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Gamma ray measurements of the runaway electron distribution function in disruption mitigation experiments at the ASDEX Upgrade and JET tokamaks

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The mitigation of runaway electrons (RE) that may be generated in disruptions is among the key priorities for the safe operation of the ITER tokamak. The most pursued mitigation techniques are currently based on the injection of a high Z impurity in the plasma (predominantly Argon) as a way to achieve RE dissipation. Examples are experiments based on Massive Gas Injection (MGI) at the ASDEX Upgrade tokamak, or on Shattered Pellet Injection (SPI), such as those recently conducted at JET. In both cases, the aim of the experiments is to gain detailed physics insight on the mechanisms that drive the RE mitigation, which is achieved by comparing data from a broad range of RE diagnostics to currently available codes. The goal is to possibly validate the theoretical models so that the results of present experiments can be reliably extrapolated to ITER.
The RE distribution function is one of the most interesting parameters for validation, but this is also challenging to measure experimentally. A possibility comes from time resolved spectral measurements of the hard x-ray emission from REs at typical energies in the MeV range, which has recently been made possible by the development of gamma-ray spectrometers with MHz counting rate capabilities and, hence, millisecond time resolution.
In this contribution we present an overview of measurements of the RE distribution function by the detection of bremsstrahlung spectra in the MeV range in MGI and SPI experiments at the ASDEX Upgrade and JET tokamaks, respectively. At ASDEX Upgrade two spectrometers observe the plasma along two toroidally separated, radial lines of sight. At JET, instead, the plasma is viewed simultaneously along a vertical and tangential lines of sight, together with an array of compact detectors (cameras) that make it possible to infer information on the RE spatial profile.
We further discuss the deconvolution methods that are used to obtain the RE distribution function from hard x-ray measurements and, in particular, to retrieve the maximum energy Emax of the RE beam and its evolution in the post-disruption phase. For the MGI scenario, we finally compare the time evolution of Emax with a one-dimensional model that, albeit simplified, is capable to capture the gross features of our experimental findings.

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