



**ALICE**

# **ALICE**

***Study of interactions of heavy ions and proton beams at the LHC***

***(JINR participation)***

***theme 02-1-1088-2015/2019***

- status report on results of 2017-2019**
- prolongation proposal for 2020-2022**

***V. Pozdnyakov for JINR-ALICE team:***

***B.Batyunya, A.Fedunov, N.Gorbunov, S.Grigoryan, E.Kislov, A.Kondratiev, A.Kuznetsov, N.Kuzmin, L.Malinina\*, K.Mikhaylov\*\*, P.Nomokonov, Yu.Petukhov, V.Pozdnyakov, E.Rogochaya, K.Roslon, G.Romanenko, B.Roumyantsev, I.Roufanov, G.Stiforov, Yu.Vertogradova, A.Vodopianov***

**\* also Skobeltsyn INP**

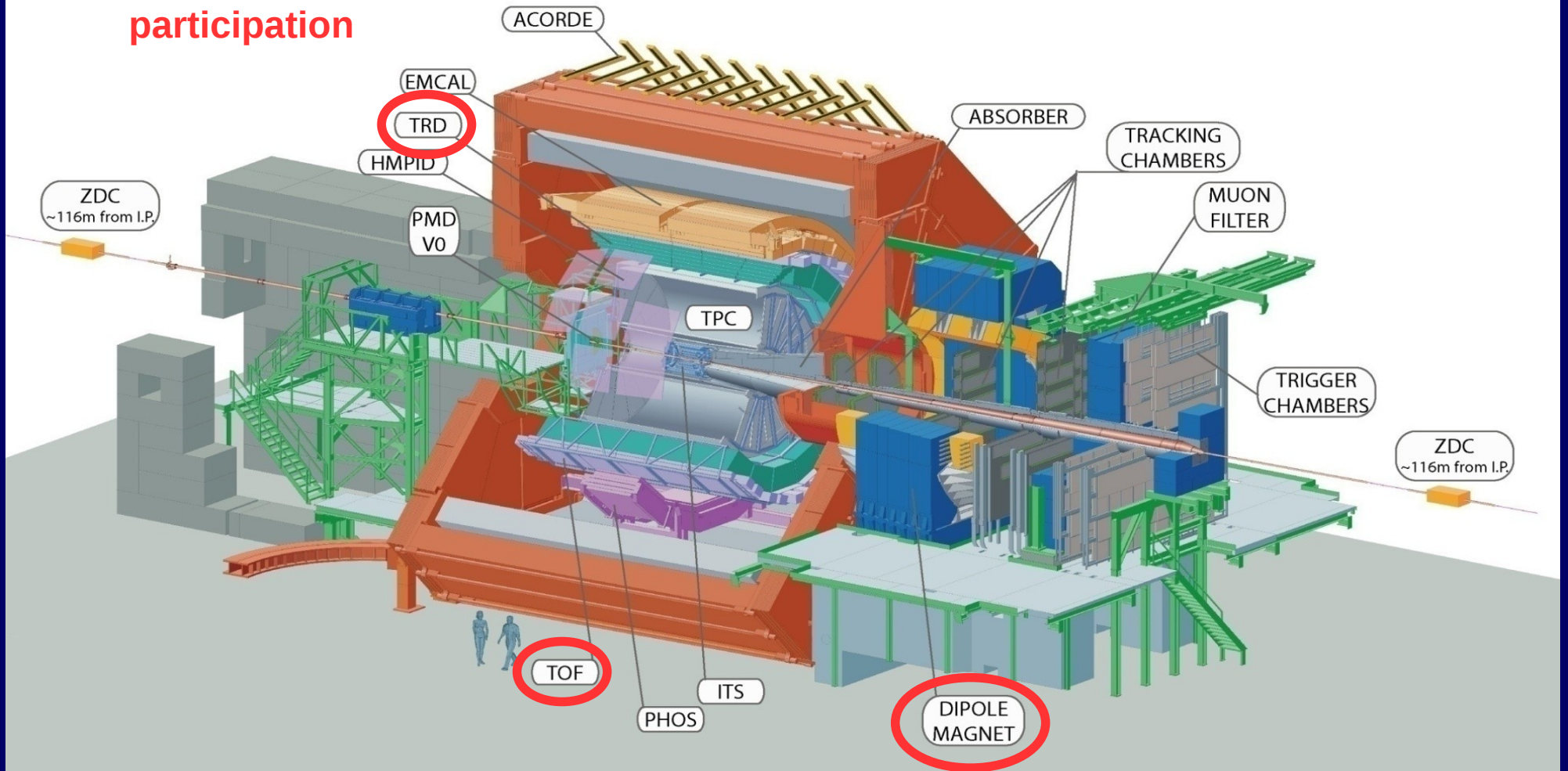
**\*\* also ITEP**

**PhD student**

**graduated student**

***Project leader - A.Vodopianov***

# JINR participation



No planned staging (phase) for ALICE setup



MoU, already signed before LHC start works



no additional MoU is foreseen

# The main activities of the JINR group in the ALICE experiment

## **Femtoscopic correlations:**

- analysis of correlations of charged kaons in p-p, p-Pb and Pb-Pb collisions was proposed, carried out and published by the group;
- software development for the analysis

## **Quarkonia:**

- development of Monte Carlo generator for  $J/\psi \rightarrow \mu\mu$  and  $\Upsilon \rightarrow \mu\mu$  in p-p, p-Pb and Pb-Pb collisions to calculate detection efficiency of these decays and for understanding of  $J/\psi$  and  $\Upsilon$  production mechanisms

## **Ultra-peripheral processes:**

- measurement of  $J/\psi$  and  $\rho^0$  photoproduction cross sections in Pb-Pb and p-Pb interactions

**GRID-ALICE at JINR** together with LIT

**Participation in data taking**, about 80 shifts per an year

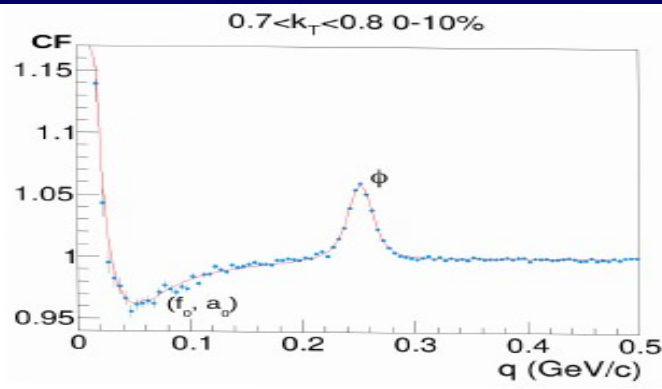
**Take part in modernization of the photon spectrometer** together with Kurchatov Institute:

*The project*

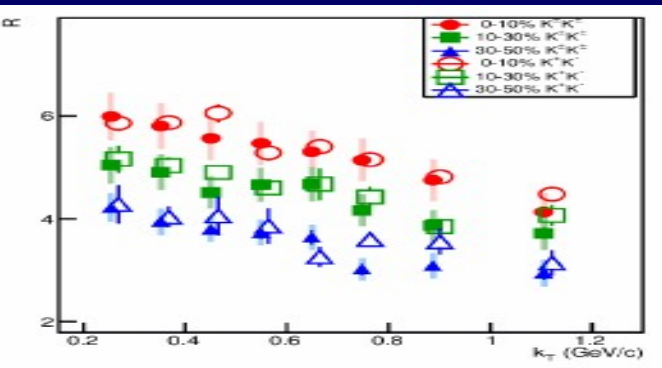
*“R&D on the ALICE photon spectrometer upgrade (JINR participation)”*

had been prolonged on 21.01.2019 by the PAC for PP for 2019-2020

# Femtoscscopy of $K^+K^-$ production in Pb-Pb interactions at $\sqrt{s}_{NN} = 2.76$ TeV



Correlation function (CF) of  $K^+K^-$  pairs as a function of difference of kaon four-momenta ( $q$ ). Curve – the result of the approximation by function Lednitsky–Lyuboshits which includes Coulomb contribution for small ( $<0.05$  GeV)  $q$ , contributions from the fall of the  $\phi$ -meson in the region (0.2–0.3) GeV and from resonance decays  $a_0$  and  $f_0$  in the intermediate domain of  $q$



Radii of sources of kaon emission ( $R_{inv}$ ) as a function of the pair transverse momentum ( $k_T$ ) for different event centralities. Identity and  $R_{inv}$  values for pairs of non-identical ( $K^+K^-$ ) and identical ( $K^+K^+ / K^-K^-$ ) kaons.

## The results presented

K. Mikhaylov “Non-identical kaon femtoscopy with ALICE experiment”, GDRE (Nantes, 2018)

L. Malinina “ $K^+K^-$  femtoscopy of PbPb collisions at 2.76 and 5.02 TeV”, GDRE (Nantes, 2017)

K. Mikhaylov “ $K^+K^-$  correlations in Pb-Pb collisions at  $\sqrt{s}_{NN} = 2.76$  TeV”, WPCF (Dubna, 2019).

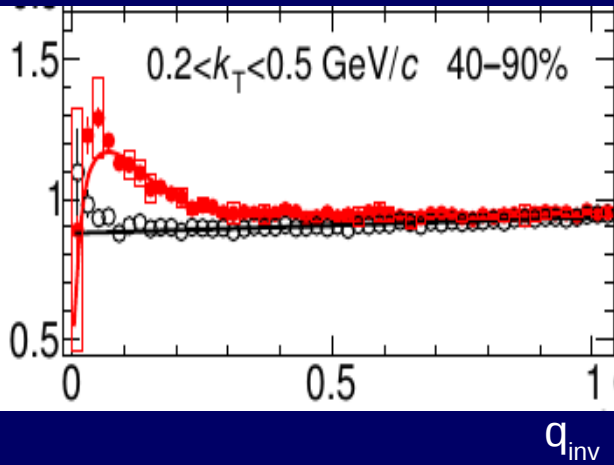
## and published

“Kaon femtoscopy in Pb–Pb collisions at  $\sqrt{s}_{NN} = 2.76$  TeV”, **ALICE Collab.**, *Phys. Rev. C* **96** (2017)

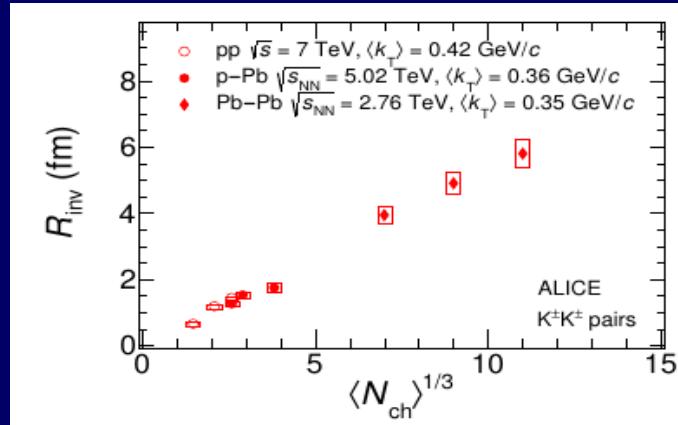
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# Femtoscscopy of $K^{+/-}K^{+/-}$ production in p-Pb interactions at $\sqrt{s}_{NN} = 5.02$ TeV

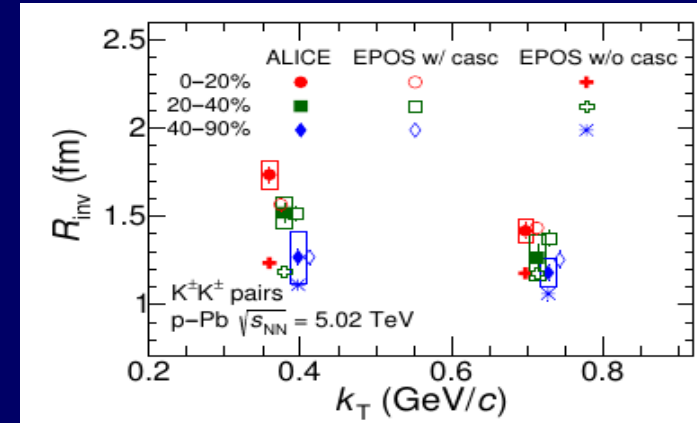
$K^{ch}K^{ch}$  CF as a function of  $q_{inv}$  for the experimental data (red points), for the fit (red curve) and a background (black points)



Radii  $R_{inv}$  of kaon source as a function of event charged multiplicity



Radii  $R_{inv}$  as a function of kaon pair transverse momentum  $k_t$  for three event centralities



## The results presented

*E. Rogochaya “Charged kaon femtoscopy correlations in p-Pb collisions at 5.02 TeV with ALICE at the LHC”, XII WPCF (Amsterdam, 2017)*

## and published

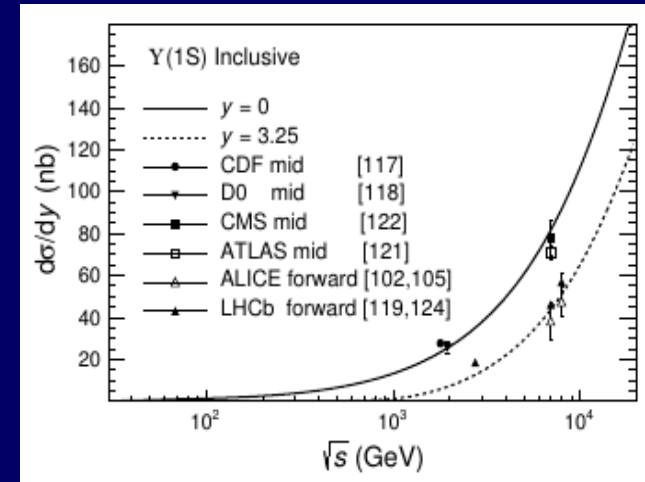
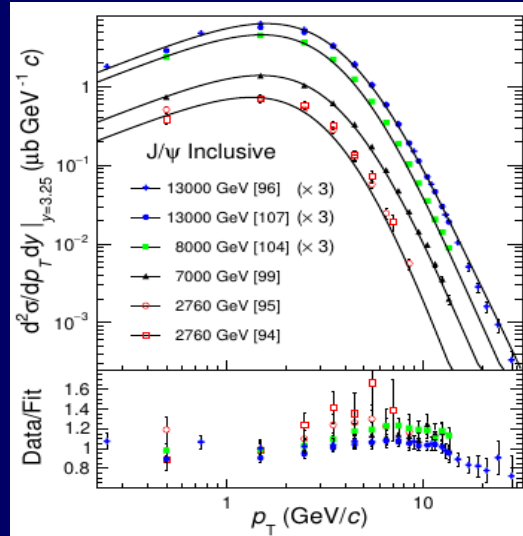
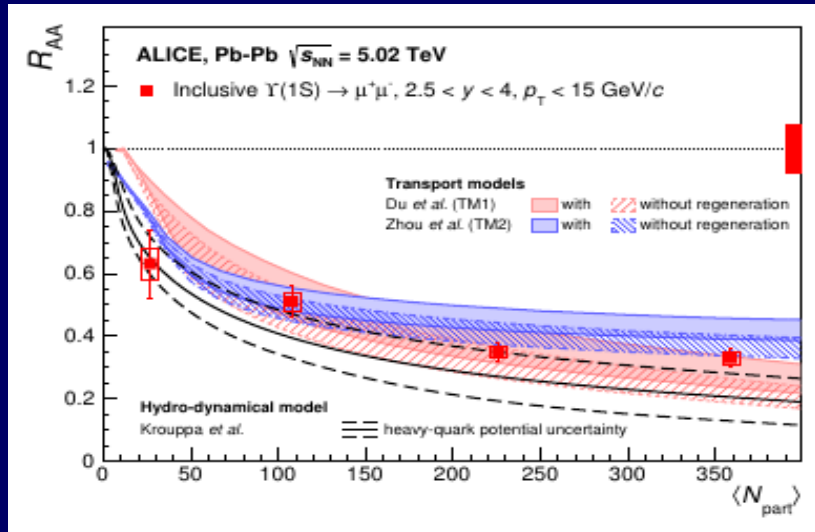
*“One-dimensional charged kaon femtoscopy in p-Pb collisions at  $\sqrt{s}_{NN} = 5.02$  TeV”, ALICE Collab., CERN-EP-2019-054, arXiv:1903.12310, submitted to PRC*

# $\Upsilon(1S)$ suppression in nuclear matter

$$R_{AA} = \frac{N^{\Upsilon}}{BR_{\Upsilon \rightarrow \mu^+ \mu^-} \cdot (A \times \epsilon)_{\Upsilon \rightarrow \mu^+ \mu^-} \cdot N_{\mu\mu\text{-MB}} \cdot F_{\text{norm}} \cdot \sigma_{pp}^{\Upsilon} \cdot \langle T_{AA} \rangle}$$

JINR-ALICE team proposed a thermal model based on Tsallis distribution and Blast-wave approach.

The model agrees with the data for pion and quarkonia in a wide energy range from 5 GeV up to 13 TeV



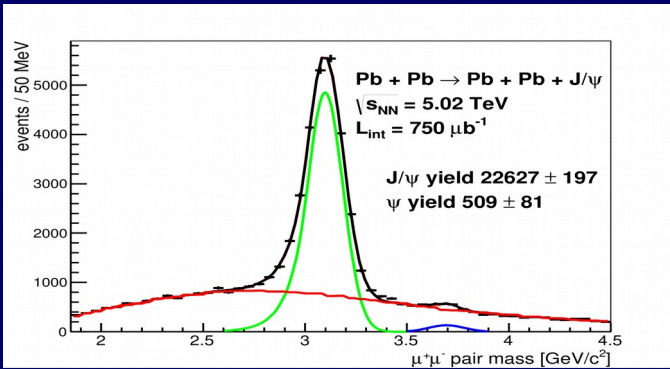
**The results presented**

S. Grigoryan "Using the Tsallis distribution for hadron spectra in pp collisions", ICNFP (Crete, 2017)

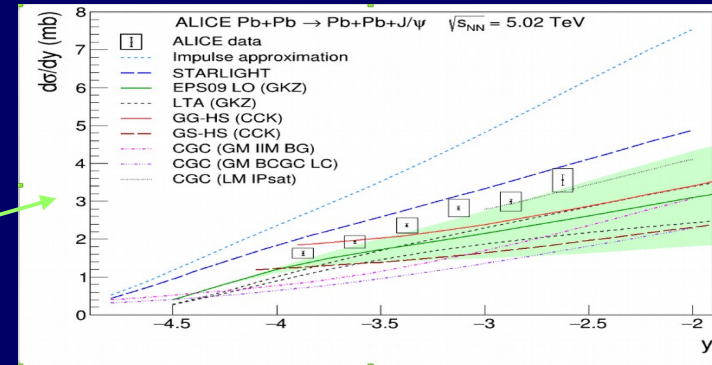
**and published**

S. Grigoryan, Phys.Rev. D95 (2017) 056021

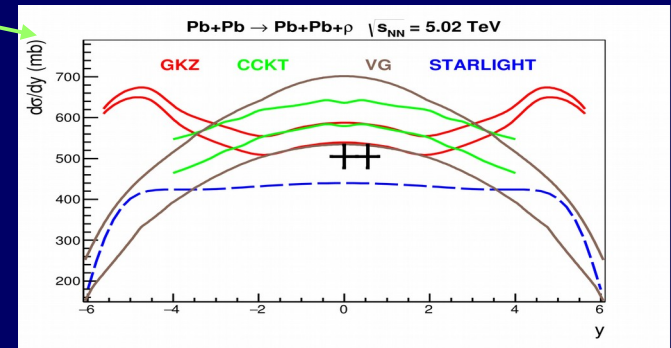
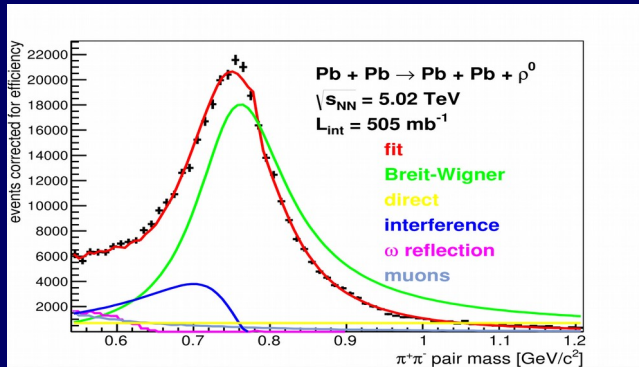
# Ultrapерipheral Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV



Measurement of coherent photoproduction cross sections of  $J/\psi$  and  $\rho^0$



Comparison with models included different level of gluon shadowing in nuclei



## The results presented

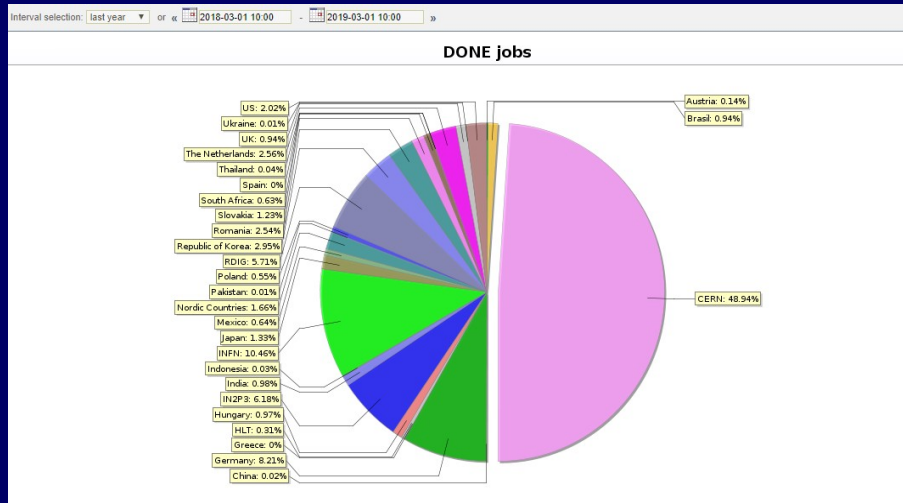
V. Pozdnyakov “Measurements of vector meson photoproduction with ALICE in ultra-peripheral Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV”, EPS Conference on HEP (Venice, 2017)

V. Pozdnyakov “Ultra-peripheral vector meson photoproduction in Pb-Pb interactions at ALICE”, QCD18 21th Conference on HEP (Montpellier, 2018)

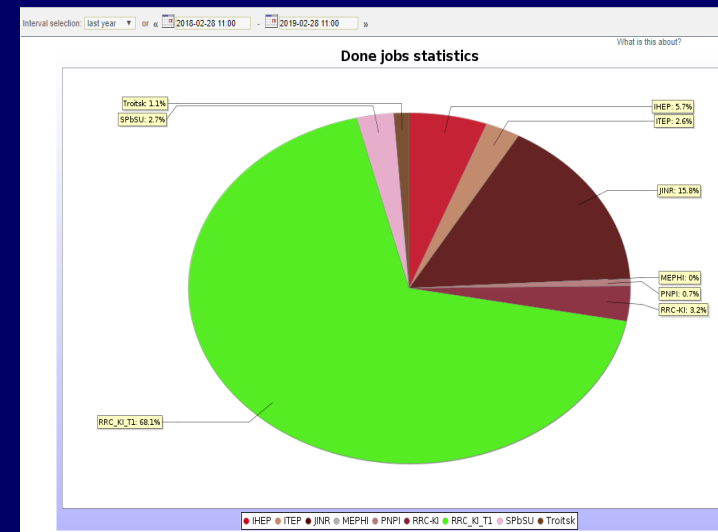
## and published

“Coherent  $J/\psi$  photoproduction at forward rapidity in ultraperipheral Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV” ALICE Collab., arXiv:1904.06272, accepted by PLB

# GRID-ALICE in JINR



ALICE Institutions in GRID, Russian ~5.7%



JINR / Russian Institutions ~15.8%  
Highest among Tier-2 of Russia

## Other activities of JINR group in ALICE

- L. Malinina became so-convener of a femtoscopy subgroup
- take part in internal revision committees for ALICE publications
- take part in institutional revision committees for ALICE publications



## Publications in the 2017-2019 years with a most activity of JINR group:

1. One-dimensional charged kaon femtoscopy in p–Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV, ALICE Collab., CERN-EP-2019-054, arXiv:1903.12310, accepted to PRC
2. Coherent  $J/\psi$  photoproduction at forward rapidity in ultraperipheral Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV, ALICE Collab., arXiv:1904.06272, accepted by PLB
3. Kaon femtoscopy in Pb–Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV, ALICE Collab., Phys.Rev.C96 (2017) 064613
4. Using the Tsallis distribution for hadron spectra in pp collisions: pions and quarkonia at  $\sqrt{s} = 5–13000$  GeV, S. Grigoryan, Phys.Rev. D95 (2017) 056021
5. Measuring  $K^0_s K^\pm$  interactions using Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV, ALICE Collab., Phys.Let. B774 (2017) 64
6. Azimuthally differential pion femtoscopy relative to the third harmonic event plane in Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.78$  TeV, ALICE Collab., Phy.Lett. B785 (2018) 320
7. pp, p- $\Lambda$  and  $\Lambda$ - $\Lambda$  correlations studied via femtoscopy in pp reactions at  $\sqrt{s_{NN}} = 7$  TeV", ALICE Collab., arXiv:1805.12455 (2018)
8. Event-shape and multiplicity dependence of freeze-out radii in pp collisions at  $\sqrt{s_{NN}} = \text{TeV}$ , ALICE Collab., arXiv:1901.05518 (2019)
9. Measuring  $K^0_s K^\pm$  interactions using pp collisions at  $\sqrt{s_{NN}} = 7$  TeV, ALICE Collab., Phys.Lett. B790 (2019)22
10.  $\Upsilon$  suppression at forward rapidity in Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV, ALICE Collab., Phys.Lett. B790 (2019) 89.

## Presentations on conferences by JINR team in the 2017-2019 years

1. K. Mikhaylov (JINR/ITEP), Kaon femtoscopy with EPOS3 model”, GDRE Workshop (Subatech, 2017)
2. L.Malinina (JINR/MSU, SINR),  $K^{\text{ch}}K^{\text{ch}}$  femtoscopy of PbPb collisions at 2.76 and 5.02 TeV, GDRE Workshop (Subatech, 2017)
3. E. Rogochaya, Charged kaon femtoscopy correlations in p-Pb collisions at 5.02 TeV with ALICE at the LHC, XII WPCF (Amsterdam, 2018)
4. V.Pozdnyakov, Measurements of vector meson photoproduction with ALICE in ultra-peripheral Pb-Pb collisions at  $\sqrt{s_{\text{NN}}} = 5.02$  TeV, EPS Conference on HEP (Venice, 2017)
5. S.Grigoryan, Using the Tsallis distribution for hadron spectra in pp collisions: pions and quarkonia at  $\sqrt{s} = 5 - 13000$  GeV, CNFP (Crete, 2017)
6. K. Mikhaylov (JINR/ITEP), Non-identical kaon femtoscopy with ALICE experiment, XX GDRE Workshop (Nantes, 2018)
7. V. Pozdnyakov, Ultra-peripheral vector meson photoproduction in Pb-Pb interactions at ALICE, QCD18 21th Conference on HEP (Montpellier, 2018)
8. G.Stiforov, Operations and plans—RDIG, T1/T2 Workshop (Derby, 2018)

# JINR-ALICE group plans for 2020-2022

## Femtoscropy:

- 2020 year: finalize 1-D analysis for kaon pairs in p-Pb and Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  and 5.02 TeV and publish the results as the ALICE paper;

In the 2020-2022 years:

- carry out 3-D analysis of kaon pair correlations in p-Pb and Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV with the data collected during LHC Run-2 of 160 million and 78 million events, respectively;
- make 1-D analysis of correlations of identical kaon pairs in pp interactions at  $\sqrt{s_{NN}} = 13$  TeV for spherical and jet events in order to check an ALICE result obtained for charged pions that  $R_{inv}$  does not depend on pair  $k_T$  for spherical events;
- carry out 1-D analysis of non-identical  $K^+K^-$  correlations in p-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV;
- 2022: learn the possible study of  $\varphi$  meson pairs correlations in pp interactions at  $\sqrt{s_{NN}} = 13$  TeV.

## Quarkonia:

- support and update the software for quarkonia production and the generator of heavy flavors using new LHC results and theoretical developments; participation in the results interpretations.
- prepare next version of the phenomenological thermal model based on Tsallis-distribution for p-Pb and Pb-Pb collisions.

## **Ultra-peripheral processes:**

– 2020 : finalize  $\rho^0$  coherent cross section measurement (data 2015) in Pb-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV. measure cross sections of  $\rho^0$  and  $J/\psi$  incoherent photoproduction ;

2020-2022 yeas:

– analyze four-prong final states to measure parameters of  $\rho^0(1450)$ ;

– study (and compare with HERA ) the photoproduction of  $\rho^0$  for p-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV;

– 2022: search for vector meson pair production (emphases on  $\rho^0+J/\psi$  states) in two-photon interactions.

## **GRID-ALICE at JINR:**

– upgrade software, regular replacement of obsolete computing nodes and data storage systems with new ones, take part in the project of using supercomputers and other GRID technologies in ALICE;

– support of stable functioning of the local cluster.

**Participation in data taking:** the same amount of shifts per year is expected for 2021-2022.



Предлагаемый план-график и необходимые ресурсы для осуществления проекта  
**«ALICE: A Large Ion Collider Experiment at CERN LHC (JINR participation)»**  
 “ALICE: Исследование взаимодействий пучков тяжелых ионов и протонов на LHC  
 (участие ОИЯИ)”  
 (продление проекта)



| Наименование узлов и систем установки, ресурсов, источников финансирования |                               | Стоимость узлов установки (тыс. дол. США)<br>Потребности в ресурсах | 1 год        | 2 год        | 3 год        |              |
|--|-------------------------------|---|--------------|--------------|--------------|--------------|
|  |                               |   |              |              |              |              |
| Основные узлы и оборудование   | 1. Платежи в ЦЕРН             | 360.0   | 120.0        | 120.0        | 120.0        |              |
|  | 2. Компьютерное оборудование. | 120.0   | 40.0         | 40.0         | 40.0         |              |
|  | 3. Командировочные расходы    | 400.0   | 120.0        | 140.0        | 140.0        |              |
|  | <b>ИТОГО</b>                  | <b>880.0</b>  | <b>280.0</b> | <b>300.0</b> | <b>300.0</b> |              |
| Необходимые ресурсы  | Нормо-часы                    | ООЭП ЛФВЭ   |              |              |              |              |
| Источники финансирования   | Бюджет                        | Затраты из бюджета  | <b>880.0</b> | <b>280.0</b> | <b>300.0</b> | <b>300.0</b> |
|  | Внебюджетные средства         | Целевое финансирование  |              |              |              |              |

**FTE = 14.5**



## Summary



- for the reviewed period the ALICE experiment continued to take the data (2017-2018) and return back to the physics data taking in 2021 for another three years.
- the data taking was very successful and the experiment collected huge amount of the data. It allows us to make finer measurements (3-D instead of 1-D) and searching jobs
- next period of the data taking will be first one with NO trigger and continued recording of the data
- several presentations on main physics conferences and publications per year
- technical issues (GRID) in good shape

JINR-ALICE group asks PAC to approve the proposal to prolong JINR participation in the ALICE experiment for 2020-2022