U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

Ideas & Opportunity for Collaboration in ECH & EBW

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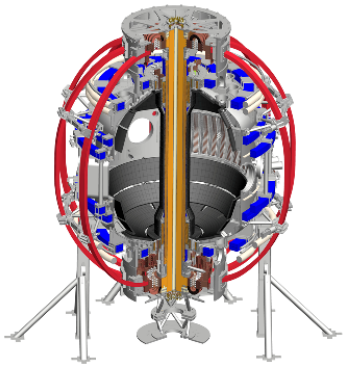
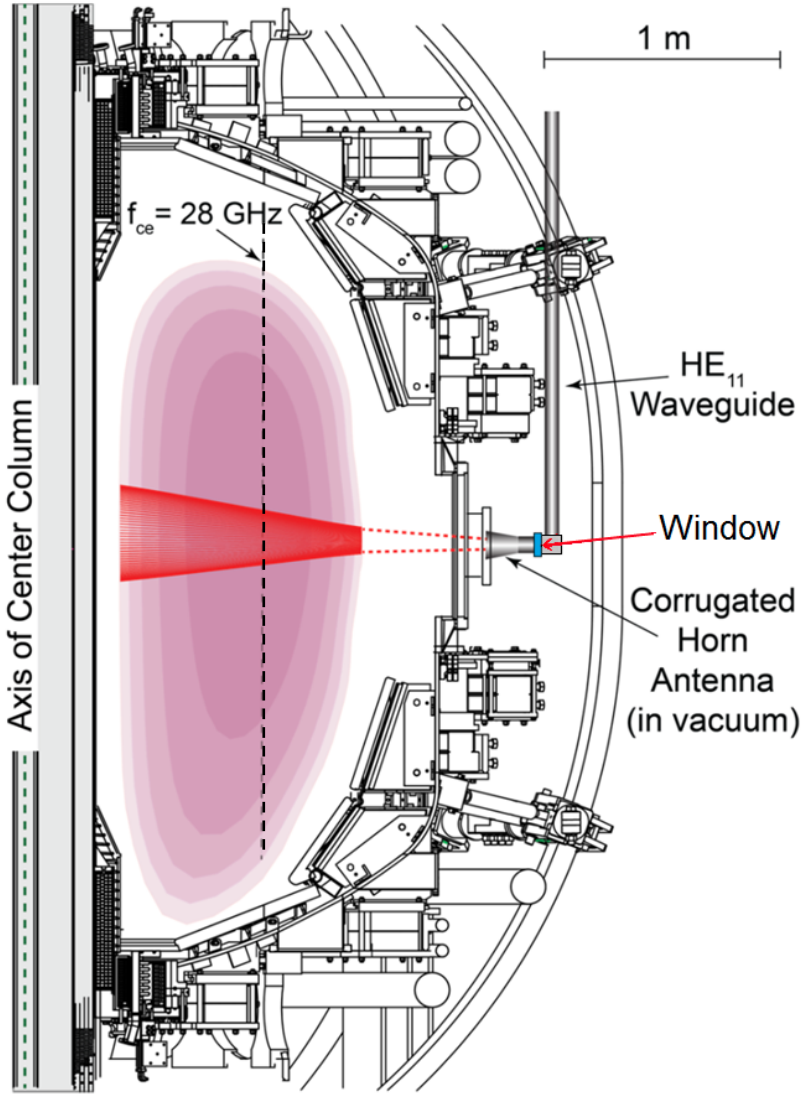
PPPL



ECH/EBW system is being designed to support start-up and ramp-up on NSTX-U



- Horn-type launcher is to be located at Bay E
- Gyrotron and power supplies to be located in the TFTR Test Cell basement
  - Long low loss waveguide run is planned from the source to the launcher
- Would like to collaborate with the QUEST project to gain experience with operations at 28 GHz
- Participation in current drive studies would be very valuable preparation for the NSTX-U applications

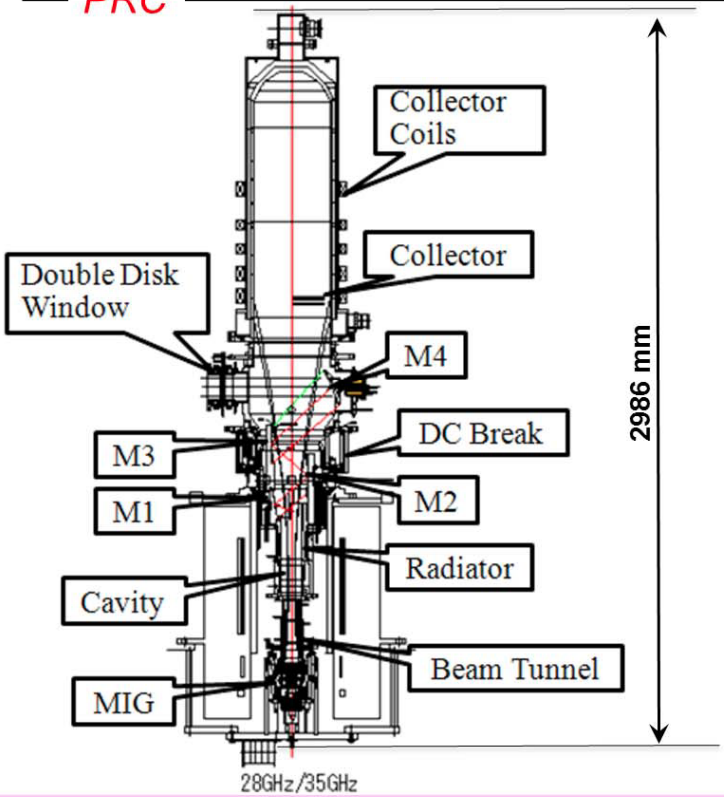
Horn launcher to be located at Bay E

Plasma Research Center (PRC) at the University of Tsukuba gyrotron will be used for the NSTX-U ECH/EBW system

28 GHz 1.5 - 2 MW Prototype Gyrotron for NSTX-U and G-10/PDX

PRC

NSTX-U



● Design Parameters of New Tube

28 GHz 2 MW Dual-frequency Gyrotron for GAMMA 10/PDX, QUEST, NSTX-U			
Frequency	28 GHz		34.77 GHz
Output Power	2 MW	0.4 MW	1 MW
Pulse Width	3 s	CW	3 s
Output Efficiency	50% (with CPD)		
Beam Voltage	80 kV	70 kV	80 kV
Beam Current	70 A	20 A	40 A
MIG		triode	
Cavity mode	$TE_{8,5}$		$TE_{10,6}$
Output mode	Gaussian like		
Output Window	Sapphire Double Disk		
Collector	Depressed Collector Sweeping coils		

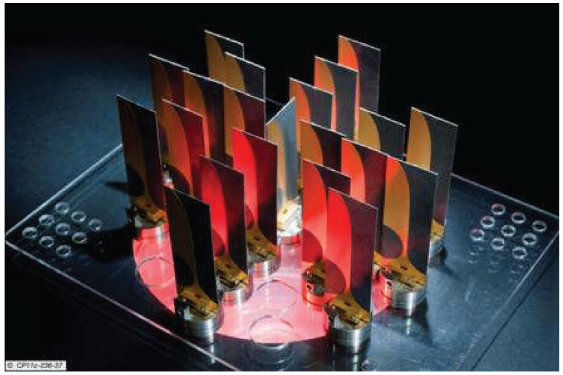
→ New design of cathode, cavity and mode converter for 1.5 – 2 MW output.

Slide courtesy: Imai

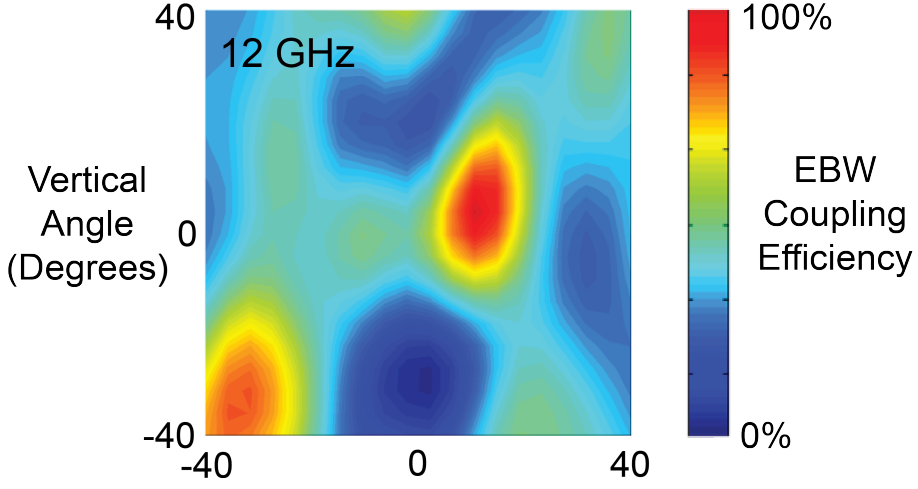
NSTX-U Research: Synthetic aperture microwave imaging (SAMI) diagnostic to image EBW emission

- Assess O-X-B coupling efficiency versus poloidal and toroidal angle
  - Important for EBW heating design (mirror aiming)
- Image Doppler reflectometry to measure edge plasma flows
- Can observe density fluctuation on millisecond timescale
- Will measure magnetic pitch near edge region

[Collaboration with University of York and CCFE]



SAMI Antenna Array

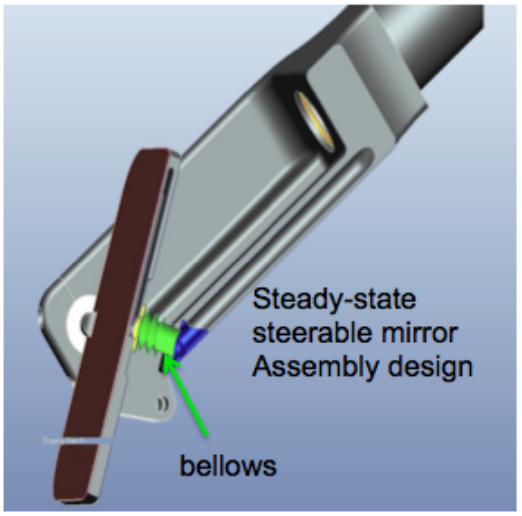


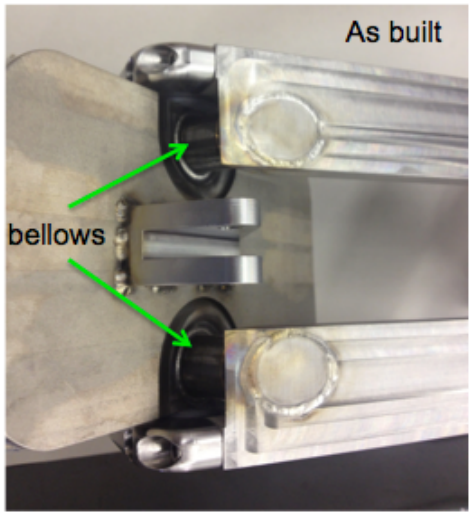
MAST SAMI EBW Emission Data

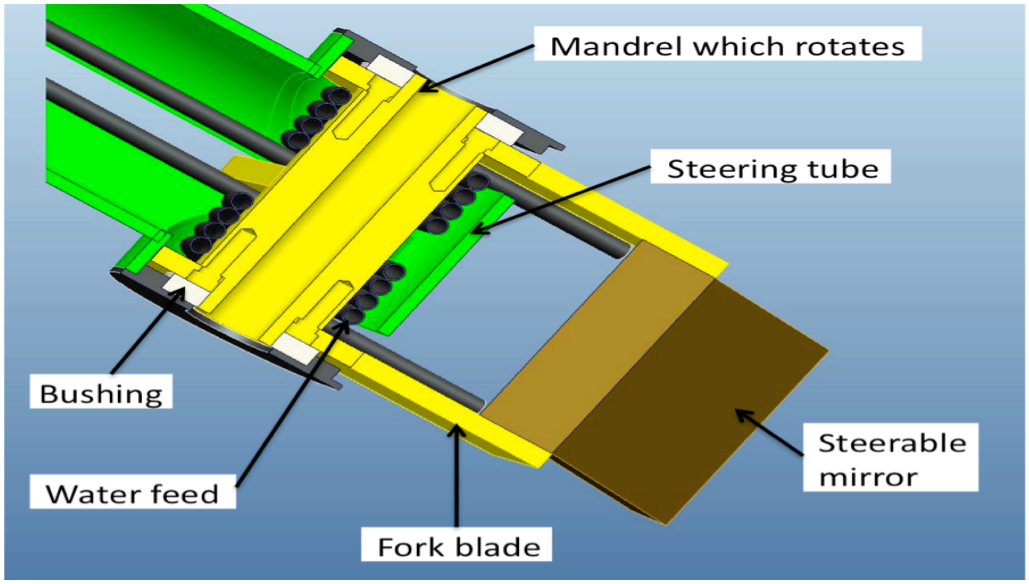
PPPL Engineering: Enabling ECH on KSTAR; would like to continue technology development

- Designed and fabricated a fixed water-cooled steady-state mirror for the existing ECH launcher.
  - Fabricated with additive manufacturing (3D printing)
  - 1 MW steady-state power handling
- Designed and fabricated steady-state steerable mirror and steering assembly
  - Steering range and speed maintained with bellows in the water feeds for rapid NTM tracking
- Started conceptual design of an advanced steady-state water-cooled two-channel 2 MW ECH launcher
  - Supports increased ECH power for NTM modes stabilization.

R. Ellis and J. Hosea, *Additive Manufacturing Techniques for ECH Launcher Components*, KSTAR Conference 2015







Want to collaborate with technology and experiments; gain experience for future ECH/EBW system on NSTX-U

Technology

- Gyrotron operation
  - Univ. Tsukuba
- Low-loss transmission line
- Polarizers: design for maximum flexibility
  - LATE
- Launchers & mirrors
  - QUEST, LATE

Experimental Physics

- ECH in start-up plasma & current ramp
  - QUEST
- Optimize EBW heating through polarization & launch angle
  - LATE
- Synergies between EC/EBW and parallel electron heating (e.g. LH or HHFW)