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Towards ITER-Relevant CW Extraction at Negative Ion Sources for Fusion

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Negative hydrogen or deuterium ion sources for neutral beam injection (NBI) systems used at fusion devices are based on the surface production process at a caesiated low work function converter surface. The ITER NBI system will deliver a large beam ($\approx 2 \text{ m} \times 1 \text{ m}$, extraction area $\approx 0.2 \text{ m}^2$) with an accelerated current of 40 A negative deuterium ions (46 A in hydrogen) with a high homogeneity, low divergence and being stable over one hour. While producing a stable and homogeneous negative ion beam is not an issue, during long pulses typically a significant increase in the co-extracted electrons is observed, limiting the pulse length or the achievable performance. This effect is particularly pronounced in deuterium and it is attributed to an increasing work function of the converter surface. A major and still open challenge is to develop conditioning techniques providing a homogeneous and stable low work function of the converter surface.

In the last years the negative ion source test facilities at IPP Garching, BATMAN Upgrade (using the small prototype source) and ELISE (using a source of the same width but only half the height of the ITER NBI source) have been converted into CW machines. While BATMAN Upgrade focusses on basic physics investigations, aim of ELISE is to demonstrate that the ITER targets can be achieved by ion sources with an ITER-relevant size.

The contribution presents the status of both test facilities as well as latest results achieved during long pulse operation in hydrogen and deuterium. Investigations are performed on homogenizing and stabilizing the co-extracted electrons by either actively modifying plasma properties close to the converter surface or by modifying the flux of Cs onto the converter. For example, vertical plasma asymmetries, caused by plasma drifts, can be affected by biasing surfaces or introducing additional surfaces into the plasma and Cs can be evaporated in direct vicinity to the converter for a more controllable caesiation.

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Email Address

dirk.wuenderlich@ipp.mpg.de

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Yes

Presenter if not the submitter of this abstract

Primary author: WÜNDERLICH, Dirk (Max-Planck-Institut für Plasmaphysik)

Co-authors: WIMMER, Christian (Max-Planck-Institut f. Plasmaphysik); Dr DEN HARDER, Niek (Max-Planck-Institut für Plasmaphysik); Dr BARNES, Michael (Max-Planck-Institut für Plasmaphysik); Dr HEILER, Adrian (Max-Planck-Institut für Plasmaphysik (IPP)); Dr NAVARRO, Araceli (Max-Planck-Institut für Plasmaphysik); RIEDL, Rudi (Max-Planck-Institut für Plasmaphysik); YORDANOV, Dimitar (Max Planck Institute for Plasma Physics); FANTZ, Ursel (Max-Planck-Institut für Plasmaphysik (IPP)); HEINEMANN, Bernd (Max-Planck-Institut für Plasmaphysik)

Presenter: WÜNDERLICH, Dirk (Max-Planck-Institut für Plasmaphysik)