Answers to the questions raised in the

Referee report by Hans H. Gutbrod on

Measurement of the Rare Decay K+→ π+nn at the CERN SPS

NA62 Project (prolongation for 2022-2024)

Theme 02-1-1096-2010/2022

The primary goal of the four stages of the NA62 experiment is the measurement of the very rare kaon decay K+→ π+nn. This measurement is planned to make a decisive test of the Standard Model (SM) by means of the 10%-precision measurement of the Cabibbo-Kobayashi-Maskawa (CKM) matrix parameter Vtd.

The chosen strategy of the ongoing NA62 experiment is based on the measurement

of the high energy K+ decays *in flight* in a very long vacuum tube.

**Scientific merit:**

The referee must confess that he is not expert enough to check the validity of the stated single event sensitivity of 1.11x 10 -11, nor to see the validity of the 17 signal candidates in view of understanding all systematic errors, nor to be able to judge whether a 10% precision measurement could be achieved by identifying 100 *golden* signal candidates and how this would be precision enough for testing the validity of the SM. He assumes that referees of the SPSC are more able to judge the proposal for its scientific value and contribution.

**Experimental questions:**

JINR experts together with those from CERN have contributed to the NA62 set-up by providing the construction and installation of the track spectrometer detectors (STRAW tracker) designed and built during the two NA62 project stages completed in JINR earlier (in 2010-2012 and in 2013-2015).

The referee fully respects the experimental difficulties in observing and measuring 2x1013 well identified K+ decays. The authors report past difficulties of beam spill structures which did not allow running at the full requested intensity. Additional unforeseen back ground problems increased among others the halo. The last problem has been solved by the NA62 collaboration by improving shielding upstream of the experiment, by adding special halo detectors, and optimizing the DACQ system. The referee assumes that all detectors are now able to stand the high rate in this experiment, including the slower calorimeters.

An open question is the observed micro structure of the high intensity beam of the SPS during slow extraction. Usually that is caused by jitter of some power supplies but could also have more serious causes due to the high beam intensity. Has it been solved?

The beam time structure in our case additionally depends on the SPS machine optimization for the LHC purposes rather than for the fixed target experiments like NA62, that was an extra reason of the beam intensity variations. This is why we did not rely on improving the incoming beam and focused on developing the NA62 electronics, which are now expected to handle much higher peak intensities. Thus, we assume that the problem has been solved to a reasonable extent, since we do not expect further beam degradation.

**Human resources:**

The JINR-NA62 group member list shows a good number of scientists and technicians fully dedicated to the experiment. The list of presentations however, states that E. Goudzovski, a 0.1 FTE member, was giving the last 4 talks in 2019 and 2020. E. Goudzovski is listed in the NA62 organizational structure as *Responsible for* *Rare Decays* and is the only person from JINR mentioned in the management structure of NA62.

Why is he involved only with 10% of his time? Why could these talks not be given by members more involved into the experiment NA62?

Actually, the second JINR person listed at the moment in the NA62 organizational structure is V. Falaleev (DCS coordinator, paid mainly by CERN with 10% official employment in JINR). In the nearest future, this management position is expected to be occupied by S. Shkarovskiy (100% paid by JINR).

E. Goudzovskiy started his work in the NA48-NA62 experiments within the JINR group, and at the moment he is involved into the NA62 activity in much higher fraction, than 10%. But currently he is mainly paid by the University of Birmingham, UK. We attribute 10% of his efforts to our Institute according to his current official JINR position and his real involvement into the specific JINR group rare decay analyses.

 Why is JINR not better recognized for its contributions to NA62?

The question is based on the management duties, reflected in the NA62 organizational structure. But management was not our first priority. Main attention was paid to the leading roles in the hardware development and in the analysis papers writing. Management NA62 position never was a main recognition of contribution to the experiment (we are not so centralistic collaboration). The best expert may just not want to be a manager, or he may have other important management duties inside his home institute. For example, Vladimir Kekelidze was a spokesperson of the previous experiment NA48/2, but now he has a duty of the NICA project leader. Youri Potrebenikov currently also has very important management duties in the JINR Laboratory and NICA project.

With our limited team and 6% contribution to the common fund, our group has no limitation on the number of co-authors of the NA62 papers. We are solving a series of important NA62 analysis tasks (at least 5) and essentially contribute to the common sofware development and detector maintaining. Larger contribution and visibility would require more resources and people from JINR. But we understand the importance of their concentration on the home NICA-related projects, that is why we don’t request more resources.

8 journal NA62 papers (see the references [15,16,18,23,24,25,26,27] of the NA62 prolongation proposal) have been published with the Dubna group participation in 2019-2021 (16 co-authors from JINR). In 3 of them [18,23,25], the Dubna group members are the principal co-authors. One should also take into account the 2018 NA48/2 paper [19] with Dubna principal co-authors and the methodical paper [12] on the NA62 straw stability published by the Dubna group. Obtained results in 2019-2021 were presented at the international conferences, including 11 presentations given by the members of JINR group [28-38].

During the NA62 experimental runs in 2016-2018, the JINR group member S. Shkarovskiy was an official expert responsible for the Spectrometer performance and for the Spectrometer part of the Detector Control System (DCS). Why is he not listed any longer as such? Does JINR has an obligation for servicing the tracking chambers?

In the section “JINR group responsibilities” of our proposal there is an item “Support of the NA62 spectrometer during the data taking runs”. In the section “Human resources” S.Shkarovskiy is listed as a person responsible for DCS development, hardware support and analysis. He is an official expert responsible for the Spectrometer and DCS, and in the nearest future we expect, that he will become a responsible coordinator listed in the NA62 organizational structure.

**Risks:**

The authors state that the NA62 has not yet the go-ahead of the SPSC for further running. One should not speculate if SPSC would stop a high quality experiment due to Covid-19.

The authors point out that there may be not enough manpower for analyzing the data. They state that work on NA48/2 data collected in 2003/2004 is still going on, but what has caused the delay of 17 years?

This is not a delay in the main task solution, this is a late additional analysis topics, appearing after the main NA48/2 CP-violation program completion. The excellent quality of the collected data gives a possibility to write first-class experimental papers during a long period after the experiment official end.

Furthermore the authors point out a main weakness caused by the temporary difficulties of transition from the mainly hardware activity to the data analysis stage that is overlaid with the lasting NA62 Spectrometer-related duties. The JINR team sees the need to attract young researchers able to do the analysis of the new data.

- We have a complete analysis team at the moment. The possible increase of the team is considered only in the “potential risks” section of the proposal, where we must consider unexpected problems. At the moment, our group is widely involved in the ongoing analysis, that is described in the section “JINR group contributions and responsibilities”. The possible impression, that our present plans depend on the new participants hiring, is not correct. But we may expect additional analysis topics, that may require more people in future. If we will limit the number of the possible physical papers with our leading participance, no need in additional people may appear.

**Summary:**

The JINR NA62 team proposed a Prolongation of Measurement of the Rare Decay K+→ π+nn at the CERN SPS.

The JINR team made substantial instrumental contributions to the experiment but is unfortunately not recognized as a *leading player* in this collaboration.

-There is no a single leading player (apart from CERN itself) in this collaboration. Our present role is quite visible, especially with respect to the number of participant and to the requested moderate resources.

However, the JINR team intends to increase substantially its contribution in the data and physics analysis by searching for new young talents.

- The possibility to increase the team is considered only in the “potential risks” section of the proposal, where we must consider unexpected problems. The ongoing analysis does not depend on the search for new young participants, it is just a question of eventual analysis program extension.

The potential for more discoveries in K-decay exists.

This extension of NA62- if approved by CERN SPS -will bind the JINR team for a much longer period that the requested period from 2022 to 2024, especially in view of the intended strong participation in data analysis. The authors state that the participation in software development and detector calibration for NA62 will increase the qualification of young participants that may be needed in other JINR experiments. Here one needs to look at the colliding interests in in-house experiments and CERN participation.

Actually, this is an example of completely collinear interests, nothing is colliding here. The NA62 group has transferred yet the majority of its Spectrometer team to the JINR-based experiments, and their international experience helps a lot. Our best managers and the project leaders (V. Kekelidze and Yu. Potrenenikov) after asquiring of international management experience in the NA48-NA48/2 collaborations, currently play key roles in the NICA project. The same will happen with the software and analysis teams involved into the NA62 ongoing analysis.

Finally, I rate this proposal as a good project which requires -however- success in hiring excellent junior scientists and approval by the CERN-SPSC.

The proposal does’t require an additional hiring, it is just a possible unexpected scenario from the “potential risks” section. Regarding the SPSC support, in April 2021, SPSC recommended approval of NA62 up to LS3 (up to 2024). From the minutes of the SPSC for the April session:

*"The Committee congratulates the NA62 Collaboration for achieving the desired improvement in sensitivity and acceptance, and for the release of the (to-date) best determination of the K+->pi+ nu nubar decay rate.

The SPSC is looking forward to the additional improvements and reduction of backgrounds expected for the 2021 run, which would allow the experiment approaching the level of the theoretical uncertainties of the decay process. The Committee recognises that the experimental precision at the level of the theoretical uncertainties is only achievable with running over the full period until Long Shutdown LS3, thus recommends approval of NA62 up to LS3.

The SPCS encourages the collaboration to proceed with the works on the hydrogen CEDAR aiming to reduce the beam-gas scattering background."*