

Multi-device study of E_r and its sensitivity to magnetic topology in tokamaks

S. Rienäcker¹, L. Vermare¹, P. Hennequin¹, C. Honoré¹, S. Coda², B. Labit², O. Grover³, M. Willensdorfer³, L. Frassinetti⁴, the TCV team⁵, the WEST team⁶, the AUG team⁷, and the EUROfusion Tokamak Exploitation Team⁸

¹*Laboratoire de Physique des Plasmas, CNRS, Sorbonne Université, École polytechnique, Institut Polytechnique de Paris, Palaiseau, France*

²*Ecole Polytechnique Fédérale de Lausanne, Swiss Plasma Center, Lausanne, Switzerland*

³*Max-Planck-Institut für Plasmaphysik, Garching, Germany*

⁴*Division of Fusion Plasma Physics, KTH Royal Institute of Technology, Stockholm, Sweden*

The E_r “well” at the edge of tokamak plasmas displays a complex phenomenology. The main mechanisms controlling its detailed structure are not well identified yet. Moreover, the link between edge $E_r \times B$ shear and access to higher confinement regimes remains to be clarified. Among the most telling examples—and the focus of this study—is the empirical sensitivity of the E_r well to magnetic ($B \times \nabla B$) topology in L-mode^{1–3} and its probable connection to the altered L-H transition threshold⁴: The sharper E_r well witnessed in “favorable” compared to “unfavorable” $B \times \nabla B$ drift (pointing towards or away from the X-point, respectively) appears consistent with facilitated H-mode access in the former. However, this causality is not established yet, and the fundamental cause for such pronounced asymmetry remains elusive. As part of a multi-device effort to elucidate this phenomenon, we present and compare results from the WEST, AUG, and TCV tokamaks. Particular focus is given to recent TCV experiments, enabled by a Doppler backscattering diagnostic on loan from LPP, which allowed the first extended edge E_r measurements on this device⁵. TCV results concerning the favorable/unfavorable asymmetry are broadly in line with AUG^{1,3} and WEST², showing a shallower well in unfavorable $B \times \nabla B$ ⁶. Yet, the observations in TORE SUPRA⁷ and WEST^{2,8} of a strong variation of E_r shear with I_p in unfavorable $B \times \nabla B$ is not recovered in TCV⁶, nor in recent AUG experiments. Possible reasons for the discrepancy are discussed. Beyond the sensitivity to I_p , the role of other parameters including density and shaping is examined. Finally, the evolution of E_r approaching the L-H transition in favorable and unfavorable magnetic topologies points to a central role of the inner $E_r \times B$ shear layer in facilitating the L-H transition.

[1] J. Schirmer et al. In: *Nucl. Fusion* 46.9 (2006).

[2] L. Vermare et al. In: *Nucl. Fusion* 62.2 (2021).

[3] U. Plank et al. In: *Phys. Plasmas* 30.4 (2023).

[4] F. Wagner et al. In: *Nucl. Fusion* 25.10 (1985).

[5] S. Rienäcker et al. In: *Plasma Phys. Contr. Fus.* (2025).

[6] S. Rienäcker et al. In: *50th EPS Conference on Plasma Physics*. 2024.

[7] P. Hennequin et al. In: *37th EPS Conference on Plasma Physics P1.1040*. 2010.

[8] S. Rienäcker et al. In: *27th Joint EU-US Transport Task Force Meeting*. Poster. 2023.

⁵See author list of H. Reimerdes et al 2022 *Nucl. Fusion* [62 042018](#)

⁶See author list of J. Bucalossi et al 2022 *Nucl. Fusion* [62 042007](#)

⁷See author list of H. Zohm et al 2024 *Nucl. Fusion* [64 112001](#)

⁸See author list of E. Joffrin et al 2024 *Nucl. Fusion* [64 112019](#)