[illegible]

[illegible]

# [illegible]

## [illegible] $\sqrt{s} =$ [illegible]

[illegible][*]

## Abstract

[illegible] $\sqrt{s} =$ [illegible] $^{-1}$. [illegible] $M_{\mathrm{S}}$ [illegible]

*Published in Physical Review D as* `doi:10.1103/PhysRevD.98.092001.`

---

[*] [illegible]

# 1 Introduction

[illegible] $M_\mathrm{P} \sim 10^{19}$ [illegible]

[illegible] $n_\mathrm{D}$ [illegible] $r_\mathrm{c}$, [illegible] $M_\mathrm{P}$ [illegible] $M_\mathrm{P}^2 \sim M_{\mathrm{P}\,(4+n_\mathrm{D})}^{2+n_\mathrm{D}} r_\mathrm{c}^{n_\mathrm{D}}$. [illegible] $n_\mathrm{D}$ [illegible] $r_\mathrm{c}$, [illegible] $(4+n_\mathrm{D})$ [illegible] $M_{\mathrm{P}\,(4+n_\mathrm{D})}$, [illegible]

[illegible] $k$. [illegible] $r_\mathrm{c}$. [illegible] $m_0$ [illegible] $m = \mathrm{e}^{-kr_\mathrm{c}\pi} m_0$. [illegible] $m_0 \sim M_\mathrm{P}$ [illegible] $kr_\mathrm{c} \approx$ [illegible]

[illegible] $N$ [illegible] $N \to \infty$, [illegible]

[illegible]

[illegible] ($m_{\gamma\gamma}$) [illegible] $\tilde{k} \equiv k/\overline{M_{\mathrm{P}}}$, [illegible] $\overline{M_{\mathrm{P}}} = M_{\mathrm{P}}/\sqrt{8\pi}$ [illegible] $m_{\gamma\gamma}$ [illegible]

[illegible]

[illegible] $\sqrt{s} =$ [illegible] $\sqrt{s} = 7$ [illegible] $\sqrt{s} =$ [illegible]

[illegible] $^{-1}$. [illegible]

[illegible]

## 2 The CMS detector

[illegible] $\eta$) [illegible]

[illegible]

[illegible] $|\eta| < $ [illegible] $< |\eta| < 3$ [illegible] $|\eta| = 1$ [illegible] $|\eta| = 4$ [illegible]

[illegible] $\mu$s [illegible]

[illegible]

## 3 Event reconstruction and selection

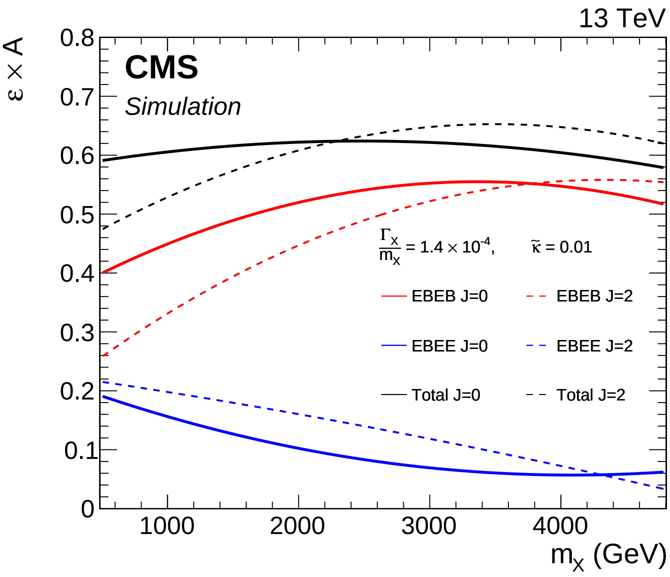
[illegible] $\phi$) [illegible] $Z \to e^+e^-$ [illegible]

[illegible] $\sigma_{\eta\eta}$, [illegible] $\eta$ [illegible] $(\eta, \phi)$ [illegible] $\Delta R = $ [illegible] $(\eta_\gamma, \phi_\gamma)$, [illegible] $\Delta R = \sqrt{(\eta - \eta_\gamma)^2 + (\phi - \phi_\gamma)^2}$. [illegible]

[illegible] $p_T >$ [illegible] $p_T >$ [illegible] $|\eta| <$ [illegible] $< |\eta| < 2$ [illegible]

[illegible] $m_{\gamma\gamma} > 2$ [illegible] $m_{\gamma\gamma} >$ [illegible] $\Delta R >$ [illegible]

[illegible] $\varepsilon$) [illegible] $A$) [illegible]



[illegible] $\varepsilon$) [illegible] $m_X$ [illegible] $\Gamma_X/m_X = 1.4 \times 10^{-4}$ [illegible] $= 0$ [illegible] $= 2$ [illegible]

[illegible]

[illegible]

[illegible] $\rightarrow e^+e^-$ [illegible] $R_9$ [illegible] $\times$ [illegible] $\eta$ [illegible]

[illegible] $\rightarrow e^+e^-$ [illegible]

[illegible] $z$ [illegible] $p_T^2$ [illegible] $p_T$ [illegible]

# 4 Signal simulation

[illegible]

[illegible] $M_S$, [illegible] $n_D$ [illegible] $M_S$. [illegible] $\eta_G = \mathcal{F}/M_S^4$, [illegible] $\mathcal{F}$ [illegible]

[illegible]

$$\mathcal{F} = \begin{cases} 1 & \text{[illegible]} \\ \log\left(\frac{M_S^2}{\hat{s}}\right), & \text{f[illegible]}\ n_D = 2 \\ \frac{2}{n_D - 2}, & \text{f[illegible]}\ n_D > 2 \\ \pm\frac{2}{\pi} & \text{[illegible]} \end{cases} \quad \text{[illegible]} \qquad (1)$$

[illegible] $\sqrt{\hat{s}}$ [illegible]

[illegible] $\eta_G$ [illegible] $n_D = 2$ [illegible] $\mathcal{F} = -2/\pi$. [illegible] $< M_S <$ [illegible]

[illegible]

$$\theta(m_{\gamma\gamma} - k)\frac{\text{[illegible]}\ M_S^8}{\text{[illegible]}\ \pi M_5^3}\sqrt{1 - \frac{k^2}{m_{\gamma\gamma}^2}}\frac{1}{m_{\gamma\gamma}^5}\left[1 + \frac{(5^2)(7)(\text{[illegible]})}{(\text{[illegible]})(2^8)}\left(1 - \frac{k}{m_{\gamma\gamma}}\right)^9\sqrt{\frac{m_{\gamma\gamma}}{k}}\right]^{-1}. \qquad (2)$$

[illegible] $M_S$ [illegible] $M_5$ [illegible] $k$ [illegible] $M_5$ [illegible] $k < M_5$.

[illegible] $m_{\gamma\gamma}$ [illegible] $\Gamma_X/m_X =$ [illegible] $\times 10^{-4}$, [illegible] $\times 10^{-2}$, [illegible] $\times 10^{-2}$, [illegible] $\tilde{k} =$ [illegible]

[illegible]

[illegible]

# 5 Background determination

[illegible]

## 5.1 Background for resonant diphoton search

[illegible] $m_{\gamma\gamma}$ [illegible] $m_{\gamma\gamma}$:

$$f(m_{\gamma\gamma}) = m_{\gamma\gamma}^{a+b\log(m_{\gamma\gamma}/\mathrm{GeV})},$$

[illegible] $a$ [illegible] $b$ [illegible]

[illegible] $m_{\gamma\gamma}$ [illegible]

[illegible] $m_{\gamma\gamma}$ [illegible] $\chi^2$ [illegible]

[illegible] $m_{\gamma\gamma}$, [illegible]

## 5.2 Background for nonresonant diphoton search

[illegible] $K$ [illegible] $K$ [illegible] $K$ [illegible] $m_{\gamma\gamma}$. [illegible] $\Delta R_{\gamma\gamma}$ ($<$ [illegible] $K$ [illegible] $K$ [illegible]

[illegible]

[illegible]

[illegible] $\sigma_{\eta\eta}$ [illegible] $\sigma_{\eta\eta}$ [illegible] $\sigma_{\eta\eta}$ [illegible] $\sigma_{\eta\eta}$ [illegible] $p_{\mathrm{T}}$ [illegible] $\sigma_{\eta\eta}$ [illegible] $p_{\mathrm{T}}$ [illegible]

[illegible]

[illegible] $p_{\mathrm{T}}$ [illegible] $< m_{\gamma\gamma} <$ [illegible] $m_{\gamma\gamma} >$ [illegible]

# 6 Systematic uncertainties

## 6.1 Systematic uncertainties for the resonant search

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]

- [illegible]

## 6.2 Systematic uncertainties for the nonresonant search

[illegible] $m_{\gamma\gamma}$ [illegible] $K$ [illegible] $m_{\gamma\gamma}$ [illegible] $m_{\gamma\gamma}$. [illegible] $m_{\gamma\gamma}$ [illegible]

[illegible] $\pm 1$ [illegible] $m_{\gamma\gamma}$ [illegible] $\eta$, [illegible]

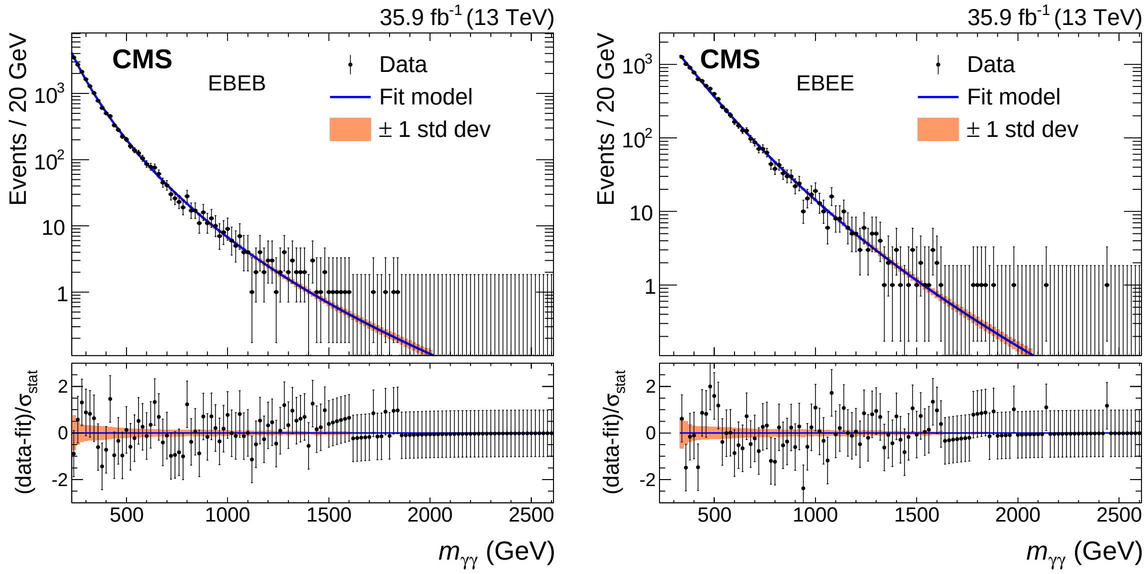
[illegible]

# 7 Results

## 7.1 Results of the search for resonant excesses

[illegible] $m_{\gamma\gamma}$ [illegible]

[illegible]



[illegible]

[illegible]

$$q(\mu) = -2\log\frac{L(\mu S + B|\hat{\theta}_{\mu})}{L(\hat{\mu} S + B|\hat{\theta})}, \qquad (4)$$

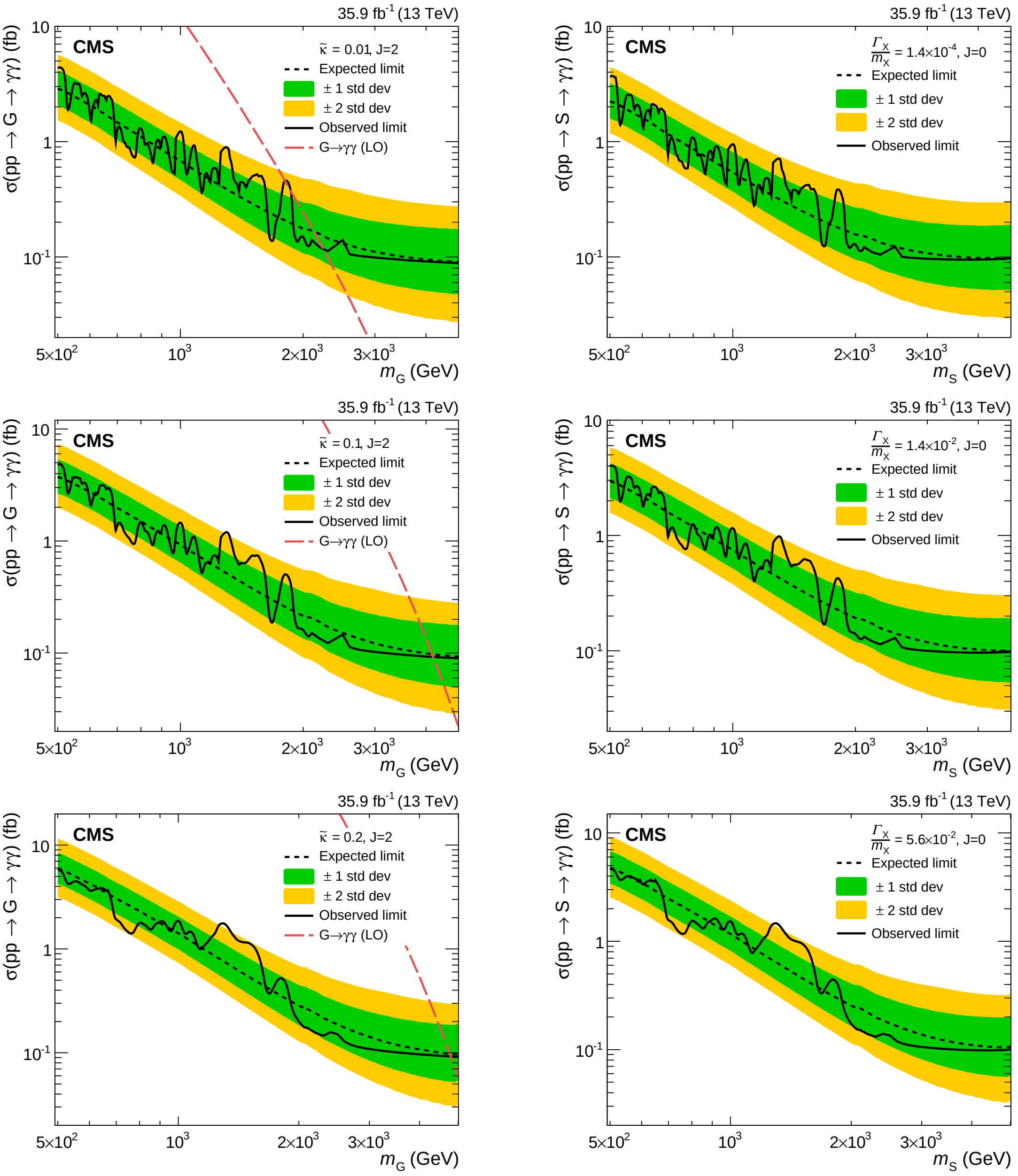
[illegible] $S$ [illegible] $B$ [illegible] $\mu$ [illegible] $\theta$ [illegible] $\hat{x}$ [illegible] $x$, [illegible] $\hat{x}_y$ [illegible] $x$, [illegible] $y$.

[illegible]

[illegible]

[illegible] $m_X$ [illegible] $\tilde{k} =$ [illegible] $\Gamma_X/m_X =$ [illegible]

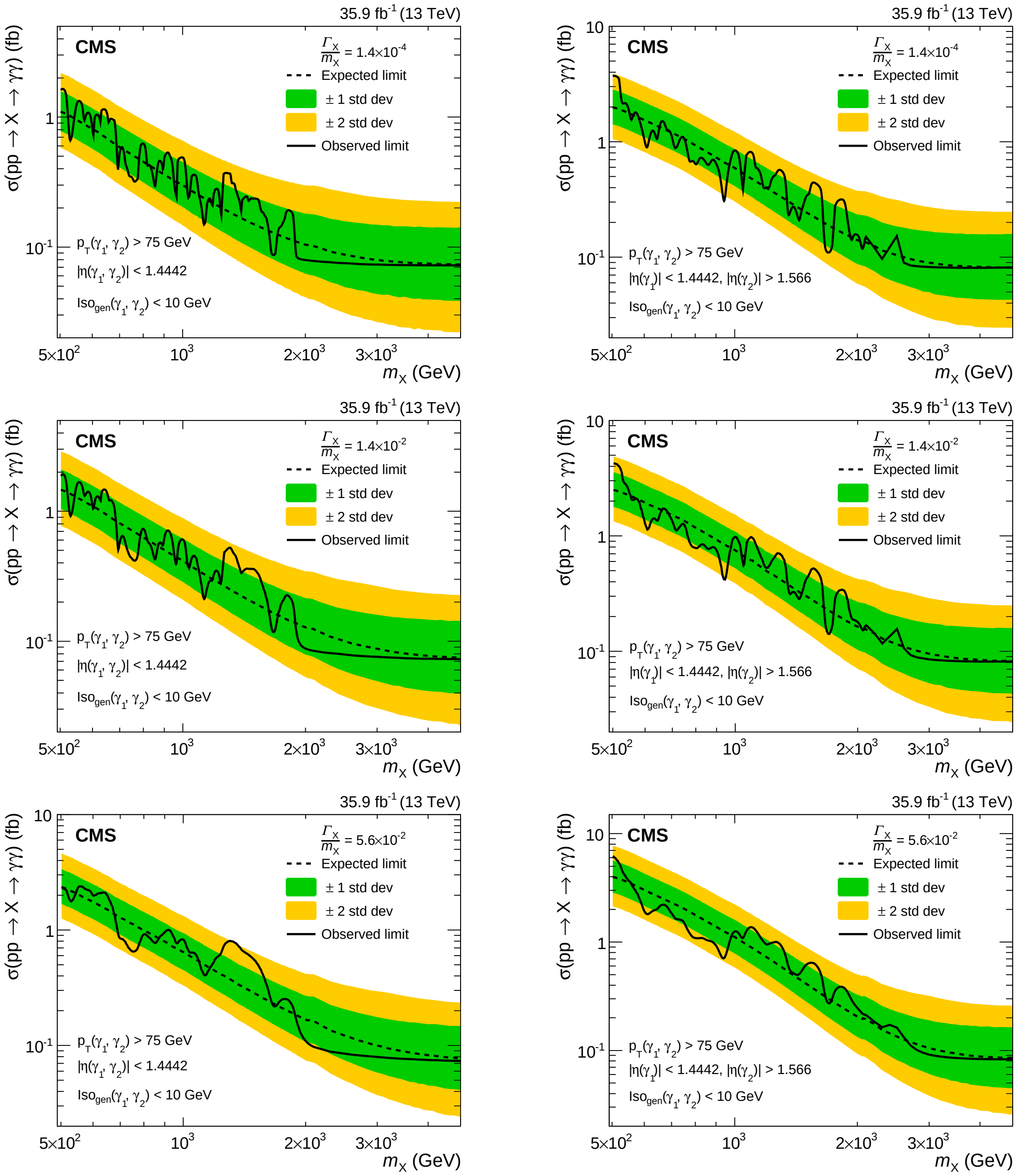
[illegible] $\to \gamma\gamma$ [illegible]



[illegible] $m_G$ [illegible] $\tilde{k}$ [illegible] $m_S$ [illegible]

[illegible] $p_T >$ [illegible] $p_T$ [illegible]

[illegible] $\Gamma_X/m_X = 1.4 \times 10^{-4}, 1.4 \times 10^{-2}, 5.6 \times 10^{-2}$. [illegible]



[illegible]

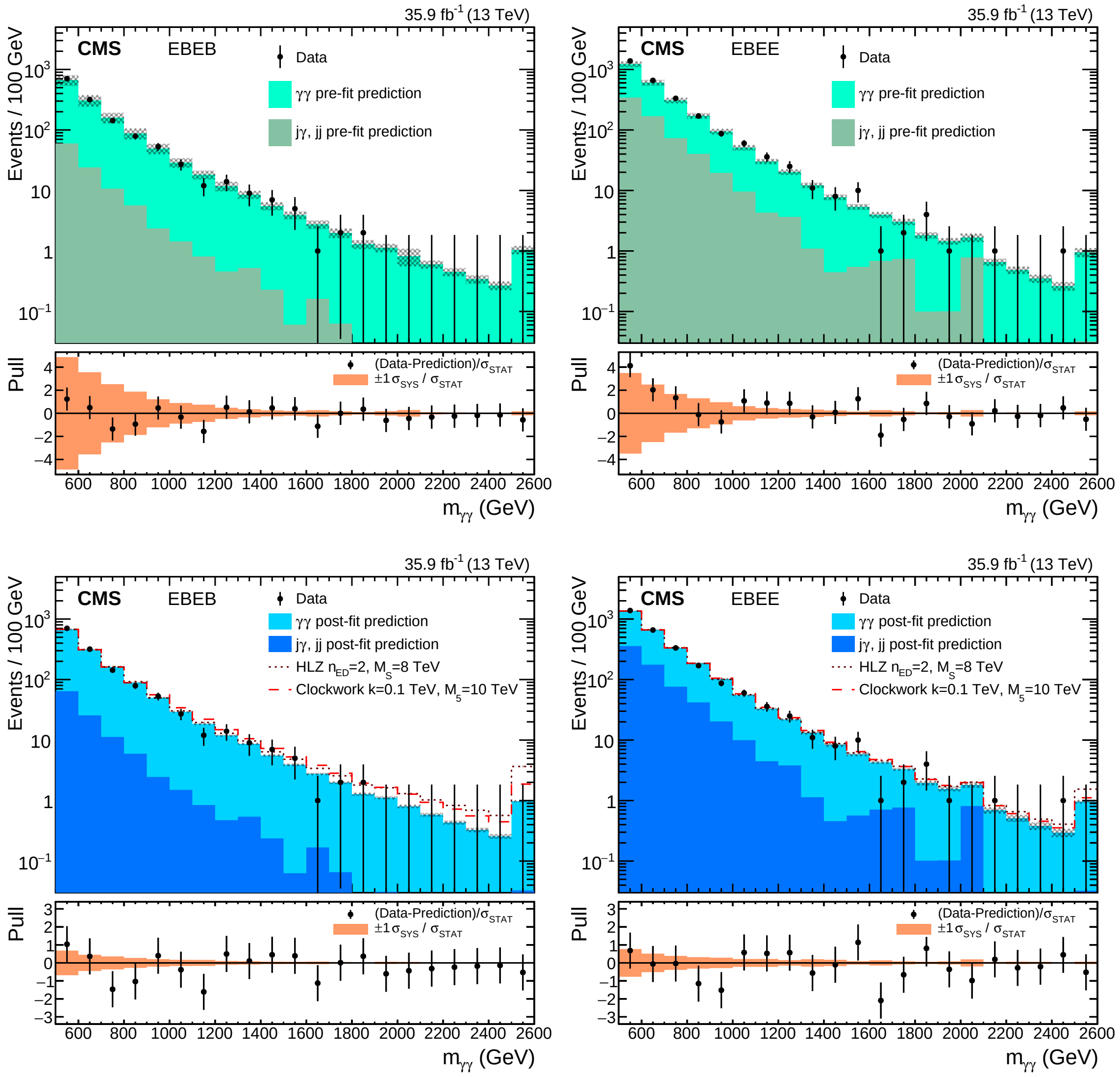
[illegible] $\to \gamma\gamma$ [illegible]

[illegible]

## 7.2 Results of the search for nonresonant excesses

[illegible]

[illegible]


35.9 fb$^{-1}$ (13 TeV)
CMS
EBEB
EBEE
Data
γγ pre-fit prediction
jγ, jj pre-fit prediction
γγ post-fit prediction
jγ, jj post-fit prediction
HLZ $n_{ED}$=2, $M_S$=8 TeV
Clockwork k=0.1 TeV, $M_5$=10 TeV
Events / 100 GeV
(Data-Prediction)/$\sigma_{STAT}$
±1$\sigma_{SYS}$ / $\sigma_{STAT}$
Pull
$m_{\gamma\gamma}$ (GeV)

[illegible]

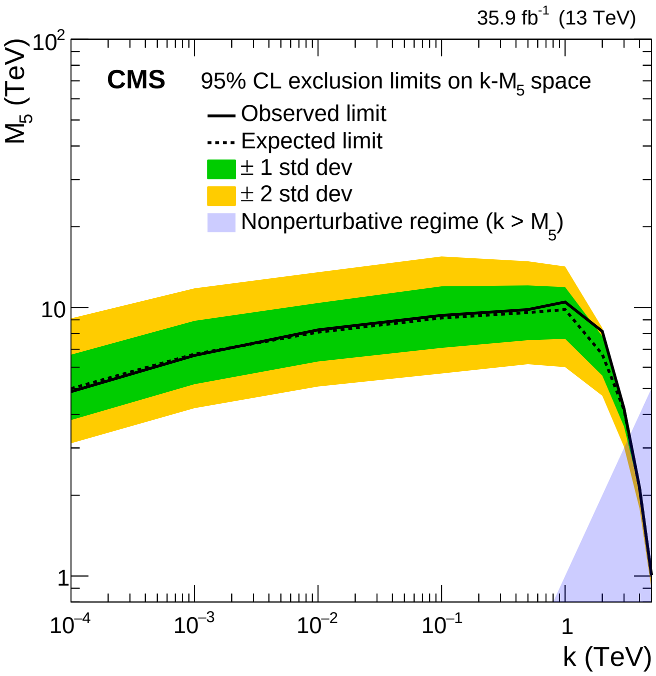
[illegible]

[illegible] $M_S$ [illegible] $M_S$ [illegible] $M_S$ [illegible]

[illegible] $M_S$ [illegible]

| [illegible] | [illegible] | [illegible] | $n_{ED} = 2$ | $n_{ED} = 3$ | $n_{ED} = 4$ | $n_{ED} = 5$ | $n_{ED} = 6$ | $n_{ED} = 7$ |
|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

[illegible] $m_{\gamma\gamma} >$ [illegible] $m_{\gamma\gamma} >$ [illegible] $M_5^{-3}$, [illegible] $M_5$ [illegible] $k$) [illegible] $k$–$M_5$ [illegible] $M_5$ [illegible] $k$ [illegible] $k > M_5$ [illegible]



[illegible] $k$–$M_5$ [illegible] $k > M_5$ [illegible]

# 8 Summary

[illegible] $^{-1}$ [illegible] A [illegible]

[illegible] $< \tilde{k} <$ [illegible] $\gamma\gamma$ [illegible] $< M_{\mathrm{S}} <$ [illegible] $M_{\mathrm{S}}$ [illegible]

# Acknowledgments

[illegible]

[illegible]

[illegible]

## References

[1] [illegible] *Nucl. Phys. B* **188** [illegible] doi:10.1016/0550-3213(81)90006-7.

[2] [illegible] *Nucl. Phys. B* **193** [illegible] doi:10.1016/0550-3213(81)90522-8.

[3] [illegible] *Phys. Lett. B* **429** [illegible] doi:10.1016/S0370-2693(98)00466-3, arXiv:hep-ph/9803315.

[4] [illegible] *Phys. Lett. B* **436** [illegible] doi:10.1016/S0370-2693(98)00860-0, arXiv:hep-ph/9804398.

[5] [illegible] *Phys. Rev. D* **59** [illegible] doi:10.1103/PhysRevD.59.086004, arXiv:hep-ph/9807344.

[6] [illegible] *Phys. Rev. Lett.* **83** [illegible] doi:10.1103/PhysRevLett.83.3370, arXiv:hep-ph/9905221.

[7] [illegible] *Phys. Rev. Lett.* **83** [illegible] doi:10.1103/PhysRevLett.83.4690, arXiv:hep-th/9906064.

[8] [illegible] *JHEP* **02** [illegible] doi:10.1007/JHEP02(2017)036, arXiv:1610.07962.

[illegible] *JHEP* **05** [illegible] doi:10.1088/1126-6708/2001/05/055, arXiv:hep-th/0103033.

[illegible] *Phys. Rev. Lett.* **108** [illegible] doi:10.1103/PhysRevLett.108.081602, arXiv:1102.4043.

[illegible] *JHEP* **01** [illegible] doi:10.1007/JHEP01(2016)149, arXiv:1511.00132.

[illegible] *Phys. Rev. D* **93** [illegible] doi:10.1103/PhysRevD.93.085007, arXiv:1511.01827.

[illegible] *Phys. Rev. D* **85** [illegible] doi:10.1103/PhysRevD.85.125019, arXiv:1202.6674.

[illegible] *JHEP* **06** [illegible] doi:10.1007/JHEP06(2018)009, arXiv:1711.08437.

[illegible] *Phys. Rept.* **516** [illegible] doi:10.1016/j.physrep.2012.02.002, arXiv:1106.0034.

[illegible] $T$ [illegible] *Phys. Rev. D* **8** [illegible] doi:10.1103/PhysRevD.8.1226.

[illegible] arXiv:1305.2424.

[illegible] $^{-1}$ [illegible] $\sqrt{s} =$ [illegible] *Phys. Lett. B* **775** [illegible] doi:10.1016/j.physletb.2017.10.039, arXiv:1707.04147.

[illegible] *Phys. Lett. B* **767** [illegible] doi:10.1016/j.physletb.2017.01.027, arXiv:1609.02507.

[illegible] $\sqrt{s} =$ [illegible] *JHEP* **09** [illegible] doi:10.1007/JHEP09(2016)001, arXiv:1606.03833.

[illegible] $\sqrt{s} = 8$ [illegible] *Phys. Rev. Lett.* **117** [illegible] doi:10.1103/PhysRevLett.117.051802, arXiv:1606.04093.

[illegible] $\sqrt{s} = 8$ [illegible] *Phys. Rev. D* **92** [illegible] doi:10.1103/PhysRevD.92.032004, arXiv:1504.05511.

[illegible] $\sqrt{s} = 8$ [illegible] *Phys. Lett. B* **750** [illegible] doi:10.1016/j.physletb.2015.09.062, arXiv:1506.02301.

[illegible] [illegible] $\sqrt{s} =$ [illegible] *New J. Phys.* **15** [illegible] doi:10.1088/1367-2630/15/4/043007, arXiv:1210.8389.

[illegible] [illegible] *Phys. Rev. Lett.* **108** [illegible] doi:10.1103/PhysRevLett.108.111801, arXiv:1112.0688.

[illegible] [illegible] *Phys. Rev. Lett.* **107** [illegible] doi:10.1103/PhysRevLett.107.051801, arXiv:1103.4650.

[illegible] [illegible] $^{-1}$ [illegible] [illegible] $\sqrt{s} =$ [illegible] *Phys. Rev. Lett.* **104** [illegible] doi:10.1103/PhysRevLett.104.241802, arXiv:1004.1826.

[illegible] [illegible] $\sqrt{s} =$ [illegible] *JINST* **10** [illegible] doi:10.1088/1748-0221/10/08/P08010, arXiv:1502.02702.

[illegible] *JINST* **12** [illegible] doi:10.1088/1748-0221/12/01/P01020, arXiv:1609.02366.

[illegible] *JINST* **3** [illegible] doi:10.1088/1748-0221/3/08/S08004.

[illegible] [illegible] *JINST* **12** [illegible] doi:10.1088/1748-0221/12/10/P10003, arXiv:1706.04965.

[illegible] [illegible] *Eur. Phys. J. C* **74** [illegible] doi:10.1140/epjc/s10052-014-3076-z, arXiv:1407.0558.

[illegible] [illegible] $\sqrt{s} =$ [illegible] arXiv:1804.02716. [illegible] *JHEP*.

[illegible] *JHEP* **02** [illegible] doi:10.1088/1126-6708/2009/02/007, arXiv:0811.4622.

[illegible] *Phys. Rev. D* **82** [illegible] doi:10.1103/PhysRevD.82.074024, arXiv:1007.2241.

[illegible] *Phys. Rev. D* **89** [illegible] doi:10.1103/PhysRevD.89.033009, arXiv:1302.6246.

[illegible] *JHEP* **09** [illegible] doi:10.1088/1126-6708/2003/09/001, arXiv:hep-ph/0306182.

[illegible] [illegible] *Nucl. Phys. B* **544** [illegible] doi:10.1016/S0550-3213(99)00044-9, arXiv:hep-ph/9811291.

[illegible] *Phys. Rev. D* **59** [illegible] doi:10.1103/PhysRevD.59.105006, arXiv:hep-ph/9811350.

[illegible] *Phys. Rev. Lett.* **82** [illegible] doi:10.1103/PhysRevLett.82.4765, arXiv:hep-ph/9811356.

[illegible] *Nucl. Instrum. Meth. A* **506** [illegible] doi:10.1016/S0168-9002(03)01368-8.

[illegible] *Comput. Phys. Commun.* **191** [illegible] doi:10.1016/j.cpc.2015.01.024, arXiv:1410.3012.

[illegible] *Nucl. Phys. B* **867** [illegible] doi:10.1016/j.nuclphysb.2012.10.003, arXiv:1207.1303.

[illegible] *Eur. Phys. J. C* **76** [illegible] doi:10.1140/epjc/s10052-016-3988-x, arXiv:1512.00815.

[illegible] *Phys. Rev. D* **81** [illegible] doi:10.1103/PhysRevD.81.034026, arXiv:0912.3501.

[illegible] *JHEP* **07** [illegible] doi:10.1007/JHEP07(2016)148, arXiv:1603.02663.

[illegible] *Eur. Phys. J. C* **16** [illegible] doi:10.1007/s100520050024, arXiv:hep-ph/9911340.

[illegible] https://cds.cern.ch/record/2257069.

[illegible] *Eur. Phys. J. C* **63** [illegible] doi:10.1140/epjc/s10052-009-1072-5, arXiv:0901.0002.

[illegible] arXiv:1101.0536.

[illegible] arXiv:1101.0538.

[illegible] *Nucl. Instrum. Meth. A* **434** [illegible] doi:10.1016/S0168-9002(99)00498-2, arXiv:hep-ex/9902006.

[illegible] *J. Phys. G* **28** [illegible] doi:10.1088/0954-3899/28/10/313.

[illegible] https://cds.cern.ch/record/1379837.

[illegible] *Eur. Phys. J. C* **71** [illegible] doi:10.1140/epjc/s10052-011-1554-0, arXiv:1007.1727. [illegible] doi:10.1140/epjc/s10052-013-2501-z]

[illegible] *J. Chem. Phys.* **21** [illegible] doi:10.1063/1.1699114.

# A The CMS Collaboration

**Yerevan Physics Institute, Yerevan, Armenia**
[illegible]

**Institut für Hochenergiephysik, Wien, Austria**
[illegible]
[illegible] [1], [illegible] [1], [illegible]
[illegible] [1], [illegible]
[illegible] [1], [illegible]

**Institute for Nuclear Problems, Minsk, Belarus**
[illegible]

**Universiteit Antwerpen, Antwerpen, Belgium**
[illegible]
[illegible]

**Vrije Universiteit Brussel, Brussel, Belgium**
[illegible]
[illegible]
[illegible]

**Université Libre de Bruxelles, Bruxelles, Belgium**
[illegible]
[illegible]
[illegible]

**Ghent University, Ghent, Belgium**
[illegible] [2], [illegible]
[illegible]

**Université Catholique de Louvain, Louvain-la-Neuve, Belgium**
[illegible]
[illegible]
[illegible]

**Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil**
[illegible]
[illegible]

**Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil**
[illegible] [3], [illegible]
[illegible] [4], [illegible]
[illegible]
[illegible]
[illegible] [3], [illegible]

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

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

**Bulgaria**
[illegible]
[illegible]

**University of Sofia, Sofia, Bulgaria**
[illegible]

**Beihang University, Beijing, China**
[illegible][5], [illegible][5], [illegible]

**Institute of High Energy Physics, Beijing, China**
[illegible]
[illegible][6], [illegible]
[illegible][6], [illegible]

**State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China**
[illegible]

**Tsinghua University, Beijing, China**
[illegible]

**Universidad de Los Andes, Bogota, Colombia**
[illegible]
[illegible]

**University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split, Croatia**
[illegible]

**University of Split, Faculty of Science, Split, Croatia**
[illegible]

**Institute Rudjer Boskovic, Zagreb, Croatia**
[illegible][7], [illegible]

**University of Cyprus, Nicosia, Cyprus**
[illegible]
[illegible]

**Charles University, Prague, Czech Republic**
[illegible][8], [illegible][8]

**Escuela Politecnica Nacional, Quito, Ecuador**
[illegible]

**Universidad San Francisco de Quito, Quito, Ecuador**
[illegible]

**Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt**
[illegible][9], [illegible][10], [illegible][11]

**National Institute of Chemical Physics and Biophysics, Tallinn, Estonia**
[illegible]
[illegible]

**Department of Physics, University of Helsinki, Helsinki, Finland**
[illegible]

**Helsinki Institute of Physics, Helsinki, Finland**
[illegible]

**Lappeenranta University of Technology, Lappeenranta, Finland**
[illegible]

**IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France**
[illegible]

**Laboratoire Leprince-Ringuet, Ecole polytechnique, CNRS/IN2P3, Université Paris-Saclay, Palaiseau, France**
[illegible][2], [illegible]

**Université de Strasbourg, CNRS, IPHC UMR 7178, Strasbourg, France**
[illegible][3], [illegible][3], [illegible][3], [illegible]

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

**Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France**
[illegible][4], [illegible]

**Georgian Technical University, Tbilisi, Georgia**
[illegible][8]

**Tbilisi State University, Tbilisi, Georgia**
[illegible][8]

**RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany**
[illegible][1][illegible]

**RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany**
[illegible]

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

[illegible]

**Deutsches Elektronen-Synchrotron, Hamburg, Germany**

[illegible]

**University of Hamburg, Hamburg, Germany**

[illegible]

**Karlsruher Institut fuer Technologie, Karlsruhe, Germany**

[illegible]

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

[illegible]

**National and Kapodistrian University of Athens, Athens, Greece**

[illegible]

**National Technical University of Athens, Athens, Greece**

[illegible]

**University of Ioánnina, Ioánnina, Greece**

[illegible]

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

[illegible]

**Wigner Research Centre for Physics, Budapest, Hungary**

[illegible]
[illegible]†

**Institute of Nuclear Research ATOMKI, Debrecen, Hungary**
[illegible]

**Institute of Physics, University of Debrecen, Debrecen, Hungary**
[illegible]

**Indian Institute of Science (IISc), Bangalore, India**
[illegible]

**National Institute of Science Education and Research, HBNI, Bhubaneswar, India**
[illegible]

**Panjab University, Chandigarh, India**
[illegible]

**University of Delhi, Delhi, India**
[illegible]

**Saha Institute of Nuclear Physics, HBNI, Kolkata, India**
[illegible]

**Indian Institute of Technology Madras, Madras, India**
[illegible]

**Bhabha Atomic Research Centre, Mumbai, India**
[illegible]

**Tata Institute of Fundamental Research-A, Mumbai, India**
[illegible]

**Tata Institute of Fundamental Research-B, Mumbai, India**
[illegible]

**Indian Institute of Science Education and Research (IISER), Pune, India**
[illegible]

**Institute for Research in Fundamental Sciences (IPM), Tehran, Iran**
[illegible]

**University College Dublin, Dublin, Ireland**
[illegible]

**INFN Sezione di Bari [a], Università di Bari [b], Politecnico di Bari [c], Bari, Italy**
[illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,c], [illegible][a,b], [illegible][a,c], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,c], [illegible][a,b], [illegible][a,b], [illegible][a,c], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a,b],

[illegible][a,c], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a], [illegible][a], [illegible][a]

INFN Sezione di Bologna [a], Università di Bologna [b], Bologna, Italy
[illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a,b,5], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a]

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

INFN Sezione di Firenze [a], Università di Firenze [b], Firenze, Italy
[illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a,2], [illegible][a], [illegible][a], [illegible][a]

INFN Laboratori Nazionali di Frascati, Frascati, Italy
[illegible]

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

INFN Sezione di Milano-Bicocca [a], Università di Milano-Bicocca [b], Milano, Italy
[illegible][a], [illegible][b], [illegible][a,b], [illegible][a,b], [illegible][a,b,5], [illegible][a,d,5], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible]

INFN Sezione di Napoli [a], Università di Napoli 'Federico II' [b], Napoli, Italy, Università della Basilicata [c], Potenza, Italy, Università G. Marconi [d], Roma, Italy
[illegible][a], [illegible][a,c], [illegible][a,b], [illegible][a,c], [illegible][a], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a], [illegible][a,d,5], [illegible][a,5], [illegible][a,b], [illegible][a,b]

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

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

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

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

**INFN Sezione di Roma [a], Sapienza Università di Roma [b], Rome, Italy**
[illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a], [illegible][a,b], [illegible][a,b], [illegible][a,b], [illegible][a], [illegible][a,b]

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

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

**Kyungpook National University, Daegu, Korea**
[illegible]

**Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea**
[illegible]

**Hanyang University, Seoul, Korea**
[illegible][2], [illegible]

**Korea University, Seoul, Korea**
[illegible]

**Sejong University, Seoul, Korea**
[illegible]

**Seoul National University, Seoul, Korea**
[illegible]

**University of Seoul, Seoul, Korea**
[illegible]

**Sungkyunkwan University, Suwon, Korea**
[illegible]

**Vilnius University, Vilnius, Lithuania**
[illegible]

**National Centre for Particle Physics, Universiti Malaya, Kuala Lumpur, Malaysia**
[illegible]

**Universidad de Sonora (UNISON), Hermosillo, Mexico**
[illegible]

**Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico**
[illegible]

**Universidad Iberoamericana, Mexico City, Mexico**
[illegible]

**Benemerita Universidad Autonoma de Puebla, Puebla, Mexico**
[illegible]

**Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico**
[illegible]

**University of Auckland, Auckland, New Zealand**
[illegible]

**University of Canterbury, Christchurch, New Zealand**
[illegible]

**National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan**
[illegible]

**National Centre for Nuclear Research, Swierk, Poland**
[illegible]

**Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland**
[illegible]

**Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal**
[illegible]

**Joint Institute for Nuclear Research, Dubna, Russia**
[illegible]

**Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia**
[illegible]

**Institute for Nuclear Research, Moscow, Russia**
[illegible]

**Institute for Theoretical and Experimental Physics, Moscow, Russia**
[illegible]
[illegible]

**Moscow Institute of Physics and Technology, Moscow, Russia**
[illegible]

**National Research Nuclear University 'Moscow Engineering Physics Institute' (MEPhI), Moscow, Russia**
[illegible]

**P.N. Lebedev Physical Institute, Moscow, Russia**
[illegible]

**Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia**
[illegible]
[illegible]
[illegible]

**Novosibirsk State University (NSU), Novosibirsk, Russia**
[illegible]

**Institute for High Energy Physics of National Research Centre 'Kurchatov Institute', Protvino, Russia**
[illegible]
[illegible]
[illegible]

**National Research Tomsk Polytechnic University, Tomsk, Russia**
[illegible]

**University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia**
[illegible]

**Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain**
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

**Universidad Autónoma de Madrid, Madrid, Spain**
[illegible]

**Universidad de Oviedo, Oviedo, Spain**
[illegible]
[illegible]
[illegible]

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

[illegible]
[illegible]

**University of Ruhuna, Department of Physics, Matara, Sri Lanka**
[illegible]

**CERN, European Organization for Nuclear Research, Geneva, Switzerland**
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

**Paul Scherrer Institut, Villigen, Switzerland**
[illegible]
[illegible]

**ETH Zurich - Institute for Particle Physics and Astrophysics (IPA), Zurich, Switzerland**
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

**Universität Zürich, Zurich, Switzerland**
[illegible]
[illegible]
[illegible]

**National Central University, Chung-Li, Taiwan**
[illegible]
[illegible]

**National Taiwan University (NTU), Taipei, Taiwan**
[illegible]
[illegible]

**Chulalongkorn University, Faculty of Science, Department of Physics, Bangkok, Thailand**
[illegible]

**Çukurova University, Physics Department, Science and Art Faculty, Adana, Turkey**
[illegible]
[illegible]
[illegible]
[illegible]

**Middle East Technical University, Physics Department, Ankara, Turkey**
[illegible]

**Bogazici University, Istanbul, Turkey**
[illegible]

**Istanbul Technical University, Istanbul, Turkey**
[illegible]

**Institute for Scintillation Materials of National Academy of Science of Ukraine, Kharkov, Ukraine**
[illegible]

**National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine**
[illegible]

**University of Bristol, Bristol, United Kingdom**
[illegible]

**Rutherford Appleton Laboratory, Didcot, United Kingdom**
[illegible]

**Imperial College, London, United Kingdom**
[illegible]

**Brunel University, Uxbridge, United Kingdom**
[illegible]

**Baylor University, Waco, USA**
[illegible]

**Catholic University of America, Washington DC, USA**
[illegible]

**The University of Alabama, Tuscaloosa, USA**
[illegible]

**Boston University, Boston, USA**
[illegible]

**Brown University, Providence, USA**
[illegible]

**University of California, Davis, Davis, USA**
[illegible]

[illegible]
[illegible]
[illegible]

**University of California, Los Angeles, USA**
[illegible]
[illegible]

**University of California, Riverside, Riverside, USA**
[illegible]
[illegible]
[illegible]

**University of California, San Diego, La Jolla, USA**
[illegible]
[illegible]
[illegible][5], [illegible] [illegible]
[illegible]

**University of California, Santa Barbara - Department of Physics, Santa Barbara, USA**
[illegible]
[illegible]
[illegible]

**California Institute of Technology, Pasadena, USA**
[illegible]
[illegible]

**Carnegie Mellon University, Pittsburgh, USA**
[illegible]

**University of Colorado Boulder, Boulder, USA**
[illegible]
[illegible]

**Cornell University, Ithaca, USA**
[illegible]
[illegible]
[illegible]

**Fermi National Accelerator Laboratory, Batavia, USA**
[illegible]
[illegible][†], [illegible]
[illegible]
[illegible] [illegible]
[illegible]
[illegible]
[illegible]
[illegible][6], [illegible]
[illegible]
[illegible]
[illegible]

### University of Florida, Gainesville, USA

[illegible]
[illegible]
[illegible]

### Florida International University, Miami, USA

[illegible]

### Florida State University, Tallahassee, USA

[illegible]
[illegible]

### Florida Institute of Technology, Melbourne, USA

[illegible]
[illegible]

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

[illegible]
[illegible]
[illegible]

### The University of Iowa, Iowa City, USA

[illegible]
[illegible]
[illegible]

### Johns Hopkins University, Baltimore, USA

[illegible]
[illegible]

### The University of Kansas, Lawrence, USA

[illegible]
[illegible]
[illegible]

### Kansas State University, Manhattan, USA

[illegible]
[illegible]

### Lawrence Livermore National Laboratory, Livermore, USA

[illegible]

### University of Maryland, College Park, USA

[illegible]
[illegible]

### Massachusetts Institute of Technology, Cambridge, USA

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

**University of Minnesota, Minneapolis, USA**
[illegible]
[illegible]

**University of Mississippi, Oxford, USA**
[illegible]

**University of Nebraska-Lincoln, Lincoln, USA**
[illegible]
[illegible]

**State University of New York at Buffalo, Buffalo, USA**
[illegible]
[illegible]

**Northeastern University, Boston, USA**
[illegible]
[illegible]

**Northwestern University, Evanston, USA**
[illegible]
[illegible]

**University of Notre Dame, Notre Dame, USA**
[illegible]
[illegible]
[illegible]
[illegible]

**The Ohio State University, Columbus, USA**
[illegible]
[illegible]

**Princeton University, Princeton, USA**
[illegible]
[illegible]
[illegible]

**University of Puerto Rico, Mayaguez, USA**
[illegible]

**Purdue University, West Lafayette, USA**
[illegible]
[illegible]
[illegible]

**Purdue University Northwest, Hammond, USA**
[illegible]

**Rice University, Houston, USA**
[illegible]
[illegible]

**University of Rochester, Rochester, USA**
[illegible]
[illegible]

**Rutgers, The State University of New Jersey, Piscataway, USA**
[illegible] [illegible]
[illegible]
[illegible]
[illegible]

**University of Tennessee, Knoxville, USA**
[illegible]

**Texas A&M University, College Station, USA**
[illegible][7], [illegible]
[illegible][7], [illegible] [illegible]
[illegible]

**Texas Tech University, Lubbock, USA**
[illegible]
[illegible]

**Vanderbilt University, Nashville, USA**
[illegible]
[illegible]

**University of Virginia, Charlottesville, USA**
[illegible]
[illegible]

**Wayne State University, Detroit, USA**
[illegible]

**University of Wisconsin - Madison, Madison, WI, USA**
[illegible]
[illegible] [illegible]
[illegible]

†: [illegible]
1: [illegible]
2: [illegible] [illegible]
3: [illegible]
4: [illegible]
5: [illegible] [illegible]
6: [illegible]
7: [illegible]
8: [illegible]
9: [illegible]
10: [illegible]
11: [illegible]
12: [illegible]
13: [illegible] [illegible]
14: [illegible]
[illegible]
15: [illegible]
16: [illegible]
17: [illegible]

[illegible]

[illegible]

[illegible] [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]