NA62 PROJECT REPORT

1. General information on the project

1.1. Scientific field
Elementary Particle Physics and Relativistic Nuclear Physics

1.2. Title of the project
Rare decay $K^+ \rightarrow \pi^+ \nu\nu$ measurement at CERN SPS (NA62 experiment)

1.3. Project code ***02-1-1096-1-2010/2024***

1.4. Theme code ***02-1-1096-2010***

1.5. Actual duration (reporting period) of the project ***2021-2024***

1.6. Project Leader V. D. Kekelidze (deputy D.T. Madigozhin)

2. Scientific report

2.1. Annotation

The project is a continuation of the four stages of the NA62 project implemented at VBLHEP JINR in 2010-2021. The aim of all phases of the project is participation in the NA62 experiment at SPS CERN, which plans to measure the very rare decay $K^+ \rightarrow \pi^+ \nu\nu$, that will be a decisive test of the Standard Model (SM) by measuring the V_{td} parameter of the Cabibbo-Kobayashi-Maskawa matrix (CKM) with an accuracy of the order of 10%. The strategy of the NA62 experiment is based on measuring high-energy kaon decays in flight. The large kaon decay flux required for such a measurement allows planning a number of parallel precision measurements for rare kaon decay modes, allowing one to test the applicability of the SM and chiral perturbation theory (ChPT), which provides a low-energy approximation for describing strong interactions.
As part of the NA62 experiment at CERN, the JINR and CERN groups were jointly responsible for the design, production, calibration and operational support of the NA62 magnetic spectrometer, as well as the development of software for modeling and reconstructing the events recorded in the spectrometer. In addition, the JINR group is involved in the analysis of experimental data of NA48/2 and NA62.

During the reporting period, the result of measuring the $K^+ \rightarrow \pi^+ \nu\nu$ decay probability was published based on 20 selected candidates registered in 2016-2018. In addition, a number of measurements and searches for rare and forbidden decays of charged kaons at the limit of the intensity of the decay flux have been performed, which makes it possible to refine the ChPT parameters and establish additional restrictions for the possibility of going beyond the Standard Model. NA62 data collection continues to achieve the originally planned accuracy in measuring the decay of a charged kaon into a pion and two neutrinos.

2.2. A detailed scientific report

2.2.2. A description of the conducted experiment.

The project goal is the participation in the NA62 experiment at SPS CERN, where a measurement of the very rare kaon decay $K^+ \to \pi^+ \nu\nu$ is planned to make a decisive test of the Standard Model (SM) by means of measurement of the Cabibbo-Kobayashi-Maskawa (CKM) matrix parameter *Vtd* with a precision of the order of 10%. The project is a continuation of the four stages of the NA62 project, implemented in VBLHEP JINR in 2010 - 2021.

Using the Wolfenstein notation of CKM, the relationship between the parameters ρ and η may be represented by the unitarity triangle shown in Figure 1. The "golden modes" $K^0 \to \pi^0 \nu\nu$ and $K^+ \to \pi^+ \nu\nu$ give an opportunity to make a very sensitive tests of SM, as their probabilities are directly related to η^2 (height of the triangle) and $(\rho - 1.4)^2 + \eta^2$. The SM predictions for these two decay rates have accuracy to 2% and 8% respectively, and in the case if significant deviations from the predictions will be observed, it will undoubtedly be the evidence of the phenomenon beyond the SM.

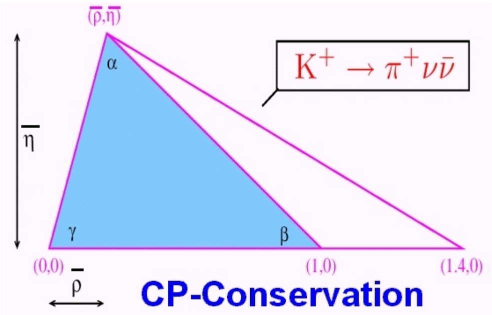

Figure 1. The decay $K^+ \to \pi^+ \nu\nu$ probability defines the length of the right segment of the triangle.

Large kaon flux makes it possible to search for other rare kaon decays and to study their characteristics, including a check of the existence of Goldstone fermion superpartners. A series of precision measurements may be performed for the kaon rare decay modes to check the validity of the Chiral perturbation theory (ChPT). Search for the rare decays forbidden or suppressed in the frameworks of SM opens a possibility to discover a new physics or to set new limits on the validity of SM and some its extensions. It includes the search for the light candidates to the dark matter that may be generated in rare kaon decays, including heavy neutral lepton.

The strategy of the ongoing NA62 experiment is based on the measurement of the high energy K^+ decays in flight. In this case, the kaons production cross section is optimized as a function of the proton energy, and the photons detection is efficient due to their high energies in the laboratory system.

NA62 experimental setup (Figure 2) includes the following detector systems:

- **CEDAR** identifies the K^+ component in the beam with respect to the other beam particles by employing an upgraded differential Čerenkov counter.

- Gigatracker **(GTK)** consists of three Si micro-pixel stations measuring time, direction and momentum of the beam particles.

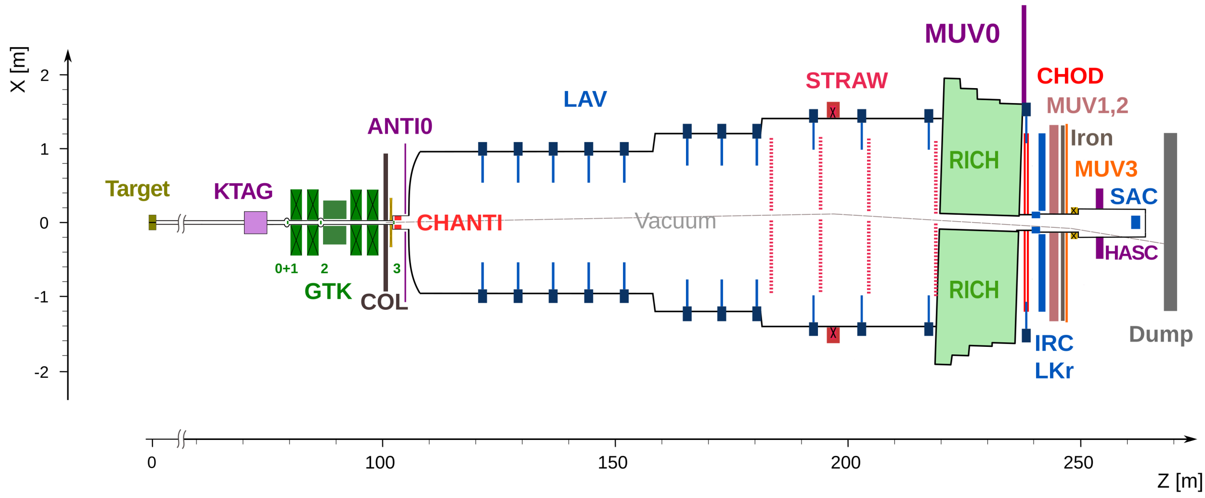

Figure 2. Schematic view of the NA62 experimental setup.

- **STRAW tracker** consists of 4 straw chambers. It measures the coordinates and momentum of secondary charged particles originating from the decay region. In order to minimize multiple scattering the chambers are built of ultra-light material and are installed inside the vacuum tank. The four Straw chambers are arranged around a large aperture dipole magnet (MNP33, black at the scheme), providing a vertical B-field of 0.36 T.

- **RICH detector** consists of 17m long radiator filled with Neon gas at 1 atm. allowing the separation of pions and muons between 15 and 35 GeV/c.

- A system of Photon-Veto detectors provides hermetic coverage of the decay region from zero to large (~50 mrad) angles. This is assured by: the high-resolution Liquid Krypton electromagnetic calorimeter (**Lkr**), the Intermediate Ring (**IRC**) and Small-Angle (**SAC**) Calorimeters and a series of 12 annular photon-veto (**LAV**) detectors.

- The Muon-Veto detectors (**MUV**) are composed of the two-part hadron calorimeter followed by the additional layer of iron and the transversally segmented hodoscope. This system provides redundancy in the detection of muons.

These detectors are complemented by “guard-ring” counters (**CHANTI**) surrounding the last GTK station, and the charged-particle hodoscope (**CHOD**), covering the acceptance and located between the RICH and the LKr. Additional **ANTI0** and **HASC** veto counters make it possible to reduce the background from interactions in the beam and from some rare decays. All the detectors are operated and inter-connected with a high-performance **trigger** and **data-acquisition** (**TDAQ**) system.

During the previous implementation period of the project, NA62 experimental setup has been constructed and tested in 2014 with CERN SPS beams. Experts from JINR and CERN have provided the construction and installation of the track spectrometer detectors designed and built during the two NA62 project stages completed in JINR earlier (in 2010-2012 and in 2013-2015).

2.2.3. A description of the research undertaken and the results obtained.

In the framework of the NA62 experiment at CERN, the JINR and CERN groups are jointly responsible for the development, production, calibration and maintenance of the NA62 magnetic spectrometer, as well as the development of software for modeling and reconstructing events recorded in the spectrometer. In addition, the JINR group is involved in the analysis of the experimental data of NA48/2 and NA62.

The following main results (not included in the previous report) were obtained in 2021, 2022, 2023 and 2024. These were the years of NA62 data acquisition after two years of "Long Shutdown" of the LHC accelerator at CERN in 2019-2020.

According to the topical plan:

1 During 2021, 2022 and 2023, the JINR group provided one of two main experts for the Spectrometer (Sergei Shkarovskiy), who also is the main expert on the Spectrometer Detector Control System (DCS). He participated in the Spectrometer control during the NA62 runs and in the DCS maintaining and development.

2 Analysis of the NA48/2 and NA62 experimental data was continued:

- In June 2021, a new NA62 result on measuring the relative probability of the $K^+ \to \pi^+ \nu\nu$ decay, based on data collected in 2016-2018, was published in a journal [1]:

  $BR(K^+ \to \pi^+ \nu\nu) = (10.6^{+4.0}_{-3.4} \pm 0.9 syst) \times 10^{-11}$ at 68% CL. The measurement is based on 20 selected candidates with an expected background of 7 events, which corresponds to the observation of this rare decay with a statistical significance of 3.4 σ. (Fig. 3 shows 17 candidates from 2018 data set). NA62 data collection continues to achieve the originally planned accuracy of the order of 10%.

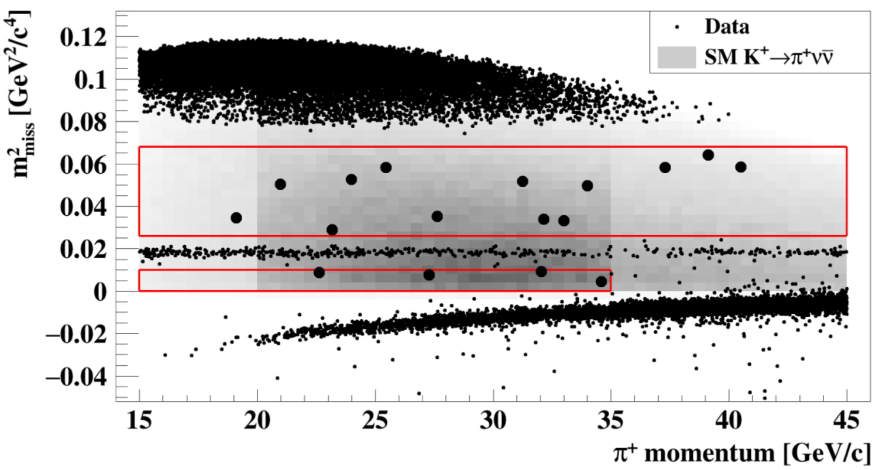

Figure 3. Missing mass squared vs pion momentum for the $K^+ \to \pi^+ \nu\nu$ decay 17 candidates selected from the NA62 data collected in 2018.

- Searches for the lepton number violating decay $K^+ \to \pi^- \mu^+ e^+$ and the lepton flavor violating $K^+ \to \pi^+ \mu^- e^+$ and $\pi^0 \to \mu^- e^+$ decays where performed using data collected by the NA62 experiment at CERN in 2017–2018 [2]. No evidence for these decays is found, and upper limits of the branching ratios are obtained at 90% confidence level: $BR(K^+ \to \pi^- \mu^+ e^+) < 4.2 \times 10^{-11}$, $BR(K^+ \to \pi^+ \mu^- e^+) < 6.6 \times 10^{-11}$ and $BR(\pi^0 \to \mu^- e^+) < 3.2 \times 10^{-10}$. These results improve by an order of magnitude over previous results for these decay modes.

- Searches for $K^+ \to \mu^+ N$ and $K^+ \to \mu^+ \nu X$ decays, where N and X are massive invisible particles, have been performed using the 2016–2018 data set [3]. The N particle is assumed to be a heavy neutral lepton, and the results are expressed as upper limits of $O(10^{-8})$ of the neutrino mixing parameter $|U_{\mu 4}|^2$ for N masses in the range 200–384 MeV/c^2 and lifetime exceeding 50 ns (see Fig. 4 left plot). The X particle is considered a scalar or vector hidden sector mediator decaying to an invisible final state, and upper limits of the decay branching fraction for X masses in the range 10–370 MeV/c^2 are reported for the first time, ranging from $O(10^{-5})$ to $O(10^{-7})$ (see Fig. 4 right plot). An improved upper limit of 1.0×10^{-6} is established at 90% CL on the $K^+ \to \mu^+ \nu\nu\nu$ branching fraction.

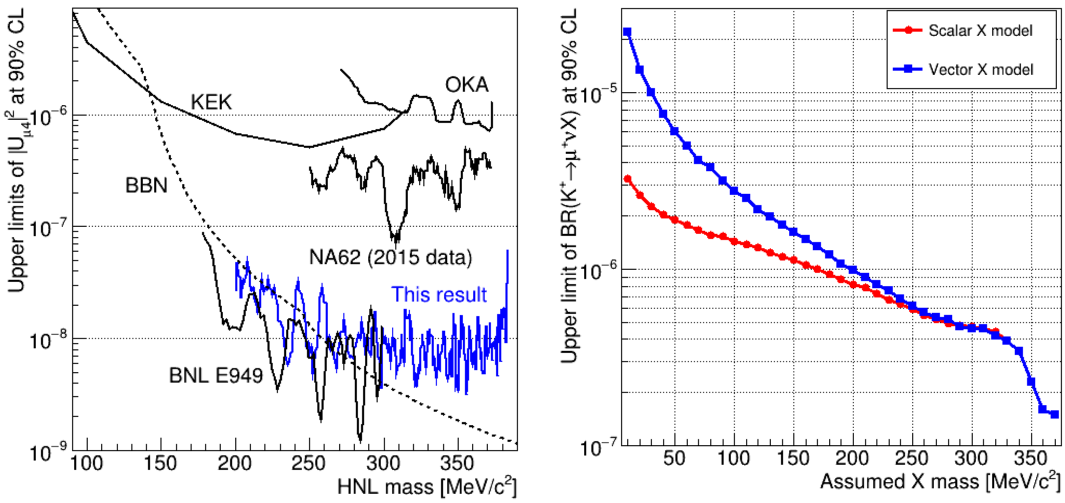

Figure 4. Results of the NA62 searches for $K^+ \to \mu^+ N$ and $K^+ \to \mu^+ \nu X$ decays. Left: Upper limits at 90% CL of $|U_{\mu4}|^2$ obtained for each assumed HNL mass. Right: upper limits of $B(K^+ \to \mu^+ \nu X)$ obtained at 90% CL for each X mass hypothesis for the scalar and vector mediator models.

- A sample of 2.8×10^4 $K^+ \to \pi^+\mu^+\mu^-$ candidates with negligible background collected by the NA62 experiment at the CERN SPS in 2017–2018 was analysed [4]. The model-independent branching fraction is measured to be $(9.15 \pm 0.08) \times 10^{-8}$, a factor three more precise than previous measurements. The decay form factor is presented as a function of the squared dimuon mass. A measurement of the form factor parameters and their uncertainties is performed using a description based on Chiral Perturbation Theory at $O(p^6)$.

- Searches for lepton number violating $K^+ \to \pi^- e^+ e^+$ and $K^+ \to \pi^- \pi^0 e^+ e^+$ decays have been performed using the complete dataset collected by the NA62 experiment at CERN in 2016–2018. Upper limits of and are obtained on the decay branching fractions at 90% confidence level [5]. The former result improves by a factor of four over the previous best limit, while the latter result represents the first limit on the decay rate.

- A search for the $K^+ \to \mu^- \nu e^+ e^+$ decay [6], forbidden within the Standard Model by either lepton number or lepton flavour conservation depending on the flavour of the emitted neutrino, has been performed using the dataset collected by the NA62 in 2016–2018. An upper limit of 8.1×10^{-11} is obtained for the decay branching fraction at 90% CL, improving by a factor of 250 over the previous search.

- The first search for ultra-rare decays of K^+ to the final state $\pi^+e^+e^-e^+e^-$ was performed [7] using a set of data collected during the NA62 experiment at CERN in 2017–2018. An upper limit of 1.4×10^{-8} at 90% CL is obtained for the relative decay probability $K^+ \to \pi^+e^+e^-e^+e^-$, for which the Standard Model predicts $(7.2 \pm 0.7)\times10^{-11}$. Upper limits at 90% CL were obtained at the level of 10^{-9} for the probabilities of two cascades of decay with the formation of pairs of hidden sector mediators: $K^+ \to \pi^+ aa$, $a \to e^+e^-$ and $K^+ \to \pi^+ S$, $S \to A'A'$, $A' \to e^+e^-$.

- The final results of the analysis of the decay $K^+ \to \pi^0 e^+ \nu\gamma$ based on NA62 data have been published [8]. A set of 1.3×10^5 $K^+ \to \pi^0 e^+ \nu\gamma$ candidates with less than 1% background was recorded by the NA62 experiment at CERN SPS in 2017–2018. Measurements of the decay probability in three limited kinematic regions are performed with a relative accuracy of one percent, which improves existing results by more than a factor of two. A possible decay asymmetry associated with T-violation was investigated, but no evidence of its presence was found within the achieved accuracy.

- Dark photons can be generated in the NA62 experiment by protons dumped onto the absorber and reach the decay volume, which begins 80 m further down the beam. A search for dark photons decaying into $\mu^+\mu^-$ in flight was carried out [9] based on the analysis of 1.4×10^{17} protons on an absorber collected in 2021. No evidence of a dark photon signal is observed. A new region of parameter space is excluded at 90% CL, which improves on previous experimental limits in the dark photon mass region from 215 to 550 MeV/c^2.

- A sample of 3984 candidates of the $K^+ \to \pi^+\gamma\gamma$ decay, with an estimated background of 291±14 events, was collected by the NA62 experiment at CERN during 2017–2018 [10]. In order to describe the observed di-photon mass spectrum, the next-to-leading order contribution in chiral perturbation theory was found to be necessary. The decay branching ratio in the full kinematic range is measured to be $(9.61\pm0.17)\times10^{-7}$. The first search for production and prompt decay of an axion-like particle with gluon coupling in the process $K^+ \to \pi^+ a$, $a \to \gamma\gamma$ has been performed.

- The final results of the analysis of the never before observed rare $K_{\mu4}^{00}$ decay have been accepted for journal publication [11]. Based on 2437 detected candidate signals with a signal-to-background ratio of about 6 (Fig. 5), the relative decay probability was determined with high accuracy. In the region of squared dilepton masses above 0.03 GeV^2/c^4, the probability of decay is $BR(K_{\mu4}^{00}, S_l>0.03) = (0.65\pm0.03)\times10^{-6}$. The result for the full phase space $BR(K_{\mu4}^{00}) = (3.4 \pm 0.2) \times 10^{-6}$, depending on the extrapolation based on the decay model, is in reasonable agreement with the prediction of the form factor R from the 1-loop approximation of Chiral Perturbation Theory (Fig. 6).

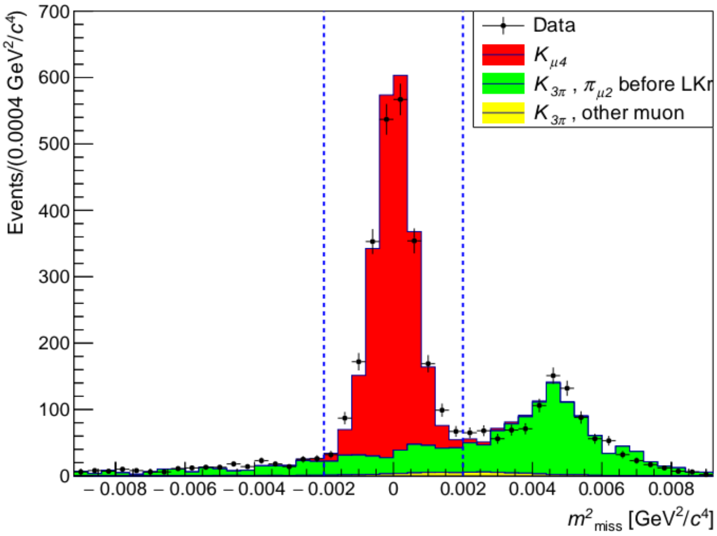

Figure 5. Distribution of squared missing mass for selected experimental data events (markers), as well as simulated background and signal contributions (histograms). Vertical lines show the signal area.

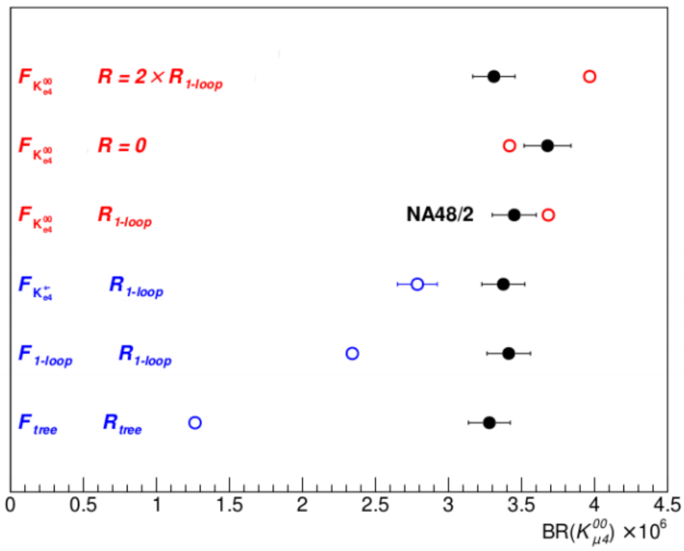

Figure 6. Comparison of the BR($K_{\mu4}^{00}$) value (solid markers) obtained from six different form factor models with the corresponding theoretical calculations (open markers). The lower three values are obtained using the F and R form factors from the CPT tree approximation, the one-loop approximation, and the beyond one-loop approximation, respectively. In the fourth comparison, the description of F obtained from the K_{e4}^{+-} measurement is replaced by a more accurate one obtained from the K_{e4}^{00} data. The last two values represent variations in the R description that are less consistent with the NA48/2 result.

- In the Dubna group, based on NA62 data, the analysis of the following kaon decay modes continues: $K^+ \to \pi^+\pi^-\mu^+\nu$, $K^+ \to \mu^+\mu^-\mu^+\nu$, $K^+ \to e^+e^-\mu^+\nu$, $K^+ \to \mu^+\mu^-e^+\nu$, $K^+ \to e^+e^-e^+\nu$, $K^+ \to \pi^+e^-e^+\gamma$. Signals are observed, development of event selection algorithms continues.

In parallel with the experimental works, the following methodical and theoretical results have been obtained:

- The technology for producing straws with a diameter of 5 mm and a wall thickness of 19 μm has been improved, and new straws have been made for prototyping purposes. Two prototypes of the new straw-based tracker were built and tested using the Fe-55 radioactive source with new FPGA-based NA62 electronics. A technology for manufacturing straws from a 12 mm thick Mylar film is being developed. The Dubna group took part in sessions on SPS test beams. Mass production of straws with a length of 2.5 m, a diameter of 5 mm and a wall thickness of 20 mm has begun. The prototype electronics of the new NA62 straw chamber have been tested both on the beam and in the laboratory. A new gas gain monitor with a new interface has been developed [12]. A new device has been developed to measure the tension of the anode wire. Preliminary muon beam measurements made using straw tube chambers on the CERN SPS test beam were compared with predictions obtained using the GARFIELD simulation package coupled with the LTSpice electronic circuit simulation software [13,14].

- Production of charged pairs in the Coulomb field of the nucleus has been studied and calculated in the Born approximation using explicit expressions for the differential cross sections and their connection with the total cross section $\sigma(\gamma\gamma \to \pi^+\pi^-)$ [15]. Production of unstable particles on various nuclei makes it possible to determine the total cross section for the interaction of vector mesons with nucleons [16]. This interaction is determined by a set of amplitudes corresponding to the transverse or longitudinal polarization of the vector meson. The total cross section for the interaction of transversely polarized vector mesons with nucleons was obtained from the coherent photoproduction of vector mesons on nuclei, and the production of vector mesons in charge exchange reaction $\pi^{\pm}(K^{\pm})+A \to V^0(K^{*0})+A'$ provides a unique opportunity to obtain not yet measured total cross section of a longitudinally polarized vector meson interacting with a nucleon.

- A technique has been developed and software has been written to calibrate the LKr response based on reconstructed decays of a neutral pion into a pair of photons [17].

Obtained results were presented at the international conferences, including 17 presentations of JINR group representatives. Experts from JINR participated in 236 shifts on site during the experimental runs at SPS in 2021, 2022 and 2023, participation in the 2024 and 2025 runs is planned.

2.2.4. List of the main publications of the JINR authors on the results of the project.

1. E. Cortina Gil et al. (NA62 collaboration). Measurement of the very rare $K^+ \to \pi^+ \nu\nu$ decay. *JHEP* 06 (2021) 093. Jun 15, 2021.
2. E. Cortina Gil et al. (NA62 collaboration). Search for Lepton Number and Flavor Violation in K^+ and π^0 Decays. *Phys.Rev.Lett.* 127 (2021) 13, 131802. Sep 24, 2021.
3. E. Cortina Gil et al. (NA62 collaboration). Search for K^+ decays to a muon and invisible particles. *Phys.Lett.B* 816 (2021) 136259. May 10, 2021.
4. E. Cortina Gil et al. (NA62 collaboration). A measurement of the $K^+ \to \pi^+ \mu^+ \mu^-$ decay. *JHEP 11 (2022) 011.*
5. E. Cortina Gil et al. (NA62 collaboration). Searches for lepton number violating $K^+ \to \pi^-(\pi^0)e^+e^+$ decays. *Phys.Lett.B* 830 (2022) 137172.
6. E. Cortina Gil et al. (NA62 collaboration). A search for the $K^+ \to \mu^- \nu e^+ e^+$ decay. *Phys.Lett.B* 838 (2023) 137679.
7. E. Cortina Gil et al. (NA62 collaboration). Search for K^+ decays into the $\pi^+ e^+ e^- e^+ e^-$ final state. *Phys.Lett.B* 846 (2023) 138193.
8. E. Cortina Gil et al. (NA62 collaboration). A study of the $K^+ \to \pi^0 e^+ \nu\gamma$ decay. *JHEP* 09 (2023) 040.
9. E. Cortina Gil et al. (NA62 collaboration). Search for dark photon decays to $\mu^+\mu^-$ at NA62. *JHEP* 09 (2023) 035.
10. E. Cortina Gil et al. (NA62 collaboration). Measurement of the $K^+ \to \pi^+ \gamma\gamma$ *decay. Phys.Lett.B 850 (2024) 138513.*
11. R.J. Batley et al. (NA48/2 collaboration). First observation and study of the $K^{\pm} \to \pi^0 \pi^0 \mu^{\pm} \nu$ decay. E-Print: 2310.20295 [hep-ex]. Accepted for publication in the Journal of High Energy Physics.
12. V. Bautin, K. Salamatin, T. Enik, O. Minko, Y. Kambar. Online Gas Gain Monitoring System. *Phys.Part.Nucl.Lett.* 20 (2023) 5, 1240-1242.
13. A. Zelenov, V. Bautin, S. Bulanova, T. Enik, E. Kuznetsova, V. Maleev, S. Nasybulin, K. Salamatin, D. Sosnov. Testbeam measurements and realistic simulation for straw drift tubes. *Phys.Atom.Nucl.* 86 (2023) 5, 832-837.

14. V. Bautin, M. Demichev, T. Enik, E. Kuznetsova, V. Maleev, R. Petti, S. Nasybulin, K. Salamatin, D. Sosnov, A. Zelenov. VMM3 ASIC as a potential front end electronics solution for future Straw Trackers. *Nucl.Instrum.Meth. A* 1047 (2023) 167864.
15. S. Gevorkyan, I. Larin, R. Miskimen, E. Smith. Photoproduction of pion pairs at high energy and small angles. *Phys.Rev.C 105 (2022) 6, 065202.*
16. S.R. Gevorkyan, A.V. Guskov. Impact of vector mesons polarization on its interaction with matter. Eur. Phys. J. C. 84 (2024) 1, 7.
17. F. Brizioli, D. Madigozhin, K. Massri, LKr energy fine calibration based on $\pi^0 \rightarrow \gamma\gamma$ decay. Internal note NA62-21-01, 2021.

2.2.5. A complete list of publications is in the electronic annex.

2.2.6 List of talks given at international conferences and meetings is in electronic annex.

2.3. Status and stage of the project:

ongoing project, the stage of data taking and analysis.

2.4. Results of related activities

2.4.1. Research and education activities.

Project employee V.N. Gorbunova in 2021-2022 conducted educational activities within the framework of cooperation between JINR and the University "Dubna":

18. *Lectures were given for the department "Designing electronics for megascience installations”: "Physical and chemical foundations of technology of electronic means", "Quality management of electronic means".*
19. *Support was provided for the functioning of the classroom and laboratory room for lectures and practical work classes for the departments: "Design of electronics for megascience installations" and "Department of physical and technical systems ".*
20. *Educational and methodological work was carried out with graduate students in the direction of training "System Analysis, Management and Information Processing".*

    Project employee A. Baeva in 2021 and 2022 was a lecturer at the JINR University Centre for Seminars on methods of elementary particle physics for students of Moscow State University and Moscow Institute of Physics and Technology.

2.4.2. JINR grants (scholarships) received.

Project employee A. Baeva received the "Grant for Young Scientists and Specialists of JINR 2022".

2.4.4. Other results (expert investigation, organizational, outreach activities).

Project employee D.T. Madigozhin was a member of the jury of the JINR Prize for 2021 and a member of the jury of the VBLHEP Markov Scholarship for 2021 and 2022.

3. International cooperation

Actually participating countries, institutions and organizations

Organization	Country	City	Participants	Kind of agreement
Centre de Physique de Particules de Marseille	France	Marseille	M. Perrin-Terrin	MoU CERN
Charles University	Czech Republic	Prague	K. Kampf + 7	MoU CERN
Comenius University	Slovakia	Bratislava	T. Blazek + 6	MoU CERN
Ecole Polytechnique Federale Lausanne	Switzerland	Lausanne	R.I. Marchevski + 4	MoU CERN
European Organiz. for Nuclear Res. (CERN)	Switzerland	Geneva	A. Ceccucci + 31	MoU CERN
George Mason University	USA	Fairfax	P.D. Rubin + 3	MoU CERN
Horia Hulubei National Institute of Physics and Nuclear Engineering	Romania	Bucharest	A.M. Bragadireanu+4	MoU CERN
INFN Sezione di Pisa, Universita' e Scuola Normale Superiore	Italy	Pisa	M.S. Sozzi +15	MoU CERN
Institute for High Energy Physics of NRC Kurchatov Institute	Russia	Protvino	V. Obraztsov + 15	MoU CERN
Institute for Nuclear Research	Russia	Moscow	Y. Kudenko + 7	MoU CERN
Institute of Nuclear Physics	Kazakhstan	Almaty	Y. Kambar + 5	MoU CERN
Instituto de Fisica	Mexico	San Luis Potosi	J. Engelfried + 5	MoU CERN
Johannes Gutenberg Universitaet	Germany	Mainz	R. Wanke + 10	MoU CERN
Laboratori Nazionali di Frascati	Italy	Frascati	A. Antonelli + 15	MoU CERN
Max-Planck-Institut fur Physik	Germany	Munich	B. Dobrich + 5	MoU CERN
Lancaster University	United Kingdom	Lancaster	R. Jones + 5	MoU CERN
University of Bristol	United Kingdom	Bristol	Helen F. Heath	MoU CERN
Sezione di Roma I (INFN)	Italy	Rome	M. Raggi + 13	MoU CERN
Sezione di Roma Tor Vergata INFN	Italy	Rome	R. Ammendola + 5	MoU CERN
SLAC National Accelerator Laboratory	USA	Menlo Park	D. Coward	MoU CERN
TRIUMF	Canada	Vancouver	D.A. Bryman + 4	MoU CERN
Universita degli studi di Ferrara	Italy	Ferrara	A. Gianoli + 21	MoU CERN
Universita e INFN, Firenze	Italy	Firenze	F. Bucci + 10	MoU CERN
Universita e INFN, Perugia	Italy	Perugia	M. Pepe + 11	MoU CERN
Universita e INFN Torino	Italy	Torino	C. Biino + 12	MoU CERN
Universita Federico II e	Italy	Naples	F. Ambrosino + 11	MoU CERN

INFN Sezione di Napoli				
Universite Catholique de Louvain (UCL)	Belgium	Louvain	E.C. Gil + 4	MoU CERN
University of Birmingham	United Kingdom	Birmingham	C. Lazzeroni +13	MoU CERN
University of British Columbia	Canada	Vancouver	D. A. Bryman	MoU CERN
University of Glasgow	United Kingdom	Glasgow	D. Britton + 3	MoU CERN

4. Analysis of planed vs actually used resources: manpower (including associated personnel), financial, IT, infrastructure

4.1 Manpower (actual at the time of reporting)

No.	Personnel category	JINR staff, amount of FTE	JINR associated personnel, amount of FTE
1.	research scientists	10.6	0
2.	engineers	0.7	0
3.	specialists	1.0	0
	Total:	**12.3**	**0**

4.2 The actual estimated cost of the project

Names of costs, resources, funding sources		Cost (thousands of US dollars) / Resource request	Allocation of funding and resources				
			2021 year	2022 year	2023 year	4	5
	International cooperation	223.7	55.0	85.0	83.7		
	Materials	273.3	133.6	67.3	72.4		
	Equipment, Third-party company services						
	Commissioning						
	R&D contracts with other research organizations						
	Software purchasing						
	Design/construction						
	Service costs (*planned in case of direct project affiliation)*						
R es St a n d	Resources						

ources required	ard hours	- the amount of FTE,	36.9	12.3	12.3	12.3		
		- accelerator/installation,						
		- reactor,…						
Sources of funding	JINR Budget	JINR budget *(budget items)*	497.0	188.6	152.3	156.1		
	Extra fudning (supplementary estimates)	Contributions by partners Funds under contracts with customers Other sources of funding						

5. Conclusion

At the current stage, the NA62 facility is working successfully, new data is being collected, publications are being published based on the results of the analysis of the data collected in 2016-2018. To continue the work, mainly current costs for participation in data collection sessions and conferences are required, as well as material costs for research and development in the field of new straw cameras, which are also used in a number of other JINR projects. The published results were obtained at the limit of the intensity of kaon decays available in the world. The quality of publications and methodological results corresponds to the world level. The results achieved correspond to the financial costs of the project.

6. Proposed reviewers

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