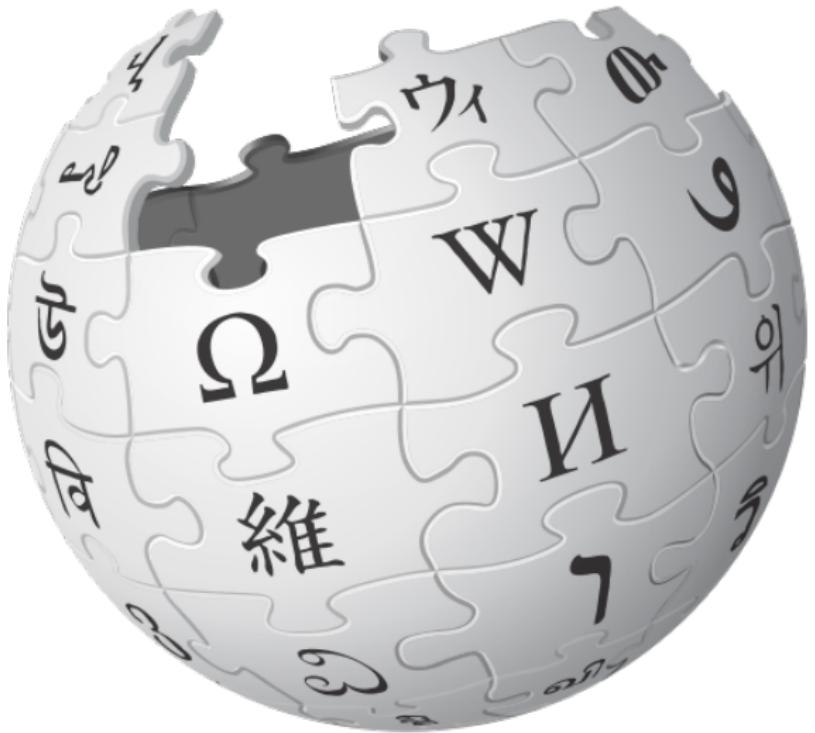


# Getting Started Workshop: The Fragile Families Challenge, round 2

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and people from around the world

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# Initial sequencing and analysis of the human genome

**International Human Genome Sequencing Consortium\***

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# Combined Measurement of the Higgs Boson Mass in $p\bar{p}$ Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments

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 O. Biebel,<sup>101,‡</sup> S. P. Bienniek,<sup>143,‡</sup> M. Biglietti,<sup>134,‡</sup> J. Bibao De Mendizabal,<sup>60,‡</sup> H. Bilokon,<sup>67,‡</sup> M. Bindl,<sup>54,‡</sup> S. Binet,<sup>117,‡</sup>  
 A. Biebel,<sup>193,‡</sup> C. Bini,<sup>132a,132b,‡</sup> C. Black,<sup>150,‡</sup> J. Blaak,<sup>13,‡</sup> M. Black,<sup>22,‡</sup> D. Blackburn,<sup>138,‡</sup> R. E. Blair,<sup>6,‡</sup>  
 J.-B. Blanchard,<sup>136,‡</sup> J. E. Blanco,<sup>77,‡</sup> T. Blazek,<sup>144,‡</sup> I. Bloch,<sup>42,‡</sup> C. Blocker,<sup>23,‡</sup> W. Blum,<sup>83,‡</sup> U. Blumenschein,<sup>54,‡</sup>  
 G. J. Bobbink,<sup>107,‡</sup> V. S. Bobrovnikov,<sup>109,‡</sup> S. S. Bocchetta,<sup>81,‡</sup> A. Bocci,<sup>145,‡</sup> C. Bock,<sup>100,‡</sup> M. Boehler,<sup>48,‡</sup> J. A. Bogaerts,<sup>30,‡</sup>  
 A. G. Bogodanchikov,<sup>108,‡</sup> C. Bohm,<sup>164,‡</sup> V. Botvits,<sup>77,‡</sup> T. Bole,<sup>130,‡</sup> V. Boldea,<sup>26a,‡</sup> A. S. Boldyrev,<sup>99,‡</sup> M. Bombe,<sup>80,‡</sup>  
 M. Bona,<sup>95,‡</sup> M. Boonekamp,<sup>130,‡</sup> A. Borisov,<sup>170,‡</sup> G. Borisov,<sup>72,‡</sup> S. Borroni,<sup>42,‡</sup> J. Borfeldt,<sup>105,‡</sup> V. Bortolotto,<sup>60a-60c,‡</sup>  
 K. Bos,<sup>107,‡</sup> D. Boscherini,<sup>20a,‡</sup> M. Bosman,<sup>12,‡</sup> J. Bourdaud,<sup>125,‡</sup> J. Bouffard,<sup>2,‡</sup> E. V. Bouhouva-Thacker,<sup>72,‡</sup>  
 D. Boumediene,<sup>34,‡</sup> C. Bourdarios,<sup>117,‡</sup> N. Boussoin,<sup>144,‡</sup> A. Boveia,<sup>30,‡</sup> J. Boyd,<sup>30,‡</sup> I. R. Boyke,<sup>65,‡</sup> I. Bozic,<sup>13,‡</sup>  
 J. Braciinski,<sup>18,‡</sup> A. Brandt,<sup>48,‡</sup> G. Brandt,<sup>54,‡</sup> O. Brandt,<sup>156,‡</sup> U. Bratzler,<sup>156,‡</sup> B. Brau,<sup>46,‡</sup> J. E. Brau,<sup>116,‡</sup> H. M. Braun,<sup>178a,‡</sup>  
 S. F. Brazzale,<sup>164a,164b,‡</sup> K. Brendlinger,<sup>122,‡</sup> A. J. Brennan,<sup>88,‡</sup> L. Brenner,<sup>107,‡</sup> R. Brenner,<sup>166,‡</sup> S. Bressler,<sup>172,‡</sup>  
 K. Bristow,<sup>145,‡</sup> T. M. Bristow,<sup>46,‡</sup> D. Britton,<sup>53,‡</sup> D. Britzger,<sup>42,‡</sup> F. M. Brochu,<sup>26,‡</sup> I. Brock,<sup>21,‡</sup> R. Brock,<sup>90,‡</sup> J. Bronner,<sup>101,‡</sup>  
 G. Brooijmans,<sup>35,‡</sup> T. Brooks,<sup>77,‡</sup> W. K. Brooks,<sup>10,‡</sup> J. Brosamer,<sup>15,‡</sup> E. Brost,<sup>136,‡</sup> J. Brown,<sup>55,‡</sup>  
 P. A. Bruckman de Renstrom,<sup>39,‡</sup> D. Bruncko,<sup>144b,‡</sup> R. Bruniere,<sup>48,‡</sup> A. Brunni,<sup>26a,‡</sup> G. Bruni,<sup>26a,‡</sup> M. Bruschi,<sup>20a,‡</sup>  
 L. Bryngemark,<sup>48,‡</sup> T. Buanes,<sup>14,‡</sup> Q. Buaat,<sup>142,‡</sup> P. Bucholz,<sup>141,‡</sup> A. G. Buckley,<sup>53,‡</sup> S. L. Buda,<sup>26a,‡</sup> I. A. Budagov,<sup>65,‡</sup>  
 F. Buehrer,<sup>48,‡</sup> L. Buggy,<sup>119,‡</sup> M. K. Buggy,<sup>119,‡</sup> O. Bulekov,<sup>48,‡</sup> D. Bullock,<sup>8,‡</sup> H. Burckhardt,<sup>30,‡</sup> S. Burdin,<sup>53,‡</sup>  
 B. Burghgraeve,<sup>108,‡</sup> S. Burke,<sup>131,‡</sup> I. Burmeister,<sup>43,‡</sup> E. Busato,<sup>34,‡</sup> D. Büscher,<sup>48,‡</sup> V. Büscher,<sup>93,‡</sup> P. Bussey,<sup>53,‡</sup>  
 P. C. Buszello,<sup>164,‡</sup> J. M. Butler,<sup>22,‡</sup> A. I. Butt,<sup>3,‡</sup> C. M. Buttar,<sup>53,‡</sup> J. M. Butterworth,<sup>76,‡</sup> P. Buttli,<sup>107,‡</sup> W. Buttinger,<sup>28,‡</sup>  
 A. Butazu,<sup>53,‡</sup> V. Buzkayko,<sup>109,‡</sup> S. Cabrera Urbán,<sup>107,‡</sup> D. Caforio,<sup>128,‡</sup> V. M. Cairo,<sup>37a,37b,‡</sup> O. Cakir,<sup>46,‡</sup> P. Calafuria,<sup>15,‡</sup>  
 A. Calandri,<sup>136,‡</sup> G. Calderini,<sup>101,‡</sup> P. Calfayan,<sup>100,‡</sup> L. P. Caloba,<sup>24‡</sup> D. Calver,<sup>34,‡</sup> R. Camacho Toro,<sup>31,‡</sup>  
 S. Camarda,<sup>42,‡</sup> P. Camarri,<sup>133a,133b,‡</sup> D. Cameron,<sup>119,‡</sup> L. M. Caminada,<sup>15,‡</sup> R. Caminada Armadans,<sup>12,‡</sup> S. Campana,<sup>8,‡</sup>  
 M. Campanelli,<sup>78,‡</sup> A. Campanvere,<sup>148,‡</sup> V. Canale,<sup>30a,30b,‡</sup> A. Canepa,<sup>148,‡</sup> M. Canete Beri,<sup>76,‡</sup> J. Cantero,<sup>42,‡</sup>  
 R. Cantrell,<sup>126a,‡</sup> T. Cao,<sup>40,‡</sup> M. D. M. Capaenos Garrido,<sup>30,‡</sup> I. Caprini,<sup>26a,‡</sup> M. Caprini,<sup>26a,‡</sup> M. Capua,<sup>37a,37b,‡</sup> R. Caputo,<sup>83,‡</sup>  
 R. Cardarelli,<sup>133a,‡</sup> T. Carli,<sup>30,‡</sup> G. Carino,<sup>104a,‡</sup> L. Carmatin,<sup>91,91b,‡</sup> S. Caron,<sup>106,‡</sup> E. Carquin,<sup>32a,‡</sup> G. D. Carrillo-Montoya,<sup>8,‡</sup>  
 J. R. Carter,<sup>28,‡</sup> J. Carvalho,<sup>126a,126b,‡</sup> D. Casader,<sup>78,‡</sup> M. P. Casado,<sup>12,‡</sup> M. Casolino,<sup>12,‡</sup> E. Castaneda-Miranda,<sup>149b,‡</sup>  
 A. Castelli,<sup>107,‡</sup> V. Castillo Gimenez,<sup>107,‡</sup> N. F. Castro,<sup>128,‡</sup> P. Catastini,<sup>59,‡</sup> A. Catimacco,<sup>30,‡</sup> J. R. Catmore,<sup>119,‡</sup>  
 A. Cattai,<sup>30,‡</sup> J. Cauldon,<sup>83,‡</sup> V. Cavaliere,<sup>165,‡</sup> M. Cavalli,<sup>27,‡</sup> M. Cavalli-Sforza,<sup>12,‡</sup> V. Cavasinni,<sup>124a,124b,‡</sup>  
 F. Ceradini,<sup>134a,134b,‡</sup> B. C. Cerio,<sup>45,‡</sup> K. Cerny,<sup>129,‡</sup> A. S. Cerqueira,<sup>24b,‡</sup> A. Cerni,<sup>49,‡</sup> L. Cerrito,<sup>76,‡</sup> F. Cerutti,<sup>15,‡</sup> M. Cerv,<sup>30,‡</sup>  
 A. Cervelli,<sup>27,‡</sup> S. A. Cetin,<sup>136,‡</sup> A. Chafaq,<sup>135a,‡</sup> D. Chakraborty,<sup>108,‡</sup> I. Chalupkova,<sup>128,‡</sup> P. Chang,<sup>165,‡</sup> B. Chapleau,<sup>87,‡</sup>  
 J. D. Chapman,<sup>28,‡</sup> D. G. Charlton,<sup>18,‡</sup> C. C. Chan,<sup>128,‡</sup> C. A. Chavez Barajas,<sup>49,‡</sup> S. Cheatham,<sup>132,‡</sup> A. Chegwidden,<sup>90,‡</sup>  
 S. Chekanov,<sup>6,‡</sup> S. V. Chekuliev,<sup>159a,‡</sup> G. A. Chelkov,<sup>65,‡</sup> M. A. Chelstowska,<sup>99,‡</sup> C. Chen,<sup>64,‡</sup> H. Chen,<sup>25,‡</sup> K. Chen,<sup>148,‡</sup>  
 L. Chen,<sup>33a,‡</sup> S. Chen,<sup>33c,‡</sup> Y. Chen,<sup>67,‡</sup> H. C. Cheng,<sup>90,‡</sup> Y. Cheng,<sup>31,‡</sup> A. Cheplakov,<sup>65,‡</sup> E. Cheremushkina,<sup>130,‡</sup>  
 R. Cherkouai El Mousli,<sup>135c,‡</sup> V. Chernyatin,<sup>25,‡</sup> E. Cheu,<sup>7,‡</sup> L. Chevalier,<sup>136,‡</sup> V. Chiarella,<sup>47,‡</sup> J. T. Childers,<sup>6,‡</sup>  
 G. Chiodini,<sup>73,‡</sup> A. S. Chisholm,<sup>18,‡</sup> R. T. Chislett,<sup>78,‡</sup> A. Chitan,<sup>26a,‡</sup> M. V. Chizhov,<sup>65,‡</sup> K. Choi,<sup>41,‡</sup> S. Chouridou,<sup>9,‡</sup>  
 B. K. B. Chow,<sup>200,‡</sup> V. Christodoulou,<sup>78,‡</sup> D. Chromek-Burckhardt,<sup>30,‡</sup> M. L. Chu,<sup>131,‡</sup> J. Chudoba,<sup>127,‡</sup> A. J. Chujnowski,<sup>87,‡</sup>  
 J. J. Chwastowski,<sup>39,‡</sup> L. Chytka,<sup>115,‡</sup> G. Ciapetti,<sup>132a,132b,‡</sup> A. Ciftci,<sup>46,‡</sup> D. Cinca,<sup>53,‡</sup> V. Cindro,<sup>75,‡</sup> I. A. Ciocara,<sup>21,‡</sup>  
 A. Ciocio,<sup>15,‡</sup> Z. H. Citron,<sup>172,‡</sup> M. Ciubancan,<sup>26a,‡</sup> A. Clark,<sup>40,‡</sup> B. L. Clark,<sup>37,‡</sup> P. J. Clark,<sup>46,‡</sup> R. N. Clarke,<sup>15,‡</sup>  
 W. Cleland,<sup>125,‡</sup> C. Clement,<sup>146a,146b,‡</sup> Y. Coadou,<sup>83,‡</sup> M. Cobal,<sup>164a,164c,‡</sup> A. Coccaro,<sup>138,‡</sup> J. Cochran,<sup>64,‡</sup> L. Coffey,<sup>23,‡</sup>

- J. G. Cogan,<sup>143,t</sup> B. Cole,<sup>35,t</sup> S. Cole,<sup>108,t</sup> A. P. Colijn,<sup>107,t</sup> J. Collot,<sup>55,t</sup> T. Colombo,<sup>58c,f</sup> G. Compastella,<sup>101,t</sup>  
 P. Conde Muñoz,<sup>126a,126b,t</sup> E. Conovatis,<sup>48,t</sup> S. H. Connell,<sup>148b,t</sup> L. A. Connolly,<sup>17,t</sup> S. M. Consonni,<sup>92a,b,t</sup> V. Consorti,<sup>48,t</sup>  
 S. Constantinescu,<sup>26a,t</sup> C. Conta,<sup>123a,123b,t</sup> G. Conti,<sup>30,t</sup> F. Conventi,<sup>104a,t</sup> M. Cooke,<sup>15,t</sup> B. D. Cooper,<sup>78,t</sup>  
 A. M. Cooper-Sarkar,<sup>120,t</sup> T. Cornelissen,<sup>175,t</sup> M. Corradi,<sup>20,t</sup> F. Corriveau,<sup>87,t</sup> A. Corso-Radu,<sup>103,t</sup> A. Cortes-Gonzalez,<sup>12,t</sup>  
 G. Cortiana,<sup>101,t</sup> G. Costa,<sup>91a,t</sup> M. J. Costa,<sup>107,t</sup> D. Costanzo,<sup>139,t</sup> D. Côte,<sup>8,t</sup> G. Cottin,<sup>28,t</sup> G. Cowan,<sup>77,t</sup> B. E. Cox,<sup>84,t</sup>  
 K. Cranmer,<sup>110,t</sup> G. Cree,<sup>29,t</sup> S. Crépel-Renaudin,<sup>46,t</sup> F. Crescioli,<sup>40,t</sup> W. A. Cribbs,<sup>146a,146b,t</sup> M. Crispin Ortuzar,<sup>120,t</sup>  
 M. Cristinziani,<sup>21,t</sup> V. Croft,<sup>106,t</sup> G. Crosetti,<sup>27a,27b,t</sup> T. Cuhadar Donszelmann,<sup>139,t</sup> J. Cummings,<sup>176,t</sup> M. Curatolo,<sup>47,t</sup>  
 C. Cuthbert,<sup>150,t</sup> H. Czaj,<sup>141,t</sup> P. Czodrowski,<sup>3,t</sup> S. D'Auria,<sup>53,t</sup> M. D'Onofrio,<sup>74,t</sup>  
 M. J. Da Cunha Sargedas De Sousa,<sup>123a,123b,t</sup> C. Da Via,<sup>84,t</sup> W. Dabrowski,<sup>38a,t</sup> A. Dafinac,<sup>120,t</sup> T. Dai,<sup>99,t</sup> O. Dale,<sup>14,t</sup>  
 F. Dallaire,<sup>6,t</sup> C. Dellapiccola,<sup>36,t</sup> M. Dam,<sup>36,t</sup> R. J. Dandoy,<sup>31,t</sup> N. P. Pang,<sup>48,t</sup> A. C. Daniells,<sup>18,t</sup> M. Danninger,<sup>166,t</sup>  
 M. Dano Hoffmann,<sup>136,t</sup> V. Dav,<sup>48,t</sup> G. Darbo,<sup>50a,t</sup> S. Darmora,<sup>8,t</sup> J. Dassoulas,<sup>3,t</sup> A. Datta Gupta,<sup>61,t</sup> W. Davy,<sup>21,t</sup>  
 C. David,<sup>109,t</sup> T. Davidek,<sup>129,t</sup> E. Davies,<sup>53,t</sup> M. Davies,<sup>153,t</sup> P. Davison,<sup>78,t</sup> Y. Davygora,<sup>58,t</sup> E. Dawe,<sup>88,t</sup> I. Dawson,<sup>139,t</sup>  
 R. K. Daya-Ishumkhametova,<sup>96,t</sup> K. De,<sup>8,t</sup> R. De Asmundis,<sup>104a,t</sup> D. De Castro,<sup>20a,20b,t</sup> S. De Cecco,<sup>80,t</sup> N. De Groot,<sup>106,t</sup>  
 P. de Jong,<sup>107,t</sup> H. De la Torre,<sup>82,t</sup> F. De Lorenzi,<sup>64,t</sup> L. De Nooit,<sup>107,t</sup> D. De Pepe,<sup>132a,t</sup> A. De Salvo,<sup>122a,t</sup> U. De Sanctis,<sup>149,t</sup>  
 A. De Santo,<sup>149,t</sup> J. B. De Vivie De Regie,<sup>117,t</sup> W. J. Deamey,<sup>149,t</sup> R. Debbe,<sup>25,t</sup> C. Debenedetti,<sup>137,t</sup> D. V. Dedovich,<sup>65,t</sup>  
 I. Deigaard,<sup>107,t</sup> J. Del Peso,<sup>82,t</sup> T. Del Prete,<sup>124a,124b,t</sup> D. Delgove,<sup>117,t</sup> F. Delion,<sup>116,t</sup> C. M. Delitzsch,<sup>49,t</sup> M. Deliyergiyev,<sup>75,t</sup>  
 A. Dell'Acqua,<sup>30,t</sup> L. Dell'asta,<sup>22,t</sup> M. Dello Russo,<sup>124a,124b,t</sup> M. Della Pietra,<sup>30a,b,t</sup> D. della Volpe,<sup>49,t</sup> M. Delmastro,<sup>5,t</sup>  
 P. A. Delsart,<sup>55,t</sup> C. Deluca,<sup>107,t</sup> D. A. DeMarco,<sup>158,t</sup> S. Demers,<sup>176,t</sup> M. Demichev,<sup>85,t</sup> A. Demilly,<sup>80,t</sup> S. P. Denisov,<sup>130,t</sup>  
 D. Derendarz,<sup>39,t</sup> J. E. Derkaoui,<sup>155,t</sup> F. Derue,<sup>80,t</sup> P. Dervan,<sup>34,t</sup> K. Desch,<sup>21,t</sup> C. Deterre,<sup>42,t</sup> P. O. Deviereiros,<sup>30,t</sup>  
 A. Dewhurst,<sup>131,t</sup> S. Dhaliwal,<sup>107,t</sup> A. Di Ciaccio,<sup>133a,133b,t</sup> L. Di Ciazzo,<sup>5,t</sup> A. Di Domenico,<sup>132a,132b,t</sup> C. Di Donato,<sup>104a,104b,t</sup>  
 A. Di Girolamo,<sup>30,t</sup> B. Di Girolamo,<sup>30,t</sup> A. Di Mattia,<sup>152,t</sup> B. Di Micco,<sup>152,t</sup> R. Di Nardo,<sup>47,t</sup> A. Di Simone,<sup>48,t</sup>  
 R. Di Sipio,<sup>158,t</sup> D. Di Valentino,<sup>29,t</sup> C. Diaconi,<sup>83,t</sup> M. Diamond,<sup>138,t</sup> F. A. Dias,<sup>46,t</sup> M. A. Diaz,<sup>32a,t</sup> E. B. Diehl,<sup>99,t</sup>  
 J. Dietrich,<sup>16,t</sup> S. Diglio,<sup>85,t</sup> A. Dimitrijevska,<sup>13,t</sup> J. Dijngfelder,<sup>21,t</sup> P. Dita,<sup>26a,t</sup> S. Dittus,<sup>20a,t</sup> F. Dittus,<sup>30,t</sup> F. Djama,<sup>85,t</sup>  
 T. Djobava,<sup>51b,t</sup> J. I. Djuvland,<sup>58a,t</sup> M. A. B. do Vale,<sup>24c,t</sup> D. Dobos,<sup>30,t</sup> M. Dobre,<sup>26a,t</sup> C. Doglioni,<sup>49,t</sup> T. Dolhmae,<sup>155,t</sup>  
 J. Dolejši,<sup>129,t</sup> Z. Doležal,<sup>129,t</sup> B. A. Dolgoshein,<sup>98a,t</sup> M. Donadelli,<sup>24d,t</sup> S. Donati,<sup>124a,124b,t</sup> P. Dondero,<sup>121a,121b,t</sup>  
 J. Donini,<sup>34,t</sup> J. Dopke,<sup>131,t</sup> A. Doris,<sup>104a,t</sup> M. T. Dova,<sup>71,t</sup> A. T. Doyle,<sup>33,t</sup> E. Drechsler,<sup>84,t</sup> M. Dris,<sup>10,t</sup> E. Dubreuil,<sup>34,t</sup>  
 E. Duchovný,<sup>172,t</sup> G. Duckeck,<sup>100,t</sup> O. A. Duda,<sup>20a,20b,t</sup> D. Duda,<sup>175,t</sup> A. Dularayev,<sup>30,t</sup> L. Duflo,<sup>117,t</sup> L. Duguid,<sup>77,t</sup>  
 M. Dührssen,<sup>30,t</sup> M. Dunford,<sup>58a,t</sup> H. Duran Yıldız,<sup>46,t</sup> M. Dürren,<sup>52,t</sup> A. Durgishvili,<sup>51b,t</sup> D. Duschinger,<sup>44,t</sup> M. Dyndal,<sup>38a,t</sup>  
 C. Eckardt,<sup>42,t</sup> K. M. Ecker,<sup>201,t</sup> R. C. Edgar,<sup>98,t</sup> W. Edson,<sup>96,t</sup> N. C. Edwards,<sup>17,t</sup> W. Ehrenfeld,<sup>21,t</sup> T. Elifert,<sup>30,t</sup> G. Eigen,<sup>14,t</sup>  
 K. Einsweiler,<sup>15,t</sup> T. Ekelof,<sup>166,t</sup> M. El Kacimi,<sup>135,t</sup> M. Ellert,<sup>166,t</sup> S. Elles,<sup>8,t</sup> F. Ellinghaus,<sup>83,t</sup> A. A. Elliott,<sup>169,t</sup> N. Ellis,<sup>30,t</sup>  
 J. Elmsheuser,<sup>100,t</sup> M. Eising,<sup>30,t</sup> D. Emelyanov,<sup>131,t</sup> Y. Enari,<sup>155,t</sup> O. C. Endner,<sup>33,t</sup> M. Endo,<sup>118,t</sup> R. Engelmann,<sup>148,t</sup>  
 J. Erdmann,<sup>43,t</sup> A. Ereditato,<sup>175,t</sup> G. Ernis,<sup>175,t</sup> J. Ernst,<sup>2,t</sup> M. Ernst,<sup>25,t</sup> S. Errede,<sup>165,t</sup> E. Ertel,<sup>83,t</sup> M. Escalier,<sup>117,t</sup> H. Esch,<sup>43,t</sup>  
 J. Erdmann,<sup>125,t</sup> B. Esposito,<sup>47,t</sup> A. I. Etienne,<sup>136,t</sup> E. Etzion,<sup>133,t</sup> H. Evans,<sup>64,t</sup> A. Ezhilov,<sup>123,t</sup> L. Fabriti,<sup>20a,20b,t</sup> G. Facini,<sup>31,t</sup>  
 C. Escobar,<sup>125,t</sup> B. Espósito,<sup>47,t</sup> A. I. Etienne,<sup>136,t</sup> E. Etzion,<sup>133,t</sup> H. Evans,<sup>64,t</sup> A. Ezhilov,<sup>123,t</sup> L. Fabriti,<sup>20a,20b,t</sup> G. Facini,<sup>31,t</sup>  
 R. M. Fakhruddinov,<sup>130,t</sup> S. Falcondo,<sup>132,t</sup> R. J. Falla,<sup>78,t</sup> J. Fallota,<sup>120,t</sup> Y. Fang,<sup>33,t</sup> M. Fanti,<sup>91a,91b,t</sup> A. Farbin,<sup>8,t</sup>  
 A. Farilla,<sup>134a,t</sup> T. Farooque,<sup>12,t</sup> S. Farrell,<sup>15,t</sup> S. M. Farrington,<sup>170,t</sup> P. Farthouat,<sup>30,t</sup> F. Fassa,<sup>135a,t</sup> P. Fasnacht,<sup>30,t</sup>  
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Liang,<sup>17,†</sup> H. Liao,<sup>34,†</sup> B. Liberti,<sup>133a,†</sup> A. Liblong,<sup>158,†</sup> P. Lichard,<sup>30,†</sup> K. Lie,<sup>165,†</sup> J. Liebal,<sup>21,†</sup> W. Liebig,<sup>14,†</sup> C. Limbach,<sup>21,†</sup> A. Limosani,<sup>130,†</sup> S. C. Lin,<sup>151,†</sup> T. H. Lin,<sup>131,†</sup> F. Linde,<sup>107,†</sup> B. E. Lindquist,<sup>148,†</sup> J. T. Linnemann,<sup>90,†</sup> E. Lipelies,<sup>122,†</sup> A. Lipniacka,<sup>14,†</sup> M. Lisoviy,<sup>26b,†</sup> T. M. Liss,<sup>165,†</sup> D. Lissauer,<sup>25,†</sup> A. Lister,<sup>168,†</sup> M. A. Litke,<sup>157,†</sup> B. Liu,<sup>151,†</sup> D. Liu,<sup>151,†</sup> J. Liu,<sup>85,†</sup> J. B. Liu,<sup>133b,†</sup> K. Liu,<sup>165,†</sup> L. Liu,<sup>165,†</sup> M. Liu,<sup>145,†</sup> M. Liu,<sup>33b,†</sup> Y. Liu,<sup>33b,†</sup> M. Livian,<sup>121a,121b,†</sup> A. Lleres,<sup>55,†</sup> J. Llorente Merino,<sup>84,†</sup> E. Llorente Merino,<sup>84,†</sup> F. Llorente Merino,<sup>84,†</sup> P. 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 T. Maeno,<sup>25,†</sup> A. Maevskiy,<sup>99,†</sup> E. Magradze,<sup>54,†</sup> K. Mahboubi,<sup>48,†</sup> J. Mahstedt,<sup>107,†</sup> C. Maiani,<sup>136,†</sup> C. Maidantchik,<sup>24a,†</sup>  
 A. A. Maier,<sup>101,†</sup> T. Maier,<sup>100,†</sup> A. Maior,<sup>128a,128b,128d,†</sup> S. Majewski,<sup>98,†</sup> Y. Makide,<sup>68,†</sup> N. Makovec,<sup>80,†</sup>  
 P. Malecki,<sup>39,†</sup> V. Maleev,<sup>20,†</sup> F. Malek,<sup>55,†</sup> U. Mallik,<sup>63,†</sup> D. Malon,<sup>6,†</sup> C. Malone,<sup>143,†</sup> S. Maltezos,<sup>10,†</sup>  
 V. M. Malyshev,<sup>108,†</sup> S. Malyukov,<sup>20,†</sup> J. Mamuzic,<sup>42,†</sup> G. Mancini,<sup>47,†</sup> B. Mandelli,<sup>30,†</sup> L. Mandelli,<sup>91a,†</sup> I. Mandic,<sup>75,†</sup>  
 R. Mandrysch,<sup>61,†</sup> J. Manreira,<sup>126a,126b,†</sup> A. Manfredini,<sup>101,†</sup> L. Manhaes de Andrade Filho,<sup>126,†</sup> J. Manjares Ramos,<sup>150b,†</sup>  
 A. Mann,<sup>108,†</sup> P. M. Manning,<sup>137,†</sup> A. Manousakis-Katsikakis,<sup>9,†</sup> B. Mansouli,<sup>136,†</sup> R. Mantel,<sup>83,†</sup> M. Mantouani,<sup>54,†</sup>  
 L. Mapelli,<sup>30,†</sup> L. March,<sup>145,†</sup> G. Marchiori,<sup>103,†</sup> M. Marcusi,<sup>127,†</sup> C. Marta,<sup>109,†</sup> M. Marano,<sup>109,†</sup> M. Marjanovic,<sup>13,†</sup> F. Marroquin,<sup>24a,†</sup>  
 S. P. Marsden,<sup>44,†</sup> Z. Marshall,<sup>15,†</sup> F. L. Marti,<sup>17,†</sup> S. Marti-Garcia,<sup>106,†</sup> B. Martin,<sup>90,†</sup> T. A. Martin,<sup>170,†</sup> V. J. Martin,<sup>46,†</sup>  
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 B. Meirois,<sup>41,†</sup> B. R. Mellado Garcia,<sup>145,†</sup> F. Meloni,<sup>17,†</sup> A. Mengarelli,<sup>21a,21b,†</sup> S. Menke,<sup>101,†</sup> E. Meoni,<sup>161,†</sup>  
 K. M. Mercurio,<sup>57,†</sup> S. Mergelman,<sup>21,†</sup> P. Memrod,<sup>49,†</sup> L. Merolla,<sup>104a,104b,†</sup> C. Meromi,<sup>91a,†</sup> F. S. Merritt,<sup>31,†</sup>  
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 K. Mochizuki,<sup>85,†</sup> S. Mohapatra,<sup>25,†</sup> W. Mohr,<sup>48,†</sup> S. Molander,<sup>146a,146b,†</sup> R. Moles-Valls,<sup>107,†</sup> K. Möng,<sup>42,†</sup> C. Monini,<sup>55,†</sup>  
 J. Monk,<sup>36,†</sup> E. Monnier,<sup>83,†</sup> J. Montejo Berlingen,<sup>12,†</sup> F. Monticelli,<sup>71,†</sup> S. Monzani,<sup>132a,132b,†</sup> R. W. Moore,<sup>3,†</sup>  
 N. Morane,<sup>117,†</sup> D. Moreno,<sup>162,†</sup> M. Moreno Llacer,<sup>54,†</sup> P. Morettini,<sup>50a,†</sup> M. Morgenstern,<sup>44,†</sup> M. Mori,<sup>57,†</sup>  
 M. Morinaga,<sup>135,†</sup> V. Moritsub,<sup>119,†</sup> S. Moritz,<sup>83,†</sup> A. K. Morley,<sup>147,†</sup> G. Moronaci,<sup>36,†</sup> J. D. Morris,<sup>76,†</sup> S. S. Mortensen,<sup>36,†</sup>  
 A. Morton,<sup>51,†</sup> L. Morvaj,<sup>103,†</sup> M. Mosidze,<sup>31b,†</sup> J. Moss,<sup>111,†</sup> K. Motohashi,<sup>157,†</sup> R. Mount,<sup>143,†</sup> E. Mountricha,<sup>25,†</sup>  
 S. V. Mouravious,<sup>96,†</sup> E. J. W. Moyse,<sup>86,†</sup> S. Muanza,<sup>85,†</sup> R. D. Mudd,<sup>18,†</sup> F. Mueller,<sup>101,†</sup> J. Mueller,<sup>123,†</sup> K. Mueller,<sup>21,†</sup>  
 R. S. P. Mueller,<sup>108,†</sup> T. Mueller,<sup>28,†</sup> D. Muenstermann,<sup>40,†</sup> P. Mullen,<sup>53,†</sup> Y. Munwes,<sup>153,†</sup> J. A. Murillo Quijada,<sup>54,†</sup>  
 W. J. Murray,<sup>170,171,†</sup> H. Musheghyan,<sup>85,†</sup> E. Musto,<sup>162,†</sup> A. G. Myagkov,<sup>130a,130b,†</sup> M. Myska,<sup>128,†</sup> O. Nackenhorst,<sup>54,†</sup>  
 J. Nadai,<sup>54,†</sup> K. Nagai,<sup>120,†</sup> R. Nagai,<sup>157,†</sup> Y. Nagai,<sup>45,†</sup> K. Nagano,<sup>66,†</sup> A. Nagarkar,<sup>111,†</sup> Y. Nagasaki,<sup>99,†</sup> K. Nagata,<sup>160,†</sup>  
 M. Nagel,<sup>101,†</sup> E. Nagy,<sup>85,†</sup> A. M. Nairz,<sup>30,†</sup> Y. Nakahama,<sup>30,†</sup> K. Nakamura,<sup>66,†</sup> T. Nakamura,<sup>155,†</sup> I. Nakano,<sup>112,†</sup>  
 H. Namasyanayam,<sup>41,†</sup> R. F. Narango Garcia,<sup>31,†</sup> R. Narayan,<sup>31,†</sup> T. Naumann,<sup>42,†</sup> G. Navarro,<sup>162,†</sup> R. Nayyar,<sup>7,†</sup> H. A. Neal,<sup>89,†</sup>  
 P. Yu. Nechaeva,<sup>96,†</sup> T. J. Neep,<sup>64,†</sup> P. D. Neff,<sup>145,†</sup> A. Negri,<sup>121a,121b,†</sup> M. Negriini,<sup>200,†</sup> S. Nektarievic,<sup>106,†</sup> C. Nellist,<sup>117,†</sup>  
 A. Nelson,<sup>163,†</sup> J. Nemecic,<sup>177,†</sup> P. Nemethy,<sup>110,†</sup> A. A. Nepomuceno,<sup>24a,†</sup> M. Nessi,<sup>30a,c,†</sup> M. S. Neuhaber,<sup>165,†</sup>  
 M. Neumann,<sup>175,†</sup> R. M. Neves,<sup>110,†</sup> P. Newski,<sup>25,†</sup> P. R. Newman,<sup>18,†</sup> D. H. Nguyen,<sup>61,†</sup> R. B. Nickerson,<sup>120,†</sup>  
 R. Nicolaidou,<sup>136,†</sup> B. Nicquevert,<sup>30,†</sup> J. Nielsen,<sup>137,†</sup> N. Nikiforou,<sup>153,†</sup> N. Nikiforou,<sup>16,†</sup> V. Nikolaenko,<sup>130,13b,†</sup>  
 I. Nikolic-Audit,<sup>80,†</sup> K. Niklopoulos,<sup>18,†</sup> J. Nilsen,<sup>119,†</sup> P. Nilsson,<sup>25,†</sup> Y. Ninomiya,<sup>155,†</sup> A. Nisati,<sup>132a,†</sup> R. Nisius,<sup>101,†</sup>  
 T. Nobe,<sup>157,†</sup> M. Nomachi,<sup>118,†</sup> I. Nomidis,<sup>20,†</sup> T. Nooney,<sup>76,†</sup> S. Norberg,<sup>113,†</sup> M. Nordberg,<sup>30,†</sup> O. Novgorodova,<sup>44,†</sup>  
 S. Nowak,<sup>101,†</sup> M. Nowak,<sup>66,†</sup> L. Nozka,<sup>115,†</sup> K. Niekras,<sup>10,†</sup> G. Nunes Haminger,<sup>88,†</sup> T. Nunnemann,<sup>100,†</sup> E. Nurse,<sup>78,†</sup>  
 F. Nutt,<sup>88,†</sup> B. J. O'Brien,<sup>46,†</sup> F. O'Grady,<sup>7,†</sup> D. C. O'Neill,<sup>142,†</sup> V. O'Shea,<sup>53,†</sup> F. G. Oakham,<sup>20,6,†</sup> H. Oberlack,<sup>108,†</sup>  
 T. Obermann,<sup>21,†</sup> J. Ocariz,<sup>18,†</sup> A. Ochi,<sup>167,†</sup> L. Ochoa,<sup>76,†</sup> P. J. Ochoa-Ricoux,<sup>32a,†</sup> S. Oda,<sup>70,†</sup> S. Oda,<sup>68,†</sup> H. Ogren,<sup>61,†</sup>  
 A. Oh,<sup>84,†</sup> S. H. Oh,<sup>101,†</sup> C. C. Ohm,<sup>166,†</sup> H. Ohne,<sup>30,†</sup> H. Oide,<sup>30,†</sup> S. Okamura,<sup>218,†</sup> H. Okawa,<sup>200,†</sup> Y. Okumura,<sup>31,†</sup>  
 T. Okuyama,<sup>155,†</sup> A. Olarin,<sup>26a,†</sup> S. A. Olivares Pino,<sup>46,†</sup> D. Oliveira Damazio,<sup>25,†</sup> E. Oliver Garcia,<sup>167,†</sup> A. Olszewski,<sup>39,†</sup>  
 J. Olszowska,<sup>134a,134b,†</sup> A. Onofre,<sup>31,†</sup> P. U. E. Onyisi,<sup>31,†</sup> C. J. Oram,<sup>159a,†</sup> M. J. Oreglia,<sup>31,†</sup> Y. Oren,<sup>153,†</sup>  
 D. Orestano,<sup>134a,134b,†</sup> N. Orlando,<sup>154,†</sup> C. Oropeza Barrera,<sup>33,†</sup> R. S. Orr,<sup>158,†</sup> B. Osculati,<sup>30a,50b,†</sup> R. Ospanol,<sup>39,†</sup>

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Pantea,<sup>26a,‡</sup> L. Paolozzi,<sup>49,‡</sup> Th.D. Papadopoulos,<sup>101,‡</sup> K. Papageorgiou,<sup>184,‡</sup> A. Paramonov,<sup>6,‡</sup> D. Paredes Hernandez,<sup>154,‡</sup> M. A. Parker,<sup>28,‡</sup> K. A. Parker,<sup>130,‡</sup> F. Parodi,<sup>50a,50b,‡</sup> J. A. Parsons,<sup>35,‡</sup> U. Parzefall,<sup>46,‡</sup> E. Pasqualucci,<sup>132a,‡</sup> S. Passaggio,<sup>20a,‡</sup> F. Pastore,<sup>134a,134b,‡</sup> Fr. Pastore,<sup>77,‡</sup> G. Pásztor,<sup>29,‡</sup> S. Pataraia,<sup>175,‡</sup> N. D. Patel,<sup>150,‡</sup> J. R. Pater,<sup>94,‡</sup> T. Pauri,<sup>30,‡</sup> J. Pearce,<sup>169,‡</sup> B. Pearson,<sup>113,‡</sup> L. E. Pedersen,<sup>36,‡</sup> M. Pedersen,<sup>189,‡</sup> S. Pedraza Lopez,<sup>167,‡</sup> R. Pedro,<sup>126a,126b,‡</sup> S. V. Peleganchuk,<sup>108,‡</sup> D. Pelikan,<sup>196,‡</sup> H. Peng,<sup>108,‡</sup> B. Penning,<sup>31,‡</sup> J. Penwell,<sup>26,‡</sup> P. Perellesta,<sup>25,‡</sup> E. Perez Codina,<sup>159,‡</sup> M. T. Pérez García-Estate,<sup>167,‡</sup> L. Perini,<sup>91a,91b,‡</sup> H. Permegger,<sup>30,‡</sup> S. Perrella,<sup>104a,104b,‡</sup> R. Peschke,<sup>42,‡</sup> V. D. Peschekhonov,<sup>65,‡</sup> K. Peters,<sup>30,‡</sup> R. F. Y. Peters,<sup>84,‡</sup> B. A. Petersen,<sup>134a,134b,‡</sup> T. C. Petersen,<sup>36,‡</sup> E. Petit,<sup>42,‡</sup> A. Petridis,<sup>146a,146b,‡</sup> C. Petridou,<sup>154,‡</sup> E. Petrolo,<sup>132a,‡</sup> F. Petrucci,<sup>18,‡</sup> E. N. Pettersson,<sup>187,‡</sup> R. Pezoa,<sup>32b,‡</sup> P. W. Phillips,<sup>131,‡</sup> G. Picciadio,<sup>143,‡</sup> E. Pianori,<sup>170,‡</sup> A. Picazio,<sup>49,‡</sup> E. Piccaro,<sup>16,‡</sup> M. Piccinini,<sup>20a,20b,‡</sup> M. A. Pickett,<sup>126,‡</sup> R. Piegaia,<sup>27,‡</sup> D. T. Pignotti,<sup>111,‡</sup> J. E. Pilcher,<sup>31,‡</sup> A. D. Pilkington,<sup>84,‡</sup> J. Pina,<sup>126a,126b,126d,‡</sup> M. Pinamonti,<sup>164a,164c,48,‡</sup> J. L. Pinfol,<sup>37,‡</sup> A. Pingel,<sup>36,‡</sup> B. Pinto,<sup>126a,‡</sup> S. Pires,<sup>80,‡</sup> M. Pitt,<sup>172,‡</sup> C. Pizio,<sup>91a,91b,‡</sup> L. Plazak,<sup>144a,‡</sup> M.-A. Pleier,<sup>28,‡</sup> V. Plesko,<sup>129,‡</sup> D. P. Plotnikova,<sup>65,‡</sup> P. Plucinski,<sup>146a,146b,‡</sup> D. Pluth,<sup>64,‡</sup> R. Poettgen,<sup>83,‡</sup> L. Poglioni,<sup>117,‡</sup> D. Polh,<sup>21,‡</sup> G. Pollesello,<sup>121,‡</sup> A. Pollicicchio,<sup>19,‡</sup> R. Polifka,<sup>158,‡</sup> A. Polini,<sup>26b,‡</sup> C. S. Pollard,<sup>53,‡</sup> V. Polychronakos,<sup>25,‡</sup> K. Pommeis,<sup>30,‡</sup> I. Pontecorvo,<sup>132a,‡</sup> B. G. Pope,<sup>90,‡</sup> G. A. Popenciu,<sup>21b,‡</sup> D. S. Popovic,<sup>13,‡</sup> A. Popleton,<sup>30,‡</sup> S. Pospisil,<sup>128,‡</sup> K. Potamianos,<sup>15,‡</sup> I. N. Potrat,<sup>65,‡</sup> C. J. Potter,<sup>149,‡</sup> C. T. Potter,<sup>116,‡</sup> G. Poulard,<sup>53,‡</sup> J. J. Poveda,<sup>74a,‡</sup> V. Pozdnjakov,<sup>65,‡</sup> P. Pralavorio,<sup>85,‡</sup> A. Pranko,<sup>15,‡</sup> S. Prasad,<sup>30,‡</sup> S. Prell,<sup>64,‡</sup> D. Price,<sup>94,‡</sup> L. Price,<sup>6,‡</sup> M. Primavera,<sup>74a,‡</sup> S. Prince,<sup>65,‡</sup> M. Proissl,<sup>46,‡</sup> K. Prokofiev,<sup>16,‡</sup> F. Prokoshin,<sup>37b,‡</sup> E. Protopapadaki,<sup>136,‡</sup> S. Protopopescu,<sup>25,‡</sup> J. Proudfoot,<sup>6,‡</sup> M. Przybycien,<sup>38a,‡</sup> J. Ptacek,<sup>116,‡</sup> D. Puddu,<sup>134a,134b,‡</sup> E. Pueschl,<sup>66,‡</sup> D. Puldorn,<sup>148,‡</sup> M. Purnohi,<sup>84,‡</sup> P. Puzzo,<sup>117,‡</sup> J. Qian,<sup>90,‡</sup> G. Qin,<sup>53,‡</sup> Y. Qin,<sup>94,‡</sup> A. Quadt,<sup>34,‡</sup> D. R. Quarrie,<sup>15,‡</sup> W. B. Quayle,<sup>16,‡</sup> M. Queitsch-Maitland,<sup>64,‡</sup> D. Quilty,<sup>53,‡</sup> S. Radduin,<sup>119,‡</sup> V. Radeka,<sup>25,‡</sup> V. Radescu,<sup>42,‡</sup> S. K. Radhakrishnan,<sup>148,‡</sup> P. Radloff,<sup>116,‡</sup> P. Rados,<sup>83,‡</sup> F. Ragusa,<sup>91a,91b,‡</sup> G. Rahal,<sup>178,‡</sup> S. Rajagopalan,<sup>25,‡</sup> M. Rammenhoven,<sup>30,‡</sup> C. Rangel-Smith,<sup>81,‡</sup> F. Rauscher,<sup>100,‡</sup> S. Rave,<sup>83,‡</sup> T. Ravencroft,<sup>53,‡</sup> M. Raymond,<sup>30,‡</sup> A. L. Read,<sup>119,‡</sup> N. P. Readoff,<sup>24,‡</sup> D. M. Rebuzzi,<sup>121a,121b,‡</sup> A. Redelbach,<sup>174,‡</sup> G. Redlinger,<sup>25,‡</sup> R. Reece,<sup>137,‡</sup> K. Reeves,<sup>41,‡</sup> L. Rehmsch,<sup>16,‡</sup> H. Reisin,<sup>27,‡</sup> M. Relich,<sup>163,‡</sup> C. Rembser,<sup>30,‡</sup> H. Ren,<sup>35a,‡</sup> A. Renaud,<sup>117,‡</sup> M. Rescigno,<sup>132a,‡</sup> S. Resconi,<sup>91a,‡</sup> O. L. Rezanova,<sup>109,‡</sup> P. Reznickz,<sup>123,‡</sup> R. Rezvani,<sup>95,‡</sup> R. Richter,<sup>88,‡</sup> S. Richter,<sup>78,‡</sup> E. Richter-Was,<sup>88,‡</sup> O. Ricken,<sup>21,‡</sup> M. Ridel,<sup>80,‡</sup> P. Rieck,<sup>16,‡</sup> C. J. Riegel,<sup>175,‡</sup> J. Rieger,<sup>54,‡</sup> M. Rijssenbeek,<sup>148,‡</sup> A. Rimoldi,<sup>121a,121b,‡</sup> L. Rinaldi,<sup>175,‡</sup> B. Ristic,<sup>49,‡</sup> E. Ritsch,<sup>62,‡</sup> I. Riu,<sup>12,‡</sup> F. Rizatdinova,<sup>114,‡</sup> E. Rizvi,<sup>76,‡</sup> S. H. Robertson,<sup>87,‡</sup> A. Robichaud-Veronneau,<sup>87,‡</sup> D. Robinson,<sup>28,‡</sup> J. E. M. Robinson,<sup>84,‡</sup> A. Robson,<sup>53,‡</sup> C. Roda,<sup>124a,124b,‡</sup> S. Roe,<sup>30,‡</sup> O. Roßnhe,<sup>119,‡</sup> S. Rolli,<sup>161,‡</sup> A. Romanik,<sup>96,‡</sup> M. Romano,<sup>80,‡</sup> S. M. Romano Saez,<sup>34,‡</sup> E. Romere Adam,<sup>167,‡</sup> N. Rompotis,<sup>136,‡</sup> M. Ronzani,<sup>48,‡</sup> L. Roos,<sup>20,‡</sup> E. Ros,<sup>167,‡</sup> S. Rosati,<sup>112,‡</sup> K. Rosbach,<sup>46,‡</sup> P. Rose,<sup>137,‡</sup> P. L. Rosendahl,<sup>147,‡</sup> O. Rosenthal,<sup>141,‡</sup> V. Rossetti,<sup>146a,146b,‡</sup> E. Rossi,<sup>104a,104b,‡</sup> L. P. Rossi,<sup>50a,‡</sup> R. Rosten,<sup>138,‡</sup> M. Rotaru,<sup>26a,‡</sup> I. Roth,<sup>172,‡</sup> J. Rothberg,<sup>138,‡</sup> D. Rousseau,<sup>117,‡</sup> C. R. Royon,<sup>136,‡</sup> A. Rozanov,<sup>85,‡</sup> Y. Rozen,<sup>152,‡</sup> X. Ruan,<sup>145c,‡</sup> F. Rubbo,<sup>143,‡</sup> I. Rubinsky,<sup>42,‡</sup> V. I. Rud,<sup>99,‡</sup> C. Rudolph,<sup>44,‡</sup> M. S. Rudolph,<sup>158,‡</sup> F. Rühr,<sup>48,‡</sup> A. Ruiz-Martinez,<sup>30,‡</sup> Z. Runikova,<sup>48,‡</sup> N. A. Rusakovitch,<sup>65,‡</sup> A. Ruschke,<sup>100,‡</sup> H. L. Russell,<sup>138,‡</sup> J. P. Rutherford,<sup>7,‡</sup> N. Ruthmann,<sup>48,‡</sup> F. Y. Ryabov,<sup>123,‡</sup> M. Rybar,<sup>129,‡</sup> G. Rybkina,<sup>117,‡</sup> N. C. Ryder,<sup>120,‡</sup> A. F. Saavedra,<sup>150,‡</sup> G. Sabato,<sup>107,‡</sup> S. Sacerdoti,<sup>27,‡</sup> A. Sadidze,<sup>14,‡</sup> H. F.-W. Sadrozinski,<sup>137,‡</sup> R. Sadykov,<sup>65,‡</sup> F. Safai Tehrani,<sup>132a,‡</sup> M. Samipert,<sup>136,‡</sup> H. Sakamoto,<sup>155,‡</sup> Y. Sakurai,<sup>171,‡</sup> G. Salamanna,<sup>134a,134b,‡</sup> A. Salamon,<sup>133a,‡</sup> M. Saleem,<sup>113,‡</sup> D. Salek,<sup>107,‡</sup> P. H. Sales De Bruin,<sup>158,‡</sup> D. Salihagic,<sup>101,‡</sup> A. Salnikov,<sup>143,‡</sup> J. Salt,<sup>167,‡</sup> D. Salvatore,<sup>170a,170b,‡</sup> F. Salvatore,<sup>140,‡</sup> A. Salucci,<sup>106,‡</sup> A. Salzburger,<sup>154,‡</sup> D. Sampsonidis,<sup>154,‡</sup> A. Sanchez,<sup>104a,104b,‡</sup> J. Sánchez,<sup>167,‡</sup> V. Sanchez Martinez,<sup>167,‡</sup> H. Sandaker,<sup>4,‡</sup> R. L. Sandbach,<sup>76,‡</sup> H. G. Sander,<sup>83,‡</sup> M. P. Sanders,<sup>100,‡</sup> M. Sandhoff,<sup>175,‡</sup> C. Sandoval,<sup>162,‡</sup> R. Sandstrom,<sup>101,‡</sup> D. P. C. Sankey,<sup>131,‡</sup> M. Sammizo,<sup>50a,50b,‡</sup> A. Sansoni,<sup>47,‡</sup> C. Santoni,<sup>34,‡</sup> R. Santonicio,<sup>133a,133b,‡</sup> H. Santos,<sup>126a,‡</sup> L. Santoyo Castillo,<sup>149,‡</sup> K. Sapp,<sup>125,‡</sup> A. Sapromov,<sup>65,‡</sup> J. G. Sarava,<sup>126a,126b,‡</sup> B. Sarrazinot,<sup>21,‡</sup> O. Sasaki,<sup>66,‡</sup> Y. Sasaki,<sup>155,‡</sup> K. Satō,<sup>160,‡</sup> G. Sauvage,<sup>5,‡</sup> E. Sauvan,<sup>5,‡</sup> G. Savage,<sup>77,‡</sup> P. Savard,<sup>128,‡</sup> C. Sawyer,<sup>120,‡</sup> L. Sawyer,<sup>70,‡</sup> J. Saxon,<sup>31,‡</sup> C. Sharra,<sup>20a,‡</sup> A. Shbrizi,<sup>120,‡</sup> T. Scanlon,<sup>78,‡</sup> D. A. Scannicchio,<sup>83,‡</sup> M. Scarcella,<sup>150,‡</sup> V. Scarfone,<sup>37a,37b,‡</sup> J. Schaarschmidt,<sup>172,‡</sup> P. Schacht,<sup>101,‡</sup> D. Schaefer,<sup>30,‡</sup> R. Schaefer,<sup>42,‡</sup> J. Schaeffer,<sup>83,‡</sup> S. Schaepe,<sup>21,‡</sup> S. Schatzel,<sup>50b,‡</sup> U. Schäfer,<sup>83,‡</sup> A. C. Schaffer,<sup>117,‡</sup> D. Schala,<sup>100,‡</sup> R. D. Schamberger,<sup>140,‡</sup> V. Scharf,<sup>90a,‡</sup>

- V. A. Schegelsky,<sup>128,†</sup> D. Scheirich,<sup>129,†</sup> M. Schernau,<sup>163,‡</sup> C. Schiavi,<sup>50a,50b,‡</sup> C. Schillo,<sup>48,†</sup> M. Schioppa,<sup>37a,37b,†</sup>  
 S. Schlenker,<sup>30,‡</sup> E. Schmidt,<sup>48,†</sup> K. Schmieden,<sup>30,‡</sup> C. Schmitt,<sup>48,†</sup> S. Schmitt,<sup>42,†</sup> B. Schneider,<sup>189a,†</sup>  
 Y. J. Schnellbach,<sup>74,†</sup> U. Schoonroock,<sup>44,†</sup> L. Schoofel,<sup>136,†</sup> A. Schoening,<sup>20b,†</sup> B. D. Schoenrock,<sup>90,†</sup> E. Schopf,<sup>21,†</sup>  
 A. L. S. Schorlemmer,<sup>54,†</sup> M. Schott,<sup>83,†</sup> D. Schouten,<sup>159a,†</sup> J. Schovancova,<sup>8,†</sup> S. Schramm,<sup>158,†</sup> M. Schreyer,<sup>174,†</sup>  
 C. Schroeder,<sup>83,†</sup> N. Schuh,<sup>83,†</sup> M. J. Schulmes,<sup>21,†</sup> H.-C. Schultz-Coulon,<sup>98,†</sup> H. Schulz,<sup>16,†</sup> M. Schumacher,<sup>48,†</sup>  
 B. A. Schumann,<sup>137,†</sup> Ph. Schune,<sup>136,†</sup> C. Schwanenberger,<sup>143,†</sup> A. Schwartzman,<sup>143,†</sup> T. A. Schwarz,<sup>90,†</sup> Ph. Schwegler,<sup>101,†</sup>  
 Ph. Schwemling,<sup>136,†</sup> R. Schwienhorst,<sup>90,†</sup> J. Schwindt,<sup>21,†</sup> M. Schwoerer,<sup>5,†</sup> F. G. Sciacca,<sup>47,†</sup>  
 E. Seifo,<sup>117,†</sup> G. Sciolta,<sup>23,†</sup> F. Scuri,<sup>21,†</sup> E. Seuti,<sup>21,†</sup> J. Seucy,<sup>89,†</sup> G. Sedov,<sup>42,†</sup> E. Sedykh,<sup>93,†</sup> P. Seema,<sup>21,†</sup>  
 S. C. Seidel,<sup>105,†</sup> A. Seiden,<sup>137,†</sup> F. Seifert,<sup>128,†</sup> J. M. Sexias,<sup>24a,†</sup> G. Sekhniaidze,<sup>83,†</sup> K. Sekhon,<sup>89,†</sup> S. J. Sekula,<sup>40,†</sup>  
 K. E. Selbach,<sup>46,†</sup> D. M. Silverman,<sup>123,8,†</sup> N. Semprini-Cesari,<sup>20a,20b,†</sup> C. Serfon,<sup>30,†</sup> L. Serin,<sup>117,†</sup> L. Serkin,<sup>164,164b,†</sup>  
 T. Serre,<sup>85,†</sup> M. Sessa,<sup>134,134b,†</sup> R. Seuster,<sup>159a,†</sup> H. Severini,<sup>113,†</sup> T. Stilfsgoj,<sup>75,†</sup> F. Sforza,<sup>101,†</sup> A. Sfyrla,<sup>20,†</sup> E. Shabalina,<sup>54,†</sup>  
 M. Shamini,<sup>116,†</sup> L. Y. Shan,<sup>33a,†</sup> R. Shang,<sup>165,†</sup> J. T. Shank,<sup>22,†</sup> M. Shapiro,<sup>15,†</sup> P. B. Shatalov,<sup>140,†</sup> K. Shaw,<sup>164a,164b,†</sup>  
 S. M. Shaw,<sup>84,†</sup> A. Scherbakov,<sup>140a,140b,†</sup> C. Y. Shehu,<sup>140,†</sup> P. Sherwood,<sup>78,†</sup> L. Shi,<sup>131,131b,†</sup> S. Shimizu,<sup>63,†</sup> C. O. Shimmin,<sup>163,†</sup>  
 M. Shimojima,<sup>102,†</sup> M. Shiyakova,<sup>65,†</sup> A. Shmeleva,<sup>96,†</sup> D. Shoalahe Saadi,<sup>42,†</sup> M. J. Shochet,<sup>71,†</sup> S. Shojaii,<sup>91,91b,†</sup>  
 S. Shrestha,<sup>111,†</sup> E. Shulga,<sup>98,†</sup> M. A. Shupe,<sup>7,†</sup> S. Shushkevich,<sup>42,†</sup> P. Sicho,<sup>127,†</sup> O. Sidiropolou,<sup>174,†</sup> D. Sidorov,<sup>134,†</sup>  
 A. Sidoti,<sup>20a,20b,†</sup> F. Siegert,<sup>44,†</sup> D. Sijacki,<sup>13,†</sup> J. Silva,<sup>126a,126d,†</sup> Y. Silver,<sup>153,†</sup> S. B. Silverstein,<sup>146a,†</sup> V. Simak,<sup>128,†</sup>  
 O. Simard,<sup>83,†</sup> Lj. Simic,<sup>13,†</sup> S. Simon,<sup>117,†</sup> E. Simioni,<sup>83,†</sup> B. Simmonis,<sup>48,†</sup> D. Simon,<sup>34,†</sup> R. Simonello,<sup>91a,91b,†</sup> P. Sinervo,<sup>158,†</sup>  
 N. B. Sinev,<sup>118,†</sup> G. Siragusa,<sup>174,†</sup> A. Sisakyan,<sup>85,†</sup> S. Yu. Sivoklokov,<sup>90,†</sup> J. Sjolin,<sup>146a,146b,†</sup> T. B. Bjursen,<sup>14,†</sup>  
 M. B. Skinner,<sup>72,†</sup> H. P. Skottowe,<sup>37,†</sup> P. Skubic,<sup>118,†</sup> M. Slater,<sup>25,†</sup> T. Slavicek,<sup>128,†</sup> M. Slawinska,<sup>107,†</sup> K. Sliwa,<sup>161,†</sup>  
 V. Smakhtin,<sup>172,†</sup> B. H. Smart,<sup>46,†</sup> L. Smestad,<sup>14,†</sup> S. Yu. Smirnov,<sup>98,†</sup> Y. Smirnov,<sup>88,†</sup> L. N. Smirnova,<sup>99,99b,†</sup> O. Smirnova,<sup>81,†</sup>  
 M. N. K. Smith,<sup>35,†</sup> R. W. Smith,<sup>35,†</sup> M. Smizanska,<sup>72,†</sup> K. Smolek,<sup>126,†</sup> A. A. Snesarev,<sup>43,†</sup> G. Smidero,<sup>26,†</sup> S. Snyder,<sup>98,†</sup>  
 R. Sobie,<sup>109,109,†</sup> F. Socher,<sup>44,†</sup> A. Soffer,<sup>133,†</sup> D. A. Soh,<sup>151,151,†</sup> C. A. Solans,<sup>93,†</sup> M. Solar,<sup>128,†</sup> J. Solc,<sup>128,†</sup> E. Yu. Soldatov,<sup>98,†</sup>  
 U. Soldevila,<sup>167,†</sup> A. A. Solodkov,<sup>130,†</sup> A. Soloshenko,<sup>65,†</sup> O. V. Solovyanov,<sup>130,†</sup> V. Solov'yev,<sup>123,†</sup> P. Sommer,<sup>48,†</sup>  
 H. Y. Song,<sup>93,†</sup> N. Soni,<sup>1,†</sup> A. Sood,<sup>15,†</sup> A. Sopeck,<sup>128,†</sup> B. Sopko,<sup>128,†</sup> V. Sorin,<sup>12,†</sup> D. Sosa,<sup>58b,†</sup>  
 M. M.索塞比,<sup>42,†</sup> C. L. Sotiriopoulou,<sup>126a,126b,†</sup> F. Soualah,<sup>164,164c,†</sup> P. Souseid,<sup>83,†</sup> A. M. Soukharev,<sup>109,109,†</sup> D. South,<sup>42,†</sup>  
 B. C. Sowden,<sup>77,†</sup> S. Spagnolo,<sup>77a,77b,†</sup> M. Spalla,<sup>124a,124b,†</sup> F. Spanò,<sup>77,†</sup> W. R. Spearman,<sup>77,†</sup> F. Spettel,<sup>101,†</sup> R. Spighi,<sup>20a,†</sup>  
 G. Spiga,<sup>30,†</sup> L. A. Spiller,<sup>88,†</sup> M. Spousa,<sup>129,†</sup> T. Spritzer,<sup>158,†</sup> R. D. St. Denz,<sup>53,53,†</sup> S. Staerz,<sup>44,†</sup> J. Stahlin,<sup>119,†</sup>  
 R. Stamen,<sup>58,†</sup> S. Stamm,<sup>96,†</sup> E. Staneecka,<sup>49,†</sup> C. Stanescu,<sup>134,8,†</sup> M. Stanescu-Bellu,<sup>42,†</sup> M. M. Stanizki,<sup>42,†</sup> S. Stappnes,<sup>25,†</sup>  
 E. A. Starchenko,<sup>130,†</sup> J. Stark,<sup>58,†</sup> P. Staroba,<sup>127,†</sup> P. Starovitz,<sup>42,†</sup> R. Staszewski,<sup>98,†</sup> P. Stavina,<sup>146a,146b,†</sup> P. Steinberg,<sup>25,†</sup>  
 B. Stelzer,<sup>142,†</sup> H. J. Stelzer,<sup>103,†</sup> O. Stielzer-Chilton,<sup>159a,†</sup> F. Soualah,<sup>164,164c,†</sup> S. Stern,<sup>20,20,†</sup> G. A. Stewart,<sup>53,†</sup> J. A. Stillings,<sup>21,†</sup>  
 M. C. Stockton,<sup>87,†</sup> M. Stoebe,<sup>47,†</sup> G. Stoica,<sup>26a,†</sup> P. Stoltz,<sup>54,†</sup> S. Stonjek,<sup>201,†</sup> A. R. Stradling,<sup>8,†</sup> A. Straessner,<sup>34,†</sup>  
 M. E. Stramaglia,<sup>17,†</sup> J. Strandberg,<sup>147,†</sup> S. Strandberg,<sup>146a,146b,†</sup> A. Strandlie,<sup>119,†</sup> E. Strauss,<sup>113,†</sup> M. Strauss,<sup>113,†</sup>  
 P. Strizelecki,<sup>144,†</sup> R. Strömler,<sup>143,†</sup> D. M. Strom,<sup>116,†</sup> J. Stroykowski,<sup>40,†</sup> A. Strubig,<sup>108,†</sup> S. A. Stucci,<sup>13,†</sup> B. Stugu,<sup>14,†</sup>  
 N. A. Styles,<sup>42,†</sup> D. Su,<sup>143,†</sup> J. Sun,<sup>125,†</sup> R. Subramanian,<sup>79,†</sup> A. Succurro,<sup>12,†</sup> Y. Sugaya,<sup>118,†</sup> C. Suhr,<sup>108,†</sup> M. Suk,<sup>128,†</sup>  
 V. V. Sulim,<sup>96,†</sup> S. T. Sun,<sup>4c,†</sup> T. Sumida,<sup>68,†</sup> S. Sun,<sup>57,†</sup> X. Sun,<sup>33a,†</sup> J. E. Sundermann,<sup>48,†</sup> K. Suruliz,<sup>149,†</sup>  
 G. Susimmo,<sup>37a,37b,†</sup> M. R. Sutton,<sup>149,†</sup> S. Suzuki,<sup>66,†</sup> Y. Suzuki,<sup>66,†</sup> M. Svatos,<sup>127,†</sup> S. Swedish,<sup>168,†</sup> M. Swiatlowski,<sup>144,†</sup>  
 I. Sykora,<sup>144a,†</sup> I. Sykora,<sup>129,7,†</sup> D. Ta,<sup>90,†</sup> C. Tacconi,<sup>134a,134b,†</sup> K. Tackmann,<sup>42,†</sup> J. Taenzer,<sup>158,†</sup> A. Taffard,<sup>163,†</sup> R. Tarifour,<sup>159a,†</sup>  
 N. Taiblum,<sup>153,†</sup> H. Takai,<sup>25,†</sup> T. Takashima,<sup>69,†</sup> H. Takeda,<sup>87,†</sup> T. Takeishi,<sup>140,†</sup> Y. Takubo,<sup>66,†</sup> M. Talby,<sup>83,†</sup>  
 A. A. Talyshev,<sup>109,109,†</sup> J. Y. C. Tan,<sup>174,†</sup> K. G. Tan,<sup>38,†</sup> J. Tanaka,<sup>158,†</sup> R. Tanaka,<sup>117,†</sup> S. Tanaka,<sup>66,†</sup> B. B. Tannenwald,<sup>111,†</sup>  
 N. Tamoury,<sup>21,†</sup> S. Tapprogue,<sup>83,†</sup> S. Tarem,<sup>152,†</sup> F. Tarrade,<sup>29,†</sup> G. F. Tartarelli,<sup>21a,†</sup> P. Tas,<sup>128,†</sup> M. Tasevsky,<sup>127,†</sup>  
 T. Tashiro,<sup>161,†</sup> E. Tassi,<sup>37a,37b,†</sup> A. Tavares Delgado,<sup>126a,126b,†</sup> Y. Tayalati,<sup>135d,†</sup> F. E. Taylor,<sup>94,†</sup> G. N. Taylor,<sup>88,†</sup> W. Taylor,<sup>159b,†</sup>  
 F. A. Teischinger,<sup>30,†</sup> M. Teixeira Dias Castanheira,<sup>76,†</sup> P. Teixeira-Dias,<sup>77,†</sup> K. K. Temming,<sup>48,†</sup> H. Ten Kate,<sup>30,†</sup>  
 P. K. Teng,<sup>151,†</sup> J. J. Teoh,<sup>118,†</sup> F. Tepel,<sup>178,†</sup> S. Terada,<sup>66,†</sup> K. Terashi,<sup>155,†</sup> J. Terren,<sup>82,†</sup> S. Terzo,<sup>101,†</sup> M. Testa,<sup>47,†</sup>  
 R. J. Teuscher,<sup>158,158,†</sup> J. Therhaag,<sup>21,†</sup> T. Theveneau-Pelzer,<sup>34,†</sup> J. Thomas,<sup>18,†</sup> J. J. Thomas-Wilsker,<sup>77,†</sup> E. N. Thompson,<sup>35,†</sup>  
 P. D. Thompson,<sup>18,†</sup> R. J. Thompson,<sup>84,†</sup> A. S. Thompson,<sup>53,53,†</sup> A. S. Thomas,<sup>122,†</sup> E. Thomson,<sup>122,†</sup> M. Thomson,<sup>26,†</sup>  
 R. P. Thun,<sup>30,30,†</sup> M. J. Tibbets,<sup>25,†</sup> E. Tiece Torres,<sup>85,†</sup> S. Tokimori,<sup>96,96,†</sup> Yu. A. Tikhonov,<sup>109,109,†</sup> S. Timoshenko,<sup>98,†</sup>  
 E. Tiouchichine,<sup>85,†</sup> P. Tipton,<sup>176,†</sup> S. Tisserant,<sup>85,†</sup> T. Todoro,<sup>5,†</sup> S. Todorova-Nova,<sup>120,†</sup> J. Tojo,<sup>70,†</sup> S. Tokář,<sup>144a,†</sup>  
 K. Tokushuku,<sup>66,†</sup> K. Tolleson,<sup>90,†</sup> E. Tolley,<sup>57,†</sup> L. Tomlinson,<sup>84,†</sup> M. Tomoto,<sup>103,†</sup> L. Tompkins,<sup>143,143,†</sup> K. Toms,<sup>105,†</sup>  
 E. Torrence,<sup>116,†</sup> H. Torres,<sup>142,†</sup> E. Torrò Pastor,<sup>167,†</sup> J. Toth,<sup>85,85,†</sup> F. Touchard,<sup>85,†</sup> D. R. Tovey,<sup>139,†</sup> T. Trefzger,<sup>174,†</sup>

- L. Tremblet,<sup>30,†</sup> A. Tricoli,<sup>30,‡</sup> I. M. Trigger,<sup>159a,§</sup> S. Trincaz-Duvord,<sup>30,||</sup> M. F. Tripiana,<sup>12,†</sup> W. Trischuk,<sup>158,¶</sup> B. Trocmé,<sup>55,¶</sup> C. Troncon,<sup>94,¶</sup> M. Trottier-McDonald,<sup>12,†</sup> M. Trouvaille,<sup>12a,13a,¶</sup> P. True,<sup>90,‡</sup> L. Truong,<sup>164,164c,¶</sup> M. Trzebinski,<sup>99,¶</sup> A. Trzupek,<sup>30,‡</sup> C. Tsarouchas,<sup>30,‡</sup> J.-C.-L. Tseng,<sup>120,‡</sup> P. V. Tsiareska,<sup>92,‡</sup> D. Tsionis,<sup>154,‡</sup> G. Tsipoliti,<sup>10,§</sup> N. Tsiririanitis,<sup>9,‡</sup> S. Tsikaridze,<sup>12,†</sup> V. Tsikaridze,<sup>48,‡</sup> E. G. Tskhadadze,<sup>51,‡</sup> I. I. Tsukerman,<sup>97,‡</sup> V. Tsulai,<sup>15,‡</sup> S. Tsuno,<sup>66,‡</sup> D. Tyshychev,<sup>148,‡</sup> A. Tudorache,<sup>26a,†</sup> V. Tudorache,<sup>26a,†</sup> A. N. Tuna,<sup>20a,†</sup> S. A. Tuppur,<sup>20a,20b,†</sup> S. Turchikhin,<sup>99,¶</sup> D. Turecek,<sup>128,‡</sup> R. Turra,<sup>91a,91b,†</sup> A. J. Turvey,<sup>40,‡</sup> P. M. Tuts,<sup>14,‡</sup> A. Tykhonov,<sup>20,†</sup> M. Tymiad,<sup>148a,148b,†</sup> M. Tyndel,<sup>131,‡</sup> I. Ueda,<sup>155,‡</sup> R. Ueno,<sup>20,‡</sup> M. Ughetto,<sup>140a,140b,†</sup> M. Uglan,<sup>14,‡</sup> M. Uhlenbroek,<sup>21,‡</sup> F. Ukegawa,<sup>160,‡</sup> G. Unal,<sup>30,‡</sup> A. Undrus,<sup>25,‡</sup> G. Unel,<sup>48,‡</sup> F. C. Ungaro,<sup>48,‡</sup> Y. Unno,<sup>66,‡</sup> C. Unverdorben,<sup>100,‡</sup> J. Urban,<sup>140b,†</sup> P. Usquijo,<sup>88,‡</sup> P. Uriegola,<sup>83,‡</sup> G. Usaï,<sup>83,‡</sup> A. Usanova,<sup>62,‡</sup> L. Vacavant,<sup>48,‡</sup> V. Vacek,<sup>120,‡</sup> B. Vachon,<sup>87,‡</sup> C. Valkeronis,<sup>9,‡</sup> N. Valencic,<sup>9,‡</sup> S. Valentim,<sup>20a,20b,†</sup> A. Valero,<sup>167,‡</sup> L. Valery,<sup>12,‡</sup> S. Valkar,<sup>129,‡</sup> E. Valladolid Gallego,<sup>167,‡</sup> S. Vallecorta,<sup>49,‡</sup> J. A. Valls Ferre,<sup>197,‡</sup> W. Van Den Wollenberg,<sup>107,‡</sup> P. C. Van Der Deijl,<sup>107,‡</sup> R. van der Geer,<sup>107,‡</sup> H. van der Graaf,<sup>107,‡</sup> R. Van Der Leeuw,<sup>107,‡</sup> N. van Eldik,<sup>152,‡</sup> P. van Gemmeren,<sup>6,‡</sup> J. Van Nieuwkoop,<sup>142,‡</sup> I. van Vulpen,<sup>107,‡</sup> M. C. van Woerden,<sup>38,‡</sup> M. Vanadia,<sup>132a,132b,†</sup> W. Vandael,<sup>30,‡</sup> R. Vanguri,<sup>122,‡</sup> A. Vaniacchine,<sup>6,‡</sup> F. Vannucci,<sup>80,‡</sup> G. Vardanyan,<sup>347,‡</sup> R. Varri,<sup>132,‡</sup> E. W. Varner,<sup>7,‡</sup> T. Varol,<sup>40,‡</sup> R. Varouchas,<sup>80,‡</sup> A. Varnapetian,<sup>8,‡</sup> K. E. Varvel,<sup>150,‡</sup> F. Vazeille,<sup>347,‡</sup> T. Vazquez Schroeder,<sup>87,‡</sup> J. Veatch,<sup>7,‡</sup> L. M. Veloci,<sup>158,‡</sup> F. Veloso,<sup>126a,126b,†</sup> T. Velz,<sup>21,‡</sup> S. Veneziano,<sup>132a,‡</sup> A. Ventura,<sup>73a,73b,‡</sup> D. Ventura,<sup>86,‡</sup> M. Venturi,<sup>169,‡</sup> N. Venturi,<sup>158,‡</sup> A. Venturini,<sup>23,‡</sup> V. Vercesi,<sup>121a,‡</sup> M. Verducci,<sup>132a,132b,‡</sup> W. Verkerke,<sup>107,‡</sup> J. C. Vermeulen,<sup>107,‡</sup> A. Vest,<sup>44,‡</sup> M. C. Vetterli,<sup>142,‡</sup> O. Viazlo,<sup>81,‡</sup> I. Ichou,<sup>185,‡</sup> T. Vickey,<sup>139,‡</sup> O. E. Vickey Boeriu,<sup>139,‡</sup> G. H. A. Viehhauser,<sup>120,‡</sup> S. Viel,<sup>15,‡</sup> R. Vigne,<sup>30,‡</sup> M. Villa,<sup>20a,20b,†</sup> M. Villaplana Perez,<sup>91a,91b,‡</sup> E. Vilucchi,<sup>47,‡</sup> M. G. Vinctor,<sup>29,‡</sup> V. B. Vinogradov,<sup>65,‡</sup> I. Vivarelli,<sup>140,‡</sup> F. Vives Vaque,<sup>3,‡</sup> S. Vlachos,<sup>10,‡</sup> D. Vladou,<sup>100,‡</sup> M. Vlasak,<sup>128,‡</sup> M. Vogel,<sup>128,‡</sup> P. Vokac,<sup>128,‡</sup> M. Volpi,<sup>88,‡</sup> H. von der Schmitz,<sup>101,‡</sup> H. von Radziewski,<sup>48,‡</sup> E. von Toerne,<sup>27,‡</sup> K. Vorobel,<sup>28,‡</sup> M. Vos,<sup>30,‡</sup> R. Voss,<sup>74,‡</sup> N. Vranjes,<sup>31,‡</sup> J. H. Vossebeld,<sup>74,‡</sup> N. Vranjes,<sup>31,‡</sup> M. Vranjes Milosavljevic,<sup>13,‡</sup> V. Vrba,<sup>127,‡</sup> M. Vreeswijk,<sup>107,‡</sup> R. Vuillermet,<sup>30,‡</sup> L. Vukotic,<sup>31,‡</sup> Z. Vykydal,<sup>128,‡</sup> P. Wagner,<sup>21,‡</sup> W. Wagner,<sup>175,‡</sup> H. Wahlberg,<sup>71,‡</sup> S. Wahrund,<sup>44,‡</sup> J. Wakabayashi,<sup>103,‡</sup> J. Walker,<sup>72,‡</sup> R. Walker,<sup>108,‡</sup> W. Walkowiak,<sup>141,‡</sup> C. Wang,<sup>33c,‡</sup> F. Wang,<sup>173,‡</sup> H. Wang,<sup>15,‡</sup> L. Wang,<sup>40,‡</sup> J. Wang,<sup>42,‡</sup> J. Wang,<sup>33a,‡</sup> K. Wang,<sup>37,‡</sup> R. Wang,<sup>6,‡</sup> S. M. Wang,<sup>151,‡</sup> T. Wang,<sup>21,‡</sup> X. Wang,<sup>27b,‡</sup> C. Wanotayaroj,<sup>116,‡</sup> A. Warburton,<sup>87,‡</sup> C. P. Ward,<sup>26,‡</sup> D. R. Wardrobe,<sup>76,‡</sup> M. Warsinsky,<sup>48,‡</sup> A. Washbrook,<sup>46,‡</sup> C. Wasicki,<sup>42,‡</sup> P. M. Watson,<sup>18,‡</sup> L. J. Watson,<sup>150,‡</sup> M. F. Watson,<sup>18,‡</sup> G. Watts,<sup>128,‡</sup> S. Watts,<sup>84,‡</sup> B. M. Waugh,<sup>84,‡</sup> S. Webb,<sup>84,‡</sup> M. S. Weber,<sup>84,‡</sup> S. W. Webber,<sup>174,‡</sup> J. S. Webster,<sup>31,‡</sup> A. R. Weidberg,<sup>120,‡</sup> B. Weinert,<sup>61,‡</sup> J. Weingarten,<sup>54,‡</sup> C. Weiser,<sup>48,‡</sup> H. Weiss,<sup>107,‡</sup> P. S. Wells,<sup>30,‡</sup> T. Wenaus,<sup>28,‡</sup> T. Wengler,<sup>30,‡</sup> S. Wenzl,<sup>30,‡</sup> N. Wermes,<sup>21,‡</sup> M. Werner,<sup>40,‡</sup> P. Werner,<sup>30,‡</sup> M. Wessels,<sup>20a,‡</sup> J. Wetter,<sup>84,‡</sup> K. Whalen,<sup>29,‡</sup> A. M. Wharton,<sup>72,‡</sup> A. White,<sup>8,‡</sup> M. J. White,<sup>12,‡</sup> R. White,<sup>32b,‡</sup> S. White,<sup>124a,124b,†</sup> D. Whiteson,<sup>165,‡</sup> F. J. Wickens,<sup>131,‡</sup> W. Wiedemann,<sup>173,‡</sup> M. Wieler,<sup>131,‡</sup> P. Wienemann,<sup>21,‡</sup> C. Wiglesworth,<sup>36,‡</sup> L. A. M. Wiik-Fuchs,<sup>21,‡</sup> A. Wildauer,<sup>101,‡</sup> H. G. Wilkens,<sup>30,‡</sup> H. H. Williams,<sup>122,‡</sup> S. Williams,<sup>107,‡</sup> C. Willis,<sup>90,‡</sup> S. Willcoq,<sup>86,‡</sup> A. Wilson,<sup>89,‡</sup> J. A. Wilson,<sup>18,‡</sup> I. Wingerter-Seetz,<sup>5,‡</sup> F. Winklmeier,<sup>116,‡</sup> B. T. Winter,<sup>21,‡</sup> M. Wittgen,<sup>144,‡</sup> J. Wittkowski,<sup>100,‡</sup> S. J. Wolffstadt,<sup>83,‡</sup> M. W. Wolter,<sup>98,‡</sup> H. Wolters,<sup>120a,120c,‡</sup> B. K. Wosiak,<sup>39,‡</sup> J. Wotschack,<sup>30,‡</sup> M. J. Woudstra,<sup>84,‡</sup> K. W. Woźniak,<sup>98,‡</sup> M. Wu,<sup>35,‡</sup> M. Wu,<sup>21,‡</sup> S. L. Wu,<sup>273,‡</sup> X. Wu,<sup>49,‡</sup> Y. Wu,<sup>89,‡</sup> T. R. Wyatt,<sup>84,‡</sup> B. M. Wynne,<sup>46,‡</sup> S. S. Xella,<sup>36,‡</sup> D. Xu,<sup>33a,‡</sup> L. Xu,<sup>33b,‡</sup> B. Yabsley,<sup>150,‡</sup> S. Yacoob,<sup>148,‡</sup> Y. Yakabe,<sup>67,‡</sup> M. Yamada,<sup>66,‡</sup> Y. Yamaguchi,<sup>118,‡</sup> A. Yamamoto,<sup>66,‡</sup> S. Yamamoto,<sup>155,‡</sup> T. Yamashita,<sup>155,‡</sup> K. Yamanchi,<sup>103,‡</sup> Y. Yamazaki,<sup>67,‡</sup> Z. Yan,<sup>22,‡</sup> H. Yang,<sup>3,‡</sup> H. Yang,<sup>173,‡</sup> Y. Yang,<sup>151,‡</sup> L. Yao,<sup>36a,‡</sup> W.-M. Yao,<sup>15,‡</sup> Y. Yao,<sup>66,‡</sup> E. Yatsenko,<sup>5,‡</sup> K. Hay,Wong,<sup>21,‡</sup> J. Ye,<sup>40,‡</sup> S. Ye,<sup>23,‡</sup> I. Yetleksiz,<sup>65,‡</sup> A. L. Yen,<sup>37,‡</sup> E. Yıldırım,<sup>42,‡</sup> K. Yorita,<sup>171,‡</sup> R. Yoshida,<sup>6,‡</sup> K. Yoshihara,<sup>122,‡</sup> C. Young,<sup>143,‡</sup> C. J. S. Young,<sup>30,‡</sup> S. Yousell,<sup>22,‡</sup> D. R. Yu,<sup>15,‡</sup> J. Yu,<sup>8,‡</sup> J. M. Yu,<sup>89,‡</sup> J. Yu,<sup>114,‡</sup> L. Yuan,<sup>67,‡</sup> A. Yurkewicz,<sup>108,‡</sup> I. Yusoff,<sup>28,‡</sup> B. Zabinsk,<sup>19,‡</sup> R. Zaidan,<sup>63,‡</sup> A. M. Zaitsev,<sup>130,3b,‡</sup> J. Zalewicka,<sup>84,‡</sup> A. Zaman,<sup>148,‡</sup> S. Zamitbo,<sup>57,‡</sup> L. Zanello,<sup>132a,132b,‡</sup> D. Zanzi,<sup>98,‡</sup> C. Zeitlin,<sup>175,‡</sup> M. Zeman,<sup>128,‡</sup> A. Zemla,<sup>38a,‡</sup> K. Zengel,<sup>23,‡</sup> O. Zenin,<sup>130,‡</sup> T. Ženčík,<sup>144,‡</sup> D. Žerwas,<sup>177,‡</sup> D. Zhang,<sup>103,‡</sup> F. Zhang,<sup>173,‡</sup> L. Zhang,<sup>6,‡</sup> L. Zhang,<sup>48,‡</sup> R. Zhang,<sup>30b,‡</sup> X. Zhang,<sup>33d,‡</sup> Z. Zhang,<sup>117,‡</sup> X. Zhao,<sup>40,‡</sup> Y. Zhao,<sup>33a,17,‡</sup> Z. Zhao,<sup>33b,‡</sup> A. Zhemchugov,<sup>65,‡</sup> J. Zhong,<sup>120,‡</sup> B. Zhou,<sup>80,‡</sup> C. Zhou,<sup>45,‡</sup> L. Zhou,<sup>35,‡</sup> L. Zhou,<sup>40,‡</sup> N. Zhou,<sup>16,‡</sup> C. G. Zhu,<sup>33d,‡</sup> H. Zhu,<sup>33a,‡</sup> J. Zhu,<sup>89,‡</sup> Y. Zhu,<sup>33b,‡</sup> X. Zhuang,<sup>33a,‡</sup> K. Zhukov,<sup>96,‡</sup> A. Zibell,<sup>174,‡</sup> D. Ziemińska,<sup>61,‡</sup> N. I. Zimine,<sup>65,‡</sup> C. Zimmermann,<sup>83,‡</sup> S. Zimmermann,<sup>54,‡</sup> M. Zinser,<sup>83,‡</sup> M. Ziolkowski,<sup>141,‡</sup> L. Živković,<sup>173,‡</sup> G. Zobemig,<sup>179,‡</sup> A. Zoccoli,<sup>20a,20b,†</sup> M. zur Nedden,<sup>16,‡</sup> G. Zarzolo,<sup>104a,104b,†</sup> L. Zwalski,<sup>30,‡</sup> V. Khachatryan,<sup>173,‡</sup> A. M. Sirunyan,<sup>170,‡</sup> A. Tumasyan,<sup>170,‡</sup> W. Adam,<sup>180,‡</sup> E. Asilar,<sup>180,‡</sup> T. Bergauer,<sup>180,‡</sup> J. Brandstötter,<sup>180,‡</sup> E. Brondolin,<sup>180,‡</sup> M. Dragicevic,<sup>180,‡</sup> J. Erő,<sup>180,‡</sup> M. Flechi,<sup>180,‡</sup> M. Friedl,<sup>180,‡</sup> R. Fröhwith,<sup>180,‡</sup> V. M. Ghete,<sup>180,‡</sup> C. Hartl,<sup>180,‡</sup> N. Hörmann,<sup>174,‡</sup> J. Huubec,<sup>180,‡</sup> M. Jeitler,<sup>180,‡</sup> A. König,<sup>180,‡</sup>

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Seva,<sup>184,2</sup> L. Thomas,<sup>184,2</sup> C. Vander Velde,<sup>184,2</sup> P. Vanhae,<sup>184,2</sup> J. Wang,<sup>184,2</sup> R. Yonamine,<sup>184,2</sup> F. Zenoni,<sup>184,2</sup> F. Zhang,<sup>184,2</sup> K. Beernaert,<sup>185,2</sup> L. Benucci,<sup>185,2</sup> A. Cimmino,<sup>185,2</sup> S. Crucy,<sup>185,2</sup> A. Fagot,<sup>185,2</sup> G. Garcia,<sup>185,2</sup> M. Gui,<sup>185,2</sup> J. Mccartin,<sup>185,2</sup> A. Ocampo Rios,<sup>185,2</sup> D. Poyraz,<sup>185,2</sup> D. Ryckbosch,<sup>185,2</sup> S. Salva Gibala,<sup>185,2</sup> M. Sigamani,<sup>185,2</sup> N. Strobbe,<sup>185,2</sup> M. Tytgat,<sup>185,2</sup> W. Van Diressche,<sup>185,2</sup> E. Yazgan,<sup>185,2</sup> N. Zaganidis,<sup>185,2</sup> S. Basegemez,<sup>186,mn,2</sup> C. Beluffi,<sup>186,mn,2</sup> O. Bondu,<sup>186,2</sup> G. Bruno,<sup>186,2</sup> R. Castello,<sup>186,2</sup> A. Caudron,<sup>186,2</sup> L. Ceard,<sup>186,2</sup> G. G. Da Silveira,<sup>186,2</sup> C. Delaere,<sup>186,2</sup> D. Favart,<sup>186,2</sup> L. Forthomme,<sup>186,2</sup> A. Giannamico,<sup>186,2</sup> J. Hollar,<sup>186,2</sup> A. Jafari,<sup>186,2</sup> P. Jez,<sup>186,2</sup> M. Komm,<sup>186,2</sup> V. Lemaitre,<sup>186,2</sup> A. Mertens,<sup>186,2</sup> C. Nuttens,<sup>186,2</sup> L. Perni,<sup>186,2</sup> A. Pin,<sup>186,2</sup> K. Piotrkowski,<sup>186,2</sup> A. Popov,<sup>186,2</sup> L. Quertenmont,<sup>186,2</sup> M. Selvaggi,<sup>186,2</sup> M. Vidal Marono,<sup>186,2</sup> N. Bely,<sup>187,2</sup> T. Caeberg,<sup>187,2</sup> G. H. Hammad,<sup>187,2</sup> W. L. Aldá Junior,<sup>187,2</sup> G. A. Alves,<sup>187,2</sup> L. Brito,<sup>187,2</sup> M. Corre Martins Junior,<sup>188,2</sup> T. Dos Reis Martins,<sup>188,2</sup> C. Hensel,<sup>188,2</sup> C. Mora Herrera,<sup>188,2</sup> A. Morais,<sup>188,2</sup> M. E. Pot,<sup>188,2</sup> P. Rebello Teles,<sup>188,2</sup> E. Belchior Batista Das Chagas,<sup>189,2</sup> W. Carvalho,<sup>189,2</sup> J. Chinellato,<sup>189,2</sup> A. Custodio,<sup>189,2</sup> E. M. Da Costa,<sup>189,2</sup> D. De Jesus Damiao,<sup>189,2</sup> C. D. Oliveira Martins,<sup>189,2</sup> S. Fonseca De Souza,<sup>189,2</sup> L. M. Huertas Guativa,<sup>189,2</sup> H. Malbouisson,<sup>189,2</sup> D. Matos Figueiredo,<sup>189,2</sup> L. Mundini,<sup>189,2</sup> H. Nogima,<sup>189,2</sup> W. L. Prado Da Silva,<sup>189,2</sup> A. Santoro,<sup>189,2</sup> A. Sznaider,<sup>189,2</sup> E. J. Tonelli Mangano,<sup>189,2</sup> A. Vilela Pereira,<sup>189,2</sup> S. Ahuja,<sup>189,2</sup> C. A. Bernardes,<sup>189,2</sup> A. De Souza Santos,<sup>189,2</sup> S. Dogra,<sup>189,2</sup> T. R. Fernandez Perez Tomei,<sup>189,2</sup> E. M. Gregores,<sup>189,2</sup> G. Mercadante,<sup>189,2</sup> S. Moon,<sup>189,2</sup> S. F. Novais,<sup>189,2</sup> Sandra S. Padula,<sup>189,2</sup> D. Romero Abad,<sup>189,2</sup> J. C. Ruiz Vargas,<sup>189,2</sup> A. Aleksandrov,<sup>191,2</sup> V. Genchev,<sup>191,2</sup> R. Hadjiska,<sup>191,2</sup> P. Iaydjiev,<sup>191,2</sup> A. Marinov,<sup>191,2</sup> S. Piperov,<sup>191,2</sup> M. Rodozov,<sup>191,2</sup> S. Stoykova,<sup>191,2</sup> G. Sultanov,<sup>191,2</sup> M. Utovata,<sup>191,2</sup> A. Dimitrov,<sup>192,2</sup> I. Glushkov,<sup>192,2</sup> L. Litov,<sup>192,2</sup> B. Pavlov,<sup>192,2</sup> P. Petkov,<sup>192,2</sup> M. Ahmad,<sup>193,2</sup> J. G. Bian,<sup>193,2</sup> G. M. Chen,<sup>193,2</sup> H. S. Chen,<sup>193,2</sup> M. Chen,<sup>193,2</sup> T. Cheng,<sup>193,2</sup> R. Du,<sup>193,2</sup> C. H. Jiang,<sup>193,2</sup> R. Pestina,<sup>193,2</sup> F. Romeo,<sup>193,2</sup> S. M. Shahaeen,<sup>193,2</sup> J. Tao,<sup>193,2</sup> C. Wang,<sup>193,2</sup> Z. Wang,<sup>193,2</sup> H. Zhang,<sup>193,2</sup> C. Asawatangtrakuldej,<sup>194,2</sup> Y. Ban,<sup>194,2</sup> G. Chen,<sup>194,2</sup> Q. Li,<sup>194,2</sup> J. Liu,<sup>194,2</sup> Y. Mao,<sup>194,2</sup> S. J. Qian,<sup>194,2</sup> D. Wang,<sup>194,2</sup> M. Wang,<sup>194,2</sup> Q. Wang,<sup>194,2</sup> Z. 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Kalinin,<sup>274,1</sup> D. Konstantinov,<sup>274,1</sup> V. Krychkine,<sup>274,1</sup> V. Petrov,<sup>274,1</sup> R. Rytin,<sup>274,1</sup> A. Sobol,<sup>274,1</sup> L. Touarchanovich,<sup>274,1</sup> S. Troshin,<sup>274,1</sup> N. Tyurin,<sup>274,1</sup> A. Uzunian,<sup>274,1</sup> A. Volkov,<sup>274,1</sup> P. Adzie,<sup>274,1</sup> M. Ekmekci,<sup>274,1</sup> J. Milosevic,<sup>274,1</sup> V. Rekovic,<sup>274,1</sup> J. Alcaraz Maestre,<sup>276,1</sup> E. Calvo,<sup>276,1</sup> M. Cerrada,<sup>276,1</sup> M. Chamizo Llatas,<sup>276,1</sup> N. Colino,<sup>276,1</sup> B. De La Cruz,<sup>276,1</sup> A. Delgado Peris,<sup>276,1</sup> D. Dominguez Vázquez,<sup>276,1</sup> A. Escalante Del Valle,<sup>276,1</sup> C. Fernandez Bedoya,<sup>276,1</sup> J. P. Fernández Ramos,<sup>276,1</sup> J. Fliz,<sup>276,1</sup> M. C. Fouz,<sup>276,1</sup> P. Garcia-Abla,<sup>276,1</sup> O. González Lopez,<sup>276,1</sup> S. Goy Lopez,<sup>276,1</sup> J. M. Hernández,<sup>276,1</sup> M. I. 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 K. Krajcarz,<sup>280,1</sup> P. Lecoq,<sup>280,1</sup> C. Lourenço,<sup>280,1</sup> M. T. Lucchini,<sup>280,1</sup> N. Magni,<sup>280,1</sup> L. Malgeri,<sup>280,1</sup> M. Mannelli,<sup>280,1</sup>  
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 L. Pape,<sup>280,1</sup> E. Perez,<sup>280,1</sup> A. Petrelli,<sup>280,1</sup> G. Petruccianni,<sup>280,1</sup> A. Pfeiffer,<sup>280,1</sup> D. Piparo,<sup>280,1</sup> A. Racz,<sup>280,1</sup> G. Rolandi,<sup>280,1</sup>  
 M. Rovere,<sup>280,1</sup> M. Ruan,<sup>280,1</sup> H. Sakulin,<sup>280,1</sup> C. Schäfer,<sup>280,1</sup> C. Schwick,<sup>280,1</sup> A. Sharma,<sup>280,1</sup> P. Silva,<sup>280,1</sup> M. Simon,<sup>280,1</sup>  
 P. Spighi,<sup>280,1</sup> D. Spiga,<sup>280,1</sup> J. Stegemann,<sup>280,1</sup> B. Stieger,<sup>280,1</sup> M. Stoye,<sup>280,1</sup> Y. Takahashi,<sup>280,1</sup> D. Treille,<sup>280,1</sup>  
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 K. Deiters,<sup>280,1</sup> W. Erdmann,<sup>280,1</sup> Horisberger,<sup>280,1</sup> H. C. Kaestli,<sup>280,1</sup> D. Kotlinski,<sup>280,1</sup>  
 U. Langenegg,<sup>280,1</sup> T. Rohr,<sup>280,1</sup> F. Bachmaier,<sup>280,1</sup> L. Biati,<sup>280,1</sup> L. Bianchini,<sup>280,1</sup> M. A. Buchmann,<sup>280,1</sup> B. Casal,<sup>280,1</sup>  
 G. Dissertori,<sup>280,1</sup> M. Dittmar,<sup>280,1</sup> M. Donega,<sup>280,1</sup> M. Dünnser,<sup>280,1</sup> P. Eller,<sup>280,1</sup> C. Grab,<sup>280,1</sup> C. Heidegger,<sup>280,1</sup> D. Hits,<sup>280,1</sup>  
 J. Hoss,<sup>280,1</sup> G. Kasieczka,<sup>280,1</sup> W. Lustermann,<sup>280,1</sup> B. Mangano,<sup>280,1</sup> A. C. Marini,<sup>280,1</sup> M. Marionneau,<sup>280,1</sup>  
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 J. Pata,<sup>280,1</sup> F. Pauss,<sup>280,1</sup> L. Perrozzi,<sup>280,1</sup> M. Peruzzo,<sup>280,1</sup> M. Quittman,<sup>280,1</sup> M. Rossini,<sup>280,1</sup> A. Starodumov,<sup>280,1</sup>  
 M. Takahashi,<sup>280,1</sup> V. R. Tavolari,<sup>280,1</sup> K. Theofilatos,<sup>280,1</sup> R. Wallny,<sup>280,1</sup> H. A. Weber,<sup>280,1</sup> T. K. Arrestadt,<sup>280,1</sup>  
 C. Amsler,<sup>280,1</sup> M. F. Canelli,<sup>280,1</sup> V. Chiochia,<sup>280,1</sup> A. De Rosa,<sup>280,1</sup> C. Galloni,<sup>280,1</sup> A. Hinzmam,<sup>280,1</sup> T. Hreus,<sup>280,1</sup>  
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 S. Taromi,<sup>280,1</sup> Y. Yang,<sup>280,1</sup> M. Cardaci,<sup>280,1</sup> K. H. Chen,<sup>280,1</sup> T. H. Doan,<sup>280,1</sup> C. Ferro,<sup>280,1</sup> M. Konyushikhin,<sup>280,1</sup>  
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 Y. Chao,<sup>280,1</sup> K. Chen,<sup>280,1</sup> P. H. Chen,<sup>280,1</sup> C. Dietz,<sup>280,1</sup> F. Fiori,<sup>280,1</sup> U. Grunfeld,<sup>280,1</sup> W.-S. Hou,<sup>280,1</sup> Y. Hsiung,<sup>280,1</sup>  
 Y. F. Liu,<sup>280,1</sup> R.-S. Lu,<sup>280,1</sup> M. Mifiana Moya,<sup>280,1</sup> E. Petrucco,<sup>280,1</sup> J. F. Tsai,<sup>280,1</sup> Y. M. Tzeng,<sup>280,1</sup> R. Wilken,<sup>280,1</sup>  
 B. Asavapibhop,<sup>280,1</sup> K. Kovingtonpoon,<sup>280,1</sup> G. Singh,<sup>280,1</sup> N. Sriwanobhas,<sup>280,1</sup> N. Suwonjandee,<sup>280,1</sup> A. Adiguzel,<sup>280,1</sup>  
 S. Cerci,<sup>280,1</sup> C. Dozen,<sup>280,1</sup> S. Girgis,<sup>280,1</sup> G. Golokub,<sup>280,1</sup> Y. Guler,<sup>280,1</sup> E. Gurpinar,<sup>280,1</sup> I. Hos,<sup>280,1</sup>  
 E. E. Kangal,<sup>280,1</sup> A. Kayis Topaksu,<sup>280,1</sup> G. Onengu,<sup>280,1</sup> K. Ozdemir,<sup>280,1</sup> S. Ozturk,<sup>280,1</sup> B. Tali,<sup>280,1</sup>  
 H. Topakli,<sup>280,1</sup> M. Vergili,<sup>280,1</sup> C. Zorbuluk,<sup>280,1</sup> I. V. Akin,<sup>280,1</sup> B. Bilin,<sup>280,1</sup> S. Bilmis,<sup>280,1</sup> B. Isildak,<sup>280,1</sup>  
 G. Karapinar,<sup>280,1</sup> M. Yilmaz,<sup>280,1</sup> O. Yilmaz,<sup>280,1</sup> P. Yilmaz,<sup>280,1</sup> M. Zeyrek,<sup>280,1</sup> E. A. Albayrak,<sup>280,1</sup> E. Gülmeliz,<sup>280,1</sup>  
 M. Kaya,<sup>280,1</sup> O. Kaya,<sup>280,1</sup> T. Yetkin,<sup>280,1</sup> K. Cankocak,<sup>280,1</sup> S. Sen,<sup>280,1</sup> F. I. Vardarli,<sup>280,1</sup> B. Grynyov,<sup>280,1</sup>  
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 M. Kenzie,<sup>280,1</sup> R. Lane,<sup>280,1</sup> R. Lucas,<sup>280,1</sup> L. Lyons,<sup>280,1</sup> A. M. Magnan,<sup>280,1</sup> S. Malik,<sup>280,1</sup> J. Nash,<sup>280,1</sup>  
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 J. E. Cole,<sup>280,1</sup> R. Hobson,<sup>280,1</sup> A. Khan,<sup>280,1</sup> P. Kyberd,<sup>280,1</sup> D. Leggett,<sup>280,1</sup> D. Leslie,<sup>280,1</sup> I. D. Reid,<sup>280,1</sup> P. Symonds,<sup>280,1</sup>  
 L. Teodorescu,<sup>280,1</sup> M. Turner,<sup>280,1</sup> A. Borzou,<sup>280,1</sup> J. Dittmar,<sup>280,1</sup> K. Hatakeyama,<sup>280,1</sup> A. Kasmi,<sup>280,1</sup> H. Liu,<sup>280,1</sup>  
 N. Pastika,<sup>280,1</sup> O. Charaf,<sup>280,1</sup> S. J. Cooper,<sup>280,1</sup> C. H. Henderson,<sup>280,1</sup> P. Rumerio,<sup>280,1</sup> A. Avetisyan,<sup>280,1</sup> T. Bose,<sup>280,1</sup>  
 C. Fantasia,<sup>280,1</sup> D. Gaster,<sup>280,1</sup> P. Lawson,<sup>280,1</sup> D. Rankin,<sup>280,1</sup> C. Richardson,<sup>280,1</sup> J. Rohl,<sup>280,1</sup> J. St. John,<sup>280,1</sup> L. Sulak,<sup>280,1</sup>  
 D. Zou,<sup>280,1</sup> J. Alimenta,<sup>280,1</sup> E. Berry,<sup>280,1</sup> S. Bhattacharya,<sup>280,1</sup> D. Cutts,<sup>280,1</sup> N. Dhingra,<sup>280,1</sup> A. Ferapontov,<sup>280,1</sup>  
 A. Garabedian,<sup>280,1</sup> U. Heintz,<sup>280,1</sup> E. Laird,<sup>280,1</sup> G. Landsberg,<sup>280,1</sup> Z. Mao,<sup>280,1</sup> M. Narain,<sup>280,1</sup> S. Sagiv,<sup>280,1</sup>  
 T. Senthuprasad,<sup>280,1</sup> R. Breedon,<sup>280,1</sup> G. Breto,<sup>280,1</sup> M. Calderon De La Barca Sanchez,<sup>280,1</sup> S. Chauhan,<sup>280,1</sup> M. Chertok,<sup>280,1</sup>  
 J. Conway,<sup>280,1</sup> R. Conway,<sup>280,1</sup> P. T. Cox,<sup>280,1</sup> R. Erbacher,<sup>280,1</sup> M. Gardner,<sup>280,1</sup> W. Ko,<sup>280,1</sup> R. Lander,<sup>280,1</sup> M. Mulhearn,<sup>280,1</sup>  
 D. Pellett,<sup>280,1</sup> J. Pilot,<sup>280,1</sup> F. Ricci-Tam,<sup>280,1</sup> S. Shalhout,<sup>280,1</sup> J. Smith,<sup>280,1</sup> M. Squires,<sup>280,1</sup> D. Stolp,<sup>280,1</sup> M. Tripathi,<sup>280,1</sup>

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 V. Sharma,<sup>304,1</sup> S. Simon,<sup>304,1</sup> M. Tadel,<sup>304,1</sup> Y. Tu,<sup>304,1</sup> A. Vartak,<sup>304,1</sup> S. Wasserbaech,<sup>304,1</sup> C. Welke,<sup>304,1</sup>  
 F. Würthwein,<sup>304,1</sup> A. Yagil,<sup>304,1</sup> G. Zevi Delta Porta,<sup>304,1</sup> D. Barge,<sup>305,1</sup> J. Bradmiller-Feld,<sup>305,1</sup> C. Campagnari,<sup>305,1</sup>  
 A. Dishaw,<sup>305,1</sup> V. Dutta,<sup>305,1</sup> K. Flowers,<sup>305,1</sup> M. Franco Sevilla,<sup>305,1</sup> P. Geffert,<sup>305,1</sup> C. George,<sup>305,1</sup> F. Golf,<sup>305,1</sup>  
 L. Gouskos,<sup>305,1</sup> J. Gran,<sup>305,1</sup> J. Incandela,<sup>305,1</sup> C. Justus,<sup>305,1</sup> N. Mccoll,<sup>305,1</sup> S. D. Mullin,<sup>305,1</sup> J. Richman,<sup>305,1</sup> D. Stuart,<sup>305,1</sup>  
 I. Suarez,<sup>305,1</sup> W. To,<sup>305,1</sup> C. West,<sup>305,1</sup> J. Yoo,<sup>305,1</sup> D. Anderson,<sup>306,1</sup> A. Apresyan,<sup>306,1</sup> A. Bornheim,<sup>306,1</sup> J. Bunn,<sup>306,1</sup>  
 Y. Chen,<sup>306,1</sup> J. Duarte,<sup>306,1</sup> A. Mott,<sup>306,1</sup> H. B. Newman,<sup>306,1</sup> C. Penna,<sup>306,1</sup> M. Pierini,<sup>306,1</sup> M. Spiropulu,<sup>306,1</sup>  
 J. R. Vlimant,<sup>307,1</sup> S. Xie,<sup>306,1</sup> R. Y. Zhu,<sup>306,1</sup> V. Azzolini,<sup>307,1</sup> A. Calamia,<sup>307,1</sup> B. Carlson,<sup>307,1</sup> T. Ferguson,<sup>307,1</sup>  
 Y. Iiyama,<sup>307,1</sup> P. Xenitidis,<sup>307,1</sup> J. Russ,<sup>307,1</sup> M. Sun,<sup>307,1</sup> H. Vogel,<sup>307,1</sup> J. P. Cumalat,<sup>308,1</sup> W. T. Ford,<sup>308,1</sup>  
 A. Gaz,<sup>308,1</sup> F. Jensen,<sup>308,1</sup> A. Johnson,<sup>308,1</sup> M. Krohn,<sup>308,1</sup> T. Mulholland,<sup>308,1</sup> U. Nauenberg,<sup>308,1</sup> J. G. Smith,<sup>308,1</sup>  
 K. Stenson,<sup>308,1</sup> S. R. Wagner,<sup>308,1</sup> J. Alexander,<sup>309,1</sup> A. Chatterjee,<sup>309,1</sup> J. Chaves,<sup>309,1</sup> J. Chu,<sup>309,1</sup> S. Dittmer,<sup>309,1</sup>  
 N. Eggert,<sup>309,1</sup> N. Mirman,<sup>309,1</sup> G. Nicolas Kaufman,<sup>309,1</sup> J. R. Patterson,<sup>309,1</sup> A. Rinkevicius,<sup>309,1</sup> A. Ryd,<sup>309,1</sup>  
 L. Skinnari,<sup>309,1</sup> L. Sofoff,<sup>309,1</sup> W. Sun,<sup>309,1</sup> S. M. Tan,<sup>309,1</sup> W. D. Teo,<sup>309,1</sup> J. Thom,<sup>309,1</sup> J. Thompson,<sup>309,1</sup> J. Tucker,<sup>309,1</sup>  
 Y. Weng,<sup>309,1</sup> P. Watiach,<sup>309,1</sup> S. Abdulla,<sup>310,1</sup> M. Albrow,<sup>310,1</sup> J. Anderson,<sup>310,1</sup> G. Apollinaris,<sup>310,1</sup> L. A. T. Bauerdick,<sup>310,1</sup>  
 A. Beretvas,<sup>310,1</sup> J. Berryhill,<sup>310,1</sup> P. C. Bhattacharya,<sup>310,1</sup> G. Bella,<sup>310,1</sup> K. Burkett,<sup>310,1</sup> J. N. Butler,<sup>310,1</sup> H. W. K. Cheung,<sup>310,1</sup>  
 F. Cilebana,<sup>310,1</sup> S. Chang,<sup>310,1</sup> V. D. Elvira,<sup>310,1</sup> I. Fisk,<sup>310,1</sup> J. Freeman,<sup>310,1</sup> E. Gottschalk,<sup>310,1</sup> L. Gray,<sup>310,1</sup> D. Green,<sup>310,1</sup>  
 S. Grünendahl,<sup>310,1</sup> O. Gutsche,<sup>310,1</sup> J. Hanlon,<sup>310,1</sup> D. Hare,<sup>310,1</sup> R. M. Harris,<sup>310,1</sup> J. Hirschauer,<sup>310,1</sup> B. Hooberman,<sup>310,1</sup>  
 Z. Hu,<sup>310,1</sup> S. Jindariani,<sup>310,1</sup> M. Johnson,<sup>310,1</sup> U. Joshi,<sup>310,1</sup> A. W. Jung,<sup>310,1</sup> B. Klima,<sup>310,1</sup> B. Kreis,<sup>310,1</sup> S. Kwan,<sup>310,1</sup>  
 S. Lammel,<sup>310,1</sup> J. Linacre,<sup>310,1</sup> D. Lincoln,<sup>310,1</sup> T. Liu,<sup>310,1</sup> R. Lopes De Sa,<sup>310,1</sup> J. Lykken,<sup>310,1</sup>  
 K. Maeshima,<sup>310,1</sup> J. M. Marrapino,<sup>310,1</sup> V. I. Martinez,<sup>310,1</sup> Outschorn,<sup>310,1</sup> S. Maruyama,<sup>310,1</sup> D. Mason,<sup>310,1</sup> P. McBride,<sup>310,1</sup>  
 P. Merkel,<sup>310,1</sup> K. Mishra,<sup>310,1</sup> S. Mirena,<sup>310,1</sup> S. Nahm,<sup>310,1</sup> C. Newman-Holmes,<sup>310,1</sup> V. O'Dell,<sup>310,1</sup> O. Prokofyev,<sup>310,1</sup>  
 E. Sexton-Kennedy,<sup>310,1</sup> A. Soha,<sup>310,1</sup> W. J. Spalding,<sup>310,1</sup> L. Spiegel,<sup>310,1</sup> L. Taylor,<sup>310,1</sup> S. Tkaczyk,<sup>310,1</sup> N. V. Tran,<sup>310,1</sup>  
 L. Uplegger,<sup>310,1</sup> E. W. Vaandering,<sup>310,1</sup> C. Vernieri,<sup>310,1</sup> M. Verzocchi,<sup>310,1</sup> R. Vidal,<sup>310,1</sup> A. Whitehead,<sup>310,1</sup> F. Yang,<sup>310,1</sup>  
 H. Yin,<sup>310,1</sup> D. Acosta,<sup>310,1</sup> P. Avery,<sup>311,1</sup> P. Bortignon,<sup>311,1</sup> D. Bourikis,<sup>311,1</sup> A. Carnes,<sup>311,1</sup> M. Carver,<sup>311,1</sup> D. Curry,<sup>311,1</sup>  
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 L. Muniz,<sup>311,1</sup> D. Rank,<sup>311,1</sup> L. Shchukina,<sup>311,1</sup> G. Martinez,<sup>312,1</sup> M. Snowball,<sup>312,1</sup> D. Sperka,<sup>312,1</sup> S. J. Wang,<sup>312,1</sup> J. Yeltos,<sup>312,1</sup>  
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 K. F. Johnson,<sup>312,1</sup> A. Khatiwada,<sup>312,1</sup> H. Prosper,<sup>312,1</sup> V. Veeraraghavan,<sup>312,1</sup> M. Weinberg,<sup>312,1</sup> V. Bhopatkar,<sup>314,1</sup>  
 M. Hohlmann,<sup>314,1</sup> H. Kalakshety,<sup>314,1</sup> D. Mareska-paleck,<sup>314,1</sup> T. Roy,<sup>314,1</sup> F. Yumiceva,<sup>314,1</sup> M. R. Adams,<sup>314,1</sup>  
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 A. Mestvirishvili,<sup>316,1</sup> J. Moeller,<sup>316,1</sup> J. Nachtman,<sup>316,1</sup> H. Ogul,<sup>316,1</sup> Y. Onel,<sup>316,1</sup> F. Ozok,<sup>316,1</sup> A. Penzo,<sup>316,1</sup>  
 C. Snyder,<sup>316,1</sup> P. Tan,<sup>316,1</sup> E. Tiras,<sup>316,1</sup> J. Wetzel,<sup>316,1</sup> K. Yu,<sup>316,1</sup> I. Anderson,<sup>317,1</sup> B. A. Barnett,<sup>317,1</sup> B. Blumenfeld,<sup>317,1</sup>  
 D. Fehling,<sup>317,1</sup> L. Feng,<sup>317,1</sup> A. V. Grishin,<sup>317,1</sup> P. Makrisovic,<sup>317,1</sup> C. Martin,<sup>317,1</sup> K. Nash,<sup>317,1</sup> M. Osherson,<sup>317,1</sup>  
 M. Swartz,<sup>317,1</sup> M. Xiao,<sup>317,1</sup> Y. Xin,<sup>317,1</sup> P. Baringer,<sup>318,1</sup> A. Bean,<sup>318,1</sup> G. Benelli,<sup>318,1</sup> C. Bruner,<sup>318,1</sup> J. Gray,<sup>318,1</sup>  
 R. P. Kenny III,<sup>318,1</sup> D. Majumder,<sup>318,1</sup> M. Malek,<sup>318,1</sup> M. Murray,<sup>318,1</sup> D. Noonan,<sup>318,1</sup> S. Sanders,<sup>318,1</sup> R. Stringer,<sup>318,1</sup>  
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<sup>59</sup>Also at Institute of High Energy Physics and Informatology, Tbilisi State University, Tbilisi, Georgia.  
<sup>60</sup>Also at St. Petersburg State Polytechnical University, St. Petersburg, Russia.  
<sup>61</sup>Also at National Research Nuclear University "Moscow Engineering Physics Institute" (MEPhI), Moscow, Russia.  
<sup>62</sup>Also at California Institute of Technology, Pasadena, CA, USA.  
<sup>63</sup>Also at Faculty of Physics, University of Belgrade, Belgrade, Serbia.  
<sup>64</sup>Also at Facoltà di Ingegneria, Università di Roma, Roma, Italy.  
<sup>65</sup>Also at National Technical University of Athens, Athens, Greece.  
<sup>66</sup>Also at Scuola Normale e Sezione dell'INFN, Pisa, Italy.  
<sup>67</sup>Also at University of Athens, Athens, Greece.  
<sup>68</sup>Also at Warsaw University of Technology, Institute of Electronic Systems, Warsaw, Poland.  
<sup>69</sup>Also at Institute for Theoretical and Experimental Physics, Moscow, Russia.  
<sup>70</sup>Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland.  
<sup>71</sup>Also at Adiyaman University, Adiyaman, Turkey.  
<sup>72</sup>Also at Mersin University, Mersin, Turkey.  
<sup>73</sup>Also at Cag University, Mersin, Turkey.  
<sup>74</sup>Also at Piri Reis University, İstanbul, Turkey.  
<sup>75</sup>Also at Gaziosmanpasa University, Tokat, Turkey.  
<sup>76</sup>Also at Ozyegin University, Istanbul, Turkey.  
<sup>77</sup>Also at Izmir Institute of Technology, Izmir, Turkey.  
<sup>78</sup>Also at Mimar Sinan University, İstanbul, İstanbul, Turkey.  
<sup>79</sup>Also at Marmara University, İstanbul, Turkey.  
<sup>80</sup>Also at Yildiz Technical University, İstanbul, Turkey.  
<sup>81</sup>Also at Hacettepe University, Ankara, Turkey.  
<sup>82</sup>Also at Rutherford Appleton Laboratory, Didcot, United Kingdom.  
<sup>83</sup>Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.  
<sup>84</sup>Also at Instituto de Astrofísica de Canarias, La Laguna, Spain.  
<sup>85</sup>Also at Utah Valley University, Orem, UT, USA.  
<sup>86</sup>Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia.  
<sup>87</sup>Also at Argonne National Laboratory, Argonne, IL, USA.  
<sup>88</sup>Also at Erzincan University, Erzincan, Turkey.  
<sup>89</sup>Also at Texas A&M University at Qatar, Doha, Qatar.  
<sup>90</sup>Also at Kyungpook National University, Daegu, Korea.

# Fragile Families Challenge

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A scientific mass collaboration combining

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- ▶ predictive modeling,

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## Fragile Families Challenge

A scientific mass collaboration combining

- ▶ predictive modeling,
- ▶ causal inference,
- ▶ and in-depth qualitative interviews

to improve the lives of disadvantaged children in the US.

# FFragile Families

& Child Wellbeing Study  
PRINCETON | COLUMBIA



- ▶ Birth cohort panel study
- ▶ ≈ 5,000 children born in 20 U.S. cities
- ▶ Followed from birth through age 15

**Key research question:** What can be done to improve the life chances of disadvantaged children?

Hundreds of papers and dozens of dissertations

<http://crcw.princeton.edu/publications/publications.asp>

Social Scientists ←→ Data Scientists

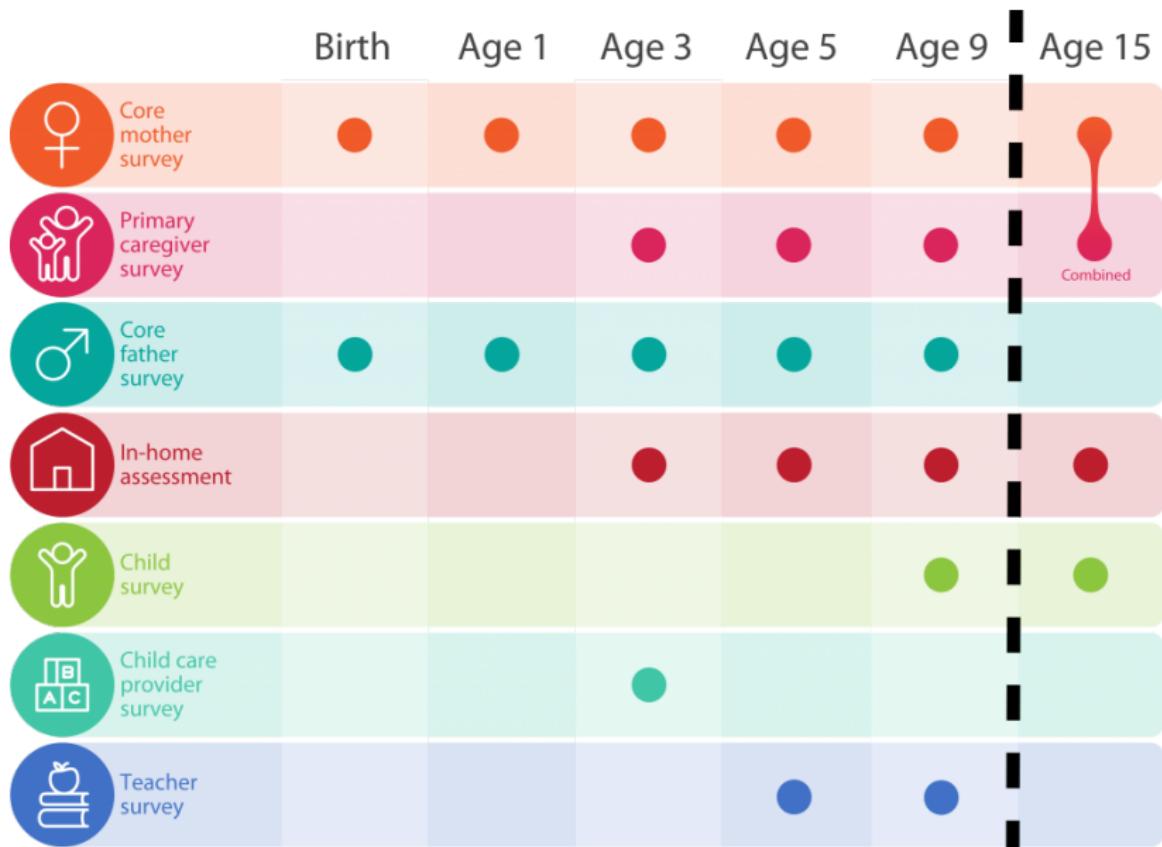
Social Scientists  $\longleftrightarrow$  Data Scientists

$$\hat{\beta} \quad \& \quad \hat{y}$$

Mullainathan and Spiess (2017):

<http://dx.doi.org/10.1257/jep.31.2.87>

	Birth	Age 1	Age 3	Age 5	Age 9
 Core mother survey	●	●	●	●	●
 Primary caregiver survey			●	●	●
 Core father survey	●	●	●	●	●
 In-home assessment			●	●	●
 Child survey					●
 Child care provider survey			●		
 Teacher survey				●	●



5,000 families

Birth to age 9  
12,000 features

Age 15  
1,500 features

4,200 families

12,000 features  
birth to age 9

6 outcomes  
age 15

Training

Leaderboard

Holdout

Continuous outcomes:

- ▶ GPA
- ▶ Grit
- ▶ Material hardship

Binary outcomes:

- ▶ Housing eviction
- ▶ Layoff of a caregiver
- ▶ Job training for a caregiver

## Fragile Families Challenge:

1. common task method

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1. common task method
2. use submissions to do cool stuff

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## What has happened so far?

- ▶ Launched one year ago in COS 424
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- ▶ Results were . . . disappointing (talk summarizing the results: <https://youtu.be/HrYPTdXeSaM>).
- ▶ Why were the results disappointing?

Why should we care about the predictability of social outcomes?

- ▶ Scientific reasons

## Why should we care about the predictability of social outcomes?

- ▶ Scientific reasons
- ▶ Policy reasons



We need to understand the strengths *and* weakness of predictive models of social behavior

- ▶ A team of people<sup>1</sup> has spent months making the data easier to use.

---

<sup>1</sup>Alexander Kindel, Kristin Catena, Thomas Hartshorne, Kate Jaeger, Dawn Koffman, Sara McLanahan, Maya Phillips, Shiva Rouhani, Ryan Vinh, Matthew Salganik.

- ▶ A team of people<sup>1</sup> has spent months making the data easier to use.
- ▶ Is it possible to do better than last time? Or, is there a fundamental limit with this data and this task?

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- ▶ Let's see if it improves performance,

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- ▶ A team of people<sup>1</sup> has spent months making the data easier to use.
- ▶ Is it possible to do better than last time? Or, is there a fundamental limit with this data and this task?
- ▶ Let's see if it improves performance, and, let's see if you can help make this easier for future researchers.

---

<sup>1</sup>Alexander Kindel, Kristin Catena, Thomas Hartshorne, Kate Jaeger, Dawn Koffman, Sara McLanahan, Maya Phillips, Shiva Rouhani, Ryan Vinh, Matthew Salganik.

How to participate

<https://codalab.fragilefamilieschallenge.org/competitions/20>

## Introducing the outcome variables

GPA<sup>2</sup>

---

<sup>2</sup>Learn more at <http://www.fragilefamilieschallenge.org/gpa/>

GPA<sup>2</sup>

How do kids beat the odds academically?

---

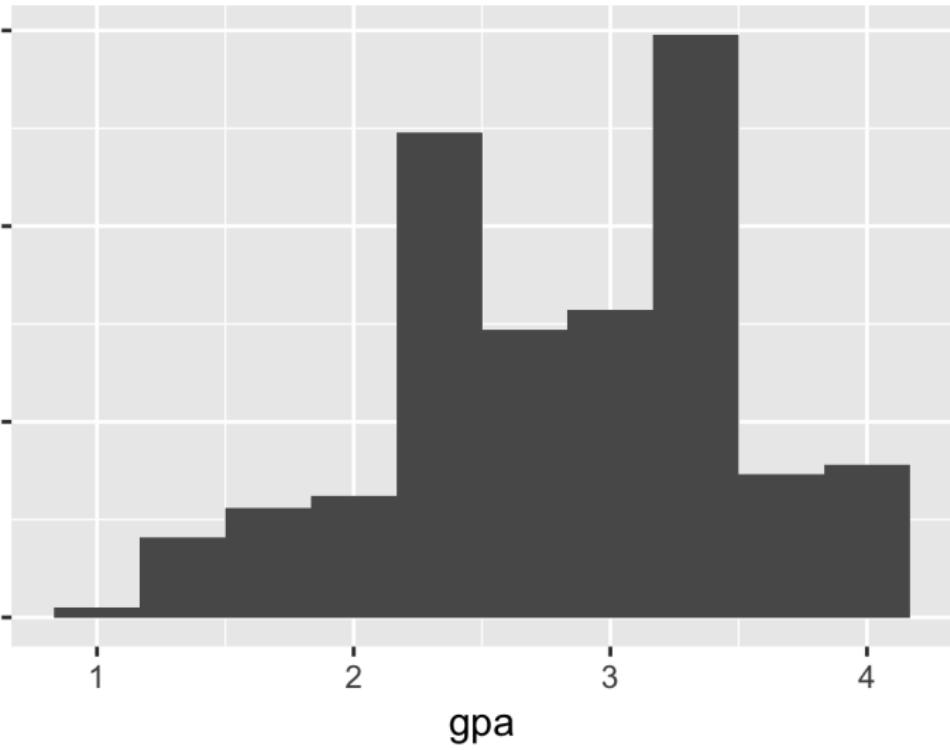
<sup>2</sup>Learn more at <http://www.fragilefamilieschallenge.org/gpa/>

# GPA<sup>3</sup>

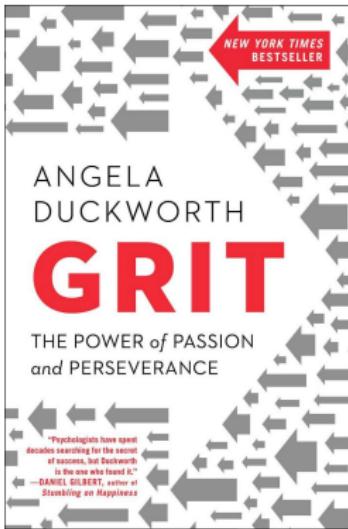
B20. At the {most recent grading period/last grading period in the spring} what was your grade in ...

	A	B	C	D OR LOWE R	NO GRADE OR PASS/FAIL	REF	DK	N/A HOMESCHOoled
B20A English or language arts? ..	1	2	3	4	5	-1	-2	7 → GO TO B22A
B20B Math? .....	1	2	3	4	5	-1	-2	7 → GO TO B22A
B20C History or social studies? ..	1	2	3	4	5	-1	-2	7 → GO TO B22A
B20D Science? .....	1	2	3	4	5	-1	-2	7 → GO TO B22A

<sup>3</sup>This variable is reverse-coded in the data file so that higher values represent higher GPAs.

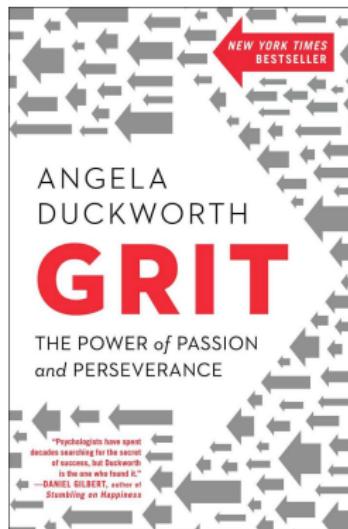


“Grit” predicts success, possibly more than IQ.<sup>4</sup>



<sup>4</sup>Learn more at <http://www.fragilefamilieschallenge.org/grit/>

“Grit” predicts success, possibly more than IQ.<sup>4</sup>



What makes some kids gritty?

<sup>4</sup>Learn more at <http://www.fragilefamilieschallenge.org/grit/>

# Grit<sup>5</sup>

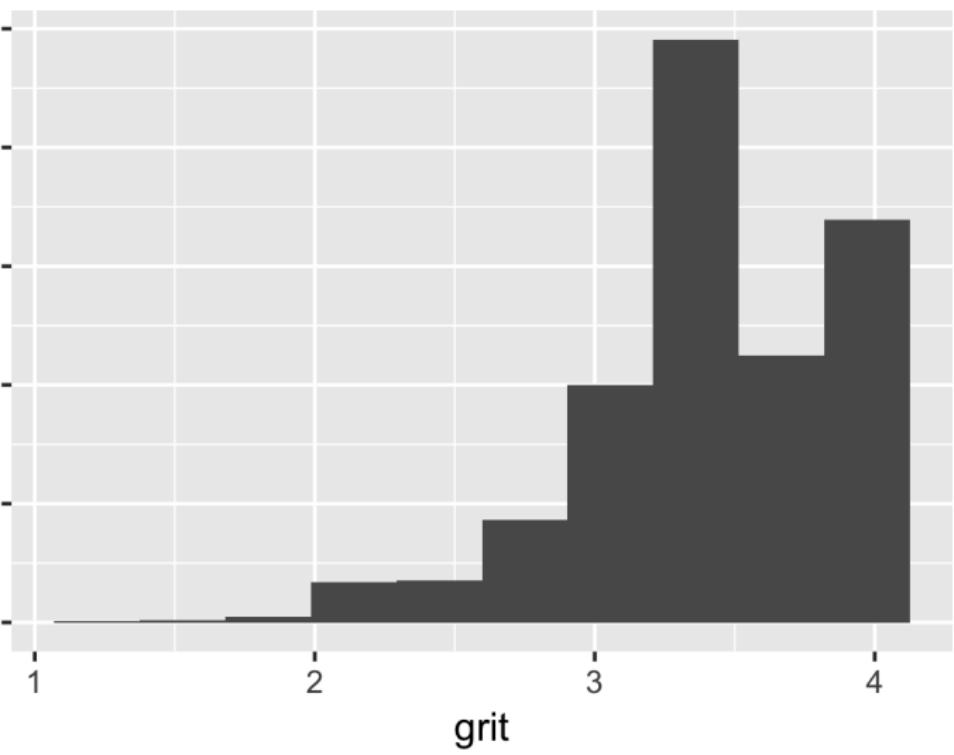
D2. Thinking about how you have behaved or felt during the past four weeks, please tell me whether you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with the following statements.

PROBE: Thinking about the past four weeks, do you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with this statement?

	STRONGLY AGREE	SOMEWHAT AGREE	SOMEWHAT DISAGREE	STRONGLY DISAGREE	REF	DK
D2I. I keep at my schoolwork until I am done with it.....	1	2	3	4	-1	-2
D2K. Once I make a plan to get something done, I stick to it.....	1	2	3	4	-1	-2
D2M. I finish whatever I begin.....	1	2	3	4	-1	-2
D2V. I am a hard worker	1	2	3	4	-1	-2

---

<sup>5</sup>This variable is reverse-coded in the data file so that higher values represent more grit.



## Material hardship<sup>6</sup>

---

<sup>6</sup>Learn more at

<http://www.fragilefamilieschallenge.org/material-hardship/>

## Material hardship<sup>6</sup>

What unmeasured predictors are associated with families unexpectedly escaping severe deprivation?

---

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## Material hardship<sup>6</sup>

What unmeasured predictors are associated with families unexpectedly escaping severe deprivation?

What sends families unexpectedly into deep poverty?

---

<sup>6</sup>Learn more at

<http://www.fragilefamilieschallenge.org/material-hardship/>

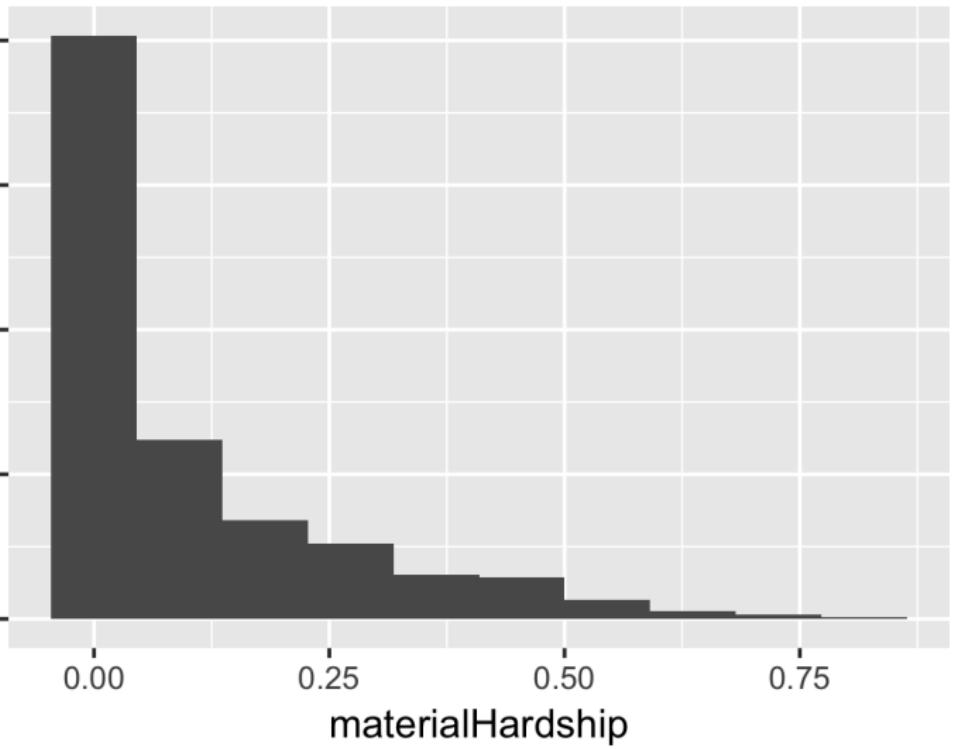
# Material hardship

We are also interested in some of the problems that families face making ends meet. In the past twelve months, did you do any of the following because there wasn't enough money?

		YES	NO	REF	DK
J37.	In the past twelve months, did you receive free food or meals?	1	2	-1	-2
J38.	In the past twelve months, were you ever hungry, but didn't eat because you couldn't afford enough food?	1	2	-1	-2
J39.	In the past twelve months, did you ever not pay the full amount of rent or mortgage payments?	1	2	-1	-2
J40.	In the past twelve months, were you evicted from your home or apartment for not paying the rent or mortgage?	1	2	-1	-2
J41.	In the past twelve months, did you not pay the full amount of gas, oil, or electricity bill?	1	2	-1	-2
J42.	In the past twelve months, was your gas or electric services ever turned off, or the heating oil company did not deliver oil, because there wasn't enough money to pay the bills?	1	2	-1	-2
J43.	In the past twelve months, did you borrow money from friends or family to help pay bills?	1	2	-1	-2
J44.	In the past twelve months, did you move in with other people even for a little while because of financial problems?	1	2	-1	-2

# Material hardship

J45.	In the past twelve months, did you stay at a shelter, in an abandoned building, an automobile or any other place not meant for regular housing, even for one night?	1	2	-1	-2
J46.	In the past twelve months, was there anyone in your household who needed to see a doctor or go to the hospital but couldn't go because of the cost?	1	2	-1	-2
J47.	In the past twelve months, was your telephone service (mobile or land line) cancelled or disconnected by the telephone company because there wasn't enough money to pay the bill?	1	2	-1	-2



# Eviction<sup>7</sup>

---

<sup>7</sup>Learn more at <http://www.fragilefamilieschallenge.org/eviction/>

<sup>8</sup>Note: You will just create propensity scores for eviction given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

## Eviction<sup>7</sup>

Does housing eviction **cause** worse outcomes as kids transition to adulthood?<sup>8</sup>

---

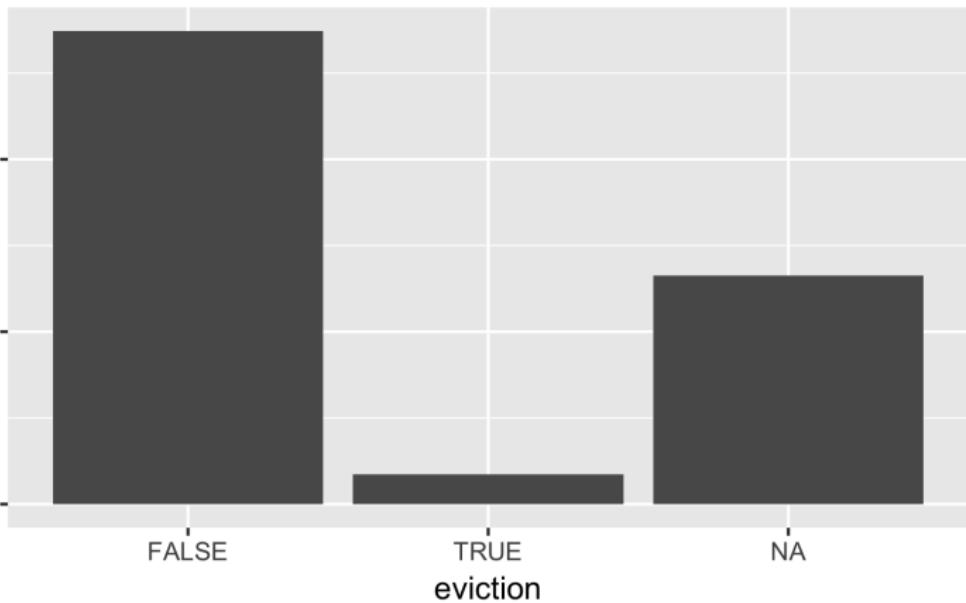
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<sup>8</sup>Note: You will just create propensity scores for eviction given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

# Eviction

J51. Since {MONTH AND YEAR COHORT CITY FIELDDED IN YR 9}, were you evicted from your home or apartment for not paying the rent or mortgage?

YES .....	1
NO .....	2
REFUSED .....	-1
DON'T KNOW .....	-2



## Caregiver layoff<sup>9</sup>

---

<sup>9</sup>Learn more at <http://www.fragilefamilieschallenge.org/layoff/>

<sup>10</sup>Note: You will just create propensity scores for caregiver layoff given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

## Caregiver layoff<sup>9</sup>

Does layoff of a caregiver **cause** collateral damage for kids?<sup>10</sup>

---

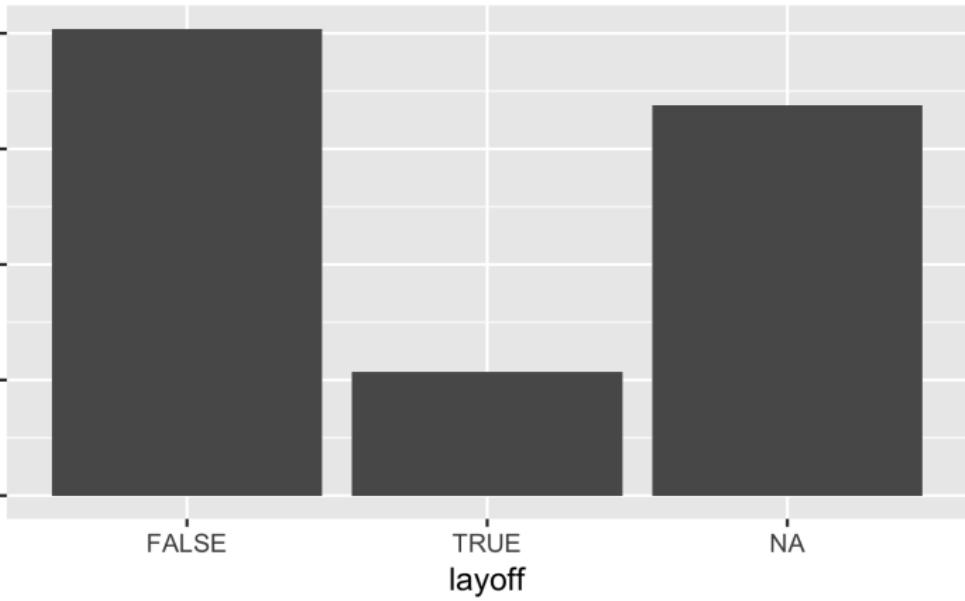
<sup>9</sup>Learn more at <http://www.fragilefamilieschallenge.org/layoff/>

<sup>10</sup>Note: You will just create propensity scores for caregiver layoff given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

# Caregiver layoff

K13. Since {MONTH AND YEAR COHORT CITY FIELDDED IN YR 9}, have you been laid off from your employer for any time?

- |                  |    |
|------------------|----|
| YES .....        | 1  |
| NO.....          | 2  |
| REFUSED.....     | -1 |
| DON'T KNOW ..... | -2 |



## Job training<sup>11</sup>

---

<sup>11</sup>Learn more at

<http://www.fragilefamilieschallenge.org/job-training/>

<sup>12</sup>Note: You will just create propensity scores for job training given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

## Job training<sup>11</sup>

Does job training for a caregiver **cause** collateral benefits for children?<sup>12</sup>

---

<sup>11</sup>Learn more at

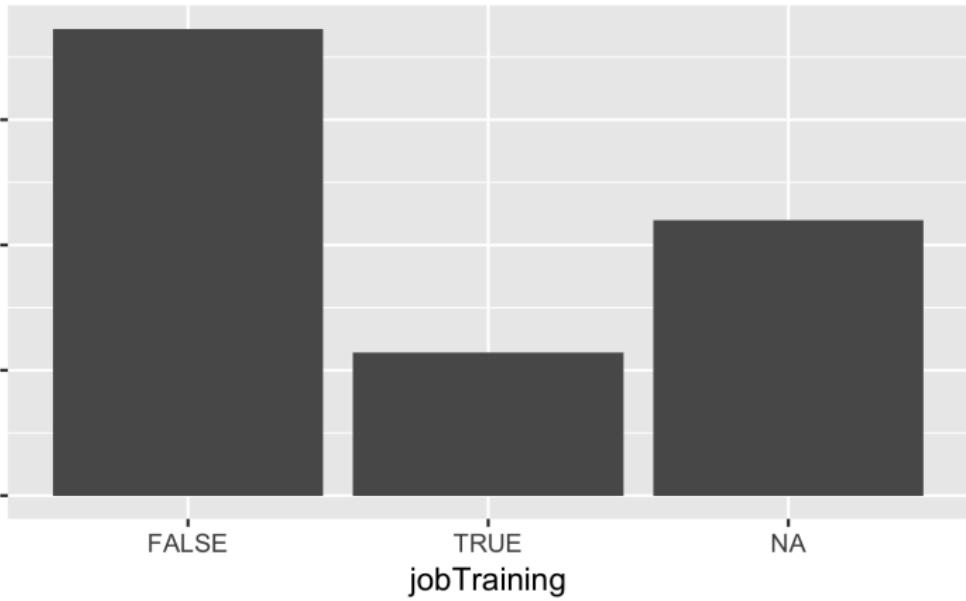
<http://www.fragilefamilieschallenge.org/job-training/>

<sup>12</sup>Note: You will just create propensity scores for job training given background variables; causal inference comes in the second stage of the Challenge when outcomes are measured several years from now.

# Caregiver job training

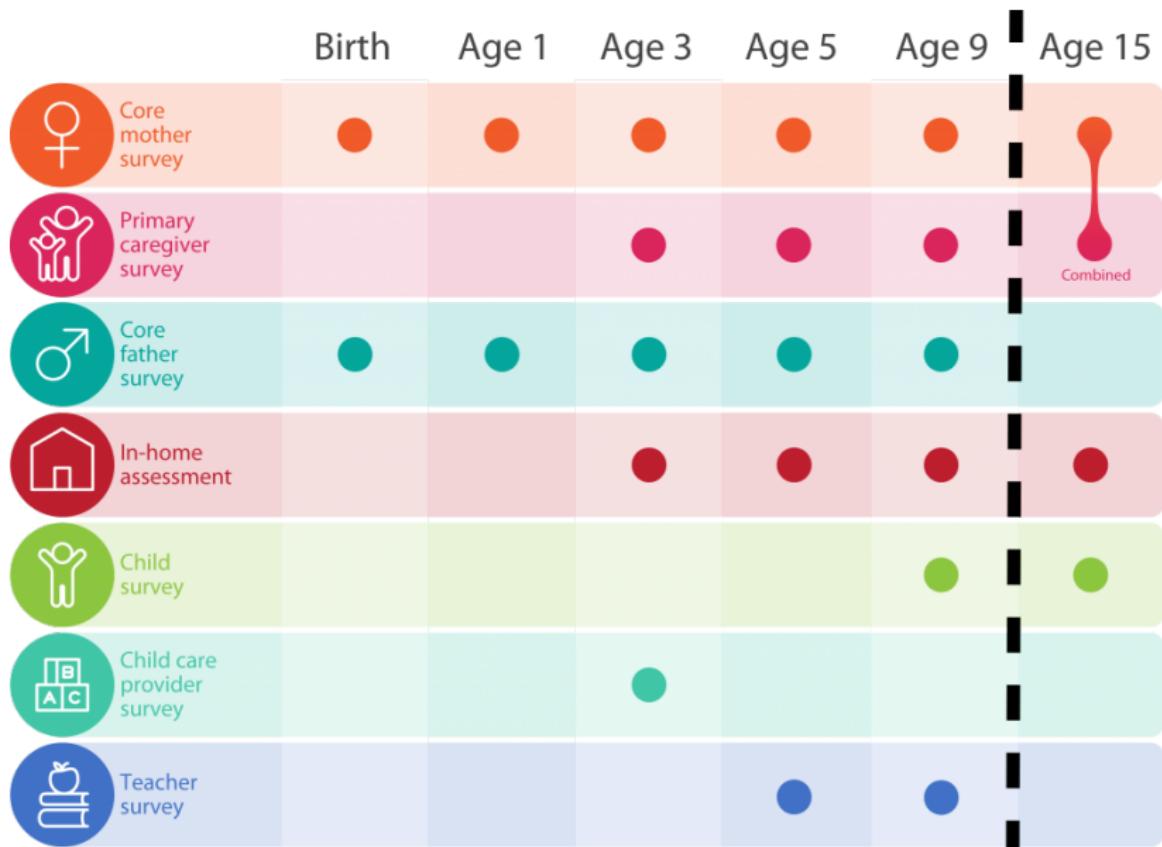
K4. Since {MONTH AND YEAR COHORT CITY FIELDDED IN YR 9}, have you taken any classes to improve your job skills, such as computer training or literacy classes?

- |                 |     |
|-----------------|-----|
| YES .....       | .1  |
| NO.....         | .2  |
| REFUSED.....    | -.1 |
| DON'T KNOW..... | -.2 |



## Introducing the data

**The Fragile Families and Child Wellbeing Study is a dataset of real people who have selflessly opened up their lives to us for the last 15 years so that their experiences can contribute to scientific research. By participating in the Fragile Families Challenge, you become a collaborator in this project. It is of the utmost importance that you respect the families in the data by using what they have told us responsibly.**



RStudio Source Editor

fsf x Filter

	fsf1	fsf1a	fsf2	fsf3	fsf3a	fsf3b	fsf3b1	fsf4	fsf4a	fsf4b	fsf5	fsf6	fsf7a	fsf7b	fsf7c	fsf8a1	fsf8b1	fsf8c1	fsf8a2	fsf8b2	fsf8c2	fsf8a3
1	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
2	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
3	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
4	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
5	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
6	2	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	2	2	2	2	-6	-6	1	12	600	
7	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
8	1	3	2	-6.00	-6.00	-6.000000	-3	196.26903	1	2	2	2	2	2	2	-6	-6	2	-6	-6	-6	
9	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
10	1	1	1	-6.00	-6.00	-6.000000	-3	1310.50458	-10	2	2	2	2	2	2	-6	-6	2	-6	-6	-6	
11	1	5	4	149734....	11087.07	1.271596	-3	-6.00000	-6	-6	-6	-6	1	2	2	-6	-6	2	-6	-6	-6	
12	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
13	1	2	1	-6.00	-6.00	-6.000000	-3	1024.43600	3	2	2	2	2	2	2	-6	-6	2	-6	-6	-6	
14	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
15	1	5	3	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	2	-6	2	2	2	-6	-6	2	-6	-6	-6	
16	2	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	2	2	2	-6	-6	2	-6	-6	-6	
17	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
18	1	3	1	-6.00	-6.00	-6.000000	-3	877.82490	1	2	2	2	1	1	2	1	3	176	2	-6	-6	
19	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
20	-6	-6	-6	-6.00	-6.00	-6.000000	-3	-6.00000	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6	
21	-9	-9	-9	-9.00	-9.00	-9.000000	-3	-9.00000	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	
22	1	1	1	-6.00	-6.00	-6.000000	-3	720.26305	1	2	2	2	1	2	2	-6	-6	2	-6	-6	-6	

Showing 1 to 24 of 4,242 entries



# How do I know what these variables are?

The screenshot shows a web browser window with the title bar "FFCWS Metadata | Variables". The address bar contains the URL "browse.fragilefamiliesmetadata.org/variables". The page itself features the "Fragile Families & Child Wellbeing Study" logo, which includes a large stylized "FF" monogram, the text "Fragile Families", "& Child Wellbeing Study", and "PRINCETON | COLUMBIA". Below the logo is a grid of nine small photographs depicting various family members and children. At the top right of the page are several navigation icons. A horizontal menu bar below the logo includes links for "FFCWS Metadata", "Browse variables", "Download metadata", "Feedback", and "About FFCWS". The main content area is titled "Search variables" and contains a search bar with the placeholder "Search for..." and a "Search »" button. To the right of the search bar is a "Filter" section with three dropdown menus: "Topic", "Wave", and "Respondent".

<http://browse.fragilefamiliesmetadata.org/variables>

Introducing cm1relf

<http://browse.fragilefamiliesmetadata.org/variables/cm1relf>

You can filter variables by:

- ▶ Topic
- ▶ Wave
- ▶ Respondent
- ▶ Source
- ▶ Variable Type

# Why cm1relf?

## Why cm1relf?

Response type	Respondent	Wave	Leaf
(blank): questionnaire c: constructed	m - mother f - father p - primary caregiver k - child t - teacher h - home o - observations n - non parental caregiver d - child care center r - family care center u - post center observations q - couple	1 - baseline 2 - year 1 3 - year 3 4 - year 5 5 - year 9 6 - year 15	(letter): survey section + (number): question number  OR  (string): Constructed variable ID  OR  ( <del>string</del> ): national or city weight

Want direct access to the metadata?

Want direct access to the metadata? No problem

- ▶ API: [api.fragilefamiliesmetadata.org/](http://api.fragilefamiliesmetadata.org/)
- ▶ Python package:  
[github.com/fragilefamilieschallenge/ffmetadata-py](https://github.com/fragilefamilieschallenge/ffmetadata-py)
- ▶ R package:  
[github.com/fragilefamilieschallenge/ffmetadata](https://github.com/fragilefamilieschallenge/ffmetadata)
- ▶ Raw metadata:  
[api.fragilefamiliesmetadata.org/get\\_metadata](http://api.fragilefamiliesmetadata.org/get_metadata)



# Building a submission

Submissions include:

1. Predictions
2. Code
3. Narrative explanation

Submission preparation instructions:

[www.fragilefamilieschallenge.org/upload-your-contribution/](http://www.fragilefamilieschallenge.org/upload-your-contribution/)

# Get on the leaderboard

← → ⌂ codalab.fragilefamilieschallenge.org/#results

 Fragile Families CHALLENGE

Help Sign Up Sign In



Results							
#	User	GPA ▲	Grit ▲	Material hardship ▲	Eviction ▲	Layoff ▲	Job training ▲
1	wjlei1990	0.36854 (1)	0.21896 (3)	0.02436 (1)	0.05341 (7)	0.17435 (5)	0.20224 (3)
2	OldDriver.ffc	0.37099 (2)	0.22979 (18)	0.02471 (2)	0.05341 (7)	0.17435 (5)	0.20224 (3)
3	yjpeng	0.37120 (3)	0.21759 (2)	0.02493 (3)	0.05223 (2)	0.17048 (1)	0.20169 (2)
4	hamidrezaomidvar	0.37136 (4)	0.22191 (13)	0.02523 (5)	0.05227 (3)	0.18784 (7)	0.21409 (7)
5	t.f.schaffner	0.37143 (5)	0.21755 (1)	0.02499 (4)	0.05660 (8)	0.22453 (9)	0.27736 (9)
6	andrewor	0.37143 (5)	0.21755 (1)	0.02499 (4)	0.06038 (10)	0.26792 (13)	0.30755 (13)
7	pc12	0.37583 (6)	6.18762 (29)	0.03536 (24)	0.94340 (18)	0.77547 (19)	0.72264 (18)
8	mannyg	0.37789 (7)	0.21997 (7)	0.02880 (17)	0.05341 (7)	0.17435 (5)	0.20224 (3)
9	ppz	0.37810 (8)	0.23896 (19)	0.02859 (14)	0.12830 (16)	0.30755 (15)	0.36981 (16)
10	lazs	0.38407 (9)	0.22054 (9)	0.02877 (16)	0.05660 (8)	0.22453 (9)	0.27736 (9)
11	mloyola	0.38644 (10)	0.21969 (4)	0.02880 (17)	0.05341 (7)	0.17435 (5)	0.20224 (3)
12	agalle	0.38846 (11)	0.22137 (11)	0.02740 (8)	0.05341 (7)	0.17435 (5)	0.20224 (3)
13	weggert	0.38868 (12)	0.24682 (21)	0.02546 (6)	0.05660 (8)	0.24528 (12)	0.29245 (11)
14	ieremvfreese	0.39077 (13)	0.22060 (10)	0.02803 (12)	0.05295 (5)	0.17379 (4)	0.20132 (1)

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# Advice

## Get started with the constructed variables

- ▶ These are variables that domain experts think are important
- ▶ These variables have been partially pre-cleaned
- ▶ These variables add the additional prefix **c** to the front of the variable name.
- ▶ For instance, cm1ethrace indicates constructed mother's wave 1 race/ethnicity.
- ▶ blog post:

<http://www.fragilefamilieschallenge.org/quick-start/>

# Leverage the hundreds of papers already written with this data by domain experts

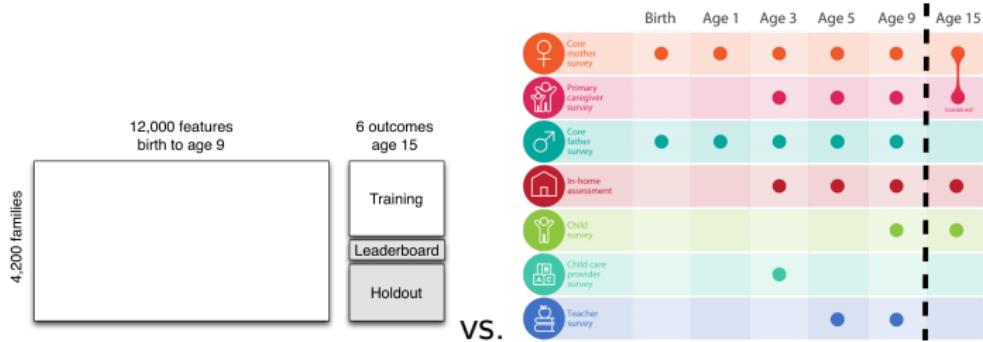
## Published Articles

Authors	Date	Title / Link
Brianne Pragg, Chris Knoester	Forthcoming	"Parental Leave Use Among Disadvantaged Fathers" <i>Journal of Family Issues</i> .
Jessica Hardie, Kristin Turney	Forthcoming	"The Intergenerational Consequences of Parental Health Limitations" <i>Journal of Marriage and Family</i> .
Robin Hognas, Heidi Williams	Forthcoming	"Maternal Kinship Involvement and Father Identity in Fragile Families" <i>Journal of Family and Economic Issues</i> .
Manuel Jiménez, Roy Wade, Ofira Schwartz-Solcher, Yong Lin, Nancy Reichman	Forthcoming	"Adverse Childhood Experiences and ADHD Diagnosis at Age 9 in a National Urban Sample" <i>Academic Pediatrics</i> .
Samara Gunter	Forthcoming	"Dynamics of Urban Informal Labor Supply in the United States" <i>Social Science Quarterly</i> .
Juan Shao-Chiu, Heather Washington, Megan Kurlychek	Forthcoming	"Breaking the Intergenerational Cycle: Partner violence, child-parent attachment, and children's aggressive behaviors" <i>Journal of Interpersonal Violence</i> .
Youngmin Yi, Kristin Turney, Christopher Wilderman	Forthcoming	"Mental Health Among Jail and Prison Inmates" <i>American Journal of Men's Health</i> .
Michael McFarland, Sara McLanahan, Bridget Goosby, Nancy Reichman	Forthcoming	"Grandparents' Education and Infant Health: Pathways Across Generations" <i>Journal of Marriage and Family</i> .
Christian King	Forthcoming	"Food Insecurity and Housing Instability in Vulnerable Families" <i>Review of Economics of the Household</i> .
Wan-Yi Chen, Yookyoung Lee	Forthcoming	"The Impact of Community Violence, Personal Victimization, and Paternal Support on Maternal Harsh Parenting" <i>Journal of Community Psychology</i> .
Marcia Carlson, Alicia VanOrman	Forthcoming	"Trajectories of relationship supportiveness after childbirth: Does marriage matter?" <i>Social Science Research</i> .
Jared Durtschi, Kristy Soloski, Jonathan Kimmes	Forthcoming	"The Dyadic Effects of Supportive Coparenting and Parental Stress on Relationship Quality Across the Transition to Parenthood" <i>Journal of Marital and Family Therapy</i> .
Anne Martin, Rebecca Ryan, Elizabeth Riina, Jeannine Brooks-Gunn	Forthcoming	"Coreidential Father Transitions and Biological Parents' Coparenting Quality in Early and Middle Childhood" <i>Journal of Family Issues</i> .
Lawrence Berger, Sarah Font, Kristen Slack, Jane Waldfogel	Forthcoming	"Income and child maltreatment in unmarried families: evidence from the earned income tax credit" <i>Review of Economics of the Household</i> .
Sung-Bong Cho, Ming Cui, Amy Claridge	Forthcoming	"Cohabiting parents' marriage plans and marriage realization: Gender differences, couple agreement, and longitudinal effects" <i>Journal of Social and Personal Relationships</i> .
M. Blake Berryhill	Forthcoming	"Single mothers' home-based school involvement: a longitudinal analysis" <i>Journal of Family Studies</i> .
Colin Flood, Karen Sheehan, Marie Crandall	Forthcoming	"Predictors of Emergency Department Utilization Among Children in Vulnerable Families" <i>Pediatric Emergency Care</i> .
Sarah James, Lauren Hale	Forthcoming	"Sleep Duration and Child Well-Being: A Nonlinear Association" <i>Journal of Clinical Child &amp; Adolescent Psychology</i> .

<http://crcw.princeton.edu/publications/publications.asp>

Use the structure in the data

## Use the structure in the data



How can you optimally combine human and machine effort?

How can you optimally combine human and machine effort?

- ▶ automatic feature selection
- ▶ human-assisted automatic feature selection
- ▶ computer-assisted human feature selection
- ▶ some other hybrid

## Common missing codes<sup>13</sup>

Not all missing data is the same

- ▶ -9 Not in wave - Did not participate in survey/data collection component
- ▶ -6 Valid skip - Intentionally not asked question; question does not apply to respondent or response known based on prior information.
- ▶ -2 Don't know - Respondent asked question; responded "Don't Know".
- ▶ -1 Refuse - Respondent asked question; refused to answer question
- ▶ NA also used occasionally

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<sup>13</sup>For more complete list and explanation, see  
<http://www.fragilefamilieschallenge.org/missing-data/>

performance and interpretability

## How you can help

Please open source your assignment to help science

COMPUTER SCIENCE

# *Artificial intelligence faces reproducibility crisis*

Unpublished code and sensitivity to training conditions make many claims hard to verify

[dx.doi.org/10.1126/science.359.6377.725](https://dx.doi.org/10.1126/science.359.6377.725)

COMPUTER SCIENCE

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These guidelines will help:

<https://tinyurl.com/ffchallenge-reproducibility>

Help improve our metadata infrastructure

- ▶ Let us know if you find error in the metadata  
([fragilefamilieschallenge@gmail.com](mailto:fragilefamilieschallenge@gmail.com))

- ▶ Let us know if you find error in the metadata  
([fragilefamilieschallenge@gmail.com](mailto:fragilefamilieschallenge@gmail.com))
- ▶ Submit bug reports, feature requests, and pull request for
  - ▶ API:  
[github.com/fragilefamilieschallenge/metadata\\_api](https://github.com/fragilefamilieschallenge/metadata_api)
  - ▶ web app:  
[github.com/fragilefamilieschallenge/metadata\\_app](https://github.com/fragilefamilieschallenge/metadata_app)
  - ▶ Python package:  
[github.com/fragilefamilieschallenge/ffmetadata-py](https://github.com/fragilefamilieschallenge/ffmetadata-py)
  - ▶ R package:  
[github.com/fragilefamilieschallenge/ffmetadata](https://github.com/fragilefamilieschallenge/ffmetadata)

- ▶ Let us know if you find error in the metadata  
([fragilefamilieschallenge@gmail.com](mailto:fragilefamilieschallenge@gmail.com))
- ▶ Submit bug reports, feature requests, and pull request for
  - ▶ API:  
[github.com/fragilefamilieschallenge/metadata\\_api](https://github.com/fragilefamilieschallenge/metadata_api)
  - ▶ web app:  
[github.com/fragilefamilieschallenge/metadata\\_app](https://github.com/fragilefamilieschallenge/metadata_app)
  - ▶ Python package:  
[github.com/fragilefamilieschallenge/ffmetadata-py](https://github.com/fragilefamilieschallenge/ffmetadata-py)
  - ▶ R package:  
[github.com/fragilefamilieschallenge/ffmetadata](https://github.com/fragilefamilieschallenge/ffmetadata)
- ▶ Want to help in other ways? Just ask . . .

[www.fragilefamilieschallenge.org](http://www.fragilefamilieschallenge.org)

## Questions?

- ▶ Email: [fragilefamilieschallenge@gmail.com](mailto:fragilefamilieschallenge@gmail.com)
- ▶ Blog: [www.fragilefamilieschallenge.org/blog-posts/](http://www.fragilefamilieschallenge.org/blog-posts/)
- ▶ Github: [www.github.com/fragilefamilieschallenge](http://www.github.com/fragilefamilieschallenge)