Development of a 10 MeV Electron Beam Diagnostics Beamline

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1. Introduction

At the Advanced Radiation Technology Institute (ARTI) in Jeongeup, an electron accelerator for pulse radiolysis is being established to investigate the physical properties of advanced polymeric materials, biological materials, and environmental process. An existing 10 MeV electron accelerator, originally designed for irradiation applications, is being modified to generate nanosecond electron beams, and an electron beam diagnostics beamline is currently being developed to characterize the beam properties.

The electron beam is expected to have an energy of 10 MeV, a bunch charge of approximately 1 nC, and a pulse duration of 1 ns minimum. The objective is to establish a beam diagnostics system capable of reliably transporting the electron beam with these specifications while accurately measuring its beam properties. In this context, the configuration of the electron beam diagnostics beamline will be discussed.

2. Beamline configuration

The electron accelerator for pulse radiolysis accelerates a 10 MeV electron beam in the downward direction. The beam is then bent into the horizontal direction by two 45° dipole magnets before being injected into the material analysis chamber. The beamline consists of beam diagnostics for measuring the electron beam properties, quadrupole magnets for beam focusing, and a pumping system for maintaining the required vacuum conditions. The configuration of the diagnostics beamline is shown in Figure 1.

The electron beam energy is determined by measuring the beam trajectory through the dipole magnets according to the following relation.

$$p[\mathrm{GeV/c}] = 0.2998 B[\mathrm{T}]\, \rho[\mathrm{m}] \quad (1)$$

Here, (p) denotes the momentum of the electron beam, (B) is the magnetic field strength of the dipole magnet, and (ρ) is the radius of curvature of the electron beam trajectory. In actual measurements, the radius of curvature will be determined from the beam position after passing through the dipole magnet. The vacuum chamber installed inside the dipole magnet should be designed to minimize beam loss associated with the change in the electron beam trajectory.

The electron beam charge will be measured using an ICT (Integrated Current Transformer). When charged particles pass through the ICT core, the induced current generated in the transformer coil is used to determine the bunch charge. A Bergoz ICT model, which is widely used for accelerator beam diagnostics worldwide, will be employed. The selected model is capable of measuring bunch charges ranging from 800 pC to 400 nC with an accuracy of approximately 1 pC [1].

The electron beam pulse duration will be measured using an FCT (Fast Current Transformer). The measurement principle is essentially the same as that of the ICT; however, the FCT provides a much higher temporal resolution, allowing the electron beam pulse duration to be measured with sub-nanosecond resolution. A Bergoz FCT model will also be used for this measurement.

The transverse distribution of the electron beam will be measured using beam imaging screens. YAG and OTR screens suitable for 10 MeV electron beams will be employed. The screens will be mounted on actuator systems so that they can be inserted into or retracted from the beam path as required. The beam profiles obtained from the screens will be observed using a CCD camera, and a dark-room optical system will be implemented to minimize the effects of external light and optical noise on the acquired images.

The transverse position of the electron beam will be measured using a stripline BPM (Beam Position Monitor). The beam position will be calculated from the voltage signals measured by four stripline electrodes using a signal acquisition module. The system will be designed to achieve a beam position measurement accuracy of better than 100 μm.

3. Conclusion

The electron accelerator diagnostics beamline is designed to characterize 10 MeV electron beams with a pulse duration of approximately 1 ns. It consists of two dipole magnets, one ICT, one FCT, two screen chambers, and three BPMs. The construction of the

beamline is scheduled to be completed by the end of this year.

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REFERENCES

[1] https://www.bergoz.com/products/ict/

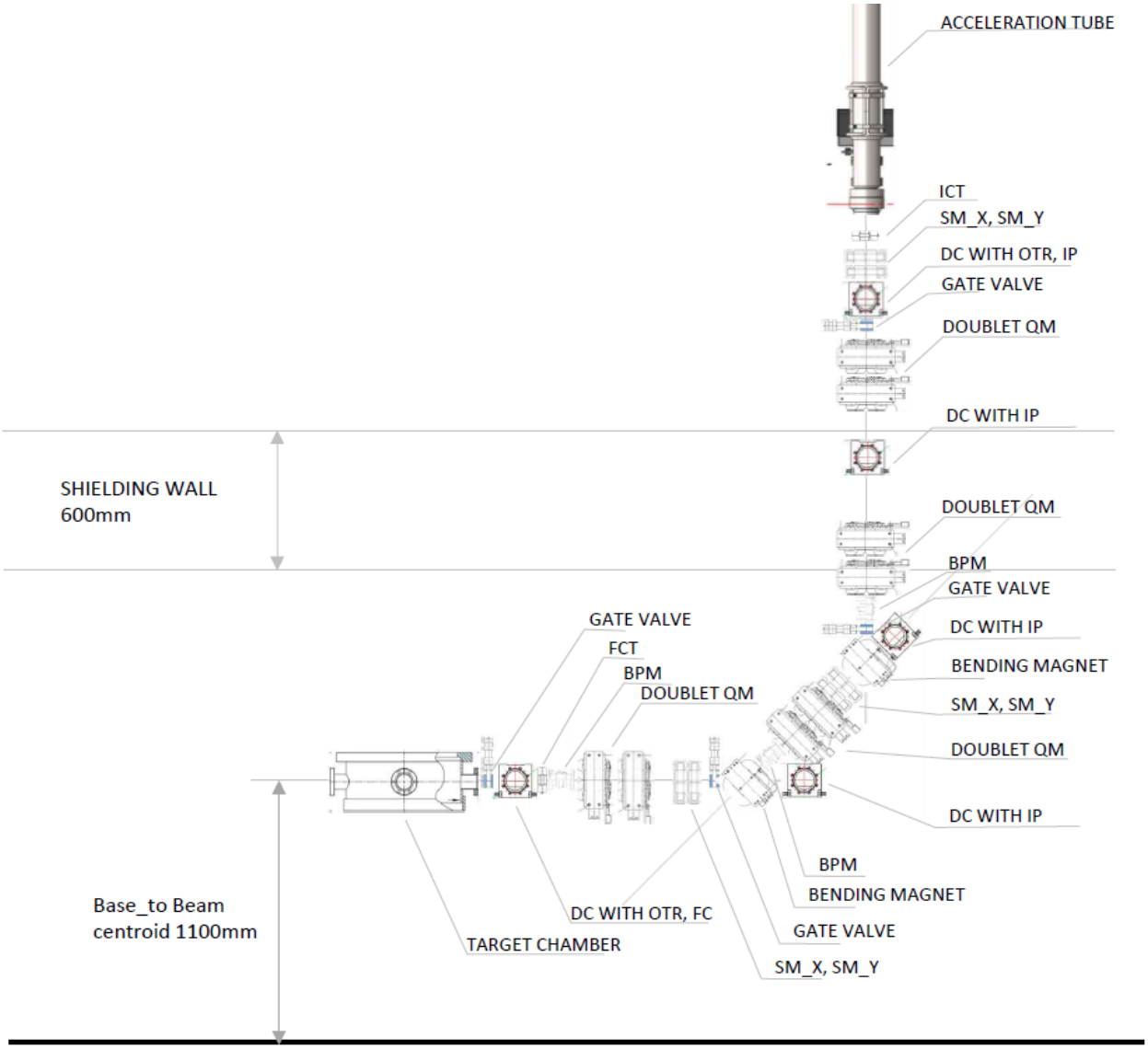


Figure 1. Configuration of 10 MeV Electron Beam Diagnostics Beamline