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Analysis of runaway beam suppression experiments in FTU

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The challenging task for a disruption mitigation system (DMS) is the implementation of reliable strategies in order to mitigate thermal, mechanical and electromagnetic loads at disruptions. Furthermore, the DMS has to cope with control and suppression of runaway electron beams, which are possibly generated during major disruptions, in order to avoid localized high-energy deposition causing deep melting of the structures. Strategies for runaway electron (RE) suppression are Massive Gas Injection (MGI) or Shattered Pellet Injection (SPI) although alternative or simultaneous strategies based on RE current dissipation via the central solenoid (ohmic coil) have been proposed. In ITER a preemptive strategy exploiting the central solenoid to deal with current quenches (CQ), yielding RE beam onset with current drop less than 5MA, has been proposed. In the case the position control of the RE beam is not lost during the CQ, the maximum RE beam current decay rate has to remain below 0.5MA/s, a limit that increases up to 1MA/s for initial RE current of 12 MA.
In FTU a large database (650 pulses) of highly energetic post-disruption RE beams, produced spontaneously or with high-Z gas injection, have been analyzed. The study reveals that the decay rate during RE beam current ramp-down is an important parameter for runaway energy suppression. We have proposed a possible performance index to define suitable characteristics of the RE beam controller. Analysis of experimental data indicates that the reduction of the runaway current is possible when associated to small decay rate (longer confinement) of about 1MA/s and a dedicated RE beam controller. Other important factors of RE beam premature final loss have been found to be: the large radial shift of the RE beam that potentially causes impacts on the low field side of the vessel during the plateau phase, MHD instabilities induced by large electrical field, VDE (elongated beams). The hysteretic behavior of the runaway dynamics has been highlighted and experimentally quantified. Such nonlinearity affects runaway dynamics leading to increased density thresholds for runaway suppression once they have been previously formed.

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