3-D Modeling of Heat Transport in Wendelstein 7-X Startup Plasmas with EMC3-EIRENE

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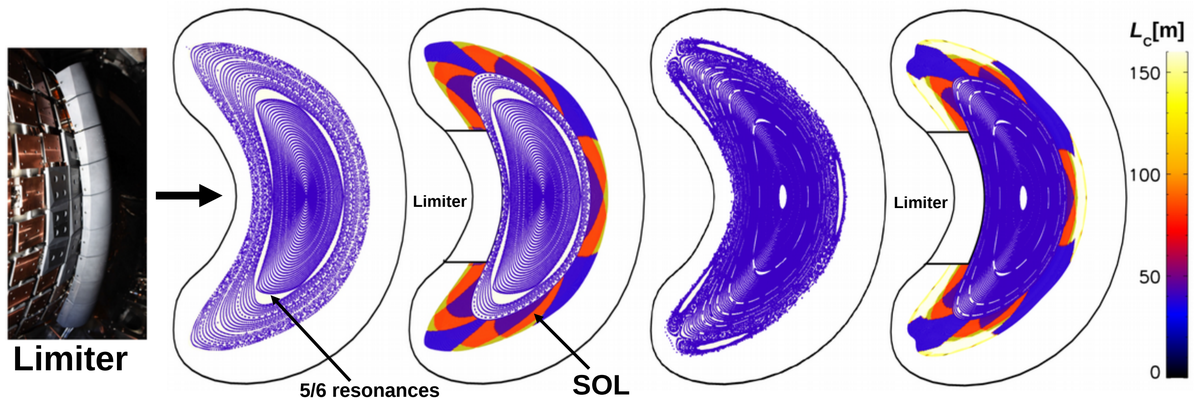
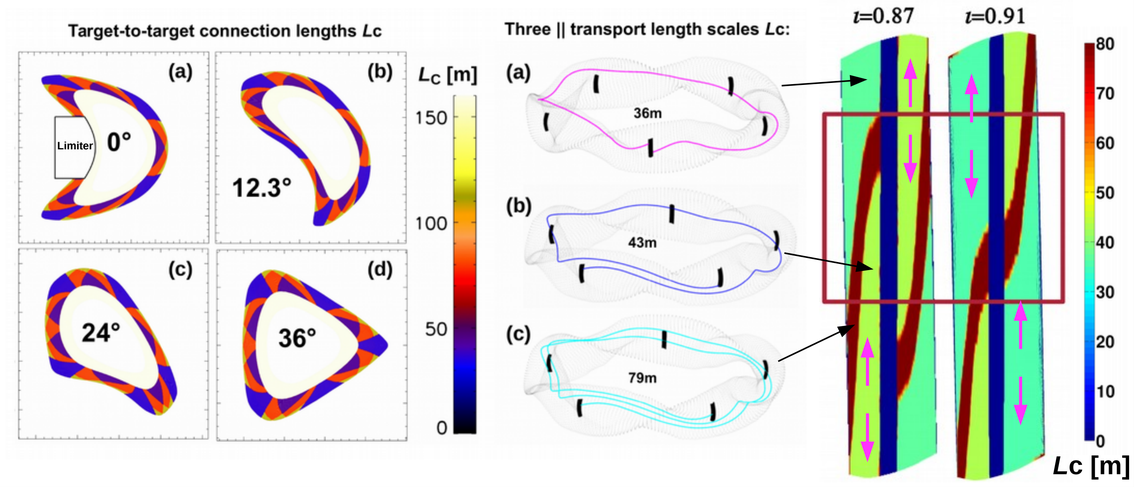
First operational phase (OP1.1): five graphite inboard limiters define a 3D helical scrape off layer (SOL)



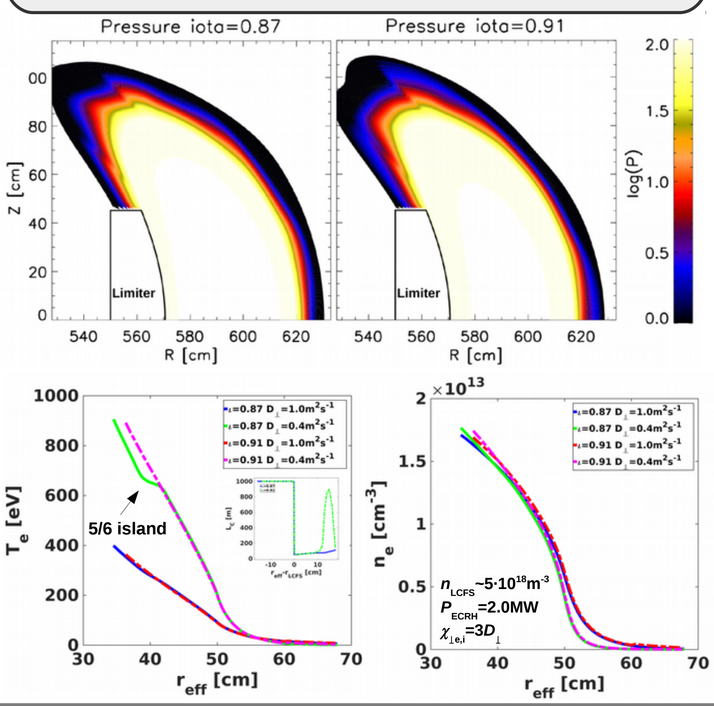
OP1.1 standard limiter field configuration: ι=0.87

Increased rotational transform → ι=0.91

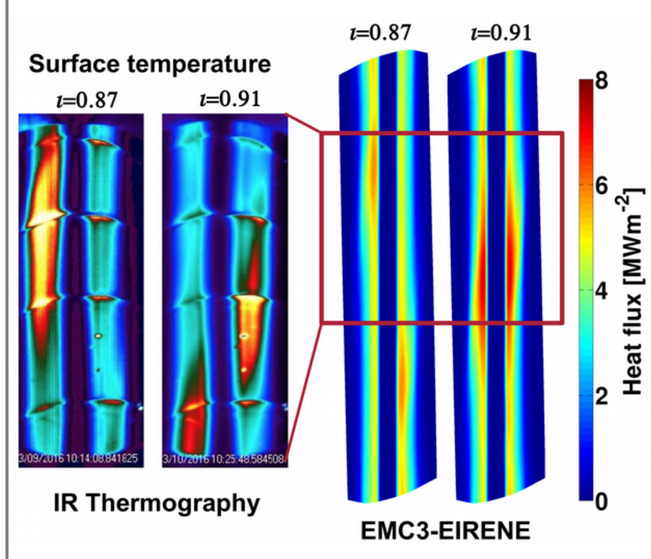
SOL magnetic topology decomposes into three types of helical magnetic flux tubes of different lengths *L*c



Plasma parameters strongly correlated to magnetic topology



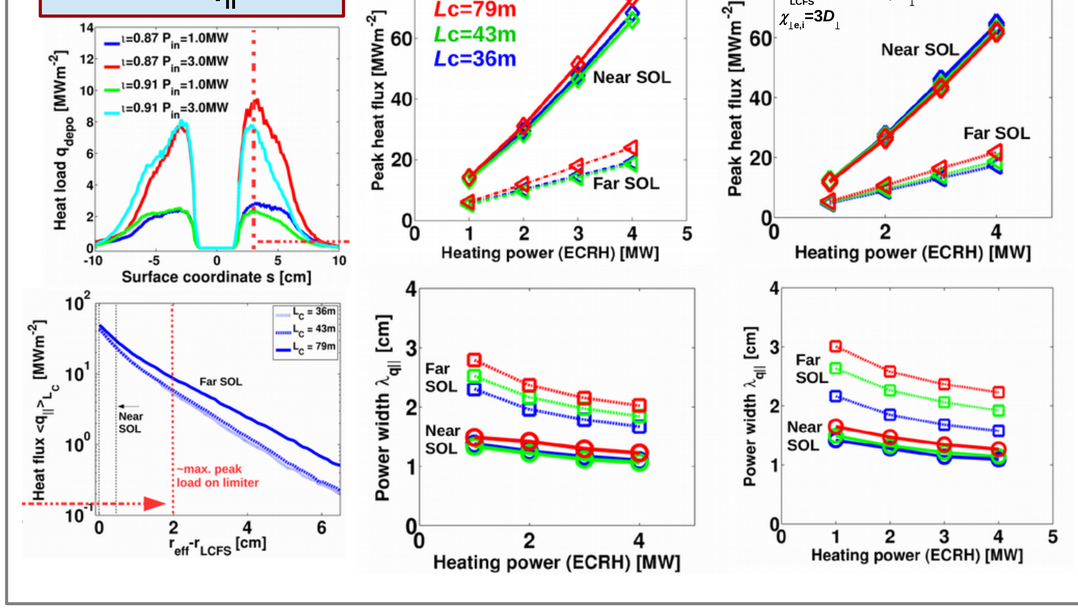
Comparison with IR confirms heat load asymmetry ~ *L*c



Heat load patterns correlated to magnetic footprint – max. q_{depo} in long *L*c domain

Near and far SOL feature different power widths $\lambda_{q||}$ → power flux level q_{peak} scales linearly with P_{ECRH}

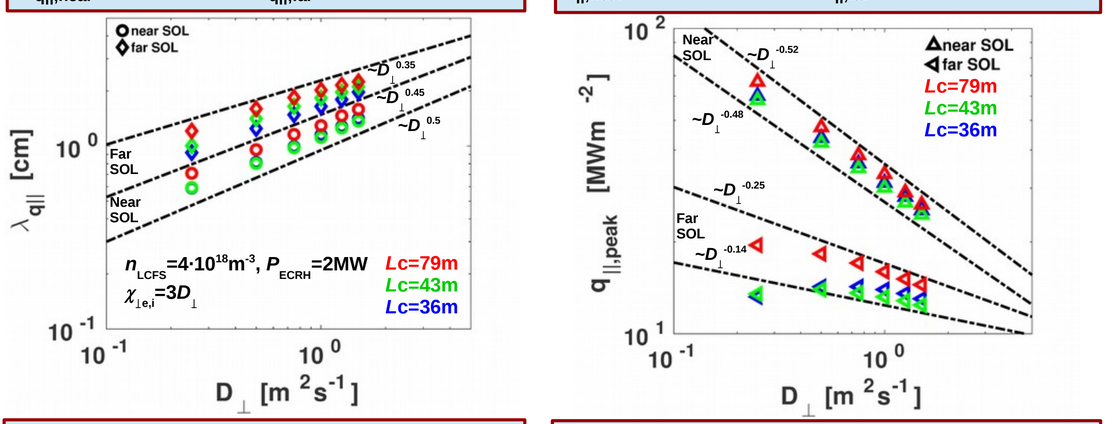
Limiter peak loads ~ far SOL $q_{||}$



Scan of anomalous $D_\perp$ shows somewhat simple SOL scaling of power flux level q_{peak} and power width $\lambda_{q||}$

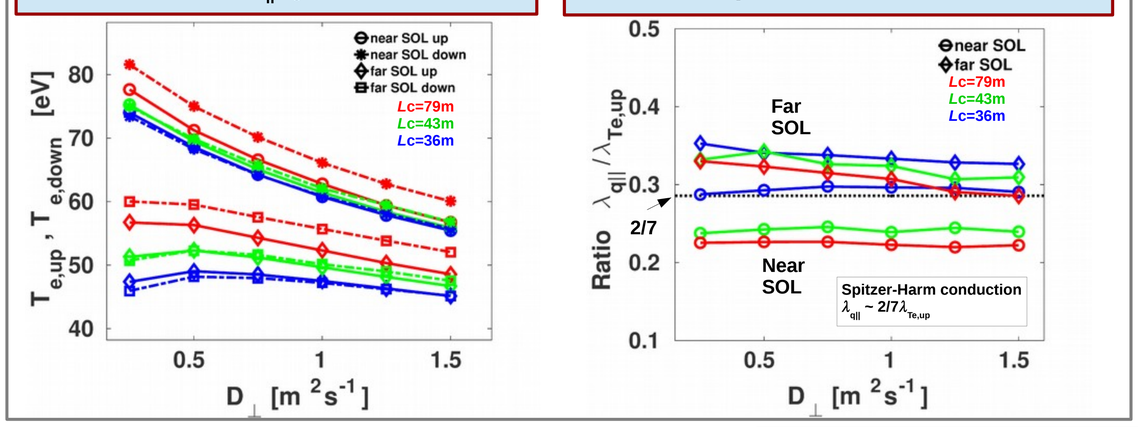
Power width $\lambda_{q||}$ increases with $D_\perp$ → $\lambda_{q||,near}$~0.6-1.6cm, $\lambda_{q||,far}$~0.9-2.3cm

Power levels decrease with $D_\perp$: $q_{||,near}$~67-25MWm^{-2}, $q_{||,far}$~12.4-19.5MWm^{-2}



No significant parallel temperature gradients (max. $\nabla_{||}T_e$~3/40eV/m)

Scaling of $\lambda_{q||}$ with upstream λ_{Te} deviates from ideal Spitzer-Harm relation

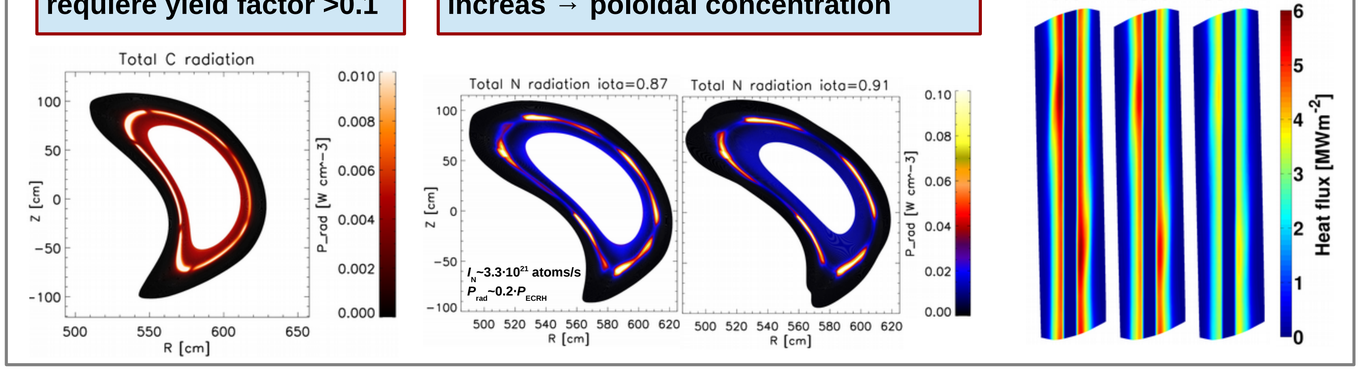


ι increase causes stronger poloidal localization of impurities and line emission due to local compression of long *L*c

Power losses >15% by eroded carbon would requiere yield factor >0.1

Seeded nitrogen accumulates in long connection lengths flux tubes, iota increas → poloidal concentration

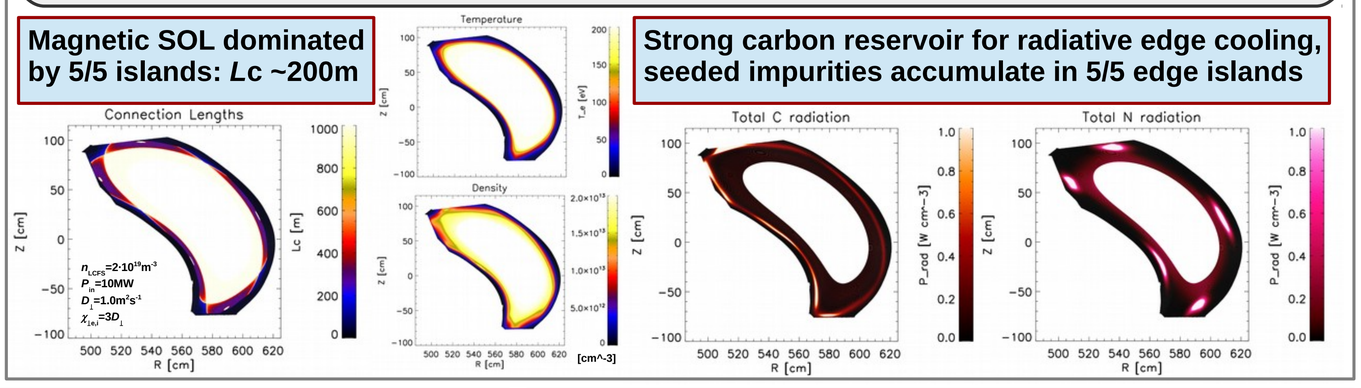
Heat load mitigation: (Power losses by N) 0% 10% 30%



Power flux mitigation by radiative edge cooling in future island divertor scenarios → strong accumulation in 5/5 islands

Magnetic SOL dominated by 5/5 islands: *L*c ~200m

Strong carbon reservoir for radiative edge cooling, seeded impurities accumulate in 5/5 edge islands



Conclusion:

- Startup field configuration facilitates the investigation of links between PSI and magnetic topology → 3D modeling and measurement show a strong correlation
- Near and far SOL feature different heat flux characteristics
- Heat flux characteristic shows scaling of $\lambda_{q||} \sim D_\perp^{\delta}$, δ=0.35-0.5 and $q_{||,peak} \sim D_\perp^{\varepsilon}$, ε~-0.5
- Downstream power width $\lambda_{q||}$ related to upstream T_e decay $\lambda_{Te,up}$ by scaling factor of 2.5-3.5
- Seeded impurities concentrate in longest flux tubes, stronger accumulation for increased ι and clear sub-confinement expected for considered 5/5 standard island divertor scenario

Ackowledgments:

This work was supported in part by the **U.S. Department of Energy (DoE)** under **grant DE-SC0014210** and by **start up funds** of the **Department of Engineering Physics** and of the **College of Nuclear Engineering at the University of Wisconsin - Madison**, USA.
This research was performed using the computer resources and assistance of the UW-Madison **Center For High Throughput Computing (CHTC)** and the high performance computing system "**Hydra**" of the **Max-Planck-Society at Rechenzentrum Garching (RZG)**.
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** under **grant agreement No 633053**. The views and opinions expressed herein do not necessarily reflect those of the European Commission.