ID: EX/P2-34

CURRENT DRIVE EXPERIMENTS IN SST1 TOKAMAK WITH LOWER HYBRID WAVES.

[1,2]P. K. SHARMA, [1,2]D. RAJU, [1,2]S. K. PATHAK, [1,2]R. SRINIVASAN, [1]K. K. AMBULKAR, [1]P. R. PARMAR, [1]C. G. VIRANI, [1]J. KUMAR, [1]S. SHARMA, [1]C. SINGH, [1]A. L. THAKUR, [1,2]V. L. TANNA, [1]U. PRASAD, [1,2]Z. KHAN, [1]D. C. RAVAL, [1]C. N. GUPTA, [1]B. KRISHNAN, [1]S. NAIR, [1]D. K. SHARMA, [1]B. DOSHI, [1]M. VASANI, [1]K. MAHAJAN, [1]R. RAJPAL, [1]R. MANCHANDA, [1]K. ASUDANI, [1]M. K. GUPTA, [1]M. B. CHOWDHURI, [1,3]R. L. TANNA, SST-1 AND DIAGNOSTIC TEAMS

[1]Institute for Plasma Research, Bhat Gandhinagar – 382428, Gujarat, INDIA
[2]HBNI, Training School Complex, Anushakti Nagar, Mumbai – 400085, Maharashtra, INDIA
[3]Institute of Science, Nirma University, Ahmedabad 382 481, Gujarat, INDIA
pramod@ipr.res.in

ABSTRACT

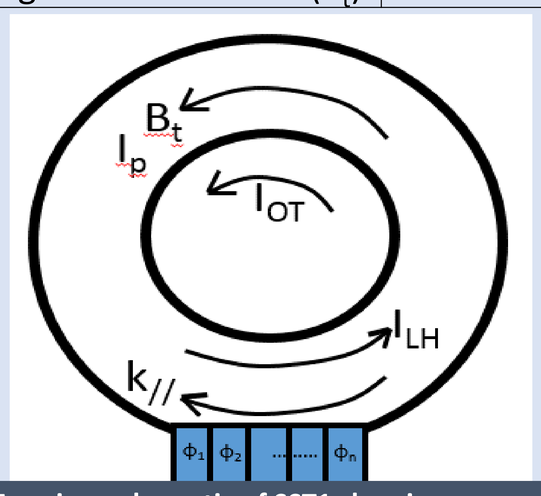
•Fully/partially non-inductive plasma current driven in SST1 tokamak with LHCD. Discharges with zero loop voltages were obtained. The longest discharge of ~650ms could be obtained in SST1 with the help of LHW's.

•Interaction of LHWs with plasma and generation of suprathermal electrons could be established using energy spectra measured by CdTe detectors, drop in loop voltages, negative loop voltages, spikes in hard x-rays and increase in 2nd harmonic ECE signal

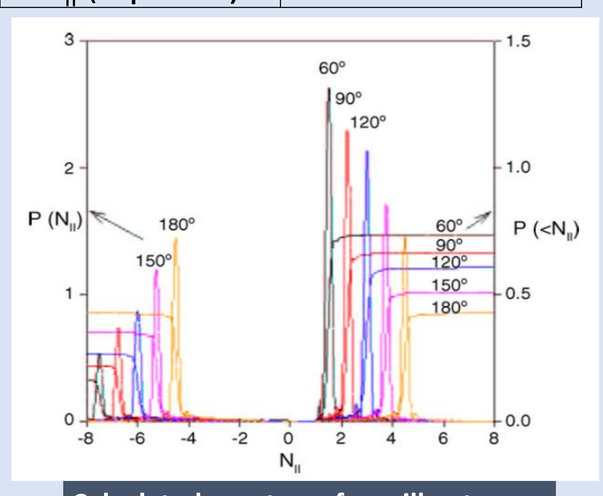
• Beneficial effect of LHW's in suppressing hard x-rays was also demonstrated in these experiments.

EXPERIMENTAL SETUP

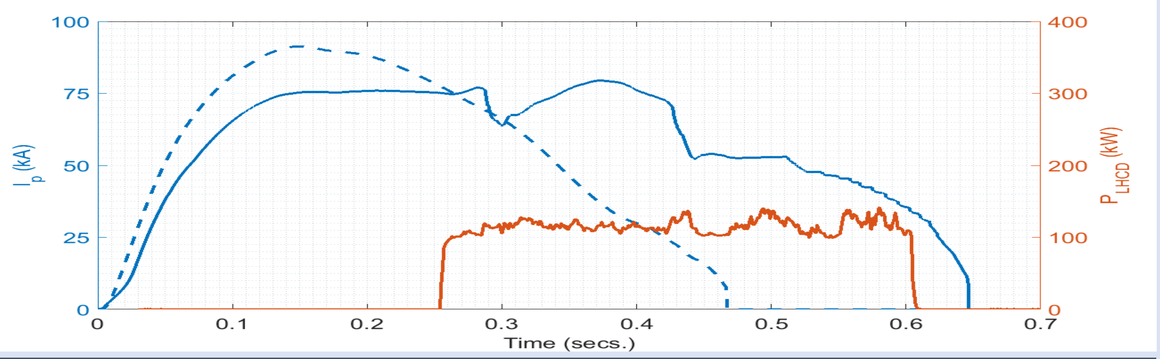
SST1 Parameter		LHCD parameter	
Major radius (R_o)	1.1 m	Frequency (f_o)	3.7 GHz
Minor radius (a_o)	0.2 m	Antenna type	Grill
Magnetic field at axis (B_t)	1.5 T	$N_{||}$ ($\Delta\phi$=90°)	2.25



Top view schematic of SST1 showing direction of various parameter and grill

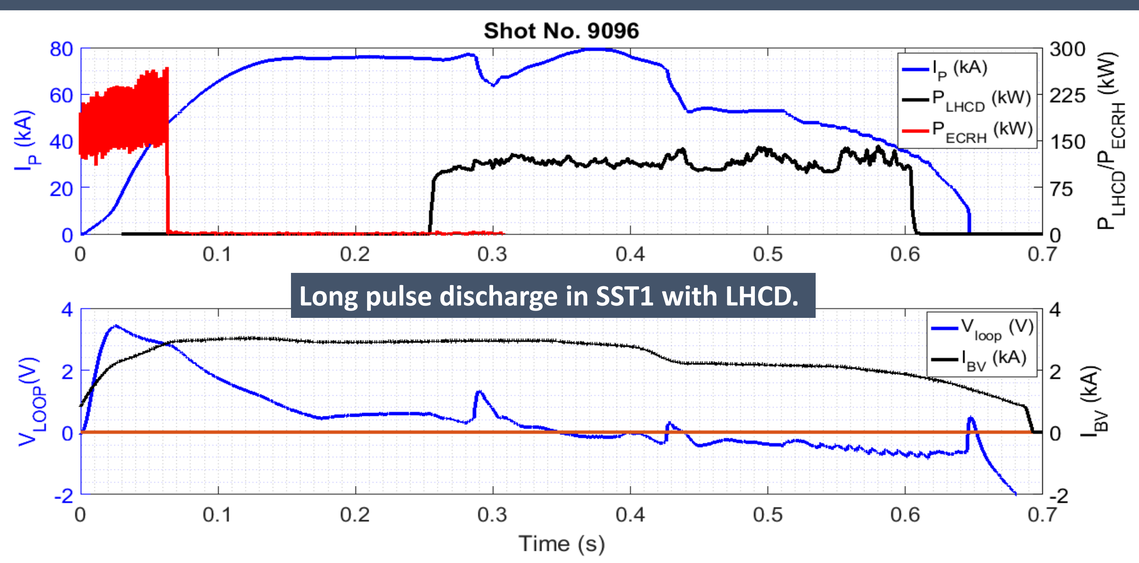


Calculated spectrum for grill antenna with different phasing.



Plasma current with & without LHCD showing its effect both in increasing magnitude and time

RESULTS AND DISCUSSIONS



* In SST1 [1], ECR assisted plasma breakdown and current startup at low loop voltages (~4V) is achieved to overcome issues of continuous cryostat/vacuum vessel like in other superconducting machines [2-3].

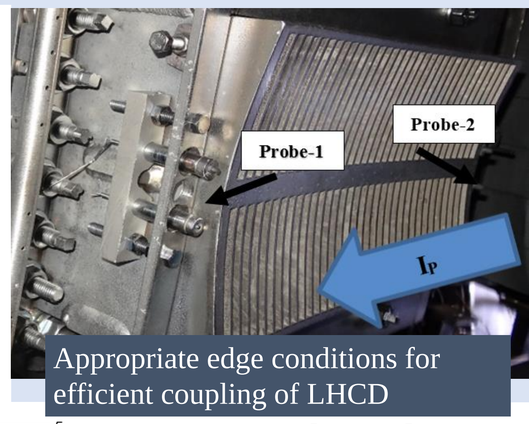
* Once an Ohmic target plasma is formed, LHCD [4] power is injected in to the plasma to drive plasma current non-inductively.

* Initially ECR assisted Ohmic discharge is formed and once a stable target plasma at ~75kA is achieved, ~125kW of LH power is injected at ~250 ms. Thereafter, the plasma is maintained with LHW's up to ~650ms.

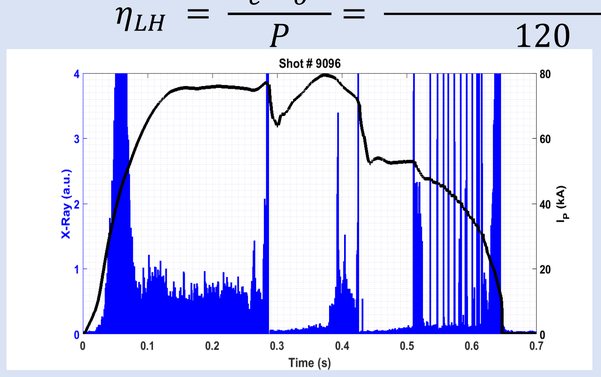
* The temporal evolution of loop voltage and vertical magnetic field provides equilibrium to the plasma.

* Assuming typical density scale-length (L_n) ~5mm between limiter and grill launcher, the density near grill mouth is about two times (~$e^{x/Ln}$) the density measured by the probes.

* The edge density varies up to ~[5-6] x 10^{17} m^{-3} which provides an estimate edge density near the launcher to be around 10^{18} m^{-3}.



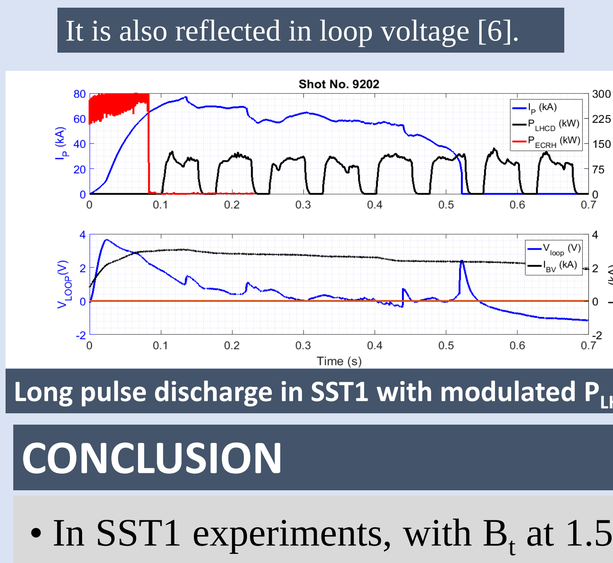
Appropriate edge conditions for efficient coupling of LHCD



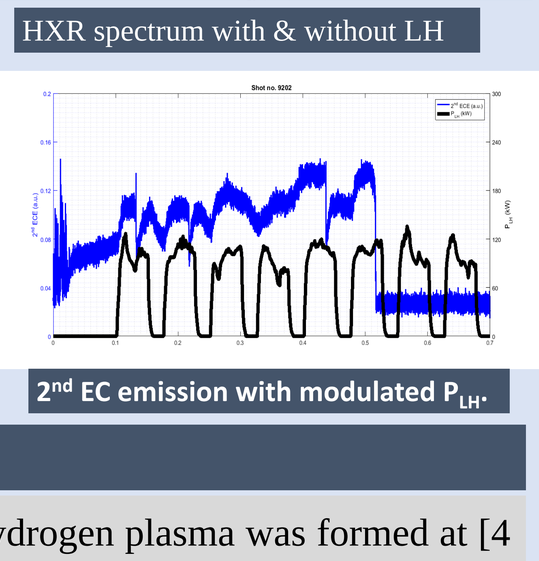
* For good coupling the density near the launcher mouth should be ~$n_c N_{//}^2$ ~ 1.8 x 10^{17} x $(2.25)^2$ ~ 10^{18} m^{-3}.

* The line averaged density of similar shots is estimated to be ~[6-8]x10^{18} m^{-3} and yields figure of merit for LH current drive as,

$$\eta_{LH} = \frac{n_e R_o I}{P} = \frac{0.7 \times 10^{19} \times 1.1 \times 80}{120} \sim 0.05 \times 10^{20}\ A/W/m^2$$

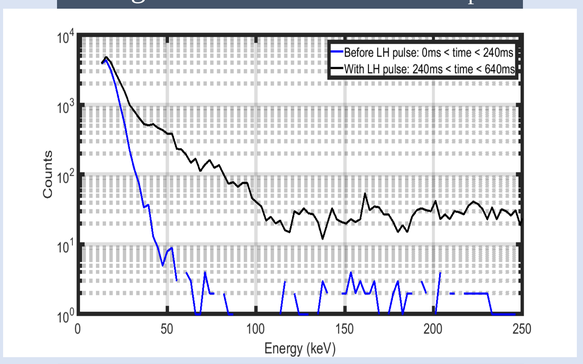


The hard x-ray emission drastically reduces [5]



Strong correlation of HXR with I_P.

It is also reflected in loop voltage [6].



HXR spectrum with & without LH

Long pulse discharge in SST1 with modulated P_{LH}.

2nd EC emission with modulated P_{LH}.

CONCLUSION

• In SST1 experiments, with B_t at 1.5T, hydrogen plasma was formed at [4 – 6] x 10^{-5} mbar pressure, having typical line averaged densities ~ [6-8] x 10^{18} m^{-3} and plasma current ~75kA.

• In these experiments, plasma current could be driven non-inductively with LH up to ~650msec.

• The plasma current could be fully driven with LH power both by injecting continuous or modulated LH power.

• The beneficial effect of LHW's suppressing the HXR is demonstrated in SST1. The increase in population of suprathermal electrons with LH power is established by PHA of CdTe signal & 2nd harmonic ECE signal.

REFERENCES

[1] Saxena, Y. C., SST1 Team, Nucl. Fusion, 40 (6), 1069, 2000.
[2] Wan Yuanxi, et al.and EAST team, Plasma Sci. Technol. 8 (2006) 253.
[3] Y.S. Bae, et al., and the KSTAR team, Nucl. Fusion 49 (2009) 022001
[4] Sharma, P. K., Fusion Science and Technology, 65, 103, 2014.
[5] Nakamura, M., Cho, T., Kubo, S., Shimozuma, T., et. al., Phys. Rev. Lett., Vol-47(26), 1981, pg-1902.
[6] Luckhardt, S. C., Porkolab, M., Knowlton, S. F., Chen, K. I., et. al., Phy., Rev. Lett., 48(3), 152, 1982.