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Laboratorio Nacional de Fusión

Ciemat

Heat transport and power balance analysis in AUG

D. Carralero[1,2], S. Artene[2], G. Birkenmeier[2,3], M. Faitsch[2], F. Laggner[2], P. Manz[2,3], P. deMarne[2], B. Sieglin[2], U. Stroth[2], M. Wischmeier[2], E. Wolfrum[2], the ASDEX Upgrade team[2]

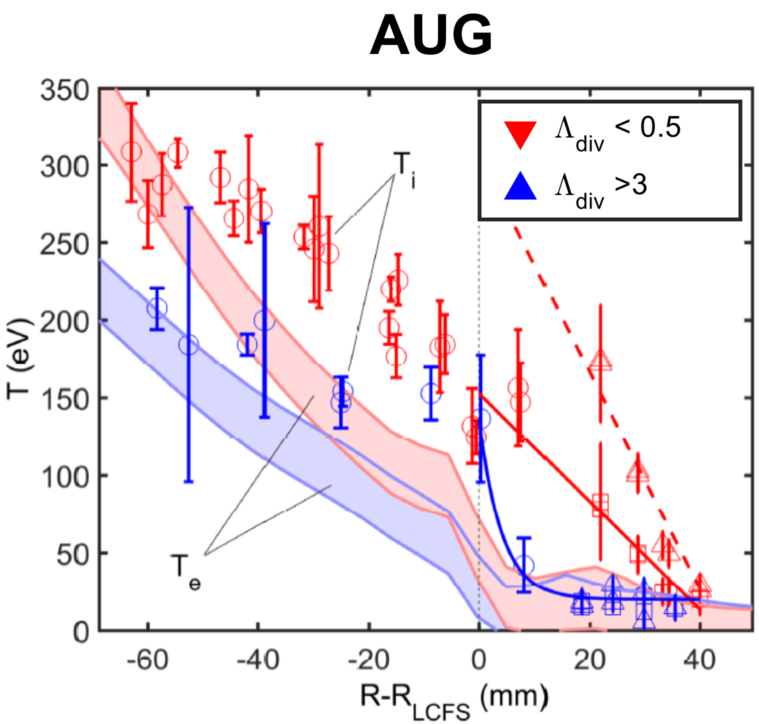
[1]Laboratorio Nacional de Fusión, Av. Complutense 40, 28040, Madrid, Spain.
[2]Max-Planck-Institut für Plasmaphysik, Garching, Germany.
[3]Physik-Department E28, Technische Universität München, Garching, Germany.

MST1 Topic 21 Meeting
May 17th 2018

A database of SOL measurements

In 2014-2016, around **30 L-mode discharges** were carried out in AUG with equivalent configuration. Data base of filament properties, I_{sat}, T_e, T_i profiles, etc.

D. Carralero et al. NF, 2014; D. Carralero et al., PRL, 2015; D. Carralero et al., NF, 2017.



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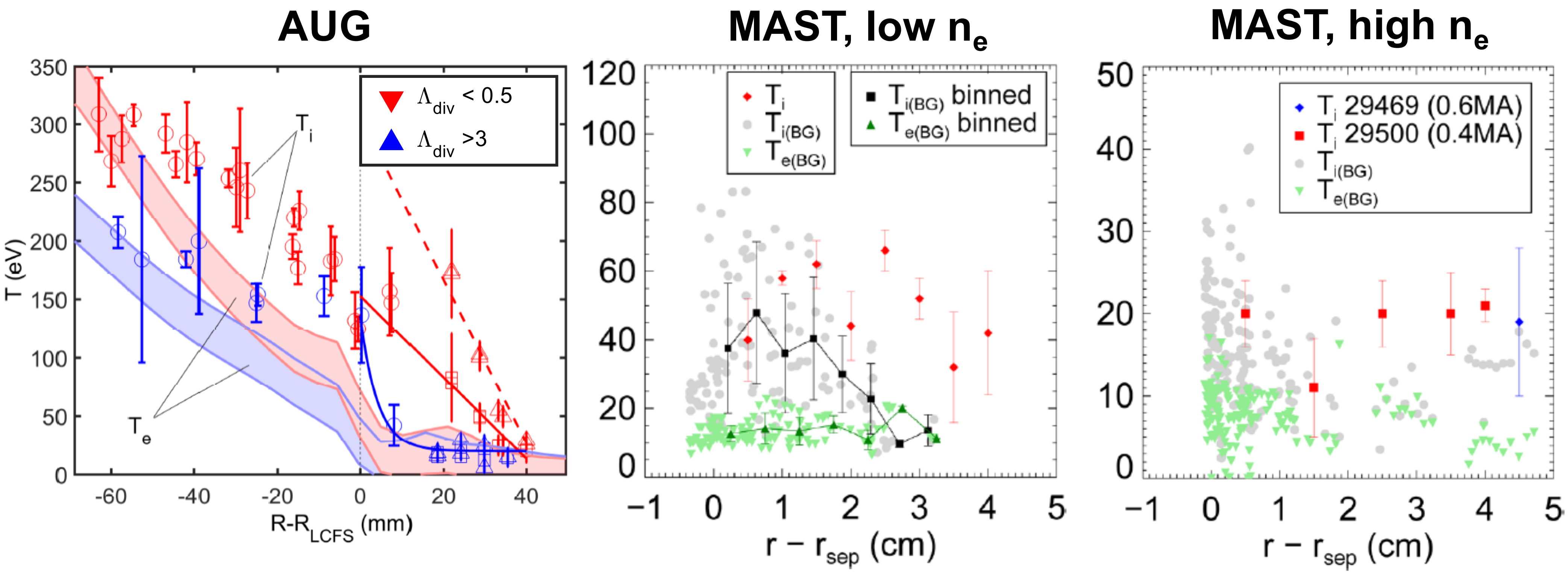

S.Y. Allan et al., PPCF, 2016

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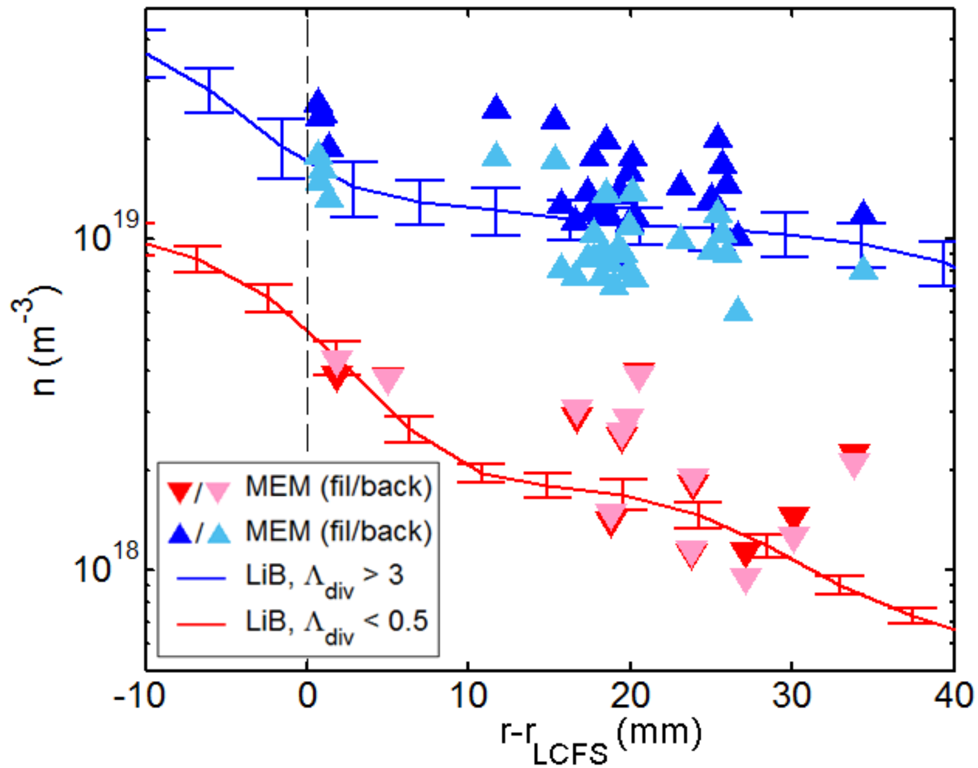
Data is **consistent** with other diagnostics:

$$n_e = \frac{2I_{sat}}{A_{probe}Z}\sqrt{\frac{T_e + T_i}{m_D}}$$



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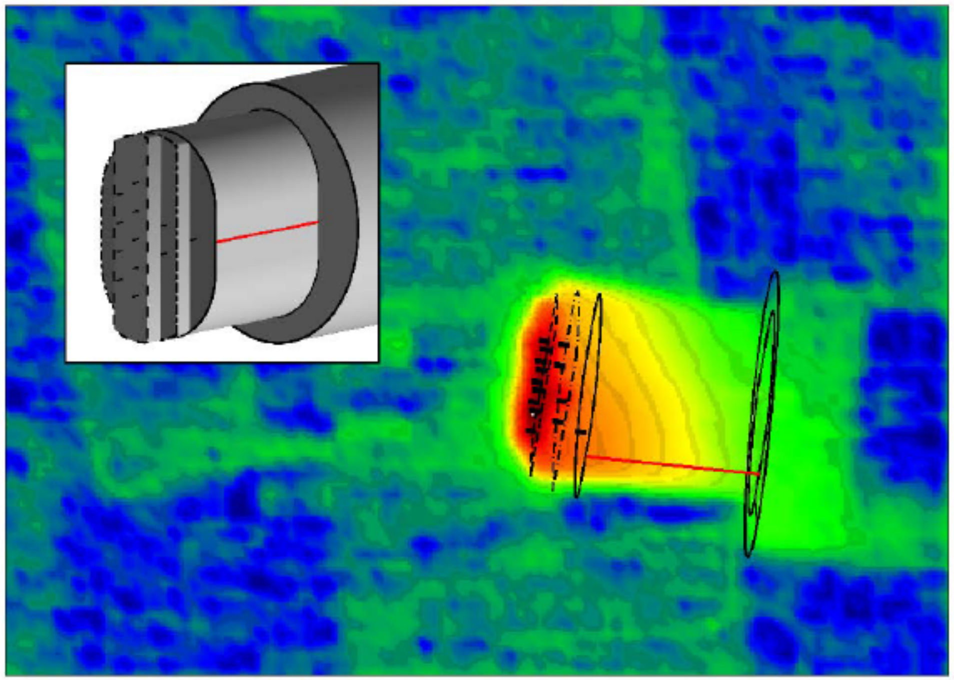
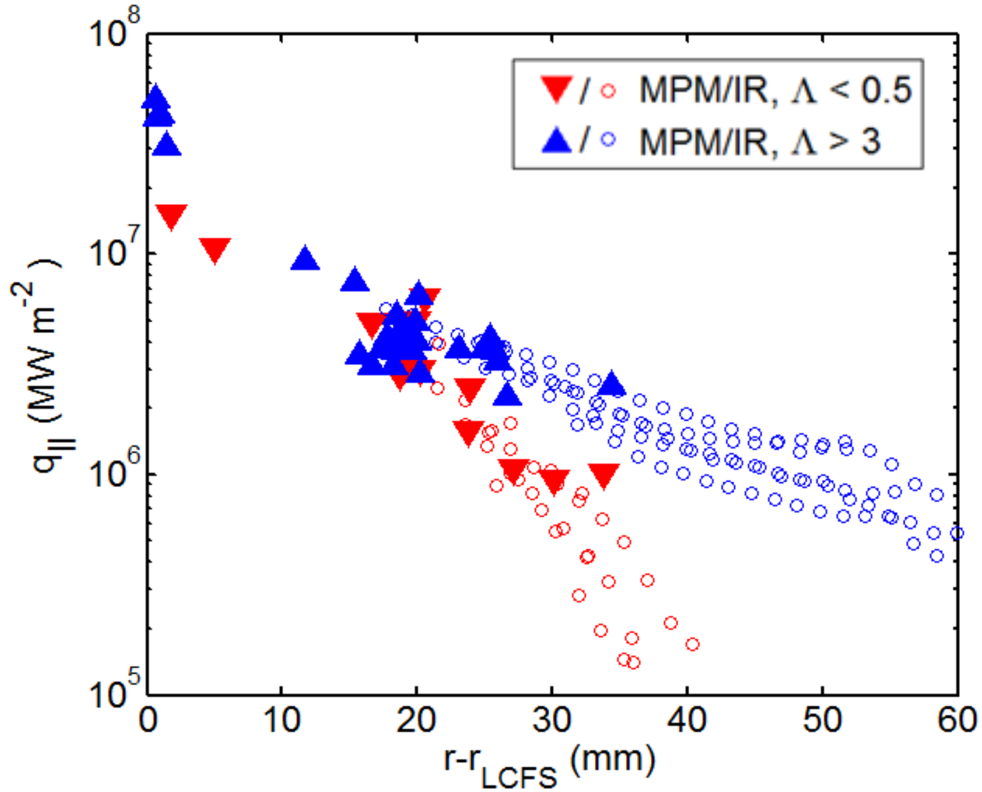
Data is **consistent** with other diagnostics:

$$q_W = \frac{I_{sat}}{A_{probe} Ze}(T_e[\gamma_i \tau_i (1 - R_E) + \gamma_e] + E_{rec})$$

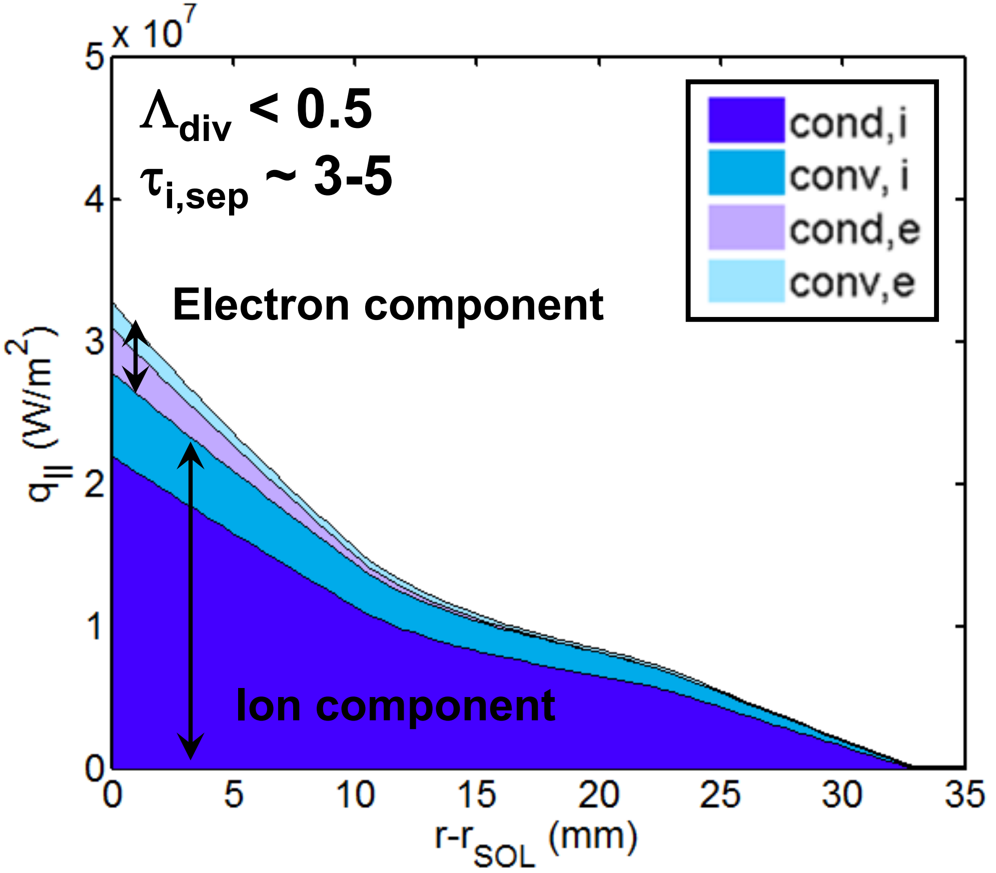


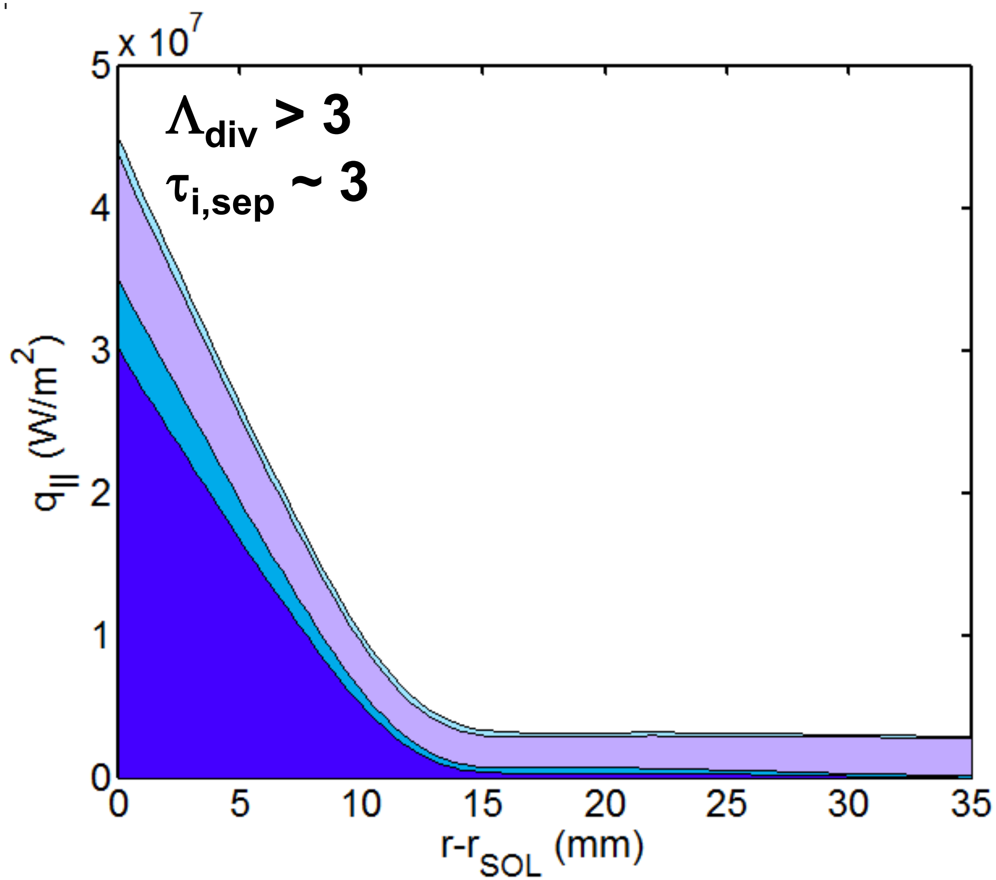


Parallel heat flux

Under these conditions, **ion conduction dominates parallel transport**.

$$q_{\|} = \frac{2}{7}\kappa_{0,i}\frac{T_i^{7/2} - T_{div}^{7/2}}{L_{\|}} + \frac{1}{2}nc_sM(5T_i + m_D(c_sM)^2) + \frac{2}{7}\kappa_{0,e}\frac{T_e^{7/2} - T_{div}^{7/2}}{L_{\|}} + \frac{5}{2}nc_sMT_e$$

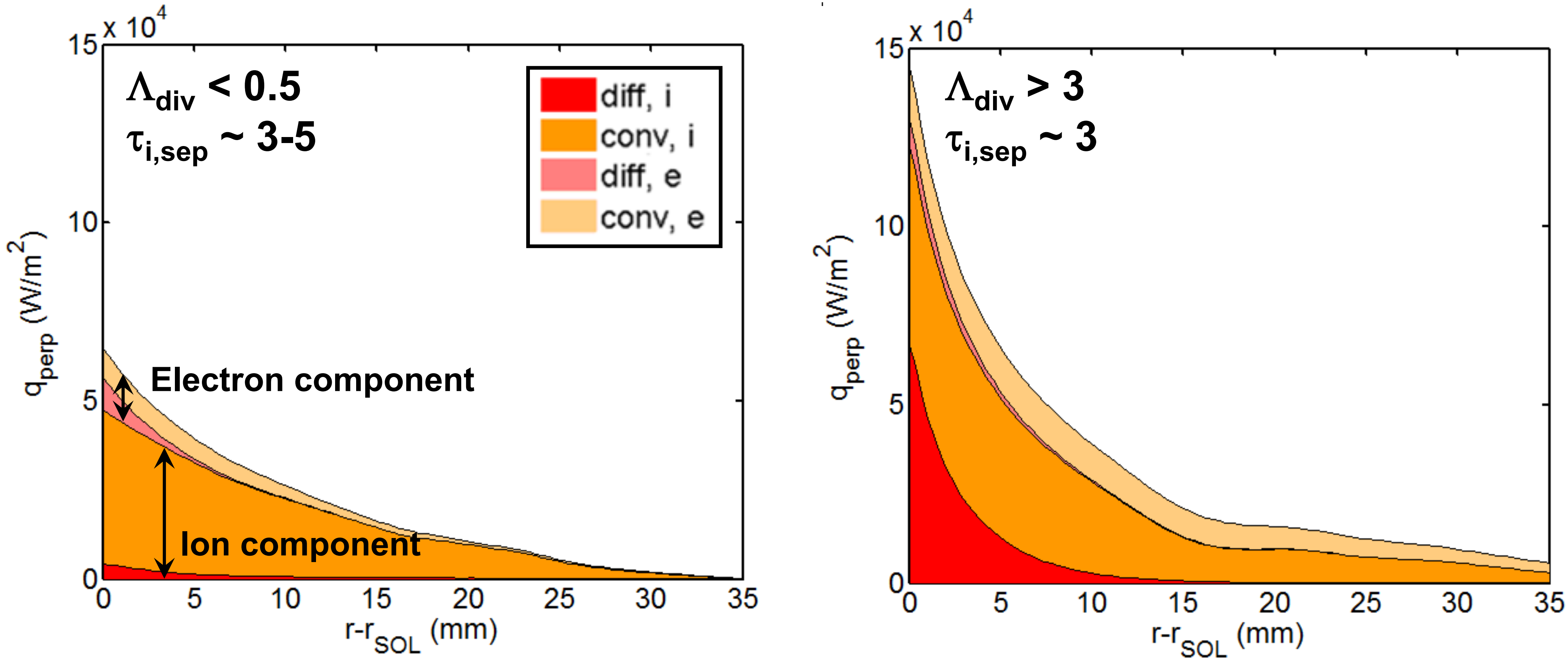




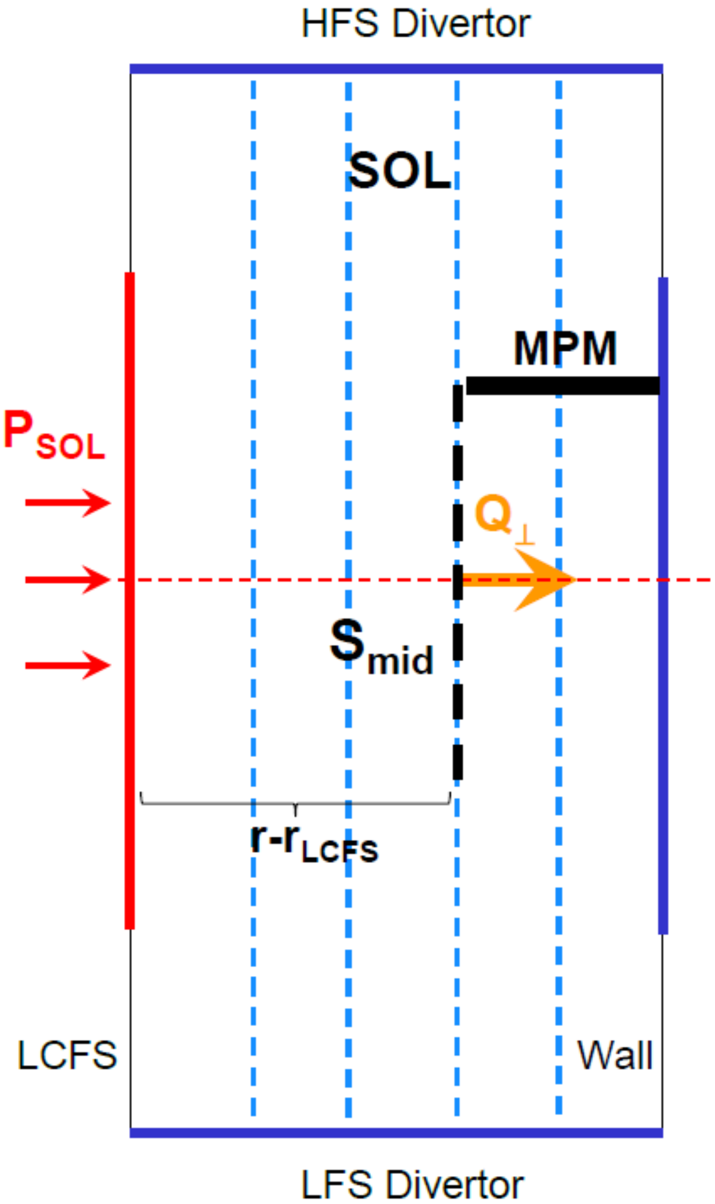
Perpendicular heat flux

Similarly, **ion convection dominates** perpendicular transport

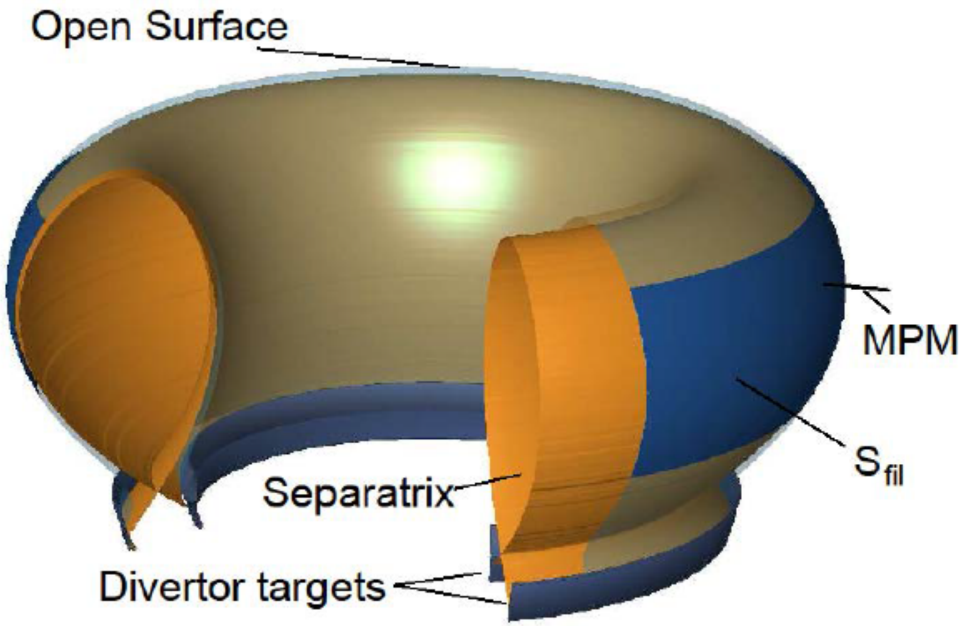
$$q_\perp = n\chi_i \nabla_\perp T_i + \frac{1}{2}\left(5\Gamma_{\perp,eff}T_{i,eff} + \Gamma_\perp m_D (c_s M)^2\right) + n\chi_e \nabla_\perp T_e + \frac{5}{2}\Gamma_{\perp,eff}T_{e,eff}$$



An estimation of global transport



For a given $r\text{-}r_{LCFS}$, a relevant surface for total midplane perpendicular transport can be defined, $Q_\perp = q_\perp S_{mid}$.



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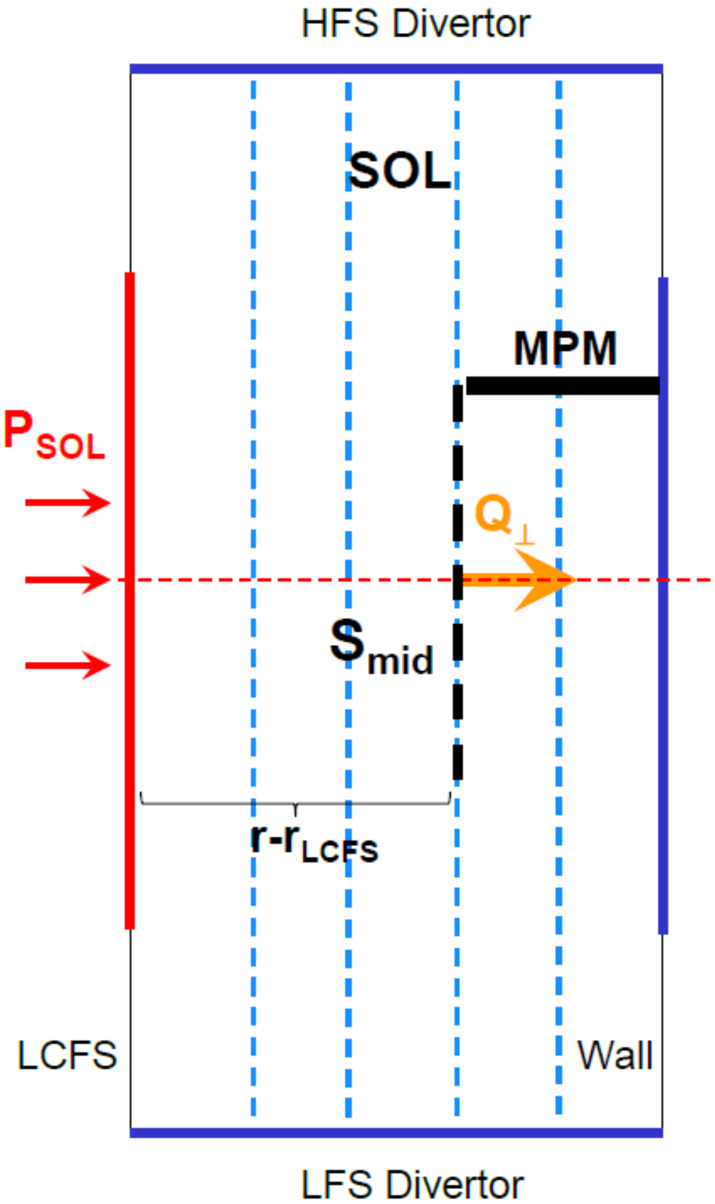
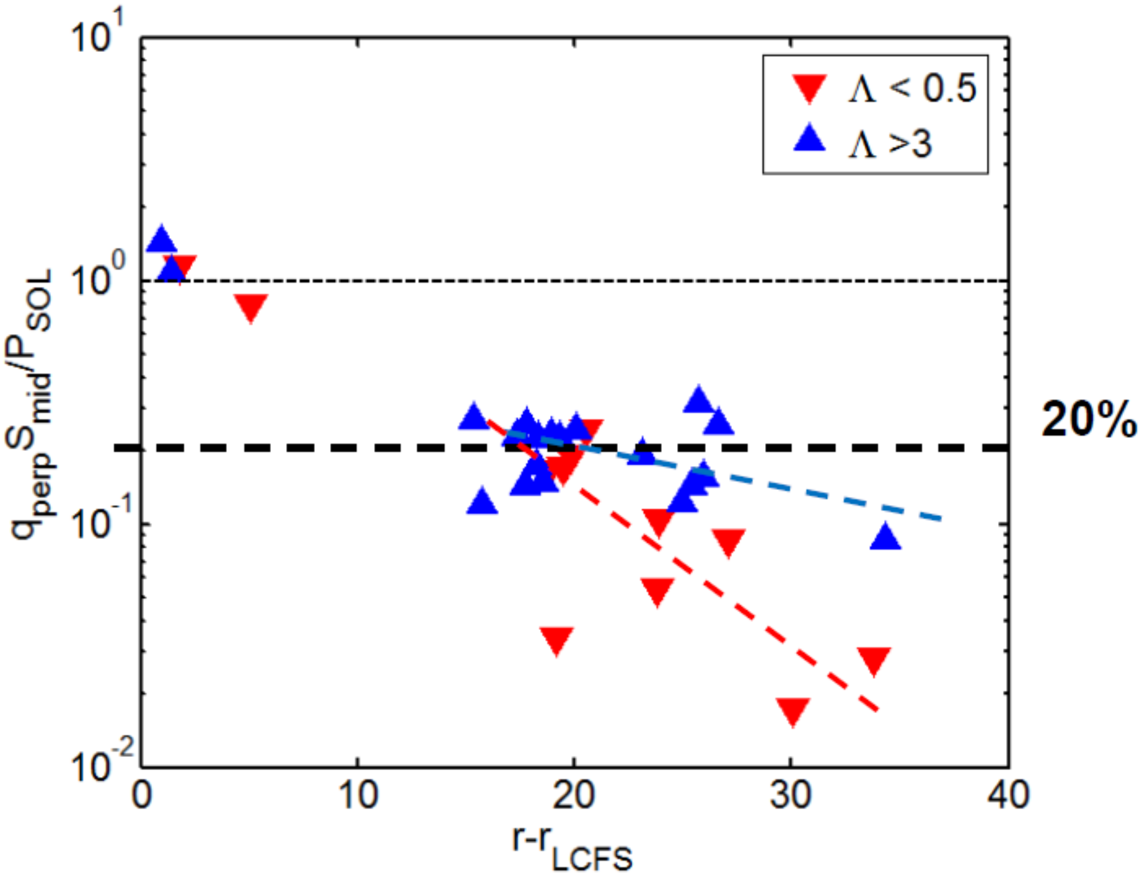


For a given r-r_{LCFS}, a relevant surface for total midplane perpendicular transport can be defined, $Q_\perp = q_\perp S_{mid}$.



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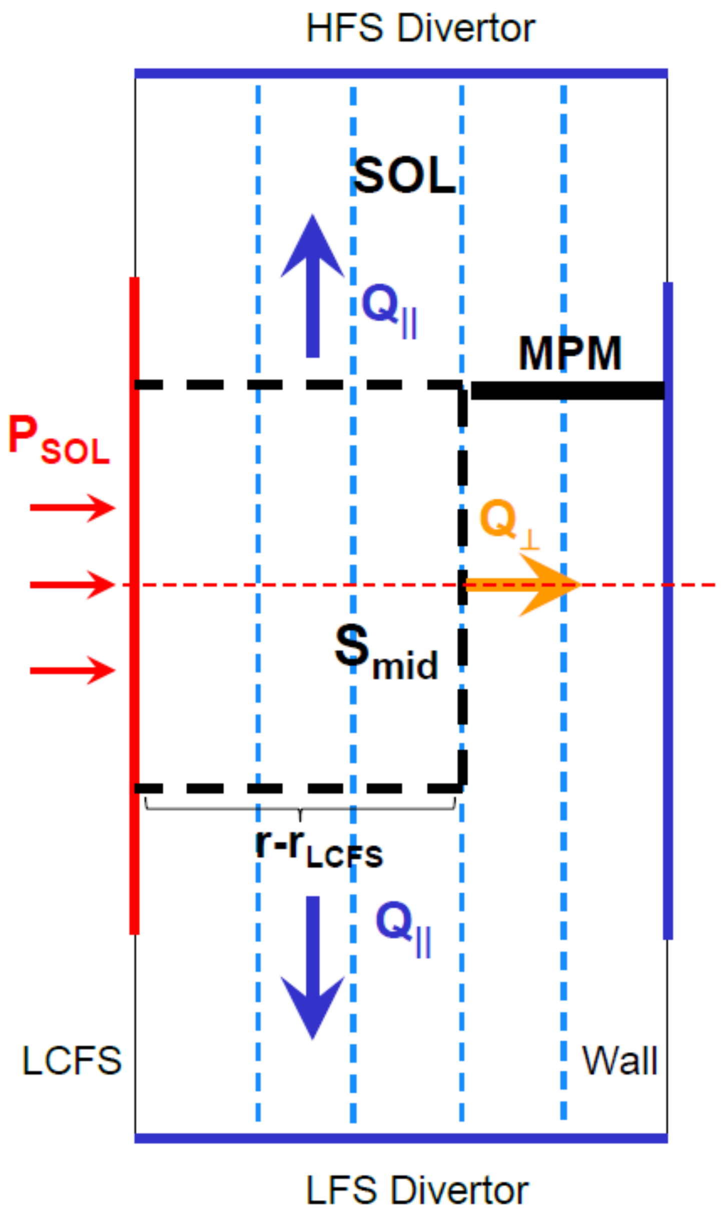


For a given r-r_{LCFS}, a relevant surface for total midplane perpendicular transport can be defined, $Q_{\perp} = q_{\perp}S_{mid}$.

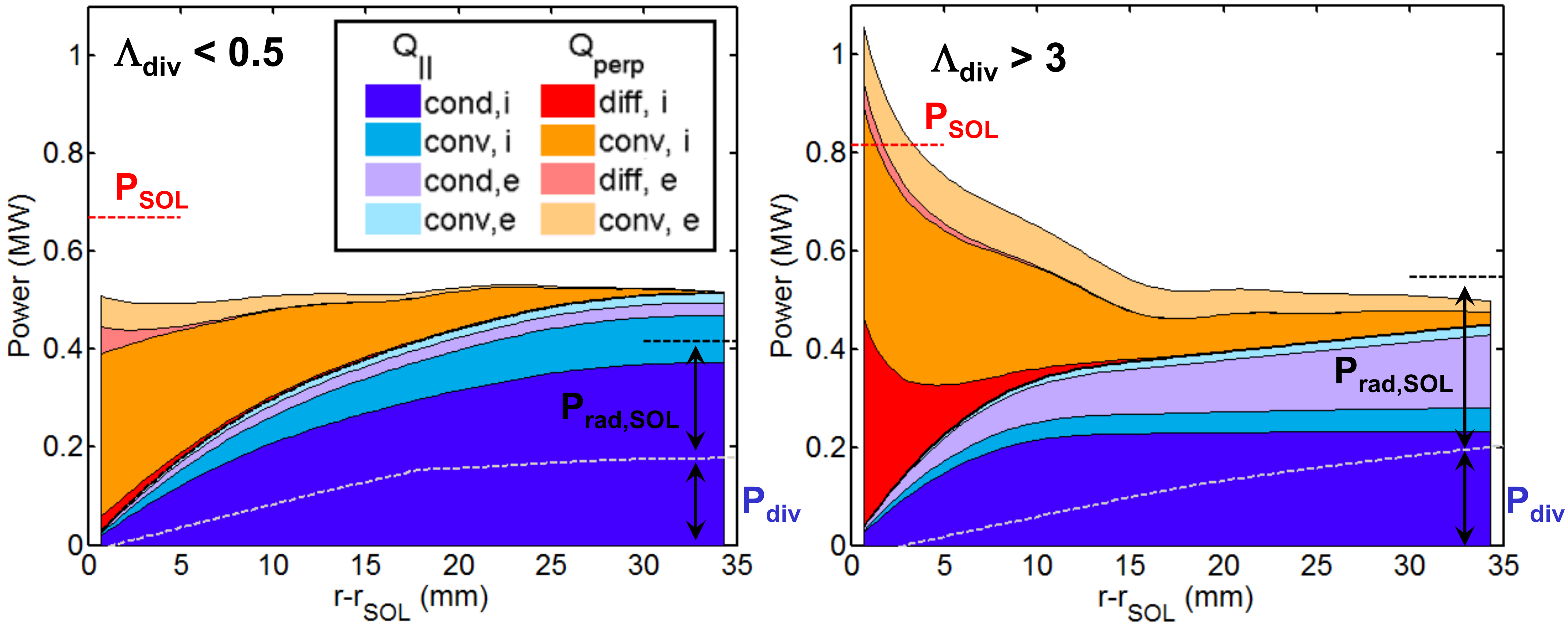
Finally, the total parallel flux leaving the midplane before the r-r_{LCFS} flux surface:

$$Q_{||}(r) = 2\pi \int_{r_{LCFS}}^{r} q_{||} \frac{B_z}{B} dr$$

Power balance can be done on the defined domain for each r-r_{LCFS}.

This is not the heat flux arriving onto the target!

Global transport: SOL power balance

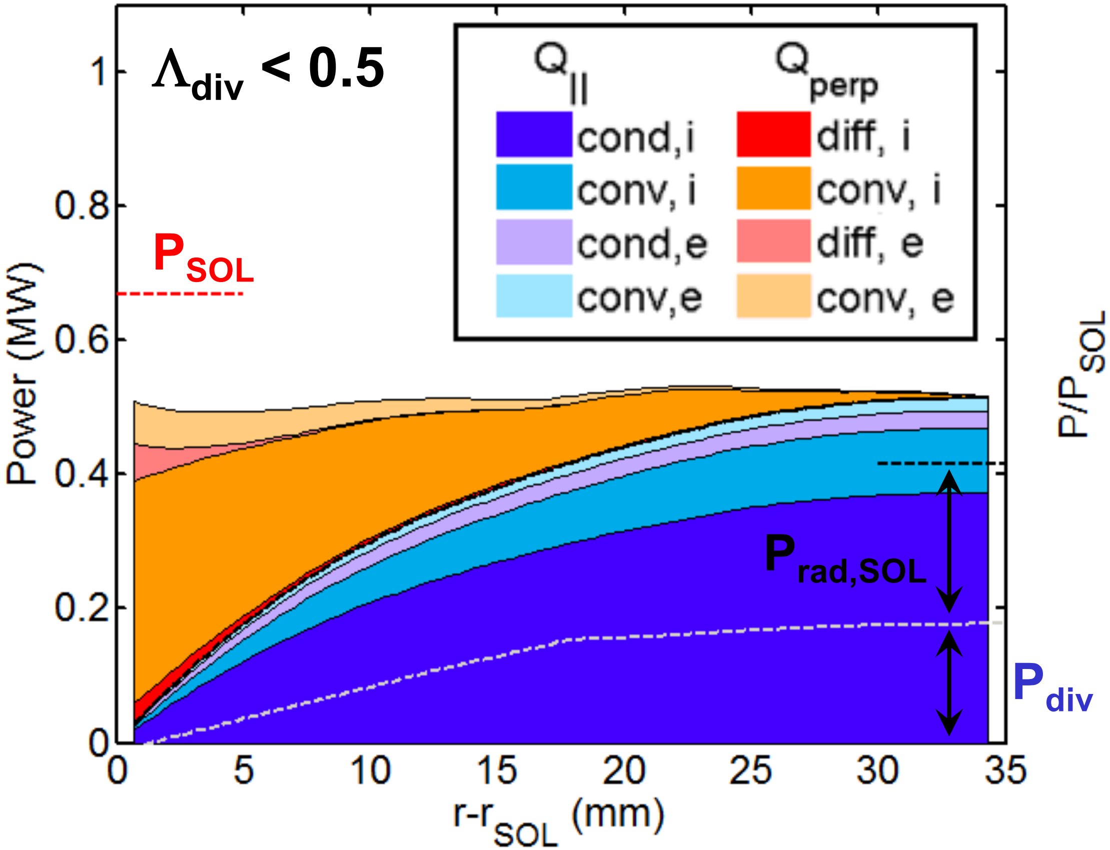


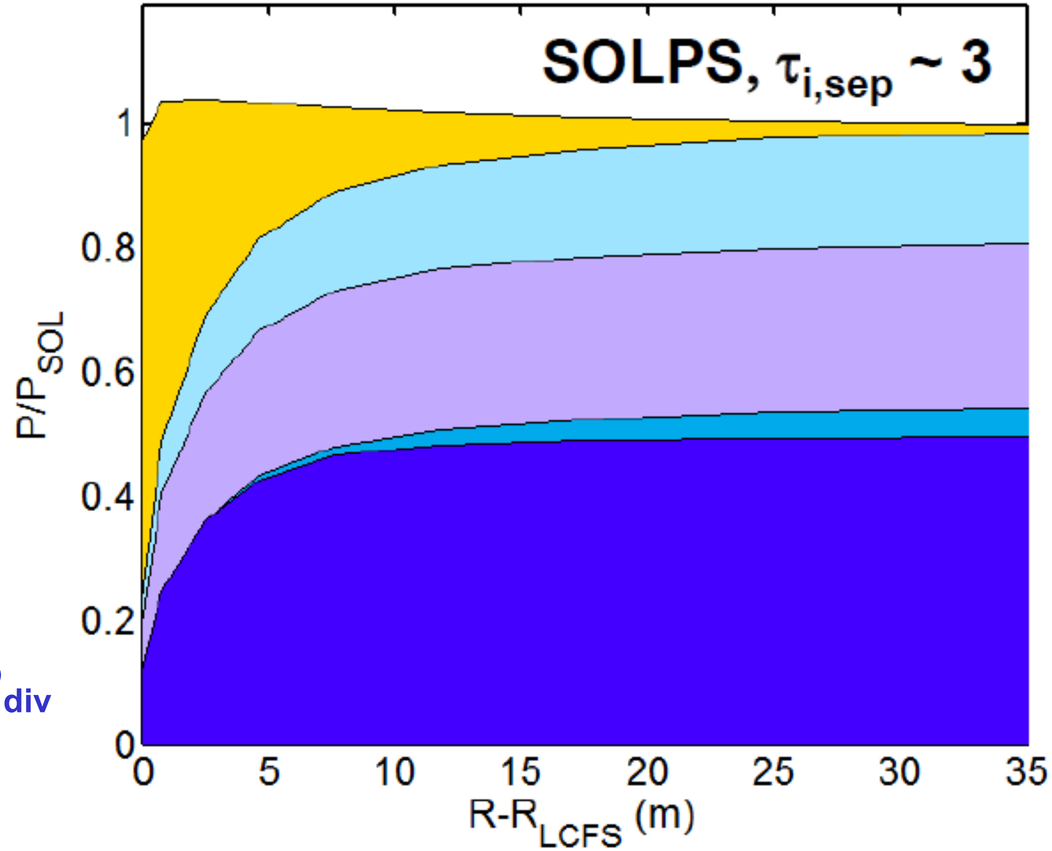
The **quantitative analysis makes sense**: total power input/output is matched within ~20%.

Main features are recovered:

- **Electron transport is not dominant**
- A substantial fraction of **P_{SOL} still remains in $Q_{\perp}$** for $r-r_{LCFS}$ ~ 20 mm

Global transport: Comparison to SOLPS





SOLPS simulations have been carried out to compare with the experimental power balance. No shoulder formation has been simulated yet, and only τ_i ~ 3 was achieved.

- We can see a qualitative agreement with experimental results.
- Just with **τ_i ~ 3, electron parallel transport is no longer dominant.**

This is still work in progress!

Outlook

Further lines of work from these results:

Experiment

- Improvement of T_i and T_e database.
- Power balance analysis of H-mode shoulder formation.
- Comparison of parallel transport results with probe/IR divertor data.

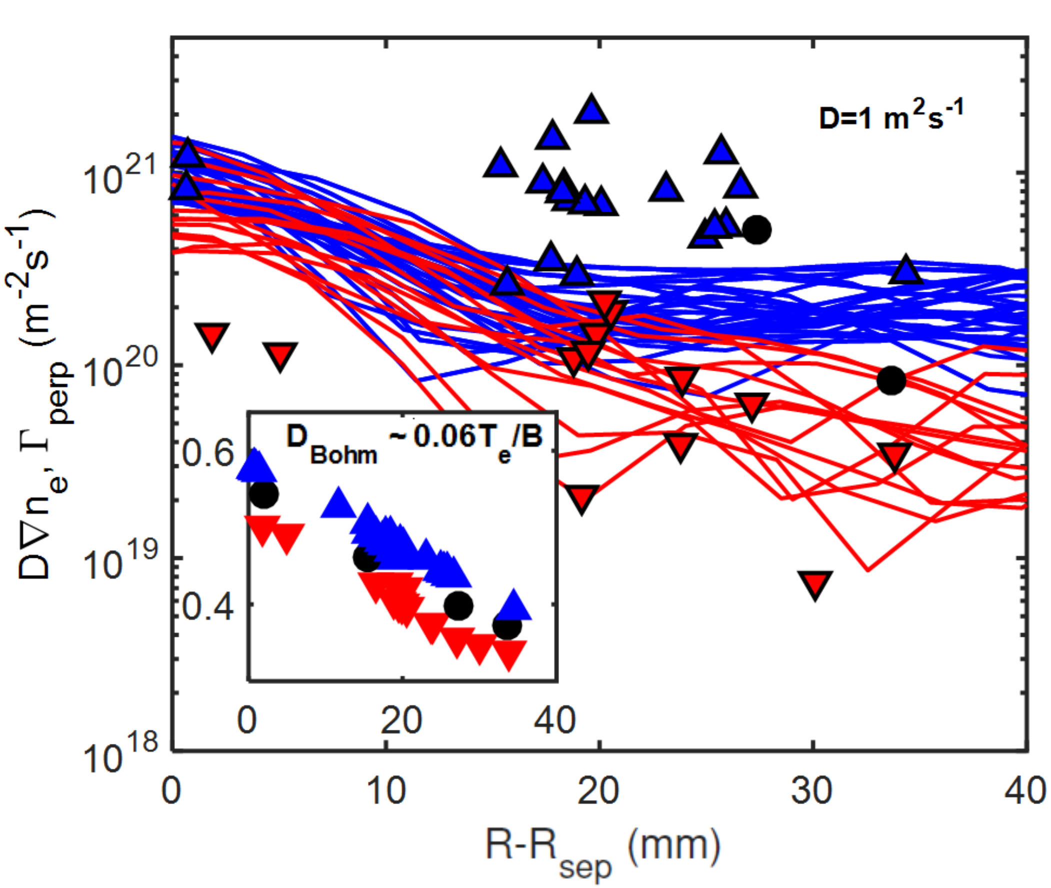
Modelling

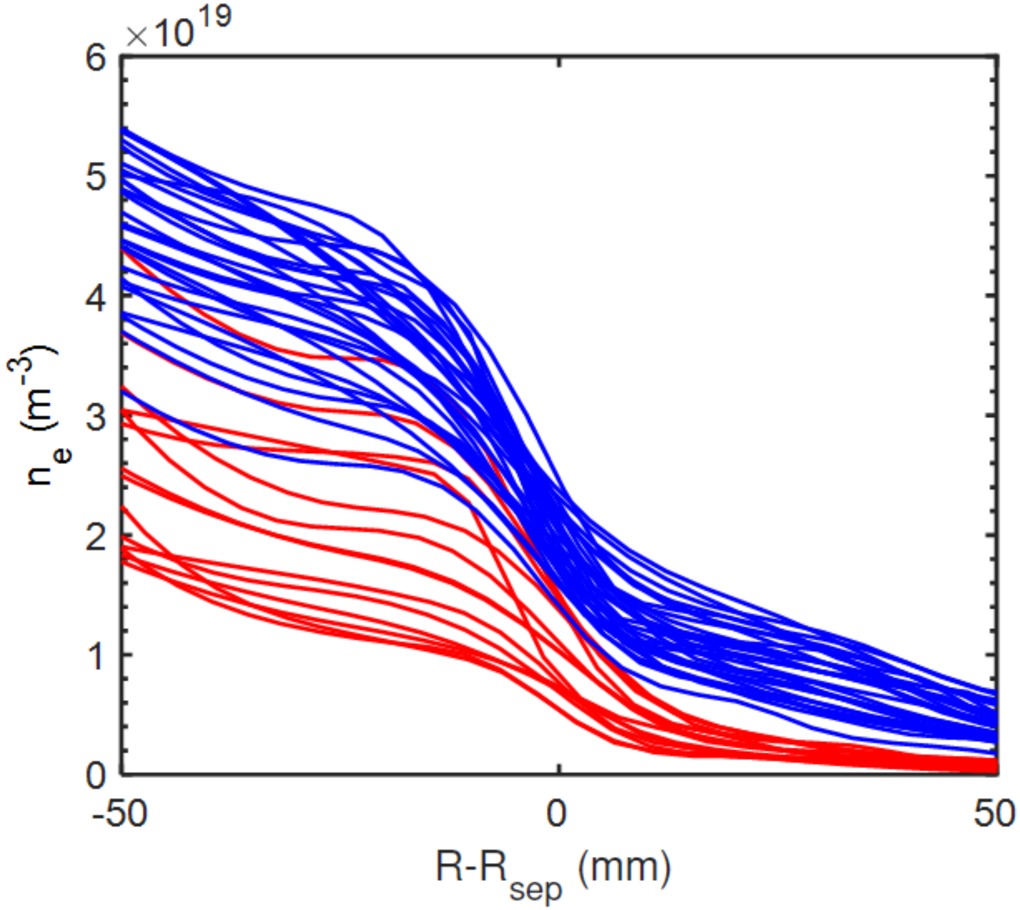
- Full development of equivalent SOLPS scenarios.
- Comparison of perpendicular transport to experimental values.
- Simulation of turbulent transport using HESEL/GEMR.
- Development of effective transport coefficient based on turbulence properties.
- EMC3-EIRENE simulation of neutral fluxes, incl. effect of ionization, CX, etc.

Finally, **implications of these results for ITER/DEMO** should be addressed.

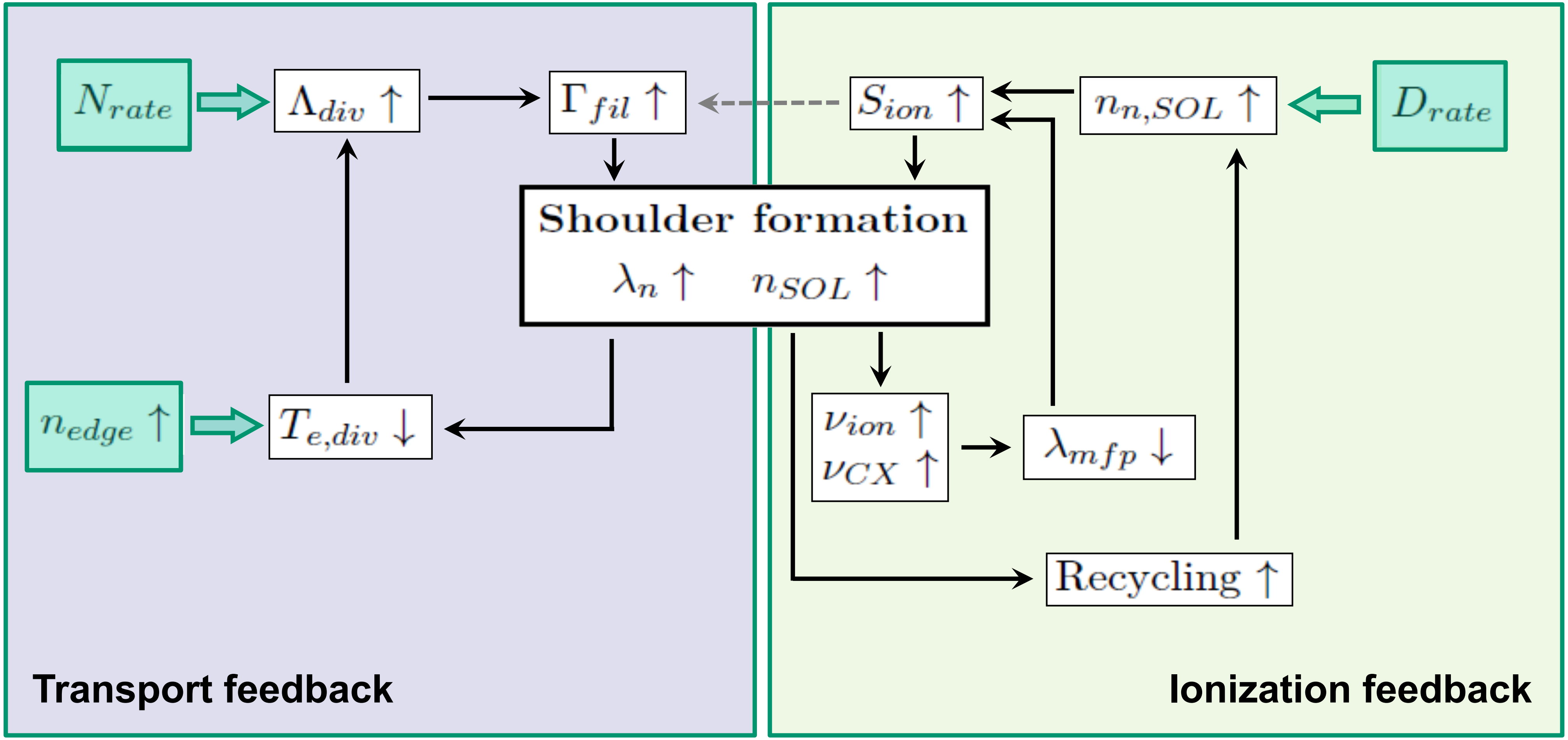
Additional Slides

Filamentary transport





A general framework



D. Carralero et al., NF, 2017.