RADIATION BEHAVIOUR DURING ADDITIONAL HEATING OF JET PLASMAS

K Behringer[‡], A Edwards, H-U Fahrbach[+], R D Gill, R Granetz, N Gottardi,
H Jaeckel[+], G Magyar, E R Mueller[+], A Weller[+] and D Zasche[+]

JET Joint Undertaking, Abingdon, Oxon OX14 3EA, UK
[+]EURATOM-IPP Association, Garching

Abstract

Additional heating in JET with ICRH or NBI leads to an increase of the total radiated power. This is partly due to the density increase caused by the applied heating method. The relative power loss P_{rad}/P_{tot} reaches higher values with RF heating. The density increase can be partly controlled when the plasma is attached to the inner wall.

Radiation sources at the plasma edge lead to asymmetric radiation flux profiles. For this case the local emissivities can be derived from the bolometer measurement by a tomographic reconstruction method. Reliable values for the central radiation can be evaluated from the soft X-ray diagnostic when measuring with a 4.4 µm Be filter.

The radiative power loss of the JET plasma can be measured by bolometers in the energy range 5 eV $\leq E_{ph} \leq$ 9 KeV and with surface barrier diodes (soft X-ray diagnostic) in the range 300 eV $\leq E_{ph} \leq$ 10 KeV. The lower threshold energy of the diodes can be shifted to higher values by using Be-filters of different thickness. For both diagnostics two camera systems are available, viewing the plasma from the bottom ("vertical cameras") and the side ("horizontal cameras") on the same ports. In the immediate vicinity two RF antennae are installed which generate local radiation sources due to their interaction with the plasma. These sources contribute to the bolometer signal as well as to the soft X-ray signal (provided the latter is operated without filter). This may lead to an overestimation (up to about 10%) of the total radiated power derived from the vertical bolometer camera.

At present additional heating on JET with RF or NB provides similar maximum power levels ($P_{AH} \leq 5.5$ MW). The evolution of the electron density and hence of the radiated power during additional heating depends sensitively on whether the plasma is attached to the outer limiters or to the inner wall carbon protection plates. A strong increase of the electron density (particularly with NB-heating) and of the radiation loss is observed when the plasma is attached to the outer limiters. In inner wall operation, the density increase can be reduced or the density can even be kept constant. High radiation peaks may occur at the plasma edges. Fig.1 shows the radiation flux distribution for two NB-heated (Fig. 1a, 1b) and two RF-heated discharges (Fig. 1c, 1d) for limiter operation (top) and inner wall operation (bottom). The sudden appearance of a pronounced radiation peak at the inner plasma edge during the limiter bound discharge of Fig.1 is due to a shift of the plasma to the inner wall.

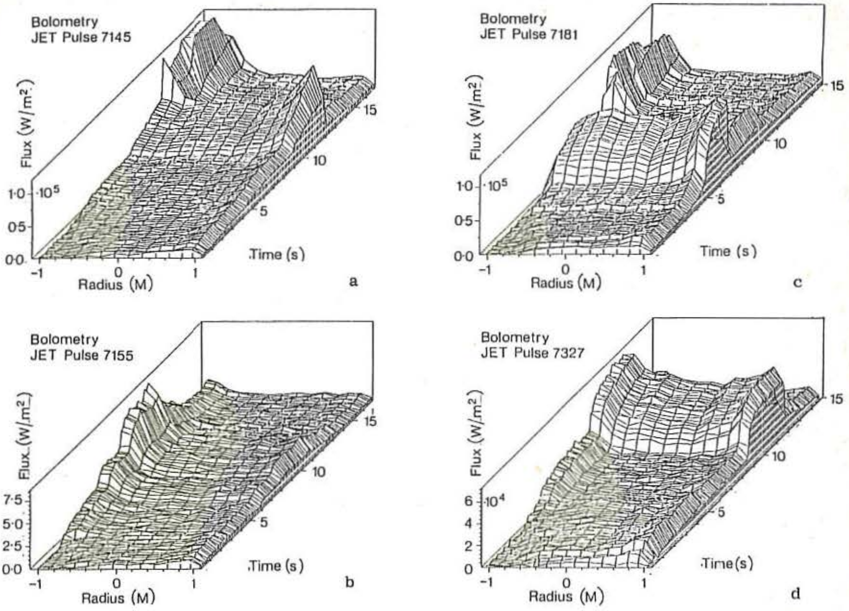

Fig. 1 Brightness distribution measured by the vertical bolometer camera for NB- (left) and RF-heated (right) discharges.

The relative power loss reaches 70% in the case of RF-heating (high <ne>). It can be kept quite low for NB-heating, when the density increase is controlled by shifting the plasma to the inner wall (Fig.2). Even in the high density NB-heated discharges the relative power loss is only about half of that in the corresponding RF-heated discharge.

The local emissivities can be evaluated by Abel inversion only for radially symmetric flux profiles. Using a tomographic reconstruction method /1/ one can derive local emissivities also when $m = 1$ and $m = 2$ deviations from the poloidal symmetry occur. Fig. 3 shows the emissivity distribution obtained from a tomographic reconstruction and from an Abel inversion (dashed curve) of the flux profile of the vertical bolometer camera. In the latter case the channels which are affected by the outer local radiation source have been omitted.

The emissivity in the centre cannot be derived accurately when asymmetries or hollow flux profiles occur. In that case the central emissivities can be obtained from soft X-ray measurements. Using a 4.4 μm Be filter ($E_{ph} \geq 750$ eV) leads to an attenuation of the radiation predominantly from the plasma edge and hence to radially almost symmetric emissivity profiles (Fig.4). In this case the $m = 0$ component gives reliable values for the central radiation. For the hollow radial profile shown in Fig.4 the contribution to the soft X-ray signal can arise from resonance lines of H-

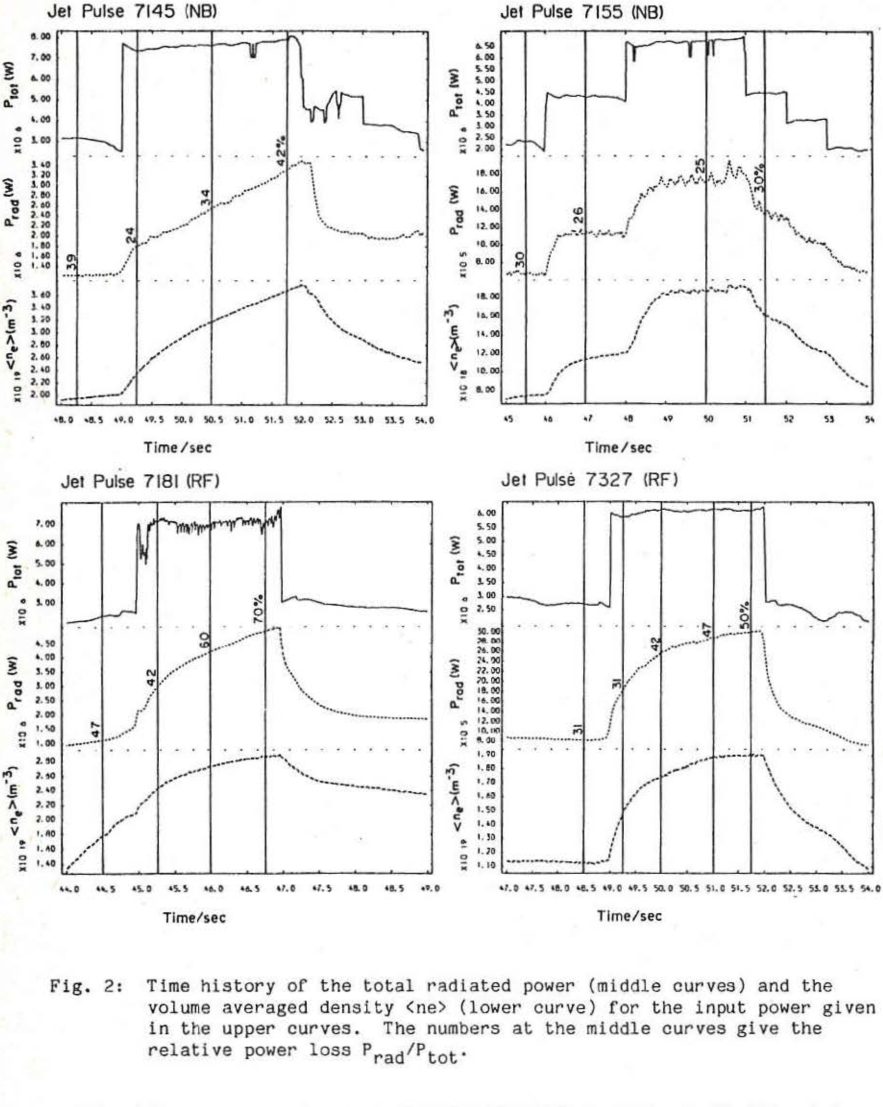

Fig. 2: Time history of the total radiated power (middle curves) and the volume averaged density <ne> (lower curve) for the input power given in the upper curves. The numbers at the middle curves give the relative power loss P_{rad}/P_{tot}.

and He- like oxygen and/or from metallic impurities in Ne- to Li-like states. Carbon line radiation is almost completely supressed by the 4.4 µm Be filter. For the discharge of Fig.4 a concentration of ~ 0.09% metallic impurties estimated from the soft X-ray measurements are in agreement with spectroscopic results /2/. For oxygen line radiation transport calculations usually show the radiation shell closer to the plasma edge than one would derive from the soft X-ray emission profile.

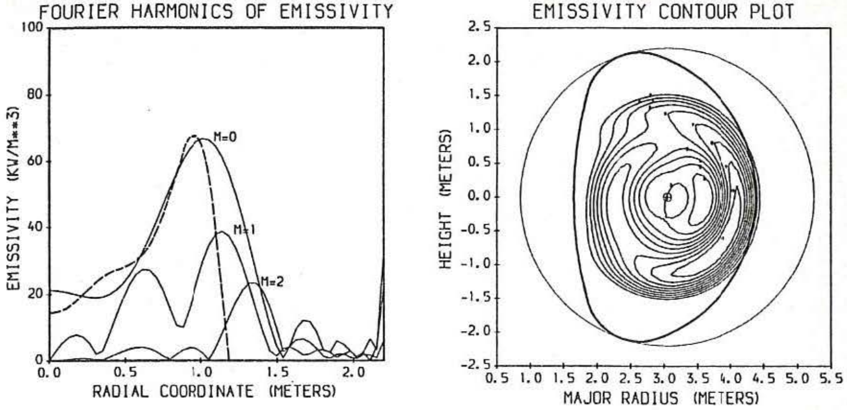

Fig. 3: Emissivity distribution of an RF-heated discharge derived by a tomographic method and by Abel inversion (dashed curve).

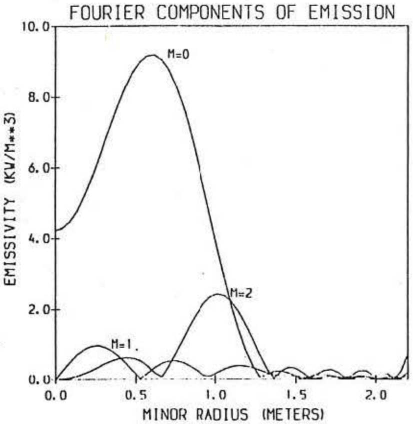

Fig. 4: Fourier components of the emissivity obtained from a soft X-ray measurement using a 4.4 μm Be filter.

References

/1/ R.S. Granetz and J.F. Camacho, Nucl. Fus. 25, 727 (1985)
and
J.F. Camacho and R.S. Granetz, Rev. Sci. Instr., 52, 417 (1986)

/2/ B. Denne, et al., this conference.