Session I Summary

ITER Needs for disruption modeling

- Michael Lehnen (ITER)

Impact of ITER-like Wall at JET on disruptions

- Peter de Vries (JET, DIFFER)

Session I Summary

Disruption Loads:

- Asymmetric (rotating) VDEs
- Heat Loads
- Runaway Electrons

Disruption Mitigation:

- Understanding mitigation process and predicting efficiency
- Runaway electron control mitigation
- Refining system requirements

Disruption Causes and Prediction:

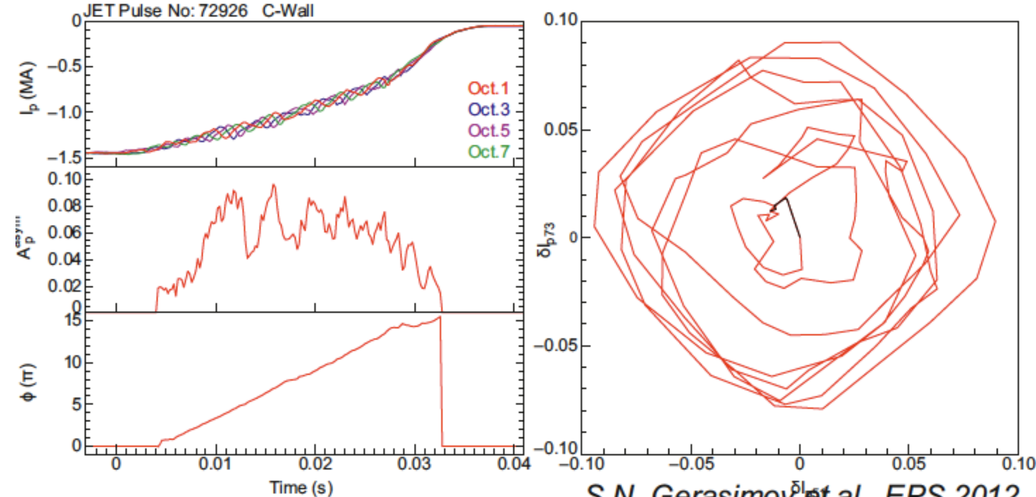
- Identification of disruption causes
- Can theory/ modelling improve reliability?

Disruption Loads – Rotating Asymmetric VDEs

Rotating VDEs:

- rotation of asymmetric VDEs can increase structural loads in ITER by dynamic amplification
- frequency range observed in JET covers resonant frequencies of ITER VV and in-vessel structures

JET: plasma current asymmetries

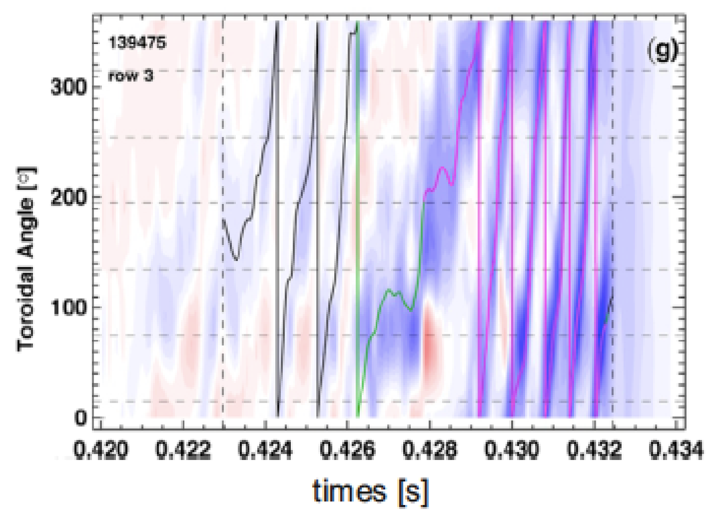


S.N. Gerasimov et al., EPS 2012

Required research:

- understanding of processes driving rotation needed (eg diamagnetic drive?)
- need an improved basis for extrapolation to ITER
- is a specific mitigation measure possible?

NSTX, S. Gerhardt, NF 2013



Disruption Loads – Heat Loads

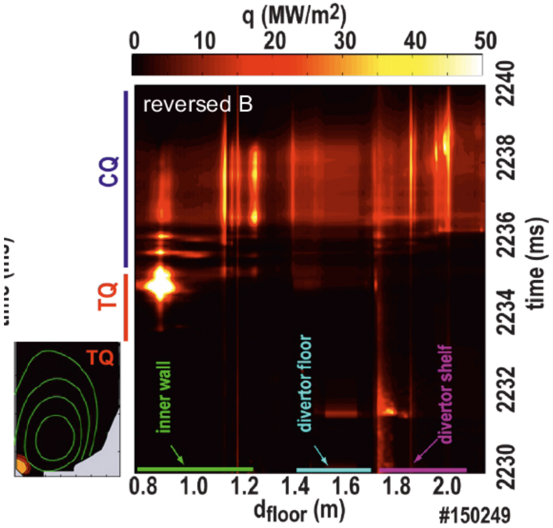
Heat Loads:

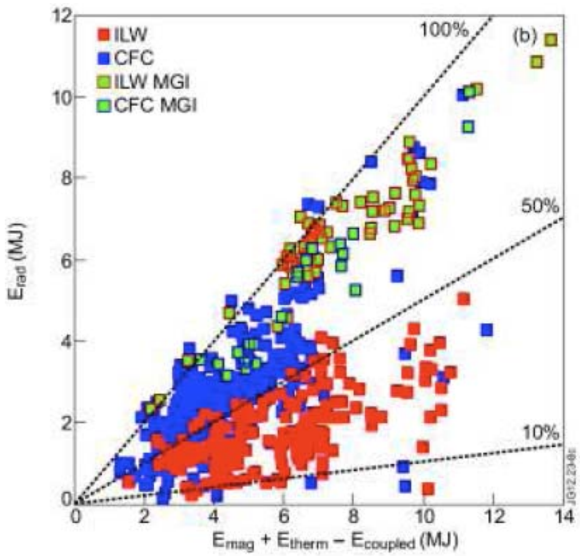
- present heat load predictions based on ‘simple’ assumptions on symmetry of heat distribution
- significant asymmetries can occur
- ILW experiments in JET underline importance of wall material/ mitigation

Required research:

- improved characterization of observed heat loads
- Is a better quantitative link between growth of mhd and heat loads possible

DIII-D, E. Hollmann et al., EPS 2013





[1] M Lehnen, et al, Journ. Nucl. Mat. **438** (2013) S102

Disruption Loads – Runaway Electrons

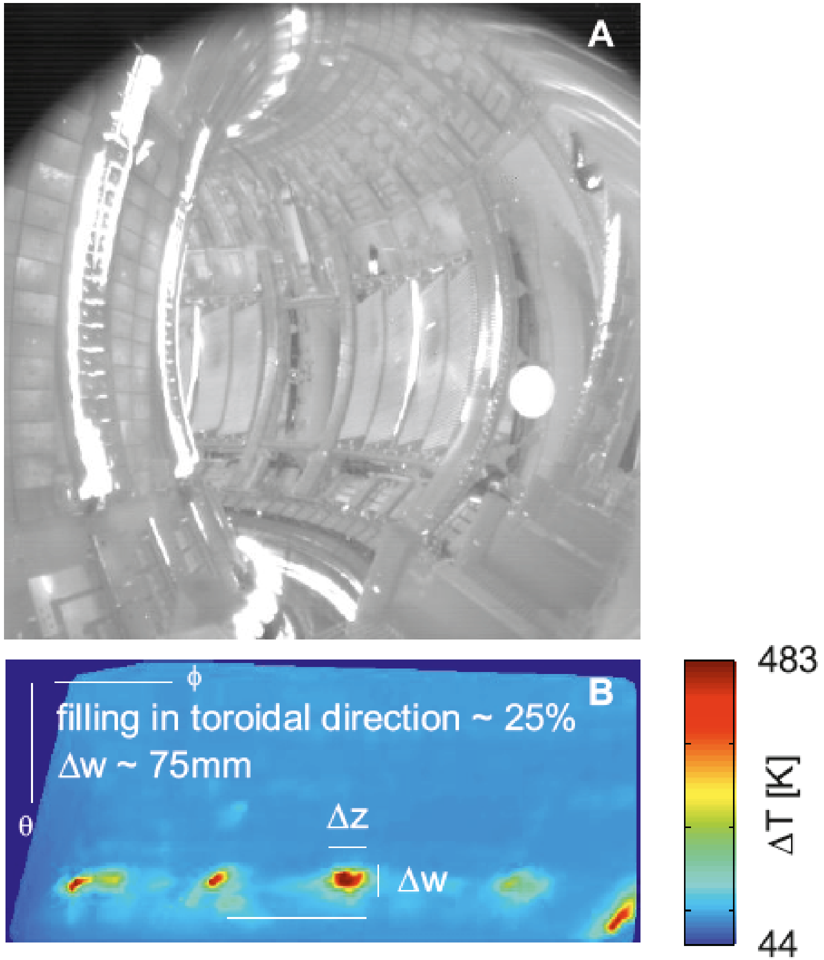
Runaway Electrons:

- Simplest predictions of RE generation in ITER predict ~10 MA at 10-20 MeV
- potential for PFC damage
- control and mitigation challenging

Required research:

- lessons learned in present devices
- improved analysis of RE generation and loss mechanisms (energy/ energy distribution/ radial profile, RE mhd stability)
- role of MHD and other instabilities in loss
- improved understanding of localization of heat loads

JET RE impact*

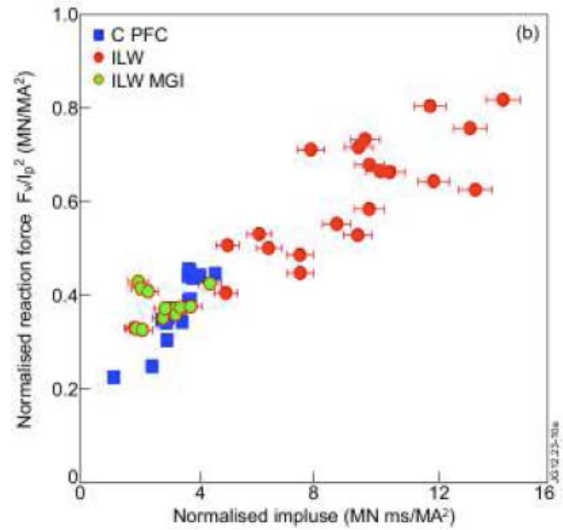


*M. Lehnen et al., JNM 2009

Disruption Mitigation – Methods/ Efficiency

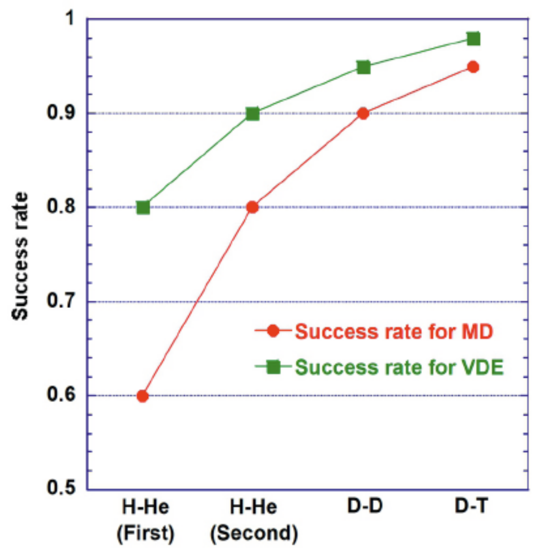
Disruption Mitigation:

- required with high efficiency and reliability in ITER to reduce heat and EM loads (NB: PFC lifetime)
- several options under study
- both physics and technology challenges



JET

Prediction Success
(mitigated disruptions/total disruptions)



ITER

Required research:

- require simulation capability for mitigation processes
- address material penetration, radiation efficiency, asymmetries, role of MHD etc
- validate models vs experiments to provide improved predictive capability

Disruption Mitigation – RE Mitigation

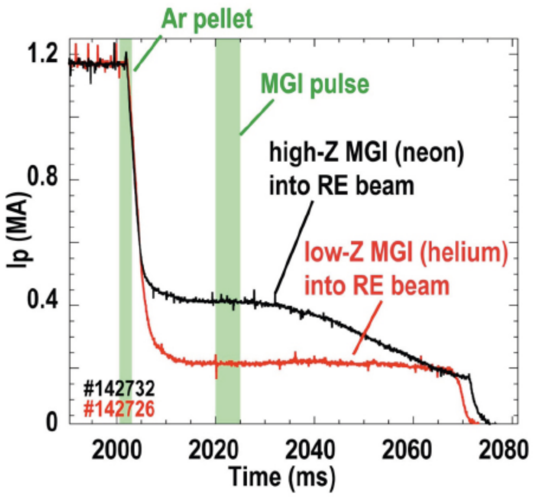
Runaway Electron Mitigation:

- essential above moderate currents in ITER
- Rosenbluth density not attainable in ITER
- experiments and modelling suggest RE scattering and energy dissipation possible at lower impurity density

Required research:

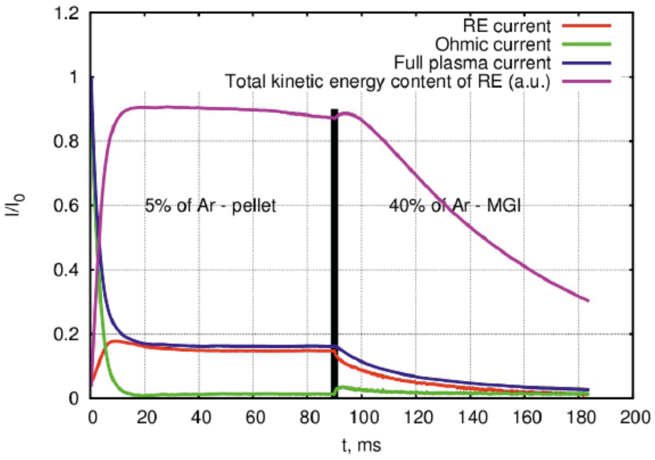
- continued R&D on RE suppression/ mitigation methods
- improvement of RE modelling, included loss mechanisms and validation against experiments

DIII-D: Impurity injection in RE beam



E. Hollmann et al., IAEA 2012

Model: RE/impurity pitch angle scattering and synchrotron emission



K.O. Aleynikova, P.B. Aleynikov, et al., EPS2013

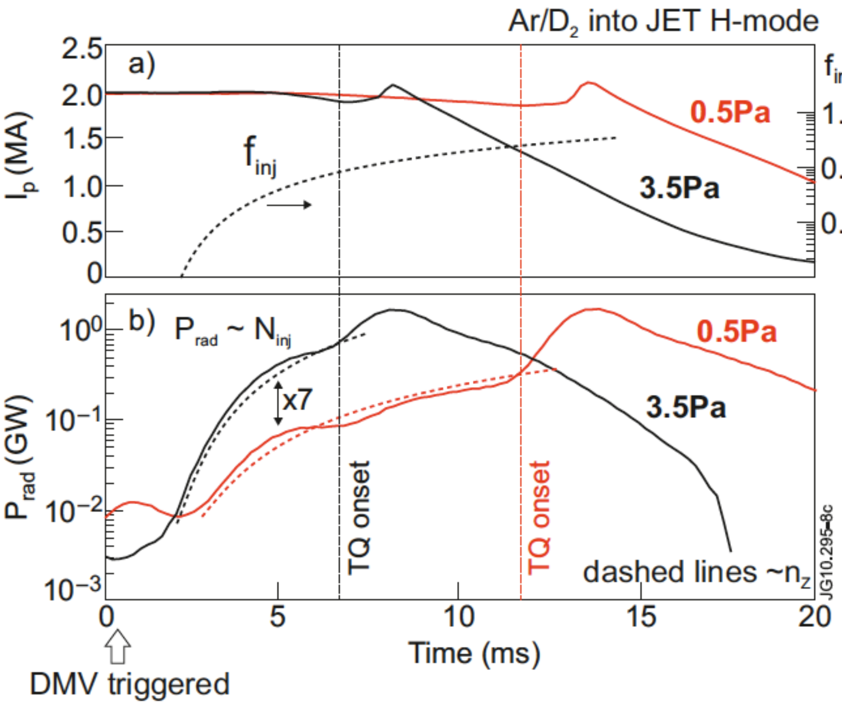
Disruption Mitigation – System Requirements

DNS System Requirements:

- DMS in ITER environment challenging
- Conflicts among timescales, injection efficiency, radiation symmetry and technology

Required research:

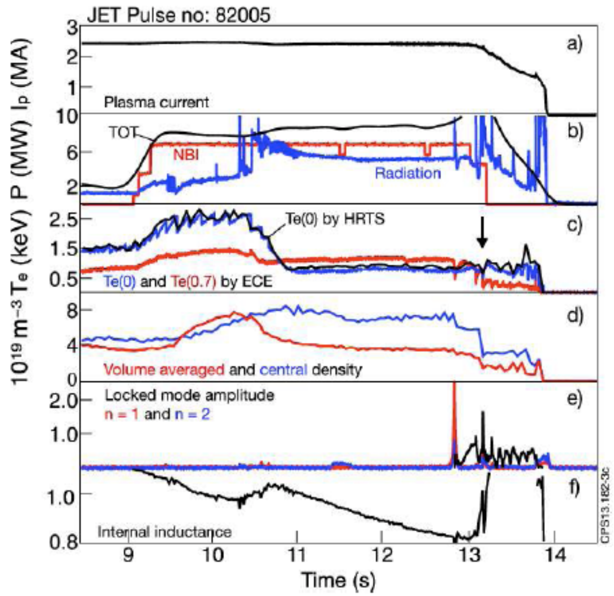
- modelling capability required to improve specification of ITER DMS
- coordinated program of disruption mitigation experiments, improved modelling and validation and technology R&D
- timescale for converging on final specification short (FDR 2017)



Disruption Causes and Prediction

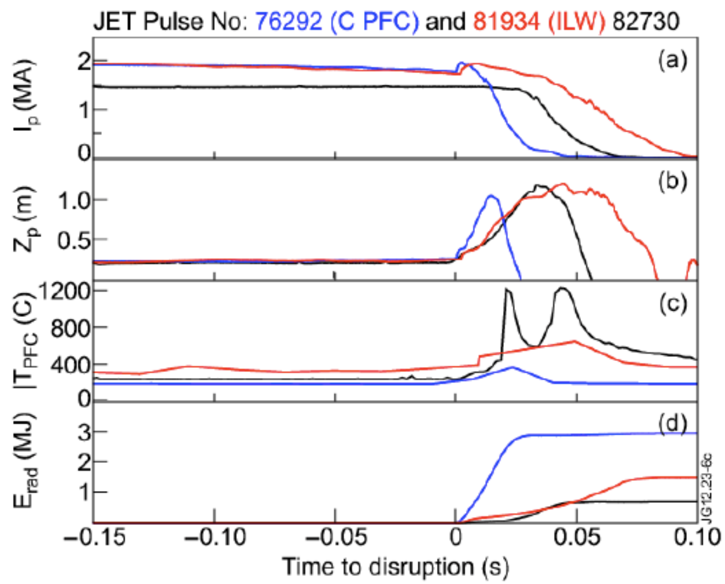
Disruption Causes and Effects:

- ILW experiments in JET emphasize role of PFMs in disruption processes
- need to readjust our thinking about disruptions causes and processes vis-à-vis carbon PFCs



Required research:

- need to develop methods for control of high-Z impurities
- modelling needs improved treatment of impurities in disruption processes



Longer current quench

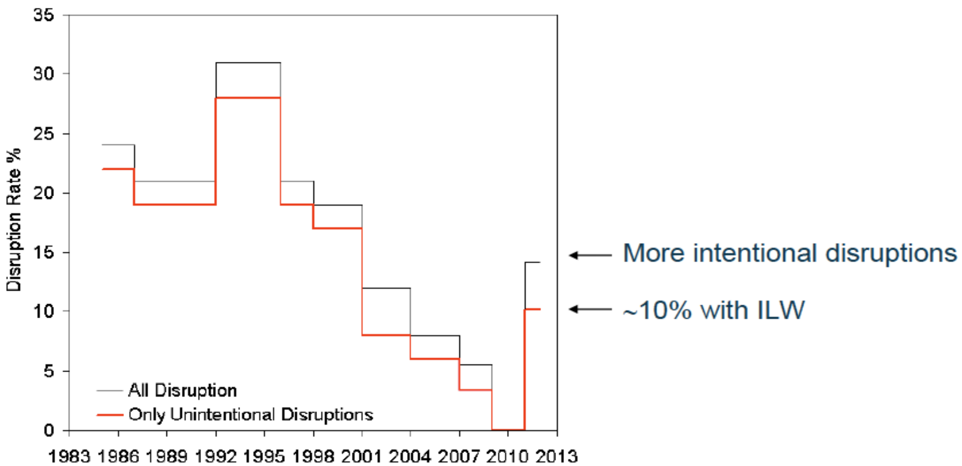
Higher ΔT_{PFC} with ILW

Less energy radiated

Disruption Causes and Prediction

Disruption Frequency:

- important lesson from ILW experiments in relation to 'learning in the environment'
- necessary in ITER, but limited statistics likely – modelling support?

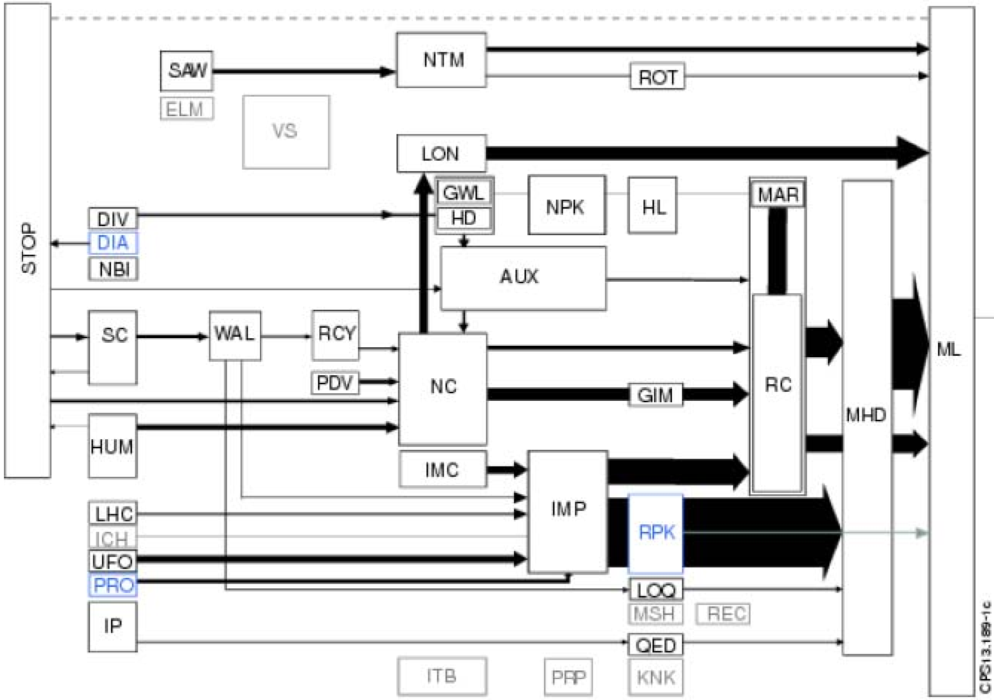


[1] P.C. de Vries, et al., Nucl. Fusion 51 2011 053018

Required research:

- perhaps improved predictive capability for stability boundaries combined with limited experimental statistics can improve predictive capability

Disruption Causes and Prediction



Disruption Causes:

- this approach to analysis of disruption causes provides many insights

Required research:

- which of causes are amenable to predictive modelling?
- can we transfer experience from existing devices (perhaps with support of modelling)?
- can control theory help?