# Transverse energy analysis of relativistic heavy ion collisions through the use of identified particles spectra

A Thesis Presented for the

Master of Science

Degree

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May 2018

# Table of Contents

# List of Tables

# List of Figures

# Chapter 1

# Introduction

One of the main focuses of current experimental and theoretical nuclear physics research is the study of the phase diagram of nuclear matter at a range of temperatures and baryon chemical potentials. In experiments involving the collisions of heavy ions at high and low energies, different regions of the phase diagram can be probed by varying the collision energy [4]. For instance, the high-baryon chemical potential regime corresponds to lower beam energies and higher temperatures correspond to higher beam energies. The results of these experiments and model calculations can be used to study the nature of transitions in the phase diagram.

Quantum chromodynamics (QCD) – the gauge theory of strong interaction [12, 20] – predicts a phase transition, at energy densities above 0.2-1 GeV/fm$^3$ [1] and around a critical temperature of about 200 MeV [14], of nuclear matter to a phase with quarks and gluons in thermal and chemical equilibrium representing the relevant degrees of freedom and behaving like an almost perfect quantum fluid [8]. This deconfined state of quarks and gluons, which is what the weakening of the strong interaction due to the polarization of the QCD vacuum is expected to lead to at high energies, is termed the quark-gluon plasma (QGP) in analogy to the quantum electrodynamical plasma phase of matter. The expectation of this phase transition also makes sense in terms of the chiral symmetry of the QCD Lagrangian, which is spontaneously broken at low temperatures, but restored at high temperatures, providing a sufficient condition for the deconfinement.

A schematic representing the QCD phase diagram on the temperature (T) and quark chemical potential ($\mu$) plane is shown in Figure 1.1 [6]. A second-order transition is predicted at low baryon chemical potentials (close to baryon-antibaryon symmetry) and high temperatures reminiscent of the early universe but within reach at modern facilities, specifically the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory and the Large Hadron Collider (LHC) at CERN. At low temperatures and high chemical potentials, loose predictions have been made regarding the existence of exotic phases of high density matter, and programs, such as the Compressed Baryonic Matter experiment at the Facility for Antiproton and Ion Research in Germany, are being designed to study this region of the phase diagram.

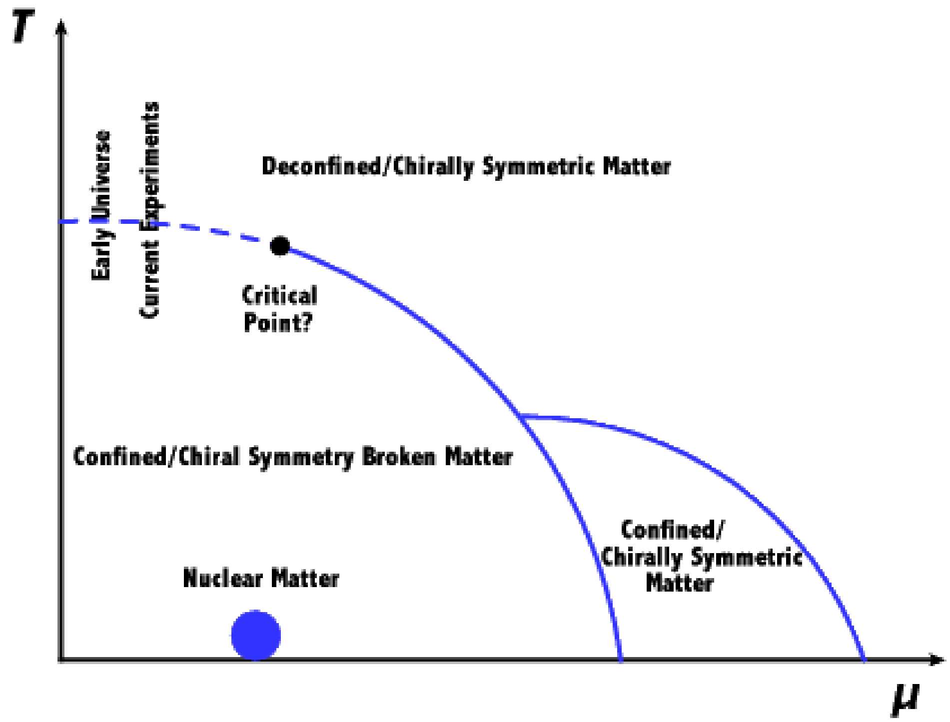


**Figure 1.1:** Schematic of the QCD phase diagram [6].

The existence and properties of the QGP in the aftermath of high-energy heavy-ion collisions can be probed using different techniques relevant to several theoretical characteristics of the phase. For instance, the interacting nuclei carry no net strangeness before colliding, and so a post-collision observation of strange and multi-strange particles can be a trigger for an antecedent existence of deconfined quarks and gluons [10]. This trigger, when complemented with an observation of the suppression of J/$\psi$ production, provides a strong hint of the formation of QGP. This can be further complemented with the estimate of the energy density and the temperature attained after the collision.

Analyses of experimental results have thus far provided signatures of the formation of matter with partonic degrees of freedom at the early stages of the collisions. Such signatures include a diminished multiplicity of high-transverse momentum $p_T$ (transverse with respect to the beam axis) hadrons in heavy ion collisions as compared to scaled p-p collisions as well as the differences between the elliptic flows associated with baryons and mesons at intermediate $p_T$ [2]. Experiments also reveal the initial energy density of this matter to be about two orders of magnitude larger than that of low energy nuclear matter – comfortably more than the deconfinement phase transition critical density predicted by lattice QCD [11].

The state of the colliding nuclei before the collision at LHC and top RHIC energies has indications of being a Color Glass Condensate – strongly interacting, weakly coupled highly coherent gluonic matter [15]. The characteristics of the initial states of these nuclei affect the partonic distributions within the nuclei and ultimately the products of the collision. The collision products are also affected by variables such as the initial energy and entropy densities of the partonic matter [11].

Different observables can be used to study different aspects of heavy ion collisions. The charged particle multiplicity, $\langle N_{ch} \rangle$, is a global variable that relates to the entropy production during the collision (analysis note). The transverse energy, $E_T$, a global variable related to $\langle N_{ch} \rangle$, provides information about the conversion of the initial beam-direction kinetic energy into energy flowing in the transverse direction after the collision. Together, the studies of the fluctuation of the $\langle N_{ch} \rangle$ and the $E_T$ pseudorapidity [footnote] density with respect to the beam energy and the collision centrality [footnote] help probe the characteristics of the initial conditions at the time of the collision. One can study, for instance, the distinctions between models based on quark participants against those based on nucleon participants [analysis note]. These quantities can also lead to the rough estimate of the initial energy density through the use of the Bjorken formula [16]:

$$\epsilon \geq \frac{\frac{dE_T}{d\eta}}{\tau_0 \pi R^2} = \frac{3}{2} \langle \frac{E_T}{N} \rangle \frac{\frac{dN_{ch}}{d\eta}}{\tau_0 \pi R^2} \tag{1.1}$$

The transverse energy and the charged particle pseudorapidity densities have conventionally been calculated by using the transverse energy measurements obtained from calorimeters. This thesis details the use of particle spectra, reported as $\frac{d^2N}{dydp_T}$, from Au+Au collisions at RHIC to calculate the same global variables and serve as a method to cross check the ones involving calorimeters.

The organization of the thesis is as follows. Chapter II contains brief descriptions of different conventional methods used to estimate $E_T$ as well as an elaboration of the method specific to this thesis.

# Chapter 2

# Method

In theory, $E_T$ from a collision can be defined as the sum of the transverse masses, $m_T$, of all the particles produced in the collision, i.e.,

$$E_T \equiv \sum_i m_{T,i} \tag{2.1}$$

with

$$m_T \equiv \sqrt{p_T^2 + m^2} \tag{2.2}$$

where $m$ is the rest mass of the particle and $p_T$ is its transverse momentum. Using this definition to calculate the $E_T$ requires perfect identification of all the particles. It has not been possible to do so in experiments, and so a more feasible, operational definition of $E_T$ is fabricated. A commonly accepted definition in case of the feasibility of calorimetric measurements is [5, 15]:

$$E_T = \sum_i E_i \sin\theta_i, \tag{2.3}$$

$$\frac{dE_T}{d\eta} = \sin\theta \frac{dE}{d\eta}, \tag{2.4}$$

where the index $i$ runs over all the particles going into a fixed solid angle for each event, $\theta$ is the polar angle, i.e, the angle with respect to the beam axis, $\eta$ is the pseudorapidity defined as

$$\eta \equiv -\ln\tan\frac{\theta}{2}, \tag{2.5}$$

and $E_i$ is the energy deposited in the calorimeter by the $i^{th}$ particle. $E_i$ is considered to be, by convention [5]???, the following

$$E_i = \begin{cases} E_i^{tot} - m_0 & \text{for baryons} \\ E_i^{tot} + m_0 & \text{for anti-baryons} \\ E_i^{tot} & \text{otherwise} \end{cases} \tag{2.6}$$

where $E_i^{tot}$ is the total energy of the $i^{th}$ particle defined canonically as

$$E^{tot} \equiv \sqrt{p^2 + m_0^2} \tag{2.7}$$

and $m_0$ is the particle's rest mass. In order to account for the particles that are not identified by the calorimeters, corrections are made based on GEANT simulations of the collision and detection physics using models of the nucleus such as the Glauber model. (Doesn't that mean we use the model to make corrections in the analysis and the result of the analysis to judge the model????) Corrections to account for unidentified particles are made for the tracking detectors also, but these turn out to be less than those made in case of the calorimeters. Hence, if the tracking detectors are able to give any information that can be used to estimate the total $E_T$, then we should be able to get a better estimate of the total $E_T$ than we would if we used the calorimeters. In fact, the tracking detectors in experiments such as the STAR (Solenoidal Tracker At RHIC) experiment and ALICE (A Large Ion Collider Experiment) at CERN include Time Projection Chambers (TPCs) and Time-of-Flight (TOF) detectors that can give us the $p_T$ spectra, yields and particle ratios of the identified charged hadrons [19, 2]. The TPCs provide measurements of particle trajectories – that can be used to determine the momenta for low-momentum particles – and of their specific energy loss,

$$\frac{dE}{dx}, \tag{2.8}$$

which can be used with the trajectories to make particle identifications using the Bethe-Bloch formula [7]. TOF detectors, on the other hand, cover the high-momentum part of the measurements. In ALICE, the combination of the measurements of the TPC with those of the Inner Tracking System (ITS) effectively adds the tracking length, thereby improving the resolution of the measured $p_T$ spectrum. Details about the particle identification and momentum determination capabilities of the detectors in ALICE can be found in [9].

In the STAR experiment, the TPC is the primary tracking detector. It is 4.2 m long and it cylindrically enshrouds the accelerator beam pipe from its outside, with an inner diameter of 1 m and an outer diameter of 4 m [17]. !!!!!!!!! more details about the TPC, then its limitation in high momentum resolution, then transition to TOF and some of its details !!!!!!!!!

The RHIC, in 2010, started a multi-phase Beam Energy Scan (BES) program to study the QCD phase diagram. The collider has the unique facility to collide nulclei at a range of center-of-mass energies per nucleon, $\sqrt{s_{NN}}$. It also has two different detectors, STAR and PHENIX (Pioneering High Energy Nuclear Interactions eXperiment), which facilitate the cross-checking of results. Between 2010 and 2011, under the exploratory phase I of the BES program, 7.7, 11.5 (not completed in PHENIX), 19.6, 27, and 39 GeV collisions were completed using pairs of Au nuclei. Together with the data formerly collected by the RHIC at higher collision energies, BES phase I data can scan the interval from 450 MeV to 20 MeV in $\mu_B$ space [18, 13]. One of the things that can be studied with the data associated with this region of the phase space is statedly the possibility of a "turn-off of new phenomena already established at higher RHIC energies" (https://drupal.star.bnl.gov/STAR/starnotes/public/sn0493). Results corresponding to the high-$\mu_B$ region might provide evidence of a first order phase transition, and possibly the critical point [13].

One of the ways to study the fluctuations in the properties of the post-collision system of matter is by measuring the transverse energy. Specifically, one can study the scaling of the transverse energy after the collision with the longidutional energy at the time of the collision, $\sqrt{s_{NN}}$. This can be done in several ways for a detector like STAR or PHENIX that is made up of sub-systems such as the TOF detectors, TPCs/Time Expansion Chambers, and calorimeters.

Adare et al. [4] use calorimetry in PHENIX to analyze the transverse energy corresponding to several different pairs of species colliding at a range of energies. They use the raw transverse energy measured by the EMCal, $E_{TEMC}$, to obtain the total hadronic $E_T$ by making corrections in three different steps. They first scale the data by a constant factor calculated to account for the fiducial acceptance in azimuth and pseudorapidity. The second factor is calculated to adjust for the effects of the calorimeter towers that are disabled. The third factor, $k$, is computed as follows

$$k = k_{response} \times k_{inflow} \times k_{losses} \tag{2.9}$$

where $k_{response}$ corresponds to hadronic particles only depositing a fraction of their total energy while passing through the EMCal, $k_{inflow}$ is attributable to the energy deposited by particles coming from outside the EMCal's fiducial aperture, and $k_{losses}$ accounts for the energy not registered in the EMCal due to energy thresholds, edge effects, and more importantly due to the particles that make it into the fiducial aperture but decay into products outside the aperture.

Another method of transverse energy analysis, employed in this thesis, is to use the $p_T$ spectra available from the tracking detectors. The TPCs and TOF detectors in STAR, for instance, can identify particles as well as their trajectories and ultimately their multiplicity distributions with respect to the momenta. Adams et al. [3] report ............ Example plot from the paper. These ......... were used to calculate an estimate of the total transverse energy per event carried by each of the particles. This result was then used to estimate the total transverse energy due to all the collision products.

...... mathematics involved in getting ET out of pT spectra, including the extrapolation using the BGBW............

...... assumption leading to total ET estimate, i.e, how the scaling up is done, and the errors associated with it...............

chapter 3: data analysis go through the steps from getting the data to getting the final results example fit plots justification of using chi-squared

chapter 4: results plots and tables compared to what's been published. Anything interesting seen?

chapter 5: conclusion chapter 6: future work

acknowledgments christine, adam, charles, soren, andy, will, chrisanne.

# Bibliography

[1] Adam, J., Adamova, D., Aggarwal, M. M., Aglieri Rinella, G., Agnello, M., Agrawal, N., Ahammed, Z., Ahmad, S., Ahn, S. U., Aiola, S., Akindinov, A., Alam, S. N., Silva De Albuquerque, D., Aleksandrov, D., Alessandro, B., Alexandre, D., Alfaro Molina, J. R., Alici, A., Alkin, A., Millan Almaraz, J. R., Alme, J., Alt, T., Altinpinar, S., Altsybeev, I., Alves Garcia Prado, C., Andrei, C., Andronic, A., Anguelov, V., Anticic, T., Antinori, F., Antonioli, P., Aphecetche, L. B., Appelshaeuser, H., Arcelli, S., Arnaldi, R., Arnold, O. W., Arsene, I. C., Arslandok, M., Audurier, B., Augustinus, A., Averbeck, R. P., Azmi, M. D., Badala, A., Baek, Y. W., Bagnasco, S., Bailhache, R. M., Bala, R., Balasubramanian, S., Baldisseri, A., Baral, R. C., Barbano, A. M., Barbera, R., Barile, F., Barnafoldi, G. G., Barnby, L. S., Ramillien Barret, V., Bartalini, P., Barth, K., Bartke, J. G., Bartsch, E., Basile, M., Bastid, N., Basu, S., Bathen, B., Batigne, G., Batista Camejo, A., Batyunya, B., Batzing, P. C., Bearden, I. G., Beck, H., Bedda, C., Behera, N. K., Belikov, I., Bellini, F., Bello Martinez, H., Bellwied, R., Belmont Iii, R. J., Belmont Moreno, E., Belyaev, V., Bencedi, G., Beole, S., Berceanu, I., Bercuci, A., Berdnikov, Y., Berenyi, D., Bertens, R. A., Berzano, D., Betev, L., Bhasin, A., Bhat, I. R., Bhati, A. K., Bhattacharjee, B., Bhom, J., Bianchi, L., Bianchi, N., Bianchin, C., Bielcik, J., Bielcikova, J., Bilandzic, A., Biro, G., Biswas, R., Biswas, S., Bjelogrlic, S., Blair, J. T., Blau, D., Blume, C., Bock, F., Bogdanov, A., Boggild, H., Boldizsar, L., Bombara, M., Book, J. H., Borel, H., Borissov, A., Borri, M., Bossu, F., Botta, E., Bourjau, C., Braun-Munzinger, P., Bregant, M., Breitner, T. G., Broker, T. A., Browning, T. A., Broz, M., Brucken, E. J., Bruna, E., Bruno, G. E., Budnikov, D., Buesching, H., Bufalino, S., Buncic, P., Busch, O., Buthelezi, E. Z., Bashir Butt, J., Buxton, J. T., Cabala, J., Caffarri, D., Cai, X., Caines, H. L., Calero Diaz, L., Caliva, A., Calvo Villar, E., Camerini, P., Carena, F., Carena, W., Carnesecchi, F., Castillo Castellanos, J. E., Castro, A. J., Casula, E. A. R., Ceballos Sanchez, C., Cepila, J., Cerello, P., Cerkala, J., Chang, B., Chapeland, S., Chartier, M., Charvet, J.-L. F., Chattopadhyay, S., Chattopadhyay, S., Chauvin, A., Chelnokov, V., Cherney, M. G., Cheshkov, C. V., Cheynis, B., Chibante Barroso, V. M., Dobrigkeit Chinellato, D., Cho, S., Chochula, P., Choi, K., Chojnacki, M., Choudhury, S., Christakoglou, P., Christensen, C. H., Christiansen, P., Chujo, T., Chung, S.-U., Cicalo, C., Cifarelli, L., Cindolo, F., Cleymans, J. W. A., Colamaria, F. F., Colella, D., Collu, A.,

Colocci, M., Conesa Balbastre, G., Conesa Del Valle, Z., Connors, M. E., Contreras Nuno, J. G., Cormier, T. M., Corrales Morales, Y., Cortes Maldonado, I., Cortese, P., Cosentino, M. R., Costa, F., Crochet, P., Cruz Albino, R., Cuautle Flores, E., Cunqueiro Mendez, L., Dahms, T., Dainese, A., Danisch, M. C., Danu, A., Das, D., Das, I., Das, S., Dash, A. K., Dash, S., De, S., De Caro, A., De Cataldo, G., De Conti, C., De Cuveland, J., De Falco, A., De Gruttola, D., De Marco, N., De Pasquale, S., Deisting, A., Deloff, A., Denes, E. S., Deplano, C., Dhankher, P., Di Bari, D., Di Mauro, A., Di Nezza, P., Diaz Corchero, M. A., Dietel, T., Dillenseger, P., Divia, R., Djuvsland, O., Dobrin, A. F., Domenicis Gimenez, D., Donigus, B., Dordic, O., Drozhzhova, T., Dubey, A. K., Dubla, A., Ducroux, L., Dupieux, P., Ehlers Iii, R. J., Elia, D., Endress, E., Engel, H., Epple, E., Erazmus, B. E., Erdemir, I., Erhardt, F., Espagnon, B., Estienne, M. D., Esumi, S., Eum, J., Evans, D., Evdokimov, S., Eyyubova, G., Fabbietti, L., Fabris, D., Faivre, J., Fantoni, A., Fasel, M., Feldkamp, L., Feliciello, A., Feofilov, G., Ferencei, J., Fernandez Tellez, A., Gonzalez Ferreiro, E., Ferretti, A., Festanti, A., Feuillard, V. J. G., Figiel, J., Araujo Silva Figueredo, M., Filchagin, S., Finogeev, D., Fionda, F., Fiore, E. M., Fleck, M. G., Floris, M., Foertsch, S. V., Foka, P., Fokin, S., Fragiacomo, E., Francescon, A., Frankenfeld, U. M., Fronze, G. G., Fuchs, U., Furget, C., Furs, A., Fusco Girard, M., Gaardhoeje, J. J., Gagliardi, M., Gago Medina, A. M., Gallio, M., Gangadharan, D. R., Ganoti, P., Gao, C., Garabatos Cuadrado, J., Garcia-Solis, E. J., Gargiulo, C., Gasik, P. J., Gauger, E. F., Germain, M., Gheata, M., Ghosh, P., Ghosh, S. K., Gianotti, P., Giubellino, P., Giubilato, P., Gladysz-Dziadus, E., Glassel, P., Gomez Coral, D. M., Gomez Ramirez, A., Sanchez Gonzalez, A., Gonzalez, V., Gonzalez Zamora, P., Gorbunov, S., Gorlich, L. M., Gotovac, S., Grabski, V., Grachov, O. A., Graczykowski, L. K., Graham, K. L., Grelli, A., Grigoras, A. G., Grigoras, C., Grigoryev, V., Grigoryan, A., Grigoryan, S., Grynyov, B., Grion, N., Gronefeld, J. M., Grosse-Oetringhaus, J. F., Grosso, R., Guber, F., Guernane, R., Guerzoni, B., Gulbrandsen, K. H., Gunji, T., Gupta, A., Gupta, R., Haake, R., Haaland, O. S., Hadjidakis, C. M., Haiduc, M., Hamagaki, H., Hamar, G., Hamon, J. C., Harris, J. W., Harton, A. V., Hatzifotiadou, D., Hayashi, S., Heckel, S. T., Hellbar, E., Helstrup, H., Herghelegiu, A. I., Herrera Corral, G. A., Hess, B. A., Hetland, K. F., Hillemanns, H., Hippolyte, B., Horak, D., Hosokawa, R., Hristov, P. Z., Humanic,

T., Hussain, N., Hussain, T., Hutter, D., Hwang, D. S., Ilkaev, R., Inaba, M., Incani, E., Ippolitov, M., Irfan, M., Ivanov, M., Ivanov, V., Izucheev, V., Jacazio, N., Jacobs, P. M., Jadhav, M. B., Jadlovska, S., Jadlovsky, J., Jahnke, C., Jakubowska, M. J., Jang, H. J., Janik, M. A., Pahula Hewage, S., Jena, C., Jena, S., Jimenez Bustamante, R. T., Jones, P. G., Jusko, A., Kalinak, P., Kalweit, A. P., Kamin, J. A., Kang, J. H., Kaplin, V., Kar, S., Karasu Uysal, A., Karavichev, O., Karavicheva, T., Karayan, L., Karpechev, E., Kebschull, U. W., Keidel, R., Keijdener, D. L., Keil, M., Khan, M. M., Khan, P., Khan, S. A., Khanzadeev, A., Kharlov, Y., Kileng, B., Kim, D. W., Kim, D. J., Kim, D., Kim, H., Kim, J., Kim, M., Kim, S. Y., Kim, T., Kirsch, S., Kisel, I., Kiselev, S., Kisiel, A. R., Kiss, G., Klay, J. L., Klein, C., Klein, J., Klein-Boesing, C., Klewin, S., Kluge, A., Knichel, M. L., Knospe, A. G., Kobdaj, C., Kofarago, M., Kollegger, T., Kolozhvari, A., Kondratev, V., Kondratyeva, N., Kondratyuk, E., Konevskikh, A., Kopcik, M., Kostarakis, P., Kour, M., Kouzinopoulos, C., Kovalenko, O., Kovalenko, V., Kowalski, M., Koyithatta Meethaleveedu, G., Kralik, I., Kravcakova, A., Krivda, M., Krizek, F., Kryshen, E., Krzewicki, M., Kubera, A. M., Kucera, V., Kuhn, C. C., Kuijer, P. G., Kumar, A., Kumar, J., Kumar, L., Kumar, S., Kurashvili, P., Kurepin, A., Kurepin, A., Kuryakin, A., Kweon, M. J., Kwon, Y., La Pointe, S. L., La Rocca, P., Ladron De Guevara, P., Lagana Fernandes, C., Lakomov, I., Langoy, R., Lapidus, K., Lara Martinez, C. E., Lardeux, A. X., Lattuca, A., Laudi, E., Lea, R., Leardini, L., Lee, G. R., Lee, S., Lehas, F., Lemmon, R. C., Lenti, V., Leogrande, E., Leon Monzon, I., Leon Vargas, H., Leoncino, M., Levai, P., Li, S., Li, X., Lien, J. A., Lietava, R., Lindal, S., Lindenstruth, V., Lippmann, C., Lisa, M. A., Ljunggren, H. M., Lodato, D. F., Lonne, P.-I., Loginov, V., Loizides, C., Lopez, X. B., Lopez Torres, E., Lowe, A. J., Luettig, P. J., Lunardon, M., Luparello, G., Lutz, T. H., Maevskaya, A., Mager, M., Mahajan, S., Mahmood, S. M., Maire, A., Majka, R. D., Malaev, M., Maldonado Cervantes, I. A., Malinina, L., Mal'Kevich, D., Malzacher, P., Mamonov, A., Manko, V., Manso, F., Manzari, V., Marchisone, M., Mares, J., Margagliotti, G. V., Margotti, A., Margutti, J., Marin, A. M., Markert, C., Marquard, M., Martin, N. A., Martin Blanco, J., Martinengo, P., Martinez Hernandez, M. I., Martinez-Garcia, G., Martinez Pedreira, M., Mas, A. J.-M., Masciocchi, S., Masera, M., Masoni, A., Mastroserio, A., Matyja, A. T., Mayer, C., Mazer, J. A., Mazzoni,

A. M., Mcdonald, D., Meddi, F., Melikyan, Y., Menchaca-Rocha, A. A., Meninno, E., Mercado-Perez, J., Meres, M., Miake, Y., Mieskolainen, M. M., Mikhaylov, K., Milano, L., Milosevic, J., Mischke, A., Mishra, A. N., Miskowiec, D. C., Mitra, J., Mitu, C. M., Mohammadi, N., Mohanty, B., Molnar, L., Montano Zetina, L. M., Montes Prado, E., Moreira De Godoy, D. A., Perez Moreno, L. A., Moretto, S., Morreale, A., Morsch, A., Muccifora, V., Mudnic, E., Muhlheim, D. M., Muhuri, S., Mukherjee, M., Mulligan, J. D., Gameiro Munhoz, M., Munzer, R. H., Murakami, H., Murray, S., Musa, L., Musinsky, J., Naik, B., Nair, R., Nandi, B. K., Nania, R., Nappi, E., Naru, M. U., Ferreira Natal Da Luz, P. H., Nattrass, C., Rosado Navarro, S., Nayak, K., Nayak, R., Nayak, T. K., Nazarenko, S., Nedosekin, A., Nellen, L., Ng, F., Nicassio, M., Niculescu, M., Niedziela, J., Nielsen, B. S., Nikolaev, S., Nikulin, S., Nikulin, V., Noferini, F., Nomokonov, P., Nooren, G., Cabanillas Noris, J. C., Norman, J., Nyanin, A., Nystrand, J. I., Oeschler, H. O., Oh, S., Oh, S. K., Ohlson, A. E., Okatan, A., Okubo, T., Olah, L., Oleniacz, J., Oliveira Da Silva, A. C., Oliver, M. H., Onderwaater, J., Oppedisano, C., Orava, R., Oravec, M., Ortiz Velasquez, A., Oskarsson, A. N. E., Otwinowski, J. T., Oyama, K., Ozdemir, M., Pachmayer, Y. C., Pagano, D., Pagano, P., Paic, G., Pal, S. K., Pan, J., Pandey, A. K., Papikyan, V., Pappalardo, G., Pareek, P., Park, W., Parmar, S., Passfeld, A., Paticchio, V., Patra, R. N., Paul, B., Pei, H., Peitzmann, T., Pereira Da Costa, H. D. A., Peresunko, D. Y., Perez Lara, C. E., Perez Lezama, E., Peskov, V., Pestov, Y., Petracek, V., Petrov, V., Petrovici, M., Petta, C., Piano, S., Pikna, M., Pillot, P., Ozelin De Lima Pimentel, L., Pinazza, O., Pinsky, L., Piyarathna, D., Ploskon, M. A., Planinic, M., Pluta, J. M., Pochybova, S., Podesta Lerma, P. L. M., Poghosyan, M., Polishchuk, B., Poljak, N., Poonsawat, W., Pop, A., Porteboeuf, S. J., Porter, R. J., Pospisil, J., Prasad, S. K., Preghenella, R., Prino, F., Pruneau, C. A., Pshenichnov, I., Puccio, M., Puddu, G., Pujahari, P. R., Punin, V., Putschke, J. H., Qvigstad, H., Rachevski, A., Raha, S., Rajput, S., Rak, J., Rakotozafindrabe, A. M., Ramello, L., Rami, F., Raniwala, R., Raniwala, S., Rasanen, S. S., Rascanu, B. T., Rathee, D., Read, K. F., Redlich, K., Reed, R. J., Rehman, A. U., Reichelt, P. S., Reidt, F., Ren, X., Renfordt, R. A. E., Reolon, A. R., Reshetin, A., Reygers, K. J., Riabov, V., Ricci, R. A., Richert, T. O. H., Richter, M. R., Riedler, P., Riegler, W., Riggi, F., Ristea, C.-L., Rocco, E., Rodriguez Cahuantzi, M.,

Rodriguez Manso, A., Roeed, K., Rogochaya, E., Rohr, D. M., Roehrich, D., Ronchetti, F., Ronflette, L., Rosnet, P., Rossi, A., Roukoutakis, F., Roy, A., Roy, C. S., Roy, P. K., Rubio Montero, A. J., Rui, R., Russo, R., Di Ruzza, B., Ryabinkin, E., Ryabov, Y., Rybicki, A., Saarinen, S., Sadhu, S., Sadovskiy, S., Safarik, K., Sahlmuller, B., Sahoo, P., Sahoo, R., Sahoo, S., Sahu, P. K., Saini, J., Sakai, S., Saleh, M. A., Salzwedel, J. S. N., Sambyal, S. S., Samsonov, V., Sandor, L., Sandoval, A., Sano, M., Sarkar, D., Sarkar, N., Sarma, P., Scapparone, E., Scarlassara, F., Schiaua, C. C., Schicker, R. M., Schmidt, C. J., Schmidt, H. R., Schuchmann, S., Schukraft, J., Schulc, M., Schutz, Y. R., Schwarz, K. E., Schweda, K. O., Scioli, G., Scomparin, E., Scott, R. M., Sefcik, M., Seger, J. E., Sekiguchi, Y., Sekihata, D., Selyuzhenkov, I., Senosi, K., Senyukov, S., Serradilla Rodriguez, E., Sevcenco, A., Shabanov, A., Shabetai, A., Shadura, O., Shahoyan, R., Shahzad, M. I., Shangaraev, A., Sharma, A., Sharma, M., Sharma, M., Sharma, N., Sheikh, A. I., Shigaki, K., Shou, Q., Shtejer Diaz, K., Sibiryak, Y., Siddhanta, S., Sielewicz, K. M., Siemiarczuk, T., Silvermyr, D. O. R., Silvestre, C. M., Simatovic, G., Simonetti, G., Singaraju, R. N., Singh, R., Singha, S., Singhal, V., Sinha, B., Sarkar Sinha, T., Sitar, B., Sitta, M., Skaali, B., Slupecki, M., Smirnov, N., Snellings, R., Snellman, T. W., Song, J., Song, M., Song, Z., Soramel, F., Sorensen, S. P., Derradi De Souza, R., Sozzi, F., Spacek, M., Spiriti, E., Sputowska, I. A., Spyropoulou-Stassinaki, M., Stachel, J., Stan, I., Stankus, P., Stenlund, E. A., Steyn, G. F., Stiller, J. H., Stocco, D., Strmen, P., Alarcon Do Passo Suaide, A., Sugitate, T., Suire, C. P., Suleymanov, M. K. O., Suljic, M., Sultanov, R., Sumbera, M., Sumowidagdo, S., Szabo, A., Szanto De Toledo, A., Szarka, I., Szczepankiewicz, A., Szymanski, M. P., Tabassam, U., Takahashi, J., Tambave, G. J., Tanaka, N., Tarhini, M., Tariq, M., Tarzila, M.-G., Tauro, A., Tejeda Munoz, G., Telesca, A., Terasaki, K., Terrevoli, C., Teyssier, B., Thaeder, J. M., Thakur, D., Thomas, D., Tieulent, R. N., Tikhonov, A., Timmins, A. R., Toia, A., Trogolo, S., Trombetta, G., Trubnikov, V., Trzaska, W. H., Tsuji, T., Tumkin, A., Turrisi, R., Tveter, T. S., Ullaland, K., Uras, A., Usai, G., Utrobicic, A., Vala, M., Valencia Palomo, L., Vallero, S., Van Der Maarel, J., Van Hoorne, J. W., Van Leeuwen, M., Vanat, T., Vande Vyvre, P., Varga, D., Diozcora Vargas Trevino, A., Vargyas, M., Varma, R., Vasileiou, M., Vasiliev, A., Vauthier, A., Vazquez Doce, O., Vechernin, V., Veen, A. M., Veldhoen, M., Velure, A., Vercellin, E.,

Vergara Limon, S., Vernet, R., Verweij, M., Vickovic, L., Viinikainen, J. S., Vilakazi, Z., Villalobos Baillie, O., Villatoro Tello, A., Vinogradov, A., Vinogradov, L., Vinogradov, Y., Virgili, T., Vislavicius, V., Viyogi, Y., Vodopyanov, A., Volkl, M. A., Voloshin, K., Voloshin, S., Volpe, G., Von Haller, B., Vorobyev, I., Vranic, D., Vrlakova, J., Vulpescu, B., Wagner, B., Wagner, J., Wang, H., Wang, M., Watanabe, D., Watanabe, Y., Weber, M., Weber, S. G., Weiser, D. F., Wessels, J. P., Westerhoff, U., Whitehead, A. M., Wiechula, J., Wikne, J., Wilk, G. A., Wilkinson, J. J., Williams, C., Windelband, B. S., Winn, M. A., Yang, P., Yano, S., Yasin, Z., Yin, Z., Yokoyama, H., Yoo, I.-K., Yoon, J. H., Yurchenko, V., Yushmanov, I., Zaborowska, A., Zaccolo, V., Zaman, A., Zampolli, C., Correia Zanoli, H. J., Zaporozhets, S., Zardoshti, N., Zarochentsev, A., Zavada, P., Zavyalov, N., Zbroszczyk, H. P., Zgura, S. I., Zhalov, M., Zhang, H., Zhang, X., Zhang, Y., Chunhui, Z., Zhang, Z., Zhao, C., Zhigareva, N., Zhou, D., Zhou, Y., Zhou, Z., Zhu, H., Zhu, J., Zichichi, A., Zimmermann, A., Zimmermann, M. B., Zinovjev, G., and Zyzak, M. (2016). Measurement of transverse energy at midrapidity in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV. *Phys. Rev. C*, 94(CERN-EP-2016-071. CERN-EP-2016-071):034903. 30 p. 30 pages, 14 captioned figures, 2 tables, authors from page 25, published version, figures at http://aliceinfo.cern.ch/ArtSubmission/node/2400. 1

[2] Adamczyk, L., Adkins, J. K., Agakishiev, G., Aggarwal, M. M., Ahammed, Z., Ajitanand, N. N., Alekseev, I., Anderson, D. M., Aoyama, R., Aparin, A., Arkhipkin, D., Aschenauer, E. C., Ashraf, M. U., Attri, A., Averichev, G. S., Bai, X., Bairathi, V., Behera, A., Bellwied, R., Bhasin, A., Bhati, A. K., Bhattarai, P., Bielcik, J., Bielcikova, J., Bland, L. C., Bordyuzhin, I. G., Bouchet, J., Brandenburg, J. D., Brandin, A. V., Brown, D., Bunzarov, I., Butterworth, J., Caines, H., Calderón de la Barca Sánchez, M., Campbell, J. M., Cebra, D., Chakaberia, I., Chaloupka, P., Chang, Z., Chankova-Bunzarova, N., Chatterjee, A., Chattopadhyay, S., Chen, X., Chen, J. H., Chen, X., Cheng, J., Cherney, M., Christie, W., Contin, G., Crawford, H. J., Das, S., De Silva, L. C., Debbe, R. R., Dedovich, T. G., Deng, J., Derevschikov, A. A., Didenko, L., Dilks, C., Dong, X., Drachenberg, J. L., Draper, J. E., Dunkelberger, L. E., Dunlop, J. C., Efimov, L. G., Elsey, N., Engelage, J., Eppley, G., Esha, R., Esumi, S., Evdokimov, O., Ewigleben,

J., Eyser, O., Fatemi, R., Fazio, S., Federic, P., Federicova, P., Fedorisin, J., Feng, Z., Filip, P., Finch, E., Fisyak, Y., Flores, C. E., Fulek, L., Gagliardi, C. A., Garand, D., Geurts, F., Gibson, A., Girard, M., Grosnick, D., Gunarathne, D. S., Guo, Y., Gupta, A., Gupta, S., Guryn, W., Hamad, A. I., Hamed, A., Harlenderova, A., Harris, J. W., He, L., Heppelmann, S., Heppelmann, S., Hirsch, A., Hoffmann, G. W., Horvat, S., Huang, T., Huang, B., Huang, X., Huang, H. Z., Humanic, T. J., Huo, P., Igo, G., Jacobs, W. W., Jentsch, A., Jia, J., Jiang, K., Jowzaee, S., Judd, E. G., Kabana, S., Kalinkin, D., Kang, K., Kauder, K., Ke, H. W., Keane, D., Kechechyan, A., Khan, Z., Kikoła, D. P., Kisel, I., Kisiel, A., Kochenda, L., Kocmanek, M., Kollegger, T., Kosarzewski, L. K., Kraishan, A. F., Kravtsov, P., Krueger, K., Kulathunga, N., Kumar, L., Kvapil, J., Kwasizur, J. H., Lacey, R., Landgraf, J. M., Landry, K. D., Lauret, J., Lebedev, A., Lednicky, R., Lee, J. H., Li, X., Li, C., Li, W., Li, Y., Lidrych, J., Lin, T., Lisa, M. A., Liu, H., Liu, P., Liu, Y., Liu, F., Ljubicic, T., Llope, W. J., Lomnitz, M., Longacre, R. S., Luo, S., Luo, X., Ma, G. L., Ma, L., Ma, Y. G., Ma, R., Magdy, N., Majka, R., Mallick, D., Margetis, S., Markert, C., Matis, H. S., Meehan, K., Mei, J. C., Miller, Z. W., Minaev, N. G., Mioduszewski, S., Mishra, D., Mizuno, S., Mohanty, B., Mondal, M. M., Morozov, D. A., Mustafa, M. K., Nasim, M., Nayak, T. K., Nelson, J. M., Nie, M., Nigmatkulov, G., Niida, T., Nogach, L. V., Nonaka, T., Nurushev, S. B., Odyniec, G., Ogawa, A., Oh, K., Okorokov, V. A., Olvitt, D., Page, B. S., Pak, R., Pandit, Y., Panebratsev, Y., Pawlik, B., Pei, H., Perkins, C., Pile, P., Pluta, J., Poniatowska, K., Porter, J., Posik, M., Poskanzer, A. M., Pruthi, N. K., Przybycien, M., Putschke, J., Qiu, H., Quintero, A., Ramachandran, S., Ray, R. L., Reed, R., Rehbein, M. J., Ritter, H. G., Roberts, J. B., Rogachevskiy, O. V., Romero, J. L., Roth, J. D., Ruan, L., Rusnak, J., Rusnakova, O., Sahoo, N. R., Sahu, P. K., Salur, S., Sandweiss, J., Saur, M., Schambach, J., Schmah, A. M., Schmidke, W. B., Schmitz, N., Schweid, B. R., Seger, J., Sergeeva, M., Seyboth, P., Shah, N., Shahaliev, E., Shanmuganathan, P. V., Shao, M., Sharma, A., Sharma, M. K., Shen, W. Q., Shi, Z., Shi, S. S., Shou, Q. Y., Sichtermann, E. P., Sikora, R., Simko, M., Singha, S., Skoby, M. J., Smirnov, N., Smirnov, D., Solyst, W., Song, L., Sorensen, P., Spinka, H. M., Srivastava, B., Stanislaus, T. D. S., Strikhanov, M., Stringfellow, B., Sugiura, T., Sumbera, M., Summa, B., Sun, Y., Sun, X. M., Sun, X., Surrow, B., Svirida,

D. N., Tang, A. H., Tang, Z., Taranenko, A., Tarnowsky, T., Tawfik, A., Thäder, J., Thomas, J. H., Timmins, A. R., Tlusty, D., Todoroki, T., Tokarev, M., Trentalange, S., Tribble, R. E., Tribedy, P., Tripathy, S. K., Trzeciak, B. A., Tsai, O. D., Ullrich, T., Underwood, D. G., Upsal, I., Van Buren, G., van Nieuwenhuizen, G., Vasiliev, A. N., Videbæk, F., Vokal, S., Voloshin, S. A., Vossen, A., Wang, G., Wang, Y., Wang, F., Wang, Y., Webb, J. C., Webb, G., Wen, L., Westfall, G. D., Wieman, H., Wissink, S. W., Witt, R., Wu, Y., Xiao, Z. G., Xie, W., Xie, G., Xu, J., Xu, N., Xu, Q. H., Xu, Y. F., Xu, Z., Yang, Y., Yang, Q., Yang, C., Yang, S., Ye, Z., Ye, Z., Yi, L., Yip, K., Yoo, I.-K., Yu, N., Zbroszczyk, H., Zha, W., Zhang, Z., Zhang, X. P., Zhang, J. B., Zhang, S., Zhang, J., Zhang, Y., Zhang, J., Zhang, S., Zhao, J., Zhong, C., Zhou, L., Zhou, C., Zhu, X., Zhu, Z., and Zyzak, M. (2017). Bulk properties of the medium produced in relativistic heavy-ion collisions from the beam energy scan program. *Phys. Rev. C*, 96:044904. 3, 6

[3] Adams, J. et al. (2004). Measurements of transverse energy distributions in Au + Au collisions at s(NN)**(1/2) = 200-GeV. *Phys. Rev.*, C70:054907.

[4] Adare, A. et al. (2016). Transverse energy production and charged-particle multiplicity at midrapidity in various systems from $\sqrt{s_{NN}} = 7.7$ to 200 GeV. *Phys. Rev.*, C93(2):024901. 1, 7

[5] Adler, S. S., Afanasiev, S., Aidala, C., Ajitanand, N. N., Akiba, Y., Al-Jamel, A., Alexander, J., Aoki, K., Aphecetche, L., Armendariz, R., Aronson, S. H., Averbeck, R., Awes, T. C., Azmoun, B., Babintsev, V., Baldisseri, A., Barish, K. N., Barnes, P. D., Bassalleck, B., Bathe, S., Batsouli, S., Baublis, V., Bauer, F., Bazilevsky, A., Belikov, S., Bennett, R., Berdnikov, Y., Bjorndal, M. T., Boissevain, J. G., Borel, H., Boyle, K., Brooks, M. L., Brown, D. S., Bruner, N., Bucher, D., Buesching, H., Bumazhnov, V., Bunce, G., Burward-Hoy, J. M., Butsyk, S., Camard, X., Campbell, S., Chai, J.-S., Chand, P., Chang, W. C., Chernichenko, S., Chi, C. Y., Chiba, J., Chiu, M., Choi, I. J., Choudhury, R. K., Chujo, T., Cianciolo, V., Cleven, C. R., Cobigo, Y., Cole, B. A., Comets, M. P., Constantin, P., Csanád, M., Csörgő, T., Cussonneau, J. P., Dahms, T., Das, K., David, G., Deák, F., Delagrange, H., Denisov, A., d'Enterria, D., Deshpande, A., Desmond, E. J., Devismes, A., Dietzsch, O., Dion, A., Drachenberg, J. L., Drapier,

O., Drees, A., Dubey, A. K., Durum, A., Dutta, D., Dzhordzhadze, V., Efremenko, Y. V., Egdemir, J., Enokizono, A., En'yo, H., Espagnon, B., Esumi, S., Fields, D. E., Finck, C., Fleuret, F., Fokin, S. L., Forestier, B., Fox, B. D., Fraenkel, Z., Frantz, J. E., Franz, A., Frawley, A. D., Fukao, Y., Fung, S.-Y., Gadrat, S., Gastineau, F., Germain, M., Glenn, A., Gonin, M., Gosset, J., Goto, Y., Granier de Cassagnac, R., Grau, N., Greene, S. V., Grosse Perdekamp, M., Gunji, T., Gustafsson, H.-A., Hachiya, T., Hadj Henni, A., Haggerty, J. S., Hagiwara, M. N., Hamagaki, H., Hansen, A. G., Harada, H., Hartouni, E. P., Haruna, K., Harvey, M., Haslum, E., Hasuko, K., Hayano, R., He, X., Heffner, M., Hemmick, T. K., Heuser, J. M., Hidas, P., Hiejima, H., Hill, J. C., Hobbs, R., Holmes, M., Holzmann, W., Homma, K., Hong, B., Hoover, A., Horaguchi, T., Hur, M. G., Ichihara, T., Iinuma, H., Ikonnikov, V. V., Imai, K., Inaba, M., Inuzuka, M., Isenhower, D., Isenhower, L., Ishihara, M., Isobe, T., Issah, M., Isupov, A., Jacak, B. V., Jia, J., Jin, J., Jinnouchi, O., Johnson, B. M., Johnson, S. C., Joo, K. S., Jouan, D., Kajihara, F., Kametani, S., Kamihara, N., Kaneta, M., Kang, J. H., Katou, K., Kawabata, T., Kawagishi, T., Kazantsev, A. V., Kelly, S., Khachaturov, B., Khanzadeev, A., Kikuchi, J., Kim, D. J., Kim, E., Kim, E. J., Kim, G.-B., Kim, H. J., Kim, Y.-S., Kinney, E., Kiss, A., Kistenev, E., Kiyomichi, A., Klein-Boesing, C., Kobayashi, H., Kochenda, L., Kochetkov, V., Kohara, R., Komkov, B., Konno, M., Kotchetkov, D., Kozlov, A., Kroon, P. J., Kuberg, C. H., Kunde, G. J., Kurihara, N., Kurita, K., Kweon, M. J., Kwon, Y., Kyle, G. S., Lacey, R., Lajoie, J. G., Lebedev, A., Le Bornec, Y., Leckey, S., Lee, D. M., Lee, M. K., Leitch, M. J., Leite, M. A. L., Li, X. H., Lim, H., Litvinenko, A., Liu, M. X., Maguire, C. F., Makdisi, Y. I., Malakhov, A., Malik, M. D., Manko, V. I., Mao, Y., Martinez, G., Masui, H., Matathias, F., Matsumoto, T., McCain, M. C., McGaughey, P. L., Miake, Y., Miller, T. E., Milov, A., Mioduszewski, S., Mishra, G. C., Mitchell, J. T., Mohanty, A. K., Morrison, D. P., Moss, J. M., Moukhanova, T. V., Mukhopadhyay, D., Muniruzzaman, M., Murata, J., Nagamiya, S., Nagata, Y., Nagle, J. L., Naglis, M., Nakamura, T., Newby, J., Nguyen, M., Norman, B. E., Nyanin, A. S., Nystrand, J., O'Brien, E., Ogilvie, C. A., Ohnishi, H., Ojha, I. D., Okada, K., Omiwade, O. O., Oskarsson, A., Otterlund, I., Oyama, K., Ozawa, K., Pal, D., Palounek, A. P. T., Pantuev, V., Papavassiliou, V., Park, J., Park, W. J., Pate, S. F., Pei, H., Penev, V., Peng, J.-C., Pereira, H., Peresedov, V., Peressounko,

D., Pierson, A., Pinkenburg, C., Pisani, R. P., Purschke, M. L., Purwar, A. K., Qu, H., Qualls, J. M., Rak, J., Ravinovich, I., Read, K. F., Reuter, M., Reygers, K., Riabov, V., Riabov, Y., Roche, G., Romana, A., Rosati, M., Rosendahl, S. S. E., Rosnet, P., Rukoyatkin, P., Rykov, V. L., Ryu, S. S., Sahlmueller, B., Saito, N., Sakaguchi, T., Sakai, S., Samsonov, V., Sanfratello, L., Santo, R., Sarsour, M., Sato, H. D., Sato, S., Sawada, S., Schutz, Y., Semenov, V., Seto, R., Sharma, D., Shea, T. K., Shein, I., Shibata, T.-A., Shigaki, K., Shimomura, M., Shohjoh, T., Shoji, K., Sickles, A., Silva, C. L., Silvermyr, D., Sim, K. S., Singh, C. P., Singh, V., Skutnik, S., Smith, W. C., Soldatov, A., Soltz, R. A., Sondheim, W. E., Sorensen, S. P., Sourikova, I. V., Staley, F., Stankus, P. W., Stenlund, E., Stepanov, M., Ster, A., Stoll, S. P., Sugitate, T., Suire, C., Sullivan, J. P., Sziklai, J., Tabaru, T., Takagi, S., Takagui, E. M., Taketani, A., Tanaka, K. H., Tanaka, Y., Tanida, K., Tannenbaum, M. J., Taranenko, A., Tarján, P., Thomas, T. L., Togawa, M., Tojo, J., Torii, H., Towell, R. S., Tram, V.-N., Tserruya, I., Tsuchimoto, Y., Tuli, S. K., Tydesjö, H., Tyurin, N., Uam, T. J., Vale, C., Valle, H., van Hecke, H. W., Velkovska, J., Velkovsky, M., Vértesi, R., Veszprémi, V., Vinogradov, A. A., Volkov, M. A., Vznuzdaev, E., Wagner, M., Wang, X. R., Watanabe, Y., Wessels, J., White, S. N., Willis, N., Winter, D., Wohn, F. K., Woody, C. L., Wysocki, M., Xie, W., Yanovich, A., Yokkaichi, S., Young, G. R., Younus, I., Yushmanov, I. E., Zajc, W. A., Zaudtke, O., Zhang, C., Zhou, S., Zimányi, J., Zolin, L., and Zong, X. (2014). Transverse-energy distributions at midrapidity in $p+p$, $d+$ Au, and Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 62.4\breve{}200$ gev and implications for particle-production models. *Phys. Rev. C*, 89:044905. 5, 6

[6] Ayala, A. (2016). Hadronic matter at the edge: A survey of some theoretical approaches to the physics of the qcd phase diagram. *Journal of Physics: Conference Series*, 761(1):012066. v, 1, 2

[7] Bethe, H. A. and Ashkin, J. (1953). Passage of radiations through matter experimental nuclear physics vol 1 ed e segre. 6

[8] Chatrchyan, S., Khachatryan, V., Sirunyan, A. M., Tumasyan, A., Adam, W., Bergauer, T., Dragicevic, M., Erö, J., Fabjan, C., Friedl, M., Frühwirth, R., Ghete, V. M., Hammer, J., Hörmann, N., Hrubec, J., Jeitler, M., Kiesenhofer, W., Knünz, V., Krammer, M., Liko,

D., Mikulec, I., Pernicka, M., Rahbaran, B., Rohringer, C., Rohringer, H., Schöfbeck, R., Strauss, J., Taurok, A., Wagner, P., Waltenberger, W., Walzel, G., Widl, E., Wulz, C.-E., Mossolov, V., Shumeiko, N., Suarez Gonzalez, J., Bansal, S., Cornelis, T., De Wolf, E. A., Janssen, X., Luyckx, S., Maes, T., Mucibello, L., Ochesanu, S., Roland, B., Rougny, R., Selvaggi, M., Staykova, Z., Van Haevermaet, H., Van Mechelen, P., Van Remortel, N., Van Spilbeeck, A., Blekman, F., Blyweert, S., D'Hondt, J., Gonzalez Suarez, R., Kalogeropoulos, A., Maes, M., Olbrechts, A., Van Doninck, W., Van Mulders, P., Van Onsem, G. P., Villella, I., Clerbaux, B., De Lentdecker, G., Dero, V., Gay, A. P. R., Hreus, T., Léonard, A., Marage, P. E., Reis, T., Thomas, L., Vander Velde, C., Vanlaer, P., Wang, J., Adler, V., Beernaert, K., Cimmino, A., Costantini, S., Garcia, G., Grunewald, M., Klein, B., Lellouch, J., Marinov, A., Mccartin, J., Ocampo Rios, A. A., Ryckbosch, D., Strobbe, N., Thyssen, F., Tytgat, M., Verwilligen, P., Walsh, S., Yazgan, E., Zaganidis, N., Basegmez, S., Bruno, G., Castello, R., Ceard, L., Delaere, C., du Pree, T., Favart, D., Forthomme, L., Giammanco, A., Hollar, J., Lemaitre, V., Liao, J., Militaru, O., Nuttens, C., Pagano, D., Pin, A., Piotrzkowski, K., Schul, N., Vizan Garcia, J. M., Beliy, N., Caebergs, T., Daubie, E., Hammad, G. H., Alves, G. A., Correa Martins Junior, M., De Jesus Damiao, D., Martins, T., Pol, M. E., Souza, M. H. G., Aldá Júnior, W. L., Carvalho, W., Custódio, A., Da Costa, E. M., De Oliveira Martins, C., Fonseca De Souza, S., Matos Figueiredo, D., Mundim, L., Nogima, H., Oguri, V., Prado Da Silva, W. L., Santoro, A., Soares Jorge, L., Sznajder, A., Bernardes, C. A., Dias, F. A., Fernandez Perez Tomei, T. R., Gregores, E. M., Lagana, C., Marinho, F., Mercadante, P. G., Novaes, S. F., Padula, S. S., Genchev, V., Iaydjiev, P., Piperov, S., Rodozov, M., Stoykova, S., Sultanov, G., Tcholakov, V., Trayanov, R., Vutova, M., Dimitrov, A., Hadjiiska, R., Kozhuharov, V., Litov, L., Pavlov, B., Petkov, P., Bian, J. G., Chen, G. M., Chen, H. S., Jiang, C. H., Liang, D., Liang, S., Meng, X., Tao, J., Wang, J., Wang, X., Wang, Z., Xiao, H., Xu, M., Zang, J., Zhang, Z., Asawatangtrakuldee, C., Ban, Y., Guo, S., Guo, Y., Li, W., Liu, S., Mao, Y., Qian, S. J., Teng, H., Wang, S., Zhu, B., Zou, W., Avila, C., Gomez, J. P., Gomez Moreno, B., Osorio Oliveros, A. F., Sanabria, J. C., Godinovic, N., Lelas, D., Plestina, R., Polic, D., Puljak, I., Antunovic, Z., Kovac, M., Brigljevic, V., Duric, S., Kadija, K., Luetic, J., Morovic, S., Attikis, A., Galanti, M., Mavromanolakis,

G., Mousa, J., Nicolaou, C., Ptochos, F., Razis, P. A., Finger, M., Finger, M., Assran, Y., Elgammal, S., Ellithi Kamel, A., Khalil, S., Mahmoud, M. A., Radi, A., Kadastik, M., Müntel, M., Raidal, M., Rebane, L., Tiko, A., Azzolini, V., Eerola, P., Fedi, G., Voutilainen, M., Härkönen, J., Heikkinen, A., Karimäki, V., Kinnunen, R., Kortelainen, M. J., Lampén, T., Lassila-Perini, K., Lehti, S., Lindén, T., Luukka, P., Mäenpää, T., Peltola, T., Tuominen, E., Tuominiemi, J., Tuovinen, E., Ungaro, D., Wendland, L., Banzuzi, K., Karjalainen, A., Korpela, A., Tuuva, T., Besancon, M., Choudhury, S., Dejardin, M., Denegri, D., Fabbro, B., Faure, J. L., Ferri, F., Ganjour, S., Givernaud, A., Gras, P., Hamel de Monchenault, G., Jarry, P., Locci, E., Malcles, J., Millischer, L., Nayak, A., Rander, J., Rosowsky, A., Shreyber, I., Titov, M., Baffioni, S., Beaudette, F., Benhabib, L., Bianchini, L., Bluj, M., Broutin, C., Busson, P., Charlot, C., Daci, N., Dahms, T., Dobrzynski, L., Granier de Cassagnac, R., Haguenauer, M., Miné, P., Mironov, C., Nguyen, M., Ochando, C., Paganini, P., Sabes, D., Salerno, R., Sirois, Y., Veelken, C., Zabi, A., Agram, J.-L., Andrea, J., Bloch, D., Bodin, D., Brom, J.-M., Cardaci, M., Chabert, E. C., Collard, C., Conte, E., Drouhin, F., Ferro, C., Fontaine, J.-C., Gelé, D., Goerlach, U., Juillot, P., Le Bihan, A.-C., Van Hove, P., Fassi, F., Mercier, D., Beauceron, S., Beaupere, N., Bondu, O., Boudoul, G., Chasserat, J., Chierici, R., Contardo, D., Depasse, P., El Mamouni, H., Fay, J., Gascon, S., Gouzevitch, M., Ille, B., Kurca, T., Lethuillier, M., Mirabito, L., Perries, S., Sordini, V., Tosi, S., Tschudi, Y., Verdier, P., Viret, S., Tsamalaidze, Z., Anagnostou, G., Beranek, S., Edelhoff, M., Feld, L., Heracleous, N., Hindrichs, O., Jussen, R., Klein, K., Merz, J., Ostapchuk, A., Perieanu, A., Raupach, F., Sammet, J., Schael, S., Sprenger, D., Weber, H., Wittmer, B., Zhukov, V., Ata, M., Caudron, J., Dietz-Laursonn, E., Erdmann, M., Güth, A., Hebbeker, T., Heidemann, C., Hoepfner, K., Klingebiel, D., Kreuzer, P., Lingemann, J., Magass, C., Merschmeyer, M., Meyer, A., Olschewski, M., Papacz, P., Pieta, H., Reithler, H., Schmitz, S. A., Sonnenschein, L., Steggemann, J., Teyssier, D., Weber, M., Bontenackels, M., Cherepanov, V., Flügge, G., Geenen, H., Geisler, M., Haj Ahmad, W., Hoehle, F., Kargoll, B., Kress, T., Kuessel, Y., Nowack, A., Perchalla, L., Pooth, O., Rennefeld, J., Sauerland, P., Stahl, A., Aldaya Martin, M., Behr, J., Behrenhoff, W., Behrens, U., Bergholz, M., Bethani, A., Borras, K., Burgmeier, A., Cakir, A., Calligaris, L., Campbell, A., Castro, E., Costanza, F., Dammann, D., Diez Pardos, C., Eckerlin, G., Eckstein, D., Flucke, G., Geiser, A., Glushkov, I., Gunnellini, P., Habib, S., Hauk, J., Jung, H., Kasemann, M., Katsas, P., Kleinwort, C., Kluge, H., Knutsson, A., Krämer, M., Krücker, D., Kuznetsova, E., Lange, W., Lohmann, W., Lutz, B., Mankel, R., Marfin, I., Marienfeld, M., Melzer-Pellmann, I.-A., Meyer, A. B., Mnich, J., Mussgiller, A., Naumann-Emme, S., Olzem, J., Perrey, H., Petrukhin, A., Pitzl, D., Raspereza, A., Ribeiro Cipriano, P. M., Riedl, C., Ron, E., Rosin, M., Salfeld-Nebgen, J., Schmidt, R., Schoerner-Sadenius, T., Sen, N., Spiridonov, A., Stein, M., Walsh, R., Wissing, C., Autermann, C., Blobel, V., Draeger, J., Enderle, H., Erfle, J., Gebbert, U., Görner, M., Hermanns, T., Höing, R. S., Kaschube, K., Kaussen, G., Kirschenmann, H., Klanner, R., Lange, J., Mura, B., Nowak, F., Peiffer, T., Pietsch, N., Sander, C., Schettler, H., Schleper, P., Schlieckau, E., Schmidt, A., Schröder, M., Schum, T., Sola, V., Stadie, H., Steinbrück, G., Thomsen, J., Vanelderen, L., Barth, C., Berger, J., Chwalek, T., De Boer, W., Dierlamm, A., Feindt, M., Guthoff, M., Hackstein, C., Hartmann, F., Heinrich, M., Held, H., Hoffmann, K. H., Honc, S., Katkov, I., Komaragiri, J. R., Lobelle Pardo, P., Martschei, D., Mueller, S., Müller, T., Niegel, M., Nürnberg, A., Oberst, O., Oehler, A., Ott, J., Quast, G., Rabbertz, K., Ratnikov, F., Ratnikova, N., Röcker, S., Scheurer, A., Schilling, F.-P., Schott, G., Simonis, H. J., Stober, F. M., Troendle, D., Ulrich, R., Wagner-Kuhr, J., Weiler, T., Zeise, M., Daskalakis, G., Geralis, T., Kesisoglou, S., Kyriakis, A., Loukas, D., Manolakos, I., Markou, A., Markou, C., Mavrommatis, C., Ntomari, E., Gouskos, L., Mertzimekis, T. J., Panagiotou, A., Saoulidou, N., Evangelou, I., Foudas, C., Kokkas, P., Manthos, N., Papadopoulos, I., Patras, V., Bencze, G., Hajdu, C., Hidas, P., Horvath, D., Sikler, F., Veszpremi, V., Vesztergombi, G., Beni, N., Czellar, S., Molnar, J., Palinkas, J., Szillasi, Z., Karancsi, J., Raics, P., Trocsanyi, Z. L., Ujvari, B., Beri, S. B., Bhatnagar, V., Dhingra, N., Gupta, R., Jindal, M., Kaur, M., Mehta, M. Z., Nishu, N., Saini, L. K., Sharma, A., Singh, J., Ahuja, S., Bhardwaj, A., Choudhary, B. C., Kumar, A., Kumar, A., Malhotra, S., Naimuddin, M., Ranjan, K., Sharma, V., Shivpuri, R. K., Banerjee, S., Bhattacharya, S., Dutta, S., Gomber, B., Jain, S., Jain, S., Khurana, R., Sarkar, S., Sharan, M., Abdulsalam, A., Choudhury, R. K., Dutta, D., Kailas, S., Kumar, V., Mehta, P., Mohanty, A. K., Pant, L. M., Shukla, P., Aziz, T., Ganguly, S., Guchait, M.,

Maity, M., Majumder, G., Mazumdar, K., Mohanty, G. B., Parida, B., Sudhakar, K., Wickramage, N., Banerjee, S., Dugad, S., Arfaei, H., Bakhshiansohi, H., Etesami, S. M., Fahim, A., Hashemi, M., Hesari, H., Jafari, A., Khakzad, M., Mohammadi Najafabadi, M., Paktinat Mehdiabadi, S., Safarzadeh, B., Zeinali, M., Abbrescia, M., Barbone, L., Calabria, C., Chhibra, S. S., Colaleo, A., Creanza, D., De Filippis, N., De Palma, M., Fiore, L., Iaselli, G., Lusito, L., Maggi, G., Maggi, M., Marangelli, B., My, S., Nuzzo, S., Pacifico, N., Pompili, A., Pugliese, G., Selvaggi, G., Silvestris, L., Singh, G., Zito, G., Abbiendi, G., Benvenuti, A. C., Bonacorsi, D., Braibant-Giacomelli, S., Brigliadori, L., Capiluppi, P., Castro, A., Cavallo, F. R., Cuffiani, M., Dallavalle, G. M., Fabbri, F., Fanfani, A., Fasanella, D., Giacomelli, P., Grandi, C., Guiducci, L., Marcellini, S., Masetti, G., Meneghelli, M., Montanari, A., Navarria, F. L., Odorici, F., Perrotta, A., Primavera, F., Rossi, A. M., Rovelli, T., Siroli, G., Travaglini, R., Albergo, S., Cappello, G., Chiorboli, M., Costa, S., Potenza, R., Tricomi, A., Tuve, C., Barbagli, G., Ciulli, V., Civinini, C., D'Alessandro, R., Focardi, E., Frosali, S., Gallo, E., Gonzi, S., Meschini, M., Paoletti, S., Sguazzoni, G., Tropiano, A., Benussi, L., Bianco, S., Colafranceschi, S., Fabbri, F., Piccolo, D., Fabbricatore, P., Musenich, R., Benaglia, A., De Guio, F., Di Matteo, L., Fiorendi, S., Gennai, S., Ghezzi, A., Malvezzi, S., Manzoni, R. A., Martelli, A., Massironi, A., Menasce, D., Moroni, L., Paganoni, M., Pedrini, D., Ragazzi, S., Redaelli, N., Sala, S., Tabarelli de Fatis, T., Buontempo, S., Carrillo Montoya, C. A., Cavallo, N., De Cosa, A., Dogangun, O., Fabozzi, F., Iorio, A. O. M., Lista, L., Meola, S., Merola, M., Paolucci, P., Azzi, P., Bacchetta, N., Bellan, P., Bisello, D., Branca, A., Carlin, R., Checchia, P., Dorigo, T., Dosselli, U., Gasparini, F., Gasparini, U., Gozzelino, A., Kanishchev, K., Lacaprara, S., Lazzizzera, I., Margoni, M., Meneguzzo, A. T., Nespolo, M., Ronchese, P., Simonetto, F., Torassa, E., Vanini, S., Zotto, P., Zumerle, G., Gabusi, M., Ratti, S. P., Riccardi, C., Torre, P., Vitulo, P., Biasini, M., Bilei, G. M., Fanò, L., Lariccia, P., Lucaroni, A., Mantovani, G., Menichelli, M., Nappi, A., Romeo, F., Saha, A., Santocchia, A., Taroni, S., Azzurri, P., Bagliesi, G., Boccali, T., Broccolo, G., Castaldi, R., D'Agnolo, R. T., Dell'Orso, R., Fiori, F., Foà, L., Giassi, A., Kraan, A., Ligabue, F., Lomtadze, T., Martini, L., Messineo, A., Palla, F., Rizzi, A., Serban, A. T., Spagnolo, P., Squillacioti, P., Tenchini, R., Tonelli, G., Venturi, A., Verdini, P. G., Barone, L., Cavallari, F., Del Re, D., Diemoz, M., Grassi, M., Longo, E., Meridiani, P., Micheli, F., Nourbakhsh, S., Organtini, G., Paramatti, R., Rahatlou, S., Sigamani, M., Soffi, L., Amapane, N., Arcidiacono, R., Argiro, S., Arneodo, M., Biino, C., Cartiglia, N., Costa, M., Demaria, N., Graziano, A., Mariotti, C., Maselli, S., Migliore, E., Monaco, V., Musich, M., Obertino, M. M., Pastrone, N., Pelliccioni, M., Potenza, A., Romero, A., Ruspa, M., Sacchi, R., Solano, A., Staiano, A., Vilela Pereira, A., Belforte, S., Candelise, V., Cossutti, F., Della Ricca, G., Gobbo, B., Marone, M., Montanino, D., Penzo, A., Schizzi, A., Heo, S. G., Kim, T. Y., Nam, S. K., Chang, S., Kim, D. H., Kim, G. N., Kong, D. J., Park, H., Ro, S. R., Son, D. C., Son, T., Kim, J. Y., Kim, Z. J., Song, S., Choi, S., Gyun, D., Hong, B., Jo, M., Kim, H., Kim, T. J., Lee, K. S., Moon, D. H., Park, S. K., Choi, M., Kim, J. H., Park, C., Park, I. C., Park, S., Ryu, G., Cho, Y., Choi, Y., Choi, Y. K., Goh, J., Kim, M. S., Kwon, E., Lee, B., Lee, J., Lee, S., Seo, H., Yu, I., Bilinskas, M. J., Grigelionis, I., Janulis, M., Juodagalvis, A., Castilla-Valdez, H., De La Cruz-Burelo, E., Heredia-de La Cruz, I., Lopez-Fernandez, R., Magaña Villalba, R., Martínez-Ortega, J., Sánchez-Hernández, A., Villasenor-Cendejas, L. M., Carrillo Moreno, S., Vazquez Valencia, F., Salazar Ibarguen, H. A., Casimiro Linares, E., Morelos Pineda, A., Reyes-Santos, M. A., Krofcheck, D., Bell, A. J., Butler, P. H., Doesburg, R., Reucroft, S., Silverwood, H., Ahmad, M., Asghar, M. I., Hoorani, H. R., Khalid, S., Khan, W. A., Khurshid, T., Qazi, S., Shah, M. A., Shoaib, M., Bialkowska, H., Boimska, B., Frueboes, T., Gokieli, R., Górski, M., Kazana, M., Nawrocki, K., Romanowska-Rybinska, K., Szleper, M., Wrochna, G., Zalewski, P., Brona, G., Bunkowski, K., Cwiok, M., Dominik, W., Doroba, K., Kalinowski, A., Konecki, M., Krolikowski, J., Almeida, N., Bargassa, P., David, A., Faccioli, P., Ferreira Parracho, P. G., Gallinaro, M., Seixas, J., Varela, J., Vischia, P., Belotelov, I., Bunin, P., Gavrilenko, M., Golutvin, I., Gorbunov, I., Kamenev, A., Karjavin, V., Kozlov, G., Lanev, A., Malakhov, A., Moisenz, P., Palichik, V., Perelygin, V., Shmatov, S., Smirnov, V., Volodko, A., Zarubin, A., Evstyukhin, S., Golovtsov, V., Ivanov, Y., Kim, V., Levchenko, P., Murzin, V., Oreshkin, V., Smirnov, I., Sulimov, V., Uvarov, L., Vavilov, S., Vorobyev, A., Vorobyev, A., Andreev, Y., Dermenev, A., Gninenko, S., Golubev, N., Kirsanov, M., Krasnikov, N., Matveev, V., Pashenkov, A., Tlisov, D., Toropin, A., Epshteyn, V., Erofeeva, M., Gavrilov, V., Kossov, M., Lychkovskaya, N.,

Popov, V., Safronov, G., Semenov, S., Stolin, V., Vlasov, E., Zhokin, A., Belyaev, A., Boos, E., Ershov, A., Gribushin, A., Klyukhin, V., Kodolova, O., Korotkikh, V., Lokhtin, I., Markina, A., Obraztsov, S., Perfilov, M., Petrushanko, S., Popov, A., Sarycheva, L., Savrin, V., Snigirev, A., Vardanyan, I., Andreev, V., Azarkin, M., Dremin, I., Kirakosyan, M., Leonidov, A., Mesyats, G., Rusakov, S. V., Vinogradov, A., Azhgirey, I., Bayshev, I., Bitioukov, S., Grishin, V., Kachanov, V., Konstantinov, D., Korablev, A., Krychkine, V., Petrov, V., Ryutin, R., Sobol, A., Tourtchanovitch, L., Troshin, S., Tyurin, N., Uzunian, A., Volkov, A., Adzic, P., Djordjevic, M., Ekmedzic, M., Krpic, D., Milosevic, J., Aguilar-Benitez, M., Alcaraz Maestre, J., Arce, P., Battilana, C., Calvo, E., Cerrada, M., Chamizo Llatas, M., Colino, N., De La Cruz, B., Delgado Peris, A., Domínguez Vázquez, D., Fernandez Bedoya, C., Fernández Ramos, J. P., Ferrando, A., Flix, J., Fouz, M. C., Garcia-Abia, P., Gonzalez Lopez, O., Goy Lopez, S., Hernandez, J. M., Josa, M. I., Merino, G., Puerta Pelayo, J., Quintario Olmeda, A., Redondo, I., Romero, L., Santaolalla, J., Soares, M. S., Willmott, C., Albajar, C., Codispoti, G., de Trocóniz, J. F., Brun, H., Cuevas, J., Fernandez Menendez, J., Folgueras, S., Gonzalez Caballero, I., Lloret Iglesias, L., Piedra Gomez, J., Brochero Cifuentes, J. A., Cabrillo, I. J., Calderon, A., Chuang, S. H., Duarte Campderros, J., Felcini, M., Fernandez, M., Gomez, G., Gonzalez Sanchez, J., Jorda, C., Lopez Virto, A., Marco, J., Marco, R., Martinez Rivero, C., Matorras, F., Munoz Sanchez, F. J., Rodrigo, T., Rodríguez-Marrero, A. Y., Ruiz-Jimeno, A., Scodellaro, L., Sobron Sanudo, M., Vila, I., Vilar Cortabitarte, R., Abbaneo, D., Auffray, E., Auzinger, G., Baillon, P., Ball, A. H., Barney, D., Benitez, J. F., Bernet, C., Bianchi, G., Bloch, P., Bocci, A., Bonato, A., Botta, C., Breuker, H., Camporesi, T., Cerminara, G., Christiansen, T., Coarasa Perez, J. A., D'Enterria, D., Dabrowski, A., De Roeck, A., Di Guida, S., Dobson, M., Dupont-Sagorin, N., Elliott-Peisert, A., Frisch, B., Funk, W., Georgiou, G., Giffels, M., Gigi, D., Gill, K., Giordano, D., Giunta, M., Glege, F., Gomez-Reino Garrido, R., Govoni, P., Gowdy, S., Guida, R., Hansen, M., Harris, P., Hartl, C., Harvey, J., Hegner, B., Hinzmann, A., Innocente, V., Janot, P., Kaadze, K., Karavakis, E., Kousouris, K., Lecoq, P., Lee, Y.-J., Lenzi, P., Lourenço, C., Mäki, T., Malberti, M., Malgeri, L., Mannelli, M., Masetti, L., Meijers, F., Mersi, S., Meschi, E., Moser, R., Mozer, M. U., Mulders, M., Musella, P., Nesvold, E., Orimoto, T., Orsini, L., Palencia Cortezon, E., Perez, E., Perrozzi, L., Petrilli, A., Pfeiffer, A., Pierini, M., Pimiä, M., Piparo, D., Polese, G., Quertenmont, L., Racz, A., Reece, W., Rodrigues Antunes, J., Rolandi, G., Rommerskirchen, T., Rovelli, C., Rovere, M., Sakulin, H., Santanastasio, F., Schäfer, C., Schwick, C., Segoni, I., Sekmen, S., Sharma, A., Siegrist, P., Silva, P., Simon, M., Sphicas, P., Spiga, D., Spiropulu, M., Tsirou, A., Veres, G. I., Vlimant, J. R., Wöhri, H. K., Worm, S. D., Zeuner, W. D., Bertl, W., Deiters, K., Erdmann, W., Gabathuler, K., Horisberger, R., Ingram, Q., Kaestli, H. C., König, S., Kotlinski, D., Langenegger, U., Meier, F., Renker, D., Rohe, T., Sibille, J., Bäni, L., Bortignon, P., Buchmann, M. A., Casal, B., Chanon, N., Deisher, A., Dissertori, G., Dittmar, M., Dünser, M., Eugster, J., Freudenreich, K., Grab, C., Hits, D., Lecomte, P., Lustermann, W., Martinez Ruiz del Arbol, P., Mohr, N., Moortgat, F., Nägeli, C., Nef, P., Nessi-Tedaldi, F., Pandolfi, F., Pape, L., Pauss, F., Peruzzi, M., Ronga, F. J., Rossini, M., Sala, L., Sanchez, A. K., Starodumov, A., Stieger, B., Takahashi, M., Tauscher, L., Thea, A., Theofilatos, K., Treille, D., Urscheler, C., Wallny, R., Weber, H. A., Wehrli, L., Aguilo, E., Amsler, C., Chiochia, V., De Visscher, S., Favaro, C., Ivova Rikova, M., Millan Mejias, B., Otiougova, P., Robmann, P., Snoek, H., Tupputi, S., Verzetti, M., Chang, Y. H., Chen, K. H., Kuo, C. M., Li, S. W., Lin, W., Liu, Z. K., Lu, Y. J., Mekterovic, D., Singh, A. P., Volpe, R., Yu, S. S., Bartalini, P., Chang, P., Chang, Y. H., Chang, Y. W., Chao, Y., Chen, K. F., Dietz, C., Grundler, U., Hou, W.-S., Hsiung, Y., Kao, K. Y., Lei, Y. J., Lu, R.-S., Majumder, D., Petrakou, E., Shi, X., Shiu, J. G., Tzeng, Y. M., Wan, X., Wang, M., Adiguzel, A., Bakirci, M. N., Cerci, S., Dozen, C., Dumanoglu, I., Eskut, E., Girgis, S., Gokbulut, G., Gurpinar, E., Hos, I., Kangal, E. E., Karapinar, G., Kayis Topaksu, A., Onengut, G., Ozdemir, K., Ozturk, S., Polatoz, A., Sogut, K., Sunar Cerci, D., Tali, B., Topakli, H., Vergili, L. N., Vergili, M., Akin, I. V., Aliev, T., Bilin, B., Bilmis, S., Deniz, M., Gamsizkan, H., Guler, A. M., Ocalan, K., Ozpineci, A., Serin, M., Sever, R., Surat, U. E., Yalvac, M., Yildirim, E., Zeyrek, M., Gülmez, E., Isildak, B., Kaya, M., Kaya, O., Ozkorucuklu, S., Sonmez, N., Cankocak, K., Levchuk, L., Bostock, F., Brooke, J. J., Clement, E., Cussans, D., Flacher, H., Frazier, R., Goldstein, J., Grimes, M., Heath, G. P., Heath, H. F., Kreczko, L., Metson, S., Newbold, D. M., Nirunpong, K., Poll, A., Senkin, S., Smith, V. J., Williams, T., Basso, L., Bell, K. W., Belyaev, A., Brew, C., Brown, R. M., Cockerill, D. J. A.,

Coughlan, J. A., Harder, K., Harper, S., Jackson, J., Kennedy, B. W., Olaiya, E., Petyt, D., Radburn-Smith, B. C., Shepherd-Themistocleous, C. H., Tomalin, I. R., Womersley, W. J., Bainbridge, R., Ball, G., Beuselinck, R., Buchmuller, O., Colling, D., Cripps, N., Cutajar, M., Dauncey, P., Davies, G., Della Negra, M., Ferguson, W., Fulcher, J., Futyan, D., Gilbert, A., Guneratne Bryer, A., Hall, G., Hatherell, Z., Hays, J., Iles, G., Jarvis, M., Karapostoli, G., Lyons, L., Magnan, A.-M., Marrouche, J., Mathias, B., Nandi, R., Nash, J., Nikitenko, A., Papageorgiou, A., Pela, J., Pesaresi, M., Petridis, K., Pioppi, M., Raymond, D. M., Rogerson, S., Rose, A., Ryan, M. J., Seez, C., Sharp, P., Sparrow, A., Stoye, M., Tapper, A., Vazquez Acosta, M., Virdee, T., Wakefield, S., Wardle, N., Whyntie, T., Chadwick, M., Cole, J. E., Hobson, P. R., Khan, A., Kyberd, P., Leslie, D., Martin, W., Reid, I. D., Symonds, P., Teodorescu, L., Turner, M., Hatakeyama, K., Liu, H., Scarborough, T., Charaf, O., Henderson, C., Rumerio, P., Avetisyan, A., Bose, T., Fantasia, C., Heiste (2012). Measurement of the pseudorapidity and centrality dependence of the transverse energy density in pb-pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. *Phys. Rev. Lett.*, 109:152303. 1

[9] Collaboration, T. A., Aamodt, K., Quintana, A. A., Achenbach, R., Acounis, S., Adamov, D., Adler, C., Aggarwal, M., Agnese, F., Rinella, G. A., Ahammed, Z., Ahmad, A., Ahmad, N., Ahmad, S., Akindinov, A., Akishin, P., Aleksandrov, D., Alessandro, B., Alfaro, R., Alfarone, G., Alici, A., Alme, J., Alt, T., Altinpinar, S., Amend, W., Andrei, C., Andres, Y., Andronic, A., Anelli, G., Anfreville, M., Angelov, V., Anzo, A., Anson, C., Antici, T., Antonenko, V., Antonczyk, D., Antinori, F., Antinori, S., Antonioli, P., Aphecetche, L., Appelshuser, H., Aprodu, V., Arba, M., Arcelli, S., Argentieri, A., Armesto, N., Arnaldi, R., Arefiev, A., Arsene, I., Asryan, A., Augustinus, A., Awes, T. C., ysto, J., Azmi, M. D., Bablock, S., Badal, A., Badyal, S. K., Baechler, J., Bagnasco, S., Bailhache, R., Bala, R., Baldisseri, A., Baldit, A., Bn, J., Barbera, R., Barberis, P.-L., Barbet, J. M., Barnfoldi, G., Barret, V., Bartke, J., Bartos, D., Basile, M., Basmanov, V., Bastid, N., Batigne, G., Batyunya, B., Baudot, J., Baumann, C., Bearden, I., Becker, B., Belikov, J., Bellwied, R., Belmont-Moreno, E., Belogianni, A., Belyaev, S., Benato, A., Beney, J. L., Benhabib, L., Benotto, F., Beol, S., Berceanu, I., Bercuci, A., Berdermann,

E., Berdnikov, Y., Bernard, C., Berny, R., Berst, J. D., Bertelsen, H., Betev, L., Bhasin, A., Baskar, P., Bhati, A., Bianchi, N., Bielik, J., Bielikov, J., Bimbot, L., Blanchard, G., Blanco, F., Blanco, F., Blau, D., Blume, C., Blyth, S., Boccioli, M., Bogdanov, A., Bggild, H., Bogolyubsky, M., Boldizsr, L., Bombara, M., Bombonati, C., Bondila, M., Bonnet, D., Bonvicini, V., Borel, H., Borotto, F., Borshchov, V., Bortoli, Y., Borysov, O., Bose, S., Bosisio, L., Botje, M., Bttger, S., Bourdaud, G., Bourrion, O., Bouvier, S., Braem, A., Braun, M., Braun-Munzinger, P., Bravina, L., Bregant, M., Bruckner, G., Brun, R., Bruna, E., Brunasso, O., Bruno, G. E., Bucher, D., Budilov, V., Budnikov, D., Buesching, H., Buncic, P., Burns, M., Burachas, S., Busch, O., Bushop, J., Cai, X., Caines, H., Calaon, F., Caldogno, M., Cali, I., Camerini, P., Campagnolo, R., Campbell, M., Cao, X., Capitani, G. P., Romeo, G. C., Cardenas-Montes, M., Carduner, H., Carena, F., Carena, W., Cariola, P., Carminati, F., Casado, J., Diaz, A. C., Caselle, M., Castellanos, J. C., Castor, J., Catanescu, V., Cattaruzza, E., Cavazza, D., Cerello, P., Ceresa, S., ern, V., Chambert, V., Chapeland, S., Charpy, A., Charrier, D., Chartoire, M., Charvet, J. L., Chattopadhyay, S., Chattopadhyay, S., Chepurnov, V., Chernenko, S., Cherney, M., Cheshkov, C., Cheynis, B., Chochula, P., Chiavassa, E., Barroso, V. C., Choi, J., Christakoglou, P., Christiansen, P., Christensen, C., Chykalov, O. A., Cicalo, C., Cifarelli-Strolin, L., Ciobanu, M., Cindolo, F., Cirstoiu, C., Clausse, O., Cleymans, J., Cobanoglu, O., Coffin, J.-P., Coli, S., Colla, A., Colledani, C., Combaret, C., Combet, M., Comets, M., Balbastre, G. C., del Valle, Z. C., Contin, G., Contreras, J., Cormier, T., Corsi, F., Cortese, P., Costa, F., Crescio, E., Crochet, P., Cuautle, E., Cussonneau, J., Dahlinger, M., Dainese, A., Dalsgaard, H. H., Daniel, L., Das, I., Das, T., Dash, A., Silva, R. D., Davenport, M., Daues, H., Caro, A. D., de Cataldo, G., Cuveland, J. D., Falco, A. D., de Gaspari, M., de Girolamo, P., de Groot, J., Gruttola, D. D., Haas, A. D., Marco, N. D., Pasquale, S. D., Remigis, P. D., de Vaux, D., Decock, G., Delagrange, H., Franco, M. D., Dellacasa, G., Dell'Olio, C., Dell'Olio, D., Deloff, A., Demanov, V., Dnes, E., D'Erasmo, G., Derkach, D., Devaux, A., Bari, D. D., Bartolomeo, A. D., Giglio, C. D., Liberto, S. D., Mauro, A. D., Nezza, P. D., Dialinas, M., Diaz, L., Valdes, R. D., Dietel, T., Dima, R., Ding, H., Dinca, C., Divi, R., Dobretsov, V., Dobrin, A., Doenigus, B., Dobrowolski, T., Domnguez, I., Dorn, M., Drouet, S., Dubey, A. E., Ducroux, L., Dumitrache, F., Dumonteil, E., Dupieux, P., Duta, V., Majumdar, A. D., Majumdar, M. D., Dyhre, T., Efimov, L., Efremov, A., Elia, D., Emschermann, D., Engster, C., Enokizono, A., Espagnon, B., Estienne, M., Evangelista, A., Evans, D., Evrard, S., Fabjan, C. W., Fabris, D., Faivre, J., Falchieri, D., Fantoni, A., Farano, R., Fearick, R., Fedorov, O., Fekete, V., Felea, D., Feofilov, G., Tllez, A. F., Ferretti, A., Fichera, F., Filchagin, S., Filoni, E., Finck, C., Fini, R., Fiore, E. M., Flierl, D., Floris, M., Fodor, Z., Foka, Y., Fokin, S., Force, P., Formenti, F., Fragiacomo, E., Fragkiadakis, M., Fraissard, D., Franco, A., Franco, M., Frankenfeld, U., Fratino, U., Fresneau, S., Frolov, A., Fuchs, U., Fujita, J., Furget, C., Furini, M., Girard, M. F., Gaardhje, J.-J., Gabrielli, A., Gadrat, S., Gagliardi, M., Gago, A., Gaido, L., Torreira, A. G., Gallio, M., Gandolfi, E., Ganoti, P., Ganti, M., Garabatos, J., Lopez, A. G., Garizzo, L., Gaudichet, L., Gemme, R., Germain, M., Gheata, A., Gheata, M., Ghidini, B., Ghosh, P., Giolu, G., Giraudo, G., Giubellino, P., Glasow, R., Glssel, P., Ferreiro, E. G., Gutierrez, C. G., Gonzales-Trueba, L. H., Gorbunov, S., Gorbunov, Y., Gos, H., Gosset, J., Gotovac, S., Gottschlag, H., Gottschalk, D., Grabski, V., Grassi, T., Gray, H., Grebenyuk, O., Grebieszkow, K., Gregory, C., Grigoras, C., Grion, N., Grigoriev, V., Grigoryan, A., Grigoryan, C., Grigoryan, S., Grishuk, Y., Gros, P., Grosse-Oetringhaus, J., Grossiord, J.-Y., Grosso, R., Grynyov, B., Guarnaccia, C., Guber, F., Guerin, F., Guernane, R., Guerzoni, M., Guichard, A., Guida, M., Guilloux, G., Gulkanyan, H., Gulbrandsen, K., Gunji, T., Gupta, A., Gupta, V., Gustafsson, H.-A., Gutbrod, H., Hadjidakis, C., Haiduc, M., Hamar, G., Hamagaki, H., Hamblen, J., Hansen, J. C., Hardy, P., Hatzifotiadou, D., Harris, J. W., Hartig, M., Harutyunyan, A., Hayrapetyan, A., Hasch, D., Hasegan, D., Hehner, J., Heine, N., Heinz, M., Helstrup, H., Herghelegiu, A., Herlant, S., Corral, G. H., Herrmann, N., Hetland, K., Hille, P., Hinke, H., Hippolyte, B., Hoch, M., Hoebbel, H., Hoedlmoser, H., Horaguchi, T., Horner, M., Hristov, P., Hivnov, I., Hu, S., Guo, C. H., Humanic, T., Hurtado, A., Hwang, D. S., Ianigro, J. C., Idzik, M., Igolkin, S., Ilkaev, R., Ilkiv, I., Imhoff, M., Innocenti, P. G., Ionescu, E., Ippolitov, M., Irfan, M., Insa, C., Inuzuka, M., Ivan, C., Ivanov, A., Ivanov, M., Ivanov, V., Jacobs, P., Jacholkowski, A., Janurov, L., Janik, R., Jasper, M., Jena, C., Jirden, L., Johnson, D. P., Jones, G. T., Jorgensen, C., Jouve, F., Jovanovi, P., Junique, A., Jusko, A., Jung, H., Jung, W., Kadija, K., Kamal, A., Kamermans, R., Kapusta, S., Kaidalov, A., Kakoyan, V., Kalcher, S., Kang, E., Kapitan, J., Kaplin, V., Karadzhev, K., Karavichev, O., Karavicheva, T., Karpechev, E., Karpio, K., Kazantsev, A., Kebschull, U., Keidel, R., Khan, M. M., Khanzadeev, A., Kharlov, Y., Kikola, D., Kileng, B., Kim, D., Kim, D. S., Kim, D. W., Kim, H. N., Kim, J. S., Kim, S., Kinson, J. B., Kiprich, S. K., Kisel, I., Kiselev, S., Kisiel, A., Kiss, T., Kiworra, V., Klay, J., Bsing, C. K., Kliemant, M., Klimov, A., Klovning, A., Kluge, A., Kluit, R., Kniege, S., Kolevatov, R., Kollegger, T., Kolojvari, A., Kondratiev, V., Kornas, E., Koshurnikov, E., Kotov, I., Kour, R., Kowalski, M., Kox, S., Kozlov, K., Krlik, I., Kramer, F., Kraus, I., Kravkov, A., Krawutschke, T., Krivda, M., Kryshen, E., Kucheriaev, Y., Kugler, A., Kuhn, C., Kuijer, P., Kumar, L., Kumar, N., Kumpumaeki, P., Kurepin, A., Kurepin, A. N., Kushpil, S., Kushpil, V., Kutovsky, M., Kvaerno, H., Kweon, M., Labb, J.-C., Lackner, F., de Guevara, P. L., Lafage, V., Rocca, P. L., Lamont, M., Lara, C., Larsen, D. T., Laurenti, G., Lazzeroni, C., Bornec, Y. L., Bris, N. L., Gailliard, C. L., Lebedev, V., Lecoq, J., Lee, K. S., Lee, S. C., Lefvre, F., Legrand, I., Lehmann, T., Leistam, L., Lenoir, P., Lenti, V., Leon, H., Monzon, I. L., Lvai, P., Li, Q., Li, X., Librizzi, F., Lietava, R., Lindegaard, N., Lindenstruth, V., Lippmann, C., Lisa, M., Listratenko, O. M., Littel, F., Liu, Y., Lo, J., Lobanov, V., Loginov, V., Noriega, M. L., Lpez-Ramrez, R., Torres, E. L., Lorenzo, P. M., Lvhiden, G., Lu, S., Ludolphs, W., Lunardon, M., Luquin, L., Lusso, S., Lutz, J.-R., Luvisetto, M., Lyapin, V., Maevskaya, A., Magureanu, C., Mahajan, A., Majahan, S., Mahmoud, T., Mairani, A., Mahapatra, D., Makarov, A., Makhlyueva, I., Malek, M., Malkiewicz, T., Mal'Kevich, D., Malzacher, P., Mamonov, A., Manea, C., Mangotra, L. K., Maniero, D., Manko, V., Manso, F., Manzari, V., Mao, Y., Marcel, A., Marchini, S., Mare, J., Margagliotti, G. V., Margotti, A., Marin, A., Marin, J.-C., Marras, D., Martinengo, P., Martnez, M. I., Martinez-Davalos, A., Garcia, G. M., Martini, S., Chiesa, A. M., Marzocca, C., Masciocchi, S., Masera, M., Masetti, M., Maslov, N. I., Masoni, A., Massera, F., Mast, M., Mastroserio, A., Matthews, Z. L., Mayer, B., Mazza, G., Mazzaro, M. D., Mazzoni, A., Meddi, F., Meleshko, E., Menchaca-Rocha, A., Meneghini, S., Meoni, M., Perez, J. M., Mereu, P., Meunier, O., Miake, Y., Michalon, A., Michinelli, R., Miftakhov, N., Mignone, M., Mikhailov, K., Milosevic, J., Minaev, Y., Minafra, F., Mischke, A., Mikowiec, D., Mitsyn, V., Mitu, C., Mohanty, B., Moisa, D., Molnar, L., Mondal, M., Mondal, N., Zetina, L. M., Monteno, M., Morando, M., Morel, M., Moretto, S., Morhardt, T., Morsch, A., Moukhanova, T., Mucchi, M., Muccifora, V., Mudnic, E., Mller, H., Mller, W., Munoz, J., Mura, D., Musa, L., Muraz, J. F., Musso, A., Nania, R., Nandi, B., Nappi, E., Navach, F., Navin, S., Nayak, T., Nazarenko, S., Nazarov, G., Nellen, L., Nendaz, F., Nianine, A., Nicassio, M., Nielsen, B. S., Nikolaev, S., Nikolic, V., Nikulin, S., Nikulin, V., Nilsen, B., Nitti, M., Noferini, F., Nomokonov, P., Nooren, G., Noto, F., Nouais, D., Nyiri, A., Nystrand, J., Odyniec, G., Oeschler, H., Oinonen, M., Oldenburg, M., Oleks, I., Olsen, E. K., Onuchin, V., Oppedisano, C., Orsini, F., Ortiz-Velzquez, A., Oskamp, C., Oskarsson, A., Osmic, F., sterman, L., Otterlund, I., Ovrebekk, G., Oyama, K., Pachr, M., Pagano, P., Pai, G., Pajares, C., Pal, S., Pal, S., Plla, G., Palmeri, A., Pancaldi, G., Panse, R., Pantaleo, A., Pappalardo, G. S., Pastirk, B., Pastore, C., Patarakin, O., Paticchio, V., Patimo, G., Pavlinov, A., Pawlak, T., Peitzmann, T., Pnichot, Y., Pepato, A., Pereira, H., Peresunko, D., Perez, C., Griffo, J. P., Perini, D., Perrino, D., Peryt, W., Pesci, A., Peskov, V., Pestov, Y., Peters, A. J., Petrek, V., Petridis, A., Petris, M., Petrov, V., Petrov, V., Petrovici, M., Peyr, J., Piano, S., Piccotti, A., Pichot, P., Piemonte, C., Pikna, M., Pilastrini, R., Pillot, P., Pinazza, O., Pini, B., Pinsky, L., Morais, V. P., Pismennaya, V., Piuz, F., Platt, R., Ploskon, M., Plumeri, S., Pluta, J., Pocheptsov, T., Podesta, P., Poggio, F., Poghosyan, M., Poghosyan, T., Polk, K., Polichtchouk, B., Polozov, P., Polyakov, V., Pommeresch, B., Pompei, F., Pop, A., Popescu, S., Posa, F., Pospil, V., Potukuchi, B., Pouthas, J., Prasad, S., Preghenella, R., Prino, F., Prodan, L., Prono, G., Protsenko, M. A., Pruneau, C. A., Przybyla, A., Pshenichnov, I., Puddu, G., Pujahari, P., Pulvirenti, A., Punin, A., Punin, V., Putschke, J., Quartieri, J., Quercigh, E., Rachevskaya, I., Rachevski, A., Rademakers, A., Radomski, S., Radu, A., Rak, J., Ramello, L., Raniwala, R., Raniwala, S., Rasmussen, O. B., Rasson, J., Razin, V., Read, K., Real, J., Redlich, K., Reichling, C., Renard, C., Renault, G., Renfordt, R., Reolon, A. R., Reshetin, A., Revol, J.-P., Reygers, K., Ricaud, H., Riccati, L., Ricci, R. A., Richter, M., Riedler, P., Rigalleau, L. M., Riggi, F., Riegler, W., Rindel, E., Riso, J., Rivetti, A., Rizzi, M., Rizzi, V., Cahuantzi, M. R., Red, K., Rhrich, D., Romn-Lpez, S., Romanato, M., Romita, R., Ronchetti, F., Rosinsky, P., Rosnet, P., Rossegger, S., Rossi, A., Rostchin, V., Rotondo, F., Roukoutakis, F., Rousseau, S., Roy, C., Roy, D., Roy, P., Royer, L., Rubin, G., Rubio, A., Rui, R., Rusanov, I., Russo, G., Ruuskanen, V., Ryabinkin, E., Rybicki, A., Sadovsky, S., afak, K., Sahoo, R., Saini, J., Saiz, P., Salur, S., Sambyal, S., Samsonov, V., ndor, L., Sandoval, A., Sann, H., Santiard, J.-C., Santo, R., Santoro, R., Sargsyan, G., Saturnini, P., Scapparone, E., Scarlassara, F., Schackert, B., Schiaua, C., Schicker, R., Schioler, T., Schippers, J. D., Schmidt, C., Schmidt, H., Schneider, R., Schossmaier, K., Schukraft, J., Schutz, Y., Schwarz, K., Schweda, K., Schyns, E., Scioli, G., Scomparin, E., Snow, H., Sedykh, S., Segato, G., Sellitto, S., Semeria, F., Senyukov, S., Seppnen, H., Serci, S., Serkin, L., Serra, S., Sesselmann, T., Sevcenco, A., Sgura, I., Shabratova, G., Shahoyan, R., Sharkov, E., Sharma, S., Shigaki, K., Shileev, K., Shukla, P., Shurygin, A., Shurygina, M., Sibiriak, Y., Siddi, E., Siemiarczuk, T., Sigward, M. H., Silenzi, A., Silvermyr, D., Silvestri, R., Simili, E., Simion, V., Simon, R., Simonetti, L., Singaraju, R., Singhal, V., Sinha, B., Sinha, T., Siska, M., Sitr, B., Sitta, M., Skaali, B., Skowronski, P., Slodkowski, M., Smirnov, N., Smykov, L., Snellings, R., Snoeys, W., Soegaard, C., Soerensen, J., Sokolov, O., Soldatov, A., Soloviev, A., Soltveit, H., Soltz, R., Sommer, W., Soos, C., Soramel, F., Sorensen, S., Soyk, D., Spyropoulou-Stassinaki, M., Stachel, J., Staley, F., Stan, I., Stavinskiy, A., Steckert, J., Stefanini, G., Stefanek, G., Steinbeck, T., Stelzer, H., Stenlund, E., Stocco, D., Stockmeier, M., Stoicea, G., Stolpovsky, P., Strme, P., Stutzmann, J. S., Su, G., Sugitate, T., umbera, M., Suire, C., Susa, T., Kumar, K. S., Swoboda, D., Symons, J., Szarka, I., Szostak, A., Szuba, M., Szymanski, P., Tadel, M., Tagridis, C., Tan, L., Takaki, D. T., Taureg, H., Tauro, A., Tavlet, M., Munoz, G. T., Thder, J., Tieulent, R., Timmer, P., Tolyhy, T., Topilskaya, N., de Matos, C. T., Torii, H., Toscano, L., Tosello, F., Tournaire, A., Traczyk, T., Trger, G., Tromeur, W., Truesdale, D., Trzaska, W., Tsiledakis, G., Tsilis, E., Tsvetkov, A., Turcato, M., Turrisi, R., Tuveri, M., Tveter, T., Tydesjo, H., Tykarski, L., Tywoniuk, K., Ugolini, E., Ullaland, K., Urbn, J., Urciuoli, G. M., Usai, G. L., Usseglio, M., Vacchi, A., Vala, M., Valiev, F., Vyvre, P. V., Brink, A. V. D., Eijndhoven, N. V., Kolk, N. V. D., van Leeuwen, M., Vannucci, L., Vanzetto, S., Vanuxem, J.-P., Vargas, M. A., Varma, R., Vascotto, A., Vasiliev, A., Vassiliou, M., Vasta, P., Vechernin, V., Venaruzzo, M., Vercellin, E., Vergara, S., Verhoeven, W., Veronese, F., Vetlitskiy, I., Vernet, R., Victorov, V., Vidak, L., Viesti, G., Vikhlyantsev, O., Vilakazi, Z., Baillie, O. V., Vinogradov, A., Vinogradov, L., Vinogradov, Y., Virgili, T., Viyogi, Y., Vodopianov, A., Volpe, G., Vranic, D., Vrlkov, J., Vulpescu, B., Wabnitz, C., Wagner, V., Wallet, L., Wan, R., Wang, Y., Wang, Y., Wheadon, R., Weis, R., Wen, Q., Wessels, J., Westergaard, J., Wiechula, J., Wiesenaecker, A., Wikne, J., Wilk, A., Wilk, G., Williams, C., Willis, N., Windelband, B., Witt, R., Woehri, H., Wyllie, K., Xu, C., Yang, C., Yang, H., Yermia, F., Yin, Z., Yin, Z., Ky, B. Y., Yushmanov, I., Yuting, B., Zabrodin, E., Zagato, S., Zagreev, B., Zaharia, P., Zalite, A., Zampa, G., Zampolli, C., Zanevskiy, Y., Zarochentsev, A., Zaudtke, O., Zvada, P., Zbroszczyk, H., Zepeda, A., Zeter, V., Zgura, I., Zhalov, M., Zhou, D., Zhou, S., Zhu, G., Zichichi, A., Zinchenko, A., Zinovjev, G., Zoccarato, Y., Zubarev, A., Zucchini, A., and Zuffa, M. (2008). The alice experiment at the cern lhc. *Journal of Instrumentation*, 3(08):S08002. 7

[10] Elia, D. and the ALICE Collaboration (2013). Strangeness production in alice. *Journal of Physics: Conference Series*, 455(1):012005. 2

[11] Jacobs, P. and Wang, X.-N. (2005). Matter in extremis: ultrarelativistic nuclear collisions at RHIC. *Progress in Particle and Nuclear Physics*, 54:443–534. 3

[12] Kapusta, J. I. (1979). Quantum chromodynamics at high temperature. *Nuclear Physics B*, 148(3):461 – 498. 1

[13] Luo, X. (2016). Exploring the qcd phase structure with beam energy scan in heavy-ion collisions. *Nuclear Physics A*, 956:75 – 82. The XXV International Conference on Ultrarelativistic Nucleus-Nucleus Collisions: Quark Matter 2015. 7

[14] Martinez, G. (2013). Advances in Quark Gluon Plasma. *ArXiv e-prints*. 1

[15] McLerran, L. (2013). The color glass condensate, glasma and the quark gluon plasma in the context of recent ppb results from lhc. *Journal of Physics: Conference Series*, 458(1):012024. 3, 5

[16] Müller, B., Schukraft, J., and Wysłouch, B. (2012). First Results from Pb+Pb Collisions at the LHC. *Annual Review of Nuclear and Particle Science*, 62:361–386. 3

[17] Nattrass, C. (2009). *System, energy, and flavor dependence of jets through di-hadron correlations in heavy ion collisions*. PhD thesis, Yale University. 7

[18] Odyniec, G. (2013). The rhic beam energy scan program in star and what's next ... *Journal of Physics: Conference Series*, 455(1):012037. 7

[19] Preghenella, R. (2011). Transverse momentum spectra of identified charged hadrons with the ALICE detector in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. *PoS*, EPS-HEP2011:118. 6

[20] Shuryak, E. V. (1988). The qcd vacuum and quark-gluon plasma. *Zeitschrift für Physik C Particles and Fields*, 38(1):141–145. 1

# Appendices