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Towards NIO2, a 5 kW RF compact H- ion source

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The negative ion sources operation of neutral beam injectors (NBI) for tokamak must be carefully optimized for low beam divergence, minimal Cs use, and related HV stability. The long term operation (LTO) is challenging, especially because not only plasma but also evolving surface wall conditions are involved in H- or D- production; moreover, in a full-size source (as SPIDER) installed RF (radio frequency) power may reach 800 kW and H gas consumption 16 mg/s with consequential pumping, so that reduced size or compact ion sources are very convenient for studying the underlying physics and for flexibility in testing innovations. The NIO1 (negative ion optimization phase 1) source was indeed operated since 2014 (in close collaboration between Consorzio RFX and INFN) as a convenient benchmark, but it is limited to 9 beamlets and about 2 kW RF power; evidence of both of fast transients and slow evolution in LTO was demonstrated. Based on these experiences, design of a companion source NIO2 is proposed, with a larger expansion chamber and at least 25 beamlet extraction, for better beam uniformity studies. Generalization of the seamless match of magnetic filter and multipole confinement introduced in NIO1 is discussed, considering optimization of expansion backplate magnets also. The spacing between source rear plate and RF coil and the large aspect ratio length/radius of this coil (which were introduced as design rules in NIO1 and in following studies for the Divertor Test Tokamak) are maintained. Results and issues with Langmuir probe RF compensation measured in MetAlice LNL test-stand are also summarized. Improved gas and Cs injection are also proposed. The application of additive manufacturing at least to Faraday Shields (as recently build) and to the extraction grid is fostered.

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