CHAPTER V
CONCLUSION

This thesis comprised three main components: CST simulations, system assembly, and hands-on experiments. Using CST Studio Suite and SolidWorks modeling, a compact low-energy negative carbon ion beamline was designed, incorporating an octupole deflector, an Einzel lens, and a four-blade aperture slit. Simulations demonstrated that a 40 keV C^- ion beam could be focused to an RMS size of 2.42 × 2.38 mm² with an emittance of 8 mm·mrad (equivalent to 1.6 mm·mrad·√MeV) at the slit, achieving 99% transmission through a fully open 20 × 20 mm² aperture. Optimization of the Einzel lens identified a central-electrode bias of –20,139 V for precise focusing, while the octupole deflector enabled independent X and Y beam steering.

Misalignment studies established that the octupole deflector tolerates up to a 2° tilt and 2 mm offset, maintaining over 99 % transmission, and that its steering fields can correct 1 mm beam shifts with less than 300 V adjustments. The Einzel lens, however, demanded tighter tolerances of 0.4 mm offset and 0.6° tilt, beyond which the beam was lost due to field-symmetry disruption.

Existing SLRI vacuum components were cleaned, He leak-tested to 10^{-9} mbar·L/s, and assembled into a tabletop UHV system with turbo-molecular pumps (300, 350, 700 L/s) and a scroll pump. Ten DC high-voltage supplies from Matsusada Precision (five for the cesium sputter source, floating on an isolation transformer; one for the Einzel lens; and four 1 kV units for the octupole rods) were controlled via CO-HV and CO-E32 fiber-optic interfaces, all mounted beneath the table on ceramic standoffs so that the chamber exterior remains at ground potential for safety.

The ionizer heater used a toroidal MoRe filament (0.9 mm diameter) designed to deliver ~150 W at 1200 °C. Ohm's law and electrical resistance formula yielded a 20 cm coil length wound in 22 turns, later doubled to halve the power draw to ~70 W. A 3D-printed tamper tool applied a 1 mm insulator layer; future aluminum tooling is expected to improve surface finish. Filament testing (pyrometer range 249–1370 °C) confirmed that resistance rises linearly with temperature (TCR behavior) and that power consumption follows a T^4 trend (Stefan–Boltzmann radiation). Vacuum measurements showed decreasing chamber and pump pressures with temperature—typical for UHV systems—with slight pressure spikes at 400 °C, 800 °C, and 1300 °C due to material outgassing.

Overall, the integrated design meets all performance targets, including compact footprint, beam quality, alignment tolerances, vacuum integrity, and reliable heating. It establishes a robust foundation for Thailand's first in-country AMS radiocarbon dating system.