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Progress Toward 200-MeV Upgrade of KOMAC

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1. Introduction

The Korea Multi-purpose Accelerator Complex (KOMAC) has been operating a 100-MeV proton linear accelerator since 2013 to provide proton beams for a wide range of research and industrial applications, including materials science, biotechnology, semiconductor irradiation, and nuclear and basic sciences. The accelerator has established stable user operation and has supported more than 3,700 users through various beamlines since its commissioning.

In recent years, the demand for higher-energy proton beams has increased, particularly for applications requiring high-energy neutrons and radiation environments representative of terrestrial and space environments. For example, semiconductor radiation testing requires neutron energies substantially higher than those available from the existing 100-MeV facility. Previous studies at KOMAC have indicated that neutron energies of approximately 200 MeV or higher are desirable for applications related to international radiation-testing standards such as ISO 26262 and JEDEC89A [1].

To address these emerging requirements and further expand the utilization of the facility, an energy upgrade of the existing proton linac from 100 to 200 MeV is being pursued. Several accelerator technologies, including superconducting half-wave resonator and normal-conducting separated drift tube linac (SDTL) structures, have been investigated [2]. Recent studies have focused on the SDTL-based approach, which provides a technically robust extension of the existing normal-conducting DTL while allowing flexible optimization of the accelerating and focusing structures.

The 200-MeV upgrade is planned not only to extend the beam energy but also to enhance the utilization capability of KOMAC through the development of new experimental beamlines and irradiation facilities. In particular, the upgraded facility is expected to provide proton and neutron beams for semiconductor radiation testing, space-radiation studies, and other high-energy radiation applications. The upgrade program therefore includes the development of the 200-MeV linac section together with new beamlines, target systems, building expansion, and associated utilities.

This paper presents the current status and technical development of the KOMAC 200-MeV proton linac upgrade, with emphasis on the accelerator configuration, the SDTL-based linac design, and the ongoing R&D activities toward its implementation.

2. Progress toward 200-MeV Upgrade

The main objective of the second phase of KOMAC is to increase the proton beam energy from 100 MeV to 200 MeV, as shown in Fig. 10. We plan to use separated drift tube linac, or SDTL, structure for the new acceleration section. The upgrade will provide two major beamline capabilities. The first is a low-flux proton beamline for space radiation simulation. The second is a combined proton and neutron beamline for proton irradiation and terrestrial radiation simulation.

The upgraded facility will mainly support semiconductor radiation testing, while providing a higher energy injector for future accelerator development as well. An important advantage of this approach is that we can make use of the existing tunnel and infrastructure with only a relatively minor building extension.

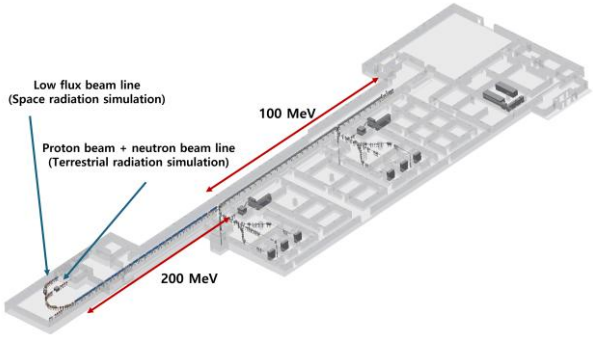


Fig. 1. Layout of 200 MeV linac upgrade.

For the 100 MeV-to-200 MeV acceleration section, we optimized the SDTL structure and drift tube geometry. The design uses a 350-MHz RF frequency, consistent with the existing linac. The SDTL tank consists of six cells containing five drift tubes. With an accelerating field of approximately 3.8 MV per meter and a synchronous phase of minus 28 degrees, the proton energy can reach 200 MeV by using 16 SDTL tanks. The tank length is approximately 2.25 to 2.89 meters, and the total SDTL section is about 55 meters long. For a 20-mA beam, the required RF power is approximately 820 to 1,110 kW per tank. These parameters are being optimized while considering RF performance, beam dynamics, manufacturability, and operational reliability. Table 1 shows the designed cell parameters.

Table 1: Designed cell parameters

Parameter	Value
RF frequency	350 MHz
Reference temperature	27 °
Energy range	100~ 200 MeV
E0	3.8 MV/m
Max. Kilpatrick	1.4
Tank diameter	475 mm
Drift tube diameter	14 mm
Bore radius	15 mm
Drift tube face angle	70 °
Stem diameter	36 mm

We use a doublet focusing structure between the SDTL tanks, and this lattice provides a practical way to extend the existing accelerator while maintaining a compact and manageable focusing structure (Fig. 2).

We have also performed error studies to evaluate the robustness of the SDTL design. We considered errors in quadrupole magnets and RF cavities, including transverse displacement, rotation, gradient errors, cavity displacement, accelerating voltage errors, and phase errors. For a 20-mA beam, the simulations show that the maximum emittance growth due to the considered quadrupole errors is approximately 2%, while the beam centroid and angle can have a more significant effect on emittance growth. This result emphasizes the importance of accurate beam matching and steering at the entrance to the SDTL section. These studies are being used to establish practical alignment and commissioning tolerances for the new accelerator section.

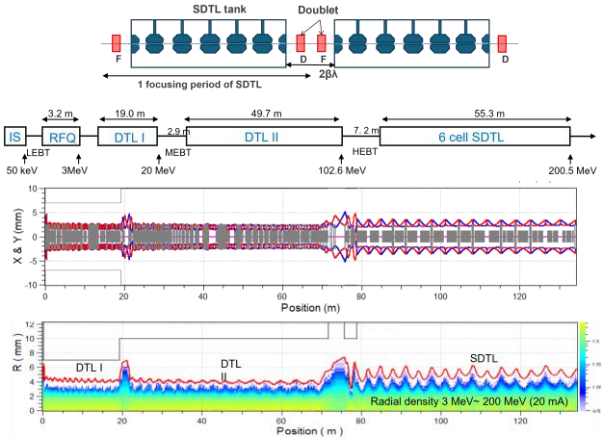


Fig. 2. Lattice structure and beam envelop.

Based on the beam dynamics and RF design, we have started prototype development [3]. Figure 3 shows the 6-cell SDTL tanks and the drift tube structure with the doublet magnets between two tanks. One of the engineering issues we are studying is efficient cooling of the drift tubes. We designed separate cooling channels for the central and peripheral regions. In addition to the copper prototype, we fabricated an acrylic model so that we could directly visualize the coolant flow, as shown in Fig. 4. This type of prototyping is important for reducing technical risks before full-scale fabrication.

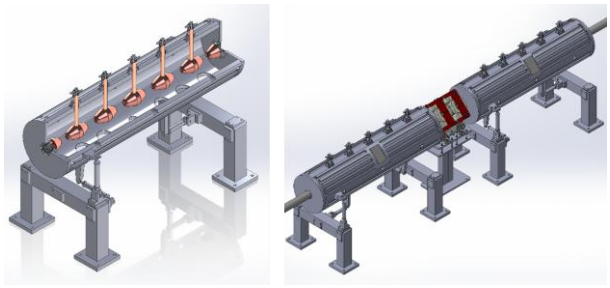


Fig. 3. 6-cell SDTL trank and doublet magnets.

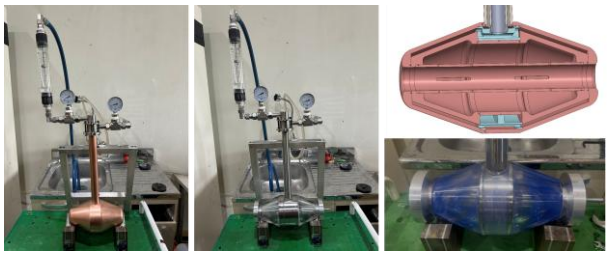


Fig. 4. Prototyping of drift tube for SDTL.

We started the pilot R&D project for the 200-MeV upgrade in April 2026, and it is planned to continue through December 2028. The scope includes the first four SDTL tanks with their RF systems, which include the LLRF systems, klystrons, high-voltage modulators, and supporting utilities for performance test (Fig. 5). The objective is not simply to fabricate four tanks, but to demonstrate the key technologies and reduce the technical risk before moving toward the full 200-MeV accelerator.

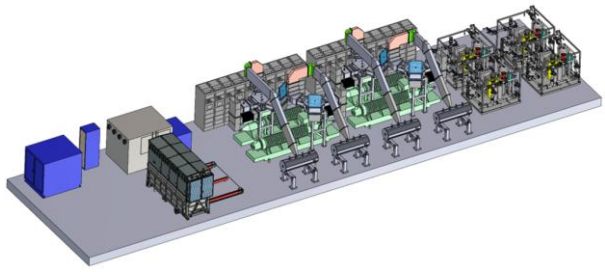


Fig. 5. Test bench layout of the pilot R&D for 200 MeV linac upgrade, showing 4 SDTK tanks and RF systems.

The 200-MeV upgrade is not the final goal of KOMAC. Our long-term vision is to develop a GeV-class accelerator and a spallation neutron source. The future facility will require a GeV-grade RCS, a neutron-generation target, neutron instruments, and dedicated buildings and utilities. In this roadmap, the 200-MeV linac will serve as the injector for the future high-energy accelerator. Therefore, the 200-MeV upgrade should be considered not only as an independent project, but also as an important step toward the next-generation KOMAC facility (Fig. 6).

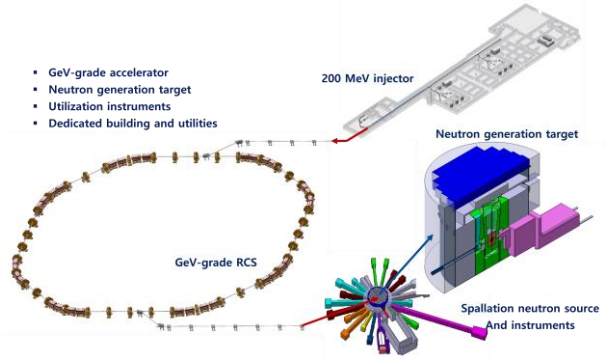


Fig. 6. Long-term plan of KOMAC.

3. Summary

A phased upgrade of the KOMAC proton linac from 100 MeV to 200 MeV is being pursued to expand its application to high-energy radiation testing and other advanced research fields. The proposed upgrade adopts a normal-conducting separated drift tube linac (SDTL) for the additional accelerating section, providing a technically robust and relatively low-risk solution without the need for a cryogenic system. Beam dynamics studies and error analyses have demonstrated the feasibility and robustness of the proposed 200-MeV linac design. The upgraded facility will include new beam transport systems and two target rooms for proton and proton/neutron irradiation. These facilities are intended to support space-radiation testing of semiconductor devices, terrestrial radiation testing using high-energy neutrons, and other high-energy proton applications. The upgrade also includes building expansion and associated utility improvements to accommodate the new accelerator and experimental facilities.

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