



EBW/ECH Heating Collaboration on NSTX

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NSTX EBW/ECH Research Program

- Demonstrate the coupling of power into the NSTX plasma during under and overdense conditions
- Enhance performance during startup phase
- Provide >100 kW of microwave power for pulse lengths of ~ 0.5 seconds
 - 15.3 GHz for fundamental operation
 - 28 GHz for harmonic operation
- Perform heating experiments for several configurations
- Utilize existing equipment where feasible to reduce cost and schedule
- Serve as a prototype and provide upgrade path wherever possible to a 4 MW EBW H & CD system

Physics Issues

- Several physics issues will be addressed, including:
 - ECH preionization for standard inductive discharges
 - VF only EC/EB heated electron startup at low density
 - Solenoid free EC heated electron startup with CHI
 - ECH/EBW/CHI transition to HHFW current ramp up
 - EBW profile H&CD test at high density/beta
- Launcher design will be optimized to provide EBW coupling based on current EBE experimental results and modeling

ORNL/PPPL hardware capable of 100-350 kW for ~0.5 seconds per tube

- Gyrotrons
 - Single gyrotron tube/socket operated at either 28 GHz or 15.3 GHz
 - The same tube can be used for both frequencies, although the power output at 15.3 GHz will be lower than at 28 GHz
 - 350/100 KW at 28/15.3 GHz pulsed (~500 msec) tube
 - Second gyrotron can be added to provide 700/200 KW
- Power supply
 - PPPL power supply with ORNL modulator-regulator unit
 - Capable of >50 A beam current; up to 2 MW ECH power
- Testing of the 28 GHz gyrotron tube at 15.3 GHz to determine efficiency at the lower operating frequency
 - Initial testing will take place at ORNL to find optimum operating parameters
 - Will use a 40 kW stand-alone system for testing

40 kW test stand being re-installed & tested



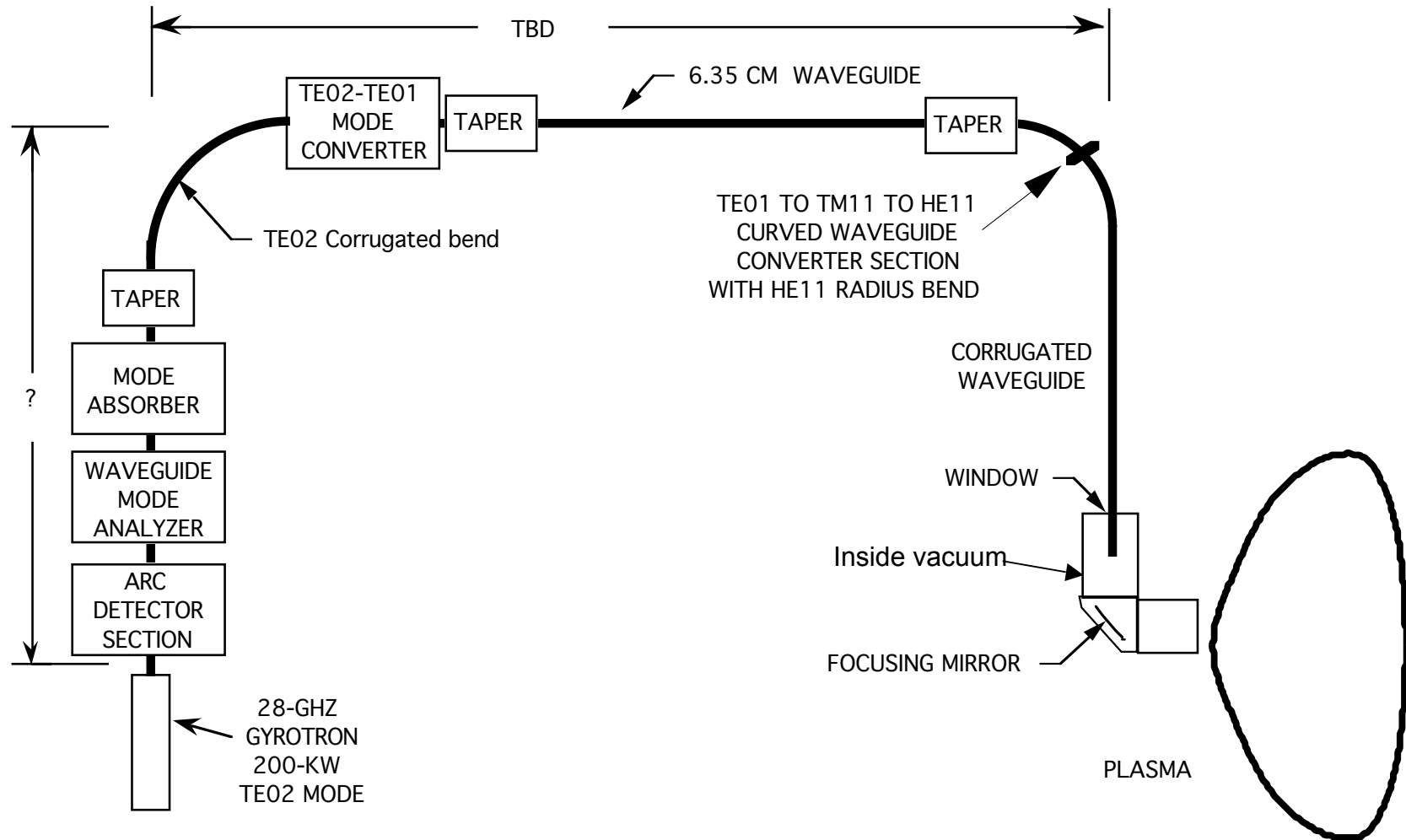
Testing of gyrotrons at 28 & 15.3 GHz

- ~ 40 kW capability at 28 GHz
- CW or pulse tubes
- Test stand should be online in 1 month
- (long delays getting equipment moved)
- Testing of gyrotron at 0.6 T in TE01 mode to generate 15.3 GHz
- EGUN modeling of beam transport at 15.3

Transmission lines & launchers

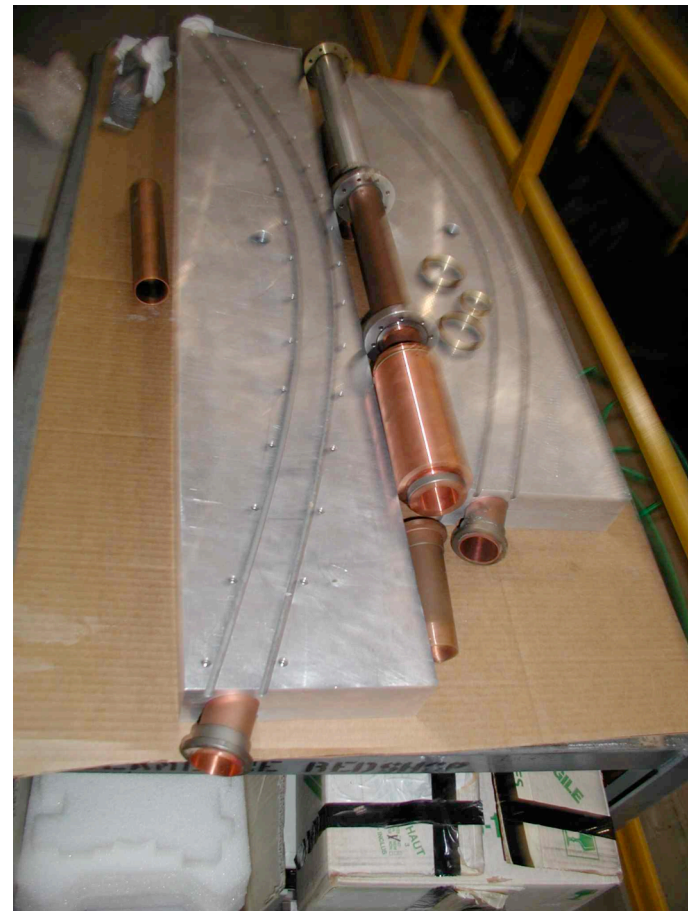
- Maximum experimental capability requires high mode purity
- Utilize TE₀₂, TE₀₁ and HE₁₁ (corrugated transmission)
- Utilize HE₁₁ gaussian-like launch into focusing mirror
- Use multiple gyrotron outside-mirror launcher configuration
 - Originally used on ATF
 - Can be mounted on modified NSTX midplane outside port
 - Can produce narrow focused beam with modest steering capability

28 or 15.3 GHz waveguide and launcher configuration

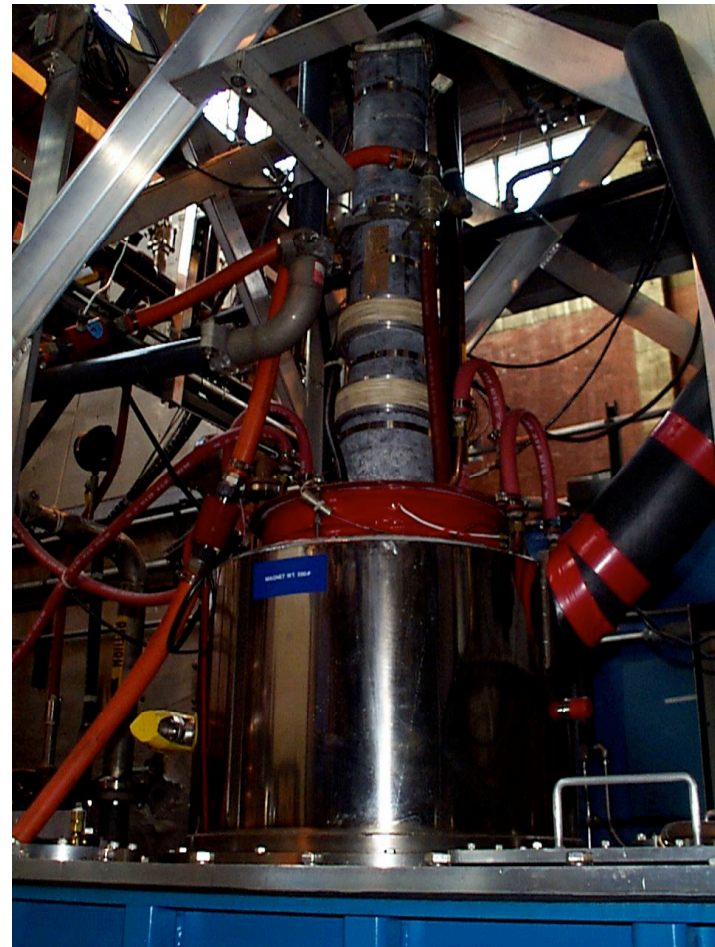
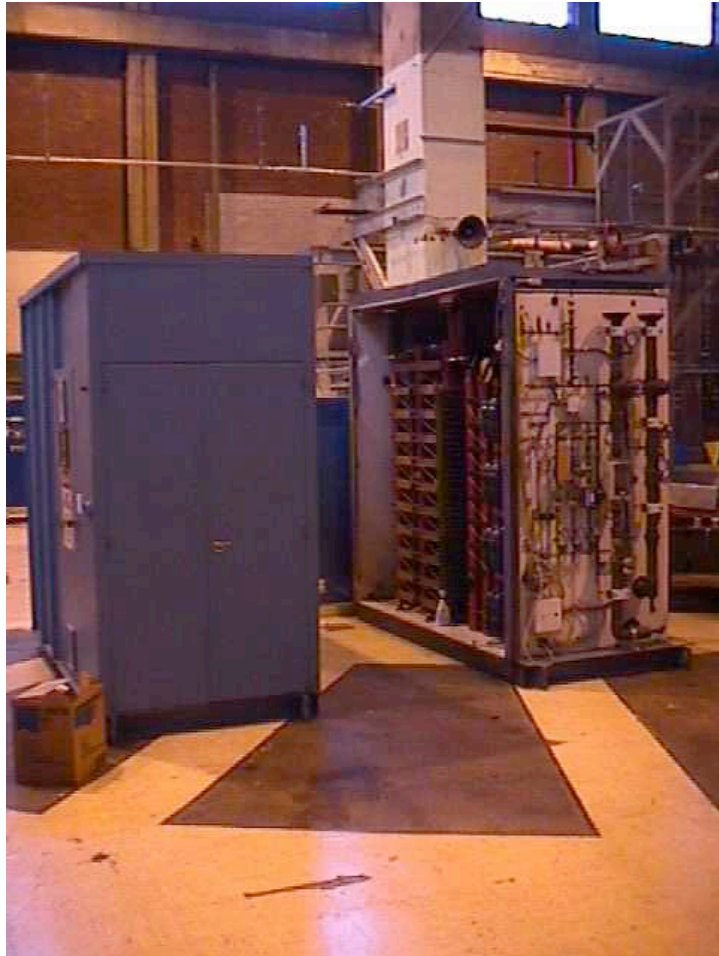


BLOCK DIAGRAM PROPOSED NSTX 28 GHZ ECH SYSTEM

Launcher & Waveguide hardware



Modulator / Regulator & Gyrotron Sockets



Proposed Tasks and Schedule

- Evaluate 28 GHz to 15.3 GHz efficiency at ORNL: Nov 06 - Feb 07
- Refurbish gyrotron sockets at ORNL Mar - Aug 07
- Refurbish Mod/Reg at ORNL Mar - Sept 07
- Move system to PPPL: Nov 07
- Design transmission & launching system: Jan-June 07
- PPPL reconfigure HVDC power supply:
- Install transmission line at PPPL: July - Oct 07
- Finish utility installation at PPPL: July - Nov 07
- Install launcher: November 07
- Commission system: Nov 07 - Feb 08

Summary

- ORNL & PPPL are collaborating on EBW/ECH in several areas involving moderate to high power microwave applications
 - ECH preionization for standard inductive discharges
 - VF only EC/EB heated electron startup at low density
 - Solenoid free EC heated electron startup with CHI
 - ECH/EBW/CHI transition to HHFW current ramp up
 - EBW profile H&CD test at high density/beta
- Hardware for 15.3 and 28 GHz power at >100 kW for ~0.5 seconds is being installed
 - Single or double gyrotron tubes for power up to ~200 kW at 15.3 GHz or 700 kW at 28 GHz
 - Needs only modest development and testing (e.g., 15.3 GHz operation, combining, launcher, etc.)
- Aggressive program can get hardware installed and commissioned in time for FY08 run campaign
- Hardware is upgradeable with higher power gyrotrons