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First demonstration of full ELM suppression in low input torque plasmas for ITER using *n*=4 RMP in EAST

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ABSTRACT

- Full suppression of ELMs in low torque plasmas by *n*=4 RMP has been demonstrated for ITER for the first time in EAST.
  - low torque (T_{NBI} ~0.44Nm < 0.9Nm ITER equivalent) , β_N ~ 1.5-2 with W divertor
- Energy confinement does not obviously drop (<10%), while core tungsten concentration is clearly reduced during ELM suppression is achieved.
- Suppression windows in both q_{95} and plasma density are observed.
  - q_{95} ~3.6-3.75, n_e ~40-60% n_{GW}
- Lower plasma rotation favours for access to ELM suppression.
- ELM suppression window is consistent with the MARS-F modeling

BACKGROUND

- The transient heat loads induced by type-I Edge Localized Modes (ELMs) in ITER have to be reduced significantly to ensure sufficient life time for the tungsten divertor target.
- Appling Resonant magnetic perturbations (RMPs) by dedicated in-vessel coil systems has been demonstrated as one of the most effective tools for ELM control in many tokamaks.
- Previously ELM suppression was mainly carried out in high Neutral Beam Injection (NBI) input torque plasmas.
- There has also not yet been any demonstration of ELM suppression with *n*=4 RMP (ITER planned) until present.
- EAST equip with *n*=4 RMPs and operates with low input torque.

Observations of full ELM suppression by *n*=4 RMPs

- The normalized parameters of the target plasma for these experiments in EAST are specifically chosen to be relevant to the ITER type-I ELMy H-mode (Q =10) scenario.
  - T_{NBI} ~ 0.44Nm (Lower than ITER equivalent torque 0.9Nm)
- Good confinement is maintained and it is compatible with W divertor

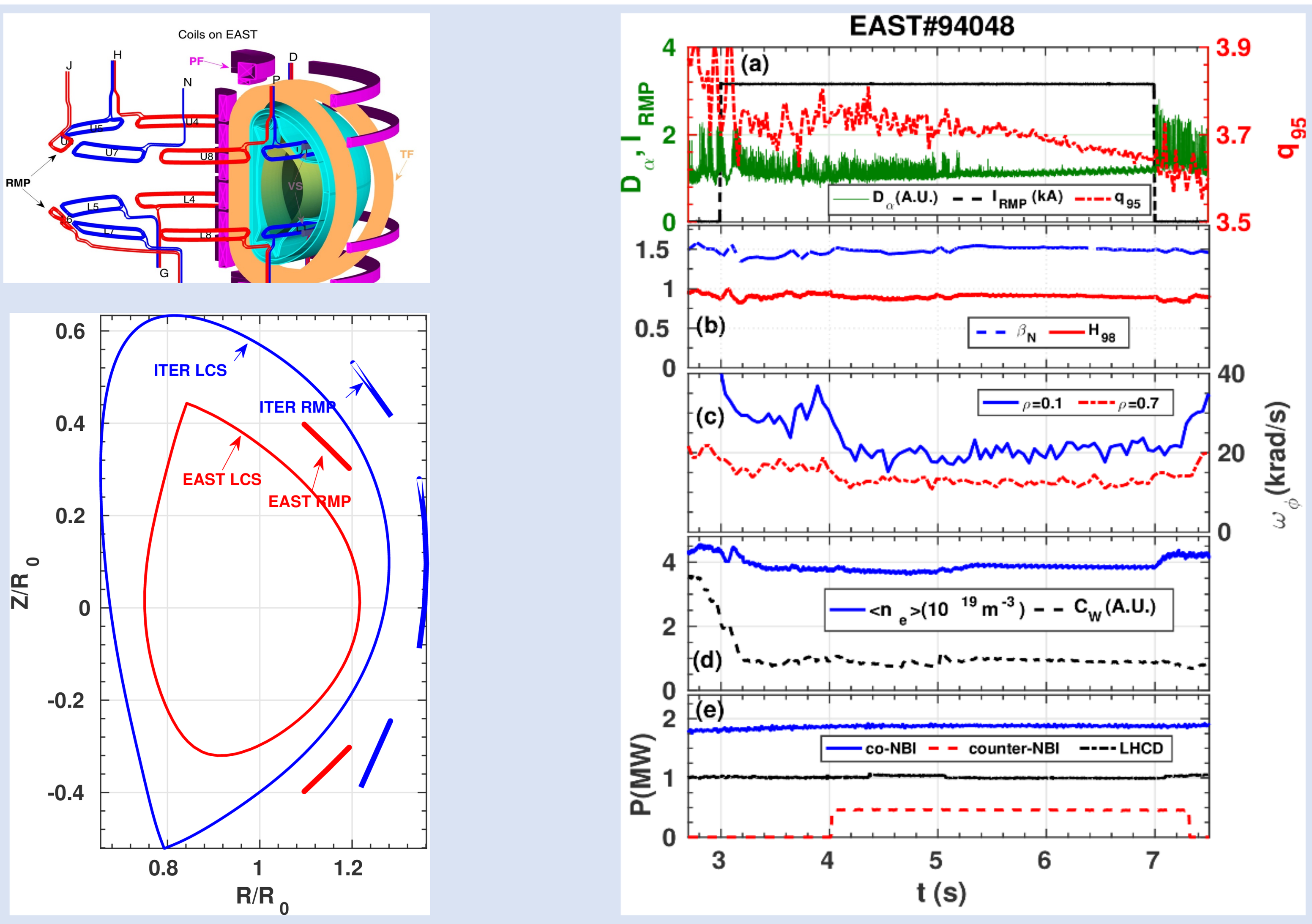

FIG 1 Full ELM suppression by *n*=4 RMPs in EAST

CONCLUSION

- Full suppression of type-I ELMs using *n*=4 RMPs has been demonstrated for the first time, and it is achieved in EAST plasmas with ITER relevant type-I ELMy H-mode operational scenario, thus also addressing significant scenario integration issues for ITER.
- These results expand the physical understanding of ELM suppression and demonstrate the effectiveness of *n*=4 RMPs for reliably control ELMs in future ITER high Q plasma scenarios with minimum detrimental effects on plasma confinement.

ELM suppression window

- Lower plasma rotation favours for access to ELM suppression in EAST.
- ELM suppression has been achieved by *n*=4 odd RMP coil configuration but not the even one
- Suppression windows in both q_{95} and plasma density are observed.
  - q_{95} ~3.6-3.75, n_e ~40-60% n_{GW}

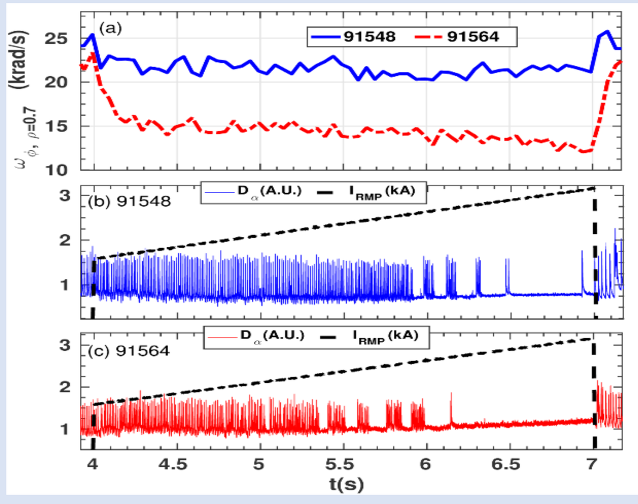

FIG 2 Lower torque is even better

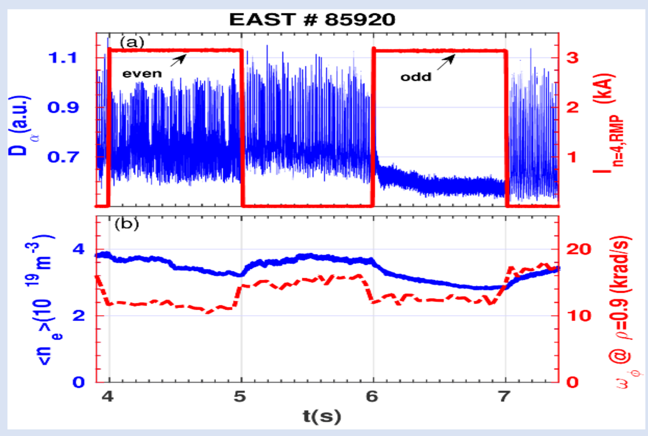

FIG 3 odd *n*=4 RMP is better

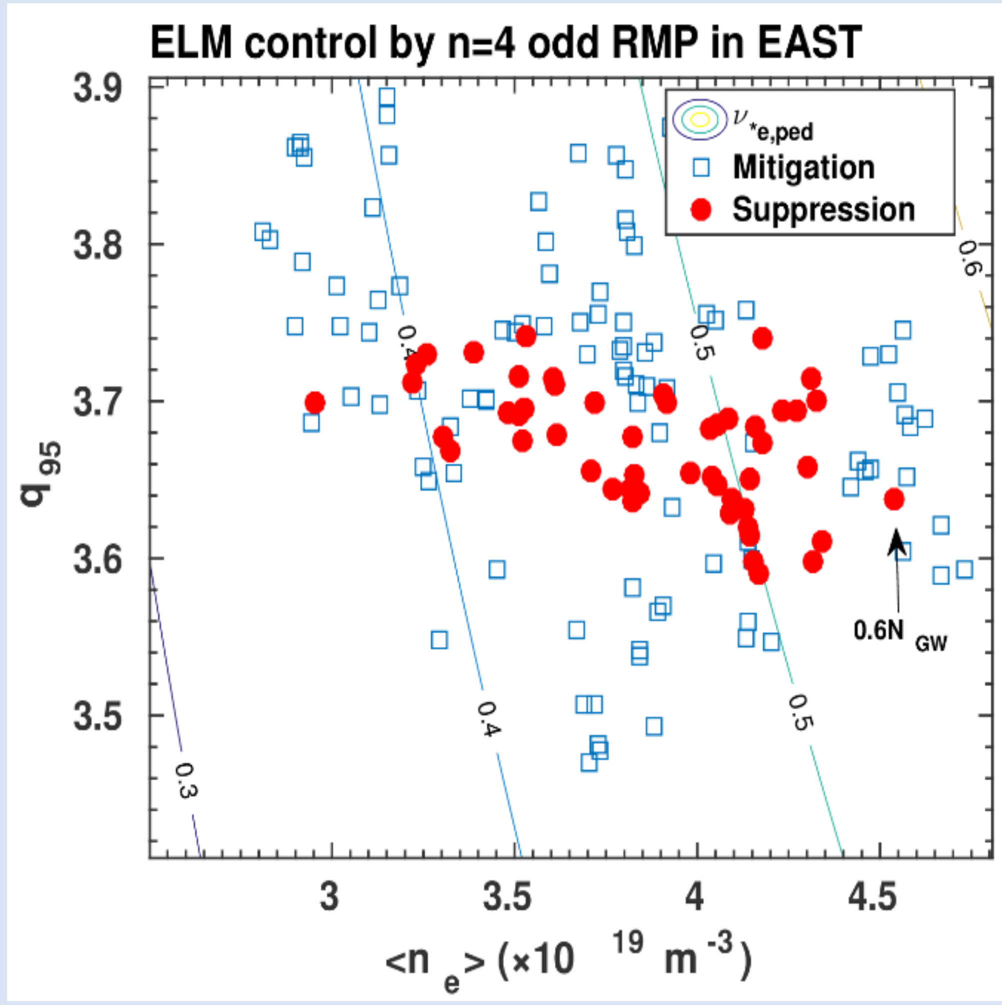

FIG 4 Suppression window

Understanding ELM suppression by *n*=4 RMPs

- Odd *n*=4 coil configuration provides stronger edge resonant magnetic field with plasma response.
- The observed ELM suppression window is consistent with the peak in the modelled edge resonant field strength using the MARS-F code.
- The modelling results also predict more possible windows for ELM suppression at lower q_{95} close to 3, nearer the q_{95} value for the ITER high-Q baseline scenario.
- Plasma responses in the two discharges with different torque input are very similar, while the NTV torque densities are quite different, which might influence the non-linear plasma response.

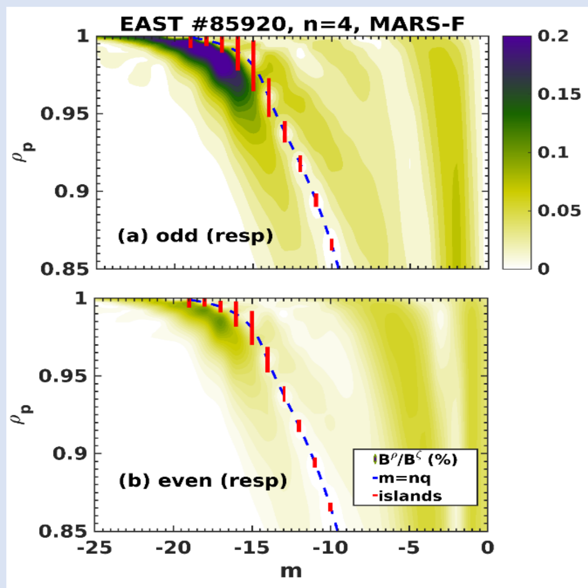

FIG 5 plasma response in different spectra

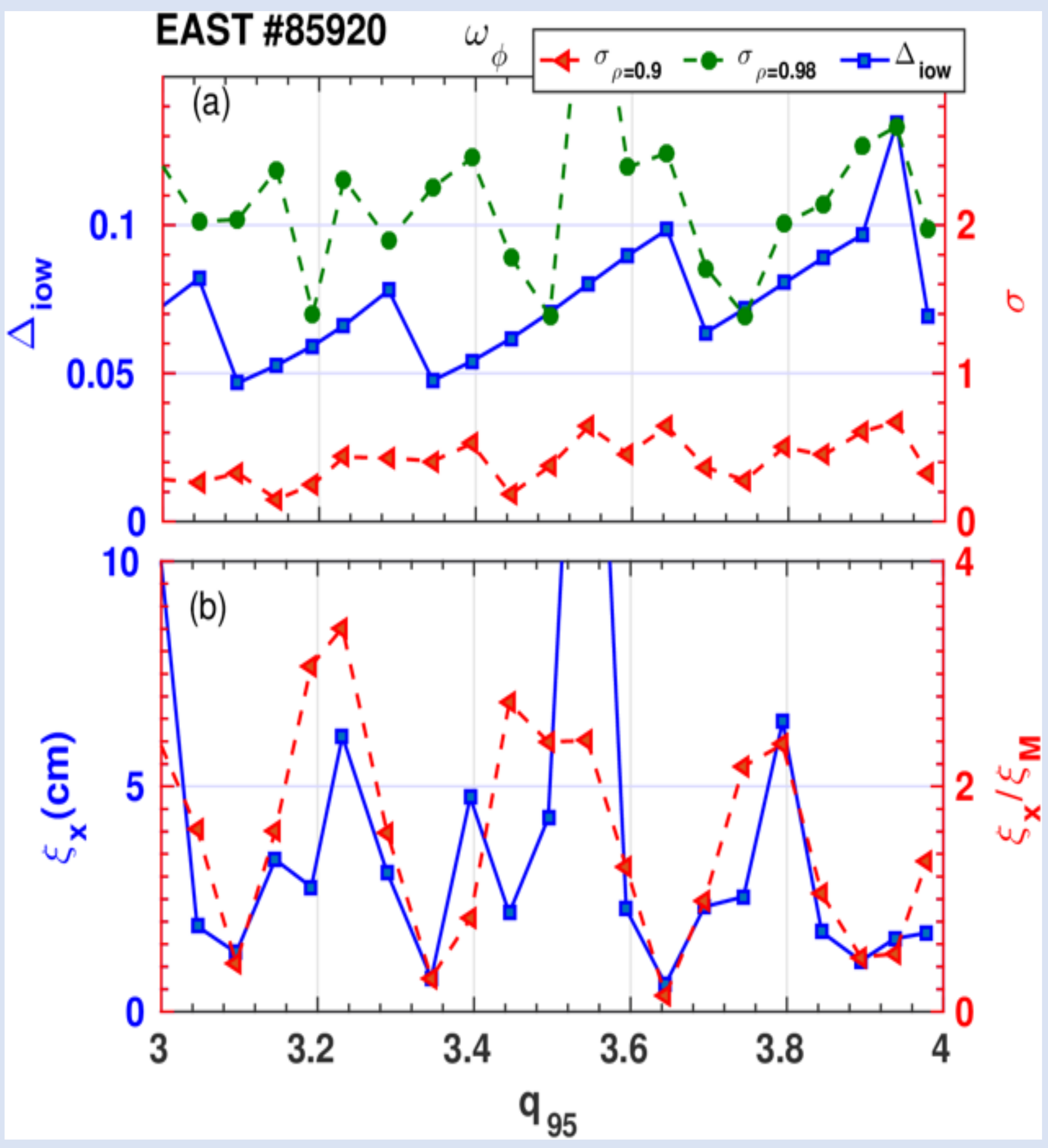

FIG 6 q_{95} dependence of plasma response

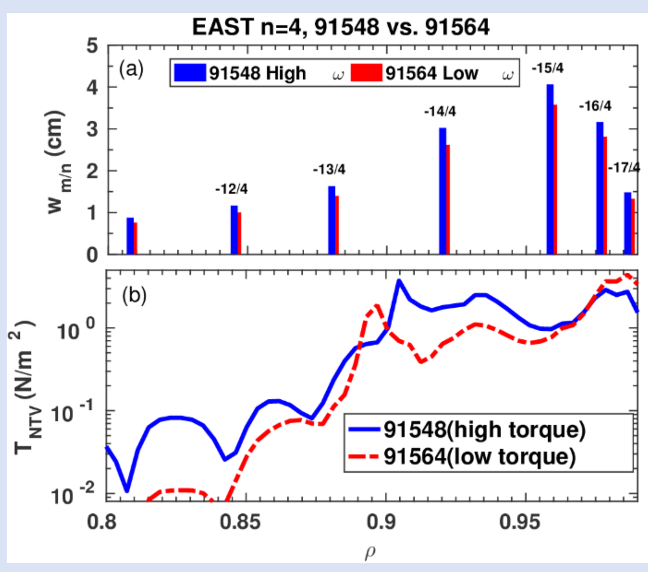

FIG 7 Comparison of plasma responses and NTV torque in two discharges

ACKNOWLEDGEMENTS / REFERENCES

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