GeV Grade Energy Upgrade Option of the KOMAC Linac

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1. Introduction

Korea Multi-purpose Accelerator Complex (KOMAC) has been operating a 100 MeV proton linear accelerator (linac). It started 24-hours beam service and neutron beam service based on the user demands. Another strong demand from users is the energy upgrade [1]. KOMAC linac is a kind of high power proton accelerator with high average current. There are several application fields of the high power proton accelerator, those are 1) spallation neutron source, 2) secondary particle production, 3) radioactive ion beam production, 4) material irradiation facility, 5) accelerator driven system [2]. The energies of the most high power proton accelerators are over GeV in order to produce secondary particles (neutron, muon, RI beam and so on) effectly. KOMAC considers phased energy upgrade. The first is to increase energy to 200 MeV from 100 MeV and the second is to increase energy to GeV grade from 200 MeV [3]. The status of the high power proton accelerators in the world and the location of the KOMAC is shown in Fig. 1 [4]. KOMAC1 is the existing 100 MeV linac, KOMAC2 is 200 MeV (the first upgrade) and KOMAC3 is GeV grade (the second upgrade)

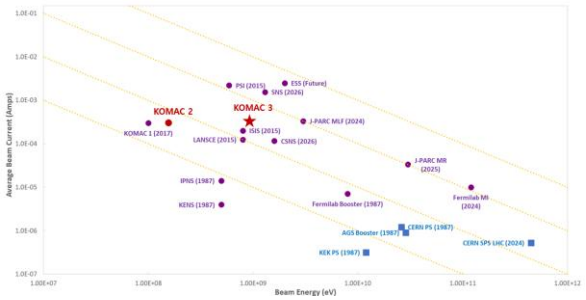


Fig. 1. High power proton accelerator around the world.

2. 200 MeV Energy Upgrade

There are several reasons to upgrade the existing linac to 200 MeV. The first is the needs from the users, especially semiconductor and space parts industries, because the international guide line such as JEDEC (JESD89B, JESD234) and ESA (ESCC 25100) requires minimum proton energy for the single event upset (SEU) is 200 MeV [5][6][7]. The second is the 200 MeV linac can be developed using one accelerating structure with the same frequency of the existing linac. The third is the 200 MeV facilities can be constructed within existing site without further developing the ground.

The parameters of the 200 MeV linac is summarized in Table 1.

Table 1: 200 MeV Linac Parameters

Parameters	Values
Input energy	102.6 MeV
Output energy	200 MeV
Peak beam current	20 mA (40 mA upgradable)
Maximum pulse width	1 ms
Maximum repetition rate	30 Hz

The accelerating structure is Separated type Drift Tube Linac (SDTL) and 16 SDTL tanks need. The operating frequency is 350 MHz, which is the same with the existing linac. The focusing structure is doublet located between SDTL tanks. The length is 54.5 m. The design parameters of SDTL is summarized in Table 2 and the layout is shown in Fig. 2.

Table 2: SDTL Parameters

Parameters	Values
RF frequency	350 MHz
E0	3.8 MV/m
Max. Kilpatrick	1.4
Synchronous phase	-28°
Tank inner diameter	475 mm
Drift tube diameter	140 mm
Bore radius	15 mm
Stem diamter	36 mm
Cell number per tank	6
DT number per tank	5
Number of tank	16
Distance between tank	2βλ
Total length	54,502.7 mm
Maximum RF power (including 40 mA beam power, 80% Q)	1.231 MW

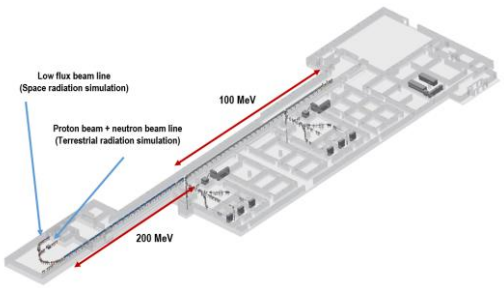


Fig. 2. 200 MeV linac layout

2. GeV Grade Energy Upgrade

The main application fields of the GeV grade proton linac is spallation neutron source. The examples of the sciences of the spallation neutrons can be shown through the science highlight in the Oak Ridge National Laboratory which operates two large neutron facilities, SNS and HFIR. The result is shown in Fig. 3 [8]. The application fields are quantum materials, condensed matter physics, bio & life science, energy material and functional materials and soft matter & polymers.

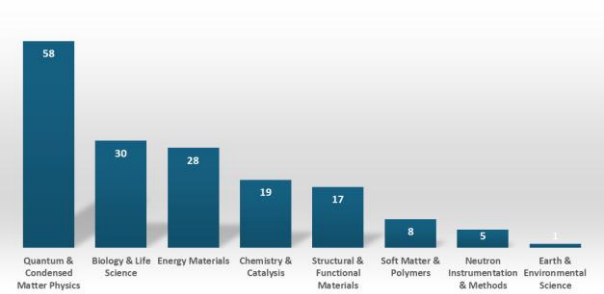


Fig. 3. Sciences using neutrons from "neutron science highlights" in the ORNL

Most of the spallation neutron sources produce muon as a secondary particles in order to study the muon itself and use a muon as another tool for surface analysis (μSR). Examples are J-PARC and CSNS. Especially J-PARC has a plan to accelerate the muon to study the anomalous magnetic moment and electric dipole moment of muon [9].

Also, most of the spallation neutron facilities plan to use a high energy protons. CSNS plans to develop a High-energy Proton-beam Experimental Station (HPES). The main application fields of HPES which uses 1.6 GeV proton beams are 1) irradiation hardness studies of the chips 2) particle detector development 3) nuclear data measurement [10]. J-PARC plans to develop a proton beam irradiation facility by using 400 MeV proton beams. The main application fields are 1) material irradiation 2) soft error testing of semiconductor devices 3) RI production 4) proton beam application [11].

KOMAC also considers a 1 GeV RCS (Rapid Cycling Synchrotron, 2 GeV upgradable) based spallation neutron source as the second upgrade. Also the proposed facilities can produce a secondary particle such as muon and install proton irradiation facilities. The design parameters of the RCS is summarized in Table 3.

Table 3: RCS Parameters

Parameters	Values
Input energy	200 MeV
Output energy	1 GeV / 2 GeV
Beam power	125 kW / 500 kW
Linac peak beam current	20 mA / 40 mA

In order to use a 200 MeV linac as an injector to the above RCS, the linac should be modified as follows. 1) the linac should accelerate negative hydrogen ion beam instead of proton beam because of the charge exchange injection into the RCS 2) fast chopper to chop the beam ~ 500 ns pulse length in MHz repetition rate 3) peak beam current increases from 20 mA to 40 mA in order to satisfy the 500 kW beam power requirement. In the design stage of the 200 MeV linac, KOMAC considered these modifications. The layout of the facility is shown in Fig. 4 [3].

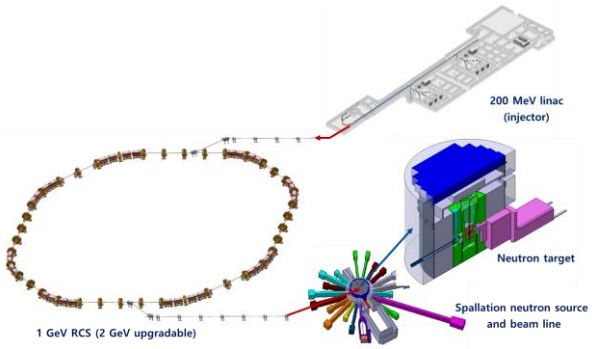


Fig. 4. RCS based spallation neutron source

4. Conclusions

KOMAC considers the phased upgrade plan, the first is 200 MeV then GeV grade. The main purpose of the GeV grade upgrade is a spallaion neutron source as well as secondary particle production and high energy proton irradiation. A 200 MeV linac was designed to satisfy the requirement of the GeV grade RCS.

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