Installation and Initial Testing of the Electric Tokamak Folded Waveguide

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A 57MHz folded waveguide (FWG) has been installed on the UCLA Electric Tokamak (ET). The FWG has a 28.9cm square cross section and can be rotated for operation as either a fast wave or Ion Bernstein wave launcher. Two sets of planar faceplates allow for either a monopole launch spectrum or dipole (0-pi) phasing. The FWG offers the potential to provide high power density with low electric fields at the launch end as compared to conventional loop antennas. The FWG has the potential to become an important part of RF heating experiments on ET, intended to investigate current profile control for high beta applications. Initial low field side coupling tests were performed with the FWG mounted above the horizontal midplane outside a polypropylene vacuum window with a 4.6cm gap between the monopole faceplate and the inside of the window. These network analyzer measurements during plasma operations indicate sufficient loading in this configuration. Installation of the antenna directly on the tokamak is underway. A 30-60 MHz, 20kW transmitter will be utilized for modest power operations.

*** Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S.Dept. of Energy under contract DE-AC05-00OR22725.**

Outline

Folded waveguide concept

Electric tokamak

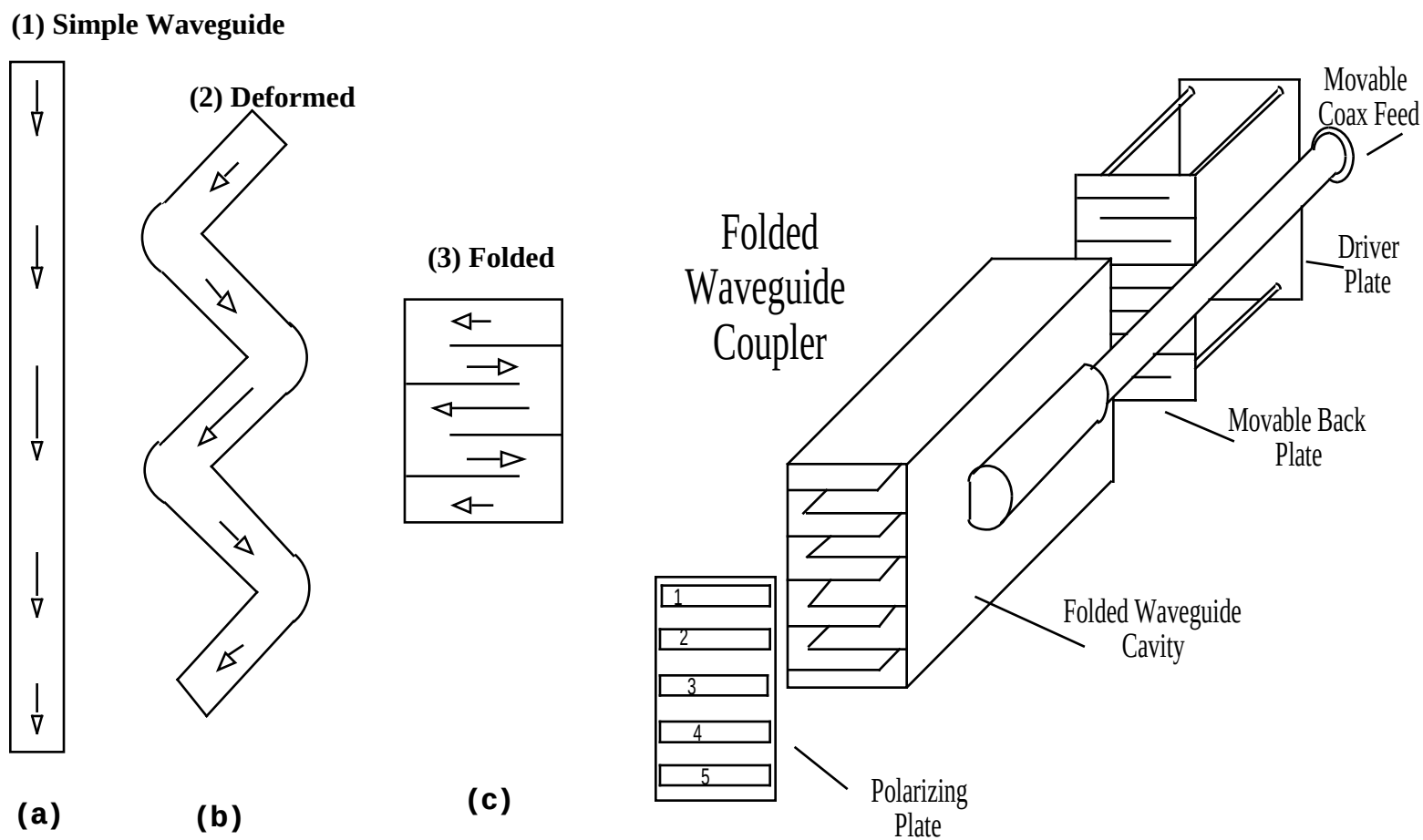
57 MHz folded waveguide

Antenna phasing options

Low power coupling experiments

Initial results with various plasma discharges

The Folded Waveguide Concept



Owens, T.L., IEEE Trans. Plasma Sci. PS14, 934-46 (1986)

ICRF experiments on ET

Investigate current profile control for high beta applications.

ET currently operates with several low frequency ICRF antennas.

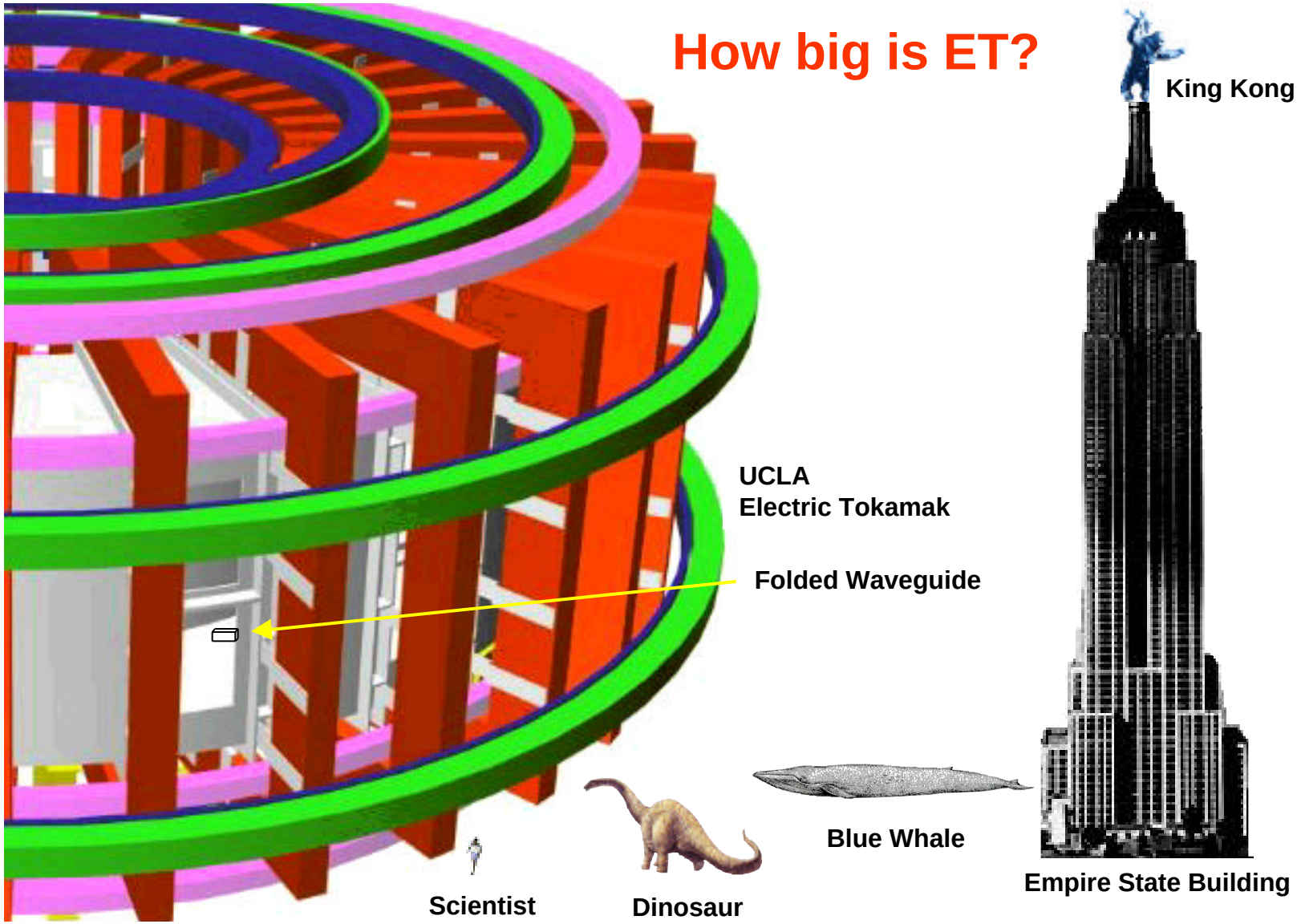
The folded waveguide (FWG) adds higher frequency capability to ET.

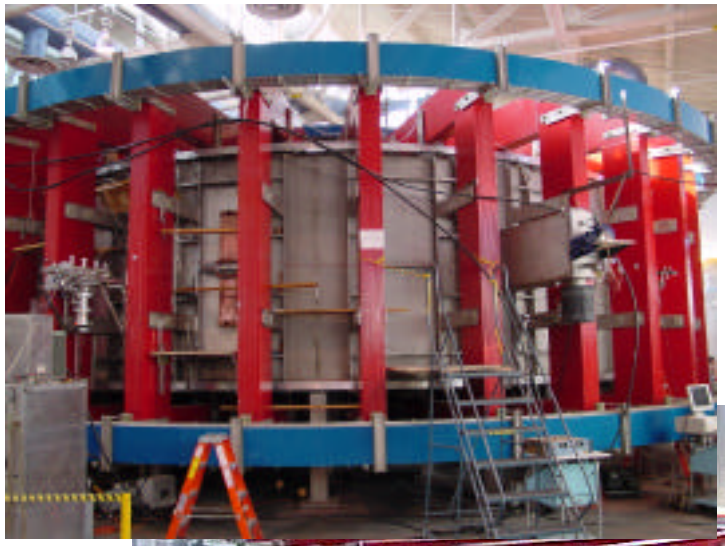
Initial low power scans indicate good loading.

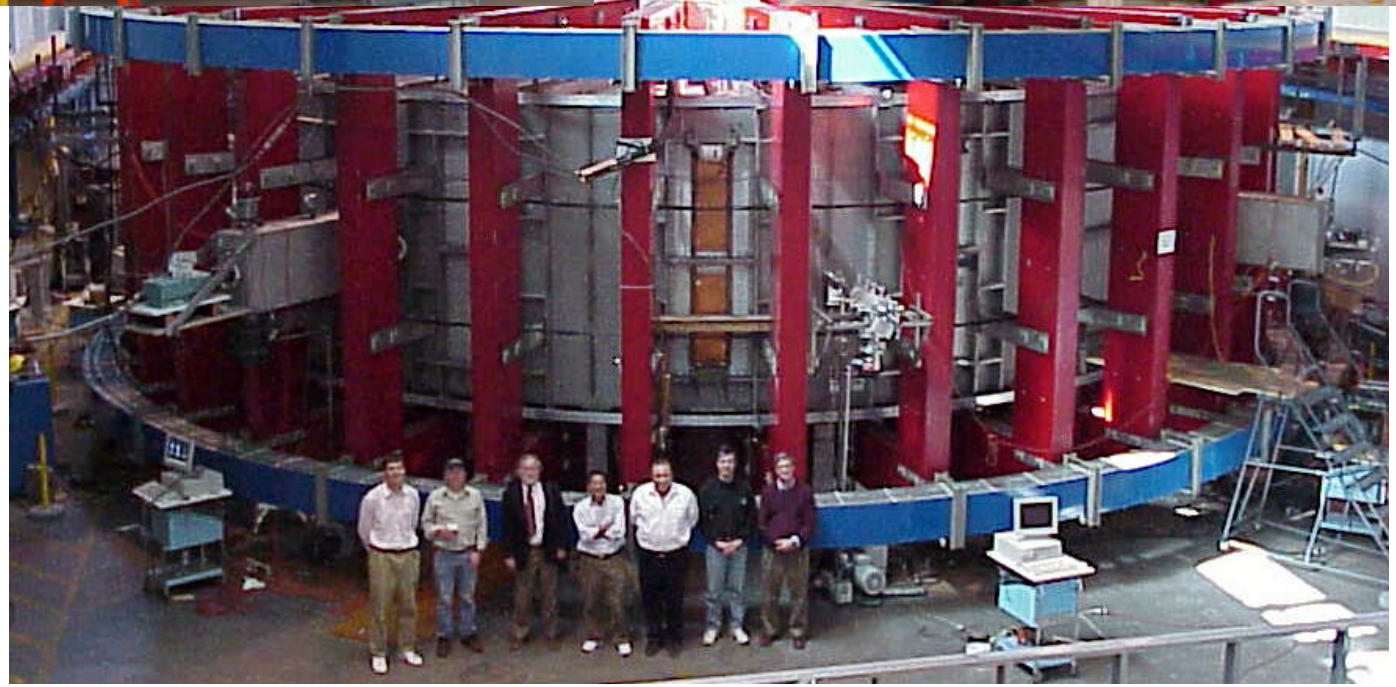
20kW transmitter is used to explore the FWG operating space at modest power.

Loading comparisons will be made in both the fast wave and IBW configuration with dipole and monopole faceplates and for various plasma conditions.

Folded Waveguide Installed on UCLA Electric Tokamak



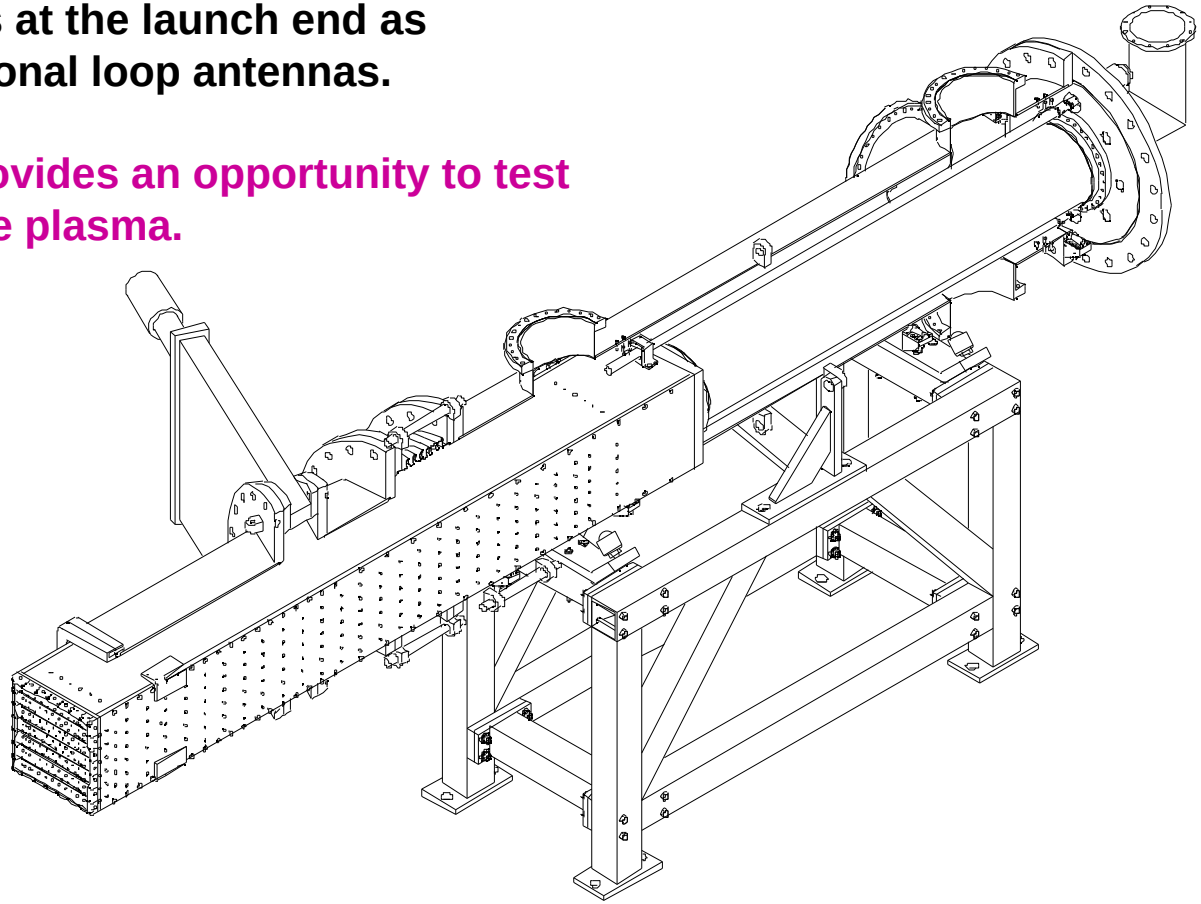




57 MHz Folded Waveguide

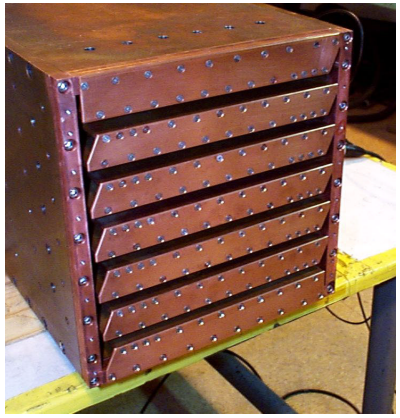
The folded waveguide provides high power density with low electric fields at the launch end as compared to conventional loop antennas.

The ET experiment provides an opportunity to test this concept on a large plasma.

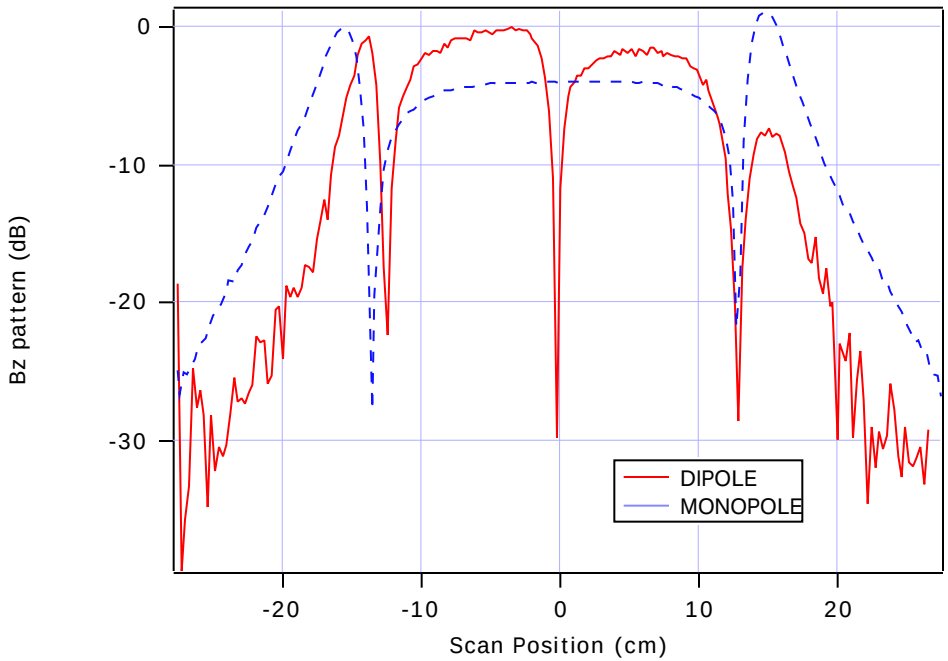


Bigelow, T.S., *.et al.*, Conference on RF Power in Plasmas, Savannah, Ga., AIP Conf. Proc. # **403** p413-16 (1997)

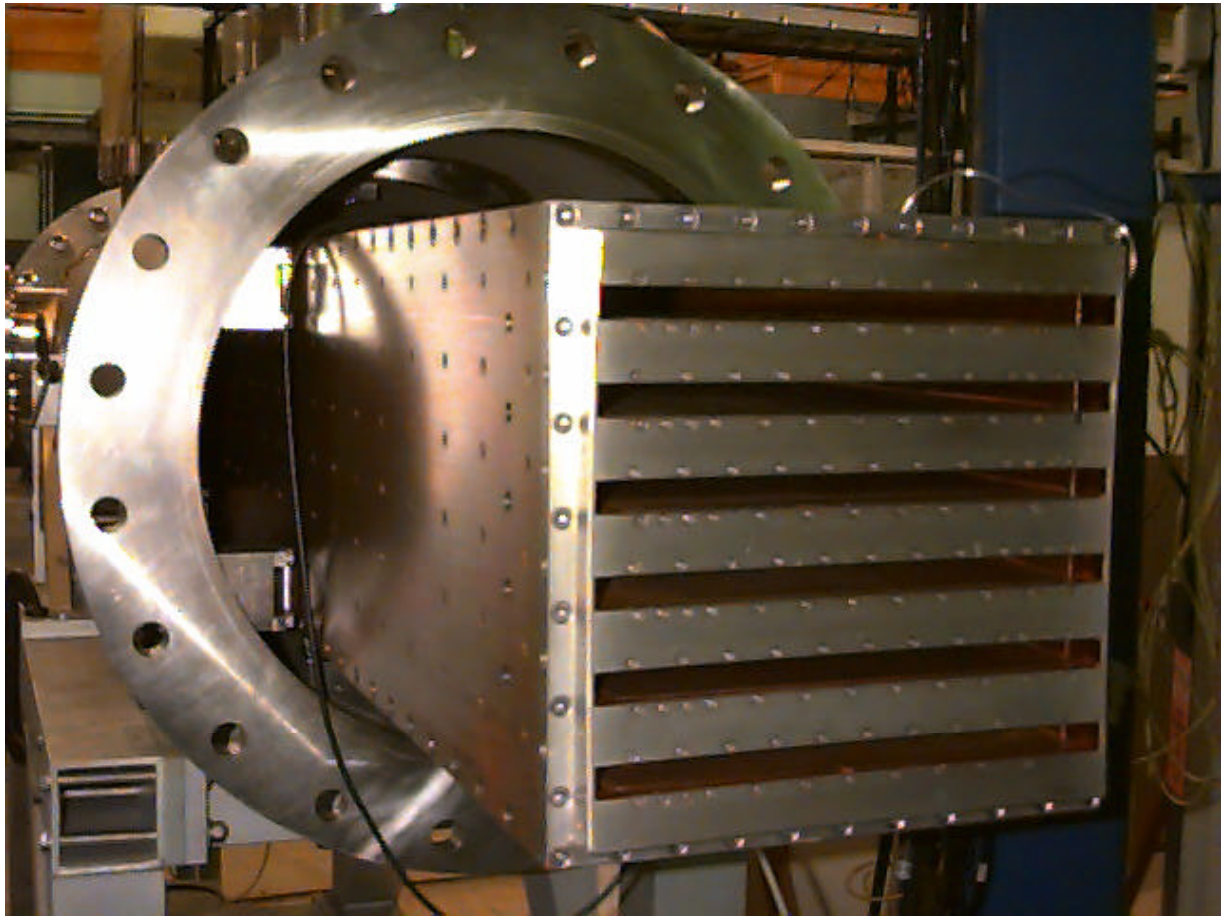
Antenna Patterns for Dipole and Monopole Faceplates



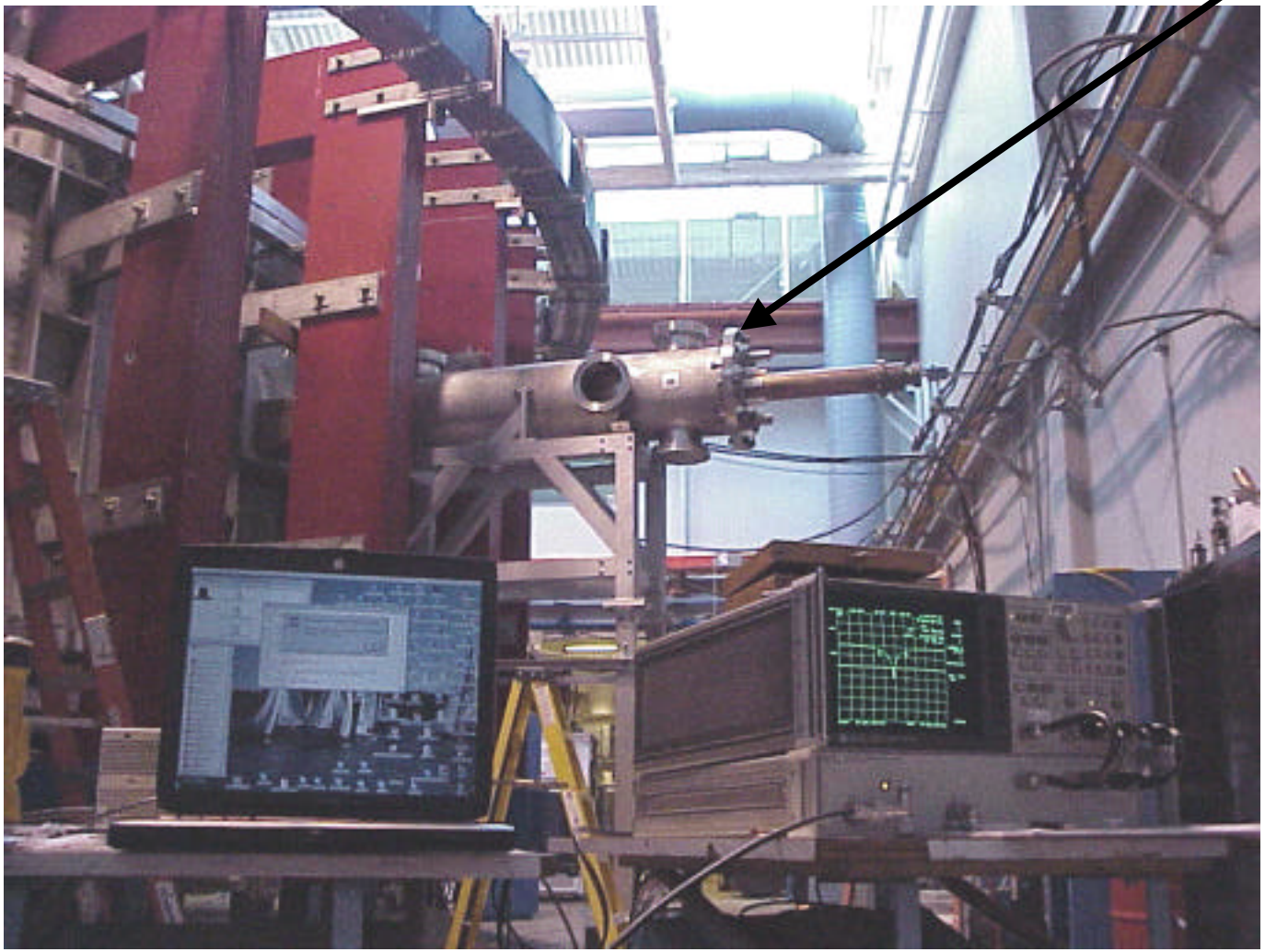
Two sets of planar faceplates allow for either a monopole launch spectrum or dipole (0-pi) phasing.



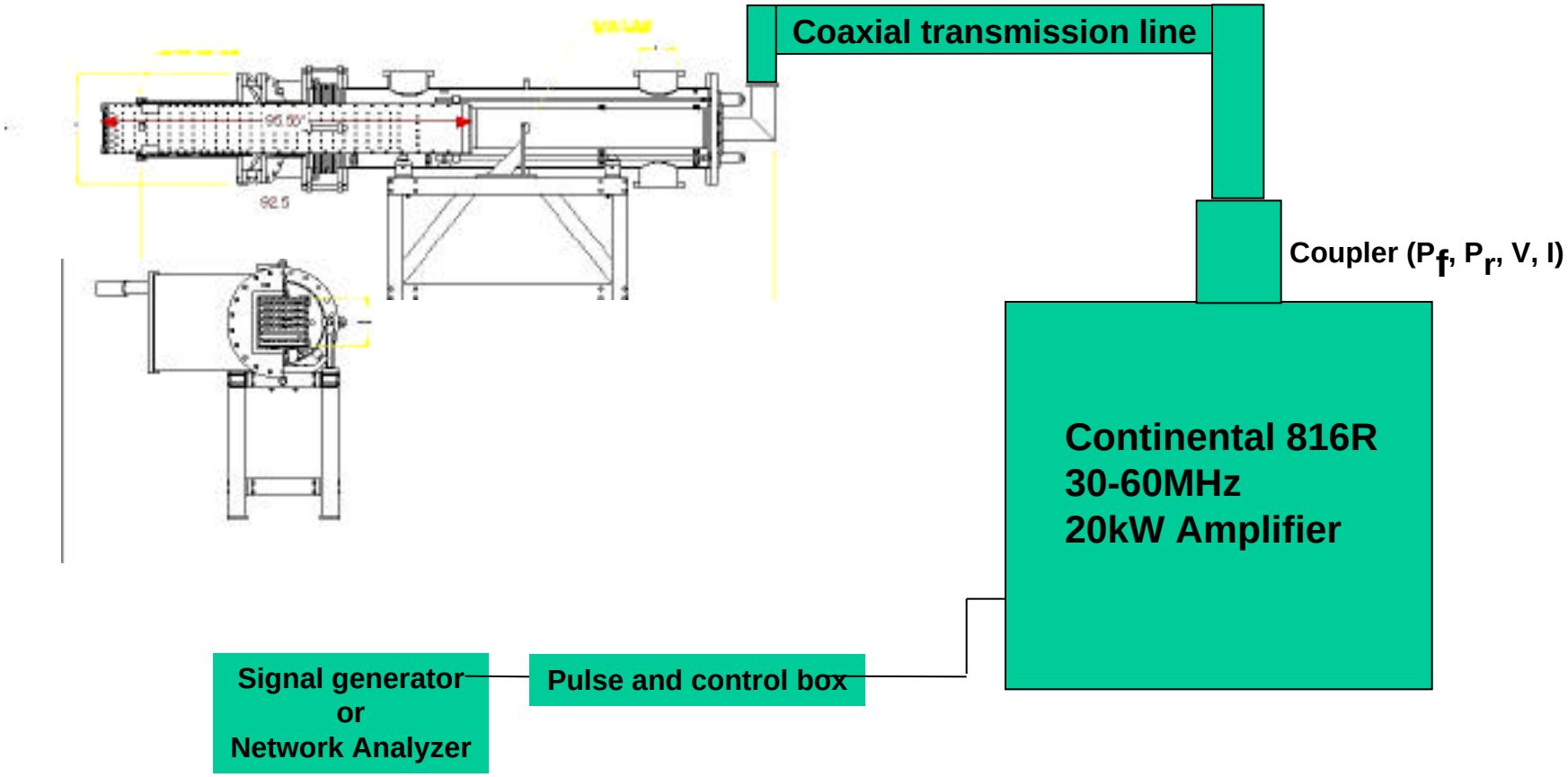
The FWG can be rotated for operation as either a fast wave or an Ion Bernstein wave launcher.



57 MHz FWG preliminary installation for initial low power loading studies

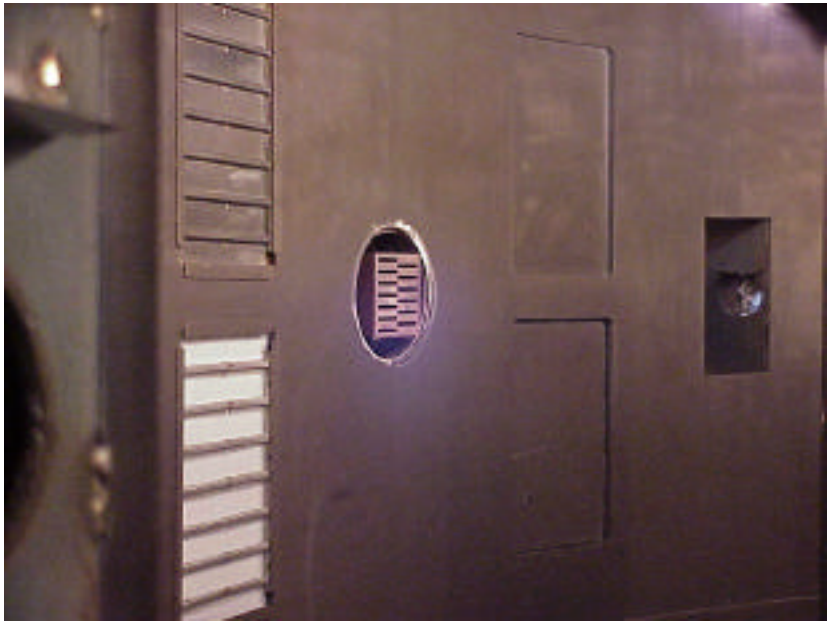


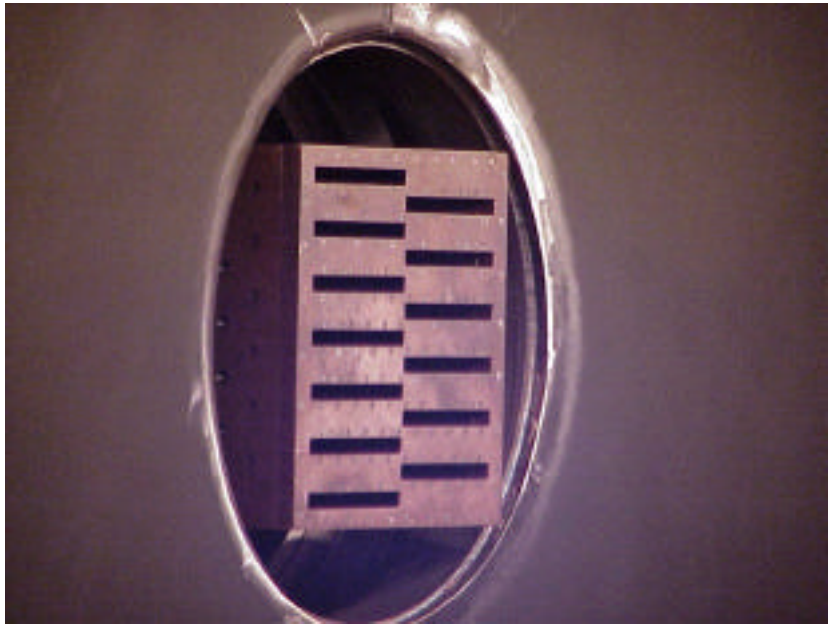
Folded Waveguide tested on UCLA ET



Preliminary loading study led to installation of gate valve (for vacuum access) and 20 kW transmitter

Folded Waveguide tested on UCLA ET





Folded waveguide antenna installed on ET with dipole face plate.

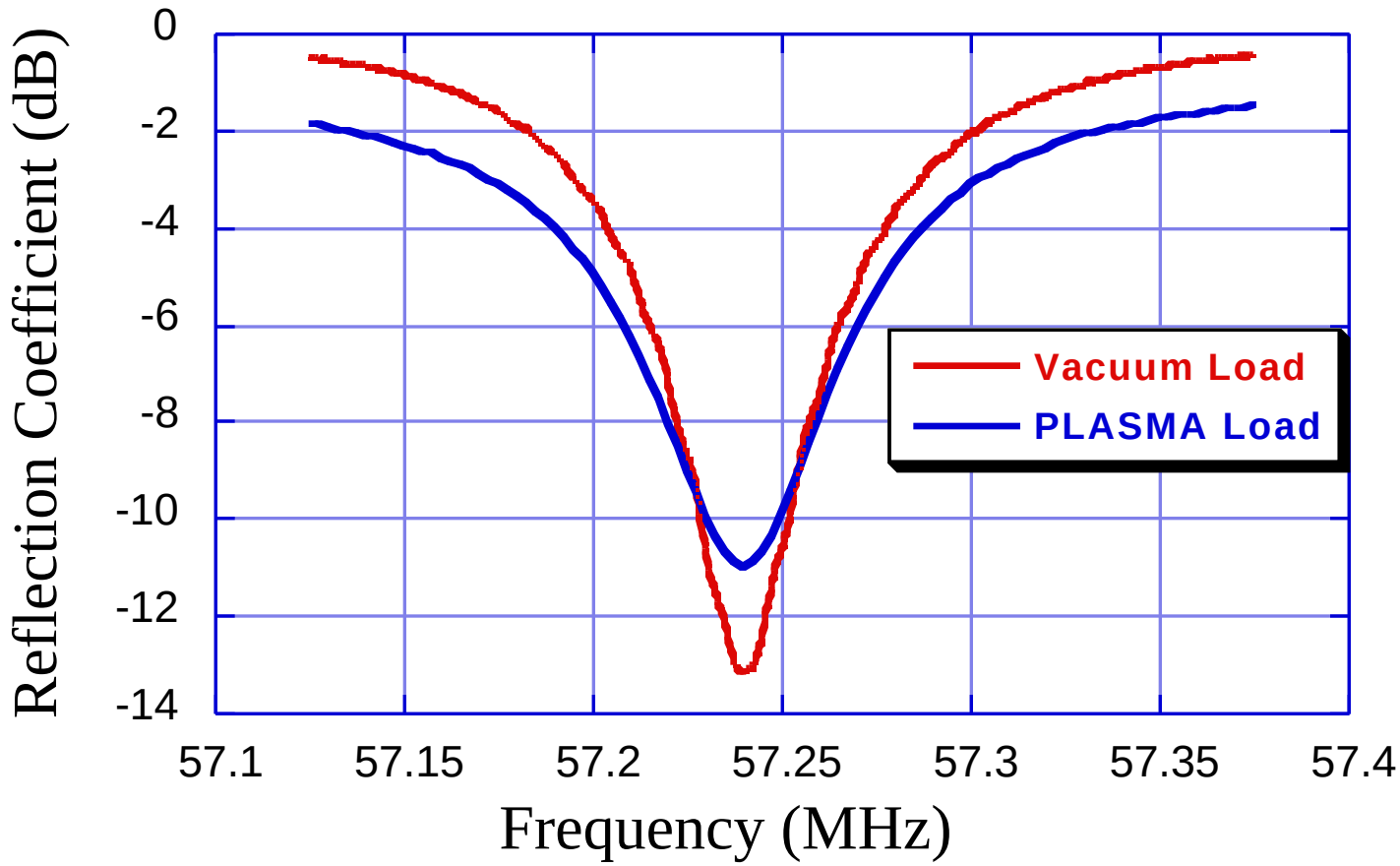
Folded Waveguide tested on UCLA ET

57 MHz power used initially for plasma breakdown

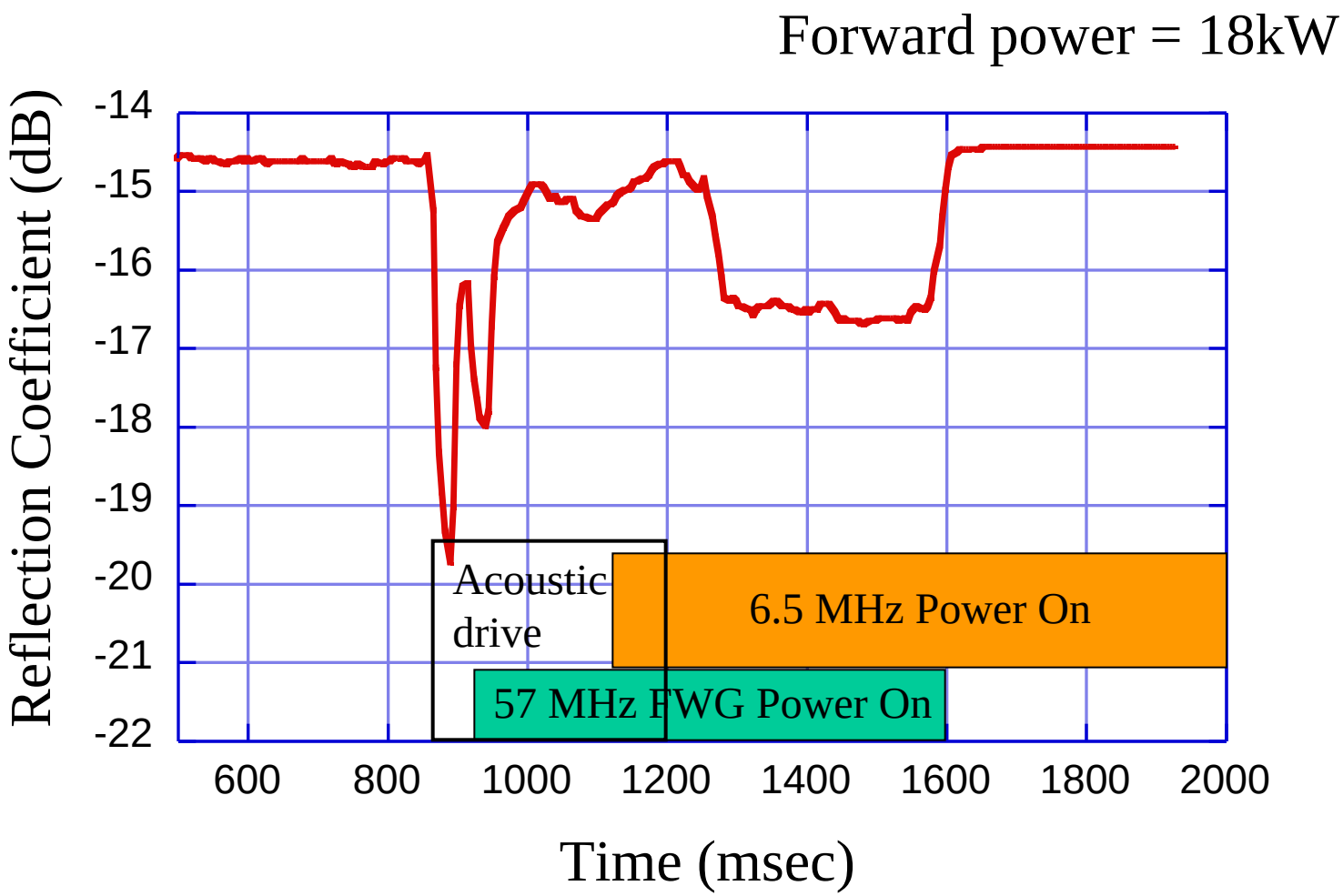
Next step is to understand plasma coupling at higher density with both dipole and monopole phase plates

Plasma discharge initiated with 57 MHz ICRF from the folded waveguide antenna.

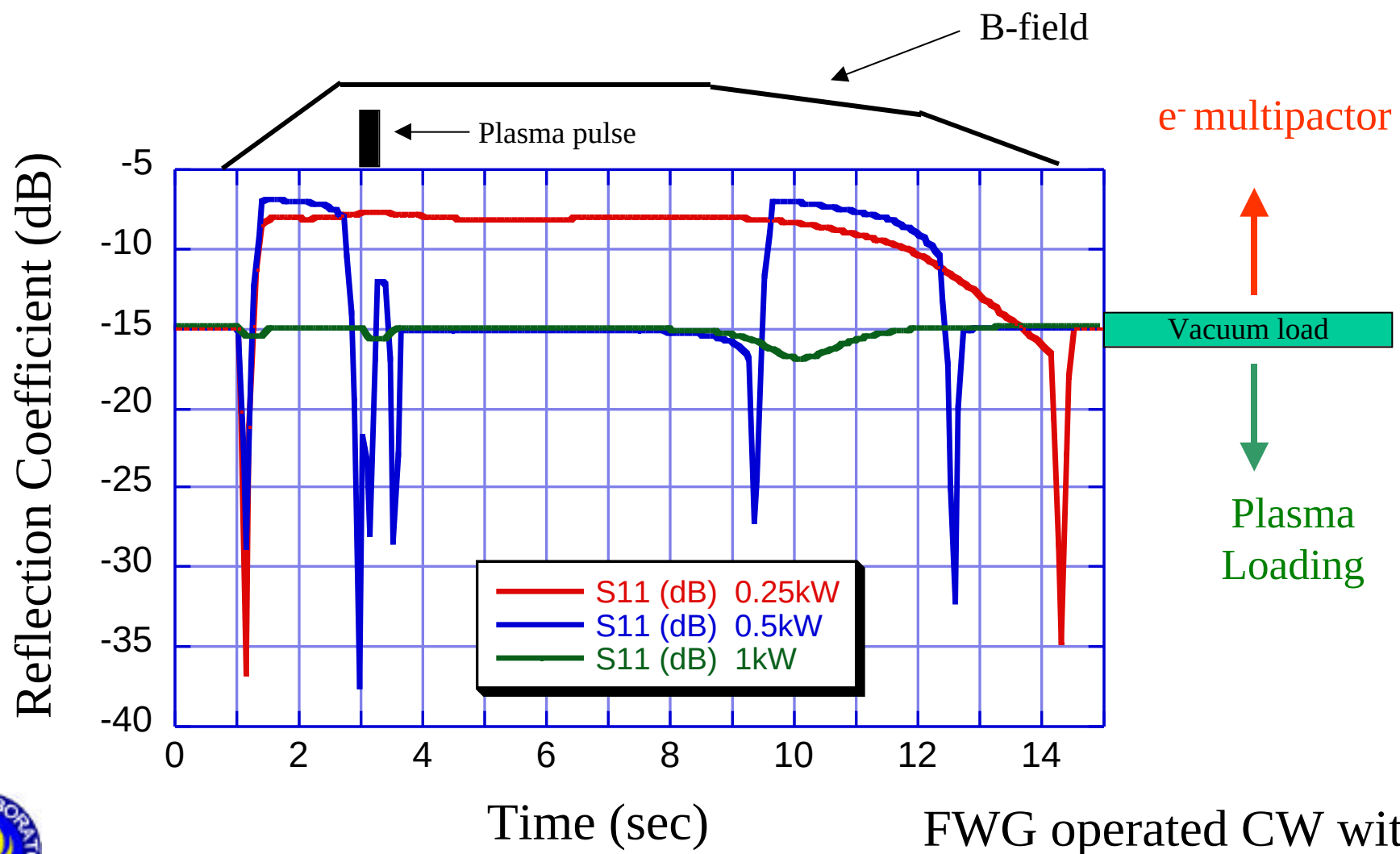
Low power measurements in tokamak plasmas show good loading with negligible frequency shift



High power measurements in discharge cleaning plasmas show good loading



Power dependence of mulipactor and breakdown phenomenon



FWG operated CW with Variable B-field

Initial results

- **Folded waveguide loads well into glow and pulsed discharge plasmas.**

- **Multipactor and breakdown phenomenon can be observed during cw RF operation with:**
  - **Vacuum only**
  - **Vacuum and B-field**
  - **B-field and pulsed discharge cleaning plasma**

- **High reflected power observed in tokamak discharges**
  - **RF > 200 W results in 100% reflection**

Next Steps

- **Understand cause of high reflection coefficient in tokamak discharges observed for forward power > 200 W**
- **Get power into the plasma**
- **Scan the antenna - plasma gap to optimize loading**
- **Compare monopole and dipole operation**
- **Obtain and compare $E_{//}$ vs $E_{\perp}$ data**
- **Modification of the edge profile with a boron nitride limiter is under consideration**