THE KOMAC ACCELERATOR FACILITY*

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Abstract

The development of the KOMAC (Korea multi-purpose accelerator complex) accelerator facility was finished and will go into the operation period from July 2013. The facility consists of a 100-MeV proton linac including a 50-keV ion source, a 3-MeV RFQ (radio-frequency quadrupole), and a 100-MeV DTL, and 20-MeV and 100-MeV beam lines. The linac and beam lines were developed by the Proton Engineering Frontier Project (PEFP), the first phase of KOMAC, from 2002 to 2012 [1]. The goal of the beam commissioning is delivering 100-MeV 1-kW proton beams to a beam bump in a 100-MeV target room. After finishing the commissioning, the user beam service will start from July 2013. The KOMAC user facility consists of 2 beam lines in the initial operation stage and it will be increased to 10 beam lines in future. One beam line is for 20-MeV proton beams which are extracted after 20-MeV part of the DTL tanks. A medium energy beam transport (MEBT) is installed there for the 20-MeV beam extraction and the beam matching to the next DTL tank. The other beam line is for 100-MeV proton beams. This work summarized the status of the KOMAC accelerator and beam lines.

KOMAC 100-MeV PROTON LINAC

The KOMAC accelerator building consists of 3 stories. The first floor includes the linac tunnel, and 20-MeV and 100-MeV beam line halls. There is a klystron gallery in the second floor. The third one is the modulator room. The accelerator building is shown in Figure 1. The main parameter of the linac is summarized in Table 1.

Figure 1: Accelerator building which includes the linac and beam lines.

The injector of the KOMAC accelerator consists of a microwave ion source [2] with the extraction energy of 50keV, and a low energy beam transport (LEBT) for matching proton beams into the RFQ. The ion source can work in cw (continuous wave) and pulsed modes. The peak beam current is 20 mA. Figure 2 shows the injecotr which was installed and tested in the tunnel.

The 20-MeV part of the linac consists of a 3-MeV RFQ and a 20-MeV DTL (drift tube linac) [3]. The peak beam current and the maximum beam duty are respectively 20 mA and 24%. The RFQ is a four vane type with the resonant coupling and dipole rods for field stabilization. The DTL includes four tanks which are driven by a klystron. The FFDD lattice was adopted for the 20-MeV DTL with pool-type quadrupole magnets. Figure 3 is the 3-MeV RFQ which was tested in the linac tunnel.

Table 1: Parameters of KOMAC Linac

Parameters	Value
Frequency	350 MHz
Beam Energy	100 MeV
Operation Mode	Pulsed
Max. Peak Current	20 mA
Pulse Width	<1.33 ms (< 2.0 ms for 20 MeV)
Max. Beam Duty	8% (24% for 20 MeV)
Max. Beam Power	160 kW (96 kW for 20 MeV)

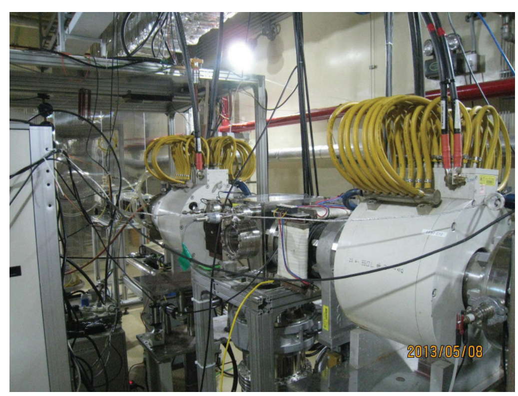

Figure 2: 50-keV njector including ion source and LEBT.

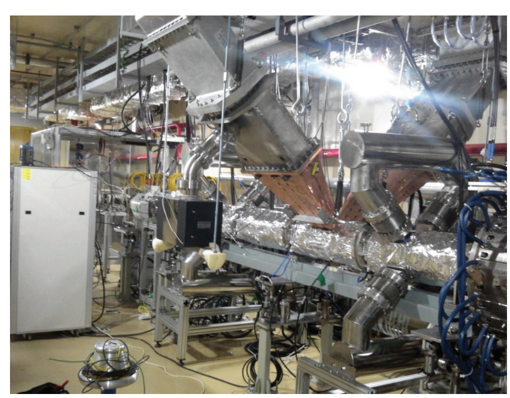

Figure 3: 3-MeV RFQ in the accelerator tunnel.

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The 100-MeV part of the linac consists of 7 DTL tanks [1]. The maximum beam duty is 8% and the peak beam current is 20 mA. In this part, each klystron drives a DTL tank. The focusing lattice is also FFDD with quadrupole magnets whose integrated field is 1.75 T. The DTL tanks are given in Figure 4. The installation was finished and the commissioning will start from May 2013.

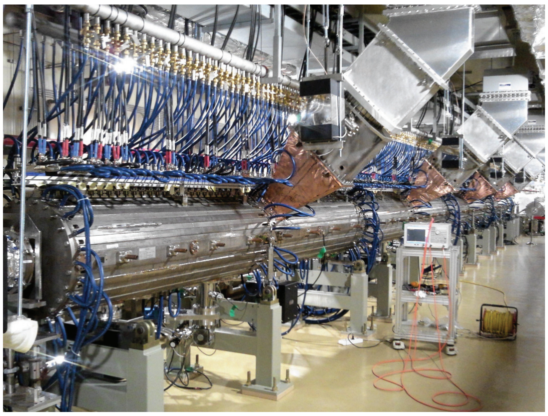

Figure 4: DTL in the accelerator tunnel.

There are 4 high voltage convertor modulators. Each modulator drives 2 or 3 klystrons. The peak output power is 5.8 MW and the average power is 520 kW with a duty of 9% [4]. The pulse width and the repetition rate are 1.5 ms and 60 Hz, respectively. The modulator used the insulated gate bipolar transistor (IGBT) as the high frequency switching method. Figure 5 shows modulators which were installed and tested in the modulator room.

Figure 5: The modulator which was installed in the modulator room.

In the 20-MeV part of the linac, there are 2 klystrons, one for RFQ and the other for 4 DTL tanks of the 20-MeV linac. In the energy range between 20-MeV and 100-MeV, 7 klystrons are used and each one drives one DTL tank. The peak power of klystrons is 1.6 MW for 100-MeV part [5]. The high power rf (HPRF) systems including wave guide, circulator, and rf windows were installed in the klystron gallery and the accelerator tunnel. We also developed a digital low level rf (LLRF) system which can control the rf amplitude and phase with 1% and ±1°, respectively. The HPRF system is shown in Figure 6.

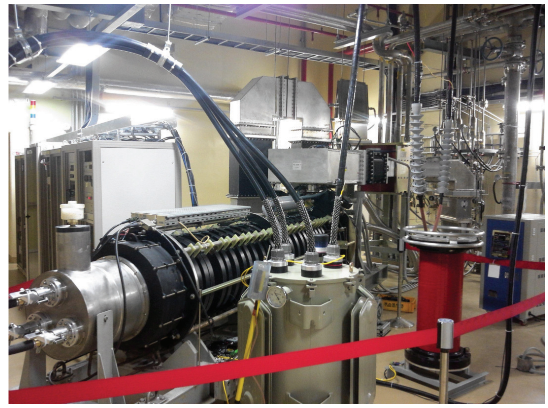

Figure 6: High power rf system with klystron installed in the klystron gallery.

In order to control the cooling water temperature of drift tubes in DTL tanks, a resonant control cooling system (RCCS) was developed. The operation range of the temperature is between 21 and 33 °C and it can control the temperature within ±0.1 °C. There are 11 sets of RCCS installed in the klystron gallery as shown in Figure 7.

Figure 7: Resonant control cooling system installed in the klystron gallery.

BEAM LINES

The KOMAC accelerator facility can provide 20-MeV and 100-MeV proton beams to users [6]. The 100-MeV beam line starts from the end of the linac. The 20-MeV beam line extracts proton beams in the middle of the linac. In order to install a 45-degress bending magnet for beam extraction and a beam matching system into the next DTL tank, we installed a MEBT system after the 20-MeV part of the linac. The 20-MeV beam line starts at the bending magnet. In the initial stage, two beam lines will be used, one for 20-MeV and the other for 100-MeV proton beams. In future, they will be extended 10 beam lines, 5 for 20-MeV and 5 for 100-MeV, respectively. The MEBT and the initial part of the 20-MeV beam line are shown in Figure 8. Figure 9 is the 100-MeV beam line in the beam line hall..

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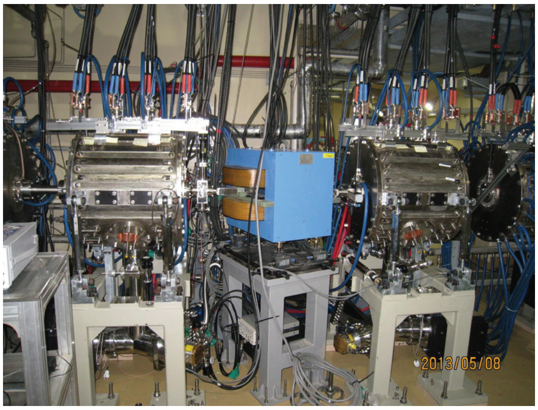

Figure 8: The medium energy beam transport system for 20-MeV beam extraction and beam matching.

Figure 9: The 100-MeV beam lines.

INITIAL BEAM TEST

The beam test of the 20-MeV part of the linac performed on April 25, 2013 in order to check the machine performance. The rf signal for the RFQ is shown in Figure 10. The green line represents the cavity power corresponding to 400 kW. We measured 20-MeV proton beams for the beam current of 1 mA at the end of the 20-MeV DTL. Figure 11 are the initial beam signal of the RFQ and 20-MeV DTL. From this experiment, we checked the performance of rf system, the resonant control cooling system, the control system, and the diagnostics.

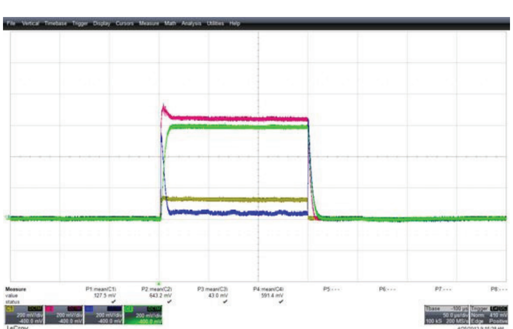

Figure 10: The rf signal for the 3-MeV RFQ.

Figure 11: Initial beam signal of the 3-MeVRFQ and 20-MeV DTL.

CONCLUSION

The development of the KOMAC 100-MeV linac was finished. The machine test and initial beam test were successfully finished on April 25, 2013 for the 20-MeV part of the linac. The 100-MeV beam commissioning will start in May 2013 and will be finished at the end of June 2013 by following the beam commissioning plan [7, 8]. The user beam service will begin from July 2013 through the 20-MeV and 100-MeV proton beam lines.

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