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Development and Performance Testing of a 1.2 MV DC Power Supply for an Electrostatic Tandem Proton Accelerator in Accelerator-Based Boron Neutron Capture Therapy

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I. Boron Neutron Capture Therapy (BNCT) as Cancer Treatment

A. Potential alternative to traditional radiation therapy
- o Effective for malignant brain tumors (e.g., glioblastoma)
- o Promising for head and neck recurrent cancers
- o Useful for superficial melanomas (skin and genital regions)

II. Development and Role of Accelerators in BNCT

A. Epi-thermal neutron accelerators discussed since the 1980s

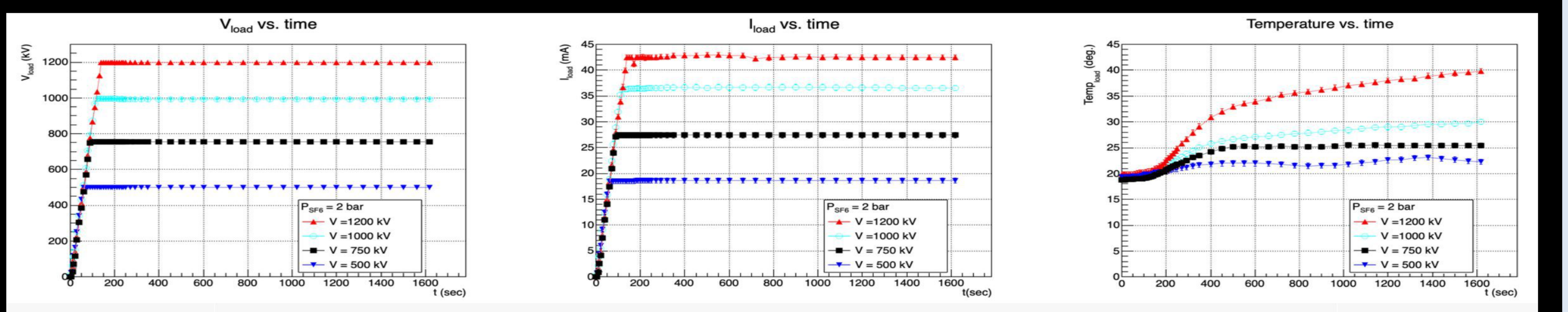
B. Significant research on accelerator-based neutron sources (ABNS) began in early 2000s

C. Types of reactions in ABNSs:
- o Lithium-7 reaction (7Li(p,n)7Be): 1.9-3.0 MeV proton energy
- o Beryllium-9 reaction (9Be(p,n)9B): 5-30 MeV proton energy
- o Lithium-7 advantage: lower energy neutrons allow smaller moderators, cleaner beams, reduced neutron activation

III. Accelerator Development by Korea Institute of Radiological and Medical Sciences (KIRAMS)

A. Developing a 2.4 MeV electrostatic proton accelerator using lithium-7 reaction

B. Categories of accelerators used globally for BNCT:
- o Cyclotrons
- o Linear accelerators
- o Electrostatic accelerators



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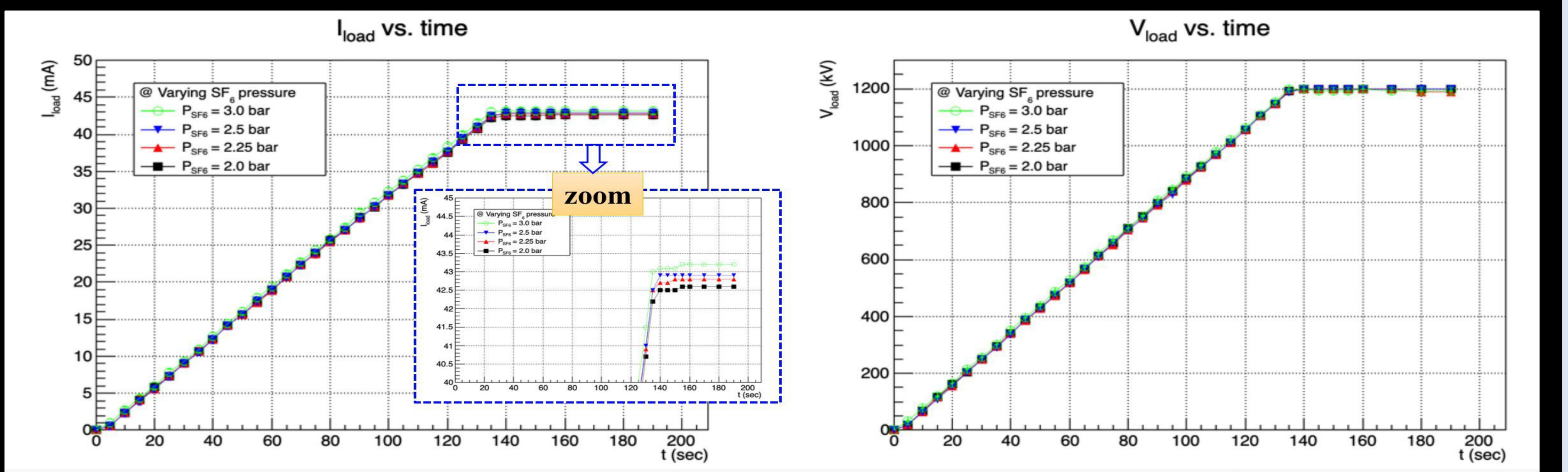

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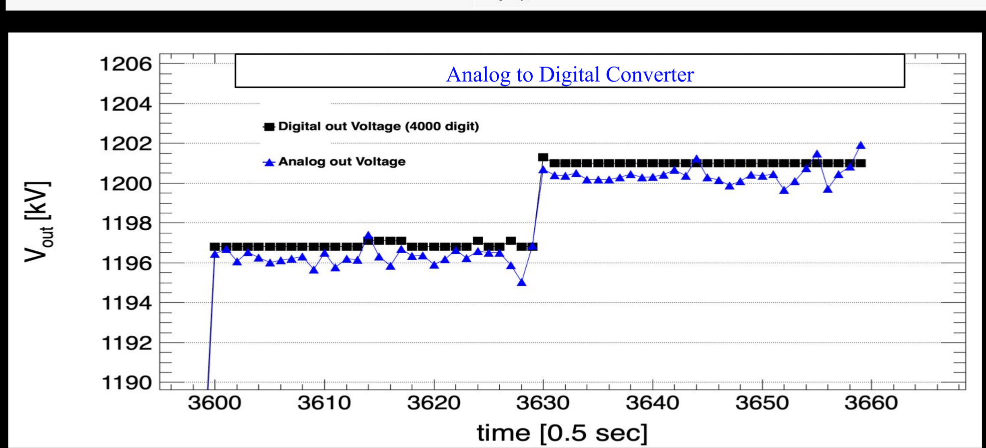
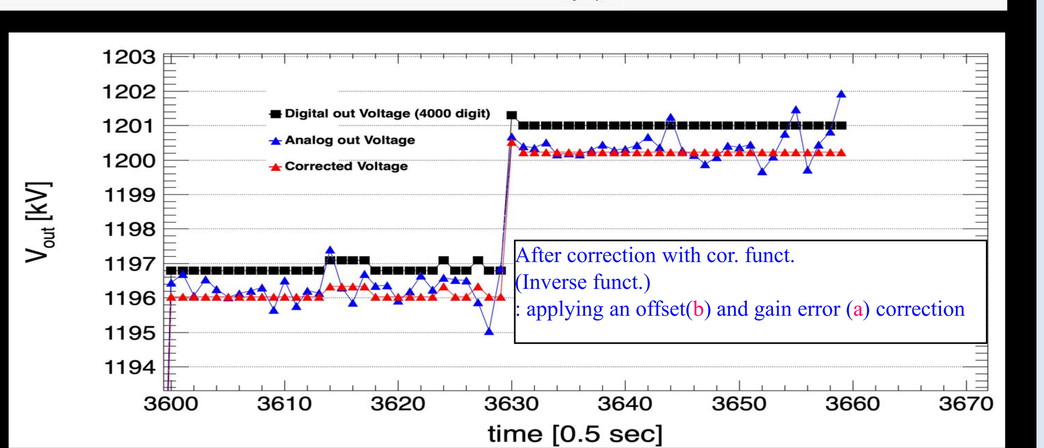
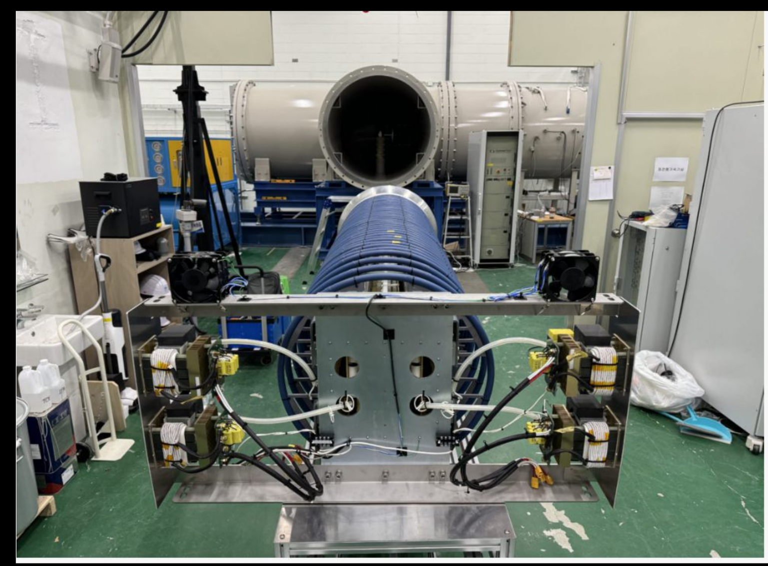
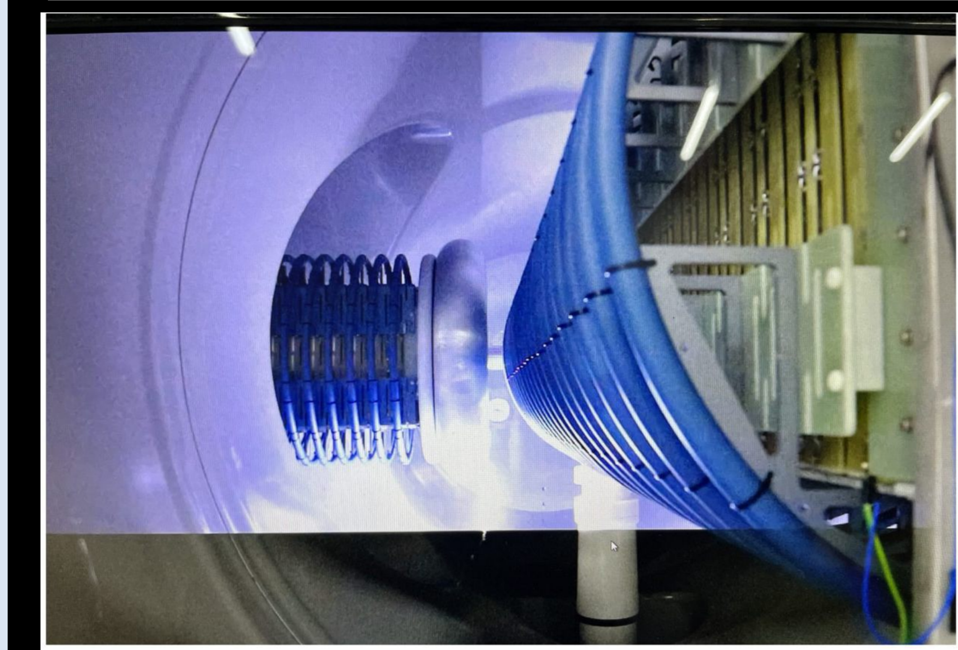
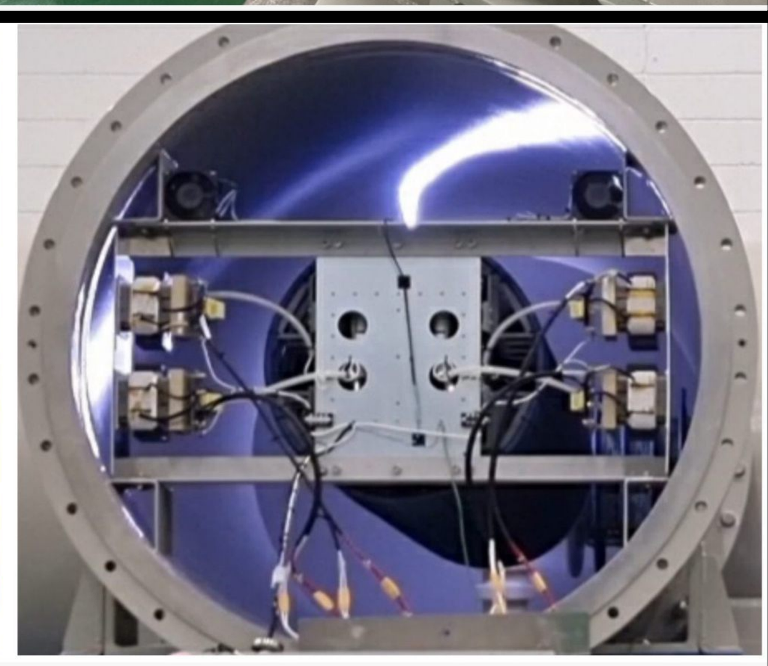










IV. Development of Tandem-Type Electrostatic Accelerator

A. System chosen to produce H- ions and accelerate protons via stripping process

B. Positive high voltage applied using a DC power supply for consistent deck voltage

C. Ongoing development goal: propel protons up to 2.4 MeV

V. High-Voltage DC Power Supply Milestone

A. Development of 1.2 MV-45 mA high-voltage DC power supply

B. Testing results:
- o Achieved 750 kV/40 mA under atmospheric conditions

VI. Prior Investigation on Cockcroft-Walton (CW) Multiplier

A. 23-stage CW multiplier performance:
- o Stable at 620 kV/35 mA for 2 hours
- o Peak performance at 758 kV/44.2 mA under atmospheric conditions

VII. Upgrades and Testing for Maximum Output

A. Inverter and rectifier stages upgraded for 1.2 MV/45 mA output

B. Realistic load resistance created for testing

VIII. Testing in SF6 Gas Environment

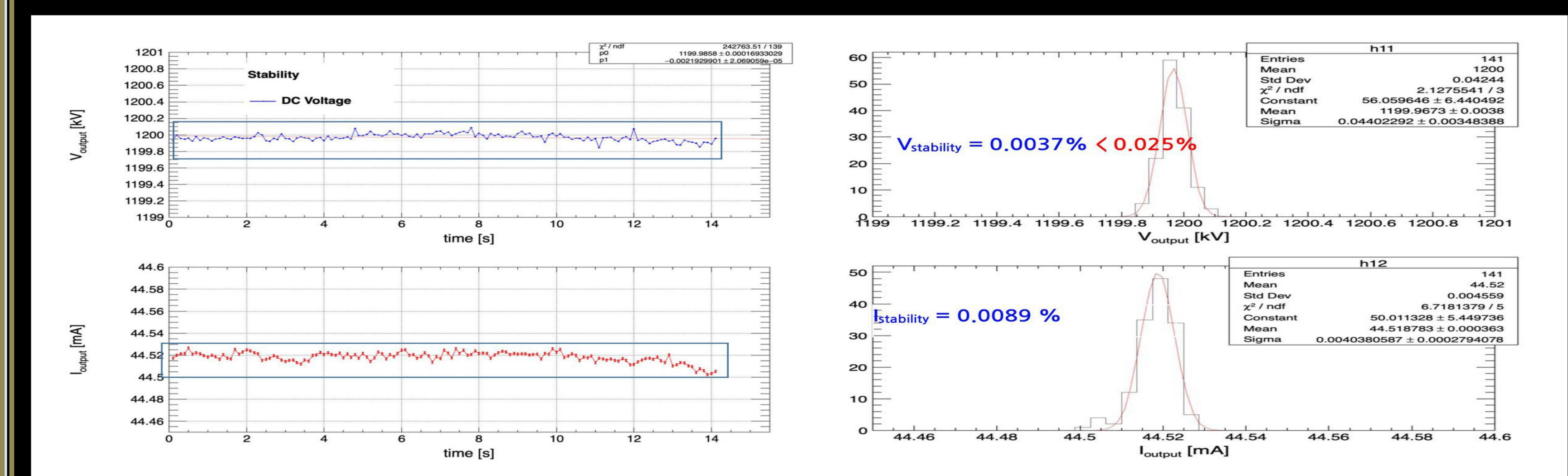
A. Conducted in SF6-filled tank to simulate realistic conditions

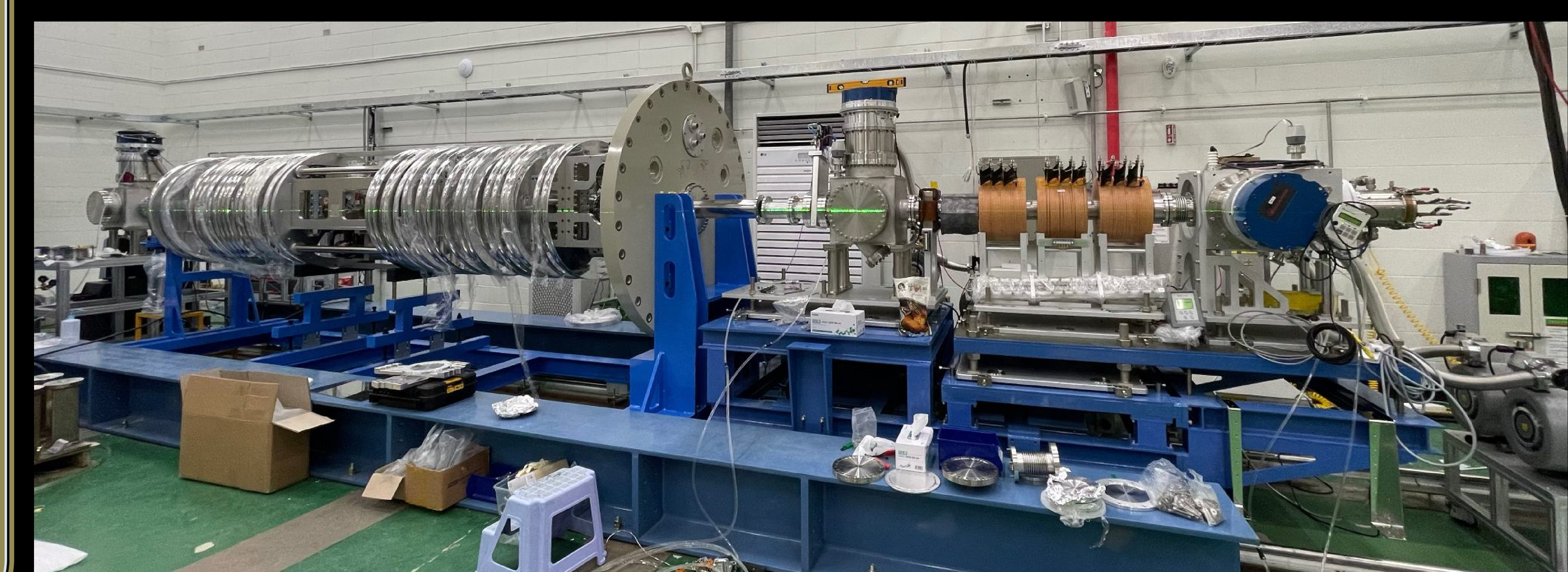
B. Installation of SF6 gas recovery system in tandem accelerator

IX. Reliability and Performance Evaluation

A. Maximum voltage maintenance for over 30 minutes is essential for BNCT

B. Assessment of power supply reliability and output relative to SF6 gas pressure





Summary

I. Power Supply System Enhancements
- A. Upgraded Cockcroft-Walton (CW) rectifier stage
- B. Realistic load resistance created
- C. Final testing conducted in SF6 gas-filled tank

II. Circuit and Voltage Control Enhancements
- A. Rectifier stage upgraded for higher voltage
- B. Series-current resonance method applied for voltage control

III. Performance Testing and Stability
- A. Tested in atmospheric and SF6 gas environments:
  1. Stable operation at 1.2 MV/45 mA
  2. Challenges addressed: corona discharge and electrical arcing
- B. Reliable 54 kW power supply to dummy load with stable voltage and current

IV. Contribution to Medical Applications
- A. Advancement in high-voltage power supply for neutron therapy and cancer treatment
- B. Potential for accelerator-based BNCT with improved treatment efficacy and reduced side effects