DESIGN OF 20MEV DTL FOR KOMAC TEST FACILITY*

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Abstract

KOMAC (Korea Multipurpose Accelerator Complex) Test Facility (KTF) has been prepared to develop accelerator technologies and low energy proton beam applications with a 20MeV proton accelerator. For the KTF accelerator, a conventional DTL (Drift Tube Linac) from 3MeV to 20MeV has been designed with 10% duty. It consists of 350MHz DTL cavities with permanent quadrupole magnet and a 1MW RF source. The details of the DTL design are reported.

1 INTRODUCTION

The Korea Multipurpose Accelerator Complex (KOMAC) project has been initiated to develop and build a high current proton linear accelerator capable of delivering an 1GeV cw proton beam with an intensity of 20mA in the final stage. For the first phase of the KOMAC project, we will develop cw accelerating structure upto 20MeV, and operate the accelerator in 10% duty pulse mode. After the 1st stage, 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 2003. After the commissioning, KTF will provide the proton beam for the many industrial applications

At the KTF, we are developing 50keV proton injector, 3MeV RFQ, 20MeV CCDTL, and RF system. Also we have a plan to develop the basic Super-Conducting cavity technology in the KTF for the 2nd stage super-conducting accelerator of the KOMAC. Fig. 1 shows the plan of the KTF with the floor size of 36m x 9m.

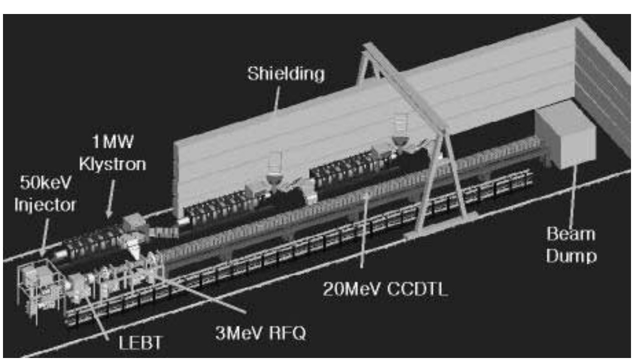

Figure 1: KTF Accelerator Plan

The proton injector is already developed, and the 3MeV RFQ is being constructed as shown in Figure 2. For the utility, we have the plan to build 3 cooling systems of 2MW and 3 high voltage power supplies of 2MW for klystron as shown in Figure 3, and we already have the buildings for utilities. One cooling system and one power supply for the klystron of the KTF RFQ are prepared as shown in Figure 4.

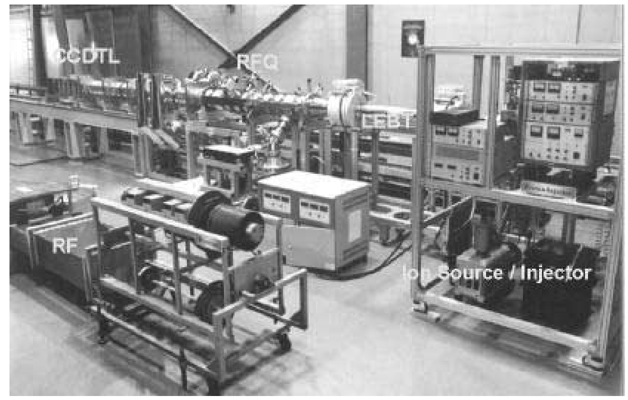

Figure 2: Status of KTF Accelerator

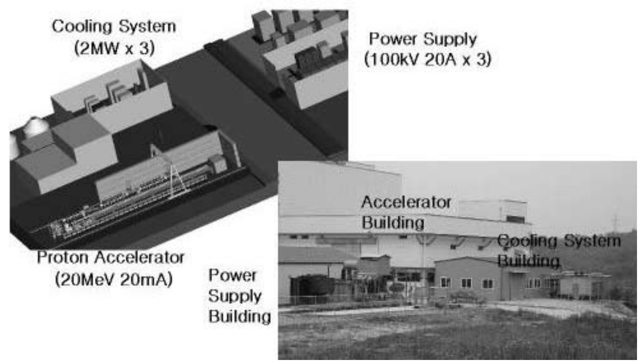

Figure 3: Utility Plan and Utility Buildings

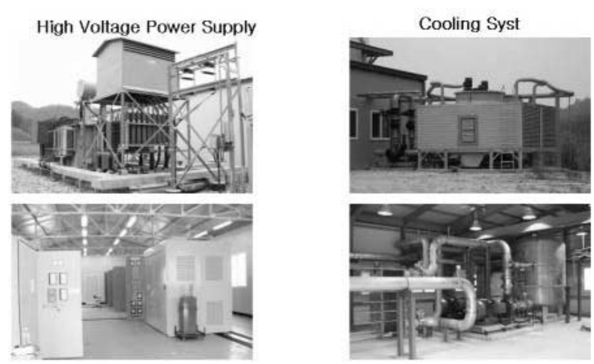

Figure 4: Utility for KTF Accelerator

For KTF CCDTL accelerator, there are two problems. One is the cost of RF system for KTF CCDTL, for which 2MW RF system is necessary, and the other is the uncertainty of CCDTL operation. To overcome these problems, we have to check the possibility that we can construct the DTL, which is verified for pulsed operation,

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with one RF system of 1.2MW, which is available.

2 KTF DTL DESIGN

The specifications of DTL accelerator for KTF are given as Table 1. It will accelerate the 3MeV proton beam to the energy of 20MeV. The duty factor of the accelerator for the 1st stage is 10%. But the final goal of the KTF accelerator will be 100%. The design of the DTL is based on the 100% duty factor.

Table 1: Specifications of KTF DTL Accelerator

- Ion : Proton
- Input Beam : 3MeV (From 350MHz RFQ)
- Max. Beam Current : 20mA
- Input Beam Emittance :
0.3 π mm mrad (Transverse)
0.4 π Deg. MeV (Longitudinal)
- Final Energy : 20MeV
- Duty : 10% (1st Stage), 100% (2nd Stage)

2.1 DTL Cavity Design

The 350MHz frequency, which is the same frequency of the KTF RFQ, can be used for the DTL. The design parameters of the DTL cavity are shown in Table 2. The values of the surface E-field and the real estate accelerating gradient are conservative for easy fabrication and cw operation of the 2nd stage.

Table 2: Design Parameters of DTL

- Frequency : 350MHz
- Real Estate E : <1MV/m
- ZTT : >40MΩ/m
- Surface E : <0.9 Kilpatrick
- Synchronous Phase : -30 degree
- Focusing : 1 βλ FODO
- Aperture diameter : 1.6cm

The aperture of the DTL can be optimised by iterative calculations of the shunt impedance and the beam trajectory for the optimisation. A larger aperture decreases the shunt impedance, but increases the ratio of aperture to beam size (less beam loss).

The cavity shapes with the design parameters in Table 3 are determined by SUPERFISH code as shown in Figure 4. Figure 6 and Figure 7 show the shunt impedance In spite of the small aperture, the effective shunt impedance is small in the first part of the DTL.

Table 3: Design Parameters of DTL

- Tank Diameter : 50cm
- Drift Tube Outer Diameter : 8cm
- Bore Diameter : 1.6cm
- Drift Tube Face Angle : 0
- Accelerating Gap : 1.1 ~ 4.3cm
- Stem : 2cm x 1 / Drift Tube
- Stabilisation : Post Coupler

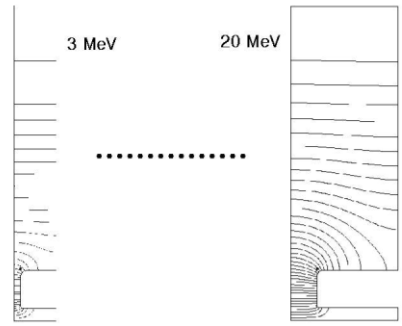

Figure 5: DTL Cavity

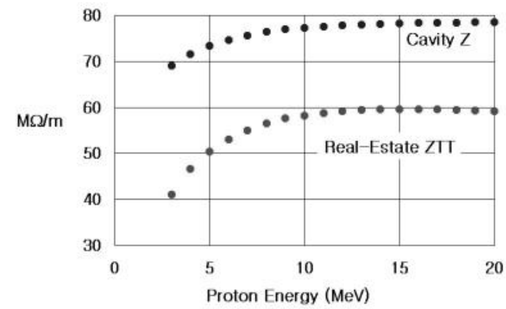

Figure 6: Shunt Impedance

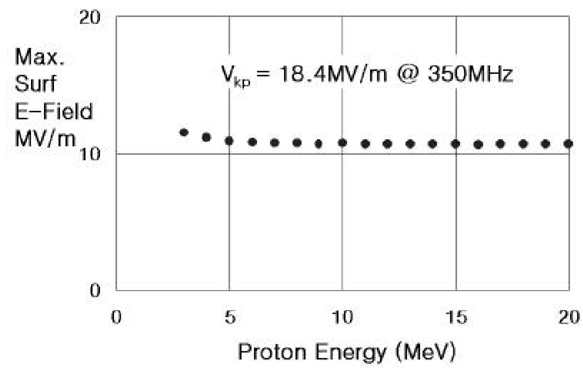

Figure 7: Surface E-Field

The shunt impedance and the surface E-field is within the requirements

2.2 Beam Dynamics

Beam dynamics calculations for the KOMAC DTL are performed using the PARMILA code. The input longitudinal emittance is 0.4π degree·MeV, and the input transverse rms emittance is 0.34π mm·mrad. At the end of the acceleration, there is virtually no growth in transverse emittance and in longitudinal emittance as shown in Figure 8 and 9.

To estimate the tolerances of the DTL structure, an error analysis has been done with PARMILA code. With the error in Table 3, which is achievable, the beam envelope calculated with PARMILA code does not grow more than 20%.

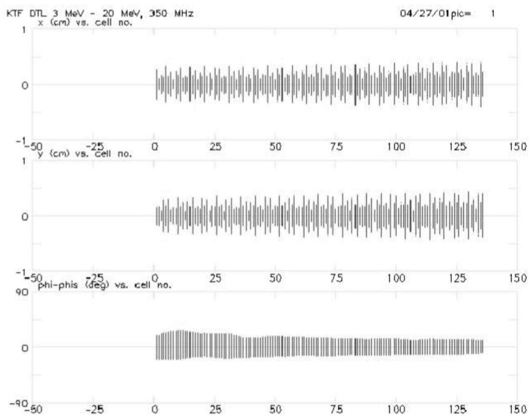

Figure 8: Beam trajectory in DTL

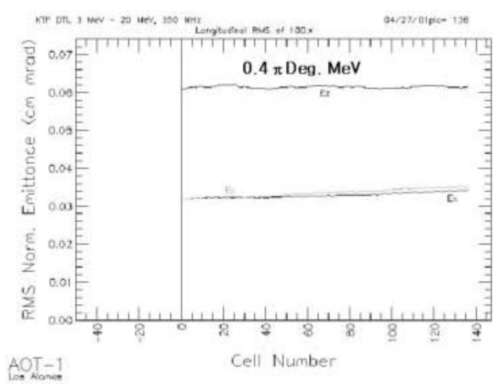

Figure 9: Emittance in DTL

The PMQ is designed with PANDIRA code. The aperture is 20mm, the permanent magnet is distributed in the Halbach type geometry [2]. The calculated quadrupole strength is 14kG/cm with the surface field of 12kG. The required pole length is 4cm. The field profile is shown in Figure 10.

The calculated total length of the DTL is 16.46m. In consideration of the machining and the cost for DTL, the length of each tank should be ~4m. The number of tanks is 4, and 1.2MW RF can be fed into 4 tanks by 4 RF coupler.

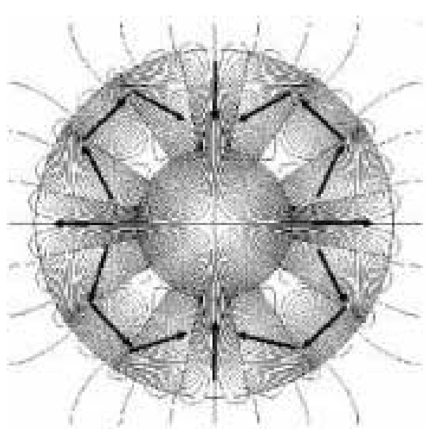

Figure 10: PMQ

Table 3: Tolerances of the DTL

- Field Amplitude : 1%
- Field Gradient : 1%
- Phase : 1 Degree
- Quadrupole displacement : 0.1mm
- Quadrupole rotation : 1 Degree
- Quadrupole strength (GL) : 1%

3 SUMMARY

The design of KOMAC DTL is summarised in Table 4. As the results of this study, we can check the possibility that a 20MeV DTL with one 1.2MW RF system can be designed. But, due to the low acceleration gradient, the length of the DTL is long. So, we need to study the cost of manufacturing accelerator, and then compare it with RF costs. After the cost estimations for each case, we will decide DTL or CCDTL for the KTF accelerator.

Table 4: Design Summary of the CCDTL cavity

- Energy : 3 ~ 20MeV
- Structure : 350MHz DTL
- Length : 16.46m
- Aperture Diameter : 16mm
- No of PMG : 137
- Total Structure Power : 549kW
- Structure Power per length : 3.3kW/m @ 10%
- Surface E : <0.9 Kilpatrick

4 REFERENCES

[1] Pierre M.Lapostolle et al, "Linear Accelerator", North-Holland Publishing Company (1970).
[2] K. Halbach, "The Art and Science of Magnet Design", Lawrence Berkeley Laboratory (1995).