

# Experiments and Modelling towards Long Pulse High Confinement Operation with RF Heating and Current Drive in EAST

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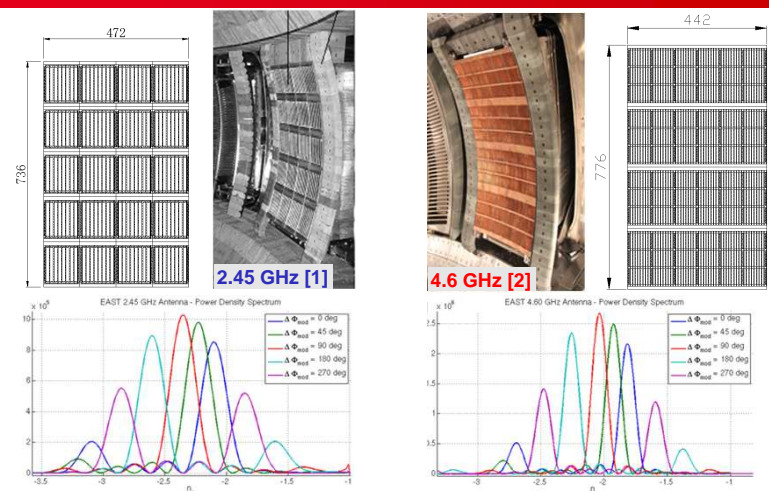
## Introduction

Associated Laboratory CEA/IRFM – ASIPP created in 2013; three main collaboration subjects:

- Long pulse H-mode operation with radiofrequency (RF) systems in EAST and WEST.
- Fabrication of three ICRH antennas for WEST.
- Articulated inspection arm for EAST and WEST.

This work deals with Lower Hybrid Current Drive (LHCD) experiments and modelling, in view of long pulse operation in EAST, and in view of preparing WEST operation.

## LHCD antennas in EAST and antenna modelling



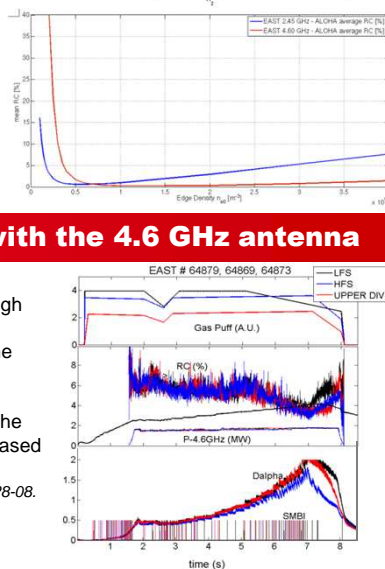
ALOHA-code [3] extensively used for computations of  $n_{rf}$ -spectra and LH wave coupling in EAST, e.g. [2,4,5].

- [1] E.H. Kong et al., *PPCF* **56** (2014).
- [2] F.K. Liu, et al., *Nucl. Fusion* **55** (2015).
- [3] J. Hillairet et al., *Nucl. Fusion* **50** (2010).
- [4] B.J. Ding et al., *Nucl. Fusion*, accepted.
- [5] M.H. Li et al., *Phys. Plasmas*, submitted.

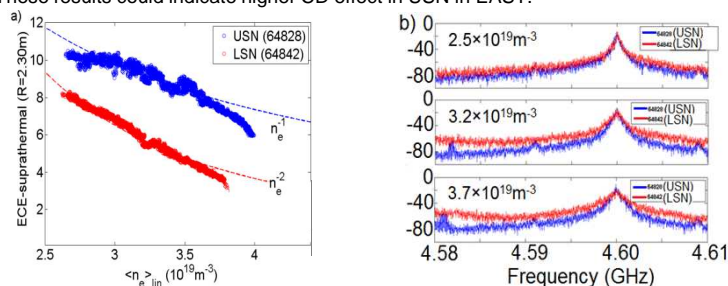
## Coupling and CD effect with the 4.6 GHz antenna

- Different gas feeding locations tested (high field side, low field side, upper divertor).
- No difference in LH coupling found for the different gas feed locations.
- SMBI has a favourable effect on the LH coupling, due the increase of density in the scrape-off layer, probably linked to increased radial transport during SMBI [5].

[6] X.L. Zou et al., 24<sup>th</sup> IAEA FEC (2012), paper PD/P8-08.



- Two plasma configurations tested: upper single null (USN) & lower single null (LSN).
- Higher supra-thermal EC emission and higher hard X-ray emission in USN.
- Lower spectral broadening in USN.
- ➔ These results could indicate higher CD effect in USN in EAST.

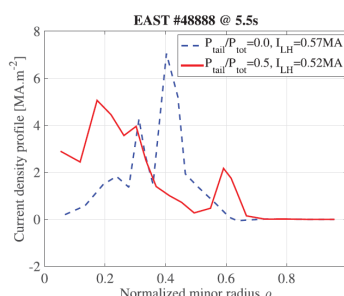


## Acknowledgements

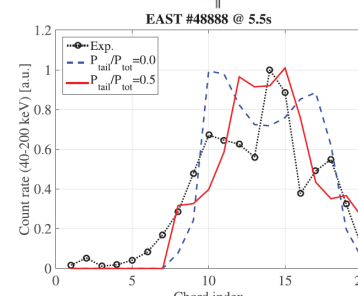
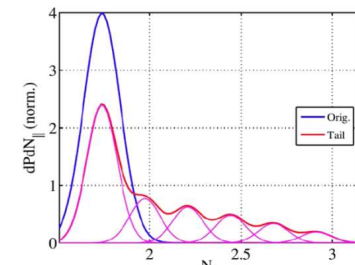
The CEA/IRFM members warmly acknowledge the hospitality of the ASIPP team. This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

## LH current profile modelling

- LHCD experiments are accompanied by modelling using the RT/FP-codes C3PO/LUKE [7].
- Extended studies of zero loop voltage discharges confirm the importance of a tail in the initial LH power spectrum.
- Using the "tail LH model", consistent results are obtained with measured line-integrated hard X-ray profiles (20 - 200 keV), plasma current and internal inductance [8, 9].



[7] Y. Peysson and J. Decker, *Fusion Sci. Technol.* **65** (2014).



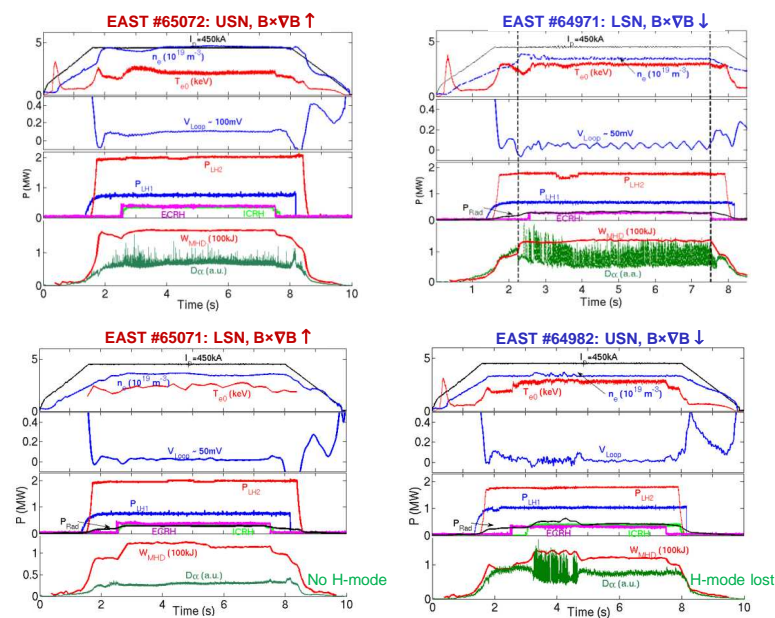
[8] Y. Peysson et al., *PPCF* **58** (2016).

[9] B.J. Ding et al., this conference, paper EX/P7-5.

## Preparation of long pulse H-mode experiments

H-mode experiments with pure RF heating & CD carried out in April 2016.

Four configurations: **USN and LSN with BxVB ↑** **LSN and USN with BxVB ↓**



- Easier H-mode access when BxVB towards the target, as expected [10].
- Highest stored energy in USN configuration, BxVB ↑.

[10] G.R. McKee et al., *Nucl. Fusion* **49** (2009).

**A 60s long H-mode discharge, in USN (W-divertor) configuration, using RF systems (LHCD, ICRH, ECRH), has now been obtained [11].**

[11] B.N. Wan et al., this conference, paper OV/2-2.

## Summary and outlook

LH coupling and CD studies in EAST indicate no effect on LH coupling with main gas feed location, but improved coupling with SMBI; Higher CD effect in USN than in LSN. C3PO/LUKE modelling taking into account a tail the initial  $n_{rf}$ -spectrum can reproduce experimental trends (integrated hard X-ray signals, internal inductance, plasma current). H-mode experiments with RF heating & CD systems indicated best performance with USN and BxVB ↑.

Experiments carried out in EAST will help prepare WEST-operation.