Beamlet scraping and its influence on the beam divergence at the BATMAN Upgrade test facility

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Abstract:
For the ITER fusion experiment, two neutral beam injectors are required for plasma heating and current drive. Each injector supplies a power of about 17 MW, obtained from neutralization of 40 A (46 A), 1 MeV (0.87 MeV) negative deuterium (hydrogen) ions. The full beam is composed of 1280 beamlets, formed in 16 beamlet groups, and strict requirements apply to the beamlet core divergence (<7 mrad). The test facility BATMAN Upgrade uses an ITER-like grid with one beamlet group, which consists of 70 apertures. In a joint campaign performed by IPP and Consorzio RFX to better assess the beam optics, the divergence of a single beamlet was compared to a group of beamlets at BATMAN Upgrade. The single beamlet is measured with a carbon fiber composite tile calorimeter and by beam emission spectroscopy, whereas the divergence of the group of beamlets is measured by beam emission spectroscopy only. When increasing the RF power at low extraction voltages, the divergence of the beamlet and of the group of beamlets is continuously decreasing and no inflection point toward an over perveant beam is found. At the same time, scraping of the extracted ion beam at the second grid (extraction grid) takes place at higher RF power, supported by the absence of the normally seen linear behavior between the measured negative ion density in the plasma close to the extraction system and the measured extracted ion current. Beside its influence on the divergence, beamlet scraping needs to be considered for the determination of the correct perveance and contributes to the measured coextracted electron current.