Ion Cyclotron Transmission Lines

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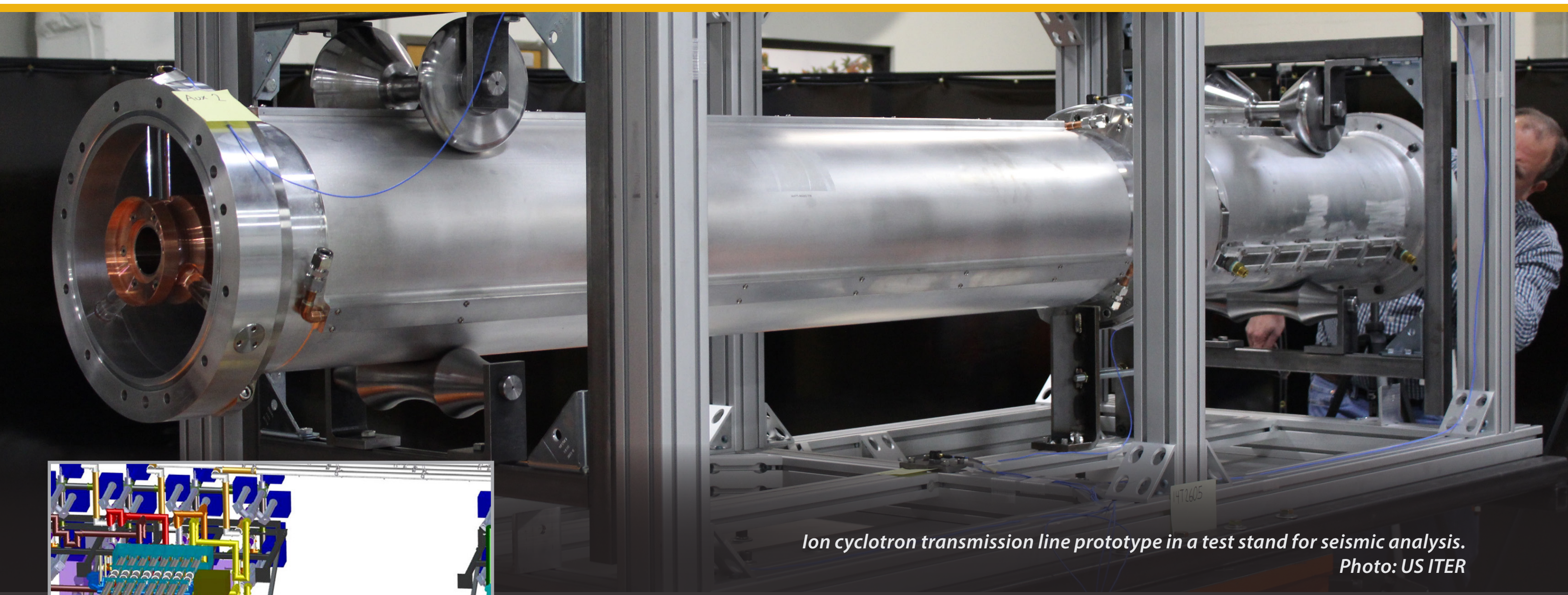
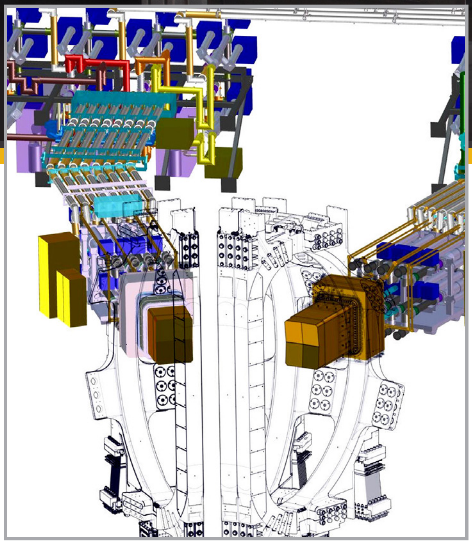
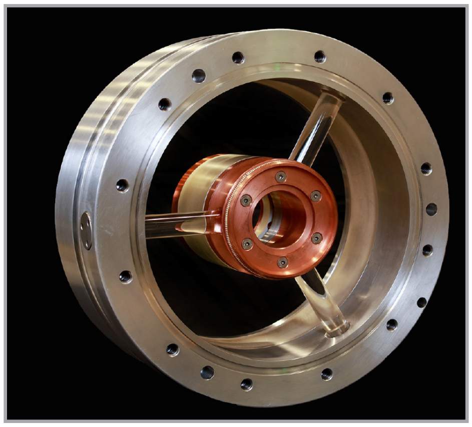


Ion cyclotron transmission line prototype in a test stand for seismic analysis. Photo: US ITER



Ion cyclotron transmission lines design. Image: US ITER



Inner conductor support prototype with quartz rods. Photo: US ITER/ORNL

US Contribution

US ITER is responsible for the ion cyclotron transmission lines and impedance matching system, including research and development, design, and fabrication.

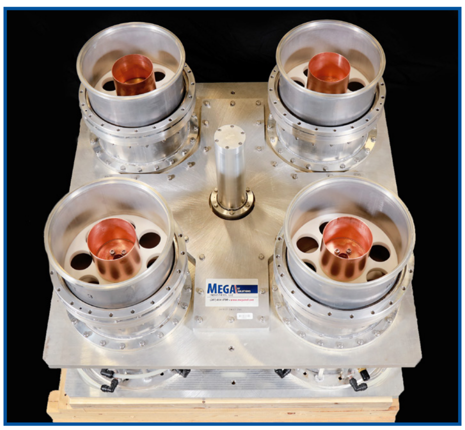
Overview

The ion cyclotron transmission lines enable a mission-critical burning plasma in ITER through advancements in radio frequency transmission and matching technology. The ion cyclotron heating and current drive system heats the ions and electrons in the plasma with a high-intensity beam of electromagnetic fields. Generators produce high-power radio frequency waves that are carried along multiple transmission lines to antennas located in the vacuum vessel, which launch the heating fields into the plasma. The ion cyclotron transmission lines will provide efficient power (20 MW) transfer from 40–55 MHz between the radio frequency sources and the plasma heating antennas. The system will include coaxial transmission lines and a matching/tuning system to minimize power transfer losses. The pressurized lines can transmit up to 6 MW per line. In total, approximately 1.5 km of line connects eight sources to 16 antenna feeds.

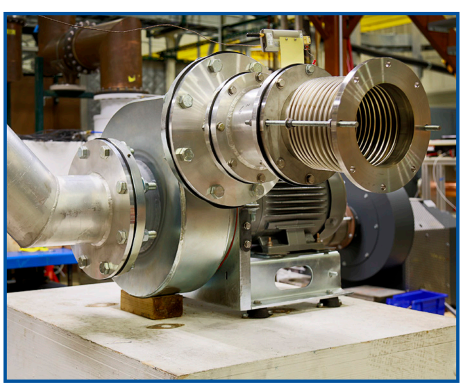
Status

Final design is complete for the system layout, constituent transmission line components, and auxiliary equipment needed to support high-power radio-frequency source testing and commissioning in Building 15 during the first plasma stage of operations. Industry partners are currently fabricating prototypes with testing scheduled for early 2024. The team is currently focused on the full post-first plasma components that deliver power from the radio-frequency sources to the antennas. An end-to-end preliminary design review is planned for mid-2025.

The resonant ring test stand at ORNL is used to test prototype components. Photo: US ITER



Rotary joint four-port switch prototype. Photo: US ITER/ORNL



A blower component for the high-powered resonant test line at ORNL. Photo: US ITER/ORNL

Technical Description

Transmission line operational frequency range: 40-55 MHz

Transmission line connects 8 RF sources to 16 antenna feeds

1.5 km combined length, 30 cm diameter coaxial transmission lines through three buildings

Transmission lines guide up to 12 MW peak between the matching system and the antenna

Power coupled to plasma per antenna: 10 MW (upgrade, 20 MW)

Maximum pulse length: 3600 s, 25% duty cycle (1 hour on, 3 hours off)

Provide fast arc detection, real-time processing of a multivariable state-space impedance control system to enable maximum radio frequency power transmission to the plasma.

Contributors include

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