## Max-Planck-Institut für Plasmaphysik

# **Impurity Transport in Ion- and Electron-Root Plasmas of** Wendelstein 7-X



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# Abstract/Motivation

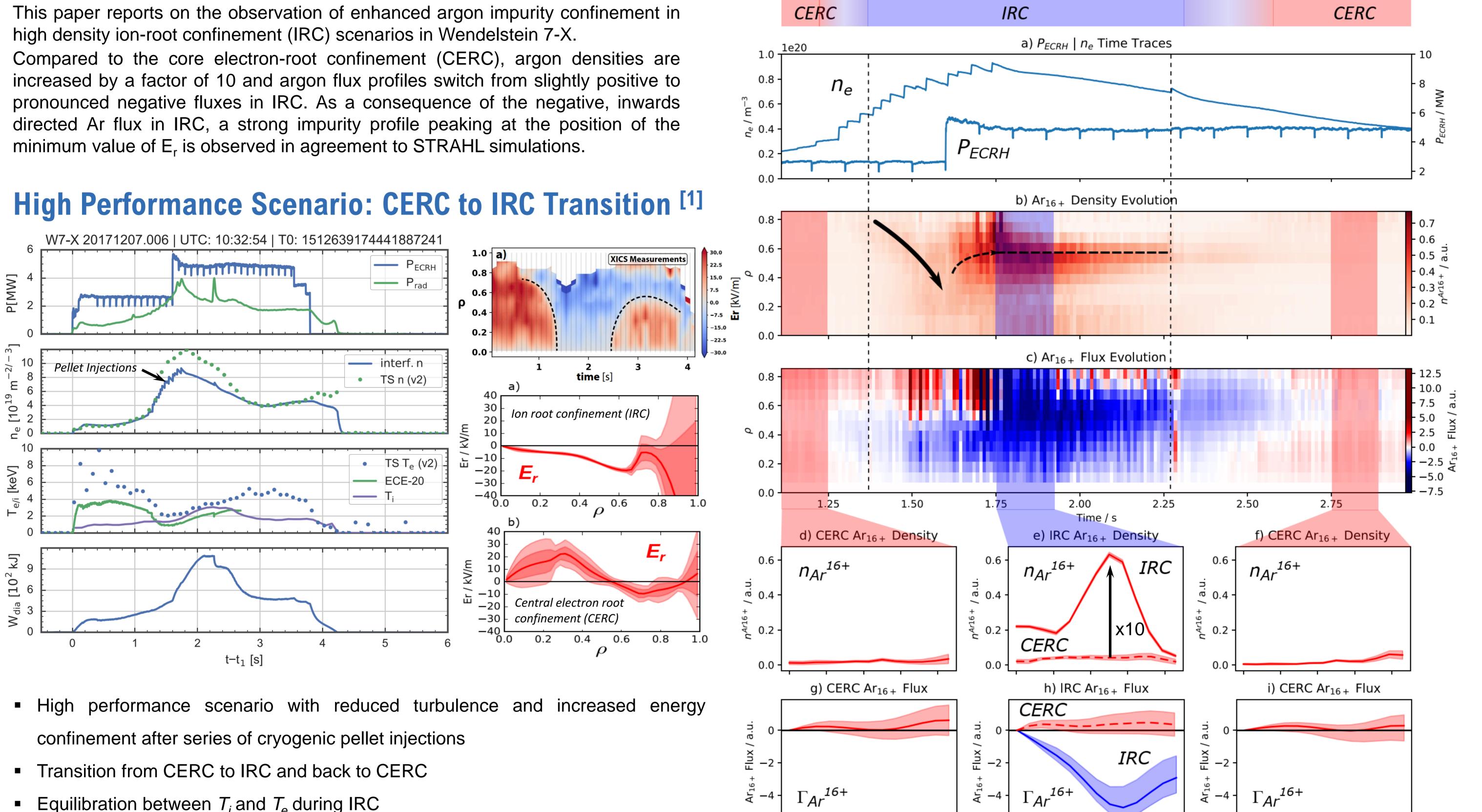
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This paper reports on the observation of enhanced argon impurity confinement in high density ion-root confinement (IRC) scenarios in Wendelstein 7-X.

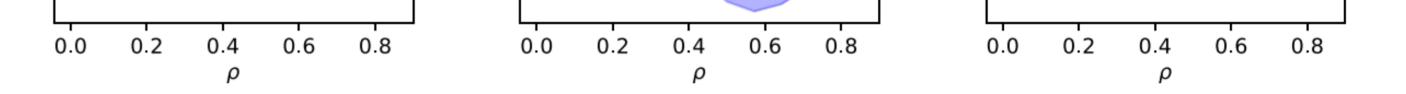
increased by a factor of 10 and argon flux profiles switch from slightly positive to pronounced negative fluxes in IRC. As a consequence of the negative, inwards directed Ar flux in IRC, a strong impurity profile peaking at the position of the minimum value of E<sub>r</sub> is observed in agreement to STRAHL simulations.

# High Performance Scenario: CERC to IRC Transition<sup>[1]</sup>

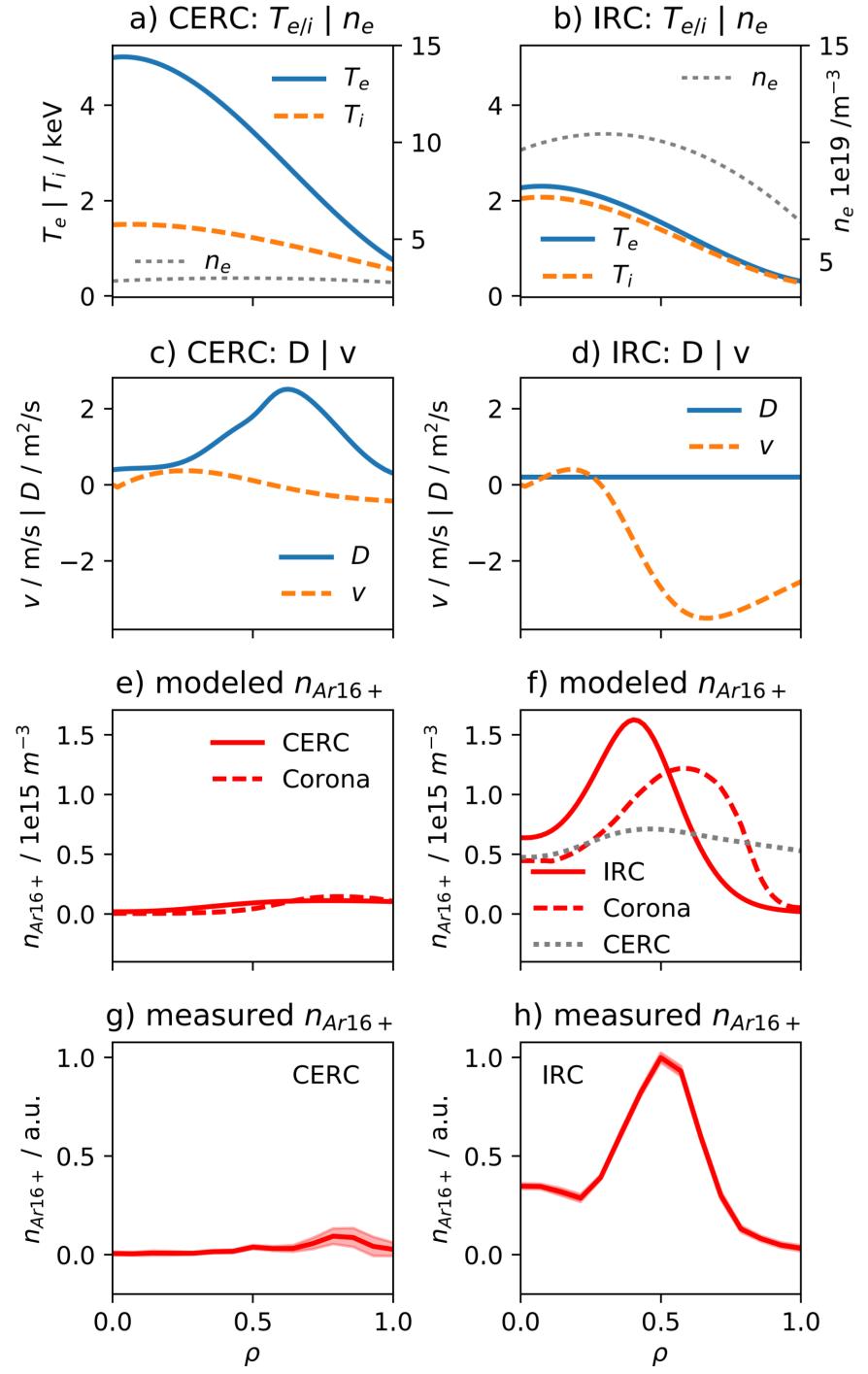
# **Experimental Ar Density and Flux Profiles: CERC vs. IRC**



- Equilibration between  $T_i$  and  $T_e$  during IRC
- Negative E<sub>r</sub> along entire plasma radius in IRC



### **STRAHL Modeled CERC vs. IRC**



Performed STRAHL simulations initial Of transport guess for profiles D+V with parameter optimal match respect to between modeled and measured n<sub>Ar</sub><sup>16+</sup> profiles.

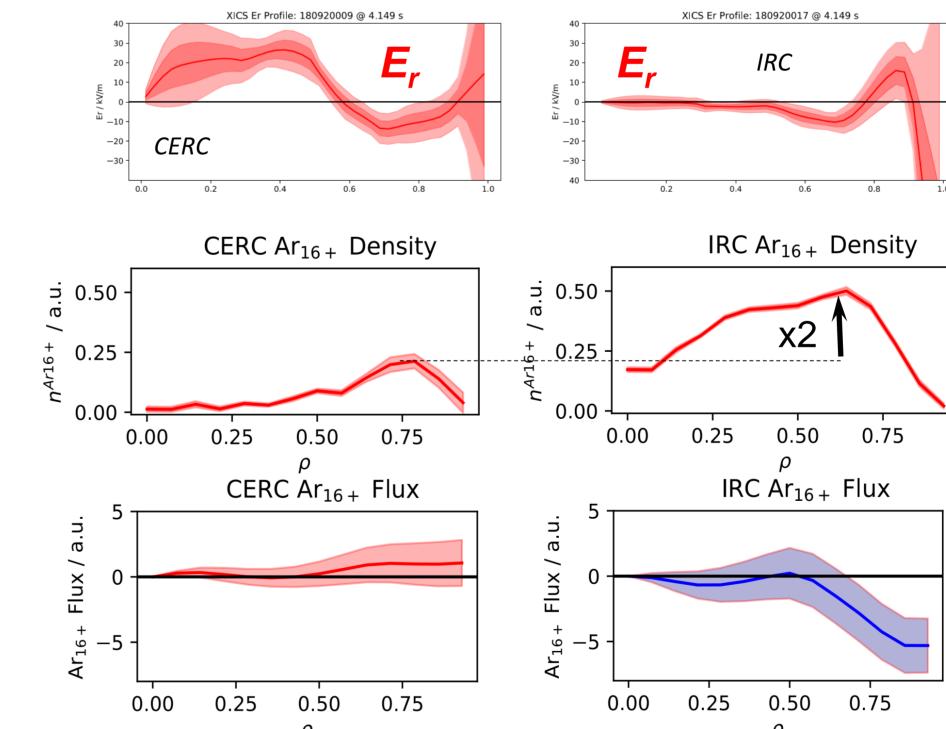
#### **CERC**:

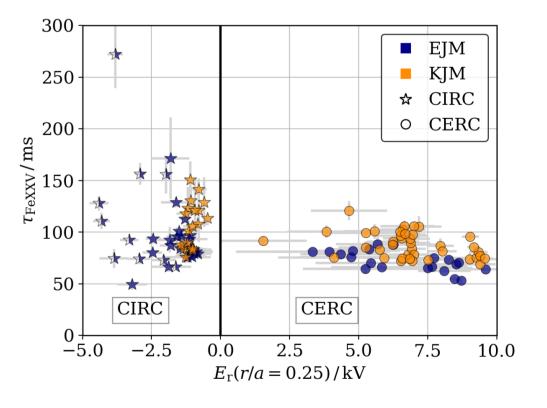
- Assumed typical D+V profiles significant anomalous with transport as observed in W7-X
- modeled Resulting broad n<sub>Ar</sub><sup>16+</sup> profiles match observed ones.
- As n<sub>Ar</sub><sup>16+</sup> profile is broad already in Corona equilibrium, strong D doesn't affect n<sub>Ar</sub><sup>16+</sup> profile shape much.

#### **IRC:**

D and Assumed reduced

## Ar Density and Flux Profiles: CERC vs. IRC, no Pellets





- impurity con-Enhanced finement in IRC scenarios observed for Fe impurities by LBO and injected TESPEL systems at W7-X.
- Without pellets, reduced turbulence suppression and weaker negative  $E_r$  in IRC.
- Weaker  $E_r$  yields also reduced negative radial Ar<sup>16+</sup> fluxes and less enhanced  $n_{Ar}^{16+}$

significantly negative V (from negative Ar<sup>16+</sup> flux).

- Resulting modeled peaked  $n_{Ar}^{16+}$  profiles at  $\rho = 0.5$  match observed ones.
- Corona approximation yields too broad  $n_{Ar}^{16+}$  profile shape. Assuming CERC D+V profiles

broad n<sub>Ar</sub>16+ yields profile

[1] N.A. Pablant, A. Langenberg, A. Alonso et al. Nuclear Fusion 60 036021 (2020) [2] A. Langenberg, Th. Wegner, N.A. Pablant et al. Physics of Plasmas 27 052510 (2020) [3] A. Langenberg, F. Warmer, G. Fuchert et al. Plasma Phys. Control. Fusion 61 014030 (2019) [4] Th. Wegner, B. Geiger, F. Kunkel et al. Rev. Scient. Instrum 89 073505 (2018)

profiles (x2) compared to the CERC scenario.

Enhanced impurity confinement in IRC is a combined effect of negative  $E_r$  and turbulence suppression.

# Conclusions

- Factor of x10 enhanced Ar impurity densities in IRC scenarios with respect to CERC.
- Strong negative radial Ar fluxes for IRC, slightly positive for CERC.
- Radial Ar impurity fluxes follow temporal evolution of  $E_r$  profiles, as observed by XICS [1].
- Ar<sup>16+</sup> density profile shapes can be reproduced with STRAHL simulations for IRC and CERC, assuming reduced diffusion and inwards directed transport parameters in IRC.
- Assumptions correlates with observed reduced turbulence and increased confinement in IRC scenarios at W7-X.

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shape.

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