Physics Letters B 759 (2016) 479–500

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Search for supersymmetry in electroweak production with photons and large missing transverse energy in pp collisions at $\sqrt{s} = 8\,\text{TeV}$

The CMS Collaboration *

CERN, Switzerland

ARTICLE INFO

Article history:
Received 28 February 2016
Received in revised form 4 May 2016
Accepted 27 May 2016
Available online 1 June 2016
Editor: M. Doser

Keywords:
CMS
Physics
Supersymmetry

ABSTRACT

Results are reported from a search for supersymmetry with gauge-mediated supersymmetry breaking in electroweak production. Final states with photons and large missing transverse energy (E_T^miss) were examined. The data sample was collected in pp collisions at $\sqrt{s} = 8\,\text{TeV}$ with the CMS detector at the LHC and corresponds to $7.4\,\text{fb}^{-1}$. The analysis focuses on scenarios in which the lightest neutralino has bino- or wino-like components, resulting in decays to photons and gravitinos, where the gravitinos escape undetected. The data were obtained using a specially designed trigger with dedicated low thresholds, providing good sensitivity to signatures with photons, E_T^miss, and low hadronic energy. No excess of events over the standard model expectation is observed. The results are interpreted using the model of general gauge mediation. With the wino mass fixed at 10 GeV above that of the bino, wino masses below 710 GeV are excluded at 95% confidence level. Constraints are also set in the context of two simplified models, for which the analysis sets the lowest cross section limits on the electroweak production of supersymmetric particles.

1. Introduction

Supersymmetry [1–14] (SUSY) can stabilize the mass of the Higgs boson, recently measured to be around 125 GeV [15,16], and hence the electroweak scale against large quantum corrections, thus providing a solution to the gauge hierarchy problem [17]. Searches for supersymmetric partners of standard model (SM) particles with photons in the final state are already probing SUSY parameter space at the TeV scale [18–21]. There is a strong interest in probing so-called natural SUSY scenarios, where a subset of SUSY partners can remain light, while many other SUSY partners can have large masses that are inaccessible to present searches. These regions of SUSY parameter space are still largely unexplored.

In this analysis, R-parity [22,23] is assumed to be conserved, so that SUSY particles are always produced in pairs. In SUSY models of gauge-mediated SUSY breaking (GMSB) [24–30] the gravitino ($\widetilde{\mathrm{G}}$) is the lightest SUSY particle (LSP) and escapes undetected, leading to missing transverse energy (E_T^miss) in the detector. In the studied cases, the next-to-lightest SUSY particle (NLSP) is the lightest neutralino ($\widetilde{\chi}_1^0$). Depending on its composition, the $\widetilde{\chi}_1^0$ can decay according to $\widetilde{\chi}_1^0 \to N\widetilde{\mathrm{G}}$, where N is either a photon γ, a SM Higgs boson H, or a Z boson. If the gauginos are nearly mass-degenerate, chargino ($\widetilde{\chi}_1^\pm$) decays according to $\widetilde{\chi}_1^\pm \to \mathrm{W}^\pm\widetilde{\mathrm{G}}$ are also possible.

The ATLAS and CMS Collaborations have searched for direct electroweak production of gauginos. Final states with at least one photon and one electron or muon have been examined [21,31], requiring one gaugino decaying to $\gamma\widetilde{\mathrm{G}}$ and one to $\mathrm{W}^\pm\widetilde{\mathrm{G}}$. The NLSP masses below 540 GeV in the simplified model spectra TChiWg scenario, introduced below, were excluded at the 95% confidence level (CL). In decays into any of the heavy standard model bosons (H, Z, $\mathrm{W}^\pm$), higgsino (chargino) masses up to 380 GeV (210 GeV) have been excluded at the 95% CL [32–34]. Other analyses requiring two photons in the final state [19–21] probe bino-like neutralinos and within the context of general gauge mediation (GGM) [35–40] exclude electroweakly produced winos with masses up to 740 GeV, depending on the bino mass. A previous single-photon analysis [20] has set limits on bino- and wino-like neutralinos for strong production, but the search is insensitive to electroweak production because the chosen trigger requires $H_\mathrm{T} > 500\,\text{GeV}$, where H_T is the scalar sum of transverse energy clustered in jets.

To provide sensitivity to GMSB scenarios with low gaugino masses and mass differences, this analysis uses signatures with at least one photon together with large E_T^miss. In signal events, hadronic energy arises only from initial-state radiation or from the

---

* *E-mail address:* cms-publication-committee-chair@cern.ch.

http://dx.doi.org/10.1016/j.physletb.2016.05.088

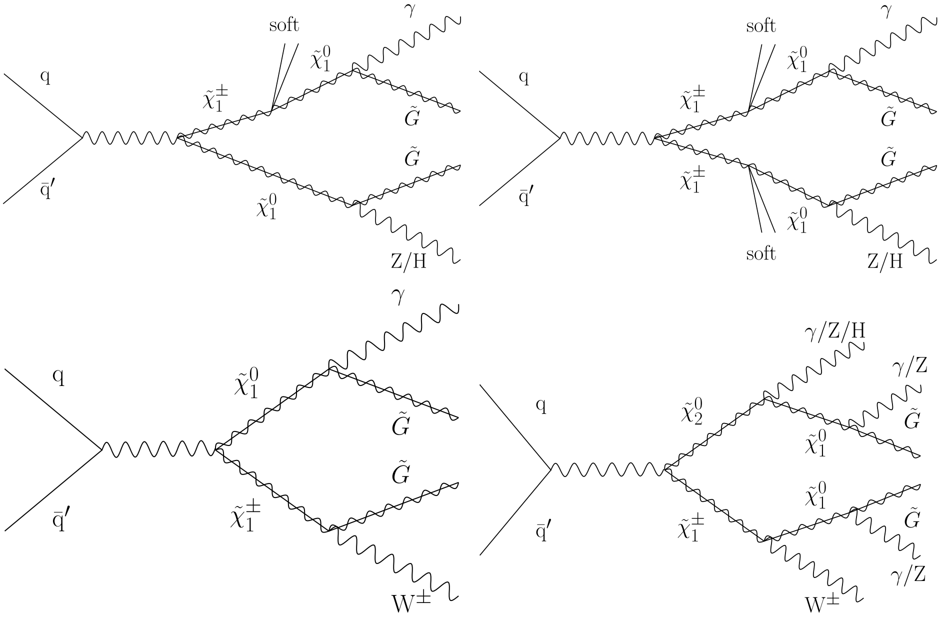

Fig. 1. Scenarios for the production and decay of charginos and neutralinos considered in this analysis. In the TChiNg scenario (top row), the charginos are only slightly heavier than the neutralinos, leading to chargino to neutralino decays accompanied by soft radiation. One neutralino decays to a photon and a gravitino, while the other decays into a Z or an H boson and a gravitino with equal probability. In the TChiWg scenario (bottom left), the gauginos are mass-degenerate and the $\widetilde{\chi}_1^0$ decays are as shown. Within GGM models, the $\widetilde{\chi}_1^0 \to \gamma\widetilde{\mathrm{G}}$ to $\widetilde{\chi}_1^0 \to \mathrm{Z}\widetilde{\mathrm{G}}$ branching fraction depends on the neutralino mass. The dominant process for electroweak GGM production is shown in bottom right. A smaller amount of hadronic energy compared to strong production and at least one photon and $E_{\mathrm{T}}^{\mathrm{miss}}$ are common features of all scenarios.

decays of a $\mathrm{W}^\pm$ or Z boson, collectively denoted as V bosons. We concentrate on final states with only a moderate amount of H_{T} due to direct electroweak production of gauginos. The lightest gauginos are assumed to be either bino- or wino-like, leading to final states with $E_{\mathrm{T}}^{\mathrm{miss}}$ and $\gamma\gamma$, γV, or VV.

We consider three signal scenarios: The scenario TChiNg models the electroweak pair and associated production of nearly mass-degenerate charginos and neutralinos, which then decay into the NLSP, as shown in Fig. 1 (top row). The branching fractions of the NLSP decay correspond here to a wino-like $\widetilde{\chi}_1^0$ of similar mass. The TChiWg scenario models associative production of mass-degenerate charginos and neutralinos, which then decay as shown in Fig. 1 (bottom left). The third scenario is electroweak production within the GGM context; the dominant production channel is shown in Fig. 1 (bottom right). Masses of the bino- and wino-like neutralinos involved in this scenario are scanned, while the squark and gluino masses are decoupled. The amount of $E_{\mathrm{T}}^{\mathrm{miss}}$ and the photon transverse momentum (p_{T}) is determined by the mass of the $\widetilde{\chi}_1^0$, while the mass of the $\widetilde{\chi}^\pm$ determines the production cross section. In the GGM framework, where the gauginos are not mass-degenerate by construction, a larger $\widetilde{\chi}^\pm$–$\widetilde{\chi}_1^0$ mass difference increases the hadronic energy in the final state.

The analysis uses a special data set corresponding to an integrated luminosity of $7.4\,\mathrm{fb}^{-1}$ recorded with a trigger requiring a photon candidate with $p_{\mathrm{T}} > 30\,\mathrm{GeV}$ measured within $|\eta| < 1.44$ and $E_{\mathrm{T}}^{\mathrm{miss}} > 25\,\mathrm{GeV}$, where the $E_{\mathrm{T}}^{\mathrm{miss}}$ is calculated using calorimeter information without correcting for muons. Compared to the available triggers in the full 2012 data set, which require a photon candidate with $p_{\mathrm{T}} > 135\,\mathrm{GeV}$ or events with $E_{\mathrm{T}}^{\mathrm{miss}} > 120\,\mathrm{GeV}$, these low trigger thresholds enable a high signal sensitivity to electroweak production and compressed mass spectrum scenarios. The data set was recorded during the second half of the 2012 data-taking period but only reconstructed during the Long Shutdown 1 of the LHC as part of the so-called “parked-data” program [41].

2. The CMS detector

The central feature of the CMS apparatus is a superconducting solenoid of 6 m internal diameter, providing a magnetic field of 3.8 T. Within the solenoid volume are a silicon pixel and strip tracker, a lead tungstate crystal electromagnetic calorimeter (ECAL), and a brass and scintillator hadron calorimeter (HCAL), each composed of a barrel and two endcap sections. Extensive forward calorimetry complements the coverage provided by the barrel and endcap detectors. Muons are measured in gas-ionization detectors embedded in the steel flux-return yoke outside the solenoid.

In the barrel section of the ECAL, an energy resolution of approximately 1% is achieved for unconverted or late-converting photons arising from the $\mathrm{H} \to \gamma\gamma$ decay. The remaining barrel photons have an energy resolution of about 1.3% up to a pseudorapidity of $|\eta| = 1$, rising to about 2.5% at $|\eta| = 1.4$ [42].

A more detailed description of the CMS detector, together with a definition of the coordinate system used and the relevant kinematic variables, can be found in Ref. [43].

3. Object reconstruction and simulation

Photons are reconstructed [42] from clusters in the ECAL barrel with $|\eta| < 1.44$ and are required to be isolated. The energy deposit in the HCAL tower closest to the seed of the ECAL supercluster assigned to the photon divided by the energy deposit in the ECAL is required to be less than 5%. A photon-like shower shape is required. The photon isolation is determined by computing the transverse energy in a cone centered around the photon momentum vector. The cone has an outer radius of 0.3 in $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$, where ϕ is azimuthal angle in radians, and the contribution of the photon is removed. Corrections for the effects of multiple interactions in the same bunch crossing (pileup) are applied to all isolation energies, depending on the η of the photon. Discrimination against electrons is achieved by requiring that photons have no matching pattern of hits in the pixel detector.

All objects used in this search, i.e. photons, electrons, muons, and jets, are reconstructed using the particle-flow (PF) algorithm [44,45]. Jets are reconstructed with the anti-k_T clustering algorithm [46] as implemented in the FastJet [47] package, using a distance parameter of 0.5. The jets are required to have transverse momenta above 30 GeV and to satisfy the requirement $|\eta| < 2.4$. Pileup corrections and corrections for the response of the detector are applied to the momenta of the jets [48,49].

The missing p_T vector is defined as the projection onto the plane perpendicular to the beams of the negative vector sum of the momenta of all reconstructed particles in an event. Its magnitude is referred to as E_T^{miss}. The E_T^{miss} is calculated using all particles identified by the PF algorithm. Filters against anomalously high E_T^{miss} from instrumental effects are applied [50].

The dimensionless variable E_T^{miss}-significance ($E_T^{miss,signif}$) [50] is a measure of the probability that the E_T^{miss} in a given event arises from genuine noninteracting stable particles, such as neutrinos or gravitinos, and not as a consequence of the limited energy resolution of objects, such as jets, photons, or leptons. The $E_T^{miss,signif}$ is proportional to the logarithm of the likelihood ratio of both hypotheses. Energy and angular resolutions of the relevant objects, determined by data and simulation studies, are taken into account. For processes where the reconstructed E_T^{miss} only arises from the limited energy resolution, the $E_T^{miss,signif}$ is an exponentially falling distribution, falling by three orders of magnitude for $0 < E_T^{miss,signif} < 25$. SM processes with genuine E_T^{miss} have approximately the same decrease between 0 and 125. Electroweak SUSY processes intrinsically have high values of genuine E_T^{miss} along with a significantly lower presence of jets, which otherwise increase the energy uncertainty used in the calculation of $E_T^{miss,signif}$. Therefore, the $E_T^{miss,signif}$ distribution of those processes does not decrease monotonically, and a considerable fraction has $E_T^{miss,signif} > 200$.

The SM $t\bar{t}\gamma$ and QCD multijet production samples, as well as the TChiNg and TChiWg signal scenarios, are simulated with the MadGraph 5.1.3 generator [51]. The diboson event samples and the electroweak GGM signal scan are generated using pythia 6.4 [52]. All Monte Carlo (MC) samples incorporate the CTEQ6L1 [53] parton distribution functions (PDF) and use the pythia program to describe the parton showering and the hadronization. The Geant4 [54] package is used to model the detector and detector response. The cross sections of the electroweak GGM signal scan are calculated at next-to-leading-order (NLO) accuracy using the prospino 2.1. [55] program, the cross sections for the TChiNg and TChiWg signal points are calculated at NLO + NLL (next-to-leading logarithm) accuracy [56–58].

4. Analysis

The data are selected by a trigger with E_T^{miss} and photon p_T requirements. The events are subsequently required to contain at least one tightly isolated photon measured in the ECAL barrel with a p_T of at least 40 GeV. The E_T^{miss} is required to exceed 100 GeV. In addition, H_T is required to exceed 100 GeV, improving the signal-to-background ratio. With this selection the parked data set trigger efficiency is uniform and measured to be $86.5^{+1.0}_{-1.3}\%$. No selection criteria were applied on the presence or absence of an identified lepton. All events are required to have $E_T^{miss,signif} > 80$ and a transverse mass $M_T(E_T^{miss}, p_T^{\gamma_1}) > 300$ GeV, where $p_T^{\gamma_1}$ is the transverse momentum of the photon with the highest p_T. The cut on $E_T^{miss,signif}$ strongly reduces the contribution of backgrounds without genuine E_T^{miss}, whereas the cut on $M_T(E_T^{miss}, p_T^{\gamma_1})$ affects all backgrounds but retains most of the signal events, since only in signal processes the photon and the source for E_T^{miss} are expected to originate from the same mother particle. To increase the sensitivity to higher gaugino masses, the signal region is divided into four exclusive bins defined by regions in the variables S_T^{γ} and $E_T^{miss,signif}$, where S_T^{γ} is defined by $S_T^{\gamma} = \sum_i p_T^{\gamma_i} + E_T^{miss}$. The boundaries of the bins are at $S_T^{\gamma} = 600$ GeV and $E_T^{miss,signif} = 200$.

The dominant SM backgrounds are vector-boson production with initial- or final-state photon radiation (Vγ) and direct photon production (γ + jets). The normalization of these two backgrounds is determined simultaneously by a χ^2-fit in the control region selection defined by $E_T^{miss,signif} > 10$ and $M_T(E_T^{miss}, p_T^{\gamma_1}) > 100$ GeV, but excluding the signal region defined above. The distribution of $E_T^{miss}/\sqrt{H_T}$ is chosen as template variable for the χ^2-fit, which sufficiently separates the shapes of Vγ and γ + jets, so that scaling one background cannot compensate the other. The shape of both backgrounds is simulated with MadGraph 5.1.3. Under the constraint of a fixed total yield, the scale factors for the Vγ and γ + jets simulations are given by the minimum of the χ^2/ndf distribution and found to be $f_{V\gamma} = 0.94 \pm 0.23$ and $f_{\gamma+\text{jets}} = 2.20 \pm 0.31$, respectively. Before performing the normalization, the Vγ background is scaled to the NLO cross section [59], whereas γ + jets is used with LO cross section calculated by the event generator. The upper and lower uncertainty is given by the difference of the best estimate and the scale factor corresponding to the χ^2/ndf values at the minimum of the parabola increased by unity. The measured scale factors and their uncertainties were studied and found stable with respect to systematic variations in the background prediction over different control regions, template variables, and binnings of the template variables. The anticorrelation of the Vγ and γ + jets systematic uncertainties due to the fixed total normalization is taken into account in the interpretation. Signal contamination becomes relevant if the gauginos are light because the signal kinematics for light gauginos are similar to that of Vγ production. In the examined phase space, signal contamination is negligible.

A subdominant background arises from electrons misidentified as photons ($e \to \gamma$). The misidentification rate $f_{e\to\gamma} = (1.46 \pm 0.16)\%$ is determined from $Z \to e^+e^-$ decays in data [20]. The background is estimated from a data control sample with the same event selection, but containing an identified electron instead of a photon. The prediction of electrons misidentified as photons is then obtained by scaling this control sample by $f_{e\to\gamma}/(1 - f_{e\to\gamma})$. The uncertainty of this estimation is 11%, which is dominated by the misidentification rate uncertainty. Further minor contributions from $t\bar{t}\gamma$, diboson, and QCD multijet production are estimated using MC simulations and are corrected for electrons misidentified as photons at the generator level to avoid overlaps. For the cross sections, 26%, 50%, and 100% systematic uncertainties are assigned to $t\bar{t}\gamma$, diboson, and QCD multijet backgrounds, respectively. Based on simulation studies, the background from QCD multijet events is found to be negligible.

The systematic uncertainties with respect to the choice of the PDF in the signal acceptance are determined by the difference in acceptance using different sets of PDFs [60–64] and vary from less than 1% to 11%. Further systematic uncertainties arise from the jet energy correction (0.1–2.4% for the signal, 1.3% for the background estimation) and from the integrated luminosity measurement (2.6%) [65]. When evaluating the exclusion contours for SUSY particle masses in specific models, signal cross sections (σ_s) are conservatively lowered by one standard deviation (4–8%) corresponding to the combined theoretical uncertainty in σ_s due to the choices of the renormalization and factorization scales and the PDFs. All systematic uncertainties are summarized in Table 1.

Table 1
Summary table of systematic uncertainties relevant for the analysis. Uncertainties due to the luminosity and trigger efficiency measurement apply only to the backgrounds estimated using MC simulation without data normalization, namely $t\bar{t}\gamma$, diboson, and multijet, and for the signal. The total uncertainty is dominated by the uncertainty in the Vγ background.

Source	Sample	Relative uncert. (%)	
		In sample	In total bkg
Vγ normalization	Vγ	24	19
γ + jets normalization	γ + jets	14	1
$Z \to e^+e^-$ fit	$e \to \gamma$	11	0.3
Cross section measurement	$t\bar{t}\gamma$	26	3
Cross section	Diboson	50	1
Cross section	Multijet	100	0
Integrated luminosity	Diboson, multijet, and signal	2.6	–
Trigger efficiency	Diboson, multijet, and signal	1.2	–
Jet energy scale	Diboson, multijet, and signal	1–2	–
PDF uncertainty in acceptance	Signal	<1–11	–
PDF and scale uncertainty	Signal	4–8	–

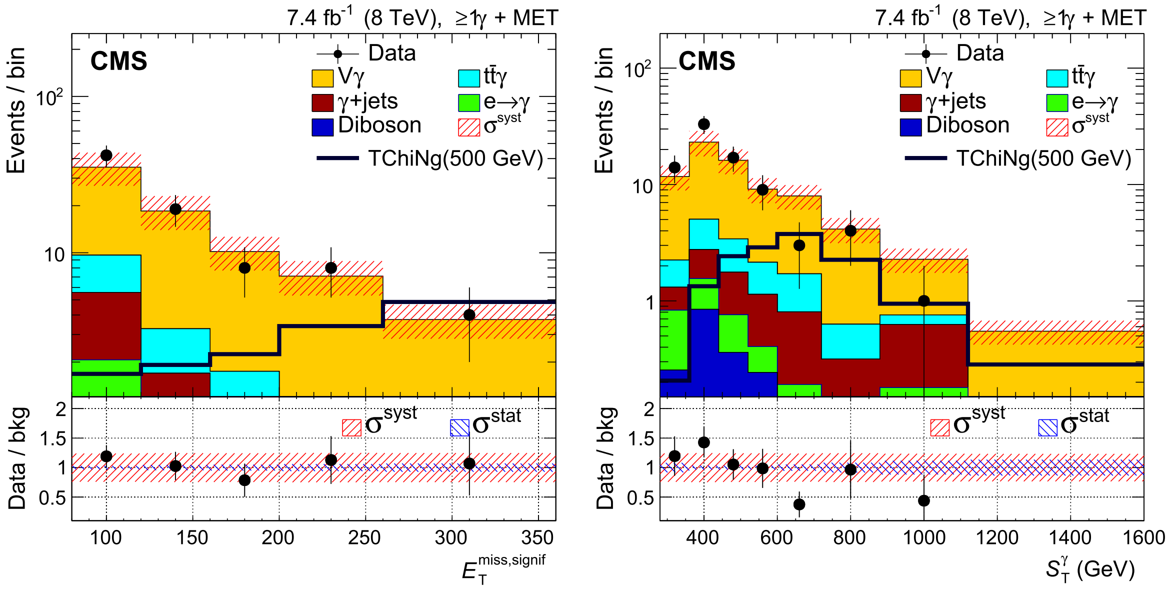

Fig. 2. The $E_T^{\text{miss,signif}}$ (left) and S_T^{γ} (right) variables are shown in the signal selection and used to define four search regions with $E_T^{\text{miss,signif}} = 200$ and $S_T^{\gamma} = 600$ GeV partitions. A benchmark TChiNg signal point with an NLSP mass of 500 GeV is shown for comparison.

5. Results and interpretation

As shown in Fig. 2, the observed data are in agreement with the total standard model background expectation within the combined statistical and systematic uncertainties. Shown are the distributions of $E_T^{\text{miss,signif}}$ (Fig. 2, left) and S_T^{γ} (Fig. 2, right) used to define the four search regions described in Section 4. The results are summarized in Table 2. No sign of new physics is observed.

Cross section limits are calculated combining the results of all four search regions defined in the S_T^{γ}–$E_T^{\text{miss,signif}}$ plane at the 95% CL, using the modified frequentist CL$_s$ criterion [66–68] with a test statistic corresponding to a profile likelihood ratio of the background-only and signal-plus-background hypotheses. Asymptotic formulae [69] are used in the calculation.

The interpretation of the TChiNg and TChiWg scenarios is shown in Fig. 3. The analysis excludes NLSP masses below 570 (680) GeV at the 95% CL in the TChiNg (TChiWg) scenario.

The 95% CL observed upper cross section limit, as well as the observed and expected exclusion contours, for the GGM signal scan in the M_{wino}–M_{bino} plane are shown in Fig. 4. For nearly mass-degenerate gauginos, i.e. for $M_{\text{wino}} = M_{\text{bino}} + 10$ GeV, wino masses up to approximately $M_{\text{wino}} = 710$ GeV are excluded.

6. Conclusion

We have searched for electroweak production of gauginos in the framework of gauge mediated supersymmetry breaking in final states with photons and E_T^{miss}. A dataset, corresponding to an integrated luminosity of 7.4 fb^{-1}, recorded with a special trigger with low thresholds is used. The data are found to agree with the SM expectation. The analysis is sensitive to electroweak production and compressed mass spectra which are characterized by minimal hadronic activity in the final state, complementing previously published searches. Limits in the TChiNg scenario are set for the first time, excluding NLSP masses below 570 GeV at 95% CL. In the TChiWg scenario, NLSP masses below 680 GeV are excluded at 95% CL, increasing the previous mass limit in this scenario [31] by 140 GeV. In the general gauge mediation model for compressed mass spectrum scenarios with e.g. $M_{\text{wino}} - M_{\text{bino}} = 10$ GeV, wino masses below 710 GeV can be excluded, increasing the previous CMS limit [19] by about 220 GeV.

Acknowledgements

We congratulate our colleagues in the CERN accelerator departments for the excellent performance of the LHC and thank the

Table 2
Event yields for data corresponding to 7.4 fb^{-1} and the estimated backgrounds. The signal yields correspond to the benchmark TChiNg signal point with $M_{\text{wino}} = 500\,\text{GeV}$ shown in Fig. 2, also stating the acceptance times efficiency $A\varepsilon$ for each search region. The contribution from QCD multijet background is negligible in all regions.

Selection	$E_T^{\text{miss,signif}} > 200$, $S_T^{\gamma} > 600\,\text{GeV}$	$E_T^{\text{miss,signif}} < 200$, $S_T^{\gamma} > 600\,\text{GeV}$	$E_T^{\text{miss,signif}} < 200$, $S_T^{\gamma} < 600\,\text{GeV}$	$E_T^{\text{miss,signif}} > 200$, $S_T^{\gamma} < 600\,\text{GeV}$
Vγ	4.7 ± 1.2	7.0 ± 1.8	42.3 ± 10.4	5.0 ± 1.3
γ + jets	0.1 ± 0.1	1.3 ± 0.3	3.4 ± 0.7	0.0 ± 0.1
$t\bar{t}\gamma$	0.3 ± 0.1	1.1 ± 0.3	5.5 ± 1.5	0.4 ± 0.1
Diboson	0.1 ± 0.1	0.2 ± 0.1	1.5 ± 0.8	0.2 ± 0.1
$e \to \gamma$	0.1 ± 0.1	0.1 ± 0.1	1.6 ± 0.2	0.2 ± 0.1
Background	5.3 ± 1.2	9.7 ± 1.8	54.3 ± 10.6	5.8 ± 1.3
Data	4	4	65	8
Signal	6.2 ± 0.2	2.1 ± 0.1	4.6 ± 0.1	3.3 ± 0.1
$A\varepsilon$ [%]	12.2 ± 0.3	4.2 ± 0.1	9.0 ± 0.2	6.5 ± 0.2

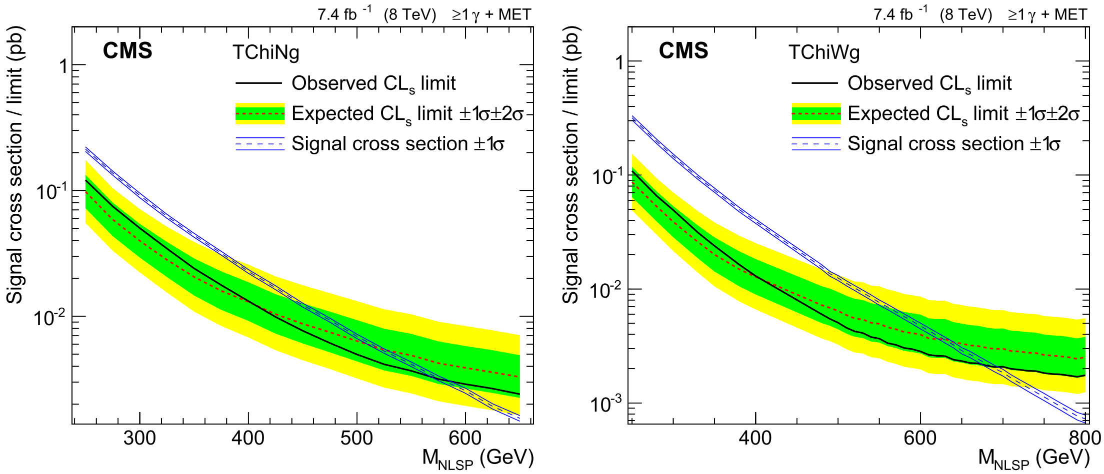

Fig. 3. Exclusion limits at 95% CL for the TChiNg (left) and TChiWg (right) scenario. In the TChiNg scenario NLSP masses below 570 GeV are excluded, in the TChiWg scenario NLSP masses below 680 GeV are excluded.

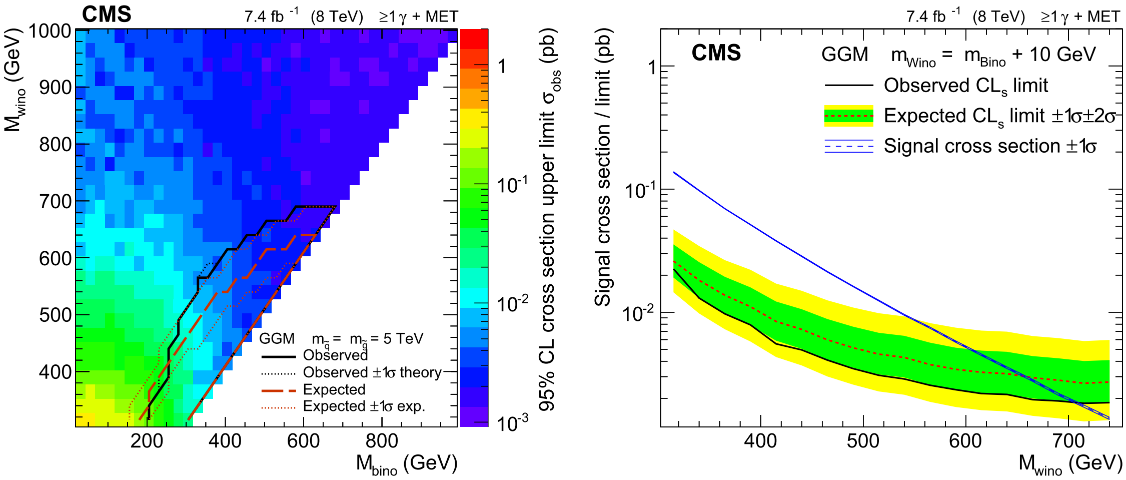

Fig. 4. Observed upper cross section CL$_s$ limit at the 95% CL for the GGM signal points in the M_{wino}–M_{bino} plane (left). Also shown are the 95% CL expected and observed exclusion contours. The GGM signal points near the diagonal, e.g. for $M_{\text{wino}} = M_{\text{bino}} + 10\,\text{GeV}$ up to a wino mass of $M_{\text{wino}} = 710\,\text{GeV}$ are excluded (right).

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 centers and personnel of the Worldwide LHC Computing Grid 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 and the CMS detector provided by the following funding agencies: BMWFW and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, and FAPESP (Brazil); MES (Bulgaria); CERN; CAS, MOST, and NSFC (China); COLCIENCIAS (Colombia); MSES and CSF (Croatia); RPF (Cyprus); MoER, ERC IUT and ERDF (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRT (Greece); OTKA and NIH (Hungary); DAE and DST (India);

IPM (Iran); SFI (Ireland); INFN (Italy); MSIP and NRF (Republic of Korea); LAS (Lithuania); MOE and UM (Malaysia); CINVESTAV, CONACYT, SEP, and UASLP-FAI (Mexico); MBIE (New Zealand); PAEC (Pakistan); MSHE and NSC (Poland); FCT (Portugal); JINR (Dubna); MON, RosAtom, RAS and RFBR (Russia); MESTD (Serbia); SEIDI and CPAN (Spain); Swiss Funding Agencies (Switzerland); MST (Taipei); ThEPCenter, IPST, STAR and NSTDA (Thailand); TUBITAK and TAEK (Turkey); NASU and SFFR (Ukraine); STFC (United Kingdom); DOE and NSF (USA).

References

[1] P. Ramond, Dual theory for free fermions, Phys. Rev. D 3 (1971) 2415, http://dx.doi.org/10.1103/PhysRevD.3.2415.

[2] P. Ramond, An interpretation of dual theories, Nuovo Cimento A 4 (1971) 544, http://dx.doi.org/10.1007/BF02731370.

[3] Y.A. Golfand, E.P. Likhtman, Extension of the algebra of Poincaré group generators and violation of P invariance, JETP Lett. 13 (1971) 323, http://www.jetpletters.ac.ru/ps/1584/article_24309.pdf.

[4] D.V. Volkov, V.P. Akulov, Possible universal neutrino interaction, JETP Lett. 16 (1972) 438, http://dx.doi.org/10.1007/BFb0105270.

[5] J. Wess, B. Zumino, Supergauge transformations in four-dimensions, Nucl. Phys. B 70 (1974) 39, http://dx.doi.org/10.1016/0550-3213(74)90355-1.

[6] D.Z. Freedman, P. van Nieuwenhuizen, S. Ferrara, Progress toward a theory of supergravity, Phys. Rev. D 13 (1976) 3214, http://dx.doi.org/10.1103/PhysRevD.13.3214.

[7] S. Deser, B. Zumino, Consistent supergravity, Phys. Lett. B 62 (1976) 335, http://dx.doi.org/10.1016/0370-2693(76)90089-7.

[8] D.Z. Freedman, P. van Nieuwenhuizen, Properties of supergravity theory, Phys. Rev. D 14 (1976) 912, http://dx.doi.org/10.1103/PhysRevD.14.912.

[9] S. Ferrara, P. van Nieuwenhuizen, Consistent supergravity with complex spin 3/2 gauge fields, Phys. Rev. Lett. 37 (1976) 1669, http://dx.doi.org/10.1103/PhysRevLett.37.1669.

[10] P. Fayet, Supergauge invariant extension of the Higgs mechanism and a model for the electron and its neutrino, Nucl. Phys. B 90 (1975) 104, http://dx.doi.org/10.1016/0550-3213(75)90636-7.

[11] A.H. Chamseddine, R.L. Arnowitt, P. Nath, Locally supersymmetric grand unification, Phys. Rev. Lett. 49 (1982) 970, http://dx.doi.org/10.1103/PhysRevLett.49.970.

[12] R. Barbieri, S. Ferrara, C.A. Savoy, Gauge models with spontaneously broken local supersymmetry, Phys. Lett. B 119 (1982) 343, http://dx.doi.org/10.1016/0370-2693(82)90685-2.

[13] L.J. Hall, J.D. Lykken, S. Weinberg, Supergravity as the messenger of supersymmetry breaking, Phys. Rev. D 27 (1983) 2359, http://dx.doi.org/10.1103/PhysRevD.27.2359.

[14] G.L. Kane, C.F. Kolda, L. Roszkowski, J.D. Wells, Study of constrained minimal supersymmetry, Phys. Rev. D 49 (1994) 6173, http://dx.doi.org/10.1103/PhysRevD.49.6173, arXiv:hep-ph/9312272.

[15] CMS Collaboration, Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, Phys. Lett. B 716 (2012) 30, http://dx.doi.org/10.1016/j.physletb.2012.08.021, arXiv:1207.7235.

[16] ATLAS Collaboration, Observation of a new particle in the search for the standard model Higgs boson with the ATLAS detector at the LHC, Phys. Lett. B 716 (2013) 1, http://dx.doi.org/10.1016/j.physletb.2012.08.020, arXiv:1207.7214.

[17] R. Barbieri, G.F. Giudice, Upper bounds on supersymmetric particle masses, Nucl. Phys. B 306 (1988) 63, http://dx.doi.org/10.1016/0550-3213(88)90171-X.

[18] CMS Collaboration, Search for supersymmetry in pp collisions at $\sqrt{s} = 7$ TeV in events with two photons and missing transverse energy, Phys. Rev. Lett. 106 (2011) 211802, http://dx.doi.org/10.1103/PhysRevLett.106.211802, arXiv:1103.0953.

[19] CMS Collaboration, Search for new physics in events with photons, jets, and missing transverse energy in pp collisions at $\sqrt{s} = 7$ TeV, J. High Energy Phys. 03 (2013) 111, http://dx.doi.org/10.1007/JHEP03(2013)111, arXiv:1211.4784.

[20] CMS Collaboration, Search for supersymmetry with photons in pp collisions at $\sqrt{s} = 8$ TeV, Phys. Rev. D 92 (2015) 072006, http://dx.doi.org/10.1103/PhysRevD.92.072006, arXiv:1507.02898.

[21] ATLAS Collaboration, Search for photonic signatures of gauge-mediated supersymmetry in 8 TeV pp collisions with the ATLAS detector, Phys. Rev. D 92 (2015) 072001, http://dx.doi.org/10.1103/PhysRevD.92.072001, arXiv:1507.05493.

[22] R. Barbier, C. Berat, M. Besancon, M. Chemtob, A. Deandrea, E. Dudas, P. Fayet, S. Lavignac, G. Moreau, E. Perez, Y. Sirois, R-parity violating supersymmetry, Phys. Rep. 420 (2005) 1, http://dx.doi.org/10.1016/j.physrep.2005.08.006, arXiv:hep-ph/0406039.

[23] G.R. Farrar, P. Fayet, Phenomenology of the production, decay, and detection of new hadronic states associated with supersymmetry, Phys. Lett. B 76 (1978) 575, http://dx.doi.org/10.1016/0370-2693(78)90858-4.

[24] P. Fayet, Mixing between gravitational and weak interactions through the massive gravitino, Phys. Lett. B 70 (1977) 461, http://dx.doi.org/10.1016/0370-2693(77)90414-2.

[25] H. Baer, M. Brhlik, C.H. Chen, X. Tata, Signals for the minimal gauge-mediated supersymmetry breaking model at the Fermilab Tevatron collider, Phys. Rev. D 55 (1997) 4463, http://dx.doi.org/10.1103/PhysRevD.55.4463, arXiv:hep-ph/9610358.

[26] H. Baer, P.G. Mercadante, X. Tata, Y.L. Wang, Reach of Tevatron upgrades in gauge-mediated supersymmetry breaking models, Phys. Rev. D 60 (1999) 055001, http://dx.doi.org/10.1103/PhysRevD.60.055001, arXiv:hep-ph/9903333.

[27] S. Dimopoulos, S. Thomas, J.D. Wells, Sparticle spectroscopy and electroweak symmetry breaking with gauge-mediated supersymmetry breaking, Nucl. Phys. B 488 (1997) 39, http://dx.doi.org/10.1016/S0550-3213(97)00030-8, arXiv:hep-ph/9609434.

[28] J.R. Ellis, J.L. Lopez, D.V. Nanopoulos, Analysis of LEP constraints on supersymmetric models with a light gravitino, Phys. Lett. B 394 (1997) 354, http://dx.doi.org/10.1016/S0370-2693(97)00019-1, arXiv:hep-ph/9610470.

[29] M. Dine, A.E. Nelson, Y. Nir, Y. Shirman, New tools for low energy dynamical supersymmetry breaking, Phys. Rev. D 53 (1996) 2658, http://dx.doi.org/10.1103/PhysRevD.53.2658, arXiv:hep-ph/9507378.

[30] G.F. Giudice, R. Rattazzi, Gauge-mediated supersymmetry breaking, in: Perspectives on Supersymmetry, World Scientific, Singapore, 1998, p. 355.

[31] CMS Collaboration, Search for supersymmetry with a photon, a lepton, and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV, arXiv:1508.01218, 2015.

[32] CMS Collaboration, Searches for electroweak neutralino and chargino production in channels with Higgs, Z, and W bosons in pp collisions at 8 TeV, Phys. Rev. D 90 (2014) 092007, http://dx.doi.org/10.1103/PhysRevD.90.092007, arXiv:1409.3168.

[33] ATLAS Collaboration, Search for direct pair production of a chargino and a neutralino decaying to the 125 GeV Higgs boson in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector, Eur. Phys. J. C 75 (2015) 208, http://dx.doi.org/10.1140/epjc/s10052-015-3408-7, arXiv:1501.07110.

[34] ATLAS Collaboration, Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector, J. High Energy Phys. 04 (2014) 169, http://dx.doi.org/10.1007/JHEP04(2014)169, arXiv:1402.7029.

[35] P. Meade, N. Seiberg, D. Shih, General gauge mediation, Prog. Theor. Phys. Suppl. 177 (2009) 143, http://dx.doi.org/10.1143/PTPS.177.143, arXiv:0801.3278.

[36] M. Buican, P. Meade, N. Seiberg, D. Shih, Exploring general gauge mediation, J. High Energy Phys. 03 (2009) 016, http://dx.doi.org/10.1088/1126-6708/2009/03/016, arXiv:0812.3668.

[37] J.T. Ruderman, D. Shih, General neutralino NLSPs at the early LHC, J. High Energy Phys. 08 (2012) 159, http://dx.doi.org/10.1007/JHEP08(2012)159, arXiv:1103.6083.

[38] Y. Kats, P. Meade, M. Reece, D. Shih, The status of GMSB after 1/fb at the LHC, J. High Energy Phys. 02 (2012) 115, http://dx.doi.org/10.1007/JHEP02(2012)115, arXiv:1110.6444.

[39] Y. Kats, M.J. Strassler, Probing colored particles with photons, leptons, and jets, J. High Energy Phys. 11 (2012) 097, http://dx.doi.org/10.1007/JHEP11(2012)097, arXiv:1204.1119.

[40] P. Grajek, A. Mariotti, D. Redigolo, Phenomenology of general gauge mediation in light of a 125 GeV Higgs, J. High Energy Phys. 07 (2013) 109, http://dx.doi.org/10.1007/JHEP07(2013)109, arXiv:1303.0870.

[41] CMS Collaboration, Data parking and data scouting at the CMS experiment, CMS performance note CMS-DP-2012-022, https://cds.cern.ch/record/1480607, 2012.

[42] CMS Collaboration, Performance of photon reconstruction and identification with the CMS detector in proton–proton collisions at $\sqrt{s} = 8$ TeV, J. Instrum. 10 (2015) P08010, http://dx.doi.org/10.1088/1748-0221/10/08/P08010, arXiv:1502.02702.

[43] CMS Collaboration, The CMS experiment at the CERN LHC, J. Instrum. 3 (2008) S08004, http://dx.doi.org/10.1088/1748-0221/3/08/S08004.

[44] CMS Collaboration, Particle-flow event reconstruction in CMS and performance for jets, taus, and $E_{\mathrm{T}}^{\mathrm{miss}}$, CMS physics analysis summary CMS-PAS-PFT-09-001, http://cdsweb.cern.ch/record/1194487, 2009.

[45] CMS Collaboration, Commissioning of the particle-flow event reconstruction with the first LHC collisions recorded in the CMS detector, CMS physics analysis summary CMS-PAS-PFT-10-001, http://cdsweb.cern.ch/record/1247373, 2010.

[46] M. Cacciari, G.P. Salam, G. Soyez, The anti-k_t jet clustering algorithm, J. High Energy Phys. 04 (2008) 063, http://dx.doi.org/10.1088/1126-6708/2008/04/063, arXiv:0802.1189.

[47] M. Cacciari, G.P. Salam, G. Soyez, FastJet user manual, Eur. Phys. J. C 72 (2012) 1896, http://dx.doi.org/10.1140/epjc/s10052-012-1896-2, arXiv:1111.6097.

[48] M. Cacciari, G.P. Salam, Pileup subtraction using jet areas, Phys. Lett. B 659 (2008) 119, http://dx.doi.org/10.1016/j.physletb.2007.09.077, arXiv:0707.1378.

[49] CMS Collaboration, Determination of jet energy calibration and transverse momentum resolution in CMS, J. Instrum. 6 (2011) 11002, http://dx.doi.org/10.1088/1748-0221/6/11/P11002, arXiv:1107.4277.

[50] CMS Collaboration, Performance of the CMS missing transverse momentum reconstruction in pp data at $\sqrt{s} = 8$ TeV, J. Instrum. 10 (2015) P02006, http://dx.doi.org/10.1088/1748-0221/10/02/P02006, arXiv:1411.0511.

[51] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H.S. Shao, T. Stelzer, P. Torrielli, M. Zaro, The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, J. High Energy Phys. 07 (2014) 079, http://dx.doi.org/10.1007/JHEP07(2014)079, arXiv:1405.0301.

[52] T. Sjöstrand, S. Mrenna, P.Z. Skands, PYTHIA 6.4 physics and manual, J. High Energy Phys. 05 (2006) 026, http://dx.doi.org/10.1088/1126-6708/2006/05/026, arXiv:hep-ph/0603175.

[53] J. Pumplin, D.R. Stump, J. Huston, H.L. Lai, P.M. Nadolsky, W.K. Tung, New generation of parton distributions with uncertainties from global QCD analysis, J. High Energy Phys. 07 (2002) 012, http://dx.doi.org/10.1088/1126-6708/2002/07/012, arXiv:hep-ph/0201195.

[54] S. Agostinelli, et al., GEANT4 Collaboration, GEANT4—a simulation toolkit, Nucl. Instrum. Methods Phys. Res., Sect. A, Accel. Spectrom. Detect. Assoc. Equip. 506 (2003) 250, http://dx.doi.org/10.1016/S0168-9002(03)01368-8.

[55] W. Beenakker, R. Hopker, M. Spira, PROSPINO: a program for the production of supersymmetric particles in next-to-leading order QCD, arXiv:hep-ph/9611232, 1996.

[56] M. Kramer, A. Kulesza, R. van der Leeuw, M. Mangano, S. Padhi, T. Plehn, X. Portell, Supersymmetry production cross sections in pp collisions at $\sqrt{s} = 7$ TeV, arXiv:1206.2892, 2012.

[57] B. Fuks, M. Klasen, D.R. Lamprea, M. Rothering, Gaugino production in proton–proton collisions at a center-of-mass energy of 8 TeV, J. High Energy Phys. 10 (2012) 081, http://dx.doi.org/10.1007/JHEP10(2012)081, arXiv:1207.2159.

[58] B. Fuks, M. Klasen, D.R. Lamprea, M. Rothering, Precision predictions for electroweak superpartner production at hadron colliders with Resummino, Eur. Phys. J. C 73 (2013) 2480, http://dx.doi.org/10.1140/epjc/s10052-013-2480-0, arXiv:1304.0790.

[59] CMS Collaboration, Search for new phenomena in monophoton final states in proton–proton collisions at $\sqrt{s} = 8$ TeV, Phys. Lett. B 755 (2016) 102–124, http://dx.doi.org/10.1016/j.physletb.2016.01.057, arXiv:1410.8812.

[60] S. Alekhin, et al., The PDF4LHC Working Group interim report, arXiv:1101.0536, 2011.

[61] M. Botje, J. Butterworth, A. Cooper-Sarkar, A. de Roeck, J. Feltesse, S. Forte, A. Glazov, J. Huston, R. McNulty, T. Sjöstrand, R.S. Thorne, The PDF4LHC Working Group interim recommendations, arXiv:1101.0538, 2011.

[62] R.D. Ball, V. Bertone, S. Carrazza, C.S. Deans, L. Del Debbio, S. Forte, A. Guffanti, N.P. Hartland, J.I. Latorre, J. Rojo, M. Ubiali, NNPDF Collaboration, Parton distributions with LHC data, Nucl. Phys. B 867 (2013) 244, http://dx.doi.org/10.1016/j.nuclphysb.2012.10.003, arXiv:1207.1303.

[63] A.D. Martin, W.J. Stirling, R.S. Thorne, G. Watt, Parton distributions for the LHC, Eur. Phys. J. C 63 (2009) 189, http://dx.doi.org/10.1140/epjc/s10052-009-1072-5, arXiv:0901.0002.

[64] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P.M. Nadolsky, J. Pumplin, C.-P. Yuan, New parton distributions for collider physics, Phys. Rev. D 82 (2010) 074024, http://dx.doi.org/10.1103/PhysRevD.82.074024, arXiv:1007.2241.

[65] CMS Collaboration, CMS luminosity based on pixel cluster counting — summer 2013 update, CMS physics analysis summary CMS-PAS-LUM-13-001, https://cds.cern.ch/record/1598864, 2013.

[66] T. Junk, Confidence level computation for combining searches with small statistics, Nucl. Instrum. Methods A 434 (1999) 435, http://dx.doi.org/10.1016/S0168-9002(99)00498-2, arXiv:hep-ex/9902006.

[67] A.L. Read, Presentation of search results: the CLs technique, J. Phys. G 28 (2002) 2693, http://dx.doi.org/10.1088/0954-3899/28/10/313.

[68] ATLAS, CMS, LHC Higgs Combination Group Collaborations, Procedure for the LHC Higgs boson search combination in Summer 2011, Technical Report CMS-NOTE-2011-005. ATL-PHYS-PUB-2011-11, 2011, https://cds.cern.ch/record/1379837.

[69] E. Gross, O. Vitells, Trial factors or the look elsewhere effect in high energy physics, Eur. Phys. J. C 70 (2010) 525, http://dx.doi.org/10.1140/epjc/s10052-010-1470-8, arXiv:1005.1891.

CMS Collaboration

V. Khachatryan, A.M. Sirunyan, A. Tumasyan

Yerevan Physics Institute, Yerevan, Armenia

W. Adam, E. Asilar, T. Bergauer, J. Brandstetter, E. Brondolin, M. Dragicevic, J. Erö, M. Flechl, M. Friedl, R. Frühwirth[1], V.M. Ghete, C. Hartl, N. Hörmann, J. Hrubec, M. Jeitler[1], V. Knünz, A. König, M. Krammer[1], I. Krätschmer, D. Liko, T. Matsushita, I. Mikulec, D. Rabady[2], N. Rad, B. Rahbaran, H. Rohringer, J. Schieck[1], R. Schöfbeck, J. Strauss, W. Treberer-Treberspurg, W. Waltenberger, C.-E. Wulz[1]

Institut für Hochenergiephysik der OeAW, Wien, Austria

V. Mossolov, N. Shumeiko, J. Suarez Gonzalez

National Centre for Particle and High Energy Physics, Minsk, Belarus

S. Alderweireldt, T. Cornelis, E.A. De Wolf, X. Janssen, A. Knutsson, J. Lauwers, S. Luyckx, M. Van De Klundert, H. Van Haevermaet, P. Van Mechelen, N. Van Remortel, A. Van Spilbeeck

Universiteit Antwerpen, Antwerpen, Belgium

S. Abu Zeid, F. Blekman, J. D'Hondt, N. Daci, I. De Bruyn, K. Deroover, N. Heracleous, J. Keaveney, S. Lowette, L. Moreels, A. Olbrechts, Q. Python, D. Strom, S. Tavernier, W. Van Doninck, P. Van Mulders, G.P. Van Onsem, I. Van Parijs

Vrije Universiteit Brussel, Brussel, Belgium

P. Barria, H. Brun, C. Caillol, B. Clerbaux, G. De Lentdecker, G. Fasanella, L. Favart, R. Goldouzian, A. Grebenyuk, G. Karapostoli, T. Lenzi, A. Léonard, T. Maerschalk, A. Marinov, L. Perniè, A. Randle-conde, T. Seva, C. Vander Velde, P. Vanlaer, R. Yonamine, F. Zenoni, F. Zhang[3]

Université Libre de Bruxelles, Bruxelles, Belgium

K. Beernaert, L. Benucci, A. Cimmino, S. Crucy, D. Dobur, A. Fagot, G. Garcia, M. Gul, J. Mccartin, A.A. Ocampo Rios, D. Poyraz, D. Ryckbosch, S. Salva, M. Sigamani, M. Tytgat, W. Van Driessche, E. Yazgan, N. Zaganidis

Ghent University, Ghent, Belgium

S. Basegmez, C. Beluffi [4], O. Bondu, S. Brochet, G. Bruno, A. Caudron, L. Ceard, C. Delaere, D. Favart, L. Forthomme, A. Giammanco [5], A. Jafari, P. Jez, M. Komm, V. Lemaitre, A. Mertens, M. Musich, C. Nuttens, L. Perrini, K. Piotrzkowski, A. Popov [6], L. Quertenmont, M. Selvaggi, M. Vidal Marono

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

N. Beliy, G.H. Hammad

Université de Mons, Mons, Belgium

W.L. Aldá Júnior, F.L. Alves, G.A. Alves, L. Brito, M. Correa Martins Junior, M. Hamer, C. Hensel, A. Moraes, M.E. Pol, P. Rebello Teles

Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil

E. Belchior Batista Das Chagas, W. Carvalho, J. Chinellato [7], A. Custódio, E.M. Da Costa, D. De Jesus Damiao, C. De Oliveira Martins, S. Fonseca De Souza, L.M. Huertas Guativa, H. Malbouisson, D. Matos Figueiredo, C. Mora Herrera, L. Mundim, H. Nogima, W.L. Prado Da Silva, A. Santoro, A. Sznajder, E.J. Tonelli Manganote [7], A. Vilela Pereira

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

S. Ahuja [a], C.A. Bernardes [b], A. De Souza Santos [b], S. Dogra [a], T.R. Fernandez Perez Tomei [a], E.M. Gregores [b], P.G. Mercadante [b], C.S. Moon [a,8], S.F. Novaes [a], Sandra S. Padula [a], D. Romero Abad, J.C. Ruiz Vargas

[a] *Universidade Estadual Paulista, São Paulo, Brazil*
[b] *Universidade Federal do ABC, São Paulo, Brazil*

A. Aleksandrov, R. Hadjiiska, P. Iaydjiev, M. Rodozov, S. Stoykova, G. Sultanov, M. Vutova

Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria

A. Dimitrov, I. Glushkov, L. Litov, B. Pavlov, P. Petkov

University of Sofia, Sofia, Bulgaria

M. Ahmad, J.G. Bian, G.M. Chen, H.S. Chen, M. Chen, T. Cheng, R. Du, C.H. Jiang, D. Leggat, R. Plestina [9], F. Romeo, S.M. Shaheen, A. Spiezia, J. Tao, C. Wang, Z. Wang, H. Zhang

Institute of High Energy Physics, Beijing, China

C. Asawatangtrakuldee, Y. Ban, Q. Li, S. Liu, Y. Mao, S.J. Qian, D. Wang, Z. Xu

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

C. Avila, A. Cabrera, L.F. Chaparro Sierra, C. Florez, J.P. Gomez, B. Gomez Moreno, J.C. Sanabria

Universidad de Los Andes, Bogota, Colombia

N. Godinovic, D. Lelas, I. Puljak, P.M. Ribeiro Cipriano

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

Z. Antunovic, M. Kovac

University of Split, Faculty of Science, Split, Croatia

V. Brigljevic, K. Kadija, J. Luetic, S. Micanovic, L. Sudic

Institute Rudjer Boskovic, Zagreb, Croatia

A. Attikis, G. Mavromanolakis, J. Mousa, C. Nicolaou, F. Ptochos, P.A. Razis, H. Rykaczewski

University of Cyprus, Nicosia, Cyprus

M. Bodlak, M. Finger[10], M. Finger Jr.[10]

Charles University, Prague, Czech Republic

A.A. Abdelalim[11,12], A. Awad, A. Mahrous[11], A. Radi[13,14]

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

B. Calpas, M. Kadastik, M. Murumaa, M. Raidal, A. Tiko, C. Veelken

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia

P. Eerola, J. Pekkanen, M. Voutilainen

Department of Physics, University of Helsinki, Helsinki, Finland

J. Härkönen, V. Karimäki, R. Kinnunen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Peltola, J. Tuominiemi, E. Tuovinen, L. Wendland

Helsinki Institute of Physics, Helsinki, Finland

J. Talvitie, T. Tuuva

Lappeenranta University of Technology, Lappeenranta, Finland

M. Besancon, F. Couderc, M. Dejardin, D. Denegri, B. Fabbro, J.L. Faure, C. Favaro, F. Ferri, S. Ganjour, A. Givernaud, P. Gras, G. Hamel de Monchenault, P. Jarry, E. Locci, M. Machet, J. Malcles, J. Rander, A. Rosowsky, M. Titov, A. Zghiche

DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France

I. Antropov, S. Baffioni, F. Beaudette, P. Busson, L. Cadamuro, E. Chapon, C. Charlot, O. Davignon, N. Filipovic, R. Granier de Cassagnac, M. Jo, S. Lisniak, L. Mastrolorenzo, P. Miné, I.N. Naranjo, M. Nguyen, C. Ochando, G. Ortona, P. Paganini, P. Pigard, S. Regnard, R. Salerno, J.B. Sauvan, Y. Sirois, T. Strebler, Y. Yilmaz, A. Zabi

Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3–CNRS, Palaiseau, France

J.-L. Agram[15], J. Andrea, A. Aubin, D. Bloch, J.-M. Brom, M. Buttignol, E.C. Chabert, N. Chanon, C. Collard, E. Conte[15], X. Coubez, J.-C. Fontaine[15], D. Gelé, U. Goerlach, C. Goetzmann, A.-C. Le Bihan, J.A. Merlin[2], K. Skovpen, P. Van Hove

Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France

S. Gadrat

Centre de Calcul de l'Institut National de Physique Nucleaire et de Physique des Particules, CNRS/IN2P3, Villeurbanne, France

S. Beauceron, C. Bernet, G. Boudoul, E. Bouvier, C.A. Carrillo Montoya, R. Chierici, D. Contardo, B. Courbon, P. Depasse, H. El Mamouni, J. Fan, J. Fay, S. Gascon, M. Gouzevitch, B. Ille, F. Lagarde, I.B. Laktineh, M. Lethuillier, L. Mirabito, A.L. Pequegnot, S. Perries, J.D. Ruiz Alvarez, D. Sabes, L. Sgandurra, V. Sordini, M. Vander Donckt, P. Verdier, S. Viret

Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France

T. Toriashvili[16]

Georgian Technical University, Tbilisi, Georgia

Z. Tsamalaidze[10]

Tbilisi State University, Tbilisi, Georgia

C. Autermann, S. Beranek, L. Feld, A. Heister, M.K. Kiesel, K. Klein, M. Lipinski, A. Ostapchuk, M. Preuten, F. Raupach, S. Schael, J.F. Schulte, J. Schulz, T. Verlage, H. Weber, V. Zhukov[6]

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

M. Ata, M. Brodski, E. Dietz-Laursonn, D. Duchardt, M. Endres, M. Erdmann, S. Erdweg, T. Esch, R. Fischer, A. Güth, T. Hebbeker, C. Heidemann, K. Hoepfner, S. Knutzen, P. Kreuzer, M. Merschmeyer, A. Meyer, P. Millet, S. Mukherjee, M. Olschewski, K. Padeken, P. Papacz, T. Pook, M. Radziej, H. Reithler, M. Rieger, F. Scheuch, L. Sonnenschein, D. Teyssier, S. Thüer

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

V. Cherepanov, Y. Erdogan, G. Flügge, H. Geenen, M. Geisler, F. Hoehle, B. Kargoll, T. Kress, A. Künsken, J. Lingemann, A. Nehrkorn, A. Nowack, I.M. Nugent, C. Pistone, O. Pooth, A. Stahl

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

M. Aldaya Martin, I. Asin, N. Bartosik, O. Behnke, U. Behrens, K. Borras[17], A. Burgmeier, A. Campbell, C. Contreras-Campana, F. Costanza, C. Diez Pardos, G. Dolinska, S. Dooling, T. Dorland, G. Eckerlin, D. Eckstein, T. Eichhorn, G. Flucke, E. Gallo[18], J. Garay Garcia, A. Geiser, A. Gizhko, P. Gunnellini, J. Hauk, M. Hempel[19], H. Jung, A. Kalogeropoulos, O. Karacheban[19], M. Kasemann, P. Katsas, J. Kieseler, C. Kleinwort, I. Korol, W. Lange, J. Leonard, K. Lipka, A. Lobanov, W. Lohmann[19], R. Mankel, I.-A. Melzer-Pellmann, A.B. Meyer, G. Mittag, J. Mnich, A. Mussgiller, S. Naumann-Emme, A. Nayak, E. Ntomari, H. Perrey, D. Pitzl, R. Placakyte, A. Raspereza, B. Roland, M.Ö. Sahin, P. Saxena, T. Schoerner-Sadenius, C. Seitz, S. Spannagel, K.D. Trippkewitz, R. Walsh, C. Wissing

Deutsches Elektronen-Synchrotron, Hamburg, Germany

V. Blobel, M. Centis Vignali, A.R. Draeger, J. Erfle, E. Garutti, K. Goebel, D. Gonzalez, M. Görner, J. Haller, M. Hoffmann, R.S. Höing, A. Junkes, R. Klanner, R. Kogler, N. Kovalchuk, T. Lapsien, T. Lenz, I. Marchesini, D. Marconi, M. Meyer, D. Nowatschin, J. Ott, F. Pantaleo[2], T. Peiffer, A. Perieanu, N. Pietsch, J. Poehlsen, D. Rathjens, C. Sander, C. Scharf, P. Schleper, E. Schlieckau, A. Schmidt, S. Schumann, J. Schwandt, V. Sola, H. Stadie, G. Steinbrück, F.M. Stober, H. Tholen, D. Troendle, E. Usai, L. Vanelderen, A. Vanhoefer, B. Vormwald

University of Hamburg, Hamburg, Germany

C. Barth, C. Baus, J. Berger, C. Böser, E. Butz, T. Chwalek, F. Colombo, W. De Boer, A. Descroix, A. Dierlamm, S. Fink, F. Frensch, R. Friese, M. Giffels, A. Gilbert, D. Haitz, F. Hartmann[2], S.M. Heindl, U. Husemann, I. Katkov[6], A. Kornmayer[2], P. Lobelle Pardo, B. Maier, H. Mildner, M.U. Mozer, T. Müller, Th. Müller, M. Plagge, G. Quast, K. Rabbertz, S. Röcker, F. Roscher, M. Schröder, G. Sieber, H.J. Simonis, R. Ulrich, J. Wagner-Kuhr, S. Wayand, M. Weber, T. Weiler, S. Williamson, C. Wöhrmann, R. Wolf

Institut für Experimentelle Kernphysik, Karlsruhe, Germany

G. Anagnostou, G. Daskalakis, T. Geralis, V.A. Giakoumopoulou, A. Kyriakis, D. Loukas, A. Psallidas, I. Topsis-Giotis

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

A. Agapitos, S. Kesisoglou, A. Panagiotou, N. Saoulidou, E. Tziaferi

National and Kapodistrian University of Athens, Athens, Greece

I. Evangelou, G. Flouris, C. Foudas, P. Kokkas, N. Loukas, N. Manthos, I. Papadopoulos, E. Paradas, J. Strologas

University of Ioánnina, Ioánnina, Greece

G. Bencze, C. Hajdu, A. Hazi, P. Hidas, D. Horvath [20], F. Sikler, V. Veszpremi, G. Vesztergombi [21], A.J. Zsigmond

Wigner Research Centre for Physics, Budapest, Hungary

N. Beni, S. Czellar, J. Karancsi [22], J. Molnar, Z. Szillasi [2]

Institute of Nuclear Research ATOMKI, Debrecen, Hungary

M. Bartók [23], A. Makovec, P. Raics, Z.L. Trocsanyi, B. Ujvari

University of Debrecen, Debrecen, Hungary

S. Choudhury [24], P. Mal, K. Mandal, D.K. Sahoo, N. Sahoo, S.K. Swain

National Institute of Science Education and Research, Bhubaneswar, India

S. Bansal, S.B. Beri, V. Bhatnagar, R. Chawla, R. Gupta, U. Bhawandeep, A.K. Kalsi, A. Kaur, M. Kaur, R. Kumar, A. Mehta, M. Mittal, J.B. Singh, G. Walia

Panjab University, Chandigarh, India

Ashok Kumar, A. Bhardwaj, B.C. Choudhary, R.B. Garg, S. Malhotra, M. Naimuddin, N. Nishu, K. Ranjan, R. Sharma, V. Sharma

University of Delhi, Delhi, India

S. Bhattacharya, K. Chatterjee, S. Dey, S. Dutta, N. Majumdar, A. Modak, K. Mondal, S. Mukhopadhyay, A. Roy, D. Roy, S. Roy Chowdhury, S. Sarkar, M. Sharan

Saha Institute of Nuclear Physics, Kolkata, India

A. Abdulsalam, R. Chudasama, D. Dutta, V. Jha, V. Kumar, A.K. Mohanty [2], L.M. Pant, P. Shukla, A. Topkar

Bhabha Atomic Research Centre, Mumbai, India

T. Aziz, S. Banerjee, S. Bhowmik [25], R.M. Chatterjee, R.K. Dewanjee, S. Dugad, S. Ganguly, S. Ghosh, M. Guchait, A. Gurtu [26], Sa. Jain, G. Kole, S. Kumar, B. Mahakud, M. Maity [25], G. Majumder, K. Mazumdar, S. Mitra, G.B. Mohanty, B. Parida, T. Sarkar [25], N. Sur, B. Sutar, N. Wickramage [27]

Tata Institute of Fundamental Research, Mumbai, India

S. Chauhan, S. Dube, A. Kapoor, K. Kothekar, S. Sharma

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

H. Bakhshiansohi, H. Behnamian, S.M. Etesami [28], A. Fahim [29], M. Khakzad, M. Mohammadi Najafabadi, M. Naseri, S. Paktinat Mehdiabadi, F. Rezaei Hosseinabadi, B. Safarzadeh [30], M. Zeinali

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

M. Felcini, M. Grunewald

University College Dublin, Dublin, Ireland

M. Abbrescia [a,b], C. Calabria [a,b], C. Caputo [a,b], A. Colaleo [a], D. Creanza [a,c], L. Cristella [a,b], N. De Filippis [a,c], M. De Palma [a,b], L. Fiore [a], G. Iaselli [a,c], G. Maggi [a,c], M. Maggi [a], G. Miniello [a,b], S. My [a,c], S. Nuzzo [a,b], A. Pompili [a,b], G. Pugliese [a,c], R. Radogna [a,b], A. Ranieri [a], G. Selvaggi [a,b], L. Silvestris [a,2], R. Venditti [a,b]

[a] *INFN Sezione di Bari, Bari, Italy*

[b] Università di Bari, Bari, Italy
[c] Politecnico di Bari, Bari, Italy

G. Abbiendi [a], C. Battilana [2], A.C. Benvenuti [a], D. Bonacorsi [a,b], S. Braibant-Giacomelli [a,b], L. Brigliadori [a,b], R. Campanini [a,b], P. Capiluppi [a,b], A. Castro [a,b], F.R. Cavallo [a], S.S. Chhibra [a,b], G. Codispoti [a,b], M. Cuffiani [a,b], G.M. Dallavalle [a], F. Fabbri [a], A. Fanfani [a,b], D. Fasanella [a,b], P. Giacomelli [a], C. Grandi [a], L. Guiducci [a,b], S. Marcellini [a], G. Masetti [a], A. Montanari [a], F.L. Navarria [a,b], A. Perrotta [a], A.M. Rossi [a,b], T. Rovelli [a,b], G.P. Siroli [a,b], N. Tosi [a,b,2]

[a] INFN Sezione di Bologna, Bologna, Italy
[b] Università di Bologna, Bologna, Italy

G. Cappello [b], M. Chiorboli [a,b], S. Costa [a,b], A. Di Mattia [a], F. Giordano [a,b], R. Potenza [a,b], A. Tricomi [a,b], C. Tuve [a,b]

[a] INFN Sezione di Catania, Catania, Italy
[b] Università di Catania, Catania, Italy

G. Barbagli [a], V. Ciulli [a,b], C. Civinini [a], R. D'Alessandro [a,b], E. Focardi [a,b], V. Gori [a,b], P. Lenzi [a,b], M. Meschini [a], S. Paoletti [a], G. Sguazzoni [a], L. Viliani [a,b,2]

[a] INFN Sezione di Firenze, Firenze, Italy
[b] Università di Firenze, Firenze, Italy

L. Benussi, S. Bianco, F. Fabbri, D. Piccolo, F. Primavera [2]

INFN Laboratori Nazionali di Frascati, Frascati, Italy

V. Calvelli [a,b], F. Ferro [a], M. Lo Vetere [a,b], M.R. Monge [a,b], E. Robutti [a], S. Tosi [a,b]

[a] INFN Sezione di Genova, Genova, Italy
[b] Università di Genova, Genova, Italy

L. Brianza, M.E. Dinardo [a,b], S. Fiorendi [a,b], S. Gennai [a], R. Gerosa [a,b], A. Ghezzi [a,b], P. Govoni [a,b], S. Malvezzi [a], R.A. Manzoni [a,b,2], B. Marzocchi [a,b], D. Menasce [a], L. Moroni [a], M. Paganoni [a,b], D. Pedrini [a], S. Ragazzi [a,b], N. Redaelli [a], T. Tabarelli de Fatis [a,b]

[a] INFN Sezione di Milano-Bicocca, Milano, Italy
[b] Università di Milano-Bicocca, Milano, Italy

S. Buontempo [a], N. Cavallo [a,c], S. Di Guida [a,d,2], M. Esposito [a,b], F. Fabozzi [a,c], A.O.M. Iorio [a,b], G. Lanza [a], L. Lista [a], S. Meola [a,d,2], M. Merola [a], P. Paolucci [a,2], C. Sciacca [a,b], F. Thyssen

[a] INFN Sezione di Napoli, Napoli, Italy
[b] Università di Napoli 'Federico II', Napoli, Italy
[c] Università della Basilicata, Potenza, Italy
[d] Università G. Marconi, Roma, Italy

P. Azzi [a,2], N. Bacchetta [a], L. Benato [a,b], D. Bisello [a,b], A. Boletti [a,b], R. Carlin [a,b], P. Checchia [a], M. Dall'Osso [a,b,2], T. Dorigo [a], U. Dosselli [a], F. Gasparini [a,b], U. Gasparini [a,b], F. Gonella [a], A. Gozzelino [a], M. Gulmini [a,31], S. Lacaprara [a], M. Margoni [a,b], A.T. Meneguzzo [a,b], F. Montecassiano [a], J. Pazzini [a,b,2], N. Pozzobon [a,b], P. Ronchese [a,b], F. Simonetto [a,b], E. Torassa [a], M. Tosi [a,b], M. Zanetti, P. Zotto [a,b], A. Zucchetta [a,b,2], G. Zumerle [a,b]

[a] INFN Sezione di Padova, Padova, Italy
[b] Università di Padova, Padova, Italy
[c] Università di Trento, Trento, Italy

A. Braghieri [a], A. Magnani [a,b], P. Montagna [a,b], S.P. Ratti [a,b], V. Re [a], C. Riccardi [a,b], P. Salvini [a], I. Vai [a,b], P. Vitulo [a,b]

[a] INFN Sezione di Pavia, Pavia, Italy
[b] Università di Pavia, Pavia, Italy

L. Alunni Solestizi[a,b], G.M. Bilei[a], D. Ciangottini[a,b,2], L. Fanò[a,b], P. Lariccia[a,b], G. Mantovani[a,b], M. Menichelli[a], A. Saha[a], A. Santocchia[a,b]

[a] INFN Sezione di Perugia, Perugia, Italy
[b] Università di Perugia, Perugia, Italy

K. Androsov[a,32], P. Azzurri[a,2], G. Bagliesi[a], J. Bernardini[a], T. Boccali[a], R. Castaldi[a], M.A. Ciocci[a,32], R. Dell'Orso[a], S. Donato[a,c,2], G. Fedi, L. Foà[a,c,†], A. Giassi[a], M.T. Grippo[a,32], F. Ligabue[a,c], T. Lomtadze[a], L. Martini[a,b], A. Messineo[a,b], F. Palla[a], A. Rizzi[a,b], A. Savoy-Navarro[a,33], A.T. Serban[a], P. Spagnolo[a], R. Tenchini[a], G. Tonelli[a,b], A. Venturi[a], P.G. Verdini[a]

[a] INFN Sezione di Pisa, Pisa, Italy
[b] Università di Pisa, Pisa, Italy
[c] Scuola Normale Superiore di Pisa, Pisa, Italy

L. Barone[a,b], F. Cavallari[a], G. D'imperio[a,b,2], D. Del Re[a,b,2], M. Diemoz[a], S. Gelli[a,b], C. Jorda[a], E. Longo[a,b], F. Margaroli[a,b], P. Meridiani[a], G. Organtini[a,b], R. Paramatti[a], F. Preiato[a,b], S. Rahatlou[a,b], C. Rovelli[a], F. Santanastasio[a,b], P. Traczyk[a,b,2]

[a] INFN Sezione di Roma, Roma, Italy
[b] Università di Roma, Roma, Italy

N. Amapane[a,b], R. Arcidiacono[a,c,2], S. Argiro[a,b], M. Arneodo[a,c], R. Bellan[a,b], C. Biino[a], N. Cartiglia[a], M. Costa[a,b], R. Covarelli[a,b], A. Degano[a,b], N. Demaria[a], L. Finco[a,b,2], B. Kiani[a,b], C. Mariotti[a], S. Maselli[a], E. Migliore[a,b], V. Monaco[a,b], E. Monteil[a,b], M.M. Obertino[a,b], L. Pacher[a,b], N. Pastrone[a], M. Pelliccioni[a], G.L. Pinna Angioni[a,b], F. Ravera[a,b], A. Romero[a,b], M. Ruspa[a,c], R. Sacchi[a,b], A. Solano[a,b], A. Staiano[a]

[a] INFN Sezione di Torino, Torino, Italy
[b] Università di Torino, Torino, Italy
[c] Università del Piemonte Orientale, Novara, Italy

S. Belforte[a], V. Candelise[a,b], M. Casarsa[a], F. Cossutti[a], G. Della Ricca[a,b], B. Gobbo[a], C. La Licata[a,b], M. Marone[a,b], A. Schizzi[a,b], A. Zanetti[a]

[a] INFN Sezione di Trieste, Trieste, Italy
[b] Università di Trieste, Trieste, Italy

A. Kropivnitskaya, S.K. Nam

Kangwon National University, Chunchon, Republic of Korea

D.H. Kim, G.N. Kim, M.S. Kim, D.J. Kong, S. Lee, Y.D. Oh, A. Sakharov, D.C. Son

Kyungpook National University, Daegu, Republic of Korea

J.A. Brochero Cifuentes, H. Kim, T.J. Kim

Chonbuk National University, Jeonju, Republic of Korea

S. Song

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

S. Cho, S. Choi, Y. Go, D. Gyun, B. Hong, H. Kim, Y. Kim, B. Lee, K. Lee, K.S. Lee, S. Lee, J. Lim, S.K. Park, Y. Roh

Korea University, Seoul, Republic of Korea

H.D. Yoo

Seoul National University, Seoul, Republic of Korea

M. Choi, H. Kim, J.H. Kim, J.S.H. Lee, I.C. Park, G. Ryu, M.S. Ryu

University of Seoul, Seoul, Republic of Korea

Y. Choi, J. Goh, D. Kim, E. Kwon, J. Lee, I. Yu

Sungkyunkwan University, Suwon, Republic of Korea

V. Dudenas, A. Juodagalvis, J. Vaitkus

Vilnius University, Vilnius, Lithuania

I. Ahmed, Z.A. Ibrahim, J.R. Komaragiri, M.A.B. Md Ali[34], F. Mohamad Idris[35], W.A.T. Wan Abdullah, M.N. Yusli, Z. Zolkapli

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

E. Casimiro Linares, H. Castilla-Valdez, E. De La Cruz-Burelo, I. Heredia-De La Cruz[36], A. Hernandez-Almada, R. Lopez-Fernandez, A. Sanchez-Hernandez

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

S. Carrillo Moreno, F. Vazquez Valencia

Universidad Iberoamericana, Mexico City, Mexico

I. Pedraza, H.A. Salazar Ibarguen

Benemerita Universidad Autonoma de Puebla, Puebla, Mexico

A. Morelos Pineda

Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico

D. Krofcheck

University of Auckland, Auckland, New Zealand

P.H. Butler

University of Canterbury, Christchurch, New Zealand

A. Ahmad, M. Ahmad, Q. Hassan, H.R. Hoorani, W.A. Khan, T. Khurshid, M. Shoaib

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

H. Bialkowska, M. Bluj, B. Boimska, T. Frueboes, M. Górski, M. Kazana, K. Nawrocki, K. Romanowska-Rybinska, M. Szleper, P. Zalewski

National Centre for Nuclear Research, Swierk, Poland

G. Brona, K. Bunkowski, A. Byszuk[37], K. Doroba, A. Kalinowski, M. Konecki, J. Krolikowski, M. Misiura, M. Olszewski, M. Walczak

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

P. Bargassa, C. Beirão Da Cruz E Silva, A. Di Francesco, P. Faccioli, P.G. Ferreira Parracho, M. Gallinaro, J. Hollar, N. Leonardo, L. Lloret Iglesias, F. Nguyen, J. Rodrigues Antunes, J. Seixas, O. Toldaiev, D. Vadruccio, J. Varela, P. Vischia

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

S. Afanasiev, P. Bunin, M. Gavrilenko, I. Golutvin, I. Gorbunov, A. Kamenev, V. Karjavin, A. Lanev, A. Malakhov, V. Matveev[38,39], P. Moisenz, V. Palichik, V. Perelygin, S. Shmatov, S. Shulha, N. Skatchkov, V. Smirnov, A. Zarubin

Joint Institute for Nuclear Research, Dubna, Russia

V. Golovtsov, Y. Ivanov, V. Kim[40], E. Kuznetsova, P. Levchenko, V. Murzin, V. Oreshkin, I. Smirnov, V. Sulimov, L. Uvarov, S. Vavilov, A. Vorobyev

Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia

Yu. Andreev, A. Dermenev, S. Gninenko, N. Golubev, A. Karneyeu, M. Kirsanov, N. Krasnikov, A. Pashenkov, D. Tlisov, A. Toropin

Institute for Nuclear Research, Moscow, Russia

V. Epshteyn, V. Gavrilov, N. Lychkovskaya, V. Popov, I. Pozdnyakov, G. Safronov, A. Spiridonov, E. Vlasov, A. Zhokin

Institute for Theoretical and Experimental Physics, Moscow, Russia

A. Bylinkin, M. Chadeeva, R. Chistov, M. Danilov, V. Rusinov

National Research Nuclear University 'Moscow Engineering Physics Institute' (MEPhI), Moscow, Russia

V. Andreev, M. Azarkin[39], I. Dremin[39], M. Kirakosyan, A. Leonidov[39], G. Mesyats, S.V. Rusakov

P.N. Lebedev Physical Institute, Moscow, Russia

A. Baskakov, A. Belyaev, E. Boos, M. Dubinin[41], L. Dudko, A. Ershov, A. Gribushin, V. Klyukhin, O. Kodolova, I. Lokhtin, I. Miagkov, S. Obraztsov, S. Petrushanko, V. Savrin, A. Snigirev

Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia

I. Azhgirey, I. Bayshev, S. Bitioukov, V. Kachanov, A. Kalinin, D. Konstantinov, V. Krychkine, V. Petrov, R. Ryutin, A. Sobol, L. Tourtchanovitch, S. Troshin, N. Tyurin, A. Uzunian, A. Volkov

State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia

P. Adzic[42], P. Cirkovic, J. Milosevic, V. Rekovic

University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia

J. Alcaraz Maestre, E. Calvo, M. Cerrada, M. Chamizo Llatas, N. Colino, B. De La Cruz, A. Delgado Peris, A. Escalante Del Valle, C. Fernandez Bedoya, J.P. Fernández Ramos, J. Flix, M.C. Fouz, P. Garcia-Abia, O. Gonzalez Lopez, S. Goy Lopez, J.M. Hernandez, M.I. Josa, E. Navarro De Martino, A. Pérez-Calero Yzquierdo, J. Puerta Pelayo, A. Quintario Olmeda, I. Redondo, L. Romero, J. Santaolalla, M.S. Soares

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

C. Albajar, J.F. de Trocóniz, M. Missiroli, D. Moran

Universidad Autónoma de Madrid, Madrid, Spain

J. Cuevas, J. Fernandez Menendez, S. Folgueras, I. Gonzalez Caballero, E. Palencia Cortezon, J.M. Vizan Garcia

Universidad de Oviedo, Oviedo, Spain

I.J. Cabrillo, A. Calderon, J.R. Castiñeiras De Saa, P. De Castro Manzano, M. Fernandez, J. Garcia-Ferrero, G. Gomez, A. Lopez Virto, J. Marco, R. Marco, C. Martinez Rivero, F. Matorras, J. Piedra Gomez, T. Rodrigo, A.Y. Rodríguez-Marrero, A. Ruiz-Jimeno, L. Scodellaro, N. Trevisani, I. Vila, R. Vilar Cortabitarte

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

D. Abbaneo, E. Auffray, G. Auzinger, M. Bachtis, P. Baillon, A.H. Ball, D. Barney, A. Benaglia, J. Bendavid, L. Benhabib, G.M. Berruti, P. Bloch, A. Bocci, A. Bonato, C. Botta, H. Breuker, T. Camporesi, R. Castello, G. Cerminara, M. D'Alfonso, D. d'Enterria, A. Dabrowski, V. Daponte, A. David, M. De Gruttola, F. De Guio,

A. De Roeck, S. De Visscher, E. Di Marco[43], M. Dobson, M. Dordevic, B. Dorney, T. du Pree, D. Duggan, M. Dünser, N. Dupont, A. Elliott-Peisert, G. Franzoni, J. Fulcher, W. Funk, D. Gigi, K. Gill, D. Giordano, M. Girone, F. Glege, R. Guida, S. Gundacker, M. Guthoff, J. Hammer, P. Harris, J. Hegeman, V. Innocente, P. Janot, H. Kirschenmann, M.J. Kortelainen, K. Kousouris, K. Krajczar, P. Lecoq, C. Lourenço, M.T. Lucchini, N. Magini, L. Malgeri, M. Mannelli, A. Martelli, L. Masetti, F. Meijers, S. Mersi, E. Meschi, F. Moortgat, S. Morovic, M. Mulders, M.V. Nemallapudi, H. Neugebauer, S. Orfanelli[44], L. Orsini, L. Pape, E. Perez, M. Peruzzi, A. Petrilli, G. Petrucciani, A. Pfeiffer, M. Pierini, D. Piparo, A. Racz, T. Reis, G. Rolandi[45], M. Rovere, M. Ruan, H. Sakulin, C. Schäfer, C. Schwick, M. Seidel, A. Sharma, P. Silva, M. Simon, P. Sphicas[46], J. Steggemann, B. Stieger, M. Stoye, Y. Takahashi, D. Treille, A. Triossi, A. Tsirou, G.I. Veres[21], N. Wardle, H.K. Wöhri, A. Zagozdzinska[37], W.D. Zeuner

CERN, European Organization for Nuclear Research, Geneva, Switzerland

W. Bertl, K. Deiters, W. Erdmann, R. Horisberger, Q. Ingram, H.C. Kaestli, D. Kotlinski, U. Langenegger, T. Rohe

Paul Scherrer Institut, Villigen, Switzerland

F. Bachmair, L. Bäni, L. Bianchini, B. Casal, G. Dissertori, M. Dittmar, M. Donegà, P. Eller, C. Grab, C. Heidegger, D. Hits, J. Hoss, G. Kasieczka, P. Lecomte[†], W. Lustermann, B. Mangano, M. Marionneau, P. Martinez Ruiz del Arbol, M. Masciovecchio, M.T. Meinhard, D. Meister, F. Micheli, P. Musella, F. Nessi-Tedaldi, F. Pandolfi, J. Pata, F. Pauss, L. Perrozzi, M. Quittnat, M. Rossini, M. Schönenberger, A. Starodumov[47], M. Takahashi, V.R. Tavolaro, K. Theofilatos, R. Wallny

Institute for Particle Physics, ETH Zurich, Zurich, Switzerland

T.K. Aarrestad, C. Amsler[48], L. Caminada, M.F. Canelli, V. Chiochia, A. De Cosa, C. Galloni, A. Hinzmann, T. Hreus, B. Kilminster, C. Lange, J. Ngadiuba, D. Pinna, G. Rauco, P. Robmann, D. Salerno, Y. Yang

Universität Zürich, Zurich, Switzerland

M. Cardaci, K.H. Chen, T.H. Doan, Sh. Jain, R. Khurana, M. Konyushikhin, C.M. Kuo, W. Lin, Y.J. Lu, A. Pozdnyakov, S.S. Yu

National Central University, Chung-Li, Taiwan

Arun Kumar, P. Chang, Y.H. Chang, Y.W. Chang, Y. Chao, K.F. Chen, P.H. Chen, C. Dietz, F. Fiori, U. Grundler, W.-S. Hou, Y. Hsiung, Y.F. Liu, R.-S. Lu, M. Miñano Moya, E. Petrakou, J.f. Tsai, Y.M. Tzeng

National Taiwan University (NTU), Taipei, Taiwan

B. Asavapibhop, K. Kovitanggoon, G. Singh, N. Srimanobhas, N. Suwonjandee

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

A. Adiguzel, M.N. Bakirci[49], S. Damarseckin, Z.S. Demiroglu, C. Dozen, E. Eskut, F.H. Gecit, S. Girgis, G. Gokbulut, Y. Guler, E. Gurpinar, I. Hos, E.E. Kangal[50], G. Onengut[51], M. Ozcan, K. Ozdemir[52], A. Polatoz, D. Sunar Cerci[53], B. Tali[53], H. Topakli[49], C. Zorbilmez

Cukurova University, Adana, Turkey

B. Bilin, S. Bilmis, B. Isildak[54], G. Karapinar[55], M. Yalvac, M. Zeyrek

Middle East Technical University, Physics Department, Ankara, Turkey

E. Gülmez, M. Kaya[56], O. Kaya[57], E.A. Yetkin[58], T. Yetkin[59]

Bogazici University, Istanbul, Turkey

A. Cakir, K. Cankocak, S. Sen[60], F.I. Vardarlı

Istanbul Technical University, Istanbul, Turkey

B. Grynyov

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

L. Levchuk, P. Sorokin

National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine

R. Aggleton, F. Ball, L. Beck, J.J. Brooke, E. Clement, D. Cussans, H. Flacher, J. Goldstein, M. Grimes, G.P. Heath, H.F. Heath, J. Jacob, L. Kreczko, C. Lucas, Z. Meng, D.M. Newbold[61], S. Paramesvaran, A. Poll, T. Sakuma, S. Seif El Nasr-storey, S. Senkin, D. Smith, V.J. Smith

University of Bristol, Bristol, United Kingdom

K.W. Bell, A. Belyaev[62], C. Brew, R.M. Brown, L. Calligaris, D. Cieri, D.J.A. Cockerill, J.A. Coughlan, K. Harder, S. Harper, E. Olaiya, D. Petyt, C.H. Shepherd-Themistocleous, A. Thea, I.R. Tomalin, T. Williams, S.D. Worm

Rutherford Appleton Laboratory, Didcot, United Kingdom

M. Baber, R. Bainbridge, O. Buchmuller, A. Bundock, D. Burton, S. Casasso, M. Citron, D. Colling, L. Corpe, P. Dauncey, G. Davies, A. De Wit, M. Della Negra, P. Dunne, A. Elwood, D. Futyan, G. Hall, G. Iles, R. Lane, R. Lucas[61], L. Lyons, A.-M. Magnan, S. Malik, J. Nash, A. Nikitenko[47], J. Pela, M. Pesaresi, D.M. Raymond, A. Richards, A. Rose, C. Seez, A. Tapper, K. Uchida, M. Vazquez Acosta[63], T. Virdee, S.C. Zenz

Imperial College, London, United Kingdom

J.E. Cole, P.R. Hobson, A. Khan, P. Kyberd, D. Leslie, I.D. Reid, P. Symonds, L. Teodorescu, M. Turner

Brunel University, Uxbridge, United Kingdom

A. Borzou, K. Call, J. Dittmann, K. Hatakeyama, H. Liu, N. Pastika

Baylor University, Waco, USA

O. Charaf, S.I. Cooper, C. Henderson, P. Rumerio

The University of Alabama, Tuscaloosa, USA

D. Arcaro, A. Avetisyan, T. Bose, D. Gastler, D. Rankin, C. Richardson, J. Rohlf, L. Sulak, D. Zou

Boston University, Boston, USA

J. Alimena, E. Berry, D. Cutts, A. Ferapontov, A. Garabedian, J. Hakala, U. Heintz, O. Jesus, E. Laird, G. Landsberg, Z. Mao, M. Narain, S. Piperov, S. Sagir, R. Syarif

Brown University, Providence, USA

R. Breedon, G. Breto, M. Calderon De La Barca Sanchez, S. Chauhan, M. Chertok, J. Conway, R. Conway, P.T. Cox, R. Erbacher, G. Funk, M. Gardner, W. Ko, R. Lander, C. Mclean, M. Mulhearn, D. Pellett, J. Pilot, F. Ricci-Tam, S. Shalhout, J. Smith, M. Squires, D. Stolp, M. Tripathi, S. Wilbur, R. Yohay

University of California, Davis, Davis, USA

R. Cousins, P. Everaerts, A. Florent, J. Hauser, M. Ignatenko, D. Saltzberg, E. Takasugi, V. Valuev, M. Weber

University of California, Los Angeles, USA

K. Burt, R. Clare, J. Ellison, J.W. Gary, G. Hanson, J. Heilman, M. Ivova Paneva, P. Jandir, E. Kennedy, F. Lacroix, O.R. Long, M. Malberti, M. Olmedo Negrete, A. Shrinivas, H. Wei, S. Wimpenny, B.R. Yates

University of California, Riverside, Riverside, USA

J.G. Branson, G.B. Cerati, S. Cittolin, R.T. D'Agnolo, M. Derdzinski, A. Holzner, R. Kelley, D. Klein, J. Letts, I. Macneill, D. Olivito, S. Padhi, M. Pieri, M. Sani, V. Sharma, S. Simon, M. Tadel, A. Vartak, S. Wasserbaech[64], C. Welke, F. Würthwein, A. Yagil, G. Zevi Della Porta

University of California, San Diego, La Jolla, USA

J. Bradmiller-Feld, C. Campagnari, A. Dishaw, V. Dutta, K. Flowers, M. Franco Sevilla, P. Geffert, C. George, F. Golf, L. Gouskos, J. Gran, J. Incandela, N. Mccoll, S.D. Mullin, J. Richman, D. Stuart, I. Suarez, C. West, J. Yoo

University of California, Santa Barbara, Santa Barbara, USA

D. Anderson, A. Apresyan, A. Bornheim, J. Bunn, Y. Chen, J. Duarte, A. Mott, H.B. Newman, C. Pena, M. Spiropulu, J.R. Vlimant, S. Xie, R.Y. Zhu

California Institute of Technology, Pasadena, USA

M.B. Andrews, V. Azzolini, A. Calamba, B. Carlson, T. Ferguson, M. Paulini, J. Russ, M. Sun, H. Vogel, I. Vorobiev

Carnegie Mellon University, Pittsburgh, USA

J.P. Cumalat, W.T. Ford, A. Gaz, F. Jensen, A. Johnson, M. Krohn, T. Mulholland, U. Nauenberg, K. Stenson, S.R. Wagner

University of Colorado Boulder, Boulder, USA

J. Alexander, A. Chatterjee, J. Chaves, J. Chu, S. Dittmer, N. Eggert, N. Mirman, G. Nicolas Kaufman, J.R. Patterson, A. Rinkevicius, A. Ryd, L. Skinnari, L. Soffi, W. Sun, S.M. Tan, W.D. Teo, J. Thom, J. Thompson, J. Tucker, Y. Weng, P. Wittich

Cornell University, Ithaca, USA

S. Abdullin, M. Albrow, G. Apollinari, S. Banerjee, L.A.T. Bauerdick, A. Beretvas, J. Berryhill, P.C. Bhat, G. Bolla, K. Burkett, J.N. Butler, H.W.K. Cheung, F. Chlebana, S. Cihangir, V.D. Elvira, I. Fisk, J. Freeman, E. Gottschalk, L. Gray, D. Green, S. Grünendahl, O. Gutsche, J. Hanlon, D. Hare, R.M. Harris, S. Hasegawa, J. Hirschauer, Z. Hu, B. Jayatilaka, S. Jindariani, M. Johnson, U. Joshi, B. Klima, B. Kreis, S. Lammel, J. Linacre, D. Lincoln, R. Lipton, T. Liu, R. Lopes De Sá, J. Lykken, K. Maeshima, J.M. Marraffino, S. Maruyama, D. Mason, P. McBride, P. Merkel, S. Mrenna, S. Nahn, C. Newman-Holmes[†], V. O'Dell, K. Pedro, O. Prokofyev, G. Rakness, E. Sexton-Kennedy, A. Soha, W.J. Spalding, L. Spiegel, S. Stoynev, N. Strobbe, L. Taylor, S. Tkaczyk, N.V. Tran, L. Uplegger, E.W. Vaandering, C. Vernieri, M. Verzocchi, R. Vidal, M. Wang, H.A. Weber, A. Whitbeck

Fermi National Accelerator Laboratory, Batavia, USA

D. Acosta, P. Avery, P. Bortignon, D. Bourilkov, A. Brinkerhoff, A. Carnes, M. Carver, D. Curry, S. Das, R.D. Field, I.K. Furic, S.V. Gleyzer, J. Konigsberg, A. Korytov, K. Kotov, P. Ma, K. Matchev, H. Mei, P. Milenovic[65], G. Mitselmakher, D. Rank, R. Rossin, L. Shchutska, M. Snowball, D. Sperka, N. Terentyev, L. Thomas, J. Wang, S. Wang, J. Yelton

University of Florida, Gainesville, USA

S. Hewamanage, S. Linn, P. Markowitz, G. Martinez, J.L. Rodriguez

Florida International University, Miami, USA

A. Ackert, J.R. Adams, T. Adams, A. Askew, S. Bein, J. Bochenek, B. Diamond, J. Haas, S. Hagopian, V. Hagopian, K.F. Johnson, A. Khatiwada, H. Prosper, M. Weinberg

Florida State University, Tallahassee, USA

M.M. Baarmand, V. Bhopatkar, S. Colafranceschi[66], M. Hohlmann, H. Kalakhety, D. Noonan, T. Roy, F. Yumiceva

Florida Institute of Technology, Melbourne, USA

M.R. Adams, L. Apanasevich, D. Berry, R.R. Betts, I. Bucinskaite, R. Cavanaugh, O. Evdokimov, L. Gauthier, C.E. Gerber, D.J. Hofman, P. Kurt, C. O'Brien, I.D. Sandoval Gonzalez, P. Turner, N. Varelas, Z. Wu, M. Zakaria, J. Zhang

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

B. Bilki[67], W. Clarida, K. Dilsiz, S. Durgut, R.P. Gandrajula, M. Haytmyradov, V. Khristenko, J.-P. Merlo, H. Mermerkaya[68], A. Mestvirishvili, A. Moeller, J. Nachtman, H. Ogul, Y. Onel, F. Ozok[69], A. Penzo, C. Snyder, E. Tiras, J. Wetzel, K. Yi

The University of Iowa, Iowa City, USA

I. Anderson, B.A. Barnett, B. Blumenfeld, N. Eminizer, D. Fehling, L. Feng, A.V. Gritsan, P. Maksimovic, M. Osherson, J. Roskes, A. Sady, U. Sarica, M. Swartz, M. Xiao, Y. Xin, C. You

Johns Hopkins University, Baltimore, USA

P. Baringer, A. Bean, G. Benelli, C. Bruner, R.P. Kenny III, D. Majumder, M. Malek, W. Mcbrayer, M. Murray, S. Sanders, R. Stringer, Q. Wang

The University of Kansas, Lawrence, USA

A. Ivanov, K. Kaadze, S. Khalil, M. Makouski, Y. Maravin, A. Mohammadi, L.K. Saini, N. Skhirtladze, S. Toda

Kansas State University, Manhattan, USA

D. Lange, F. Rebassoo, D. Wright

Lawrence Livermore National Laboratory, Livermore, USA

C. Anelli, A. Baden, O. Baron, A. Belloni, B. Calvert, S.C. Eno, C. Ferraioli, J.A. Gomez, N.J. Hadley, S. Jabeen, R.G. Kellogg, T. Kolberg, J. Kunkle, Y. Lu, A.C. Mignerey, Y.H. Shin, A. Skuja, M.B. Tonjes, S.C. Tonwar

University of Maryland, College Park, USA

A. Apyan, R. Barbieri, A. Baty, K. Bierwagen, S. Brandt, W. Busza, I.A. Cali, Z. Demiragli, L. Di Matteo, G. Gomez Ceballos, M. Goncharov, D. Gulhan, Y. Iiyama, G.M. Innocenti, M. Klute, D. Kovalskyi, Y.S. Lai, Y.-J. Lee, A. Levin, P.D. Luckey, A.C. Marini, C. Mcginn, C. Mironov, S. Narayanan, X. Niu, C. Paus, C. Roland, G. Roland, J. Salfeld-Nebgen, G.S.F. Stephans, K. Sumorok, M. Varma, D. Velicanu, J. Veverka, J. Wang, T.W. Wang, B. Wyslouch, M. Yang, V. Zhukova

Massachusetts Institute of Technology, Cambridge, USA

B. Dahmes, A. Evans, A. Finkel, A. Gude, P. Hansen, S. Kalafut, S.C. Kao, K. Klapoetke, Y. Kubota, Z. Lesko, J. Mans, S. Nourbakhsh, N. Ruckstuhl, R. Rusack, N. Tambe, J. Turkewitz

University of Minnesota, Minneapolis, USA

J.G. Acosta, S. Oliveros

University of Mississippi, Oxford, USA

E. Avdeeva, R. Bartek, K. Bloom, S. Bose, D.R. Claes, A. Dominguez, C. Fangmeier, R. Gonzalez Suarez, R. Kamalieddin, D. Knowlton, I. Kravchenko, F. Meier, J. Monroy, F. Ratnikov, J.E. Siado, G.R. Snow

University of Nebraska–Lincoln, Lincoln, USA

M. Alyari, J. Dolen, J. George, A. Godshalk, C. Harrington, I. Iashvili, J. Kaisen, A. Kharchilava, A. Kumar, S. Rappoccio, B. Roozbahani

State University of New York at Buffalo, Buffalo, USA

G. Alverson, E. Barberis, D. Baumgartel, M. Chasco, A. Hortiangtham, A. Massironi, D.M. Morse, D. Nash, T. Orimoto, R. Teixeira De Lima, D. Trocino, R.-J. Wang, D. Wood, J. Zhang

Northeastern University, Boston, USA

S. Bhattacharya, K.A. Hahn, A. Kubik, J.F. Low, N. Mucia, N. Odell, B. Pollack, M. Schmitt, K. Sung, M. Trovato, M. Velasco

Northwestern University, Evanston, USA

N. Dev, M. Hildreth, C. Jessop, D.J. Karmgard, N. Kellams, K. Lannon, N. Marinelli, F. Meng, C. Mueller, Y. Musienko[38], M. Planer, A. Reinsvold, R. Ruchti, G. Smith, S. Taroni, N. Valls, M. Wayne, M. Wolf, A. Woodard

University of Notre Dame, Notre Dame, USA

L. Antonelli, J. Brinson, B. Bylsma, L.S. Durkin, S. Flowers, A. Hart, C. Hill, R. Hughes, W. Ji, T.Y. Ling, B. Liu, W. Luo, D. Puigh, M. Rodenburg, B.L. Winer, H.W. Wulsin

The Ohio State University, Columbus, USA

O. Driga, P. Elmer, J. Hardenbrook, P. Hebda, S.A. Koay, P. Lujan, D. Marlow, T. Medvedeva, M. Mooney, J. Olsen, C. Palmer, P. Piroué, D. Stickland, C. Tully, A. Zuranski

Princeton University, Princeton, USA

S. Malik

University of Puerto Rico, Mayaguez, USA

A. Barker, V.E. Barnes, D. Benedetti, D. Bortoletto, L. Gutay, M.K. Jha, M. Jones, A.W. Jung, K. Jung, A. Kumar, D.H. Miller, N. Neumeister, B.C. Radburn-Smith, X. Shi, I. Shipsey, D. Silvers, J. Sun, A. Svyatkovskiy, F. Wang, W. Xie, L. Xu

Purdue University, West Lafayette, USA

N. Parashar, J. Stupak

Purdue University Calumet, Hammond, USA

A. Adair, B. Akgun, Z. Chen, K.M. Ecklund, F.J.M. Geurts, M. Guilbaud, W. Li, B. Michlin, M. Northup, B.P. Padley, R. Redjimi, J. Roberts, J. Rorie, Z. Tu, J. Zabel

Rice University, Houston, USA

B. Betchart, A. Bodek, P. de Barbaro, R. Demina, Y. Eshaq, T. Ferbel, M. Galanti, A. Garcia-Bellido, J. Han, A. Harel, O. Hindrichs, A. Khukhunaishvili, K.H. Lo, G. Petrillo, P. Tan, M. Verzetti

University of Rochester, Rochester, USA

J.P. Chou, E. Contreras-Campana, D. Ferencek, Y. Gershtein, E. Halkiadakis, M. Heindl, D. Hidas, E. Hughes, S. Kaplan, R. Kunnawalkam Elayavalli, A. Lath, K. Nash, H. Saka, S. Salur, S. Schnetzer, D. Sheffield, S. Somalwar, R. Stone, S. Thomas, P. Thomassen, M. Walker

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

M. Foerster, G. Riley, K. Rose, S. Spanier, K. Thapa

University of Tennessee, Knoxville, USA

O. Bouhali[70], A. Castaneda Hernandez[70], A. Celik, M. Dalchenko, M. De Mattia, A. Delgado, S. Dildick, R. Eusebi, J. Gilmore, T. Huang, T. Kamon[71], V. Krutelyov, R. Mueller, I. Osipenkov, Y. Pakhotin, R. Patel, A. Perloff, A. Rose, A. Safonov, A. Tatarinov, K.A. Ulmer[2]

Texas A&M University, College Station, USA

N. Akchurin, C. Cowden, J. Damgov, C. Dragoiu, P.R. Dudero, J. Faulkner, S. Kunori, K. Lamichhane, S.W. Lee, T. Libeiro, S. Undleeb, I. Volobouev

Texas Tech University, Lubbock, USA

E. Appelt, A.G. Delannoy, S. Greene, A. Gurrola, R. Janjam, W. Johns, C. Maguire, Y. Mao, A. Melo, H. Ni, P. Sheldon, S. Tuo, J. Velkovska, Q. Xu

Vanderbilt University, Nashville, USA

M.W. Arenton, B. Cox, B. Francis, J. Goodell, R. Hirosky, A. Ledovskoy, H. Li, C. Lin, C. Neu, T. Sinthuprasith, X. Sun, Y. Wang, E. Wolfe, J. Wood, F. Xia

University of Virginia, Charlottesville, USA

C. Clarke, R. Harr, P.E. Karchin, C. Kottachchi Kankanamge Don, P. Lamichhane, J. Sturdy

Wayne State University, Detroit, USA

D.A. Belknap, D. Carlsmith, M. Cepeda, S. Dasu, L. Dodd, S. Duric, B. Gomber, M. Grothe, M. Herndon, A. Hervé, P. Klabbers, A. Lanaro, A. Levine, K. Long, R. Loveless, A. Mohapatra, I. Ojalvo, T. Perry, G.A. Pierro, G. Polese, T. Ruggles, T. Sarangi, A. Savin, A. Sharma, N. Smith, W.H. Smith, D. Taylor, P. Verwilligen, N. Woods

University of Wisconsin–Madison, Madison, WI, USA

[†] Deceased.
[1] Also at Vienna University of Technology, Vienna, Austria.
[2] Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland.
[3] Also at State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China.
[4] Also at Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France.
[5] Also at National Institute of Chemical Physics and Biophysics, Tallinn, Estonia.
[6] Also at Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia.
[7] Also at Universidade Estadual de Campinas, Campinas, Brazil.
[8] Also at Centre National de la Recherche Scientifique (CNRS) – IN2P3, Paris, France.
[9] Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3–CNRS, Palaiseau, France.
[10] Also at Joint Institute for Nuclear Research, Dubna, Russia.
[11] Also at Helwan University, Cairo, Egypt.
[12] Now at Zewail City of Science and Technology, Zewail, Egypt.
[13] Also at British University in Egypt, Cairo, Egypt.
[14] Now at Ain Shams University, Cairo, Egypt.
[15] Also at Université de Haute Alsace, Mulhouse, France.
[16] Also at Tbilisi State University, Tbilisi, Georgia.
[17] Also at RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany.
[18] Also at University of Hamburg, Hamburg, Germany.
[19] Also at Brandenburg University of Technology, Cottbus, Germany.
[20] Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary.
[21] Also at Eötvös Loránd University, Budapest, Hungary.
[22] Also at University of Debrecen, Debrecen, Hungary.
[23] Also at Wigner Research Centre for Physics, Budapest, Hungary.
[24] Also at Indian Institute of Science Education and Research, Bhopal, India.
[25] Also at University of Visva-Bharati, Santiniketan, India.
[26] Now at King Abdulaziz University, Jeddah, Saudi Arabia.
[27] Also at University of Ruhuna, Matara, Sri Lanka.
[28] Also at Isfahan University of Technology, Isfahan, Iran.
[29] Also at University of Tehran, Department of Engineering Science, Tehran, Iran.
[30] Also at Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[31] Also at Laboratori Nazionali di Legnaro dell'INFN, Legnaro, Italy.
[32] Also at Università degli Studi di Siena, Siena, Italy.
[33] Also at Purdue University, West Lafayette, USA.

[34] Also at International Islamic University of Malaysia, Kuala Lumpur, Malaysia.
[35] Also at Malaysian Nuclear Agency, MOSTI, Kajang, Malaysia.
[36] Also at Consejo Nacional de Ciencia y Tecnología, Mexico city, Mexico.
[37] Also at Warsaw University of Technology, Institute of Electronic Systems, Warsaw, Poland.
[38] Also at Institute for Nuclear Research, Moscow, Russia.
[39] Now at National Research Nuclear University 'Moscow Engineering Physics Institute' (MEPhI), Moscow, Russia.
[40] Also at St. Petersburg State Polytechnical University, St. Petersburg, Russia.
[41] Also at California Institute of Technology, Pasadena, USA.
[42] Also at Faculty of Physics, University of Belgrade, Belgrade, Serbia.
[43] Also at INFN Sezione di Roma; Università di Roma, Roma, Italy.
[44] Also at National Technical University of Athens, Athens, Greece.
[45] Also at Scuola Normale e Sezione dell'INFN, Pisa, Italy.
[46] Also at National and Kapodistrian University of Athens, Athens, Greece.
[47] Also at Institute for Theoretical and Experimental Physics, Moscow, Russia.
[48] Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland.
[49] Also at Gaziosmanpasa University, Tokat, Turkey.
[50] Also at Mersin University, Mersin, Turkey.
[51] Also at Cag University, Mersin, Turkey.
[52] Also at Piri Reis University, Istanbul, Turkey.
[53] Also at Adiyaman University, Adiyaman, Turkey.
[54] Also at Ozyegin University, Istanbul, Turkey.
[55] Also at Izmir Institute of Technology, Izmir, Turkey.
[56] Also at Marmara University, Istanbul, Turkey.
[57] Also at Kafkas University, Kars, Turkey.
[58] Also at Istanbul Bilgi University, Istanbul, Turkey.
[59] Also at Yildiz Technical University, Istanbul, Turkey.
[60] Also at Hacettepe University, Ankara, Turkey.
[61] Also at Rutherford Appleton Laboratory, Didcot, United Kingdom.
[62] Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.
[63] Also at Instituto de Astrofísica de Canarias, La Laguna, Spain.
[64] Also at Utah Valley University, Orem, USA.
[65] Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia.
[66] Also at Facoltà Ingegneria, Università di Roma, Roma, Italy.
[67] Also at Argonne National Laboratory, Argonne, USA.
[68] Also at Erzincan University, Erzincan, Turkey.
[69] Also at Mimar Sinan University, Istanbul, Istanbul, Turkey.
[70] Also at Texas A&M University at Qatar, Doha, Qatar.
[71] Also at Kyungpook National University, Daegu, Korea.