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Overlap of Plasma and Beam Properties in ITER-Relevant Negative Ion Sources

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The ITER neutral beam injection (NBI) system will deliver a large negative deuterium or hydrogen beam (≈2 m×1 m) with an accelerated current of 40 A negative deuterium ions (46 A in hydrogen). The ion beam is extracted from an ion source where a plasma is generated in eight cylindrical RF drivers by inductive coupling (P_{RF}<100 kW/driver, f=1 MHz). Four horizontal pairs of drivers are powered in series by one RF generator each. The plasma expansion and overlap into a rectangular vessel is strongly affected by vertical plasma drifts. The resulting plasma homogeneity close to the extraction system is of high relevance for the properties of the extracted negative ion beam and in particular for the co-extracted electrons.

Investigations on the plasma overlap have been conducted at the half-size (four RF drivers) test facility ELISE at IPP Garching by request of the ITER Organization to support the interpretation of similar experiments done at the full-size SPIDER test facility at Consorzio RFX, Padova. Systematic parameter variations have been done using either all the four RF drivers at the same time or only the upper or lower pair of drivers. The plasma parameters from a comprehensive set of diagnostics as well as the properties of the beam are compared for these three operational modes.

While the results confirm the effect of drifts on the plasma expansion, the sum of the extracted negative ion current for individual operation of the top and bottom RF generators is higher than the current achieved when operating both generators. This demonstrates that at least one step in the process chain connecting the production of precursor particles (hydrogen atoms and positive ions), their transport and the production and extraction of negative ions shows a non-linear behavior.
The contribution presents and discusses the results of the different investigations and their implications on the operation of large-area sources for negative hydrogen ions.

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

Co-authors: KNAACK, Jasper (Max-Planck-Institut f. Plasmaphysik); MUSSINI, Daniele (Max-Planck-Institut für Plasmaphysik); Dr NAVARRO, Araceli (Max-Planck-Institut für Plasmaphysik); RIEDL, Rudi (Max-Planck-Institut f. Plasmaphysik); YORDANOV, Dimitar (Max-Planck-Institut f. Plasmaphysik); DÖRING, Andreas (Max--Planck-Institut f. Plasmaphysik); FANTZ, Ursel (Max-Planck-Institut für Plasmaphysik); MARIO, Isabella (Consorzio RFX (CNR, ENEA, INFN, Università di Padova, Acciaierie Venete SpA), C.so Stati Uniti 4, 35127 - Padova, Italy); SARTORI, Emanuele (Università degli Studi di Padova); ZANIOL, Barbara (Consorzio RFX (CNR, ENEA, INFN, Università di Padova, Acciaierie Venete S.p.A.), Corso Stati Uniti 4, 35127 Padova, Italy); POGGI, Carlo (ITER Organization); VELTRI, Pierluigi (ITER Organization)

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

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