W7-X Neutral-Beam-Injection: Selection of the NBI source positions for experiment start-up

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The stellarator W7-X will be equipped with two Neutral-Beam-Injector (NBI) boxes for balanced injection. Each NBI box has 2 source positions that have more tangential injection angle and 2 source positions with a more radial injection angle. For the experiment start-up phase each NBI box will be equipped with 2 ion sources with a neutral power before the duct: of 2.5MW using deuterium and 1.7MW using hydrogen and a maximum pulse-length of 10s. For the selection of the initial 2 NBI source positions per box the following three physical aspects were examined. The first aspect is the difference of the transmission through the duct for the different sources and the related thermal power-load to the duct. The next is the thermal power-load to the W7-X inner wall opposite to the NBI ducts and the density dependence of this shine-through for the different sources using both hydrogen and deuterium injection. Finally, the different heating efficiencies for the sources were calculated.

As some W7-X coils intrude into the NBI duct there are two bottlenecks that limit beam transmission through the duct. For one of the tangential source positions the effect is significantly stronger than for all the other sources. In addition the poor transmission produces the largest thermal power-load on the duct wall.

Without plasma present the thermal power-load of the inner wall is very high (up to $48MW/m^2$). It decreases significantly both with rising plasma density and for deuterium injection. On the other hand the geometry of the inner vessel in the region of the NBI beam footprint is quite complex. Additionally there are diverse components with different power-load capabilities: a baffle a target element of the W7-X divertor, heat shield modules and standard W7-X wall panels. As a result of the presented calculations the inner wall will be modified in order to enhance the maximal power-load of some inner wall components and therefore to reduce the related NBI pulse-length limitation.

Using hydrogen injection the heating power to the plasma is about 1.3MW for the tangential sources and 1.1MW for the radial sources (standard magnetic field configuration and central density $1E20/m^3$). For deuterium injection the heating power is significantly larger (2MW for the tangential sources, 1.8MW for the radial sources). There is little difference between Co- and Counter-injection.

The results of the calculations will be presented and discussed in detail. Considering all the mentioned physical aspects the decision was made to use one tangential source and one radial source per box for the experiment start-up phase.