Questionnaire

for Joint session of the PAC for Particle Physics and the PAC for Nuclear Physics for the assessment of the JINR Neutrino Projects

PART A: Achievements

1. Contributions of the JINR group in GERDA:

- ~ 15 kg of enriched ^{76}Ge
- Plastic muon veto system
- Nylon mini-shrouds for mitigation of background from ^{42}Ar
- Liquid argon veto system (together with TUM group)
- Organization and leadership of all operations with bare germanium detectors
- Participation in the development of pulse shape discrimination methods in germanium detectors
- Involvement in physics analysis

Responsibilities of JINR group members within the management structure of the GERDA collaboration:

K.Gusev:	technical coordinator of the GERDA experiment; leader of detectors integration, operation & maintenance task group.
A.Smolnikov:	member of Editorial Board
A.Lubashevskiy:	member of Speakers Bureau
D.Zinatulina:	co-leader of muon veto task group

2. Publications:

1. «Mitigation of ^{42}Ar/^{42}K background for the GERDA Phase II experiment», Eur. Phys. J. C 78 (2018) 15. JINR contribution: JINR group member is the corresponding author, realization of a key equipment and performing of most investigations by JINR team.

2. «Upgrade for Phase II of the GERDA Experiment», Eur. Phys. J. C 78 (2018) 388. JINR contribution: realization of a key equipment, described in the “contribution” section.

3. «Improved Limit on Neutrinoless Double-β Decay of ^{76}Ge from GERDA Phase II», Phys. Rev. Lett. 120 (2018) 132503. JINR contribution: realization of a key equipment, described in the “contribution” section, participation in physics analysis.

4. «Characterization of 30 ^{76}Ge enriched Broad Energy Ge detectors for GERDA Phase II», Eur. Phys. J. C. 79 11 (2019) 978. JINR contribution: participation of JINR group members in characterization activity and in the analysis of collected data.

5. «Probing Majorana neutrinos with double-β decay», Science 365 (2019) 1445. JINR contribution: realization of a key equipment, described in the “contribution” section, participation in physics analysis.

6. «Modeling of GERDA Phase II data», Journal of High Energy Physics 03 (2020) 139. JINR contribution: realization of a key equipment, described in the “contribution” section, participation in physics analysis.

7. «First Search for Bosonic Superweakly Interacting Massive Particles with Masses up to 1 MeV/c2 with GERDA», Phys. Rev. Lett. 125 (2020) 011801. JINR contribution: realization of a key equipment, described in the “contribution” section, participation in physics analysis.

8. «Final Results of GERDA on the Search for Neutrinoless Double-β Decay», accepted by Physical Review Letters, arXiv: 2009.06079. JINR contribution: realization of a key equipment, described in the “contribution” section, participation in physics analysis.

3. PhD theses:

D.Zinatulina: «Ordinary muon capture studies in ^{48}Ti, ^{76}Se, ^{82}Kr, ^{106}Cd and ^{150}Sm isotopes», graduated in 2019.

N.Rumyantseva: preliminary title: «Investigation of novel background suppression methods in double beta decay experiments», expected to be completed within 2021.

E.Shevchik: preliminary title: «Investigation of active background rejection by using cryogenic liquids», expected to be completed within 2021.

4. Talks (since the last approval of the GERDA project):

Invited plenary talks:

- Neutrino Oscillation Workshop 2018 (NOW 2018), September 9-16, 2018, Brindisi, Italy, «Neutrinoless double beta decay: Experimental challenges», K. Gusev
- 12th Matrix Elements for the Double beta decay Experiments meeting (MEDEX’19), May 27-31, 2019, Prague, Czech Republic «GERDA searches for 0νββ and other ββ decay modes of ^{76}Ge», A. Smolnikov

Parallel talks:

- 68th Conference on nuclear spectroscopy and atomic nucleus structure (Nucleus 2018), July 1-6, 2018, Voronezh, Russia, «New results of the search for neutrinoless double beta decay from GERDA Phase II», N. Rumyantseva
- 27th International Workshop on Weak interactions and Neutrinos (WIN2019), June 3-8 2019, Bari, Italy, «Status of the search for neutrinoless double-beta decay with GERDA», A. Lubashevskiy
- 69th Conference on nuclear spectroscopy and atomic nucleus structure (Nucleus 2019), July 1-5, 2019, Dubna, Russia, «Upgrade of the GERDA Phase II experiment», E. Shevchik
- The 27th International Nuclear Physics Conference (INPC 2019), July 29 – August 2 2019, Glasgow, UK, «Latest results from the first background free search for neutrinoless double beta decay – GERDA Phase II», K. Gusev
- 8th International Conference on New Frontiers in Physics (ICNFP 2019), August 21-29 2019, Crete, Greece, «Status of the GERDA Phase II experiment», N. Rumyantseva
- 40th International Conference on High Energy Physics (ICHEP 2020), July 28 – August 6 2020, Prague (virtual conference), «Results of the GERDA Phase II experiment», K. Gusev

PART B: Plans and requests

5. Plans

2021-2022:

- JINR group plans to dismount the plastic muon veto on top of the GERDA clean room. Then we will decide whether we need to mount it back or the new liquid argon instrumentation can be used as muon veto for LEGEND-200.

- Joint JINR and TUM team will work on the new liquid argon veto system: finalize the design, produce and install it.

- We will produce the modified nylon mini-shrouds for the first LEGEND strings in the clean room at JINR. Then we are going to mount them in the experiment.

- JINR team will complete the design of the string movement system in the LEGEND glove box, procure and install this system on-site.

- JINR group is going to play the central and leading role in the integration of the first strings and start data taking of the LEGEND experiment.

- Our specialists will continue working on the conceptual design of LEGEND-1000. We plan to pay most attention to R&D on germanium detectors and low background materials, as well as on liquid argon veto instrumentation and detector mounting.

- JINR physicists are going to continue the analysis of the GERDA data set in order to obtain new limits on exotic decay modes, such as ββ decay into excited states, ββ decay with Majorons emission, tri-nucleon decay, etc.

2022-2023:

- JINR team will produce the nylon mini-shrouds for all LEGEND-200 strings and mount them in the experiment.

- Based on the experience gained during the integration of the first LEGEND strings JINR group plans to improve the process, if needed, and lead the integration of the full array.

- JINR analysis team will start to work with first LEGEND data and fully integrate in the LEGEND-200 analysis group.

- JINR group will keep working on the design of LEGEND-1000. First prototype of new detector type will be designed, produced and tested. First sample(s) of new low background materials will be procured and analyzed.

2023-2024:

- JINR group will keep the leading role in LEGEND detector operation and maintenance; continue analyzing their stability and performance.

- Our specialists will organize adding of the new detectors strings in the center of the LEGEND-200 array if the collaboration will decide to do so.

- JINR team will continue the analysis of LEGEND-200 data and will be strongly involved in the publications activity.

- JINR group will keep working on the ^{42}Ar and other background mitigation techniques, providing new solutions for LEGEND-1000.

- Liquid argon instrumentation design, done by common group that includes JINR team as one of the leaders, will be mainly completed at the end of this period. JINR plans to provide to the collaboration our developments in new detector types and low background materials.

6. Group size, composition and budget

- List the JINR personnel involved in the project (the **total number of people** in the **LEGEND** collaboration at the time of writing is **240**):

Name	Status	Project role	FTE
K.N.Gusev	PI	Project Leader	0.6
A.V.Lubashevskiy	senior researcher	Deputy Leader	0.3
N.S.Rumyantseva	researcher	Deputy Leader	0.4
V.B.Brudanin	senior researcher	Participant	0.1
M.V.Fomina	researcher	Participant	0.2
S.A.Evseev	engineer	Participant	0.1
D.V.Filosofov	senior researcher	Participant	0.1
L.Grubchin	senior researcher	Participant	0.1
Yu.B.Gurov	senior researcher	Participant	0.2
Zh.H.Hushvaktov	researcher	Participant	0.2
I.I.Kamnev	technician	Participant	0.2
A.A.Klimenko	senior researcher	Participant	0.7
F.Mamedov	senior researcher	Participant	0.2
I.B.Nemchenok	senior researcher	Participant	0.2
A.V.Rakhimov	technician	Participant	0.1
S.V.Rozov	senior researcher	Participant	0.1
V.G.Sandukovsky	senior researcher	Participant	0.5
K.V.Shakhov	researcher	Participant	0.1
E.A.Shevchik	senior engineer	Participant	0.3
Yu.A.Shitov	senior researcher	Participant	0.1
A.A.Smolnikov	senior researcher	Participant	0.7
S.I.Vasilev	senior researcher	Participant	1.0
V.P.Volnikh	technician	Participant	0.1
E.A.Yakushev	senior researcher	Participant	0.1
I.V.Zhitnikov	researcher	Participant	0.1
			Total FTE = 6.8

- GERDA (LEGEND) requested resources, excluding salaries, are reflected in the forms No.26 and No.29 of the written Project and duplicated on the next pages. Taking into account the total FTE of the Project, about 115600US$ or 7398400₽ per year is needed for salaries. Estimation based on 2020 data and includes spending on technical personnel not listed in the project. 1US$ equal to 64₽ assumed in the estimation.

Form No. 26

Schedule proposal and resources required for the implementation of the Project GERDA (LEGEND)

Expenditures, resources, financing sources			Costs (k$) Resource requirements	Proposals of the Laboratory on the distribution of finances and resources		
				1st year	2nd year	3rd year
Expenditures		1. R&D of ultrapure materials 2. Procurement of ^{76}Ge detectors 3. R&D of active veto systems 4. R&D on Ge detectors 5. R&D of ^{42}Ar/^{42}K background mitigation	30 150 30 140 30	10 50 10 60 10	10 50 10 20 10	10 50 10 60 10
		Construction/repair of premises				
		Materials: 1. Enriched ^{76}Ge 2. Scintillating and clean materials 3. Chemicals for Ge detectors	 150 45 6	 50 15 2	 50 15 2	 50 15 2
Required resources	Standard hour	Resources of – Laboratory design bureau; – JINR Experimental Workshop; – Laboratory experimental facilities division; – accelerator; – computer. Operating costs.	300 600	100 200	100 200	100 200
Financing sources	Budgetary resources	Budget expenditures including foreign-currency resources.	581	207	167	207
	External resources	Contributions by collaborators. Grants. Contributions by sponsors. Contracts. Other financial resources, etc.	30	10	10	10

Form No. 29

Estimated expenditures for the Project GERDA (LEGEND): searching for neutrinoless double beta decay of Ge-76

Expenditure items	Full cost	1st year	2nd year	3rd year
Direct expenses for the Project				
1. Accelerator, reactor	h			
2. Computers	h			
3. Computer connection	6 k$	2	2	2
4. Design bureau	standard hour	100	100	100
5. Experimental Workshop	standard hour	200	200	200
6. Materials	201 k$	67	67	67
7. Equipment	380 k$	140	100	140
8. Construction/repair of premises	k$			
9. Payments for agreement-based research	k$			
10. Travel allowance, including:	150 k$			
a) non-rouble zone countries		30	30	30
b) rouble zone countries				
c) protocol-based		20	20	20
Total direct expenses	737	259	219	259