Questionnaire (for projects seeking continuation):

Project COMET

A. Scientific merit

1. Goals of the experiment:

1a. Give a short description of the goals of the experiment

The COMET experiment is devoted to study the fundamental question of the flavour charges conservation in Nature.

The f*lavour violation has been observed in quarks and neutrinos, so it is natural to expect flavour violating effects among the charged leptons as well. Charged-lepton flavour-violating (CLFV) processes provide unique discovery potential for physics Beyond the Standard Model (BSM). These CLFV processes explore new physics parameter space in a manner complementary to the collider, dark matter, dark energy, and neutrino physics programmes. Experimentally, there are three primary muon-to-electron transitions used to search for CLFV: a muon decaying into an electron plus a photon,* $\mu^+ \rightarrow e^+\gamma$ *; a muon decaying into three electrons,* $\mu^+ \rightarrow e^+e^-e^+$ *; and direct muon-to-electron conversion via an interaction with a nucleus,* $\mu^- N \rightarrow e^- N$*.* The *COMET experiment aims to investigate the last process, namely it seeks to measure the neutrinoless, coherent transition of a muon to an electron (μ → e conversion) in the field of an aluminum nucleus.*

The experiment will be carried out using a two-staged approach, Phase-I and Phase-II. 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 better than the current experimental limit of* $B(\mu^- + Au \rightarrow e^- + Au) \leq 7\times10^{-13}$ *from SINDRUM-II at PSI.*

1b. Explain what the project adds to the international scenario:

The study of *CLFV processes is an important part of scientific programs of word leading centers of elementary particle physics. In particularly, using high-intensity muon beams, the MEG II, COMET and Mu2e experiments are prepared, respectively, in PSI, J-PARC and Fermilab.* Starting from *the latter half of the next decade, upgrades to the beamlines at these centers make it possible to increase the intensity of muons beams by 10-1000 times and therefore to improve bounds on CLFV processes. The current best limits for CLFV μ → e transitions are in the* $10^{-12} – 10^{-13}$ *range and probe effective new physics mass scales above* 10^3 *TeV/*c^2 *and planned experiments (MEG II, COMET and Mu2e) expect to extend the sensitivity about two-four order of magnitude.*

Particularly, the COMET experiment expects to improve these sensitivities by as much as two orders of magnitude on the timescale at 2023-2024 in Phase-I, and four orders at 2026-2027 in Phase-II. This dramatic improvement in sensitivity offers genuine discovery possibilities in a wide range of new physics models with SUSY, Extra Dimensions, an extended Higgs sector, leptoquarks, or those arising from GUT models.

B. Achievements

2. Contributions of the JINR group:

2a. List of the specific contributions of the JINR group in hardware (including use of JINR computing resources for the project), software development and physics analyses.

The JINR contribution to COMET consists of participation in the R&D and production of three main detector systems of the experiment: the electromagnetic calorimeter (ECAL), the straw tracker, the Cosmic Ray Veto (CRV), and in a variety of works on related simulation.

Namely, the following specific contribution by the JINR group have been made:

1) *For ECAL—— R&D of LYSO crystals and all LYSO crystals certification;*
2) *For Straw tracker —- R&D of straw-tube and their production (around 2700 tubes) and preliminary testing at JINR, including study of their properties, and final testing at KEK, J-PARC and Straw-ECAL combine test beam at Tohoku University.*
3) *For CRV: JINR physicists have implemented a full-scale R&D program to create a CRV. The program was completed successfully, and the results were reported at the collaboration meetings. Based on these results, all the parameters and methods for creating the CRV are determined. JINR group plans to create of the s-called "Module-0" and test, definition of final design of CRV.*

2b. List of the responsibilities of JINR group members within the management structure of the collaboration, if any, giving the name of the JINR member, the managerial role and the appointment period.

- *The JINR group is fully responsible for manufacturing of all straw tubes, including different procedures of the tube tests in accordance with the COMET requirements. Also JINR takes full responsibility for the next step to this direction, carrying out of R&D works of straw tubes for the COMET Phase-II, with the tubes of 5 mm diameter and 12μ wall thickness. JINR physicists together with the KEK colleagues take full responsibility in assembling, tests and installation of the full-scale straw tracker for Phase-I. The member of JINR-COMET team Dr. Petr Evtoukhovitch since 2012 is one of the coordinator for the straw tracker system.*
- *JINR proposed the idea (It is accepted by the Collaboration Board) takes full responsibility in production of a full-scale straw station, with new type of straw tubes.*
- *JINR takes full responsibility for development and optimization of a crystal calibration method for the calorimeter for COMET Phase I and Phase-II, and together with KEK and Kyushu University takes full responsibility for assembling, testing, installation and operation of the calorimeter.*
- *JINR group take full responsibility for the certification of crystals, and are the leaders in the crystals R&D work.*
- *JINR scientists is fully responsible in the assembly, testing and installation and operation of the CRV. The member of JINR-COMET team Dr. Davit Chokheli since 2021 is COMET-CRV leader.*

3. Publications:

List the papers published in the refereed literature (no conference proceedings) in which the JINR group had a major contribution (e.g. author of the analysis, promoter of the experiment, corresponding author, realization of a key equipment etc.). Give title of paper, reference and describe in 1-2 sentences the JINR contribution. Only papers published since the last approval of the project should be listed.
Mention the total number of papers published by the project in the same time period.

1. *H. Nishiguchi, P. Evtoukhovitch, Y. Fujii, E. Hamada, N. Kamei, S. Mihara, A. Moiseenko, K. Noguchi, K. Oishi, J. Suzuki, J. Tojo, Z. Tsamalaidze, N. Tsverava, K. Ueno, A. Volkov, Construction on vacuum-compatible straw tracker for COMET Phase-I. NIM, A 958 (2020) 162800.*
2. *A. Volkov, P. Evtoukhovich, M. Kravchenko, Y. Kuno, S. Mihara, H. Nishiguchi, A. Pavlov, Z. Tsamalaidze. Properties of straw tubes for the tracking detector of the COMET experiment. NIM.A 1004 (2021) 165242.*
3. *V. Kalinnikov, E.Velicheva, A. Grabtchikov, I. Khodasevich, V. Orlovich, Y. Kuno, A. Sato. Investigation of the Light Yield Distribution in LYSO Crystals by the Optical Spectroscopy Method for the Electromagnetic Calorimeters of the COMET Experiment. Nonlin.Phenom.Complex Syst. 23 (2020) 4, 374-385.*
4. *V. Kalinnikov, E. Velicheva, Yusuke Uozumi. Comparison of the Scintillation Properties of Long LYSO:Ce Crystals from Different Manufacturers. //Physics of Particles and Nuclei Letters, 2021, Vol. 18, No. 4, pp. 457–468*
5. COMET Phase-I TDR, COMET Collaboration, PTEP 2020, 3, 033C01

4. PhD theses:

List the PhD theses completed within the last 3 years, or expected to be completed within one year, by JINR students within the project, giving the student name, thesis title and graduation year.

5. Talks:

5a. List the invited plenary talks given by members of the JINR group at international conferences, workshops… since the last approval of the project: give name and date of the Conference, title of talk and speaker name.
5b. Give a similar list for parallel talks.

1. *M. Kravchenko. “Mechanical properties of the thin-walled straws of the COMET experiment”, The EPS-HEP2019 Conference, Ghent, Belgium, 10-17 July, 2019*
2. *N. Tsverava et al., “Development of Ultrathin 12 μm Thick Straw Tubes for the Tracking Detector of COMET Experiment”, Proceedings, 2019 IEEE Nuclear Science Symposium*

(NSS) and Medical Imaging Conference (MIC) (NSS/MIC 2019): Manchester, United Kingdom, October 26- November 02, 2019

3. D. Chokheli. " High Efficiency Muon Registration System based on Scintillator Strips", CM32 workshop, Tokai, 2-6 November, 2020
4. S. Tereshchenko. " Proposal for Improvement of the efficiency and electronic for the CRV", CM32 workshop, Tokai, J-PARC, 2-6 November, 2020
5. D. Chokheli. " R&D for CRV system based on scintillator strips for the COMET experiment", CM33 workshop, Tokai, J-PARC, 22 February to 4 March, 2021.

C. Plans and requests

6. Plans

Describe the plans of the JINR group within the project, in physics analysis, data taking, software development. detector R&D, detector operation and maintenance, upgrade activities… for the period of time of the requested extension.

Now the crucial stage of preparation of the experiment's detector systems is underway. The plans of the JINR group are related to the creation of all the main detector systems, Straw tracker, ECAL and CRV of the experiment.

The preparation of detector systems includes: R&D, simulation and optimization, defining detectors design, assembly, testing, installation, maintenance and operation during a physical run, data acquisition and analysis.

7. Group size, composition and budget.

7a. List the JINR personnel involved in the project, including name, status (e.g. PI, researcher, post-doc, student, engineer, technician…) and FTE. Mention the total number of people in the collaboration.

COMET JINR group members (bold – new members)

#	Name	FTE	Position	Work (apart common duties like shifts)
1	**G. Adamov**	0.7	Junior researcher PhD student	Hardware and Software tools development, data quality control, analysis
2	**A.M.Artikov**	0.5	Senior scientist	Hardware development and support of CRV
3	D. Aznabayev	0.3	Junior researcher	Theoretical issues, physics analysis
4	D. Baygarashev	0.4	Junior researcher	Data quality control, calibration, physics analysis
5	**A. Boikov**	0.3	Junior researcher PhD student	CRV electronics, R&D COMET
6	**D. Chokheli**	1.0	Senior scientist	CRV construction, Leader of COMET-CRV detector system

7	V.N. Duginov	0.8	Deputy head of department	Calorimeter development, analysis
8	T.L. Enik	0.3	Senior scientist	Hardware development and support
9	I.L. Evtoukhovitch	0.9	Senior engineer	Hardware development and support
10	D. Goderidze	0.5	Junior researcher PhD student	Software/analysis
11	P.G. Evtoukhovitch	1.0	Senior scientist	Coordinator of Straw Tracker detector system
12	A. Issadykov	0.3	Senior scientist	Theoretical issues, physics analysis
13	V.A. Kalinnikov	1.0	Leading scientist	Calorimeter development, MC, analysis
14	E.S. Kaneva	1.0	Engineer	Hardware/software
15	X. Khubashvili	0.9	Engineer	Hardware development and support
16	A. Khvedelidze	0.4	Leading scientist	Theoretical issues, models development
17	**A. Kobey**	0.5	Master student	Calorimeter development, MC, analysis
18	G.A. Kozlov	0.3	Leading scientist	Theoretical issues, models development
19	A.S. Moiseenko	1.0	Scientist	Hardware development and support
20	A.V. Pavlov	1.0	Junior researcher PhD student	MC, Data quality control, physics analysis
21	B.M. Sabirov	1.0	Scientist	Hardware development and support
22	A.G. Samartsev	0.4	Senior engineer	Hardware development, detector design
23	**A.V. Simonenko**	1.0	Senior scientist	CRV creation and maintenance
24	**V.V. Tereschenko**	0.3	Head of group	CRV electronics, R&D COMET
25	**S.V. Tereschenko**	0.5	Engineer	CRV electronics, R&D COMET
26	Z. Tsamalaidze	0.8	Head of sector	Leader of COMET-JINR group, IB represent.
27	N. Tsverava	1.0	Junior researcher PhD student	Hardware development, calibration, analysis
28	**I.I. Vasilyev**	0.3	Junior researcher	Calorimeter R&D and tests
29	E.P. Velicheva	1.0	Senior scientist	Calorimeter development, MC, analysis
30	A.D. Volkov	1.0	Scientist	Hardware development
31	**I. Zimin**	0.5	Junior scientist PhD student	Software, simulation, analysis
	Total FTE	**20.9**		

7b. Present the JINR group budget for the period of time of the requested extension, specifying the main budget items (equipment, computing, salaries, common funds, travel…)

	Expenditure items (k$)	Full cost	2022	2023	2024
	Direct expenses for the Project (k$)				
2	Computers	30	10	10	10
6	Materials	190	70	70	50
7	Equipment	110	30	30	50
9	Research operation fee	60	20	20	20
10	Travel allowance	300	100	100	100
	Total direct expenses	690	230	230	230

7c. Indicate the use or needs of JINR computing resources for the group and for the project if any.

As noted in the project, carrying out a comet experiment using high-intensity proton and muon beams; superconducting magnets; high-speed data collection systems; work in harsh radiation conditions; needed software and computing systems that can satisfy the requirements of the experiment.

In this regard, we plan that with the help of the Laboratory of Information Technologies of JINR , we can create a COMET server for software development, simulation and data analysis.