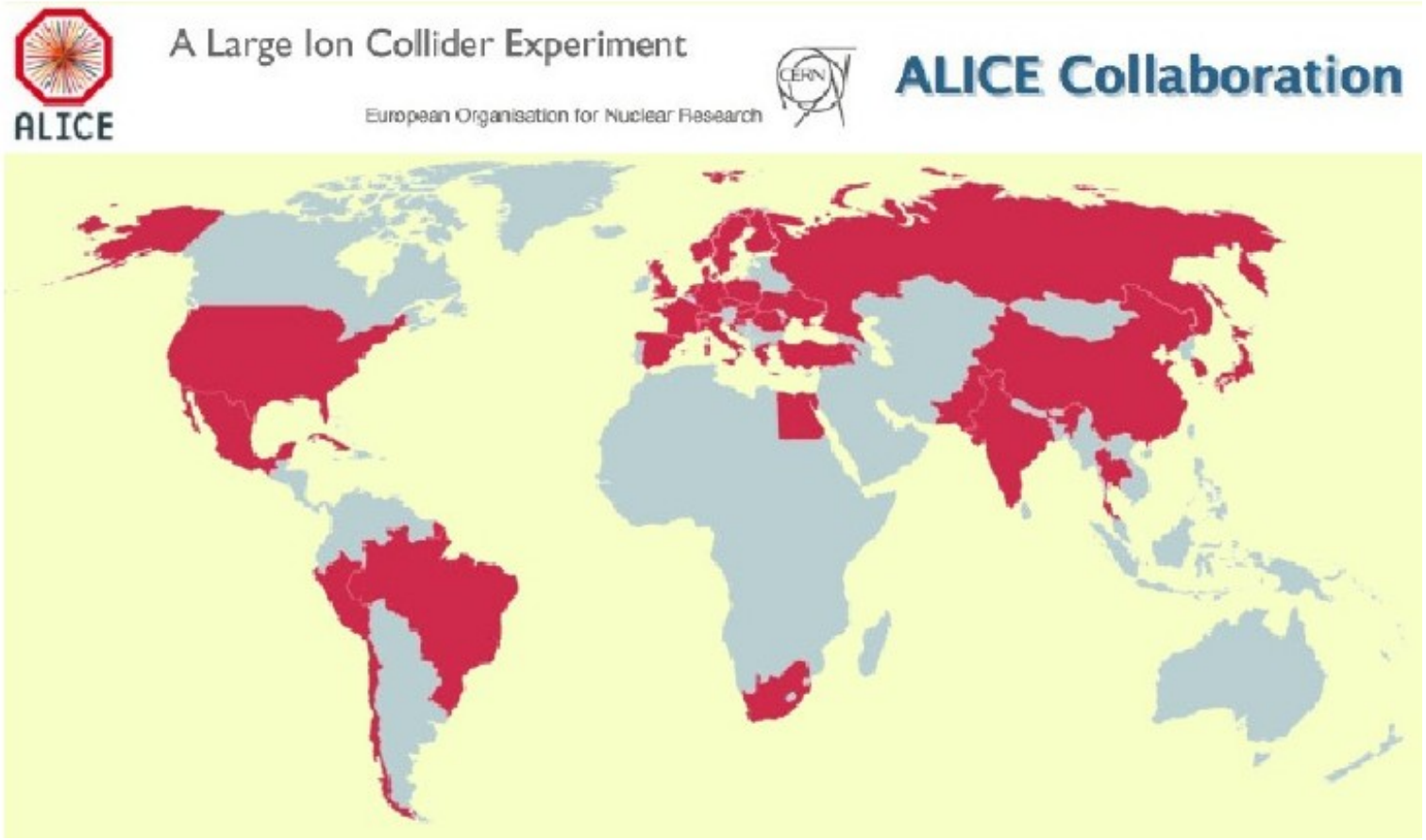
New results obtained in the ALICE experiment with a participation of the JINR team.

B.Batyunya

50th PAC, Dubna, 21.01.2019



42 coutries, 174 institutes, >1800 members

The ALICE JINR analysis group:

-- 6 physicists;

-- 2 PhD students;

-- 1 undergraduate student

-- 1 expert for the root software updating and GRID computing management.

Most interest activity of Dubna team

– **Bothe-Einstein correlations (femtoscopy physics):**

Analysis of two-charged kaons correlations in p-p, p-Pb and Pb-Pb collisions. Updating of the analysis software.

– **Quarkonia physics:**

Creation and updating of the special models using for an estimation of the detector efficiency and for understanding of J/ψ, and ϒ production mechanisms.

– **Ultraperipheral collisions of heavy ions:**

Study of charmonium state J/ψ and ρ^0 photoproduction in the Pb-Pb collisions.

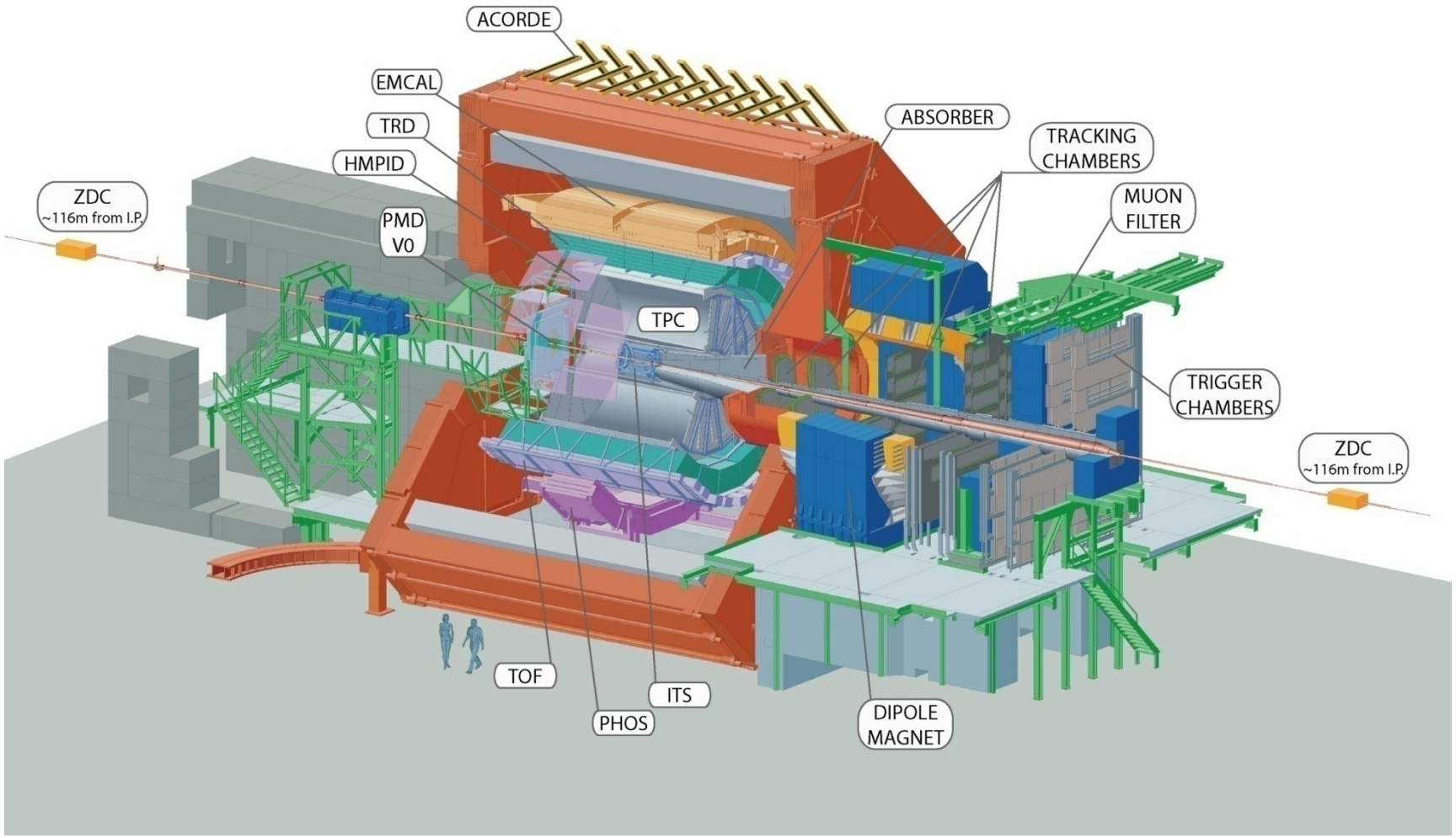
– **Tensor polarizasion physics of vector mesons (ϕ, K*):**

With the team of P.J. Safaric University, Kosice, Slovakia (according to the collaboration protocol).

– **GRID computing and software activities.**

– **Participation in the ALICE Shifts (78 shifts in 2018 year – JINR quota).**

ALICE Setup


ACORDE
EMCAL
TRD
HMPID
ZDC
~116m from I.P.
PMD
V0
ABSORBER
TRACKING
CHAMBERS
MUON
FILTER
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
TOF
PHOS
ITS
DIPOLE
MAGNET

The first preliminary results of the 3-D femtoscopic correlation analysis for identical K±K± pair production in p-Pb collisions at 5.02 TeV (per nucleon pair) were obtained in the statistics 160 mln events of Run2 (three times larger as compared with Run1).

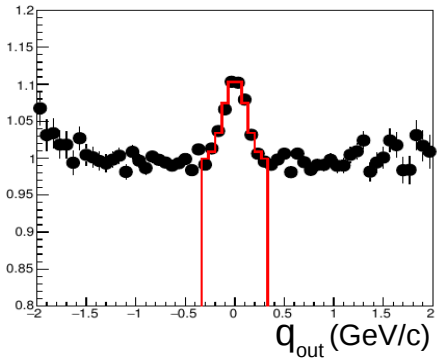


Fig.2. Projection of C(q) in the out direction (Fig.1). Red Line – fit of BS formula.

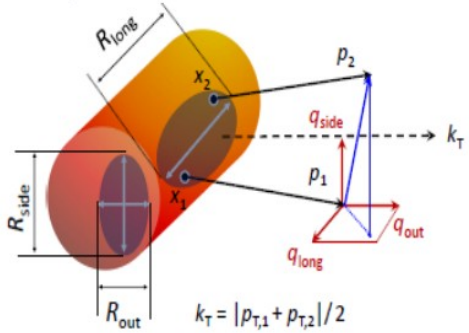


Fig.1. Image of the 3-D particle emission source radii (long || beam).

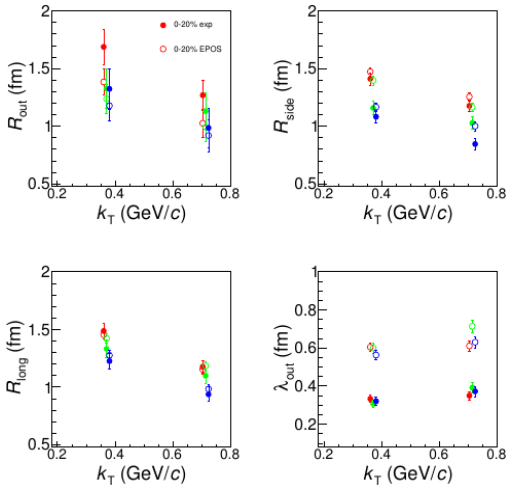


Fig.3. 3-D particle emission source radii (Fig.1) versus transverse pair momentum (k_T) for KK pairs for different collision centralities: 0-20% (blue), 20-40% (green), 40-90% (red). The Results from EPOS model are shown also.

C(**q**) = A(**q**)/B(**q**) – Correlation function), **q** = $\mathbf{p}_1$-$\mathbf{p}_2$,

A(**q**) and B(**q**) – from the same and different (mixed) events respectively.

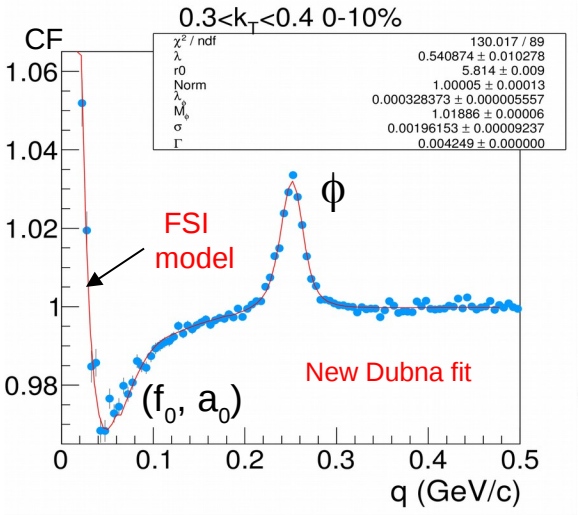
$$C(\mathbf{q}) = N(1-\lambda) + N\lambda K(q)\left[1 + \exp\left(-R_{out}^2 q_{out}^2 - R_{side}^2 q_{side}^2 - R_{long}^2 q_{long}^2\right)\right]$$ -

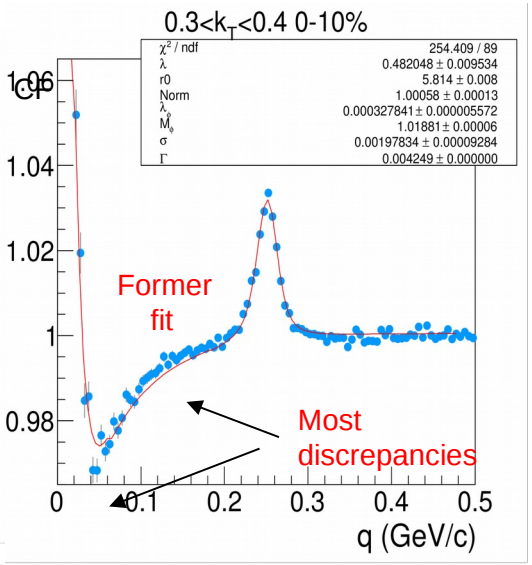
Bowler-Sinyukov formula, where K(q) – Coulomb factor, N (normalization) and λ (correlation strength) – parameters.

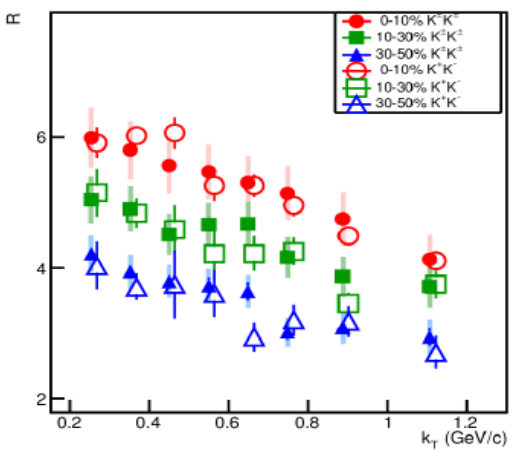
The predicted radii behaviour is seen from Fig.3

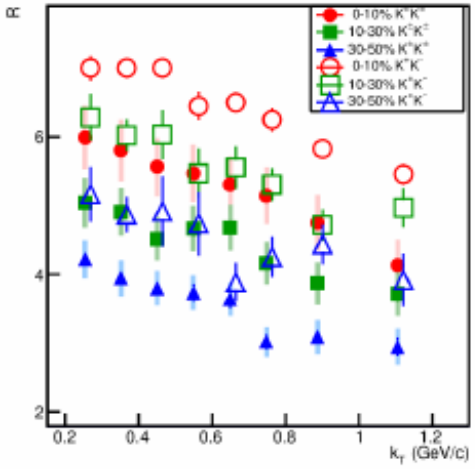
These results were reported in the ALICE Femtoscopic Meeting at CERN.

New preliminary results were obtained by JINR-ALICE group for femtoscopic correlation of nonidentical K^+K^- pairs in Pb-Pb collisions at 2.76 TeV (per nucleon pair).
Comparison with predictions of FSI Model [R.Lednicky, V.Lyuboshitz, Sov.J.Nucl.Phys. 35(1982)770; R.Lednicky Phys.Part.Nucl.40(2009)307] has been done.
The results were reported in the International GDRE XX Workshop (Nantes, France, July 2018).









The correlation functions (CF).

The left panel: New Dubna fit with traditional parameters of $a_0(980)$ (Martin, Achasov, Antonelli) and free parameters for $f_0(980)$,The good data and model agreement is seen. The right panel: Former fit with traditional parameters of f_0 (Martin, Achasov, Antonelli) leads to some data - model discrepancies. The new value of f_0 width, 7.0 ± 2.2 MeV, was obtained from Dubna fit which corresponds to the result of BES3 collaboration, 9.5 ± 1.1 MeV, which is smaller of the mean PDG value, 30-40 MeV.

The theoretical explanation of the BES3 results is the isotopic symmetry violation in the decay channels

$$J/\psi \rightarrow \gamma\eta(1405) \rightarrow \gamma f^0(980)\pi^0 \rightarrow \gamma\pi^+\pi^-\pi^0$$

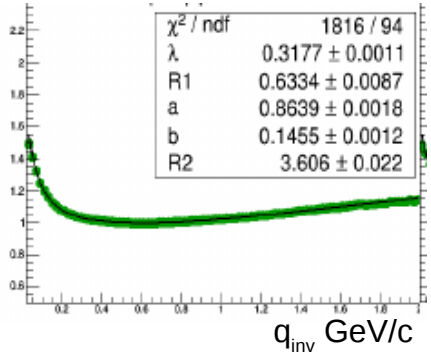
Our results is in under discussion with R. Lednicky using the possible deviation of some model parameters.

The femtoscopic radii (fm) for K^+K^- and identical KK pairs anf different event centralities.

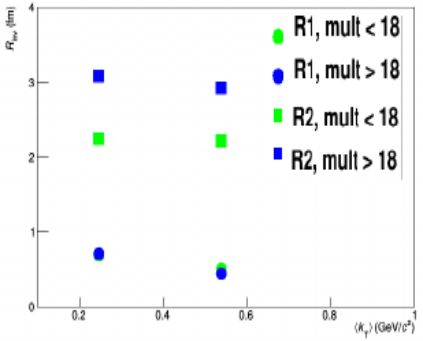
The left panel: the new Dubna fit results for K^+K^- pairs are compatible with the ones for identical charged kaon pairs. The right panel: the former fit results with visible discrepancies between K^+K^- and identical charged kaon pairs which are not clear with the theoretical point of view.

New preliminary results of the 1-D femtoscopic correlation analysis for identical $\pi^{\pm}\pi^{\pm}$ and $K^{\pm}K^{\pm}$ pairs production in pp collisions at 13 TeV were obtained in the statistics 1500 mln events of Run2 with a fit of CF by the **double Exponential functions:** $C(q_{inv}) = 1 + (1-\lambda)\exp(-R_1 q_{inv}) + \lambda\exp(-R_2 q_{inv}) + a + b\, q_{inv}$

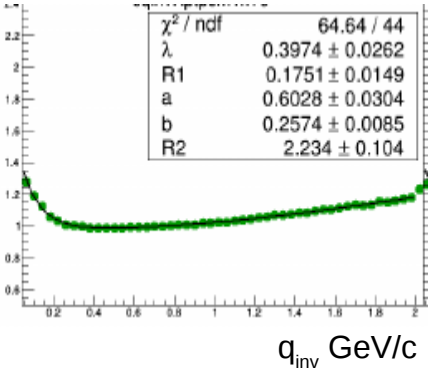
$q_{inv} = \sqrt{|\mathbf{q}|^2 - q_0^2}$, $\mathbf{q} = \mathbf{p}_1 - \mathbf{p}_2$, $q_0 = E_1 - E_2$



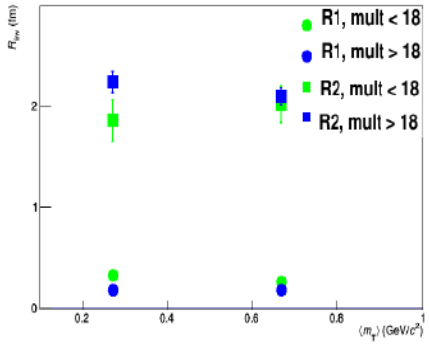
Correlation function for pions



Radii for pions versus $K_T = (p_{T_1} + p_{T_2})/2$ for different event multiplicities



Correlation function for kaons



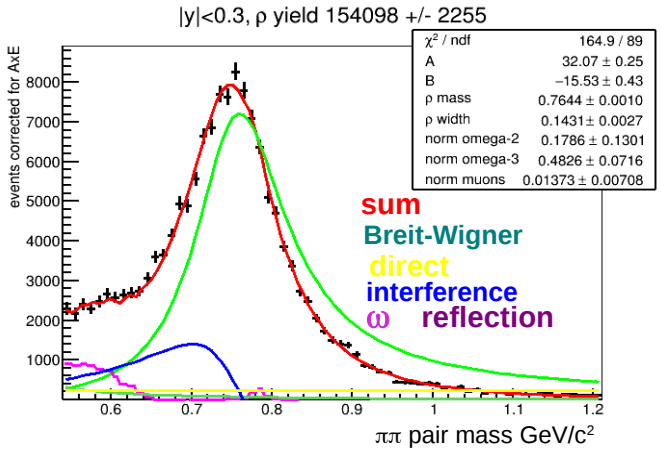
Radii for kaons versus KT for different event multiplicities

Theoretical motivations of the double exponential fit are two scales of radii according to the direct (smaller R) and resonance Decay (larger R) particles [R.Lednicky, Progulova, Z.Phys.C55 (1992) 295], or one-Pomeron (smaller R) and multi-Pomeron (larger R) exchange mechanisms (V.A.Khoze et al., EPJ, C76 (2016) 1931601).

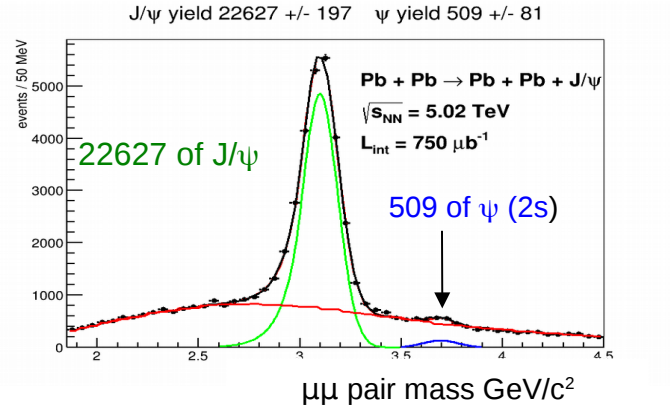
The very small R_1 radii for kaons (~0.2 fm) are under discussion.

These results were reported in the ALICE Femtoscopic Meeting at CERN.

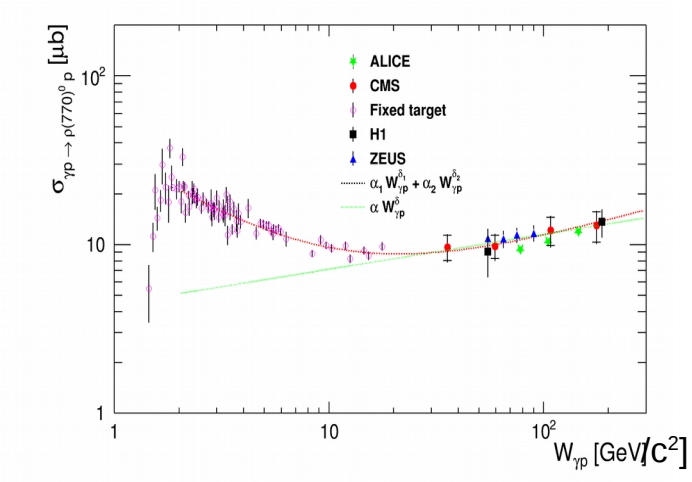
New (preliminary) results were obtained with the JINR team participation for the ρ^0, J/ψ and ψ(2s) coherent photoproduction (photons Interect through Pomeron with whole nucleus) in ultraperiferel Pb-Pb and Pb-p collisions (UPC) at 5.02 TeV per nucleon pairs. The results were presented in the CERN UPC Meeting.



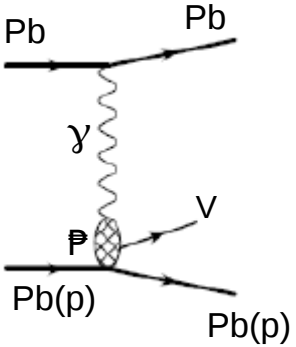
Mass spectrum of unlike pions pairs in Pb-Pb UPC.
The fit was done by the function (red) with a convolution of all contributions.

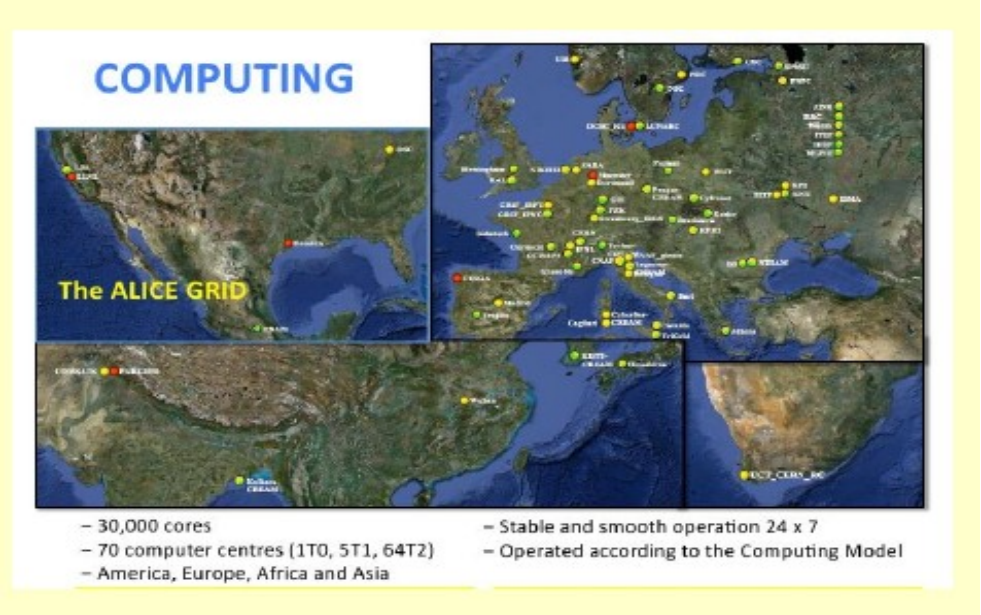


Spectrum of ($\mu^+\mu^-$) pair invariant mass in Pb-Pb UPC.
Black line is the fit result of the data with the convolution of Crystal-Ball function (green) and background continuum (red).
Blue line is Breit-Wigner fit of ψ(2s).



Total cross section versus (γP) mass of ρ^0 production In Pb-p UPC. The lines are the fit results with single or double power functions.

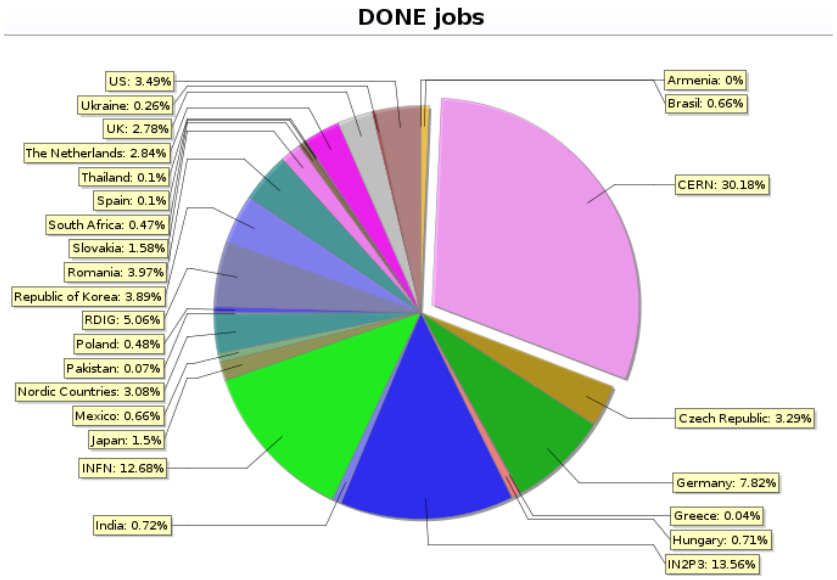




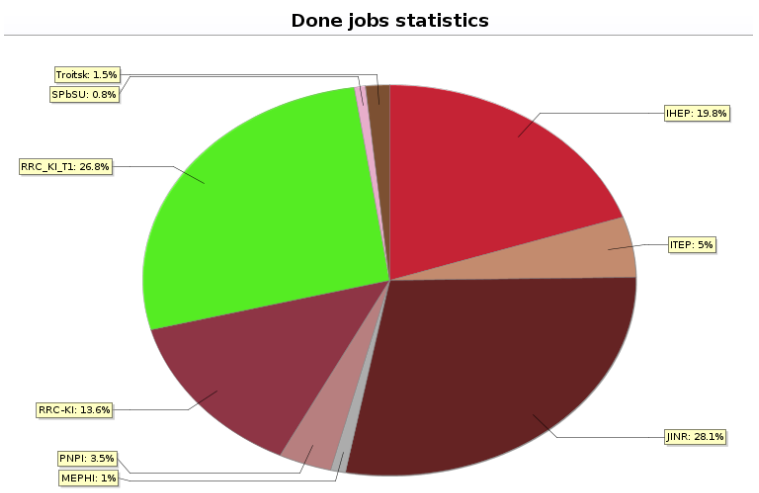
The JINR ALICE GRID is going in the Frame of 9-th Russian ALICE GRID Centers (RDIG – Russian Data Intensive Grid).

The resource of JINR GRID Farm: 6500 cores CPU, 438 Tb Disk-SE.

In additional there is ALICE analysis Farm: 48 cores, 14 Tb Disk-SE.



RDIG contribution to the ALICE-GRID is 5.6%



JINR contribution to the RDIG-GRID is 22% (near 8×10^5 events per year).

Conferences in the 2018 year.

1. K. Mikhaylov (JINR/Moscow ITEP), “Non-identical kaon femtoscopy with ALICE experiment”, XX GDRE Workshop, Subatech, Nantes, July 2018.

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

3. G.Stiforov (JINR), A.Zarochentsev (SpbSU), “Operations and plans – RDIG”, T1/T2 Workshop (Derby. GB, April, 2018).

Publications in the 2018 year with a most activity of JINR group.

1. **“**Azimuthally differential pion femtoscopy relative to the third harmonic event plane in Pb-Pb collisions at $(s_{NN})^{1/2}$ = 2.78 TeV.”, ALICE Collaboration (S.Acharya et al.), Phy.Lett. B785 (2018) 320-331.

2. “pp, p-Λ and Λ-Λ correlations studied via femtoscopiy in pp reactions at $s^{1/2}$ = 7 TeV”, ALICE Collaboration (S.Acharya et al), arXiv:1805.12455, 2018.

3. “ Measuring $K^0_s K^{\pm}$ interactions using pp collisions at $s^{1/2}$ = 7 TeV”, ALICE Collaboration, (S.Acharya et al), arXiv:1809.07899, 2018.

4. “Inclusive J/P production in Xe-Xe collisions at $(s_{NN})^{1/2}$ = 5.02 TeV”, ALICE Collaboration

(S.Acharya et al) , Phys.Lett. B785 (2018) 419-428. “
“

Other scientific activities.

– Election of Ludmila Malinina (JINR/Moscow St. University, SINR) as the ALICE convener of Femtoscopy Analysis team.

– Participation of L. Malinina (chair person), K. Mikhaylov (chair person) and E. Rogochaya in the Inner Review Committees (IRC) for the different ALICE publications.

– Participation in the 78 ALICE shifts for the collection of experimental data.

Conclusions

– The JINR ALICE team carries out successfully the physical analysis of the experimental data.

– All analysis results were reported in the International Forums and some finished ones were published in the Periodical Journals. Some other publications are under preparation.

– The JINR ALICE GRID is going with good results.

JINR plans for the 2019 year.

– Finish the paper of 1-D femtoscopic analisys for charged kaon pairs in p-Pb at 5.02 TeV.

– Start the paper for femtoscopic analysys for $K^{+}K^{-}$ pairs in Pb-Pb collisions at 2.76 TeV.

– Go on the femtoscopic analysis, using the large Run2 total statistics for minimum bias events: ~1700 mln of pp at 13 TeV (4 X Run1), ~760 mln of p-Pb at 5.02 TeV (3 X Run1), ~160 mln of Pb-Pb at 5.02 TeV (5 X Run1).

– 3-D analysys for $K^{ch}K^{ch}$ pairs in Pb-Pb collisions at 5.02 TeV .

– 1-D(3-D) analysys for $K^{ch}K^{ch}$ pairs in the p-p collisions at 13 TeV.

– 3-D analysys for $K^{ch}K^{ch}$ in p-Pb collisions at 5.02 TeV.

– Go on the analysis of J/ψ and ρ^0 photoproduction in the ultraperiferal Pb-Pb collisions at 5.02 TeV. Start the paper preparation for ρ^0 production.

– Update and support of the quarkonia production software and generators.

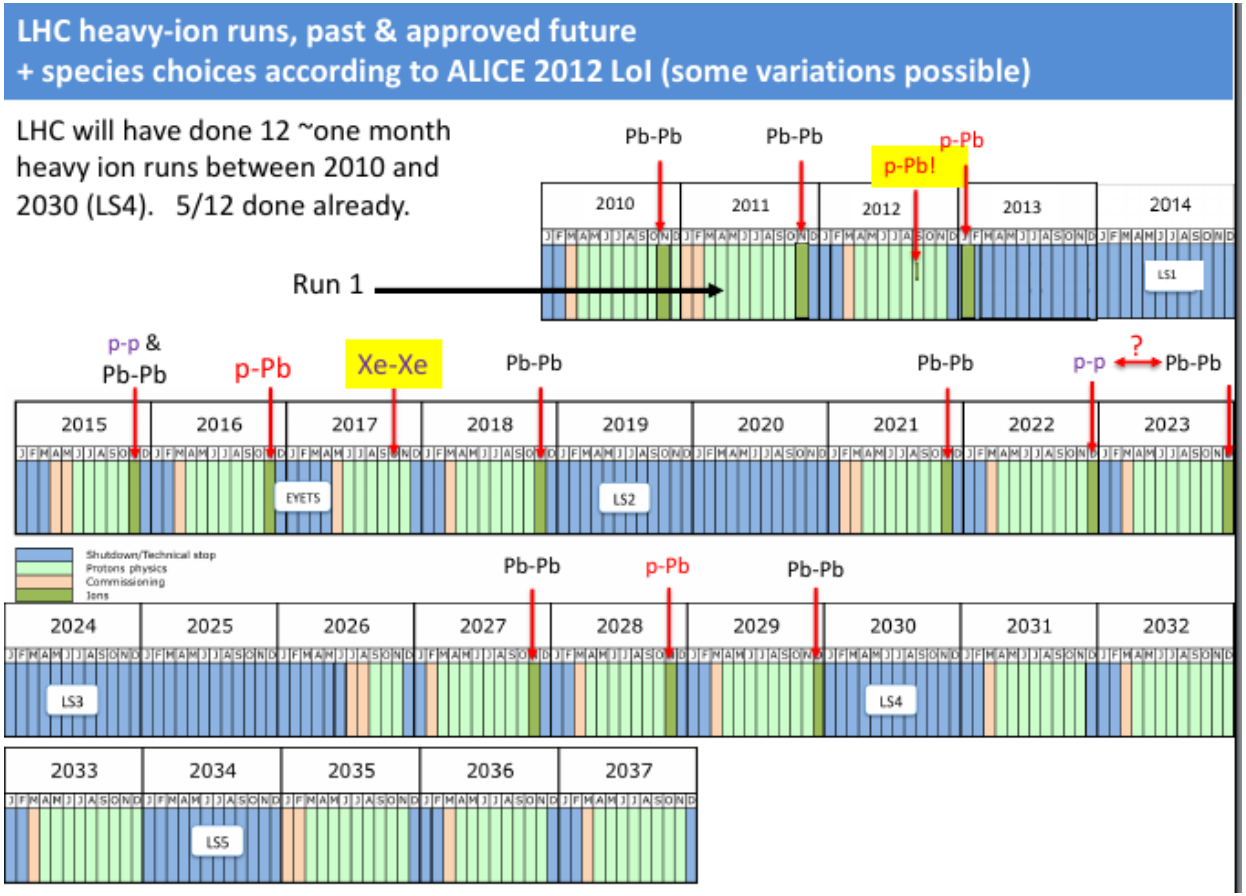
– Maintenance of the ALICE GRID software in the JINR computing system.

– The preparation all documents and reports for the JINR-ALICE Project prolongation.

Thank you for your attention

Backup

ALICE future (perspective) plans.



Fore Pb-Pb at 5.02 TeV:

– 2015-2018 years: Run-2, ~1 nb^{-1} of integrated Luminosity (L_{int})

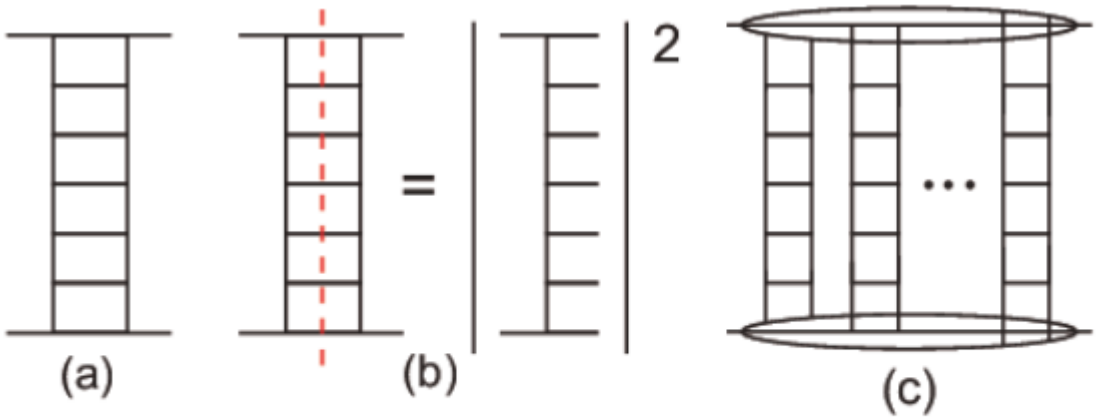
– 2021-2023 years: Run-3, $L_{int} \cong 6\ nb^{-1}$; start of High Luminosity LHC (HL LHC) with the $L_{peak} = 6\cdot10^{27}\ cm^{-2}s^{-1}$

– 2018-2023 years: the Medium Term Plan approved by CERN Council with strong support.

– 2026 -2029 years: Run-4, HL LHC, $L_{int} \cong 7\ nb^{-1}$;

– up to 2037 year: HL LHC → Run5, Run6, but (?) possible start of the Future Circular Collider (FCC).

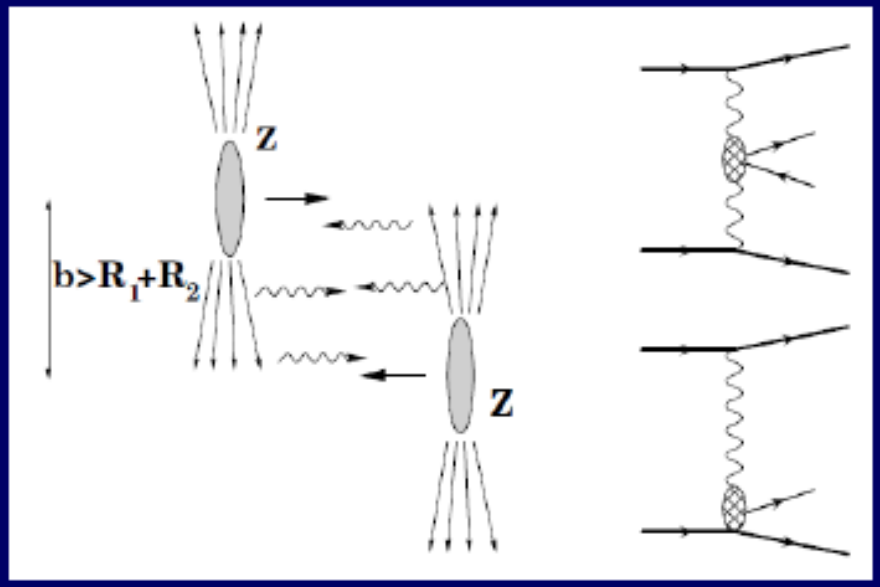
The JINR team considers the suggestions for a participation in the future HL LHC and possible FCC experiments with up to $(s_{NN})^{1/2}$ = 39 and 63 TeV for Pb-Pb and p-Pb collisions, respectively.



(a) The ladder diagram for one-Pomeron exchange; (b) cutting one-Pomeron exchange
e multiperipheral chain of final state particles; (c) a multi-Pomeron exchange diagram.

The pairs of particles may be created with the both ones from the same one-Pomeron ladder (the smaller R of particle source), or from the different Pomeron ladders (larger R).

Ultra-Peripheral Collisions (UPC) of heavy ions



Ultra-peripheral collisions (UPC) occur when ions collide at impact parameter *b* greater than sum of nuclear radii. Thus UPC are photon-induced reactions.

Electromagnetic field in UPC is described by a flux of virtual photons within Weizsäcker-Williams approach and intensity of the field is proportional to Z^2

UPC offer pure EM two-photon or photo-nuclear collisions

The LHC in heavy-ion mode works as a powerful source of quasi-real photons

Vector meson (VM) photoproduction (photon-Pomeron exchange) can occur either coherently off whole nucleus (p_T~30 MeV/c) or incoherently off nucleons (p_T~300 MeV/c)

UPC studies are mainly intended to address gluon shadowing in nuclei

UPC review : A.J. Baltz et al., Phys.Rept. 458 (2008) 1.

Future Circular Collider Study
Goal: CDR for European Strategy Update 2018/19

International FCC collaboration (CERN as host lab) to design:

- ***pp*-collider (*FCC-hh*)**
  → main emphasis, defining infrastructure requirements

~16 T ⇒ 100 TeV *pp* in 100 km

- **80-100 km tunnel infrastructure** in Geneva area, site specific
- ***e*⁺*e*⁻ collider (*FCC-ee*),** as a possible first step
- ***p-e* (*FCC-he*) option,** one IP, FCC-hh & ERL
- **HE-LHC** w *FCC-hh* technology