

## QUESTIONNAIRE (theme 1134, COMET)

### 1. Goals of the experiment:

*1a. Give a short description of the goals of the experiment - limited to 1/2 page.*

COMET (COherent Muon to Electron Transition) is the experiment at J-PARC (JAPAN) to search for coherent neutrino-less conversion of muons to electrons  $\mu^- \rightarrow e^-$  in the presence of a nucleus,  $\mu^- + N(A,Z) \rightarrow e^- + N(A,Z)$ , with a single event sensitivity  $\text{Br}(\mu^- N \rightarrow e^- N) \sim 10^{-17}$ , which is around four orders better than previous experiment SINDRUM II ( $< 7.0 \times 10^{-13}$ ).

Taking into account the risks of an ambitious goal to increase 10000 times the sensitivity of measurements, it is necessary to study experimentally all expected background processes and possible obstacles. With this aim, the project is split into two phases, Phase-Phase-II and I.

The main goals of the COMET Phase-I are:

1) The direct measurement of the proton beam extinction and other potential background sources for the full COMET experiment, using the actual COMET beam line,

And

2) Carrying out a search for  $\mu^- \rightarrow e^-$  conversion with a single-event sensitivity of  $3.0 \times 10^{-15}$  which is 200 times better than the current world best SINDRUM-II limit.

The main goals of the COMET Phase-II include:

Creation of a full beam line, use of higher beam intensity, and modifications of the detector configuration. The 8 GeV proton beam power will increase from 3.2 kW at Phase-I to 56 kW at Phase-II.

The main detectors for observation of the  $\mu^- - e^-$  conversion will be the Straw tracker and ECAL instead of CDC. These modifications, together with experience gained during the Phase-I, will make possible to carry out a search for  $\mu^- - e^-$  conversion at the single-event sensitivity of  $3 \cdot 10^{-17}$ .

*1b. Explain what the project adds to the international scenario: limited to 1/2 page.*

Nowadays the Standard Model (SM) of elementary particle physics does not provide an answer to a number of fundamental questions and requires certain modification. One of the main direction of modern experimental elementary particle physics is the search for a direct manifestation of processes beyond the SM. The COMET experiment is one of the world wide recognized experiment in this area. The realization of the COMET experiment allows improving around four orders better than previous estimates of indication to a charge lepton flavor violation.

In the framework of the modified SM with allowance for the neutrino oscillations, the expected relative probability of muon-electron conversion is less than  $10^{-50}$ , so its observation could be a clear signal from the physics outside the Standard Model.

*2a. Give an itemized 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 - limited to 1 page.*

JINR's group contribute to R&D and construction of two basic detector systems of the COMET experiment, namely the Electromagnetic CALorimeter (ECAL) and Straw tracker detector.

JINR contribution to the creation of the Electromagnetic Calorimeter includes:

- R&D of LYSO crystals based calorimeter
- LYSO crystals parameters investigation
- Measurements with Calorimeter prototype

- Certification of the LYSO crystals for calorimeter
- Simulation of Calorimeter

JINR contribution to the creation of the Straw tracking detector includes:

- The straw tubes design
- The straw tubes (around 2700) production for Phase I, preliminary tests, checking of properties.
- The simulation of straw tracker
- The creation of the manufacturing area (at DLNP JINR) for straw-tube R&D and their production for Phase-II of the COMET experiment.
- Study of gas mixtures for the Phase-I
- The effect of the seam on the collection of primary ionization
- The study of the temperature dependence of the straw physical properties and their change over time.

2b. Give a 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.

Arsen Khvedelidze – member of the COMET experiment TDR Editorial Board

Petr Evtoukhovitch - coordinator of the Straw tracking detector of the COMET experiment

**3. Plans.** Give a short description limited to ½ page of the JINR group plans (in data taking, analysis, detector R&D, upgrade activities...) till the end of the currently approved project.

Works on COMET Electromagnetic Calorimeter include:

- R&D research of a new type of the LYSO (engineered) crystals
- GEANT4 simulation of the ECAL
- Continued work on the certification of crystals

Works on the Straw tracking detector include:

- Straw tubes checking in Japan

The next step before installing straw tubes is a final quality checks. As mentioned above, all tubes were pressurized for long-term storage. By design, straws should be released from pressure and cut from glued end-plugs with a length of 5 cm Mylar. After relaxation of the material, each tube should be checked by the following parameters: uniformity of the straw tube's cylindrical shape, uniform diameter over the entire length of the cylinder, mechanical damages, any detachment of aluminum from the Mylar surface, preparing tubes for assembly (in accordance with the assembly technology).

- The straw-tube R&D at DLNP, JINR

It is planned to work on R&D straw tubes with a diameter of 5 mm from 12 µm of aluminized mylar and their production.

After finalizing of the preparation of the laboratory room (clean room) the study and production of new type of straws will start. The clean room is already equipped with the tools and measurement stands. A new equipment allows us to control characteristics of all produced tubes with high accuracy. The production new type of straw tubes, testing, creation of straw tracker prototypes and beam-test in vacuum is planned.

- The straw simulation

To obtain drift lines in a 3-dimensional view and make changes in the algorithm for construction of isochronous drift lines in Garfield ++ taking into account the design features of the COMET experiment. To simulate the response of the straw tracker in ISEDUST.

**4. Publications:** *List the papers published in 2016, 2017 and 2018 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. Mention the total number of papers published by the project in the same time period.*

1. V. Kalinnikov, E. Velicheva, Z. Tsamalaidze, Lobko, O. Missevitch, Y. Kuno. Spatial and temporal evolution of scintillation light in LYSO electromagnetic calorimeter for non-paraxial electromagnetic showers. //Nonlinear Phenomena in Complex. V. 19, No 4 (2016). Pp. 345 – 357.
2. COMET Phase-I. Technical Design Report 2016 (prepared with participation of the JINR physicists).
3. H. Nishiguchi, P. Evtukhovitch, A. Moiseenko, Z. Tsamalaidze, N. Tsverava, A. Volkov, et al. Development of an extremely thin-wall straw tracker operational in vacuum- The COMET straw tracker system. NIM, A845, 269-272, 2017.
4. K. Ueno, P. Evtukhovitch, A. Moiseenko, A. Samartsev, Z. Tsamalaidze, N. Tsverava, et al. Development of a thinwall straw-tube tracker for COMET experiment. PoS EPS-HEP2017, 524, 2017
5. Volkov A. D. et al. Influence of internal pressure on stress of welded straws. // Advances in Applied Physics, 2018, Vol. 6, № 1, p. 82 – 89
6. Volkov A. D., Tsamalaidze Z. The method of determining the Poisson's ratio material sealed thin-walled polymer tube. Published: 07. 05.2018 Bull. № 13

**5. PhD theses:** *List the PhD theses completed within the last 3 years, or expected to be completed within 2019, by JINR students within the project, giving the student name, thesis title and graduation year.*

1) M. Kravchenko's PhD thesis "Development and application of readout electronics using FPGA and software-hardware complex for straw-tracker and electromagnetic calorimeter of the COMET experiment for searching for  $\mu$ -e conversion" is approved in the laboratory, and is in progress.

2) A.Paulau's PhD thesis "Development and use of software tools in the ICEDUST shell for modeling and analyzing COMET experiment data on searching for a  $m \rightarrow e$  conversion" is approved in the laboratory, and is in progress.

3) N. Tsverava is PhD student of the Georgian Technical University (GTU) and his PhD thesis "Tracking Detector System of the COMET Experiment" is in progress.

## **6. Talks:**

*6a. List the invited plenary talks given by members of the JINR group in 2016, 2017 and 2018 at international conferences, workshops, give name and date of the Conference, title of talk and speaker name.*

1) Fifth International Conference "Scintillation Material Engineering and Radiation Technologies". (ISMART 2016), September 26-30, 2016 Minsk, Belarus. "Development of homogeneous electromagnetic calorimeters on heavy crystals operating in magnetic fields", V. Kalinnikov, E. Velicheva

2) 19th COMET Collaboration Meeting & Integration Workshop, May 16-21 2016 at BSU, Physics Department, Minsk "JINR activity for the straw tube production", N. Tsverava

3) 19th COMET Collaboration Meeting & Integration Workshop, Minsk, Belarus, May 16-21, 2016, "One remark concerning influence of synchrotron radiation on the uncertainty of energy resolution of 100 MeV electron in the field of 1 T", P. Evtoukhovitch

4) 21th COMET Collaboration Meeting & Integration Workshop, J-PARC, Tokai, Japan, November 29 - December 3, 2016, "A couple of remarks of particularities of electron drifting in straw-tubes in presence of magnetic field specific for COMET configuration", P. Evtoukhovitch

- 5) 22th COMET Collaboration Meeting & Integration Workshop, J-PARC, Tokai, Japan, May 22 – 26, 2017, “The status and plans of JINR activity in the COMET experiment”, Z. Tsamalaidze
- 6) 23rd COMET Collaboration Meeting & Integration Workshop 2017, September 24-30 2017 at TU-Dresden, Dresden, Germany “JINR straw tube laboratory status”, N. Tsverava
- 7) 25th COMET Collaboration Meeting, May 21-25, 2018 at J-PARC “Checking and monitoring of straw tubes for Phase-I”, N. Tverava
- 8) 26th COMET Collaboration Meeting & Integration Workshop, Georgian Technical University, Tbilisi, Georgia, October 1 - 5, 2018. “Scintillation crystals on the base of oxyorthosilicate of lutetium: crystal structure, scintillation properties, features, disadvantages and problems of LYSO:Ce crystals”, V. Kalinnikov, E. Velicheva.
- 9) 26th COMET Collaboration Meeting & Integration Workshop, Georgian Technical University, Tbilisi, Georgia, October 1 - 5, 2018, "Stress relaxation measurement of the 9.8 mm straws", M. Kravchenko.
- 10) 26th COMET Collaboration Meeting & Integration Workshop, Georgian Technical University, Tbilisi, Georgia, October 1 - 5, 2018, "STATUS of the manufacturing area for straw-tube production at JINR" B. Sabirov
- 11) 26th COMET Collaboration Meeting & Integration Workshop, Georgian Technical University, Tbilisi, Georgia, October 1 - 5, 2018, “The pasportization the LYSO (Ce) crystals for COMET”, V. Duginov.
- 12) 26th COMET Collaboration Meeting & Integration Workshop, Georgian Technical University, Tbilisi, Georgia, October 1 - 5, 2018, “Viscoelastic properties of straws”, A. Volkov.
- 13) 23rd COMET Collaboration Meeting & Integration Workshop 2017, 24-30 September, TU-Dresden, Dresden, Germany. « Position resolution of the straw-tube» A. Paulau
- 14) 25th Collaboration Meeting & Integration Workshop, J-PARC, Tokai, Japan, May 21 - 26, 2018, "Present status of the Straw module prototype with 5mm straws", P. Evtoukhovitch
- 15) 25th COMET Collaboration Meeting & Integration Workshop 2018, 1– 5 May, Tokai, J–PARC, Japan. «Some new results on straw-tube simulation» A. Paulau
- 16) The European Schools of High-Energy Physics, ESHEP 2018, 20 June - 3 July, Maratea, Italy. Poster report « The effect of the seam on the collection of primary ionization» A. Paulau
- 17) 26th COMET Collaboration Meeting & Integration Workshop 2018, 1 – 5 October, Tbilisi, GTU. «Simulation of drift lines. The nature of the electron motion in the tube» A. Paulau

6b. Give a similar list for parallel talks. -----

## 7. Group size, composition and budget.

7a. Present in a Table the list of 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.

N	Name	Status	FTE
1	G. Adamov	Engineer	0.5
2	D. Aznabayev	Post-doc	0.5
3	D. Baygarashev	Researcher	0.5
4	V.N.Duginov	Senior Researcher	0.5
5	T.L.Enik	Senior researcher	0.2
6	V.V.Elsha	Researcher	0.2
7	D. Goderidze	PhD tudent	0.5
8	K.I.Gritsai	Researcher	0.3

9	I.L.Evtoukhovitch	Senior engineer	1.0
10	P.G.Evtoukhovitch	Senior researcher	1.0
11	V.A.Kalinnikov	Leading researcher	1.0
12	E.S.Kaneva	Engineer	1.0
13	X.Khubashvili	Engineer	1.0
14	A.Khvedelidze	Leading researcher	0.3
15	G.A. Kozlov	Leading researcher	0.2
16	M.D.Kravchenko	PhD student	1.0
17	A.S.Moiseenko	Researcher	1.0
18	S.N.Movchan	Leading researcher	0.1
19	A.Issadikov	Researcher	0.5
20	A.V.Pavlov	PhD student	1.0
21	B.M.Sabirov	Researcher	1.0
22	A.G.Samartsev	Senior engineer	0.3
23	Z.Tsamalaidze	PI	0.8
24	N.Tsverava	PhD student	1.0
25	S.N.Shkarovski	researcher	0.1
26	E.P.Velicheva	Senior researcher	1.0
27	A.D.Volkov	researcher	1.0
	<b>Total FTE</b>		<b>20.5</b>

7b. Indicate the expected changes in the group size, if any, till the end of the currently approved project.

In the next 2019, we expect to enlarge the JINR group by adding 2-3 young specialists and students.

7c. Present the JINR group budget from 2018 till the end of the currently approved project in a Table specifying the main budget items (equipment, computing, salaries, common funds, travel...)

N	The COMET (theme 1134) budget (kUSD)	2018	2019
1.	Salaries	125	227
2.	Computing	-	-
3.	Design bureau	300 hours	200 hours
4.	Workshop LNP	500 hours	200 hours
5.	Materials	80	50
6.	Equipment	20	50
7.	Business trips	50	58

7d. Indicate the use of JINR computing resources for the group and for the project if any.

At present time, we do not use JINR computing resources, but the creation of the COMET computer farm at LIT JINR for the Collaboration usage is planned.