K. Liyanage , N. Perera , N. Wickramage 



























CERN, European Organization for Nuclear Research, Geneva, Switzerland








T.K. Aarrestad , D. Abbaneo , J. Alimena , E. Auffray , G. Auzinger , J. Baechler,
P. Baillon[†], D. Barney , J. Bendavid , M. Bianco , A. Bocci , T. Camporesi ,
M. Capeans Garrido , G. Cerminara , N. Chernyavskaya , S.S. Chhibra , M. Cipriani ,
L. Cristella , D. d'Enterria , A. Dabrowski , A. David , A. De Roeck , M.M. Defranichis ,
M. Deile , M. Dobson , M. Dünser , N. Dupont, A. Elliott-Peisert, N. Emriskova,
F. Fallavollita⁵², D. Fasanella , A. Florent , G. Franzoni , W. Funk , S. Giani, D. Gigi,
K. Gill, F. Glege , L. Gouskos , M. Haranko , J. Hegeman , V. Innocente , T. James ,
P. Janot , J. Kaspar , J. Kieseler , M. Komm , N. Kratochwil , C. Lange , S. Laurila ,
P. Lecoq , A. Lintuluoto , K. Long , C. Lourenço , B. Maier , L. Malgeri , S. Mallios,
M. Mannelli , A.C. Marini , F. Meijers , S. Mersi , E. Meschi , F. Moortgat ,
M. Mulders , S. Orfanelli, L. Orsini, F. Pantaleo , L. Pape, E. Perez, M. Peruzzi ,
A. Petrilli , G. Petrucciani , A. Pfeiffer , M. Pierini , D. Piparo , M. Pitt , H. Qu ,
T. Quast, D. Rabady , A. Racz, G. Reales Gutiérrez, M. Rieger , M. Rovere , H. Sakulin ,
J. Salfeld-Nebgen , S. Scarfi, C. Schäfer, M. Selvaggi , A. Sharma , P. Silva , W. Snoeys ,
P. Sphicas ⁵³, S. Summers , K. Tatar , V.R. Tavolaro , D. Treille , P. Tropea , A. Tsirou,
G.P. Van Onsem , J. Wanczyk ⁵⁴, K.A. Wozniak , W.D. Zeuner

Paul Scherrer Institut, Villigen, Switzerland























L. Caminada ⁵⁵, A. Ebrahimi , W. Erdmann , R. Horisberger , Q. Ingram ,
H.C. Kaestli , D. Kotlinski , M. Missiroli ⁵⁵, L. Noehte ⁵⁵, T. Rohe 

**ETH Zurich — Institute for Particle Physics and Astrophysics (IPA), Zurich,
Switzerland**




K. Androsov ⁵⁴, M. Backhaus , P. Berger, A. Calandri , A. De Cosa , G. Dissertori ,
M. Dittmar, M. Donegà , C. Dorfer , F. Eble , K. Gedia , F. Glessgen ,
T.A. Gómez Espinosa , C. Grab , D. Hits , W. Lustermann , A.-M. Lyon ,
R.A. Manzoni , L. Marchese , C. Martin Perez , M.T. Meinhard , F. Nessi-Tedaldi ,
J. Niedziela , F. Pauss , V. Perovic , S. Pigazzini , M.G. Ratti , M. Reichmann 

C. Reissel , T. Reitenspiess , B. Ristic , D. Ruini, D.A. Sanz Becerra , V. Stampf, J. Steggemann ⁵⁴, R. Wallny , D.H. Zhu 










Universität Zürich, Zurich, Switzerland

C. Amsler ⁵⁶, P. Bärttschi , C. Botta , D. Brzdechko, M.F. Canelli , K. Cormier , A. De Wit , R. Del Burgo, J.K. Heikkilä , M. Huwiler , W. Jin , A. Jofrehei , B. Kilminster , S. Leontsinis , S.P. Liechi , A. Macchiolo , P. Meiring , V.M. Mikuni , U. Molinatti , I. Neutelings , A. Reimers , P. Robmann, S. Sanchez Cruz , K. Schweiger , Y. Takahashi 

National Central University, Chung-Li, Taiwan

C. Adloff⁵⁷, C.M. Kuo, W. Lin, A. Roy , T. Sarkar ³⁷, S.S. Yu 



















National Taiwan University (NTU), Taipei, Taiwan

L. Ceard, Y. Chao , K.F. Chen , P.H. Chen , W.-S. Hou , Y.y. Li , R.-S. Lu , E. Paganis , A. Psallidas, A. Steen , H.y. Wu, E. Yazgan , P.r. Yu




Chulalongkorn University, Faculty of Science, Department of Physics, Bangkok, Thailand

B. Asavapibhop , C. Asawatangtrakuldee , N. Srimanobhas 

Çukurova University, Physics Department, Science and Art Faculty, Adana, Turkey

F. Boran , S. Damarseekin ⁵⁸, Z.S. Demiroglu , F. Dolek , I. Dumanoglu ⁵⁹, E. Eskut, Y. Guler ⁶⁰, E. Gurpinar Guler ⁶⁰, C. Isik , O. Kara, A. Kayis Topaksu , U. Kiminsu , G. Onengut , K. Ozdemir ⁶¹, A. Polatoz , A.E. Simsek , B. Tali ⁶², U.G. Tok , S. Turcpar , I.S. Zorbakir 

Middle East Technical University, Physics Department, Ankara, Turkey

B. Isildak ⁶³, G. Karapinar⁶⁴, K. Ocalan ⁶⁵, M. Yalvac ⁶⁶

Bogazici University, Istanbul, Turkey

B. Akgun , I.O. Atakisi , E. Gülmez , M. Kaya ⁶⁷, O. Kaya ⁶⁸, Ö. Özçelik , S. Tekten ⁶⁹, E.A. Yetkin ⁷⁰


Istanbul Technical University, Istanbul, Turkey

A. Cakir , K. Cankocak ⁵⁹, Y. Komurcu , S. Sen ⁷¹

Istanbul University, Istanbul, Turkey

S. Cerci ⁶², I. Hos ⁷², B. Kaynak , S. Ozkorucuklu , D. Sunar Cerci ⁶², C. Zorbilmez 
















Institute for Scintillation Materials of National Academy of Science of Ukraine, Kharkiv, Ukraine

B. Grynyov 
















**National Science Centre, Kharkiv Institute of Physics and Technology,
Kharkiv, Ukraine**

L. Levchuk 





























University of Bristol, Bristol, United Kingdom

D. Anthony , E. Bhal , S. Bologna, J.J. Brooke , A. Bundock , E. Clement , D. Cussans ,
H. Flacher , J. Goldstein , G.P. Heath, H.F. Heath , L. Kreczko , B. Krikler ,
S. Paramesvaran , S. Seif El Nasr-Storey, V.J. Smith , N. Stylianou ⁷³, K. Walkingshaw Pass,
R. White 

Rutherford Appleton Laboratory, Didcot, United Kingdom

K.W. Bell , A. Belyaev ⁷⁴, C. Brew , R.M. Brown , D.J.A. Cockerill , C. Cooke ,
K.V. Ellis, K. Harder , S. Harper , M.-L. Holmberg , J. Linacre , K. Manolopoulos,
D.M. Newbold , E. Olaiya, D. Petyt , T. Reis , T. Schuh, C.H. Shepherd-Themistocleous ,
I.R. Tomalin, T. Williams 













Imperial College, London, United Kingdom

R. Bainbridge , P. Bloch , S. Bonomally, J. Borg , S. Breeze, O. Buchmuller, V. Cepaitis ,
G.S. Chahal ⁷⁵, D. Colling , P. Dauncey , G. Davies , M. Della Negra , S. Fayer,
G. Fedi , G. Hall , M.H. Hassanshahi , G. Iles , J. Langford , L. Lyons ,
A.-M. Magnan , S. Malik, A. Martelli , D.G. Monk , J. Nash ⁷⁶, M. Pesaresi,
D.M. Raymond, A. Richards, A. Rose , E. Scott , C. Seez , A. Shtipliyski, A. Tapper ,
K. Uchida , T. Virdee ²², M. Vojinovic , N. Wardle , S.N. Webb , D. Winterbottom

Brunel University, Uxbridge, United Kingdom

K. Coldham, J.E. Cole , A. Khan, P. Kyberd , I.D. Reid , L. Teodorescu, S. Zahid 

Baylor University, Waco, Texas, USA

S. Abdullin , A. Brinkerhoff , B. Caraway , J. Dittmann , K. Hatakeyama ,
A.R. Kanuganti , B. McMaster , N. Pastika , M. Saunders , S. Sawant ,
C. Sutantawibul , J. Wilson 
















Catholic University of America, Washington, DC, USA

R. Bartek , A. Dominguez , R. Uniyal , A.M. Vargas Hernandez 

















The University of Alabama, Tuscaloosa, Alabama, USA

A. Buccilli , S.I. Cooper , D. Di Croce , S.V. Gleyzer , C. Henderson , C.U. Perez ,
P. Rumerio ⁷⁷, C. West 


















Boston University, Boston, Massachusetts, USA

A. Akpinar , A. Albert , D. Arcaro , C. Cosby , Z. Demiragli , E. Fontanesi ,
D. Gastler , S. May , J. Rohlf , K. Salyer , D. Sperka , D. Spitzbart , I. Suarez ,
A. Tsatsos , S. Yuan , D. Zou

Brown University, Providence, Rhode Island, USA

G. Benelli , B. Burkle , X. Coubez²³, D. Cutts , M. Hadley , U. Heintz , J.M. Hogan ⁷⁸, T. KWON , G. Landsberg , K.T. Lau , D. Li, M. Lukasik, J. Luo , M. Narain, N. Pervan , S. Sagir ⁷⁹, F. Simpson , E. Usai , W.Y. Wong, X. Yan , D. Yu , W. Zhang

University of California, Davis, Davis, California, USA

J. Bonilla , C. Brainerd , R. Breedon , M. Calderon De La Barca Sanchez , M. Chertok , J. Conway , P.T. Cox , R. Erbacher , G. Haza , F. Jensen , O. Kukral , R. Lander, M. Mulhearn , D. Pellett , B. Regnery , D. Taylor , Y. Yao , F. Zhang 





















University of California, Los Angeles, California, USA

M. Bachtis , R. Cousins , A. Datta , D. Hamilton , J. Hauser , M. Ignatenko , M.A. Iqbal , T. Lam , W.A. Nash , S. Regnard , D. Saltzberg , B. Stone , V. Valuev 

















University of California, Riverside, Riverside, California, USA

K. Burt, Y. Chen, R. Clare , J.W. Gary , M. Gordon, G. Hanson , G. Karapostoli , O.R. Long , N. Manganelli , M. Olmedo Negrete, W. Si , S. Wimpenny, Y. Zhang














University of California, San Diego, La Jolla, California, USA

J.G. Branson, P. Chang , S. Cittolin, S. Cooperstein , N. Deelen , D. Diaz , J. Duarte , R. Gerosa , L. Giannini , D. Gilbert , J. Guiang , R. Kansal , V. Krutelyov , R. Lee , J. Letts , M. Masciovecchio , F. Mokhtar , M. Pieri , B.V. Sathia Narayanan , V. Sharma , M. Tadel , A. Vartak , F. Würthwein , Y. Xiang , A. Yagil 










University of California, Santa Barbara — Department of Physics, Santa Barbara, California, USA

N. Amin, C. Campagnari , M. Citron , A. Dorsett , V. Dutta , J. Incandela , M. Kilpatrick , J. Kim , B. Marsh, H. Mei , M. Oshiro , M. Quinnan , J. Richman , U. Sarica , F. Setti , J. Sheplock , D. Stuart , S. Wang 









California Institute of Technology, Pasadena, California, USA

A. Bornheim , O. Cerri, I. Dutta , J.M. Lawhorn , N. Lu , J. Mao , H.B. Newman , T. Q. Nguyen , M. Spiropulu , J.R. Vlimant , C. Wang , S. Xie , Z. Zhang , R.Y. Zhu 
















Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

J. Alison , S. An , M.B. Andrews , P. Bryant , T. Ferguson , A. Harilal , C. Liu , T. Mudholkar , M. Paulini , A. Sanchez , W. Terrill 



































































University of Colorado Boulder, Boulder, Colorado, USA

J.P. Cumalat , W.T. Ford , A. Hassani , E. MacDonald, R. Patel, A. Perloff , C. Savard , K. Stenson , K.A. Ulmer , S.R. Wagner 

























Cornell University, Ithaca, New York, USA

J. Alexander , S. Bright-Thonney , Y. Cheng , D.J. Cranshaw , S. Hogan , J. Monroy , J.R. Patterson , D. Quach , J. Reichert , M. Reid , A. Ryd , W. Sun , J. Thom , P. Wittich , R. Zou 









Fermi National Accelerator Laboratory, Batavia, Illinois, USA

M. Albrow , M. Alyari , G. Apollinari , A. Apresyan , A. Apyan , S. Banerjee ,
 L.A.T. Bauerdick , D. Berry , J. Berryhill , P.C. Bhat , K. Burkett , J.N. Butler ,
 A. Canepa , G.B. Cerati , H.W.K. Cheung , F. Chlebana , M. Cremonesi,
 K.F. Di Petrillo , V.D. Elvira , Y. Feng , J. Freeman , Z. Geise , L. Gray , D. Green,
 S. Grünendahl , O. Gutsche , R.M. Harris , R. Heller , T.C. Herwig , J. Hirschauer ,
 B. Jayatilaka , S. Jindariani , M. Johnson , U. Joshi , T. Klijsma , B. Klima ,
 K.H.M. Kwok , S. Lammel , D. Lincoln , R. Lipton , T. Liu , C. Madrid ,
 K. Maeshima , C. Mantilla , D. Mason , P. McBride , P. Merkel , S. Mrenna , S. Nahn ,
 J. Ngadiuba , V. O'Dell, V. Papadimitriou , K. Pedro , C. Pena ⁸⁰, O. Prokofyev,
 F. Ravera , A. Reinsvold Hall , L. Ristori , E. Sexton-Kennedy , N. Smith , A. Soha ,
 W.J. Spalding , L. Spiegel , J. Strait , L. Taylor , S. Tkaczyk , N.V. Tran ,
 L. Uplegger , E.W. Vaandering , H.A. Weber 

University of Florida, Gainesville, Florida, USA

D. Acosta , P. Avery , D. Bourilkov , L. Cadamuro , V. Cherepanov , F. Errico ,
 R.D. Field, D. Guerrero , B.M. Joshi , M. Kim, E. Koenig , J. Konigsberg , A. Korytov ,
 K.H. Lo, K. Matchev , N. Menendez , G. Mitselmakher , A. Muthirakalayil Madhu ,
 N. Rawal , D. Rosenzweig , S. Rosenzweig , J. Rotter , K. Shi , J. Sturdy , J. Wang ,
 E. Yigitbasi , X. Zuo 





















Florida State University, Tallahassee, Florida, USA

T. Adams , A. Askew , R. Habibullah , V. Hagopian , K.F. Johnson, R. Khurana,
 T. Kolberg , G. Martinez, H. Prosper , C. Schiber, O. Viazlo , R. Yohay , J. Zhang











Florida Institute of Technology, Melbourne, Florida, USA

M.M. Baarmand , S. Butalla , T. Elkafrawy ¹⁷, M. Hohlmann , R. Kumar Verma ,
 D. Noonan , M. Rahmani, F. Yumiceva 












University of Illinois at Chicago (UIC), Chicago, Illinois, USA

M.R. Adams , H. Becerril Gonzalez , R. Cavanaugh , X. Chen , S. Dittmer ,
 O. Evdokimov , C.E. Gerber , D.A. Hangal , D.J. Hofman , A.H. Merrit , C. Mills ,
 G. Oh , T. Roy , S. Rudrabhatla , M.B. Tonjes , N. Varelas , J. Viinikainen ,
 X. Wang , Z. Wu , Z. Ye 




























The University of Iowa, Iowa City, Iowa, USA

M. Alhusseini , K. Dilsiz ⁸¹, R.P. Gandrajula , O.K. Köseyan , J.-P. Merlo,
 A. Mestvirishvili ⁸², J. Nachtman , H. Ogul ⁸³, Y. Onel , A. Penzo , C. Snyder,
 E. Tiras ⁸⁴




Johns Hopkins University, Baltimore, Maryland, USA

O. Amram , B. Blumenfeld , L. Corcodilos , J. Davis , M. Eminizer , A.V. Gritsan ,
 S. Kyriacou , P. Maksimovic , J. Roskes , M. Swartz , T.Á. Vámi 

The University of Kansas, Lawrence, Kansas, USA

A. Abreu , J. Anguiano , C. Baldenegro Barrera , P. Baringer , A. Bean , A. Bylinkin ,
 Z. Flowers , T. Isidori , S. Khalil , J. King , G. Krintiras , A. Kropivnitskaya ,
 M. Lazarovits , C. Lindsey, J. Marquez , N. Minafra , M. Murray , M. Nickel ,
 C. Rogan , C. Royon , R. Salvatico , S. Sanders , E. Schmitz , C. Smith ,
 J.D. Tapia Takaki , Q. Wang , Z. Warner, J. Williams , G. Wilson 
















Kansas State University, Manhattan, Kansas, USA

S. Duric, A. Ivanov , K. Kaadze , D. Kim, Y. Maravin , T. Mitchell, A. Modak, K. Nam






















Lawrence Livermore National Laboratory, Livermore, California, USA

F. Rebassoo , D. Wright 









University of Maryland, College Park, Maryland, USA

E. Adams , A. Baden , O. Baron, A. Belloni , S.C. Eno , N.J. Hadley , S. Jabeen ,
 R.G. Kellogg , T. Koeth , A.C. Mignerey , S. Nabili , C. Palmer , M. Seidel , A. Skuja ,
 L. Wang , K. Wong 















Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

D. Abercrombie, G. Andreassi, R. Bi, S. Brandt, W. Busza , I.A. Cali , Y. Chen ,
 M. D'Alfonso , J. Eysermans , C. Freer , G. Gomez-Ceballos , M. Goncharov, P. Harris,
 M. Hu , M. Klute , D. Kovalskyi , J. Krupa , Y.-J. Lee , C. Mironov , C. Paus ,
 D. Rankin , C. Roland , G. Roland , Z. Shi , G.S.F. Stephans , J. Wang, Z. Wang ,
 B. Wyslouch 











University of Minnesota, Minneapolis, Minnesota, USA

R.M. Chatterjee, A. Evans , P. Hansen, J. Hiltbrand , Sh. Jain , M. Krohn , Y. Kubota ,
 J. Mans , M. Revering , R. Rusack , R. Saradhy , N. Schroeder , N. Strobbe ,
 M.A. Wadud 


















University of Nebraska-Lincoln, Lincoln, Nebraska, USA

K. Bloom , M. Bryson, S. Chauhan , D.R. Claes , C. Fangmeier , L. Finco , F. Golf ,
 C. Joo , I. Kravchenko , M. Musich , I. Reed , J.E. Siado , G.R. Snow[†], W. Tabb ,
 F. Yan , A.G. Zecchinelli 





State University of New York at Buffalo, Buffalo, New York, USA

G. Agarwal , H. Bandyopadhyay , L. Hay , I. Iashvili , A. Kharchilava , C. McLean ,
 D. Nguyen , J. Pekkanen , S. Rappoccio , A. Williams 


























Northeastern University, Boston, Massachusetts, USA

G. Alverson , E. Barberis , Y. Haddad , A. Hortiangtham , J. Li , G. Madigan ,
 B. Marzocchi , D.M. Morse , V. Nguyen , T. Orimoto , A. Parker , L. Skinnari ,
 A. Tishelman-Charny , T. Wamorkar , B. Wang , A. Wisecarver , D. Wood 









Northwestern University, Evanston, Illinois, USA

S. Bhattacharya , J. Bueghly , Z. Chen , A. Gilbert , T. Gunter , K.A. Hahn , Y. Liu ,
N. Odell , M.H. Schmitt , M. Velasco




















University of Notre Dame, Notre Dame, Indiana, USA

R. Band , R. Bucci , A. Das , N. Dev , R. Goldouzian , M. Hildreth ,
K. Hurtado Anampa , C. Jessop , K. Lannon , J. Lawrence , N. Loukas , L. Lutton ,
N. Marinelli , I. Mcalister , T. McCauley , C. Mcgrady , K. Mohrman , Y. Musienko ¹³,
R. Ruchti , P. Siddireddy , A. Townsend , M. Wayne , A. Wightman , M. Zarucki ,
L. Zygala 

The Ohio State University, Columbus, Ohio, USA

B. Bylsma , B. Cardwell , L.S. Durkin , B. Francis , C. Hill , M. Nunez Ornelas , K. Wei,
B.L. Winer , B. R. Yates 






















Princeton University, Princeton, New Jersey, USA

F.M. Addesa , B. Bonham , P. Das , G. Dezoort , P. Elmer , A. Frankenthal ,
B. Greenberg , N. Haubrich , S. Higginbotham , A. Kalogeropoulos , G. Kopp , S. Kwan ,
D. Lange , D. Marlow , K. Mei , I. Ojalvo , J. Olsen , D. Stickland , C. Tully 

University of Puerto Rico, Mayaguez, Puerto Rico, USA

S. Malik , S. Norberg

















Purdue University, West Lafayette, Indiana, USA

A.S. Bakshi , V.E. Barnes , R. Chawla , S. Das , L. Gutay , M. Jones , A.W. Jung ,
S. Karmarkar , D. Kondratyev , M. Liu , G. Negro , N. Neumeister , G. Paspalaki ,
S. Piperov , A. Purohit , J.F. Schulte , M. Stojanovic , J. Thieman , F. Wang ,
R. Xiao , W. Xie 












Purdue University Northwest, Hammond, Indiana, USA

J. Dolen , N. Parashar 





















Rice University, Houston, Texas, USA






















































A. Baty , M. Decaro , S. Dildick , K.M. Ecklund , S. Freed , P. Gardner , F.J.M. Geurts ,
A. Kumar , W. Li , B.P. Padley , R. Redjimi , W. Shi , A.G. Stahl Leiton , S. Yang ,
L. Zhang , Y. Zhang 


















University of Rochester, Rochester, New York, USA

A. Bodek , P. de Barbaro , R. Demina , J.L. Dulemba , C. Fallon , T. Ferbel , M. Galanti,
A. Garcia-Bellido , O. Hindrichs , A. Khukhunaishvili , E. Ranken , R. Taus 

Rutgers, The State University of New Jersey, Piscataway, New Jersey, USA

B. Chiarito , J.P. Chou , A. Gandrakota , Y. Gershtein , E. Halkiadakis , A. Hart ,
M. Heindl , O. Karacheban ²⁶, I. Laflotte , A. Lath , R. Montalvo , K. Nash , M. Osherson ,
S. Salur , S. Schnetzer , S. Somalwar , R. Stone , S.A. Thayil , S. Thomas , H. Wang 

University of Tennessee, Knoxville, Tennessee, USAH. Acharya, A.G. Delannoy , S. Fiorendi , S. Spanier **Texas A&M University, College Station, Texas, USA**O. Bouhali ⁸⁵, M. Dalchenko , A. Delgado , R. Eusebi , J. Gilmore , T. Huang ,
T. Kamon ⁸⁶, H. Kim , S. Luo , S. Malhotra, R. Mueller , D. Overton , D. Rathjens ,
A. Safonov **Texas Tech University, Lubbock, Texas, USA**N. Akchurin , J. Damgov , V. Hegde , S. Kunori, K. Lamichhane , S.W. Lee , T. Mengke,
S. Muthumuni , T. Peltola , I. Volobouev , Z. Wang, A. Whitbeck **Vanderbilt University, Nashville, Tennessee, USA**E. Appelt , S. Greene, A. Gurrola , W. Johns , A. Melo , H. Ni, K. Padeken ,
F. Romeo , P. Sheldon , S. Tuo , J. Velkovska **University of Virginia, Charlottesville, Virginia, USA**M.W. Arenton , B. Cox , G. Cummings , J. Hakala , R. Hirosky , M. Joyce ,
A. Ledovskoy , A. Li , C. Neu , C.E. Perez Lara , B. Tannenwald , S. White , E. Wolfe **Wayne State University, Detroit, Michigan, USA**N. Poudyal **University of Wisconsin — Madison, Madison, Wisconsin, USA**K. Black , T. Bose , C. Caillol , S. Dasu , I. De Bruyn , P. Everaerts , F. Fienga ,
C. Galloni, H. He , M. Herndon , A. Hervé , U. Hussain, A. Lanaro, A. Loeliger ,
R. Loveless , J. Madhusudanan Sreekala , A. Mallampalli , A. Mohammadi , D. Pinna,
A. Savin, V. Shang , V. Sharma , W.H. Smith , D. Teague, S. Trembath-Reichert,
W. Vetens **Authors affiliated with an institute or an international laboratory covered by a cooperation agreement with CERN**S. Afanasiev, V. Andreev , Yu. Andreev , T. Aushev , M. Azarkin , A. Babaev ,
A. Belyaev , V. Blinov⁸⁷, E. Boos , V. Borshch , D. Budkouski , V. Bunichev ,
O. Bychkova, V. Chekhovsky, R. Chistov ⁸⁷, M. Danilov ⁸⁷, A. Dermenev , T. Dimova ⁸⁷,
I. Dremin , M. Dubinin ⁸⁰, L. Dudko , V. Epshteyn ⁸⁸, A. Ershov , G. Gavrilo ,
V. Gavrilo , S. Gninenko , V. Golovtcov , N. Golubev , I. Golutvin, I. Gorbunov ,
V. Ivanchenko , Y. Ivanov , V. Kachanov , L. Kardapoltsev ⁸⁷, V. Karjavine ,
A. Karneyeu , V. Kim ⁸⁷, M. Kirakosyan, D. Kirpichnikov , M. Kirsanov , V. Klyukhin ,
D. Konstantinov , V. Korenkov , N. Korneeva , A. Kozyrev ⁸⁷, N. Krasnikov ,
E. Kuznetsova⁸⁹, A. Lanev , A. Litomin, N. Lychkovskaya , V. Makarenko , A. Malakhov ,
V. Matveev ⁸⁷, V. Murzin , A. Nikitenko ⁹⁰, S. Obraztsov , V. Okhotnikov ,
V. Oreshkin , A. Oskin, I. Ovtin ⁸⁷, V. Palichik , P. Parygin ⁹¹, A. Pashenkov,
V. Perelygin , M. Perfilov, G. Pivovarov , S. Polikarpov ⁸⁷, V. Popov, O. Radchenko ⁸⁷,
M. Savina , V. Savrin , D. Seitova, V. Shalae , S. Shmatov , S. Shulha , Y. Skovpen ⁸⁷,

S. Slabospitskii , I. Smirnov, V. Smirnov , D. Sosnov , A. Stepennov , V. Sulimov ,
 E. Tcherniaev , A. Terkulov , O. Teryaev , M. Toms ⁹², A. Toropin , L. Uvarov ,
 A. Uzunian , E. Vlasov ⁹³, P. Volkov, S. Volkov, A. Vorobyev, N. Voytishin ,
 B.S. Yuldashev⁹⁴, A. Zarubin , I. Zhizhin , A. Zhokin 

[†] Deceased

¹ Also at Yerevan State University, Yerevan, Armenia

² Also at TU Wien, Vienna, Austria

³ Also at Institute of Basic and Applied Sciences, Faculty of Engineering, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt

⁴ Also at Université Libre de Bruxelles, Bruxelles, Belgium

⁵ Also at Universidade Estadual de Campinas, Campinas, Brazil

⁶ Also at Federal University of Rio Grande do Sul, Porto Alegre, Brazil

⁷ Also at The University of the State of Amazonas, Manaus, Brazil

⁸ Also at University of Chinese Academy of Sciences, Beijing, China

⁹ Also at UFMS, Nova Andradina, Brazil

¹⁰ Also at Nanjing Normal University Department of Physics, Nanjing, China

¹¹ Now at The University of Iowa, Iowa City, Iowa, USA

¹² Also at University of Chinese Academy of Sciences, Beijing, China

¹³ Also at an institute or an international laboratory covered by a cooperation agreement with CERN

¹⁴ Also at Helwan University, Cairo, Egypt

¹⁵ Now at Zewail City of Science and Technology, Zewail, Egypt

¹⁶ Also at British University in Egypt, Cairo, Egypt

¹⁷ Now at Ain Shams University, Cairo, Egypt

¹⁸ Also at Purdue University, West Lafayette, Indiana, USA

¹⁹ Also at Université de Haute Alsace, Mulhouse, France

²⁰ Also at Tbilisi State University, Tbilisi, Georgia

²¹ Also at Erzincan Binali Yildirim University, Erzincan, Turkey

²² Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland

²³ Also at RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany

²⁴ Also at University of Hamburg, Hamburg, Germany

²⁵ Also at Isfahan University of Technology, Isfahan, Iran

²⁶ Also at Brandenburg University of Technology, Cottbus, Germany

²⁷ Also at Forschungszentrum Jülich, Juelich, Germany

²⁸ Also at Physics Department, Faculty of Science, Assiut University, Assiut, Egypt

²⁹ Also at Karoly Robert Campus, MATE Institute of Technology, Gyongyos, Hungary

³⁰ Also at Institute of Physics, University of Debrecen, Debrecen, Hungary

³¹ Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary

³² Also at MTA-ELTE Lendület CMS Particle and Nuclear Physics Group, Eötvös Loránd University, Budapest, Hungary

³³ Also at Wigner Research Centre for Physics, Budapest, Hungary

³⁴ Also at G.H.G. Khalsa College, Punjab, India

³⁵ Also at Shoolini University, Solan, India

³⁶ Also at University of Hyderabad, Hyderabad, India

³⁷ Also at University of Visva-Bharati, Santiniketan, India

³⁸ Also at Indian Institute of Technology (IIT), Mumbai, India

³⁹ Also at IIT Bhubaneswar, Bhubaneswar, India

⁴⁰ Also at Institute of Physics, Bhubaneswar, India

⁴¹ Also at Deutsches Elektronen-Synchrotron, Hamburg, Germany

⁴² Also at Sharif University of Technology, Tehran, Iran

⁴³ Also at Department of Physics, University of Science and Technology of Mazandaran, Behshahr, Iran

⁴⁴ Also at Italian National Agency for New Technologies, Energy and Sustainable Economic

- Development, Bologna, Italy
- ⁴⁵ Also at Centro Siciliano di Fisica Nucleare e di Struttura Della Materia, Catania, Italy
- ⁴⁶ Also at Università di Napoli ‘Federico II’, Napoli, Italy
- ⁴⁷ Also at Consiglio Nazionale delle Ricerche — Istituto Officina dei Materiali, Perugia, Italy
- ⁴⁸ Also at Consejo Nacional de Ciencia y Tecnología, Mexico City, Mexico
- ⁴⁹ Also at IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France
- ⁵⁰ Also at Faculty of Physics, University of Belgrade, Belgrade, Serbia
- ⁵¹ Also at Trincomalee Campus, Eastern University, Sri Lanka, Nilaveli, Sri Lanka
- ⁵² Also at INFN Sezione di Pavia, Università di Pavia, Pavia, Italy
- ⁵³ Also at National and Kapodistrian University of Athens, Athens, Greece
- ⁵⁴ Also at Ecole Polytechnique Fédérale Lausanne, Lausanne, Switzerland
- ⁵⁵ Also at Universität Zürich, Zurich, Switzerland
- ⁵⁶ Also at Stefan Meyer Institute for Subatomic Physics, Vienna, Austria
- ⁵⁷ Also at Laboratoire d’Annecy-le-Vieux de Physique des Particules, IN2P3-CNRS, Annecy-le-Vieux, France
- ⁵⁸ Also at Şirnak University, Sirnak, Turkey
- ⁵⁹ Also at Near East University, Research Center of Experimental Health Science, Mersin, Turkey
- ⁶⁰ Also at Konya Technical University, Konya, Turkey
- ⁶¹ Also at Izmir Bakircay University, Izmir, Turkey
- ⁶² Also at Adiyaman University, Adiyaman, Turkey
- ⁶³ Also at Ozyegin University, Istanbul, Turkey
- ⁶⁴ Also at Izmir Institute of Technology, Izmir, Turkey
- ⁶⁵ Also at Necmettin Erbakan University, Konya, Turkey
- ⁶⁶ Also at Bozok Universitetesi Rektörlüğü, Yozgat, Turkey
- ⁶⁷ Also at Marmara University, Istanbul, Turkey
- ⁶⁸ Also at Milli Savunma University, Istanbul, Turkey
- ⁶⁹ Also at Kafkas University, Kars, Turkey
- ⁷⁰ Also at Istanbul Bilgi University, Istanbul, Turkey
- ⁷¹ Also at Hacettepe University, Ankara, Turkey
- ⁷² Also at Istanbul University — Cerrahpasa, Faculty of Engineering, Istanbul, Turkey
- ⁷³ Also at Vrije Universiteit Brussel, Brussel, Belgium
- ⁷⁴ Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom
- ⁷⁵ Also at IPPP Durham University, Durham, United Kingdom
- ⁷⁶ Also at Monash University, Faculty of Science, Clayton, Australia
- ⁷⁷ Also at Università di Torino, Torino, Italy
- ⁷⁸ Also at Bethel University, St. Paul, Minnesota, USA
- ⁷⁹ Also at Karamanoğlu Mehmetbey University, Karaman, Turkey
- ⁸⁰ Also at California Institute of Technology, Pasadena, California, USA
- ⁸¹ Also at Bingol University, Bingol, Turkey
- ⁸² Also at Georgian Technical University, Tbilisi, Georgia
- ⁸³ Also at Sinop University, Sinop, Turkey
- ⁸⁴ Also at Erciyes University, Kayseri, Turkey
- ⁸⁵ Also at Texas A&M University at Qatar, Doha, Qatar
- ⁸⁶ Also at Kyungpook National University, Daegu, Korea
- ⁸⁷ Also at another institute or international laboratory covered by a cooperation agreement with CERN
- ⁸⁸ Now at Istanbul University, Istanbul, Turkey
- ⁸⁹ Now at University of Florida, Gainesville, Florida, USA
- ⁹⁰ Also at Imperial College, London, United Kingdom
- ⁹¹ Now at University of Rochester, Rochester, New York, USA
- ⁹² Now at Baylor University, Waco, Texas, USA
- ⁹³ Now at INFN Sezione di Torino, Università di Torino, Torino, Italy; Università del Piemonte Orientale, Novara, Italy
- ⁹⁴ Also at Institute of Nuclear Physics of the Uzbekistan Academy of Sciences, Tashkent, Uzbekistan