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LH Generated Hot Spots on the JET Divertor

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Introduction

- During LHCD on Tore Supra and TdeV strong localised heat loads have been observed on components that are magnetically connected to the grill region.
- A probable reason for the hot spots are the electrons accelerated in front of the LH grill by parasitic absorption of LH power.
  - ions accelerated by the charge separation field
- The fast particle problem is most pronounced during a high power LHCD experiment.
- There were good reasons to believe that hot spots also exist on JET.
- Purpose was to get direct or indirect evidence of the fast particles created by parasitic absorption of LH power in front of the grill.
- The long term aim is to understand the mechanism behind parasitic generation of fast particles.
- In order to find a way to avoid the hot spots, it is necessary to find the parameters that control their formation.

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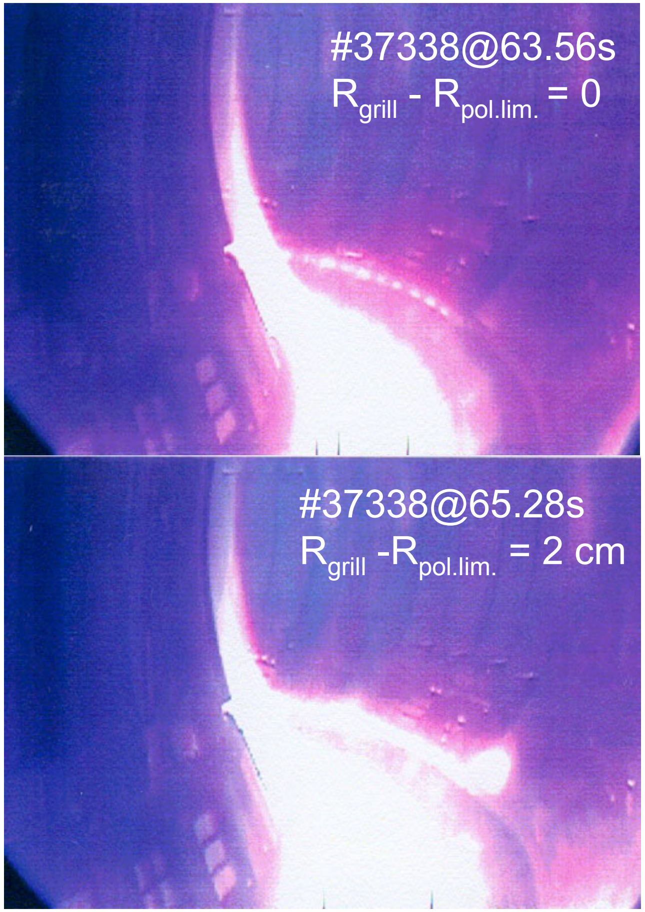
Hot Spots on JET

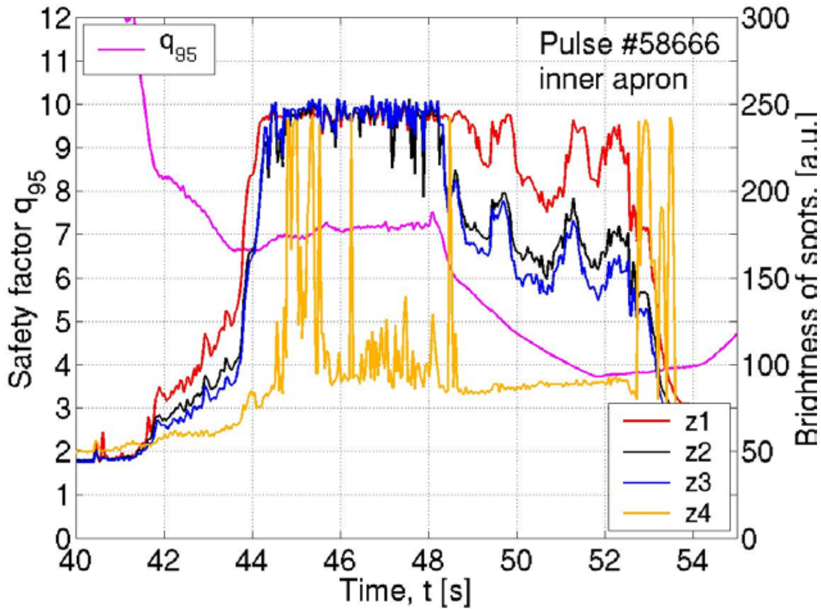
- Hot spots in locations magnetically connected to the JET LH grill mouth were first seen on videos from shots 37338, 38804-5 [Goniche et al. JET-R(97)14].
  - Low q, $q_{95} \approx 3.1$
  - Short magnetic field connection
  - Hot spots on outer divertor apron
  - Brighter spots when grill behind the limiter ?

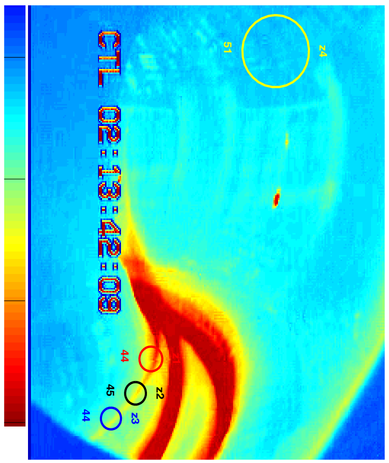


CCD images for $F = 5.3 \times 10^{21}$ el/s and P_{LH} = 2.5 MW

Spots on the inner apron

- The Infra Red Movie Analyser IRMA software was used to analyse the CCD videos of the shots that showed hot spots on the divertor apron.
- The analysis shows clear increases in the brightness of the measuring points in the second phase of the shots with clear correlation with the end of the hot spots and the LH power.
- The ELM activity can be seen very clearly as sharp peaks in the background brightness.





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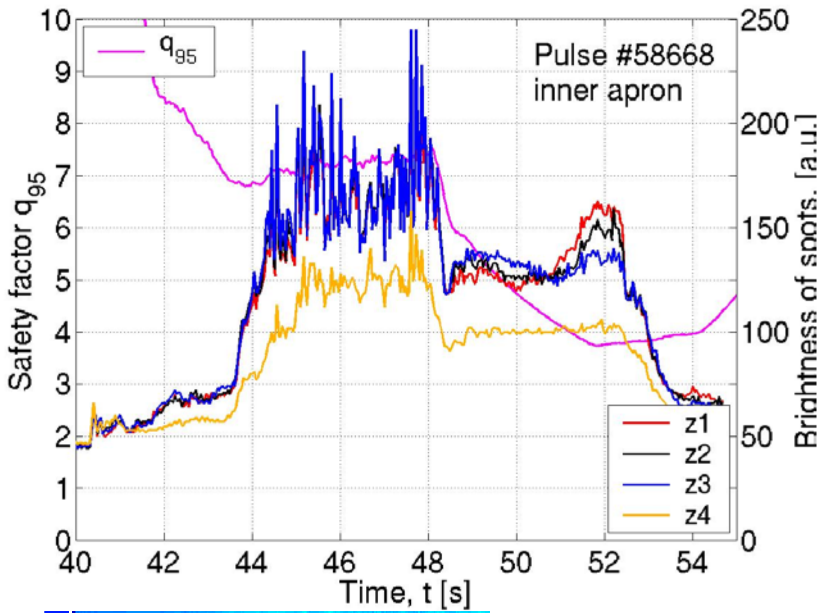
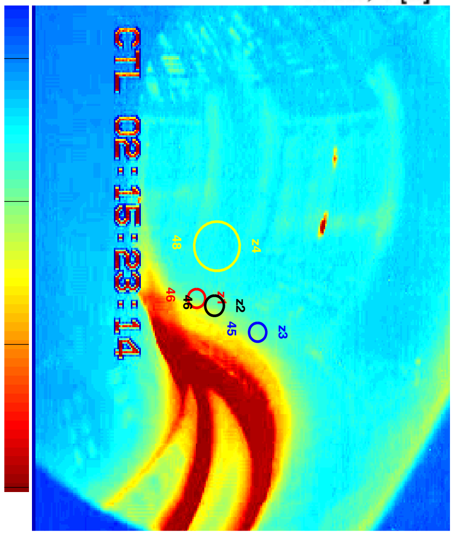
Spots on the outer apron

- The IRMA analysis also showed hot spots on the outer apron.
- The drop of the brightness agrees very well with the end of the LH power.
- The increase in the brightness at the red and black measuring points starts at about t=51 s and ends when the LH power end at t=52.5 s.





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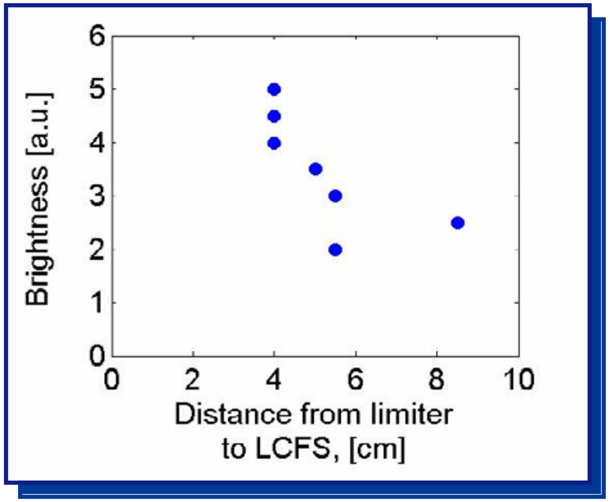
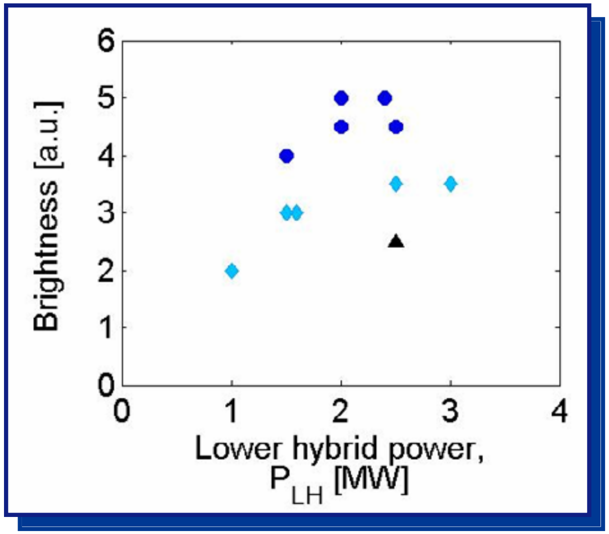
Trends of the Hot Spots Behaviour

- Experimental observations at Tore Supra and TdeV indicate a dependence on the LH power and the edge density.
- Simulations suggest also a dependence on the edge temperature.
- Experiments at JET indicate that the hot spots are weaker when operating at large distance.
  - The density in front of the launcher is lower (coupling was similar, however).
  - The propagation of the particle beam further away from the launcher in a less dense plasma is different (due to instabilities).





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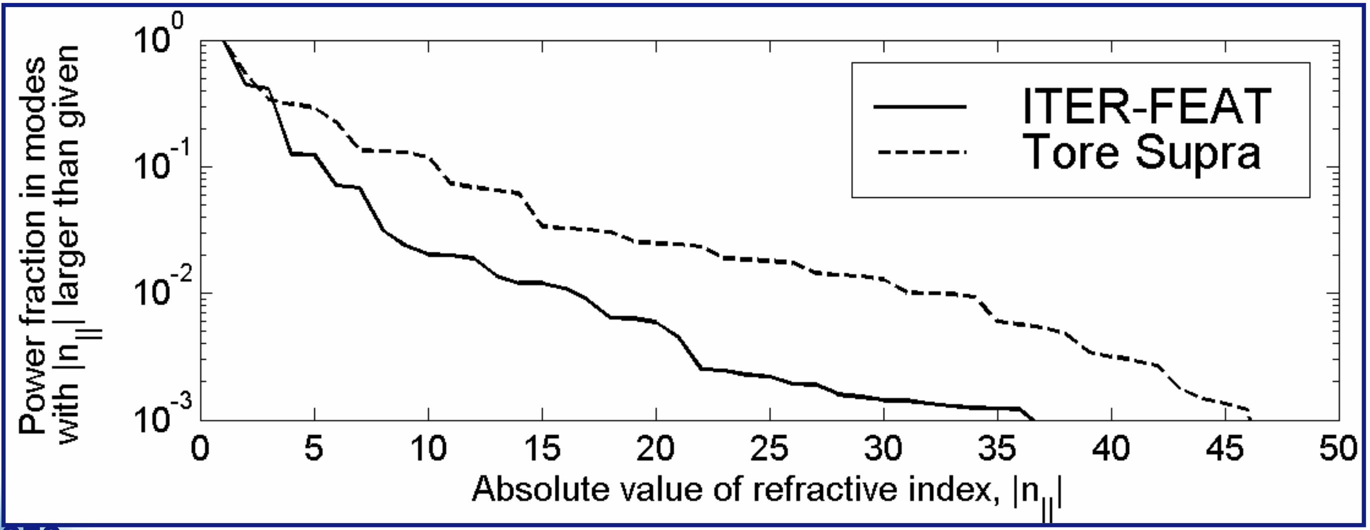
Consequences for ITER

- At nominal power density for ITER (33 MW/m^2), the parallel heat flux is expected to be less than 7 MW/m^2 at edge density is lower than $0.6 \times 10^{18} m^{-3}$.
- This flux is easily manageable for ITER plasma-facing components except for Be first wall, which will require alignment of field lines to the wall within 2.5°.
- Significant reduction of the heat flux could result from a reduction of the high-$N_{||}$ content of the spectrum launched by the PAM.
- LHCD experiments with a distance up to 10 cm between the last closed flux surface and the antenna have shown that increasing this distance to ITER-relevant conditions has a beneficial effect on the heat flux deposition.



Further work

- A few good reference pulses found.
- We should get a better understanding of conditions in which the hot spots appear at a given location
- Dependence of the intensity of the hot spots on parameters like plasma density (difficult – gas puffing!), LH power, grill position, ROG, etc., should be further investigated.
- Better statistics (more shots) would be needed to confirm tendencies shown on the previous slide.
- The hot spots should be brought into the IR camera view to find the thermal loads that they cause.
- Direct the fast particle beam into the RFA slit at low LH powers (not to damage the RFA) in order to find whether the fast ions participate in the heating (and in erosion – sputtering).
- May be not just piggy-back experiments only?