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Experimental results of the SPIDER negative ion accelerator in view of the next operations

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Three years of experiments on SPIDER allowed characterizing the main features of the source plasma and of the negative ion beam, in the original design configuration. For the large dimensions of the source chamber, and of the extraction area, the investigation of the single-beamlet currents and of the source plasma uniformity had to be carried out to extend the knowledge gained in smaller prototype sources. The design based on multi-RF driver configuration, and the filter field topology were found to determine a peculiar behavior of the plasma confinement in the drivers favouring left-right asymmetries [also reflected on the available negative ion current], even after the early implementation of a new scheme of plasma-grid current and return busbars that greatly improved the performance at high filter field. The plasma properties in the driver and expansion region as well as the positive ion energy at the extraction region were studied in different experimental conditions, and interpreted also with the support of numerical models, suggesting that an improved plasma confinement could contribute to the increase of the plasma density, and –to a certain extent –tailoring the profile of the space potential; this is essential in order to maximize the presence of cold negative ions for the formation of low-divergence beamlets. Early results related to RF discharges on the back of the plasma source and the gas conductance of the beam source suggested the reduction of the vessel pressure as mitigation, leading to the definition of a new pumping system. The difficulties related to the simultaneous operation, stable control and high-power operation of multiple RF self-oscillators were an unambiguous obstruction to the experimentation, calling for the implementation of RF solid-state amplifiers. The initial tests related to caesium management, the non-uniform plasma properties at different location across the plasma grid, and the challenges in the measurement of the current and divergence of the accelerated beamlet, unambiguously resulted in the need of new diagnostic systems to investigate with better resolution the spatial uniformities. This contribution summarises how the main experimental findings in the previous experimental campaigns are driving modifications to the SPIDER experiment, during this year shut down, in view of the future operation.

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