Analysis of RE beams in COMPASS and JET using betatron equilibrium and radiation diagnostics

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High energy runaway electron (RE) beams in tokamaks require significant vertical field to be maintained in a stable radial position within the tokamak chamber, and this field is not only dependent on the beam current but also on its average electron energy. What would appear as a radial outward drift of an accelerated relativistic particle in a static magnetic equilibrium background becomes macroscopic radial movement of the whole magnetic equilibrium in the case of a beam current formed exclusively by the relativistic particles even in configurations with strong toroidal magnetic field. This additional relativistic pressure needs to be compensated by increased external vertical field. This effect appears to be dominant in small tokamaks like COMPASS [1],[2], allowing for a rough estimate of the total beam kinetic energy based on the radial position and vertical magnetic field or beta normalised (β_N) calculated by MHD equilibrium reconstruction code EFIT. Implementation of this effect of the RE beam energy also allowed us to improve position control during the RE beam phase. The JET magnetic equilibrium data suggest that this effect may be also observed in runaway electron experiments at large devices so that β_N values allow for an estimate of the energy evolution. In this contribution, we present the method of energy estimate and discuss its limitations. The estimated energy evolution based on the magnetic measurements is compared with synchrotron radiation measurements based on IR and visible camera data and simulations using SOFT [3]. Furthermore, it is discussed whether a gradual pattern and intensity changes observed in the camera data are more likely related to runaway electron density n_{RE} profile changes or to changes in the energy. This information is especially important in the discharges with D_2 shattered pellet injection into the RE beam that caused an increase of current but surprisingly a decay of the RE energy. A possible explanation of effects observed in other radiation diagnostics during this event - e.g. the sudden disappearance of the SXR signal - will be also given.

References

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