Statistical analysis of temporal and spatial evolution of in-vessel dust particles in fusion devices by using CCD images

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Motivation

- Flaking of radioactive tritated co-deposits of nano- to micrometer size.
  - -> Tritium(10% of 35g) was trapped in deposited a-C:H layers during the JET DTE1 campaign.
  - -> These amorphous layers are the main source of mobilizeable dusts in tokamaks.
- A strong chemical reactivity with air (hot dusts, ITER accidental scenario).
- Damage to first wall & diagnostics due to high velocity impact.
- **To control the amount of dusts in vacuum vessel , it is important to monitor the dust creation events of dust particles in Fusion devices.**

CCD image processing

CCD image processing technique [1]

Pattern recognition

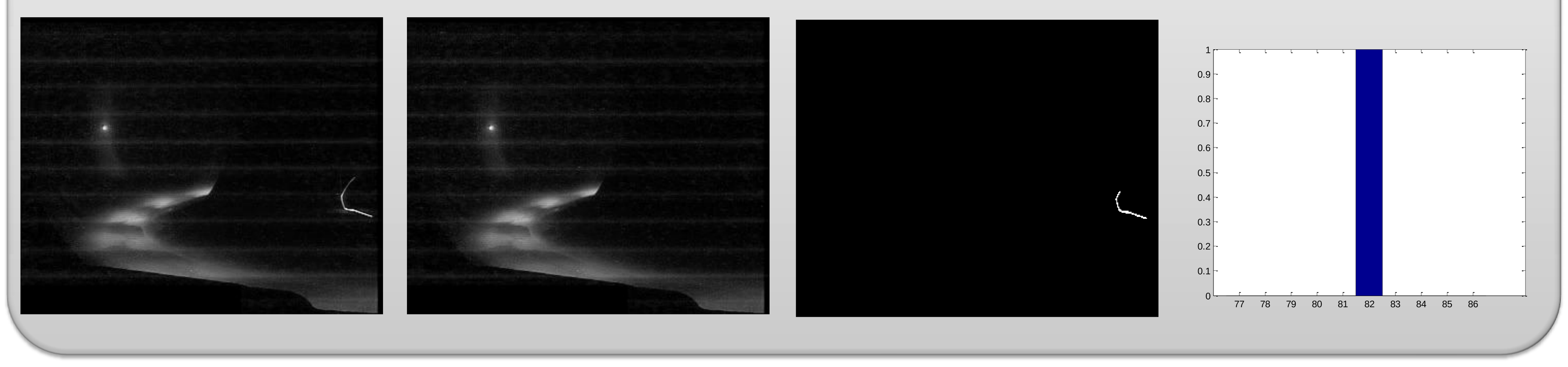
- Background : Plasma emission intensity
  - -> Temporal change in the plasma emission intensity has to be slower than the acquisition speed of CCD cameras
- Target pattern : Well-defined straight line-like trajectories of dust

1] Suk-Ho Hong *Phys. Control. Fusion* **51** 075013 2009

Procedures

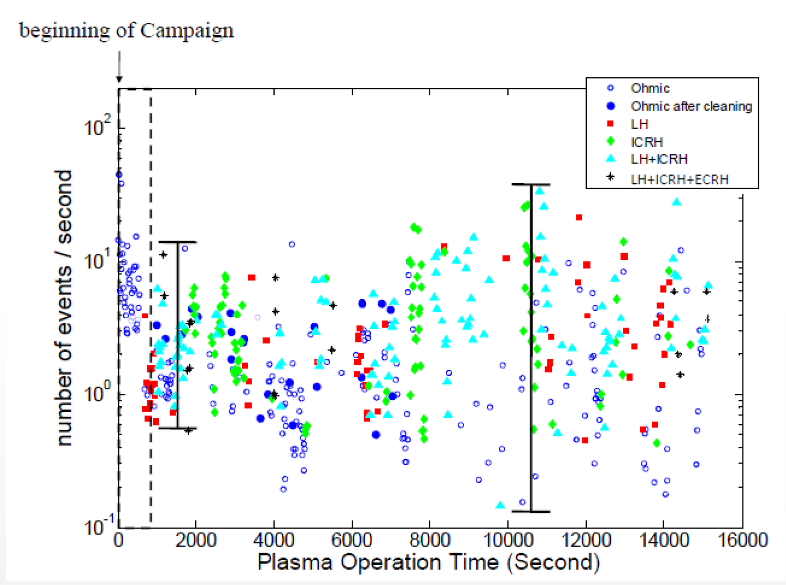
1) Conversion to the grayscale images
2) Filters for noises
3) Subtraction between the target frame and the background frame
4) Conversion to the 1bit black and white (BW) images

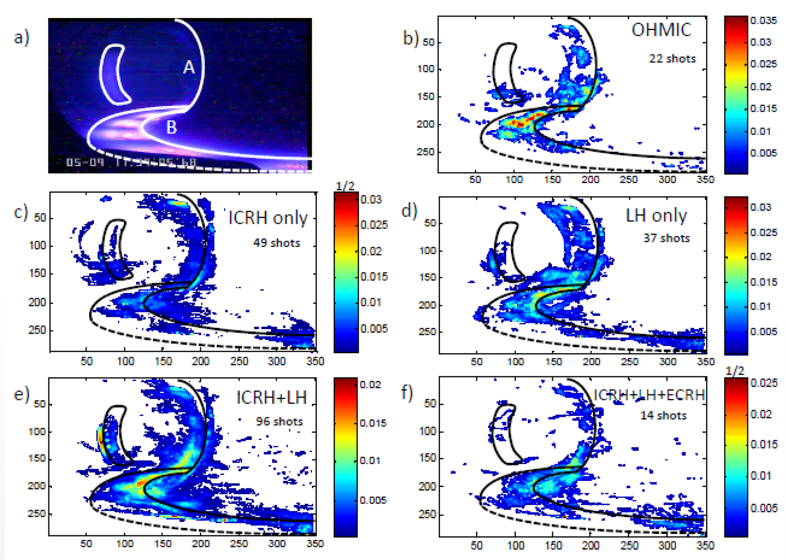
→ Counting dust particles, integrating frames
(The frequency of the events / The creation zone of the dust particles)



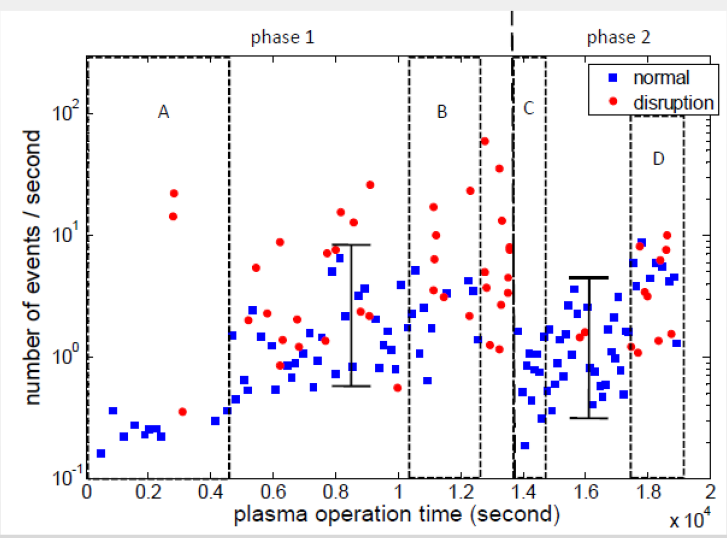
DCEs in Tore Supra

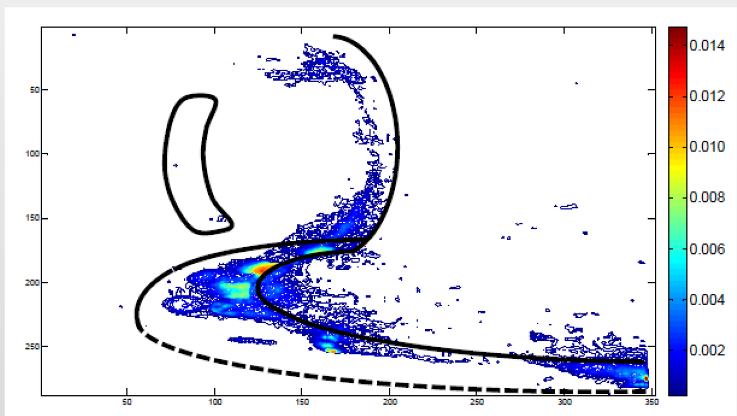
CIMES Campaign





DITS Campaign

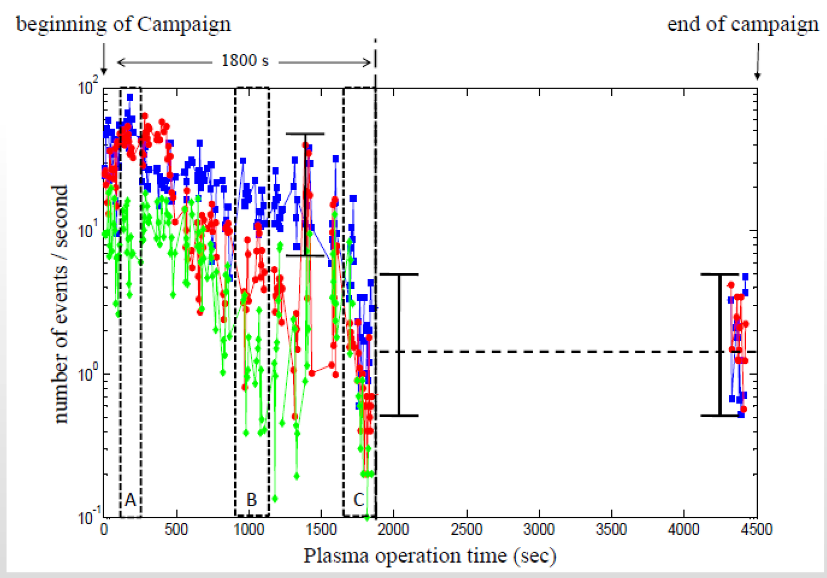


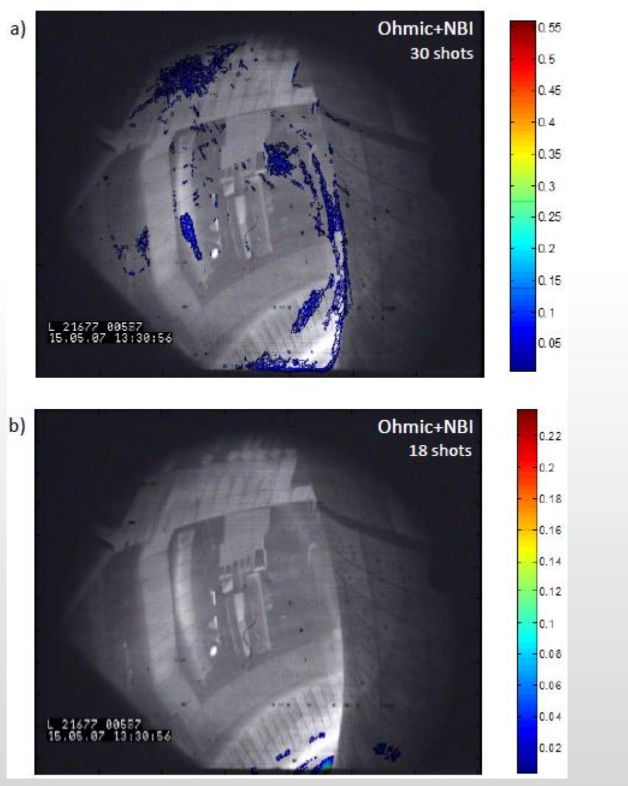


- Large amount of DCEs during the restart of the machine, but soon decreased.
- DCEs are strongly dependent on plasma operation scenarios (input power) and machine history.
- Frequent disruptions were occurred during the DITS campaign with repetitive long pulse. DCEs in DITS campaign show that dusts can limit the plasma operation.
- The origins of DCEs were identified.

DCEs in AUG

AUG 2007 campaign

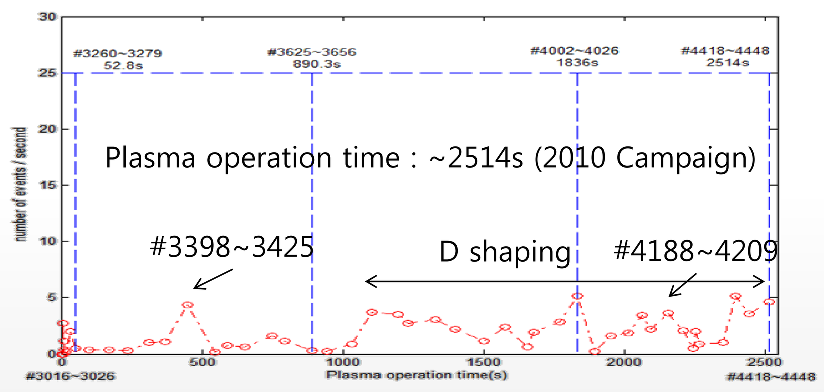


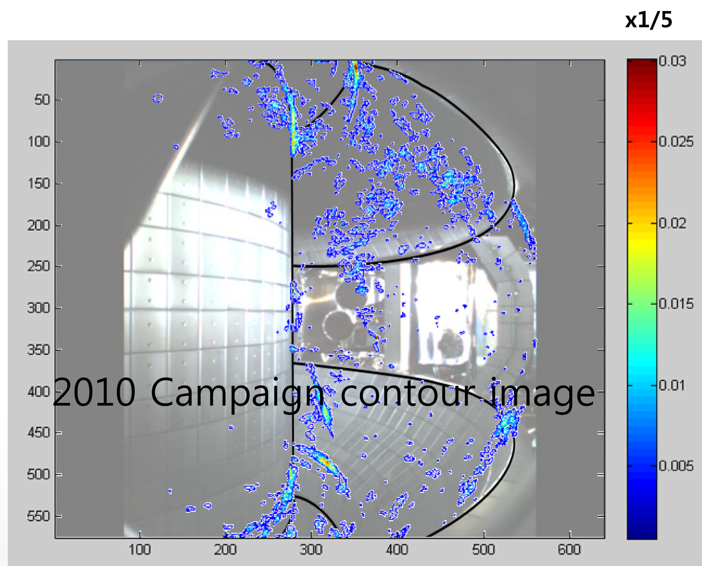


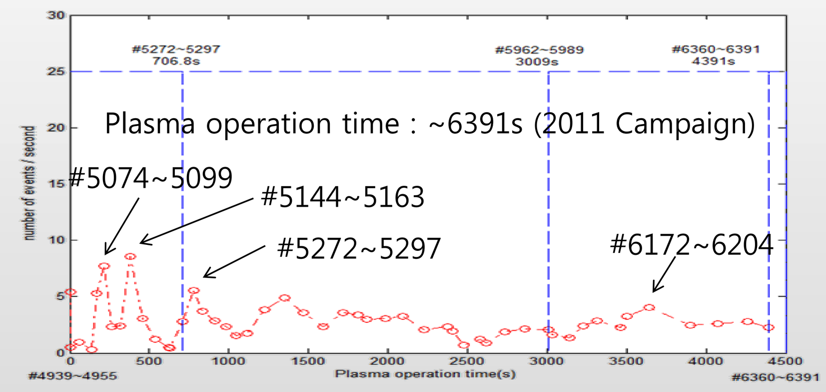
- DCEs decrease as the plasma operation time increases.
- DCEs are dominant at divertor.

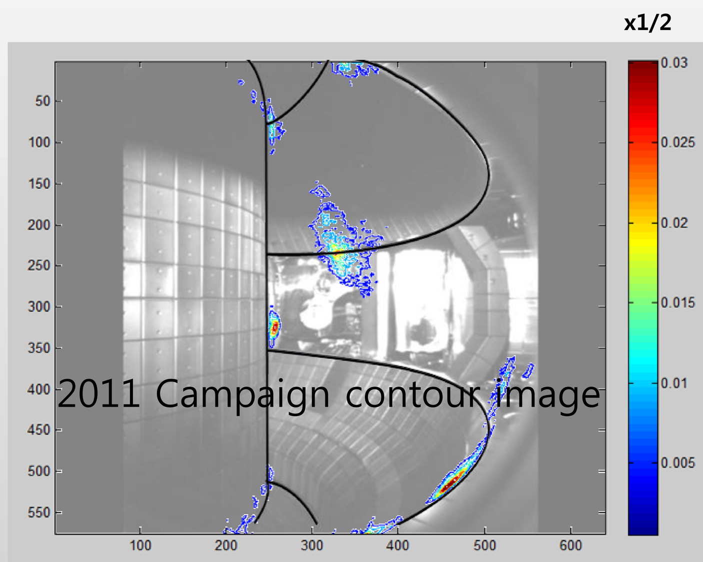
DCEs in KSTAR

KSTAR 2010, 2011 campaign









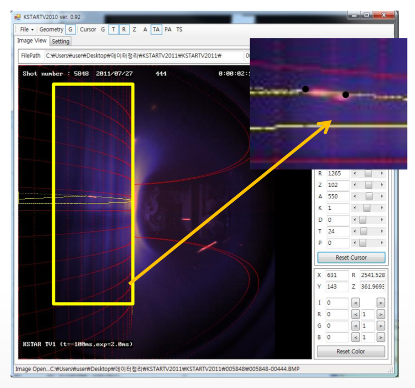
	2010	2011
NEPS	1.8878	2.741
Duration (s)	2543.8s	4316.3s

- DCEs increases during D-shaping experiment, then stays low and almost constant during the campaign.
- DCEs are dominant at divertor as in the case of AUG.

Dust Velocity distribution

KSTARTV2011 program [2]

[2] Y.U.Nam *Review of scientific instrument* **81** 093505 2010



- Identify the plasma position.
- Measure the well-defined straight line-like trajectories of dust along the toroidal direction.
- Measure Θ both ends of dust trajectory.
- Trajectories at inboard side.
- Dusts can not get through into the core plasma.

Dust velocity distribution