# Realistic 1D Scrape-off Layer Simulation

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## Introduction

In this paper we report on realistic 1D simulations of the main heat flux channel in the scrape-off layer (SOL) from target to stagnation point. We benchmark DIV1D simulations of the SOL from target to stagnation point on static 2D scrape-of-layer plasma simulations from SOLPS-ITER [1] (which couples a kinetic neutral description to a fluid plasma description). We extend the benchmark in [2] going from the target beyond the X-point to the stagnation point. For TCV, the goal of this work is to find settings for DIV1D such that it self-consistently matches the upstream and target plasma quantities as function of core and external fluxes. To demonstrate generality, we also benchmark DIV1D on SOLPS-ITER simulations of ASDEX-Upgrade and MAST-U.

## The DIV1D model

The DIV1D model is detailed in [2] and based on the assumption that parallel plasma transport dominates cross-field transport in the SOL. The plasma is quasi-neutral with equal ion and electron temperatures. Similar models have been implemented by various authors in their respective 1D codes [3, 4] but seem to focus on simulating a single magnetic flux tube instead of the main heat flux channel.

The domain of DIV1D is extended – with respect to [2] – to include the full core SOL and a second divertor SOL with second target. Here we focus on simulations with a single target and imply zero flux boundary conditions at the point where the ion flow reverses direction, defined as stagnation point. Fluxes from the core are converted to sources in the SOL through a geometry set by major radius, magnetic field, heat flux channel width, and connection length.

## SOLPS-ITER simulations

The SOLPS-ITER simulations used to benchmark DIV1D are based on an L-mode plasma in TCV from [5], L-mode plasma in ASDEX-Upgrade [6], and L-mode plasma in MAST-U [7]. All simulations feature kinetic neutrals, whereas only the TCV and ASDEX-Upgrade simulations include drifts.

Figure 1: *Mapping SOLPS-ITER to 1D profiles of the main heat flux channel based on FWHM of parallel heat flux: (a) on the B2.5 grid; (b) in spatial coordinates; (c) as heat flux distributions from X-point to target. The FWHM captures roughly 70% of the total heat flux to the target.*

## Mapping SOLPS-ITER solutions to 1D

In this work, 1D SOL equilibria represent the main heat flux channel instead of single flux tubes. The main heat flux channel is illustrated in Figure 1 and is bounded by the full width half max of the heat flux distributions, containing approximately 70% of the heat flux. Averaged quantities along the leg on the red area represent mapped 1D profiles with a value interval given by minima, and maxima. On the left in Figure 1, it can be seen that the peak heat flux (dashed dotted line) drifts from x=15 to x=20 in the divertor SOL (SOL). In this case, a single flux tube (e.g. with x=15) clearly misses the peak heat flux on the target. This is the reason for comparing to the main heat flux channel, using the FWHM mapping instead of single flux tubes.

## Settings for DIV1D simulations

The settings for DIV1D are to the greatest extend extracted from 1D mapped SOLPS-ITER simulations on TCV [8], AUG [6], and MAST-U [7]. The methodology follows [2] but upstream boundaries are set to zero flux and sources are determined by cross-channel fluxes. An overview of inputs is given in Table 1. For TCV, the geometry is entirely taken from SOLPS-ITER with arrays for radius $R$, magnetic field $B$ and pitch angle $\sin(\theta)$. For MAST-U and AUG we use constant values for $R$ and $\sin(\theta)$. The X-point heat flux is matched using the core SOL width $\lambda_q$ (i.e. altering volumes that transform core-fluxes to sol sources). A fraction $f_{\text{ion}}^{\text{core}}$ of the core-SOL neutral influx can pass the SOL and ionize in the core changing the neutral source in the SOL, we use it to match the particle balance. The divertor SOL neutral profiles of DIV1D are matched using a neutral exchange velocity $v_{\text{ex}}$ (i.e. $\lambda_q$ divided by the exchange time $\tau_{\text{ex}}$ in [2])