Direct Measurement of Neutral/Ion Beam Power using Thermocouple Analysis (P3-B-356)

Ian Day, Stephen Gee

EURATOM/UKAEA Fusion Association Culham Science Centre OX143DB Abingdon UK

Modern Neutral Beam Injection systems such as those used on JET and MAST routinely use thermocouples embedded close to the surface of beam stopping elements, such as calorimeters and ion dumps, coupled to high speed data acquisition systems to determine beam profile and position from temperature rise data. With the availability of low cost data acquisition and storage systems it is now possible to record data from all thermocouples in a fully instrumented calorimeter or ion dump on 20ms timescales or better. This sample rate is sufficiently fast to enable the thermocouple data to be used to calculate the incident power density from 1d heat transfer theory. This power density data coupled with appropriate Gaussian fits enables the determination of the 2d beam profile and thus allows an instantaneous and direct measurement of beam power.

The theory and methodology required to analyse the fast thermocouple data from the MAST calorimeter and residual ion dump thermocouples is presented and direct measurements of beam power density are demonstrated. The power of desktop computers allows such analysis to be carried out virtually instantaneously. The methods used to automate this analysis are discussed in detail. A code, utilising the theory and methodology, has been developed to allow immediate measurements of beam power on a pulse by pulse basis. The uncertainty in determining the beam power density is shown to be less than 10%. This power density data is then fitted to a 2d Gaussian beam profile and integrated to establish the total beam power.

Results of this automated analysis for the neutral beam and residual ion power of the MAST duopigatron and PINI NBI systems are presented. This technology could be applied to a beam power safety interlock system. The application to a beam shine through protection system for the inner wall of the JET Tokamak is discussed as an example.

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