

# Experimental evidence of beam ion acceleration during edge localized modes in the ASDEX Upgrade tokamak

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Experimental evidence of beam ion acceleration due to edge localized modes (ELM) has been observed for the first time in the ASDEX Upgrade tokamak. Bursts of enhanced fast ion losses associated to individual ELM filaments are measured with the fast ion loss detector (FILD) [1] (Fig.1). Multiple pitch angle structures are observed for different beam sources and  $q_{95}$  values at well-defined energies above the main neutral beam injection energy in the velocity space of the lost ions, which is reconstructed by means of tomographic inversion techniques of the FILD signal (Fig.2). This suggests that the acceleration results from a resonant interaction between the beam ions and the parallel electric field generated during the ELM filaments eruption. Consistent with the FILD measurements, bursts in electron cyclotron emission are observed at the onset of the ELM as well as in soft X-ray channels with lines of sight tangential to the plasma edge. These are both indicative of electron acceleration [2], strongly supporting the hypothesis of a parallel electric field as responsible for the particle acceleration. Full orbit fast ion simulations have been carried out including the 3D perturbation fields of the ELM modelled with JOREK. Key experimental observations such as the filamentary pattern in the temporal evolution of the losses and the ion acceleration via resonances with the parallel electric field can be reproduced. This finding may shed light to the contribution of fast particles to the ELM stability as well as the loss of energy and particles during the ELM cycle.

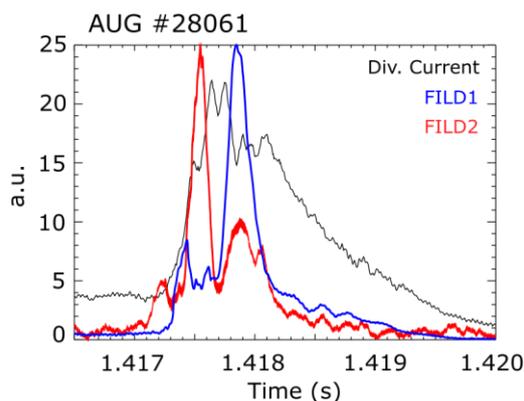


Fig.1. Fast-ion filaments measured by FILD during an ELM. The blue and red curves show the signals of two FILDs located at different toroidal positions. The black curve represents the divertor current signal.

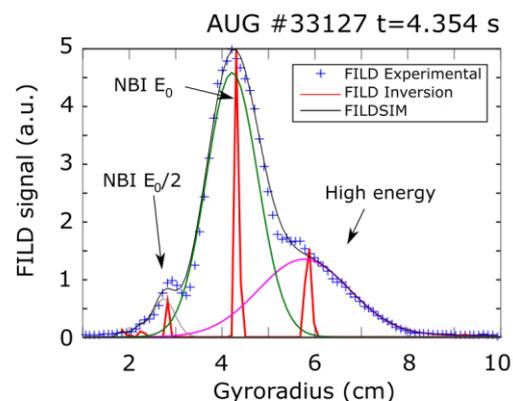


Fig.2. Gyroradius profile of fast ion losses measured by FILD during an ELM. The blue curve shows the experimental signal. The red curve shows the energy components of the tomographic inversion. The grey, green and pink curves show the synthetic FILD signal for the different components. The total synthetic FILD signal is shown in black.

[1]M.Garcia-Munoz et al, Plasma Phys. Control. Fusion **55** 124014 (2013)

[2]S.Freethy et al, Phys. Rev. Lett. **114** 125004 (2015)