Annex 3.

Form of opening (renewal) for Project

APPROVED

JINR DIRECTOR

_____/_____

"____" _____ 2026

SCIENTIFIC AND TECHNICAL REASONING FOR THE OPENING / RENEWAL OF THE PROJECT IN RESEARCH AREA WITHIN THE TOPICAL PLAN FOR JINR RESEARCH

1. General information on the project

1.1. Theme code (02-1-1096-2010)

1.2. Project (02-1-1096-2-2017/2026)

1.3. Laboratory VBLHEP

1.4. Scientific field Particle physics and Hugh-Energy heavy ion physics

1.5. The name of the Project NA64

1.6. Project Leader(s) V.A.Matveev, D.V.Peshekhonov

1.7. Project Deputy Leader(s)

1.8. Scientific supervisor of the project

2. Scientific rationale and organizational structure

2.1. Annotation

The fixed-target experiment NA64 at the CERN SPS is dedicated to the search for new Dark Sector (DS) particles with masses < 1 GeV weakly interacting with Standard Model (SM) leptons and quarks. The concept of the setup is based on the use of a hermetic detector to search for hidden particles manifesting themselves as events with large missing energy in the scattering of electrons/positrons, muons, and hadrons off the nuclei in an active target. This feature is the main advantage of the project, as the probability of detecting a signal event in NA64 is proportional to the square of the coupling constant, in contrast to its fourth power for the detection probability in "beam-dump" type setups. This allows NA64 to achieve high sensitivity with significantly lower statistics and a low background level.

Since its approval in 2016, NA64 has been a pioneering experiment and the world leader in the search for Light Dark Matter (LDM). The results obtained are in high demand by the scientific community, and the research programme remains relevant and supported by CERN. To fully implement the scientific potential of the project, the NA64 collaboration plans to upgrade the experimental setup during the third CERN Long Shutdown LS3, which will enable further data taking at higher beam intensities. The

planned modernization includes both an upgrade of existing experimental equipment and the production of new components to improve the hermeticity of the setup; the ability to operate at higher beam intensities thanks to faster electronics and the development of tracking chambers for magnetic spectrometers.

After LS3, the NA64 collaboration plans to continue data taking with ~10^{13} electrons, ~10^{11} positrons, ~2×10^{13} muons, and ~10^{11} hadrons on target. This will significantly expand the search region for both dark matter – with the potential for discovery or conclusive exclusion of its main well-motivated models – and other manifestations of new physics beyond the SM.

2.2. Scientific justification (purpose, relevance and scientific novelty, methods and approaches, methodologies, expected results, risks)

Purpose of the project: The search for Light Dark Matter (LDM) and manifestations of physics beyond the SM at the extracted beams of the CERN SPS and PS accelerators.

Relevance: Undoubtedly, the main task of particle physics today is to explain the origin and nature of Dark Matter (DM) in the Universe, which, despite intensive searches at the LHC and in laboratory experiments, has still not been discovered. Until recently, one of the most popular and motivated candidates for the role of DM were weakly interacting massive particles (WIMP). The negative results from the extensive WIMP detection programme has stimulated the expansion of further research. Thus, relatively recently, a variety of alternative DM candidates was proposed, suggesting the existence of "dark" (or hidden) sectors (DS) in the Universe, providing a natural framework for explaining the origin and properties of DM. In these models, DM is part of a hidden sector composed of particles that are singlets of the $SU(3)_C \times SU(2)_L \times U(1)_Y$ gauge group of the SM, interacting with ordinary matter through gravity and, potentially, other feeble forces.

One of the most popular scenarios assumes the existence of a new (portal) interaction between the DS and visible matter, mediated by a vector boson A′, the so-called dark photon. The A′ boson could be light, with a mass $m_{A'}$ ~O(1) GeV, associated with the spontaneous breaking of $U(1)_D$ gauge symmetry, and interacting with SM particles through kinetic mixing with the ordinary photon, usually parameterized by $\varepsilon << 1$. Remarkably, the predicted mass range for DM particles m_{DM}, as well as for $m_{A'}$ and ε, that explains the relic DM density lies in a parameter region accessible for detection at modern accelerators. This served as an impetus for changing the strategy and shifting the focus of accelerator DM searches from those typically performed at high energies to experiments at lower energies and high intensities.

Today, NA64 is the leading fixed-target experiment in the search for Dark Sector manifestations in electron/positron, muon, and hadron scattering off the nuclei in an active target, combined with the technique of registering events with missing energy.

Scientific novelty, methods and approaches, methodologies: The NA64 project proposed an effective technique for sensitive searches for hidden sector particles based on a combination of a hermetic detector with an active target and the registration of events with missing energy**.**

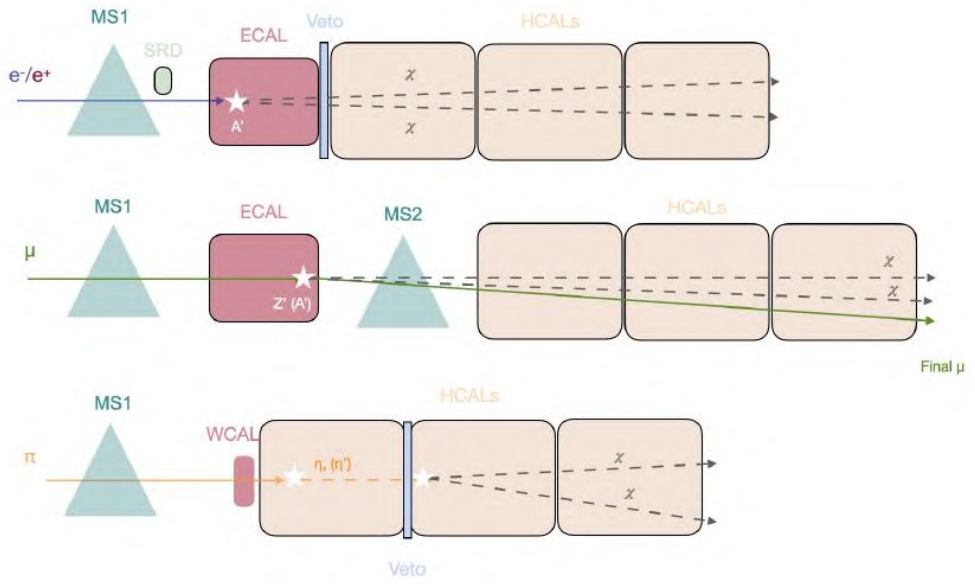

Fig. 1. Schematic diagram of the NA64 setup for conducting research on electron, muon, and hadron beams: MS1/2 – magnetic spectrometer; ECAL/WCAL – electromagnetic calorimeter used as an active target; SRD – synchrotron radiation detector; HCAL - hadron calorimeter; Veto - scintillation counter.

The search method in the **NA64$_e$** experiment at the H4 SPS beamline is as follows: the vector boson A′ can be produced by the dark Bremsstrahlung reaction when electrons scatter off the nuclei in the lead active target, for which a Sc-Pb electromagnetic (e-m) calorimeter (ECAL) is used.

The production of A′, $e^-Z \rightarrow e^-ZA'$, would typically occur in the first few radiation lengths ($X_0 \sim 1$cm) of the target. It is then assumed that A' decays into invisible dark matter particles, which escape the setup undetected. The occurrence of A' and its decay A' → invisible in e^-Z interactions would appear as an event with a single e-m shower in the ECAL target and "zero" energy deposition in the HCAL (not exceeding that arising from possible background sources). In this case, the energy deposition in the ECAL is $< \sim 50\%$ of the beam energy ~100 GeV.

It is assumed that the process of dark photon production and subsequent decay A' → invisible will be very rare, at $\leq 10^{-12}$ eot. This leads to requirements for the design and structure of the experimental setup. One of the main sources of background is associated with the "low-energy tail" in the energy distribution of primary beam electrons. It arises from the interaction of electrons with passive material in the beam, such as beamline entrance windows, residual gas, etc. Another source of such electrons is associated with the decay of pions or muons in flight during beam transfer in the channel.

To suppress this background, NA64 uses a system for tagging high-energy e^- by registering the synchrotron radiation (SR) they emit in the dipole magnet of the tracking spectrometer (see Fig.1). In this case, electrons with lower energy are effectively suppressed because the total energy of SR photons is $\sim E_{e^-}^3$. The expected conservative contribution from various background sources for a beam with an energy of 100 GeV is $<10^{-12}/e^-$.

The **NA64$_\mu$** experiment searches for DS particles in missing energy events at the CERN SPS M2 beamline using 160 GeV muons. A number of interesting models predict the existence of dark sector particles predominantly weakly coupled to the second and, possibly, third generations of Standard Model particles. In addition to gravity, this new very weak interaction between the visible and dark sectors

could be explained by either scalar (S_μ) or U'(1) gauge bosons Z_μ interacting with ordinary muons. In the class of L_μ - L_τ models (the difference between muon and tau lepton numbers), the corresponding Z_μ could be light and interact with coupling constants lying in an experimentally accessible region. The main decay mode of Z_μ in the **NA64μ** setup is Z_μ -> invisible, either into neutrinos or into light dark matter particles.

The production reaction for Z_μ is the muon bremsstrahlung process on a nucleus: $\mu + Z \rightarrow \mu' + Z + Z_\mu$. A fraction of the primary beam energy is carried away by the scattered muon, which is registered by the magnetic spectrometer located behind the active target ECAL (see Fig. 1). The remaining part of the primary muon's energy is carried out beyond the setup by particles from the Z_μ -> invisible decay. Thus, the occurrence of Z_μ appears as an event with a single scattered muon with an energy in the final state lower than the initial one, and the absence of energy deposition in the HCAL of the setup (see Fig. 1).

The main difference in the experimental approach used in NA64μ from NA64e is that it requires precise reconstruction of the incoming and scattered muon momentum to measure the missing energy in a possible Z_μ (or A') production and its subsequent invisible decay. Therefore, the main components of the NA64μ setup are two magnetic spectrometers with an advanced tracking system and the hermetic calorimetry system HCAL.

The main goal of the **NA64h** experiment is to search for hidden sector particles interacting predominantly with light SM quarks, in accordance with the predictions of several models with so-called leptophobic interactions. The experiment uses the technique of detecting missing energy events as a signature of physics beyond the SM, using beams of pions, kaons, and protons from the CERN PS and SPS accelerators. The first proof-of-concept results from the search for invisible decays of neutral mesons $\eta,\eta' \rightarrow$ invisible, produced in the charge-exchange reaction of 50 GeV π^- on the material of an active target, significantly improved existing PDG limits and were published in Phys. Rev. Lett. (2024).

Contribution and responsibility of the JINR group

The JINR group includes the co-spokesman, S. Gninenko, and the technical coordinator of the project, V. Polyakov. A significant contribution to the formation of the experiment's scientific programme is made by BLTP employees under the leadership of V. Matveev. The JINR group is responsible for the production and operation of tracking detectors based on straw-tube technology, which are a fundamental element of the magnetic spectrometers. Together with RF institutes, JINR participated in the production of the electromagnetic, veto-hadron, and hadron calorimeters of the setup; currently, the JINR group is partially responsible for their operation. JINR group members actively participate in data taking, simulation, data processing and analysis, and the publication of obtained results.

Expected results, risks:

Currently, the NA64 experiment has registered 2.5×10^{12} e^-, ~2.4×10^{10} e^+, 3.5×10^{11} μ, and ~1.4×10^{10} π, K on target. In the 2026 run, it is planned to increase the statistics by ~ 8×10^{11} e^- on target. According to the plan, the CERN accelerator complex upgrade (LS3) will begin in the second half of 2026; two years later, in the second half of 2028, the PS will start operation, and a year after that, in 2029, the SPS will resume. During the period without beams, the collaboration plans to carry out an upgrade of the setups, including:

- produce new straw tracking detectors sized 40x20 cm² and their electronics, jointly with colleagues from INP (Kazakhstan), for the NA64μ and NA64e setups;

- upgrade the electromagnetic calorimeter to enhance its radiation hardness; replace part of the scintillators, conduct detailed studies to select radiation-hard WLS fiber (from Kalinin Plant and/or Kuraray), and replace it;
- jointly with colleagues from Zurich and Bologna, upgrade the hadron calorimeter of the setup to improve muon identification. This involves splitting the hadron modules into two parts depth-wise, replacing the PMTs with green-sensitive ones, and replacing the WLS fiber;
- jointly with colleagues from Chile, design and develop 4 two-coordinate scintillation hodoscopes with a spatial resolution of ~2-3 mm, an active area of 60x60 cm², SiPM readout, and production of electronics;
- jointly with colleagues from Chile, design and develop a hodoscopic target for pion and kaon charge-exchange reactions to search for new particles at the NA64h setup;
- create and equip a test stand for checking straw detectors and hodoscopes using cosmic rays and at the Nuclotron;
- produce a tungsten/beryllium absorber-target for an experiment with ion beams at the Nuclotron.

At the SPS beams, it is planned to continue data taking to accumulate statistics of ~10^{13} e^-, ~10^{11} e^+ (at 40 and 60 GeV), and ~2×10^{13} μ on target. According to estimates, this will significantly expand the search area for dark matter and manifestations of new physics beyond the SM, with the potential for their discovery or conclusive exclusion of its main well-motivated models. As part of preparing the NA64h programme, in 2023-2024 the collaboration conducted test runs with a 50 GeV pion beam, registering ~10^{10} particles on target. In 2025, a test run took place at the T9 beamline of the PS accelerator. The collaboration is currently finalizing the preparation of a proposal for searching for Dark Sector manifestations and related measurements with hadron beams at the PS accelerator after the LS3 shutdown.

In collaboration with leading theorists from INR and JINR, JINR group members are studying the possibility of using the high-intensity extracted beams of the NICA accelerator complex to conduct search experiments involving the scattering of xenon and bismuth beams on a tungsten target, extending the capabilities of the NA64h programme at the PS. We currently consider this part of the scientific programme as an activity.

The main risks for the successful implementation of the collaboration's and JINR group's plans in the NA64 project are:

- changes in the scheduled timeline of the accelerator shutdown within LS3 could affect the collaboration's data-taking plans;
- restrictions imposed on JINR by CERN concerning the involvement of new personnel, including students and PhD candidates; making payments; and the procurement and delivery of equipment and electronics.

2.3. Estimated completion date

The NA64 collaboration plans to perform data taking at CERN accelerator beams until the accelerator shutdown scheduled for 2034. Currently, we request the extension of the JINR group's participation in the project for a period of 5 years, covering the period from 2027 to 2031.

2.4. Participating JINR laboratories

VBLHEP, LTP, DLNP, JINR Directorate

2.4.1. MICC resource requirements

Computing resources	Distribution by year				
	1st year	2nd year	3rd year	4th year	5th year
Data storage (TB) - EOS - Ribbons	180	200	230	260	300
Tier 1 (core-hour)					
Tier 2 (core-hour)					
SC Talker (core-hour) - CPU - GPU					
Clouds (CPU cores)					

2.5. Participating countries, scientific and educational organisations

Organisation	Country	City	Participants	Type of agreement
UTFSM UAB	Chile	Valparaiso Santiago	S.Kuleshov+8	Joint work
University of Bonn	Germany	Bonn	B.Ketzer+	Joint work
INFN	Italy	Genua Padova Bologna	A.Celentano+10 D.Luchessi+4 S.Pascoli+3	Joint work
ETH	Switzerland	Zurich	P.Crivelli+4	Joint work
INP	Kazakhstan	Almaaty	S.Sakhiev+3	Joint work
IFIS	Spain	Valinsia	L.Molina-Bueno+6	Joint work

2.6. Co-executing organisations *(those collaborating organisations/partners without whose financial, infrastructural participation the implementation of the research programme is impossible. An example is JINR's participation in the LHC experiments at CERN).*

3. Staffing

3.1. Staffing needs in the first year of implementation (total number of participants)

№№ n/a	Category employee	Core staff Amount of FTE	Associated Personnel Amount of FTE
1.	scientific staff	6,1	
2.	engineers		
3.	professionals	0,2	
4.	employees		
5.	workers		
Total:		**6,3**	

№№ п/п	Category employee	Name	division	position	Amount of FTE
1	scientific staff	V.A.Matveev	JINR Directorate	JINR Scientific Leader	0,1
2	scientific staff	D. Peshekhonov	VBLHEP	Division Leader	0,7
3	scientific staff	G.Kekelidze	VBLHEP	Group leader	0,3
4	scientific staff	S.Gertzenberger	VBLHEP	Researcher	0,5
5	scientific staff	A.Ivanov	VBLHEP	Researcher	0,5
6	scientific staff	V.Polyakov	VBLHEP	Researcher	0,5
7	scientific staff	S.Gninenko	VBLHEP	Researcher	0,5
8	scientific staff	M.Kirsanov	VBLHEP	Researcher	0,8
9	scientific staff	D.Schukin	VBLHEP	Researcher	1,0
10	scientific staff	A.Zhevlakov		Researcher	0,3
11	scientific staff	V.Frolov		Researcher	0,2
12	scientific staff	I.Tlisova	VBLHEP	Researcher	0,2
13	scientific staff	Y.Kambar	VBLHEP	Researcher	0,5
14	professionals	I.Zhukov	VBLHEP	Technician	0,2
	Total				**6,3**

3.2. Human resources available

3.2.1. JINR core staff (total number of participants)

№№ п/а	Category of employees	Division	Position	Amount of FTE
1.	scientific staff			
2.	engineers			
3.	professionals			
4.	workers			
Total:				

3.2.2. JINR associated personnel (total number of participants)

№№ п/a	Category of employees	Partner organisation	Amount of FTE
1.	Scientific employees		
2.	engineers		
3.	professionals		
4.	workers		
Total:			

4. Financial support

4.1. Total estimated cost of the project / subproject

Forecast of the total estimated cost (specify cumulatively for the whole period, excluding FPC).

The details are given in a separate form. 1150 k$

4.2. Extrabudgetary funding sources

Estimated funding from co-executors/customers - total.

Project Leader _____ / V.A. Matveev /

Date of submission of the project to DSOA: 05.05.2026

Date of decision of the laboratory's STC: 28.04.26 document number: 2

Year of the project opening: 2017

(for renewable projects) -- Project start year: 2023

Schedule proposal and resources required for the implementation of the Project

Names of costs, resources, sources of funding			Cost (thousands of dollars) resource requirements	Cost, distribution by year				
				1st year	2nd year	3rd year	4th year	5th year
		International cooperation (IC)	600	100	110	130	130	130
		Materials	400	130	120	100	30	20
		Equipment and third-party services (commissioning)	100	20	20	20	20	20
		Commissioning work						
		Services of research organisations	50	10	10	10	10	10
		Acquisition of software						
		Design/construction						
		Service costs (*planned in case of direct project affiliation)*						
Resources required	**Normo-hours**	Resources						
		– the amount of FTE,	31,5	6,3	6,3	6,3	6,3	6,3
		– accelerator/installation,						
		– reactor,….						
Sources of funding	**Budgetary resources**	JINR budget *(budget items)*	1150	260	260	260	190	180
	Extrabudgetary (supplementary estimates)	Contributions by co-contractors Funds under contracts with customers Other sources of funding						

Project Leader _____ / V. A. Matveev /

Laboratory Economist _____ / V. V. Mordev /

APPROVAL SHEET FOR PROJECT

NAME OF THE PROJECT ___NA64 Experiment__

SHORT NAME OF THE PROJECT ___NA64____

PROJECT CODE: __02-1-1096-2-2017/2026___

THEME CODE: __02-1-1096-2010___

PROJECT LEADER (s) _) V.A.Matveev, D.V.Peshekhonov___

AGREED

JINR VICE-DIRECTOR	SIGNATURE	NAME	DATE
CHIEF SCIENTIFIC SECRETARY	SIGNATURE	NAME	DATE
CHIEF ENGINEER	SIGNATURE	NAME	DATE

LABORATORY DIRECTOR	SIGNATURE	Butenko AV NAME	28.04.26 DATE
CHIEF LABORATORY ENGINEER	SIGNATURE	Semin NAME	04.05.26 DATE
LABORATORY SCIENTIFIC SECRETARY	SIGNATURE	Yermakov AN NAME	28.04.26 DATE
THEME LEADER	SIGNATURE	Kekelidze V.D. NAME	20.04.26 DATE
PROJECT LEADER	SIGNATURE	V.A Matveev NAME	20.04.26 DATE
PROJECT LEADER	SIGNATURE	NAME	DATE

- to sign in frame after PAC

APPROVED BY THE PAC	SIGNATURE	NAME	DATE

Annex 4.

Project report form

APPROVED

Director of Laboratory

Бутенко А.В.

"28" апреля 2026

REPORT ON PROJECT (INFRUSTRUCTURE PROJECT) IN FIELD OF RESEARCH WITHIN THE TOPICAL PLAN FOR JINR RESEARCH

1. General information on the Project

1.1. Scientific field Particle physics and high-energy heavy ion physics

1.2. Name of the Project NA64

1.3. Project code 02-1-1096-2-2017/2026

1.4. Theme code 02-1-1096-2010

1.5. Actual duration of the Project

1.6. Project Leader(s) V.A.Matveev, D.V.Peshekhonov

2. Scientific report

2.1. Annotation

NA64 is a pioneering fixed-target experiment searching for Light Dark Matter using electron [1], positron [2], muon [3], and hadron [4] beams.

Since the beginning of its operation in 2016, it has demonstrated the ability to operate in a nearly background-free mode, and its contribution to the search for new physics is regarded by the CERN Directorate and the scientific community as significant, complementary, and worthy of continuation. The main feature and advantage of the NA64 project is an effective method for searching for new hidden sector particles and other new physics, combining the use of a hermetic detector and an active target with the technique of registering missing energy events. Consequently, the probability of detecting the signal of interest increases significantly since the cross section for producing new particles in the target is proportional to the square of the coupling constant, unlike in setups operating in the traditional beam-dump mode, where the search sensitivity is proportional to its fourth power. This allows NA64 to achieve high sensitivity with significantly lower statistics and a low background level.

Currently, the NA64 experiment has registered 2.5×10^{12} e^-, $\sim2.4\times10^{10}$ e^+, 3.5×10^{11} μ, and $\sim1.4\times10^{10}$ π^- on target. In the 2026 run, it is planned to increase the statistics by $\sim 8\times10^{11}$ e^- on target. According to

the plan, the CERN accelerator complex upgrade (LS3) will begin in the second half of 2026; two years later, in the second half of 2028, the PS will start operation, and a year after that, in 2029, the SPS will resume.

The collaboration plans to upgrade the setup and continue data taking with the goal of accumulating ~10^{13} e^-, ~10^{11} e^+ (at 40 and 60 GeV), and ~2×10^{13} μ on target. According to estimates, this will significantly expand the search area for dark matter and manifestations of new physics beyond the SM, with the potential for their discovery or conclusive exclusion of its main well-motivated models. As part of preparing the NA64h programme, in 2023-2024 the collaboration conducted test runs with a 50 GeV pion beam, registering ~10^{10} particles on target. In 2025, a test run took place at the T9 beamline of the PS accelerator. The collaboration is currently finalizing the preparation of a proposal for searching for Dark Sector manifestations and related measurements with hadron beams at the PS accelerator after the LS3 shutdown.

2.2. A detailed scientific report

2.2.1. Description of the mode of operation and functioning of the main systems and equipment

To conduct the search for LDM in the NA64e experiment, a secondary SPS e^- beam is used. The 400 GeV energy of the primary SPS proton beam allows for electron beams in the energy range from 10 to 300 GeV with typical intensities of 10^5 to 10^7 electrons per SPS spill. The admixture of other charged particles in the beam (beam purity) is less than 10^{-2}.

Experiment searching for the decay A′ → invisible (invisible decay mode to DM particles)

It is assumed that the A' boson will predominantly decay into a pair of dark matter particles $\chi\bar{\chi}$. The production of A' in the reaction $e^-Z \rightarrow e^-ZA'$ and the subsequent decay $A' \rightarrow$ invisible are shown in Fig. 1.

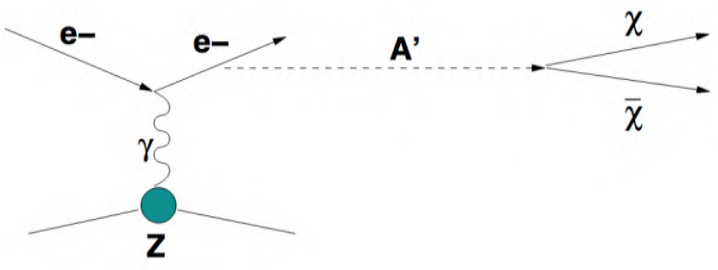

Fig. 1. Diagram illustrating the production of a massive A' boson in the reaction $e^-Z \rightarrow e^-ZA'$ of electron scattering off a nucleus (A,Z) with the subsequent decay of A' into a $\chi\bar{\chi}$ pair.

It is expected that the process of dark photon production and subsequent decay A' → invisible is a very rare event and will occur with a frequency of $\leq10^{-12}$ eot. This leads to requirements for the design and structure of the experimental setup (Fig. 2).

The method of the search is the following: A' can be produced as a result of mixing with bremsstrahlung photons from the electrons scattering off nuclei in the ECAL. The reaction $e^-Z \rightarrow e^-ZA'$, A'→ invisible would typically occur in the first few radiation lengths (X_0) of the detector. Subsequently, A' decays into two dark matter particles, which pass through the rest of the setup without interaction. A fraction f of the primary beam energy $E_1 = f E_e$ will be deposited in the active target - ECAL. The residual energy of the primary electron $E_2 = (1 - f)E_e$ is carried away by secondary particles from the $A' \rightarrow$ invisible decay. The thickness of the ECAL is ~40 X_0 (radiation lengths). Behind the target-calorimeter, a hadron calorimeter (HCAL) with a thickness of ~15 − 20 λ_{int} (nuclear interaction lengths) is placed.

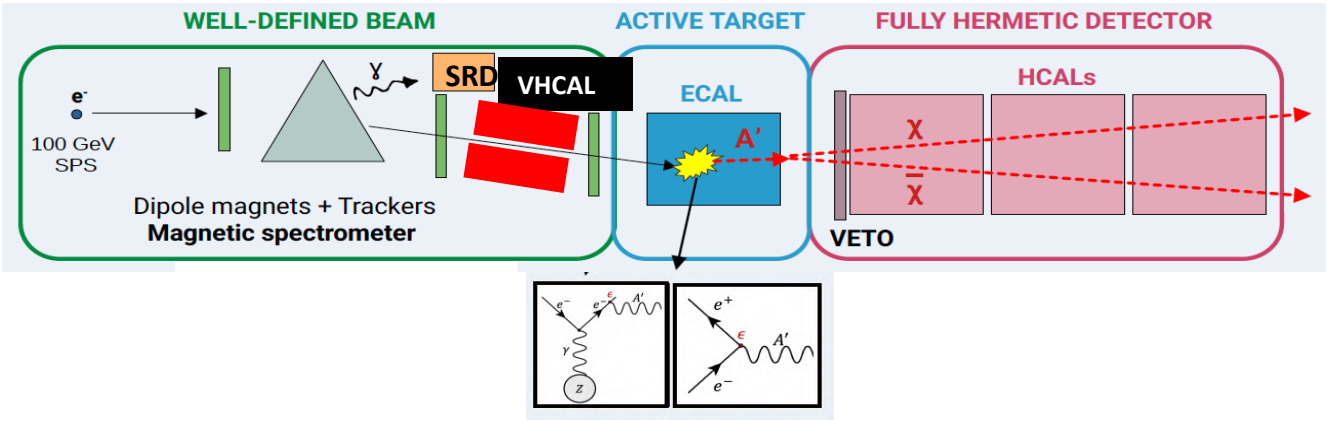

Fig. 2: Scheme of the NA64e setup for searching for dark photons using the missing energy method and an active target (ECAL). The part of the setup up to the ECAL is used to measure the momentum and identify the incoming particle; HCAL ensures the hermeticity of the setup; SRD - synchrotron radiation detector; the hadron veto calorimeter is shown in red; tracking detectors are shown in green.

The occurrence of the decay A' → invisible in e−Z interactions would appear as an event with a single e-m shower in the ECAL and "zero" energy deposition in the rest of the detector (not exceeding that arising from possible background sources).

One of the main sources of background is associated with the low-energy tail in the energy distribution of primary beam electrons. It arises from the interaction of electrons with passive material in the beam, such as beamline entrance windows, residual gas, etc. Another source of such electrons is associated with beam contamination due to the decay of pions or muons during beam transfer in the channel.

To suppress this source, a system for tagging high-energy e^- is used, by measuring the synchrotron radiation (SR) they emit in a dipole magnet. Low-energy electrons can be effectively rejected because the total SR photon energy is ~ $E_{e^-}^3$. The expected conservative contribution from various background sources for a beam with an energy of 100 GeV is $<10^{-12}/ e^-$.

Candidate signal events must satisfy the following selection criteria:

- the energy of the beam electron corresponds to the required value (~100 GeV);
- the starting point of the electromagnetic shower in the ECAL is localized within the first few radiation lengths X_0;
- the transverse and longitudinal development of the shower in the ECAL corresponds to the shape of an electromagnetic shower; the fraction of the total energy deposition in the ECAL is $f < 0.5$ E_{e^-};
- no energy deposition in the HCAL;
- no signal in the veto detectors.

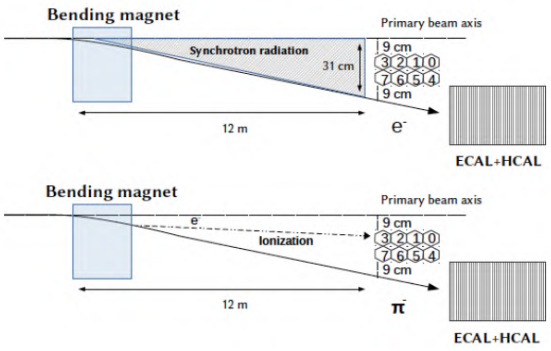

Fig. 3. Scheme for tagging beam electrons using their synchrotron radiation in a dipole magnet.

Hadronic background can be caused by hadrons being mistakenly identified as electrons. This background source is related to the admixture of pions, protons, etc., in the electron beam. Another source of this type of background is the possible production and leakage of hadrons in the ECAL target. To eliminate the neutral and charged components of the hadronic background, hadron veto calorimeters and straw chambers located near the target-calorimeter, and a scintillation wall located in front of the HCAL are used. The expected conservative contribution from various background sources for a beam with an energy of 100 GeV is $<10^{-12}/ e^-$.

Experiment searching for the A′ → e^+e^- decay

A schematic illustration of the experimental setup for the search for the visible decay A′ → e^+e^- is shown in Fig. 4.

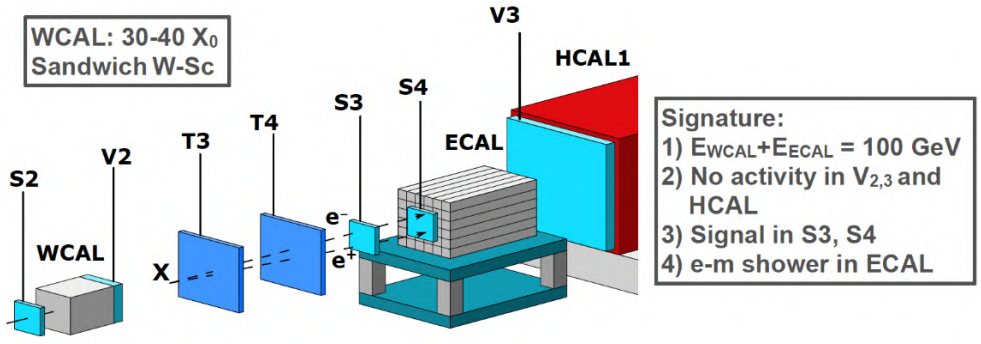

Fig. 4. Schematic illustration of the setup upgrade for searching for dark photons in the visible decay mode. The absorption of beam electron energy in the WCAL calorimeter is accompanied by the emission of A′ in the eZ → eZA′ reaction of electron scattering off nuclei due to γ - A' mixing. Part of the primary beam energy remains in the WCAL, while the remaining part is carried away by A', which passes through the WCAL without interactions and decays into an e^+e^- pair, which generates a second electromagnetic shower in the ECAL, leading to a signature of two showers in the detector. The total energy absorbed in WCAL+ECAL equals the energy of the primary beam electron.

In this experimental mode, WCAL serves as the active target. The residual energy of primary electrons $E_2 = (1 - f)E_{e\text{-}}$ is carried out of WCAL by A' and absorbed in the downstream ECAL due to the in-flight decay of A' into an e^+e^- pair (Fig. 4). The expected opening angle Θ_{e+e-} between the particles of the e^+e^- pair is too small to resolve two e-m showers in the ECAL, so a single/total electromagnetic shower is registered; the electron and positron pair can be registered by tracking detectors. The occurrence of the decay A′ → e^+e^-, caused by the e^-Z interaction, thus appears as an event with two e-m-like showers in the detector (Fig. 4) and the registration of e^+e^- pair tracks.

Experiment searching for dark sector particles weakly interacting with muons

The **NA64μ** experiment searches for DS in missing energy events using high-energy muon beams at the CERN SPS. Several models predict the existence of dark sector particles predominantly weakly coupled to the second and, possibly, third generations of Standard Model particles. In addition to gravity, this new very weak interaction between the visible and dark sectors could be explained by either scalar (S_μ) or U'(1) gauge bosons Z_μ interacting with ordinary muons. In the class of L_μ - L_τ models (the difference between muon and tau lepton numbers), the corresponding Z_μ could be light and interact with parameters in the experimentally accessible search region. The **NA64μ** setup searches for invisible decays of Z_μ into neutrinos or into light dark matter particles.

A Z_μ particle can be produced in the reaction of a muon scattering off a nucleus: $\mu + Z \rightarrow \mu' + Z + Z_\mu$. A fraction of the primary beam energy is carried away by the scattered muon, which is registered by the magnetic spectrometer located behind the active target. The remaining part of the primary muon's energy is carried beyond the setup, so the production of Z_μ appears as an event with a single scattered muon in the final state with energy lower than the initial one, and the absence of energy deposition in the HCAL detectors of the setup.

The main difference in the experimental approach used in NA64μ from NA64e is that it requires the reconstruction of the incoming and scattered muon momentum to measure the missing energy in a possible invisible Z_μ (or A') decay. Therefore, the main components of the NA64μ setup are two magnetic spectrometers with an advanced tracking system and a hermetic calorimetry system HCAL.

A schematic illustration of the experimental setup is shown in Fig. 5.

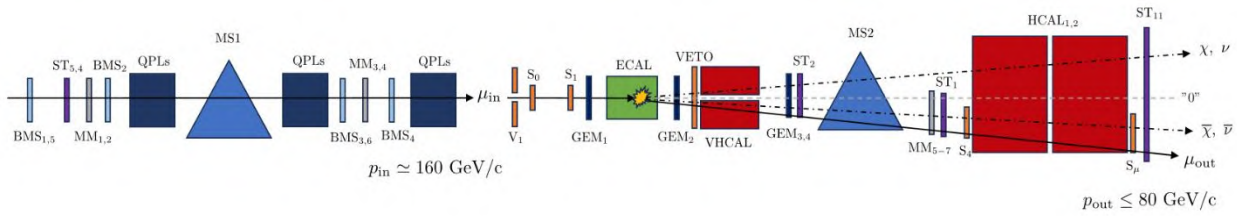

Fig. 5. Schematic illustration of the NA64μ setup for searching for DM using the high-energy muon beam at the M2 beamline at CERN.

The detector shown in Fig. 5 uses two magnetic spectrometers before (MS1) and after (MS2) the target. The spectrometers are required for independent momentum measurement of the incoming and scattered muon, respectively. The tracking system consists of Micromegas, GEM, and straw chambers, allowing for the reconstruction and measurement of incoming and scattered muon momenta. An electromagnetic calorimeter (ECAL) serves as the active target. Further downstream are the veto-calorimeter (VHCAL) and the hadron calorimeter (HCAL). They serve to register secondary particles produced as a result of muon interactions with the target. HCAL consists of several modules, each with transverse and longitudinal segmentation. To ensure hermeticity, the HCAL thickness is ~ 30 λ_{int} (nuclear interaction lengths).

Experimental search method: The first spectrometer (MS1) determines the energy of the incoming muon E_μ. Z_μ can be produced in the reaction $\mu + Z \rightarrow \mu' + Z + Z_\mu$, along the entire length of the target. A fraction f of the primary beam energy $E'_\mu = fE_\mu$ is carried away by the scattered muon, which enters the second magnetic spectrometer (MS2), tuned for efficient registration and reconstruction of the momentum of the muon $p'_\mu < p_\mu$ (Fig. 5). The remaining part of the primary muon's energy $(1-f)E_\mu$ is carried beyond the setup after Z_μ decay into neutrinos, or into light dark matter particles. As a result, an

event with missing energy $E_{miss} = E_\mu - E'_\mu$ is registered, with the signature: the appearance, at a level above the expected background, of an event with a scattered muon, with energy lower than the initial one, and the absence of energy deposition in the detectors located behind the target.

The main goal of the **NA64h** experiment is to search for hidden sector particles interacting predominantly with light SM quarks, in accordance with the predictions of several models with so-called leptophobic interactions. The experiment uses the technique of detecting missing energy events as a signature of physics beyond the SM, using beams of pions, kaons, and protons from the CERN PS and SPS accelerators. The first proof-of-concept results from the search for invisible decays of neutral mesons $\eta,\eta' \rightarrow$ invisible, produced in the charge-exchange reaction of 50 GeV π^- on the material of an active target (Fig. 6), significantly improved existing PDG limits and were published in Phys. Rev. Lett. (2024).

It is planned to continue these searches, as well as searches for possible decays of neutral mesons, $K^0_{S,L}$ -> invisible, produced in the charge-exchange reaction of 40-50 GeV K^-.

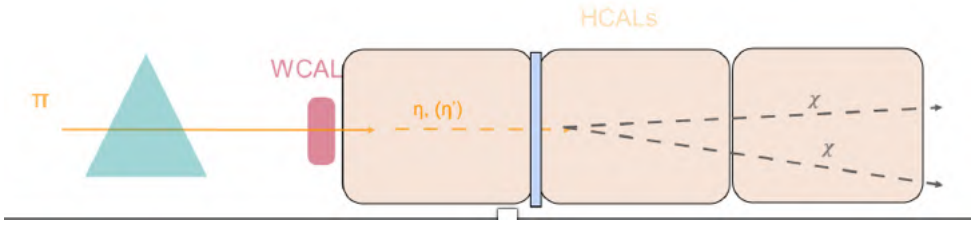

Fig. 6. Schematic representation of the experiment with the hadron beam to search for the invisible decay of the dark photon.

2.2.2. A description of the experiments carried out (for pilot projects).

2.2.3. A description of the scientific work undertaken and the results obtained.

The NA64 detector

One of the main elements of the tracking system of the NA64 experiment is straw chambers. A distinctive feature of this type of drift detectors, the technology of which was developed at JINR, is the small amount of passive material in the active area, which is extremely important in precision experiments searching for rare and super-rare processes. The JINR group produced 12 double-layer straw chambers with an active area of 200x200 mm² and 7 chambers sized 1200x600 mm² using tubes with a diameter of 6 mm. These tracking detectors are used in the magnetic spectrometers of the NA64e and NA64μ setups and as veto detectors in the NA64e setup.

Together with colleagues from the NRC Kurchatov Institute (Protvino) and INR RAS, the following were produced and are currently under JINR's responsibility:

- two electromagnetic calorimeters ECAL, $40X_0$, 150×(1.5mm Pb + 1.5mm Sc), sized 200×240×490 mm^3 (5×6) and 200×480×490 mm^3 (5×12 cells);
- three veto hadron calorimeters, each 5.0λ long, 30×(25 mm Cu + 2 mm Sc), sized 500×500×950 mm, with a central hole of 60×120 mm;
- for the visible mode target, a 16 cm tungsten WCAL calorimeter ($30X_0$);
- four hadron calorimeters, each 7.5λ long, 48×(25 mm Fe + 4 mm Sc), ~600×1200 mm^2;

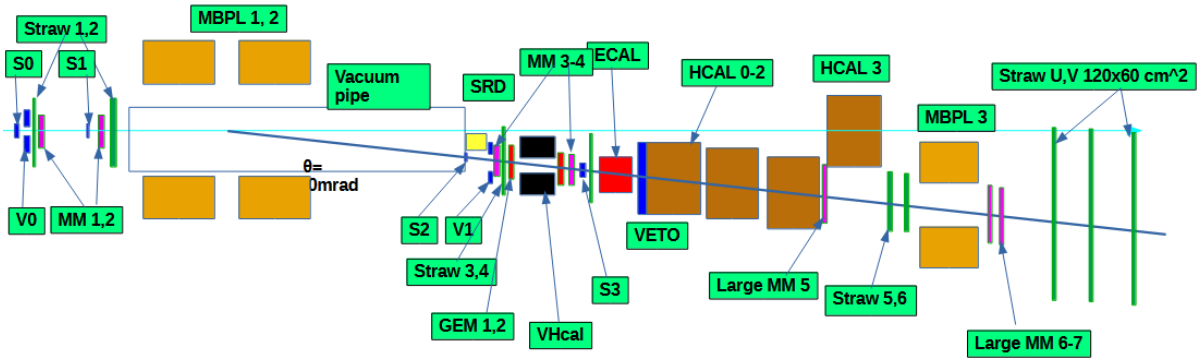

Fig 7. Scheme of the NA64e setup.

NA64 data taking

In 2024-2025, two data-taking runs took place at the NA64e setup. From April 24 to June 19, the team collected 5.2×10^{11} eot with 100 GeV electron beam at the SPS electron channel and 2.3×10^{10} pot with 70 GeV e^+ beam.

Using a positron beam allows employing the resonant annihilation channel for LDM production, where the beam positron annihilates with the atomic electron, and the following chain occurs: $e^+e^- \rightarrow A' \rightarrow \chi\chi$ [42]. Due to the resonant nature in the region $M_{A'}^2=2m_e E_{e+}$, the probability of the process increases significantly.

The beam intensity was 6-6.5×10⁶ electrons/spill. During the run, the team tested new fast electronics. It was also demonstrated that the setup is capable of operating with beam intensities up to 1.0-1.2×10⁷ electrons per spill without any loss of efficiency.

In 2025, at the SPS H4 electron beamline, the team collected 5.9×10^{11} eot with a 100 GeV electron beam, and 3.24×10^9 pot and 6.13×10^9 pot using 45 GeV and 40 GeV e^+ beams, respectively. The hermeticity of the setup was improved by installing additional hadron veto calorimeters [1]. Furthermore, all calorimeters of the setup were equipped with new fast electronics (ADC - 250 MHz, 14 bit), which increased the beam intensity during data taking by more than 20%, up to 8-10×10⁶ electrons per spill. The total statistics accumulated by the collaboration on e^{+-} beams since the start of data taking reached 2.5×10^{12} particles dumped on target.

In 2024, a data-taking run took place with the SPS muon beam with an energy of 160 GeV, as part of the programme to search for dark sector particles predominantly coupled to the second and, possibly, third generations of Standard Model particles. In addition to gravity, this new very weak interaction between the visible and dark sectors could be explained by U'(1) gauge bosons Z_μ interacting with ordinary muons. In the class of L_μ - L_τ models, the corresponding Z_μ could be light and interact in the experimentally accessible region. The **NA64μ** setup searches for decays of Z_μ into neutrino, or into light dark matter particles. During this run, ~2.5×10^{11} mot (muons on target) were registered. The total statistics reached ~3.5×10^{11} mot. Runs at the muon beamline were not conducted in 2025-2026.

In 2025, two-week test run was conducted at the T9 beamline of the PS accelerator. Its goal was to study the possibility of searching for dark matter using hadron beams. During the run, background conditions were studied using positive hadron beams with energies of 10 and 15 GeV, and negative hadron beams with energies of 8 and 15 GeV. Approximately 50 million pions on target were collected with a 15 GeV beam during the charge-exchange process $\pi^- p \rightarrow n\eta(\eta', \rho, \omega)$ as a potential channel for searching for the invisible decay of a neutral meson into a pair of dark-matter particles.

Currently, the NA64 experiment has registered 2.5×10^{12} e^-, ~2.4×10^{10} e^+, and 3.5×10^{11} μ on target. Data analysis is ongoing. The statistics processed by the collaboration allowed obtaining and publishing the following main results:

Obtained results

NA64e

NA64e set the most stringent upper limits in the kinetic mixing (ϵ) and dark photon mass plane for masses below 350 MeV. The processed data allowed setting constraints excluding scalar and Majorana DM with coupling $\alpha_D \leq 0.1$ and $m_{A'} > 3m\chi$ in the mass range $0.001 \leq m\chi \leq 0.1$ GeV (Fig. 8), where α_D is the χ-A′ coupling constant.

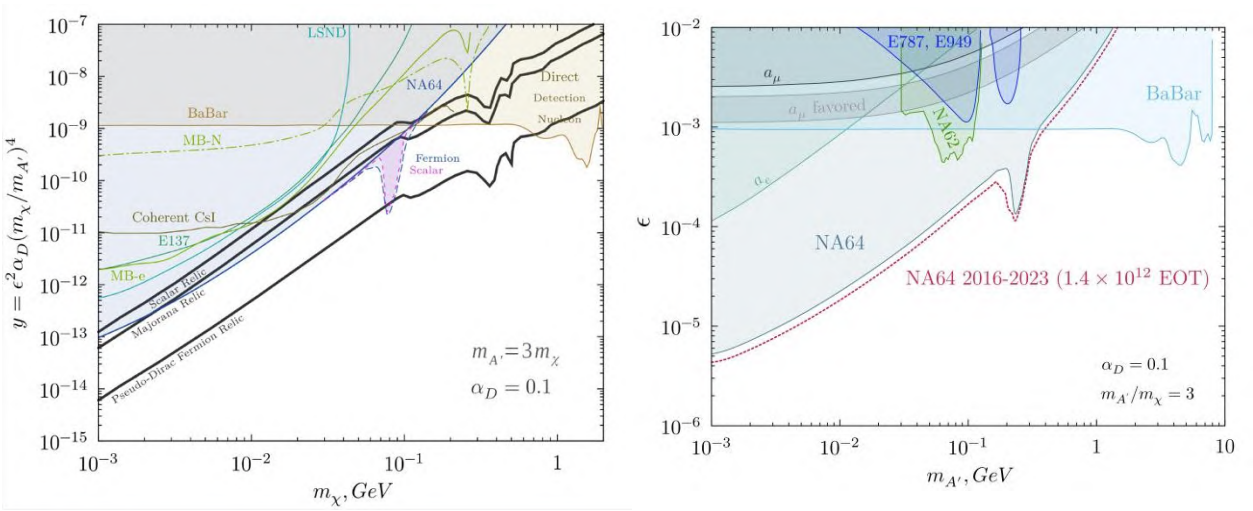

Fig. 8. The NA64 exclusion limits on the invisible decay of A′ for the Bremsstrahlung and resonant production channels (right) and on Light Dark Matter (LDM) (left). [31]

It should be noted that the obtained exclusion limits are currently the best in the world in the search for Light Dark Matter.

Other results from NA64e on the search for new physics.

- Data obtained with the electron beam allowed testing the hypothesis of the existence of scalar and pseudo-scalar axion-like particles (ALPs) produced in the Primakoff reaction $e^- Z \rightarrow a \rightarrow \gamma\gamma$. NA64 data closed the region between data obtained in beam-dump experiments and at colliders, and also part of the classical axion region (yellow band), see Fig. 9.

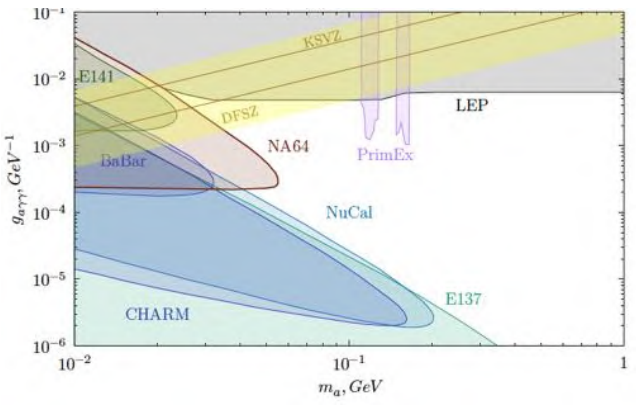

Fig. 9. The NA64 exclusion limits on the ALP-photon coupling constant.

- Based on the statistics collected in 2021, combined with 2016-2018 data ($3.2 \cdot 10^{11}$ EOT), a search was conducted for a new Z' gauge boson associated with (un)broken B-L symmetry in the keV-GeV range [22]. No candidate events were found, and the analysis allowed obtaining new exclusion limits on the coupling constant Z′-e. For the mass range $0.3 < m_{Z'} < 100$ MeV, these limits are the most stringent of all obtained previously from data in neutrino-electron scattering experiments (Fig. 4). The data also indicate the absence of background at the level of 10^{-12}.

- Another model currently under study is based on the existence of a light Z' boson interacting only with the second and third generations of leptons. This hypothetical boson is coupled to electrons through QED vertex corrections, and its existence could explain both the $(g - 2)_\mu$ anomaly and the thermal DM relic density. Such a Z' could be produced via the dark bremsstrahlung $e^- N \rightarrow e^- N Z'$ or in the resonant annihilation of secondary positrons from the shower. Using the 2016-2018 statistics, this scenario was studied in the region associated with the $(g - 2)_\mu$ anomaly, down to $m_{Z'} \sim 1$ MeV [23]. Such a light Z' could be coupled to muons, and therefore its search is also one of the physics goals of NA64μ, an extension of NA64 using a high-energy muon beam [24, 25].

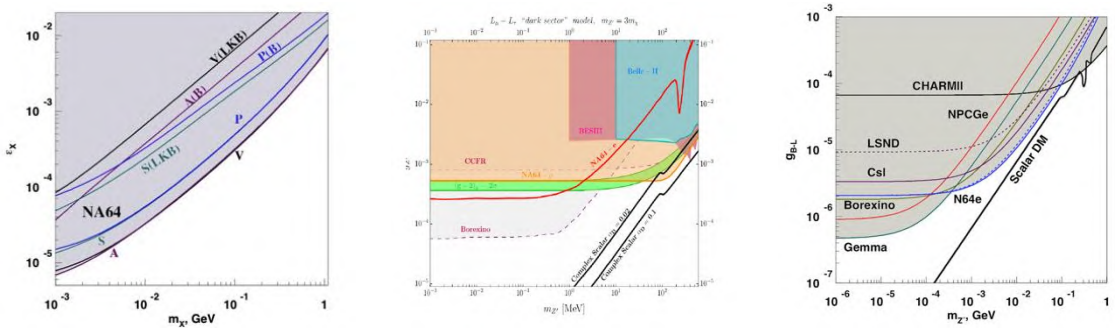

Fig. 10. Left: NA64 limits for a generic X boson, for the scalar (S), vector (V), pseudo-scalar (P) and axial vector (A) cases [8]. Center: NA64e exclusion limit for $L_\mu - L_\tau$ (red line) obtained with 2016-2018 statistics for models where Z′ can decay to DM particles [23]. Right: NA64 exclusion limits for the B-L Z′ boson [22].

- One of the new results, published by the collaboration in 2025, based on the analysis of positron data, allowed excluding the existence of the dark photon in the mass range $165 < m_{A'} < 220$ MeV, for a mixing strength ε below 2.5×10^{-4} and coupling $\alpha_D = 0.1$ [2].

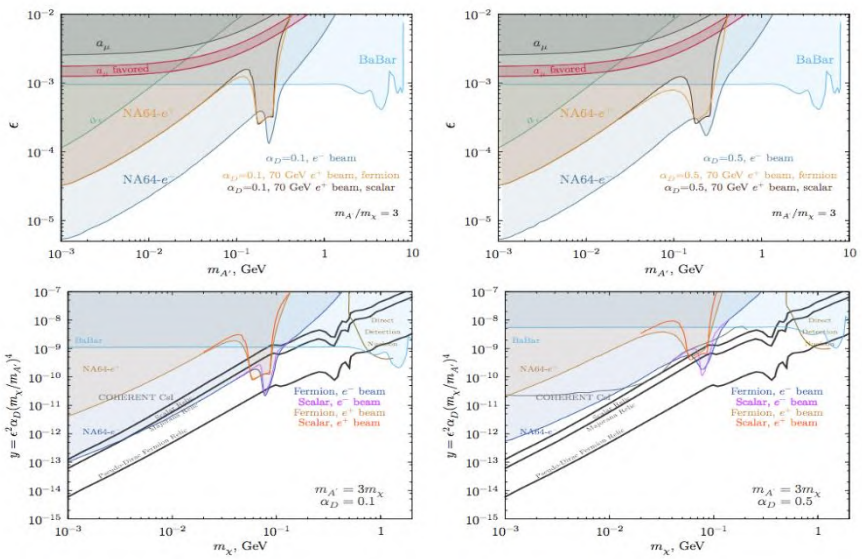

Fig. 11. Exclusion limits derived from the 70 GeV/c positron-beam missing energy measurement. Top (bottom): exclusion limits - brown and orange curves - in the [$m_{A'}$, ε] ([m_χ, α_D]) plane, for $\alpha_D = 0.1$ (left) and $\alpha_D = 0.5$ (right). The other curves and shaded areas report already-existing limits in the same parameters space from NA64 in electron-beam mode (blue and violet), COHERENT (grey), and BaBar (light blue). In the bottom plots, the black lines show the favored parameter combinations for the observed dark matter relic density for different variations of the models.

NA64μ

The NA64μ programme was started in 2021 with two pilot runs at the M2 beamline using the unique CERN 160 GeV/c muon beam. Its intensity reaches up to $2x10^8$ muons per spill, an order of magnitude higher than the intensity of the electron beam, allowing for the accumulation of large data volumes, increasing sensitivity, and expanding the search area for rare processes, complementing the studies with e^{+-} at the H4 beamline. The particles of interest could be produced in the μN → μNX reaction during muon scattering off an active target, followed by their decay X → invisible. The first run, conducted in 2022, aimed to demonstrate the validity of the proposed experimental setup concept and optimize it for the search for Z' implying the existence of particles predominantly weakly coupled to the second and, possibly, third generations of Standard Model particles with a mass below 1 GeV. About ~$2x10^{10}$ μ on target were registered, and the background in the signal box was estimated to be 0.07 ± 0.03. The main source of background was the insufficient momentum reconstruction of the scattered muon. The analysis results are shown in Fig. 12. Exclusion limits were obtained for two Z' decay models into neutrinos: the minimal and the so-called vanilla model. The obtained limits exclude $m_{Z'} \gtrsim 40$ MeV and a coupling constant $g_{Z'}$ ~6 x 10^{-4}. Nevertheless, the possibility remains for the Z′ to decay into dark matter particles. NA64μ can probe a part of the parameter space (m_χ, y), where $y = (g_\chi g_{Z'})^2 (m_\chi/m_{Z'})^4$. For $m_{Z'} = 3m_\chi$ and m_χ ~40 MeV, our data limit the parameter y to the region y ~$6x10^{-12}$.

Fig. 13 shows the results of the NA64μ data analysis complementing the dark photon search programme on electron beams [55]. The current limits are not comparable with those achieved in electron experiments, but they demonstrate the possibility of conducting a search in the mass region above 100 MeV after LS3. These are the first results from this programme obtained with high-energy muon beams [3]; they were published in Phys. Rev. Lett. and were also recommended for publication in the Physics Magazine of the American Physical Society (APS) [3].

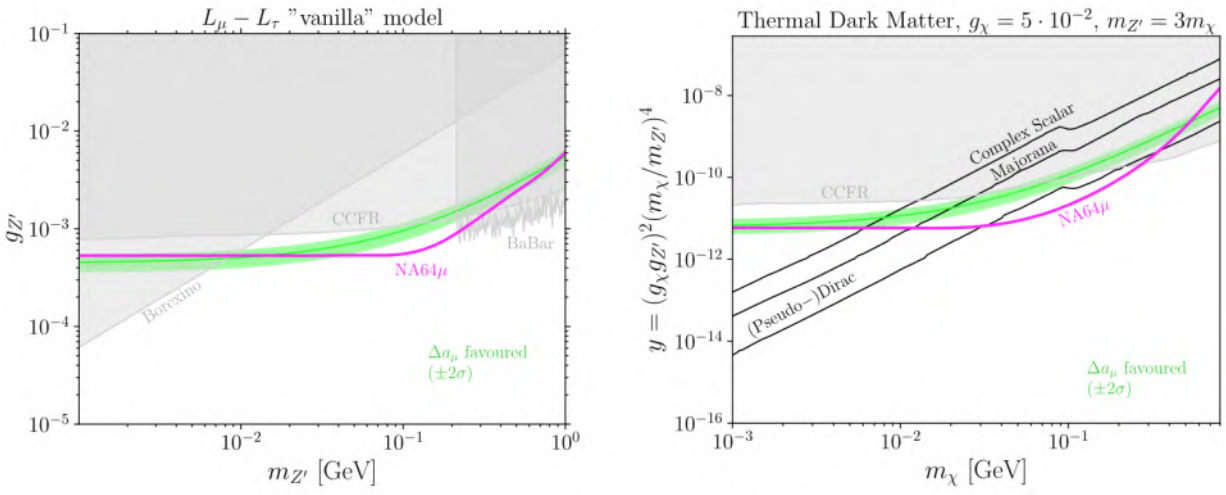

Fig. 12. Left: NA64μ 90% CL exclusion limits on the coupling $g_{Z'}$ as a function of $m_{Z'}$, for the vanilla $L_\mu - L_\tau$ model. The green band shows the 2σ region for the possible contribution of Z' to $(g-2)_\mu$. Also the limits are shown set by BABAR and the neutrino experiments BOREXINO and CCFR. Right: The

90% CL exclusion limits obtained by NA64μ in the parameter space (m_χ, y) for thermal Dark Matter in the $U(1)_{L\mu-L\tau}$ model with $m_{Z'} = 3m_\chi$ and $g_\chi = 5 \times 10^{-2}$ for 2×10^{10} mot.

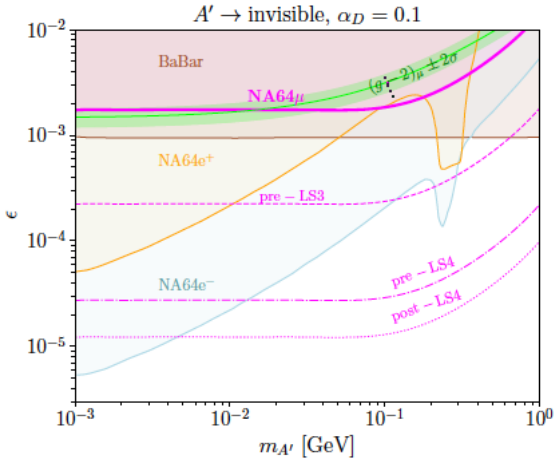

Fig. 13. Exclusion limits obtained by NA64 with electrons and muons and plans for their improvement after LS3.

NA64h

In the NA64h experiment at the CERN SPS, the first proof-of-concept results were obtained in the search for the Dark Sector predominantly coupled to SM quarks, using invisible decays of pseudoscalar η and η′ mesons.

The novel technique uses the charge-exchange reaction of π^- at an energy of 50 GeV on the nuclei of an active target as a source of neutral mesons. Invisible decays η, η′ → invisible, if they exist, would have an unusual signature — the complete disappearance of the incoming pion's energy in the detector. No evidence for such events was found in the data sample of ~ 2.9×10^9 pions on target obtained during a one-day test run. This allowed NA64h to set a stringent limit on the branching ratios $Br(\eta' \to \text{invisible}) < 2.1 \times 10^{-4}$, improving the current limit from the BESIII experiment by a factor of ~3. NA64h also set a limit on $Br(\eta \to \text{invisible}) < 1.1 \times 10^{-4}$, comparable with the existing one. These are the first results from the NA64 hadron programme obtained with high-energy pion beams; they were published in Phys. Rev. Lett.

These results also demonstrate the significant potential of the NA64h approach and provide clear guidance on how to enhance sensitivity to Dark Sector physics in future searches for invisible neutral meson decays.

It should be noted that searches in the kaon sector are of particular interest here.

References:

[1] Yu. M. Andreev et al. Search for Light Dark Matter with NA64 at CERN. Phys. Rev. Lett., 131(16):161801, 2023.

[2] Yu. M. Andreev et al. Probing light dark matter with positron beams at NA64. Phys. Rev. D, 109(3):L031103, 2024.

[3] Yu. M. Andreev et al. First Results in the Search for Dark Sectors at NA64 with the CERN SPS High Energy Muon Beam. Phys. Rev. Lett., 132(21):211803, 2024.

[4] Yu. M. Andreev et al. Dark-Sector Search via Pion-Produced η and η' Mesons Decaying Invisibly

in the NA64h Detector. Phys. Rev. Lett., 133(12):121803, 2024.

[5] L. Marsicano, M. Battaglieri, M. Bondi', C. D. R. Carvajal, A. Celentano, M. De Napoli, R. De Vita, E. Nardi, M. Raggi, and P. Valente. Dark photon production through positron annihilation in beam-dump experiments. Phys. Rev. D, 98(1):015031, 2018.

2.2.4. A list of the main publications of JINR authors, including associated personnel on the results of the project work (list of bibliographical references).

1. Searching for Light Dark Matter and Dark Sectors with the NA64 experiment at the CERN SPS, NA64 Collaboration, (May 20, 2025) e-Print: 2505.14291 [HEP-EX]
2. High efficiency veto hadron calorimeter in the NA64 experiment at CERN, NA64 Collaboration, Published in: *Nucl.Instrum.Meth.A* 1081 (2026) 170830
3. Proof of principle for a light dark matter search with low-energy positron beams at NA64, NA64 Collaboration, Published in: *JHEP* 06 (2025) 256
4. Shedding light on dark sectors with high-energy muons at the NA64 experiment at the CERN SPS, NA64 Collaboration, Published in: *Phys.Rev.D* 110 (2024) 11, 112015
5. Dark-Sector Search via Pion-Produced η and η′ Mesons Decaying Invisibly in the NA64h Detector, NA64 Collaboration, Published in: *Phys.Rev.Lett.* 133 (2024) 12, 121803
6. First Results in the Search for Dark Sectors at NA64 with the CERN SPS High Energy Muon Beam, NA64 Collaboration, Published in: *Phys.Rev.Lett.* 132 (2024) 21, 211803
7. Probing light dark matter with positron beams at NA64, NA64 Collaboration, Published in: *Phys.Rev.D* 109 (2024) 3, L031103
8. Search for Light Dark Matter with NA64 at CERN, NA64 Collaboration, Published in: *Phys.Rev.Lett.* 131 (2023) 16, 161801
9. Search for a light Z′ in the Lμ-Lτ scenario with the NA64-e experiment at CERN, NA64 Collaboration, Published in: *Phys.Rev.D* 106 (2022) 3, 032015
10. Addendum to the Proposal P348: Search for dark sector particles weakly coupled to muon with NA64 μ , NA64 Collaboration (Oct 13, 2018)
11. Search for vector mediator of Dark Matter production in invisible decay mode, NA64 Collaboration, (Oct 2, 2017) Published in: *Phys.Rev.D* 97 (2018) 7, 072002
12. Search for invisible decays of sub-GeV dark photons in missing-energy events at the CERN SPS, NA64 Collaboration, Oct 10, 2016) Published in: *Phys.Rev.Lett.* 118 (2017) 1, 011802
13. Search for a Hypothetical 16.7 MeV Gauge Boson and Dark Photons in the NA64 Experiment at CERN, NA64 Collaboration, (Mar 21, 2018) Published in: *Phys.Rev.Lett.* 120 (2018) 23, 231802
14. Search for pseudoscalar bosons decaying into e+e−e+e− pairs in the NA64 experiment at the CERN SPS, NA64 Collaboration, (Apr 27, 2021) Published in: *Phys.Rev.D* 104 (2021) 11, L111102
15. Constraints on New Physics in Electron g−2g−2 from a Search for Invisible Decays of a Scalar, Pseudoscalar, Vector, and Axial Vector, NA64 Collaboration, (Feb 3, 2021) Published in: *Phys.Rev.Lett.* 126 (2021) 21, 211802

16. Proposal for an Experiment to Search for Light Dark Matter at the SPS. 2013, S. Andreas, P. Crivelli, et al.
17. B. B. Oberhauser et al., "Development of the fully Geant4 compatible package for the simulation of Dark Matter in fixed target experiments," Comput. Phys. Commun. 300 (2024), 109199 doi:10.1016/j.cpc.2024.109199 [arXiv:2401.12573 [hep-ph]].
18. S. N. Gninenko, D. V. Kirpichnikov, S. Kuleshov, V. E. Lyubovitskij and A. S. Zhevlakov, "Test of the vector portal with dark fermions in the charge-exchange reactions in the NA64 experiment at CERN SPS," Phys. Rev. D 109 (2024) no.7, 075021 doi:10.1103/PhysRevD.109.075021 [arXiv:2312.01703 [hep-ph]].
19. S. N. Gninenko, N. V. Krasnikov and V. A. Matveev, "Search for $K_{S,L}$ oscillations and invisible decays into the dark sector at NA64," Natural Sci. Rev. 1 (2024), 5 doi:10.54546/NaturalSciRev.100105 [arXiv:2501.09772 [hep-ph]].
20. S. N. Gninenko, N. V. Krasnikov and V. A. Matveev, "Probing light dark matter with NA64 at CERN," Int. J. Mod. Phys. A 39 (2024) no.34, 2445006 doi:10.1142/S0217751X24450064

2.2.5. A complete list of publications (electronic annex, for journal publications with journal impact factor).

2.2.6. List of papers presented at international conferences and meetings (electronic annex).

2.2.7. Patent activity (if any)

2.3. Status and stage (TDR, CDR, ongoing project) of the project (including percentage of implementation of the declared milestones of the project *(if applicable)*

2.4. Results of related activities

2.4.1. Research and education activities. List of defended dissertations.

2.4.2. JINR grants (scholarships) received.

2.4.3. Awards and prizes.

2.4.4. Other results (expert, scientific-organisational, scientific-propaganda activities).

3. International scientific and technical cooperation. Actually participating countries, institutions and organisations

Organisation	Country	City	Participants	Type of agreement

4. Plan/actual analysis of resources used: human (including associated personnel), financial, IT, infrastructure

4.1. Human resources (actual at the time of reporting, total number of participants)

(total number of participants)

№№ п/а	Category employee	Core staff Amount of FTE	Associated personnel Amount of FTE
1.	scientific staff	4,8	
2.	engineers	1,5	
3.	professionals	0,2	
	Total:	**6,5**	

4.2. The actual estimated cost of the project

Names of costs, resources, funding sources			Cost (thousands of dollars) resource requirements	Proposal from the laboratory for allocation of funding and resources				
				1st year	2nd year	3rd year	4th year	5th year
		International cooperation (IC)						
		Materials						
		Equipment and third-party services						
		Commissioning work						
		Services of research organisations						
		Acquisition of software						
		Design/construction						
		Service costs (*planned in case of direct project affiliation)*						
Resources required	**Normo-hours**	Resources						
		– The amount of FTE,						
		– accelerator/installation,						
		– reactor, ...						
Sources of funding	**Budgetary resources**	JINR budget *(budget items*						
	Extrabudgetary (supplementary estimates)	Contributions by co-contractors Funds under contracts with customers Other sources of funding						

4.3. Other resources

Computer resources consumed MICC	Distribution by year				
	1st year	2nd year	3rd year	4th year	5th year
Data storage (TB) - EOS - Ribbons					
Tier 1 (core-hour)					
Tier 2 (core-hour)					
SC Talker (core-hour) - CPU - GPU					
Clouds (CPU cores)					

5. Conclusion

6. Proposed reviewers

Prof. Sergey V. Shmatov (JINR)

Theme Leader

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