**Minutes of the NICA Machine Advisory Committee at JINR (Dubna)
May 27-29, 2020**

The present limitations due to COVID-19 pandemic did not allow the usual in-person meeting. Therefore, the MAC meeting was organized as a video conference. The discussion was restricted to an update of the project and the most urgent issues of the project. Despite the unusual situation, the video meeting provided a good overview of the status and an efficient discussion of the most urgent problems. The committee thanks all participants for their professional handling of the difficult situation and an efficient and open exchange of information.

**1. Organization of NICA construction**

The formulation of the new function of the Cost and Schedule Review Committee sounds reasonable and we can share their recommendations especially,

1) Define milestones to assess the progresses with a periodicity of 3 months,

2) Identify critical items for NICA Phase I. (heavy ion collision),

3) Develop a risk analysis and mitigation plan for the most critical items. The MAC also suggested several times these critical points in the past.

Following the previous MAC recommendation, a very general organigram of the NICA project was presented. In the next MAC we would appreciate a more detailed structure of the accelerator part of the project with clear designation of the responsible persons, such as the NICA project leader(s), accelerator head and sub leaders of the accelerator section like ion source, Booster, Nuclotron and Collider, and the chief engineer responsible for all technical subjects as well as the leaders of technical subsystem development. MAC continues to request a resource loaded scheduled with clear definition of responsibilities and the critical path in the completion of the project. The organigram should also show a direct link between the MAC and the appropriate project leader. *S. Kostromin, A. Butenko*

**2. Ion source, Booster and Nuclotron**

A. Butenko reported that they have faced many difficulties, technical problems in the booster construction and the renovation of Nuclotron, but they have solved most of them.

The technological run started end of 2019 and the proposed commissioning of the booster with beam is scheduled to start in August 2020. The delay in commissioning is comprehensible, *JINR should work on a more realistic planning and establish a rigorous system for Quality Assurance/Quality Control*. Various new subsystem had to be revised for proper operation resulting in the reported delay. *S. Kostromin, A. Butenko*

Commissioning of the transfer line to the booster has already started. The key mile stone of the future Nuclotron operation is in the spring of 2021 *after the ion source Krion6T will be connected to the HILAC* and the Booster, then heavy ions will be extracted from the Booster and injected into the Nuclotron. *A. Butenko*

*The injection and extraction system and a new synchronization system still need to be implemented in the Nuclotron*. *A. Tuzikov, A. Butenko, I. Shirikov*

*MAC recommends to clarify the requirement for absolute and relative accuracy of the BPMs and the requirements for the mechanical positioning. These requirements have to account for the possibility to use beam-based methods for the alignment of BPMs. That might significantly reduce the effort invested into the mechanical alignment. Additionally, in the case of the collider the specifications have to be set for the BPM dynamic range and the requirements to different mo*des *of collider operation (initial commissioning, optics measurements, beam accumulation and cooling, transition to collisions, finally collisions).* *E. Gorbachev*

*MAC recommends to list the objectives for the first beam commissioning phase of the Booster which is planned in August/September 2020.* *A. Butenko*

V. Kekelidze presented good progress of experiments using the slow extracted Nuclotron beam for BM@N. We much appreciate the great efforts.

**3. Collider schedule**

S. Kostromin explained clearly key mile stones and difficulties for the collider construction. We appreciate their patient and hard work to achieve the collider beam commissioning in the middle of 2022 while *only 2 years are left before the commissioning*. The number of cryogenic tests of 80 magnets per year has to be increased by a factor of two. Manpower will represent a great problem, if no additional staff can be hired and trained rapidly. Based on the present situation the collider installation according to the schedule is jeopardized. *S. Kostromin, D. Nikiforov*

*MAC recommends that a plan is agreed with the project management as soon as possible.*

 *A. Butenko, S. Kostromin, E. Syresin*

We also note the upgrade project for LU-20, whose priority should be considered with respect to the collider completion. The stability of power converters is of great importance and requires special attention. *A. Butenko*

MAC appreciates the great and important work on the impedance calculations and the direct optimization of different hardware for a better impedance balance. However, MAC is concerned whether all conclusions from the simulations can be delivered in time to take them into account for the production process of components. *A. Sidorin*

MAC recommends to start planning the Collider commissioning and present a draft plan in the next MAC meeting. *E. Syresin*

**4. Beam storage in the Collider**

E. Syresin reported the concept and analysis of the beam storage process in the collider with the use of the electron cooling from low energy 1 GeV/u to the top energy 4.5 GeV/u. The reported results look reasonable while the simulation parameters are not always clearly described. This concept of usage of electron cooling for the whole energy range of the NICA collider, results in simple and compact operation if it can be established according to expectations. In order to make the critical assessment on this new concept of beam storage with the use of electron cooling only, *MAC requests documents precisely describing the simulation results*, otherwise the results cannot be evaluated. *E. Syresin*

E. Syresin reported that two RF1 cavities were delivered from BINP to JINR in 2019 and already tested. *Real measurements to demonstrate the ripples have not been shown*.

 *E. Syresin*

**5. Electron cooling**

V. Reva and V. Parkhomchuk reported the status of the 2.5 MeV, 1 Ampere electron cooler at BINP which is an area where they have great experience. The goal for assembly and commissioning time is set as the end of 2021, the location of the final test of the full system with electron beam still has to be decided. Hardware manufacture is making good progress.

 *A. Sidorin*

A limitation of the ion number, which can be cooled with 1A electron current, was discussed and could be the critical issue for the application of electron cooling to the colliding beams in NICA. As the possible reason of the limitation of the ion number, a *two-stream beam instability* was discussed. *The MAC requests more elaborated theory and simulation work for the application to the collider case.* *E. Syresin, A. Sidorin, S. Melnikov*

**6. Beamline and Injection Components**

A. Tuzikov reported on the progress of the design and production of the beam line and injection components. The fast kickers have challenging specifications, particularly the planned beam accumulation in the collider requires after pulses of minimum amplitude. Various normal-conducting pulsed beam line magnets are already produced and tested. MAC understands that they were only tested in dc mode. At least one magnet of each type should be tested including the transient behavior after the ramping in order to learn about eddy current effects for each type. *MAC recommends that it should be clarified to what extent the injection line can be commissioned with beam before the collider is ready to receive beam and if this is compatible with personal access regulations and safety rules, as well as with commissioning of collider hardware*. This may help to avoid any future delays in the collider which can arise. *A. Tuzikov*

**7. Stochastic cooling**

A. Sidorin and K. Osipov reported the new scheme of the stochastic cooling system for the NICA collider. The choice of the filter cooling method in the energy range above 3GeV/u is reasonable. The main issues of the new scheme are the use of ceramic chambers, change of the operating frequency band to 1-3 GHz and the shunt impedance evaluation of the new PU and kicker. We could not fully understand the new concept and expect that there can be many technical challenges. In addition, the basic concept of the stochastic cooling process of heavy ions in the NICA collider including simulations is not well presented. Although MAC asked already in the last meeting, no *RF-measurements with the ceramic chamber* were presented. It is a very challenging task not only the design and construction of new structures but also the complicated filter structures due to the new multiplex/demultiplex system. The usage of warm pick-ups in the arcs looks challenging. That severely limits the possibilities of transverse cooling. JINR never before presented to MAC the *possible use of stochastic cooling for the polarized proton beam*.

*MAC requests the submission of a document within 1 month where the theoretical and technical aspects on the new concept of stochastic cooling are described in detail.*

 *A .Sidorin, I. Gorelyshev, K. Osipov*

**8. Collimation**

O. S. Kozlov reported on the collimation system for the collider. Designs for the collimators were shown, and it has been reported that they are taking into account the recommendations for impedance reduction. Simulations of the collimators using Tungsten and Inconel were shown, but *the decision was not yet taken and the pros and cons of each were not clarified, including any specifications on the quality of the scraper and collector material. It should also be clarified what will happen to ions suffering recombination in the electron-cooler. The arc dispersion is very low and it is not clear where these ions will be lost and if they may represent a concern for experimental background. In addition, the accuracy and reproducibility of the movements should be clarified, as well as proper controls of the actuators.* *E. Syresin*