OBSERVATION OF MAIN-CHAMBER HEAT LOADS DURING DISRUPTIONS IN DIII-D

E. M. HOLLMANN, D. S. GRAY, N. H. BROOKS, T. E. EVANS, D. A. HUMPHREYS, C. J. LASNIER, S. C. LUCKHARDT, A. MCLEAN, R. A. MOYER, D. L. RUDAKOV, E. J. STRAIT, W. P. WEST, and D. G. WHYTE

DIII-D NATIONAL FUSION FACILITY SAN DIEGO
UCSD
GENERAL ATOMICS

Overview

1) Radiated power flashes observed from main chamber volume during thermal quench of DIII-D disruptions. Origin appears to be mostly impurities sputtered from main chamber walls.

2) The main-chamber radiation is commonly observed during thermal quench of DIII-D disruptions; suggests that plasma contact with main wall occurs often.

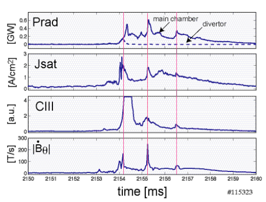
3) Initial contact usually appears at inner wall for density-limit disruptions and divertor plates for other disruptions.

4) Divertor thermography shows broad divertor heat loads during disruptions; suggests radiation also important for divertor heat load.

5) Magnetic signals show that (m/n) = (1/0) inward shift occurs during thermal quench. Large (m/n) = (1/1) and (2/1) also common (kink modes?).

1. Main wall impurities cause main-chamber radiation

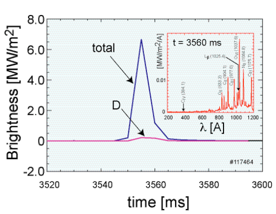
Time traces for current-limit disruption



• Flashes in main-chamber radiation are seen to correlate well with peaks in main-chamber plasma flux, main-chamber carbon sputtering, and midplane magnetic fluctuations.

• During thermal quench (TQ) plasma is hot so recombination can be ignored.

Radiation dominantly from carbon ions



• Impurity radiation much larger than deuterium radiation during disruption.

• Carbon lines dominate; radiation mfp for carbon ~ 5 cm in hot plasma, so expect radiation to be localized to strike points.

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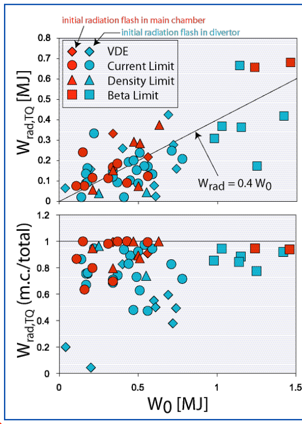
2. Significant main-chamber radiation observed during TQ of most DIII-D disruptions



• Use fast bolometer array to separate main-chamber from divertor radiation.

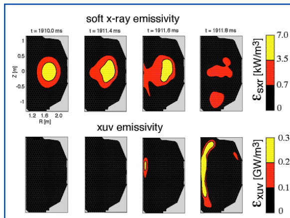
• Typically, ~ 40% of initial thermal energy is radiated away, so radiation is significant TQ loss channel.

• A large fraction of the TQ radiation is emitted from the main-chamber region, indicating main-chamber plasma flux.

• Plasmas where initial radiation flash is in main chamber (red points) tend to have higher TQ main-chamber radiated power fractions.

• Density-limit disruptions tend to have highest main-chamber radiation, VDEs the lowest.

3. SXR and XUV reconstructions show main-chamber plasma contact

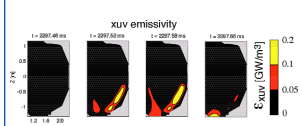


Density-limit

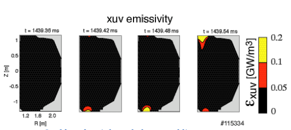
• Density-limit disruptions: dominant motion is usually(1/0) into inner wall.

• Current-limit disruption: initial heat load is usually in divertor, but occasionally in outer or inner wall.

• β-limit disruptions: initial heat load is dominantly in divertor, consistent with very high parallel conductivity.

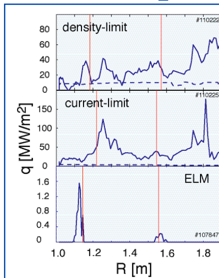


Current-limit



β-limit (double null)

4. Divertor thermography supports importance of radiation



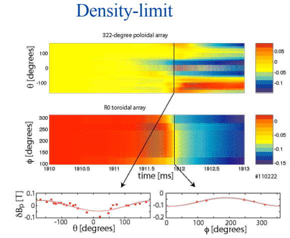
• During normal operation, divertor heat load very localized to strike points (see type-I ELM).

• During TQ, heat load does not correlate to strike points - indicates conduction into divertor is not only source of heating.

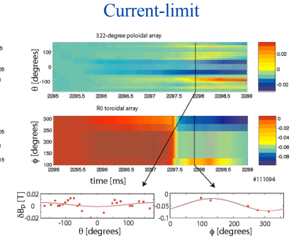
• Predicted radiation from main chamber (dashed line) can partially explain broad divertor heat deposition.

5. Magnetic signals show large-scale plasma motion during TQ

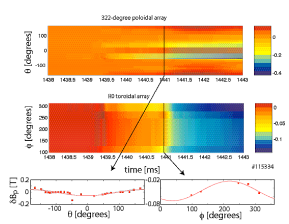
Density-limit



Current-limit



β-limit



• Poloidal mode dominantly *m*=1 plus some *m*>1 during TQ. Rise time often very fast (<1 ms), suggesting kink.

• Toroidal mode inward *n*=0 translation plus *n*=1. Inward shift due to radial force balance if β drops rapidly due to impurity radiation.

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