EBW Relationship to IPPA Milestones

- Demonstrate feasibility of high efficiency EBW mode-conversion for heating and CD for IPPA 5 year milestone
- Demonstrate sustained EBW heating and CD at high power for IPPA 10 year milestone

2004-8 EBW Research Goals

Phase I:

- Install 1 MW, 28GHz (or 15.3GHz) ORNL tubes, earliest availability in late 2005
- Demonstrate on-axis EBW heating and plasma startup in 2006 with ~ 1 MW:
  - either 28 GHz O-X-B, $2f_{ce}$ heating
    or 15.3 GHz (X-B or O-X-B) f_{ce} heating
- Provide power supplies and cooling sufficient to support phase II

Phase II:

- Install ~ 5MW, 15GHz tubes in 2007 for EBW heating, sustained CD and NTM suppression in 2008-9

Near Term Objective: Supporting EBW Emission Experiments

- Obtain ≥ 80% X-B conversion with local limiter in early 2003

- Obtain ≥ 80% O-X-B conversion with local limiter in late 2003:
  - -Is this too late to provide input to antenna design for phase I?

Theory and Modeling Issues

- Modeling needs to include realistic antenna pattern and refraction at mode conversion layer (a la GLOSI)

- Need to define typical target equilibria, kinetic profiles and NSTX needs for heating, startup, sustained CD and NTM suppression

- Complete GENRAY/CQL3D scoping study to explore sensitivity of CD efficiency to RF launch parameters (eg. poloidal launch angle, $n_{//}$, frequency) by early 2003:
  - Parallelize GENRAY (late 2002)

- Model modification of CD efficiency by transport and bootstrap current

- Model edge parametric instabilities that may occur at high RF power

- Model non-thermal EBW emission

- Determine need to incorporate relativistic effects in propagation and damping of EBWs

Hardware Issues: RF Sources

- Fundamental EBW Heating/CD has better radial access than $2f_{ce}$, especially at high β

- Four existing 28 GHz ORNL tubes could generate 1.4 MW CW, mod-regs and sockets available (use PPPL NBI power supply)

- Use 28 GHz tubes as is for second harmonic EBW heating/CD at 0.5T

- Or could try to modify 28 GHz tubes to operate at 15.3 GHz (f_{ce} at 0.6T):
  - attempt this with one tube ASAP

- Start development program with Thales (or CPI) to modify 8 GHz, 1 MW tube for 15 GHz:
  - expensive, but needed for phase II

Hardware Issues: Antenna Design

- Antenna conceptual design not defined
- Should antenna be designed for both X-B (normal incidence) and O-X-B (oblique incidence launch)?
- If O-X-B only should it still incorporate a local limiter to widen transmission window?
- Should antenna be adjustable poloidally to vary $n_{//}$ and EBW damping location
- Should consider a compact, multi-element phased array instead of a steerable mirror?

Proposed EBW Research Plan 2003-8

2003:

Obtain ≥ 80% B-X & B-X-O emission on NSTX

Modify 28 GHz RF tube for 15.3 GHz operation

Issue RFQ for possible high power 15 GHz tube

Scoping study for NSTX heating/CD

Conceptual design for EBW antenna

[MAST to test O-X-B heating]

2004:

Complete design for Phase I (1 MW) system using ORNL 28 GHz (15.3 GHz) tubes

2005:

Complete construction phase I

2006:

Demonstrate on-axis EBW heating and plasma startup with 1 MW

2007/8:

Install phase II (~ 5MW, 15 GHz)

2008/9:

Sustained CD and NTM stabilization in 2008-9