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The X-Point Radiator regime in the WEST tokamak for divertor operation in next step fusion devices



N. Rivals¹ email: nicolas.rivals@cea.fr,

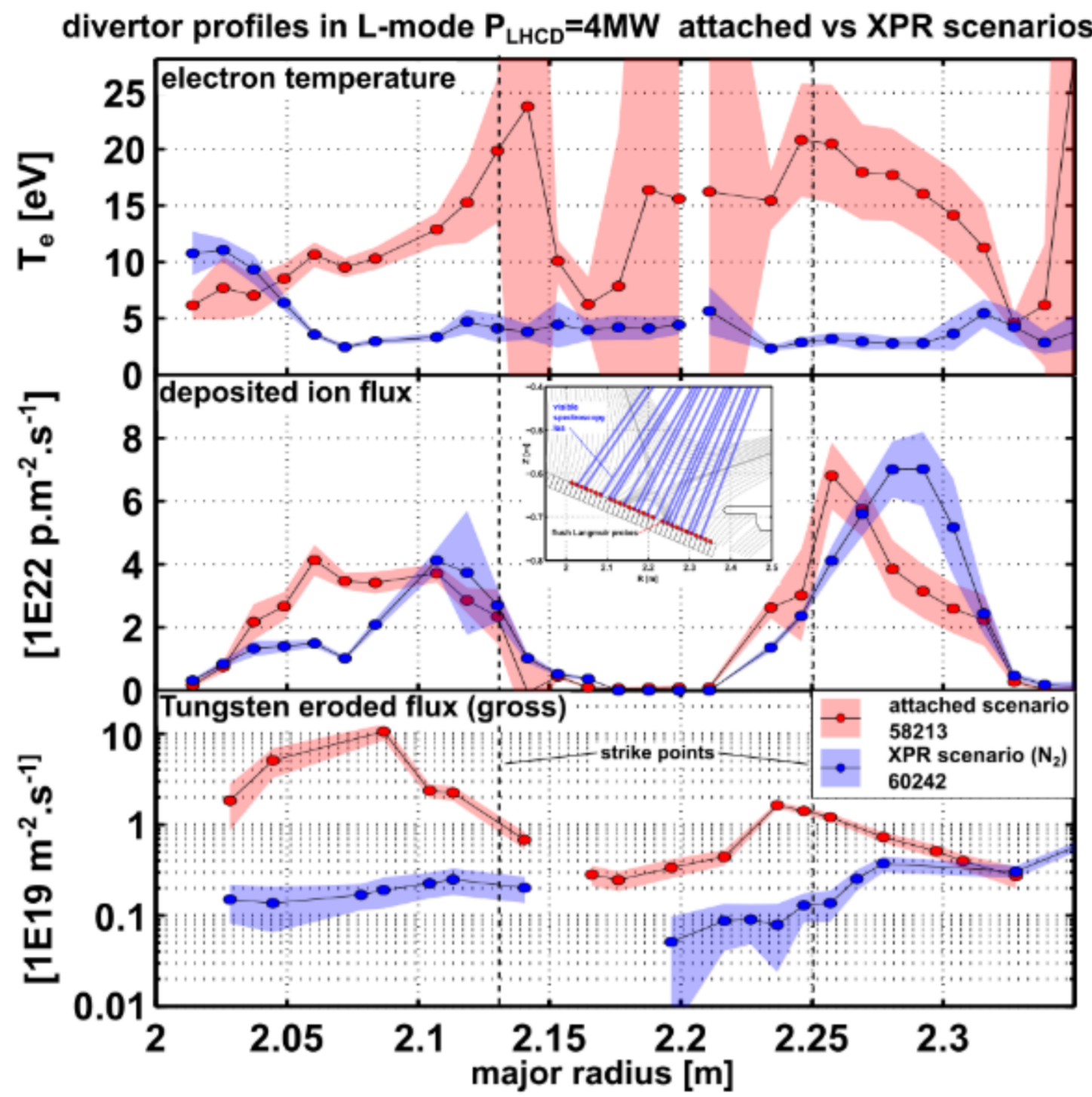
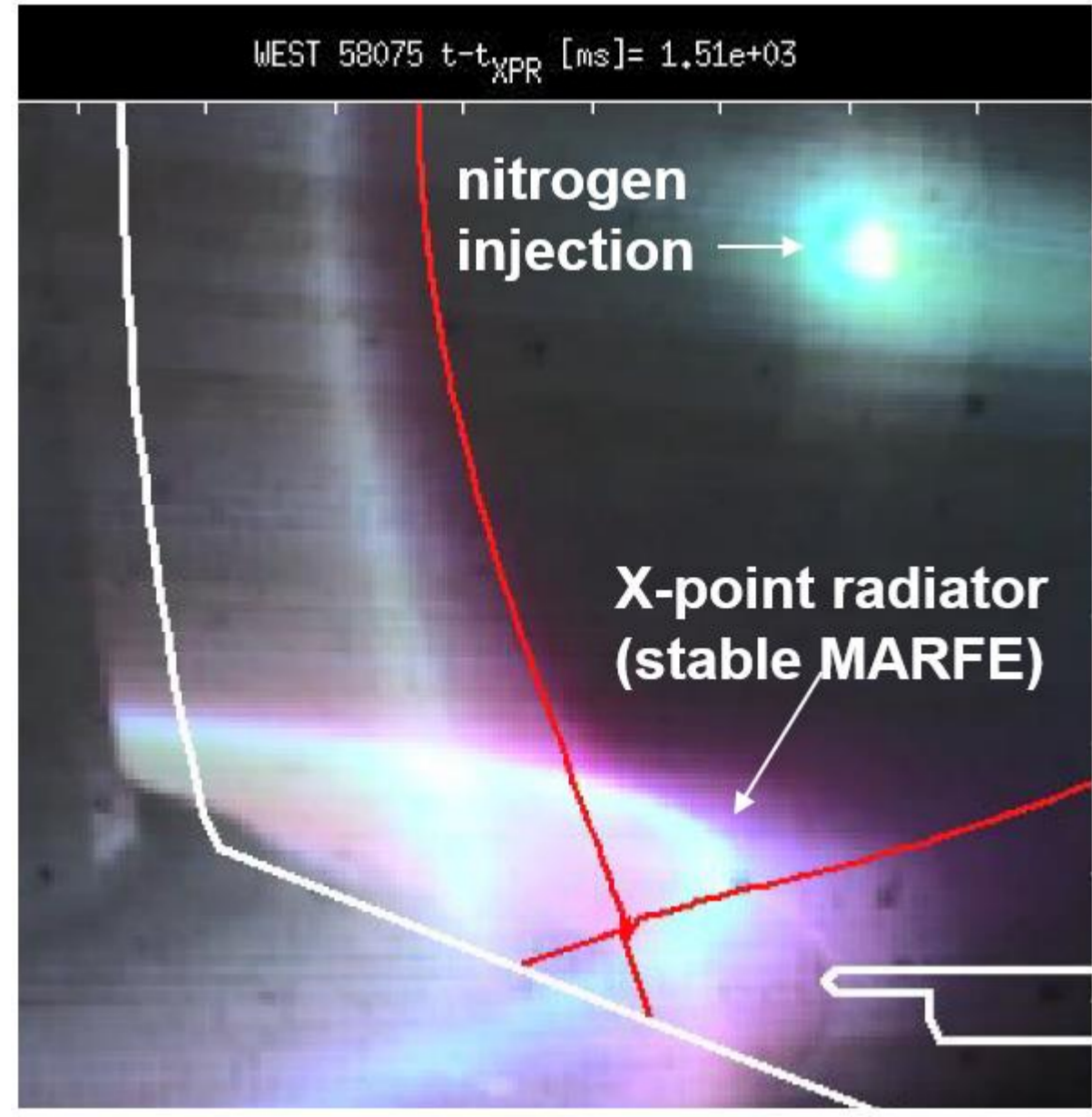
N. Fedorczak¹, E. Geulin¹, R. Nouailletas¹, D. Moiraf¹, H. Yang², C. Guillemaut¹, J.P. Gunn¹, P. Hennequin³, J. Morales¹, P. Manas¹, L. Fevre¹, J. Gaspar⁴, A. Ekedahl¹, J. Gerardin¹, Y. Corre¹, P. Maget¹, M. Bernert⁵, T. Lunt⁵, S. Henderson⁶, H. Reimerdes⁷, E. Tsitrone¹, N. Vianello⁸, the EUROfusion Tokamak Exploitation Team⁹ and the WEST team¹⁰



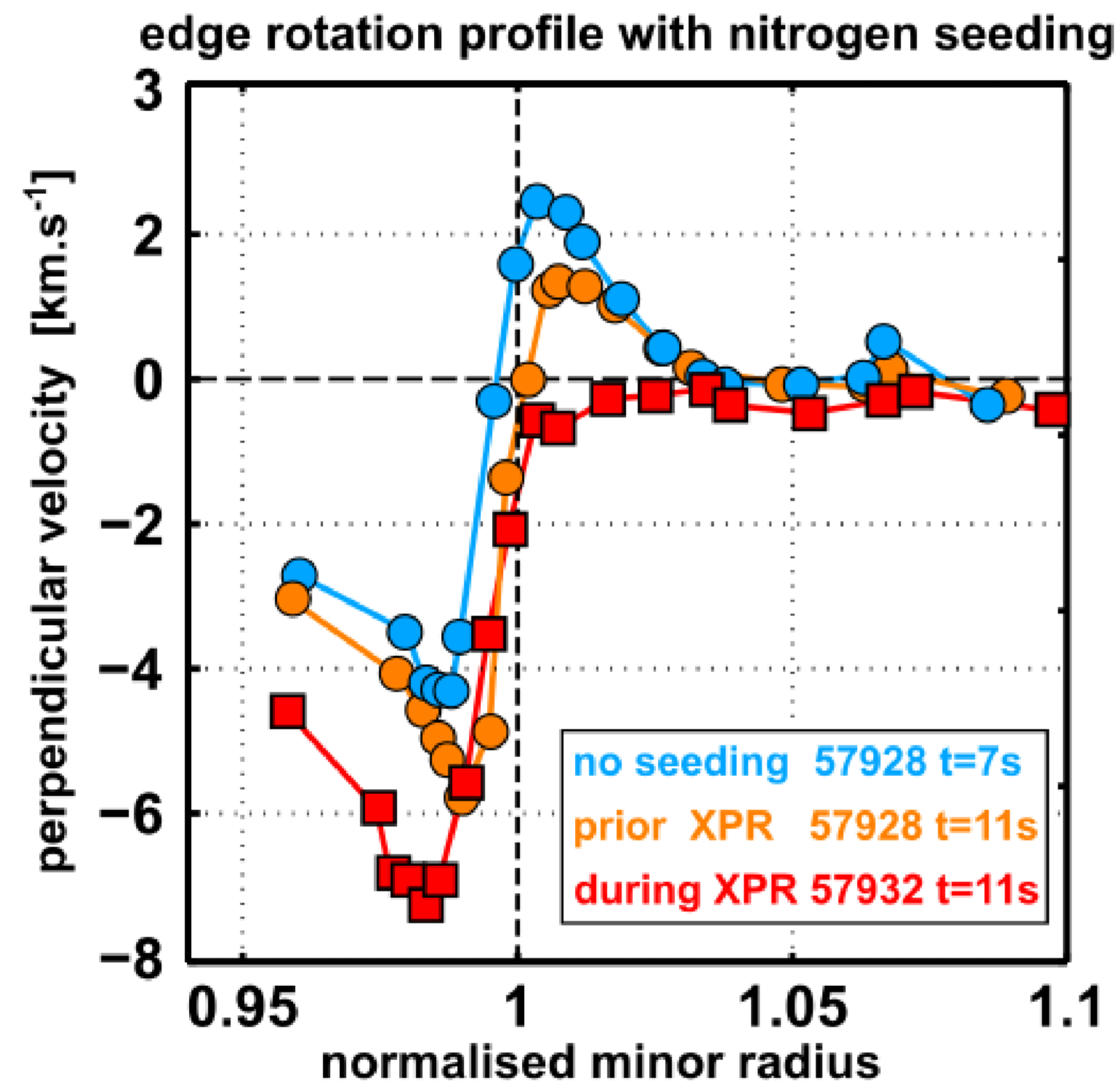
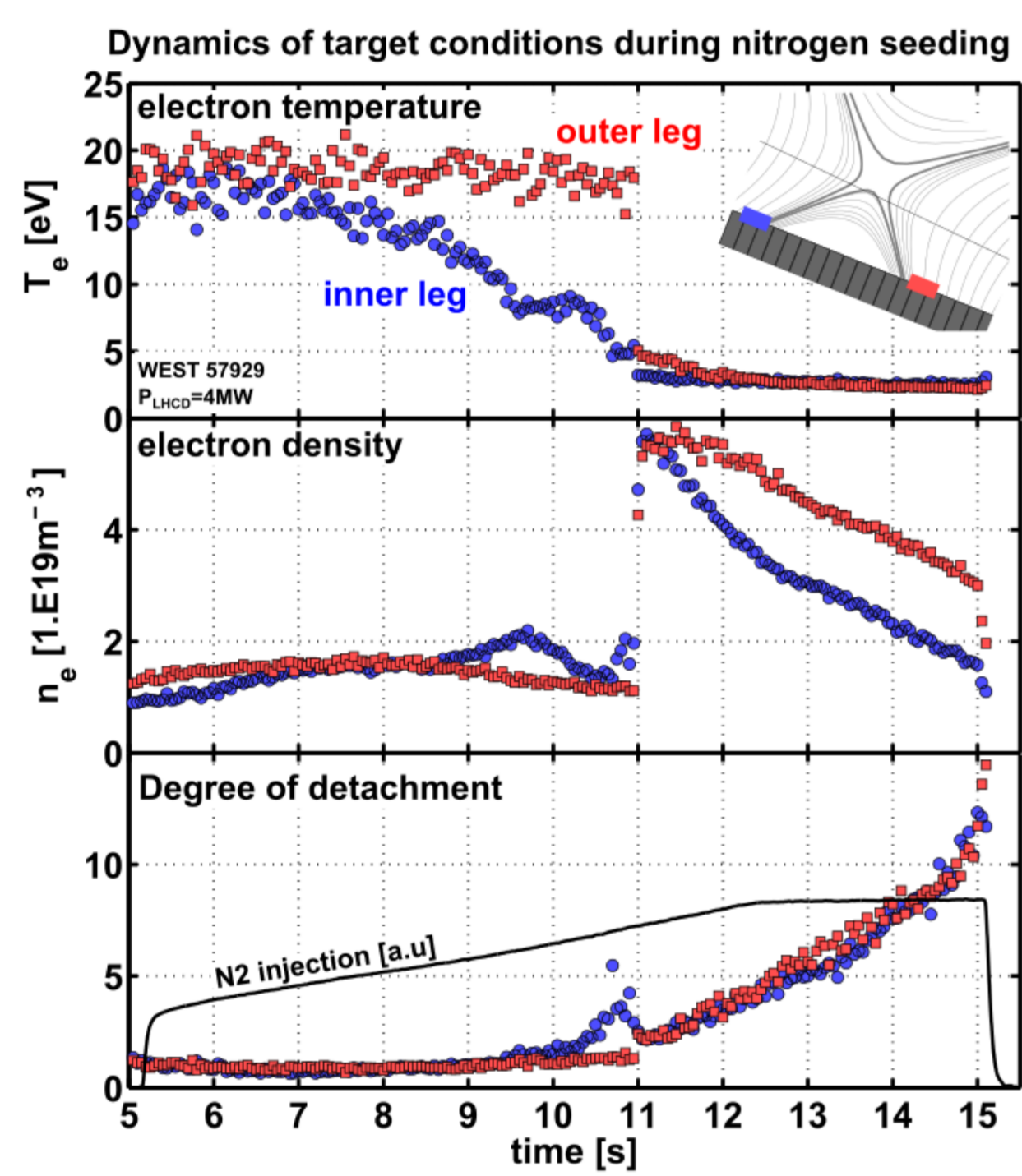
- ¹ CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France
- ² Aix-Marseille Univ., CNRS, Centrale Med., M2P2, 13013 Marseille, France
- ³ Laboratoire de Physique des Plasmas, CNRS, Sorbonne Université, École polytechnique, Institut Polytechnique de Paris, Palaiseau, France
- ⁴ Aix-Marseille Univ., CNRS, IUSTI, 13453 Marseille, France
- ⁵ Max Planck Institute for Plasma Physics, Garching, Germany
- ⁶ United Kingdom Atomic Energy Authority, Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK
- ⁷ Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), Lausanne, Switzerland
- ⁸ Consorzio RFX, Corso Stati Uniti 4, Padova, Italy
- ⁹ See the author list of E. Joffrin et al 2024 Nucl. Fusion 64 112019
- ¹⁰ See <http://west.cea.fr/WESTteam>



FEATURES OF THE WEST X-POINT RADIATOR REGIME

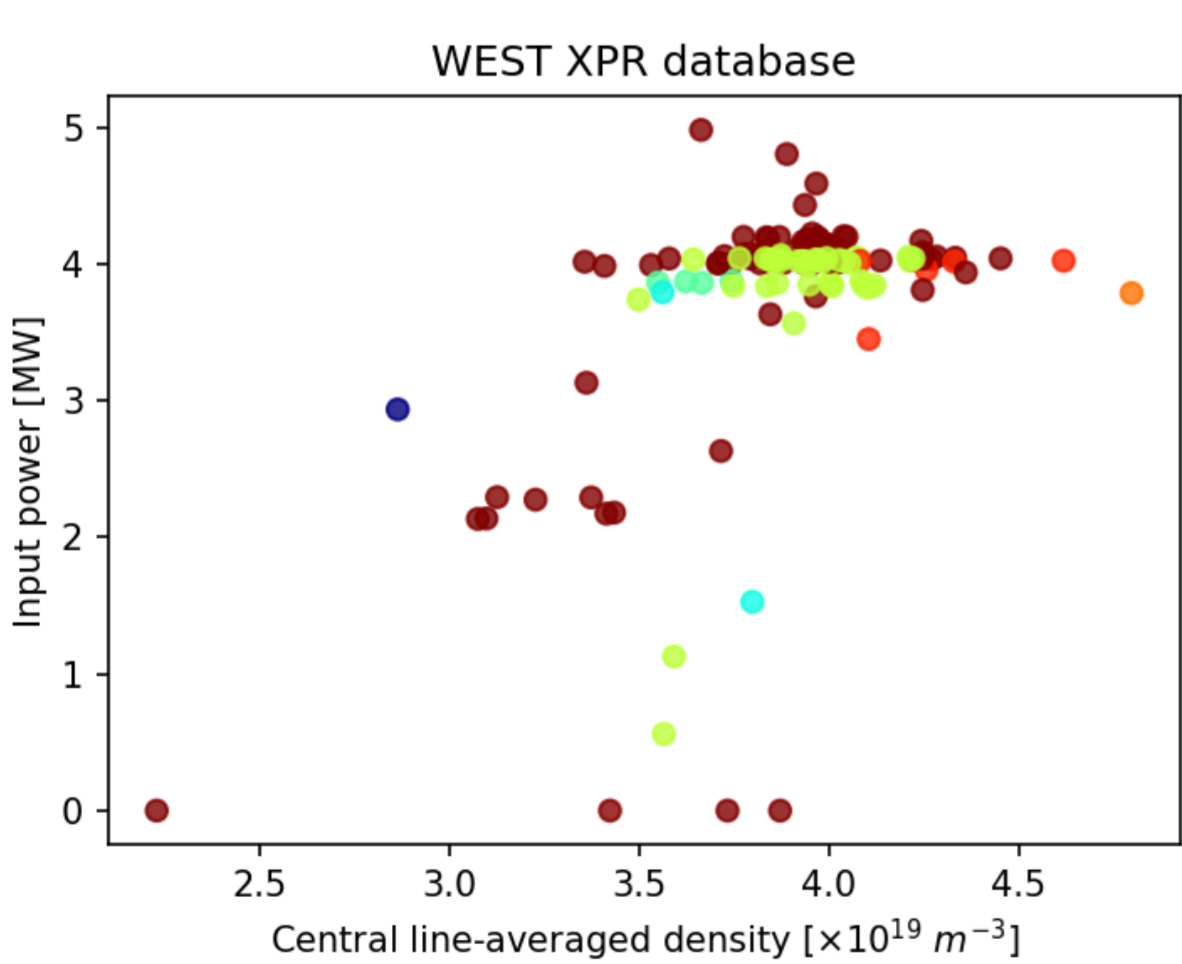


- Abrupt **plasma “condensation”** at both targets
- Times scales: **µs** (LP's) vs. **ms** (camera)
- **No particle detachment** (high particle flux)
- Up to **50-fold reduction of W erosion** source

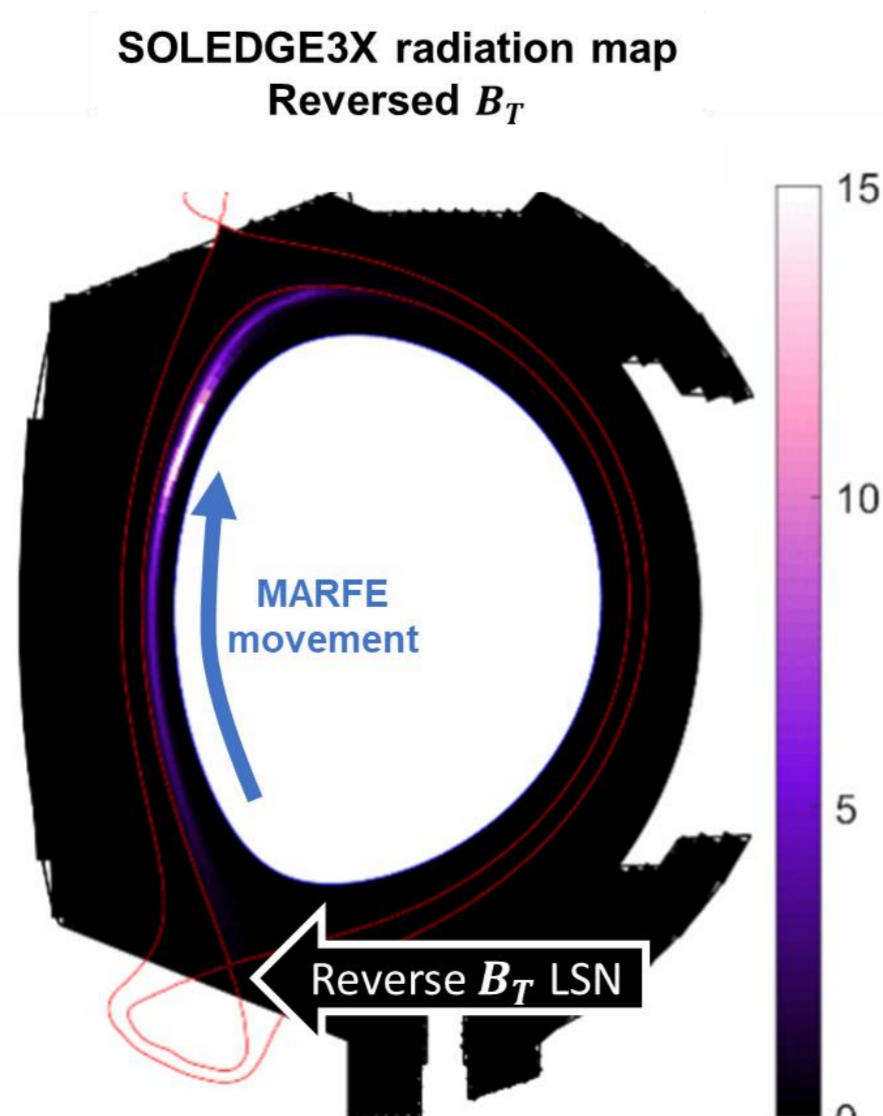
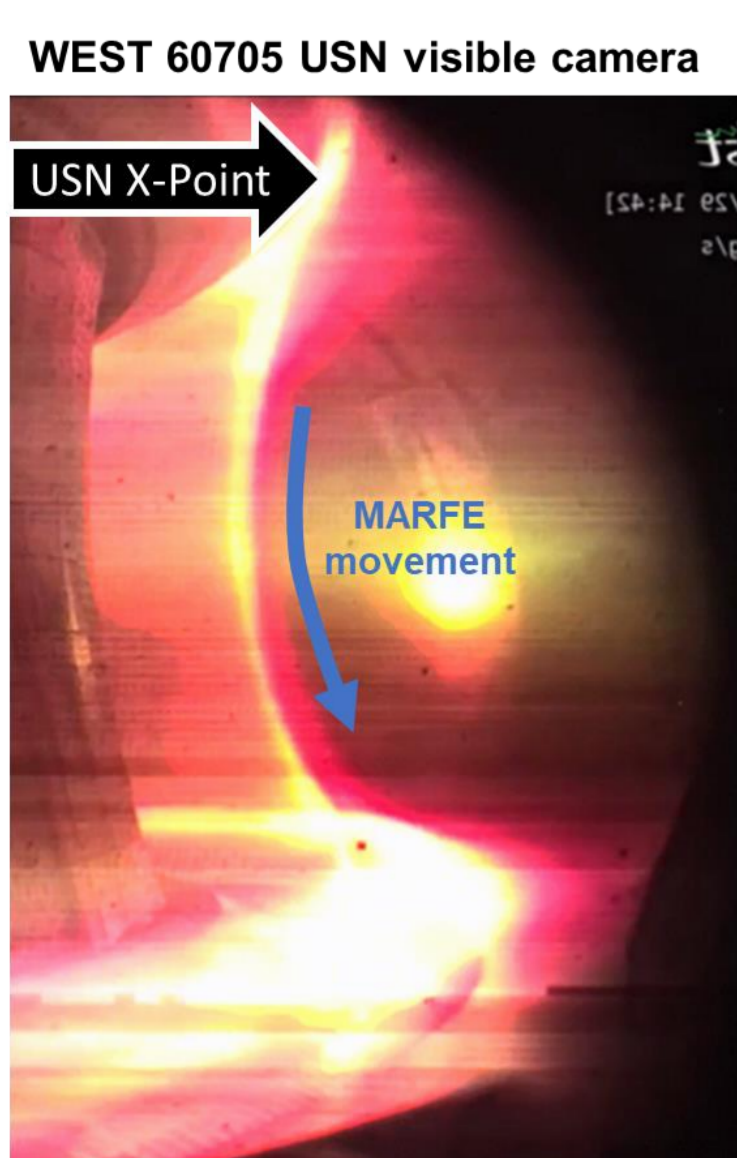


- **“Te cliff”** at the outer target only
- Gradual decrease at inner target
- Particle detachment (DoD) after the XPR onset with further seeding
- **Core performances improved** for some XPR shots, not all → **case dependent**
- **Increased perpendicular rotation**, consistent with reduced transport
- **SOL flow suppressed**: resymmetrisation of targets

THE WEST XPR DATABASE

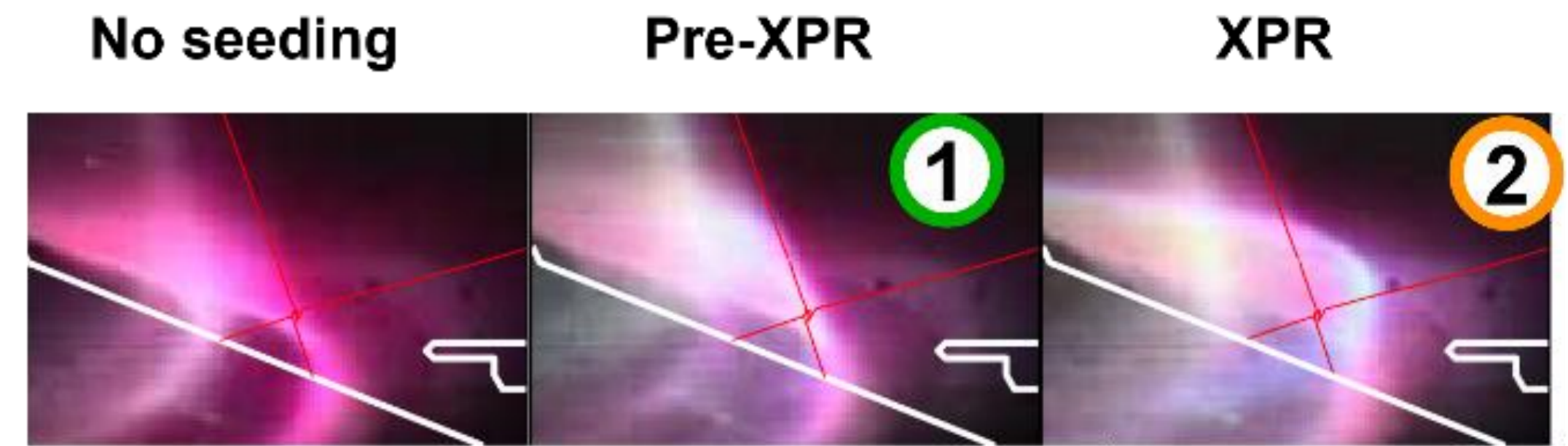


- **129 XPR pulse database**
- **Very repeatable, robust scenario** → routine scenario
- Range of density, power, currents, magnetic configurations
- LSN, USN, DN
- Favorable/unfavorable

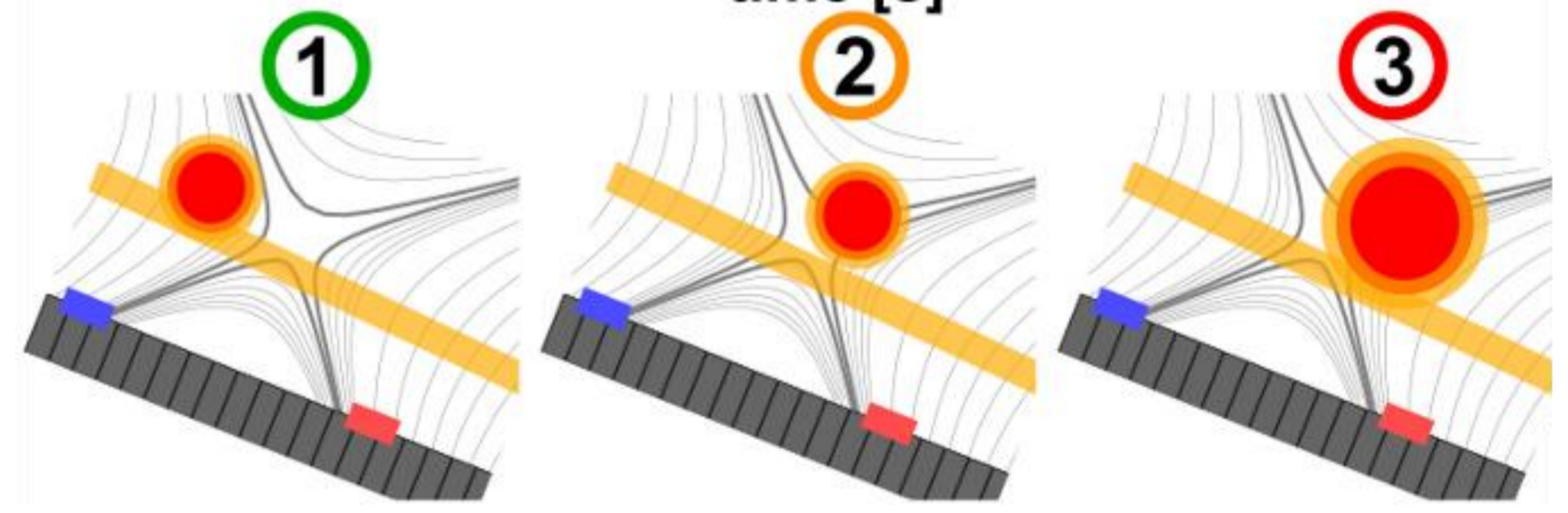
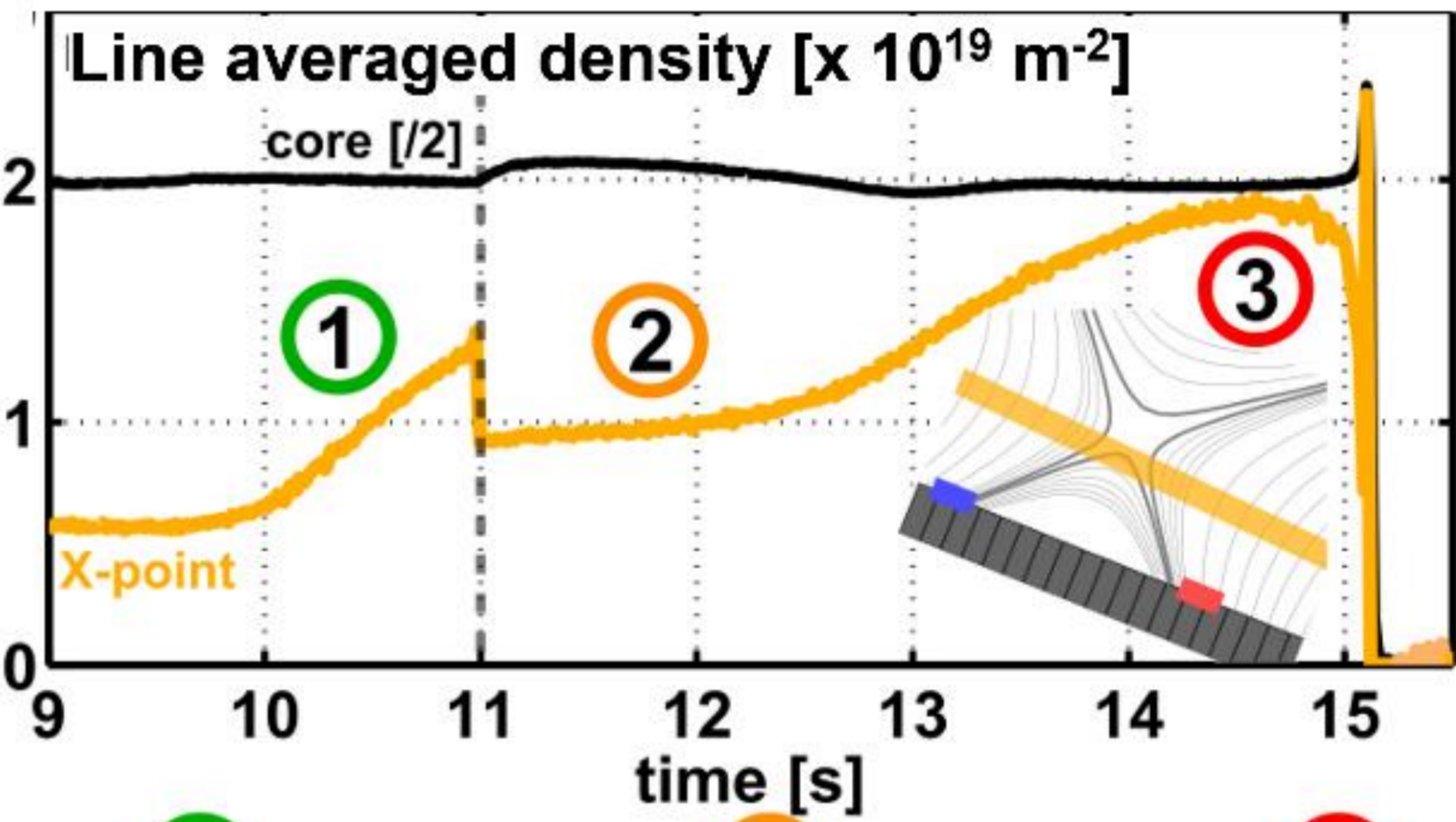


- Favorable/unfavorable shows stability difference
- **Unfavorable configuration is unstable** → MARFE movement leading to disruption
- **This difference is recovered in SOLEEDGE3X modelling**
- → **Direction of cross-field drifts matters**

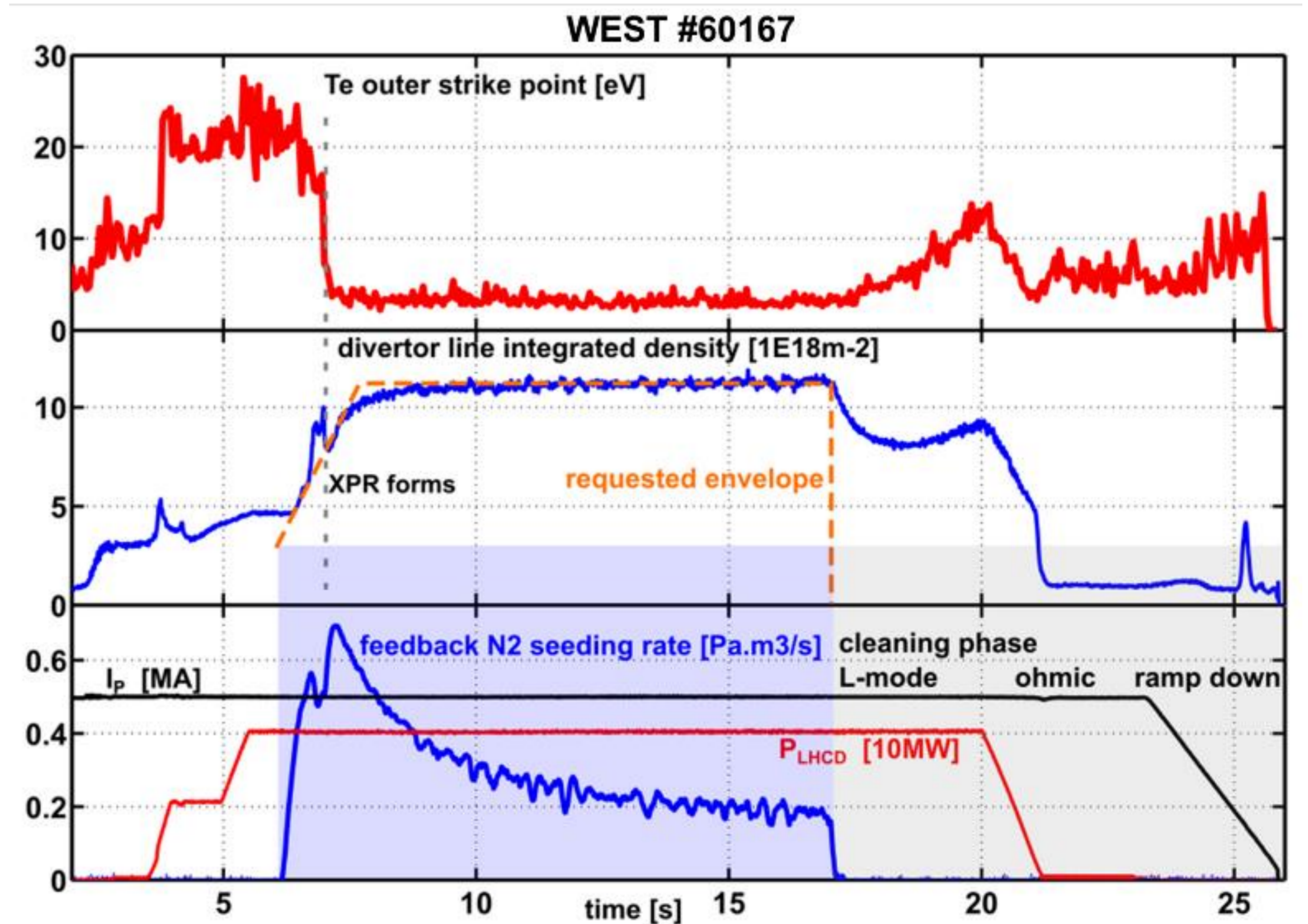
XPR SCENARIO CONTROL



Visible camera view of the lower divertor



- **X-point interferometry line-of-sight shows clear and characteristic XPR marker** → **successful real-time control for XPR's**
- **Compatible with power plant design**
- **Interpretation by MARFE movement**
- **Now routine control scheme in WEST**
- Simple observable



- **Seeding show long time scales: 5 seconds** → **34 second record XPR-phase pulse**
- N legacy is a operational challenge → importance of cleaning phases
- **Next campaign: high fluence campaign in ITER like conditions (low target T_e)**

Summary and outlook

- The XPR operational space explored in WEST full tungsten environment in L-mode scenarios
- 129 successful XPR pulses carried out in two years of experimental campaign, demonstrating the stability and reproducibility in WEST, real-time controlled with interferometry line-of-sight through the X-Point.
- In WEST, XPR scenarios produce both a cold divertor with high particle flux, tamed W divertor sources and an improved core confinement in certain cases.
- Scenario for the next high-fluence campaign at WEST to test the divertor ITER-grade PFC's by reproducing ITER divertor particle fluence with now also similar sub-10 eV plasma temperatures, and investigate residual tungsten erosion and migration.

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