Addendum to: Centrality dependence of high-pT D-meson suppression in Pb-Pb collisions at √sNN=2.76 TeV

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Source / Izvornik: **Journal of High Energy Physics, 2017, 2017**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.1007/JHEP06(2017)032

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:217:035474

Published for SISSA by Springer

Received: May 19, 2017
Accepted: May 29, 2017
Published: June 6, 2017

Addendum: Centrality dependence of high-p_T D-meson suppression in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

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Addendum to: JHEP11(2015)205

Abstract: This is an addendum to the article *JHEP* **11** (2015) 205 [1]. The figures 3 (right), 4 (right) and 5 are updated with published results on non-prompt J/ψ-meson production from the CMS collaboration [2].

ArXiv ePrint: 1506.06604

In [1] the average nuclear modification factor R_{AA} of D^0, D^+ and D^{*+} mesons in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV measured by ALICE was compared with that of non-prompt J/ψ mesons from B-meson decays measured by the CMS collaboration using 2010 data (7.28 μb^{-1}) [3]. A higher-precision measurement based on 2011 data (152 μb^{-1}) was recently published by the CMS collaboration [2]. The measurement for the p_T interval 6.5–30 GeV/c is carried out in three rapidity intervals, including $|y| < 1.2$, which is more similar to that of D mesons ($|y| < 0.5$).

Figure 1 shows the average of the D^0, D^+ and D^{*+} nuclear modification factors as a function of centrality in $8 < p_T < 16$ GeV/c, compared with the R_{AA} of non-prompt J/ψ mesons with $6.5 < p_T < 30$ GeV/c [2]. The latter is significantly higher than that of the D mesons in the five centrality intervals from 0–10% to 40–50%. For example, the average difference of the R_{AA} values of D mesons and non-prompt J/ψ mesons in the 0–10% and 10–20% centrality classes is larger than zero with a significance of 3.4 σ, obtained including the systematic uncertainties, and taking into account their correlation between

doi:10.1007/JHEP06(2017)032

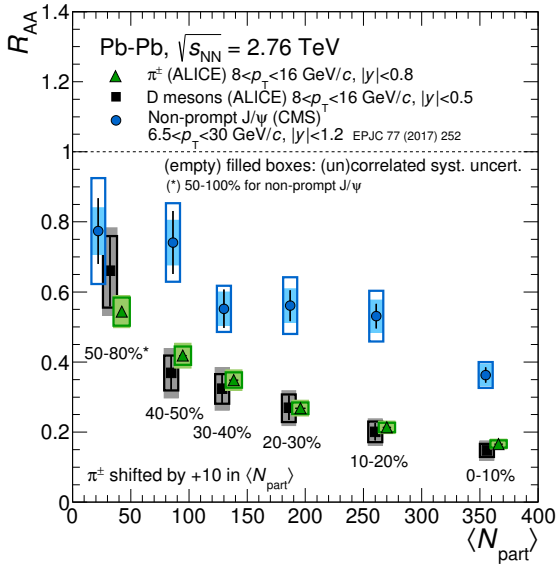

Figure 1. Comparison of the D meson R_{AA} (average of D^0, D^+ and D^{*+}) in $8 < p_{\mathrm{T}} < 16$ GeV/c [1] and of the R_{AA} of non-prompt J/ψ mesons in $6.5 < p_{\mathrm{T}} < 30$ GeV/c measured by the CMS collaboration [2]. The vertical bars represent the statistical uncertainties, while the filled (empty) boxes represent the systematic uncertainties that are correlated (uncorrelated) among centrality intervals. This figure updates figure 3 (right) of [1].

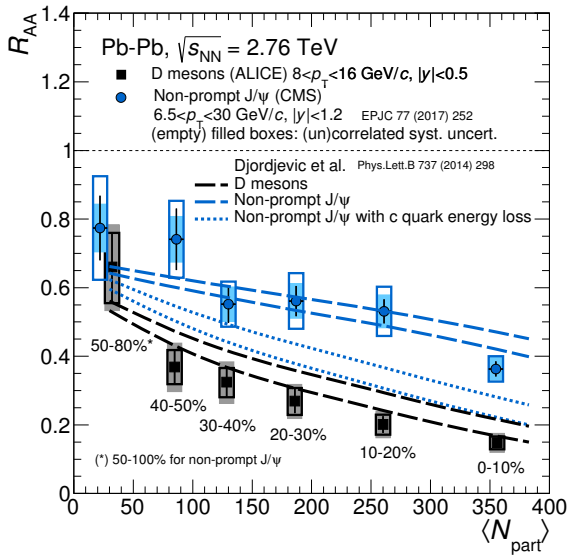

Figure 2. Comparison of the R_{AA} measurements with the calculations by Djordjevic et al. [4] including radiative and collisional energy loss. Lines of the same style enclose a band representing the theoretical uncertainty. For non-prompt J/ψ mesons in $6.5 < p_{\mathrm{T}} < 30$ GeV/c [2] the model results for the case in which the b quark interactions are calculated using the c quark mass are shown as well [7]. This figure updates figure 4 (right) of [1].

the two centrality classes. In figures 2 and 3 these measurements are compared with model calculations [4–6], as originally done in [1].

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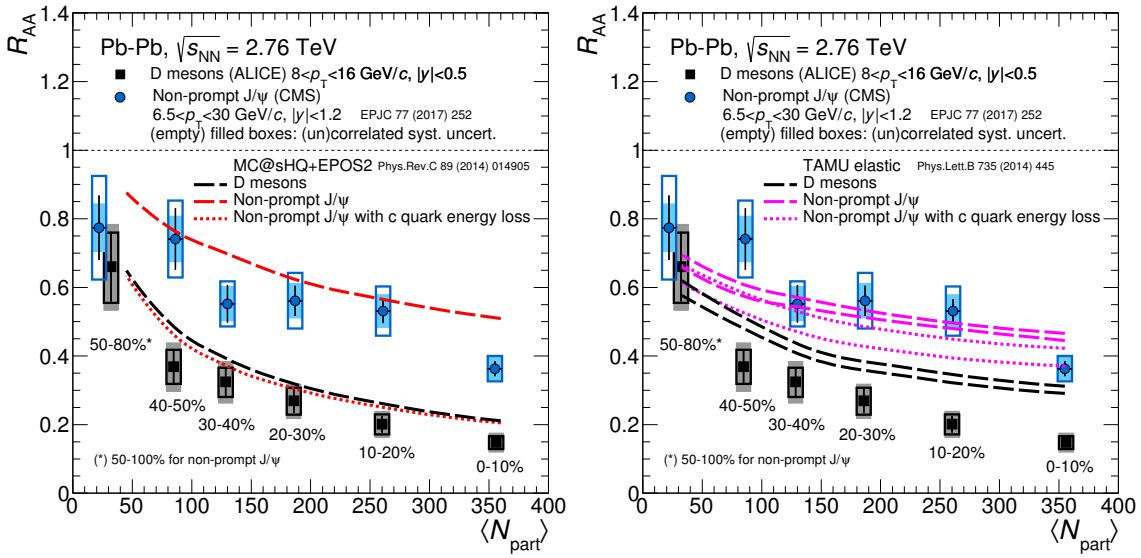

Figure 3. Comparison of the $R_{\rm AA}$ measurements with the *MC@sHQ+EPOS2* model [5] including radiative and collisional interactions (left) and with the *TAMU elastic* model [6] including collisional interactions via in-medium resonance formation. For both models, results for the case in which the b quark interactions are calculated using the c quark mass are shown as well [7]. In the right-hand panel, the band between lines with the same style represents the theoretical uncertainty. This figure updates figure 5 of [1].

The conclusions of the original publication [1] are confirmed by the comparisons that consider the new J/ψ-meson measurements. In particular, the comparison of the D-meson $R_{\rm AA}$ with the non-prompt J/ψ-meson $R_{\rm AA}$ shows a difference in the suppression of particles originating from c and b quarks in the most central collisions. This observation is described by theoretical calculations in which in-medium parton energy loss decreases with increasing quark mass.

References

[1] ALICE collaboration, *Centrality dependence of high-p_T D meson suppression in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV*, *JHEP* **11** (2015) 205 [arXiv:1506.06604] [INSPIRE].

[2] CMS collaboration, *Suppression and azimuthal anisotropy of prompt and nonprompt J/ψ production in PbPb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV*, *Eur. Phys. J.* **C 77** (2017) 252 [arXiv:1610.00613] [INSPIRE].

[3] CMS collaboration, *Suppression of non-prompt J/ψ, prompt J/ψ and $\Upsilon(1S)$ in PbPb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV*, *JHEP* **05** (2012) 063 [arXiv:1201.5069] [INSPIRE].

[4] M. Djordjevic, M. Djordjevic and B. Blagojevic, *RHIC and LHC jet suppression in non-central collisions*, *Phys. Lett.* **B 737** (2014) 298 [arXiv:1405.4250] [INSPIRE].

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[5] M. Nahrgang, J. Aichelin, P.B. Gossiaux and K. Werner, *Influence of hadronic bound states above T_c on heavy-quark observables in $Pb + Pb$ collisions at at the CERN Large Hadron Collider*, *Phys. Rev.* **C 89** (2014) 014905 [arXiv:1305.6544] [INSPIRE].

[6] M. He, R.J. Fries and R. Rapp, *Heavy Flavor at the Large Hadron Collider in a Strong Coupling Approach*, *Phys. Lett.* **B 735** (2014) 445 [arXiv:1401.3817] [INSPIRE].

[7] A. Andronic et al., *Heavy-flavour and quarkonium production in the LHC era: from proton-proton to heavy-ion collisions*, *Eur. Phys. J.* **C 76** (2016) 107 [arXiv:1506.03981] [INSPIRE].

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J. Adam[40] , D. Adamová[83] , M.M. Aggarwal[87] , G. Aglieri Rinella[36] , M. Agnello[111] , N. Agrawal[48] , Z. Ahammed[132] , S.U. Ahn[68] , I. Aimo[94 ,111] , S. Aiola[137] , M. Ajaz[16] , A. Akindinov[58] , S.N. Alam[132] , D. Aleksandrov[100] , B. Alessandro[111] , D. Alexandre[102] , R. Alfaro Molina[64] , A. Alici[105 ,12] , A. Alkin[3] , J.R.M. Almaraz[119] , J. Alme[38] , T. Alt[43] , S. Altinpinar[18] , I. Altsybeev[131] , C. Alves Garcia Prado[120] , C. Andrei[78] , A. Andronic[97] , V. Anguelov[93] , J. Anielski[54] , T. Antičić[98] , F. Antinori[108] , P. Antonioli[105] , L. Aphecetche[113] , H. Appelshäuser[53] , S. Arcelli[28] , N. Armesto[17] , R. Arnaldi[111] , I.C. Arsene[22] , M. Arslandok[53] , B. Audurier[113] , A. Augustinus[36] , R. Averbeck[97] , M.D. Azmi[19] , M. Bach[43] , A. Badalà[107] , Y.W. Baek[44] , S. Bagnasco[111] , R. Bailhache[53] , R. Bala[90] , A. Baldisseri[15] , F. Baltasar Dos Santos Pedrosa[36] , R.C. Baral[61] , A.M. Barbano[111] , R. Barbera[29] , F. Barile[33] , G.G. Barnaföldi[136] , L.S. Barnby[102] , V. Barret[70] , P. Bartalini[7] , K. Barth[36] , J. Bartke[117] , E. Bartsch[53] , M. Basile[28] , N. Bastid[70] , S. Basu[132] , B. Bathen[54] , G. Batigne[113] , A. Batista Camejo[70] , B. Batyunya[66] , P.C. Batzing[22] , I.G. Bearden[80] , H. Beck[53] , C. Bedda[111] , N.K. Behera[48 ,49] , I. Belikov[55] , F. Bellini[28] , H. Bello Martinez[2] , R. Bellwied[122] , R. Belmont[135] , E. Belmont-Moreno[64] , V. Belyaev[76] , G. Bencedi[136] , S. Beole[27] , I. Berceanu[78] , A. Bercuci[78] , Y. Berdnikov[85] , D. Berenyi[136] , R.A. Bertens[57] , D. Berzano[36 ,27] , L. Betev[36] , A. Bhasin[90] , I.R. Bhat[90] , A.K. Bhati[87] , B. Bhattacharjee[45] , J. Bhom[128] , L. Bianchi[122] , N. Bianchi[72] , C. Bianchin[135 ,57] , J. Bielčík[40] , J. Bielčíková[83] , A. Bilandzic[80] , R. Biswas[4] , S. Biswas[79] , S. Bjelogrlic[57] , F. Blanco[10] , D. Blau[100] , C. Blume[53] , F. Bock[74 ,93] , A. Bogdanov[76] , H. Bøggild[80] , L. Boldizsár[136] , M. Bombara[41] , J. Book[53] , H. Borel[15] , A. Borissov[96] , M. Borri[82] , F. Bossú[65] , E. Botta[27] , S. Böttger[52] , P. Braun-Munzinger[97] , M. Bregant[120] , T. Breitner[52] , T.A. Broker[53] , T.A. Browning[95] , M. Broz[40] , E.J. Brucken[46] , E. Bruna[111] , G.E. Bruno[33] , D. Budnikov[99] , H. Buesching[53] , S. Bufalino[36 ,111] , P. Buncic[36] , O. Busch[93 ,128] , Z. Buthelezi[65] , J.B. Butt[16] , J.T. Buxton[20] , D. Caffarri[36] , X. Cai[7] , H. Caines[137] , L. Calero Diaz[72] , A. Caliva[57] , E. Calvo Villar[103] , P. Camerini[26] , F. Carena[36] , W. Carena[36] , J. Castillo Castellanos[15] , A.J. Castro[125] , E.A.R. Casula[25] , C. Cavicchioli[36] , C. Ceballos Sanchez[9] , J. Cepila[40] , P. Cerello[111] , J. Cerkala[115] , B. Chang[123] , S. Chapeland[36] , M. Chartier[124] , J.L. Charvet[15] , S. Chattopadhyay[132] , S. Chattopadhyay[101] , V. Chelnokov[3] , M. Cherney[86] , C. Cheshkov[130] , B. Cheynis[130] , V. Chibante Barroso[36] , D.D. Chinellato[121] , P. Chochula[36] , K. Choi[96] , M. Chojnacki[80] , S. Choudhury[132] , P. Christakoglou[81] , C.H. Christensen[80] , P. Christiansen[34] , T. Chujo[128] , S.U. Chung[96] , Z. Chunhui[57] , C. Cicalo[106] , L. Cifarelli[12 ,28] , F. Cindolo[105] , J. Cleymans[89] , F. Colamaria[33] , D. Colella[36 ,59 ,33] , A. Collu[25] , M. Colocci[28] , G. Conesa Balbastre[71] , Z. Conesa del Valle[51] , M.E. Connors[137] , J.G. Contreras[11 ,40] , T.M. Cormier[84] , Y. Corrales Morales[27] , I. Cortés Maldonado[2] , P. Cortese[32] , M.R. Cosentino[120] , F. Costa[36] , P. Crochet[70] , R. Cruz Albino[11] , E. Cuautle[63] , L. Cunqueiro[36] , T. Dahms[92 ,37] , A. Dainese[108] , A. Danu[62] , D. Das[101] , I. Das[51 ,101] , S. Das[4] , A. Dash[121] , S. Dash[48] , S. De[120] , A. De Caro[31 ,12] , G. de Cataldo[104] , J. de Cuveland[43] , A. De Falco[25] , D. De Gruttola[12 ,31] , N. De Marco[111] , S. De Pasquale[31] , A. Deisting[97 ,93] , A. Deloff[77] , E. Dénes[136] , G. D'Erasmo[33] , D. Di Bari[33] , A. Di Mauro[36] , P. Di Nezza[72] , M.A. Diaz Corchero[10] , T. Dietel[89] , P. Dillenseger[53] , R. Divià[36] , Ø. Djuvsland[18] , A. Dobrin[57 ,81] , T. Dobrowolski[77 , i] , D. Domenicis Gimenez[120] , B. Dönigus[53] , O. Dordic[22] , A.K. Dubey[132] , A. Dubla[57] , L. Ducroux[130] , P. Dupieux[70] , R.J. Ehlers[137] , D. Elia[104] , H. Engel[52] , B. Erazmus[36 ,113] , I. Erdemir[53] , F. Erhardt[129] , D. Eschweiler[43] , B. Espagnon[51] , M. Estienne[113] , S. Esumi[128] , J. Eum[96] , D. Evans[102] , S. Evdokimov[112] , G. Eyyubova[40] , L. Fabbietti[37 ,92] , D. Fabris[108] , J. Faivre[71] , A. Fantoni[72] , M. Fasel[74] , L. Feldkamp[54] , D. Felea[62] , A. Feliciello[111] , G. Feofilov[131] , J. Ferencei[83] , A. Fernández Téllez[2] , E.G. Ferreiro[17] , A. Ferretti[27] , A. Festanti[30] , V.J.G. Feuillard[15 ,70] , J. Figiel[117] , M.A.S. Figueredo[124] ,

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S. Filchagin[99] , D. Finogeev[56] , E.M. Fiore[33] , M.G. Fleck[93] , M. Floris[36] , S. Foertsch[65] , P. Foka[97] , S. Fokin[100] , E. Fragiacomo[110] , A. Francescon[30,36] , U. Frankenfeld[97] , U. Fuchs[36] , C. Furget[71] , A. Furs[56] , M. Fusco Girard[31] , J.J. Gaardhøje[80] , M. Gagliardi[27] , A.M. Gago[103] , M. Gallio[27] , D.R. Gangadharan[74] , P. Ganoti[88] , C. Gao[7] , C. Garabatos[97] , E. Garcia-Solis[13] , C. Gargiulo[36] , P. Gasik[92,37] , M. Germain[113] , A. Gheata[36] , M. Gheata[62,36] , P. Ghosh[132] , S.K. Ghosh[4] , P. Gianotti[72] , P. Giubellino[36,111] , P. Giubilato[30] , E. Gladysz-Dziadus[117] , P. Glässel[93] , A. Gomez Ramirez[52] , P. González-Zamora[10] , S. Gorbunov[43] , L. Görlich[117] , S. Gotovac[116] , V. Grabski[64] , L.K. Graczykowski[134] , K.L. Graham[102] , A. Grelli[57] , A. Grigoras[36] , C. Grigoras[36] , V. Grigoriev[76] , A. Grigoryan[1] , S. Grigoryan[66] , B. Grinyov[3] , N. Grion[110] , J.F. Grosse-Oetringhaus[36] , J.-Y. Grossiord[130] , R. Grosso[36] , F. Guber[56] , R. Guernane[71] , B. Guerzoni[28] , K. Gulbrandsen[80] , H. Gulkanyan[1] , T. Gunji[127] , A. Gupta[90] , R. Gupta[90] , R. Haake[54] , Ø. Haaland[18] , C. Hadjidakis[51] , M. Haiduc[62] , H. Hamagaki[127] , G. Hamar[136] , A. Hansen[80] , J.W. Harris[137] , H. Hartmann[43] , A. Harton[13] , D. Hatzifotiadou[105] , S. Hayashi[127] , S.T. Heckel[53] , M. Heide[54] , H. Helstrup[38] , A. Herghelegiu[78] , G. Herrera Corral[11] , B.A. Hess[35] , K.F. Hetland[38] , T.E. Hilden[46] , H. Hillemanns[36] , B. Hippolyte[55] , R. Hosokawa[128] , P. Hristov[36] , M. Huang[18] , T.J. Humanic[20] , N. Hussain[45] , T. Hussain[19] , D. Hutter[43] , D.S. Hwang[21] , R. Ilkaev[99] , I. Ilkiv[77] , M. Inaba[128] , M. Ippolitov[76,100] , M. Irfan[19] , M. Ivanov[97] , V. Ivanov[85] , V. Izucheev[112] , P.M. Jacobs[74] , S. Jadlovska[115] , C. Jahnke[120] , H.J. Jang[68] , M.A. Janik[134] , P.H.S.Y. Jayarathna[122] , C. Jena[30] , S. Jena[122] , R.T. Jimenez Bustamante[97] , P.G. Jones[102] , H. Jung[44] , A. Jusko[102] , P. Kalinak[59] , A. Kalweit[36] , J. Kamin[53] , J.H. Kang[138] , V. Kaplin[76] , S. Kar[132] , A. Karasu Uysal[69] , O. Karavichev[56] , T. Karavicheva[56] , L. Karayan[97,93] , E. Karpechev[56] , U. Kebschull[52] , R. Keidel[139] , D.L.D. Keijdener[57] , M. Keil[36] , K.H. Khan[16] , M.M. Khan[19] , P. Khan[101] , S.A. Khan[132] , A. Khanzadeev[85] , Y. Kharlov[112] , B. Kileng[38] , B. Kim[138] , D.W. Kim[44,68] , D.J. Kim[123] , H. Kim[138] , J.S. Kim[44] , M. Kim[44] , M. Kim[138] , S. Kim[21] , T. Kim[138] , S. Kirsch[43] , I. Kisel[43] , S. Kiselev[58] , A. Kisiel[134] , G. Kiss[136] , J.L. Klay[6] , C. Klein[53] , J. Klein[36,93] , C. Klein-Bösing[54] , A. Kluge[36] , M.L. Knichel[93] , A.G. Knospe[118] , T. Kobayashi[128] , C. Kobdaj[114] , M. Kofarago[36] , T. Kollegger[97,43] , A. Kolojvari[131] , V. Kondratiev[131] , N. Kondratyeva[76] , E. Kondratyuk[112] , A. Konevskikh[56] , M. Kopcik[115] , M. Kour[90] , C. Kouzinopoulos[36] , O. Kovalenko[77] , V. Kovalenko[131] , M. Kowalski[117] , G. Koyithatta Meethaleveedu[48] , J. Kral[123] , I. Králik[59] , A. Kravčáková[41] , M. Krelina[40] , M. Kretz[43] , M. Krivda[102,59] , F. Krizek[83] , E. Kryshen[36] , M. Krzewicki[43] , A.M. Kubera[20] , V. Kučera[83] , T. Kugathasan[36] , C. Kuhn[55] , P.G. Kuijer[81] , I. Kulakov[43] , A. Kumar[90] , J. Kumar[48] , L. Kumar[79,87] , P. Kurashvili[77] , A. Kurepin[56] , A.B. Kurepin[56] , A. Kuryakin[99] , S. Kushpil[83] , M.J. Kweon[50] , Y. Kwon[138] , S.L. La Pointe[111] , P. La Rocca[29] , C. Lagana Fernandes[120] , I. Lakomov[36] , R. Langoy[42] , C. Lara[52] , A. Lardeux[15] , A. Lattuca[27] , E. Laudi[36] , R. Lea[26] , L. Leardini[93] , G.R. Lee[102] , S. Lee[138] , I. Legrand[36] , F. Lehas[81] , R.C. Lemmon[82] , V. Lenti[104] , E. Leogrande[57] , I. León Monzón[119] , M. Leoncino[27] , P. Lévai[136] , S. Li[7,70] , X. Li[14] , J. Lien[42] , R. Lietava[102] , S. Lindal[22] , V. Lindenstruth[43] , C. Lippmann[97] , M.A. Lisa[20] , H.M. Ljunggren[34] , D.F. Lodato[57] , P.I. Loenne[18] , V. Loginov[76] , C. Loizides[74] , X. Lopez[70] , E. López Torres[9] , A. Lowe[136] , P. Luettig[53] , M. Lunardon[30] , G. Luparello[26] , P.H.F.N.D. Luz[120] , A. Maevskaya[56] , M. Mager[36] , S. Mahajan[90] , S.M. Mahmood[22] , A. Maire[55] , R.D. Majka[137] , M. Malaev[85] , I. Maldonado Cervantes[63] , L. Malinina[ii,66] , D. Mal'Kevich[58] , P. Malzacher[97] , A. Mamonov[99] , V. Manko[100] , F. Manso[70] , V. Manzari[36,104] , M. Marchisone[27] , J. Mareš[60] , G.V. Margagliotti[26] , A. Margotti[105] , J. Margutti[57] , A. Marín[97] , C. Markert[118] , M. Marquard[53] , N.A. Martin[97] , J. Martin Blanco[113] , P. Martinengo[36] , M.I. Martínez[2] , G. Martínez García[113] , M. Martinez Pedreira[36] , Y. Martynov[3] , A. Mas[120] , S. Masciocchi[97] , M. Masera[27] , A. Masoni[106] , L. Massacrier[113] , A. Mastroserio[33] , H. Masui[128] , A. Matyja[117] , C. Mayer[117] , J. Mazer[125] , M.A. Mazzoni[109] , D. Mcdonald[122] , F. Meddi[24] , Y. Melikyan[76] , A. Menchaca-Rocha[64] , E. Meninno[31] , J. Mercado

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