

## Assimilation of deuterium into relativistic runaway electron beams and the implications for benign terminations in present devices, ITER, and future devices

Thursday, 5 September 2024 09:00 (40 minutes)

Localized wall damage from post-disruption runaway electron (RE) wall impact is a significant concern for future large tokamaks. One possible method for reducing this wall damage in the event of an unavoidable RE-wall impact is massive injection of low-Z (H<sub>2</sub> or D<sub>2</sub>) gas. This injection can have the effect of partially recombining the cold thermal background plasma, resulting in a greatly increased RE final loss instability MHD amplitude, larger RE wetted area, and reduced local RE heat flux and damage. Experimental trends in thermal plasma partial recombination resulting from massive D<sub>2</sub> injection into high-Z (Ar) containing runaway electron (RE) plateaus in DIII-D and JET were studied with the goal of understanding the parameters needed to achieve sufficiently low electron density ( $n_e \approx 10^{18}/\text{m}^3$ ) to increase the RE final loss MHD levels. In both DIII-D and JET, thermal electron density  $n_e$  is found to drop by  $\sim 100\times$  when the thermal plasma partially recombines, with a minimum at a vacuum vessel-averaged D<sub>2</sub> density in the range  $10^{20}$ - $10^{21}/\text{m}^3$ . RE effective resistivity also drops after partial recombination, indicating expulsion of the Ar content. Achieving partial recombination is found to become more difficult as RE current is increased. The amount of initial Ar in the RE plateau is not observed to have a strong effect on partial recombination. Partial recombination timescales of order 5 ms in DIII-D and 15 ms in JET are observed. These basic trends and timescales are matched with a 1D diffusion model, which is then used to extrapolate to ITER and SPARC tokamaks. It is predicted that ITER will be able to achieve sufficiently low  $n_e$  values on time scales faster than expected RE plateau vertical drift timescales (of order 100 ms), provided sufficient D<sub>2</sub> or H<sub>2</sub> is injected. In SPARC, it is predicted that achieving significant  $n_e$  recombination will be challenging, due to the very high RE current density. In both ITER and SPARC, it is predicted that achieving low  $n_e$  will be easier with Ar as a background impurity (rather than Ne).

### Speaker's title

Mr

### Speaker's email address

ehollmann@gmail.com

### Speaker's Affiliation

UCSD, La Jolla

### Member State or IGO

United States of America

**Primary author:** HOLLMANN, Eric (UC San Diego)

**Co-authors:** BAYLOR, Larry (Oak Ridge National Laboratory); Dr CARVALHO, Pedro (UKAEA); Dr BOBOC, Alexandru (UKAEA); EIDIETIS, Nicholas (General Atomics); HERFINDAL, Jeffrey (UsOakRidge); JACHMICH, Stefan (ITER Organization); Dr LVOVSKIY, Andrey (General Atomics); Prof. PAZ-SOLDAN, Carlos (Columbia University); REUX, Cédric (CEA, IRFM, F-13108 Saint Paul-lez-Durance, France.); SHIRAKI, Daisuke (Oak Ridge National Laboratory); SWEENEY, Ryan (Commonwealth Fusion Systems, Devens, MA, USA)

**Presenter:** HOLLMANN, Eric (UC San Diego)

**Session Classification:** Mitigation

**Track Classification:** Mitigation