Predictive transport code: status and plans

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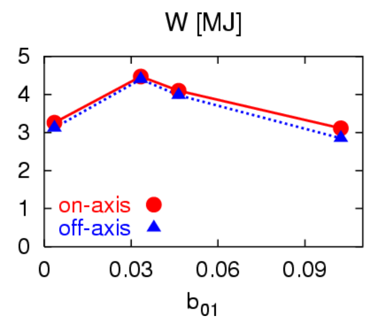
What is available? Status

Activity / Module	Status	Priority	Responsible
Numeric scheme, PDE Solver, **Initial framework ,** (GUI) ***Scenario Editor* must be designed**	Ready, used for modeling		**IPP**, Y. Turkin, W7-X Team
ECRH/ECCD module; **TRAVIS** code (GUI)	Ready,	**high**	**IPP**, N.Marushchenko, Turkin
NBI/NBCD module **NBI** code	Ready NBI, NBCD needed	**high**	**IPP**, Y. Turkin, H. Maaßberg
Neoclassical transport modeling, Neoclassical Database	Ready, coef. for several conf. DB is needed	**high**	**IPP**, C. Beidler, H. Maaßberg, Collaboration with **PPPL**, **NIFS, CIEMAT, TU-Graz, KIPT-Kharkov**
Magnetic Configuration Database (**MCDB**)	Ready, testing, filling phase	**high**	**IPP**, A.Dinklage, E3-Applied Theory, W7-X Team, XDV
Geometry module (**MCONF**) **MCviewer** code (GUI)	Ready	**high**	**IPP**, Y. Turkin, A.Werner, & W7-X Team
Equilibrium, Function Parameterization	In good progress	**high**	**IPP**, J.Geiger
Anomalous transport	Started	**high**	**IPP**, R.Kleiber

Simulation done

- Neoclassical DB initiated



- Neoclassical confinement has been modeled

  transport dependencies on magnetic configuration

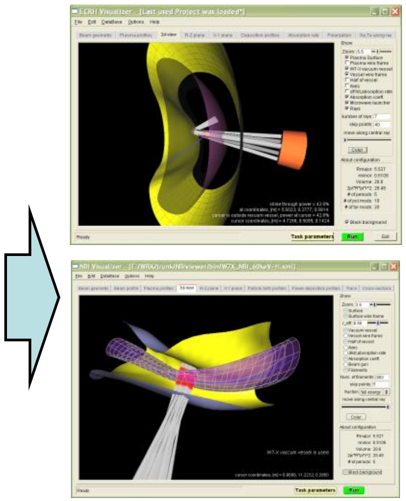
- Current evolution studied: more modeling is needed (W7-X 10sec initially)

- Ray tracing code TRAVIS is coupled with the transport code and used for modeling of heating and Current Drive for X2, X3, and O2 ($n>10^{20}m^{-3}$), self-consistent CD modeling (for current control)

- NBI modeling possible (birth profile, power deposition)

- Modules as stand alone projects -- this concept is realized

- Profile collection initiated (IPP internal network; WIKI page)



Collection of Plasma Profiles

ECRH; configuration scan; Diffusion model: DKES database - Microsoft Internet Explorer

Datei Bearbeiten Ansicht Favoriten Extras ?

Zurück Suchen Favoriten

Adresse D:\WIKI.W7X-transport.ipp.mpg.de\Transport_Modeling\ECRH_magConf_scan\configuartionScan.html Wechseln zu

updated August 2, 2007
updated September 10, 2007

Transport and Bootstrap Current in W7-X

C.D.Beidler, H.Maaßberg, Y. Turkin

The simulations have been done by TransportCode using Neoclassical Database for the following magnetic configuration:
w7x-lm1, w7x-sc1, w7x-sc1-beta=2%, w7x-sc1-beta=4%, w7x-hm1

$X_{anomalous}[m^2/s] = 7x10^{18}/n[m^{-3}]$ at the edge only

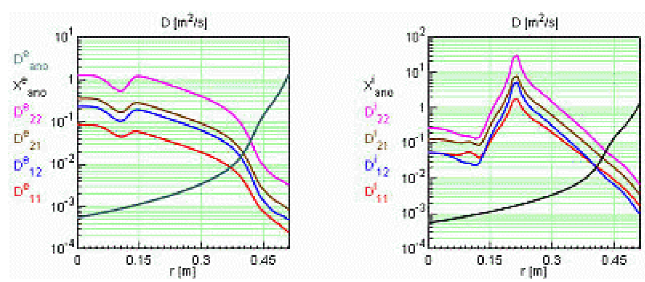
small contribution of anomalous diffusion to transport

4MW ECRH at $n_e = 0.7 \cdot 10^{20} m^{-3}$

on-axis deposition with large E_r >0 in center

off-axis deposition with large E_r >0 in center

off-axis deposition with small E_r <0 in center

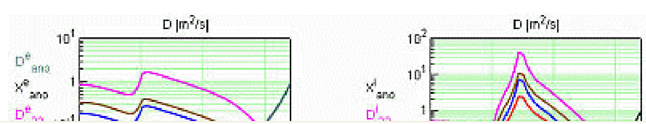


updated August 2, 2007

$X_{anomalous}[m^2/s] = 7x10^{18}/n[m^{-3}]$ at the edge only

small contribution of anomalous diffusion to transport

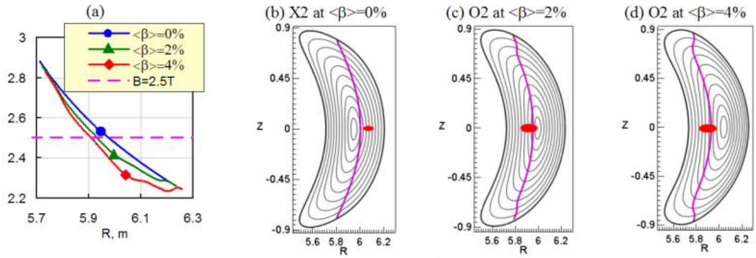
10MW ECRH at $n_e = 10^{20} m^{-3}$



Arbeitsplatz

Outlook

- Continue creating of W7-X profile collection for various parameters/ configurations/scenarios; move to real DB (A.Dinklage, H.Funaba)
- Extend neoclassical DB, attach to Magn. Conf. DB (MCDB)
- Use Func.Param. for equilibrium – beta effects are important for ECRH

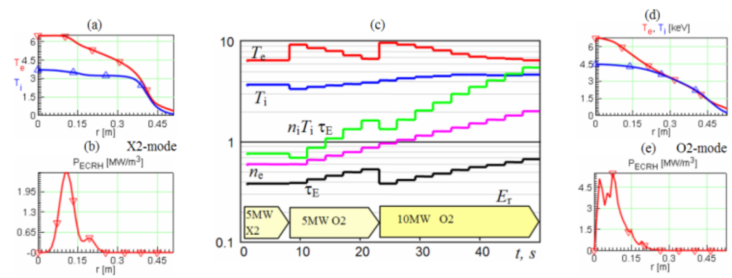


- Self-consistent modeling with density evolution included:

  anomalous transport for particle.

- Some means for scenario description; like in real experiment: events/actions/feedback/forward control

  (Mathlab – Simulink ??)



- Benchmark neoclassic

Proposal for benchmarking of thermal neoclassical transport coefficients

Motivation

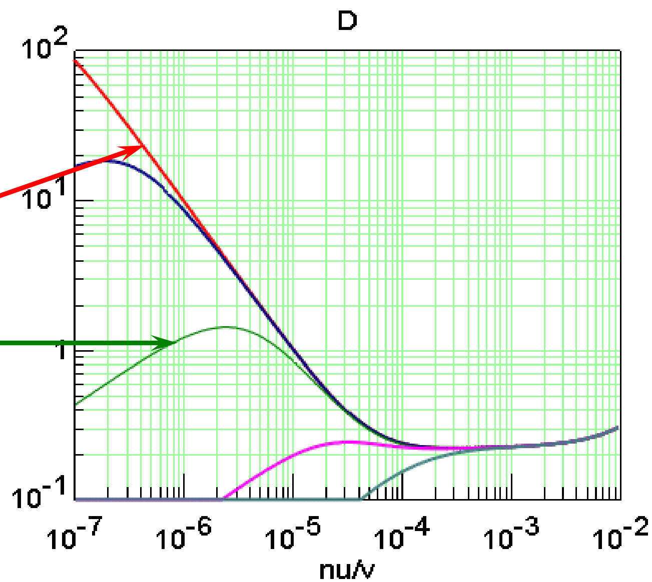
- Monoenergetic diffusion coefficients are successfully benchmarked

$$\frac{1}{D} = \frac{1}{D_{1/\nu}} + \frac{1}{D_{\sqrt{\nu}}} + \frac{1}{D}$$

$$D_{1/\nu} \propto \left(\varepsilon_{eff}\right)^{3/2} \frac{T^2}{\nu}$$

$$D_{\sqrt{\nu}} \propto \frac{\sqrt{\nu}}{E_r^{3/2}} T^2$$

$$D_{\nu} \propto \frac{\nu}{E_r^2} T^2$$



In the frame of International collaboration on Neoclassical transport.
C. Beidler, H. Maassberg, PPPL, ORNL, NIFS, CIEMAT, TU-Graz, KIPT-Kharkov

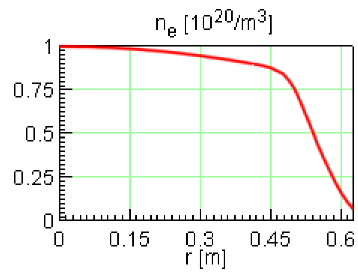
- Time to do testing of thermal/full transport matrix

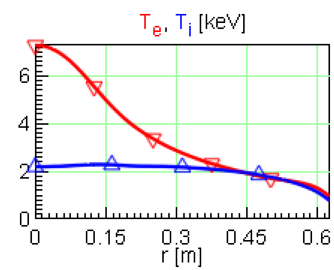
Motivation

We propose to start benchmarking of thermal neoclassical transport coefficients

1. Numerical experiment using predictive modeling – (IPP Greifswald)

Plasma profiles





2. LHD and TJ-2 teams analyze these profiles using their transport software:

DCOM/NNW and MOCA

- We (IPP Greifswald) need this to be confident in our transport modeling
- We are not intent to do a lot of simulations for foreign machines

Thermal transport matrix

Neoclassical transport matrix **D** is the energy convolution of monoenergetic coefficients produced by DKES / DCOM / MOCA runs.

$$\begin{bmatrix} \dfrac{\Gamma_\alpha^{neo}}{n_\alpha} \\ \dfrac{q_\alpha^{neo}}{n_\alpha T_\alpha} \\ \dfrac{j_{bs}^a}{e\, z_\alpha\, n_\alpha} \end{bmatrix} = -\begin{bmatrix} D_{11}^\alpha & D_{12}^\alpha \\ D_{21}^\alpha & D_{22}^\alpha \\ D_{31}^\alpha & D_{32}^\alpha \end{bmatrix} \cdot \begin{bmatrix} \dfrac{n'_\alpha}{n_\alpha} - \dfrac{z_\alpha E_r}{T_\alpha} \\ \dfrac{T'_\alpha}{T_\alpha} \end{bmatrix}$$

$$D_{11}^a = \frac{2}{\sqrt{\pi}} \int_0^\infty dx\ x^{1/2} D(x) e^{-x}$$

- Typical file created by running DKES:

  contains ~3000 records $D(\mathrm{r}, \mathrm{E_r/v}, \nu/\mathrm{v})$
- Interpolation routine (Greifswald) or Neural network technique (NNW)
- Integrating with Maxwell distribution function

Transport matrix depends on plasma profiles

$$\mathbf{D} = \mathbf{D}\left(r, n_\alpha, T_a, E_r, z, z_{eff}\right)$$

Transport Equations

$$\frac{\partial n_e}{\partial t}+\frac{1}{V'}\frac{\partial}{\partial r}V'\Gamma_e=S\ ,$$

$$\frac{3}{2}\frac{\partial n_e T_e}{\partial t}+\frac{1}{V'}\frac{\partial}{\partial r}V'Q_e=-E_r\Gamma_e+P_e,$$

$$\frac{3}{2}\frac{\partial n_i T_i}{\partial t}+\frac{1}{V'}\frac{\partial}{\partial r}V'Q_i=E_r z_i\Gamma_i+P_i,$$

$$\frac{\partial E_r}{\partial t}-\frac{1}{V'}\frac{\partial}{\partial r}V'D_E\left(\frac{\partial E_r}{\partial r}-\frac{E_r}{r}\right)=\frac{|e|}{\varepsilon}\left(\Gamma_e-z_i\Gamma_i\right),$$

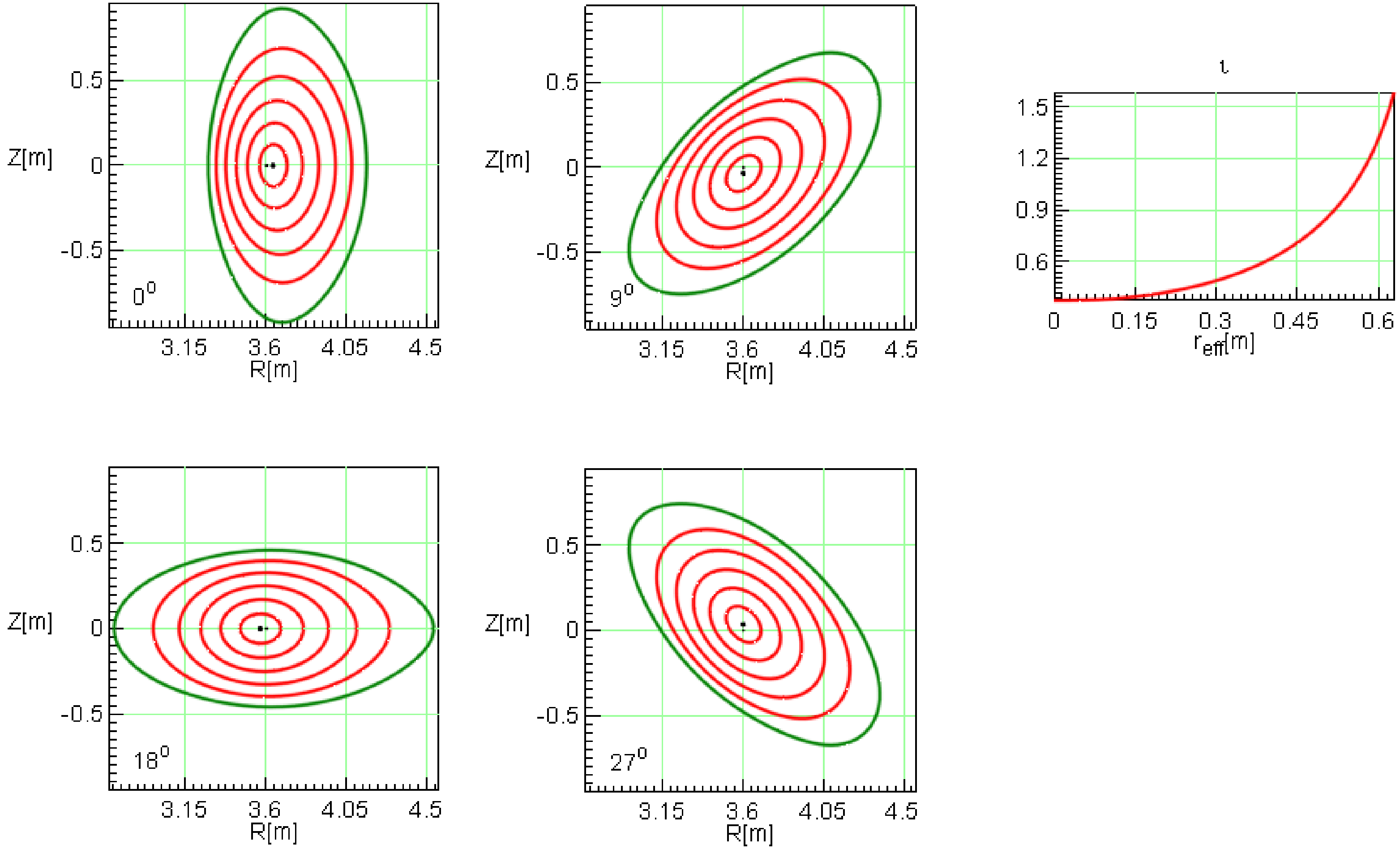
$$\Gamma_\alpha=\Gamma_\alpha^{neo}+\Gamma_\alpha^{an},\quad Q_\alpha=Q_\alpha^{neo}+Q_\alpha^{an},\qquad \alpha=e,i$$

$$\Gamma_\alpha^{neo}=-n_\alpha\left[D_{11}^\alpha\left(\frac{n_\alpha'}{n_\alpha}-\frac{z_\alpha E_r}{T_\alpha}\right)+D_{12}^\alpha\frac{T_\alpha'}{T_\alpha}\right],\qquad Q_\alpha^{neo}=-n_\alpha T_\alpha\left[D_{21}^\alpha\left(\frac{n_\alpha'}{n_\alpha}-\frac{z_\alpha E_r}{T_\alpha}\right)+D_{22}^\alpha\frac{T_\alpha'}{T_\alpha}\right],$$

$$\Gamma_\alpha^{an}=-D^{an}n_\alpha',\qquad Q_\alpha^{an}=-\chi_\alpha^{an}n_\alpha T_\alpha'+\frac{5}{2}\Gamma_\alpha^{an}T_\alpha$$

lhd_boz10.r360q100b004a8020 inward shifted **LHD**

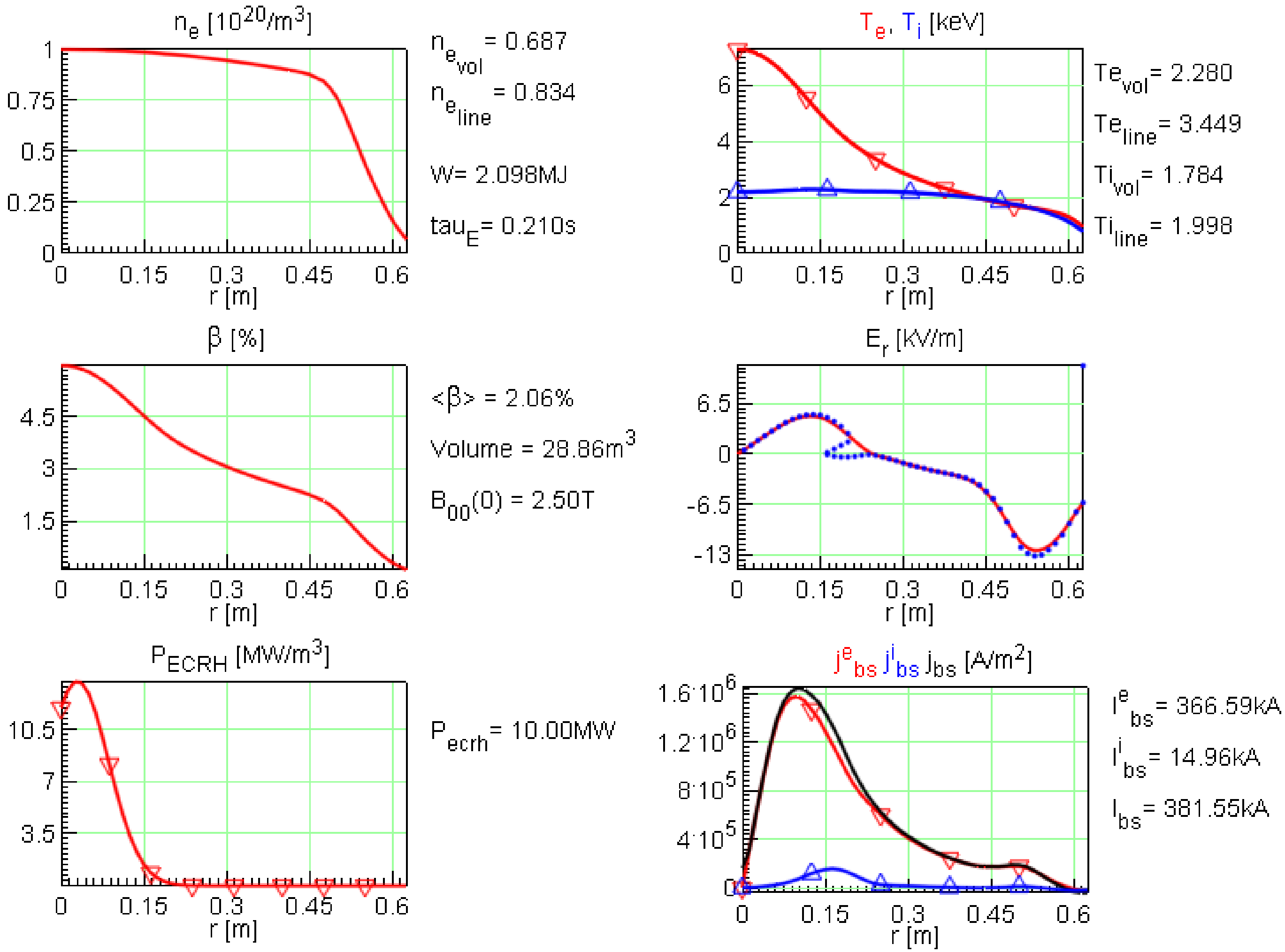
R_{ax} = 3.6   a = 0.63   Volume = 28.9m^3 Edge iota = 1.6



lhd-360n.dk -- neoclassical data calculated with DKES3 by H. Maassberg
contains ~2800 records *D*(r, Er/v, ν/v)

Plasma profiles

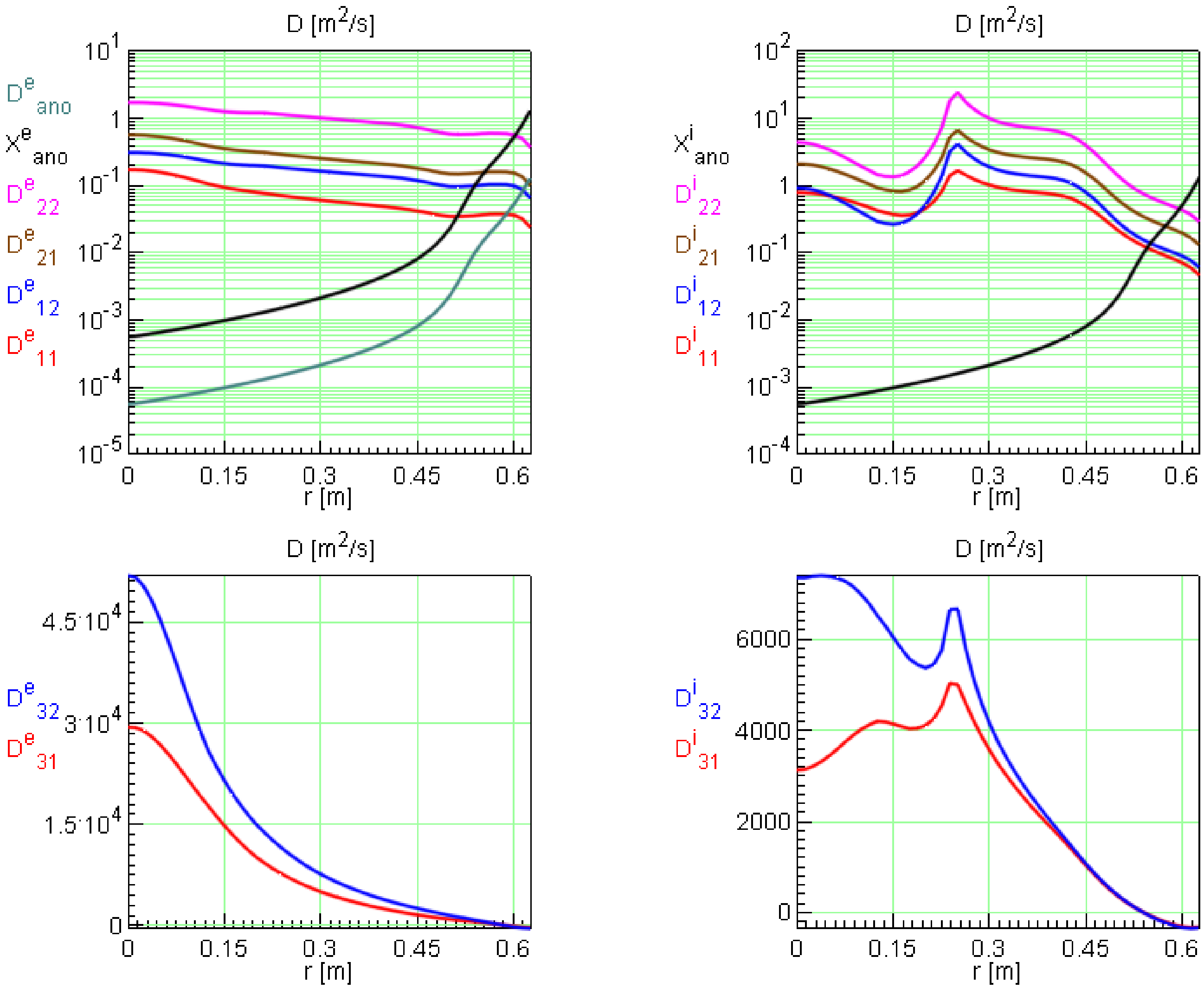
LHD



Have been sent to S. Murakami

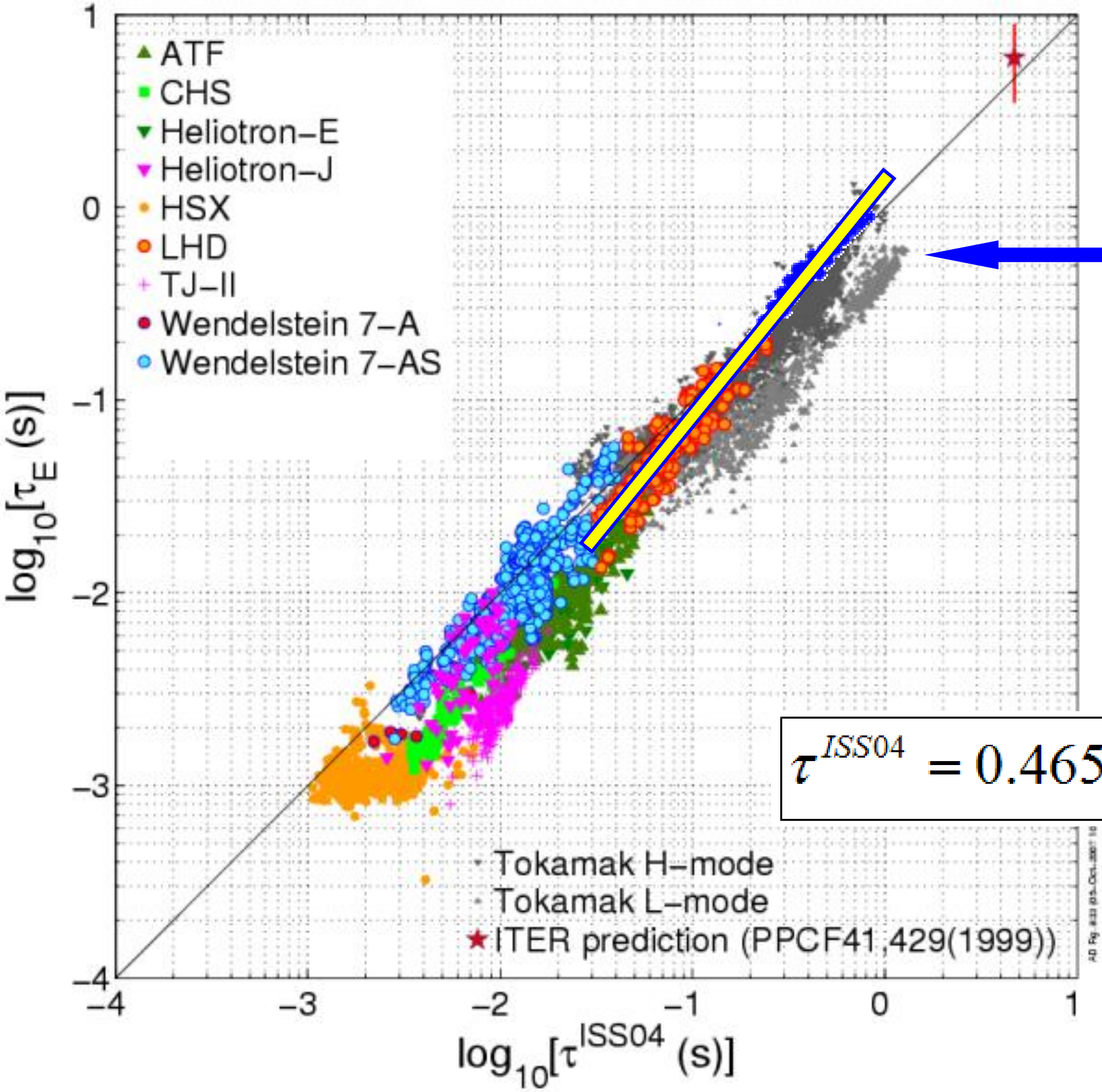
Plasma profiles

LHD



Curiosity led me to look at τ_E scaling

LHD



Scan:
n = (0.4 – 1) x $10^{20}m^{-3}$
P = (1 – 4) MW
B = 3T
Configuration:
lhd_boz10.r360q100b004a8020

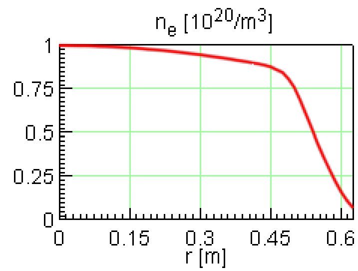
$$\tau^{ISS04} = 0.465\, a^{2.28} R^{0.64}\ P^{-0.61}\ n^{0.54}\ B^{0.84} \iota_{2/3}^{0.41}$$

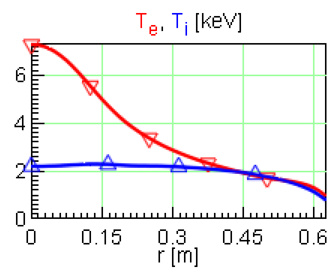
Summary

Benchmarking of thermal neoclassical transport coefficients

1. Numerical experiment using predictive modeling – (IPP Greifswald)

Plasma profiles





2. LHD and TJ-2 teams use these profiles in their transport analysis software:

DCOM/NNW and MOCA