

DEVELOPMENT OF 100MeV PROTON ACCELERATOR FOR KOMAC 2nd PHASE*

Y.S. Cho[†], J.M. Han, H.J. Kwon, B.H. Choi
Proton Engineering Frontier Project
KAERI, Daejeon, Korea 305-353

Abstract

KAERI (Korea Atomic Energy Research Institute) has been performing the project named KOMAC (Korea Multi-purpose Accelerator Complex). The final objective of KOMAC is to build a 20-MW (1 GeV and 20 mA) cw (100% duty factor) proton linear accelerator to study basic researches and nuclear transmutation with spallation neutrons. As the first phase, the low energy accelerator up to 3MeV has been developed, and the 20MeV accelerator will be developed in KTF (KOMAC Test Facility). The 100MeV proton accelerator for KOMAC 2nd phase will be the duplication and extension of KTF accelerator in other site. The status and plan for 100MeV proton accelerator will be reported.

1 INTRODUCTION

The KOMAC accelerator has been designed to accelerate a 20 mA cw proton/H⁺ with the final energy 1GeV cw super-conducting linac [1]. As the 2nd phase of the project, we are developing cw accelerating structure up to 20MeV, and operate the accelerator in 10% duty pulse mode. After the initial operation, we will challenge the cw operation of the accelerator. The 20MeV proton accelerator is constructing in the KTF (KOMAC Test Facility), and will be commissioned in 2005. After the commissioning, KTF will provide the proton beam for the many industrial applications.

In the KTF, we are developing the proton injector, LEBT, 3MeV RFQ, 20MeV DTL, and RF system. The proton injector is already developed, and the 3MeV RFQ will be constructed in this fiscal year. Also we have a plan to develop the basic Super-Conducting cavity technology in the KTF for the second stage super-conducting accelerator of the KOMAC.

The final goal of this phase is 100MeV proton accelerator. The construction of this accelerator will be based on the KTF accelerator and technologies.

2 DEVELOPMENTS IN KTF

2.1 Proton Injector [2]

For 20 mA proton beam at the final stage, KOMAC requires the ion source with the proton beam current of 30 mA at the extraction voltage of 50 kV. Normalized

rms emittance of less than 0.3π mm•mrad is also required for good matching of ion beam into RFQ.

The system is composed of an accelerating high voltage power supply, ion source power supplies in a high voltage deck, gas feeding system, and vacuum system.

The injector has reached beam currents of up to 50 mA at 50 kV extraction voltage with 150 V, 10 A arc power. The extracted beam has a normalized emittance of 0.2π mm•mrad from 90 % beam current and proton fraction of over 80 %. The proton fraction is measured with deflection magnet and scanning wire.

The beam can be extracted without any fluctuation in beam current, with a high voltage arcing in 4 hours. The cathode lifetime is about 40hr. To increase the filament lifetime, it is necessary to lower the arc current or to change the tungsten filament to other cathode such as oxide cathode.

2.2 LEBT

Low-energy beam transport (LEBT) consists of two solenoids, two steering magnets, diagnostic system, beam control system, and funnelling system to transports and matches the H⁺ for 20mA and H⁻ for 3mA, beams from the ion source into the RFQ. The main goal of the LEBT design is to minimise beam losses. The design codes used are TRACE 3D and PARMTEQM. The PARMTEQM-simulated solenoid settings are B=2800G and B=3900G, the RFQ transmission rate is more than 90%. Two solenoid magnets constructed are 20.7cm-long, 16cm-i.d., are surrounded by a low carbon steel and provide dc fields ≤ 5000 G on the axis. During the winter of 2000, we will test the LEBT to obtain a proper matching condition with the RFQ.

2.3 RFQ [3]

The KTF RFQ bunches, focuses, and accelerates the 50keV H⁺/H⁻ beams, and derives a 3.0MeV beam at its exit, bunched with a 350MHz. The RFQ is a 324cm-long, 4-vanes type, and consists of 56 tuners, 16 vacuum ports, 1 coupling plate, 4 rf drive couplers, 96 cooling passages, and 8 stabiliser rods. The RFQ is machined of OFH-Copper, integrate from separate four sections which are constructed by using vacuum furnace brazing. The RF system for the RFQ is operated with 350MHz at 100% duty-factor by one klystron of 1MW.

[†]choys@kaeri.re.kr

2.4 High Power RF System

Two types of RFQ have been developed. The one is 0.45 MeV RFQ whose purpose is to check the basic RFQ technologies such as tuning, beam matching and so on, the other is 3 MeV main RFQ which was fabricated and vacuum tight checked already. The required RF power for 0.45 MeV RFQ is 110 kW CW and for 3 MeV is 417 kW CW respectively. The 1 MW, 350 MHz RF system has been developed to deliver a RF power to the RFQ. The high power RF system consists of klystron, circulator, RF window, various waveguide components, klystron power supplies and cooling system. Recently all components of the RF system were prepared and are being tested.

2.5 low level RF System

The LLRF consists of a 350MHz signal generator, a 160W solid state amplifier, amplitude/phase control loops, and RF interlocks. The designed field stability in the RFQ cavity is within $\pm 1\%$ amplitude and $\pm 1.4^\circ$ phase using feedback control loops in the LLRF. For frequency control, another tuner controller module was used. The RF interlock signals comes from excessive reflected RF power, circulator arcs and window arcs.

2.6 DTL [4]

DTL will accelerate the 3MeV 20mA proton beam to the energy of 20MeV. The structure design of DTL is based on the 100% duty factor.

For 20MeV to 100MeV, CCDTL cold models are fabricated to check the design, the tuning method, and the coupling coefficients and the fabrication method. The super-drilled coolant path is well fabricated, and this type cooling method will be used for the CCDTL construction. The field profile is measured with a bead perturbation method.

The design and fabrication technologies have been acquired, and the DTL for 2nd phase accelerator will be fabricated from this year.

2.7 Power Supply System

The specifications of the high voltage power supplies for the KTF klystron are 100 kV, 20 A with the conditions that the voltage peak to peak ripple and the voltage regulation are less than 1 %, and energy deposition in the klystron at the tube arc is less than 20 J. The power supply that meets the above conditions has been designed, manufactured and tested. The main components of the high voltage power supply are Induction-Voltage-Regulator, transformer & rectifier tank for 12 pulses rectification, L-C filter, and ignitron crowbar. Voltage dividing resistors and a tetrode tube were used to provide variable high voltage to modulating anode of the klystron. The variable voltage modulating anode power supply gives the flexibility of klystron operation.

2.8 Cooling System

A 2 MW DI water cooling system for KTF RFQ and RF system was prepared as shown in Figure 5. The

required cooling loops for RF system are circulator, RF load, RF window cooling loops and body, cavity, collector cooling loops for klystron. Because the coolant of the RF load is a mixture of water and ethylene glycol, a separate cooling loop for RF load with storage tank, pump and heat exchanger was installed. Also pump for pressurization was installed in klystron body cooling loop, because the pressure of the DI water cooling loop was too low to supply enough flow to that cooling loop.

2.9 Status of KTF

In the KTF, we have developed the technologies for proton accelerators from low energy part. As a result of this development, we have constructed and tested 3MeV proton accelerator system. Figure 1 shows the status of KTF. The 20MeV accelerator in KTF will be constructed and commissioned in 2005. The experiences in KTF will be a basis of the 2nd phase accelerator of 100MeV final energy.

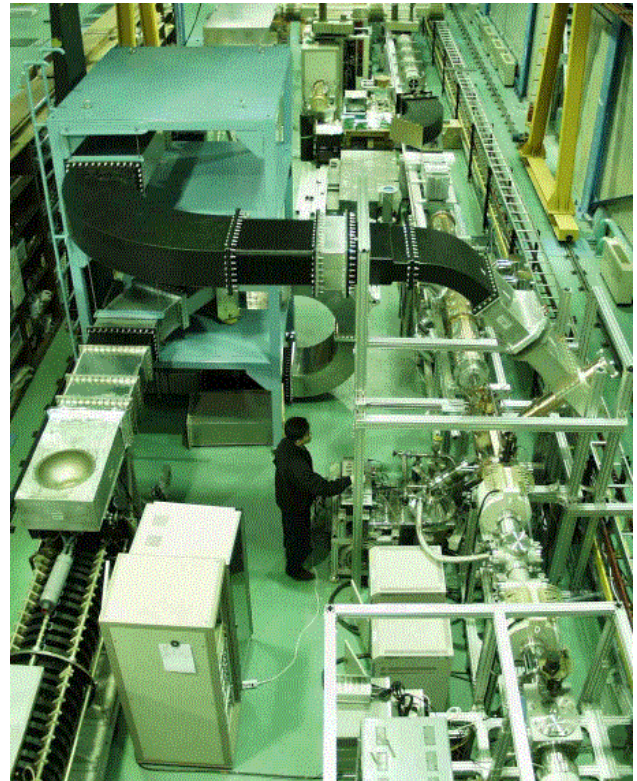


Figure 1: KOMAC Test Facility

3 KOMAC 2ND PHASE ACCELERATOR

3.1 Development Plan

The specifications of KOMAC 2nd phase accelerator are given as Table 1. The duty factor of the accelerator for the initial stage is 10%. But the final goal of the accelerator will be 100%. The technologies for the

accelerator will be acquired in KTF. Also at this phase, the following technologies will be developed in KTF.

- Negative Ion Source
- Super-Conducting Cavity Technology
- Continuous Beam Sharing Technology

Table 1: KOMAC 2nd Phase Accelerator

- Ion : Proton
- Proton Injector : 50keV
- RFQ : 3MeV @ 350MHz
- DTL : 20MeV @ 350MHz
- CCDTL : 100MeV @ 700MHz
- Max. Beam Current : 20mA
- Beam Emittance :
0.3 π mm mrad (Transverse)
0.4 π Deg. MeV (Longitudinal)
- Duty : 10% (Initial Stage), 100% (Final Stage)
- Beam Switching : 20MeV & 100MeV

3.2 Beam Line for 2nd Phase Accelerator

For proton beam applications, the 2nd phase accelerator will supply beams with 20MeV and 100MeV. Figure 2 shows the schematic diagram for the beam line. The 50keV beam from injector will be chopped with time-structure suitable for applications, and supplied via switching magnets at each energy stages.

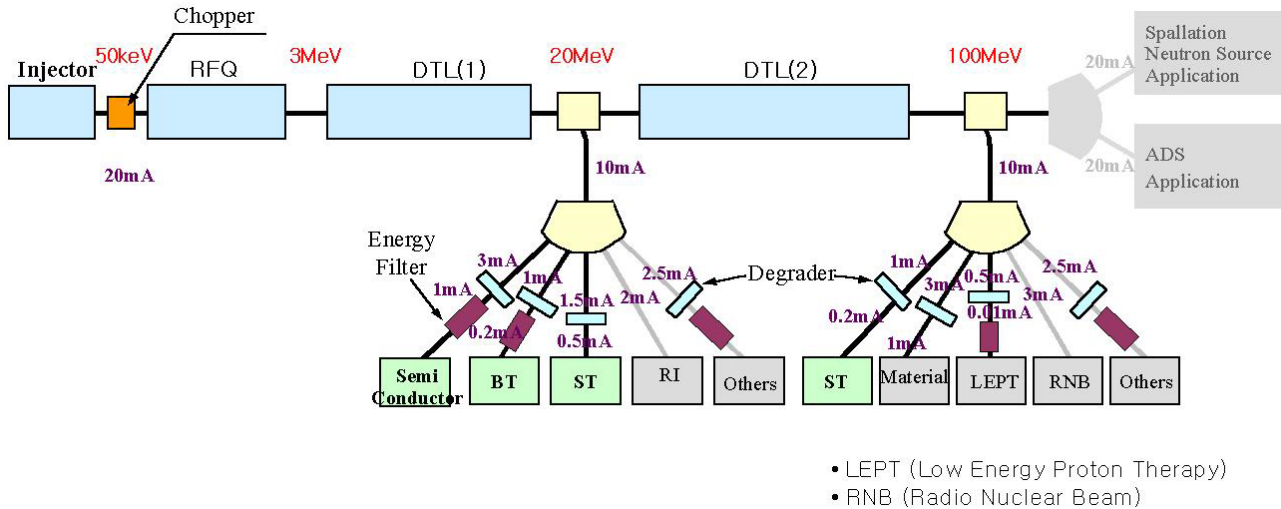


Figure 2: Proton Beam Line for 2nd Phase Accelerator

4 SUMMARY

The technologies for proton accelerators from low energy part have been developed, and 3MeV proton accelerator system has been constructed in KTF. The 20MeV accelerator in KTF will be constructed and commissioned in 2005. With the technologies developed in KTF, the 2nd phase accelerator of 100MeV final energy will be constructed in 2010.

It will supply beams for many applications of industries and basic sciences with energy of 20MeV and 100MeV.

5 ACKNOWLEDGEMENT

The Korea Ministry of Science and Technology supports this work.

6 REFERENCES

- [1] B.H.Choi et al, "Overview of the KOMAC Project", Proceedings Of the 3rd International Conference ADTTA'99 (1999).
- [2] Y.S.Cho, et al, "High-current ion source development for the Korea Multipurpose Accelerator Complex", Rev. Sci. Instr., 71, 969(2000).
- [3] J.M. Han et al, "A 3MeV KOMAC/KTF RFQ Linac", in this conference (2000).
- [4] Y.S. Cho et al, "Cold Model Test of The KOMAC CCDTL Cavities", Proceeding of EPAC2000, Vienna, (2000).