Annex 3.

Form of opening (renewal) for Project / Sub-project of LRIP

APPROVED

JINR DIRECTOR

____________/__________________

"____" ____________________ 202 г.

PROJECT PROPOSAL FORM

Opening/renewal of a research project/subproject of the large research infrastructure project within the Topical plan of JINR

1. General information on the research project of the theme/subproject of the large research infrastructure project (hereinafter LRIP subproject)

1.1 Theme code / LRIP (for extended projects) - *the theme code includes the opening date, the closing date is not given, as it is determined by the completion dates of the projects in the topic.*

02-2-1144-2021

1.2 Project/LRIP subproject code (for extended projects)

02-2-1144-2021/2024

1.3 Laboratory

DLNP

1.4 Scientific field

Particle Physics

1.5 Title of the project/LRIP subproject

Experiment COMET

1.6 Project/LRIP subproject leader(s)

Tsamalaidze Zviad

1.7 Project/LRIP subproject deputy leader(s) (scientific supervisor(s))

2 Scientific case and project organization

2.1 Annotation

Charged-lepton flavour-violating (CLFV) processes offer deep probes for new physics with discovery sensitivity to a broad array of new physics models - SUSY, Higgs Doublets, Extra Dimensions, and, particularly, models explaining the neutrino mass hierarchy and the matter- antimatter asymmetry in the Universe via leptogenesis. The most sensitive exploration of CLFV is provided by experiments that utilize high intensity muon beams to search for CLFV $\mu \rightarrow e$ transitions. COMET (COherent Muon to Electron Transition) experiment at J-PARC is one of such experiments, it's aim is to search for the coherent neutrinoless conversion of a muon into an electron in the field of an aluminum nucleus $\mu^- N \rightarrow e^- N$.

COMET experiment will be realized in two phases, Phase-I and Phase-II. The experimental sensitivity goal for this process in the Phase-I experiment is 3.1×10^{-15}, or 90% upper limit of branching ratio of 7×10^{-15}, which is a factor of 100 improvement over the existing limit. The expected number of background events is 0.032. To achieve the target sensitivity and background level, the 3.2kW 8 GeV proton beam from J-PARC will be used. Two types of detectors, CyDet and StrECAL, will be used for detecting the μ-e conversion events, and for measuring the beam-related background events in view of the Phase-II experiment, respectively.

Scientists from JINR are participating successfully in the preparation stage of the COMET experiment. For the COMET Phase-I experiment JINR scientists produced and tested in accordance with the requirement all set of 9.8 mm straw tubes, about 2700 pcs, and for Phase – II make a full set of 5 mm straw tubes, also participate strongly in the creation and operation of straw-tracker, electromagnetic calorimeter and Cosmic Ray Veto (CRV) system. The contribution to simulations with further data analysis are also in charge.

2.2 Scientific case (aim, relevance and scientific novelty, methods and approaches, techniques, expected results, risks)

Historically, flavour-changing neutral currents have played a significant role in revealing details of the underlying symmetries at the foundation of the SM. In the SM there is no known symmetry that conserves lepton flavour. The discoveries of quark mixing and neutrino mixing, provided profound insights to the underlying physics. Motivated by these past successes, there exists a global programme to explore CLFV processes providing deep, broad probes of Beyond Standard Model (BSM) physics.

The objective is to search for evidence of new physics beyond the SM using CLFV processes in the muon sector. These processes offer powerful probes of BSM physics and are sensitive to effective new physics mass scales of 10^3-10^4 TeV/c^2, well beyond what can be directly probed at colliders. Over the next few years, currently planned experiments and will begin taking data and will extend the sensitivity to CLFV interactions by orders of magnitude. Further improvements are possible and new or upgraded experiments are being considered that would utilize upgraded accelerator facilities at J-PARC, PSI, and Fermilab and could begin taking data in the 2024-2030 timeframe.

Experimentally, one of the promising process to search for CLFV is direct muon-to-electron conversion via an interaction with a nucleus, $\mu^- N \to e^- N$ ($\mu \to e$ conversion). The COMET experiment seeks to measure the neutrinoless, coherent transition of a muon to an electron ($\mu \to e$ conversion) in the field of an aluminum nucleus.

The event signature of coherent neutrinoless $\mu^- \to e^-$ conversion in a muonic atom is the emission of a mono energetic single electron in a defined time interval. The energy of the signal electron ($E_{\mu e}$) for aluminium $E_{\mu e}$ = 104.97 MeV and the lifetime of the muonic atom is 864 ns.

This makes neutrinoless $\mu^- \to e^-$ conversion very attractive experimentally. Firstly, the e^- energy of about 105 MeV is well above the end-point energy of the muon decay spectrum (~ 52.8 MeV). Secondly, since the event signature is a mono-energetic electron, no coincidence measurement is required. Thirdly, the long lifetime means backgrounds associated with the beam flash can be eliminated. Thus, the search for this process has the potential to improve sensitivity by using a high muon rate without suffering from accidental background events. The experiment will be carried out using a two-staged approach, **Phase-I** [1] and **Phase-II** [2].

The COMET **Phase-I** aims at a signal sensitivity (SES) of 3.1×10^{-15}, roughly a factor 100 better than the current experimental limit. The goal of the full experiment is a SES of 2.6×10^{-17}, which we refer to as **Phase-II**. This ultimate sensitivity goal is a factor of about 10,000 betters than the current experimental limit of $B(\mu^- + \text{Au} \to e^- + \text{Au}) \leq 7\times10^{-13}$ from SINDRUM-II at PSI [3]. A schematic layout of the COMET (Phase-I and Phase-II) experiment is shown in Fig. 1.

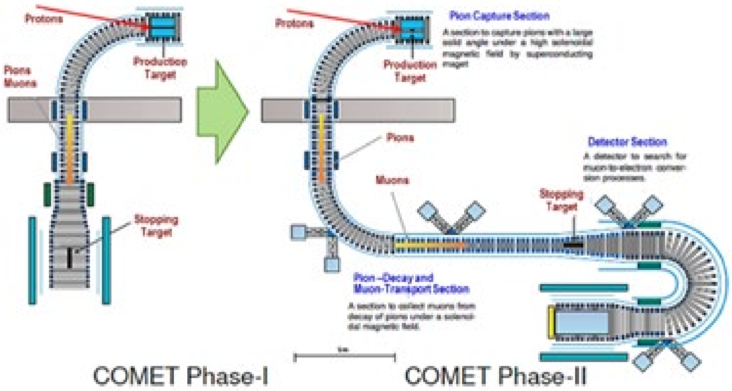

Fig. 1. Schematic layout of COMET Phase-I and COMET Phase-II.

The purpose of COMET Phase-I is two-fold. The first is to make **background measurements** for COMET Phase-II and the second is a **search for μ−e conversion** at an intermediate sensitivity. The COMET Phase-I serves several roles that are highly complementary to the Phase-II experiment. It provides a working experience of many of the components to be used in Phase-II and enables a direct measurement of backgrounds. Significantly, it will also produce competitive physics results, both of the μ−e conversion process and of other processes that COMET Phase-II cannot investigate.

The experiment will be carried out in the Nuclear and Particle Physics Experimental Hall (NP Hall) at J-PARC using a bunched 8 GeV pulsed proton beam with high inter-bunch extinction factor, that is slow-extracted from the J-PARC Main Ring (MR). Muons for the COMET experiment will be generated from the decay of pions produced by collisions of the 8 GeV proton beam on a production target. The yield of low-momentum muons transported to the experimental area is enhanced using a superconducting pion-capture solenoid surrounding the proton target in the pion-capture section. Muons are momentum- and charge-selected using curved superconducting solenoids in the muon-transport section, before being stopped in an aluminum target. The signal electrons from the muon-stopping target are then transported by additional curved solenoids to the main detector system, including a cylindrical drift chamber (CDC), a straw-tube tracker and electron calorimeter, called the StrECAL detector.

The COMET Phase-I will have the pion-capture and the muon-transport sections up to the end of the first 90° bend of the full experiment. The muons will then be stopped in the aluminum target at the center of a cylindrical drift chamber in a 1T magnetic field. A schematic layout of the COMET Phase-I setup is shown in Fig. 2.

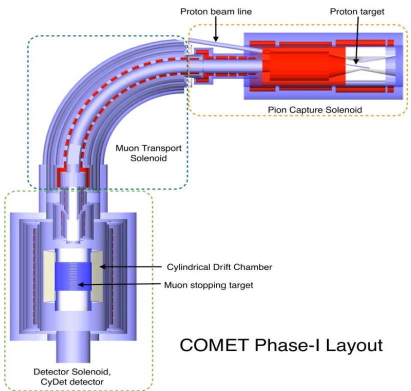

Fig. 2. Schematic layout of COMET Phase-I.

The COMET Phase-I experiment will utilize about 3 kW of 8 GeV protons from the J-PARC MR, delivered in pulses spaced by 1.17 μs. For COMET Phase-I, the primary detector for the neutrinoless μ−e conversion signals consists of a CDC and a set of triggers hodoscope counters, referred to as the CyDet detector. The experimental setup for Phase-I will be augmented with prototypes of the Phase-II

StrECAL detector. As well as providing valuable experience with the detectors, the StrECAL and CyDet detectors will be used to characterize the beam and measure backgrounds to ensure that the Phase-II single event sensitivity of 2.6×10^{-17} can be realized [4].

For Phase-I a total number of protons on target (POT) of 3.2×10^{19} is planned which will provide around 1.5×10^{16} muons stopped in the target. This will enable the design goal of COMET Phase-I to be achieved; a single event sensitivity, which, in the absence of a signal, translates to a 90% confidence level branching ratio limit of 7×10^{-15}. This is a factor of about 100 more than that of the current limit on gold from SINDRUM-II [3].

References:

1. COMET Phase-I TDR, COMET Collaboration, PTEP 2020, 3, 033C01.
2. The COMET Collaboration, *Conceptual design report for experimental search for lepton flavor violating $\mu^- \to e^-$ conversion at a sensitivity of* 10^{-16} *with a slow-extracted bunched proton beam (COMET)*, KEK Report 2009–10
3. W. Bertl, et al. (SINDRUM-II Collaboration), Eur. Phys. J. C47 (2006) 337
4. B. Krikler. “Sensitivity and Background Estimates for Phase-II of the COMET Experiment.” 2016. URL http://hdl.handle.net/10044/1/45365

2.3 Estimated completion date

2024 - 2026

2.4 Participating JINR laboratories

DLNP, BLTP, MLIT, VBLHEP

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 - Tapes					
Tier 1 (CPU core hours)					
Tier 2 (CPU core hours)					
SC Govorun (CPU core hours) - CPU - GPU					
Clouds (CPU cores)					

2.5. Participating countries, scientific and educational organizations

Organization	Country	City	Participants	Type of agreement
Imp. college Rutherf. Lab.	England	London	Uchida Yoshi + 6 pers. Clark D. + 4 pers.	Collaborations
IF NANB	Belarus	Minsk	Shelkovyi D.V. + 3 pers. Orlovich V, Grabchikov A, Khodasevich I	Joint work
BGU	Belarus	Minsk	Anishchik V.M. + 5 pers.	Collaborations
INR, BGU	Belarus	Minsk	Lobko A., Misevich O.	Collaborations
Tech. Univ	Germany	Dresden	Zuber K. + 4 pers.	Collaborations
IHEP-TSU	Georgia	Tbilisi	Devidze G. + 4 pers.	Collaborations
GTU	Georgia	Tbilisi	Lomidze D. + 6 pers.	Collaborations
UG	Georgia	Tbilisi	Gogilidze + 2 pers.	Collaborations
INP ME	Kazakhstan	Almaty	Zdorovets M.+3 pers.	Collaborations
BINP RAS	Russia	Novosibirsk	Grigoriev D. + 6 pers.	Collaborations
NSU	Russia	Novosibirsk	Bondar A. + 6 pers.	Collaboration
CNRS-IN2P3	France	Paris	Paris Kapusta F. + 4 pers.	Collaboration
Karlov Univ.	Czech Republic	Prague	Finger M. + 4 pers.	Collaborations
KEK	Japan	Tsukuba	Mihara S. + 18 pers.	Collaborations

Osaka Univ.	Japan	Osaka	Kuno Y. + 14 pers.	Collaborations
Kyushu Univ.	Japan	Fukuoka	J. Tojo + 8 pers.	Collaborations

2.6. Key partners *(those collaborators whose financial, infrastructural participation is substantial for the implementation of the research program. An example is JINR's participation in the LHC experiments at CERN).*

3. Manpower
3.1. Manpower needs in the first year of implementation

№№ n/a	Category of personnel	JINR staff, amount of FTE	JINR Associated Personnel, amount of FTE
1.	research scientists	13.4	
2.	engineers	3.7	
3.	specialists		
4.	office workers		
5.	technicians		
	Total:	**17.1**	

3.2. Available manpower
3.2.1. JINR staff

No.	Category of personnel	Full name	Division	Position	Amount of FTE
1.	research scientists	D. Aznabaev	BLTP	Researcher	0,3
2.	research scientists	D. Baigarashev	VBLHEP	Researcher	0,4
3.	research scientists	A. Boikov	DLNP	Junior researcher	0.3
4.	research scientists	D.Chokheli	DLNP	Senior researcher	1.0
5.	research scientists	T.L. Enik	VBLHEP	Senior researcher	0.3
6.	research scientists	D. Goderidze	MLIT	Junior researcher	0.5
7.	research scientists	P.G. Evtukhovich	DLNP	Senior researcher	1.0
8.	research scientists	A. Issadikov	BLTP	Senior researcher	0.3
9.	research scientists	V.A. Kalinnikov	DLNP	Leading researcher	1.0
10.	research scientists	A. Khvedelidze	MLIT	Leading researcher	0.4
11.	research scientists	G.A. Kozlov	BLTP	Leading researcher	0.3
12.	research scientists	A.V. Pavlov	DLNP	Junior researcher	1.0
13.	research scientists	B.M. Sabirov	DLNP	Researcher	1.0
14.	research scientists	A.V. Simonenko	DLNP	Senior researcher	1.0
15.	research scientists	V.V. Tereshchenko	DLNP	Group Leader	0.3
16.	research scientists	Z. Tsamalaidze	DLNP	Head of the Sector	0,7
17.	research scientists	N. Tsverava	DLNP	Junior researcher	1.0
18.	research scientists	I.I. Vasiliev	DLNP	Junior research	0,3
19.	research scientists	E.P. Velicheva	DLNP	Senior researcher	1.0
20.	research scientists	A.D. Volkov	DLNP	Researcher	1.0
21.	research scientists	I. Zimin	DLNP	Junior researcher	0.3
22.	engineers	I.L. Evtukhovich	DLNP	Senior engineer	0.9

23.	engineers	E.S. Kaneva	DLNP	Engineer	1.0
24.	engineers	X. Khubashvili	DLNP	Engineer	0.9
25.	engineers	A.G. Samartsev	DLNP	Senior engineer	0.4
26.	engineers	S.V. Tereshchenko	DLNP	Engineer	0.5
27.	specialists				
28.	technicians				
	Total:				**17.1**

3.2.2. JINR associated personnel

No.	Category of personnel	Partner organization	Amount of FTE
1.	research scientists		
2.	engineers		
3.	specialists		
4.	technicians		
	Total:		

4. Financing
4.1 Total estimated cost of the project/LRIP subproject
The total cost estimate of the project (for the whole period, excluding salary).
630,000 USD
The details are given in a separate table below.

4.2 Extra funding sources
Expected funding from partners/customers – a total estimate.

Project (LRIP subproject) Leader __________/____Tsamalaidze Z.____/

Date of submission of the project (LRIP subproject) to the Chief Scientific Secretary: _________
Date of decision of the laboratory's STC: _________ document number: _________

Year of the project (LRIP subproject) start: ________________

(for extended projects) – Project start year: _______

Proposed schedule and resource request for the Project / LRIP subproject

Expenditures, resources, funding sources			Cost (thousands of US dollars)/ Resource requirements	Cost/Resources, distribution by years				
				1st year	2nd year	3rd year	4th year	5th year
		International cooperation	300	100	100	100		
		Materials	190	70	70	50		
		Equipment, Third-party company services	140	40	40	60		
		Commissioning						
		R&D contracts with other research organizations	-					
		Software purchasing						
		Design/construction						
		Service costs (*planned in case of direct project affiliation)*						
Resources required	**Standard hours**	Resources						
		– the amount of FTE,						
		– accelerator/installation,	900	350	350	200		
		– reactor,…						
Sources of funding	**JINR Budget**	JINR budget *(budget items)*	630	210	210	210		
	Extra fudning (supplementary estimates)	Contributions by partners						
		Funds under contracts with customers						
		Other sources of funding						

Project (LRIP subproject) Leader__________/__Tsamalaidze Z.______/

Laboratory Economist __________/_________________/

APPROVAL SHEET FOR PROJECT / LRIP SUBPROJECT

TITLE OF THE PROJECT/LRIP SUBPROJECT

SHORT DESIGNATION OF THE PROJECT / SUBPROJECT OF THE LRIP

PROJECT/LRIP SUBPROJECT CODE

THEME / LRIP CODE

NAME OF THE PROJECT/ LRIP SUBPROJECT LEADER

AGREED

JINR VICE-DIRECTOR	____________ SIGNATURE	____________ NAME	____________ DATE
CHIEF SCIENTIFIC SECRETARY	____________ SIGNATURE	____________ NAME	____________ DATE
CHIEF ENGINEER	____________ SIGNATURE	____________ NAME	____________ DATE
LABORATORY DIRECTOR	____________ SIGNATURE	____________ NAME	____________ DATE
CHIEF LABORATORY ENGINEER	____________ SIGNATURE	____________ NAME	____________ DATE
LABORATORY SCIENTIFIC SECRETARY THEME / LRIP LEADER	____________ SIGNATURE	____________ NAME	____________ DATE
PROJECT / LRIP SUBPROJECT LEADER	____________ SIGNATURE	____________ NAME	____________ DATE

APPROVED BY THE PAC	____________ SIGNATURE	____________ NAME	____________ DATE

Annex 4.

Project (LRIP subproject) report form

PROJECT REPORT

1. General information on the project / LRIP subproject

1.1. Scientific field

1.2. Title of the project / LRIP subproject

Search for new physics in the lepton sector

1.3. Project (LRIP subproject) code

1.4. Theme / LRIP code

Example (theme 04-4-1140-2024, **MIP** ***04-4-1140-2024)***

1.5. Actual duration of the project/ LRIP subproject

1.6. Project / LRIP subproject Leader(s)

2. Scientific report

2.1. Annotation

2.2. A detailed scientific report

2.2.1. Description of the mode of operation and functioning of the main systems and equipment (for the LRIP subproject).
2.2.2. A description of the conducted experiments (for experimental projects).
2.2.3. A description of the research undertaken and the results obtained.
2.2.4. A list of the main publications of the JINR authors, including associated personnel on the results of the project (list of bibliographical references).
2.2.5. A complete list of publications (electronic annex, for journal publications with journal impact factor).
2.2.6 List of talks given 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 (subproject) (including percentage of implementation of the declared milestones of the project (LRIP subproject) *(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 investigation, organizational, outreach activities).

3. International cooperation
Actually participating countries, institutions and organizations

Organization	Country	City	Participants	Type of agreement

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		
2.	engineers		
3.	specialists		
	Total:		

4.2 The actual estimated cost of the project/ LRIP subproject

Names of costs, resources, funding sources		Cost (thousands of US dollars) / Resource request	Proposal from the laboratory for allocation of funding and resources				
			1 year	2 year	3 year	4 year	5 year
	International cooperation						
	Materials						
	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)*						
Resources required **Standard hours**	Resources						
	– the amount of FTE,						
	– accelerator/installation,						

		– reactor,…						
Sources of funding	JINR Budget	JINR budget *(budget items)*						
	Extra fudning (supplementary estimates)	Contributions by partners Funds under contracts with customers Other sources of funding						

4.3 Other resources

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

5. Conclusion

6. Proposed reviewers

Theme / LRIP Leader

______________/________________/
"______"_____________________ 202_г.

Project leader (project code) / LRIP subproject
______________/_____/
"______"_____________ 202_г.

Laboratory Economist
_______/________/
"______"_____________ 202_ г.