DEVELOPMENT TOWARDS AN ELM-FREE DEMO

PEDESTAL RADIATIVE COOLING SCENARIO IN ASDEX UPGRADE

A. KALLENBACH, R. DUX, M. BERNERT, M. CAVEDON, P. DAVID, M. DUNNE, L. GIL+, M. GRIENER, R.M. MCDERMOTT, V. ROHDE,
ASDEX UPGRADE TEAM, EUROFUSION MST1 TEAM
Max Planck Institute f. Plasma Physics, Garching, Germany
+Instituto de Plasmas e Fusao Nuclear, IST, Universidade de Lisboa, Lisboa, Portugal
arne.kallenbach@ipp.mpg.de

ID: 741
P6.1441

ABSTRACT

A future DEMO is expected to operate in a no-ELM scenario that is integrated with pedestal/core (medium Z) impurity seeding and an at least partially detached divertor which will require (low Z) seed impurity radiation. The EDA H-mode, an ELM free scenario with good energy confinement, has been extended to high heating power by controlled Ar seeding and combined with N seeding for further heat flux reduction at the target due to divertor radiation

TOOLBOX FOR AN INTEGRATED NO-ELM SCENARIO

- No-ELM conditions need to be integrated with core/pedestal and divertor impurity seeding
- The different elements can be regarded as parts of a tool-box

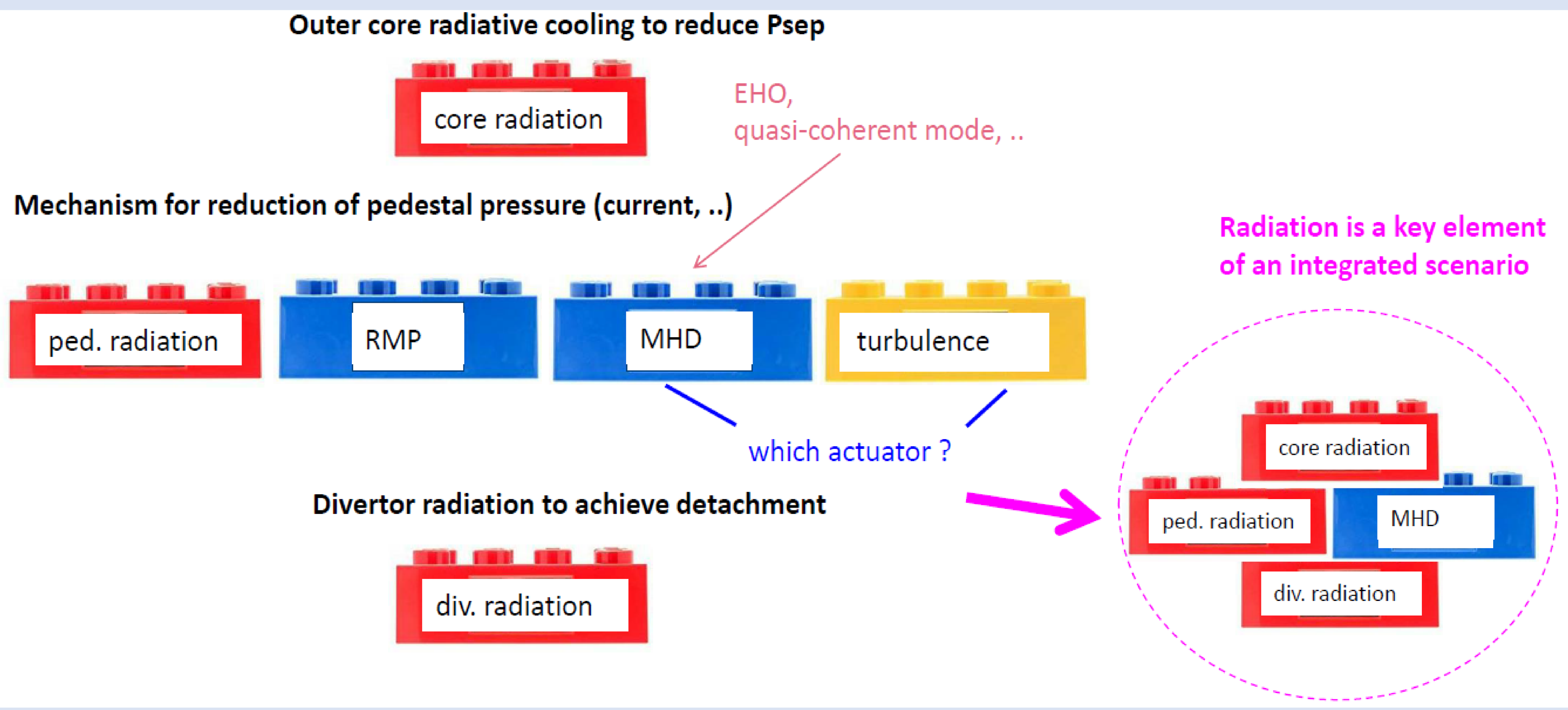

Fig 1: toolbox for an integrated, high power, detached no-ELM scenario

Pedestal radiation as key element for ELM avoidance

- The EDA H-mode has a narrow window of existence regarding power through the pedestal/separatrix
- By controling P_{sep}, this power window can be significantly extended

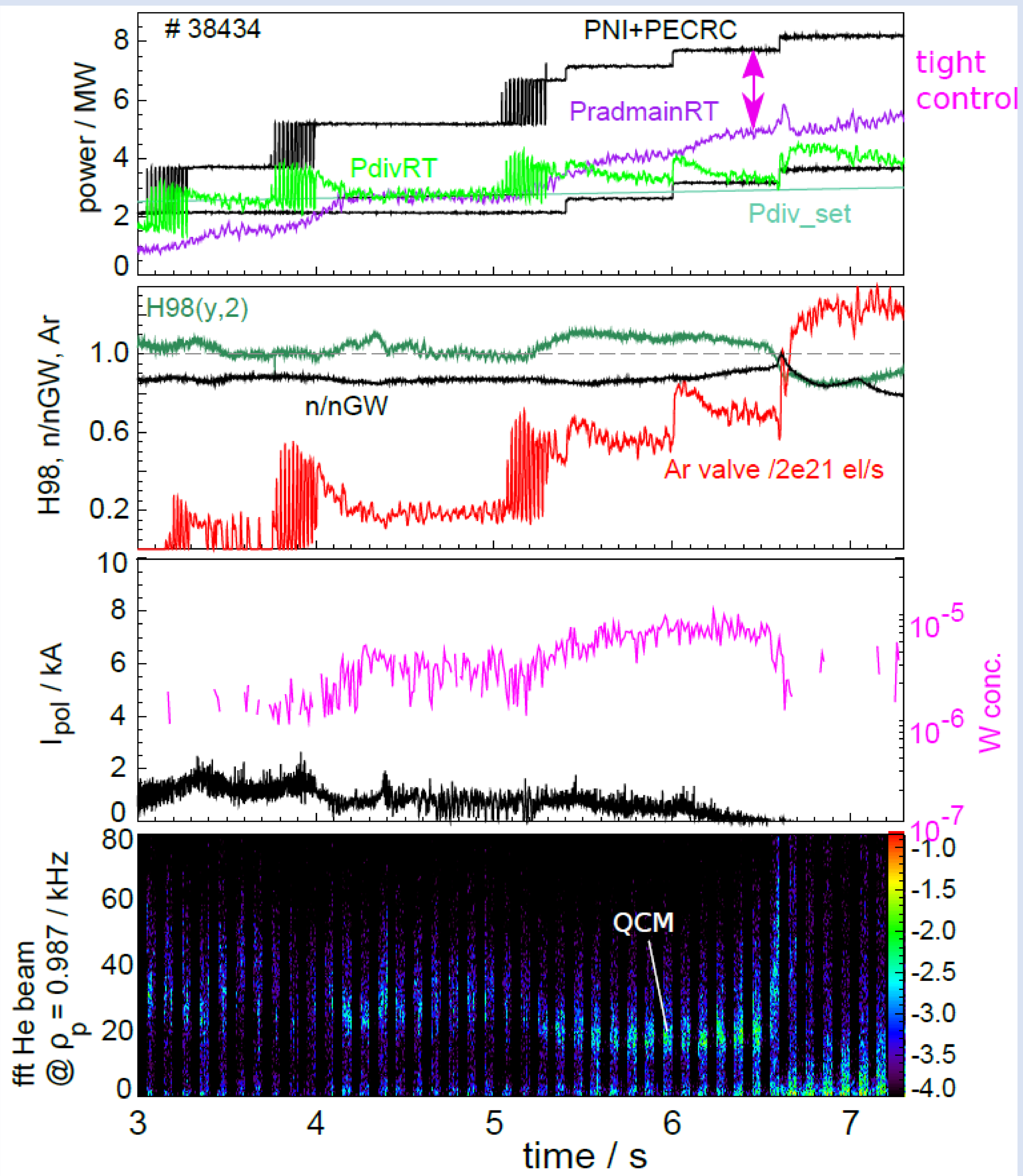

Fig 2: feedback control of P_{sep} by argon radiation

RESULTS

An integrated scenario has been obtained with the quasi-coherent mode (QCM) providing ELM suppression, Ar radiation to allow high heating power while maintaining the QCM and N radiation for divertor detachment

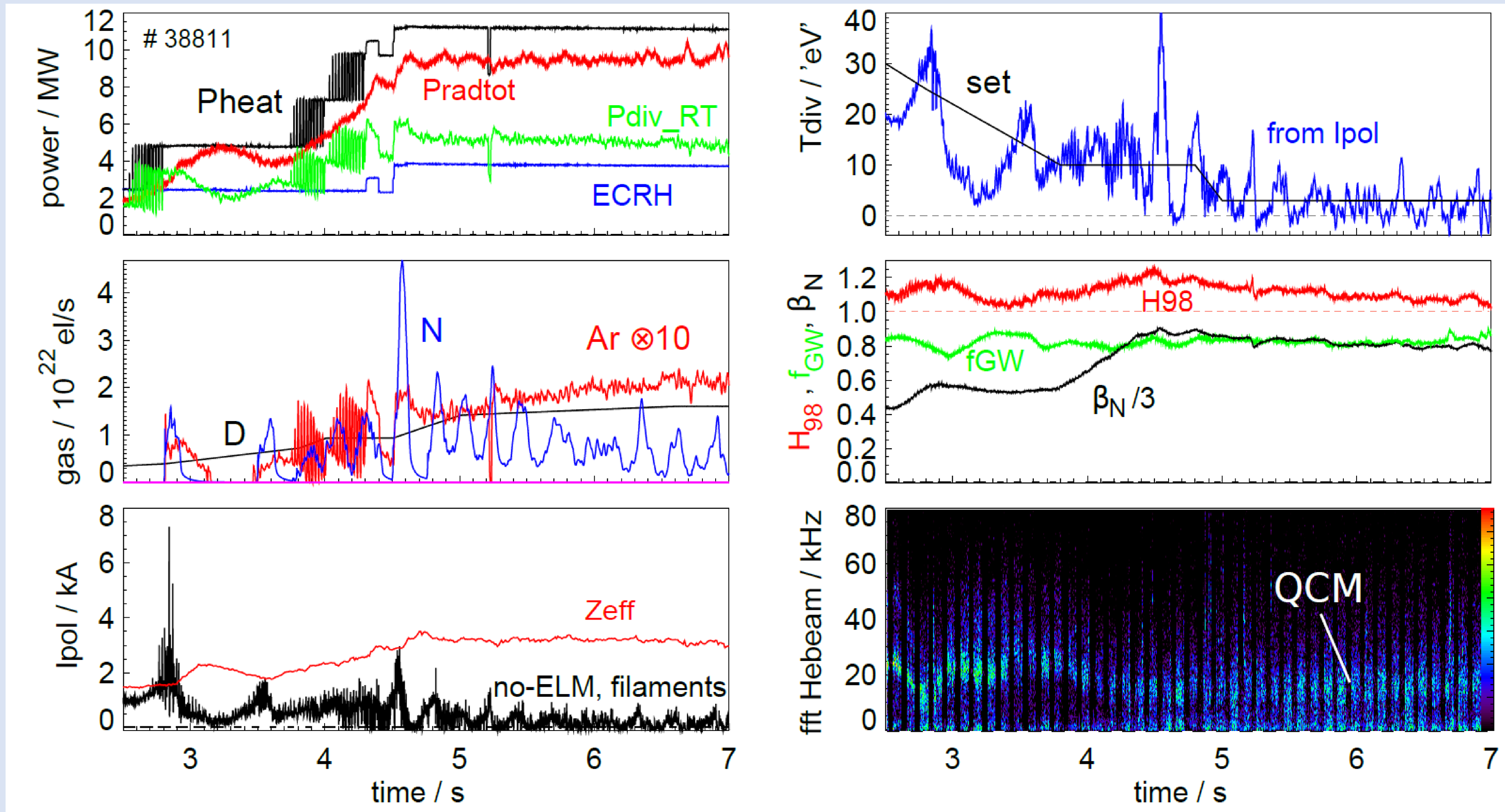

FIG. 3. Time traces of a discharge in EDA H-mode with double feedback of the power into the divertor, Pdiv, by Ar injection and the electron temperature at the target, Tdiv, by N injection. After 5s, the discharge is stationary, ELM-free, and partially detached with $H_{98} > 1$ and β_N= 2.4. I_p= 0.7 MA, δ_{up}=0.45, δ_{low}=0.54, q_{95}=5.7.

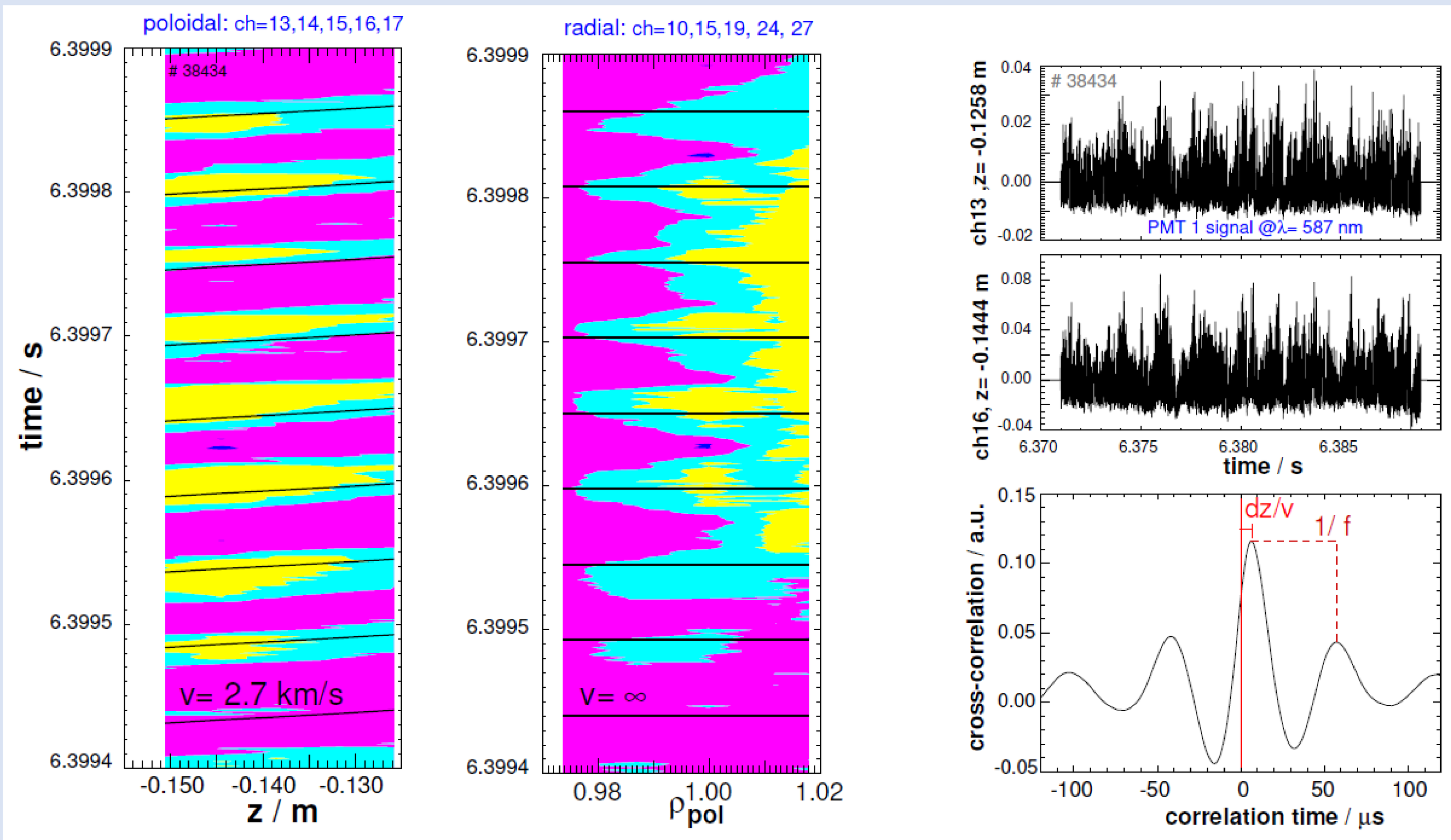

Fig. 4. Visualisation of the quasi-coherent mode by the He 587 nm line intensity of the He-beam diagnostics below the outer mid-plane. The intensity variations move upwards (in electron diamagnetic drift direction) with a speed of 2.7 km/s. There is a scatter of individual mode structures from the positions expected from a regular grid with uniform rotation frequency of 19 kHz.

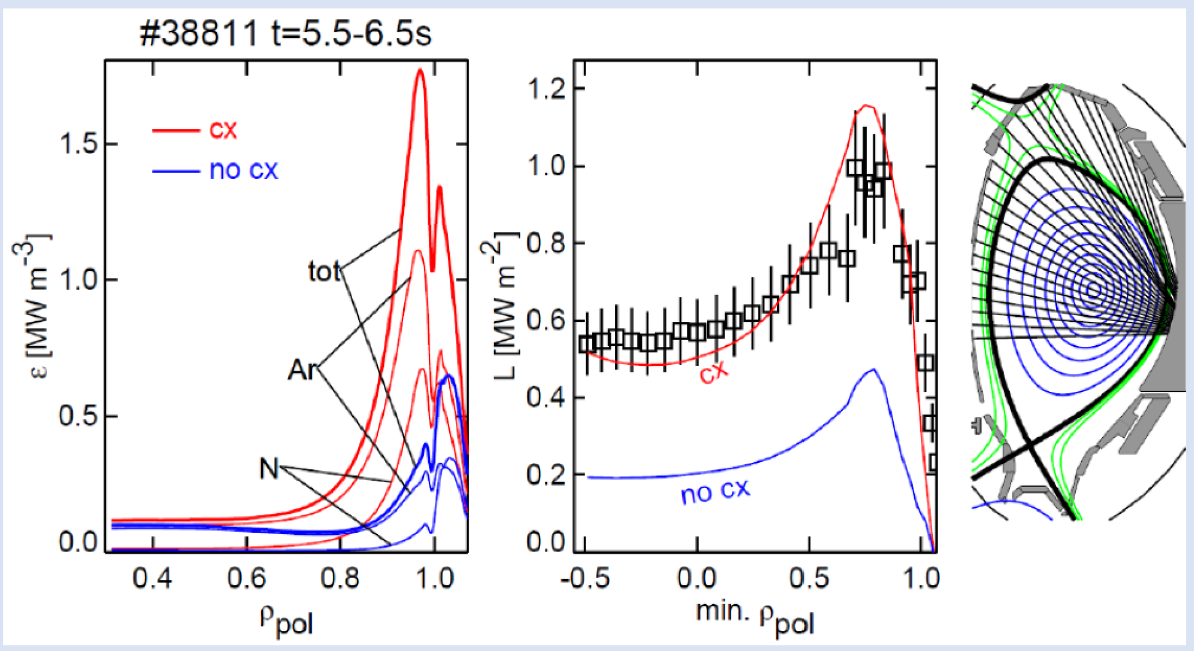

Fig. 5. Reconstruction of the bolometer line integrals by STRAHL modelling, including SPRED and SXR data. Ar dominates the pedestal radiation, the effect of CX with D^0 enhances both Ar and N radiation considerably. Concentrations $c_{Ar} \approx 0.3$ % and $c_N \approx 1$ %

CONCLUSION

- An integrated scenario was obtained combining additional pedestal transport through a quasi-coherent mode (n ~ 20) with radiative power extraction in the pedestal mainly by Ar and in the divertor by N. This results in an attractive DEMO scenario with H98 ≥ 1 and partial divertor detachment at high heating power.

ACKNOWLEDGEMENTS / REFERENCES

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Nuclear Fusion paper already published: KALLENBACH, A. et al., Nucl Fusion **61** (2021) 016002.