DOI: 10.18721/JPM.12208
УДК 539.126.3

THE MEASUREMENT OF ETA MESON NUCLEAR MODIFICTION FACTORS IN BINARY COLLISIONS OF URANIUM NUCLEI

P.V. Radzevich, A.Ya. Berdnikov, Ya.A. Berdnikov, D.O. Kotov, S.V. Zharko

Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russian Federation

Invariant spectra of η mesons production and nuclear modification factors of η и π^0 mesons produced in binary collisions of uranium nuclei at energy of 192 GeV have been presented in the paper. This data was obtained using the PHENIX spectrometer of RHIC. These experimental results were analyzed and compared with similar data on binary collisions of gold nuclei at 200 GeV. The η и π^0 mesons yields in central collisions of both uranium and gold nuclei (at energy values mentioned) were established to be suppressed equally. In the peripheral collisions, the nuclear modification factors of η и π^0 mesons measured in the uranium nuclei collisions were suppressed more than those obtained in the gold ones. An analysis of a ratio of the η meson to π^0 meson production spectra in the uranium nuclei collisions (at 192 GeV) revealed that the ratio was independent of the centrality class and the transverse momenta.

Keywords: quark-gluon plasma, eta meson, jet-quenching effect, nuclear modification factor

Citation: P.V. Radzevich, A.Ya. Berdnikov, Ya.A. Berdnikov, D.O. Kotov, S.V. Zharko, The measurement of eta meson nuclear modification factors in binary collisions of uranium nuclei, St. Petersburg Polytechnical State University Journal. Physics and Mathematics. 12 (2) (2019) 98–107. DOI: 10.18721/JPM.12208

ИЗМЕРЕНИЕ ФАКТОРОВ ЯДЕРНОЙ МОДИФИКАЦИИ ЭТА-МЕЗОНОВ ПРИ СТОЛКНОВЕНИЯХ ЯДЕР УРАНА

П.В. Радзевич, А.Я. Бердников, Я.А. Бердников, Д.О. Котов, С.В. Жарко

Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Российская Федерация

В статье представлены инвариантные спектры рождения η-мезонов и факторы ядерной модификации η- и π^0-мезонов, рожденных в парных столкновениях ядер урана при энергии 192 ГэВ. Эти данные получены на спектрометре PHENIX, расположенном на релятивистском коллайдере RHIC. Проведен анализ этих экспериментальных результатов, и они сопоставлены с аналогичными данными для парных столкновений ядер золота при энергии 200 ГэВ. Установлено, что выходы η- и π^0-мезонов в центральных парных столкновениях ядер как урана, так и золота (при указанных значениях энергии) подавлены в равной степени. В периферийных же столкновениях факторы ядерной модификации η- и π^0-мезонов, измеренные в столкновениях ядер урана, подавлены сильнее, чем данные факторы, полученные в столкновениях ядер золота. Анализ отношения спектров рождения η-мезонов к спектрам π^0-мезонов, рожденных в парных столкновениях ядер урана при энергии 192 ГэВ, показал, что оно не зависит ни от класса центральности, ни от поперечного импульса.

Ключевые слова: кварк-глюонная плазма, эта-мезон, эффект гашения струй, фактор ядерной модификации

Ссылка при цитировании: Радзевич П.В., Бердников А.Я., Бердников Я.А., Котов Д.О., Жарко С.В. Измерение факторов ядерной модификации эта-мезонов при парных столкновениях ядер урана // Научно-технические ведомости СПбГПУ. Физико-математические науки. 2019. Т. 12. № 2. С. 101–110. DOI: 10.18721/JPM.

Introduction

Transition of nuclear matter to quark-gluon plasma (QGP) at high energy densities and/or temperatures ($\varepsilon \approx 1$ GeV/fm^3, $T \approx 170$ MeV) was first predicted in 1970 using calculations of quantum chromodynamics (QCD) [1–5]. Phase transitions from colorless hadronic matter to QGP are studied in experiments on collisions of ultrarelativistic nuclei. QGP studies contribute substantially to modern understanding of the evolution of the early Universe, as the temperature of the Universe was at one stage equivalent to the temperature of QGP ($T \approx 10^{12}$ K) [6]. The behavior of nuclear matter at high temperatures and energy densities carries information on the nature of forces between quarks and gluons; these studies are in great demand in cosmology, providing insights on the properties of neutron stars [7, 8].

The properties of QGP in collisions of ultrarelativistic nuclei are detected by analyzing the effects of the initial and final states of nuclear matter. The effect of quenching of hadronic jets is related to phenomena occurring in the final state of nuclear matter and manifests itself in collisions of heavy nuclei with high energy [9]. Jet quenching is a result of hard scattering of partons produced in collisions of heavy ultrarelativistic nuclei. This effect is studied by measuring the production spectra and nuclear modification factors of the hadrons produced in interactions of nuclei. It is convenient to use η mesons to estimate the degree of suppression of hadron yields in the region of high transverse momenta.

Production spectra and nuclear modification factors of η mesons are measured with the purpose of studying the jet quenching effect in a specific system of colliding nuclei. Comparing the production spectra and nuclear modification factors of η mesons with those for π^0 mesons allows to obtain the dependence of jet quenching on the masses of produced particles and on their quark composition.

The binary system of colliding uranium nuclei (U + U) with the energy $\sqrt{s_{NN}} = 192$ GeV is particularly interesting. Uranium nuclei have a non-spherical shape, so the effects of QGP can be studied with different geometrical configurations of colliding nuclei. In central collisions, The U + U system of colliding nuclei has the maximum energy density available at the Relativistic Heavy Ion Collider (RHIC) [10].

Problem statement and description

The goal of this study has been to investigate the production of η mesons in collisions of uranium nuclei (U + U) at an energy $\sqrt{s_{NN}} = 192$ GeV.

To identify the mechanisms for production of particles in scattering of hard partons produced in collisions of U + U nuclei at $\sqrt{s_{NN}} = 192$ GeV, we had to measure the production spectra of η mesons and calculate their nuclear modification factors. The invariant production spectra and nuclear modification factors of η mesons were analyzed taking into account their centrality class and depending on the transverse momentum.

The transverse momentum p_T characterizes the interaction energy in a system of colliding nuclei. Centrality, measured as a percentage, is the degree of overlap of colliding nuclei with a fixed impact parameter. Collisions with the maximum degree of overlap correspond to a centrality of 0–20% and are called central, and collisions with the minimum degree of overlap are called peripheral and correspond to a centrality of 60–80%.

Study procedure

We have developed a procedure for studying the effect of jet quenching with the help of η mesons produced in collisions of U + U nuclei at $\sqrt{s_{NN}} = 192$ GeV. The procedure includes the following steps:

processing the experimental data;

measuring the yields of η mesons in different p_T ranges and centrality classes;

calculating the particle reconstruction efficiency for the detector;

measuring the invariant spectra of η meson production in collisions of U + U nuclei at $\sqrt{s_{NN}} = 192$ GeV in different p_T ranges and centrality classes;

assessing the systematic measurement errors;

measuring the nuclear modification factors of η mesons in U + U collisions at $\sqrt{s_{NN}} = 192$ GeV in different p_T ranges and centrality classes.

The experimental data used in the study were obtained with the PHENIX spectrometer at RHIC. Electromagnetic calorimeters were used to detect the decay products of η mesons in the $\eta \to \gamma\gamma$ channel. Such devices measure the energy and coordinates of photons, electrons and hadrons emitted from the region of nuclear interaction. The electromagnetic calorimeter system at the PHENIX experiment provided an overall acceptance $\varphi = 2 \cdot \pi/2$ in the azimuth and $|\eta| < 0.35$ in pseudorapidity.

The system of electromagnetic calorimeters consisted of two subsystems: the lead scintillation sampling calorimeter (PbSc) and the lead-glass Cherenkov calorimeter (PbGl). Each of the devices had its own segmentation. Using both types of calorimeters made it possible to cross-check the results obtained separately for the PbSc and PbGl subsystems within a single experiment.

Processing the experimental data. The data were prepared by establishing the criteria for selecting the desired events recorded by the electromagnetic calorimeter.

Constraints were imposed on the shape of detected electron showers yo separate the signals recorded during interaction of hadrons and photons with the active volume of the electromagnetic calorimeter. The constraint $\chi^2 < 3$ was imposed in the PbSc subsystem, and *photon_prob* > 0.02 in the PbGl subsystem. Here χ^2 and *photon_prob* are statistical variables described in [11].

The average energy transferred by charged hadrons is $E \approx 300$ MeV. Therefore, to better separate the signals from hadrons, we impose an additional constraint on the energy of reconstructed clusters: $E_\gamma > 400$ MeV.

To improve the signal-to-background ratio, we use the constraint on energy asymmetry between the photons combined in reconstruction of η mesons:

$$\frac{|E_{\gamma 1} - E_{\gamma 2}|}{E_{\gamma 1} + E_{\gamma 2}} < 0.8.$$

Particles were detected in collisions of uranium nuclei for 22 days. Equipment malfunctions could have occurred for a variety of reasons during this period. In view of this, we discarded data segments with a small number of recorded events in our analysis.

The interaction vertex (z_{coll}) is one of the main parameters in the system of colliding nuclei. This parameter was determined using the beam-beam counter in the PHENIX experiment. To select the data, we used a constraint on the vertex

$$-20 < z_{coll} < +20,$$

since the efficiency of the collision counter, measured in U + U collisions, is constant in this interval.

Measuring the yields of η mesons in different p_T ranges and centrality classes. This procedure is done by constructing the effective mass distribution of two gammas, selected after processing the experimental data, in different p_T ranges and centrality classes. To find the yields of η mesons, the useful signal recorded as a result of decay of η mesons is separated from the background, which is divided into the correlated (a pair of γ quanta is the product of particle decay) and uncorrelated (random combination of γ quanta) components.

To separate the uncorrelated background, γ pairs taken from two different events with similar characteristics (vertex and centrality) are combined. The distribution of effective mass of combined γ quanta (background) is constructed, normalized in the range

$$0.7 < M_{\gamma\gamma} < 0.8 \text{ GeV}/c^2$$

by the distribution of effective mass of real events (signal and background) and subtracted from it.

The result of subtracting two distributions is approximated by a Gaussian function to describe the signal from the reconstructed η mesons and by a second-degree polynomial to describe the residual correlated background, in the interval

$$0.40 < M_{\gamma\gamma} < 0.75 \text{ GeV}/c^2$$

in the range $p_T < 10$ GeV/c
and

$$0.35 < M_{\gamma\gamma} < 0.75 \text{ GeV}/c^2$$

in the range $p_T > 10$ GeV/c.

Yields of η mesons are measured by counting the number of samples and subtracting the integral under the second-degree polynomial. The region where η meson yields are counted lies in the range

$$0.48 < M_{\gamma\gamma} < 0.62 \text{ GeV}/c^2.$$

Calculating the particle reconstruction efficiency for the detector. This procedure allows to separate the number of η mesons reconstructed in the electromagnetic calorimeter from the number of η mesons in the active volume of the detector.

The reconstruction efficiency is found by simulating the passage of η mesons in the PHENIX spectrometer by the Monte Carlo method. The specialized PISA package implemented in GEANT-3 [11] is used for this simulation.

The reconstruction efficiency is calculated as the ratio of the number of particles reconstructed during simulation to the initial number of particles.

Measuring the invariant spectra of η meson production in collisions of U + U nuclei at $\sqrt{s_{NN}}$ = 192 GeV in different p*T* ranges and centrality classes. The following formula is used for these measurements:

$$I_\eta(p_T) = dN_{AA}(p_T) = \\ = \frac{1}{2\pi p_T}\frac{N_\eta(p_T)}{N_{event}\Delta p_T \varepsilon_{rec.ef}(p_T)}, \quad (1)$$

where N_η is the yield of neutral η mesons; $\varepsilon_{rec.ef}$ is the reconstruction efficiency; N_{event} is the number of events analyzed.

Invariant spectra of particle production are measured in different centrality classes.

Assessing the systematic measurement errors. This is done by varying different parameters (energy scale, energy resolution, weighting factors, parameters of detected particles, boundaries of detected γ clusters, conversion, geometry of the experimental setup and model) used to measure the yields of η mesons.

Statistical and systematic errors of nuclear modification factors are calculated as the sum of the squares of statistical and systematic errors of the numerator and denominator of formula (1).

Measuring the nuclear modification factors of η mesons in U + U collisions at $\sqrt{s_{NN}}$ = 192 GeV in different p_T ranges and centrality classes. The following formula is used for this purpose:

$$R_{AA} = \frac{1}{\langle N_{coll}\rangle}\frac{dN_{AA}}{dN_{pp}}, \quad (2)$$

where dN_{AA}, dN_{pp} are hadron yields in (*A* + *A*) and proton (*p* + *p*) collisions, respectively, in a given range of transverse momenta; $\langle N_{coll}\rangle$ is the average number of inelastic nucleon-nucleon collisions.

The value of $\langle N_{coll}\rangle$ is found by Monte Carlo simulation based on the Glauber theory taking into account the geometry of colliding nuclei. Normalization to this number is based on the assumption that hadrons are produced in elementary parton-parton interactions.

To study collective effects (effects of the final and initial states of nuclear matter) in the system of colliding nuclei, we used nuclear modification factors R_{AA}. If R_{AA} = 1, then there are no collective effects in the system of colliding nuclei. If R_{AA} is different from unity, this points to either suppressed or excessive particle yield.

Results and discussion

Fig. 1 shows invariant spectra of η mesons production measured in collisions of uranium nuclei (U + U) at $\sqrt{s_{NN}}$ = 192 GeV depending on the transverse momentum for different centrality classes.

The spectra were measured in a wide range of transverse momenta in central collisions (up to 14 GeV/*c*). There were limitations to measuring the production spectra in the region of low transverse momenta due to small capacity of the detector setup. The limitations in the region of high momenta were due to insufficient statistical data.

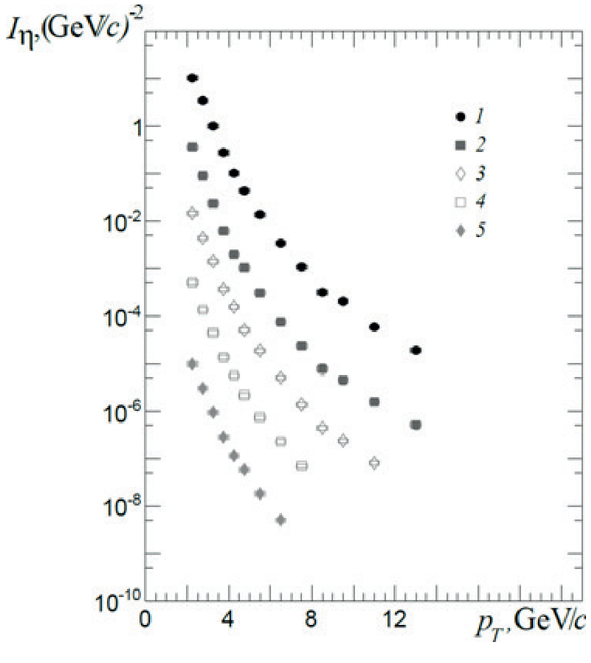

Fig. 1. Invariant spectra of η mesons measured in U + U collisions as function of transverse momentum for different centrality classes, %: 0–80 (*1*), 0–20 (*2*), 20–40 (*3*), 40–60 (*4*), 60–80 (*5*); $\sqrt{s_{NN}}$ = 192 GeV.
The vertical bars and the horizontal grey rectangles on the points here and below correspond to statistical and systematic measurement error, respectively

Fig. 2 shows a comparison of nuclear modification factors of η mesons measured in collisions of uranium (U + U) and gold (Au + Au) nuclei [12, 13] at energies $\sqrt{s_{NN}}$ = 192 and 200 GeV, respectively, with close values of N_{coll} (see Table). The nuclear modification factors of η mesons (see Fig. 2) were calculated by formula (2) using two different sets of average number N_{coll} of nucleon-nucleon collisions in different centrality classes in U + U collisions at $\sqrt{s_{NN}}$ = 192 GeV. Two sets of N_{coll} are used because of uneven distribution of nucleons in spherically asymmetric uranium nuclei.

The nuclear modification factors measured in collisions of uranium and gold nuclei at $\sqrt{s_{NN}}$ = 192 and 200 GeV, respectively, coincide for high values of N_{coll}, which indicates that the jet quenching effect does not depend on the geometric shape of colliding nuclei.

The nuclear modification factors obtained in

Table

Number of collisions N_{coll} as function of centrality for different types of interactions (see Fig. 2)

Centrality, %	N_{coll}	Fig. 2
Au + Au (*set 1*), 200 GeV		
0–5	1065.4105.3±	*a*)
20–40	300.832.6±	*b*)
40–50	120.313.7±	*c*)
60–92	17.13.9±	*d*)
Au + Au (*set 2*), 200 GeV		
0–10	967.392.9±	*a*)
60–92	17.23.5±	*d*)
U + U (*variant I*), 192 GeV		
0–20	934.597.5±	*a*)
20–40	335.033.0±	*b*)
40–60	95.913.0±	*c*)
60–80	17.53.8±	*d*)
U + U (*variant II*), 192 GeV		
0–20	999.0114.0±	*a*)
20–40	375.045.0±	*b*)
40–60	110.014.6±	*c*)
60–80	19.74.4±	*d*)

Note. Different variants possible for collisions of uranium nuclei are due to different degrees of deformation of uranium nuclei in calculations of the nucleon number N_{coll} in the Glauber model [12, 13].

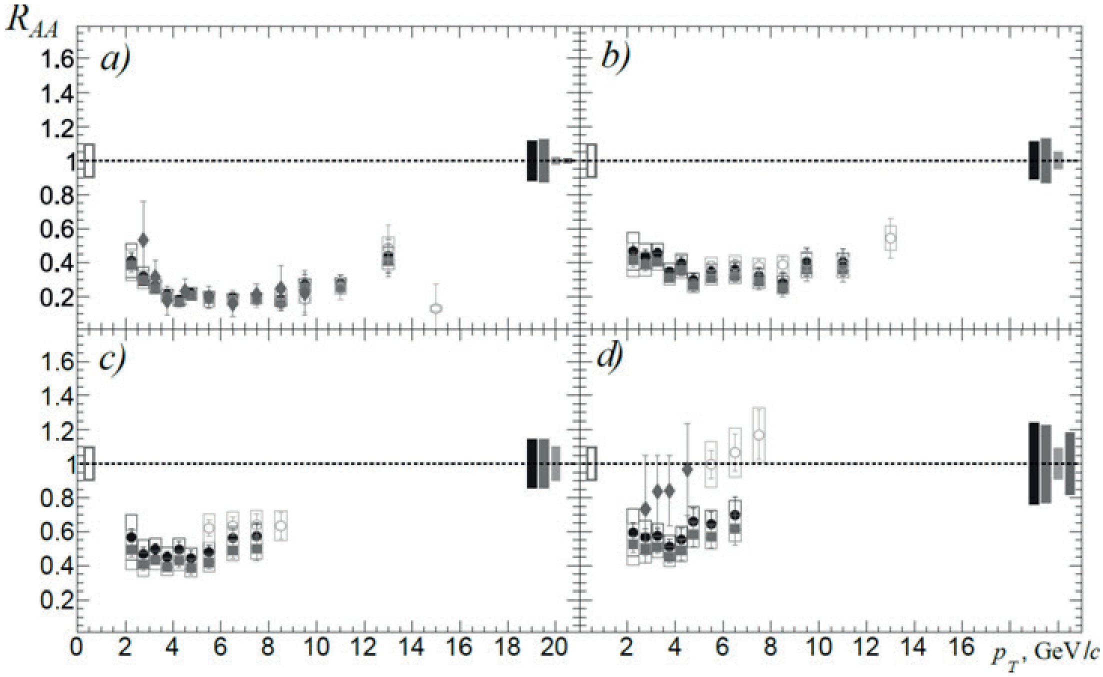

Fig. 2. Nuclear modification factor R_{AA} as function of transverse momentum p_T for η mesons in (U + U) interactions (solid circles and squares) and (Au + Au) interactions (circles and diamonds) [12, 13] with energies of 192 and 200 GeV, respectively (see Table)

Rectangles over the dashed lines indicate the systematic error for N_{coll}

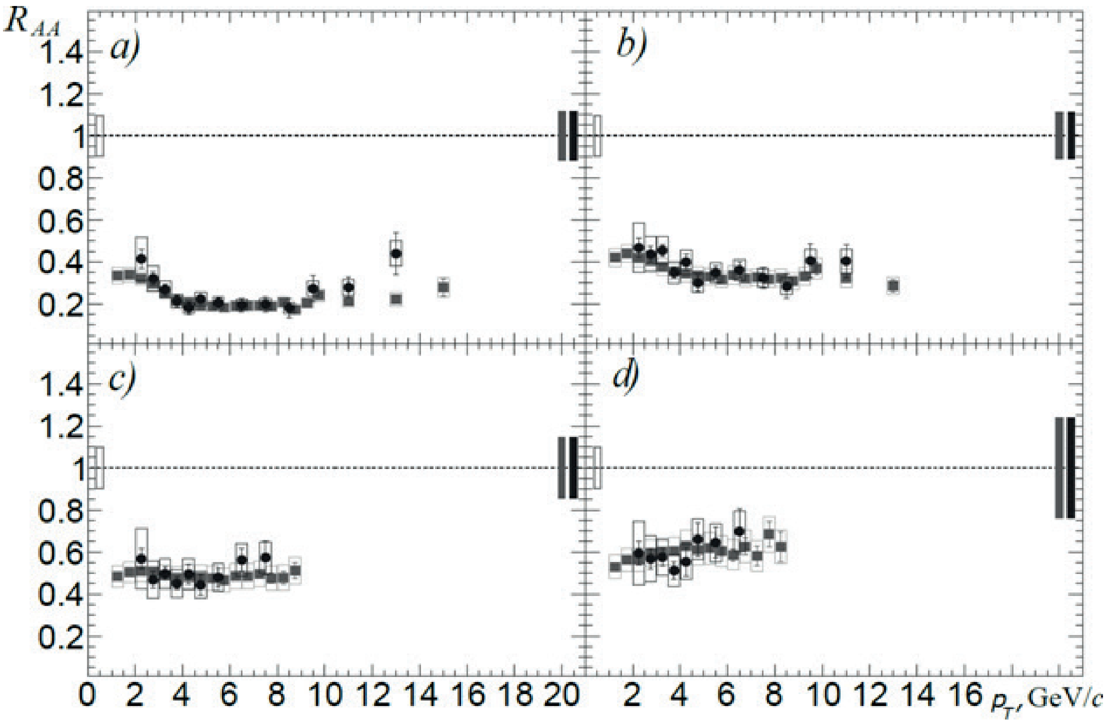

Fig. 3. Nuclear modification factor R_{AA} as function of transverse momentum p_T for π^0 mesons (squares) and η mesons (circles) in (U + U) interactions with energies of 192 and 200 GeV, respectively, for different centrality classes, %: 0–20 (*a*), 20–40 (*b*), 40–60 (*c*), 60–80 (*d*).

Rectangles over the dashed lines indicate the systematic error for N_{coll}

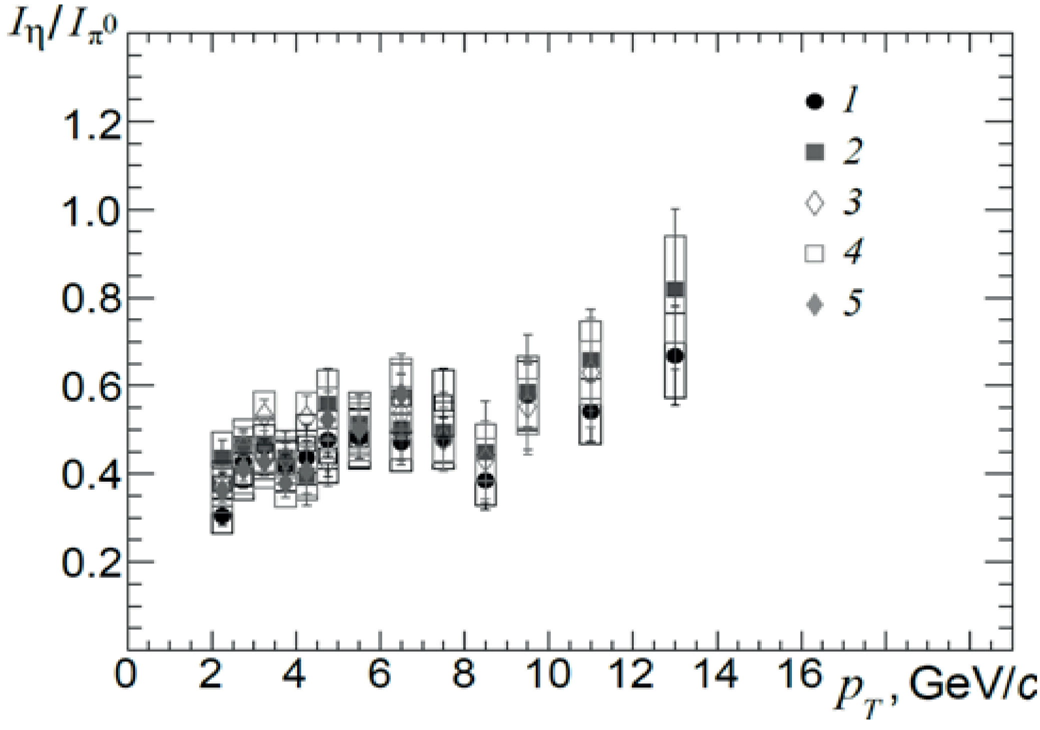

Fig. 4. Ratios for η meson production spectra to π^0 meson production spectra measured in U + U collisions at $\sqrt{s_{NN}}$ = 192 GeV as function of transverse momentum for different centrality classes, %: 0–80 (*1*), 0–20 (*2*), 20–40 (*3*), 40–60 (*4*), 60–80 (*5*)

collisions of uranium and gold nuclei at $\sqrt{s_{NN}}$ = 192 and 200 GeV, respectively, are somewhat different for small values of N_{coll}; however, the given quantities cannot be clearly separated due to large systematic error.

Fig. 3 shows a comparison of nuclear modification factors for π^0 and η mesons measured in collisions of uranium nuclei (U + U) at $\sqrt{s_{NN}}$ = 192 GeV, in different centrality classes. Evidently, these values coincide within systematic and statistical error in the entire range of transverse momenta and in all centrality classes.

Ultimately, the behavior of the ratios of η/π^0 spectra measured in collisions of uranium nuclei at $\sqrt{s_{NN}}$ = 192 GeV (Fig. 4) does not depend on centrality and transverse momentum within the systematic error.

Conclusion

Invariant spectra of η mesons have been measured in this study in five classes of centrality and nuclear modification factors of η mesons have been measured in four classes of centrality depending on the transverse momentum at an energy of $\sqrt{s_{NN}}$ = 192 GeV in pair collisions of uranium nuclei (U + U).

Coinciding nuclear modification factors of η mesons have been obtained for colliding uranium (U + U) and gold (Au + Au) systems with equal average numbers of inelastic nucleon-nucleon collisions in the region of high transverse momenta for central and semi-central collisions, which indicates that the effects of the final state do not depend on the geometric properties of the colliding nuclei.

We have established that the yields of η mesons in peripheral collisions of uranium (U + U) at $\sqrt{s_{NN}}$ = 192 GeV were suppressed more strongly than in collisions of gold (Au + Au) at $\sqrt{s_{NN}}$ = 200 GeV, but it proved impossible to clearly separate the obtained values due to large systematic and statistical error.

Analyzing the data for the ratios of η/π^0 spectra and comparing the nuclear modification factors of π^0 and η mesons, we have found that fragmentation of hard partons does not depend on the mass and composition of π^0 and η meson quarks produced in pair collisions of uranium nuclei at $\sqrt{s_{NN}}$ = 192 GeV.

The results of this study were obtained within the framework of State Task of the Ministry of Education and Science of Russian Federation 3.1498.2017/4.6.

REFERENCES

1. **Greutz M.,** Gauge fixing, the transfer matrix, and confinement on a lattice, Phys. Rev. D. 15 (4) (1977) 1128–1136.
2. **Wilson K.G.,** Confinement of quarks, Phys. Rev. D. 10 (8) (1974) 2445–2459.
3. **Wilson K.G., Walhout T.S., Harindranath A., et al.,** Nonperturbative QCD: A weak-coupling treatment on the light front, Phys. Rev. D. 49 (12) (1994) 6720–6766.
4. **Laermann E., Philipsen O.,** The status of lattice QCD at finite temperature, Annual Review of Nuclear and Particle Science. 53 (2003) 163–198.
5. **Adcox K., Adler S.S., Afanasiev S., et al.,** Formation of dense partonic matter in relativistic nucleus-nucleus collisions at RHIC: experimental evaluation by the PHENIX collaboration, Nucl. Phys. A. 757 (1–2) (2005) 184–283.
6. **Karsch F.,** Lattice QCD at high temperature and density, In: Lectures on quark matter, W. Plessas, L. Mathelitsch (Eds), Lecture Notes in Physics, Berlin: Springer. 582 (2002) 209–249.
7. **Collins J.C.,** Superdense matter: neutrons or asymptotically free quarks? Phys. Rev. Lett. 34 (21) (1975) 1353–1356.
8. **Rajagopal** K.**,** The phases of QCD in heavy ion collisions and compact stars, AIP Conference Proceedings. 549 (1) (2000) 95–119.
9. **Berdnikov A.Ya., Berdnikov Ya.A., Zharko S.V., et al.,** Experimental study of pion production in U + U interactions at 192 GeV, Bulletin of the Russian Academy of Sciences: Physics. 82 (10) (2018) 1262–1265.
10. **Iordanova A.,** U+U and Cu+Au results from PHENIX , Journal of Physics: Conference Series. 458 (2013) 012004.
11. **Adler S.S., Chujo T., Desmond E.J., et al.,** PHENIX on-line and off-line computing, Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. 499 (2/3) (2003) 593–602.
12. **Adler** S.S.**, et al. (PHENIX Collaboration),** High transverse momentum η meson production in $p + p$, d + Au and Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, Phys. Rev. C. 75 (2) (2007) 024909.
13. **Adare A., et al. (PHENIX Collaboration),** Transverse momentum dependence of η meson suppression in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, Phys. Rev. C. 82 (1) (2010) 011902.

Received 04.02.2019, accepted 11.03.2019.

THE AUTHORS

RADZEVICH Pavel V.
Peter the Great St. Petersburg Polytechnic University
29 Politechnicheskaya St., St. Petersburg, 195251, Russian Federation
radzevichp@gmail.com

BERDNIKOV Alexandr Ya.
Peter the Great St. Petersburg Polytechnic University
29 Politechnicheskaya St., St. Petersburg, 195251, Russian Federation
alexber@phmf.spbstu.ru

BERDNIKOV Yaroslav A.
Peter the Great St. Petersburg Polytechnic University
29 Politechnicheskaya St., St. Petersburg, 195251, Russian Federation
berdnikov@spbstu.ru

KOTOV Dmitry O.
Peter the Great St. Petersburg Polytechnic University
29 Politechnicheskaya St., St. Petersburg, 195251, Russian Federation
dmitriy.kotov@gmail.com

ZHARKO Sergei V.
Peter the Great St. Petersburg Polytechnic University
29 Politechnicheskaya St., St. Petersburg, 195251, Russian Federation
zharkosergey94@gmail.com

СПИСОК ЛИТЕРАТУРЫ

1. **Greutz M.** Gauge fixing, the transfer matrix, and confinement on a lattice // Phys. Rev. D. 1977. Vol. 15. No. 4. Pp. 1128–1136.

2. **Wilson K.G.** Confinement of quarks // Phys. Rev. D. 1974. Vol. 10. No. 8. Pp. 2445–2459.

3. **Wilson K.G., Walhout T.S., Harindranath A., Zhang W.-M., Perry R.J., Głazek D.S.** Nonperturbative QCD: A weak-coupling treatment on the light front // Phys. Rev. D. 1994. Vol. 49. No. 12. Pp. 6720–6766.

4. **Laermann E., Philipsen O.** The status of lattice QCD at finite temperature // Annual Review of Nuclear and Particle Science. 2003. Vol. 53. Pp. 163––198.

5. **Adcox K., Adler S.S., Afanasiev S., et al.** Formation of dense partonic matter in relativistic nucleus-nucleus collisions at RHIC: experimental evaluation by the PHENIX Collaboration // Nucl. Phys. A. 2005. Vol. 757. No. 1–2. Pp. 184–283.

6. **Karsch F.** Lattice QCD at high temperature and density // Lectures on quark matter. Plessas W., Mathelitsch L. (Eds). Lecture Notes in Physics. 2002. Vol. 583. Berlin: Springer. Pp. 209–249.

7. **Collins J.C.** Superdense matter: neutrons or asymptotically free quarks? // Phys. Rev. Lett. 1975. Vol. 34. No. 21. Pp. 1353–1356.

8. **Rajagopal K.** The phases of QCD in heavy ion collisions and compact stars // AIP Conference Proceedings. 2000. Vol. 549. No. 1. Pp. 95–119.

9. **Бердников А.Я., Бердников Я.А., Жарко С.В., Котов Д.О., Радзевич П.В.** Эксперименн тальные исследования рождения π-мезонов в U+U-взаимодействиях при энергии 192 Гэв // Известия РАН. Сер. физическая. 2018. Т. 82. № 10. С. 1391–1394.

10. **Iordanova A.** U+U and Cu+Au results from PHENIX // Journal of Physics: Conference Series. 2013. Vol. 458. P. 012004.

11. **Adler S.S., Chujo T., Desmond E.J., et al.** PHENIX on-line and off-line computing // Nuclear Instruments and Methods in Physics Research. Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. 2003. Vol. 499. No. 2/3. Pp. 593–602.

12. **Adler S.S., et al.** (PHENIX Collaboration), High transverse momentum η meson production in $p + p$, d + Au and Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV // Phys. Rev. C. 2007. Vol. 75. No. 2. P. 024909.

13. **Adare A., et al.** (PHENIX Collaboration), Transverse momentum dependence of η meson suppression in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV // Phys. Rev. C. 2010. Vol. 82. No. 1. P. 011902.

Статья поступила в редакцию 04.02.2019, принята к публикации 11.03.2019.

СВЕДЕНИЯ ОБ АВТОРАХ

РАДЗЕВИЧ Павел Владиславович – *аспирант кафедры экспериментальной ядерной физики Санкт-Петербургского политехнического университета Петра Великого.*

195251, Российская Федерация, г. Санкт-Петербург, Политехническая ул., 29
radzevichp@gmail.com

БЕРДНИКОВ Александр Ярославич – *кандидат физико-математических наук, доцент кафее дры экспериментальной ядерной физики Санкт-Петербургского политехнического университета Петра Великого.*

195251, Российская Федерация, г. Санкт-Петербург, Политехническая ул., 29
alexber@phmf.spbstu.ru

БЕРДНИКОВ Ярослав Александрович – *доктор физико-математических наук, профессор, зав ведующий кафедрой экспериментальной ядерной физики Санкт-Петербургского политехнического университета Петра Великого.*

195251, Российская Федерация, г. Санкт-Петербург, Политехническая ул., 29
berdnikov@spbstu.ru

КОТОВ Дмитрий Олегович – *кандидат физико-математических наук, доцент кафедры экспериментальной ядерной физики Санкт-Петербургского политехнического университета Петра Великого.*

195251, Российская Федерация, г. Санкт-Петербург, Политехническая ул., 29
dmitriy.kotov@gmail.com

ЖАРКО Сергей Вячеславович – *ассистент кафедры экспериментальной ядерной физики Санкт-Петербургского политехнического университета Петра Великого.*

195251, Российская Федерация, г. Санкт-Петербург, Политехническая ул., 29
zharkosergey94@gmail.com