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Search for new physics in events with same-sign dileptons and b jets in pp collisions at $\sqrt{s} = 8\,\mathrm{TeV}$

The CMS Collaboration[*]

Abstract

A search for new physics is performed using events with isolated same-sign leptons and at least two bottom-quark jets in the final state. Results are based on a sample of proton-proton collisions collected at a center-of-mass energy of 8 TeV with the CMS detector and corresponding to an integrated luminosity of $10.5\,\mathrm{fb}^{-1}$. No excess above the standard model background is observed. Upper limits are set on the number of events from non-standard-model sources and are used to constrain a number of new physics models. Information on acceptance and efficiencies is also provided so that the results can be used to confront an even broader class of new physics models.

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[*] See Appendix A for the list of collaboration members

1 Introduction

Events with same-sign, isolated leptons (e or μ) from standard model (SM) processes in proton-proton collisions are extremely rare. As a result, searches for anomalous production of same-sign dileptons can be very sensitive to new physics contributions. These include supersymmetry (SUSY) [1–3], universal extra dimensions [4], pair production of $T_{5/3}$ particles (fermionic partners of the top quark) [5], heavy Majorana neutrinos [6], and same-sign top-pair production [7, 8]. More specifically, the signature of same-sign dileptons accompanied by bottom quarks can arise from SUSY processes where third-generation quark superpartners are lighter than other squarks [9–13], resulting in an abundance of top and bottom quarks produced in cascade decays. These scenarios are particularly interesting for two reasons. First, because they have not been excluded by early SUSY searches at the Large Hadron Collider (LHC); second, because relatively light bottom and top squarks are necessary if SUSY is to be the "natural", (i.e., not fine-tuned), solution to the gauge hierarchy problem (see for example the discussion in Ref. [12]).

In this Paper we present the result of a search for new physics in events with same-sign isolated dileptons and two or more bottom-quark jets (b jets). The search was performed on a dataset corresponding to an integrated luminosity of $10.5\,\mathrm{fb}^{-1}$ of proton-proton (pp) collisions collected at a center-of-mass energy of 8 TeV with the Compact Muon Solenoid (CMS) [14] detector at the LHC. This search is an extension of the search at 7 TeV described in Ref. [15].

In the analysis, we select events with two isolated, high transverse momentum (p_{T}), same-sign leptons (e or μ), and at least two jets identified as b jets (b-tagged jets). The numbers of observed events in signal regions defined by additional requirements on missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$), the number of b-tagged jets, and the scalar sum of jet p_{T} (H_{T}), are compared with SM expectations. Having found no evidence for a beyond-the-SM contribution to the event counts, we set limits on the number of events from new physics in the event sample. These limits are then translated into a limit on the same-sign top-pair production cross section and are used to bound the parameters of other new physics models. Finally, we include additional information on the event selection efficiencies so that our results can be used to test models of new physics not explicitly considered here.

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. The CMS experiment uses a right-handed coordinate system, with the origin defined to be the nominal interaction point, the x axis pointing to the center of the LHC ring, the y axis pointing up (perpendicular to the LHC plane), and the z axis pointing in the counterclockwise beam direction. The polar angle θ is measured from the positive z axis and the azimuthal angle ϕ is measured in the x-y (transverse) plane. The pseudorapidity η is defined as $\eta = -\ln\left[\tan\left(\theta/2\right)\right]$. Within the field volume are a silicon pixel and strip tracker, a crystal electromagnetic calorimeter, and a brass-scintillator hadron calorimeter. Muons are measured in gas-ionization detectors embedded in the steel return yoke. Full coverage is provided by the tracker, calorimeters, and the muon detectors within $|\eta| < 2.4$. In addition to the barrel and endcap calorimeters up to $|\eta| = 3$, CMS has extensive forward calorimetry reaching $|\eta| \lesssim 5$. A more detailed description of the CMS apparatus can be found in Ref. [14].

3 Event selection and Monte Carlo simulation

The event selection is essentially the same as for the 7 TeV analysis [15]. We require two isolated same-sign leptons (e or μ), consistent with originating from the same vertex and with pair invariant mass above 8 GeV, and at least two b-tagged jets. Events are collected with dilepton triggers. The kinematic requirements on leptons and jets are summarized in Table 1. Events with a third lepton are rejected if the lepton forms an opposite-sign same-flavor pair with one of the first two leptons, and if the invariant mass $m_{\ell\ell}$ of the pair satisfies $m_{\ell\ell} < 12\,\text{GeV}$ ($p_{\mathrm{T}} > 5\,\text{GeV}$) or $76 < m_{\ell\ell} < 106\,\text{GeV}$ ($p_{\mathrm{T}} > 10\,\text{GeV}$), where the conditions in parentheses show the respective p_{T} requirement on the third lepton. These requirements are designed to minimize backgrounds from events with $\gamma^* \to \ell^+\ell^-$, low-mass bound-state, and multi-boson (WZ and ZZ, as well as tribosons) production.

Table 1: Kinematic requirements for leptons and jets in this analysis.

	p_{T}	η
electrons	$p_{\mathrm{T}} > 20\,\text{GeV}$	$\lvert\eta\rvert < 1.442$ or $1.566 < \lvert\eta\rvert < 2.4$
muons	$p_{\mathrm{T}} > 20\,\text{GeV}$	$\lvert\eta\rvert < 2.4$
jets	$p_{\mathrm{T}} > 40\,\text{GeV}$	$\lvert\eta\rvert < 2.4$
b-tagged jets	$p_{\mathrm{T}} > 40\,\text{GeV}$	$\lvert\eta\rvert < 2.4$

With respect to Ref. [15], there have been a few modifications in the lepton identification and isolation requirements. The main difference is that lepton isolation is now computed with particle-flow information [16] rather than with charged tracks and calorimeter deposits, and an event-by-event correction is made to account for the effect of multiple pp interactions in the same bunch crossing (pileup); the mean number of interactions in the same crossing is 15. This correction consists of subtracting from the measured sum-P_T in the isolation cone the estimated contribution from pileup. This contribution is of order 1 GeV, and it is calculated based on a measurement of the hadronic event activity not associated with the pp interaction that produced the leptons. As a result of this correction, the efficiency of the isolation requirement for leptons from W and Z decays is almost independent of pileup.

The jet reconstruction is the same as in Ref. [15], but the b-tagging algorithm has been changed slightly. We now use the CSV method of Ref. [17], which is based on the combination of secondary-vertex reconstruction and track-based lifetime information. Efficiencies for lepton identification, trigger efficiency, and b-tagging are summarized in Sections 6 and 7.

Monte Carlo (MC) simulations including pileup are used to estimate some of the SM backgrounds (see Section 4), as well as to calculate the efficiency for various new physics scenarios. In this analysis, SM background samples and new physics signal samples are generated with the MADGRAPH V5 [18] and PYTHIA V6.4 [19] programs, respectively. Standard model processes are simulated using a GEANT4-based model [20] of the CMS detector; the simulation of new physics signals is performed using the CMS fast simulation package [21]. All simulated events are processed with the same chain of reconstruction programs used for collision data.

4 Backgrounds

There are three sources of SM background to potential new physics signals:

- "fake leptons", i.e., leptons from heavy-flavor decay, misidentified hadrons, muons from light-meson decay in flight, or electrons from unidentified photon conversions.

These are estimated from a sample of events with at least one lepton that passes a loose selection but fails the full set of tight identification and isolation requirements. The background estimation uses the “tight-to-loose” ratio, i.e., the probability for a loosely identified fake lepton to also pass the full set of requirements, as determined from studies of fake leptons in multijet events.

- “charge flips”, i.e., events with opposite-sign isolated leptons where one of the leptons is an electron and its charge is misreconstructed due to severe bremsstrahlung in the tracker material (this effect is negligible for muons). Charge flips are estimated by selecting opposite-sign ee or eμ events passing the full kinematic selection, weighted by the p_{T}- and η-dependent probability of electron charge misassignment. This probability is obtained from MC simulation and is validated on a sample of $\mathrm{Z} \to \mathrm{ee}$ events.
- rare SM processes that yield same-sign high-p_{T} leptons and b jets, mostly from $\mathrm{t\bar{t}W}$ and $\mathrm{t\bar{t}Z}$ production. This background contribution is obtained from Monte Carlo simulation.

More details on the background estimation can be found in Refs. [15, 22]. The systematic uncertainties are 20% for charge flips, and 50% for both fake and rare SM backgrounds. The next-to-leading order $\mathrm{t\bar{t}W}$ and $\mathrm{t\bar{t}Z}$ production cross sections used to normalize the MC predictions are 232 fb [23] and 208 fb [24, 25], respectively.

5 Event yields

The search is based on comparing the event yields and background predictions in nine signal regions (SRs) with different requirements on $E_{\mathrm{T}}^{\mathrm{miss}}$, H_{T}, and the number of b-tagged jets. In order to improve the sensitivity to $\mathrm{pp} \to \mathrm{tt}$ production, we also define a SR with positive leptons only. The requirements for the SRs are loosely motivated by possible new physics scenarios. For example, signal regions with high $E_{\mathrm{T}}^{\mathrm{miss}}$ are most sensitive to R-parity-conserving SUSY models with relatively light neutralinos; requiring larger H_{T} reduces the SM background while generally maintaining good efficiency to detect new heavy particles that are produced via the strong interaction; the signal region with three or more b-tagged jets is sensitive to final states that include several b quarks.

Table 2: A summary of the results of this search. For each signal region (SR), we show its distinguishing kinematic requirements, the prediction for the three background (BG) components, as well as their total, and the observed number of events. We also show the 95% CL upper limit on the number of new physics events (N_{UL}) under different assumptions on the signal efficiency uncertainty. Note that the number of jets on the first line of the table includes both b-tagged and non b-tagged jets.

	SR0	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8
No. of jets	≥ 2	≥ 2	≥ 2	≥ 4	≥ 4	≥ 4	≥ 4	≥ 3	≥ 4
No. of btags	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 2	≥ 3	≥ 2
Lepton charges	$++/--$	$++/--$	$++$	$++/--$	$++/--$	$++/--$	$++/--$	$++/--$	$++/--$
$E_{\mathrm{T}}^{\mathrm{miss}}$	>0 GeV	>30 GeV	>30 GeV	>120 GeV	>50 GeV	>50 GeV	>120 GeV	>50 GeV	>0 GeV
H_{T}	>80 GeV	>80 GeV	>80 GeV	>200 GeV	>200 GeV	>320 GeV	>320 GeV	>200 GeV	>320 GeV
Fake BG	25 ± 13	19 ± 10	9.6 ± 5.0	0.99 ± 0.69	4.5 ± 2.9	2.9 ± 1.7	0.7 ± 0.5	0.71 ± 0.47	4.4 ± 2.6
Charge-flip BG	3.4 ± 0.7	2.7 ± 0.5	1.4 ± 0.3	0.04 ± 0.01	0.21 ± 0.05	0.14 ± 0.03	0.04 ± 0.01	0.03 ± 0.01	0.21 ± 0.05
Rare SM BG	11.8 ± 5.9	10.5 ± 5.3	6.7 ± 3.4	1.2 ± 0.7	3.4 ± 1.8	2.7 ± 1.5	1.0 ± 0.6	0.44 ± 0.39	3.5 ± 1.9
Total BG	40 ± 14	32 ± 11	17.7 ± 6.1	2.2 ± 1.0	8.1 ± 3.4	5.7 ± 2.4	1.7 ± 0.7	1.2 ± 0.6	8.1 ± 3.3
Event yield	43	38	14	1	10	7	1	1	9
N_{UL} (13% unc.)	27.2	26.0	9.9	3.6	10.8	8.6	3.6	3.7	9.6
N_{UL} (20% unc.)	28.2	27.2	10.2	3.6	11.2	8.9	3.7	3.8	9.9
N_{UL} (30% unc.)	30.4	29.6	10.7	3.8	12.0	9.6	3.9	4.0	10.5

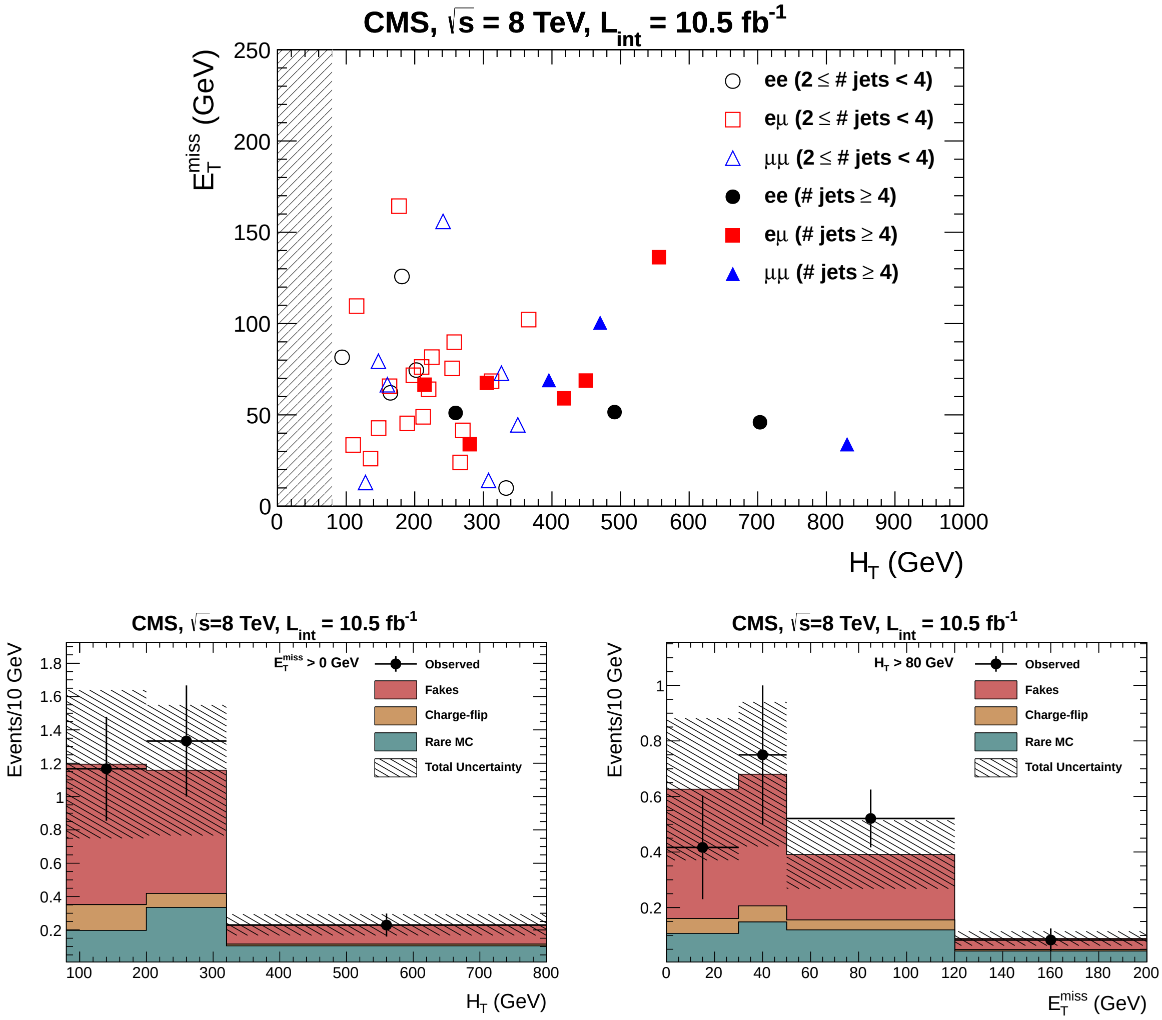

Figure 1: Top plot: distribution of $E_{\mathrm{T}}^{\mathrm{miss}}$ versus H_{T} for the 43 events in the most inclusive signal region (SR0). Note that the ≥ 2 jets requirement in SR0 implies $H_{\mathrm{T}} > 80\,\mathrm{GeV}$. Bottom-left plot: projection of the top plot on the H_{T} axis. Bottom-right plot: projection of the top plot on the $E_{\mathrm{T}}^{\mathrm{miss}}$ axis. For the one-dimensional distributions, the number of events in each bin is scaled appropriately to reflect units of events per 10 GeV and is compared with the background predictions, with their uncertainties. The binning of the one-dimensional distributions is chosen to match the $E_{\mathrm{T}}^{\mathrm{miss}}$ and H_{T} boundaries of the different signal regions.

The definition of the signal regions and the observations of the search are summarized in Table 2. The basic kinematic properties of the selected events are shown in Fig. 1. The results are consistent with the background predictions.

Table 2 also shows the 95% confidence level (CL) observed upper limit (N_{UL}) on the number of non-SM events, calculated using the CL$_{\mathrm{s}}$ method [26–28] under three different assumptions for the signal efficiency uncertainty. As can be seen from Table 2, the limits are only weakly dependent on this uncertainty. The uncertainty on the signal efficiency is discussed in Section 6.

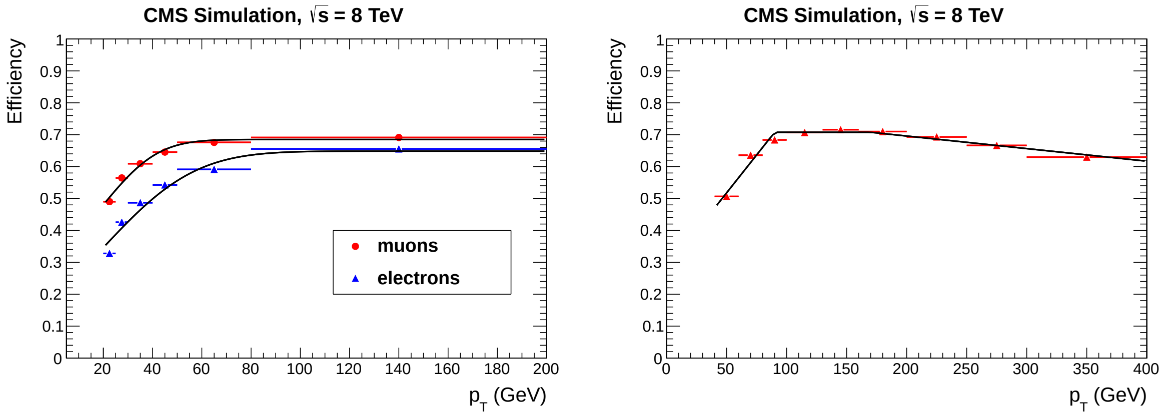

Figure 2: Lepton selection efficiency as a function of p_T (left); b-tagging efficiency as a function of the b-quark p_T (right). The superimposed curves represent the efficiency parametrizations discussed in Section 7.

6 Efficiencies and associated uncertainties

The dilepton triggers require one lepton to have $p_T > 17\,\text{GeV}$ and the other $p_T > 8\,\text{GeV}$. The trigger efficiency, measured using events collected with hadronic triggers, is $96 \pm 5\%$ for ee, $93 \pm 5\%$ for eμ, and $88 \pm 4\%$ for $\mu\mu$. All acceptances, which are calculated from MC simulation, include a correction factor for the trigger efficiency.

The lepton selection efficiencies, determined using a sample of simulated events from a typical signal scenario involving multiple top quarks in the final states arising from gluino decay [29, 30], are displayed in Fig. 2. Studies of large samples of $Z \to ee$ and $Z \to \mu\mu$ events indicate that the lepton selection efficiencies are reproduced to better than 2% by the simulation. However, leptons in SUSY events have significantly lower isolation efficiency due to the large amount of hadronic activity that is expected in these scenarios. As a result, we conservatively assign an uncertainty of 5% per lepton to the lepton selection efficiency.

Figure 2 also shows the b-tagging efficiency, obtained from simulation, for b quarks with $|\eta| < 2.4$. The uncertainty on this efficiency is a function of b-jet p_T; it is 4.4% at $p_T = 40\,\text{GeV}$, 2.7% at $p_T = 100\,\text{GeV}$, and 10% at $p_T = 500\,\text{GeV}$ [17].

The uncertainty on the energy scale of jets in this analysis is also a function of p_T [31]. It varies between 5% and 2% in the p_T range 40–100 GeV for jets with $|\eta| < 2.4$.

The importance of these effects depends on the signal region and the model of new physics. In general, models with high hadronic activity and large E_T^{miss} are less affected by the uncertainty on the jet energy scale.

The total uncertainty on the acceptance for the models described in Section 8 is in the 13–20% range. Finally, there is a 4.4% uncertainty on the yield of events from any new physics model due to the uncertainty in the luminosity normalization [32].

7 Information for model testing

Our results can be used to confront models of new physics in an approximate way through generator-level studies that compare the expected numbers of events with the upper limits from Table 2. The prescription to be used is given in Ref. [15], Section 7. The E_T^{miss} and H_T

turn-on curves in this analysis are the same as those of Ref. [15]. However the lepton and b-tagging efficiencies are slightly different because of the changes in the underlying selections. Their current parametrizations are given below.

The parametrization of the lepton efficiency, shown in Fig. 2 (left), is

$$\epsilon = \epsilon_\infty \,\mathrm{erf}\left(\frac{p_\mathrm{T} - 20\,\mathrm{GeV}}{\sigma}\right) + \epsilon_{20}\left[1 - \mathrm{erf}\left(\frac{p_\mathrm{T} - 20\,\mathrm{GeV}}{\sigma}\right)\right], \tag{1}$$

with $\epsilon_\infty = 0.65$ (0.69), $\epsilon_{20} = 0.35$ (0.48), and $\sigma = 42\,\mathrm{GeV}$ (25 GeV) for electrons (muons). The parametrization of the simulated b-tagging efficiency, shown in Fig. 2 (right), is $\epsilon = 0.71$ for $90 < p_\mathrm{T} < 170\,\mathrm{GeV}$; at higher (lower) p_T it decreases linearly with a slope of -0.0004 (-0.0047) GeV^{-1}.

8 Limits on models of new physics

The results of the search are used to constrain specific models of new physics. For each model considered, limits are derived from the signal region expected to give the most stringent limit on the cross section at a given point in the parameter space of the model. The event selection efficiency for a given model is obtained from MC simulation, and the limits are calculated including systematic uncertainties on lepton efficiency, trigger efficiency, luminosity, jet energy scale, and b-tagging efficiency. The latter two uncertainties are evaluated at each point in the parameter space.

The results from SR1 and SR2 are used to set limits on the cross section for same-sign top-quark pair production, $\sigma(\mathrm{pp} \to \mathrm{tt} + \overline{\mathrm{t}}\overline{\mathrm{t}})$ from SR1, and $\sigma(\mathrm{pp} \to \mathrm{tt})$ from SR2. Here $\sigma(\mathrm{pp} \to \mathrm{tt} + \overline{\mathrm{t}}\overline{\mathrm{t}})$ is shorthand for the sum $\sigma(\mathrm{pp} \to \mathrm{tt}) + \sigma(\mathrm{pp} \to \overline{\mathrm{t}}\overline{\mathrm{t}})$. Note that in most new physics scenarios $\mathrm{pp} \to \overline{\mathrm{t}}\overline{\mathrm{t}}$ is suppressed with respect to $\mathrm{pp} \to \mathrm{tt}$ because of the parton distribution functions of the proton. These limits are calculated using simulated $\mathrm{pp} \to \mathrm{t}\bar{\mathrm{t}}$ events to model the acceptance. This acceptance, including branching fractions, is $0.29 \pm 0.04\%$. We find upper limits $\sigma(\mathrm{pp} \to \mathrm{tt} + \overline{\mathrm{t}}\overline{\mathrm{t}}) < 0.87$ pb and $\sigma(\mathrm{pp} \to \mathrm{tt}) < 0.30\,\mathrm{pb}$ at the 95% CL; the median expected limits are 0.72 and 0.37 pb, respectively.

Next, we present limits on the parameter spaces of four R-parity-conserving SUSY models with third-generation squarks. The decay chains under consideration are shown schematically in Fig. 3.

Scenarios A1 and A2 represent models of gluino pair production resulting in the $\mathrm{tt}\overline{\mathrm{t}}\overline{\mathrm{t}}\widetilde{\chi}^0_1\widetilde{\chi}^0_1$ final state, where $\widetilde{\chi}^0_1$ is the lightest neutralino [12, 29, 30, 33, 34]. In model A1, the gluino undergoes a three-body decay $\widetilde{\mathrm{g}} \to \mathrm{t}\bar{\mathrm{t}}\widetilde{\chi}^0_1$ mediated by an off-shell top squark. In model A2, the gluino decays to a top quark and and an anti-top squark, with the on-shell anti-squark further decaying into an anti-top quark and a neutralino.

Models B1 and B2 have bottom squarks decaying as $\widetilde{\mathrm{b}}_1 \to \mathrm{t}\widetilde{\chi}^-_1$ and $\widetilde{\chi}^-_1 \to \mathrm{W}^-\widetilde{\chi}^0_1$. Model B1 is a model of bottom-squark pair production, followed by one of the most likely decay modes of the bottom squark; model B2 consists of gluino pair production followed by $\widetilde{\mathrm{g}} \to \widetilde{\mathrm{b}}_1\bar{\mathrm{b}}$. The gluino decay modes in models A1 and A2 would be dominant if the top squark is the lightest supersymmetric quark. Conversely, if the bottom squark is lightest, the decay mode in model B2 would be the most probable.

Excluded regions in the parameter space of the four models are shown in Fig. 4. For the gluino-initiated models (A1, A2, and B2), we exclude gluinos with masses below around 1 TeV, with

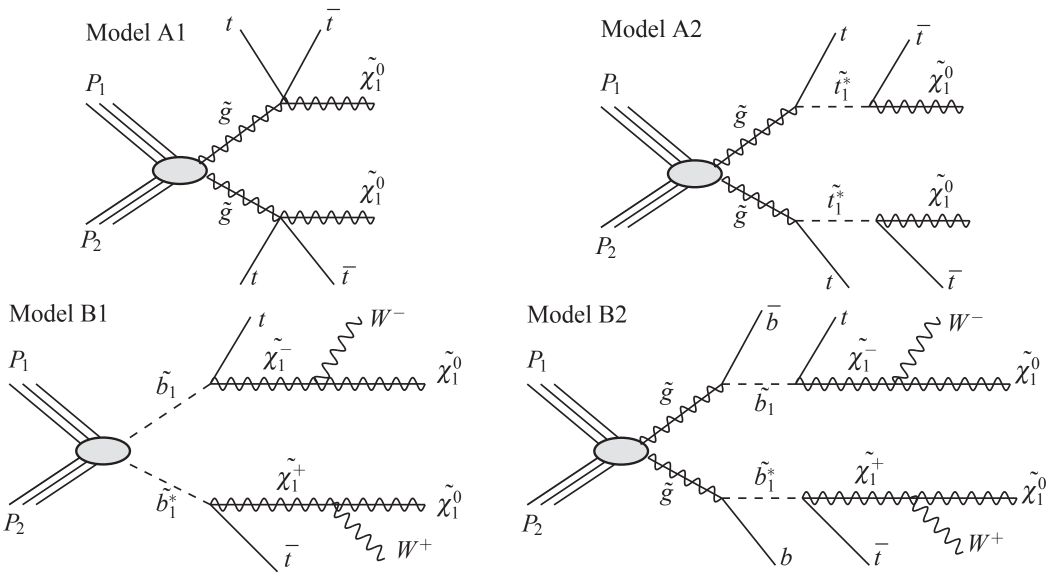

Figure 3: Diagrams for the four SUSY models considered (A1, A2, B1, and B2).

only a small dependence on the details of the models. This is because the limits are driven by the common gluino pair production cross section. In the case of bottom squark pair production (model B1) we set a limit $m(\widetilde{b}_1) > 450\,\mathrm{GeV}$ at 95% CL.

These models are also probed by other CMS new physics searches in different decay modes, although other searches have so far been interpreted in the context of model A1 but not A2, B1, or B2. For model A1 the limits given here are complementary to the limits from the single-lepton and "razor" searches [36]: less stringent at low $m(\widetilde{\chi}_1^0)$ but more stringent at high $m(\widetilde{\chi}_1^0)$. A similar conclusion applies to model A2, since the final state is the same. Comparable limits for model A1, as well as for similar models with top and bottom quarks from gluino decays, have been reported by the ATLAS collaboration [37–39]. In the case of bottom-squark pair production, the ATLAS collaboration has reported a limit $m(\widetilde{b}_1) > 390\,\mathrm{GeV}$, but assuming the decay mode $\widetilde{b}_1 \to b\widetilde{\chi}_1^0$ instead of the model B1 mode $\widetilde{b}_1 \to t\widetilde{\chi}_1^-$ [40].

9 Summary

In summary, we have presented results of a search for same-sign dileptons with bottom-quark jets using the CMS detector at the LHC, based on a $10.5\,\mathrm{fb}^{-1}$ data sample of pp collisions at $\sqrt{s}$ = 8 TeV. No significant deviations from the standard model expectations are observed.

The results are used to set upper limits on the same-sign top-pair production cross section $\sigma(\mathrm{pp} \to \mathrm{tt} + \overline{\mathrm{t}}\overline{\mathrm{t}}) < 0.87$ pb and $\sigma(\mathrm{pp} \to \mathrm{tt}) < 0.30\,\mathrm{pb}$ at the 95% confidence level.

We also exclude gluinos with masses up to approximately 1 TeV if they decay exclusively into top or bottom squarks, and we place a lower limit on the bottom-squark mass of 450 GeV. Our results assume that the top and bottom squarks decay as $\widetilde{t}_1 \to t\widetilde{\chi}_1^0$ and $\widetilde{b}_1 \to t\widetilde{\chi}_1^-$, respectively. In the latter case we have also assumed $\widetilde{\chi}_1^- \to W^-\widetilde{\chi}_1^0$.

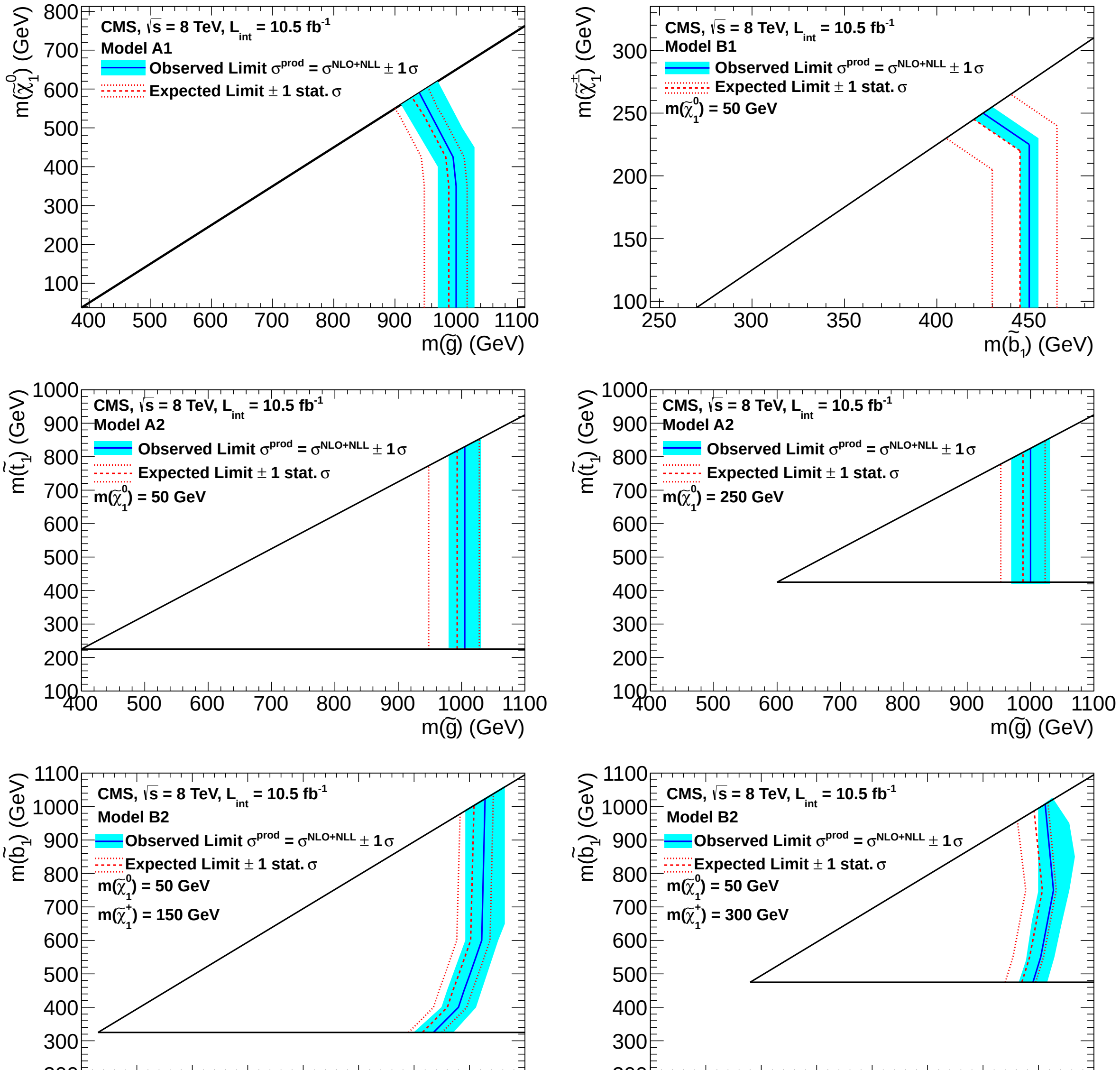

Figure 4: Exclusion regions at 95% CL in the planes of $m(\tilde{\chi}^0_1)$ vs. $m(\tilde{g})$ (model A1), $m(\tilde{\chi}^-_1)$ vs. $m(\tilde{b}_1)$ (model B1), $m(\tilde{t}_1)$ vs. $m(\tilde{g})$ (model A2), and $m(\tilde{b}_1)$ vs. $m(\tilde{g})$ (model B2). Models A2, B1, and B2 have more than two mass parameters, and cannot be fully represented in a two dimensional plot. The assumed values of the additional mass parameters are indicated in the plots. The black lines represent the kinematic boundaries of the models. The excluded regions are those within the kinematic boundaries and to the left of the bands. The effects of the theoretical uncertainties on the next-to-leading-order plus next-to-leading-log calculations of the production cross sections [35] are indicated by the shaded bands; the expected limits and their ±1 standard-deviation variations are also shown.

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References

[1] R. M. Barnett, J. F. Gunion, and H. E. Haber, “Discovering supersymmetry with like-sign dileptons”, *Phys. Lett. B* **315** (1993) 349, `doi:10.1016/0370-2693(93)91623-U`, `arXiv:hep-ph/9306204`.

[2] M. Guchait and D. P. Roy, “Like-sign dilepton signature for gluino production at CERN LHC including top quark and Higgs boson effects”, *Phys. Rev. D* **52** (1995) 133, `doi:10.1103/PhysRevD.52.133`, `arXiv:hep-ph/9412329`.

[3] H. Baer et al., “Signals for minimal supergravity at the CERN large hadron collider. II: Multi - lepton channels”, *Phys. Rev. D* **53** (1996) 6241, `doi:10.1103/PhysRevD.53.6241`, `arXiv:hep-ph/9512383`.

[4] H.-C. Cheng, K. T. Matchev, and M. Schmaltz, “Bosonic supersymmetry? Getting fooled at the CERN LHC”, *Phys. Rev. C* **66** (2002) 056006, `doi:10.1103/PhysRevD.66.056006`, `arXiv:hep-ph/0205314`.

[5] R. Contino and G. Servant, “Discovering the top partners at the LHC using same-sign dilepton final states”, *JHEP* **06** (2008) 026, `doi:10.1088/1126-6708/2008/06/026`, `arXiv:0801.1679`.

[6] F. M. L. Almeida Jr. et al., “Same-sign dileptons as a signature for heavy Majorana neutrinos in hadron-hadron collisions”, *Phys. Lett. B* **400** (1997) 331, `doi:10.1016/S0370-2693(97)00143-3`, `arXiv:hep-ph/9703441`.

[7] Y. Bai and Z. Han, “Top-antitop and top-top resonances in the dilepton channel at the CERN LHC”, *JHEP* **04** (2009) 056, `doi:10.1088/1126-6708/2009/04/056`, `arXiv:0809.4487`.

[8] E. L. Berger et al., “Top Quark Forward-Backward Asymmetry and Same-Sign Top Quark Pairs”, *Phys. Rev. Lett.* **106** (2011) 201801, `doi:10.1103/PhysRevLett.106.201801`, `arXiv:1101.5625`.

[9] A. G. Cohen, D. B. Kaplan, and A. E. Nelson, “The more Minimal Supersymmetric Standard Model”, *Phys. Lett. B* **388** (1996) 588, `doi:10.1016/S0370-2693(96)01183-5`, `arXiv:hep-ph/9607394`.

[10] S. Dimopoulos and G. F. Giudice, "Naturalness constraints in supersymmetric theories with non-universal soft terms", *Phys. Lett. B* **357** (1995) 573, `doi:10.1016/0370-2693(95)00961-J`, `arXiv:hep-ph/9507282`.

[11] R. Barbieri, G. R. Dvali, and L. J. Hall, "Predictions from a U(2) flavour symmetry in supersymmetric theories", *Phys. Lett. B* **377** (1996) 76, `doi:10.1016/0370-2693(96)00318-8`, `arXiv:hep-ph/9512388`.

[12] M. Papucci, J. T. Ruderman, and A. Weiler, "Natural SUSY Endures", *JHEP* **09** (2012) 035, `doi:10.1007/JHEP09(2012)035`, `arXiv:1110.6926`.

[13] C. Csaki, L. Randall, and J. Terning, "Light Stops from Seiberg Duality", *Phys. Rev. D* **86** (2012) 075009, `doi:10.1103/PhysRevD.86.075009`, `arXiv:1201.1293`.

[14] CMS Collaboration, "The CMS experiment at the CERN LHC", *JINST* **3** (2008) S08004, `doi:10.1088/1748-0221/3/08/S08004`.

[15] CMS Collaboration, "Search for new physics in events with same-sign dileptons and b-tagged jets in pp collisions at $\sqrt{s} = 7$ TeV", *JHEP* **08** (2012) 110, `doi:10.1007/JHEP08(2012)110`, `arXiv:1205.3933`.

[16] 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, (2009).

[17] CMS Collaboration, "Identification of b-quark jets with the CMS experiment", (2012). `arXiv:1211.4462`.

[18] J. Alwall et al., "MadGraph 5 : Going Beyond", *JHEP* **06** (2011) 128, `doi:10.1007/JHEP06(2011)128`, `arXiv:1106.0522`.

[19] T. Sjöstrand, S. Mrenna, and P. Z. Skands, "PYTHIA 6.4 physics and manual", *JHEP* **05** (2006) 026, `doi:10.1088/1126-6708/2006/05/026`, `arXiv:hep-ph/0603175`.

[20] GEANT4 Collaboration, "GEANT4–a simulation toolkit", *Nucl. Instrum. Meth. A* **506** (2003) 250, `doi:10.1016/S0168-9002(03)01368-8`.

[21] S. Abdullin et al., "The fast simulation of the CMS detector at LHC", *J. Phys. Conf. Ser.* **331** (2011) 032049, `doi:10.1088/1742-6596/331/3/032049`.

[22] CMS Collaboration, "Search for new physics with same-sign isolated dilepton events with jets and missing transverse energy at the LHC", *JHEP* **06** (2011) 077, `doi:10.1007/JHEP06(2011)077`, `arXiv:1104.3168`.

[23] J. M. Campbell and R. K. Ellis, "$t\bar{t}W^{\pm}$ production and decay at NLO", *JHEP* **07** (2012) 052, `doi:10.1007/JHEP07(2012)052`, `arXiv:1204.5678`.

[24] A. Kardos, Z. Trocsanyi, and C. Papadopoulos, "Top quark pair production in association with a Z-boson at NLO accuracy", *Phys. Rev. D* **85** (2012) 054015, `doi:10.1103/PhysRevD.85.054015`, `arXiv:1111.0610`.

[25] M. V. Garzelli et al., "Z^0-boson production in association with a $t\bar{t}$ pair at next-to-leading-order accuracy with parton shower effects", *Phys. Rev. D* **85** (2012) 074022, `doi:10.1103/PhysRevD.85.074022`, `arXiv:1111.1444`.

[26] T. Junk, "Confidence level computation for combining searches with small statistics", *Nucl. Instrum. Meth. A* **434** (1999) 435, `doi:10.1016/S0168-9002(99)00498-2`, `arXiv:hep-ex/9902006`.

[27] ATLAS and CMS Collaborations, "Procedure for the LHC Higgs boson search combination in summer 2011", ATL-PHYS-PUB-2011-011, CMS NOTE-2011/005, (2011).

[28] A. L. Read, "Presentation of search results: the CL_s technique", *J. Phys. G* **28** (2002) 2693, `doi:10.1088/0954-3899/28/10/313`.

[29] LHC New Physics Working Group Collaboration, "Simplified models for LHC new physics searches", *J. Phys. G* **39** (2012) 105005, `doi:10.1088/0954-3899/39/10/105005`, `arXiv:1105.2838`. Model of Section IV.E with topology (B+B).

[30] R. Essig et al., "Heavy Flavor Simplified Models at the LHC", *JHEP* **01** (2012) 074, `doi:10.1007/JHEP01(2012)074`, `arXiv:1110.6443`.

[31] CMS Collaboration, "Determination of jet energy calibration and transverse momentum resolution in CMS", *JINST* **6** (2011) P11002, `doi:10.1088/1748-0221/6/11/P11002`, `arXiv:1107.4277`.

[32] CMS Collaboration, "CMS luminosity based on pixel cluster counting - Summer 2012 Update", CMS Physics Analysis Summary CMS-PAS-LUM-12-001, (2012).

[33] B. S. Acharya et al., "Identifying Multi-Top Events from Gluino Decay at the LHC", (2009). `arXiv:0901.3367`.

[34] G. L. Kane et al., "Top Channel for Early SUSY Discovery at the LHC", *Phys. Rev. D* **84** (2011) 095004, `doi:10.1103/PhysRevD.84.095004`, `arXiv:1101.1963`.

[35] M. Krämer et al., "Supersymmetry production cross sections in pp collisions at $\sqrt{s} = 7$ TeV", (2012). `arXiv:1206.2892`. Unpublished.

[36] CMS Collaboration, "Interpretation of searches for supersymmetry with simplified models", (2013). `arXiv:1301.2175`.

[37] ATLAS Collaboration, "Search for Gluinos in Events with Two Same-Sign Leptons, Jets and Missing Transverse Momentum with the ATLAS Detector in pp Collisions at $\sqrt{s} = 7$ TeV", *Phys. Rev. Lett.* **108** (2012) 241802, `doi:10.1103/PhysRevLett.108.241802`, `arXiv:1203.5763`.

[38] ATLAS Collaboration, "Search for supersymmetry in pp collisions at $\sqrt{s} = 7$ TeV in final states with missing transverse momentum and b-jets with the ATLAS detector", *Phys. Rev. D* **85** (2012) 112006, `doi:10.1103/PhysRevD.85.112006`, `arXiv:1203.6193`.

[39] ATLAS Collaboration, "Search for top and bottom squarks from gluino pair production in final states with missing transverse energy and at least three b-jets with the ATLAS detector", *Eur. Phys. J. C* **72** (2012) 2174, `doi:10.1140/epjc/s10052-012-2174-z`, `arXiv:1207.4686`.

[40] ATLAS Collaboration, "Search for Scalar Bottom Quark Pair Production with the ATLAS Detector in pp Collisions at $\sqrt{s} = 7$ TeV", *Phys. Rev. Lett.* **108** (2012) 181802, `doi:10.1103/PhysRevLett.108.181802`, `arXiv:1112.3832`.

A The CMS Collaboration

Yerevan Physics Institute, Yerevan, Armenia
S. Chatrchyan, V. Khachatryan, A.M. Sirunyan, A. Tumasyan

Institut für Hochenergiephysik der OeAW, Wien, Austria
W. Adam, E. Aguilo, T. Bergauer, M. Dragicevic, J. Erö, C. Fabjan[1], M. Friedl, R. Frühwirth[1], V.M. Ghete, N. Hörmann, J. Hrubec, M. Jeitler[1], W. Kiesenhofer, V. Knünz, M. Krammer[1], I. Krätschmer, D. Liko, I. Mikulec, M. Pernicka[†], D. Rabady[2], B. Rahbaran, C. Rohringer, H. Rohringer, R. Schöfbeck, J. Strauss, A. Taurok, W. Waltenberger, C.-E. Wulz[1]

National Centre for Particle and High Energy Physics, Minsk, Belarus
V. Mossolov, N. Shumeiko, J. Suarez Gonzalez

Universiteit Antwerpen, Antwerpen, Belgium
M. Bansal, S. Bansal, T. Cornelis, E.A. De Wolf, X. Janssen, S. Luyckx, L. Mucibello, S. Ochesanu, B. Roland, R. Rougny, M. Selvaggi, H. Van Haevermaet, P. Van Mechelen, N. Van Remortel, A. Van Spilbeeck

Vrije Universiteit Brussel, Brussel, Belgium
F. Blekman, S. Blyweert, J. D'Hondt, R. Gonzalez Suarez, A. Kalogeropoulos, M. Maes, A. Olbrechts, W. Van Doninck, P. Van Mulders, G.P. Van Onsem, I. Villella

Université Libre de Bruxelles, Bruxelles, Belgium
B. Clerbaux, G. De Lentdecker, V. Dero, A.P.R. Gay, T. Hreus, A. Léonard, P.E. Marage, A. Mohammadi, T. Reis, L. Thomas, C. Vander Velde, P. Vanlaer, J. Wang

Ghent University, Ghent, Belgium
V. Adler, K. Beernaert, A. Cimmino, S. Costantini, G. Garcia, M. Grunewald, B. Klein, J. Lellouch, A. Marinov, J. Mccartin, A.A. Ocampo Rios, D. Ryckbosch, M. Sigamani, N. Strobbe, F. Thyssen, M. Tytgat, S. Walsh, E. Yazgan, N. Zaganidis

Université Catholique de Louvain, Louvain-la-Neuve, Belgium
S. Basegmez, G. Bruno, R. Castello, L. Ceard, C. Delaere, T. du Pree, D. Favart, L. Forthomme, A. Giammanco[3], J. Hollar, V. Lemaitre, J. Liao, O. Militaru, C. Nuttens, D. Pagano, A. Pin, K. Piotrzkowski, J.M. Vizan Garcia

Université de Mons, Mons, Belgium
N. Beliy, T. Caebergs, E. Daubie, G.H. Hammad

Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil
G.A. Alves, M. Correa Martins Junior, T. Martins, M.E. Pol, M.H.G. Souza

Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil
W.L. Aldá Júnior, W. Carvalho, A. Custódio, E.M. Da Costa, D. De Jesus Damiao, C. De Oliveira Martins, S. Fonseca De Souza, H. Malbouisson, M. Malek, D. Matos Figueiredo, L. Mundim, H. Nogima, W.L. Prado Da Silva, A. Santoro, L. Soares Jorge, A. Sznajder, A. Vilela Pereira

Universidade Estadual Paulista [a], Universidade Federal do ABC [b], São Paulo, Brazil
T.S. Anjos[b], C.A. Bernardes[b], F.A. Dias[a,4], T.R. Fernandez Perez Tomei[a], E.M. Gregores[b], C. Lagana[a], F. Marinho[a], P.G. Mercadante[b], S.F. Novaes[a], Sandra S. Padula[a]

Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria
V. Genchev[2], P. Iaydjiev[2], S. Piperov, M. Rodozov, S. Stoykova, G. Sultanov, V. Tcholakov, R. Trayanov, M. Vutova

University of Sofia, Sofia, Bulgaria
A. Dimitrov, R. Hadjiiska, V. Kozhuharov, L. Litov, B. Pavlov, P. Petkov

Institute of High Energy Physics, Beijing, China
J.G. Bian, G.M. Chen, H.S. Chen, C.H. Jiang, D. Liang, S. Liang, X. Meng, J. Tao, J. Wang, X. Wang, Z. Wang, H. Xiao, M. Xu, J. Zang, Z. Zhang

State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China
C. Asawatangtrakuldee, Y. Ban, Y. Guo, W. Li, S. Liu, Y. Mao, S.J. Qian, H. Teng, D. Wang, L. Zhang, W. Zou

Universidad de Los Andes, Bogota, Colombia
C. Avila, C.A. Carrillo Montoya, J.P. Gomez, B. Gomez Moreno, A.F. Osorio Oliveros, J.C. Sanabria

Technical University of Split, Split, Croatia
N. Godinovic, D. Lelas, R. Plestina[5], D. Polic, I. Puljak[2]

University of Split, Split, Croatia
Z. Antunovic, M. Kovac

Institute Rudjer Boskovic, Zagreb, Croatia
V. Brigljevic, S. Duric, K. Kadija, J. Luetic, D. Mekterovic, S. Morovic

University of Cyprus, Nicosia, Cyprus
A. Attikis, M. Galanti, G. Mavromanolakis, J. Mousa, C. Nicolaou, F. Ptochos, P.A. Razis

Charles University, Prague, Czech Republic
M. Finger, M. Finger Jr.

Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt
Y. Assran[6], S. Elgammal[7], A. Ellithi Kamel[8], M.A. Mahmoud[9], A. Mahrous[10], A. Radi[11,12]

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia
M. Kadastik, M. Müntel, M. Murumaa, M. Raidal, L. Rebane, A. Tiko

Department of Physics, University of Helsinki, Helsinki, Finland
P. Eerola, G. Fedi, M. Voutilainen

Helsinki Institute of Physics, Helsinki, Finland
J. Härkönen, A. Heikkinen, V. Karimäki, R. Kinnunen, M.J. Kortelainen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Mäenpää, T. Peltola, E. Tuominen, J. Tuominiemi, E. Tuovinen, D. Ungaro, L. Wendland

Lappeenranta University of Technology, Lappeenranta, Finland
K. Banzuzi, A. Karjalainen, A. Korpela, T. Tuuva

DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France
M. Besancon, S. Choudhury, M. Dejardin, D. Denegri, B. Fabbro, J.L. Faure, F. Ferri, S. Ganjour, A. Givernaud, P. Gras, G. Hamel de Monchenault, P. Jarry, E. Locci, J. Malcles, L. Millischer, A. Nayak, J. Rander, A. Rosowsky, M. Titov

Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France
S. Baffioni, F. Beaudette, L. Benhabib, L. Bianchini, M. Bluj[13], P. Busson, C. Charlot, N. Daci, T. Dahms, M. Dalchenko, L. Dobrzynski, A. Florent, R. Granier de Cassagnac, M. Haguenauer,

P. Miné, C. Mironov, I.N. Naranjo, M. Nguyen, C. Ochando, P. Paganini, D. Sabes, R. Salerno, Y. Sirois, C. Veelken, A. Zabi

Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France
J.-L. Agram[14], J. Andrea, D. Bloch, D. Bodin, J.-M. Brom, M. Cardaci, E.C. Chabert, C. Collard, E. Conte[14], F. Drouhin[14], J.-C. Fontaine[14], D. Gelé, U. Goerlach, P. Juillot, A.-C. Le Bihan, P. Van Hove

Centre de Calcul de l'Institut National de Physique Nucleaire et de Physique des Particules, CNRS/IN2P3, Villeurbanne, France
F. Fassi, D. Mercier

Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France
S. Beauceron, N. Beaupere, O. Bondu, G. Boudoul, S. Brochet, J. Chasserat, R. Chierici[2], D. Contardo, P. Depasse, H. El Mamouni, J. Fay, S. Gascon, M. Gouzevitch, B. Ille, T. Kurca, M. Lethuillier, L. Mirabito, S. Perries, L. Sgandurra, V. Sordini, Y. Tschudi, P. Verdier, S. Viret

Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, Georgia
Z. Tsamalaidze[15]

RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany
C. Autermann, S. Beranek, B. Calpas, M. Edelhoff, L. Feld, N. Heracleous, O. Hindrichs, R. Jussen, K. Klein, J. Merz, A. Ostapchuk, A. Perieanu, F. Raupach, J. Sammet, S. Schael, D. Sprenger, H. Weber, B. Wittmer, V. Zhukov[16]

RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany
M. Ata, J. Caudron, E. Dietz-Laursonn, D. Duchardt, M. Erdmann, R. Fischer, A. Güth, T. Hebbeker, C. Heidemann, K. Hoepfner, D. Klingebiel, P. Kreuzer, M. Merschmeyer, A. Meyer, M. Olschewski, P. Papacz, H. Pieta, H. Reithler, S.A. Schmitz, L. Sonnenschein, J. Steggemann, D. Teyssier, S. Thüer, M. Weber

RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany
M. Bontenackels, V. Cherepanov, Y. Erdogan, G. Flügge, H. Geenen, M. Geisler, W. Haj Ahmad, F. Hoehle, B. Kargoll, T. Kress, Y. Kuessel, J. Lingemann[2], A. Nowack, L. Perchalla, O. Pooth, P. Sauerland, A. Stahl

Deutsches Elektronen-Synchrotron, Hamburg, Germany
M. Aldaya Martin, J. Behr, W. Behrenhoff, U. Behrens, M. Bergholz[17], A. Bethani, K. Borras, A. Burgmeier, A. Cakir, L. Calligaris, A. Campbell, E. Castro, F. Costanza, D. Dammann, C. Diez Pardos, G. Eckerlin, D. Eckstein, G. Flucke, A. Geiser, I. Glushkov, P. Gunnellini, S. Habib, J. Hauk, G. Hellwig, H. Jung, M. Kasemann, P. Katsas, C. Kleinwort, H. Kluge, A. Knutsson, M. Krämer, D. Krücker, E. Kuznetsova, W. Lange, J. Leonard, W. Lohmann[17], B. Lutz, R. Mankel, I. Marfin, M. Marienfeld, I.-A. Melzer-Pellmann, A.B. Meyer, J. Mnich, A. Mussgiller, S. Naumann-Emme, O. Novgorodova, J. Olzem, H. Perrey, A. Petrukhin, D. Pitzl, A. Raspereza, P.M. Ribeiro Cipriano, C. Riedl, E. Ron, M. Rosin, J. Salfeld-Nebgen, R. Schmidt[17], T. Schoerner-Sadenius, N. Sen, A. Spiridonov, M. Stein, R. Walsh, C. Wissing

University of Hamburg, Hamburg, Germany
V. Blobel, H. Enderle, J. Erfle, U. Gebbert, M. Görner, M. Gosselink, J. Haller, T. Hermanns, R.S. Höing, K. Kaschube, G. Kaussen, H. Kirschenmann, R. Klanner, J. Lange, F. Nowak, T. Peiffer, N. Pietsch, D. Rathjens, C. Sander, H. Schettler, P. Schleper, E. Schlieckau, A. Schmidt,

M. Schröder, T. Schum, M. Seidel, J. Sibille[18], V. Sola, H. Stadie, G. Steinbrück, J. Thomsen, L. Vanelderen

Institut für Experimentelle Kernphysik, Karlsruhe, Germany
C. Barth, J. Berger, C. Böser, T. Chwalek, W. De Boer, A. Descroix, A. Dierlamm, M. Feindt, M. Guthoff[2], C. Hackstein, F. Hartmann[2], T. Hauth[2], M. Heinrich, H. Held, K.H. Hoffmann, U. Husemann, I. Katkov[16], J.R. Komaragiri, P. Lobelle Pardo, D. Martschei, S. Mueller, Th. Müller, M. Niegel, A. Nürnberg, O. Oberst, A. Oehler, J. Ott, G. Quast, K. Rabbertz, F. Ratnikov, N. Ratnikova, S. Röcker, F.-P. Schilling, G. Schott, H.J. Simonis, F.M. Stober, D. Troendle, R. Ulrich, J. Wagner-Kuhr, S. Wayand, T. Weiler, M. Zeise

Institute of Nuclear Physics "Demokritos", Aghia Paraskevi, Greece
G. Anagnostou, G. Daskalakis, T. Geralis, S. Kesisoglou, A. Kyriakis, D. Loukas, I. Manolakos, A. Markou, C. Markou, E. Ntomari

University of Athens, Athens, Greece
L. Gouskos, T.J. Mertzimekis, A. Panagiotou, N. Saoulidou

University of Ioánnina, Ioánnina, Greece
I. Evangelou, C. Foudas, P. Kokkas, N. Manthos, I. Papadopoulos, V. Patras

KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
G. Bencze, C. Hajdu, P. Hidas, D. Horvath[19], F. Sikler, V. Veszpremi, G. Vesztergombi[20], A.J. Zsigmond

Institute of Nuclear Research ATOMKI, Debrecen, Hungary
N. Beni, S. Czellar, J. Molnar, J. Palinkas, Z. Szillasi

University of Debrecen, Debrecen, Hungary
J. Karancsi, P. Raics, Z.L. Trocsanyi, B. Ujvari

Panjab University, Chandigarh, India
S.B. Beri, V. Bhatnagar, N. Dhingra, R. Gupta, M. Kaur, M.Z. Mehta, N. Nishu, L.K. Saini, A. Sharma, J.B. Singh

University of Delhi, Delhi, India
Ashok Kumar, Arun Kumar, S. Ahuja, A. Bhardwaj, B.C. Choudhary, S. Malhotra, M. Naimuddin, K. Ranjan, V. Sharma, R.K. Shivpuri

Saha Institute of Nuclear Physics, Kolkata, India
S. Banerjee, S. Bhattacharya, S. Dutta, B. Gomber, Sa. Jain, Sh. Jain, R. Khurana, S. Sarkar, M. Sharan

Bhabha Atomic Research Centre, Mumbai, India
A. Abdulsalam, D. Dutta, S. Kailas, V. Kumar, A.K. Mohanty[2], L.M. Pant, P. Shukla

Tata Institute of Fundamental Research - EHEP, Mumbai, India
T. Aziz, S. Ganguly, M. Guchait[21], A. Gurtu[22], M. Maity[23], G. Majumder, K. Mazumdar, G.B. Mohanty, B. Parida, K. Sudhakar, N. Wickramage

Tata Institute of Fundamental Research - HECR, Mumbai, India
S. Banerjee, S. Dugad

Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
H. Arfaei[24], H. Bakhshiansohi, S.M. Etesami[25], A. Fahim[24], M. Hashemi[26], H. Hesari, A. Jafari, M. Khakzad, M. Mohammadi Najafabadi, S. Paktinat Mehdiabadi, B. Safarzadeh[27], M. Zeinali

INFN Sezione di Bari[a], Università di Bari[b], Politecnico di Bari[c], Bari, Italy
M. Abbrescia[a,b], L. Barbone[a,b], C. Calabria[a,b,2], S.S. Chhibra[a,b], A. Colaleo[a], D. Creanza[a,c], N. De Filippis[a,c,2], M. De Palma[a,b], L. Fiore[a], G. Iaselli[a,c], G. Maggi[a,c], M. Maggi[a], B. Marangelli[a,b], S. My[a,c], S. Nuzzo[a,b], N. Pacifico[a], A. Pompili[a,b], G. Pugliese[a,c], G. Selvaggi[a,b], L. Silvestris[a], G. Singh[a,b], R. Venditti[a,b], P. Verwilligen[a], G. Zito[a]

INFN Sezione di Bologna[a], Università di Bologna[b], Bologna, Italy
G. Abbiendi[a], A.C. Benvenuti[a], D. Bonacorsi[a,b], S. Braibant-Giacomelli[a,b], L. Brigliadori[a,b], P. Capiluppi[a,b], A. Castro[a,b], F.R. Cavallo[a], 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], M. Meneghelli[a,b,2], A. Montanari[a], F.L. Navarria[a,b], F. Odorici[a], A. Perrotta[a], F. Primavera[a,b], A.M. Rossi[a,b], T. Rovelli[a,b], G.P. Siroli[a,b], N. Tosi, R. Travaglini[a,b]

INFN Sezione di Catania[a], Università di Catania[b], Catania, Italy
S. Albergo[a,b], G. Cappello[a,b], M. Chiorboli[a,b], S. Costa[a,b], R. Potenza[a,b], A. Tricomi[a,b], C. Tuve[a,b]

INFN Sezione di Firenze[a], Università di Firenze[b], Firenze, Italy
G. Barbagli[a], V. Ciulli[a,b], C. Civinini[a], R. D'Alessandro[a,b], E. Focardi[a,b], S. Frosali[a,b], E. Gallo[a], S. Gonzi[a,b], M. Meschini[a], S. Paoletti[a], G. Sguazzoni[a], A. Tropiano[a,b]

INFN Laboratori Nazionali di Frascati, Frascati, Italy
L. Benussi, S. Bianco, S. Colafranceschi[28], F. Fabbri, D. Piccolo

INFN Sezione di Genova[a], Università di Genova[b], Genova, Italy
P. Fabbricatore[a], R. Musenich[a], S. Tosi[a,b]

INFN Sezione di Milano-Bicocca[a], Università di Milano-Bicocca[b], Milano, Italy
A. Benaglia[a], F. De Guio[a,b], L. Di Matteo[a,b,2], S. Fiorendi[a,b], S. Gennai[a,2], A. Ghezzi[a,b], S. Malvezzi[a], R.A. Manzoni[a,b], A. Martelli[a,b], A. Massironi[a,b], D. Menasce[a], L. Moroni[a], M. Paganoni[a,b], D. Pedrini[a], S. Ragazzi[a,b], N. Redaelli[a], S. Sala[a], T. Tabarelli de Fatis[a,b]

INFN Sezione di Napoli[a], Università di Napoli 'Federico II'[b], Università della Basilicata (Potenza)[c], Università G. Marconi (Roma)[d], Napoli, Italy
S. Buontempo[a], N. Cavallo[a,c], A. De Cosa[a,b,2], O. Dogangun[a,b], F. Fabozzi[a,c], A.O.M. Iorio[a,b], L. Lista[a], S. Meola[a,d,29], M. Merola[a], P. Paolucci[a,2]

INFN Sezione di Padova[a], Università di Padova[b], Università di Trento (Trento)[c], Padova, Italy
P. Azzi[a], N. Bacchetta[a,2], D. Bisello[a,b], A. Branca[a,b,2], R. Carlin[a,b], P. Checchia[a], T. Dorigo[a], F. Gasparini[a,b], U. Gasparini[a,b], A. Gozzelino[a], K. Kanishchev[a,c], S. Lacaprara[a], I. Lazzizzera[a,c], M. Margoni[a,b], A.T. Meneguzzo[a,b], J. Pazzini[a,b], N. Pozzobon[a,b], P. Ronchese[a,b], F. Simonetto[a,b], E. Torassa[a], M. Tosi[a,b], S. Vanini[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
M. Gabusi[a,b], S.P. Ratti[a,b], C. Riccardi[a,b], P. Torre[a,b], P. Vitulo[a,b]

INFN Sezione di Perugia[a], Università di Perugia[b], Perugia, Italy
M. Biasini[a,b], G.M. Bilei[a], L. Fanò[a,b], P. Lariccia[a,b], G. Mantovani[a,b], M. Menichelli[a], A. Nappi[a,b†], F. Romeo[a,b], A. Saha[a], A. Santocchia[a,b], A. Spiezia[a,b], S. Taroni[a,b]

INFN Sezione di Pisa[a], Università di Pisa[b], Scuola Normale Superiore di Pisa[c], Pisa, Italy
P. Azzurri[a,c], G. Bagliesi[a], J. Bernardini[a], T. Boccali[a], G. Broccolo[a,c], R. Castaldi[a], R.T. D'Agnolo[a,c,2], R. Dell'Orso[a], F. Fiori[a,b,2], L. Foà[a,c], A. Giassi[a], A. Kraan[a], F. Ligabue[a,c], T. Lomtadze[a], L. Martini[a,30], A. Messineo[a,b], F. Palla[a], A. Rizzi[a,b], A.T. Serban[a,31], P. Spagnolo[a], P. Squillacioti[a,2], R. Tenchini[a], G. Tonelli[a,b], A. Venturi[a], P.G. Verdini[a]

INFN Sezione di Roma [a], Università di Roma [b], Roma, Italy
L. Barone[a,b], F. Cavallari[a], D. Del Re[a,b], M. Diemoz[a], C. Fanelli[a,b], M. Grassi[a,b,2], E. Longo[a,b], P. Meridiani[a,2], F. Micheli[a,b], S. Nourbakhsh[a,b], G. Organtini[a,b], R. Paramatti[a], S. Rahatlou[a,b], L. Soffi[a,b]

INFN Sezione di Torino [a], Università di Torino [b], Università del Piemonte Orientale (Novara) [c], Torino, Italy
N. Amapane[a,b], R. Arcidiacono[a,c], S. Argiro[a,b], M. Arneodo[a,c], C. Biino[a], N. Cartiglia[a], S. Casasso[a,b], M. Costa[a,b], N. Demaria[a], C. Mariotti[a,2], S. Maselli[a], E. Migliore[a,b], V. Monaco[a,b], M. Musich[a,2], M.M. Obertino[a,c], N. Pastrone[a], M. Pelliccioni[a], A. Potenza[a,b], A. Romero[a,b], M. Ruspa[a,c], R. Sacchi[a,b], A. Solano[a,b], A. Staiano[a]

INFN Sezione di Trieste [a], Università di Trieste [b], Trieste, Italy
S. Belforte[a], V. Candelise[a,b], M. Casarsa[a], F. Cossutti[a], G. Della Ricca[a,b], B. Gobbo[a], M. Marone[a,b,2], D. Montanino[a,b,2], A. Penzo[a], A. Schizzi[a,b]

Kangwon National University, Chunchon, Korea
T.Y. Kim, S.K. Nam

Kyungpook National University, Daegu, Korea
S. Chang, D.H. Kim, G.N. Kim, D.J. Kong, H. Park, D.C. Son, T. Son

Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea
J.Y. Kim, Zero J. Kim, S. Song

Korea University, Seoul, Korea
S. Choi, D. Gyun, B. Hong, M. Jo, H. Kim, T.J. Kim, K.S. Lee, D.H. Moon, S.K. Park, Y. Roh

University of Seoul, Seoul, Korea
M. Choi, J.H. Kim, C. Park, I.C. Park, S. Park, G. Ryu

Sungkyunkwan University, Suwon, Korea
Y. Choi, Y.K. Choi, J. Goh, M.S. Kim, E. Kwon, B. Lee, J. Lee, S. Lee, H. Seo, I. Yu

Vilnius University, Vilnius, Lithuania
M.J. Bilinskas, I. Grigelionis, M. Janulis, A. Juodagalvis

Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico
H. Castilla-Valdez, E. De La Cruz-Burelo, I. Heredia-de La Cruz, R. Lopez-Fernandez, J. Martínez-Ortega, A. Sanchez-Hernandez, L.M. Villasenor-Cendejas

Universidad Iberoamericana, Mexico City, Mexico
S. Carrillo Moreno, F. Vazquez Valencia

Benemerita Universidad Autonoma de Puebla, Puebla, Mexico
H.A. Salazar Ibarguen

Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico
E. Casimiro Linares, A. Morelos Pineda, M.A. Reyes-Santos

University of Auckland, Auckland, New Zealand
D. Krofcheck

University of Canterbury, Christchurch, New Zealand
A.J. Bell, P.H. Butler, R. Doesburg, S. Reucroft, H. Silverwood

National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan
M. Ahmad, M.I. Asghar, J. Butt, H.R. Hoorani, S. Khalid, W.A. Khan, T. Khurshid, S. Qazi, M.A. Shah, M. Shoaib

National Centre for Nuclear Research, Swierk, Poland
H. Bialkowska, B. Boimska, T. Frueboes, M. Górski, M. Kazana, K. Nawrocki, K. Romanowska-Rybinska, M. Szleper, G. Wrochna, P. Zalewski

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland
G. Brona, K. Bunkowski, M. Cwiok, W. Dominik, K. Doroba, A. Kalinowski, M. Konecki, J. Krolikowski, M. Misiura

Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal
N. Almeida, P. Bargassa, A. David, P. Faccioli, P.G. Ferreira Parracho, M. Gallinaro, J. Seixas, J. Varela, P. Vischia

Joint Institute for Nuclear Research, Dubna, Russia
I. Belotelov, P. Bunin, M. Gavrilenko, I. Golutvin, I. Gorbunov, A. Kamenev, V. Karjavin, G. Kozlov, A. Lanev, A. Malakhov, P. Moisenz, V. Palichik, V. Perelygin, S. Shmatov, V. Smirnov, A. Volodko, A. Zarubin

Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia
S. Evstyukhin, V. Golovtsov, Y. Ivanov, V. Kim, P. Levchenko, V. Murzin, V. Oreshkin, I. Smirnov, V. Sulimov, L. Uvarov, S. Vavilov, A. Vorobyev, An. Vorobyev

Institute for Nuclear Research, Moscow, Russia
Yu. Andreev, A. Dermenev, S. Gninenko, N. Golubev, M. Kirsanov, N. Krasnikov, V. Matveev, A. Pashenkov, D. Tlisov, A. Toropin

Institute for Theoretical and Experimental Physics, Moscow, Russia
V. Epshteyn, M. Erofeeva, V. Gavrilov, M. Kossov, N. Lychkovskaya, V. Popov, G. Safronov, S. Semenov, I. Shreyber, V. Stolin, E. Vlasov, A. Zhokin

Moscow State University, Moscow, Russia
A. Belyaev, E. Boos, V. Bunichev, M. Dubinin[4], L. Dudko, A. Ershov, A. Gribushin, V. Klyukhin, O. Kodolova, I. Lokhtin, A. Markina, S. Obraztsov, M. Perfilov, S. Petrushanko, A. Popov, L. Sarycheva[†], V. Savrin

P.N. Lebedev Physical Institute, Moscow, Russia
V. Andreev, M. Azarkin, I. Dremin, M. Kirakosyan, A. Leonidov, G. Mesyats, S.V. Rusakov, A. Vinogradov

State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia
I. Azhgirey, I. Bayshev, S. Bitioukov, V. Grishin[2], V. Kachanov, D. Konstantinov, V. Krychkine, V. Petrov, R. Ryutin, A. Sobol, L. Tourtchanovitch, S. Troshin, N. Tyurin, A. Uzunian, A. Volkov

University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia
P. Adzic[32], M. Djordjevic, M. Ekmedzic, D. Krpic[32], J. Milosevic

Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain
M. Aguilar-Benitez, J. Alcaraz Maestre, P. Arce, C. Battilana, E. Calvo, M. Cerrada, M. Chamizo Llatas, N. Colino, B. De La Cruz, A. Delgado Peris, D. Domínguez Vázquez, C. Fernandez

Bedoya, J.P. Fernández Ramos, A. Ferrando, J. Flix, M.C. Fouz, P. Garcia-Abia, O. Gonzalez Lopez, S. Goy Lopez, J.M. Hernandez, M.I. Josa, G. Merino, J. Puerta Pelayo, A. Quintario Olmeda, I. Redondo, L. Romero, J. Santaolalla, M.S. Soares, C. Willmott

Universidad Autónoma de Madrid, Madrid, Spain
C. Albajar, G. Codispoti, J.F. de Trocóniz

Universidad de Oviedo, Oviedo, Spain
H. Brun, J. Cuevas, J. Fernandez Menendez, S. Folgueras, I. Gonzalez Caballero, L. Lloret Iglesias, J. Piedra Gomez

Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain
J.A. Brochero Cifuentes, I.J. Cabrillo, A. Calderon, S.H. Chuang, J. Duarte Campderros, M. Felcini[33], M. Fernandez, G. Gomez, J. Gonzalez Sanchez, A. Graziano, C. Jorda, A. Lopez Virto, J. Marco, R. Marco, C. Martinez Rivero, F. Matorras, F.J. Munoz Sanchez, T. Rodrigo, A.Y. Rodríguez-Marrero, A. Ruiz-Jimeno, L. Scodellaro, I. Vila, R. Vilar Cortabitarte

CERN, European Organization for Nuclear Research, Geneva, Switzerland
D. Abbaneo, E. Auffray, G. Auzinger, M. Bachtis, P. Baillon, A.H. Ball, D. Barney, J.F. Benitez, C. Bernet[5], G. Bianchi, P. Bloch, A. Bocci, A. Bonato, C. Botta, H. Breuker, T. Camporesi, G. Cerminara, T. Christiansen, J.A. Coarasa Perez, D. D'Enterria, A. Dabrowski, A. De Roeck, S. Di Guida, M. Dobson, N. Dupont-Sagorin, A. Elliott-Peisert, B. Frisch, W. Funk, G. Georgiou, M. Giffels, D. Gigi, K. Gill, D. Giordano, M. Girone, M. Giunta, F. Glege, R. Gomez-Reino Garrido, P. Govoni, S. Gowdy, R. Guida, S. Gundacker, J. Hammer, M. Hansen, P. Harris, C. Hartl, J. Harvey, B. Hegner, A. Hinzmann, V. Innocente, P. Janot, K. Kaadze, E. Karavakis, K. Kousouris, P. Lecoq, Y.-J. Lee, P. Lenzi, C. Lourenço, N. Magini, T. Mäki, M. Malberti, L. Malgeri, M. Mannelli, L. Masetti, F. Meijers, S. Mersi, E. Meschi, R. Moser, M.U. Mozer, M. Mulders, P. Musella, E. Nesvold, L. Orsini, E. Palencia Cortezon, E. Perez, L. Perrozzi, A. Petrilli, A. Pfeiffer, M. Pierini, M. Pimiä, D. Piparo, G. Polese, L. Quertenmont, A. Racz, W. Reece, J. Rodrigues Antunes, G. Rolandi[34], C. Rovelli[35], M. Rovere, H. Sakulin, F. Santanastasio, C. Schäfer, C. Schwick, I. Segoni, S. Sekmen, A. Sharma, P. Siegrist, P. Silva, M. Simon, P. Sphicas[36], D. Spiga, A. Tsirou, G.I. Veres[20], J.R. Vlimant, H.K. Wöhri, S.D. Worm[37], W.D. Zeuner

Paul Scherrer Institut, Villigen, Switzerland
W. Bertl, K. Deiters, W. Erdmann, K. Gabathuler, R. Horisberger, Q. Ingram, H.C. Kaestli, S. König, D. Kotlinski, U. Langenegger, F. Meier, D. Renker, T. Rohe

Institute for Particle Physics, ETH Zurich, Zurich, Switzerland
L. Bäni, P. Bortignon, M.A. Buchmann, B. Casal, N. Chanon, A. Deisher, G. Dissertori, M. Dittmar, M. Donegà, M. Dünser, P. Eller, J. Eugster, K. Freudenreich, C. Grab, D. Hits, P. Lecomte, W. Lustermann, A.C. Marini, P. Martinez Ruiz del Arbol, N. Mohr, F. Moortgat, C. Nägeli[38], P. Nef, F. Nessi-Tedaldi, F. Pandolfi, L. Pape, F. Pauss, M. Peruzzi, F.J. Ronga, M. Rossini, L. Sala, A.K. Sanchez, A. Starodumov[39], B. Stieger, M. Takahashi, L. Tauscher[†], A. Thea, K. Theofilatos, D. Treille, C. Urscheler, R. Wallny, H.A. Weber, L. Wehrli

Universität Zürich, Zurich, Switzerland
C. Amsler[40], V. Chiochia, S. De Visscher, C. Favaro, M. Ivova Rikova, B. Kilminster, B. Millan Mejias, P. Otiougova, P. Robmann, H. Snoek, S. Tupputi, M. Verzetti

National Central University, Chung-Li, Taiwan
Y.H. Chang, K.H. Chen, C. Ferro, C.M. Kuo, S.W. Li, W. Lin, Y.J. Lu, A.P. Singh, R. Volpe, S.S. Yu

National Taiwan University (NTU), Taipei, Taiwan
P. Bartalini, P. Chang, Y.H. Chang, Y.W. Chang, Y. Chao, K.F. Chen, C. Dietz, U. Grundler, W.-S. Hou, Y. Hsiung, K.Y. Kao, Y.J. Lei, R.-S. Lu, D. Majumder, E. Petrakou, X. Shi, J.G. Shiu, Y.M. Tzeng, X. Wan, M. Wang

Chulalongkorn University, Bangkok, Thailand
B. Asavapibhop, N. Suwonjandee

Cukurova University, Adana, Turkey
A. Adiguzel, M.N. Bakirci[41], S. Cerci[42], C. Dozen, I. Dumanoglu, E. Eskut, S. Girgis, G. Gokbulut, E. Gurpinar, I. Hos, E.E. Kangal, T. Karaman, G. Karapinar[43], A. Kayis Topaksu, G. Onengut, K. Ozdemir, S. Ozturk[44], A. Polatoz, K. Sogut[45], D. Sunar Cerci[42], B. Tali[42], H. Topakli[41], L.N. Vergili, M. Vergili

Middle East Technical University, Physics Department, Ankara, Turkey
I.V. Akin, T. Aliev, B. Bilin, S. Bilmis, M. Deniz, H. Gamsizkan, A.M. Guler, K. Ocalan, A. Ozpineci, M. Serin, R. Sever, U.E. Surat, M. Yalvac, E. Yildirim, M. Zeyrek

Bogazici University, Istanbul, Turkey
E. Gülmez, B. Isildak[46], M. Kaya[47], O. Kaya[47], S. Ozkorucuklu[48], N. Sonmez[49]

Istanbul Technical University, Istanbul, Turkey
K. Cankocak

National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine
L. Levchuk

University of Bristol, Bristol, United Kingdom
J.J. Brooke, E. Clement, D. Cussans, H. Flacher, R. Frazier, J. Goldstein, M. Grimes, G.P. Heath, H.F. Heath, L. Kreczko, S. Metson, D.M. Newbold[37], K. Nirunpong, A. Poll, S. Senkin, V.J. Smith, T. Williams

Rutherford Appleton Laboratory, Didcot, United Kingdom
L. Basso[50], K.W. Bell, A. Belyaev[50], C. Brew, R.M. Brown, D.J.A. Cockerill, J.A. Coughlan, K. Harder, S. Harper, J. Jackson, B.W. Kennedy, E. Olaiya, D. Petyt, B.C. Radburn-Smith, C.H. Shepherd-Themistocleous, I.R. Tomalin, W.J. Womersley

Imperial College, London, United Kingdom
R. Bainbridge, G. Ball, R. Beuselinck, O. Buchmuller, D. Colling, N. Cripps, M. Cutajar, P. Dauncey, G. Davies, M. Della Negra, W. Ferguson, J. Fulcher, D. Futyan, A. Gilbert, A. Guneratne Bryer, G. Hall, Z. Hatherell, J. Hays, G. Iles, M. Jarvis, G. Karapostoli, L. Lyons, A.-M. Magnan, J. Marrouche, B. Mathias, R. Nandi, J. Nash, A. Nikitenko[39], J. Pela, M. Pesaresi, K. Petridis, M. Pioppi[51], D.M. Raymond, S. Rogerson, A. Rose, M.J. Ryan, C. Seez, P. Sharp[†], A. Sparrow, M. Stoye, A. Tapper, M. Vazquez Acosta, T. Virdee, S. Wakefield, N. Wardle, T. Whyntie

Brunel University, Uxbridge, United Kingdom
M. Chadwick, J.E. Cole, P.R. Hobson, A. Khan, P. Kyberd, D. Leggat, D. Leslie, W. Martin, I.D. Reid, P. Symonds, L. Teodorescu, M. Turner

Baylor University, Waco, USA
K. Hatakeyama, H. Liu, T. Scarborough

The University of Alabama, Tuscaloosa, USA
O. Charaf, C. Henderson, P. Rumerio

Boston University, Boston, USA
A. Avetisyan, T. Bose, C. Fantasia, A. Heister, J. St. John, P. Lawson, D. Lazic, J. Rohlf, D. Sperka, L. Sulak

Brown University, Providence, USA
J. Alimena, S. Bhattacharya, G. Christopher, D. Cutts, Z. Demiragli, A. Ferapontov, A. Garabedian, U. Heintz, S. Jabeen, G. Kukartsev, E. Laird, G. Landsberg, M. Luk, M. Narain, D. Nguyen, M. Segala, T. Sinthuprasith, T. Speer

University of California, Davis, Davis, USA
R. Breedon, G. Breto, M. Calderon De La Barca Sanchez, S. Chauhan, M. Chertok, J. Conway, R. Conway, P.T. Cox, J. Dolen, R. Erbacher, M. Gardner, R. Houtz, W. Ko, A. Kopecky, R. Lander, O. Mall, T. Miceli, D. Pellett, F. Ricci-Tam, B. Rutherford, M. Searle, J. Smith, M. Squires, M. Tripathi, R. Vasquez Sierra, R. Yohay

University of California, Los Angeles, USA
V. Andreev, D. Cline, R. Cousins, J. Duris, S. Erhan, P. Everaerts, C. Farrell, J. Hauser, M. Ignatenko, C. Jarvis, G. Rakness, P. Schlein[†], P. Traczyk, V. Valuev, M. Weber

University of California, Riverside, Riverside, USA
J. Babb, R. Clare, M.E. Dinardo, J. Ellison, J.W. Gary, F. Giordano, G. Hanson, H. Liu, O.R. Long, A. Luthra, H. Nguyen, S. Paramesvaran, J. Sturdy, S. Sumowidagdo, R. Wilken, S. Wimpenny

University of California, San Diego, La Jolla, USA
W. Andrews, J.G. Branson, G.B. Cerati, S. Cittolin, D. Evans, A. Holzner, R. Kelley, M. Lebourgeois, J. Letts, I. Macneill, B. Mangano, S. Padhi, C. Palmer, G. Petrucciani, M. Pieri, M. Sani, V. Sharma, S. Simon, E. Sudano, M. Tadel, Y. Tu, A. Vartak, S. Wasserbaech[52], F. Würthwein, A. Yagil, J. Yoo

University of California, Santa Barbara, Santa Barbara, USA
D. Barge, R. Bellan, C. Campagnari, M. D'Alfonso, T. Danielson, K. Flowers, P. Geffert, C. George, F. Golf, J. Incandela, C. Justus, P. Kalavase, D. Kovalskyi, V. Krutelyov, S. Lowette, R. Magaña Villalba, N. Mccoll, V. Pavlunin, J. Ribnik, J. Richman, R. Rossin, D. Stuart, W. To, C. West

California Institute of Technology, Pasadena, USA
A. Apresyan, A. Bornheim, Y. Chen, E. Di Marco, J. Duarte, M. Gataullin, Y. Ma, A. Mott, H.B. Newman, C. Rogan, M. Spiropulu, V. Timciuc, J. Veverka, R. Wilkinson, S. Xie, Y. Yang, R.Y. Zhu

Carnegie Mellon University, Pittsburgh, USA
V. Azzolini, A. Calamba, R. Carroll, T. Ferguson, Y. Iiyama, D.W. Jang, Y.F. Liu, M. Paulini, H. Vogel, I. Vorobiev

University of Colorado at Boulder, Boulder, USA
J.P. Cumalat, B.R. Drell, W.T. Ford, A. Gaz, E. Luiggi Lopez, J.G. Smith, K. Stenson, K.A. Ulmer, S.R. Wagner

Cornell University, Ithaca, USA
J. Alexander, A. Chatterjee, N. Eggert, L.K. Gibbons, B. Heltsley, W. Hopkins, A. Khukhunaishvili, B. Kreis, N. Mirman, G. Nicolas Kaufman, J.R. Patterson, A. Ryd, E. Salvati, W. Sun, W.D. Teo, J. Thom, J. Thompson, J. Tucker, J. Vaughan, Y. Weng, L. Winstrom, P. Wittich

Fairfield University, Fairfield, USA
D. Winn

Fermi National Accelerator Laboratory, Batavia, USA
S. Abdullin, M. Albrow, J. Anderson, L.A.T. Bauerdick, A. Beretvas, J. Berryhill, P.C. Bhat, K. Burkett, J.N. Butler, V. Chetluru, H.W.K. Cheung, F. Chlebana, V.D. Elvira, I. Fisk, J. Freeman, Y. Gao, D. Green, O. Gutsche, J. Hanlon, R.M. Harris, J. Hirschauer, B. Hooberman, S. Jindariani, M. Johnson, U. Joshi, B. Klima, S. Kunori, S. Kwan, C. Leonidopoulos[53], J. Linacre, D. Lincoln, R. Lipton, J. Lykken, K. Maeshima, J.M. Marraffino, S. Maruyama, D. Mason, P. McBride, K. Mishra, S. Mrenna, Y. Musienko[54], C. Newman-Holmes, V. O'Dell, O. Prokofyev, E. Sexton-Kennedy, S. Sharma, W.J. Spalding, L. Spiegel, S. Tkaczyk, N.V. Tran, L. Uplegger, E.W. Vaandering, R. Vidal, J. Whitmore, W. Wu, F. Yang, J.C. Yun

University of Florida, Gainesville, USA
D. Acosta, P. Avery, D. Bourilkov, M. Chen, T. Cheng, S. Das, M. De Gruttola, G.P. Di Giovanni, D. Dobur, A. Drozdetskiy, R.D. Field, M. Fisher, Y. Fu, I.K. Furic, J. Gartner, J. Hugon, B. Kim, J. Konigsberg, A. Korytov, A. Kropivnitskaya, T. Kypreos, J.F. Low, K. Matchev, P. Milenovic[55], G. Mitselmakher, L. Muniz, M. Park, R. Remington, A. Rinkevicius, P. Sellers, N. Skhirtladze, M. Snowball, J. Yelton, M. Zakaria

Florida International University, Miami, USA
V. Gaultney, S. Hewamanage, L.M. Lebolo, S. Linn, P. Markowitz, G. Martinez, J.L. Rodriguez

Florida State University, Tallahassee, USA
T. Adams, A. Askew, J. Bochenek, J. Chen, B. Diamond, S.V. Gleyzer, J. Haas, S. Hagopian, V. Hagopian, M. Jenkins, K.F. Johnson, H. Prosper, V. Veeraraghavan, M. Weinberg

Florida Institute of Technology, Melbourne, USA
M.M. Baarmand, B. Dorney, M. Hohlmann, H. Kalakhety, I. Vodopiyanov, F. Yumiceva

University of Illinois at Chicago (UIC), Chicago, USA
M.R. Adams, I.M. Anghel, L. Apanasevich, Y. Bai, V.E. Bazterra, R.R. Betts, I. Bucinskaite, J. Callner, R. Cavanaugh, O. Evdokimov, L. Gauthier, C.E. Gerber, D.J. Hofman, S. Khalatyan, F. Lacroix, C. O'Brien, C. Silkworth, D. Strom, P. Turner, N. Varelas

The University of Iowa, Iowa City, USA
U. Akgun, E.A. Albayrak, B. Bilki[56], W. Clarida, F. Duru, S. Griffiths, J.-P. Merlo, H. Mermerkaya[57], A. Mestvirishvili, A. Moeller, J. Nachtman, C.R. Newsom, E. Norbeck, Y. Onel, F. Ozok[58], S. Sen, P. Tan, E. Tiras, J. Wetzel, T. Yetkin, K. Yi

Johns Hopkins University, Baltimore, USA
B.A. Barnett, B. Blumenfeld, S. Bolognesi, D. Fehling, G. Giurgiu, A.V. Gritsan, Z.J. Guo, G. Hu, P. Maksimovic, M. Swartz, A. Whitbeck

The University of Kansas, Lawrence, USA
P. Baringer, A. Bean, G. Benelli, R.P. Kenny Iii, M. Murray, D. Noonan, S. Sanders, R. Stringer, G. Tinti, J.S. Wood

Kansas State University, Manhattan, USA
A.F. Barfuss, T. Bolton, I. Chakaberia, A. Ivanov, S. Khalil, M. Makouski, Y. Maravin, S. Shrestha, I. Svintradze

Lawrence Livermore National Laboratory, Livermore, USA
J. Gronberg, D. Lange, F. Rebassoo, D. Wright

University of Maryland, College Park, USA
A. Baden, B. Calvert, S.C. Eno, J.A. Gomez, N.J. Hadley, R.G. Kellogg, M. Kirn, T. Kolberg,

Y. Lu, M. Marionneau, A.C. Mignerey, K. Pedro, A. Peterman, A. Skuja, J. Temple, M.B. Tonjes, S.C. Tonwar

Massachusetts Institute of Technology, Cambridge, USA
A. Apyan, G. Bauer, J. Bendavid, W. Busza, E. Butz, I.A. Cali, M. Chan, V. Dutta, G. Gomez Ceballos, M. Goncharov, Y. Kim, M. Klute, K. Krajczar[59], A. Levin, P.D. Luckey, T. Ma, S. Nahn, C. Paus, D. Ralph, C. Roland, G. Roland, M. Rudolph, G.S.F. Stephans, F. Stöckli, K. Sumorok, K. Sung, D. Velicanu, E.A. Wenger, R. Wolf, B. Wyslouch, M. Yang, Y. Yilmaz, A.S. Yoon, M. Zanetti, V. Zhukova

University of Minnesota, Minneapolis, USA
S.I. Cooper, B. Dahmes, A. De Benedetti, G. Franzoni, A. Gude, S.C. Kao, K. Klapoetke, Y. Kubota, J. Mans, N. Pastika, R. Rusack, M. Sasseville, A. Singovsky, N. Tambe, J. Turkewitz

University of Mississippi, Oxford, USA
L.M. Cremaldi, R. Kroeger, L. Perera, R. Rahmat, D.A. Sanders

University of Nebraska-Lincoln, Lincoln, USA
E. Avdeeva, K. Bloom, S. Bose, D.R. Claes, A. Dominguez, M. Eads, J. Keller, I. Kravchenko, J. Lazo-Flores, S. Malik, G.R. Snow

State University of New York at Buffalo, Buffalo, USA
A. Godshalk, I. Iashvili, S. Jain, A. Kharchilava, A. Kumar, S. Rappoccio

Northeastern University, Boston, USA
G. Alverson, E. Barberis, D. Baumgartel, M. Chasco, J. Haley, D. Nash, T. Orimoto, D. Trocino, D. Wood, J. Zhang

Northwestern University, Evanston, USA
A. Anastassov, K.A. Hahn, A. Kubik, L. Lusito, N. Mucia, N. Odell, R.A. Ofierzynski, B. Pollack, A. Pozdnyakov, M. Schmitt, S. Stoynev, M. Velasco, S. Won

University of Notre Dame, Notre Dame, USA
L. Antonelli, D. Berry, A. Brinkerhoff, K.M. Chan, M. Hildreth, C. Jessop, D.J. Karmgard, J. Kolb, K. Lannon, W. Luo, S. Lynch, N. Marinelli, D.M. Morse, T. Pearson, M. Planer, R. Ruchti, J. Slaunwhite, N. Valls, M. Wayne, M. Wolf

The Ohio State University, Columbus, USA
B. Bylsma, L.S. Durkin, C. Hill, R. Hughes, K. Kotov, T.Y. Ling, D. Puigh, M. Rodenburg, C. Vuosalo, G. Williams, B.L. Winer

Princeton University, Princeton, USA
E. Berry, P. Elmer, V. Halyo, P. Hebda, J. Hegeman, A. Hunt, P. Jindal, S.A. Koay, D. Lopes Pegna, P. Lujan, D. Marlow, T. Medvedeva, M. Mooney, J. Olsen, P. Piroué, X. Quan, A. Raval, H. Saka, D. Stickland, C. Tully, J.S. Werner, S.C. Zenz, A. Zuranski

University of Puerto Rico, Mayaguez, USA
E. Brownson, A. Lopez, H. Mendez, J.E. Ramirez Vargas

Purdue University, West Lafayette, USA
E. Alagoz, V.E. Barnes, D. Benedetti, G. Bolla, D. Bortoletto, M. De Mattia, A. Everett, Z. Hu, M. Jones, O. Koybasi, M. Kress, A.T. Laasanen, N. Leonardo, V. Maroussov, P. Merkel, D.H. Miller, N. Neumeister, I. Shipsey, D. Silvers, A. Svyatkovskiy, M. Vidal Marono, H.D. Yoo, J. Zablocki, Y. Zheng

Purdue University Calumet, Hammond, USA
S. Guragain, N. Parashar

Rice University, Houston, USA
A. Adair, B. Akgun, C. Boulahouache, K.M. Ecklund, F.J.M. Geurts, W. Li, B.P. Padley, R. Redjimi, J. Roberts, J. Zabel

University of Rochester, Rochester, USA
B. Betchart, A. Bodek, Y.S. Chung, R. Covarelli, P. de Barbaro, R. Demina, Y. Eshaq, T. Ferbel, A. Garcia-Bellido, P. Goldenzweig, J. Han, A. Harel, D.C. Miner, D. Vishnevskiy, M. Zielinski

The Rockefeller University, New York, USA
A. Bhatti, R. Ciesielski, L. Demortier, K. Goulianos, G. Lungu, S. Malik, C. Mesropian

Rutgers, the State University of New Jersey, Piscataway, USA
S. Arora, A. Barker, J.P. Chou, C. Contreras-Campana, E. Contreras-Campana, D. Duggan, D. Ferencek, Y. Gershtein, R. Gray, E. Halkiadakis, D. Hidas, A. Lath, S. Panwalkar, M. Park, R. Patel, V. Rekovic, J. Robles, K. Rose, S. Salur, S. Schnetzer, C. Seitz, S. Somalwar, R. Stone, S. Thomas, M. Walker

University of Tennessee, Knoxville, USA
G. Cerizza, M. Hollingsworth, S. Spanier, Z.C. Yang, A. York

Texas A&M University, College Station, USA
R. Eusebi, W. Flanagan, J. Gilmore, T. Kamon[60], V. Khotilovich, R. Montalvo, I. Osipenkov, Y. Pakhotin, A. Perloff, J. Roe, A. Safonov, T. Sakuma, S. Sengupta, I. Suarez, A. Tatarinov, D. Toback

Texas Tech University, Lubbock, USA
N. Akchurin, J. Damgov, C. Dragoiu, P.R. Dudero, C. Jeong, K. Kovitanggoon, S.W. Lee, T. Libeiro, I. Volobouev

Vanderbilt University, Nashville, USA
E. Appelt, A.G. Delannoy, C. Florez, S. Greene, A. Gurrola, W. Johns, P. Kurt, C. Maguire, A. Melo, M. Sharma, P. Sheldon, B. Snook, S. Tuo, J. Velkovska

University of Virginia, Charlottesville, USA
M.W. Arenton, M. Balazs, S. Boutle, B. Cox, B. Francis, J. Goodell, R. Hirosky, A. Ledovskoy, C. Lin, C. Neu, J. Wood

Wayne State University, Detroit, USA
S. Gollapinni, R. Harr, P.E. Karchin, C. Kottachchi Kankanamge Don, P. Lamichhane, A. Sakharov

University of Wisconsin, Madison, USA
M. Anderson, D.A. Belknap, L. Borrello, D. Carlsmith, M. Cepeda, S. Dasu, E. Friis, L. Gray, K.S. Grogg, M. Grothe, R. Hall-Wilton, M. Herndon, A. Hervé, P. Klabbers, J. Klukas, A. Lanaro, C. Lazaridis, R. Loveless, A. Mohapatra, I. Ojalvo, F. Palmonari, G.A. Pierro, I. Ross, A. Savin, W.H. Smith, J. Swanson

†: Deceased
1: Also at Vienna University of Technology, Vienna, Austria
2: Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland
3: Also at National Institute of Chemical Physics and Biophysics, Tallinn, Estonia
4: Also at California Institute of Technology, Pasadena, USA

5: Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France
6: Also at Suez Canal University, Suez, Egypt
7: Also at Zewail City of Science and Technology, Zewail, Egypt
8: Also at Cairo University, Cairo, Egypt
9: Also at Fayoum University, El-Fayoum, Egypt
10: Also at Helwan University, Cairo, Egypt
11: Also at British University in Egypt, Cairo, Egypt
12: Now at Ain Shams University, Cairo, Egypt
13: Also at National Centre for Nuclear Research, Swierk, Poland
14: Also at Université de Haute-Alsace, Mulhouse, France
15: Also at Joint Institute for Nuclear Research, Dubna, Russia
16: Also at Moscow State University, Moscow, Russia
17: Also at Brandenburg University of Technology, Cottbus, Germany
18: Also at The University of Kansas, Lawrence, USA
19: Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary
20: Also at Eötvös Loránd University, Budapest, Hungary
21: Also at Tata Institute of Fundamental Research - HECR, Mumbai, India
22: Now at King Abdulaziz University, Jeddah, Saudi Arabia
23: Also at University of Visva-Bharati, Santiniketan, India
24: Also at Sharif University of Technology, Tehran, Iran
25: Also at Isfahan University of Technology, Isfahan, Iran
26: Also at Shiraz University, Shiraz, Iran
27: Also at Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, Tehran, Iran
28: Also at Facoltà Ingegneria, Università di Roma, Roma, Italy
29: Also at Università degli Studi Guglielmo Marconi, Roma, Italy
30: Also at Università degli Studi di Siena, Siena, Italy
31: Also at University of Bucharest, Faculty of Physics, Bucuresti-Magurele, Romania
32: Also at Faculty of Physics of University of Belgrade, Belgrade, Serbia
33: Also at University of California, Los Angeles, USA
34: Also at Scuola Normale e Sezione dell'INFN, Pisa, Italy
35: Also at INFN Sezione di Roma, Roma, Italy
36: Also at University of Athens, Athens, Greece
37: Also at Rutherford Appleton Laboratory, Didcot, United Kingdom
38: Also at Paul Scherrer Institut, Villigen, Switzerland
39: Also at Institute for Theoretical and Experimental Physics, Moscow, Russia
40: Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland
41: Also at Gaziosmanpasa University, Tokat, Turkey
42: Also at Adiyaman University, Adiyaman, Turkey
43: Also at Izmir Institute of Technology, Izmir, Turkey
44: Also at The University of Iowa, Iowa City, USA
45: Also at Mersin University, Mersin, Turkey
46: Also at Ozyegin University, Istanbul, Turkey
47: Also at Kafkas University, Kars, Turkey
48: Also at Suleyman Demirel University, Isparta, Turkey
49: Also at Ege University, Izmir, Turkey
50: Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom
51: Also at INFN Sezione di Perugia; Università di Perugia, Perugia, Italy

52: Also at Utah Valley University, Orem, USA
53: Now at University of Edinburgh, Scotland, Edinburgh, United Kingdom
54: Also at Institute for Nuclear Research, Moscow, Russia
55: Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia
56: Also at Argonne National Laboratory, Argonne, USA
57: Also at Erzincan University, Erzincan, Turkey
58: Also at Mimar Sinan University, Istanbul, Istanbul, Turkey
59: Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
60: Also at Kyungpook National University, Daegu, Korea