The Construction and Commissioning of the Electron Bernstein Wave Heating and Current Drive System for MAST-U

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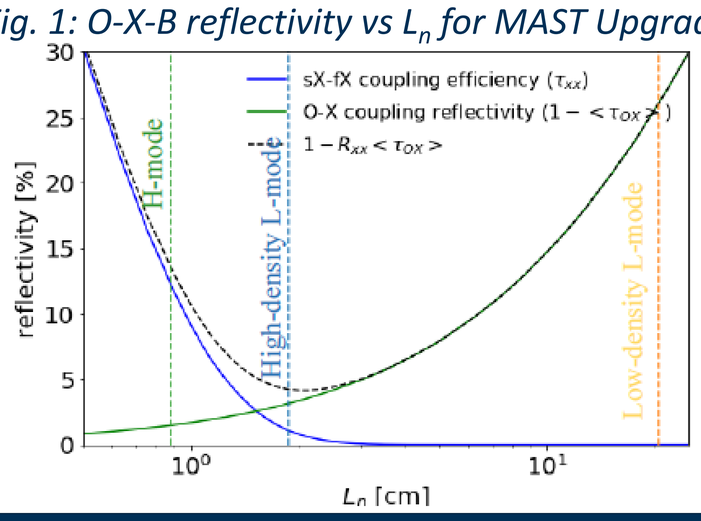
MAST-U EBW Physics Case

- 1.8 MW Electron Bernstein Wave (EBW) system for MAST-Upgrade; 1.5-1.6 MW injected in plasma [1]
- To validate predictions of current drive capabilities, in support of UK's Spherical Tokamak for Energy Production (STEP) programme [2]
- Verify CD predictions in a ST tokamak
- n_e perturbations and non-linear effects degrades O-X-B coupling?
- Study EBW non-inductive start-up [3]

Fig. 1: O-X-B reflectivity vs L_n for MAST Upgrade parameters



Launchers

- Upper/ off axis (34.8GHz, co-plasma current direction only)
- Mid-plane:
  - 28GHz or 34.8GHz HCD
  - Co or counter plasma current direction
  - 28GHz start-up (High Field Side)

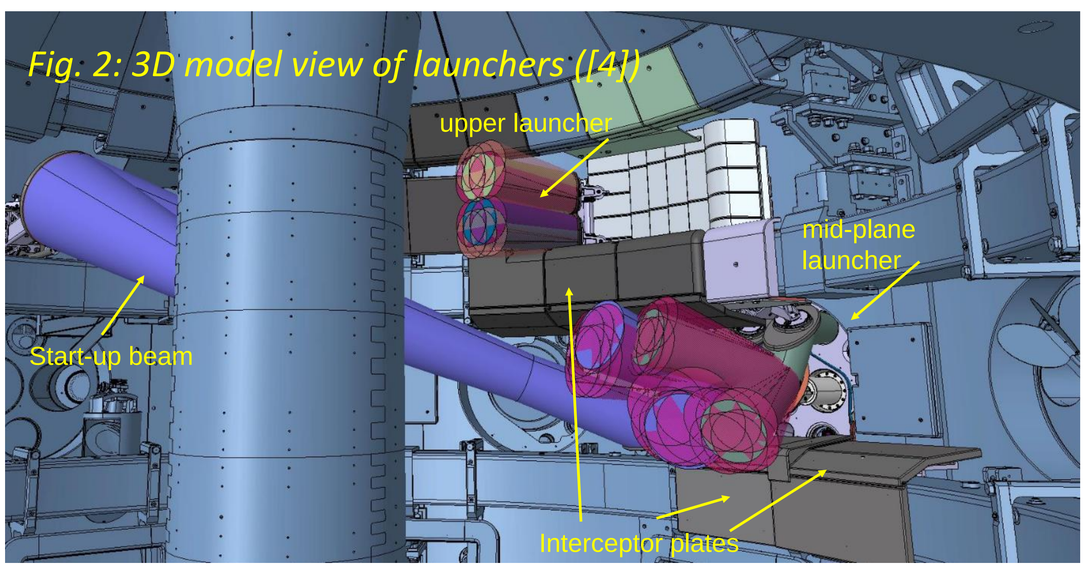


Fig. 2: 3D model view of launchers ([4])

Transmission Lines

- Cylindrical, corrugated HE_{11} waveguide, 88.9mm diameter; layout in Fig. 3
- Transmission efficiency (including launcher) ~85%

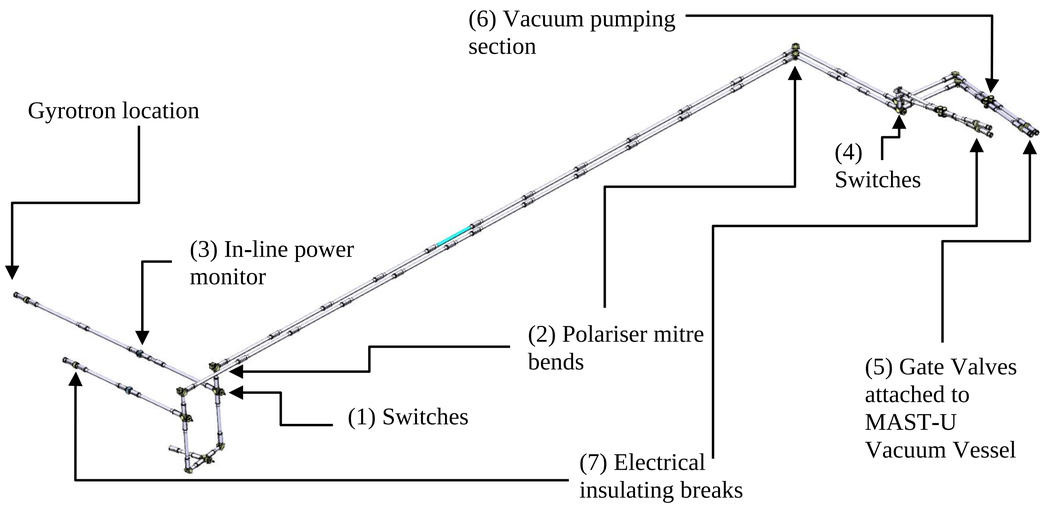


Fig. 3: Transmission Lines Configuration

Gyrotron System Overview

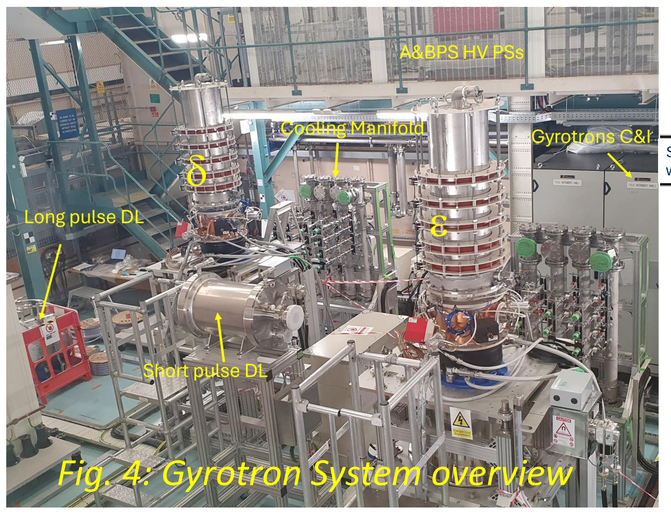


Fig. 4: Gyrotron System overview

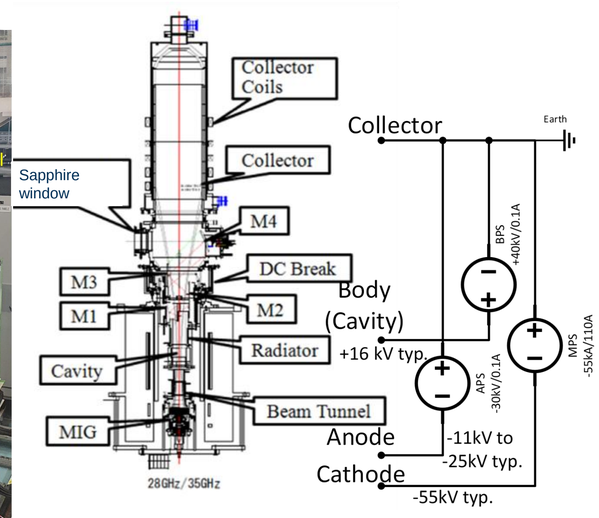


Fig. 5: Gyrotron block diagram [5]

System Status

	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26	Mar-26
LV Installation				(cooling)							
Cooling System Installation											
Cooling System Commisioning											
HV System Installation											
JEMA HV System Commissioning (MPS/BPS)											
KF HV System Commissiong (APS)											
Getting Ready for SCM tests											
SCM Tests											
C&I Installation											
Gyrotrons System Installation											
Short Pulse Tests											
Getting ready for Long Pulse Tests											
Long Pulse tests											SAT

- Launcher System design complete
- Prototypes for critical components produced, under test
- 70% of launcher parts manufactured
- All transmission line components delivered to site

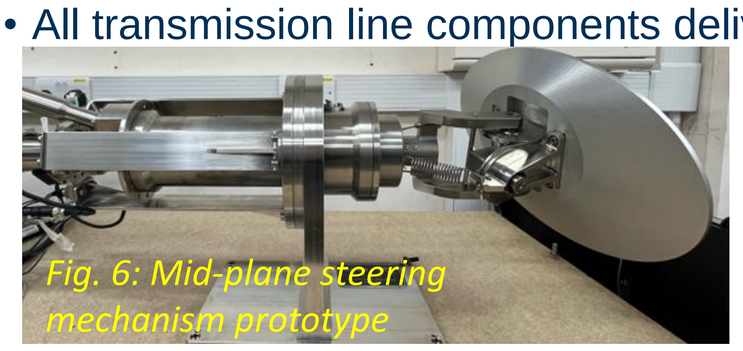


Fig. 6: Mid-plane steering mechanism prototype

Fig. 7: Coated mirror

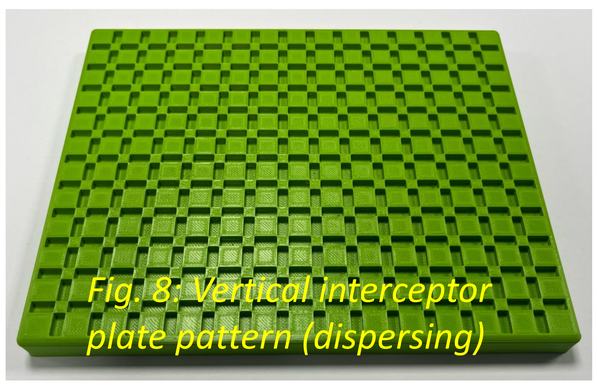


Fig. 8: Vertical interceptor plate pattern (dispersing)

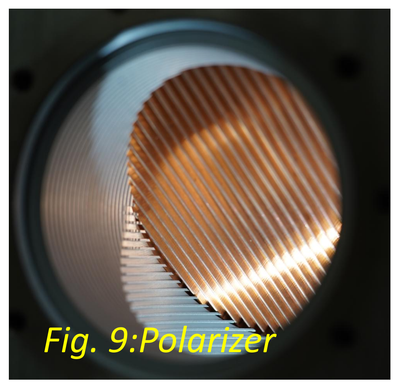


Fig. 9:Polarizer

Conclusions and Future Plans

- EBW-CD can greatly reduce the parasitic load for STEP, improving net electricity generated → tested on MAST-U in 2027
- Gyrotrons being installed and commissioned in Q4 2025
- Option to double MAST-U EBW power in 2029

	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027
Gyrotron System Instal. and Commissioning												
Launcher Design and mfg												
Launcher Installation												
TL supports / Blockhouse components design and mfg												
Blockhouse C&I design and procurement												
TL supports / Blockhouse components Installation												
EBW/MAST-U commissioning												
EBW/MAST-U Physics exploitation												

MAST-U Engineering Break

REFERENCES

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[2] S. Freethy et al., EPJ Web of Conferences 277, 04001 (2023)
[3] V.F. Shevchenko et al 2015 EPJ Web of Conferences 87 02007
[4] J. Allen et al., 2024 IEEE Trans. Plasma Sci. 52 3797–801
[5] T. Kariya et al., Nucl. Fusion 59 (2019) 066009 (10pp)