15th ITPA meeting on SOL/Div

1. Fuel removal (MD modeling)
2. Fuel removal
4. Dust

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プラズマ物理クラスター　スクレープオフ層とダイバータ物理サブクラスター会合

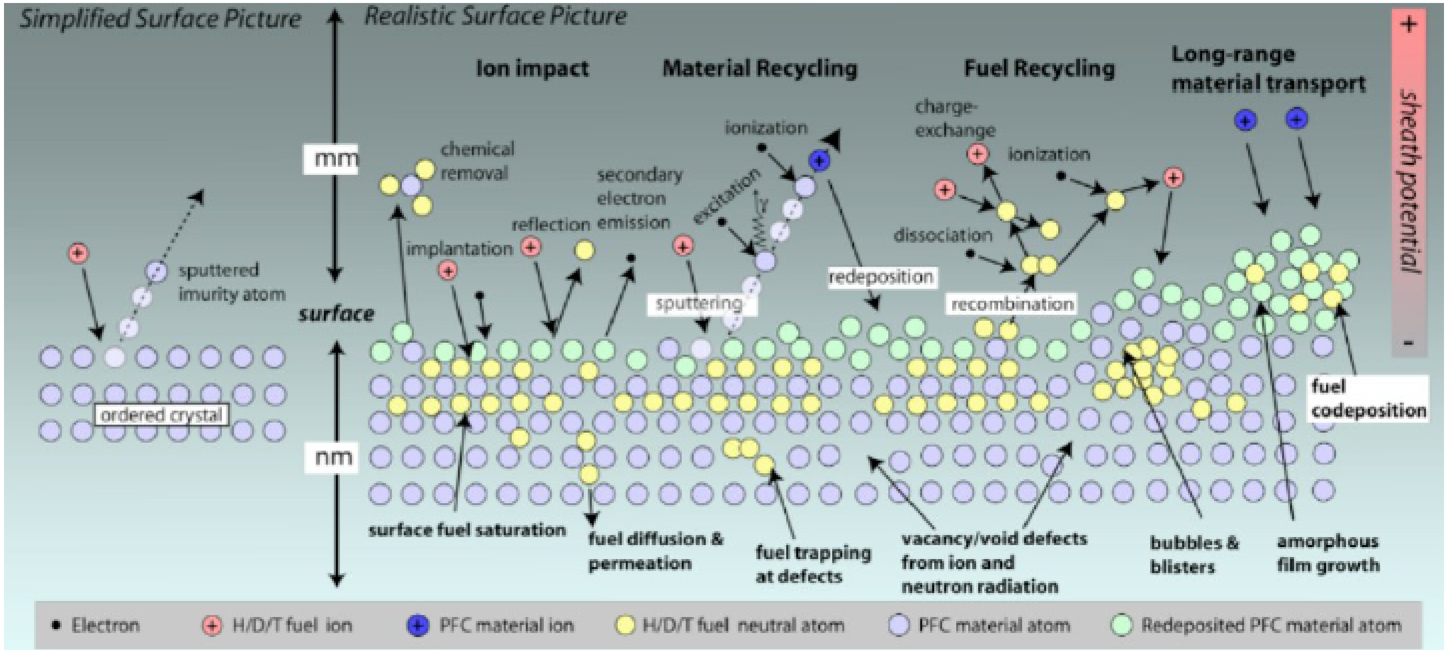
つくばサイエンスインフォメーションセンター

2011年7月20日

1. Fuel removal (MD modeling) ： 7件

- K. Schmid“What can MD bring to PWI modelling ? “
- Z. Yang” MD simulations of PWI at ASIPP”
- Udo v. Toussaint “Hydrogen transport in tungsten”
- Y Ferro “The Interaction of H/T with Be and C from Density Functional Theory calculation - Formation of mixed Be/C materials”
- Heinola “Hydrogen retention in W - A Multiscale Approach”
- N. Juslin “MD simulation of H and He defects in W”
- F. Sefta “Modeling tungsten surfaces exposed to low-energy He/H plasmas on extended time scales (beyond MD) “

Modeling PSI

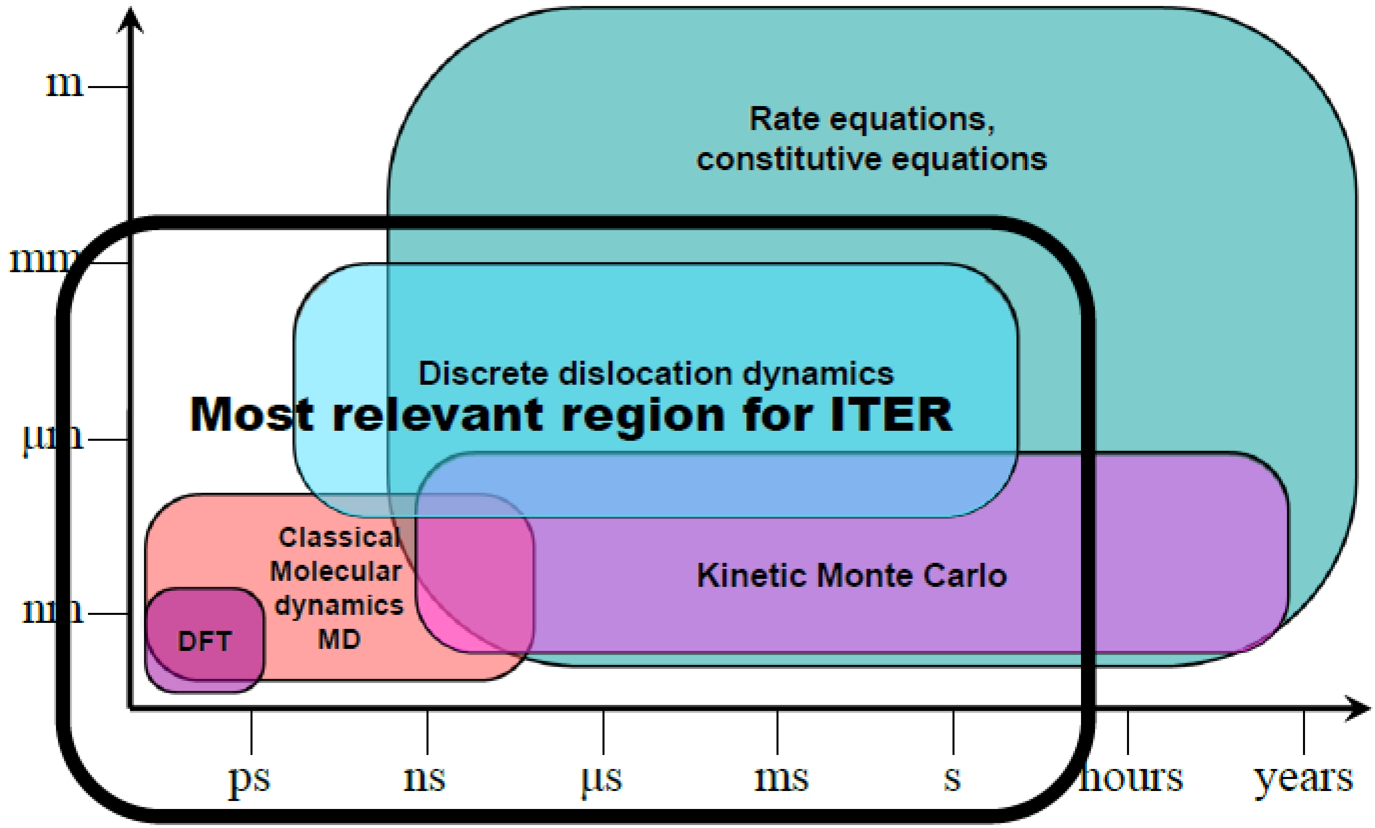


- Many processes related to surface modification and He defect evolution well suited for MD simulation length and time scales
  - –
  - –
- Bu
  car
  - Multiscale simulations needed

N. Juslin, : Surface modification
F. Sefta:Bubble
U.Toussaint ,Kalle Heinol:リテンションのモデリング＆マルチスケール手法

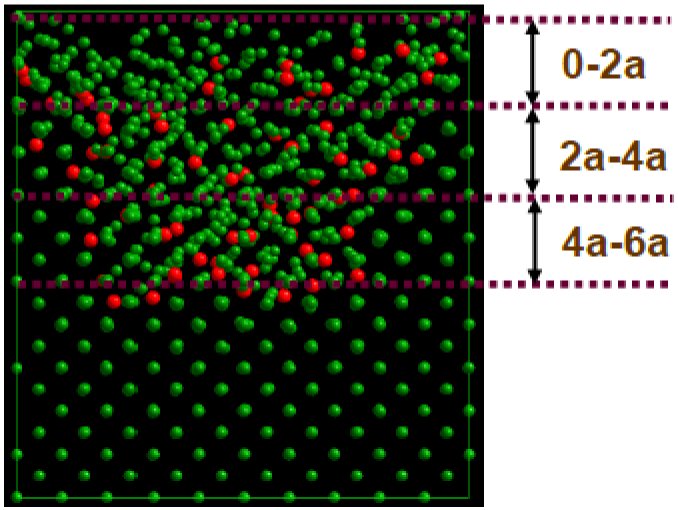
Need for Multiscale modelling

Association Euratom–Tekes



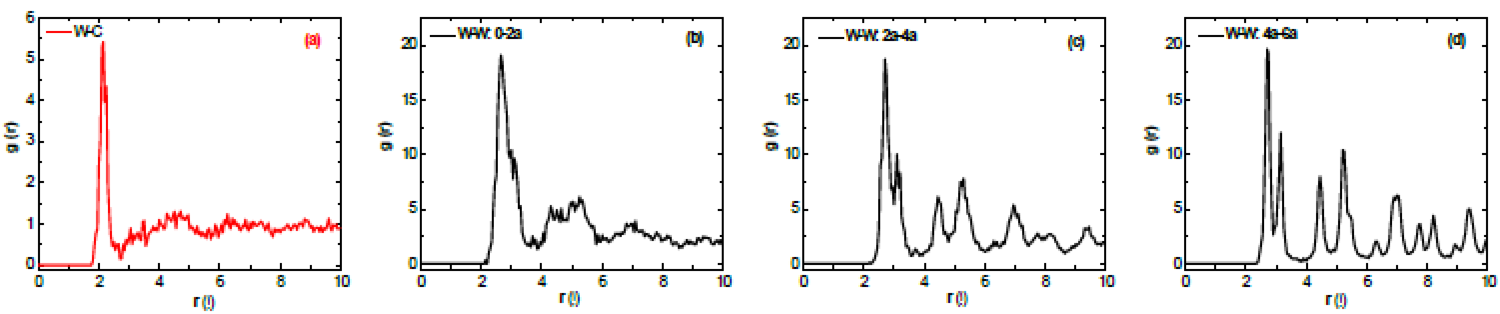
Z. Yang
ASIPP

C-W Mixed Layer



C-W mixed layers:
68 (/200 C) atoms trapped on the W surface
(E_i = 150 eV)

- Most C atoms trapped on the octahedral interstitial site
- Amorphous W-C structure in the mixed layers



W-C pair distribution function g(r) (a) and *W-W pair distribution function g(r) at different depth from the surface: (b) 0 -2a, (c) 2a - 4a, (d) 4a – 6a, a is lattice constant of bcc-W*

- 0 - 2a, typical amorphous structure from g(r) for W-W
- > 4a, near to crystalline structure from g(r) for W-W

**Reflection behavior of C atoms on W surface*

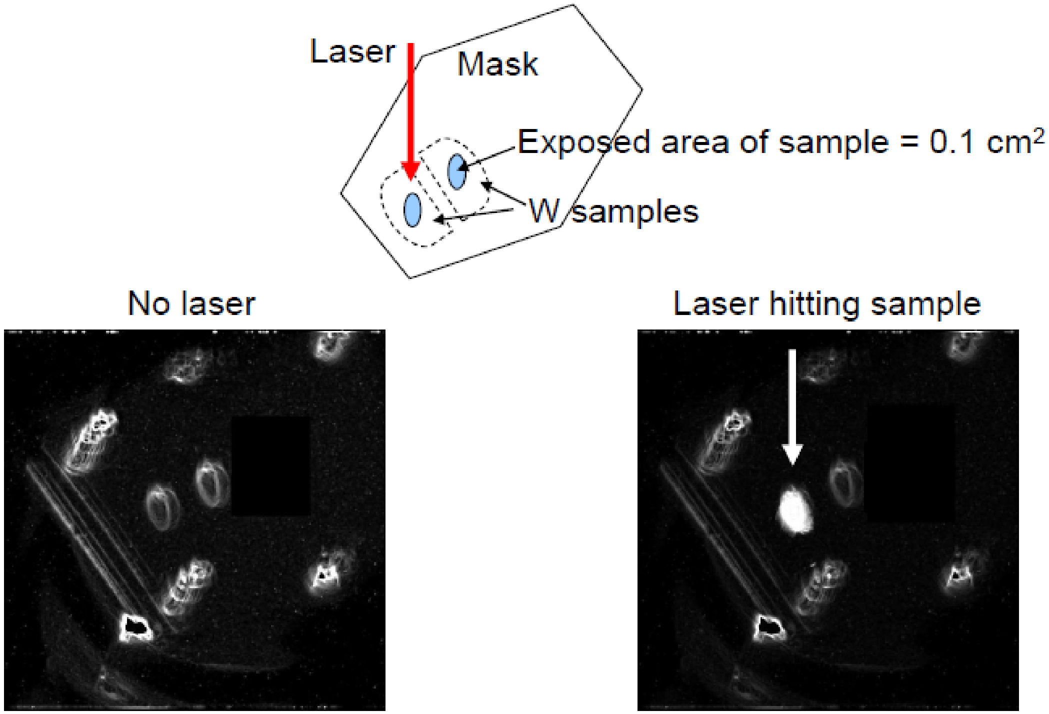
2. Fuel removal　：　4件

- R. Doerner "Be flash heating"
- V. Philipps "W flash heating"
- J. Davis "D reabsorption by depleted codeposits"
- M. Shimada "deuterium retention in neutron-irradiated tungsten"

➢Goal of the project is to investigate the effectiveness of various heat pulses associated with radiative plasma termination, as a means of tritium removal from Be codeposits in ITER.

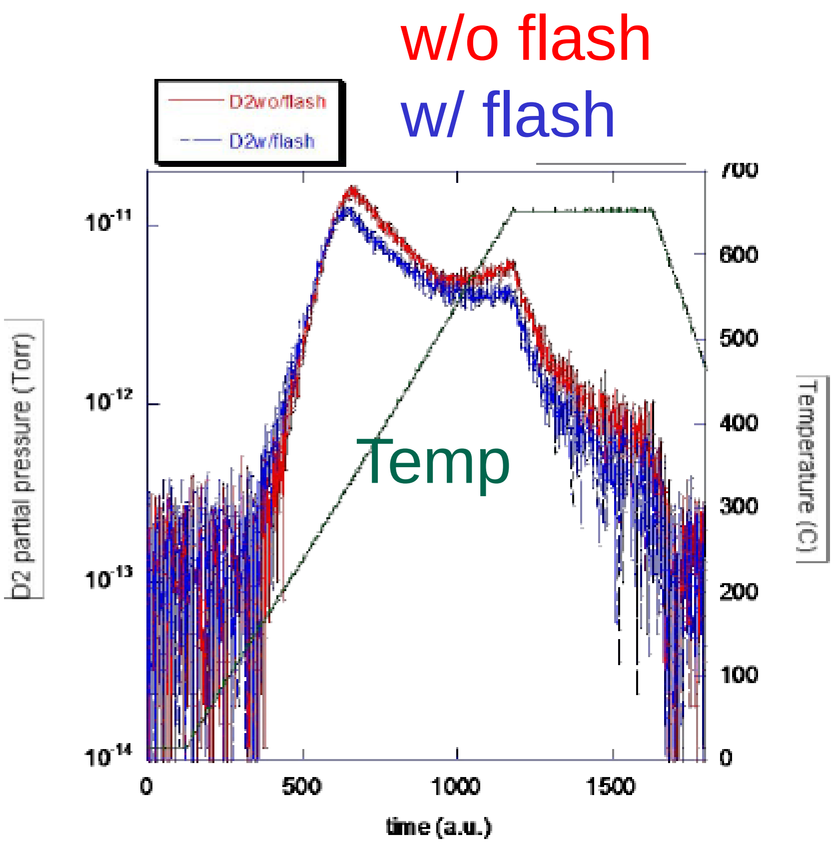
➢A 50 J laser (@1064 nm) is used to vary the temperature of Be codeposit formed in PISCES-B.

Fast imaging used to verify alignment of laser and pyrometer view on sample



Flash heating of Be codeposits continues to show little release of retained D

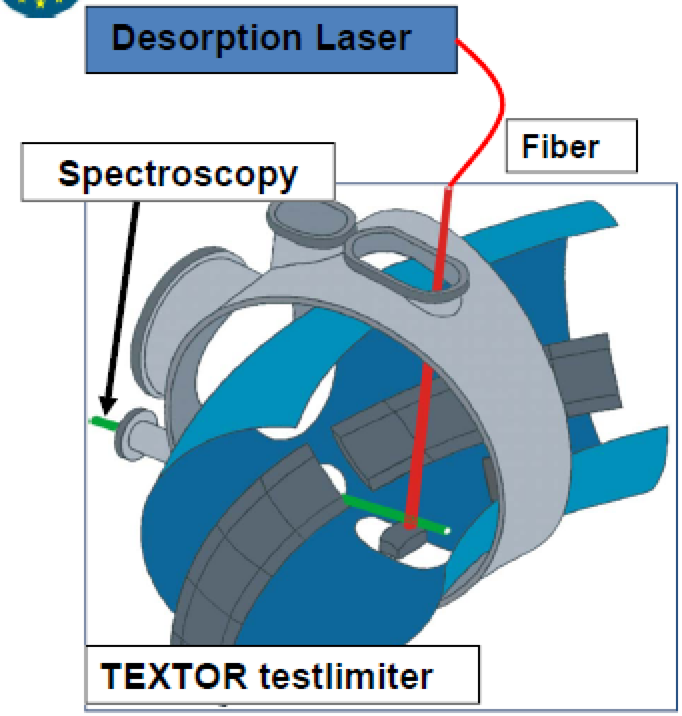
- ΔT is measured to be ~1000 K
- Shape of release curve is nearly identical
- Integrated retention in flashed codeposit is 80% of retention in un-flashed codeposit
- Consistent with Keroack & Terreault JNM 1994.



R. Doerner

UCSD

W flash heating

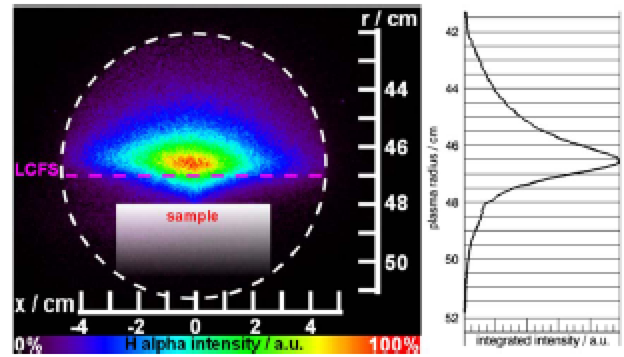


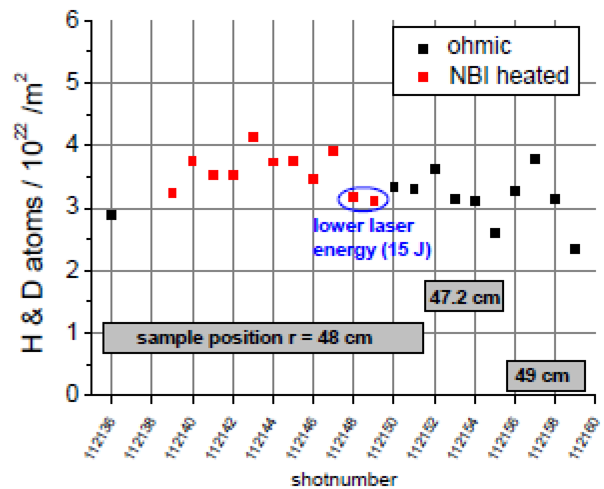
In situ Hydrogen inventory determination by laser desorption (3ms heating) and Hα light detection

detection limit: $3 \cdot 10^{21}$ H/m^2 (NBI)

$4 \cdot 10^{20}$ H/m^2 (OH)

2.5 µm thick a-C:H layer

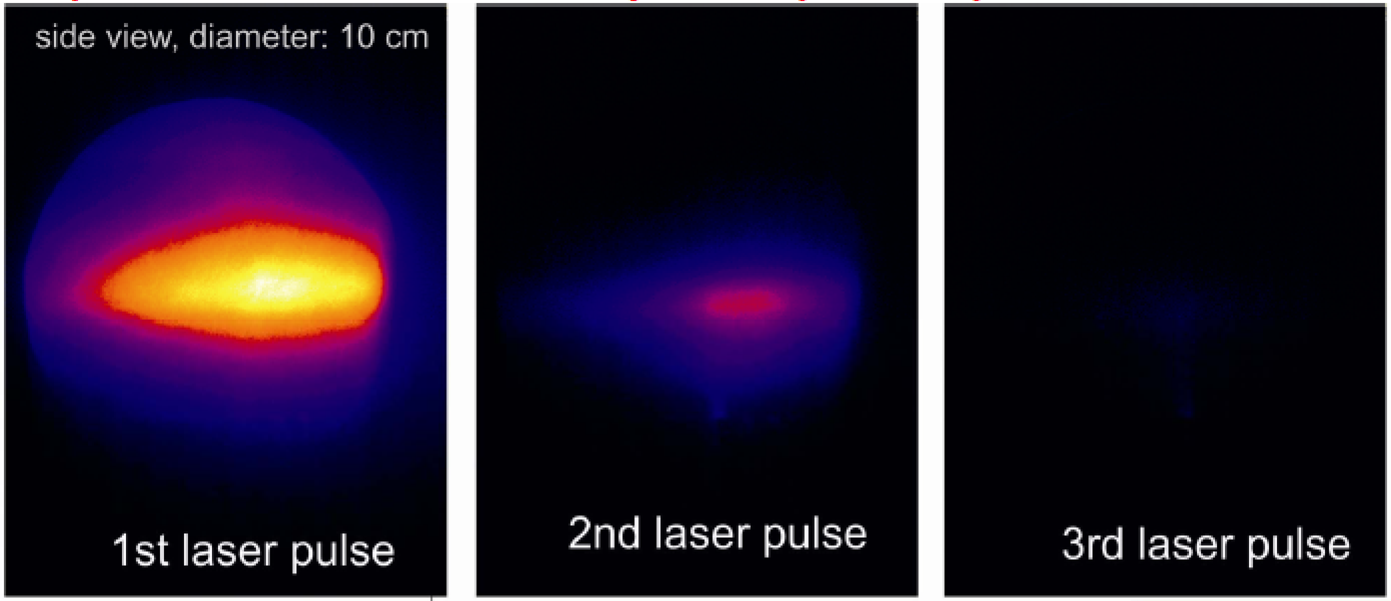




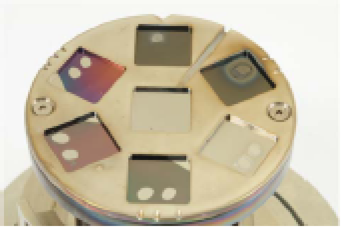
V. Philipps

Alternative method:

Hydrogen detection by laser ablation (20 ns ! , removal of deposits , also to measure layer composition)



Hα light by Laser ablation (20ns) of an 800 nm ac:H layer on W



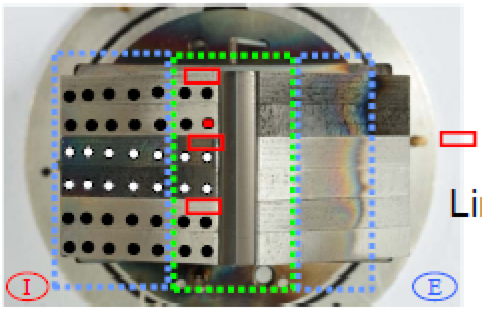
V. Philipps

Laser heating of W coatings (JET CMSII coatings on CFC)

Exposure of **JET W coatings (CMSII)**
in TEXTOR under identical conditions

Plasma side: Te = 40-50eV ≈ 2 10^{25} D/m^2

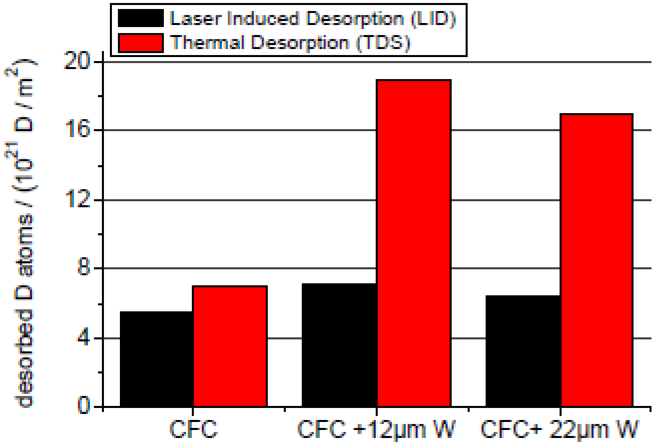
Ts< 400C



- **Laser Desorption**

=TDS

Limiter top view



Retention erosion area

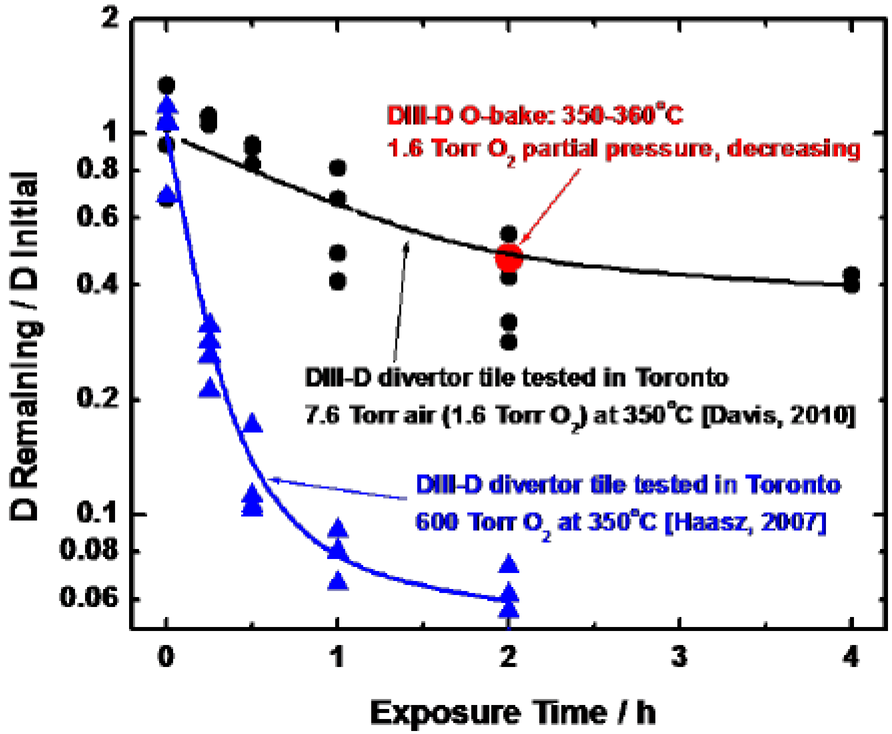
Large retention in W coatings

≈ x 3 compared with bulk CFC
> compared with bulk W

In addition:
TDS of laser spots after Laser heating
Microbeam NRA mapping in and outside laser spots

V. Philipps

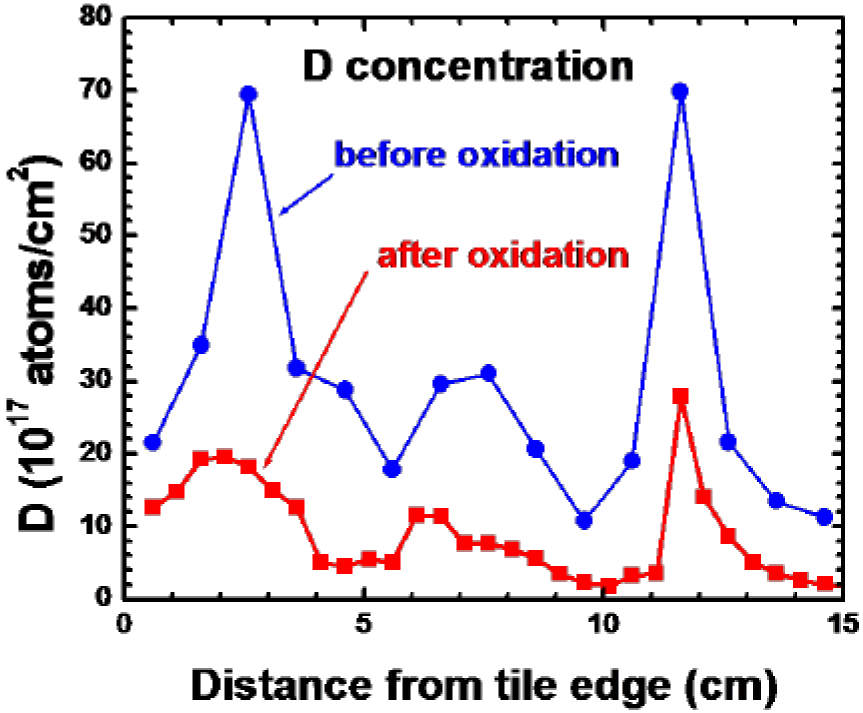
DIII-D Oxidation Experiment



- On average, 53% of D was released, in excellent agreement with laboratory measurements.

J. Davis

DIII-D Oxidation Experiment



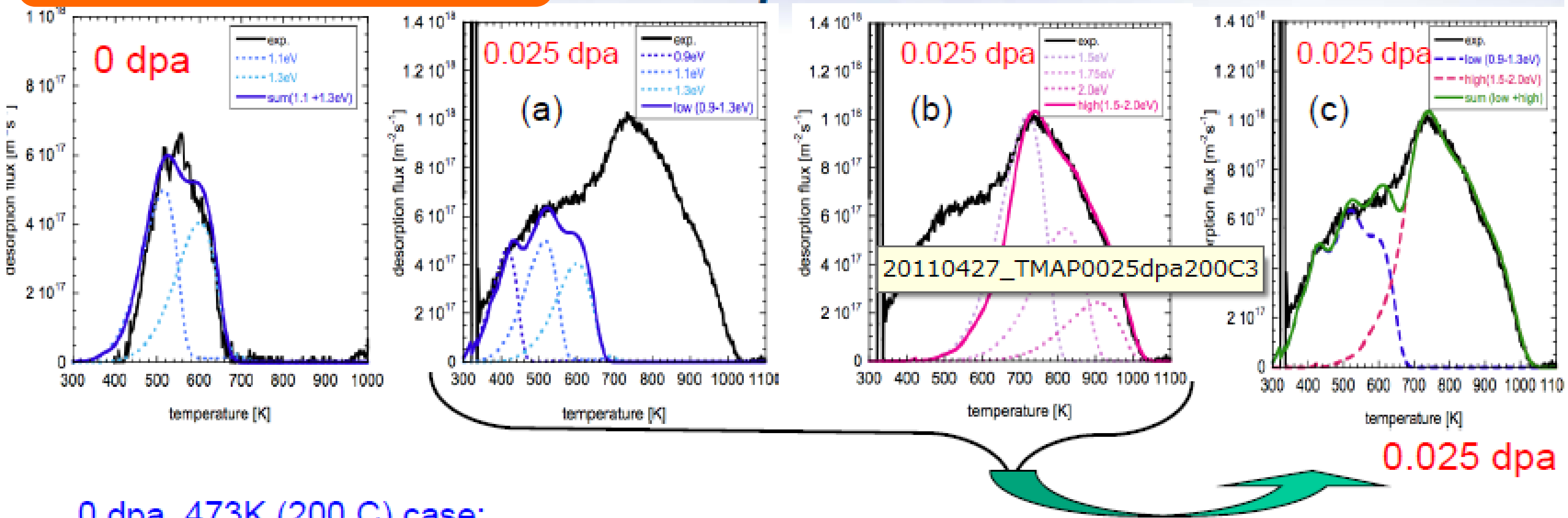
Wampler, et al, PFMC13

- NRA analysis of DIII-D divertor tiles before and after the DIII-D oxidation experiment.

J. Davis

Idaho National Laboratory

TMAP7 simulation of TDS spectrum at 200C



0 dpa, 473K (200 C) case:

- Two traps (1.1 eV and 1.3 eV) with 0.17 and 0.15 at.% D/W give reasonable fit TDS
- Combined trap conc. (0.3 at.%) is higher than the D/W (0.1-0.2 at.%) by NRA

0.025 dpa, 473K (200C) case:

- Six traps (0.9 ~ 2.0 eV) with (0.14~0.45) at.% D/W are required to fit TDS
- Combined trap conc. (1.3 at.%) is higher than the D/W (0.2-0.4 at.%) by NRA
- Four (0.9, 1.5, 1.75, 2.0 eV) traps are induced by neutron-irradiation, indicating that different trapping mechanisms exist for neutron-irradiated and non neutron-irradiated tungsten. Further investigation is needed.

**Neutron-irradiation at HFIR, ORNL*

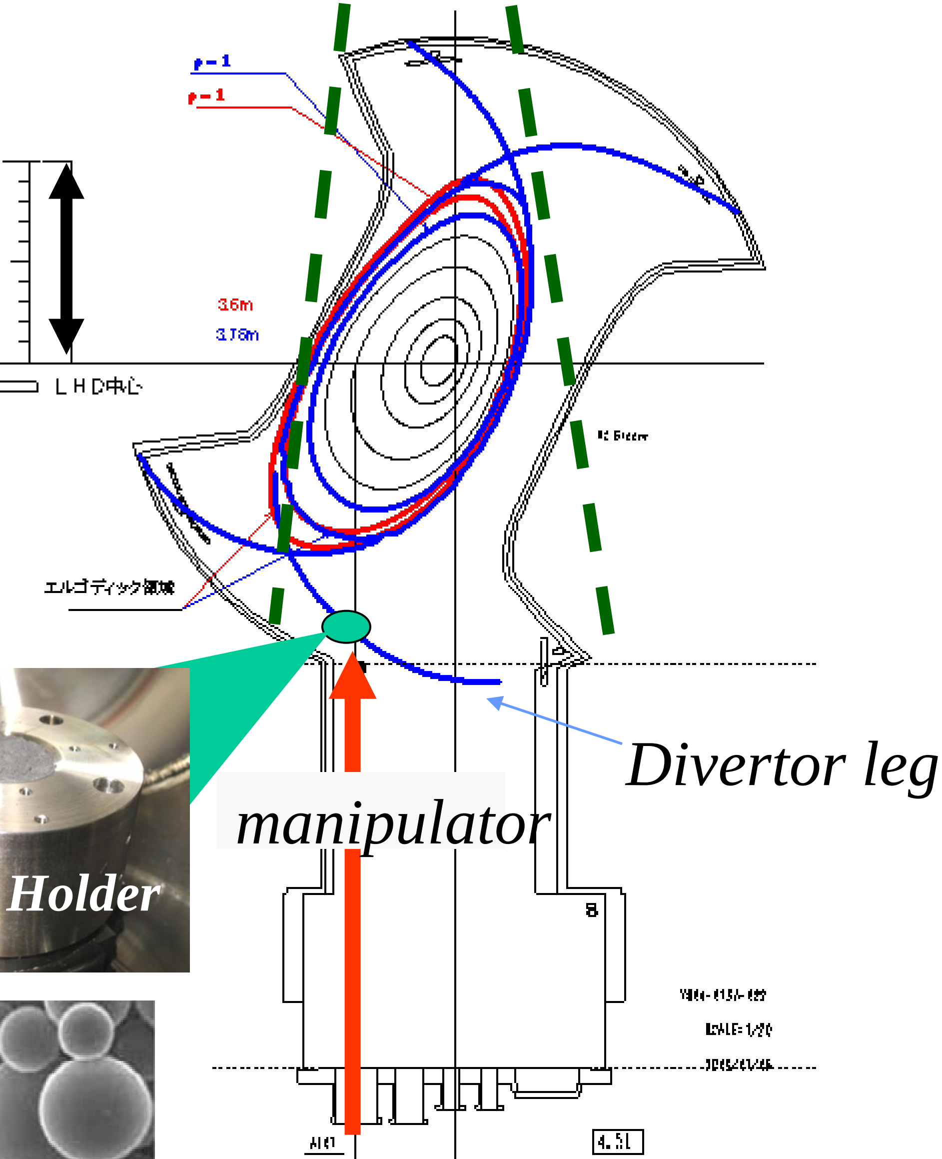
4. Dust ： 5件

•N. Ashikawa "Dust ejection experiment using sphere carbon dust with different diameters in LHD"
•A.Litnovsky "First results of a new dust campaign at TEXTOR / DIIID "
•S.H. Hong "Large size high velocity dust observed in KSTAR + First experiment in TReD device (Transport and Removal Experiment of Dust) Modification of CDG for dust detection"
•S. Budaev "Dust generation in T-10 and QSPA + Dust immobilization in tokamaks"
•Volker Rohde "Dust investigations in AUG (collection, classification, comparison to lab measurements) "

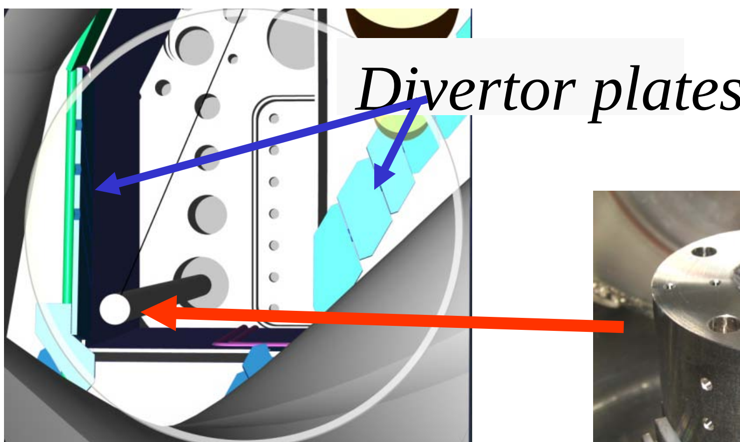
Experimental setup for dusts ejection in LHD

- *A dust holder was installed from the bottom port.*

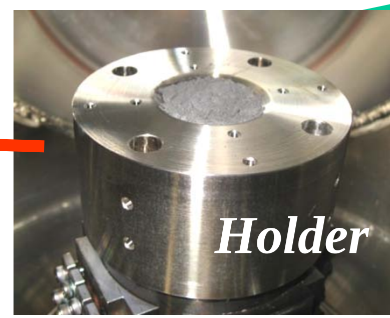
- *A <u>high speed camera</u> observed dusts behaviors from the upper port to the dust holder at the bottom port.*



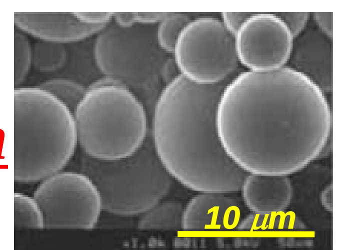
The poloidal cross-section of LHD at the holder position



Field of view of the camera

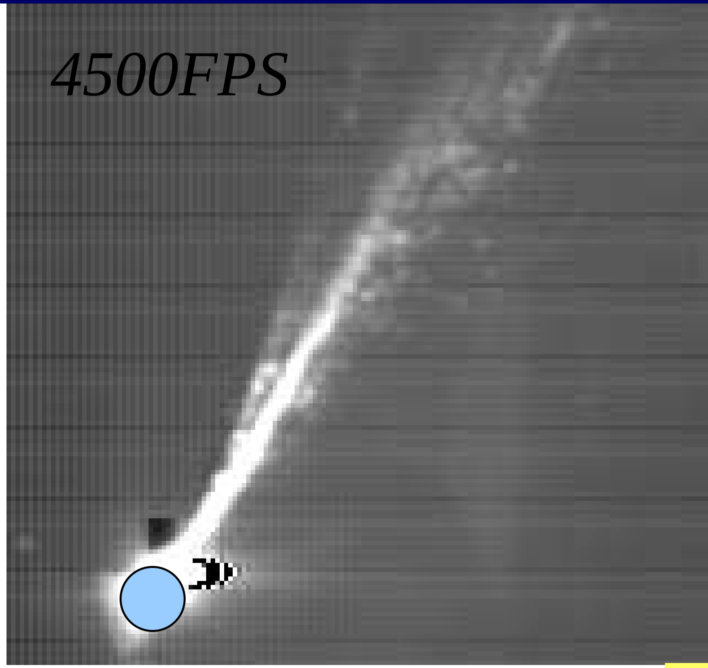


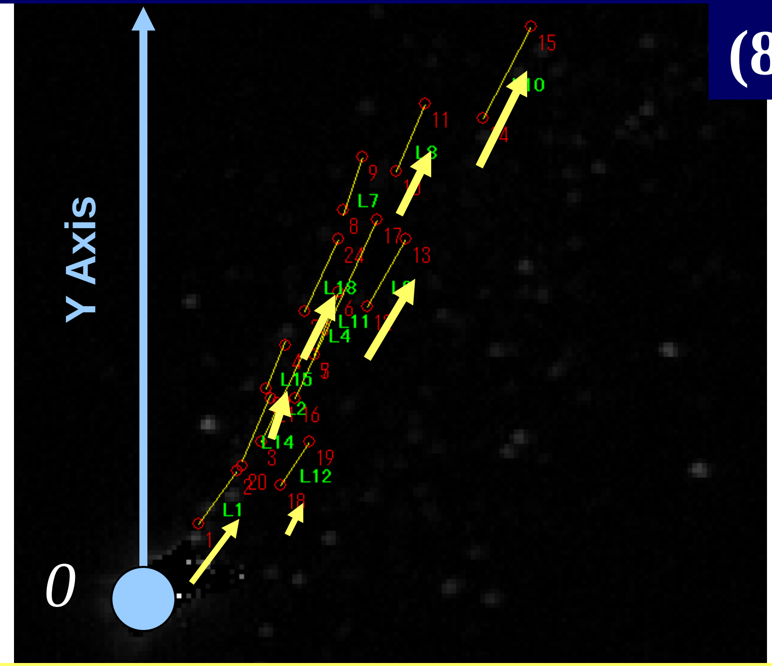
<u>Diameters of sphere carbon dust are 8 and 120 micron</u>

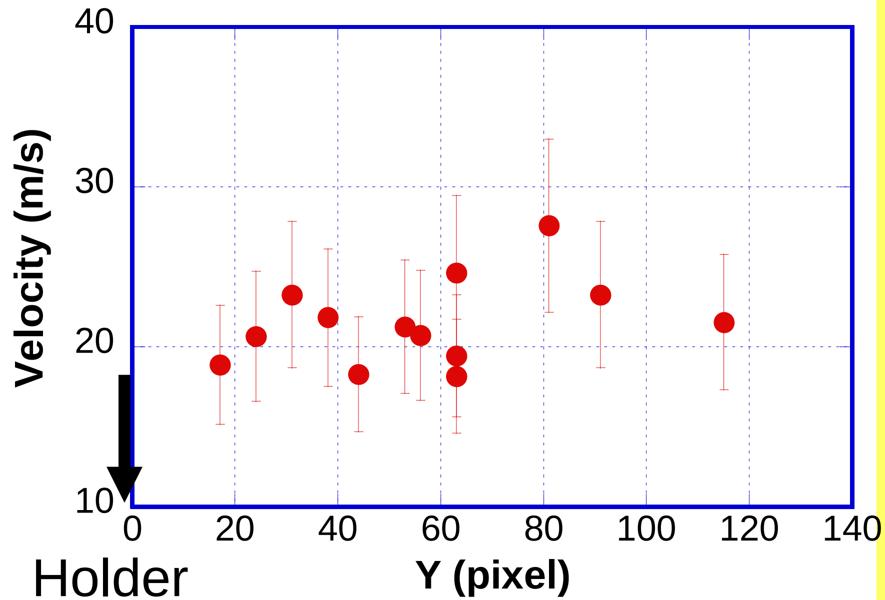


Many ejected dusts have constant velocities up to 40 m/s

(8 μm)

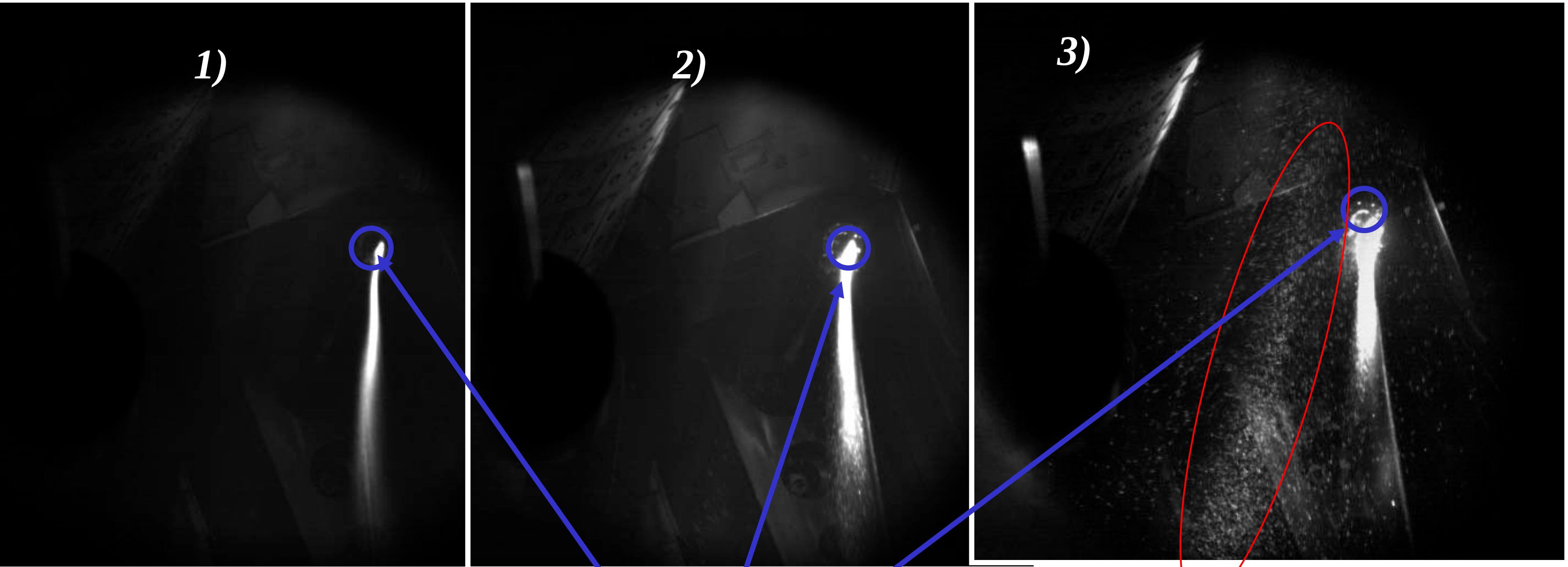


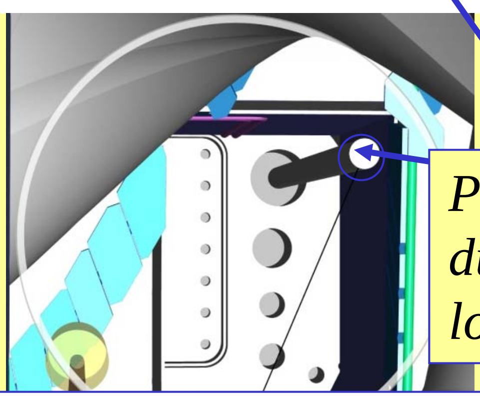




- Velocity is not dependent on the their distances from the holder.
- Direction of motion is limited.
- Time of illumination for each particle is less than 5ms.
- Starting points of illumination are not the same. Only heated particles can be observed.

New 8 micron experiment : improvement of image's contrast





Position of dust holder at lower port

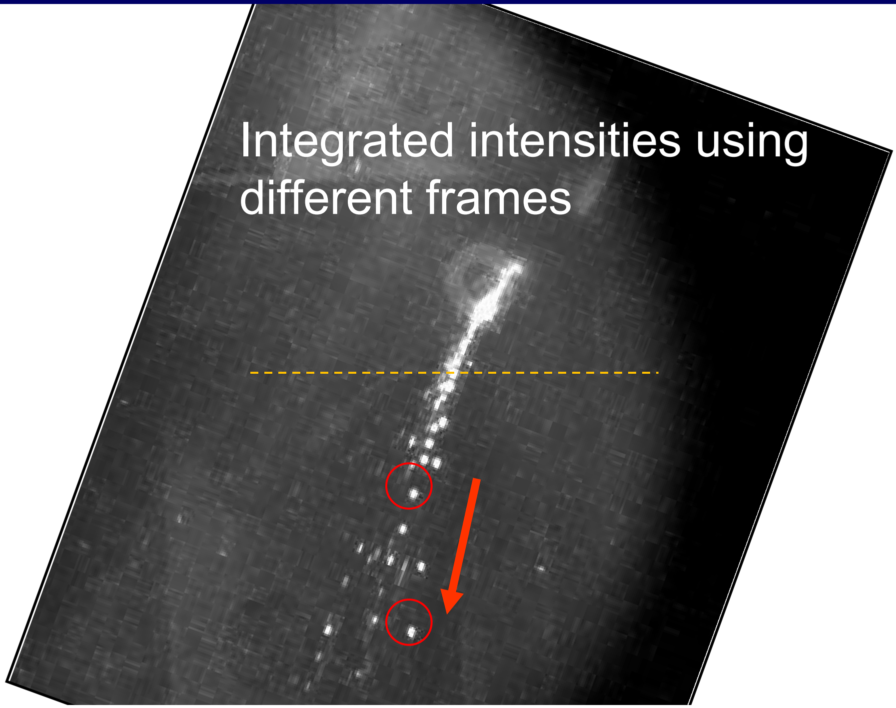
Camera observed from upper to lower

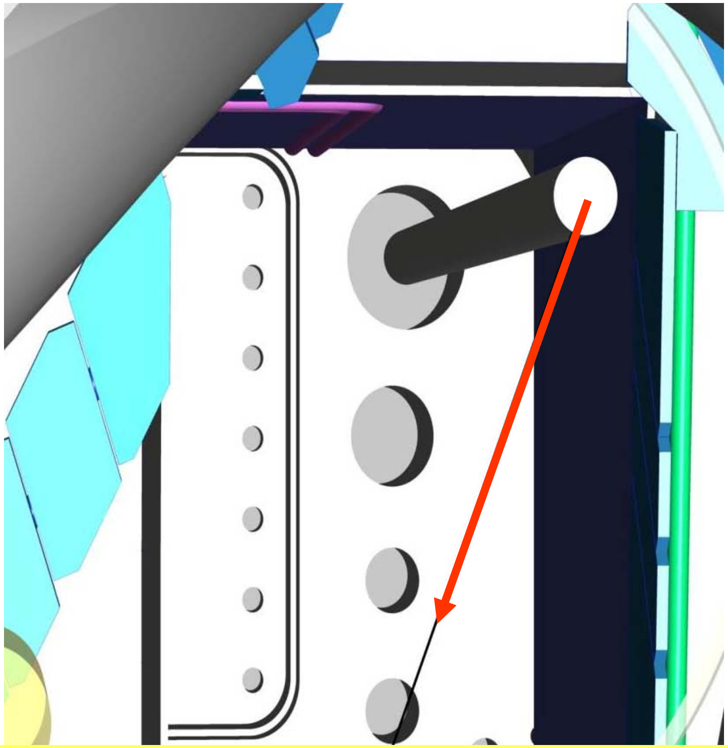
(1) Direction of motion is unstable.

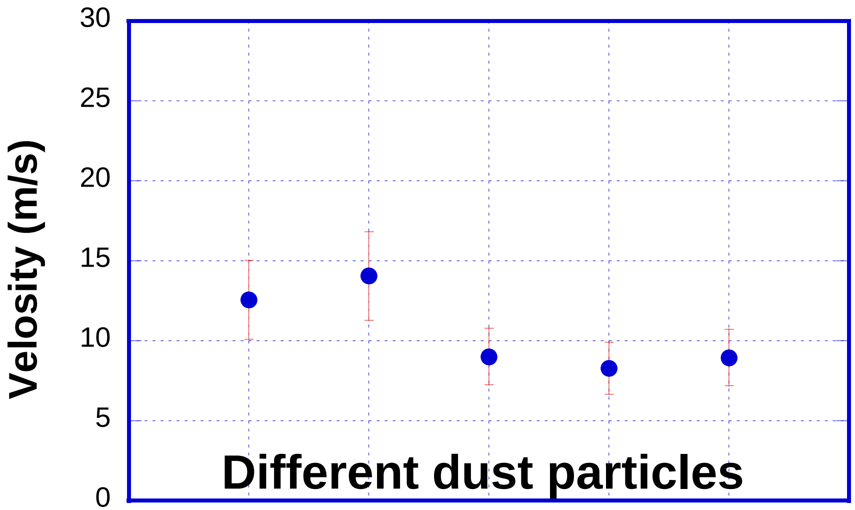
(2) Direction of motion is limited.

(3) At different radial position, remained dust particles (not ablated yet) were observed at different radial position (red circle)

120 micron experiment : velocities are less than 20 m/s







- ➢Direction of motion is limited.
- ➢Typical illumination time is from 5 to 10 ms
  - ➢Depending on the sensitivity of camera detector

Experiment description II in TEXTOR: discharge scenario and dust types, 5th May 2011
Operated by A.Litnovsky

Spherical test limiter with dust holder

<<Discharge scenario>>

- *Identical NBI heated repetitive discharges;*
- *NBI 2, 1 MW, NBI 1 (first two units on first day);*
- *Counter-current and reversed B_t;*
- *I_p=350 kA; B_t=2.25 T;*
- *dust launches for 1-3 discharges;*

<<What is new>>

- ***Carbon spherical dust** of different sizes: **8 um** vs. **60 + 8 um** (request from modeling)*
- *High resolution fast camera: Phantom v. 641, 4 MPix@ 5kframes/sec, max. 219 kframes/sec.*

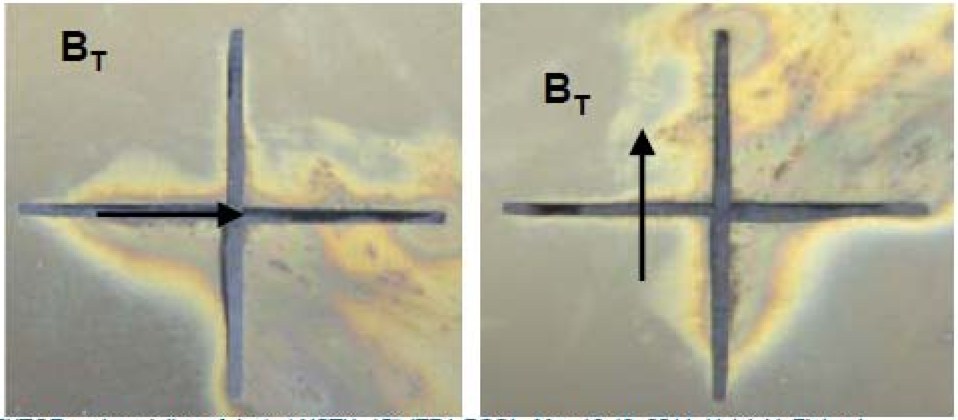
	LHD	TEXTOR
Installation/position	Divertor plasma/lower	Limiter/upper
Initial condition	Dry powder	Wetted by ethanol (DIII-D type)

This work is being made under IEA-ITPA Joint Experiments Program, task DSOL 21, IEA / TEXTOR collaboration

N. Ashikawa &A.Litnovsky

- Upon the sample extraction, dust loss to a depth of 0.5 – 1 mm was observed
- This is consistent with the earlier NSTX results

Amount of the dust lost
~ 3 mm^3 or ~ 1 mg



A. Litnovsky et al., "Recent results of dust campaigns at DIII-D, TEXTOR and modeling of dust at NSTX, 15th ITPA DSOL, May 16-19, 2011, Helsinki, Finland

Dust collector

dust classification (N.Endstrasser)

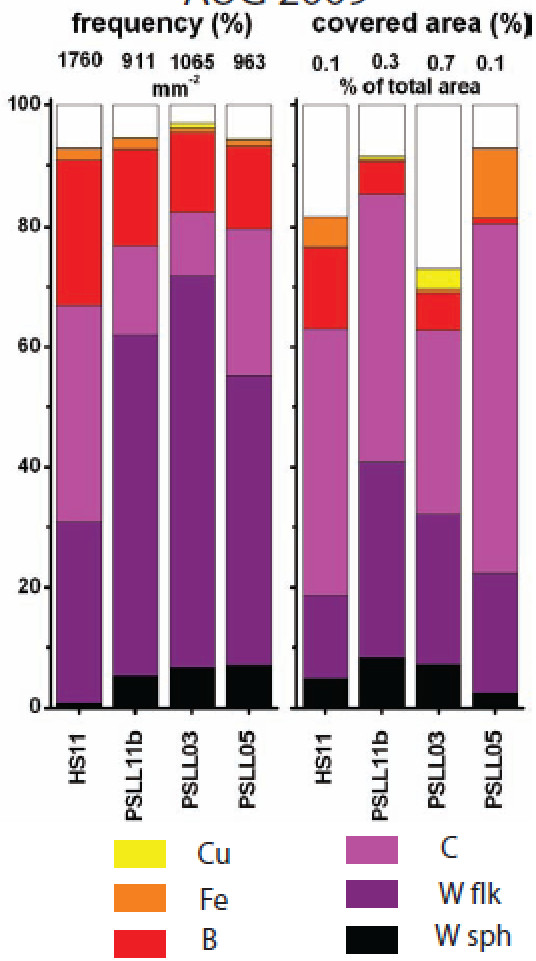
1e5 particels measured up to now
classification scheme still developing

example AUG 2009
- toroidal symmetric
- central column: more carbon
- 60 % of particles are W dominated
- 10 % W spheres
- Cu at one location (arcs on PSL)

detailed investigation started (Endstrasser PFMC)
analysis of probes ongoing....

2009: 3 x Boron, 1101 shots, 5275 sec
5(4) Si wafers, 10 filters, 41 taps
2008b: 2 x Boron, 354 shots, 1822 sec
5(4) Si wafers
2008a: 3 x Boron, 755 shots, 3553 sec:
3(2) Si wafers
2007: 0 x Boron, 383 shots, 1847 sec
3(3) Si wafers

AUG 2009



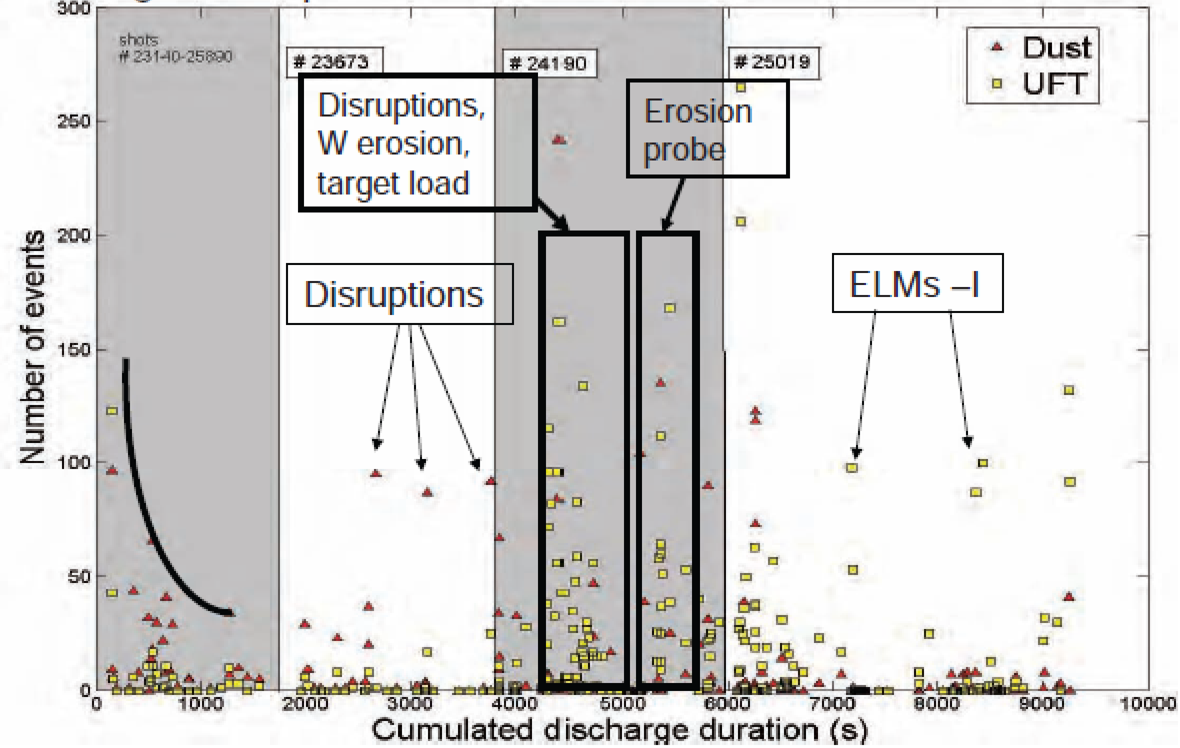
V. Rohde

Video observation

evaluation of fast camera

Statistical analysis of 4 campaigns (500 movies done, ongoing…)

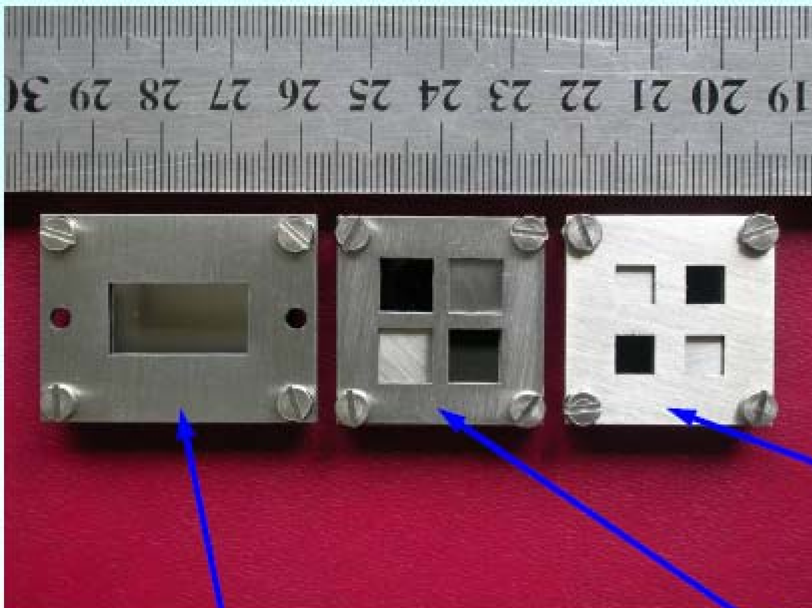
Analyses are running automatically, and seem correct. However, interpretation is not automatic; it requires taking into account the history of discharges, with plasma conditions.



V. Rohde

QSPA-T Dust collectors

The modernized target vacuum chamber allow to place various dust collectors



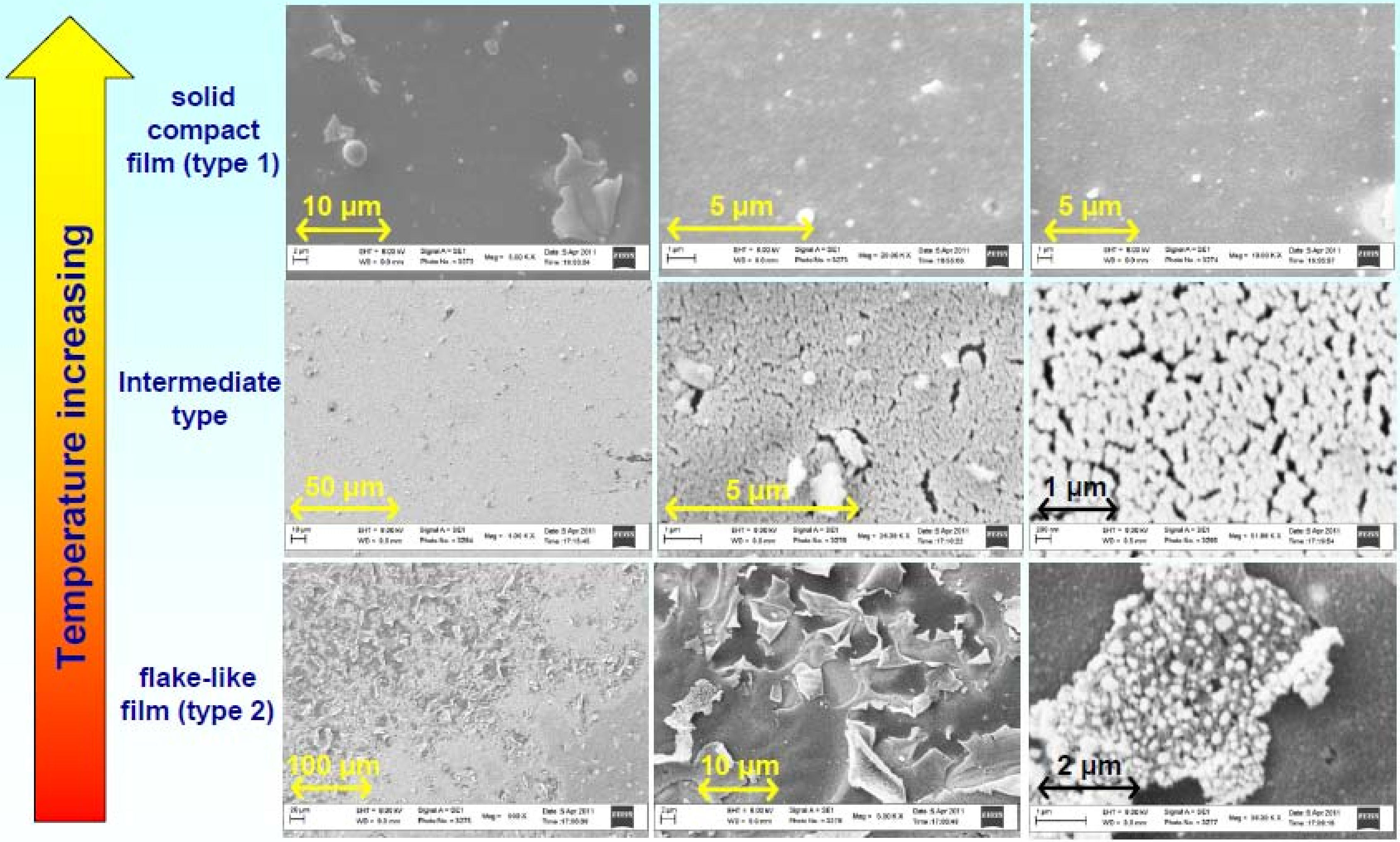
Collectors of type I:
thickness, volume, and mass measurements,
SEM,
X-ray spectrum analysis

Collectors of type II:
thermodesorption spectroscopy,
X-ray structure analysis,
thickness, volume, and mass measurements

Collectors of type III:
SIMS, thickness, volume, and mass measurements

S. Budaev

QSPA-T *Electron microscopy of the films*



S. Budaev